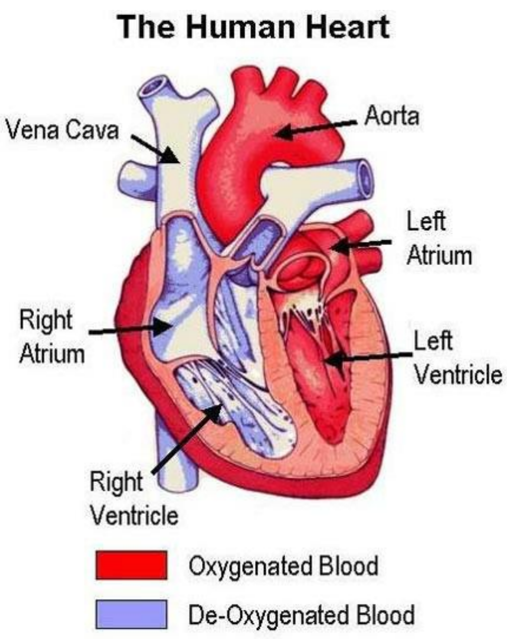
THE HEART

1. The central organ of the cardiovascular system is the heart. This is a hollow, muscular organ that contracts at regular intervals, forcing blood through the circulatory system.

2. The heart is cone-shaped, about the size of a fist, and is located in the centre of the thorax, between the lungs, directly behind the **sternum** (breastbone). The heart is tilted so that the base is tilted to the left.



3. The walls of the heart are made up of **three** layers of tissue:

a) The outer and inner layers are **epithelial tissue.**

b) The middle layer, comprising the **cardiac muscle** of the heart itself, is called the **myocardium**.

4. For obvious reasons, the cardiac muscle is not under the conscious control of the nervous system, and can generate its own electrical rhythm (**myogenic)**. For the same reasons, cardiac muscle **cannot respire anaerobically** and so the muscle **cannot get tired** (or develop cramp!)

5. Cardiac muscle has a rich supply of blood, which ensures that it gets plenty of oxygen. This is brought to the heart through the **coronary artery.** Since the heart relies on aerobic respiration to supply its energy needs, cardiac muscle cells are richly supplied with mitochondria.

6. Our hearts beat about once every second of every day of our lives, or over 2.5 million times in an average life span. The only time the heart gets a rest is between beats.

HOW THE HEART WORKS

1. The heart can be thought of as two pumps sitting side by side – **each** of which has an upper **atrium** and a lower **ventricle** – a total of 4 chambers. It functions as two pumps inside one.

2. The **right side** of the heart pumps '**deoxygenated blood**' (actually, blood low in oxygen) from the body into the lungs, where **gas exchange** takes place. In that process, carbon dioxide is lost to the air and oxygen is absorbed. This oxygen is almost all carried by the Red Blood Cells (RBC's).

3. The **left side** of the heart pumps oxygenated blood from the lungs to the rest of the body.

4. The heart is enclosed in a protective membrane-like sac called the **pericardium**, which surrounds the heart and secretes a fluid that reduces friction as the heart beats.

5. The **atria** (upper chambers) of the heart receive blood coming into the heart. Then have thin walls, so allowing them to be filled easily. They pump the blood into the **ventricles** (lower chambers), thus filling them.

6. The ventricles pump blood out of the heart and the **left ventricle has the thickest walls** of the heart because it has to do most of the work to pump blood to all parts of the body. **This is where the blood has the highest pressure**.

7. Vertically dividing the two sides of the heart is a wall, known as the **septum.** The septum prevents the mixing of oxygenated (left side) and deoxygenated (right side) blood.

