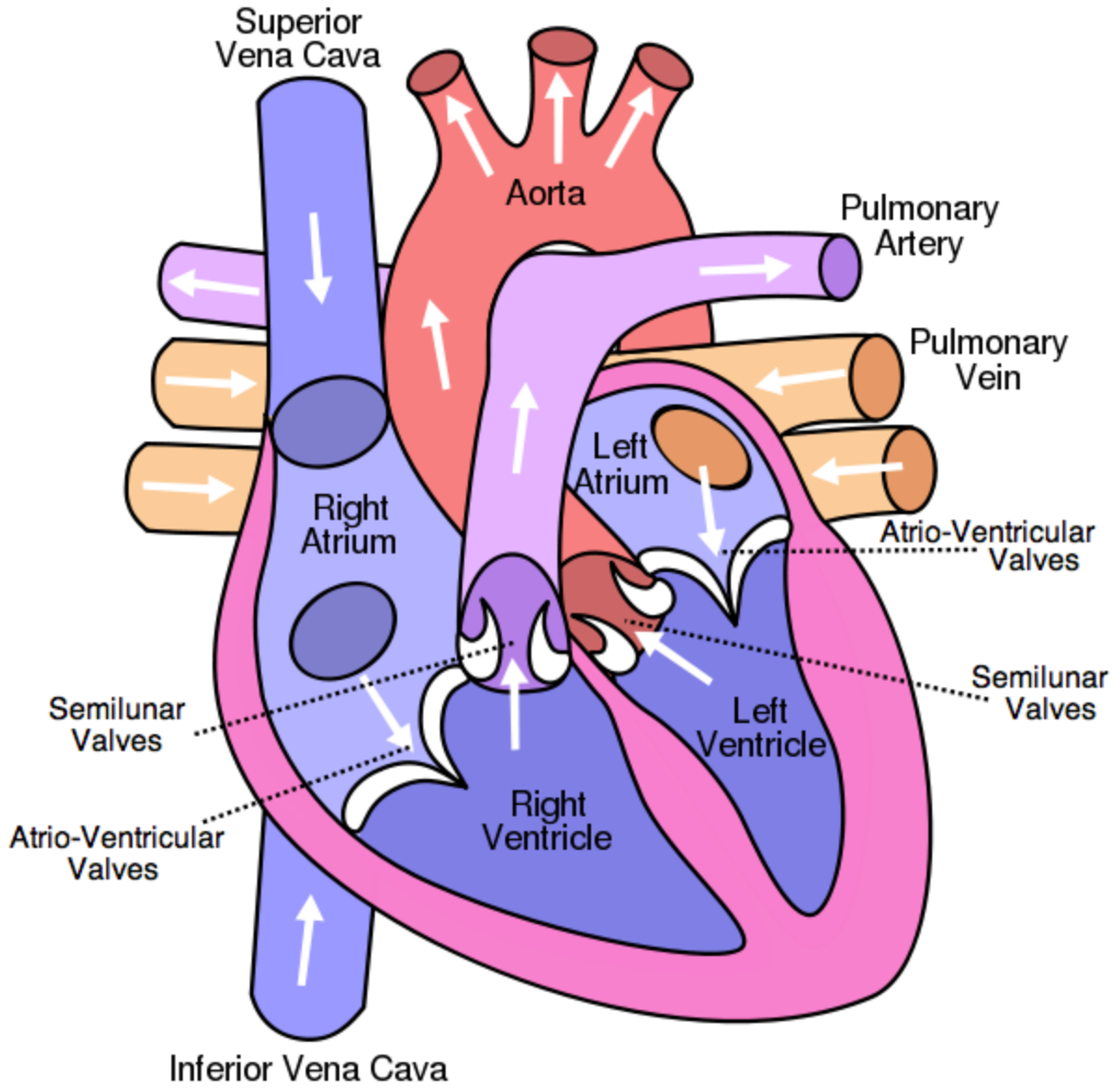
Ib biology B3.2

The transport system

Draw and label a diagram of the heart showing the four chambers, associated blood vessels, valves and the route of blood through the heart.



- The human heart

State that the coronary arteries supply heart muscle with oxygen and nutrients.

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

The right atrium collects blood from the superior and inferior vena cava and the left atrium collects blood from the pulmonary veins. This blood then flows into the right and left ventricle which pump the blood into the arteries. The direction of the blood flow is controlled by the atrioventricular valves and semilunar valves. When the atria contract the blood flows through the atrioventricular valves which are open, into the ventricle. At this stage the semilunar valves are closed so the ventricle fills with blood. The ventricles then contract which causes a rise in pressure. This rise in pressure first causes the atrioventricular valves to close preventing back flow of blood into the atria. Then the semilunar valves open allowing the expulsion of blood into the arteries. As this happens, the atria start to fill with blood again. The ventricles stop contracting leading to a fall in pressure which causes the semilunar valves to close, preventing back flow of blood from the arteries. When the ventricular pressure drops below the atrial pressure the atrioventricular valves open again and the cycle repeats.

