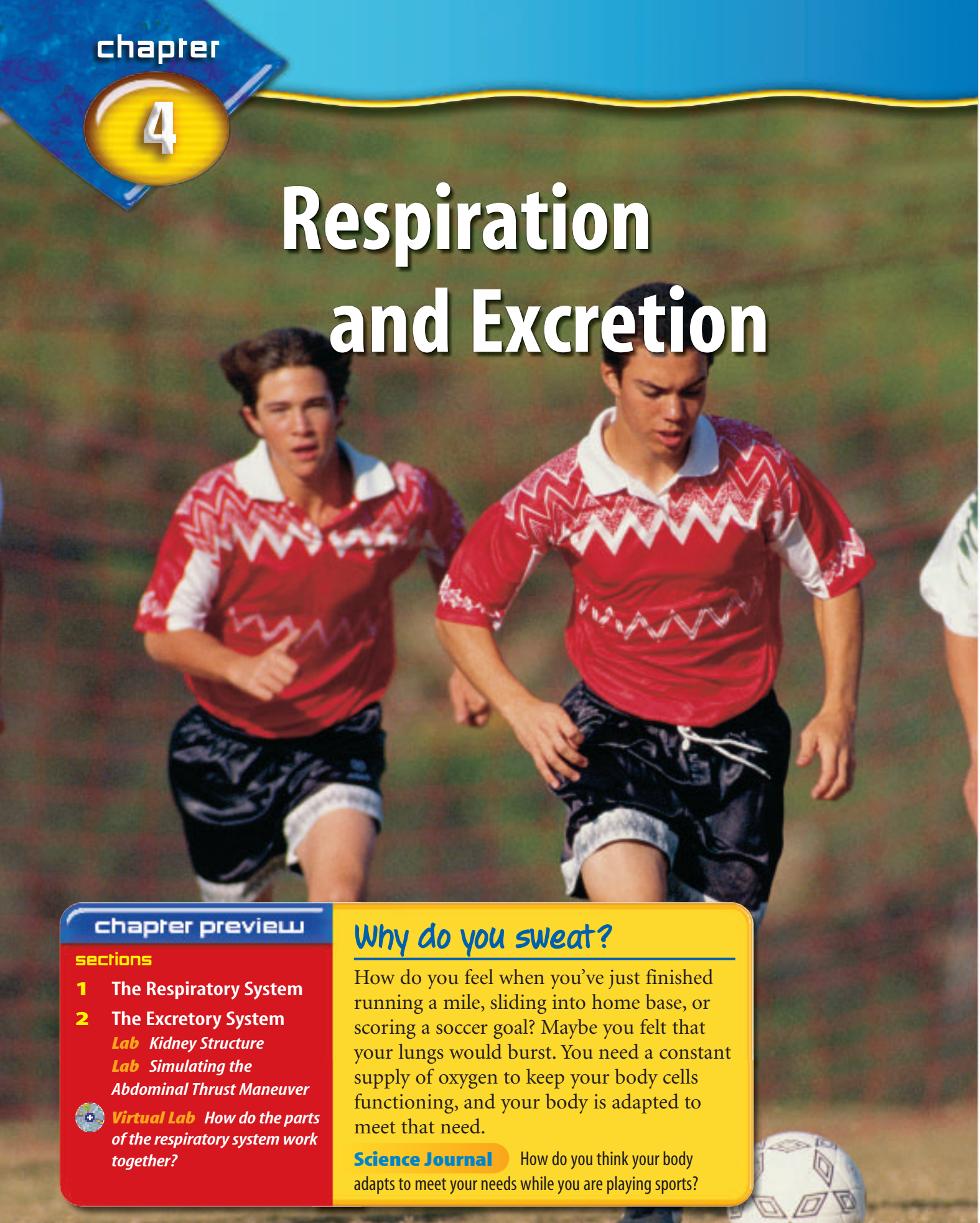
chapter 4

Respiration and Excretion



chapter preview

sections

1 The Respiratory System

2 The Excretory System

Lab *Kidney Structure*

Lab *Simulating the Abdominal Thrust Maneuver*

Virtual Lab *How do the parts of the respiratory system work together?*

Why do you sweat?

How do you feel when you've just finished running a mile, sliding into home base, or scoring a soccer goal? Maybe you felt that your lungs would burst. You need a constant supply of oxygen to keep your body cells functioning, and your body is adapted to meet that need.

Science Journal How do you think your body adapts to meet your needs while you are playing sports?

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Start-Up Activities

Launch Lab

Effect of Activity on Breathing

Your body can store food and water, but it cannot store much oxygen. Breathing brings oxygen into your body. In the following lab, find out about one factor that can change your breathing rate.

1. Put your hand on the side of your rib cage. Take a deep breath. Notice how your rib cage moves out and upward when you inhale.
2. Count the number of breaths you take for 15 s. Multiply this number by four to calculate your normal breathing rate for 1 min.
3. Repeat step 2 two more times, then calculate your average breathing rate.
4. Do a physical activity described by your teacher for 1 min and repeat step 2 to determine your breathing rate now.
5. Time how long it takes for your breathing rate to return to normal.
6. **Think Critically** Explain how breathing rate appears to be related to physical activity.

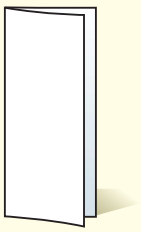
ScienceOnline | Preview this chapter's content and activities at bookd.msscience.com

Foldables Study Organizer

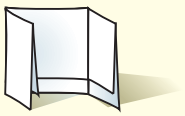
Respiration and Excretion

Make the following Foldable to help you identify what you already know, what you want to know, and what you learned about respiration.

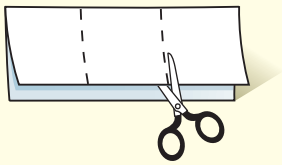
STEP 1 **Fold** a vertical sheet of paper from side to side. Make the front edge about 1.25 cm shorter than the back edge.



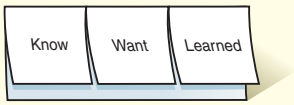
STEP 2 **Turn** lengthwise and **fold** into thirds.



STEP 3 **Unfold and cut** only the top layer along both folds to make three tabs.



STEP 4 **Label** each tab.



Read and Write Before you read the chapter, write what you already know about respiration under the left tab of your Foldable, and write questions about what you'd like to know under the center tab. After you read the chapter, list what you learned under the right tab.

section 1

The Respiratory System

as you read

What You'll Learn

- **Describe** the functions of the respiratory system.
- **Explain** how oxygen and carbon dioxide are exchanged in the lungs and in tissues.
- **Identify** the pathway of air in and out of the lungs.
- **Explain** the effects of smoking on the respiratory system.

Why It's Important

Your body's cells depend on your respiratory system to supply oxygen and remove carbon dioxide.

Review Vocabulary

lungs: saclike respiratory organs that function with the heart to remove carbon dioxide from blood and provide it with oxygen

New Vocabulary

- pharynx
- larynx
- trachea
- bronchi
- alveoli
- diaphragm
- emphysema
- asthma

Functions of the Respiratory System

Can you imagine an astronaut walking on the Moon without a space suit or a diver exploring the ocean without scuba gear? Of course not. You couldn't survive in either location under those conditions because you need to breathe air. Earth is surrounded by a layer of gases called the atmosphere (AT muh sfihr). You breathe atmospheric gases that are closest to Earth. As shown in **Figure 1,** oxygen is one of those gases.

For thousands of years people have known that air, food, and water are needed for life. However, the gas in the air that is necessary for life was not identified as oxygen until the late 1700s. At that time, a French scientist experimented and discovered that an animal breathed in oxygen and breathed out carbon dioxide. He measured the amount of oxygen that the animal used and the amount of carbon dioxide produced by its bodily processes. After his work with animals, the French scientist used this knowledge to study the way that humans use oxygen. He measured the amount of oxygen that a person uses when resting and when exercising. These measurements were compared, and he discovered that more oxygen is used by the body during exercise.

Figure 1 Air, which is needed by most organisms, is only 21 percent oxygen.

