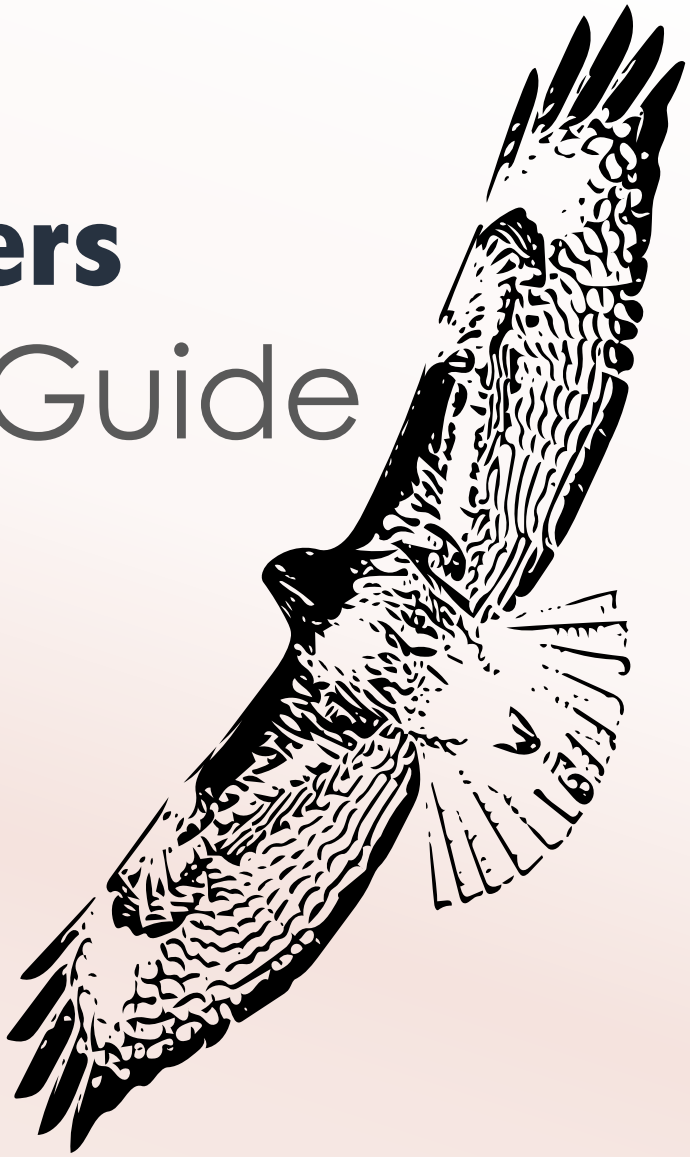
Mojave Explorers

Curriculum Guide



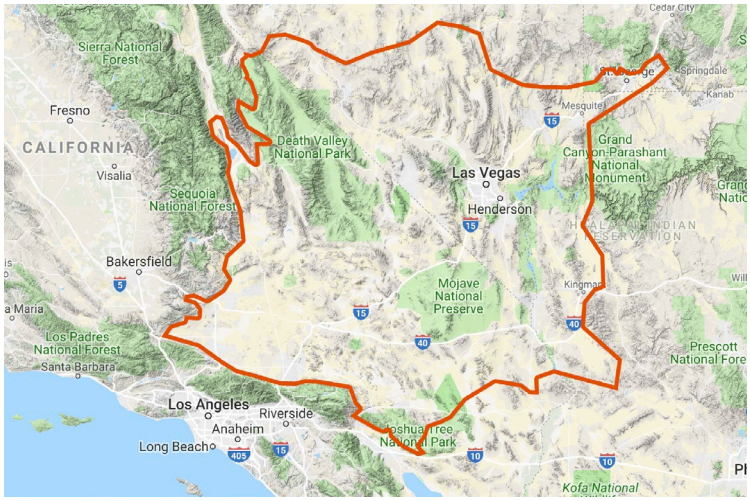
Contents

Mojave Explorers *Curriculum Guide*

Building Students' Understanding of the Mojave Desert

Incorporating the local ecosystem into our lesson plans not only builds a student's appreciation for the wildlands in their backyard, but it also enhances the relevance of each lesson. Curriculum standards are no longer abstract concepts, but landscapes and processes that students can observe on a daily basis in the environment around them.

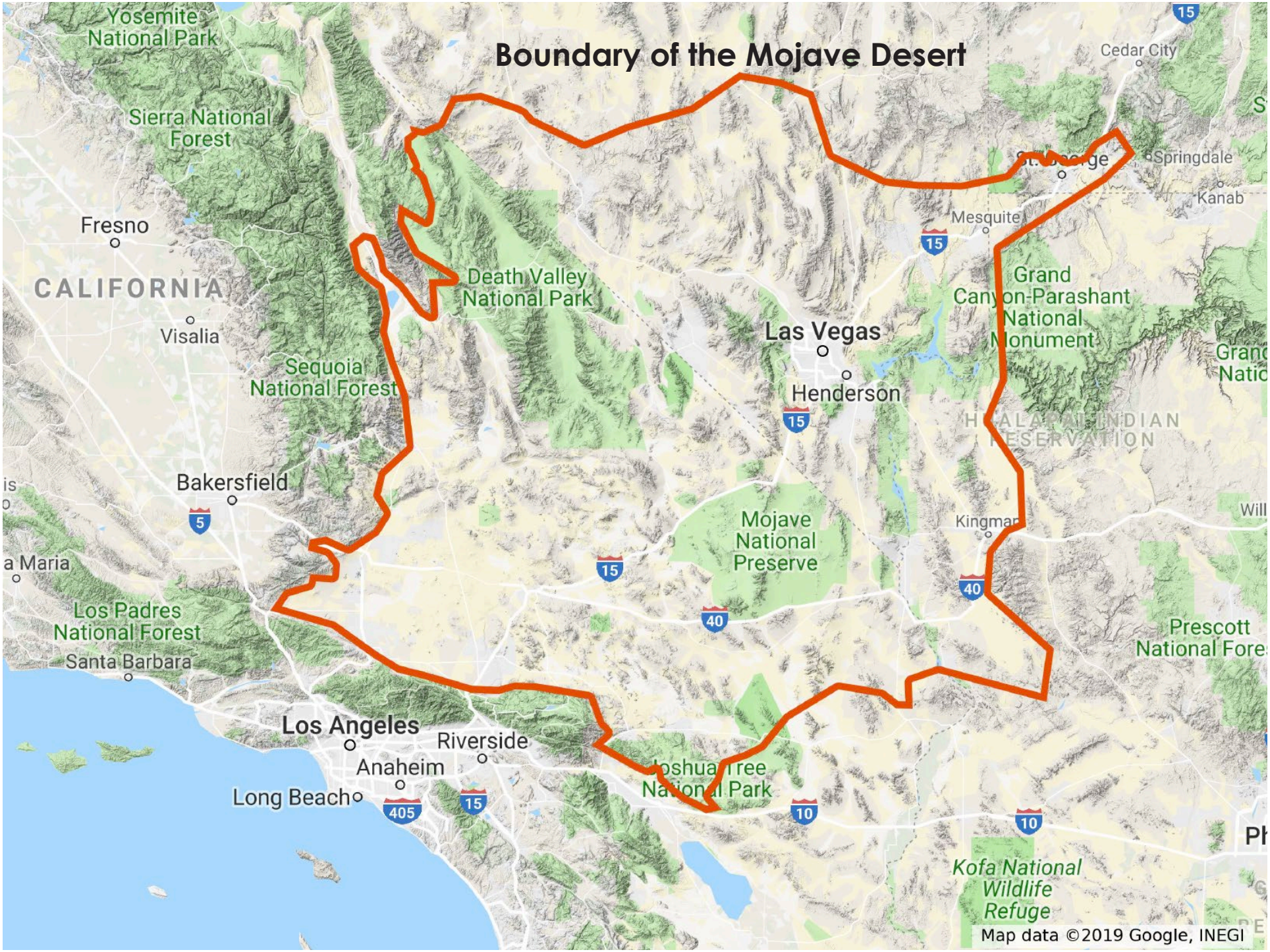
Hundreds of thousands of people live in cities across the Mojave Desert. From Las Vegas to Victorville, Palmdale to Needles, Ridgecrest to Twentynine Palms. But they may not always have opportunities to learn about the Mojave and its wild inhabitants. Brief references to desert ecosystems in their text books are likely to mention the camels that roam the Arabian Desert and the saguaros that can be found in the Sonoran Desert. Building students' understanding about the ecosystem in their backyard is a great way to spark their curiosity in nature, as well as a means to enrich curriculum.



The Mojave Desert spans across parts of California, Nevada, Arizona and Utah. Click on image to expand. Click again to minimize.

