National Park Service
U.S. Department of the Interior

Southeast Utah National Parks & Monuments

Canyon Country Outdoor Education
Fifth Grade Curriculum

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National Park Service
Utah

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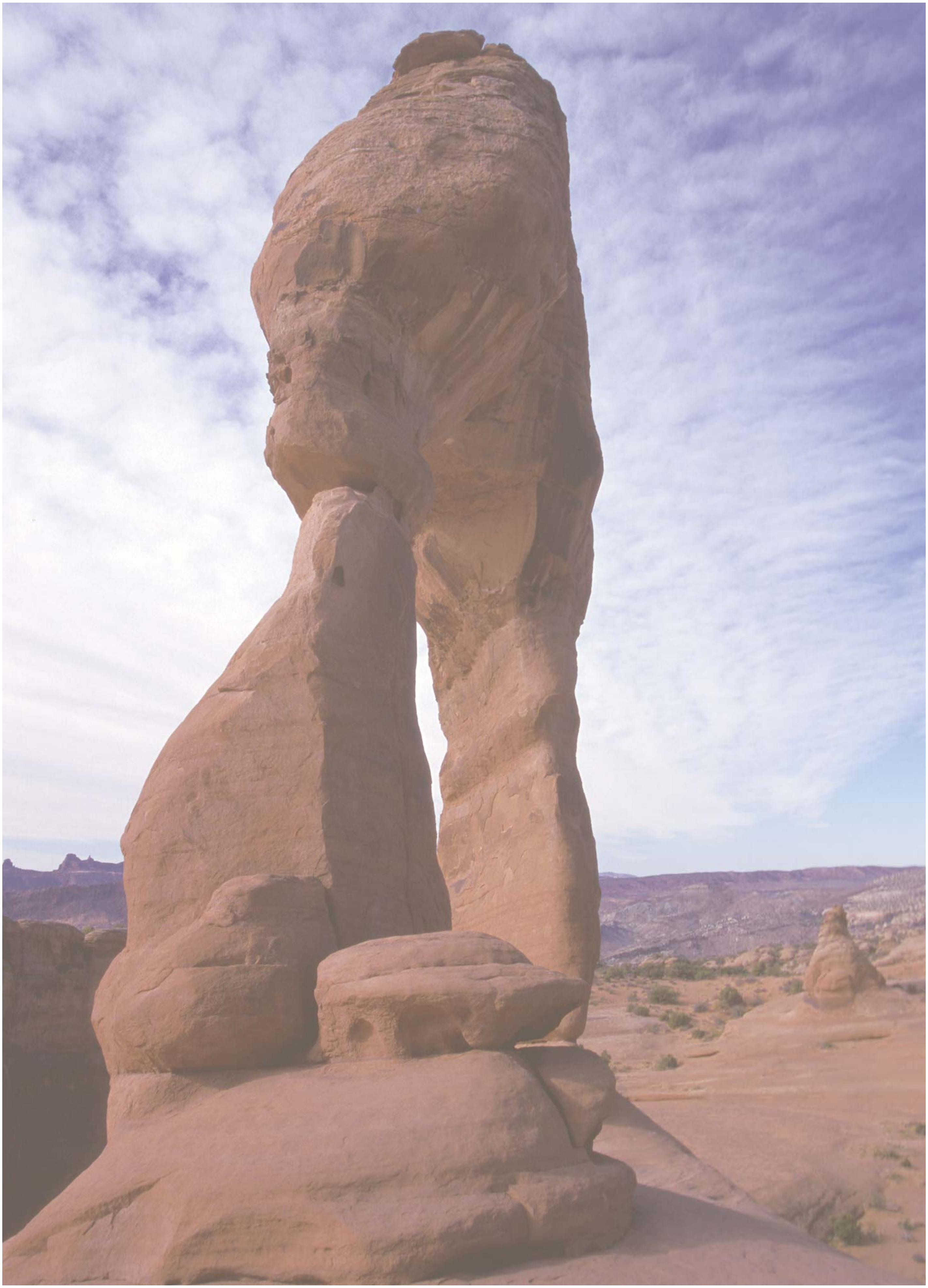
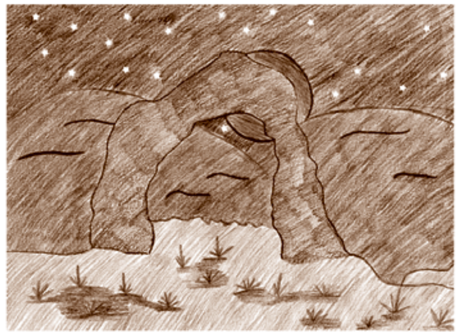
Contents

Prickly pear cactus





MICHELLE SAGGBOY

FIELD TRIP

Physical Features

Theme
Geologic processes cause continuous changes in the earth's physical features.

Utah State Science Core Curriculum Topic
Standard Two: Students will understand that volcanoes, earthquakes, uplift, weathering, and erosion reshape Earth's surface.

Objective One: Describe how weathering and erosion change Earth's surface.
Objective Two: Explain how volcanoes, earthquakes, and uplift affect Earth's surface.
Objective Three: Relate the building up and breaking down of Earth's surface over time to the various physical land features.

Field Trip Location
Bloody Mary Wash, immediately west of the Arches National Park Visitor Center parking lot. This site is unique in having a fossiliferous limestone in the wash bottom and a beautifully exposed geologic fault. All stations could be adapted for various geologic settings in southeastern Utah, but perhaps nowhere would have all the combined features of this site.

Times
Field trip stations are 30 minutes each. Pre and post trip lessons are 45 minutes

Science Language Students Should Use
Earthquakes, erode, erosion, faults, uplift, volcanoes, weathering, buttes, arches, glaciers, geological, deposition

Background

The rock layers and fault exposed at the entrance to Arches National Park are of textbook quality. The layers are easy to see; they have different colors as well as different compositions.

By looking at the rocks close-up, we learn about the ancient environments in which the sediments of the rock layers were deposited. Most *mudstones* and *siltstones* formed in low-gradient streams or tidal-flat environments. Some *sandstones* were deposited in steeper streams or on beaches. *Sandstones* made up of very rounded sand grains that are all the same size (*well-rounded* and *well-sorted*, in geological terms) indicate aeolian or windblown deposition in a relatively dry environment.

Limestones usually indicate a marine environment, and many contain fossils. (A few thin limestone layers in the Moab area were deposited in freshwater lakes.)

Any plant or animal that dies on earth can be fossilized if the conditions are correct. In order for a creature, or evidence of a creature, to be preserved as a fossil, the creature cannot be broken down or disintegrated. Many fossils are formed at the bottom of oceans, where deposition is continuously occurring and dead organisms are quickly buried. This, and the fact that many marine creatures have hard shells that don't decompose easily, is why most fossils are of marine organisms. Fossils of land-dwelling creatures are less common. The Honaker Trail

Formation, found in the bottom of Bloody Mary Wash, contains an abundance of fossils. This limestone layer was deposited in an offshore marine environment about 300 million years ago. There are fossils of crinoids, brachiopods, bryozoans, horn corals, and occasional clams, snails, and trilobites.

A *geologic fault* is a break or fracture in the rock, along which there is displacement of the strata. Most faults form during earthquakes or volcanic activity associated with the shifting of tectonic plates. In southeastern Utah, however, much faulting is associated with an unusual phenomenon, the movement of underground salt layers. Faults are commonly buried by sediment and difficult to see, but the Moab fault is spectacularly exposed at the field trip site. The Honaker Trail Limestone has been shifted 2,500 feet upward on the west side of the fault, past seven other rock layers. It is now on the same level as the Entrada Sandstone (Dewey Bridge Member) east of the fault.

Arches National Park's erosional landscape of valleys, towers, fins, canyons, pinnacles, and arches began to form about 10 million years ago. That's relatively young in geologic terms; the rock layers in the park were deposited roughly 300 million to 150 million years ago.

Based on the definition of an arch as an opening at least three feet in one direction, there are over 2,000 named arches in Arches National Park, most within the Entrada Formation. Water is the main culprit in arch formation. Rainwater is usually slightly acidic, which weakens the cement between grains in the sandstone. The process of frost wedging involves water freezing (expanding) and thawing (contracting) in pores and cracks. This process is key in breaking apart sand grains, especially because of the large temperature fluctuations of the high desert climate. In addition to water, wind and gravity aid in the process of erosion by removing the weathered parts of rocks. Arches can be classified by their shapes; categories include free-standing arches, cliff-wall arches, and jug-handle arches. Natural bridges, unlike arches, are formed by flowing streams.