Randy Lincks/CORBIS

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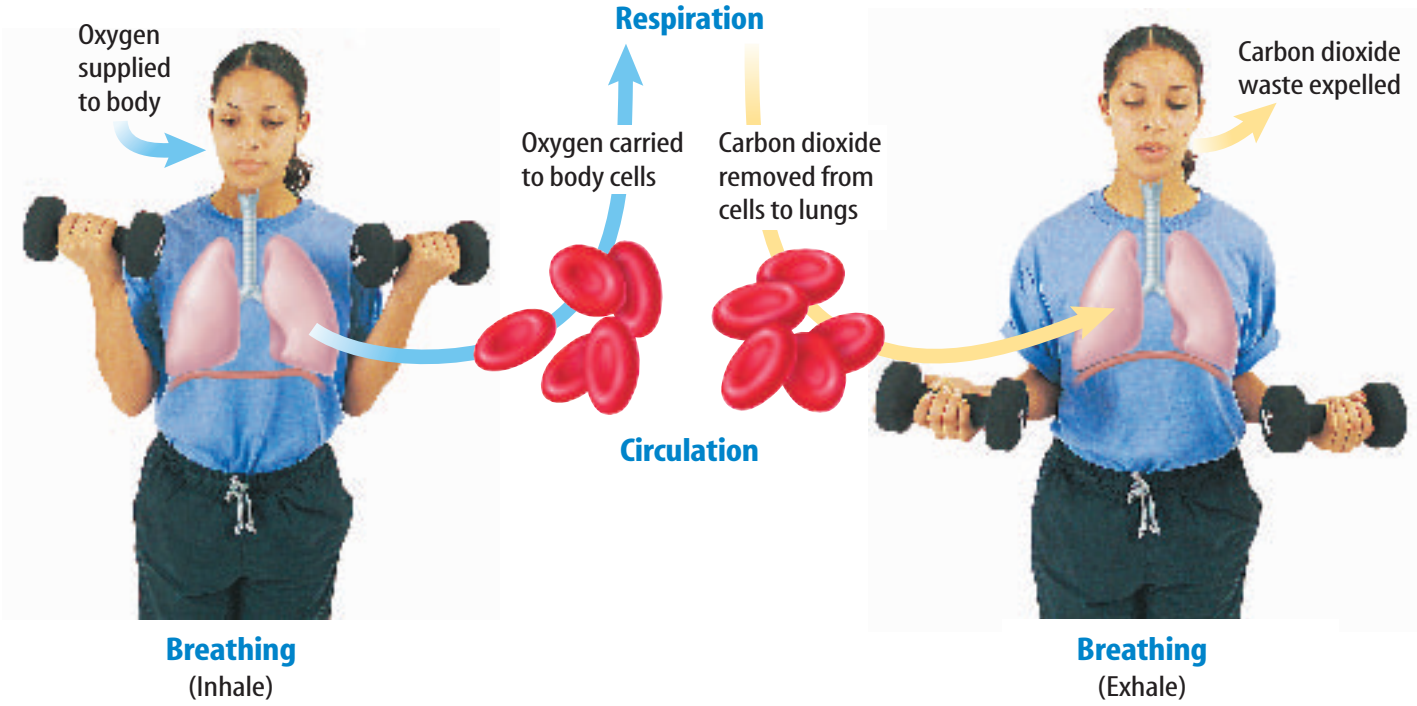
Figure 2 Several processes are involved in how the body obtains, transports, and uses oxygen.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$$

Glucose + Oxygen ⟶ Carbon dioxide + Water + Energy



Breathing and Respiration

People often confuse the terms *breathing* and *respiration*. Breathing is the movement of the chest that brings air into the lungs and removes waste gases. The air entering the lungs contains oxygen. It passes from the lungs into the circulatory system because there is less oxygen in the blood than in cells of the lungs. Blood carries oxygen to individual cells. At the same time, the digestive system supplies glucose from digested food to the same cells. The oxygen delivered to the cells is used to release energy from glucose. This chemical reaction, shown in the equation in **Figure 2,** is called cellular respiration. Without oxygen, this reaction would not take place. Carbon dioxide and water molecules are waste products of cellular respiration. They are carried back to the lungs in the blood. Exhaling, or breathing out, eliminates waste carbon dioxide and some water molecules.

Reading Check ***What is respiration?***

Water Vapor The amount of water vapor in the atmosphere varies from almost none over deserts to nearly four percent in tropical rain forest areas. This means that every 100 molecules that make up air include only four molecules of water. In your Science Journal, infer how breathing dry air can stress your respiratory system.

Organs of the Respiratory System

The respiratory system, shown in **Figure 3,** is made up of structures and organs that help move oxygen into the body and waste gases out of the body. Air enters your body through two openings in your nose called nostrils or through the mouth. Fine hairs inside the nostrils trap dust from the air. Air then passes through the nasal cavity, where it gets moistened and warmed by the body's heat. Glands that produce sticky mucus line the nasal cavity. The mucus traps dust, pollen, and other materials that were not trapped by nasal hairs. This process helps filter and clean the air you breathe. Tiny, hairlike structures, called cilia (SIH lee uh), sweep mucus and trapped material to the back of the throat where it can be swallowed.

Pharynx Warmed, moist air then enters a tubelike passageway used by food, liquid, and air called the **pharynx** (FER ingks). At the lower end of the pharynx is a flap of tissue called the epiglottis (eh puh GLAH tus). When you swallow, your epiglottis folds down to prevent food or liquid from entering your airway. The food enters your esophagus instead. If you began to choke, what do you think has happened?

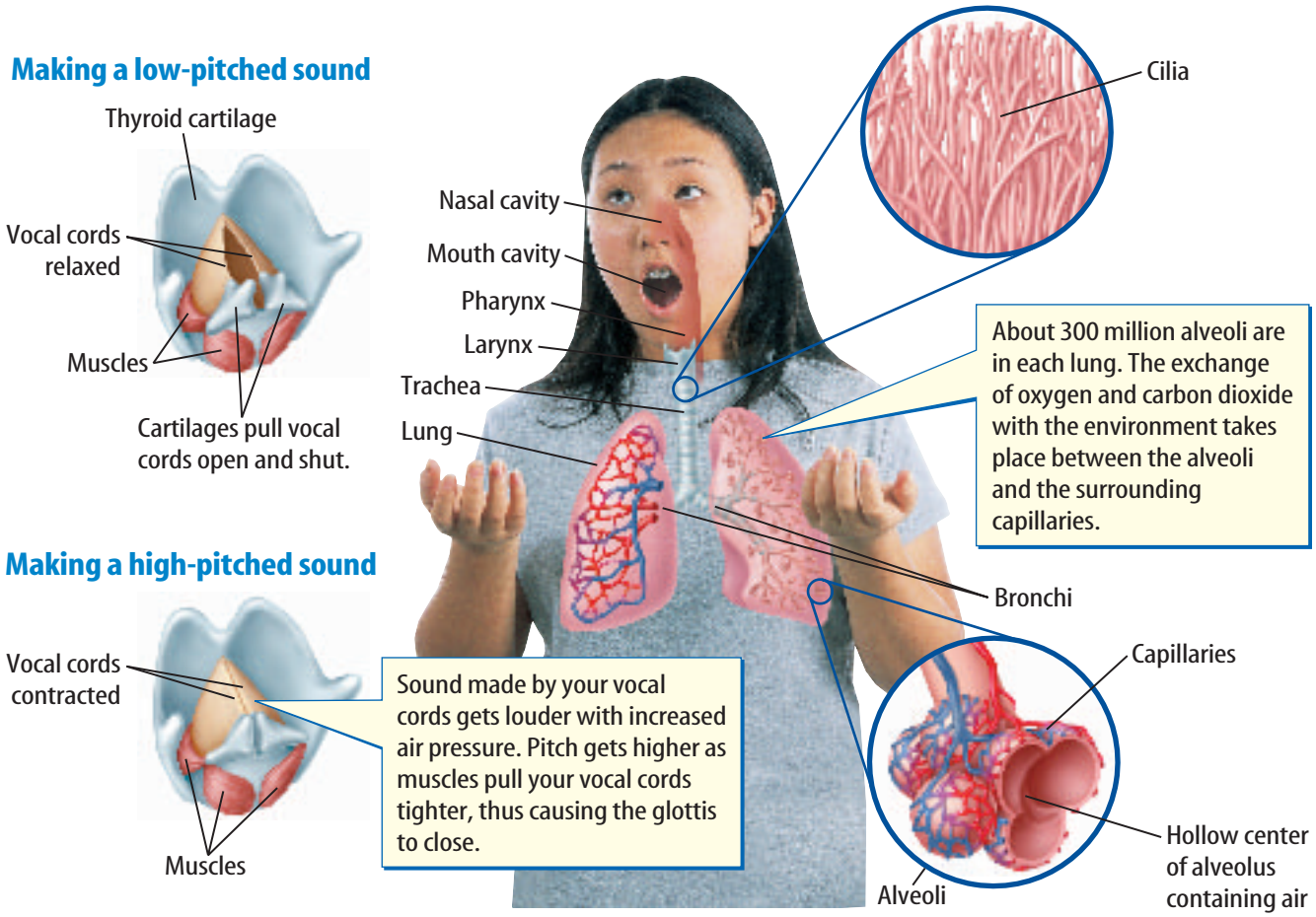


Figure 3 Air can enter the body through the nostrils and the mouth.
Explain *the advantages of having air enter through the nostrils.*

Bob Daemmrich
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Larynx and Trachea Next, the air moves into your larynx (LER ingks). The **larynx** is the airway to which two pairs of horizontal folds of tissue, called vocal cords, are attached as shown in **Figure 3.** Forcing air between the cords causes them to vibrate and produce sounds. When you speak, muscles tighten or loosen your vocal cords, resulting in different sounds. Your brain coordinates the movement of the muscles in your throat, tongue, cheeks, and lips when you talk, sing, or just make noise. Your teeth also are involved in forming letter sounds and words.