This guide provides plans for educators to weave the Mojave into lessons on Earth and Life Sciences, for elementary through middle school grade levels. Many of these activities involve the Mojave Explorers Wildlife Guide, a free online resource that provides an overview of the Mojave landscape and wildlife.

Although many of these activities may focus on enhancing students' science-based understanding of the desert, it is important to recognize that students may experience nature through different lenses. While some students may appreciate a fact-based investigation of the desert's living and non-living qualities, other students may be more comfortable exploring the desert through art or creative writing. As they build their understanding of the Mojave, language and visual art projects may also provide an opportunity for students to express their knowledge of the desert.


Boundary of the Mojave Desert
Yosemite National Park
Sierra National Forest
Fresno
CALIFORNIA
Visalia
Sequoia National Forest
Death Valley National Park
Bakersfield
Las Vegas
Henderson
Mojave National Preserve
Grand Canyon-Parashant National Monument
Cedar City
Springdale
Kanab
Mesquite
Kingman
Prescott National Fores
Los Padres National Forest
Santa Barbara
Los Angeles
Riverside
Anaheim
Long Beach
Joshua Tree National Park
Kofa National Wildlife Refuge
Map data ©2019 Google, INEGI

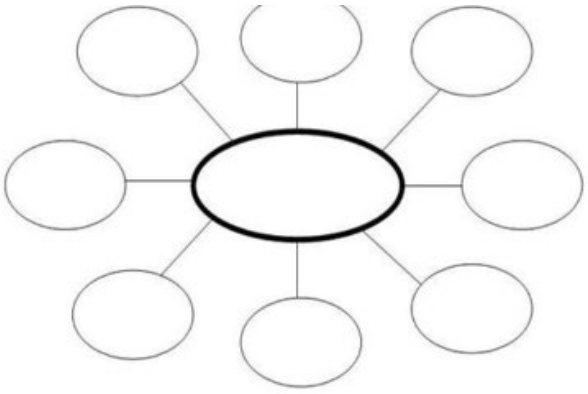
Lesson 1: Baseline Assessment of Students Knowledge of the Mojave Desert

Grade Levels: Can be adapted for Grades 2-6

Goal: Assessing student's baseline understanding of the Mojave Desert, and deserts in general. This will set the stage for all future activities in this guide.

Curriculum Standards: This activity can be an exercise in critical thinking and English language arts, in the form of creative writing or class presentations and discussion.

Activity: For lower grade levels, have students draw a bubble map on a sheet of paper. In the center bubble, they should write Mojave Desert. In the surrounding bubbles, they should fill in qualities of the Mojave, such as their observations of climate/temperature, precipitation, description of the landscape, existence of plants/animals, etc. For upper grade levels, students could be asked to specifically describe the biotic (living) and abiotic (non-living) qualities of the Mojave in the same or two separate bubble maps.



Example of a Bubble Map

Variations of this activity for upper grade levels could involve students doing a creative writing project describing a real or imagined camping and hiking trip in the Mojave. What do they experience? What do they find on their hike in the desert? What challenges do they face and how do they overcome them?

After completing the bubble maps or writing projects, have students briefly present to the class. Students should be asked to explain why they chose some of the qualities of the Mojave; the educator can use this an opportunity to explore students' perceptions of the desert, and whether any of the students can cite informational sources or past experiences for their responses.

Educator Notes: Some students may have had past experiences or exposure to informational sources that will likely be demonstrated through an understanding that the Mojave landscape consists of different habitat types, such as mountains, sand dunes, natural springs, and cactus-yucca scrub. They should also recognize that there is a diverse range of plant and animal life in the desert that is adapted to the scarcity of water.

Other students may have less background knowledge on the Mojave, and may describe the desert as relatively devoid of life. Some students may be focused on its harsh qualities, such as the lack of water, plants characterized by sharp cactus spines and animals such as venomous snakes. Students may also elect to describe the desert in aesthetic terms, as either beautiful or unappealing.

Lesson 1: Baseline Assessment of Students Knowledge of the Mojave Desert (continued)

Educator Notes (continued):

In either case, students should be asked why they describe the desert in the way that they do. Regarding the biotic and abiotic qualities of the desert, they should be asked to support claims with clear reasons and relevant evidence. Class discussion could be formatted as a debate for upper-grade levels, challenging students to use critical thinking in how they describe the Mojave Desert ecosystem, and also explore competing perceptions of the desert across the class. Finding ways to record a student's observations or perceptions of the desert will be useful to compare/contrast how that perception changes after additional lessons in this guide that will introduce them to the diversity of the Mojave landscape and its wild inhabitants.

Lesson 2: Introduction to the Mojave: Diverse Habitats and Wildlife

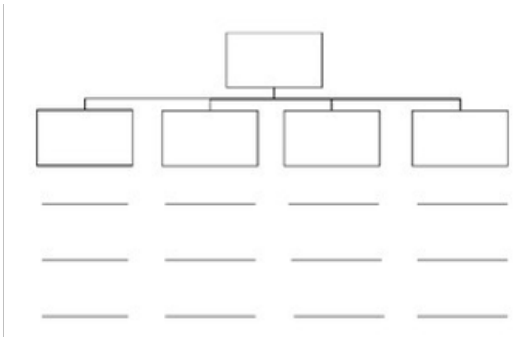
Grade Levels: Can be adapted for Grades 2-6

Goal: Build students' foundational understanding of the different habitat types within the Mojave Desert ecoregion, ranging from desert dunes, cactus-yucca scrub, and Joshua tree woodland. Exploring and understanding these different habitats within the Mojave Desert provides a basis for further instruction on wildlife adaptations, and exploration of weather, climate, and Earth's surface processes.

Curriculum Standards:
This activity serves as an introduction to the diversity of plants and animals in the Mojave Desert ecosystem and could be adapted to all primary and middle school grade levels. At a basic level, it applies to Grade 2 Disciplinary Core Idea: **2-LS4-1 "Make observations of plants and animals to compare the diversity of life in different habitats."** However, for all grade levels, this activity establishes foundational knowledge about the Mojave Desert that will then support additional activities centered on Earth Sciences, to include 3-LS4-2, 4-ESS3-1/4-ESS3-2, 5-ESS2-1, 5-ESS3-1, and MS-ESS2-4.

Activity: Introduce students to the Mojave Explorers Wildlife Guide, particularly pages 8-27. These pages provide an overview of the geographic extent of the Mojave, the different habitat types and wildlife one may encounter in the Mojave.

Have students draw a tree map with Mojave Desert written in the top box. Have students **select four** of the habitat types from pages 10-25 of the Wildlife Guide. In the fields below, they should list plants, animals, or non-living (abiotic) characteristics of each of those habitat types. If time permits, they may also browse the wildlife pages in the guide to learn about wildlife that may live in each habitat type, or research other sources online to complete their tree map.



Example of a Tree Map

For upper grade levels, educators could ask students to conduct a research project comparing and contrasting two of the habitat types, to include biotic (wildlife) and abiotic (climate, soil, availability of water, etc) characteristics. Students may use a double bubble map or a Venn diagram to present their findings. Many desert wildlife will range across different habitat types, but other wildlife can only survive in one type. An educator-led discussion could ask students which animals can be found throughout different habitat types, and which ones may only be found in one. Why is this? How does precipitation or temperature vary in these different habitat types, and why? If the students are in the Mojave, which habitat types do the students encounter in their local area?

Lesson 3: Animal Relationship with their Habitat

Grade Levels: Can be adapted for Grades 2-6

Goal: Students will be able to identify specific adaptations that allow three specific desert wildlife to survive in their specific habitat types within the Mojave, and why those species would have difficulty surviving in other habitat types.

Curriculum Standards:
2-LS4-1 - Make observations of plants and animals to compare the diversity of life in different habitats.
3-LS4-3 - Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
4-LS1-1 - Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
MS-LS1-5 - Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Activity: This activity builds on the knowledge students gained in Activity 2 regarding the different habitat types within the Mojave. They will explore how three different species -- the desert bighorn sheep, the cactus wren, and the Mojave fringe-toed lizard -- have adapted to life in the desert, and how each habitat type in the Mojave can determine which species can survive there. All are found in the Mojave, but they each prefer a specific type of habitat within the Mojave Desert. Students can research these animals in the Wildlife Guide and online. They could be asked to do so individually or in groups.

Have each student research the three animals in the Wildlife Guide and online (see some of the online resource links below for each animal). Then have the students draw a picture of these three animals and their habitats/homes based on the research. Some questions that students should be able to answer through their research and incorporate in their drawings include:

- How do these animals stay safe from predators?
- What features do they need in their habitat in order to escape predators?
- How do they get the water/moisture they need to survive?

