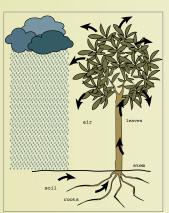
**Transpiration** 



Transpiration

#### **ACTIVITY OVERVIEW**

In this investigation, students venture outside for a teacher-led, plant investigations walk in their own schoolyard. This activity is offered as an alternative field investigation for classes unable to visit the Desert Botanical Garden. The purpose of this activity is to get students outside and involved in real, hands-on field investigations about transpiration in plants. It is suggested that classes first conduct the *Transpiration* Inquiry in the Garden-Stage 1 in preparation for this investigation. Although that introductory activity is primarily for classes visiting the Desert Botanical Garden, it provides foundational concepts and activities which are further explored in this investigation.

#### **TEACHER PREPARATION**

The purpose of the plant investigations walk is for students to observe plants in nature and to follow the scientific method as they investigate aspects of transpiration. It is suggested that teachers first scout the school grounds before taking the students outside. Decide on a route that would be good for a plant investigations walk. The route should include a variety of plants including trees, shrubs, and cacti (if possible). It is recommended that at least three specific places or "stops" be identified along the route that would serve as focal points to investigate plant roots, stems, and leaves. Students will be better prepared for this investigation if the class first reviews and discusses *Transpiration* Inquiry in the Garden-Stage 1 and conducts the preparatory activities associated with that lesson.

#### **MATERIALS**

- Three pieces of rope or string approximately 16 feet in length
- Optional depending on selected activities: soda straws, celery stalks, knife, water, red food dye, beaker or clear glass jar, dry and flattened sponge, several 1" wide x 11" long strips of paper, string, magnifying lenses, 15 ml centrifuge or test tubes, stopper or plastic wrap to cover tubes
- Picture of leaf stomata (provided as a download)
- Student Investigation Journal
- Student Study Guide-Results and Conclusion



**Transpiration** 

#### GENERAL PROCEDURES

Guide students on an outdoor plant investigation walk following your pre-planned route. At each stop, conduct an inquiry using the *Discussion Questions* to convey the *Teaching Points* presented for that stop. Following each discussion, conduct one or more of the *Suggested Activities*, having students record in their *Student Investigation Journals*. Wrap up your walk by discussing students' discoveries and reviewing the *General Teaching Points*. Complete student investigations by using the *Student Study Guide-Results and Conclusion*, which replaces Inquiry in the Garden-Stage 3.

#### PLANT INVESTIGATIONS WALK - GENERAL TEACHING POINTS

- Transpiration is the evaporative loss of water through the leaves, but the process involves the entire plant.
- Water moves from the soil into plant roots, up through the stems, and up and out through the leaves into the air.
- Osmosis is the movement of water from area of high concentration to low concentration through a cellular membrane.
- Stems transport water from the roots to the leaves.
- Leaves lose water to the air through their stomata.
- In warm, dry, desert climates, some plants develop special adaptations to conserve water during the transpiration process.
- Some plants (succulents) have special features for storing water.
- Some leaves (especially those in dry climates) have adaptations to reduce transpiration and thus conserve water.

#### **ROOT STOP**



Creosote

#### DESCRIPTION

The roots stop should offer the opportunity to see a variety of plants (including trees, shrubs, and small forbs). A large tree would be a good focal point for the discussion at this stop. Additionally, a flat, grassy area nearby would be an ideal location for playing the osmosis demonstration game.

#### **TEACHING POINTS**

- Transpiration is the evaporative loss of water through the leaves, but the process involves water moving into plant roots from the soil, up through the stems, and up and out through the leaves into the air.



#### **Transpiration**



Palo Verde

#### continued

- Water moves into the roots from moist soil.
- Water moves from areas of higher concentrations to areas of lower concentration.
- The movement of water from area of high concentration to low concentration through a cellular membrane is called osmosis.
- Without the continuous process of water moving through the roots, up the stems, and out the leaves, some plants would wilt.

