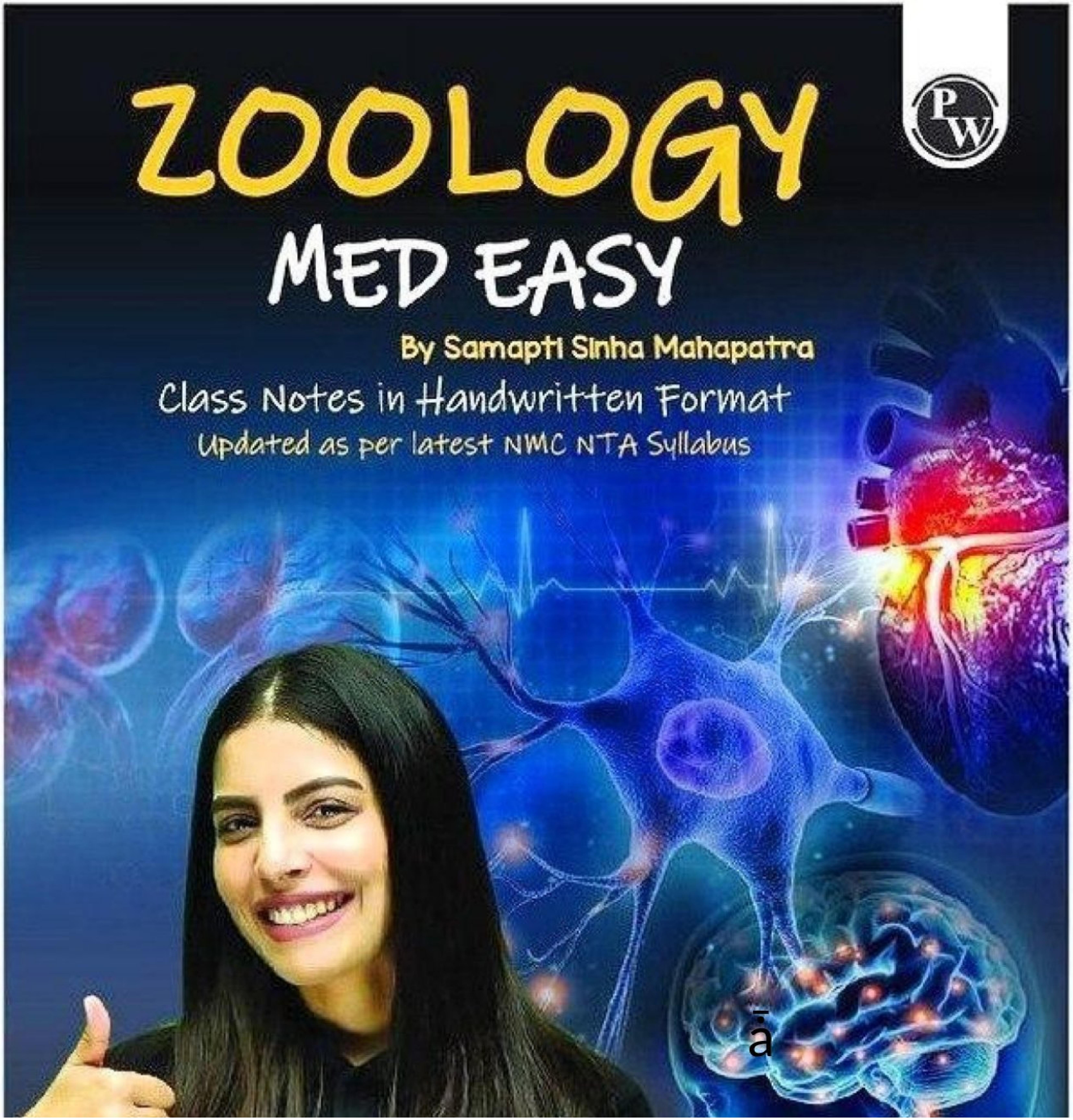

ZOOLOGY
MED EASY
By Samapti Sinha Mahapatra
Class Notes in Handwritten Format
Updated as per latest NMC NTA Syllabus
PW

1

Animal Kingdom

ANIMAL KINGDOM: (KINGDOM ANIMALIA /METAZOANS)

- Multicellular
- Heterotrophs: Dependent on others for food
- Holozoic mode of Nutrition
  → First ingestion, then Digestion

Metazoans/Kingdom Animalia

→ Subkingdom Parazoa
  → Primitive Metazoans (old)
    → Phylum Porifera

→ (Advanced) Subkingdom Eumetazoa

PHYLA:
- Coelenterata/Cnidaria
- Ctenophora
- Platyhelminthes
- Aschelminthes/Nemathelminthes/Nematoda
- Annelida
- Arthropoda
- Mollusca
- Echinodermata
- Hemichordata
- Chordata

↓ Advanced

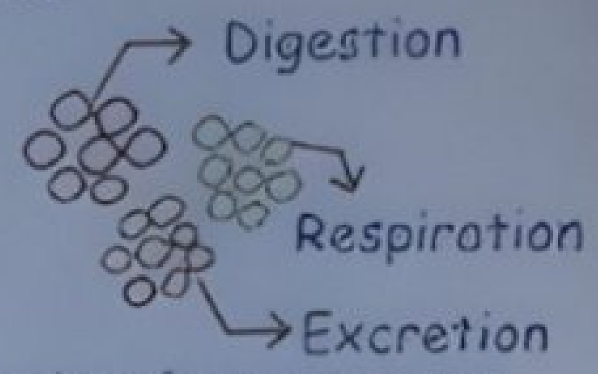
Basis of Classification

In spite of differences in structure & form of different animals, there are fundamental features common to them that are used as the basis of animal classification

1. Level of organisation (L O O)

→ Cellular: Only cells are present. eg: Porifera

→ Tissue: Group of similar cells organised to Perform a specific function
eg: Coelenterata, Ctenophora



→ Organ: Tissues are organised to form an organ
eg: Platyhelminthes
↓
(ALSO ORGAN SYSTEM-TABLE 4.2 NCERT)

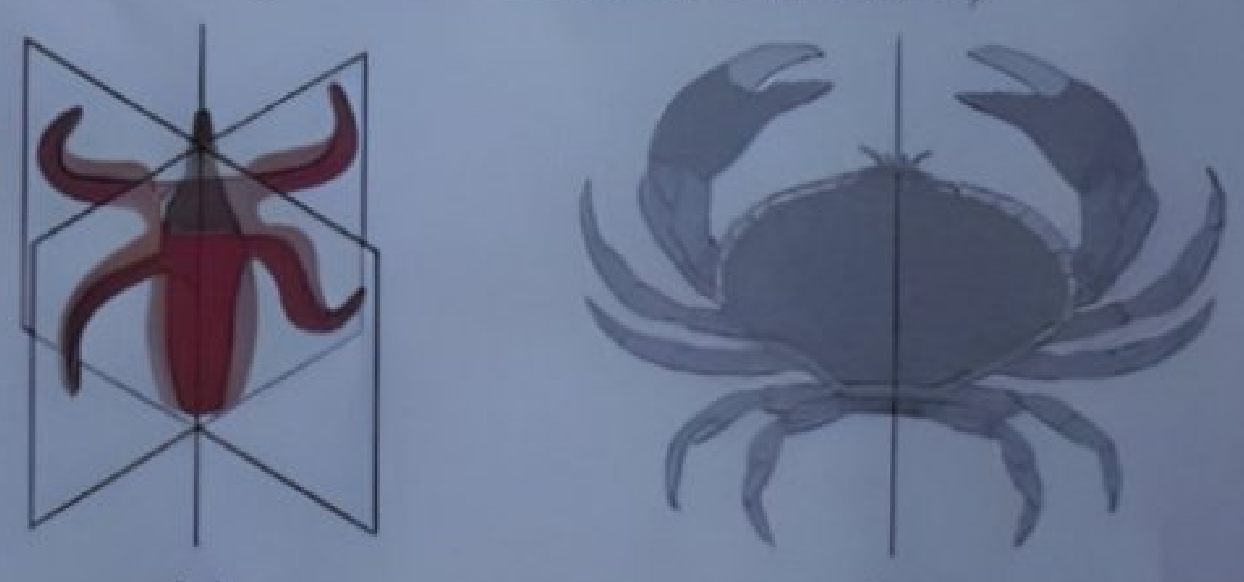
→ Organ-system: Organs are organised to form organ system. eg: From Aschelminthes upto Chordata

2. Symmetry

→ i) Asymmetrical: Body can't be divided into equal halves passing through any plane that passes through centre
eg: Mostly Porifera (sponges)

→ ii) Radially Symmetrical: Body can be divided into equal halves passing through any plane that passes through centre
eg: Coelenterata, Ctenophora
" ECHINODERMS (ADULT)

→ iii) Bilaterally Symmetrical: Body can be divided into equal halves passing through only one plane through centre
eg: Platyhelminthes upto Chordata
(*ECHINODERMATA LARVA)



(a) (b)

Figure: (a) Radial symmetry, (b) Bilateral symmetry

3. Body plan (Not in NCERT directly)

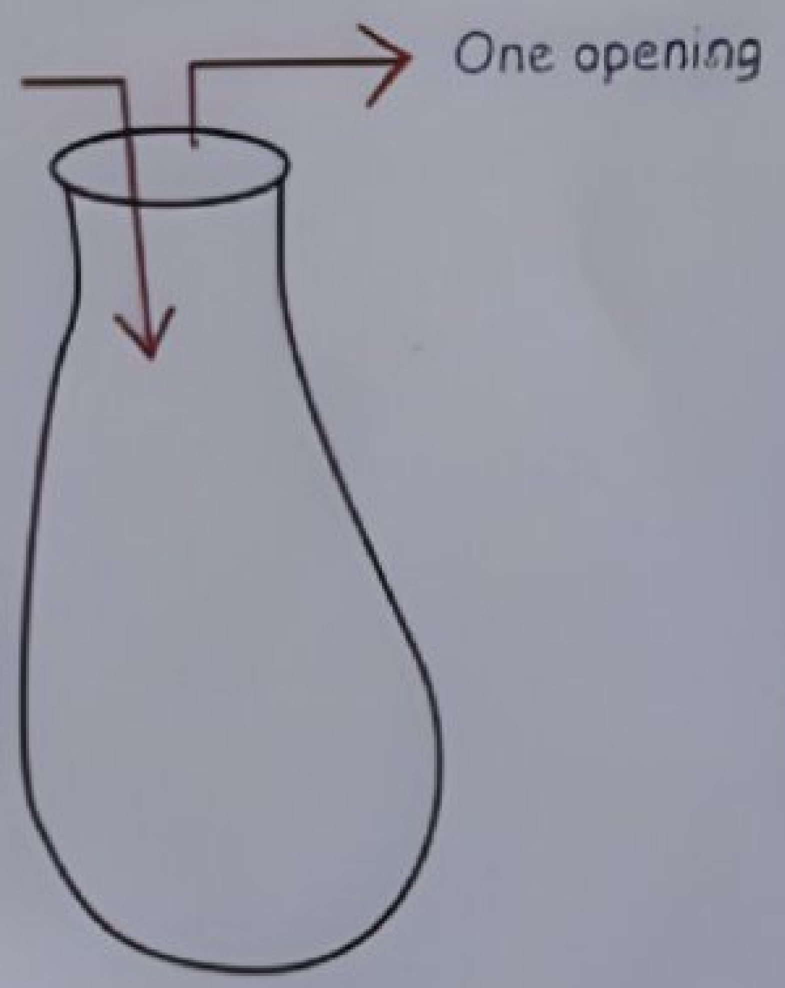
(अतिरिक्त Gyaan)

→ i) Cellular aggregation: Only cell are diffused in body.

eg: Porifera

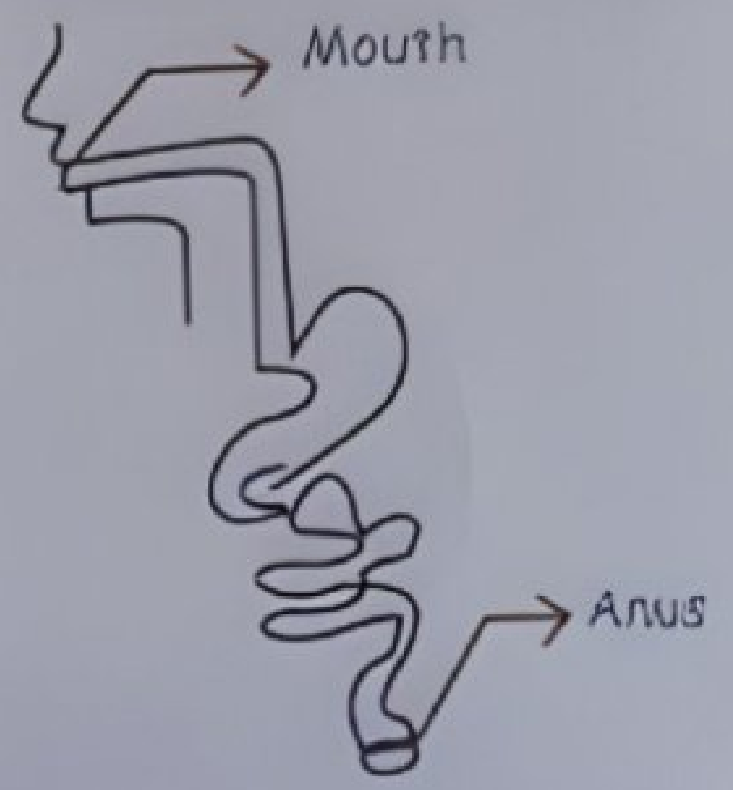
→ ii) Blind sac: Body has only one opening for entry or exit of substances

eg: Coelenterata, Ctenophora, Platyhelminthes

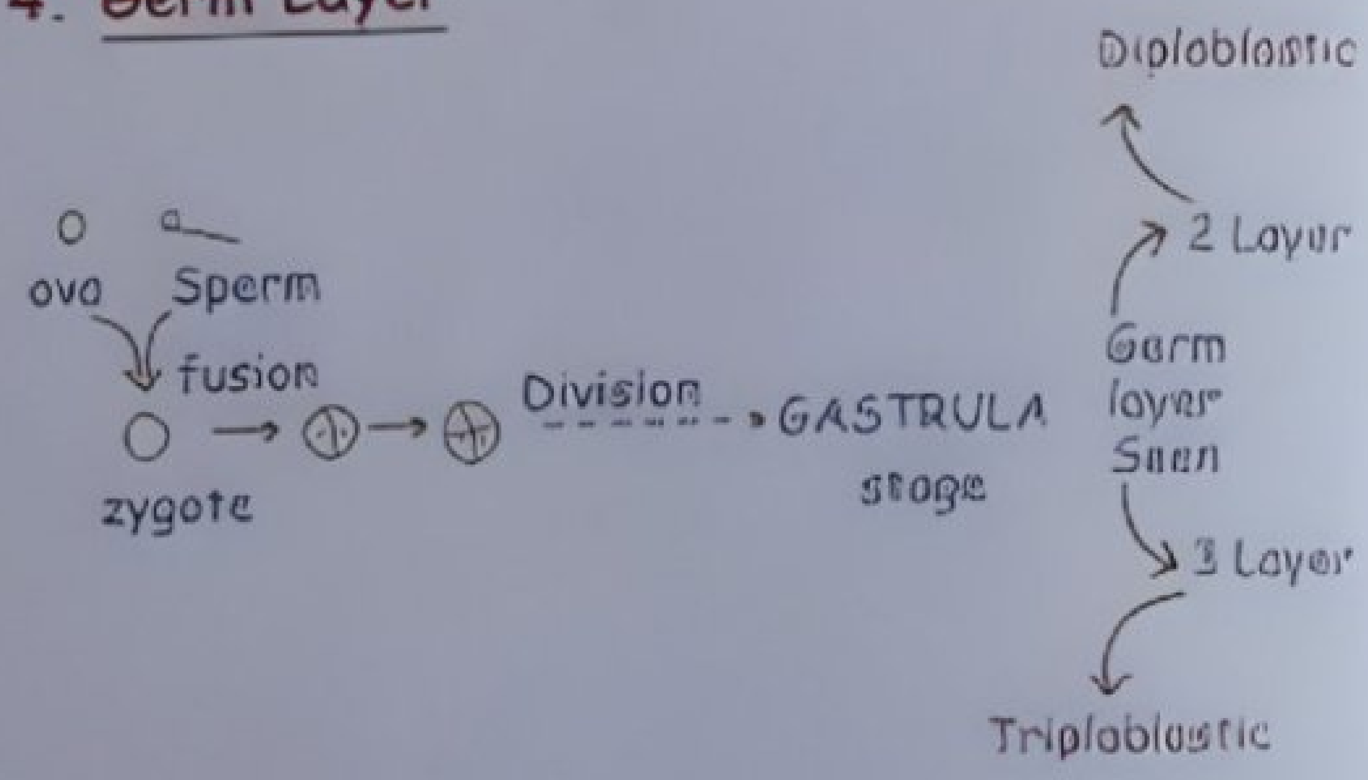


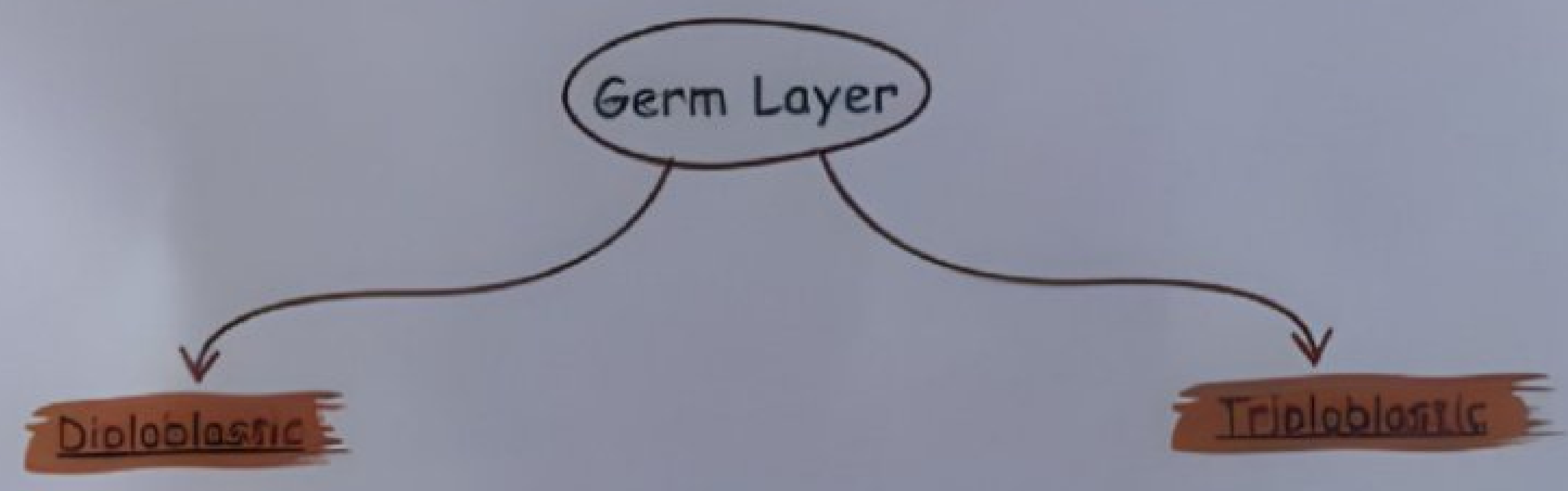
→ iii) Tube within tube: 2 separate openings are present, one acting as a mouth & another like a anus

eg: Aschelminthes upto Chordata



4. Germ Layer



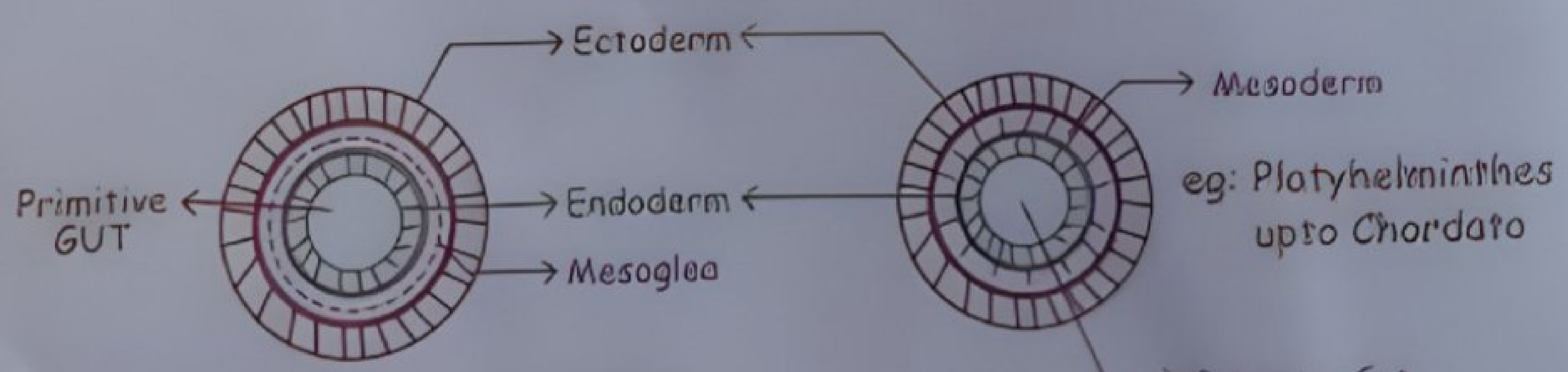


Diploblastic

- Animals in which only 2 germ layers: Ectoderm & Endoderm are found.
- A non-cellular MESOGLEA is present Between them.

Triploblastic

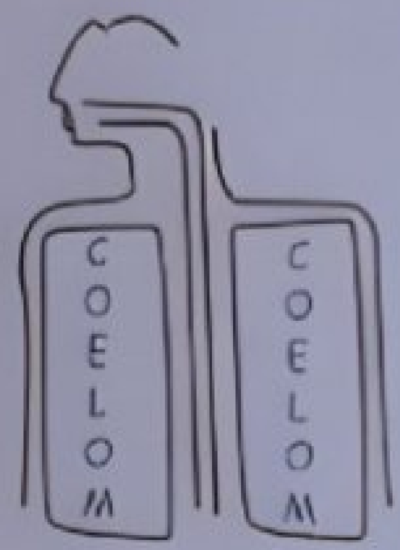
- Animals in which 3 germ layers are found ECTODERM, ENDODERM & MESODERM.



eg: Coelenterata, Ctenophora

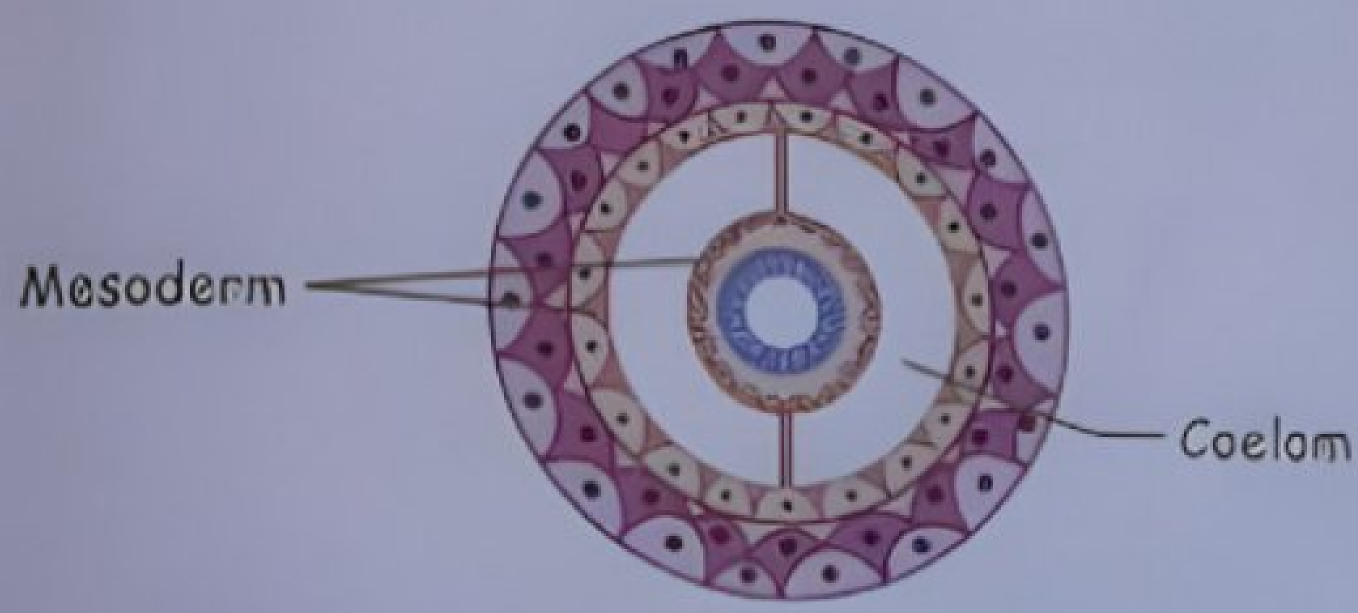
eg: Platyhelminthes upto Chordata

5. Coelom

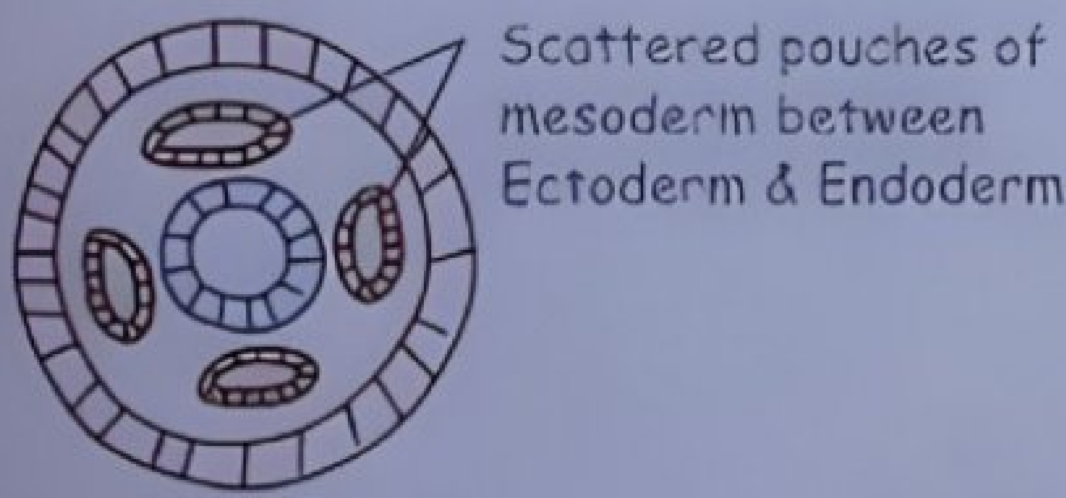


- → Acoelomate: Absence of Coelom eg. Porifera, Coelenterata, Ctenophora, Platyhelminthes
- → Pseudocoelomate: Aschelminthes
- → Eucoelomate: Annelida upto Chordata

Eucoelomate (TRUE COELOM): The body cavity which is lined by mesoderm on the both sides.



Pseudocoelomate (False coelom): Mesoderm is present as scattered pouches between ectoderm and endoderm



Acoelomate: (No coelom) : Body cavity is absent.

In PLATYHELMINTHES, even though Mesoderm was present but it does not split & remains SOLID

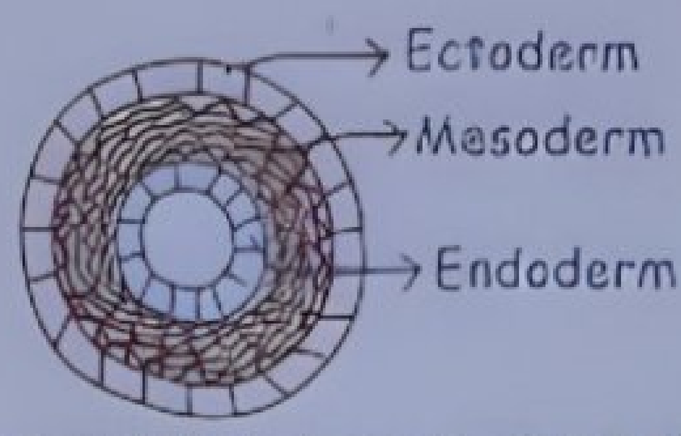


Figure: Solid Mesoderm in platyhelminthes

6. Metameric Segmentation

Body can be divided externally, internally with serial repetition of at least some organs is known as 'METAMERISM'

eg: Annelida, Arthropoda, Chordata

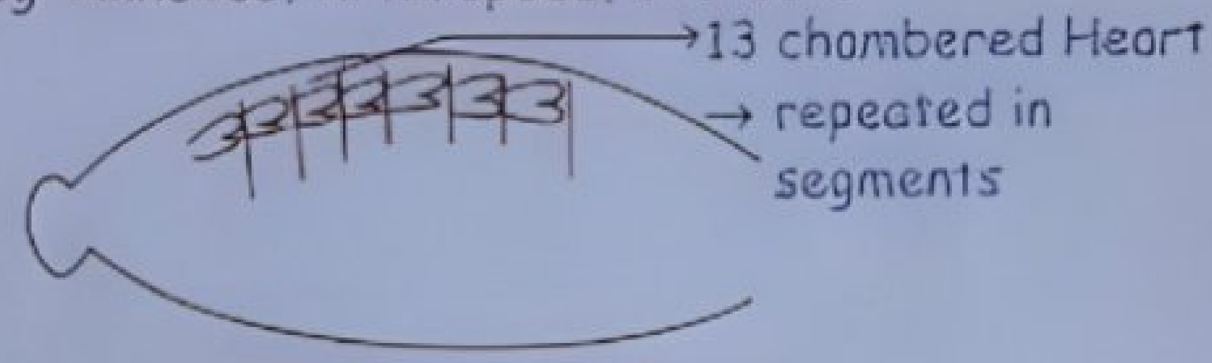


Figure: Cockroach

7. Notochord

A supporting mesodermally derived structure present Dorsally only in CHORDATES.

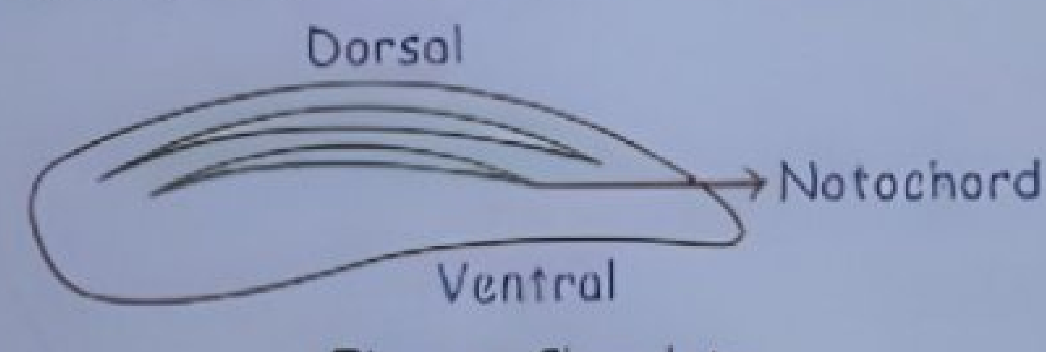


Figure: Chordata

8. Digestive system

- Complete → 2 opening present in alimentary canal.
  eg., Aschelminthes upto Chordate
- Incomplete → Only single opening present in alimentary canal.
  eg., Coelenterata upto Platyhelminthes

9. Respiratory system

→ It was properly seen for the first time in Arthropods

10. Circulatory system

- Open (Blood vessels not bounded by capillary)
- Closed (Blood vessels bounded by capillary) → eg., Chordata

A N T H E → Arthropoda, Non-cephalopod Mollusca, Hemichordata, Echinodermata, Tunicata

eg., of open Circulatory system

PORIFERA (SPONGES)

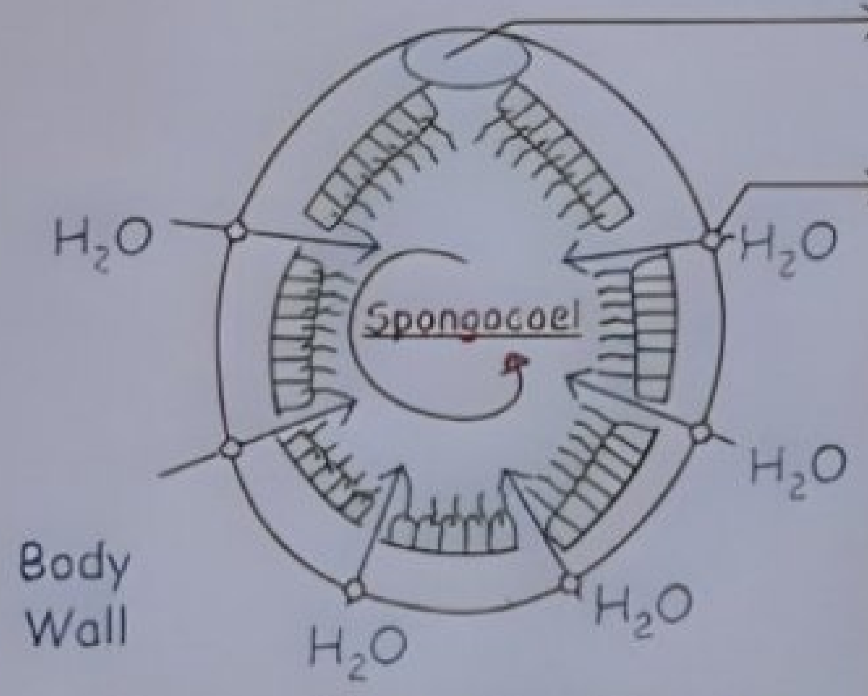
'Pore' Bearers

General Characteristics

1. Habitat: All are aquatic, few fresh water But mostly marine

- These are SESSILE animals → attached to the Substratum/ Ocean floor

2. Level of Organisation: Cellular
3. Symmetry: Asymmetrical mostly
4. Germ layer: Absent
5. Body plan: Cellular aggregation
6. Coelom: Absent
7. Metamerism: Absent
8. Notochord: Absent



→ OSCULUM (Water exit) → SINGLE

→ OSTIA : Minute pores present in the body of porifera

Figure: Water Canal System

flagella

Collar cells / Choanocytes

These are flagellated cells lining the spongocoel & helps in the movement of H_2O

WATER-CANAL-SYSTEM

Helps in
- OSTIA ⟶ SPONGOCOEL ⟶ OSCULUM
- Digestion, respiration, excretion, Reproduction (transfer of gamete)

NOTE The body is supported with SKELETON made of spongin fibers, SPICULES (Calcium or Silicon)

Physiology

1. Digestive system: Intracellular
2. Respiratory system: Absent
3. Circulatory system: Absent
4. Excretory system: Absent
5. Reproduction: Hermaphrodite, 'Sexual' & Asexual (By Fragmentation)
6. Fertilisation: Internal fertilisation
7. Development: Indirect (via larval Stages)

NOTE

UNISEXUAL /DIOECIOUS : Sexes are separate

BISEXUAL /MONOECIOUS / HERMAPHRODITE: Sexes are not separate, male & female reproductive organs are present within the same individual

eg. Euspongia (Common Bath Sponge)
Spongilla (Freshwater Sponge)
Sycon (Scypha)

