Neural control & Co ordination

Introduction:

- The process through which two are more organs interact and complement the functions of one another is called **co ordination**.
- The organs and organ systems in our body must be co-ordinated to maintain **Homeostasis**
- The system that provides an organised network of point to point connections for a quick co ordination is **neural system**
- Neural system is poorly developed in organisms with a static mode of life, but well developed in those which are active. In protozoans and sponges, the individual cells are directly exposed to the environment.
- For the maintenance of structural and functional integrity two '**integrative** systems' are developed to transmit coded information from one part of the body to the other.
- They are 1. Nervous system and 2. Endocrine System

NEURAL SYSTEM:

- This is structurally and functionally a complicated system found only in animals.
- The study of nervous system and receptors is called **Neurology.**
- Nervous system plays three vital roles. 1. Response to stimuli, 2. Coordination, 3.Learning
- Specialised cells that can detect, receive and transmit different kinds of stimuli are **Neurons**

HUMAN NEURAL SYSTEM:

- For convenience the nervous system is divided into two parts.

  1. Central nervous system (CNS)

  2. Peripheral nervous system (PNS)

    - Central nervous system includes **brain** and a **spinal cord and coordinates** the impulses **received from** receptors and transmits to effectors.
- CNS is the site of **information processing and control**
- All the nerves of the body associated with CNS are called **Peripheral nervous system (PNS)**
- The nerve fibres of the PNS are of two type's **i. afferent neurons ii. Efferent neurons**

- The nerve fibres transmitting impulses from the tissues and organs to CNS are called **Afferent nerves**
- The nerve fibres transmitting regulatory impulses from the CNS to tissues and organs are called **Efferent nerves**
- The PNS is divided in to **a) Somatic neural system b) Autonomic Neural system**
- The PNS that relays impulses from the CNS to skeletal muscles is **somatic neural system**
- The PNS that relays impulses from the CNS to involuntary organs is **Autonomic neural system**
- The Autonomic neural system is further divided into **Sympathetic & Para sympathetic neural system**

Generation and conduction of nerve impulse

- Like muscle cells, neurons are also electrically excitable. The neurons in the body are connected with one another.
- Axon of the nerve cell is the nerve fibre. The cytoplasm of the nerve fibre is **axoplasm** and the membrane surrounding it is **axolemma.**
- Neurons communicate with one another using **action potentials,** which are used for short and long distance communications with in the body.
- Production of these action potentials depends on two basic features of neuron: the existence of resting membrane potential and presence of specific types of ion channels across the axolemma.
- Separation of positive and negative charges by axolemma is a form of **potential energy.**
- Two main channels are the leakage channels and voltage gated channels.
- A plasmamembrane has more potassium leakage channels than the sodium leakage channels. So plasmamembrane is more permeable to potassium a the resting state.
- Voltage gated channels of sodium have two gates : activation gate and inactivation gate.
- Potassium channels have only one gate.
- Voltage gated channels cause action potentials.

1. Resting membrane potential:

- The resting membrane potential exists because of a small build up of negative ions in the axoplasm and the equal build up of positive ions in the extra cellular fluid (ECF).
- Such separation of positive and negative charges is a form of **potential energy.**
- If the difference in charge is more across the axolemma, the membrane potential is larger. This difference close to the axolemma is calle axolemma, the membrane potential is larger.
- This difference close to the axolemma is called **resting membrane potential.**

- The resting membrane potential is maintained due to two conditions: unequal distribution of ions across the axolemma and variable permeability of axolemma.
- ECF contains large amounts of sodium ions. The axoplasm contains a large amount of diffusible potassium ions and non diffusible organic phosphates and complex organic molecules.
- These non diffusible ions and molecules cause the resting membrane potential.
- Most of the solutes in ECF and axoplasm are electrolytes. Neurilemma is moderately permeable to Na^+ but 50 to 100 times more permeable to K^+.
- Concentration of Na^+ ions in ECF is about 10 times more in ECF than in axoplasm.
- The concentration of K^+ ions in axoplasm is about 30 times more in axoplasm than in ECF.
- There is a slow influx of Na^+ ions into the axoplasm, and continuous out flux of K^+ from axoplasm through leakage channels during the resting state.
- In the resting state activation gate of sodium channel is closed, inactivation gate is opened.
- Gated channels of potassium are closed.
- The average resting membrane potential is –70 mV on inner side of the membrane.
- Hence, at the resting state the axolemma is polarised.

