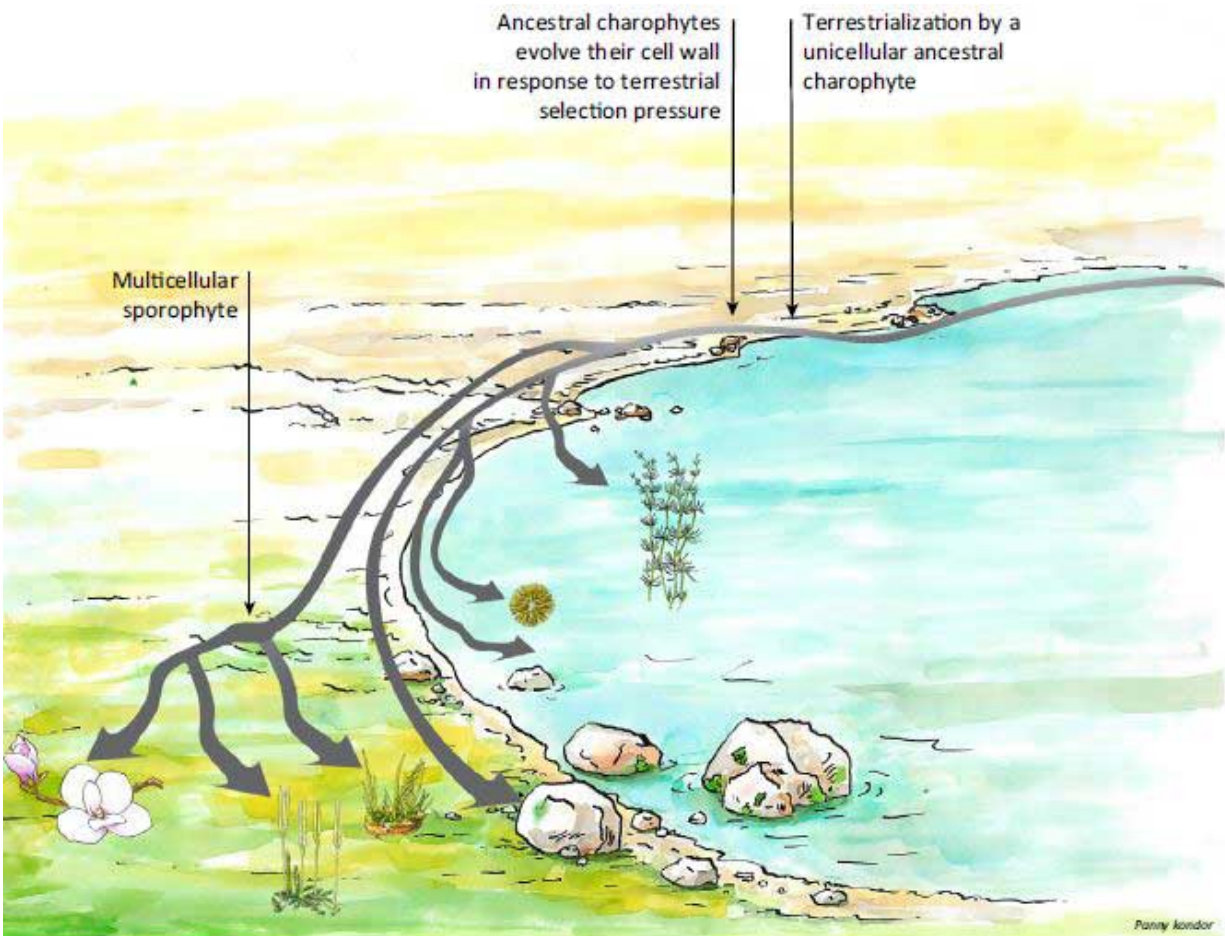


Plants crawled onto land earlier than we give them credit, genetic evidence suggests

December 16 2015



This graphic shows key events in the establishment of a land flora. These were the primordial terrestrialization event by a unicellular ancestral charophyte followed by evolution of a novel cell wall in response to the new types of selection pressure. A particular successful lineage evolved the multicellular sporophyte as a platform for the development of complex body plans and

vascularization, the latter facilitated by the new cell wall. Other lineages established themselves as extant terrestrial charophytes, here exemplified by *Klebsormidium* growing on a stone, while other taxa secondarily adopted an aquatic lifestyle yet retained the terrestrial traits in their cell wall as clues to their terrestrial ancestry. Credit: Panny Kondor

Plant biologists agree that it all began with green algae. At some point in our planet's history, the common ancestor of trees, ferns, and flowers developed an alternating life cycle—presumably allowing their offspring to float inland and conquer Earth. But on December 16 in *Trends in Plant Science*, Danish scientists argue that some green algae had been hanging out on land hundreds of millions of years before this adaptation and that land plants actually evolved from terrestrial, not aquatic, algae.

Botanists have suspected this possibility since 1980, but supporters have lacked proof. Now, Carlsberg Laboratory's Jesper Harholt and University of Copenhagen's Øjvind Moestrup and Peter Ulvskov present genetic and morphological evidence that corroborates the theory. Notably, traits that land plants use to survive on land today are well conserved in some species of green algae.

The collaboration began while Harholt and Ulvskov were studying the evolution of the plant cell wall, long considered to be a key adaptation for a terrestrial lifestyle, as it provides body support for plants growing under the influence of gravity.

"We realized that algae have a [cell wall](#) that's similarly complex to terrestrial plant cell walls, which seemed peculiar because ancient algae were supposedly growing in water," says Harholt, Science Manager at the Carlsberg Laboratory. "We then started looking for other traits that would support the idea that algae were actually on land before they

turned into land plants."

