Maple Tree Cells and Makeup
Middle School

Objective: Students will understand the internal structure of maple trees and the different types of cells that makeup these trees. Students will understand why maples are able to be tapped for sap.

This lesson corresponds to:
-S.7.LS.1/MS-LS1-1: Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells.

Materials:
-Sponges, the kind with holes
-Water

Vocabulary:
-Diffuse Porous Hardwood
-Freeze/Thaw Cycle
-Phloem
-Xylem
-Photosynthetic Cells
-Vessels and Tracheids
-Fiber cells

Background Information: Maple trees are a member of the *diffuse porous hardwood* family. Hardwood trees are classified based on the arrangement of vessels within the annual growth rings. Each year a tree is alive and grows another growth ring is added, that is how the trunks of trees get larger and larger. During a year where a tree grows a lot the annual ring will be wider, in contrast during a poor growth year the annual ring will be thinner. Diffuse porous hardwoods produce small, uniform size vessels throughout the growing season, these vessels are used to transport sap and nutrients up and down the tree. Other types of hardwoods produce different sized vessels at different points during the year. The vessels, pores or holes, in the annual rings of maple trees are filled with carbon dioxide gas and not liquid. It is this unique characteristic of maple trees that allow the sap to run on a warm day after a freezing night.

The sap runs in maple trees only during *freeze/thaw* cycles, meaning when there is a below freezing night followed by an above freezing day, due to a change in pressure inside the tree. Maple trees use their roots to suck up water from the ground which is then combined with sugars already in the tree to make sweet sap. During freezing temperatures, the carbon dioxide gas in the vessels compresses and makes room for extra water. Due to the negative pressure created inside the tree, it will suck up extra water that is then combined with sugar already in the tree to create sweet sap. This sap is stored as frost in the vessels and fiber cells. Once the temperature rises and the gas and frost melt and expand there is positive, or high,

pressure created within all of the vessels in the tree. When everything melts the positive pressure pushes sap around to all parts of the tree and out of the tap hole.

Maple trees, like all organisms, have specialized cells that allow them to function uniquely, produce sweet sap, change color in the fall, grow and disperse nutrients from the roots and leaves to all parts of the tree. The major parts of a maple tree's internal structure are defined and explained below.

-*Phloem:* The phloem is made up of dead cells and runs as a pipeline from the tree's leaves, branches and crown down to the roots. The phloem is located just inside the bark. The phloem transports glucose made using photosynthesis to different parts of the tree.

-*Xylem:* The xylem is made up of dead cells and runs as a pipeline from the roots up to the branches, leaves and crown of a tree. The xylem is more inward than the phloem, closer to the center of the tree and creates the sapwood and heartwood of a maple.

-*Photosynthetic Cells:* All green plants have plant cells, the photosynthetic plant cells that makeup the green part of the plant contain chloroplast. Photosynthetic cells, where the chloroplast is located and photosynthesis is carried out, are located on green leaves. Chloroplast is the part of the plant cell that carries out photosynthesis, taking in carbon dioxide and water and converting it to glucose in the presence of sunlight. Chloroplasts contain stroma and grana. The stroma contains enzymes that create glucose through the Calvin Cycle. Grana are membranes containing chlorophyll a and chlorophyll b that absorb sunlight. The glucose produced in these cells is used by plants and trees for food.

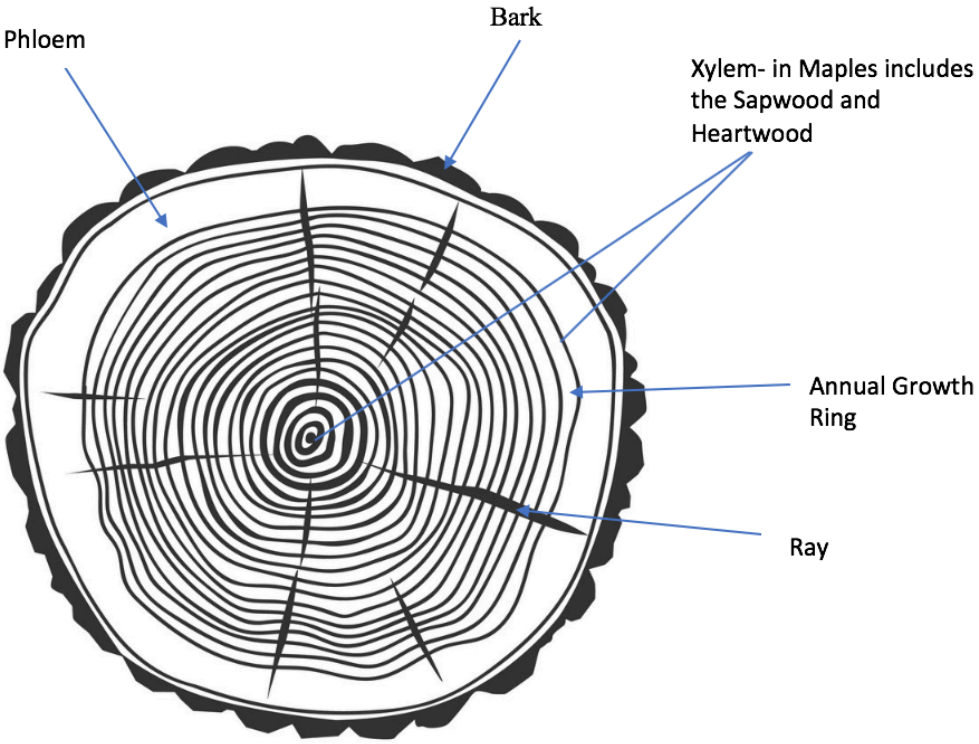
-*Ray Cells:* Ray cells appear as lines radiating from the bark towards the center of the tree. They are living cells, living cells are also referred to as parenchyma. Ray cells transport glucose from the phloem to the xylem where they are stored for later use. They also move metabolic waste and phenolic compounds towards the dead heartwood in the center of the tree.

