What are waves?

The world is full of waves. Water waves are just one of many kinds of waves. Sound and light are also waves. A **wave** is a disturbance that transfers energy from one place to another.

Waves Are Disturbances

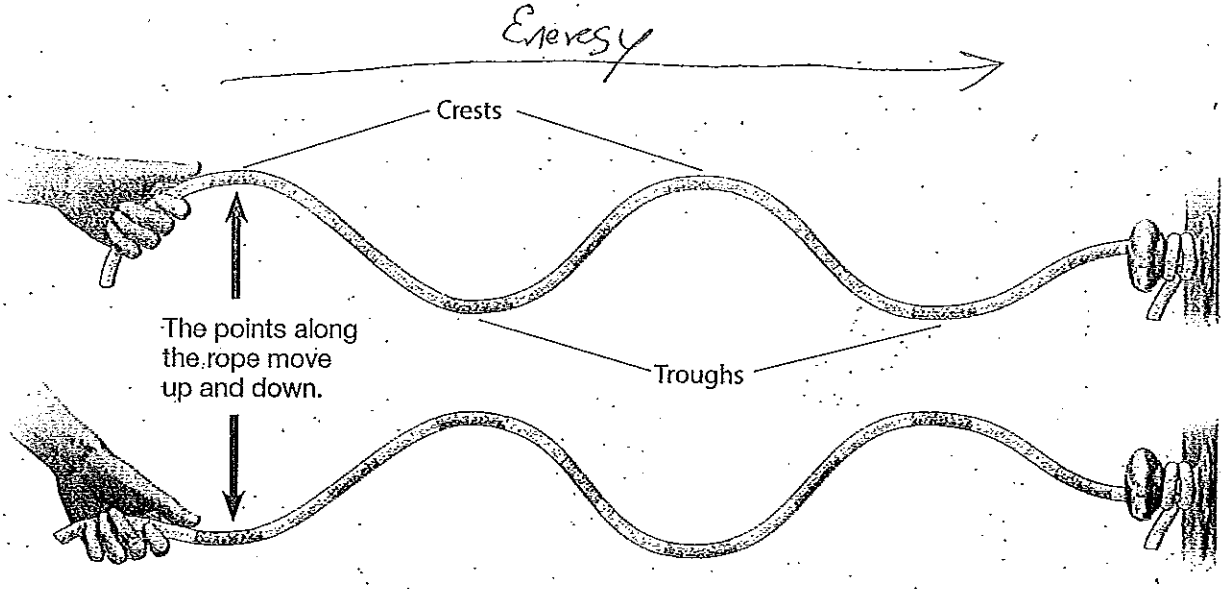
Active Reading

5 **Identify** Underline the names for the highest and lowest points of a wave.

Many waves travel by disturbing a material. The material then returns to its original place. A **medium** is the material through which a wave travels.

You can make waves on a rope by shaking the end up and down. The rope is the medium, and the wave is the up-and-down disturbance. As the part of the rope nearest your hand moves, it causes the part next to it to move up and down too. The motion of this part of the rope causes the next part to move. In this way, the wave moves as a disturbance down the whole length of the rope.

Each piece of the rope moves up and down as a wave goes by. Then the piece of rope returns to where it was before. A wave transfers energy from one place to another. It does not transfer matter. The points where the wave is highest are called crests. The points where the wave is lowest are called troughs.



Visualize It!

