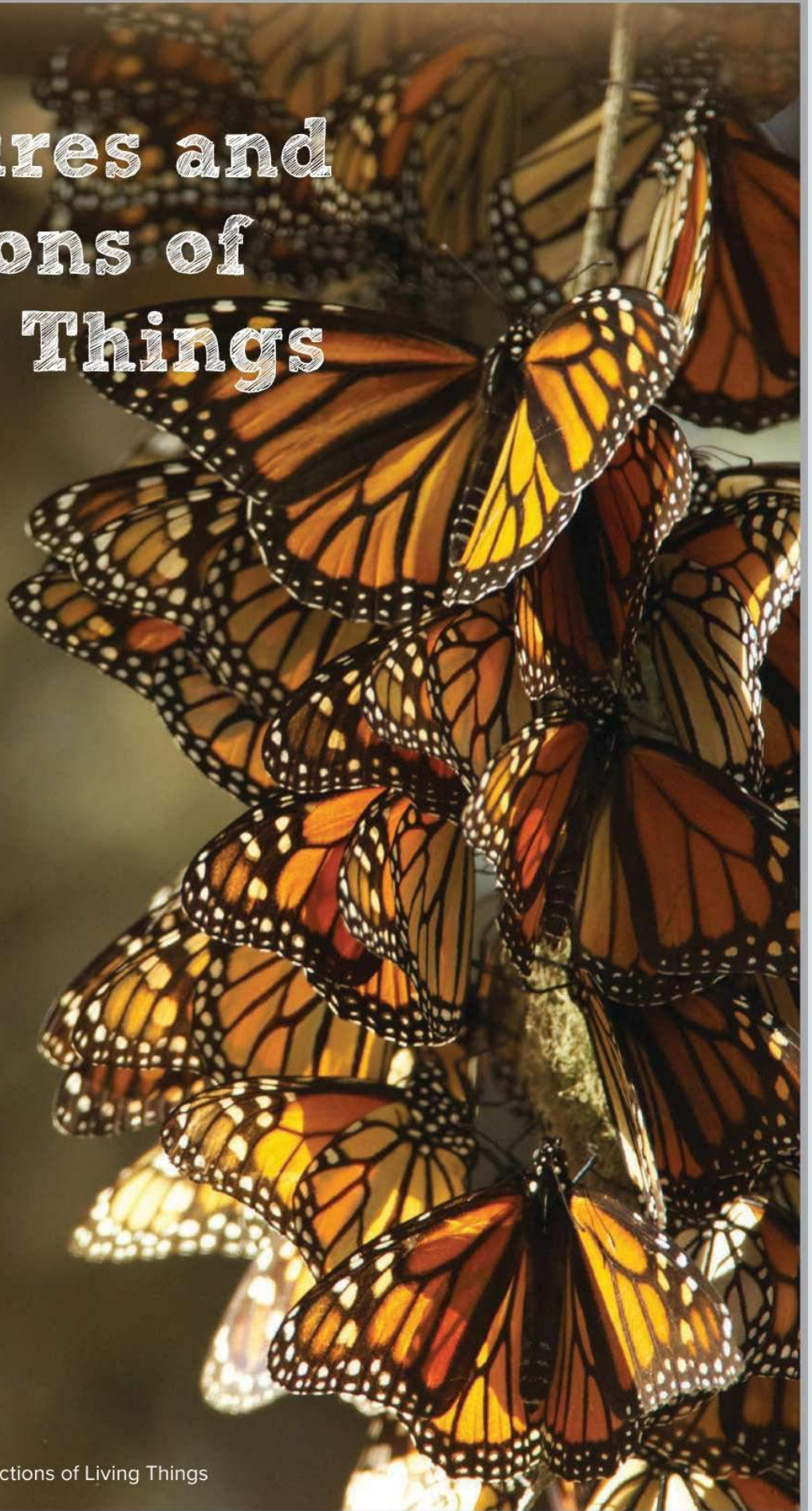


# Structures and Functions of Living Things





## ENCOUNTER THE PHENOMENON

How do structures help living things survive?



### GO ONLINE

Check out *Butterfly* to see the phenomenon in action.

### Talk About It

Look at the photo and watch the video of monarch butterflies. What structures do you observe? What are you curious about? Talk about your thoughts with a partner.

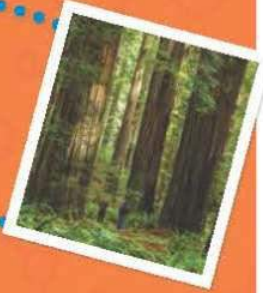
### Did You Know?

Monarch butterflies have organs located on their feet and heads that help them identify different plants.



## STEM Module Project Launch Science Challenge

**Lesson 1**  
Structures  
and  
Functions  
of Plants



**Lesson 2**  
Structures  
and  
Functions of  
Animals



# National Park Presentation

You are a forest technician in a national park. It is your job to put together a presentation for the park's visitors about an endangered species in your park. Your presentation should include a model to explain functions of the organism's structures and identify a problem the species faces. Be sure to let the visitors know how they can help.

*Congratulations! As a forest technician, you will teach visitors how an organism's structures help it survive.*



**POPPY**  
Park Ranger

Do you enjoy talking to people and being outside? Forest technicians work outside, protecting the woodlands. They also help educate visitors about a park's wildlife and natural history.



## STEM Module Project

### Plan and Complete the Science Challenge

You will use what you learn to teach others about how an organism's structures help it survive.

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## LESSON 1 LAUNCH

## Plant Parts

Plants are made up of different parts that help a plant live in its environment. Circle all of the parts that can be found on a plant.

Roots	Leaves	Bark
Flower	Nuts	Seeds
Spines	Stems	Trunk
Branch	Pine needles	Tubes that carry water
Root hairs	Fruit	Waxy coating

Explain your thinking. How did you decide which things were parts of a plant?

**Sample answer:** I think that all of these parts could be found on plants. I used my knowledge of different types of plants to help me answer this question.

You will revisit the Page Keeley Science Probe later in the lesson.

LESSON 1

# Structures and Functions of Plants

The coast redwood is a cone-bearing tree found along the coast of the northwest region of the United States.

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## ENCOUNTER

### THE PHENOMENON

# Why are these trees so tall?



#### GO ONLINE

Check out *Forest* to see the phenomenon in action.

#### Talk About It

Look at the photo and watch the video of the redwood trees. Circle items in the photo that you can compare to the trees to judge their height. What do you observe? Talk about your observations with a partner. Record or illustrate your thoughts below.

Sample answer: How do the trees use their tall trunks? How do they get water and nutrients up to their leaves? How fast do they grow? How do they reproduce?

#### Did You Know?

Redwood trees can grow to be taller than the Statue of Liberty. They can live to be 2,000 years old.



# INQUIRY ACTIVITY

## Hands On

### Plant Parts

Think of all the plants that you observed on your way to school. Earth has a great variety of plants. All plants are made of structures, or parts, each having a specific purpose. In this investigation, you will be comparing two different plants.

**Make a Prediction** How do the same plant parts compare between two different plants?

**Sample answer:** Plants differ in shape and size, but they all have a stem and leaves and are anchored in one spot by roots.

### Carry Out an Investigation

**BE CAREFUL** Observe the plants without touching them.

1. Take a walk around your schoolyard with your class.
2. Find two different plants to observe and sketch. Draw the plants below. Use the hand lens to get a better look at the plants' parts.
3. Identify as many of the plant parts as you can. Label them in your drawings.



### Materials



hand lens

Plant 1

Plant 2

### Communicate Information

4. How were the shapes of the leaves on the two different plants similar and different?

Sample answer: Both types of leaves that I observed were flat. One was shaped like a heart. The other had five points.

5. How were the shapes of the stems on the two different plants similar and different?

Sample answer: Both types of stems were long and tube-shaped. One stem was skinny, and the other was much thicker.

6. Think about the plants that you observed and other plants that you have seen. How are plants different from one another?

Sample answer: Stems are long, and tube-shaped, but their size and outer covering differ. Leaves are usually thin, and most are flat, but their shapes can vary. Some plants lose their leaves in the winter, while others do not. Some plants have bright colors, while other plants are just green.



### Talk About It

Did your observations support your prediction?  
Discuss with a partner.



## VOCABULARY

Look for these words as you read:

**adaptation**

**response**

**stimulus**

**transpiration**

**tropism**

# Plant Needs

The redwood trees that you saw in the lesson phenomenon and the two schoolyard plants you observed in the Inquiry Activity, *Plant Parts*, probably look very different. But they aren't as different as you might think. All plants have the same basic needs and a set of typical structures.

The basic needs of plants are air, water, sunlight, nutrients, and space. Plants must live in an environment where their needs are met.

The air around Earth is a mixture of gases. Plants need one of these gases, carbon dioxide, to make food. They need another gas, oxygen, to break down the food. Plants have pores, or stomata, in their leaves that allow gases to move in and out of the plant.

Plants use sunlight to make food. They use the energy from sunlight to make sugar. The sugar provides the energy plants need to survive. Some plants need more sunlight than others. Plants use their leaves to gather sunlight.



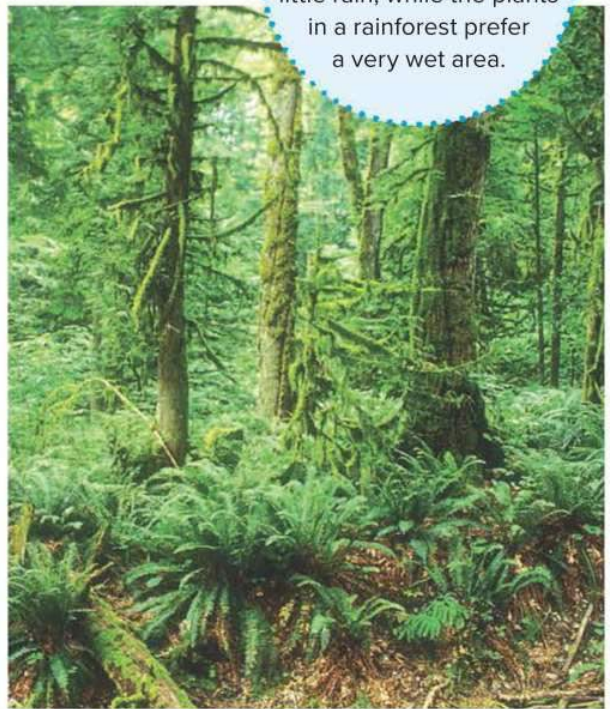
Palm trees require a lot of sunlight. Mosses and ferns can grow in shady areas.

All living things, including plants, need water. Water is another material that plants use to make food. Water is also used to move nutrients through plants. In plants, water also provides support. Plants that do not get enough water will start to droop, or wilt. Most plants take in water through their roots. The water then moves into a system of tubes that distribute the water throughout the plant.

Substances that a living thing needs to stay healthy are called nutrients. Plants need nutrients found in their environment. Most plants take in nutrients, which are dissolved in water, through their roots.

Plants need enough space to get the air, water, sunlight, and nutrients they need to survive. Plants that are crowded close together have a harder time getting the things they need.

Some plants need more water than others. Cacti can survive in deserts with little rain, while the plants in a rainforest prefer a very wet area.



Copyright © McGraw-Hill Education (i)Bear Dancer Studios/Mark Dierker, (r)©Steven P. Lynch

What needs might not be met if you plant the plants in your garden too close together?

Sample answer: The plants will not have enough space, so they might not be able to get enough water, air, sunlight, or nutrients. They might die.

# Plant Parts

Most plants have roots, stems, and leaves. These parts, or structures, help the plant meet its needs and carry out life functions.

## Roots

Plant roots take in water and dissolved nutrients from the soil. Roots also hold the plant in place. Some roots store food the plant has made.

## Stem

The stem supports the plant. It is also part of a plant's transport system. There are two types of stems: soft stems and woody stems. Soft stems are green and are flexible. Woody stems are hard and are often covered in bark. Tree trunks are examples of woody stems.

Stems also allow materials to move inside the plant through a system of tubes. The tubes in the stems carry water and dissolved nutrients.

## Label a Diagram: Roots, Stems, and Leaves

Label the different parts of the plant. Then describe the functions of each of the plant parts below.

### Roots:

hold the plant in place,  
take in water and  
nutrients

### Stems:

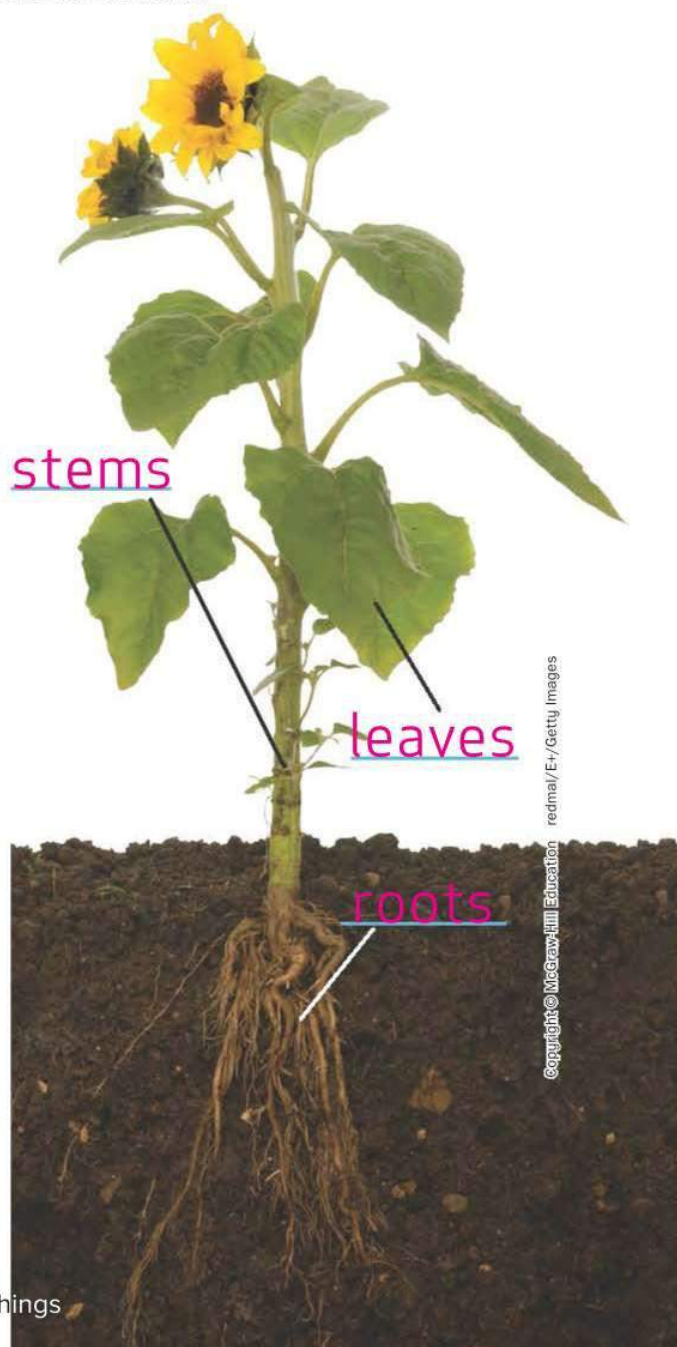
support the plant,  
transport materials

### Leaves:

capture light and are the  
site of gas exchange

## Talk About It


Use evidence to construct an argument that plant structures function to support survival.



