Amplify Core Knowledge Language Arts®

Unit 5

Reader | Grade 3

Adventures in Light and Sound

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Reader

Amplify Core Knowledge Language Arts

Core Knowledge®

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Table of Contents

Adventures in Light and Sound

Unit 5 Reader

Chapter 1
What Is Light?

Did you know that the sun is the greatest **source** of light for our planet, Earth? But what is light? Why is it so important?

Hot gases of the sun give off both light and heat **energy**. Light carries **energy**, with the long **wavelengths** carrying the least and the short **wavelengths** carrying the most. When you think of something with lots of **energy**, what comes to mind?

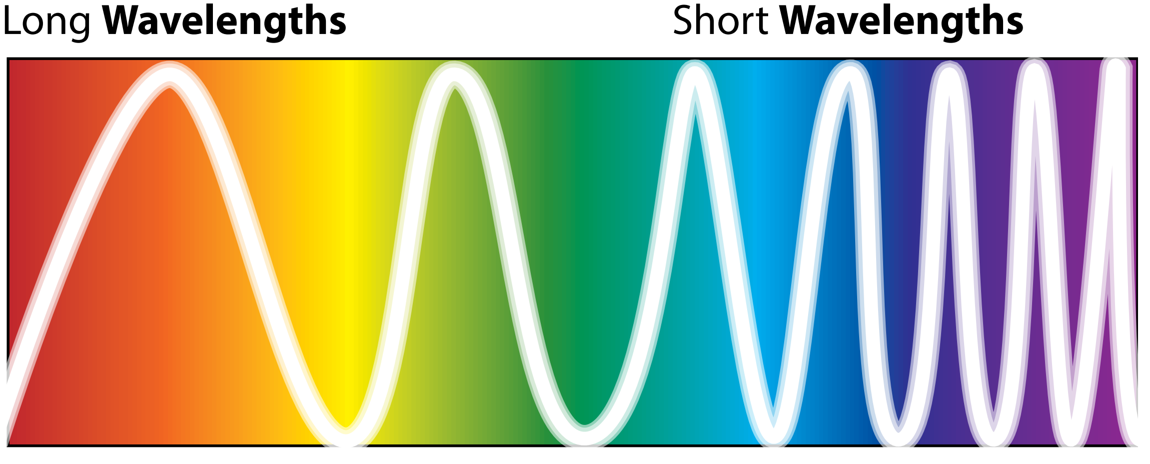
Do you think of something fast like a race car? Do you think of something with great force like a very strong wind knocking down a tree?

Believe it or not, light can be many times more energetic than a car or the wind.

*The sun is the greatest **source** of light for Earth.*

Light travels at 186,000 miles every second in a **vacuum**. At that **speed**, light can go around Earth more than seven times every second! No human-made machine can go that fast—not even a jet plane or rocket!

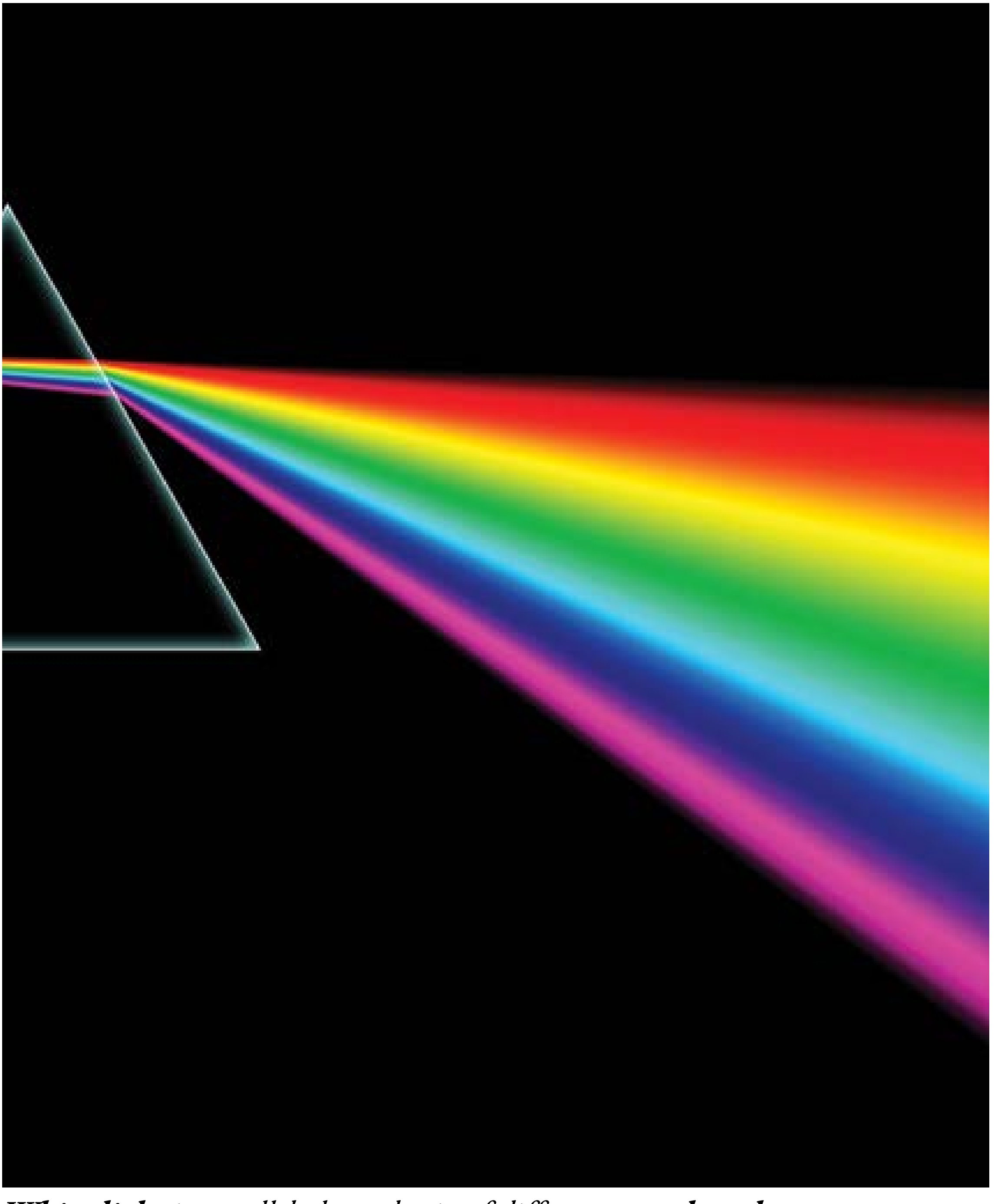
One way that light travels, including light from the sun, is in the form of **waves**. Scientists can measure how long light **waves** are. **Waves** can be different sizes—some are long and some are short. Some light **waves** are visible and some are invisible. Whether you can see light or not depends on the length of the **wave**. The longest **wavelength** of visible light is seen as red and the shortest **wavelength** is violet. Short **wavelengths** carry the most **energy**.



*One way light from the sun travels is in **waves**. **Waves** can be different sizes. Short **wavelengths**, like those at the far right, carry the most **energy**.*

The sun gives off what is called **white light**. Perhaps you think of the light from the sun as having no color at all. Maybe you think the light from the sun is more yellow in color. It may surprise you to know that the sun's light, **white light**, is made up of all the colors of the rainbow. **White light** includes light of different **wavelengths**, including all the colors we can see.

Of all the **wavelengths** in the sun's light, there is just a little more of the yellow **wavelengths** than the other colors. This is why the sun looks yellow when we see it against the blue sky. Still, the light from the sun includes all of the other colors and **wavelengths**. You will learn more about **white light**, visible light, and colors in a later chapter in this Reader.



White light *is a well-balanced mix of different* ***wavelengths****.*

Although the sun is the greatest **source** of visible light, there are also other **sources** of light. What else in the sky provides light? The other stars in the night sky provide light, though it is not as bright as the light from the sun during the day. The moon is not a star and does not give off its own light.

Can you think of other **sources** of light? Is there light in your classroom right now? Perhaps it is from the sun shining through the windows. Chances are good, though, that some of the light in the room may be coming from light bulbs. Like the sun, most light bulbs give off **white light**. **Electric** lights are such a part of our everyday life, we don't even think about them—unless the **electricity** goes off! This doesn't happen often, but sometimes it does during a bad storm. When the electricity goes off and we do not have light from light bulbs, people sometimes use other **sources** of light, like flashlights or candles.

Can you think of ***sources*** *of light other than the sun?*

Light is important for many reasons. Light and heat **energy** from the sun warms Earth. Without the light and heat **energy** from the sun, Earth would be freezing cold. You also learned back in kindergarten that the sun's light is needed for plants to grow. Also, without light, there would be no colors. Can you think of another reason that light is important?

Try to imagine a world in which there is no light—no sun, no stars, no candles, and no light bulbs. What would be different? If you just said that it would be dark, you are only partly right. What else would change? Without light, you would not be able to see anything! A world without light is almost impossible to imagine.

Here is a scene with lots of light.

Here is the same scene without any light.

Chapter 2

How Are Shadows Made?

Do you remember any interesting facts about how light travels? In the last chapter, you learned that it travels in waves that can be measured as wavelengths. You also learned that it travels at a very high rate of speed. Here's another interesting fact—light waves travel from a source in straight lines that spread out in all directions, like rays.

Take a look at the image on the opposite page. In this image, there are several light sources. Each source or dot of light has several rays of light shooting out. Put your finger on the source you can see. Now, using your finger, trace the lines of light coming out from that source. Each ray of light is a straight line.

Light travels in straight lines like rays from its source.

Have you ever wondered what happens when a line or path of light bumps into something in its way? Different things may happen depending on what exactly is in the light's path.

If a path of light hits something that is **transparent**, most of the light will pass right through. Air, water, and glass are all **transparent**. When light hits these **transparent** objects, it passes through to the other side. It is almost as if the object isn't there.

Most buildings have glass windows so that natural sunlight can travel from the outdoors inside. Have you ever been in a building that has a glass roof or **skylight**? Sometimes you can even see blue sky and clouds through the **skylight**!

*How do you know that the glass in this **skylight** is **transparent**?*

Light cannot travel through all materials. If a path of light hits something that is **opaque**, the light is **absorbed** and blocked by the object. It cannot continue in a straight line through the object. Wood, cardboard, and even a person's body are all **opaque** objects. Light cannot pass through to the other side. Instead, a **shadow** is created because the light is **absorbed**.

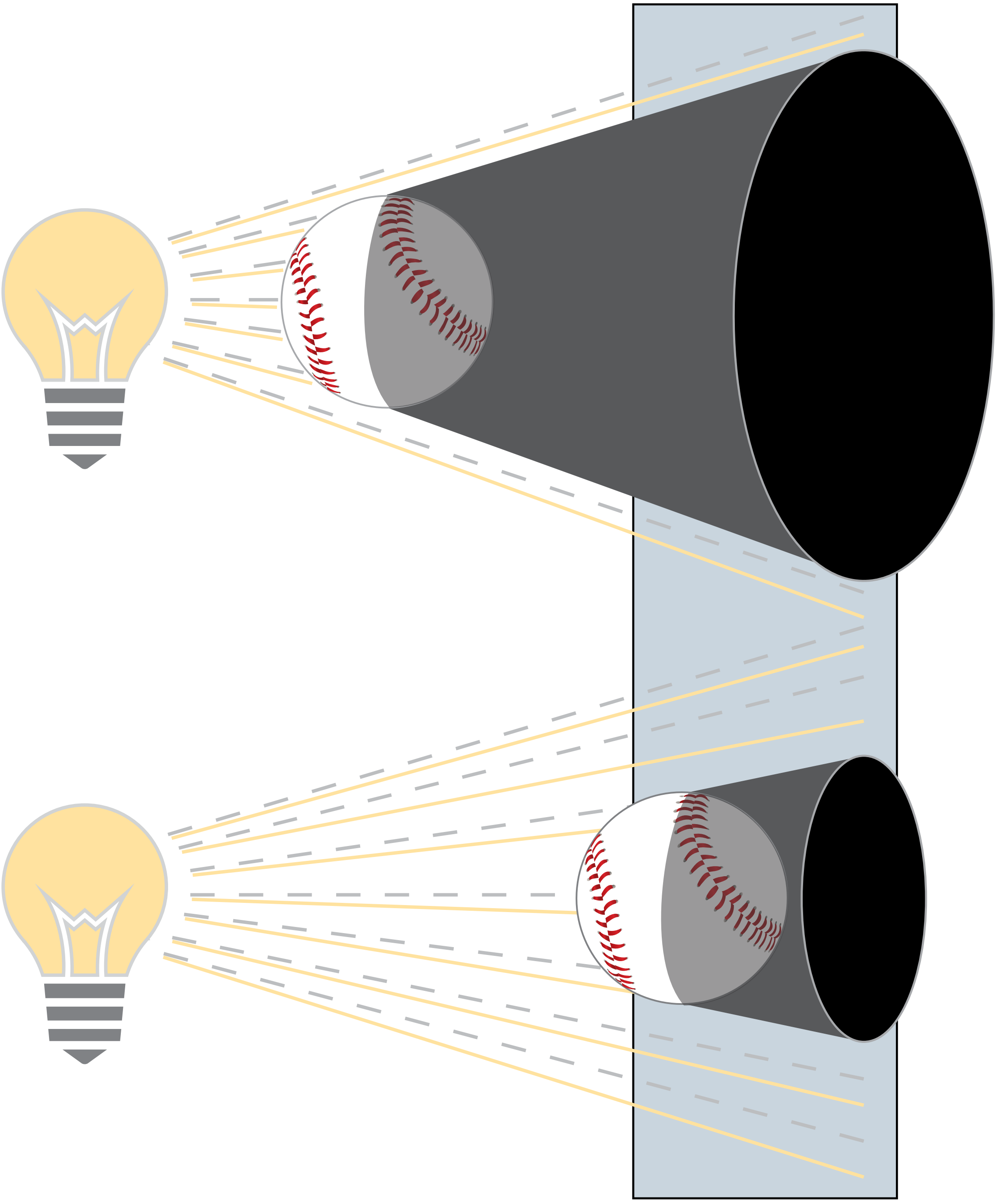
Look around your classroom. Do you see **transparent** objects through which light is passing? Can you also find **opaque** objects? You will probably find that your classroom has many more **opaque** objects than **transparent** objects. Do you see any **shadows**?