Online resources to aid students' research on each species:
Mojave Fringe-toed lizard
https://www.youtube.com/watch?v=Zqhla5sJZp0
https://www.youtube.com/watch?v=VgsUCyHnL0s

Desert Bighorn Sheep
https://www.youtube.com/watch?v=fspe5pnJg2s
https://www.nps.gov/jotr/learn/nature/bighorn.htm

Cactus Wren:
https://www.youtube.com/watch?v=U1XqsOTvTnc
https://nhpbs.org/natureworks/cactuswren.htm
https://www.youtube.com/watch?v=pzhamk6THOY

Class discussion
Have students present their findings to the class. Ask students to discuss how the desert bighorn sheep, cactus wren, and Mojave fringe-toed lizards escape or stay safe from predators? What features do they need in their environment to do so? After discussing the responses for all three animals, ask students what would happen if you put a Mojave fringe-toed lizard in the desert bighorn sheep's preferred habitat of rocky, steep hillsides? Could a cactus wren find a nesting spot in the middle of a desert dune habitat where the Mojave fringe-toed lizard thrives? What human activities in each of these habitat types could imperil these species?

Educator Notes:
The *desert bighorn sheep* prefers steep, rocky slopes of mountains. The bighorn uses well-adapted hooves and a sense of balance to bound quickly up these steep slopes to escape predators. The bighorn's primary predator is the mountain lion. Bighorn need to have access to water at nearby desert springs or riparian areas where they can stay hydrated. Occasionally, bighorn will migrate across open desert to get to another mountain range, but they prefer to remain close to steep slopes.

The *Mojave fringe-toed lizard* is adapted to forage for food in desert dunes and dry washes with very fine, wind-blown sand (similar to the sand you would find at a beach). This is because the fringe-toed lizard will bury itself in the sand to escape predators, and also to avoid the heat of the day. The fringe-toed lizard got its name because of fringed scales along the edge of toes that allow it to run faster on the fine sand (almost like its own track shoes). The shape of the lizard's snout is chisel-shaped, which allows it to burrow more quickly into the sand. The fringe-toed lizard eats small insects, beetles and arachnids, in addition to seeds leaves and flowers. It gets its water from these food sources.

The *cactus wren* prefers to build nests in cholla cactus, but will also build nests in dense plants or trees. So the cactus wren is usually found in areas of the Mojave where there are ample cholla cactus or other dense vegetation nearby. This is typically in cactus-yucca scrub, and Joshua tree woodland. The spines of the cholla cactus provide the bird with one of its favorite places to build a nest, keeping the nest and hatchlings safe from predators. Although a cactus wren may forage for food on rocky slopes or in desert dunes, it would not be able to survive in those habitats without a habitat type nearby that supports lots of cacti and other good nesting spots.


Cactus Wren


Mojave Fringe-Toed Lizard


Desert Bighorn Sheep

Classroom Lab (Optional)
Educators may also demonstrate the relationship between an organism and its habitat through a hands-on activity. In this activity, each student will be assigned a different utensil. The objective will be to pick up as many marbles as possible during three rounds of 20 seconds each, with each round using a different types of container or surface. The marbles will represent food, and each container or surface will represent different habitat traits. The utensils will represent the students' adaptations to be able to forage for the marbles.

Supplies:
Various utensils, such as tongs, a large spoon, a large spatula, etc.
Marbles
A large container or box
Biodegradable packing peanuts or similarly light and loose material
Large bowl
Tape
3 cups or large bowls.

Steps:
1.) Set up habitat #1: A large box or tub with biodegradable packing peanuts or similarly loose material. Add marbles.
2.) Set up habitat #2: A 3x3 foot square on the floor marked off with tape. Add marbles (any marbles pushed outside of the marked area by the students are considered "lost."
3.) Set up habitat #3: A large bowl filled 2/3 with water. Add marbles.
4.) Next to each habitat, place a cup or cereal bowl where the students will deposit the marbles that they collect from the "habitats."
4.) Assign three students one of the utensils and one of the "habitats."
5.) Explain the rules. Have them attempt to collect as many marbles as possible in 20 seconds from their assigned habitat. Any marbles that fall out of the container or marked areas are lost. The students may only use one hand - the hand holding the assigned utensil. And they must deposit the collected marbles in a cup or cereal bowl.
6.) After the first round, count and record how many marbles each student collected in each habitat and with which utensil.
7.) Replace the marbles in the habitats. Have the students use their same assigned utensil in a different habitat type. Repeat until each utensil has been used in each habitat type to observe differences in how easy/difficult it is to forage for marbles in each one.

Class Discussion:
What did students notice about using the utensils in each habitat. Were some utensils better-suited to collect marbles in one habitat over another? For organisms with very specialized adaptations, what happens if you remove them from the habitat to which they are adapted and place them in a different habitat?

Lesson 4: Inheritance of Traits

Grade Levels: Can be adapted for Grade levels 3-6

Goal:
Students will be able to discuss how sexual reproduction of the Western side-blotched leads to variations in traits over time, and that the traits of certain populations of the side-blotched lizard have been influenced by their environment over time.

Curriculum Standards:
3-LS3-1. - Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.
3-LS3-2. - Use evidence to support the explanation that traits can be influenced by the environment.
3-LS4-2. - Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing
MS-LS3-2. - Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

Activity A:
The common side-blotched lizard is a reptile that many human residents of the Mojave may have seen on hikes or even in their backyards. Students may wonder what could be so special about this lizard. Scientists have found that its genes can vary substantially across a local population, and they seem to efficiently adapt their coloration to the most common type of soil or rock where they live so that they are better camouflaged from predators. The side-blotched is not a chameleon – an individual side-blotched lizard does not change color depending on where it is resting. But over time, local populations of the lizard adapt their coloration to the local rock/soil color. (For educator reference, one of the scientific studies can be found here: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0047694 .)

Step 1
Print out or electronically share the attached photo of a side-blotched lizard (**Figure 1**, attached). The coloration of the side-blotched lizard in this photo is common. Have each student recreate this image by drawing a copy of the lizard using whatever coloring materials they have available. Then have them cut out that lizard from the paper on which they drew it.

Step 2
Have the students share their drawings with the rest of the class. During the class discussion, point out that:
1.) Not every drawing of the side-blotched is the same. There can be small (or even large) variations. They are not an exact copy of the original photograph. This is also a lot like how

genetics work, with small variations across the species. No side-blotched lizard is an exact copy of its parents.
2.) Have students pay close attention to the coloration of their side-blotched lizard drawings. Are some darker, lighter, or include more vibrant colors?

Step 3
Now provide students with a light brown background, and a black background. This can be done with colored construction paper, the top of a light brown desk, or a blackboard. Pretend that these backgrounds are the rocks and soil in the side-blotched lizard's habitat. Have each student place their lizard on the light background and then the dark background. The educator or another student can pretend to be a roadrunner, which feasts on side-blotched lizards. The lizards that are the least camouflaged (that contrast the most with their background) will become lunch for the roadrunner. The better camouflaged side-blotched will survive to reproduce and make more side-blotched lizards.

In another class discussion, present the two photos of side-blotched lizard – one with darker coloration and another with lighter coloration (**Figure 2,** attached). Then display two photos of desert habitat, one with lava rock (as can be found near Amboy Crater, the Cinder Cones in the Mojave National Preserve, near Yucca Mountain, Nevada, or near Pisgah Crater along Interstate 40 near Ludlow, California.) The other photo will be of a typical creosote bush scrub habitat with lighter brown soil and rocks. (**Figures 3 and 4**, attached)

Ask the students which of the side-blotched lizard color patterns they would expect to see in each of those habitats. Explain that the side-blotched lizards with darker coloration were found in lava rock fields in the Mojave Desert, while the lizards with lighter coloration were found in habitat types with lighter soil/rock colors.

