chapter 2

Sound

section 2 Music

What You'll Learn

- the difference between music and noise
- how instruments produce music
- how you hear

Before You Read

What is your favorite song? What do you like about it?

_____

_____

Mark the Text

Locate Information As you read this section, highlight the main ideas about stringed instruments in one color. Highlight the main ideas about percussion instruments in another color. Highlight the main ideas about brass and woodwind instruments in a third color.

Read to Learn

What is music?

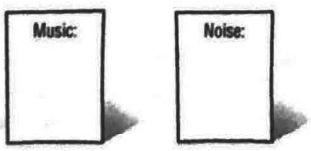
Turn on the radio to your favorite station and you hear music. Drop a plate on the kitchen floor and you hear noise. Music and noise are both groups of sounds. Why do humans hear some sounds as music and others as noise?

The answer is that music and noise have different patterns of sound. **Music** is a group of sounds put together on purpose to make a regular pattern. Look at the figure below. The wave pattern on the left shows noise. It has no regular pattern. The wave on the right shows the wave pattern of a piece of music. Notice that the pattern repeats itself. The sounds that make up music usually have a regular pattern of pitches, or notes. Some natural sounds also have regular patterns. That is why sounds like rain on a roof or birds singing may sound musical to some people.

Noise Music

FOLDABLES

B Compare and Contrast Make the following Foldable to help you understand the differences between music and noise. Include examples of each.



How is music made?

Music is made by vibrations. Your vocal cords vibrate when you sing. When you play a guitar, the strings vibrate. When you beat a drum, the drumhead vibrates. ☑

Tap a bell with a hard object and the bell makes a sound. Tap another bell that has a different size or shape and you will hear a different sound. The bells sound different because each bell vibrates at different frequencies.

The frequencies at which a bell vibrates depend on the bell's shape and the material it is made from. The certain frequencies at which an object vibrates are called its **natural frequencies**.

Reading Check

1. **Explain** how music is made.

How are natural frequencies used in music?

When an object is struck or plucked, it vibrates at one or more natural frequencies. The natural frequencies of any object depend on its size, shape, and the material it is made from. Musical instruments use the natural frequencies of strings, drumheads, and air inside pipes to produce different musical notes. ☑

Reading Check

2. **List** the three things the natural frequencies of an object depend on.

What is resonance?

Sometimes sound waves can make an object vibrate. When a tuning fork is struck, it vibrates at its natural frequency and produces a sound wave. The sound wave has the same frequency as the natural frequency of the tuning fork.

Suppose you have two tuning forks that have the same natural frequency. You strike one tuning fork. The sound waves it makes strike the other tuning fork. These sound waves cause the tuning fork that was not struck to absorb energy and vibrate. This is an example of resonance. **Resonance** happens when an object is made to vibrate at its natural frequencies by absorbing energy from a sound wave or another object vibrating at these frequencies.

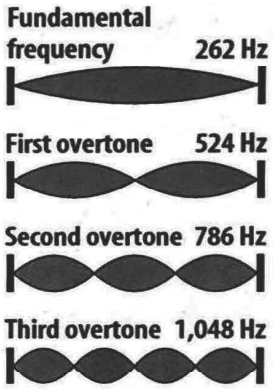
How do musical instruments use resonance?

Musical instruments use resonance to make their sounds louder. If a vibrating tuning fork is placed against a table, the sound waves made by the tuning fork may make the table resonate, or vibrate at the same frequency. The vibrations of the tuning fork and the table combine. This makes the sound louder.

Overtones

The same note played on different instruments sounds different even though it has the same pitch. Why? A tuning fork produces a single frequency called a pure tone. Musical instruments do not produce pure tones. Most objects vibrate at more than one natural frequency, so they produce sound waves of more than one frequency.

If you play one note on a guitar, the pitch you hear is the lowest frequency produced by the vibrating string. The **fundamental frequency** is the lowest frequency produced by a vibrating object. The string also vibrates at higher frequencies. **Overtones** are the frequencies higher than an instrument's fundamental frequency. The figure below shows that overtones are multiples of the fundamental frequency. The different overtones produced by each musical instrument make them sound different from each other.

