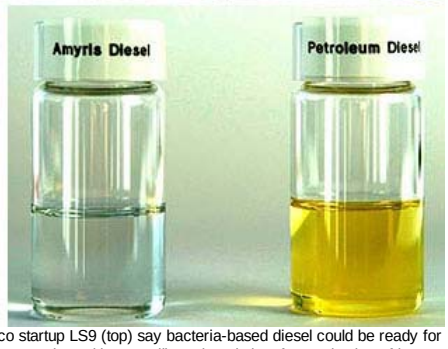
For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria

Scientists are looking way beyond ethanol to a new generation of power—one that's designed on a computer, produced by bacteria and acts just like good old gasoline. The countdown to production-ready designer fuels has begun.



Through a twist of synthetic biology, researchers at San Francisco startup LS9 (top) say bacteria-based diesel could be ready for cars by 2011, while Emeryville, Calif.-based Amyris (bottom) has teamed up with a Brazilian ethanol giant for production of its own third-generation alternative fuel, which may come even sooner. (Photographs Courtesy of LS9 and Amyris Biotechnologies)

By Chris Ladd

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The key to the next generation of biofuels isn't growing in a field; it's mutating in a lab. By swapping natural genes in yeast and bacteria for synthetic ones, scientists have tricked the microbes into producing hydrocarbons—creating, in essence, billions of tiny refineries to turn simple sugars into environmentally friendly diesel, gasoline, jet fuel and biocrude.

"We've been making a lot of things using micro-organisms for a long time," says Jim McMillan, biorefining process R&D manager at the National Renewable Energy Laboratory (NREL). "The real breakthrough here, I think, is recognizing that you can get these microbial factories to produce these very high-energy fuel molecules, like hydrocarbons."

Moonshine, penicillin, even certain cheeses all rely on millions of similar little helpers. But recent advances in genetics have allowed researchers to design genes on computers and splice them into a microbe's DNA, no longer simply refining the natural abilities of microorganisms, but creating in them new talents entirely.

"Essentially, we take what would normally be converted into triethylglycerides—effectively, fats—and divert that off into these hydrocarbons that we care about," says Greg Pal, a senior director at LS9 in San Francisco, which hopes to bring bacterial diesel fuel to commercial scale by 2011.

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Amidst increasing criticisms of ethanol's shortcomings—lower energy density, energy-intensive production and distillation, and the inability to transport the fuel within existing pipelines—a growing handful of companies are betting that the biofuels of the future will look almost identical to the petroleum-based fuels of the present.

"It's getting easier and easier, but it still takes a decent amount of effort to engineer a biological system into doing something that you want it to do," says Neil Renninger, co-founder of four-year-old Amyris Biotechnologies, a company that previously engineered microbes to churn out inexpensive antimalarial drugs. "So before going down the route of engineering a bug to make a biofuel, we wanted to make sure we were making the best biofuel possible."

Amyris first studied the highest performing compounds of diesel, gasoline and jet fuel, then tinkered with the genetic structures of E. coli and yeast to produce bioequivalents, Renninger says, leveraging the same cutting-edge technology previously employed to produce pharmaceutical-quality medicines at commodity-level prices. The company recently announced a deal with the Brazilian sugar and ethanol manufacturer Crystalsev to launch a joint facility south of São Paulo, giving Amyris access to 2 million tons of sugar to feed its mutated strains of yeast. It projects commercial production of some 30 million gallons of diesel as early as 2010, with production of gasoline and jet fuel roughly one and two years behind, respectively.

LS9 plans to open a pilot facility this summer and a 50- to 100-million-gallon plant three years later, producing a drop-in replacement for diesel, as well as a biocrude to be processed in traditional refineries. Rogue scientist J. Craig Venter, who helped lead an international consortium of scientists to map the human genome, has announced plans to engineer bacteria able to create hydrocarbons not just from sugars, but from CO_2 pulled straight from the atmosphere.

"If you look at where sugar cane is in Brazil, or at where biomass will be here in the near future, we're pretty confident that we can compete with oil around the $50-a-barrel range," Pal says. "The key driver of the cost really is the cost of raw materials."

For the moment, microbial hydrocarbons, like ethanol, rely on an inexpensive supply of simple sugars to convert into fuel. In the United States, that supply has traditionally come from the starches found in corn kernels, a feedstock with questionable environmental benefits and marginal economic ones. Until technologies exist to easily derive sugars from tough cellulosic material, such as corn's remaining stalks, leaves and cobs, companies like LS9 and Amyris are likely to feed their fuels with sugar cane—a relatively green source of easy-to-use sucrose, albeit one with limited domestic potential.