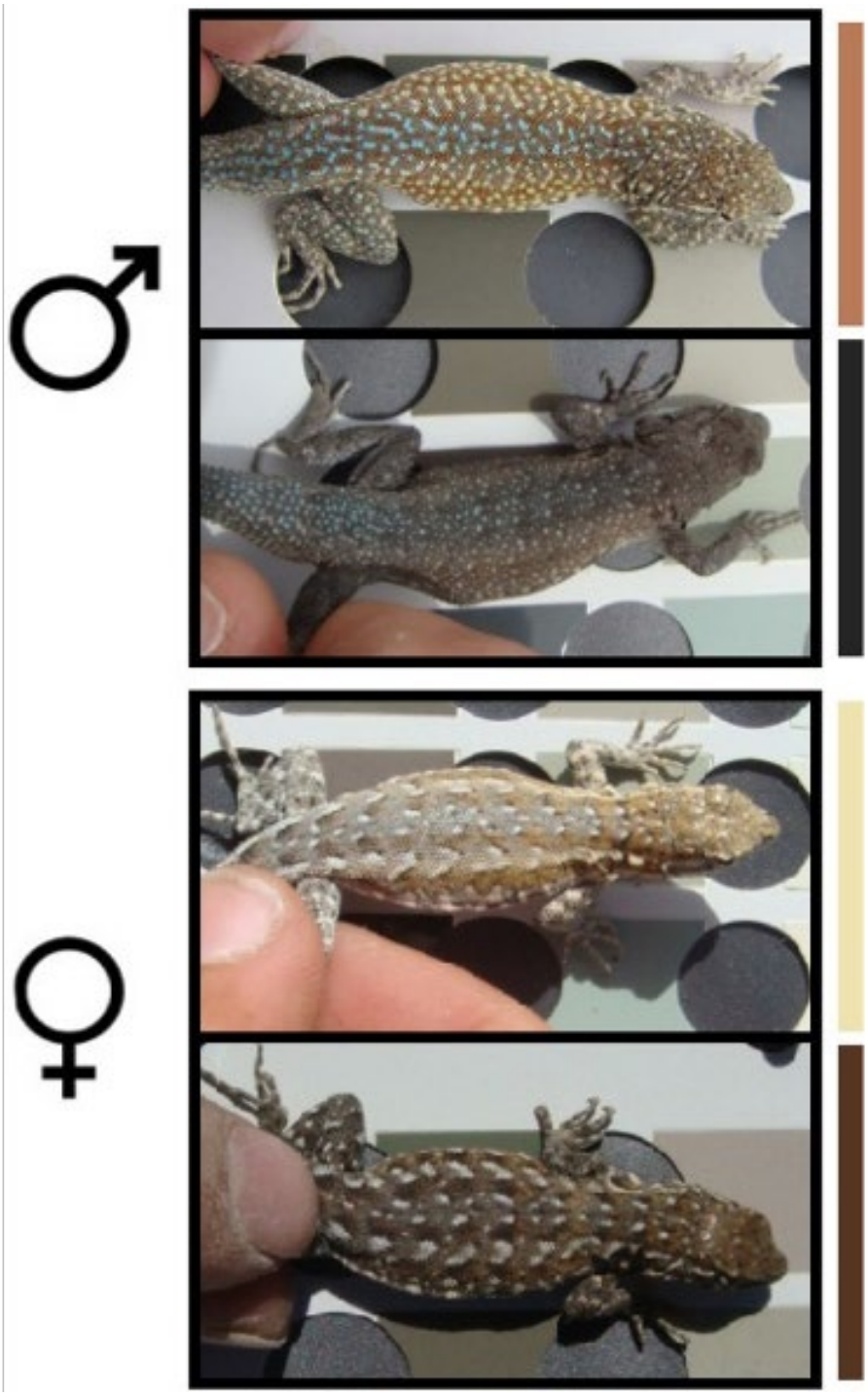
Ask the students to discuss what other traits or characteristics in animals change over time? How does this help them survive?

Lesson 4, Figure 1

Western Side-Blotched Lizard

Photo by Alan Schmierer

Lesson 4, Figure 2



Male and female side-blotched lizards. The lighter color lizards were found in areas of the Mojave with lighter-colored granite sands, and the darker specimens in areas with a lot of dark lava rock.

Credit: https://doi.org/10.1371/journal.pone.0047694.g001

Study titled: Adaptive Color Polymorphism and Unusually High Local Genetic Diversity in the Side-Blotched Lizard, Uta stansburiana

Figure 3: What traits would increase the odds of survival for a Western side-blotched lizard living in this part of the Mojave?

Figure 4: What traits would increase the odds of survival for a Western side-blotched lizard living in this part of the Mojave?

Classroom Lab (Optional)
This activity will demonstrate for the students the basic function of camouflage. In this activity, the educator will cut out 40 small sized pieces from construction paper. There will be four colors, with 10 pieces of each color - red, yellow, black and brown. Scatter the pieces across a couple of surfaces or throughout a classroom. The surfaces should closely matches one or two of the paper colors so that some colors contrast more brightly with the background than others. Select two students and tell them they have only 6 seconds to gather as many pieces of construction paper as possible, but they can only use one hand. Record how many pieces of each color each student collected, and then re-scatter the collected pieces.

Class discussion
Which color construction paper pieces were collected the most? Often times, under the pressure of time, students will gravitate toward the colors that contrast the most with their background. The most frequently collected papers are likely to be those that contrast the most with the surfaces (for example, the red and yellow pieces are likely to be picked up the most if the papers are scattered across brown flooring). Ask students to talk about how much pressure they had to collect the paper pieces. Imagine real predators in the wild. What pressure are they under to find food in the quickest and most efficient manner? For the prey (the construction paper), which traits are likely to disappear from the population over time?

Lesson 5: The Desert on a Map

Grade Levels: 4-7

Goal: Build student proficiency reading data on maps and using satellite imagery to identify features of the Earth's surface, as well as different visual hallmarks of erosion and water flow across the Mojave.

Curriculum Standards:
4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

Activity:
For this activity, students will use the Mojave National Preserve Habitats Map, available on-line, and Google Maps to identify and observe features of different habitat types throughout the Mojave National Preserve.

Step 1
Ask students to find the 4 locations below on the Preserve map and then cross-reference them on Google Maps using the satellite imagery layer to observe patterns and features of the Earth's surface:

1.) Kelso Dunes
2.) Granite Pass
3.) New York Mountains
4.) Black Tank Wash (not labeled in the Mojave National Preserve Map, but searchable in Google Earth. Located just west of the Cinder Cone Lava Beds on the Preserve map.)

Note: Students should be able to easily search for the place names above in Google Earth, but in case they are difficult to find, links are provided here for educator reference. A.) Kelso Dunes (link) B.) Granite Pass (link), C.) New York Mountains (link) D.) Black Tank Wash (link)
.

Step 2
Using Google Maps (including Street View, where available) and the Mojave National Preserve Habitats Map, have students identify the habitat types at each of those locations. The Habitats Map is shaded in different colors to identify various habitat types found throughout the Preserve. Students can then refer to the Mojave Explorers Wildlife Guide, pages 10-25, for visual reference of these habitat types. They can then zoom in on the satellite imagery to observe how those habitat types appear in satellite imagery. Ask students to make observations with regard to the presence of vegetation, elevation, or erosion patterns.

Answer Key:
-Kelso Dunes – desert dunes, formed by wind carrying sand and routinely sculpted by winds.
-Granite Pass – Cactus-yucca scrub. Students may alternatively identify the nearby pinyon-juniper woodland.
-New York Mountains – Pinyon-juniper woodland and/or Joshua tree woodland, depending on which part of the New York Mountains they investigate. Located at a higher elevation where average temperatures are cooler and that tend to receive more precipitation.
-Black Tank Wash – Desert wash habitat, near lava fields. This location is searchable in Google Maps, but is not labeled in the Mojave National Preserve Habitat Types map. So this will be slightly more challenging for them to identify the habitat type as they will have to cross-reference the Google Earth maps and the Habitat Map.

Step 3
As students explore satellite imagery of the Mojave National Preserve on Google Maps, ask students to take a screenshot of signs that rainfall, wind or other geologic activity helped shape the lands (alternatively, students can drop a pin and send the link to a teacher). It may be useful to first ask the class to discuss where we might see evidence of erosion on the desert landscape (rocks/soil eroding from a mountain, sediment carried down a desert wash by rainwater, signs of wind-blown sand, etc) so that they have ideas to search for in the satellite imagery afterward. Students may need to patiently study the satellite imagery in Google Maps and think critically about the patterns they see. If students are able, ask them to use the "terrain" or topographic feature in Google maps to view information on elevation of the landscape. This can help students draw conclusions about the flow of water and sediment.

Some examples they may point out are attached here for educator reference or classroom discussion after students have identified their own examples.

