7th Grade Textbook Packet

3/30/2020-4/3/2020

1 The Frontier Wars

BEFORE YOU READ

Reading Focus

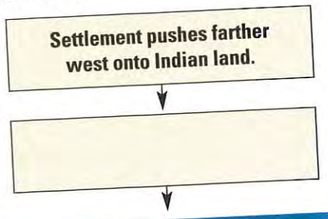
- Why did American officials and many Native American leaders agree that the Indians should move to reservations?
- Why was the Red River War significant?
- What effect did the Frontier Wars have on the Texas Indians?

Key Terms

treaty
extinction

Taking Notes

Copy this chart. As you read the section, fill in the chart with information about the order in which events occurred leading up to the settlement of the frontier. Add as many boxes as you need.



Main Idea After the Civil War, the United States fought a series of wars against the Indians living in Texas. The defeat of the Indians opened West Texas to white settlement.

Experiencing Texas History

In the special activity that accompanies this chapter, you will explore the closing of the frontier.

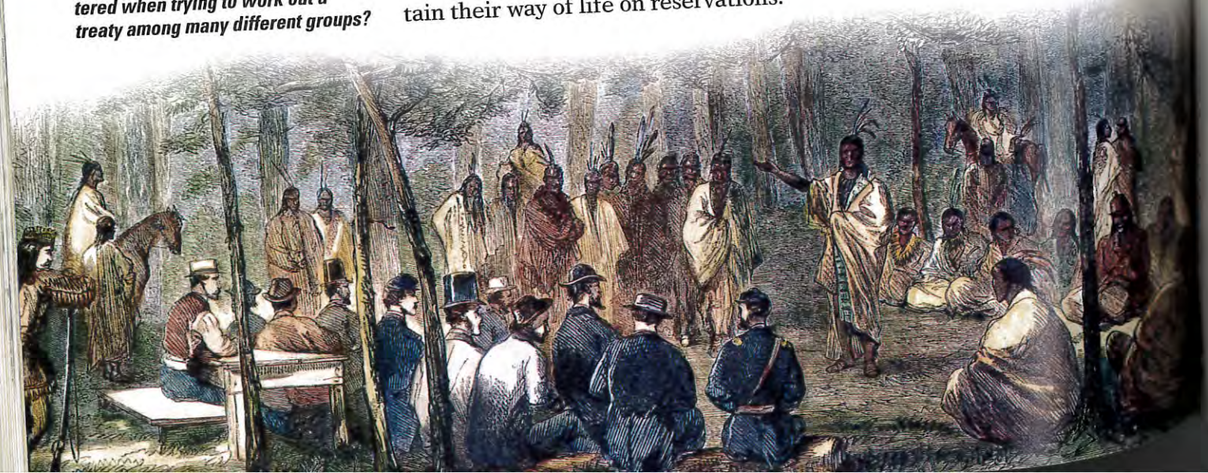
Setting the Scene The United States forced Texas Indians to give up the land on which they had lived and hunted. Ten Bears, a Comanche leader, protested this treatment.

> "My people have never first drawn a bow or fired a gun against the whites. There has been trouble on the line between us and my young men have danced the war dance. But it was not begun by us. . . . If the Texans had kept out of my country, there might have been peace. But that which you now say we must live on is too small. The Texans have taken away the places where the grass grew the thickest and the timber was the best. The white man has the country which we loved, and we only wish to wander the prairie until we die."

Ten Bears spoke movingly about the experiences of his people. However, he was not entirely truthful. He said that the Comanches had never started the violence with white settlers. Both the Comanches and the whites had attacked each other. Ten Bears told the truth about the Comanche way of life, though. They would never be able to maintain their way of life on reservations.

A Troubled Treaty

In 1867, leaders of the U.S. government and several Indian tribes signed the Medicine Lodge Treaty. The Comanches and Kiowas refused to sign the peace agreement, however. **Ask Questions** ***What difficulties might be encountered when trying to work out a treaty among many different groups?***



A History of Conflict

Conflicts with Native Americans developed as soon as the first Europeans arrived in North America. Fighting flared at times between the two groups through the 1800s. After gaining freedom from Spain, Mexico continued the fight against Indians over land in Texas.

Conflicts over land increased when Anglos settled in Texas. The Republic of Texas continued to fight the Indians for land. Under Texas president Mirabeau Lamar, Texans drove the Cherokees out of East Texas. As Anglos moved west, Plains Indians fought to prevent settlers from taking more land.

When Texas became a state, the U.S. Army entered the conflict. Fighting flared up on the Texas frontier through the 1840s and 1850s. The absence of troops in the region during the Civil War weakened frontier defenses. Indians in West Texas and Mexico attacked settlements on the frontier. They pushed the settlers farther east.

Soldiers defending Texas After the Civil War, the U.S. government sent troops to Texas. At first, many of the troops went to enforce Reconstruction. Texans, however, wanted the troops to end the Indian raids. Settlers hoped to reclaim the land along the frontier, which they believed was theirs by right. By tradition, however, the Indians believed that the land was their own.

By 1867, federal troops had moved to forts along the frontier. However, the forts were too far apart to stop Indian raids. Supplying these distant outposts was difficult. Also, Native Americans in West Texas had several advantages over the soldiers. The Indians used hit-and-run tactics with great effectiveness. They rode into battle, fired their arrows, and then rode away. Some Indians also had rifles. The Indians knew the land in Texas well.

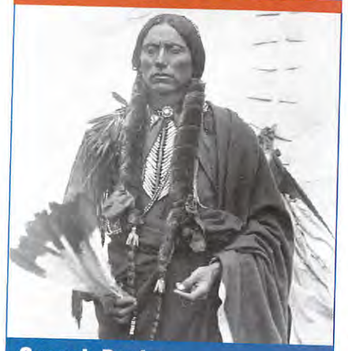
After years of conflict, tribal leaders met with government officials in Kansas in 1867. They signed the Medicine Lodge Treaty. A **treaty** is a formal agreement between two nations. In the treaty, the Indians agreed to move to reservations in Indian Territory (now Oklahoma). They agreed to stop raiding white settlements. In exchange, the government provided them with food and supplies.

Some Native Americans believed that the treaty would bring peace. However, many Comanches and Kiowas opposed the treaty. They wanted to live on the plains as hunters and raiders. The treaty did not bring peace.

U.S. president Ulysses Grant then made another attempt at peace. He sent some Quakers to the Indian reservations. The Quakers used peaceful means, rather than the threat of war, to run the reservations. However, many Indians did not trust any whites. Indian raids continued in Texas and the Quaker peace plan failed.

Reservation policy As the peace policy broke down, fighting continued in Texas. Federal troops could not stop the raids. Many Southerners moved to Texas after the Civil War. They hoped to make their living on the open lands in West Texas. However, with Indians in control of the frontier, settlers could not move into the western part of the state. Texas called for the federal government to do more.

A Texas Profile



Quanah Parker
c. 1845–1911

Quanah Parker lived in two worlds. Comanches had captured his mother, Cynthia Ann Parker, when she was a child. She adopted Indian culture and married a Comanche war chief. In 1860, Texas Rangers killed Quanah's father and captured his mother. Quanah, left behind, went to live with the Quahadi band of Comanches.

Quanah Parker became a skilled warrior and a Quahadi leader. Quanah led a series of raids on Texas settlements. The United States cavalry tracked Quanah and his men but could not capture them. By 1874 buffalo hunters had greatly reduced the Quahadi's food supply. Quanah led an attack on the hunters' camp at Adobe Walls. A year later, Quanah and his starving band of Quahadis surrendered.

Quanah adapted to white culture and helped other Indians do the same. Quanah became wealthy through ranching and investing. He had many important white friends, including President Theodore Roosevelt. Quanah Parker died on February 23, 1911.

In what ways did Quanah Parker live in two different worlds?

AS YOU READ **Monitor Your Reading** Why did troops have little success controlling the Indians?

In 1871, President Grant sent army general William T. Sherman to Texas. Sherman toured the forts on the frontier. Later that year, the Kiowa leader Satanta led 100 warriors to raid a wagon train at Salt Creek. The Indians killed seven teamsters and burned the wagons. This event became known as the Salt Creek Massacre.

The Salt Creek Massacre outraged Texans. It led Sherman to change the army's policy. The army no longer just defended the frontier. Now it tried to move all Indians onto reservations. Sherman ordered the arrest of Satanta and two other Kiowa leaders. Fighting in Texas intensified.

Leaders Several important leaders emerged in the Frontier Wars in West Texas. Sherman, a Union hero in the Civil War, commanded the army. He named General Philip Sheridan to direct the campaign against the Indians. Sheridan was a Union hero, too. He directed five separate field armies against the Comanches and Kiowas in the 1870s.

Colonel Ranald S. Mackenzie led much of the fighting against the Indians. Many thought he was the best Indian fighter in the West. General Nelson Miles led several campaigns against the Indians in Texas. Colonel John Davidson led units in the Panhandle.

Quanah Parker was the son of a Comanche father and a white mother, Cynthia Ann Parker. Quanah Parker became a Comanche warrior and leader. For several years, Mackenzie tried to catch Parker and his forces. During that time, Parker led several successful raids.

Lone Wolf, a Kiowa leader, did not sign the Medicine Lodge Treaty. He opposed settlement on reservations. He, too, led several raids against the Texans.

GEOGRAPHY Skills

1. **Location** *On the map, locate* ***(a)*** *Battle of Adobe Walls,* ***(b)*** *Red River.*
2. **Region** *In which region of Texas did the Red River War take place?*
3. **Critical Thinking Drawing Conclusions** *What caused the Frontier Wars?*

The Frontier Wars

The Frontier Wars in the Panhandle

In 1871, more soldiers arrived to enforce the reservation policy. General Sherman sent more troops to Texas. The soldiers had more horses and better weapons than in the past.

The Native Americans still had advantages of their own. They were skilled at fighting on horseback. By this time, many more of them had rifles. They knew the land well, so they usually fought in areas where they had an advantage.

Strategies To overcome the Native Americans, the army attacked Indian villages. Troops captured food, blankets, and other supplies. They burned the villages and killed the horses.

AmericanHeritage MAGAZINE

HISTORY HAPPENED HERE

Palo Duro Canyon

Palo Duro Canyon is one of the most spectacular landscapes in Texas. It was also the site of the major battle of the Red River War. A dawn raid led by Ranald Mackenzie surprised the Comanches, Kiowas, and Cheyennes camped there. The Texans' victory forced the Native Americans back to their reservations.

Take It to the NET

Virtual Field Trip For an interactive look at Palo Duro Canyon, visit the *Lone Star* section of **www.PHSchool.com.**

The army tried another tactic to defeat Native Americans. It destroyed the buffalo—the major food source for Plains Indians. General Sheridan urged professional buffalo hunters to come to Texas. He even had his new recruits use buffalo for target practice. The army and the buffalo hunters nearly drove the animals to **extinction.** Extinction means complete destruction. Without buffalo to hunt, the Plains Indians could not support their way of life.

Red River War In June 1874, Quanah Parker and Lone Wolf led an attack on a camp of hunters at Adobe Walls. Several hundred Cheyennes, Comanches, and Kiowas surrounded the hunters. The hunters held off the attack with their rifles. After five days, reinforcements arrived. The Indians had to retreat. This became known as the Battle of Adobe Walls.

This battle led to a new campaign—the Red River War—against the Indians in the Panhandle. The Texas Rangers joined the fighting against the Indians and called themselves the Frontier Battalion. Major John B. Jones led this unit of Rangers.

The key battle in the Red River War took place at Palo Duro Canyon. Mackenzie and Miles led their troops against Cheyennes and Comanches. Mackenzie's men captured the Indians' horses and their entire winter food supply. He ordered more than 1,000 horses killed. He then pursued the Native Americans. Without horses, few Indians could escape. At the Battle of Palo Duro Canyon, the southern Plains Indians had made their last effort to resist the white settlers.

Native Americans suffered through the winter of 1874 to 1875. They had lost their winter food supply, buffalo were scarce, and they

had no horses. Indian resistance broke as they starved that winter. In the spring, some Indian leaders surrendered. In June, Quanah Parker surrendered to Mackenzie. The Red River War had ended. Few Indians remained on the Texas plains. Most now lived on the reservations.

The Frontier Wars in Southern Texas

The end of the Red River War did not stop the violence in Texas. Fighting continued in the southern part of the state. Apaches raided Texas settlements in the late 1870s. Outlaws also thrived in these areas. Even after Quanah Parker's surrender, Texas was not at peace.

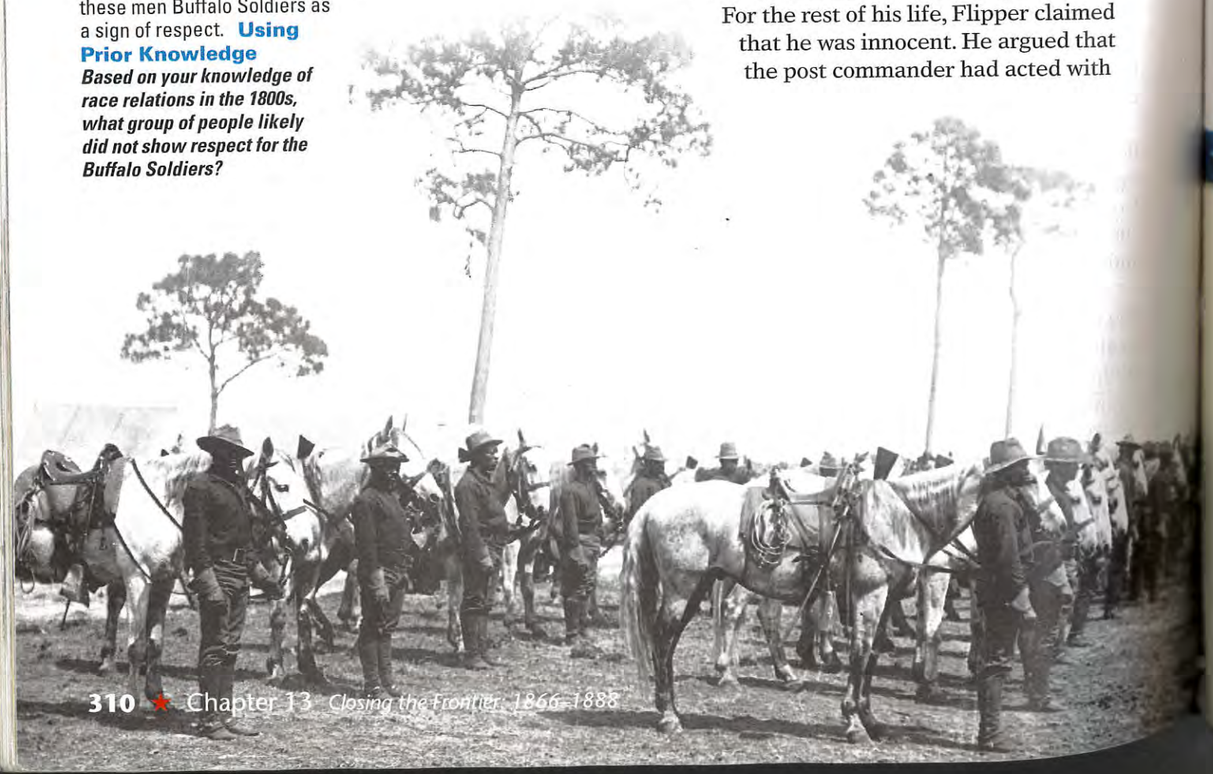
Rio Grande campaigns In 1877, the government ordered the Apaches onto a reservation in Arizona. The conditions there were poor. Tribal leader Victorio and several hundred Apaches left the reservation. They carried out raids across the Southwest and Mexico.

American and Mexican forces pursued the Apache leader. Victorio and his people escaped into Mexico. There, a Mexican force killed him and most of his warriors.

Buffalo Soldiers Two of the units chasing the Apaches consisted of African American troops led mostly by white officers. The Indians called them Buffalo Soldiers—a name of respect. The Buffalo Soldiers fought in many Indian campaigns.

Henry Ossian Flipper was the first African American graduate of West Point. He served on the Texas frontier for four years. Like many in his unit, however, he faced unfair treatment from whites. The army dismissed Flipper in 1882. He was wrongfully convicted of "conduct unbecoming an officer." For the rest of his life, Flipper claimed that he was innocent. He argued that the post commander had acted with bias against him. In 1976, the army granted him an honorable discharge, backdated to 1882.

Buffalo Soldiers
This photograph, taken around 1895, shows African American members of the U.S. Cavalry. Indians called these men Buffalo Soldiers as a sign of respect. **Using Prior Knowledge** ***Based on your knowledge of race relations in the 1800s, what group of people likely did not show respect for the Buffalo Soldiers?***



Outlaws Even with the end of the Indian Wars, Texas was still not a safe place in the 1870s and 1880s. Cattle thieves were common in frontier Texas. Outlaws, such as Sam Bass, robbed stagecoaches and trains. Cattle ranchers and sheep ranchers fought over land. Violence against African Americans and Mexican Americans had risen.

The Texas Rangers responded to this lawlessness. Jones's Frontier Battalion and a Special Force under Captain L. H. McNelly took action. They broke up large cattle rustling groups. Jones and his men tracked down the infamous outlaw Sam Bass.

Much of the trouble centered on an area along the Mexican border, the "Nueces Strip." Bandits raided towns in Texas. Mexicans and Texans battled each other over cattle. Juan Cortina led a ring of Mexican cattle rustlers. He also fought for the rights of Mexican Texans. Many considered him a folk hero. The Rangers greatly reduced cattle stealing along the border. However, racial tensions remained high.

The war ends After January 1881, Indian resistance in Texas ended. This brought a close to more than 300 years of warfare.

The Texas Frontier Wars had a terrible effect on the Indians. In fighting to protect their tribal lands, many Indians died in battle. Many more died from hunger and diseases such as smallpox and cholera. Forced from their homes, they had to live on reservations of poor arid land. They lost their traditional way of life. A few Indians, like Quanah Parker, adapted and even prospered. Most Indians, like Satanta, were not happy on the reservations.

Victory in the Frontier Wars opened the entire state to white settlers. Cattle ranchers moved into West Texas. New railroad lines crossed all parts of the state. Settlers built homes, schools, and churches. The Texas frontier had closed.

Primary Source

The Extermination of the Buffalo

The killing of the buffalo in the 1870s forced the Indians to yield to U.S. forces. John R. Cook, a hunter, describes the activities of one group on a hunt.

"Too late to stop and moralize now. And sentiment must have no part on our thoughts from this time on. We must have these 3,361 hides that this region is to furnish us inside three months, within a radius of eight miles from this main camp. . . . Hart started out, and in two hours had killed sixty-three bison. . . . We then had stacked up and drying 2,003 hides; 902 of them I had skinned, and was so accredited. This was an average of 22 buffaloes a day for 41 days. At 25 cents per hide I had earned $225.50."

—*The Border and the Buffalo*, John R. Cook

Analyzing Primary Sources ***How do you think the author feels about the killing of the buffalo?***

AS YOU READ **Summarize** How was the ongoing conflict between Native Americans and white settlers finally resolved by the 1880s?

AFTER YOU READ

Section 1 Assessment

Recall

1. **Define** **(a)** treaty, **(b)** extinction.
2. **Identify** Explain the significance of each of the following: **(a)** Medicine Lodge Treaty, **(b)** Ranald Mackenzie, **(c)** Battle of Palo Duro Canyon, **(d)** Victorio.

Comprehension

3. What advantages did the Indians have when fighting the U.S. soldiers?
4. How did the Salt Creek Massacre affect the policy of the U.S. army?
5. How did the widespread killing of buffalo affect the Plains Indians?
6. What led to the start of the Red River War?

Critical Thinking and Writing

7. **Exploring the Main Idea** How did the Frontier Wars affect Native Americans?
8. **Identifying Points of View** Explain why some Indians rejected the Medicine Lodge Treaty and chose to remain at war with Americans.

ACTIVITY

Take It to the NET

Problem Solving

You are a government official who must make peace between the Indians and whites in Texas. How can you reach an agreement that is fair to both sides? For help in starting this activity, visit the *Lone Star* section of www.PHSchool.com.

BEFORE YOU READ

2 Cattle Kingdoms

Reading Focus

- Who first established the cattle industry in Texas?
- What hardships did cowboys face on the trail?
- Why did the big cattle drives end in the 1880s?

Key Terms

vaqueros
lariats
quarantine
drovers
remuda
mustang

Taking Notes

Copy this outline. As you read the section, fill in the major causes and effects of the rise of the cattle kingdom in Texas. Under each heading, add additional subheads where needed.

Causes
1. Civil War begins
   a.
   b.
2. Civil War ends
   a.
   b.

Texas cattle kingdom emerges

Effects
1.
2.
3.

Main Idea The Texas cattle industry enjoyed huge growth after the Civil War. This led to large cattle drives and the establishment of vast cattle ranches.

Setting the Scene Frank Hastings was a prosperous rancher. Yet he had difficulty putting together a crew for a cattle drive. He described the problems.

> "The foreman and wagon boss had been through the aggravating experience of getting an outfit together. It had been no trouble to find riders, but to secure a cook, a 'hoss wrangler,' and a hoodlum wagon driver was a problem. No one wants to drive the hoodlum wagon, with the duties of supplying wood and water for camp and branding, helping the cook with his dishes or other odd jobs. The 'hoss wrangler' was not hard to find, but whoever takes the job aches all the time to be promoted to a riding job, and is therefore dissatisfied."

The life of a cowboy on the cattle trail was hardly glamorous. It was hot, dusty, and often tiring work.

Spanish Origins

Spanish explorers had first brought cattle and horses to what is now Texas. By 1774, about 25,000 Spanish cows and steers were in the Nueces Valley. Some of them escaped and roamed wild on the plains. Over time, these Spanish cows mixed with the heavier animals brought by the Anglos. This resulted in the lean and tough Texas longhorn. They grew horns up to eight feet wide from tip to tip. Within 40 years, nearly a million wild longhorns roamed the Texas landscape.

South Texas was ideal for raising cattle. Vast grasslands covered the Nueces Valley. It rarely snowed there, so the cows always had green grass. Spaniards allowed their cattle to roam the grasslands. They marked their cows with a brand to show ownership.

Spanish **vaqueros** (bah-KEH-rohz), or cowboys, developed skills in riding, roping, herding, and branding. They wore broad-brimmed hats to provide shade from the sun. Chaps protected their legs from thorns. Saddles with horns carried the cowboys' rope, blanket, rifle, and canteen. Spanish cowboys used **lariats** to round up cattle from horseback. A lariat is a long rope with a noose at one end.

The first cattle ranchers in Texas Spanish priests and soldiers were the first cattle ranchers in Texas. In the 1820s, Anglos entered the cattle business. Americans brought their own heavier breed of cattle, which they called the "Texas." The first Anglos in Texas herded on foot. They kept their cattle within fences and did not brand them. Soon, the Americans adopted many ways of the Spanish-Mexican vaqueros.

A few Americans built ranching fortunes before the Civil War. James Taylor White gathered a herd of longhorns in the 1820s. Later, he sold cattle in New Orleans. Edward Piper drove 1,000 cattle to Ohio in 1846. Vast cattle empires emerged. Richard King bought 75,000 acres of land in South Texas in 1852. King's future partner, Mifflin Kenedy, also had a large ranch in South Texas. H.L. Kinney started his cattle empire at the same time. Samuel Maverick let his cattle roam the plains without branding them. Unbranded cattle that roamed the plains were soon known as "mavericks."

AS YOU READ **Summarize** How did the Spanish establish cattle ranching in Texas?

