E-MODULE ON PHYSIOLOGY OF NERVOUS SYSTEM

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PHYSIOLOGY OF NERVOUS SYSTEM

Nervous system is the organized group of cells specialized for the conduction of electrochemical stimuli from sensory receptors through a network to the site at which a response occur

FUNCTIONS OF NERVOUS SYSTEM

- **1.Control and coordination**
- a)Sensory input
- b)Integration
- c)Motor Output

- **2.Memory**
- **3.Homeostasis**

DIVISION OF NERVOUS SYSTEM

- **1Central nervous system**
- a)brain b)spinal cord
- **2.Peripheral nervous system**
- a)cranial nerves b)spinal nerves
- **3.Autonomic nervous system**
- a) Sympathetic b)Parasympathetic nervous system

CNS

- **The central nervous system (CNS)** is made up of the a)Brain

b)Spinal cord.

- The Brain controls most body functions, including awareness, movements, sensations, thoughts, speech and memory.
- The Spinal cord is connected to the brain at the brainstem and is covered by the vertebrae of the spine.
- Nerves exit the spinal cord to both sides of the body.
- The spinal cord carries signals back and forth between the brain and the nerves in the rest of the body.

PERIPHERAL AND AUTONOMIC NERVOUS SYSTEM

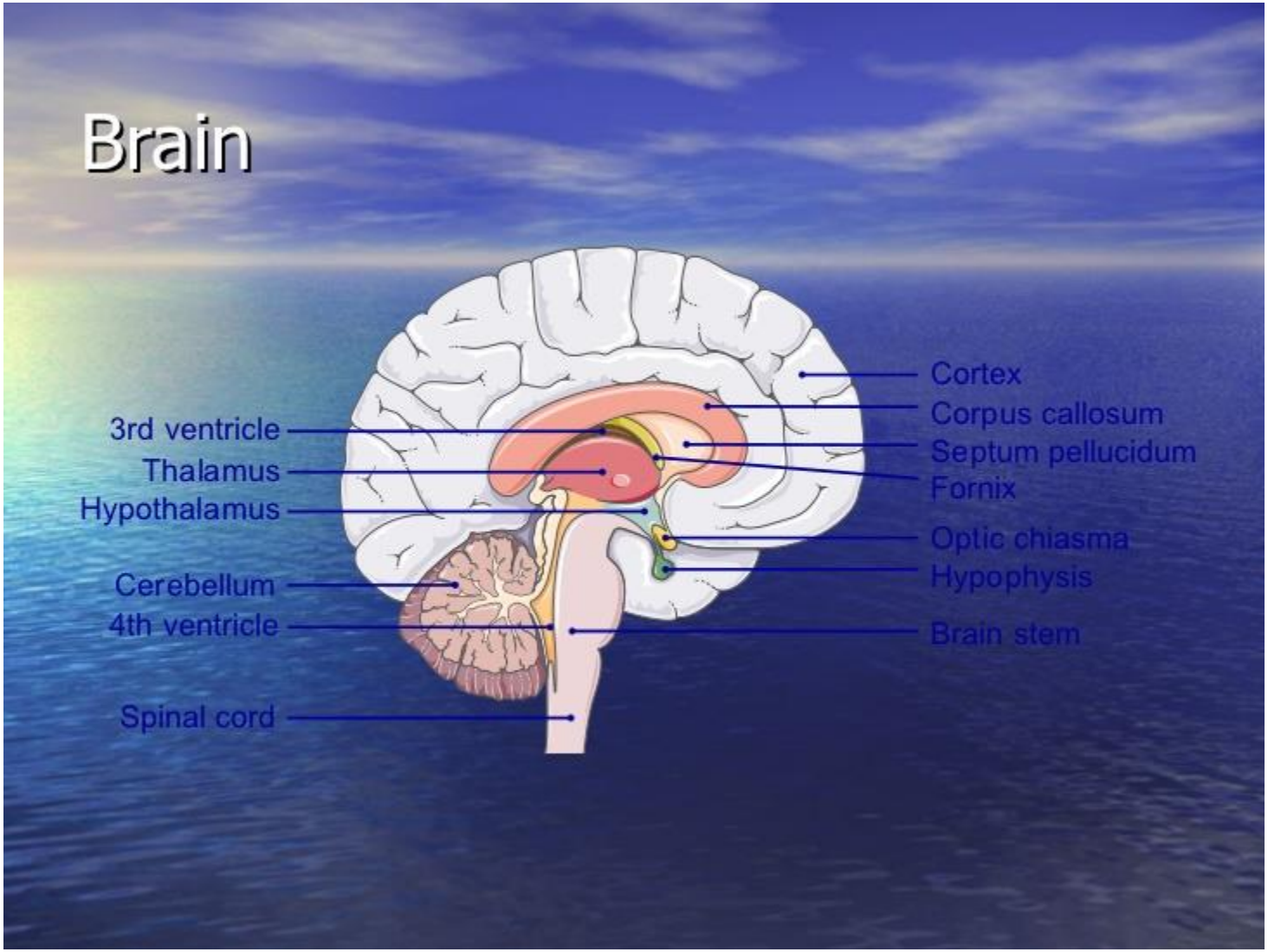
- Peripheral Nervous System. It is made up of nerves that send signals to and receive signals from the CNS.
- The PNS consists of nerves whch originate from brain(Cranial nerves) and spinal cord(Spinal nerves) and it extends between CNS and sense organs or body effectors(glands,muscle vells etc)
- The Autonomic nervous system controls involuntary functions that the body does on its own such as breathing and digestion.
- The autonomic nervous system is further divided into the Sympathetic and the Parasympathetic nervous system

