

Physiology

Topic : Nerve physiology

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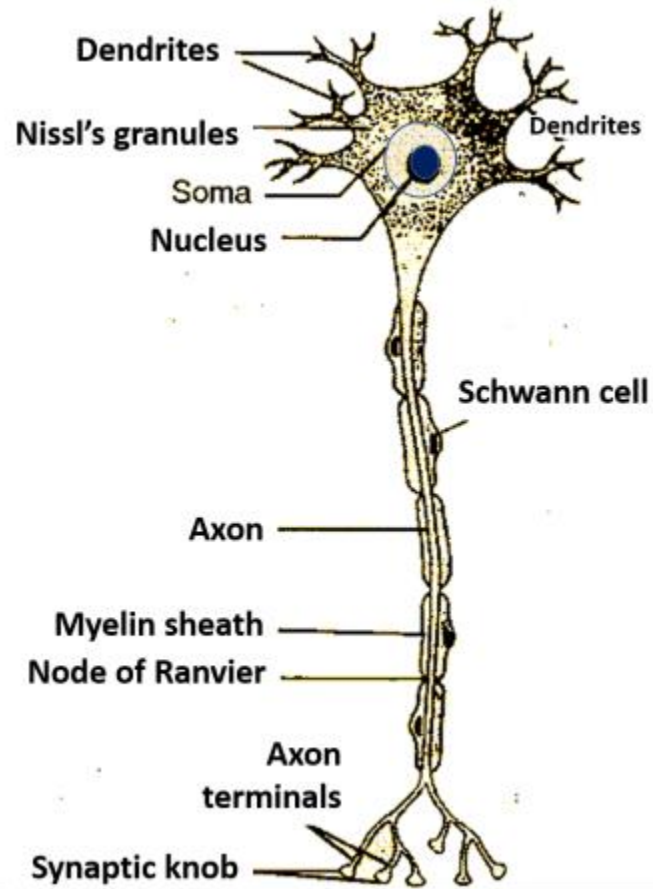
Functions

- Perception of senses
- Elicitation and transmission of impulses
- Response to stimuli
- Control and co ordination of body activities
- Homeostasis

Nervous Tissues

- Neurons (nerve cells)
- Neuroglia (glial cells)
- Nerve fibres

Structure of a typical neuron



Neuroglia/glial cells

- Unexcitable, non-nervous, supportive and protective connective tissue cells
- Absent in coelenterates and ctenophores
- In mammals their no. is nearly 10 times greater than the no. of neurons
- Provide mechanical and metabolic support to brain and spinal cord
- Repair the damages of nerves and nerve fibres
- Common source of tumours of nervous system

Different types of glial cells

- **Microglia:** brain macrophages, protect CNS by phagocytising cellular debris and microbes
- **Macroglia:** larger glial cells of CNS
- 1. *Astrocytes:* largest and most numerous, form supporting network around neurons of brain and spinal cord, attach neurons to blood vessels, regulate external environment of neurons, recycling of neurotransmitter
- Protoplasmic astrocytes in grey matter and fibrous astrocytes in white matter

- ***Oligodendrocytes***: only fewer and shorter processes, formation of myelin sheath and support neurons of brain and spinal cord
- ***Ependymal or ependymocytes***: single layer of squamous or columnar cells lining the internal cavity of CNS, help in circulation of cerebrospinal fluid
- ***Radial cells***: retina of eye
- Schwann cells and satellite cells similar to oligodendrocytes

Nerve fibres

- Axons arranged in bundles to form nerves
- Primary sheath – neurilemma or Schwann sheath
- Secondary sheath – Myelin or medullary sheath (insulated jacket)
- Invertebrates – myelinated
- Impulses travel much faster in myelinated fibre
- Multiple sclerosis – auto immune disease caused by patchy destruction of myelin sheath

Classification of nerves and nerve fibres

- Medullated fibres
- Non – medullated fibres
- Somatic fibres
- Visceral fibres
- Sensory fibres
- Motor fibres
- Mixed fibres
- Cranial and spinal fibres
- Adrenergic and cholinergic fibres

