DESERT BATTLE: NINJA RAT VS RATTLESNAKE

A SCIENCE 3D ADVENTURE

MIDDLE SCHOOL

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symbio education™

KEY WORDS

ABIOTIC FACTOR

ADAPTATION

BEHAVIOR

BIOTIC FACTOR

CELLULAR RESPIRATION

COMMUNITY

DEPOSITION

ECOSYSTEM

ELEVATION

ENZYME

EROSION

EVAPORATION

LATERAL UNDULATION

NEURONS

NUTRIENTS

PHOTOSYNTHESIS

POPULATION

PREDATOR

PREY

PRODUCER

PROTEIN

SPECIES

STOMATA

VENOM

WEATHERING

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DESERT BATTLE

Conditions in subtropical deserts are harsh. Blistering temperatures occur during summer days. Bone-chilling nights are common in the winter. Water is almost impossible to find for long periods of time. For plants, **nutrients** in the soil are scarce. And, for animals, shelter is hard to find. Organisms have to battle against the stresses of these **abiotic factors**, or non-living factors, to survive. Their bodies have to adapt to cope with the environment. And, they have to have the right behaviors to thrive.

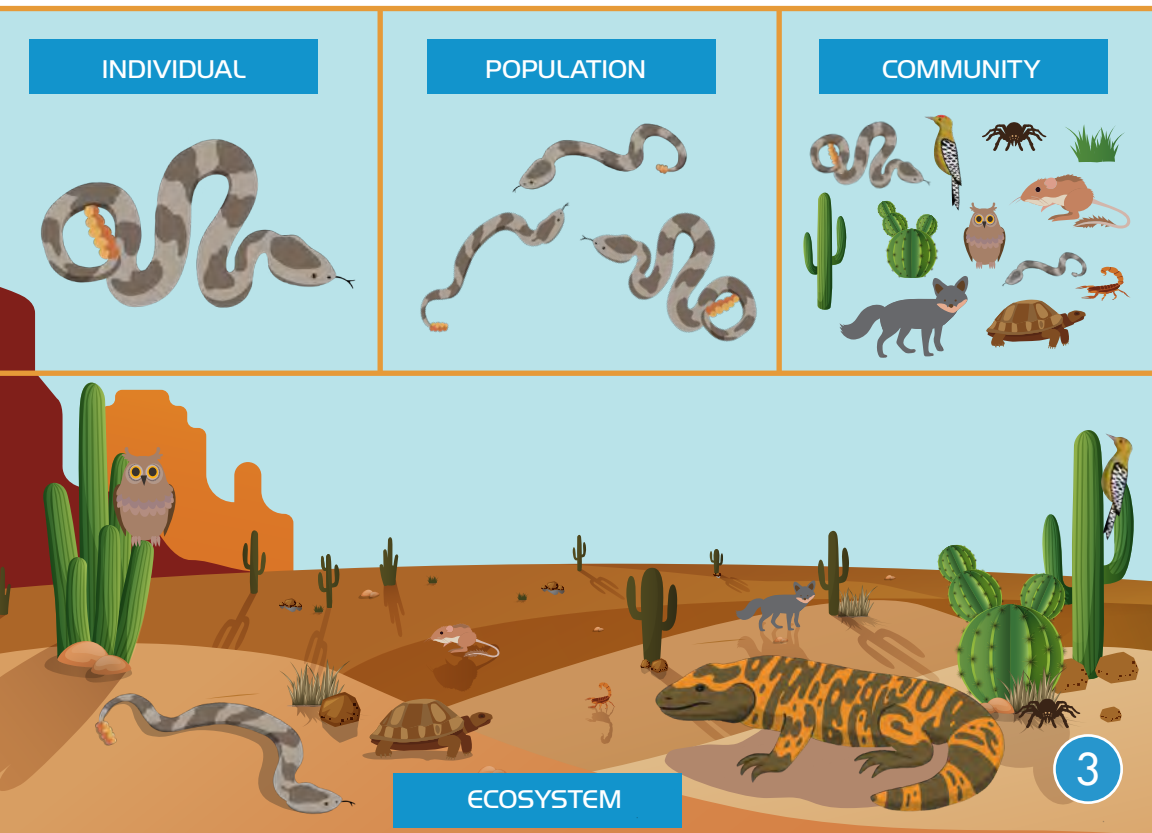
Biotic factors, or living factors, can be just as big of a challenge! Plants have to defend themselves from ravenous insects. Animals need to find enough food. And predators of all shapes and sizes can be a lethal challenge for their prey.

Let's have an inside look at a daily battle for survival in the Sonoran Desert of the American southwest. The contenders are the rattlesnake and kangaroo rat, also known as the "ninja rat."

As if surviving the harsh conditions isn't hard enough, kangaroo rats have to avoid becoming a meal for a rattlesnake!

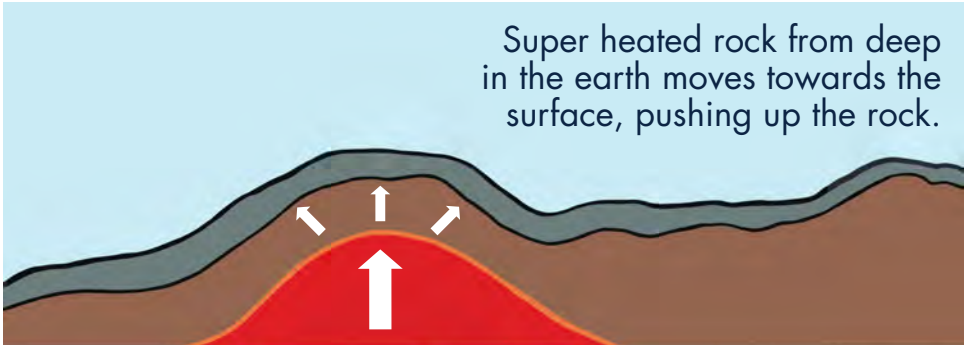
DESERT ECOSYSTEM

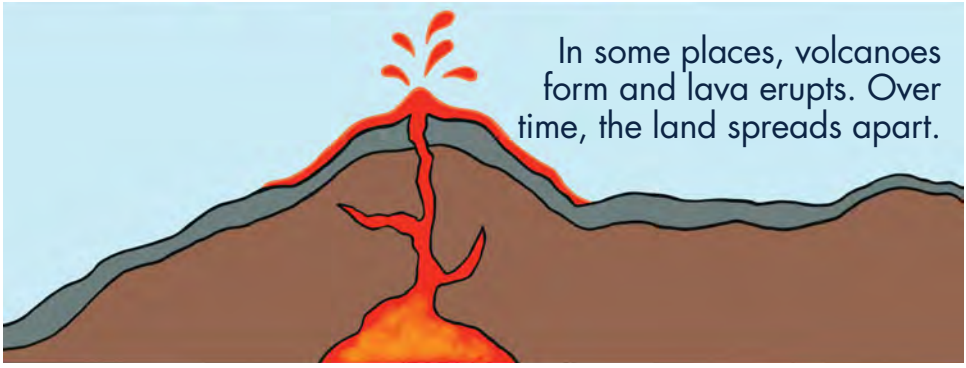
The organisms that call an **ecosystem** home can be organized into different levels. A **species** is all the individuals of the same type that can reproduce and produce offspring that can reproduce. Within an ecosystem, the first level of organization is an individual of a species. Groups of individuals of a species that live in the same area at the same time are called a **population**. There are populations of many different species in one place at the same time. This collection of the populations is called a **community**. It is basically all of the organisms in an area at one time. An ecosystem is the biotic community and the abiotic factors in an area. Important abiotic components of the ecosystem include air, sunlight, water, soil, nutrients, and landscape features like caves or other forms of shelter. Biotic components include predators, prey, parasites, and organisms that can form shelter or provide other resources (like trees providing places for birds to nest).