-*Transport Cells:* Transport cells move water and nutrients up, down and around the tree; there are two main types: *tracheids* and *vessels.*

-*Tracheids:*

-*Vessels:* In maples vessels are responsible for the majority of nutrient and water transportation. Vessels are long straws composed of cells called vessel elements, at maturity vessel elements are dead which allows sap to travel freely through them. Vessel elements are connected horizontally by pores, allowing sap to move around the outside of the tree. Vessel elements grow differently in different types of hardwoods, in diffuse porous hardwoods they grow uniformly throughout the growing season.

-*Fiber Cells:* The xylem consists primarily of fiber cells, they provide structural support and make the tree strong. Fiber cells are dead at maturity. Fiber cells contain special proteins that prevent them from exploding when water freezes and expands inside them. In maple trees fiber cells are filled with carbon dioxide gas, not water; one of the unique properties of maple trees that allow the sap to run.



Introduction: Maples are unique and special trees in their ability to produce sap. It is not the ability to produce sap that makes them special, all trees make sap, but their ability to produce sap in such a high quantity and have it run out of the tree.

Activity 1: Cell Debate: Students will explore the function and structure of the different cell types that make up a maple tree.

Procedure:

1. Divide the class into groups, one for each cell type or as many as you would like to cover.
2. Give each group a synopsis of their cell type, or allow them to do some research on their cells.
3. Have each group draw or construct a model of their cell type.
4. Moderate a debate.
    a. Give each group five minutes to present their cell and why it is important.
    b. Allow two minutes for questions.
    c. (Optional) Allow for a three-minute rebuttal from each group.
    d. Have the class vote on which cell type is most important.

Activity 2: Freeze/Thaw Cycles Demonstration: Students will understand how freeze/thaw cycles work and why the sap runs in maples.

Demonstration:

-A dish sponge with holes in it represents the fiber cells located in an annual growth ring of a diffuse porous hardwood tree, i.e. maple trees, the holes in the sponge are all of a uniform size and spread throughout the entire sponge.

-The seemingly empty holes are filled with carbon dioxide gas

-Put 1 end of the sponge in water and squeeze it, this represents the roots pulling in water during the night due to negative pressure in the tree.

-The water takes up some space in the holes of the sponge- this represents the frost that forms in the fiber cells and vessels.

-Squeeze the sponge to represent the positive pressure that is created inside of the tree when the frost formed in the fiber cells expands.

-When you squeeze the sponge, or when there is positive pressure due to thawing, all of the frosted gas and sap expand and create positive pressure within the tree. The positive pressure pushes sap up and around the tree, to all of the branches and out of the tap hole.

-The change from negative pressure at night to positive pressure during the day is what causes the sap to flow. Freezing nights create negative pressure and warm days create positive pressure in the tree, the temperature change is a key factor.

-Do this a second time, but before squeezing the sponge wrap it in saran wrap or a Ziploc bag and poke a hole in one part of it to represent a tap hole.

-This will demonstrate sap flowing out of the tap hole during the thaw cycle.

-Additionally, you can turn the lights off during the freezing part of the cycle and then back on again when you squeeze the sponge to demonstrate during which parts of the day the temperature changes are occurring.

**If students are having trouble understanding what positive and negative pressure inside of a tree looks like try using these analogies:

-Negative pressure in a tree causes it to pull up extra water from the ground= a vacuum cleaner sucking up dirt from a floor

-Positive pressure in a tree happens when all the space in the xylem is full of liquid and the liquid is then pushed around and circulated, when there is a tap hole the sap will be pushed out of the hole= an inflated tire, there is enough space for all of the air but when a hole is made it all flows out.

References and Resources:

Rechlin, M. *Maple Syrup: An Introduction to the Science of a Forest Treasure*. McDonald & Woodward Publishing Company. January 15, 2016.

"Educator Resources for Build-A-Cell: Plant" BrainPop Educators. Retrieved 30 January, 2019. https://educators.brainpop.com/bp-game/build-a-cell-plant/