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## Leaves

Leaves vary in shape and size. Most leaves have a line of symmetry, which means their shape can be divided into two identical parts. Leaves are the site of gas exchange and food production. Most leaves are broad and flat, which allows them to collect sunlight efficiently. Plants break down the food they make in the leaves and use it for growth and repair. **Transpiration** is the release of water vapor, mainly through the small openings in the underside of leaves. This process drives the movement of material throughout a plant.

 **GO ONLINE** Watch the video *Plant Structure and Function* to see more plant structures and functions.

## Talk About It

What parts of a plant have a line of symmetry? Discuss with a partner.

## **FOLDABLES**

Cut out the Notebook Foldables tabs given to you by your teacher. Glue the anchor tabs. Use evidence to explain how the structures present in the photo help plants survive and grow.

*Glue anchor tab here.*

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# Plant Reproduction

Plants have many structures that are used for reproduction. Some of the structures are flowers, cones, seeds, and fruits.

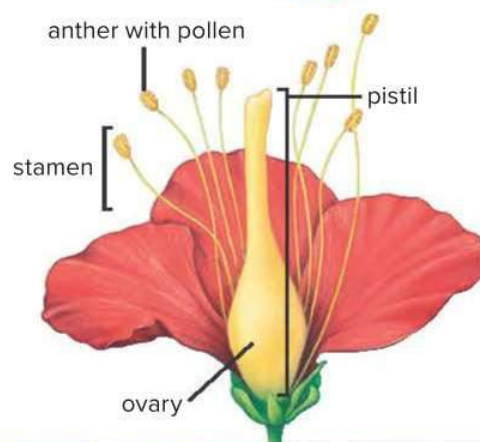
## Flowers

Most flowers contain male and female parts. The stamen is the male part. It contains the anther, where pollen is produced. The pistil is the female part. It contains the ovary, where egg cells are produced. Insects, birds, and wind help move pollen. Fertilization occurs once the content inside the pollen joins the egg cells inside the ovary. Seeds develop after fertilization.

Although flowers come in different colors and shapes, they all contain the same structures used in reproduction.

## Cones

Some seed plants reproduce with cones. These plants usually produce both male and female cones. The male cones produce pollen that is released into the wind. The female cones produce a sticky liquid that captures the pollen. Fertilization occurs in the female cone.



## Talk About It

Explain to a classmate the parts of a flower that help it reproduce.



Pollen is produced in the smaller male cones. Seeds develop in the larger female cones.

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## Seeds

A seed contains an embryo surrounded by a food supply, or cotyledon, and an outer seed coat. An embryo is the beginning of a new organism. It will live off of the food supply until it is big enough to make its own food.

## Fruits

As a seed develops, the ovary enlarges into a fruit, which protects the seed. Some fruits appeal to animals, which eat the fruits and spread the plant's seed in their droppings.



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Use evidence to construct an argument that a plant's system has parts that work together to support reproduction.

**Sample answer: An embryo is needed for reproduction. The embryo gets food from the seed and is protected by the seed coat.**

**REVISIT** Revisit the Page Keeley Science Probe on page 5.



# Plant Survival and Behavior

Environments can present challenges to the organisms that live there. An **adaptation** is a physical trait or behavior that helps an organism survive in its environment.

**GO ONLINE** Use the simulation *Plant Structures* to learn how the structures in plants function.

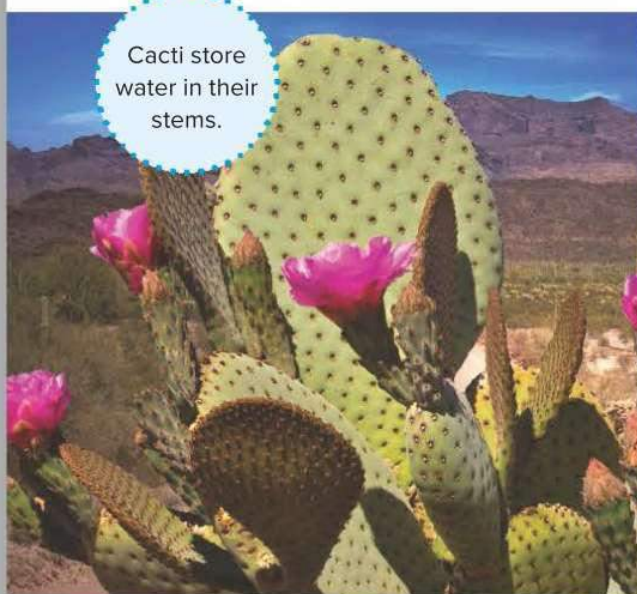
Many plants have parts that are physical adaptations. For example, desert plants have adaptations for living in a hot, dry environment. Cacti have thick, waxy stems that store water. They have dense, shallow roots to soak up rain quickly. Rainforest plants, such as orchids, have adaptations that help them survive in hot, wet conditions. An orchid's aerial roots absorb nutrients and anchor the plant high in a tree. Orchids also have leaves that are shaped to drain excess water to prevent rotting.

Many plants have adaptations to defend themselves from animals that would eat them. Some plants have thorns. Others produce chemicals that are poisonous or taste bad.



**Construct an argument from evidence** to explain how the **parts** of each plant's **system** help it survive.

**Sample answer: The roots, stems, leaves, and flowers help them get the resources that they need to survive and reproduce in their unique habitats. Their structures look different but still have mostly the same purpose.**



Cacti store water in their stems.



Orchids have aerial roots and drip tip leaves that help them survive in warm, moist conditions.

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## Plant Behavior

Plants have internal structures that enable them to react to changes in their environments. A change in an environment that causes an organism to respond is called a **stimulus**. The reaction or change in behavior of an organism is called a **response**. Plants respond to stimuli such as sunlight, water, and gravity.

A plant responds to a stimulus by changing its pattern of growth. A plant's response to water, gravity, light, and touch is called **tropism**.

Plants respond to light by growing toward the light source. This response is known as phototropism. Most plant roots grow downward, the same direction as the pull of gravity, while most stems grow upward. This is called gravitropism. Roots sense water in the soil and grow toward or away from it. This response is known as hydrotropism. Some plants respond to touch, or contact with an object, by curling around that object or clinging to it. This is known as thigmotropism.

1. List the types of tropisms on the lines below. Identify and label the types of tropism shown in the photos on this page.

phototropism,  
gravitropism,  
hydrotropism,  
thigmotropism

2. Use evidence to construct an argument that plants have structures that support behavior.

Sample answer: Plants have internal structures that allow them to react to a stimulus and change their behavior in order to get the resources they need to live and grow.



## STEM Connection

# How Could You Become a Horticultural Scientist?



Do you like growing plants and helping people? **Horticultural scientists** help farmers improve crop production. Plants are an essential part of our lives. All of the food that we eat comes directly or indirectly from plants. Horticultural scientists play an important role in making sure we have enough food to eat. Some horticultural scientists conduct research. Others work with farmers to help them grow more plants. They have knowledge of plant biology, soils, and pests that might affect crops. Some study genetics and diseases.

To become a horticultural scientist, you will take courses in biology, botany, soil science, and entomology, the study of insects.

### It's Your Turn

Think like a horticultural scientist as you study plants in different habitats in the next activity.



### Talk About It

How would knowing about different habitats help a horticultural scientist?

## INQUIRY ACTIVITY

### Research



## Survival in Different Habitats

The plants that you observed in the Inquiry Activity, *Plant Parts*, all live in the same habitat, yet their structures are different. There are many different habitats found throughout the United States. How will the structures of plants that live in different habitats differ?

**Make a Prediction** Choose two habitats from the table below. Make a prediction about how plants from the two habitats will differ.

**Sample answer:** A plant from the North American desert will have adaptations to prevent water loss, like a thick stem with a waxy cuticle. A plant from the northwestern coastal forest will have adaptations to fog, like leaves that allow water in the fog to drip off onto the roots, where it can be absorbed.

### Carry Out an Investigation

1. Use the table below to choose two plants from different habitats.

Type of Habitat	Common Plants
Tundra	arctic moss, reindeer lichen
Northwestern Forested Mountains	thimbleberry
Eastern Temperate Forests	spruce, magnolia
Great Plains	big bluestem grass, buffalo grass
North American Desert	saguaro cactus, desert holly
Northwestern Coastal Forests	coast redwood

## INQUIRY ACTIVITY

2. Research the two habitats from which you chose your plants. Describe the habitats below.

Sample answer: The northwestern coastal forest has moist, foggy conditions. The North American desert has a low elevation and is hot and dry year-round.

3. Research each plant you chose. Identify and describe its structures, including any adaptations. Draw the plants and label their structures below.

Students should draw each plant and label major external structures, including roots, stems, and leaves. They should

point out any adaptations, such as thorns or thick stems or leaves that store water.

4. What adaptations are found in each of the plants that you chose?

Sample answer: The coast redwood has thick bark that helps it survive wildfires and shallow, spreading roots that protect the trees from flood damage and help them stand up to strong winds. The saguaro cactus has white flowers that attract pollinators and spines for protection. Its roots grow 4-6 inches deep into the ground, which allows it to absorb surface water. Saguaro cacti have pleats that expand to store extra water.

5. **ENVIRONMENTAL Connection** Do more research to find out how humans have affected each of the habitats that you chose. Take notes below.

Sample answer: The northwestern coastal forest has been changed by logging. The North American desert is affected by habitat modification by humans and invasive species.

### Communicate Information

6. How did the plants that you chose for your investigation differ?

Sample answer: The coast redwood is tall and has flat needles. The saguaro cactus expands to store water, and contracts as it uses its water supply. It has prickly spines and waxy skin.



**Engage in an argument from evidence** to explain how the plants from your investigation have **structures that function** to support survival in different environments.

Sample answer: Most plants have roots, stems, and leaves. They vary in shape and size. Plant structures are adapted to obtain the resources a plant needs to survive. Plants in moist habitats do not have thick stems because they have plenty of water compared to plants in desert areas.



### Talk About It

How is an organism's structure related to its function? Discuss your ideas with a partner.





LESSON 1

# Review

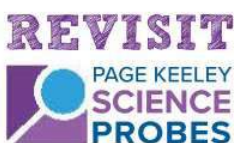
## EXPLAIN THE PHENOMENON

Why are these trees so tall?

### Summarize It

Construct an argument about how structure in plants support growth, survival, and reproduction.

Sample answer: The structure of the redwood trees helps them grow, survive, and reproduce. Their stems are very tall and woody to support them. The tall trunks also help them reach the foggy sky. Their leaves help move the moisture from the fog to the ground, where it can be absorbed by their roots. Their thick bark helps them survive forest fires.

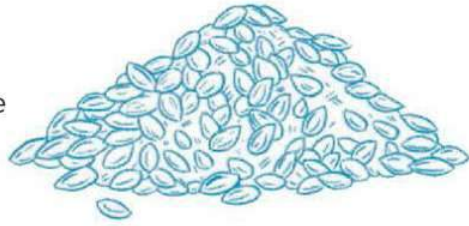


Revisit the Page Keeley Science Probe on page 5. Has your thinking changed? If so, explain how it has changed.



## Extend It

How does human activity affect plants? Think back to the Inquiry Activity, *Survival in Different Habitats*. Identify a negative effect that human activity has on plants, and propose a solution to the problem.



Sample answer: Habitat modification and development threaten many plants in my area. Habitats are destroyed to make room for homes and businesses, and water is rerouted. To solve this problem, development can be limited to certain areas, and people can use native species to landscape their lawns. This will help to keep habitats from being broken up. By landscaping with native plant species, people will not need to worry about the climate and amount of water needed for the plants to survive.

### OPEN INQUIRY

What questions do you still have about plants' structures and their functions?

Sample answer: Can a plant's structure change over time?

Plan and carry out an investigation or research to find the answer to your question.

## KEEP PLANNING

STEM Module Project  
Science Challenge



Now that you have learned about the structures and functions of plants, go to your Module Project to explain how this information will affect your plan for your national park presentation.

LESSON 2 LAUNCH

## Animal Parts

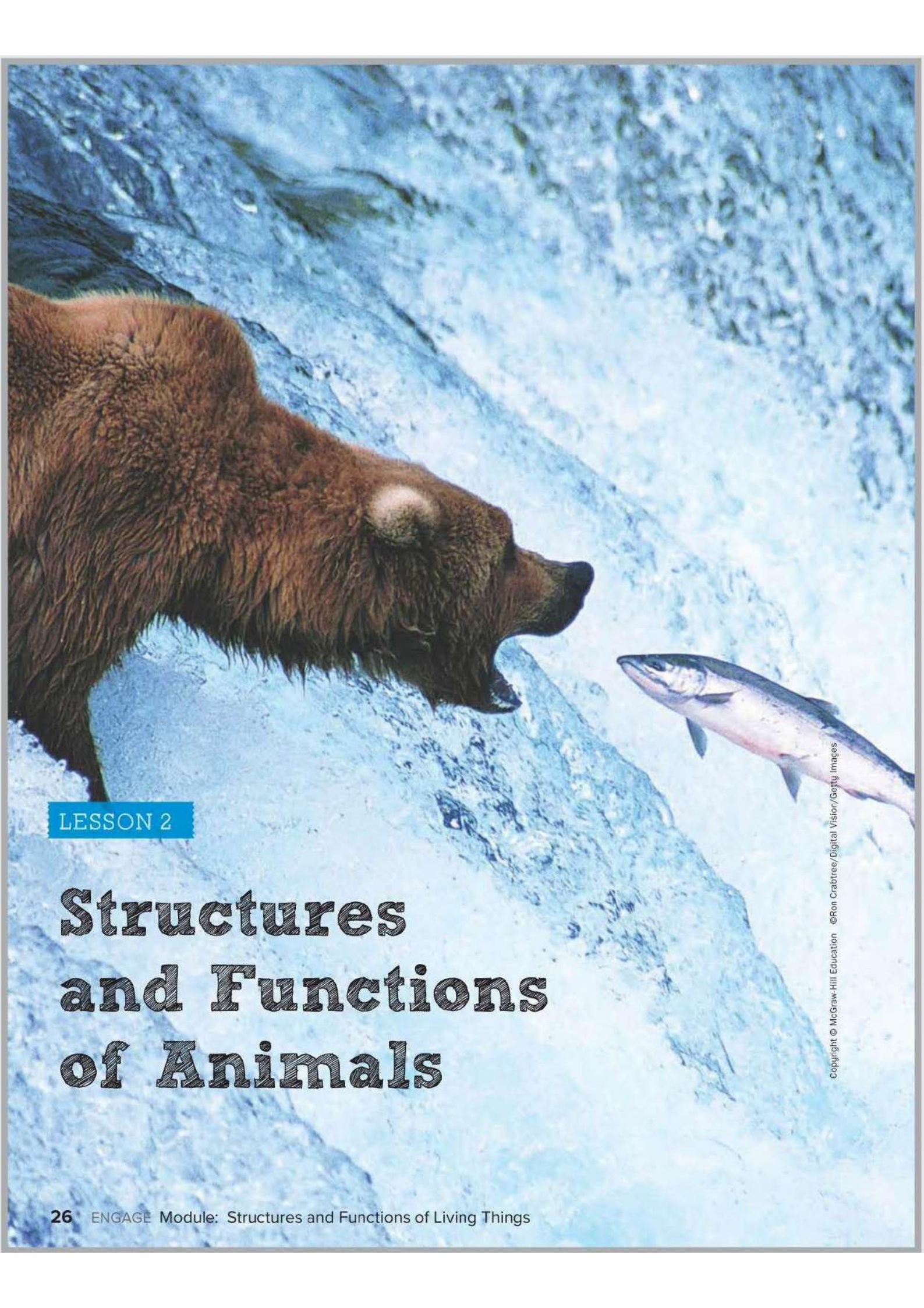
Animals are made up of different parts that help an animal live in its environment. Circle all of the parts that could be found on an animal.