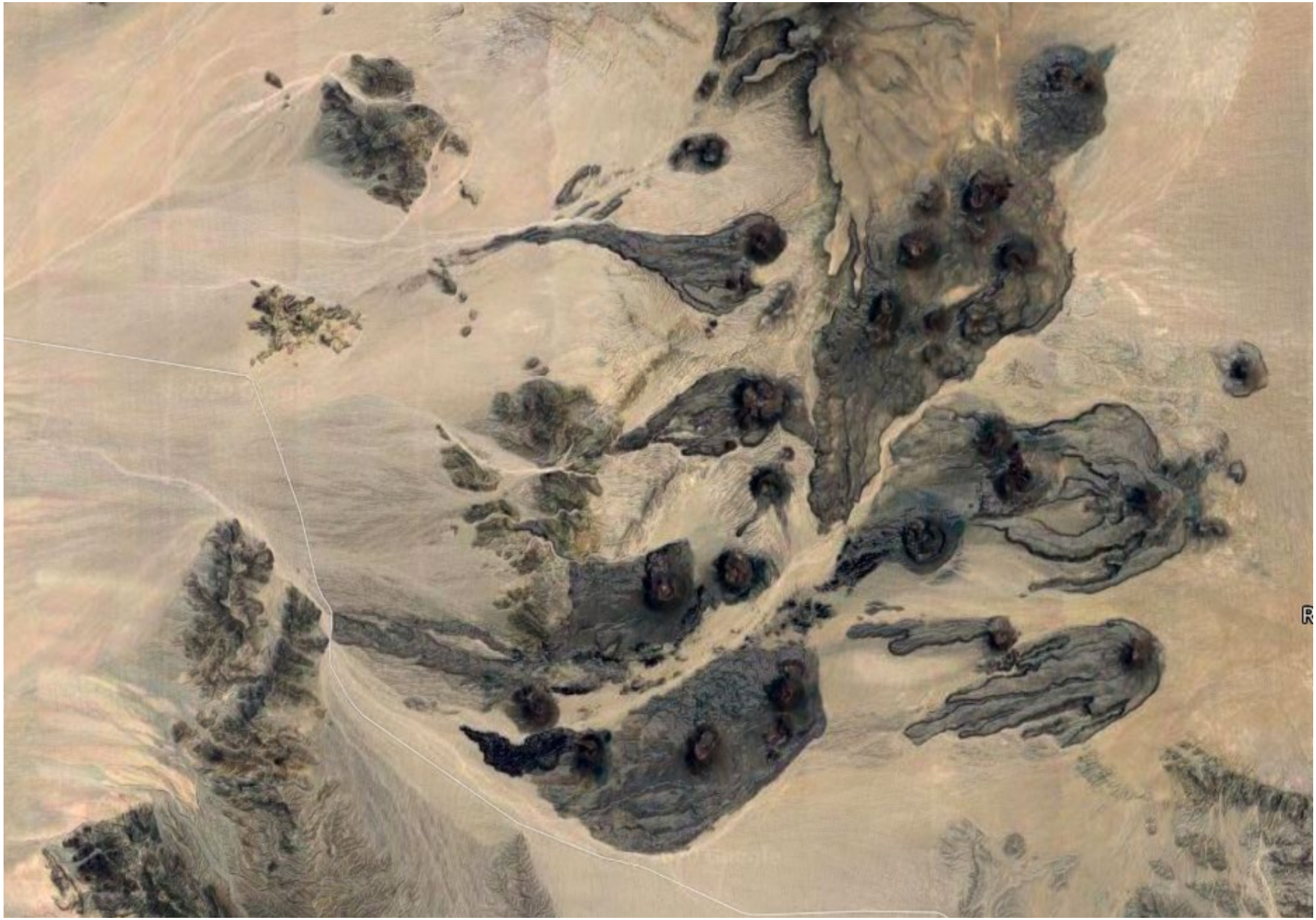
The first screenshot is of a portion of the Mojave National Preserve along Essex Road, south of the Providence Mountains and mostly north of Interstate 40 (link to Google Maps location). The multiple desert washes look like lines braiding through the desert landscape. They depict the effects of erosion after rain water flowing downhill from the Providence Mountains, carrying sediment (soil and rocks) down to lower elevations. The soil and rocks in the valley below mostly originated from the Providence Mountain range to the north.

The second screenshot lava fields and cinder cones in this Google Maps image (link to Google Maps location) of the Mojave National Preserve (along Kelbaker Road, and south of Baker, California), show the effects of volcanic activity on the Earth's surface. The lava rock (the black and darker features in the image) provide habitat to species that have specialized in surviving there, to include the chuckwalla lizard, which forages on plants and wedges itself between the numerous lava rocks to escape predators.

The third image is of the Kelso Dunes (link to Google Maps location), another feature of the Mojave resulting from erosion. The giant field of sand dunes is the result of wind blowing sand (which itself, is eroded rock) from as near as Soda Dry Lake (location). But much of the sand from there may have originated as far as the San Gabriel and San Bernardino Mountains (location). Erosion of those mountains dumped sediment into the Mojave River (location), which terminates in Soda (dry) Lake. The winds blowing across Soda Dry Lake picked up the sand and carried it across the desert until the Providence Mountains – near Kelso Dunes – interrupted the wind, which resulted in the sand dropping to the ground, forming the Kelso Dunes.

(Images attached in following pages)


Edgar Peak
Providence Mountains State Recreation...
Temporarily closed
Multiple desert washes. Erosion from rainfall.
Google
40



Lesson 4: Google Earth satellite imagery of the cinder cones in the Mojave Desert. Ancient lava flow that hardened into dark-colored basalt rock.

Lesson 4: Google Earth satellite image of the Kelso Dunes. Other features visible in this image include dry washes and foothills of the Granite Mountains.

Lesson 6: Tracing Energy and Matter Through A Desert Ecosystem

Grade Levels: Can be adapted for grades 5-7

Goal: Students will be able to describe how matter and energy flows through a desert ecosystem through plants, animals, decomposers and the environment. Students will be able to recognize the critical role plants, in particular, play as a foundation for providing food for a multitude of organisms, including those that are not herbivores.

Curriculum Standards:
5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers and the environment.
5-PS3-1: Use models to describe that energy in animals' food (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun.

Activity:
This is a multi-part lesson that will build students' ability to draw on different information sources to answer questions efficiently and accurately. It involves researching and learning about three organisms that thrive in desert dune ecosystems - the creosote bush, kangaroo rat, and sidewinder rattlesnake - and tracing energy and matter flow through these species and the broader ecosystem. The lessons include suggested experiments that students can do at home or in the classroom with common materials to engage with the concepts discussed in the lesson.

Students will study each organism, then use reason and logic to describe how they are connected to each other in the ecosystem. This activity can be done by dividing the class into groups and giving each group one of the below sections, or each student can take on each section as a project over the course of several days. In any case, students should share what they learned from each section with the rest of the class.

To set the stage for this multi-part lesson, ask students to imagine that they are starting a hike at the edge of the Kelso Dunes in the Mojave National Preserve. (See Lesson 6, Figure 1)

The sand dunes nearby are dotted with plants, including grasses, wildflowers and creosote bushes. These plants help stabilize portions of the sand dunes, making it possible for some animals to dig burrows in the sand. The students encounter the tracks of many insects, reptiles, mammals, and birds in the sand. Each organism's survival depends upon other living things in the ecosystem..

To provide the students with an opportunity to explore the Kelso Dunes visually, you may ask them to spend some time researching the dunes on iNaturalist, a website that includes wildlife observations and identifications from citizen naturalists. Students may also use Google Earth for overhead imagery of the dune field's features, and read the Desert Dunes description in the Wildlife Guide.

Lesson 6, Section 1:

Sub-Goal: Recognize the role of plants in converting rainfall and the sun's energy into matter of nutrient value, and passing that energy on to herbivores and omnivores.

Activity A
The creosote bush is one of the most common shrubs in the Mojave Desert. If your students live in the Mojave Desert, they have seen a creosote bush. But what do they know about this amazing plant?

Introduce students to the creosote bush and ask them to do some research in the guidebook, online or at the library about this desert plant. You can also use the attached photos of creosote bushes (Figures 1-3). This shrub is seen throughout the Mojave Desert. Its blooms are small yellow flowers, and its small seeds are coated in a white fuzz. The creosote bush is also responsible for the "smell of rain" in the Mojave. When rain drops fall on the creosote bush's many leaves, resins on the leaves release that scent into the air, which is then carried by winds ahead of the storm. That is why we can often smell the scent of creosote bush when it is raining nearby in the Mojave.

Ask your students to prepare a short presentation on the creosote bush. Depending on grade level, this could be in the form of a short research paper, an oral presentation, and/or a drawing that presents answers to some of the following questions:

1.) How long can a creosote bush live?
2.) Describe or sketch creosote bush leaves and stems?
3.) What adaptations allow the creosote to grow in the desert where there is so little rain?
4.) What do its seeds look like and what animals forage on them? In what other ways do animals benefit from the creosote bush?
5.) Bonus question: About how many species of bees receive pollen from creosote bushes?

Some research resources:
Joshua Tree National Park website: < https://www.nps.gov/jotr/learn/nature/creosote.htm >
New Mexico State University website: < https://jornada.nmsu.edu/blog/7-things-you-didnt-know-about-creosote-bush >
Wikipedia: < https://en.wikipedia.org/wiki/Larrea_tridentata >

Answer Guide:

1.) Botanists estimate that the average creosote bush lives for several hundred years. The oldest branches of a creosote die when the plant is between 30 and 90 years old, but the crown of the plant splits, becoming a clone of the original plant. This splitting process can repeat itself until the plant becomes a ring of creosote bushes, each a clone of the original plant. The oldest

known creosote ring is known as “King Clone” near Lucerne Valley, California. That creosote clone is believed to be 11,700 years old.

