30.1 Respiratory and Circulatory Functions

VOCABULARY

- circulatory system
- respiratory system
- trachea
- lung
- alveoli
- diaphragm
- heart
- artery
- vein
- capillary

KEY CONCEPT **The respiratory and circulatory systems bring oxygen and nutrients to the cells.**

MAIN IDEAS

- The respiratory and circulatory systems work together to maintain homeostasis.
- The respiratory system moves gases into and out of the blood.
- The circulatory system moves blood to all parts of the body.

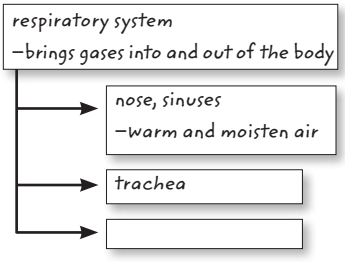
Connect to Your World

You have thousands of kilometers of blood vessels in your body and several hundred *million* tiny air sacs in your lungs. Blood circulates constantly through the vessels, while air continually fills and empties from the tiny air sacs. Your heart keeps beating and your lungs keep working 24 hours a day, every day of your life. Even more amazing, everything works without your having to think about it.

READING TOOLBOX

TAKING NOTES

Use a supporting main ideas strategy to help you remember the respiratory and circulatory structures and their functions.



MAIN IDEA

The respiratory and circulatory systems work together to maintain homeostasis.

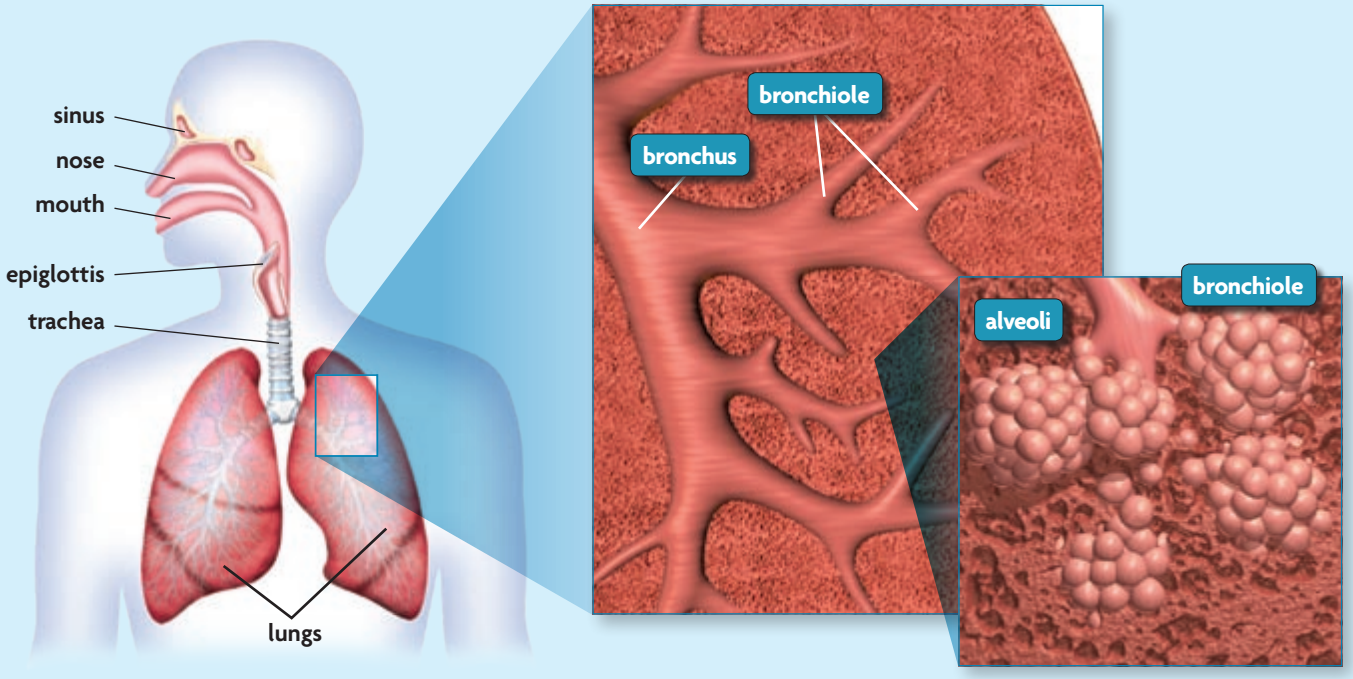
Every cell in your body needs nutrients and oxygen to function and needs to get rid of its waste products. The **circulatory system** is the body system that transports blood and other materials. It brings vital supplies to the cells and carries away their wastes. The blood vessels of the circulatory system also keep oxygen-poor blood from mixing with oxygen-rich blood. The **respiratory system** is the body system in which gas exchange takes place. You can think of your respiratory system as a major supply depot where the blood can pick up oxygen (O_2) and deposit excess carbon dioxide (CO_2). The lungs of the respiratory system are the only place in your body where gases in the blood are exchanged with gases from the atmosphere.