*Are people's bodies **transparent** or **opaque**? How do you know?*

The **shadow** created by blocked light takes on the shape of the object. Can you guess the object or objects that are making the **shadows** in these images?

*What objects created these **shadows**? Are these objects **opaque** or **transparent**?*

The size of a **shadow** depends on several different things. The closer an object is to a light source, the larger the **shadow** will be. If you move the same object farther away from the light source, the **shadow** will become smaller. So the size of the **shadow** changes, even though the size of the object does not. What makes the **shadow** larger or smaller is the distance of the object from the source of light.



Shadows *can be different sizes. What causes the size of a* ***shadow*** *to change?*

You can experiment making larger and smaller **shadows** just by using your hand. You will need:

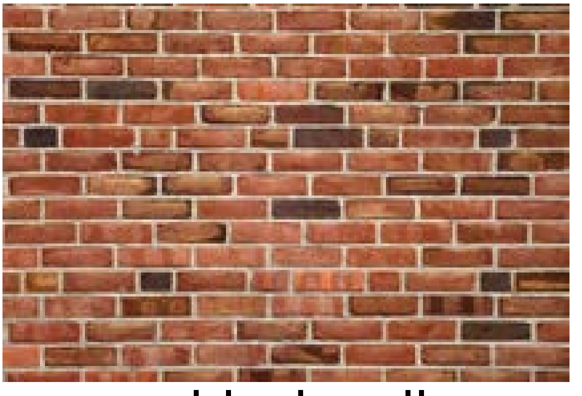
- a light source, such as a flashlight or **projector**
- several sheets of large white paper and a marker
- masking tape
- a blank wall
- several helpers
- a cardboard cutout of a tree

First, tape a piece of white paper to the wall. Then, mark a spot on the floor and tell a classmate to stand on that spot to **project** the light. He or she should not move. Now, try holding the cutout of the tree in front of the light so that a shadow is **projected** onto the white paper. Have one classmate put a piece of masking tape marked "1" on the floor next to where you are standing. At the same time, another classmate should trace the **shadow** of the tree on the white paper. Mark this tracing of your **shadow** with a "1."

a light source

masking tape

paper and marker



a blank wall

helpers

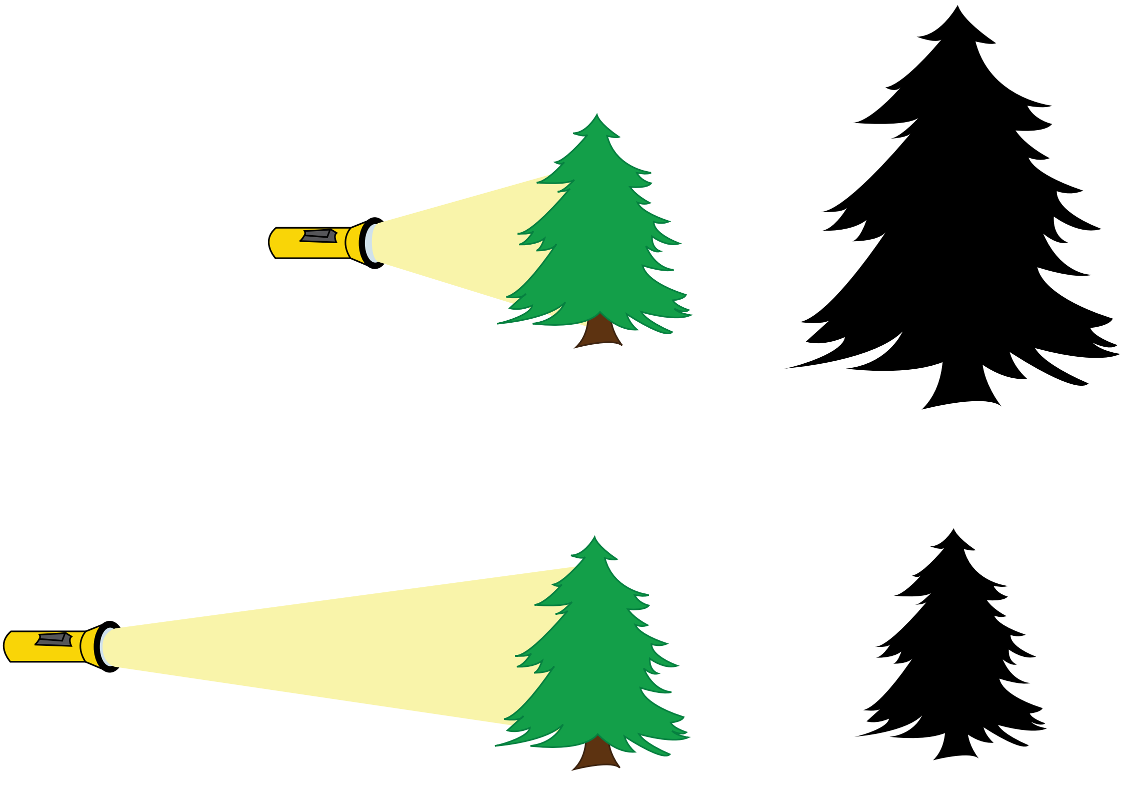
tree cutout

*Here's what you need to experiment with **shadows**.*

Next, tape up another sheet of white paper. This time, move away from the light, closer to the sheet of paper. Have your classmates mark the floor and **shadow** tracing with a "2."

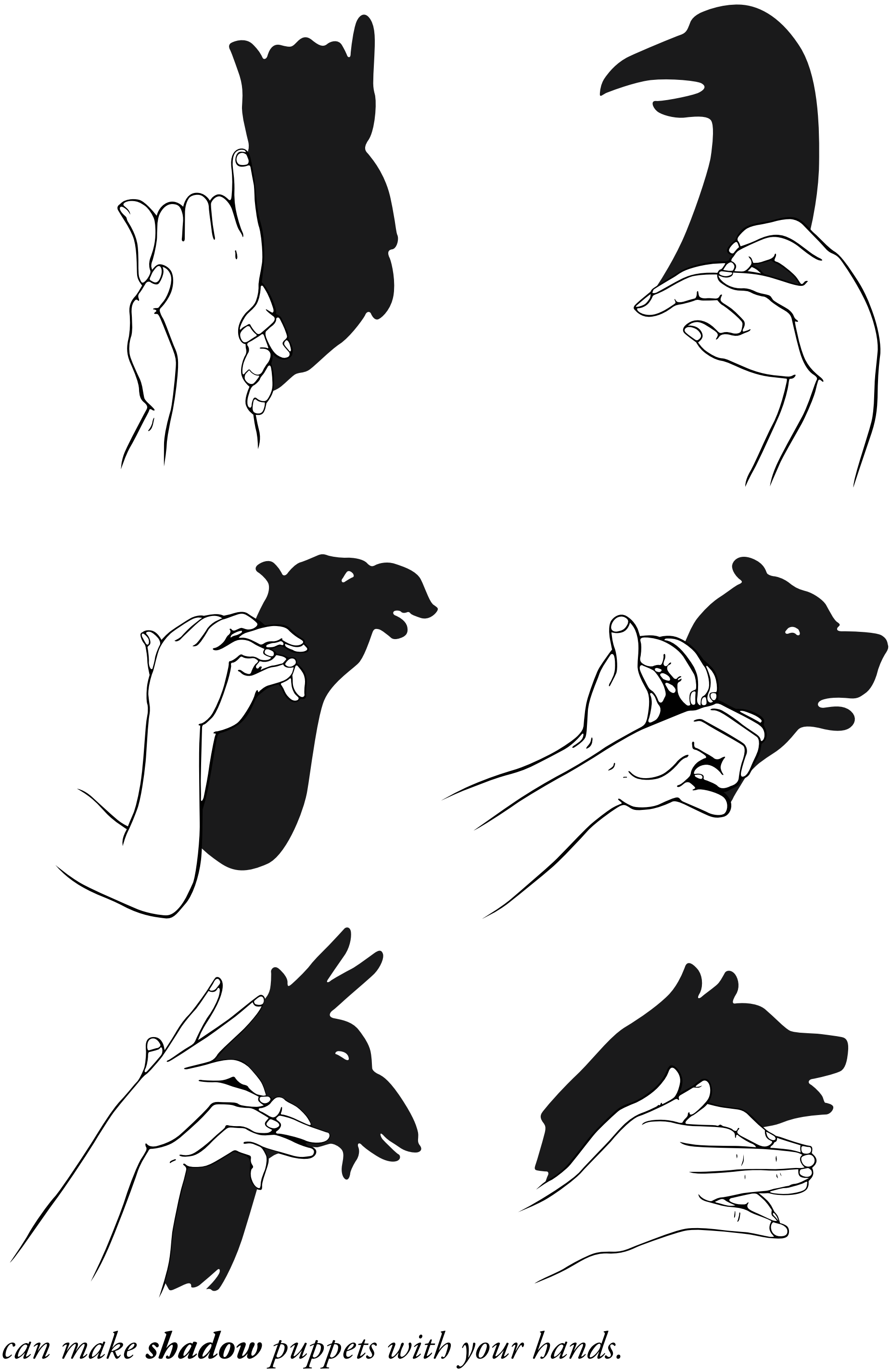
Last, try it one more time. This time move closer to the light—even closer than the spot marked "2." Have your classmates mark the floor and **shadow** tracing with a "3."

Now, compare the tracings. Which is the biggest? Where were you standing in relation to the light when the tree made the biggest **shadow**? Where were you standing when the tree made the smallest **shadow**?



*Is the cutout of the tree making these **shadows** closer to the light in the top image or bottom image?*

You can have even more fun making **shadows** with your hands. Try making the **shadows** in these drawings. Look carefully at one drawing at a time. Try placing your hands exactly as shown in the drawing. Practice several times. When you think you have it right, try making the shape in front of the light. If you get really good, you might want to put on a show for your family!



*You can make **shadow** puppets with your hands.*

Chapter 3

Mirrors and Reflections

Have you been to the dentist recently? Do you remember if he or she used a tool with a **mirror** to look at your teeth? Think for a minute about how useful that **mirror** is. Why does the dentist use it? This simple tool allows him or her to see the back of your teeth. He or she can also see teeth way in the back of your mouth. Without it, he or she couldn't do his or her job nearly as well! Ask to see this tool the next time you're at the dentist.

So what is a **mirror**? A **mirror** has a smooth, shiny **surface** that **reflects** light. Light that is **reflected** bounces off of something in its path. You have already learned that light travels in a straight line, unless it runs into something in its way. If light hits a transparent object, it passes right through the object. If it hits an opaque object, the light is absorbed and blocked so a shadow is made. If light hits a smooth, shiny surface like a **mirror**, it is **reflected**.

*Light **reflected** from the surface of this **mirror** allows the dentist to see the back of this person's teeth.*

When a **mirror** is made, glass is coated with hot, **silvery** metals and then cooled. This coating makes the **mirror** shiny so it **reflects** back all the light that hits it.

Did you know that there are different types of **mirrors**? You probably use a **plane mirror** every morning when you get ready for school. A **plane mirror** has a more or less flat **surface**. The **reflection** of something in a **plane mirror** is almost the same size as the real object.

This little girl is looking at her ***reflection*** *in a* ***plane mirror****.*

Plane mirrors are used in many tools. Cameras, telescopes, and microscopes sometimes use **plane mirrors**. Some toys even use **plane mirrors**. Have you ever looked through a toy called a **kaleidoscope**? A **kaleidoscope** is a tube with **plane mirrors** inside. There are also tiny bits of colored glass and beads sealed up inside the **kaleidoscope**. You look through a small hole at one end of the **kaleidoscope** and point it toward the light. As you rotate the tube, you will see beautiful, colored patterns.