Plate tectonics is the driving force for faulting, earthquakes, and the melting and pressure that recycles rocks into new igneous and metamorphic rocks. The Earth has several layers: crust, mantle, outer core and inner core. The lithosphere, which is the crust plus the upper part of the mantle, is broken up into different pieces called plates that move around in different directions on the Earth's surface. There are three basic types of boundaries between these plates. Convergent boundaries are where plates crash together. In this case, one plate usually descends beneath the other. Plates made up of oceanic crust are thicker and heavier, so they sink below the lighter, thinner continental plates. Here, friction causes massive pressure, earthquakes, faulting, and mountain building. The descending plate melts, only to rise up as a liquid magma and form volcanoes along the edge of the overriding plate. In a few cases, when both of the lithospheric plates are made up of continental crust, neither plate descends, and the earthquakes and faulting create massive mountains such as the Himalaya. Divergent plate boundaries or rifts, where plates spread apart, are usually in the middle of oceans. Basaltic lavas flow from these boundaries, creating new crust. Transform plate boundaries, where plates slide by each other, are illustrated by the San Andreas fault in California.

A Piece at a Time

Friction at these boundaries creates earthquakes and faulting.

Objectives

Students will be able to:

a. Name the three main types of rocks.
b. Describe the processes that created four different landforms.

Materials

Igneous, metamorphic, and sedimentary posters; rock cycle jigsaw puzzles; question sheets; a set of numbered pictures of local landforms for each group.

PROCEDURE

1) Write *geology* on the board, and define it as the study of the earth's history. Inform students that geologists study the earth by looking at rocks, particularly those rocks found very near the earth's surface. Explain that there are many kinds of rocks and that geologists group them into three types based on how the rocks formed.

2) Quickly review the three major types of rocks: igneous, metamorphic, and sedimentary. Explain that the names give clues about how the rocks form: *sediments* make up sedimentary rocks, *metamorphosis* means changing form (as in insect life cycles), and they can think of *ignite* for igneous. Tell the students that given enough time rocks change, what form they change into depends on the amount of and the type of elements they are exposed to (i.e. heat, pressure, weathering). This process is called the rock cycle. Stress how slowly this takes place.

3) Divide the students into groups, and distribute rock cycle jigsaw puzzles. Ask the students to complete the jigsaw puzzle. Specify 2 or 3 questions for each group to answer from the questions included in the package on a separate piece of paper. Tell students that they are welcome to answer other questions but they will report on the questions they are assigned.

4) On their answer sheet, have the students write the part of the rock cycle that caused the creation of each numbered landform. Go over the answers to the rock cycle questions as a class.

5) Inform students that they live in a fantastic place for exploring rocks. Tell them that, on this field trip, they will be both looking at sedimentary rocks near the entrance to Arches National Park and exploring how these rocks formed and changed over time. Review field trip expectations and the items students need to bring on the field trip.

PUZZLE QUESTIONS

1. What types of rocks were most recently liquid?
2. Name a local landform created by intrusive igneous rock?
3. Name three types of extrusive igneous rocks?
4. Eroded material turns into what types of rock? What quickly happens to this rock?
5. How old is the earth?
6. Three times in the past, almost all the life on earth was extinguished how long ago did each one occur?
7. Describe the change in the continents on earth?
8. How are metamorphic rocks created?
9. What types of rocks can melt and become metamorphic?
10. Name a characteristic of metamorphic rock?
11. Is the rock cycle a one way cycle?

Puzzle currently unavailable.

INTRODUCTORY ACTIVITY
Rock and Roll

(adapted from Fluegelman 1976, 69)

Objectives
Students will be able to:
a. Name sand grains as the main component of sandstone.

Materials
None

PROCEDURE

1) This game works best with 6 to 10 people. Have students stand elbow-to-elbow in a circle, and tell them to imagine they are sand grains.

2) Instruct students to step forward and each grasp two hands, of two different people, with their hands. Once they have all completed this step, tell them to imagine that they have now hardened into sandstone.

3) Guide students in untying the knot they have made without letting go of each other's hands. This involves climbing between arms, stretching in unusual ways, and laughter. As they begin to untie, orally create the image of rain, frost wedging, and erosion of the sandstone.

4) Once they are standing in a circle, hand in hand, have them drop hands and become individual sand grains again.

An outdoor education instructor discusses faults near the Moab Fault in Bloody Mary Wash

STATION #1
Fossil Frolic

Objectives
Students will be able to:
a. Name three types of marine fossils.
b. Describe the environment in which the limestone was deposited.

Materials
Fossils; fossil field guides; *What was it like here 300 million years ago?* poster (enlarged illustration from Rhodes, Zim, and Shaffer 1962, 42).

PROCEDURE

1) Show students the poster of the ancient marine environment, and explain that this is what it looked like here 300 million years ago. Briefly explain that environmental conditions change slowly through time, partly because of plate tectonics. Tell the students that this spot was near the equator and that the sea here was shallow, allowing sunlight to reach the bottom and supporting lots of creatures. Discuss how remains of sea life were turned into fossils and the length of this process.

2) Show examples of fossils. When applicable, have students find the creature in the poster that corresponds to each fossil. Briefly discuss each fossil creature, disclosing how the creature lived or how to recognize the fossil. For example, explain that crinoids were animals rooted on the ocean bottom and were filter feeders. (Have students suck air in between clenched teeth.)

3) Save much of the time in this station for finding fossils. Give boundaries, and reinforce that students may look at and show others fossils that they find, but they are not to take any. Be sure to bring reference books with you, and have an idea of what you'll be finding. Guide students to some rich fossil areas to get them started in their search. Share their enthusiasm.

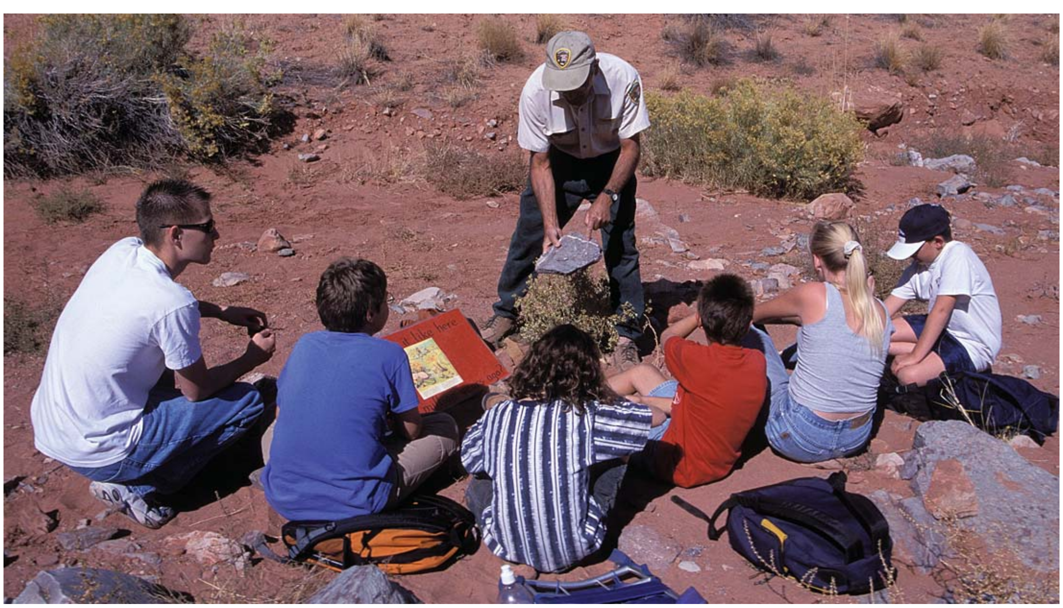
4) Gather students and have them stand in a circle for a game that strongly reinforces the names of the common fossils in the area. Have an example of each of these fossils for the "A What?" game. Direct the first round of the game. First show a brachiopod, for example, and hand it to a student to your right (student A) and say "This is a brachiopod." Instruct that student to ask "a what?" Respond, "a brachiopod." Then have student A pass the fossil to the student to her right (student B), saying, "This is a brachiopod." That student responds "a what?" and then student A turns to you and says "a what?" You respond "a brachiopod." The "a what?" question must always come back around to the person who first passed the fossil, and then the answer ("a brachiopod") must be passed all the way back to the student holding the fossil. Continue until the brachiopod comes all the way around the circle, and then start a different fossil. After two or three rounds, start two fossils at the same time, going in opposite directions around the circle.

