

Neural Control and Coordination

1 INTRODUCTION

- Coordination is the process through which two or more organs **interact** and **complement** the functions of one another to **maintain homeostasis** in our body.
- The **neural system** and the **endocrine system** jointly coordinate and integrate all the activities of the organs so that they **function in a synchronised fashion**.

4 TYPES OF AXONS/NERVE FIBRES

Parameters	Myelinated	Non-myelinated
Myelin sheath	+	-
Node of Ranvier	+	-
Location	Cranial & spinal nerves	Autonomic and somatic neural system

- Schwann cells surround both myelinated and non-myelinated nerve fibres but they form myelin sheath only in myelinated fibres.

5 CONCENTRATION GRADIENT ACROSS AXONAL MEMBRANE

- Excitability** of neurons is attributed to polarised state of neural membranes.
- It has **selectively permeable ionic channels** responsible for differential concentration gradient across the axonal membrane
- Axonal membranes** are **more permeable for K^+** , **nearly impermeable to Na^+** and **impermeable to negatively charged proteins**.

Types of fluids Composition

Types of fluids	Composition
ECF	K^+ ↓, Na^+ ↑
ICF	K^+ ↑, Na^+ ↓

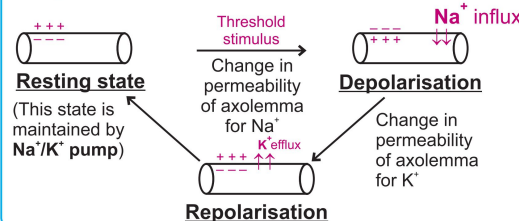
- Ionic gradients** across resting membrane are maintained by the active transport of ions by the **sodium-potassium pump** which pumps $3Na^+$ outwards and $2K^+$ into the cell

2 SYSTEMS MAINTAINING HOMEOSTASIS

PARAMETERS	NEURAL SYSTEM	ENDOCRINE SYSTEM
Integration	Through neurotransmitters	Through hormones
Coordination	Quicker	Slower
Neural system provides an organised network of point to point connections with target cells.		

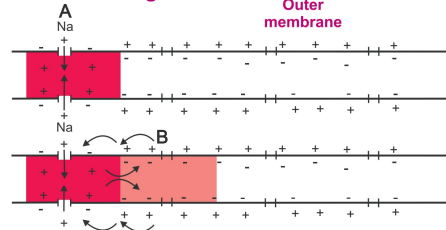
6 GENERATION OF IMPULSE

- The electrical potential difference across the resting plasma membrane is called the **resting potential**
- The electrical potential difference across the axonal membrane after receiving **threshold stimulus** is called **action potential/nerve impulse**.
- Cycle of events:**



7 CONDUCTION OF IMPULSE

- Impulse generated at a site arrives at another site and same sequence is repeated along the length of axon.
- Current flows in a circuit when it moves from A to B site.**
- Flow of charge is from A to B**



3 NEURON

- Neuron is the structural and functional unit of the neural system
- Composed** of a cell body, dendrites and axon

Types	No. of Dendrites	Location
Multipolar	2 or more	Cerebral cortex
Bipolar	1	Retina of eye
Unipolar	0	Embryonic stage

- Above given neurons have only one axon.
- Cell body contains cell organelles.
- Impulse from dendrite moves towards cell body and in axon away from cell body.

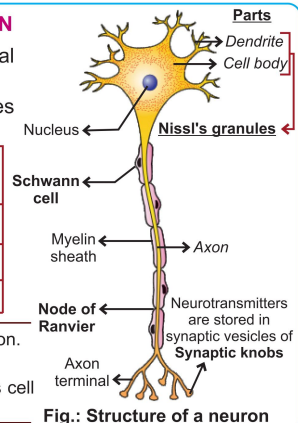


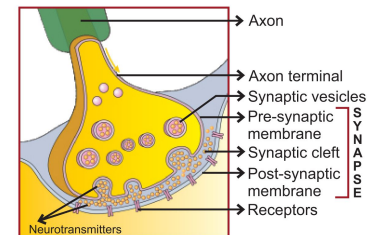
Fig.: Structure of a neuron

8 TRANSMISSION OF IMPULSE

- Nerve impulse is transmitted from one neuron to another across a **synapse**.

