Section 3 Music

Objectives

After this lesson, students will be able to

O.2.3.1 Identify what determines the sound quality of a musical instrument.

O.2.3.2 Name the basic groups of musical instruments.

O.2.3.3 Describe how acoustics is used in concert hall design.

Target Reading Skill

Previewing Visuals Explain that looking at the visuals before they read helps students activate prior knowledge and predict what they are about to read.

Answers

Sample questions and answers:

Musical Instruments

How is pitch changed in each type of instrument? *(By changing the frequency of the vibrations)* **How is loudness changed in each type of instrument?** *(By changing the energy of the vibrations)*

All in One Teaching Resources

- Transparency O22

Preteach

Build Background Knowledge

L2

Comparing Instrumental Sounds

Ask students who play different musical instruments to bring their instruments to class. Have each student play the same note at the same volume. Call on students in the class to describe how the different instruments sound. Ask: **What do you think causes the instruments to sound different from one another?** *(Students might say construction materials, size, and shape.)*

Section 3 Music

Reading Preview

Key Concepts

- What determines the sound quality of a musical instrument?
- What are the basic groups of musical instruments?
- How is acoustics used in concert hall design?

Key Terms

- music
- fundamental tone
- overtone
- acoustics
- reverberation

Target Reading Skill

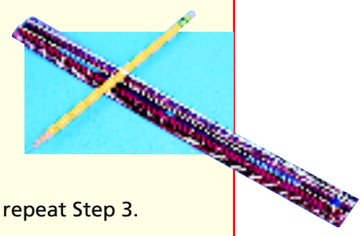
Previewing Visuals When you preview, you look ahead at the material to be read. Preview Figure 15. Then write two questions that you have about the diagrams in a graphic organizer like the one below. As you read, answer your questions.

Musical Instruments

Q. How is pitch changed in each type of instrument?
A.
Q.

Lab zone Discover Activity

How Can You Change Pitch?



1. Wrap two rubber bands of different thickness lengthwise around a 30-cm plastic ruler. The bands should not touch each other.
2. Place a pencil under the bands at the 10-cm mark.
3. Pluck each band. How are the sounds different?
4. Move the pencil to the 15-cm mark and repeat Step 3.

Think It Over

Drawing Conclusions Why are the sounds you made in Step 4 different from the sounds in Step 3?

You are late. When you arrive at your orchestra rehearsal, your friends are already tuning up. With all the instruments playing different notes, it sounds like noise! You quickly pull out your instrument and take your seat. Then the music starts, and everything changes. What makes noise and music different? The answer is in the way sound waves combine.

Orchestra rehearsal ▶

Lab zone Discover Activity

Skills Focus Developing hypotheses L2

Materials 2 rubber bands of different thicknesses, 30-cm ruler, pencil

Time 15 minutes

Tips Rubber bands that are too thick will not stretch enough. Caution students to avoid launching the rubber bands with the rulers.

Expected Outcome Because they have different thicknesses, the rubber bands will have different natural frequencies and produce sounds of different pitches. When the pencil is moved from the 5-cm mark to the 15-cm mark, the pitch becomes higher.

Think It Over In Step 4, the pitch is higher because the part of the rubber band that is vibrating is shorter.

Sound Quality

Most people agree on what is or is not music. **Music** is a set of notes that combine in patterns that are pleasing. Noise, on the other hand, has no pleasing patterns. When you describe a sound as pleasant or unpleasant, you are describing sound quality. The sound quality of music depends on the instruments making the music. **The sound quality of musical instruments results from blending a fundamental tone with its overtones. Resonance also plays a role in the sound quality.**

Fundamental Tones and Overtones In Chapter 1, you learned that standing waves occur when waves with just the right frequency interfere as they reflect back and forth. Standing waves occur in musical instruments when they are played. In a guitar, for example, standing waves occur in a vibrating string. In a trumpet, standing waves occur in a column of vibrating air.

