Exploiting Anaerobes for Biomass Breakdown and Sustainable Chemistry

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Abstract:
Renewable chemicals derived from plant biomass are attractive alternatives to those made from petroleum. To produce chemicals from biomass, enzymes are used to break down cellulose into simple sugars, which are later fermented into value-added products. However, since cellulose is tightly bound within a network of crystalline cellulosic fibers and lignin, existing biomass degrading enzymes are not very efficient. To develop new technologies that break down plant material into sugar, much can be learned by studying how microbes digest lignocellulose in biomass-rich environments, such as the digestive tract of large herbivores. Our goal is to develop new experimental tools to engineer anaerobic microbial gut consortia for lignocellulose breakdown and chemical production. To accomplish this goal, we isolated a panel of anaerobic fungi and associated microbes from different herbivores and screened for their ability to degrade several types of lignin-rich agricultural waste. By focusing on model anaerobic fungi from the *Piromyces*, *Neocallimastix*, and *Anaeromyces* genera, we discovered thousands of new genes from these systems, revealing hundreds of novel biomass-degrading enzymes that are already competitive with industrial standards. We characterized key regulatory patterns for these enzymes, which depend on the environment of the fungus. Using this information, we are developing new genetic engineering strategies to manipulate gut fungi at the molecular level, along with ‘bottom-up’ strategies to synthesize microbial consortia for compartmentalized breakdown and bioproduction.