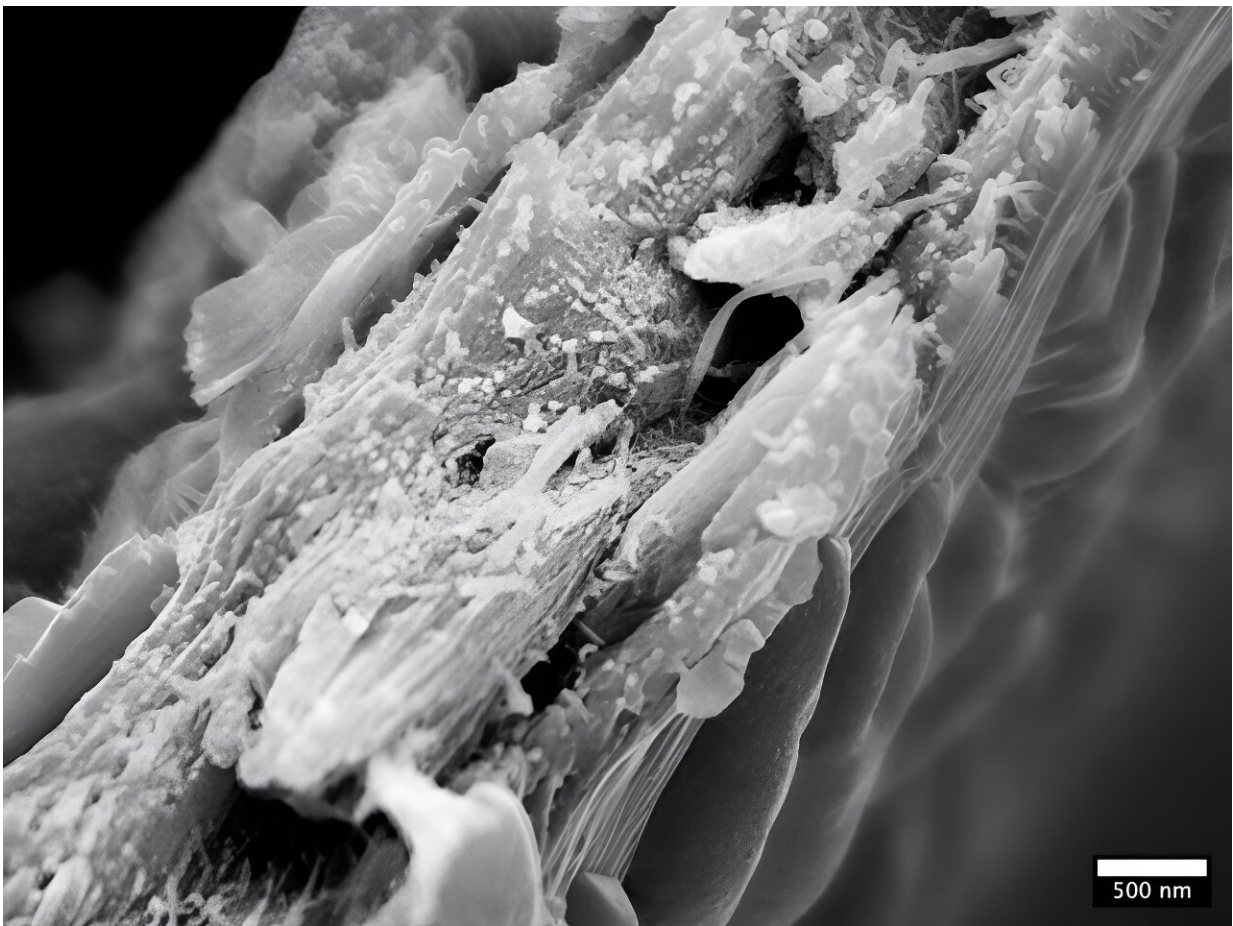


Scientists discover entirely new wood type that could be highly efficient at carbon storage

July 30 2024



Liriodendron tulipifera wood ultrastructure observed under a cryo-SEM reveals enlarge macrofibril structures. Credit: Jan J Lyczakowski and Raymond Wightman

Researchers undertaking an evolutionary survey of the microscopic structure of wood from some of the world's most iconic trees and shrubs have discovered an entirely new type of wood.

This discovery may open new opportunities to improve [carbon sequestration](#) in plantation forests by planting a fast-growing tree more commonly seen in ornamental gardens.

