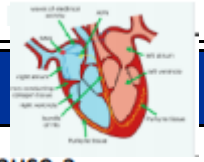
Biology: Organisms Response to Changes in their Internal and External Environment

Simple Responses

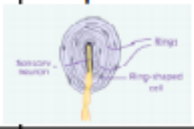
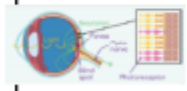
Taxis	A simple response whose direction is determined by the direction of the stimulus
Kinesis	A non-directional response to a stimulus which brings about increased random movements
Tropism	A growth movement of a part of a plant in response to a directional stimulus - Indoleacetic acid (IAA) causes elongation of shoot cells, while it also inhibits root cell elongation in order to cause positive geotropism (to gravity) & phototropism (to light)
Reflexes	Rapid responses that don't require conscious thought. Reflexes can quickly protect the body from harm, as it does not involve many synapses, they use simple mechanisms and are localized to the part of the body where they occur.

Simple Responses

Heart is myogenic	Contraction is initiated from within the muscle itself (not from nervous system).
SAN → AVN → Bundle of His	The sinoatrial node sends out waves of electrical activity to the left & right atrial wall causing contraction. waves are then passed onto the atrioventricular node, then to the bundle of His, with a slight delay. The bundle of His splits into the Purkynge tissue, causing contraction of the left & right ventricles from the bottom up.
Medulla oblongata	Found in the autonomic nervous system – controls impulses to SAN.
Receptors – in aorta or carotid arteries	Baroreceptors detect changes in blood pressure, chemoreceptors detect pH changes (e.g due to high CO_2)



Receptors

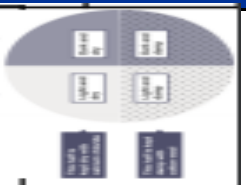
Pacinian corpuscle 	Detect changes in pressure in the skin. Increases in pressure cause a deformation of the concentric rings of the Pacinian corpuscle, opening stretch-mediated sodium channels in the membrane. Sodium ions enter the sensory neuron, causing a generator potential which can trigger an action potential.
The retina	Contain photoreceptors known as rod cells and cone cells.
Rod cells 	Detect light in the middle of the visible spectrum. High visual sensitivity. Use the pigment rhodopsin. More abundant than cone cells. Located on the edge of the retina (not in fovea). Show retinal convergence. Provide poor visual acuity.
Cone cells	Three different types (detect red, blue and green light) to give colour vision. Use the pigment iodopsin. Found at the fovea. Only one cone to each bipolar cell. Have good visual acuity.

Key Vocabulary

Stimulus	A detectable change in the internal or external environment of an organism
Response	The result of a stimulus on an organism
Receptor	A cell or organ which detects a stimulus
Effector	A cell, tissue, organ or system which responds to a stimulus
Coordinator	The link between a sensory neurone and motor neurone in the spinal cord
Autonomic	A division of the motor nervous system which carries nerve impulses to glands, smooth and cardiac muscle and is not under voluntary control (subconscious)
Sympathetic	An autonomic pathway which stimulates effectors and so speeds up an activity (e.g. heart rate) using noradrenaline
Parasympathetic	An autonomic pathway which inhibits effectors and so slows down an activity using acetylcholine
Retinal convergence	Many rods connected to one bipolar cell
Visual acuity	Ability to resolve fine detail
Visual sensitivity	Ability to detect low light intensity
Fovea	The point receives the highest intensity of light because light focuses on it by the lens.
Blind spot	The point of entry of the optic nerve on the retina which is insensitive to light.

Required Practical 10

Investigation into the effect of an environmental variable e.g. light on the movement of an animal using either a choice chamber or a maze.



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Key Vocabulary

Resting potential	A potential difference of -65mV found inside a resting neurone relative to its outside, which results in the axon being polarised.
Generator potential	A nervous impulse produced by a sensory receptor following transduction (or conversion) of one form of energy into electrical energy
Threshold value	The minimum level of stimulus needed to trigger an action potential
Polarised	Condition used to describe the axon when the inside of an axon is negatively charged relative to the outside (at the resting potential usually around -65mV).
Voltage gated channels	Channels in the axon membrane which change shape, and hence open or close, depending on the voltage across the membrane.
Depolarised	Condition used to describe when the inside of the membrane has a positive charge of around +40mV (when an action potential is happening).
Hyperpolarisation	When the inside of the axon is more negative (relative to the outside) than the usual.
Repolarisation	When the resting potential of -65mV is re-established the axon is described as this.