EXTENSIONS

Have students name three kinds of fossil creatures and tell something about how each lived.

Have students describe the environment in which these creatures lived.

Studying fossils



STATION #2

Who's Fault Is It Anyway?

Objectives

Students will be able to:

a. Define a geologic fault.

b. Describe how the rock layers moved along the Moab fault.

Materials

Fault definition cards, fault cross-section, plastic knives, clay, cardboard bases for clay work

PROCEDURE

1) Hand out a fault definition card to each student. Have students take turns reading their definitions. Ask which definition they think we'll be exploring in this station. Ask students if they have ever experienced an earthquake. Have students tell the others what the earthquake was like. Tell the students that an earthquake is what we feel when rocks move along a fault. Explain that the more the rocks move, the bigger the earthquake. Use your hands to demonstrate this concept. Discuss and/or demonstrate the different types of earthquakes.

2) Walk students over to the fault area. Have them put their faces against the fault. Is the rock cold or hot? Have them step back and describe the rock. Point out the *slickenside* scratches on the rock, explaining that these resulted from rocks moving past each other along the fault. To demonstrate the rocks' movement, have students put their hands together and move one side past the other. This is the action of a fault. Show the students this action with the tri-colored card.

3) Seat students in limestone amphitheater. Tell students that they will be making their own rock layers out of clay and then faulting them. Distribute cardboard workboards and one color of clay at a time. Tell the students to flatten each piece of clay into a pancake shape and place each flat layer on top of another. After the students have made at least two or three layers, have them cut the layers at a steep angle to form a fault plane.

4) Ask the students to bring their clay and stand with one shoulder to the fault. Have students move their rock layers so the one closest to the fault goes up, just like in the real rock. Then, tell the students to move the clay so that the rock layers move past each other along the fault. Be sure to make appropriate rock crushing noises! Remove the top layer on the uphill side of the clay faults to simulate how the upper layers have been eroded away. Discuss how their models are similar to what actually happened along the Moab Fault, but on a much faster time scale.

EXTENSION

Assign students to research and make models of different types of geologic faults.

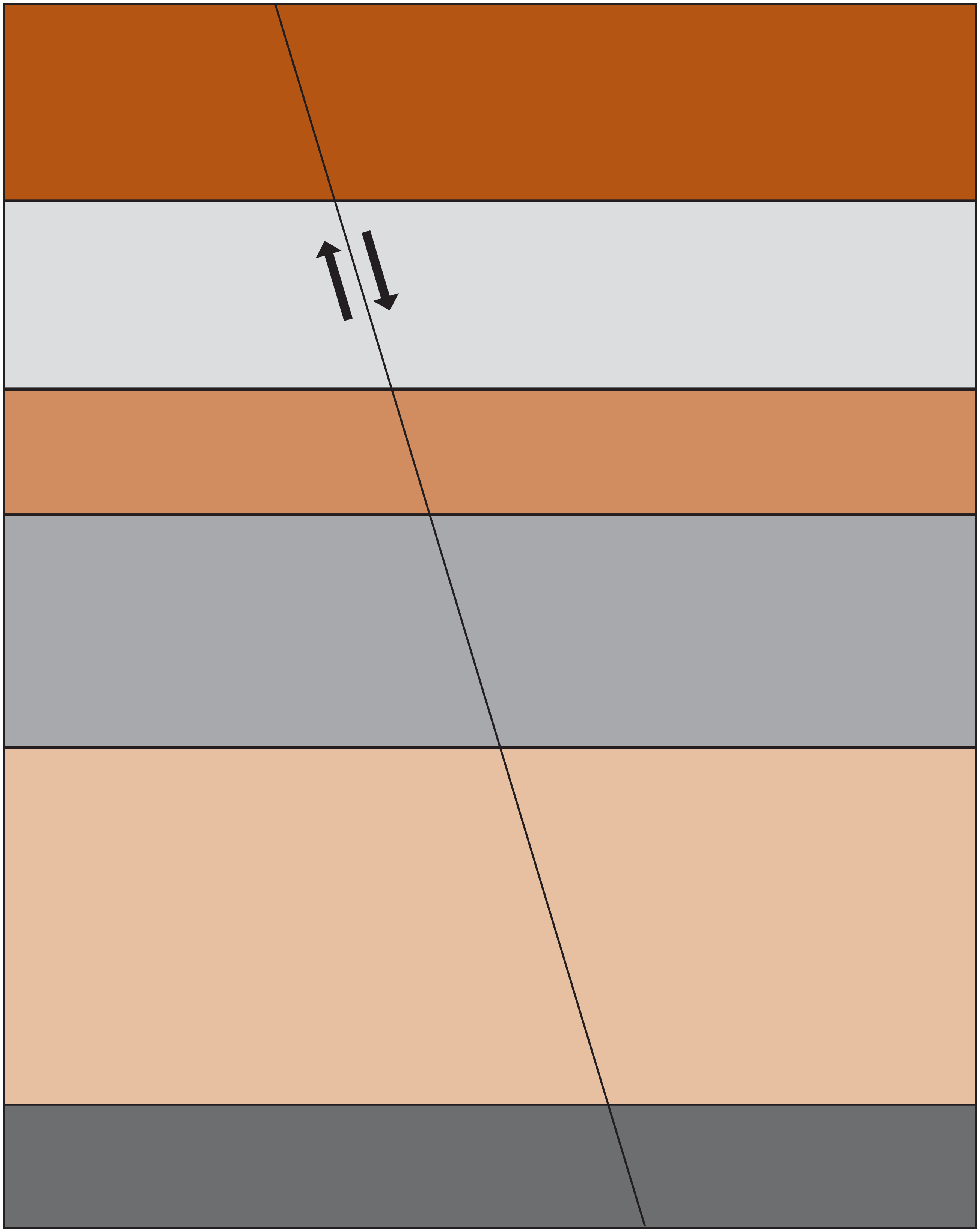
Insert fault definition cards and fault cross section from current guide

FAULT DEFINITION CARDS

Fault: Responsibility for something wrong	**Fault:** A mistake or small violation
Fault: A bad service, as in tennis	**Fault:** A break in rocks along which the rocks have moved.

FAULT CROSS-SECTION

Print on tagboard or glue printed paper to cardboard, then cut out block and cut block into two pieces along the diagonal fault line.



STATION #3

Falling Arches

Objectives

Students will be able to:

a. Name three types of arches.

b. Describe two weathering processes involved in arch formation.

Materials

Deep tray of moist sand; *types of arches* poster; drawings or photographs of specific arches; paper, pencils and clipboards; cardboard strips (for relay) with names of three types of arches

PROCEDURE

1) In the Arches Visitor Center, review the rock cycle, making sure the students know that the rocks in Arches are all sedimentary rocks. Introduce arches as the subject of this station. Inform students that there are over 2,000 named arches in the park. Review the size definition of an arch. Using the displays, show students that most arches in the park are in the sandstone layer called the Entrada Formation. Go over the processes involved in arch formation, including chemical weathering by rainwater, frost wedging, gravity, and wind. Emphasize that water is the main factor in arch formation. Contrast arches with natural bridges.

2) Outside, use the bucket of sand to demonstrate the creation of an arch. Introduce three types of arches, showing the *Types of Arches* poster and modeling them in the sand. Ask students the names of any arches they've seen, and see if they can figure out which types of arches they were.

3) Have each student choose one of the cards with drawings or photographs of named arches, read the arch name, show the card to the group, explain why they think that arch was given its name, and place the card by the correct type of arch on the *Types of Arches* poster. Hand out paper, pencil, and clipboard to each student. Have each student draw an imaginary arch, name it, write what type of arch it is, and present it to the group.

