Biofuel Science Research at the University of Maryland

Biofuels promise energy alternatives that are renewable and sustainable; they combust like traditional fossil fuels, such as gasoline and propane, but they are made from fermented plant matter, rather than oil, coal, or natural gas. Ideally, the production of biofuels would absorb as much pollution as the fuels release during combustion, since plant stocks can consume vast quantities of carbon dioxide during their growth. But for the promise of renewable carbon-neutral energy to be realized, new sources of biofuels must be found. The current manufacture of biofuels from corn and other grains is inefficient and creates a precarious competition between food and fuel. Researchers at the University of Maryland are developing the biofuel sources of the future, and they are advancing technologies that will make the production and use of these fuels more efficient.

Steven Hutcheson uses the enzymes produced by grass-eating bacteria to turn useless grass fibers into fermentable, ethanol-producing sugars.

Rick Kohn examines how the bacteria found in cow stomachs can be used to create ethanol and methane. Eventually, large cultures of cow-gut bacteria could produce fuel at industrial scales.

Jennifer Becker is developing microbe-powered fuel cells from plant waste. These cells can convert plant material directly to electrical energy, which could be far more efficient than fermenting plants into combustible materials.

Gary Coleman studies fast-growing poplar trees, a potential source of bulk biomass. Understanding the molecular mechanisms behind the trees' rapid growth could lead to genetically engineered poplar strains that generate fermentable biomass even more rapidly.

Using Microbial Enzymes to Convert Grass to Ethanol

Steven Hutcheson uses the unique enzyme of a grass-dwelling bacterium found in Chesapeake marshes to create biofuel from plant fibers. Though biofuels are typically made from grains like corn, the technology exists to also make fuel from cellulose, the tough fibrous part of plants. But the cost of making fuel from cellulose is about twice as high as the cost of making ethanol from grain. Hutcheson's bacterium—*Microbulbifer degradans*—could dramatically reduce these costs.

M. degradans lives in the decaying marsh grasses of Chesapeake Bay, and it demonstrates a remarkable ability to convert fibrous material into glucose, a sugar that can be converted into ethanol. Hutcheson is working to harvest the microbe's fiber-eating enzymes to develop processes for breaking down large quantities of grass cellulose. These processes could provide industrial-scale sugar stocks from inedible plants.

In his lab at the university, Hutcheson is studying the enzyme systems in *M. degradans*. As the founder of a company called Zymetis, he is working to economically produce key enzymes from the bacteria. In 2007 the university's Office of Technology Commercialization awarded Hutcheson an Outstanding Invention of the Year prize.

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Bacteria from Cow Stomachs Convert Fiber to Fuel

Rick Kohn also sees bacteria as the key to converting cellulose to biofuel. Kohn and his research group are working on ways to control the behavior of cattle-gut microbes; large cultures of these bacteria could be used to convert plant fibers into ethanol and methane fuels.

Kohn studies fermentation in the cattle stomach, where bacteria efficiently break down large amounts of grass into sugar. But for Kohn to replicate this process at larger scales, he must first characterize the bacteria population. Cattle rely on several of types of bacteria to convert grass to sugar, but more than half of the organisms in cattle stomachs have never been successfully cultured before. Kohn is using DNA fingerprinting and other methods to estimate the diversity of these microbial communities.

Kohn's research also has implications for methane production. Up to 12 percent of the energy from cattle feed ends up as methane, which is released into the air as flatulence. By studying the process of methane production in cattle, Kohn hopes to make methane a more efficient and cost-effective biofuel.

Ultimately, Kohn wants to culture microbial communities that can make either methane or ethanol from plant fibers. The challenge lies in finding brews of microorganisms that can coexist and produce fuel efficiently.

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Efficient Electricity from Agricultural Waste

Jennifer Becker is developing fuel cells that covert agricultural wastes directly into electricity.

Becker is in the preliminary stages of designing fuel cells that incorporate microorganisms able to digest solid plant wastes, like corn stalks. These bio-fueled "batteries" would convert the biochemical energy from this waste directly into electrical energy. The process merges two steps in one: Instead of first digesting cellulose into sugar and then creating usable energy by fermenting the sugar, the bacteria in Becker's fuel cells would convert plant biomass into ionic solutions that could generate a usable electron flow.

This method of generating energy will not be rapid, but it should be extremely energy-efficient.

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Fast Growing Trees as a Source of Fuel

Gary Coleman studies the factors that stimulate the growth of poplar trees. These trees grow rapidly in temperate climates and could be an excellent source of biomass for biofuels. With sufficient light and water, a small poplar cutting can grow 75 feet in 5 years.

Using genomic tools to identify the poplar's growth genes, Coleman is working to understand the molecular mechanisms that underlie the onset of dormancy in autumn and the resumption of growth in the spring. Understanding these mechanisms could help researchers design trees with extended growing seasons, which would make the generation of fuel-stock biomass even more efficient.

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