Ear	Shell	Claw
Heart	Leaf	Feather
Tentacle	Tail	Fur
Roots	Lungs	Skin
Teeth	Antennae	Wings
Fin	Beak	Seeds

Explain your thinking. How did you decide which things are parts of an animal?

Sample answer: I think all of them could be found on an animal except the leaf, roots, and seeds. These are parts of plants, not animals. As I read each word, I tried to think of an animal that has that part.

You will revisit the Page Keeley Science Probe later in the lesson.



LESSON 2

# Structures and Functions of Animals

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# ENCOUNTER

## THE PHENOMENON

How do grizzly bears use their structures?



### GO ONLINE

Check out *Grizzly Bear* to see this phenomenon in action.

Look at the photo and watch the video of grizzly bears. What do you observe? Discuss your thoughts with a partner. Record your thoughts below.

Sample answer: What structures does the bear use to catch its food? Do all bears have the same structures? How do structures help the bear survive in its environment?

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### Did You Know?

Grizzly bear claws are 5 to 10 centimeters (2–4 inches) long.



# INQUIRY ACTIVITY

## Hands On

### Animal Parts

There is a great variety of life on Earth. Apart from plants, this planet is crawling with life, from the tiny earthworm to the elusive mountain lion that roams the mountains. Think of all the animals that you hear or see when you take a walk outside. In this investigation, you will compare the parts, or structures, of two different animals.

**Make a Prediction** How do the same structures on two different animals compare?

**Sample answer:** Structures will be different shapes and sizes on different animals.

#### Materials



#### Carry Out an Investigation

1. Think of two different animals you saw.
2. Draw the first animal you chose, and label all the parts of the animal that you know.

**Sample answer:** Drawing of a mountain lion with the following structures labeled: fur, claws, teeth, ears, tail, eyes.

3. Draw the second animal you chose, and label its parts.

Sample answer: Drawing of a western fence lizard with the following structures labeled: scales, claws, mouth, nostrils, tail, eyes.

4. In the table, list each animal structure that you labeled. Think about how the animals use each structure, and add the possible function to the table. Use a separate piece of paper if needed.

Structure	Possible Function
teeth	break down food
eyes	find prey
claws	defense
scales	protection

# INQUIRY ACTIVITY

## Communicate Information

5. Think back to the module phenomenon of a bear. How is one of the animals you chose similar to a bear? How are they different?

Sample answer: Both the bear and the mountain lion have fur covering their bodies. They have similar nose and ear structures. The mountain lion has a longer tail than the bear.

6. How are the structures of the two animals you chose alike?

Sample answer: The mountain lion and the lizard have four legs, a tail, two eyes, and claws.

7. How are the structures of the two animals you chose different?

Sample answer: The mountain lion's body is covered in fur, while the lizard's body is covered with scales. Also, the mountain lion has noticeable ears, while the lizard's ears are not visible.



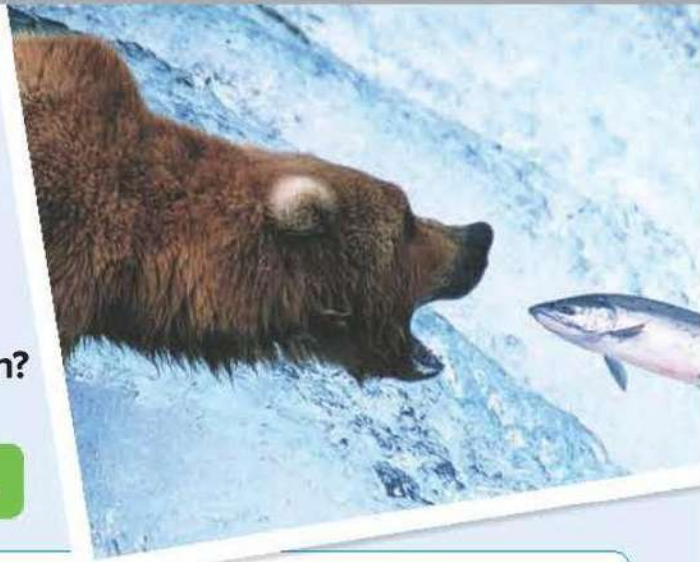
## Talk About It

Compare one of your animals to one of a classmate's animals. How are their structures alike? How are they different? Talk to your partner.



## MAKE YOUR CLAIM

Think back to the different animals in the investigation. How do animals use their structures to support survival, growth, behavior, and reproduction?



Make your claim. Use your investigation.

### CLAIM

Animals have external and internal structures that \_\_\_\_\_ to support survival, growth, behavior, and reproduction.

Sample answer: work together

Cite evidence from the activity.

### EVIDENCE

The investigation showed that \_\_\_\_\_.

Sample answer: animals have different structures that perform different functions. Some animals migrate or hibernate.

Discuss your reasoning as a class. Tell about your discussion.

### REASONING

The evidence supports the claim because \_\_\_\_\_.

Sample answer: structures work together as part of a body system to keep an animal healthy. Behavioral adaptations allow animals to survive and reproduce.

You will revisit your claim to add more evidence later in this lesson.

## VOCABULARY

Look for these words as you read:

external structure

internal structure

structural adaptation

# Animal Needs and Structures

Animals need food, water, space, and shelter to survive.

While all animals have the same needs, they meet their needs in a variety of ways and places.

## Food, Oxygen, and Water

Unlike plants, which produce their own food, animals eat other organisms to get energy. Animals use the energy from food to grow, survive, and reproduce. Oxygen, a gas found in air and water, helps animals get energy from food. Water keeps the parts inside an animal's body working properly.

Some animals that live in water need to come to the surface to breathe air. However, most animals that live in water take in oxygen from the water. For example, fish are adapted to exchange gases with the water that surrounds them. They have structures called gills for this purpose.

## Space and Shelter

Animals need space to hunt for food, escape from predators, and build homes. A shelter is where an animal makes its home. Shelters provide protection for the animals that live in them. They also provide a place for animals to give birth and raise their young. Birds build nests in trees and on cliffs. Woodchucks and squirrels dig burrows.

1. Explain why animals need food and space.

Sample answer: Food provides energy for animals; animals need space so they can hunt for food, escape from danger, and build homes.

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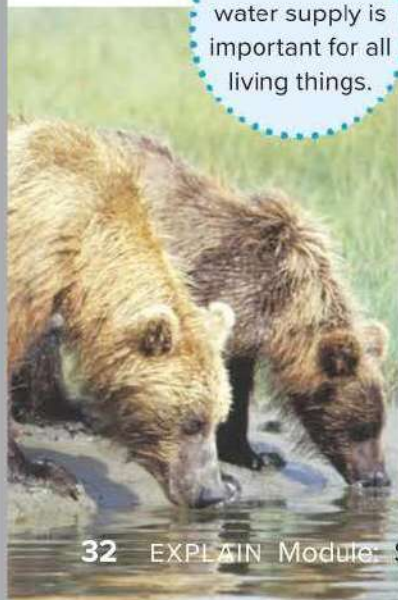
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Butterflies have a body part called a proboscis which helps them get food from flowers and fruits.

An abundant water supply is important for all living things.



## Structures

Structures inside and outside animals' bodies work together to obtain nutrients, digest food, eliminate waste, and reproduce. These parts keep an animal alive and help it reproduce.

**Internal structures** are structures found inside an organism's body. These structures, like the major organs, have specific functions. For example, the brain's main function is to process information. The stomach helps digest food. The intestines absorb nutrients. Kidneys help eliminate waste. Lungs help with the exchange of gases. Animals can reproduce once their reproductive organs reach maturity.

**External structures** are found outside of an organism's body. A shark's teeth and a bird's beak are examples of external structures that help these animals get food.

- 2. WRITING Connection** Revisit the Explore activity. Research the two different animals that you compared, focusing on their internal structures this time. Write a short summary explaining how these structures help each animal survive its environment. Use a separate piece of paper if needed.

Sample answer: Both mountain lions and lizards have many organs in common such as a brain to help process information, intestines to absorb nutrients, and kidneys to eliminate waste from their system.

**GO ONLINE** Watch the video *Animal Structures* to learn more about animal structures.



Orangutans move by swinging from tree to tree. They need plenty of space to find shelter and food.



Robins build nests that are high off the ground so that they can safely lay eggs and raise their young.



Fish take in oxygen from the water through their gills.

# Structural Adaptations

An organism's **structural adaptations** are inherited changes to physical features that help an organism survive and reproduce. Fur color, long limbs, strong jaws, and the ability to run fast are structural adaptations. Some structural adaptations help organisms survive in certain environments. Other structural adaptations protect prey from predators or enable predators to hunt more successfully.

## Camouflage

Camouflage is any coloring, shape, or pattern that allows an organism to blend in with its environment. Predators with camouflage sneak up on prey. Camouflage also helps prey animals hide from predators.

## Mimicry

Mimicry is an adaptation in which an animal is protected against its predators by its resemblance to a different animal or object. For example, the spicebush swallowtail caterpillar's head has spots that look like a snake's head. This shape frightens away most predators.

1. Explain how structural adaptations help animals survive.

Structural adaptations can help prey escape from predators, or help predators hunt more successfully.

2. Circle the animal that shows mimicry. Put a square around the animal that is using camouflage.

This stick bug avoids predators by looking just like bark, leaves, or twigs.



Spicebush swallowtail caterpillar

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**REVISIT** Revisit the Page Keeley Science Probe

**PAGE KEELEY SCIENCE PROBES** on page 25.

# Behavioral Adaptations

An adjustment in an organism's behavior is a behavioral adaptation. For example, many animals travel in herds for protection from predators. Others, such as wolves, hunt in packs to capture larger prey.

Many animals—such as birds, butterflies, and fish—migrate. Migration is the movement of animals from one place to another. Animals migrate to find food, reproduce in better conditions, or find a less severe climate.

Some animals endure cold winters by hibernating. Hibernation is a period of inactivity during cold weather. During this time, animals remain inactive until warmer temperatures return in spring. Grizzly bears prepare for hibernation around November. They will not eat, drink, or eliminate bodily wastes during hibernation, which lasts approximately five months.

1. Why do animals travel in herds?

**Sample answer: Traveling in herds reduces the chance of being attacked by a predator.**

2. What is the advantage of hunting in a group?

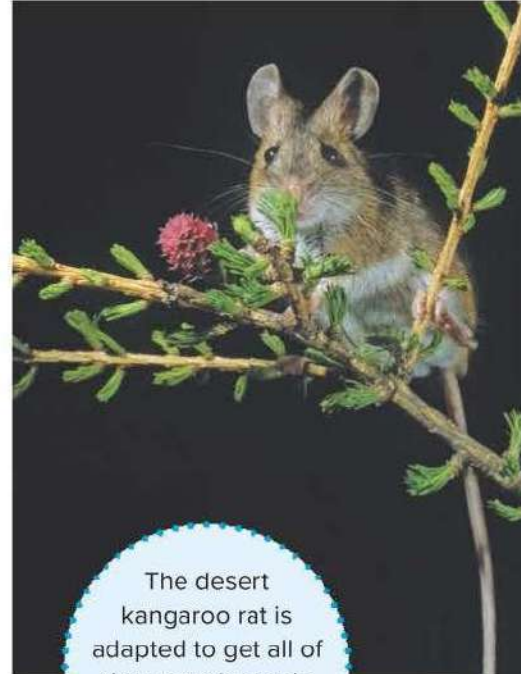
**Sample answer: Animals that hunt in a group can work together to catch larger prey.**



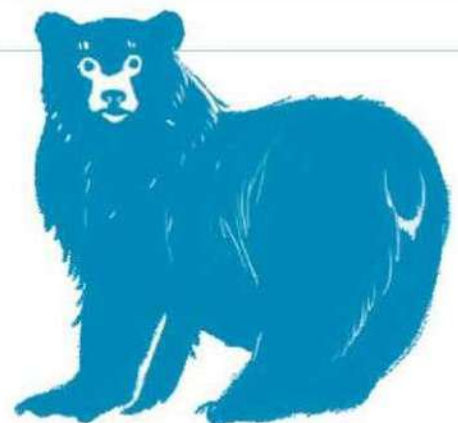
## Talk About It

Why do animals hibernate during winter and not during summer? Discuss with a partner.

**GO ONLINE** Explore *How Animals Survive* to learn more about what helps animals stay alive.



The desert kangaroo rat is adapted to get all of the water it needs from food. It never needs to drink.







## INQUIRY ACTIVITY

### Hands On

# Put Your Best Foot Forward

You have read that animals have different structures that help them to be better suited to their environment. Have you ever wondered what type of feet would be best for swimming? What type of feet would be best for picking things up? Look at the tongue depressor, fork, and tweezers. You will use these tools to simulate how birds use their feet to survive in nature.

**Make a Prediction** Take a look at the activities listed in the data table. Which tool will be best for each activity?

Sample answer: I think that the tongue depressor will be the best for paddling, the tweezers will be best for picking things up, and the fork will be best for digging in debris.

### Carry Out an Investigation

**BE CAREFUL** Wear safety goggles during this activity.

1. Add water to one container until it is half full. Add about 2 inches of pea gravel to the second container.
2. Place a handful of the colored gravel into each container.
3. Observe the different tools. They represent different types of feet you might find on birds.
4. Experiment with the tools to determine which would best help a bird to grasp and pick up food (colored gravel), swim in water, and dig through debris (pea gravel).
5. **Record Data** In the table, rate each tool from one to three based on how well it performed in each test. One is good, two is ok, and three is poor.

### Materials



safety goggles



2 plastic containers



water



pea gravel



colored gravel



tongue depressor



fork



tweezers



colored pencils

Types of Activity			
	Digging for food in debris	Paddling through water	Picking up and grasping food
Tongue depressor <b>blue</b>	2	1	3
Fork <b>green</b>	1	2	3
Tweezers <b>orange</b>	2	3	1

- 6. Analyze Data** In the data table, use orange to shade the tool that was best for grasping and picking up. Use blue to shade the tool that was best for paddling in water. Use green to shade the tool that was best for digging.

### Communicate Information

7. Why do you think it is helpful for birds to have different types of body structures?

Sample answer: Having different types of body structures, allows some birds to search for food where other birds cannot.



Use evidence **to engage in an argument** to support a claim about the **function of structures** in different birds.

Sample answer: All birds have feet, but they vary in their function. Feet that are good for swimming are wider, while feet that are thinner and good for picking up food.



### Talk About It

Did the result support your prediction? Discuss your results with a partner.



### COLLECT EVIDENCE

Add evidence to your claim on page 31 about how structures work together to help animals survive.