Types of neurons

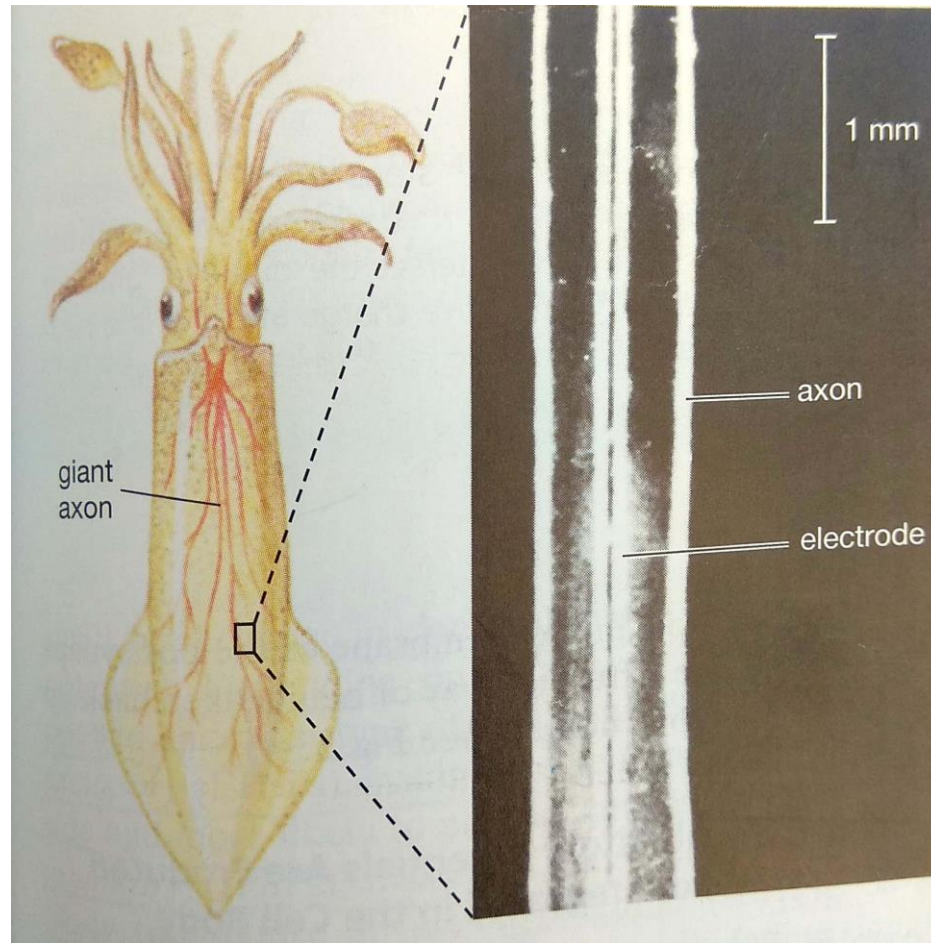
- Based on no. of processes arising from neuron
- 1. **Apolar**: no axon and dendron, impulses radiate in all directions (Hydra)
- 2. **Unipolar**: has axon but no dendron (invertebrates, embryos and dorsal root ganglion of spinal nerves)
- 3. **Bipolar**: one axon and one dendron (retina, inner ear and olfactory epithelium)
- 4. **Multipolar**: one axon and several dendrites (brain and spinal cord)

Based on nature and direction of impulses

- Sensory neuron
- Internuncial/ connecting/association neuron
- Motor neuron

Giant nerve fibres

- A nerve fibre with a very large diameter, found in many types of invertebrate (e.g. earthworms, Squilla, cray fish and squids).
- Its function is to allow extremely rapid transmission of nervous impulses and hence rapid escape movements in emergencies.
- Isethionate (2-hydroxyethanesulfonate) — characteristic of cephalopod neuron
- Based on ontogeny classified into unicellular and multicellular fibre
- Mouthner fibres — giant fibres of aquatic vertebrates



Giant nerve fibre of squid

Regeneration of medullary nerve fibres

- No regeneration in neurons of brain and spinal cord (scar formation by astrocytes)
- Only the myelinated axons of peripheral nerves have limited powers of repair and regeneration

