Edexcel IAL Biology A-level

8.1-8.10 - Structure and Function of Nerve Tissue and Responses to Stimuli

Flashcards

State the three types of functional neurones

State the three types of functional neurones

- Sensory neurone
- Relay neurone
- Motor neurone

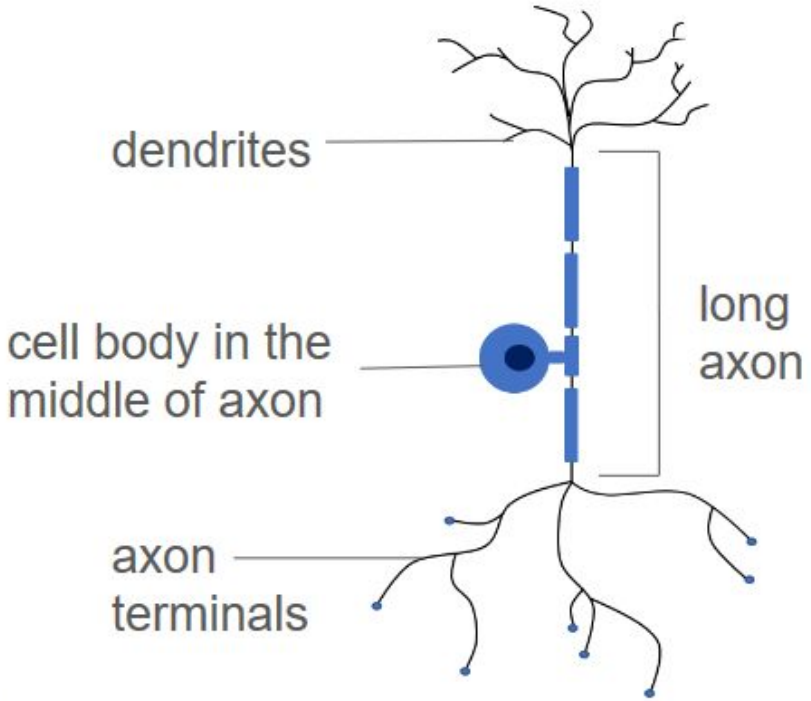
Describe the structure of a sensory neurone

Describe the structure of a sensory neurone

Usually unipolar

Transmits impulses from receptors to CNS

Cell body in the **centre** of the axon



State the function of a sensory neurone

State the function of a sensory neurone

Carries nerve impulses from the receptors to the CNS via the dorsal root

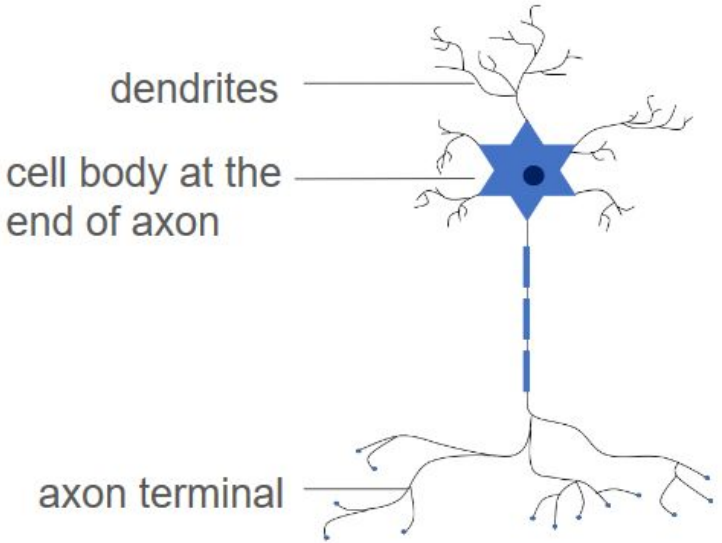
Describe the structure of a motor neurone

