

Edexcel (B) Biology A-level

Topic 9 - Control Systems

Definitions and Concepts

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9.1 - Homeostasis

Homeostasis - The process of maintaining internal body conditions in a state of dynamic equilibrium despite fluctuations in external conditions.

Negative feedback - A process which detects and counteracts change to maintain an equilibrium around a normal level.

pH - A measure of the acidity or alkalinity of a solution based (inversely) on the concentration of hydrogen ions.

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

Thermoregulation - The homeostatic process of maintaining a constant body temperature.

9.2 - Chemical control in mammals

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

Adrenaline - A hormone that is secreted by the adrenal glands under stressful conditions. It serves as a 'primary messenger' and activates adenylyl cyclase.

Endocrine gland - A type of gland which secretes hormones directly into the bloodstream.

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

Hormone - A chemical messenger which is carried in an organism's transport systems and binds to a specific receptor.

Oestrogen - A steroid hormone which is the main female sex hormone and brings about its effects through binding to intracellular estrogen receptors (ER) which bind to DNA and act as transcription factors.

Receptor - A structure that detects a specific type of stimulus and triggers a response.

Secondary messenger - A chemical released inside a cell after the activation of a receptor by an extracellular signal.

Target cells - Cells containing a specific type of receptor which a certain hormone can bind to.

Transcription factors - Proteins which bind to regulatory regions of DNA and control DNA transcription.



9.3 - Chemical control in plants

Antagonistic hormones - Hormones which have effects that directly oppose each other.

Apical dominance - A state of growth which leads to vertical growth of the plant. The growth of lateral buds is inhibited while the main 'apical' shoot is allowed to grow.

Auxins - A class of plant hormones synthesised at the growing shoots that control cell elongation and inhibit the growth of lateral buds.

Cytokinins - A class of plant growth hormones produced in the root tips that promote cell division in the growing parts of plants.

Gibberellins - A class of plant growth hormones which promote seed germination and stem elongation.

Photomorphogenesis - The regulation of developmental processes based on light levels and wavelength.

Phytochrome - A light sensing molecule (photoreceptor) used to regulate light-dependent processes in plants.

9.4 - Structure and function of the mammalian nervous system

Autonomic nervous system - The parts of the nervous system which control involuntary processes without conscious thought.

Central nervous system (CNS) - The part of the nervous system which involves the brain and the spinal cord only.

Cerebellum - A region of the brain that coordinates voluntary movement and controls balance.

Cerebrum - A region of the brain split into a left and right hemisphere which controls sensory perception, thoughts and the initiation of voluntary movement.

Hypothalamus - The region of the brain located near the pituitary gland that is involved in homeostatic control including thermoregulation.

Medulla oblongata - A region of the brainstem which controls involuntary actions such as heart rate and breathing.

Parasympathetic nervous system - The parts of the autonomic nervous system which are associated with 'rest and digest' processes such as decreasing heart rate and increasing digestion.

Peripheral nervous system (PNS) - All parts of the nervous system which do not involve the brain and spinal cord.



Somatic nervous system - The parts of the nervous system which control voluntary processes usually associated with skeletal muscles.

Spinal cord - A long column made of nervous tissue containing a central grey matter portion surrounded by white matter which transmits impulses between the brain and the PNS and interfaces reflex arcs.

Sympathetic nervous system - The parts of the autonomic nervous system which are associated with 'fight or flight' reflexes such as increasing heart rate and breathing rate.

9.5 - Nervous transmission

Acetylcholine - A neurotransmitter used in the parasympathetic nervous system.

Action potential - The temporary change in electrical potential across the membrane of an axon in response to the transmission of a nerve impulse.

All-or-nothing principle - Any generator potential which reaches or exceeds the threshold potential will produce an action potential of equal magnitude.

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

Cholinergic synapse - A synapse which uses the neurotransmitter acetylcholine.

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

Excitatory postsynaptic potential (EPSP) - An impulse which stimulates an action potential in the postsynaptic neuron.