## STEM Connection

# What Does a Zoologist Do?



**A zoologist** is a scientist who studies animals. Zoologists also study animals that are extinct. Zoologists observe animals in their natural habitat and in a laboratory and collect data to learn more about the animals they are studying. They study an animal's physical characteristics, diet, and behaviors. They often work for universities, museums, or zoos. They may work outside in the field, in a laboratory, or in an office.

## It's Your Turn

Like a zoologist, you will now analyze data to learn more about animals. Complete the activity on the next page to find out more about how birds' structures help them survive in their environment.

## Talk About It

How might a zoologist help an animal survive? Discuss with a partner.



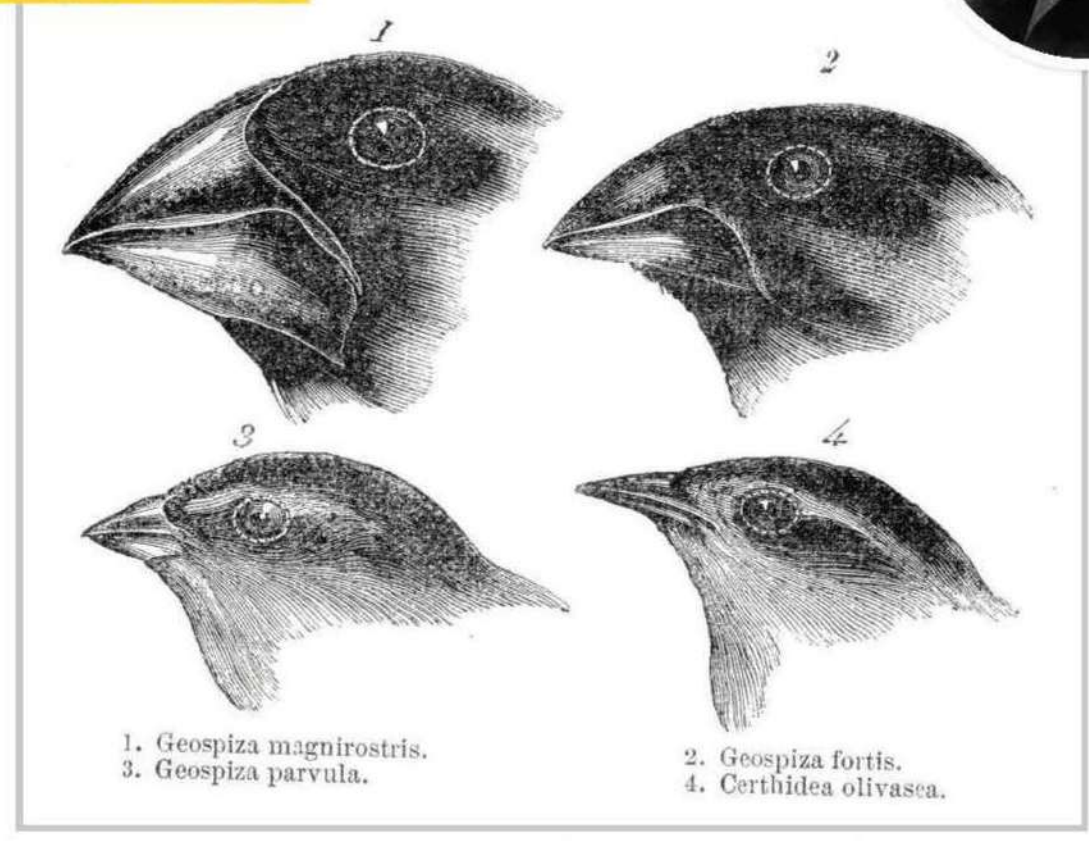
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# Darwin's Finches

Charles Darwin was a British naturalist, geologist, and biologist who studied the variation in structures of living things. In 1831, he traveled around the world for five years. During his voyage, he arrived at the Galápagos Islands and started to explore. He noticed that each island had different types of food available to finches. The food supply included thick-shelled seeds, insects, fruits, and other resources.



## PRIMARY SOURCE



Analyze the sketches of the finches' beaks. Form an argument, supported by evidence, about how the finches' beaks allow them to obtain food from their environment.

**Sample answer:** Beak types allowed finches to eat particular types of food. Tougher beaks were better at breaking apart thick-shelled seeds. Thinner beaks were better to poke into holes to obtain food.



LESSON 2

# Review

## EXPLAIN THE PHENOMENON

How do grizzly bears use their structures?

### Summarize It

Explain the function of structures in animals.

Sample answer: Many animals have the same structures; however, sometimes these structures have different functions that make the animal better suited to its environment. For example, birds that spend most of their time in water have feet that help them swim. Birds that spend most of their time on land have feet suited for digging or picking things up from the ground. These adaptations help animals survive.

### REVISIT



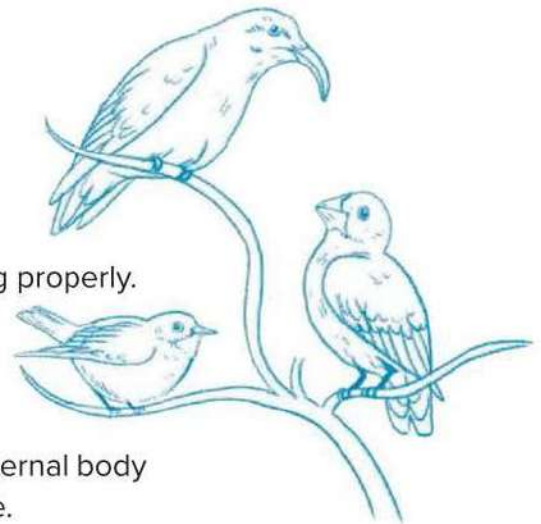
Revisit Page Keeley Science Probe on page 25. Has your thinking changed? If so, explain how it has changed.



## Three-Dimensional Thinking

1. Animals need certain things to survive. Circle all of the things animals need to survive.

- A. Animals need food for energy.
- B. Animals need water to keep their organs working properly.
- C. Animals need sunlight to make their own food.
- D. Animals need oxygen to raise their young.



2. Use an analogy to help explain how internal and external body structures work together to help an animal stay alive.

Sample answer: An animal's body system is like a school. Each person inside the school has a specific job. The principal, like the brain, makes decisions. The janitor, like the intestines, gets rid of waste. The walls of the school are like the skin, which helps protect everything inside. Together they can make the school run properly.

3. Look at the photos. What kind of adaptations does the milk snake have? Explain your answer.



Sample answer: The milk snake has a structural adaptation known as mimicry because it has markings that resemble those on a coral snake.

## Extend It

You are a zoologist. Study the effects of releasing invasive species into the wild. How might you communicate the effects of invasive species on native species to the people in your community?

Write a speech, draw a poster, create a flyer, or use media.

Sample answer: Invasive species can have a negative effect on native species by competing for the same food supply and space or by becoming a new predator in the area. People should avoid releasing their exotic pets, such as Burmese Pythons, green iguanas, and red lion fish, into an area they are not originally from. These animals can harm the local plants and animals in the area.



### KEEP PLANNING

STEM Module Project  
Science Challenge



Now that you have learned about animals' structures and functions, go to your Module Project to explain how this information will affect your plan for your National Park Presentation.

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## National Park Presentation

You have been hired as a forest technician in a national park. Using what you have learned throughout this module, prepare a presentation about an endangered species in your park. You will use a model to identify internal and external structures. Include evidence that

explains how internal and external structures work together to support the organism's survival, growth, behavior, and reproduction. Be sure to let visitors know about a problem the organism faces and a solution to help save the species.



### Planning after Lesson 1

Apply what you have learned about plants and their structures to your project planning.

What factors can decrease the chances of survival in plants?

**Sample answer: Reduced or no access to space, nutrients, water, air, and sunlight can limit a plant's growth, or even kill it.**

Record information to help you plan your project after each lesson.





## STEM Module Project Science Challenge

### Planning after Lesson 2

Apply what you have learned about the structures found in animals to your project planning.

How can animals survive in a changing environment?

**Sample answer:** Some animals, like monarch butterflies, can migrate during the harsh winter months. They can huddle together to stay safe. They can use their wings to glide and cover long distances to reach overwinter sites.



Read the Investigator article, *Artificial Skin*, to find more information about how technology can help people, who have lost a leg or an arm, restore their sense of touch.

How can engineers and doctors help people, who have lost all or part of an arm, feel pressure on their artificial arm?

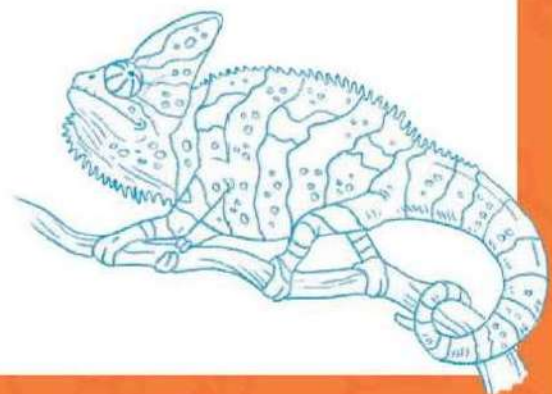
**Sample answer:** Engineers and doctors are working together to create artificial skin that can send electrical signals to nerves in the remaining parts of the arm. Nerve cells carry electrical signals to the brain. The brain reads the signals and tells the person to feel pressure on his or her artificial arm.



### Research the Problem

Research endangered species by going online to teacher-approved websites, or find books at your local library.

Students should use teacher-approved online resources. Students' research should be on an endangered species and it should include information about why the species is endangered. Students should include information about the organism's structures and how they function to help it survive in the wild. Research should include possible solutions to one of the problems the species faces.





## National Park Presentation

Look back at the planning you did after each lesson.  
Use that information to complete your final module project.

### Define the Problem

Sample answer: According to my research, the monarch butterfly is considered to be endangered due to changes in its environment. If nothing is done, they might become extinct in the future.

### Build Your Model

1. Determine the materials you will need to make your presentation and model. List the materials on the lines provided.
2. Use your project planning and your research to design a model of your species' structures.
3. Label the structures on your model.
4. Include relevant and sufficient information about the functions of each structure.
5. Include an explanation of how all the parts work together to support the organism's growth, survival, behavior, and reproduction.
6. Identify a problem the species faces and propose a solution for saving the species.

### Materials

Sample answer:  
colored pencils,  
markers,  
poster board,  
ruler,  
scissors,  
construction paper, glue

### Sketch Your Model

Sketch a draft of your model. Remember to label the organism's internal and external structures.

Students' drawings should show the external structures. Students can include a cross-section of their organism to show the internal structures. All structures should be clearly labeled.

### Cite Evidence

Compare your model and research with that of another classmate. Provide feedback about the strengths and weaknesses of their explanation. Determine if they have enough evidence to support their claim of how the structures support survival, growth, behavior, and reproduction. On the lines below, record ideas for improving your own presentation.

Sample answer: In my argument, I need to include that the heart pumps blood through the body. This organ helps transport the nutrients that are absorbed in the small intestines to the rest of the body.

Share your plans for your model with another group.





## STEM Module Project Science Challenge

### Communicate Your Results

Remember that you will speak as a forest technician when you present your model, along with your research and argument, to the class. Write your research presentation on the lines below.

Students should include evidence of why the organism they chose is endangered, the reason for saving their organism, and a solution to save the species. The presentation should also include an explanation of how structures function together to help the organism grow, survive, react, and reproduce.

After listening to all of the presentations, pick one that you like the best. Write an opinion piece on what species is the most important to save. Use evidence to explain your reasoning. Use a separate piece of paper if needed.

Sample answer: I think that it is important to save the monarch butterflies. They help plants reproduce by moving pollen. Without butterflies, plants would not be able to reproduce. Without plants, we would run out of food and oxygen.



## MODULE WRAP-UP

### REVISIT THE PHENOMENON

Using what you learned in this module, explain how living things use their structures to survive.



Sample answer: When I researched information about an endangered species, I found that my endangered species has structures that help it survive in its environment. For example, it uses internal organs such as the brain to tell if it is in danger. It also uses external structures, like the markings on its body to tell animals that it does not taste good. As I completed the project, I found out that despite the organism's protective structures, changes in the environment can reduce its numbers in nature.

Revisit your project if you need to gather more evidence.



Have your ideas changed? Explain your answer.

Sample answer: Yes. Now I know that butterflies migrate to warmer areas to avoid unfavorable conditions that could kill them.

LESSON 2 LAUNCH

# Animal Eyes



Two friends were talking about animals' eyes. They noticed that animals that are active at night have very large eyes. This is what they said:

Laura: *Animals like owls have large eyes so they can see in the dark. They do not need light to see.*

Jayden: *Animals like owls have large eyes to help them see in the dark. They still need some light to see.*

Whom do you agree with more? **Jayden**

Explain why you agree.

**Sample answer: I don't think an animal could see without any light at all. I think that the reason night animals have large eyes is to gather as much light as possible so they can see.**

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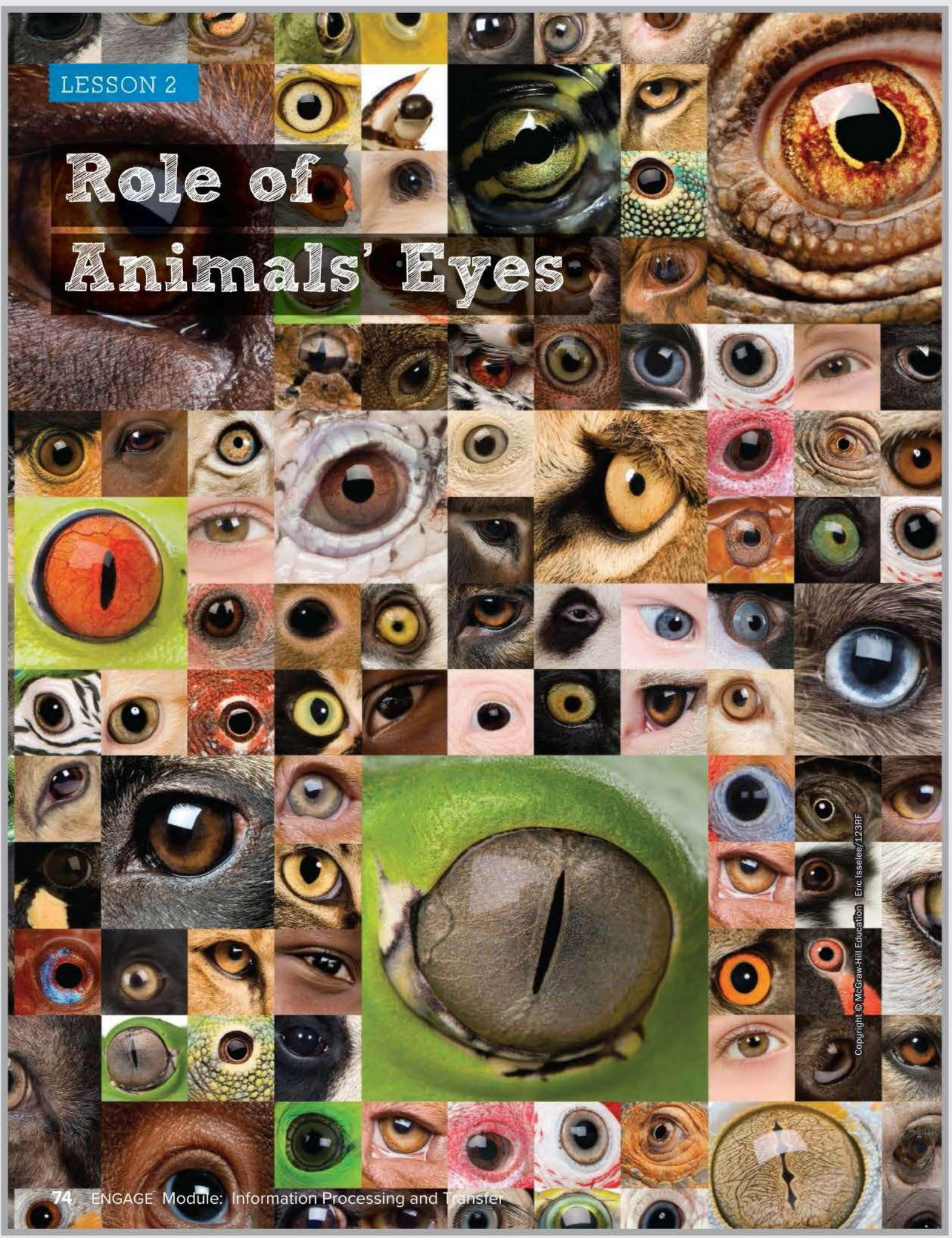


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You will revisit the Page Keeley Science Probe later in the lesson.