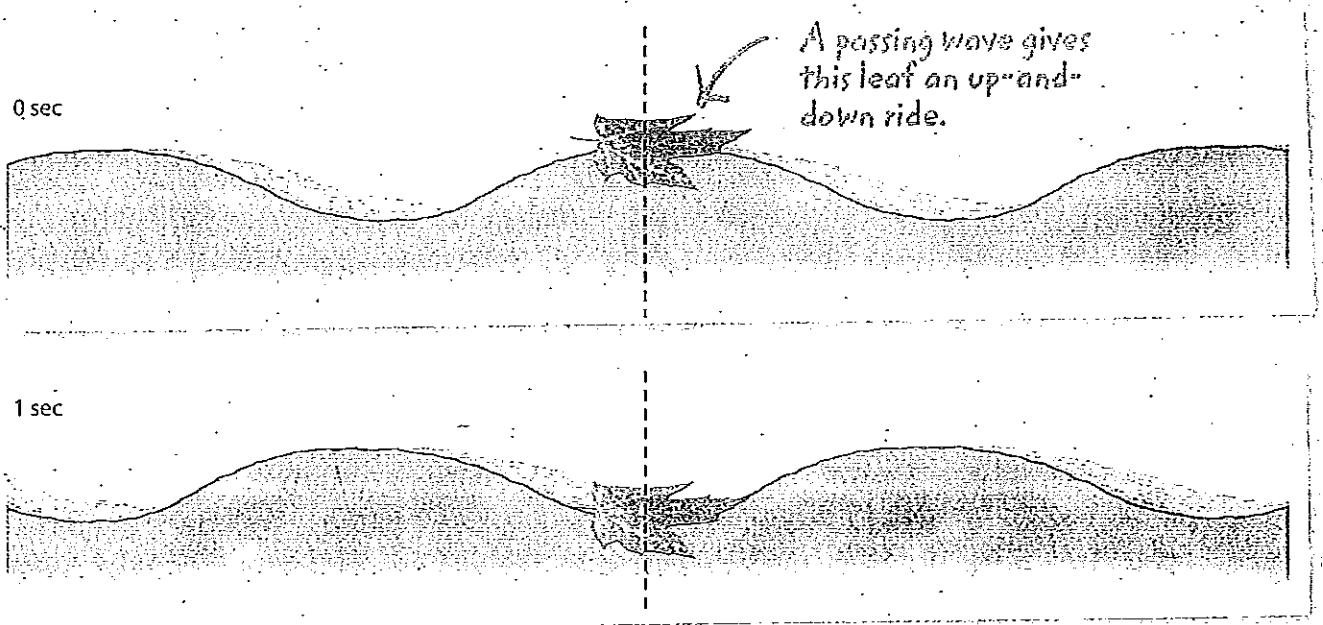
6 **Label** Draw an arrow near the rope to show the direction the wave travels. (Energy)

Waves Are a Transfer of Energy

A wave is a disturbance that transfers energy. Some waves need a medium to transfer energy, such as waves in the ocean that move through water and waves that are carried on guitar or cello strings when they vibrate. Some waves can transfer energy without a medium. One example is visible light. Light waves from the sun transfer energy to Earth across empty space.

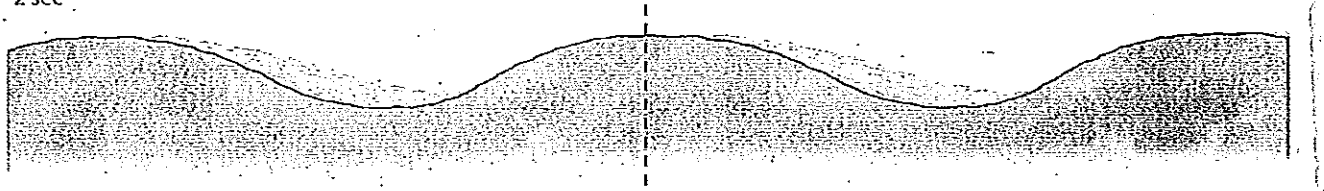
Visualize It!

Each snapshot below shows the passage of a wave. The leaf rises and falls as crests and troughs carry it.



7 Illustrate In the picture below, draw the leaf in the location it will be after 2 seconds.

2 sec



8 Model In the space below, draw the leaf and wave as they will appear after 3 seconds.

3 sec

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How does a wave transfer energy?

A wave transfers energy in the direction it travels. However, the disturbance may not be in the same direction as the wave. Each wave can be classified by comparing the direction of the disturbance, such as the motion of the medium, with the direction the wave travels.

