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## The Heart and Circulation

To understand heart disease and its effects on your body, it may help to learn more about your heart. This booklet explains the structure of the heart and blood vessels and how they work. Words in bold are explained in a word list at the end of the resource.

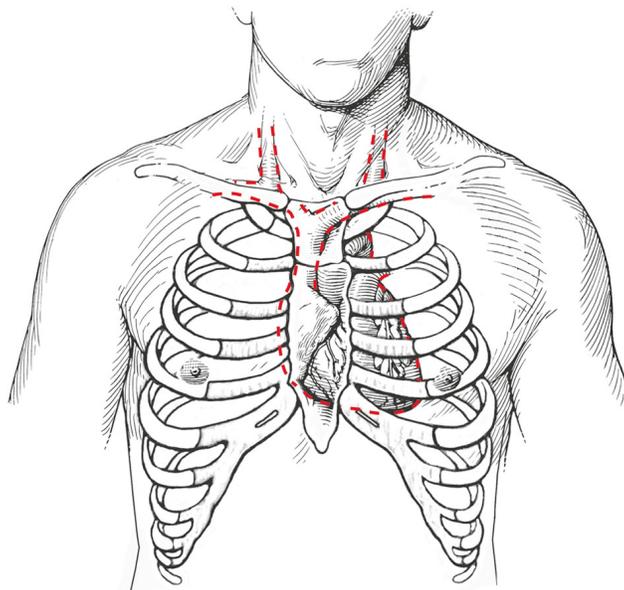
**Objectives:** This information may help you:

- Identify the size and location of your heart.
- Identify the three layers of the heart.
- Identify the four **chambers** of your heart.
- Explain the purpose of the **valves**.
- Describe the three main kinds of blood vessels.
- Explain the role of **coronary (heart) arteries** in the functioning of your heart.
- Discuss the difference between the systolic and diastolic **blood pressure**.
- Trace the basic route of your heart's electrical conduction system on the diagram provided.

### LOCATION AND SIZE OF THE HEART

Your heart is located under your rib cage beneath and to the left of your breastbone (sternum) (figure 1). About the size of your fist, the heart is a hollow, muscular organ that weighs less than a pound.

Hardworking and powerful, the heart pumps blood to all parts of the body — to every cell, muscle, bone, and organ.

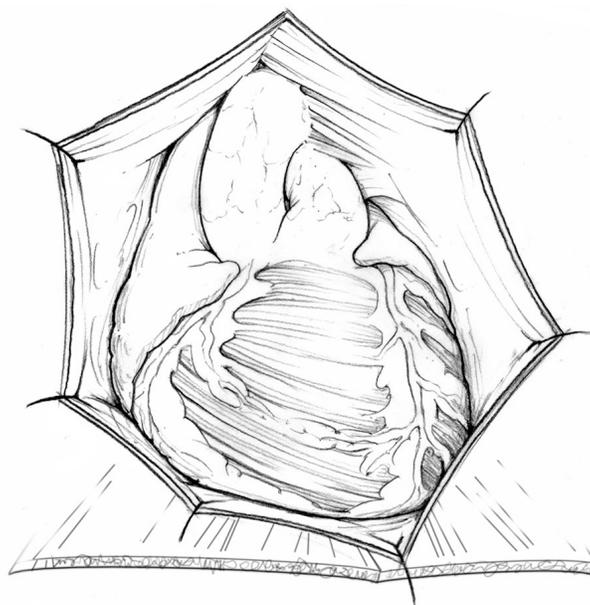


**Figure 1.** The heart is under the rib cage beneath and to the left of the breastbone (sternum). The low tip of the heart is called the apex.

