Desert Plant Adaptations
Transpiration

Objectives:
Students will be able to:

- identify three types of desert plant adaptations.
- explain transpiration in plants.
- understand how leaf shape and waxy leaf coating can affect transpiration.
- relate water use by plants to desert urban landscaping choices.

Author
Ecology Explorers Education Team - Adapted from Desert Water Keepers, Lawrence Hall of Science, UC Berkeley, CA

Time
50-60 minutes

Grade Level
3-5

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 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.

In deserts, precipitation is low and the temperature is often hot, so evaporation is also high. Water can be scarce in the desert. How do desert organisms maintain a healthy water balance in their cells?

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. Adaptations are features of organisms that help them survive and reproduce. They are the traits that result from many generations of Natural Selection.

Desert plants have several types of adaptations that help them conserve water.

1. A leathery or waxy coating on the leaves and stems reduces evaporation.
2. Thick stems or other plant parts provide water storage space.
3. Small leaves or spines (modified leaves) reduce the surface area of the plant exposed to the sun. (Some plants such as the ocotillo and palo verde shed their leaves during dry spells, further reducing their surface area.)
4. Spines and fine hairs reflect heat and reduce the air flow over the plant's surface.

Many plants have a combination of these adaptations. For example, the hedgehog cactus has enlarged stems, a thick waxy coating and a dense cover of spines.

Vocabulary:
adaptation: - 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

stomata - openings on the surface of leaves that are controlled by guard cells and allow gas exchange with the atmosphere

transpiration - the process by which plants release water from their leaves into the atmosphere

conserve - to use less or use well

Advanced Preparation:
Preparing paper leaves is a preliminary craft activity that may take 30-50 minutes for students. For younger students or to save time, the teacher may prepare and color the paper leaves in advance.

From the template, make three leaf shapes (narrow, medium and wide) out of cardboard. Trace the cardboard leaves onto blotter paper (available at art stores) and cut

them out. Each group will receive six leaves, one pair of each shape. Color one of each pair with crayon on both sides and the edges. Staple a coffee stirrer to each leaf stem lengthwise to reinforce it.

Make the leaf holders by taping the end of a drinking straw closed. Crumple paper and put it in the bottom of a plastic cup.

Identify a sunny place outdoors where the leaves will sit for at least 20 minutes during the investigation. (It may be easier for students to assemble and fill their leaf holders at this site.)

Just before the lesson, soak both types of leaves in the basin of water.

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

Materials:

for each group of 4-6:

- 2 plastic coffee stirrers (double-straw type)
- 6 blotter-paper leaves (2 of each shape and 1 of each shape colored with crayon)
- 2 leaf holders (drinking straw, tape, plastic cup)
- 1 clear plastic cup

for the class:

- 1 small bucket or basin of water (extra cup/table)
- squirt bottle containing 1 cup colored water (200 mL) with red, green, or blue food coloring
- stapler
- several crayons
- masking tape or transparent tape
- extra plastic bags

Recommended Procedure:

Engagement

1) Review water scarcity in deserts. Ask: What is unique about deserts? What challenges do plants face to survive and reproduce in a desert?

2) Pass out Student Worksheet 1 - Transpiration and introduce the background questions:

   -How do plants use water?

   -Where does the water go?

3) Using arrows, ask students to draw the pathway of water into, through and out of a plant using the diagram on their worksheet. Label the water as liquid or vapor in the soil, in the plant, and in the air.

4) To help students relate to this process ask: 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 evapotran spire. These words rhyme. Compare pores with stomata.

5) Introduce the term transpiration.

6) Have students write the word on their worksheet.

7) 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.

8) 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

9) Show students the paper leaf shapes. Ask: how would you describe these shapes?

10) Remind students, in a science investigation we need to start with a research question.

11) How do leaf shape and surface type affect water loss from leaves?

12) Ask students to discuss the answer to this question in their groups and circle their predictions on Student Worksheet 2 - Paper Leave Investigation.

13) Hand out materials to each group including both sets (colored and uncolored) of three leaves. (For younger students these can be done as two separate investigations)

14) Demonstrate how to fill the leaf holders (taped drinking straws). Place the taped end into a cup so that the straw stands upright. With the squirt bottle, fill the straws to within a centimeter from the top.

15) Instruct each group to:

- set up their leaf holders in crumpled paper in a plastic cup.
- retrieve their leaves from the soaking basin .

▪stand next to their leaf holders.

▪put their leaves into their holders at your signal!

▪check to make sure their holders are full of dyed water.

16) Record the time (when the leaves went in) on the data sheet, and leave the leaf models in the sun for at least twenty minutes.

17) Return to the classroom to discuss background content and predictions. (Students may also use this time to practice measuring with rulers.)

Explanation

18) Review the concept of adaptation - characteristics/ traits that help an organism to survive and reproduce. Adaptations are inherited from parents and passed on to offspring.

19) Ask students to distinguish between adaptations and behavioral adjustments.

