All the forests in the world from a single layer of cells

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From a sapling to a forest monster, all trees grow from a thin layer of cells between the bark and the wood. Credit: Pixabay

From ancient European beech trees to gigantic Californian redwoods and Australian mountain ashes, new research has found the enormous trunks of these trees are all formed from a single layer of cells no wider than
the tip of a needle.

This discovery by our research team at the University of Melbourne's Creswick Campus, brings opportunities to increase the growth potential of trees and possibly grow and produce more wood, faster.

Trees have inspired humans for millennia. These plants are the largest organism on the planet – defying gravity, the elements, disease, pests, and even humans.

For a long time, scientists have puzzled over the mystery of the structure and function of the cells that produce the wood and bark within the trunks of trees. Now, we have determined that all the wood and bark produced by a tree appears to be created by a single layer of cells just under a tree's bark.

Often described as 'lungs of the earth', trees and forests directly impact life on Earth by contributing to the composition of our atmosphere through the release of oxygen and the conversion of carbon dioxide into biomass. Central to this process is a cylinder of actively dividing cells in a tree's trunk and branches, found just under the bark.

Called the vascular cambium, these cells produce wood (xylem) towards the inside of a growing stem, and bark (phloem) towards the outside. As the tree grows and the branches thicken, this cylinder of cells expands and produces much of the planet's forest biomass in the form of wood.

Wood is one of the world's most important renewable resources, so you'd think we'd have an understanding of how it grows. But until now we didn't know exactly how cells within the vascular cambium go about their business. The number of cell layers that make up the vascular cambium, and to what degree the fate of individual cells within the cambium is predetermined, has been a matter of debate for over a
century.

Some cells in the vascular cambium are stem cells, meaning they are yet to differentiate into their final form. Each cell could go on to form wood or bark, or possibly something else. To avoid confusion with the other definition of stem – a branch – we call these vascular cambium stem cells 'initiating cells' or 'initials'.

We've known for a long time that some cell layers in the vascular cambium consist of initials, but we didn't know how many. To work this out, our team developed a unique process called Induced Somatic Sector Analysis (ISSA). This technique places a genetic label on individual cells within the stems of poplar trees, which then allow us to follow a cell's journey towards wood or bark formation.

Since the discovery of the vascular cambium in the late 1800s, botanists have tried to understand its structure and function. One school of thought suggested the vascular cambium was made up of multiple initiating cell layers, while another predicted a single layer of initiating cells.

Our results reveal that the vascular cambium features a single cell layer of true cambial initials that contribute to wood and bark formation.

ISSA uses a transgenic approach to introduce a so-called 'reporter gene' directly into the stem of trees. We used this to label hundreds of individual cells within the growing region of tree stems which, following many rounds of cell divisions, forms tissue sectors that can be easily identified and analysed. Because our reporter gene was passed from an individual cell to its descendants, careful analysis of the resulting growth patterns allows us to determine which cells become wood, which cells become bark and which ones remain as stem cells.
By looking at the specific fates of individual cells and their frequencies, we see clear evidence for the existence of distinct cell identities within the cambium region that have preferred developmental pathways, and this reveals the structure of the initiating layer.

True cambial initials frequently disintegrate and are lost from the cambium – about a third of them from late spring to late summer. By looking at wood and bark sector patterns, we see that the rate at which wood and bark cells divide is controlled independently of each other.

These findings could have profound implications for the forestry industry. A better understanding of how wood and bark are formed from an initiating layer of cells can be incorporated into tree improvement programs, helping to develop better timber and bark products.

As we continue to improve our understanding of the genes that control rates of cambial cell divisions, we can use this to harness increased growth potential in tree stems – possibly producing more wood, faster.

There are many opportunities to use these new insights for commercial gain but fundamentally our findings add to our understanding of what makes a tree tick. It is amazing to think that the enormous trunks of ancient beeches, giant redwoods and towering mountain ash all form from a single layer of cells no wider than the tip of a needle.

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