ASU LightWorks
ARIZONA STATE UNIVERSITY

Light-Inspired Solutions

Bioenergy/Microalgae

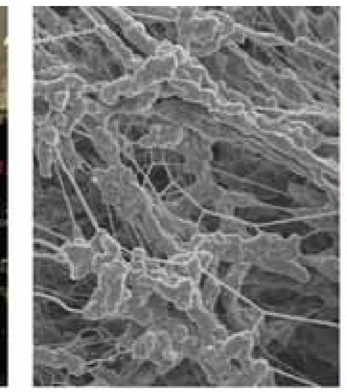
capturing all energy and nutrients from microalgae

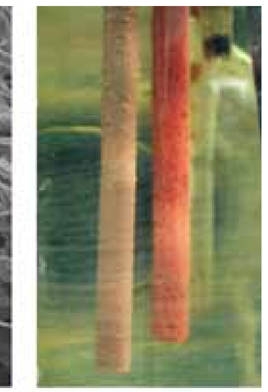
Replacing liquid transportation fuels with renewable sources is our nation's most pressing need, because petroleum reserves will be depleted and are located in politically sensitive regions.

Photosynthetic microorganisms can produce very large amounts of high-lipid biomass that can be used to generate renewable and carbon-neutral transportation fuels (Rittmann, 2008). While the focus naturally is on the lipids in the photosynthetic biomass, much of the energy and almost all of the nutrients (N and P) are in the non-lipid biomass. Given that P reserves are as much at risk of depletion as petroleum (Elser and Stuart, 2010), any large-scale scheme that grows and harvests photosynthetic biomass must recover and recycle almost all of the P. Furthermore, capturing all of the energy and nutrients in the non-lipid biomass is critical to economic viability.

This project will develop the novel technologies needed to capture the energy value of the organic C in the non-lipid biomass of photobioreactors and to capture and recycle the N and P. Figure 1 is a schematic of how the technologies interact to create an integrated, microbe-based energy system. The non-lipid biomass will be transformed to the most desirable simple organic molecules via selective fermentation. These simple products will feed a microbial fuel/electrolysis cell (collectively, MXC) that will produce either electrical energy or hydrogen fuel. Nutrients (N and P) from the effluent of the MXC will be captured for recycling to production of photosynthetic microorganisms using innovative approaches that are tailored to using photosynthetic biomass as the input.

The research will be carried out at the bench scale for fermentation, MXCs, and nutrient recovery. Our team has extensive experience in each of these areas and will produce and test novel adaptations that fit the integrated system based on phototrophic biomass. Our team also has on-going research with photobioenergy, and this will provide us with photosynthetic biomass for testing. Over the two-year period, we will advance each component so that it is ready to be integrated into the integrated system at the pilot scale (the follow up step).





With more research and incentives, we can break our dependence on oil with biofuels...instead of subsidizing yesterday's energy, let's invest in tomorrow's...

We're issuing a challenge. We're telling America's scientists and engineers that, if they assemble teams of the best minds in their fields and focus on the hardest problems in clean energy, we'll fund the Apollo Projects of our time...

Clean energy technology—an investment that will strengthen our security, protect our planet, and create countless new jobs for our people.

