Your notes

Edexcel GCSE Biology

Co-ordination & Response

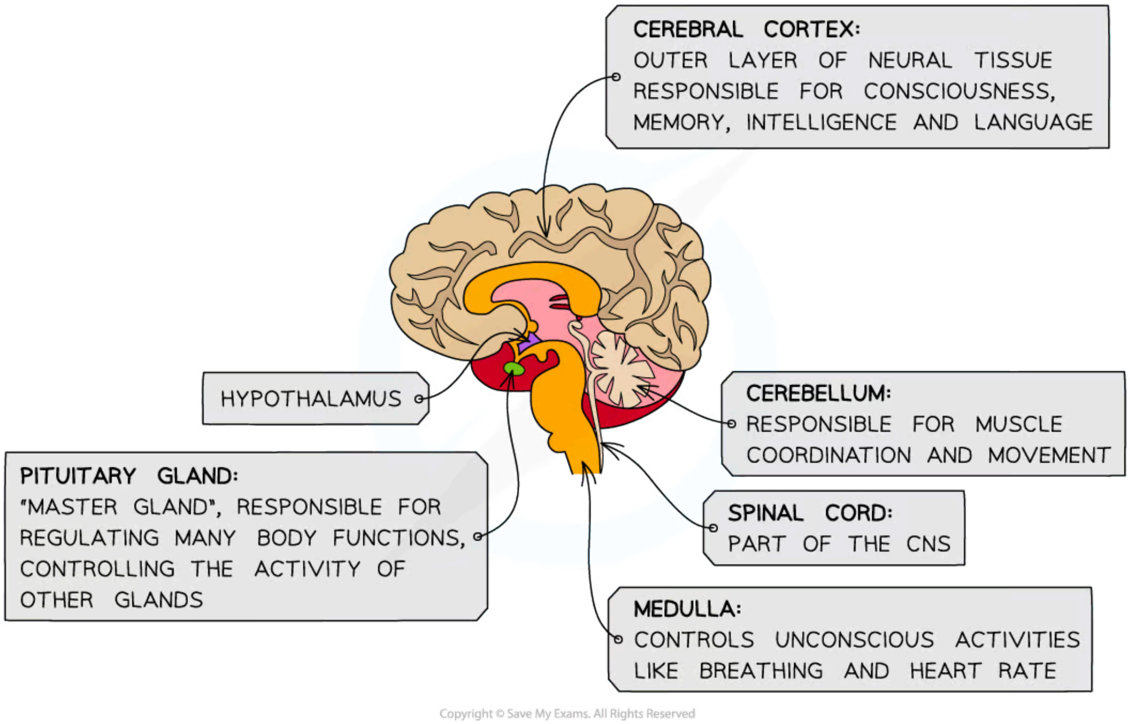
Contents

The Brain

Your notes

The Brain

- Our **central nervous system** includes the **brain** alongside the **spinal cord**
  - The spinal cord extends down from the base of the brain and is formed from a **bundle of neurones** which branch off to different parts of the body
  - The brain is made of **billions** of **interconnected neurones** and is responsible for controlling complex behaviours
- Scientists have discovered that **different regions** of the brain seem to be responsible for controlling **different functions**, these regions include:
  - **The cerebral cortex or cerebrum:** this is the outer layer of the brain which is divided into **two hemispheres** (left and right). It's highly folded and is responsible for higher-order processes such as **intelligence, memory, consciousness and personality**
  - **The cerebellum:** this is underneath the cerebral cortex and is responsible for **balance, muscle coordination** and **movement**
  - **The medulla oblongata:** this region controls **unconscious** activities such as **heart rate** and **breathing**



The brain is made from billions of interconnected neurones which are organised into regions

Scanning The Brain

Your notes

Understanding the Brain

Higher Tier Only

- Our understanding of brain structure and function is limited for several reasons
  - The brain is incredibly **complex** and **very delicate**
  - Different regions can't be studied in **isolation**
- Consequently, it is extremely difficult for neuroscientists to study it to find out how the brain works
- Specialised **scanners** can be used to study the brain without having to resort to **surgical intervention**

CT scanners (Computerised Tomography)

- CT scans produce **3D images** of the brain using **X-rays** which are fired at the brain from multiple different directions
- A scan produced in this way shows **physical structures** of the brain and allows visualisation of any tissue damage
- The scans **don't directly show the functions** of the regions of the brain, however, symptoms caused by tissue damage can allow neurologists to work out which regions of the brain are responsible for which functions
- CT scans are not recommended for **pregnant patients or children** due to the risks of exposure to the X-ray radiation, which is given at a **higher level** than in a normal X-ray

PET scanners (Positron Emission Tomography)

- PET scans use **radioactive tracers** which collect in areas where there is an **increased blood flow**
  - This includes the **active regions** within the brain as well as **cancerous tissues** which have a **higher blood flow than healthy tissues**
- The tracer is introduced to the blood in advance of the scan so that it can be detected by the scanner
- Neurologists can use the images to study the **structure** and **function** of the brain in **real time**
  - This has been useful in building understanding of specific diseases such as Parkinson's

Treating damage and disease to the CNS

- Our limited understanding means that treating **damage and disease in the CNS** is very difficult for many reasons

- Cancerous tumours can be located deep into the brain or spinal cord and so **cannot be surgically removed** at all from some regions
- Tissues of the nervous system **don't repair** in the same way that other tissues do
- We do not know exactly which regions of the brain are responsible for which functions
- Due to the delicate nature of nerve tissue, any potential treatment carries **risks of further damage** occurring which can lead to increased problems
  - Accidental damage could lead to **speech or motor issues**, or **changes to personality** which are permanent