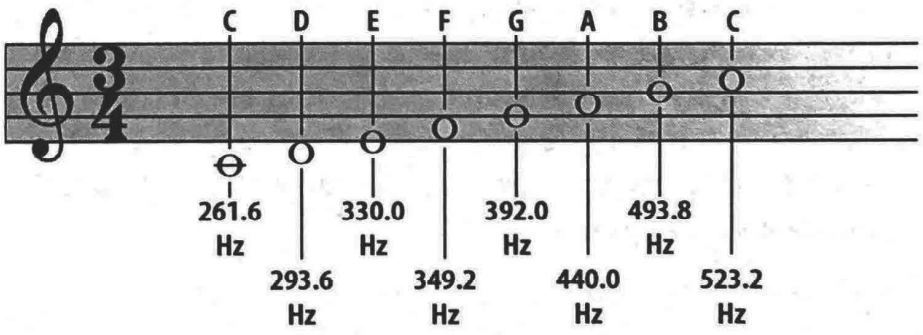


Think it Over

3. **Think Critically** Why does a note played on a piano sound different than the same note played on a guitar?

Musical Scales

A musical instrument produces musical sounds. The sounds often are part of a musical scale that is a series of notes with certain frequencies. The figure below shows a sequence of notes from a musical scale. Notice that the frequency of the eighth note in the scale is twice that of the first note. The frequency doubles every eight notes.



Applying Math

4. **Calculate** the frequency of the next C note in the sequence shown in the figure.

Stringed Instruments

A piano, a violin, and a guitar are all stringed instruments. Stringed instruments produce music by making strings vibrate. Piano strings are struck. A bow is slid across violin strings. Guitar strings are plucked.

Strings for these instruments often are made of wire. The pitch of a note depends on the length of the string, the thickness of the string, and how tight the string is. Shorter, narrower, or tighter strings produce higher pitches. For example, a thinner guitar string produces a higher pitch than a thicker string.

How do stringed instruments use resonance?

A vibrating string usually produces a soft sound. To make the sound louder, most stringed instruments have a hollow space that contains air. This space is called a resonator. The resonator absorbs energy from the vibrating strings. Then, it begins to vibrate at its natural frequencies. ☑

For example, the body of a guitar is a resonator. It makes the vibrating strings sound louder. When a guitar is played, the strings vibrate. The vibrating strings make the guitar's body and the air inside it resonate. The vibrating guitar strings sound louder, just as the vibrating tuning fork that was placed against a table sounded louder.

Percussion

You have to strike a percussion instrument to make a sound. Drums are percussion instruments. When you strike a drumhead, it vibrates. The vibrating drumhead is attached to a hollow chamber filled with air. The chamber resonates and makes the sound louder.

Can you change the pitch of a drum?

Some drums have a fixed pitch, but some can be tuned to play different notes. If the drumhead is tightened, the natural frequency of the drumhead is increased. The pitches produced by the drum get higher. A steel drum plays different notes in the scale when you hit different areas in the drum.

A xylophone is another percussion instrument. It is made of wood or metal bars of different lengths. You strike these bars when you play a xylophone. The longer the bar is, the lower the note it produces when it is struck.

Reading Check

5. Explain What makes the sound of stringed instruments louder?

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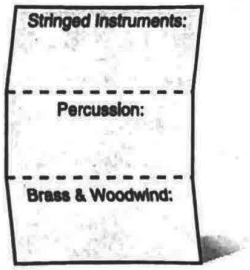
FOLDABLES™

C Classify Make the following Foldable to organize musical instruments into groups. Give examples of instruments and how they make music.

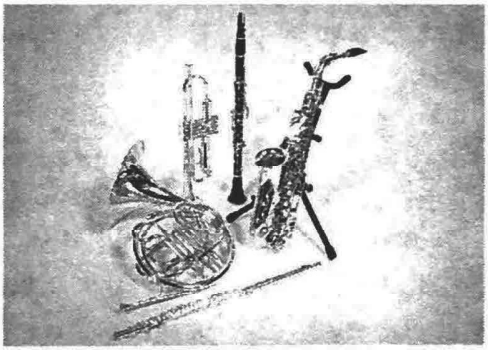


Brass and Woodwinds

Brass and woodwind instruments, like those in the figure below, are made of one or more pipes of different lengths. The pipes can be straight or twisted. The pipes contain columns of air. The columns of air have different natural frequencies. Music is made when the air in an instrument vibrates at different frequencies. ☑

Reading Check

6. **Identify** What vibrates inside the pipes of a brass instrument?



There are different ways to make the air column vibrate. To play a brass instrument like a trumpet, a musician vibrates the lips and blows into the mouthpiece. The air column vibrates and a note sounds on the trumpet.

