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## Standards

**Arizona**

> **6.L2U3.12:** Engage in argument from evidence to support a claim about the factors that cause species to change and how humans can impact those factors.

> **6.L2U1.13:** Develop and use models to demonstrate the interdependence of organisms and their environment including biotic and abiotic factors.

**NGSS**

> **MS-LS2-1:** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

## Materials

> **PowerPoint**
Plant Adaptations for Arid Lands
> **Blank White Paper**
> **Colored Pencils**

## Overview

This lesson introduces students to the idea of a biological adaptation and explains how plants adapt to a desert environment. Students will get to create their own imaginary plant that is adapted to the desert.

## Goals

• Students will be able to recognize and explain the adaptations that allow plants to live in a desert.

## Learning Objectives

• Students will be able to create an imaginary desert plant that is correctly adapted for arid lands after learning about several real desert plants and their adaptations.

## Vocabulary

• **Adaptation:** (noun) A change by which an organism or species becomes better suited to its environment. Can be either a physical change to the body or is a behavioral change.

• **Dissipate:** (verb) 1. To disappear or cause to disappear. 2. To lose (heat, electricity, etc.)

• **Legume:** (noun) A type of plant that produces long seedpods such as beans, peanuts, and lentils. Most legume plants have specialized groups of bacteria on their roots (called nodules) that convert nitrogen from the air and make it available in the soil for plant uptake.

## Set Up

Plan for either digital access or access to live plants: saguaro, creosote, palo verde, ocotillo, mesquite, guar, and guayule. If you can take the class outside, be ready to identify and explain to students the adaptations of each plant. For at home schooling adaptations, you may ask students to identify these plants in their own yards or neighborhoods or by having them take a photo and sharing. For an online presentation, follow the notes in this lesson plan and process noted on each slide of the PowerPoint presentation.

## Lesson Procedure

Follow the PowerPoint as a guide to the lesson.

### Step 1: Introduction (5 minutes)

Slide 2: Conduct a think, pair, and share using the following question: What do you notice about plants in the desert compared to plants in forests? **What are some of the conditions plants in arid lands experience compared to plants in**

## Lesson Procedure (*continued)*

**forests?** After students discuss this question with their groups, ask the class to share possible answers. The expected answers include the following ideas:

- The ability of the plant to get enough water during harsh desert conditions.
- The intense heat and light that plants experience in the desert.
- The soils surrounding the plants may have poor conditions such as limited amounts of nutrients.
- There is intense wind in the desert.

### Step 2: Definitions and examples: Adaptations (5 minutes)

Slide 3: Share the definition of "adaptation" provided. Discuss the idea that adaptation types are either physical or behavioral. An example of a physical adaptation is that our human bodies can tolerate and adapt to heat by sweating. A behavioral adaptation would be seeking shade in the intense sunlight and heat of the day.

Review the parts of the term "adaptation" and give an example of a sentence containing the verb (adapt to) and noun (adaptation). The noun adaptation is derived from the root verb "adapt". **Sample sentences could be:** Some plants adapt themselves to harsh living environments very well. Adaptations to the environment help plants conserve food, energy, and water.

Slide 4: Provide examples of a physical adaptation and a behavioral adaptation. For the physical adaptation, the example of the kangaroo rat is provided. A kangaroo rat doesn't need to drink water because hydration is from seeds. It can also be mentioned that kangaroo rats don't urinate when they get rid of waste. Instead, they excrete small solid waste pellets. In the behavioral example, you can provide a concrete example such as a student not usually wanting to play or run outside at noon during the middle of summer.

Slide 5: Discuss the idea that plants have their own challenges in adapting to desert conditions. Explain the need for plant physical adaptations with the following ideas.

- Plants can't physically move to another location, which makes it impossible to relocate to another place with more water or find a location where there is shade.
- Plants must develop physical and behavioral adaptations to deal with conditions such as a lack of water and too much sunshine or heat.

### Step 3: Discussion of specific desert plants with adaptations (15 minutes)

Note: Before beginning this part of the lesson, mention to the students that they should take notes on the specific adaptations presented in the PowerPoint. They will use those notes later to design a plant that has its own adaptations. Each slide discusses main adaptations for 7 distinct species (use the written points on the slide). A summary of each point is provided in the descriptions below.