LESSON 2

# Role of Animals' Eyes



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# ENCOUNTER

## THE PHENOMENON

### How do eyes help animals see?



#### GO ONLINE

Check out *The Eyes* to see the phenomenon in action.

#### Talk About It

Look at the photo showing different shapes and sizes of animal eyes. What do you observe? What questions do you have about animal eyes? Discuss your observations with a partner. Record your thoughts below.

Sample answer: Are animal eyes like human eyes? Can animal eyes see in the dark? Do all animals have two eyes? How do eyes help animals communicate?

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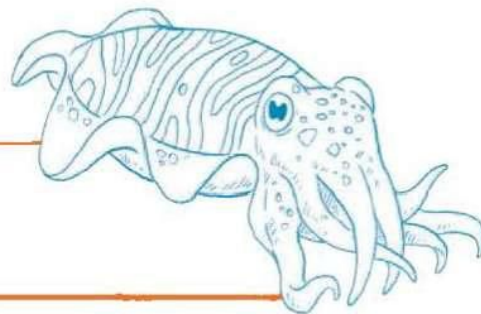
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#### Did You Know?

The human eye is made up of more than two million working parts.



# INQUIRY ACTIVITY

## Hands On

### How Light Travels

Animal eyes come in different shapes and sizes, but all eyes allow light to enter so objects can be seen. How does light from different objects get to your eyes?

**Make a Prediction** What happens when you shine a light on different kinds of objects in a darkened room?

Sample answer: I think that shiny objects will reflect the most light, making them easier to see in a darkened room.

### Carry Out an Investigation

**BE CAREFUL** Do not shine the flashlight directly in someone's eyes.

1. Work with a partner. Use the mirror as a straightedge. Draw a line across the center of the white paper. Hold the mirror upright along this line.
2. Place the flashlight on the other side of the piece of paper so that it shines directly at the mirror.
3. Have your partner trace the ray of light. Place arrows to indicate direction.
4. Change the angle of the mirror. Have your partner draw new lines for the mirror and the ray of light. Use a protractor to measure the angle. What happened to the direction of the beam of light?

Sample answer: The direction of the beam of light changed as I changed the angle of the mirror.

5. In a darkened room, shine the flashlight on each object, and record how the light interacts with the objects. Record your observations for each object in the table.

### Materials



mirror



white paper



flashlight



protractor



cup of sand



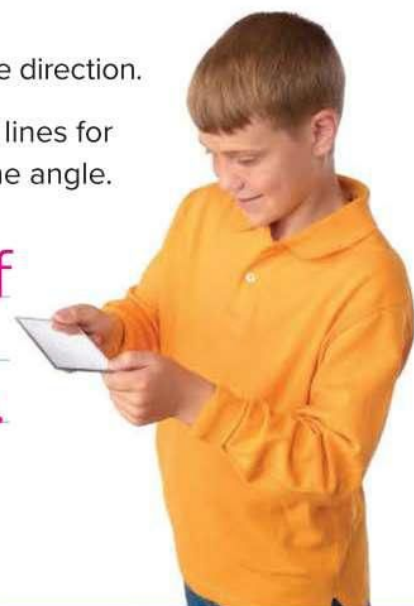
clear cup of water



index card



hand lens



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## Communicate Information

Object	Observations
mirror	The light bounced back.
sand	The light didn't pass through.
water	The light shined through.
index card	The light didn't go through.
hand lens	The light changed direction slightly.

6. How does the surface of an object affect how much light bounces back?

Sample answer: The shinier the surface of an object, the more light bounces back.

7. How do you think the clear objects in this investigation affect the path of a beam of light?

Sample answer: The lens and the water let the light through without shifting its path too much.



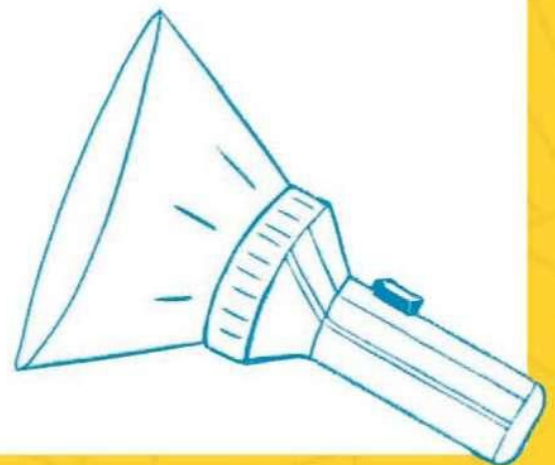
How would you **use a model** to show how light travels? How would you **cause** the light to shift directions?

Sample answer: I would use a series of mirrors to bounce the light from one side of a room to the other side of a room.



### Talk About It

Do the results support your prediction? Discuss with a partner.



## VOCABULARY

Look for these words as you read:

concave lens

convex lens

image

opaque

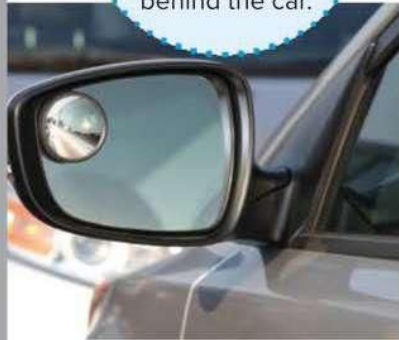
reflection

refraction

translucent

transparent

A mirror that is convex, or curved outward, allows a driver to see a wide area behind the car.



# Reflection and Refraction

Recall how the beam of light traveled in the Inquiry Activity *How Light Travels*. Light has the properties of reflection and refraction.

**Reflection** is the bouncing of light waves off a surface. Most of the light that reaches your eye is reflected light. Look at your desk. If the desk did not reflect light, you could not see it. Most surfaces reflect at least some light. Smooth, shiny surfaces such as mirror reflect almost all of the light falling on them. Dull, rough surfaces reflect the least amount of light. The colors that you see are the colors that are reflected from objects.

When light reflects off a surface, it changes direction. Think about the mirror and flashlight in the Explore activity. The light rays moving toward a surface are the incoming rays. The reflected light rays are the outgoing rays. The angles of the incoming and outgoing rays are always equal. This is called the law of reflection. The **image** you see in the mirror is a “picture” of the light source that light rays make when bounced off a polished, shiny surface.

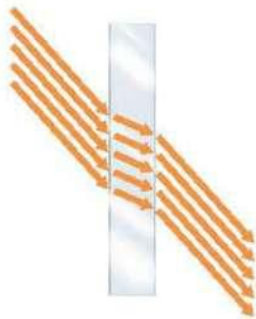
1. Draw a diagram to show how light allows objects to be seen. Include the light source, the eye, and label the direction of the light rays. Use the diagram to describe what happens if the eye is closed. What happens if the light is blocked or its path is changed? What if the light source is removed?

Students could draw light coming from the Sun and traveling to an object. The light should change direction (reflect) off of the object and enter the eye.

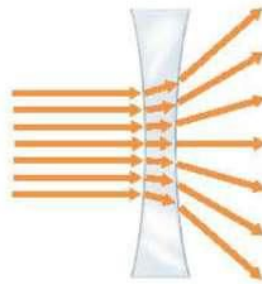
Sample answer: If the eye is closed or the light source is removed, nothing can be seen. If the light is blocked or its path is changed, the object will not be seen because its reflected light will not enter the eye.

**Refraction** is the bending of a light wave as it changes angles passing from one substance into another. Light slows down when it moves from one material to a denser material. This decrease in speed causes the light's angle to change, or its direction to bend.

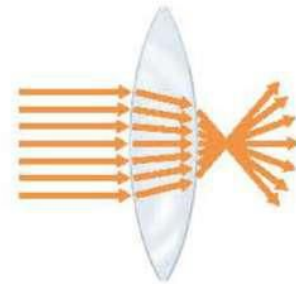
A clear piece of glass or plastic through which light travels is called a lens. If the lens is flat, the light's path shifts a little, but its final direction does not change. A lens that is thinner in the middle is a **concave lens**. Light that passes through a concave lens spreads outward. A lens that is thicker in the middle is a **convex lens**. Light that passes through a convex lens will come together at a focus point. The image you see when you look at an object through a convex lens depends on how far away the object is. Up close, the lens will cause the object to look bigger. Far away, the image will appear upside-down and smaller.



flat lens



concave lens



convex lens

2. What is the difference between refraction and reflection?

**Sample answer: Refraction is bending of light as it passes from one material to another. Reflection is when light hits a surface and bounces off.**

Concave lenses are used in eyeglasses for people who are nearsighted, or have trouble seeing objects that are far away. Convex lenses are needed for people who are farsighted, or have trouble seeing objects that are up close.



### **Talk About It**

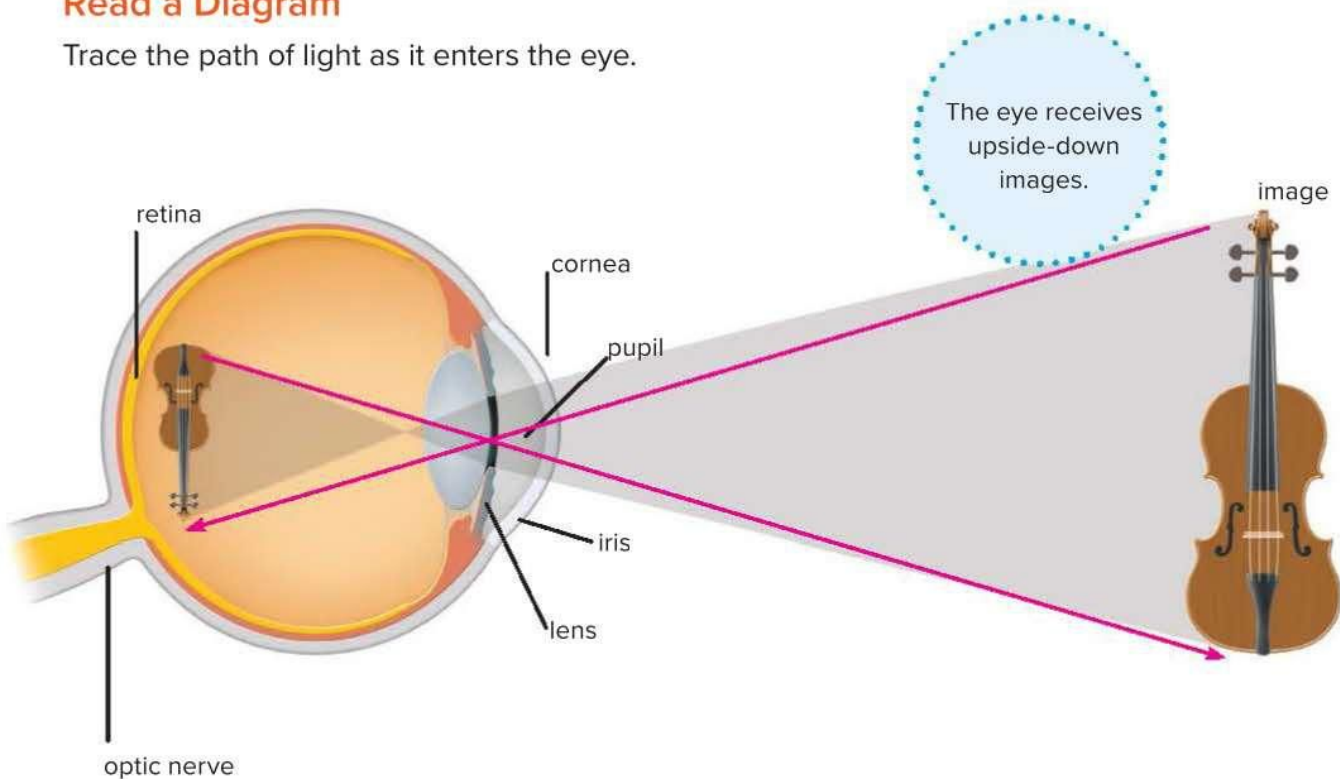
Discuss with a partner. What is the difference between a concave lens and a convex lens?

# The Human Eye

You see an image when light reflects off an object and enters your eye. The diagram shows the different parts of the eye that light passes through. Light passes through the cornea and the pupil in your iris. The lens refracts the light so that it hits the retina on the back of the eye. The retina sends signals to the brain, and the brain interprets the signals as images. The eyes of other animals work in a similar way.

## Read a Diagram

Trace the path of light as it enters the eye.



1. How do reflection and refraction allow animals to see?

Sample answer: Animals rely on reflection of light to be able to see objects. If light did not reflect off an object, the object would not be visible unless it gave off its own light. Light entering the eye is refracted. Without refraction, vision would be blurry.

**REVISIT** Revisit the Page Keeley Science Probe on page 73.




## Transparent, Translucent, and Opaque



Light that strikes a material may pass through it. Materials that let light through, so objects on the other side can be seen clearly, are called **transparent**. Clear glass and clear plastic are transparent. You can see objects when you look at them through a transparent material.

Materials that let some light through, so objects on the other side appear blurry, are called **translucent**. Waxed paper and frosted glass are examples of translucent materials. If an object completely blocks light from passing through, it is called **opaque**. Whether an object is transparent, translucent, or opaque depends on the material, its thickness, and the color of light. Thicker objects tend to be more opaque.

2.  **ENGINEERING Connection** When designing a new device, when would you want to use translucent materials? Give an example.

**Sample answer:** You would use translucent materials when you need to let light in but you do not need to be able to see objects clearly. These types of materials work well in situations where people need light, but also want privacy. An example is a shower door.

# The Way Eyes See It

Eyes are like cameras. Both structures contain a lens that helps gather, focus, and transmit light. The brain uses information from the eyes to understand the world.

Animal eyes are different from human eyes. Different animals have different types of eyes, depending on where and how they live. All animal eyes use light in different ways to survive in the wild. Some animals have eyes on the front of their head, while some have eyes on the sides of their head. Still other animals, such as frogs, have eyes on the top of their head. Some animals can see many colors. Other animals can only see black, white, and grey. And some animals have better eyesight than others.