Early ranchers in Texas faced many problems. Drought, disease, and theft were constant risks. Ranchers had trouble finding markets for their stock. Ranchers shipped some cattle to Chicago, but the distance was great and transporting cattle was difficult. Some businesses tried to ship cattle from the Texas coast by steamboat. They generally failed.

Influence of the Civil War The Civil War changed the Texas cattle industry. The Union blockade took its toll on the Confederacy during the war. The need for food in the Southern states increased the demand for Texas beef. The Confederate Army also needed food.

Texans could not take full advantage of the increase in demand. The Union blockade made it difficult to move cattle by ship. Union armies had cut Texas off from the Confederate states in the East. Ranchers had no way to ship their beef out of the state. The industry declined as wild longhorns roamed the plains untended.

The end of the war marked the beginning of the cattle boom. New markets opened for Texas ranchers. Both armies had fed their troops beef during the war, which helped it become a staple of the American diet. As the nation's population grew, demand for beef soared.

The demands of the Civil War had sharply reduced the cattle herds in the Northern states. Meanwhile, Texas cattle had multiplied during the war. By 1865, between three million and six million wild, unbranded longhorns roamed the Texas plains. Longhorns were worth $3 to $4 in Texas, but they sold for $30 to $40 in the East. A large supply and a high demand for beef created great profits for Texas ranchers. The cattle boom helped Texas recover from the war.

Cattle Trails

The Northern demand for beef led to the rise of the cattle trails. A cattle drive began with a roundup, which took place in the spring when grass was green. Cowboys then drove the herds north to towns with rail

Cash Cows
As demand for beef increased, so did the price. Some people, such as the author of the book shown here, saw a chance to get rich.
Identifying Cause and Effect
What led people to go into the cattle ranching business?

stations. The cattle were then sent by rail to the Northern states, where they would be slaughtered for meat. Ranchers could make big profits moving a herd to market.

Problems Texans first drove large herds north in the spring of 1866. The trail went to Sedalia, Missouri. The cowboys on this trail faced big problems. Bandits stole cattle. Farmers complained that the cattle trampled their crops and that the longhorns spread a disease called Texas fever to their cows. Longhorns were immune to the disease, but they could spread it to other cattle. Angry farmers in Missouri tried to turn back the herds. Some states passed **quarantine** laws to keep Texas cattle away from settled areas. To quarantine means to isolate or separate to prevent the spread of disease.

The future of the cattle industry was in doubt. An Illinois cattle buyer, Joseph McCoy, persuaded the Kansas Pacific Railroad to run its tracks to Abilene, Kansas. McCoy also urged Kansas leaders not to enforce the quarantine laws. His plan worked. **Drovers** moved 35,000 head to Abilene. A drover is a person who moves livestock to market.

AS YOU READ **Ask Questions** What might have happened to the Texas cattle industry if Joseph McCoy had not stepped in?

Famous trails Ranchers called the route from Texas to Abilene, Kansas, the Chisholm Trail. Jesse Chisholm had used the same route to ship goods north from Texas to Kansas. In 1871, about 600,000 cattle moved north on the Chisholm Trail. By 1884, five million Texas cattle had traveled over the Chisholm Trail.

In 1874, the Great Western Trail developed to the west of the Chisholm Trail. Drover John T. Lytle established this route through Indian Territory to Dodge City in western Kansas. The trail then ran north to a rail station in Nebraska.

A third major cattle trail grew even farther west. The Goodnight-Loving trail ran from West Texas through New Mexico, then Colorado, and into Wyoming. Charles Goodnight and Oliver Loving blazed that trail. They chose the route to avoid hostile Plains Indians.

Towns quickly grew up along the major trails. The towns gained reputations for their violence and lawlessness. Ranchers and northern shippers made business deals in these towns.

Life in the Saddle
Cowboys drove cattle across miles of land to reach towns with rail centers, such as Abilene, Kansas.
Drawing Inferences ***Based on the photograph, what hardships did cowboys face on the trail?***

Life on the trail Cowboys rounded up the cattle into a central camp in early spring. There, they branded the animals and divided them into herds. Herd sizes varied. A typical trail herd numbered about 3,000 head.

A manager, or trail boss, planned the cattle drive. He decided how many men and horses would be needed. The number of men on a cattle drive ranged from 11 to 18. This included a cook and a scout. To ensure that the horses stayed fresh, the cowboys needed 50 to 60 good horses. Cowboys called the group of spare horses the **remuda** (reh-MOO-dah).

The trail boss picked the route and was responsible for the success of the drive. He made $100 or more for a month of work. Cooks received about $75. Horse wranglers made $50 a month. Waddies, or trail hands, earned $25 to $40 a month.

Two skilled cowboys, called pointers, led the cattle. Two or three more cowboys rode on each side, or flank, of the herd. Several more rode behind the herd, the worst position on a drive. Cowboys in the rear rode into the dust kicked up by the herd. Those riding drag—at the rear—also had to make sure the weaker animals did not fall behind.

A herd moved about 10 to 15 miles a day. The cattle sometimes broke into a stampede. Storms, dust, and heat made life unpleasant on the trail. Even after a long day in the saddle, work was not over. Each cowboy (except the boss, cook, and horse wrangler) spent two hours each night on guard duty.

Most cowboys were in their teens to mid-20s. They often had a small build. Large men were too heavy on the horses. About two out of every three cowboys was an Anglo. The remaining third were African Americans, Tejanos, or Mexicans. Indians also rode the trail. Although rare, a few women also rode on cattle drives.

One of the most famous African American cowboys was Bose Ikard. He rode with Goodnight for four years. Matthew Hooks became famous for breaking, or taming, horses. Daniel Webster Wallace earned the nickname "80 John" by branding a large "80" on cattle for rancher John Nunn. Wallace later bought his own ranch. His estate was worth more than a million dollars.

Few Mexican American cowboys led their own drives north. They usually worked for Anglo trail bosses. Miguel Gutiérrez was one of the Mexican Americans who owned his own ranch in southern Texas. Some large Mexican American ranches had as many as 25,000 head of cattle.

Although there were few of them, some of the women who rode the trail became rich and powerful in the cattle industry. Lizzie E. Johnson Williams was an early Texas "cattle queen." She may have been the first woman to ride the Chisholm Trail with a herd under her own brand. Margaret Heffernan Borland took over the family cattle business after her husband died. In 1873, she became the only woman to lead a cattle drive.

The daily life of cowboys was less glamorous than what is shown in the movies. Riding the trail was often boring, dirty work. Cowboys spent up to 36 hours straight in the saddle. They faced many dangers and hardships. Rainstorms, stampedes, extreme heat, rattlesnakes, and river crossings were part of trail life. Indian and bandit attacks added to the dangers.

Primary Source

On the Trail During a Drought

Andy Adams's 1903 book, The Log of a Cowboy, *gave one of the first real-life accounts of cowboy life. In this selection, Adams and his fellow cowboys are driving a herd of cattle to market during a drought.*

"Good cloudy weather would have saved us, but in its stead [place] was a sultry morning without a breath of air, which bespoke another day of sizzling heat. . . .Over three days had now elapsed without water for the cattle, and they became feverish and ungovernable. The lead cattle turned back several times, wandering aimlessly in any direction. . . . They would surge hither and yon, sometimes half a mile, as ungovernable as the waves of an ocean. . . . For the first time a fact dawned on us that chilled the marrow in our bones—*the herd was going blind.*"

—*The Log of a Cowboy,* Andy Adams

Analyzing Primary Sources
How did the drought affect the cattle?

AS YOU READ **Predict** How do you think large ranches will affect the frontier?

Big Ranches

By the late 1870s, land and cattle companies owned over half the land in West Texas. Ranchers soon enclosed nearly all the rangeland in South and Southwest Texas. This brought an end to the big cattle drives.

Kenedy, King, and Goodnight Huge ranches spread across Texas. Richard King started with 15,000 acres in Nueces County in 1852. A few years later Mifflin Kenedy joined him. They bought more land. When King died in 1885, he owned more than 600,000 acres. His son-in-law, Robert Justus Kleberg, and widow, Henrietta King, more than doubled the size of the ranch. The King ranch grew to more than one million acres—about as large as the state of Rhode Island. Large ranches like

Wild Horses
This illustration, created in 1834, shows cowboys using lassos to capture wild horses. **Analyzing Images** ***How does the artist show that the horses are wild?***

Charles Goodnight's JA Ranch covered more than one million acres by the late 1880s. The ranch supported about 100,000 cattle. Goodnight improved his cattle through careful breeding. His ranch produced some of the nation's finest beef. The XIT Ranch was another large Panhandle operation. It enclosed more than three million acres, surrounded by almost 6,000 miles of barbed wire fence. The XIT Ranch was almost as large as the state of Connecticut. A group of investors from Chicago owned the XIT. They had received the land after building a new capitol in Austin in 1888.

The sheep industry also thrived in Texas. Central and South Texas became popular areas for sheep ranchers. By 1886, Texans owned nearly five million sheep. Goat ranching also expanded in Texas in the late 1800s. Some Texans owned **mustang** ranches. Mustangs, or wild horses, had been in Texas since the Spanish brought them to the area in the 1500s. Thousands were on the plains in the mid-1800s.

Cowboy legend and reality The cowboys who rode the trails became legendary, hailed as heroes of the West. Songs, books, and movies celebrated their lives. Americans still dress like they did. Children play games in which they pretend to be cowboys. Many people regard the cowboy as a self-made adventurer who tamed the frontier. The reality for cowboys was very different.

Many stories developed around cowboys. In fact, cowboys generally did not fight with Native Americans. Drovers tried to avoid Indians. Cowboys wanted the army to eliminate the threat of Indians. Not all cowboys carried guns. Few bosses allowed waddies to carry guns. An accidental shot could start a stampede. Many more cowboys have died in the movies than met that fate on the trail.

AS YOU READ **Summarize** How did the growth of the cattle industry affect Texas cowboys and ranchers?

AFTER YOU READ — Section 2 Assessment

Recall
1. **Define** **(a)** vaqueros, **(b)** lariats, **(c)** quarantine, **(d)** drovers, **(e)** remuda, **(f)** mustang.
2. **Identify** Explain the significance of each of the following: **(a)** Joseph McCoy, **(b)** Charles Goodnight, **(c)** XIT Ranch.

Comprehension
3. Who first brought cattle into Texas?
4. Why did cattle drives take place?
5. What was life really like for cowboys on cattle drives?

Critical Thinking and Writing
6. **Exploring the Main Idea** Why did the cattle industry enjoy a period of great growth after the Civil War?
7. **Summarizing** How did the growth of the cattle industry lead to the end of the cattle drives?

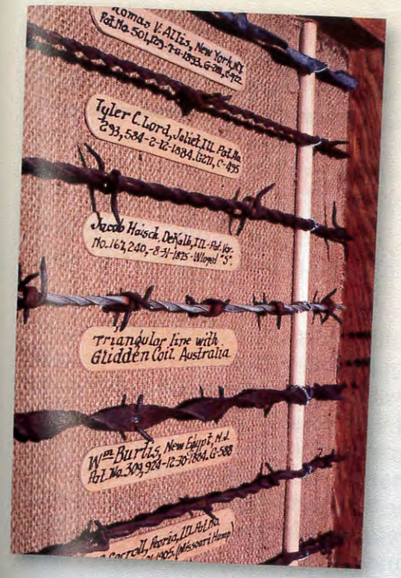
ACTIVITY

Writing a Letter
You have just completed a cattle drive. Write a letter home describing your experience on the trail. Include a description of everyday life as well as some of the uncommon events that occurred on a drive.

BARBED WIRE

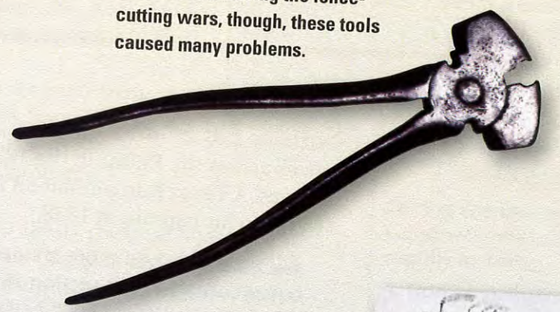
Life on the open prairies changed in the late 1870s. A need for cheap and lightweight fencing material led to the invention of barbed wire. In 1875, Joseph Glidden's barbed wire appeared in Texas. Within a few years, sales soared and miles of barbed wire began enclosing the open range.

Study the photographs and read the descriptions. Then answer the questions that follow.



▲ The "Tribute to Barbed Wire" monument at the Devil's Rope Museum in McLean includes two 370-pound balls of barbed wire. Other museum exhibits include the history of cattle brands and cowboy tools.

▼ Wire cutters were essential tools for ranchers. During the fence-cutting wars, though, these tools caused many problems.



▶ Joseph Glidden was not the only person to design a barbed wire fence. Yet his product became the best-selling barbed wire on the market. This advertisement shows a portrait of Glidden above an image of his famous fencing material.

Skills Assessment

1 Which of the following is an exhibit at the Devil's Rope Museum?
- A history of Texas trains
- B history of the Texas navy
- C history of cotton farming
- D history of cattle brands

2 Why is Joseph Glidden's barbed wire so well known?
- A it was the strongest
- B it was the least expensive
- C it was the best-selling
- D it was the first on the market

3 **Critical Thinking** **Drawing Conclusions** How might advertising have helped Glidden to become more successful than his rivals?

BEFORE YOU READ

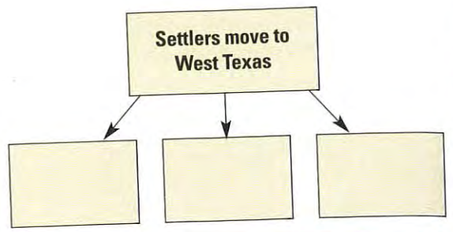
Reading Focus

- Why did many people stream into West Texas in the 1870s?
- What were the fence-cutting wars?

Key Terms

enclosures
felony

Copy this chart. As you read the section, fill in the empty squares with the effects of settlement on West Texas.



Main Idea After the Civil War, thousands of Texans moved west, leading to the closing of the frontier.

Setting the Scene As ranchers began putting up barbed wire fences across the Plains in the 1880s, fence cutting became widespread in Texas. A Texas Ranger named Ira Aten proposed a drastic solution in a letter to his captain in 1888.

> "I have only one more chance with any hopes of stopping fence-cutting in this section & that is with my dynamite boom as I call it. . . . I will have my boom set & when the fence is cut, why they will hear of it in Austin . . . it will scare them so bad that they will never cut another fence. . . . Don't be uneasy about my actions for I will use the greatest precaution with my boom's & see that no innocent men get's hurt with them. . . . However, if I get blowed up, you will know I was doing a good cause."

Ranchers and farmers put up mile after mile of barbed wire fence in the 1870s and 1880s. The open range was disappearing.

The Western Frontier After the Civil War

At the time of the Civil War, Anglos had settled less than half of Texas. The troops who guarded the frontier left Texas to fight in the war. With the absence of soldiers, Native Americans raided white settlements and

Train Traveling to Texas
Some people came to Texas in wagon trains. These travelers faced many challenges, including river crossings and confrontations with Native Americans. **Drawing Inferences** ***Why might travelers choose to join a large wagon train rather than travel alone?***

600,000. The state's population doubled between 1870 and 1880. By 1900, more than three million people lived in the state. The open lands of West Texas seemed ripe with opportunity. Many Texans hoped to make their fortunes in the unsettled lands. Settlers could acquire land cheaply in Texas. A married settler could easily acquire a homestead of 160 acres. He only had to agree to live there for three years.

Western settlement After the Frontier Wars, Texans moved west in large numbers. Many Americans believed that it was God's will for them to expand into new areas. Settlers used the idea of manifest destiny to justify forcing Indians off the land.

Hundreds of people traveled west through Texas on wagon trains in the 1840s and 1850s. Some used the Butterfield Overland trail that ran near Fort Davis. Some settlers traveled all the way to California.

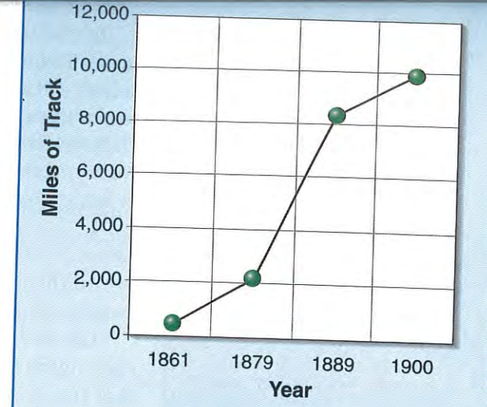
Ranchers and farmers move west In the 1870s, the goal of some of the covered wagons was to reach West Texas. Cattle and sheep ranchers led the way in settling West Texas. Cattle ranchers saw great future profits in putting millions of longhorns out on the plains.

Farmers followed close behind the ranchers. Without timber, the settlers lived in sod houses. Rattlesnakes and rodents often invited themselves into these dwellings. Settlers had to burn hay, cornstalks, and buffalo dung for fuel. They ate wild game, such as rabbits, turkeys, and quail. Grasshopper swarms and blizzards added to the hardships.

Western populations Despite the problems, settlements and towns grew up across the region. The number of Tejano settlers in West Texas was about equal to the number of Anglo settlers at that time.

Settlers often lived long distances from one another. They tried to overcome this isolation through social events such as quilting bees and house-raisings. People often traveled miles in their wagons to attend a religious service. Most Anglos were Protestant. Baptist and Methodist churches were the most popular in the area. Most Tejanos were Catholic and attended Catholic churches.

Railroad companies promoted the settlement of West Texas by building lines through the region. In 1870 Texas had only 583 miles of track. By 1900, there were 10,000 miles of railroad in Texas.



GRAPHIC ORGANIZER Skills

During the time of western expansion, railroads grew rapidly in Texas.

1. **Comprehension** *About how many miles of track were built in Texas between 1879 and 1889?*
2. **Critical Thinking Drawing Inferences** *Why do you think that westward expansion led to an increase in railroad tracks?*

Geography

AS YOU READ **Monitor Your Reading** How did the Civil War change conditions on the frontier?

The Closing of the Western Frontier

The removal of the Indians from West Texas ended the violence between Indians and white settlers on the plains. However, disagreements flared up among the new residents on the open plains. These conflicts usually involved land.

Promoting the Promised Land
Railroads used advertisements, such as the one shown here, to encourage people to move to Texas.
Analyzing Images ***What claims does the advertisement make to encourage people to move to Texas?***

Barbed wire In 1874, an Illinois farmer, Joseph Glidden, acquired a patent for a popular design of barbed wire. The metal wire was light, strong, and cheap. Texans bought five tons of barbed wire in 1874. Six years later, they bought 40,000 tons. Barbed wire changed Texas forever.

In the 1880s, ranchers strung thousands of miles of barbed wire across Texas. Some fences blocked roads and interfered with mail delivery. Ranchers put up fences to protect their cattle. Within the **enclosures,** fenced-in areas, they controlled the breeding of their animals. Windmills enabled ranchers to provide water for their cattle. Farmers later put up fences to protect their crops. The open range in Texas ceased to exist in the 1880s. It had been fenced in.

Fence cutting wars The widespread use of barbed wire fences helped to end the cattle drives. Cut off from the grasslands, landless cattle owners could not compete with the ranchers and their fences.

Landless cattle owners resorted to cutting fences. War erupted once again on the Texas range. In 1883, a Texas newspaper estimated that fence cutting occurred in half of the state's counties. Fence cutters sought a return to the open ranges where cattle had access to grass and water. Fence cutters threatened ranchers and burned their pastures.

Fence cutting caused damage estimated at $20 million. Texas governor John Ireland called a special session of the legislature to deal with the problem. In 1884, Texas passed a law making it a **felony** to cut a fence. A felony is a serious crime that usually results in a jail sentence.

The fence laws reduced the number of cutting incidents. However, fence cutting still occurred regularly in some areas. The Texas Rangers often went undercover to catch fence cutters. One Ranger even set traps with dynamite. The trap exploded if the wire was cut or the fence was torn down. By the end of the decade, the Rangers brought an end to the fence cutting wars.

The frontier closes By the end of the 1880s, the frontier in Texas had disappeared. Native Americans no longer hunted buffalo on the plains. Cowboys no longer drove herds of cattle north. Railroads, telegraph wires, and fences crossed West Texas. An era had ended, but the legacy of the frontier left a lasting mark on America and its culture.

AS YOU READ **Summarize** What factors led to the closing of the frontier in Texas?

AFTER YOU READ — Section 3 Assessment

Recall
1. **Define** **(a)** enclosures, **(b)** felony.
2. **Identify** Explain the significance of the following: **(a)** sod houses, **(b)** Joseph Glidden, **(c)** John Ireland.

Comprehension
3. What groups of people moved to West Texas after the Civil War?
4. What hardships did settlers face in West Texas?
5. Why did some Texans cut fences in the 1880s?

Critical Thinking and Writing
6. **Exploring the Main Idea** What attracted settlers to West Texas?
7. **Identifying Points of View** Why did Texas ranchers put up fences around their property?

ACTIVITY
Problem Solving
You are a Texas Ranger assigned to stop the fence cutting war. How would you end the incidents? Your plan should be safe, and any punishment should fit the crime.

SKILLS FOR LIFE

Problem Solving

You face problems every day. Some may be small, such as what to eat for lunch. Others are more complex, such as how to travel to a place you've never been before. Although the situations are different, you can deal with them in similar ways.

Charles Goodnight, one of the most famous Texas ranchers of the late 1800s, wrote a vivid description of a cattle drive. Read the passage below. Then think about the problems faced on such a trip and about possible solutions.

"In laying off [blazing] a trail, the foreman or the owner of the cattle would ride ahead twenty or thirty miles—that is, if he did not find water sooner. He rode a good horse and explored both sides of the way. . . . If he found that he was striking a desert, he would return to the herd and inform the men what they should expect. Then they knew that the cattle were to be moved with all possible speed. . . . The owner then changed horses and rode on ahead once more until he found water. . . . This was kept up until our destination was reached. Our trail was now established and two or three more drives would plainly mark it."

—Charles Goodnight, "Managing a Trail Herd"

Learn the Skill *To solve a problem, keep the following guidelines in mind:*
- **Identify** the problem.
- **Decide** how serious the problem is. Is the problem so serious that it needs an immediate solution? What might happen if the problem were allowed to continue?
- **Consider** several possible solutions. Which would be the most effective? Which would be the easiest to carry out?
- **Decide** which is the most effective solution.

Practice the Skill *Read the selection, then answer these questions.*
1. What problem did Charles Goodnight write about?
2. How big a problem was this for cattle drovers? Explain your answer.
3. What are some possible solutions to this problem?
4. Of the solutions you devised, which is likely to be the most effective? Why is that the best solution?

Apply the Skill *To apply this skill, see the Chapter Review and Assessment.*

4 The Texas Rangers

BEFORE YOU READ

Reading Focus

- What caused Stephen F. Austin to raise a force of Rangers in 1823?
- How did the Texas Rangers change under President Lamar?
- What were the main tasks of the Rangers during the 1870s?

Key Terms

dragoons
guerrilla
desperados

Taking Notes

Copy this incomplete outline. As you read the section, fill in the outline with the role of the Rangers during each time period.

A. Texas Revolution
   1.
   2.
B. Lamar Administration
   1.
   2.
C. Mexican War
   1.
   2.
D. Civil War
   1.
   2.

Main Idea The Texas Rangers worked to enforce the law—but they did not protect all Texans equally.