Describe the structure of a motor neurone

Short dendrites carry impulses from CNS to cell body

Cell body found at **one end** of neurone

Long axon carries impulses from cell body to effectors



State the function of a motor neurone

State the function of a motor neurone

Carries nerve impulses from the CNS to the effectors via the ventral root

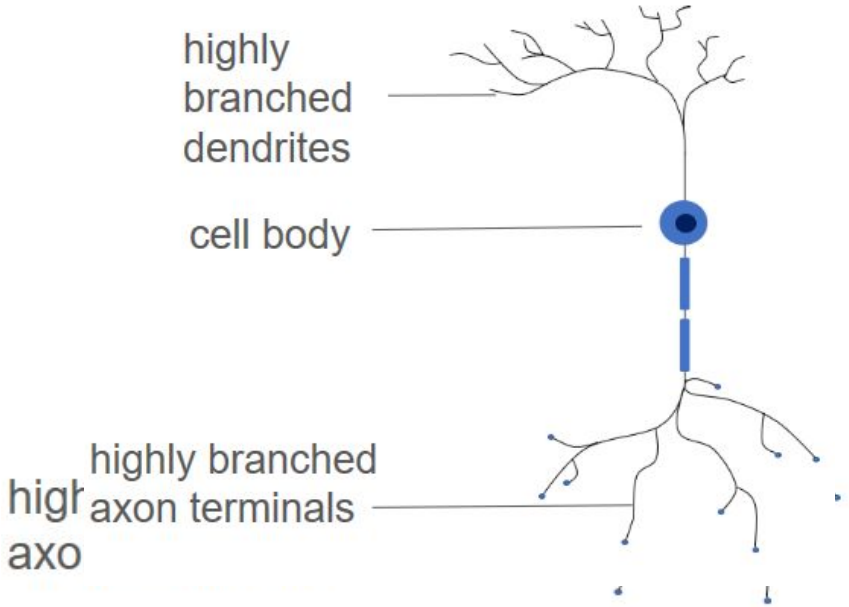
Describe the structure of a relay neuron

Describe the structure of a relay neuron

Usually bipolar

Transmits impulses between neurons

They are found in the CNS



State the function of a relay neurone

State the function of a relay neurone

Located in the spinal cord

Links the sensory neurone to the motor neurone

What are Schwann cells?

What are Schwann cells?

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

Explain why myelinated axons conduct impulses faster than unmyelinated axons

Explain why myelinated axons conduct impulses faster than unmyelinated axons

Saltatory propagation: Impulse 'jumps' from one node of Ranvier to another (depolarisation cannot occur where myelin sheath acts as electrical insulator). Therefore, impulse does not travel along whole axon length

Why are neurones not myelinated along their entire length (why do they need Nodes of Ranvier)?

Why are neurones not myelinated along their entire length (why do they need Nodes of Ranvier)?

The Na^+ ions would diffuse and dissipate and the concentration wouldn't be high enough to allow for the action potential to propagate along the entire length of the neurone. Instead, the Nodes of Ranvier provide gaps where there are ion channels which boost the action potential

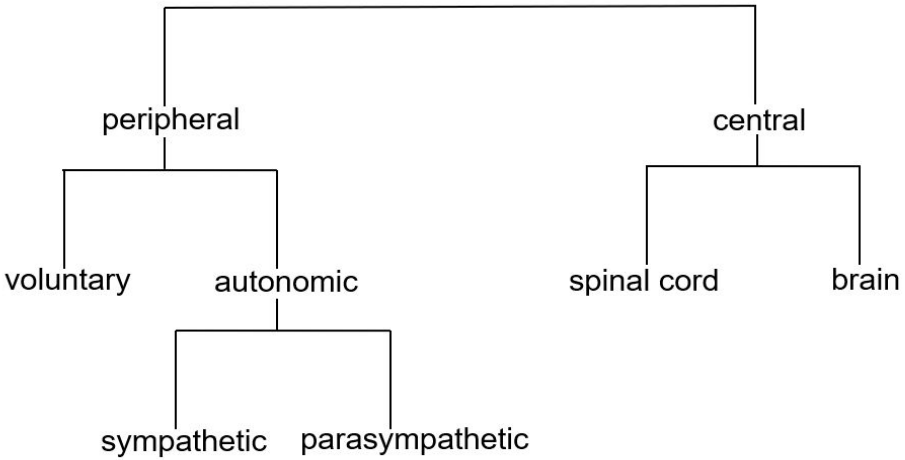
Name the two main divisions of the nervous system

Name the two main divisions of the nervous system

- Central nervous system (CNS)
- Peripheral nervous system (PNS)

Outline the gross structure of the mammalian nervous system

Outline the gross structure of the mammalian nervous system



What is the central nervous system (CNS)?

What is the central nervous system (CNS)?

Brain and spinal cord

What is the peripheral nervous system (PNS)?

What is the peripheral nervous system (PNS)?

Pairs of nerves that originate from the CNS and carry nerve impulses into and out of the CNS

What is an effector?

What is an effector?