Here's what the outside tube of a toy ***kaleidoscope*** *looks like.*

Here's what you might see if you looked inside a ***kaleidoscope****.*

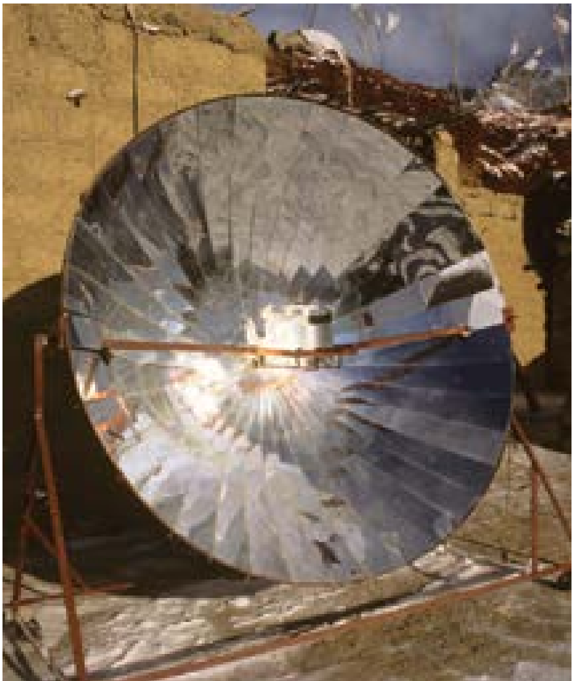
There are two other types of mirrors that are different from **plane mirrors**. **Plane mirrors** have flat surfaces, but **concave** and **convex** mirrors have **curved** surfaces. The smooth, shiny side of a **concave mirror curves** inward like a spoon. The smooth, shiny side of a **convex mirror curves** outward.

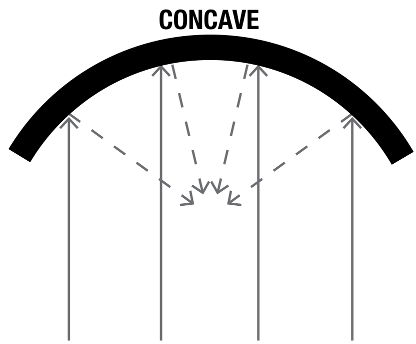
Here's another way that **concave** and **convex mirrors** are different from **plane mirrors**. Remember that in a **plane mirror,** the **reflection** of an object is about the same size as the object. In **concave** and **convex mirrors**, the **reflection** can look larger or smaller than the real object.

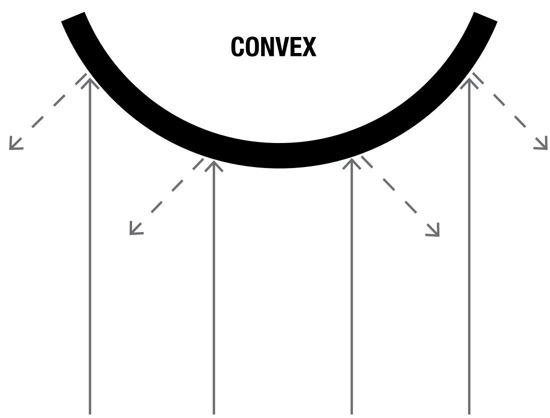
*Three types of **mirrors***

Concave and **convex mirrors** are also useful. **Concave mirrors** can be used to provide heat using the light from the sun. Remember that sunlight is a form of light and heat energy. The large **concave mirror** in the image on the next page **reflects** the sun's energy so that people can warm their hands or bodies outside.

What about **convex mirrors**? The next time you get on a bus, take a look at the mirrors on the sides of the bus. Most buses and large trucks have a small, extra **convex mirror** on the side-view **plane mirror**. The **convex mirror** makes objects look smaller but shows a wider area so you can see more. It helps drivers avoid hitting something they might not see in the regular **plane mirror**.







***Curved mirrors** change the look of things because of the ways they bounce light rays back.*

So now you see how useful **mirrors** are in our everyday lives. **Mirrors** can also be a lot of fun. A circus or carnival sometimes has a place called the "Funhouse," or "House of **Mirrors**." If you go in, there are lots of **concave** and **convex mirrors**. When you look in these **mirrors**, you might not recognize yourself! Your **reflection** is **distorted**. What makes that happen? Now you know it's **concave** and **convex mirrors**.

***Concave** and **convex mirrors** can **distort** the **reflection** of an object.*

Chapter 4 Refraction and Lenses

In the previous chapters, you have been reading about how light travels. You already know that light travels at a very fast speed—faster than any machine made by humans.

You also know that light travels in a straight line, unless it runs into something in its way.

When light hits a transparent object, it passes right through the object.

When light hits an opaque object, the light is absorbed and blocked so a shadow is made.

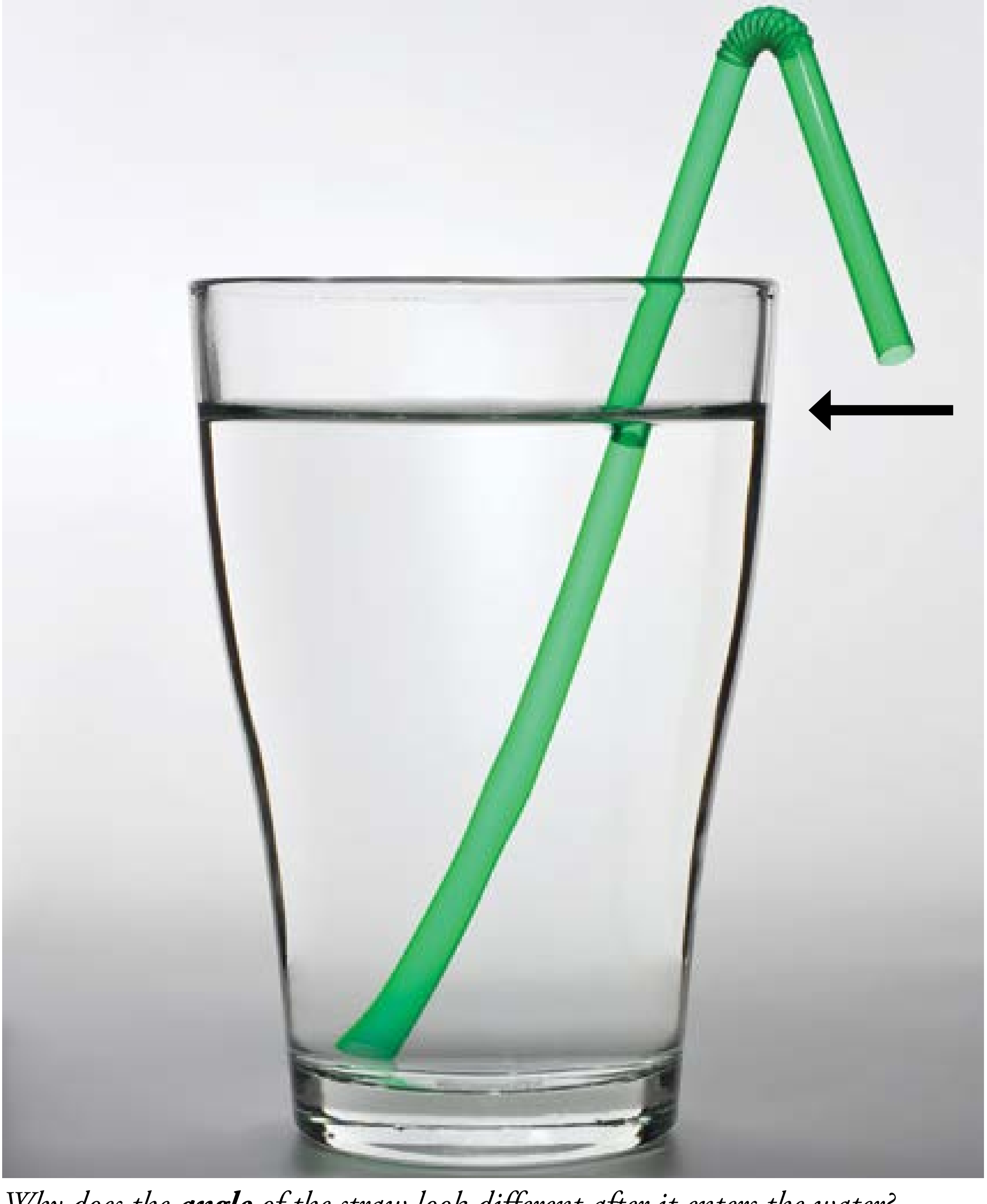
When light hits a smooth, shiny surface like a mirror, it is reflected.

One of the things we haven't studied yet is what happens to the speed of light when it passes through something transparent. As fast as light is, when it passes through something transparent, it does slow down. So, when light passes through windows, water, and even air, it slows down. The **denser** or heavier something is, the slower light travels through it. For example, light travels more slowly through glass than it does through water or air. It travels more slowly through water than it does through air.

Does light travel fastest through glass, water, or air?

When light moves through one thing that is transparent to something different that is transparent, it changes speed. When light changes speed, the **angle** of the light rays change and appear to bend.

Take a straw and put it in a glass of water. Now, look at the straw where it enters the water. Can you see that it appears to be at a different **angle**? That is called **refraction**. It's caused by the slowing down of light as it moves from air to water. As the light enters the water, it changes **angle** direction because it slows down. It seems like magic, but it's really just how light travels—no trick.



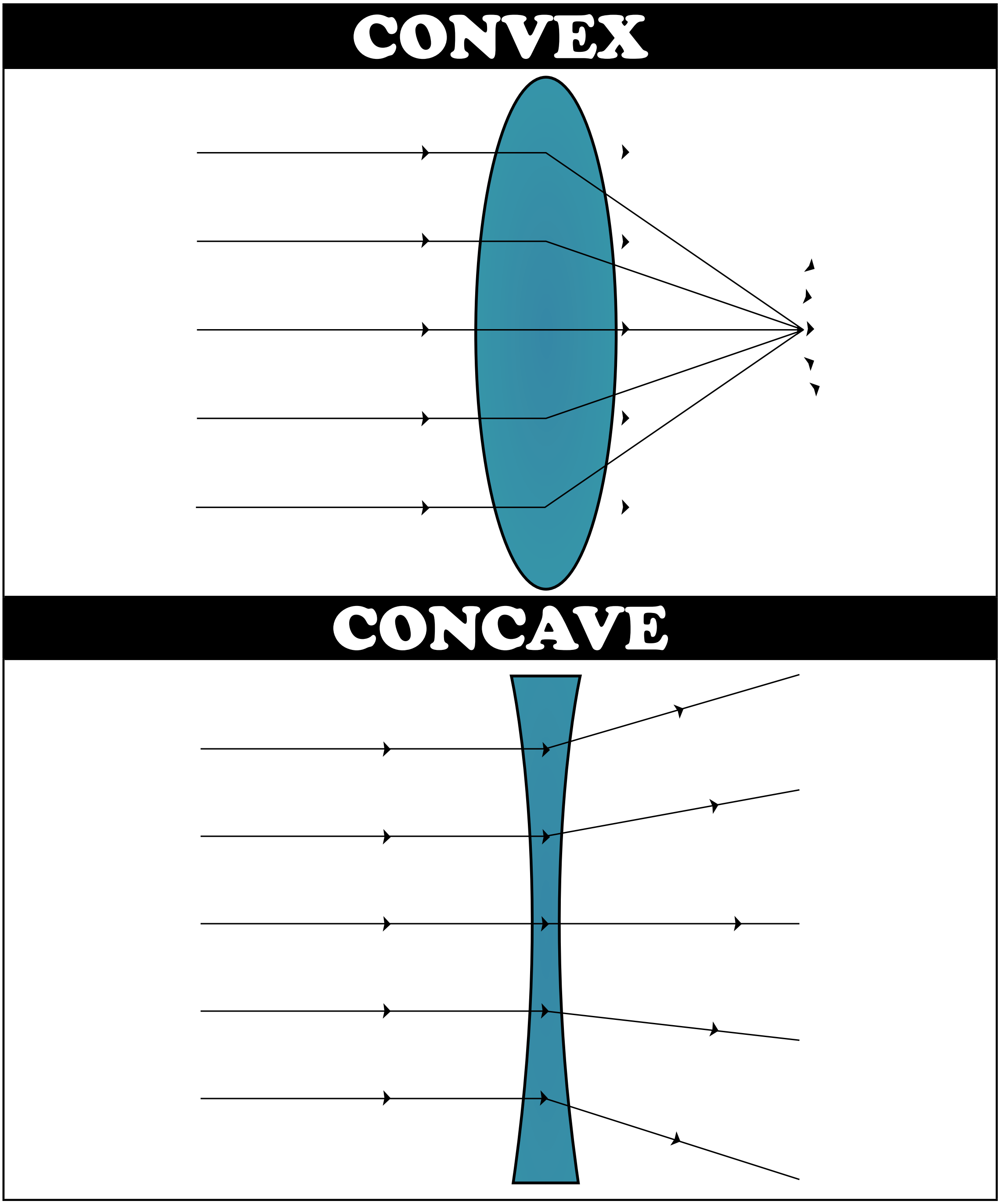
*Why does the **angle** of the straw look different after it enters the water?*

You may be surprised to learn that there are many ways that we use light **refraction** every day. Do you or any of your classmates wear eyeglasses? The **lenses** in eyeglasses correct different kinds of vision problems by **refracting** light. Transparent glass or plastic **lenses** are made to **refract** light in different ways. Like mirrors, these **lenses** can be convex **lenses** or concave **lenses**.

