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RESPONDING TO THE ENVIRONMENT (HUMANS)

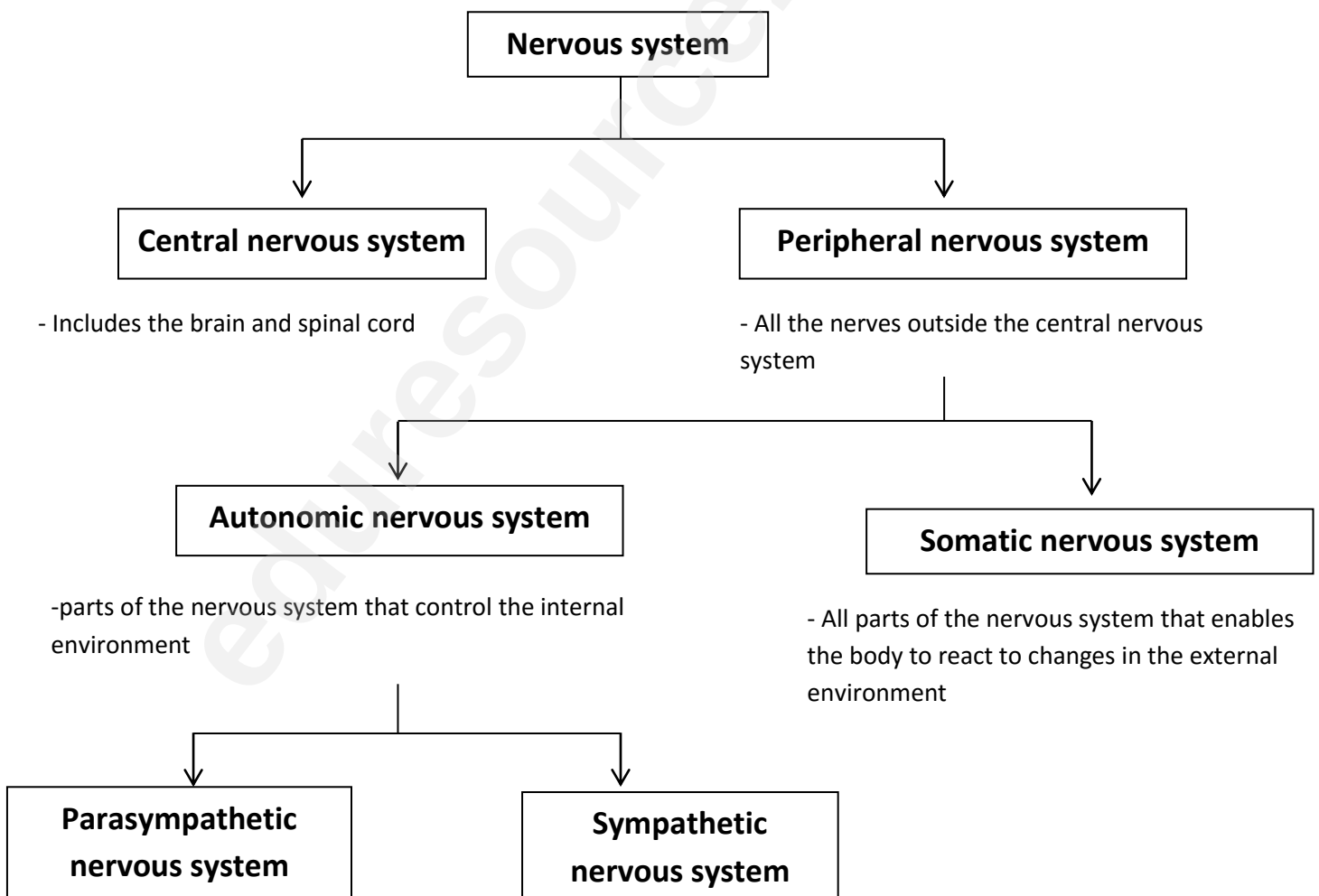
Introduction

- The **nervous system** (involving nerves) and **endocrine system** (involving hormones) are two components that help us respond to the environment
- **Stimulus** is a detectable change in the external or internal environment

Human nervous system

The need for a nervous system in humans:

- Reaction to stimuli (stimuli can be external and internal)
- Coordination of the various activities of the body



Central nervous system

- The brain and spinal cord are protected by meninges and the Cerebrospinal fluid
- **Meninges** are membranes that surround and protect the central nervous system
- **Cerebrospinal fluid** functions acts a shock absorber and prevents dehydration