From the larynx, air moves into the **trachea** (TRAY kee uh), which is a tube about 12 cm in length. Strong, C-shaped rings of cartilage prevent the trachea from collapsing. The trachea is lined with mucous membranes and cilia, as shown in **Figure 3,** that trap dust, bacteria, and pollen. Why must the trachea stay open all the time?

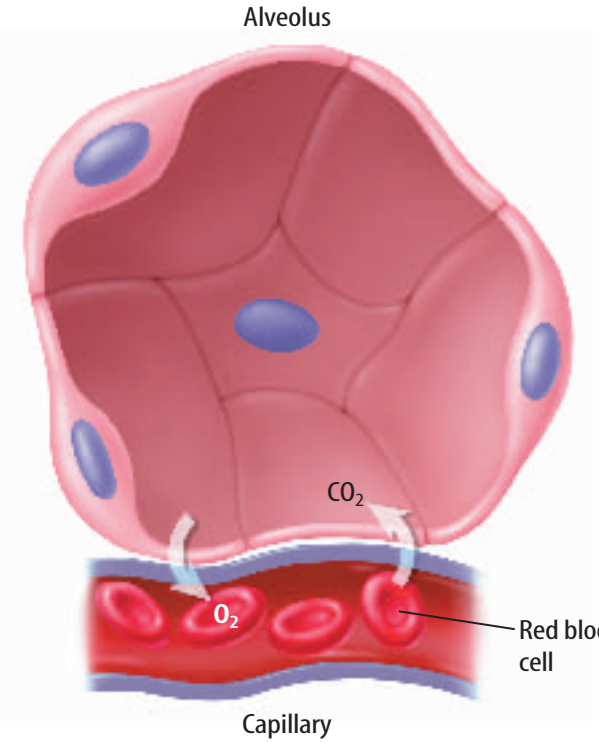


Figure 4 The thin capillary walls allow gases to be exchanged easily between the alveoli and the capillaries.

Bronchi and the Lungs Air is carried into your lungs by two short tubes called **bronchi** (BRAHN ki) (singular, *bronchus*) at the lower end of the trachea. Within the lungs, the bronchi branch into smaller and smaller tubes. The smallest tubes are called bronchioles (BRAHN kee ohlz). At the end of each bronchiole are clusters of tiny, thin-walled sacs called **alveoli** (al VEE uh li). Air passes into the bronchi, then into the bronchioles, and finally into the alveoli. Lungs are masses of alveoli arranged in grapelike clusters. The capillaries surround the alveoli like a net, as shown in **Figure 3.**

The exchange of oxygen and carbon dioxide takes place between the alveoli and capillaries. This easily happens because the walls of the alveoli (singular, *alveolus*) and the walls of the capillaries are each only one cell thick, as shown in **Figure 4.** Oxygen moves through the cell membranes of the alveoli and then through the cell membranes of the capillaries into the blood. There the oxygen is picked up by hemoglobin (HEE muh gloh bun), a molecule in red blood cells, and carried to all body cells. At the same time, carbon dioxide and other cellular wastes leave the body cells. The wastes move through the cell membranes of the capillaries. Then they are carried by the blood. In the lungs, waste gases move through the cell membranes of the capillaries and through the cell membranes of the alveoli. Then waste gases leave the body during exhalation.

ScienceOnline

Topic: Speech

Visit bookd.msscience.com for Web links to information about how speech sounds are made.

Activity In your Science Journal, describe the changes in the position of your lips and tongue when you say each letter of the alphabet.

Mini LAB

Comparing Surface Area

Procedure

1. Stand a **bathroom-tissue cardboard tube** in an **empty bowl.**
2. Drop **marbles** into the tube, filling it to the top.
3. Count the number of marbles used.
4. Repeat steps 2 and 3 two more times. Calculate the average number of marbles needed to fill the tube.
5. The tube's inside surface area is approximately 161.29 cm^2. Each marble has a surface area of approximately 8.06 cm^2. Calculate the surface area of the average number of marbles.

Analysis

1. Compare the inside surface area of the tube with the surface area of the average number of marbles needed to fill the tube.
2. If the tube represents a bronchus, what do the marbles represent?
3. Using this model, explain what makes gas exchange in the lungs efficient.

Try at Home

Why do you breathe?

Signals from your brain tell the muscles in your chest and abdomen to contract and relax. You don't have to think about breathing to breathe, just like your heart beats without you telling it to beat. Your brain can change your breathing rate depending on the amount of carbon dioxide present in your blood. As carbon dioxide increases, your breathing rate increases. When there is less carbon dioxide in your blood, your breathing rate decreases. You do have some control over your breathing—you can hold your breath if you want to. Eventually, though, your brain will respond to the buildup of carbon dioxide in your blood. The brain's response will tell your chest and abdomen muscles to work automatically, and you will breathe whether you want to or not.

Inhaling and Exhaling Breathing is partly the result of changes in air pressure. Under normal conditions, a gas moves from an area of high pressure to an area of low pressure. When you squeeze an empty, soft-plastic bottle, air is pushed out. This happens because air pressure outside the top of the bottle is less than the pressure you create inside the bottle when you squeeze it. As you release your grip on the bottle, the air pressure inside the bottle becomes less than it is outside the bottle. Air rushes back in, and the bottle returns to its original shape.

Your lungs work in a similar way to the squeezed bottle. Your **diaphragm** (DI uh fram) is a muscle beneath your lungs that contracts and relaxes to help move gases into and out of your lungs. **Figure 5** illustrates breathing.

Reading Check *How does your diaphragm help you breathe?*

When a person is choking, a rescuer can use abdominal thrusts, as shown in **Figure 6,** to save the life of the choking victim.

