Neural Control and Coordination.

Coordination : The mechanism by which two or more organs communicate and complement each other's functions is called coordination.

→ The nervous system and the endocrine system jointly coordinate and integrate all the activities of organs in our body so that they function in a synchronised fashion.

→ Neural system offers a proper point-to-point network of connections for rapid coordination.

Neural system

→ Neurons are highly specialised cells of the neural system of all animals which can detect, receive and transmit different kinds of stimuli.

→ Nervous system absent is phylum Porifera.
In Hydra, neural system is composed of a network of neurons, without brain.

→ A brain is present along with a number of ganglia and neural tissues in the insects, neural system in insects is better organised.

→ A more developed neural system is seen in the vertebrates.

Human Neural system

→ derived from ectoderm

→ All the nerves of the body associated with the CNS (brain and spinal cord) are included in the PNS.

→ The nerve fibres of the PNS are of two types :
a) afferent fibres or sensory
b) Efferent fibres or motor

→ Impulse from tissues/organs to the CNS are transmitted by the afferent nerve fibres, efferent fibres transmitted regulatory impulses from the CNS to concerned Peripheral tissues/organs

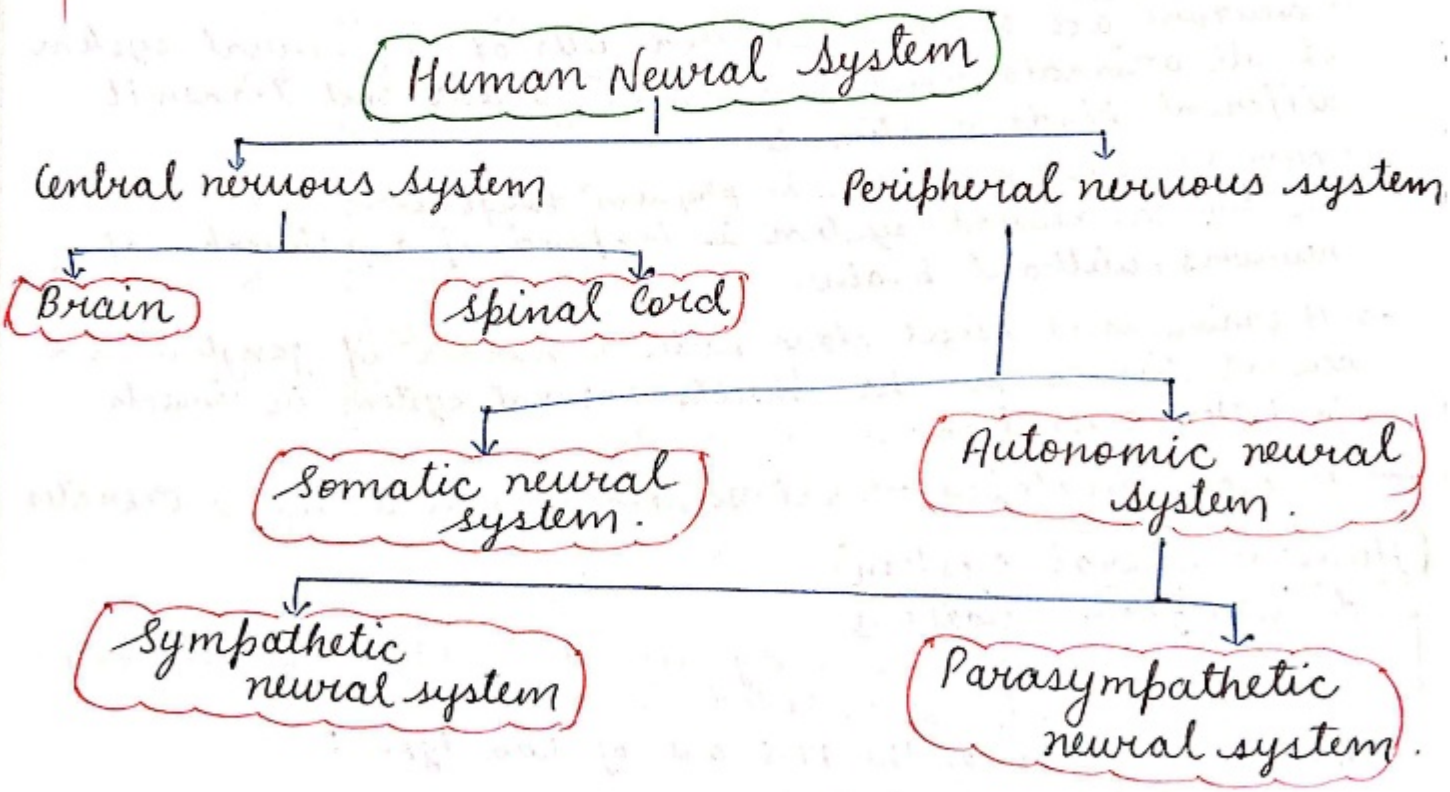
→ Somatic neural system relays impulses from the CNS to ~~involuntary Organs & smooth muscles of the body~~ skeleton muscles (Voluntary)