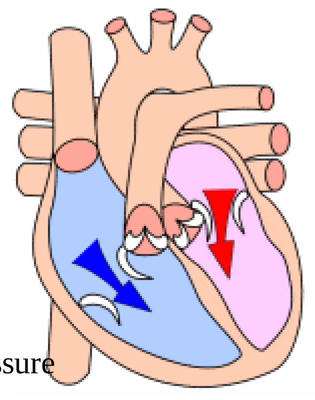
8. It also carries electrical signals instructing the ventricles when to contract. These impulses pass down specially-modified muscle cells (**Purkinje fibres**), collectively known as the **Bundle of His**.

THE RIGHT SIDE OF THE HEART

1. Deoxygenated blood from the body enters the right side of the heart through **two** large veins called the **vena cavae.** The **superior** vena cava returns blood from the head and arms; the **inferior** vena cava from the rest of the body (except, of course, the lungs!)

2. Both empty into the **right atrium**. **This is where the blood pressure is lowest** (even negative). When the heart relaxes (between beats), pressure in the circulatory system causes the right atrium to fill with blood.

3. When the atria contract, pressure inside it rises, the **right atrio-ventricular (AV) valve opens,** and blood is squeezed from the right atrium into the right ventricle. This valve is also known as the **tricuspid valve.** The closing of this valve makes a sound – 'lub'.



Atria contract

4. When the atrium is empty, the pressure inside it falls, and the pressure inside the ventricle begins to rise. This causes the atrio-ventricular valve to shut quickly, preventing the back-flow of blood.

5. The general purpose of all valves in the circulatory system is to prevent the back-flow of blood, and so ensure that blood flows in only one direction.

6. When the right ventricle contracts, blood is forced out through the **semi-lunar valve** (also known as the **pulmonary valve**), into the pulmonary arteries, where it goes to the lungs. These are the **only** arteries to carry deoxygenated blood.

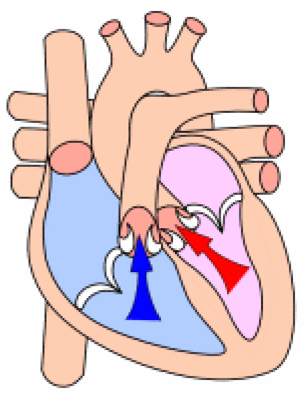
7. When the right ventricle is empty, the pressure inside falls **below** that in the pulmonary artery, and this causes the semi-lunar valve to snap shut. The closing of these valves also causes a sound – 'dup'. A normal heart-beat is thus 'lub…dup'.

THE LEFT SIDE OF THE HEART

1. Oxygenated blood leaves the lungs and returns to the heart through the **pulmonary veins.** These are the **only** veins to carry oxygenated blood.

2. This blood enters the **left atrium,** which, when full, forces blood into the left ventricle, filling it. The valve which opens is called the **left atrio-ventricular** (AV) **valve**, (or **bicuspid** or **mitral** valve). As on the right side of the heart, this valve closes when the atrium is empty and pressure begins to rise in the ventricle.

3. From the left ventricle, blood is forced at very high pressure through another **semi-lunar valve** (the **aortic valve**), into the **aorta**, which carries blood throughout the body (apart from the lungs!).



Ventricles contract

4. This surge of blood from the ventricles causes the walls of the aorta to expand and the muscles within to stretch – we can detect this as a **pulse**.

5. When the ventricle is almost empty, the pressure begins to fall below that in the aorta, and this causes the semi-lunar valve to snap shut, **as the elastic walls of the aorta recoil**, thus preventing back-flow of blood into the heart.