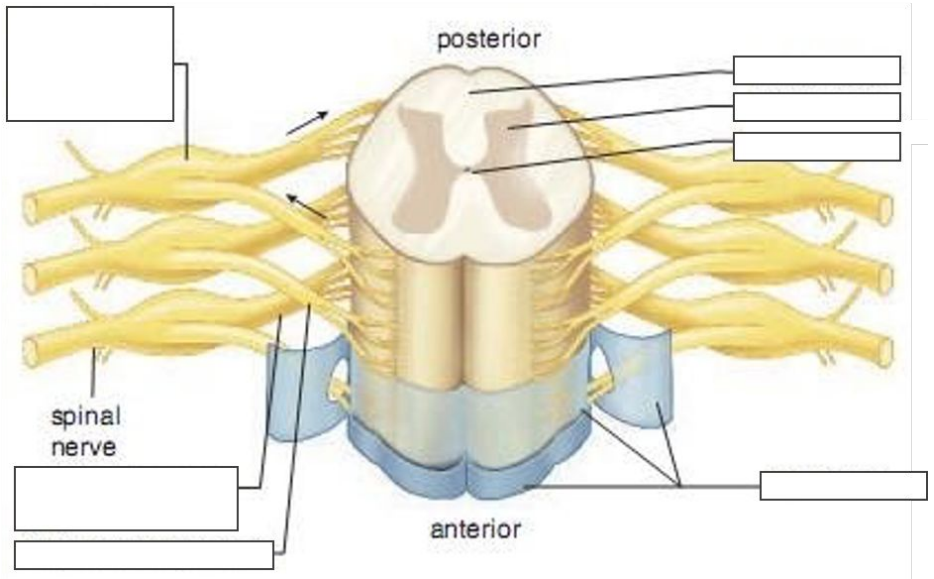
An organ, tissue, or cell that produces a response to a stimulus

What is a stimulus?

What is a stimulus?

An internal or external change or factor which triggers a response

Fill in the missing labels in this diagram of a spinal cord



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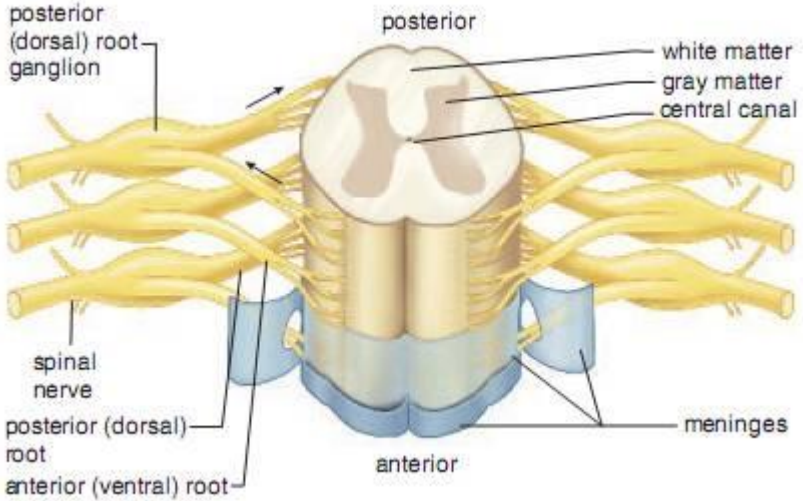
Fill in the missing labels in this diagram of a spinal cord



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What is grey matter?

What is grey matter?

The darker tissue of the central nervous system which lies centrally and consists of relay and motor neurone cell bodies

What is white matter?

What is white matter?

The lighter tissue of the central nervous system which surrounds grey matter and consists of myelinated axons

What is the dorsal root?

What is the dorsal root?

- One of two roots that emerges from the spinal cord
- Travels to the dorsal root ganglion
- Sensory neurones enter the spinal cord via the dorsal root

What is the ventral root?

What is the ventral root?

- One of two roots that emerges from the spinal cord
- Motor neurones leave the spinal cord via the ventral root

What is a reflex?

What is a reflex?

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

Outline a simple reflex arc

Outline a simple reflex arc.

stimulus → receptor → sensory neurone → relay neurone (in CNS) → motor neurone → effector → response

What is resting potential?

What is resting potential?

Potential difference (voltage) across neuron membrane when not stimulated (-50 to -90 mV, usually about -70 mV in humans)

How is resting potential established?

How is resting potential established?

1. Membrane is more permeable to K^+ than Na^+.
2. Sodium-potassium pump actively transports $3Na^+$ out of cell & $2K^+$ into cell

establishes electrochemical gradient: cell contents more negative than extracellular environment

Name the stages in generating an action potential

Name the stages in generating an action potential

1. Depolarisation
2. Repolarisation
3. Hyperpolarisation
4. Return to resting potential

What happens during depolarisation?

What happens during depolarisation?

1. Stimulus → facilitated diffusion of Na^+ into cell down electrochemical gradient
2. p.d. across membrane becomes more positive
3. If membrane reaches threshold potential (-50mV), voltage-gated Na^+ channels open. (positive feedback mechanism)
4. Significant influx of Na^+ ions reverses p.d. to +40mV

What happens during repolarisation?

What happens during repolarisation?