AUTONOMIC NERVOUS SYSTEM

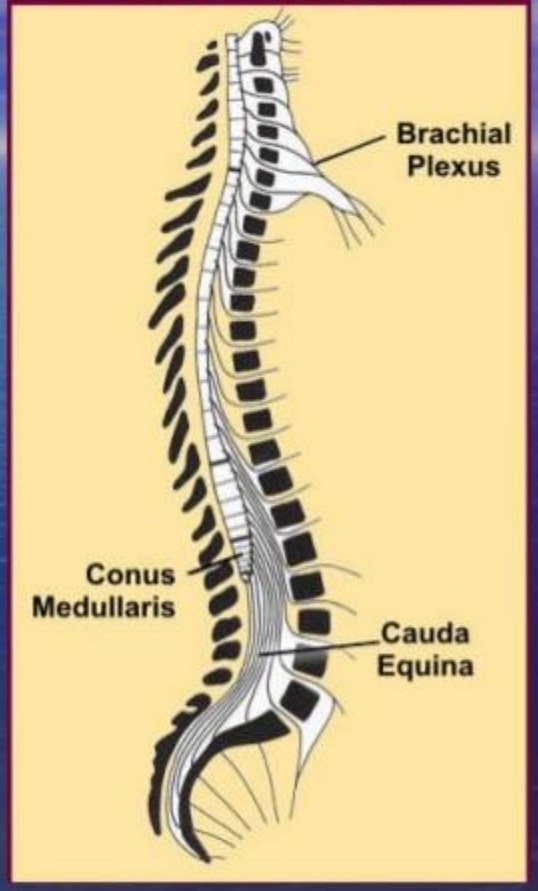
The Sympathetic Nervous System prepare the body for situations that require strength and heightened awareness e.g. It causes the heart to beat faster, makes you breathe quicker and more shallowly, dilates the pupils and increases metabolism.

The Parasympathetic Nervous System has a calming effect on the body. It returns heart rate and breathing to normal, constricts the pupils and slows down metabolism to conserve energy.

Brain


Cortex
Corpus callosum
Septum pellucidum
Fornix
Optic chiasma
Hypophysis
Brain stem
3rd ventricle
Thalamus
Hypothalamus
Cerebellum
4th ventricle
Spinal cord

The Spinal Cord & Nerve Roots



NERVOUS TISSUE

- NEURONS
- NERVE FIBRES
- NERVES
- NEUROGLIA
- EPENDYMAL CELLS
- NEUROSECRETORY CELLS

NEURON

- The neuron is the basic structural and functional unit of the nervous system. It is a specialized conductor cell that receives and transmits electrochemical nerve impulses.
- A typical neuron has a cell body and long cell processes(axon and dendrons) that conduct impulses from one body part to another body part.

NEURONS

Neurons have the unique ability to communicate with each other through the transmission of electrical impulses.

- The basic structure of a neuron is composed of a cell body, an axon (wrapped in myelin) and dendrites.

