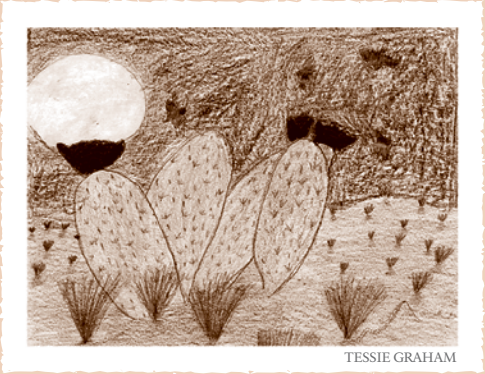


TESSIE GRAHAM

FIELD TRIP

Plant Adaptations

Theme
Plants that live in the high desert climate have various adaptations that help them survive and thrive.

Utah Science Core Curriculum Topic
Standard Five: Students will understand that traits are passed from the parent organisms to their offspring, and that sometimes the offspring may possess variations of these traits that may help or hinder survival in a given environment.

Objective One: Using supporting evidence, show that traits are transferred from a parent organism to its offspring.

Objective Two: Describe how some characteristics could give a species a survival advantage in a particular environment.

Field Trip Location
This field trip was designed for Upper Courthouse Wash, 1/4 mile above the bridge in Arches National Park. Other suitable locations would have both riparian and desert zones, with a diversity of plants. Because many materials are specific to particular plants, some may need to be altered to fit a different location's plants. For the most overlap in plants, choose a site with an elevation as near 4100 feet as possible.

Times
All lessons are 30 minutes

Science Language Students Should Use
Inherited, environment, species, offspring, traits, variations, survival, instincts, population, specialized structure, organism, life cycle, parent organism, learned behavior

Background

Desert plants are adapted to their arid environment in many different ways. *Stomata* are the holes in plant leaves through which they transpire water. Many desert plants have very small stomata and fewer stomata than those of other plants. The stomata of many cacti lie deep in the plants' tissues. This adaptation helps cacti reduce water loss by keeping the hot, dry wind from blowing directly across the stomata.

The leaves and stems of many desert plants have a thick, waxy covering. This waxy substance does not cover the stomata, but it covers most of the leaves, keeping the plants cooler and reducing evaporative loss.

Small leaves on desert plants also help reduce moisture loss during transpiration. Small leaves mean less evaporative surface per leaf. In addition, a small leaf in the sun doesn't reach as high a temperature as a large leaf in the sun.

Some plants, such as Mormon tea and cacti, carry out most or all of their photosynthesis in their green stems. (Cactus pads are stems, botanically speaking.) Some desert plants grow leaves during the rainy season and then shed them when it becomes dry again. These plants, including blackbrush, photosynthesize in their leaves during wet periods. When drought sets in and the plants lose their leaves, some of these plants can photosynthesize in their stems.

Others cut down on water loss even further by temporarily shutting down photosynthesis.

Other desert adaptations shared by a number of plants include shallow widespread roots to absorb a maximum of rainfall moisture and spines or hairs to shade plants and break up drying winds across the leaf surface.

Other specific desert plant adaptations follow:

Cacti - Cactus pads are modified stems with a waxy coating. Their root system is very shallow, drinking up ephemeral rainwater. Small *rain roots* can grow as soon as soil is moistened by rain. They later dry up. Prickly spines are modified leaves that break up the evaporative winds blowing across pad surfaces and can help shade the stem. Cacti utilize CAM photosynthesis, in which stomata open only at night when the plant is relatively cool, so less moisture is lost through transpiration. Gases, including carbon dioxide going in and oxygen going out, pass through the stomata as well. This gas exchange is part of the process of photosynthesis. But, photosynthesis also requires sunlight. The CAM process includes a way of chemically storing the carbon dioxide until the sun comes out, when it can be used to complete the photosynthetic process. (A stoma is like a window; it has to be open to let air and water in or out, but sunlight can come in even if it's closed.)

Desert Annuals - These avoid drought and heat by surviving as long-lived seeds stored in the soil, sometimes for decades. The seeds have adaptations assuring that they germinate and grow during wet periods.