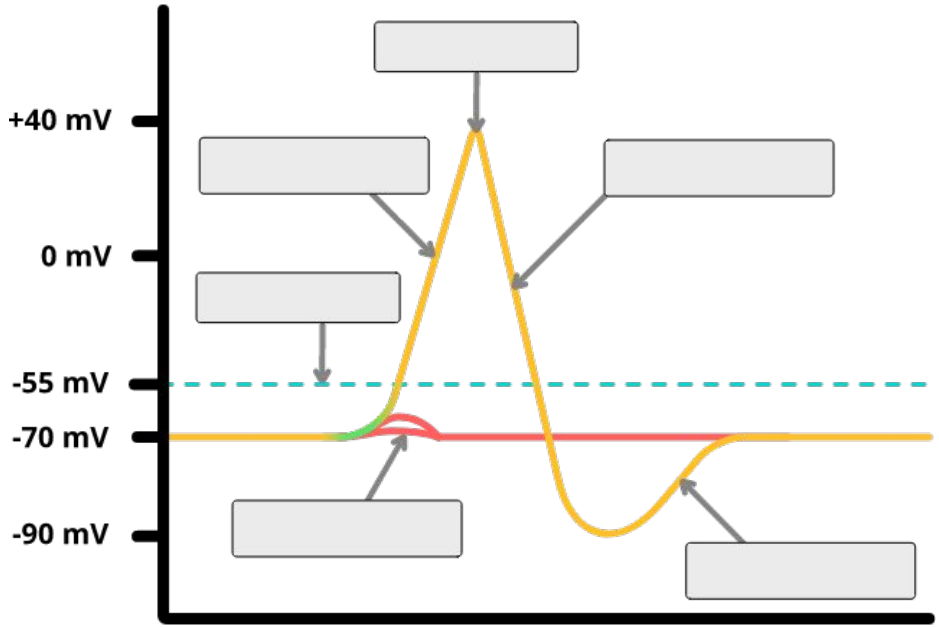
1. Voltage-gated Na^+ channels close and voltage-gated K^+ channels open
2. Facilitated diffusion of K^+ ions out of cell down their electrochemical gradient
3. p.d. across membrane becomes more negative

What happens during hyperpolarisation?

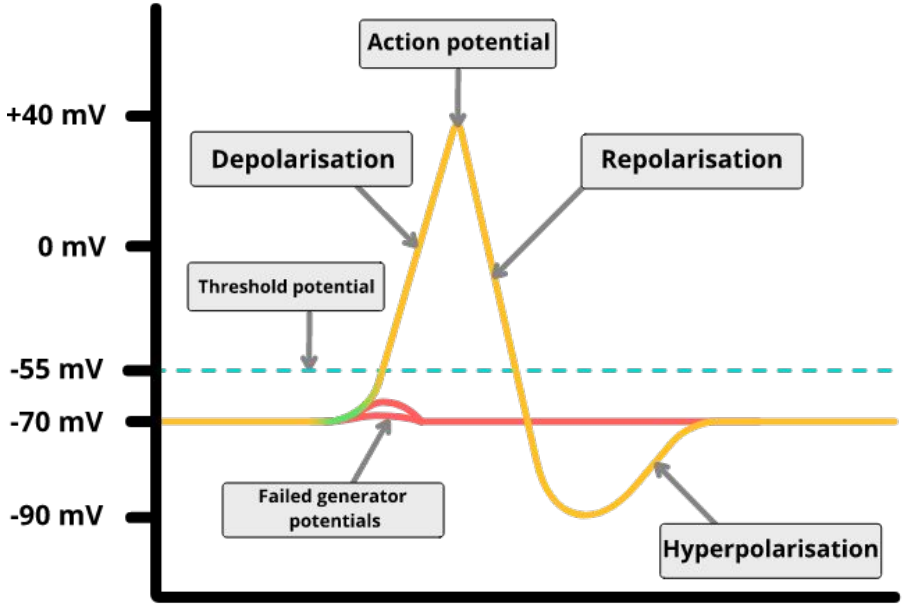
What happens during hyperpolarisation?

1. 'Overshoot' when K^+ ions diffuse out = p.d. becomes more negative than resting potential
2. Refractory period: no stimulus is large enough to raise membrane potential to threshold
3. Voltage-gated K^+ channels close & sodium-potassium pump re-establishes resting potential

Label this graph of an action potential



Label this graph of an action potential



Describe the ‘all or nothing’ law

Describe the ‘all or nothing’ law

Principle that states that all stimuli above a certain threshold value will generate the same size of action potential, regardless of the strength of the stimulus

What is saltatory conduction?

What is saltatory conduction?

