Definitions and Concepts for OCR (A) Biology A-Level

Topic 5 - Communication, Homeostasis & Energy

Topic 5.1: Communication and homeostasis

Abscisic acid (ABA): A plant hormone that stimulates stomatal cloning, maintains seed dormancy and triggers cold protective responses.

Abscission: The shedding of leaves in plants.

Acetylcholine: A type of neurotransmitter that is used for communication between neurones.

Actin: A type of protein filament found in myofibrils. It forms thin filaments consisting of two long twisted chains.

Actin-myosin binding site: A site on actin that is normally blocked by tropomyosin. During muscle contraction, it becomes exposed, allowing a myosin head to attach.

Actin-myosin cross-bridge: The cross-bridge formed when a myosin head attaches to the myosin binding site on an actin filament.

Adenylyl cyclase: An enzyme that catalyses the conversion of ATP to cAMP.

Adrenal glands: Glands which are located on the top of the kidneys and produce adrenaline and steroid hormones.

Adrenaline: A hormone that is secreted by the adrenal glands under stressful conditions. It serves as a 'primary messenger', activating adenylyl cyclase.

Afferent arteriole: The larger diameter arteriole which carries blood to the glomerulus for ultrafiltration.

Alkaloids: A group of nitrogenous compounds found in plants. They are bitter-tasting and affect the metabolism of animals or insects that take them in.

All-or-nothing principle: The principle that describes how any generator potential which reaches or exceeds the threshold potential will produce an action potential of equal magnitude.

Alpha cells (α cells): Cells found in the pancreas which secrete glucagon into the blood to raise glucose concentration.

Anisotropic (A) bands: The darker bands in a myofibril, which consist of overlapping actin and myosin filaments.

Anabolic steroids: A class of performance enhancing drugs that are structurally similar to testosterone and used illegally by athletes to promote muscle growth.

Anterior pituitary gland: The region of the pituitary gland that produces and secretes hormones.

Antidiuretic hormone (ADH): A hormone released from the posterior pituitary gland that increases the reabsorption of water in the kidney tubules.

Aquaporin: A membrane channel used for the selective transport of water in and out of the cell.

Autonomic nervous system: A branch of the nervous system that carries nerve impulses to muscles and glands. It controls involuntary activities and has two divisions: the sympathetic nervous system and the parasympathetic nervous system.

Auxins: A class of plant hormones that control cell elongation, produce tropisms, prevent abscission, maintain apical dominance and stimulate the production of ethene.

Axon: An extension from a nerve cell that carries impulses away from the cell body.

Beta cells (β cells): Cells found in the pancreas which secrete insulin into the blood to lower glucose concentration.

Bile canaliculi: Vessels which collect the bile produced by hepatocytes.

Blinking reflex: The involuntary blinking of the eyelid when an object is held close to the eye. It is the last reflex to be lost.

Cardiac muscle: A myogenic muscle found in the walls of the heart.

Central nervous system (CNS): The brain and spinal cord.

Cerebellum: The region of the brain that controls muscle coordination and non-voluntary movement (e.g. balance, posture).

Cerebrum: The largest region of the brain, consisting of two hemispheres, that receives sensory information from receptors and sends information via the motor neurones to effectors. It is responsible for all voluntary and some involuntary responses.

Cholinergic synapse: A synapse which uses the neurotransmitter acetylcholine.

Creatine phosphate: A compound stored in muscles that serves as a phosphate reserve, enabling ATP regeneration.

Cutting: A small section of the root or stem of an adult plant.

Cyclic AMP (cAMP): A 'second messenger' involved in the action of adrenaline that activates protein kinase.

Dendron: An extension from a nerve cell that carries impulses towards the cell body.

Depolarisation: The rapid influx of sodium ions into the cell which cause it to lose its negative charge and the membrane potential to increase.

Ectotherm: A type of organism which is dependent on its environment to maintain its body temperature.

Effector: An organ, tissue, or cell that produces a response to a stimulus.

Efferent arteriole: The smaller diameter arteriole which carries the blood away from the glomerulus after ultrafiltration.

Endocrine signalling: A type of signalling that uses hormones secreted by endocrine cells into the blood which produce an effect on receptors.

Endotherm: A type of organism which can regulate its own body temperature without relying on external heat sources.

Ethene: A plant hormone that stimulates the ripening of fruit and promotes abscission in deciduous trees.

Excitatory postsynaptic potential (EPSP): An impulse which stimulates an action potential in the postsynaptic neurone.

Excretion: The process of removing metabolic waste from an organism.

Fight or flight response: The physiological reaction of the body in response to a potentially dangerous situation.