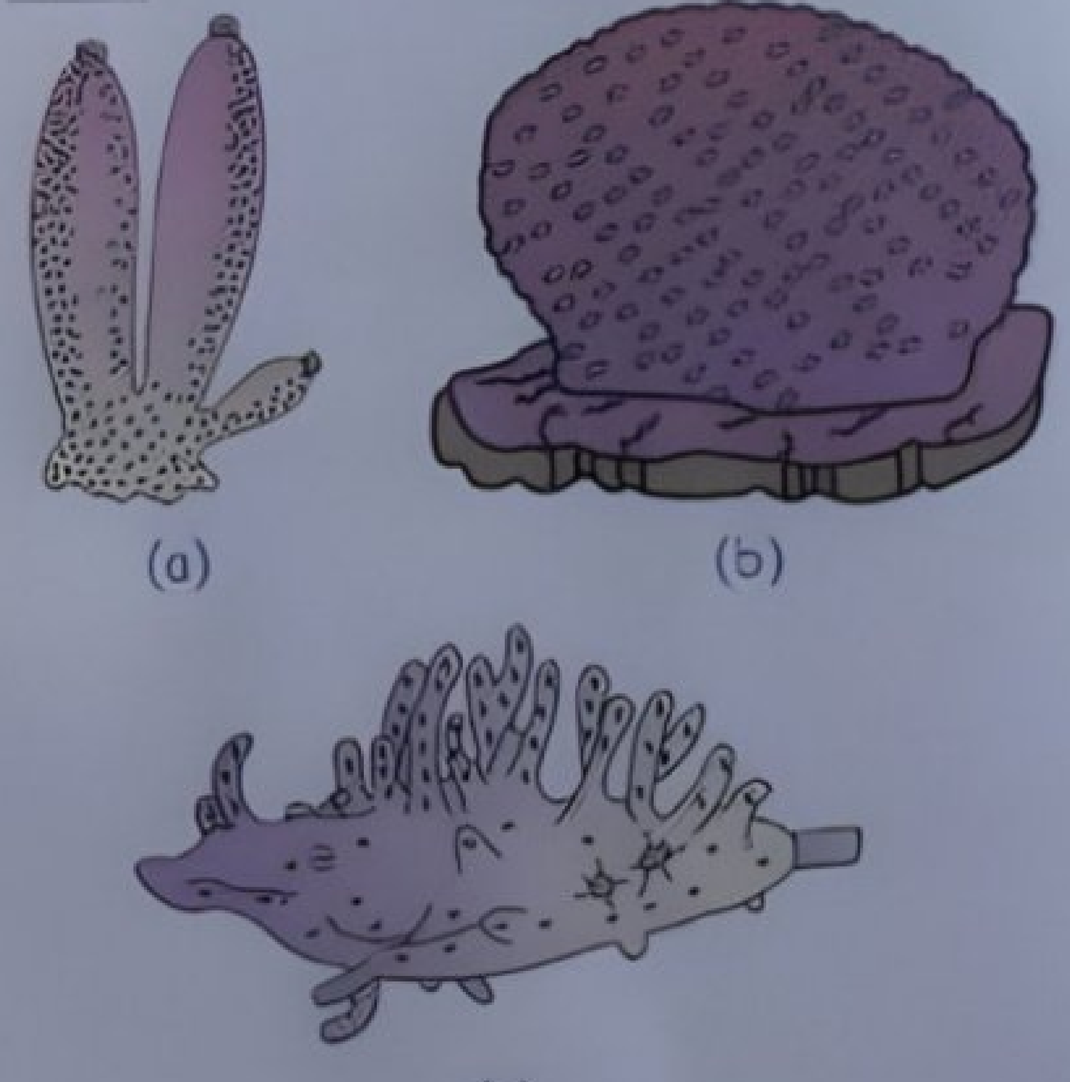


Figure: Examples of Porifera
(a) Sycon (b) Euspongia (c) Spongilla

COELENTERATA/CNIDARIA

Because of the presence of Stinging cell known as Cnidocyte

General Characteristic

1. Habitat All are Aquatic, mostly marine, few fresh water, both Sessile or free-Swimming. → move along with water current
2. Level of Organisation: Tissue
3. Symmetry: Radially
4. Body Plan: Blind sac
5. Germ Layer: Diploblastic
6. Coelom: Acoelomate
7. Metamerism: Absent
8. Notochord: Absent

Coelenterates have 2 body forms

Polyp	Medusa
○ Cylindrical	○ Umbrella like
○ Sessile	○ Free-swimming
○ Asexual form	○ Sexual form
eg: Hydra, Adamsia	eg: Aurelia

- A few coelenterates exhibits alternation of generation also known as 'METAGENESIS'

i.e from POLYP ⇌ MEDUSA

Asexually

Polyp → Medusa

Medusa → Polyp

Sexually

i.e Physalia, Obelia

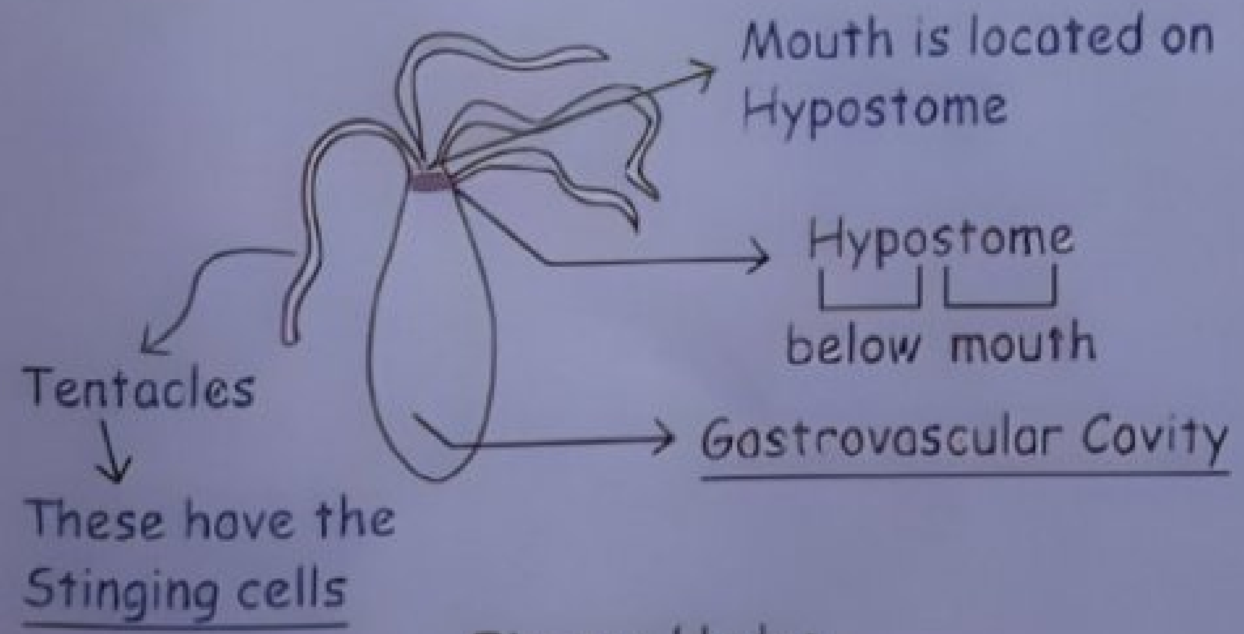


Figure: Hydra

- Corals have a skeleton composed of calcium carbonate

STINGING CELL (Cnidoblast or Cnidocyte)

→ It has the STINGING CAPSULE : Nematocyst → CAPSULE

FUNCTIONS:

- Offense & defense
- Capturing prey
- Anchorage

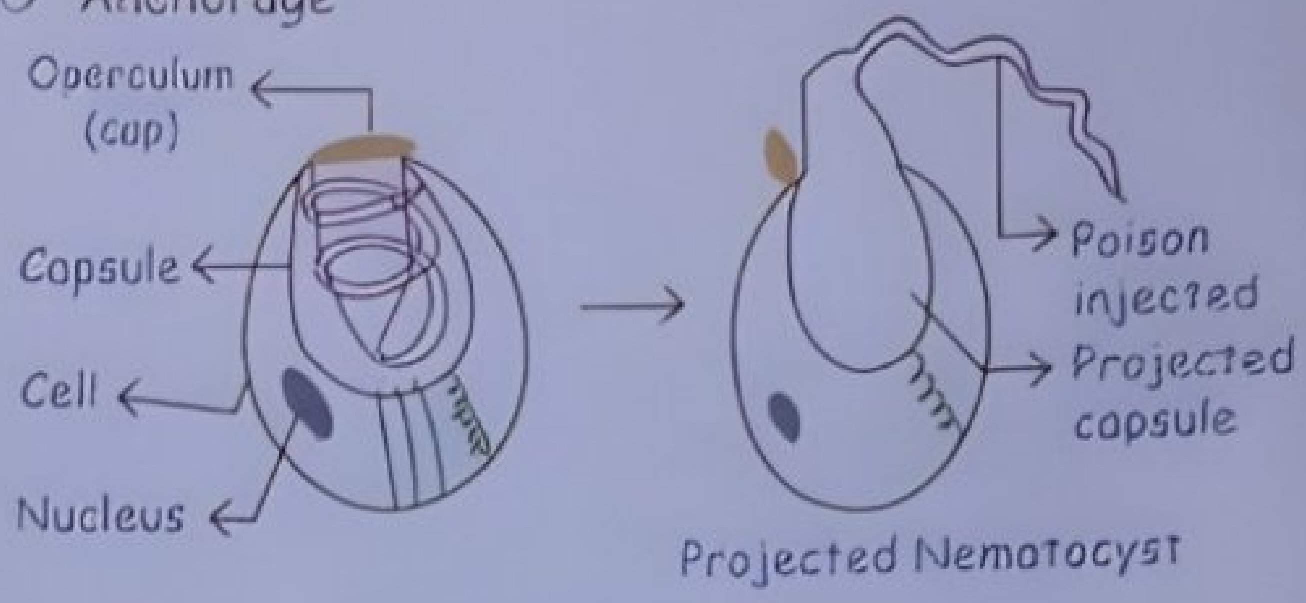


Figure: Cnidoblast

PHYSIOLOGY

1. Digestive system: Incomplete digestive system. Both intracellular & extracellular
2. Respiratory system: Absent
3. Circulatory system: Absent
4. Excretory system: Absent

EX

- Hydra (Freshwater Polyp)
- Adamsia (Sea-anemone)
- Aurelia (Jellyfish)
- Obelia (Sea fur)
- Physalia (Portuguese man of war)
- Pennatula (Sea Pen)
- Gorgonia (Sea fan)
- Meandrina (Brain coral)

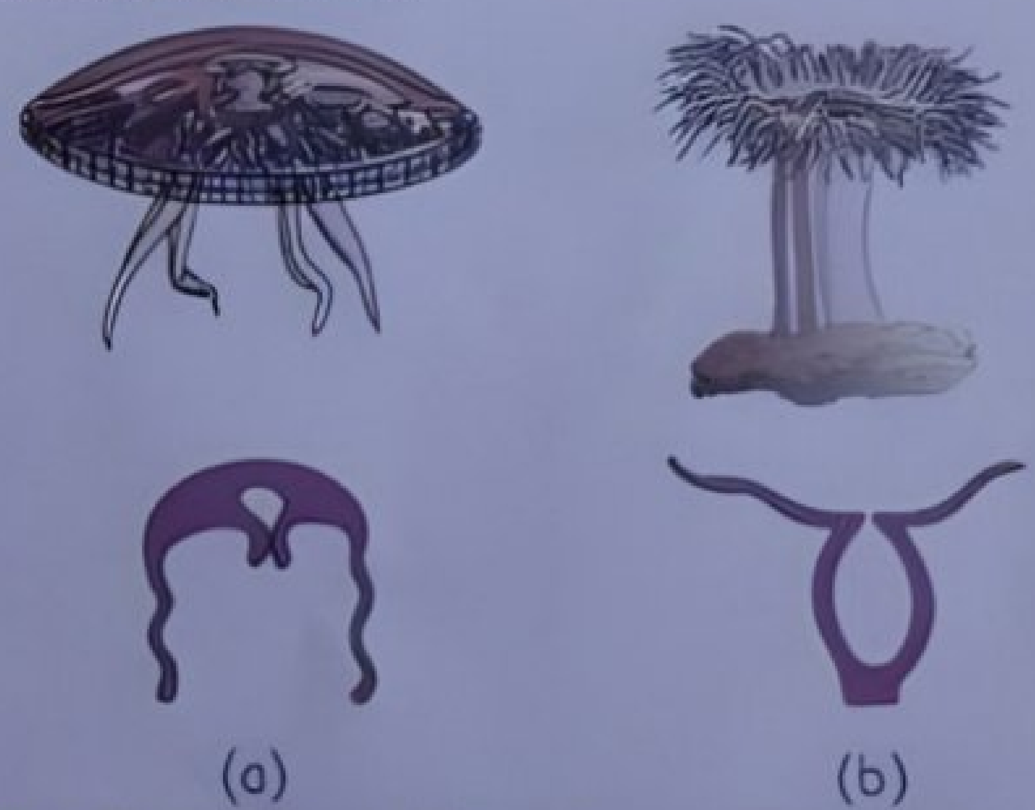


Figure: Examples of Coelenterata indicating outline of their body form
(a) Aurelia (Medusa) (b) Adamsia (Polyp)

CTENOPHORA

→ Commonly known as 'Sea- WALNUTS' or 'COMB-JELLIES', Sea Gooseberry

- They have 8 external rows of Ciliated Comb Plates
  ↓
  USED FOR LOCOMOTION
- They show a property of Bioluminescence → Emission of light

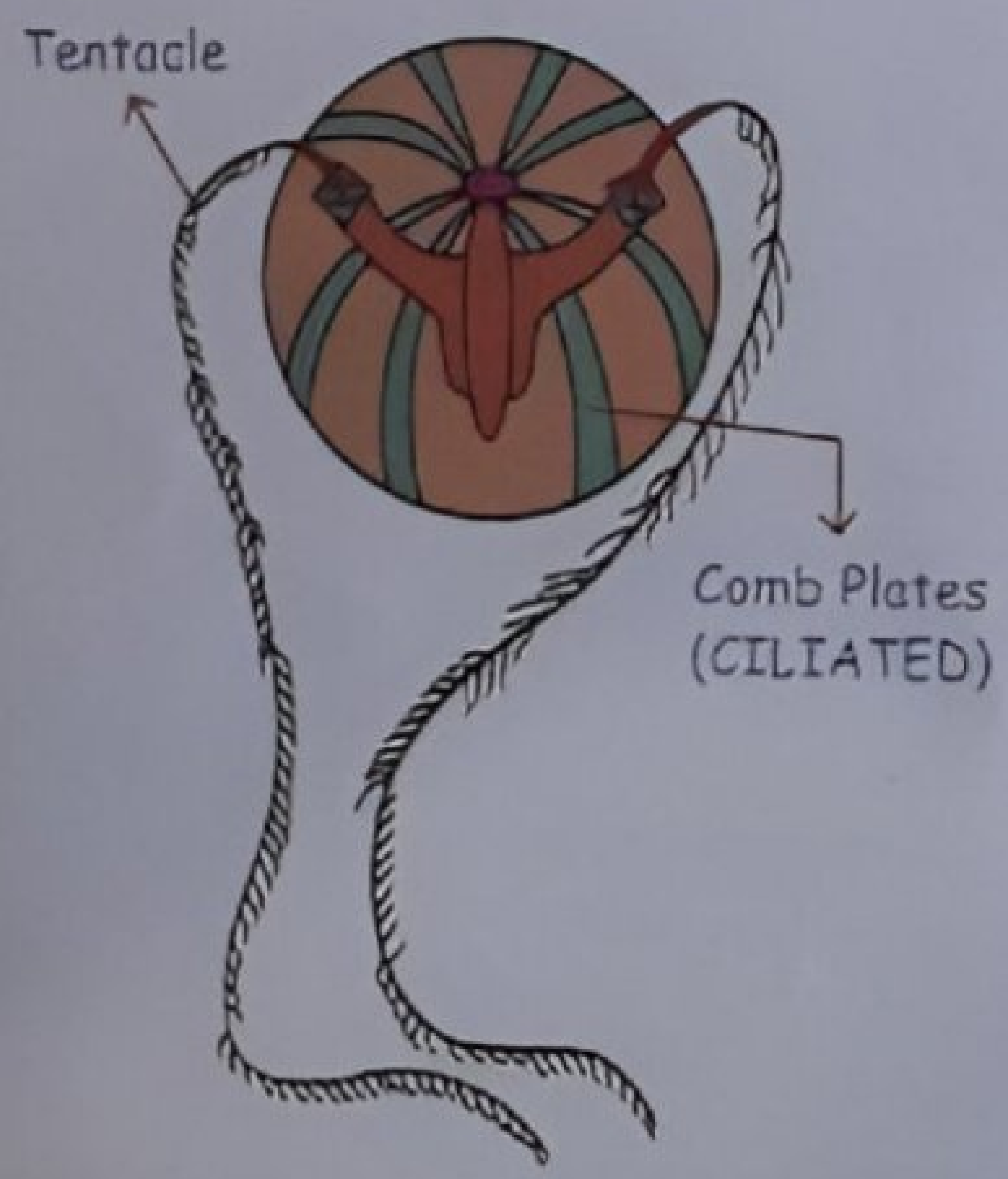


Figure: Example of Ctenophora (Pleurobrachia)

General Characters

1. Habitat*: Exclusively Marine (**V. Imp.**)
2. Level of Organisation: Tissue
3. Body Plan: Blind Sac
4. Symmetry: Radially
5. Germ Layer: Diploblastic
6. Coelom: Acoelomate
7. Metameriam: Absent
8. Notochord: Absent

Physiology

1. Digestive System: Incomplete, both extracellular & intracellular
2. Respiratory System: Absent
3. Circulatory System: Absent
4. Excretory System: Absent
5. Reproduction: Sexual, Bisexual
6. Fertilisation: External
7. Development: Indirect

eg. Pleurobrachia, Ctenoplana

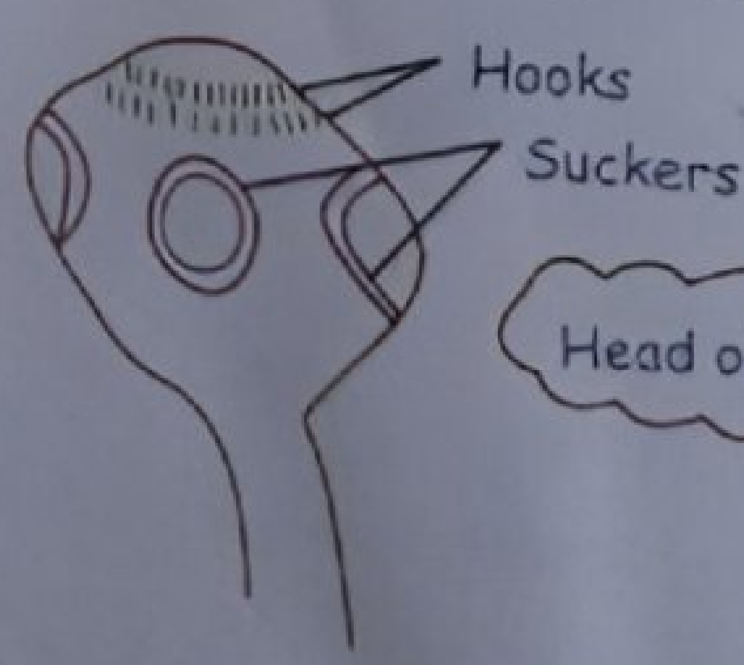
PLATYHELMINTHES

$\underbrace{\text{PLATY}}_{\text{Flat}}\underbrace{\text{HELMINTHES}}_{\text{Worms}}$

1. Habitat: Aquatic or terrestrial, free living or Endoparasite (within host)
   ↓
   Mostly in $\boxed{\text{Animals}}$
   ↓
   Act as host including humans
2. Level of Organisation: Organ or organ system
3. Body Plan: Blind Sac
4. Germ Layer: Triploblastic
5. COELOM: Acoelomate
6. Symmetry: Bilaterally
7. Metamerism: Absent
8. Notochord: Absent

Parasitic Adaptations

1. Thick Tegument (prevent action of any Digestive enzymes)
2. Some parasites may develop 'HOOK' for attachment to the host body.
3. Some may also have 'SUCKERS' for absorbing nutrients from the host.
4. Some have the capability to directly absorb nutrients from their body surface.

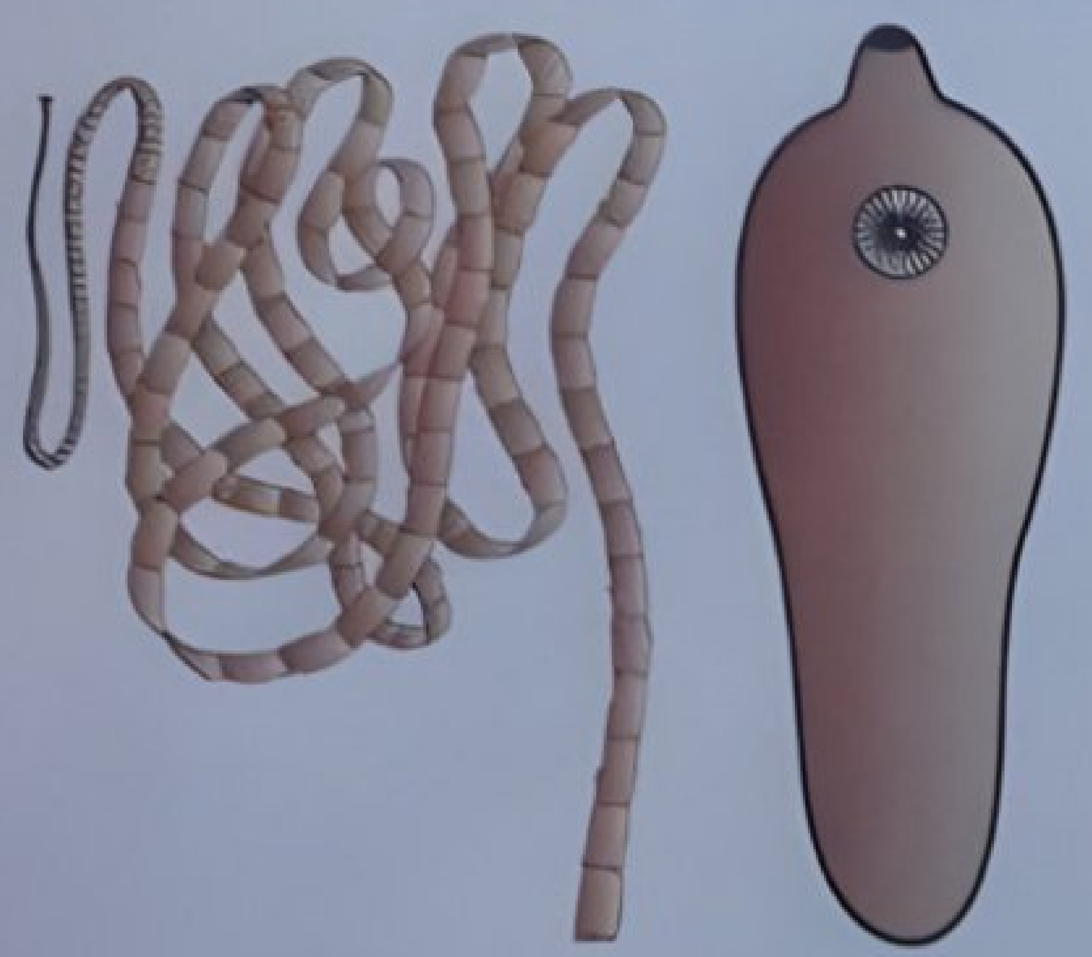


Head of Taenia

Physiology

1. Digestive System: Incomplete
2. Respiratory System: Absent, Simple diffusion, general body surface
3. Circulatory System: Absent
4. Excretory System: 'Flame-cells' for Excretion & Osmoregulation
5. Reproduction: Bisexual
6. Fertilisation: Internal
   eg: Taenia (tapeworm), Fasciola (liver Fluke) → Parasitic
7. Development: Indirect

NOTE Free living Planaria → High regeneration capacity



(a) (b)

Figure: Examples of Platyhelminthes
(a) Tapeworm (b) Liver fluke

ASCHELMINTHES/NEMATHELMINTHES/ NEMATODA

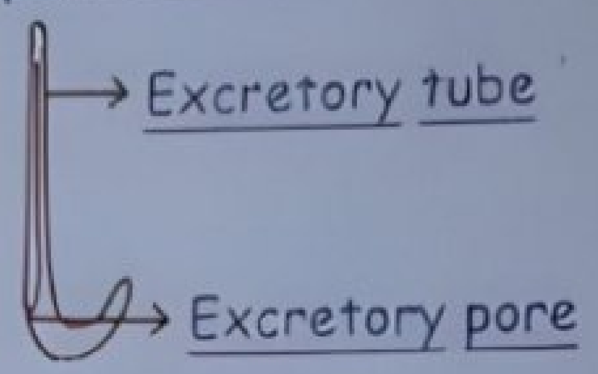
→ Commonly known as 'Roundworms' → Cross section: Appears Circular

General Characteristics

1. Habitat: Aquatic or terrestrial, free living or Parasitic *(they can be parasitic for Plants as well as Animals).
2. Level of Organisation: Organ System
3. Body Plan: Tube within Tube
4. Germ Layer: Triploblastic
5. Coelom: Pseudocoelom
6. Symmetry: Bilateral
7. Metamerism: Absent
8. Notochord: Absent

Physiology

1. Digestive System: A well developed muscular pharynx is associated with its Digestive system which helps in sucking of food with complete Digestive system
2. Respiratory System: Absent
3. Circulatory System: Absent
4. Excretory System: There is an excretory tube which eliminates the N_2 waste via an excretory pore that opens outside



5. Reproduction: Unisexual
6. Fertilisation: Internal
7. Development: Direct & Indirect

eg:
- Wuchereria (Filarial worm) $\xrightarrow{\text{Causes}}$ Elephantiasis
- Ancylostoma (Hookworm)
- Ascaris (Common roundworm) $\xrightarrow{\text{Causes}}$ Ascariasis

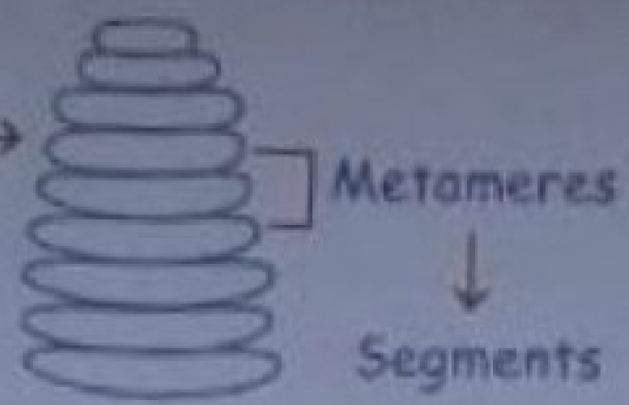
♂ ♀

- Male usually shorter → Usually longer
- Posterior tail is curved → Posterior tail is Straight

Figure: Aschelminthes: Roundworm

ANNELIDA

ANNELIDA → 'ANNULI' - LITTLE RING



General Characteristics

1. Habitat: Aquatic or terrestrial, Free Living or Parasitic.
2. Level of Organisation: Organ System
3. Body Plan: Tube within Tube
4. Germ Layer: Triploblastic
5. Symmetry: Bilaterally
6. Coelom: Eucoelom
7. Metamerism: Metameric segmentation is present
8. Notochord: Absent

Physiology

1. Digestive System: Complete Digestive System.
2. Respiratory System: ABSENT. Earthworm respires via moist Cuticle
3. Circulatory System: Closed Circulatory system
4. Excretory System: Nephridia are the excretory and Osmoregulatory structure
5. Nervous System: Paired ganglia connected by lateral nerves to Double Ventral Solid Nerve Cord
6. Reproduction: Sexual

Nereis → Unisexual

Leech, Earthworm → Bisexual

7. Locomotion: They may use some circular & Longitudinal muscles for locomotion.

- Some aquatic forms also have structures known as Parapodia which helps in swimming.

Eg Nereis (Sandworm)
Pheretima (Earthworm)
Hirudinaria (Blood sucking leech)

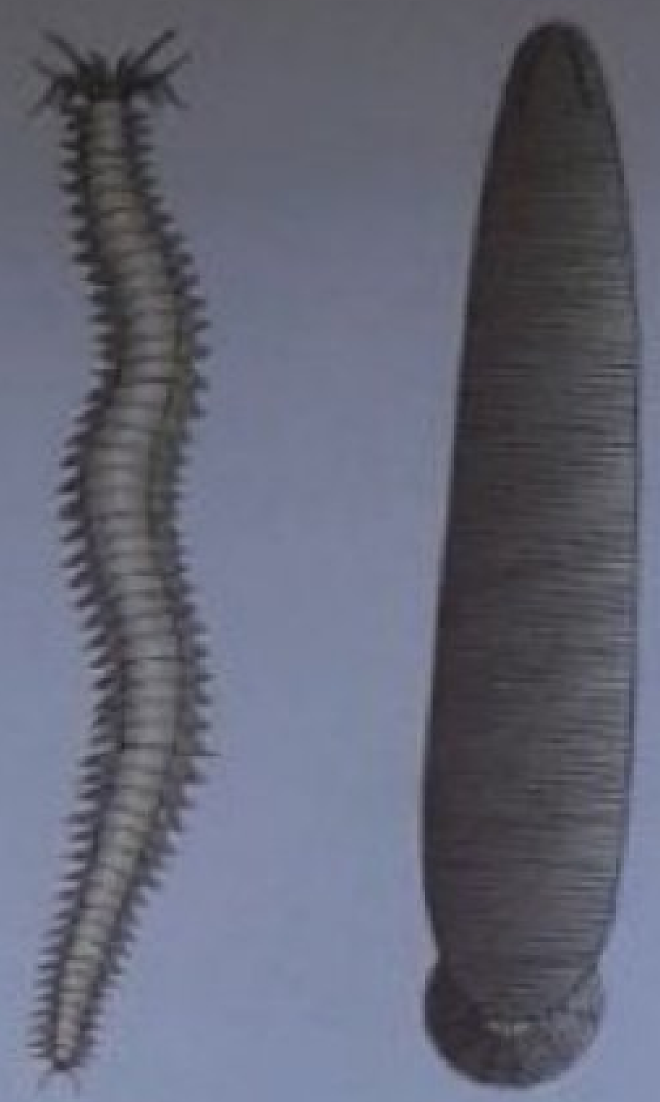


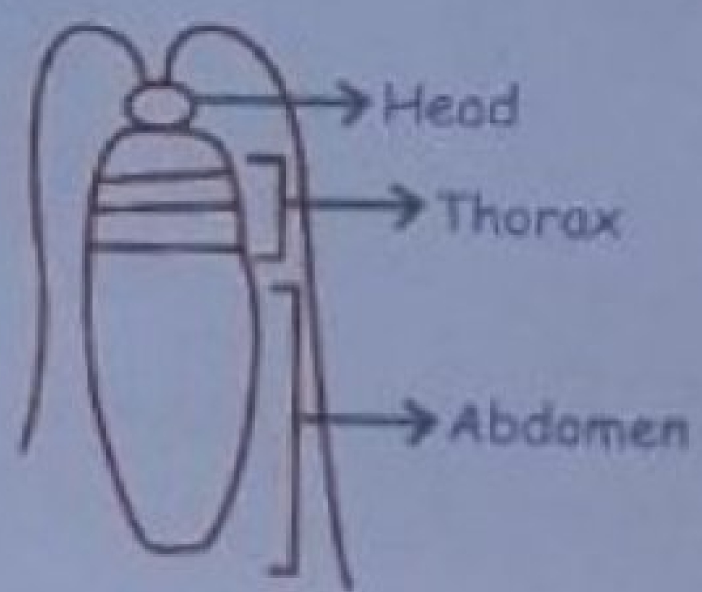
Figure: Examples of Annelida :
(a) Nereis (b) Hirudinaria

ARTHROPODA

- Largest Phylum of the Animal kingdom, over 2/3 named species on earth are arthropods.

