Edexcel (B) Biology A-level

Topic 4 - Exchange and Transport

Definitions and Concepts

4.1 - Surface area to volume ratio

Surface area - The amount of contact an object has with its environment.

Surface area to volume ratio (SA:V) - The size of the object compared with the amount of area where it contacts its environment.

4.2 - Cell transport mechanisms

Active transport - The active movement of substances from a low concentration to a higher concentration (up their concentration gradient) with the use of energy in the form of ATP.

Adenosine triphosphate (ATP) - The energy currency of cells which is composed of a molecule of adenosine bound to three consecutive phosphate groups.

Diffusion - The passive net movement of molecules from an area of high concentration to an area of low concentration.

Endocytosis - The bulk uptake of substances into a cell by invagination of the membrane to form a vesicle trapping the substances inside the cell with the use of energy in the form of ATP.

Exocytosis - The bulk transport of substances out of a cell using a vesicle that fuses with the plasma membrane using energy in the form of ATP.

Facilitated diffusion - The net movement of substances from a high concentration to a lower concentration (down their concentration gradient) through transport proteins without the use of energy.

Fluid mosaic model - A model that describes membrane structure as a sea of mobile phospholipids studded with various proteins.

Hydrophilic - A molecule which is attracted to water.

Hydrophobic - A molecule which repels water.

Integral membrane protein - A type of protein bound to the membrane with strong interactions.

Osmosis - The diffusion of water molecules from an area of high water potential to an area of lower water potential through a partially permeable membrane.

Peripheral membrane protein - A type of protein that is weakly bound to the surface of the membrane.

Phagocytosis - The ingestion of solid material (particularly pathogens and foreign material) by phagocytic cells.

Phospholipid - A type of lipid formed by the condensation of one molecule of glycerol, two molecules of fatty acid and a phosphate group.

Turgor pressure - The force that the water within a plant cell exerts on the cell membrane which pushes it against the cell wall.

Vesicle - A small membrane bound aqueous compartments found within cells used to hold molecules for transport in or out of the cell.

Water potential - A measure of the tendency of water molecules to move from one area to another measured in kilopascals (kPa) and given the symbol Ψ which is measured using the following equation:

$$\text{Water potential} = \text{turgor pressure} + \text{osmotic potential} \quad (\Psi = P + \boldsymbol{\pi})$$

4.3 - Gas Exchange

Alveoli - Small air sacs found in the lungs at the end of bronchioles which provide a large surface area for gas exchange.

Bronchi - The two airways branching out from the trachea and leading to the smaller bronchioles.

Bronchioles - Small airways which branch out from the bronchi and end at the alveoli.

Buccal cavity - The space in the mouth of bony fish.

Countercurrent flow - An adaptation for gaseous exchange in bony fish. Blood in the gill filaments and water moving over the gills flow in opposite directions, maintaining a steep oxygen concentration gradient.

Diaphragm - A large sheet of muscle below the lungs to create pressure changes necessary for ventilation.

Expiration - During expiration (exhalation) the diaphragm relaxes and reverts to a dome. The external intercostal muscles relax, moving the ribs down and in. The volume of the thorax decreases and thoracic pressure exceeds air pressure. Air moves out of the trachea.

External intercostal muscles - A set of muscles found between the ribs on the outside that are involved in forced and quiet inhalation.

Gill filaments - Small divisions of the gills in fish that extend off the gill arch.

Gill lamellae - Small protrusions on the gill filaments designed to increase the surface area available for gas exchange.

Gill plates - Large stacks of gill filaments.

Goblet cells - Specialised cells that secrete mucus onto the trachea lining. The mucus traps harmful substances and microorganisms, preventing their entry into the lungs.

Guard cells - A type of cell usually found in pairs that is specialised to control the opening and closing of stomata.

Inspiration - During inspiration (inhalation) the diaphragm contracts and flattens and the external intercostal muscles contract, moving the ribs up and out. The volume of the thorax increases and thoracic pressure falls below air pressure. Air moves into the trachea.

