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HOW OLD ARE TREES AND HOW FAST DO THEY GROW?

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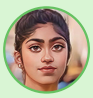
YOUNG REVIEWERS:


ANAGHA
AGE: 9


ANVITHA
AGE: 12


HARMONY
AGE: 12


SRINIKA
AGE: 13

Have you ever wondered how old a big tree is, or counted the rings in a tree stump to discover a tree's age? Why do the rings tell us about a tree's age anyway? Trees grow taller and fatter using special cells called meristems, located at the tip of every branch and around their stems under the bark. This special way of growing means that many trees have growth rings that we can count and measure to find out how old they are and how fast they are growing. Scientists are concerned that climate change is changing how fast trees grow and even how long they can live. They have found that many trees are growing slower than they did a few decades ago. When trees grow slower, they absorb less carbon dioxide from the air. This can cause climate change to speed up, making it even worse for trees.

HOW DO TREES GROW?

Have you ever looked up at a giant tree and wondered how old it is? Have you wondered how long it takes a little acorn to grow into a big oak tree? It turns out that we can "ask" trees how old they are and even how fast they grow. But before we can ask these questions, we first need to understand *how* trees grow.

Trees grow in two different ways at the same time—they get taller *and* fatter, thanks to special cells called **meristems**. Trees have meristems at the tips of every branch, to help the branches grow longer and the trees to grow taller. Trees also have meristems beneath their bark, to help them grow fatter. When you look at the top of a tree stump or at the end of a cut log, you can see the bark on the outside, followed by the **cambium**. The cambium contains three types of tissues: the bark meristem, the **phloem**, and the **xylem** meristem (Figure 1). The bark meristem creates new bark as the tree grows and the old bark wears off. The phloem consists of tubes that transport the sugars made in

MERISTEMS

Plant cells that are actively dividing or reproducing.

CAMBIUM

Tissue layer producing the immature cells needed for plant growth.

PHLOEM

Tubes transporting sugars made in the leaves to feed the rest of the plant's cells.

XYLEM

Tubes transporting water and nutrients from the roots to the leaves.

