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TREE BARK: A SURPRISING AND DIVERSE RESERVOIR FOR WATER

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YOUNG REVIEWERS:

AVIV
AGE: 9

EVAN
AGE: 8

Bark is the outside layer of wood that all trees have. Bark protects trees from harsh environmental conditions including weather, pests, disease, and damage from hungry animals. Just like leaves, bark is different across species. Some trees have thick, rough bark while others have thin, smooth bark. When it rains, bark acts like a sponge and absorbs water. Some trees have bark with large pore spaces that make it easy to absorb rain water quickly. Other trees have bark with smaller pore spaces, which absorb water slowly. Each tree species has a maximum storage capacity of water that can be held in the bark. In fact, some mature trees can store more than 100 L of water in their bark—that is about as much water as you would use in a 10-min shower! In this way, bark influences the water cycle of individual trees and entire forests.

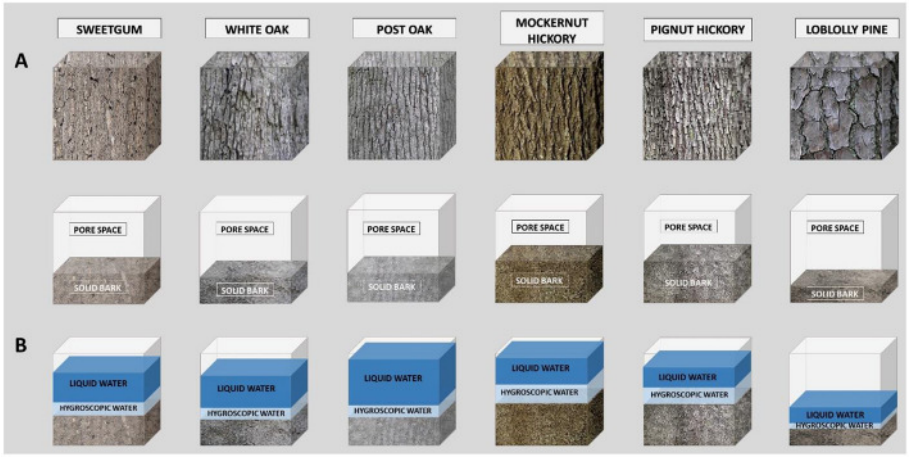

Figure 1

The barks of different tree species absorb different amounts of water. **(A)** The barks of various tree species are shown in the top row. If we squeeze all the solid bark together and separate it from the open pore space, we can see that some species have more open pore space and some have less. **(B)** Some of this pore space is always occupied by hygroscopic water, which is water absorbed from the atmosphere, and whatever pore space is left over determines the amount of additional water the tree bark can store from rain storms.

WATER CYCLE

Movement of water between the Earth and the atmosphere.

HYDROLOGY

The scientific study of water and its movement on Earth.

THROUGHFALL

Rainwater that falls through forest canopies to the forest floor.

STEMFLOW

Rainwater that runs down tree trunks.

INTERCEPTION

Rainwater that is captured by forest canopies and evaporated back to the atmosphere.

PORE SPACE

Open voids that can be filled with water or air.

THE WATER CYCLE IN THE FOREST

Have you ever thought about where rain goes when it falls from the sky? There are scientists called hydrologists who do just this. They study the **water cycle** as water moves through our environment, and this area of study is called **hydrology**. Rain is just one small part of the water cycle. The water cycle describes the movement of water on Earth and includes rain and snow, rivers and oceans, groundwater below our feet, and water that evaporates from soil, lakes, and leaves [1]. If we look closely at a forest, even more parts of the water cycle can be found. Some water lands on the leaves of trees and drops to the ground—this is called **throughfall**. Some water lands on leaves and flows down branches to the tree trunk and then to the soil—this is called **stemflow**. And some water lands on leaves and bark and is held there before being evaporated back into the atmosphere—this is called **interception**. Hydrologists care about how much water reaches the forest floor by throughfall and stemflow. We also care about how much water is "lost" to interception because that water cannot be used by the trees or animals in the forests, or by humans who might rely on the forests for drinking water.

WHAT IS BARK'S ROLE IN THE WATER CYCLE?

Bark is the outside layer of wood that all trees have. Bark protects trees from harsh environmental conditions including weather, pests, disease, and physical damage from hungry animals. Bark is an important component of the water cycle because it acts like a sponge during storms. That means some of the rainwater is absorbed into the bark and does not make it to the forest floor. The amount of water that can be absorbed by bark depends on the tree species and its physical structure [2]. For example, if we compare the same amount (or volume) of bark among six different tree species, loblolly pine bark is about 18% solid bark and the rest of bark volume is open **pore space** (Figure 1A,

Figure 2

Sometimes bark must be removed from trees so experiments can be performed on that bark in the lab. This is called destructive sampling. In this picture, a piece of bark was pried from a loblolly pine tree in the Bankhead National Forest in northern Alabama. Don't worry, the tree will be ok!