→ Somatic neural system and autonomic neural system are the two divisions of peripheral neural system.

→ The autonomic neural system transmits impulses from CNS to involuntary organs & smooth muscles of the body.

→ The two divisions of autonomic neural system are sympathetic neural system (emergency) and parasympathetic neural system (normal/relax).

→ Visceral nervous system (involuntary)
↳ part of peripheral nervous system comprises the whole complex of nerves, fibres, ganglia and plexuses by which impulses travel from the central nervous system to the viscera and from the viscera to the central nervous system.



↦ Neuron as structural and Functional unit of neural system.

- A microscopic structure called neuron
- Composed of three major parts: 1) Cell body
  2) Dendrites
  3) Axon
  } called Neuron

1.) Cell body

→ Containing a large nucleus, called cyton
or Perikaryon
or Soma

→ Nissl's granules are certain granular bodies that are found in the cytoplasm cell body also contains typical cell organelles.

RER and ribosomes make up Nissl's bodies.

NOTE:

→ Group of cell bodies in CNS is called nuclei
→ Group of cell bodies in PNS is called ganglia

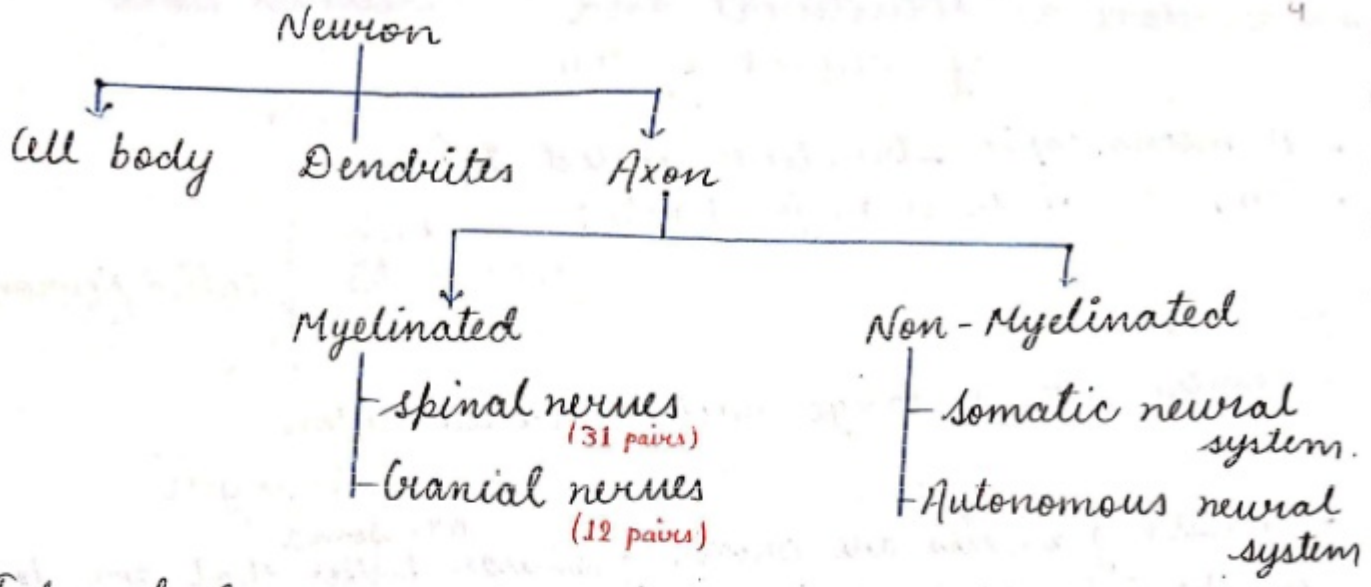
2.) Dendrites

- short fibres branched repeatedly and project out of the cell body also contains Nissl's granules.
- helps in transmitting impulses towards the cell body

3) Axons

- long fibre
- plasma membrane called axolemma covers the axons and has cytoplasm known as axoplasm.
- distal end of axon is branched.
  Branch terminates as a bulb-like structure called synaptic knob possess synaptic vesicles containing chemicals
  ↓
  Neurotransmitters
- Transmission of nerve impulses away from the cell body to a synapse or to a neuro-muscular junction done by axons.

bundle of axons called nerve in PNS
tract in CNS.