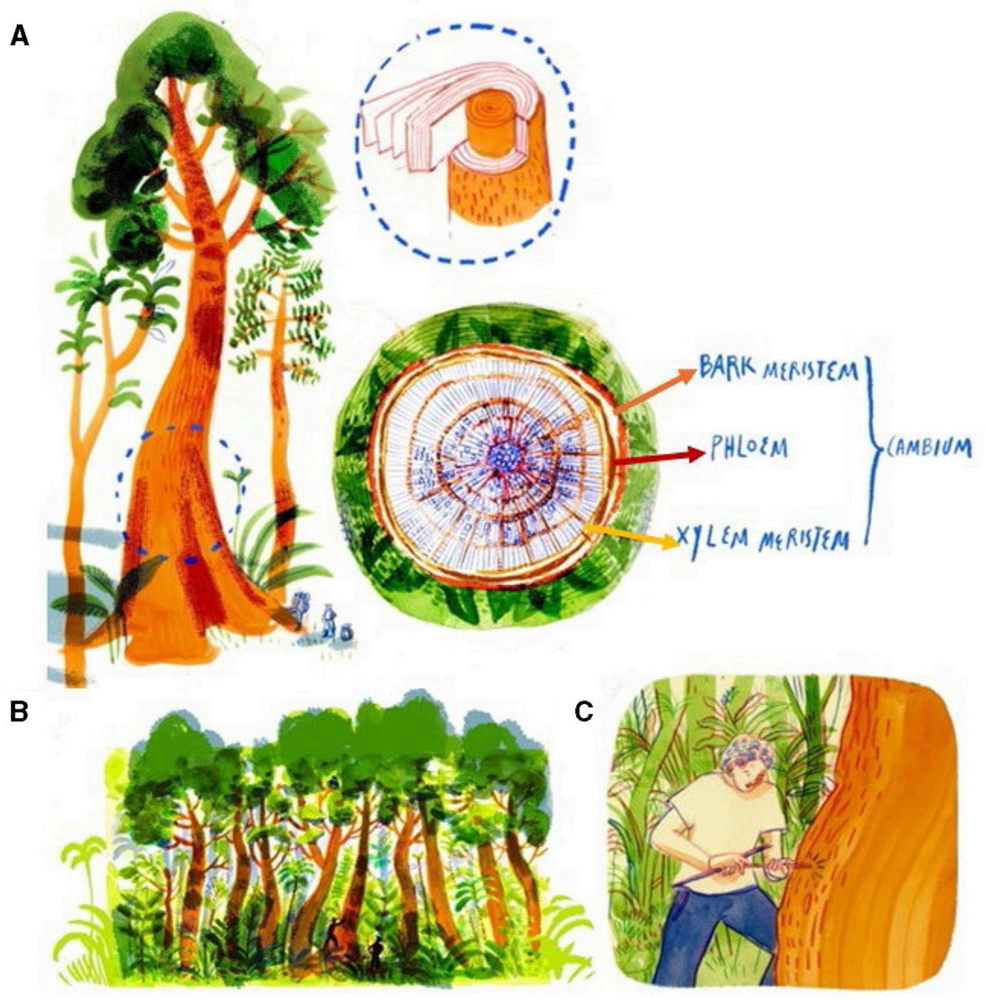


Figure 1

Figure 1

(A) A tall tree and a tree stump cross-section, showing the types of tissues in wood. **(B)** A forest being sampled by scientists for dendrochronology studies. **(C)** A scientist using an increment borer to collect a sample without cutting down the tree. The sample can be used in dendrochronology analyses to find out how old the tree is and how fast it grew in different years (illustrations by Elizabeth Builes, @mira.pal.cielo).

the trees' leaves to all the cells in other parts of the tree. The xylem meristem produces new xylem, which are the tubes that transport water up from the roots to the rest of the tree. Past the cambium you can see the old xylem. The old xylem tubes and their surrounding cells are what we call wood. As the tree grows, it makes more xylem that gets added to the outside of the old xylem. This means that, as the tree grows, it is always getting fatter—and the bark always needs to grow bigger to make room for all that new wood.

Trees often grow in places that are seasonal, which means that the climate changes during different times of the year. In some places, there are cold winters and hot summers. In other places, the temperature stays the same all year but there are dry seasons and rainy seasons. Sometimes these seasonal changes in temperature and rainfall mean that trees can only grow during part of the year. Maybe the winter is too cold and dark for trees to grow, so they only grow in the summer. Or maybe part of the year is too dry, so trees only grow in the rainy season. This seasonal growth means that the meristems produce new xylem in distinct layers, or **annual growth rings**. Each ring within the tree shows us exactly how much wood was added in one year of growth.

ANNUAL GROWTH RINGS

Concentric rings found at the end of a log or tree stump, with each ring having been added during a single growth period.

The presence of annual growth rings enables scientists to investigate the age of trees and how fast trees grow (Figures 1B, C). When you are looking at the cut end of a log, you can count the number of rings between the bark and the center, and that will tell you exactly how many years old that tree or branch was before it was cut. Fortunately, we can also count trees' growth rings without cutting them down. To do this, scientists use a special drill called an **increment borer** to pull out a small sample of wood, about the size of a pencil, from the tree's bark to the tree's center (Figure 2). This does not hurt the tree, and it allows scientists to count the tree's rings to find out how old it is.

INCREMENT BORER

A hollow drill used for cutting out from a tree a core from which increments are estimated by counting annual rings.

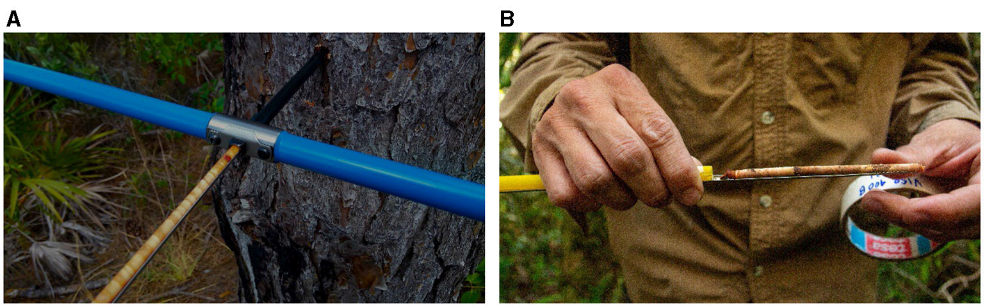


Figure 2

Figure 2

(A) A tree being sampled with a special type of drill called an increment borer. You can see the wood core that is being removed from the tree sticking out the back of the drill. **(B)** A scientist stores and labels a wood core collected from a tree in a straw, for later processing in the lab.

COUNTING RINGS DOES NOT ALWAYS WORK

Unfortunately, we cannot always count rings to know how old trees are. For example, in a lot of tropical rainforests it is hot and wet all year, so some of the trees do not ever need to stop growing—therefore they do not make visible growth rings. However, scientists have found that many tropical trees do in fact exhibit annual growth rings, even in the wettest rainforests of the world and under unfavorable conditions [1]. There is evidence that growth rings in tropical rainforest trees are different for every species, so the formation of tree rings in some species are related to a lack of water, but others to an excess of water.

SUPERORGANISM

A group of individuals that all behave as one unified organism.

