

OCR (B) Biology A-level

Topic 2.2 - Transport and Gas Exchange Systems

Definitions and Concepts

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2.2.1 The heart and monitoring heart function

Aorta - The artery that takes oxygenated blood away from the heart to the body.

Arteriole - A type of blood vessel that connects the arteries and capillaries. The walls of the arterioles contain large amounts of smooth muscle, some elastic fibres and some collagen.

Artery - A type of blood vessel that carries blood away from the heart to the tissues under high pressure. The walls of the arteries contain collagen, smooth muscle and elastic fibres.

Atrial systole - The stage of the cardiac cycle in which the atria contract, pushing blood into the ventricles. The AV valves are pushed open fully and the atria are emptied of blood.

Atrioventricular node (AVN) - A group of cells located between the atria that slow down the wave of excitation and pass it between the ventricles along the bundle of His.

Atrioventricular valves (AV valves) - The valves found between the atria and ventricles. They prevent the backflow of blood from the ventricles into the atria. There are two types of atrioventricular valves: bicuspid and tricuspid.

Atrium - Chamber of the heart that receives blood from the veins.

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

Bradycardia - A slow heart rate below 60 bpm.

Bundle of His - A collection of Purkinje fibres which run from the AVN down to the apex of the ventricles.

Cardiac arrest - A sudden loss of blood flow due to an electrical problem in the heart.

Cardiac cycle - Describes the sequence of events involved in one complete contraction and relaxation of the heart. There are three stages: atrial systole, ventricular systole and diastole.

Cardiac output - The volume of blood pumped by the heart in a given time, calculated using:

$$\text{cardiac output} = \text{heart rate} \times \text{stroke volume}$$

Cardiopulmonary resuscitation (CPR) - Chest compressions and artificial ventilation to keep the brain oxygenated while the heart is not beating.

Defibrillator - Device which administers a large electric current to the heart to restore its natural rhythm.

Diastole - The stage of the cardiac cycle in which the heart muscle relaxes. The atria and ventricles fill with blood. The AV valves are open.

Electrocardiogram (ECG) - A graph showing the electrical activity in the heart during the cardiac cycle.



Fibrillation - A fast irregular heartbeat.

Heart attack - A sudden loss of blood flow due to problems with heart vessels.

Inferior vena cava (IVC) - The vein that returns deoxygenated blood to the heart from the lower body.

Mass transport system - A system designed to move large quantities of dissolved substances from one area to another.

Mitral valve (bicuspid valve) - The atrioventricular valve found between the left atrium and left ventricle.

Myogenic - Contraction initiated from within a muscle itself rather than by nerve impulses.

Pulmonary arteries - The arteries that carry deoxygenated blood away from the heart to the lungs.

Pulmonary veins - The veins that carry oxygenated blood from the lungs to the heart.

Pulse - When blood enters arteries as a result of heart contraction, a slight throb can be felt. The strongest pulses are found in the wrist (radial), neck (carotid) and elbow (brachial).

Purkyne tissue (Purkinje fibres) - Specialised cardiac muscle fibres which make up the bundle of His and conduct the wave of excitation through the septum from the AVN down to the apex of the ventricles.

Semilunar valves - A pair of valves found between the ventricles and arteries. They prevent the backflow of blood from the arteries into the ventricles.

Sino-atrial node (SAN) - A group of cells in the wall of the right atrium that generate electrical activity, causing the atria to contract. The SAN is often referred to as the heart's pacemaker.

S-T elevation - When the trace on an ECG is higher than the baseline.

Stroke volume - The volume of blood that the left ventricle pumps per contraction.

Superior vena cava (SVC) - The vein that returns deoxygenated blood to the heart from the head and upper body.

Surface area to volume ratio - Surface area divided by volume.

Tachycardia - A fast heart rate above 100 bpm.

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

Ventricle - Chamber of the heart which receives blood from the atria. Chamber of the heart which receives blood from the atria.



Ventricular systole - The stage of the cardiac cycle in which the ventricles contract, pushing blood into the arteries. The semilunar valves are pushed open fully.

2.2.2 Transport systems in mammals

Arteriole - A type of blood vessel that connects the arteries and capillaries. The walls of the arterioles contain large amounts of smooth muscle, some elastic fibres and some collagen.