Some woodwind instruments, like clarinets, saxophones, and oboes, use one or two reeds to make sounds. The reeds vibrate when the musician blows on them. This makes the air column vibrate and you hear a note. Flutes also are woodwind instruments. To play the flute, a musician blows across a small opening in the instrument to make the air column vibrate.

How do you change pitch in woodwinds?

To change a note played on a woodwind, a musician changes the length of the vibrating air column. If the length of the vibrating air column is made shorter, the pitch of the sound goes higher. Musicians change the length of the vibrating column of air by closing and opening finger holes along the instrument.

How is pitch changed in brass instruments?

Musicians playing a brass instrument can blow harder to change the pitch of a sound. Blowing harder makes the air column resonate at a higher natural frequency. This makes the pitch higher. Another way to change the pitch is by pressing valves that change the length of the tube.

Think it Over

7. **Infer** If you made the column of air in a woodwind instrument longer, what would happen to the pitch?

Beats

Interference happens when two waves overlap and combine to make a new wave. The new wave can have a different frequency, wavelength, and amplitude than the two original waves.

Suppose two notes close in frequency are played at the same time. The two notes interfere to make a new sound. The new sound gets louder and softer several times each second. If you were listening to the sound, you would hear a series of beats as the sound got louder and softer. The number of beats you would hear each second is called the beat frequency. The beat frequency is equal to the difference in the frequencies of the two notes.

Suppose the frequency of the first note is 329 Hz and the frequency of the second note is 332 Hz. The beat frequency is the difference in these two frequencies, or 332 Hz − 329 Hz. The beat frequency is 3 Hz. That means you would hear the sound get louder and softer three times each second. In other words, you would hear three beats each second.

What are beats used for?

In music, beats are used to help tune instruments. To tune a piano, a piano tuner might hit a tuning fork that vibrates at a certain frequency. The piano tuner then hits the key on the piano that makes a note of the same frequency. Beats are heard if the pitch of the note from the piano is different from the pitch of the tuning fork. When the piano string is tuned correctly, the beats disappear.

Reverberation

You have learned that sound reflects off hard surfaces. If you stand in an empty gym and speak in a loud voice, the sound of your voice will be reflected back and forth several times. The sound of your voice will bounce off the floor, walls, and ceiling. It will reverberate. Repeated echoes of sound are called **reverberation**. ☑

In the gym, reverberation makes the sound of your voice stay for awhile before the sound dies out. Some reverberation makes voices and music sound lively. Not enough reverberation makes sounds flat and lifeless. But sometimes, reverberation can produce a confusing mess of noise. This happens when too many sounds stay for too long.

Applying Math

8. Calculate What is the beat frequency between a note with a frequency of 293 Hz and a note with a frequency of 295 Hz?

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☑ Reading Check

9. Describe What do you hear when you hear repeated echoes of sound?

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How is reverberation controlled?

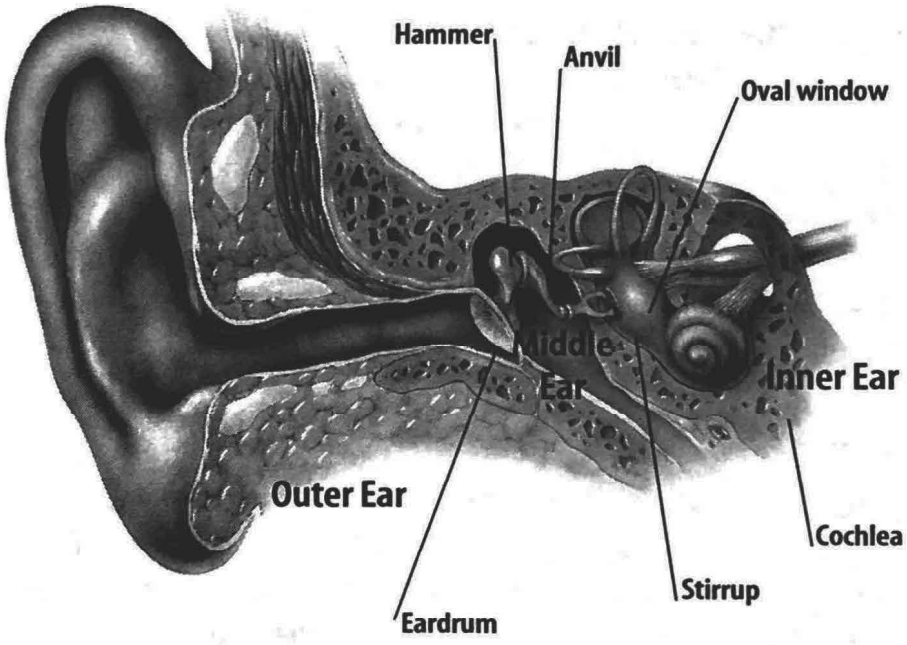
Concert halls and theaters are designed to produce just the right amount of reverberation. Sometimes the walls, floors, and ceiling are covered with soft materials. This reduces echoes. Sometimes special panels are put on walls or hung from the ceiling. These panels are designed to reflect sound toward the audience.