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## LAYERS OF THE HEART

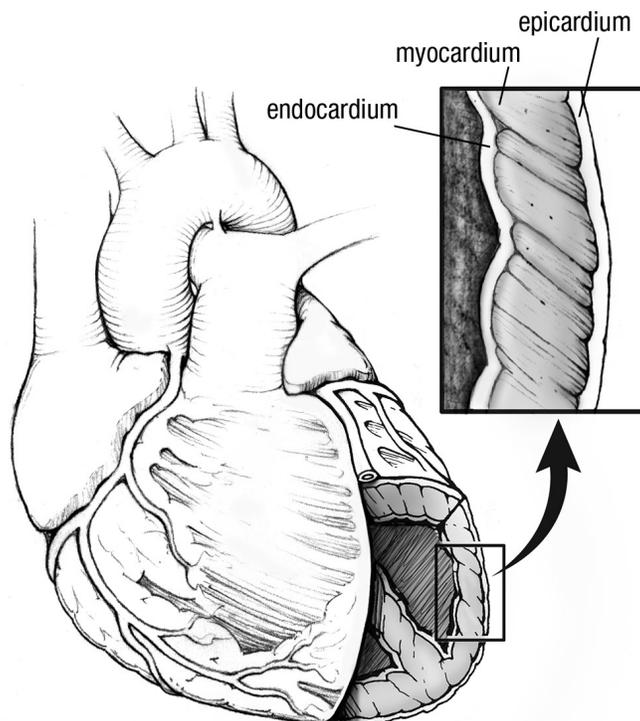
The heart lies inside a protective sac of fibrous tissue called the **pericardium** (figure 2). The heart itself has three layers of tissue: the **epicardium**, the **myocardium**, and the **endocardium**.



**Figure 2.** This drawing shows the pericardium pulled away from the heart. Normally the pericardium lies directly on the surface of the heart.

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The epicardium is a thin, shiny membrane covering the surface of the heart. Under the epicardium is a thick layer of muscle called the myocardium. The inside of the heart is covered with another smooth, shiny membrane called the endocardium. It covers the inside of the chambers of the heart, the heart valves, and the muscles attached to the valves (figure 3).



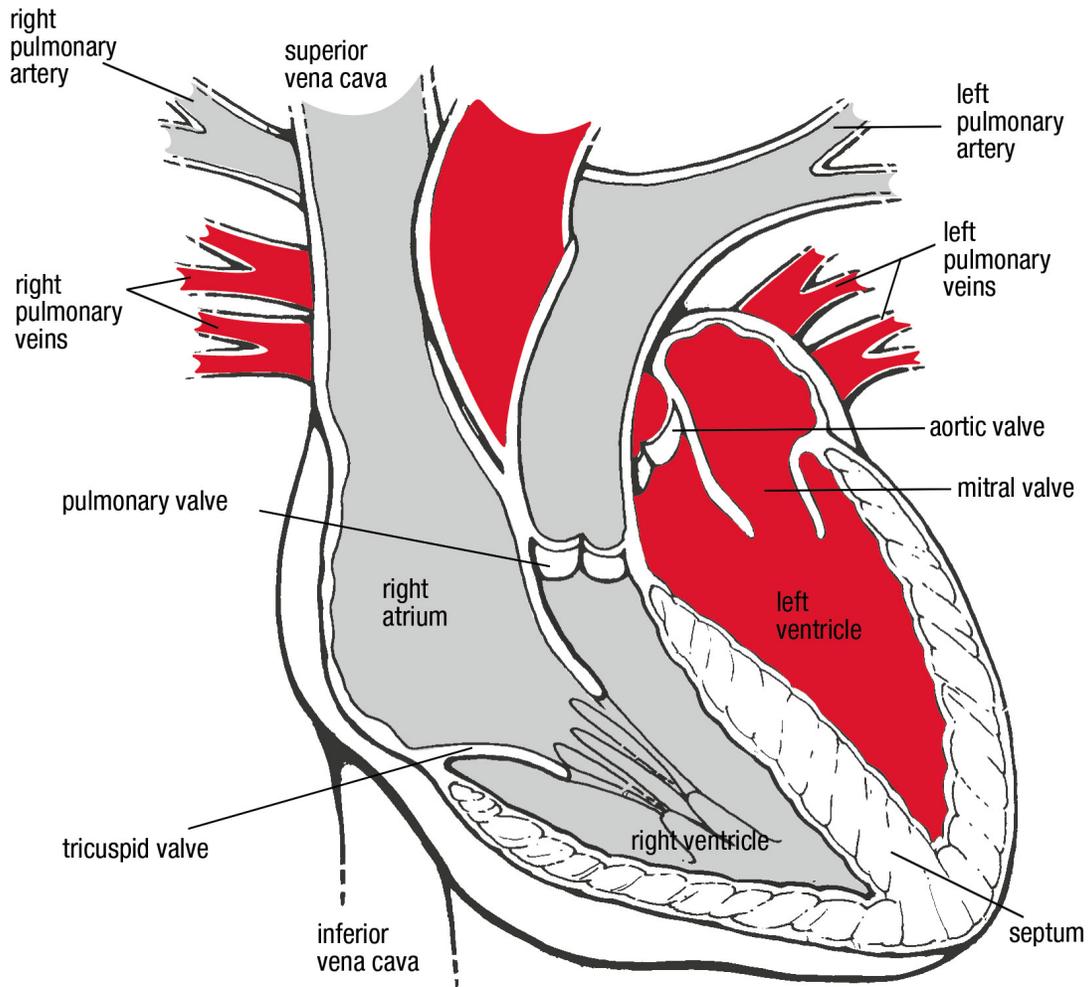
**Figure 3.** The epicardium, the myocardium and the endocardium are the three layers of heart tissue.