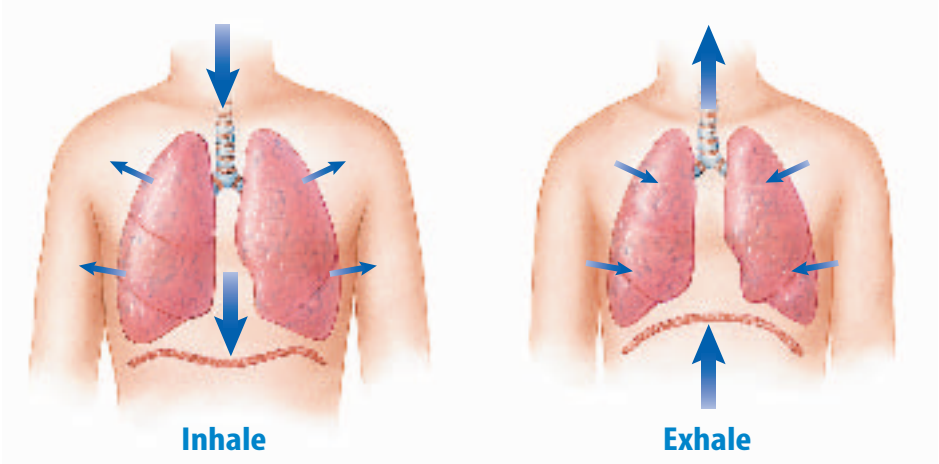


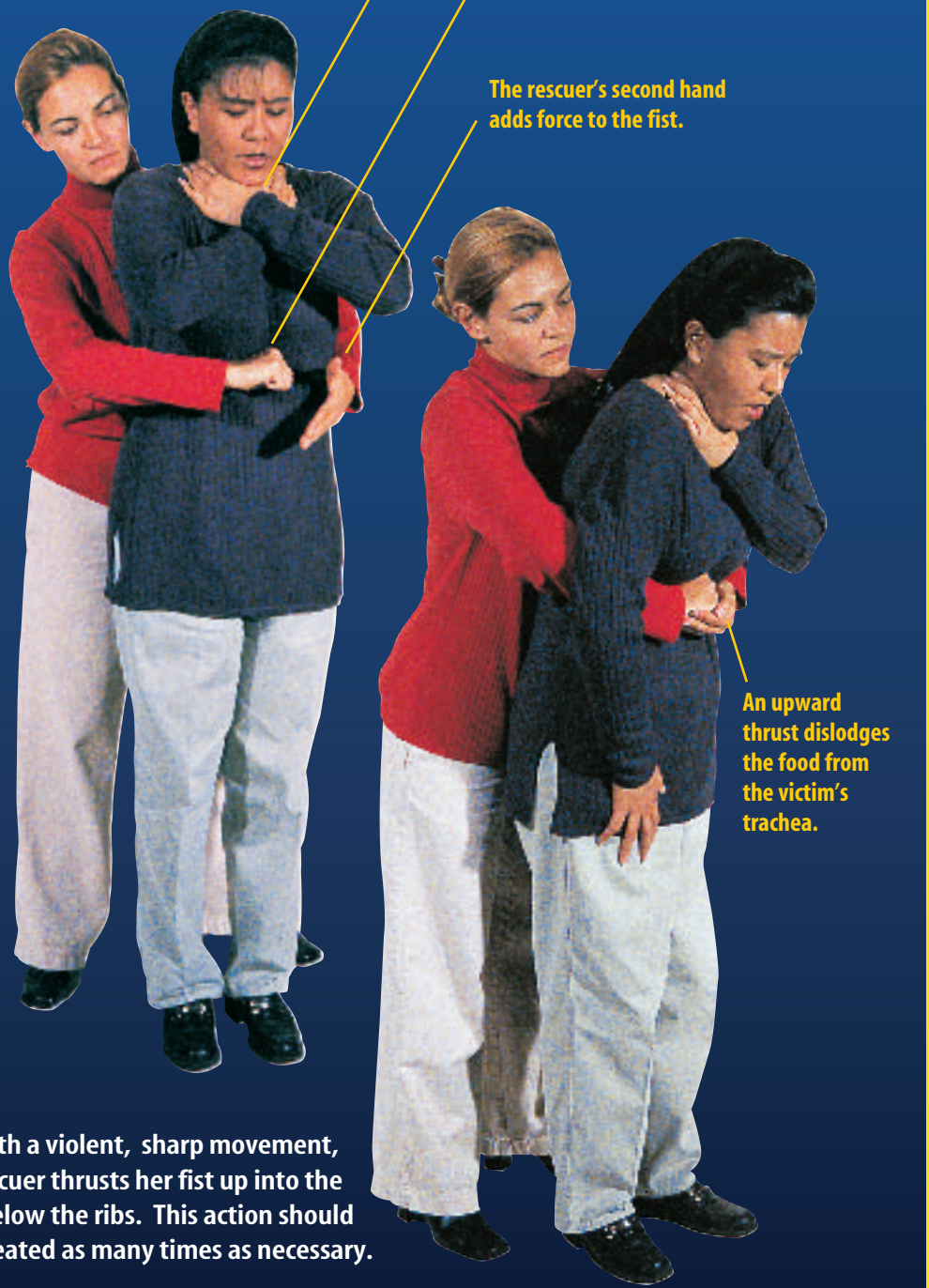
Figure 5 Your lungs inhale and exhale about 500 mL of air with an average breath. This increases to 2,000 mL of air per breath when you do strenuous activity.

NATIONAL GEOGRAPHIC

VISUALIZING ABDOMINAL THRUSTS

Figure 6

When food or other objects become lodged in the trachea, airflow between the lungs and the mouth and nasal cavity is blocked. Death can occur in minutes. However, prompt action by someone can save the life of a choking victim. The rescuer uses abdominal thrusts to force the victim's diaphragm up. This decreases the volume of the chest cavity and forces air up in the trachea. The result is a rush of air that dislodges and expels the food or other object. The victim can breathe again. This technique is shown at right and should only be performed in emergency situations.



A The rescuer stands behind the choking victim and wraps her arms around the victim's upper abdomen. She places a fist (thumb side in) against the victim's stomach. The fist should be below the ribs and above the navel.

B With a violent, sharp movement, the rescuer thrusts her fist up into the area below the ribs. This action should be repeated as many times as necessary.

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Richard T. Nowitz

Table 1 Smokers' Risk of Death from Disease

Disease	Smokers' Risk Compared to Nonsmokers' Risk
Lung cancer	23 times higher for males, 11 times higher for females
Chronic bronchitis and emphysema	5 times higher
Heart disease	2 times higher

Diseases and Disorders of the Respiratory System

If you were asked to list some of the things that can harm your respiratory system, you probably would put smoking at the top. As you can see in **Table 1,** many serious diseases are related to smoking. The chemical substances in tobacco—nicotine and tars—are poisons and can destroy cells. The high temperatures, smoke, and carbon monoxide produced when tobacco burns also can injure a smoker's cells. Even if you are a nonsmoker, inhaling smoke from tobacco products—called secondhand smoke—is unhealthy and has the potential to harm your respiratory system. Smoking, polluted air, coal dust, and asbestos (as BES tus) have been related to respiratory problems such as bronchitis (brahn KI tus), emphysema (em fuh SEE muh), asthma (AZ muh), and cancer.

Science Online

Topic: Second-Hand Smoke

Visit bookd.msscience.com for Web links to information about the health concerns of second-hand smoke.

Activity Make a poster to teach younger students about the dangers of second-hand smoke.

Respiratory Infections Bacteria, viruses, and other microorganisms can cause infections that affect any of the organs of the respiratory system. The common cold usually affects the upper part of the respiratory system—from the nose to the pharynx. The cold virus also can cause irritation and swelling in the larynx, trachea, and bronchi. The cilia that line the trachea and bronchi can be damaged. However, cilia usually heal rapidly. A virus that causes influenza, or flu, can affect many of the body's systems. The virus multiplies in the cells lining the alveoli and damages them. Pneumonia is an infection in the alveoli that can be caused by bacteria, viruses, or other microorganisms. Before antibiotics were available to treat these infections, many people died from pneumonia.

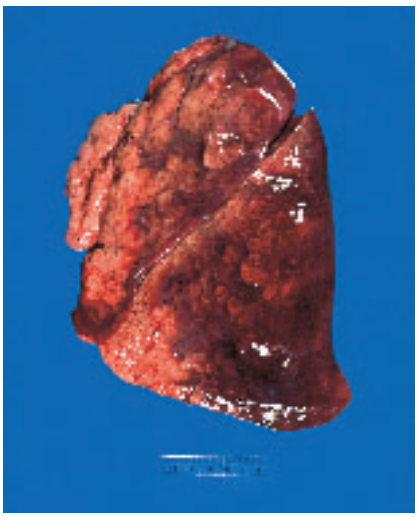
What parts of the respiratory system are affected by the cold virus?

Chronic Bronchitis When bronchial tubes are irritated and swell, and too much mucus is produced, a disease called bronchitis develops. Sometimes, bacterial infections occur in the bronchial tubes because the mucus there provides nearly ideal conditions for bacteria to grow. Antibiotics are effective treatments for this type of bronchitis.

Many cases of bronchitis clear up within a few weeks, but the disease sometimes lasts for a long time. When this happens, it is called chronic (KRAH nihk) bronchitis. A person who has chronic bronchitis must cough often to try to clear the excess mucus from the airway. However, the more a person coughs, the more the cilia and bronchial tubes can be harmed. When cilia are damaged, they cannot move mucus, bacteria, and dirt particles out of the lungs effectively. Then harmful substances, such as sticky tar from burning tobacco, build up in the airways. Sometimes, scar tissue forms and the respiratory system cannot function properly.

Emphysema A disease in which the alveoli in the lungs enlarge is called **emphysema** (em fuh SEE muh). When cells in the alveoli are reddened and swollen, an enzyme is released that causes the walls of the alveoli to break down. As a result, alveoli can't push air out of the lungs, so less oxygen moves into the bloodstream from the alveoli. When blood becomes low in oxygen and high in carbon dioxide, shortness of breath occurs. Some people with emphysema require extra oxygen as shown in **Figure 7.** Because the heart works harder to supply oxygen to body cells, people who have emphysema often develop heart problems, as well.

Figure 7 Lung diseases can have major effects on breathing.



A normal, healthy lung can exchange oxygen and carbon dioxide effectively.

A diseased lung carries less oxygen to body cells.

Emphysema may take 20 to 30 years to develop.

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Figure 8 More than 85 percent of all lung cancer is related to smoking. Smoking also can play a part in the development of cancer in other body organs indicated above.

Lung Cancer The third leading cause of death in men and women in the United States is lung cancer. Inhaling the tar in cigarette smoke is the greatest contributing factor to lung cancer. Tar and other ingredients found in smoke act as carcinogens (kar SIH nuh junz) in the body. Carcinogens are substances that can cause an uncontrolled growth of cells. In the lungs, this is called lung cancer. As represented in **Figure 8,** smoking also has been linked to the development of cancers of the esophagus, mouth, larynx, pancreas, kidney, and bladder.

Reading Check *What happens to the lungs of people who begin smoking?*

Asthma Shortness of breath, wheezing, or coughing can occur in a lung disorder called **asthma.** When a person has an asthma attack, the bronchial tubes contract quickly. Inhaling medicine that relaxes the bronchial tubes is the usual treatment for an asthma attack. Asthma is often an allergic reaction. An allergic reaction occurs when the body overreacts to a foreign substance. An asthma attack can result from breathing certain substances such as cigarette smoke or certain plant pollen, eating certain foods, or stress in a person's life.

section 1 review

Summary

Functions of the Respiratory System

- Breathing brings air into the lungs and removes waste gases.
- Cellular respiration converts oxygen and glucose to carbon dioxide, water, and energy.

Organs of the Respiratory System

- Air is carried into the lungs by bronchi.
- Bronchioles are smaller branches of bronchi, and at the ends of these are alveoli.