Another case in which we cannot use rings is when trees grow as **superorganisms**. When this happens, an entire forest may be just one tree! For example, the Pando tree (Figure 3A) is a gigantic aspen tree growing from a single root system, with almost 50,000 genetically identical trunks growing in an area as big as 80 football fields. In this case, scientists can count rings to know how old each of the individual trunks are, but that does not tell them how old the entire tree is—since

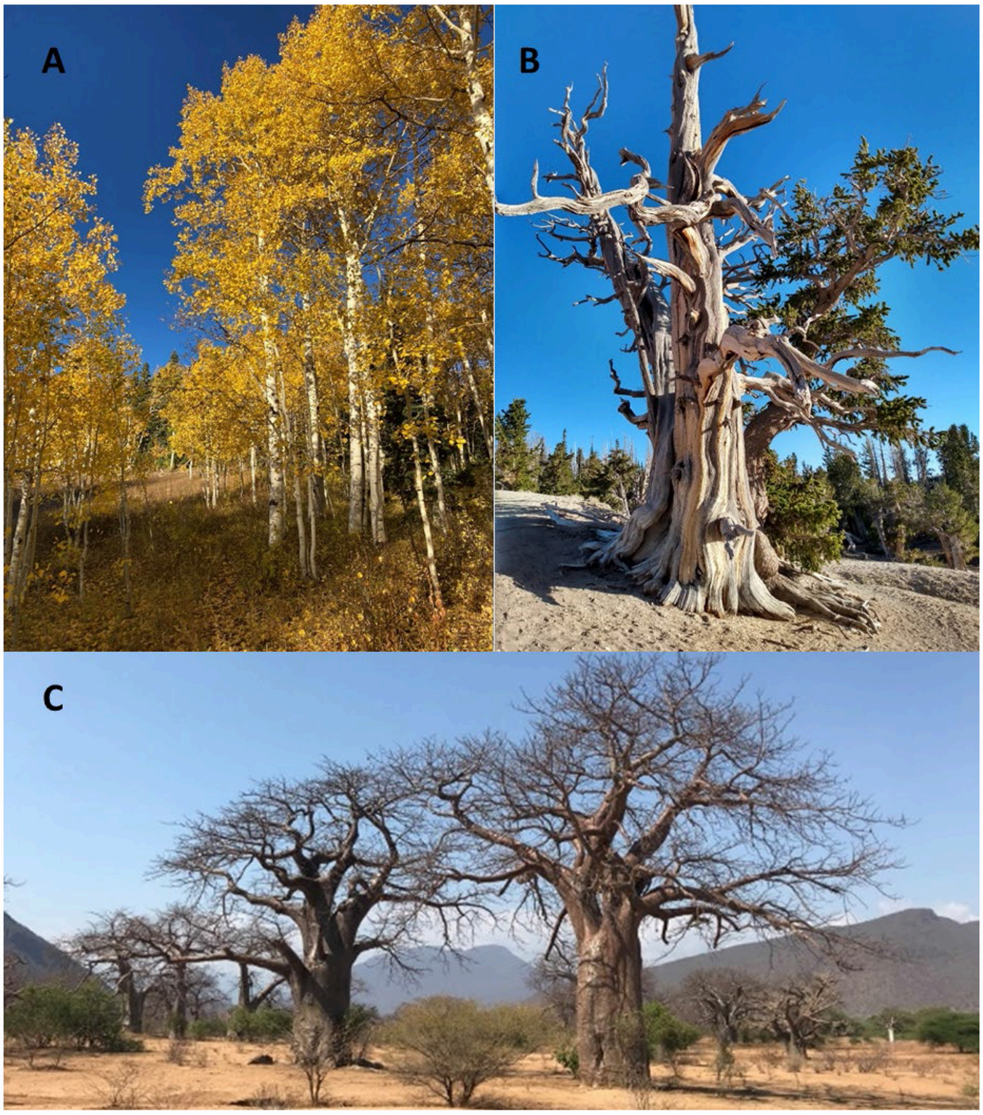


Figure 3

Figure 3

(A) Pando tree (*Populus tremoloides*), https://www.inaturalist.org/observations/187196408, photo by: Otto De Groff. **(B)** Bristlecone pine (*Pinus longaeva*), https://www.inaturalist.org/observations/184726532, photo by: John Powers **(C)** Baobab (*Adansonia digitata*), https://www.inaturalist.org/observations/150386932, photo by: Kat Milligan.

it is a superorganism that is always making new trunks and losing old trunks. By using methods such as carbon 14 dating and collecting lots of trunks, branches, and buried logs, scientists estimate the Pando tree may be more than 80,000 years old [2]!