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## THE CHAMBERS OF THE HEART

The heart is divided into four chambers (figure 4). The top two chambers are called the right and left **atria** (plural for **atrium**). The two lower chambers, the **ventricles**, are larger, thick-walled chambers that pump the blood to all parts of the body.

The **septum** is a muscular wall that divides the right atrium from the left atrium and the right ventricle from the left ventricle. The septum prevents blood from passing from one side of the heart to the other. The right atrium and right ventricle together are referred to as the “right heart.” The left atrium and left ventricle together are called the “left heart.”



**Figure 4.** Chambers and valves of the heart

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## VALVES OF THE HEART

Four valves keep blood flowing in the proper direction through the heart, to the lungs, and to the body. The valves are flexible flaps of tissue surrounded by semirigid rings (figure 4).

On the right side of the heart, the **tricuspid valve** allows blood to flow from the right atrium down into the right ventricle and prevents blood from flowing in the opposite direction.

From the right ventricle, the blood is pumped through the **pulmonary valve** to the lungs, where it picks up **oxygen** and gets rid of carbon dioxide and other waste products.

From the lungs, the oxygen-rich blood flows through the **pulmonary veins** to the left atrium.

From the left atrium the blood flows through the **mitral valve** into the left ventricle.

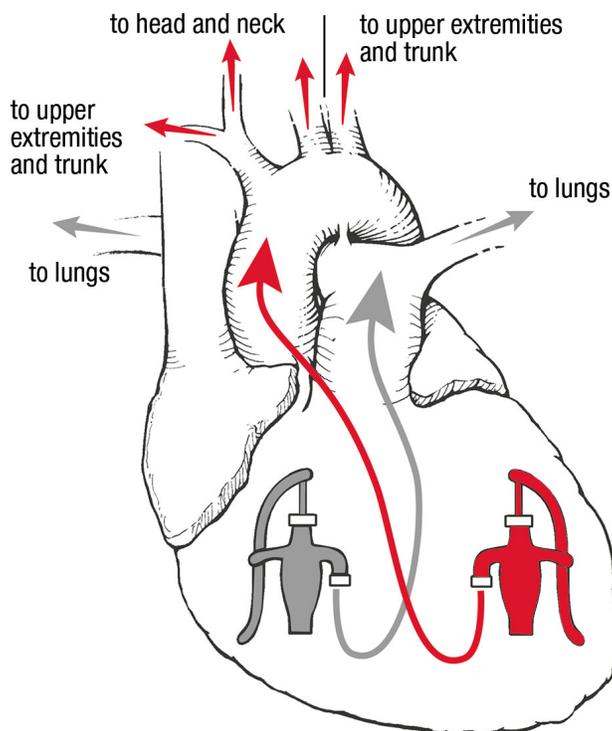
From the left ventricle, the blood is pumped through the **aortic valve** to all parts of the body.