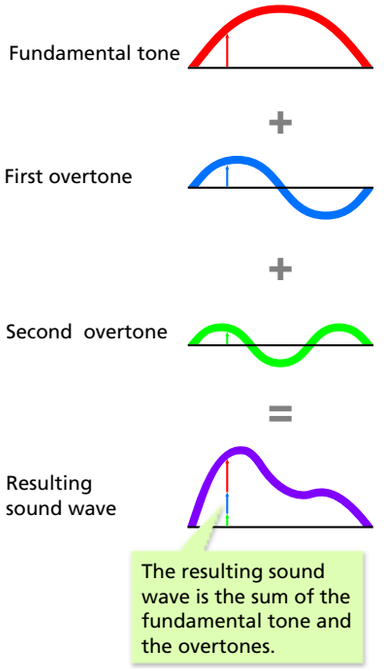
A standing wave can occur only at specific frequencies that are called natural frequencies. Every object has its own natural frequencies. The lowest natural frequency of an object is called the **fundamental tone.** The object's higher natural frequencies are called **overtones.** Overtones have frequencies that are two, three, or more times the frequency of the fundamental tone. Look at Figure 14 to see how the natural frequencies of a guitar string add together to produce a unique sound.

The fundamental tone determines what note you hear. For example, when a guitar and a trumpet play middle C, they both produce waves with a frequency of 262 Hz. But each instrument produces different overtones, so the blending of the fundamental tones and overtones produces different sound qualities.

Resonance Resonance affects the sound quality of a musical instrument by increasing the loudness of certain overtones. Recall that resonance occurs when one object causes a nearby object to vibrate at a natural frequency. A musical instrument is designed so that a part of it will resonate with the overtones it produces. In a guitar, for example, the vibrating strings cause the guitar's hollow body to resonate. The shape and material of the guitar determine which overtones are loudest.

Reading Checkpoint **What are overtones?**

FIGURE 14
Sound Quality
A guitar string can resonate at several frequencies that combine to produce a unique sound quality.
Interpreting Data *What determines the resulting wave?*



Differentiated Instruction

Special Needs L1
Observing Tones of Different Frequencies Help students understand how overtones are related to the fundamental tone. Have students use a pitch pipe or two tuning forks to play middle C (262 Hz) followed by the C above middle C (524 Hz). Explain how the two notes are related to Figure 14. **learning modality: kinesthetic**

Gifted and Talented L3
Demonstrating Resonance Ask students who play wind instruments to bring their instruments to class. Have them play a sound using only the mouthpiece, followed by a sound using the whole instrument. Challenge them to explain to the class how this demonstrates resonance. **learning modality: kinesthetic**

Instruct

Sound Quality

Teach Key Concepts L2

Sound Quality and Natural Frequencies

Focus Introduce sound quality as the characteristic that allows you to distinguish one musical instrument from another by sound alone.

Teach Tell students that different instruments vibrate at different natural frequencies. Explain that this is one reason why each type of instrument has a unique sound.

Apply Ask: **What factors might account for the natural frequency of a particular instrument?** *(Size, shape, material)* **learning modality: verbal**

All in One **Teaching Resources**
Transparency O23

Independent Practice L2

All in One **Teaching Resources**
- Guided Reading and Study Worksheet: *Music*

Student Edition on Audio CD

Monitor Progress L2

Writing Have students explain why the same song sounds different when played on a piano and a flute.

Answers
Figure 14 The sum of the fundamental tone and overtones

Reading Checkpoint Overtones are an object's higher natural frequencies that are two, three, or more times the frequency of the fundamental tone.

Groups of Musical Instruments

Teach Key Concepts L2

Musical Instrument Groups

Focus Introduce the three groups of musical instruments.

Teach Have students read the caption and labels of Figure 15. Write the terms *Strings, Winds,* and *Percussion* on the board. Challenge students to brainstorm the names of different instruments, including both band and orchestra instruments. Tell them to try to think of other instruments besides the examples shown in the figure. As students name the instruments, write them under the appropriate headings. *(Sample answer: Strings include banjo, guitar, violin, cello, piano, harpsichord, harp; winds include harmonica, flute, oboe, bassoon, clarinet, saxophone, trumpet, trombone, and tuba; percussion include snare drum, cymbal, base drum, tympani, castanet, xylophone, and bell.)*

Extend The ***active art*** will show students how musical instruments in the three groups produce sounds and change pitch and loudness. **learning modality: visual**

Go Online active art

For: Musical instruments activity
Visit: PHSchool.com
Web Code: cgp-5023

Students can interact with the art of musical instruments online.