As the world continues to consume some 150 million gallons of oil every hour, any potentially game-changing solutions will need not only to work, but to work cheaply and at truly massive scales.

"We could be harvesting on a sustainable basis over a billion tons of dry biomass in the United States if we got serious about it, and that would get us somewhere close to 30 percent of our liquid transportation fuels," NREL's McMillan says. "So while sucrose is undoubtedly part of the solution, to really get that huge volume impact, you have to go to those cellulosic feedstocks."

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Reader Comments

20. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
The solution is near... the sustitution oil fuel is a necessary to Climate Change mitigation. Gerencia y Energia

19. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
Superbugs need to be engineered to withstand higher concentrations of alcohol to improve overall efficiency. However, confining microbes is nearly impossible. So, what happens when alcohol gels (like Purell) in hospitals and on cruise ships are no longer effective against microbes that can tolerate high alcohol concentrations? And, what IS that smell in your fuel tank?

18. Check the math...
Price of sugar on NYMEX is ~15 cents/lb...know how much a barrel of crude weighs?...about 350lbs. That's ~$50 per barrel if you had 100% mass conversion (impossible), ignoring stoichiometry, biomass of the bacteria, etc. Oh yeah, and assuming that taking down 10 million tons of sugar A DAY wouldn't affect that market?

17. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
along with using plants to feed the bacteria, why not use sewage as well. Solve several problems all at once.

16. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
Is'nt this being done at Penn State U. to make clean water and hydrogen, called microbio fuelcells.

15. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
Response to reply no. 7: Why would it contribute to global warming? You are removing more hydrocarbons from the atmosphere than burning the fuel can create. In effect, the more you use it, the more you reduce the total concentration of carbons.

14. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
We have so many options open to us right now. The future of these fuels looks really good and although electricity is cheaper, it won't be if everyone drove an electric. We simply don't have the infrastructure for everyone to plug it in at night for a charge, not without building 50 new nuclear power plants! Solar and wind, while great, supply 7% of our power, while wind and solar have yet to be reliable enough for mass production. Currently the Southwest has the best chance at solar and the biggest of it's kind solar power plant is under construction. John McCain has been a strong supporter of this too.

13. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
wondering if someone can provide some simple numbers, like, how much BTU of ethanol can be generated from one acre of corn field, and same number of this LS9 bug.

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12. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
When a plant grows, it uses CO2 as its carbon source. If the plant (corn, sugar, switch grass) is then fermented and burned in a motor, the carbon goes back. This is exactly the same as if the bacterium uses CO2 to grow and produce a fuel. This is different than taking carbon that is buried in the ground for a million years and burning it. The net gain is positive for CO2 in the air in that case. Duh.

11. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
Website: www.wealthystep.ffivideo.com
I've been involved with this company for a few years, the product is marketed via networking, and provides an extra source of income to a lot of people. We could market this world wide via such a vehicle. The geometric progression of numbers really works. Think about this.1.Your bringing a product to market the fastest and most economically feasible way.2.Not only contributing to cleaning the air, but helping the millions in an extra source of income. Ed Hebert San Francisco edwards@edwardj.biz

10. Expect this to be resisted at every level by the Environmentalist clique
We can be no GMO solution to the problem...

9. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
I thing the idea of coverting the CO2 is the real winner, as it will help offset the Coal from powerplants

8. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
See sapphireenergy.com for details on a modified algae that will directly product gasoline from sunlight, water, oxygen, etc. This looks to be in the same time window as LS9 and Amyris.

7. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
Won't this still contribute to global warming?

6. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
I can't wait to have the first bumper sticker saying "Proudly Powered by FrankenFuel!" Of course, that fact (genetic manipulation) would allow the AGW hysterics to block this innovative source of BioFuels for a few years.

5. Ideally we will someday use the sun
Instead of feeding plant-derived sugars to modified bacteria, why don't we work on an organism with chloroplasts (i.e., plant life), which itself makes liquid fuel such as ethanol or an oil, using energy from the sun?

4. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
We are too dependant on internal combustion, why not alter microbes to be photovoltaic. Electricity is much cleaner and safer.

3. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
Website: http://macgecko.blogspot.com/
Looks like a good choice I hope they will be able to bring it to market sooner rather then later.

2. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
That is what I am talking about; now, if we make sure that these bacteria are photosynthetic then we are also producing more oxygen to solve the climate crisis.

1. RE: For Future of Biofuel, Secret of MPG Ooze Lies in Mutant Bacteria
Website: http://www.betterconstructed.com
This is Mealer Companies right? John McCain has been pushing this for years if not decades. Google McCain 3R Economic Plan/

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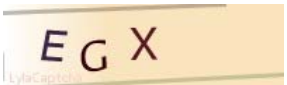

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