Evening Primrose - Thickened taproots store water and food.

Globemallow - These are covered with dense, star-shaped grayish hairs that reflect sunlight and break up the wind.

Juniper - Leaves are reduced to tiny, waxy scales that cover the twigs and small branches. Fruits are also covered with a waxy coating. Junipers have the ability to cut off water to a major branch during a drought, resulting in a dead branch but a live tree.

Sego Lily - It can lie dormant as a bulb during the driest years.

Paintbrushes - They are partial parasites. Their roots tap into nearby plant roots, usually sagebrush or grasses, to suck food and moisture from their host.

Piñon Pines - They depend on enormous root systems. Piñon taproots stretch down 40 feet or more in deep soils; in shallow soils, lateral roots stretch outward the same distance.

Sagebrush - Hairy leaves insulate this plant against heat, cold, and dry winds. Retaining its leaves year-round allows the plant to produce food most of the year. Sagebrush has adaptations to cold winters; it can photosynthesize when temperatures are near freezing, and its leaves point in all directions, allowing them to catch sunlight from many different angles.

Some desert plants take advantage of the nights' cooler temperatures to become "active." Some evening-blooming plants in the desert include evening primrose, sacred datura, sand verbena and yucca. Cacti also take advantage of cooler nights. Cacti stomata are open mostly during the nighttime. Therefore, the plant can transpire, or lose water, during a time when it is likely to lose the least amount of it. The rest of the cacti photosynthesis process takes place during the daylight hours.

Desert animals also take advantage of nighttime's cool refuge. Without light for visual cues, desert animals rely on their other senses to help them navigate. Nectar-eating bats use echolocation to identify evening blooming plants. Echolocation works similar to radar; the bat sends out a call, and then receives the waves that are reflected back. The reflection indicates the direction and distance of the reflecting object.

The yucca and the yucca moth have a fascinating nighttime association. After mating, the female moth gathers pollen from one yucca flower, packs it into a ball, and then flies into the night locating other yucca flowers primarily by "smelling" with her antenna. She visits several flowers, each time laying some eggs in the base of the pistil and packing some of the pollen from her pollen ball down the pistil for her young to feed on. Thus, she fertilizes the yucca flowers. Yucca flowers are only pollinated by yucca moths, and yucca moth young only feed on yucca pollen.

PRET-TRIP ACTIVITY

What's My Adaptation?

Objectives

Students will be able to:

a. Describe or give an example of an adaptation.

b. Name two environmental characteristics to which an organism may adapt.

Materials

30 pictures of plants or animals, each with adaptation descriptions on the back

Note

Please keep remarks on heredity in the context of plant adaptations. Some teachers do not appreciate human evolution being taught in their classrooms.

PROCEDURE

1) Have students hold their thumbs against their palms and then untie and tie their shoes. If they don't have laces, have them write their name on a sheet of paper. After a few minutes, re-focus them, and ask if these tasks were difficult. Explain that thumbs are an adaptation that help us do many things and that all animals have body parts and other physical adaptations that help them to survive. Tell the students that on our field trip, we will look at the physical adaptations that plants have for survival.

2) Ask if students remember the definition of "ADAPTS" from their fourth grade fall field trip. Write *Animals Depend on Activities and Parts To Survive* on the board. Have students mention both some activities and some parts that are adaptations for survival. Explain that plant adaptations are physical ones (parts). Draw a plant on the board, and show examples of physical adaptations (i.e. extra long roots to reach deep water, hairy, gray leaves to shade leaf surfaces and break up the wind in sunny, windy areas, and light, fluffy cottonwood seeds to disperse in the wind). Explain that plants have many physical adaptations, but they do not have behavioral adaptations (activities) like animals. Stress that humans or other animals can sometimes adapt behaviorally to new situations, but physical adaptations evolve slowly, over many generations. Discuss the conditions a plant or animal around Moab would have to adapt to, including lack of water, hot summertime temperatures, cold winter nights, and wind.