## THE DOUBLE PUMP

The heart can be thought of as a double pump. One pump, the right heart, receives blood from all parts of the body through two large **veins** called the **superior** and **inferior vena cava**. Blood headed for the right heart has just delivered oxygen and nutrients to the body. Because it has less oxygen, this blood is called **deoxygenated** (oxygen-poor) blood (shown in blue). The right heart pumps this blood to the lungs where it picks up additional oxygen.

Freshly **oxygenated** blood (shown in red) passes to the left heart. From the left heart, blood is pumped to the body through the **aorta**, the largest blood vessel in the body. The aorta divides into several branches to supply blood to various parts of the body.

The heart, then, is a double pump. It receives blood from the veins, pumps it to the lungs, receives it from the lungs, and pumps it into the body through arteries. This cycle is repeated thousands of times each day (figure 5).



**Figure 5.** The heart receives oxygen poor blood from the veins, pumps it to the lungs, receives oxygenated (oxygen rich blood) back from the lungs, and pumps it through the arteries to the entire body.

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## EJECTION FRACTION

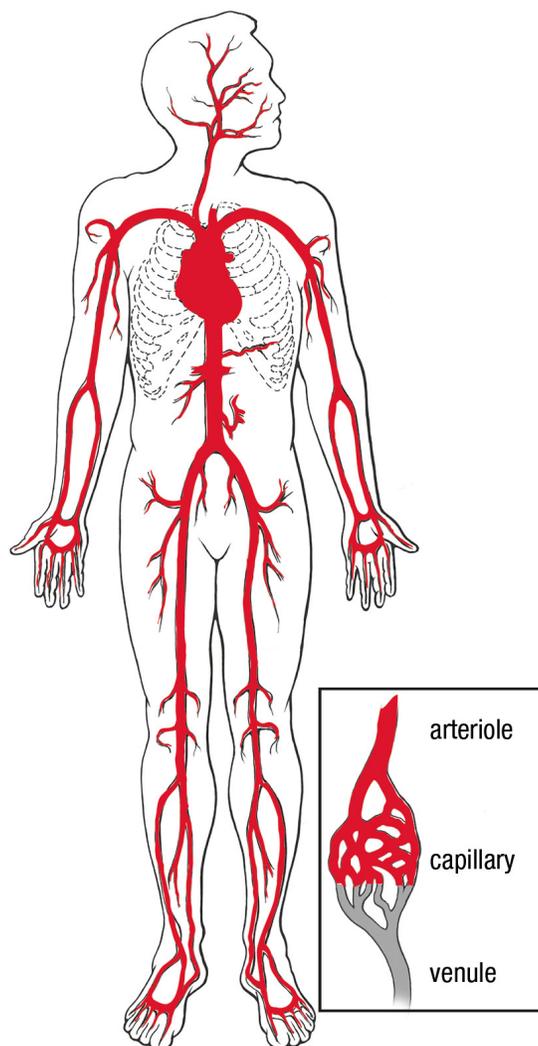
No matter how strong the contraction, your heart does not pump all the blood out of both ventricles with each beat. The portion of blood that is pumped out of a filled ventricle is called the “ejection fraction.”

A normal ejection fraction is 50 to 65 percent or more. So at least half the blood in the ventricle is pumped out on each beat. The ejection fraction is a good measure of the overall function of your heart. In a healthy person, the ejection fraction of the heart might increase by about 5 to 10 percent with exercise. It can diminish to 20 to 30 percent or lower if the ventricles are not functioning normally.

## **BLOOD VESSELS**

Several types of blood vessels carry blood to all parts of your body. Arteries carry fresh, oxygen-rich blood away from the heart to tissues throughout the body. Veins carry blood containing waste products such as carbon dioxide back through the heart to the lungs. The lungs exchange the carbon dioxide for a fresh supply of oxygen.