Diseases and Disorders of the Respiratory System

- Emphysema is a disease that causes the alveoli to enlarge.
- Lung cancer occurs when carcinogens cause an uncontrolled growth of cells.

Self Check

1. **Describe** the main function of the respiratory system.
2. **Explain** how oxygen, carbon dioxide, and other waste gases are exchanged in the lungs and body tissues.
3. **Identify** how air moves into and out of the lungs.
4. **Think Critically** How is the work of the digestive and circulatory systems related to the respiratory system?

Applying Skills

5. **Research Information** Nicotine in tobacco is a poison. Using library references, find out how nicotine affects the body.
6. **Communicate** Use references to find out about lung disease common among coal miners, stonecutters, and sandblasters. Find out what safety measures are required now for these trades. In your Science Journal, write a paragraph about these safety measures.

Renee Lynn/Photo Researchers
Science Online bookd.msscience.com/self_check_quiz
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section 2

The Excretory System

Functions of the Excretory System

It's your turn to take out the trash. You carry the bag outside and put it in the trash can. The next day, you bring out another bag of trash, but the trash can is full. When trash isn't collected, it piles up. Just as trash needs to be removed from your home to keep it livable, your body must eliminate wastes to remain healthy. Undigested material is eliminated by your large intestine. Waste gases are eliminated through the combined efforts of your circulatory and respiratory systems. Some salts are eliminated when you sweat. These systems function together as parts of your excretory system. If wastes aren't eliminated, toxic substances build up and damage organs. If not corrected, serious illness or death occurs.

The Urinary System

The **urinary system** rids the blood of wastes produced by the cells. **Figure 9** shows how the urinary system functions as a part of the excretory system. The urinary system also controls blood volume by removing excess water produced by body cells during respiration.

as you read

What You'll Learn

- **Distinguish** between the excretory and urinary systems.
- **Describe** how the kidneys work.
- **Explain** what happens when urinary organs don't work.

Why It's Important

The urinary system helps clean your blood of cellular wastes.

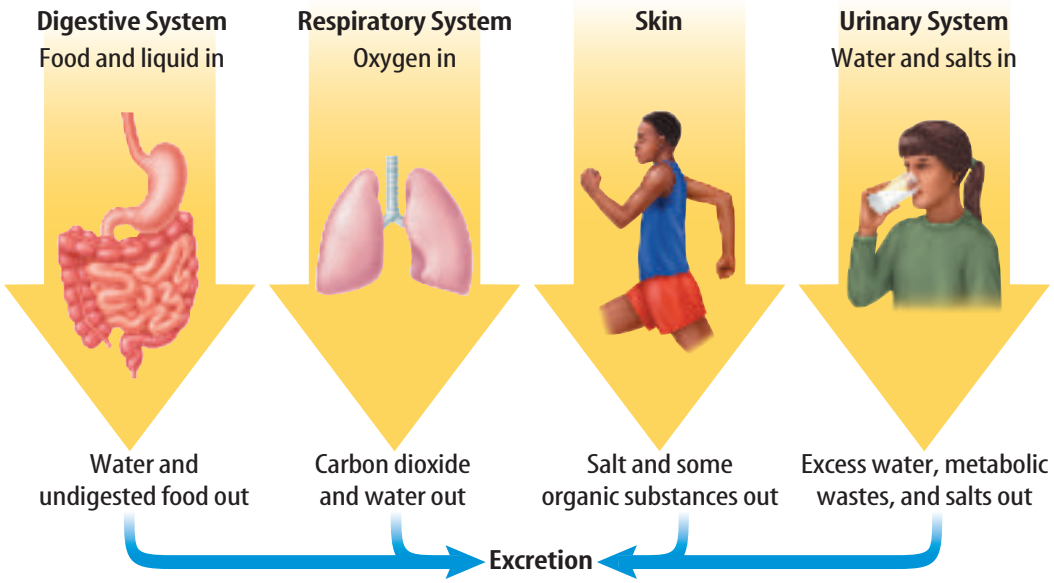
Review Vocabulary

blood: tissue that transports oxygen, nutrients, and waste materials throughout your body

New Vocabulary

- urinary system
- urine
- kidney
- nephron
- ureter
- bladder
- urethra

Figure 9 The excretory system includes other body systems.



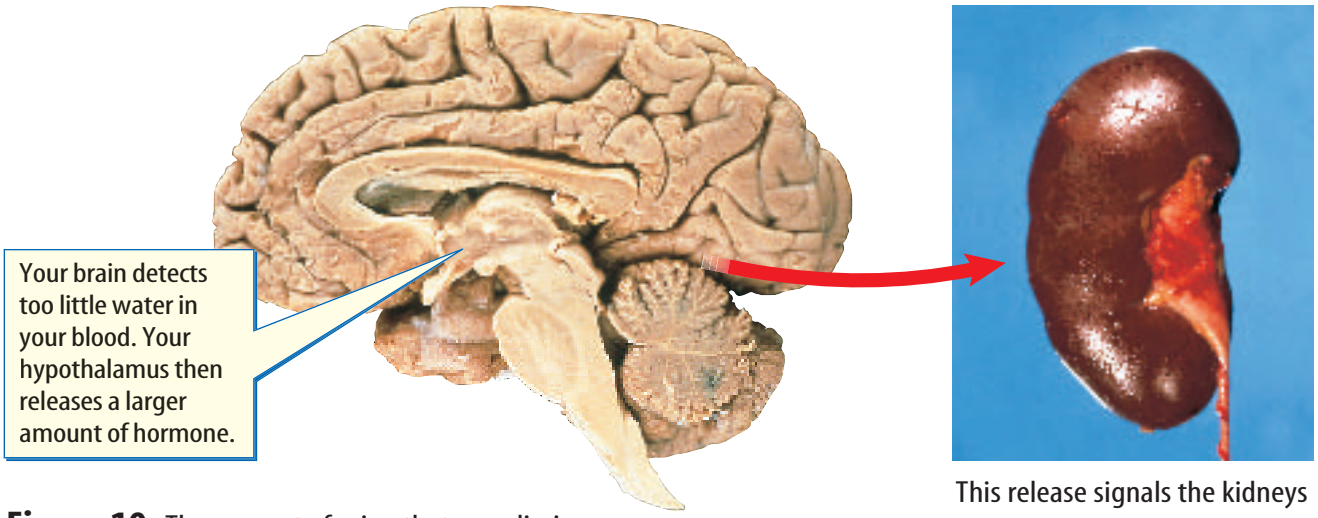


Figure 10 The amount of urine that you eliminate each day is determined by the level of a hormone that is produced by your hypothalamus.

Regulating Fluid Levels To stay in good health, the fluid levels within the body must be balanced and normal blood pressure must be maintained. An area in the brain, the hypothalamus (hi poh THA luh mus), constantly monitors the amount of water in the blood. When the brain detects too much water in the blood, the hypothalamus releases a lesser amount of a specific hormone. This signals the kidneys to return less water to the blood and increase the amount of wastewater, called **urine,** that is excreted. **Figure 10** indicates how the body reacts when too little water is in the blood.

Reading Check ***How does the urinary system control the volume of water in the blood?***

A specific amount of water in the blood is also important for the movement of gases and excretion of solid wastes from the body. The urinary system also balances the amounts of certain salts and water that must be present for all cell activities to take place.

Organs of the Urinary System Excretory organs is another name for the organs of the urinary system. The main organs of the urinary system are two bean-shaped **kidneys.** Kidneys are located on the back wall of the abdomen at about waist level. The kidneys filter blood that contains wastes collected from cells. In approximately 5 min, all of the blood in your body passes through the kidneys. The red-brown color of the kidneys is due to their enormous blood supply. In **Figure 11,** you can see that blood enters the kidneys through a large artery and leaves through a large vein.