The Ear

You hear sounds with your ears. Your ear is an organ that can hear sounds of many different frequencies. It can hear sounds from about 20 Hz to 20,000 Hz. Your ear can also hear very loud sounds and very soft sounds. The softest sounds you can hear have about one trillionth the amount of energy as the loudest sounds you can hear. The figure below shows a human ear. It has three parts—the outer ear, the middle ear, and the inner ear.

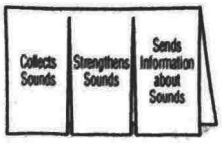
Picture This

10. Identify Highlight the ear canal in the figure.



FOLDABLES

D Make Drawings Make the following Foldable to show how the ear works. Draw the parts of the ear under the tabs. Label each part.



What does the outer ear do?

Your outer ear collects sound waves. Then, it directs the sound waves into the ear canal. Look at the figure again. Notice that the outer ear looks something like a funnel. This shape helps it collect the sound waves.

How do animals collect sounds?

Some animals use their ears to find food or to keep away from danger. These animals often have large outer ears. A barn owl uses its ears to hunt for food at night. Its outer ears are not made of flesh. The feathers on the owl's face help direct the sound to its ears. Sea mammals hear very well even though their outer ears are small holes.

What does the middle ear do?

When sound waves reach the middle ear, they make the eardrum vibrate. The **eardrum** is a thin skin-like structure, or membrane, that stretches across the ear canal like a drumhead. When the eardrum vibrates, it makes the three small bones next to it vibrate. These bones are connected to each other. They are called the hammer, the anvil, and the stirrup. These bones make the vibrations stronger. ☑

Reading Check

11. Identify What vibrates when sound waves reach the middle ear?

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What does the inner ear do?

The stirrup vibrates another membrane. This membrane is called the oval window. The inner ear begins at the oval window. The inner ear is filled with fluid. The fluid vibrates when the vibrations from the middle ear reach the inner ear. When the fluid vibrates, it makes special hair-tipped cells inside the cochlea vibrate.

Different sounds vibrate these cells in different ways. The cells send signals with information about the sound's frequency and strength. The cells also send information about how long a sound lasts. The signals travel to the brain along the auditory nerve. They go to the part of the brain that is responsible for hearing.

Hearing Loss

Some diseases can damage your ears. Loud sounds also can damage your ears. If you listen to loud sounds for long periods of time, the sounds can damage the hair cells in the cochlea. These hair cells may die if they are damaged. You cannot grow new hair cells. When the hair cells die, some of your hearing is lost. ☑

Reading Check

12. Explain why listening to loud sounds for a long time can damage your hearing.

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As people get older, they can lose their hearing. Some hair cells and nerves in the ear stop working properly. About 30 percent of people older than 65 have some hearing loss due to aging.

After You Read

Mini Glossary

eardrum: a very thin layer of skin that stretches across the ear canal like a drumhead

fundamental frequency: the lowest frequency made by a vibrating object

music: a group of sounds put together on purpose to make a regular pattern

natural frequencies: the certain frequencies at which an object vibrates

overtones: the frequencies higher than an instrument's fundamental frequency

resonance: happens when an object is made to vibrate at its natural frequencies by absorbing energy from a sound wave or another object vibrating at these same frequencies

reverberation: repeated echoes of sound

1. Review the terms and their definitions in the Mini Glossary. Use the terms *music* and *eardrum* in a sentence together.

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_____

_____

2. Write the letter of the statement in Column 2 that best matches the term in Column 1.

Column 1	Column 2
_____ 1. music	**a.** used by musical instruments to make their sounds louder
_____ 2. musical scale	**b.** part of the ear that collects sounds
_____ 3. outer ear	**c.** percussion instrument
_____ 4. resonance	**d.** organized sound
_____ 5. xylophone	**e.** a series of notes
_____ 6. hair cells	**f.** send signals about a sound to the brain

3. How could you show a younger student what reverberation is?

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End of Section

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