Chapter Menu

THE BIG IDEA

How do sound and light waves travel and interact with matter?

Get Ready

What do you think?

Before you begin, decide if you agree or disagree with each of these statements. As you view this presentation, see if you change your mind about any of the statements.

Get Ready

Do you agree or disagree?

1. Vibrating objects make sound waves.
2. Human ears are sensitive to more sound frequencies than any other animal's ears.
3. Unlike sound waves, light waves can travel through a vacuum.

Get Ready

Do you agree or disagree?

4. Light waves always travel at the same speed.

5. All mirrors form images that appear identical to the object itself.

6. Lenses always magnify objects.

Lesson 1

Sound

Key Concepts

- How are sound waves produced?
- Why does the speed of sound waves vary in different materials?
- How do your ears enable you to hear sounds?

Lesson 1

Sound

Vocabulary

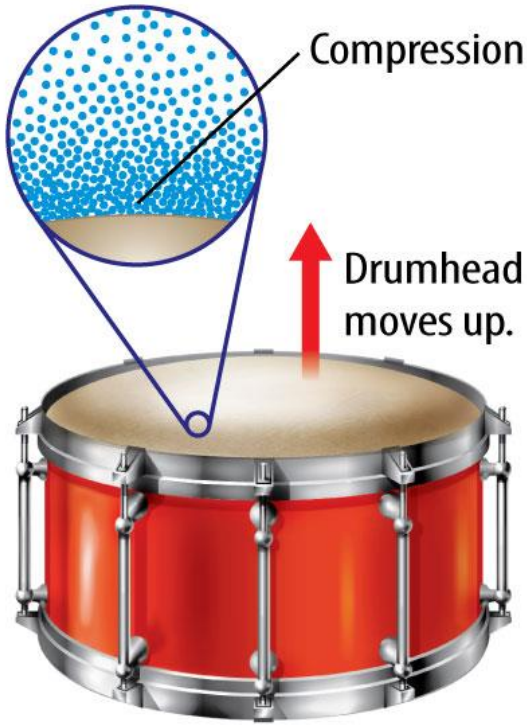
- sound wave
- pitch
- echo

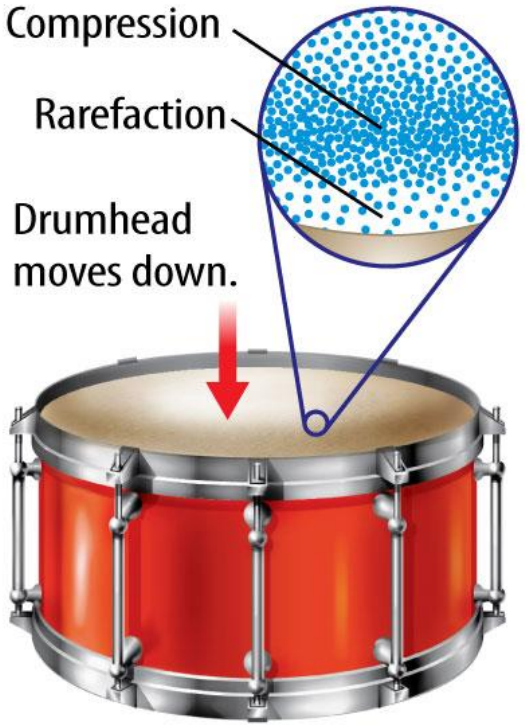
What is sound?

- A **sound wave** is a longitudinal wave that can travel only in matter.
- Vibrations produce sound waves by moving molecules in air.

What is sound? (cont.)

The region where molecules are closer together is a compression.





What is sound? (cont.)

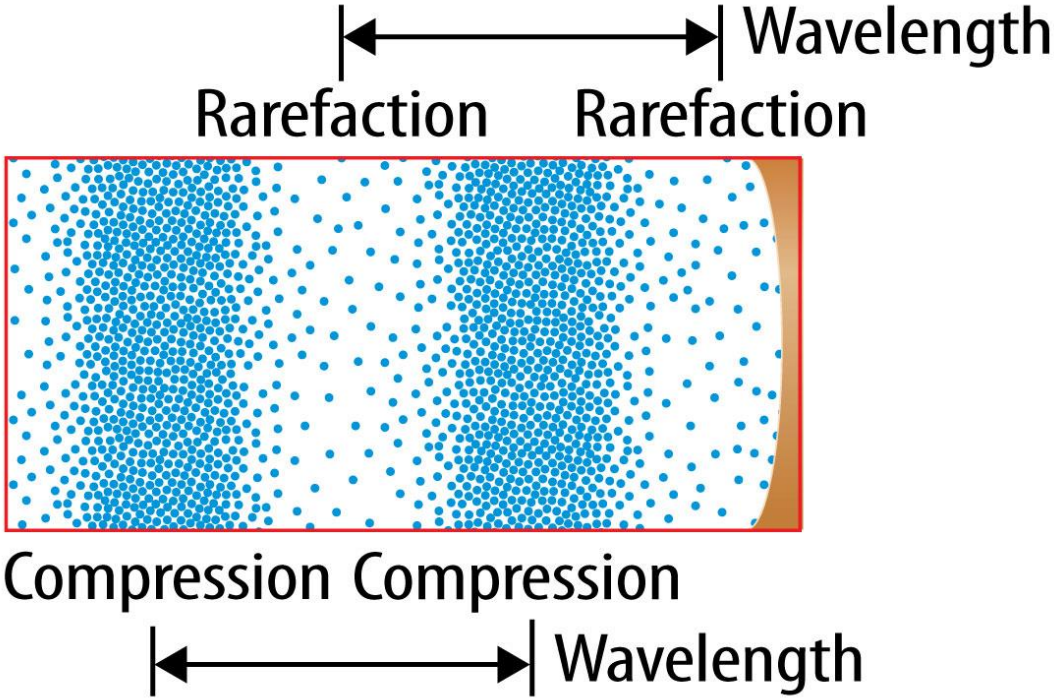
The region where molecules are farther apart is a rarefaction.

Key Concept Check

How do vibrating objects produce sound waves?

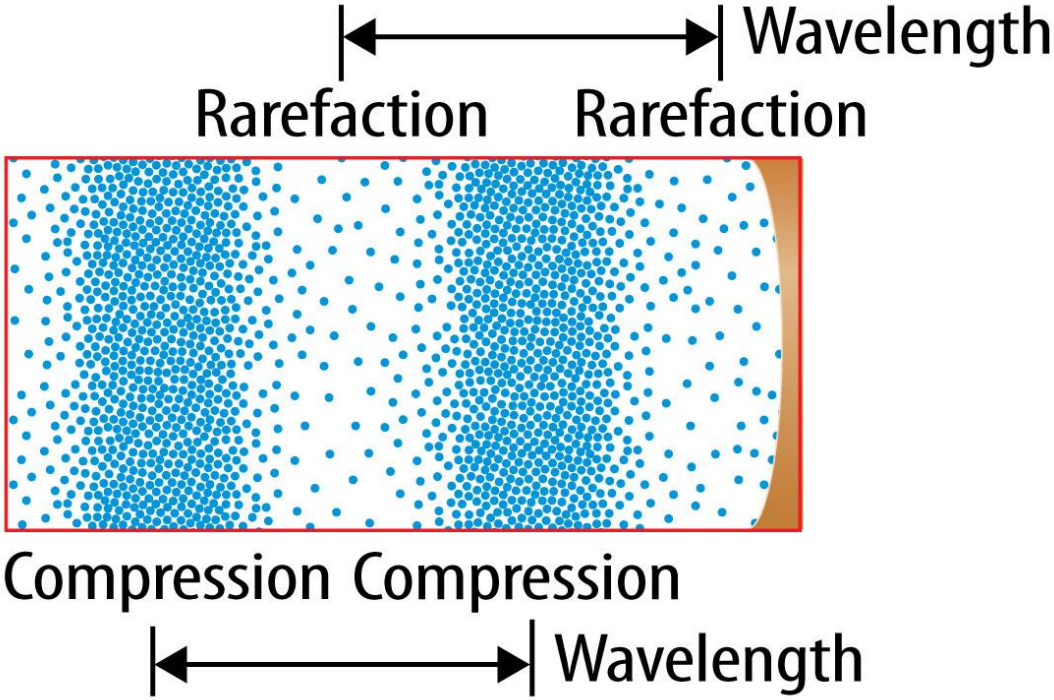
What is sound? (cont.)

Wavelength is the distance between a point on a wave and the nearest point just like it.



What is sound? (cont.)

A sound wave's frequency is the number of wavelengths that pass a given point in one second.



Speeds of Sound Waves

- The speed of a sound wave depends on the material in which it travels.
- Sound waves usually travel faster in solids than in liquids or gases.

The Speed of Sound Waves in Different Materials

Gases (0°C)		Liquids (25°C)		Solids	
Material	Speed (m/s)	Material	Speed (m/s)	Material	Speed (m/s)
Carbon dioxide	259	Ethanol	1,207	Brick	3,480
Dry Air	331	Mercury	1,450	Ice	3,850
Water vapor	405	Water	1,500	Aluminum	6,420
Helium	965	Glycerine	1,904	Diamond	17,500

Speeds of Sound Waves (cont.)

- The speed of a sound wave depends mainly on the strength of the forces between the particles in the material.
- These forces are usually strongest in solids and weakest in gases.
- Sound waves travel faster in a material as the temperature of the material increases.