3) Have students close their eyes to begin the "What's My Adaptation?" game (adapted from Cornell, 1979, 69). Hang a picture around each student's neck, with the picture on his/her back. Instruct students to open their eyes, but not to look at their own tags. Show them a sample, and tell them that each picture is either a plant or an animal from our area. Instruct them to walk around the room and ask each other yes/no questions that will help them figure out what organism is on their back. A student may ask another student up to three questions before moving on to someone else. Review examples of good questions before the students get up from their seats. As students figure out their creatures, they should sit down, turn their nametag over, and read the creature's adaptations written on the back of the tag. When all students are seated, ask for volunteers to share their identities and read their adaptations.

4) Review the items that students need to bring to school on the day of their field trip.

STATION #1

Desert Plant Mystery Trail

Objectives

Students will be able to:

a. Name three desert plant adaptations.

b. List two factors that make life in the desert challenging for plants.

Materials

Clue cards, describing the location of the Mystery Trail plants and their adaptation cards/objects; *Adaptation Cards*; objects symbolizing adaptations; two pictures of each plant on the Mystery Trail, on index cards.

Note

Adaptation Objects and *Adaptation Cards* must be hidden in advance.

PROCEDURE

1) Have students list what plants need to survive, and be sure that they include water, soil, and sunlight. Discuss characteristics of the desert that make it difficult for plants to grow. For example, it is dry, windy, hot in the summer, cold on winter nights, and there are animals that might eat the plants. Ask the students if a seed from a plant that usually lived near the river could grow in this environment. Have them discuss why. Tell the students that occasionally a plant develops a different adaptation. If the adaptation helps the plant, it is passed down to its seedlings. If the adaptation does not help, the plant will not survive to reproduce. Each of the plants here in the desert, at one point or another, developed adaptations that made them more likely to survive than the plants without these adaptations.

2) Tell students that they will be following clues to discover specific adaptations of plants living in this environment. Ask the group to listen carefully as the clues are read. Have student #1 read the first clue card. The clue will lead students to a specific plant. Here, there will be both a hidden object that gives a clue about an adaptation of that plant and a *Desert Plant Mystery Trail Adaptation Card* explaining the connection. Ask that only student #1 pick up the object and adaptation card. Have the students guess what the adaptation is from looking at the object. Then, have student #1 read the card. Briefly discuss the adaptation. Then, hand student #2 the next clue card to read. Proceed until all the clues have been read, pursued, and discussed.

3) Ask students if they can make up an adaptation that would make it harder for the plants they have seen to survive in the desert (e.g. big showy flowers, thin porous skin, short roots). Ask them if they think plants with these adaptations would get a chance to produce seeds or if their adaptations would be passed down to the next generation of plants.

4) If there's time, introduce and play the desert plant adaptation relay as a review. Divide students into two groups, and designate a starting line for them to form two lines behind. Place plant cards together about 50 feet away. Read one clue at a time:

- There is an animal nearby that eats plants, but it won't munch on you.
- It's 110°, but your leaves are adapted to keep much of your water.
- The dry wind won't evaporate your water.
- It hasn't rained in weeks, but you have stored water to use.
- The sun is bright, but your leaves reflect much of the sunlight, keeping you cooler.
- Though the soil is dry, your roots can reach moisture deep in the ground.

Give the two teams ten seconds or so to discuss the answer. Then, give them a go signal. The first student on each team should run, pick up an appropriate card, and run back. The first student back scores a point for her team *if* she picked the correct card. If not, the other team gets a point, *if* their runner picked the correct card. There may be more than one right answer to some clues.

ADAPTATION OBJECTS

Juniper: Bag of crayons

Single Leaf Ash: One narrow-mouthed water bottle and one broad-mouthed water bottle

Rabbitbrush: White cloth

Prickly Pear Cactus: Sponge

Sagebrush: Fuzzy cloth

Prickly Pear Cactus: Stocking cap with pipe cleaners sticking through it to look spiny

Yucca: Garden hose (or picture of one)

ADAPTATION CARDS

Cut Adaptation Cards apart along dashed lines.