***Lenses** can be used to **refract** light to correct vision problems.*

Remember that something convex curves outward. A convex **lens refracts** and bends light rays closer together. When you look through a convex **lens**, an object will look larger and closer. It looks **magnified** because the light rays are closer together.

A concave lens curves inward. A concave **lens refracts** and spreads light rays apart. If you look through a concave **lens**, an object will look smaller. It looks smaller because the light waves are spread apart.



*Convex and concave **lenses** bend light in different directions. Do objects look larger or smaller through a convex **lens**? What about through a concave **lens**?*

A **magnifying glass** is an example of a simple convex **lens**. If you hold and look at something closely through a magnifying glass, it will look larger. People use a **magnifying glass** to more clearly see the details of something small.

*A **magnifying glass** has a convex **lens** that makes small details appear larger if you hold the **magnifying glass** close to the object you are looking at.*

Convex **lenses** are also found in scientific instruments. A scientist might look through a microscope with a convex **lens**. The **lens magnifies** very small things that cannot be seen with the naked eye.

Scientists study outer space with telescopes. Telescope **lenses** are also convex. They make the moon, stars, and planets look larger and closer so scientists can learn more about them.

Scientists look through microscopes with a convex ***lens*** *to see tiny things that are not visible to the naked eye, like these germs.*

Scientists also use telescopes with convex ***lenses*** *to study outer space.*

Concave **lenses** are also useful. Remember that concave **lenses** spread out light rays. Concave **lenses** are used in **security cameras** because they provide a wider view of a place.

Do you have a peephole in your door at home? If so, you may have a concave **lens**. In many homes and apartments, the peepholes of doors have two lenses, one of which is concave. The other lens is convex and magnifies the image made by the concave **lens**. The people looking in from the outside can barely see what's inside. (Remember, concave **lenses** make things look smaller.) However, if you are looking from the inside out, you can see who is standing in front of your door.

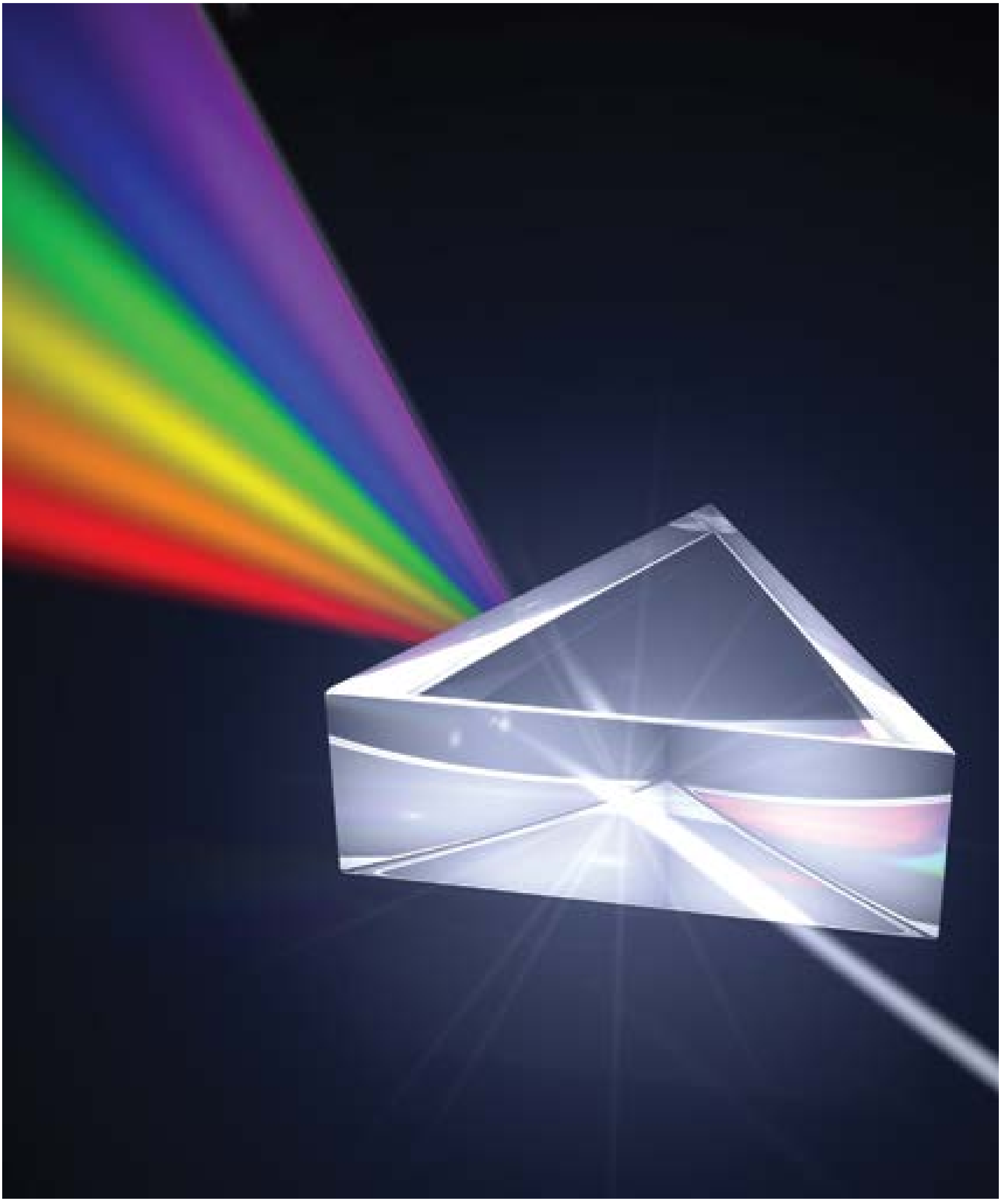
*Concave **lenses** that spread out light rays are useful for **security** purposes.*

Chapter

5 Color and Light

Do you remember what color sunlight is? Hopefully, you didn't say, no color! You learned that sunlight is white light. You also learned that instead of being "no color," white light is made up of all the colors of the rainbow. Remember, the sun looks yellow because it gives off more yellow light than it does the other colors.

You can prove that white light is really many colors if you have a wedge-shaped piece of transparent glass called a **prism**. If you hold a **prism** near a sunny window, light will shine through and make a rainbow-like band of colors. This shows that white light is really made up of all colors.



*A **prism** refracts white light into all of the colors of a rainbow.*

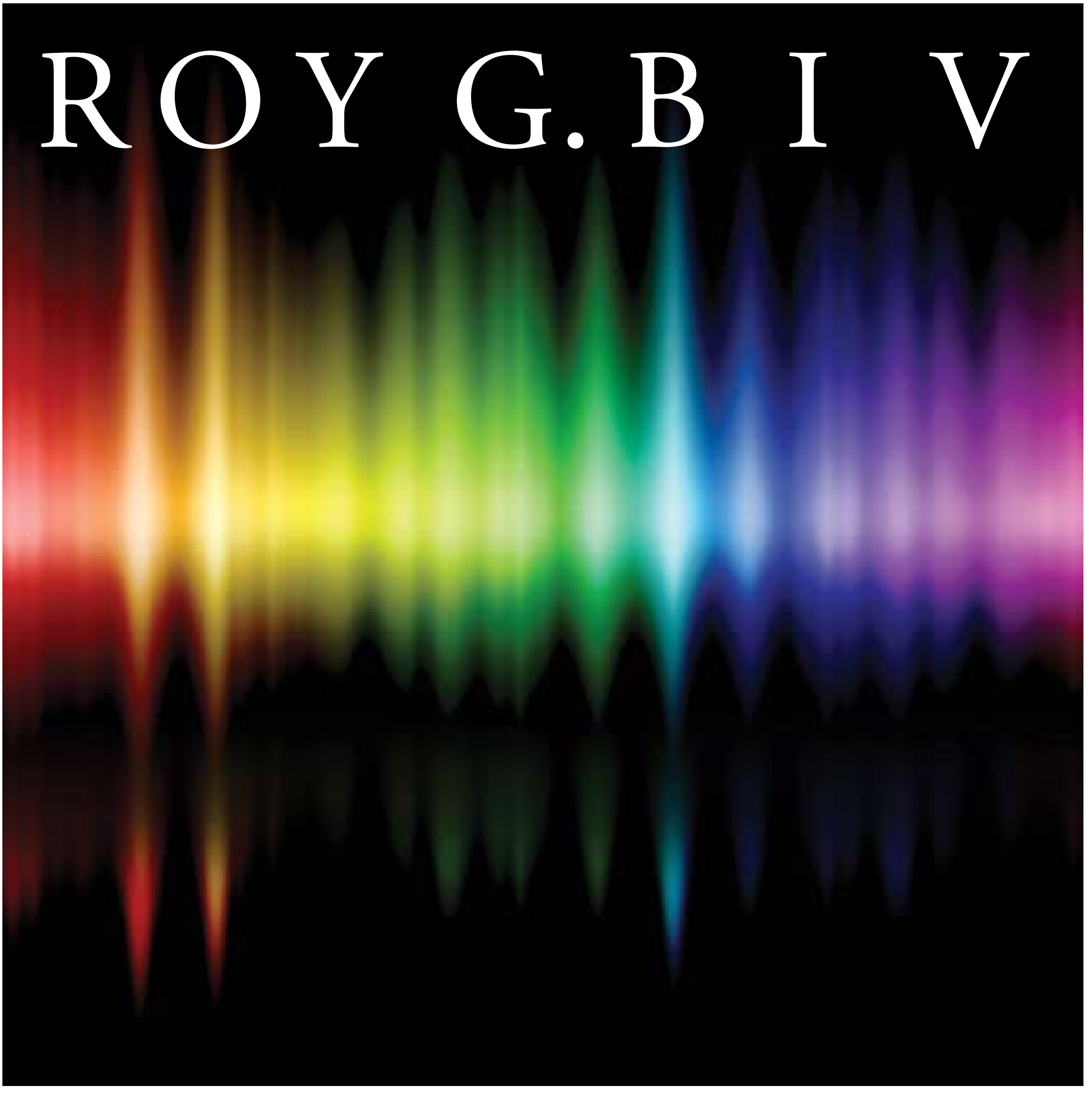
Do you remember what you learned about refraction? What happens to light when it passes through something transparent like glass? The light slows down and changes its path. A **prism** has a special shape that refracts white light into all of the colors of the rainbow.

Have you ever seen a rainbow in the sky when the sun comes out after it rains? Raindrops in the sky refract the light, just like a **prism**. This is what creates the rainbow.

A rainbow occurs when raindrops refract sunlight into all of the colors of visible light.

When white light is refracted, it often separates into a combination of colors called the **spectrum**. The colors in the **spectrum** always appear in the same order: red, orange, yellow, green, blue, **indigo**, and violet. These colors are part of the visible light **spectrum**. They are the light waves that humans can see. The colors of visible light are a result of differences in wavelength. Red light has long wavelengths and violet light has short wavelengths.

You can remember the names of the colors in the visible light **spectrum** in the right order if you can remember this funny name: “Roy G. Biv.” Each letter in that name stands for a color in the rainbow. Say it out loud. Try to remember it!



You can remember the order of the colors in the visible light ***spectrum*** *if you remember "Roy G. Biv."*

Did you know that the color of any object depends on what light wavelengths it reflects? Different objects absorb light wavelengths of some colors, but reflect others. This is what creates color.

Blue jeans appear blue because something in the **material** reflects blue light and absorbs all of the other light colors. Do you see anyone in your class today wearing a red sweater? The sweater appears red because something in the **material** reflects red light and absorbs all of the other light.

What about things that appear to be white? They look white because the object reflects all of the white light wavelengths and doesn't absorb any light. Can you guess why something looks black? Things that appear black do not reflect any light. They absorb all of the light wavelengths.






Can you explain why each thing appears to be the color it is?

Remember that the colors we see are from light of specific wavelengths. But, there is much more to light than just the wavelengths we can see. In fact, visible light is only a small part of the energy waves that come from sunlight.

For example, on the shorter wavelength end of the light **spectrum**, there are invisible **ultraviolet** light waves that cause sunburn. X-rays are even shorter wavelengths of light. We can't see these light x-rays but they can travel through the human body. You learned in *How Does Your Body Work?* that x-rays are used to create black and white photos of what's inside the body. Do you know of any other ways that x-rays are used?

We can't see x-ray wavelengths but these light waves can pass through your hand and create an image of your bones on special x-ray film.

Another type of invisible light is **infrared** waves. The wavelengths of **infrared** light are longer than those of red light. These are the type of light waves that you use when you click on the **remote control** to change television channels!

Certain wavelengths of light are invisible. We can't see the ***infrared*** *light from a* ***remote control*** *but we can see its effect when a channel is changed.*

Chapter

6 What Is Sound?

An alarm clock rings, a dog barks, a voice calls, "Time to get up!" Every day is full of familiar sounds but what exactly is sound?

Sound is caused by a back and forth movement called vibration. Try this. Close your lips and hum. While you are humming, feel your throat under your chin. Do you feel something buzzing or vibrating? What you feel is caused by something moving back and forth very fast. When you hum, the **vocal cords** in your throat vibrate back and forth. This makes the air around them vibrate, which then creates the sound you hear.