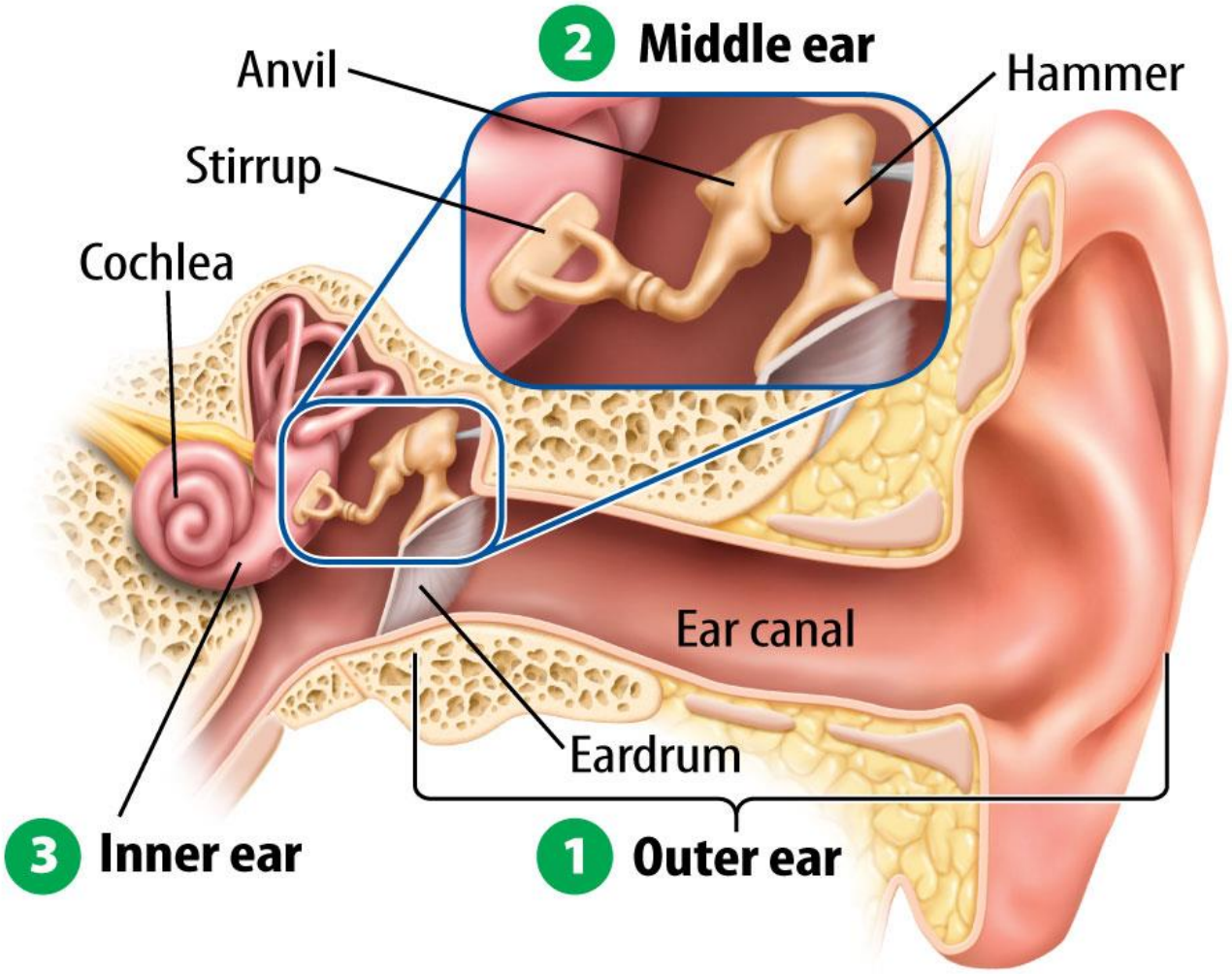
Speeds of Sound Waves (cont.)

Key Concept Check

Why is the speed of sound waves faster in solids than in liquids or gases?

The Human Ear

Get Animated



The Human Ear (cont.)

- The outer ear collects sound waves. The visible part of the outer ear funnels sound waves into the ear canal.
- The middle ear includes a thin membrane called the eardrum and three tiny bones which amplify sound waves.
- The inner ear consists of a small, fluid-filled chamber called the cochlea that converts vibrations to nerve signals that travel to the brain.

The Human Ear (cont.)

Key Concept Check

What is the function of each of the three parts of the ear?

The Human Ear (cont.)

Humans hear sounds with frequencies between about 20 and 20,000 Hz. Some animals can hear sounds with frequencies greater than 100,000 Hz.

Frequencies Humans and Animals Can Hear

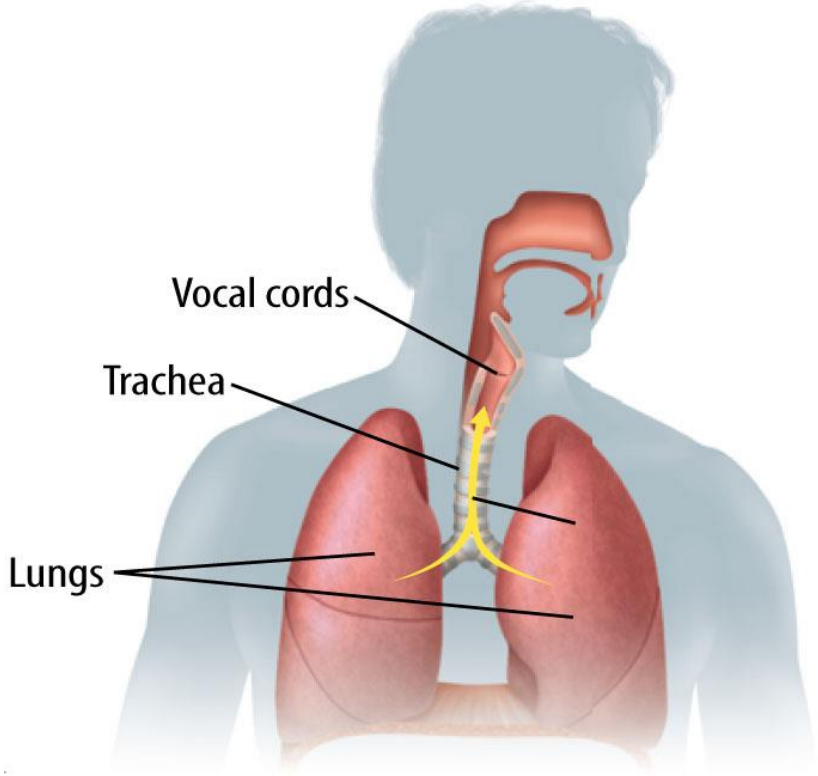
Creature	Frequency Range (Hz)
Human	20–20,000
Dog	67–45,000
Cat	45–64,000
Bat	2,000–110,000
Beluga whale	1,000–123,000
Porpoise	75–150,000

Sound and Pitch

- The **pitch** of a sound is the human sensation of how high or low the sound seems to be.
- A sound wave with a higher frequency has a higher pitch. A sound wave with lower frequency has a lower pitch.

Sound and Pitch (cont.)

The vocal cords—two membranes in your neck above your windpipe, or trachea—allow you to produce sounds of different pitches.

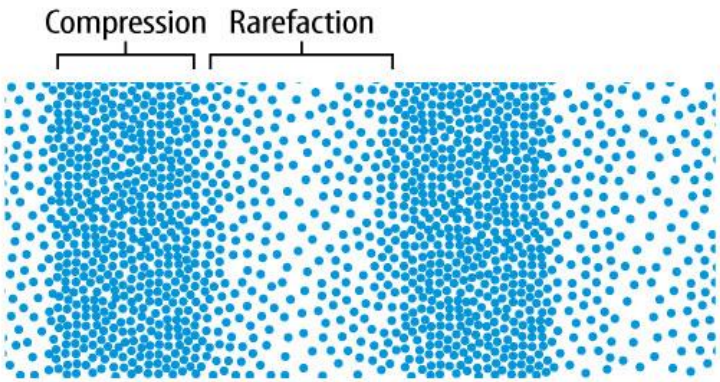


Sound and Loudness

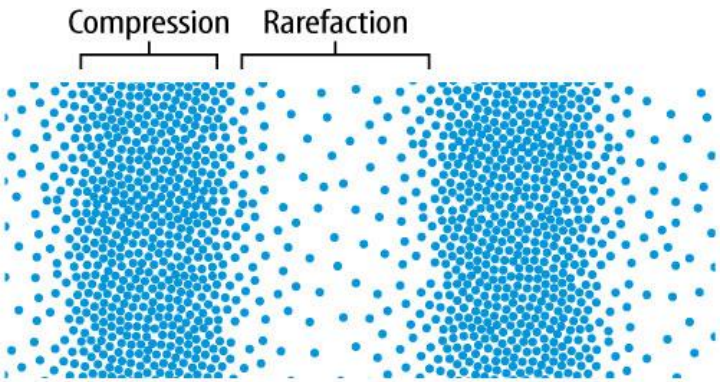
- Loudness is the human sensation of how much energy a sound wave carries.
- The amount of energy a sound wave carries depends on its amplitude.
- A shout carries more energy than a whisper.

Sound and Loudness (cont.)

The amplitude of a sound wave depends on how close together or far apart the particles are in the compressions and rarefactions.



Low amplitude sound wave

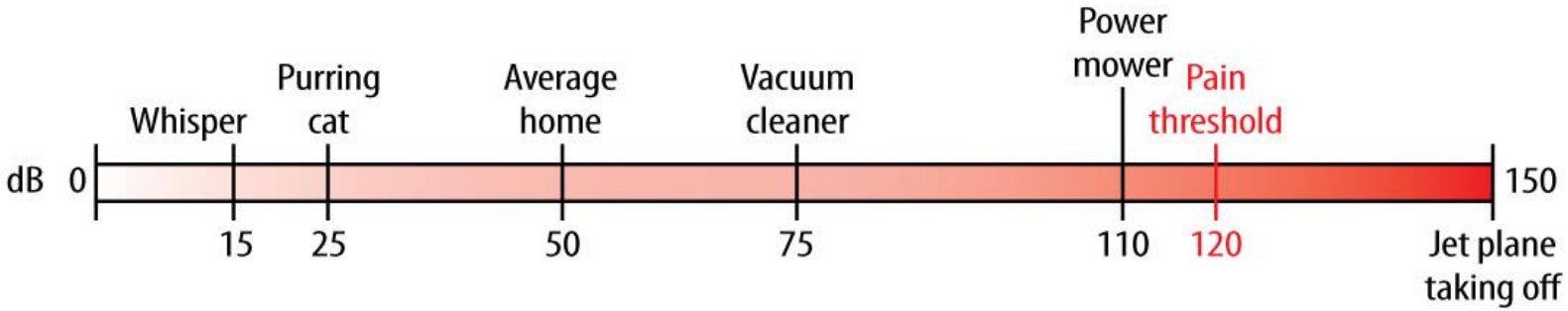


High amplitude sound wave

Get Animated

Sound and Loudness (cont.)

The decibel scale is one way to compare the loudness of sounds.



Using Sound Waves

An echo is a reflected sound wave.