NEURON STRUCTURE

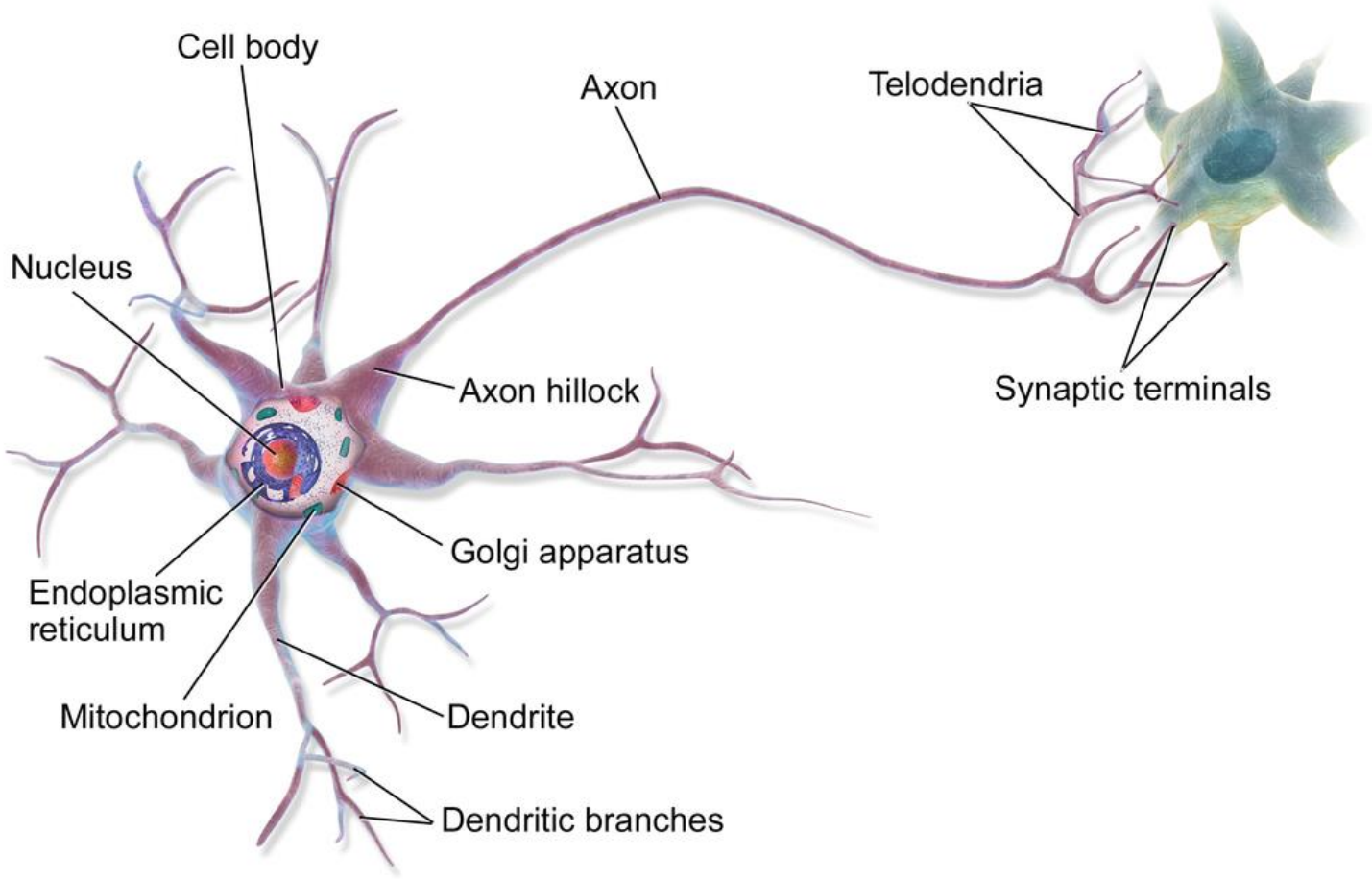
- **Cell body-** it carries genetic information, maintains the neuron's structure, and provides energy for activities.
- It contains a nucleus and specialized organelles. It's enclosed by a membrane which both protects it and allows it to interact with its immediate surroundings.

NEURON STRUCTURE

Axon: It is a long, tail-like structure which joins the cell body. Many axons are insulated with a fatty substance called myelin. Myelin helps axons to conduct an electrical signal.