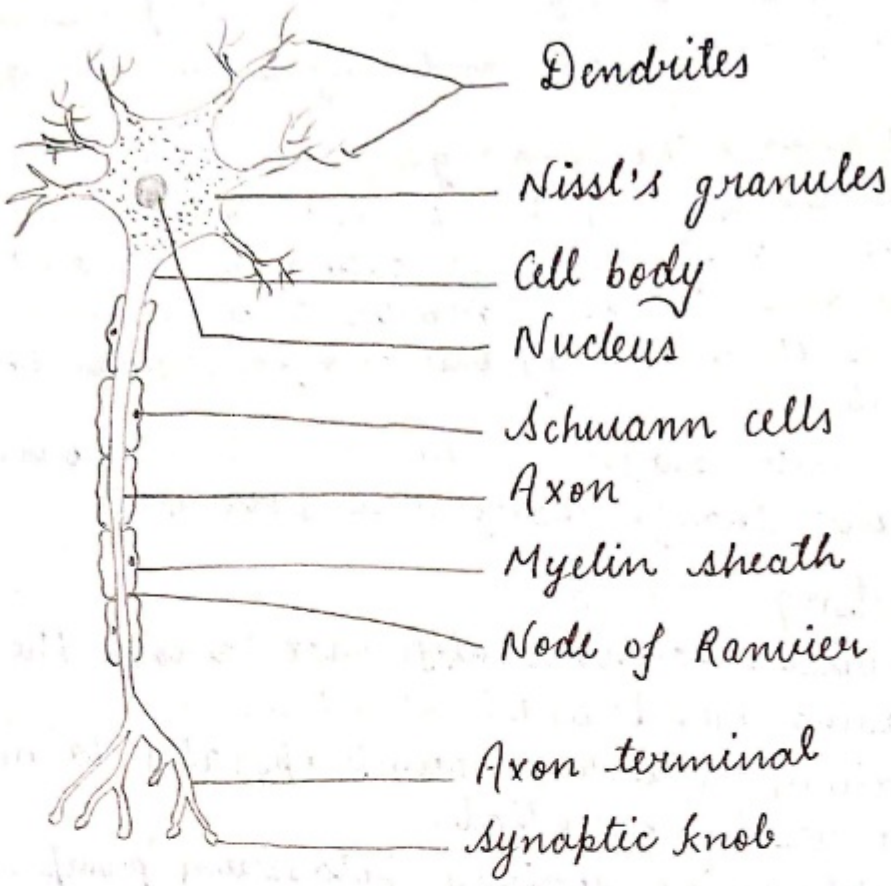
Types of Axons or Nerve fibres.

- Myelinated and non-myelinated are two kinds of axons
- Schwann cells from envelop the myelinated nerve fibres.
- Schwann cells form a myelin sheath around axon.
- HW Two adjacent myelin sheaths - a gaps knowns as nodes of Ranvier.
- Myelinated nerve fibres in spinal and cranial nerves.
- Unmyelinated nerve fibre is enclosed by a Schwann cell but does not form a myelin sheath around axon, usually seen in autonomous and the somatic neural systems.

Types of Neurons

Depending on no. of axons and dendrites, the neurons divided in three types:

1) Unipolar: Cell body with one axon only
   eg: found usually in embryonic stage.
2) Bipolar: With one axon and one dendrite
   eg: found in retina of eye.
3) Multipolar: With one axon and two or more dendrites
   eg: found in Cerebral Cortex.



Structure of a neuron

↦ Generation and Conduction of Nerve Impulse

→ membranes are in a polarised state
→ neurons are excitable cells.
→ On the neural membrane different forms of ions channels are present.
→ The channels of ions selectively permeable to different ions.

* Resting stage

→ Axonal membrane comparatively more permeable to potassium ions (K^+) & almost impermeable to sodium ions (Na^+) and -ve charge protein present in axoplasm when a neuron does not conducting any impulse.
→ axoplasm within the axon therefore contains high K^+ Concentrations & negatively charged proteins, low Na^+ Concentrations.