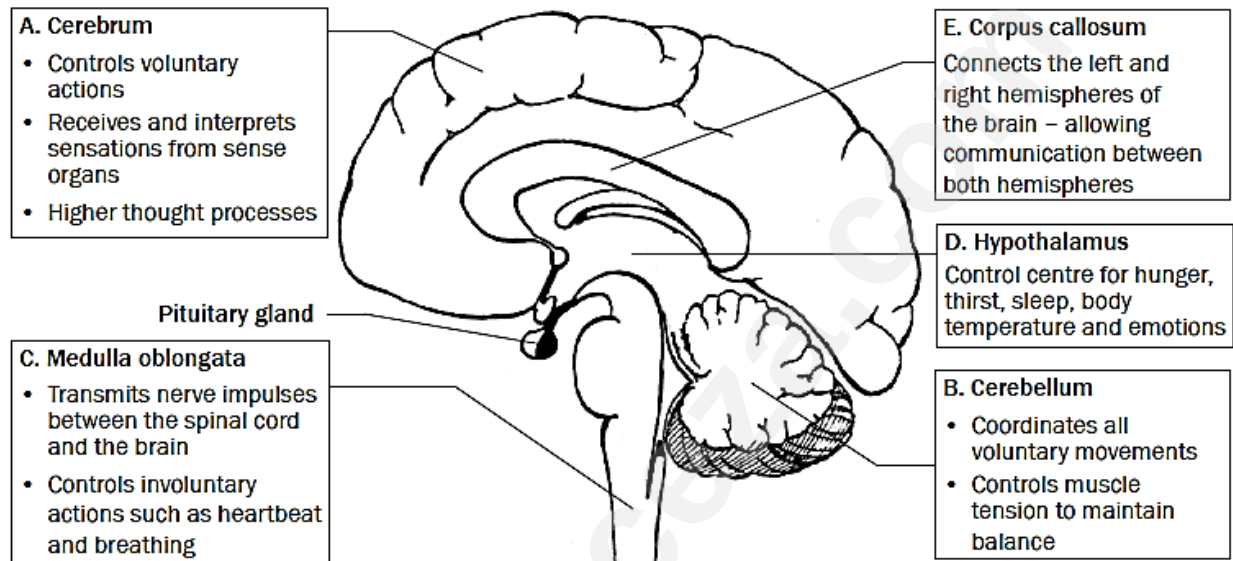


Figure 6.1 The structure and functions of the brain

Peripheral nervous system (PNS)

- Includes all nerves outside the brain and spinal cord (cranial and spinal nerves)
- Transmits impulses from the body to the CNS and from the CNS to the body
- PNS forms the somatic nervous system and autonomic nervous system
- **Somatic nervous system** – receives information from sensory organs and the brain
- **Autonomic nervous system** – controls involuntary actions

Autonomic nervous system

- Consist of the sympathetic and parasympathetic system
- **Sympathetic nervous system** – prepare the body for the stress or emergency by increasing the heart rate and breathing rate
- **Parasympathetic nervous system** – slows down the body by decreasing the heart rate and breathing rate
- The sympathetic nervous system and parasympathetic nervous system work **antagonistically** (work against each other)
- Each organ will have nerves both sympathetic and parasympathetic systems and this is called **Double innervation**

Structure and functioning of a nerve

- Nervous tissue is made up of nerve cells called **Neurons**
- All neurons consist of a cell body, dendrites and an axon
- Impulses always travel from the dendrites to the cell body then to the axon

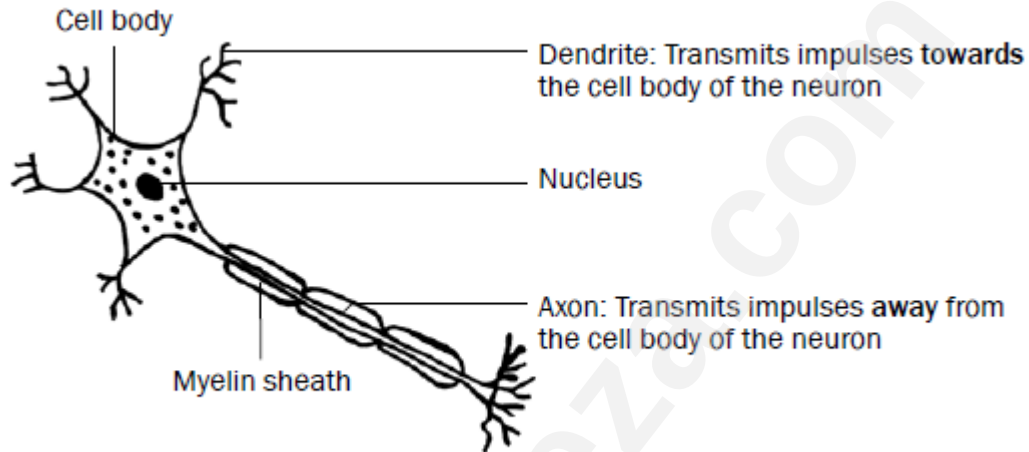
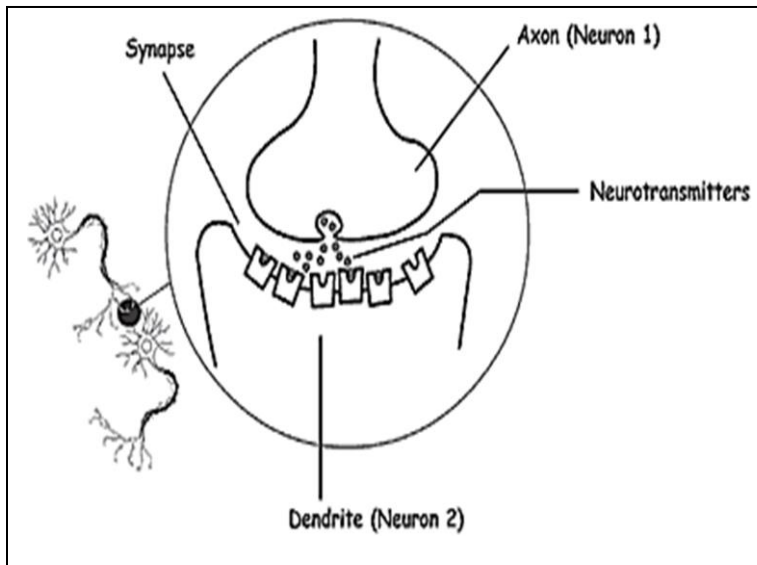