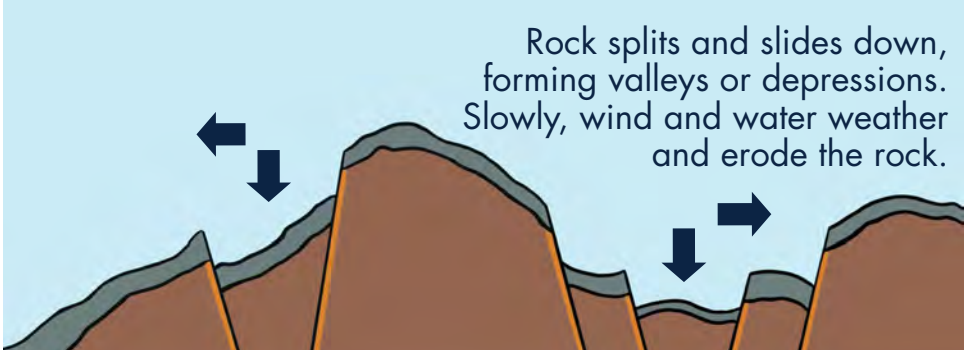


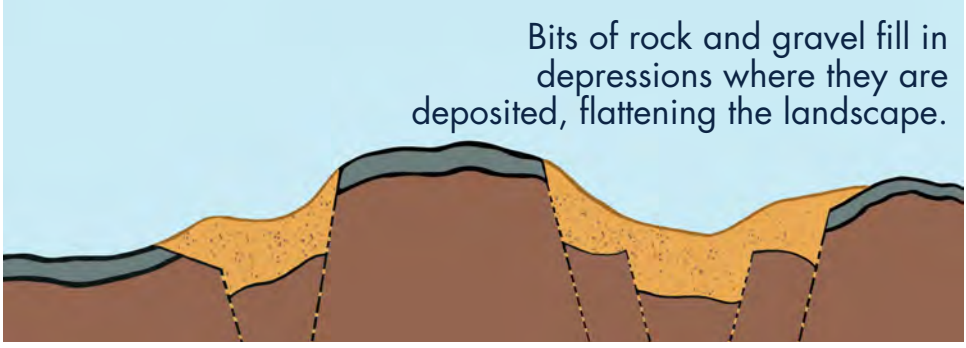
The Sonoran Desert is found in the southwest United States and northwestern Mexico. The landscape of the desert has been formed by volcanic activity and processes like **weathering**, **erosion**, and **deposition**. Mountains were formed by heating from deep in the earth. The magma from underground led to the formation of volcanos and volcanic eruptions. Over millions of years, the movement of the earth caused cracks to form and large elevated areas of the land to drop and create valleys. Pieces of weathered rock were carried away by water through the process of erosion and deposited in lower areas.

FORMATION OF A LANDSCAPE

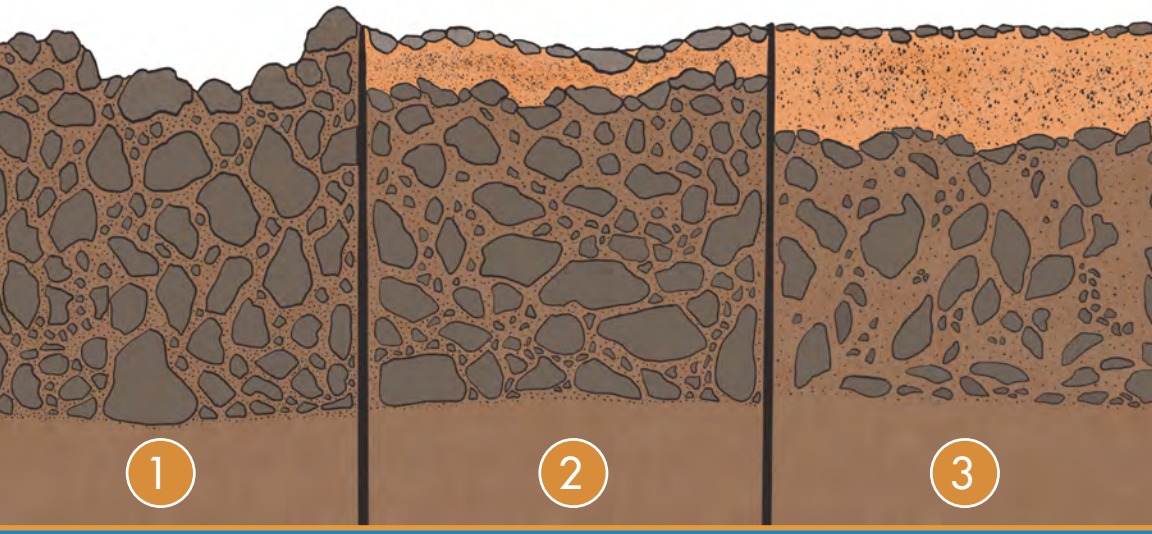








Soils are a mixture of organic remains (dead stuff), clay, and rock particles. In places with less plant life, like the desert, soils are shallow and have little organic matter.



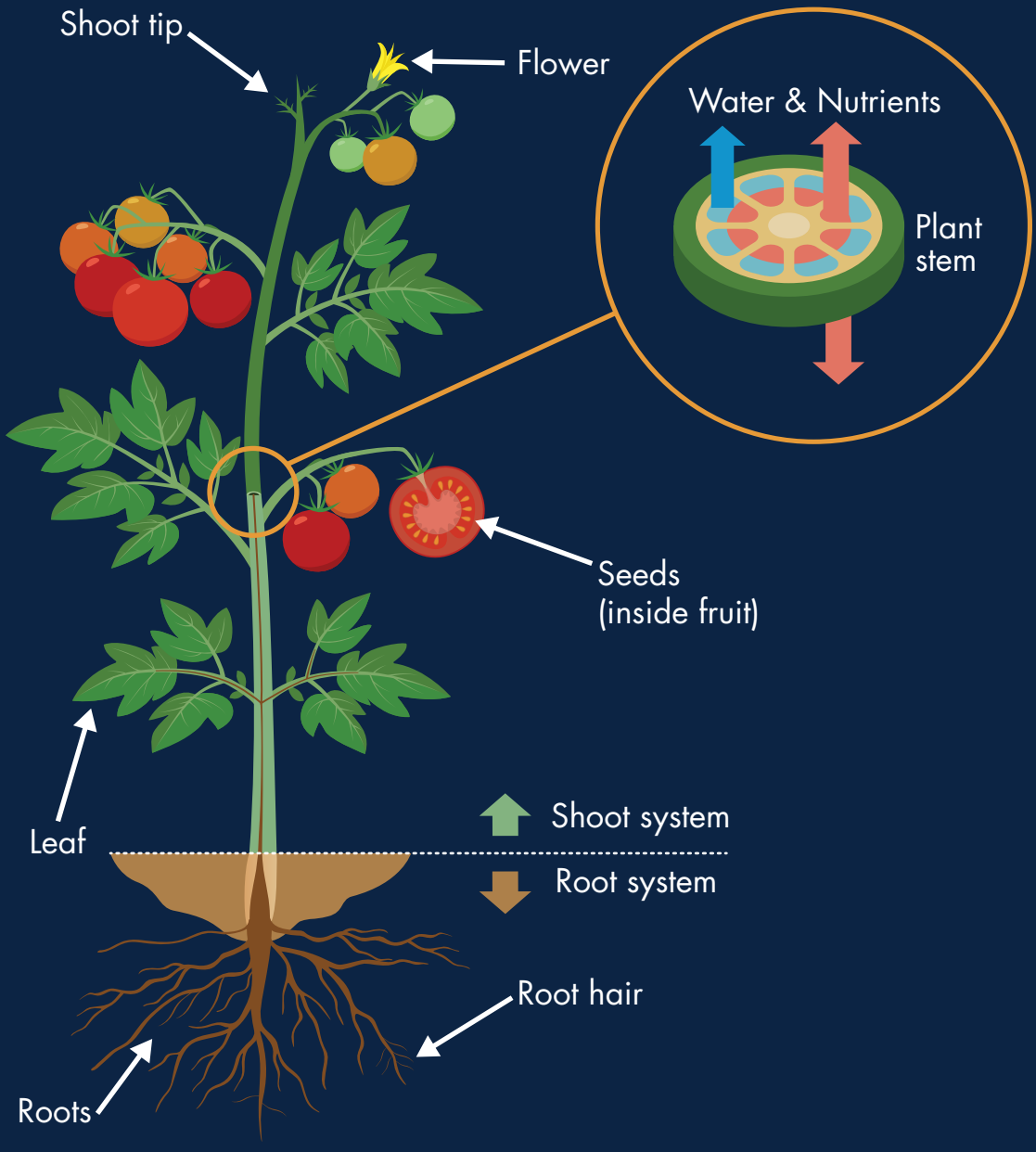
Soils in the Sonoran Desert were formed by 1) weathering of stones near the surface, breaking them into smaller pieces; 2) further weathering of rocks near the surface, creating small stone fragments near the surface and larger fragments below; 3) decaying plants and animals, causing organic matter to mix with the stones near the surface.

