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Extremophilic Microalgae for Biofuel Production

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Nestled between Idaho, Montana, and Wyoming is one of the last, nearly intact, ecosystems on earth which a myriad of wildlife call home. Established by Congress in 1872, Yellowstone National Park boasts breathtaking views and over 10,000 hydrothermal features. In fact, Yellowstone contains over one-half of the world's hydrothermal features. This is due to Yellowstone being an active supervolcano that last erupted 640,000 years ago. But what most people don't know, is that all of that geothermal activity causes gradients in temperature, pH, and toxic chemicals that source from the hot springs and geysers which run into rivers and streams. This sets the stage for extremophilic microorganisms to naturally adapt to survive in these extreme environments (for example, 220°F and very low pH). Locating and isolating these microorganisms is called bioprospecting, and is a boundless benefit for society. For example, in 1966 Dr. Thomas Brock discovered *Thermus aquaticus*, a heat tolerant bacterium, which he successfully cultivated in his lab. An enzyme in *T. aquaticus* called Taq polymerase has made DNA studies practical and led to the realization of DNA fingerprinting, genomic diagnosis, genetic engineering, and DNA-based studies of nature.

A new facet in the Renewable Energy Group at the West Central Research and Outreach Center is the Gardner Research Group, UMN Department of Bioproducts and Biosystems Engineering and housed at USDA-ARS Facility, who focus on the interface between microbiology and chemical engineering to harness naturally evolved microbial processes to convert sunlight into useful products. One example of this is cultivating algae, which uses sunlight and CO_2 to grow biomass and lipids, which can then be converted into biodiesel. This concept is not new, originally evaluated in the 1980's as part of the Aquatic Species Program, but due to unfavorable economic cultivation, harvesting, and processing costs, the technology is still at demonstration scale. New scientific breakthroughs are needed to reach full commercial realization.

One of the challenges facing algal cultivation is how to deal with open pond contamination. Imagine an array of one acre ponds growing green algae for biodiesel production. This array is open to other algal species (those that may not produce lipids for biodiesel) and predatory microorganisms that could blow in on the wind, be transferred by waterfowl, or infiltrate based on any number of other ways. One approach to avoid contamination complications is to tailor the water in the open ponds to make it inhospitable to almost everything other than the alga of choice. The addition of high amounts of salt, use of production water with a high concentrations of heavy metals, or adjusting the pH to alkaline conditions all can act to keep contamination down. However, this necessitates that your algae be able to survive in these harsh environmental conditions. This is what I call the "Roundup like" approach. Bioprospecting algae from places like Yellowstone National Park helps isolate extremophiles that can be used in harsh environments to produce valuable fuels and chemicals in production ponds, benefiting industry and the environment. Part of the Gardner Research Group here in Morris is focused on investigating the growth characteristics of alkaliphilic, thermophilic, and halophilic algae isolated from extreme environments across the United States. In hopes that we can learn unique metabolic functions that can be exploited for commercial biofuel and specialty bioproducts production.

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