# Coordination in Humans

Regulation of substances and response to stimuli in 2 ways

- Nerves that transmit information in the form of electrical impulses. These nerves make up the Nervous System

- Chemical messengers (hormones) that are carried in the blood. These hormones and their networks make up the Endocrine system.

★ Nervous System

Made of 2 ~~parts~~ types:

- (CNS) The Central nervous system (Brain & Spinal Cords)
- The peripheral nervous system (Nerves and extension)

- Information from one part of the body is communicated to other parts by nerve impules. These travel at very high speeds along neurones. Neurones carry info from source to target cell of an impulse.

★ Types of Neurones

→ Sensory Neurone (Receptor → CNS
→ Motor Neurone ( CNS → Effector)
→ Relay Neurone (CNS → CNS

Structure of motor neurone

→ It has a cell body that lies within the brain or the spinal cord
→ It has a nucleus within its cell body, and the cell body has thin extension called dendrites
→ It has a very long axon which conducts impulses over long distance

- In the axon of the motor neurone, the ends of the axon have large no.s of mitochondria and vesicles containing ~~neurotra~~ neurotransmitters.

# Reflex arc

An involuntary action ~~requiring~~ ~~a~~ and a pathway through which impules are transmitted from a receptor to an effector without involving conscious regions of the brain. It is a fast, automatic response to a stimulus

# Myelin and its role in neurones

→ Myelin Sheath is present around the axon of ~~a~~ most motor neurones.

→ Myelin is made ~~of~~ of when schwann cells wrap themselves along the length of the axon, thereby wrapping the axon in a sheath called myelin sheath. Spaces in between of the myelin sheath are known as the nodes of Ranvier. Myelinated neurones conduct impulses faster than unmyelinated neurones because action potentials jump from one node to the next. (Saltatory Conduction)

# Transmission of nerve impulses

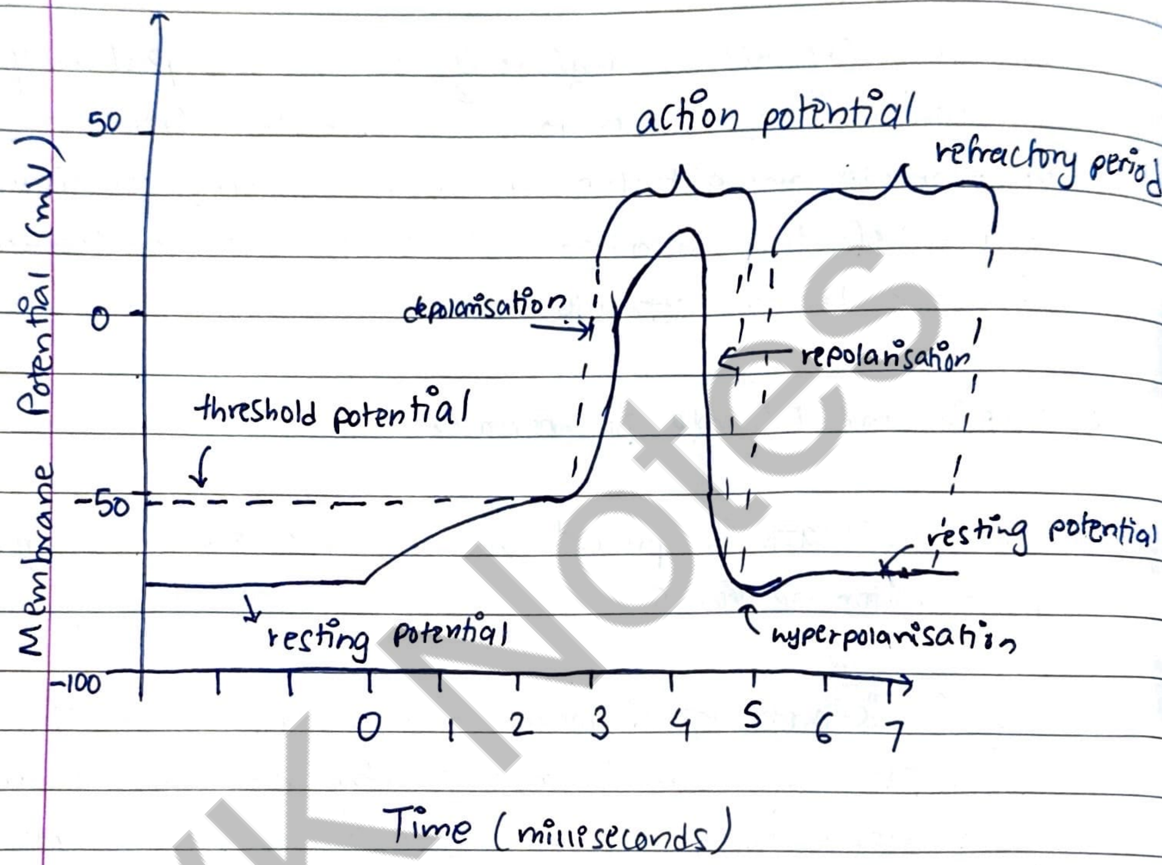
→ Nerve impulses are transmitted as electrical impulses which travel rapidly along the cell surface membrane.