↳ Concentration gradient across axonal membrane.
→ The fluid outside axon, by comparison, has a low K^+ concentrations and ~~negatively charged proteins~~, a high Na^+ concentration

↳ During Resting stage
- Active transport of ions by the sodium – Potassium Pump which transports 3 Na^+ outwards for 2 K^+ into the cell maintains the ionic gradients across the resting membrane.
- This results in a negative charge inside the axonal membrane.
- The outer surface of the axonal membrane possesses a positive charge therefore is polarised.

↳ Resting Potential
- Electrical potential difference across the resting Plasma membrane (−70 mV)
- Sodium Potassium pump operates to maintain the resting potential.
- stoppage of Sodium-potassium pump results in initiation of nerve impulse.

↳ During Excited stage
- On a polarised membranes a stimulus is applied at a site (Eg. Point A), the membrane at the site A becomes freely permeable to Na^+ which leads to a rapid influx of Na^+ followed by reversal of polarity at that site i.e outer surface of membranes become -vely charged and inner side becomes positively charged

↳ Depolarization
- At the site A the polarity of the membrane is reversed and hence membrane is depolarised and the phenomenon called depolarization.

↦ Nerve Impulse

- Action potential is the electrical potential difference across the plasma membrane at the site A. (+20 mv to 60 mv).

↦ Inner surface Current / Outer surface Current.

- The membrane of axon, immediately ahead (eg-, site B) has a positive charge on the outer surface and a negative charge on its inner surface.
- In result a current flows on the inner surface from site A to site B.
- To complete the circuit of current flow. The current flows from site B to site A on outer surface.
- This results in reversal of the Polarity and an action potential is generated at site B. This leads to the arrival of impulse (action potential) at site B generated at site A.
- along the length of the axon, the sequence is repeated and the impulse is ~~connected~~ Conducted Consequently.

↦ Inshort :

i) In Resting stage

→ Axonal membrane permeable for k^+ ions and impermeable for Na^+ ions and -ve charge protein.

→ Sodium potassium pump works in this condition.

→ So, sodium potassium transport 3 Na^+ outside to axonal membrane and 2 k^+ inside to axonal membrane i.e in axoplasm.

→ Axonal membrane outer positive & inner negative.

ii) In Excited stage

→ axonal membrane permeable for Na^+ ion i.e Na^+ ion enter into axoplasm.

→ Inner axonal plasma membrane +ve
Outer axonal membrane -ve

→ Sodium Potassium Pump stops

→ generate action potential or electrochemical wave.

→ (-ve) — (+ve) — (-ve)