Lab zone Build Inquiry L1

Applying Concepts

Materials whistle

Time 10 minutes

Focus Have students apply their knowledge about musical instruments as they examine a whistle.

Teach Blow into a whistle, and have students evaluate its pitch. Ask: **Does a whistle make sound waves with a high or low frequency? How can you tell?** *(It has a high pitch, so it makes sound waves with a high frequency.)* **In which group of musical instruments would you classify a whistle? Why?** *(A whistle is a wind instrument, because movement of air through or across the mouthpiece causes the air inside the whistle to vibrate.)*

Apply Challenge students to explain how the size of a whistle is related to the frequency of the sound waves it produces. *(Because a whistle is small, the column of vibrating air is short, and a short air column produces high frequency sound waves.)* **learning modality: kinesthetic**

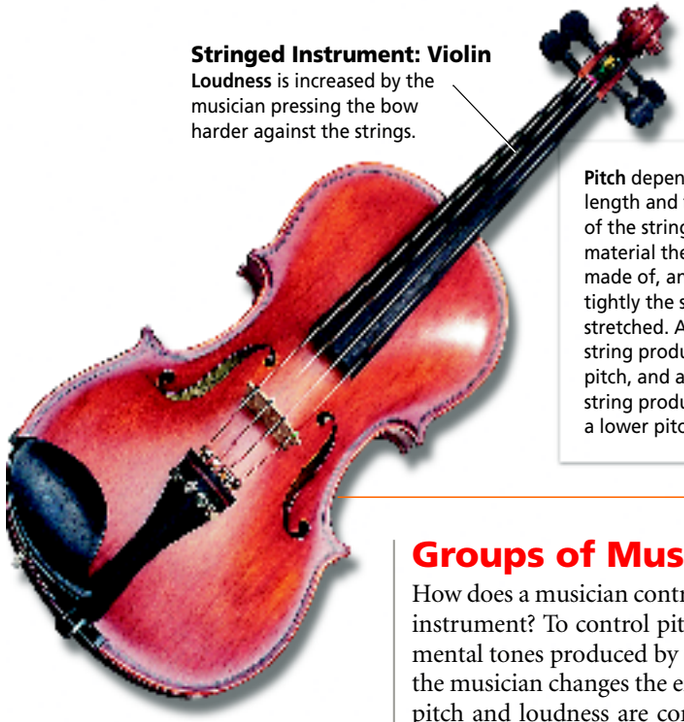
Go Online active art

For: Musical Instruments activity
Visit: PHSchool.com
Web Code: cgp-5023

FIGURE 15
Musical Instruments
A musician controls the vibrations of a musical instrument to change pitch and loudness. **Classifying** *How would you classify a tuba, a tambourine, and a banjo?*

Wind Instrument: Clarinet
Loudness is controlled by how hard the musician blows.

Stringed Instrument: Violin
Loudness is increased by the musician pressing the bow harder against the strings.

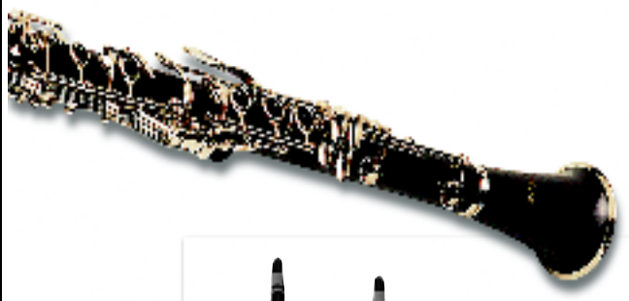


Pitch depends on the length and thickness of the strings, the material they are made of, and how tightly the strings are stretched. A short string produces a high pitch, and a longer string produces a lower pitch.