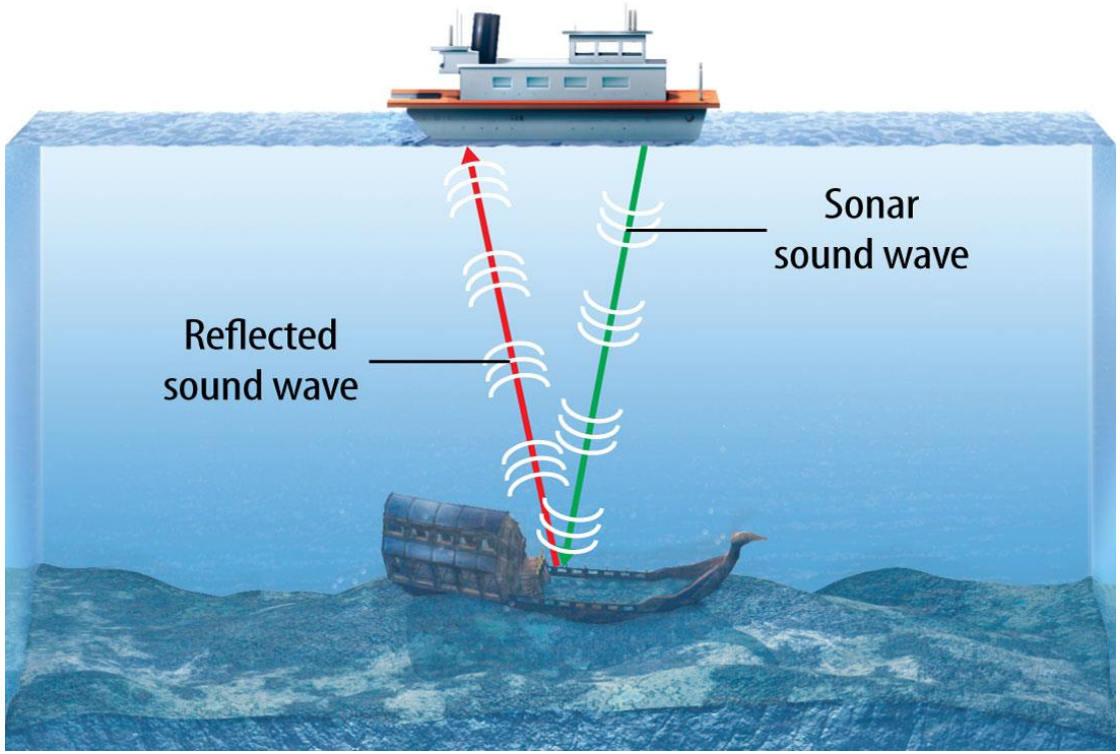
WORD ORIGIN

echo

from Greek *ekhe*, means “sound”

Using Sound Waves (cont.)

Sonar systems use reflected sound waves to locate objects under water.

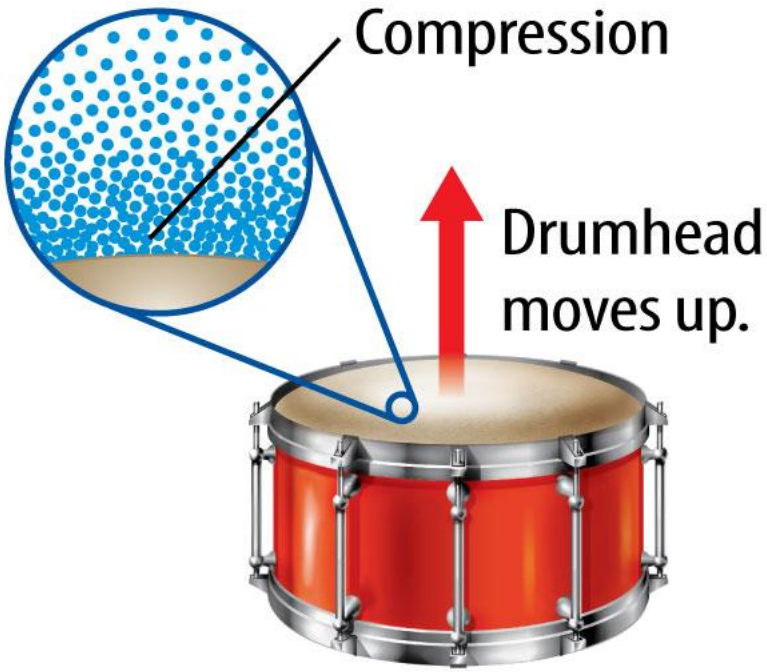


Using Sound Waves (cont.)

- Some animals, such as bats and dolphins, use a method called echolocation to navigate and hunt.
- Ultrasound scanners convert high-frequency sound waves to images of internal body parts.
- The scanner analyzes the reflected waves and produces images, called sonograms, of the body structures.

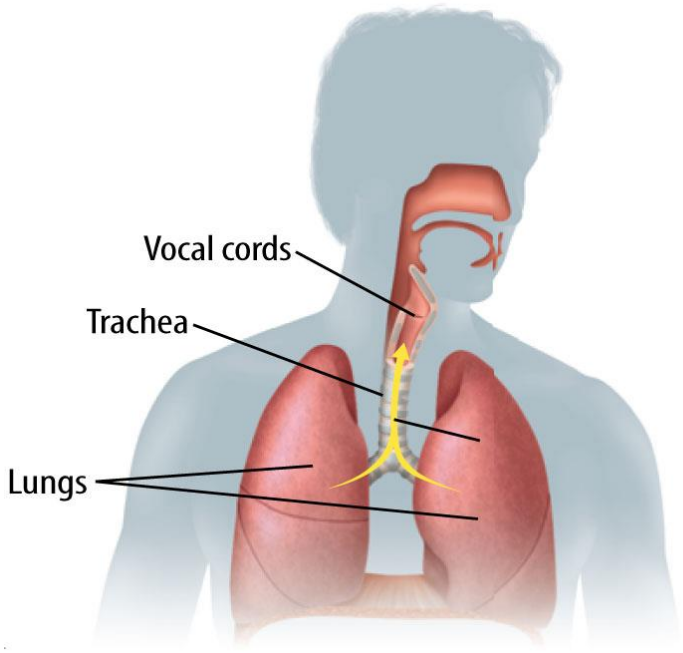
Summary

- A sound wave is a longitudinal wave that can travel only through matter.



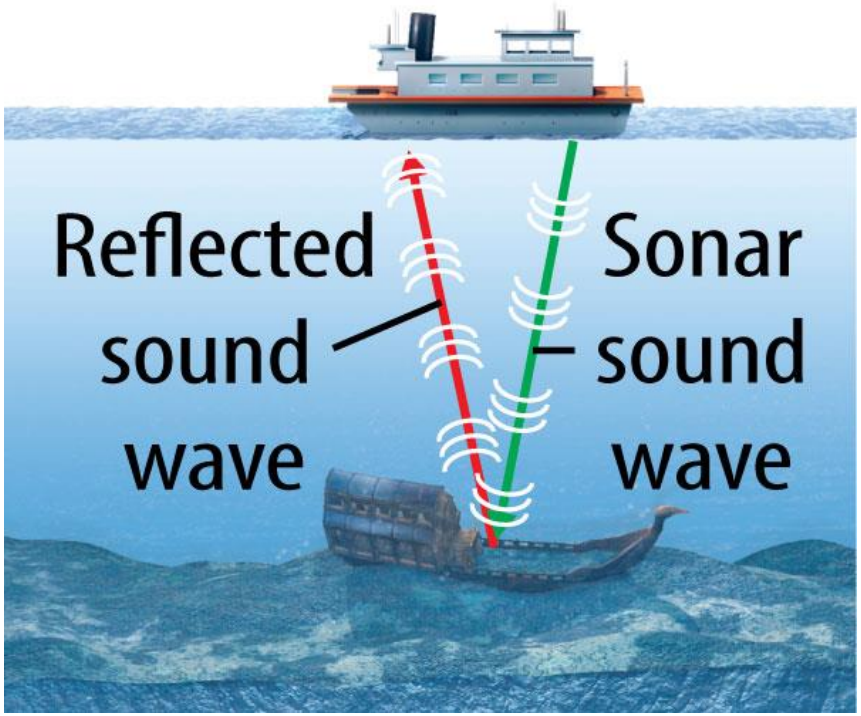
Summary

- The pitch is how high or low the frequency of a sound wave is. You create different pitches using your vocal cords.



Summary

- An echo is a reflected sound wave. Ships use sonar to find underwater objects.



Lesson Review

Which refers to the human sensation of how high or low a sound seems to be?

A. echo

B. loudness

C. pitch

D. sound waves

Lesson Review

Which describes the two membranes in your neck that produce different pitches?

A. windpipe

B. vocal cords

C. stirrup

D. pitch

Lesson Review

Which is a reflected sound wave?

A. sound

B. pitch

C. loudness

D. echo

Lesson Review

What do you think NOW?

Do you agree or disagree?

1. Vibrating objects make sound waves.
2. Human ears are sensitive to more sound frequencies than any other animal's ears.

Lesson 2

Light

Key Concepts

- How are light waves different from sound waves?
- How do waves in the electromagnetic spectrum differ?
- What happens to light waves when they interact with matter?

Lesson 2

Light

Vocabulary

- light source
- light ray
- transparent
- translucent
- opaque

What is light?

- Light is an electromagnetic wave that can travel through matter.
- Unlike sound waves, light can also travel through a vacuum, where no matter is present.
- Light waves travel much faster than sound waves.

What is light? (cont.)

Light waves slow down when they travel through matter.

Speed of Light Waves in Some Materials

Material	Wave Speed (km/s)
Vacuum	300,000
Air	299,920
Water	225,100
Glass	193,000

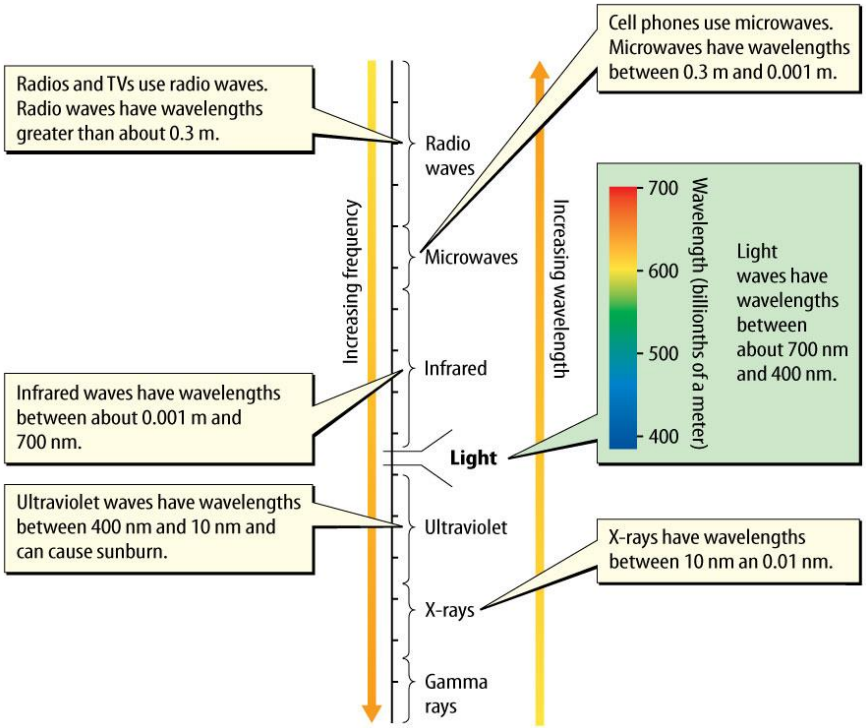
What is light? (cont.)