Geotropism: A plant's growth response to gravity.

Gibberellins: Plant hormones that control stem elongation, trigger the growth of the pollen tube during fertilisation and stimulate the mobilisation of food storage reserves during seed germination.

Glomerular filtration rate (GFR): A method of measuring kidney function which assesses the amount of blood plasma filtered per unit of time and produces a value which should be above 90mL/min in healthy adults.

Glomerulus: The bundle of blood vessels at the beginning of a kidney nephron where ultrafiltration takes place.

Haemodialysis: A type of dialysis used where a patient's blood is fed into a dialysis machine and passed across an artificial membrane to remove waste.

Hepatic artery: The main artery which supplies the liver tissue with oxygenated blood from the heart.

Hepatic portal vein: The main vein which carries blood rich in nutrients from the small intestine and pancreas to the liver.

Hepatic vein: The main vein which takes deoxygenated blood away from the liver back to the heart.

Homeostasis: Maintaining a constant internal environment around an optimum despite external change.

Hormonal weedkillers: Hormones such as synthetic dicot auxins that alter plant metabolism, promoting rapid growth that is unsustainable.

Hormones: Cell signalling molecules produced by endocrine glands and released into the blood. They travel to target cells and bind to specific receptors, initiating a response. The effects of hormones are usually long-lasting.

Hyperpolarisation: The drop in membrane potential below the resting potential after repolarization due to open potassium ion channels.

Hypothalamus: The region of the brain that serves as the control centre for the autonomic nervous system. It is responsible for production of hormones, the regulation of the water potential of body fluids and the control of behavioural patterns.

H-zone: The lighter region in the centre of each A band.

Inhibitory postsynaptic potential (IPSP): An impulse which inhibits the next neurone from generating an action potential.

Islet of Langerhans: Regions of the pancreas which contain α and β cells.

Isotropic (I) bands: The lighter bands in a myofibril, which consist of non-overlapping actin and myosin filaments.

Knee-jerk reflex: A type of spinal reflex commonly tested by doctors. It involves the sudden involuntary movement of the lower leg when the patella is tapped.

Kupffer cell: A specialised type of macrophage which is located within the sinusoids of the liver and removes pathogens and dead cells.

Loop of Henle: A large hairpin shaped loop found in the kidney tubule used to regulate the water and salt concentration of the blood.

Negative tropism: The growth of a plant away from a stimulus.

Neurotransmitters: Chemicals that are used for communication between neurones and their target cells. Neurotransmitters are stored in synaptic vesicles in the presynaptic neurone and released into the synaptic cleft.

Medulla oblongata: The region of the brain that regulates autonomic activities such as ventilation, heart rate and peristalsis. It is made up of regulatory centres of the autonomic nervous system.

Metabolic waste: Products produced in metabolic reactions which have no benefit to the organism.

***Mimosa pudica*:** A plant that exhibits rapid leaf-folding and collapse in response to touch. This serves as a protective mechanism against larger herbivores and small insects.

Monoclonal antibodies: Antibodies which have been produced by plasma cells that are identical clones of the same parent cell.

Motor neurone: A neurone that carries nerve impulses from the CNS to the effectors.

Myelination: The formation of a myelin sheath around nerve cells by Schwann Cells.

Myofibrils: Tiny contractile muscle fibres which group together. Numerous myofibril bundles constitute muscles. Myofibrils consist of two protein filaments: actin and myosin.

Myogenic: Describes cardiac muscle tissue that initiates its own contraction without outside stimulation from nervous impulses.

Myosin: A type of protein filament found in myofibrils. It forms thick filaments, consisting of long tails with bulbous heads, positioned to the side.

Negative feedback: The product of a process that counteracts change to maintain an equilibrium around a normal level.

Neuromuscular junction: An excitatory synapse formed between a motor neurone and a muscle fibre that uses the neurotransmitter, acetylcholine.

Nodes of Ranvier: Unmyelinated sections of nerve cells which allow for the propagation of an action potential due to their many ion channels.

Osmoreceptor: A type of receptor found in the hypothalamus which can detect the water concentration of blood plasma to maintain an appropriate water balance in the body.

Pacinian Corpuscle: A type of sensory receptor which detects changes in pressure on the skin.

Pancreas: An organ which has both exocrine and endocrine functions and is involved in both digestion and the homeostatic control of blood glucose levels.

Paracrine signalling: A type of signalling which occurs between adjacent cells.

Parasympathetic nervous system: A branch of the autonomic nervous system that is active under normal, resting conditions. It inhibits effectors, slowing down activity.

