Water Use In Plants
Transpiration with leaves

Objectives
Students will be able to:

- understand the pathway water takes through a plant as a result of evapotranspiration.
- identify three different types of water conservation adaptations in plants.
- understand that precipitation is low in deserts.
- identify Phoenix as an urban desert ecosystem with extra water input from human activities.
- recognize that types of plants and plant growth rate are different in rural desert vs. urban areas.

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Time
50-60 min.

Grade Level
4-8

Standards
AZ Science Standards:
Inquiry, Investigation, Analysis, Communication, Nature of Science, Plant Adaptations, Ecosystems

NGSS Core Ideas:
Earth Systems, Matter & Energy Cycles, Ecosystem Dynamics, Biodiveristy & Humans

Specific Standards are on pages 3-4.

Background:
How is water important to organisms? Water makes up most of every living creature. Every cell in an organism needs water for important processes, such as turning food into usable energy. Plants are special because they make their own food through photosynthesis in the cells of their leaves. The process of photosynthesis requires water.

Plants move water from their roots to their leaves and this water evaporates from the leaf through small pores called stomata. Most stomata in terrestrial plants are on the underside of leaves. This evaporation into the air is the force that draws water upward against gravity. Water molecules cling to each other through weak attractive forces and they move upward along the inside walls of the plants' vascular tubes (xylem) due to cohesion. This water transport through the plant due to evaporation from leaves is called transpiration.

Students can observe transpiration by collecting water vapor in plastic bags, which re-condenses into liquid water as it cools. Transpiration, and the resulting water collected in the bag, increases with increasing temperature.

In deserts, precipitation is low and the temperature is often hot, so evaporation is also high. Water can be scarce in the desert. Over many generations in the dry, desert environment, the most successful organisms survive and reproduce the best. These organisms are well-suited to their environment because they have special adaptations to desert conditions. Some plant adaptations to conserve water include:

1) small leaves, less surface area and fewer stomata
2) leathery or waxy coating
3) stems store water

Also spines and hairs reflect heat and reduce airflow (evaporation) – they make tiny shadows to cool leaf.

Vocabulary:
conserve - to use less or use well

ecosystems-all the biotic and abiotic components within a specific area (i.e. Sonoran desert ecosystem

adaptations- characteristics/traits that help an organism to survive and reproduce

evapotranspiration-transpiration from leaves and evaporation from soil

organisms- living things such as plants, animals, fungi and bacteria

photosynthesis-the process by which plants convert water and carbon dioxide into chemical energy (sugars) and release oxygen

rural-outside of cities, countryside

stomata- openings on the surface of leaves that are controlled by guard cells and

allow gas exchange with the atmosphere

urban-pertaining to cities

Advanced Preparation:
Students should have some prior familiarity with desert ecosystems and the concept of adaptations.

Materials:
- plastic whirl bags (1/student) or baggies with ties
- clip boards
- student worksheets

-Plant Adaptation & Evapotranspiration slideshow (optional) https://ecologyexplorers.asu.edu/docs/explorers/plant_adaptations_and_evapotranspiration_slides.pdf

Recommended Procedure:

Engagement

1) What happens to us when we get hot? We sweat ...or perspire. Water and salts come out of the pores in our skin. Plants don't perspire, but they transpire. These words rhyme. Compare pores with stomata.

2) How does water get into plants in the first place? Have students complete the path of water in Worksheet 1

3) Review desert plant adaptations

4) Using images or real plants, guide students to name three types of adaptations that help plants to conserve water in the desert.

   1) small leaves, less area

   2) leathery or waxy coating

   3) stems store water

   Also spines and hairs reflect heat and reduce airflow (evaporation) – they make tiny shadows.

5) Ask students, which type of plants would transpire more, a native desert plant or a plant from a cool wet forest? Show some images and have students locate cooler, wetter areas on a map.