Key Concept Check

How are light waves different from sound waves?

What is light? (cont.)

- X-rays and radio waves are some of the other types of electromagnetic waves.
- Scientists classify electromagnetic waves into groups based on their wavelengths and frequencies.



What is light? (cont.)

Key Concept Check

How are waves in the electromagnetic spectrum different?

What is light? (cont.)

- A **light source** is something that emits light.
- A **light ray** is a narrow beam of light that travels in a straight line.

What is light? (cont.)

- Unless light rays come in contact with a surface or pass through a different material, they travel in straight lines.
- In order to see an object that is not a light source, light waves must reflect from an object and enter your eyes.

The Interaction of Light and Matter

- Like all waves, when light waves interact with matter they can be transmitted, absorbed, or reflected.
- Transmission occurs when light waves travel through a material.
- Absorption occurs when a material absorbs energy from light waves that are traveling in the material.

The Interaction of Light and Matter (cont.)

Reflection occurs when light waves come in contact with the surface of a material and bounce off.

Key Concept Check

What can happen to light waves when they interact with matter?

The Interaction of Light and Matter (cont.)

- Depending on how they interact with light, materials can be classified as transparent, translucent, or opaque.
- A material is **transparent** if it transmits light waves, and objects can be seen clearly through the material.

The Interaction of Light and Matter (cont.)

- A material is **translucent** if it transmits light waves, but objects cannot be seen clearly through the material.
- A material is **opaque** if light waves cannot travel through the material.

The Interaction of Light and Matter (cont.)

WORD ORIGIN

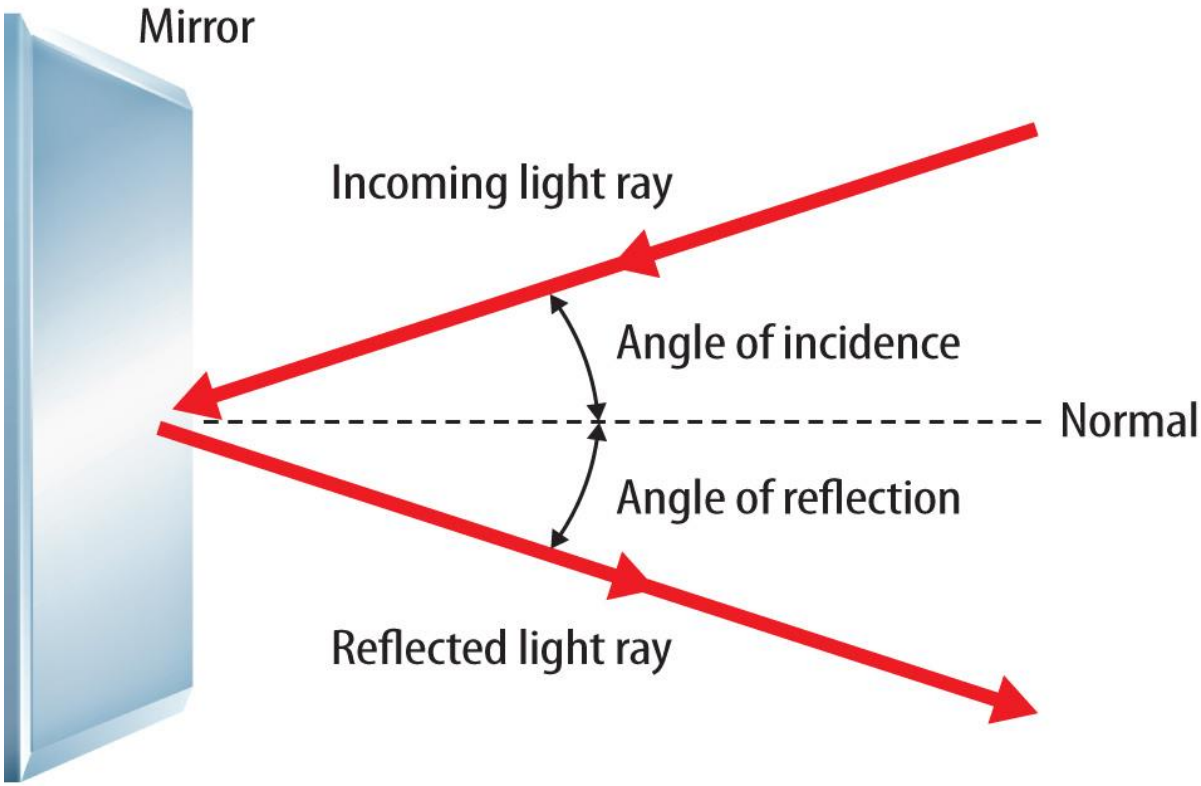
opaque

from Latin *opacus*, means “shady, dark”

The Interaction of Light and Matter (cont.)

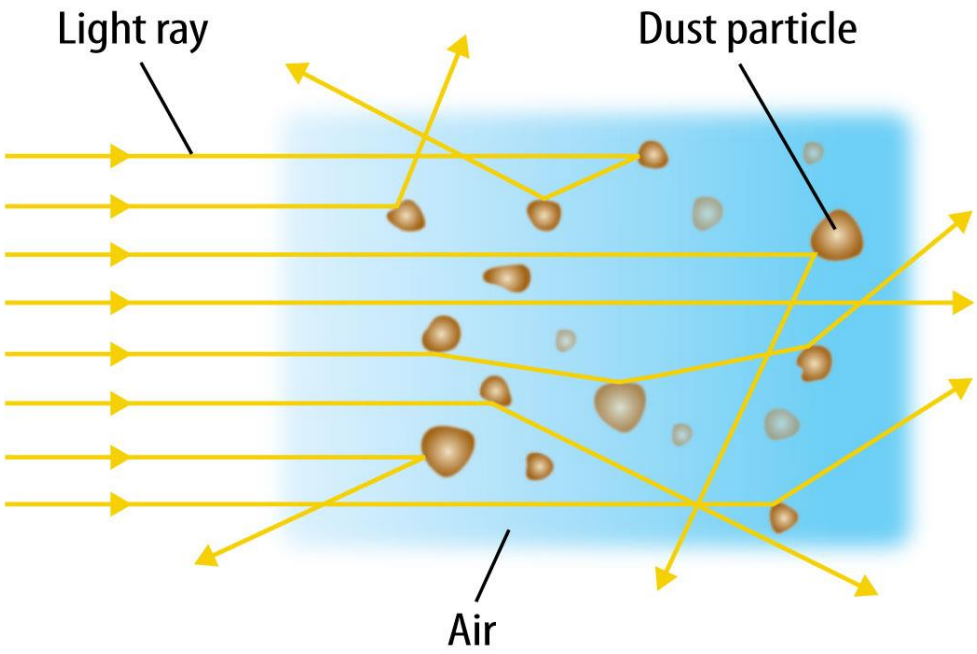
- All waves, including light waves, obey the law of reflection.
- According to the law of reflection, the angle of incidence always equals the angle of reflection.

When a surface reflects a light ray, the angle of incidence equals the angle of reflection.



The Interaction of Light and Matter (cont.)

Scattering occurs when light waves traveling in one direction are made to travel in many directions.

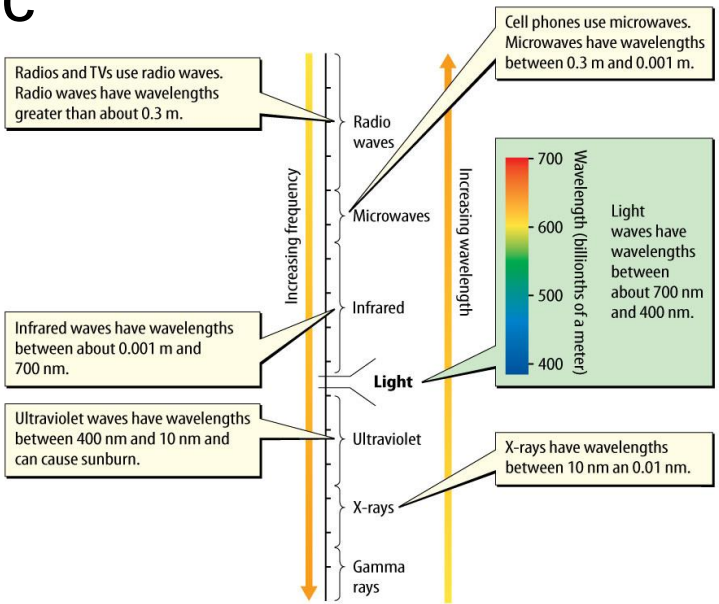


The Interaction of Light and Matter (cont.)

- A wave that changes direction as it travels from one material to another is refracting.
- Refraction occurs when a wave changes speed.
- The greater the change in speed, the more the light wave refracts or changes direction.

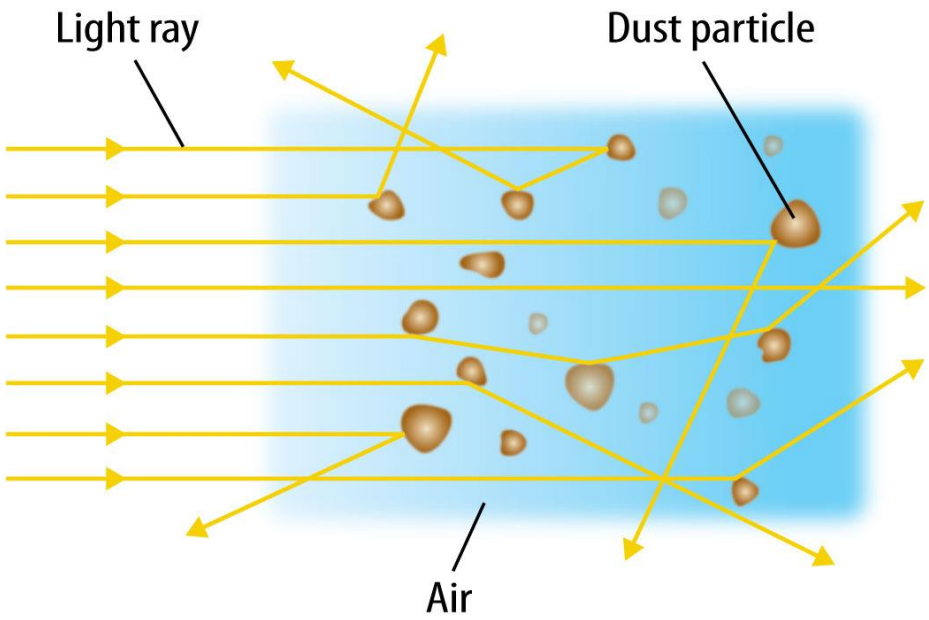
Summary

- An object is seen when light waves emitted by the object or reflected by the object enter the eye.
- The electromagnetic spectrum includes electromagnetic waves of different wavelengths, such as X-rays.



