The Heart and Circulation

**Vocabulary**
- atrium
- ventricle
- valve
- pacemaker
- pulmonary circulation
- systemic circulation

**Key Concept**  The heart is a muscular pump that moves the blood through two pathways.

**Main Ideas**
- The tissues and structures of the heart make it an efficient pump.
- The heart pumps blood through two main pathways.

**Connect to Your World**

*Lub-dub, lub-dub.* This is the sound of your heart beating. The *lub* sound occurs when the valves between the upper and lower chambers of the heart snap shut. The *dub* sound is made by valves closing the two arteries that carry blood out of the heart. If a valve does not close properly and allows blood to leak backward, the sound of the heart changes. A heart with a leaky valve might sound like this: *Lub-dub-shhh, lub-dub-shhh.* The sounds your heart makes can tell a physician a great deal about how it is performing.

**Main Idea**

The tissues and structures of the heart make it an efficient pump.

Each day your heart beats about 100,000 times, circulating blood through nearly 96,000 kilometers of blood vessels—roughly one-quarter of the distance to the moon. Over 70 years, your heart will beat about 2.5 billion times. How can it keep going? One reason is that cardiac muscle tissue, unlike skeletal muscle tissue, can work continuously without becoming tired. Also, the structures of the heart make this organ an efficient pump.

**Structures of the Heart**

The largest structures in your heart are the four chambers. As shown in **FIGURE 3.1**, the two smaller chambers are the right and left atrium (plural, atria), and the two larger chambers are the right and left ventricles. The ventricles are separated by the septum, a thick wall of tissue. The heart valves are flaps of tissue that prevent blood from flowing backward. They open when the atria or ventricles contract, and close when the atria or ventricles relax.

After blood fills a chamber, the cardiac muscle contracts and pumps the blood out of the chamber. The heart is an amazingly powerful pump.
The reason has to do with the small size of the heart, which allows the strong cardiac muscles to exert a great deal of force on the chamber. The combination of small size and large force results in a powerful pumping action. The heart is also an efficient, self-regulating pump. It can respond to signals from the nervous system to change the speed and force of its pumping action. For example, if you increase your level of activity, your heart will pump faster.

The Heartbeat
The heartbeat consists of two contractions: the first takes place in the atria and the second in the ventricles. The contractions occur partly because the cardiac muscle fibers of the chambers have a unique property. Whenever one fiber is stimulated to contract, all of the fibers contract at the same time.

The first contraction of the heart begins in the right atrium at a signal from the sinoatrial (SA) node, shown in Figure 3.2. The SA node is known as the heart’s pacemaker because the cells in this node generate an electrical signal that starts the wave of contractions. Once the atria have contracted, the electrical signal spreads through conducting fibers to the atrioventricular (AV) node, located in the wall of the right ventricle. The AV signal stimulates both ventricles to contract at the same time.

If the SA node is seriously damaged by injury or disease, it can be replaced with an artificial pacemaker that is implanted into the heart. This device, like the SA node, sends electrical signals to the muscle fibers of the atria.

Blood Flow in the Heart
Once you know the basic structures and actions of the heart, you can follow how oxygen-rich and oxygen-poor blood flow through this organ. Study Figure 3.3, which illustrates this pathway. Notice that blood always enters the heart through an atrium and leaves the heart through a ventricle. The contractions of the atria and then of the ventricles keep blood moving in this sequence.

1. Oxygen-poor blood from the body enters the right atrium. The SA node signals the atria to contract, and blood flows into the right ventricle.
2. When the AV node signals the ventricles to contract, blood is pumped from the right ventricle into the pulmonary artery. This artery, which goes to the lungs, is the only artery in the body that carries oxygen-poor blood. The blood enters the lungs, where CO₂ and water vapor diffuse into the alveoli and O₂ diffuses into the blood.
3. Oxygen-rich blood returns to the heart through the pulmonary vein and enters the left atrium. This is the only vein in the body that carries oxygen-rich blood. As the atria contract, blood is pumped into the left ventricle, the largest chamber in the heart.
4. When the ventricles contract, blood is pumped from the left ventricle into a large artery, the aorta, and is circulated to the rest of the body.

After oxygen has been delivered to the cells, the oxygen-poor blood returns through the veins to the heart, and the sequence begins again.

Analyze The left ventricle is the largest chamber of the heart. How is its size related to its function?
The structures of the heart keep oxygen-poor blood separated from oxygen-rich blood.

If the valves in the right ventricle do not close properly, where in the body might circulation be affected the most?

**Critical Viewing**

1. The right atrium receives oxygen-poor blood from the body and pumps it to the right ventricle.
2. The right ventricle pumps oxygen-poor blood to the lungs.
3. The left atrium receives oxygen-rich blood from the lungs and pumps it to the left ventricle.
4. The left ventricle pumps oxygen-rich blood to all parts of the body.
The heart pumps blood through two main pathways.

Circulating blood follows two separate pathways that meet at the heart, as shown in Figure 3.4. These pathways are called the pulmonary and systemic circulation. All of your blood travels through both of these pathways.

**Pulmonary circulation** (PUL-muh-NEHR-ee) occurs only between the heart and the lungs. The main function of this circulation is to carry oxygen-poor blood to the lungs, where it picks up O₂, expels excess CO₂ and water, and carries oxygen-rich blood back to the heart. Each lung is supplied by its own pulmonary artery and pulmonary vein. **Systemic circulation** (sihs-STEHM-ihk) occurs between the heart and the rest of the body, except for the lungs. The main function of this circulation is to carry oxygen-rich blood to all cells and transport oxygen-poor blood back to the heart. Systemic circulation begins when blood leaves the left ventricle, the largest chamber of the heart. The blood then circulates through the torso, arms, legs, and head, and then returns to the heart.

As the body’s need for oxygen changes, sensors in the walls of major arteries in the pulmonary and systemic pathways send information to the medulla in the brain stem. The medulla coordinates this information with signals from the respiratory system. Homeostasis is maintained by matching heart rate and respiration rate with the oxygen needs of the body.

In extreme conditions, such as severe cold, the pulmonary and systemic circulation systems serve another vital function—making sure the body’s brain, heart, and other major organs remain at a constant temperature. When the body is exposed for any length of time to a cold environment, blood vessels to the arms and legs begin to constrict. The blood flow to the arms and legs is reduced in order to keep the torso and head warm. Once you reach a warmer environment, these blood vessels dilate and normal circulation resumes.

**Infer** Why is it important to have two separate pathways for circulation?

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**MAIN IDEA**

The heart pumps blood through two main pathways.

**FIGURE 3.4** The circulatory system has two general pathways. Pulmonary circulation moves blood between the heart and the lungs. Systemic circulation moves blood between the heart and the rest of the body.

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**30.3 Formative Assessment**

**REVIEWING MAIN IDEAS**

1. What structures make the heart an efficient pump? In your answer, describe the direction of blood flow into and out of the heart.
2. Briefly describe the **pulmonary** and **systemic circulation** pathways.

**CRITICAL THINKING**

3. **Predict** Explain how leaky heart valves might damage the heart over time.
4. **Predict** How might a high fever affect a person’s heart and breathing rates? Explain your answer.

**CONNECT TO ANIMALS**

5. Unlike a human heart, an amphibian heart has two **atria** but only a single **ventricle**. How might living in a watery environment help reduce the work that an amphibian heart needs to do?