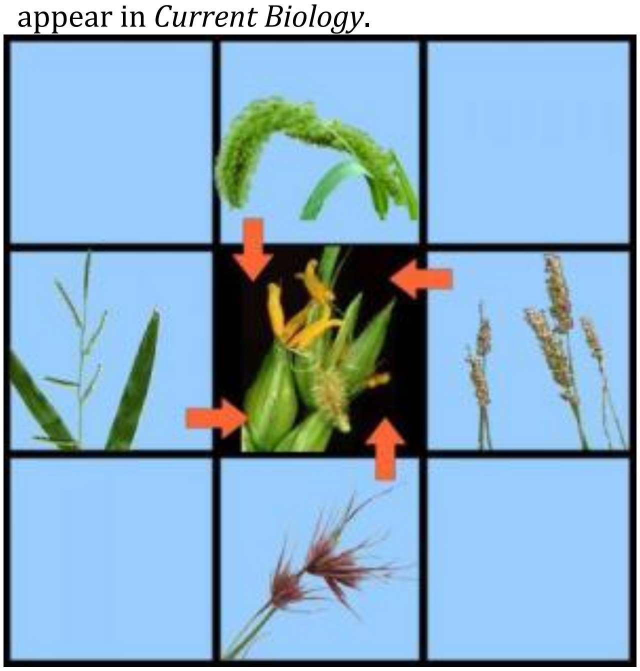
Reading Questions:

1. How are genes generally transferred within populations?
2. What are C4 plants? What kinds of climates do plants that do C4 photosynthesis generally thrive in?
3. What are the genes of interest that researchers are studying? Why were these genes selected for study?
4. What were researchers hoping to understand by studying Alloteropsis grasses?
5. What was researchers' initial hypothesis concerning Alloteropsis genes? What lead them to reject this hypothesis?
6. What is lateral gene transfer? Describe the researchers' hypothesis as to how genes are passed between distantly related plants.
7. How could lateral gene transfer serve as an agent for rapid evolution?
8. How could lateral gene transfer complicate reconstructing species' evolutionary history?
9. Lateral gene transfer (also called horizontal gene transfer) continues between prokaryotes today, since many can uptake genes from their environment and exchange genes via conjugation. How can lateral gene transfer contribute to bacterial resistance to antibiotics?
10. How does the endosymbiotic origin of mitochondria/chloroplasts demonstrate lateral gene transfer?

Genes May Travel from Plant to Plant to Fuel Evolution

Feb. 16, 2012 — Evolutionary biologists at Brown University and the University of Sheffield have documented for the first time that plants swap genes from plant to plant to fuel their evolutionary development. The researchers found enzymes key to photosynthesis had been shared among plants with only a distant ancestral relationship. The genes were incorporated into the metabolic cycle of the recipient plant, aiding adaptation. Results appear in *Current Biology*.



New research shows genes can travel from plant to plant between distant cousins, not just from one generation to the next. This "short cut" could be a mechanism for rapid evolution. Credit: Les Watson and Wikimedia Commons

The evolution of plants and animals generally has been thought to occur through the passing of genes from parent to offspring and genetic modifications that happen along the way. But evolutionary biologists from Brown University and the University of Sheffield have documented another avenue, through the passing of genes from plant to plant between species with only a distant ancestral kinship.

How this happened is unclear. But the researchers show that not only did a grouping of grasses pass genes multiple times over millions of years, but that some of the genes that were transferred became integral cogs to the plants' photosynthetic machinery, a critical distinguishing feature in C4 plants, which dominate in hot, tropical climes and now make up 20 percent of Earth's vegetational covering.

"As far as we know, this is the first case where nuclear genes that have been transmitted between plants have been incorporated into the primary metabolism and contributed to the evolution of a new trait, in this case C4 photosynthesis," said Pascal-Antoine Christin, a postdoctoral researcher in the Department of Ecology and Evolutionary Biology at Brown.