The leaves of **Juniper** are like crayons because they have waxy coatings. The waxy coatings keeps moisture in the leaves. Why would this plant need to conserve moisture?

Prickly Pear Cactus is like a sponge because its pads absorb water when it rains. The cactus stores and uses the water until the next rainstorm. The pads may look fat if it's been rainy lately. They may look shriveled if it hasn't rained in a long time. Does this cactus have fat or shriveled pads?

Light colors absorb less heat than dark colors. **Rabbitbrush** has light-colored leaves that absorb less heat. What would a plant gain from staying cool?

Openings in leaves called stomata allow water and air to escape from the plant. In some plants, the openings are large, like the large-mouthed water bottle. In **Single Leaf Ash**, the openings are small, like the water bottle with a smaller mouth. How does this adaptation help **Single Leaf Ash** to survive in the desert?

The **Sagebrush** has fuzzy leaves like this cloth. Plants and animals dry out when water evaporates from skin or transpires from leaves. Wind on our skin or on leaves speeds up the drying. But if we wear a shirt or leaves have hairs on them, the wind is broken up. Less water is lost. Look closely at the leaf hairs.

Prickly Pear Cactus is like this hat because of its spines. Like the hairs on the Sagebrush leaves, spines break up wind and lessen evaporation. The spines also keep some animals from munching on the cactus.

Like a garden hose, a **Yucca's** roots move water from one place to another. A Yucca has a taproot that can grow up to 15 feet long. How does this long taproot help the plant?

STATION #2

Are Leaves Adapted?

Objectives

Students will be able to:

a. Find a desert plant, and explain its leaf adaptation.

b. Describe the steps of the scientific process.

Materials

Hand lenses; small poster listing five adaptations; clipboards; pencils; copies of *Science Investigation Form: Are Leaves Adapted?*

PROCEDURE

1) Review and discuss the following concepts: All life comes from the sun's energy, and this energy is gathered in leaves of plants and converted into useable plant energy. By-products of this process include oxygen and water. Loss of water is a concern for plants in the desert; therefore many plants have adaptations in their leaves to avoid losing large quantities of water. Some of those leaf adaptations are: (1) hairy or fuzzy leaves, (2) small leaves, (3) curled-up leaves, (4) wax-coated leaves, and (5) green stems but no leaves. Display small poster listing these five adaptations, and discuss them. Define small leaves as less than one inch long. Discuss the other adaptation of growing and reproducing fast before the hot season hits, then dying off. Discuss what might happen to a plant if they did not have these adaptations.

2) Tell students they are going to work in pairs and do a scientific investigation. Explain that they will be using the scientific process. Pass out copies of the *Science Investigation Form: Are Leaves Adapted?*, pencils, and clipboards. Go over the form, discussing the steps of the scientific process. Our question for the investigation will be, "If we observe six different leaves, how many of them will have one of the adaptations that we've listed for the desert environment?" Have them write the question and then their hypotheses.

3) Explain the procedure that students will follow. They will be looking at six different types of leaves, drawing them, and describing which adaptations they see, if any. (Adjust the number of leaves as dictated by time.) In order for the investigation to be unbiased, they need to collect the first eight different leaves that they can find (make sure they stay in a defined area). Descriptions may be brief. Have students write the following procedural steps on their form: (1) Find leaves. (2) Draw each leaf and describe its adaptation, if it has one. At this point, have students divide the back of their investigation sheet into six squares for their drawings and descriptions. Define the study area, and send students out to collect data.

4) Gather students. Share some of their pictures and descriptions. Ask them how many of their six leaves had at least one of the adaptations on our list. Have them write this number down under results. Discuss why some of the leaves didn't have the adaptations. (They may be annuals with seed adaptations rather than leaf adaptations, or they may have other types of adaptations.) Discuss, and have them write conclusions.

Learining about leaf adaptations

SCIENCE INVESTIGATION FORM

Are Leaves Adapted?

Scientist name: _____

Question: If we collect __ different leaves, how many of them will have at least one of the desert adaptations we have listed?