Peripheral nervous system (PNS): Pairs of nerves that originate from the CNS and carry nerve impulses into and out of the CNS. It is divided into the sensory nervous system and motor nervous system.

Peritoneal dialysis: A type of dialysis where dialysis fluid is placed inside the abdomen and waste substances are passed across the peritoneal membrane from the blood.

Pheromones: A cell-signalling molecule produced by an organism that affects the social behaviour of other members of the same species.

Photoperiodism: A plant's growth response to seasonal changes in the length of daylight.

Phototropism: A plant's growth response to light.

Pituitary gland: A small, hormone-producing gland located at the base of the brain. It is divided into two regions, the anterior pituitary and the posterior pituitary.

Positive feedback: A process which causes an increase in change away from the normal

Positive tropism: The growth of a plant towards a stimulus.

Posterior pituitary gland: The region of the pituitary gland that stores and secretes hormones produced by the hypothalamus.

Postsynaptic neurone: The neurone after the synapse which contains specific receptor proteins on its membrane, complementary to the neurotransmitter.

Presynaptic neurone: The neurone before the synapse which releases neurotransmitters from synaptic vesicles into the synaptic cleft.

Receptor: Specialised structure that detects a specific type of stimulus.

Reflex: A rapid, automatic response to a sensory stimulus by the body. It serves as a protective mechanism.

Reflex arc: The pathway of neurones involved in a reflex action:

stimulus → receptor → sensory neurone → relay neurone → motor neurone → effector → response

Relay neurone: A neurone located in the spinal cord that links the sensory neurone to the motor neurone.

Resting potential: The potential difference across the cell membrane of a neurone at rest which is typically between -60 and -70 millivolts (mV).

Rooting powder: A hormone powder applied to cuttings that increases root formation and the chance of successful propagation.

Saltatory conduction: The setting up of localised circuits between nodes of Ranvier which allows for the rapid propagation of an action potential.

Sarcomere: Each repeating unit of striations between adjacent Z-lines.

Sarcoplasm: The cytoplasm shared by muscle fibres. It consists of a high concentration of mitochondria and endoplasmic reticulum.

Schwann cells: Cells that form the myelin sheath around nerve cells in the peripheral nervous system.

Second messenger model: The mechanism by which a hormone (e.g. adrenaline or glucagon) has an effect inside a cell by triggering the production of a second messenger such as cAMP.

Selective reabsorption: The selective reuptake of useful substances along the kidney nephron using membrane transport proteins.

Sensory neurone: A neurone that carries nerve impulses from the receptors to the CNS.

Sinusoid: A type of vessel found in the liver which is formed from the convergence of the hepatic artery and the hepatic portal vein.

Skeletal muscle: A voluntary muscle responsible for movement. It makes up the majority of body muscle and is attached to the skeleton by tendons.

Sliding filament theory: The mechanism by which a muscle contracts. During contraction, myosin filaments pull actin filaments to the centre of the sarcomere. The actin filaments slide along the myosin filaments. The sarcomere is shortened and the muscle length is reduced.

Smooth muscle: An involuntary muscle under the control of the autonomic nervous system. It is found in the walls of the blood vessels, digestive tract and organs.

Somatic nervous system: A branch of the nervous system that carries impulses to the skeletal muscles. It controls voluntary activities.

Summation: The combination of many impulses that can cumulatively stimulate the generation of an action potential in a postsynaptic neurone.

Sympathetic nervous system: A branch of the autonomic nervous system that is active under stressful conditions. It stimulates effectors, speeding up activity.

Synapse: The junction between two nerve cells or a nerve cell and an effector.

Synaptic vesicles: Secretory vesicles located in the presynaptic neurone that store neurotransmitters. Upon fusion with the presynaptic membrane, their contents are released into the synaptic cleft.

Tannins: Phenols produced by many plants. They serve as a chemical defence against herbivory; their bitter taste deters animals from eating them and they are toxic to insects.

The Ornithine Cycle: The cycle of reactions responsible for producing urea from ammonia for detoxification and excretion.

Tropism: The growth response of a plant to a directional stimulus.

Type 1 diabetes: An autoimmune disorder in which the beta cells are destroyed and the pancreas fails to produce sufficient insulin which is characterised by uncontrolled high blood glucose levels.

Type 2 diabetes: A type of diabetes where the body fails to produce enough insulin or when the pancreas no longer reacts to insulin which can be caused by a poor diet and a lack of exercise.

Ultrafiltration: The removal of small substances from the blood through the pressure created by the structure of the kidney nephron.

Z-line: The line in the centre of each I band.