→ Nerve impulses differ from electric current as ~~it~~ it is not a flow of electrons, but rather changes in the distribution of electrical charges across the cell surface membrane

- This brief change ~~is~~ in electrical charge distribution is known as action potential

→ Action potentials are caused by the rapid movement of sodium and potassium ions in & out of the axon

## ✱ Action potential in a neuron graph




## ✱ Resting Potential

- In a resting axon, the inside of the axon is always slightly negative (-60mV to -70mV) compared to the outside
- This creates a difference in electric potential which is p.d. Difference is known as resting potential

→ The resting potential is produced by the difference in concentration of sodium & potassium ions inside and out of the cell.

→ Sodium - potassium pumps in the cell surface membrane move sodium ions out of the axon and potassium ions into the axon. For every 3 sodium ions pumped out, 2 potassium ions are brought in.

→ But there are more potassium channels than sodium channels, ~~so~~ potassium tends to diffuse out of cell. However, some large negative ions inside cell prevent $K^+$ ions from diffusing out.

→ This results in the inside of the membrane being more negative than outside.

★ How Action Potential is generated.

- The axon receives a stimulus.
- This causes the opening of the voltage-gated channels (channel proteins that respond to electrical impulse) in the cell surface membrane.
- Sodium ions ~~pass~~ are pumped out of the cell
- The higher concentration of $Na^+$ ions outside the cell causes sodium to flow back into the cell through a few channels that are open.
- This changes the potential difference across the membrane and makes the cell less negative on the inside.
- This is called depolarisation
- This causes more channels to open so that more sodium ions can enter.
- This increases depolarisation (+30mV)

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- Action potential are generated when the potential difference value reaches about -50mV. These are the threshold potentials, and when the p.d is less than this, no action potential is generated.

- After 1 ms, all the voltage-gated sodium channels so sodium ions stop diffusing into the axon. Potassium channels open and potassium ions diffuse out of the axon down the concentration gradient.

- This removes the (+) charge from inside the axon and returns to potential difference to normal (-70mV). This is called repolarisation.
- The potassium ion channels close and the sodium ion channels respond to depolarisation again.

→ Action potential will always have a p.d of +30mV, no matter how strong stimulus. However a strong stimulus results in a higher frequency of action potential.

→ Receptor cell ~~is the~~ initiates ~~first~~ the 1st action potential. They are transducers as they convert sensory energy to electrical energy.