Internal intercostal muscles - A set of muscles found between the ribs on the inside that are involved in forced exhalation.

Lenticels - Porous and loosely packed sections of tissue found on the surface of plants that allow for gas exchange to occur.

Opercular cavity - The space exterior to the gills which is below the buccal cavity of bony fish.

Operculum - A bony flap which covers the gills of a fish.

Sphincters - Rings of muscle which surround the openings to spiracles. They control the size of the opening to maintain a balance between gas exchange and water loss.

Spiracles - Small openings on the surface of insects that allow for the exchange of gases with their environment.

Stomata - Small openings in the leaves or stem of a plant that can be opened or closed by guard cells in response to varying conditions.

Tracheae (insects) - Tubes leading from the spiracles to the tracheoles that are part of the gaseous exchange system.

Ventilation - The process of exchanging air between the lungs and the atmosphere.

4.4 - Circulation

Aorta - The main artery that carries oxygenated blood away from the heart at high pressure.

Arteriole - A smaller type of blood vessel that connects arteries with capillaries.

Artery - A type of blood vessel that carries blood at high pressure away from the heart.

Atherosclerosis - A disease characterised by a buildup of plaque within arteries which narrows them and can lead to heart attacks and strokes.

Atrial systole - The phase in the cardiac cycle following diastole where the atria contract and force the blood into the ventricles.

Atrioventricular node (AVN) - A group of cells found in the septum of the heart which receives the electrical impulse from the SAN and passes it down the bundles of His after a short delay.

Atrium - A type of chamber in the heart which receives blood directly from a vein and passes it on to a ventricle.

Bicuspid valves - The atrioventricular valves found between the left atrium and left ventricle.

Blood - The transport medium in the mammalian circulatory system. It consists of plasma, red blood cells, white blood cells and platelets.

Bradycardia - An abnormally slow heartbeat which is often characterised by a heart rate of below 60 BPM.

Bundles of His - Bundles of specialised heart muscle cells which carry the electrical impulse from the AVN to the Purkyne fibres.

Capillary - A very small blood vessel with thin walls and a small diameter used for substance exchange in tissues.

Cardiac diastole - The phase in the cardiac cycle following ventricular systole where the atria and ventricles are both relaxed and blood flows into the atria.

Coronary artery - The main artery that supplies the heart tissue with blood.

Double circulatory system - A type of circulatory system where the blood passes through the heart twice for every circuit of the body.

Elastic fibres - Fibres of elastin that allow the alveoli to stretch as air is drawn in and recoil back to normal size, expelling air. They are also found in the trachea, bronchi and bronchioles.

Electrocardiogram (ECG) - A recording which measures the electrical activity of the heart and can be used to aid the diagnosis of heart conditions.

Erythrocytes (Red blood cells) - A type of cell found in the blood which has a biconcave shape and contains no nucleus. It is specialised to transport gases in the blood.

Fibrin - An insoluble protein formed from fibrinogen under the action of thrombin which is used to seal the wound during blood clotting.

Fibrinogen - A soluble protein which is the precursor of insoluble fibrin.

Left atrium - The chamber in the heart that receives oxygenated blood from the pulmonary vein and passes it on to the left ventricle.

Left ventricle - The chamber in the heart that receives oxygenated blood from the left atrium and pumps it out of the heart to the rest of the body.

Leukocytes (White blood cells) - Immune cells found in the blood.

Myogenic - A characteristic of cardiac muscle. It can initiate its own contractions without the need for nervous stimulation.

Platelets - Small fragments of cells which are involved in the process of blood clotting.

Prothrombin - The inactive form of thrombin.

Pulmonary artery - The main artery that carries deoxygenated blood from the heart to the lungs for reoxygenation.

Pulmonary vein - The main vein that carries oxygenated blood away from the lungs and back to the heart.

Right atrium - The chamber in the heart that receives deoxygenated blood directly from the vena cava and passes it to the right ventricle.