Summary:

1. Atria collect blood from veins.
2. Atria contract, atrioventricular valves open.
3. Blood is pumped into ventricles.
4. Ventricle contracts, atrioventricular valves close and semilunar valves open.
5. Blood is pumped into arteries, semilunar valves close.
6. Cycle repeats.

Outline the control of the heartbeat in terms of myogenic muscle contraction, the role of the pacemaker, nerves, the medulla of the brain and epinephrine (adrenaline).

The heart muscle can contract by itself, without the stimulation of a nerve. This is called myogenic muscle contraction. The region that initiates each contraction is found in the wall of the right atrium and is called the pacemaker. Every time the pacemaker sends out a signal, a heartbeat results. The pacemaker is under the influence of nerves and adrenaline. One nerve carries messages from the medulla of the brain to the pacemaker and speeds up the beating of the heart. Another nerve carries messages from the medulla of the brain to the pacemaker and slows down the beating of the heart. Finally, adrenaline (epinephrine) is carried by the blood and once it reaches the pacemaker it signals it to increase the beating of the heart.

Summary:

1. Heart muscle can contract by itself (myogenic muscle contraction).
2. Pacemaker initiates contractions.

3. One nerve carries messages from the brain to the pacemaker to speed up the beating of the heart.
4. One nerve carries messages from the brain to the pacemaker to slow down the beating of the heart.
5. Adrenaline signals the pacemaker to increase the beating of the heart.

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

Arteries have a thick outer layer of longitudinal collagen and elastic fibers to avoid leaks and bulges. They have a thick wall which is essential to withstand the high pressures. They also have thick layers of circular elastic fibres and muscle fibres to help pump the blood through after each contraction of the heart. In addition the narrow lumen maintains the high pressure inside the arteries.

Veins are made up of thin layers with a few circular elastic fibres and muscle fibres. This is because blood does not flow in pulses and so the vein walls cannot help pump the blood on. Veins also have thin walls which allows the near by muscles to press against them so that they become flat. This helps the blood to be pushed forwards towards the heart. There is only a thin outer layer of longitudinal collagen and elastic fibres as there is low pressure inside the vein and so little chance of bursting. Finally, a wide lumen is needed to accommodate the slow flowing blood due to the low pressure.

Capillaries are made up of a wall that is only one cell layer thick and results in the distance for diffusion in and out of the capillary being very small so that diffusion can occur rapidly. They also contain pores within the their wall which allow some plasma to leak out and form tissue fluid. Phagocytes can also pass through these pores to help fight infections. In addition, the lumen of the capillaries is very narrow. This means that many capillaries can fit in a small space, increasing the surface area for diffusion.

Summary:

Arteries:

1. Thick outer layer of longitudinal collagen and elastic fibres prevents leaks and bulges.
2. Thick wall withstands high pressure.
3. Thick layers of circular elastic fibres and muscle fibres to pump blood.
4. Narrow lumen to maintain high pressure.

Veins:

1. Thin layer with few circular elastic fibres and muscle fibres as blood does not flow in pulses.
2. Thin walls so that nearby muscles can help push blood towards the heart.
3. Thin outer layer of longitudinal collagen and elastic fibers as pressure is low.
4. Wide lumen to accomodate the slow flowing blood.

Capillaries:

1. Wall is one cell layer thick so distance for diffusion is small.

2. Pores allow plasma to leak out and form tissue fluid. Phagocytes can also pass through pores.
3. Very narrow lumen so that many can fit in a small space.

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

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

Nutrients, oxygen, carbon dioxide, hormones, antibodies, urea and heat are all transported by the blood.

Transport in plants

Outline how the root system provides a large surface area for mineral ion and water uptake by means of branching and root hairs.

Plant roots are very important for water and mineral ion absorption as well as the anchoring of the plant into the ground. Germination causes the embryonic root to break through the seed coat and start growing down into the soil. A whole root system then develops by the branching of this embryonic root into new roots, increasing the surface area for absorption. The surface area is further increased by the branching of root hairs from these roots.9.2.2 List ways in which mineral ions in the soil move to the root.

Mineral ions in the soil move to roots via fungal hyphae (mutualism), mass flow of water in the soil carrying ions and the diffusion of mineral ions.