Topic 5.2: Energy for biological processes

Acetyl coenzyme A: A two-carbon molecule formed in oxidative decarboxylation when an acetyl group is bound by coenzyme A. It is oxidised in the Krebs cycle.

Adenosine triphosphate (ATP): The universal energy carrier found in all living cells.

Aerobic respiration: A form of cellular respiration that takes place in the presence of oxygen and produces carbon dioxide, water and ATP. Overall:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

Alcoholic fermentation: A type of fermentation that takes place in plant root cells and yeast cells, and produces ethanol and carbon dioxide.

Anaerobic respiration: A form of cellular respiration that takes place in the absence of oxygen. It produces less ATP than in aerobic respiration.

ATP synthase: An enzyme found embedded in cellular membranes that phosphorylates ADP to form ATP as protons flow through it.

Calvin cycle: See 'Light-independent reaction'.

Chemiosmotic theory: The synthesis of ATP through the movement of protons down their concentration gradient across a semipermeable membrane, catalysed by ATP synthase.

Chlorophyll: A photosynthetic pigment located in the thylakoids of chloroplasts that absorbs light energy. There are two main types, chlorophyll a and chlorophyll b.

Chloroplast: An organelle found in plants and algae that is the site of photosynthesis.

Citrate: A six-carbon molecule formed in the first stage of the Krebs cycle from the reaction of acetyl coenzyme A and oxaloacetate.

Coenzyme A: A coenzyme that binds an acetyl group to form acetyl coenzyme A during oxidative decarboxylation of aerobic respiration.

Coenzymes: Molecules that help enzymes carry out their function e.g. NAD, FAD, coenzyme A and NADP.

Cristae: Folds of the inner mitochondrial membrane that provide a large surface area for oxidative phosphorylation.

Cyclic photophosphorylation: The formation of ATP involving photosystem I only.

Decarboxylation: The removal of a carbon dioxide molecule.

Dehydrogenation: The removal of a hydrogen atom.

Electron acceptor: Oxygen acts as the final electron acceptor in the electron transfer chain:

$$\tfrac{1}{2}O_2 + 2e^- + 2H^+ \longrightarrow H_2O$$

Electron carriers: Protein molecules that accept and release electrons e.g. NAD, NADP.

Electron transport chain: A series of electron carrier proteins that transfer electrons in a chain of oxidation-reduction reactions.

FAD: A coenzyme that becomes reduced when it takes up hydrogen atoms during the Krebs cycle, forming reduced FAD.

Fermentation: A type of anaerobic respiration that does not involve an electron transport chain.

Glycerate 3-phosphate (GP): A three-carbon molecule that is reduced by reduced NADP in the light-independent stage of photosynthesis to form two molecules of TP. This requires ATP.

Glycolysis: An anaerobic process that takes place in the cytosol of the cell and breaks down glucose into two molecules of pyruvate. Two molecules of ATP and two molecules of reduced NAD are also formed.

Grana: Stacks of thylakoids connected by intergranal lamellae.

Hexose bisphosphate: The compound formed from the phosphorylation of glucose in glycolysis. It splits into two molecules of triose phosphate.

Inner mitochondrial membrane: The mitochondrial membrane that segregates the matrix from the intermembrane space. It is the site of the electron transport chain.

Intermembrane space: The small space between the inner and outer mitochondrial membranes. The electron transport chain results in a high proton concentration here.

Krebs cycle: A series of oxidation-reduction reactions in the matrix of the mitochondria in which acetyl coenzyme A is oxidised, generating reduced NAD, reduced FAD, ATP and carbon dioxide.

Lactate dehydrogenase: An enzyme that catalyses the conversion of pyruvate to lactate.

Lactate fermentation: A type of fermentation that takes place in animal cells and produces lactate.

Lamellae: Membranous channels that connect adjacent grana in a chloroplast.

Light-dependent reaction: The first stage of photosynthesis that uses light energy to produce ATP, reduced NADP and oxygen. It takes place in the thylakoids of the chloroplast.

Light-harvesting system: A collection of protein and chlorophyll molecules found in the thylakoid membranes of chloroplasts that absorbs light energy of varying wavelengths and transfers it to the reaction centre. It is also known as an antennae complex.

Light-independent reaction: The second stage of photosynthesis, also known as the Calvin cycle, in which the products of the light-dependent stage and carbon dioxide are used to build organic molecules. It does not require light energy and takes place in the stroma.

Limiting factor: A variable that limits the rate of a particular reaction.

Link reaction: See 'oxidative decarboxylation'.