4) Choose one of the following review activities:

a. Human Arches: Keeping the *Types of Arches* poster visible, divide the group into pairs and whisper an arch type to each pair. Instruct pairs to create their arch type with their bodies, joining hands, kneeling, or whatever works! Have each pair show their arch while the rest of the group guesses which type it is. If time allows, have the group work together to make one last human arch.

b. Arch-Type Relay: Divide the group into two teams, in two lines. Show a picture of an arch and read its name. Then, say, "go!" Instruct the first person in each line to run to a pile of cards, each with one of the three arch-types printed on it. The goal is to pick up a correct card and run back to their team members. The first runner back gets a point for their team, if they have a correct card. If not, the other team has a chance to get a point, if they have a correct card. Play until time runs out or the students are exhausted.

One student's imaginary arch


Types of Arches
Free Standing
Jug Handle
Cliff Wall
MARY MORGAN

STATION #4
Picture This

Objectives
Students will be able to:
a. List three of the rock layers in Arches National Park.
b. Describe three environments in which the rock layers were deposited.

Materials
Rock layers and environments of deposition poster; pictures of environments: *Ocean, Tidal Flats, Stream, Sand Dunes*; laminated formation names; rock samples

PROCEDURE

1) Point out the distinct, relatively flat layers of the surrounding rocks, correlating the different layers with the *Rock Layers-Environment* poster. Use food analogies for the different layers, such as Navajo whipped cream and Entrada cherries for the sandstone east of the Visitor Center or a few chunks of Kayenta peanut brittle atop the Wingate cliffs on the western skyline.

2) Have students line up from oldest to youngest. Discuss the concept that each of the rock layers began as sediments deposited in different environments. Using the poster, hand a formation name to the corresponding student in the lineup, pointing out the layer and its look and discussing the environment in which it was created. Hand out pictures of the environments in which the layers were created to the corresponding students as well. Have each student introduce her layer and tell what environment created it. If students are having difficulty, leave the poster within site. Emphasize the huge amounts of geologic time involved.

3) Hand rock samples to corresponding students, and reinforce the understanding of superposition by having students attempt to stack their rocks, with the oldest formation on the bottom and the youngest on the top. Have students see how high they can stack their rocks, without touching any of the ones underneath, before they fall. To review, again ask each student what type of environment existed when his layer was deposited.

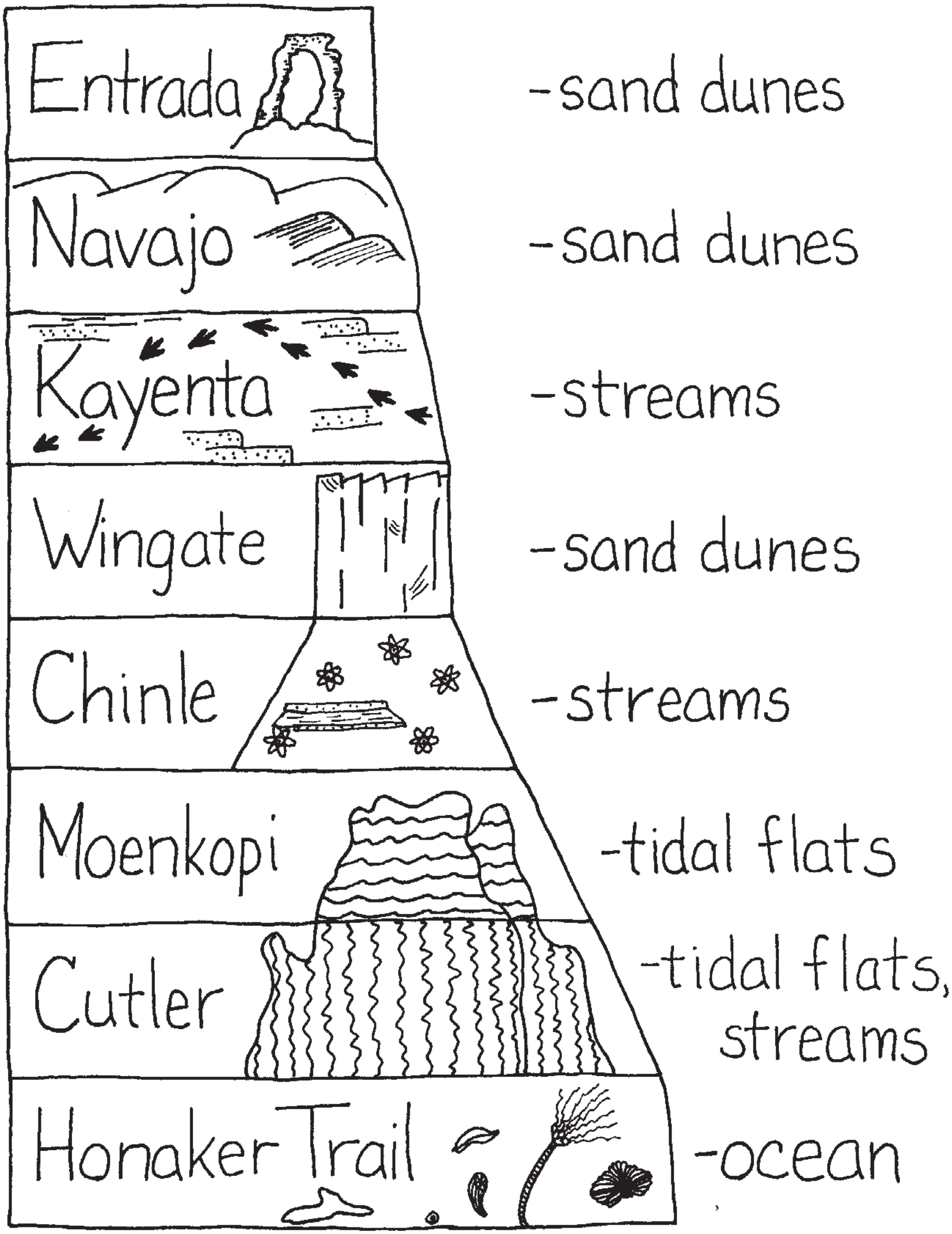
4) Reinforce these layers and their names with a relay. Place formation names 25-50 feet from a starting line, and have students line up in two teams. Instruct the two starting runners to retrieve the correct formation name based on a clue that you give. Instruct other students to help out by whispering (or shouting) the answer to their team runner. The first runner back with the correct formation wins a point for her team and goes to the back of the line. Vary the clues to relate to environment of deposition, what the layer looks like, or the layer's age relative to other layers.

EXTENSION

Have students draw a profile of the wall east of the visitor center, labeling the depositional environment of each layer: stream, sand dune, or tidal flat. (There are no layers representing ocean environments east of the Moab fault.)

The rock formation relay

Rock Layers and Environments



POST-TRIP ACTIVITY
Plates on the Go

(adapted from *Geology: The active earth,* 1988, 11-12.)

Objectives
Students will be able to:
a. Explain why earthquakes are most common along plate boundaries.
b. Explain how plate tectonics creates new igneous and metamorphic rocks.

Materials
Earthquake Data; laminated world map with latitude and longitude lines, cut into sections corresponding to the sets of data; erasable markers; cloth for erasing; masking tape; phone books; plate overlay transparency (enlarged from *Geology: The active earth,* 1988, 16).

PROCEDURE

1) Review the rock cycle, incorporating concepts and experiences from the field trip into the discussion. Comment that they learned about erosion and deposition of sedimentary rocks on the field trip, but in this activity they will learn about the forces in the earth that cause much of the pressure and melting that can lead to the formation of new igneous and metamorphic rocks. Tell the students that whereas they had previously been discussing changes in rocks that took place over long periods of time. Today they are going to discuss a very quick way the appearance of rocks can change.

2) Discuss earthquakes, incorporating what an earthquake is, how long earthquakes normally last, earthquake magnitude, and how scientists measure an earthquake's magnitude. Show the students pictures of a rictor scale recording earthquake data. Explain how a 5.5 quake is ten times more intense than a 4.5 quake. Be sure that students know that earthquakes are caused by the movement of rock along fractures, or faults, in the earth. Tell the students they will be mapping all the earthquakes of magnitude 6.6 or greater that occurred during 1997, 1998, and 1999, on a world map. Review longitude and latitude, and plot one or two earthquakes on the map to demonstrate. Inform students that you've divided the **Earthquake Data** and maps into seven sections, and divide them into seven groups. Give each group one map section, corresponding earthquake data, and a marker.