Figure 6.2 A neuron

- **Myelin sheath** – surrounds (insulates) the axons of a neuron in order to accelerate the speed of transmission of an impulse
- **Nucleus** – controls all the cell's functions
- **Cell body** – consists of the cytoplasm with a nucleus

	Sensory neuron (Afferent)	Interneuron/connector neuron	Motor neuron (Efferent)
Structure	Direction of impulses Cell body	Cell body	Cell body Direction of impulses
Function	- carry impulses from receptors to CNS	- carry impulses inside CNS from sensory neuron to motor neuron	- carry impulses from the CNS to effectors (muscles and glands)
Polarity (Position of cell body)	Unipolar/bipolar (Dendrites at each pole)	Multipolar (Many dendrites leaving the cell body)	Multipolar (Many dendrites leaving the cell body)

Synapse/synaptic gap



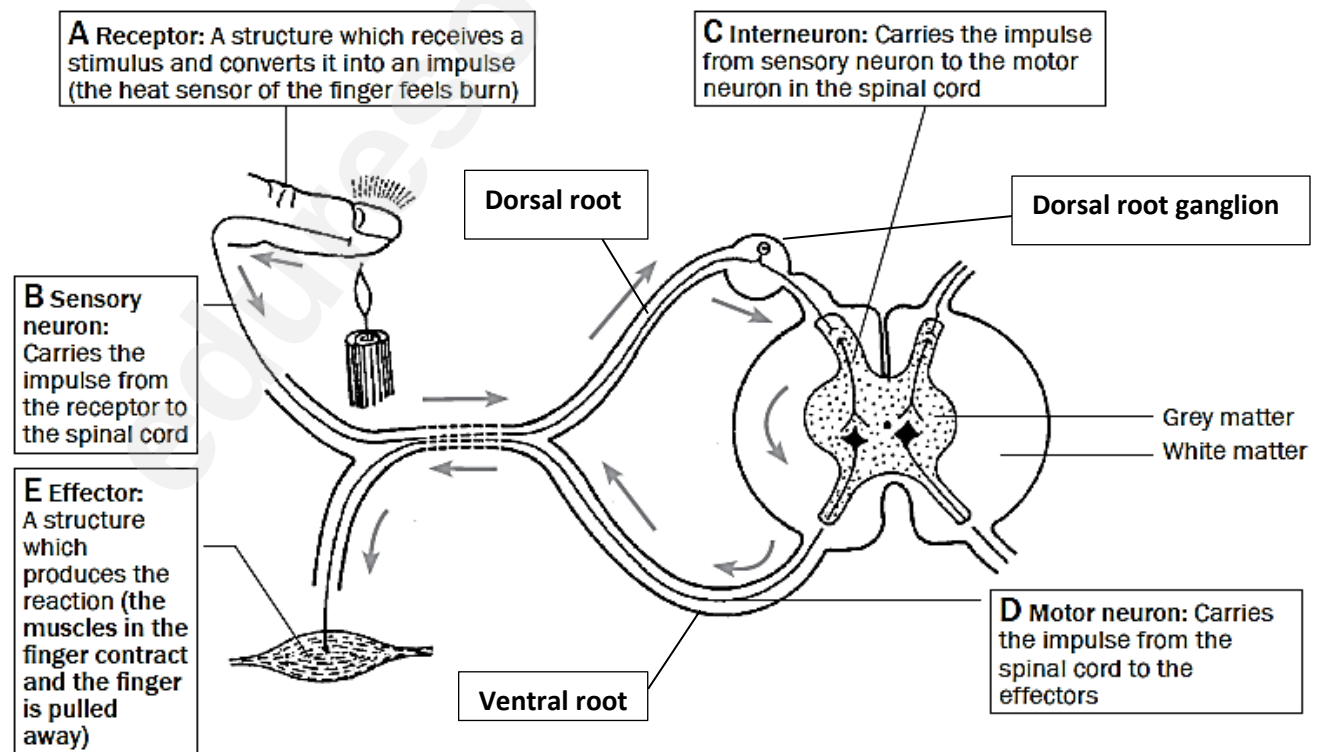
-**Synapse** is a point where an impulse passes from the end of one neuron to the dendrite of the next

-Therefore the neurons never touch each other.

-The synaptic gap insures impulses can only **travel in one direction** and it prevents continuous stimulation of the neurons

The simple reflex arc

- **Reflex action** – is a rapid, automatic (involuntary) response to a stimulus received by an organ or other receptor
- **Reflex arc** – the path taken by an impulse in bringing about a response to a stimulus during a reflex action



The path of a reflex arc:

Receptor (A) → Sensory neuron (B) → Interneuron (C) → Motor neuron (D) → Effector (E)

- Sensory neurons enter the **Dorsal root** of the spinal nerves, while interneurons are situated in the spinal cord and motor neurons leave the spinal cord through the **Ventral root**
- **Dorsal root ganglion** contains cell bodies of sensory neurons
- **White matter** consist of myelinated axons of numerous neurons and **Grey matter** consist of cell body and dendrites of numerous neurons

Describing a reflex action

- Receptors in the skin
- receive the stimulus
- Stimulus is converted into a nerve impulse
- The impulse travels along the sensory neuron towards the spinal cord
- along the dorsal root of the spinal nerve
- In the spinal cord, the sensory neuron makes synaptic contact with the connector/interneuron
- and then the impulses are transmitted along the motor neuron
- along the ventral root of the spinal nerve to the effector organ/muscle
- which contracts and pulls the hand away
- The reflex action provides a quick response to the stimulus so injury is minimised