Setting the Scene John Armstrong spotted John Wesley Hardin sitting in the train car. Hardin was one of the most feared gunmen in the West. He had reportedly killed more than 30 men. Seated next to Hardin were four members of his gang. Armstrong drew his Colt .45 revolver and slowly walked down the aisle of the train car. The Texas Ranger commanded Hardin and his gang to surrender.

Hardin recognized Armstrong's weapon as a favorite of the Rangers. He exclaimed, "Texas, by God!" and reached for his own gun. One of his gang members fired at Armstrong, knocking off his hat. The Ranger killed him with a single shot. Hardin then kicked Armstrong. The Ranger struck Hardin over the head with his revolver, knocking him out. Armstrong then disarmed the other gang members.

The Rangers helped enforce the law in frontier Texas. However, their tactics were often violent.

The Rangers' Organization

In 1823, Stephen F. Austin raised a small force of experienced frontiersmen as Rangers to protect the settlers against Indians. Even so, Indian raids on the frontier increased. Tensions with Mexico mounted. People wanted protection. In 1835, lawmakers in Texas formally organized the Texas Rangers to better protect the frontier. The Rangers served both as a special police force and as a military unit.

Characteristics The original Texas Rangers consisted of 56 men organized into three companies. A major led each company. The major enlisted new recruits into the Rangers and enforced the company's rules. He reported to the commander in chief of the regular Texas Army.

Officers' pay, $1.25 per day, was the same as **dragoons,** or mounted soldiers, in the U.S. Army. Rangers provided their own horses. They also supplied their own weapons, equipment, and rations. Rangers refused to wear standard uniforms. The men who joined the Rangers were usually young, single men with few family ties. They often retired by the age of 30.

Lone Ranger
Texas Ranger John Coffee Hays first gained fame as an Indian fighter. This oil painting depicts the skirmish at Enchanted Rock, where he stood alone against a band of Comanches. **Analyzing Images** *How might Hays's location have helped protect him?*

Skills The Rangers' main task was to protect settlers from Indian raids and attacks by Mexicans. Most Rangers, like most Texans, wanted the Indians out of the state.

The Rangers adopted the tactics of their enemies. Like many Indians, they became skilled horsemen. They developed expert marksmanship and tracking skills. Riding, tracking, and shooting became the Rangers' hallmark.

Weapons of War
Superior weapons often enabled the Texas Rangers to defeat large groups of Indians. **Comparing** ***What are the differences between the weapons of the opposing sides?***

The Rangers in Action

In time, the Texas Rangers gained a national reputation as an elite force. They evolved slowly, however. The group saw little combat in the Texas Revolution. It was during Mirabeau Lamar's administration that the Rangers saw real action.

The Rangers during the Texas Revolution In the Texas Revolution, the Rangers aided the war effort as scouts and messengers. During the Runaway Scrape, Rangers helped people flee from the Mexican army (even though that was against the government's policy at the time). Their glory days had not yet arrived.

The Rangers under Lamar's administration President Lamar wanted all Native Americans removed from East Texas. He called for a larger force of Texas Rangers. Henry Karnes played a major role in this effort.

In 1839, the Rangers mounted a full-scale war against the Cherokees and Comanches of Texas. Karnes, John Coffee "Jack" Hays, and Ben McCulloch were important Ranger officers in these battles. The Rangers' campaign reduced the Indians' strength in East Texas.

Sam Houston returned to the presidency in 1841. By then, he understood the value of the Rangers in defending the frontier. Houston used the force more than he had before. Hays rose to the rank of major in the 1840s. He trained his men in frontier warfare. From 1840 to 1846, Hays and his Rangers fought many battles against Indians and Mexicans. Famous Ranger captains who served under Hays included Ben and Henry McCulloch, Samuel Walker, William A. A. "Big Foot" Wallace, and Robert Addison "Ad" Gillespie.

The Rangers and the Mexican War In 1846, the United States declared war against Mexico. The Texas Rangers played a major role in this conflict. Hays's Rangers served as the cavalry for General Zachary Taylor's army.

The Texas Rangers scouted Mexican troop movements. They found the best route for Taylor's army to reach Monterrey. In 1847, the Rangers helped the U.S. forces win the Battle of Buena Vista.

The Rangers also faced combat in Mexico. **Guerrilla** fighters took a heavy toll on U.S. troops and supplies. Guerrillas are soldiers who are not part of the regular army. They usually fight behind enemy lines.

AS YOU READ **Drawing Inferences**
How did adopting the tactics of the Indians help the Rangers?

The Texas Rangers became famous for their actions in the Mexican War. Many Americans saw them as fierce fighters. Songs and stories celebrated their deeds. However, not all Rangers were particularly noble. Some committed outright murder, while others remained undisciplined law enforcers. Many Mexicans called them *los diablos Tejanos,* meaning "the Texas devils."

The True Value of the Rangers

After the Mexican War, the U.S. Army guarded the frontier. The Rangers had no official function. The Texas government did not want the expense of maintaining a large Ranger force. Many of its best men left the force. This would prove to be devastating to the safety of the frontier.

AS YOU READ **Monitor Your Reading** How did the Civil War confirm the importance of the Rangers in Texas?

The Rangers in the Civil War The outbreak of the Civil War caused more men to leave the force. They went off to fight in the Confederate Army. The Rangers did not fight together as a group, though. The Eighth Texas Cavalry went by the name Terry's Texas Rangers, but it was not connected to the Texas Rangers. Its founder, Benjamin Terry, had never been a Texas Ranger.

While the former Rangers fought in the Civil War, frontier defense weakened. In 1862, the state created a Frontier Regiment of Rangers to provide protection from Indian attacks. This force was ineffective. The best fighters served in the war. Only old men and young boys remained to defend the frontier. After the war, U.S. soldiers and the short-lived state police took charge of defense and law enforcement. It was clear, though, that Texas still needed the Rangers.

The Rangers bring order back to Texas The absence of the Rangers during the Civil War made Texas an unsafe place. Outlaws robbed banks and rustlers stole cattle. Native Americans staged raids on the frontier. Mexican bandits attacked Texas towns. In 1874, the Texas legislature created two groups of Texas Rangers to combat these problems. The Frontier Battalion under Major John B. Jones fought Indians. The Special Force led by Captain Leander H. McNelly dealt with the disorder along the Mexican border.

Catching Crooks
A Texas Ranger's most important possessions for law enforcement were his horse and his guns.
Linking Past and Present
What types of equipment do modern law enforcers use to catch outlaws?

Keeping the peace Jones led a Frontier Battalion of six companies. In its first 17 months, the battalion fought 21 Indian battles. By 1875, the Rangers had helped federal troops break the power of the Comanches and the Kiowas along the frontier.

In the spring of 1875 McNelly's Special Force of 40 men went to the Nueces Strip. The area was a hotbed of crime. From Mexico, Juan Cortina directed a cattle-stealing ring in the Strip. McNelly led his Rangers in several bold actions against Cortina's men. The Rangers entered Mexico several times. McNelly did not care that his actions violated international law.

The Rangers' methods were often violent. McNelly's men once killed 12 men and stacked the bodies in the Brownsville square. This served as an example to those who opposed them. McNelly lost his command because he crossed the border illegally to attack Mexicans.

Law and order The Texas Rangers also performed more routine police work. They transported prisoners and collected taxes. The Frontier Battalion cleared cattle rustlers and outlaws from Kimble and Big Bend Counties. The Battalion dealt with more than 3,000 **desperados** in Texas. Desperados are reckless, bold outlaws.

The Rangers provided law and order to a violent frontier area. As crime decreased in Texas in the late 1800s, there was less need for the Rangers. In 1901, the legislature cut their size to only four companies of 20 men each.

Today, songs, books, television shows, and movies celebrate the Rangers' work. The major league baseball team in Arlington still bears their name. The first major league baseball team in Texas, the Houston Colt .45s, took its name from the favorite weapon of the Rangers.

AS YOU READ **Summarize** What was the purpose of the Texas Rangers? How well did they carry out their duties?

AFTER YOU READ

Section 4 Assessment

Recall
1. **Define** **(a)** dragoons, **(b)** guerrilla, **(c)** desperados.
2. **Identify** Explain the significance of the following: **(a)** John Coffee "Jack" Hays, **(b)** Frontier Battalion, **(c)** Leander H. McNelly.

Comprehension
3. How did the Texas Rangers help the U.S. Army during the Mexican War?
4. Why did their enemies so often fear the Texas Rangers?
5. Why did the Texas legislature bring the Rangers back into existence in 1874?

Critical Thinking and Writing
6. **Exploring the Main Idea** What did the Texas Rangers do to protect American settlers in Texas?
7. **Drawing Conclusions** Why did the Texas Rangers use violent and aggressive tactics?
8. **Evaluating** What characteristics did the Rangers have that made them well suited to take on the problems on the frontier?

ACTIVITY

Designing a Flier

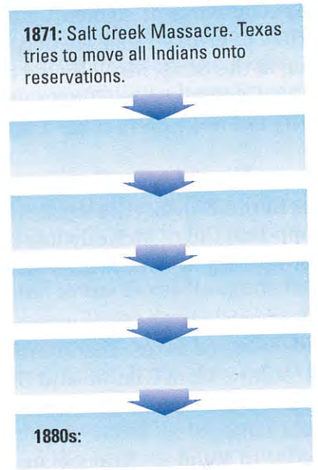
You are a recruiter for the Texas Rangers in the 1870s. Create a flier to attract new recruits. Describe the types of skills that are needed to be a part of a Ranger unit.

CHAPTER

13 Review and Assessment

Creating a Chapter Summary

On a sheet of paper, draw a flowchart like this one. Include 6 to 8 boxes. Fill in each box with a key event in the closing of the Texas frontier. For each event, include the date as well as one important result of the event. Some information has been filled in to help you get started.



Take It to the NET

Web Site Review For additional review of the major concepts of Chapter 13, see the *Lone Star* section of **www.PHSchool.com.**

Chapter Self-Test For practice test questions for Chapter 13, see the *Lone Star* section of **www.PHSchool.com.**

Building Vocabulary

Take this vocabulary challenge: Use each word in a sentence that demonstrates the meaning of the word in the context of the settlement of Texas.

1. reservations
2. treaty
3. vaqueros
4. lariats
5. quarantine
6. drovers
7. remuda
8. enclosures
9. felony
10. guerrilla
11. desperados

Reviewing Key Facts

12. What strategies led to the defeat of the Indians in the Frontier Wars?
13. Why did the Texas cattle industry become so profitable after the Civil War?
14. What issues caused conflict between Native Americans and Texans?
15. List three ways the Texas Rangers brought law and order to Texas following the Civil War.

Critical Thinking and Writing

16. **Connecting to Geography** **Movement** Why did Texans drive their cattle north when the largest markets for beef were in the east?
17. **Evaluating** Why was the Mexican War an important event for the Texas Rangers?
18. **Decision Making** What reasons did Texans have to settle in the western section of the state?
19. **Drawing Conclusions** How did the Salt Creek Massacre promote the settlement of West Texas?
20. **Problem Solving** Suppose that the fence cutting wars occurred in Texas today. Think of some possible solutions to this problem.

Skills Assessment
Problem Solving

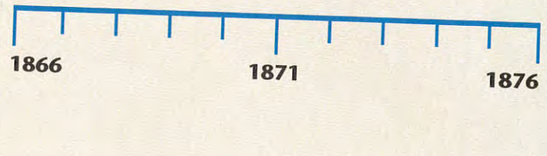
George Martin moved to Texas as a young boy in 1870. When he was a teenager, he got a job as a cowboy on a cattle ranch. He later talked about his experiences on the ranch in the 1880s.

> "It was a hard job for us . . . to keep in touch with each other and work together trying to keep the herd from scattering. In doing that, we didn't know whether we were with the herd or a bunch scattered away from the main bunch. To let the others know where we were, we would shoot our gun twice. The first shot would attract attention, and . . . the fire flash of the second shot could be seen, which would enable you to tell where a rider was."

21. What problem did the cattle workers have when they were trying to keep the herd together?
22. How did the workers solve the problem?

Skills Assessment
Sequencing Events

23. Listed below are important events from Chapter 13. Find the dates on which these events occurred and rewrite the events in their correct chronological order. Then draw a time line beginning with the year 1866 and ending with 1876, placing each event in its correct place.
    a. U.S. Congress readmits Texas into the Union.
    b. Texans buy five tons of barbed wire.
    c. Salt Creek Massacre occurs.
    d. Buffalo hunters move into Texas.
    e. Rangers help federal troops break the power of the Comanches and Kiowas.
    f. Medicine Lodge Treaty is signed.
    g. The era of Texas trail drives begins.



Activities

History in Your Own Backyard

Geography and History Research ghost towns in your area. Choose one that is closest to your hometown. Consult your local history sources, such as your public library or historical association, and the Internet, to learn about it.

- What county is your ghost town in? What town is it near? What year was it founded? What year was it abandoned? Did any historic events occur there? Why was it abandoned?
- Use your findings to design a poster to encourage tourists to visit your ghost town. Explain why your ghost town is interesting. Include any interesting facts you may find. You may also include photos or drawings of the ghost town, either as it looks today or as it looked years ago.

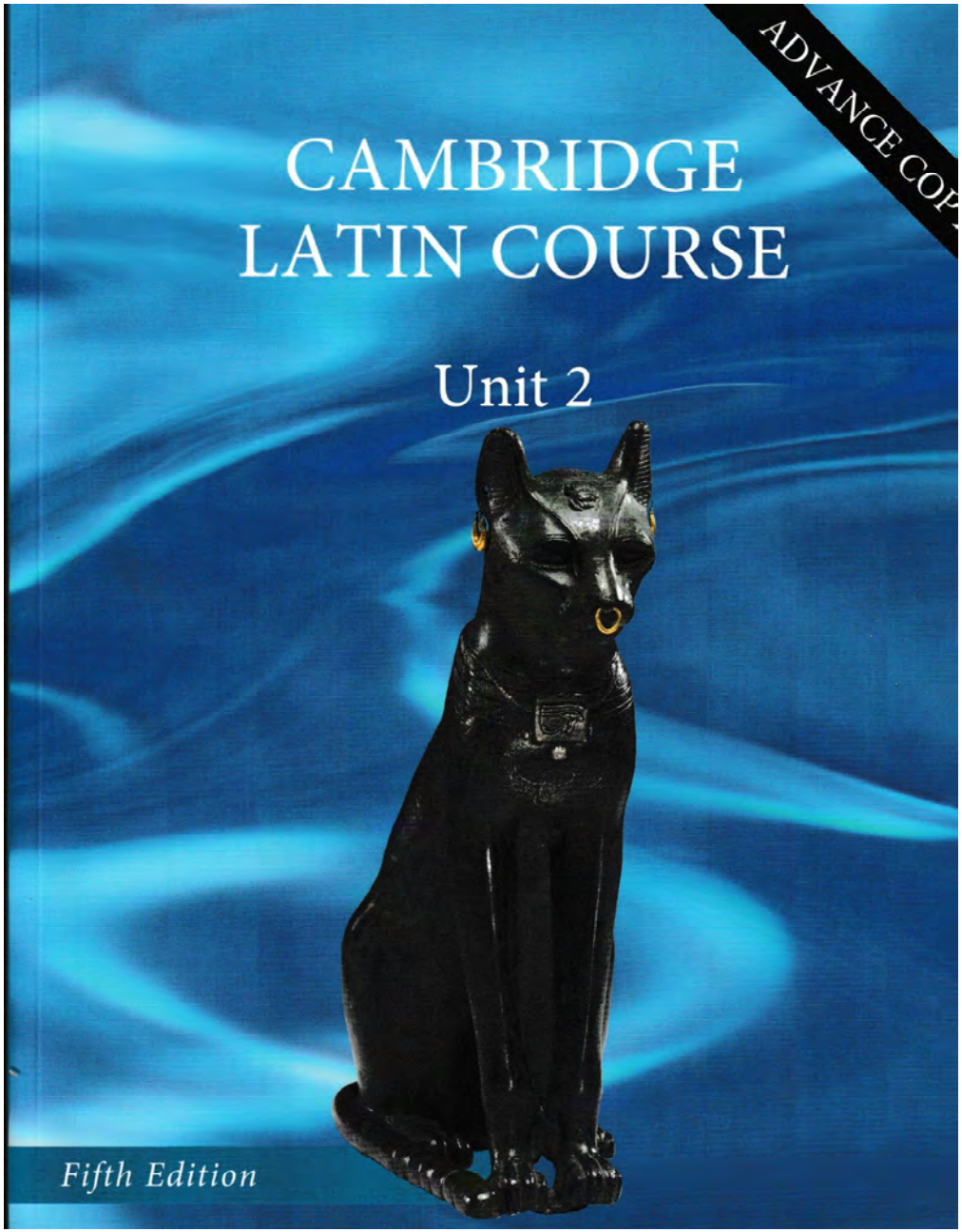
Take It to the NET

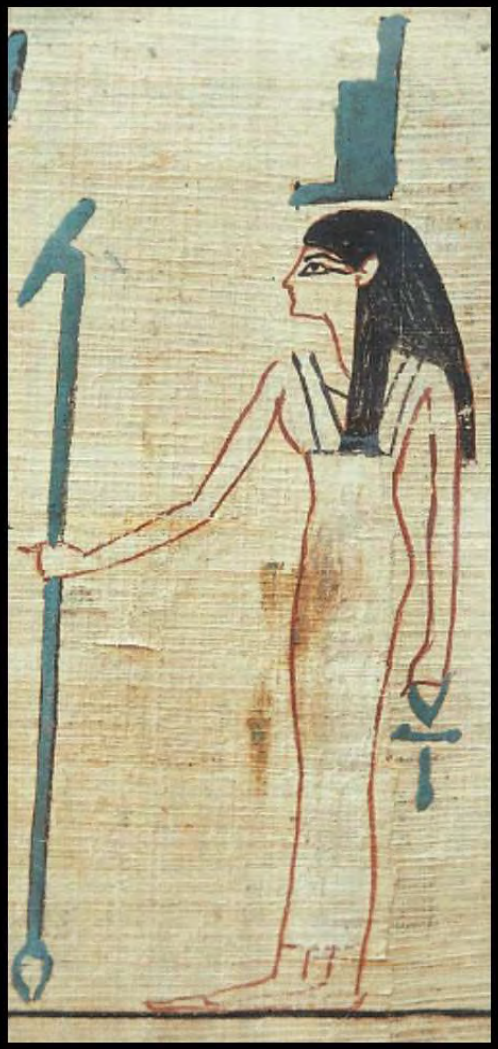
Connecting to Today

Once the frontier opened to settlement, the population of Texas grew rapidly. Use the Internet to find out what the population of Texas was according to the census in the years 1850 though 2000. How did the population of Texas change from 1870 until 1900? How did it change between 1870 and 2000? For help in starting this activity, visit the *Lone Star* section of **www.PHSchool.com.**

Internet Detective

Use the Internet to find sites related to the closing of the Texas frontier. Write a review comparing two of these sites in terms of source, type of information available, and reliability. Include addresses and, if possible, a sample page from each. For help in starting this activity, visit the *Lone Star* section of **www.PHSchool.com.**





ISIS

Stage 19

pompa

pompa adveniēbat. prō pompā currēbant multae puellae, quae flōrēs in viam spargēbant. post multitūdinem puellārum tubicinēs et puerī prōcēdēbant. puerī suāviter cantābant. tubicinēs tubās īnflābant. nōs, quī pompam plānē vidēre poterāmus, assiduē plaudēbāmus. duo iuvenēs tamen, quōs Galatēa ē locō ēmōverat, pompam vidēre vix poterant.

spargēbant: spargere *scatter*
tubicinēs: tubicen *trumpeter*
īnflābant: īnflāre *blow*
plānē *clearly*

Helena: spectā illās rosās, quās fēminae in viam spargunt! rosās pulchriōrēs quam illās numquam vīdī.

rosās: rosa *rose*

iuvenis prīmus: pompam vidēre nōn possum. sed spectā illam puellam! puellam pulchriōrem quam illam rārō vīdī.

rārō *rarely*

Galatēa: Helena! hūc venī! stā prope mē! Aristō! cūr fīliam tuam in tantā multitūdine nōn cūrās?

(*subitō omnēs tubicinēs tubās vehementer īnflābant.*)

Galatēa: ō mē miseram! ō caput meum! audīte illōs tubicinēs! audīte illum sonitum! quam raucus est sonitus tubārum!

sonitum: sonitus *sound*
raucus *harsh*

iuvenis secundus: tubicinēs vix audīre possum. quam raucae sunt vōcēs fēminārum Graecārum!

vōcēs: vōx *voice*

(*post turbam puerōrum tubicinumque vēnit dea ipsa. quattuor sacerdōtēs effigiem deae in umerīs ferēbant.*)

Galatēa: spectā illam stolam! pulcherrima est illa stola, pretiōsissima quoque. ēheu! vīlēs sunt omnēs stolae meae, quod marītus avārus est.

vīlēs: vīlis *cheap*

(*subitō iuvenēs, quī effigiem vidēre nōn poterant, Galatēam trūsērunt. iuvenis forte pedem Galatēae calcāvit.*)

trūsērunt: trūdere *push, shove*
calcāvit: calcāre *tread on*

ō iuvenem pessimum nōlī mē vexāre! nōn decōrum est mātrōnam trūdere. num bēstia es?

mātrōnam: mātrōna *lady*

Helena: māter! hic iuvenis forte tibi nocuit. spectātōrēs nōs premunt, quod pompam vidēre cupiunt.

nocuit: nocēre *hurt*
premunt: premere *push*

Galatēa: Helena! nōlī istum iuvenem dēfendere! īnsolentissimus est. Aristō! cūr mē nōn servās? uxōrem fīliamque numquam cūrās. miserrima sum!

Aristō: ēheu! uxor mē vexat, fīlia mātrem. clāmōrēs eārum numquam effugere possum. facile est mihi tragoediās scrībere. tōta vīta mea est tragoedia!

eārum *their*

tōta vīta mea est tragoedia!

About the language 2: imperatives

1 In the following sentences, one or more persons are being told to do something:

māter! **spectā** pompam!	māter! pater! **spectāte** pompam!
Mother! Look at the procession!	*Mother! Father! Look at the procession!*
Helena! **venī** ad mē!	servī! **venīte** ad mē!
Helena! Come to me!	*Slaves! Come to me!*

The form of the verb in **boldface** is known as the **imperative**. If only one person is being told to do something, the imperative singular is used; if more than one person, the imperative plural is used.

2 Compare the imperative forms with the infinitive:

	IMPERATIVE		INFINITIVE
	SINGULAR	PLURAL	
first conjugation	portā!	portāte!	portāre
	carry!	*carry!*	*to carry*
second conjugation	docē!	docēte!	docēre
	teach!	*teach!*	*to teach*
third conjugation	trahe!	trahite!	trahere
	drag!	*drag!*	*to drag*
fourth conjugation	audī!	audīte!	audīre
	listen!	*listen!*	*to listen*

3 Study the way in which people are ordered **not** to do things:

SINGULAR	nōlī currere!	*don't run!*
	nōlī cantāre!	*don't sing!*
PLURAL	nōlīte festīnāre!	*don't hurry!*
	nōlīte trūdere!	*don't push!*

nōlī and **nōlīte** are the imperative forms of the verb **nōlō**. Notice that they are used with the infinitive. **nōlī currere** literally means "be unwilling to run" and so "don't run."

4 Further examples:

a iuvenēs! tacēte!
b dīligenter labōrā!
c date mihi pecūniam!
d mē adiuvā!
e nōlī dormīre!
f nōlīte discēdere!
g nōlīte Rōmānōs interficere!
h nōlī mē pūnīre!