Hyperpolarisation - The membrane potential drops below the resting potential after repolarization due to open potassium ion channels.

Inhibitory postsynaptic potential (IPSP) - An impulse which stimulates hyperpolarisation in the postsynaptic neuron which prevents the generation of an action potential.

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

Neurotransmitter - A chemical which diffuses across the synaptic gap to stimulate other neurons or effector cells.

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

Noradrenaline - A neurotransmitter which is used in the sympathetic nervous system.

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



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

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

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

Threshold potential - The minimum potential which must be reached to initiate an action potential.

9.6 - Effects of drugs on the nervous system

Cobra venom - A neurotoxin which blocks acetylcholine receptors by competitive inhibition and can cause paralysis.

Lidocaine - A local anaesthetic which works by blocking Na^+ ion channels to prevent the sending of nervous impulses to the brain.

Nicotine - A chemical found in tobacco which mimics the neurotransmitter acetylcholine in the brain and triggers dopamine release.

9.7 - Detection of light by mammals

Cones - A type of photoreceptor that transduces light energy into a generator potential. Cone cells are concentrated in the fovea, detect light of high intensity, and lead to colour images. One cone cell forms a synapse with a single bipolar cell, giving high visual acuity.

Iris - The pigmented muscular ring that surrounds the pupil and controls its diameter.

Opsin - A GPCR that forms part of rhodopsin along with retinal and is involved in converting detected photons into electrochemical signals.

Pupil - The hole in the centre of the iris which can contract and dilate using the iris to alter the amount of light which contacts the retina.

Retina - The structure at the back of the eye which is composed of photoreceptors and is specialised to detect light.

Retinal - A protein that makes up rhodopsin along with opsin and forms the light sensitive part of the complex.

Rhodopsin - A protein found in rod cells that converts dim light into an electrochemical impulse.

Rod cells - A type of photoreceptor that transduces light energy into a generator potential. They are located at the periphery of the retina, detect light of low intensity and lead to black



and white images. Many rod cells form a synapse with a single bipolar cell, giving low visual acuity.

9.8 - Control of heart rate in mammals

Accelerans nerve - A sympathetic nerve which connects the medulla oblongata with the sinoatrial nerve and causes an increase in heart rate using the neurotransmitter noradrenaline.

Baroreceptor - A type of pressure receptor located in major arteries which can send impulses to the medulla oblongata to control blood pressure.

Cardiac centre - The region of the medulla oblongata which controls the heart rate and blood pressure through hormones and nerve impulses.

Chemoreceptor - A type of pH receptor located in major arteries like the aortic arch which sends impulses to the medulla oblongata so that a constant blood pH can be maintained.

Vagus nerve - A parasympathetic nerve which connects the medulla oblongata with the sinoatrial nerve and causes a decrease in heart rate using the neurotransmitter acetylcholine.

9.9 - Osmoregulation and temperature regulation

Countercurrent multiplication - The process in the Loop of Henle where solutes are actively transported out of the ascending limb to create a large concentration gradient for the reabsorption of water.

Dipodomys sp. (Kangaroo rats) - Small rats which are adapted to living in very dry conditions by producing a small amount of very concentrated urine. This is achieved by having a much longer Loop of Henle than other rats which allows for more reabsorption of water.

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

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

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

Kidneys - Two bean-shaped organs located towards the back of the abdomen underneath the rib-cage which are involved in osmoregulation and the removal of waste and toxins from the blood.



Loop of Henle - A large hairpin shaped loop found in the kidney tubule used to regulate the water and salt concentration of the blood by acting as a countercurrent multiplier system.

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

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

Osmoregulation - The process of controlling the water and dissolved mineral balance in the body.

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

Thermoreceptors - A type of temperature receptor found in many places around the body of endotherms such as in the skin which detect temperature changes and send impulses to the hypothalamus which returns the body temperature back to the homeostatic norm.

Urea - A waste molecule produced in the liver as a product of amino acid breakdown which is excreted in urine.

