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How the first plant came to be

A genetic analysis reveals the ancient, complex — and symbiotic — roots of photosynthesis in plants.

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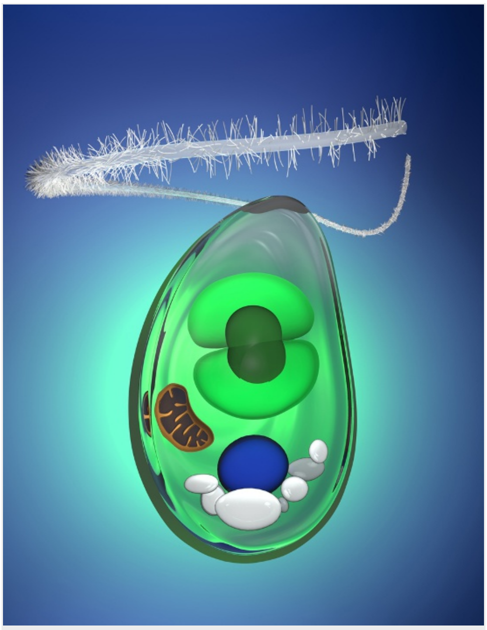

Science/AAAS

The genome of *Cyanophora paradoxa* provides essential clues to the origin of photosynthesis in algae and plants.

Earth is the planet of the plants — and it all can be traced back to one green cell. The world's lush profusion of photosynthesizers — from towering redwoods to ubiquitous diatoms — owe their existence to a tiny alga eons ago that swallowed a cyanobacteria and turned it into an internal solar power plant.

By studying the genetics of a "glaucophyte" — one of a group of just 13 unique microscopic freshwater blue-green algae, sometimes called "living fossils" — an international consortium of scientists led by molecular bioscientist Dana Price of the University of Queensland, Brisbane, has elucidated the evolutionary history of plants. The glaucophyte *Cyanophora paradoxa* still retains a less domesticated version of this original cyanobacteria than most other plants.

According to the analysis of *C. paradoxa*'s genome of roughly 70 million base pairs, this capture must have occurred only once because most modern plants share the genes that make the merger of photosynthesizer and larger host cell possible. That union required cooperation not just from the original host and the formerly free-ranging photosynthesizer but also, apparently, from a bacterial parasite. *Chlamydia*-like cells, such as *Legionella* (which includes the species that causes Legionaire's disease), provided the genes that enable the ferrying of food from domesticated cyanobacteria, now known as plastids, or chloroplasts, to the host cell.

"These three entities forged the nascent organelle, and the process was aided by multiple horizontal gene transfers as well from other bacteria," explains biologist Debashish Bhattacharya of Rutgers University, whose lab led the work published in *Science* on 17 February. "Gene recruitment [was] likely ongoing" before the new way of life prospered and the hardened cell walls of most plants came into being.

In fact, such a confluence of events is so rare that evolutionary biologists have found only one other example: the photosynthetic amoeba *Paulinella* domesticated cyanobacteria roughly 60 million years ago. "The amoeba plastid is still a 'work in progress' in evolutionary terms," Bhattacharya notes. "We are now analyzing the genome sequence from *Paulinella* to gain some answers" as to how these events occur.

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The work provides the strongest support yet for the hypothesis of late biologist Lynn Margulis, who first proposed in the 1960s to widespread criticism the theory that all modern plant cells derived from such a symbiotic union, notes biologist Frederick Spiegel of the University of Arkansas in Fayetteville, who was not involved in the work. That thinking suggests that all plants are actually chimeras — hybrid creatures cobbled together from the genetic bits of this ancestral union, including the enabling parasitic bacteria.

The remaining question is why this complex union took place roughly 1.6 billion years ago. One suggestion is that local conditions may have made it more beneficial for predators of cyanobacteria to stop eating and start absorbing, due to a scarcity of prey and an abundance of sunlight. "When the food runs out but sunlight is abundant, then photosynthesis works better" to support an organism, Bhattacharya notes. And from that forced union a supergroup of extremely successful organisms — the plants — sprang.

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References

1. Price, D.C. et al. *Science*. **335**, 843–847. (2012).