Examples of reflex action

- Blinking
- Coughing
- Sneezing
- knee-jerk
- Pulling your hand away from a hot object

Significance of a reflex action

- Helps to protect the body by reacting quickly
- The interneuron makes a short cut not going to the brain/uses a reflex pathway that is immediately available

Disorders of the CNS

Alzheimer's disease (AD)	Multiple sclerosis
• An irreversible neuro-degenerative disease that damages the mental and intellectual functioning of the brain • Usually occurs in older people but is not part of normal aging process • Symptoms include memory loss, diminished intellectual capacity and loss of judgment	• Occurs when the body's own immune system destroys the myelin sheath. • A person with multiple sclerosis has problems with sensation, movement and mental abilities • Symptoms include muscle weakness, speech difficulties and visual problems

Injury to the central nervous system

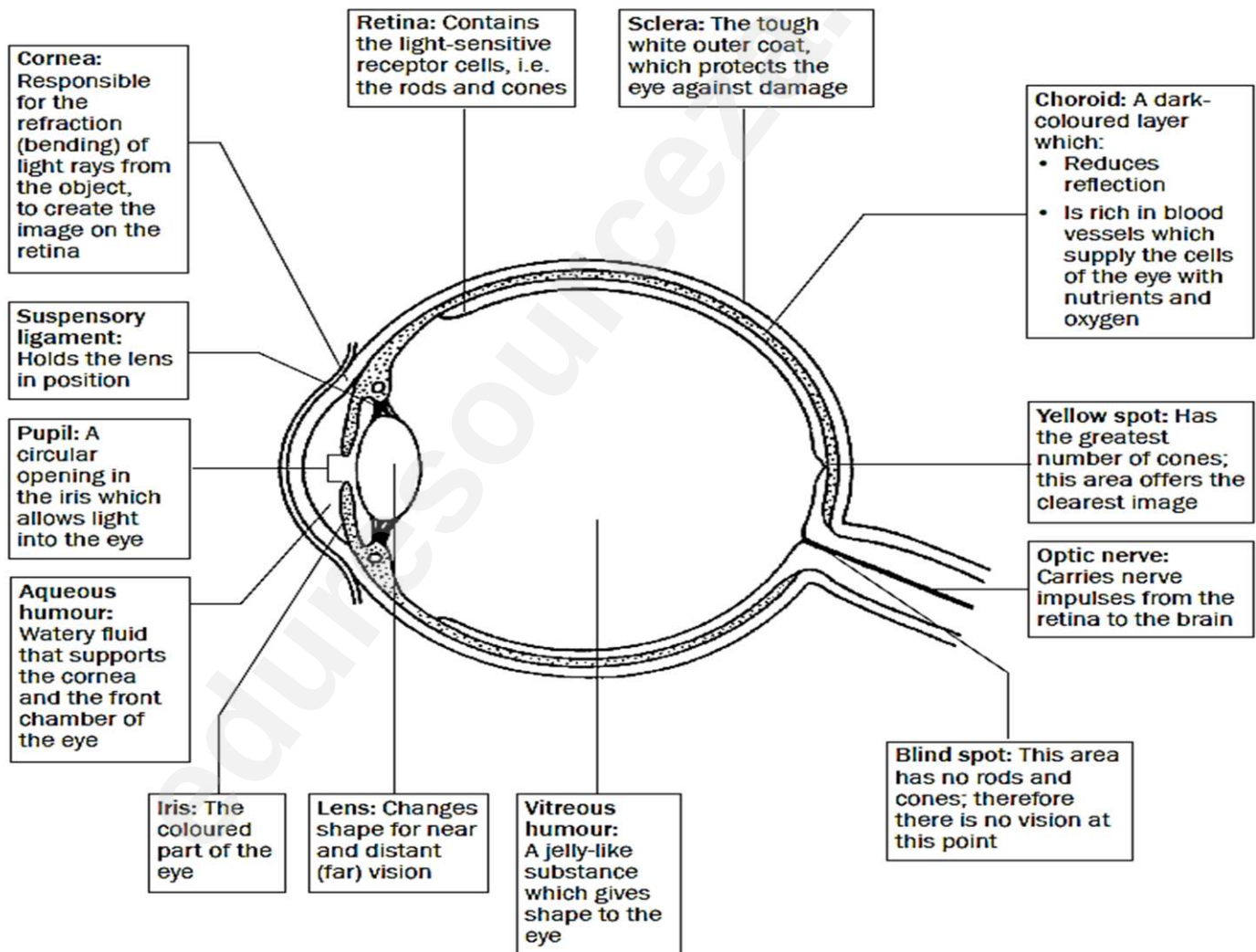
- Injuries to the CNS depend on which part of the brain is damaged
- Injuries can be caused by a direct blow to the brain or spinal cord or by stroke which reduces blood flow to the brain
 - **Damage to the cerebrum**, sensation will be affected and inability to perform voluntary movements
 - **Damage to the cerebellum**, will affect balance and equilibrium as well as the coordination of voluntary movements
 - **Damage to the medulla oblongata**, leads to difficulties in breathing paralysis and death
 - **Damage to the spinal cord**, will affect transmission of impulses from the brain to and from different parts of the brain
- **Drugs** also can damage the central nervous system
- **Alcohol** slows down the transmission of impulses and weakens co-ordination