*When you hum, your **vocal cords** vibrate to make sounds.*

Sound, like light, is a form of energy. Also like light, sound moves in waves. **Sound waves** move out from a vibrating object, making the air move back and forth in a way that we can't see.

Two things must happen to create a sound. First, something needs to vibrate and create **sound waves**. Then, something like air or another **medium** needs to carry the **sound waves**. You hear sounds more clearly if you are close to whatever is vibrating and making the **sound waves**. The farther away that the **sound waves** spread out, the weaker they get. That is why you can hear a friend standing right next to you better than if they are calling to you from across the street.

This is what a ***sound wave*** *might look like if we could see it.*

The next time you turn on your radio or TV, lightly put your fingers on the speakers. Do you feel the sound vibrations?

Sound travels not only through air, which is a gas, but through other **mediums**. In fact, sound can travel through solids, liquids, and gases.

Think about sound traveling through solids, like a window or even a closed door. If you are close enough, you can still hear sounds on the other side of a window or door.

How about liquids? Have you ever been underwater in a swimming pool when you have heard someone's voice or another sound? It probably sounded different than it would if you were not under water, but you were still able to hear it. This is an example of sound traveling through a liquid—the water in the pool.

One place that sound cannot travel is in outer space. Sound cannot travel through the emptiness, or vacuum, of space. There is no sound in outer space because there is no **medium** to carry it.

Sound travels through solids, liquids, and gases (air).

You might wonder about the speed at which sound travels. **Sound waves** travel much slower than light waves. **Sound waves** travel at about 750 miles per hour. That's fast, but not close to the 186,000 miles per second that light can travel. It would take a sound 33 hours to travel around Earth once. Remember that light can go seven times around Earth every second!

Here's an example to prove that light travels faster than sound. Think about the last time you were around a storm with thunder and lightning. Did you notice that you saw each flash of lightning before you heard the clap of thunder? That's because light travels faster than sound!

During a storm, you will see lightning before you hear thunder. That is because light travels faster than sound.

The **medium** through which sound travels affects its rate of speed. Interestingly, **sound waves** travel fastest through solids. In old western movies, you may have seen a cowboy put his ear down to the steel railroad tracks to hear if a train is coming. That is because the sound travels faster through the steel than through the air.

Try this. Listen while you drum your fingers on your desk. Now, rest your ear right on the surface of the desk and drum your fingers again. Which way sounded louder?

The sound was louder when you put your head on the desk. This is because the sound traveling through the solid wood of your desk traveled faster than if it had first traveled through the air. Every time sound changes **mediums**, it loses some of its loudness.

Sound travels fastest through solids, such as the wood of your desk or a wall.

Chapter 7 Characteristics of Sound

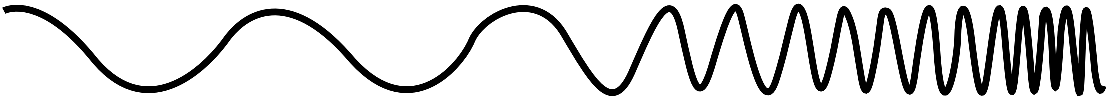
Let's review what you have learned so far about sound by comparing it to light. How is sound different from light? Sound must have a medium to travel through—a solid, liquid, or gas. Light does not need a medium. Remember, light can travel through the emptiness, or vacuum, of outer space. Sound cannot.

The speed at which light and sound travel is also different. Light travels much faster than sound.

There are important ways that light and sound are similar. They are both forms of energy that travel in waves. There are also other similarities.

sound waves

light waves



Both light and sound are forms of energy that travel in waves.

When you learned about light, you learned that light waves can be different lengths. Some are long and some are short. It is the length of a light wave that makes it appear to be a particular color.

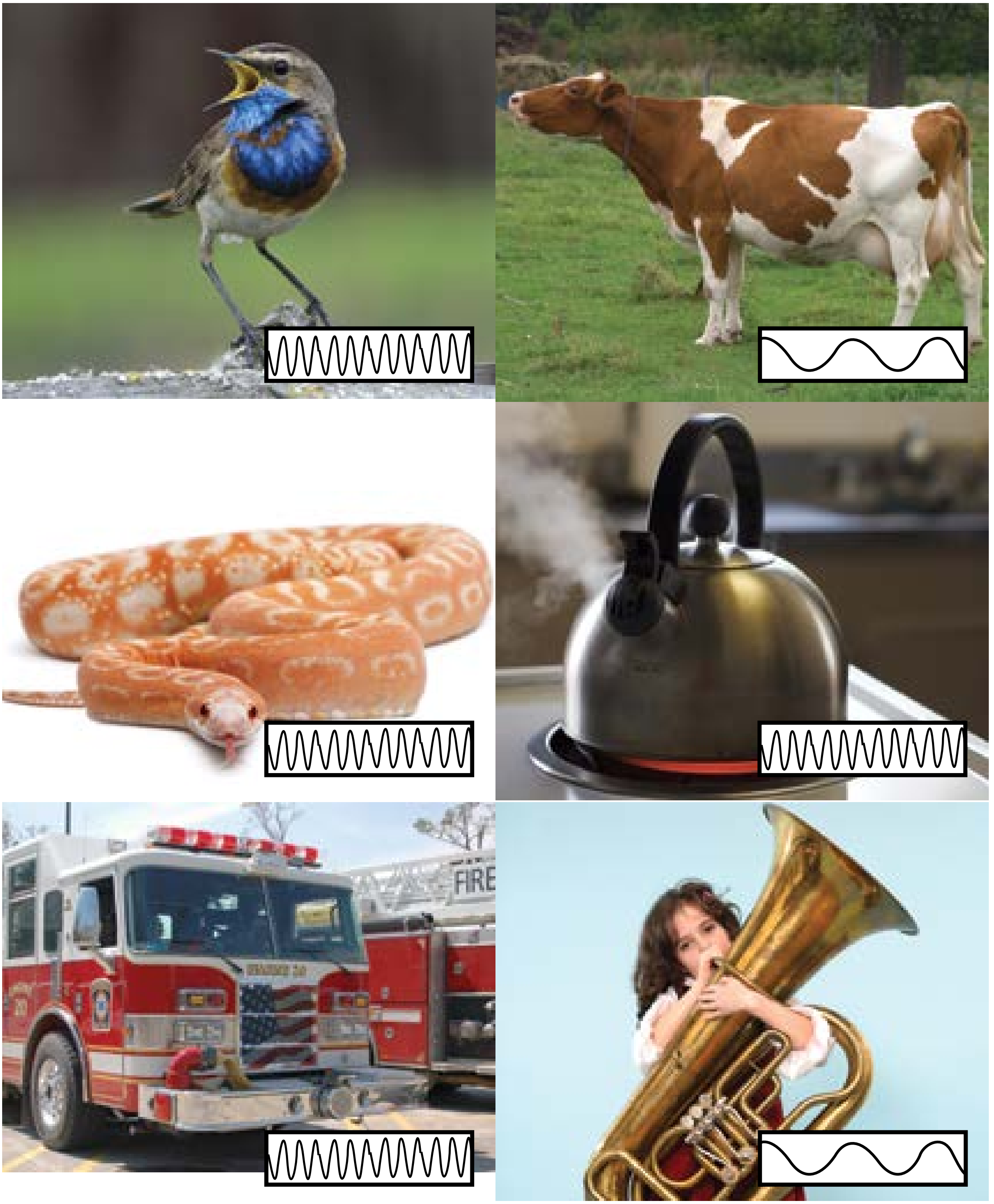
Perhaps you are wondering whether sound waves differ from one another. Imagine these two sounds—a baby crying for its mother and an adult yelling. Both of these are sounds. The sound waves of each travel through the same medium, air, so they are alike in that way. But a baby crying surely sounds different than an adult yelling! The baby makes a high-**pitched**, "screeching" sound. When an adult yells, it is a low-**pitched**, deep tone. Could this difference in **pitch**, or how high or how low a sound is, come from different kinds of sound waves?

Both of these sounds travel through air. How are they different?

The answer is yes and it has to do with the length of the sound waves! It helps if we first understand how vibrations affect sound waves. Faster vibrations produce shorter sound waves, which make sounds with a higher **pitch**. The baby's screeching sound vibrates very rapidly, making shorter, but more, sound waves. Can you think of some other sounds that have a high **pitch**?

Slower vibrations produce longer waves, which make sounds with a lower **pitch**. A yelling voice makes longer, fewer waves so you hear a lower **pitch**. **Pitch** describes the highness or lowness of a sound. Can you think of some sounds that have a low **pitch**?

Try changing your voice **pitch**. Can you speak in a high, squeaky voice? Can you speak in a low, rumbling voice?



*Which sounds are high-**pitched**? Which are low-**pitched**?*

Sound also varies in loudness. If you're listening to the radio and a favorite song comes on, you might say, "Turn it up!" and reach for the knob marked **VOLUME**.

When you turn up the **volume**, you are making the sound louder. A scientist might say that you are increasing the sound's **intensity**. More **intense** sound waves carry more energy and make louder sounds.

How far away you can hear a sound depends on its **intensity**. A quiet sound, like a whisper, doesn't travel very far. A really loud sound can travel for hundreds of miles. When fireworks are set off, the sound can be heard miles away.

*Sounds with greater **intensity** are louder and travel greater distances.*

Very loud sounds can **damage** your hearing. People who work around loud sounds all day long often wear ear coverings or plugs to protect their hearing. You should be careful, too, not to turn the **volume** too loud if you like to listen to music.

*Listening to loud sounds repeatedly can **damage** your hearing.*

Chapter 8 The Human Voice

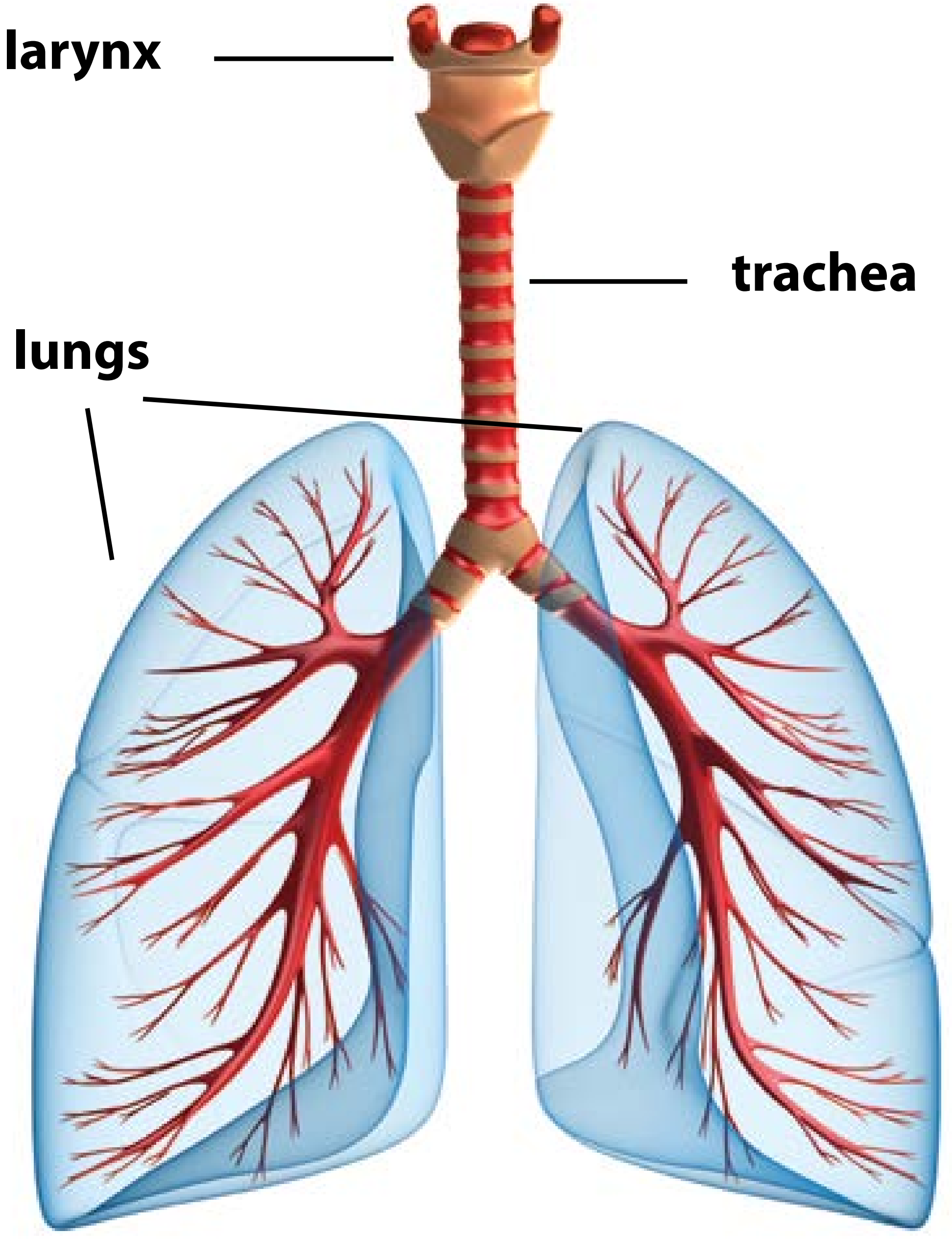
Have you ever noticed how well you know your mother or grandmother's voice? You have heard it so often that you can tell right away who it is. Each person has a distinct voice. It's a voice that can make many sounds with different pitch and intensity. It can make high- and low-pitched sounds, loud and soft sounds.