As a Longitudinal Wave

Active Reading

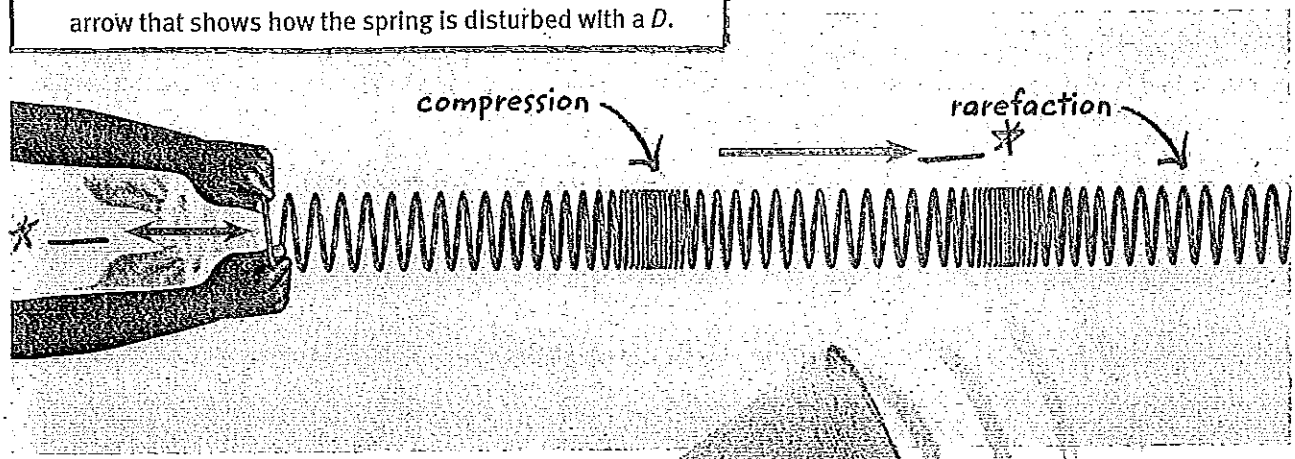
9 Identify As you read, underline the type of wave that sound is.

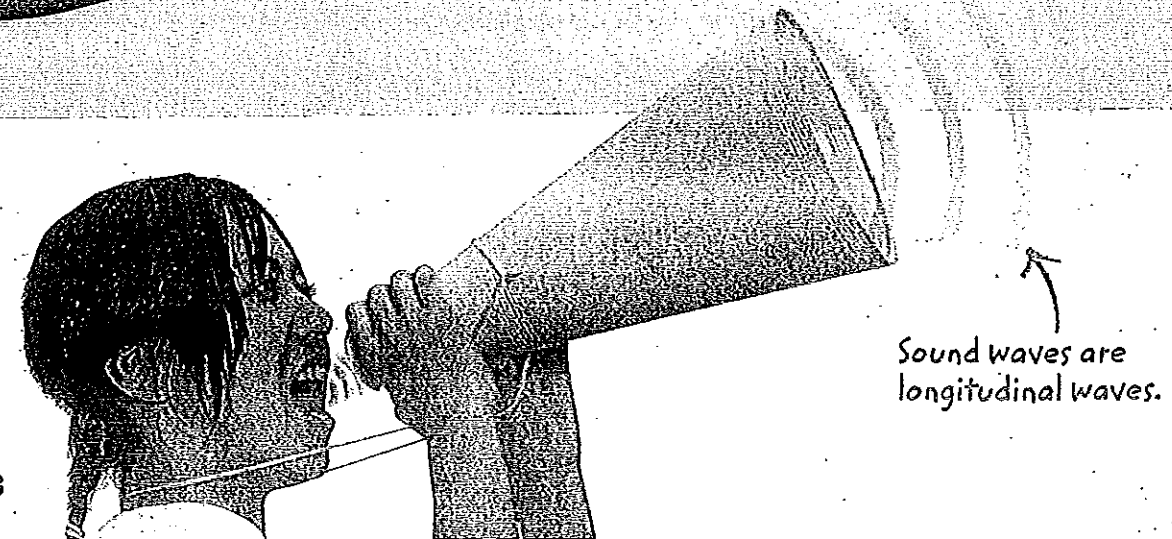
When you pull back on a spring toy like the one below, you spread the coils apart and make a *rarefaction*. When you push forward, you squeeze the coils closer together and make a *compression*. The coils move back and forth as the wave passes along the spring toy. This kind of wave is called a longitudinal wave. In a **longitudinal wave** (lahn•jih•TOOD•n•uhl), particles move back and forth in the same direction that the wave travels, or parallel to the wave.

