Introduction:
There are tens of thousands of known species of microalgae, some of which have been shown to be excellent sources of biofuels, foods, feedstock, nutraceuticals, health foods, industrial chemicals, pharmaceuticals, and other major commercial products. These often benefit from the ability to grow across a wide range of habitats and conditions, in particular conditions that are not generally useful for terrestrial food crops. For example, there are waste streams that allow algae to grow at their full potential, indicating that the waste stream allowed the algae to grow at its full potential. In this case, the waste stream was used to compare yields in the two systems. The average daily aerial productivity was calculated.

Biofuel:
The promise of one day using algae as a low-cost source for biofuels is coming closer and closer to fruition. Existing algal strains are already producing high lipid content, which can be extracted and converted to fuels. New strains and genetically-modified strains are also continually being researched, as evidenced by variations in many different culture conditions in order to increase lipid and desirable co-product production.

A recent study examined the effect of light and temperature variations on the growth and physiology of the biofuel candidate marine microalgal species *Nannochloropsis oculata*. An array of interconnected PBR101 photobioreactors integrated with metabolic sensors was used to vary light and temperature conditions, varying them according to sinusoidal day/night light/dark and heating/cooling cycles. The specific experiments were performed with algal cultures maintained at a constant 20°C versus a 15°C to 25°C diel temperature cycle, where light intensity also followed a diel cycle. While no differences in algal growth were found, it was determined that the changes in environmental conditions had a great effect on the metabolic processes. The combination of strong light and high temperature in the second set of experiments caused greater damage to this second photosystem. In addition, after photosynthesis and also found to perform differently, this was thought to be due to the effect on temperature on respiration.

These experiments demonstrated the promise of deploying *Nannochloropsis oculata* in similar field conditions for commercial biofuel production. In addition, this study showed that the PBR101, with high-level environmental control facilities in a Photosynthetic CO2 exchange and carbonate chemistry in the PBR101 photobioreactor. Gas exchange determined the degree of carbon limitation experienced by the algae. Carbon limitation was confirmed by delivering more CO2, which increased net photosynthesis back to its steady-state maximum.

Further research examined the induction of oil accumulation in algae for biofuel production. This effect is often achieved by nitrogen starvation. However, withholding nitrogen also reduces total biomass yield, which reduces crop yield. In this report, it was demonstrated using the PBR101 photobioreactor that Chlorella sorokiniana will not only accumulate substantial quantities of neutral lipids when grown in the absence of nitrogen, but will also exhibit unimpeded growth rates for up to 2 weeks, finding with significant commercial implications.

A related study provided the first in-depth analysis of CO2 limitation on the biomass productivity of *Nannochloropsis oculata* using PBR101 photobioreactors. Net photosynthesis decreased by 60% from 125 to 50 μmol O2/L h⁻¹ over a 12 h light cycle as a direct result of carbon limitation. Continuous dissolved O2 and pH measurements were used to develop a detailed diurnal model for the interaction between photosynthesis, gas exchange, and carbonate chemistry in the PBR101 photobioreactor. Gas exchange determined the degree of carbon limitation experienced by the algae. Carbon limitation was confirmed by delivering more CO2, which increased net photosynthesis back to its steady-state maximum.

Industrial Wastewater Cleanup:
Industrial wastewaters are often produced on extremely large volumes. Many of these wastewaters can potentially serve as a source of biomass crops for biofuel production. In addition, higher lipid production and lower biomass were observed when 5% CO2 in air was used as CO2 supplementation as compared to pure CO2. Further, optimal growth conditions were determined to produce the lowest ARA/EPA ratio, which is most desirable for maximum nutritional value.

Animal Feed:
Corn is a popular animal feed, and is a good representative of the feedstock commercial market. Algae has a much shorter yield-cycle than corn, and thus significantly reduces total growth time (from planting to harvest) and also greatly improves total annual yield. That is, with algae, you get multiple harvests in a single year rather than just one with corn, while at the same time also reducing costs.

Nitrogen and Phosphorus are important components of animal feed. Accordingly, a study was performed to determine if algae could convert N and P into animal feed in smaller and acreage than crops such as crops. At the same time, this study sought to optimize the nutritional value of algae produced for animal feed.

An array of PBR101s was programmed to simulate solar radiation and day length. Pond cultures were isolated and pH was controlled by the addition of CO2. As a result, a variety of pure strains were isolated in the lab from the pond cultures and determined to be appropriate for pond inoculation based on several requirements, including maximization of the nutritional value of algae for feed, optimization of pathogen inactivation methods, and quantification and control of any toxic cyanobacteria.

Nutraceuticals and Health Foods:
Nutraceuticals – dietary nutrients and supplements – are a growing industry worldwide. The search for new and more diverse nutritional materials at a lower cost has led many researchers to discover that algae is an very viable source for a wide variety of nutraceutical ingredients. As an example, it is now common to find Spirulina, as well as other algae strains, in nutritional supplements and other dietary products. One recent study found that microalgae lipids could serve as a source of eicosapentaenoic acid (EPA), a fatty acid also found in fish oils. This and other research of its kind is important for the increasingly large population of consumers who are strict vegetarians and will not accept fish as a soybean meal, which is often a rich source of fish oils. Moreover, maximizing biomass production does not lead to optimizing lipid production. Therefore, maximizing biomass production does not lead to optimizing lipid production. In addition, higher lipid production and lower biomass were observed when 5% CO2 in air was used as CO2 supplementation as compared to pure CO2. Further, optimal growth conditions were determined to produce the lowest ARA/EPA ratio, which is most desirable for maximum nutritional value.

Bench-Scale Production of Algae Yields:
The Phenometrics PBR101 is a bench-top photobioreactor (approximately 600-650 ml working volume) that is used to develop algae culture protocols for containment; therefore, each potential production strain must be optimized for both co-product yield and culture growth prior to production scale implementation. Thus, if optimization at bench scale can accurately predict production yield, then time, resources and CAPEX can be significantly reduced and ROI maximized.

The Phenometrics PBR101 was chosen as the cultivation medium for a particular set of experiments. In fact, Los Alamos (National Laboratories) do a particular set of experiments. In fact, Los Alamos (National Laboratories) and CAPEX can be significantly reduced and ROI maximized.

Molecular Biology of a Model Organism for Biofuel, Industrial Chemicals, and Pharmaceuticals Production:
Cyanobacteria are an excellent model for the study of photosynthesis in the laboratory. However, only a small percentage of cyanobacterial genes and intergenic regions have been experimentally evaluated for their impact on fitness and survival. In the laboratory, it is essential to have the entire set of essential intergenic regions necessary for survival in a cyanobacterium.

Synechococcus elongatus PCC 7942, a model organism for studying photosynthesis and the circadian clock, is also being developed for the production of fuel, industrial chemicals, and pharmaceuticals. It would be thus be beneficial to identify a comprehensive set of genes and intergenic regions that impacts fitness in S. elongatus. A pooled library of ~260,000 transposon mutants was created and sequencing was used to identify the insertion locations. For testing the library, growth under standard laboratory conditions was accomplished by cultures grown in several conditions, including in a Phenometrics PBR101 Photobioreactor. By analyzing the distribution and survival of these mutants, 718 of the organism’s 2,723 generocytes were subsequently analyzed as essential for survival under laboratory conditions. In addition to improving our fundamental understanding of Cyanobacteria, from a commercial perspective this research more broadly defines the essential genes and intergenic regions that must be maintained in any genetically engineered strains designed for optimized commercial production.

References: