

Quillwort genome highlights divergences in aquatic CAM photosynthesis

November 3 2021



The genome of this humble quillwort (*Isoetes taiwanensis*) could hold secrets to help make crops use water or carbon dioxide more efficiently. Credit: Yao-Moan Huang

The humble quillworts are an ancient group of about 250 small, aquatic plants that have largely been ignored by modern botanists. A group of

researchers, led by Boyce Thompson Institute's Fay-Wei Li, have sequenced the first quillwort genome and uncovered some secrets of the plant's unique method of photosynthesis—secrets that could eventually lead to the engineering of crops with more efficient use of water and carbon dioxide.

Most plants breathe in carbon dioxide (CO₂) and use sunlight to turn the gas into sugar during the day, and then stop breathing when the sun goes down. But plants in arid regions have evolved to breathe in CO₂ at night, and then stop breathing during the day while they conduct photosynthesis. This strategy—called CAM photosynthesis—helps the plants save water.

Forty years ago, quillworts—plants of the genus *Isoetes*—became the first group of [aquatic plants](#) discovered to use CAM photosynthesis. Daytime water loss is clearly not a problem for the aquatic plants. Instead, quillworts use CAM to collect CO₂ dissolved in water and store it overnight, to avoid competing with other aquatic plants and organisms, such as algae, that deplete water levels of the gas during the daytime.

To investigate the genetic mechanisms regulating quillworts' CAM photosynthesis process, Li's team assembled a high-quality genome for *I. taiwanensis*, and found some similarities between quillwort and land plant CAM photosynthesis, but also a number of differences.

"As aquatic plants, *Isoetes* have evolved CAM photosynthesis in a fundamentally different environment than terrestrial plants in dry habitats," says Li, who is also an adjunct assistant professor of plant biology at Cornell University. "These results tell us there are more evolutionary pathways to CAM than we previously thought."



The genome of this humble quillwort (*Isoetes taiwanensis*) could hold secrets to help make crops use water or carbon dioxide more efficiently. Credit: Yao-Moan Huang

The findings were published in *Nature Communications* November 3.

The team used the genome to identify CAM pathway genes and to examine their expression patterns, including how those patterns changed across the day/night cycle. One notable difference between CAM in quillworts and terrestrial plants is in the function of phosphoenolpyruvate carboxylase (PEPC). All plants have two types of PEPC: plant-type, long known for its essential role in photosynthesis;

and bacterial-type, which resembles the PEPC found in bacteria.

"In all other plants, bacterial-type PEPC plays a role in a range of metabolic processes but not photosynthesis," said David Wickell, a Ph.D. student in Li's laboratory and first author on the study. "In Isoetes, both types appear to be involved in CAM—something that hasn't been found in any other plant and points to a distinct role for bacterial-type PEPC in aquatic CAM."

All plants have the multiple components of CAM, which is why the process has evolved so many times, says Li. But aquatic and terrestrial plants recruited different versions of those components possibly to meet the needs imposed by their differing environments.

The team also found that expression levels of a few circadian regulators peaked at different times of day in quillworts than in terrestrial plants, indicating the circadian clock might regulate CAM functions differently in Isoetes.



The genome of this humble quillwort (*Isoetes taiwanensis*) could hold secrets to help make crops use water or carbon dioxide more efficiently. Credit: Pi-Fong Lu

The team's next steps include examining CAM gene expression patterns in *I. engelmannii* (Engelmann's quillwort), which uses CAM when fully submerged in water and C3 [photosynthesis](#) when above water.

Longer term, the findings could be used to engineer crops to withstand environmental stresses. "It would boil down to manipulating the circadian clock genes that regulate CAM components to help [plants](#) become more efficient at conserving water or making better use of the available CO₂," said Wickell. "It's an exciting idea to consider."

The group's interest in Isoetes builds on a fantastic research legacy at BTI. The standard reference summarizing the characteristics and habitats of the genus is still Norma Pfeiffer's [*Monograph on the Isoetaceae*](#), published in 1922. Pfeiffer was one of BTI's original scientists when the Institute opened its doors in Yonkers, NY, in 1924. The plant morphologist remained at BTI until she retired in 1955.

The team included researchers from National Tsing Hua University, the University of Göttingen, the Taiwan Forestry Research Institute, the University of Texas at Austin, the University of Arizona, and The Salk Institute for Biological Studies.

More information: Underwater CAM photosynthesis elucidated by Isoetes genome, *Nature Communications* (2021). [DOI: 10.1038/s41467-021-26644-7](#)

Provided by Boyce Thompson Institute

Citation: Quillwort genome highlights divergences in aquatic CAM photosynthesis (2021, November 3) retrieved 12 July 2024 from <https://phys.org/news/2021-11-quillwort-genome-highlights-divergences-aquatic.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.