Sound waves are longitudinal waves. When sound waves pass through the air, particles that make up air move back and forth in the same direction that the sound waves travel.

Visualize It!

10 Label In this longitudinal wave, label the arrow that shows the direction the wave travels with a *T*. Label the arrow that shows how the spring is disturbed with a *D*.





As a Transverse Wave

The same spring toy can be used to make other kinds of waves. If you move the end of the spring toy up and down, a wave also travels along the spring. In this wave, the spring's coils move up and down as the wave passes. This kind of wave is called a **transverse wave**. In a transverse wave, particles move perpendicularly to the direction the wave travels.

Transverse waves and longitudinal waves often travel at different speeds in a medium. In a spring toy, longitudinal waves are usually faster. An earthquake sends both longitudinal waves (called P waves) and transverse waves (called S waves) through Earth's crust. In this case, the longitudinal waves are also faster. During an earthquake, the faster P waves arrive first. A little while later, the S waves arrive. The S waves are slower but usually more destructive.

A transverse wave and a longitudinal wave can combine to form another kind of wave called a surface wave. Ripples on a pond are an example of a surface wave.

When these fans do "The Wave," they are modeling the way a disturbance travels through a medium.

12 Categorize Is the stadium wave shown above a transverse wave or a longitudinal wave?

Energy ↓ People

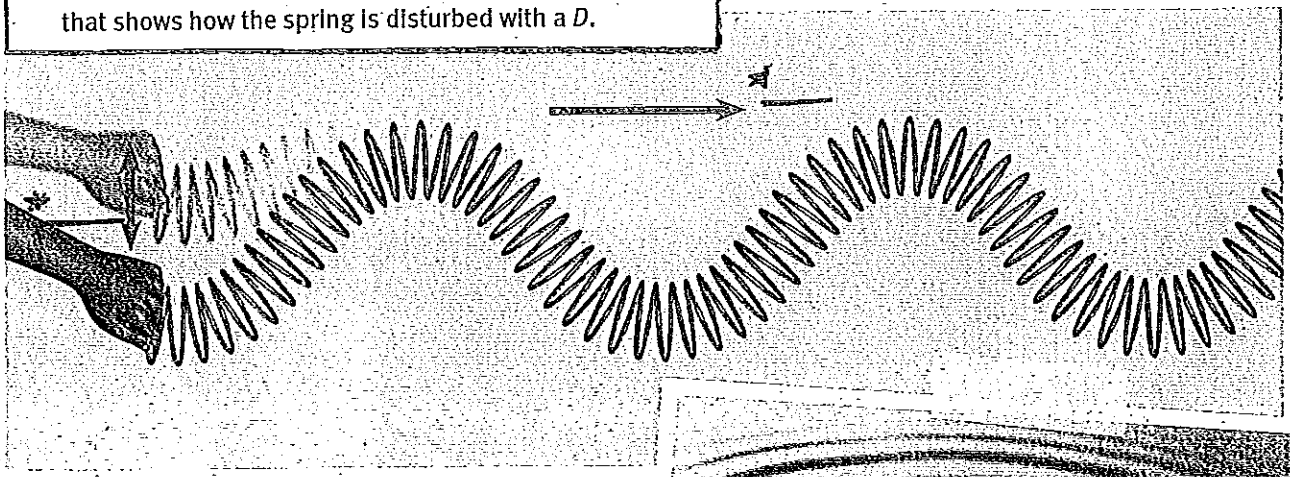
Transverse