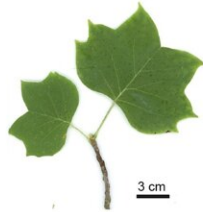
The study found that Tulip Trees, which are related to magnolias and can grow well over 100 feet tall, have a unique type of [wood](#) that does not fit into either category of hardwood or softwood.

Scientists from Jagiellonian University and the University of Cambridge used a low temperature scanning electron microscope (cryo-SEM) to image the nanoscale architecture of secondary cell walls (wood) in their native hydrated state.

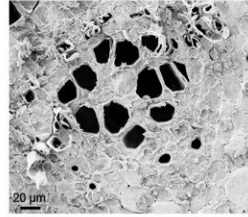
The researchers found the two surviving species of the ancient Liriodendron genus, commonly known as the Tulip Tree (*Liriodendron tulipifera*) and the Chinese Tulip Tree (*Liriodendron chinense*) have much larger macrofibrils than their hardwood relatives (macrofibrils are long fibers aligned in layers in the secondary cell wall).

Lead author of the research published in *New Phytologist*, Dr. Jan Łyczakowski from Jagiellonian University, said, "We show Liriodendrons have an intermediate macrofibril structure that is significantly different from the structure of either softwood or hardwood. Liriodendrons diverged from Magnolia Trees around 30–50 million years ago, which coincided with a rapid reduction in atmospheric CO₂. This might help explain why Tulip Trees are highly effective at carbon storage."

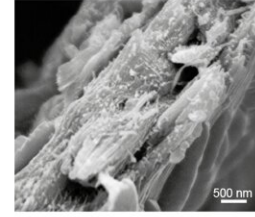
Tulip Tree
Liriodendron tulipifera



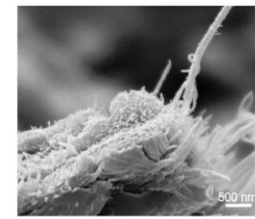
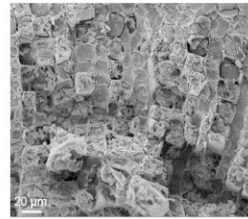
Wood cells and cell walls
(x1000)



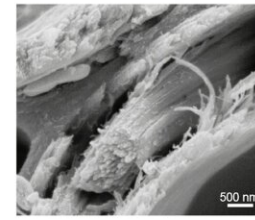
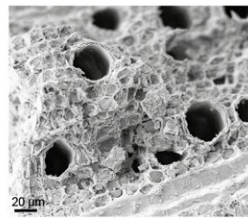
Macrofibrils
(x50,000)



Amborella
Amborella trichopoda



Joint fir
Gnetum edule



Wood ultrastructure of the Tulip Tree (*Liriodendron tulipifera*), Amborella (*Amborella trichopoda*) and Joint fir (*Gnetum edule*) at x1,000 and x50,000 magnifications under cryo-SEM. Wood cells and cell walls are visible in the lower magnification. Macrofibrils are visible at the higher magnification. Credit: Jan J Lyczakowski and Raymond Wightman

The team suspect it is the larger macrofibrils in this "midwood" or "accumulator-wood" that is behind the Tulip Trees' rapid growth.

Lyczakowski added, "Both Tulip Tree species are known to be exceptionally efficient at locking in carbon, and their enlarged

macrofibril structure could be an adaptation to help them more readily capture and store larger quantities of carbon when the availability of atmospheric carbon was being reduced.

"Tulip Trees may end up being useful for carbon capture plantations. Some east Asian countries are already using *Liriodendron* plantations to efficiently lock in carbon, and we now think this might be related to its novel wood structure."

Liriodendron tulipifera are native to northern America and *Liriodendron chinense* is a native species of central and southern China and Vietnam.

The discovery was part of a survey of 33 tree species from the Cambridge University Botanic Garden's [Living Collections](#) exploring how wood ultrastructure evolved across softwoods (gymnosperms such as pines and conifers) and hardwoods (angiosperms including oak, ash, birch, and eucalypts).

Łyczakowski said, "Despite its importance, we know little about how the structure of wood evolves and adapts to the external environment. We made some key new discoveries in this survey—an entirely novel form of wood ultrastructure never observed before and a family of gymnosperms with angiosperm-like hardwood instead of the typical gymnosperm softwood.