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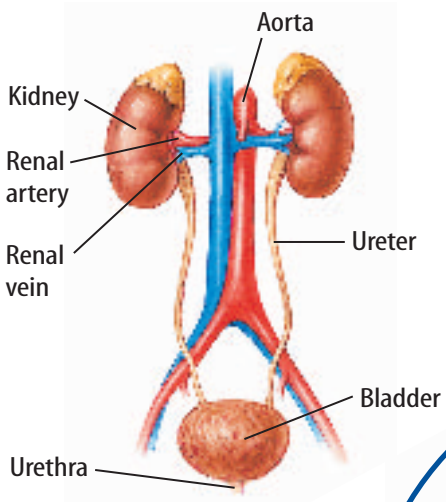
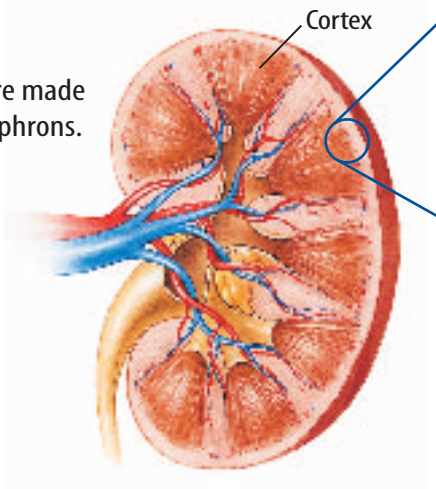
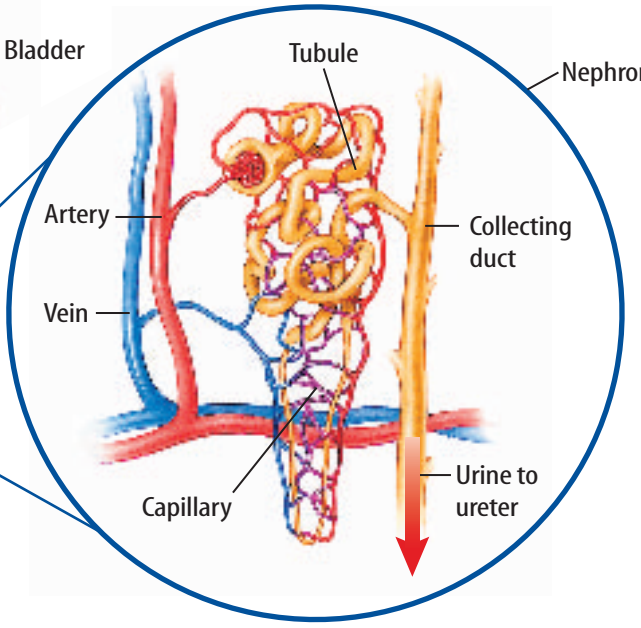
Filtration in the Kidney The kidney, as shown in **Figure 11A,** is a two-stage filtration system. It is made up of about 1 million tiny filtering units called **nephrons** (NEF rahnz), which are shown in **Figure 11B.** Each nephron has a cuplike structure and a tubelike structure called a duct. Blood moves from a renal artery to capillaries in the cuplike structure. The first filtration occurs when water, sugar, salt, and wastes from the blood pass into the cuplike structure. Left behind in the blood are red blood cells and proteins. Next, liquid in the cuplike structure is squeezed into a narrow tubule. Capillaries that surround the tubule perform the second filtration. Most of the water, sugar, and salt are reabsorbed and returned to the blood. These collection capillaries merge to form small veins, which merge to form a renal vein in each kidney. Purified blood is returned to the main circulatory system. The liquid left behind flows into collecting tubules in each kidney. This wastewater, or urine, contains excess water, salts, and other wastes that are not reabsorbed by the body. An average-sized person produces about 1 L of urine per day.

Figure 11 The urinary system removes wastes from the blood and includes the kidneys, the bladder, and the connecting tubes.





A Kidneys are made up of many nephrons.



B A single nephron is shown in detail.
Describe *the main function of the nephron.*

Mini LAB

Modeling Kidney Function

Procedure

1. Mix a small amount of **soil** and **fine gravel** with **water** in a **clean cup.**
2. Place the **funnel** into a **second cup.**
3. Place a small piece of **wire screen** in the funnel.
4. Carefully pour the mud-water-gravel mixture into the funnel. Let it drain.
5. Remove the screen and replace it with a piece of **filter paper.**
6. Place the funnel in **another clean cup.**
7. Repeat step 4.

Analysis

1. What part of the blood does the gravel represent?
2. How does this experiment model the function of a person's kidneys?

Urine Collection and Release The urine in each collecting tubule drains into a funnel-shaped area of each kidney that leads to the ureter (YOO ruh tur). **Ureters** are tubes that lead from each kidney to the bladder. The **bladder** is an elastic, muscular organ that holds urine until it leaves the body. The elastic walls of the bladder can stretch to hold up to 0.5 L of urine. When empty, the bladder looks wrinkled and the cells lining the bladder are thick. When full, the bladder looks like an inflated balloon and the cells lining the bladder are stretched and thin. A tube called the **urethra** (yoo REE thruh) carries urine from the bladder to the outside of the body.

Applying Science

How does your body gain and lose water?

Your body depends on water. Without water, your cells could not carry out their activities and body systems could not function. Water is so important to your body that your brain and other body systems are involved in balancing water gain and water loss.

Identifying the Problem

Table A shows the major sources by which your body gains water. Oxidation of nutrients occurs when energy is released from nutrients by your body's cells. Water is a waste product of these reactions. **Table B** lists the major sources by which your body loses water. The data show you how daily gain and loss of water are related.

Solving the Problem

1. What is the greatest source of water gained by your body?
2. Explain how the percentages of water gained and lost would change in a person who was working in extremely warm temperatures. In this case, what organ of the body would be the greatest contributor to water loss?

Table A

Major Sources by Which Body Water is Gained

Source	Amount (mL)	Percent
Oxidation of nutrients	250	10
Foods	750	30
Liquids	1,500	60
Total	**2,500**	**100**

Table B

Major Sources by Which Body Water is Lost

Source	Amount (mL)	Percent
Urine	1,500	60
Skin	500	20
Lungs	350	14
Feces	150	6
Total	**2,500**	**100**

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Other Organs of Excretion

Large amounts of liquid wastes are lost every day by your body in other ways, as shown in **Figure 12.** The liver also filters the blood to remove wastes. Certain wastes are converted to other substances. For example, excess amino acids are changed to a chemical called urea (yoo REE uh) that is excreted in urine. Hemoglobin from broken-down red blood cells becomes part of bile, which is the digestive fluid from the liver.

Figure 12 On average, the volume of water lost daily by exhaling is a little more than the volume of a soft-drink can. The volume of water lost by your skin each day is about the volume of a 20-ounce soft-drink bottle.

Urinary Diseases and Disorders

What happens when someone's kidneys don't work properly or stop working? Waste products that are not removed build up and act as poisons in body cells. Water that normally is removed from body tissues accumulates and causes swelling of the ankles and feet. Sometimes these fluids also build up around the heart, causing it to work harder to move blood to the lungs.

Without excretion, an imbalance of salts occurs. The body responds by trying to restore this balance. If the balance isn't restored, the kidneys and other organs can be damaged. Kidney failure occurs when the kidneys don't work as they should. This is always a serious problem because the kidneys' job is so important to the rest of the body.

Infections caused by microorganisms can affect the urinary system. Usually, the infection begins in the bladder. However, it can spread and involve the kidneys. Most of the time, these infections can be cured with antibiotics.

Because the ureters and urethra are narrow tubes, they can be blocked easily in some disorders. A blockage of one of these tubes can cause serious problems because urine cannot flow out of the body properly. If the blockage is not corrected, the kidneys can be damaged.

Reading Check ***Why is a blocked ureter or urethra a serious problem?***

Detecting Urinary Diseases Urine can be tested for any signs of a urinary tract disease. A change in the urine's color can suggest kidney or liver problems. High levels of glucose can be a sign of diabetes. Increased amounts of a protein called albumin (al BYOO mun) indicate kidney disease or heart failure. When the kidneys are damaged, albumin can get into the urine, just as a leaky water pipe allows water to drip.

INTEGRATE Social Studies

Desalination Nearly 80 percent of Earth's surface is covered by water. Ninety-seven percent of this water is salt water. Humans cannot drink salt water. Desalination is a process that removes salt from salt water making it safe for human consumption. Research to learn which countries use desalination as a source of drinking water. Mark the countries' locations on a world map.

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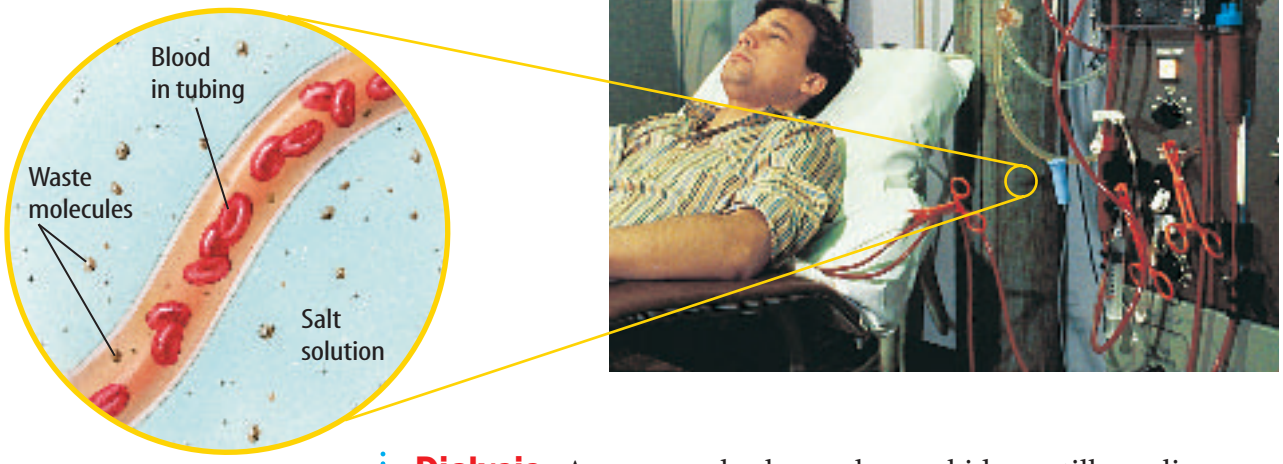
Figure 13 A dialysis machine can replace or help with some of the activities of the kidneys in a person with kidney failure. Like the kidney, the dialysis machine removes wastes from the blood.