In each example, state whether the order is given to one person or more than one.

hodiē sōl Arietī appropinquat. *According to legend, the heavens were supported on the shoulders of a giant, Atlas. In this sculpture of Atlas carrying the globe of the heavens, the constellation Aries (the Ram) can be seen towards the left, across three narrow parallel lines that mark the path of the Sun across the heavens.*

vēnātiō

I

Barbillus mē et Aristōnem ad vēnātiōnem invītāvit. māne vīlicum Phormiōnem cum multīs servīs ēmīsit. Phormiō sēcum duōs haedōs dūxit. sed, ubi ē vīllā discēdēbāmus, astrologus Barbillī commōtus ad nōs cucurrit.

"domine, quō festīnās?" clāmāvit. "cūr ē vīllā hodiē exīre vīs?"

"ad praedium meum iter facimus," Barbillus astrologō respondit.

"sed, domine," inquit astrologus, "immemor es. perīculōsum est tibi hodiē ē vīllā exīre, quod hodiē sōl Arietī appropinquat."

ubi hoc audīvī, astrologum dērīsī. Barbillus, quamquam eī crēdēbat, mē offendere nōluit. postquam rem diū cōgitāvit,

"mihi placet exīre," inquit.

astrologus igitur, ubi dominō persuādēre nōn potuit, amulētum eī dedit. tum sēcūrī ad praedium Barbillī contendimus. per partem praediī flūmen Nīlus lēniter fluēbat.

ubi illūc advēnimus, multōs servōs vīdimus collēctōs. in hāc multitūdine servōrum erant nōnnūllī Aethiopes, quī hastās in manibus tenēbant. prope Aethiopas stābat Phormiō, vīlicus Barbillī.

Phormiō "salvē, domine!" inquit. "omnia tibi parāvimus. scaphās, quās postulāvistī, comparāvimus."

"haedōs cecīdistis?" rogāvit Barbillus.

"duōs haedōs cecīdimus, domine," respondit vīlicus. "eōs in scaphās iam posuimus."

haedōs: haedus *kid, young goat*
astrologus *astrologer*
commōtus *alarmed, excited*
praedium *estate*
immemor *forgetful*
Arietī: Ariēs *the Ram (sign of the zodiac)*
offendere *displease*
persuādēre *persuade*
amulētum *amulet, lucky charm*
flūmen Nīlus *river Nile*
lēniter *gently*
collēctōs: collēctus *assembled*
Aethiopes *Ethiopians*
omnia *everything, all things*
scaphās: scapha *punt, small boat*
cecīdistis: caedere *kill*

II

tum Phormiō nōs ad rīpam flūminis dūxit, ubi scaphae, quās comparāverat, dēligātae erant. postquam scaphās cōnscendimus, ad palūdem, in quā crocodīlī latēbant, cautē nāvigāvimus. ubi mediae palūdī appropinquābāmus, Barbillus Phormiōnī signum dedit. haedōs Phormiō in aquam iniēcit. crocodīlī, ubi haedōs cōnspexērunt, praecipitēs eōs petēbant. tum Aethiopes crocodīlōs agitāre coepērunt. hastās ēmittēbant et crocodīlōs interficiēbant. magna erat fortitūdō crocodīlōrum, maior tamen perītia Aethiopum. mox multī crocodīlī mortuī erant.

subitō ingentem clāmōrem audīvimus.

"domine!" clāmāvit Phormiō. "hippopotamus, quem Aethiopes ē palūde excitāvērunt, scapham Barbillī ēvertit. Barbillum et trēs servōs in aquam dēiēcit."

quamquam ad Barbillum et ad servōs, quī in aquā natābant, celeriter nāvigāvimus, crocodīlī iam eōs circumvēnerant. hastās in crocodīlōs statim ēmīsimus. ubi crocodīlōs dēpulimus, Barbillum et ūnum servum servāre potuimus. sed postquam Barbillum ex aquā trāximus, eum invēnimus vulnerātum. hasta, quam servus ēmīserat, umerum Barbillī percusserat. Barbillus ā servō suō graviter vulnerātus erat.

rīpam: rīpa *bank*
dēligātae: dēligātus *tied up, moored*
palūdem: palūs *marsh, swamp*
crocodīlī: crocodīlus *crocodile*
iniēcit: inicere *throw in*
praecipitēs: praeceps *headlong, straight for*
fortitūdō *courage*
perītia *skill*

hippopotamus *hippopotamus*
ēvertit: ēvertere *overturn*

dēpulimus: dēpellere *drive off*

ā servō suō *by his own slave*

A mosaic showing pygmies hunting a crocodile and hippos in the river Nile.

An amulet, in the form of the hippopotamus god Thueris.

Vocabulary checklist 19

Adjectives from now on are usually listed as in the Language information section (see page 158).

amō, amāre, amāvī	*love, like*	**locus, locī, m.**	*place*
cārus, cāra, cārum	*dear*	**māne**	*in the morning*
cōgitō, cōgitāre, cōgitāvī	*think, consider*	**nōvī**	*I know*
comparō, comparāre, comparāvī	*obtain*	**perīculum, perīculī, n.**	*danger*
cōnficiō, cōnficere, cōnfēcī	*finish*	**plūrimī**	*very many*
cūrō, cūrāre, cūrāvī	*look after*	**poscō, poscere, poposcī**	*demand, ask for*
fluō, fluere, flūxī	*flow*	**tot**	*so many*
forte	*by chance*	**vexō, vexāre, vexāvī**	*annoy*
grātiās agō	*I thank, give thanks*	**vīvō, vīvere, vīxī**	*live*
hasta, hastae, f.	*spear*	**vix**	*hardly, scarcely*
illūc	*there, to that place*		
iter, itineris, n.	*journey*	**vōx, vōcis, f.**	*voice*

In Egyptian mythology, the male hippo was identified with Seth, the god of storms and the enemy of Isis and Osiris. Small figures like this are often found in tombs.

Part One: About the language

Nouns

1

	first declension	*second declension*			*third declension*						
gender	f.	m.	m.	n.	m.	m.	f.	m. f.	n.	n.	*gender*
SINGULAR											SINGULAR
nominative and vocative	puella	servus (*voc.* serve)	faber	templum	mercātor	leō	vōx	cīvis	nōmen	mare	*nominative and vocative*
genitive (of)	puellae	servī	fabrī	templī	mercātōris	leōnis	vōcis	cīvis	nōminis	maris	*genitive (of)*
dative (to, for)	puellae	servō	fabrō	templō	mercātōrī	leōnī	vōcī	cīvī	nōminī	marī	*dative (to, for)*
accusative	puellam	servum	fabrum	templum	mercātōrem	leōnem	vōcem	cīvem	nōmen	mare	*accusative*
ablative (by, with)	puellā	servō	fabrō	templō	mercātōre	leōne	vōce	cīve	nōmine	marī	*ablative (by, with)*
PLURAL											PLURAL
nominative and vocative	puellae	servī	fabrī	templa	mercātōrēs	leōnēs	vōcēs	cīvēs	nōmina	maria	*nominative and vocative*
genitive (of)	puellārum	servōrum	fabrōrum	templōrum	mercātōrum	leōnum	vōcum	cīvium	nōminum	marium	*genitive (of)*
dative (to, for)	puellīs	servīs	fabrīs	templīs	mercātōribus	leōnibus	vōcibus	cīvibus	nōminibus	maribus	*dative (to, for)*
accusative	puellās	servōs	fabrōs	templa	mercātōrēs	leōnēs	vōcēs	cīvēs	nōmina	maria	*accusative*
ablative (by, with)	puellīs	servīs	fabrīs	templīs	mercātōribus	leōnibus	vōcibus	cīvibus	nōminibus	maribus	*ablative (by, with)*

2 The vocative case is used when someone is being spoken to:

ubi es, serve? *Where are you, slave?*

3 Some 2nd declension nouns such as **faber** have a nominative and vocative singular ending in **-er**. All their other cases are formed like the cases of **servus**.

2nd declension nouns ending **-ius** drop the ending completely in the vocative (e.g. **fīlī**, **Salvī**).

4 The ablative case is used with certain prepositions:

sacerdōs in templō stābat. *The priest was standing in the temple.*

5 1st declension nouns like **puella** are usually feminine.

2nd declension nouns are usually either masculine like **servus**, or neuter like **templum**.

3rd declension nouns may be either masuline like **mercātor**, or feminine like **vōx**, or neuter like **nomen**.

6 Study the two nouns **templum** and **nōmen**. Notice that the forms **templum** and **nōmen** can be either nominative or accusative singular, and that **templa** and **nōmina** can be either nominative or accusative plural. That is because **templum** and **nōmen** are *neuter*. Every neuter noun uses the same form for both its nominative and accusative.

7 With the help of the noun tables find the Latin for the words in **boldface** in the following sentences:

a We saw the **lion** in the wood.
b The **girls** were reading in the garden.
c The sound of their **voices** stopped Aristo writing.
d Many **merchants** travelled to Britain.
e The master gave a reward to his brave **slaves**.
f The eruption terrified the **citizens**.
g The **craftsman** carved a beautiful statue.
h Do you like my **name**?

Verbs

	first conjugation	*second conjugation*	*third conjugation*	*fourth conjugation*
PRESENT TENSE	*I carry, you carry, etc.*	*I teach, you teach, etc.*	*I drag, you drag, etc.*	*I hear, you hear, etc.*
	portō	doceō	trahō	audiō
	portās	docēs	trahis	audīs
	portat	docet	trahit	audit
	portāmus	docēmus	trahimus	audīmus
	portātis	docētis	trahitis	audītis
	portant	docent	trahunt	audiunt
IMPERFECT TENSE	*I was carrying*	*I was teaching*	*I was dragging*	*I was hearing*
	portābam	docēbam	trahēbam	audiēbam
	portābās	docēbās	trahēbās	audiēbās
	portābat	docēbat	trahēbat	audiēbat
	portābāmus	docēbāmus	trahēbāmus	audiēbāmus
	portābātis	docēbātis	trahēbātis	audiēbātis
	portābant	docēbant	trahēbant	audiēbant
PERFECT TENSE	*I (have) carried*	*I (have) taught*	*I (have) dragged*	*I (have) heard*
	portāvī	docuī	trāxī	audīvī
	portāvistī	docuistī	trāxistī	audīvistī
	portāvit	docuit	trāxit	audīvit
	portāvimus	docuimus	trāximus	audīvimus
	portāvistis	docuistis	trāxistis	audīvistis
	portāvērunt	docuērunt	trāxērunt	audīvērunt
PLUPERFECT TENSE	*I had carried*	*I had taught*	*I had dragged*	*I had heard*
	portāveram	docueram	trāxeram	audīveram
	portāverās	docuerās	trāxerās	audīverās
	portāverat	docuerat	trāxerat	audīverat
	portāverāmus	docuerāmus	trāxerāmus	audīverāmus
	portāverātis	docuerātis	trāxerātis	audīverātis
	portāverant	docuerant	trāxerant	audīverant
INFINITIVE	*to carry* portāre	*to teach* docēre	*to drag* trahere	*to hear* audīre
IMPERATIVE	*carry!* portā	*teach!* docē	*drag!* trahe	*hear!* audī
	portāte	docēte	trahite	audīte

1 Translate the following examples:

portābant; portāvimus; trahēbās; trahitis; docuērunt; audīvī; portābāmus; docuistī

2 Translate the following examples, then change them to mean "I..." instead of "he..." and translate again.

trahēbat; audīvit; docet; intrāvit; dormiēbat; sedet

3 Translate the following examples, then change them from the plural to the singular, so that they mean "you (singular)..." instead of "they...," and translate again.

portāvērunt; trahunt; audīverant; manēbant; laudant; intellēxērunt

Persons and endings

1 The forms of the verb which indicate "I," "you" (singular), and "he" (or "she" or "it") are known as **1st**, **2nd**, and **3rd person singular**.The forms which indicate "we," "you" (plural), and "they" are known as the **1st**, **2nd**, and **3rd person plural**.

The following table summarizes the Latin verb endings and the English translations which are used to indicate the different persons:

English		Latin verb ending	
		PRESENT IMPERFECT PLUPERFECT	PERFECT
I	1st person singular	**-ō or -m**	**-ī**
you	2nd person singular	**-s**	**-istī**
he, she, it	3rd person singular	**-t**	**-it**
we	1st person plural	**-mus**	**-imus**
you	2nd person plural	**-tis**	**-istis**
they	3rd person plural	**-nt**	**-ērunt**

So a word like **trāxerant** can be either translated (*they had dragged*) ordescribed (3rd person plural pluperfect). Two further examples, **portāvī** and **docent**, are translated and described as follows:

portāvī	*I carried*	1st person singular perfect
docent	*they teach*	3rd person plural present

2 Describe and translate the following examples.

trāxī; audīs; portābāmus; docuerant; ambulāvistī; dīxerat

towards him?

Soothsayer. None that I know will be, much
that I fear may chance.[196]
Good morrow to you. Here the street is narrow;
The throng that follows Caesar at the heels,
Of senators, of praetors,[197] common suitors,
Will crowd a feeble man almost to death.
I'll get me to a place more void,[198] and there
Speak to great Caesar as he comes along.

[*Exit.*]

Portia. I must go in. [Aside] Ay me, how weak a
thing
The heart of woman is! O Brutus,
The heavens speed thee in thine enterprise!
Sure the boy heard me.—Brutus hath a suit
That Caesar will not grant.—O, I grow faint.—
Run, Lucius, and commend me[199] to my lord;
Say I am merry.[200] Come to me again,
And bring me word what he doth say to thee.

[*Exeunt severally.*[201]]

[196] *chance*: come to be.
[197] *praetors*: elected magistrates (Brutus was *praetor urbanus*, the chief justice).
[198] *more void*: less crowded with people.
[199] *commend me*: give my greetings and goodwill.
[200] *merry*: cheerful, even frivolous.
[201] *severally*: ...

ACT 3

Scene 1. *Rome. A street before the Capitol.*

Flourish. Enter Caesar, Brutus, Cassius, Casca, Decius, Metellus, Trebonius, Cinna, Antony, Lepidus, Artemidorus, Popilius, Publius, and the Soothsayer.

Caesar. The ides of March are come.

Soothsayer. Ay, Caesar, but not gone.

Artemidorus. Hail, Caesar! Read this schedule.[1]

Decius. Trebonius doth desire you to o'er-read,
At your best leisure, this his humble suit.

Artemidorus. O Caesar, read mine first; for
mine's a suit
That touches Caesar nearer. Read it, great
Caesar.

Caesar. What touches us ourself shall be last
serv'd.[2]

Artemidorus. Delay not, Caesar; read it
instantly.

Caesar. What, is the fellow mad?

Publius. Sirrah,[3] give place.[4]

Cassius. What, urge you your petitions in the
street?
Come to the Capitol.

Caesar enters the Capitol, the rest following.

[1] *schedule*: scroll.
[2] *serv'd*: presented, delivered (legal term, as in a legal writ or other document).
[3] *Sirrah*: term of address to inferiors.

Popilius. I wish your enterprise to-day may thrive.

Cassius. What enterprise, Popilius?

Popilius. Fare you well.

[*Advances to Caesar.*]

Brutus. What said Popilius Lena?

Cassius. He wish'd to-day our enterprise might thrive.
I fear our purpose is discovered.

Brutus. Look how he makes to[5] Caesar. Mark him.

Cassius. Casca, be sudden,[6] for we fear prevention.[7]
Brutus, what shall be done? If this be known,
Cassius or Caesar never shall turn back,[8]
For I will slay myself.

Brutus. Cassius, be constant.[9]
Popilius Lena speaks not of our purposes;
For look, he smiles, and Caesar doth not change.[10]

Cassius. Trebonius knows his time; for look you, Brutus,
He draws Mark Antony out of the way.

[*Exeunt Antony and Trebonius.*]

[5] *...* heads toward.
[6] *...den*: swift.
[7] *prevention*: being forestalled.
[8] *Cassius or Caesar never shall turn back*: I.e., either Cassius or Caesar will die.
[9] *constant*: (1) calm; (2) resolved in purpose.
[10] *change*: i.e., change in his expression or appearance (he is not enraged or appalled).

Decius. Where is Metellus Cimber? Let him go
And presently prefer[11] his suit to Caesar.

Brutus. He is address'd;[12] press near and second him.

Cinna. Casca, you are the first that rears your hand.

Caesar. Are we all ready? What is now amiss
That Caesar and his Senate must redress?

Metellus. Most high, most mighty, and most puissant[13] Caesar,
Metellus Cimber throws before thy seat
An humble heart. [*Kneeling.*]

Caesar. I must prevent thee, Cimber.
These couchings[14] and these lowly[15] courtesies
Might fire the blood of ordinary men,
And turn pre-ordinance and first decree[16]
Into the law of children. Be not fond[17]
To think that Caesar bears such rebel blood[18]
That will be thaw'd from the true[19] quality[20]
With that which melteth fools—I mean, sweet words,
Low-crooked curtsies, and base spaniel[21] fawning.
Thy brother by decree is banished;
If thou dost bend, and pray, and fawn for him,

[11] *presently prefer*: at once, immediately present.
[12] *address'd*: ready, prepared.
[13] *puissant*: powerful, influential.
[14] *couchings*: crouching, bowing protestations.
[15] *lowly*: (1) humble; (2) abasing.
[16] *pre-ordinance and first decree*: ancient customs or laws.
[17] *fond*: foolish enough.
[18] *rebel blood*: uncontrolled, rebellious blood (feelings).
[19] *true*: proper.
[20] *quality*: (1) character; (2) degree of excellence.
[21] *spaniel*: breed of dog with drooping ears, known for its blind obedience.

I spurn thee like a cur out of my way.
Know, Caesar doth not wrong; nor without cause
Will he be satisfied.

Metellus. Is there no voice more worthy than my own
To sound more sweetly in great Caesar's ear
For the repealing[22] of my banish'd brother?

Brutus. I kiss thy hand, but not in flattery, Caesar,
Desiring thee that Publius Cimber may
Have an immediate freedom of repeal.

Caesar. What, Brutus!

Cassius. Pardon, Caesar! Caesar, pardon!
As low as to thy foot doth Cassius fall,
To beg enfranchisement[23] for Publius Cimber.

Caesar. I could be well mov'd, if I were as you;
If I could pray to move,[24] prayers would move me;
But I am constant as the northern star,[25]
Of whose true-fix'd and resting[26] quality
There is no fellow[27] in the firmament.
The skies are painted with unnumb'red[28] sparks,
They are all fire, and every one doth shine;
But there's but one in all doth hold[29] his place.
So in the world: 'tis furnish'd well with men,
And men are flesh and blood, and apprehensive;[30]

[22] *repealing*: recalling, bringing back (from banishment).
[23] *enfranchisement*: freedom, restoration to the proper rights of a citizen.
[24] *move*: i.e., sway or influence the opinions or decisions of others.
[25] *northern star*: Polaris, the polestar, used as a point of navigation.
[26] *resting*: changeless, having constancy of character.
[27] *fellow*: equal.
[28] *unnumb'red*: innumerable, uncountable.
[29] *hold*: hold to, keep to.
[30] *apprehensive*: capable of reason or perception.

Yet in the number I do know but one
That unassailable holds on his rank,
Unshak'd of motion; and that I am he,
Let me a little show it, even in this—
That I was constant[31] Cimber should be banish'd,
And constant do remain to keep him so.

Cinna. O Caesar!

Caesar. Hence! Wilt thou lift up Olympus?[32]

Decius. Great Caesar!

Caesar. Doth not Brutus bootless[33] kneel?

Casca. Speak, hands, for me!

[*They stab Caesar. Casca strikes the first, Brutus the last blow.*]

Caesar. Et tu, Brute?[34]—Then fall, Caesar!

[*Dies.*]

Cinna. Liberty! Freedom! Tyranny is dead!
Run hence, proclaim, cry it about the streets.

Cassius. Some to the common pulpits,[35] and cry out
'Liberty, freedom, and enfranchisement!'

Brutus. People and Senators, be not affrighted.
Fly not; stand still. Ambition's debt is paid.[36]

Casca. Go to the pulpit, Brutus.

Decius. And Cassius too.

[31] *constant*: determined.
[32] *Olympus*: mountain in Thessaly that is the abode of the gods in classical mythology.
[33] *bootless*: in vain.
[34] *Et tu, Brute?* And you (too), Brutus? (Latin).
[35] *pulpits*: speaker's stands.
[36] *Ambition's debt is paid*: Caesar's ambition has received its just deserts.

Brutus. Where's Publius?

Cinna. Here, quite confounded with this mutiny.[37]

Metellus. Stand fast together, lest some friend of Caesar's
Should chance—

Brutus. Talk not of standing.[38] Publius, good cheer!
There is no harm intended to your person,
Nor to no Roman else. So tell them, Publius.

Cassius. And leave us, Publius, lest that the people,
Rushing on us, should do your age some mischief.

Brutus. Do so; and let no man abide[39] this deed
But we the doers.

Re-enter Trebonius.

Cassius. Where is Antony?

Trebonius. Fled to his house amaz'd.[40]
Men, wives, and children, stare, cry out, and run,
As[41] it were doomsday.

Brutus. Fates,[42] we will know your pleasures.
That we shall die, we know; 'tis but the time,
And drawing days out, that men stand upon.[43]

[37] *confounded with this mutiny*: overwhelmed by all the tumult.
[38] *standing*: organizing, planning out a stance.
[39] *abide*: bear the consequences of.
[40] *amaz'd*: confused, dismayed.
[41] *As*: as if.
[42] *Fates*: in classical mythology, three goddesses who ruled over the lives of men.
[43] *stand upon*: strive, hope for.

Cassius. Why, he that cuts off twenty years of life
Cuts off so many years of fearing death.

Brutus. Grant that, and then is death a benefit.
So are we Caesar's friends, that have abridg'd
His time of fearing death. Stoop, Romans, stoop,
And let us bathe our hands in Caesar's blood
Up to the elbows, and besmear our swords.
Then walk we forth, even to the marketplace,[44]
And waving our red weapons o'er our heads,
Let's all cry 'Peace, freedom, and liberty!'

Cassius. Stoop then, and wash. How many ages hence
Shall this our lofty scene be acted over
In states unborn and accents[45] yet unknown!

Brutus. How many times shall Caesar bleed in sport,[46]
That now on Pompey's basis[47] lies along[48]
No worthier than the dust!

Cassius. So oft as that shall be,
So often shall the knot[49] of us be call'd
The men that gave their country liberty.

Decius. What, shall we forth?

Cassius. Ay, every man away.
Brutus shall lead, and we will grace his heels
With the most boldest[50] and best hearts of Rome.

Enter a Servant.

[44] *marketplace*: the Roman Forum, the center of Roman public life.
[45] *accents*: languages.
[46] *in sport*: as part of a public entertainment.
[47] *Pompey's basis*: base of the pedestal of the statue of Pompey.
[48] *along*: stretched out at full length.
[49] *knot*: close group.
[50] *most boldest*: an emphatic superlative.

Brutus. Soft,[51] who comes here? A friend of Antony's.

Servant. Thus, Brutus, did my master bid me kneel;
Thus did Mark Antony bid me fall down;
And, being prostrate, thus he bade me say:
Brutus is noble, wise, valiant, and honest;
Caesar was mighty, bold, royal,[52] and loving.
Say I love Brutus, and I honour him;
Say I fear'd Caesar, honour'd him, and lov'd him.
If Brutus will vouchsafe that Antony
May safely come to him, and be resolv'd[53]
How Caesar hath deserv'd to lie in death,
Mark Antony shall not love Caesar dead
So well as Brutus living; but will follow
The fortunes and affairs of noble Brutus
Thorough[54] the hazards of this untrod state[55]
With all true faith. So says my master Antony.

