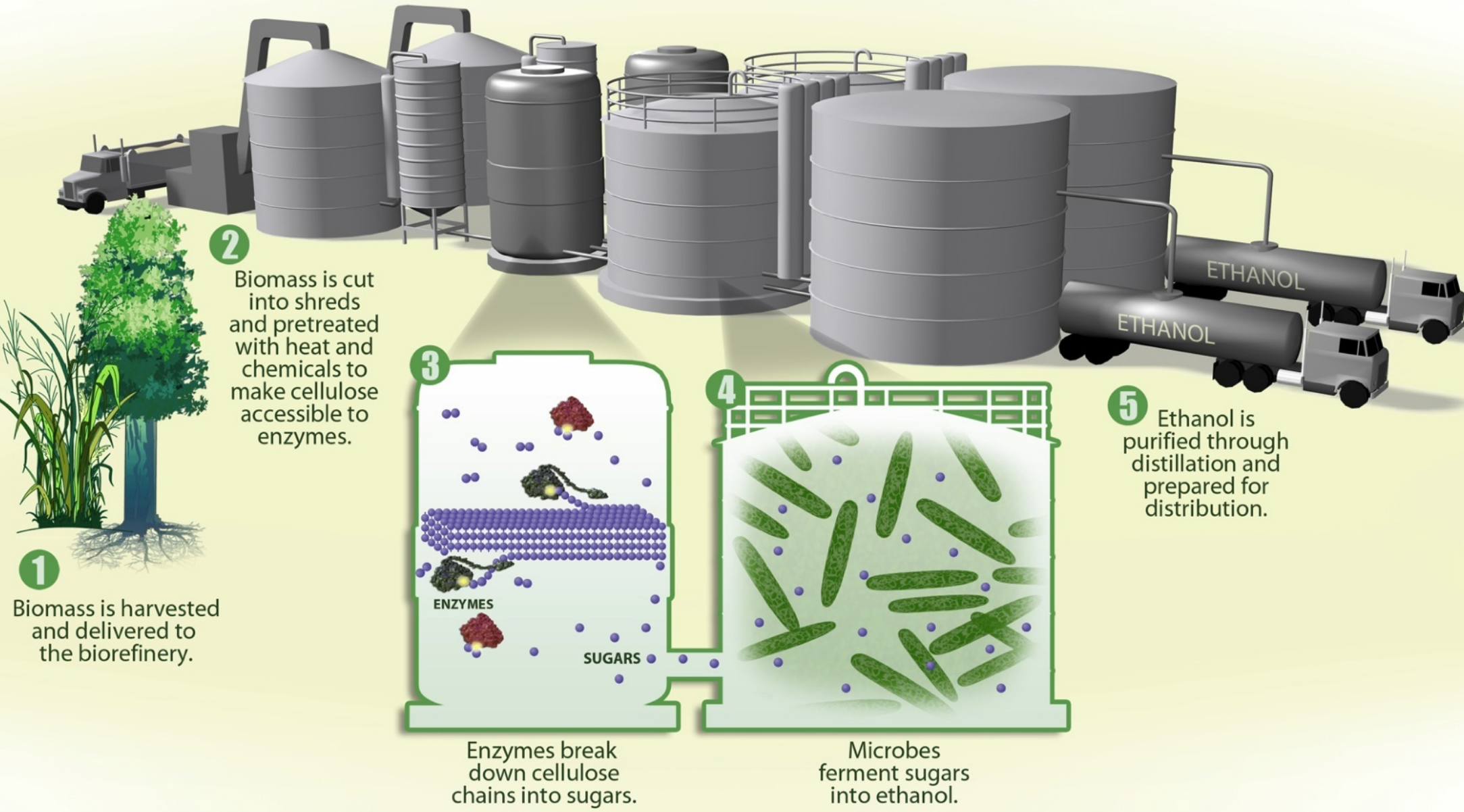


# How Cellulosic Ethanol is Made



## From Biomass to Cellulosic Ethanol

Ethanol from cellulosic biomass—the most abundant biological material on the planet—has the potential to revolutionize the fuel ethanol industry and decrease U.S. dependence on imported oil. Despite its abundance, cellulosic biomass is a complex feedstock that requires more extensive processing than corn grain, the primary feedstock for conventional fuel ethanol production in the United States. Several scientific breakthroughs are needed to make cellulosic ethanol production cost-efficient enough to operate at a commercial scale.

This figure highlights some key processing steps in an artist's conception of a future large-scale, cellulosic ethanol production facility. (1) Cellulosic biomass from trees, grasses, or agricultural wastes is harvested and delivered to the biorefinery. (2) Biomass is ground into small, uniform particles. Thermal or chemical pretreatment separates cellulose, a tough polymer of tightly bound sugar chains, from other biomass materials and opens up the cellulose surface to enzymatic attack. (3) A mix of enzymes is added to break down cellulose into simple sugars. (4) Microbes produce ethanol by fermenting sugars from cellulose and other biomass carbohydrates. (5) Ethanol is separated from water and other components of the fermentation broth and purified through distillation.

To bring down costs, continued progress is needed in the development of energy crops dedicated to biofuel production, biomass-collection technologies, pretreatment methods that minimize the release of inhibitory by-products, and more efficient enzymes and microbes robust enough to withstand the stresses of industrial processing.



A high-resolution version of this image is available for download from the U.S. Department of Energy's Genomics:GTL Program Image Gallery at <http://genomics.energy.gov/gallery/>.

Credit: U.S. Department of Energy  
Genomics:GTL Program