## Synapses

- Neurones don't touch each other though they are connected. There is a gap of about 20nm wide b/w them called a synaptic cleft

* Synaptic Transmission

Impulses are transmitted from one neurone to another by using transmitter molecules to stimulate the next neurone

* Cholinergic Synapses

- cholinergic synapses uses acetylcholine as their transmitter substance

- In the membrane of the pre-synaptic neurone, the action potential does not only cause the opening of sodium ion voltage-gated channels. It also results in opening of calcium ion voltage gated channels which causes calcium ions to also flow into the cytoplasm of the pre-synaptic neurone.

- The inflow of calcium ions stimulates vesicles containing acetylcholine to move toward the presynaptic membrane and fuse with it. The vesicles then empty their content into the synaptic cleft. (Each vesicle contains up to 10000 molecules of ACH and ACH diffuses across in 0.5 ms)

- On the membrane of the post-synaptic neurone, there are receptor proteins having a complementary shape to ACH. This allows Ach to bind temporarily with the receptors. These receptor proteins are chemically-gated as they are stimulated by chemicals.

- This binding causes the proteins to change their shape and results in the opening of channels through which sodium ions can pass into the cytoplasm of the postsynaptic neurone. The influx of sodium ions depolarize the membrane of the postsynaptic membrane.

- Acetylcholine is recycled after ~~causing~~ depolarization of the post synaptic membrane. An enzyme acetylcholinesterase breaks ~~a~~ Ach to acetate & Choline. Choline is taken ~~back~~ back to the presynaptic membrane combined with acetyl coenzyme A to form Ach again.

★ Role of Synapses

- Synapses ~~2~~ ensure transmission occurs in one direction, i.e one way transmission
- Synapses allow for the integration of ~~pathways~~ nerve pathways
- Synapses allow integration of impulses
- Synapses are involved in memory and learning.

★ Muscle contraction

→ Types of muscles

- Cardiac muscle
- Skeletal muscle (striated muscles)
- Smooth muscle

Striated muscles: muscles that are attached to the skeleton. They only contract in response to impulses that arrive via the motor neurones. The muscles are also called neurogenic muscles because they contract in response to nerve impulses

cardiac muscles are also called myogenic muscles. They do not need any impulses to contract.

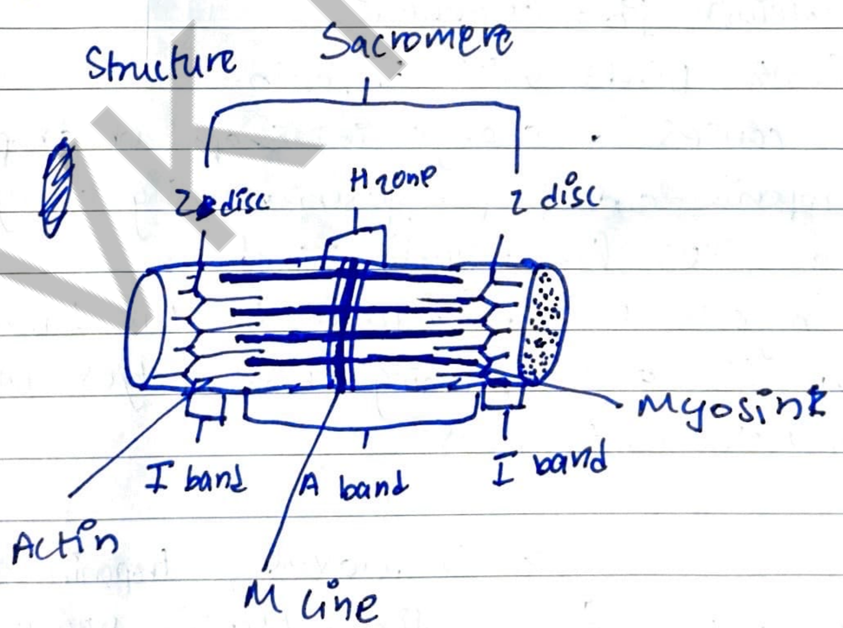
• Structure of striated musle

→ The cell surface membrane of a muscle cell is called the sarcolemma and ~~a~~ the endoplasmic reticulum is called sarcoplasmic reticulum (SR)

→ The membranes of SR have calcium pumps that pump calcium into cisternae of SR.