Think Outside the Book Inquiry

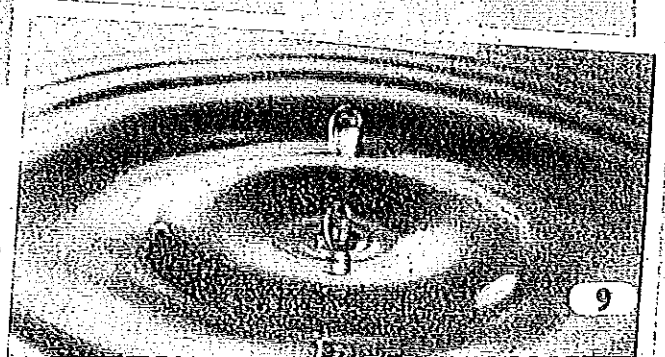
13 Identify What do the letters *S* in S waves and *P* in P waves stand for? Relate this to earthquakes and discuss it with a classmate.

Visualize It!

11 Label In this transverse wave, label the arrow that shows the direction the wave travels with a *T*. Label the arrow that shows how the spring is disturbed with a *D*.



Water waves are surface waves, a combination of transverse and longitudinal waves.



What are some types of waves?

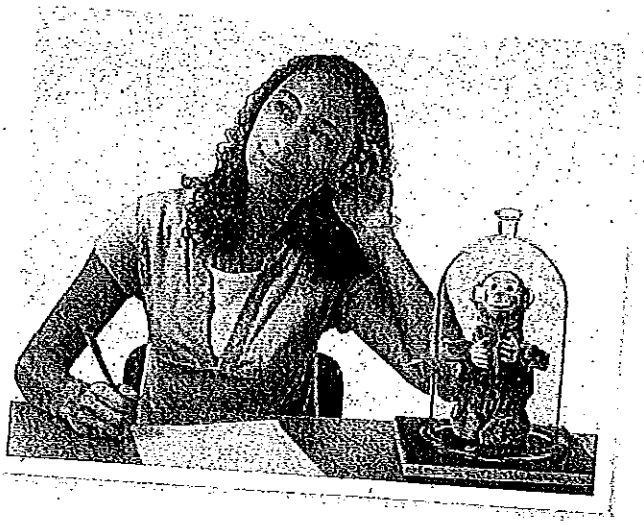
As you have learned, waves are disturbances that transfer energy. Waves can be classified by the direction of disturbance. But they can also be classified by what is disturbed.

Mechanical Waves

Most of the waves we have talked about so far are waves in a medium. For water waves, water is the medium. For earthquake waves, Earth is the medium. A wave that requires a medium through which to travel is called a **mechanical wave.**

Some mechanical waves can travel through more than one medium. For example, sound waves can move through air, through water, or even through a solid wall. The waves travel at different speeds in the different media. Sound waves travel much faster in a liquid or a solid than in air.

Mechanical waves can't travel without a medium. Suppose all the air is removed from beneath a glass dome, or bell jar, as in the photograph below. In a vacuum, there is no air to transmit sound waves. The vibrations made inside the bell jar can't be heard.



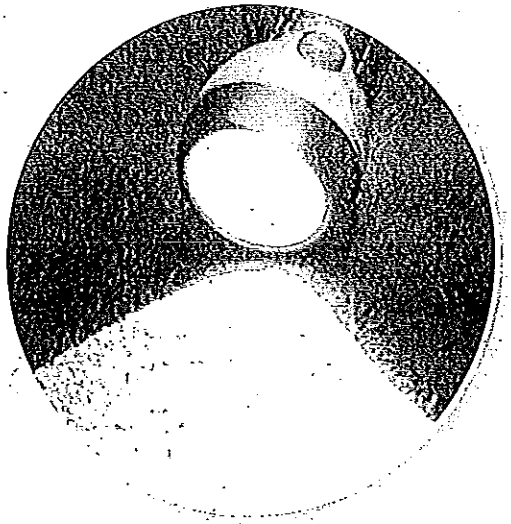
The sound from the toy cannot be heard because there is no air to transmit the sound.