Arthropoda : jointed appendages
Jointed appendage

- Their Body is covered with hard Chitinous Exoskeleton
- Body is divisible into 3 parts: Head, Thorax, Abdomen



General Characters

1. Habitat: Aquatic or terrestrial, free living or Parasitic.
2. Level of Organisation: Organ System
3. Symmetry: Bilaterally
4. Body plan: Tube within Tube
5. Germ Layer: Triploblastic
6. Coelom: Eucoelomate
7. Metamerism: Metamerism is present
8. Notochord: Absent

Physiology

1. **Digestive System:** Complete
2. **Respiratory System:**
   → Gills
   → Book gills
   → Book Lungs
   → Tracheal system → Insect
3. **Circulatory System:** Open Circulatory System
   (Color less Blood): Known as Hemolymph
4. **Excretory System:** Malpighian tubules, green gland/antennary gland, which helps in Excretion, Osmoregulation.
5. **Nervous System:** Ganglions with Double Ventral Solid Nerve Cord.
6. **Reproduction:** Mostly unisexual.
7. **Fertilisation:** Usually Internal,
   Mostly Oviparous → egg laying animals
8. **Development:** Direct and indirect Both.
9. **Sensory structures:** Eyes (Simple or compound), Antennae, Balancing structure "Statocyst"

Ex $\boxed{\text{Economically Important Insects}}$

→ Apis (Honey bee)
→ Bombyx (Silkworm)
→ Laccifer (Lac insect)

$\boxed{\text{Insects as Vector}}$

♀ Anopheles mosquito (Malaria)
♀ Aedes mosquito (Dengue, Chikungunya)
♀ Culex mosquito (Elephantiasis)

$\boxed{\text{Gregarious pest}}$ → attack in groups
→ Locusta (Locust)

Other eg: Limulus (King Crab) → Living Fossil

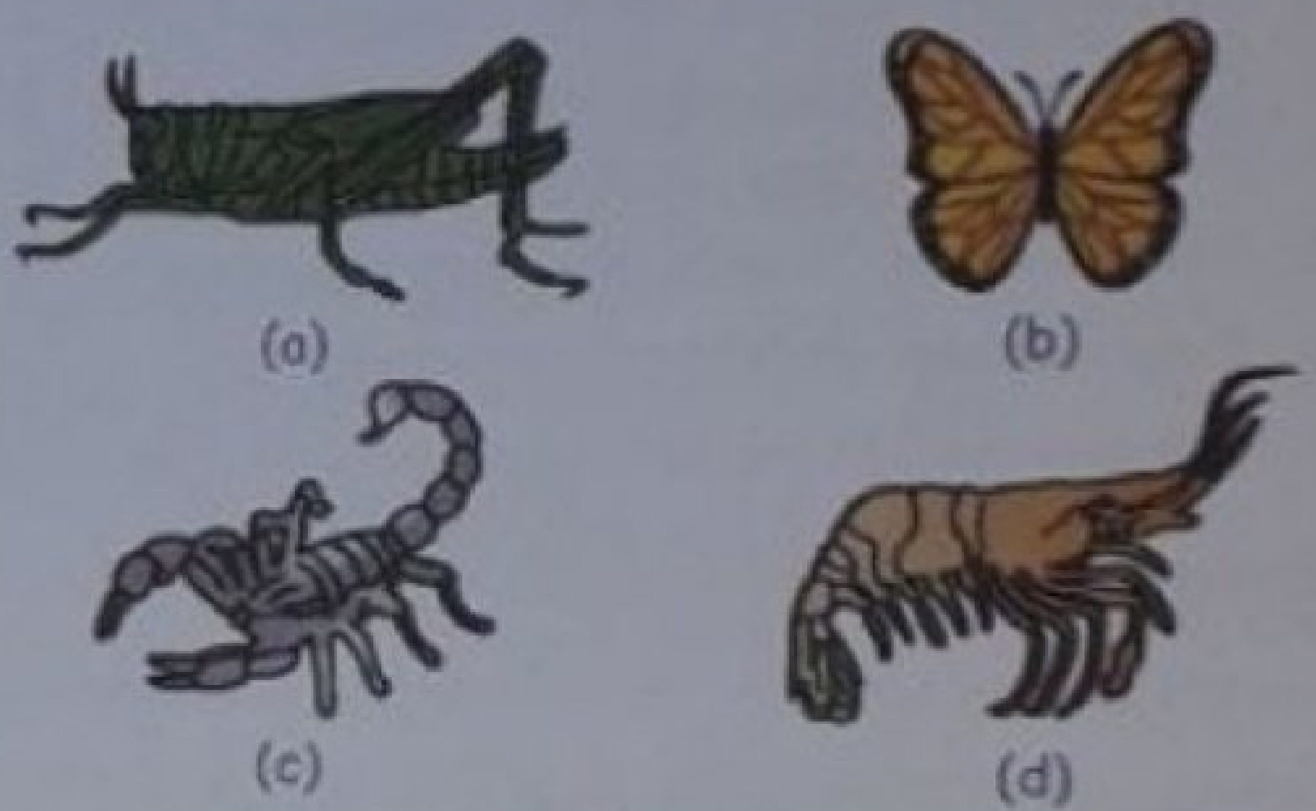


Figure: Examples of Arthropods:
(a) Locust (b) Butterfly
(c) Scorpion (d) Prawn

MOLLUSCA: Second Largest Phylum
Mollis → $\boxed{\text{Soft Bodied Animals}}$

Body
→ ① Head
→ ② Visceral hump/mass
→ ③ muscular foot

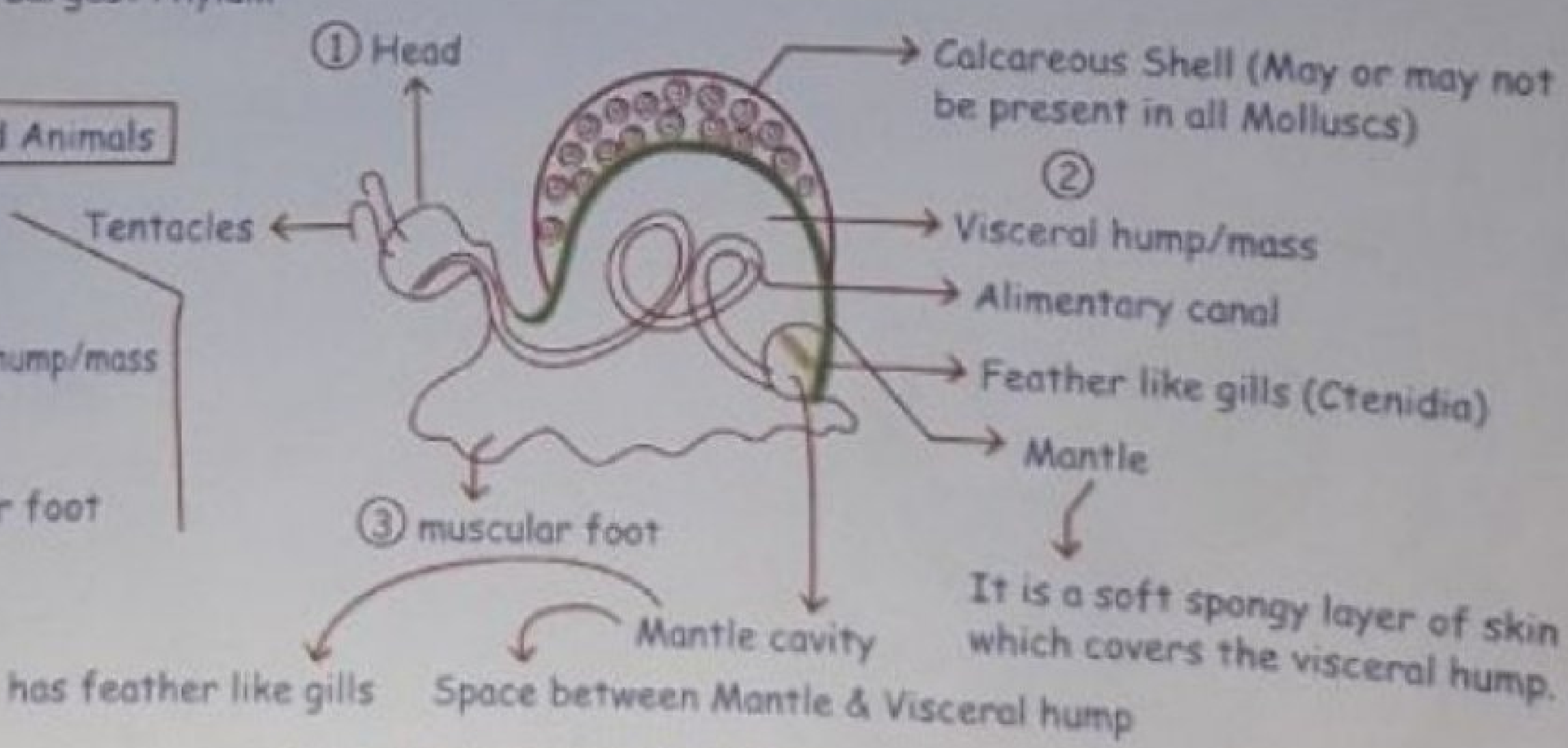


Figure: Body parts of Molluscs

General Characters

1. **Habitat:** Aquatic (Both freshwater and marine) as well as Terrestrial
2. **Level of Organisation:** Organ System
3. **Body Plan:** Tube within Tube
4. **Symmetry:** Bilaterally
5. **Germ Layer:** Triploblastic
6. **Coelom:** Eucoelomate
7. **Metamerism:** Absent
8. **Notochord:** Absent

Physiology

1. **Digestive System:** Complete Digestive System. Mouth is provide with file-like rasping organ known as Radula
2. **Respiratory System:** Feather like gills
3. **Circulatory System:** Both Open & Closed
4. **Excretory System:** Feather like gills
5. **Reproduction:** Usually unisexual, oviparous
6. **Development:** Indirect development
7. **Sensory Structure:** Head with sensory tentacles.

Examples

- Pila (Apple snail)
- Dentalium (Elephant tusk shell)
- Chaetopleura (Chiton)
- Octopus (Devil fish)
- Loligo (Squid)
- Sepia (Cuttlefish)
- Aplysia (Sea hare)
- Pinctada (Pearl oyster)

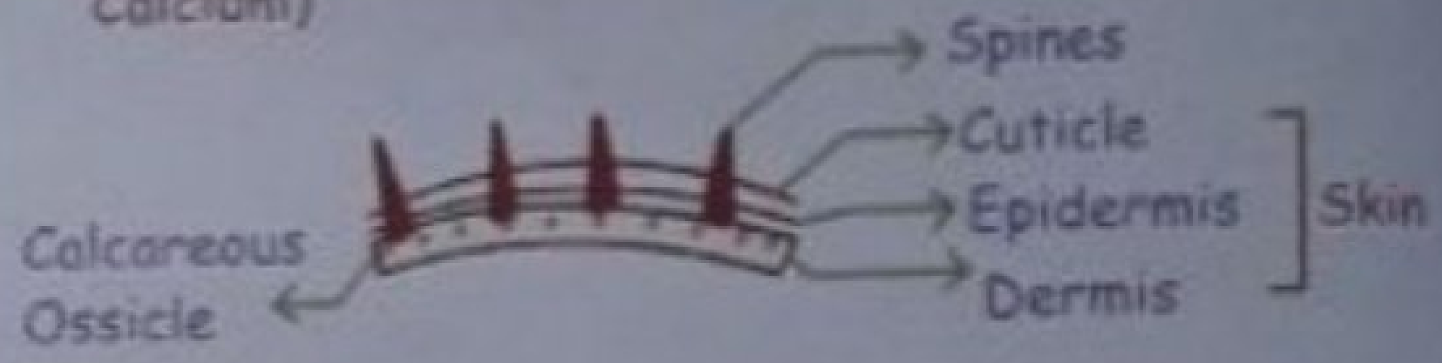
Figure: Examples of Mollusca:
(a) Pila (b) Octopus

ECHINODERMATA → Spiny skinned Animals
Spiny Skin

General Characters

1. **Habitat:** Exclusively marine
2. **Level of Organisation:** Organ System
3. **Body Plan:** Tube within Tube
4. **Symmetry:** Adults: Radial, Larva: bilateral
4. **Germ Layer:** Triploblastic
6. **Coelom:** Eucoelom
7. **Metamerism:** Absent
8. **Notochord:** Absent

- SPINY SKINNED & body has an endoskeleton made up of CALCAREOUS OSSICLE (made of Calcium)



Physiology

1. **Digestive System:** Complete, Mouth is on Ventral side (Lower), whereas Anus on the Dorsal (ABOVE)
2. **Respiratory System:** Present
3. **Circulatory System:** Open
4. **Excretory System:** Absent (Water vascular system helps in it)
5. **Reproduction:** Sexual, Unisexual
6. **Fertilisation:** Usually External
7. **Development:** Indirect

Examples

- Asterias (Starfish)
- Ophiura (Brittle star)
- Antedon (Sea lily)
- Echinus (Sea Urchin)
- Cucumaria (Sea Cucumber)

NOTE

The most distinctive feature of Echinoderm is the presence of **Water Vascular System**

→ Capturing of food
→ Respiration
→ Locomotion
→ Excretion

Figure: Examples of Echinodermata
(a) Asterias (b) Ophiura

HEMICHORDATA

- Earlier it was placed under Phylum chordata due to a structure similar to Notochord known as, 'Stomochord' but later it was found to have a different origin (Ectodermal) than Notochord (Mesodermal) hence placed under a separate phylum.

Body is Divisible into
- → Proboscis
- → Collar
- → Trunk

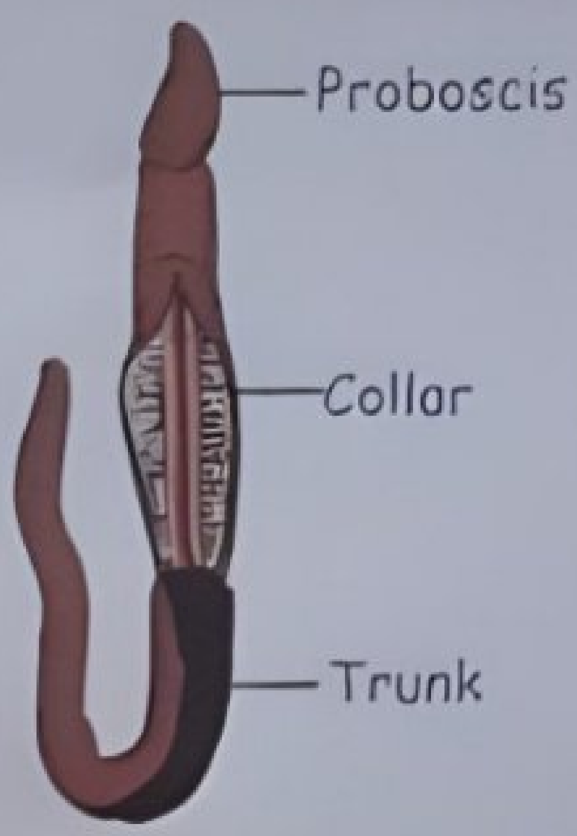


Figure: Balanoglossus

General Characters

1. Habitat: Exclusively Marine
2. Level of Organisation: Organ System
3. Body Plan: Tube within Tube
4. Symmetry: Bilaterally
5. Germ Layer: Triploblastic
6. Coelom: Eucoelomate
7. Metamerism: Absent
8. Notochord: Absent

Physiology

1. Digestive System: Complete Digestive System
2. Respiratory System: Gills
3. Circulatory System: Open
4. Excretory System: Proboscis gland
5. Reproduction: Unisexual, Sexual
6. Fertilisation: External
7. Development: Indirect

eg: Balanoglossus, Saccoglossus] Tongue worms

Table: Salient features of non-chordates. (ONLY those mentioned in NCERT) ['—' Means NOT in NCERT]

PHYLUM	Digestive System	Respiratory system	Circulatory system	Excretory system	Nervous system	Locomotion	Sensory structure	Reproduction	Fertilisation	Development
Porifera	Absent Intracellular	Absent	Absent	Absent	—	—	—	Both Sexual and Asexual, Bisexual	Internal	Indirect
Coelenterata	Incomplete, Both intra & extra	Absent	Absent	Absent	—	—	—	—	—	—
Ctenophora	-	Absent	Absent	Absent	—	Comb Plates	—	Sexual, Bisexual	External	Indirect
Platyhelminthes	Incomplete	Absent	Absent	Flame cells	—	—	—	Bisexual	Internal	Indirect
Aschelminthes	Complete	Absent	Absent	Excretory tube	—	—	—	Unisexual, Sexual	Internal	Both
Annelida	-	Absent	Closed	Nephridia	Double ventral solid nerve cord	Parapodia, Muscles	—	Sexual both Unisexual and Bisexual	—	—
Arthropod	-	Gill, Book Gills Book Lungs, Tracheal system	Open	Malpighian tubule	Double ventral solid nerve cord	—	Eyes, statocyst, antennae	Mostly Unisexual	Usually internal	Direct or Indirect

PHYLUM	Digestive System	Respiratory system	Circulatory system	Excretory system	Nervous system	Locomotion	Sensory structure	Reproduction	Fertilization	Development
Mollusca	-	Feather like gills	Both	Feather like gills	—	—	—	Mostly Unisexual	—	Indirect
Echinoderm	-	Water vascular system	Open	Absent	—	Water Vascular System	—	Sexual Unisexual	External	Indirect
Hemichordata	-	Gills	Open	Proboscis gland	—	—	—	"	"	"

PHYLUM CHORDATA

- Presence of dorsal notochord at any stage of life.
- Presence of dorsal nerve cord " " "
- Presence of Paired pharyngeal gill slits
- Presence of Post anal tail

Figure: Chordata

- Heart is usually ventral

NOTE Notochord & Nerve cord both are dorsal structure but Nerve cord is most Dorsal.

Table: Chordates vs non-chordates.

S.No.	Chordates	Non-chordates
1.	Notochord present.	Notochord absent.
2.	Central nervous system is dorsal hollow and single.	Central nervous system is ventral solid and double
3.	Pharynx perforated by gill slits	Gill slits are absent.
4.	Heart is ventral	Heart is dorsal (if present)
5.	A post-anal part (tail) is present	Post-anal tail is absent.

PHYLUM CHORDATA

- Group Protochordates/Acraniata
  - Sub-Phylum
    - Urochordata
    - Cephalochordata
- Group Euchordate/Craniata
  - Sub-Phylum
    - VERTEBRATA
      - Division Agnatha
        - CLASS Cyclostomata
      - Division Gnathostomata
        - Superclass Pisces
          - Class Chondrichthyes
          - Class Osteichthyes
        - Superclass Tetrapoda
          - CLASS
            - Amphibia
            - Reptilia
            - Aves
            - Mammals

Protochordata/Acraniata: ○ Primitive chordates, cranium Absent, all are marine

Proto → Primitive; A → Absence; cranium → cranium

Sub-Phylum: Urochordata

Uro → tail

- Notochord is present only in the larval tail
- They are known as Tunicates as their body is covered with Tunicin which is made up of cellulose like substance.

  eg: Ascidia, Salpa, Doliolum

Figure: Ascidia

Sub-Phylum: Cephalochordata

Cephalo → Head

- Notochord is present from head to tail.

  eg: Branchiostoma (Amphioxus/ lancelet)
- Euchordata / Craniata : True Chordates, Brain Box is Present.

Sub-Phylum: VERTEBRATA

- Notochord is replaced by a vertebral column
- Heart can be 2 / 3 / 4 chambered.
- Respiration through gills /Lungs.
- Paired appendages: Fins/Limbs may be present.
- Kidney for Excretion and Osmoregulation.
- Gonads present.

NOTE

All VERTEBRATES are CHORDATES But all CHORDATES are not VERTEBRATES

→ Division Agnathostome

Agnatho → Jaw Absent; stome → Mouth

- Jawless Vertebrates

→ Division Gnathostomata

- Jawed Vertebrate

Division Agnathostome

CLASS CYCLOSTOME:

- All are Aquatic
- They have Circular, Suctorial mouth without any jaws.
- All living members are Ectoparasites on Some Fishes.
- They have 6-15 pairs of gill slits for respiration.
- Scales & paired fins are absent.
- Cranium & vertebral column are Cartilaginous.
- They are Marine water animals but for spawning they migrate to freshwater.
- After spawning, the adults die & the larva develops into adult & migrates back to the marine water.

NOTE

Spawning : It means to lay egg & sperm

eg: Petromyzon (Lamprey), Myxine (Hagfish)

Figure: Jawless vertebrate- Petromyzon

Division Gnathostome

SUPERCLASS PISCES

→ True Fish

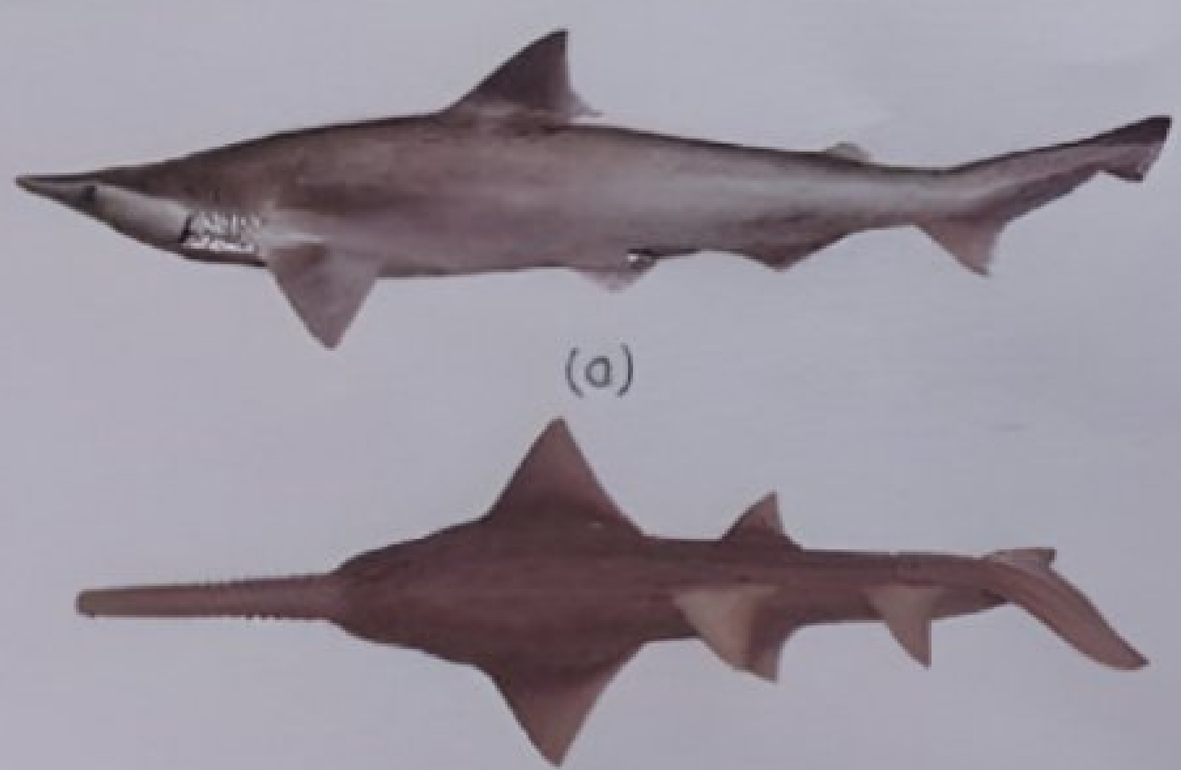
General Characters:

- Aquatic
- RESPIRATION: GILLS
- Heart 2 chambered, Single circulation
- Scales & fins present
- Nictitating membrane on eye for protection under water.
- Cold Blooded / Poikilothermal.

  → They do not have a fixed body temperature, instead it changes with the change in outer temperature.

Table: Salient features of chondrichthyes and osteichthyes.

Chondrichthyes	Osteichthyes
They have CARTILAGINOUS endoskeleton known as Cartilaginous Fish.	Endoskeleton is Bony known as Bony fishes.
MARINE water only.	Fresh & marine water
Mouth is VENTRAL	Mouth is terminal
Notochord is persistent throughout life. (incomplete replacement of vertebral column)	Notochord completely replaced by vertebral column.
Swim bladder/air Bladder is absent, hence have to constantly swim to avoid sinking.	Air Bladder is present to provide them with Buoyancy.
Operculum is Absent → GILL COVERING	4 pairs of gill slits present & covered with operculum
Scales: Placoid scales Their scales are modified to form backwardly directed teeth.	Scales : Cycloid & Ctenoid
Internal fertilisation	Direct Development External fertilisation
Viviparous : Directly giving Birth to young ones.	Oviparous
Examples Pristis (Sawfish) Scoliodon (Dogfish) Carcharodon (Great white shark) Trygon (Sting ray) Torpedo (Electric ray)	Examples Marine water Hippocampus (Sea horse) → Parental care → Male has BROOD POUCH to Care of egg before they hatch Exocoetus (flying fish) Fresh water Labeo (Rohu) Catla (Katla) Clarias (Magur) Aquarium Betta (Fighting fish) Pterophyllum (Angel fish)



(a)

(b)

Figure: Examples of Cartilaginous fishes
(a) Scoliodon (b) Pristis

(a) (b)

Figure: Examples of Bony fishes:
(a) Hippocampus (b) Catla

NOTE

In chondrichthyes:

- Male bear Claspers on their Pelvic fin to help in Copulation
- Usually Predatory in nature : Electric organ (Torpedo), Poisonous Sting (Trygon).

SUPERCLASS TETRAPODA
→ Four legged vertebrates

Table: Comparative Anatomy & Morphology of Classes of Tetrapods

Characteristics	AMPHIBIA	REPTILE	AVES	MAMMAL
1) Exoskeleton	Skin is Moist glandular without any Scales	Skin is Dry with Epidermal Scales /Scutes which often shed called as ecdysis/moulting	Body is covered with Feathers & scales on Hindlegs	Skin with Hair, Nails.
2) Skull	Dicondylic → 2 occipital condyles	Monocondylic → 1 occipital condyle	Monocondylic	Dicondylic
3) Respiration	Skin, Lungs, Buccopharynx, Gills	Lungs	Lungs	Lungs
4) Circulation	3 Chambered Heart, Mixed Circulation	3 Chambered Heart, Mixed Circulation (except Crocodile, Alligator	4 chambered Heart, Double Circulation	4 chambered Heart, Double Circulation
5) Excretion	Kidney Aquatic - NH_3 Terrestrial-UREA	Kidney URIC-ACID	Kidney URIC-ACID	Kidney UREA
6) Fertilisation	External	Internal	Internal	Internal
7) Development	Indirect	Direct	Direct	Direct
8) Oviparous/ Viviparous	Oviparous	Oviparous	Oviparous	Mostly viviparous
9) Body temperature	Cold-blooded/ Poikilotherm	Cold-blooded/ Poikilotherm	Warm blooded /Homeotherm	Warm blooded /Homeotherm

NOTE Homeotherm: Animals having fixed body temperature.

AMPHIBIANS: $\underbrace{\text{AMPHI}}_{\text{dual}}\underbrace{\text{BIANS}}_{\text{Bio}}$ dual Life [Water / Terrestrial]

- Body divisible into [Head / Trunk] (Tail may be present in some)

- Nictitating membrane covering the eye.
- *CLOACA is present (Common chamber for alimentary, reproductive & excretory canal opening)
- Tympanum represents the external ear

- Eyelids are present

  eg: Rana (Frog)

  Bufo (Toad)

  Hyla (Tree frog)

  Ichthyophis (Limbless Amphibian)

  Salamandra (Salamander)

(a) (b)

Figure: Examples of Amphibia (a) Salamandra (b) Rana

REPTILES

↳ Creeping & crawling animals

- First true land Vertebrates
- Tympanum represents external ear
- Cloaca is present
- Snakes & Lizard shed their skin as skin cast

  eg: Alligator (Alligator)

  Crocodilus (Crocodile)

  Testudo (Tortoise)

  Chelone (Turtle)

  Chameleon (Tree lizard)

  Calotes (Garden lizard)

  Hemidactylus (Wall Lizard)

Poisonous Snakes

Naja (Cobra), Vipera (Viper)

Bangarus (Krait)

Non-poisonous

↳ Python

(a) (b) (c) (d)

Figure: Reptiles: (a) Chameleon, (b) Crocodilus, (c) Chelone, (d) Naja

AVES

- Forelimbs are modified into wings, hindlimb with CLAWS: walk, hold.
- No glands except at the base of tail: Uropygeal gland/oil gland.
- Beak is present.
- *Alimentary canal with additional chambers [Crop, Gizzard]
- Lungs provided with 'AIR-SACS' additionally to supplement Respiration.
- Bones are fully ossified (Bony) & Pneumatic (long Bones are Hollow).
- Cloaca is present
- The waste/excretory product: Paste/Pellet

  eg: Pavo (Peacock)

  Psittacula (Parrot)

  Neophron (Vulture)

  ↱ Largest flightless bird

  Struthio (Ostrich)

  Corvus (Crow)

  Aptenodytes (Penguin)

  Columba (Pigeon)

(a) (b)

(c) (d)

Figure: Some birds: (a) Neophron (b) Struthio (c) Psittacula (d) Pavo

MAMMALS

→ Unique mammalian feature
→ Ear pinna
→ Hair
→ Mammary glands

→ Heterodont Dentition (Different types of Teeth)

→ Skin possess Various types of gland.

→ Forelimbs modified for
→ Walking
→ Swimming
→ Flying etc.

eg: Rattus (Rat)

Camelus (Camel)

Elephas (Elephant)

Panthera tigris (Tiger)

Panthera leo (Lion)

Macaca (Monkey)

Macropus (Kangaroo)

Equus (Horse)

Canis (Dog)

Felis (Cat)

Pteropus (Flying fox)

Balaenoptera (Giant Blue Whale)

Ornithorhynchus (Duck Billed Platypus)

→ Oviparous

Delphinus (Dolphin)

(a) (b) (c) (d)

Figure: Some mammals: (a) Ornithorhynchus (b) Macropus (c) Pteropus (d) Balaenoptera

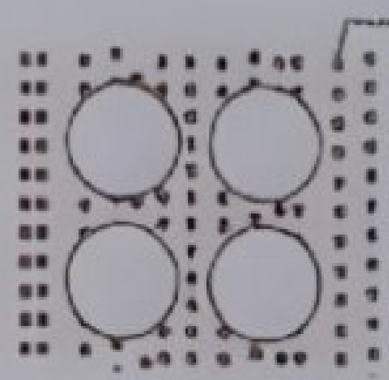
2

Structural Organisation in Animals

ANIMAL TISSUES

Tissue

Group of similar cells having some intercellular spaces between them which is filled with MATRIX/ Intercellular substance and performing a SPECIFIC FUNCTION.



→ Intercellular space
↓
Matrix/ Intercellular substance
↓ made of
(Glycoproteins + Mucopolysaccharides)

Cells ⟶ Tissues ⟶ Organ ⟶ Organ system

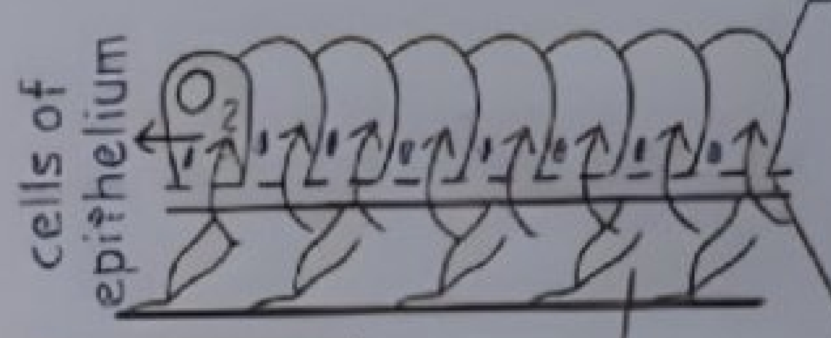
- Cells, Tissues, Organs, Organ systems exhibit division of labour

4 Types of Tissue:

TISSUE	BASIC FUNCTION
EPITHELIAL/EPITHELIUM	Protection, Covering & Lining
CONNECTIVE TISSUE	Support & Linkage
MUSCULAR	Locomotion & Movement
NEURAL/NERVOUS	Control & Coordination

1. $\underbrace{\text{EPI}}_{\text{upon}}\underbrace{\text{THELIAL}}_{\text{to rest}}$ TISSUE:

- It always rest upon some other tissue.
- Cells are compactly packed with little intercellular substance.
- $\underbrace{\text{A}}_{\text{Absence}}\underbrace{\text{vascular}}_{\text{blood vessel}}$: They do not have blood vessel supply
- Highest Regeneration



Blood Vessel

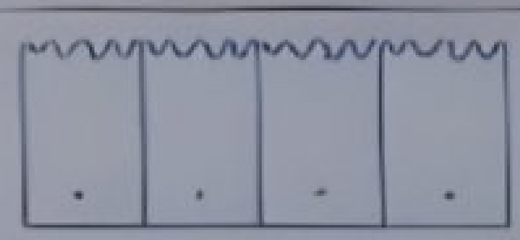
Apical surface/ Free Surface
* either faces external environment or it faces the body fluids.

Connective tissue

Basement Membrane (noncellular)
↓
Mucopolysaccharides & glycoprotein

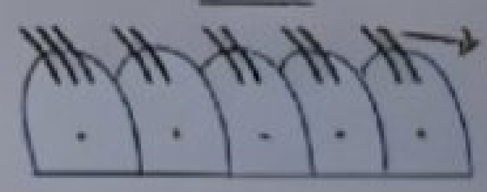
Free SURFACE
↓
It may show some modifications

Microvilli/ Brush-border



Plasma membrane of the cell gets folded to form finger like projections called as microvilli
↓
Increased surface area for Absorption & secretion

Cilia



Cilia moves UNIDIRECTIONALLY for the movement of Substances
They usually lines the hollow organs

EPITHELIUM

(A) Simple Epithelium

- Single layer of Cells
- Major Role in FILTRATION, DIFFUSION, SECRETION, ABSORPTION.

(B) Compound Epithelium

- Multilayered of cell
- Less role in Secretion and Absorption, mainly helps in PROTECTION against chemical and mechanical stress and COVERING

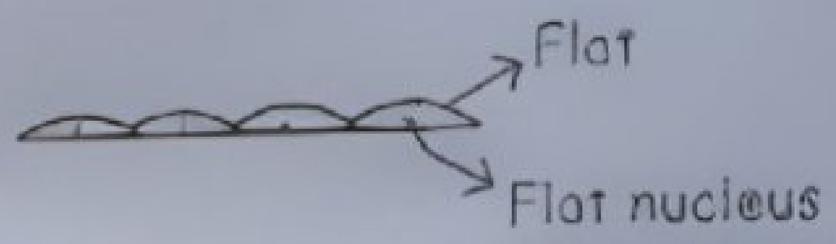
(A) Simple Epithelium

On the Basis of Structural modification of cells.

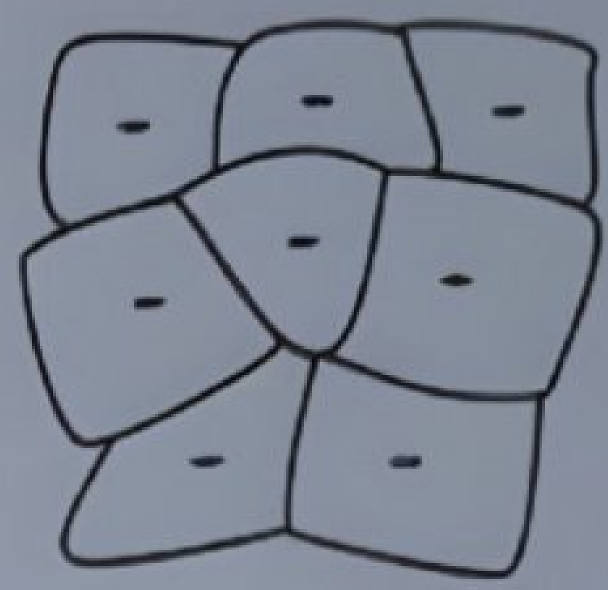
1. → Simple SQUAMOUS
2. → Simple CUBOIDAL
3. → Simple COLUMNAR

1. Simple Squamous:

- Cells are FLAT, Nucleus is FLAT & is located in the centre.



- The Tissue appears like TILES on the floor, hence also known as PAVEMENT EPITHELIUM.



- Cells are with IRREGULAR BOUNDARIES

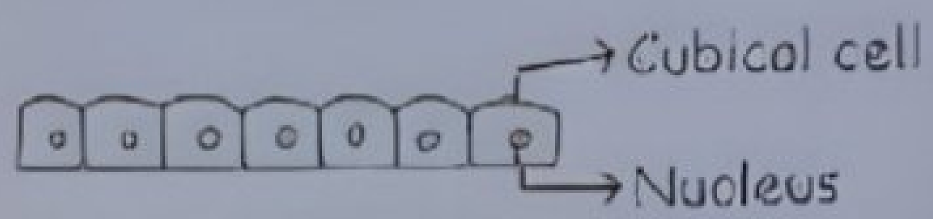
Function: Filtration and Diffusion

Examples: ALVEOLI, Blood capillary, Blood vessel, GLOMERULUS, Bowman's capsules

NOTE

Simple squamous epithelium of blood vessel is known as endothelium.

2. Cuboidal Epithelium



- Cells are cubical
- Nucleus is Round and in centre

1. Simple Cuboidal

e.g., DCT, Thyroid follicle,

* Smaller duct of glands

Functions: Secretion & Absorption

2. Brush Bordered Cuboidal/ Microvilli cuboidal

e.g., PCT, Proximal Convoluted Tubule

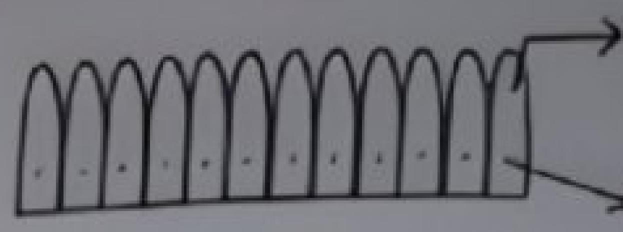
Functions: Secretion & Absorption

3. Ciliated cuboidal

e.g., Smaller Bronchioles

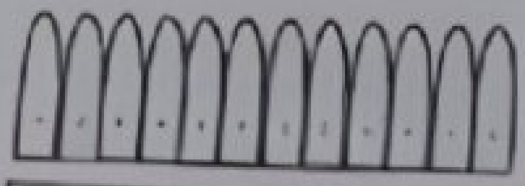
Functions: Movement of Substances (mucus)

3. Columnar Epithelium



- Cells are TALL/SLENDER
- Nucleus is OVAL & located at the base

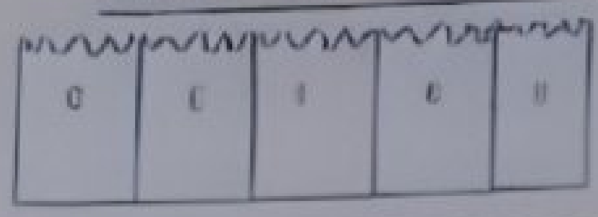
1. Simple Columnar



e.g: GI tract → gastrointestinal tract (Stomach)

Functions: Secretion & Absorption

2. Brush Bordered Columnar/ Microvilli Columnar

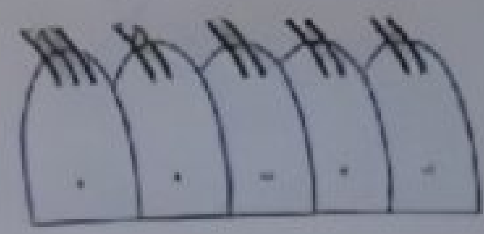


E.g., GOBLET cell found in alimentary canal → mucus producing Cells

Intestine

Functions: Secretion & Absorption

3. Ciliated Columnar



E.g., Fallopion tube, Large Bronchioles

Functions: Movement of Substances like ova in fallopian tube

GLANDULAR EPITHELIUM

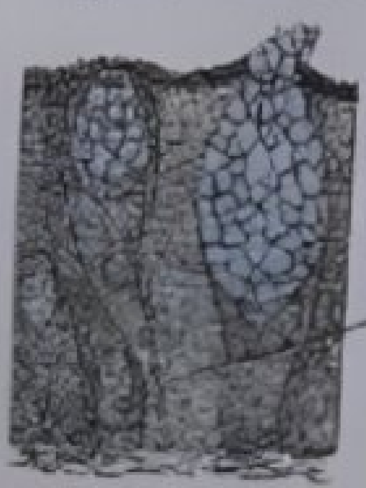
- It is a type of simple epithelium
- It has Cuboidal or Columnar cells ; Specialised for secretions.