Dialysis A person who has only one kidney still can live normally. The remaining kidney increases in size and works harder to make up for the loss of the other kidney. However, if both kidneys fail, the person will need to have his or her blood filtered by an artificial kidney machine in a process called dialysis (di AH luh sus), as shown in **Figure 13.**

section 2 review

Summary

The Urinary System

- The urinary system rids the blood of wastes produced by your cells.
- The hypothalamus monitors and regulates the amount of water in the blood.
- Nephrons are tiny filtering units in the kidneys that remove water, sugar, salt, and wastes from blood.
- Urine from the kidneys drains into the ureter, then into the bladder, and is carried outside the body by the urethra.

Urinary Diseases and Disorders

- Waste products that are not removed build up and act as poisons in your cells.
- If both kidneys fail, your blood will need to be filtered using a process called dialysis.
- Urine can be tested for kidney and liver problems, heart failure, and diabetes.

Self Check

1. **Explain** how the kidneys remove wastes and keep fluids and salts in balance.
2. **Describe** what happens when the urinary system does not function properly.
3. **Compare** the excretory system and urinary system.
4. **Concept Map** Using a network-tree concept map, compare the excretory functions of the kidneys and the lungs.
5. **Think Critically** Explain why reabsorption of certain materials in the kidneys is important to your health.

Applying Math

6. **Solve One-Step Equations** In approximately 5 min, all 5 L of blood in the body pass through the kidneys. Calculate the average rate of flow through the kidneys in liters per minute.

LAB

Kidney Structure

As your body uses nutrients, wastes are created. One role of the kidneys is to filter waste products out of the bloodstream and excrete this waste outside the body. How can these small structures filter all the blood in the body in 5 min?

Real-World Question

How does the structure of the kidney relate to the function of a kidney?

Goals

- **Observe** the external and internal structures of a kidney.

Materials

large animal kidney
**model of a kidney*
scalpel
magnifying lens
disposable gloves
dissecting tray
**Alternate materials*

Safety Precautions

WARNING: *Use extreme care when using sharp instruments. Wear disposable gloves. Wash your hands with soap after completing this lab.*

Procedure

1. **Examine** the outside of the kidney supplied by your teacher.
2. If the kidney still is encased in fat, peel off the fat carefully.
3. Using a scalpel, carefully cut the tissue in half lengthwise around the outline of the kidney. This cut should result in a section similar to the illustration on this page.
4. **Observe** the internal features of the kidney using a magnifying lens, or view these features in a model.
5. **Compare** the specimen or model with the kidney in the illustration.
6. **Draw** the kidney in your Science Journal and label its structures.

Conclude and Apply

1. What part makes up the cortex of the kidney? Why is this part red?
2. **Describe** the main function of nephrons.
3. The medulla of the kidney is made up of a network of tubules that come together to form the ureter. What is the function of this network of tubules?
4. How can the kidney be compared to a portable water-purifying system?

Communicating Your Data

Compare your conclusions with those of other students in your class. **For more help, refer to the Science Skill Handbook.**

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LAB

Model and Invent

Simulating the Abdominal *Thrust* Maneuver

Goals

- **Construct** a model of the trachea with a piece of food stuck in it.
- **Demonstrate** what happens when the abdominal thrust maneuver is performed on someone.
- **Predict** another way that air could get into the lungs if the food could not be dislodged with an abdominal thrust maneuver.

Possible Materials

paper towel roll or other tube
paper (wadded into a ball)
clay
bicycle pump
sports bottle
scissors

Safety Precautions

Always be careful when you use scissors.

Real-World Question

Have you ever taken a class in CPR or learned about how to help a choking victim? Using the abdominal thrust maneuver, or Heimlich maneuver, is one way to remove food or another object that is blocking someone's airway. What happens internally when the maneuver is used? What can you use to make a model of the trachea? How can you simulate what happens during an abdominal thrust maneuver using your model?

Make a Model

1. **List** the materials that you will need to construct your model. What will represent the trachea and a piece of food or other object blocking the airway?
2. How can you use your model to simulate the effects of an abdominal thrust maneuver?
3. Suggest a way to get air into the lungs if the food could not be dislodged. How would you simulate this method in your model?

CONTENTS

Matt Meadows

4. **Compare** your plans for the model and the abdominal thrust maneuver simulation with those of other students in your class. Discuss why each of you chose the plans and materials that you did.
5. Make sure your teacher approves your plan and materials for your model before you start.

Test the Model

1. **Construct** your model of a trachea with an object stuck in it. Make sure that air cannot get through the trachea if you try blowing softly through it.
2. Simulate what happens when an abdominal thrust maneuver is used. Record your observations. Was the object dislodged? How hard was it to dislodge the object?
3. Replace the object in the trachea. Use your model to simulate how you could get air into the lungs if an abdominal thrust maneuver did not remove the object. Is it easy to blow air through your model now?
4. Model a crushed trachea. Is it easy to blow air through the trachea in this case?

Analyze Your Data

1. **Describe** how easy it was to get air through the trachea in each step in the Make the Model section above. Include any other observations that you made as you worked with your model.
2. Think about what you did to get air into the trachea when the object could not be dislodged with an abdominal thrust maneuver. How could this be done to a person? Do you know what this procedure is called?

Conclude and Apply

Explain why the trachea has cartilage around it to protect it. What might happen if it did not?

Communicating Your Data

Explain to your family or friends what you have learned about how the abdominal thrust maneuver can help choking victims.

Overcoming the Odds

Guts and determination helped one pioneering doctor to save the lives of thousands

Overcoming the odds is a challenge that many people face. Dr. Samuel Lee Kountz, Jr. had the odds stacked against him. Thanks to his determination he beat them.

Dr. Kountz was interested in kidney transplants, a process that was still brand new in the 1950s. For many patients, a kidney transplant added months or a year to one's life. But then a patient's body would reject the kidney, and the patient would die. Dr. Kountz was determined to see that kidney transplants saved lives and kept patients healthy for years.

A donated organ is on its way to save a life.

Fixing the Problem

Kountz discovered the root of the problem—why and how a patient's body rejected the transplanted kidney. He discovered that the patient's cells attacked and destroyed the small blood vessels of the transplanted kidney. So the new kidney would die from lack of blood-supplied oxygen. From this, doctors knew when to give patients the right kinds of drugs, so that their bodies could overcome the rejection process.

In 1959, Kountz performed the first successful kidney transplant. He went on to develop a procedure to keep body organs healthy for up to 60 hours after being taken from a donor. He also set up a system of organ donor cards through the National Kidney Foundation. And in his career, Dr. Kountz transplanted more than 1,000 kidneys himself—and paved the way for thousands more.

Research **What kinds of medical breakthroughs has the last century brought? Locate an article that explains either a recent advance in medicine or the work that doctors and medical researchers are doing. Share your findings with your class.**

ScienceOnline

For more information, visit bookd.msscience.com/time

Reviewing Main Ideas

Section 1 The Respiratory System

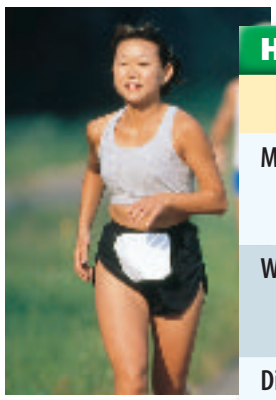
1. The respiratory system brings oxygen into the body and removes carbon dioxide.
2. Inhaled air passes through the nasal cavity, pharynx, larynx, trachea, bronchi, and into the alveoli of the lungs.
3. Breathing brings air into the lungs and removes waste gases.
4. The chemical reaction in the cells that needs oxygen to release energy from glucose is called cellular respiration.
5. The exchange of oxygen and carbon dioxide between aveoli and capillaries, and between capillaries and body cells, happens by the process of diffusion.
6. Smoking causes many problems throughout the respiratory system, including chronic bronchitis, emphysema, and lung cancer.

Section 2 The Excretory System

1. The kidneys are the major organs of the urinary system. They filter wastes from all of the blood in the body.
2. The first stage of kidney filtration occurs when water, sugar, salt, and wastes from the blood pass into the cuplike part of the nephron. The capillaries surrounding the tubule part of the nephron perform the second filtration, returning most of the water, sugar, and salt to the blood.
3. The urinary system is part of the excretory system. The skin, lungs, liver, and large intestine are also excretory organs.
4. Urine can be tested for signs of urinary tract disease and other diseases.
5. A person who has only one kidney still can live normally. When kidneys fail to work, an artificial kidney can be used to filter the blood in a process called dialysis.