Summary

- When light waves interact with matter, they can be absorbed, reflected, or transmitted.



Lesson Review

What word describes a material that transmits light waves so that objects can be seen clearly through the material?

A. transparent

B. translucent

C. reflection

D. opaque

Lesson Review

Which term describes a wave that changes direction as it travels from one material to another?

A. scattering

B. reflecting

C. refracting

D. absorbing

Lesson Review

Which is a narrow beam of light that travels in a straight line?

A. light wave

B. light source

C. light reflection

D. light ray

Lesson Review

What do you think NOW?

Do you agree or disagree?

3. Unlike sound waves, light waves can travel through a vacuum.
4. Light waves always travel at the same speed.

Lesson 3

Mirrors, Lenses, and the Eye

Key Concepts

- What is the difference between regular and diffuse reflection?
- What types of images are formed by mirrors and lenses?
- How does the human eye enable a person to see?

Lesson 3

Mirrors, Lenses, and the Eye

Vocabulary

- mirror
- lens
- cornea
- pupil
- iris
- retina

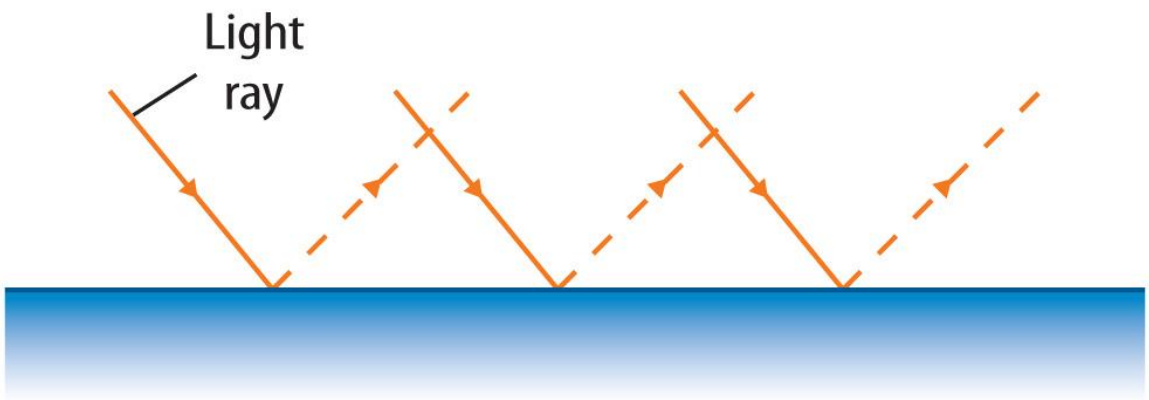
Why are some surfaces mirrors?

- Regular reflection occurs when a smooth surface reflects light rays traveling in the same direction at the same angle.
- Because the light rays travel the same way relative to each other before and after reflection, the reflected light rays form a sharp image.

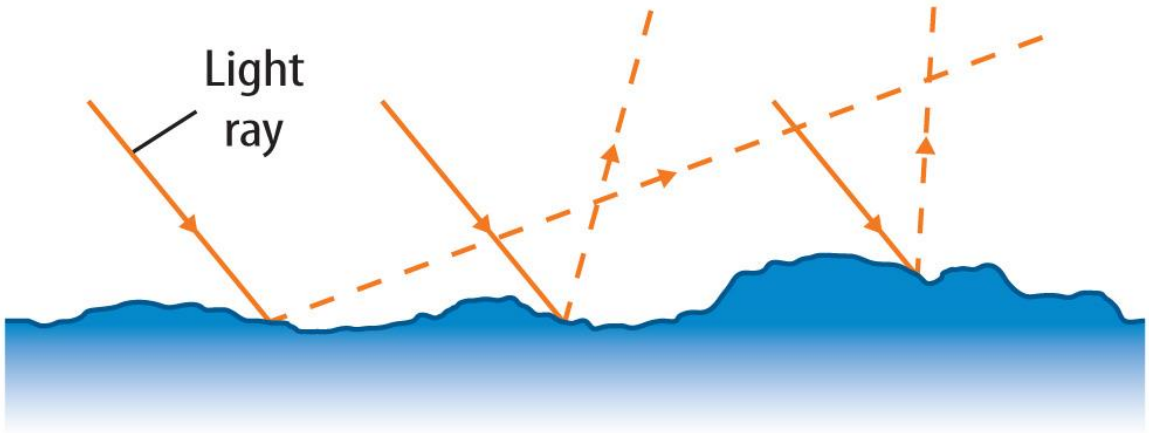
Why are some surfaces mirrors? (cont.)

- Diffuse reflection occurs when light rays traveling in the same direction hit a rough surface at different angles, reflecting light rays in many different directions.
- You don’t see a clear image when diffuse reflection occurs.

Light waves always obey the law of reflection, whether the surface is smooth or rough.



Regular reflection



Diffuse reflection

Why are some surfaces mirrors? (cont.)

KEY CONCEPT CHECK

Contrast regular and diffuse reflection.

Types of Mirrors

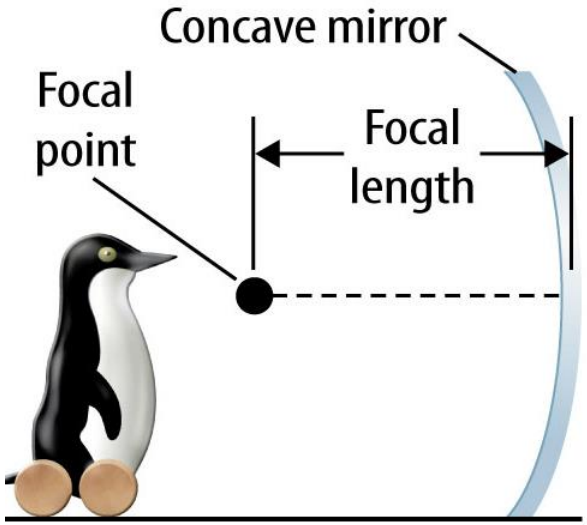
- A **mirror** is any reflecting surface that forms an image by regular reflection.
- The image formed by a mirror depends on the shape of the mirror's surface.

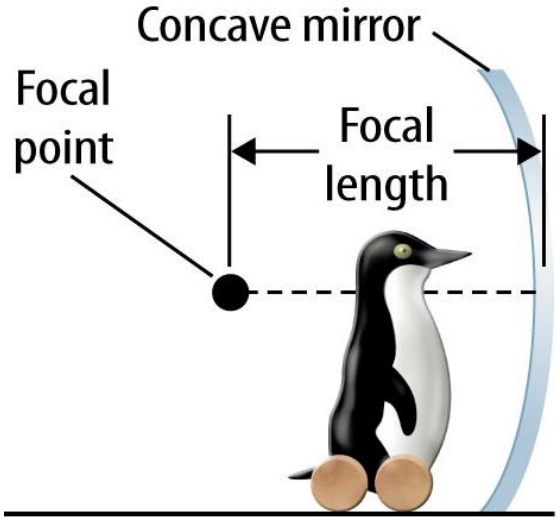
Types of Mirrors (cont.)

- A plane mirror is a mirror that has a flat reflecting surface.
- The image formed by the mirror looks like a photograph of the object except that the image is reversed left to right.
- The size of the image in the mirror depends on how far the object is from the mirror. The image gets smaller as the object gets farther from the mirror.

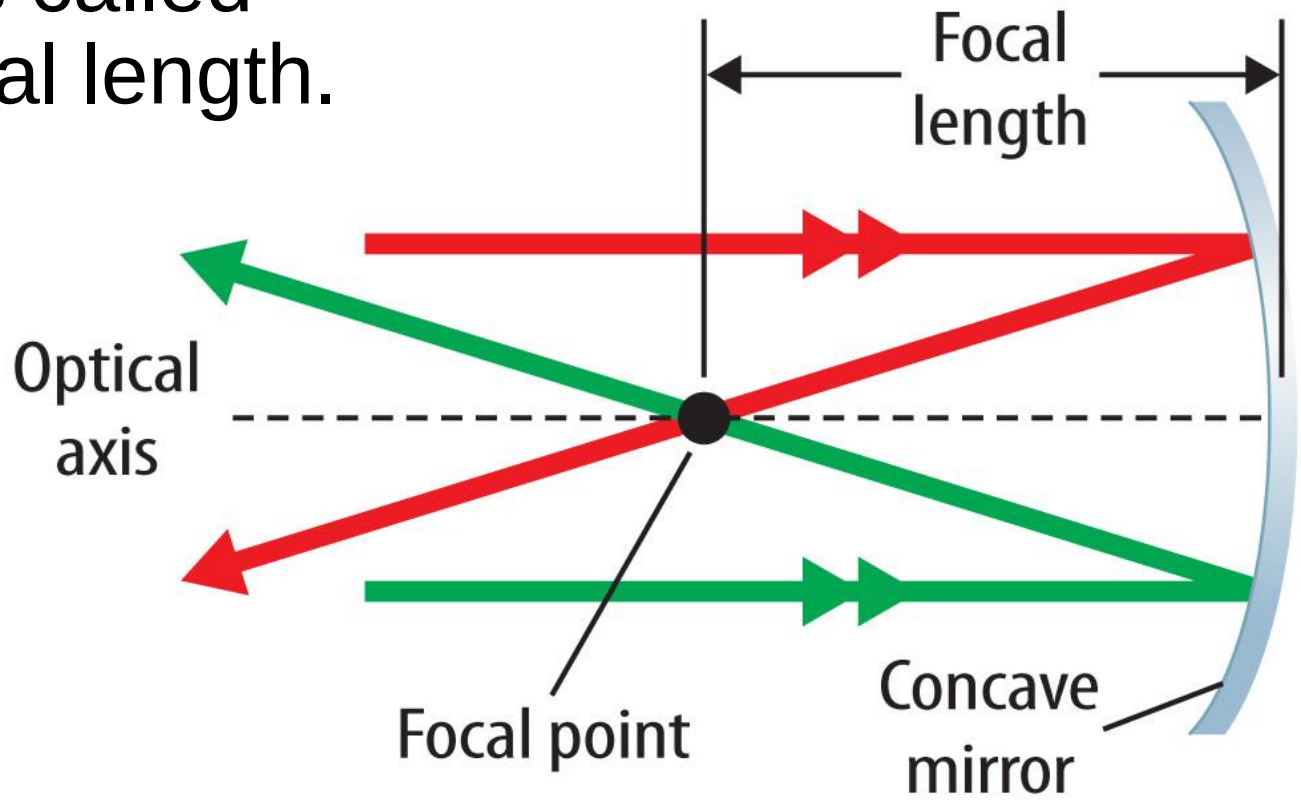
Types of Mirrors (cont.)