—President Barack Obama
State of the Union Address
January 25, 2011

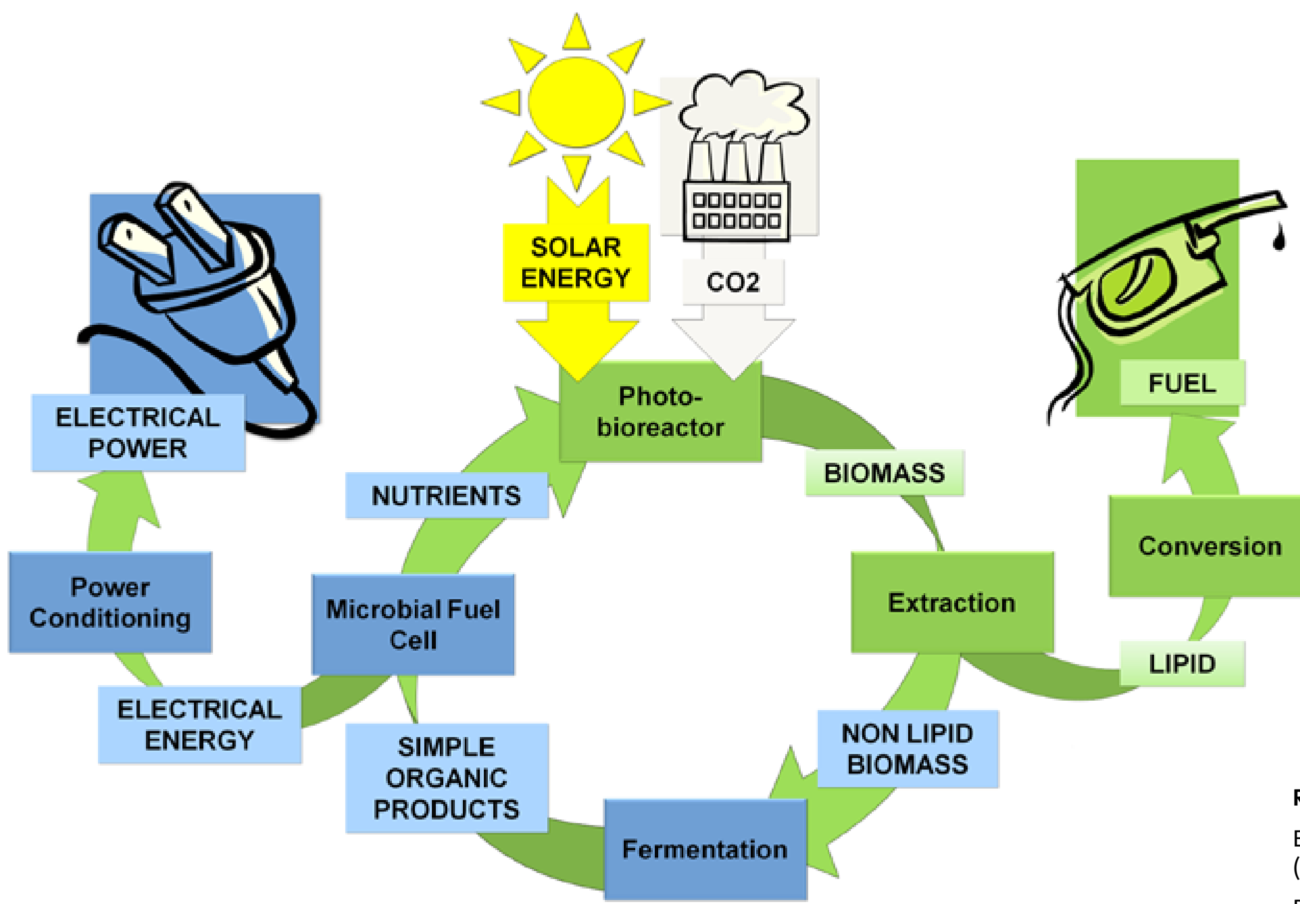
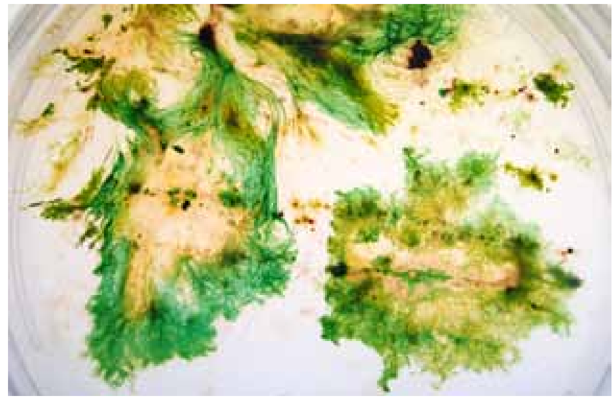


Figure 1. *Schematic of the integrated microbe-based system to capture all of the energy from photosynthetic biomass and recycle the nutrients and water. The focus for this research project will be on fermentation to produce simple organic products, development of MXC technology to capture the energy value as electrical power (the MFC, as shown here) or renewable H_2 gas with an MEC, not shown), and capture of N and P in recyclable form.*

References:

Elser, J. and S. White (2010). Peak phosphorus, and why it matters. *Foreign Policy*, April 20, 2010 (http://www.foreignpolicy.com/articles/2010/04/20/

Rittmann B.E. (2008) Opportunities for renewable bioenergy using microorganisms. *Biotechnology and Bioengineering*, 100, 203-212.



Swette Center
for Environmental Biotechnology

Biodesign Institute at Arizona State University

The Swette Center for Environmental Biotechnology focuses on "managing microbial communities to provide services to society."

To manage microbial communities well, Center researchers conduct fundamental research to understand what microorganisms are present, what reactions they are capable of carrying out, what reactions they are carrying out, and how they interact with each and their environment. This research brings to bear state-of-the-art research tools involving genomics, proteomics, chemistry, and mathematical modeling.

Armed with understanding, Center researchers design and evaluate systems that create conditions allowing the right microorganisms to flourish and perform the needed services. Managing the microbial communities means creating the ideal "win-win" situation: The microorganisms thrive while providing the services. This more applied research often is carried out in the field in partnership with leading practitioners. The idea is to move Center technologies to practical application with a firm foundation.

The Center has two large research themes: sustainable energy and water. For each theme, Center researchers follow a two-step strategy. The first step is to "think like the microorganisms." This means understanding how the different microorganisms work, what they need to do their jobs, and how they work together as community. The second step, based on the understanding from the first step, can be described as "work for the microorganisms so that they work for us."

Within the energy realm, the Center has a portfolio of options that are complementary to each other.

On one end of the spectrum, we work on ways to improve the well-established biotechnology of improving the performance of anaerobic processes that generate methane gas.

On the other end of the spectrum, we carry out leading-edge research on the fundamentals of microbial electrochemical cells (MXCs) that can produce hydrogen gas or electricity from organic wastes.

A major source of biomass for methanogenesis or MXCs is from animal wastes. Other sources include crop residues, food-processing waste, and human waste.

The Center is developing and evaluating several novel photobioreactors to growth the photosynthetic bacteria and harvest the products.

The Center is directed by Regents' Professor Bruce Rittmann, who is a member of the National Academy of Engineering, a Fellow of the American Association for the Advancement of Sciences, a recipient of the Simon Freese Environmental Engineering Prize from the American Society of Civil Engineers, and one of the world's most highly cited researchers.