BUILT TO SURVIVE

Cacti and rattlesnakes are two icons of the American desert. Seeing a cactus or hearing the rattle of a rattlesnake makes most people envision a beating sun and a struggle to find water. Both are built to survive in the desert, just like the other organisms that call this ecosystem home. Rattlesnakes and other organisms also have **behaviors** that are adapted to desert survival. The plants that form the base of the ecosystem are the key to survival for all living things in the desert.

IT STARTS AT THE BASE

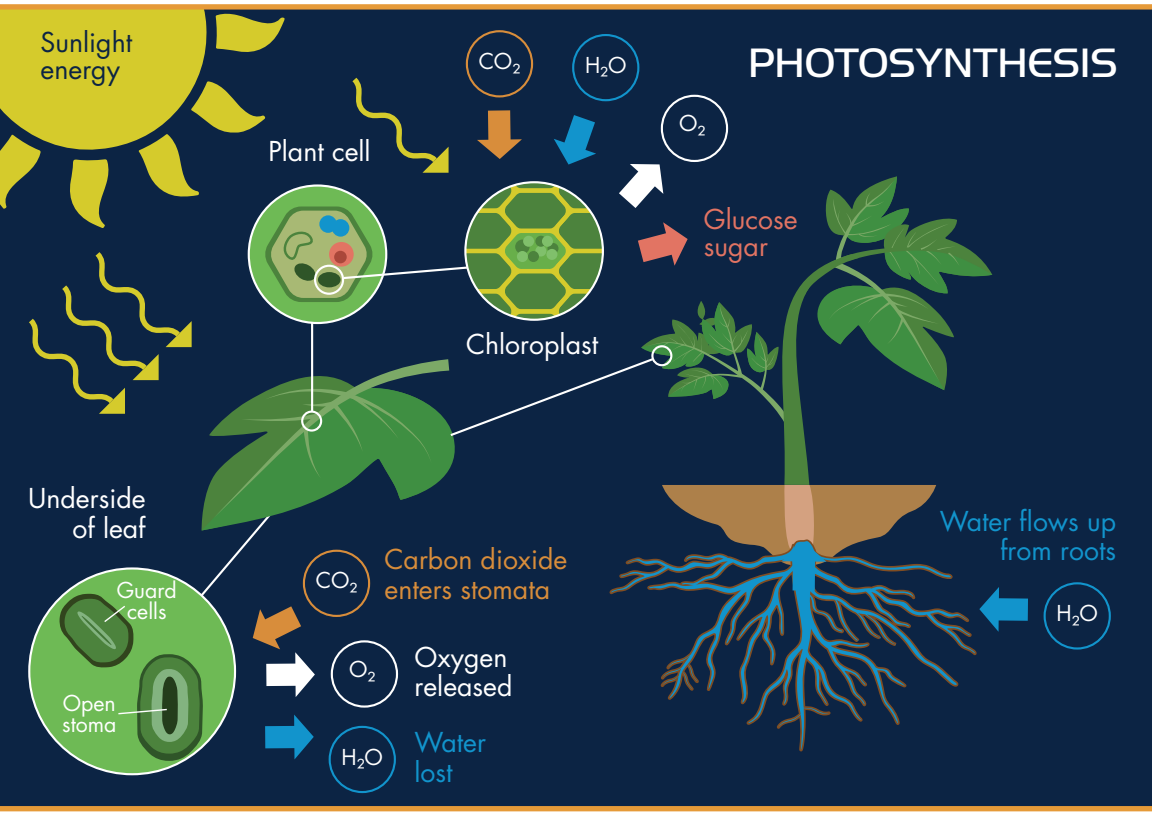
TYPICAL PLANT STRUCTURE



Roots collect water and provide support. The stem provides support and moves water and nutrients. Leaves make food.

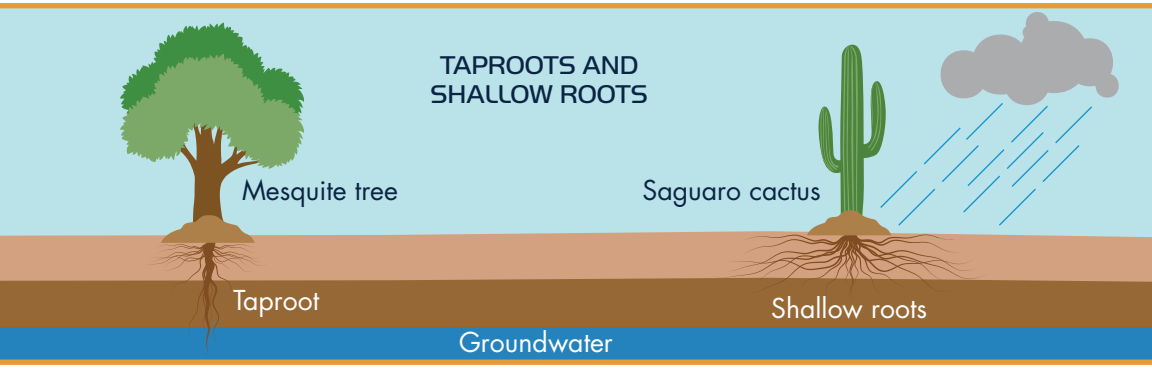
Energy in deserts and other ecosystems comes from the sun. **Producers**, like plants, use the energy from the sun and matter from the environment (for example, carbon dioxide in the air) to make food in the form of sugar (glucose). The glucose stores the energy from the sun in chemical bonds. This process also releases oxygen. **Photosynthesis** takes place in the leaves of plants. The chemical equation for photosynthesis is:

$$\text{Sunlight} + 6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$



For photosynthesis to occur, plants need water (H_2O). In the desert, water isn't easy to gather. The hot temperatures also make it easy to lose water, especially since the plants open pores in their leaves called **stomata** to let the carbon dioxide (CO_2) they need into the leaf.

Desert plants have two ways to gather enough water. Some, like mesquite, have taproots that go very deep, maybe more than 60 m (195 ft), to ensure a constant water supply. Most cacti work in an opposite way. They have many small roots that are very shallow and absorb water quickly when it rains. After, water is stored in the fleshy stem of the cactus.



To retain as much water as possible, desert plants have special types of photosynthesis. For example, cacti and some other plants only open their stomata at night when it is cool. Desert plants have other adaptations to hold onto their water. Some plants have waxy leaves to hold onto water. Leaves are usually very narrow, so there is less surface area to lose water from compared to a broad leaf. Cacti don't have true leaves. They have spines, which are modified leaves. Photosynthesis occurs in the body of the cactus. The spines of a cactus aren't just for protection! They shade the body of the cactus and break up winds that would cause more **evaporation**.

