



# Extracting Nature's Energy

Georgia researchers uncover new ways to meet America's alternative energy needs. By Kathy Brister

For a view of what scientists, entrepreneurs and even the president say could help solve America's energy problems, take a stroll through your own backyard. Ethanol made from trees, grass and other common plants could one day supply most of the United States' ethanol.

By combining such cellulosic ethanol with that made from crops such as corn, the country could cut gasoline use by a third in about 20 years and slash yearly fossil-fuel emissions by 250 million tons—equivalent to what's emitted from 45 coal-fired power plants. These recent projections from the U.S. Department of Energy's Sandia National Laboratories are feeding intense interest in bioenergy.

Georgia—with its tradition of farming, wealth of agricultural and engineering research, and 24 million acres of timberland—wants to be at the center of this green-power movement. It's one component of a statewide push into biotechnology, which combines scientific innovation with industrial commercialization to drive developments in medicine, agriculture and energy.

Much of the state's bioenergy effort is focused on cellulosic ethanol, which is touted by some as the holy grail of biofuels. Cellulosic has potential advantages over the corn-based ethanol already in production. The process of making fuel from corn takes a great deal of power, offsetting some of its green-energy benefits. Plus, redirecting food crops for fuel can affect world food supplies.

## Corn

Corn-based ethanol is already in production, but researchers are examining other sources of fuel, including trees, grass and other common plants.



But if cellulosic ethanol is to live up to its promise, scientists must solve the mystery of how to extract plants' fuel-bearing sugars in a way that is efficient and environmentally sensitive.

Dozens of researchers in Georgia are on the case. Both the University of Georgia and Georgia Tech are part of a \$125 million Department of Energy Bioenergy Science Center focused primarily on developing cost-effective means of producing biofuels from plants. Georgia scientists have attracted millions more in other bioenergy research funds.

The Georgia Research Alliance is directing 70 percent of its \$30 million in state funding annually toward biotechnology efforts, including bioenergy. Much of the money is used to recruit "Eminent Scholars" to state universities and to foster growth of start-up companies.

State economic developers attracted more than \$3 billion in commercial green-energy projects over the past three years. Jill Stuckey of the Georgia Environmental Facilities Authority says Georgia will get another boost from the federal economic stimulus package, which contains \$500 million for "leading-edge" biofuel projects.

Here's a look at some of the bioenergy innovations under way in Georgia.

## Tapping Timber Power

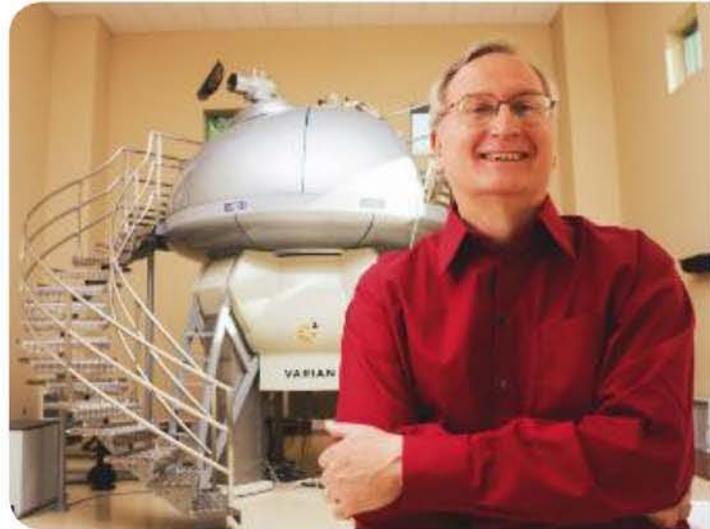
A patch of woods in southeast Georgia is getting a world of attention these days. That's where bioenergy company Range Fuels plans to crank up what's being billed as the United States' first commercial-scale cellulosic ethanol plant by mid-2010. If scientific vision and market reality unite as researchers and investors hope, what happens on those 280 acres in Soperton, Georgia, could change the way America fills up.

Range Fuels uses a thermo-chemical process to convert wood biomass into biofuels. It has been working on its cellulosic ethanol recipe since the company was established in 2006, including at a pilot plant near the company's Colorado headquarters. But the real test will come once Range Fuels flips the switch at its \$100 million-plus plant in Georgia, a location chosen for one key reason: It's surrounded by acres of timberland.