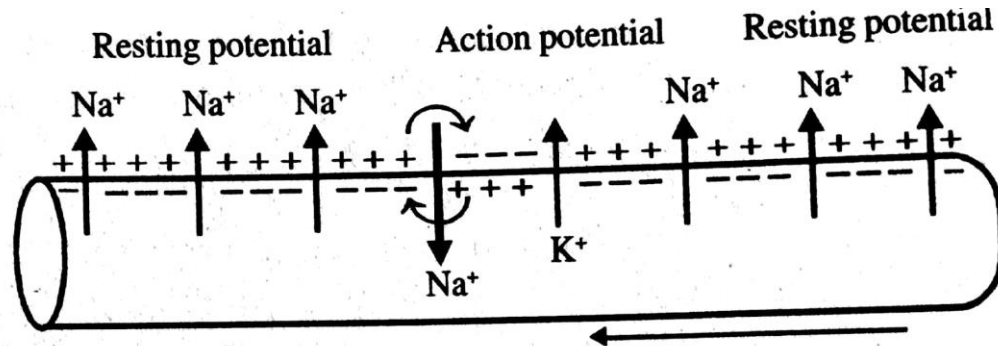
Neurtrophins

- A family of closely related proteins, originally identified as growth factors for survival, development, and function of neurons in both the central and peripheral nervous systems
- **Examples:** Nerve growth factor, Brain Derived Neurotrophic Factor(BDNF), Neurotrophin – 3, Neurotrophin 4/5

Regeneration of peripheral fibres

- Retrograde / Wallerian degeneration (that results when a nerve fiber is cut or crushed and the part of the axon distal to the injury degenerates)
- Initiation of reparative mechanism
- **Neurotrophism** – growth of neurofibril towards distal part of neurilemma
- **Neuroma** – tumour like mass formed by neurofibrils

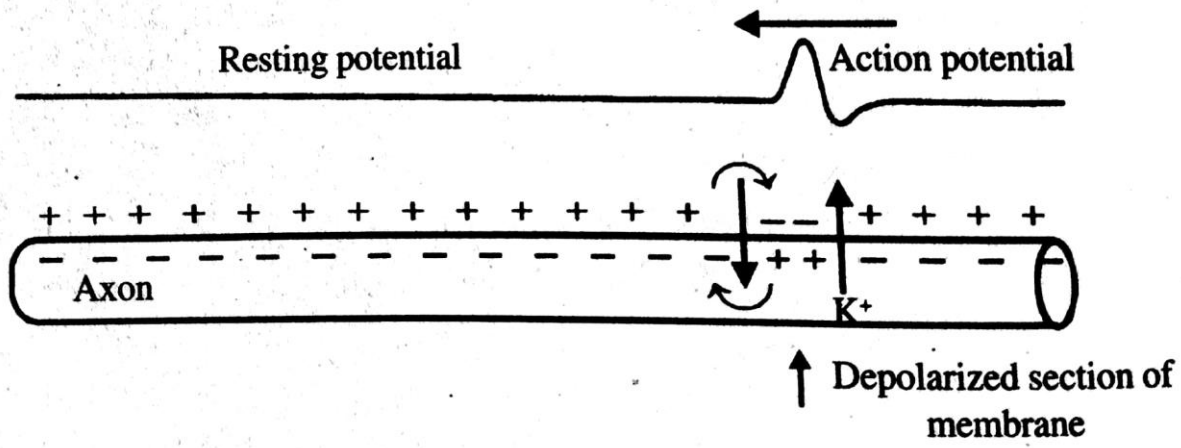
Transmission of nerve impulses



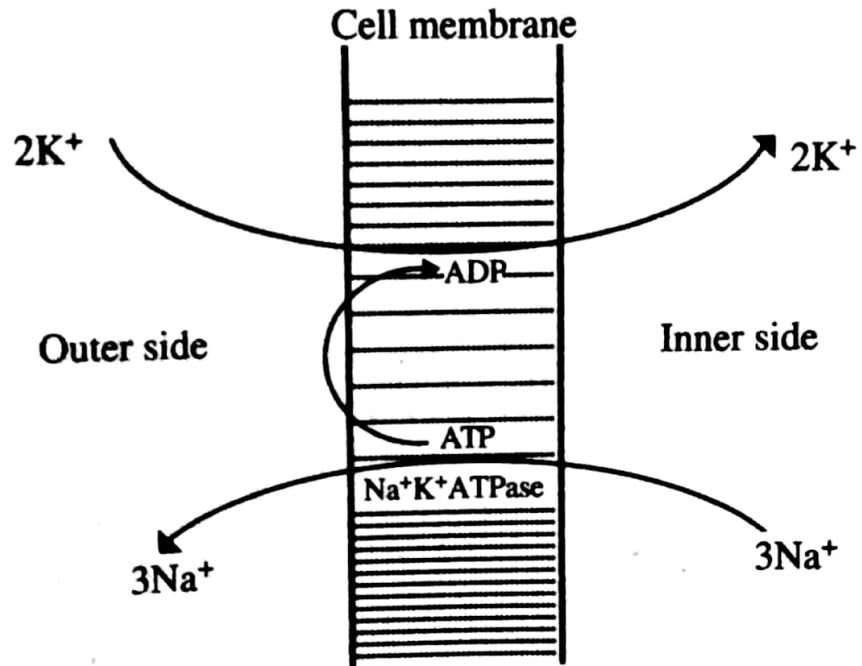
(iii) Sodium pump operates again. Membrane gets repolarised: outside positive, inside negative.