Concave mirrors are reflecting surfaces that are curved inward.



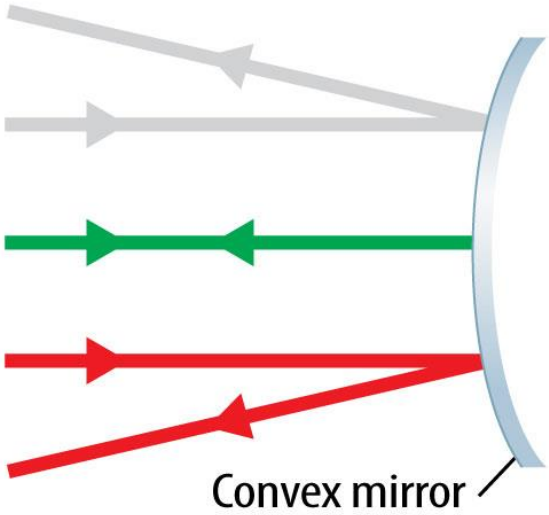


- Light rays that are parallel to the optical axis are reflected through the focal point.
- The distance from the mirror to the focal point is called the focal length.



Types of Mirrors (cont.)

A convex mirror has a reflecting surface that is curved outward.



The image in a convex mirror is always right-side up and smaller than the object.

Types of Mirrors (cont.)

KEY CONCEPT CHECK

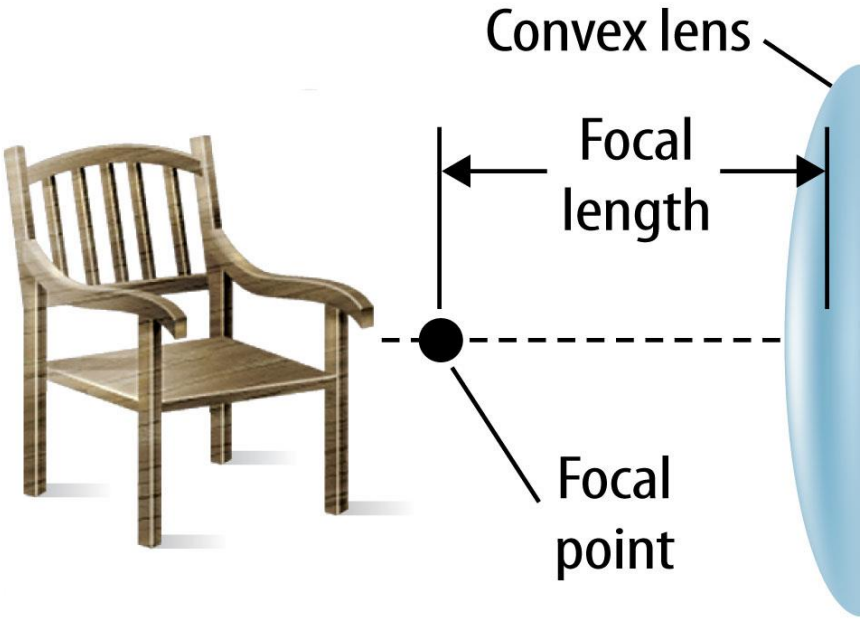
How do the images formed by plane mirrors, concave mirrors, and convex mirrors depend on the distance of an object from the mirror?

Types of Lenses

- A **lens** is a transparent object with at least one curved side that causes light to change direction.
- The more curved the sides of a lens, the more the light changes direction as it passes through the lens.
- A convex lens is curved outward on at least one side so it is thicker in the middle.

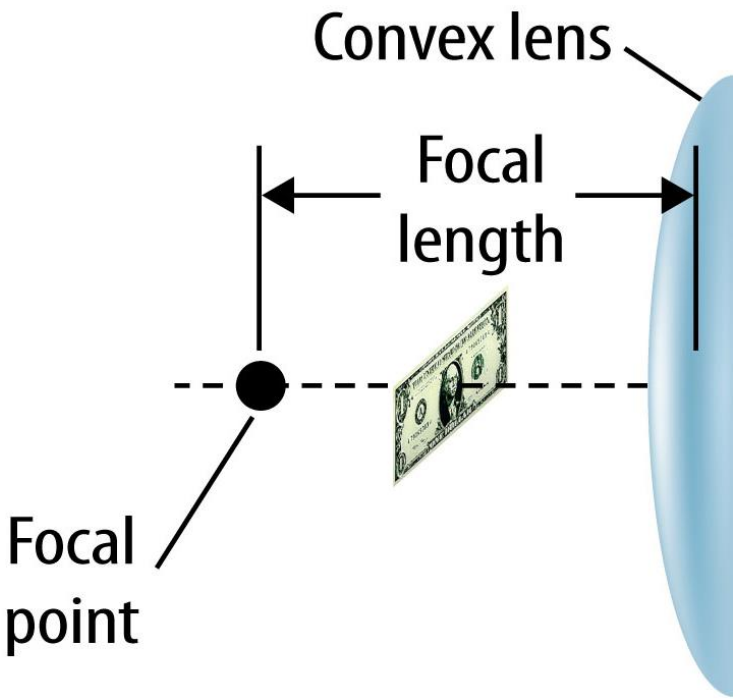
Types of Lenses (cont.)

- The image formed by a convex lens depends on where the object is, just like it does for a concave mirror.
- When an object is farther than one focal length from a convex lens, the image is upside down.



Types of Lenses (cont.)

When an object is less than one focal length from a convex lens, the image is larger and right side up.



Types of Lenses (cont.)

KEY CONCEPT CHECK

How does the image formed by a convex lens depend on the distance of the object from the lens?

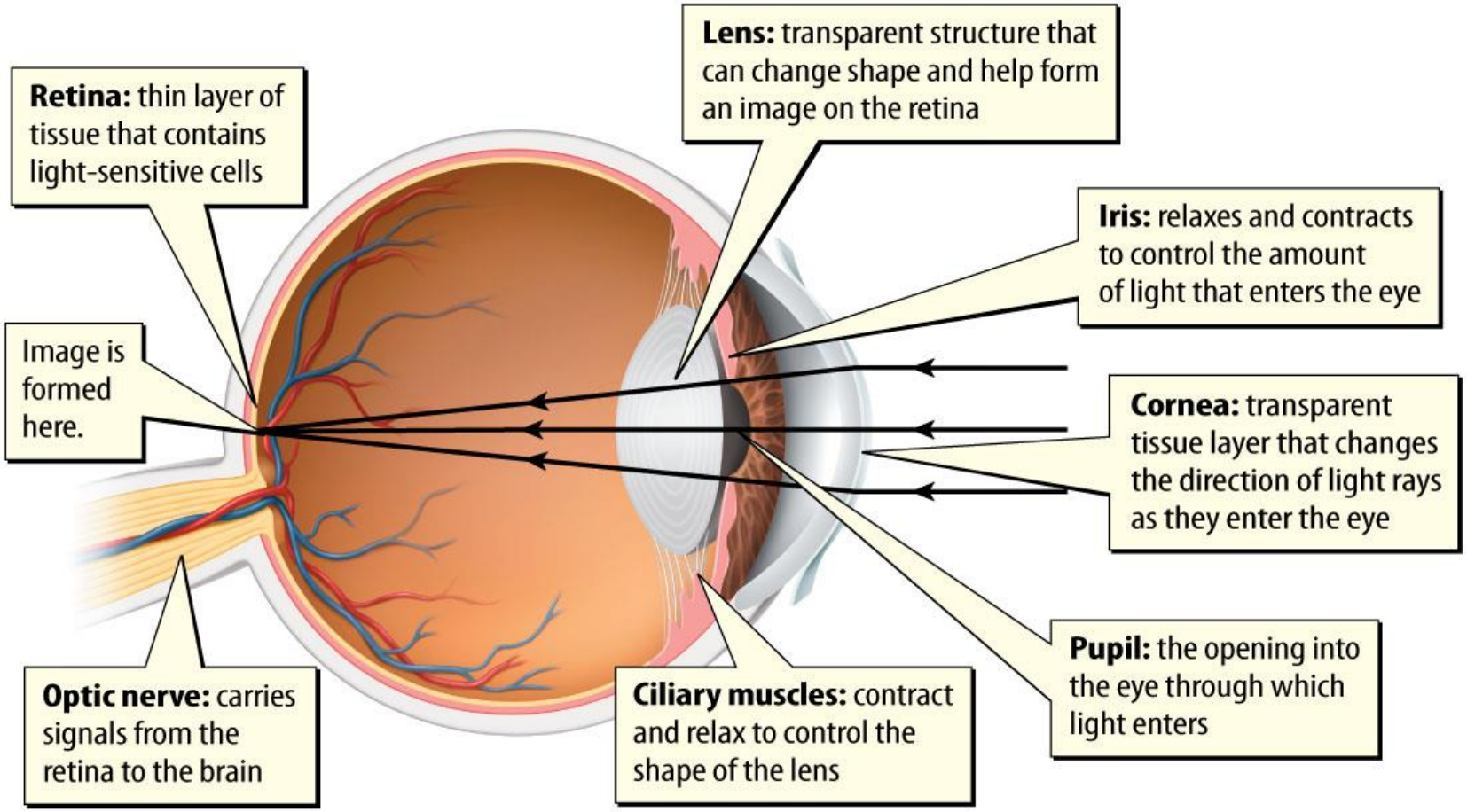
Types of Lenses (cont.)

- A concave lens is curved inward on at least one side and thicker at the edges.
- The image formed by a concave lens is upright and smaller than the object
- Concave lenses are usually used in combinations with other lenses in instruments such as telescopes and microscopes.

Light and the Human Eye

To see an object, light waves from an object travel through two convex lenses in the eye—the cornea and the lens.

The eye is made of a number of parts that have different functions.