Dendrites are fibrous roots that branch out from the cell body to receive and process signals from the axons of other neurons. Neurons can have more than one set of dendrites, known as dendritic trees.

NEURON STRUCTURE



TYPES OF NEURONS

There are three types of neurons :

- Sensory neurons
- Motor neurons
- Interneurons
- All three have different functions, but the brain needs all of them to communicate effectively with the rest of the body .

FUNCTION OF NEURON

- The neurons, which are the functional unit of the neural system, have the ability to detect, receive and also transmit the various kinds of stimuli.
- In other words the way these neurons communicate with each other is a nerve impulse. These are generally electrical signals that travel along the axon of the neuron.

NEURON POLARITY

- The nerve fibers conduct impulses in one direction only, from dendrites to cyton and then down the axon.
- So one end of neuron is receiving the impulse and other end is discharging the impulse. This is called neuron polarity.

NERVE FIBRES

- Axon and dendrite of neuron is covered with one or two sheaths is termed as nerve fibres.There are two types or nerve fibres
- Medullated nerve fibres
- A)Axis cylinder b)Mylein sheath c)Neurilemma
- Non medullated nerve fibres

TYPES OF NERVES

- Sensory or Afferent nerves having sensory nerves fibres e.g olfactory,optic,auditory nerves.
- Motor or Efferent nerves having motor nerve fibres e.g oculomotor, pathetic etc.
- Mixed nerves having both sensory and motor nerve fibres e.g trigeminal,facial nerve etc.

NERVE IMPULSE

- Nerve impulse is a physio-chemical electrical charge in the membrane of a nerve fiber produced by a stimulus which is conducted along the length of a nerve fiber.

OR

A wave of reversed polarisation and depolarisation moving down an axon is nerve impulse.

PROPERTIES OF NERVE FIBRES

- It has been known for many years that electric phenomena are associated with transmission of nerve impulse and muscle contraction. The common terms used are
- Resting Potential
- Action Potential

MEMBRANE POTENTIAL

- Membrane potential – It is the difference in the total charge between the inside of the cell and the outside of the cell.
- Resting membrane potential – It is the difference in voltage across the cell membrane in a resting state. (A neuron is said to be at rest when it does not conduct any impulse. At this stage, the axonal membrane of the neuron is more permeable to the potassium ions and not permeable to the sodium ions.)

RESTING POTENTIAL

- When the neuron is inactive and polarized, it's said to be at its resting potential.ie, the outside of the membrane is positive, and the inside of the membrane is negatively charged and It remains this way until a stimulus comes along.

ACTION POTENTIAL

- When a stimulus reaches a resting neuron, the gated ion channels on the resting neuron's membrane open suddenly and allow the Na+ that was on the outside of the membrane to go rushing into the cell.
- As this happens, the neuron goes from being polarized to being depolarized and action potential is created

THRESHOLD STIMULUS

- A stimulus of minimum threshold intensity is required to produce an action potential is called threshold stimulus intensity.
- And once an action potential is generated it passes through whole nerve fiber without any change.

ALL OR NONE PRINCIPLE

- "All-or-none" means that if a stimulus doesn't exceed the threshold level no action potential results; however, after the threshold is crossed, all stimuli having intensity above threshold will induce same action potential.
- Complete depolarization occurs and the stimulus will be transmitted.
- The difference in stimulus intensity are communicated by frequency and not the strength of action potential.

MEMBRANE OR IONIC THEORY OF NERVE IMPULSE

- A nerve impulse is generated when the stimulus is strong.
- This stimulus triggers the electrical and chemical changes in the neuron.
- The exterior side has sodium ions that are positively charged and are more in number.
- The interior side of the cell is negatively charged with more potassium ions.
- Due to this difference in the charges, there is an electrochemical difference.