Arteries branch into **arterioles**, which become smaller and smaller until they are big enough to allow only one cell of blood to pass through at a time. These smallest vessels are called **capillaries**. While passing through the capillaries the tissues get the oxygen they need and transfer carbon dioxide to the blood. The blood begins its return to the heart through tiny veins called **venules**. Blood flows from venules to larger and larger veins until it reaches the right atrium (figure 6).

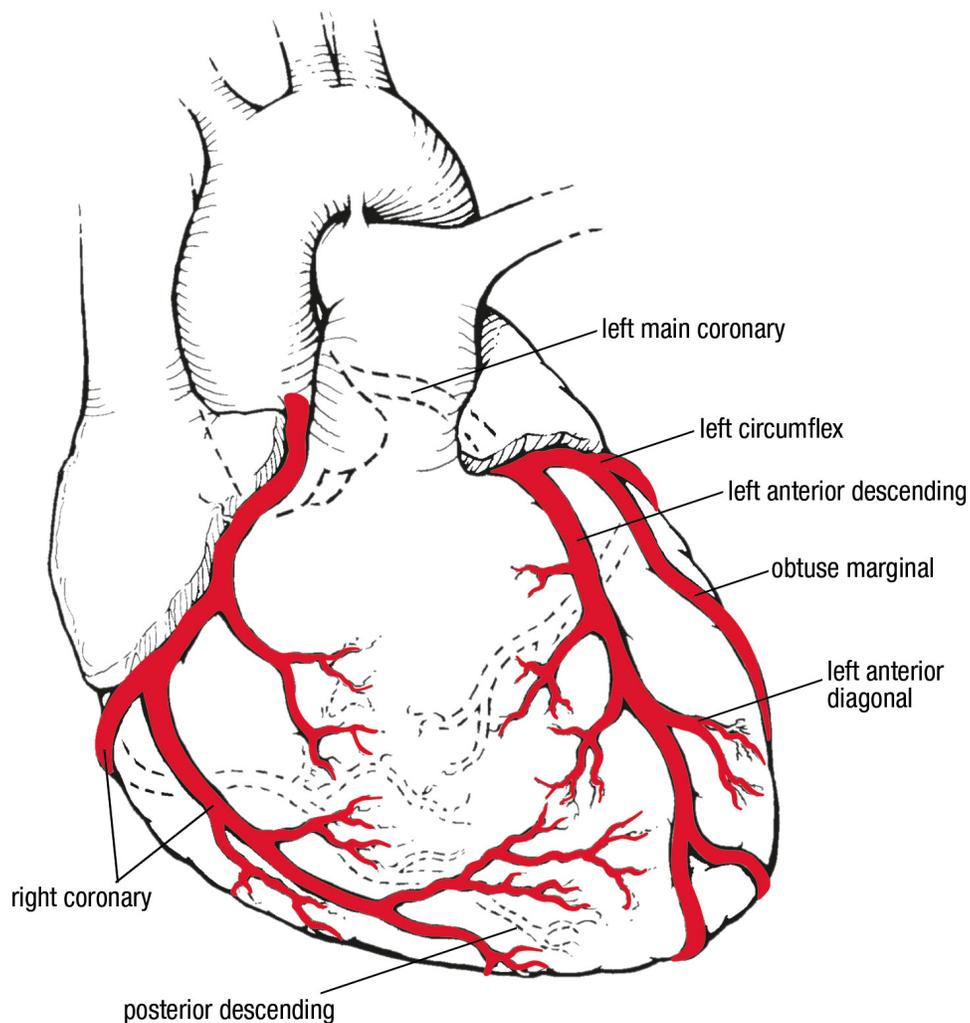


**Figure 6.** Arteries in the body. The inset shows a highly magnified illustration of capillaries where the exchange of oxygen for carbon dioxide occurs.