Your notes

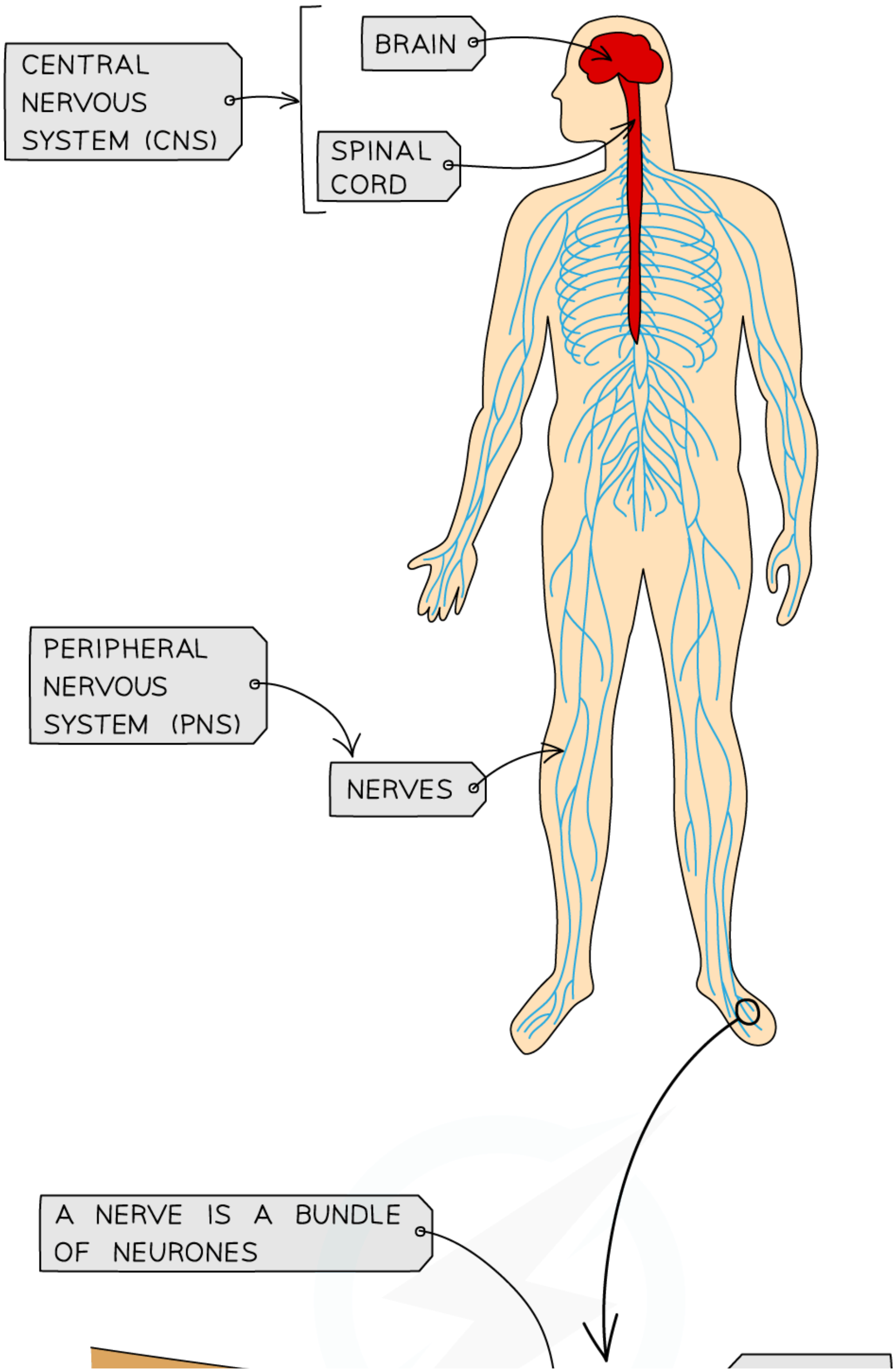
The Human Nervous System

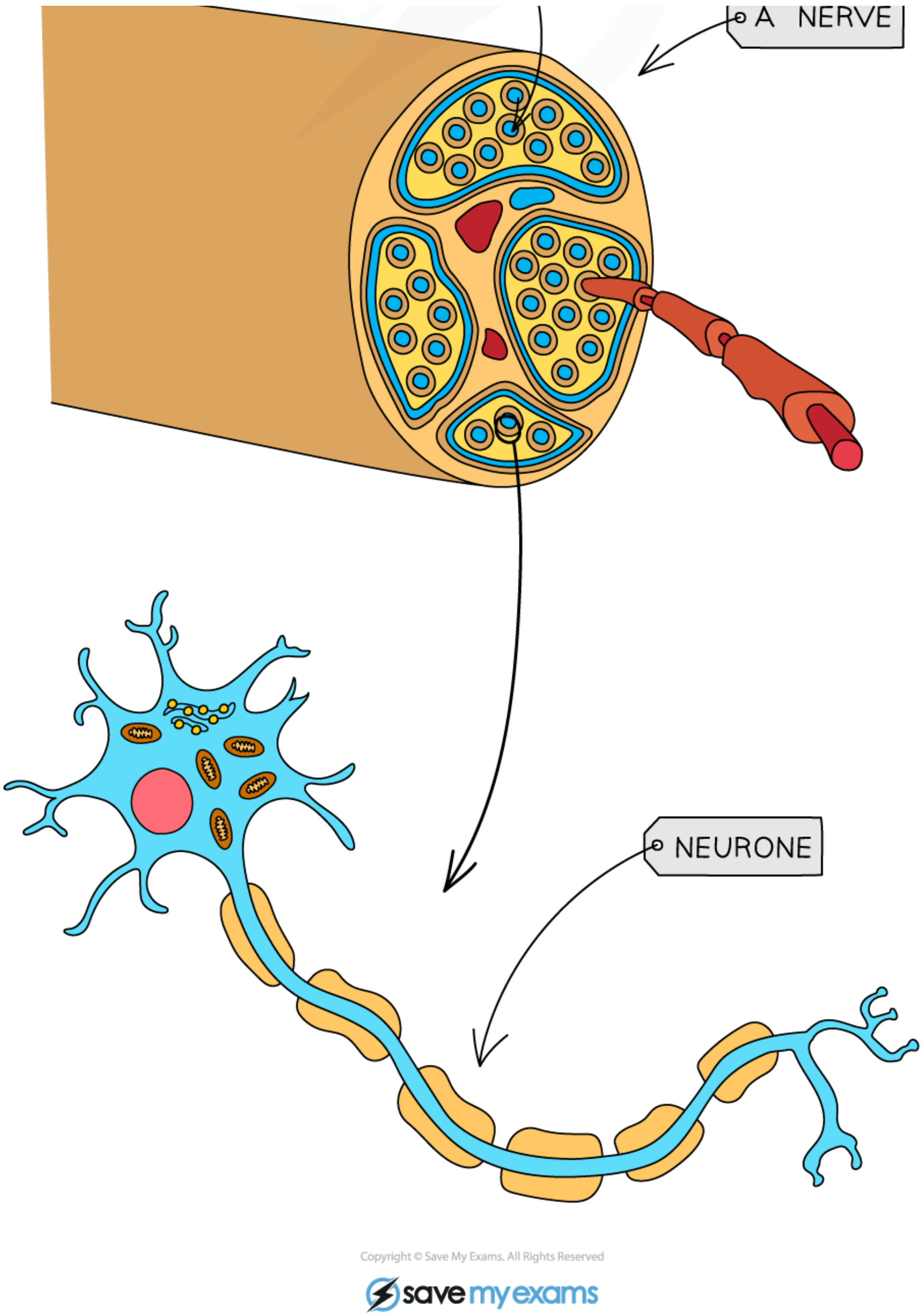
Your notes

The Human Nervous System: Structure

- The human nervous system consists of:
  - **Central nervous system** (CNS) – the **brain** and **spinal cord**
  - **Peripheral nervous system** (PNS) – all of the **nerves** in the body
- Information is sent through the nervous system as **electrical impulses** – these are electrical signals that pass along **nerve cells** known as **neurones**
  - A **bundle of neurones** is known as a **nerve**
- The nerves spread out from the central nervous system to **all other regions of the body** and importantly, to all of the **sense organs**
  - The **CNS**, therefore, acts as a **central coordinating centre** for the impulses that come in from (or are sent out to) any part of the body

Your notes


CENTRAL NERVOUS SYSTEM (CNS)
BRAIN
SPINAL CORD
PERIPHERAL NERVOUS SYSTEM (PNS)
NERVES
A NERVE IS A BUNDLE OF NEURONES



The human nervous system is comprised of the CNS and the PNS

Adaptations of neurones

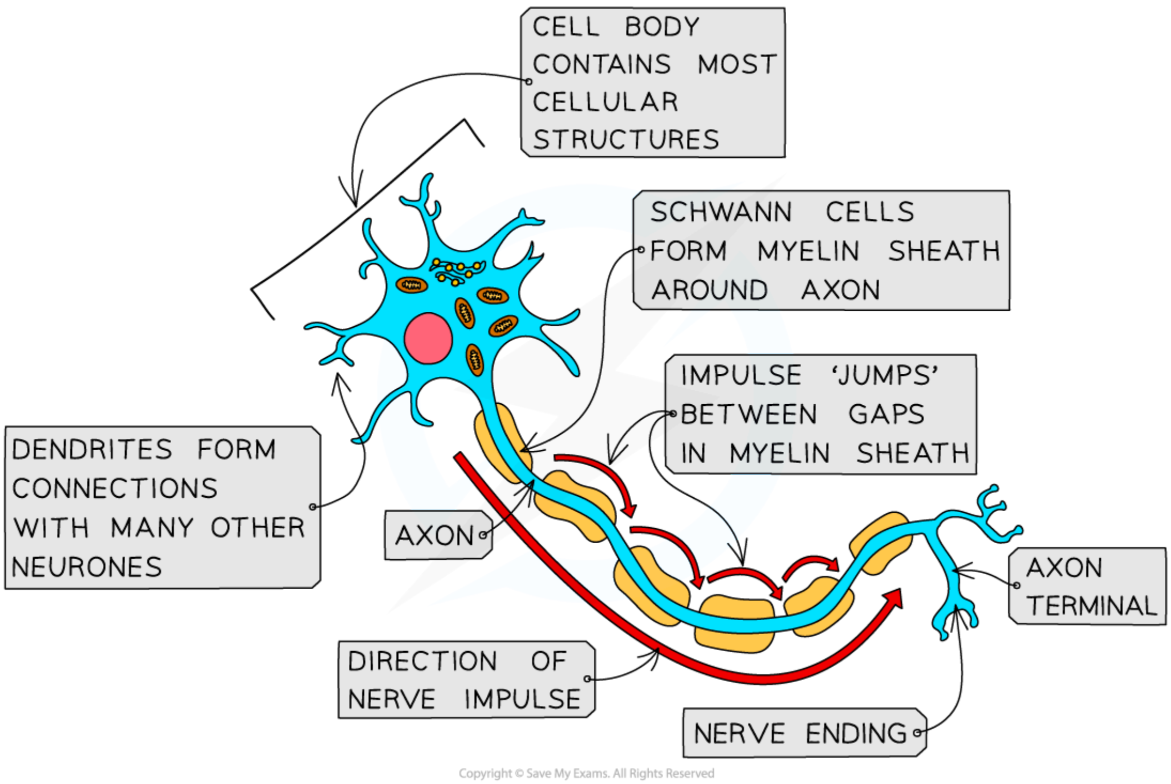
- Neurones have a **cell body** (where the nucleus and main organelles are found) and cytoplasmic extensions from this body called **axons** and **dendrites**

Your notes

- The axon is the **main long fibre of the neurone**
- Some human neurones have axons over a metre in length (but only 1 - 4 micrometres wide)
  - This is far more efficient than having multiple neurones to convey information from the CNS to effectors – less time is wasted transferring electrical impulses from one cell to another
- The axon is **insulated** by a **fatty myelin sheath** with **small uninsulated sections** along its length (called **nodes**)
  - This means that the electrical impulse does not travel down the whole axon, but jumps from one node to the next

Your notes

- Many extensions called dendrites extend out from the cell body of the neurone and at the far end of the axon
  - This means neurones can **connect to many other neurones** and receive impulses from them, forming a **network** for easy communication



The structure of a myelinated neurone.