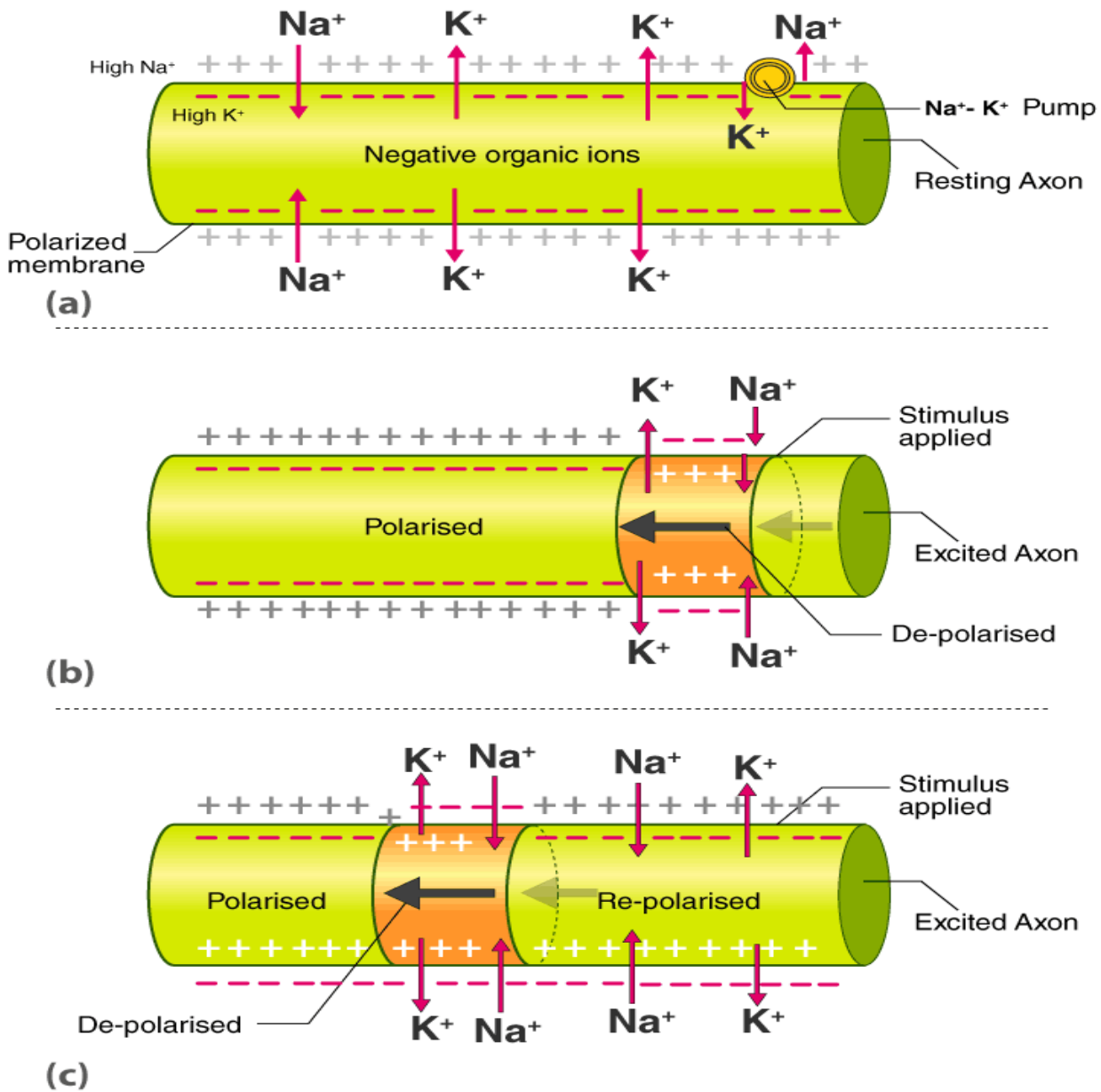
MEMBRANE OR IONIC THEORY OF NERVE IMPULSE(CONTD.)

- When a nerve impulse is generated, there is a change in the permeability of the cell membrane.
- The sodium ions flow inside and potassium ions flow outside, and leads to reversal of charges. The membrane is now called **depolarized.**

The depolarization results in an action potential which causes the nerve impulse to move along the length of the axon.

- This depolarization of the membrane occurs along the nerve.