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## THE CORONARY ARTERIES

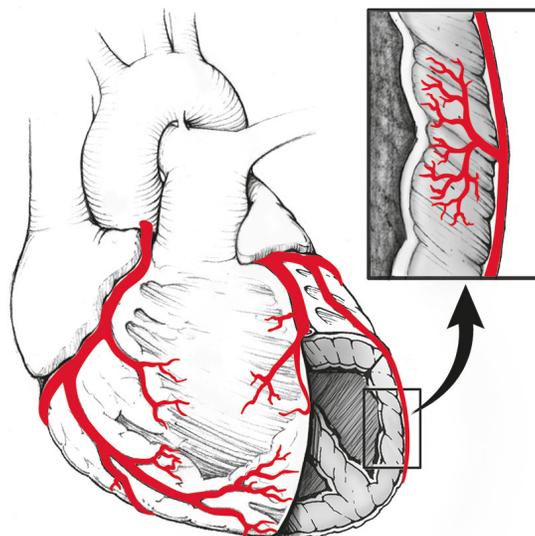
The heart, like all other muscles, needs oxygen and nutrients and has its own set of arteries that supply them. These arteries, called coronary arteries, branch off the aorta just as it leaves the heart. The right coronary **artery** supplies the bottom and back of the heart. The left coronary artery, which has two main branches (the left circumflex and the left anterior descending), supplies the top, front, and left sides, and an area of the back of the heart (figure 7).



**Figure 7.** Two coronary arteries carry blood to the heart muscle. Dotted lines show vessels on the back of the heart.

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The coronary arteries and their many small branches nourish the heart muscle, so it is important that the coronary circulation be efficient (figure 8).



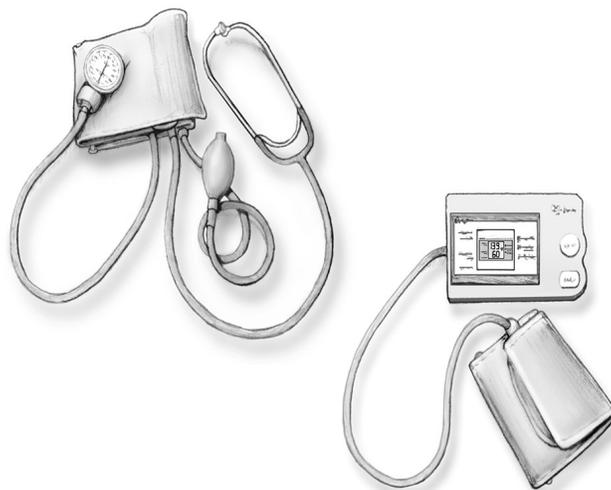
**Figure. 8** Vessels extend through the heart muscle to supply all the layers of the muscle.

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## BLOOD PRESSURE

There is always pressure in blood vessels. When the left ventricle pumps blood into the arteries, the pressure rises. Between heartbeats, while the left ventricle is refilling, the pressure falls. These two phases in the pumping cycle are used to measure blood pressure. The highest pressure occurs when the left ventricle is pumping blood into the arteries. This is called the **systolic pressure**. The lowest pressure occurs when the left ventricle is refilling. This is the **diastolic pressure**.

A **sphygmomanometer** is commonly used to take blood pressure (figure 9). Your blood pressure is written like a fraction with the systolic number on top and the diastolic number on the bottom. A blood pressure of 110/75 means the systolic pressure is 110 and the diastolic pressure is 75.



**Figure 9.** Sphygmomanometers

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## HEARTBEAT

The heart is a unique muscle in the body. Most muscles depend on a nerve connection to the spinal cord or brain to get the electrical stimulation to function. But the heart muscle is different. It has its own **pacemaker** that sends steady electrical impulses to tell the heart to beat.