Figure 2

far right). Pores inside bark are spaces that can be filled up by water during rain events. In contrast, mockernut and pignut hickory bark are about 38% solid bark and the rest is open pore space. So when it rains, loblolly pine has a lot more open pore space to absorb water!

HOW DO WE STUDY BARK?

Measuring surface characteristics of bark is pretty easy. We can poke and prod the tree and measure how deep the bark is, down to the underlying wood. But sometimes, we need to take the bark off of the tree and bring it back to the laboratory to perform more experiments. Using chisels and hammers, we isolate a square patch of bark and gently pry the bark sample off of the tree. When we remove a piece of a tree to study it, we call this **destructive sampling** (Figure 2). Some of the experiments we might conduct on tree bark in the lab are listed in Table 1.

DESTRUCTIVE SAMPLING

Removal of sample from the object of interest.

SOME PORES HOLD MORE WATER THAN OTHERS

Just like leaves, bark is very different depending on the tree species [3]. Some trees have thick, rough bark while others have thin, smooth bark (Figure 1A). Bark consists of two layers, the outer layer and the inner layer. The outer layer is composed of dead cells while the inner layer is living. Does bark with more pore space retain more water than bark with less pore space? Not exactly!

Loblolly pine has the most pore space but, despite this, it absorbs the lowest amount of water (Figure 1B). The pore space in post oak is very

Table 1

Experiments we conduct on tree bark to understand how water is stored.

Experiment Name	What Is It?	How Do We Do It?
Bulk density	How much mass of solid bark is in a certain volume of bark.	Submerge bark quickly in water in a graduated cylinder, to see how much the volume increases. The increase in water volume is the volume of the bark. Then dry bark in the oven for several hours and weigh bark on a scale to get dry mass. Calculate bark density as the ratio of dry mass to bark volume.
Bark porosity	How much of the bark is open pore space.	To calculate bark porosity, the bulk density and specific density of bark are needed. Specific density describes how much mass of bark is in the volume of solid bark measured without the volume of pore space.
Bark saturation	How much water it takes to fill all the open pore space in bark.	Submerge bark in water for several days. Weigh bark every day until it stops gaining weight. The difference between initial and final weight is the weight of the water absorbed into the bark.
Hygroscopicity	How much water vapor can be absorbed into bark at 100% relative humidity of the air.	Place bark in a sealed chamber on a raised platform above some water. This water will make the relative humidity of the air inside the chamber equal 100%. Weigh bark every day until it stops gaining weight. The difference between initial and final weight is the weight of the water vapor absorbed into the bark.

Table 1

similar to sweetgum and white oak, but post oak can absorb much more water than the other two species because these barks have pores of different sizes. And even though mockernut hickory bark has much less pore space than loblolly pine, mockernut hickory can absorb a lot more water. These differences tell us that water absorption into the bark is a complex process and depends on many factors. We are trying to identify these factors through our research.

Some species have larger pores and some have smaller pores, and pore size also influences how much moisture the bark can absorb directly from the atmosphere, even when it is not raining! This characteristic is call **hygroscopicity** (Figure 1B). When we account for hygroscopicity, the pore space that can absorb additional rainwater diminishes and the capacity of our "sponge" is smaller. Bark hygroscopicity may reach up to 60% of the total amount of water absorbed by bark.

HYGROSCOPICITY

The ability of a substance to absorb moisture from the environment.

CONCLUSION

Now you know that bark is a reservoir for rainwater and that different tree species can have very different bark. Managing water resources is important because forests provide more than 75% of the world's water for drinking and growing food [4]. If we want to be good managers of water resources [5], then we need to know exactly how much rainwater will make it to the forest floor and how much might be caught by leaves and absorbed into bark. By studying these topics, hydrologists help to understand the important role that trees and forests play in the water cycle.

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YOUNG REVIEWERS

AVIV, AGE: 9

A huge Harry Potter fan! I love reading books! I spend many hours reading on my Kindle, especially Harry Potter—I have read the entire series 20 times! I also love jamming on my electric piano, jump-roping and skipping when I am happy. I like eating salads and home cooked meals, but I also have a big sweet tooth—chocolate is yummy! As a vegetarian, I love nature - learning about it, protecting it, and enjoying it!

EVAN, AGE: 8

Evan has a passion for science from coding, to designing robots, to learning about planets and volcanoes, to understanding how viruses work (thanks to corona virus) and learning about different animals and their habitats. Evan is also a talented artist and loves to draw and design robots when he is not at school. His favorite activity is playing with his young brother and dad. He enjoys his mother's home baked cakes, and his favorite fruit is banana.

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