How are the eyes of animals similar to humans? How are they different?

**Sample answer: Most animals have two eyes like humans; however, the location of the eyes and the ability to see colors can vary greatly.**

**GO ONLINE** Explore the *Animals' Eyes* simulation to change an animal's eyes and see how it affects its vision.



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# How Animals Use Their Eyes

The eyes of predators, animals that hunt other animals, are usually on the front of their head. This helps them to see how far away something is, especially when hunting for other animals. The eyes of prey, animals that predators eat, are usually on the sides of their heads. This helps them to see danger coming from the side and from behind them.

Most fish have eyes on the sides of their heads. These eyes have special structures that allow fish to see movement underwater. This feature helps fish see creatures that may want to eat them. It also helps fish catch prey moving past them.

What can eyes located in front of the head do that eyes located on the sides of the head cannot do?

**Sample answer: Eyes on the front of the head can see how far away something is.**

Flies, bees, and other insects have compound eyes that look like two big bubbles. Each eye can have thousands of small lenses. These lenses allow the insect to detect danger coming from all directions. This is why it is so hard to swat a fly!

Owls have eyes that are up to a hundred times more sensitive to low light than human eyes. This helps the owl to see prey at night. The eyes of an eagle are similar in size to human eyes. Objects appear much larger to eagles than they appear to humans. This helps eagles see prey from a distance. Eyes help animals in many different ways.



## Talk About It

Compare the eyes of humans and birds.  
Discuss your ideas with a partner.

Lions have reflectors in their eyes that help them see at night. This makes them appear to glow.



**GO ONLINE** Watch the video *How Do Animals See?* to learn more about how animals use their eyes.

## INQUIRY ACTIVITY

### Hands On

## It's Time to Focus

Recall the characteristics of the front of your eyeballs. Humans and other mammals can focus by changing the shape of their lens. Fish and other aquatic animals live in a very different environment. Their eyes focus light in a different way. You will make a model to show how an aquatic animal's eye refracts light.

**Make a Prediction** What happens when you change the position of a hand lens between the white paper and the lamp?

**Sample answer:** The image projected will appear crisp when the lens is at a distance where the light focuses at one point.

### Carry Out an Investigation

1. Hold the hand lens at arm's length between the lamp and the paper. What happens when you bring the hand lens closer to the paper?

**Sample answer:** An upside-down image of the desk and lamp appears on the paper.

2. Draw and label a diagram of your eye setup.

The diagram should show the hand lens located between the lamp and the projection screen. Students might include the upside-down image that was made as the light refracted when it passed through the hand lens. The diagram should include labels of the materials.

### Materials



hand lens



white piece of paper

## Communicate Information

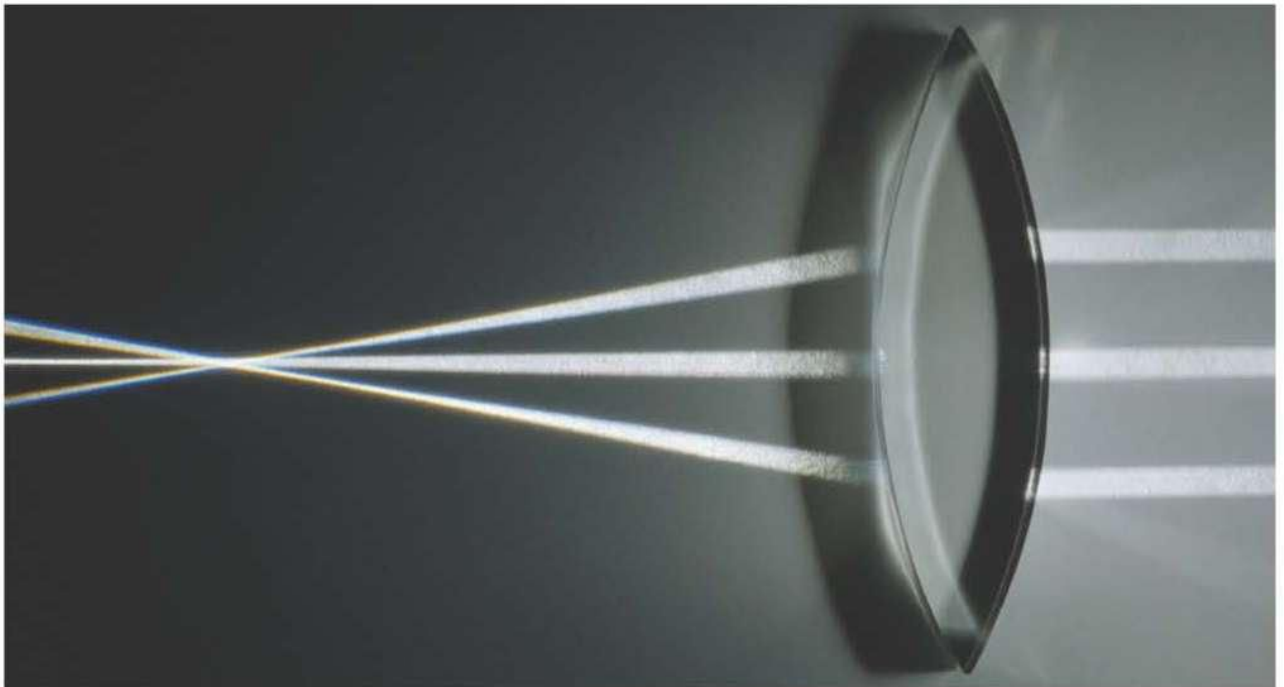
3. Do the results of your investigation support your prediction?

Sample answer: Yes. The quality of the image improved once I found the exact point of focus by moving the lens back and forth.



How does your setup **model** the way a lens helps to focus an image?  
What **causes** the image to become blurry or crisp?

Sample answer: The model shows how light travels through a lens. The hand lens represents the lens in the eye that refracts incoming light. The paper represents the back of the eye, where the image comes to focus. The distance of the lens from the sheet is what controls how blurry or crisp the image appears.



# What Does a Veterinarian Do?



Do you like to take care of animals? A **veterinarian** is a person who uses knowledge of animal structures and functions to help prevent, identify, and treat diseases in animals. These animal doctors help with many different types of medical issues. They also perform physical exams and surgeries. Treating eye problems is also an important part of a veterinarian's job. Animals, like humans, are prone to cataracts, which is an eye problem that can cause blindness if not treated. Veterinarians need to understand the structures and functions of animals' eyes to provide effective care.

## It's Your Turn

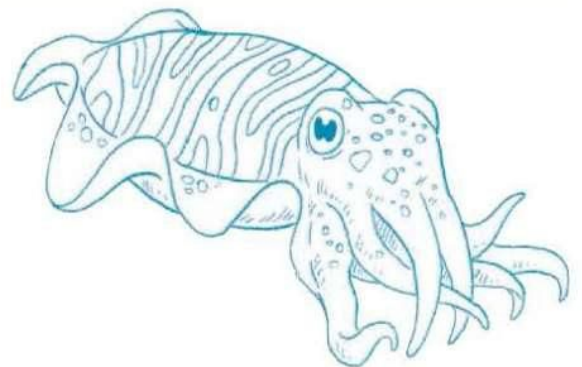
Think like a veterinarian. Complete the next activity to learn more about how eyes help animals survive.



# Field of View

**WRITING Connection** The field of view is the area that you can see at any given moment. Animals and humans have a similar field of view. Research the advantages and disadvantages of forward-facing eyes and sideways-facing eyes. Construct an argument about the location of eyes that gives an animal a better chance of spotting predators. Write your explanatory paragraph on the lines below.

Sample answer: Humans and most predators have forward-facing eyes. This allows their large brains to judge the distance and the depth of objects. This helps them catch prey or grab objects with accuracy. The disadvantage is that they have a blind spot that allows animals to sneak up from behind. Animals like antelopes have sideways-facing eyes. The advantage is that they can graze while still detecting predators approaching from behind or from the sides. Their blind spot is in front of them, but they have a great sense of smell to make up for this disadvantage. In conclusion, the evidence collected shows that sideways-facing eyes give animals the greatest advantage in detecting predators. This increases their chances for survival.









## LESSON 2

# Review

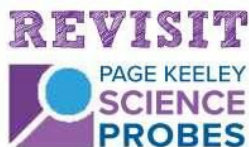
### EXPLAIN THE PHENOMENON

How do eyes help animals see?

#### Summarize It

Look at the photo again, and use what you have learned to explain the role of animals' eyes.

Sample answer: Animal eyes capture light that has reflected off of objects. When that light enters the eye, the parts work together and help an animal see objects. Animals can have front-facing eyes, sideways-facing eyes, or eyes on top of their head. The position of the eyes can have advantages and disadvantages. Animal eyes use light in different ways to help them find food and to survive.



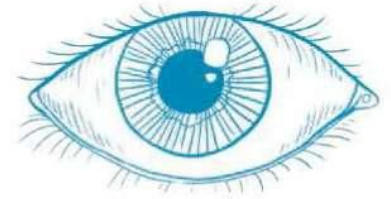
Revisit the Page Keeley Science Probe on page 73. Has your thinking changed? If so, explain how it has changed.



## Three-Dimensional Thinking

1. \_\_\_\_\_ is the bending of light waves as they change angle passing from one substance into another.

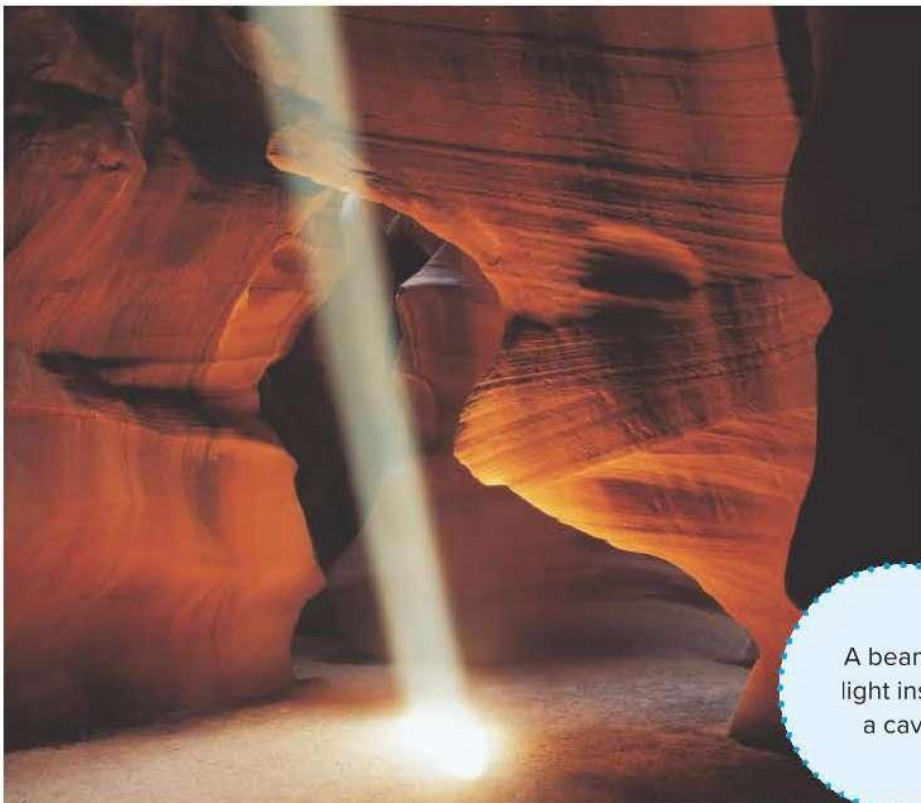
- A. Reflection
- B. Refraction
- C. Translucent
- D. Retention



2. Most predators have eyes on the front of their heads.

3. Explain how cataracts can have a negative effect on the role of animal eyes.

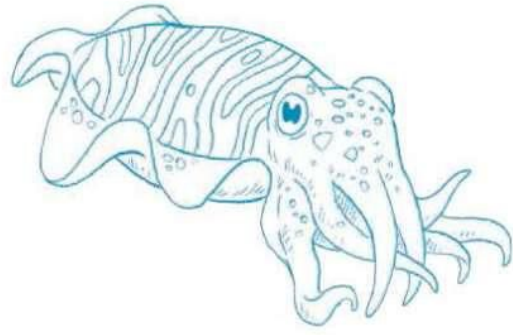
Sample answer: Animal eyes are very important for finding food and for survival. If an animal cannot see as well because of cataracts, the animal may not be able to find food as easily. It can also put the animal in harm's way if it can't see a predator in time.



A beam of light inside a cave.

## Extend It

How are your eyes like a camera? Conduct research and develop a two-dimensional model comparing a human eye to a camera. To gather information, you can visit teacher-approved websites, read books at your local library, or interview an ophthalmologist. Include an explanatory paragraph with your model.



**Sample answer:** Like the human eye, a camera has an opening that lets light flow inside its internal structure. The shutter works like our eyelids, opening and closing. Inside the camera, there are special parts that capture the image. Unlike humans, cameras have only one eye.

### OPEN INQUIRY

What questions do you still have about how your eyes see?

**Sample answer:** Does everyone perceive color the same way I do?

Plan and carry out an investigation or research to find the answer to your question.

## KEEP PLANNING

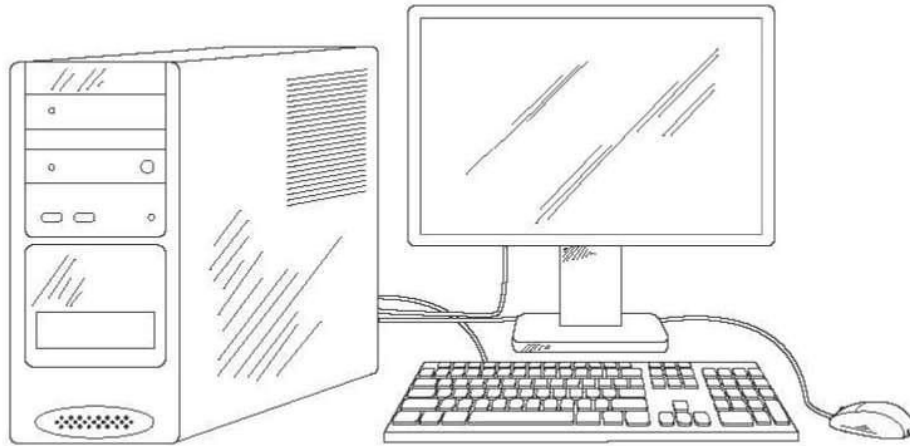
STEM Module Project  
Engineering Challenge



Now that you have learned about animals' eyes, go to your Module Project to explain how this information will affect the design of your communication device.

## LESSON 3 LAUNCH

## Moving Information



Caleb and his friends wondered how information is moved from one computer to another. They each had different ideas. This is what they said:

Caleb: *I think the information travels as tiny bits of matter.*

Suki: *I think the information travels as waves.*

Rob: *I think the information travels as rays.*

Pita: *I think the information travels as electricity.*

Jean: *I think the information travels as sound.*

Who do you think has the best idea? **Suki**

Explain your thinking.