CLASSIFICATION OF GLANDULAR EPITHELIUM:

(I) On the Basis of number of cells

Unicellular

- Single, isolated cell can act as a gland.



E.g., GOBLET cell (mucus-producing cell)

Multicellular

- Many cell together makes a secretion

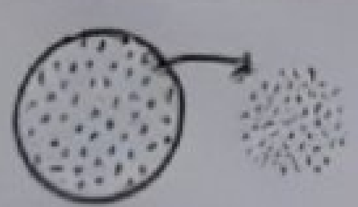
E.g., Salivary, Sweat, Mammary gland

(II) On the basis of mode of Pouring Secretion

Endocrine

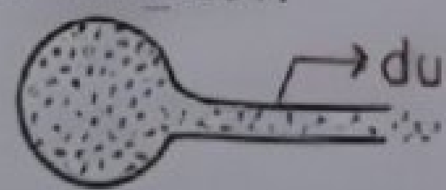
- Ductless glands directly pouring their secretions into the blood stream.

e.g, Hypothalamus, Pituitary, etc.



Exocrine

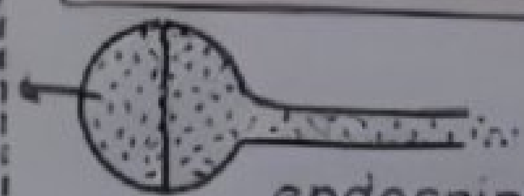
- The glands which pour their secretion via duct.



- Secretions like milk, saliva, sweat, mucus, oil, digestive enzymes etc are exocrine secretions.

E.g., Sweat, salivary, mammary gland etc.

Mixed/Heterocrine/Composite



- It has both endocrine & exocrine parts

E.g., Pancreas

Endocrine part → Islets of Langerhans → secretes hormones

Exocrine part → cells of acin → Pancreatic juice

(B) Compound Epithelium:

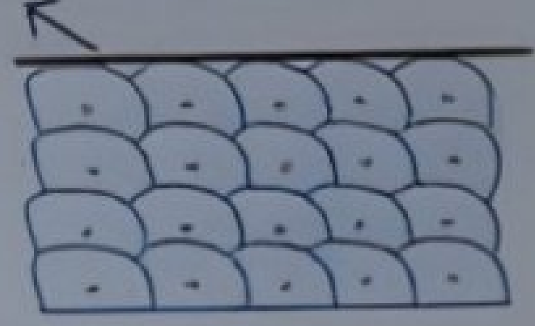
- Multilayered epithelium
- Less role in secretion and absorption, main role in PROTECTION.
- Prevent from any kind of stress (Mechanical & Chemical).

Compound Epithelium

- Transitional Epithelium (Stretchable) — eg: Urinary Bladder
- Stratified Epithelium (Non-stretchable)

अतिरिक्त Gyaan

Keratin deposition



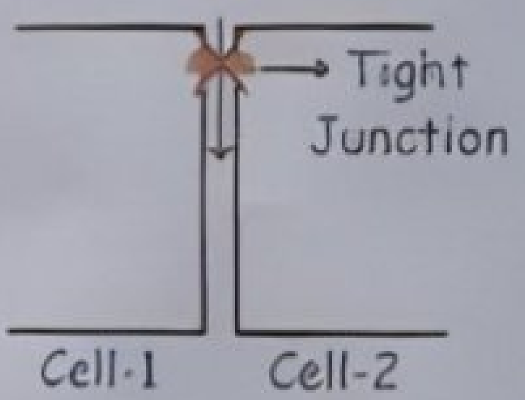
Examples of stratified epithelium on dry & moist surfaces →
- Skin: Keratinised epithelium as keratin protein get deposited making the surface DRY and impermeable for H_2O.
- Buccal cavity, Pharynx, Oesophagus, Vagina. } moist surfaces
- *Pancreatic duct, Salivary duct. } moist surfaces

CELL JUNCTIONS

- Structural and functional connection between cells.
- These are found in epithelium and other tissues.

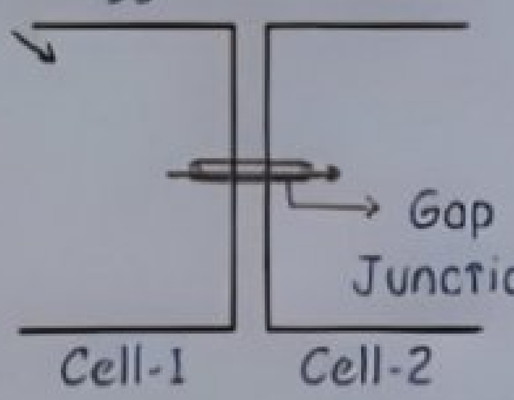
(a) Tight Junctions

- Junctions which help in preventing "LEAKAGE" across the cell.



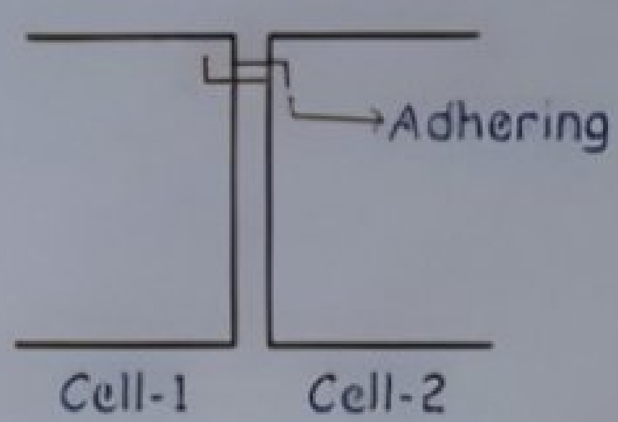
(b) Gap Junctions

- Also known as COMMUNICATING JUNCTIONS which helps in communication by connecting the cytoplasm of cells & help in transfer of ions, small molecules & sometimes even "Bigger molecules".



(c) Adhering Junctions

- Junctions which help in CEMENTING between cells.



2. CONNECTIVE TISSUE:

- The most abundant & widely distributed tissue of the body.
- They are named so because they link and support other tissues/ organs of the body

COMPOSITION OF CONNECTIVE TISSUE

- 1. Matrix
  - Ground Substance (mucopolysaccharides, Glycoproteins)
  - Fibres
- 2. Cells

Classification of Connective Tissues

- **Connective tissue**
  - Loose Connective Tissues
    - Areolar Connective Tissues
    - Adipose Connective Tissues
  - Dense Connective Tissues
    - Dense Regular
      - Ligament
      - Tendons
    - Dense Irregular
  - Specialised Connective Tissues
    - Skeletal Connective Tissues
      - Cartilage
      - Bone
    - Fluid Connective Tissues
      - Blood
      - Lymph

(1) Loose Connective Tissues

- Cells and fibres are loosely aggregated in a semifluid Matrix
- Amount of matrix is more

(i) Areolar Connective Tissues

Areolae → "SPACE"

- Acts as a packaging of organs

CELLS
- → Fibroblast = Secrete matrix
- → Macrophage
- → Mast Cell
- → Eosinophil
- → Neutrophil
- → Activated B-cell

Macrophages (Phagocytosis)
↓
engulf the pathogen & destroy them

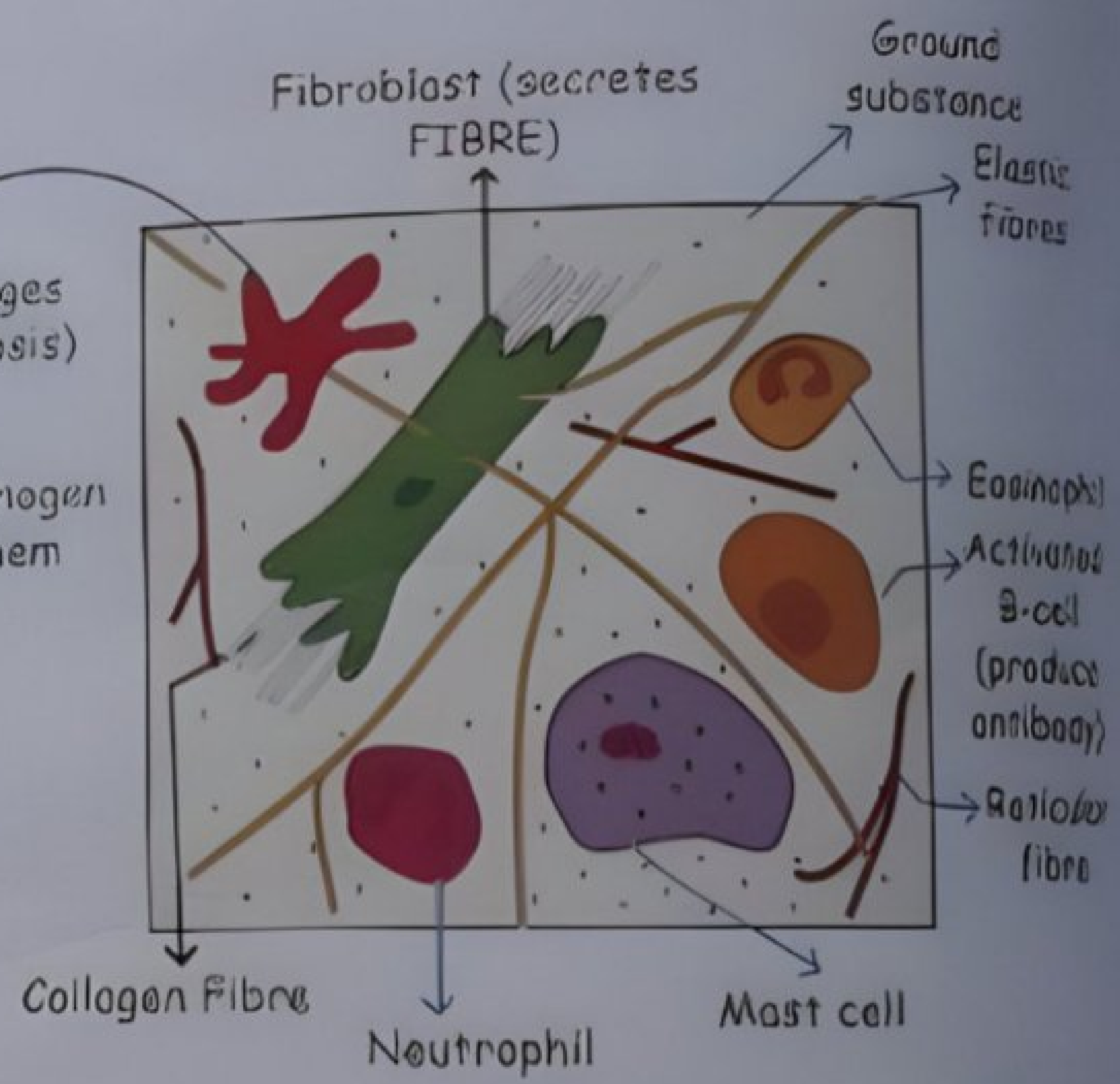


Figure: Areolar tissue

"MAST CELLS SECRETE
- → Heparin: Anticoagulant
- → Serotonin (Vasoconstrictor) — Vaso: Blood vessel; constrictor: Constrict

- → Histamine (Vasodilator) — Vaso: Blood vessel; dilator: Dilate

Fibres:

COLLAGEN

- White in color (WHITE FIBRES)
- Present in Bundles
- Unbranched
- Function: Strength

ELASTIC

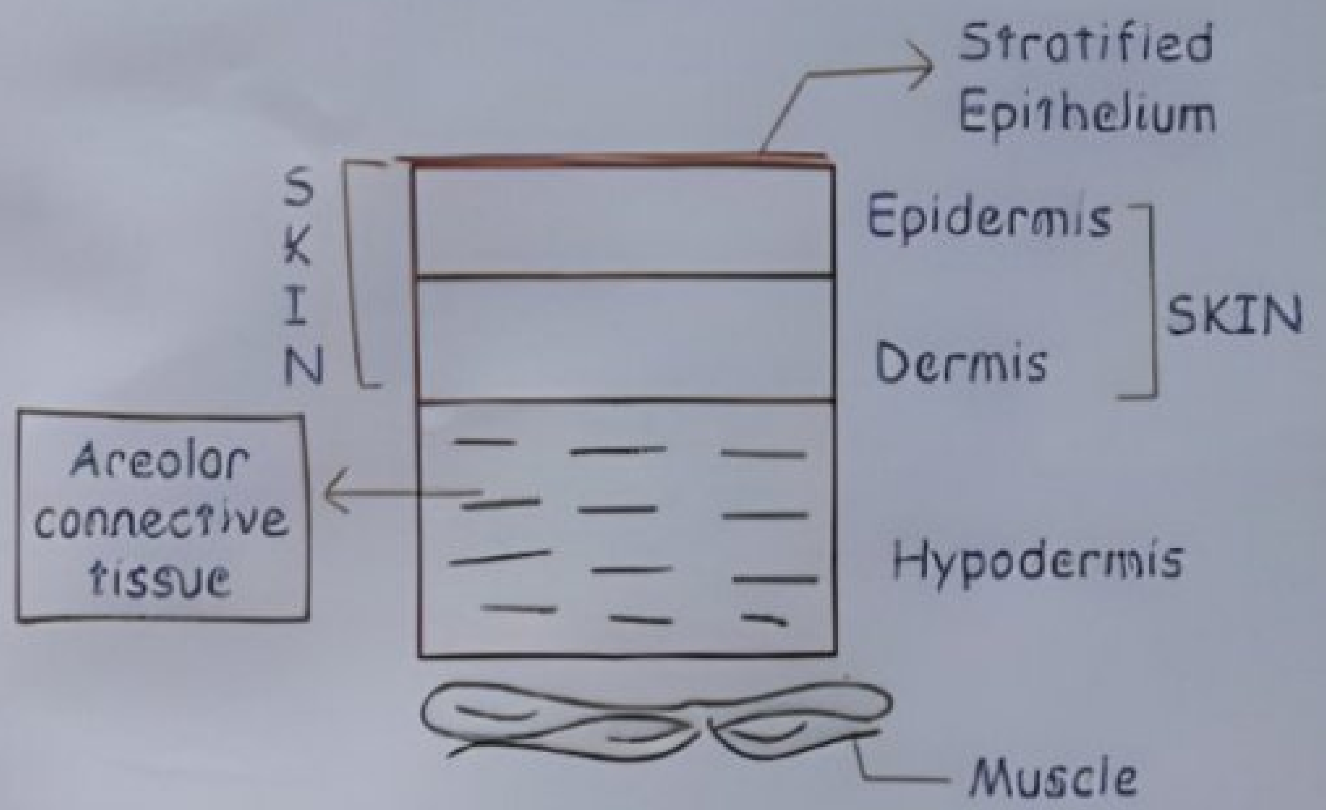
- Yellow in color (YELLOW FIBRES)
- Present Individually
- Branched
- Function: Elasticity

NOTE

Reticular fibres are delicate, branched fibres.

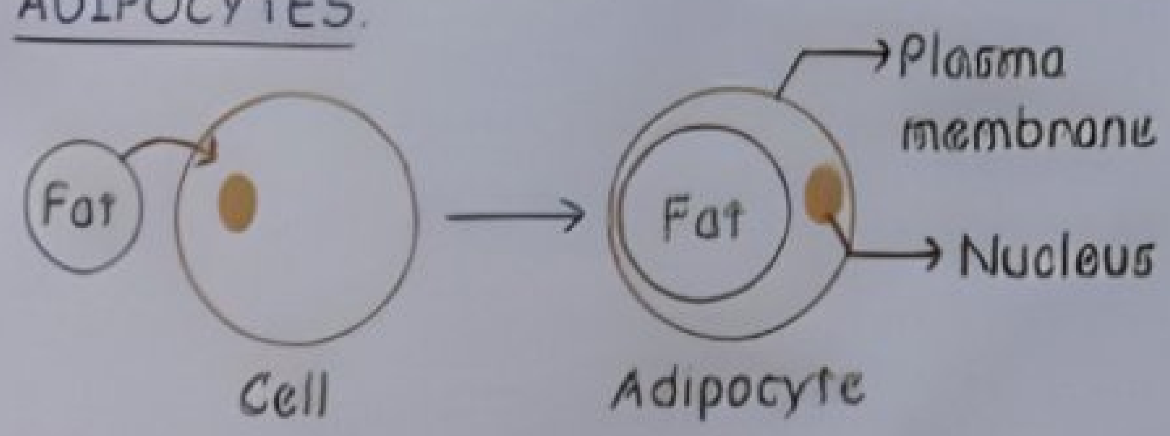
Location & Function of Areolar Connective Tissue

- Provides the basic *Framework for epithelium & is present Beneath (Below) skin, connecting the skin with underlying muscles.



(ii) Adipose Connective Tissue

- Specialised form of Connective tissue that is specialised to store fat & mainly present beneath the SKIN.
- Excess of nutrients which are not used immediately gets converted into fats & stored in cells called as ADIPOCYTES.

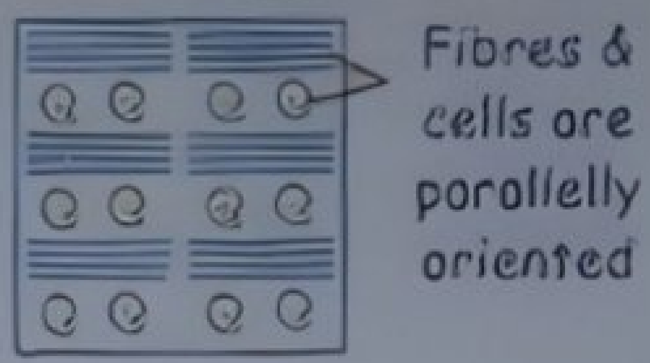


2. Dense Connective Tissue

- Matrix less
- Cells, fibres are compactly packed in matrix.

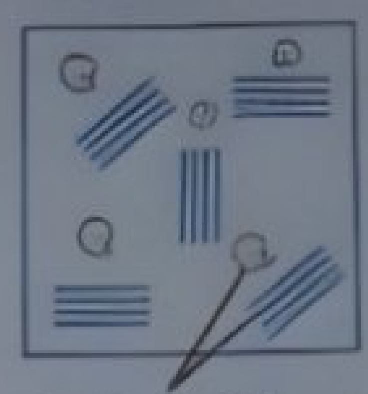
Dense Connective Tissue

(i) Dense Regular tissue



e.g., Ligament, Tendons

(ii) Dense Irregular tissue



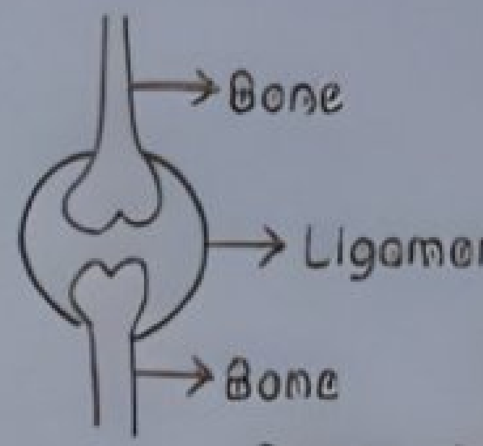
Cells & fibres have an irregular arrangement
e.g., SKIN

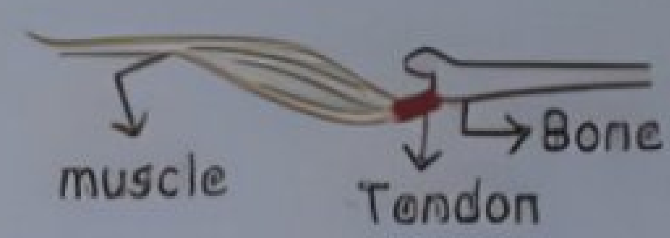
LIGAMENT

- Joins bone to bone
- Elastic + Collagen fibres

TENDONS

- Connects muscles to bone.
- Collagen fibres only





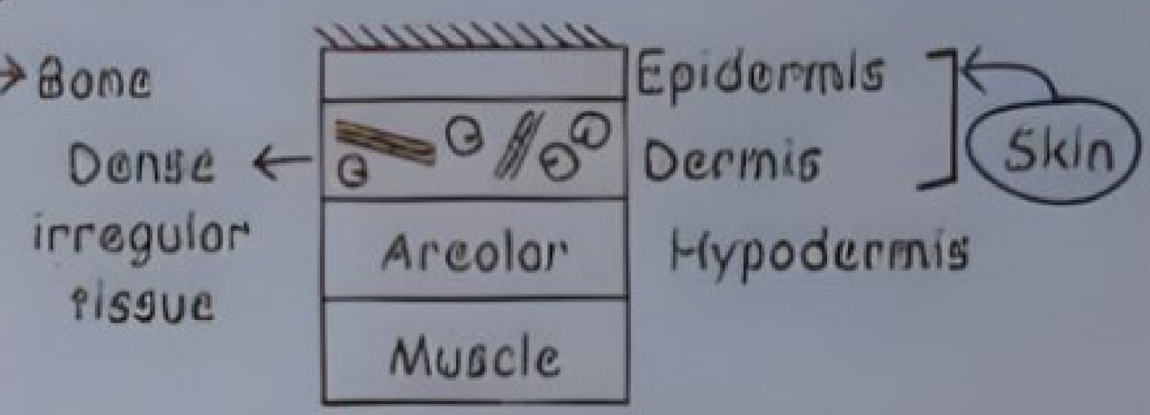


Figure: To understand Location of Dense irregular & Areolar tissue

3. Specialised Connective Tissue

(i) Skeletal Connective Tissue

- Matrix is SOLID
- Fibres present

(ii) Fluid Connective Tissue:

- Matrix Fluid
- Fibres absent

(I) SKELETAL Connective Tissue

CARTILAGE:

- *Matrix is SOLID but soft and pliable (resist compression)
- Collagen + Elastic fibre present

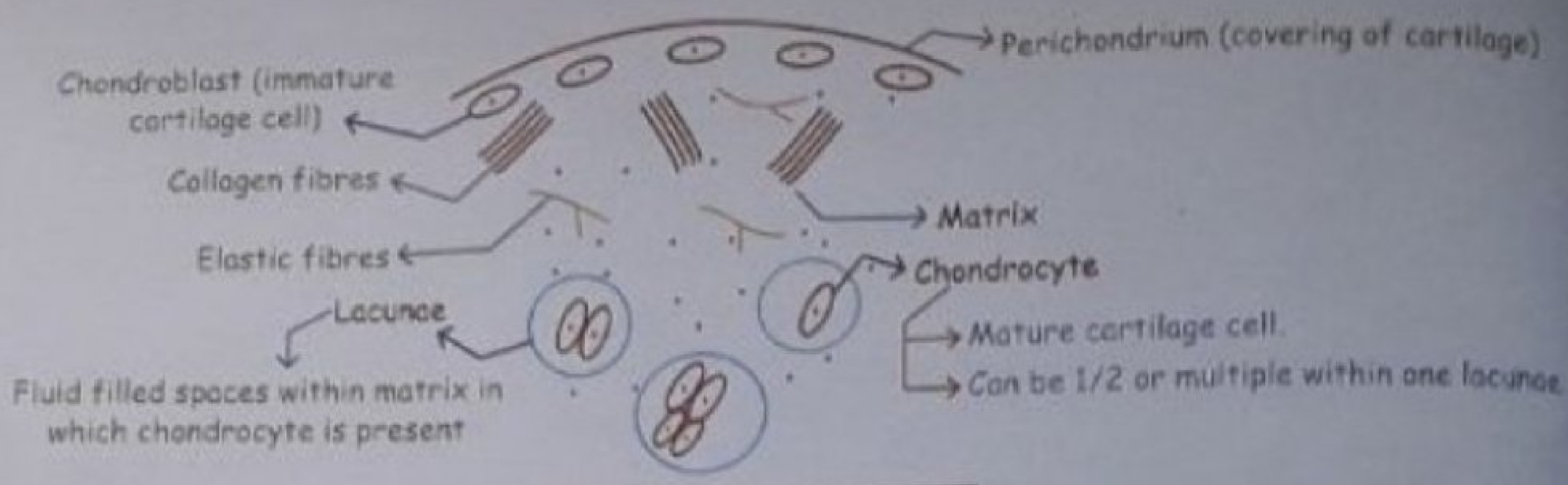


Figure: Section of cartilage

- E.g., Tip of nose, external ear joints, Tracheal rings, Intervertebral disc, Coastal cartilage of Ribs, Larynx, Pubic symphysis.

BONE:

- **Matrix:** SOLID hard & non-pliable.
- Only collagen fibre
- **Function is to provide and bear body weight:**

Bones
- Organic (10-30%) → Ossein Protein
- Inorganic (70-90%) → Calcium Salts (makes bone hard) → $CaCO_3$, Calcium phosphate

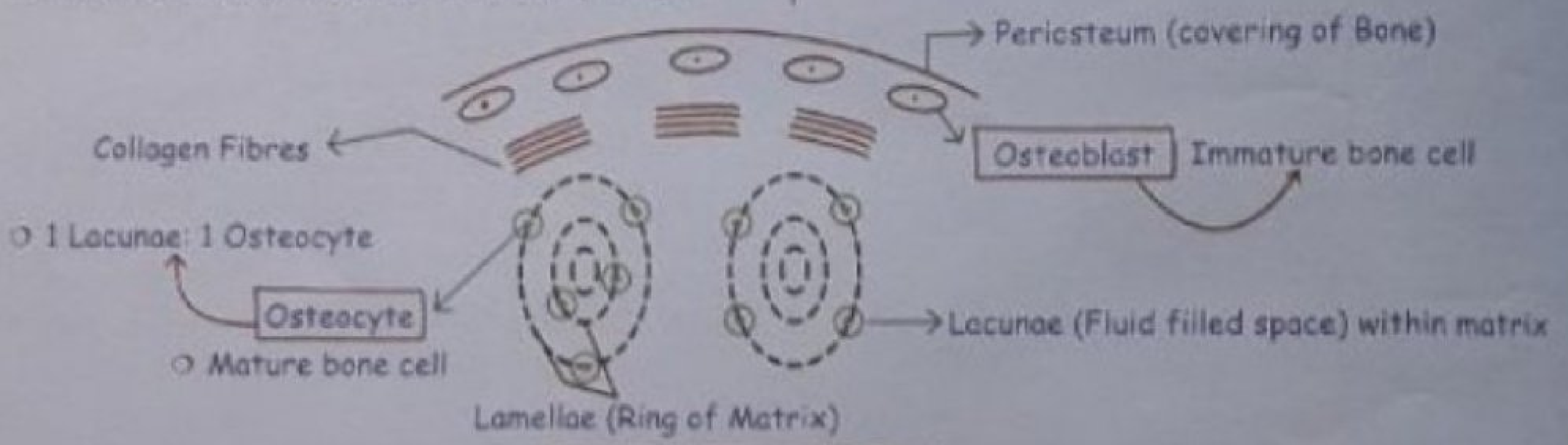
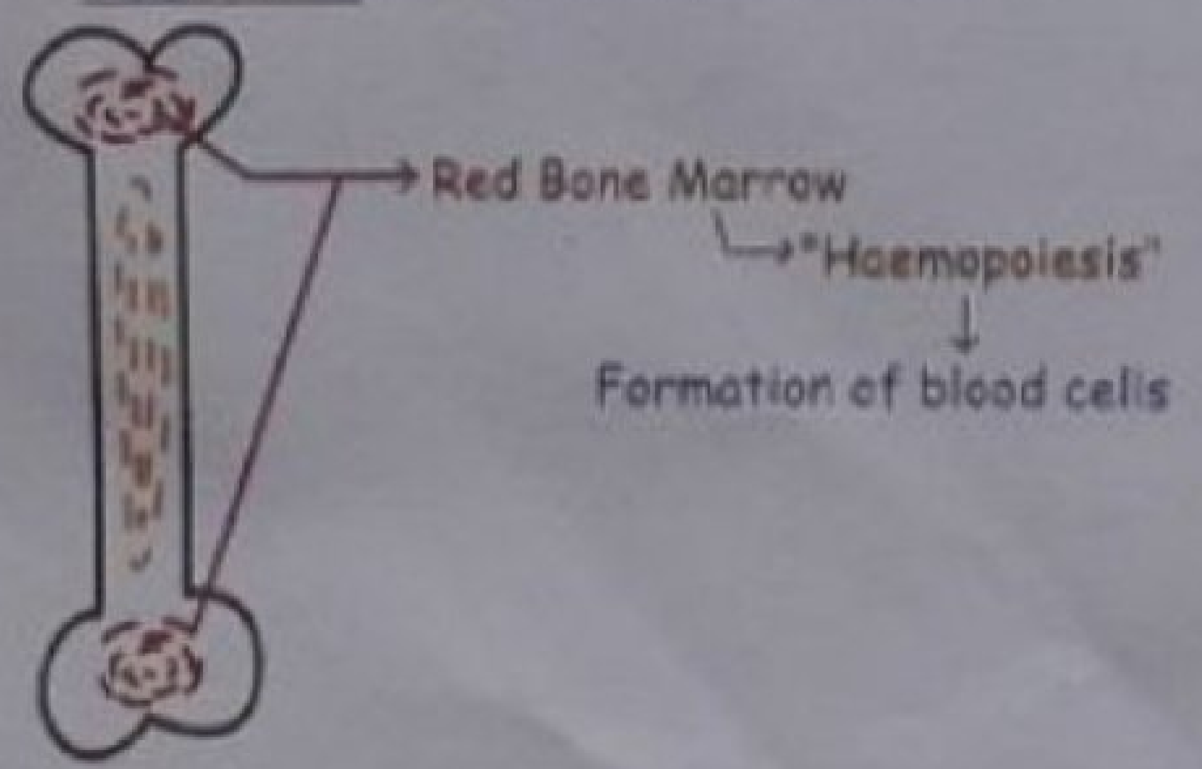


Figure: Section of bone

- e.g., Limbs Bone, etc.
- Long Bones: Sites for HAEMOPOIESIS.



(ii) FLUID Connective Tissue

BLOOD:

- **Blood** is a fluid connective tissue containing plasma, red blood cells (RBC), white blood cells (WBC) and platelets.
- It is the main circulating fluid that helps in the transport of various substances.
- Will read more about this in Body Fluids and Circulation

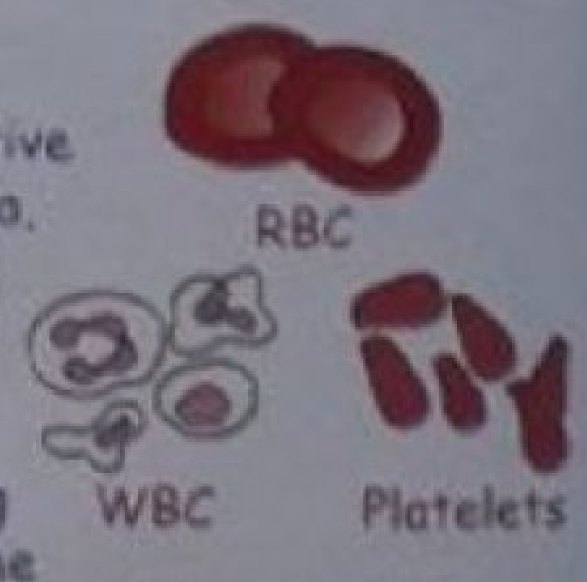


Figure: Components of Blood

ā

3. MUSCULAR TISSUE

Each Muscle
↓ has
Muscle bundles (FASCICLE)
↓ has
Muscle fibre (Long cylindrical)
↓ has
Myofibrils/Myofilaments

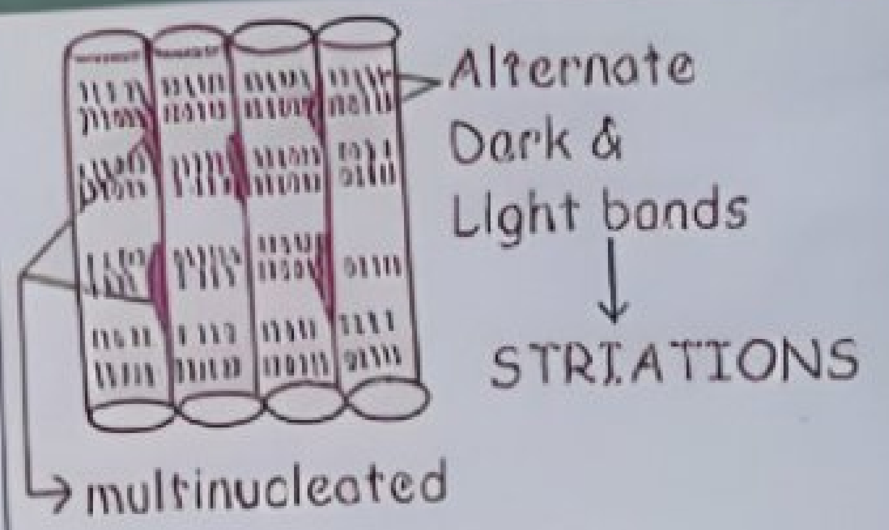
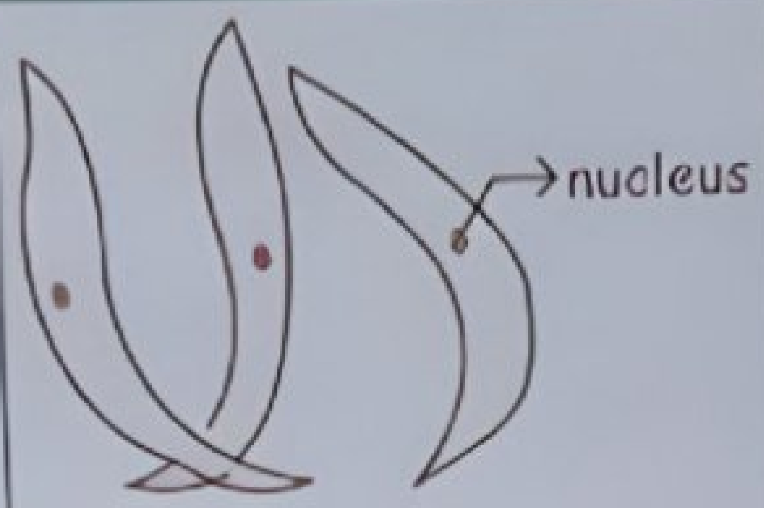
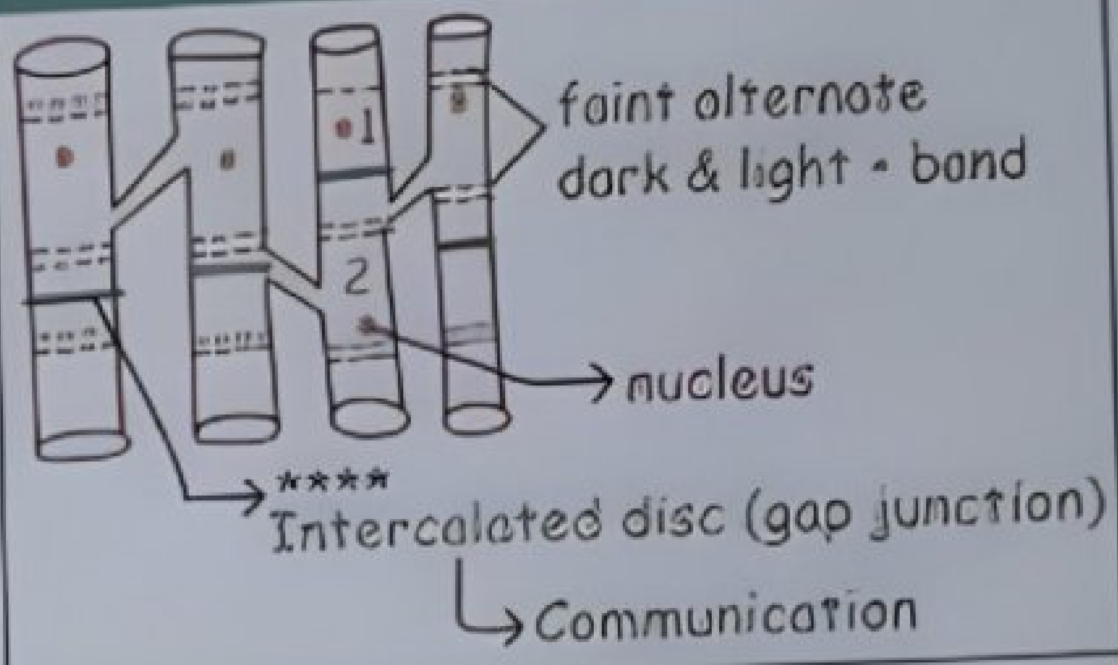
NOTE