Do you recognize the voices of your friends and people in your family?

So how does your body make all of those different sounds? You already know that something needs to vibrate to create sound waves. You also know that sound needs a medium, like air, to travel through. Here's how it works in the human body.

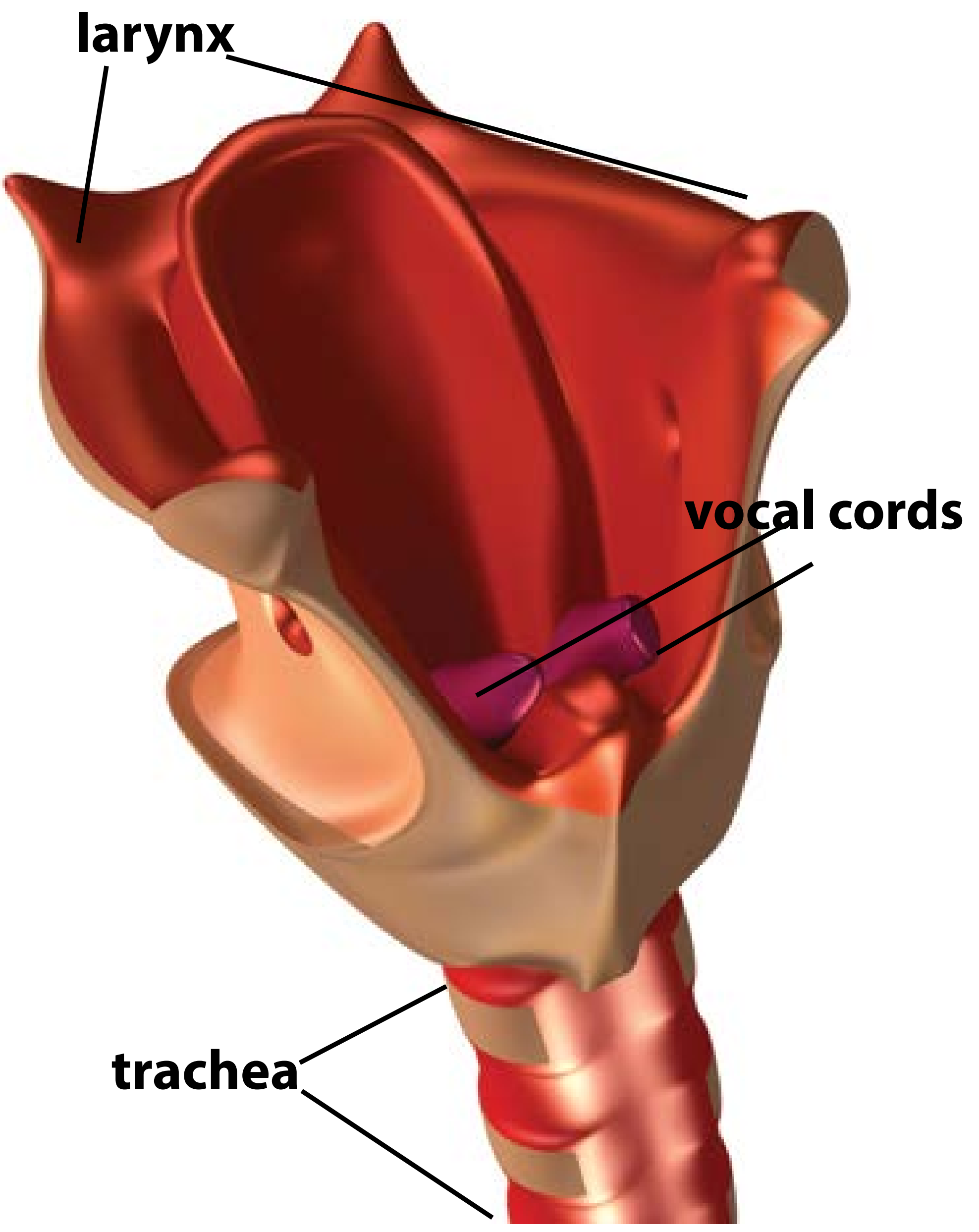
Air passes in and out of your body all of the time when you breathe. Inside your chest, your **lungs** expand to take in air and then contract to let it out.

Leading out of your **lungs** is a long tube called the **trachea**, or "windpipe." At the top of your trachea is another part of your body called the **larynx**, or "voice box."



Air passes in and out of your body through the ***larynx****,* ***trachea****, and* ***lungs****.*

Inside the **larynx** are two bundles of muscle that are known as vocal cords. When you breathe in, the vocal cords relax so that air can move past them and into your lungs. When you speak, you force the air out of your **lungs** and over the vocal cords in your **larynx**. The vocal cords vibrate to make waves in the air that continue up your throat and out of your mouth.



*When you speak, air is forced from your **lungs** and **trachea** to your **larynx**. The vocal cords in your **larynx** vibrate to make waves in the air. These vibrations make sounds.*

When you were a baby, you did not need to learn how to breathe. Your **lungs** worked **automatically**, bringing air into and out of your body. You also did not need to learn how to use your vocal cords to make sounds. When you were a baby, you made lots of funny noises and grunts. Ask your parents!

You did, however, need to learn how to change those grunts and noises into words so you could talk. You did this by listening to the people who talked to you when you were a baby. You practiced saying the same sounds and words. You learned to speak whatever language all of those people were speaking to you. If your family spoke only English to you, you learned to speak English. If your family spoke only Spanish to you, you learned to speak Spanish. People can learn to speak more than one language. Maybe you or some of your classmates speak more than one language.

When you were a baby, you learned to speak the same language that the people around you were speaking.

Your vocal cords grow as you grow. When you have shorter vocal cords, you tend to speak at a higher pitch. This is why small children have higher-pitched voices than adults. The pitch of your voice depends on the size of your vocal cords and **larynx**.

The volume of your voice, or how loudly you speak, depends on how much air is produced by your **lungs** and comes out of your mouth. When more air is pushed out of your mouth, your voice will be louder.

Who do you think has shorter vocal cords and speaks in a higher-pitched voice?

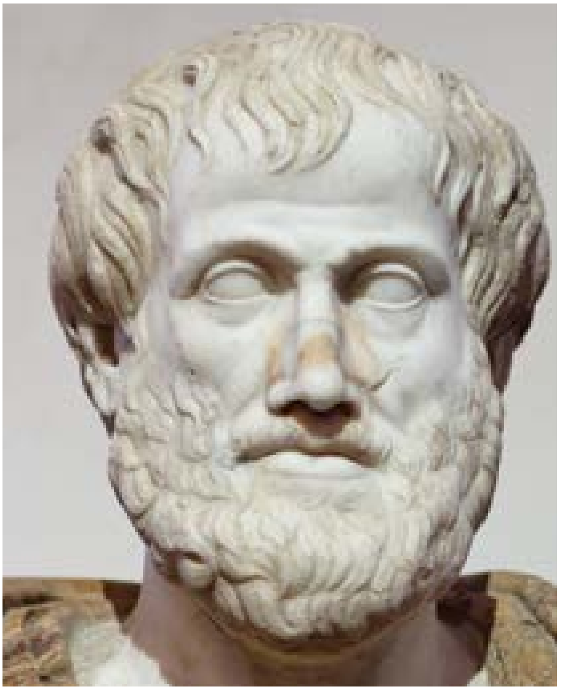
Chapter 9 Light and Photography

The word **photography** comes from two Greek words. *Photo* means "light" and *graphein* means "to draw." So you might say that **photography** means "to draw with light."

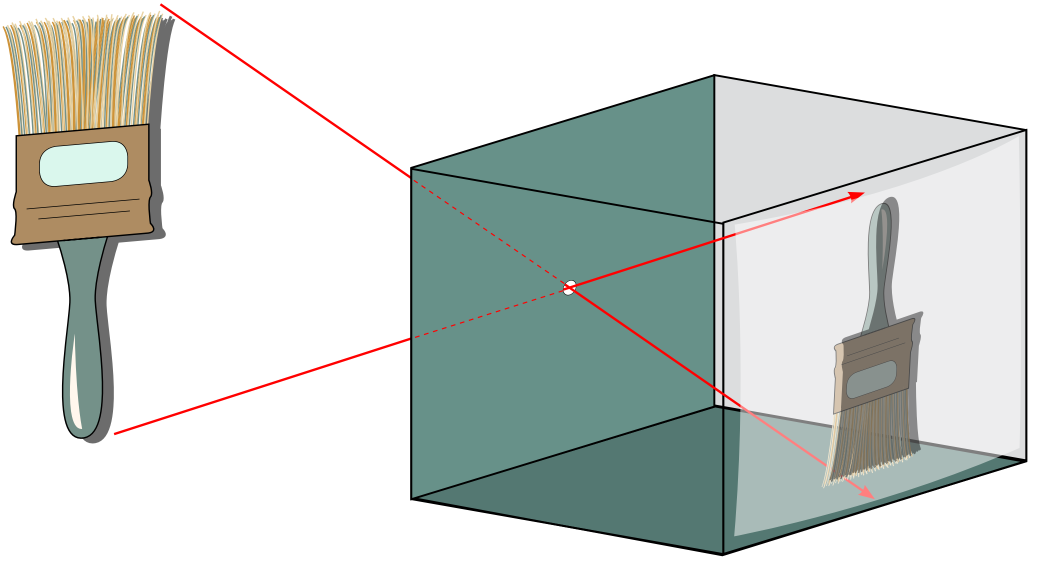
The earliest ideas for making pictures using light came in the 4th century BC from a Greek man named **Aristotle**. He observed and made notes about how light acts.

The first person to put **Aristotle's** ideas into practice was an Arab scientist, Alhazen, around 1000 AD. He made the first pinhole camera. It was a box with a small hole in one side. Light from the outside came through this little hole and projected an image on the opposite side of the box. Alhazen used it to help him draw. His camera did not take **photographs** as we know them today. Others continued to experiment with and improve pinhole cameras. Even today, some people still enjoy making

Alhazen



Aristotle



Pinhole cameras do not have lenses. There is just a small hole on one side of the box that lets light into the box. A figure is projected on the opposite side of the box.

their own simple pinhole cameras.

The first thing similar to a **photograph** was made in 1826 by a Frenchman named Joseph Niepce [NEEP-see]. He **invented** what were called **heliographs**. *Helio* is the root for "sun." He used sunlight to create images. The sunlight mixed with a form of coal and some other natural chemicals on a square, glass plate to make an image. It took eight hours in the sunlight before the image appeared! Then, it faded.

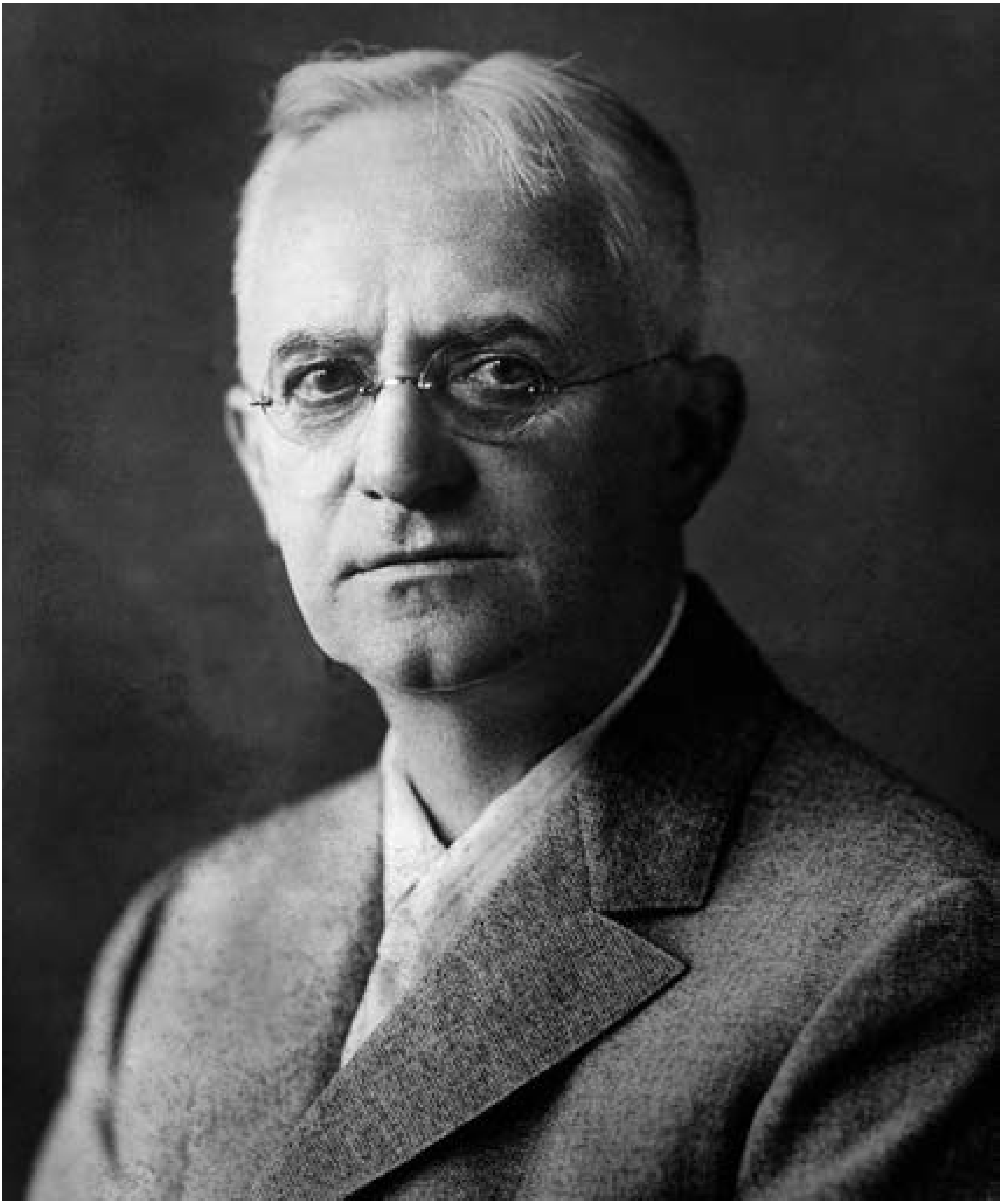
Joseph Niepce ***invented heliographs***.