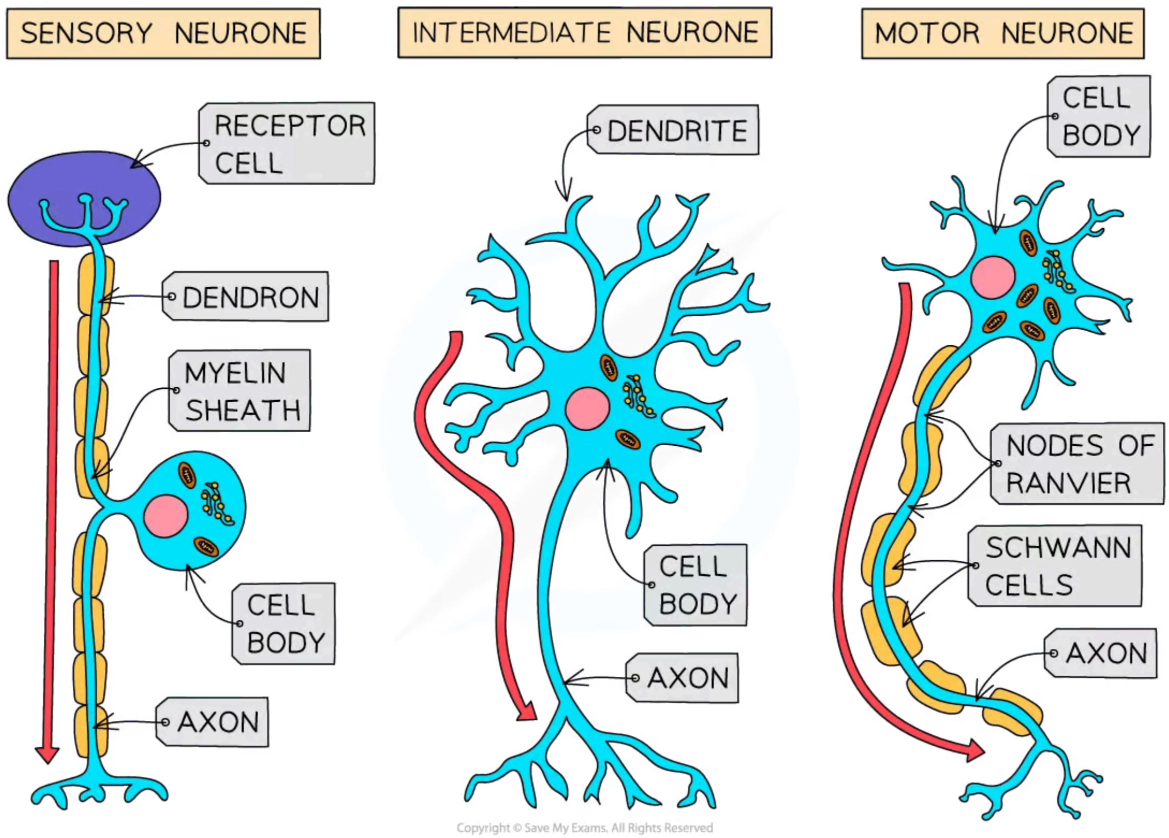
Types of neurones

- There are three main types of neurones: sensory neurones, relay neurones and motor neurones
  - Sensory neurones carry impulses **from sense organs to the CNS** (brain or spinal cord)
  - Relay neurones are found inside the CNS and **connect sensory and motor neurones**
  - Motor neurones carry impulses **from the CNS to effectors** (muscles or glands)

Identifying the three types of neurones

- Sensory neurones are long and have a cell body branching off the middle of the axon
- Relay neurones are short and have a small cell body at one end with many dendrites branching off it

- Motor neurones are long and have a large cell body at one end with long dendrites branching off it



The three types of neurones

The Human Nervous System: Function

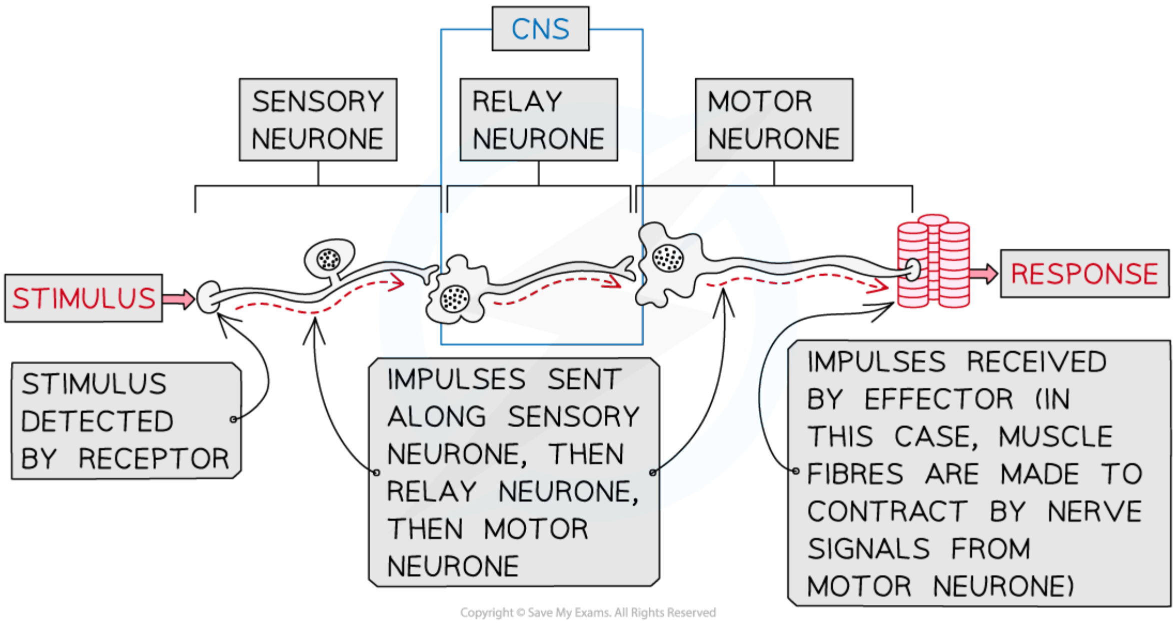
- The pathway through the nervous system can be summarised as follows:

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

- First, a **stimulus** is received by a **sensory (receptor) neurone**
  - Most receptors are specialised to detect particular stimuli
  - When a receptor is stimulated, it produces **electrical impulses**
- These impulses then travel along a sensory neurone to the **central nervous system** (the coordinator is either the brain or the spinal cord)
- In the CNS, the impulses are passed on to a **relay neurone**

Your notes

- The relay neurone links to a **motor neurone**, along which the impulses travel until they reach the **effector**
- The effector is what **carries out the response** (the effector may be a **muscle** or **gland**)



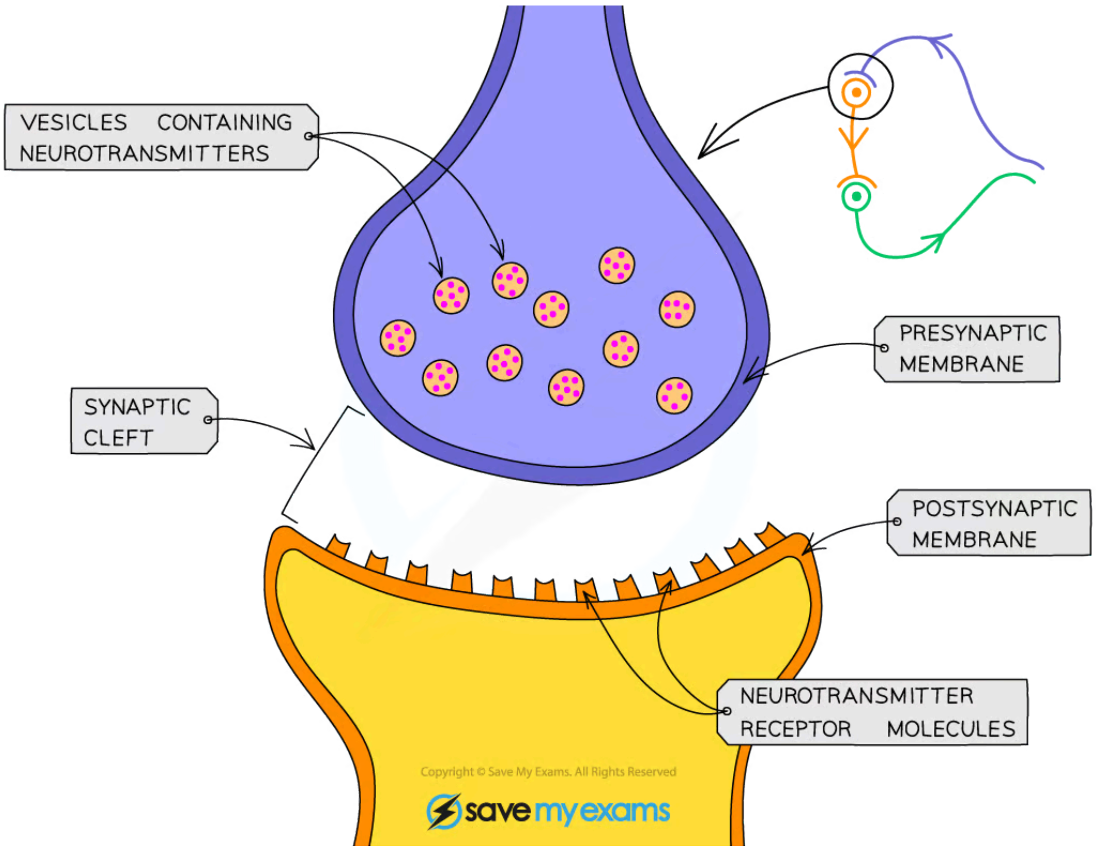
From stimulus to response: an example of a nerve pathway showing how an electrical impulse travels through sensory, relay and motor neurones

Synapses

The Role of Neurotransmitters

- Neurones do not actually come into **direct contact** with each other
- Where the **dendrites** of two neurones meet (to make a **connection** between the neurones) a junction known as a **synapse** is formed
- At a synapse, there is a very small **gap** between neurones
  - This very small gap is known as the **synaptic cleft** or **synaptic gap**
- Electrical impulses **cannot** travel directly from one neurone to the next due to the synaptic cleft (**electricity cannot 'jump' the gap**)
- Instead, the electrical signal is briefly **converted** to a **chemical signal** that **can** cross the synaptic cleft
  - The chemical signalling molecules used to transfer the signal between neurones at a synapse are known as **neurotransmitters**
- Once these neurotransmitters cross the synaptic cleft and meet the neurone on the opposite side, the signal is converted **back into an electrical impulse**, which can then pass along the neurone