#### **DISCUSSION QUESTIONS AND ACTIVITY SUGGESTIONS**

At the roots stop, conduct an inquiry using the teaching points as your guide. Questions to help students arrive at the key points for this stop could include the following:

- Why do plants have roots?
- What is transpiration?
- If transpiration is water evaporating from the leaves, what role do roots play in transpiration?
- How do roots obtain water?
- How far out from the plant do roots go? How deep do roots go?
- In what cases would plants want to grow deep roots? Shallow roots?
- Why doesn't water flow out of the roots?
- What happens when there is little or no moisture in the soil?

After students have had a chance to discuss roots, choose and conduct one or more of the following suggested activities. Students should record findings in their Student Investigation Journals.

#### Have students...

Sip water through straws playing with the height the water moves up the straw based on the amount of suction they exert on the straw. Have them compare this to the transpiration process.

Observe different types of plants and consider their root structures. Estimate how far out the roots might go if they went as far out as the plant's height.

Feel the soil under different plants for moisture. If they dig down a little, is it more or less moist? Compare and contrast conditions in which plant roots might be more successful if they were deep versus shallow and vice versa.



#### **Transpiration**

#### continued

Play a game that demonstrates osmosis. Using string or rope, create three circles of about five feet in diameter. Place rope circles on the ground a few feet apart. Have a couple of students stand in the first circle. Keep adding more students until no more can safely fit. When the circle is full, have students move to the next circle one at a time. As students leave the first circle, new students may move in to take their place. As the second circle fills, students may start moving to the third circle, creating more space for students to move into the second circle from the first circle, and so on. Have students discuss how this demonstrates osmosis.

#### STEM STOP



Agave

#### DESCRIPTION

If there are cacti in your schoolyard, the stems stop would be best located by a cactus (most preferably, a saguaro). If there are no succulents available, a site that offers a view of both larger trees and smaller herbaceous plants will be sufficient for the discussion and activities regarding the stem's role in transpiration.

#### **TEACHING POINTS**

- Transpiration is the evaporative loss of water through the leaves, but the process involves water moving into plant roots from the soil, up through the stems, and up and out through the leaves into the air.
- Stems transport water from the roots to the leaves.
- Stems provide structure and support for plants.
- Some plants (succulents) have special features for storing water.
- Saguaro cacti expand their bodies as they absorb and store water in their stems.
- Without the continuous process of water moving through the roots, up the stems, and out the leaves, some plants would wilt.

#### DISCUSSION QUESTIONS AND ACTIVITY SUGGESTIONS

At the stems stop, conduct an inquiry using the teaching points as your guide. Questions to help students arrive at the key points for this stop could include the following:

- What is the purpose of a plant's stem?
- What role do stems play in the transpiration process?



#### **Transpiration**



Saguaro

#### continued

- In general, how do stem sizes change as they move up the plant?
- What is the benefit of succulence in plants?
- In what environmental conditions do we often see succulent plants?
- What happens when there is little or no moisture in the soil?

After students have had a chance to discuss stems, choose and conduct one or more of the following suggested activities. Students should record findings in their Student Investigation Journals.

Have students...

Explore the area for different types of stems. What kinds of differences and similarities do students notice?

Locate stem succulents in the schoolyard. How are succulents different from other plants? What is the benefit of being succulent?

Place a freshly cut stalk of celery (including the upper stem and leaves) in a beaker of water darkened to a deep red color with food dye. (The celery should be cut under running water and quickly placed in the beaker to a depth of about two inches.) Have students record how long it takes the dye to travel up the celery stalk. Have them calculate the rate of flow. Discuss the experiment.

Pour water on a dry sponge and observe what happens. (This works best with a very thin, tightly pressed sponge.) Explain that some cacti expand like a sponge when they soak up water from their roots into their stems. This is an adaptation for living in a desert. Ask students if they see any plants around them with similar adaptations.