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

Describe the structure of a synapse

Describe the structure of a synapse

- **Presynaptic neurone** ends in **synaptic knob**
- Synaptic knob contains a high concentration of mitochondria, endoplasmic reticulum and vesicles of neurotransmitter
- **Synaptic cleft**, 20-30 nm gap
- **Postsynaptic neurone** has complementary receptors to neurotransmitter (ligand-gated Na^+ channels)

What is the function of synapses?

What is the function of synapses?

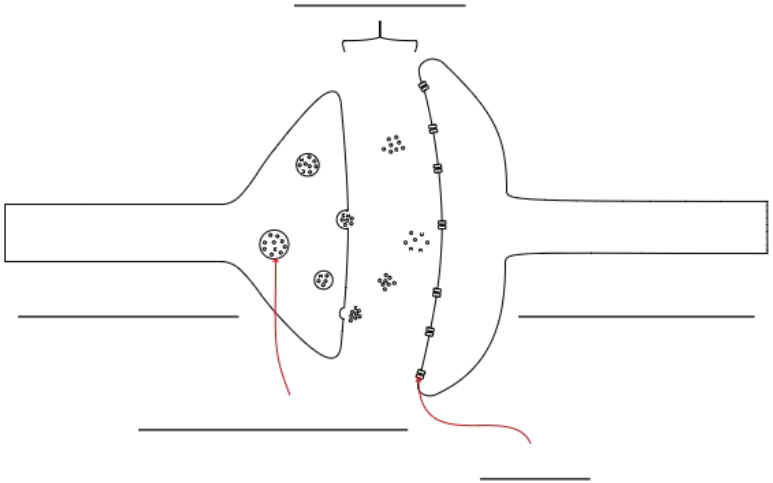
- Electrical impulse cannot cross junction
- Neurotransmitters send impulses between neurones or from neurones to effectors
- Summation of sub-threshold impulses
- New impulses can be initiated in several different neurones for multiple simultaneous responses

What is the synaptic cleft?

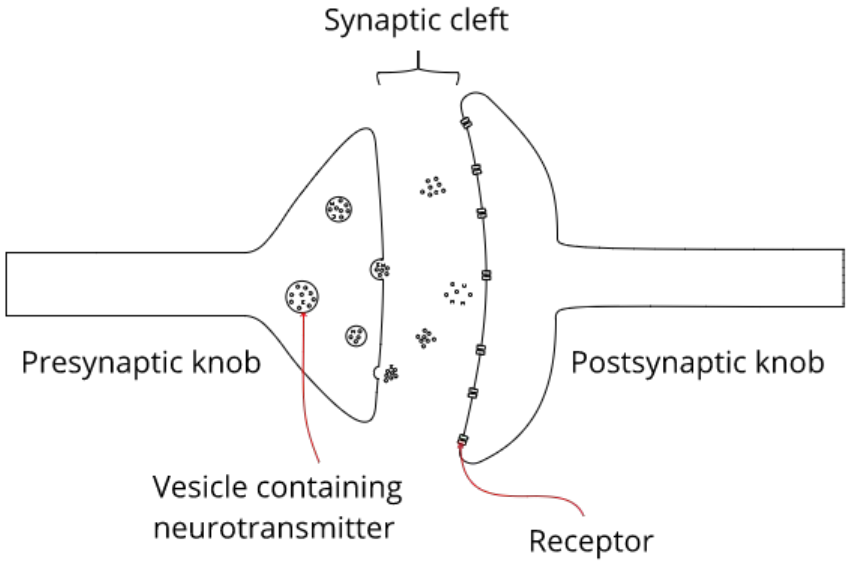
What is the synaptic cleft?

A small gap between neurones across which a nerve impulse is transmitted via neurotransmitters

Label this diagram of a synapse



Label this diagram of a synapse



Describe synaptic transmission in the presynaptic neurone

Describe synaptic transmission in the presynaptic neurone

1. Wave of depolarisation travels down presynaptic neurone, causing voltage-gated Ca^{2+} channels to open
2. Ca^{2+} cause vesicles of acetylcholine to move towards and fuse with presynaptic membrane
3. Exocytosis of neurotransmitter (e.g. acetylcholine) into synaptic cleft

How do neurotransmitters cross the synaptic cleft?

How do neurotransmitters cross the synaptic cleft?

Via simple diffusion

Describe synaptic transmission in the postsynaptic neurone

Describe synaptic transmission in the postsynaptic neurone

1. Acetylcholine diffuses across synaptic cleft and binds to specific receptors on postsynaptic membrane
2. Ligand-gated Na^+ channels open
3. If influx of Na^+ ions raises membrane to threshold potential, action potential is generated

How is the merging of impulses prevented during synaptic transmission?

How is the merging of impulses prevented during synaptic transmission?