CONDUCTION OF NERVE IMPULSE



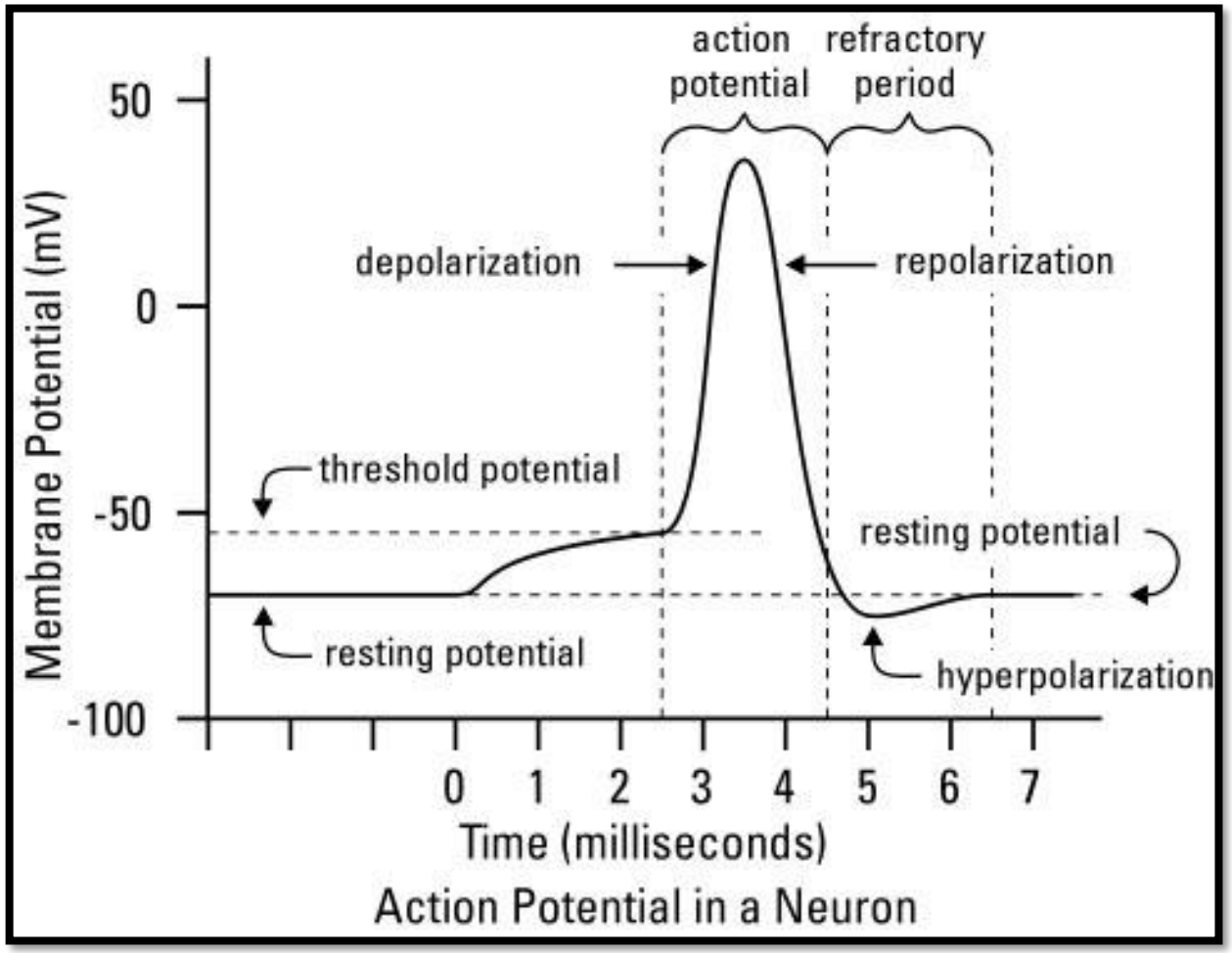
MEMBRANE OR IONIC THEORY OF NERVE IMPULSE(CONTD.)

- A series of reactions occur where the potassium ions flow back into the cell and sodium ions move out of the cell. This whole process again results in the cell getting polarized, with the charges being restored.

REPOLARISATION

- After the inside of the cell becomes positively charged flooded with,Na+, the gated ion channels on the inside of the membrane open to allow the K+ to move to the outside of the membrane.
- With K+ moving to the outside, the membrane's repolarization restores electrical balance, although it's opposite of the initial polarized membrane that had Na+ on the outside and K+ on the inside.
- Just after the K+ gates open, the Na+ gates close; otherwise, the membrane couldn't repolarize.

TRANSMISSION OF NERVE IMPULSE ACROSS MEMBRANE



REFRACTORY PERIOD

- The refractory period is when the Na+ and K+ are returned to their original sides: Na+ on the outside and K+ on the inside.
- When the neuron is busy returning to normal, it doesn't respond to any incoming stimuli.

SYNAPSE

- The neurons communicate with each other at specific points or junctions called the synapses.
- These synapses can be chemical, communicating through chemical messengers or electrical, where there is a flow of ions between the cells.