Motor Neurones and Myelination

1	Structure	Cell body – contains nucleus, cytoplasm and the cell membrane forms dendrites which connect to other neurones Axon – long extension of neurone Schwann cells – surround the axon to form the myelin sheath. Nodes of ranvier – gaps in myelin sheath Axon terminals – connect neurones
2	Importance of myelination	Increases conduction speed, as well as wider axons or warmer temperatures.
3	Saltatory conduction	Action potentials only occur at Nodes so faster transmission.

Motor Neurones and Myelination

1	Cholinergic synapse	Uses acetylcholine as its neurotransmitter.
2	Transmission across a synapse	An action potential arrives at the pre-synaptic knob, depolarising the membrane and causes voltage-gated calcium ion channels to open. The influx of Ca2+ ions causes the synaptic vesicles to fuse with the membrane, releasing the neurotransmitter into the synaptic cleft. The neurotransmitter diffuses and binds receptors on the post synaptic membrane, causing an action potential.
3	Acetylcholinesterase	Breaks down acetylcholine in the cleft. This allows it to be recycled and reused.
4	Excitatory or inhibitory synapses	If the neurotransmitter opens Na+ channels (excitatory) or if it opens chloride or potassium channels causing hyperpolarization (inhibitory)

Action Potentials

Definition	A temporary reversal of the charges across the axon membrane which increase from -65mV to +40mV, depolarising the membrane
Process	When the neurone receives an impulse from receptors, sodium channels on the dendrites open, leading to the movement of Na+ ions into the cell causing depolarisation. If this depolarisation reaches the threshold potential it activates voltage-gated sodium channels causing an action potential. After voltage-gated sodium ion channels close, and voltage-gated potassium channels open, repolarization occurs as K+ ions leave the cell. Outward diffusion of K+ ions causes hyperpolarisation and the voltage-gated potassium channels close. Finally, the Sodium-potassium pump returns the cell to the resting membrane potential.
Refractory period	Time period after an action potential when it is impossible for a further action potential to be generated because inward movement of sodium ions is prevented because the sodium voltage-gated channels are closed.
All-or-nothing principle	An action potential is exactly the same size, regardless of the size of the stimulus, providing it reaches the threshold value.

Types of Skeletal Muscle

Slow twitch	• Used for endurance • Contract slowly and for longer • Fatigue slowly • Carry out aerobic respiration • Have lots of mitochondria • Lots of myoglobin • Small glycogen/phosphocreatine stores • Dark colour
Fast twitch	• Used for short bursts of activity. • Light colour • In all other aspects they are exactly the opposite to slow twitch

Key Vocabulary Muscles

Myofibrils (muscle fibres)	A microscopic muscle fibre containing sarcoplasm and showing striped isotropic and anisotropic bands of actin and myosin.
A Band	Ansiotropic bands (dark) where thick and thin filaments overlap.
I Band	Isotropic bands (light) where thick and thin filaments do not overlap.
H zone	The centre of each A-band where there is a lighter-coloured region
Z line	The centre of each I-band.
Myoglobin	a red protein containing haem, which carries and stores oxygen in muscle cells. It is structurally similar to a subunit of haemoglobin.

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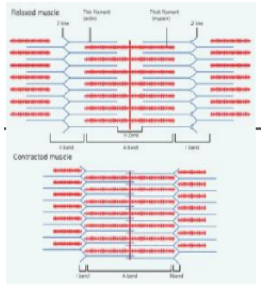
Sliding Filament Theory



How is it initiated?
An action potential travels into the muscle fibre via T tubules, causing release of calcium ions from the sarcoplasmic reticulum. The calcium ions bind to troponin on tropomyosin molecules and cause them to move, exposing the myosin binding site on the actin filament. Myosin attaches to actin forming a actin-myosin cross-bridge.