2.) This question is meant to focus students’ attention to the detail of the creosote bushes. They should be able to note the woody nature of the shrub’s stems, the small size of the leaves, and maybe even the waxy coating of the leaves and the angle of the stems. These observations will set them up to better research and respond to question #3.

3.) Students presentations may include a variety of responses that accurately capture the creosote bush’s adaptations. Its leaves only engage in photosynthesis in the morning. Plants “breathe” by opening small holes (stomata) on the underside of the leaves to take in carbon dioxide. But doing so results in the loss of moisture, a valuable resource in the desert. So creosote bushes only photosynthesize in the morning, when humidity levels are higher and temperatures are lower.

The shape of the creosote bush is also important. A research study found that creosote bushes with branches arranged in an upside down cone shape were more numerous in areas with lower rainfall, and creosote bushes growing in areas with higher rainfall had a rounder shape. The upside down cone shape helped channel more rainwater directly to the roots; the plant with branches arranged in a hemispherical shape captured less rain water during each rain event, but its branches helped it capture more organic litter, such as wind blown leaves and other materials. This leaf litter was deposited at the base of the plant and decomposed into nutrients for the soil and the plant’s roots.

4.) Seeds are small, round and coated in a white fuzz, almost like a miniature cotton ball. Many species of rodents, including the kangaroo rat, feed on the seeds. In addition to the seeds providing nutrients to animals, the desert iguana is known to snack on the creosote bush’s flowers. Creosote bushes provide shade to animals in the desert, and small mammals and reptiles often dig burrows at the base of a creosote bush, where its roots have stabilized the soil.

5) One hundred and twenty (120) different species of bees have been collected at creosote flowers, and approximately 20 of those are considered creosote “specialists,” in that they mostly or only visit creosote flowers for pollen. [Minckley, R., Cane, J., & Kervin, L. (2000). Origins and Ecological Consequences of Pollen Specialization among Desert Bees. Proceedings: Biological Sciences, 267(1440), 265-271. Retrieved August 13, 2020, from www.jstor.org/stable/2665962]

Class Discussion:
Have students provide their presentations to the class, individually or in groups. Keep count of how many animals students identify that use the creosote for food, shade, pollen, or other services. Ask students to identify other plant/animal interdependence in the desert or in their backyard. The adaptations of the creosote allow it to play an important role in converting sunshine and rainfall into a reliable source of food and moisture for desert wildlife.

Lesson 6, Section 1 (continued)

Activity B (optional)

Experiment – How does the angle of the creosote bush's branches help it make use of scarce desert rain?

This experiment will demonstrate how the angle of a creosote bush's branches can direct precious rainfall to its roots; this is another adaptation that helps the plant survive the arid environment. During a rain storm, water falling further from the center of the creosote bush is less likely to reach its roots. When water falls on a creosote bush's stems, those water drops can trickle down the stem directly to the plant's roots. But the angle of those stems makes a difference in how many of those rain drops trickle down to the roots. When the stems are at a high angle (like a 'V' shape; see the image in Figure 3 for an example), more rain water reaches the roots. When the stems are at a low angle (like pages of a book laying open on a table), more water drops fall of the stem and onto the ground further from the root zone.

Research studies found that younger creosote bushes and creosote bushes growing in sites with less soil moisture tend to mostly grow stems closer to vertical angles (example on left). Creosote bushes that are well-established or growing where they receive more rainfall - such as along a desert wash - tend to grow more stems at less than 45 degree angles (example on right).

Lesson 6, Section 1, Activity B (continued)

Description

In this experiment, students will simulate and measure rainfall pouring over the stems of a creosote bush to determine which stem angle is likely to direct the most rainfall to the plants' roots. In one half of the experiment, the "stems" will be at a steep angle, and in the other half the stems will be at a lower angle. Chopsticks or sticks gathered outside can represent the creosote bush stems. One container (a short glass for the high angle creosote bush stems, and a cereal bowl for the low angle creosote stems) will represent the root zone of the plants. A large mixing bowl will capture any water that does not make it to the roots. They will measure how much water is captured by the roots in each instance.

Have students gather the following supplies:

A. Four sticks – these can be chopsticks or small branches from a shrub outside. Each should be roughly the same length,

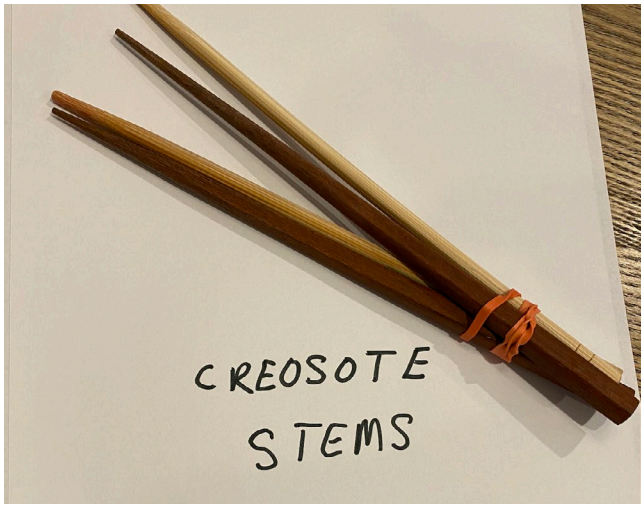
B. A measuring cup. If a measuring cup is not available, they should plan to fill a glass with the same amount of water for each step of the experiment, which can be done by marking a glass.