Receptors

- Receptors are specialized cells that detect a variety of different stimuli and convert them into nerve impulse
- Sense organs are a concentration of receptors with the same function
- Stimuli detected by receptors;
 - Light
 - Sound
 - Temperature
 - Pressure
 - Pain
 - Chemicals (taste and smell)

Human eye

- The receptors that detect light stimuli are known as **photoreceptors** and are concentrated in the eye
- The front of the eye is covered by a thin membrane called the **Conjunctiva**
- The conjunctiva also has pain receptors that are stimulated by dust and foreign particles resulting the **blink reflex**
- Each eye also has six muscles that make it possible for the eye to move in all directions
- Humans have **binocular vision** (stereoscopic vision) in which we use two eyes to see and each eye produces a slightly different image of the same object and allows **us to judge distance, depth and size of an object.**

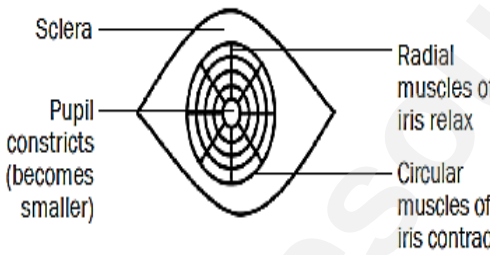
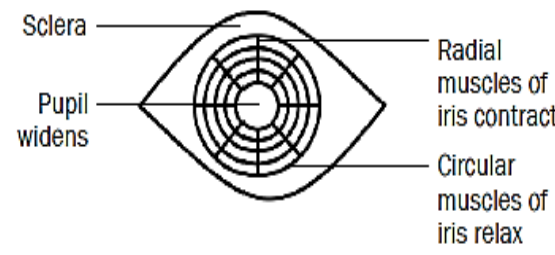


How light travels in the eye

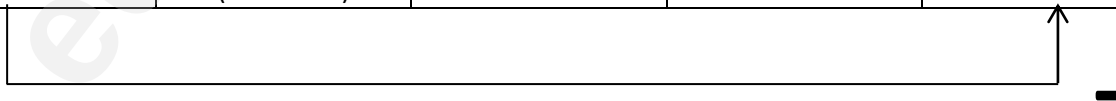
- Light enters the eye through the **cornea** which refracts the light
- Light then passes through the **aqueous humour** and the **pupil**
- The size of the pupil is adjusted by the **iris** to regulate the amount of light that enters the eye
- The light then passes through the **lens** which also refracts the light
- Light then passes through the **vitreous humour** and reaches the **retina**
- The retina has the **photoreceptors** which convert the light stimulus into a **nerve impulse**
- Nerve impulse travels using the **optic nerve** to the **cerebrum**

Pupillary mechanism

- The pupillary mechanism (or pupil reflex) regulates the amount of light entering the eye by adjusting the size of the pupil.

Bright light	Dim light
Radial muscles of the iris relax	Radial muscles of the iris contract
Circular muscles of the iris contract	Circular muscles of the iris relax
Pupil constricts (gets smaller)	Pupil widens (gets bigger)
Less light enters the eye	More light enters the eye
	

+	-	+	-	Less light enters the eye
BRIGHT LIGHT	Pupil diameter decreases (constricts)	Circular muscles contracts	Radial muscles Relaxes	

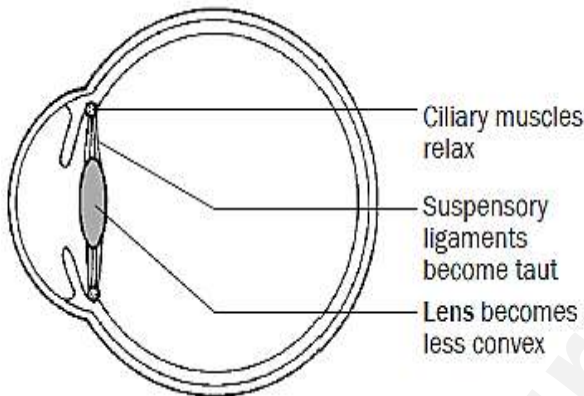
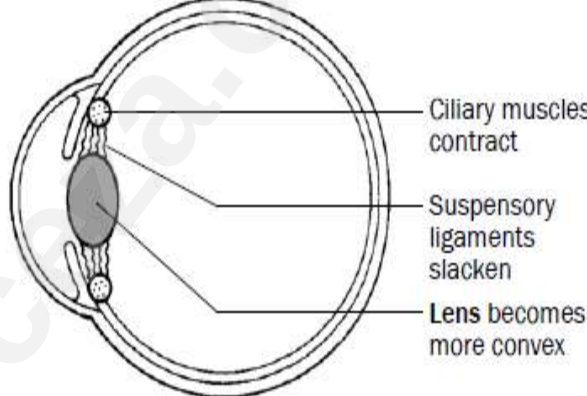


-	+	-	+	More light enters the eye
DIM LIGHT	Pupil diameter increases (dilates)	Circular muscles relaxes	Radial muscles Contracts	



Accommodation

- Accommodation is the adjustment of the shape of the lens to see objects clearly whether they are far away or close by.