3) When groups finish, have them tape the map sections together in a visible place. Discuss the earthquake patterns, particularly the lines or curves that the earthquakes delineate. Review or introduce the layers of the earth. Discuss the lithosphere (crust) and plate tectonics. Demonstrate how thin the lithosphere is by telling them that if the earth was an apple, the lithosphere would be thinner than the apple's skin. Explain, however, that the Earth's crust is not solid like an apple's skin, but rather made up of lots of pieces that are constantly bumping into each other (like boats in a river).

4) Describe what happens to the rocks at the different types of plate boundaries, using phone books to illustrate, and relate the forces created to the forces that drive the rock cycle. Reiterate that almost all faulting and earthquakes are caused by the forces at plate boundaries, so that's also where almost all earthquakes occur. Tell the students that if we had plotted small earthquakes (in addition to the larger ones) and used a longer period of time (instead of only three years), we would have seen an even clearer outline of the plate boundaries. Tape the plate overlay over the plotted earthquakes. Ask the students why the two maps might correspond. Discuss where new metamorphic and igneous rocks might be created on the map.

EARTHQUAKE DATA (1997-1999)

From National Earthquake Information Center

DATA SET 1

0-5S, 0-14N; 100-180E

Latitude	Longitude
8N	128E
4S	144E
1N	123E
5S	148E
4S	129E
5S	152E
3S	142E
3S	139E
5N	127E
1N	126E
2S	125E
1N	126E
4S	153E
5N	122E
5S	151E
4S	152E
5S	153E
0	120E

DATA SET 2

16-90S; 0-99E, 0-179W

Latitude	Longitude
22S	66W
43S	43E
32S	179W
36S	108W
30S	72W
42S	80E
29S	178W
22S	177W
31S	71W
31S	71W
16S	179W
16S	179W
24S	70W
18S	179W
40S	75W
22S	179W
18S	65W
30S	179W
29S	71W
22S	176W
21S	176W
30S	178W
19S	69W

DATA SET 3

6-90S; 100-180E

Latitude	Longitude
6S	147E
13S	167E
20S	169E
32S	179E
16S	124E
27S	178E
15S	167E
22S	171E
50S	163E
63S	150E
11S	166E
8S	112E
7S	129E
7S	129E
13S	167E
6S	150E
6S	149E
6S	149E
16S	168E
7S	106E
11S	165E

DATA SET 4

15-90N; 0-49E, 0-179W

Latitude	Longitude
18N	103W
19N	107W
51N	179W
16N	98W
36N	22E
38N	21E
53N	34W
80N	2E
37N	35E
39N	29W
53N	169W
52N	178W
18N	97W
16N	88W
41N	30E
16N	97W
35N	116W
41N	31E
57N	154W

DATA SET 5

0-15S, 0-14N; 0-99E, 0-179W

Latitude	Longitude
11N	61W
11N	63W
15S	179W
15S	176W
4N	76W
4S	77W
14S	69W
14N	91W
1S	99E
8S	74W
12S	68E
1S	80W
12N	88W
15S	179W
6N	83W
9N	84W
1S	89E

DATA SET 6

15-90N; 50-135E

Latitude	Longitude
38N	57E
30N	68E
34N	60E
35N	87E
30N	58E
22N	125E
37N	70E
23N	126E
28N	57E
31N	79E
44N	130E
24N	121E
16N	120E

DATA SET 7

15-90N; 135-180E

Latitude	Longitude
44N	149E
51N	179E
55N	162E
54N	162E
54N	162E
52N	179E
24N	142E
53N	160E
29N	139E
52N	159E

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The Few
The Proud
Crazie

JESSICA HINES

FIELD TRIP

Changes in Matter

Theme
Physical and chemical changes in matter can be observed within our natural environment.

Utah State Science Core Curriculum Topic
Standard One - Students will understand that chemical and physical changes occur in matter.

Objective One: Describe that matter is neither created nor destroyed even though it may undergo change.
Objective Two: Evaluate evidence that indicates a physical change has occurred.
Objective Three: Investigate evidence for changes in matter that occur during a chemical reaction.

Field Trip Location
Island in the Sky District, Canyonlands National Park or another quiet area with spectacular views.

Times
The pre trip lesson, ozone lesson, and air quality lesson are each 30 minutes. The hike is 1 hour. The post trip is 45 minutes.

Science Language Students Should Use
Heat, substance, chemical change, dissolve, physical change, matter, product, reactants, solid, liquid, weight

Background

Matter is the "stuff" of the universe. Everything that has mass and volume, no matter how small, is considered matter. Air, water, rocks, trees, stars, and animals all consist of matter. Matter can exist as a solid, liquid, or gas and can change in many different ways. Physical changes are those in which the weight of the matter stays the same. At the end of a physical change, the substance is still essentially the same. For example, chopping up a carrot or ice melting into water are both physical changes. Dissolving dirt into water would also be considered a physical change because the weight would equal that of the water and the dirt. Chemical changes are those where one or more substances are combined to produce a new substance. Sometimes, the product weighs the same as the ingredients. Sometimes, matter is converted into energy and emitted in the form of heat, light, or sound. At the end of a chemical change, you have a fundamentally new substance. Burning a piece of paper would be a chemical change, as would baking a cake.

Clean air is a common, often under appreciated resource of the public lands of the Colorado Plateau. The Clean Air Act names 160 federal lands with pristine air quality and mandates that air quality at these sites be monitored, preserved, and enhanced. Sixteen of these sites are on the Colorado Plateau; one site is in the Island in the Sky District of Canyonlands National Park. The equipment there measures fine particulate, acid rain, and ozone levels.

Some fine particles, or particulates, are always present in the air. The number of particulates varies; high numbers result in the visible part of air pollution. Particulate sources can be natural or human-caused. They can be the

Group at Mesa Arch

result of both chemical and physical changes in matter. They can include dust and sand from roads, fields, and windstorms, smoke from burning leaves, forest fires, and wood-burning stoves, and exhaust from cars and industries. Particulates remain in the air until gravity slowly filters them out.

Ozone is an invisible gas that is a form of oxygen. High levels of it in the lower atmosphere can cause human health problems and can contribute to the greenhouse effect. Car exhaust, the result of a chemical change in fuel, is a major contributor of ozone to the lower atmosphere. However, ozone plays a positive role in the upper atmosphere. The upper atmosphere ozone layer blocks much of the UV sunlight from reaching the earth's surface. Normal quantities of UV light are good for such things as plant growth and suntans. But, the increase in UV light that would result from a damaged ozone layer would lead to increased incidences of skin and eye disease in humans and damage to some wildlife and plants.

The single largest factor in the destruction of the ozone layer is a family of chemicals called chlorofluorocarbons (CFCs). This reaction is a chemical change in the ozone molecule. CFC's were used in manufacturing hundreds of different products, including Styrofoam packaging, aerosol spray cans, and the coolants in refrigerators and air conditioners. Their use has been outlawed in the United States and many countries. Even if all countries quit using CFCs, however, they will linger in the upper atmosphere for decades. At Canyonlands National Park, ozone is monitored at ground level. UV light is also monitored, which indirectly reflects the condition of the upper atmosphere ozone layer. Scientists monitor ozone levels in order to study trends in national parks as well as global trends.

Looking for ways that matter changes in nature on the way to Mesa Arch

PRE-TRIP ACTIVITY
Matter What?

Objectives
Students will be able to:
a. Define matter.
b. Describe the difference between physical and chemical changes in matter

Materials
Apple; scale; cards showing a picture of a substance both before and after a change.

PROCEDURE

1) Ask students to define *matter* (anything that has mass and volume). Explain that matter can be large or small and that you may or may not be able to touch and see it, even with the aid of a microscope. Have students list some things that might be matter (i.e. books, desks, themselves, air, water, bugs, etc…). Tell students that matter exists in three forms, and see if they can name and define them. A *solid* is a substance that has a definite volume and shape. *Liquid* is a substance that has a definite volume but changes shape to fit its container. A *gas* is a substance that has neither shape nor definite volume. Ask students to give examples of each form. Write types and examples on the board.