(e.g. A jack rabbit can leap away quickly from a predator = adaptation. You put on a jacket when you're cold = behavior adjustment. It is a useful action, but it is not a heritable trait. It was learned in one lifetime).

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

▪ small leaves, less area

▪leathery or waxy coating

▪stems store water

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

Which of the paper leaf shapes would be a good desert adaptation?

What leaf shapes should we look for in our yards to know which ones are the water savers or the water wasters?

21) Call attention to the crayon-colored leaves. Help the students to make the analogy to waxy leaves in nature.

22) Explain that scientists must understand why they predict what they 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.

23 Return to the outdoor site to collect data. Have the teams mark the new water level in each holder with a marking pen and measure the change in the level with the metric ruler. Record the measurements on the data sheet. (Young students may need help understanding that each leaf falls into two different categories in the table).

24) Ask students: What do you think happened to the water in the holders? How is this similar to or different from evapotranspiration?

How does the amount of water lost by the crayon-coated leaves compare with the amount of water lost by the uncoated leaves? How can you explain the difference?

Note that students measure the length of straw from which water evaporated. Teachers may wish to discuss a better measurement unit/technique.

25) 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?

Expansion

26) Complete the data analysis and synthesis questions on the worksheet. Clean up.

Evaluation:

Students will participate in discussion and investigation.

Students will record data and respond to questions on two worksheets.

Extensions:

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 among groups. Is it possible that some narrow leaves lost more water than some wide leaves? 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-GR4-5-PO2
S1-C2-GR4-8-PO1
S1-C2-GR3-4-5-PO4
S1-C2-GR3-8-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
S3-C1-GR4-PO1
S4-C1-GR3-4-PO1
S4-C1-GR6-PO1, PO6
S4-C3-GR3-PO4
S4-C3-GR3-4PO4
S4-C3-GR7-PO2, PO5
S4-C4-GR3-4-PO1
S4-C4-GR4-PO2
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