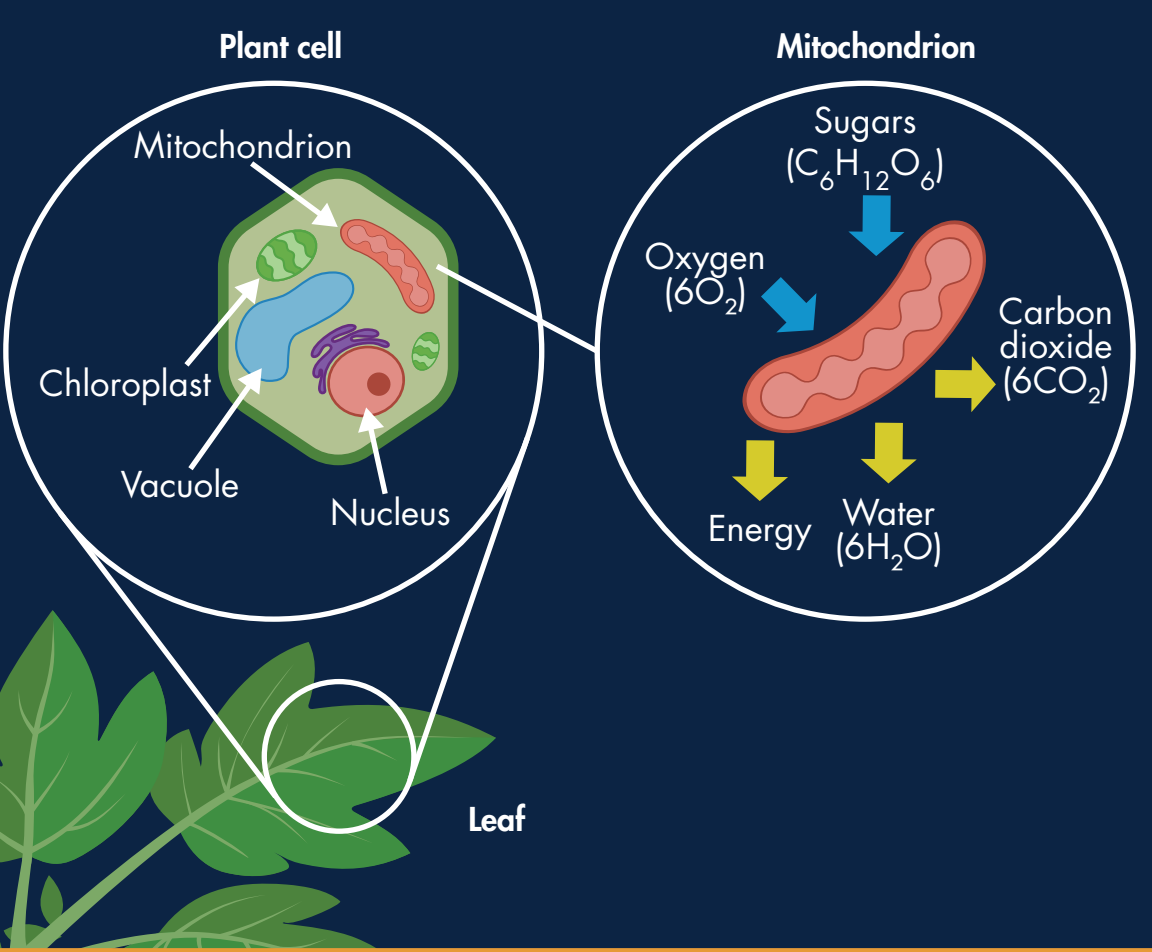
Waxy, thin leaves help prevent water loss. Cactus spines help shade the body and protect the water inside from thirsty animals.

To release the energy in the glucose bonds, plants use a process called **cellular respiration**. The chemical equation for cellular respiration is:

$$6O_2 + C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$$

Does it look like the chemical equation for photosynthesis? It should! It is basically photosynthesis backwards. Cellular respiration isn't just for plants though. It occurs in all organisms.

CELLULAR RESPIRATION

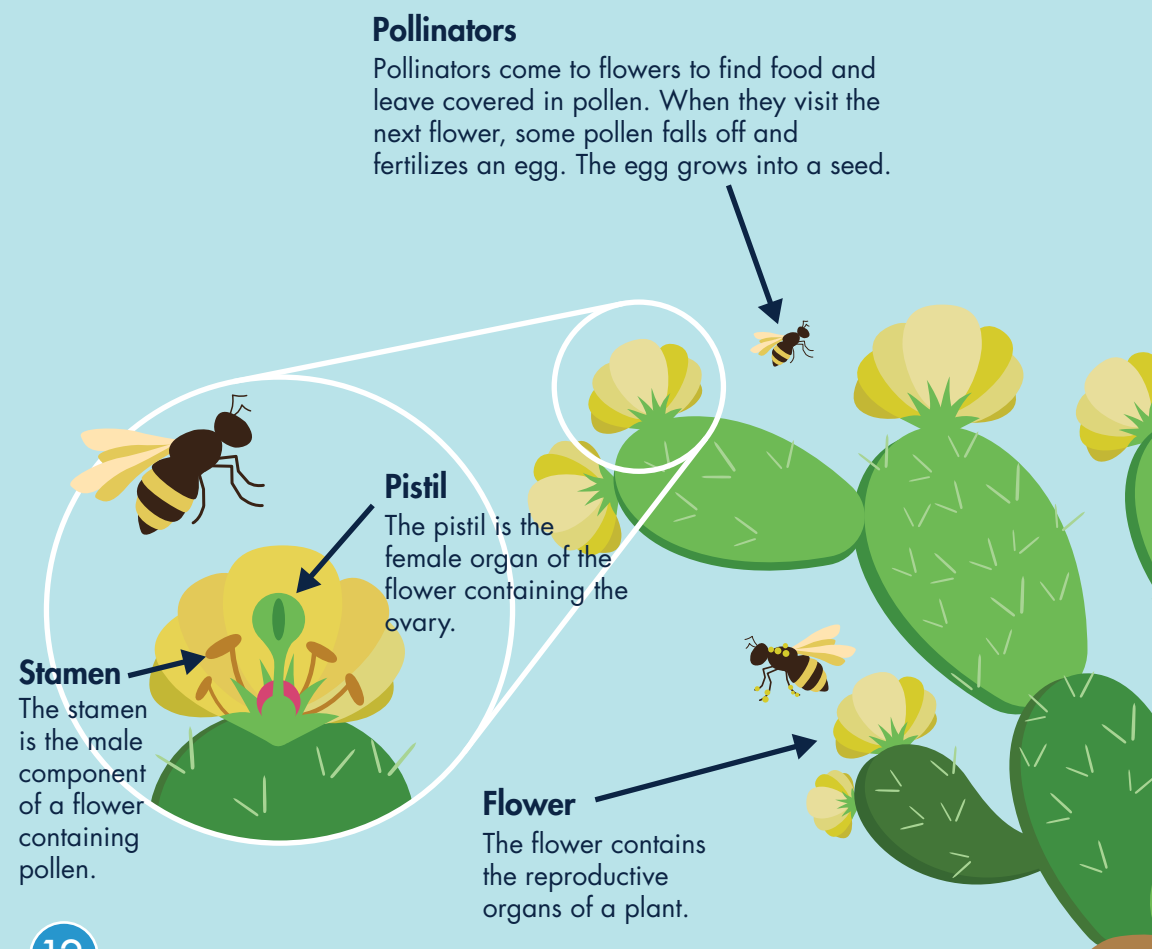


Cellular respiration is the chemical process that plants, animals, and other organisms use to release energy stored in chemical bonds. In the mitochondrion, oxygen and sugars are consumed, and energy, water, and carbon dioxide, are released.

PLANT LIFE

Reproduction in desert plants is also adapted to life in the desert. Plants that have to complete their life cycle in a single year germinate right after rain. Many plants rely on animals to move their pollen between plants and to disperse their seeds. Some animals collect seeds and stash them to eat later. Abandoned or forgotten seeds germinate into the next generation of plants. Sometimes animals consume seeds when they eat fruits. The seeds pass through the gut with waste products.

PRICKLY PEAR CACTUS



Many animals are pollinators that help plants reproduce by collecting and spreading pollen between flowers.

Animals aid in plant dispersal by eating fruits and carrying and depositing their seeds away from the parent plant.

Fruit

After pollination, the fertilized egg in a flower grows into a fleshy fruit containing the seeds of a plant.

Seeds

Seeds are the flowering plant's unit of reproduction, capable of developing into another plant.

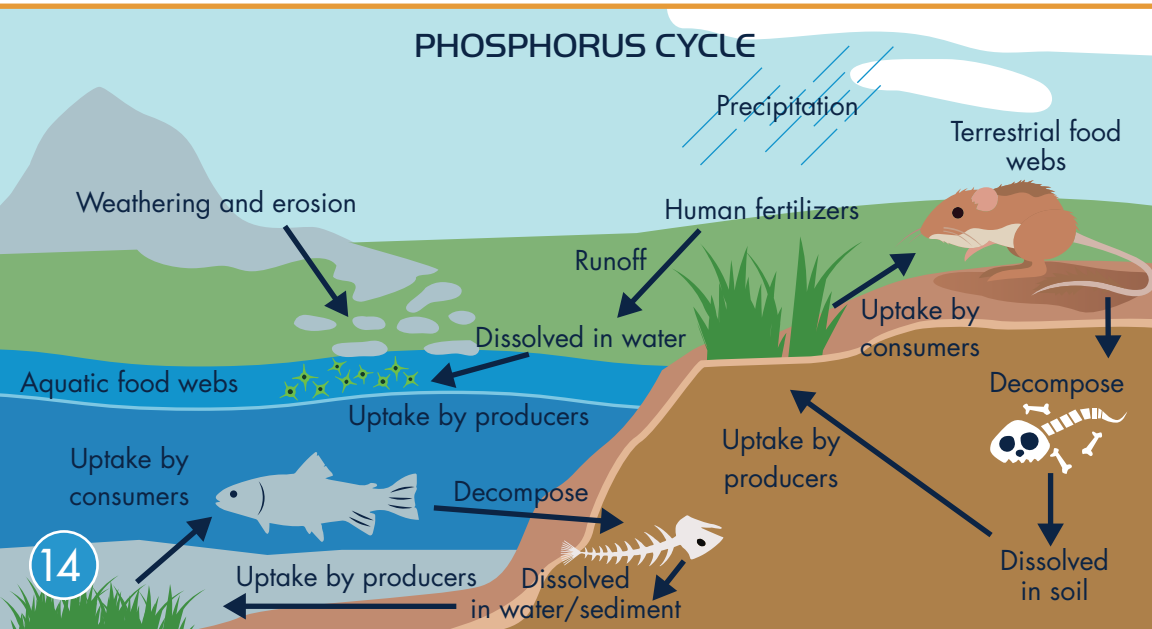
Disperser

Dispersers eat fruits and then carry and deposit their seeds away from the parent plant.