HOW OLD ARE TREES?

Scientists have counted rings to measure the ages of lots of trees. The oldest single tree that anyone has found yet is a 5,062-year-old bristlecone pine living in the White Mountains of California (Figure 3B) [3]. In the tropics, the big trees are not usually that old. The oldest tropical tree anyone has found yet is a 1,835-year-old baobab living in an African dry forest (Figure 3C) [4].

CHANGES IN TREE GROWTH

In addition to telling us how old trees are, scientists can also measure the thickness of the annual growth rings to know how much fatter a tree grew in each year of its life. An average tropical tree grows twice as fast as an average **temperate** tree (about 5.0 mm per year vs. 2.5 mm per year) [5]. If scientists compare how fast trees grow each year to the climate in that year, they can figure out what types of conditions the trees like. For example, after measuring lots of tree rings, scientists might find that a species of oak grows faster in years when there is lots of rain in the summer, and that another species of pine tree grows faster when there are shorter winters.

TEMPERATE

Ecosystems outside of the tropics, often with seasonal variation in temperature between cold winters and hot summers.

Once we know what types of climates various types of trees like and do not like, we can then look at the annual growth rings of very old trees to make guesses about what the climate was like in the past. For example, if scientists find that pine trees were growing especially slow 200 years ago, they can guess that there must have been a long winter that year. Or if oak trees grew especially fast 350 years ago, they could guess that that year must have had a very rainy summer. This is one of the ways we know what the climate was like hundreds and even thousands of years ago, long before we had weather stations to record temperature and rainfall. This process of measuring tree rings, assigning calendar years to each of them, and finding common growth patterns among trees to estimate the past climate is called **dendrochronology**.

DENDROCHRONOLOGY

From Greek words: dendro = tree, chronos = time, logos = study. The science of measuring annual tree rings and using these measurements to study past climate.

Unfortunately, global warming is making the climate worse for a lot of trees. While some trees may be better off with a new climate, scientists are finding that most trees are growing more slowly now than they did in the past [6]. They have also found that trees do not live as long when the temperature gets too hot [5].This is bad news! Trees are very important for the planet and humans. Trees make food that animals (including humans) eat; they make the wood that we use to build and heat our houses; they make shade to cool down our streets; and they help to clean our air and water. If trees grow slower and die younger, they will not be able to do as many of these good things for us. In fact, if trees start growing slower and do not take as much carbon dioxide out of the air, climate change might happen even faster, since carbon dioxide is a greenhouse gas. If climate change accelerates, trees will grow slower and die younger, making climate change speed up even more… and trees will grow even slower and die even younger… and on and on!

THE IMPORTANCE OF MEASURING TREE AGES AND GROWTH

Trees grow taller and fatter through special cells called meristems. In many trees, meristem cells are only active for part of the year. This makes trees grow in distinct pulses and causes annual growth rings to form. If we count the growth rings on a log or in a sample collected with an increment borer, we can know how old a tree is. If we measure how big each growth ring is, we will know how much the tree grew in every year of its life. Once we know how fast trees grew in particular years, we can determine what type of climate certain types of trees like, and then we can make guesses about what the climate was like in the past. Sadly, climate change is causing many trees to grow slower and die younger than they used to—and this is bad news for everyone. The good news is that if we know what type of climate the different tree species like, we can promote conservation programs to plant the right species in the right places, ensuring that trees grow fast and absorb as much carbon dioxide from the air as possible.

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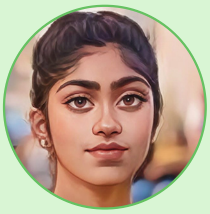
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ANAGHA, AGE: 9
I am Anagha. I love to read, draw, and dance. My favorite subjects ELA, Math, and Science. I would like to be a Teacher in the future.

ANVITHA, AGE: 12
My name is Anvitha and I think polar bears are awesome! I also love music; dancing to it, making it, or just listening to it. I enjoy learning about what is going on in the world, so I am really happy to be a Young Reviewer for the journal Frontiers for Young Minds.

HARMONY, AGE: 12
Harmony is a 12-year-old that loves birds, biology, and stick figures. Some of her favorite hobbies include birdwatching, bird photography, reading, and booping her bunny named Spot.



SRINIKA, AGE: 13

My name is Srinika, and I love trying new things. I love playing chess, drawing, and biking. I also love the outdoors. My favorite subjects are math and science. I hope, that someday in the future, I become a doctor

AUTHORS

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Manuel Bernal-Escobar got his Ph.D. from the University of Miami. He studies forest ecology and conservation with a focus on understanding how climate change, and especially temperature, is affecting the trees in tropical rainforests. In his free time, Manuel enjoys biking, hiking, and attending concerts.

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