Explain the process of mineral ion absorption from the soil into roots by active transport.

The concentration of mineral ions inside the plant's roots is a lot higher than that found in the soil. Therefore, mineral ions have to be transported into the roots via active transport. Protein pumps exist in the plasma membranes of root cells. There are many types of these protein pumps for the absorption of many different mineral ions. Active transport requires ATP production by mitochondria (aerobic cell respiration, oxygen is needed) and therefore the root cells also contain many mitochondria. The branching of roots and the formation of root hairs increases the surface area for the absorption of mineral ions by active transport.

State that terrestrial plants support themselves by means of thickened cellulose, cell turgor and lignified xylem.

Terrestrial plants support themselves by means of thickened cellulose, cell turgor and lignified xylem.

Define transpiration.

Transpiration is the loss of water vapour from the leaves and stems of plants.

Explain how water is carried by the transpiration stream, including the structure of xylem vessels, transpiration pull, cohesion, adhesion and evaporation.

Once water has been taken up by the roots it is pulled upwards into the leaves where it then evaporates. This flow of water from the roots to the leaves is called the transpiration stream. This transpiration stream occurs in xylem vessels and the movement of water is passive. Mature xylem vessels are long dead structures made up of cells arranged from end to end. The cell walls between the adjacent xylem cells are broken down and the cytoplasmic content dies to form a continuous tube. The cells also lack a plasma membrane which allows water to enter the vessels freely. In addition, they also contain pores in the outer cell walls which allows the movement of water out of the vessels and into the surrounding cells of leaves. The outer cell walls contain thickenings which resemble spirals or rings impregnated with lignin which makes the vessels strong and able to withstand low pressures. Low pressure (suction) is created in the xylem vessels when water is pulled out of the transpiration stream via evaporation of water vapour from the spongy mesophyll cell walls in the leaves. Heat from the environment is necessary as it provides the energy required for the evaporation of water. The low pressure causes more water from the roots to be pulled upwards through the xylem tubes, this is called transpiration pull. Transpiration pull works due to the cohesion of water molecules. Hydrogen bonds form between the water molecules allowing the formation of columns of water which are not easily broken by the low pressure. In addition, adhesion also plays a role in maintaining transpiration pull. The water molecules adhere to the walls of the xylem vessels preventing the columns of water from breaking. So to conclude, the structure of xylem vessels, transpiration pull, cohesion, adhesion and evaporation are all important in the carrying of water by the transpiration stream.

State that guard cells can regulate transpiration by opening and closing stomata.

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State that the plant hormone abscisic acid causes the closing of stomata.

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Explain how the abiotic factors light, temperature, wind and humidity, affect the rate of transpiration in a typical terrestrial plant.

Four abiotic factors affect the rate of transpiration in a typical terrestrial plant:

Light - The rate of transpiration is much greater when light is available as the stomata close in the dark.

Humidity - Water diffuses out of the leaf, down its concentration gradient, from a high concentration gradient inside the leaf to a lower concentration gradient in the air. The lower concentration gradient in

the air is vital for transpiration. Humidity is the water vapour in the air, therefore a rise in humidity means a larger concentration of water vapour in the air and results in a decrease in transpiration rate.

Temperature - As temperature rises, so does the rate of transpiration. This is because heat is vital for the evaporation of water vapour from the cell walls of spongy mesophyll cells. A rise in temperature leads to an increase in the evaporation rate thereby increasing transpiration rate. Higher temperatures also increase the rate of diffusion between air spaces inside the leaf and the air outside. Finally, an increase in temperature causes a reduction in humidity in the air outside the leaf which causes an increase in concentration gradient and therefore an increase in transpiration rate.

Wind - Wind increases the transpiration rate by removing the humidity around the leaf produced by transpiration.

Outline four adaptations of xerophytes that help to reduce transpiration.

Any four of the following:

1) Reduced surface area of the plant - reduced leaves such as spines in cacti (modified leaves)

2) Thick waxy cuticle covering the epidermis

3) Reduced numbers of stomata

4) Water storage tissues in roots, leaves and stems

5) CAM physiology - Stomata open during the evening/night instead of during the day (when the temperature is at its highest) as the transpiration rate will be lower during cooler hours.

Outline the role of phloem in active translocation of sugars (sucrose) and amino acids from source (photosynthetic tissue and storage organs) to sink (fruits, seeds, roots).

Phloem tissue transports sugars and amino acids from sources which include photosynthetic tissue (leaves and stems) and storage organs, to sinks which include the fruits, seeds and roots of the plant. This transport is known as active translocation and requires energy.