Brutus. Thy master is a wise and valiant Roman;
I never thought him worse.
Tell him, so[56] please him come unto this place,
He shall be satisfied and, by my honour,
Depart untouch'd.

Servant. I'll fetch him presently.[57]

[*Exit.*]

[51] *Soft*: wait.
[52] *royal*: princely, beneficent.
[53] *be resolv'd*: know for certain.
[54] *Thorough*: through.
[55] *untrod state*: unknown, new state of affairs.
[56] *so*: if he.
[57] *presently*: immediately.

Brutus. I know that we shall have him well to friend.[58]

Cassius. I wish we may. But yet have I a mind
That fears him much; and my misgiving still
Falls shrewdly to the purpose.[59]

Re-enter Antony.

Brutus. But here comes Antony. Welcome, Mark Antony.

Antony. O mighty Caesar! dost thou lie so low?
Are all thy conquests, glories, triumphs, spoils,
Shrunk to this little measure? Fare thee well.
I know not, gentlemen, what you intend,
Who else must be let blood,[60] who else is rank.[61]
If I myself, there is no hour so fit
As Caesar's death's hour; nor no instrument
Of half that worth as those your swords, made rich
With the most noble blood of all this world.
I do beseech ye, if you bear me hard,[62]
Now, whilst your purpled[63] hands do reek and smoke,[64]
Fulfil your pleasure. Live[65] a thousand years,
I shall not find myself so apt[66] to die.
No place will please me so, no mean[67] of death,

[58] *well to friend*: (1) as a good friend; (2) well worth befriending.
[59] *my misgiving . . . to the purpose*: my astute and serious concerns continue to be insightful regarding the real situation.
[60] *let blood*: (1) purified (as in "letting blood", a medical practice widely used at the time, through which unwholesome elements were supposed to be purified from the body); (2) killed.
[61] *rank*: diseased and swollen (in need of bloodletting).
[62] *bear me hard*: bear ill will toward me.
[63] *purpled*: i.e., stained with blood (and royal blood at that).
[64] *reek and smoke*: steam (with fresh blood).
[65] *Live*: though I may live.
[66] *apt*: prepared, ready.
[67] *mean*: means, manner.

As here by Caesar, and by you cut off,
The choice and master spirits of this age.

Brutus. O Antony! beg not your death of us.
Though now we must appear bloody and cruel,
As by our hands and this our present act
You see we do; yet see you but our hands,
And this the bleeding business they have done.
Our hearts you see not; they are pitiful;[68]
And pity to the general wrong of Rome,
As fire drives out fire, so pity pity,[69]
Hath done this deed on Caesar. For your part,
To you our swords have leaden[70] points, Mark
Antony;
Our arms in strength of malice,[71] and our hearts
Of brothers' temper,[72] do receive you in
With all kind love, good thoughts, and
reverence.

Cassius. Your voice[73] shall be as strong as any man's
In the disposing of new dignities.[74]

Brutus. Only be patient till we have appeas'd
The multitude, beside themselves with fear,
And then we will deliver you[75] the cause
Why I, that did love Caesar when I struck him,
Have thus proceeded.

Antony. I doubt not of your wisdom.
Let each man render me his bloody hand.

[68] *pitiful*: full of pity.
[69] *pity pity*: i.e., the pity for the situation of Rome drove out any pity for Caesar.
[70] *leaden*: i.e., blunt.
[71] *Our arms in strength of malice*: our use of weapons is motivated by feelings of anger.
[72] *our hearts / Of brothers' temper*: we feel like brothers in our hearts.
[73] *voice*: particularly as a vote in the Senate.
[74] *In the disposing of new dignities*: in dividing offices of government after Caesar's death.
[75] *deliver you*: explain to you.

First, Marcus Brutus, will I shake with you;
Next, Caius Cassius, do I take your hand;
Now, Decius Brutus, yours; now yours,
Metellus;
Yours, Cinna; and, my valiant Casca, yours.
Though last, not least in love, yours, good
Trebonius.
Gentlemen all—alas, what shall I say?
My credit[76] now stands on such slippery ground
That one of two bad ways you must conceit[77] me,
Either a coward or a flatterer.
That I did love thee, Caesar, O, 'tis true!
If then thy spirit look upon us now,
Shall it not grieve thee dearer[78] than thy death
To see thy Antony making his peace,
Shaking the bloody fingers of thy foes,
Most noble! in the presence of thy corse?[79]
Had I as many eyes as thou hast wounds,
Weeping as fast as they stream forth thy blood,
It would become me better than to close[80]
In terms of friendship with thine enemies.
Pardon me, Julius! Here wast thou bay'd,[81] brave
hart;[82]
Here didst thou fall; and here thy hunters stand,
Sign'd in thy spoil,[83] and crimson'd in thy lethe.[84]
O world, thou wast the forest to this hart;

[76] *credit*: credibility, reputation.
[77] *conceit*: judge, conceive of.
[78] *dearer*: more dearly, keenly.
[79] *corse*: corpse.
[80] *close*: join, ally oneself.
[81] *bay'd*: brought to bay (like an animal).
[82] *hart*: stag (a noble animal, also a pun on "heart").
[83] *spoil*: blood.
[84] *lethe*: life's blood. (In classical mythology, Lethe is the river of the dead of the realm of Hades, the water of which, when drunk, causes the dead to forget their lives on earth. The term is also used for the gore of dead animals, with which hunters traditionally smeared themselves.)

And this indeed, O world, the heart of thee!
How like a deer strucken[85] by many princes
Dost thou here lie!

Cassius. Mark Antony—

Antony. Pardon me, Caius Cassius.
The enemies of Caesar shall say this;
Then, in a friend, it is cold modesty.[86]

Cassius. I blame you not for praising Caesar so;
But what compact mean you to have with us?
Will you be prick'd[87] in number of our friends,
Or shall we on,[88] and not depend on you?

Antony. Therefore I took your hands; but was indeed
Sway'd from the point by looking down on Caesar.
Friends am I with you all, and love you all,
Upon this hope, that you shall give me reasons
Why and wherein Caesar was dangerous.

Brutus. Or else were this[89] a savage spectacle.
Our reasons are so full of good regard[90]
That were you, Antony, the son of Caesar,
You should be satisfied.

Antony. That's all I seek;
And am moreover suitor that I may
Produce[91] his body to the market-place

[85] *strucken*: stricken, struck down, killed.
[86] *modesty*: moderation.
[87] *prick'd*: counted, marked down (in a tally of the number of friends).
[88] *on*: go on.
[89] *were this*: this would be.
[90] *regard*: consideration, reasoning.
[91] *Produce*: present, bring forth.

And, in the pulpit, as becomes a friend,
Speak in the order[92] of his funeral.

Brutus. You shall, Mark Antony.

Cassius. Brutus, a word with you.
[*Aside to Brutus*] You know not what you do.
Do not consent
That Antony speak in his funeral.
Know you how much the people may be mov'd
By that which he will utter?

Brutus. [*Aside to Cassius*] By your pardon—
I will myself into the pulpit first,
And show the reason of our Caesar's death.
What Antony shall speak, I will protest[93]
He speaks by leave and by permission;
And that we are contented Caesar shall
Have all true rites and lawful ceremonies.
It shall advantage[94] more than do us wrong.[95]

Cassius. I know not what may fall.[96] I like it not.

Brutus. Mark Antony, here, take you Caesar's body.
You shall not in your funeral speech blame us,
But speak all good you can devise of Caesar;
And say you do't by our permission;
Else shall you not have any hand at all
About his funeral. And you shall speak
In the same pulpit whereto I am going,
After my speech is ended.

Antony. Be it so;
I do desire no more.

[92] *order*: course of a ceremony.
[93] *protest*: declare, explain.
[94] *advantage*: be to the benefit of.
[95] *wrong*: harm.
[96] *fall*: befall, happen.

Brutus. Prepare the body then, and follow us.

[*Exeunt all but Antony.*]

Antony. O, pardon me, thou bleeding piece of earth,[97]
That I am meek and gentle with these butchers!
Thou art the ruins of the noblest man
That ever lived in the tide of times.[98]
Woe to the hand that shed this costly blood!
Over thy wounds now do I prophesy—
Which like dumb[99] mouths do ope[100] their ruby lips
To beg the voice and utterance[101] of my tongue—
A curse shall light upon the limbs of men;
Domestic[102] fury and fierce civil strife
Shall cumber[103] all the parts of Italy;
Blood and destruction shall be so in use,[104]
And dreadful objects so familiar,
That mothers shall but smile when they behold
Their infants quartered with the hands of war,
All pity chok'd with custom of fell[105] deeds;
And Caesar's spirit, ranging for revenge,
With Até[106] by his side come hot from hell,
Shall in these confines[107] with a monarch's voice
Cry 'Havoc!'[108] and let slip[109] the dogs of war,

[97] *piece of earth*: i.e., man (formed from the earth).
[98] *tide of times*: the ebb and flow of the stream of history.
[99] *dumb*: mute.
[100] *ope*: open.
[101] *utterance*: (1) speech; (2) vehemence.
[102] *Domestic*: i.e., internal, national.
[103] *cumber*: encumber, oppress.
[104] *in use*: customary, widely experienced.
[105] *fell*: cruel.
[106] *Até*: in classical mythology, goddess of discord and vengeance.
[107] *in these confines*: within these boundaries, this region.
[108] *Havoc!* the order for unrestrained slaughter in a battle (which only the king could give).
[109] *let slip*: unleash.

That this foul deed shall smell above the earth
With carrion[110] men, groaning for burial.

Enter Octavius' Servant.

You serve Octavius Caesar, do you not?

Servant. I do, Mark Antony.

Antony. Caesar did write for him to come to Rome.

Servant. He did receive his letters, and is coming,
And bid me say to you by word of mouth—
O Caesar! [*Seeing the body.*]

Antony. Thy heart is big,[111] get thee apart and weep.
Passion,[112] I see, is catching; for mine eyes,
Seeing those beads of sorrow stand in thine,
Began to water. Is thy master coming?

Servant. He lies to-night within seven leagues of Rome.

Antony. Post[113] back with speed, and tell him what hath chanc'd.[114]
Here is a mourning Rome, a dangerous Rome,
No Rome[115] of safety for Octavius yet;
Hie[116] hence and tell him so. Yet stay awhile;
Thou shall not back till I have borne this corse
to the market-place. There shall I try,[117]

[110] *carrion*: dead, rotting, needing burial.
[111] *big*: swollen (with grief).
[112] *Passion*: intense emotion (grief).
[113] *Post*: travel swiftly by a relay of horses.
[114] *chanc'd*: happened.
[115] *Rome*: pronounced "room".
[116] *Hie*: hurry.
[117] *try*: test to find out.

In my oration, how the people take
The cruel issue[118] of these bloody men;
According to the which thou shalt discourse
To young Octavius of the state of things.
Lend me your hand.

[*Exeunt with Caesar's body.*]

Scene 2. *Rome. The Forum.*

Enter Brutus and Cassius, with the Plebeians.

Citizens. We will be satisfied![119] Let us be satisfied!

Brutus. Then follow me, and give me audience, friends.
Cassius, go you into the other street,
And part the numbers.[120]
Those that will hear me speak, let 'em stay here;
Those that will follow Cassius, go with him;
And public reasons[121] shall be rendered
Of Caesar's death.

1 Plebeian. I will hear Brutus speak.

2 Plebeian. I will hear Cassius, and compare their reasons,
When severally we hear them rendered.

[*Exit Cassius, with some of the Plebeians. Brutus goes into the pulpit.*]

3 Plebeian. The noble Brutus is ascended. Silence!

[118] *cruel issue*: consequences of the cruel actions.
[119] *will be satisfied*: require a full explanation.
[120] *part the numbers*: divide up the crowd.
[121] *public reasons*: (1) publicly given reasons; (2) reasons that touch the public generally.

57. $(t \div 7) - 4 = 4$ **58.** $(c \div 5) - 13 = 11$ **59.** $(y \div 3) + 15 = 36$

C **60.** $3n + 10 > 40$ **61.** $5b - 12 \leq 42$ **62.** $6m - 17 \geq 49$

63. $4d + 21 \geq 53$ **64.** $(y \div 14) - 32 \leq 38$ **65.** $(x \div 8) + 15 < 19$

Self-Test A

Simplify the numerical expression.

1. 4.3×6 **2.** $4.15 + 1.6$ **3.** $8.16 - 5.7$ **4.** $68.4 \div 9$ **[1-1]**

Evaluate the expression when $k = 4$ and $m = 6$.

5. $184 \div k$ **6.** $8 + m + 1$ **7.** $7km$

Simplify the expression.

8. $8 + 3 \times 14$ **9.** $48 \div (6 \times 2 - 4)$ **10.** $\dfrac{7 + (9 \times 3) - 2}{(5 \times 4) - (2 \times 2)}$ **[1-2]**

Evaluate the expression when $s = 12$ and $t = 18$.

11. $\frac{s}{4} + 6$ **12.** $(t + 2) \div 5$ **13.** $2s - t$

Find the solution or solutions for the given replacement set.

14. $72 - m = 43$; $\{19, 29, 31\}$ **15.** $6r = 48$; $\{6, 7, 8\}$ **[1-3]**

16. $t \div 12 = 11$; $\{23, 24, 25\}$ **17.** $4d + 16 = 28$; $\{3, 4, 5\}$

Replace ? with $=$, $>$, or $<$ to make a true statement.

18. 430 ? 403 **19.** $52 \div 17$? 19 **20.** 225 ? 9×25 **[1-4]**

Find the solutions of the inequality. The replacement set for x is the set of whole numbers.

21. $x < 5$ **22.** $x \geq 85$ **23.** $19 \leq x \leq 27$

Use inverse operations to solve.

24. $g - 32 = 12$ **25.** $7d < 112$ **26.** $5a + 4 = 49$ **[1-5]**

Self-Test answers and Extra Practice are at the back of the book.

15. Gregory ordered the following items from the Huntington Gardens catalog: a watering can for \$15.80, a trowel for \$4.49, and 6 packages of seeds for \$.75 each. He must add \$2.50 for shipping charges. He has 2 coupons, each allowing him to deduct \$2.00 from his order. How much will Gregory pay for the order?

C 16. Joy and David Kramer had \$30 to spend on dinner, a movie, and parking. Dinner cost \$15.50 and parking cost \$4. The Kramers had \$2 left after paying for everything. What was the cost of one movie ticket?

17. The museum charges \$4.50 per person for a 2 h tour with fewer than 20 people. If 20 or more people take the tour, the charge is \$3.75 per person. Of the 23 people in today's tour, 17 had paid \$4.50 in advance. How much money will the museum return as a refund?

Self-Test B

Write a variable expression for the word phrase.

1. Twelve divided by a number y [1-6]
2. Five less than a number x
3. The difference when twenty-one is subtracted from the product of nine and a number g

Write an equation or inequality for the word sentence.

4. Fifteen is the sum of nine and twice a number x. [1-7]
5. Twenty-five times the sum of a number b and 7 is greater than eleven divided by four.
6. When the product of four and a number is subtracted from twenty-four, the result is less than or equal to twelve.

Solve, using the five-step plan.

7. Laura bought a hammer for \$12.95, 5 lb of nails for \$5.20, and 8 sheets of plywood for \$12 each. What was her total bill? [1-8]
8. Between the hours of 6 A.M. and 9 P.M., 8 buses that were filled to capacity left the terminal. Since the capacity of each bus is the same and 392 tickets were sold, how many passengers were on each bus?

Self-Test answers and Extra Practice are at the back of the book.

2-1 Exponents

When two or more numbers are multiplied, these numbers are called **factors** of the product. For example,

$$\underbrace{5 \times 8}_{\text{factors}} = 40 \quad \text{and} \quad \underbrace{3 \times 7}_{\text{factors}} = 21.$$

When one factor is used a number of times, we may use an *exponent* to simplify the notation, as shown in the following example.

$$125 = \underbrace{5 \times 5 \times 5}_{\text{equal factors}} = 5^3$$

The expression 5^3 is read *5 cubed,* or *5 to the third power,* where 5 is the **base** and 3 is the **exponent.**

Since 125 is the product of three factors of 5, we say that 125 is *the third power of 5.* Examples of other bases and exponents are listed below.

$15 = 15^1$	*15 to the first power*
$36 = 6 \times 6 = 6^2$	*6 squared,* or *6 to the second power*
$64 = 4 \times 4 \times 4 = 4^3$	*4 cubed,* or *4 to the third power*
$16 = 2 \times 2 \times 2 \times 2 = 2^4$	*2 to the fourth power*

EXAMPLE 1 Express 81 as a power of 3.

Solution

$$81 = 3 \times 3 \times 3 \times 3$$
$$= 3^4$$

EXAMPLE 2 Simplify the expression $2^3 \times 5^2$.

Solution

$$2^3 = 2 \times 2 \times 2 = 8 \qquad 5^2 = 5 \times 5 = 25$$
$$2^3 \times 5^2 = 8 \times 25 = 200$$

Can we give an expression such as 7^0 a meaning? When the powers of any base are listed in order, we may recognize a pattern. Study the example at the top of the next page.

$$7^4 = 7 \times 7 \times 7 \times 7 = 2401$$
$$7^3 = 7 \times 7 \times 7 = 343$$
$$7^2 = 7 \times 7 = 49$$
$$7^1 = 7$$

Notice that in increasing order each power of 7 is seven times the preceding power. Conversely, in decreasing order, each power of 7 is the quotient of the preceding power divided by a factor of 7. That is, $7^3 = 7^4 \div 7$, $7^2 = 7^3 \div 7$, and so on. This decreasing pattern suggests that 7^0 (read *7 to the zero power*) is $7^1 \div 7$. Study the example below to verify that the expression $7^0 = 1$.

$$7^0 = 7^1 \div 7 = 7 \div 7 = 1$$

In general,

Definition

For every number a ($a \neq 0$), $a^0 = 1$.

If an expression contains powers of the same base, the expression may be written as a single power of that base. For example, $13^2 \times 13^3$ can be written as a single power of 13.

$$\begin{aligned} 13^2 \times 13^3 &= (13 \times 13) \times (13 \times 13 \times 13) \\ &= 13 \times 13 \times 13 \times 13 \times 13 \\ &= 13^5 \end{aligned}$$

Notice that the exponent in the product is the sum of the exponents in the factors, that is, $2 + 3 = 5$.

In general,

Rule

For every number a ($a \neq 0$) and all whole numbers m and n,

$$a^m \times a^n = a^{m+n}$$

Notice that the bases must be the same.

EXAMPLE 3 Write $15^3 \times 15^4$ as a single power of 15.

Solution $15^3 \times 15^4 = 15^{3+4} = 15^7$

EXAMPLE 4 Evaluate the expression if $n = 3$.

a. n^2 **b.** $4n^2$ **c.** $(4n)^2$ **d.** $n^2 \times n^2$

Solution Replace n with 3 in each expression and simplify.

a. $n^2 = 3^2 = 3 \times 3 = 9$

b. $4n^2 = 4(3^2) = 4 \times 9 = 36$

c. $(4n)^2 = (4 \times 3)^2 = 12^2 = 12 \times 12 = 144$

d. $n^2 \times n^2 = n^{2+2} = n^4 = 3^4 = 3 \times 3 \times 3 \times 3 = 81$

Notice in parts (b) and (c) of Example 4 how grouping symbols change the values of expressions that have the same numbers.

COMMUNICATION IN MATHEMATICS: *Study Helps*

Look back at this lesson. Notice that the information in the blue boxes on page 41 summarizes important ideas from the lesson. The first box gives a definition and the second box states a rule. Both are applied in the examples. Throughout the book, boxes are used to help you identify important definitions, rules, properties, facts, and formulas. Use them as reminders when you do the exercises and when you review the lesson.

Class Exercises

Read each expression.

1. 4^5 **2.** 9^1 **3.** 15^2 **4.** 3^7 **5.** 10^3 **6.** 2^8

Write using exponents.

7. 9 to the third power **8.** 15 cubed **9.** 4 squared

10. 6 to the fifth power **11.** 216 is the third power of 6.

Express the number as a power of 3.

12. 9 **13.** 27 **14.** 3 **15.** 243 **16.** 1

Simplify the expression.

17. 8^2 **18.** 2^3 **19.** 1^{11} **20.** 18^0 **21.** 83^1

Select the most reasonable estimated answer.

B

25. $89.6 + 13.5$	**a.** 90	**b.** 100	**c.** 70
26. $35 + 12 + 26 + 11$	**a.** 70	**b.** 110	**c.** 90
27. $65.43 - 8.92$	**a.** 56	**b.** 60	**c.** 90
28. $2196 - 924$	**a.** 1300	**b.** 1000	**c.** 3100
29. 6.82×4.7	**a.** 24	**b.** 35	**c.** 28
30. $54 \div 2.5$	**a.** 30	**b.** 20	**c.** 18
31. $36\overline{)283}$	**a.** 10	**b.** 3	**c.** 7
32. $4.7 \times 1.8 + 3.7$	**a.** 7	**b.** 14	**c.** 32

Self-Test A

Simplify the expression.

1. 2^4 **2.** 8^3 **3.** 9^1 **4.** $5^2 \times 5^3$ **5.** $a^6 \times a^5$ [2-1]

Replace $\underline{?}$ with $>$ or $<$ to make a true statement.

6. $30.694 \underline{?} 27.35$ **7.** $0.024 \underline{?} 0.017$ **8.** $0.87 \underline{?} 1.22$ [2-2]

Round to the place specified.

9. tens: 84.307 **10.** hundredths: 3.176 **11.** hundreds: 293.84 [2-3]

Self-Test answers and Extra Practice are at the back of the book.

CALCULATOR INVESTIGATION: *Simplifying Expressions*

Use a calculator to simplify the expressions.

1. $15^2 - 13^2$ and $(15 + 13)(15 - 13)$

2. $47^2 - 21^2$ and $(47 + 21)(47 - 21)$

3. $82^2 - 59^2$ and $(82 + 59)(82 - 59)$

4. $104^2 - 76^2$ and $(104 + 76)(104 - 76)$

Do you recognize a pattern?
Write two expressions that will result in the same pattern.

8. A photograph is enlarged so that its new dimensions are four times its original dimensions. If the new dimensions are 19.2 cm by 25.6 cm, what were the original dimensions?

9. Today the firm of Beckman and Beckman bought three types of stocks: 4780 shares of utility stocks, 1389 shares of commodity stocks, and 3542 shares of energy-related stocks. This is exactly three times the number of shares the firm bought yesterday. How many shares of stock did the firm buy in the past two days?

10. Yukio bought traveler's checks in the following denominations: five \$50 checks, thirty \$20 checks, five \$10 checks, and twenty \$5 checks. What is the total value of the checks bought?

11. Katelyn had 3 twenty-dollar bills to buy school clothes. She picked out a pair of jeans for \$15.90, two pairs of socks at \$2.35 each, and three blouses at \$12.50 each. How much change did she receive?

12. A direct dial call from Boston to Australia costs \$3.17 for the first minute and \$1.19 for each additional minute. A station-to-station operator-assisted call costs \$9.45 for the first 3 minutes and \$1.19 for each additional minute. How much money would you save by dialing direct for a 5-minute call?

Self-Test B

Use the properties of addition and multiplication to simplify.