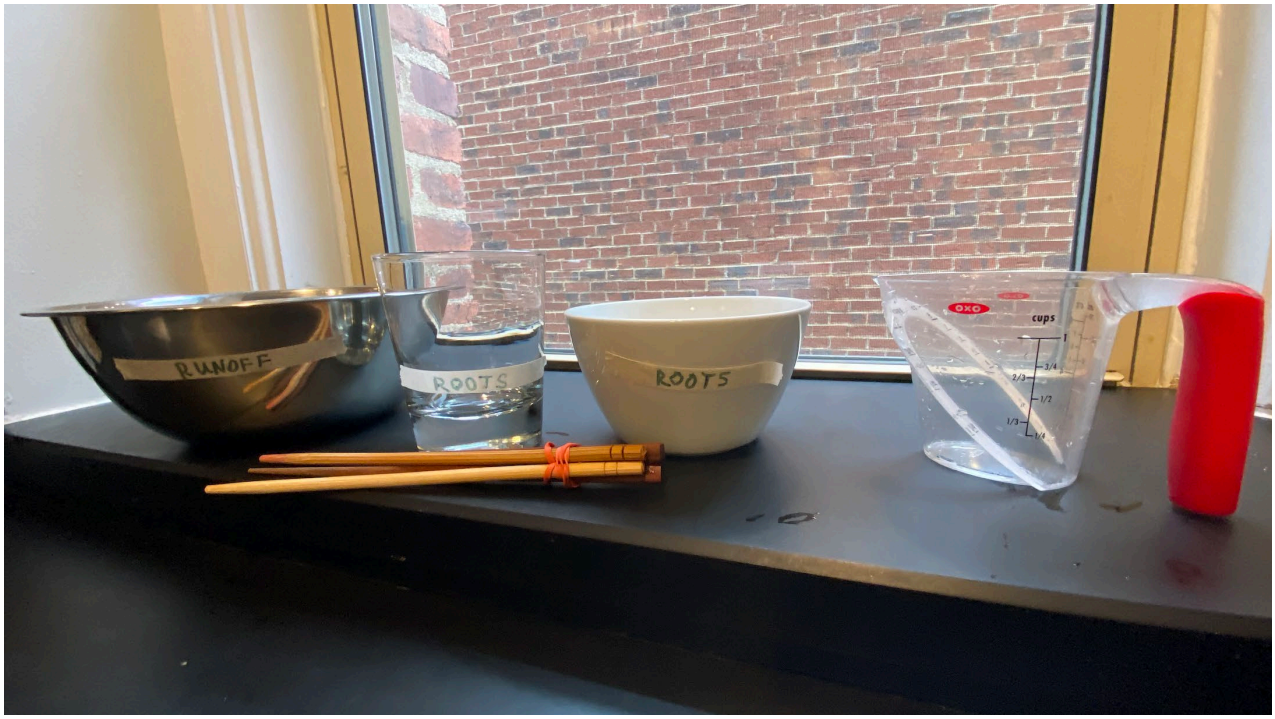
C. A short glass or cup

D. A bowl (like one you'd place your cereal in)

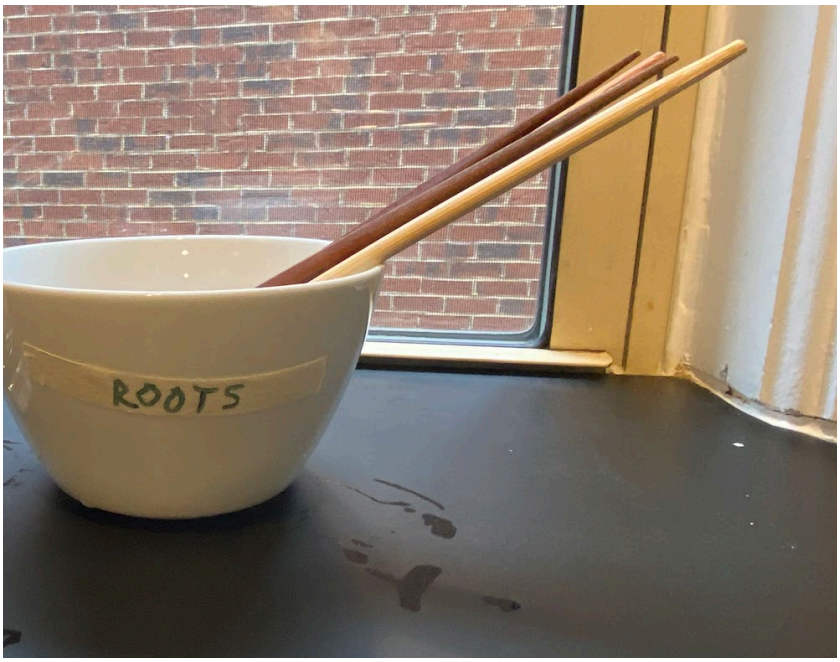
E. A large mixing bowl.

F. Some tape or a rubber band.





Chopsticks simulating creosote bush stems at a high angle in a short glass that represents the plant's root zone.



Same chopsticks resting in a cereal bowl at a lower angle.

Lesson 6, Section 1, Activity B (continued)

Steps:

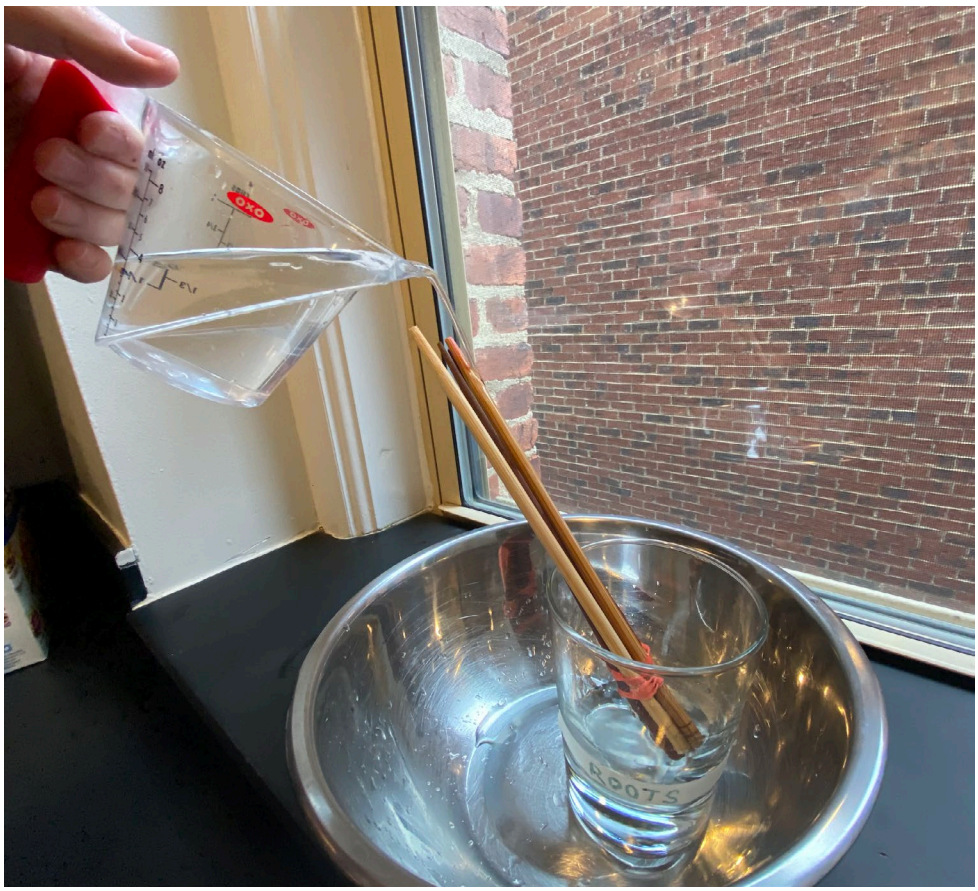
1.) Hold the four sticks and use tape or a rubber band to tie them together on one end. These will represent the stems of a creosote bush.

2.) Place the sticks (with the taped/banded end on the bottom) in the empty, short glass. The bottom of the sticks should be resting at the bottom of the glass, and the tops of the sticks should be hanging over the edge the glass at a steep angle.

3.) Fill the measuring cup with a cup of water (or fill a separate glass up to a point marked by a marker or tape).

4.) Hold or place the short glass with your sticks in the large mixing bowl. The large mixing bowl will catch any water that does not get funneled by the sticks into the short glass.

5.) Carefully and slowly pour the measured cup of water over the sticks, but only onto the top half of the sticks. They key is to pour the water over the portion of sticks hanging over the mixing bowl to see how much of the water will drip into the mixing bowl (representing runoff that will not reach the plant's roots), and how much water will run down the sticks into the short glass (representing the root zone).



6.) After emptying the measuring cup over the sticks, pour the water from the short glass (but not the mixing bowl) back into the measuring cup. Record (or mark with a marker or tape) how much water was in the short glass. This is how much rain water your creosote bush sent directly to the root system during the rain shower. The water left over in the mixing bowl is the water that dripped from the branches onto the ground. In the desert, only a fraction of that water dripping onto the ground will reach the creosote bush's roots, especially during rain showers that do not last long or result in much precipitation.

7.) Now, take the sticks from the short glass and place them in an empty cereal bowl. The sticks should hang over the bowl at a lower angle like a spoon would.

8.) Place or hold the bowl and sticks over the empty mixing bowl.

9.) Fill your measuring cup with the same amount of water that you used from step #3.

10.) Carefully and slowly pour the water over the portion of the sticks hanging outside of the cereal bowl but over the mixing bowl.

11.) After emptying the measuring cup over the sticks, pour the water from the cereal bowl into the measuring cup. This is how much water your creosote bush's stems funneled directly to its roots.
12.) Both the cereal bowl and short glass experiments can be repeated, if desired, to see if the results are consistent over multiple iterations.

13.) Discussion: Which creosote bush gathered more water from the rain storm directly to its roots? The short glass or the cereal bowl? Why? If you were a thirsty creosote bush, at what angle would you want your branches to grow at? [Teachers Note: When we see creosote bushes with more branches at lower angles, this may indicate that the shrub is growing where it is receiving more rainfall, or that more rainfall is penetrating the soil to its roots, allowing the plant to initiate more stem growth at lower angles.]

Activity C (Optional)

Up Close with the Creosote

With parental or teacher supervision, students should be encouraged to explore nearby desert wildlands where the creosote bush is likely abundant and look for evidence of kangaroo rats, or signs of other wildlife dependent on the creosote bush. Look for (but do not disturb) burrows around creosote bush mounts. Observe the waxy texture of the creosote bush leaves and (if present) the features of creosote blooms or seeds. One useful approach to marshal a student's attention to the details of any desert plant is to ask them to sketch components of the plant. Please see the California Academy of Sciences' website on using scientific sketching in the classroom. (Note: Any desert hikes should be planned to avoid the heat. Always bring plenty of water and let others know where you are going and when you plan to come back. Dehydration is one of the primary dangers of recreation in the desert southwest but can be avoided with careful planning and preparation. The creosote bush is so common in the desert southwest that you should not have to travel far to find one.)

Lesson 6, Figure 1: Creosote bushes, grasses and other plants at the edge of the Kelso Dunes in the Mojave Desert.

Lesson 6, Figure 2: Close-up of creosote bush plant.

Lesson 6, Figure 3 Creosote bush in bloom.

Lesson 6, Section 2:

Sub-Goal: Recognize the nutrient value and moisture that the kangaroo rat, and many other species receive from foraging on plants like the creosote bush. Recognize the role that the roots of the plants play in stabilizing soil to support burrowing by small mammals and reptiles.

Activity A
After completing Section 1 on the creosote bush, ask your students to research a desert kangaroo rat and prepare a sketch or drawing of a kangaroo rat in its Mojave Desert habitat and/or prepare an oral presentation on what they learned about the species. Drawings and sketches should aim to capture the features or behaviors of the kangaroo rat, as well as sketches with labels of other features of the kangaroo rat's habitat (plants, burrows, predators or its food sources).