Fold a strip of paper into an accordion with half-inch pleats. (In advance, prepare one-inch wide strips of paper that are 11 inches long.) Place the two ends of the strip together to create an accordion circle. Have students play with their accordions by shrinking and expanding the size of the circle. Explain to the students that the pleats represent the ribs in a saguaro cactus. When the pleats are close together, they represent a thirsty saguaro. When the pleats are stretched out, they represent a saguaro whose ribs have expanded after a big rainfall.

Use a piece of string to measure the circumference of a saguaro cactus (if one is available) during a dry season and again during a rainy season. Make predictions in advance about how the measurements will compare. Be sure to record the data in a safe place because many months might pass between the two measurements. (Remind students to be careful of cactus spines!)



#### **Transpiration**

#### **LEAVES STOP**



Mesquite

#### DESCRIPTION

The leaves stop should be located in an area offering a variety of plants with different types of leaves. It would be ideal if there were some nearby plants having small or otherwise modified leaves. Trees such as mesquite, palo verde, pine, or juniper would all provide good examples for the discussion points at this stop.

#### **TEACHING POINTS**

- Leaves lose water to the air through their stomata.
- As water is lost through the leaves to the air, more water is drawn up by a combination of forces including osmosis from the tissues to replace it.
- Some leaves (especially those in dry climates) have adaptations to reduce transpiration and thus conserve water.
- Some leaves have special characteristics that help them conserve water in the transpiration process including small size, waxy coatings, and hairy textures.
- Without the continuous process of water moving through the roots, up the stems, and out the leaves, some plants would wilt.

#### DISCUSSION AND ACTIVITY SUGGESTIONS

At the leaves stop, conduct an inquiry using the teaching points as your guide. Questions to help students arrive at the key points for this stop could include the following:

- What role do leaves play in the transpiration process?
- How does water exit leaves?
- Why don't leaves wilt as they transpire?
- How might leaves slow the process of transpiration?
- In what conditions would it be beneficial for leaves to slow the process of transpiration?
- Which leaves likely transpire the most, large or small?

After students have had a chance to discuss leaves, choose and conduct one or more of the following suggested activities. Students should record findings in the Student Investigation Journal.

Have students...



#### **Transpiration**



Leaf Stomata

#### continued

Observe the picture of leaf stomata (using the provided image) and discuss how stomata open and close (like little mouths) as water escapes.

Use a magnifying lens to observe the surfaces of different leaves. Look for hairy leaves, waxy leaves, small leaves, and others. Discuss how different leaf shapes, sizes, and textures affect transpiration.

Conduct an investigation in which they compare the transpiration rate of large leaves versus small leaves. (Note: This continues the investigation started in the Inquiry in the Garden-Stage 1, in which students completed the *Transpiration Adaptations Table*. Students should have stated a hypothesis about how leaf size affects transpiration.) Help students set up the investigation by obtaining two 15 ml centrifuge or test tubes. Fill with equal amounts of water. Drill or poke small holes in the caps (to fit a small plant stem) or create a lid with plastic wrap. Place one cutting of a plant with very large leaves in one centrifuge tube. Place another cutting of a plant with tiny leaves in the other centrifuge tube. Set tubes upright in the sun. Observe throughout the day noting their water use and freshness.

Follow their leaf transpiration investigation through to the results and conclusions stage by completing the Student Study Guide – *Results and Conclusions*.

#### **POST YOUR FINDINGS ON THE INTERNET!**

As part of the Inquiry Process students may share their work with others by visiting the DBG Journal of Student Findings at www.dbg.digitallearning. Here, students can submit investigation findings, poems, or original art inspired by their Inquiry in the Garden. For more ideas on art projects that tie into Garden themes, go to the Additional Resources section of the Digital Learning website.