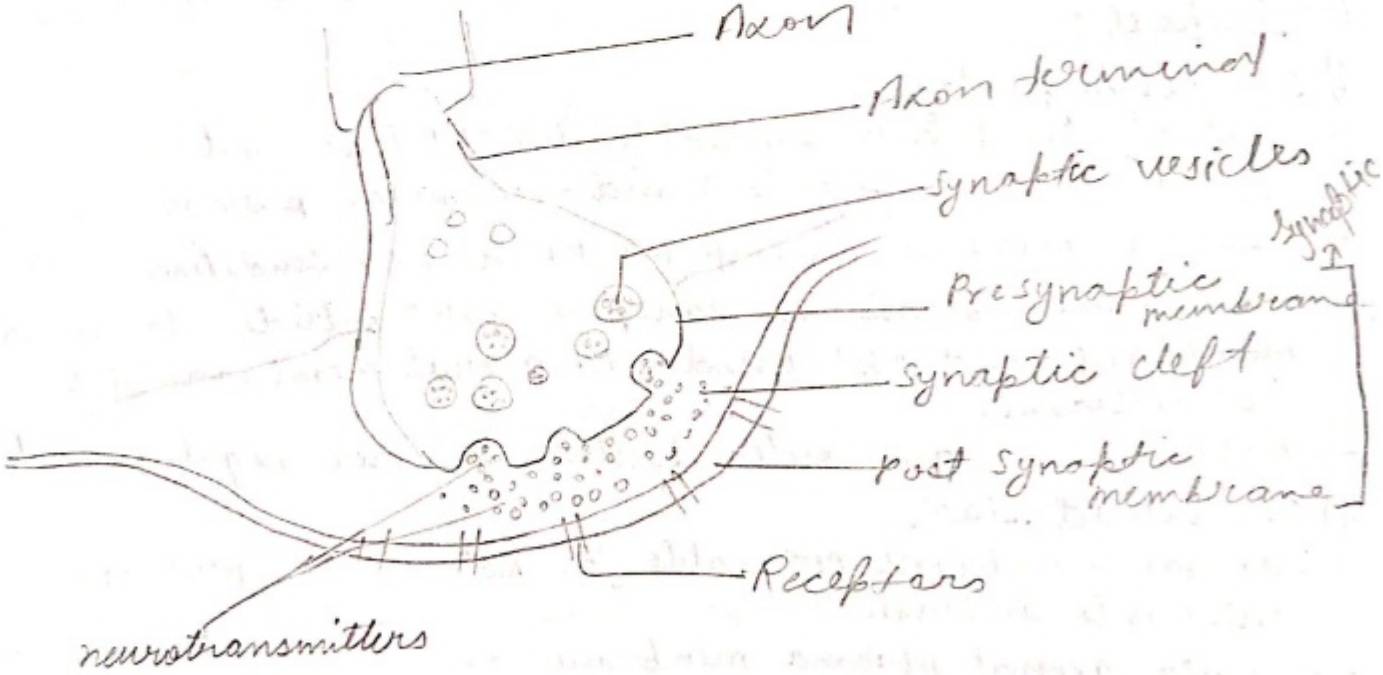
→ Value ⇒ +20 to 60 mV

Sequence

Polarization → Depolarization → Repolarization → Hyperpolarization → Polarization

↔ Electrical Synapses

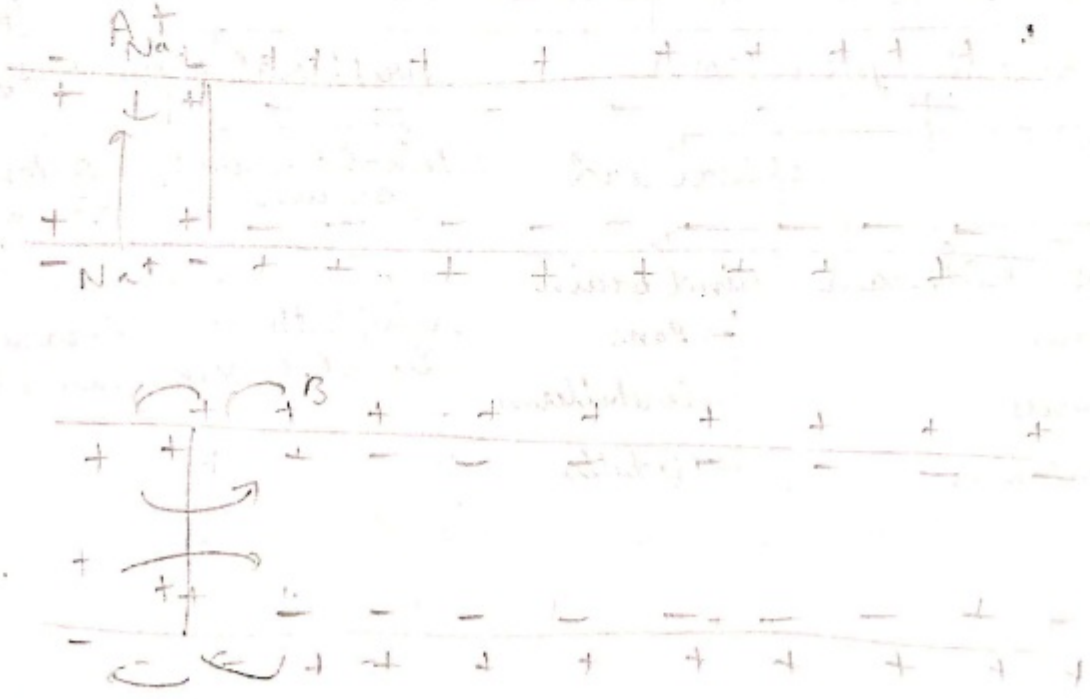
- Membranes of pre-and post-synaptic neurons are in very close proximity at electrical synapses.
- These synapses, electrical current can flow directly from one neuron into the other.
- The transmission of an impulse across electrical synapses is very similar to conduction of impulse along a single axon.
- Transmission of impulses electrical synapse across a chemical synapse is usually quicker than that.
- In human system, electrical synapses are rare.



