5.2 THE TRANSPORT SYSTEM

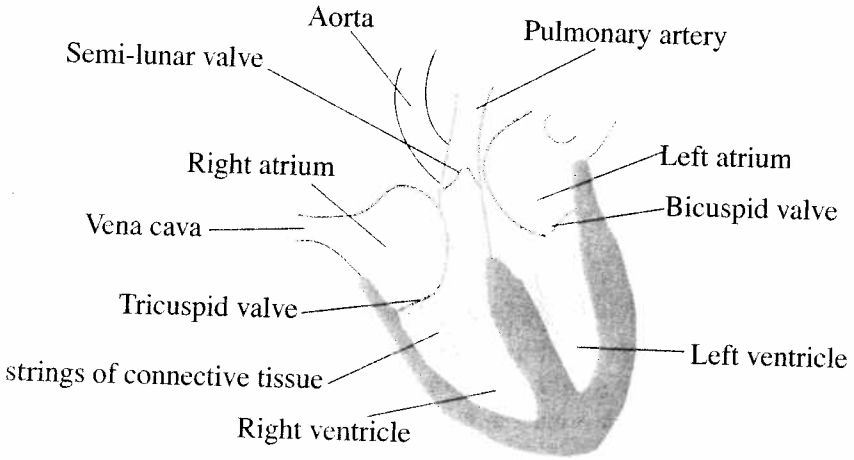
5.2.1 Draw a diagram of the heart showing all four chambers, associated blood vessels and valves.

All blood vessels connected directly to the heart, including coronary vessels, should be shown. Care should be taken to show relative wall thickness of the four chambers. The histology of the heart is not required.

5.2.2 Describe the action of the heart in terms of collecting blood, pumping blood and opening and closing valves.

A basic understanding is required, limited to the collection of blood by the atria which is then pumped out by the ventricles into the arteries. The direction of flow is controlled by atrio-ventricular and semilunar valves.

A major component of the heart is muscle tissue. The heart collects blood from the body and lungs in respectively the right and left atria. The blood is then pumped into the right and left ventricles, which are found directly below the atria. The right ventricle will pump the blood to the lungs. The wall is thicker than that of the atria but thinner than that of the left ventricle. The left ventricle pumps the blood into the aorta and from there it goes to the rest of the body. Since this is the longest way, the blood needs to be pushed out of the heart with some force. This explains why the wall of the left ventricle is the thickest wall of all the chambers of the heart.



Mammals have a double circulation, i.e. the blood coming from the body goes through the heart, to the lungs, back to the heart and then to the body. The heart is therefore divided into a right and a left side. Each side has an atrium and a ventricle. The atria collect the blood and their walls are thin; the walls of the ventricles are thick and muscular since they pump the blood into the arteries. The left ventricle has a thicker wall than the right ventricle since it has to pump the blood through the entire body.

If you look at a more detailed diagram of the heart, you will find that the vena cava really exists of two vessels: the vena cava superior, from above the heart, and the vena cava inferior, coming from below the heart. The pulmonary vein is really 4 veins, 2 from each lung.

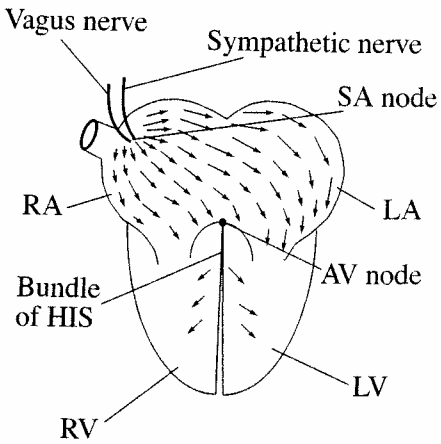
The direction of the blood flow is controlled by the valves. Valves are flaps of tissue without muscle. Valves are opened and closed by the flow of blood. As long as the blood flows in the right directions, the valves remain pushed open. As soon as the blood starts to flow in the wrong direction, they are pushed shut.