6) Which type of plant would be better to plant in our yards if we want to conserve water? (Students may need to review the term conserve = to use less or use well). You may ask which plants are better water savers?

Exploration/Explanation

7) Direct students to the worksheet and introduce the Scientific Question: How is transpiration different in different types of leaves?

8) Explain how to tie bags over stems and leaves, emphasize that the bag must be wrapped tightly to prevent water vapor from escaping.

9) Assist students to answer the THINK questions:

   What will the bag do?

   What evidence should we look for in the bags?

10) Prepare to go outside and collect data. Ask the students: What types of leaves should we look for? (narrow and wide, waxy and not waxy. Any cacti?) Will it matter if they are in the sun or the shade? Explain how the class will control for this variable (all sun, all shade, or two groups for comparison).

11) Go outside and assist each student to "bag" one plant of their choice. On the worksheet students should circle the type of leaves on their plant.

12) Back in the classroom, make a table on the board and tally the total number of leaf types for the whole class. Explain how to read a table with two categories of two variables. Assist students to complete the table on their worksheet. (If comparing sun and shade plants, include this in the table or make two separate tables).

13) Ask students to predict which leaf types will lose the most water and complete their worksheet. Discuss their reasoning.

14) Based on the reasoning above, model the construction of hypotheses as explanatory statements. Write hypothesis statements on the board.

15) Discussion and presentation on water use by plants:

- Show pictures of desert and mesic landscaping. Ask students: What differences do you see? – water!
- Ask: Where does the extra water in urban areas, like Phoenix, come from? Show pictures to illustrate irrigation and washing cars etc.
- Discuss how humans change the desert in urban areas. Explain that there is not more precipitation in the city, humans must manage and redirect water from other sources to support the water use in a desert city.
- More water means more types of non-desert plants can survive in urban areas, such as Phoenix. Growing non-desert plants means less desert ecosystem and

less water available for other uses.

16) Ask students: Which plants should we grow in Phoenix?

- Show pictures of Sonoran desert plants and other types of common landscaping plants. Ask students: Which are better water savers?

17) Explain that scientists must understand why they predict what we do so they can test it. Discuss their prior predictions based on the plant adaptations above. Allow students to change their predictions if they wish and guide them to write explanations on their worksheet.

18) Retrieve bags: Ask the teams to return to the plants they "bagged" to see if any moisture has collected in the bags. Visually compare the bags from different leaf types and sun/shade. Try to measure the water using beakers or graduated cylinders.

19) Ask students: Where do you think the moisture in the bags came from?

[You may need to explain evaporation and re-condensation]

20) Ask students to describe the leaves that gave off the most moisture and the least moisture in the bags. Based on the traits of narrow and wide, waxy and non waxy, have students fill out the results table as a class or in small groups for all plants in the investigation.

Expansion

21) Conclude by asking students: which types of plants are best to grow in a desert city (waxy leaves or not waxy; thin, medium or wide leaves?

22) Complete the data analysis and THINK questions verbally or on the back of the worksheet. Clean up.

Evaluation:

- Students will participate in discussion and investigation.
- Students will record data and respond to questions on the worksheet.

Extensions:

Students may draw a picture to illustrate their answers to the synthesis THINK questions (e.g. water vapor escaping from stomata and re-condensing in the sky as clouds, producing rain).

Students can graph the group data from their data table and compare it to the graph of another group.

As a class, graph all the narrow leaf data from each group to make a vertical bar graph on the board and compare the variation. Is it possible that some narrow leaves lost more water than some wide leaves? You can then compile the wide leaf data for comparison. This illustrates the importance of replication.

Students can combine all class data as averages and make a class graph, emphasizing that the six leaves from each group represent one replicate of the larger investigation.

Read the articles related to urban plants in the ASU Chain Reaction magazine, volume 4:

"A Shady Situation" http://chainreactionkids.org/files/issues/4/chreact4_p18_19.pdf

"Planting Water-Wise" http://chainreactionkids.org/files/issues/4/chreact4_p20_21.pdf

"Where does our water come from?" http://chainreactionkids.org/files/issues/4/chreact4_master.pdf (p 21).