Your notes



A synapse

How an impulse is passed across a synapse

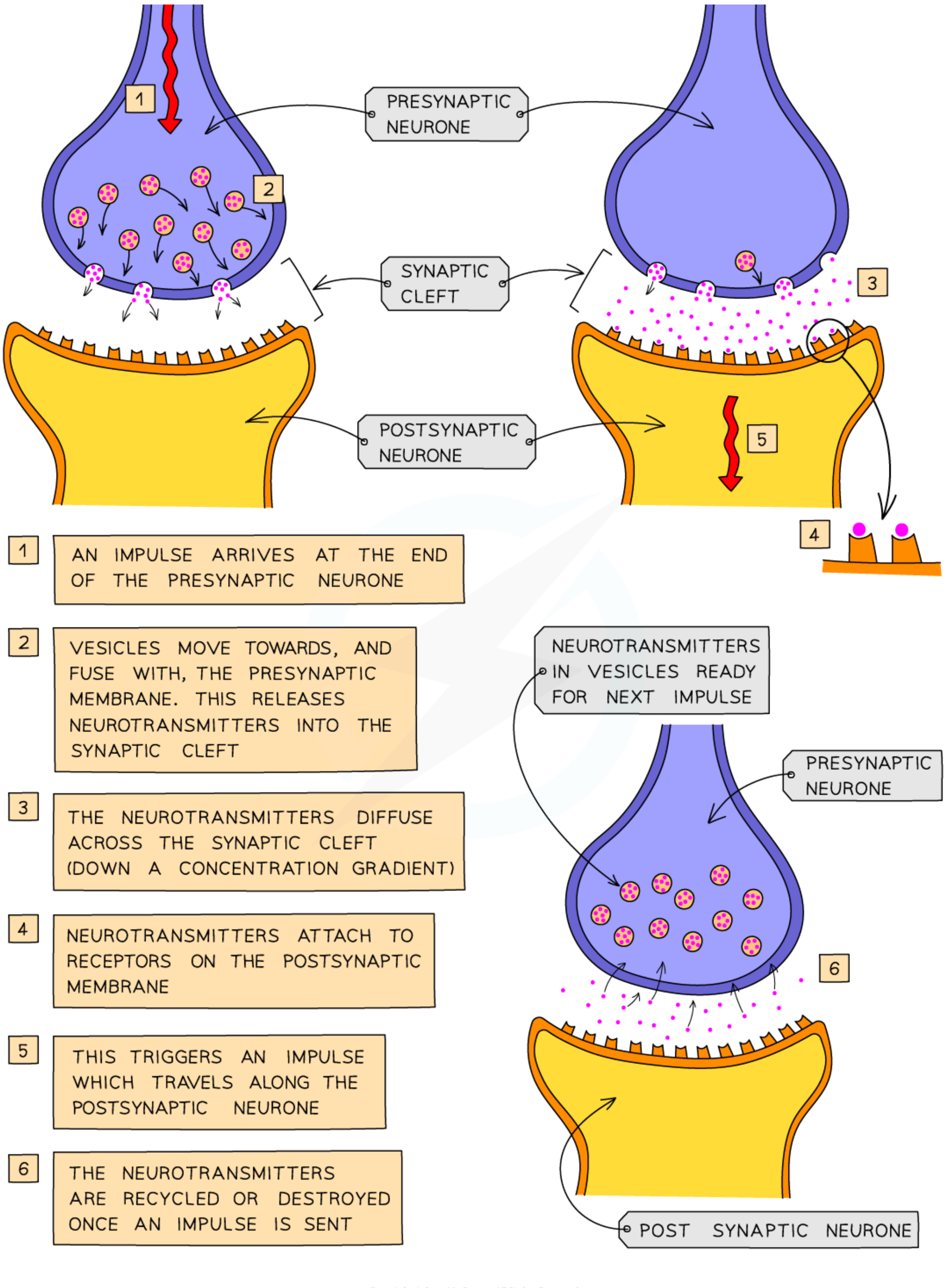
- The electrical impulse travels along the **first axon** (of the first neurone, known as the **presynaptic neurone**)
- This triggers the end of the presynaptic neurone to release chemical messengers called **neurotransmitters** from **vesicles**
  - These vesicles **fuse** with the **presynaptic membrane**, releasing their contents into the synaptic cleft
- The neurotransmitters **diffuse across the synaptic cleft** and **bind with receptor molecules** on the membrane of the second neurone (known as the **postsynaptic membrane**)
- This stimulates the second neurone to generate an **electrical impulse** (which then travels down the **second axon**)

Your notes

- The neurotransmitters are then **destroyed** to **prevent continued stimulation** of the second neurone (otherwise the neurotransmitters would cause repeated impulses to be sent)
- Synapses ensure that impulses only travel in **one direction**, avoiding the confusion that would be caused within the nervous system if impulses were able to travel in both directions

Your notes

Your notes


PRESYNAPTIC NEURONE
SYNAPTIC CLEFT
POSTSYNAPTIC NEURONE
1
2
3
4
5
6
1 AN IMPULSE ARRIVES AT THE END OF THE PRESYNAPTIC NEURONE
2 VESICLES MOVE TOWARDS, AND FUSE WITH, THE PRESYNAPTIC MEMBRANE. THIS RELEASES NEUROTRANSMITTERS INTO THE SYNAPTIC CLEFT
3 THE NEUROTRANSMITTERS DIFFUSE ACROSS THE SYNAPTIC CLEFT (DOWN A CONCENTRATION GRADIENT)
4 NEUROTRANSMITTERS ATTACH TO RECEPTORS ON THE POSTSYNAPTIC MEMBRANE
5 THIS TRIGGERS AN IMPULSE WHICH TRAVELS ALONG THE POSTSYNAPTIC NEURONE
6 THE NEUROTRANSMITTERS ARE RECYCLED OR DESTROYED ONCE AN IMPULSE IS SENT
NEUROTRANSMITTERS IN VESICLES READY FOR NEXT IMPULSE
PRESYNAPTIC NEURONE
POST SYNAPTIC NEURONE
Copyright © Save My Exams. All Rights Reserved

How an impulse is passed on at a synapse

Examiner Tips and Tricks

For maximum marks, you will need to understand the structure and functioning of a synapse and explain what happens at each step.Exam questions about neurotransmitters are a good opportunity for examiners to introduce unfamiliar examples and contexts, so remember the following:

- Neurotransmitters move by diffusion – remember, this requires a concentration gradient and is a passive process
- Receptors that are complementary in shape to neurotransmitters are located on the postsynaptic neurone
- Drugs (such as heroin, ecstasy and cocaine) can bind to neurotransmitter receptors, triggering impulses in different regions of the brain

Simple Reflex Arc

Your notes

Simple Reflex Arc

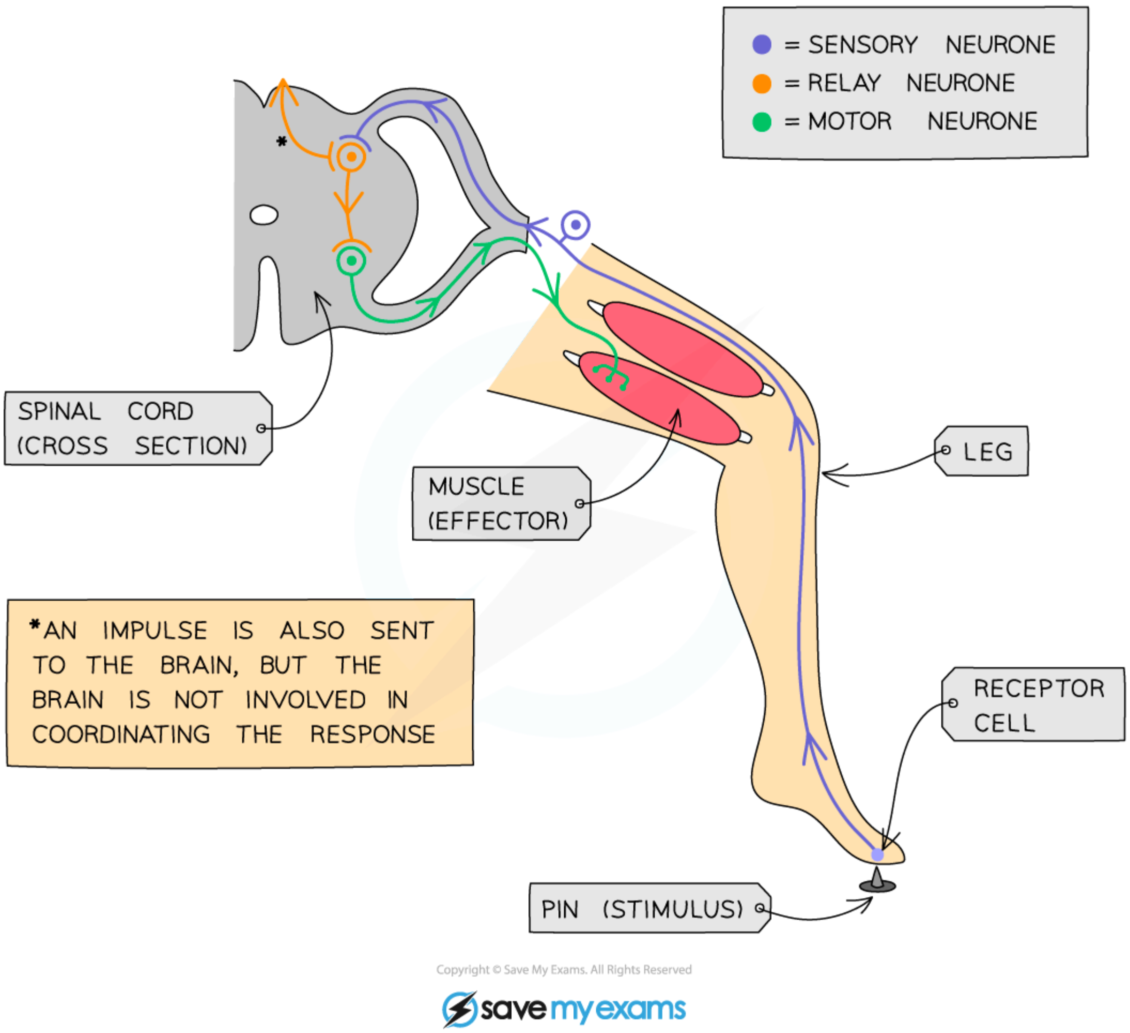
- A **reflex response** (also known as an **involuntary response**) does not involve the **conscious part of the brain** as the **coordinator** of the reaction
- Awareness of a response having happened occurs **after** the response has been carried out
- Responses are therefore **automatic** and **rapid** – this helps to **minimise damage** to the body and **aids survival**
  - Pain-withdrawal, blinking and coughing are all examples of reflex responses that help us to avoid serious injury, such as damage to the eye or choking