SYNAPSE

The place where the axon of one neuron meets the dendrite of another is called a **synapse**. Synapses are also found between neurons and other types of cells, such as muscle cells. The axon of the sending neuron does not actually touch the dendrite of the receiving neuron. There is a tiny gap between them, the synaptic cleft .

TYPES OF SYNAPSE

- Axodendritic synapse -a synapse between an axon and a dendrite.
- Axosomatic synapse-a synapse between an axon and cell body of two neurons.
- Neurotransmitter junction- a synapse between axon terminals of motor neuron and the surface of muscle fibre.

MODES OF TRANSMISSION ACROSS SYNAPSE

- Chemical transmission
- Electrical transmission
- The synapses are called chemical and electrical synapses

CHEMICAL SYNAPSE

- Chemical synapse consists of synaptic knob which contains ER , mitochondria microfilament and many synaptic vesicles.
- Synaptic vessels contain chemical called neurotransmitters which transmit nerve impulses across the synapse.

COMPONENTS OF SYNAPSE

- **Presynaptic membrane-the** membrane of synaptic knob is thickened adjacent to synapse.It is modified for the attachment of synapticle vesicles and release of neurotransmitter into synaptic cleft.
- **Synaptic cleft-a** fluid filled gap of 200A between pre and post synaptic vesicles.
- **Postsynaptic membrane-dendrite** membrane next to synapse is called postsynaptic membrane and contains receptors for neurotransmitters and has channels and pores for entry of ions.

NEUROTRANSMITTERS

The two main neurotransmitters produced in vertebrates are:

- Acetylcholine(Ach)
- Noradrenalin

NERVE IMPULSE ACROSS SYNAPSE

- When a nerve impulse reaches the end of an axon, the axon releases chemicals called **neurotransmitters**.
- Neurotransmitters travel across the synapse between the axon and the dendrite of the next neuron.
- Neurotransmitters bind to the membrane of the dendrite.
- The binding allows the nerve impulse to travel through the receiving neuron.

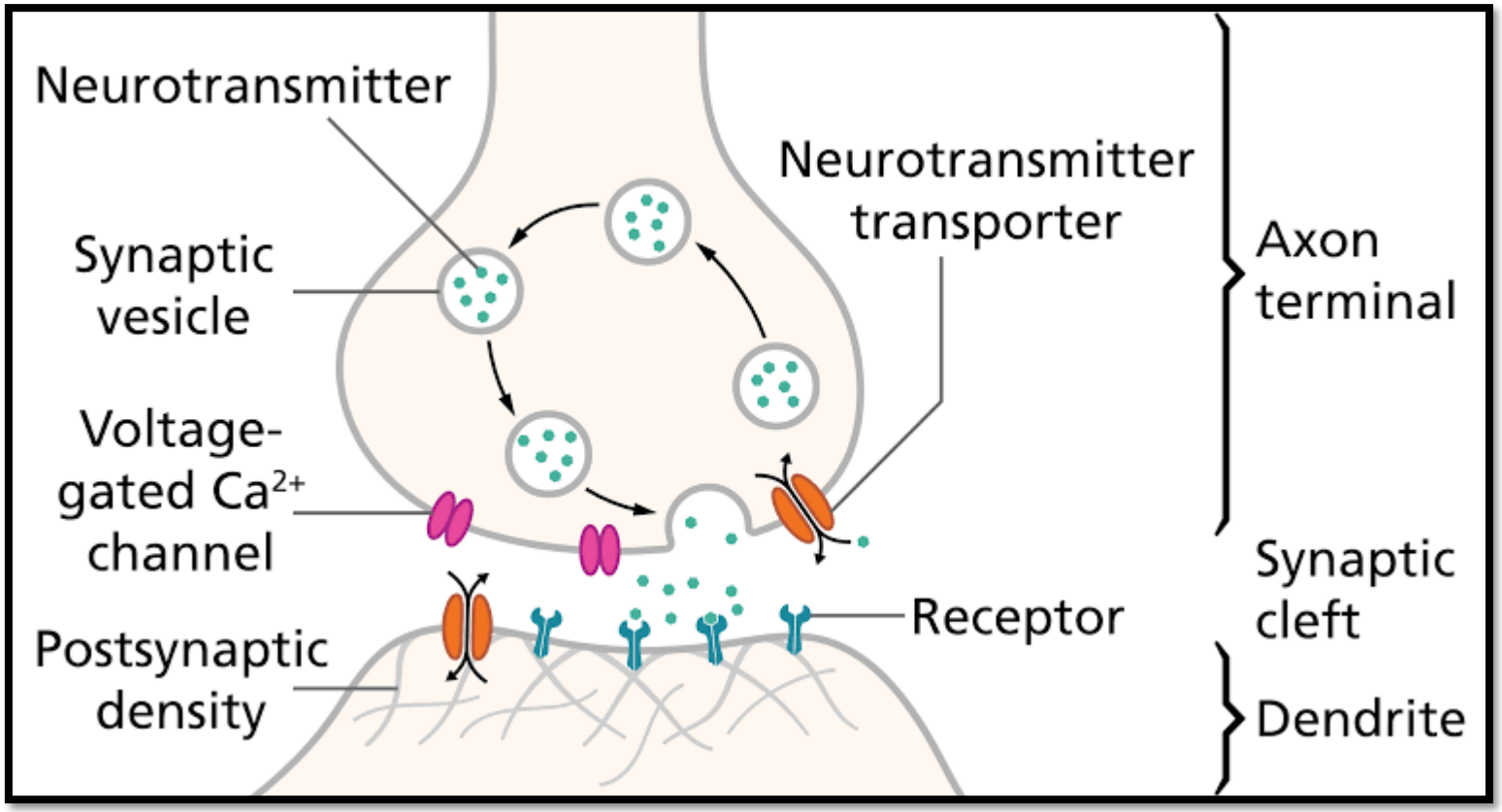
MECHANISM OF TRANSMISSION OF IMPULSE ACROSS SYNAPSE