Visualizing Main Ideas

Copy and complete the following table on the respiratory and excretory systems.



Human Body Systems

	Respiratory System	Excretory System
Major Organs		
Wastes Eliminated		
Disorders		

chapter 4 Review

Using Vocabulary

alveoli p. 95
asthma p. 100
bladder p. 104
bronchi p. 95
diaphragm p. 96
emphysema p. 99
kidney p. 102
larynx p. 95
nephron p. 103
pharynx p. 94
trachea p. 95
ureter p. 104
urethra p. 104
urinary system p. 101
urine p. 102

For each set of vocabulary words below, explain the relationship that exists.

1. alveoli—bronchi

2. bladder—urine

3. larynx—pharynx

4. ureter—urethra

5. alveoli—emphysema

6. nephron—kidney

7. urethra—bladder

8. asthma—bronchi

9. kidney—urine

10. diaphragm—alveoli

Checking Concepts

Choose the word or phrase that best answers the question.

11. When you inhale, which of the following contracts and moves down?
A) bronchioles **C)** nephrons
B) diaphragm **D)** kidneys

12. Air is moistened, filtered, and warmed in which of the following structures?
A) larynx **C)** nasal cavity
B) pharynx **D)** trachea

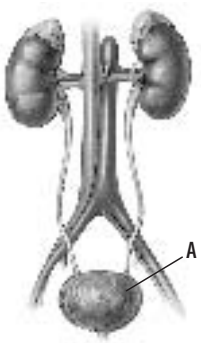
13. Exchange of gases occurs between capillaries and which of the following structures?
A) alveoli **C)** bronchioles
B) bronchi **D)** trachea

14. Which of the following is a lung disorder that can occur as an allergic reaction?
A) asthma **C)** atherosclerosis
B) cancer **D)** emphysema

15. When you exhale, which way does the rib cage move?
A) up **C)** out
B) down **D)** stays the same

16. Which of the following conditions does smoking worsen?
A) arthritis **C)** excretion
B) respiration **D)** emphysema

17. In the illustration to the right, what is the name of the organ labeled A?
A) kidneys
B) bladder
C) ureter
D) urethra



18. What are the filtering units of the kidneys?
A) nephrons **C)** neurons
B) ureters **D)** alveoli

19. Approximately 1 L of water is lost per day through which of the following?
A) sweat **C)** urine
B) lungs **D)** large intestine

20. Which of the following substances is not reabsorbed by blood after it passes through the kidneys?
A) salt **C)** wastes
B) sugar **D)** water

Thinking Critically

21. Explain why certain foods, such as peanuts, can cause choking in small children.

22. Infer why it is an advantage to have lungs with many smaller air sacs instead of having just two large sacs, like balloons.

23. Explain the damage to cilia, alveoli, and lungs from smoking.

24. Describe what happens to the blood if the kidneys stop working.

25. Explain why it is often painful when small, solid particles called kidney stones, pass into the ureter.

Use the table below to answer question 26.

Materials Filtered by the Kidneys

Substance Filtered in Urine	Amount Moving Through Kidney	Amount Excreted
Water	125 L	1 L
Salt	350 g	10 g
Urea	1 g	1 g
Glucose	50 g	0 g

26. Interpret Data Study the data above. How much of each substance is reabsorbed into the blood in the kidneys? What substance is excreted completely in the urine?

27. Recognize Cause and Effect Discuss how lack of oxygen is related to lack of energy.

28. Form a hypothesis about the number of breaths a person might take per minute in each of these situations: sleeping, exercising, and standing on top of Mount Everest. Give a reason for each hypothesis.

Performance Activities

29. Questionnaire and Interview Prepare a questionnaire that can be used to interview a health specialist who works with lung cancer patients.

Applying Math

30. Lung Capacity Make a circle graph of total lung capacity using the following data:

- volume of air in a normal inhalation or exhalation = 500 mL
- volume of additional air that can be inhaled forcefully after a normal inhalation = 3,000 mL
- volume of additional air that can be exhaled forcefully after a normal expiration = 1,100 mL
- volume of air still left in the lungs after all the air that can be exhaled has been forcefully exhaled = 1,200 mL

Use the table below to answer question 31.

Death Rates in Industry

Industry	Number of Deaths (1999)	Current Smokers (2000)
Construction	3336	37.4%
Eating and drinking places	907	39.7%
Engineering and science	55	18.7%
Mining	327	32.6%
Railroads	385	24.8%
Trucking service	1004	33.2%

31. Lung Cancer Deaths The table above shows the number of lung cancer deaths and the percentage of smokers for specified industries. How many times higher are the death rates for the construction industry than for the eating-and-drinking-places industry?

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. Which of the following diseases is caused by smoking?

A. lung cancer
B. diabetes
C. dialysis
D. bladder infection

Use the table below to answer questions 2 and 3.

Major Sources by Which Body Water is Lost		
Source	**Amount per day (mL)**	**Percent**
Urine	1,500	60
Skin	500	20
Lungs	350	14
Feces	150	6
Total	2,500	100

2. If the amount of body water lost in the urine increased by 500 mL, what percent of the total body water lost would now be lost in the urine?

A. 60%
B. 75%
C. 67%
D. 66%

3. If a person had diarrhea, which source of body water loss would increase?

A. urine
B. lungs
C. skin
D. feces

4. The movement of the chest that brings air into the lungs and removes waste gases is called

A. oxidation.
B. breathing.
C. respiration.
D. expiration.

5. What traps dust, pollen, and other materials in your nose?

A. glands
B. vocal cords
C. nasal hairs and mucus
D. epiglottis

Use the illustration below to answer question 6.

6. What is the structure shown above and to what body system does it belong?

A. capillary—circulatory
B. alveolus—respiratory
C. nephron—urinary
D. ureter—excretory

7. What is the correct order of steps in the abdominal thrust maneuver?

A. Rescuer stands behind victim and wraps arms around victim's upper abdomen; rescuer places fist against victim's stomach; rescuer thrusts fist up into area below ribs; rescuer repeats action as many times as necessary.
B. Rescuer places fist against victim's stomach; rescuer thrusts fist up into area below ribs; rescuer stands behind victim and wraps arms around victim's upper abdomen; rescuer repeats action as many times as necessary.
C. Rescuer places fist against victim's stomach; rescuer thrusts fist up into area below ribs; rescuer repeats action as many times as necessary.
D. Rescuer stands in front of victim; rescuer places fist against victim's stomach; rescuer thrusts fist up into area below ribs; rescuer repeats action as needed.

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the paragraph and table below to answer questions 8–11.

For one week, research scientists collected and accurately measured the amount of body water lost and gained per day for four different patients. The following table lists results from their investigation.

Body Water Gained (+) and Lost (−)				
Person	**Day 1 (L)**	**Day 2 (L)**	**Day 3 (L)**	**Day 4 (L)**
Mr. Stoler	+0.15	+0.15	−0.35	+0.12
Mr. Jemma	−0.01	0.00	−0.20	−0.01
Mr. Lowe	0.00	+0.20	−0.28	+0.01
Mr. Cheng	−0.50	−0.50	−0.55	−0.32

8. What was Mr. Cheng's average daily body water loss for the 4 days shown in the table?

9. Which patient had the greatest amount of body water gained on days 1 and 2?

10. According to the data in the table, on which day was the temperature in each patient's hospital room probably the hottest?

11. Which patient had the highest total gain in body water over the 4-day period?

12. What chemical substances in tobacco can destroy cells?

13. What effect can plant pollen have on the respiratory system?

14. Why do alveoli have thin walls?

15. How is energy released from glucose? What also is produced?

Part 3 Open Ended

Record your answers on a sheet of paper.

16. Explain the role of cilia in the respiratory system. Give an example of a disease in which cilia are damaged. What effects does this damage have on the respiratory system?

Use the table below to answer questions 17–19.

Urine Test Results				
Test Items	**Normal Results**	**Mrs. Beebe**	**Mrs. Chavez**	**Mrs. Jelton**
Glucose	Absent	High	Absent	Absent
Albumin	Absent	Absent	Absent	Absent
Urine volume per 24 hours	1 L	1 L	1 L	0.5 L

17. Mrs. Jelton's urine tests were done when outside temperatures had been higher than 35°C for several days. When Mrs. Jelton came to Dr. Marks' office after the urine test, he asked her about the amount of liquid that she had been drinking. Infer why Dr. Marks asked this question.

18. Assuming that Mrs. Jelton is healthy, form a hypothesis that would explain what had happened.

19. Dr. Marks called another patient to come in for more testing. Who was it? How do you know?

Test-Taking Tip

Understand Symbols Be sure you understand all symbols on a table or graph before attempting to answer any questions about the table or graph.

Questions 21–23. Notice that the unit of volume is in liters (L).