Have students discuss the articles in small groups. Ask students to explain how understanding evapotranspiration helped the scientists to do their research. Based on what they have learned from the lesson and readings, ask students to make a landscaping plan for their school yard, park or home. They may draw it as an aerial map. What are the main goals of their design (e.g. shade, water conservation, places to play, habitat for animals)? What general types of plants would they use? Which specific tree species would they use? Where would they locate them? How would they be maintained?

Standards

AZ Science Standards

S1-C1-GR3-PO2
S1-C1-GR-4-PO3
S1-C1-GR-5-PO2
S1-C1-GR-6-PO1, PO2
S1-C2-GR4-8-PO1
S1-C2-GR3-3-8-PO4, PO5
S1-C3-GR3-8-PO1

S1-C3-GR3-5-PO2
S1-C3-GR3-6-PO3
S1-C3-GR4-PO4
S1-C3-GR7-PO5
S1-C4-GR3-5-PO1
S1-C4-GR3-8-PO3
S3-C1-GR4, 7-8-PO1
S4-C1-GR3-4-PO1
S4-C1-GR6-PO1, PO6
S4-C3-GR3-4PO4
S4-C3-GR7-PO2, PO5
S4-C4-GR3-4-PO1
S4-C4-GR4-PO2
S4-C4-GR8-PO3
S6-C2-GR6-PO1

NGSS Core Ideas:
ESS2.C: The roles of water in Earth's surface processes
ESS3.C: Human impacts on Earth systems
ETS1.B: Developing Possible Solutions
LS1.C: Organization for matter and energy flow in organisms
LS2.B: Cycles of matter and energy transfer in ecosystems
LS2.C: Ecosystem dynamics, functioning, and resilience
LS4.D: Biodiversity and humans

NGSS Practices:
Planning and carrying out investigations
Analyzing and interpreting data
Using mathematics and computational thinking
Constructing explanations
Engaging in argument from evidence
Obtaining, evaluating, and communicating information

NGSS Crosscutting Concepts:
Cause and effect
Scale proportion and quantity
Systems and system models
Energy and matter: Flows, cycles, and conservation
Structure and function
Stability and change

Common Core/ELA Literacy
RST7: Integrate content from diverse formats
WHTS1: Write to support claims
WHTS2: Write to convey ideas and information
WTS4: Produce clear and coherent writing
WTS7: Research/investigate to answer a focused question
SL1: Participate in collaborations and conversations
SL2: Integrate oral information
SL4: Present effectively to listeners

Common Core/Mathematics
Domains:
Number and Quantity
Measurement and Data
Statistics and Probability
Math Practice:
2. Reason abstractly and quantitatively.

Student Worksheet
Transpiration in real leaves

Scientific Question: How is transpiration different in different types of leaves?

Procedure: We will try to observe transpiration by tying plastic bags around the leaves

THINK: What will the bag do? What evidence should we look for in the bag?

RECORD METHODS:

CIRCLE the type of leaves you bagged (may be more than one):

narrow wide waxy not waxy

COUNT the total number of each type of leaves your class bagged

	Narrow	Wide
Waxy		
Not Waxy		

PREDICT: Which leaves will lose more water?

CIRCLE your answer (may be more than one): narrow wide waxy not waxy

WRITE: Explain your prediction:

RECORD RESULTS: Make an "X" in the correct category for each leaf type, based on your investigation

	No Water	Some Water	Lots of Water
Narrow			
Wide			
Waxy			
Not Waxy			

Conclusion: Which types of leaves lost the most water through transpiration?

CIRCLE your answer (may be more than one) : narrow wide waxy not waxy

WRITE: Which types of leaves are best adapted for plants living in the desert?