SYNTHETIC BIOLOGY FOR SYNTHETIC FUELS

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Today, carbon-rich fossil fuels, primarily oil, coal and natural gas, provide 85% of the energy consumed in the United States. As world demand increases, oil reserves may become rapidly depleted. Fossil fuel use increases CO_2 emissions and raises the risk of global warming. The high-energy content of liquid hydrocarbon fuels makes them the preferred energy source for all modes of transportation. In the US alone, transportation consumes around 13.8 million barrels of oil per day and generates over 0.5 gigatons of carbon per year. This release of greenhouse gases has spurred research into alternative, non-fossil energy sources. Among the options (nuclear, concentrated solar thermal, geothermal, hydroelectric, wind, solar and biomass), only biomass has the potential to provide a high-energy-content transportation fuel. Biomass is a renewable resource that can be converted into carbon-neutral transportation fuels.

Currently, biofuels such as ethanol are produced largely from grains, but there is a large, untapped resource (estimated at more than a billion tons per year) of plant biomass that could be utilized as a renewable, domestic source of liquid fuels. Well-established processes convert the starch content of the grain into sugars that can be fermented to ethanol. The energy efficiency of starch-based biofuels is however not optimal, while plant cell walls (lignocellulose) represents a huge untapped source of energy. Plant-derived biomass contains cellulose, which is more difficult to convert to sugars, hemicellulose, which contains a diversity of carbohydrates that have to be efficiently degraded by microorganisms to fuels, and lignin, which is recalcitrant to degradation and prevents cost-effective fermentation. The development of cost-effective and energy-efficient processes to transform lignocellulosic biomass into fuels is hampered by significant roadblocks, including the lack of specifically developed energy crops, the difficulty in separating biomass components, low activity of enzymes used to deconstruct biomass, and the inhibitory effect of fuels and processing byproducts on organisms responsible for producing fuels from biomass monomers.

We are engineering the metabolism of platform hosts (*Escherichia coli* and *Saccharomyces cerevisiae*) for production of advanced biofuels. Unlike ethanol, these biofuels will have the full fuel value of petroleum-based biofuels, will be transportable using existing infrastructure, and can be used in existing automobiles and airplanes. These biofuels will be produced from natural biosynthetic pathways that exist in plants and a variety of microorganisms. Large-scale production of these fuels will reduce our dependence on petroleum and reduce the amount of carbon dioxide released into the atmosphere, while allowing us to take advantage of our current transportation infrastructure.

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