Distant vision (objects further than 6m)	Near vision (objects closer than 6m)
Ciliary muscles relax	Ciliary muscles contract
Suspensory ligaments tighten (become taut)	Suspensory ligaments slacken
Tension on lens increases	Tension on the lens decreases
Lens is less convex (flatter)	Lens becomes more convex
Light rays are refracted (bent) less	Light rays are refracted (bent) more
Light rays are focused onto the retina	Light rays are focused onto the retina
	

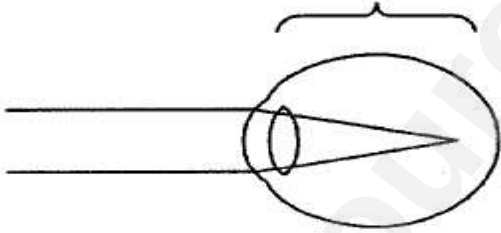
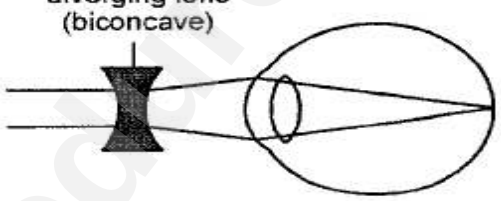
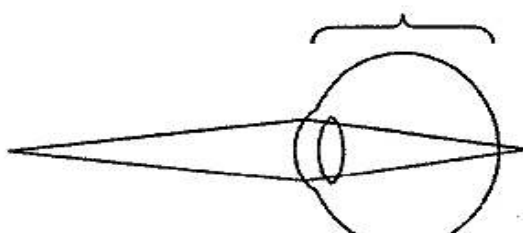
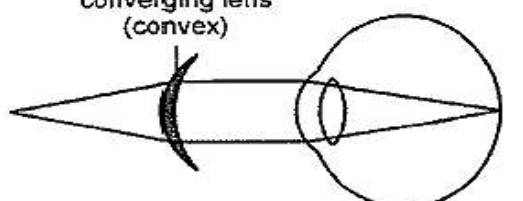
-	+	-	+	-	+	A clear image is formed on the retina
NEAR (towards)	More convex	Suspensory ligaments slacken	Ciliary muscles contract	Tension in the lens decreases	Lens bends more light	

+	-	+	-	+	-	A clear image is formed on the retina
FAR (away)	More convex	Suspensory ligaments tighten	Ciliary muscles relax	Tension in the lens increases	Lens bends less light	

Structural suitability of a lens

- Lens is elastic therefore can change shape to allow for accommodation
- Lens is transparent to allow light rays to pass through
- Lens is biconvex to refract light rays

The nature and treatment of visual defects

	Short sightedness/Myopia	Long sightedness/Hyperopia
Description	Can see near objects clearly	Can see objects that are far away
Nature of defect	➤ Inability of lens to become more flat ➤ Eyeball is longer than normal ➤ Lens bends light too much ➤ Light falls in front of the retina	➤ Inability of lens to become more convex ➤ Eyeball is shorter than normal ➤ Lens does not bend light rays enough ➤ Light falls behind the retina
Corrective measure	Glasses with concave lens	Glasses with a convex lens
Diagram	eye ball shape is longer than normal  image falls short of focal point for distant objects  diverging lens (biconcave) near-sightedness can be corrected by using a diverging lens	eye ball shape is too rounded  image falls past focal point for near objects  converging lens (convex) long-sightedness can be corrected by using a converging lens

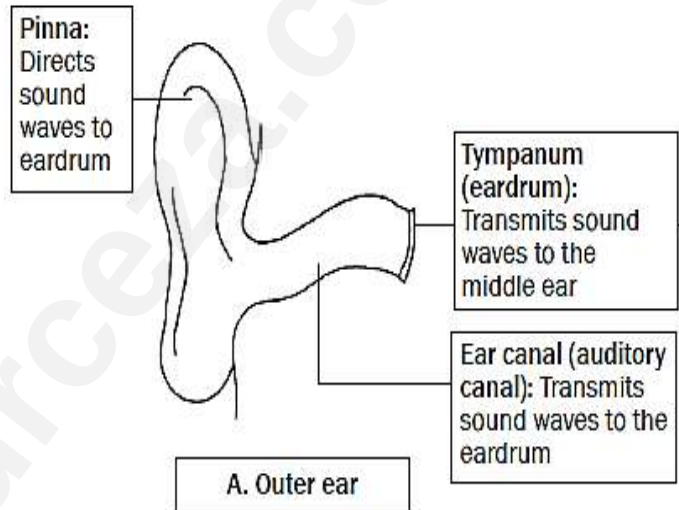
- **Astigmatism** - when the curvature of the lens or cornea is uneven resulting in distorted images. Corrected with glasses shaped to correct distortion
- **Cataracts** - when the lens becomes cloudy and opaque. Corrected by surgery to replace the lens with a synthetic lens.

Human ear

- The ears are sense organs and contain two types of sensory receptors
- One is sensitive to the stimulus of **gravity** and the other one is sensitive to **sound**
- **The ear consists of three regions:** an External air-filled region; a middle air-filled region and an inner fluid-filled region.