- Active transport of Ca^{2+} out of synaptic knob
- Role of cholinesterase
- Reabsorption of neurotransmitters

Describe the role of cholinesterase in synaptic transmission

Describe the role of cholinesterase in synaptic transmission

- Hydrolyses acetylcholine in the postsynaptic neurone
- Products diffuse back across the cleft

What is the refractory period?

What is the refractory period?

The short period of time following an action potential where another action potential cannot be generated no matter how large a stimulus is provided

What causes the refractory period?

What causes the refractory period?

The voltage gated sodium channels become **inactivated** for a period of time following an action potential and cannot open regardless of the stimulus size

Why is it important that nerves have a refractory period?

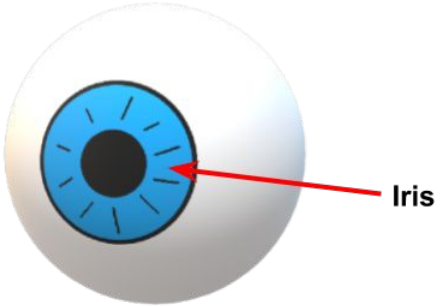
Why is it important that nerves have a refractory period?

To ensure that nervous transmission is **unidirectional** (only occurs in one direction). It also ensures that each nervous impulse is distinctly **separate** from each other so they can be interpreted individually by the brain

What is the iris and what is its function?

What is the iris and what is its function?

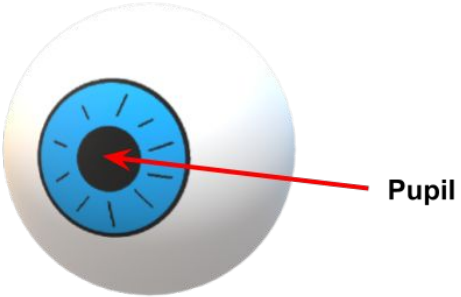
The coloured ring around the pupil that controls its diameter



What is the pupil and what is its function?

What is the pupil and what is its function?

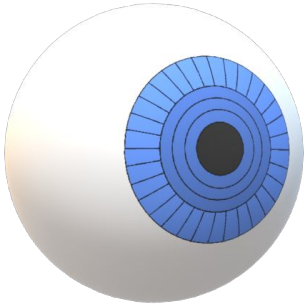
The pupil is the hole in the middle of the iris that lets light into the eye



Explain the response of the eye to bright light

Explain the response of the eye to bright light

The radial muscle contracts and the circular muscle relaxes making the pupil smaller



State the response of the eye to a lack of light

State the response of the eye to a lack of light

The pupil increases in diameter to allow more light to hit the retina

State the response of the eye to bright light

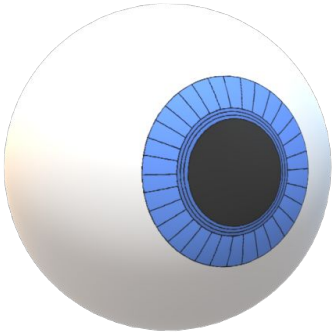
State the response of the eye to bright light

The pupil decreases in diameter to reduce the amount of light which hits the retina

Explain the response of the eye to a lack of light

Explain the response of the eye to a lack of light

The radial muscle relaxes and the circular muscle contracts making the pupil larger



How does nicotine affect nervous transmission?

How does nicotine affect nervous transmission?

It mimics the neurotransmitter acetylcholine and binds to receptors in cholinergic synapses involved in the reward centres of the brain. Binding of nicotine triggers dopamine release and so nicotine can be an addictive drug

What is nicotine?

What is nicotine?

A drug found in tobacco cigarettes which contribute to the addictive properties of cigarettes

What is lidocaine?

What is lidocaine?

Lidocaine is a drug which can be used as a local anaesthetic or to treat heart arrhythmias

How does lidocaine work as a local anaesthetic?

How does lidocaine work as a local anaesthetic?

It prevents the propagation of action potentials by blocking Na^+ ion channels in nerve cells. This prevents impulses in response to pain from being generated in the area affected by the drug

What is α-Cobratoxin?

What is α-Cobratoxin?

A type of **neurotoxin** which is found in the venom of Naja cobras

What effects does α-Cobratoxin cause?

What effects does α-Cobratoxin cause?

It causes muscle paralysis which may lead to death from respiratory failure

How does α-Cobratoxin cause muscle paralysis?

How does α-Cobratoxin cause muscle paralysis?

It reversibly blocks acetylcholine receptors at cholinergic synapses

How might drugs increase synaptic transmission?

How might drugs increase synaptic transmission?

- Inhibit AChE
- Mimic shape of neurotransmitter

How might drugs decrease synaptic transmission?

How might drugs decrease synaptic transmission?

- Inhibit release of neurotransmitter
- Decrease permeability of postsynaptic membrane to ions
- Hyperpolarise postsynaptic membrane

What is Parkinson's disease?