Events observed:

- Neurotransmitters released in synaptic cleft
- Bind to receptors on post synaptic neuronal (PSN) membrane
- Opening of ion channels in PSN
- Generates a new potential in PSN



Types of Synapse

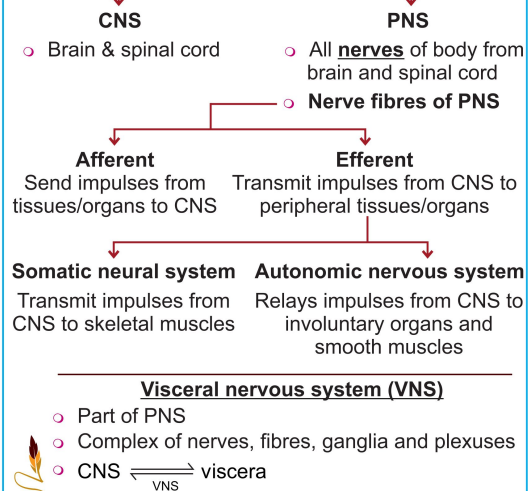
Features	Electrical synapse	Chemical synapse
Pre & post neuron	Close proximity through gap junctions	Separated by fluid-filled synaptic cleft
Flow of impulse	Direct	Through neurotransmitters
Transmission	Faster	Slower
Nature	-	Excitatory or inhibitory
Existence	Rare	Common

- Transmission of impulse across electrical synapse is very similar to impulse conduction along a single axon.

9 NEURAL SYSTEM

- Neurons can detect, receive & transmit stimulus
 - Hydra – Network of neurons
 - Insects – Organised neural system with brain and ganglia
 - Vertebrates – Well developed neural system

10 HUMAN NEURAL SYSTEM



11 CENTRAL NERVOUS SYSTEM

- Acts as command & control system of the body
- Protective coverings
 - Skull
 - Meninges
- Outer: Duramater
- Middle: Arachnoid
- Inner: Piamater
- Name of meninx: Skull
- In contact with: Brain
- Major Divisions of Brain:

Divisions	Major parts
Forebrain	Cerebrum, thalamus, hypothalamus
Midbrain	Corpora quadrigemina
Hindbrain	Pons, medulla, cerebellum

13 REFLEX ACTION AND REFLEX ARC

- It's a response to peripheral nervous stimulation
- Involuntary i.e., without conscious effort
- Involves part of CNS.

Reflex pathway

Receptor → Afferent neuron → CNS → Efferent neuron → Effector/Excitor

- Neurons are arranged in series in a reflex pathway.
- Afferent neurons transmit impulse via dorsal nerve root.
- Inter neuron is not a part of this stretch reflex

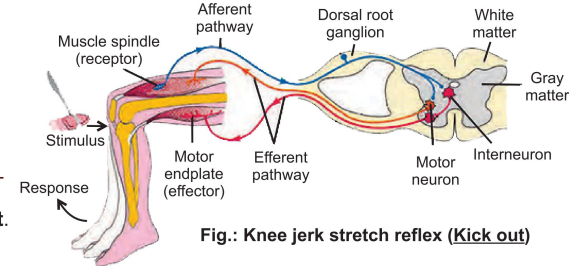


Fig.: Knee jerk stretch reflex (Kick out)

12 BRAIN

- Brain is central information processing organ of the body

Forebrain

- Cerebrum
 - Major part of brain
 - Cleft divides it longitudinally into right & left cerebral hemispheres, connected by corpus callosum
- Thalamus
 - Major coordinating centre for sensory & motor signaling

- Hypothalamus
 - Lies at base of thalamus
 - Has various centres for controlling body temperature, urge for eating and drinking
 - Secretes hormones

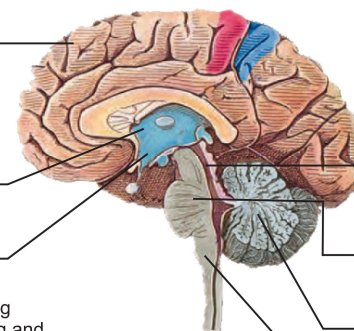


Fig.: Sagittal section of human brain

Regions in cerebral hemisphere	Appearance	Composition
Outer/cortex	Grey	Concentrated cell bodies
Inner	White	Myelinated nerve fibres

- The cerebral cortex includes

Sensory areas Motor areas Association areas (Neither sensory nor motor)



Limbic system/Limbic lobe

- Parts included: Inner part of cerebral hemisphere, hippocampus, amygdala and hypothalamus
- Functions:
 - Involved in expression of emotional reactions (e.g., excitement, pleasure, rage, fear)
 - Motivation
 - Regulation of sexual behaviour
 - Autonomic responses
 - Olfaction

Midbrain

- Corpora Quadrigemina
 - located between thalamus/hypothalamus and pons
 - 4 lobes on dorsal side between forebrain and pons.
 - Integrates visual, tactile and auditory inputs.
- Cerebral Aqueduct
 - Canal passes through midbrain

Hindbrain

- Pons
 - Fibrous tract that connects different regions of the brain
- Cerebellum
 - Convolved surface to accommodate more neurons
 - Integrates information received from semicircular canal and auditory system
- Medulla oblongata
 - Connects brain to spinal cord
 - Has centres for controlling respiration, cardiovascular reflexes and gastric secretions