→ Sarcoplasm is packed with large number of mitochondria b/w myofibrils to generate ATP for muscle contraction.

Structure




• Thick filaments are myosin, thin filaments are actin.

• Myosin is a fibrous protein with a globular head while actin is a globular protein

→ The fibrous portion of myosin helps to anchor the molecule into the thick filament.

→ Actin molecules form chains. Two chains are twisted together with tropomyosin also twisted to form a thin filament. A protein troponin is also attached at intervals.

★ How muscles contract

- An impulse travels until it reaches presynaptic synapse
- A neurotransmitter (mostly Ach) travels across neuromuscular junction.
- When Ach binds, ion channels open so sodium enters cell, depolarizes the membrane and generates an action potential in sarcolemma.
- Impulse travels along sarcolemma and stimulates opening of calcium ion channels
- Calcium binds with troponin
- This causes a change in shape of troponin, resulting in troponin and tropomyosin moving away to reveal binding sites for myosin heads.
- The myosin head attach to the binding sites on the thin filament, forming cross bridges which results in muscle contractions.

Note: When muscle is relaxed, troponin and tropomyosin prevent myosin from binding. Myosin heads tilt, pulling the actin, causing it to contract. ATP hydrolysis causes the release of myosin heads.

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# Control & Coordination of Plants

→ Plant cells also have electrochemical ~~gra~~ gradient and resting potentials.
→ The depolarization of the plant membrane is due to outflow of negative chloride ions.

## Electrical communication in venus Fly trap

→ The lobe of the plant has stiff hairs that respond to being deflected. The outer edges of the lobe have hairs which interlock and digestive enzymes to digest the insect.

→ The deflection of a sensory hair activates calcium ion channels in the cells at the base of the hair, through which calcium ions flow to generate a receptor potential. If two hairs are stimulated b/w 20-35 s ~~the~~ or 1 hair is touched twice, action potential travels across the trap.

→ If second trigger takes too long, then new time interval is set up. The time b/w stimulus and response is 0.5 s. However to seal the trap ongoing activation of trigger hairs is required. This forces the edges of the lobes together, sealing the trap. Calcium ions stimulate exocytosis of vescicles containing digestive enzymes.

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## ☆ Chemical communication of plants

- Two key plant hormones (growth regulators) are auxins & gibberlins.

- Auxin influence elongation growth which determines the overall length of roots and shoots of the plant.

- Gibberellins are involved in seed germination & control stem elongation

## ☆ Auxin

→ Auxin is synthesized in the tips of roots and shoots where the cells are dividing
→ Principal auxin is called IAA
→ After synthesized, it is transported down the shoot or up the root by active transport from cell to cell or in the phloem sap

How they stimulate growth?

→ Auxin bind to receptor protein on cell surface membrane
→ This stimulates the pumping of protons out of the cytoplasm into the cell wall
→ This leads to a decrease in pH of cell wall.
→ This activates proteins known as expansins which loosen the linkages b/w the cellulose microfibrils in the cell wall.
→ This allow water to be absorbed by osmosis, and the pressure potential causes the walls to stretch so that cells become longer & elongated.

* Gibberlins concentration is high in young leaves

→ act hand in hand with genes to aid stem elongation

→ In pea plant Le is dominat allele (plant grows tall) and le is recessive.

Role of alleles

→ Active gibberlin stimulates the division of cells and elongation in the stem causing plant to grow tall. It regulates the synthesis of the last enzyme in a pathway that leads to synthesis of GA1 → active gibberlin.

* Gibberlins & Seed Germination

- When germination begins, water is absorbed and this stimulates the embryo to produce gibberlins. These gibberlins stimulate the cells to synthesize amylase which hydrolyses starch providing energy for growth of embryo