

Activity Template

Subject Area(s) life science, science & technology, measurement

blank

Associated Unit

Yellow highlight = required component

Associated Lesson Plants and Engineering

Activity Title Plant Transpiration

Grade Level 5

Activity Dependency

Time Required 100 minutes total:

60 minutes for introduction, pre-assessment, activity setup

5 minutes for each water measurement

25 minutes for results analysis and post-assessment

Group Size

Expendable Cost per Group US\$ ____

Summary

Students learn about the transpiration process and the different parts of plants that are important to this process. They also learn that nature can sometimes be used as inspiration in engineering designs. They are given an example of how the transpiration process was used as inspiration in an engineering design and are encouraged to think of other ways nature can or have inspired engineers.

Engineering Connection

Engineers sometimes use inspiration from nature for design. Chemical and biomolecular engineers used the transpiration process as inspiration to design a synthetic tree that safely handles liquids that can easily evaporate.

Engineering Category = #1

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

plants, transpiration, engineering

Educational Standards

TEKS for Science, Texas, Beginning with School Year 2010-2011, Grade 5, 9A:

(9) Organisms and environments. The student know that there are relationships, systems, and cycles within environments. The student is expected to:

- (A) observe the way organisms live and survive in their ecosystem by interacting with the living and non-living elements

TEKS for Math, Texas, Beginning with School Year 2010-2011, Grade 5, 10A:

(10) Measurement. The student applies measurement concepts involving length (including perimeter), area, capacity/volume, and weight/mass to solve problems. The student is expected to:

- (A) perform simple conversions within the same measurement system (SI (metric) or customary)

Pre-Requisite Knowledge

The students should know the basic parts of a plant including the roots, stem, and leaves. They should also know the fundamental SI units of measurement like the meter and centimeter.

Learning Objectives

After this activity, students should be able to:

- Explain how the transpiration process works
- Identify and explain plant parts that are important to the transpiration process
- Understand that engineers sometimes use nature as an inspiration for design

Materials List

Each group needs:

- plant shoot (Works best with broad- leaved plant: maple or oak)
- one clear plastic bottle (3L or smaller depending on size of plant shoot)
- piece of cardboard

To share with the entire class:

- light source (sun lamp works best)
- water
- petroleum jelly or plastic wrap and tape
- scissors
- rulers
- 500 mL beaker

Introduction / Motivation

What does a plant need to survive? (Expected answers: **water**, air, nutrients, sunlight) What part of the plant absorbs water from the soil? (Answer: roots) Does anyone know how the water gets from the roots to the leaves of the plant? (Take suggestions and ideas but don't expect the correct answer.) This is done through a process called transpiration that occurs when water evaporates from the leaves of a plant and more water moves up through the plant to replace the lost water.

Engineers sometimes use nature for inspiration in their designs. What type of engineers do you think would use plants as inspiration? (Answer: could be any type of engineer) Any type of engineer could find inspiration in nature. Chemical and biomolecular engineers used plant transpiration as their inspiration. They built synthetic trees that had leaf and root networks with 80 micrometer channels. These synthetic trees were used to safely handle liquids that easily evaporate. Can anyone think of a liquid that evaporates easily? (Example: nail polish remover - acetone) Let's get started!

(Have the students complete the pre-assessment and then have them start the activity.)

Vocabulary / Definitions

Word	Definition
Transpiration	The process when water evaporates from the leaves of a plant and more water moves up through the plant to replace lost water
Stoma	Pores located in the bottom of leaves that let air in or give off water through evaporation
Guard Cells	Occurs in pairs that surround and control the opening and closing of the stoma

Procedure

Background

In order for the plant to make its own food, other than water, it needs minerals from the soil and carbon dioxide in air. There are small openings in the bottom of leaves, called stoma, that open and let air in as seen in Image 1. When they open water can evaporate from the leaf, which starts the transpiration process. Transpiration occurs when water evaporates from the leaves of a plant and more water moves up through the plant to replace the lost water. Guard cells surround the stoma and control when it opens and closes. When the plant needs water, the guard cells shrink and close the stoma. When the plant has enough water the guard cells get bigger and pulls the stoma open.

The outside layer of the leaf is called the epidermis and the cells of this layer discharge a waxy substance that coats the leaf. This coating is called a cuticle and helps keep water from leaving the leaf. Another important part of the leaf are the veins. They transport the food made in the leaves away to other parts of the plant. They also transport the water and minerals the leaf needs to make food from the stem into the leaf.