**Sample answer: The data sent from one computer to another is digitized. This information can then travel over long distances as electromagnetic waves.**

You will revisit the Page Keeley Science Probe later in the lesson.

# Information

# Transfer

## ENCOUNTER

### THE PHENOMENON

# How do computers encode and transmit information?



#### GO ONLINE

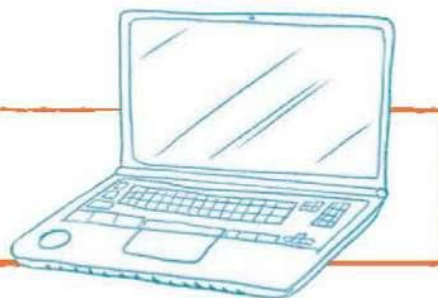
Check out *Data* to see the phenomenon in action.

Look at the photo and watch the video of the computer code. What patterns can you observe? What do you wonder about computer code? Record or illustrate your thoughts below.

Sample answer: It is difficult to find a pattern without knowing the language. How are letters, numbers, and images encoded? Why is this code used rather than another code? How can humans interpret patterns? What structures or technologies help us decode messages?

#### Did You Know?

Computers use patterns of zeros and ones to store data.



# INQUIRY ACTIVITY

## Hands On

### Secret Message

Computers use patterns of zeros and ones, like those that you just saw, to communicate and store information. What other patterns or signals are used to help us communicate?

**Make a Prediction** How can you use light to send a secret message across a room?

Sample answer: I will use a pattern of lines and zigzags to represent letters and send a message across a room.

### Carry Out an Investigation

**BE CAREFUL** Do not shine the flashlight into anyone's eyes.

- MATH Connection** Work with a partner to develop a code of light signals for the alphabet. You will be sending a message to your group members on the other side of the classroom. Your message should not be able to be interpreted by your other classmates—only your group.
- Go to the opposite side of the classroom from your group member.
- Think of a one-word secret message that you will send to your group. Record your message below.

Sample answer: Science

Students should have a unique pattern to represent each letter of the alphabet and a code to indicate a space.

### Materials



flashlight

4. Send your message to your group using your code.
5. Switch roles within your group and repeat steps 2–4. Using your code, record the message your group member sends.

Students should record the code sent by their group member.

6. Use your code to translate the message.

Students should use their code to decode the message.

### Communicate Information

7. Did the results support your prediction? Explain your answer.

Sample answer: Yes, I used patterns of lines and zigzags and sent a message to my group.



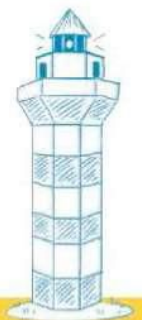
**Compare** your method of **transmitting the message** to the methods used by your classmates. Which worked best? What design criterion did you use to rate the codes?

Sample answer: Using simpler and more distinct codes and signals worked best. I used the accuracy of the decoded messages to judge which design worked best.



### Talk About It

How could you improve your methods or code?



## VOCABULARY

Look for these words as you read:

**binary code**  
**coding**

# Early Communication

Being able to sense and process information allows humans to communicate. We use our sight and hearing to sense and process messages. In the Inquiry Activity *Secret Message*, you used your sense of sight to communicate using patterns of light. Throughout history, engineers have found ways to use patterns to communicate. They use the design process to develop technology that makes the transfer of information faster and more efficient.

## Before Electricity

Early communication methods included signal fires or smoke signals. Those methods required a clear line of sight so that the signals could be seen and passed on. Writing a letter and sending it with a messenger was another early form of communication. This method was very slow and sometimes unreliable.


### Talk About It

What constraints would you face using smoke signals to communicate?

Smoke signals can be seen from miles away.



Copyright © McGraw-Hill Education. Vladimir Serov/Blend Images/Getty Images.

 **GO ONLINE** Watch the video *Information Transfer* to learn about different ways information is transmitted from various sources.

## Telegraph

The telegraph was invented in the 19<sup>th</sup> century. Solomon Brown, the first African-American to work for the Smithsonian Institution in Washington, D.C., worked together with Samuel Morse to revolutionize communication. The telegraph provided a faster and more reliable way to communicate over long distances. Information was sent through a wire using an electric signal. Telegraph operators would send electric signals in patterns of on-off tones, or clicks. This pattern system became known as Morse code. In the late 19<sup>th</sup> century, the telegraph was improved using wireless technology called radio.



Telegraph operators used patterns of clicks to send messages. They also interpreted these patterns and translated them back into messages.

## Radio

Radio is the transmission of information using a certain wavelength of electromagnetic waves. Recall that waves are disturbances that transfer energy from one point to another. A radio wave is detected by a receiver and converted to a sound wave that humans can hear.



## Sonar

Sonar is a system that uses sound waves to detect objects underwater. Some sonars send a sound wave, or pulse of sound. It then listens for the returning echo. The sound data is displayed on a monitor or heard on a loudspeaker.

How did people use patterns to send messages long ago?

Sample answer: They used patterns of smoke with signal fires, patterns of clicks sent with a telegraph, and patterns of radio waves using radios.

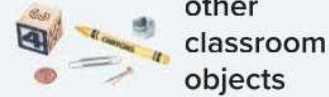
# INQUIRY ACTIVITY

## Hands On

### Morse Code Message

In the past, using a telegraph to send a message by Morse code was a fast and efficient way to communicate over long distances. In this activity, you will investigate sending a message using Morse code.

#### Materials



**Make a Prediction** How can a device be used to send a message?

Sample answer: I can use a pattern to represent each letter of the alphabet, then use a device to send the message.

#### Carry Out an Investigation

1. Think of a short, simple message to send to your partner. Write your message below. Use the Morse Code, shown below, to code each letter of your message.

Letter	Code	Letter	Code	Letter	Code
A	.-	J	.-.-	S	...-
B	-...-	K	-.-	T	-
C	-.-.	L	.-..	U	..-
D	-..	M	--	V	...-
E	.	N	-.	W	.-.-
F	..-.	O	---	X	-.-.
G	-.-	P	.-.-	Y	-.-.-
H	....	Q	-.-.	Z	---.
I	..	R	.-.		

Your Message:

Sample answer: I can sing

Your Coded Message:

Sample answer: .. -.-.-.-. .... -.-.-.

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2. Think of a way you can send your message using sound or light signals. Gather materials and construct any devices that you will need to send your message.
3. Send your message by making quick signals for a dot and long signals for a dash. Count 3 seconds between each letter and 5 seconds between each word.
4. As you flash the light, your partner will write the pattern in dots and dashes. Using the table, your partner will then decode the message.
5. Switch roles and repeat steps 1–4.

Partner's Coded Message:

Sample answer: .. - : . : - - . . . . . - : - - . - - - - - -

Partner's Message:

Sample answer: I can sing too

### Communicate Information

6. What challenges did you face in sending your message?

Sample answer: At first, it was difficult to get the timing of my light flashes so that I was communicating effectively with my partner.

7. In what kinds of situations would Morse code be useful?

Sample answer: Morse code could be useful if you need to send a message to someone that you could see, but not hear, such as on a boat.

8. Did your results support your prediction? Explain your answer.

Sample answer: Yes, I used a device to transmit a code that consisted of dots and dashes to represent a message.

# Advances in Communication Technology

## Telephone

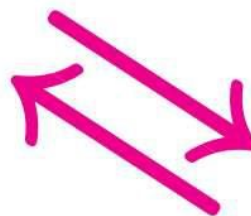
The telephone was an advancement of the radio system that allowed two or more users to conduct a conversation at the same time. The telephone converts sound into electronic signals that are transferred through cables. The signal is converted back into sound on the receiving end. In 1942, an Austrian-born movie actress, Hedy Lamarr, invented a device that would be the precursor to modern mobile communication technologies. Together with her business partner George Antheil, they were awarded the patent for a “secret communication system.”

## Cell Phones

Cell phones are a technology that allows people to communicate wirelessly. Cell phones are basically two-way radios. Each phone has a radio transmitter that sends a signal and a radio receiver that picks up signals. When a person talks on a cell phone, their phone converts their voice into an electric signal. This signal is then sent to the closest cell tower. The phone uses radio waves to send the signal. A network, or group, of cell towers then pass on the radio waves from one to another. Finally, the radio waves reach the other person’s cell phone. The other phone changes the radio waves into an electric signal and then back into sound. This all happens instantaneously!

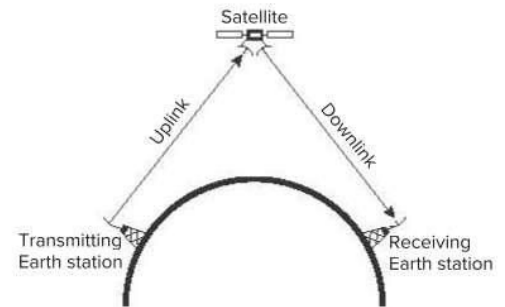
1. Draw arrows to show how signals are sent between the cell phone and cell tower.

Radio waves carry information from a cell phone to a cell tower and back.



## Communications Satellites

Radio waves are also used by communications satellites. Communications satellites orbit Earth. These satellites can receive signals and then transmit them over long distances. Information is sent by radio waves to the satellite using a transmitting station. This is called an uplink. The uplink could be carrying phone calls, Internet information, or video information. Once the satellite receives the signal, it makes it stronger before transmitting it back to Earth. This is called a downlink. The re-transmitted signal is then picked up by a receiving station. Communications satellites allow information to be sent to places where cell phones or other methods of communication do not work.



Over 1,000 working satellites currently orbit Earth.

2. What are the advantages of using a communications satellite?

Sample answer: Communications satellites can be used in areas where there are no phone lines. They can send information to the other side of Earth quickly.

# Digital Communication

Technology has greatly improved our ability to communicate voice, text, images, and video over long distances. Computers and phones send this information using patterns. These devices can process binary code.

**Binary code** is a system that represents letters, digits, or other characters using zeros and ones. Using binary code, information can be sent quickly and accurately to another device. Photos, video, text, and voice information can be sent long distances. It can be coded and decoded without affecting the original information.

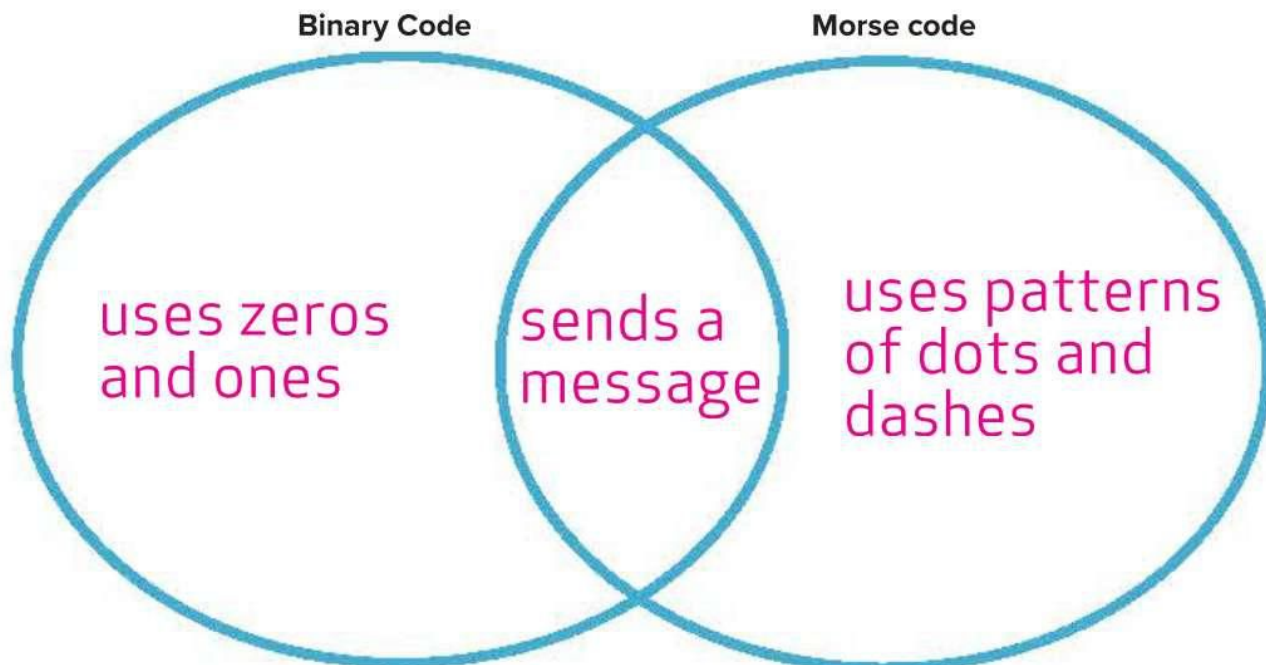
Computers use binary code to store and send information.

## Binary Code Message

The binary code uses a series of zeros and ones to code a message. For example “I love science” is represented by the pattern below.

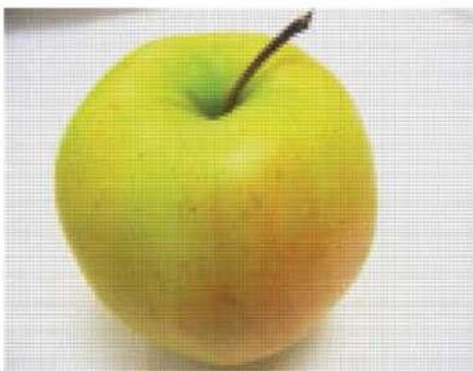
01001001 00100000 01101100 01101111 01110110 01100101 00100000  
01110011 01100011 01101001 01100101 01101110 01100011 01100101 00100001

1. How is binary code similar to Morse code? How is it different?

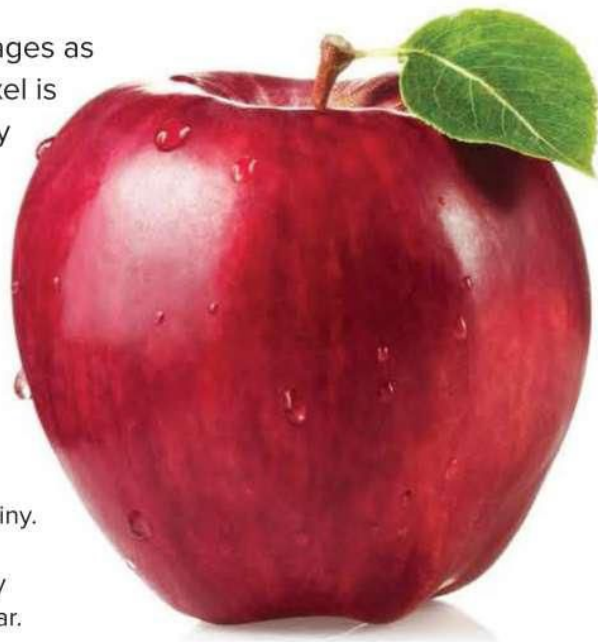


## Sending Images

Technology can be used to communicate through images as well. Digital images are made up of many pixels. A pixel is the smallest piece of a digital image. Pixels are usually arranged in a grid. The pixels of different colors fill the rows and columns of the grid to form an image.