The reflex arc

- A **reflex arc** is the **pathway of a reflex response** (specifically, the pathway taken by **electrical impulses** as they travel along **neurones**)
- An example of a reflex response is the pain-withdrawal reflex that occurs when someone steps on a pin. The reflex arc for this response is outlined below

1. The pin (the **stimulus**) is detected by a (pain/pressure/touch) **receptor** in the skin on the person's foot
2. A **sensory** neurone sends electrical impulses to the spinal cord (the **coordinator**)
3. An electrical impulse is passed to a **relay** neurone in the spinal cord (part of the **CNS**)
4. A relay neurone **synapses** with a motor neurone
5. A **motor** neurone carries an impulse to a muscle in the leg (the **effector**)
6. When stimulated by the motor neurone, the muscle will contract and pull the foot up and away from the sharp object (the **response**)
7. This all occurs within a fraction of a second

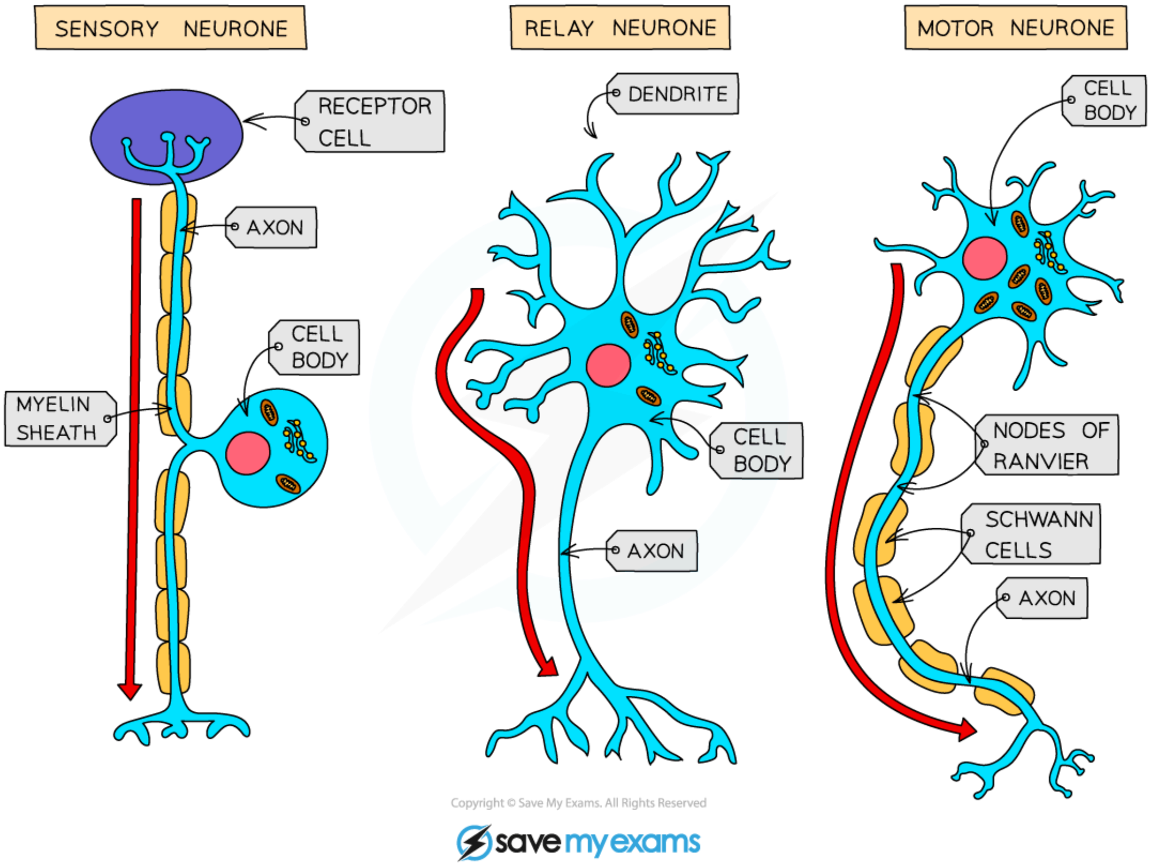
Your notes



The reflex arc pathway (in this case for a pain-withdrawal reflex). Reflex actions are automatic and rapid; they do not involve the conscious part of the brain

The neurones of the reflex arc

- There are three main types of neurone in a reflex arc: sensory, relay and motor
  - **Sensory** neurones carry impulses **from sense organs to the CNS** (brain or spinal cord)
  - **Relay** neurones are found inside the CNS and **connect sensory and motor neurones**
  - **Motor** neurones carry impulses **from the CNS to effectors** (muscles or glands)



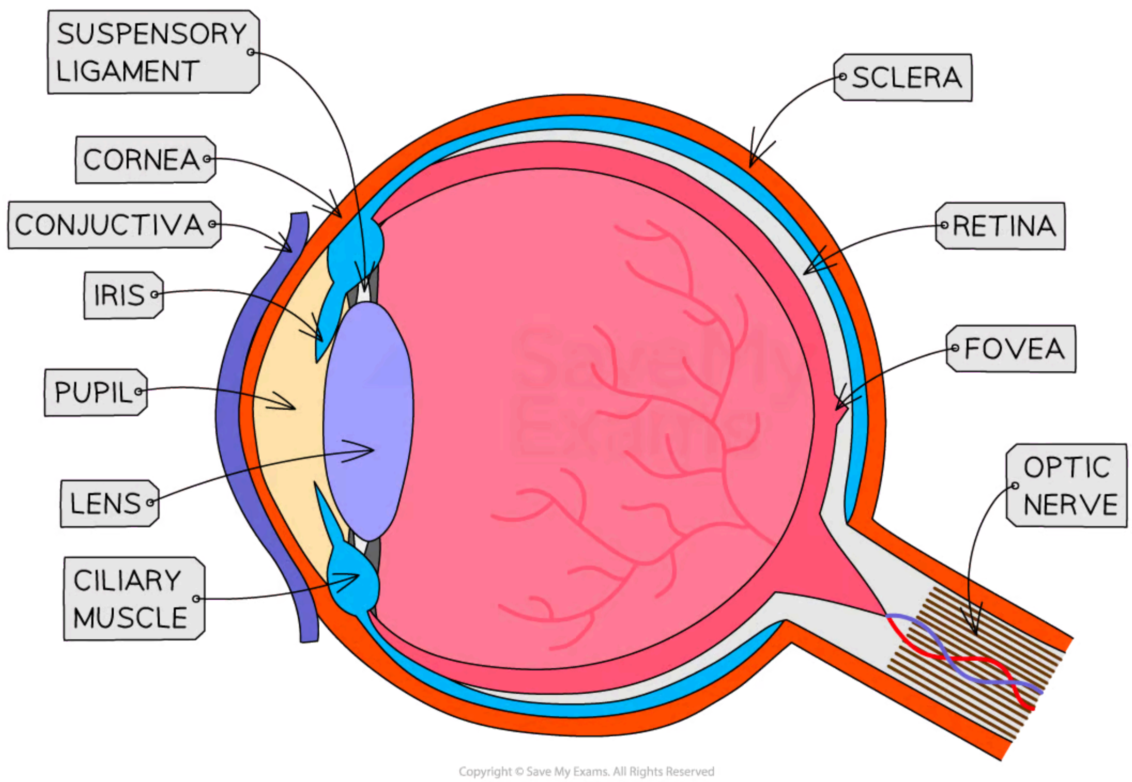
You need to be able to recognise the three types of neurone in a reflex arc

Your notes

The Human Eye

The Human Eye: Structure

- The eye is a highly specialised **sense organ** containing receptor cells that allow us to detect the stimulus of light
- The **retina** of the eye contains **two types of receptor cells**:
  - Receptor cells that are sensitive to **light**, known as **rods**, and receptor cells that can detect **colour**, known as **cones**



The eye

Functions of the Parts of the Eye Table

Your notes

STRUCTURE	FUNCTION
CORNEA	TRANSPARENT LENS THAT REFRACTS (BENDS) LIGHT AS IT ENTERS THE EYE
IRIS	CONTROLS HOW MUCH LIGHT ENTERS THE PUPIL
LENS	TRANSPARENT DISC THAT CAN CHANGE SHAPE TO FOCUS LIGHT ONTO THE RETINA
RETINA	CONTAINS LIGHT RECEPTOR CELLS – RODS (DETECT LIGHT INTENSITY) AND CONES (DETECT COLOUR)
OPTIC NERVE	SENSORY NEURONE THAT CARRIES IMPULSES BETWEEN THE EYE AND THE BRAIN
PUPIL	HOLE THAT ALLOWS LIGHT TO ENTER THE EYE

- Other structures of the eye include:
  - **conjunctiva** - a clear membrane that covers the white of the eye and the inside of the eyelids; it lubricates the eye and provides protection from external irritants
  - **The ciliary muscle** - a ring of muscle that contracts and relaxes to change the shape of the lens
  - **The suspensory ligaments** - ligaments that connect the ciliary muscle to the lens
  - **The sclera** - the strong outer wall of the eyeball that helps to keep the eye in shape and provides a place of attachment for the muscles that move the eye
  - **The fovea** - a region of the retina with the highest density of cones (colour detecting cells) where the eye sees particularly good detail
  - **The aqueous humour** - the watery liquid between the cornea and the lens
  - **The vitreous humour** - the jelly-like liquid filling the eyeball

- **The choroid** – a pigmented layer of tissue lining the inside of the sclera that prevents the reflection of light rays inside the eyeball
- **The blind spot** – the point at which the optic nerve leaves the eye, where there are no receptor cells