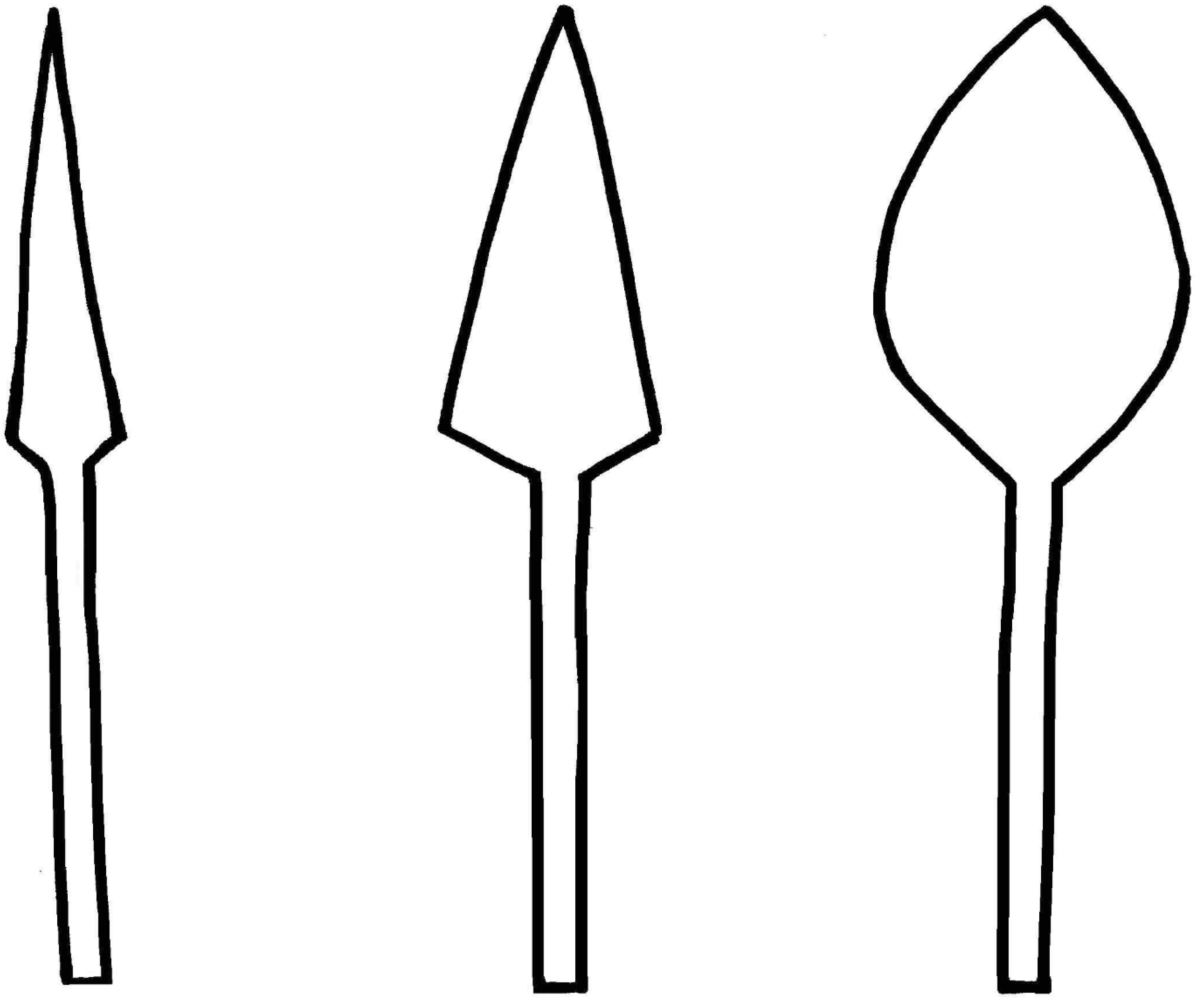
Common Core/ELA Literacy

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
Leaf Shapes (to cut out)

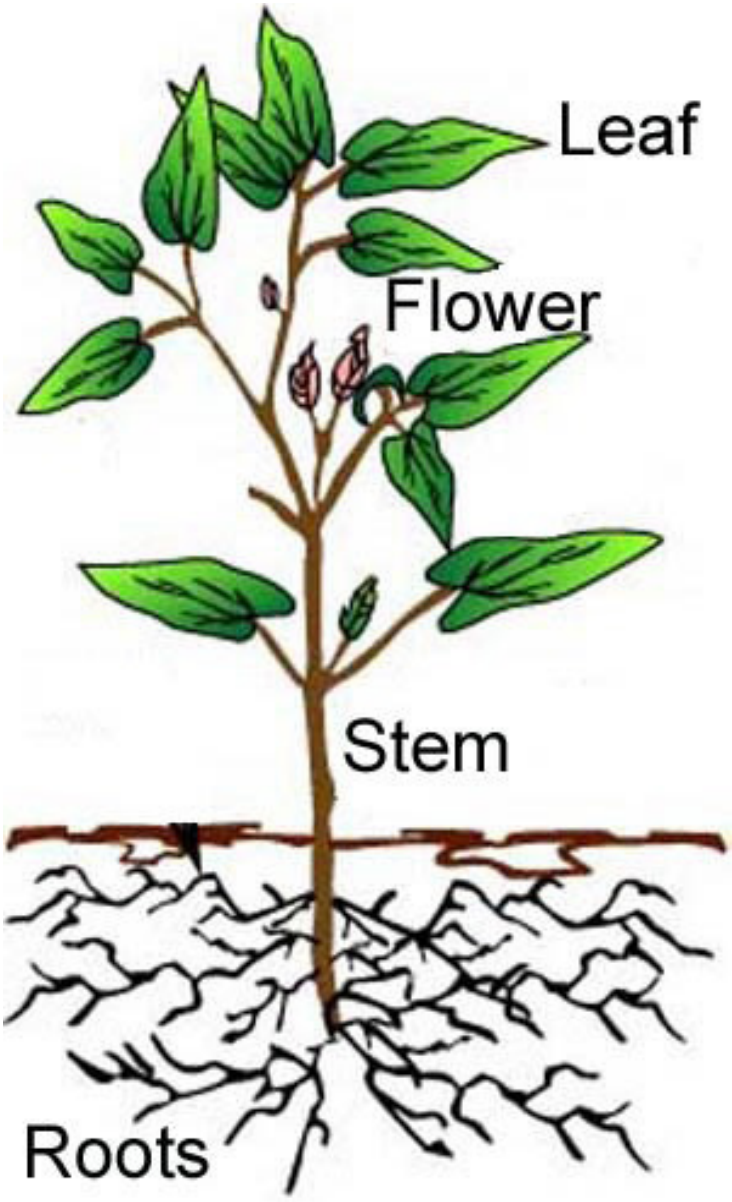


Student Worksheet (#1)
Diagram

THINK - How do plants use water?

-Where does the water go?

DRAW the pathway of water moving into, through and out of the plant using arrows.



LABEL the water as liquid or vapor in the soil, in the plant, and in the air.

WRITE the word that describes the process above.

Student Worksheet (2)
Investigation

THINK: Do leaf shape and surface type affect water movement from leaves?

PREDICT: Which leaf shape does your group think will lose the most water?

CIRCLE: narrow medium wide

PREDICT: Which leaf surface does your group think will lose the most water?

CIRCLE: waxy not waxy

WRITE: Explain your predictions above.

Leaf shape:

Leaf surface:

RECORD: start time _____ end time _____

Time in Sun start time – end time = _____min.

Water Level Changes

	Narrow	Medium	Wide
Waxy (crayon)	cm	cm	cm
Not Waxy (no crayon)	cm	cm	cm

CIRCLE: Were your predictions correct? YES NO PARTLY

WRITE your conclusions on the back of this page answering the following questions:

1) What happened to the water in the straws? How is this similar to or different from transpiration?

2) Which leaf shape is better for plants living in a desert? Why?

3) How does a waxy coating affect desert leaves?