2. Generation of Action potential

- Action potential arises according to the "**all-or-none principle"**. When depolarisation reaches threshold level, the voltage gated channels open and the same amplitude of action potential is generated.
- There is no change in the amplitude beyond the threshold stimulus.
- At the threshold level the membrane potential changes from –70 to –55.
- When any stimulus depolarises the membrane to the threshold level, voltage gated Na^+ channels open causing the influx of Na^+ ions.
- The influx of Na^+ ions changes the membrane potential from –55 to +45 mV.
- At the peak of the action potential, called **spike potential,** the inside is +45 mV.
- This phase is called **depolarising phase.**
- During the depolarising phase both gates of sodium channel are opened and the potassium channel is closed.
- Depolarising phase is followed by the **repolarising phase.**
- In the repolarising phase activation gate of sodium channel is opened and the inactivation gate is closed.

- Potassium channels are opened. K^+ ions leave the axoplasm and cause the inside of the cell more negative than the outside.
- During **hyperpolarisation** phase both gates of the sodium channels are closed.
- Potassium channels are remained opened. The membrane potential becomes –90 mV inside.
- During repolarisation and hyperpolarisation inactivation gates of Na^+ are closed.
- So neuron is insensitive to the stimulus. This period is called **refractory period.**
- This hyperpolarisation is followed by **resting state.** In the resting state potassium channels are closed.
- Inactivation gates of Na^+ channels are opened, activation gates are closed.

3. Conduction of action potentials:

- Action potentials travel along an axon, as they are self propagating. An action potential is a localised event.
- Following are the characteristic of nerve impulse conduction.
- A wave of depolarisation cannot induce another action potential behind it, but propagates only in the forward direction. Because behind it is in a refractory period.
- The speed of the transmission is directly proportional to the diameter of the axon.
- In medullated nerve fibres the relay of impulses jumps from node to node. This is called **salutatory transmission** of impulses.
- This is about 50 times faster than the impulse conducted in non-medullated fibres.

Signal transmission at synapse:

- Synapse is a place where axon terminals (presynaptic neuron) of one nerve fibre lie close to the dendrites of the adjacent neurons (postsynaptic neuron).
- These junctions are called **synapses.**
- These ensure one way or unidirectional transmission of impulses. The process of chemical transmission across synapse was discovered by Henry Dale (1936).
- He found that a synaptic knob contains many mitochondria and many synaptic vesicles which are filled with a chemical that transmits impulses to post synaptic neurons.
- The chemical transmitters are called **'neuro transmitters'.**

- Synaptic activity is a short lived activity as the **neuro transmitters** are hydrolysed very soon by enzymes. The repolarization of the postsynaptic membrane thus is soon restored.
- At these synaptic junctions acetylcholine is secreted by axon terminal ends. This accumulates on the cavity of the synapse and causes depolarisation in the dendrites of the next neuron.
- To ensure that the synapse is ready for the passage of next impulse, act of moving the acetylcholine is done by **cholinesterase.**
- The cholinesterase is found in high concentrations in the synaptic fluid. It degrades acetylecholine into acetylene and choline.
- Neuro transmitters are excitatory or inhibitory in action excitatory post synaptic potentials (EPSP). Acetylcholine is the common neuro transmitter.
- Other neurohumors secreted by the presynaptic membrane fibres, are **norepinephrine, dopamine** etc. These are excitatory in function.
- They transmit the action potential to the postsynaptic membrane at the synapse.
- The neurotransmitters like glycine, Gamma Aminobutyric Acid (GABA), serotonin etc., are inhibitory in function. Inhibitory post synaptic potentials (IPSPs).
- A neuron receives inputs from many synapses and the integration of these inputs is known as **Summation**
- Summation occurs at Axon hillock. Summation from several presynaptic buttons is called **spatial summation**
- A successive input from single presynaptic button is called **temporal summation.** Threshold is reached when the sum of all EPSPs exceeds sum of IPSPs thus generating an action potential