Artery - A type of blood vessel that carries blood away from the heart to the tissues under high pressure. The walls of the arteries contain collagen, smooth muscle and elastic fibres.

Capillaries - Microscopic blood vessels that form a large network through the tissues of the body and connect the arterioles to the venules. They are the site of exchange of substances between the blood and the tissues.

Closed circulatory system - A circulatory system in which the blood pumped by the heart is contained within blood vessels. The blood does not come into direct contact with the cells. Closed circulatory systems are found in animals, e.g. vertebrates.

Colloidal osmotic pressure - See 'oncotic pressure'.

Diastolic blood pressure - Systemic blood pressure during diastole.

Double circulatory system - A circulatory system in which the blood flows through the heart twice in two circuits. Blood is pumped from the heart to the lungs before returning to the heart. It is then pumped around the body, after which it returns to the heart again. Double circulatory systems are found in mammals.

Hydrostatic pressure - The force which fluid molecules exert on the walls of a vessel.

Hypertension - High blood pressure, associated with stroke, chest pain and heart attack.

Hypotension - Low blood pressure, associated with fainting blurred vision and difficulty concentrating.

Korotkoff sounds - Dull tapping sounds can be heard with a stethoscope when there is a transient spurt of impeded blood through an artery which has been compressed at systolic pressure.

Oncotic pressure - Osmotic pressure exerted by plasma proteins.

Pulmonary blood pressure - Pressure exerted on the pulmonary arteries by the blood. It is usually lower than systemic blood pressure.

Sphygmomanometer - A device used to measure blood pressure. A cuff linked to a pressure-monitoring device is inflated around the brachial artery.



Systemic blood pressure - Pressure exerted on vessels in the systemic circulation by the blood.

Systolic blood pressure - Systemic blood pressure during ventricular systole.

Tissue fluid - The fluid that surrounds the cells of animals. It has the same composition as plasma but does not contain red blood cells or plasma proteins.

Vein - A type of blood vessel that carries blood towards the heart under low pressure. It has a wide lumen, a smooth inner lining and valves. The walls of the veins contain smooth muscle, large amounts of collagen and little elastic fibre.

Venule - A type of blood vessel that connects the capillaries and veins. The walls of the venules contain small amounts of collagen and smooth muscle.

2.2.3 Gas exchange in mammals and plants

Air resuscitation - Commonly known as mouth-to-mouth resuscitation. Air is blown into the lungs of patients experiencing respiratory arrest.

Alveolus (pl alveoli) - Tiny air sacs that serve as the primary gaseous exchange surface. They consist of a thin epithelial cell layer, collagen and elastic fibres.

Bronchioles - Many small divisions of the bronchi. They contain smooth muscle to restrict airflow to the lungs but do not have cartilage. They are lined with a thin layer of ciliated epithelial cells.

Bronchus (pl bronchi) - Divisions of the trachea that lead into the lungs. They are small tubes supported by incomplete rings of cartilage.

Cartilage - Strong, flexible connective tissue that supports the walls of the trachea and bronchi, preventing collapse.

Ciliated epithelial tissue - Specialised cells found lining the trachea which have tiny hair-like cilia that waft mucus up to the back of the throat, where it is swallowed.

Diaphragm - A dome-shaped sheet of muscle below the ribs and above the stomach. When it contracts, it flattens.

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

Epithelial tissue - Tissue that lines organs.

Expiration - The process of expelling air from the lungs. It is mainly a passive process facilitated by elastic recoil of the lungs but is aided by pressure changes in the thorax.

FEV₁ - Volume of air that can be exhaled during the first second of forced expiration.



Goblet cells - Specialised cells that produce mucus.

Guard cells - Pairs of cells surrounding stomata. When water moves into guard cells via osmosis, they become turgid and the stomata opens.

Histology - The use of microscopes to study ultrastructure.

Inspiration - The process of moving air into the lungs. The contraction of the external intercostal muscles and diaphragm increase the volume in the thorax, thereby decreasing the pressure. Air enters down a pressure gradient.