Electromagnetic Waves

Are there waves that can travel without a medium? Yes. Sunlight travels from the sun to Earth through empty space. Although light waves can travel through a medium, they can also travel without a medium. Light and similar waves are called electromagnetic (EM) waves. An **electromagnetic wave** is a disturbance in electric and magnetic fields. They are transverse waves. Examples of EM waves include

- visible light
- radio waves
- microwaves
- ultraviolet (UV) light
- x-rays

In empty space, all these waves travel at the same speed. This speed, referred to as the speed of light, is about 300 million meters per second!



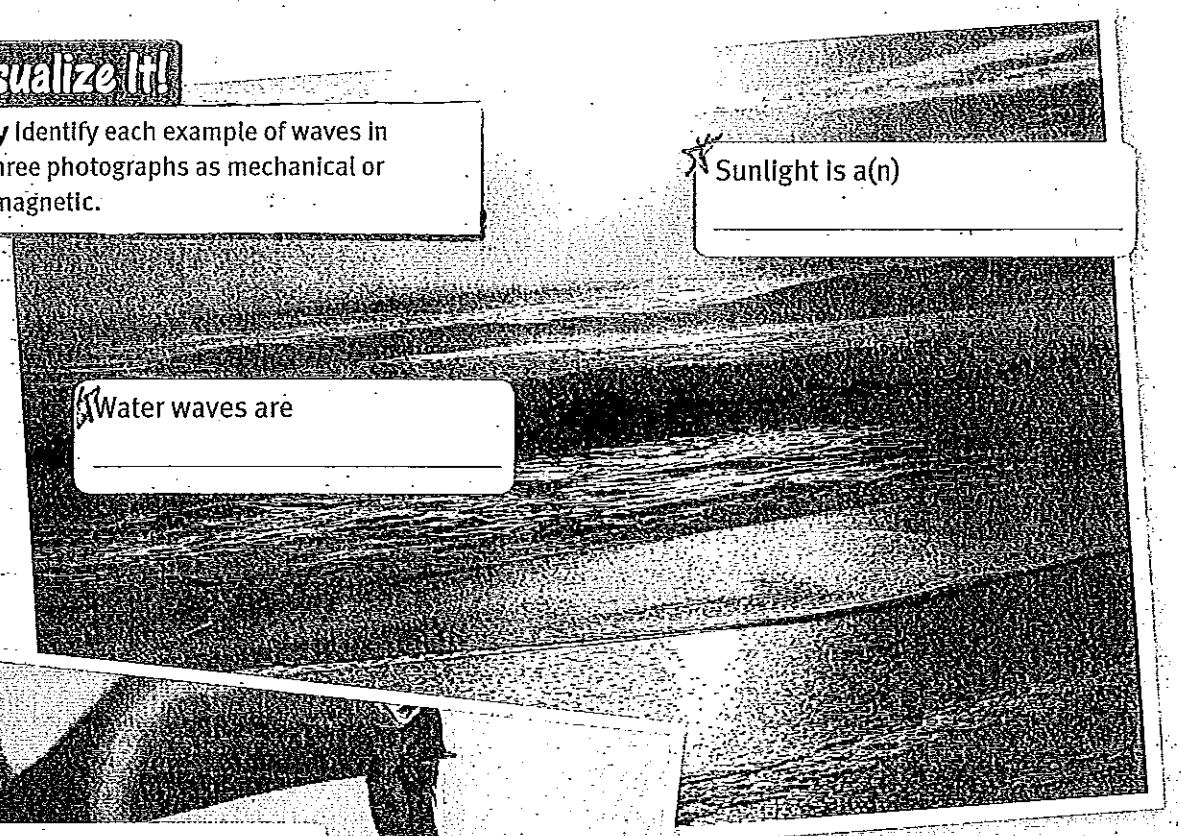
Visible light is a type of wave called an electromagnetic wave.