At maximum capacity, the plant will churn through 2,625 tons of dry wood a day, producing 100 million gallons of biofuel annually. CEO David Aldous says his company's product emits a tenth of the carbon dioxide of traditional fossil fuel.

When Range Fuels launched with \$14 million in venture capital, oil prices were on their way to record highs. In 2007, the company won a \$76 million Department of Energy grant; last year it drew another \$130 million from private investors. In January, it received an \$80 million loan guarantee from the U.S. Department of Agriculture.

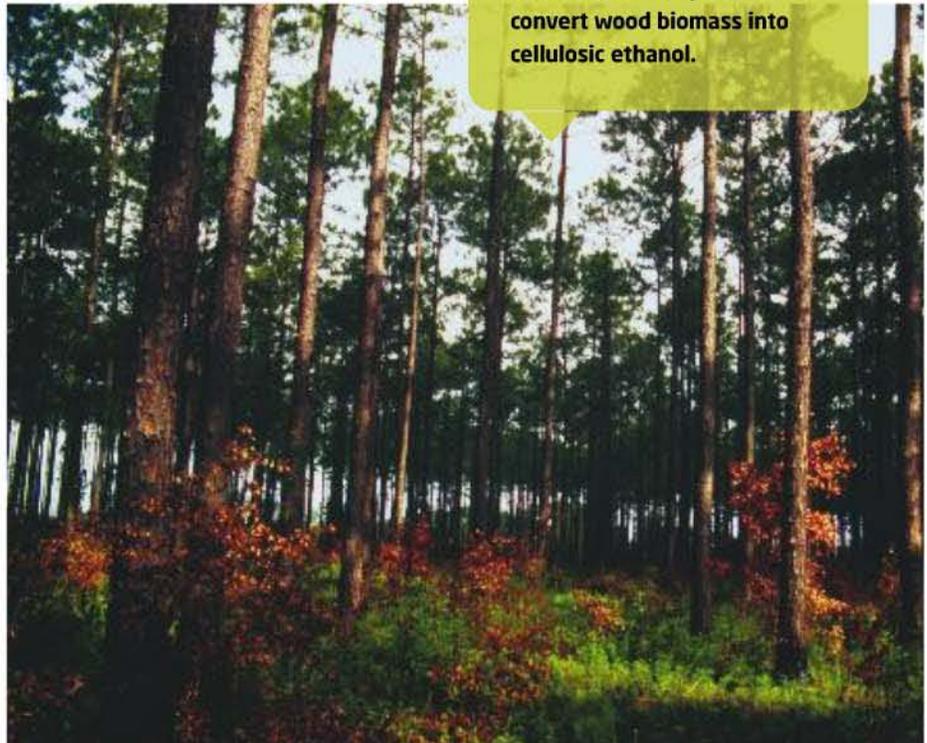
Because of lower oil prices and a global recession, the economic argument for biofuels has taken a back seat to the environmental one. Aldous says global-warming concerns will drive the market for cellulosic ethanol over the long run. "What used to be a debate about climate change has changed into a debate about what we have to do about climate change," he says.



As part of the BioEnergy Science Center (BESC) project, Will York studies the structure and dynamics of carbohydrates in plant cell walls using analytical tools such as the 900 MHz nuclear magnetic resonance spectrometer.

## Forests

**Timber could be the next major source of alternative energy. Range Fuels, a Georgia-based bioenergy company, uses a thermo-chemical process to convert wood biomass into cellulosic ethanol.**



PHOTOGRAPH COURTESY DAVID J. MOORHEAD, UNIVERSITY OF GEORGIA, BUGWOOD.ORG



## Miraculous Membranes

It may sound like a strange problem for a liquid fuel, but the fermented biomass broth that eventually becomes ethanol is just too wet. The broth contains about 90 percent water and only about 10 percent alcohol—although it's the latter that actually turns into fuel.

The previous solution involved straining the liquid through a series of sieves, then heating it to cook out the water. That takes a lot of energy. But a more efficient way to extract water from ethanol could emerge from William Koros and Sankar Nair's laboratory. The professors at Georgia Tech's School of Chemical & Biomolecular Engineering are working to develop membranes that would filter water from ethanol using little or no heat. "The dream is to never use thermal energy," Koros says.