Intercostal muscles - Muscles between the ribs. The external intercostal muscles move the rib cage upwards and outwards during inspiration. The internal intercostal muscles move the rib cage downwards and inwards during expiration.

Lenticels - Openings in a plant stem which facilitate gas exchange.

Mammalian gas exchange system - A complex system found in mammals in which oxygen and carbon dioxide gases are exchanged.

PEFR - Maximum rate of forced exhalation.

Residual volume - The volume of air that remains in the lungs after forced maximal expiration.

Respiratory arrest - Severely restricted ability to breathe, usually in conjunction with cardiac arrest.

Smooth muscle - Involuntary muscle found in the walls of the trachea and bronchi. It constricts the lumen of the bronchi by contracting, reducing airflow to the lungs.

Squamous epithelium - A single layer of flattened epithelial cells.

Stomata - Pores on the epidermis of a leaf which facilitate gas exchange with the external environment.

Surfactant - A lipid-rich substance which coats the alveolar wall and reduces surface tension.

Terrestrial plants - Plants that live on land rather than underwater.

Tidal volume - The volume of air moved in and out of the lungs in a resting breath.

Trachea (mammals) - The main airway that acts as a passage for air to pass to and from the bronchi. It is a tube supported by incomplete rings of cartilage.

Turgor pressure - The force which pushes the cell membrane against the cell wall.

Ventilation - Air is exchanged between the lungs and the atmosphere.



Vital capacity - The greatest volume of air that can be moved into and out of the lungs in one breath.

2.2.4 Transport systems in plants

Adhesion (water movement) - The formation of hydrogen bonds between carbohydrates in the xylem vessel walls and water molecules. This contributes to the capillarity of water and transpiration pull.

Apoplastic pathway - One of two pathways by which water and minerals move across the root. Water moves through intercellular spaces between cellulose molecules in the cell wall.

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

Cohesion (water movement) - The formation of hydrogen bonds between water molecules. This contributes to the capillarity of water and transpiration pull.

Cohesion-tension theory - The model that explains the movement of water from the soil to the leaves in a continuous stream.

Companion cells - Active cells of the phloem located adjacent to the sieve tube elements which produce ATP for metabolic processes in both themselves and the sieve tube elements. They retain their nucleus and organelles.

Cotransport - A form of secondary active transport. The movement of one substance down its concentration or electrochemical gradient is coupled to the transport of another substance via transmembrane proteins.

Dicotyledonous plants - Plants that produce seeds that contain two cotyledons. They have two primary leaves.

Evaporation - A transition from the liquid state to the gaseous state which requires heat energy.

Eyepiece graticule - A scale bar inside the eyepiece of a light microscope which can be calibrated against a ruler to measure structures.

Herbaceous plants - Plants which do not have woody stems.

Hydrostatic pressure - The force which fluid molecules exert on the walls of a vessel.

Phloem - A living plant transport vessel responsible for the transfer of assimilates to all parts of the plant. The phloem consists of sieve tube elements and companion cells.

Potometer - An apparatus used to measure water uptake from a cut shoot.



Root hair cells - Specialised cells responsible for the uptake of water and minerals from the soil. They have long hair-like extensions known as root hairs, which are adapted as exchange surfaces.

Sieve plates - The perforated end walls of sieve tube elements that allow plant assimilates to flow between cells unimpeded.

Sieve tube elements - The main cells of the phloem. They are elongated cells laid end-to-end with sieve plates between. They contain few organelles.

Sinks (plants) - The regions of a plant that remove assimilates e.g. roots, meristem, fruits.

Sources (plants) - The regions of a plant that produce assimilates e.g. leaves, storage organs.

Symplastic pathway - One of two pathways by which water and minerals move across the root. Water enters the cytoplasm through the plasma membrane and moves between adjacent cells via plasmodesmata. Water diffuses down its water potential gradient by osmosis.

Translocation - The bulk movement of organic compounds in plants from sources to sinks via the phloem.

Transpiration - Water loss from plant leaves and stems via diffusion and evaporation. The rate of transpiration is affected by light, temperature, humidity, air movement and soil-water availability.

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 .

Xylem - A non-living, heavily lignified plant transport vessel responsible for the transfer of water and minerals from the roots to the shoots and leaves.