Hypothesis (Prediction):

_____

_____

_____

_____

Procedure (List step by step.):

_____

_____

_____

_____

_____

_____

_____

Results (What actually happened?)

_____

_____

_____

Conclusions (What did we learn or what do our results mean?)

_____

_____

_____

STATION #3

The Riparian Ramble

Objectives

Students will be able to:

a. Describe two environmental conditions of riparian zones that are different than those in the surrounding desert.
b. Name one riparian zone plant, and describe one of its adaptations.
c. Understand that parent and offspring have similar characteristics.

Materials

Student key; copies of *A Key to Common Riparian Plants of Southeastern Utah*; *Riparian Plant Clue Cards*; optional: *Riparian Habitat* poster (Project WILD Colorado, n.d.).

PROCEDURE

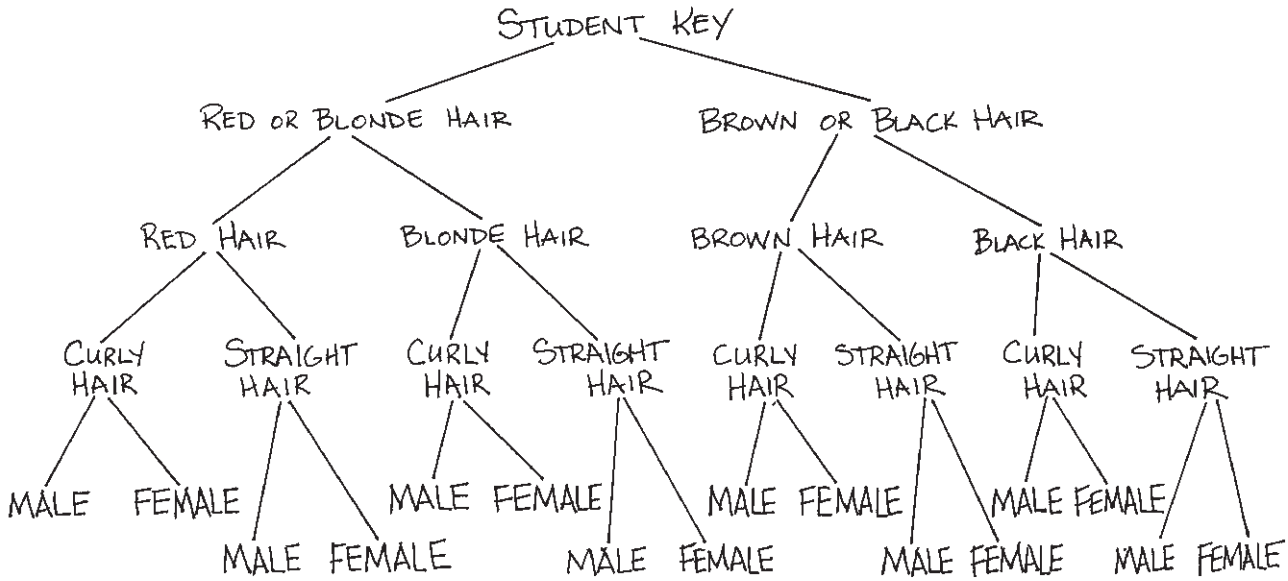
1) Define *riparian*. Explore the interactions of plants and animals in a riparian community. (Use the poster if you wish.) Mention that most of the wildlife in Utah depends on riparian areas for their survival. Have students think of some conditions that plants living near water in the desert must be adapted to (flash floods, sandy and salty soils, hot summer days, animals), and point out some plants with those adaptations. Stress that these plants do not need the water saving adaptations of desert plants because they live where there is always water at the surface or just underground. Ask the students if they think plants adapted to the desert could grow in the riparian zone.

2) Tell students we will be using what is called a plant key to identify some of the riparian plants. In order to teach students how to use a plant key, tell them that they will be first using a student key. Show the students the student key, and describe how it works. Have one student leave the group. Then, pick one student who is left to be "it." Have the first student return to the group and, using the student key, ask questions to determine which student is "it." Play several times. Ask the students to think about their parents. Do parents and children often look alike? Again, play the game. However, this time describe someone's parent. While the player is gone, have one student describe the way his or her parent looks, so that the group may all answer. Have the player try to pick the student whose parent is being described. Play several times.