# STUDENT INVESTIGATION JOURNAL

Student Name

		ence you find during the inve s recorded information later	estigation and results of any experiments.
Roots		ou learn about how roots	
	2. Is there a w	ay to estimate the width o	f a plant's root structure? What is it?
	3. What is osm	nosis?	
STEMS	4. What are so	ome similarities and differ	ences in the stems you see?
	<b>5.</b> How is a sp	onge similar to a cactus st	em?
	6. Cactus stem	n diameter	
	Dry Season	Diameter:	meters
	Wet Season	Diameter:	meters
	7. In what env	rironmental conditions do	we often see succulent plants living?



# STUDENT INVESTIGATION JOURNAL

Student Name

LEAVES	Question: V	Why are some	e desert leav	ves small?				
	Hypothesis	: Small leaves	s reduce the	e amount of v	water lost	during t	ranspirat	ion.
	8. Prediction	on:						
	If							
	then							
		ent: Describe t other informat				materials a	used, time	, locatio
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	and any	results: Start time:	ion needed to		End			



# STUDENT STUDY GUIDE - RESULTS AND CONCLUSION

Student Name\_\_\_\_\_\_Teacher\_\_\_\_\_

Instructions: Answer the questions below. Use the information from your Student Worksheet – Transpiration Adaptations Table and from your Student Investigation [Journal to complete the leaf size investigation, When fit with this Shudy Guide, prepare a display of your investigation. Be creative! You could make a poster, draw pictures, generate graphs, and/or include photos from your trip or from the internet. Then, think of a fun way to share your of You could do a team presentation, poster displays, "science fair" displays, mock interviews, 3-D models, etc. Followin, teacher's instructions, you may also post your work online on the DBG Journal of Student Findings  Name of your investigation:  1. Question. What question was generated by your original observations of desert plant leaves?  2. Hypothesis. What was your hypothesis?  3. Prediction. What prediction did you make about desert leaves' adaptations for transpiration. How much water was used by each leaf?  5. Results. In the space below, copy the results you recorded in your Student Investigation Journey How much water was used by each leaf?  6. Conclusions: In your own words, what do you conclude about your hypothesis based on you results? Is your hypothesis supported by your results?	Adaptations Table and from your Student Investigation Journal to complete the leaf size investigation. We with this Study Guide, prepare a display of your investigation. Be creative! You could make a poster, draw pic generate graphs, and/or include photos from your trip or from the internet. Then, think of a fun way to share You could do a team presentation, poster displays, "science fair" displays, mock interviews, 3-D models, etc. For	Vhen finis tures, your disp
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# STUDENT STUDY GUIDE - RESULTS AND CONCLUSION

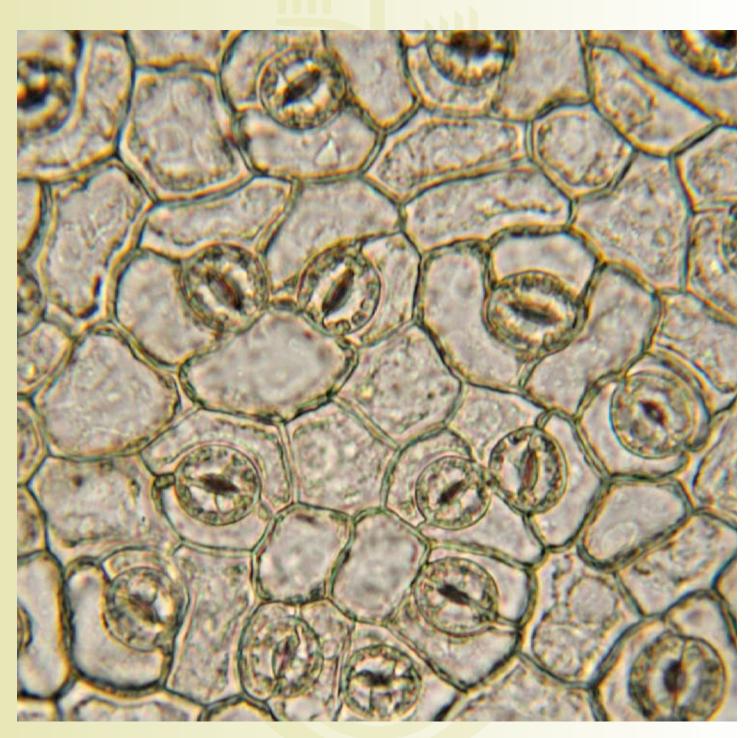
Student Name\_\_\_\_\_\_Teacher\_\_\_\_\_