We will discuss the section of muscle in detail in chapter locomotion and movement

Properties of muscles

1. Contraction: Ability to contract
2. Excitable: upon giving a stimulus, they respond
3. Extensible: can be pulled (Stretching)
4. Elasticity: Ability to return to its original length & shape after contraction or extension

Types of muscles

SKELETAL (STRIATED)	SMOOTH (VISCERAL)	CARDIAC (STRIATED)
		
1. Cylindrical muscles fibre	1. FUSIFORM/SPINDLE	1. CYLINDRICAL
2. Unbranched	2. Unbranched	2. Branched
3. Multinucleated, located along the periphery	3. Uninucleated, Centre	3. Uninucleated, Centre
4. Prominent STRIATIONS	4. NO STRIATIONS	4. Faint/light Striations
5. Voluntary	5. Involuntary	5. Involuntary
6. Fast contraction	6. Slow contraction	6. Fastest contraction
7. Easily fatigue (थक जाना)	7. Slow fatigue	7. Never fatigue
8. Rich blood supply	8. Less blood supply	8. Abundant blood supply
eg. Facial muscles, Limb muscles (Forelimb, Hind limb)	eg. Iris muscles, ciliary body muscles, stomach, intestine	eg. Heart

4. NEURAL TISSUE

Neural Tissue

(i) Neuron

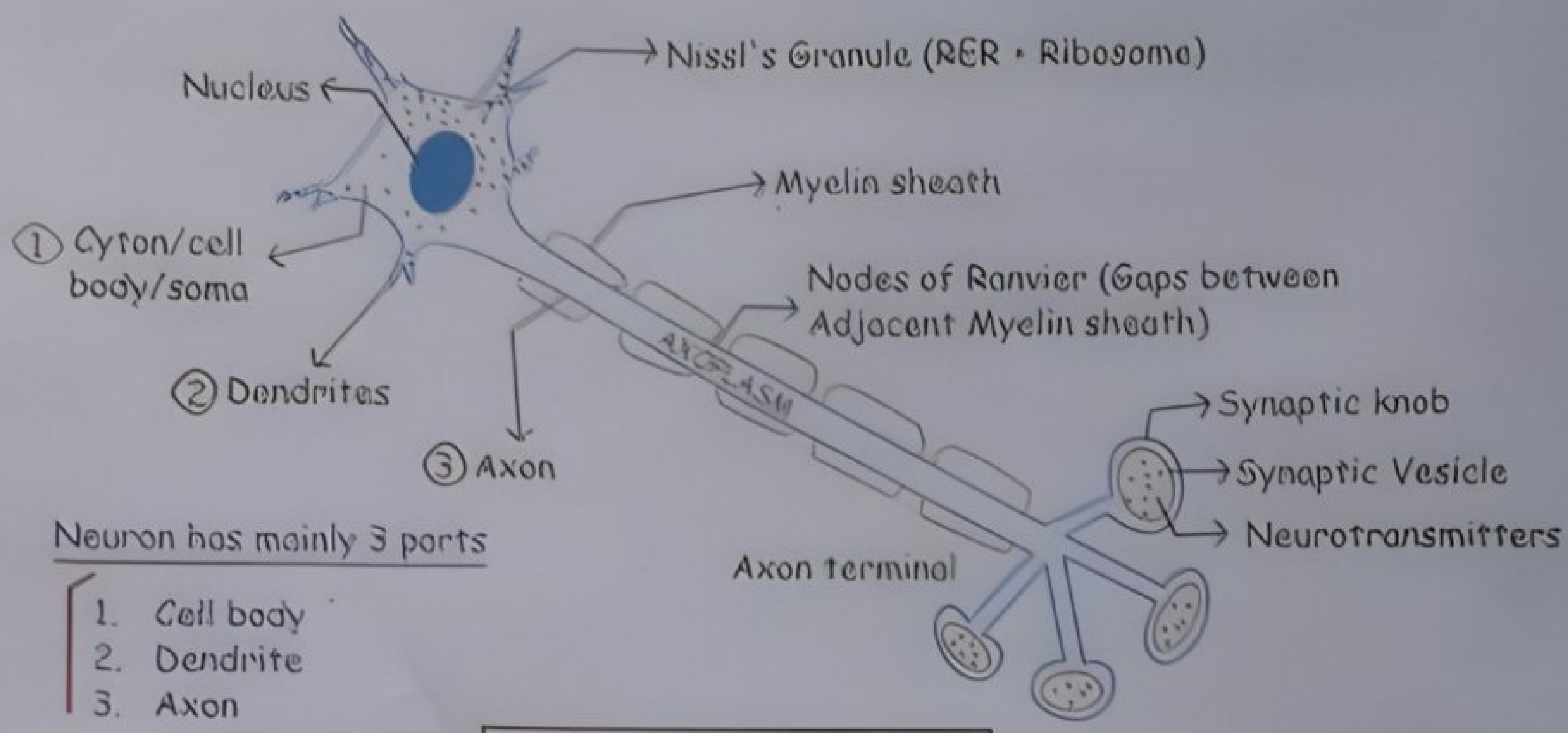
- Excitable cell
- Help in conduction
- Structural & Functional unit of neural tissue

(ii) Neuroglial cell

- Makes up more than 50% volume of neural tissue
- Supporting & packaging of neural tissue.
- Non excitable cell

E.g., Schwann cells → forms myelin sheath in PNS (Peripheral Nervous System)

Oligodendrocyte → forms myelin sheath in CNS (Central Nervous System)



Neuron has mainly 3 parts

1. Cell body
2. Dendrite
3. Axon

Figure: Structure of Neuron

NOTE

- Nissl's granule present only in Axon and dendrite help in synthesis of protein
- Myelin is lipid enrich sheath covering Axon and act as an insulator.

FROG:

- **Rana tigrina:** Most common species of frog found in India.

Kingdom: Animalia
Phylum: Chordata
Sub Phylum: Vertebrata
Super class: Tetrapoda
Class: Amphibia

General Characterstics:

- Amphibia: $\underbrace{\text{Amphi}}_{\text{dual}}\underbrace{\text{bia}}_{\text{bios}}$ → dual life → Fresh Water / Terrestrial
- COLD-BLOODED/Poikilotherm
  - ↳ do not have a constant body temperature
- During peak summer or peak winters they are not commonly spotted:
  - → Aestivation: Summer sleep
  - → Hibernation: Winter sleep
  - (make deep burrows & live inside them)
  - → When present on GRASS or LAND, they change their COLOR (Camouflage) & this type of protective coloration is known as "MIMICRY".

MORPHOLOGY

- Skin: Smooth, slippery and covered with Mucus.
- Skin is MOIST, never drinks water but absorbs through skin.
- Body is divisible into → Head, → Trunk
- A pair of simple eyes are present inside orbit of SKULL.
- External ear pinna is absent but a fold of skin called as TYMPANUM receive sound vibrations present on either sides of the eye.
- Nictitating membrane covers the eye.
- Color → Dorsal: Olive green with Dark, irregular patches
  → Ventral: Pale yellow
- Limbs: 2 Pair → Forelimbs: Ends with 4 digits
  → Hindlimbs: Ends with 5 digits
  - → "Webbed" → help in swimming
  - → "Muscular" → used as a food

  ↓ helps in leaping, walking, burrowing, swimming

Figure: External features of frog

Sexual Dimorphism

- A ♂ frog can be distinguished from a ♀ frog as:
  - ♂ have a copulatory pad on their 1st digit of forelimb which helps during COPULATION
  - ♂ have well developed VOCAL SACS

ANATOMY:

1 Digestive system:

Digestive system: Alimentary canal - Glands

↓

"SHORT"

↓

Because frog is a Carnivore: Intestine Length reduced

Parts of Alimentary Canal:

Mouth

↓

Buccal cavity

↓

Pharynx

↓

Oesophagus

↓

Stomach

↓

Intestine → Duodenum
→ Ileum
→ Rectum → CLOACA → Cloacal aperture → Outside

→ Common chamber

↓

[Alimentary canal -
Reproductive canal -
Excretory canal] Opens here

Process of Digestion:

Bilobed tongue helps in 

↓

Gathering food

↓

STOMACH → $\boxed{\text{Gastric Juice + HCl}}$

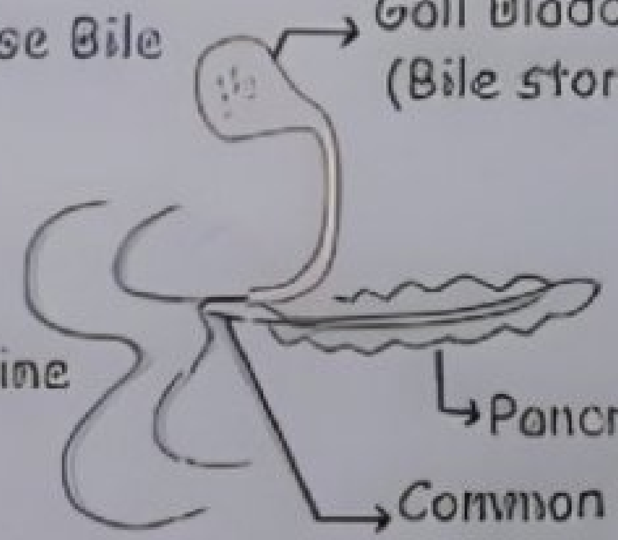
↓

When food mixed with gastric juice, it is called as "CHYME"

↓

Intestine
- → Digestion is completed here
- → Bile: Emulsification of fats
- → Pancreatic juice: Protein & Carbohydrate Digestion with the help of Pancreatic ENZYMES

NOTE Liver: Synthesise Bile



↓

(Bile + Pancreatic juice reaches the duodenum)

Absorption:

With the help of Villi and microvilli in the Intestine Absorption takes place.

Egestion:

The undigested, unabsorbed faecal matter passes through Rectum → CLOACA → Cloacal aperture → outside.

② Respiration

- → In water: Cutaneous Respiration (Skin)
  ↓
  Dissolved O_2 in water is taken by simple diffusion.
- → On land: Cutaneous, Pulmonary respiration (lungs)
  Buccopharyngeal
  ↓
  1 pair, pinkish, in the upper part of trunk
- → During Hibernation & Aestivation: Cutaneous respiration

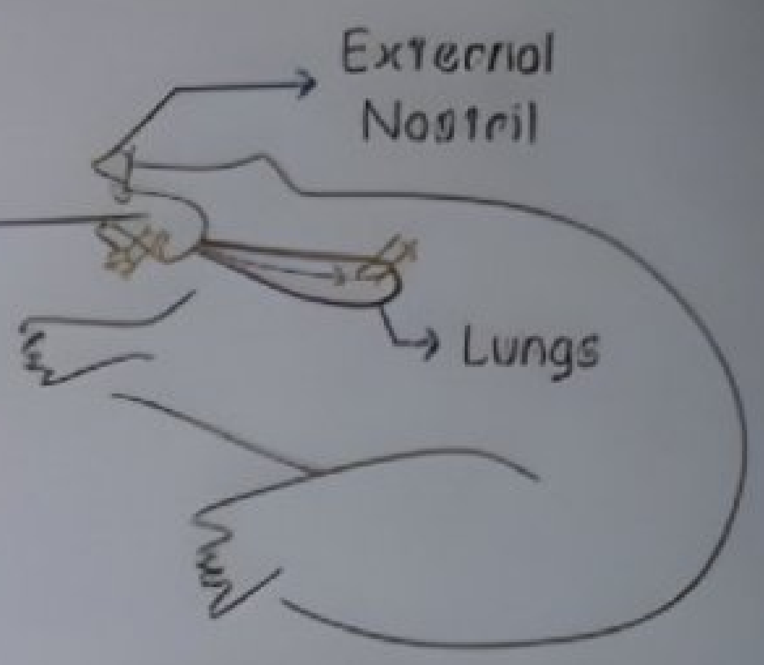


Figure: Buccopharyngeal and pulmonary respiration

③ Circulatory System

They have:

(i) → Blood Vascular system
- → Heart
- → Blood
- → Blood Vessel

(ii) → Lymphatic System
- → Lymph
- → Lymph nodes
- → Lymph Channel

Blood vascular system:

Circulatory System: CLOSED (well developed)

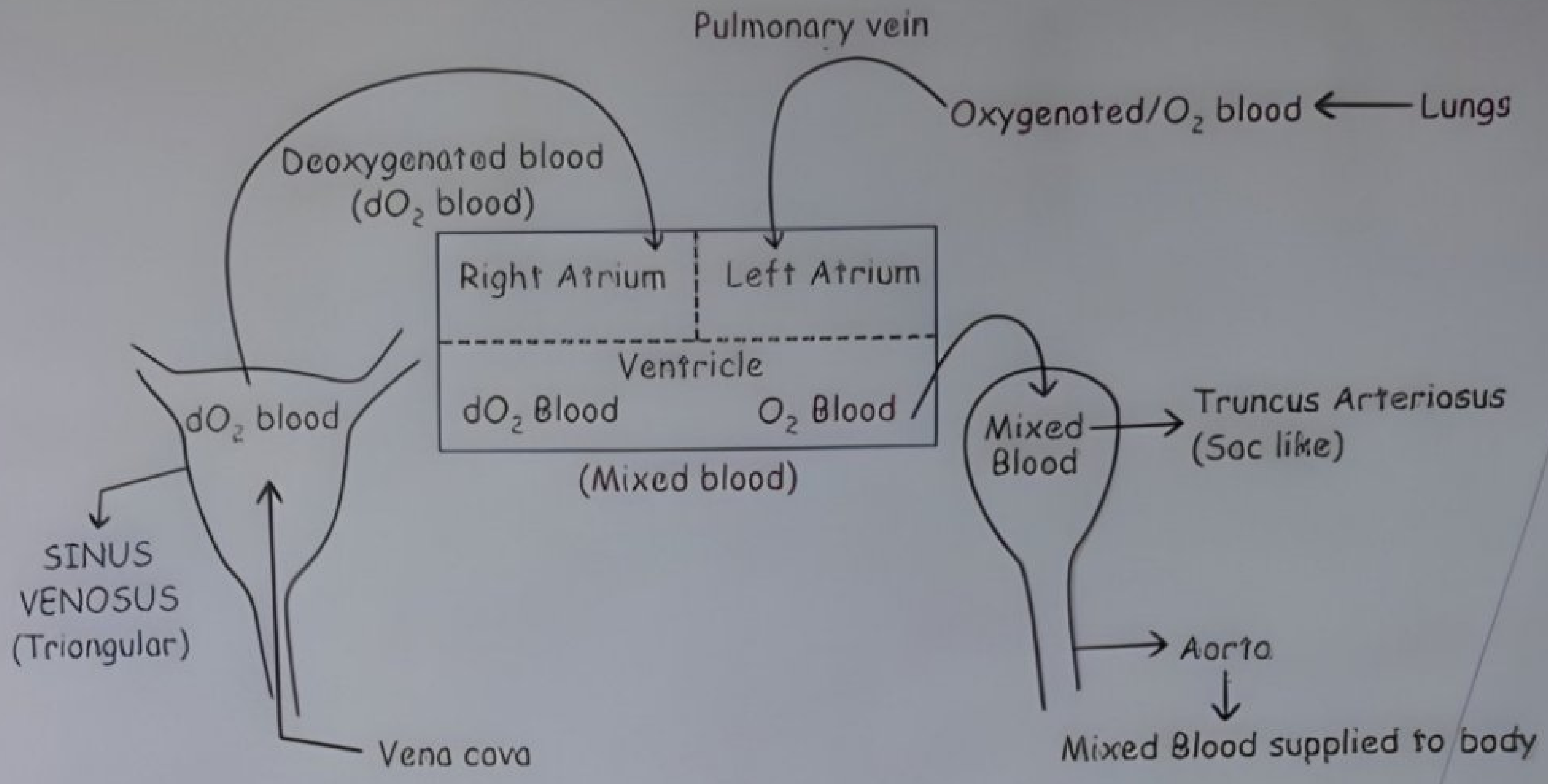
↓

Blood vessels bounded by capillary

HEART

- Covered with PERICARDIUM
- Muscular → located in the Upper part of Body
- 3 chambered Heart — 2 Atria, 1 Ventricle
- Incomplete double circulation/Mixed circulation

*Additional Chambers of Heart
- SINUS VENOSUS → Located on DORSAL SIDE of RIGHT ATRIUM
- CONUS ARTERIOSUS/ TRUNCUS ARTERIOSUS → Located on VENTRAL SIDE of Ventricle



Deoxygenated Blood
↓
Vena cava
↓
Sinus Venosus
↓
Right Atrium

Oxygenated Blood
↓
Lungs
↓
Pulmonary Vein
↓
Left Atrium

Ventricle
↓
Mixed Blood
↓
Conus/Truncus Arteriosus
↓
Aorta
↓
Body

- **Blood:** Blood cells + Plasma + Platelets

RBC (Red blood cell) — WBC (White blood cell)

RBC ↓ "Nucleated" with 'Hb'

NOTE

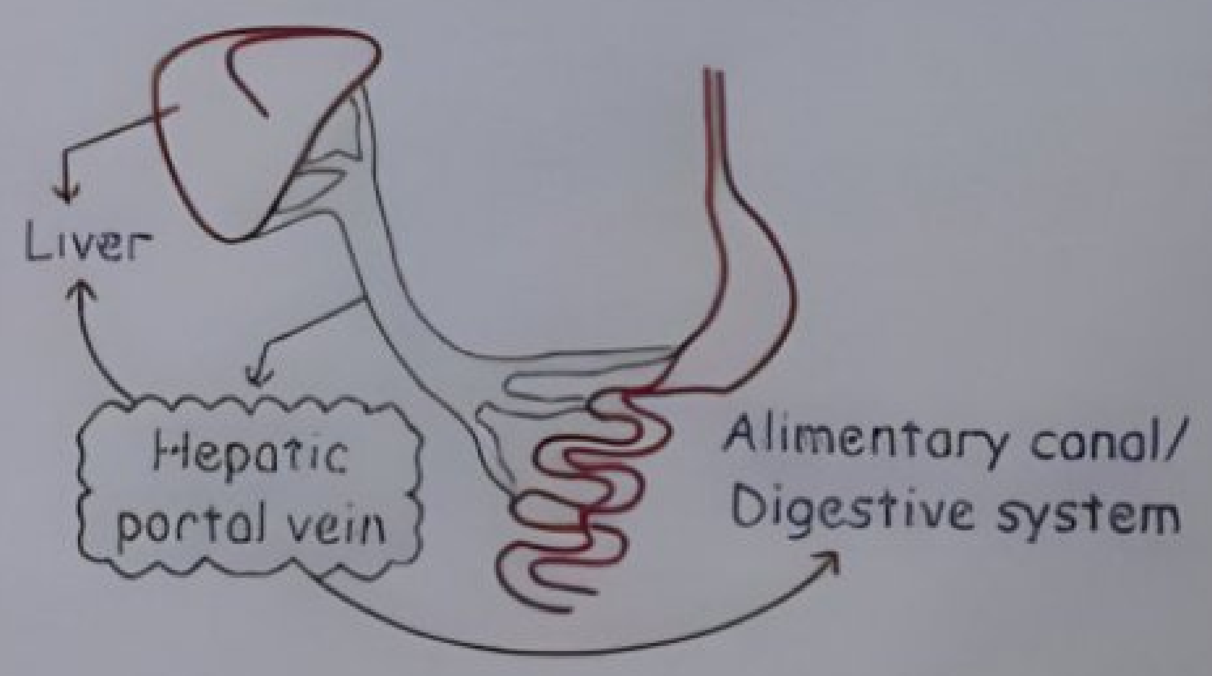
- Blood helps in transport of gases, nutrients, etc.
- Lymphatic System:
- It has Lymph: Colorless (No RBC), less proteins
- Lymph Nodes
- Lymphatic Channels
- Portal Circulation

Special vascular connection between 2 organs that starts with capillary and ends with capillary.

Portal Circulation → Hepatic Portal Circulation, Renal Portal Circulation

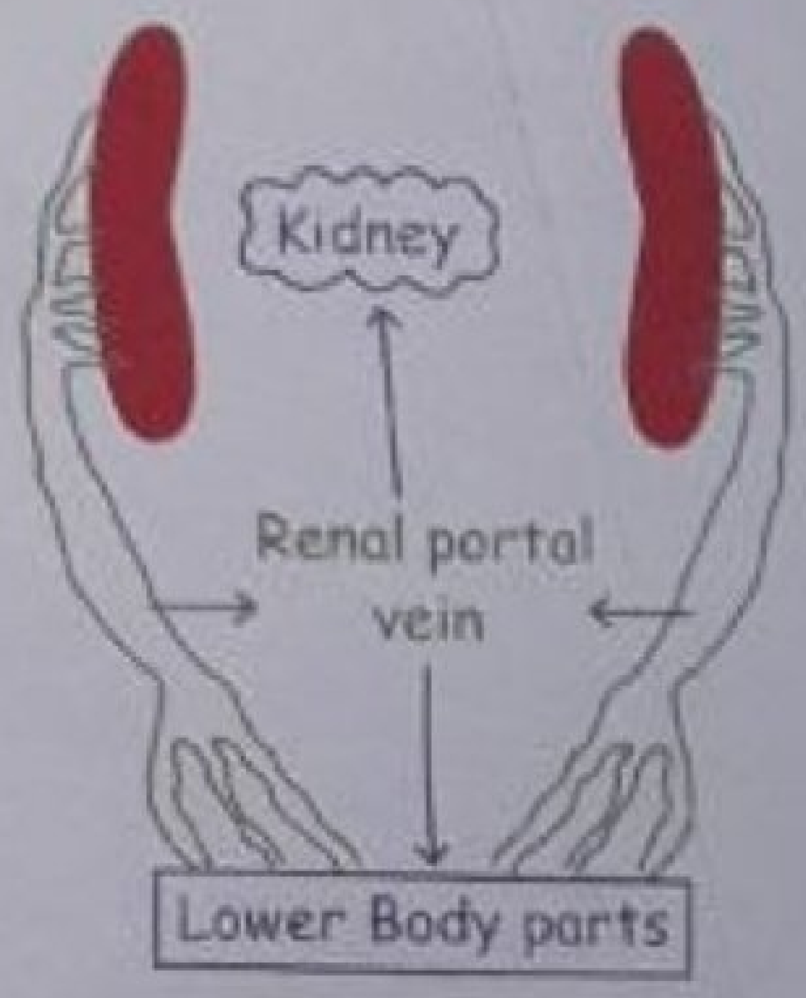
(1) HEPATIC PORTAL CIRCULATION

Connection between Liver and Alimentary canal



(2) RENAL PORTAL CIRCULATION

Connection between Kidneys and Lower Body Parts



4 Excretion

Excretory system consists of:

- A pair of KIDNEY
- A pair of Ureter
- A Urinary Bladder
- CLOACA

Kidney

- Dark Reddish, Located posteriorly on either side of Vertebral column.
- Structural & functional unit: Uriniferous tubule/ Nephron.

Excretory Product: UREOTELIC (Urea)

5 Reproductive System

(i) Male Reproductive System

A pair of yellowish ovoid TESTIS
↓
Mesorchium → Folds of peritoneum via which testis attached to kidney
↓
10-12 Vasa efferentia
↓
Bidder's canal
↓
Urinogenital duct
↓
CLOACA
↓
Cloacal aperture

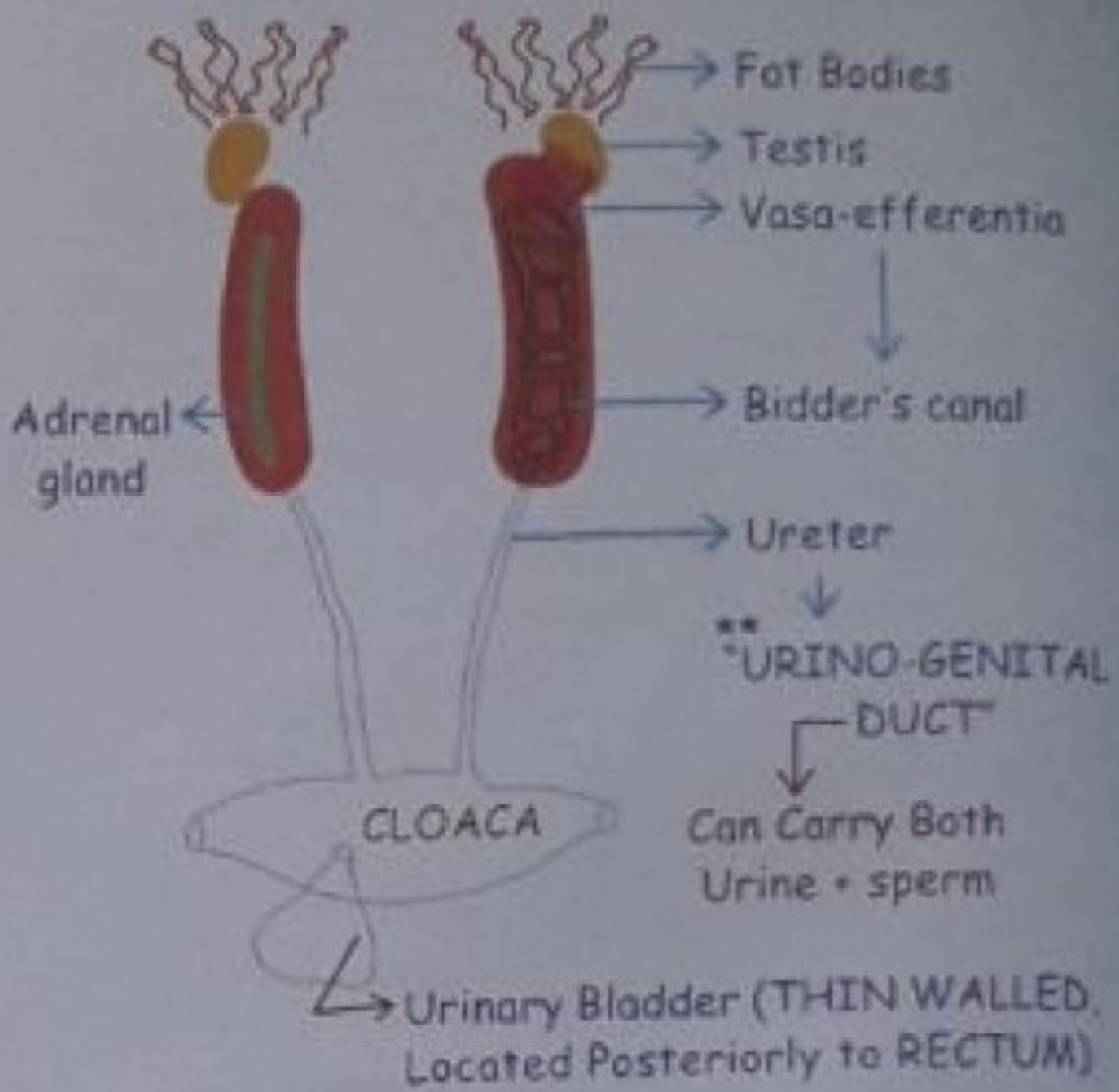


Figure: ♂ Reproductive System

(ii) Female Reproductive System

A pair of OVARY
↓
OVIDUCT
↓
CLOACA
↓
Cloacal aperture

** → No functional connection between OVARY & KIDNEY.

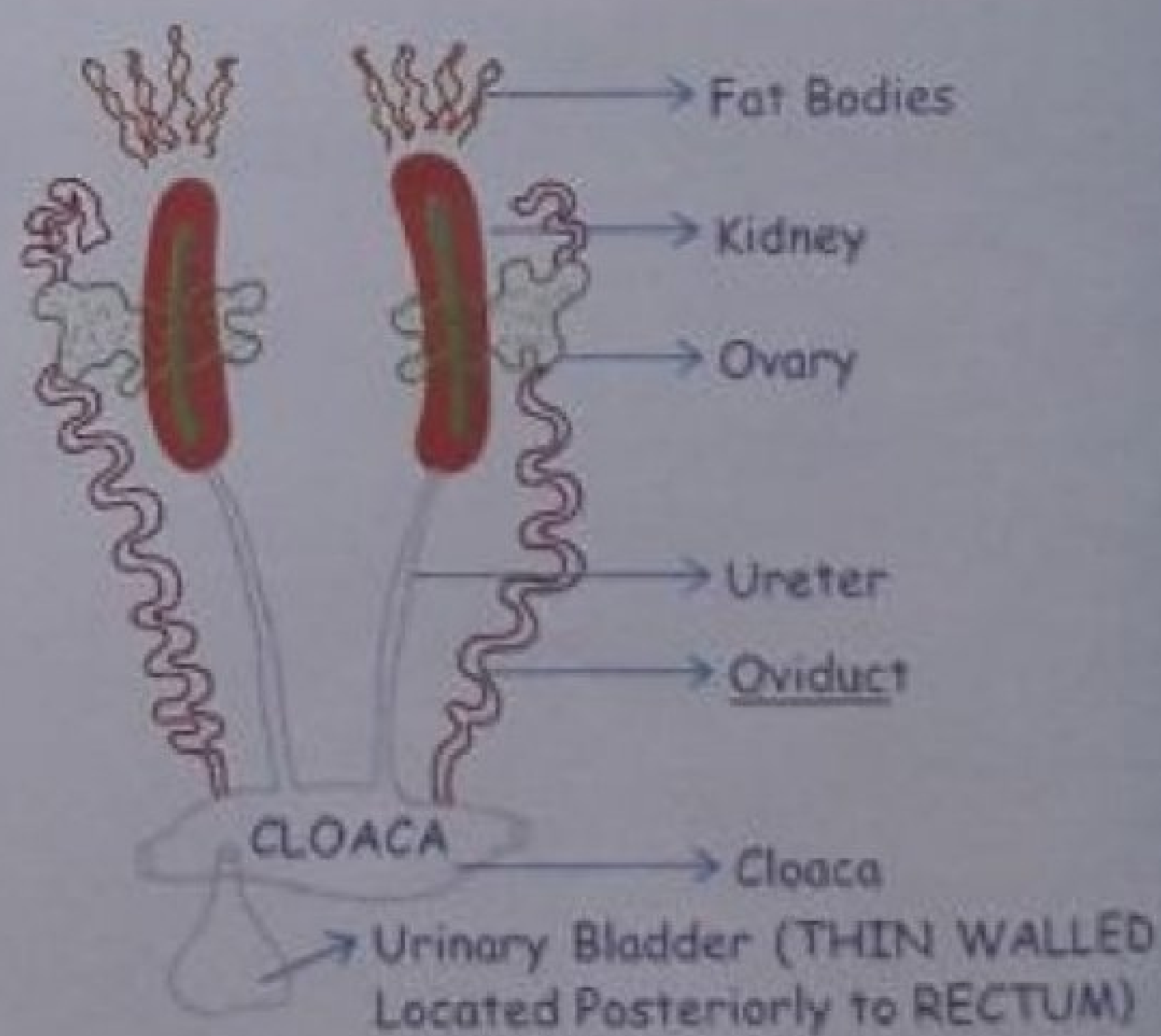


Figure: ♀ Reproductive system

Fertilisation & Development

- A ♀ frog lays 2500-3000 ova at a time
- External fertilisation: Fertilisation occurs outside the body
- Development: Indirect → Passes through 'TADPOLE' Larva → Undergoes Metamorphosis to convert into an adult frog

6 NERVOUS SYSTEM & ENDOCRINE SYSTEM

CONTROL & COORDINATION (Well Organised)

- Neural System
  - CNS Central Nervous System
    - Brain → Protected in Cranium
    - Spinal cord → Protected in Vertebral column
  - PNS Peripheral Nervous System
    - Cranial nerves 10 pairs
    - Spinal nerves 10 pairs
  - ANS Autonomic Nervous System
    - Sympathetic Nervous System
    - Parasympathetic Nervous System
- Endocrine System → Glands → Produce hormones
  - Pituitary gland, Pineal, Thyroid, Parathyroid, Thymus, Pancreatic islets, Adrenal gland, Gonads (Testis, Ovary)

Brain

- Fore Brain has
  - paired cerebral hemisphere
  - olfactory lobes
  - unpaired Diencephalon
- Mid Brain has 'Optic Lobes' (paired)
- Hind Brain has
  - Cerebellum
  - Medulla → It passes through opening in SKULL FORAMEN MAGNUM to connect to spinal cord

7 Sensory Structures

Frog has different types of sense organs, namely organs of

1. touch (sensory papillae),
2. taste (taste buds),
3. smell (nasal epithelium),

(1–3: cellular aggregation around nerve endings)

4. vision (eyes)
5. hearing (tympanum with internal ears). → Balancing

(4–5: well developed)

Frog is Beneficial to Mankind

- Their muscular legs are used as food in some countries.
- Important part of food chain & food web.
- Eat insects & protect our crop.

COCKROACH

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Genus: Periplaneta
Species: americana

General Characteristics

- Color ranges from black or brown bodied. Bright yellow, red and green bodied cockroaches reported in tropical region.
- Size ranges from 1/4 inch to 3 inches (06-7.6 cm).
- Nocturnal: active during night time.
- They live in warm/Damp places, human homes, and are serious pests and vectors of several diseases.
- Omnivores: feed on everything
- Cursorial: fast runners.
- Size of P. americana: 34-53 mm long → WINGS extends beyond Abdomen in ♂.
- Many species of cockroaches are wild and of no known economic importance yet.