(ii) Sodium pump stops and sodium ions enter axon. Membrane depolarised: inside becomes positive, outside negative

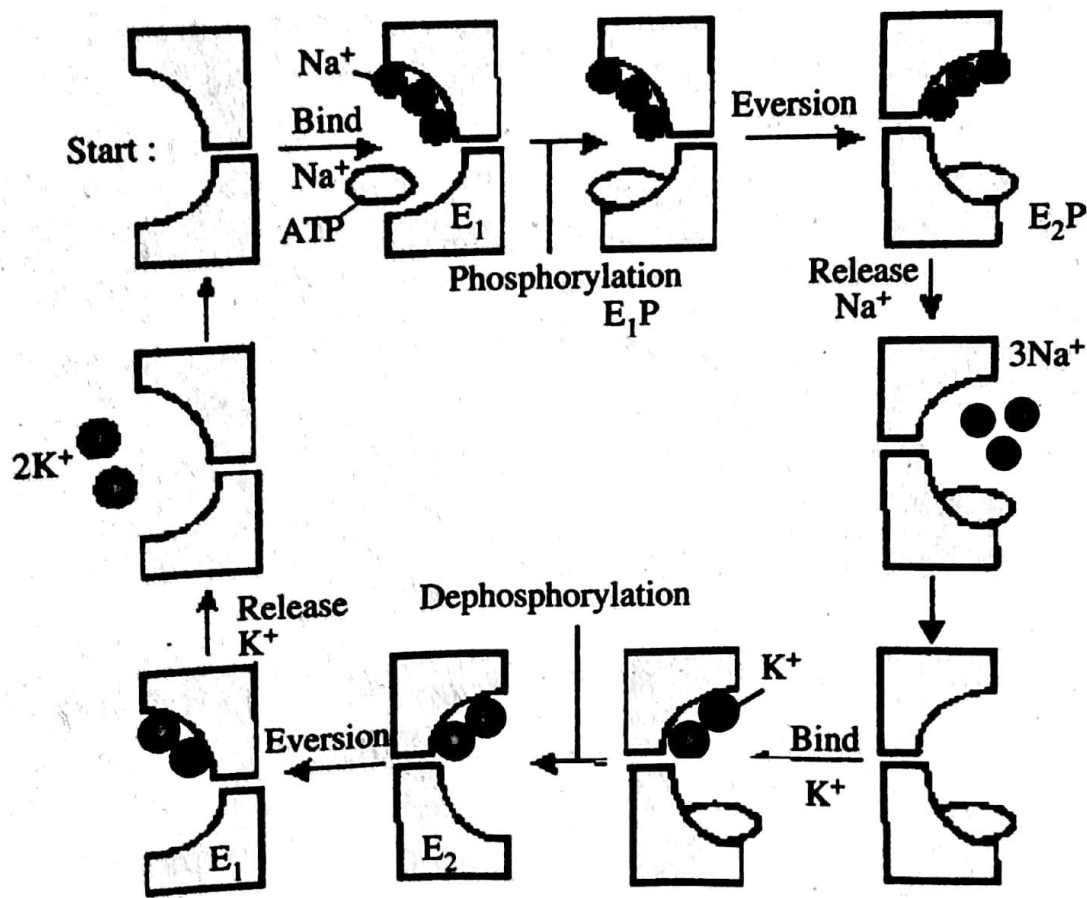
(i) Membrane polarised: outside positive, inside negative. Sodium ions expelled by sodium pump mechanism