The respiratory and circulatory systems work closely together to maintain homeostasis in the face of constant change. Every time you exercise, lie down to rest, or simply stand up, you change your needs for oxygen and nutrients. As a result, your heart speeds up or slows down and you breathe faster or slower, depending on your activity. This section gives you an overview of the major structures of the respiratory and circulatory systems and their functions. Sections 2 through 5 provide a closer look at the organs of each system, how they work, and what can damage them.

Apply **When you stand up after lying down, why do your heart rate and breathing rate increase?**

FIGURE 1.1 Respiratory Organs and Tissues

Specialized structures move air into and out of the body.



Infer **How do the structures in the lungs increase their surface area?**

MAIN IDEA

The respiratory system moves gases into and out of the blood.

The function of the respiratory system is to bring O_2 into the body and to expel CO_2 and water vapor. The structures of this system bring the gases in close contact with the blood, which absorbs O_2. The circulatory system then carries O_2 to all of the body's cells and transports CO_2 from the rest of the body to the lungs, where it is exhaled.

The specialized structures of the respiratory system are shown in **FIGURE 1.1.** The nose and mouth are the entry points to the system. When air enters the nose, mucus that lines the nasal passages warms and moistens the air. The mucus and tiny hairs called cilia help filter dust and pathogens from the air. At the back of the throat, a small piece of tissue, the epiglottis, regulates airflow into the trachea, or windpipe. The **trachea** (TRAY-kee-uh) is a long structure made of soft tissue reinforced with C-shaped rings of cartilage. It resembles the hose of a vacuum cleaner. When you swallow, the epiglottis closes the entrance to the trachea to keep food or saliva from entering the airways. The trachea divides into the two bronchi, with one branch going to each lung.

The **lungs** are the organs that absorb O_2 from the air you inhale. Inside the lungs, the bronchi divide into smaller and smaller branches that resemble the limbs and twigs of a tree. The smallest branches, the bronchioles, end in clusters of tiny air sacs called **alveoli** (al-VEE-uh-LY). One air sac is called an alveolus. The lungs have a huge number of alveoli—from 300 to 600 million.

CONNECT TO

CELLULAR RESPIRATION

You learned in **Cells and Energy** that eukaryotic cells require a constant supply of oxygen to produce ATP, which is the main energy source for cells.

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PREMIUM CONTENT
How You Breathe

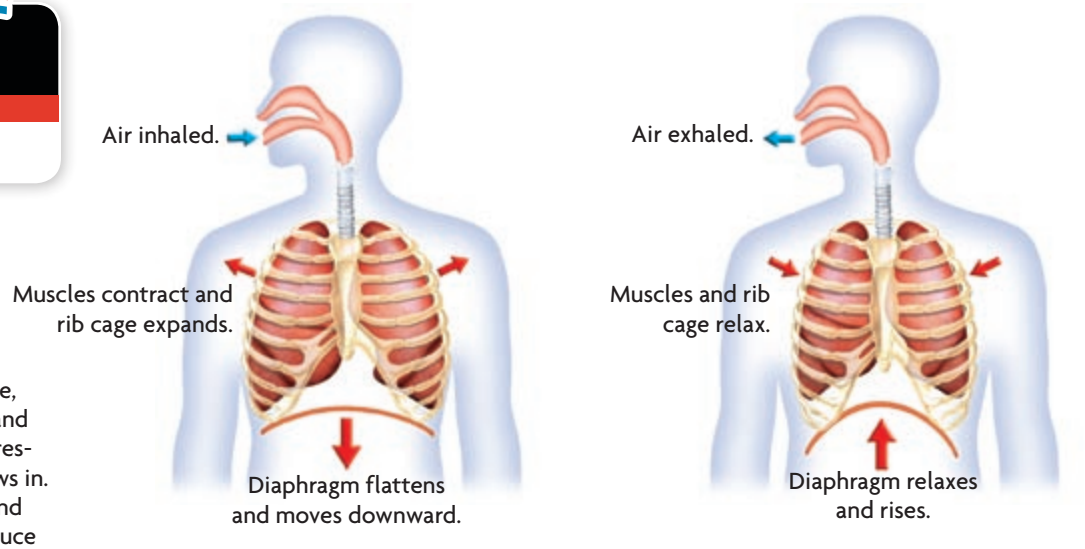

FIGURE 1.2 When you inhale, movements of the rib cage and diaphragm produce lower pressure in the lungs, and air flows in. When you exhale, rib cage and diaphragm movements produce higher pressure in the lungs, and air flows out.