(A) Morphology

- Body is divisible into → Head, → Thorax, → Abdomen

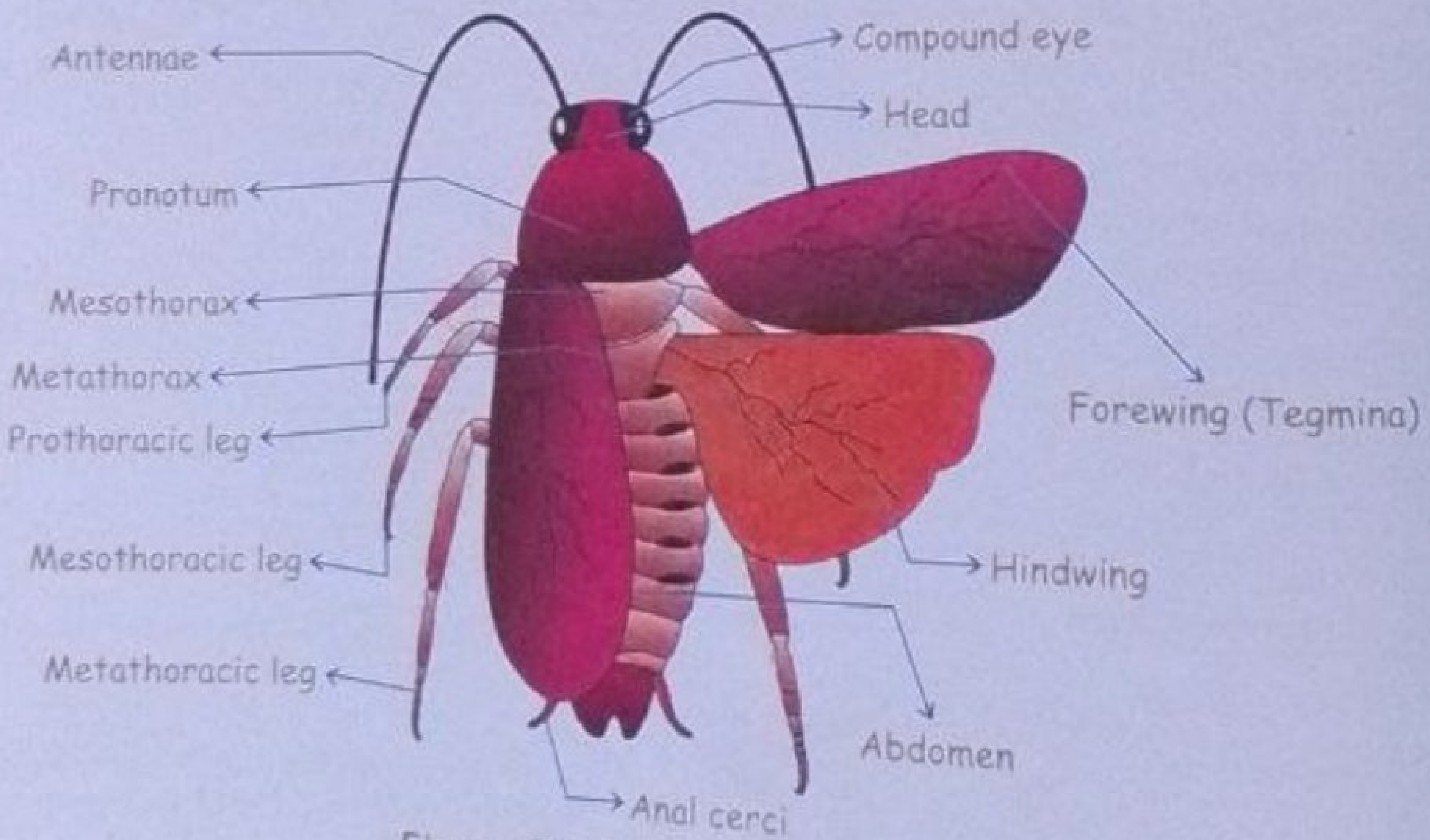


Figure: External features of cockroach

- Body is covered with hard "CHITINOUS EXOSKELETON"
- Metameric Segmentation present

Metamere ⟨ S S S ⟩ → Arthrodial membrane

Metamere ↓ Each metamere has Chitinous covering called as 'SCLERITE'

Arthrodial membrane ↓ Each sclerite is further connected with a flexible Arthrodial membrane

Each Sclerite

- Dorsally ↓ known as Tergum/Tergite
- Ventrally ↓ known as Sternum/Sterite
- Laterally ↓ known as Pleura

NOTE

- A large Chitinous Plate called as PRONOTUM conceals some part of Head & Prothorax.

- Head is connected to thorax by a flexible neck which is the extension of Prothorax

Segments:

	Head	Thorax	Abdomen	
Nymph	6	3	11	(20)
Adult	1	3	10	(14)

(1) Head

- Head is triangular & is formed by fusion of 6 segments
- It is perpendicular to the Body
- It has reduced simple eyes (OCELLI), compound eyes, Antennae & mouth parts

Head ← Body

Mouth parts → "BITING & CHEWING" Type

- → Labrum (1) → Upper lip
- → Labium (1) → Lower lip
- → Hypopharynx (1) → tongue
- → Mandible (2) → incision region
  - ↳ Crushing/Grinding
- → Maxillae (2)

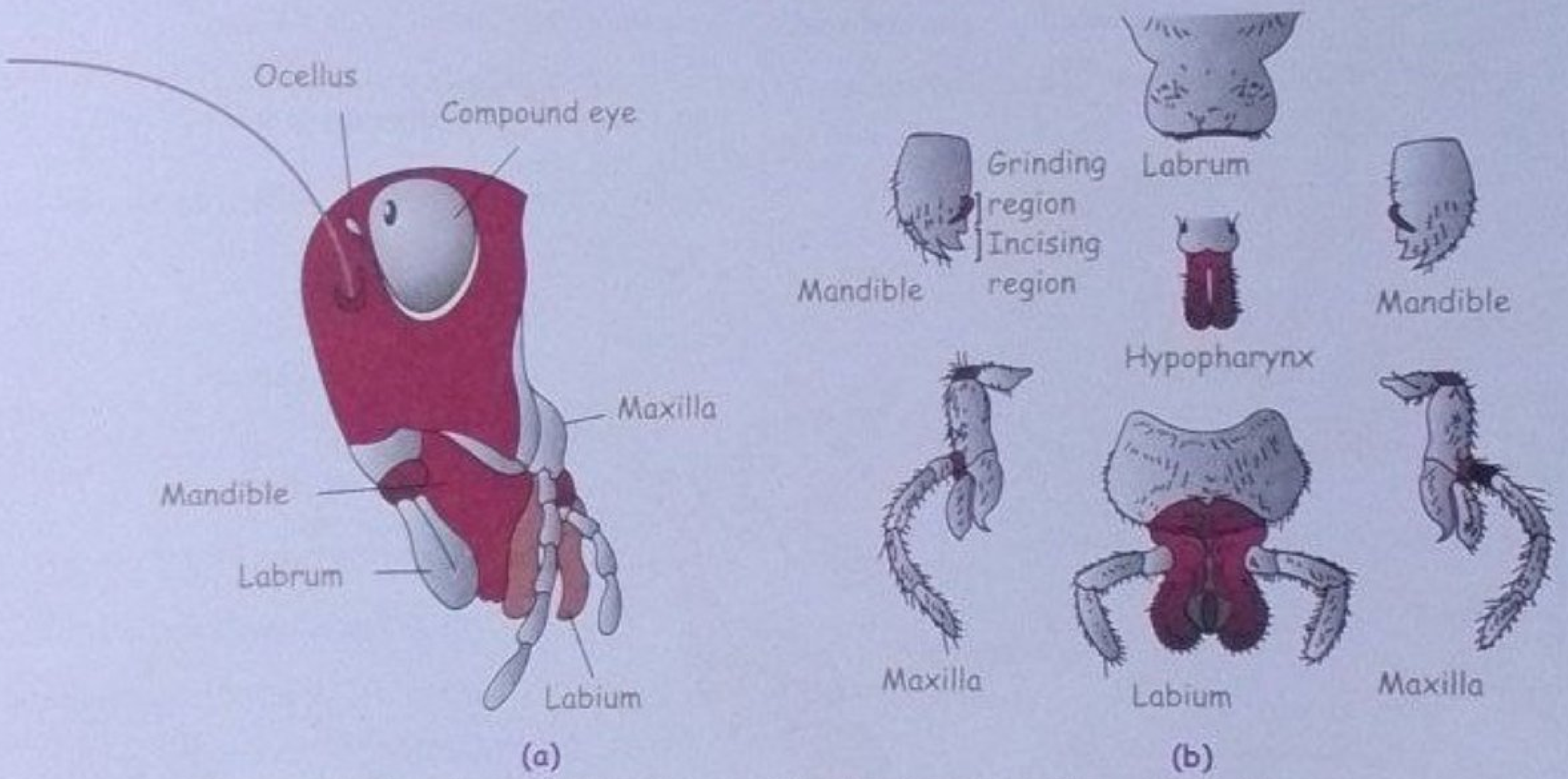


Figure: Head region of cockroach: (a) parts of head region (b) mouth parts

(2) Thorax: 3 segments
- → Prothorax
- → Mesothorax
- → Metathorax

LEGS

↓

3 pair

- Prothoracic leg
- Mesothoracic leg
- Metathoracic leg

WINGS → 2 pair

Forewings
- Mesothoracic wings
- also known as TEGMINA/ELYTRA
- Dark, opaque, leathery
- Not used for flight, only protects Hindwings at Rest

Hind wings
- Metathoracic wing
- Transparent, membranous
- Used for flight

(3) Abdomen: 10 segments

♂ : Genital pouch formed by fusion of 9^{th}, 10^{th} tergum along with 9^{th} sternum

- **Here opening of:** Dorsal anus, ventral male genital pore/gonopore & gonapophysis seen

♀: Genital pouch/Brood pouch formed by fusion of 7, 8, 9 sternum

→ * Boat shaped

Here: Common oviduct's opening (♀ gonopore), spermathecal pore & collateral gland is seen

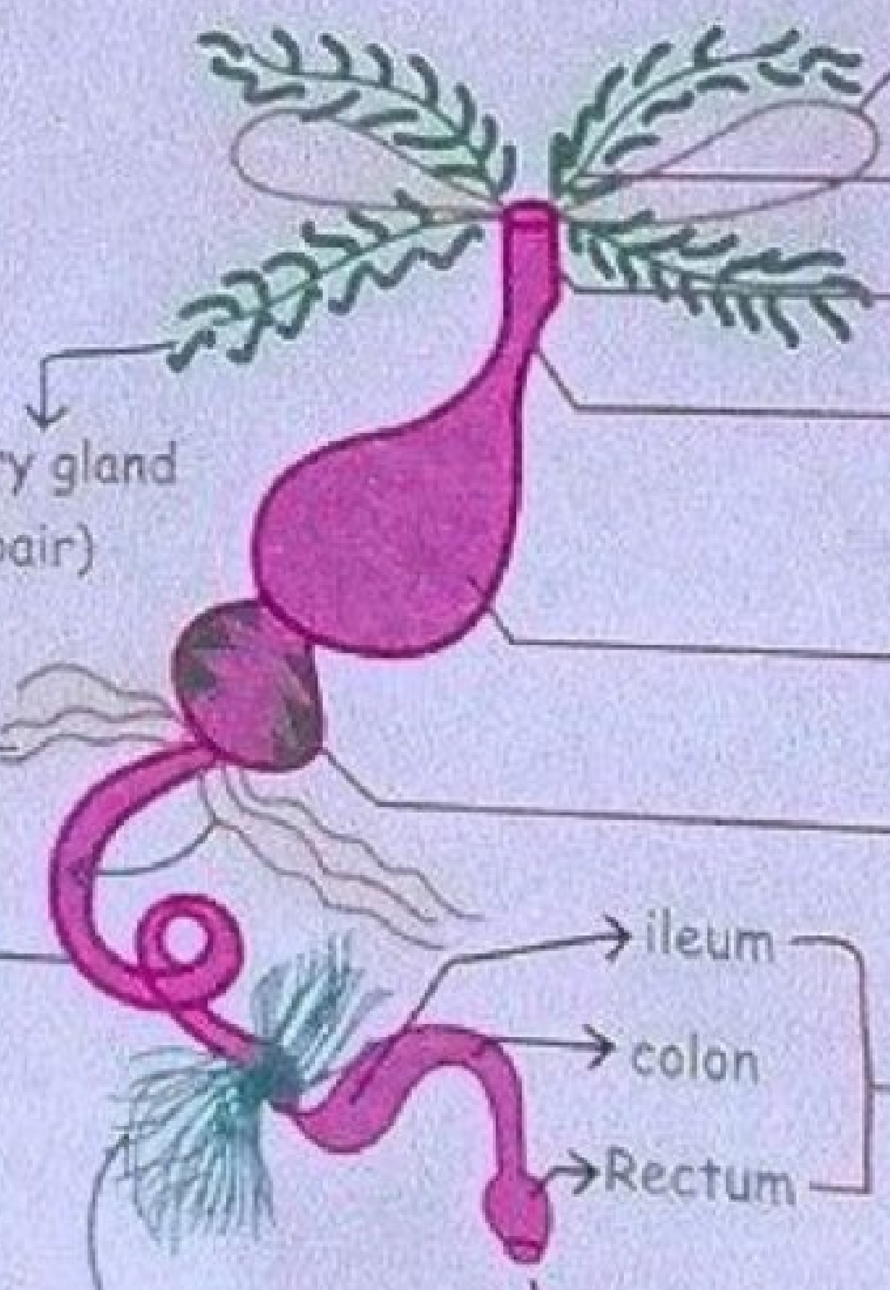
NOTE

- Male & female cockroaches can be distinguished as SEXUAL DIMORPHISM is present
- *♂ has Anal cerci as well as Caudal style/Anal styles in its 9th sternum whereas ♀ only has Anal cerci

B Anatomy

(i) Digestive System:

→ Foregut → 'mouth upto Gizzard'
→ Midgut
→ Hindgut



Salivary reservoir (1 pair)

Mouth ↓ Pharynx ↓ Oesophagus ↓ Crop ↓ Gizzard/ Proventriculus

Salivary gland (1 pair)

Crop → Large, sac like structure where food can be stored

** Hepatic/ gastric caeca
→ Location: Between foregut & midgut
→ 6-8 in number
→ Digestive juice secretion

Mid-gut/Mesenteron → Thin tube

ileum, colon, Rectum → Hindgut → Thicker tube

→ Anus

Gizzard/Proventriculus:
→ GRINDING of food
→ inside: 6 chitinous Teeth
→ Outer Circular muscle

Malpighian tubules
→ Location: Between midgut & hindgut
→ 100-150 in number (greenish yellow)
→ EXCRETORY in nature

(ii) Respiration:

Respiratory system: is known as **TRACHEAL SYSTEM**

Consist of → Spiracle, Trachea, Tracheoles

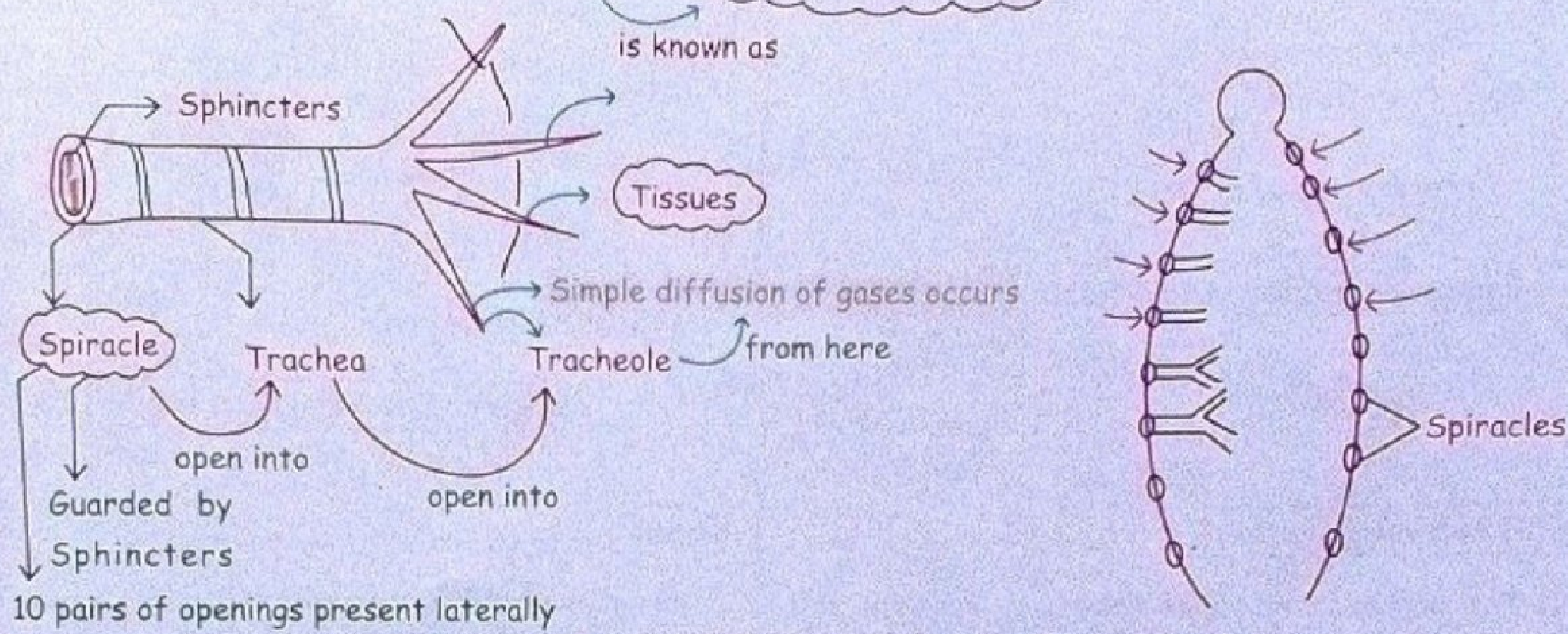


Figure: Tracheal system

(iii) Circulation: Open Circulatory System

1. Heart: *13 chambered, present mid dorsally
   - **Lateral openings:** OSTIA
   - Between 2 chamber FAN SHAPED ALARY MUSCLES Present
   - **First chamber:** Connected to Anterior Aorta
2. Haemolymph: → Colorless blood with no respiratory pigment
   - Present in OPEN spaces called as SINUSES or Haemocoel
   - **Composition:** Haemocytes (Blood cell) + Plasma
3. Anterior Aorta: Open into cephalic sinus (Head)

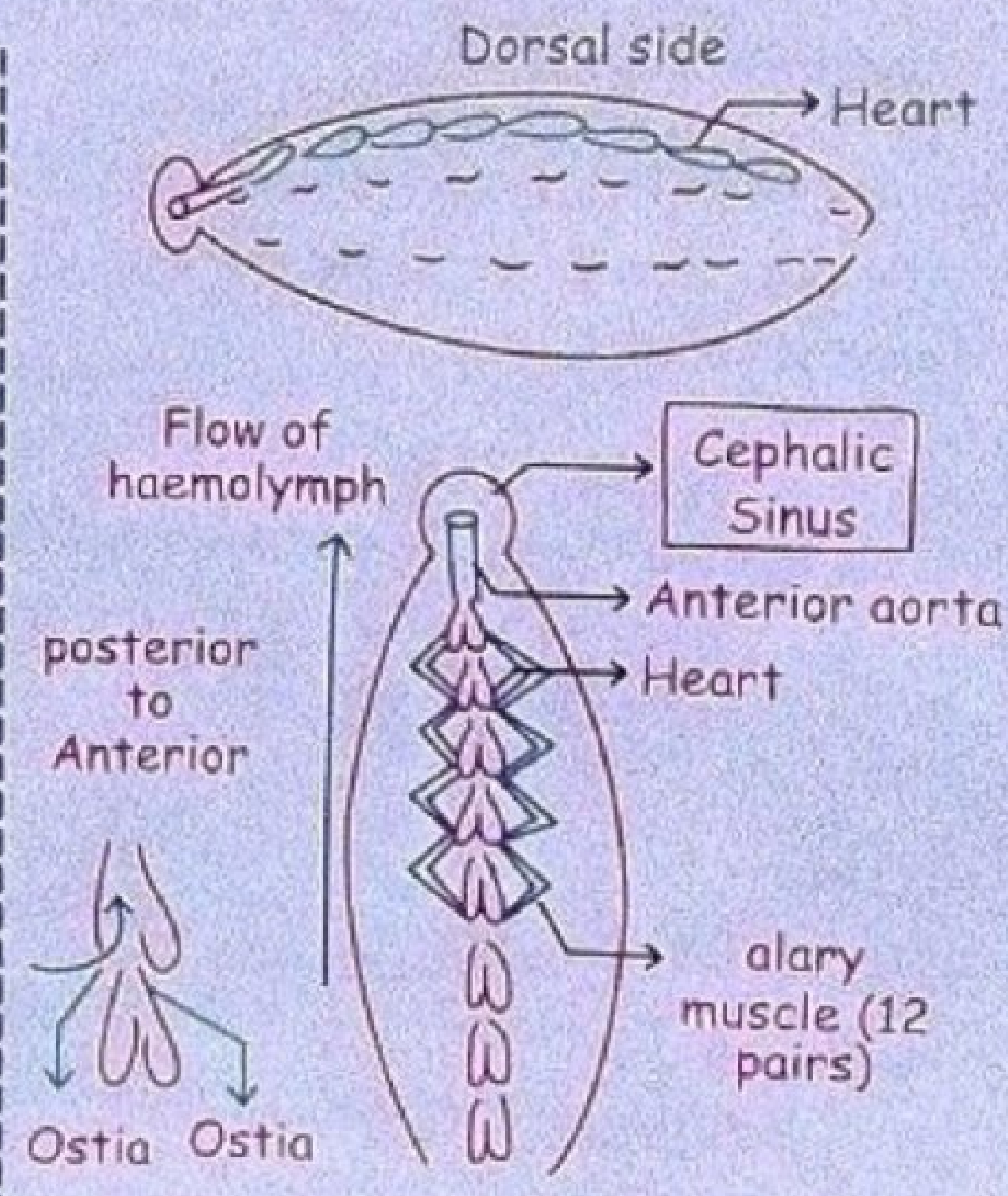
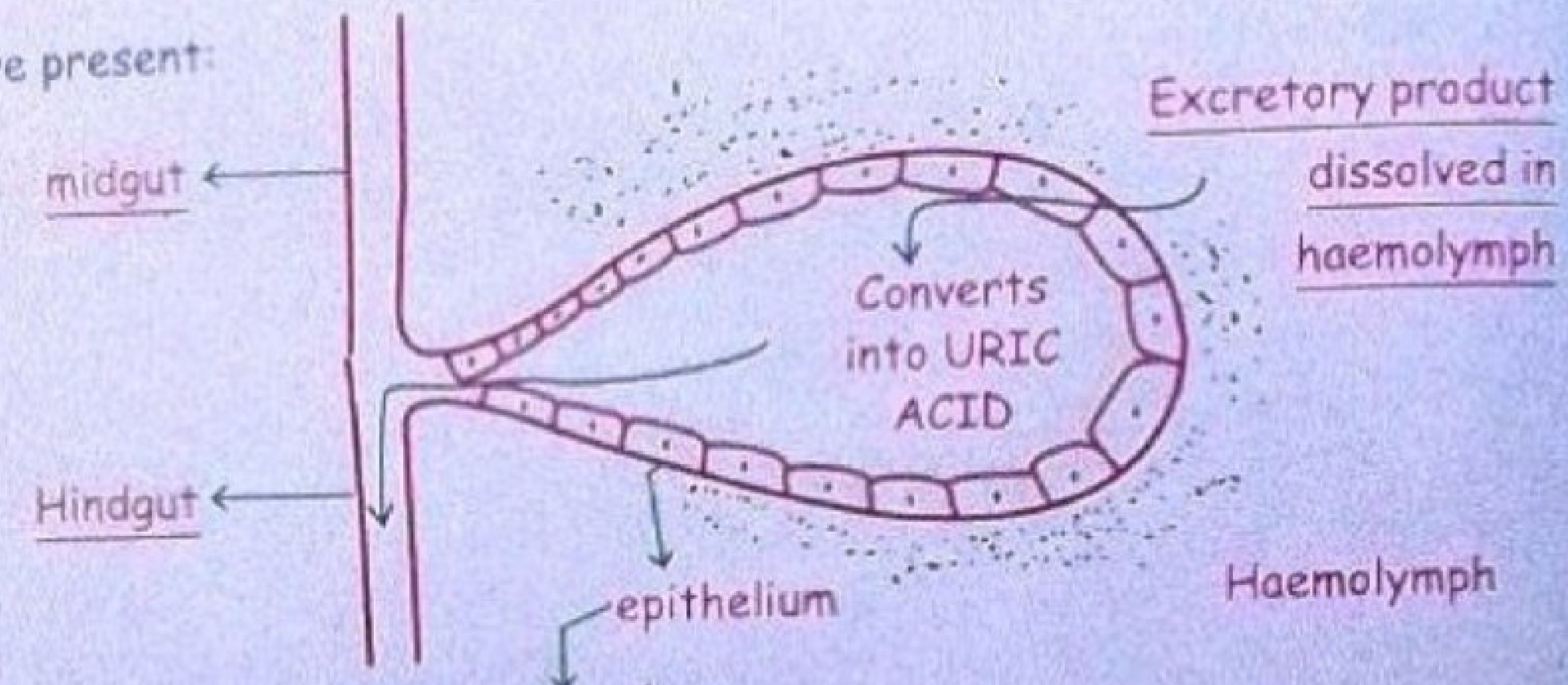


Figure: Circulatory System

(iv) Excretory System:

For excretion different structures are present:

- Malpighian tubules
- Fat bodies
- Nephrocytes
- Urecose glands → present in only in ♂

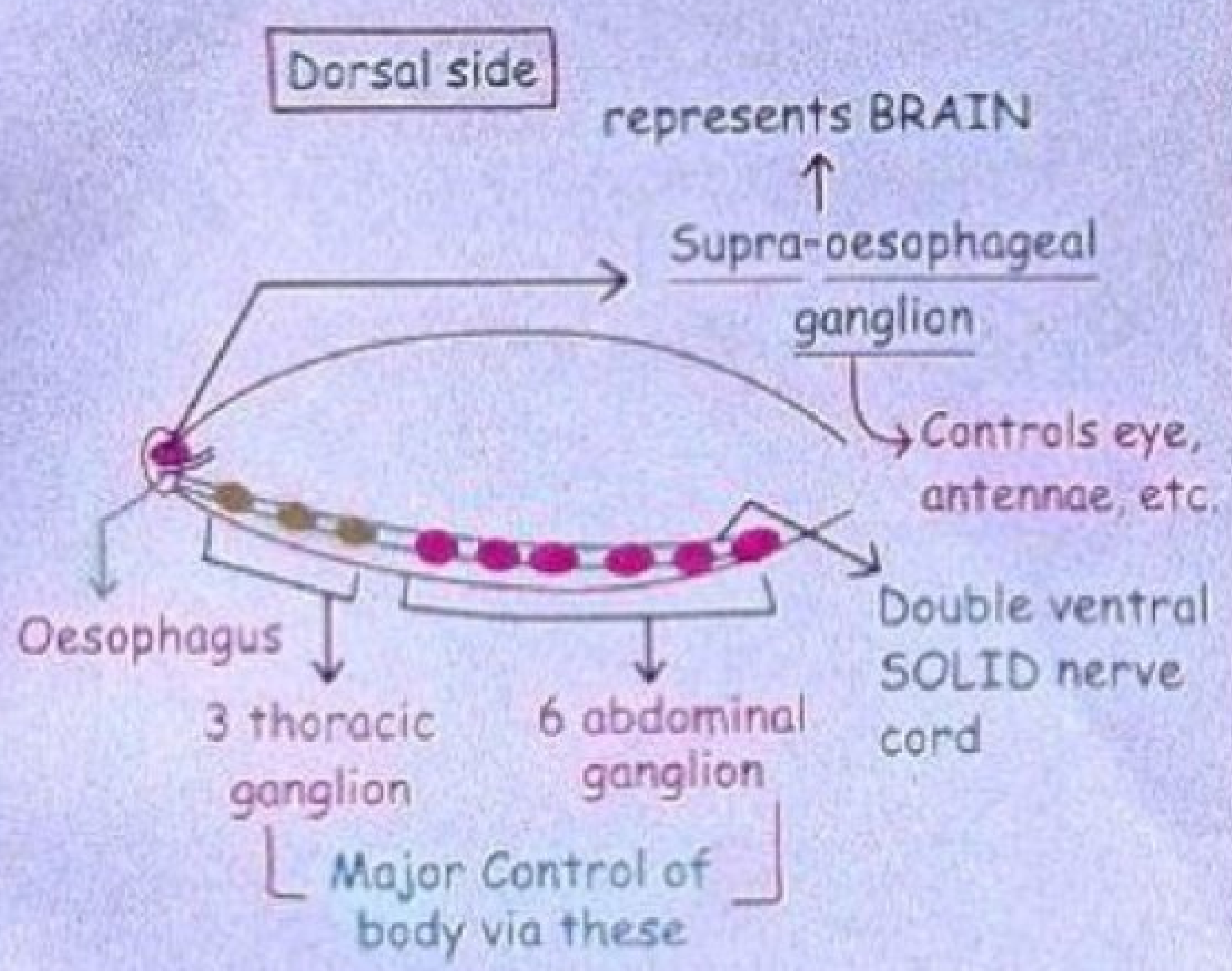


Excretory product: URIC-ACID → URICOTELIC animal

Figure: One Malpighian Tubule

(v) Nervous system

- The nervous system of cockroach consists of a series of fused, segmentally arranged ganglia
- *Three ganglia lie in the thorax and six in the abdomen
- *The head holds a bit of a nervous system while the rest is situated along the ventral (belly-side) part of its body

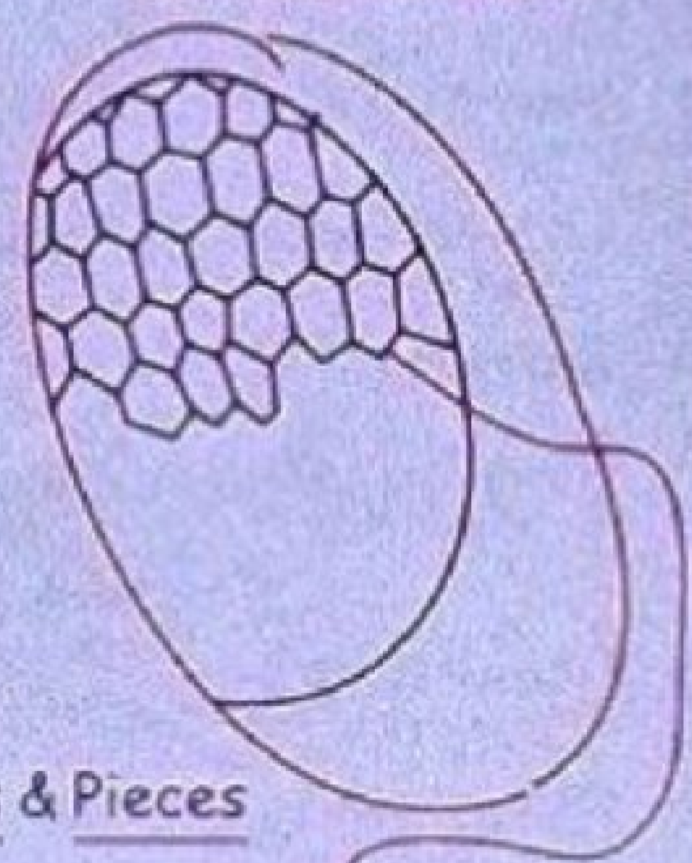


NOTE

If we cut the head of cockroach it can still survive for 1 week because head hold very little part of nervous system while majorly nervous system in located in the Belly (ventral) side

(vi) Sensory structures

- Compound eyes → present on dorsal surface of head
- Antennae
- Maxillary palps
- Labial palps
- Anal cerci



- Vision: Mosaic vision → They see the image in Bits & Pieces
- Sensitivity more
- Resolution poor

** → Common in Nocturnal animals

Each compound eye has → 2000 hexagonal structures → OMMATIDIA/OMMATIDIUM

(vii) Reproductive System

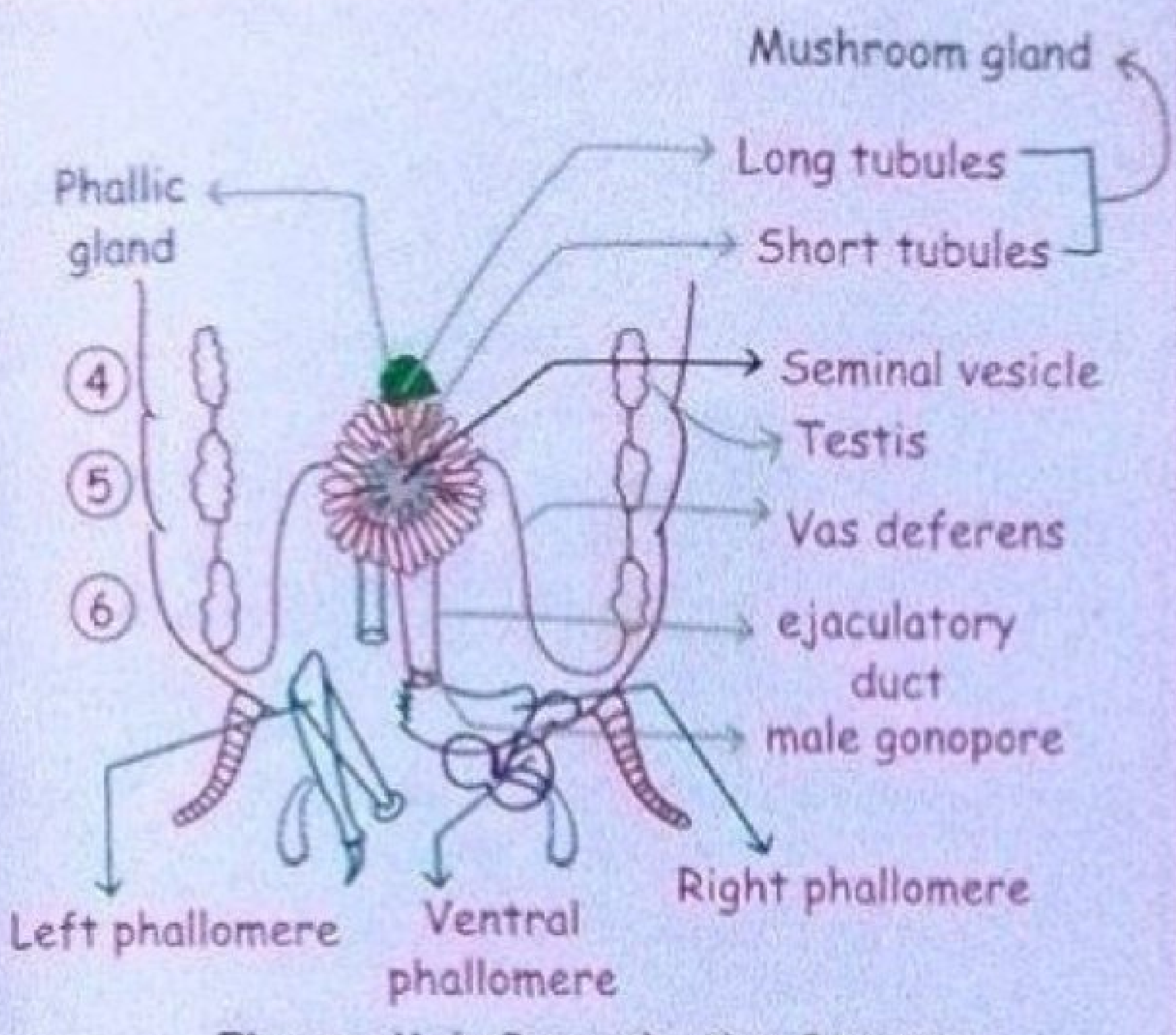


Figure: Male Reproductive System

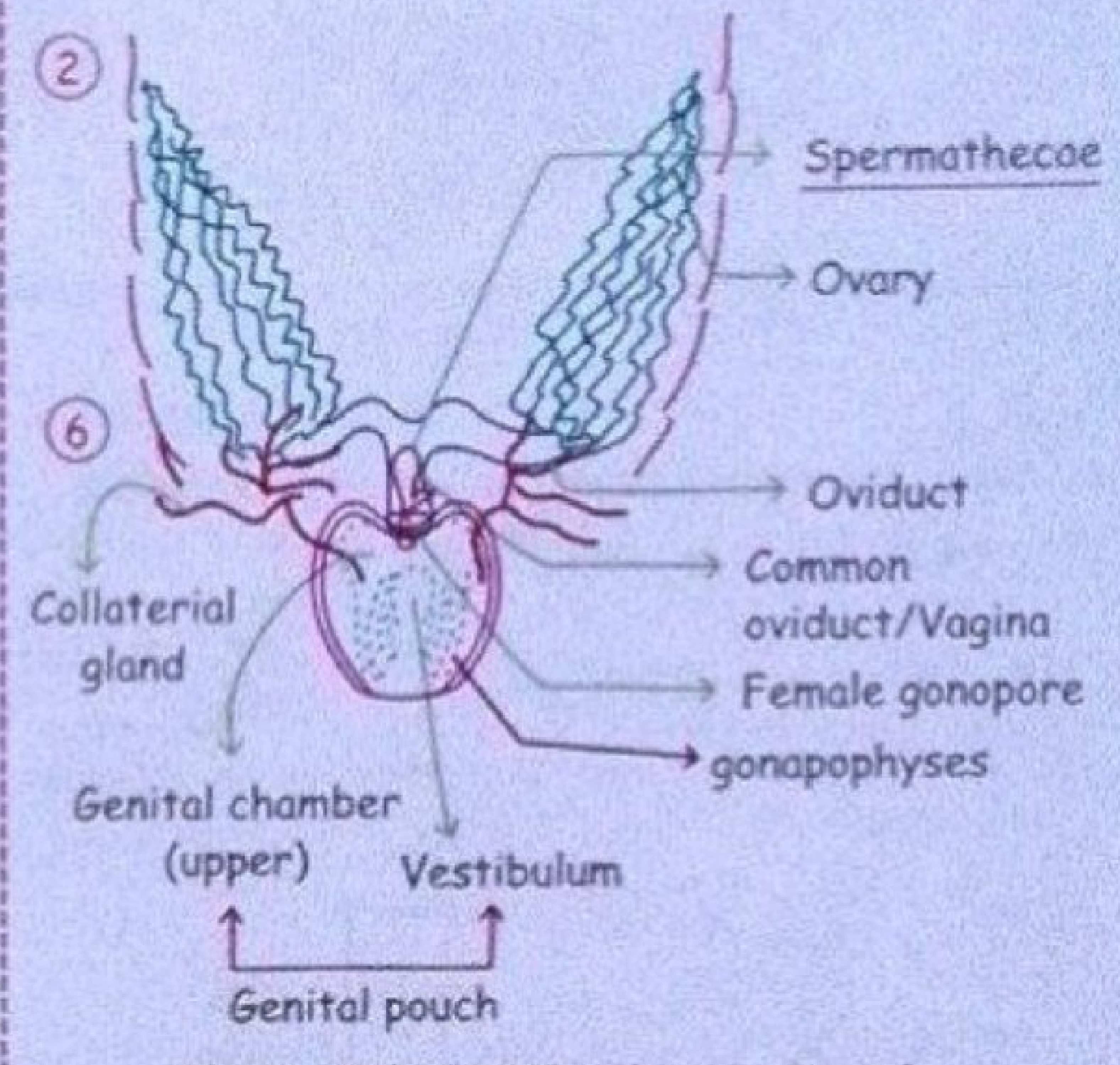


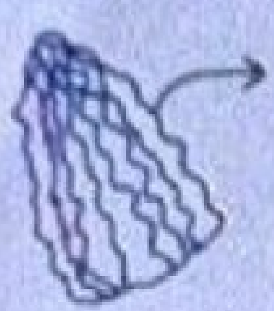
Figure: Female Reproductive System

MALE REPRODUCTIVE SYSTEM

1. **TESTIS:**
   - 1 pair
   - Each testis trilobular
   - Location — 4-6 abdominal segments
   - Involved in Spermatogenesis
2. **VAS DEFERENS:** from each testis arises one vas deferens to carry sperms
3. **EJACULATORY DUCT:** Vas deferens fuses to form common ejaculatory duct whose opening is called as ♂ gonopore
4. **SEMINAL VESICLE:** These are white shiny structures responsible for **storage of sperms & here the sperms are GLUED together to for SPERMATOPHORE
5. **MALE GENITAL POUCH:** Formed by Fusion of 9^{th}, 10^{th} tergum along with 9 sternum.
   - Here male gonopore (ventral), dorsal anus & gonapohyses opens
6. **MUSHROOM GLAND:** Also known as Utricular gland
   - Location — 6^{th}, 7^{th} adbominal segment
   - Long tubules outside, short tubles inside
   - Function — Nourishment of sperms
7. **PHALLIC GLAND:** Also known as Conglobate gland
   - Extends upto 6^{th} segment (अतिरिक्त Gyaan)
8. **GONAPOPHYSES:** Chitinous asymmetrical structures, surrounding the male gonopore
   - Also known as Phallomeres (External genitalia)