Right ventricle - The chamber in the heart that receives deoxygenated blood from the right atrium and pumps it out of the heart to the lungs for reoxygenation.

Single circulatory system - A type of circulatory system found in fish where the blood passes through the heart once for every circuit of the body.

Sinoatrial node (SAN) - A group of cells found in the right atrium of the heart that initiate the contraction of the cardiac muscle by regularly producing action potentials.

Tachycardia - An abnormally fast heartbeat which is often characterised by a heart rate of over 100 BPM.

Thrombin - The active form of prothrombin which converts soluble fibrinogen to insoluble fibrin during the process of blood clotting.

Thromboplastin - A clotting factor which converts prothrombin to thrombin during the blood clotting process.

Tissue fluid - Fluid filtered out from the blood that bathes tissues and provides the cells with substances nutrients and dissolved gases for exchange.

Tricuspid valves - The atrioventricular valves found between the right atrium and right ventricle.

Vein - A type of blood vessel that carries blood at lower pressure into the heart from other parts of the body.

Vena cava - The main vein that carries deoxygenated blood into the right atrium of the heart.

Ventricle - A type of chamber in the heart which receives blood from the atrium above it and pumps it out of the heart.

Ventricular systole - The phase in the cardiac cycle following atrial systole where the ventricles contract and force the blood out of the heart and around the body.

Venule - A smaller type of blood vessel that connects capillaries with veins.

4.5 - Transport of gases in the blood

Bohr effect - A decrease in the affinity of haemoglobin for oxygen in areas with a high carbon dioxide concentration.

Fetal haemoglobin - The higher affinity form of haemoglobin found in the blood of a developing fetus.

Haemoglobin - The oxygen-carrying conjugated protein found in erythrocytes which has a quaternary structure made of two alpha and two beta chains which each contain a haem prosthetic group.

Myoglobin - The oxygen-binding protein found in muscle tissue which contains only a single haem group.

Positive cooperativity - When oxygen molecules bind to haemoglobin, they cause conformational changes which increase the oxygen affinity so that further molecules bind more easily.

4.6 - Transfer of materials between the circulatory system and cells

Hydrostatic pressure - The pressure exerted by the blood on the blood vessel walls.

Lymph system - A network of vessels which return tissue fluid to the blood and provide immunological functions.

Oncotic pressure - The pressure associated with the difference in water potential of the blood due to plasma proteins and surrounding tissue fluid. The lower water potential of the blood causes water to enter the blood vessels from the tissue fluid at the venule end of a capillary bed.

4.7 - Transport in plants

Apoplast pathway - A pathway of water diffusion in the roots of plants where water diffuses through the cell walls of adjacent cells without entering the cytoplasm.

Casparian strip - A waterproof strip surrounding the endodermal cells of the root that blocks the apoplast pathway, forcing water through the symplast route.

Cohesion - A property of water molecules that creates an attraction between them which causes them to stick together due to hydrogen bonding.

Cohesion-tension model - The model that explains the movement of water from the roots to the leaves in a continuous stream. The tension created from the evaporation of water at the laves creates a negative pressure which pulls the water molecules up in one continuous stream due to the cohesion created by hydrogen bonding.

Mass-flow hypothesis - The hypothesis which outlines how assimilates are transported in the phloem of plants from source to sink. Sugars are actively transported into the phloem and water moves into the phloem down the osmotic gradient in response. This increases hydrostatic pressure which causes sugar movement through bulk flow.

Phloem - A tissue found in plants which is specialised for the transport of assimilates from their site of production to different parts of the plant where they are needed.

Plasmodesmata - Channels which connect the cytoplasms of neighbouring plant cells and allow the direct exchange of substances like water.

Symplast pathway - A pathway of water diffusion in the roots of plants in which water diffuses between the cytoplasm of adjacent cells through plasmodesmata.

Transpiration - The loss of water from the aerial parts of a plant.

Transpiration stream - The continuous flow of water from the roots to the leaves of plants.

Xylem - A tissue found in plants which is specialised for the transport of water and dissolved minerals up the plant.