"The main building blocks of wood are the secondary cell walls, and it is the architecture of these cell walls that give wood its density and strength that we rely on for construction. Secondary cell walls are also the largest repository of carbon in the biosphere, which makes it even more important to understand their diversity to further our carbon capture programs to help mitigate climate change."



Tulip Tree (*Liriodendron tulipifera*) towering over its neighbors in the Cambridge University Botanic Garden. This Tulip Tree is listed as a Champion Tree by The Tree Register of The British Isles. Champion Trees are either the tallest or those with the largest trunk circumference (girth) of their type in a database of 80,000+ champion trees listed on the register. Credit: Howard Rice

Wood ultrastructure

Wood ultrastructure refers to the detailed microscopic architecture of wood, encompassing the arrangement and organization of its material components. This survey of wood using a cryo-scanning electron microscope focused on:

- **The secondary cell wall:** This is composed of mainly cellulose

plus other complex sugars and is impregnated with lignin to make the whole structure rigid. These components make up the microfibril, forming long aligned fibers that are arranged in distinct layers within the secondary cell wall.

- **The microfibril:** This is currently the smallest structure we can measure using the cryoSEM and is in the order of 10–40 nanometers thick. It is composed of cellulose microfibrils (3–4 nanometers) plus other components.

Studying the wood ultrastructure is crucial for various applications, including wood processing, material science, and understanding the ecological and evolutionary aspects of trees. Understanding the biology behind tree growth and wood deposition is also valuable information when calculating carbon capture.



Tulip Tree (*Liriodendron tulipifera*) in the Cambridge University Botanic Garden. View from ground looking up into the canopy. Credit: Kathy Grube

The Living Collections of the Cambridge University Botanic Garden

The wood samples were collected from trees in the Cambridge University Botanic Garden in coordination with the Garden's Collections Coordinator, Margeaux Apple. Fresh samples of wood deposited in the previous spring growing season were collected from a selection of trees to reflect the evolutionary history of gymnosperm and angiosperm populations as they diverged and evolved.

Microscopy Core Facility Manager at the Sainsbury Laboratory Cambridge University, Dr. Raymond Wightman, said, "We analyzed some of the world's most iconic trees like the giant sequoia, Wollemi pine and so-called "living fossils" such as *Amborella trichopoda*, which is the sole surviving species of a family of plants that was the earliest still existing group to evolve separately from all other flowering plants.

"Our survey data has given us new insights into the evolutionary relationships between wood nanostructure and the cell wall composition, which differs across the lineages of angiosperm and gymnosperm plants. Angiosperm cell walls possess characteristic narrower elementary units, called microfibrils, compared to gymnosperms and this small microfibril emerged after divergence from the [Amborella trichopoda](#) ancestor."

Lyczakowski and Wightman also analyzed the cell wall microfibrils of two gymnosperm plants in the Gnetophytes family—[Gnetum gnemon](#) and *Gnetum edule*—and confirmed both have a secondary cell wall

ultrastructure synonymous with the hardwood cell wall structures of angiosperms.



Gnetum gnemon growing in the glasshouse of the Cambridge University Botanic Garden (left) and as seen under a cryo-SEM showing the secondary cell wall ultrastructure and macrofibrils (right). Credit: Jan J Lyczakowski and Raymond Wightman

This is an example of convergent evolution where the Gnetophytes have independently evolved a hardwood-type structure normally only seen in angiosperms.

The survey was undertaken while the UK was sweltering under the UK's 4th hottest ever recorded summer in 2022.

"We think this could be the largest survey, using a cryo-[electron microscope](#), of woody plants ever done," Wightman said.

"It was only possible to do such a large survey of fresh hydrated wood because the Sainsbury Lab is located within the grounds of the Cambridge University Botanic Garden. We collected all the samples during the summer of 2022—collecting in the early morning, freezing the samples in ultra-cold slush nitrogen and then imaging the samples through to midnight.

"This research illustrates the continued value and impact that botanic gardens have in contributing to modern day research. This study would not be possible without having such a diverse selection of plants represented through evolutionary time, all growing together in the same place in the Cambridge University Botanic Garden's Collections."

More information: Jan J Lyczakowski and Raymond Wightman, Convergent and adaptive evolution drove change of secondary cell wall ultrastructure in extant lineages of seed plants, *New Phytologist* (2024). [DOI: 10.1111/nph.19983](https://doi.org/10.1111/nph.19983)

All cryo-SEM images from the wood survey are publicly available in this [Mendeley repository](#).

Provided by University of Cambridge

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