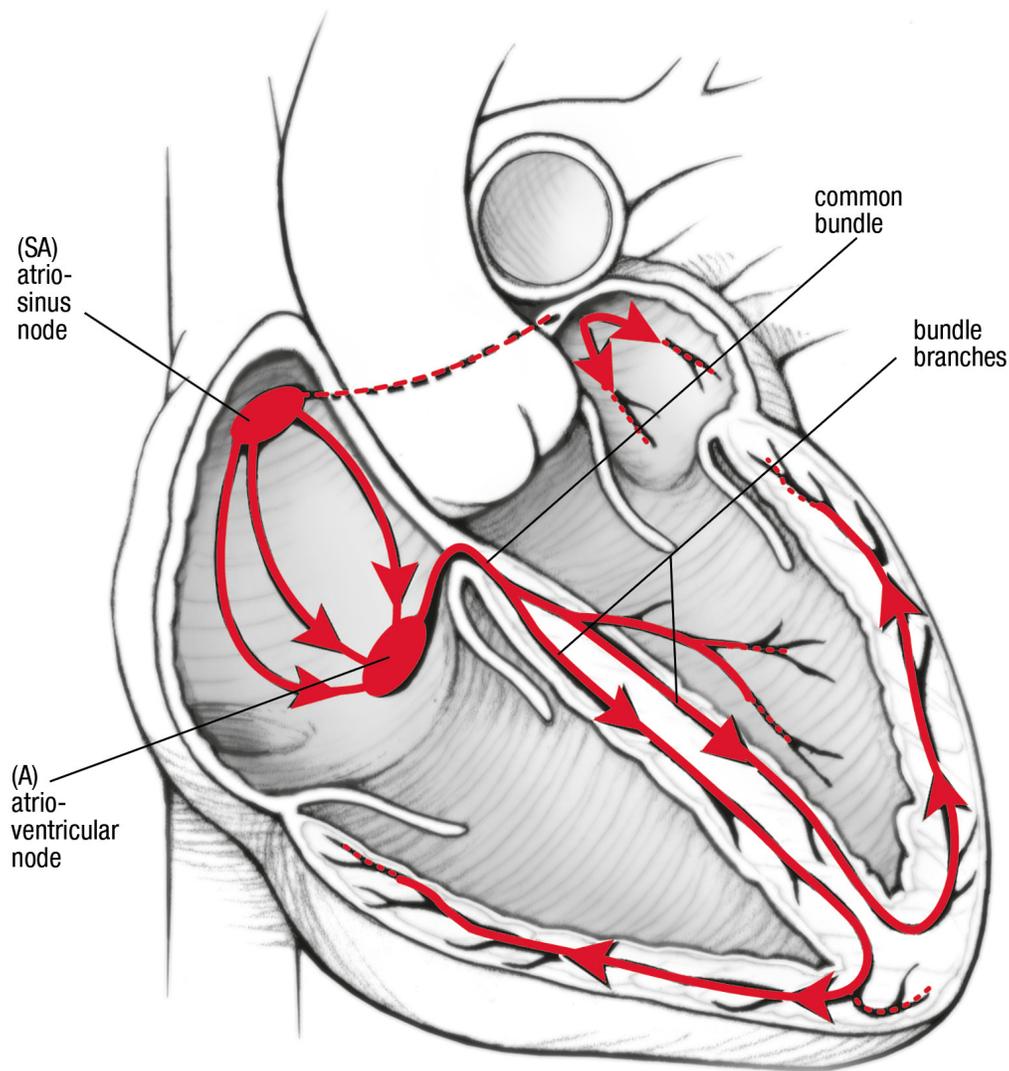
This unique pacemaker is a bundle of specialized muscle fibers called the **sinoatrial or sinus (SA) node**. It is located in the right atrium. The electrical impulse that signals each heartbeat starts here and travels through the atria, causing them to contract and to force blood into the ventricles.

The electrical signal then travels down connecting fibers to another bundle of specialized fibers called the **atrioventricular node (AV node)**. The AV node is located between the atria and ventricles.

The AV node connects to a bundle of fibers that divides into two branches running along the sides of the septum into the ventricles and then divides again into numerous branches.

This network is the heart's electrical conduction system (figure 10). The electrical impulse travels through the network and stimulates the heart to beat in a coordinated manner (in **synchrony**).