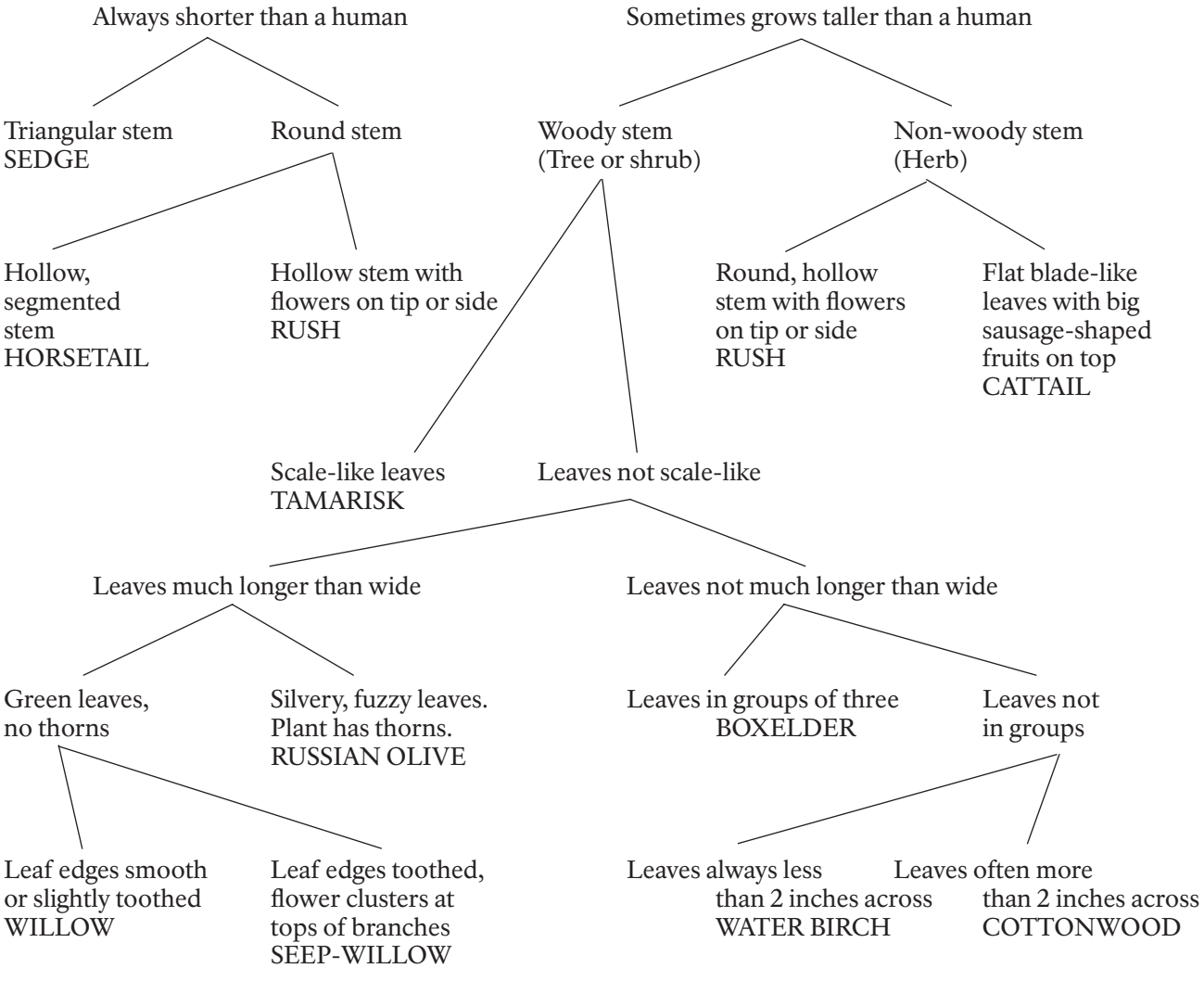
3) Pass out the copies of the *Riparian Plant Key*, and briefly discuss their use. As a group, use the key to figure out the names of a variety of plants. Discuss each plant's adaptations to living in the riparian corridor. See if students can find a seedling of each plant. If so, have the students compare the seedlings to the parent. For instance, discuss how a young cottonwood looks nothing like its stately parent, but its leaf shape is the same and it has riparian adaptations.