FEMALE REPRODUCTIVE SYSTEM

1. **OVARY:**
   - 1 pair,
   - Location — 2-6th abdominal segment,
   - Involved in Oogenesis

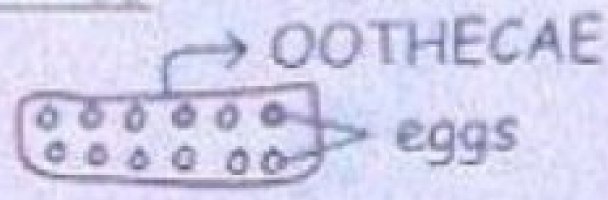


Each ovary with 8 ovarioles

1 ovariole: Produces 1 ova

2. **OVIDUCT:** One oviduct Arises from each ovary to carry ova
3. **VAGINA:** Both oviduct fuses to form this & its opening is known as ♀ gonopore

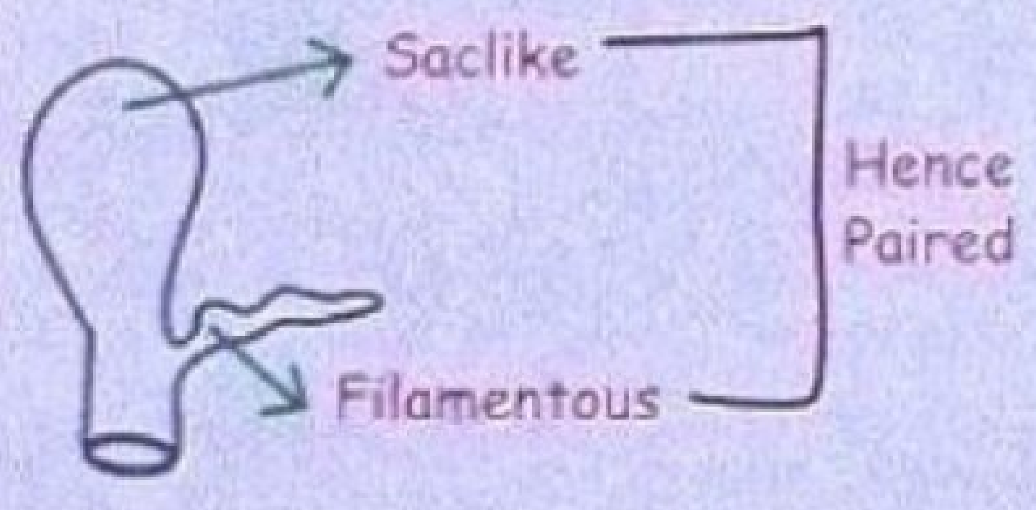
4. COLLATERIAL GLAND:* Left & Right Collaterial gland
→ Secretions form OOTHECAE/EGG CASE around the fertilised egg



5. FEMALE GENITAL POUCH: Formed by fusion of 7^{th}, 8^{th}, 9^{th} Sternum → opening of Collaterial gland, spermathecae & female gonopore is seen

6. SPERMATHECAE:

- Location — 6^{th} segment
- During copulation it can store the sperm received from male



7. GONAPOPHYSES: Chitinous structures (External genitalia) of ♀ cockroach

NOTE

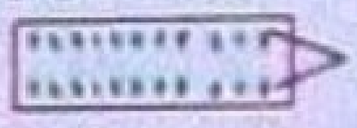
Cockroaches are DIOECIOUS i.e., sexes are separate

Fertilisation & Development:

- Internal fertilisation — Sperm and eggs are fertilised within the body
- Fertilised eggs within OOTHECAE is released from body

Dark reddish brownish

OOTHECAE



→ 14-16 fertilised egg arranged in → 2 rows

8 mm long

At one time → ♀ releases '9-10' oothecae

Development → "PAUROMETABOLOUS" METAMORPHOSIS → Gradual Metamorphosis

egg → Nymph → Adult

→ *13 times moulting

Nymph undergoes moulting for 13 times to form adult cockroach

Paurometabolous:

Nymph & Adult have same mode of life but nymph lacks wings whereas adult has wings

NOTE

The next last nymphal stage has "WING PADS"

3

Biomolecules

BIOMOLECULES:

All the 'carbon' containing compounds present in a living cell.

Analysis of Chemical Compounds

Q: What type of organic compounds are found in living organisms?

Taking a vegetable piece or a piece of Liver (Living Tissue)

↓

Using Mortar-Pestle make a SLURRY (paste) of the tissue using trichloroacetic acid

↓

Using a CHEESE CLOTH, this is filtered

① FILTERATE /Acid soluble Pool /MICROMOLECULE

- Size: Less than 1000 Dalton (18-800 Dalton)
- **It contains:**
- amino acid
- simple sugar
- Nitrogenous Base
- Nucleotides
- Inorganic Compounds

② RETENTATE /Acid insoluble /Macromolecules

- More than 10,000 Dalton
- **It contains:**
- Proteins
- Complex sugar
- Nucleic acid
- LIPIDS*

↓

molecular weight less than 800 Dalton

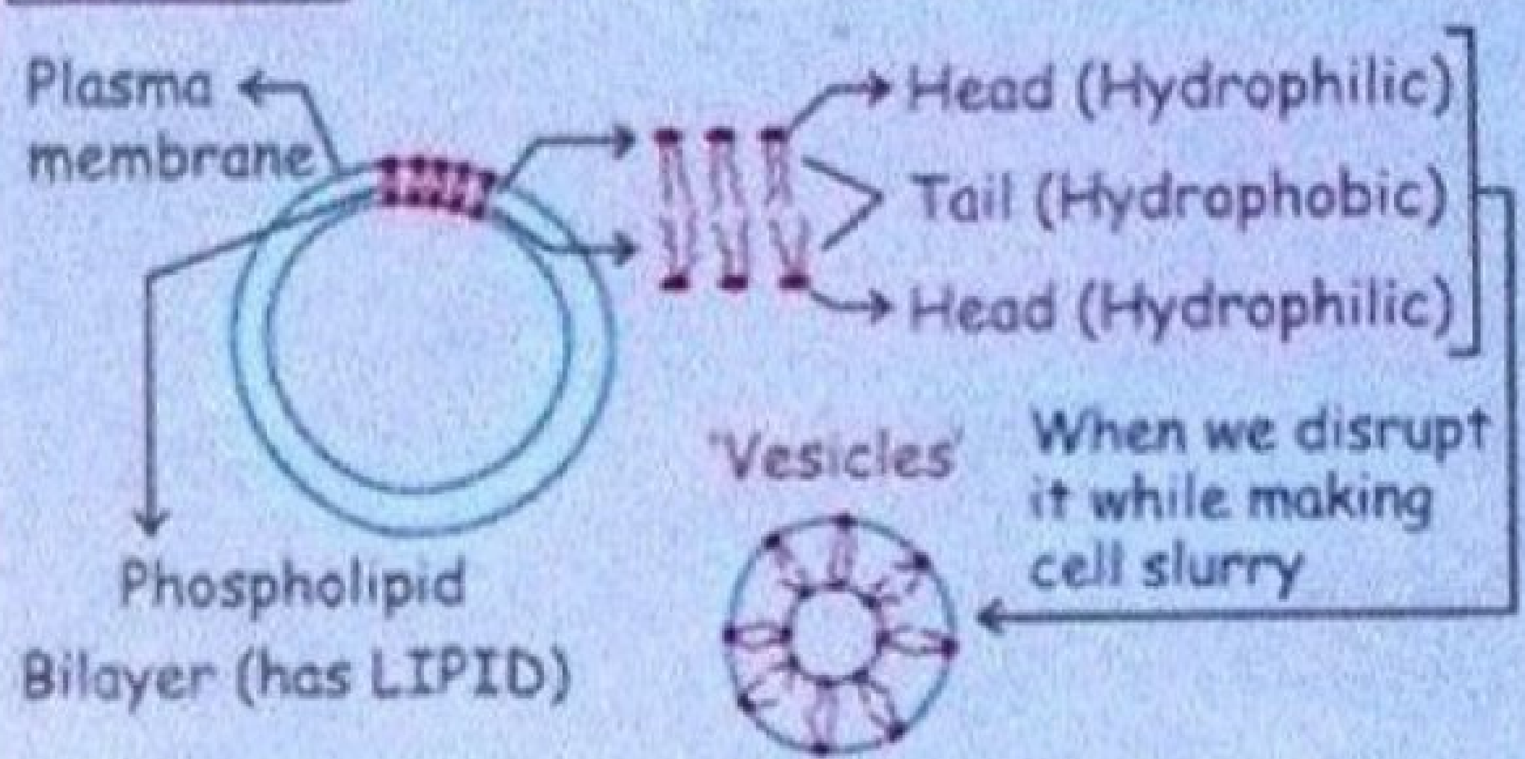
↓

Why it still comes in acid insoluble pool?

NOTE **"LIPIDS ARE NOT STRICTLY A BIOMACROMOLECULE"

- Whenever, we analyse the chemical compounds, Lipids always comes in the acid insoluble pool even though its molecular weight is less than 800 Dalton

CONCEPT



Lipid always aggregate & form small vesicle hence overall weight exceed 10000 Dalton.

NOTE

Water is the most abundant chemical present in the Living organisms.

Table: Average Composition of Cells

Component	% of the total cellular mass
Water	70-90
Proteins	10-15
Carbohydrates	3
Lipids	2
Nucleic acids	5-7
Ions	1

NOTE

Acid insoluble pool roughly represents the cytoplasmic content of the cell & macromolecule/insoluble pool is represented by rest cytoplasmic content & the content of cell organelles.

Table: A Comparison of Elements Present in Non-living and Living Matter*

Element	% Weight of Earth's crust	Human body
Hydrogen (H)	0.14	0.5
Carbon (C)	0.03	18.5
Oxygen (O)	46.6	65.0
Nitrogen (N)	very little	3.3
Sulphur (S)	0.03	0.3
Sodium (Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium (Mg)	2.1	0.1
Silicon (Si)	27.7	negligible

*Adapted from CNR Rao, Understanding Chemistry, Universities Press, Hyderabad.

Ash Analysis Test

To know about the inorganic components of the cell, we perform this test

Take a Cell

↓ Weigh

We obtain Wet Weight

↓

Cell : Heat

↓ Weigh

We obtain Dry Weight

↓

Burn

↓

Carbon part (Organic part) is burnt

↓

ASH remaining, only having inorganic components like calcium, magnesium, etc.

METABOLITES

Metabolism

Sum total of Catabolic & Anabolic reactions

Catabolic → Break down

Anabolic → formation

The substances formed in a metabolic reaction in the organisms is known as 'metabolites'.

eg: sugars, amino acids, etc.

Metabolites

→ Primary

→ Secondary

Primary → Metabolites formed in organisms which has a direct influence or control in their physiological process.

e.g.: glucose, amino acid, chlorophyll, etc.

Secondary → Metabolites formed and found in certain plants, microbes, fungi, etc., which does not have a direct control on their physiological process but can be beneficial for human welfare.

Table: Some Secondary Metabolites (V. Important)

1. Pigment	Carotenoids, Anthocyanin
2. Alkaloids	Morphine, Codeine
3. Terpenoides	Monoterpene, Diterpene
4. Essential oil	Lemon grass oil
5. Toxins	Abrin, Ricin
6. Lectins	Concanavalin A
7. Drugs	Vinblastin, curcumin
8. Polymeric SUBSTANCE	Rubber, gum, cellulose

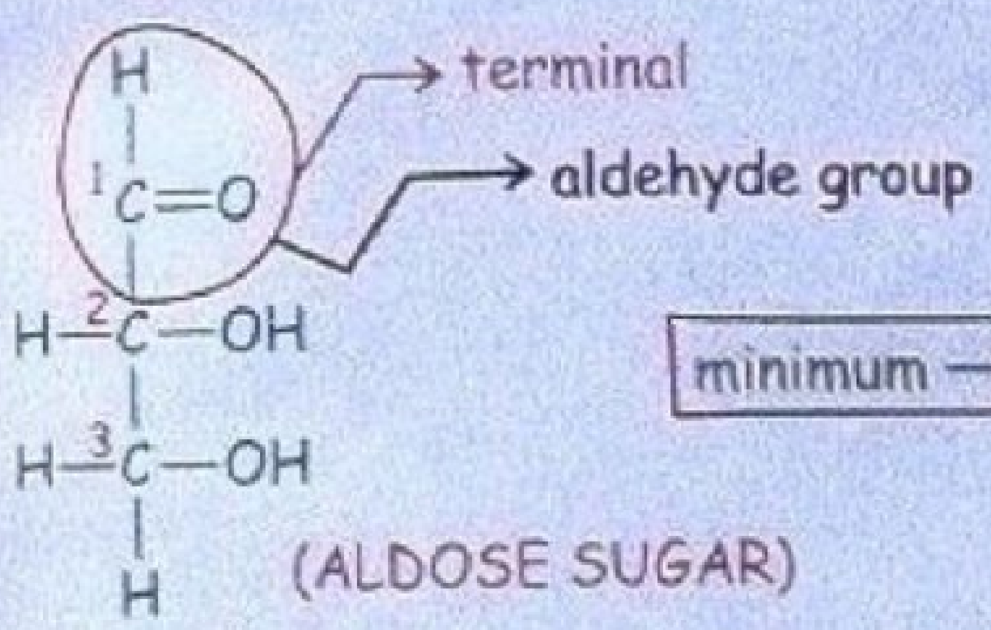
BIOMACROMOLECULE

- → Carbohydrates
- → Proteins
- → Lipids
- → Nucleic acid

CARBOHYDRATES:

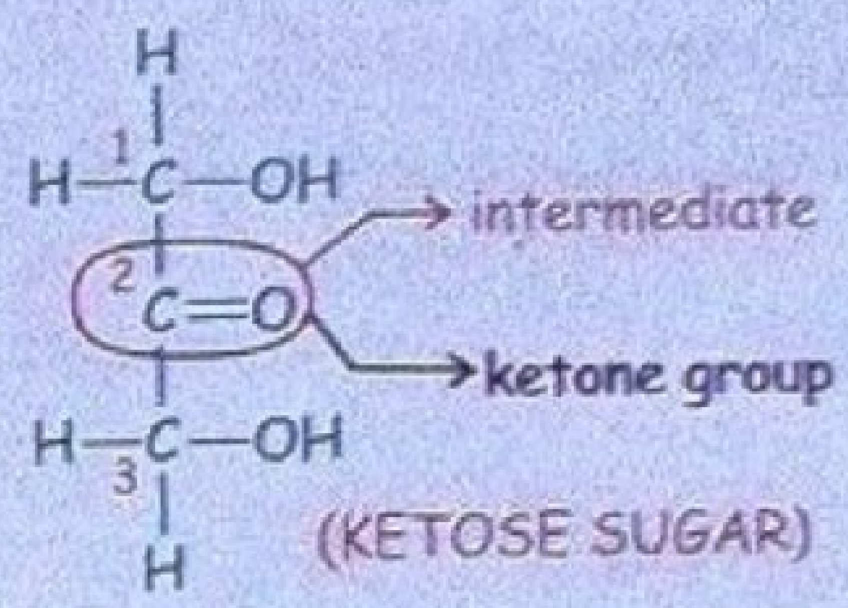
- These are either Aldose or Ketose sugar

Definition: $\underbrace{\text{Poly}}_{\text{more than 1}}\underbrace{\text{hydroxy}}_{\text{OH}}\underbrace{\text{aldehyde}}_{-\text{CHO}}$ OR $\underbrace{\text{poly}}_{\text{more than 1}}\underbrace{\text{hydroxy}}_{\text{OH}}\ \underbrace{\text{ketone}}_{-\text{C=O}}$



(ALDOSE SUGAR)

$\boxed{\text{minimum} \rightarrow \text{3C in any carbohydrate}}$



(KETOSE SUGAR)

CLASSIFICATION OF CARBOHYDRATES

'SUGAR' ← **Carbohydrate (Saccharides)** → Classified on the basis of number of 'SUGAR' units

Monosaccharide — $\underbrace{\text{Mono}}_{1}\underbrace{\text{saccharide}}_{\text{Sugar}}$ ↓ $"C_3 - C_7"$

Carbohydrates with only one sugar subunit but different Monosaccharides vary due to number of carbon which may vary between (C_3-C_7)

- → C_3: TRIOSE SUGAR
- → C_4: TETROSE SUGAR
- Most Common Sugar → $\boxed{C_5\text{: PENTOSE SUGAR}}$ → eg: RIBOSE
- Most Common Sugar → $\boxed{C_6\text{: HEXOSE SUGAR}}$ → eg: GLUCOSE
- → C_7: HEPTOSE SUGAR

Oligosaccharides — $\underbrace{\text{Oligo}}_{\text{few}}\underbrace{\text{saccharides}}_{\text{Sugar}}$

Here "2-9" sugars combines

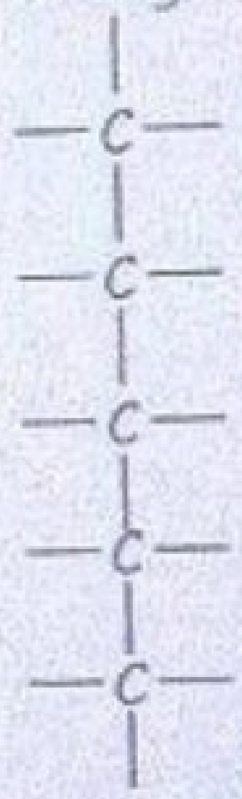
- 2 → Disaccharides
- 3 → Trisaccharides
- 4 → Tetrasaccharides
- 5 → Pentasaccharides
- 6 → Hexasaccharides
- 7 → Heptasaccharides
- 8 → Octasaccharides
- 9 → Nonasaccharides

Polysaccharide — $\underbrace{\text{Poly}}_{\text{many}}\underbrace{\text{saccharide}}_{\text{Sugar}}$

(more than 10 Sugar combine)

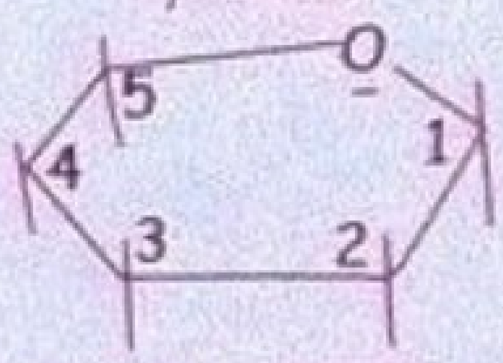
Structure of Carbohydrate May exists in

Straight chain



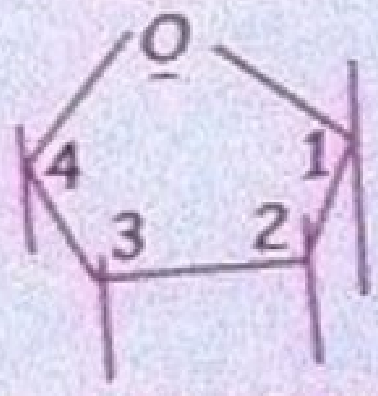
Ring form

Pyranose



→ 5-C within RING

Furanose



4-C within RING

(There might be carbons outside the ring)

Monosaccharides:

1. **Glucose**: 'Hexose SUGAR'

- Polyhydroxyaldehyde/Aldose Sugar
- Identification → 3rd C → 'H' is on its the RIGHT SIDE in straight chain form

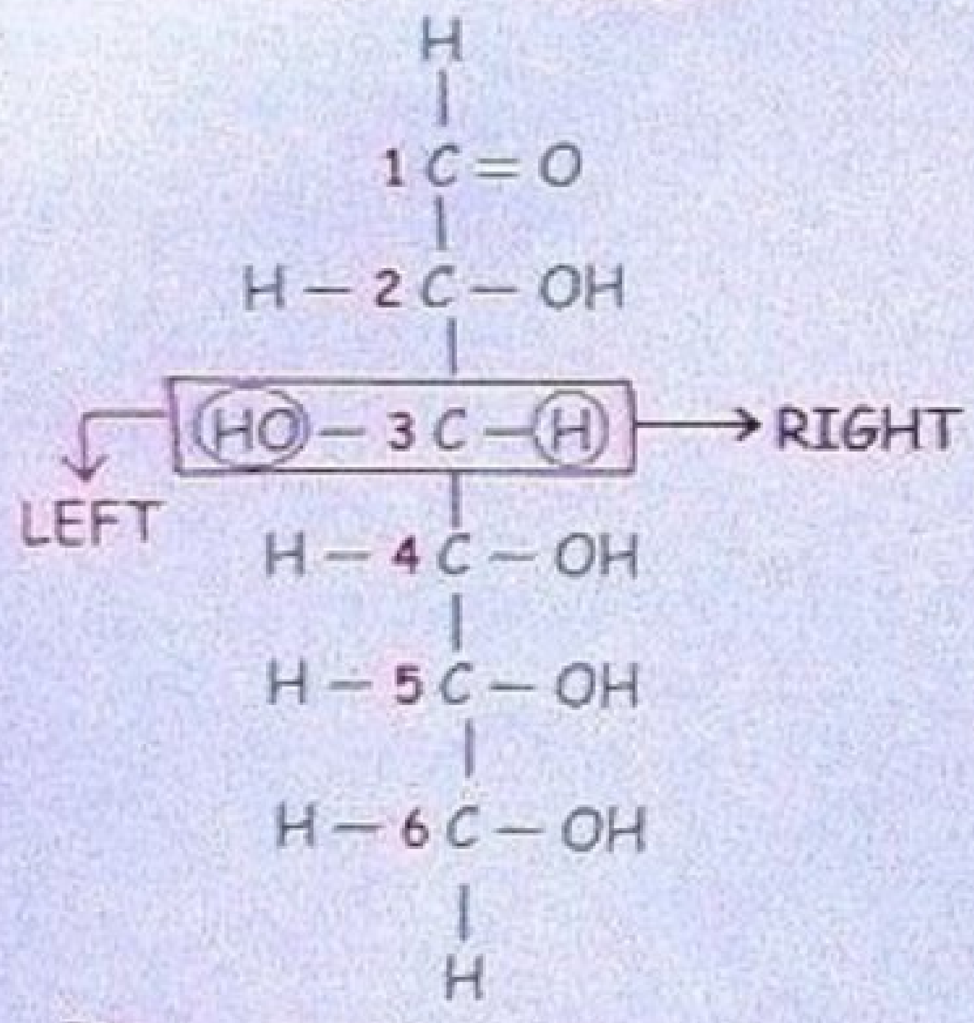
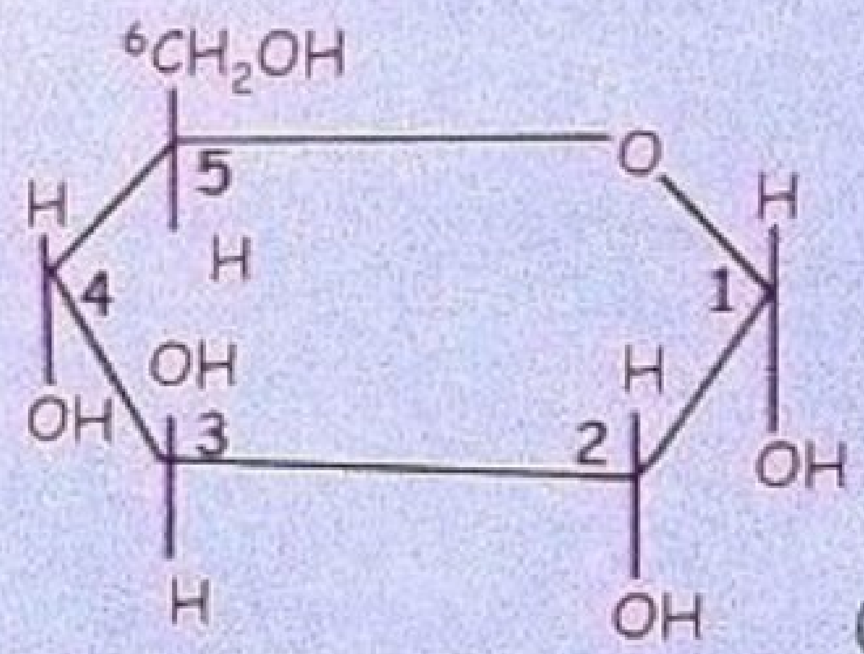


Figure: Straight chain of Glucose

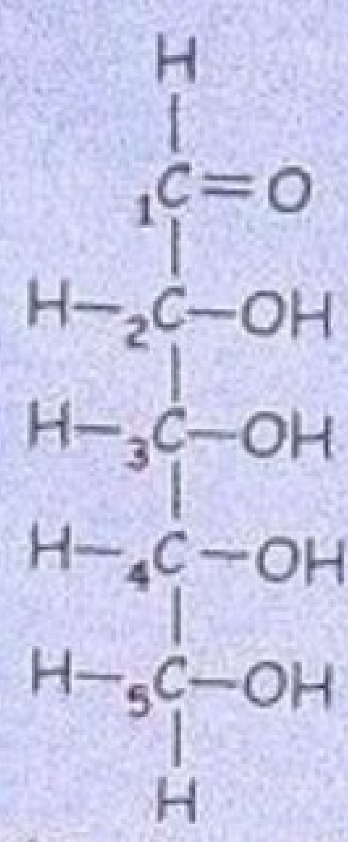


(α-Glucose)

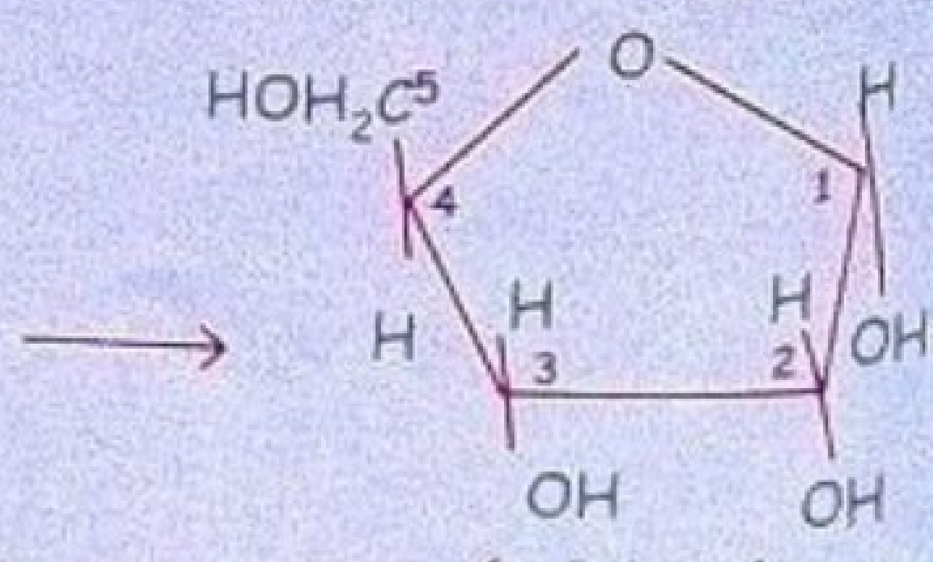
Figure: 'Ring form of Glucose'

2. **RIBOSE SUGAR**: 'Pentose (5C) SUGAR'

- Found in RNA (RIBONUCLEIC ACID)
- Aldose sugar
- All '—OH' RIGHT in straight chain



(Straight chain of Ribose)

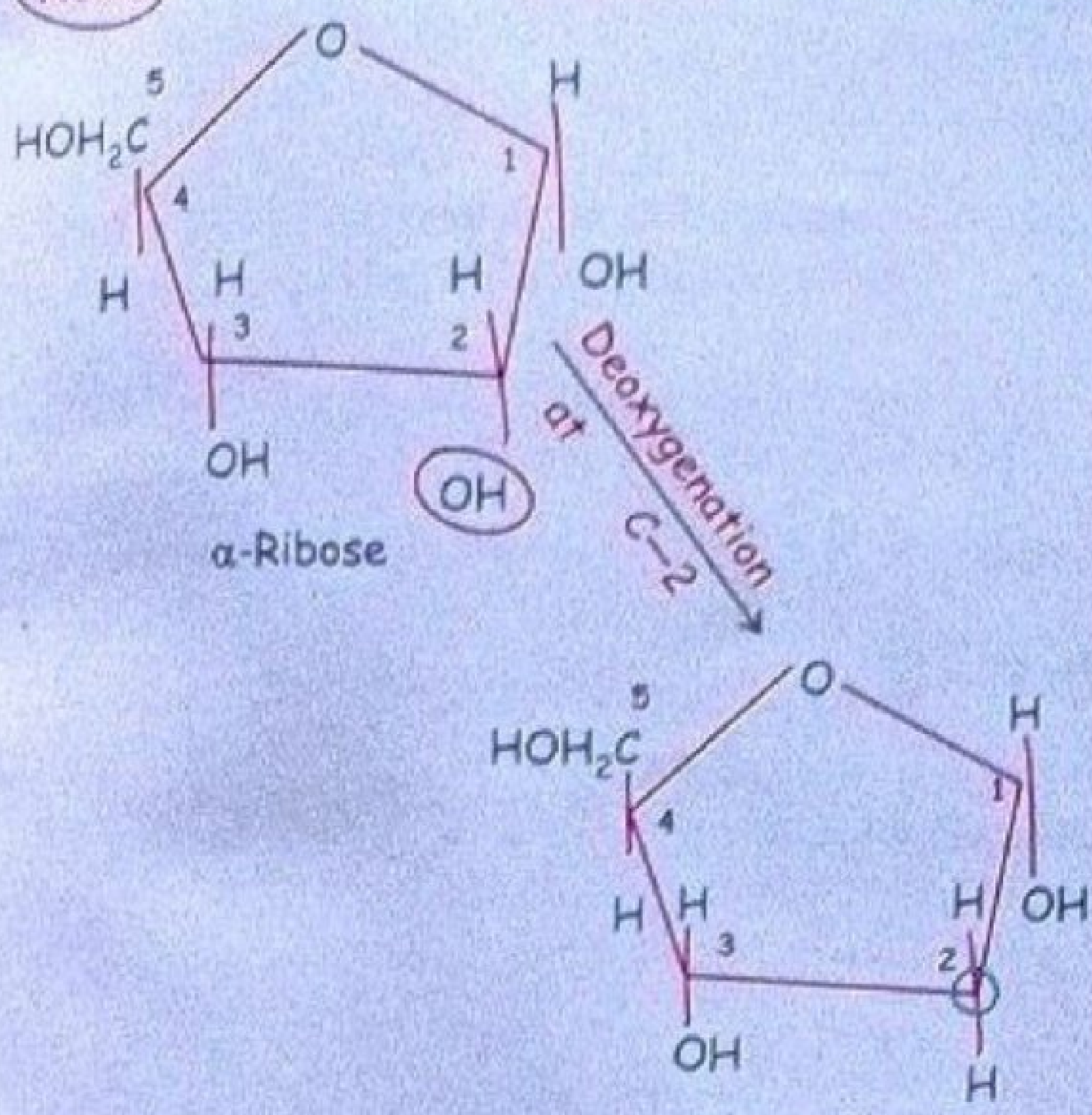


(α-Ribose)
(Ring form of Ribose)

3. DEOXYRIBOSE SUGAR:

- Derived sugar from RIBOSE
- Aldose sugar
- Pentose sugar
- **Found in DNA:** DEOXYRIBONUCLEIC ACID

NOTE In DNA & RNA, β **SUGAR** form exists



α-Ribose

α-deoxyribose

NOTE

'α' & 'β' forms

↓

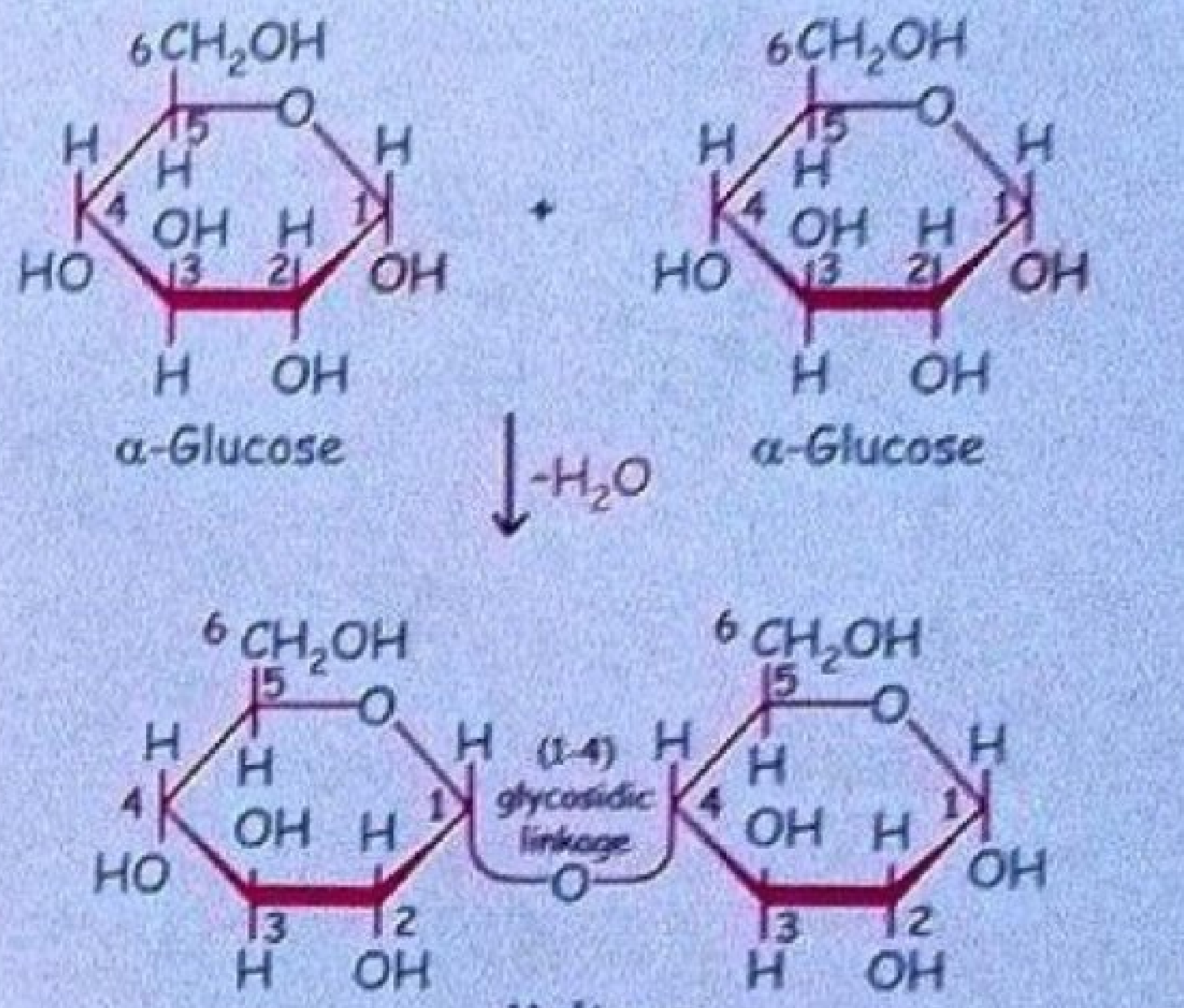
In the RINGS check the functional group carbon: if in the functional carbon: if 'OH' Lower side of ring at that carbon, it is α form & if '—OH' above: β form

OLIGOSACCHARIDES: (2-9 SUGAR COMBINE)

Disaccharides: 2 Sugar combine

Examples of disaccharides
- → Maltose (α Glucose + α Glucose)
- → Lactose (β-Glucose + β Galactose)
- → Sucrose (α-Glucose + β fructose)

Glycosidic linkage: Linkage formed between sugars with a loss of H_2O



Maltose

POLYSACCHARIDES: When more than 10 sugars combine.

