



LESSON SUMMARY

To observe and understand the importance of the transpiration process in green plants by conducting an experiment showing water vapour loss from leaves.

Activity Information

Grade Level:	Intermediate
Estimated Duration:	Up to 2 hours
Materials:	Stepladder (optional), clear plastic bags, twist ties; optional: one wet/dry bulb thermometer (muslin, water, two thermometers)
Setting:	Indoors and outdoors
Key Vocabulary:	Stomata, transpiration, capillary action, evapotranspiration

Background Information

Trees, like all green plants, lose water through tiny pores or stomata in their leaves. This process called transpiration, creates a tug or tension within the columns of water in the tree. This tension, combined with a process called capillary action, pulls water from the roots all the way up to the leaves. In this way, important minerals are transported from the roots to the leaves of the tree. Some of the water is absorbed and used by cells and tissues along the way. Excess water vapour is lost through the stomata in the leaves.

As the excess water vapour is transpired, it cools the leaves on hot days in much the same way as perspiration cools your body. On humid days people generally feel sticky. This is because the humidity prevents the sweat from evaporating as quickly as it does on less humid days. Similarly, when the humidity is high, the rate of transpiration decreases. Transpiration also varies according to other conditions such as soil moisture, temperature, and wind, as well as the size, age, and species of a tree and its position in the forest canopy. The rate of transpiration of broadleaved trees is several times greater than that of evergreens. Birch and ash have a particularly high rate of transpiration. Excess transpiration can kill plants, however, trees have developed characteristics that protect them (e.g., the thin needles of evergreen and waxy coating on cactus leaves, prevent excessive transpiration in harsh, dry climates).

In forests, tree roots bind the soil and also hold water. In forests in the temperate regions of the world, up to 90 per cent of rain is retained either in the humus layers of the forest floor or in the plant tissues. The forest acts as a giant sponge that plays a crucial role in the hydrological cycle. Rain is soaked up during storms and gradually released over the days and weeks that follow: the forest may continue to feed streams and rivers even during dry seasons. By absorbing and then gradually releasing water into the atmosphere, the forest helps regulate watershed areas.

Transpiration is part of a larger process called evapotranspiration, which includes evaporation from the soil and litter layer, not just from living tissue. Evapotranspiration plays a key role in the water or hydrological cycle: without water evaporating from the earth's surface there would be no vapour to rise, cool, condense, and fall as rain, sleet, or snow. The ability of green plants to transpire, combined with evaporation from the soil and litter layer, play key roles in the continuous motion of the water cycle that supports all life.

Trees, along with other vegetation, utilize carbon dioxide during photosynthesis, absorbing it in huge amounts. As plants transpire, they also return life-giving oxygen to the earth's atmosphere (oxygen is a by-product of photosynthesis and is released through transpiration). The burning of fossil fuel produces enormous amounts of carbon dioxide. Forests are needed to convert this carbon dioxide back to oxygen.

Gone with the Wind and Water

Locate several broadleaved trees on or near the school grounds. If the branches are too high, provide stepladders for students to reach the leaves. (This activity can also be done indoors using large house plants).

ACTIVITY #1

Take students outdoors to observe tree leaves. What do the leaves feel like? Are they dry or moist? Why does a forest feel cooler and damper on a hot day than an open field does? What do leaves need to survive? Have students create their own experiments to help them discover how much water trees need to survive. Encourage them to develop questions such as:

- How does a tree manage to get water up to its leaves? (In the case of tall trees, it may have to travel 20-30 in or more.)
- What happens to the water once it reaches the leaves?
- How can we find out?
- How can we test our ideas?
- How can we ensure that our test is fair?

Help them think through each step of their experiments and encourage students to predict what might happen. Assist them in conducting their experiments and in reaching conclusions. Alternatively, have them try the experiment in Activity #2 or use it as a model.

ACTIVITY #2

1. Discuss the human circulatory system. How does it work? What is its purpose? What is the energy source that drives the circulatory system? Does a tree have a similar system? How? What might the transport medium be?
2. Divide the class into small groups and give each group a plastic bag and a twist tie. Go outside and have each group select a leaf from a broadleaf tree (larger leaves are better).
3. Without removing the leaf from the tree, have each group carefully place a bag over a leaf, making sure the leaf retains its original position in relation to the sun. Use the twist tie to make a snug seal around the petiole (stalk) of the leaf. Ask your students to predict what will happen.
4. Leave the bags attached for at least 20 minutes. (The clear plastic bags allow the light in and allows you to observe any differences that might be created by the leaf's position on the tree.)
5. When the bags are retrieved, observe the droplets of water clinging to the inside of the bag. Compare students' predictions with what actually happened.
6. Ask students to explain where the water came from. How could they test their answers?

7. Discuss the process of plant transpiration (see Background Information). One way of effectively explaining transpiration is to compare it with human perspiration. Compare circulation systems of trees with those of mammals; discuss chemical energy versus solar energy; water versus blood. Ask your students: Why is transpiration important in forest ecosystems?
8. Ask students to predict what would happen if they coated the leaf with petroleum jelly. Encourage them to create other experiments that explore different aspects of transpiration. (For example, how could they find out if there are stomata on both sides of a leaf? How does water move up the trunk of the tree? How do we know leaves give off oxygen?)

Extensions

1. Have students determine the mass of the bag before the experiment. Have them leave the bag attached for 24 hours and then determine the mass of the bag including the transpired water. Then subtract the mass of the empty bag from the mass of the bag filled with transpired water. Have them make a rough estimate of the number of leaves on the tree and multiply this number by the mass of transpired water from one leaf to give a rough idea of the total mass of water transpired during the experiment.
2. Using a wet/dry bulb thermometer*, measure the humidity in a forest and have the class compare it to the humidity in an open field. What causes the difference? Why does it feel cooler in the forest on a hot summer day than it does in an open field?

*Wrap the bulb of one thermometer with a piece of muslin that has been soaked in water and place it beside a regular thermometer. If the air is dry, the water from the muslin will evaporate more quickly than if the air is humid. Heat energy is used as the water evaporates from the cloth, resulting in a lower temperature reading on the wet bulb thermometer. If the difference is slight, the air is humid.