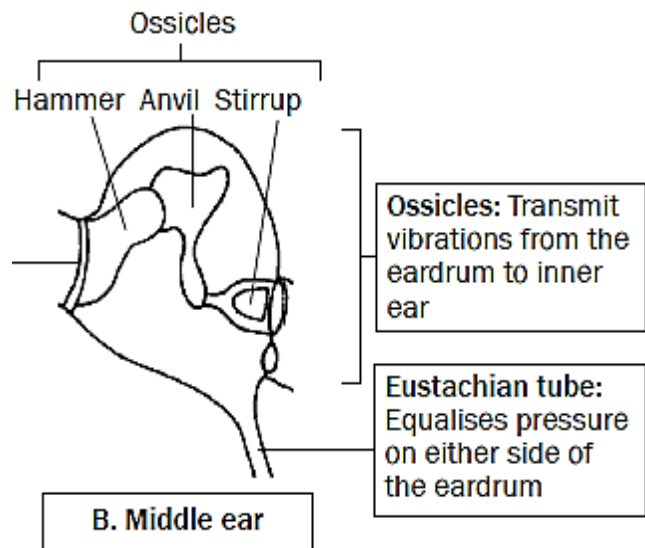
Outer ear

- Consist of the **pinna** and an **auditory canal**
- The auditory canal contains **Cerumen** (wax) and hairs that prevent small organisms from entering the ear



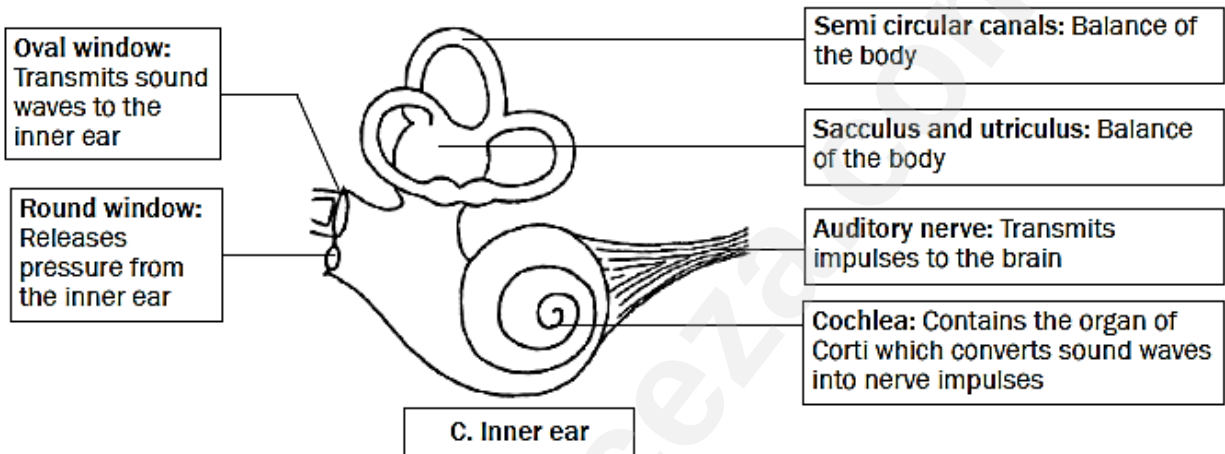
Middle ear

- Consist of the tympanic membrane, ossicles, oval window and round window
- Ossicles are the Hammer, Anvil and Stirrup (H.A.S)
- Ossicles **amplify sound vibrations**
- The **hammer** is attached to the tympanic membrane, the **anvil** lies between the hammer and stirrup while the **stirrup** is attached to the oval window
- The middle ear is connected to the pharynx (part of the throat) by the **Eustachian tube**