- Brain Stem is composed of Midbrain, Pons and Medulla oblongata

Basic Functions of Brain

- Controls the voluntary movements
- Balance of body
- Functioning of vital organs (kidneys, lungs, heart)
- Thermoregulation
- Controls hunger, thirst
- Circadian rhythms
- Human behaviour
- Activities of endocrine glands

Neural Control and Coordination

1 SENSORY RECEPTION AND PROCESSING

- Sensory organs detect all types of changes in the environment

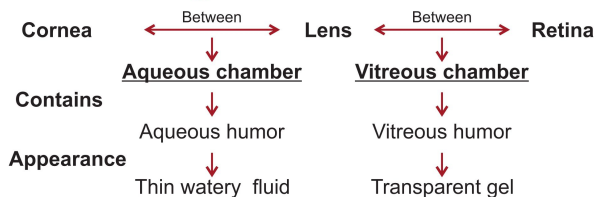


2 SENSE ORGANS

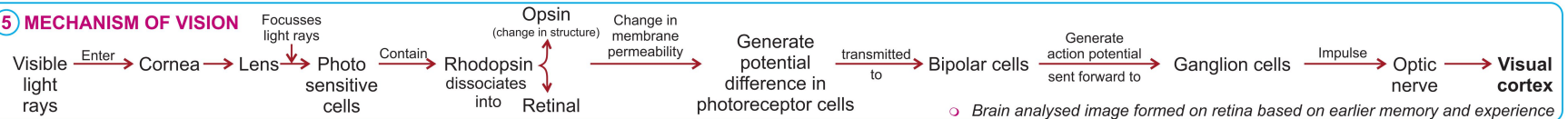
Sense organ	Sense	Features associated
Nose (single)	Smell	<ul style="list-style-type: none"> Mucus coated olfactory epithelium having three types of cells Neurons extend directly into bean sized olfactory bulb that are extensions of limbic system.
Tongue (single)	Taste	<ul style="list-style-type: none"> Input from taste buds is conveyed to the brain and a complex flavour of food or drink is perceived
Ear (paired)	Hearing, balance	<ul style="list-style-type: none"> Input from organ of Corti and vestibular apparatus is conveyed to CNS.
Eye (paired)	Vision	<ul style="list-style-type: none"> Enclosed in sockets of skull (orbits) Nearly spherical in structure

- The chemical senses of **gustation** (taste) and **olfactory** (smell) are functionally similar and inter related as they detect **dissolved** chemicals.

4 CHAMBERS IN EYE



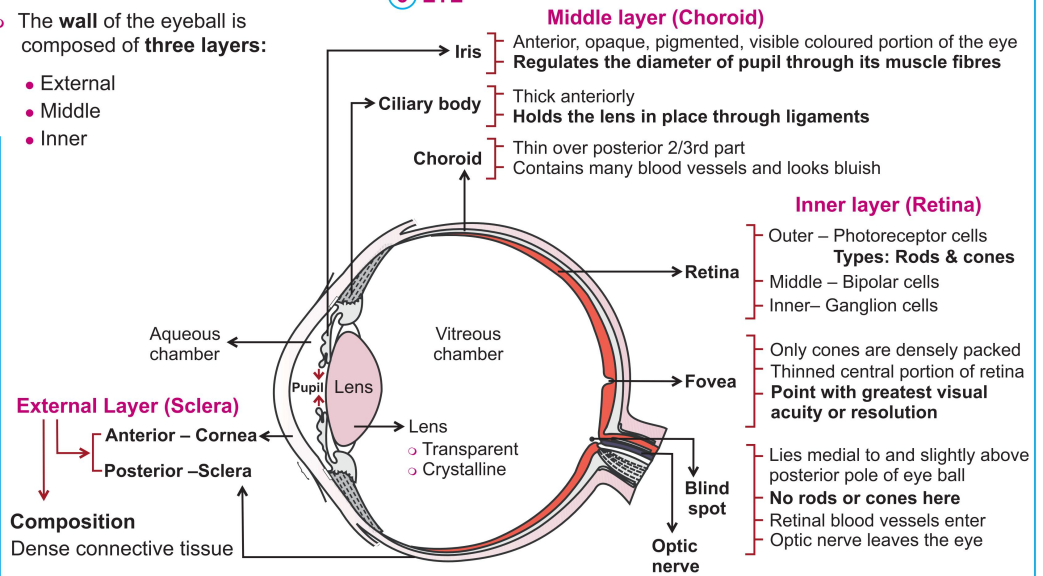
5 MECHANISM OF VISION



3 EYE

- The wall of the eyeball is composed of **three layers**:

- External
- Middle
- Inner

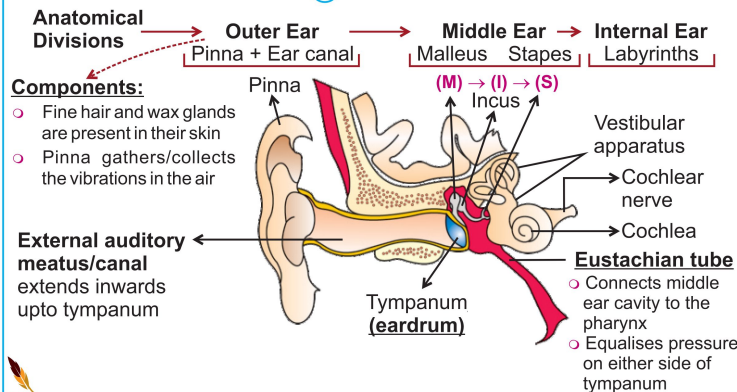


- Macula lutea** – Yellowish pigmented spot lying at the posterior pole of eye lateral to the blind spot with a central pit called **fovea**.

Photoreceptor cells	Vision	Photopigments (light sensitive proteins)
Rods	Twilight/Scotopic vision	Rhodopsin/ Purplish red protein/ visual purple
Cones	Day light/ Photopic vision and Colour vision	Types of cones <ul style="list-style-type: none"> Red Green Blue <ul style="list-style-type: none"> Different photopigments in these cones Sensation of different colours by various combinations Equal stimulation of these gives sensation of white light

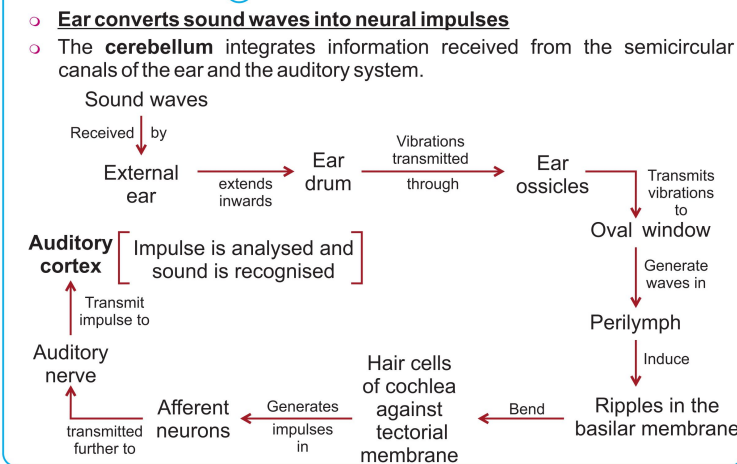
- Photopigments contain an aldehyde of vitamin A/retinal and protein, opsin.**

6 THE EAR



- Tympanic/membrane** is composed of
 - (a) Connective tissue covered with skin on the outside
 - (b) Mucus membrane on the inside
- Ear ossicles** → Arranged in a chain (M → I → S)
 - Structural details**
 - Malleus is attached to tympanum
 - Stapes is attached to the oval window
 - Function** → Increase efficiency of transmission of sound waves to the inner ear

9 MECHANISM OF HEARING



7 LABYRINTH

- It is a **fluid filled** inner ear, consists of two parts: **Bony and Membranous labyrinths**
- Bony Labyrinth → Encloses → Membranous Labyrinth (filled with perilymph) → (filled with endolymph)

Parts of Membranous labyrinth	Sub-parts	Receptors	Basic functions
<ul style="list-style-type: none"> Vestibular apparatus (complex system) 	(a) Semicircular canals (3) (b) Otolith organ Utricle Saccule	Crista ampullaris Macula	<ul style="list-style-type: none"> Maintenance of balance of the body and posture. Influenced by gravity and movements
<ul style="list-style-type: none"> Cochlea (coiled appearance) 		Sensory hair cells in organ of Corti	<ul style="list-style-type: none"> Hearing

- Semicircular canals lie at right angle to each other and the base of each canal is swollen called **ampulla**.
- These membranous canals are suspended/surrounded by perilymph of the bony canals
- Vestibular apparatus is present above the coiled cochlea.
- Receptors present in vestibular apparatus have hair cells.**

8 COCHLEA

Demarcating membrane	Chambers	Fluid present within	Terminating region
Reisner's	Scala vestibuli	Perilymph	Oval window
Basilar	Scala media	Endolymph	
	Scala tympani	Perilymph	Round window

Organ of Corti

- Located on **Basilar membrane**
- Contains **sensory hairs** present in rows on internal side of organ of Corti, that act as **auditory receptors**.
- Sensory hair cells
 - Apical part** – Possess **stereocilia**
 - Above them there is thin elastic membrane called **Tectorial membrane**
 - Basal part** – Is in close contact with **afferent nerve fibres** forming the **auditory nerve**