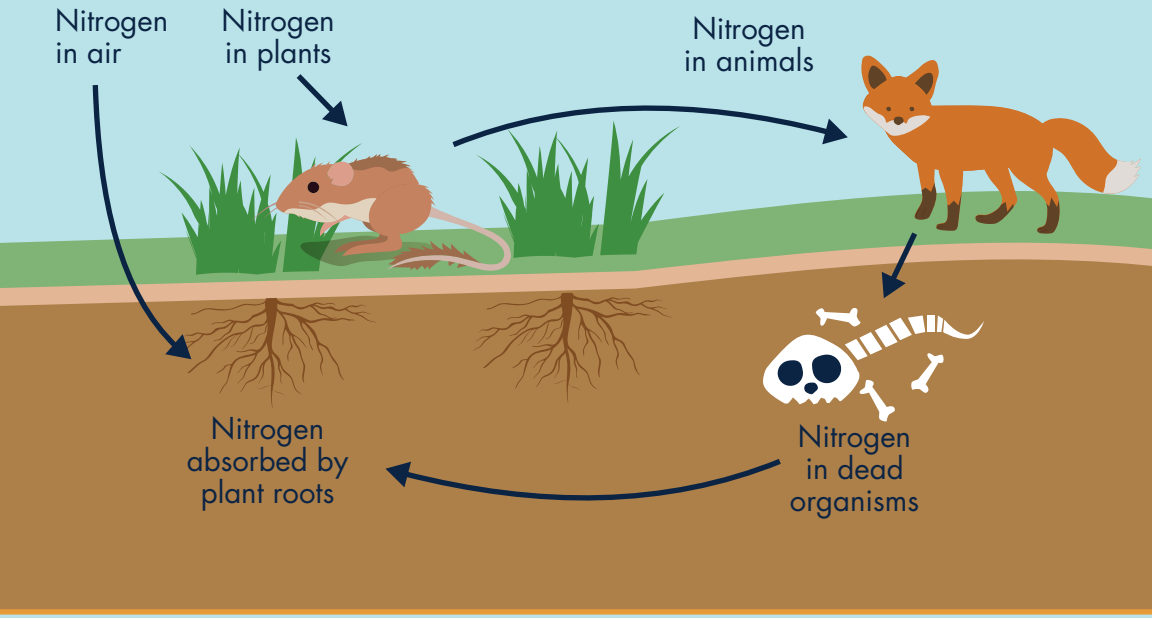
PASS THROUGH OR RECYCLE?

Animals get the matter and energy they need from eating plants or other animals. They get water from their food or from drinking. Like plants, animals use cellular respiration to release the energy from food they consume. When they do this, neither energy nor matter is destroyed. It just changes form! But energy and matter move through ecosystems differently. Energy from the sun flows continuously. Producers store this energy in chemical bonds of sugar. When the sugar is used in cellular respiration, the energy is released. When consumers eat producers or other consumers, the energy is passed along until it is used or released into the environment as heat. Energy flows through an ecosystem.

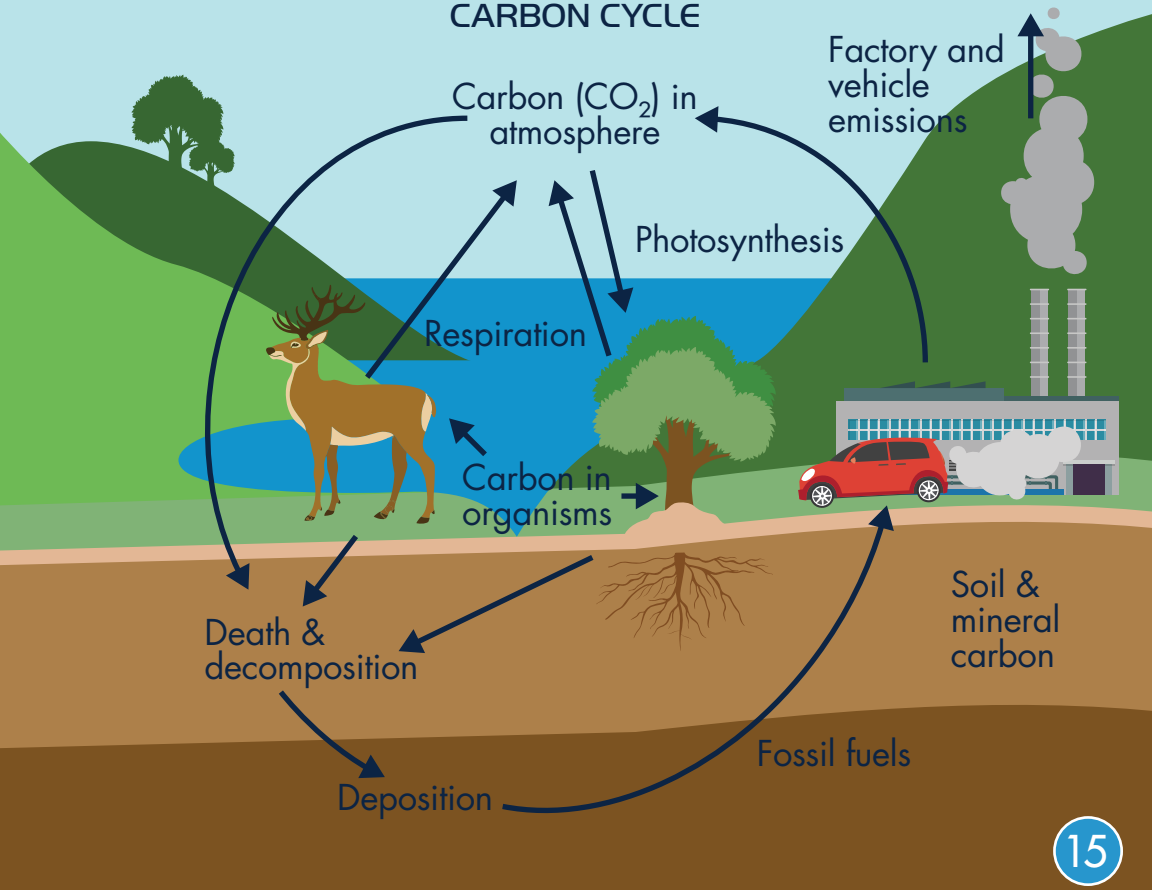
Matter is different than energy. It does not flow through a system. Like energy, it is not destroyed. Unlike energy, it cycles through the system. Carbon dioxide, for example, is used to make sugars in a producer. When a consumer eats the producer, the carbon that was originally in the air moves into the body of the consumer. The carbon can be passed from one consumer to the next. Eventually, it will be released back into the air as carbon dioxide when it is used in cellular respiration. Nutrients and water are other forms of matter that cycle. Nutrients are substances that are essential for the growth and maintenance of life. Two very important nutrients for organisms are nitrogen (N) and phosphorus (P).