2) Tell students that matter changes in two ways. Physical changes occur when an object changes form, but is still basically the same. Describe this change by discussing water. Ask students to describe what happens if you put a container of water in the freezer. Explain that although it changes form, it still is the same water. Tell the students that if they heated the ice up, it would return to the liquid water state and that there would be the same amount of water in the container. Tell students that you are going to demonstrate by using an apple. Have a student place the apple on the scale and tell the class its weight. Cut up the apple, and have another student place the apple bits on the scale and read the weight. Ask the students if the apple has changed its form. Has the apple changed what it is? Is there still the same amount of apple on the scale? Tell the students that this is a physical change.

3) Have the students eat the bits of the apple. Tell the students that they have just caused the apple to go through a chemical change. Ask them if the apple is still an apple. Would it ever be possible to reassemble it as an apple again? If we were to isolate the pieces of apple would they weight the same? Why not? What has been added or removed by your stomach? Tell the students that you have caused the apple to go through a chemical change. When a substance undergoes a chemical change, it combines with another substance or energy, such as heat or light to become a new substance.

4) Tell the students that they are going to try and figure out the way matter changes. Tell students that for this activity they will need a partner. Give everyone a change card. Have the students look at the cards and identify how the object or objects were changed. The students should then turn to their partner and share their card and conclusions. See if the partner agrees. Pass the cards to another group and repeat until time is up or cards have gone around the room.

5) Ask students if there were any examples that were easy to understand. Have students name them. Ask students if there were any examples that were difficult to figure out; discuss these. Tell the students that during the upcoming field trip, they will be looking at physical and chemical changes in matter in the real world. Have students list the things they will need to remember to bring for a winter field trip. Write the list on the board.

EXTENSION

As a class, mix the ingredients to make a large batch of cookies. As you add each ingredient, discuss what changes the ingredient has gone through, including if those changes were chemical or physical. For example, wheat changed chemically as it was growing, but only physically when it was ground into flour. Bake the cookies in the lunchroom, and discuss that adding the heat of the oven is creating a chemical change in the cookie batter. Eat the assignment.

STATION #1
Particulates and Filters

Objectives

Students will be able to:

a. Describe at least two sources of particulate matter in the air, and discuss if these particulates result from physical or chemical changes.

b. Give a basic description of how the equipment at the filtering station or transmissometer room operates.

Materials

Pictures of a city with clean and dirty air; 4 plastic funnels; paper coffee filters; water spray bottles; extra water; hand lenses.

PROCEDURE

1) Briefly discuss what makes Island in the Sky a popular place to visit. Emphasize views and clean air. Ask students if they believe there is matter in the air. Explain that there are often particles or particulate matter in the air that can obscure these views. Tell the students that since matter is constant, it has to come from somewhere. Discuss where these particulates came from (i.e. dust from dirt roads, smoke from fires, water vapor in clouds, etc…). For each type of particulate, discuss if its location in the air is the result of a chemical or a physical change. Show dual pictures of a city on a clean-air day and dirty-air day. Ask if any students have been somewhere where they could see the air, and discuss (include that city pollution is often the result of chemical changes in the fuels we use).

2) Tell the students that the air in southeastern Utah has been classified as type "A," meaning that we have some of the cleanest air in the country. At Canyonlands National Park, scientists measure the amount of matter in the air so that the national park system has baseline data of its clean air. This data would be useful if the air became "dirty" and we had to reduce point-source pollution. Explain that a telescope-like machine, the Transmissometer, sends a beam of light to a receiver at Dead Horse Point State Park, 6 miles away. Have students line up at the fence and try to throw a snowball (or a rock) as far as they can. Most of the snowballs will impact on trees. By measuring how many snowballs got through the trees, we would know how dense the forest is. The transmissometer works the same way. By measuring how much light is received at Dead Horse Point, we know how many particulates are in the air.

3) Show students the Transmissometer Room. This can be done at the beginning or end of the station, depending on the time. The group should not be in the room during the hourly monitoring time, which is between the hour and 16 minutes after the hour. Turn the dial to *ON* (but only between 16 past and the hour), and have each student take a turn looking through, being careful not to bump the gun. They may see a twinkle of light as they look through; this is the light beam hitting the receiver. The machine will chirp until you return the dial

Discussing air quality at the island in the Sky

to off. The information is sent back from the receiver into the computer on the table. Inform students that the farthest the human eye could possibly see, if the world were flat and the air perfectly clear, is 243 miles, the distance to Salt Lake City. Have them guess how far they could see today. Turn the A1 switch from *C* to *B,* but only if it isn't exactly half-past the hour, as this is when data is sent out. Then have a volunteer student use the readout number and the posted orange chart to determine the actual visibility of the moment. Compare to predictions. Do not forget to turn the switch back.

4) Go to the air quality filtering station. Show and discuss different types of filters. If the machine is not currently filtering (you'll hear it if it is running), a filter cartridge can be taken out and shown to the kids by pushing one of the red buttons until the cartridge pops off. To put it back, align the holes, seat, and push the other red button until it beeps at you. Show and explain how the equipment filters out different air particulates. Ask students why scientists might want to know what particulates are in the air. Ask students if they believe that filtering the air results in a chemical or physical change to the air. Discuss the difference between the filters that cause a physical change and chemical scrubbers that are used in factories.

5) Ask students how they think the particulates get out of the air. Ask if they think this process is a chemical or a physical change. Tell the students to look around them the answer; explain that the plants around them are holding dust (adapted from National Park Service and others 1989, 4-9). Tell the students that they will be conducting an experiment to answer this question. Have students gather closely, and pull out of your backpack a spray bottle of water, a plastic funnel, and a paper coffee filter. Demonstrate how they will use these. Explain that one student will spray water over some leaves into the funnel filter held by another student. Describe boundaries, put students in pairs, and give each pair a water bottle, funnel, and filter.

OPTIONAL

Have students find the "cleanest" and "dirtiest" plants within a designated area, including a roadside area if possible.) After students work for a few minutes, have them gather and examine the particulate content on their filters by using hand lenses. Discuss how plants filter the air and under what weather conditions (dry) and in what locations (near roads, etc.) they would expect to find the dirtiest plants. Summarize and review.

Learning how plants remove particulates from the air

STATION #2

No Zone for Ozone

Objectives

Students will be able to:

a. Explain why upper atmosphere ozone is beneficial.

b. Describe what type of reaction physical or chemical is causing ozone depletion.

c. Describe why ground level ozone is harmful to humans.

Materials

Clipboard with paper and pencil/marker; *ozone depletion* poster; map of ozone hole (Berman, 2002); ozone game tags.

PROCEDURE

1) Ask students if they can describe matter. Explain that matter can be so small you cannot see it, but it still exists. Tell the students that at this station, you will be talking about matter as individual molecules. In particular, you will be discussing the ozone molecule. Ask students to relate anything they know about ozone. On a piece of paper, draw the ozone layer as a "blanket" around the Earth. Discuss the benefit of the ozone (i.e. blocking some of the sun's ultraviolet (UV) rays).

2) Have students act out the *Ozone Depletion* poster to describe the chemical changes that CFC's are causing and explain that these chemical changes have created holes in the ozone layer. Have students pretend to be oxygen atoms and link arms to become ozone molecules. One kid will play the part of Charlie Chlorofluorocarbon. As the students act out the poster, tell a story about how each of the atoms interacts. Emphasize that in the fifty years or so that it will take Charlie to drift back to the earth's surface, he can do a lot of damage to the ozone layer. Show the students the ozone layer map, and discuss effects of the ozone hole. Explain that the hole is estimate to close by 2050. Relate the story as one of success (we are solving a huge problem), rather than one of failure (we created a huge problem.)

2) Discuss Canyonlands National Park's role as a monitoring site. Point out the equipment on the high scaffold, which includes a lens that constantly measures incoming UV rays and indirectly accesses the condition of the upper atmosphere ozone layer. (We do not take the kids up the scaffold because a shadow cast across the lens will affect the data. The machine is wired to a computer in the ozone shack, the one on the upper left as you walk in the door, where the information is processed and sent to a scientist in Athens, Georgia.)

3) Referring back to your drawing, tell students that ozone also exists in the lower atmosphere. Discuss the chemical reactions that create lower level ozone (pollution) and make it harmful to living creatures (it reacts with carbon). Ask students if anyone has ever visited a big city with bad air. Did they have a difficult time breathing?