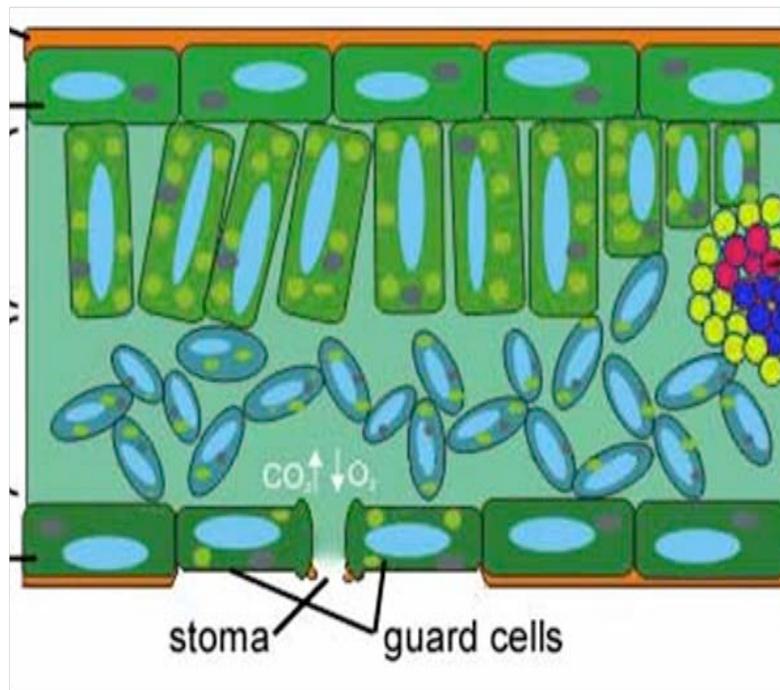


Image 1

ADA Description: This image shows the anatomy of a leaf with labels that include the stoma and guard cells.

Caption: Anatomy of leaf that is important for the transpiration process.

Image file: partsofleaves.bmp

Source/Rights:

http://commons.wikimedia.org/wiki/File:Leaf_anatomy.jpg

Before the Activity

- Group the students depending on the number of plant shoots available. Pairs work the best for this activity. Hand out the materials to each group.

Pre-Activity Investigation

Take the following measurements, in centimeters, and record your results.

- a) Length of the plant shoot
- b) Length of all the leaves
- c) Width of all the leaves

Convert at least three of these measurements into millimeters. (1 cm = 100 mm) Trace one of the leaves and label the measurements. What units of measure would you use for the veins of a leaf? Why? Touch the leaf and record your observations. Does the outside of the leaf feel waxy?

Activity Setup

- 1) Cut the bottle widthwise. Trim the edges of both pieces of the bottle to make them as even and level as possible. Trace the opening of the bottom piece of the bottle on the piece of cardboard.
- 2) Cut out the cardboard but leave about an inch of extra cardboard around the tracing. Make a small hole in the center of the cardboard. It should be just big enough for the stem of your plant shoot to fit through.
- 3) Cut the end of the plant shoot stem at an angle. Cutting it at an angle will give the plant shoot a larger area to take in water. Place the shoot through the hole in the cardboard and seal the whole with petroleum jelly or plastic wrap and tape.
- 4) Fill the bottom half of the with a known amount of water. Measure and record the amount of water. Place the cardboard on top of the bottom half of the bottle. The end of the stem should be submerged in the water.
- 5) Now place the top half of the bottle over the stem so it is resting on the piece of cardboard.

Investigate Transpiration

Now that you are setup you are ready to start your investigation of transpiration!

- 1) Place your plant shoot under the sun lamp.
- 2) Water droplets should appear on the inside of the top part of the bottle after about 20 minutes of being under the sun lamp. These droplets are caused by transpiration.
- 3) At the end of the day and for the next two days measure the amount of water lost from the bottom of the bottle. Record your measurements. This water is lost due to transpiration.

4)After all your measurements have been taken make a graph. This graph should represent the amount of water lost or transpired with a vertical axis of time in days versus amount of water in mL for the horizontal axis. Present your results as a group to the rest of the class.

Attachments

Safety Issues

•

Troubleshooting Tips

Investigating Questions

Assessment

Pre-Activity Assessment

Discussion Questions: Have the students discuss the following questions together in small groups.

- Can you think of any objects or processes that occur naturally and would be useful in engineering design?
- For each object or process you thought of:
 - What attribute or characteristic would be useful?
 - What could it help design?
 - How would this help society?

Post-Activity Assessment

Quiz: After the completion of the activity and the discussion of the results have the students complete the following fill-in-the-blanks. This can be done individually or in their activity groups.

Water enters the plant from the soil mostly through the _____. The process by which water moves through a plant is called _____. Water evaporates from holes on the underside of a leaf called _____ and the size of these holes are controlled by cells called _____. The leaf has _____ that transport water, minerals and food.

Answer Key: roots, transpiration, stomata, guard cells, veins

Activity Extensions

None

Activity Scaling

- For lower grades, ___?
- For upper grades, ___?

Additional Multimedia Support

References

- Amaud, Celia. "Transpiration Mimic: 'Synthetic Tree' Pumps Water with Negative Pressure." *Chemical and Engineering News* 86.37 (2008): n. pag. Web. 09 Sep 2010. <<http://pubs.acs.org/cen/news/86/i37/8637notw4.html>>.
- Moyer, Richard, and National Geographic. *McGraw-Hill Science*. 2000. Print.

Redirect URL

Contributors

Nicole Stewart and Corey Burton

Copyright

Supporting Program

We gratefully acknowledge financial support from University of Houston NSF GK12 program, Grant # [0840889](#) (Program Managers: Drs. Sonia Ortega and Ping Ge).

Version: September 2010