Axon terminal and synapse

↔ Chemical synapses

- Membranes of pre- and post-synaptic neurons are separated at a chemical synapse by a fluid-filled space called the synaptic cleft.
- Nerve impulse movement through synaptic clefts is Chemical phenomenon.
- Chemicals called neurotransmitters are involved in transmission of impulses.
- The terminal of axons contain vesicles filled with neurotransmitters
- When an impulse arrives at axon terminal, it stimulates the movement of synaptic vesicles towards the membrane - fuse with the plasma membrane of pre-synaptic neuron and release their neurotransmitter into synaptic cleft.
- released neurotransmitters, bind to unique receptors present on post-synaptic membrane.
- The Developed new potentials can either be exciting or inhibitory



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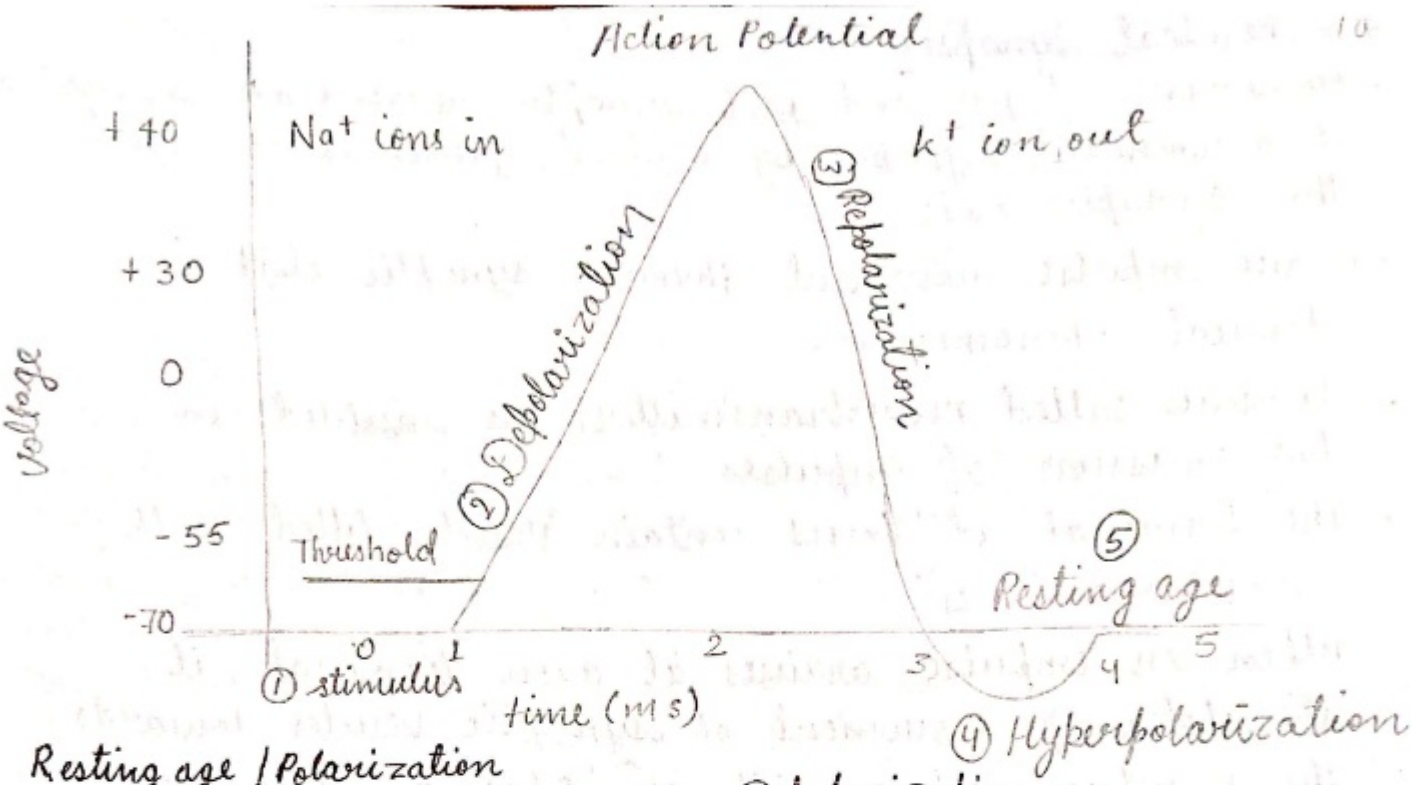