	QUESTIONS FOR DISCUSSION
	1. What is the main challenge desert plants must deal with during the process of transpiration?
	2. Would you consider your investigation a valid (or reasonable) way to test your hypothesis? Are satisfied with your results? Why or why not?
H	
	3. How might you revise your experiment to yield better results? Which variables would you char
	Describe.
H	
	4. Based on your findings, what are some other questions that arise that might lead to new investigation



**Transpiration** 

### Stomata





#### **Transpiration**

#### RELATED ADE STANDARDS:

#### WRITING STRAND 3: WRITING APPLICATIONS

CONCEPT	Performance Objective	
C2: Expository	PO 1: Record information (e.g., observations, notes, lists, charts, map labels and legends)	
	related to the topic.	

#### SCIENCE STRAND 1: INQUIRY PROCESS

CONCEPT	Performance Objective
C2: Scientific Testing (Investigating and Modeling)	PO 1: Demonstrate safe behavior and appropriate procedures (e.g., use and care of technology, materials, organisms) in all science inquiry.
	PO 2: Design an investigation to test individual variables using scientific processes.
	PO 3: Conduct a controlled investigation using scientific processes.
	PO 4: Perform measurements using appropriate scientific tools (e.g., balances, microscopes, probes, micrometers).
	PO 5: Keep a record of observations, notes, sketches, questions, and ideas using tools such as written and/or computer logs.
C3: Analysis and Conclusions	PO1: Analyze data obtained in a scientific investigation to identify trends.
	PO6: Formulate new questions based on the results of a completed investigation.
C4: Communication	PO 2: Display data collected from a controlled investigation.
	PO 5: Communicate the results and conclusion of the investigation.

#### SCIENCE STRAND 4: LIFE SCIENCE

CONCEPT	Performance Objective
C1: Structure and Function in Living Systems	PO 1: Explain the importance of water to organisms.  PO 6: Relate the following structures of living organisms to their functions:     Plants:         transpiration – roots     absorption – roots  PO 7: Describe how the various systems of living organisms work together to perform a vital function
C3: Populations of Organisms in an Ecosystem	PO 2: Describe how the following environmental conditions affect the quality of life:  • climate

#### SCIENCE STRAND 6: EARTH AND SPACE SCIENCE

CONCEPT	PERFORMANCE OBJECTIVE
C2: Earth's Processes and Systems	PO 1: Explain how water is cycled in nature.



#### **Transpiration**

#### **EDUCATIONAL TECHNOLOGY STRAND 2: COMMUNICATION AND COLLABORATION**

CONCEPT	Performance Objective
C1: Effective Communications and Digital Interactions	PO 1: Communicate digitally with others by selecting and using a variety of appropriate communication tools.

### WORKPLACE SKILLS STANDARD 1: STUDENTS USE PRINCIPLES OF EFFECTIVE ORAL, WRITTEN AND LISTENING COMMUNICATION SKILLS TO MAKE DECISIONS AND SOLVE WORKPLACE PROBLEMS.

STANDARD	PERFORMANCE OBJECTIVE
1WP-E4: Respond to oral and written presentations by formulating relevant feedback, expressing opinions, discerning the main idea and distinguishing fact from opinion.	PO 3: Formulate related questions in a presentation PO 4: Express opinions relating to the main idea in a presentation