What makes a plant a plant?

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Although scientists have been able to sequence the genomes of many organisms, they still lack a context for associating the proteins encoded in genes with specific biological processes. To better understand the genetics underlying plant physiology and ecology—especially in regard to photosynthesis—a team of researchers including Carnegie's Arthur Grossman identified a list of proteins encoded in the genomes of plants and green algae, but not in the genomes of organisms that don't generate energy through photosynthesis. Their work will be published June 17 in the *Journal of Biological Chemistry*.

Using advanced computational tools to analyze the genomes of 28 different plants and photosynthetic organisms, Grossman and his colleagues at the University of California in Los Angeles and the Joint Genome Institute of the Department of Energy were able to identify 597 proteins encoded on plant and green algal genomes, but that are not present in non-photosynthetic organisms. They call this suite of proteins the GreenCut.

Interestingly, of the 597 GreenCut proteins, 286 have known functions, while the remaining 311 have not been associated with a specific biological process and are called "unknowns."

The majority of the GreenCut proteins, 52 percent, have been localized in a cellular organelle called the chloroplast--the compartment where photosynthesis takes place. It is widely accepted that chloroplasts originated from photosynthetic, single-celled bacteria called cyanobacteria, which were engulfed by a more complex, non-photosynthetic cell more than 1.5 billion years ago. While the relationship between the two organisms was originally symbiotic, over evolutionary time the cyanobacterium transferred most of its genetic information to the nucleus of the host organism, losing its ability to live independent of its partner.

"This genetically-reduced cyanobacterium, which is now termed a chloroplast, has maintained its ability to perform photosynthesis and certain other essential metabolic functions, such as the synthesis of amino acids and fats. The processes that take place in the chloroplast must also be tightly integrated with metabolic processes that occur in other parts the cell outside of the chloroplast," Grossman explained.

While recent evidence suggests that many of the unknowns of the GreenCut are associated with photosynthetic function, not all GreenCut proteins are located in the chloroplast. But since they are unique to photosynthetic organisms and highly conserved throughout plants and other photosynthetic organisms, it is likely that they are critical for other plant-specific processes. Possible functions could be associated with regulation of metabolism, control of DNA transcription, and the functioning of other cellular organelles, including the energy producing mitochondria and the house-cleaning peroxisomes.

Expanding this work, Grossman and his colleagues found that many GreenCut proteins have been maintained in ancient cyanobacteria, red algae, and other single-celled algae called diatoms. Comparison of GreenCut proteins among various organisms is opening windows for discoveries about the roles that these proteins play in photosynthetic cells, the evolution of chloroplasts, and how photosynthetic cells might be tailored for survival under different environmental conditions.

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