4) If there is time, pass out the *Riparian Plant Clue Cards*. Although each student gets at least one card, students may work in pairs. Instruct students to look for a plant within the specified boundaries that matches each clue card. After a few minutes of looking, walk as one group up the wash, asking each student to stop the group when her plant is reached and to read her card.

Identifying plants in a riparian corridor



A KEY TO COMMON RIPARIAN PLANTS OF SOUTHEASTERN UTAH



RIPARIAN PLANT CLUE CARDS

Cut apart along lines.

I am a deciduous plant. When the weather turns cold in the fall, I shed my leaves. Because I am a riparian plant, I have plenty of water to grow new leaves every spring.	Thick bark protects me from damage caused by insects and other animals. The bark also helps to keep me from drying out.
I grow near streams where flash floods occur frequently. Because my branches are extremely flexible and bend easily, they don't break when the water rushes over me.	I grow in washes where flash floods occur frequently. I have very narrow leaves, which are resistant to being torn off in the floods.
My thorns keep animals at a distance, so they don't chew on my stems, branches, or leaves.	I produce "hitchhiker" seeds. These seeds travel in the fur of animals (or in your socks)!
I can grow in very salty soils. Find me near crusty white salt deposits.	I grow to be a large tree with large heart-shaped leaves. I lose lots of water in transpiration through my leaves, so I only grow where water is flowing or just under the surface of the ground.

STATION #4

In the Cool of the Night

Objectives

Students will be able to:

a. Name two plants that have nighttime adaptations.

b. Describe the relationship between an evening-blooming yucca and a yucca moth.

Materials

Photos of night-blooming plants (e.g. Nelson, 1976); blindfold; smells on small sponges in film canisters (two canisters of each smell); *Night Life of the Yucca* (Hauth, 1996).

Procedure

1) Go on a hike to find prickly pear cactus. Ask students if they remember how plants make their own food. Quickly review photosynthesis. Tell the students that as plants photosynthesize, they bring in carbon dioxide and release oxygen through small holes called *stomata*. Water vapor is released at the same time. We call this transpiration. Discuss the desert climate around Moab, especially the low amount of rainfall, drying winds, and hot temperatures of the summer. Explain that the plants that live here have different adaptations that allow them to survive in this climate. Ask what time of day is the coolest. Explain that some plants open their stomata only at this time, nighttime. Describe the cactus' adaptation of opening their stomata only at night to reduce transpiration. Have the students examine the cacti. See if they can think of some other adaptations it might have for surviving in the desert. Ask why they think it has such brilliantly colored flowers. Ask if students think a fuchsia or yellow flower would make the plant stand out on the hillside. Hike back to station's base area.

2) Use a field guide to show students pictures of night-blooming plants. Be sure that they notice that the flowers are light in color. Tell the students that this light color is a nighttime adaptation. Ask students to explain why the plants white bloom would help it survive. If the students cannot think of the answer, ask them what color their parents tell them to wear when they go for a walk at night. Discuss how light colors help insect pollinators see the flowers. Ask the students whether or not a mutated plant with a purple flower would be pollinated.

3) Tell students that most of these flowers have strong smells. They bloom at night because their insect pollinators come out only at night. These insects smell through their antennae. Show the students a picture of a yucca plant. Tell the students that this plant has adapted to live symbiotically with one insect. Read *Night Life of the Yucca*. Review the story, and add that each species of yucca attracts a different species of yucca moth by its individual scent. Ask the students why individual moths search out individual species of yucca plant. Discuss that the yearning for a specific scent is an instinct passed down in their genes.

