Speeding Up Evolution

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Editors note: Corn ethanol production in the United States has skyrocketed in response to the rising costs of foreign oil. But the success of biofuel programs has been a factor in driving up food costs worldwide, causing shortages, political unrest and the possibility of mass starvation. Four researchers at IUPUI think they have a solution to all that.

Call it an example of the law of unintended consequences. As oil prices have risen, the use of ethanol as an alternative to foreign oil has soared, due in part to tax breaks for fuel blenders and subsidies for corn producers. The increased demand for corn has driven its price up dramatically, from $2.17 per bushel in 2006 to nearly $8 per bushel this summer (it has since dropped to about $4 per bushel).

The spike in corn prices has been good news for farmers, but not for those for whom it is a staple food. In Mexico, the tripling of the price of tortillas caused riots. And since corn is the dominant feed ingredient for cattle, increased corn prices have driven up the price of dairy and beef products as well. The prices of wheat and other crops have also risen as farmers choose to make more money by growing corn instead.

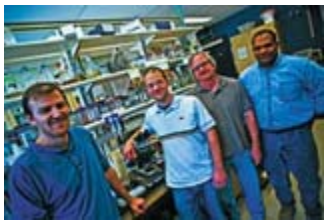
Biofuels production isn't the only cause for the current food crisis affecting the world's developing countries. Increased demand by the growing economies of China and India, decreased agricultural production in many areas due to droughts and floods, and the conversion of farmland to industrial purposes are also factors that have created a "perfect storm" that some predict could cost millions of lives. Rising prices and food shortages have caused civil strife and political instability in at least a dozen countries in addition to our neighbor to the south. And since Congress mandated in last year's Renewable Fuels Standard that ethanol production be quintupled by 2022, the situation seems guaranteed to worsen.

Unless, that is, the project that four researchers at the Richard G. Lugar Center for Renewable Energy at IUPUI have been working on is as successful as they think it will be.

Led by Dr. Mark Goebl, a professor of biochemistry and molecular biology at the Indiana University School of Medicine, the gang of four — Goebl, Ross *censormode*lin, Josh Heyen and Cary Woods — is putting the finishing touches on a strain of yeast they developed that would reduce or eliminate the need to use corn to produce fuel. Their new baby, which will go by the name Xylanol, is happy to eat a sugar that other yeasts ignore, and can produce ethanol from any plant material, such as wood chips and agricultural waste — even grass clippings. "You can go out and mow your lawn" to produce raw material to make ethanol, Goebl says.

Yeast is a beast

Yeast, a tiny organism usually about 3 to 4 microns in diameter, generally prefers to consume glucose, the type of sugar that is found in honey. When the starch in corn is ground it is broken down into glucose; when yeast eats glucose it converts it into ethanol. Other types of plant material are one-third cellulose, which can be broken down and converted to glucose, and one-third xylose, a type of sugar that yeasts ignore. Xylanol is happy to feast upon xylose as well as glucose, which doubles the ethanol yield from plant material.



“Corn is OK, but it would be far better if we could use crops that don’t go to food,” says Goebl, an engaging, 50ish man whose straight gray hair falls slightly over his ears. “We’d like to make it more feasible to use virtually anything as a potential source of ethanol.”

The trick to getting yeast to eat xylose is that it has an extremely strong preference for glucose, and will ignore any other potential food as long as even a trace amount of glucose is present. “We’ve been able to take yeast, which really has a strong preference for glucose, and completely eliminate that preference,” Goebl says.

Early testing is being done with switchgrass, a tall, perennial prairie plant that requires little care and can be grown from Nova Scotia and Saskatchewan to most of the United States east of the Rocky Mountains. It can grow in poor soils, and is drought-resistant. So hardy that it is considered an invasive species in some areas, it is able to flourish in a wide variety of climates.

Besides its ease of cultivation, switchgrass has something else going for it: a high energy return. The food issue aside, using corn to produce ethanol isn’t a very efficient use of resources. A 2007 United States Department of Agriculture study concluded that the energy returned on energy invested (EROEI) for ethanol made from corn in the U.S. is 1.34, meaning it yields 34 percent more energy than it takes to produce it; some other studies have determined that it takes nearly as much or as much energy to produce ethanol as it yields. Switchgrass does much better, with an EROEI ranging from at least 4 to as much as 10 — and those estimates are from pre-Xylanol studies.

Xylanol will be able to be genetically tuned — in essence, different strains can be optimized for specific types of plant material. This is significant because of the logistics involved in shipping ethanol from the Midwest, where it is currently produced, to fuel blending facilities in other parts of the country. Strains of yeast developed to work with whatever regional crops work best will allow ethanol to be produced closer to markets where it is used, reducing the costs associated with transporting it.

The development of new strains of organisms using genetic engineering sets off alarms with those who are concerned about the possibility of catastrophic unforeseen consequences if new creations escape into the wild. Although their focus is mainly on genetically modified food crops, Greenpeace and other organizations warn against genetic pollution and oppose patents on plants, animals and genes. Despite its creators' best intentions, could Xylanol become a dangerous Frankenyeast?

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"All we've done is speed up evolution," Josh Heyen explains, while his two young children tear around the kitchen of the family's Southside home. "It's likely that a yeast like this already exists somewhere, but it's a lot easier to develop it in a lab than to search it out." He's been working on this project for about six and a half years, but is probably right: According to Wikipedia, about 1,500 species of yeast have been described so far — about 1 percent of the total estimated to exist. "Ours is basically a brewer's yeast," Heyen adds. "It's not an opportunistic pathogen that causes infections, so it's not a health hazard." (Yeast infections affecting the skin and mucous membranes are caused by members of the Candida genus. Species of the Saccharomyces genus are used in brewing and baking.)

It remains to be seen whether the technology can make the transition from laboratory to commercial production. "Getting a process to work in a lab is one thing," Tom Skokut, plant biologist who recently retired from Dow Agrosciences, commented after learning about the project. "Scaling it up is something else entirely."

Applying the technology on a commercial scale is seen by the team as just another step in the development process. Ethanol produced by using the new method is projected to begin hitting the market in three to four years, according to Cary Woods, the team member charged with handling the bulk of the administrative duties. Woods says IU's attorneys will file a patent application for the yeast in late November, and after that the push to apply the technology will begin in earnest. The four members of the team are principals of a new company called Xylogenics, which is negotiating with IU for a license to use the patented yeast. Xylogenics will then in turn enter into agreements with other companies that will use Xylanol to produce fuel ethanol. Woods says they hope to keep the project in Indiana by partnering with other Indiana companies to continue developing the technology and to produce ethanol.

Goebl, *censormode*lin, Heyen and Woods are very matter-of-fact when talking about their project — they are scientists, after all — but there's an underlying drive and enthusiasm that keeps holding their interest. Their work has resulted in a yeast that will enable prairie grasses and agricultural waste to be used to produce fuel efficiently, and allow corn to go back to the role it plays best: being food.

News of the researchers' accomplishment has made it to the international community of biogeneticists, many of whom are excitedly discussing the breakthrough on Internet forums and message boards. Goebl and his team don't say so themselves, but they smile in acknowledgement when someone else does: Their little yeast is going to be huge.