The Human Eye: Function

The function of the eye in focusing on near and distant objects

- The way the **lens** brings about **fine focusing** is called **accommodation**
- The lens is **elastic** and its shape can be changed when the **suspensory ligaments** attached to it become **tight** or **loose**
- The changes are brought about by the **contraction** or **relaxation** of the **ciliary muscles**
- When an object is **close up**:
  - The ciliary muscles contract (the ring of muscle decreases in diameter)
  - This causes the suspensory ligaments to loosen
  - This stops the suspensory ligaments from pulling on the lens, which allows the lens to become fatter
  - Light is refracted more

Your notes

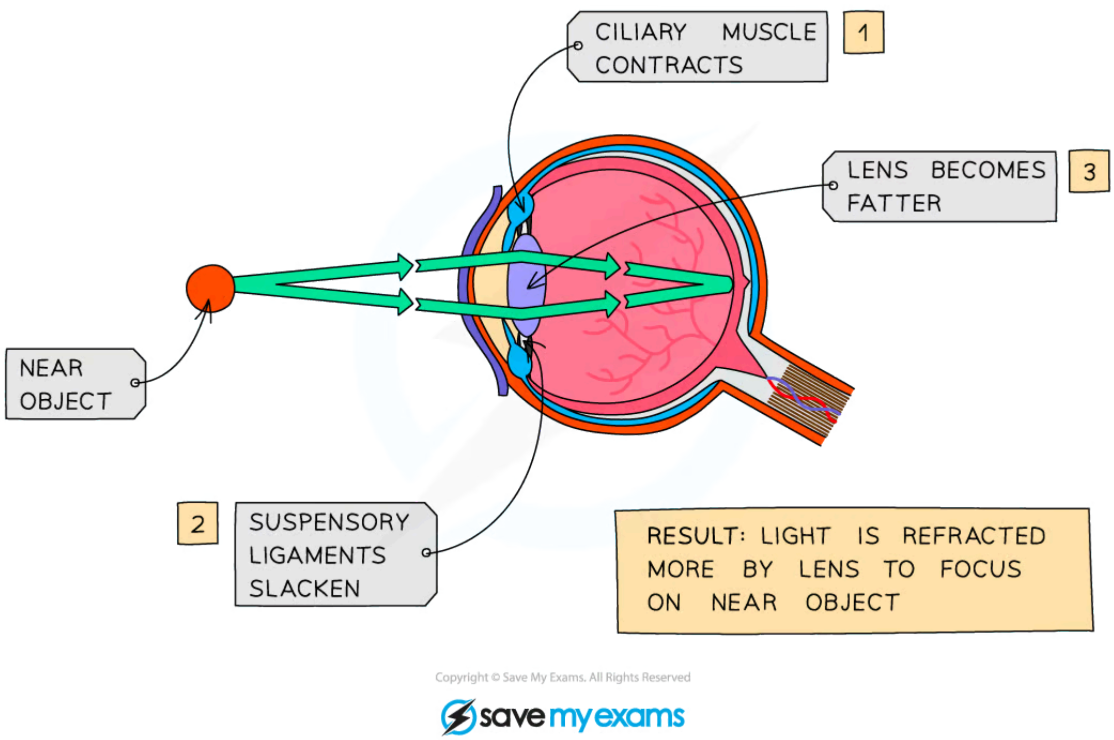


Diagram showing the eye when an object is close up

- When an object is **far away**:
  - The ciliary muscles relax (the ring of muscle increases in diameter)
  - This causes the suspensory ligaments to tighten
  - The suspensory ligaments pull on the lens, causing it to become thinner
  - Light is refracted less

Your notes

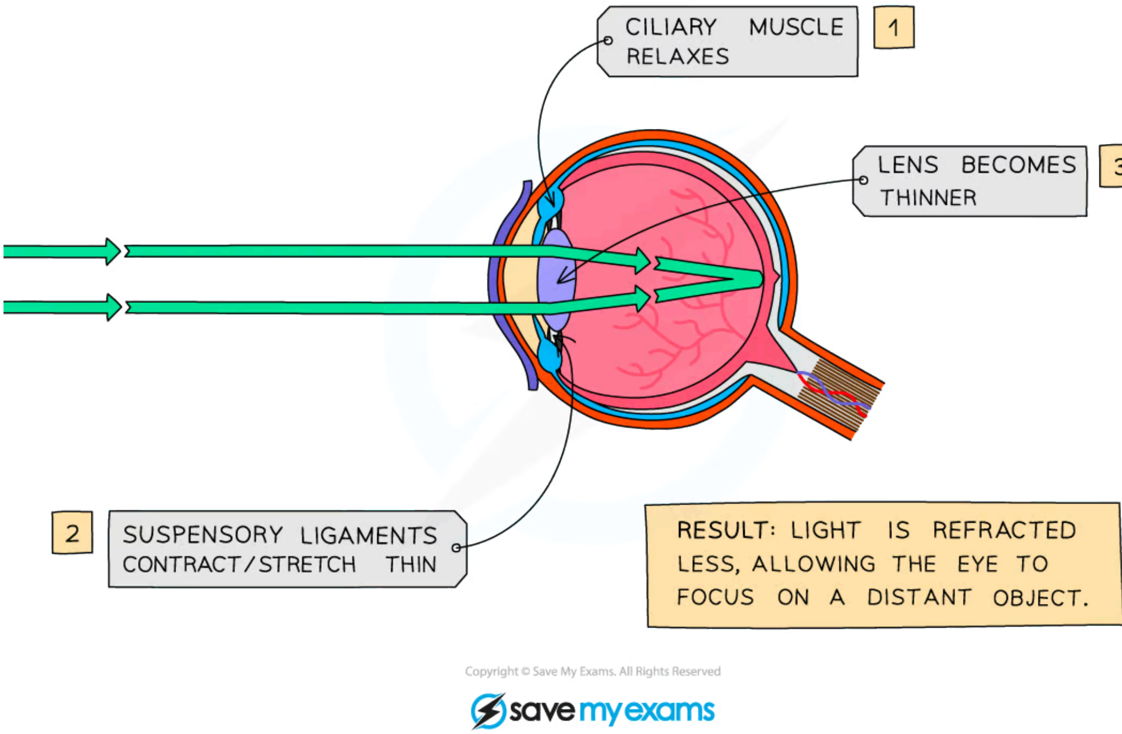


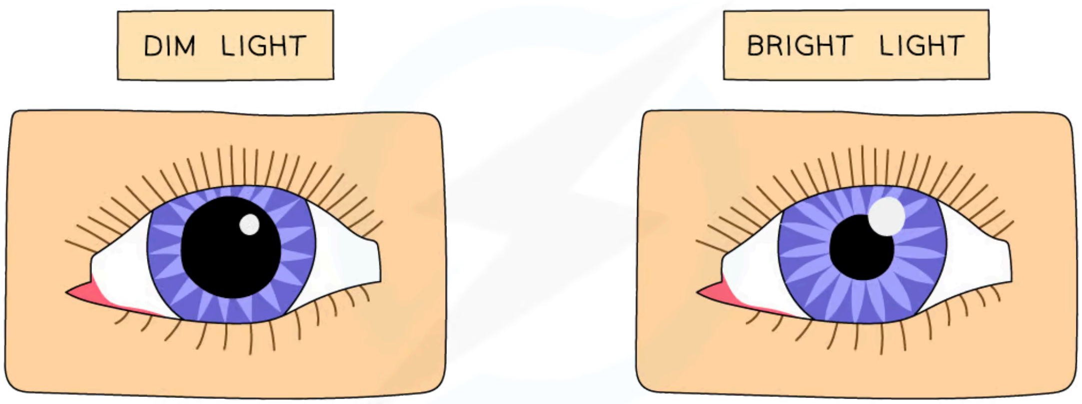
Diagram showing the eye when an object is far away

Focussing on Distant and Near Objects Table

	OBJECT FAR AWAY – THE LIGHT IS REFRACTED LESS	OBJECT CLOSE BY – THE LIGHT IS REFRACTED MORE
CILIARY MUSCLES	RELAXED	CONTRACTED
SUSPENSORY LIGAMENTS	PULLED TIGHT	SLACK
LENS	THINNER	FATTER