1. $12(15 - 8) + 6 \times 3$
2. $(31 \times 4) + (15 \times 4) - 91$ [2-4]
3. $7(56 \div 8) - 7(24 \div 6)$
4. $9(0.36 \times 4) + 55$
5. $[(128 \div 4) \div 8)]9$
6. $(12 + 9)5 + (17 - 3)6$

Simplify the expression.

7. $(6a + 7)2 + 4a$
8. $(1.26 + 3.74)^2 \div 4$ [2-5]
9. $[(12 + 6) \div 6] + [(25 + 5) \div 3]$
10. $(7b + 3)5 + (11 + 4b)2$

Solve.

11. Jeremy and his roommate share the monthly utility bills evenly. For November the cost of electricity was \$87.90, gas was \$24.35, heating fuel was \$215.80, and water was \$36.43. How much did each person pay that month? [2-6]

Self-Test answers and Extra Practice are at the back of the book.

5. A parachutist jumped from an airplane flying at an altitude of 1100 m, dropped 200 m in the first 25 s, and then dropped 350 m in the next 35 s. What was the altitude of the parachutist 60 s after jumping?

6. In Summit City, 78 cm of snow fell on Sunday. The snow melted approximately 5.8 cm on Monday, approximately 7.5 cm on Tuesday, and approximately 12 cm on Wednesday. Approximately how much snow remained?

B

7. Donna receives an allowance every 2 weeks that includes \$20 for school lunches. During the past 4 weeks, she spent \$7.50, \$8.25, \$5.25, and \$8.75 on lunches. How much did Donna have left from the money allowed for lunches for the 4 weeks?

8. Eric Chung had \$65.10 in his checking account on June 1. He wrote two checks in June, one for \$42.99. Eric forgot to write down the amount of the other check. At the end of the month, he received a notice that his account was overdrawn by \$22.11. What was the amount of Eric's second check?

Self-Test A

Replace ? with =, >, or < to make a true statement.

1. $^{-}4$? $^{-}5$ **2.** 0 ? $^{-}3$ **3.** $^{-}8$? 9 **4.** $|^{-}7|$? 7 **5.** $|0|$? 0 [3-1]

Write the numbers in order from least to greatest.

6. 0, 5.4, $^{-}4.52$, $^{-}0.25$, $^{-}54$ **7.** $^{-}3.79$, 37, $^{-}7.3$, $^{-}0.37$, $^{-}0.09$ [3-2]

Find the sum or difference.

8. $^{-}9.3 + 42.3$ **9.** $17.8 + {}^{-}17.8$ **10.** $8.76 + {}^{-}10.2$ [3-3]

11. $8 - (-27)$ **12.** $-5.1 - (-5.1)$ **13.** $0 - 36$ [3-4]

Evaluate the expression when $a = -6.4$ and $b = -5.2$.

14. $-b - a$ **15.** $a - (-b)$ **16.** $b - |a|$

Self-Test answers and Extra Practice are at the back of the book.

CHAPTER 1

Rhythm, Meter, and Tempo

Music is the art of sound in time. Its temporal aspect is the most basic place to start understanding music, and this aspect is summed up by the term **rhythm**.

> "Rhythm might be described as, to the world of sound, what light is to the world of sight. It shapes and gives new meaning."
>
> *Edith Sitwell, poet and critic, 1965*

1 Rhythm

In its broadest sense, rhythm refers to the general way music unfolds in time. The primacy of rhythm in the experience of music is taken for granted in our culture—and in most other cultures as well. Rhythm is the main driving force in music both popular and classical, music of all ages and all cultures.

In a more specific sense, "*a* rhythm" refers to the actual arrangement of durations—long and short notes—in a particular melody or some other musical passage. Of course, the term is also used in other contexts, about quarterbacks, poems, and even paintings. But no sport and no other art handles rhythm with as much precision and refinement as music.

Beat and Accent

Beats provide the basic unit of measurement for time in music; if ordinary clock time is measured in seconds, musical time is measured in beats. When listening to a marching band or a rock band, to take two clear examples, we sense a regular recurrence of short pulses. These serve as a steady, vigorous background for other, more complicated rhythms that we discern at the same time. We can't help beating time to the music, dancing to it, waving a hand or tapping a foot. The simple pulse being signaled by waving, tapping, or dancing is the music's beat.

There is, however, an all-important difference between a clock ticking and a drum beating time. Mechanically produced ticks all sound exactly the same, but it is virtually impossible for people to beat time without making some beats more emphatic than others. This is called giving certain beats an **accent**. And accents are really what enable us to beat time, since the simplest way to do this is to alternate accented ("strong") and unaccented ("weak") beats in patterns such as ONE *two* | ONE *two* | ONE *two* . . . or ONE *two three* | ONE *two three* | ONE *two three*. . . . To beat time, then, is not only to measure time according to a regular pulse but also to organize it, at least into these simple two- and three-beat patterns.

▶ Access an interactive tutorial on rhythm, meter, and tempo in the e-book at **bedfordstmartins.com/listen**

2 Meter

Any recurring pattern of strong and weak beats, such as the ONE *two* and ONE *two three* we have referred to above, is called a **meter**. Meter is a strong/weak pattern repeated again and again.

Each occurrence of this repeated pattern, consisting of a principal strong beat and one or more weaker beats, is called a **measure**, or **bar**. In Western music there are only two basic kinds of meter: duple meter and triple meter.

In *duple meter* the beats are grouped in twos (ONE *two* | ONE *two*) or in fours (ONE *two THREE four* | ONE *two THREE four*). Duple meter is instantly familiar from marches — such as "Yankee Doodle" — which tend always to use duple meter in deference to the human anatomy (LEFT *right,* LEFT *right,* LEFT *right*):

Yan-kee	doo-dle	came to	town . . .
ONE	*two*	ONE	*two*

In *triple meter* the beats are grouped in threes (ONE *two three* | ONE *two three*). Our oldest national songs, "The Star-Spangled Banner" and "My Country, 'Tis of Thee," are in triple meter:

Oh,	say	can	you	see . . .	My	coun-	try,	'tis	of thee . . .
	ONE	*two*	*three*	ONE	ONE	*two*	*three*	ONE *two*	*three*

Two other national songs, "America the Beautiful" and "God Bless America," are in duple meter.

Often the main beats of duple and triple meter are subdivided into quicker pulses. This usually happens by dividing the main beat into either twos or threes. When the main beats are divided in twos, the meter is called a **simple meter**. Dividing the main beats in threes creates **compound meters** with two or three main beats and six or nine quicker ones:

ONE	*two*	ONE	*two*	*three*
ONE *two three*	*FOUR five six*	ONE *two three*	*FOUR five six*	*SEVEN eight nine*

The round "Row, Row, Row Your Boat" is in compound duple meter. While the first voice is moving at a fast six-beat clip at the words "Merrily, merrily, merrily, merrily," the second voice comes in pounding out the basic duple meter, "ROW, *row,* ROW":

first voice:

Row,	row,	row your	boat	gently	down the	stream,		Merrily,	merrily,	merrily,	merrily,
1 2 3	4 5 6	1 2 3	4 5 6	1 2 3	4 5 6	1 2 3	4 5 6	1 2 3	4 5 6	1 2 3	4 5 6
ONE	*two*	ONE	*two*	ONE	*two*	ONE	*two*	ONE	*two*	ONE	*two*

second voice:

Row,	row,	row . . .	
ONE	*two*	ONE	*two*

Meters with five beats, seven beats, and so on have never been used widely in Western music, though they are found frequently enough in some other musical cultures. It was an unusual tour de force for nineteenth-century composer Pyotr Ilyich Tchaikovsky to have featured quintuple meter, five beats to a bar, in his popular Sixth Symphony.

Rhythm and Meter

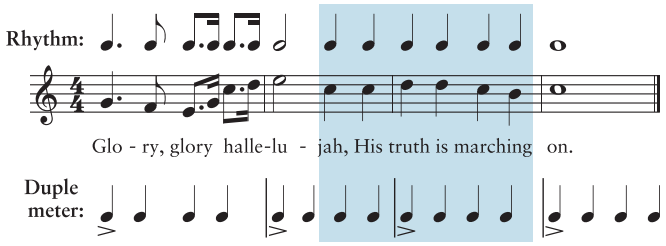
"The most exciting rhythms seem unexpected and complex, the most beautiful melodies simple and inevitable."

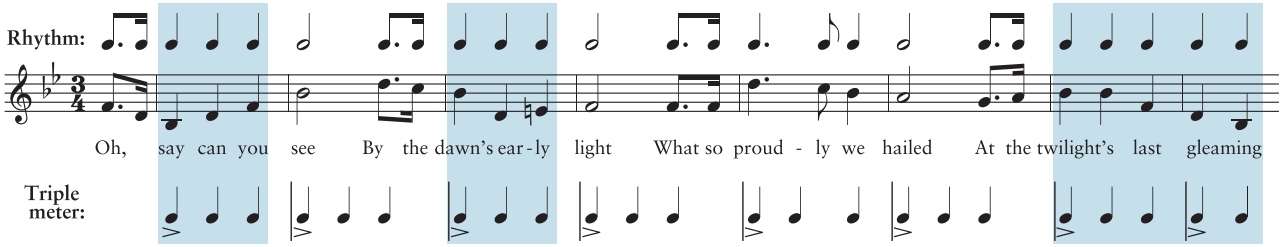
W. H. Auden, poet, 1962

Rhythm in the most general sense refers to the entire time aspect of music and, more specifically, *a* rhythm refers to the particular arrangements of long and short notes in a musical passage. In most Western music, duple or triple *meter* serves as the regular background against which we perceive music's actual rhythms.

As the rhythm first coincides with the meter, then cuts across it independently, then even contradicts it, all kinds of variety, tension, and excitement can result. Meter is background; rhythm is foreground.

Musical notation has developed a conventional system of signs (see Appendix B) to indicate relative durations, or long and short notes; combining various signs is the way of indicating rhythms. Following are examples of well-known tunes in duple and triple meters. Notice from the shading (even better, sing the tunes to yourself and *hear*) how the rhythm sometimes corresponds with the pulses of the meter and sometimes departs from them. The shading indicates passages of rhythm-meter correspondence:





The above examples should not be taken to imply that meter is always emphasized behind music's rhythms. Often the meter is not explicitly beaten out at all. It does not need to be, for the listener can almost always sense it under the surface. Naturally, meter is strongly stressed in music designed to stimulate regular body movements, such as marches, dances, and much popular music.

At the other extreme, there is *nonmetrical* music. In such music, the rhythms suggest no underlying pattern of strong and weak beats. For example, the meandering, nonmetrical rhythms of Gregorian chant contribute to the cool, otherworldly, and spiritual quality that devotees of this music cherish.

Syncopation

One way of obtaining interesting, striking effects in music is to move the accents in a foreground *rhythm* away from their normal position on the beats of the background *meter.* This may seem counterintuitive, but it works. In **syncopation**,

LISTENING EXERCISE 1

Rhythm, Meter, and Syncopation

In Unit I of this book, we illustrate the concepts that are introduced with listening examples drawn from the Companion DVD. Follow the timings in these Listening Exercises, which are simplified versions of the Listening Charts provided for complete compositions later in the book. The charts are explained on page xxviii.

For samples of *duple, triple,* and *compound meters,* listen to the following tracks on the DVD.

10, 14	Duple meter	Count ONE *two* | ONE *two* . . . etc., for about half a minute.
16	Duple meter	Count ONE *two* THREE *four* | ONE *two* THREE *four* . . . etc.
12, 19	Triple meter	Count ONE *two three* | ONE *two three* . . . etc.
17	Compound meter	Count ONE *two three* FOUR *five six* | ONE *two three* FOUR *five six* . . . etc.

10 ***Syncopation:*** In Scott Joplin's "Maple Leaf Rag," listen to the piano left hand, with its steady ONE *two* \| ONE *two* beat in duple meter, while the right hand cuts across it with syncopations in almost every measure.

as it is called, accents can be displaced so they go *one* TWO \| *one* TWO (*weak* STRONG \| *weak* STRONG) instead of the normal ONE *two* \| ONE *two* (STRONG *weak* \| STRONG *weak*). Or syncopation can occur when an accent is placed *in between* beats ONE and *two,* as in this Christmas ballad:

Ru-	***dolf***	___	the	red -		nosed		rein -		deer	___	___	___	___	___
ONE		*two*	|	ONE	*two*	|	ONE		*two*	|	ONE		*two*	

The consistent use of syncopation is the hallmark of African American–derived popular music, from ragtime to rap. See Chapter 24, and listen to the lively, uneven, *syncopated* rhythms of Scott Joplin's "Maple Leaf Rag" in Listening Exercise 1.

3 Tempo

Our discussion so far has referred to the *relative* duration of sounds—all beats are equal; some notes are twice as long as others, and so on—but nothing has been said yet about their *absolute* duration, in fractions of a second. The term for the speed of music is **tempo**; in metrical music, the tempo is the rate at which the basic, regular beats of the meter follow one another.

Tempo can be expressed exactly and measured by the **metronome**, a mechanical or electrical device that ticks out beats at any desired tempo. When composers give directions for tempo, however, they usually prefer approximate terms. Rather than freezing the music's speed by means of a metronome, they prefer to leave some latitude for different performers. Because all European music looked to Italy when this terminology first came into use, the conventional terms for tempo are Italian:

An early metronome owned by Beethoven; its inventor was a friend of his. A clockwork mechanism made the bar swing side to side, ticking at rates controlled by a movable weight.

LISTENING EXERCISE 2

Rhythm, Meter, and Tempo

DVD 11

A more advanced exercise: Our excerpt, from the middle of *Rhapsody on a Theme by Paganini*, for piano and orchestra, by Sergei Rachmaninov, consists of four continuous segments in different meters and tempos, here labeled A, B, C, and D. (If you note a family likeness among the segments, that is because they are all variations on a single theme. See page 174.)

0:00	**A**	The piano starts in ***duple meter*** (ONE *two* | ONE *two*). The loud orchestral interruptions are ***syncopated.*** (After the interruptions the meter is somewhat obscured, but it gets clearer.)
0:33		Clear duple meter by this time; then the music comes to a stop.
0:49	**B**	No meter. The piano seems to be engaged in a meditative improvisation, as if it is dreaming up the music to come.
1:45		Orchestral instruments suggest a slow ***duple meter***? Not for long.
2:24	**C**	Slow ***triple meter*** (ONE *two three* | ONE *two three*)
3:47		***Ritardando*** (getting slower)
3:56	**D**	Fast ***triple meter***, assertive (note one or two syncopated notes)
4:26		Faster ***triple meter***

COMMON TEMPO INDICATIONS

adagio:	slow
andante:	on the slow side, but not too slow
moderato:	moderate
allegretto:	on the fast side, but not too fast
allegro:	fast
presto:	very fast

LESS COMMON TEMPO INDICATIONS

largo, lento, grave:	slow, very slow
larghetto:	somewhat faster than *largo*
andantino:	somewhat faster than *andante*
vivace, vivo:	lively
molto allegro:	faster than *allegro*
prestissimo:	very fast indeed

It's interesting that in their original meaning many of these Italian words refer not to speed itself but rather to a mood, action, or quality that can be associated with tempo only in a general way. Thus, *vivace* is close to our "vivacious," *allegro* means "cheerful," and *andante,* derived from the Italian word for "go," might be translated as "walking along steadily."

The most important terms to remember are those listed under "common tempo indications" above. Composers often use tempo indications alone as headings for major sections, called movements, in long works. People refer to the "Andante" of Beethoven's Fifth Symphony, meaning a certain movement of the symphony (the second), which Beethoven specified should be played at an *andante* tempo.

SECTION 1

How the Nervous System Works

DISCOVER

ACTIVITY

How Simple Is a Simple Task?

1. Trace the outline of a penny in twelve different places on a piece of paper.
2. In no particular order, number the circles from 1 through 12.
3. Now pick up the penny again. Put it in each circle, one after another, in numerical order, beginning with 1 and ending with 12.

Think it Over

Inferring Make a list of all the sense organs, muscle movements, and thought processes in this activity. Compare your list with your classmates' lists. Identify the organ system that coordinated all the different processes involved in this task.

GUIDE FOR READING

- **What are the functions of the nervous system?**
- **What are the three types of neurons and how do they interact?**

Reading Tip **As you read, write a definition for each Key Term in your own words.**

Key Terms **neuron • nerve impulse • dendrite • axon • nerve • sensory neuron • interneuron • motor neuron • synapse**

The drums roll, and the crowd suddenly becomes silent. The people in the audience hold their breaths as the tightrope walker begins his long and dangerous journey across the wire. High above the circus floor, he inches along, slowly but steadily. One wrong movement could mean disaster.

To keep from slipping, tightrope performers need excellent coordination and a keen sense of balance. In addition, they must remember what they have learned from years of practice.

Even though you aren't a tightrope walker, you also need coordination, a sense of balance, memory, and the ability to learn. Your nervous system carries out all those functions. The nervous system consists of the brain, spinal cord, and nerves that run throughout the body. It also includes sense organs such as the eyes and ears.

Functions of the Nervous System

Like the Internet, your nervous system is a communications network. Your nervous system is much more efficient, however. **The nervous system receives information about what is happening both inside and outside your body. It also directs the way in which your body responds to this information. In addition, your nervous system helps in maintaining stable internal conditions.** Without your nervous system, you could not move, think, feel pain, or taste a spicy taco.

Figure 1 The sparkling water is an external stimulus. This toddler responds by thrusting her hands into the water and splashing.

Receiving Information Because of your nervous system, you are aware of what is happening in the environment around you. For example, you know that a soccer ball is zooming toward you, that the wind is blowing, or that a friend is telling a funny joke. Your nervous system also checks conditions inside your body, such as the level of glucose in your blood.

Responding to Stimuli As you learned in Chapter 10, any change or signal in the environment that can make an organism react is a stimulus. Stimuli can come from the outside environment or from inside your body. A zooming soccer ball is an external stimulus. Hunger and tiredness are internal stimuli.

After your nervous system analyzes the stimulus, it causes a response. A response is what your body does in reaction to a stimulus—you kick the ball toward the goal, eat a peach, or take a nap. Some nervous system responses, such as kicking a ball, are voluntary, or under your control. However, many processes necessary for life, such as heart rate, are controlled by involuntary actions of the nervous system.

Maintaining Stable Internal Conditions The nervous system helps maintain homeostasis by directing the body to respond appropriately to the information it receives. For example, when you are hungry, your nervous system directs you to eat. This action maintains stable internal conditions by supplying your body with nutrients and energy it needs.

☑ ***Checkpoint*** *What does the nervous system do?*

The Neuron—A Message-Carrying Cell

The cells that carry information through your nervous system are called **neurons** (NOO rahnz), or nerve cells. The message that a neuron carries is called a **nerve impulse.** The structure of a neuron enables it to carry nerve impulses.

The Structure and Function of a Neuron The cell body of a neuron, which contains the nucleus, has threadlike extensions. One kind of extension, a **dendrite,** carries impulses toward the cell body. An **axon** carries impulses away from the cell body. Nerve impulses begin in a dendrite, move toward the cell body, and then move down the axon. A neuron can have many dendrites, but it has only one axon. An axon, however, can have more than one tip, so the impulse can go to more than one other cell.

Axons and dendrites are sometimes called nerve fibers. Nerve fibers are often arranged in parallel bundles covered with connective tissue, something like a package of uncooked spaghetti wrapped in cellophane. A bundle of nerve fibers is called a **nerve.**

Kinds of Neurons Different kinds of neurons perform different functions. **Three kinds of neurons are found in the body—sensory neurons, interneurons, and motor neurons. Together they make up a chain of nerve cells that carry an impulse through the nervous system.** *Exploring the Path of a Nerve Impulse* shows how these three kinds of neurons work together.

A **sensory neuron** picks up stimuli from the internal or external environment and converts each stimulus into a nerve impulse. The impulse travels along the sensory neuron until it reaches an interneuron, usually in the brain or spinal cord. An **interneuron** is a neuron that carries nerve impulses from one neuron to another. Some interneurons pass impulses from sensory neurons to motor neurons. A **motor neuron** sends an impulse to a muscle, and the muscle contracts in response.

Checkpoint *What is the function of an axon?*

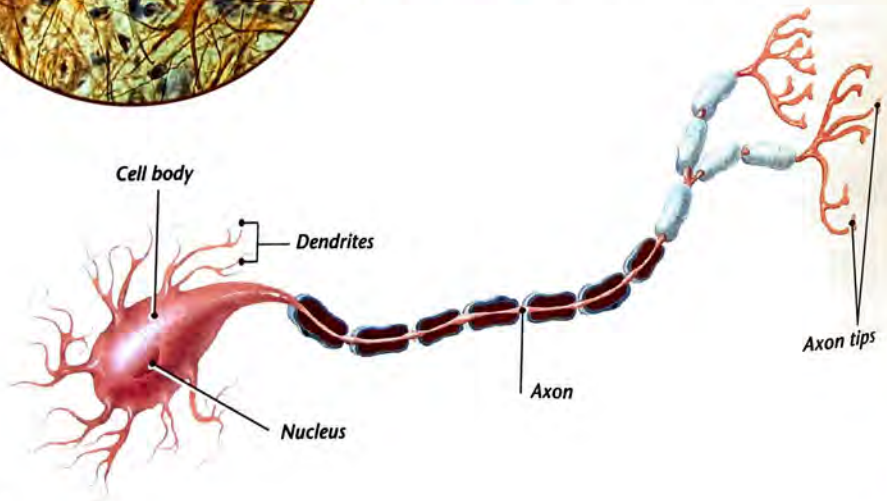
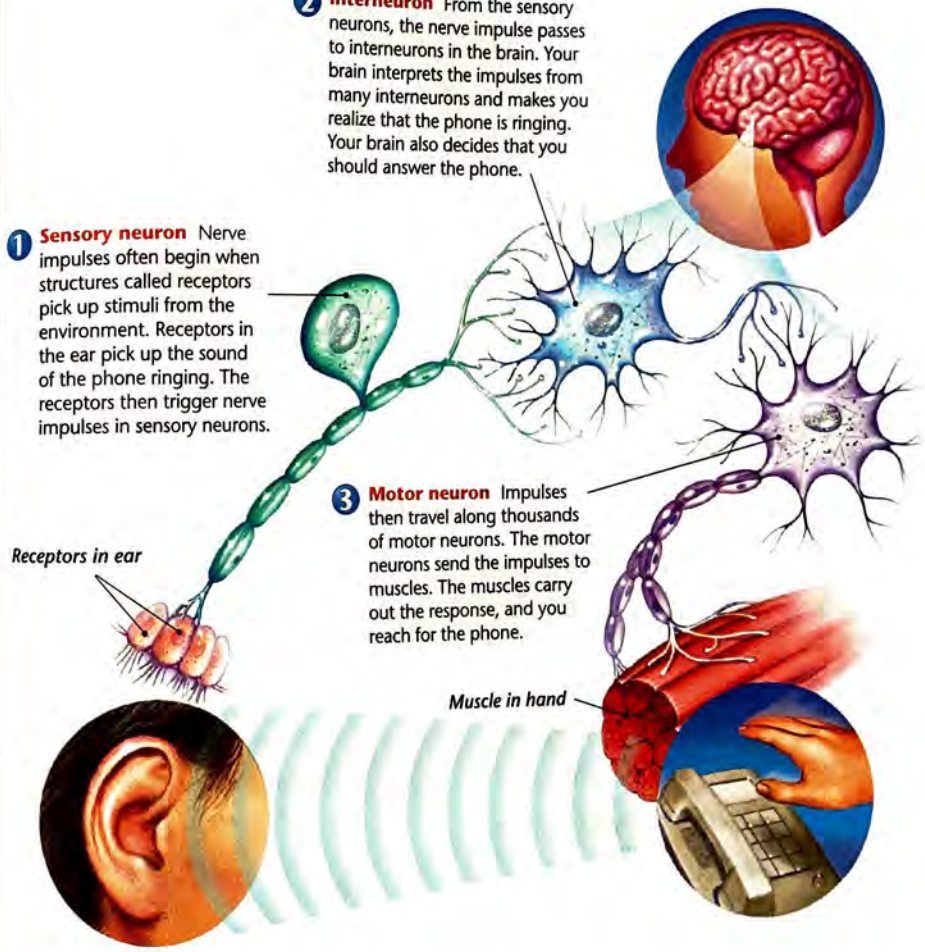


Figure 2 A neuron, or nerve cell, has one axon and many dendrites that extend from the cell body. The dendrites carry a nerve message toward the cell body, and the axon carries the message away from the cell body. *Applying Concepts How many axons can a neuron have?*

EXPLORING the Path of a Nerve Impulse

When you hear the phone ring, you pick it up to answer it. Many sensory neurons, interneurons, and motor neurons are involved in this response.