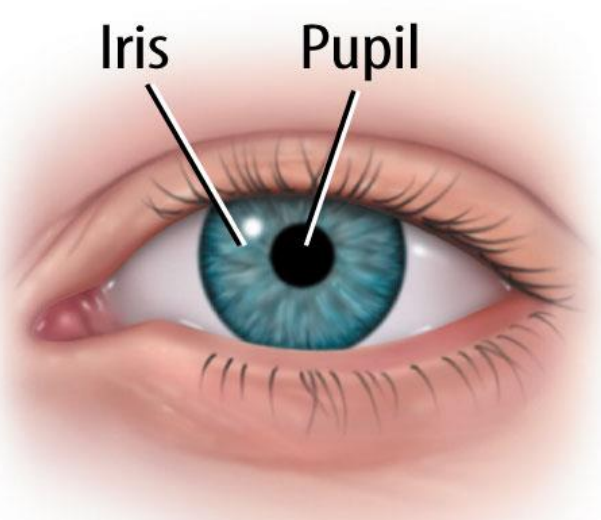


Light and the Human Eye (cont.)

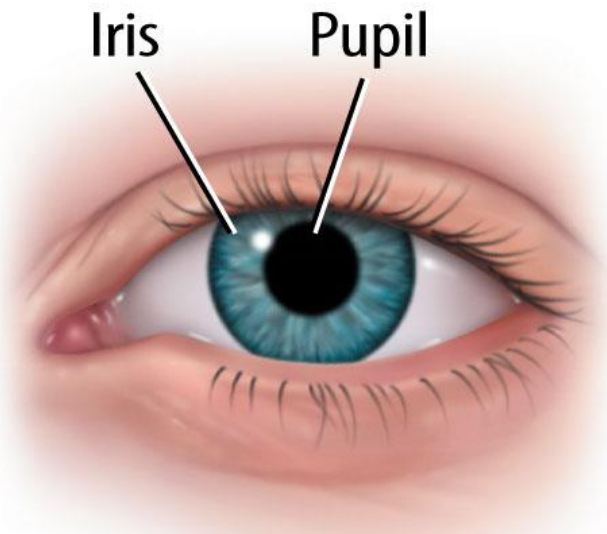
- The **cornea** is a convex lens made of transparent tissue located on the outside of the eye.
- The **pupil** is the dark opening into the interior of the eye.
- The **iris** is the colored part of the eye.

Light and the Human Eye (cont.)

When the iris changes size, the amount of light that enters the eye changes.



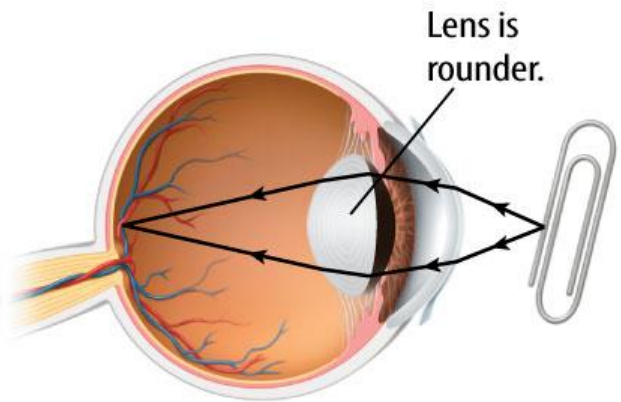
The iris relaxes in bright light.



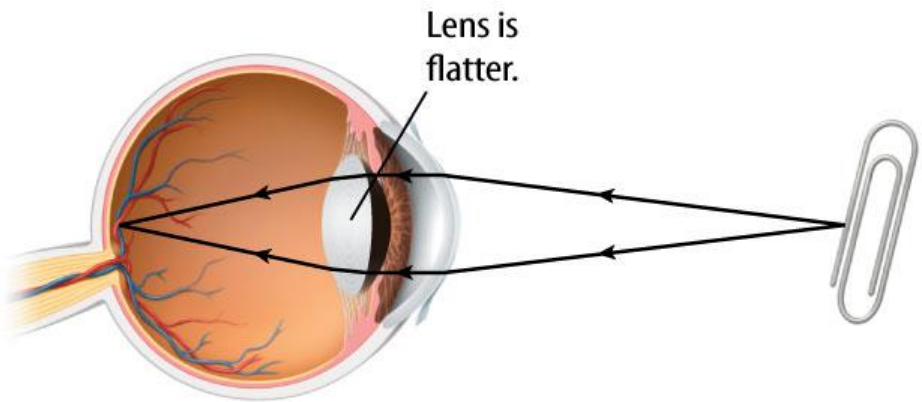
The iris contracts in dim light.

Light and the Human Eye (cont.)

The lens enables the eye to form a sharp image of nearby and distant objects. The muscles surrounding the lens change the lens's shape.



Lens becomes rounder and a sharp image forms of a nearby object.

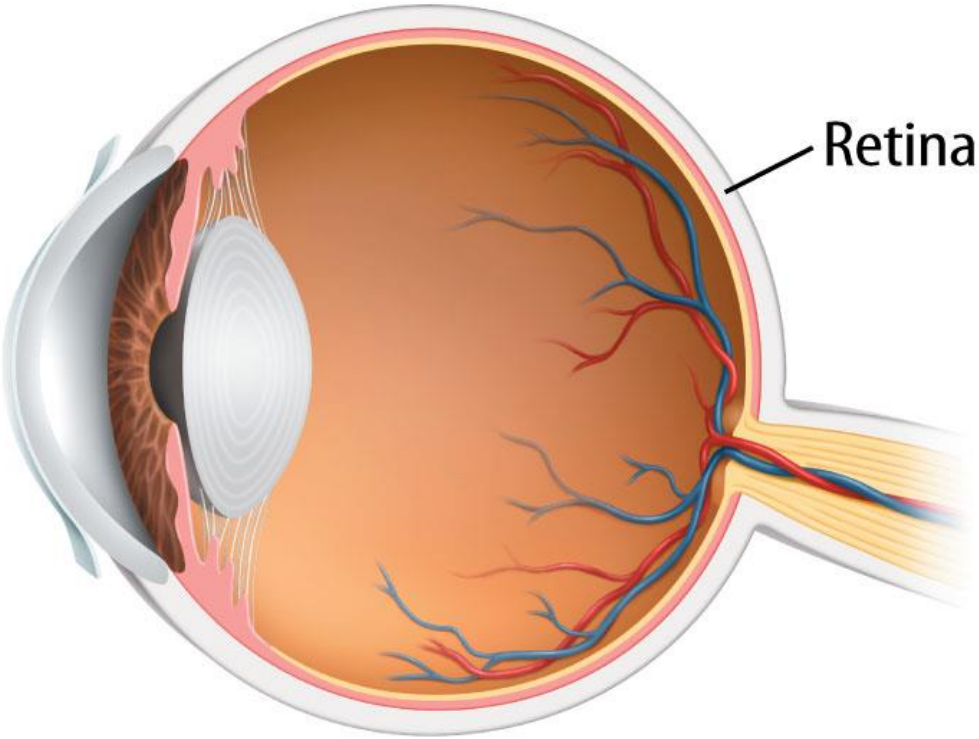


Lens becomes flatter and a sharp image forms of a distant object.

Get Animated

Light and the Human Eye (cont.)

The **retina** is a layer of special light-sensitive cells in the back of the eye.



Light and the Human Eye (cont.)

- In the retina, chemical reactions produce nerve signals that the optic nerve sends to your brain.
- Rod cells and cone cells are two types of light-sensitive cells in your retina.
- Rod cells enable people to see objects in dim light.

Light and the Human Eye (cont.)

Cone cells enable people to see colors. The retina has three types of cone cells, which respond to a different range of wavelengths.

WORD ORIGIN

retina

from Latin *rete*, means “net”

Light and the Human Eye (cont.)

Key Concept Check

Identify the parts of the eye that form a sharp image of an object and the parts that convert an image into electrical signals.

The Colors of Objects

- The color of an object depends on the wavelengths of the light waves it reflects.
- An object absorbs some light waves and reflects others.
- When light waves enter your eye, they cause the cone cells in your retina to send certain nerve signals to your brain.
- These signals cause you to see colors.

The Colors of Objects (cont.)

- A red rose reflects light waves with wavelengths that you see as red. It absorbs all other wavelengths of light.
- A banana reflects light waves with wavelengths that you see as yellow. It absorbs all other wavelengths of light.

Get Animated

The Colors of Objects (cont.)

Key Concept Check

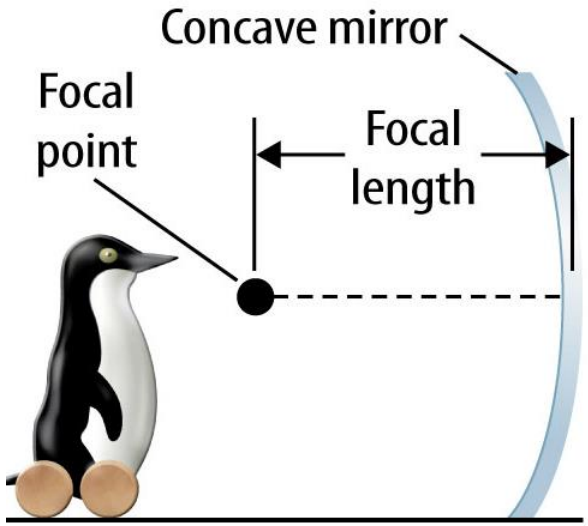
Why do you experience the sensation of color?

The Colors of Objects (cont.)

- The color of an object that emits light depends on the wavelengths of the light waves it emits.
- Light that you see as white is actually a combination of light waves of many different wavelengths.
- The appearance of an object changes under different colors of light.

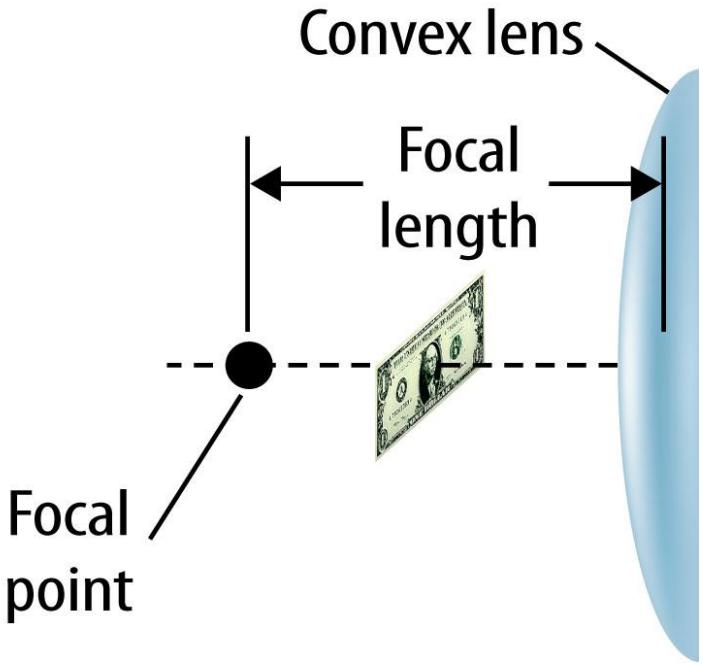
Summary

- A mirror is a surface that causes a regular reflection. The shape of the reflecting surface and the position of the object determine what the image looks like.