4) Ask one student to become a yucca moth. Blindfold him, and give him a scent in a film canister. Have the other students become different species of yucca, and give them film canisters with different scents. The yuccas take turns letting the moth smell them, and the moth identifies his yucca species by smell. Let all of the students have a turn at being the moth. Review nighttime plant activities and the reasons that plants take advantage of this time.

EXTENSION

Have students create a rap about the relationship between yucca moths and yucca plants.

A student tests her sense of smell by becoming a yucca moth

POST-TRIP ACTIVITY

Adaptation Art

(Project WILD, 1992, 114-115)

Objectives

Students will be able to:

a. Name three adaptations of a plant living in either a desert or a riparian environment.

Materials

Chart paper; markers.

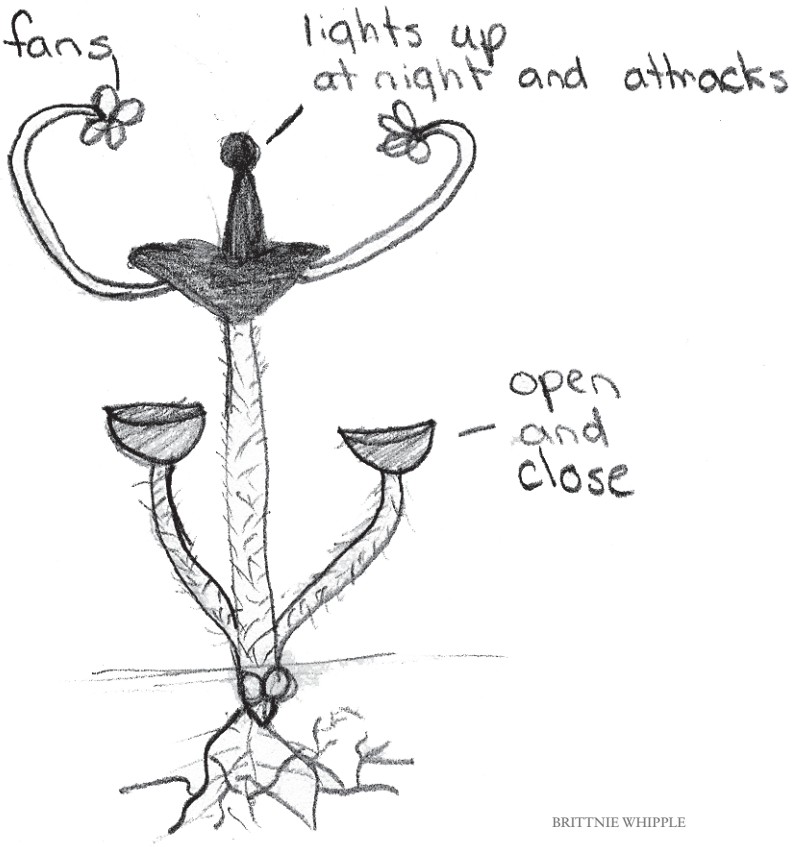
PROCEDURE

1) Briefly review some of the desert and riparian plant adaptations that students learned about on the field trip.

2) Explain that students will be creating and drawing imaginary plants with imaginary adaptations. Tell students the first step is to decide which environment the plant is going to live in, desert or riparian, and write it in the corner. As a class, create a plant as an example. Think of the wackiest adaptations possible (such as umbrella-shaped leaves for shade). Encourage students to think up their own adaptations for their plants and to be as creative as they can! Divide class into groups of three or four students for the activity. Explain that each group should create a plant with at least three physical adaptations to either a desert or riparian environment. Ask students to label their drawing with the plant's chosen name and its environment. Reinforce the concept that an adaptation must help a plant to live or reproduce in its environment. Ask that students within a group work together on ideas, and require that each student in each group have a job within the group, such as drawing the plant's leaves, drawing the remainder of the plant, writing the plant's adaptations, or writing the plant's name and environment. Pass out a sheet of chart paper and some markers to each group. Monitor and encourage students.

3) Have each group stand in front of the class, show their drawing, and explain their plant's adaptations.

One student's imaginary plant



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