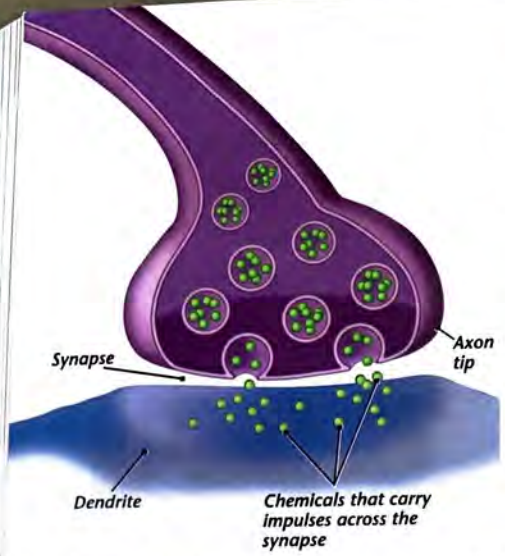


Figure 3 A synapse is the tiny space between the axon of one neuron and the dendrite of another neuron. When a nerve impulse reaches the end of an axon, chemicals are released into the synapse. These chemicals enable the nerve impulse to cross the synapse.

How a Nerve Impulse Travels

Every day of your life, millions of nerve impulses travel through your nervous system. Each of those nerve impulses begins in the dendrites of a neuron. The impulse moves rapidly toward the neuron's cell body and then down the axon until it reaches the axon tip. A nerve impulse travels along the neuron in the form of electrical and chemical signals. Nerve impulses can travel as fast as 120 meters per second!

There is a tiny space called a **synapse** (SIN aps) between each axon tip and the next structure. Sometimes this next structure is a dendrite of another neuron. Other times the next structure can be a muscle or a cell in another organ, such as a sweat gland. Figure 3 shows a synapse between the axon of one neuron and a dendrite of another neuron.

In order for a nerve impulse to be carried along, it must cross the gap between the axon and the next structure. The axon tips release chemicals that enable the impulse to cross the synapse. If that didn't happen, the impulse would stop at the end of the axon. The impulse would not be passed from sensory neuron, to interneuron, to motor neuron. Nerve impulses would never reach your brain or make your muscles contract.

You can think of a synapse as a river, and an axon as a road that leads up to the riverbank. The nerve impulse is like a car traveling on the road. To get to the other side, the car has to cross the river. The car gets on a ferry boat, which carries it across the river. The chemicals that the axon tips release are like a ferry that carries the nerve impulse across the synapse.

Section 1 Review

1. Describe three functions of the nervous system.
2. Identify the three kinds of neurons. Describe how they interact to carry nerve impulses.
3. Distinguish between external and internal stimuli. Give an example of each.
4. **Thinking Critically** **Predicting** What would happen to a nerve impulse carried by an interneuron if the tips of the interneuron's axon were damaged? Explain your answer.

Science at Home

Stimulus and Response During dinner, ask a family member to pass the salt and pepper to you. Observe what your family member then does. Explain that the words you spoke were an external stimulus and that the family member's reaction was a response. Discuss other examples of stimuli and responses with your family.

Designing Experiments

Ready or Not

Skills Lab

Do people carry out tasks better at certain times of day? In this lab, you will design an experiment to answer this question.

Problem

Do people's reactions vary at different times of day?

Materials

meter stick

Design a Plan

Part 1 Observing a Response to a Stimulus

1. Have your partner hold a meter stick with the zero end about 50 cm above a table.
2. Get ready to catch the meter stick by positioning the top of your thumb and forefinger just at the zero position as shown in the photograph.
3. Your partner should drop the meter stick without any warning. Using your thumb and forefinger only (no other part of your hand), catch the meter stick as soon as you can. Record the distance in centimeters that the meter stick fell. This distance is a measure of your reaction time.

Part 2 Design Your Experiment

4. With your partner, discuss how you can use the activity from Part 1 to find out whether people's reactions vary at different times of day. Be sure to consider the questions below. Then write up your experimental plan.
   - What hypothesis will you test?
   - What variables do you need to control?
   - How many people will you test? How many times will you test each person?
5. Have your teacher review your plan. Make any recommended changes. Construct a data chart to organize, examine, and evaluate your data. Then perform your experiment.

Analyze and Conclude

1. In this lab, what is the stimulus? What is the response? Is this response voluntary or involuntary? Explain.
2. Why can you use the distance on the meter stick as a measure of reaction time?
3. Based on your results, do people's reactions vary at different times of day? Explain.
4. **Think About It** In Part 2, why is it important to control all variables except the time of day?

More to Explore

Do you think people can do arithmetic problems more quickly and accurately at certain times of the day? Design an experiment to investigate this question. Obtain your teacher's permission before trying your experiment.

SECTION 2

Divisions of the Nervous System

DISCOVER ACTIVITY

How Does Your Knee React?

1. Sit on a table or counter so that your legs dangle freely. Your feet should not touch the floor.
2. Have your partner use the side of his or her hand to *gently* tap one of your knees just below the kneecap. Observe what happens to your leg. Note whether you have any control over your reaction.
3. Change places with your partner. Repeat Steps 1 and 2.

Think It Over

Inferring When might it be an advantage for your body to react very quickly and without your conscious control?

GUIDE FOR READING

- **What is the function of the central nervous system?**
- **What is the function of the peripheral nervous system?**
- **What is a reflex?**

Reading Tip **After you examine Figure 6, use your own words to describe the structure of the brain.**

Key Terms **central nervous system • peripheral nervous system • brain • spinal cord • cerebrum • cerebellum • brainstem • somatic nervous system • autonomic nervous system • reflex**

A concert is about to begin. The conductor gives the signal, and the musicians begin to play. The sound of music, beautiful and stirring, fills the air.

To play music in harmony, an orchestra needs both musicians and a conductor. The musicians play the music, and the conductor directs the musicians and coordinates their playing.

Similarly, your nervous system has two divisions that work together—the central nervous system and the peripheral nervous system. The **central nervous system** consists of the brain and spinal cord. The **peripheral nervous system** consists of all the nerves located outside of the central nervous system. The central nervous system is like a conductor. The nerves of the peripheral nervous system are like the musicians.

Figure 4 In an orchestra, the conductor and musicians work together to make music.

Central Nervous System Functions

You can see the structure of the central and peripheral nervous systems in Figure 5. **The central nervous system is the control center of the body.** All information about what is happening in the world inside or outside your body is brought to the central nervous system. The **brain,** located in the skull, is the part of the central nervous system that controls most functions in the body. The **spinal cord** is the thick column of nerve tissue that links the brain to most of the nerves in the peripheral nervous system.

Most impulses from the peripheral nervous system travel through the spinal cord to get to the brain. Your brain then directs a response. The response usually travels from the brain, through the spinal cord, and then to the peripheral nervous system.

For example, here is what happens when you reach under the sofa to find a lost quarter. Your fingers move over the floor, searching for the quarter. When your fingers finally touch the quarter, the stimulus of the touch triggers nerve impulses in sensory neurons in your fingers. These impulses travel through nerves of the peripheral nervous system to your spinal cord. Then the impulses race up to your brain. Your brain interprets the impulses, telling you that you've found the quarter. Your brain starts nerve impulses that move down the spinal cord. From the spinal cord, the impulses travel through motor nerves in your arm and hand. The impulses in the motor neurons cause your fingers to grasp the quarter.

☑ ***Checkpoint*** *What does the spinal cord do?*

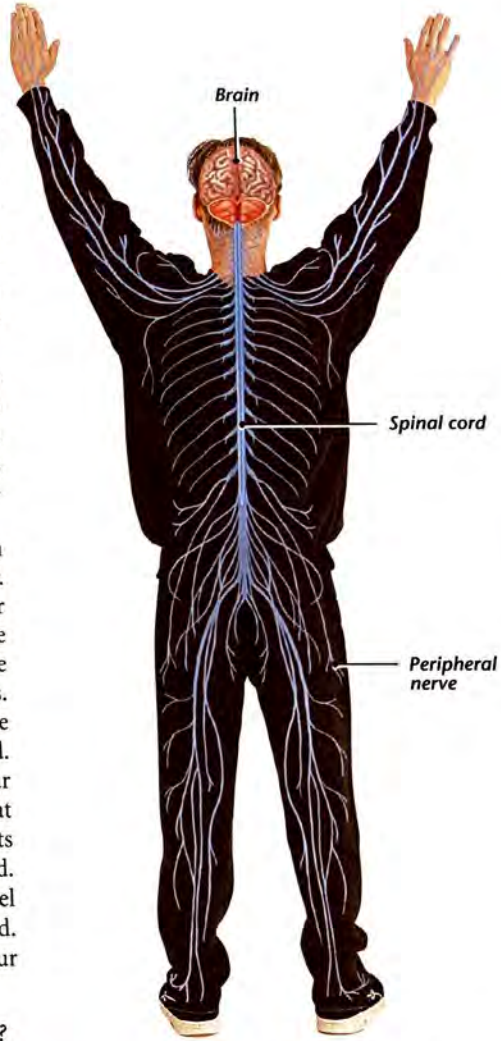


Figure 5 The central nervous system consists of the brain and spinal cord. The peripheral nervous system contains all the nerves that branch out from the brain and spinal cord.

The Structure and Functions of the Brain

Your brain contains about 100 billion neurons, most of which are interneurons. Each of those neurons may receive impulses from up to 10,000 other neurons and may send impulses to about 1,000 more! Three layers of connective tissue cover the brain. The space between the outermost layer and the middle layer is filled with a watery fluid. The skull, layers of connective tissue, and fluid all help protect the brain from injury.

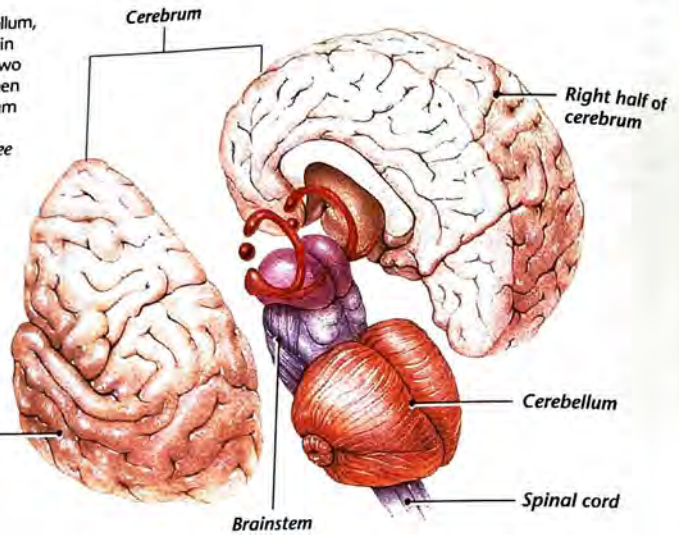


Figure 6 The cerebrum, cerebellum, and brainstem are the three main parts of the human brain. The two halves of the cerebrum have been separated to show the cerebellum and the brainstem.
Applying Concepts *What are three functions of the cerebrum?*

Cerebrum There are three main regions of the brain. These are the cerebrum, the cerebellum, and the brainstem. Find each in Figure 6. The largest part of the brain is called the cerebrum. The **cerebrum** (suh REE brum) interprets input from the senses, controls the movement of skeletal muscles, and carries out complex mental processes such as learning, remembering, and making judgments. Because of your cerebrum, you can find the comics in a newspaper and locate your favorite comic strip on the page. Your cerebrum also enables you to read the comic strip and laugh at its funny characters.

Notice in Figure 6 that the cerebrum is divided into a right and a left half. The two halves have somewhat different functions. The right half of the cerebrum contains the neurons that send impulses to the skeletal muscles on the left side of the body. In contrast, the left half of the cerebrum controls the right side of the body. When you reach with your right hand for a pencil, the messages that tell you to do so come from the left half of your cerebrum.

In addition, each half of the cerebrum controls slightly different kinds of mental activity. The right half of the cerebrum is usually associated with creativity and artistic ability. The left half, in contrast, is associated with mathematical skills, speech, writing, and logical thinking.

TRY THIS

You've Got Nerve!

ACTIVITY

Use research materials to learn more about the human nervous system. Then construct a life-size model of the human nervous system. Use materials such as wire, string, papier mâché, and chicken wire. Label the parts of your model. Your labels should explain the function of the major structures in the nervous system.

Making Models What parts of the nervous system were difficult to show in your model?

Cerebellum and Brainstem The second largest part of your brain is called the cerebellum. The **cerebellum** (sehr uh BEL um) coordinates the actions of your muscles and helps you keep your balance. When you put one foot in front of the other as you walk, the motor neuron impulses that tell your feet to move start in your cerebrum. However, your cerebellum gives you the muscular coordination and sense of balance that keep you from falling down.

The **brainstem,** which lies between the cerebellum and spinal cord, controls your body's involuntary actions—those that occur automatically. For example, the brainstem regulates your breathing and helps control your heartbeat.

Checkpoint ***What part of your brain coordinates the contractions of your muscles?***

The Spinal Cord

Run your fingers down the center of your back to feel the bones of the vertebral column. The vertebral column surrounds and protects the spinal cord. The spinal cord is the link between your brain and the peripheral nervous system. The layers of connective tissue that surround and protect the brain also cover the spinal cord. In addition, like the brain, the spinal cord is further protected by a watery fluid.

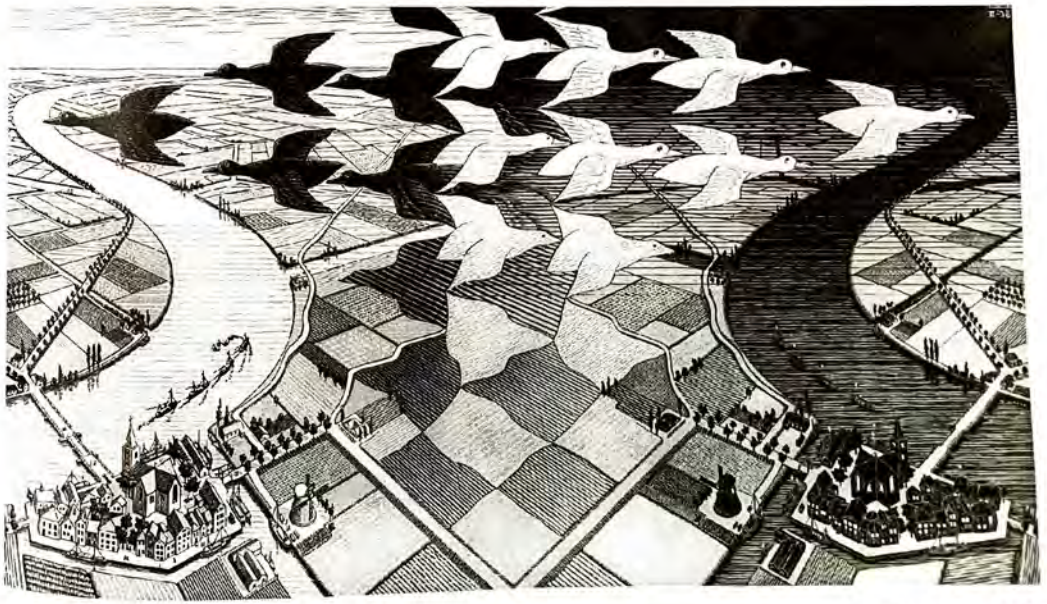
Visual Arts CONNECTION

Some artists deliberately create works of art that can be interpreted by the brain in more than one way. The Dutch artist M. C. Escher (1898–1972) delighted in drawing illustrations that played visual tricks on his viewers. Glance quickly at Escher's illustration in Figure 7. Then look at it again. Do you see the two different scenes in this single picture?

In Your Journal

Which scene did you see when you first looked at Figure 7? Did your brain interpret the picture differently the second time? Write a description of the visual trick that Escher has played in this illustration.

Figure 7 This illustration, by the Dutch artist M. C. Escher, is called "Day and Night." Escher drew this picture in 1938.



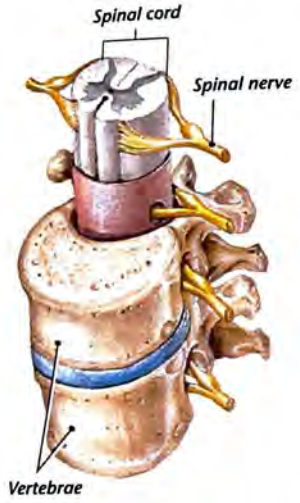


Figure 8 The spinal nerves, which connect to the spinal cord, emerge from spaces between the vertebrae. Each spinal nerve consists of both sensory and motor neurons.

Function of the Peripheral Nervous System

The second division of the nervous system is the peripheral nervous system. **The peripheral nervous system consists of a network of nerves that branch out from the central nervous system and function to connect it to the rest of your body.** A total of 43 pairs of nerves make up the peripheral nervous system. Twelve pairs originate in the brain. The other 31 pairs—the spinal nerves—begin in the spinal cord. One nerve in each pair goes to the left side of the body, and the other goes to the right. As you can see in Figure 8, spinal nerves leave the spinal cord through spaces between the vertebrae.

Two-Way Traffic A spinal nerve is a little bit like a two-lane highway. Impulses travel on a spinal nerve in two directions—both to and from the central nervous system. Each spinal nerve contains axons of both sensory and motor neurons. The sensory neurons carry impulses from the body to the central nervous system. The motor neurons carry impulses in the opposite direction—from the central nervous system to the body.

Somatic and Autonomic Systems The nerves of the peripheral nervous system can be divided into two groups, the somatic (soh MAT ik) and autonomic (awt uh NAHM ik) nervous systems. The nerves of the **somatic nervous system** control voluntary actions such as using a fork or tying your shoelaces. In contrast, nerves of the **autonomic nervous system** control involuntary actions. For example, the autonomic nervous system regulates the contractions of the smooth muscles that adjust the diameter of blood vessels.

Figure 9 The somatic nervous system controls voluntary actions. The girl's somatic nervous system is at work as she shapes the pot with her hands. *Classifying What part of the peripheral nervous system helps regulate the girl's heartbeat?*

Reflexes

Imagine that you are watching an adventure movie. The movie is so thrilling that you don't notice a fly circling above your head. When the fly zooms right in front of your eyes, however, your eyelids immediately blink shut. You didn't decide to close your eyes. The blink, which is an example of a **reflex,** happened automatically. **A reflex is an automatic response that occurs very rapidly and without conscious control.** If you did the Discover activity, you experienced a reflex response.

As you have learned, the contraction of skeletal muscles is usually controlled by the brain. However, in some reflex actions, skeletal muscles contract with the involvement of the spinal cord only—not the brain. Figure 10 shows the reflex action that occurs when you touch a sharp object, such as a cactus thorn. When your finger touches the object, sensory neurons send impulses to the spinal cord. The impulses then pass to interneurons in the spinal cord. From there the impulses pass directly to motor neurons in your arm and hand. The muscles then contract, and your hand jerks up and away from the sharp object. By removing your hand quickly, this reflex protects you from getting badly cut.

At the same time that some nerve impulses make your arm muscles contract, other nerve impulses travel up your spinal cord and to your brain. When these impulses reach your brain, your brain interprets them. You then feel a sharp pain in your finger.

Figure 10 If you touch a sharp object, your hand immediately jerks away. This action, which is known as a reflex, happens automatically. Nerve impulses begin in nerve endings **(1)** and then travel along sensory neurons **(2)** to interneurons in the spinal cord **(3).** From there, impulses travel through motor neurons **(4)** to muscles in your arm **(5).** The muscles contract to pull your hand away.

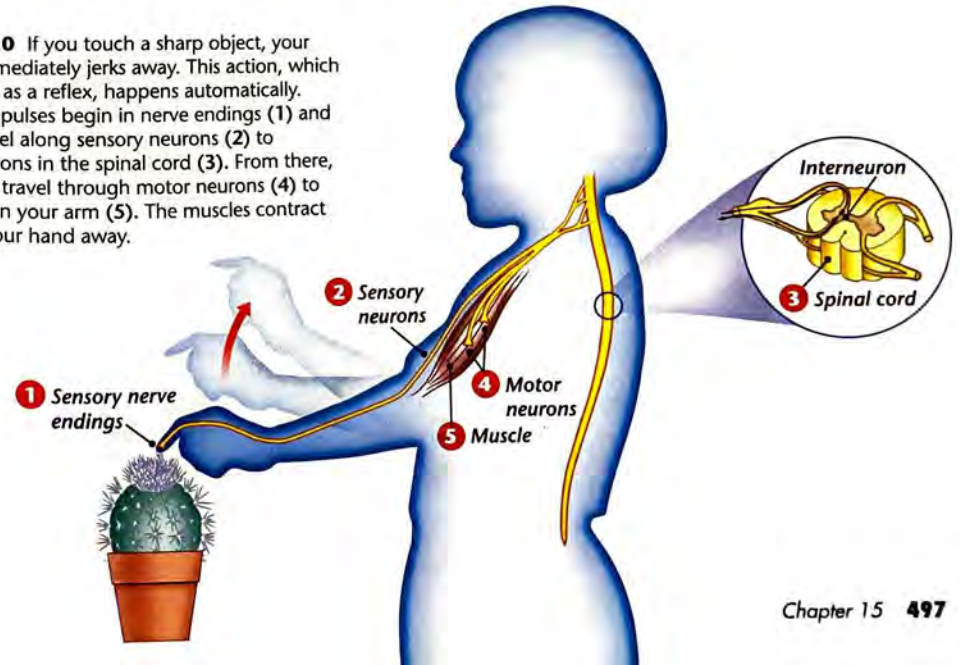


Figure 11 By wearing a helmet, this skateboarder is helping to prevent injury to his brain.

It takes longer for the pain impulses to get to the brain and be interpreted than it does for the reflex action to occur. By the time you feel the pain, you have already moved your hand away from the sharp object.

Safety and the Nervous System

INTEGRATING HEALTH

Like other parts of the body, the nervous system can suffer injuries that interfere with its functioning. Concussions and spinal cord injuries are two ways in which the nervous system can be damaged.

A concussion is a bruiselike injury of the brain. A concussion occurs when soft tissue of the cerebrum bumps against the skull. Concussions can happen during a hard fall, an automobile accident, or contact sports such as football. With most concussions, you may have a headache for a short time, but the injured tissue heals by itself. However, if you black out, experience confusion, or feel drowsy after the injury, you should be checked by a doctor. To decrease your chances of getting a brain injury, wear a helmet when bicycling, skating, or performing other activities in which you risk bumping your head.