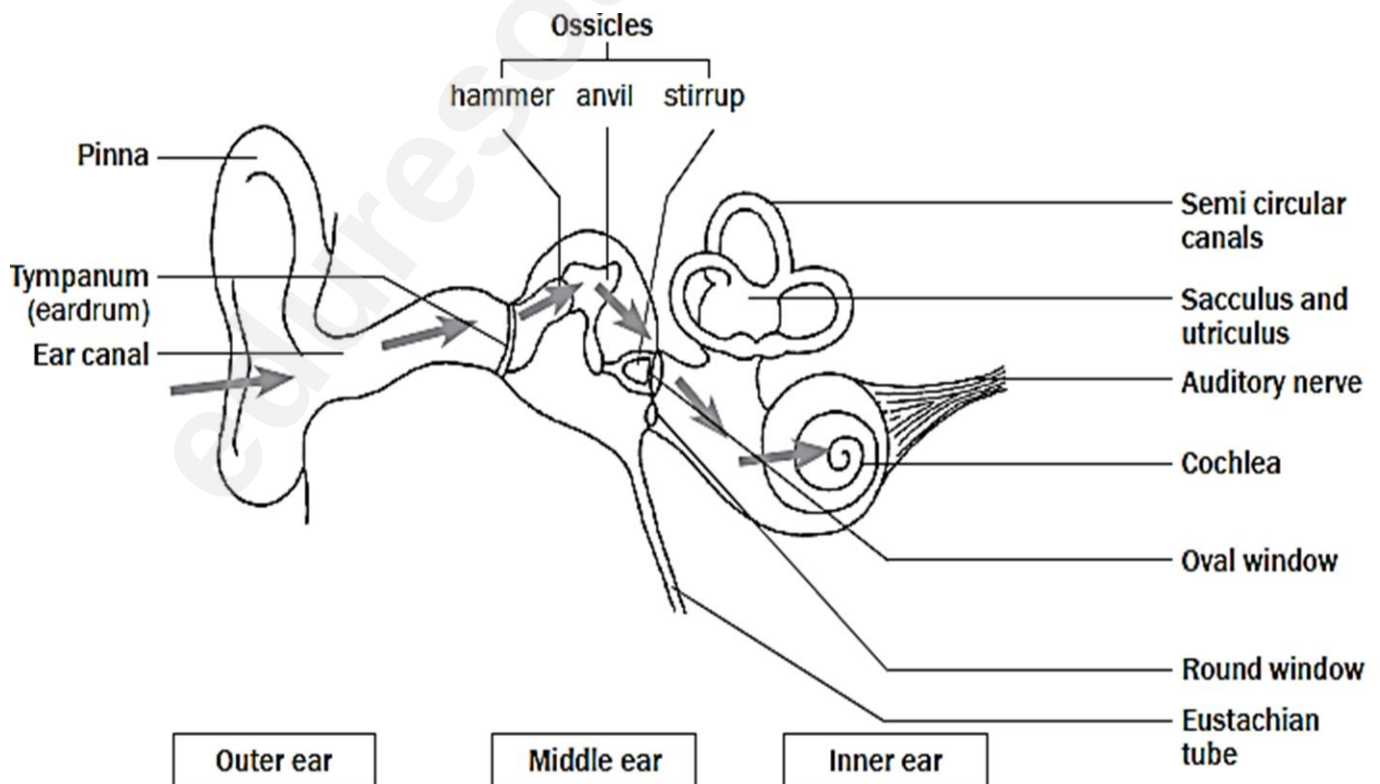


Inner ear

- Vibrations causes pressure waves in the liquid of the **perilymph** in the inner ear
- Pressure waves cause the sensory cells in the **Organ of Corti** to brush or bend against the membranes converting the stimulus into an **impulse**
- **Round window** prevents pressure accumulating and echoes



Hearing



Description of hearing

- The sound waves were directed by the **pinna** through the **auditory canal** to the **tympanic membrane**/eardrum
- the tympanic membrane vibrates
- The vibrations of the tympanic membrane are transferred to the **ossicles** in the middle ear
- Ossicles **amplify the vibrations**
- Vibrations of the ossicles cause the **oval window** to vibrate
- This set up pressure waves in the **cochlea**
- This stimulated the **Organ of Corti** in the cochlea to convert this stimulus into a **nerve impulse**
- The nerve impulse is then transmitted along the **auditory nerve** and interpreted in the **cerebrum**
- Excess pressure in the middle ear is eased through the **Eustachian tube**
- Excess pressure in the inner ear is eased through the **Round window**

Balance

- A change in the direction and speed of the body causes the movement of fluid in the semicircular canals which stimulates the **cristae**
- A change in the position of the head stimulated the **maculae** in the utricle and saccule
- The stimuli were converted into impulses which were transported along the auditory nerve and interpreted in the **cerebellum**
- which then sent impulses to the muscles
- to restore balance and equilibrium

Consequences of a blocked Eustachian tube

Air will not be taken in/released to equalise pressure on both sides of the tympanic membrane. Tympanic membrane/ossicles may not vibrate freely, this may lead to the tympanic membrane bursting and therefore could lead to hearing loss deafness/pain

Consequences of an infection in the Eustachian tube

Mucus in the middle ear will lead to the blockage of the Eustachian tube which will not be able to equalise the pressure in the middle ear resulting in pressure on the tympanic membrane that may cause the tympanic membrane to burst leading to hearing loss.

Consequences of fused ossicles

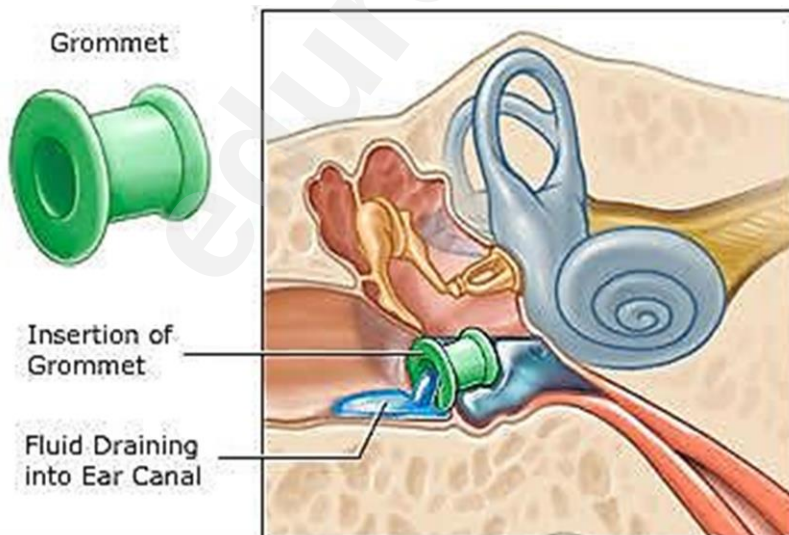
Ossicles will not be able to vibrate and transfer vibrations to the oval window and hearing will be affected

Structural suitability of the tympanic membrane and oval window

Tympanic membrane has a **larger surface area** than the oval window. Therefore the incoming sound waves are concentrated on to a smaller area thus amplifying the sound

Hearing defects

Hearing defect	Causes	Treatment
Middle ear infection	Bacterial infection that disturbs the functioning of the Eustachian tube (blocked by fluid)	• Inserting a grommet • Antibiotics
Deafness	• Injury to parts of the ear • Injury to parts of the brain responsible for hearing • Hardened wax • Fused ossicles	• Hearing aids • Cochlear implants

Grommet

-Allows air to enter the middle ear thereby taking over the function the Eustachian tube

-Allows excess fluid to drain from middle ear