This huge number of alveoli gives the lungs a massive surface area for absorbing O_2 and releasing CO_2 and water vapor. Lung tissue is spongy and elastic, which allows the lungs to expand and contract as you breathe. Lung mucus and cilia help trap and remove foreign materials and pathogens.

The mechanics of breathing involve the muscles of the rib cage and the diaphragm, as **FIGURE 1.2** shows. The **diaphragm** is a dome-shaped muscle at the base of the rib cage. When you inhale, the muscles of the rib cage contract, causing the rib cage to expand. The diaphragm then flattens and moves downward. The volume of your lungs increases, and the air pressure decreases, falling below the air pressure outside your body. Gases move from areas of greater pressure to areas of lower pressure, so air flows into the lungs.

When you exhale, the rib cage muscles relax, and the rib cage becomes smaller. The diaphragm also relaxes, causing it to rise and regain its domelike shape. Now the air pressure inside your lungs is greater than the air pressure outside your body, so air flows out.

Predict **How might damaged alveoli affect the oxygen level in the blood?**

READING TOOLBOX

VOCABULARY

The word *diaphragm* is based on the Latin *diaphragma,* which means "midriff." The midriff extends from below the breast to the waist. The diaphragm is located in this area.

MAIN IDEA

The circulatory system moves blood to all parts of the body.

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PREMIUM CONTENT
Build the Circulatory and Respiratory Systems

The function of the circulatory system is to transport O_2 and nutrients to body cells and to carry oxygen-poor blood and CO_2 back to the heart and lungs. To do its job, the system must keep blood constantly circulating.

The main parts of the circulatory system are the heart, the blood, and the blood vessels. The **heart** is a muscular pump, about the size of your fist, that keeps the blood moving to every part of the body. The blood circulates through a closed system—that is, blood in the circulatory system stays inside the vessels. The average adult body contains about 5 liters (more than 5 qt) of blood. On average, your blood circulates from your heart, throughout your body, and back to your heart about every 60 seconds.

The circulatory system has three types of blood vessels: arteries, veins, and capillaries. **Arteries** are blood vessels that carry blood away from the heart to the rest of the body. **Veins** are blood vessels that carry blood from the rest of the body back to the heart. As illustrated in **FIGURE 1.3,** arteries carry oxygen-rich blood (red) and veins carry oxygen-poor blood (blue). Blue is used for illustration purposes only. In your body, oxygen-poor blood is not actually blue but a darker red color. You can think of arteries and veins as a system of roads. Large arteries and veins are like major highways. Smaller arteries and veins are like streets that route traffic through local neighborhoods.

Arteries and veins are connected by a system of capillaries. **Capillaries** are the tiny blood vessels that transport blood to and from the cells of the body. These vessels are so small that blood cells must move through them in single file. The walls of these tiny blood vessels are only one cell thick. Materials can easily diffuse into and out of them.

In addition to transporting vital supplies to the cells, the circulatory system performs two other important functions that maintain homeostasis.

- The circulatory system collects waste materials produced by digestion and cell metabolism, and delivers them to the liver and kidneys to be filtered out of the body. For example, muscle cell activity produces a waste product known as urea. As blood moves past the muscle cells, urea is moved into the bloodstream and carried to the kidneys to be excreted.
- The circulatory system helps maintain body temperature by distributing the heat that cells produce in the muscles and internal organs. When you are active, your organs and muscles produce more heat. The heart pumps harder, and the blood vessels dilate to bring excess heat to the skin, where it can escape. In cold weather, the blood vessels constrict to conserve heat.

The heart, the blood vessels, and the blood are described in more detail in Sections 3 through 5.

FIGURE 1.3 The circulatory system is composed of the heart, arteries carrying oxygen-rich blood (red), veins carrying oxygen-poor blood (blue), and capillaries.

Infer **If a person has a weak heart, how might his or her ability to maintain a stable body temperature be affected?**

30.1 Formative Assessment

REVIEWING ▶ MAIN IDEAS

1. How do the **respiratory** and **circulatory systems** help maintain homeostasis in the body?
2. List the main parts and functions of the respiratory system.
3. Describe the basic parts and functions of the circulatory system.

CRITICAL THINKING

4. **Apply** Why can't you breathe through the mouth while you are swallowing food? What would happen if you could do this?
5. **Infer** **Arteries** and **veins** are equally distributed throughout the body. How does this arrangement help to maintain the functions of each cell?

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PREMIUM CONTENT

CONNECT TO

SCIENCE AND TECHNOLOGY

6. A mechanical ventilator breathes for a paralyzed person. During inhalation, the machine forces air under pressure into the **lungs**. During exhalation, the pressure drops and air moves out of the lungs. How does this machine compare with natural breathing?