Resting age / Polarization

- → -70 mV
- → Outer ⇒ +ve
- → Inner ⇒ -ve

Depolarization

- → +30 mv spike potential
- → Action potential / impulse
  (−) (+) (−)
- → Outer ⇒ -ve
- → Inner ⇒ +ve

Human Neural System

- Central Neural System (CNS)
  - Brain
    - Forebrain
      - → Cerebrum
      - → Thalamus
      - → Hypothalamus
    - Midbrain
    - Hind brain
      - → Pons
      - → Cerebellum
      - → Medulla
  - Spinal Cord
- Peripheral Neural system (PNS)
  - Somatic Neural system
  - Autonomic Neural system
    - Symphathetic neural system
    - Parasymphathetic neural system

✳ In short note

⇒ In resting stage

→ Axonal membrane permeable for K^+ impermeable for Na^+ & (-ve) charge protein.

→ Na & K pump work transport $3Na^+$ outside to axonal membrane & $2K^+$ inside axonal membrane i.e. in axoplasm.

Polarisation ←
↓
Depolarisation
↓
Repolarisation
↓
Hyperpolarisation

Central Neural System

→ Brain and spinal Cord are the 2 parts of CNS.
→ The Brain is human body's central information processing organ and act as 'The System of Command and Control'
→ The brain Controls voluntary movements and involuntary Organs (eg: lungs, heart & kidneys etc)
→ Skull well protects the human brain,

The Brain is surrounded by cranial meninges containing an outer layer called (dura mater)
A very thin middle layer called (Arachnoid mater)
An inner layer (Contacting brain tissue) → (Pia mater) ↓ richly supplied with capillaries.

→ Subdural space is called the space b/w the duramater and the arachnoid.
→ space b/w arachnoid and piamater is refered to as Subarachnoid.
→ Subarachnoid space is filled with Cerebrospinal fluid (CSF) ↓ Protects the brain from shocks.
→ The Human brain divided into three major parts :-

i) Forebrain
ii) Midbrain
iii) Hindbrain

* Forebrain
  └→ Composed of Cerebrum, thalamus and Hypothalamus.

1.) **Cerebrum**

→ The major part of Human brain.

→ A deep cleft longitudinally divides the cerebrum into two halves, which are called the left and right Cerebral hemispheres.

→ Corpus Callosum
↳ a tract of nerve fibres that connects right and left Cerebral hemispheres.

Outer portion consists of grey matter and is called Cerebral Cortex while,

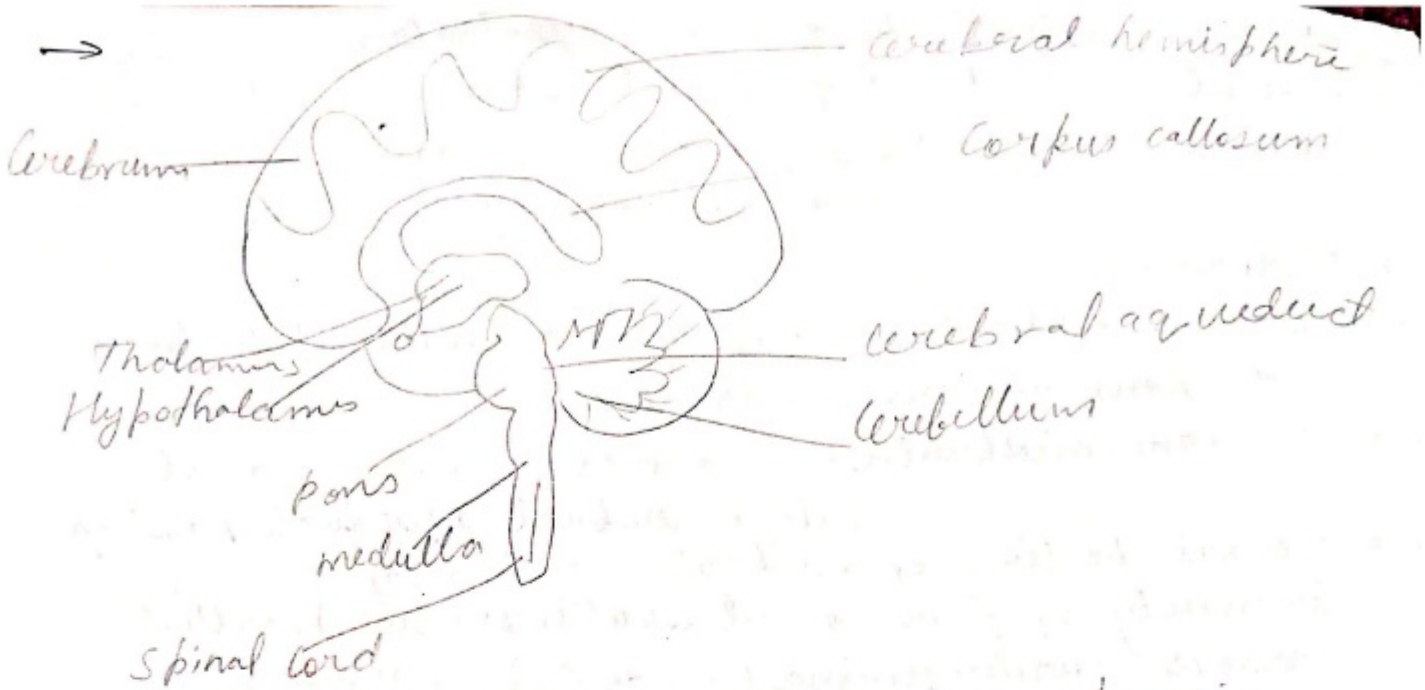
Inner part consists of white matter and is called Cerebral medulla.

