

Gene transfer gone wild reveals driving force behind mitochondrial sex

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Flowering *Amborella*, whose mitochondrial genome is amazingly rich in foreign genes and even genomes, is endemic to the island of New Caledonia. Credit: Jeffrey D. Palmer

Pioneering research led by Indiana University has identified genes from a number of plant species, including the entire mitochondrial genomes

from three green algae and one moss, in the mitochondrial genome of *Amborella trichopoda*. The South Pacific shrub is considered to be the sole survivor – the "last man standing" – of one of the two oldest lineages of flowering plants, while the other lineage comprises the other 300,000 species of flowering plants.

Working with researchers from the U.S. Department of Energy, Penn State University, and the Institute of Research for Development in New Caledonia, where *Amborella* is endemic, the team uncovered what is believed to be the largest example of horizontal [gene transfer](#) – the acquisition of foreign genes from other species – in any organism.

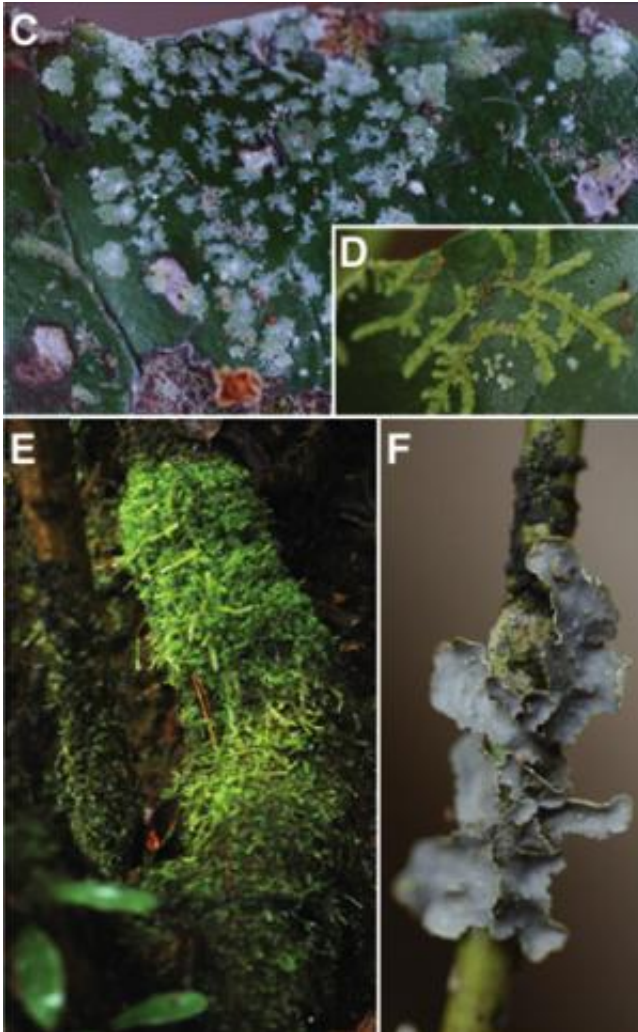
The research also shows, for the first time, that an organelle genome has captured an entire foreign genome, in this case, four of them. It is also the first description of a land plant acquiring genes from green algae.

Scientists are interested in the mechanisms behind horizontal gene transfer as an evolutionary force, and in this case, the role that mitochondrial fusion – the merger of two mitochondria within a cell – plays in [horizontal gene transfer](#) between mitochondrial genomes.

Mitochondria are the power plants of the complex cells of animals, plants, and other eukaryotes, serving as the membrane-bound compartments that finish the conversion of food into energy. They contain a genome that traces back to their symbiotic origin as once free-living bacteria that were engulfed and enslaved by a primitive, unicellular eukaryote.

Jeff Palmer, a Distinguished Professor in the IU Bloomington College of Arts and Sciences' Department of Biology, who together with IU Research Associate Danny Rice led the research, said the new work provides "compelling evidence that mitochondrial fusion is the driving force for mitochondrial gene transfer and that incompatibility in the

mechanism of mitochondrial fusion between different phyla – plants versus animals or fungi – provides the major barrier to unconstrained mitochondrial 'sex' across the evolutionary tree of life."



Amborella's epiphytes include mosses, liverworts, ferns, and other flowering plants (C to F). *Amborella* leaves and branches are covered predominantly with lichens ([C] and [F]), leafy liverworts (D), and mosses (E). Credit: Jérôme Munzinger

"The *Amborella* [mitochondrial genome](#) is like the old lady in the song

who swallows a fly, and then a spider, a bird, a cat, and so on, all the way to a horse, at which point, finally, "she's dead of course," Palmer said. "Likewise, the *Amborella* genome has swallowed whole mitochondrial genomes, of varying sizes, from a broad range of land plants and green algae. But instead of bursting from all this extra, mostly useless DNA, or purging the DNA, it's held on to it for tens of millions of years. So you can think of this genome as a constipated glutton, that is, a glutton that has swallowed whole genomes from other plants and algae and also retained them in remarkably intact form for eons."

Mitochondrial fusion occurs in much the same way in animals and fungi, so imagine what the human mitochondrial genome would look like if it had engaged in such genomic gluttony, Palmer noted.

"It would harbor large tracts, even whole genomes, of mitochondrial DNA captured from a range of animals and fungi," he said. "Who knows, like the lady in the song, the human genome might have swallowed the mitochondrial genome of a spider, a bird, a cat, and perhaps a couple of mushrooms to boot – and kept them all!"

The study provides important insight into the evolution of mitochondrial fusion, Rice added.

"We found the first evidence that mitochondria of [flowering plants](#) and [green algae](#), whose last common ancestor existed over a billion years ago, undergo fusion by the same mechanism." This mechanism appears to be different from that employed by animal and fungal mitochondria," he said.

Amborella's mitochondrial genome is so unusual – has captured and kept so much foreign DNA – for at least three reasons, the study finds:

- Ecologically, it has greater exposure to the foreign mitochondria

of epiphytes and parasites than most plants.

- Developmentally, it has a greater chance of incorporating this DNA in a new germline due to the plant's propensity to respond to wounding by forming new germ lines (meristems) and branches (called suckers).
- Molecularly, there is a greater chance of keeping this DNA due to *Amborella*'s exceptionally low rate of DNA loss.

A full description of the study, "Horizontal Transfer of Entire Genomes via Mitochondrial Fusion in the Angiosperm *Amborella*," will be published Dec. 20 in the journal *Science*. Two papers on *Amborella*'s nuclear genomes appear in the same issue: One paper, which Palmer and co-author Claude dePamphilis of Penn State contributed to, reports the nuclear genome sequence of *Amborella* and reveals a polyploid origin for flowering plants and for many of the genes important in flowering and other plant processes. The other paper, with dePamphilis again a co-author, describes the novel approach used to assemble and validate this nuclear genome sequence.

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More information: "Horizontal Transfer of Entire Genomes via Mitochondrial Fusion in the Angiosperm *Amborella*," by D.W. Rice et al. *Science*, 2013.

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