Cardiovascular System Summary Notes

The cardiovascular system includes:

The heart, a muscular pump

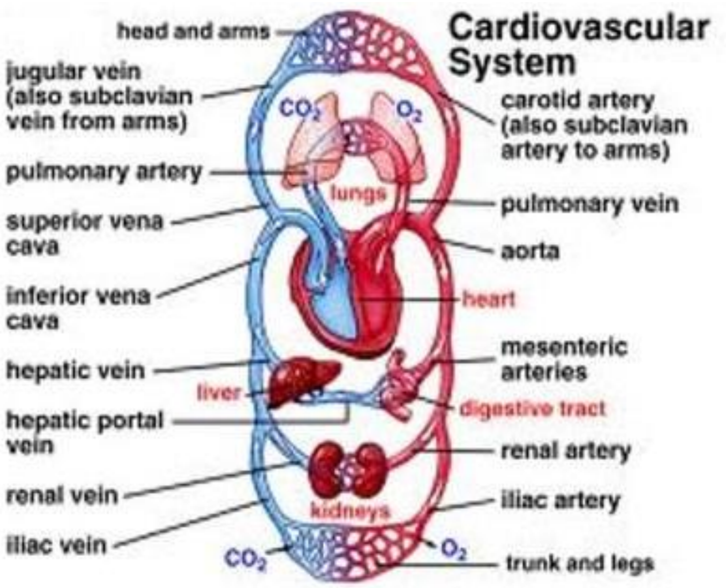
The blood, a fluid connective tissue

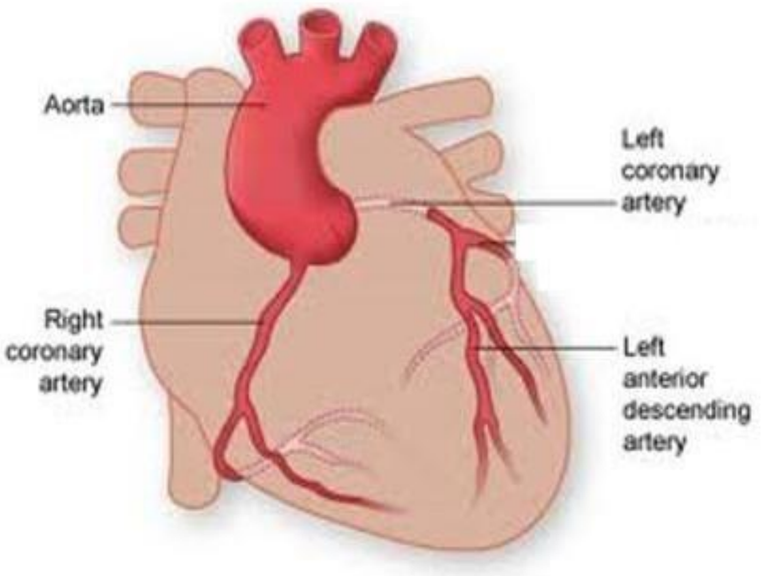
The blood vessels, arteries, veins and capillaries

Blood flows away from the heart in arteries, to the capillaries and back to the heart in the veins

There is a decrease in blood pressure as the blood travels away from the heart Arterial branches of the aorta supply oxygenated blood to all parts of the body Deoxygenated blood leaves the organs in veins

Veins unite to form the vena cava which returns the blood to the heart

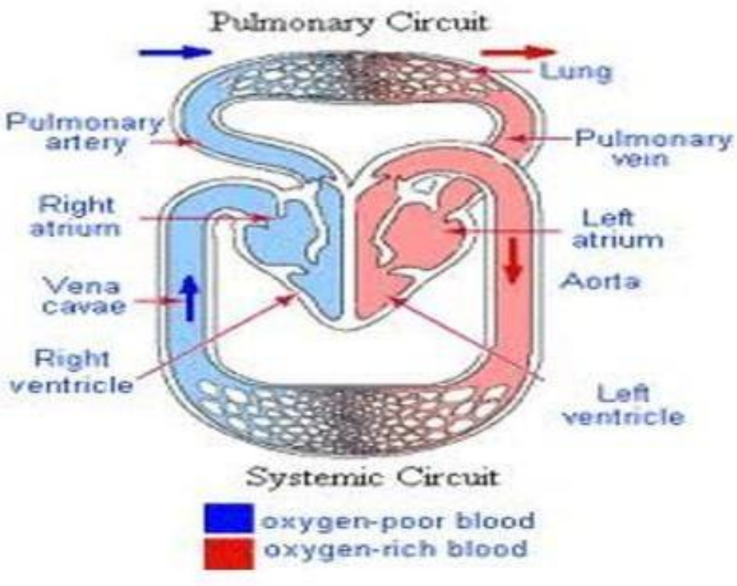




Pulmonary System

This is the route by which blood is circulated from the heart to the lungs and back to the heart again