* Cerebral Cortex : layer of cells
↓
Covers the Cerebral hemisphere and is thrown into prominent folds.

↓
greyish colour,
so called grey matter and the cell bodies of neurons are concentrated here giving the colour.

→ Cerebral cortex also contains motor areas, sensory areas, and large regions that are neither clearly sensory nor motor in fns! → This regions called association areas.
↓
responsible for Complex functions such as intersensory associations, memory and communication.

→ The fibres of tract are covered with myelin sheath
↓
forms inner part of Cerebral Hemisphere
↓
Called white matter.



Section of human brain

2.) Thalamus
- → major coordinating centre for sensory and motor signalling.
- → Cerebrum wraps around the thalamus.

3.) Hypothalamus
→ Located at the base of thalamus, hypothalamus have
↓
have a variety of centres that regulates sleep, body temp., urge for eating and drinking (appetite and Satiety centre).

→ Hypothalamic also includes
↓
several groups of neurosecretory cells called hypothalamic hormones that secrete hormones.
↓
regulates the secretion of trophic hormones from adenohypophysis (anterior pituitary)

→ It forms a bridge b/w endocrine and neural systems.
→ Diencephalon is jointly formed by thalamus & Hypothalamus.
→ Inner parts of cerebral hemispheres and a group of deep related structures, such as amygdala, hippocampus etc, form a complex system called Limbic lobe or limbic system.
↳ Concerned with Olfaction

→ Limbic system along with hypothalamus is involved in controlling sexual behaviour, expressing emotional reactions {eg: excitement, pleasure, rage & fear, and motivation}

* Midbrain
→ located b/w thalamus / hypothalamus of forebrain and pons of the hindbrain.
→ Through midbrain → one can find a canal called cerebral aqueduct passing.
→ Dorsal portion of midbrain consists of primarily of four round swellings (lobes), called Corpora quadrigemina (Connected to vision)

* Hindbrain
→ Composed of Pons, Cerebellum and medulla ↓ also called medulla oblongata.

1. Pons
→ Consists of fibre tract that interconnected different regions of the brain.

2. Cerebellum
→ very convoluted surface to provide the additional space for plenty of neurons.
→ contains flask shaped purkinje cells.
→ regulates body position in equilibrium and voluntary muscle movement (motor coordination)
Cerebellum integrates information obtained from auditory system and {semi-circular canals for the ear. } also called Vestibular apparatus.

3. Medulla oblongata
→ Medulla connected to spinal cord.
→ regulates respiration, cardiovascular reflexes and gastric secretions as well as Vomitings.

→ Inshort:

1) Forebrain (prosencephalon)
- olfactory lobe
- Cerebrum → # lateral Ventricle
  # Telencephalon
- # Epithalamus
- Thalamus } # Third Ventricle
- Hypothalamus } # Third Ventricle

Dencephalon

2) Midbrain (Mesencephalon) → four round lobes
- 2 anterior colliculi (vision)
- 2 Posterior colliculi (Auditory)

smelling.
Corpora quadrigemina & canal called cerebral aquaduct or iter.

3) Hind brain (Rhombencephalon)
- Pons } # Metencephalon
- Cerebellum } # Metencephalon
- Medulla → # fourth Ventricle
  # Myelencephalon.