17.2: Introduction to the Cardiovascular System

Ant Hill or Plumbing System?

What do you think this picture shows? Does it show a maze of underground passageways in an ant hill? A network of interconnected pipes in a complex plumbing system? The picture actually shows something that, like ant tunnels and plumbing pipes, functions as a transportation system. It shows a network of blood vessels. Blood vessels are part of the cardiovascular system.

Figure \(\PageIndex{1}\): (Jiulin Du, CC by 2.5; CK-12 foundation)

What is the Cardiovascular System?

The **cardiovascular system**, also called the circulatory system, is the organ system that transports materials to and from all the cells of the body. The materials carried by the cardiovascular system include oxygen from the lungs, nutrients from the digestive system, hormones from glands of the endocrine system, and waste materials from cells throughout the body. Transport of these and many other materials is necessary to maintain homeostasis of the body. The main components of the cardiovascular system are the heart, blood vessels, and blood. Each of these components is shown in the following figure and introduced below.
The heart is a muscular organ in the chest. It consists mainly of cardiac muscle tissue and pumps blood through blood vessels by repeated, rhythmic contractions. As shown in the figure below, the heart has four inner chambers: a right atrium and ventricle and a left atrium and ventricle. On each side of the heart, blood is pumped from the atrium to the ventricle below it and from the ventricle out of the heart. The heart also contains several valves that allow blood to flow only in the proper direction through the heart.
Anatomy of the Heart

Figure 3: The right side of the heart includes the right atrium and right ventricle. The left side includes the left atrium and left ventricle. (CC BY-NC 3.0; BruceBlaus; 2014; via wikimedia.org)

Unlike skeletal muscle, cardiac muscle routinely contracts without stimulation by the nervous system. Specialized cardiac muscle cells send out electrical impulses that stimulate the contractions. As a result, the atria and ventricles normally contract with just the right timing to keep blood pumping efficiently through the heart.

Blood Vessels
Figure \(\PageIndex{4}\)\): This diagram represents the structure and functions of the different types of blood vessels in the cardiovascular system. Arteries carry blood from the heart and to capillaries. Veins carry blood from the capillaries back to the heart. (CC BY-NC 3.0; Rupali Raju; CK-12 foundation)

The blood vessels of the cardiovascular system are like a network of interconnected, one-way roads that range from superhighways to back alleys. Like a network of roads, the blood vessels have the job of allowing the transport of materials from one place to another. There are three major types of blood vessels: arteries, veins, and capillaries. They are illustrated in Figure \(\PageIndex{4}\).

- Arteries are blood vessels that carry blood away from the heart (except for the arteries that actually supply blood to the heart muscle). Most arteries carry oxygen-rich blood, and one of their main functions is distributing oxygen to tissues throughout the body. The smallest arteries are called arterioles.
- Veins are blood vessels that carry blood toward the heart. Most veins carry deoxygenated blood. The smallest veins are called venules.
- Capillaries are the smallest blood vessels. They connect arterioles and venules. As they pass through tissues, they exchange substances including oxygen with cells.

Two Circulations

Cells throughout the body need a constant supply of oxygen. They get oxygen from capillaries in the systemic circulation. The systemic circulation is just one of two interconnected circulations that make up the human cardiovascular system. The other circulation is the pulmonary system. This is where the blood picks up oxygen to carry to cells. It takes blood about 20 seconds to make one complete transit through both circulations.

Pulmonary Circulation

The pulmonary circulation involves only the heart and lungs and the major blood vessels that connect them. It is illustrated in the figure below. Blood moves through the pulmonary circulation from the heart to the lungs, and back to the heart again, becoming oxygenated in the process. Specifically, the right ventricle of the heart pumps deoxygenated blood into the right and left pulmonary arteries. These arteries carry the blood to the right and left lungs, respectively. Oxygenated blood then returns from the right and left lungs through the two right and two left pulmonary veins. All four pulmonary veins enter the left atrium of the heart.

Figure \(\PageIndex{5}\)\): This diagram shows the heart, lungs, and major vessels that make up the pulmonary circulation. The colored arrows indicate the direction of blood flow. Oxygenated blood (in red) flows from the lungs to the left side of the heart. Deoxygenated blood (in blue) flows from the right side of the heart to the lungs. (US government; public domain: via wikimedia.org; Pulmonary circuit)
What happens to the blood while it is in the lungs? It passes through increasingly smaller arteries and finally through capillary networks surrounding the alveoli (see figure below). This is where gas exchange takes place. The deoxygenated blood in the capillaries picks up oxygen from the alveoli and gives up carbon dioxide to the alveoli. As a result, the blood returning to the heart in the pulmonary veins is almost completely saturated with oxygen.