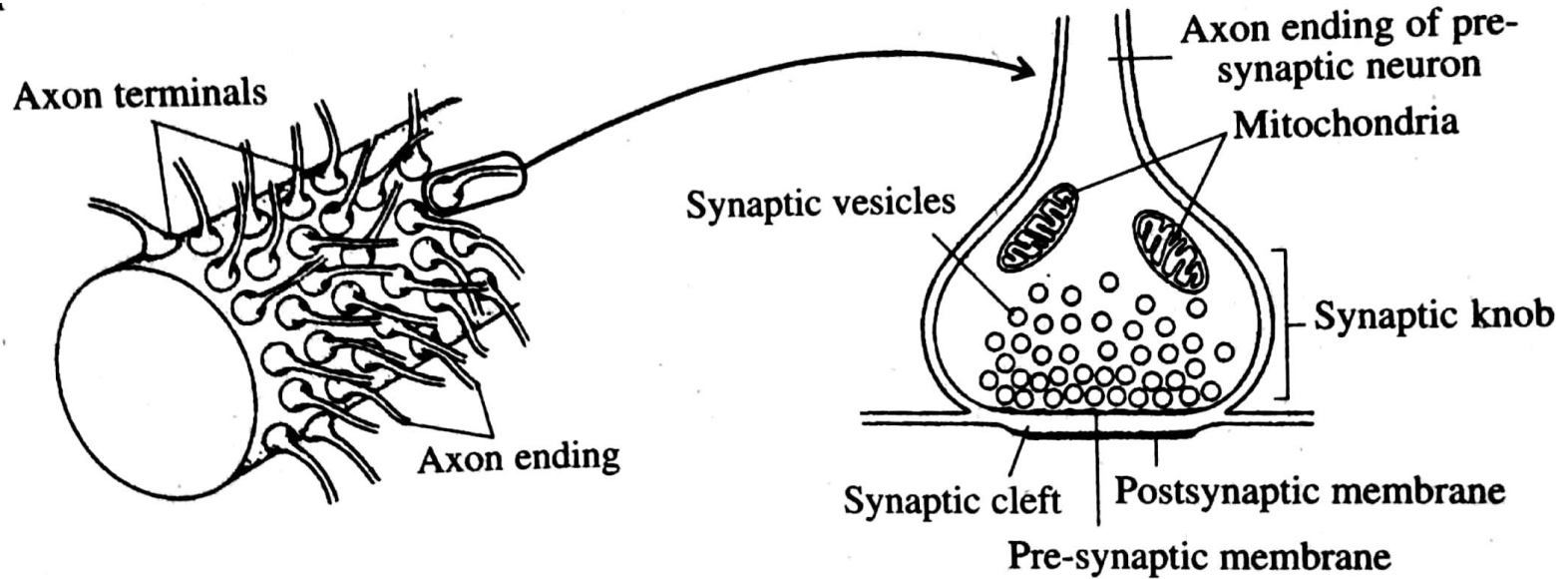
Schematic of sodium potassium pump



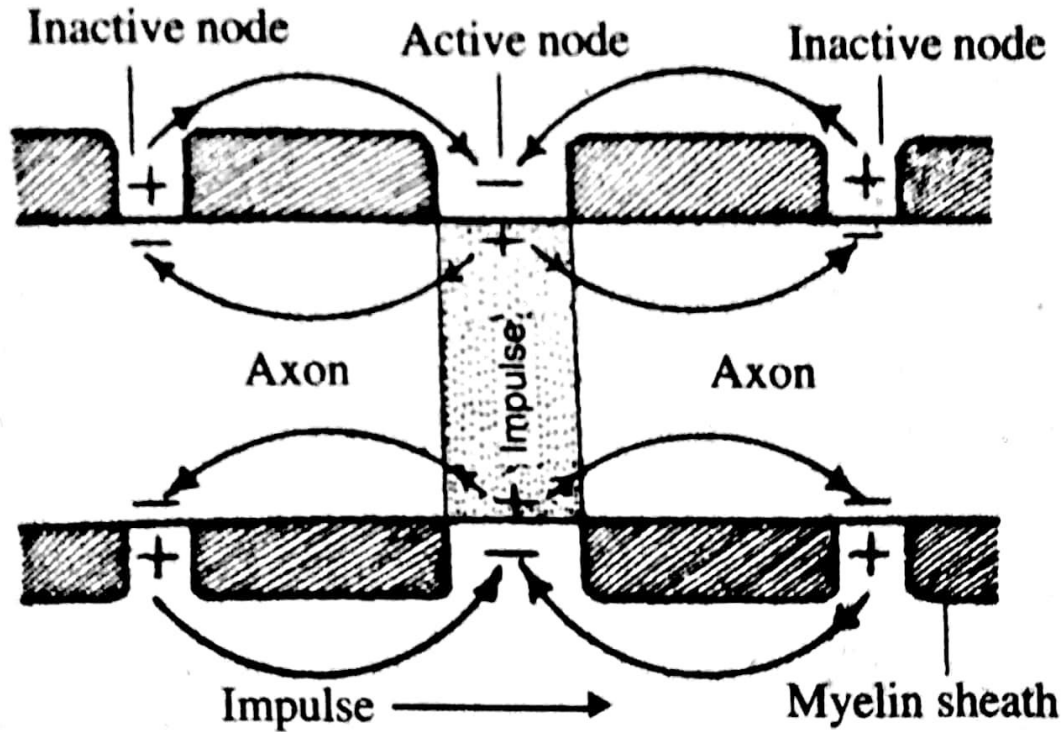
Mechanism of Na – K pump



Neuronal synapse

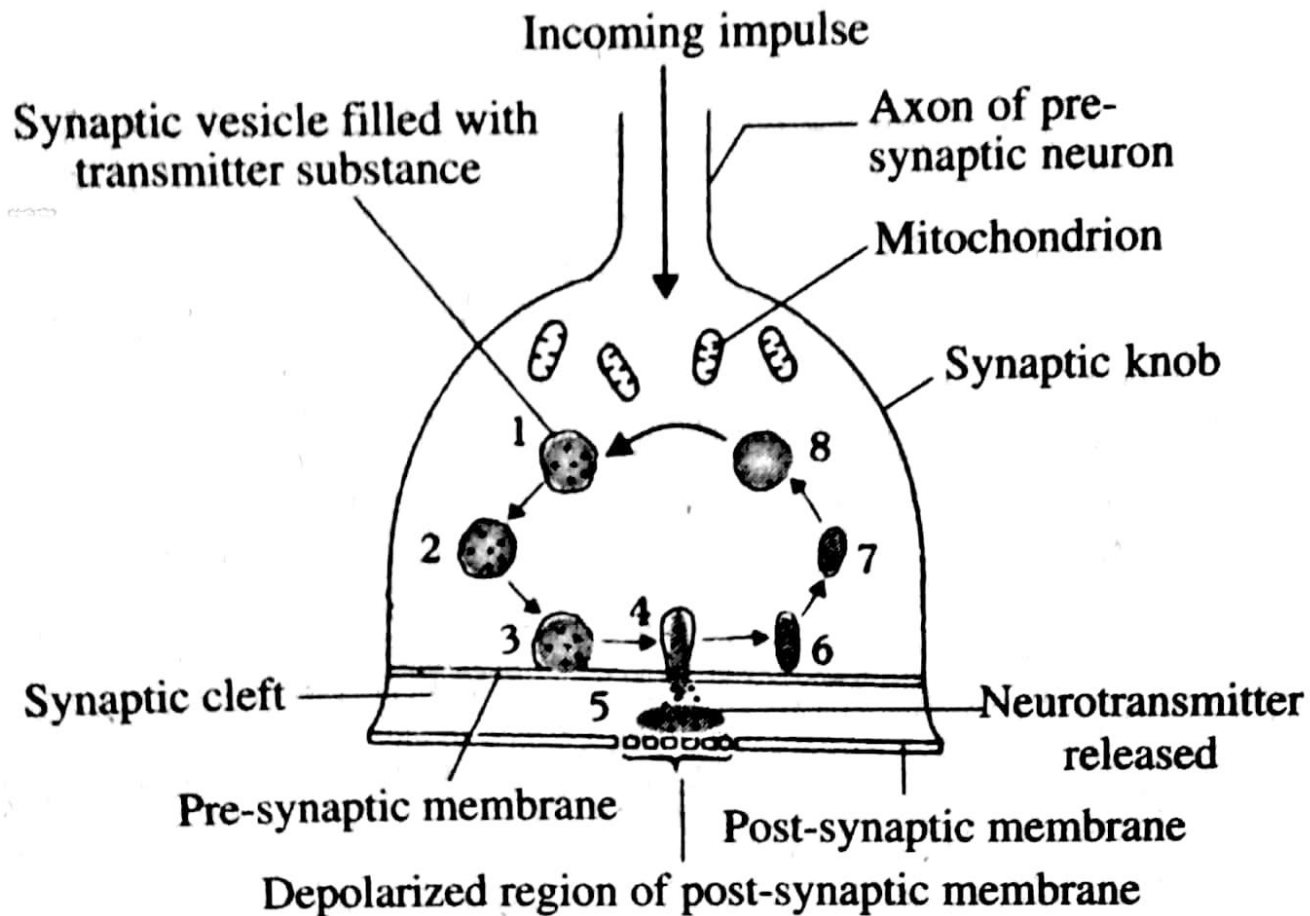


Saltatory transmission

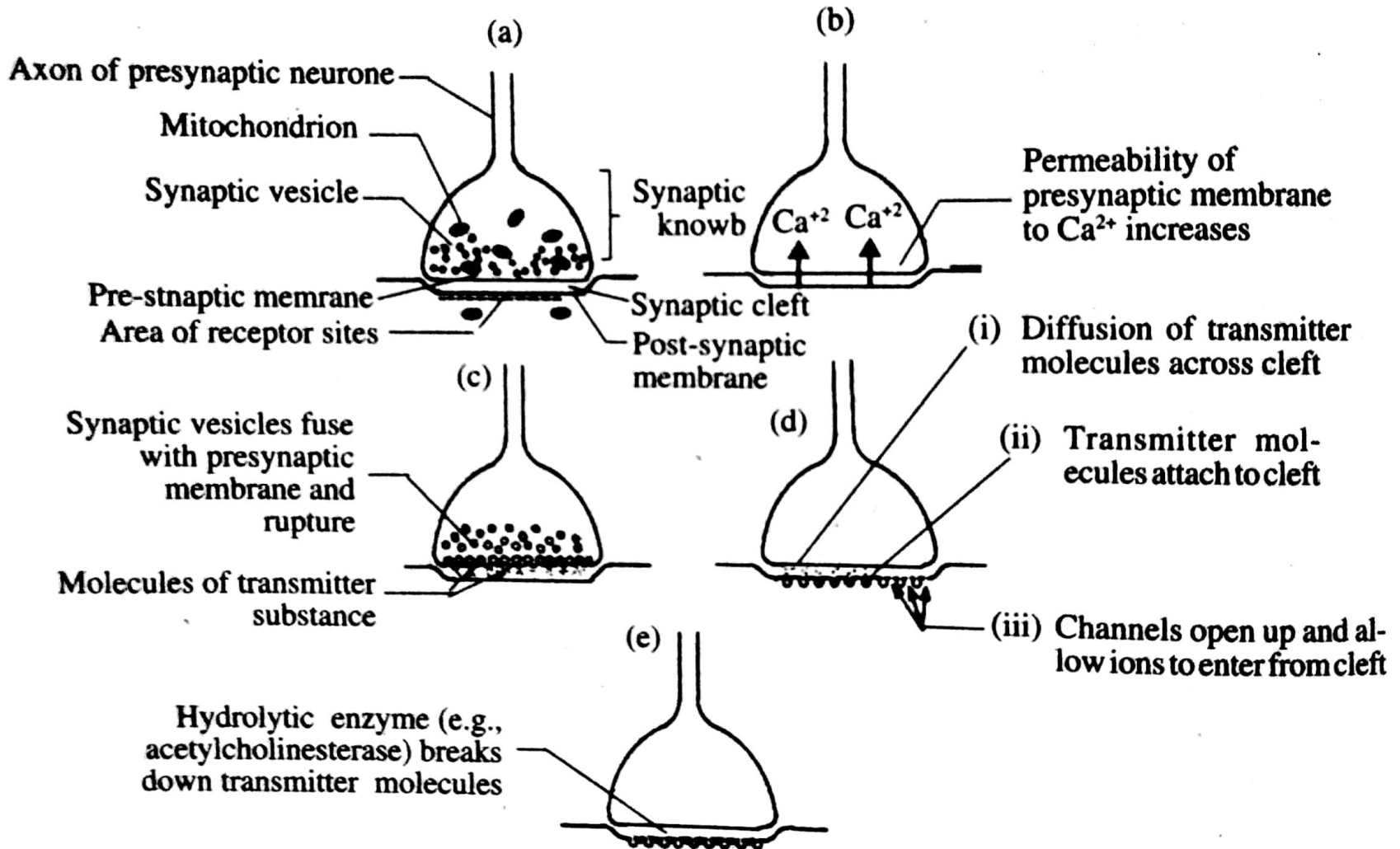


Saltatory transmission

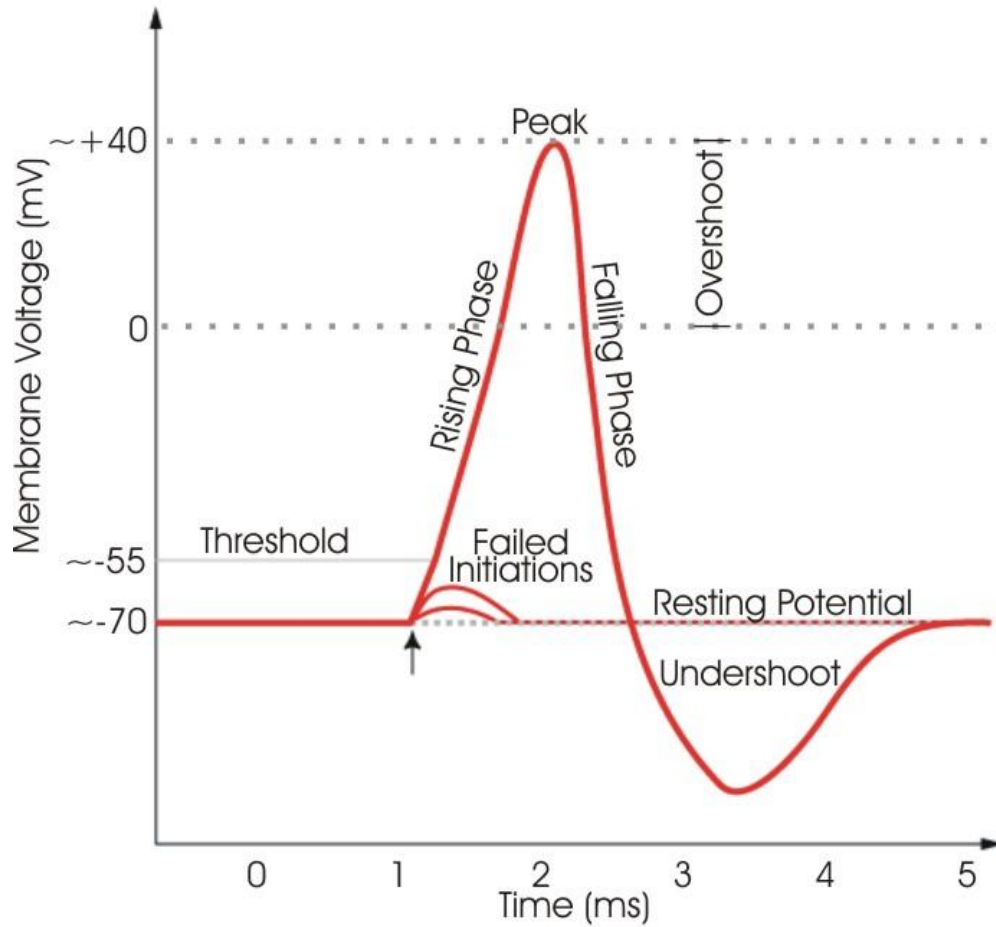
Excitatory transmission



Stages of excitatory transmission



Threshold stimulus /all or none law



Refractory period

- Interval between two successive nerve impulses
- Lasts for a few milliseconds during which the nerve will not generate action potential
- 3 phases : absolute, relative and effective refractory period

Important Neuro transmitters

Neurotransmitter	Location in Nervous System	Some Functions
Acetylcholine	Motor neuron-to-muscle synapse; autonomic nervous system, brain	Activates skeletal muscles; activates target organs of parasympathetic nervous system
Dopamine	Midbrain	Important in control of movement
Epinephrine (adrenaline)	Sympathetic nervous system	Activates target organs of sympathetic nervous system
Serotonin	Midbrain, pons, and medulla	Influences mood, sleep
Glutamate	Brain and spinal cord	Major excitatory neurotransmitter in CNS
Glycine	Spinal cord	Major inhibitory neurotransmitter in spinal cord
GABA (gamma amino butyric acid)	Throughout brain	Major inhibitory neurotransmitter in brain
Endorphins	Brain and spinal cord	Influence mood, reduce pain sensations
Nitric oxide	Brain	Important in forming memories