Working with Moestrup, an expert in algae, they also explored structures (or rather, the loss of structures) that are hard to explain if algae only lived in water. For example, some green algae have lost their flagella, whip-like organelles that help single-celled organisms move around in water. All of the algae that are close relatives to land plants no longer have an eyespot, which they would use to swim toward light.

Cell wall traits combined with the recently sequenced genome of terrestrial green algae *Klebsormidium*, (published in 2014, [DOI: 10.1038/ncomms4978](https://doi.org/10.1038/ncomms4978)), revealed that this green alga shares a number of genes with land plants related to light tolerance and drought tolerance. With the genetic evidence in hand, we know that the traits have arisen linearly, rather than by convergent evolution.



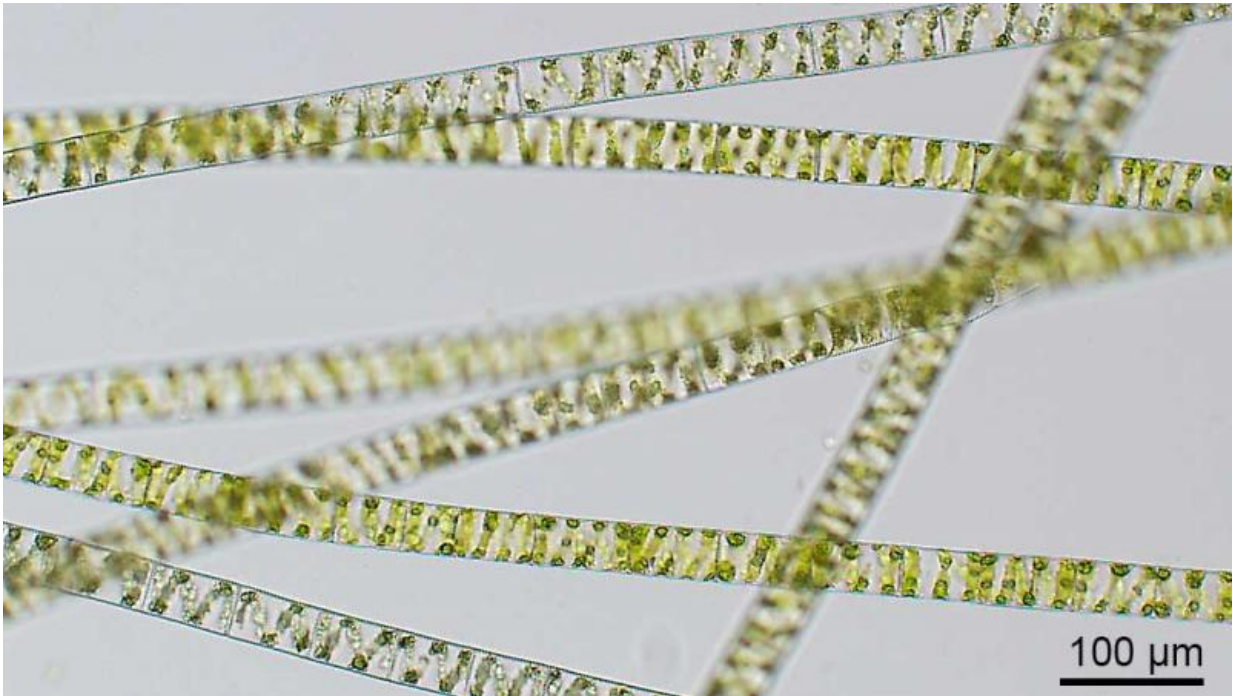
Photo of a desmid, a unicellular charophyte green algae that has lost all traces of flagella in its life cycle. Credit: Gert Hansen, SCCAP, Copenhagen

If their theory withstands scrutiny, it would begin to upend what's been cited in textbooks for over a century. The idea that plants jumped from water to land is credited to botanist Frederick Orpen Bower, although it

is unclear whether that was his intended argument. In his 1908 tome "The Origin of a Land Flora," he simply proposed that the "invention" of alternating life cycles provided early land plants with a platform—the sporophyte—for evolutionary experimentation and thus adaptability.

"With all of the genomic and morphological data we have, it is very hard to explain, evolutionarily-wise, how algae lived in water all the way up to land plants," says Ulvskov, also with Copenhagen's Department of Plant and Environmental Sciences. "We have to turn this thinking on the head—we have the evidence now."

The researchers' biggest challenge will be to prove that a period of pre-adaptation led to the complex cell walls of [land plants](#) (although about 250 new genes were required for the formation of this terrestrial-friendly cell covering, which helps their case). They believe that these terrestrial green algae were advanced enough to survive on sandy surfaces, living on rain as a source of humidity. But with a small fossil record to go on—only spores exist from this period of evolutionary history—they will need to rely heavily on genetics to make their argument.



This photo shows green algae *Spirogyra*, which reproduce sexually by a process known as conjugation. Credit: Gert Hansen, SCCAP, Copenhagen

"The strange thing for me is that if these green algae were terrestrial for a long time, how come that so few of these species are still around?" says Moestrup, an evolutionary biologist. "It could be because they were all outcompeted, but maybe one day we will find more [green algae](#) of this lineage."

"You have to be patient and sometimes pursue your crazy ideas, even when they differ from the dogmatic thinking in the field," Harholt adds. "If you pile up enough evidence, at some point you may realize that you might be correct."

More information: *Trends in Plant Science*, Harholt et al.: "Why Plants Were Terrestrial From The Beginning"

[dx.doi.org/10.1016/j.tplants.2015.11.010](https://doi.org/10.1016/j.tplants.2015.11.010)

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