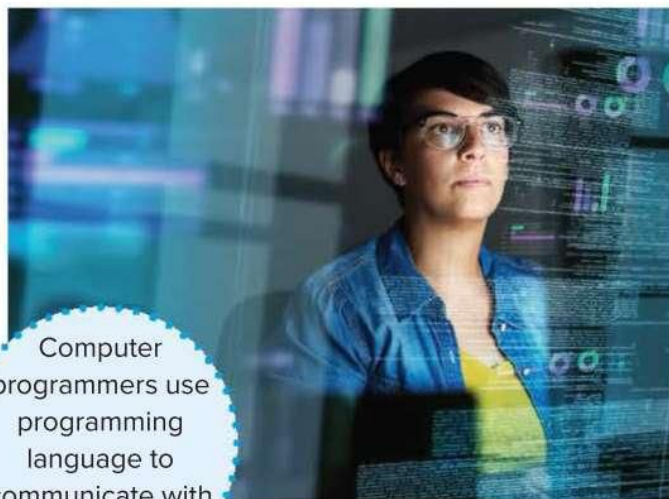


An image that is made up of few pixels will be grainy. An image that is made up of many pixels will be clear.



## Coding

The process of writing a computer program in a language that can be used by a computer is called **coding**. Each line in a computer program gives the computer instructions for a different task. The languages are exact. They do not allow for errors or misinterpretation. The apps or programs on your cell phone or tablet were written using programming language.



Computer programmers use programming language to communicate with computers.

2. How have communication devices changed over time?

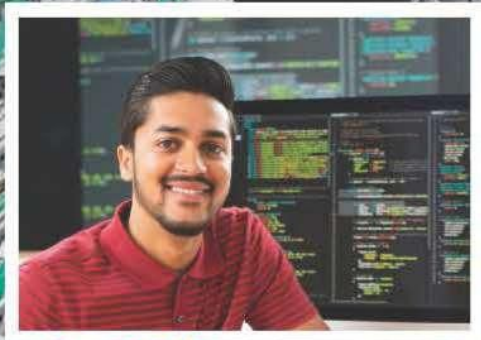
**Sample answer: Communication devices have become more efficient and faster. We can now transmit both images and sound over long distances.**

**REVISIT** Revisit the Page Keeley Science Probe on page 93.



## STEM Connection

# What Does a Computer Programmer Do?



Do you like to use computers? Are you good at writing instructions and solving problems?

**Computer programmers** write the instructions that a computer needs in order to complete a task. Some tasks are pretty easy, like turning a light on or off. Other tasks are much more complex, such as tracking weather and making predictions.

Alan Turing (1912-1954), an English mathematician and logician, is known as the father of modern computing. He is credited with developing the ideas of artificial intelligence and of the modern computer.

### It's Your Turn

Think like a computer programmer. Decode a binary code message in the next activity.



### Talk About It

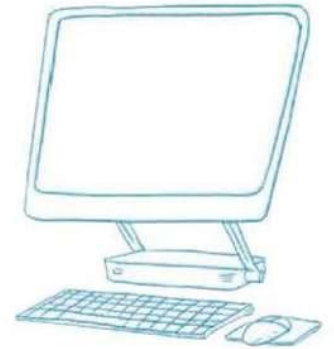
What would happen if there was an error in a computer code? Discuss with a partner.

# INQUIRY ACTIVITY

## Research

### What Does That Say?

You know that computers use binary code to communicate with other devices. You have seen messages represented in binary code and Morse code. How does binary code work?



**Make a Prediction** How can you code a message using only two numbers?

**Sample answer:** I could combine two numbers in different ways to represent each letter of the alphabet.

Take a look at the binary code below. This code represents a message that you will decode. Research the binary code for the alphabet in capital letters.

#### Binary Code Message:

01010011 01000101 01001110 01000100 01001001 01001110 01000111 00100000  
01001001 01001110 01000110 01001111 01010010 01001101 01000001 01010100  
01001001 01001111 01001110 00100000 01010111 01001001 01010100 01001000  
00100000 01010111 01000001 01010110 01000101 01010011 00100000 01001001  
01010011 00100000 01000011 01001111 01001111 01001100 00100000 01010011  
01000011 01001001 01000101 01001110 01000011 01000101

#### Carry Out an Investigation

1. Begin decoding the numbers, using what you have learned from your research.
2. Write the decoded message below:

**SENDING INFORMATION WITH WAVES IS COOL SCIENCE**

#### Communicate Information

3. How is binary code used to send a message?

**Sample answer:** Different patterns of zeros and ones represent each letter in a message.

## LESSON 3

# Review

### EXPLAIN THE PHENOMENON

How do computers encode and transmit information?

#### Summarize It

Explain how computers use patterns to send messages across distances.

Sample answer: Letters and numbers are represented as different combinations of zeros and ones. Computers use these patterns to send information quickly and accurately to other devices. Satellites help transmit these signals over long distances.



Revisit the Page Keeley Science Probe on page 93. Has your thinking changed? If so, explain how it has changed.



## Three-Dimensional Thinking

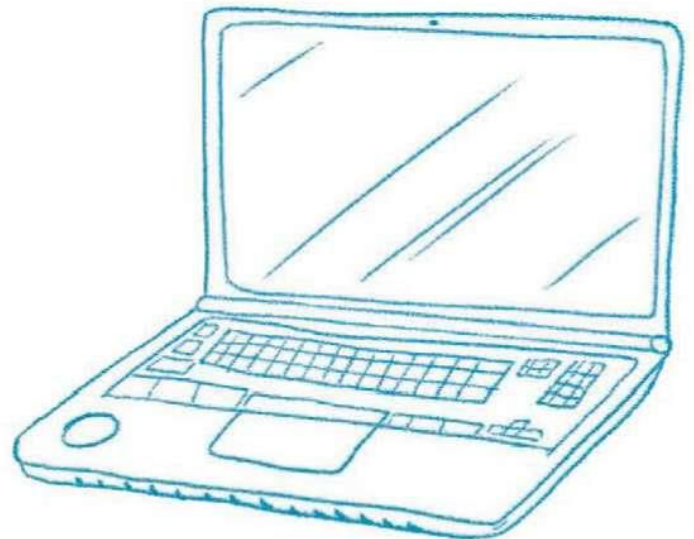
1. A design criterion for an information transfer device is the accuracy of the message received.

Information Transfer Device	Accuracy of Received Messages (%)
Design 1	89.8
Design 2	99.7
Design 3	96.4
Design 4	92.1

The table above shows the results of a test on four different designs. Order the designs from best to worst.

Design 2, Design 3, Design 4, Design 1

2. Which of the following correctly represents how cell phones work?
  - A. message → cell tower → phone 1 → phone 2 → cell tower → message
  - B. cell tower → message → phone 1 → cell tower → phone 2 → message
  - C. message → phone 1 → cell towers → phone 2 → message
  - D. phone 1 → phone 2 → messages → cell towers
3. Which is not an example of using patterns to transfer information?
  - A. Morse code
  - B. binary code
  - C. smoke signals
  - D. thermal insulators



## Extend It

Think about how communications technologies have changed over time. Research cell phones. Write a paragraph explaining how they have changed over the last 30 years. Predict how they will change over the next ten years. Use evidence from your research to support your prediction.



Sample answer: Cell phones were once capable of only voice communication. Now they can transmit voice, text, and images. Cell phones can also connect to the Internet and have many of the same capabilities as computers. They also allow users to video chat. Since people use their phones so much now, the batteries will need to be improved. Cell phones will also need to get a little larger so people can do more of the things they do on their computers.

## KEEP PLANNING

STEM Module Project  
Engineering Challenge



Now that you have learned how information is transferred, go to your Module Project to explain how this information will affect your plan for your communication device.



## Pixel Message

You have been hired as a telecommunications engineer to design a device that uses sound, light, or both to create two different binary codes. Once your device is ready, you will draw a pixel message on a 6x6 grid by shading some of the boxes to form a pattern. Then you will use the device to send the message across the classroom. Your group on the other side of the classroom will interpret the signals that you make with your device and replicate the pattern on their 6x6 grid. Be sure to repeat the procedure with the other binary code so that you can compare them and decide which way of communication was most efficient. You will use speed and accuracy as your criteria to rate your two binary codes.



### Planning after Lesson 1

Apply what you have learned about information processing in animals to your project planning.

Draw a diagram that explains how internal and external structures are involved in sending and interpreting messages. Explain how this information will help you design a device to send an image.

Record information to help you plan your image-sending devices after each lesson.

Diagrams should indicate that information is received through the eyes and ears and sent through nerves to the brain. The brain responds. Students should indicate that the code they use should be simple enough to be easily processed by the brain.





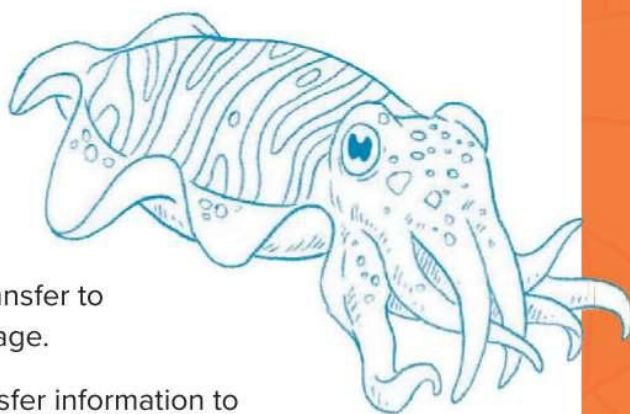
## STEM Module Project Engineering Challenge

### Planning after Lesson 2

Apply what you have learned about the role of animals' eyes to your project planning.

What causes us to see images? How will this information help you design a device to send an image?

**Sample answer:** Light reflects off of objects and enters the eye. It travels in a straight line. If I use light to send my message, I will need to make sure there are no obstacles so that my partner can see it clearly from the other side of the room.



### Planning after Lesson 3

Apply what you have learned about information transfer to identify how you will move energy to send a message.

Use what you learned about using patterns to transfer information to develop the codes for your devices.

**Sample answer:** I will use a two-symbol system to encode the message. For my first design, I will use different colors of light to represent the shaded and blank boxes on my 6x6 grid. For my second design, I will use two different sounds.

## Define the Problem

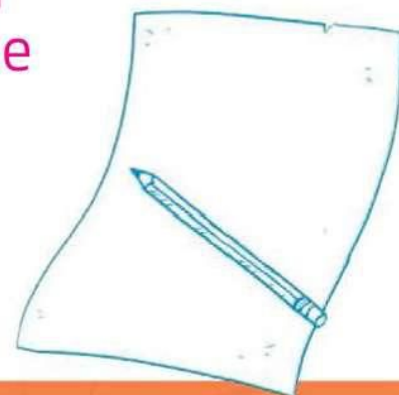
Write the problem that you will solve in your own words. Identify the criteria and constraints.

Sample answer: Problem: Design a device and code to send a pixel message across the room. Criteria: accuracy of decoded message, time to transmit and decode; Constraints: materials, time, distance.

## Sketch Your Model

Draw your ideas below. Select the best two to build and test.

Students might select a drum, bell, or other object to send sound signals. They will need to have at least two distinct sounds or patterns of light in their code. Students might also select a flashlight or build a flashlight circuit to send light signals. They will need at least two variations. Students could also use a combination of light and sound (a drum beat represents a white square and a flash of light represents a black square).

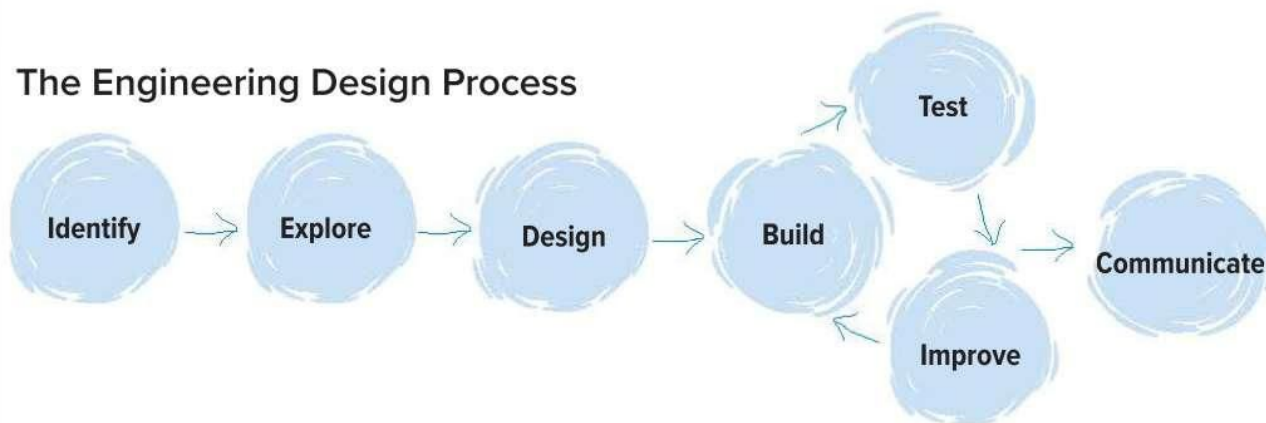




## Pixel Message

Look back at the planning you did after each lesson.  
Use that information to complete your final module project.

### The Engineering Design Process



### Build Your Model

1. Determine the materials that you will need to build your device. List the materials in the space provided.
2. Gather the materials needed. Remember that your device can use light, sound, or both to produce a two-symbol system of communication.
3. Use your project planning to create a binary code to communicate a message across the classroom.
4. Be sure that your group knows how to interpret the symbols or signals in your binary code.
5. Test your binary code by producing signals or symbols with your device.
6. Use your results to improve your model.
7. Repeat the procedure with a different binary code. You can use the same device, modify it, or build a new one. Be sure to use the project's criteria to rate the two methods of communication.

### Materials

Sample answer:  
stopwatch,  
flashlight, bell,  
whistle, drum,  
color filters

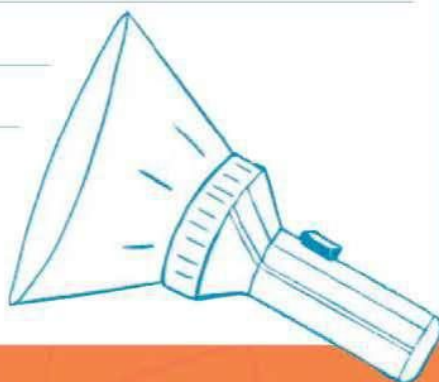




### Communicate Your Results

Which of your two binary codes worked better? Share your codes, your devices, and the results of your tests with another group. Compare the ability of each of your devices and two-symbol codes to meet the criteria. Communicate your findings below.

Students should compare their designs and use the project's criteria to evaluate the two-symbol codes. Their findings should identify the parts of the design that work and the parts that do not. Students should explain the project's strengths and weaknesses and share possible solutions to improve the design.



## MODULE WRAP-UP

### REVISIT THE PHENOMENON

Using what you learned in this module, explain how the lighthouse transfers information.



Sample answer:  
The lighthouse uses a system of lenses to bend and concentrate the light source into a powerful beam of light that can travel a great distance. Sailors see this beam and interpret it as a warning of hazardous shores ahead. Today, we use navigational systems like sonars and computers to detect and communicate the presence of underwater objects that could be dangerous to boats and other vessels.

Revisit your project if you need to gather more evidence.



Have your ideas changed? Explain your answer.

Sample answer: Yes, now I know that computers use different languages and codes to transmit information.