In a paper published in *Current Biology*, the researchers from Brown, Sheffield, and other universities in the United States, United Kingdom, and France investigated the ancestry of two genes encoding enzymes important in C4 photosynthesis -- phosphoenolpyruvate carboxylase (ppc) and phosphoenolpyruvate carboxykinase (pck) -- and these enzymes' historical presence and function in a common and well-studied grass, Alloteropsis. The biologists initially studied the genes in closely related species, three C4 plants (*Alloteropsis angusta*, *Alloteropsis cimicina*, and *Alloteropsis semialata*) and one C3 plant (*Alloteropsis eckloniana*). The goal was to learn the evolutionary history of the ppc and pck genes, which were present in their C3 common ancestor and were thought to have been adapted to aid in photosynthesis in the offspring C4 plants.

"People were wondering how these genes evolved. The global assumption was that an ancestor had the genes, but they weren't involved in photosynthesis, and so were later modified to become C4 photosynthetic agents," said Christin, the paper's corresponding author.

To test the hypothesis, the scientists took a wider view, surveying C4 plants in which the ppc enzyme was integral to photosynthesis and plants where the enzyme was present but had no photosynthetic role. They figured the ppc enzymes used in C4 photosynthesis would be closely related to the non-photosynthetic genes from closely related C3 plants, given their common ancestry.

Instead, the ppc genes involved in C4 photosynthesis were closely related to ppc genes of other C4 species with no close relation in the phylogeny, or family tree. Closer analysis also revealed these plants sharing photosynthetic ppc enzymes had diverged as many as 20 million years ago; the new finding is that despite these ancestral divergences, they exchanged genes.

In all, the researchers documented four instances in which the ppc enzyme or the pck enzyme found in the Alloteropsis C4 plants popped up in other C4 clades -- *Andropogoneae*, *Cenchrinae* and *Melinidinae*. These clades include such diverse species as corn, foxtail millet, and guinea grass.

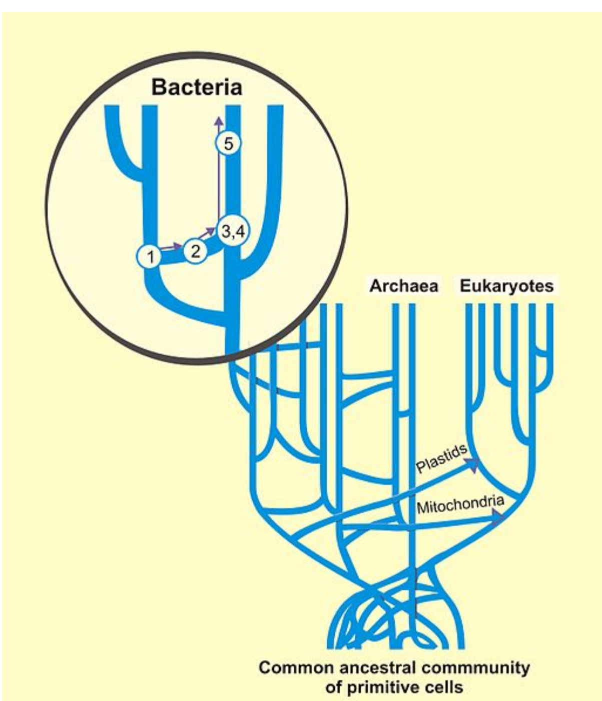
"We've long understood how evolutionary adaptations are passed from parents to offspring. Now we've discovered in plants that they can be passed between distant cousins without direct contact between the species," added Colin Osborne, an evolutionary biologist from the University of Sheffield and a corresponding author on the paper.

"What is so exciting here is that these genes are moving from plant to plant in a way we have not seen before," said Erika Edwards, assistant professor of biology at Brown and the second author on the paper. "There is no host-parasite relationship between these plants, which is usually when we see this kind of gene movement."

Scientists call this evolutionary event "lateral gene transfer." The question, then, how are the plants passing their genes? The best guess at this point is that genetic material carried airborne in pollen grains land on a different species and a small subset of genes somehow get taken up by the host plant during fertilization. Such "illegitimate pollination events," as Edwards described it, have been seen in the laboratory. "There are reproductive mishaps that occur. In some cases, these could turn out to be highly advantageous," she said.

Christin, Osborne and Edwards think gene-swapping among plants continues today. "Is it good? Bad? I don't know," Christin said. "It's good for the plants. It means that plants can adapt to new environments by taking genes from others."

"It's like a short cut," Edwards added, "that could present itself as a mechanism for rapid evolution."



Current tree of life showing vertical and horizontal gene transfers.