Spinal cord injuries occur when the spinal cord is cut or crushed. When the spinal cord is cut, all the nerve axons in that region are split, so impulses cannot pass through them. This type of injury results in paralysis, which is the loss of movement in some part of the body. Car crashes are the most common cause of spinal cord injuries. You can help protect yourself from a spinal cord injury by wearing a seatbelt when you travel in a car. Also, when you swim, make sure the water is deep enough before you dive in.

Section 2 Review

1. What is the function of the central nervous system? Which organs are part of this system?
2. What is the peripheral nervous system and what is its function?
3. Explain what a reflex is. How do reflexes help protect the body from injury?
4. **Thinking Critically** **Relating Cause and Effect** What symptoms might indicate that a person's cerebellum has been injured?

CHAPTER PROJECT

Check Your Progress

At this point, you should have chosen one or more illusions to investigate. Now write up the plan for your experiment. List some questions that you will ask to monitor people's responses to the illusions. (*Hint:* Try out your illusions and your questions on classmates to find out what responses to expect.) With your classmates, make plans for setting up the science fair.

SCIENCE AND SOCIETY

Should People Be Required to Wear Bicycle Helmets?

Bicycle riding is an enjoyable activity. But unfortunately, many bicycle riders become injured while riding. Each year about 150,000 children alone are treated in hospitals for head injuries that occur while bicycling. Head injuries can affect everything your brain does—thinking, remembering, seeing, and being able to move. Experts estimate that as many as 85 percent of bicycle-related head injuries could be prevented if all bicyclists wore helmets. But only about 18 percent of bicyclists wear helmets. What is the best way to get bicycle riders to protect themselves from head injury?

The Issues

Should Laws Require the Use of Bicycle Helmets? About 15 states have passed laws requiring bicycle riders to wear helmets. Nearly all of these laws, however, apply only to children. Some supporters of bicycle laws want to see the laws extended to all bicycle riders. Supporters point out that laws increase helmet use by 47 percent. In contrast, educational programs without laws to back them up increase bicycle helmet use by only 18 percent.

What Are the Drawbacks of Helmet Laws? Opponents of helmet laws believe it is up to the individual, not the government, to decide whether or not to wear a helmet. They say it is not the role of the government to stop people from taking risks. Rather than making people who don't wear helmets pay fines, governments should educate people about the benefits of helmets. Car drivers should also be educated about safe driving procedures near bicycles.

Are There Alternatives to Helmet Laws? Instead of laws requiring people to wear helmets, some communities and organizations have set up educational programs that teach about the advantages of helmets. Effective programs teach about the dangers of head injuries and how helmets protect riders. In addition, they point out that safe helmets can be lightweight and comfortable. Effective education programs, though, can be expensive. They also need to reach a wide audience, including children, teens, and adults.

You Decide

1. **Identify the Problem**
   In your own words, explain the issues concerning laws requiring people to wear bicycle helmets.
2. **Analyze the Options**
   List two different plans for increasing helmet use by bicycle riders. List at least one advantage and one drawback of each plan.
3. **Find a Solution**
   You are a member of the city government hoping to increase helmet use. Write a speech outlining your position for either a helmet law or an alternative plan. Support your position.

SECTION 3

The Senses

DISCOVER ACTIVITY

What's in the Bag?

1. Your teacher will give you a paper bag that contains several objects. Your challenge is to use only your sense of touch to identify each object. You will not look inside the bag.
2. Put your hand in the bag and carefully touch each object. Observe the shape of each object. Note whether its surface is rough or smooth. Also note other characteristics, such as its size, what it seems to be made of, and whether it can be bent.
3. After you have finished touching each object, write your observations on a sheet of paper. Then write your inference about what each object is.

Think It Over

Observing What could you determine about each object without looking at it? What could you not determine?

GUIDE FOR READING

- **What overall function do the senses perform?**
- **How do your eyes enable you to see?**
- **How do you hear?**

Reading Tip **As you read, write an outline of this section. Use the headings in the section as the main topics in the outline.**

Key Terms **cornea • pupil • iris • lens • retina • nearsightedness • farsightedness • eardrum • cochlea • semicircular canals**

You waited in line to get on the ride, and now it's about to begin. You grip the bars as the ride suddenly starts to move. Before you know it, you are lifted high above the ground and you feel the air whipping by. All you see is a dizzy blur.

The thrill you experience from the speed of amusement park rides comes from your senses. **Each of your major senses—vision, hearing, balance, smell, taste, and touch—picks up a specific type of stimulus from your environment. The sense organs change those stimuli into nerve impulses and send the impulses to your brain.** Your brain then interprets the information. Because of the way in which your senses and brain work together, you learn a great deal about your environment.

Figure 12 Riders and bright lights whizzing by—that's what you see when you watch this amusement park ride.

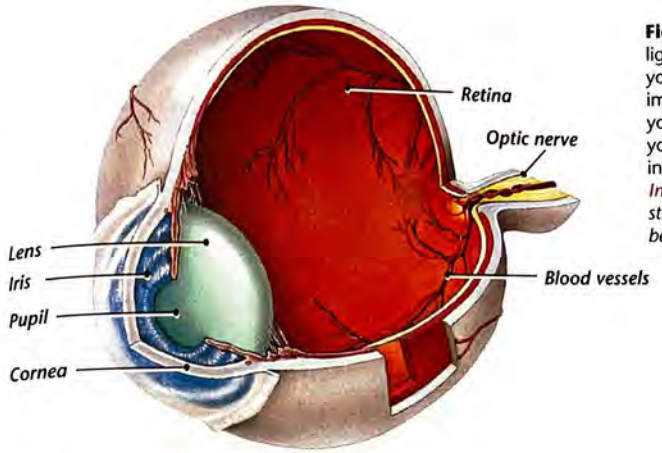


Figure 13 You see an object when light coming from the object enters your eye. The light produces an image on your retina. Receptors in your retina then send impulses to your cerebrum, and your cerebrum interprets these impulses. *Interpreting Diagrams What structures must light pass through before it reaches your retina?*

Vision

Your eyes are the sense organs that enable you to see the objects in your environment. They let you see this book in front of you, the window across the room, and the world outside the window. **Your eyes respond to the external stimulus of light. They convert that stimulus into impulses that your brain then interprets, enabling you to see.**

How Light Enters Your Eye When rays of light strike the eye, they pass through the structures shown in Figure 13. First, the light strikes the **cornea** (KAWR nee uh), the clear tissue that covers the front of the eye. The light then passes through a fluid-filled chamber behind the cornea and reaches the pupil. The **pupil** is the opening through which light enters the eye.

You may have noticed that people's pupils change size when they go from a dark room into bright sunshine. In bright light, the pupil becomes smaller. In dim light, the pupil becomes larger. The size of the pupil is adjusted by muscles in the iris. The **iris** is a circular structure that surrounds the pupil and regulates the amount of light entering the eye. The iris also gives the eye its color. If you have brown eyes, your irises are brown.

How Light Is Focused Light that passes through the pupil strikes the lens. The **lens** is a flexible structure that focuses light. The lens of your eye functions something like the lens of a camera, which focuses light on photographic film. Because of the way in which the lens of the eye bends the light rays, the image it produces is upside down and reversed. Muscles that attach to the lens adjust its shape. This adjustment produces an image that is clear and in focus.

TRY THIS

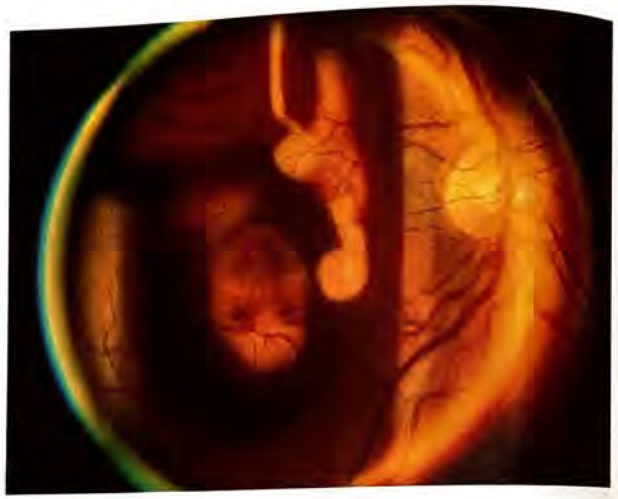
Why Do You Need Two Eyes? ACTIVITY

In this activity, you will investigate how your two eyes work together to allow you to see.

1. With your arms fully extended, hold a plastic drinking straw in one hand and a pipe cleaner in the other.
2. With both eyes open, try to insert the pipe cleaner into the straw.
3. Now close your right eye. Try to insert the pipe cleaner into the straw.
4. Repeat Step 3, but this time close your left eye instead of your right eye.

Inferring How does closing one eye affect your ability to judge distances?

Figure 14 An upside-down image is focused on the retina. *Applying Concepts When you see an object, why does it appear right-side up?*



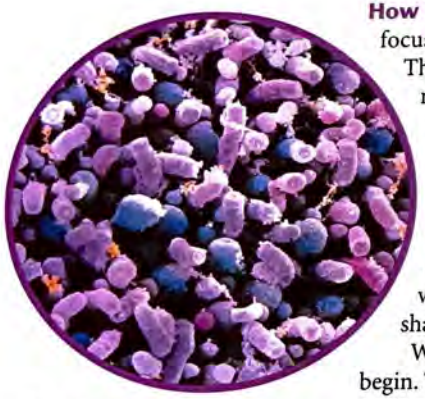


Figure 15 The retina of the eye contains light-sensitive cells. In this photograph, the rods have been colored pink, and the cones have been colored blue.

How You See an Image After passing through the lens, the focused light rays pass through a transparent, jellylike fluid. Then the light rays strike the **retina** (RET 'n uh), the layer of receptor cells that lines the back of the eye. The retina contains about 130 million receptor cells that respond to light. There are two types of receptors, rods and cones. Rod cells work best in dim light and enable you to see black, white, and shades of gray. In contrast, cone cells only work well in bright light and enable you to see colors. This difference between rods and cones explains why you see colors best in bright light, but you see only shadowy gray images in dim light.

When light strikes the rods and cones, nerve impulses begin. These nerve impulses travel to the cerebrum through the optic nerves. One optic nerve comes from the left eye and the other one comes from the right. In the cerebrum, two things happen. The brain turns the reversed image right-side up. In addition, the brain combines the images from each eye to produce a single image.

Correcting Vision Problems

Integrating Physics A lens—whether it is located in your eye, in a camera, or in eyeglasses—is a curved, transparent object that bends light rays as they pass through it. If the lens of the eye does not focus light properly on the retina, vision problems result. The glass or plastic lenses in eyeglasses can help correct such vision problems.

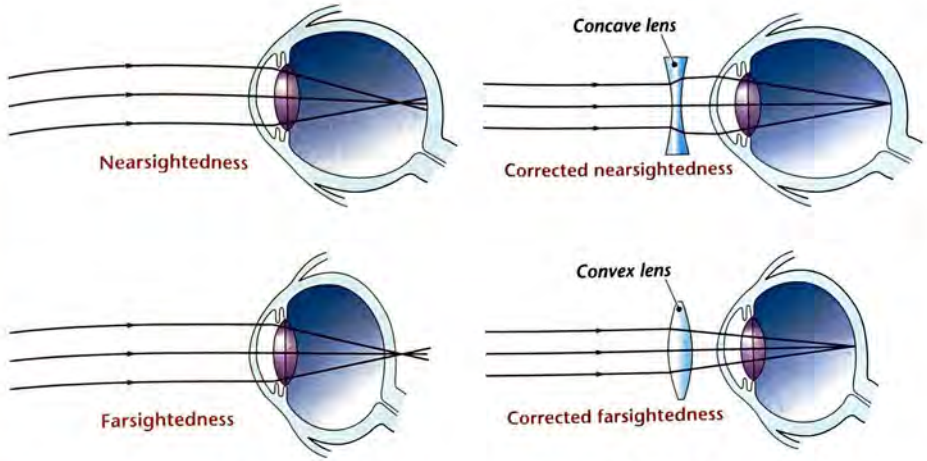


Figure 16 Nearsightedness and farsightedness are conditions in which images do not focus properly on the retina. The diagrams on the left show where the images are focused in both of these conditions. The diagrams on the right show how lenses in eyeglasses can help correct these conditions.

Nearsightedness People with **nearsightedness** can see nearby objects clearly. However, they have trouble seeing objects that are far away. Nearsightedness is caused by an eyeball that is too long. Because of the extra length that light must travel to reach the retina, distant objects do not focus sharply on the retina. Instead, the lens of the eye makes the image come into focus at a point in front of the retina, as shown in Figure 16.

To correct nearsightedness, a person needs to wear eyeglasses with concave lenses. A concave lens is a lens that is thicker at the edges than it is in the center. When light rays pass through a concave lens, they are bent away from the center of the lens. The concave lenses in glasses make light rays spread out before they reach the lens of the eye. Then, when these rays pass through the lens of the eye, they focus on the retina rather than in front of it.

Farsightedness People with **farsightedness** can see distant objects clearly. Nearby objects, however, look blurry. The eyeballs of people with farsightedness are too short. Because of this, the lens of the eye bends light from nearby objects so that the image does not focus properly on the retina. If light could pass through the retina, the image would come into sharp focus at a point behind the retina, as shown in Figure 16.

Convex lenses are used to help correct farsightedness. A convex lens is thicker in the middle than the edges. The convex lens makes the light rays bend toward one another before they reach the eye. Then the lens of the eye bends the rays even more. This bending makes the image focus exactly on the retina.

Checkpoint What type of lens is used to correct nearsightedness?

TRY THIS

Tick! Tick! Tick!

ACTIVITY

In this activity, you will determine whether one of a person's ears hears better than the other one.

1. Work in teams of three. Hold a ticking watch next to the right ear of one team member.
2. Slowly move the watch away from the ear. Stop moving it at the point where the student can no longer hear the ticking.
3. At that point, have the third team member measure the distance between the watch and the student's right ear.
4. Repeat Steps 1 through 3 to test the student's left ear.

Measuring How did the two distances compare? Do you think this is an accurate way to evaluate someone's hearing? Why or why not?

Hearing

What wakes you up in the morning? Maybe an alarm clock buzzes, or perhaps your parent calls you. On a summer morning, you might hear birds singing. Whatever wakes you up, there's a good chance that it's a sound of some sort. **Your ears are the sense organs that respond to the external stimulus of sound. The ears convert the sound to nerve impulses that your brain interprets.** So when you hear an alarm clock or other morning sound, your brain tells you that it's time to wake up.

How Sound Is Produced Sound is produced by vibrations. INTEGRATING PHYSICS The material that is vibrating, or moving rapidly back and forth, may be almost anything—a guitar string, an insect's wings, or splashing water.

The vibrations create waves. The waves move outward from the source of the sound, something like ripples moving out from a stone dropped in water. The waves consist of moving particles, such as the molecules that make up air. When you hear a friend's voice, for example, sound waves have traveled from your friend's larynx to your ears. In addition to being able to travel through gases such as air, sound waves can also travel through liquids such as water and solids such as wood.

Sound Vibrations and the Ear The structure of the ear functions to receive sound vibrations. As you can see in Figure 18, the ear consists of three parts—the outer ear, middle ear, and inner ear. The outer ear includes the part of the ear that you see. The visible part of the outer ear is shaped like a funnel.

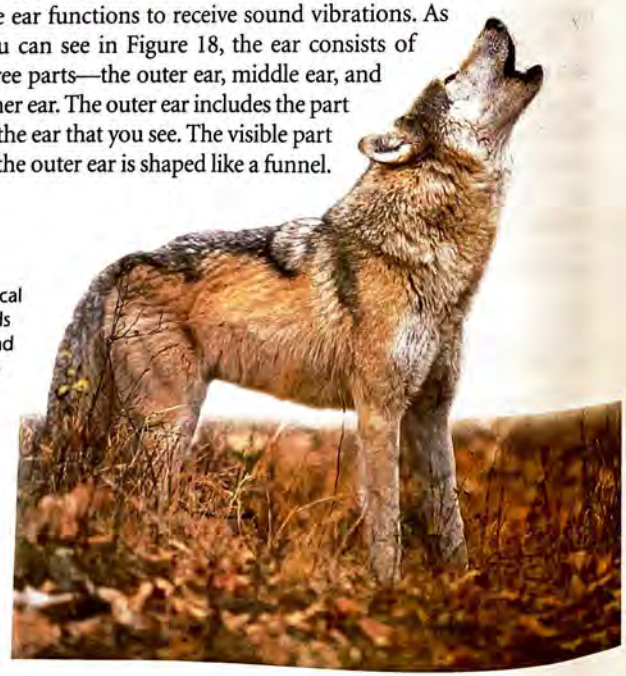


Figure 17 When a wolf howls, its vocal cords vibrate. The vibrating vocal cords produce sound waves. When the sound waves reach a person's ear, the person hears the wolf.

This funnel-like shape enables the outer ear to gather sound waves. The sound waves then travel down the ear canal, which is also part of the outer ear.

At the end of the ear canal, sound waves reach the eardrum. The **eardrum,** which separates the outer ear from the middle ear, is a membrane that vibrates when sound waves strike it. Your eardrum vibrates in much the same way that the surface of a drum vibrates when it is struck. Vibrations from the eardrum pass to the middle ear, which contains the three smallest bones in the body—the hammer, anvil, and stirrup. The names of these bones are based on their shapes. The vibrating eardrum makes the hammer vibrate. The hammer passes the vibrations to the anvil, and the anvil passes them to the stirrup.

How You Hear The stirrup vibrates against a thin membrane that covers the opening of the inner ear. The membrane channels the vibrations into the fluid in the cochlea. The **cochlea** (KAHK le uh) is a snail-shaped tube that is lined with receptors that respond to sound. When the fluid in the cochlea vibrates, it stimulates these receptors. Sensory neurons then send nerve impulses to the cerebrum through the auditory nerve. These impulses are interpreted as sounds that you hear.

☑ ***Checkpoint*** *Where in the ear is the cochlea located?*

Internal Stimuli and Balance

Your ear also controls your sense of balance. Above the cochlea in your inner ear are the **semicircular canals,** which are the structures in the ear that are responsible for your sense of balance.

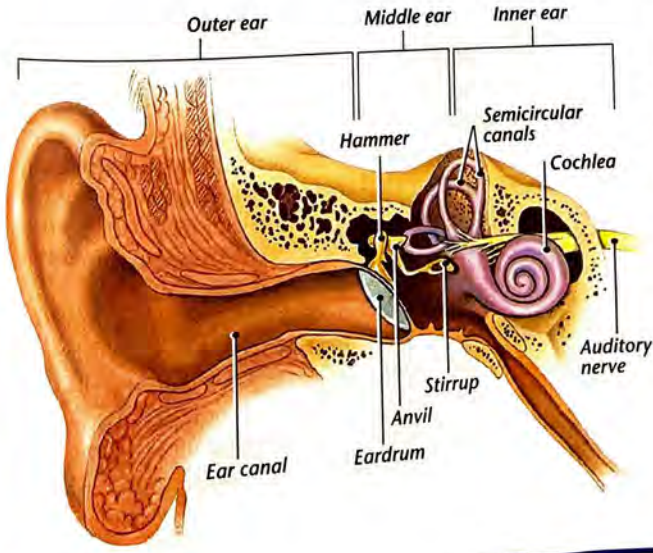


Figure 18 The ear has three regions—the outer ear, the middle ear, and the inner ear. Sound waves enter the outer ear and make structures in the middle ear vibrate. When the vibrations reach the inner ear, nerve impulses travel to the cerebrum through the auditory nerve. *Predicting What would happen if the bones of the middle ear were stuck together and could not move?*

Figure 19 The semicircular canals of the inner ear enable people to keep their balance—even in very tricky situations!

You can see how these structures got their name if you look at Figure 19. These canals, as well as two tiny sacs located behind them, are full of fluid. The canals and sacs are also lined with tiny cells that have hairlike extensions.

When your head moves, the fluid in the semicircular canals is set in motion. The moving fluid makes the cells' hairlike extensions bend. This bending is an internal stimulus that produces nerve impulses in sensory neurons. The impulses travel to the cerebellum. The cerebellum then analyzes the impulses to determine the way your head is moving and the position of your body. If the cerebellum senses that you are losing your balance, it sends impulses to muscles that help you restore your balance.

Smell and Taste

You walk into the house and smell the aroma of freshly baked cookies. You bite into one and taste its rich chocolate flavor. When you smelled the cookies, receptors in your nose reacted to chemicals carried by the air from the cookies to your nose. When you took a bite of a cookie, taste buds on your tongue responded to chemicals in the food. These food chemicals were dissolved in saliva, which came in contact with your taste buds.

The senses of smell and taste work closely together, and both depend on chemicals. The chemicals trigger responses in receptors in the nose and mouth. Nerve impulses then travel to the brain, where they are interpreted as smells or tastes.

The nose can distinguish at least 50 basic odors. In contrast, there are only four kinds of taste buds—sweet, sour, salty, and bitter. When you eat, however, you experience a much wider variety of tastes. The flavor of food is determined by both the the senses of smell and taste. When you have a cold, your favorite foods may not taste as good as they usually do. That is because a stuffy nose can decrease your ability to smell food.

Sharpen your Skills

Designing Experiments

ACTIVITY

Can people tell one food from another if they can taste the foods but not smell them? Design an experiment to find out. Use these foods: a peeled pear, a peeled apple, and a peeled raw potato. Be sure to control all variables except the one you are testing. Write your hypothesis and a description of your procedure. Show these to your teacher. Do not perform your experiment until your teacher approves your procedure.

Touch

Unlike vision, hearing, balance, smell, and taste, the sense of touch is not found in one specific place. Instead, the sense of touch is found in all areas of your skin. Your skin is your largest sense organ!

Your skin contains different kinds of touch receptors. Some of these receptors respond to light touch and others to heavy pressure. Still other receptors pick up sensations of pain and temperature change.

The receptors that respond to light touch are in the upper part of the dermis. They tell you when something brushes against your skin. These receptors also let you feel the textures of objects, such as smooth glass and rough sandpaper. Receptors deeper in the dermis pick up the feeling of pressure. Press down hard on the top of your desk, for example, and you will feel pressure in your fingers.

The dermis also contains receptors that respond to temperature and pain. Pain is unpleasant, but it can be one of the body's most important feelings, because it alerts the body to possible danger. Have you ever stepped into a bathtub of very hot water and then immediately pulled your foot out? If so, you can appreciate how pain can trigger an important response in your body.

Figure 20 Blind people use their sense of touch to read. To do this, they run their fingers over words written in Braille. Braille uses raised dots to represent letters and numbers. Here a teacher shows a blind child how to read Braille.

Section 3 Review

1. What function do the senses perform in the body?
2. Describe the process by which your eyes produce an image of your surroundings. Begin at the point at which light is focused by the lens.
3. How do sound vibrations affect structures in the ear to produce the sensation of hearing?
4. How are the senses of taste and smell similar? How are they different?
5. **Thinking Critically** **Relating Cause and Effect** Infections of the inner ear sometimes make people more likely to lose their balance and fall. Explain why this is so.

Check Your Progress

CHAPTER PROJECT

By now, you should have submitted your plans for your experiment to your teacher. Make any necessary changes in the plan. Prepare all the materials for the fair, including the illusions and questionnaire. Have a data table ready so you can record all responses. (*Hint:* Be sure the people you test cannot see or hear each other's responses. Also, test a large enough number of individuals.)