During photosynthesis, plants use light energy to synthesize food (carbohydrates) for growth from carbon dioxide and water. As the key process in plant productivity, photosynthesis plays a vital role in every aspect of agricultural production. However, researchers and farmers do not fully understand how photosynthesis is affected by environmental, molecular, and genetic constraints. Alleviating some or all of these constraints could lead to substantial increases in plant productivity. Understanding photosynthetic processes could also help researchers develop new crop varieties with improved grain or oil yield or better resistance to water, heat, and salt stress. In these ways, exploiting the photosynthetic processes underlying plant productivity could help agriculture meet increasing demands for food, fiber, and biofuels. Because photosynthesis captures carbon dioxide from the atmosphere, a better understanding of photosynthesis could also illuminate new opportunities for reducing atmospheric carbon dioxide levels—a major factor in global warming.

Who cares and why?

Regulating Photosynthesis

This project has improved our understanding of photosynthesis, thus providing new strategies for boosting plant productivity and resistance to stressful conditions.

What has the project done so far?

The NC-1168 project has brought together outstanding researchers from across the U.S. to investigate critically important areas of photosynthesis research. Over the past five years of the project, researchers have examined how photosynthetic processes are regulated, especially the genetic and environmental factors that influence photosynthetic productivity. These studies have found enzymes that could be engineered to increase plant production of starch and biomass as well as ways to alter photosynthesis so that plants are more efficient at converting sunlight into grain. Researchers have also gained better understanding of the genetic mechanisms that regulate which photosynthates—sugars like starch and sucrose—are produced by photosynthesis and where they end up in the plant (e.g. leaf cells, tissues, fruits, seeds). For example, one study revealed that day length affects the proportion of photosynthates stored in leaves as either starch or sucrose. This line of research gives scientists the potential to alter photosynthesis so that the substances produced are stored in the optimum chemical form and cellular location depending on the desired end use of the plant. Indeed, one NC-1168 study demonstrated a 10% to 20% increase in rice yields through these kinds of alterations. Additionally, NC-1168 has advanced research on the conversion of photosynthetic sugars into vegetable oils—work that is essential for engineering novel biofuel crops. NC-1168 studies on the expression of genes involved in photosynthesis have advanced the potential to breed plants that perform better under stressful conditions. For example, researchers have engineered more heat tolerant enzymes involved in photosynthesis. Other studies which measured photosynthesis in...
Future research must focus on improving the response of photosynthesis to developmental and environmental factors that limit productivity so that sufficient food and fuels can be produced in a rapidly changing climate. Researchers must also continue to improve the capture and release of carbon during photosynthesis with emphasis on reducing greenhouse gas production. A more detailed understanding of the chloroplast—the part of plant cells that harbors the photosynthetic apparatus—is also needed.

What research is needed?

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