Depolarization of presynaptic membrane:

- Increase in permeability of Ca ions
- Fusion of synaptic vesicles with presynaptic membrane.
- Release of neurotransmitter substance i.e acetylcholine.
- Acetylcholine binds to receptors on postsynaptic membrane

MECHANISM OF TRANSMISSION OF IMPULSE ACROSS SYNAPSE

- Opening of gated channels in post synaptic membrane.
- These channels allow Na+ ions to enter and K+ ions leave down the concentration gradient.
- Depolarization of postsynaptic membrane.
- Acetylcholine is inactivated by enzyme acetyl cholinesterase present in post synaptic membrane.
- Hydrolysis of acetylcholine into acetic acid and choline and membrane repolarizes.
- The components return to axon by diffusion and combine to form acetylcholine.


Neurotransmitter
Neurotransmitter transporter
Synaptic vesicle
Voltage-gated Ca^{2+} channel
Receptor
Postsynaptic density
Axon terminal
Synaptic cleft
Dendrite

TRANSMISSION OF NERVE IMPULSE ACROSS SYNAPSE

SUMMARY

- Firstly, an action potential (change in electrical potential) arrives at the pre-synaptic neuron.
- This changes the voltage in the neuron causing the voltage-gated calcium channels on the pre-synaptic neuron to open.
- Calcium ions then diffuse into the pre-synaptic neuron
- The increased concentration of Calcium in the neuron then causes synaptic vesicles, containing the neurotransmitter acetylcholine, to move towards the membrane on the pre-synaptic neuron

TRANSMISSION OF NERVE IMPULSE ACROSS SYNAPSE

- The vesicles fuse to the membrane and the neurotransmitter is released into the gap between the two neurons (known as the synaptic cleft)
- The acetylcholine neurotransmitter then diffuses across the synaptic cleft towards the post-synaptic neurons membrane.
- The acetylcholine neurotransmitter then binds to the complimentary receptors on the post-synaptic neuron's membrane

TRANSMISSION OF NERVE IMPULSE ACROSS SYNAPSE

- If these EPSPs reach a certain threshold, then an action potential is initiated in the post-synaptic neuron and the impulse has been successfully transmitted from one neuron to the next.
- The increase in concentration of the neurotransmitter causes ligand gated sodium channels in the post-synaptic neuron membrane to open, allowing sodium to diffuse into the post-synaptic neuron.
- The increased concentration of sodium ions now in the post-synaptic neuron depolarize the neuron's membrane causing EPSPs (excitatory post-synaptic potentials).

REFERENCES

- Books Referred : Textbook of Zoology by Dhami & Dhami
- From internet links.