NITROGEN CYCLE

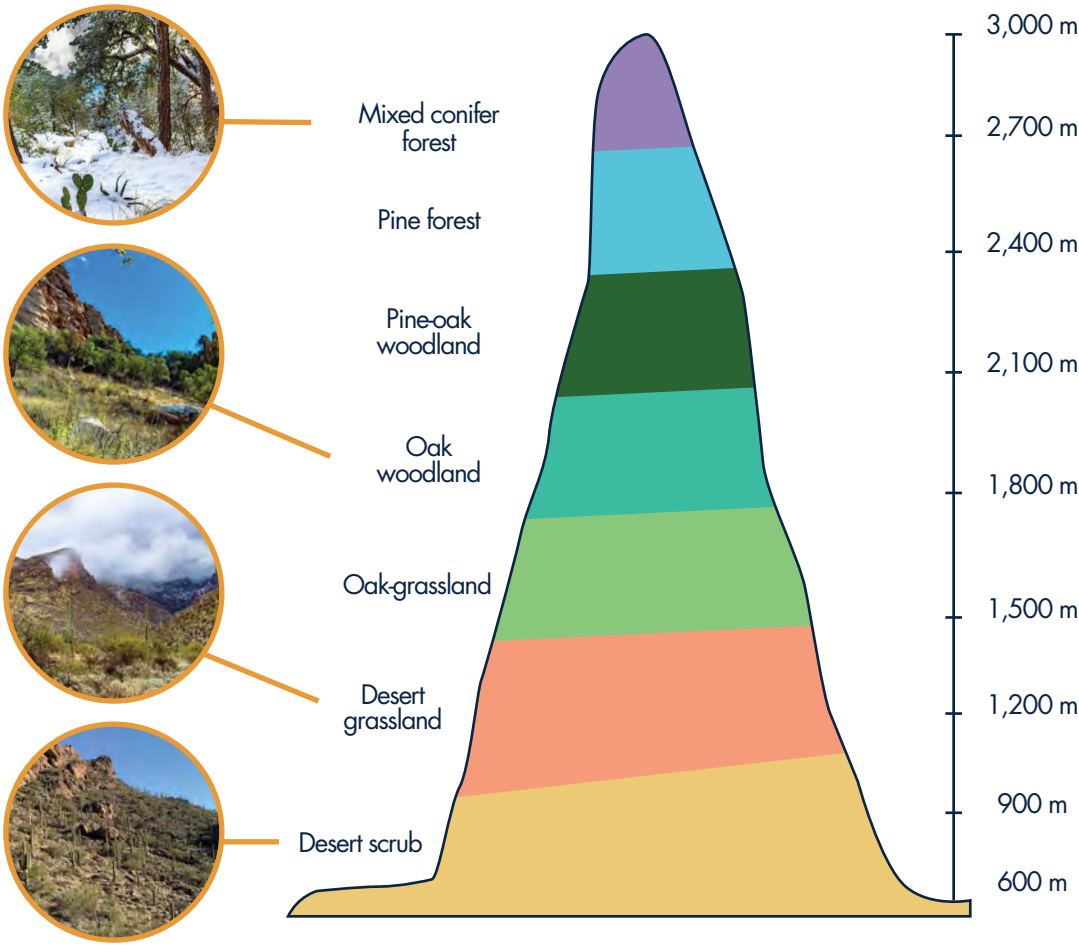


CARBON CYCLE

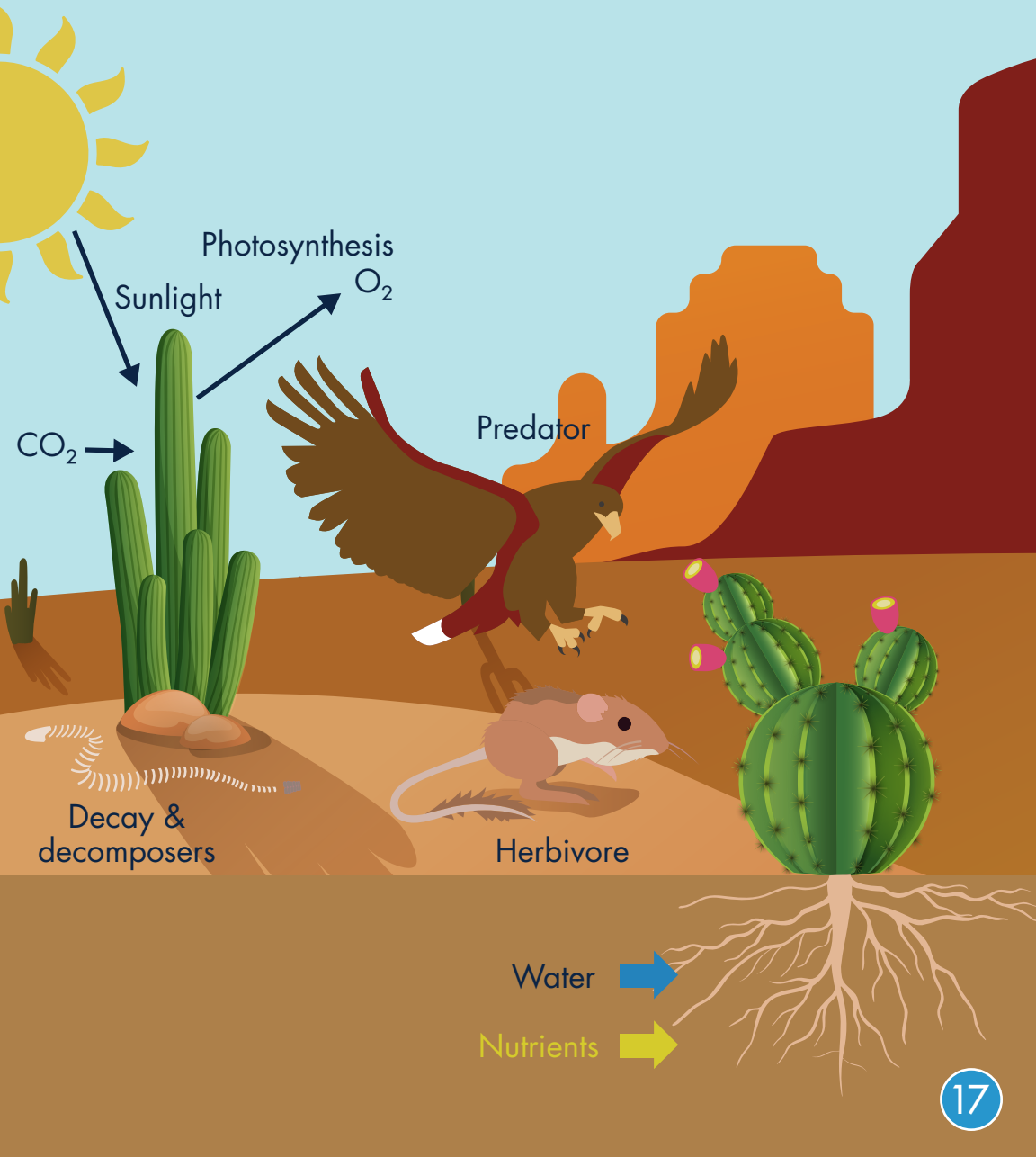


SONORAN BATTLEFIELD

The harsh but beautiful landscape of the Sonoran Desert may look largely lifeless at first glance, but it is actually teeming with life! And, there are actually many different **biomes** in the region. At higher **elevations**, the temperatures are cooler. More precipitation falls, which allows more plants to grow and die. That helps build richer soils so forests can form. At lower elevations, the temperatures are higher and there is less moisture. This is where true deserts are found.



Only plants that are adapted to survive with little water and scorching temperatures can survive in the desert scrub biome. That means that not many leaves drop or plants die and decay. Without decaying matter, the soils have few nutrients. With few nutrients and little water, there are not enough plants to support large populations of large animals. But, many smaller species thrive, including reptiles like rattlesnakes and rodents like kangaroo rats. Let's explore this predator versus prey battle.



LEGLESS IN THE DESERT

Rattlesnakes, like other snakes, are well adapted to their environment. Snake skeletons look fairly simple. It is mostly their skull and many vertebrae and ribs. Some species have more than 400 vertebrae! That is one long backbone. Snake skulls help with more than just eating and protecting the brain. When a snake rests its lower jaw on the ground it can detect vibrations moving through the ground. It can even tell what direction the vibration is coming from!