It may help to consider valves as doors. If a group of people are pushing against an outward opening door, the door will be pushed open. However, if these people suddenly turn around and try to go back, they will only push the door shut.

The atrio ventricular valve between the right atrium and the right ventricle is called the tricuspid valve; the one between the left atrium and left ventricle is called the bicuspid valve. The valves in the pulmonary artery and in the aorta are semilunar valves.The valves have some strings of connective tissue attached to them. This prevents them from opening to the wrong side.

5.2.3 Outline the control of the heartbeat in terms of the pacemaker, nerves and adrenalin.

Histology of the heart muscle, names of nerves or transmitter substances are not required. Students should understand that the heart beats 'of its own accord' (myogenic) and speeds up or slows down through involuntary control.



The contractions of the cardiac muscles are brought about by nerve impulses which originate not from the brain but from inside the heart from a specific region of the right atrium: the **Sino Atrial Node (SAN)**. The SA node is made from specialised muscle cells. The SA node releases an impulse at regular intervals which spreads across the walls of the atria, causing simultaneous contractions. The impulse cannot spread to the muscles of the ventricles except in the region of the **Atrio Ventricular Node (AVN)**. The AV node is connected to the bundle of His (specialised cardiac fibres) which branches out into the **Purkinje tissue**. From the AV node, the impulse travels through the **bundle of His** down to the apex of the heart and from there spreads up through the Purkinje tissue. This causes the ventricular contractions to start at the apex and push the blood up into the arteries.

Although the heart is largely autonomous in its contractions, the brain and some hormones can influence the frequency of the heartbeats. Impulses from a nerve from the sympathetic nervous system will increase the heart rate, messages from the vagus nerve (part of the parasympathetic system) will decrease the cardiac frequency.

Some hormones also have an effect on the heart rate: **adrenalin** (epinephrine) increases cardiac frequency.

If the SA node does not function properly, it is quite easy to implant an artificial pacemaker to carry out this function. With a well adjusted pacemaker, a person with a malfunctioning SA node can live a long and active life.

5.2.4 Explain the relationship between the structure and function of arteries, capillaries and veins.

Blood is circulated through the body by the contractions of the heart. Mammals (unlike, for example, insects) have a closed circulatory system, i.e. the blood is confined to blood vessels. There are three kinds of blood vessels:

arteries: move blood away from the heart.
have thick muscular walls but no valves.
move blood at high speed (10-40 cm/s).
contain blood at high pressure (80-120 mm Hg).

capillaries: small numerous blood vessels in tissue.
very thin walls to allow easy exchange of materials e.g. respiratory gases.
move blood at low speed (< 0.1 cm/s).
contain blood at moderate pressure (15 mm Hg).

veins: move blood towards the heart (except hepatic portal vein).
have quite thin walls and valves.
move blood at moderate speed (5-20 cm/s).
contain blood at low pressure (< 10 mm Hg).
have valves to prevent blood from flowing back.

5.2.5 State that blood is composed of plasma, erythrocytes, leucocytes (phagocytes and lymphocytes) and platelets.

By weight, about 8% of the human body is blood. It has the following composition: plasma (50 - 55%) and cells (45 - 50%).

The plasma is 90% water and dissolved in it are:

- proteins (e.g. fibrinogen, globulins, albumins).
- dissolved food.
- hormones.
- waste materials.

The cells are:

- erythrocytes (red blood cells) (90%).
- leucocytes (white blood cells).
  - phagocytes (70%): non-specific defense: phagocytosis of Antigens.
  - lymphocytes (30%): specific defense: production of Antibodies.
- thrombocytes (platelets).

5.2.6 State that the following are transported by the blood: nutrients, oxygen, carbon dioxide, hormones, antibodies and urea.

The function of the circulatory system is transport. The following are transported by the blood:

nutrients, oxygen, carbon dioxide, hormones, antibodies and waste products.

Transport of oxygen and carbon dioxide is associated with the eryothrocytes (section H.6); all the others are dissolved in the blood.