Slide 6: **Saguaro** (*Carnegiea gigantea*) Adaptations

1) Saguaros have spines that dissipate heat and provide it with shade. Present the definition of **dissipate** (see vocabulary list on page 1).

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## Lesson Procedure (*continued*)

2) You will notice how some saguaros get bigger after a rain. They can expand and contract like an accordion because they store water in their stem.

3) They have shallow roots that spread wide underground. They spread as wide as the height of the saguaro in all directions. This allows them to gather more rainwater from a storm.

4) Like all cactus, saguaros have a special version of photosynthesis that allows them to save or release less water. They only open their pores (stomata) at night to release water (crassulacean acid metabolism or "CAM" photosynthesis).

Slide 7: **Creosote** (*Larrea tridentata)* Adaptations

1) The leaves have a thick, waxy coating that reduces the loss of water. This is similar to humans wearing a raincoat during rain. This waxy coating is made of chemicals that you often smell during a summer rain.

2) The leaves of the creosote are very small. Smaller leaves mean there is less area on the leaves which leads to less water loss.

Slide 8: **Palo Verde** (*Parkinsonia florida)* Adaptations

1) When the weather is very dry, leaves tend to fall from the plant. This prevents water loss from the palo verde.

2) The bark on the tree trunk and branches is green, so there are more areas for photosynthesis to occur. It is also why the plant is named palo verde, which means 'green stick' in Spanish.

3) Soil in the desert is often of poor quality with few nutrients. The palo verde puts nitrogen back into the soil from its roots, which allows the tree to absorb nitrogen later when it needs it. Tell students that the plant is a **legume** and provide the definition (see vocabulary list on page 1). There are more examples of legumes in the upcoming slides.

Slide 9: **Ocotillo** (*Fouquieria splendens)* Adaptations

1) Similar to the palo verde, the leaves drop off the plant to save water. However, the ocotillo only has leaves shortly after a rain. When it starts to get dry, they fall off.

2) The ocotillo also has thick, waxy bark to decrease water loss from the plant-- similar to the creosote.

Slide 10: **Mesquite** (*Prosopis velutina)* Adaptations

1) Like the creosote bush, the mesquite tree has small leaves to reduce the amount of water loss.

2) Mesquite has very deep tap roots that enable the tree to find water underground. This is important when it is dry. Fun fact: Scientists found a mesquite tree with a 300- foot taproot near the Pima Mine in Arizona.

3) Similar to the palo verde tree, mesquite also adds nitrogen to the soil and can absorb nitrogen later when it needs it. Nitrogen is important for plant growth because it provides energy to the plant cells. More information is provided on the website available in the notes section of the slide.

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# Lesson Procedure (*continued*)

## Step 4 – Discussion of desert adaptations for SBAR plants (guayule and guar): (5 minutes)

Slide 11: **Guar** (*Cyamopsis tetragonoloba)* Adaptations

1) Guar has deep tap roots similar to mesquite but not usually as deep.

2) An advantage of guar is that it only needs to be watered 3-4 times before the beans are ripe for harvest. This saves on water resources. Many other crops that are grown in the desert need to be irrigated every week or every other week.

3) Guar adds nitrogen to poor quality soils and is also a legume plant like the mesquite.

4) It thrives in the heat but does poorly in cold weather. Therefore, it should live in desert environments where it rarely freezes during the night.

Slide 12: **Guayule** (*Parthenium argentatum)* Adaptations.

This plant is a plant native to the Chihuahuan Desert. You could find out from the students if they know where the Chihuahuan Desert is and then describe the area for them (parts of Arizona, New Mexico, Texas, and most of the state of Chihuahua in Mexico).

1) The guayule plant produces rubber in its bark, which helps it retain moisture. This is similar to humans using rubber boots to protect their feet from water. The rubber is like a milky latex mixture which helps keep the water within its stems.

2) It produces resins, which are organic compounds made in its leaves and stems. These resins are a natural insecticide that help keep bugs away, so they don't eat the plant.

3) Guayule has leaves that have a grey color. This allows the plant to reflect sunlight, which means the plant rarely gets too hot or becomes overstressed.