4) Tell students that the ozone shack measures the lower level ozone. Walk over to the tower outside the shack, and lower the tower using the rope. In the underside, there are two filters. The green one has a filter that collects little to no particulate matter so as to have a clean sample. The other, wider filter takes a sample of the particulate matter to be analyzed in the lab. Discuss why it would be helpful for a scientist to know what particulates occur during times of high lower atmospheric ozone. Point out to the students that both filters are connected to tubes that run the length of the tower and into the building.

5) Review the detrimental effects of lower atmosphere ozone and that it is an invisible and odorless gas. Inform students that ozone concentrations in the lower atmosphere are affected by weather conditions, so both weather and ozone is monitored daily. Point out the nearby weather station. Ask students not to touch anything in the ozone shack, and explain that the equipment is sensitive to changes in air temperature and quality (the door needs to be opened and closed as quickly as possible). Once inside, follow the tubes as they enter the building and go to the rotometer on the wall on the right. This machine measures the amount of air flowing through the machines. The silver, floating ball measures airflow in liters per minute. Discuss why scientists would want to make sure the amount of flow is consistent.

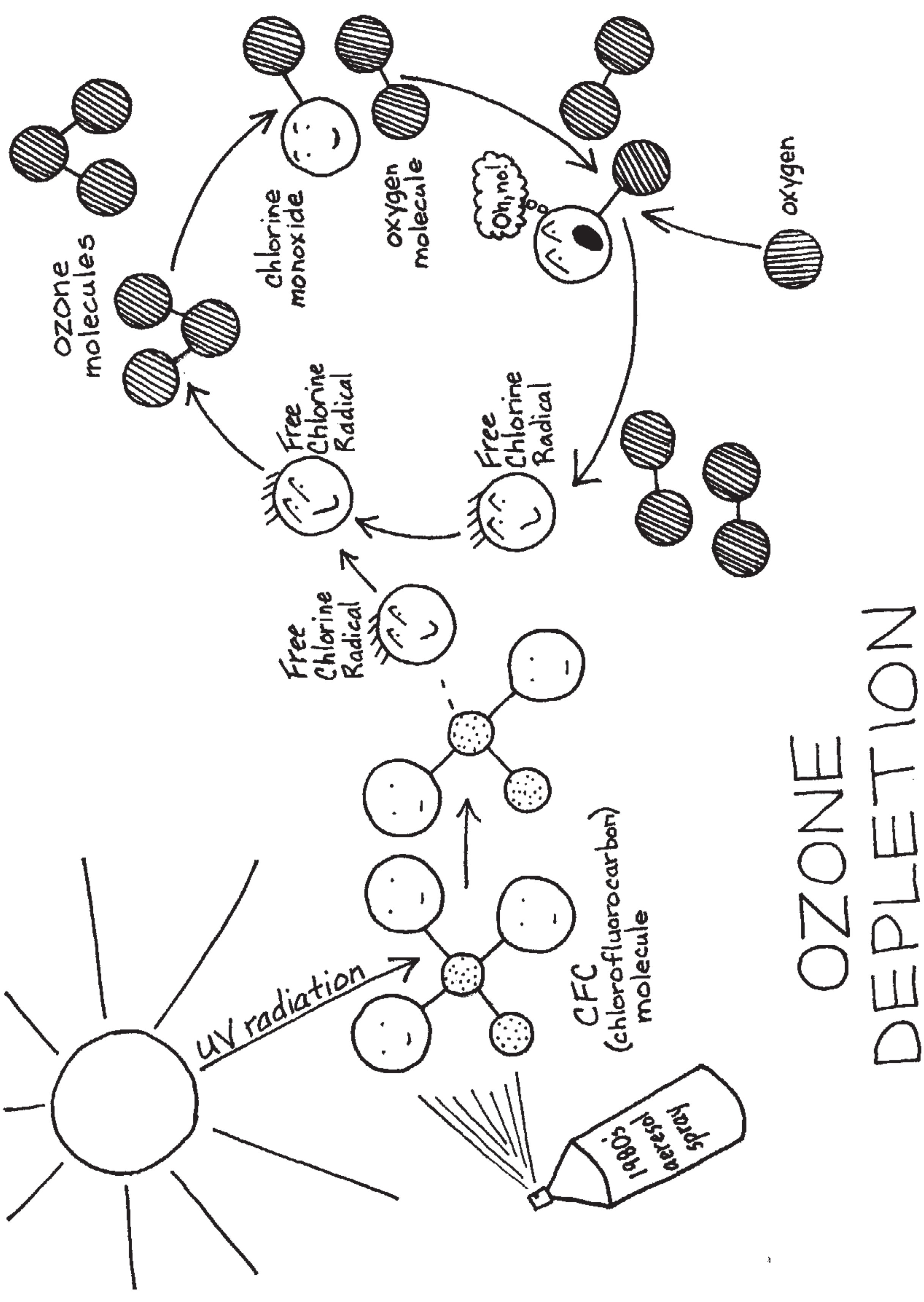
6) Have students follow the tube into a "manifold" which separates the gasses and then into the analyzer. Ask students if separating the gasses would be a physical or chemical change to the air. In the bank of computers/machines in the center of the room, the analyzer is the one on the top, closest to the wall. It displays how much ozone is in the lower atmosphere. Have the students read the number, including the decimal and PPM. Discuss PPM and how that number would be different if the machine was in a big city. (The machine just below the analyzer that looks just like it calibrates the analyzer, so the readings are exact; there is no need to discuss it much.) Point out the two computers to the left of the analyzer. Explain

that these computers compile the data and send it electronically to scientists in Fort Collins, Colorado.

7) Play Ozone Depletion Tag with as many students, teachers, and parents as you can round up. Review the beneficial properties of upper atmosphere ozone. Explain that CFCs destroy this ozone. Define boundaries, and have each participant pick and secretly look at one card to determine what type of upper atmosphere gas they will be. Have participants return their cards, and inform them that one of them is a CFC while the rest are ozone. Ask students to spread out, floating in the upper atmosphere. Instruct them that when you say, "go," the CFC should destroy ozone by tagging them. Once an ozone is tagged, it acts as a free radical chlorine and may tag other ozones. It doesn't take long until all of the ozone is gone. Play two or three rounds.

OPTIONAL ACTIVITY

Play Silent Killer to reinforce the concept of the hidden nature of ozone depletion (adapted from Fluegelman 1981, 81). Have players sit in a circle; then, distribute and recollect the cards as in the previous game. Instruct the unknown CFC to wink at an ozone when no one else is looking. Instruct any ozone that is winked at to *quietly* pause a few seconds and then say, "I've been destroyed." All live ozones should watch carefully and try to identify the CFC killer.



OZONE DEPLETION
UV radiation
CFC (chlorofluorocarbon) molecule
1980's aerosol spray
Free Chlorine Radical
Free Chlorine Radical
Free Chlorine Radical
ozone molecules
chlorine monoxide
oxygen molecule
oxygen
Oh, no!

STATION # 3

As a Matter of Fact

Objectives
Students will be able to:
a. Describe the difference between chemical and physical changes in matter.
b. Name one chemical and one physical change that can be observed at Canyonlands National Park.

Materials
Paper; pencils; field guides.

PROCEDURE

1) Take the bus with the students to the trailhead of the Mesa Arch Trail. Once on the trail, stop and explain to students that they are going to hike and look for ways that matter changes in nature. Tell them that it is important to pay attention because there will be an activity at the arch that incorporates what the group has talked about on the hike. Ask students to describe matter and to define physical and chemical changes in matter.

2) Hike to the arch. Along the way, point out examples of physical and chemical changes in matter (i.e. plants absorbing nutrients out of the ground, plants changing carbon dioxide into oxygen, photosynthesis, animals eating plants, animal scat, animal tracks, erosion of rock, creation of the canyon and arch, snow melting, and sand transportation).

3) At the arch, give students a piece of paper and have them fold it in half twice, once lengthwise and once widthwise, to make four boxes. Tell the students to draw a physical or chemical change that they have observed in each of the boxes. Each drawing should be labeled and the type of change should be included.

4) Have each student present a drawing to the group. Collect the papers to give to the teacher. Hike back to the bus.

EXTENSION

Have the students write a story from the point of view of a substance undergoing a chemical or a physical change. For example, Joe Nutrient, who is happy in a rock, gets eroded and used by a plant. Stories should be descriptive, in the first person, discuss whether a chemical or physical change is occurring, and have a title.

The trip to Mesa Arch

POST-TRIP ACTIVITY

It Does What?