Another Frenchman named Louis Daguerre [Də-GAIR] took Niepce's ideas and improved them. He was able to use light to create an image in less than thirty minutes. His images were called **daguerreotypes**, named for their **inventor**. **Daguerreotypes** used light-sensitive chemicals like silver and iodine to make an image on a metal plate. These became popular around the world.

Louis Daguerre

*Here is an 1850 **daguerreotype** of a young woman.*

The late 1800s brought even more improvements to **photography** thanks to some very creative **inventors**. One such **inventor** was the American George Eastman. In 1888, he **invented** flexible, rolled film that could replace the glass plates that were used in earlier cameras.



George Eastman ***invented*** *film for use in cameras.*

The **invention** of film led to the creation of the box camera, which was a tight box with a simple lens. The camera had film that could take as many as 100 **photos**. People could take **photos** and then send the camera back to Eastman's company to print the **photos**. The company then sent both the **photos** and camera back to you. Ask to see your family's older **photo** album. Chances are that some of the much older **photos** may have been taken with a box camera.

An early box camera and a roll of film

Color films were not **invented** until the late 1930s and early 1940s. By then, most families owned at least one camera and **photo** albums became a common, household item.

Cameras improved at a fast rate around the 1950s. Instant **photography** was **invented** by Edwin Land, who sold his first camera in 1948. With his camera, one minute after you took the **photo**, you would have a fully developed **photograph** from the camera. These cameras were popular because people did not have to wait to get their **photos**. They had them right after they shot the **photo** with their camera.

*With the **invention** of the instant film camera, a fully developed **photo** was ready one minute after you took the picture.*

Chances are that if you or your family has a camera now, it is a digital camera. Digital cameras do not use film like the early cameras described previously. Digital cameras have a special computer "chip" that takes the place of film. In fact, many cell phones now also have digital cameras. Imagine how amazed the early **inventors** would be to see all of the cameras we have today!

A digital camera

A digital memory card in a digital camera takes the place of film.

Chapter 10

Alexander Graham Bell, Part I

What makes someone famous? Who would you think of if you were asked to name someone famous today? Would you name a famous athlete? An actor or musician? Maybe you would think of a president or famous leader. One of the most famous inventors of all time lived over 100 years ago. His name was Alexander Graham Bell.

Alexander Graham Bell

Alexander Bell was born March 3, 1847. He was the middle of three sons born to Alexander and Eliza Bell of Edinburgh, Scotland. His parents nicknamed him "Aleck" as a young boy. Aleck's childhood was happy. He lived the best of both worlds by spending time at his home in the city of Edinburgh and also in the country on the weekends. More than anything, Aleck loved to learn new things.

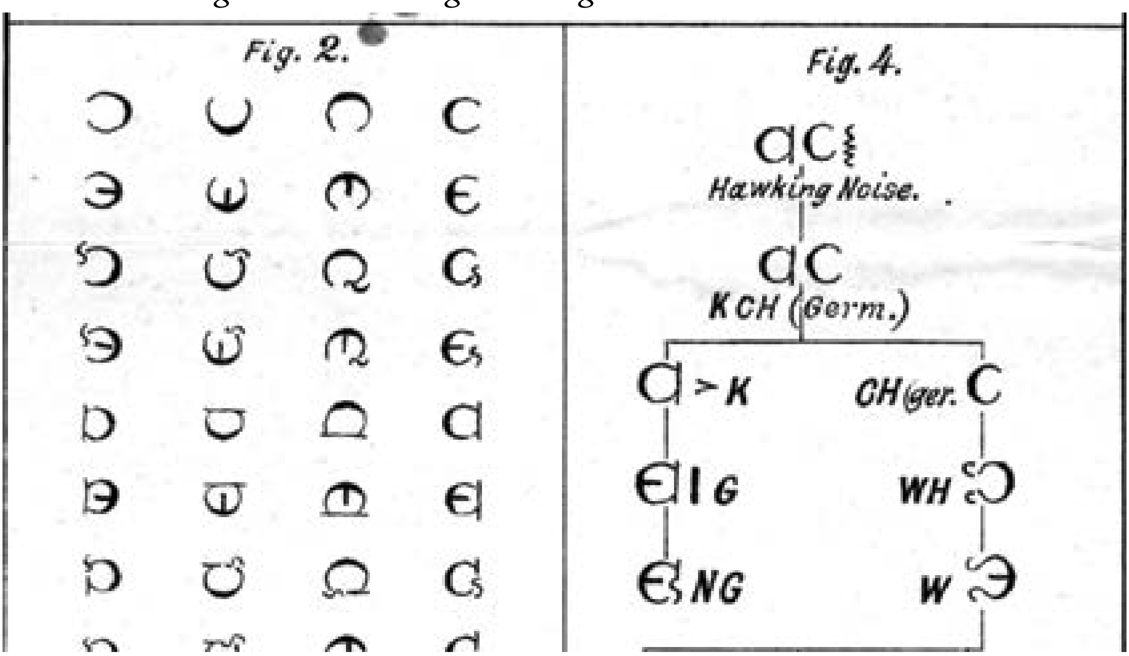
At Milton Cottage near Edinburgh, young Aleck enjoyed exploring nature. He collected plants and studied animals.

Aleck as a child with his family

In school, Aleck's best subjects were science and music, which he learned from his mother. Aleck's mother was nearly deaf, so she played music mostly by feel. To hear the music, she would put a **hearing trumpet** to the strings of the instrument. The **trumpet** magnified the sound.

Aleck's father was an important speech **professor**. He studied the sounds of the English language, similar to the phonics you studied to learn to read. He very much wanted to help his wife, Eliza, and other deaf people. In 1864, he invented a "sound alphabet" called **Visible Speech**. He spent years coming up with **symbols** to stand for any sound the human voice could make. The **symbols** that he used looked the way a person's mouth looked when making certain sounds. **Visible Speech** helped deaf people learn how to talk better so that they could communicate with others.

Aleck's parents, Alexander and Eliza Bell. Do you see the ***hearing trumpet*** *that Mrs. Bell is using to listen to her granddaughter?*



A ***Visible Speech*** *poster showing the* ***symbols*** *invented by Aleck's father to help the deaf.*

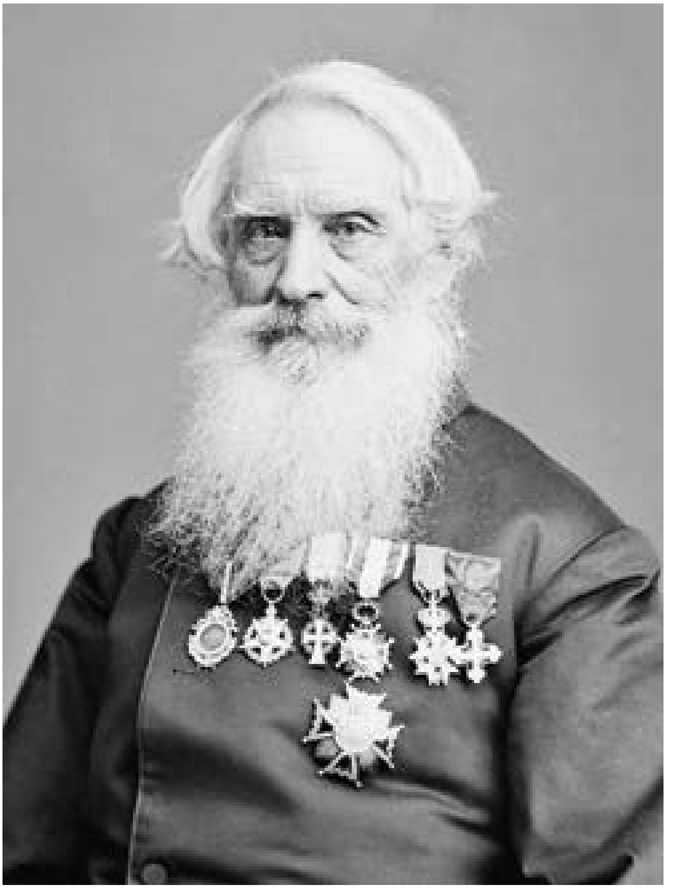
The example of both his mother and father was an **inspiration** for Aleck. He became interested in inventing things on his own. He especially wanted to invent things to help other people. Aleck and his brother actually made a "speaking machine." The machine used the voice box (larynx) of a dead sheep. Part of the machine acted like a mouth and throat and could say the word "mama."

As an adult, Aleck worked with deaf students. He later took a job as a **professor** at Boston University. Inventing things was a big part of Aleck's life. After one invention, he set his mind on others, never satisfied with the past invention. The invention that he is most famous for, however, was yet to come.

When he was young, Aleck and his brother invented a "speaking machine."

Chapter 11 Alexander Graham Bell, Part II

Aleck Bell loved thinking of new things to invent more than anything else in the world, especially to help other people. In 1837, another inventor, Samuel Morse, created a machine called the **telegraph**. The **telegraph** was a way to send messages long distances across wires. It was limited to dots and dashes and could not **transmit** human sounds. Aleck began to think about ways that he might improve upon this new invention. "I used to tell my friends that one day we should speak by **telegraph**," said Bell. He devoted all his time to this new goal. So did many others and the race for a new invention was on.



With the invention of the ***telegraph*** *by Samuel Morse, people could send messages long distances. A system of dots and dashes called* ***Morse Code*** *was used to tap out the messages on the* ***telegraph****. Three dots, followed by three dashes, followed by three more dots stands for SOS, code for "Help!"*

Boston, Massachusetts became an important place for many inventors. The Massachusetts Institute of Technology (MIT) made space in one of its labs for Aleck to do his experiments. His days were filled with teaching and then trying over and over to make human sound travel across a wire. All of his energy was spent on this creative idea. He wrote that his idea of using **electric current** to carry a sound would likely make others think him "crazy." So, he kept most of his ideas and experiments secret.

Aleck hired a young mechanic to help him. Thomas Watson knew how electricity worked. At first, their experiments failed more than they succeeded. Aleck thought they were getting closer to success. "I think the **transmission** of the human voice is much more nearly at hand than I thought." On June 2, 1875, his dreams came true.

Alexander Graham Bell and Thomas Watson worked together to try to ***transmit*** *sound using electricity.*

Like many inventions, an accident led to an important **discovery**. With the electricity turned off, Watson sent a message to Aleck that Aleck could hear. He heard tones, not just one single-pitched sound. He knew instantly it was a huge step forward! "I have (by accident) made a **discovery** of the very greatest importance," wrote Bell.

Three days later, the first telephone recorded, "Mr. Watson, come here, I want to see you." To Bell's great joy, Watson had heard and understood what Bell had said!

Fame and fortune came to Alexander Graham Bell and Thomas Watson. They soon formed the Bell Telephone Company to make and sell their new invention.

Bell’s first telephone

Bell continued to invent the rest of his life. "Self-education is a life-long affair," said Bell. "There is no failed experiment," he said to convince people to keep going with their ideas. He passed his love of learning on to his grandchildren and inspired a whole group of new inventors.

"There is no failed experiment," said Alexander Graham Bell.

Chapter 12

Thomas Edison: The Wizard of Menlo Park

Have you figured out why inventors are so important? They have helped every person's life in one way or another. Shouldn't there be an inventors' "Hall of Fame?" If there were, then a man named Thomas Alva Edison would be quickly voted in.