The pulmonary system is exceptional in that the pulmonary artery carries deoxygenated blood and the pulmonary vein carries oxygenated blood



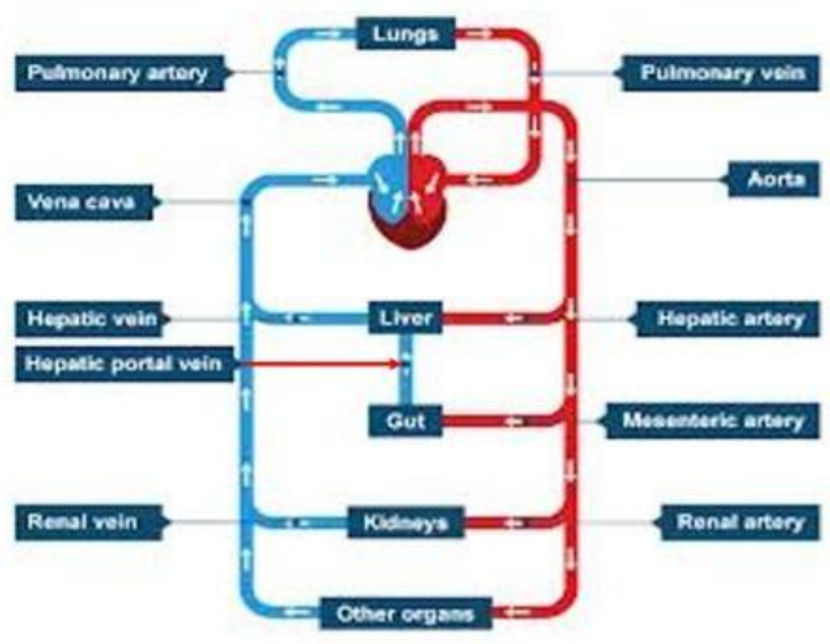
Hepatic Portal Vein

There is another exception in the circulatory system – the hepatic portal vein

Veins normally carry blood from an organ back to the heart

The hepatic portal vein carries blood from the capillary bed of the intestine to the capillary bed of the liver

As a result, the liver has three blood vessels associated with it



Arteries and Veins

The central cavity of a blood vessel is called the lumen

The lumen is lined with a thin layer of cells called the endothelium

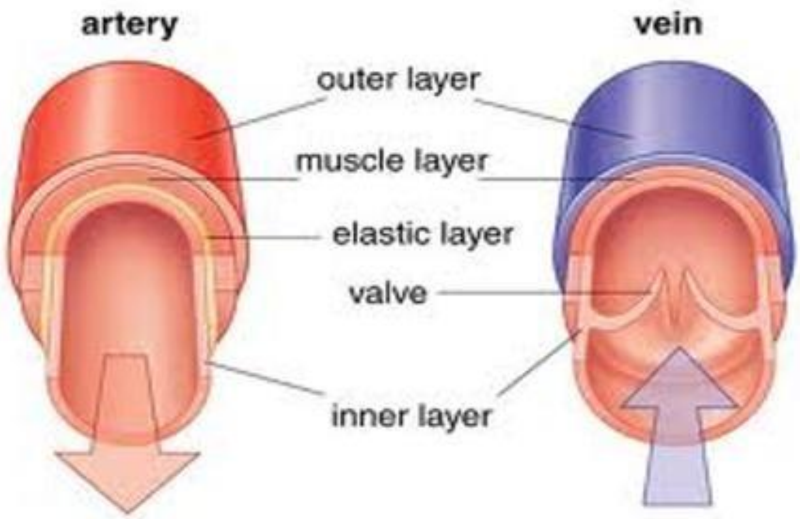
The composition of the vessel wall surrounding the endothelium is different in arteries, veins and capillaries