What is Parkinson's disease?

Neurodegenerative disorder affecting movement & cognitive function

Loss of dopaminergic neurons in cerebral cortex of brain. Characterised by formation of Lewy bodies (clumps of alpha synuclein protein)

Results in fewer threshold impulses to neurons in motor cortex

How is L-Dopa used to treat Parkinson's disease?

How is L-Dopa used to treat Parkinson's disease?

L-Dopa is a dopamine precursor that can cross brain blood barrier. It is used to produce more dopamine in the brain to replace the neurotransmitter lost by death of neurons

What is MDMA?

What is MDMA?

Chemical in ecstasy. Interacts with transmembrane proteins that transport serotonin, a neurotransmitter that regulates mood. Increases serotonin level in synaptic clefts in brain

Describe the distribution of rods and cones in the human eye

Describe the distribution of rods and cones in the human eye

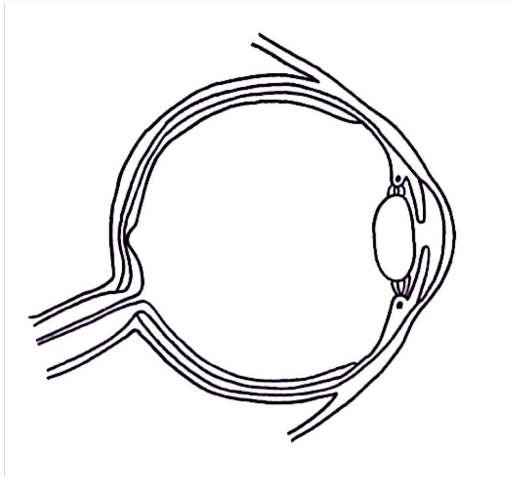
- There are typically more rods than cones evenly distributed in the retina, however in the fovea there are no rods and only cones.
- There are no photoreceptors at the blind spot where ganglion axon fibres form optic nerve

What is the fovea?

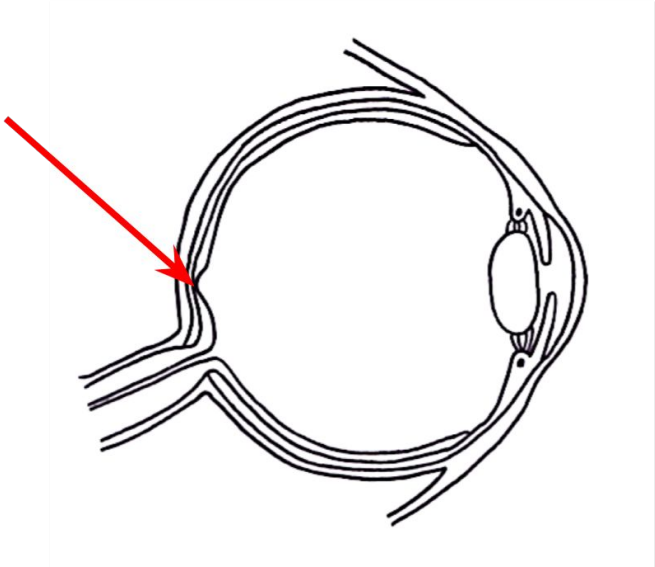
What is the fovea?

An area on the retina with lots of photosensitive cells so it has the highest visual acuity