Groups of Musical Instruments

How does a musician control the sounds produced by a musical instrument? To control pitch, the musician changes the fundamental tones produced by the instrument. To control loudness, the musician changes the energy of the vibrations. The way that pitch and loudness are controlled varies among the groups of instruments, as shown in Figure 15. **There are three basic groups of musical instruments: stringed instruments, wind instruments, and percussion instruments.**

Stringed Instruments The guitar and the violin are stringed instruments. The strings of these instruments produce sound by vibrating when they are strummed or rubbed with a bow. Their loudness is increased by resonance when the instrument's hollow body vibrates as the strings vibrate. The pitch of each string depends on four factors: its length and thickness, the material it is made from, and how tightly it is stretched. An instrument with long strings, such as a cello, produces lower notes than an instrument with short strings, such as a violin.



Pitch depends on the length of the air column, which can be changed by covering different holes. A short air column produces a high pitch, and a longer column produces a lower pitch.

Percussion Instrument: Drum
Loudness is controlled by how hard the musician strikes the drum.

Pitch depends on the size of the drum head, the material, and the tension in the drum head. A smaller drum produces a higher pitch

Wind Instruments Wind instruments include brass instruments, such as trumpets, and woodwind instruments, such as clarinets. Brass instruments produce sound when a musician's lips vibrate against the mouthpiece, causing the air column in the instrument to vibrate. Woodwinds usually contain a thin, flexible strip of material called a reed. A woodwind produces sound when the reed vibrates, causing the instrument's air column to vibrate. In wind instruments, the length of the vibrating air column determines the note that you hear. A tuba, which has a long air column, produces lower notes than a flute, which has a short air column.

Percussion Instruments Percussion instruments include drums, bells, cymbals, and xylophones. These instruments vibrate when struck. The pitch of a drum depends on its size, the material it is made of, and the tension in the drumhead. A large drum produces lower pitches than a small drum.

Reading Checkpoint **What are four examples of percussion instruments?**

Lab zone Teacher Demo L2

Controlling Pitch in Strings

Materials guitar

Time 10 minutes

Focus Show students how pitch is controlled in a stringed instrument.

Teach Have students examine the strings of a guitar. Point out that all the strings are the same length. Pluck one string after another, and have students listen for the differences in pitch. Ask: **Why do the strings produce sounds with different pitches if they are all the same length?** *(The strings differ in thickness and tension.)* Demonstrate how the pitch of each string can be raised by tightening it. Explain that this is done to tune the strings relative to one another and to other instruments.

Extend Ask: **What is another way to change the pitch of a guitar string?** *(Shorten the part of the string that vibrates by pressing it against a fret on the neck of the guitar.)* Demonstrate how this changes the pitch of a string. **learning modality: visual**

Help Students Read L1

Comparing and Contrasting Have students make a table summarizing the most important points about the three different groups of musical instruments, using as column heads *Instrument Group, Examples, How Sound Is Produced, How Pitch Is Changed, How Loudness Is Changed*. Tell them to use information from the text and from Figure 5. Then, have students use their tables to identify similarities and differences among the three types. *(Sample answer: All three types produce sounds by making something vibrate, but they differ in what vibrates and how it is made to vibrate.)*

Differentiated Instruction

English Learners/Beginning L1
Comprehension: Link to Visual Guide students in using Figure 15 to learn about the three groups of musical instruments. Explain the labels in the figure, and point out the relevant parts of the pictured instruments. Also, explain how pitch is generally controlled in instruments belonging to each group. **learning modality: visual**

English Learners/Intermediate L2
Comprehension: Ask Questions After students have read the information on groups of musical instruments, ask them to explain in their own words how loudness is controlled in instruments belonging to each group. If students make any errors, direct them to reread the relevant labels in Figure 15. **learning modality: verbal**

Monitor Progress L2

Skills Check Name several different musical instruments. Challenge students to classify each instrument by group.

Answers

Figure 15 A tuba is a wind instrument, a tambourine is a percussion instrument, and a banjo is a stringed instrument.

Reading Checkpoint Drums, bells, cymbals, and xylophones

Acoustics

Teach Key Concepts L2

Wave Interference Affects Sound

Focus State that wave interference in sound waves affects sounds.