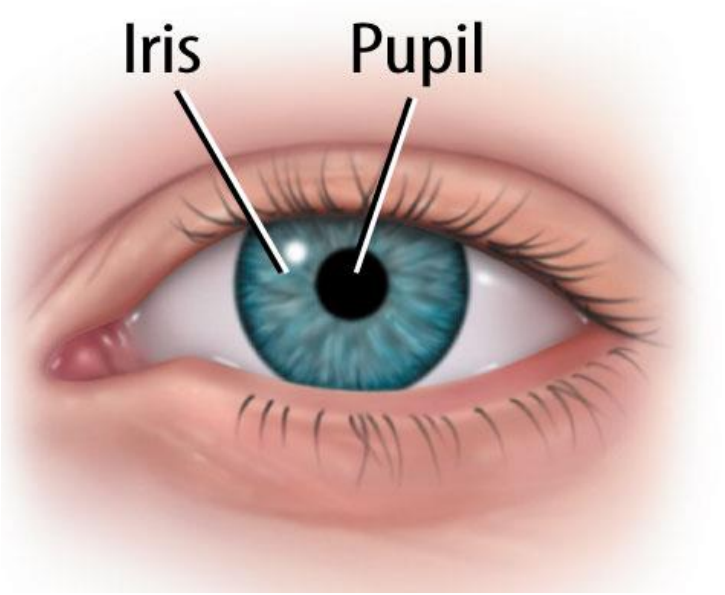
Summary

- A lens is a transparent object with at least on curved side that causes light waves to change direction. The shape of the lens and the position of the object determine how the image appears.



Summary

- The eye has different parts with different functions. The iris is the colored part of your eye. The iris opens and closes to control the amount of light that enters the eye.



Lesson Review

Which is a convex lens of transparent tissue located on the outside of the eye?

A. retina

B. pupil

C. iris

D. cornea

Lesson Review

Which term refers to any reflecting surface that forms an image by regular reflection?

A. mirror

B. light ray

C. lens

D. iris

Lesson Review

Which describes the image formed by a concave lens if an object is more than one focal length away?

A. It is upside down.

B. It is right-side up.

C. It is smaller than the object.

D. There is no image.

Lesson Review

What do you think NOW?

Do you agree or disagree?

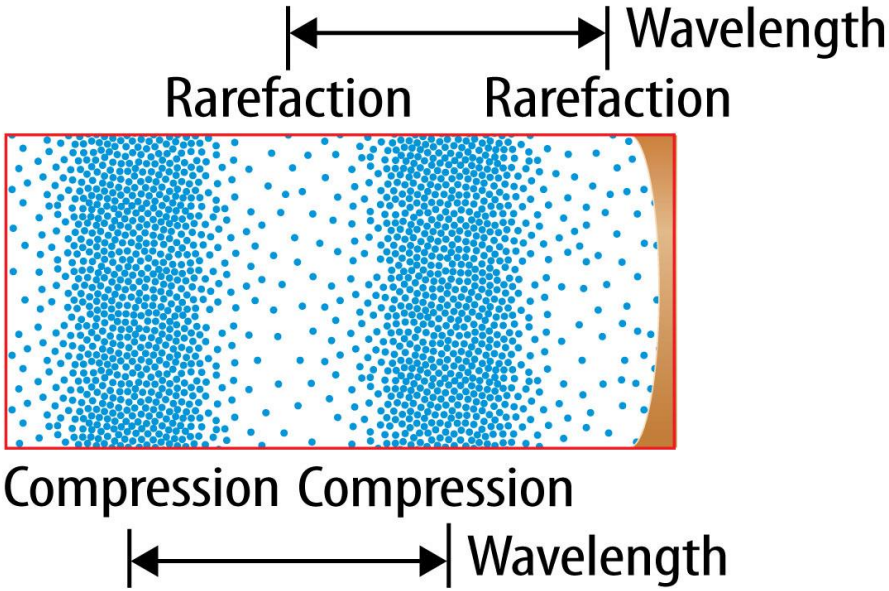
5. All mirrors form images that appear identical to the object itself.
6. Lenses always magnify objects.

Menu

Sound waves must travel through matter, while light waves can also travel in a vacuum. Waves interact with matter through absorption, transmission, and reflection.

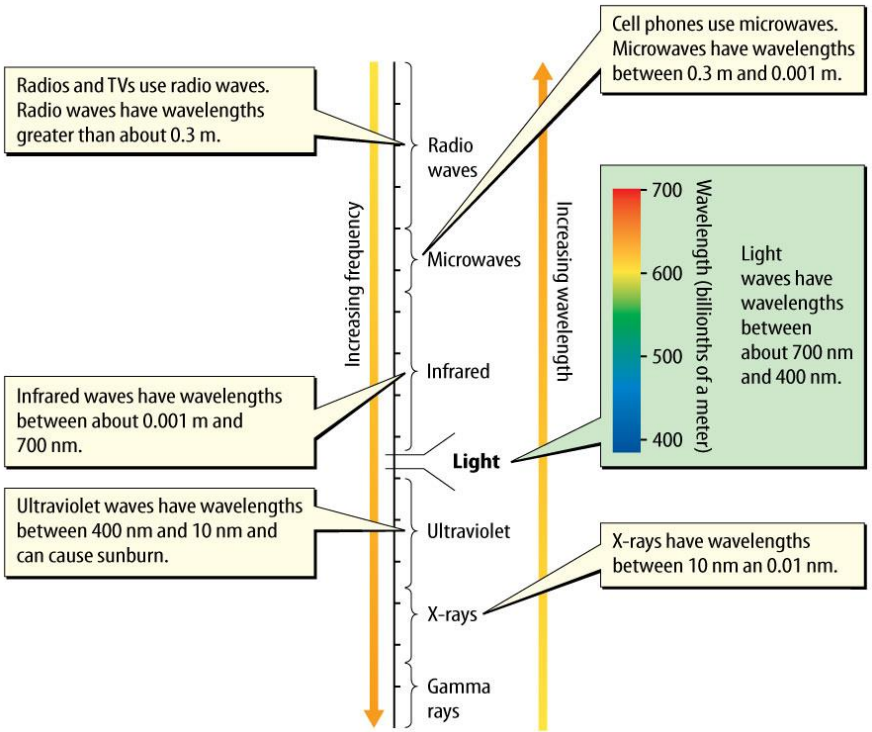
Lesson 1: Sound

- Vibrating objects produce sound waves.
- Sound waves travel at different speeds in different materials. sound waves usually travel fastest in solids and slowest in gases.
- The outer ear collects sound waves. The middle ear amplifies sound waves. The inner ear converts sound waves to nerve signals.



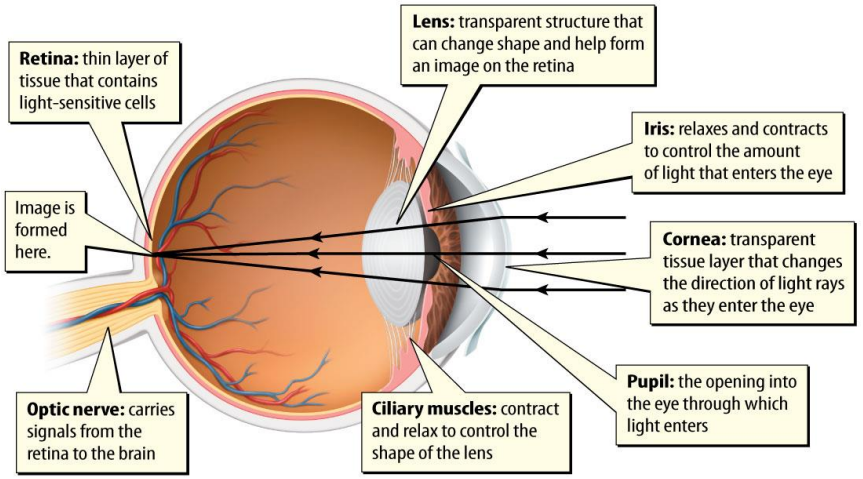
Lesson 2: Light

- Light waves are electromagnetic waves that can travel in matter and through a vacuum.
- Electromagnetic waves have different wavelengths and frequencies.
- When light waves interact with matter, they are reflected, transmitted, or absorbed.



Lesson 3: Mirrors, Lenses, and the Eye

- When regular reflection occurs from a surface, a clear image forms and the surface is a mirror. When diffuse reflection occurs from a surface, a clear image does not form.
- The shape of a mirror or a lens and the distance of an object from the mirror or lens determine what the image will look like.
- When light rays enter the eye through the cornea and pass through the pupil, an image forms on the retina. Rod and cone cells convert the image to nerve signals that travel to the brain.



Chapter Review

What does the outer ear do to sound waves?

A. amplify them

B. collect them

C. convert them

D. scatter them

Chapter Review

Which refers to a longitudinal wave that can travel only in matter?

A. wavelength

B. sound wave

C. pitch

D. loudness

Chapter Review

Which describes a material that light cannot travel through?

A. transparent

B. translucent

C. opaque

D. absorption

Chapter Review

Which term describes what happens when light waves traveling in one direction are made to travel in many directions?

A. transmitting

B. scattering

C. refracting

D. reflecting

Chapter Review

Which is a the layer of special light-sensitive cells in the back of the eye?

A. cornea

B. iris

C. pupil

D. retina

Standardized Test Practice

Which part of the ear amplifies sound waves?

A. the outer ear

B. the middle ear

C. the inner ear

D. the ear canal

Standardized Test Practice

Which is true of a sound wave with a higher frequency?

A. It has a higher pitch.

B. It has a lower pitch.

C. It is louder.

D. It is softer.

Standardized Test Practice

What is the term for something that emits light?

A. light wave

B. light ray

C. light source

D. electromagnetic wave

Standardized Test Practice

Which describes a material that transmits light waves, though objects cannot be seen clearly through the material?

A. opaque

B. reflection

C. translucent

D. transparent

Standardized Test Practice

Which is a the layer of special light-sensitive cells in the back of the eye?

A. iris

B. lens

C. pupil

D. retina