The function of the eye in responding to changes in light intensity

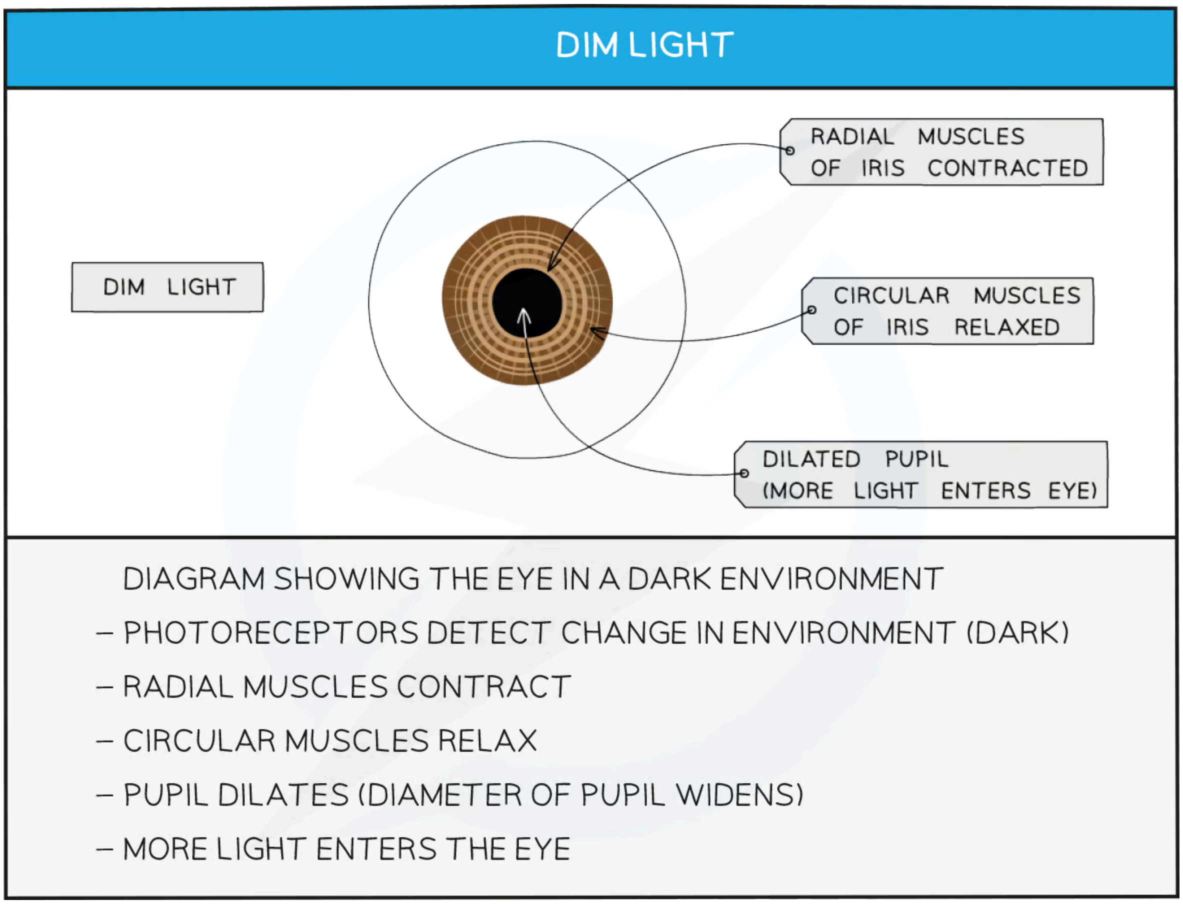
- The **pupil reflex** is a **reflex action** carried out to **protect the retina from damage**
  - In **dim light,** the pupil **dilates** (widens) in order to allow as much light into the eye as possible to improve vision
  - In **bright light,** the pupil **constricts** (narrows) in order to prevent too much light from entering the eye and damaging the retina



The pupil reflex

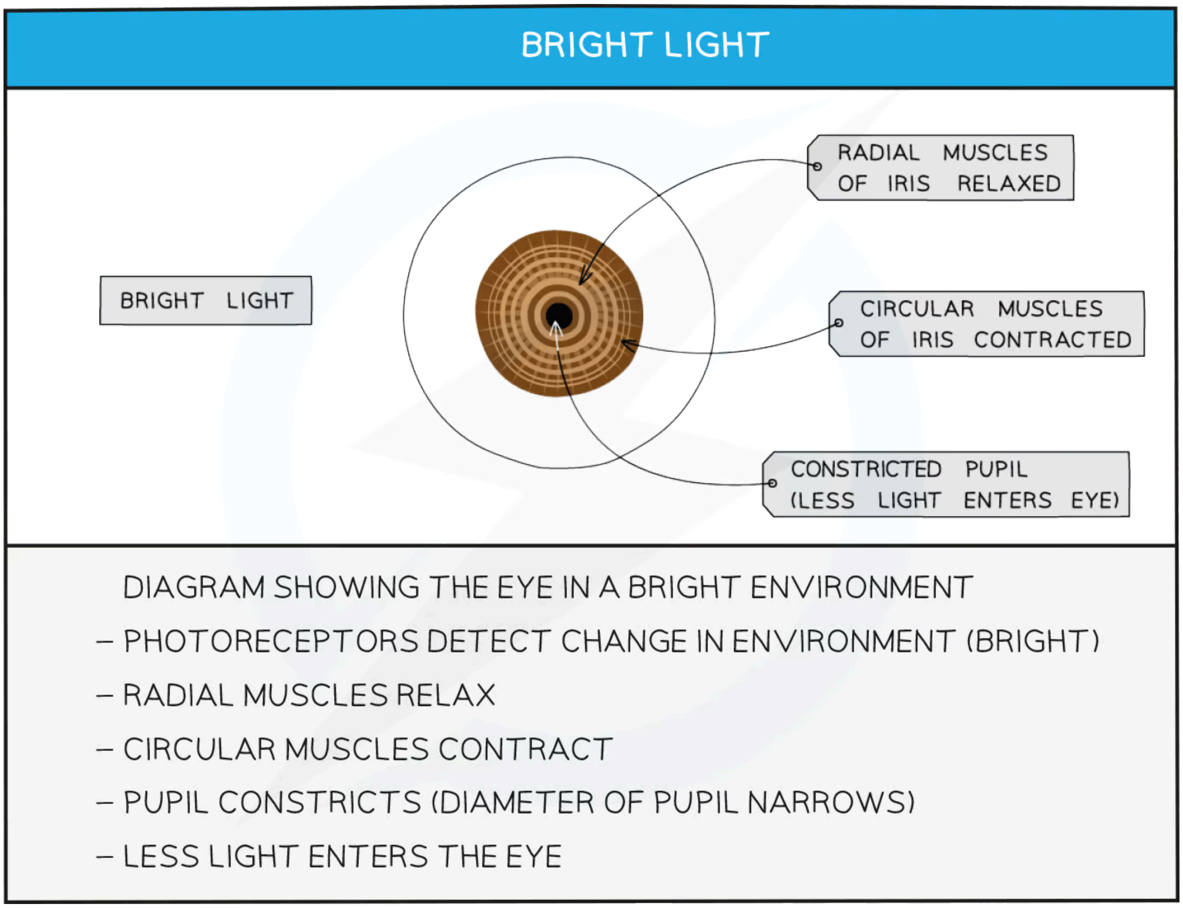
Your notes

Your notes



The pupil reflex in dim light

Your notes



The pupil reflex in bright light

Responding to Changes in Light Intensity Table

STIMULUS	RADIAL MUSCLES	CIRCULAR MUSCLES	PUPIL SIZE	AMOUNT OF LIGHT ENTERS
DARK LIGHT	CONTRACTED	RELAXED	WIDE	MORE
BRIGHT LIGHT	RELAXED	CONTRACTED	NARROW	LESS

Examiner Tips and Tricks

The focusing of the eye on distant and near objects is complex and it can be hard to remember what is happening. This is something you can work out in an exam if you have forgotten – staring at your hand right in front of your eye will make your eyes feel tight and tired after a few seconds. This is because the **ciliary muscles are contracted**. Staring at an object far away feels relaxing and comfortable because the **ciliary muscles are relaxed**.

Your notes

Defects of the Eye

Your notes

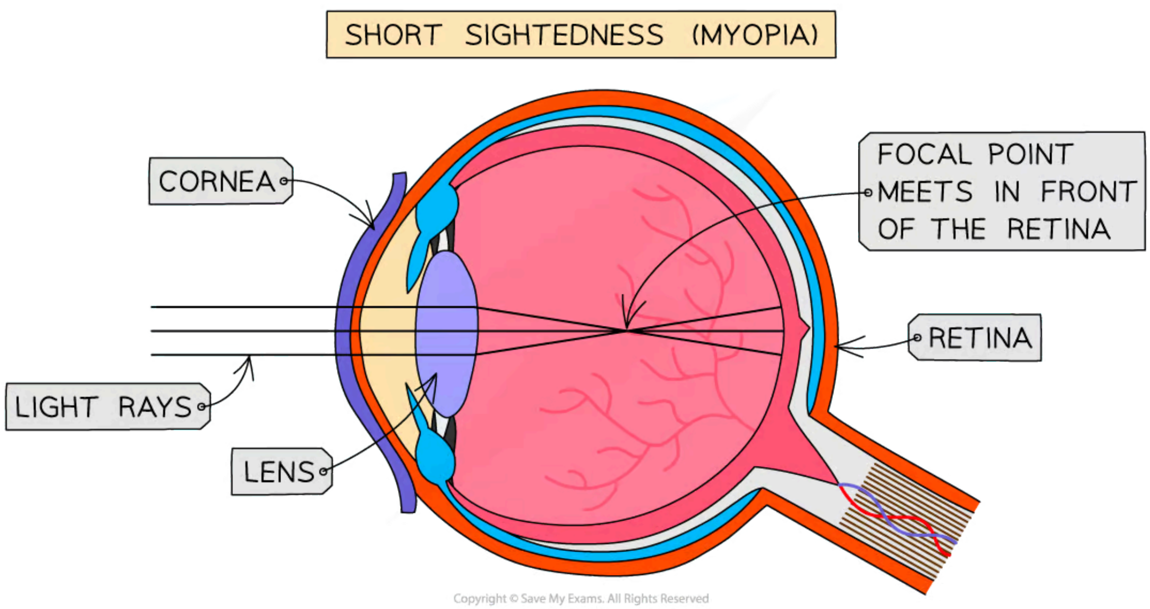
Defects of the Eye

Short-sightedness

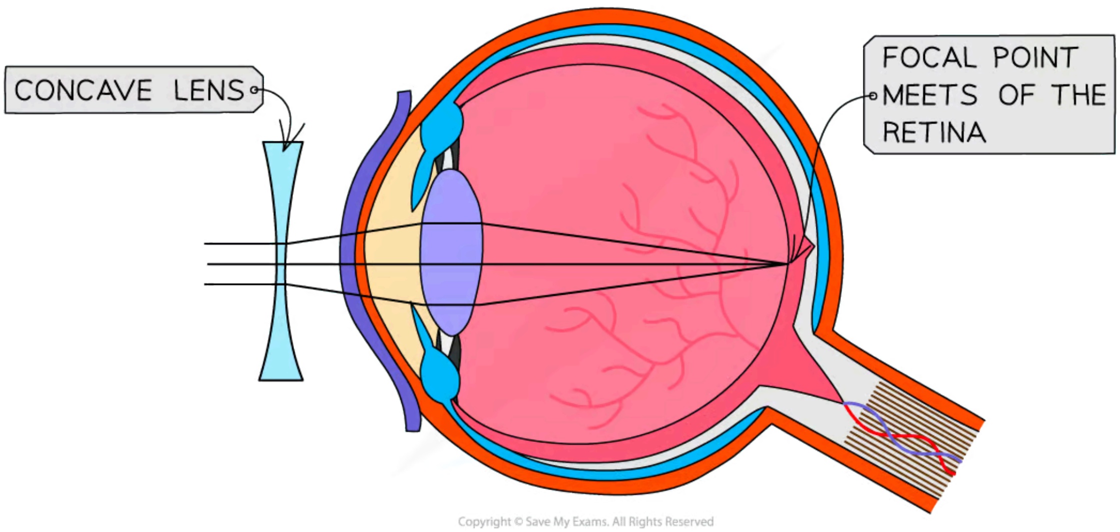
- Short-sightedness is also called myopia
- It happens when the lens is more curved than normal or the eyeball is too long which means the light is refracted too much and so the **focal point** falls in front of the retina (rather than on the retina)
  - This means that **distant objects appear blurry**