First, the ethanol broth would flow through a water-loathing membrane containing tiny particles that allow the alcohol to pass through while blocking the water. Then, a second membrane—this one hydrophilic, or water loving—would filter out any trace amounts of water left in the alcohol. The result: pure ethanol.

“The dream is to never use thermal energy. ... It's all about being able to pull one thing out and separate it from another.”

—WILLIAM KOROS, PROFESSOR,  
GEORGIA TECH

It is a simple idea that's difficult to realize. The challenge is figuring out exactly which materials make the best membranes. Koros hopes for a breakthrough within the next three years. If he and his colleagues can solve the mem-

**Extracting Cellulosic Ethanol: Today //** While cellulosic ethanol has its benefits, the extraction process takes a lot of power—offsetting some of its green-energy benefits. The following diagram from the Department of Energy BioEnergy Science Center (BESC), led by Oak Ridge National Laboratory in Oak Ridge, Tennessee, illustrates a current extraction process.



SOURCE: GENOME MANAGEMENT INFORMATION SYSTEMS, OAK RIDGE NATIONAL LABORATORY

**Extracting Cellulosic Ethanol: Tomorrow //** Researchers across the United States are searching for ways to make cellulosic ethanol extraction a more consolidated, cost-effective process. For example, the BESC project, illustrated in the diagram below, would use biotechnology approaches to combine steps 3 and 4 from the top illustration into a single step.



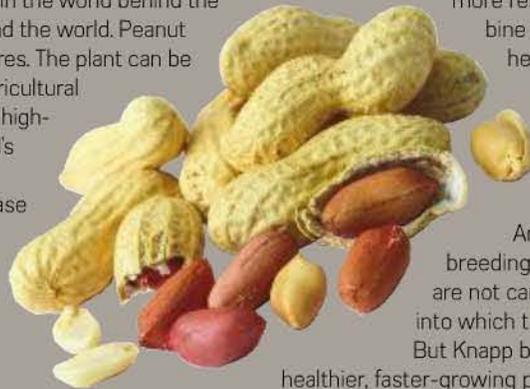
# PEANUT POWER

How one plant could feed and sustain millions.

As you break open that bag of peanuts, take a moment to consider the value of what's inside. The peanut, the second most-harvested legume in the world behind the soybean, feeds millions of people around the world. Peanut crops cover an estimated 57 million acres. The plant can be grown in almost any warm-weather agricultural area, meaning farmers can harvest the high-protein legume near some of the world's hungriest people.

But peanuts are susceptible to disease and drought. Some varieties produce more than others. How can farmers better ensure their peanuts will yield what the world needs? The answer may lie in the little-known genetic structure of this workhorse crop.

Enter University of Georgia researcher Steven Knapp, who is on a mission to understand the genetics of peanuts. Using biotechnology to determine the

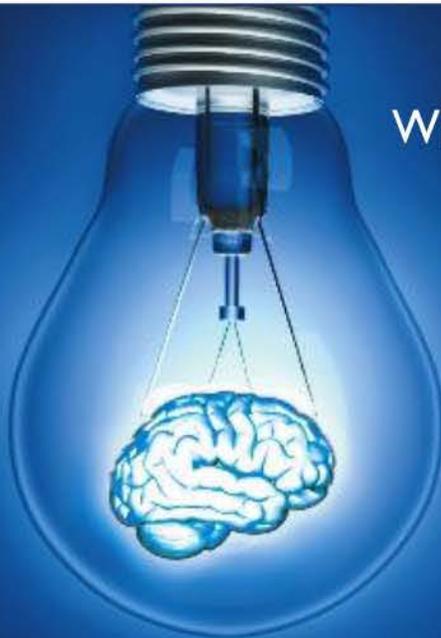


genetic pros and cons of both modern peanut varieties and their native ancestors could lead to the development of stronger, more resilient peanuts. "We're trying to combine the best traits of different varieties," he says.

The nature of the plant poses some challenges, however. "Peanuts grow out, not up," Knapp says. "They produce seeds underground, so crossing seeds is more complex."