As the electrical impulse completes one cycle, traveling from the SA node to the conducting network, it causes the heart to beat. With each heartbeat, blood circulates to all parts of the body.



**Figure 10.** Conduction pathways send electrical impulses that tell the heart to beat.

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## Word List

**Aorta** — Largest artery in the body. It carries oxygen-rich blood from the heart's left ventricle to all parts of the body.

**Aortic valve** — Valve between the left ventricle and the aorta. It allows the blood to flow from the heart into the aorta and prevents backflow. A normal aortic valve has three leaflets.

**Arteriole** — Tiny artery that joins a large artery to a capillary.

**Artery Blood** — vessel that carries blood from the heart to various parts of the body. Arteries usually carry oxygenated (oxygen-rich) blood.

However, the pulmonary artery carries deoxygenated (oxygen-poor) blood from the heart to the lungs.

**Atrioventricular** — A cluster of cells between the atria and ventricles that slows the electrical current of the heart rhythm as it passes through the ventricles. Also called AV node.

**Atrium (plural - atria)** — One of the two upper chambers of the heart that receives blood from the veins and squeezes it into a ventricle.

**Blood pressure** — Measure of the force of blood flowing against the artery walls as it moves through your body.

**Capillary** — Smallest of blood vessels through which oxygen and nutrition pass to the tissues, and carbon dioxide and waste products pass from the tissues into the bloodstream.

**Chamber** — Enclosed space or cavity (for example, chambers of the heart).

**Coronary arteries** — Arteries that supply blood to the heart muscles.

**Deoxygenated** — Without oxygen. Oxygen-poor.

**Diastolic pressure** — Lowest pressure reached during the relaxation of your heart. It is recorded as the second or bottom number of your blood pressure.

**Endocardium** — Thin, inner membrane that lines the heart muscle or valves.

**Epicardium** — Thin, exterior membrane that protects the heart muscle.

**Mitral valve** — Heart valve with two triangular flaps of tissue located between the atrium and the ventricle on the left side of the heart. This valve allows oxygen-rich blood to move into the left ventricle from the left atrium and prevents the backward flow of blood.

**Myocardium** — One of the muscle layers of the heart. See also endocardium and epicardium.

**Oxygen** — Gas vital for life that is present in the air we breathe.

**Oxygenated** — Combined or supplied with oxygen.

**Pacemaker** — Small mass of specialized cells in the right atrium of the heart that initiates the electrical impulses that cause the heart to contract. An implanted pacemaker is an electrical device that can control the beating of the heart by creating one or more rhythmic electrical impulses.

**Pericardium** — Membranous sac that encloses the heart.

**Pulmonary valve** — Valve between the right ventricle and the pulmonary artery. It is formed by three flaps of tissue.

**Pulmonary vein** — Vein that returns oxygen-rich blood from the lungs to the heart.

**Septum** — Muscular wall that normally divides the right and left sides of the heart.

**Sinoatrial or sinus node** — Also called SA node. A cluster of cells in the heart's right atrium that normally initiates electrical signals that stimulate the heart to contract.

**Sphygmomanometer** — Device used to measure blood pressure.

**Synchrony** — Linkage of two events by a fixed time interval. In the heart, atrial electrical activity is followed by ventricular electrical activity, with the interval between the two being needed for the conduction from the atria to the ventricles.

**Tricuspid valve** — Heart valve between the right atrium and right ventricle. It consists of three flaps of tissue.

**Vein** — One of the blood vessels that returns blood from various parts of the body to the heart. Usually carries deoxygenated blood. However, the pulmonary vein carries oxygenated blood from the lungs to the heart.

**Vena cava** — One of the two great veins that carries deoxygenated blood from the body to the right atrium of the heart. The superior vena cava brings blood from the upper part of the body (head, neck, and chest) while the inferior vena cava brings blood from the lower part of the body

(legs and abdomen).

**Ventricle** — One of the two main pumping chambers of the heart. The left ventricle pumps blood to the body, while the right ventricle pumps blood to the lungs.

**Venule** — Small vein.

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