Visualize It!

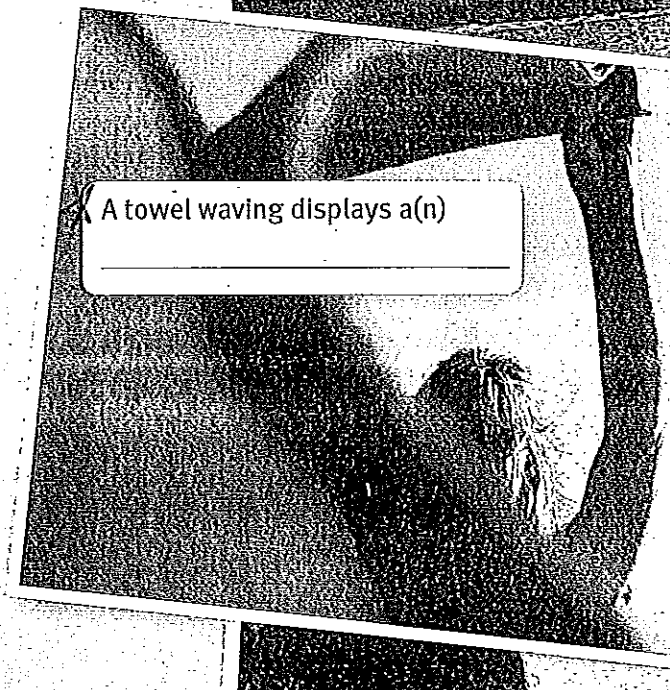
14 Classify Identify each example of waves in these three photographs as mechanical or electromagnetic.

Sunlight is a(n) _____

Water waves are _____



A towel waving displays a(n) _____



Vocal sounds are _____

Music is a(n) _____

Firelight is a(n) _____

Lesson Review

All

Vocabulary

Circle the term that best completes the following sentences.

1 A wave is a disturbance that transfers *matter/energy*.

2 In a *longitudinal/transverse* wave, the disturbance moves parallel to the direction the wave travels.

3 *Mechanical/Electromagnetic* waves require a medium in which to travel.

Key Concepts

4–6 Identify Name the medium for each of the following types of waves.

Type of wave	Medium
ocean waves	4
earthquake waves	5
sound waves from a speaker	6

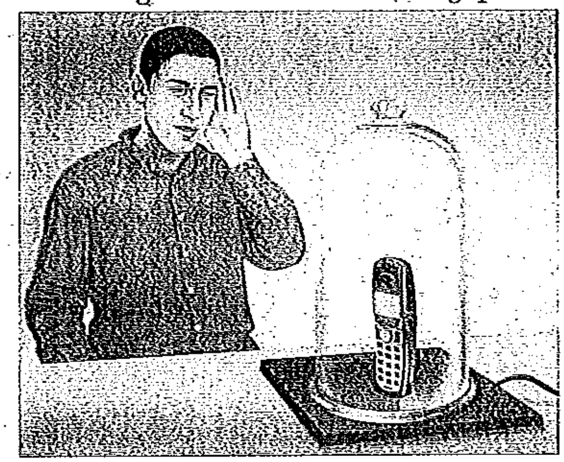
7 Describe Explain how transverse waves can be produced on a rope. Then describe how pieces of the rope move as waves pass.

8 Analyze Are the sun's rays mechanical waves or electromagnetic waves? How do you know?

Critical Thinking

9 Contrast Mechanical waves travel as disturbances in a physical medium. How do electromagnetic waves travel?

Use this image to answer the following questions.



10 Infer Even though the phone is ringing, no sound comes out of the jar. What does this tell you about the space inside the jar?

11 Infer What does this same experiment tell you about light waves? Explain.