Snake skeletons do not have legs. So how do they get around? That's where the muscular and integumentary (skin and body covering) systems come into play. Snakes are covered in dry, overlapping scales that protect their bodies. The scales on their bellies are modified to help them move. In many species, the belly scales grip the ground and the muscular system pulls them along. Other species move by moving their body back and forth like a wave. This "lateral undulation" is the most common way snakes move. To use lateral undulation, a snake needs something to push against. How would they get around in sand? The sidewinder is a species of desert snake that moves by keeping part of its body on the ground while it throws another part forward. It may look exhausting to "sidewind" like this, but it actually uses less energy than other ways of getting around on sand.

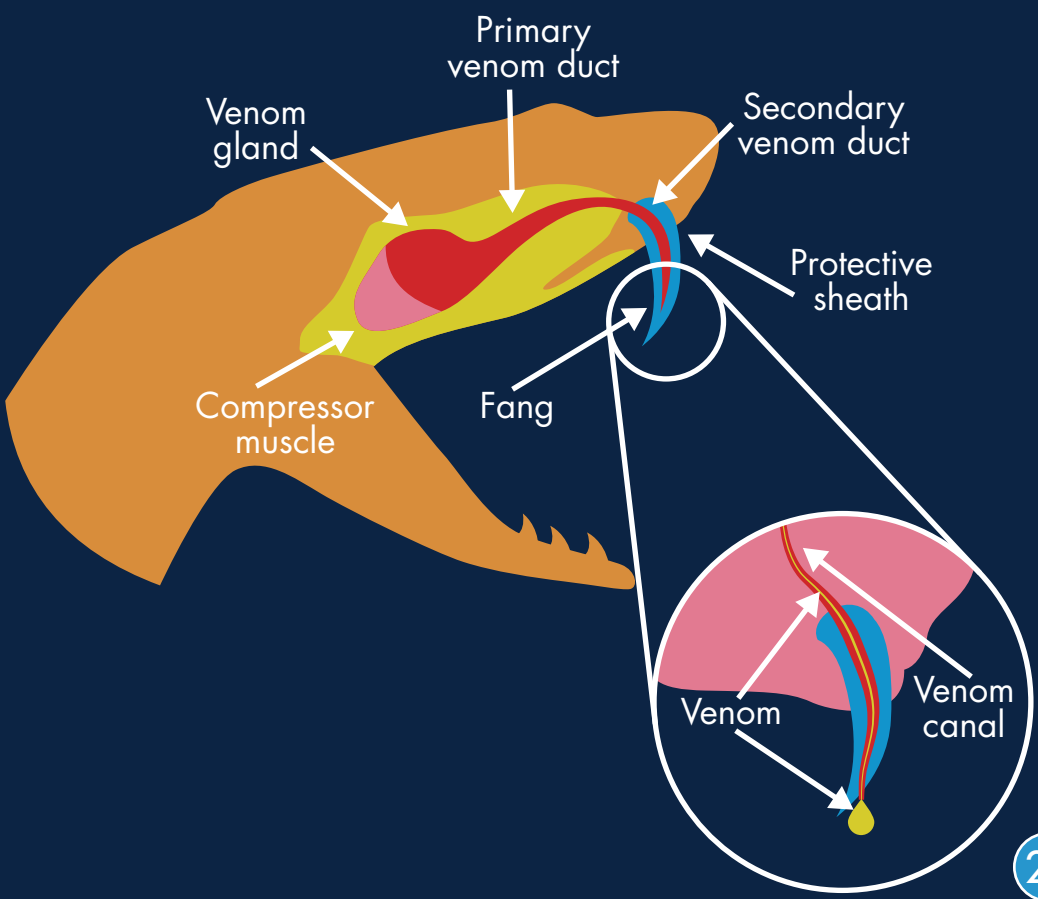
Snake bodies allow for diverse forms of locomotion.

The snake's muscular system is also important for catching prey. Most snakes, including rattlesnakes, ambush their prey. They lie still in one place and wait until their prey, like a kangaroo rat, gets close enough. Then they strike very quickly. Coiled up and ready, rattlesnakes' muscles can unleash a strike at a speed of almost 3 m (10 ft) per second. They hit their prey in 50-90 milliseconds. How fast is that? Blinking your eyes takes about 200 milliseconds! Rattlesnakes aren't the only super-fast snakes. Other snakes, including ones without venom, are just as fast!

In a successful strike, rattlesnakes sink large front teeth, called fangs, into their prey. These fangs don't just hold onto their prey, they inject **venom**. The venom immobilizes or kills prey. It can also be used as protection by killing or injuring an attacker! Even knowing that a snake might be venomous is often enough to thwart an attack. The rattle of a rattlesnake can scare off predators. So can the bright colors of the venomous coral snake.

There are three major types of venom. The venom is produced by modified salivary glands, and is made up of **proteins** that attack the victim's body. It also contains **enzymes** that speed up chemical reactions that break down molecules. *Cytotoxins* destroy the body cells in a victim. Some cytotoxins attack specific organs, such as the heart. Cytotoxins mostly work by attacking cell membranes or causing cells to undergo programmed cell death. *Neurotoxins* attack the nervous system. They disrupt chemical signals between **neurons**. Neurotoxins cause paralysis and sometimes death. Rattlesnakes primarily have *hemotoxins* that attack the circulatory system, primarily red blood cells. They cause red blood cells to burst open. Some hemotoxins prevent clotting of blood, worsening internal bleeding. Others cause blood cells to clump together, restricting the flow of blood.

VENOM DELIVERY SYSTEM OF A RATTLESNAKE



Not all snakes have venom. Some just grab a meal and then swallow it whole. Others, called constrictors, wrap their bodies around their prey and squeeze it to death. Because snakes vary greatly in size, from the diameter of a spaghetti noodle (Lesser Antellian threadsnake) to well over 6 m long (pythons and anacondas), it isn't surprising that they have many different types of prey. Smaller snakes eat smaller prey. Eggs, insects, lizards, mice, and small birds are on the menu. Bigger snakes can eat huge prey like antelope! One reason they can eat such big prey is that their lower jaws don't connect in the middle. That means they can open their mouths extremely wide and use the sides of their jaws to help move the prey down their throats!

A LEG UP

A kangaroo rat approaches a rattlesnake ambush site.

When facing an incredible predator like a rattlesnake, how does a kangaroo rat stand a chance of not becoming a meal, let alone surviving in the desert? It turns out that kangaroo rats have some serious adaptations. To survive the abiotic conditions of the desert, kangaroo rats are active at night to avoid the heat. During the day they stay in a burrow. No water? No problem. Kangaroo rats can get all the moisture they need from the seeds and insects they eat. They are also very efficient with their water. Their kidneys manage to extract most of the water that would be lost as waste products. Their waste is about five times more concentrated than in other animals, and the kangaroo rat reuses the water. Kangaroo rats may live in the desert but they don't have to drink at all!

Kangaroo rats have external and internal adaptations to survive in the desert.

A kangaroo rat is the perfect bite-sized meal for many predators, including owls and rattlesnakes. These are considered ambush predators, which means they wait for prey to come close, or sneak up on it. Then, they attack quickly. Prey of ambush predators need fast reaction times or weapons to survive. For example, buffalo in Africa aren't fast, but their horns and hooves can deliver a fatal blow to predators! Escaping a predator that chases its prey requires different **adaptations** than evading an ambush predator. For example, a snowshoe hare evading a Canada lynx needs speed, maneuverability, and endurance to escape.

Canada lynx

Snowshoe hare

African cape buffalo are hunted by lions. Their big horns and large size makes them difficult prey to take down.

Kangaroo rats have adaptations to detect ambush predators and quickly jump out of the way. Their sense of hearing is so good that they can hear a nearly silent owl swoop down at them. They can hear a rattlesnake about to strike! Their legs are incredibly strong and can propel them quickly away from a strike. Using their long tails, they can balance and turn quickly as they hop away or swivel in the air to avoid attacks. Sometimes they even turn and kick attacking snakes in the face!