And there are risks, too. High-tech breeding can narrow biodiversity if researchers are not careful stewards of the genetic pools into which they dip.

But Knapp believes the potential result—a healthier, faster-growing peanut—could help feed an ever-hungrier world. "The world's population is growing rapidly, and peanuts are one of the world's important foods; it's just a matter of producing more." —K. B.



When that little light goes on in our head,  
you can bet a big breakthrough  
is close at hand.

ATLANTA — Every day, Emory scientists shine, thinking of new ways to enhance and save lives. Every hour, we are brainstorming innovative ideas and new medical solutions: novel approaches to cardiac and brain imaging, diagnostic tests for genetic disorders, treatments for hepatitis, vaccines and industry-leading drugs for HIV. In fact, Emory receives more research funding than any academic institution in Georgia

and proudly partners with the Georgia Research Alliance, the Georgia Cancer Coalition, the Centers for Disease Control and Prevention and the National Institutes of Health. Our discoveries have led to 27 products already in the marketplace and more than 25 on the way. Bright minds coming up with the brightest ideas — a regular occurrence at Emory.

Visit [www.ott.emory.edu](http://www.ott.emory.edu) for more information about the Emory Office of Technology Transfer.

[www.emoryhealthsciences.org](http://www.emoryhealthsciences.org)



EMORY  
UNIVERSITY



brane puzzle, their discoveries could be used in other ways—such as stripping carbon dioxide from natural gas.

"It's all about being able to pull one thing out and separate it from another," Koros says.

### Breaking Through the Wall

Alan Darvill is waging war against a microscopic foe that has the force of nature behind it. The University of Georgia researcher is trying to break down plants' tiny, fortress-like cell walls and extract their sugars. Once freed, the sugars can be processed into cellulosic ethanol, an alternative fuel that could help curb America's gasoline consumption.

The challenge is that cell walls have been strengthened by millions of years of evolution; they are tough because plants need them to be. Darvill's first battlefield strategy is to go after the weakest warriors. He and his colleagues are testing a variety of plants to see which ones have cell walls that break down easily. He also is attempting to fight nature with nature. His weapons of choice include enzymes and microbes that could help chip away at cell walls.

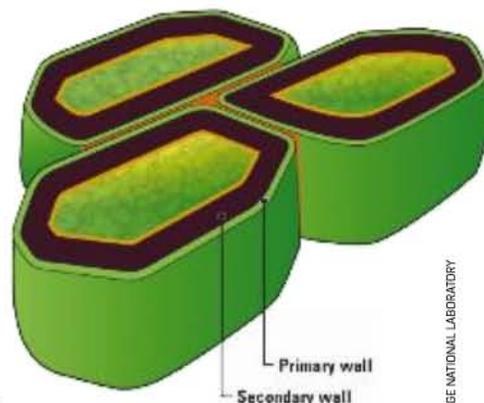
It could be five years before Darvill knows whether his work has the potential to succeed, although, he notes, preliminary results look good. The U.S. Department of Energy, which backed some of Darvill's research, wants solutions for its climate-change

and energy-diversity problems. Companies want to know how to make producing cellulosic ethanol a viable business.

For Darvill, the heightened interest has meant speeding up his cell wall campaign, built upon three decades of research. "Everyone wants an answer faster than they used to," he says.

David Lee, the man with a 30,000-foot view of the University of Georgia's research, is so sure the work underway in Georgia will yield biofuel solutions that he's on to the next challenge. "If you reduce use of petroleum fuels, you also reduce petroleum byproducts used in everything from cosmetics to plastics," says Lee, the University of Georgia's vice president for research. The question: How can manufacturers adapt their products? Georgia scientists, he says, are already working on it.

*Kathy Brister is a writer who has an earth-friendly commute to her home office in Atlanta.*



SOURCE: GENOME MANAGEMENT INFORMATION SYSTEMS, OAK RIDGE NATIONAL LABORATORY

2009 Bio International Convention  
Visit Us At  
Booth #2625

**We don't think of it as making medicines.  
We think of it as improving lives.**

Solvay  
Pharmaceuticals

901 Sawyer Road Marietta, GA 30062 770.578.9000  
www.solvaypharmaceuticals-us.com