Identify the fovea on the diagram below

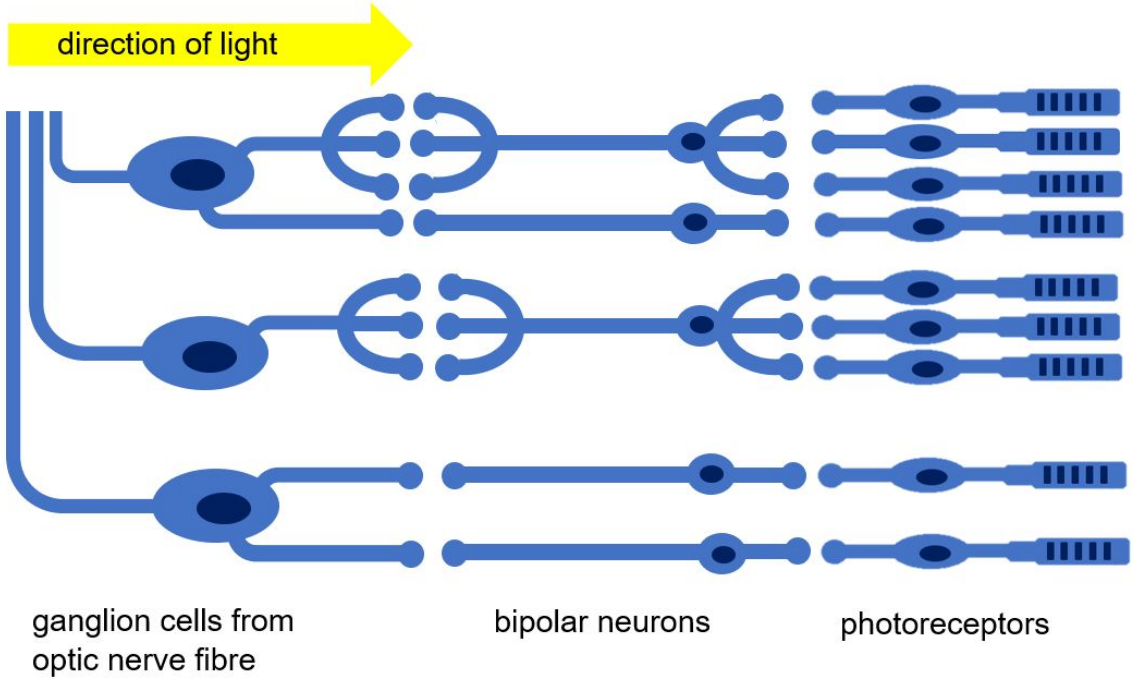


Identify the fovea on the diagram below



Describe the structure of the human retina

Describe the structure of the human retina



What is the function of rods?

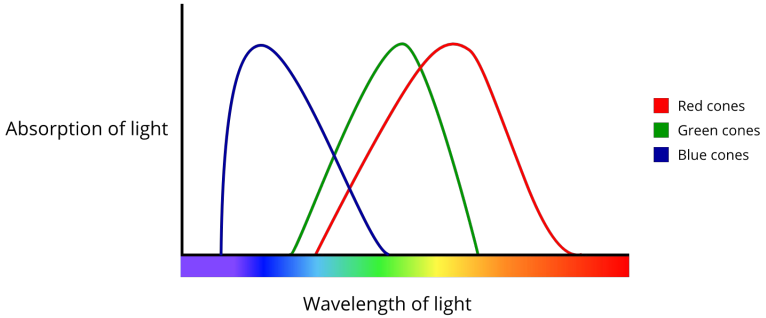
What is the function of rods?

They function in low light intensities

What is the function of cones?

What is the function of cones?

There are 3 different types of cone cells that all help to detect colour



Describe the pigments in rod and cone cells

Describe the pigments in rod and cone cells

Rod: Rhodopsin absorbs all wavelengths of light = monochromatic vision

Cone: Three types of iodopsin which absorb red, blue or green wavelengths of light = tricolour vision

Explain why rod cells do not generate action potentials in the dark

Explain why rod cells do not generate action potentials in the dark

1. Na^+ enters outer segment of rod cell via non-specific cation channels. Active transport of Na^+ out of inner segment = rod cell is slightly depolarised
2. Action potential = voltage-gated Ca^{2+} channels open. Triggers exocytosis of glutamate
3. Glutamate acts as inhibitory neurotransmitter to hyperpolarise bipolar neuron

Explain how rod cells generate an action potential in the light

Explain how rod cells generate an action potential in the light

1. Rhodopsin pigment bleaches when it absorbs light & breaks down into opsin + retinal
2. Opsin closes cation channels via a hydrolysis reaction. Active transport of Na^+ out of inner segment continues.
3. Rod cell becomes hyperpolarised. No glutamate is released, so no inhibitory signal
4. Bipolar neuron depolarises

Outline the pathway of light from a photoreceptor to the brain

Outline the pathway of light from a photoreceptor to the brain

photoreceptor → bipolar neuron →

ganglion cell of optic nerve → brain

Describe the visual acuity of rod and cone cells

Describe the visual acuity of rod and cone cells

rod: many rod cells synapse with 1 bipolar neuron = low resolution

cone: 1 cone cell synapses with 1 bipolar neuron so there is no retinal convergence = high resolution

Describe the light sensitivity of rod and cone cells

Describe the light sensitivity of rod and cone cells

Rod: very sensitive due to spatial summation of subthreshold impulses = vision in low-light conditions

Cone: less sensitive = vision in bright light

What is bleaching?

What is bleaching?

Sudden exposure to high light intensity causes rhodopsin to break down faster than it can reform

Describe the process of light and dark adaptation in the eye

Describe the process of light and dark adaptation in the eye

Light adaptation: As rhodopsin reforms after bleaching, retinal sensitivity decreases

Dark adaptation: Rod cells become functional, retinal sensitivity increases

What is habituation?

What is habituation?

The effect seen where animals gradually stop responding to a stimulus after they have been exposed to it repeatedly without a reward or punishment following