Why do muscles shorten during contraction?
ATP hydrolyses to detach the myosin head, allowing reattachment at a further site. This cycle continues, causing sarcomeres to shorten.
What happens when nervous stimulation stops?
Ca^{2+} ions are actively transported back into the sarcoplasmic reticulum. This allows tropomyosin to block the myosin binding site and muscle contraction stops. ATP can be generated via aerobic or anaerobic respiration. Phosphocreatine generates ATP quickly by adding phosphate to ADP released by the contracting muscle

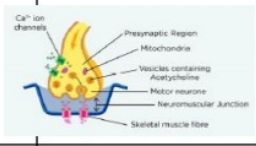
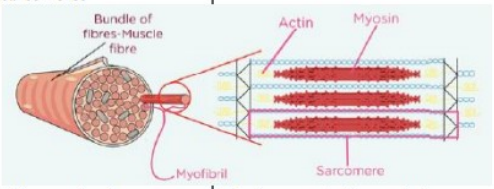
Homeostasis

Definition	Maintenance of a constant internal environment despite internal/external changes.
pH and temperature	Important to regulate to allow optimum enzyme activity and rate of metabolic reactions.
Water potential	Important to regulate to prevent cells bursting or shrinking by osmosis.
Two types of feedback from change	Positive and negative (see key vocabulary). Predominantly homeostasis is maintained by negative feedback.

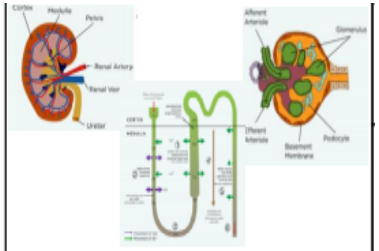
Key Vocabulary

Gluconeogenesis	Happens in the liver - conversion of non-carbohydrates (e.g. glycerol and amino acids) into glucose; literally 'glucose-new-manufacture'. Happens when glycogen supply is exhausted.
Glycogenolysis	Happens in the liver - breakdown of glycogen to glucose – 'breaking down glycogen'. Happens when blood glucose level is lower than normal.
Glycogenesis	Happens in the liver - conversion of glucose into glycogen – 'making glycogen'. Happens when blood glucose level is higher than normal.

Neuromuscular junction

1	Synapse vs neuromuscular junction 	- NJ can only be excitatory - NJ link a neurone to a muscle rather than to another neurone - Action potential ends at NJ - Only motor neurones used - NJ always use acetylcholine
2	Sarcolemma	This is the name of the membrane on the neuromuscular junction with the receptors for the acetylcholine.
3	Sarcomeres 	
	What are they?	Muscles contain fibres called myofibrils. Each myofibril is made of lots of smaller contracting units called sarcomeres.
4	The protein filaments in the sarcomere	Actin – thin filaments which "pull" along myosin filaments in contraction Myosin – has "heads" which attach to actin during contraction. Troponin/tropomysin – wrapped around actin and move when bound Ca^{2+} ions to allow myosin to bind.

Osmoregulation

Kidney structure – gross (overall) and fine (functional sections called nephrons)	
Nephrons and the formation of glomerular filtrate	Filtering out various substances in glomerulas due to the smaller diameter of afferent than efferent arteriole. Creates hydrostatic pressure.
Reabsorption	The filtrate passes into the Bowman's capsule and where certain ions (in PCT) and water (in DCT) are reabsorbed into the blood whilst the remaining filtrate is excreted as urine.
Maintaining conc. gradient	Na^{2+} is actively transported out of the PCT into blood to allow glucose & amino acids to co-transport out as Na^{2+} diffuses into the epithelial cells.

Glucose Regulation

Important to maintain because…	It allows cells to have access to the substrate for respiration, whilst preventing cell damage by dehydration caused by high concentrations.
High blood glucose	Insulin is released from β-cells in the pancreas in order to lower the concentration back to its optimum via negative feedback.
What is the process it uses?	Insulin binds to an insulin receptor, vesicles of glucose transporters fuse with the plasma membrane to allow more glucose to enter the cell. The cell also uses more glucose in respiration and activated enzymes carry out glycogenesis.
Low blood glucose	Glucagon is released from α-cells in the pancreas in order to increase the concentration back to its optimum.
What is the process it uses?	Activating enzymes which carry out (glycogenesis) as well as producing glucose from other molecules. Also by Activating enzymes that carry out gluconeogenesis (see key vocabulary).
Diabetes	Type 1 (insulin not released) and treatment is insulin injection. Type 2 (receptors unresponsive to insulin) and treatment is specialised diet and lifestyle.
Adrenaline	Released by the adrenal glands in times of stress and increases blood glucose in anticipation of increased activity. Adrenaline binds to receptors which activates adenyl cyclase. This converts ATP into cAMP, which acts as a second messenger to activate protein kinase for glycogenolysis.