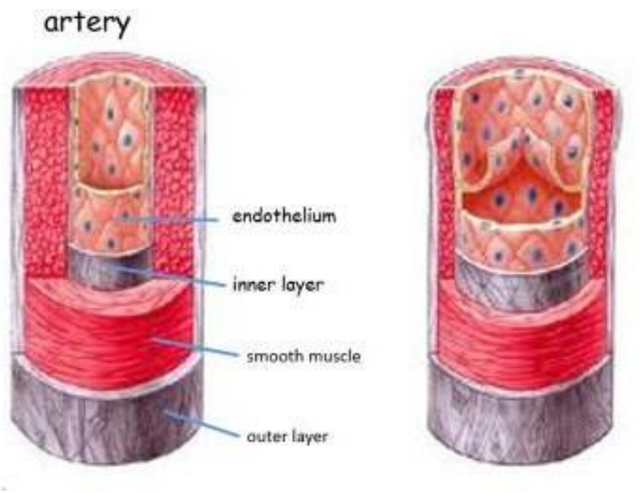
Arteries carry blood away from the heart

Arteries have a thick middle layer of smooth muscle They

have an inner and outer layer of elastic fibres

Elastic fibres enable the artery wall to pulsate, stretch and recoil, thereby accommodating the surge of blood after each contraction of the heart





Smooth muscle can contract or become relaxed

This contraction or relaxation brings about vasodilation or vasoconstriction to control blood flow

During strenuous exercise the arterioles leading to the muscles undergo vasodilation – the circular muscle in the arteriole wall is relaxed and the lumen iswide

This allows an increased blood flow to the skeletal muscles

At the same time, the arterioles leading to the small intestine undergo vasoconstriction

The circular muscles are contracted and the lumen is narrow As a

result, this reduces the blood flow to the gut

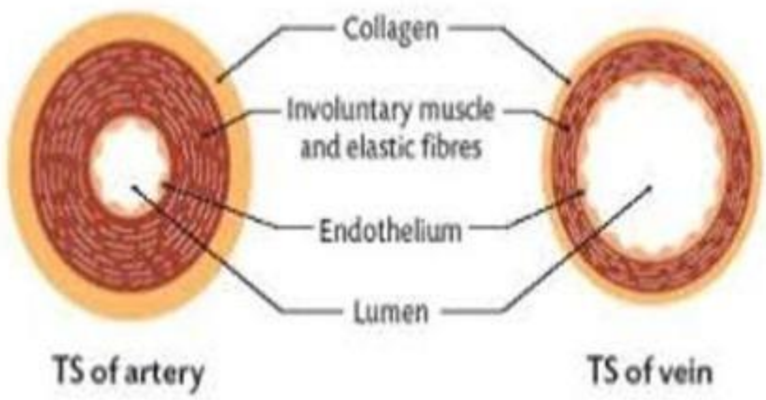
Veins carry blood back to the heart

The muscular layer and layers of elastic fibres in the vein wall are thinner than those in an artery because blood flows along a vein at low pressure