Teach Ask: **How do you think destructive and constructive interference affect sound?** *(Destructive interference diminishes or dampens sound. Constructive interference increases loudness and may distort sound.)*

Apply Have students explain how their inferences might be applied in the design of a concert hall. **learning modality: verbal**

Monitor Progress L2

Answers

Figure 16 Reflect sound downward

Assess

Reviewing Key Concepts

1. a. Sound quality results from the blending of a fundamental tone with its overtones. **b.** By increasing the loudness of certain overtones

2. a. Stringed, wind, and percussion instruments **b.** For strings, change the length or tension of a string; for winds, change the length of the air column; for percussion, strike a surface that has a different tension or size. **c.** In a guitar: by plucking the strings harder; In a drum: by striking the drumhead harder.

3. a. The study of how sounds interact with each other and the environment **b.** Curved hard surfaces reflect sound waves and direct them to different parts of the hall. Soft surfaces absorb sound waves and reduce reverberation. **c.** With too little reverberation, instruments would sound thin and distant.

Reteach L1

Call on students to explain how instruments in each of the three groups produce sound.

Performance Assessment L2

Writing Have students describe how acoustics is used in concert hall design.

All in One Teaching Resources

- Section Summary: *Music*
- Review and Reinforcement: *Music*
- Enrich: *Music*

Keep Students on Track Have students experiment with different materials and ways to vary pitch and loudness. Ask them to organize their observations in data tables so they can generalize about the sounds produced by different designs and materials.

FIGURE 16
Concert Hall Acoustics
Surfaces in concert halls are designed with a variety of materials and shapes.
Inferring *What might be the purpose of the curved panels near the ceiling?*

Acoustics

Your surroundings affect the musical sounds that you hear at a concert. To understand this, compare the sound of your voice in different places—in class, outdoors, or in a gym. The differences you hear are due to the different ways that sounds interact. **Acoustics** is the study of how sounds interact with each other and the environment.

Sound waves can interfere with each other. Constructive interference may distort sound, while destructive interference can produce "dead spots" where loudness is reduced. Sound waves interact with the environment, also. For example, if you clap your hands in a gym, you hear echoes after you clap because sound waves reflect back and forth off the hard surfaces. This is **reverberation,** in which the echoes of a sound are heard after the sound source stops producing sound waves. The sound from a handclap can take more than a second to die out in a gym.

Acoustics is used in the design of concert halls to control reverberation and interference. Curved hard surfaces are used to direct sound waves to different parts of the concert hall. Soft surfaces absorb sound waves, reducing reverberation. But some reverberation is desirable. With too little reverberation, instruments would sound thin and distant. With too much reverberation, reflected waves interfere and individual notes become hard to pick out.

Section 3 Assessment

Target Reading Skill **Previewing Visuals** Refer to your questions and answers about Figure 15 to help you answer Question 2 below.

Reviewing Key Concepts

1. **a.** **Describing** How do overtones affect the sound quality of a musical instrument?
   b. **Explaining** How does resonance affect the sound quality of a musical instrument?
2. **a.** **Listing** What are the three groups of musical instruments?
   b. **Summarizing** How is pitch controlled in each group of musical instruments?
   c. **Comparing and Contrasting** How is loudness increased in a drum and in a guitar?
3. **a.** **Defining** What is acoustics?
   b. **Relating Cause and Effect** How is acoustics used in the design of concert halls?
   c. **Making Judgments** Why is some reverberation desirable in a concert hall?

Writing in Science

Explanation A friend e-mails you and asks how your new guitar produces music. Write an e-mail that answers your friend's question. Be sure to explain how you can change pitch, and why the guitar has a hollow body.

Lab zone Chapter Project

Writing in Science

Writing Mode Exposition/How-To

Scoring Rubric

4 Exceeds criteria; includes a lucid, complete, and highly accurate explanation for the question

3 Meets criteria

2 Includes an explanation but contains some errors

1 Includes only a vague description and/or contains serious errors

Changing Pitch

Problem

When you blow across the mouth of a bottle, you can play a "note." What determines the pitch you hear?