Matrix: The fluid-filled space within the inner membrane of the mitochondria which contains mitochondrial DNA and enzymes required for aerobic respiration.

Mitochondrion: An organelle found in eukaryotic cells that is the site of aerobic respiration.

NAD: A coenzyme that becomes reduced when it takes up hydrogen atoms during aerobic respiration, forming reduced NAD.

NADP: A coenzyme that becomes reduced when it takes up hydrogen atoms during the light-dependent stage of photosynthesis, forming reduced NADP.

Non-cyclic photophosphorylation: The formation of ATP and reduced NADP involving both photosystems I and II.

Outer mitochondrial membrane: The membrane segregating the contents of the mitochondrion from the rest of the cell. It creates optimal conditions for aerobic respiration.

Oxaloacetate: A four-carbon molecule that combines with acetyl coenzyme A to produce six-carbon citrate in the first stage of the Krebs cycle. It is eventually regenerated, allowing the cycle to continue.

Oxidative decarboxylation: The first stage of aerobic respiration (also known as the 'link reaction') that takes place in the mitochondrial matrix and converts pyruvate into acetyl coenzyme A and carbon dioxide. Reduced NAD is also formed. Overall:

$$\text{Pyruvate} + \text{NAD} + \text{CoA} \longrightarrow \text{acetyl CoA} + \text{reduced NAD} + CO_2$$

Oxidative phosphorylation: The synthesis of ATP from reduced coenzymes and oxygen in the electron transport chain of aerobic respiration.

Photolysis: The splitting of a molecule of water in the presence of light that occurs during the light-dependent stage of photosynthesis. This produces protons, electrons and oxygen:

$$H_2O \longrightarrow 2H^+ + 2e^- + \tfrac{1}{2}O_2$$

Photophosphorylation: The harnessing of light energy in photosynthesis to phosphorylate ADP, forming ATP.

Photosynthesis: A complex metabolic pathway that synthesises organic molecules in the presence of light. It consists of three main stages: capturing of light energy, light-dependent reaction, light-independent reaction. Overall:

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

Photosynthetic pigments: Molecules present in chloroplasts that absorb certain wavelengths of light e.g. chlorophyll a, chlorophyll b, xanthophylls and carotenoids.

Photosystem: A protein complex consisting of a light-harvesting system and reaction centre, that is involved in the absorption of light and transfer of electrons in photosynthesis.

Pyruvate: A three-carbon molecule produced in glycolysis. In the link reaction of aerobic respiration, it is oxidised to acetate. During fermentation, it is converted to lactate (animals) or ethanol and carbon dioxide (plants and microorganisms).

Reaction centre: The region of a photosystem where energy is funneled and photosynthetic reactions take place. It contains two chlorophyll a molecules.

Respiration: A set of metabolic reactions that take place in organisms and break down respiratory substances, such as glucose, into smaller inorganic molecules, like water and carbon dioxide. This is linked to the synthesis of ATP.

Respiratory quotient (RQ): The ratio of carbon dioxide produced to oxygen consumed during respiration. Calculated using:

$$RQ = \frac{CO_2 \text{ produced}}{O_2 \text{ consumed}}$$

Respiratory substrate: An organic molecule that can be broken down via the respiratory pathways to produce ATP.

Respirometer: A device used to determine respiration rate in living organisms by measuring the change in volume of oxygen or carbon dioxide.

Retention value (R_f): Calculated using the equation:

$$R_f = \frac{\text{Distance travelled by component}}{\text{Distance travelled by solvent}}$$

Ribulose bisphosphate (RuBP): A five-carbon compound that reacts with carbon dioxide in the light-independent stage of photosynthesis, forming two molecules of GP.

Ribulose bisphosphate carboxylase (RuBisCO): An enzyme that catalyses the reaction of RuBP and carbon dioxide in the light-independent stage of photosynthesis.

Stroma: The fluid interior of chloroplasts that contains the enzymes required for the light-independent reaction.

Substrate-level phosphorylation: The synthesis of ATP by the transfer of a phosphate group from a phosphorylated intermediate to ADP.

Thin-layer chromatography (TLC): A technique used to separate photosynthetic pigments by their rate of movement when carried by a solvent, across an inert surface. Differences in rate arise due to varying solubilities in the mobile phase and interactions with the stationary phase.

Thylakoids: A series of flattened membrane-bound compartments in chloroplasts. They are stacked to form grana and contain the chlorophyll and other molecules needed for the light-dependent reaction.

Triose phosphate (TP): A three-carbon compound formed in glycolysis and the light-independent stage of photosynthesis. It may serve as a starting material for the formation of organic molecules or be used to regenerate RuBP.