The lumen of a vein is wider than that of an artery

Valves are present in veins, to prevent the backflow of blood

Following two slides compare an artery and vein

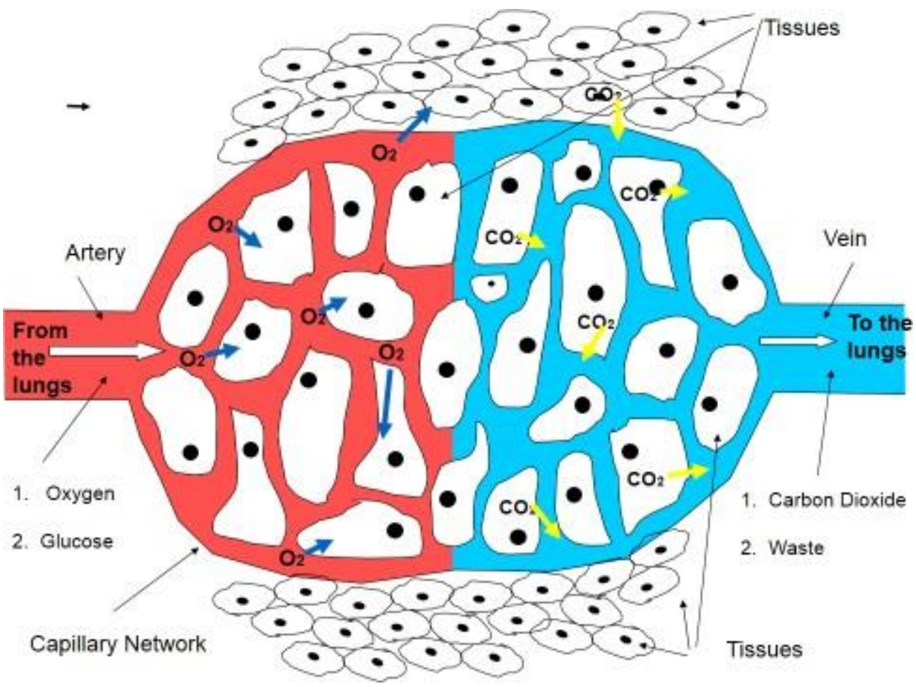


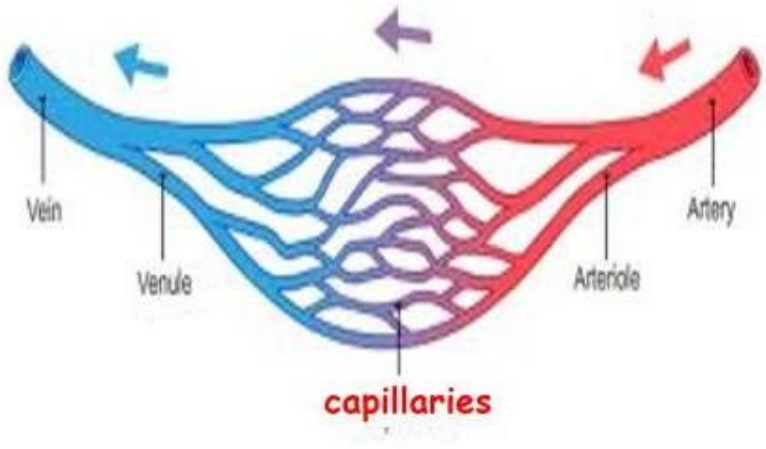
Capillaries and Exchange of Materials

Blood is transported from arterioles to venules by passing through a dense network of blood vessels called capillaries

All exchanges of substances between blood and living tissue takes place through capillary walls

Capillary walls are composed of endothelium and are only one cell thick





Plasma is a watery yellow fluid containing dissolved substances such as glucose, amino acids, blood cells, platelets and plasma proteins

Blood arriving at the arteriole end of a capillary bed is at a higher pressure thanblood in the capillaries

As blood is forced into the narrow capillaries, it undergoes pressure filtrationand much of the plasma is squeezed out through the thin walls

This liquid is called tissue fluid

The only difference between plasma and tissue fluid is that plasma has proteins

Tissue fluid contains a high concentration of dissolved food, oxygen, useful ionsetc.