DETECT AND RESPOND

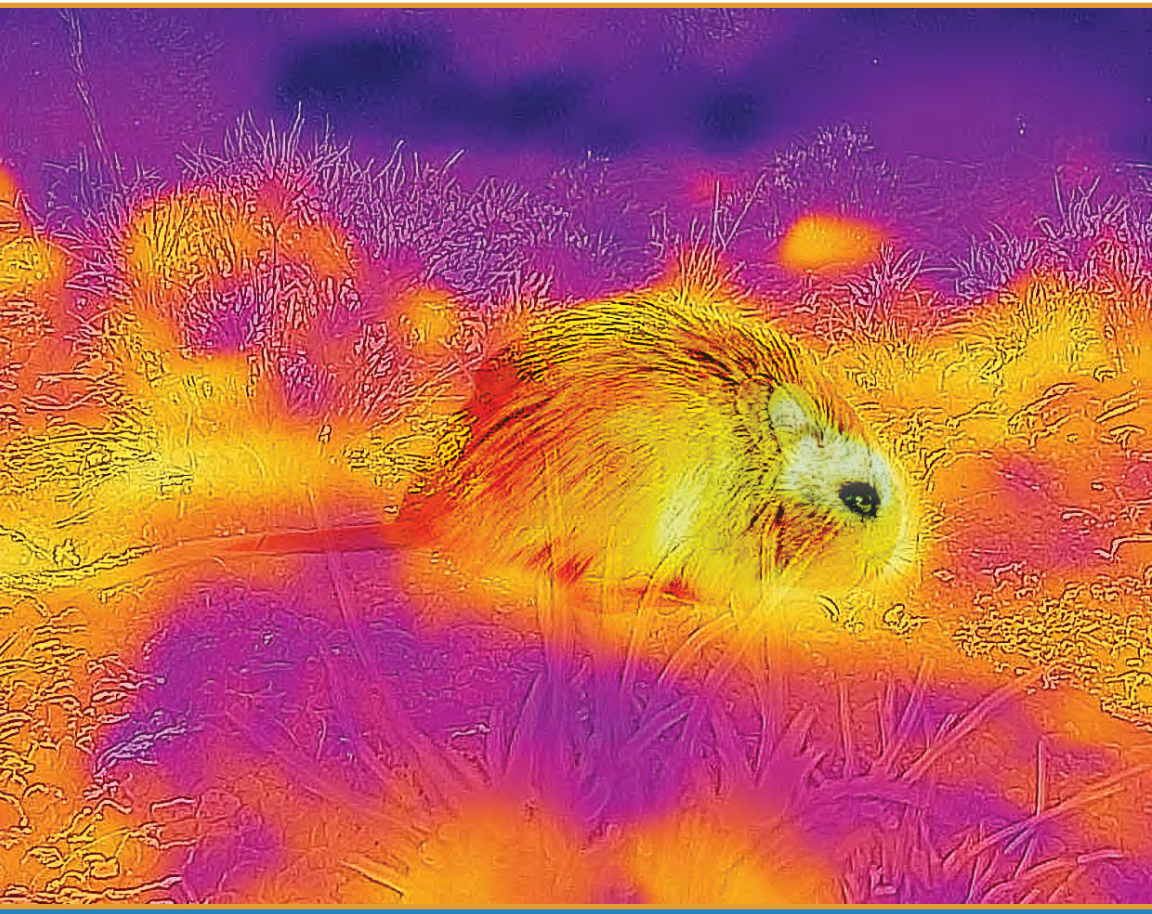
The battle between the rattlesnake and kangaroo rat starts before they ever run into one another. The rattlesnake tries to find the perfect place to lay an ambush. Its camouflage allows it to blend into its surroundings, and makes visual detection very difficult. Then, it waits…

Rattlesnakes have special adaptations to help them hunt. Their tongues detect chemical traces in the air and pits on their faces allow them to "see" radiant heat emitted by prey.

Kangaroo rats have extremely sensitive hearing that allows them to evade attacks from predators. Strong, muscular legs make for a quick escape.

Like other prey animals, kangaroo rats try to spend time in places that are as safe as possible. When it's not safe, it is on high alert. It listens for danger. It pauses to check its surroundings, scanning the environment with its ears and eyes. It integrates all its sensory information to make sure the coast is clear, before looking for the next seed.

Hoping for a meal, the rattlesnake "tastes" the air with its forked tongue. Pit organs along its head give it "heat vision." Using these senses, it detects the warm body of a kangaroo rat moving closer. It can feel the approach through its jaw touching the ground. Not sensing danger, the kangaroo rat slowly inches closer. The snake strikes…. who will win this encounter?



This is how a rattlesnake may see a kangaroo rat using heat vision.

STUDYING SNAKES AND KANGAROO RATS

Scientists around the world use technology to study snakes. They also have to be sure to have the right tools, especially if the snakes are venomous! Once snakes have been captured, scientists can mark them with different kinds of tags. PIT tags are the size of a grain of rice and are inserted under the skin. When scientists catch snakes they can scan them with a special reader and identify them. Using topographic maps and the Global Positioning System (GPS) they can mark where the snakes were found. Other tags emit radio signals. Scientists can use special receivers with antennas to find tagged snakes. Tracking data make it possible to see how far snakes move at different times of the year or whether snakes have favorite places to ambush their prey. Some studies are more low-tech, or do not use as much technology. The collection of snake scat, or snake poop, allows scientists to see what the snakes have been eating.

Researchers use many tools to study snakes.

Until recently, it was virtually impossible to study the intricate interaction between snakes and their prey at the moment of an attack. The scientists at ninjarat.org have been studying kangaroo rats and other small animals for years. As the ability for cameras to capture high-speed video has improved, scientists have been able to slow down the recorded action. This allows them to better see how a snake attacks a kangaroo rat or another small mammal. So, who wins? What does it mean for the desert ecosystem? Now you are ready to join the investigation!

GLOSSARY

ABIOTIC FACTOR
a non-living factor

ADAPTATION
a trait of an organism that helps it survive in its environment

BEHAVIOR
the way in which an organism acts

BIOTIC FACTOR
a living factor

CELLULAR RESPIRATION
the process that organisms use to release energy stored in chemical bonds of sugars

COMMUNITY
a collection of organisms of different species that live in the same area

DEPOSITION
the settling of soil or rocks in an area after being moved by wind or water

ECOSYSTEM
a biological community of interacting biotic organisms and abiotic factors in their environment

ELEVATION
the height above sea level

ENZYME
a chemical produced by organisms that speeds up biochemical reactions

EROSION
the gradual wearing away of soil, rock, or land by wind or water

EVAPORATION
the process of liquid turning into gas

NEURONS
cells within the nervous system that transmit information to other cells

NUTRIENTS
substances that provide nourishment essential for growth and life

PHOTOSYNTHESIS
the process that producers use to convert sunlight, water, and carbon dioxide into sugars and oxygen

POPULATION
all individuals of a species that live in the same area at the same time

PREDATOR
an animal that eats other animals

PREY
an animal that is eaten by another animal

PRODUCER
an organism (like a plant) that uses photosynthesis or another process to make its own food

PROTEIN
molecules made up of chains of amino acids that are important parts of body tissues

SPECIES
a group of organisms of the same type that can reproduce

STOMATA
small openings in leaves that allow movement of gasses in and out of the leaf

LATERAL UNDULATION
movement by throwing the body back and forth

VENOM
a substance that can harm or kill another animal when injected

WEATHERING
the breaking down of rocks by water, wind, ice, organisms, or chemicals

PHOTO CREDITS

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SCIENCE 3D

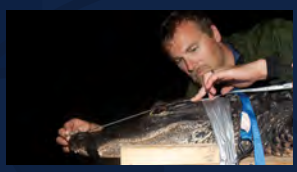
Thanks for exploring with us! Our science adventures take us around the world to uncover secrets of the most amazing animals and places. Our mission and passion is to share these scientific discoveries with you. There are so many cool things to see out there, even in your own backyard, so get outside and explore!

MIKE HEITHAUS PH.D.

Dr. Mike Heithaus is an explorer, author, educator, and television host. He is a professor of biology and Dean of the College of Arts, Sciences & Education at Florida International University. Mike and his students study sharks, whales, sea turtles, and other large marine animals around the world. They also work with people to help protect these species. Mike loves sharing his work with others. He has written text books and helped create programs for students in elementary, middle, and high school. He has been on television programs including on PBS, National Geographic, and Discovery Channel's Shark Week.

PATRICK GREENE

As a wildlife filmmaker, Patrick has always had a passion for animals. He started to draw pictures of sharks and whales when he was just five years old. Later, he went to college to become a marine biologist and learned a lot about science. Then he got a job in television and learned how to make videos, too. Since then, he's gone all over the world studying and filming wild animals. He's made shows for National Geographic, PBS and ABC, and even won an Emmy Award. He loves making videos to teach students about science and about the many creatures that share our world.



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