Skills Focus

developing hypotheses, controlling variables, designing experiments

Suggested Materials

- 1-L soda bottle
- 2-L soda bottle
- 250-mL graduated cylinder
- metric ruler
- straw
- water

Design a Plan

1. Practice making a sound by using a straw to blow across the mouth of a 1-L bottle. Then blow across the mouth of a 2-L bottle in the same way. Compare the pitches. Record your observations in your notebook.
2. Add 250 mL of water to both the 1-L bottle and the 2-L bottle. Blow across the mouth of each bottle and compare the pitches. Record your observations in your notebook.
3. Analyze your observations from Steps 1 and 2 to predict what may have affected the pitches. For example, measure the height of the air column, and calculate the volume of air in each bottle. (*Hint:* Subtract the volume of water in the bottle from the total volume of the bottle.)
4. Develop a hypothesis about what determines the pitch of the sound produced by blowing across the mouth of a bottle. Record your hypothesis in your notebook.
5. Design an experiment to test your hypothesis. Create a data table to record information about the variables. Write your plan. (*Hint:* You can change the height of the air column in a bottle by changing the amount of water in the bottle.)
6. After receiving your teacher's approval of your plan, conduct your experiment and record the results in your notebook.

Analyze and Conclude

1. **Observing** Describe the pitch of the sound produced by each bottle in Steps 1 and 2.
2. **Designing Experiments** Did your experiment support your hypothesis? Explain.
3. **Controlling Variables** Identify the manipulated and responding variables in your experiment.
4. **Inferring** If you had a 1-L bottle that contained 250 mL of water, what would you do to produce a higher-pitched sound?
5. **Drawing Conclusions** What is the relationship between the height of the air column and the pitch of the sound produced by blowing across the mouth of a bottle?
6. **Communicating** Based on your results, describe how you could use a set of bottles as a musical instrument.

More to Explore

Use a set of tuning forks or a pitch pipe to "tune" five bottles to match the notes C, D, E, F, and G. What can you conclude about the pitches of the five notes from the height of the air column in each bottle? Use the bottles to play the following notes: E D C D E E E D D D E G G E D C D E E E E D D E D C.

Analyze and Conclude

1. The 2-L bottle has a lower pitch than the 1-L bottle. Both bottles have a higher pitch after water is added.
2. Answers will vary but if students hypothesized that the height of the air column detemines pitch, their answer will be yes, because pitch changed as the height of the air column changed.
3. The manipulated variable was height of air column; the responding variable was pitch.
4. Sample answer: Add more water.
5. As height of the air column increases, pitch decreases.
6. Sample answer: Add different amounts of water to several identical bottles to produce all the notes needed to play a song.

Lab zone Design Your Own Lab

Changing Pitch

L2

Prepare for Inquiry

Skills Objectives

After this lab, students will be able to

- develop a hypothesis to explain how the level of water in a bottle will affect the pitch of sound
- design an experiment to test their hypothesis about water level and pitch
- control the variables in their experiment

Prep Time 10 minutes
Class Time 40 minutes

Advance Planning

Obtain a sufficient number of empty 1-L and 2-L soda bottles so that each student has a bottle of each size. Inexpensive pitch pipes can be obtained at most music stores.

Safety

Caution students to immediately wipe up any spilled water. Tell them not to share straws. Review the safety guidelines in Appendix A.

All in One Teaching Resources

- Lab Worksheet: *Changing Pitch*

Guide Inquiry

Invitation

Blow across the top of an empty bottle with a straw. Ask: **How could you change the pitch of the sound produced by the bottle?** *(Students may say by adding water to the bottle.)*

Introduce the Procedure

Use a pitch pipe to demonstrate tones with low, medium, and high pitches. Tell students they will try to produce different pitches by blowing across a bottle.

Expected Outcome

When the bottles are empty, the lowest pitch is produced and the 2-L bottle produces a lower pitch than the 1-L bottle. The pitch increases in each bottle as the water level rises.

Extend Inquiry

More to Explore Note C has the lowest pitch because it has the tallest air column, and pitch rises from notes C through F. The tune is "Mary Had a Little Lamb."