These diffuse, down a concentration gradient, into the surrounding cells

Carbon dioxide and other metabolic wastes diffuse out of the cells, down a concentration gradient, into the tissue fluid to be excreted

Tissue fluid and Lymph

Much of the tissue fluid returns to the blood in the capillaries at the venule end of the capillary bed

This is brought about by osmosis

Tissue fluid lacks plasma proteins so it has a higher water concentration thanthe blood plasma

Some of the tissue fluid does not return to the blood in the capillariesThis excess

tissue fluid is absorbed by thin-walled lymphatic vessels When the tissue fluid is

in the lymphatic vessel it is called lymph

Tiny lymph vessels unite to form larger vessels

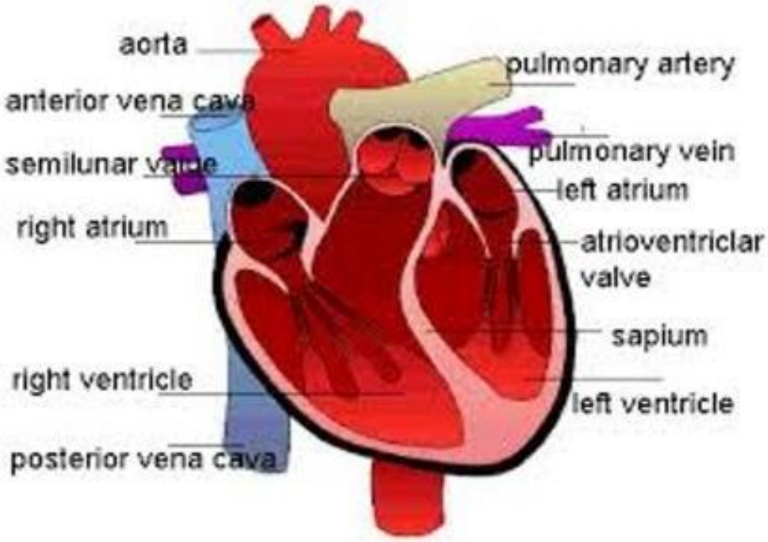
Flow of lymph is brought about by the vessels being compressed when muscles contract during breathing, movement etc.

Larger lymph vessels have valves to prevent backflow

Lymph vessels return their contents to the blood via two lymphatic ductsThese enter the

veins coming from the arms

Structure and Function of the Heart



Continuous circulation of blood is maintained by a muscular pump, the heart The heart is divided into 4 chambers, two atria and two ventricles

The right atrium receives deoxygenated blood from all parts of the body via the vena cavae

Deoxygenated blood passes into the right ventricle before leaving the heart through the pulmonary artery

The pulmonary artery divides into two branches, each leading to a lung Oxygenated blood returns to the heart by the pulmonary veins

It flows from the left atrium to the left ventricle before leaving the heart by the aorta

The wall of the left ventricle is more muscular and thicker than that of the right ventricle

The left ventricle is required to pump blood all around the body The right ventricle only pumps blood to the lungs

Valves between the atria and ventricles are the atrio-ventricular (AV) valves Valves prevent the backflow of blood

The presence of valves ensures the blood flows in one direction through the heart

Semi-lunar valves are present at the origins of the pulmonary artery and theaorta

These valves open during ventricular contraction allowing flow into the arteries When arterial pressure exceeds ventricular pressure, they close

Cardiac Function

At each contraction the right ventricle pumps the same volume of blood throughthe pulmonary artery as the left ventricle pumps through the aorta

Heart rate (pulse)

This is the number of heart beats per minute

Stroke volume

This is the volume expelled by each ventricle on contraction

Cardiac output is the volume of blood pumped out of a ventricle per minuteIt is summarised by the following equation –

CO = HR X SV

HR is heart rate, SV is stroke volume

Pulse, health indicator

If a person is fit, the quantity of cardiac muscle present in their heart wall is greater and more efficient than that of an unfit person

A very fit person tends to have a lower pulse rate than an unfit person – the fitperson's heart is larger and stronger

A fit person's stoke volume is greater

A fit person's heart does not need to contract as often to pump an equal volumeof blood round the body