Treatment of short-sightedness

- Short-sightedness can be corrected using contact lenses or glasses with a **concave lens**



Your notes



Short-sightedness is caused when the lens is fatter than normal and so can be corrected using a concave lens

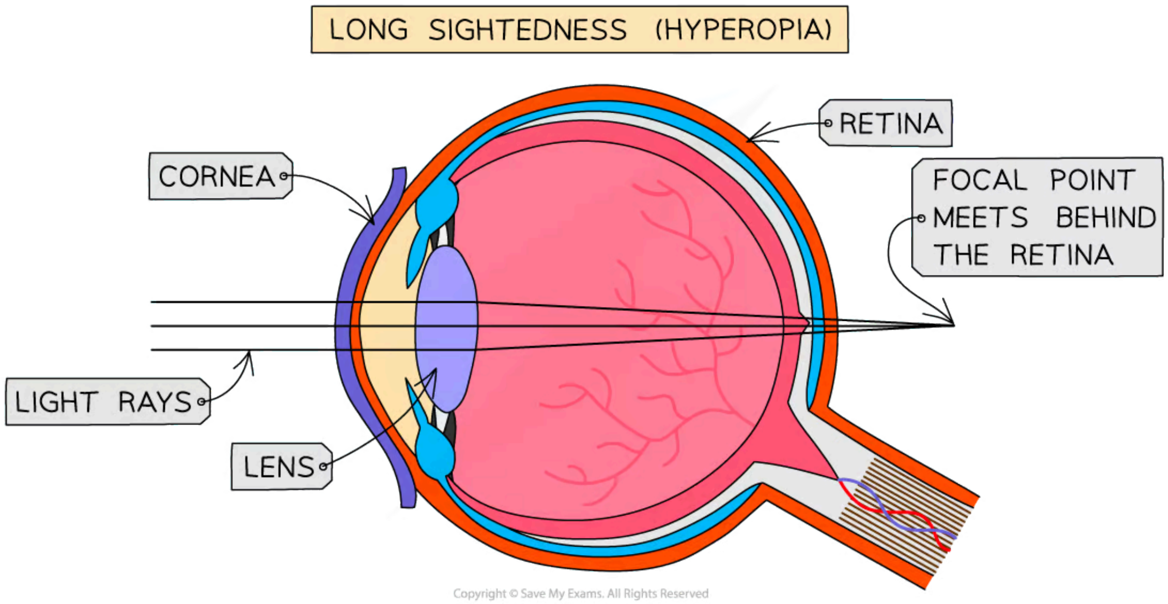
Long-sightedness

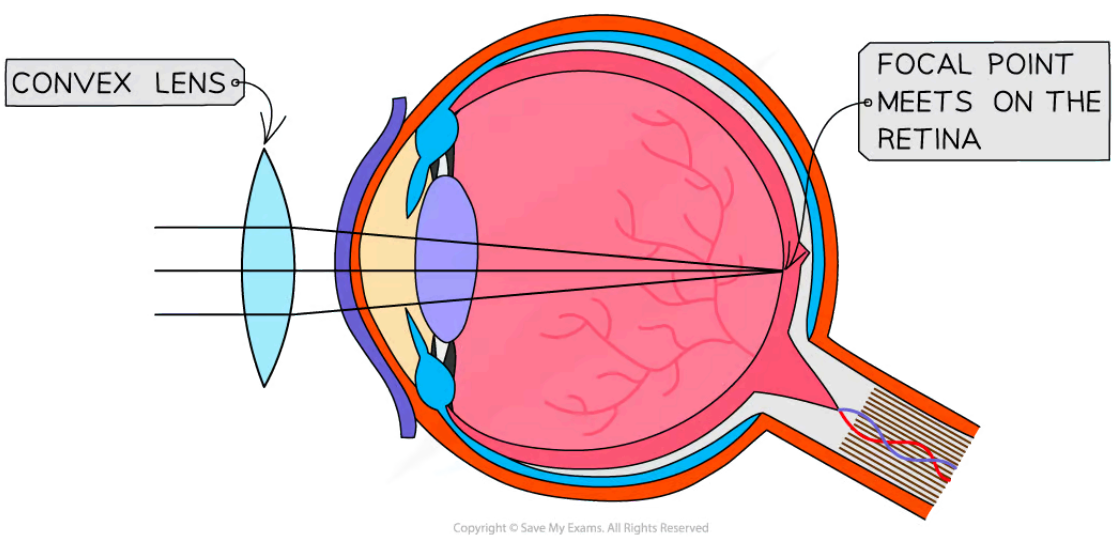
- Long-sightedness is also called hyperopia
- It happens when the lens is less curved than normal or the eyeball is too short which means the light is not refracted enough and so the focal point falls behind the retina (rather than on the retina)
  - This means that **close objects appear blurry**

Treatment of long-sightedness

- Long-sightedness can be corrected using contact lenses or glasses with a **convex lens**

Your notes





Long-sightedness is caused when the lens is thinner than normal and so can be corrected using a convex lens

Colour blindness

- People who suffer from colour blindness cannot distinguish between certain colours and in rare cases, cannot see colours at all

Your notes

- This happens because the **cones** in the **retina** do not work properly or are absent
- It is a genetically inherited condition but can also develop over time
- There are several different types of colour blindness

Treatment of colour-blindness

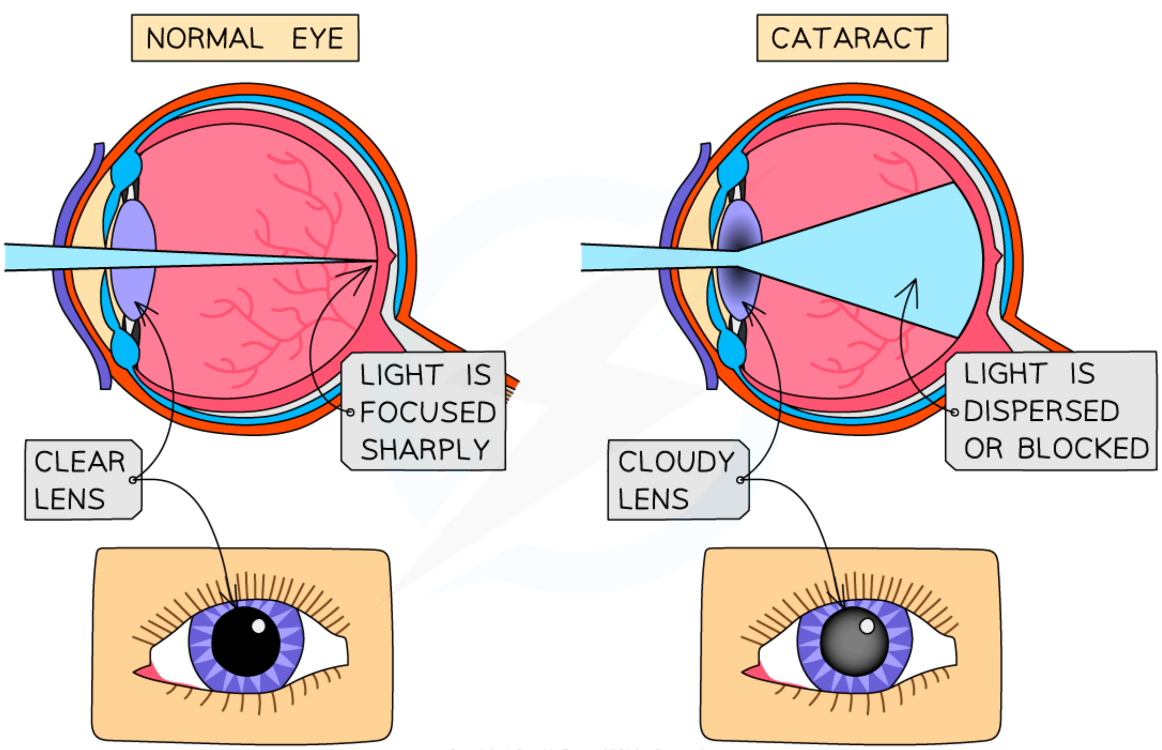
- There is currently **no cure** for colour blindness (as the cone cells cannot be replaced) so most sufferers learn to live with the condition

Cataracts

- Cataracts is a condition in which a build up of protein causes **clouding of the lens**
- A cloudy lens means that the light is dispersed throughout the eye or absorbed by the lens, rather than being sharply focussed to one particular point
- This often leads to **blurred vision**
- Eventually, if left untreated, cataracts can lead to **blindness**

Treatment of cataracts

- Cataracts can be corrected by **replacing the cloudy lens with an artificial one**



Cataracts cause the lens to become cloudy which causes the light to be dispersed or absorbed

Your notes