You may explain to students that sketching is a tool used by naturalists and biologists in the field to capture the details of plants and animals they are observing and studying (link to resources on scientific sketching). By the time they finish learning about the kangaroo rat, they should be able to deduce that the kangaroo rat shares the Mojave Desert with the creosote bush, and dine on the seeds of creosote bushes, as well as many other desert plants.

Students should be able to answer the following questions about the kangaroo rat:

1.) What time are kangaroo rats most active and how does this help them survive in the desert?
2.) What do they eat?
3.) How do they obtain water in an environment where there are very few lakes, ponds or rivers?
4.) What preys upon kangaroo rats?

Research resources for students:

Arizona-Sonora Desert Museum website: < https://www.desertmuseum.org/kids/oz/long-fact-sheets/krat.php >
Animal Diversity Web: < https://animaldiversity.org/accounts/Dipodomys_merriami/>
Animalia: < http://animalia.bio/merriams-kangaroo-rat >
Video: https://www.kqed.org/science/1957226/kangaroo-rats-are-furry-spring-loaded-ninjas
Video (BBC): https://www.youtube.com/watch?v=wkJLHnYy_G0

Answer Guide:
1.) Kangaroo rats are nocturnal, so they are primarily active at night. This helps them conserve energy and moisture, avoiding activity during the heat of the day. Bonus points if a student mentions that the kangaroo rat takes shelter in a burrow during the day.
2.) Kangaroo rats dine on the seeds of various plants, including the creosote bush, cacti, and grasses.

3.) Kangaroo rats rarely need to drink water. They obtain most of the moisture they need to survive from the seeds that they eat. In this case, they depend upon the ability of plants to absorb rainfall and pass that moisture along through a plant's seeds.
4.) Owls, snakes, coyotes, kit fox, and badgers are among the many known predators of the kangaroo rat.

Class Discussion:

Have students discuss ways in which the kangaroo rat is dependent on the creosote bush. In what ways might the kangaroo rat benefit the creosote bush?

Discussion tips: Kangaroo rats benefit from the creosote bush's ability to transform rainwater into seeds that contain nutrients and moisture for the kangaroo rat. This relationship goes two ways - the kangaroo rat eats creosote bush seeds, and it also contribute to seed dispersal. Kangaroo rats may drop seeds during foraging activity, helping the plant species by spreading the seeds around the desert. Kangaroo rats also benefit from creosote bushes because the roots stabilize the soils around it, making it is easier for kangaroo rats to dig burrows at the base of a creosote bush. This is particularly useful for kangaroo rats and other animals that live in the desert dune habitat type. Imagine trying to dig a burrow in the sand at the beach. Sand will always fill in the hole that you dig, so the plants growing in parts of the desert dunes help create areas where animals like the kangaroo rat can dig their burrows.

Activity B (optional)

A Potted Plant And a Kangaroo Rat Burrow

If the class discussion did not naturally lead to students identifying the creosote (and other plants') roots as helping small mammals like the kangaroo rat to dig their burrows, ask the students where they think a kangaroo rat is most likely to dig its burrow in the sandy desert dune habitat. Ask students to draw upon their experience from digging in a sandbox or at a beach. Sand quickly fills back in when digging a hole in those places. But a kangaroo rat needs to dig a deep burrow where it can escape the desert heat, evade predators, and store food. Looking at the photo of the desert dune habitat, ask students to identify in what part of the dunes the kangaroo rat would most likely be able to find soils stable enough for it to build its burrow. The correct answer is right next to and under plants growing in portions of the desert dune habitat, especially larger shrubs like the creosote bush. To demonstrate why this is the case, the teacher or a student can bring in a potted plant. Show how the plant cannot be easily pulled from the soil, explaining that the roots act as an anchor in the soil. If possible, remove the plant and its soil/roots from the pot. Show how the soil doesn't just all fall away. The roots hold the soil together. Explain that the root structures of plants in and around the desert dune habitat also stabilize the soils, making them sturdy enough for small mammals and reptiles to dig their burrows. However, this habitat type is very delicate. Human disturbance of dunes can crush plants and burrows.

Lesson 6, Section 3:

Sub-Goal: Recognize how the sidewinder rattlesnake benefits from both the kangaroo rat and the creosote bush (among other prey and plant species in its habitat). Set the stage for a discussion or activity on where the energy received by the sidewinder snake from eating the kangaroo rat may go next in the local ecosystem.

Activity A
Ask your students to research the sidewinder rattlesnake. By the end of this activity, students should be able to identify how the sidewinder depends upon small mammals like the kangaroo, and indirectly depends upon the creosote bush.

The sidewinder rattlesnake is especially adapted to the desert dune habitat in the Mojave. It order to conserve energy, it moves sideways across the sandy surface. It also preys upon kangaroo rats, other snakes, and lizards. The snakes sometimes use the burrows of rodents and desert tortoises for hibernation. So a kangaroo rat may not only serve as food for sidewinder, but it may also help this snake when it digs burrows. In this way, the creosote bush helps both the kangaroo rat and the sidewinder because its root systems help stabilize the soils and make it easier to dig burrows in the first place.

Students should be able to report the following to the class:

1.) What do sidewinders eat and how do they get their water?
2.) Where do sidewinders go to escape the heat of the desert?
3.) In what type of desert habitats do sidewinders prefer to live?
4.) What are at least three adaptations or behaviors that help the sidewinder rattlesnake survive in the desert?

Research resources:

Animalia website: http://animalia.bio/sidewinder
Sciencing website: < https://sciencing.com/sidewinder-snake-adaptations-6470304.html >
https://sciencing.com/sidewinder-snake-6550602.html
http://www.californiaherps.com/snakes/pages/c.c.cerastes.html
Wikipedia: < https://en.wikipedia.org/wiki/Crotalus_cerastes >

Answer Guide:
1.) Younger sidewinders mainly eat lizards, and they expand their diet to include rodents – including kangaroo rats – as they get older and grow bigger.
2.) Sidewinders use burrows constructed by other animals, such as the kangaroo rat. In this way, the sidewinder is also dependent on the soil-stabilizing roots of plants like the creosote bush. They cannot dig their own burrows, but they do sometimes bury themselves in the sand to await their prey.

3.) Sidewinders are primarily found in desert dune and creosote bush scrub habitat where there is not as much obstruction to its sideways movement. Areas with dense vegetation or large rocks would be difficult for the sidewinder to navigate.
4.) The sidewinders namesake ability to move in a sideways motion helps it move across sand and loose gravel more efficiently than other snakes. Only a small portion of its body is touching the ground at any given time, reducing its contact with the hot desert sand. The sidewinder also has large scales above its eyes that look like horns. It can use these scales to cover its eyes when it buries itself in the sand to surprise prey. The snake's coloration provides it excellent camouflage, which it uses to avoid attention from predators.

Class Discussion:

Have the class discuss the ways in which a sidewinder is dependent on the kangaroo rat. In what ways is it dependent – directly or indirectly – on the creosote bush?

Discussion tips: Ask the students what would happen if rodents like the kangaroo rat disappeared from the sidewinder rattlesnake's habitat? What would happen to the sidewinder if plants like the creosote bush died off? Have students explain their answers. The students should recognize that the creosote bush (and other plants)

Activity B
Now that the class can trace how energy and matter flows through at least three species in the Mojave (the creosote bush, kangaroo rat, and sidewinder), ask each student (or group of students) to watch the Crash Course Kids video in the resources section, below. Then have them to identify a model for how the matter in the sidewinder rattlesnake returns to the environment. The model could identify one or two more links in the chain of predator and prey, and then death and decomposition of those organisms, or the waste product (poop!) of the sidewinder or its predators. The decomposition process, aided by bacteria and fungi, then returns matter to the environment. Some of that matter may again provide nutrients to plants.

Resources:
Crash Course Kids : https://www.youtube.com/watch?v=uB61rfeeAsM
PBS Video on Decomposers and Scavengers: https://www.pbs.org/video/natureworks-decomposers-and-scavengers/

Children's Books about the Desert

This is a list of published resources that can introduce children to desert ecosystems. Some of these resources focus on other deserts outside the Mojave, uch as the Sonoran, Great Basin, or Chihuahuan Desert. However, the resources may still offer useful discussion points regarding biodiversity of the desert, adaptations, or interdependent relationships across wildlife and the landscape that can provide a launch point for classroom discussion about those same dynamics in the Mojave Desert.

Way Out in the Desert
PreK-K, 1-2

Desert Night, Desert Day
K-3

Guess Who's In the Desert
PreK-K, 1-2

The Night Flower: The Blooming of the Saguaro Cactus
PreK-K, 1-2

North American Desert Life Coloring Book, Dover Publications
K-4

Cactus Hotel
K-5

Creatures of the Desert World
1st – 3rd Grade

A Walk in the Desert
3rd-6th Grade

A Desert Scrapbook
3rd-6th Grade