Comprehension check: Before moving on to the next activity, answer the questions that students might have. Alternatively, you can ask them to list two ways that plants adapt to their environments.

## Step 5 – Draw an imaginary plant with 3 plant adaptations (20 minutes)

Slide 13: Students will use their plant adaptation notes to design and draw their own imaginary or 'super' plant that can grow in arid regions. Students should use their imaginations to create a unique-looking plant. Ask students to incorporate at least three plant adaptations. Two of those adaptations can be adaptations discussed in the PowerPoint. At least one adaptation should be a new one. For example, the way that plants protect themselves from predators in the desert.

A. Provide blank white paper and regular and colored pencils.
- Students should name their imaginary plant.
- Students should label and explain the three adaptations in one to two sentences.
- At least one of those adaptations should be an idea not shown in the slides.

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- Give the students at least 10 minutes to work on their imaginary plant drawing.
- A helpful prompt (if needed): Ask students to brainstorm possible adaptations that correspond with three areas of the plant (leaves, stems/trunk, roots).

B. Collect the plant drawings.

C. Slide 14: Options for discussion or assessment
   a. Use drawings as assessments of their understanding of plant adaptation.
   b. Gallery walk: Hang drawings around the room, students circulate and discuss.
   c. Formal class presentations by each student.

D. Prompts: What are the most creative adaptations? How would these adaptations work under different conditions (high rain, cold temperatures, hotter temperatures?

**Further Exploration (Resources, links, topics, etc.)**

- Adaptations of Desert Plants (Cactus) For Kids – Make Me Genius India (April 2015).
- MA Dimmitt (1997). How plants cope with the desert climate. Sonorensis v 17 n 1. Arizona-Sonoran Desert Museum. https://desertmuseum.org/programs/succulents_adaptation.php
- Chapter 4 Science: Chapter Adaptations in Plants | Plants Adapted to Deserts – MBD Alchemie (July 2018). https://www.youtube.com/watch?v=suGhiGavxmw&t=12s
- Field Trip – Plant Adaptations. Canyon Country Outdoor Education – Fifth Grade Curriculum p33-45. https://nps.gov/arch/learn/education/classrooms/upload/FifthGrade_PlantAdaptations.pdf
- OS Nag (July 2019). What are the special adaptations of desert plants? World Atlas. https://worldatlas.com/articles/what-are-the-special-adaptations-of-desert-plants.htm
- Sustainable Bioeconomies for Arid Regions Center for Excellence https://sbar.arizona.edu

**Author Biographies**

**Traci Klein** grew up mostly in Massachusetts, then came west to go to Brigham Young University. She graduated with a BA in Comparative Literature in 1993. After a stint in Salt Lake City, while her first husband went to medical school and their two boys were born, they moved to Tucson. Traci decided to switch fields and did graduate work in Plant Sciences at the University of Arizona and worked as a lab researcher for several years. After taking time at home to raise her sons, and after a divorce, she decided to dip her toes into education and began working as a long-term substitute in the Baboquivari School District on the Tohono O'odham nation while taking online education classes. She received her teaching certificate and has been teaching 7th-grade science at Valencia Middle School for 6 years. She has also been the MESA (Math Engineering Science Achievement) Club Advisor for 5 years. Currently, she is enrolled in the Masters in Educational Leadership program at Northern Arizona University and hopes to go into education administration.

**Matthew Katterman** is a doctoral graduate student at the University of Arizona studying Biosystems Engineering. He is interested in irrigation engineering along with computer modeling of the guayule production system. He also has an intense interest in bioproducts and biofuels production. Matthew is a native of Tucson, Arizona, and received his Bachelor's in Chemistry in 1997 as well as his Masters in Agricultural and Biosystems Engineering in 2004.

**Arisbeth Ibarra Nieblas** is a doctoral student in Environmental Engineering at the University of Arizona. She majored in Chemical Engineering at the Technological Institute of Sonora (ITSON), Ciudad Obregon, Mexico. Her graduate research involves developing a continuous corrosion monitoring station for water delivery pipe metal. As a fourth-year SBAR Fellow, Arisbeth continues to create educational content for middle school-aged students, including science experiments and activities that involve complex topics like bioeconomy.

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