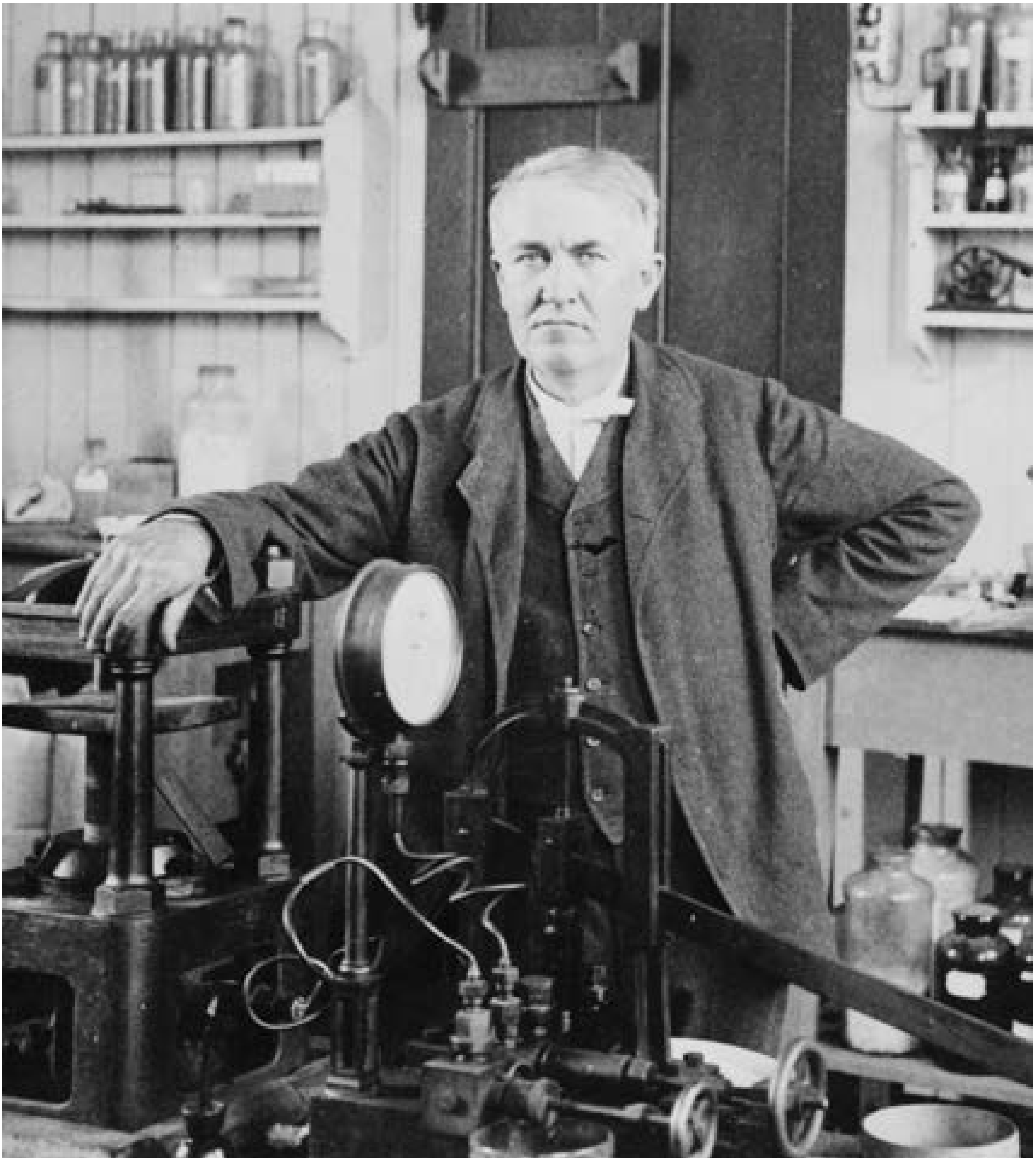
Thomas Alva Edison was born February 11, 1847, in a small, northern Ohio town. He was the last of seven children born to Sam and Nancy Edison. Al, the nickname his friends gave him, was a sickly child. He didn't even attend school until he was eight years old. Because of **scarlet fever** as a child, Al was left more than partially deaf. His illnesses did not stop his interest in nature. He asked questions that teachers didn't know how to answer: "Why is the sky blue?" or "How does fire work?" He was curious about everything and liked to figure out things on his own.

A photograph of Thomas Edison

At the age of 12, he worked selling newspapers on the railroad near his home. On the train, he heard people talking about many new ideas and inventions. He learned by listening to their stories. At 15, Al landed a job working the telegraph machine. He became an expert telegraph operator over the next six years. Even though he was deaf, he could feel the vibration of the wire.

Al liked to work with electric machines. He found a way to make the telegraph faster and sold the idea to Western Union Telegraph Company for $40,000. With the money he made from the sale, he set up his first lab to continue his experiments.

When the work Al was doing outgrew this lab, he built a bigger lab in Menlo Park, New Jersey. He hired some of the smartest scientists and engineers from around the world to work with him. Much of his early work was on sound. They called him the Wizard of Menlo Park because some of the inventions seemed magical.



Edison in his lab at Menlo Park

In this new lab, he discovered a way to make Alexander Graham Bell's new telephone louder. He sold the **patent** for his new invention for $100,000. That was a huge sum or money at the time.

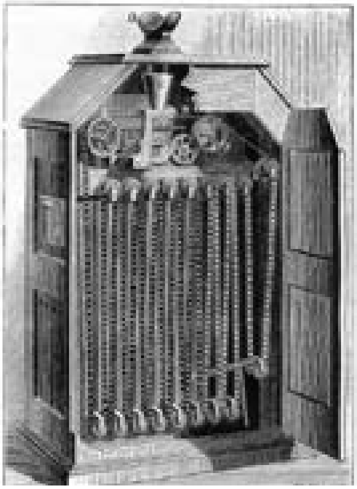
His next invention was the **phonograph**. He was able to record sound on a cylinder wrapped in tinfoil. He played a version of "Mary Had a Little Lamb" to his fellow scientists. This was the first time anyone was able to listen to recorded music.

Thomas Edison with a ***phonograph****, 1878*

The invention that Edison is best known for came next. In 1879, he invented the first **incandescent** (glowing) electric light bulb. Three years later, he lit up 85 homes at once in New York City and the age of electric light began.

By the time Edison “retired,” he had **patents** on over 1,000 inventions. They include the **kinetoscope**, which is a machine for showing movies, and the **microphone**.

What people sometimes forget is that many of Edison’s experiments “failed” at first. He caused explosions at his labs and was forced to start all over many times. However, he kept moving forward each time. He always had a positive attitude. He knew he was closer to his next success!



Thomas Edison in 1928 and two of his inventions, the ***kinetoscope*** *and the light bulb.*

Glossary for *Adventures in Light and Sound*

A

absorb—to take in or soak up (**absorbed**)

angle—the space formed when two lines or surfaces meet

Aristotle—a Greek philosopher who made notes about how light acts; His notes later helped inventors make cameras.

automatically—operating on its own without direct control

C

camera—an instrument for taking photographs (**cameras**)

concave—curved inward, like a spoon

convex—curved outward

curve—to bend (**curved**, **curves**)

D

daguerreotype—a type of early photograph invented by Daguerre; It appeared in less than 30 minutes and did not disappear as quickly as a heliograph. (**daguerreotypes**)

damage—hurt, harm

dense—thick, heavy (**denser**)

discovery—an event in which someone finds or learns something for the first time

distort—to twist out of normal shape (**distorted**)

E

electric current—the flow of electricity

electricity—energy carried over wires (**electric**)

energy—a supply of power

H

hearing trumpet—a cone-shaped tool that helps a person hear better by placing the small end in one ear

heliograph—a type of early photograph made by mixing coal and other natural elements that are then left in the sun to make the images; They took a long time to appear and disappeared quickly. (**heliographs**)

I

incandescent—glowing

indigo—a dark purplish-blue color

infrared—long light waves, beyond red on the spectrum, that can only be seen with special instruments

inspiration—something that gives a person an idea about what to do or create

intense—strong (**intensity**)

invent—to make something new that no one else has ever made (**invented**, **inventor**, **inventors**, **invention**)

K

kaleidoscope—a tube with plane mirrors and pieces of colored glass that you hold up to the light and rotate to make colorful patterns

kinetoscope—an early machine for showing movies

L

larynx—the organ in your throat that holds the vocal cords and makes it possible to speak; voice box

lens—a clear piece of curved glass or plastic that is used to make things look clearer, larger, or smaller (**lenses**)

lung—one of a pair of organs that allows animals to breathe by filling with air (**lungs**)

M

magnify—to make something look larger or sound louder (**magnified**, **magnifies**)

magnifying glass—a convex lens that makes things look larger when they are held close to the lens

material—cloth or fabric

medium—a substance that light or sound can travel through, like a solid, a liquid, or a gas (**mediums**)

microphone—an instrument for recording sound or making sound louder

mirror—a shiny surface that reflects light (**mirrors**)

Morse Code—a way of communicating with dots and dashes using the telegraph

O

opaque—not clear, blocking all light so that none gets through

P

patent—the rights to make and sell something (**patents**)

phonograph—an instrument that reproduces sounds that have been recorded on a grooved disk

photograph—a picture made with a camera (**photography**, **photographs**, **photos**, **photo**)

pitch—how high or low a sound is (**pitched**)

plane—a more or less flat surface

prism—a wedge-shaped piece of transparent glass that breaks up light into all the colors of the spectrum

professor—a college teacher

project—to cause light to appear on a surface (**projected**, **projector**)

R

reflect—to throw back light, heat, or sound from a surface (**reflections**, **reflects**, **reflected**, **reflection**)

refract—the appearance of light bending when it moves from one medium to another (**refraction**, **refracting**, **refracts**)

remote control—a device that uses infrared waves to operate equipment, such as a TV, from a distance

S

scarlet fever—a disease that causes a fever, sore throat, and a red rash

security—protection from danger

shadow—a dark shape or outline of something that is made when light is blocked (**shadows**)

silvery—shiny or silver in color

skylight—a window in a ceiling or roof that lets in light

sound wave—a series of vibrations that can be heard (**sound waves**)

source—a starting place, where something comes from (**sources**)

spectrum—the distribution of all the colors that make up the light we see

speed—how fast or slow something moves

surface—the outside layer of something

symbol—an object or picture that stands for something (**symbols**)

T

telegraph—a tool for communicating by sending electrical signals by wire or radio

trachea—a tube that air passes through going to and from the lungs; windpipe

transmit—to move or send something from one place to another (**transmission**)

transparent—clear, see-through so light gets through

U

ultraviolet—short, invisible light waves, beyond violet on the spectrum, that cause sunburn

V

vacuum—emptiness

Visible Speech—a system of communication used by deaf people in which symbols represent sounds

vocal cords—muscles that produce sound when air passes over them

volume—the loudness or intensity of a sound

W

wave—an amount of energy that moves in a rippling pattern like a wave (**waves**)

wavelength—how long a wave is, the distance from the top of one wave to the top of the next wave (**wavelengths**)

white light—light that is made up of waves with different wavelengths and includes all the colors we can see

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Elizabeth Wade, PhD, Managing Curriculum Developer

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Todd Rawson, Design Director

Julia Sverchuk, Creative Director

Erin O'Donnell, Senior Designer

Contributors

Ann Andrew, Desirée Beach, Leslie Beach, Brian Black, Stephanie Cooper, Tim Chi Ly, Nicole Crook, Stephen Currie, Kira Dykema, Carol Emerson, Jennifer Flewelling, Mairin Genova, Marc Goldsmith, Christina Gonzalez Vega, Stephanie Hamilton, Brooke Hudson, Carrie Hughes, Sara Hunt, Rowena Hymer, Jason Jacobs, Leslie Johnson, Annah Kessler, Debra Levitt, Bridget Looney, Christina Martinez, Sarah McClurg, Julie McGeorge, Evelyn Norman, Chris O'Flaherty, Cesar Parra, Leighann Pennington, Heather Perry, Tim Quiroz, Maureen Richel, Jessica Richardson, Carol Ronka, Laura Seal, Cynthia Shields, John Starr, Carmela Stricklett, Alison Tepper, Karen Venditti, Carri Waloven, Michelle Warner, Rachel Wolf

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ScribeConcepts.com

Additional Consulting Services

Erin Kist
Carolyn Pinkerton
Scott Ritchie
Kelina Summers

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Contributors to Earlier Versions of These Materials

Susan B. Albaugh, Kazuko Ashizawa, Kim Berrall, Ang Blanchette, Nancy Braier, Maggie Buchanan, Paula Coyner, Kathryn M. Cummings, Michelle De Groot, Michael Donegan, Diana Espinal, Mary E. Forbes, Michael L. Ford, Sue Fulton, Carolyn Gosse, Dorrit Green, Liza Greene, Ted Hirsch, Danielle Knecht, James K. Lee, Matt Leech, Diane Henry Leipzig, Robin Luecke, Martha G. Mack, Liana Mahoney, Isabel McLean, Steve Morrison, Juliane K. Munson, Elizabeth B. Rasmussen, Ellen Sadler, Rachael L. Shaw, Sivan B. Sherman, Diane Auger Smith, Laura Tortorelli, Khara Turnbull, Miriam E. Vidaver, Michelle L. Warner, Catherine S. Whittington, Jeannette A. Williams.

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Writers

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