Objectives

Students will be able to:

a. Describe a physical and chemical change that occurs to matter.

b. Name two indicators of a chemical change.

Materials

Five jars; balloons; poster with a list of students' choice of ingredients; milk; vinegar; baking soda; lemon juice; rock salt; Mountain Dew; dish soap; Milk of Magnesia; investigation sheets; scales; 5 thermometers.

PROCEDURE

1) Review the information students learned on the field trip. See if they can name some physical and chemical changes that they observed in nature. Tell the students that they are going to investigate changes in matter by conducting scientific experiments. Review the definitions of physical and chemical changes, and ask the students to list some indications that a chemical change has occurred. Write these on the board. The list should include: production of heat, cold, light, a gas, change to solid, and change colors.

2) Divide the class into groups of four or five. Tell students that they are going to be performing science experiments and recording the results. Hand out science investigation worksheets, and discuss the experiment's procedure with the class. Tell students that they will be able to choose two or three things from the poster to mix together. Describe the choices for the students. Ask students to designate one person from the group to fill out the investigation sheet and two people to collect materials. Have the collectors get jars, scales, thermometers, and balloons for each group. Ask each group what they would like to try and mix. Give the ingredients to the students. Have students predict the results of the experiment. Then, they should add both ingredients to the jar, quickly putting the balloon on top

3) Have students examine their results. Weigh the finished product, and observe the temperature. If the balloon changed, measure the balloon. Then, record their results. If matter seemed to disappear (chemical change), students must record where it went (i.e. converted to energy or was emitted as heat or light). In complete sentences, the group will need to record their conclusion. Their conclusion should include what they mixed together and whether a physical or chemical change occurred. They should support their conclusion with a justification of why they believe the change to be chemical or physical. Have students pour their concoctions in the sink. Allow students to repeat the experiment (filling out new investigation sheet for each mixture) as often as time allows.

4) Have groups present their experiments to the class. Students should explain what they mixed, what happened, and if it was a chemical or physical change.

MATTER INVESTIGATION

Scientists Names ____

Question: What happens when you mix ______________ and _________________?

Hypothesis:

____

____

____

____

Procedure:

1. Measure materials

2. Mix Materials

3. Observe results

4. Measure results

Results:

____

____

____

____

Conclusion (What type of reaction occurred? How did you know?):

____

____

____

____

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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

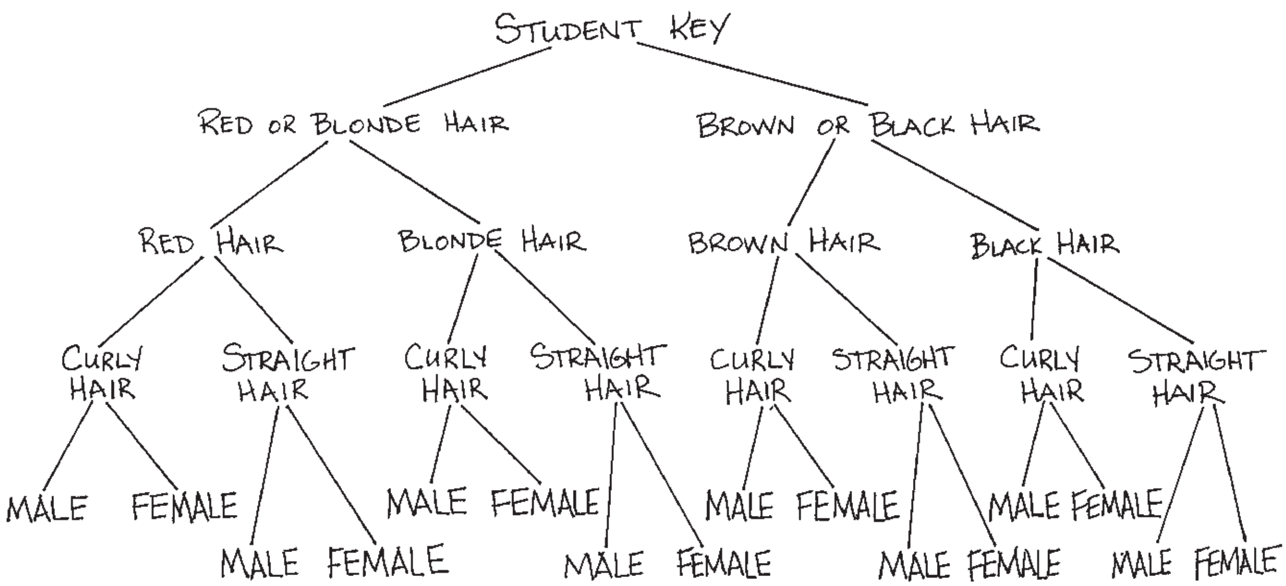
1) Define *riparian*. Explore the interactions of plants and animals in a riparian community. (Use the poster if you wish.) Mention that most of the wildlife in Utah depends on riparian areas for their survival. Have students think of some conditions that plants living near water in the desert must be 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

Always shorter than a human

- Triangular stem
  SEDGE
- Round stem
  - Hollow, segmented stem
    HORSETAIL
  - Hollow stem with flowers on tip or side
    RUSH

Sometimes grows taller than a human

- Woody stem (Tree or shrub)
  - Scale-like leaves
    TAMARISK
  - Leaves not scale-like
    - Leaves much longer than wide
      - Green leaves, no thorns
        - Leaf edges smooth or slightly toothed
          WILLOW
        - Leaf edges toothed, flower clusters at tops of branches
          SEEP-WILLOW
      - Silvery, fuzzy leaves. Plant has thorns.
        RUSSIAN OLIVE
    - Leaves not much longer than wide
      - Leaves in groups of three
        BOXELDER
      - Leaves not in groups
        - Leaves always less than 2 inches across
          WATER BIRCH
        - Leaves often more than 2 inches across
          COTTONWOOD
- Non-woody stem (Herb)
  - Round, hollow stem with flowers on tip or side
    RUSH
  - Flat blade-like leaves with big sausage-shaped fruits on top
    CATTAIL

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.

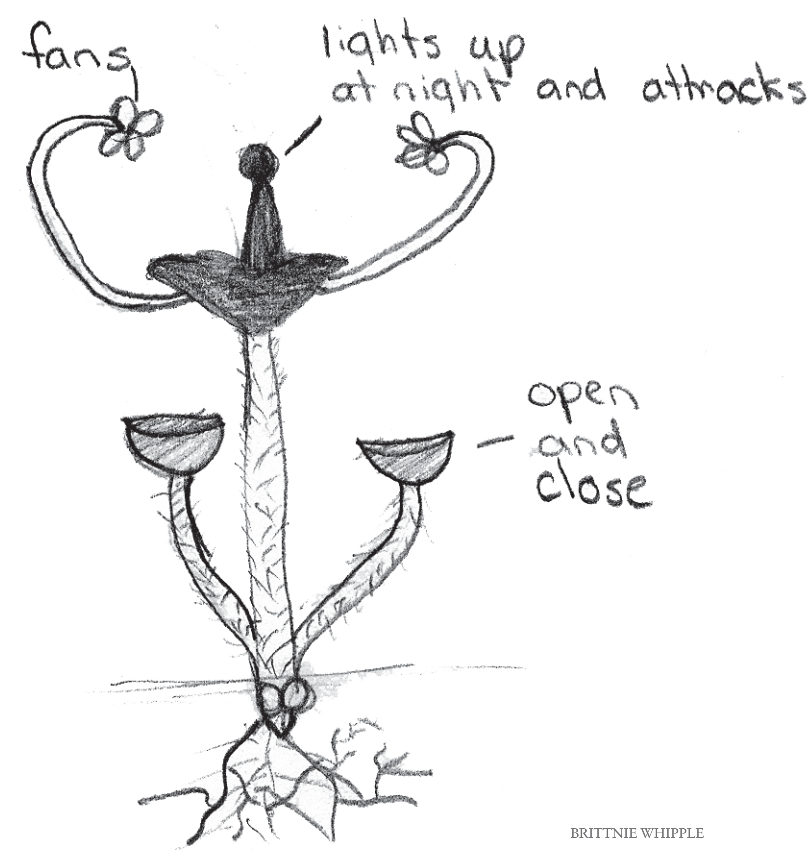
PROCEDURE

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



BRITTNIE WHIPPLE

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