Systemic Circulation

The oxygenated blood that enters the left atrium of the heart in the pulmonary circulation then passes into the systemic circulation. This is the part of the cardiovascular system that transports blood to and from all of the tissues of the body to provide oxygen and nutrients and pick up wastes. It consists of the heart and blood vessels that supply the metabolic needs of all the cells in the body, including those of the heart and lungs.
the heart to the rest of the body; and the inferior and superior venae cavae (blue), which return deoxygenated blood to the heart from the body. The colored arrows in the diagram indicate the direction of blood flow, red for oxygenated and blue for deoxygenated. (public domain; US government)

As shown in Figure \(\PageIndex{7}\), in the systemic circulation, the left atrium pumps oxygenated blood to the left ventricle, which pumps the blood directly into the aorta, the body's largest artery. Major arteries branching off the aorta carry the blood to the head and upper extremities. The aorta continues down through the abdomen and carries blood to the abdomen and lower extremities. The blood then returns to the heart through the network of increasingly larger veins of the systemic circulation. All of the returning blood eventually collects in the superior vena cava (upper body) and inferior vena cava (lower body), which empty directly into the right atrium of the heart.

**Blood**

Blood is a fluid connective tissue that circulates throughout the body in blood vessels by the pumping action of the heart. Blood carries oxygen and nutrients to all the body's cells, and it carries carbon dioxide and other wastes away from the cells to be excreted. Blood also transports many other substances, defends the body against infection, repairs body tissues, and controls the body's pH, among other functions.

The fluid part of blood is called plasma. It is a yellowish, watery liquid that contains many dissolved substances and blood cells. Types of blood cells in plasma include red blood cells, white blood cells, and platelets, all of which are illustrated in the following photomicrograph and described below.

![Figure \(\PageIndex{8}\): The three types of cells in the blood are pictured here: red blood cell (left), platelet (center), and white blood cell (right).](https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/17%3A_Cardiovasc...)

- Red blood cells have the main function of carrying oxygen in the blood. Red blood cells consist mostly of hemoglobin, a protein containing iron that binds with oxygen.
- White blood cells are far fewer in number than red blood cells. They defend the body in various ways. For example, white blood cells called phagocytes swallow and destroy pathogens, dead cells, and other debris in the blood.
- Platelets are cell fragments involved in blood clotting. They stick to tears in blood vessels and to each other, forming a plug at the site of injury. They also release chemicals that are needed for clotting to occur.
Summary

• The cardiovascular system is the organ system that transports materials to and from all the cells of the body. The main components of the cardiovascular system are the heart, blood vessels, and blood.

• The heart is a muscular organ in the chest that consists mainly of cardiac muscle and pumps blood through blood vessels by repeated, rhythmic contractions. The heart has four chambers through which blood flows and valves that keep blood flowing in just one direction.

• Blood vessels carry blood throughout the body. Major types of blood vessels are arteries, which mainly carry blood away from the heart; veins, which carry blood toward the heart; and capillaries, which exchange substances between the blood and cells of the body.

• The cardiovascular system has two interconnected circulations. The pulmonary circulation carries blood between the heart and lungs, where blood is oxygenated. The systemic circulation carries blood between the heart and the rest of the body, where it delivers oxygen.

• Blood is a fluid connective tissue that circulates throughout the body in blood vessels. It consists of a liquid part, called plasma, which contains many dissolved substances; and cells, including red blood cells, white blood cells, and platelets.

Review

1. What is the cardiovascular system? What are its main components?
2. Describe the heart and how it functions.
3. List the three major types of blood vessels and their basic functions.
4. Compare and contrast the pulmonary and systemic circulations.
5. What is blood? What are its chief constituents?
6. True or False. The circulatory system brings blood to and from the body, while the cardiovascular system brings blood to and from the lungs only.
7. True or False. Arteries carry mainly oxygenated blood.
8. Name three different types of substances that are transported by the cardiovascular system.
9. Describe where and how the pulmonary and systemic circulation systems meet.
10. Which of the following carries blood to the lungs? Choose all that apply.
   A. Left pulmonary artery
   B. Left pulmonary vein
   C. Right pulmonary artery
   D. Right pulmonary vein
11. Put the following structures in order of how blood flows from the heart out to the body and back again.
    capillaries; venules; aorta; veins; arteries
12. Explain why the heart and lungs need blood from the systemic circulation.
13. *Choose one.* Blood vessels carrying deoxygenated blood from the body back to the heart get increasingly (larger/smaller).

14. Blood becomes oxygenated in the lungs through gas exchange into:

   A. Arterioles
   
   B. Capillaries
   
   C. Venules
   
   D. Bronchioles

15. Which type of blood cell carries oxygen?

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