Polysaccharides

1. **Homopolysaccharides** (Similar)
   - Similar sugar subunits combine
   - (i) STORAGE HOMOPOLYSACCHARIDE
     - Stored in BULK
     - Chemically & OSMOTICALLY INACTIVE
     - (a) → GLYCOGEN
     - (b) → STARCH
     - (c) → INULIN
   - (ii) STRUCTURAL HOMOPOLYSACCHARIDE
     - (a) → CELLULOSE
     - (b) → CHITIN

2. **Heteropolysaccharides** (Different)
   - Different sugar subunits combine
   - (i) STRUCTURAL HETEROPOLYSACCHARIDE
     - → Hyaluronic acid
     - → Peptidoglycan

HOMOPOLYSACCHARIDES

(1) Storage Homopolysaccharides:

(a) GLYCOGEN:

- Stored food in animals
- Stored in the liver
- Made up of 30000 α -D GLUCOSE
- It is a BRANCHED Structure
  - α (1-4) Linkage → Between C-1 and C-4 in the Straight part between GLUCOSE subunits
  - α (1-6) Linkage → Between C-1 and C-6 at branching point between GLUCOSE subunits

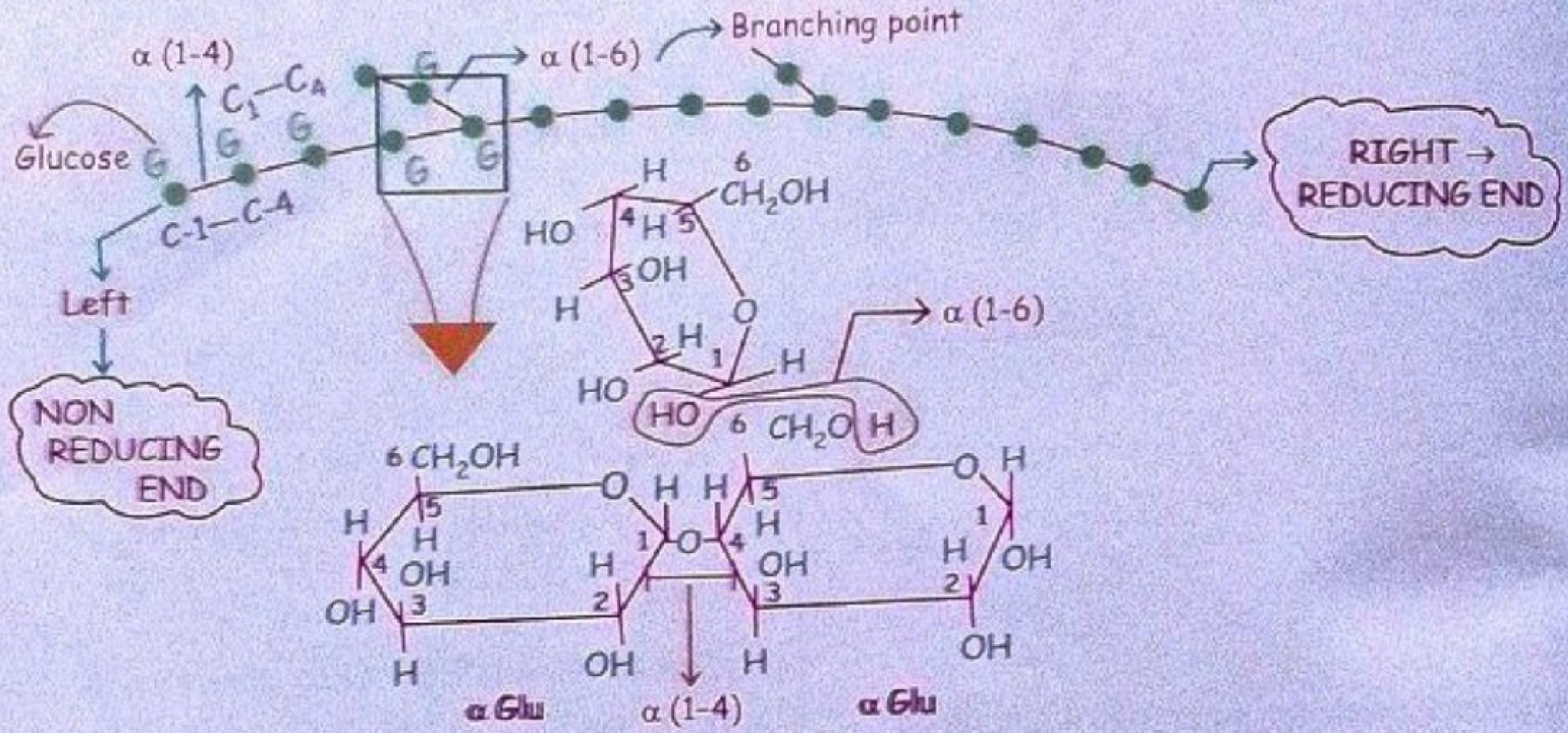


Figure: Glycogen

NOTE

- Right end of glycogen is known as the reducing end whereas the left end is known as Non reducing end.
- Reducing & non reducing sugars explained later

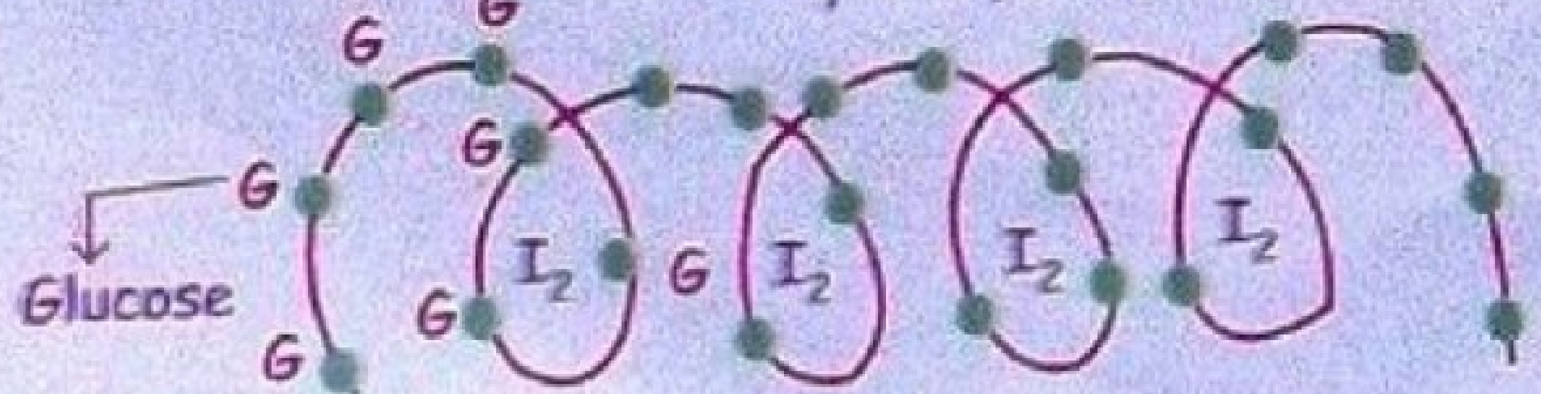
(b) STARCH:

- Storage polysaccharide in plants
- Subunits → α - glucose

Starch exists in 2 forms (अतिरिक्त Gyaan)

Amylose (30%)

Amylopectin (70%)



Helical form

NOTE**

Starch upon Iodine test gives a positive result which is a BLUE BLACK color as the iodine gets trapped in its HELIX

(c) INULIN:

- Storage homopolysaccharide in plants like Dahlia, etc.
- Subunits: β-fructose

(2) Structural Homopolysaccharides

Structural Homopolysaccharide

(i) Cellulose

- Found in the cell wall of plants
- Made up of β-glucose
- * Most abundant ORGANIC SUBSTANCE found on earth
- Paper made from plant pulp and other fiber is cellulosic

(ii) Chitin

- Found in the exoskeleton of Insects
- Made up of 'NAG': N-acetylglucosamine
- * 2nd most abundant ORGANIC SUBSTANCE found on earth

(3) Structural Heteropolysaccharide

Structural Heteropolysaccharide

(i) Hyaluronic acid

- Found in the Matrix of cartilage
- SUBUNITS: NAG + Glucuronic acid

(ii) Peptidoglycan

- Found in the bacterial cell wall
- SUBUNITS: NAG + NAM

N-acetyl muramic

NOTE

Reducing & Non Reducing Sugar:

- Benedict/ Fehling's test is performed to understand which sugars are reducing.
- The ability to reduce $\boxed{Cu^{2+}\text{ ion}}$ in this test by a sugar Makes it a Reducing Sugar
- All monosaccharides, Maltose, lactose, & right end of Glycogen is Reducing
- $\boxed{\text{'SUCROSE' is a Non-Reducing sugar}}$

NOTE

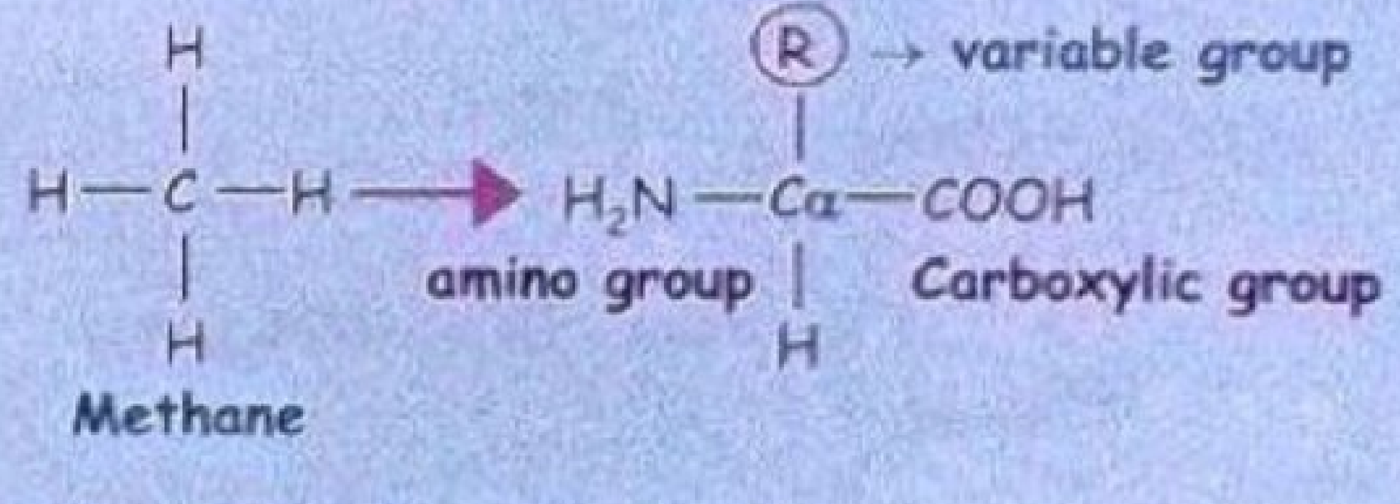
Modified sugars (Glucosamine, N-acetyl galactosamine) which are more complex polysaccharide also exist in nature.

AMINO ACIDS: Building Blocks for protein

acidic group (-COOH)

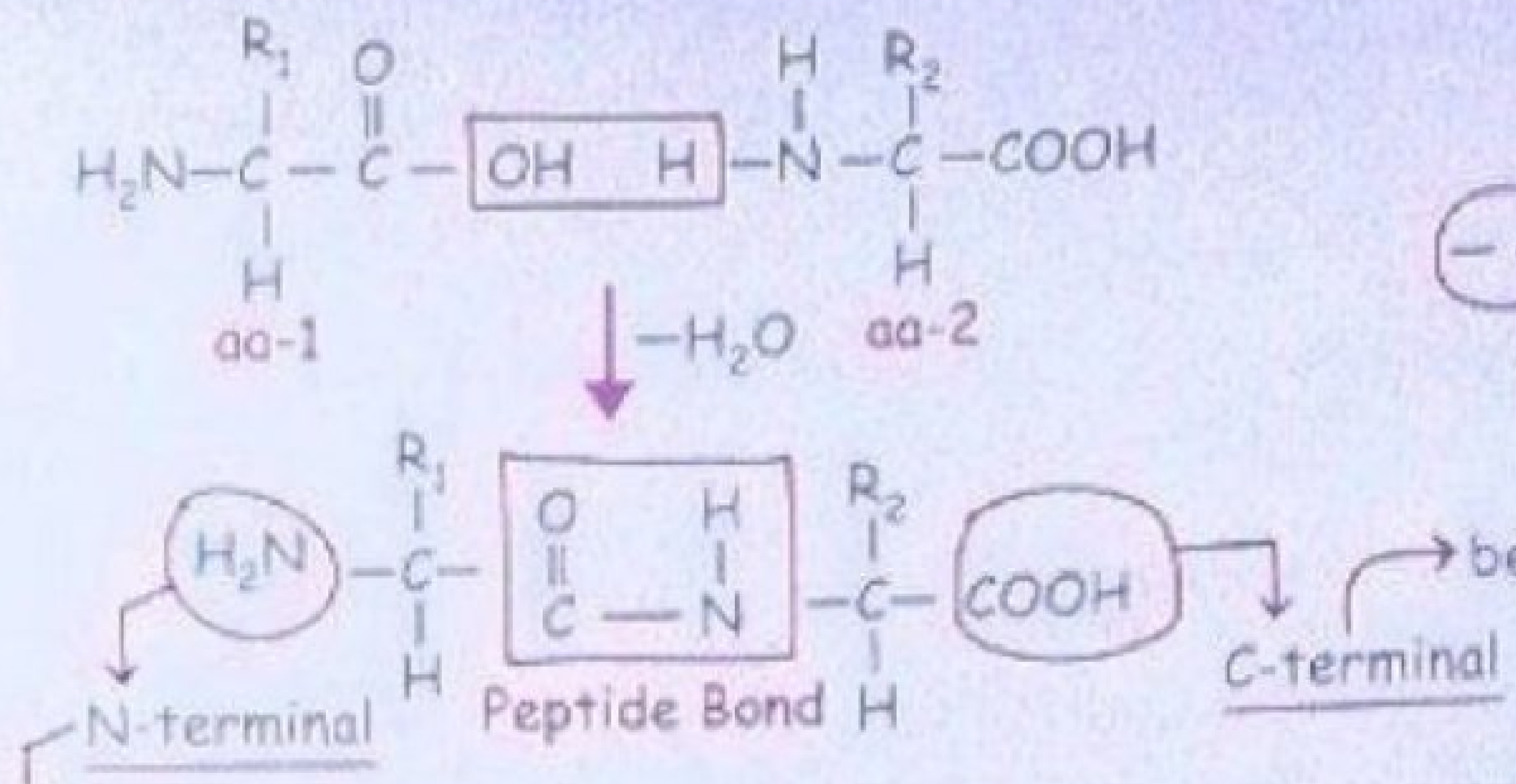
amino group ($-NH_2$)

- Amino acids (aa) are 'SUBSTITUTED METHANE'



- The physical & chemical properties of any 'amino acid' is determined by its, 'NH_2'. 'R' & —'COOH' group
- The 'C' to which $-NH_2$ & $-COOH$ attached is an α-carbon

Peptide Bond Amino acids are linked together by peptide bond by loss of one water molecule.



$-aa-aa-aa-aa-aa-$

because last amino acid will always have free 'COOH'

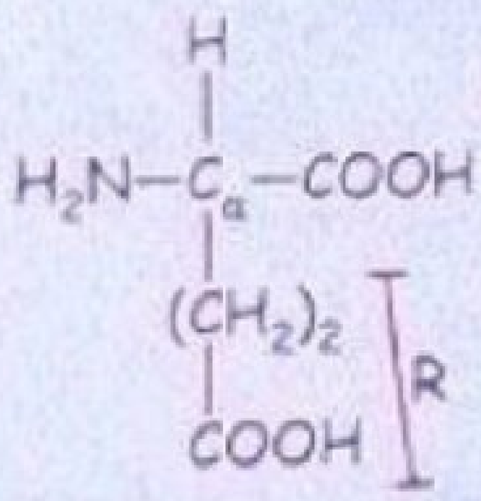
first amino acid always have free NH_2 group

Amino-acids:

- There are approximately 20 amino acids which makes up proteins in human body.

1. **Acidic amino acids:** They have additional —'COOH' in their 'R'

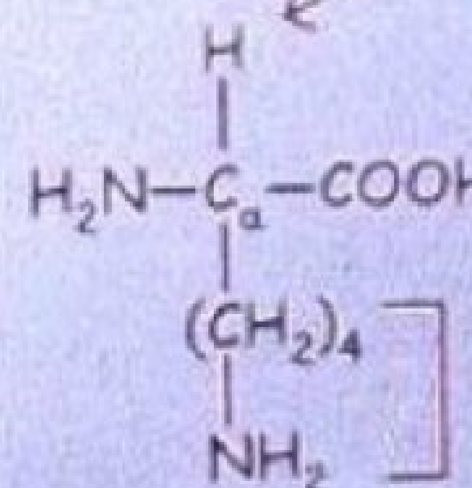
   eg. Aspartic acid, glutamic acid



R: $-(CH_2)_2COOH$

2. **Basic amino acids:** Additional —'NH_2' group in their 'R' group.

   eg. Arginine, lysine, histidine



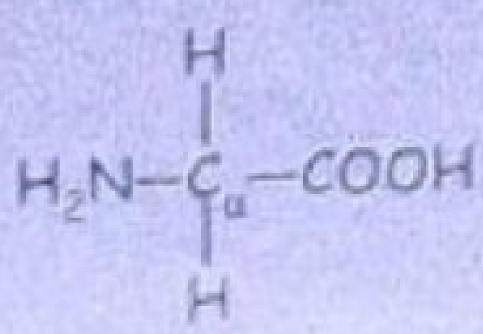
R—group 'R':- $-(CH_2)_4NH_2$

**
3. **Neutral amino acids:** Equal 'NH_2' & '—COOH'

V. Important

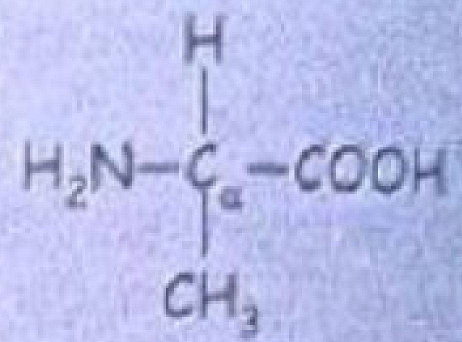
eg: GLYCINE ⟶ *R: 'H'

(Simplest amino acids)



V. Important

ALANINE ⟶ *'R' : 'CH_3'

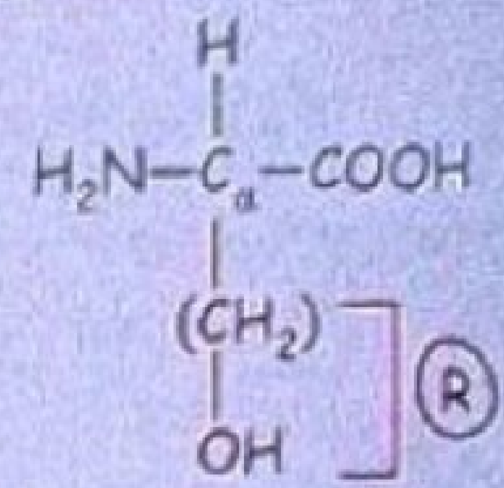


4. **Hydroxyl amino acids:** additional —'OH' in R group

   eg: Serine ⟶ 'R' $(CH_2)-OH$

   Threonine

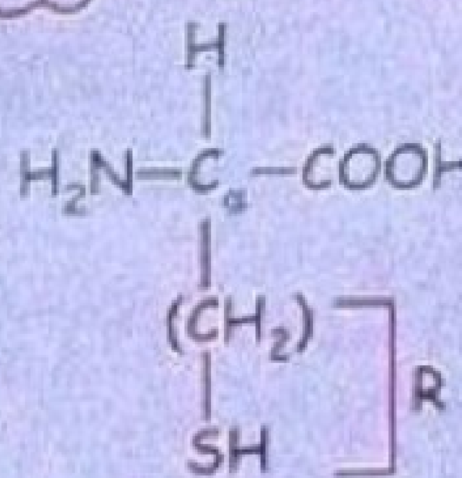
   Serine, ⟶



5. **Sulphur containing:** R : additional 'S' in their group

   eg: Methionine,

   Cysteine ⟶ 'R' $(CH_2)-SH$



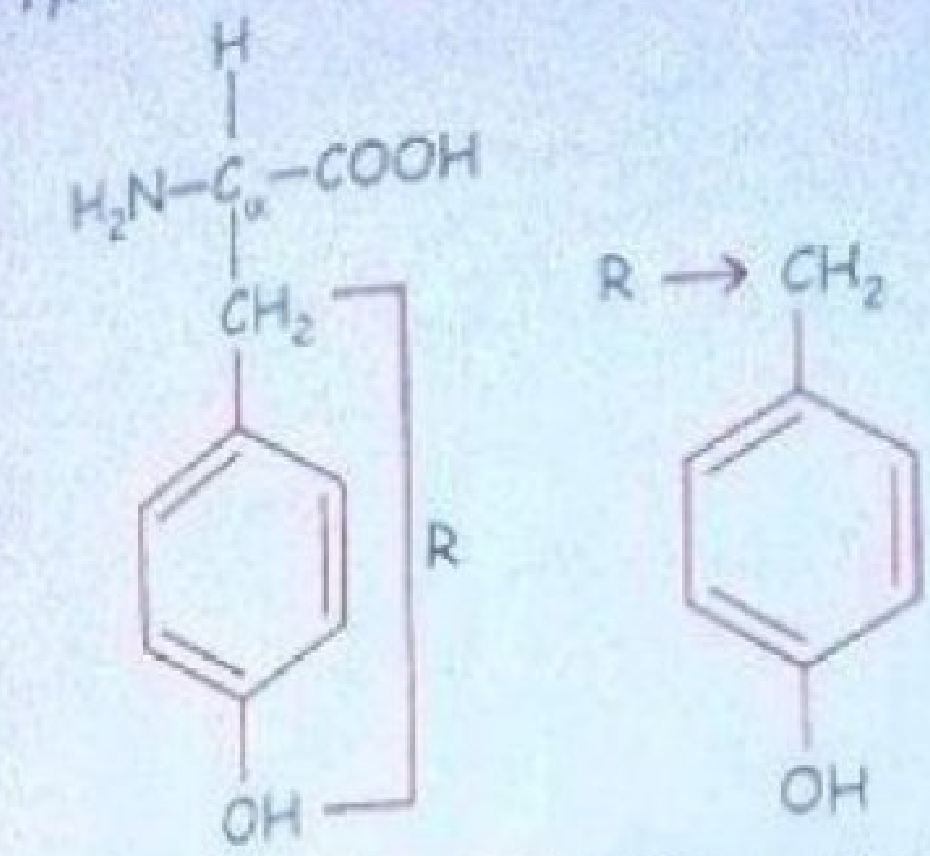
NOTE

Cystine is a DIMER (2) of cysteine

6. **Aromatic amino acids:** Additional 'RINGS' in their 'R' group

   eg: Phenylalanine, Tryptophan, Tyrosine

Tyrosine



<u>Heterocyclic amino acids:</u> Rings with different atoms

eg: Proline, Hydroxyproline

Amino acids	'R'
1. Glutamic acid	$\longrightarrow$ $-(CH_2)_2\,COOH$
2. Lysine	$\longrightarrow$ $-(CH_2)_4\,NH_2$
3. Glycine	$\longrightarrow$ $-H$
4. Alanine	$\longrightarrow$ CH_3
5. Serine	$\longrightarrow$ $-(CH_2)\,OH$
6. Cysteine	$\longrightarrow$ $-(CH_2)\,SH$
7. Tyrosine	$\longrightarrow$ 

AMINO ACIDS

ESSENTIAL

- Amino acids which are not synthesised within body, hence required from outside

eg

- TRYPTOPHAN
- PHENYLALANINE
- METHIONINE
- THREONINE
- LEUCINE
- ISOLEUCINE
- LYSINE
- PROLINE

(अतिरिक्त Gyaan)

SEMI ESSENTIAL

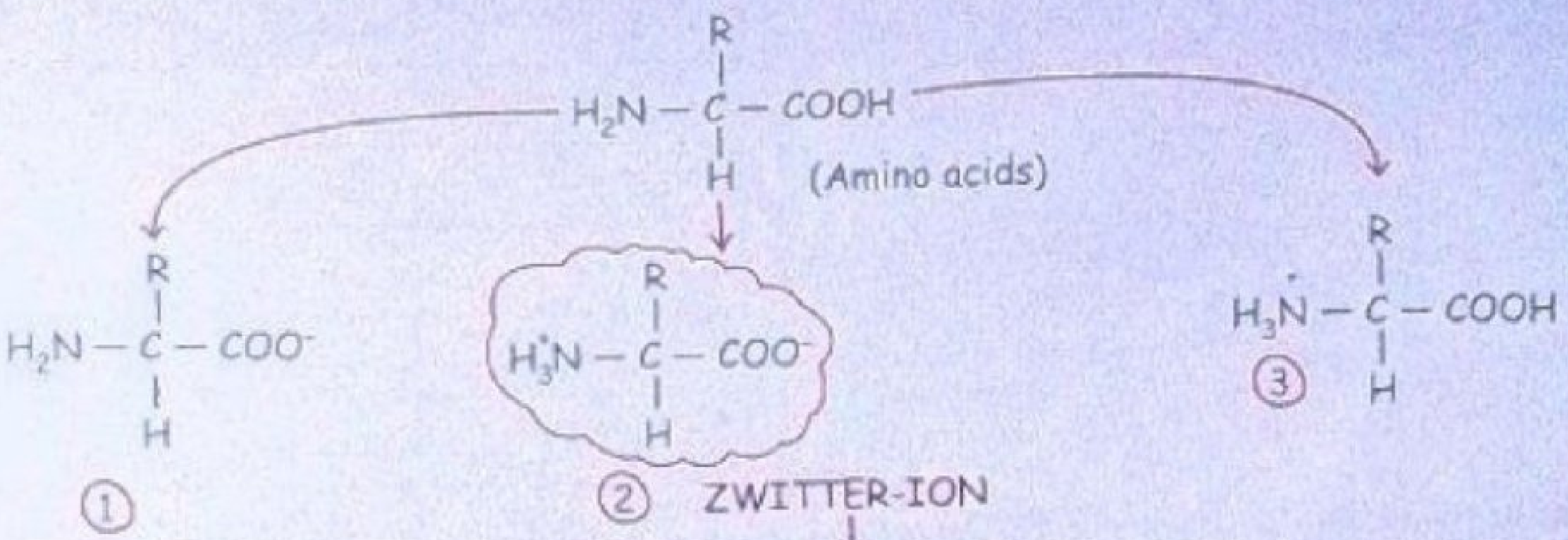
- Slowly synthesised within body

eg Arginine, Histidine

NON ESSENTIAL

- Amino acids which are synthesised within the body hence not required from outside

*ZWITTERION: Amino acids have the tendancy to exist in zwitterionic form due to the ionisable nature of $-NH_2$ & $-COOH$ group in a solution



Here, equal positive & negative charge in possessed

- Different amino acids exist in zwitterionic form at different pH but the pH in which they exist in zwitterion: ISOELECTRIC pH

PROTEINS

- Building block: amino acids

Polypeptide: more than 50 amino acids combine to form Protein/Polypeptide

- Never HOMOPOLYMER, always made up of different amino acids
- *most abundant protein
  - → whole BIOSPHERE → RuBisCO (Ribulose Bisphosphate carboxylase oxygenase)
  - → in ANIMAL world → Collagen

Structure of Proteins

1°/ Primary Structure | 2°/Secondary Structure | 3°/Tertiary Structure | 4°/Quaternary Structure

Fig: Sapoli's hair straight

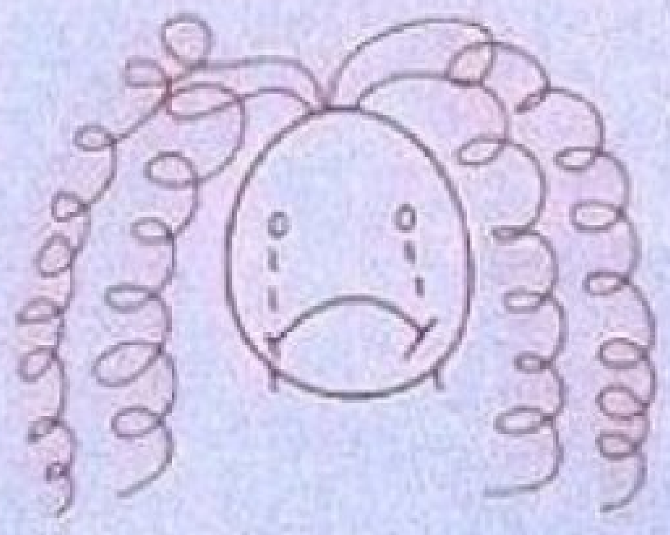
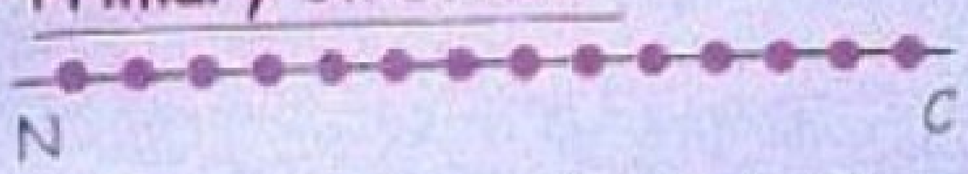


Fig: Sapoli's hair curl

Fig: Sapoli's bun

Fig: Sapoli made multiple buns

1. **Primary structure:**

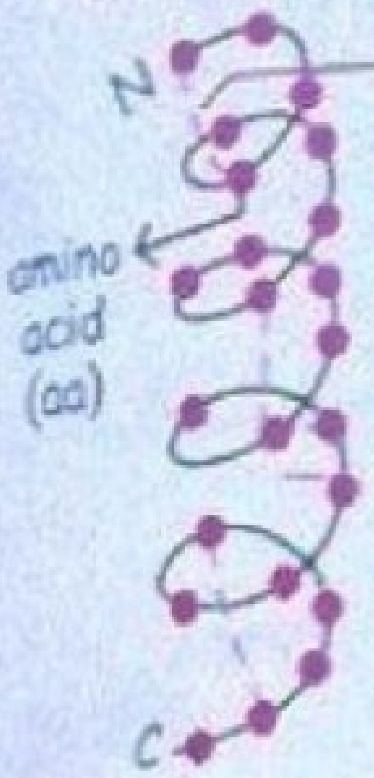


- It represents straight chain of protein
- Only Peptide bond present between amino acids
- It only gives POSITIONAL INFORMATION about amino acids
  eg: Insulin chain

2. Secondary structure:

2°

$\boxed{\alpha \text{ HELIX}}$ eg: 'Keratin' Protein



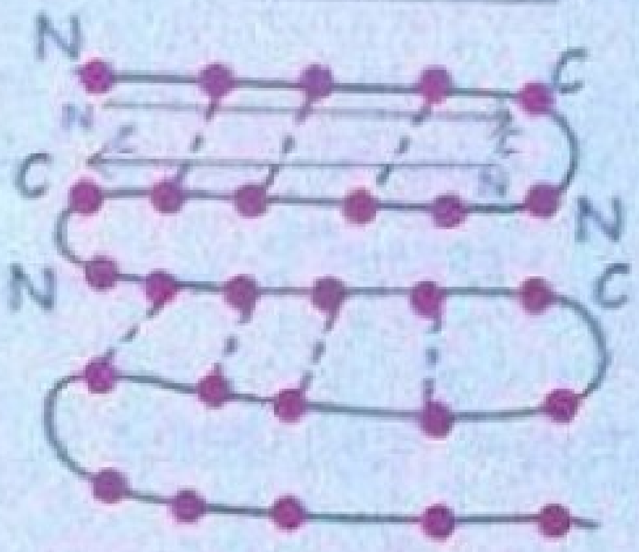
→ Hydrogen Bond between 'aa'

- Right handed helix always

Fig. ● → Represents amino acids

$\boxed{\beta \text{ PLEATED}}$ eg: Fibroin proteins
↳ SILK

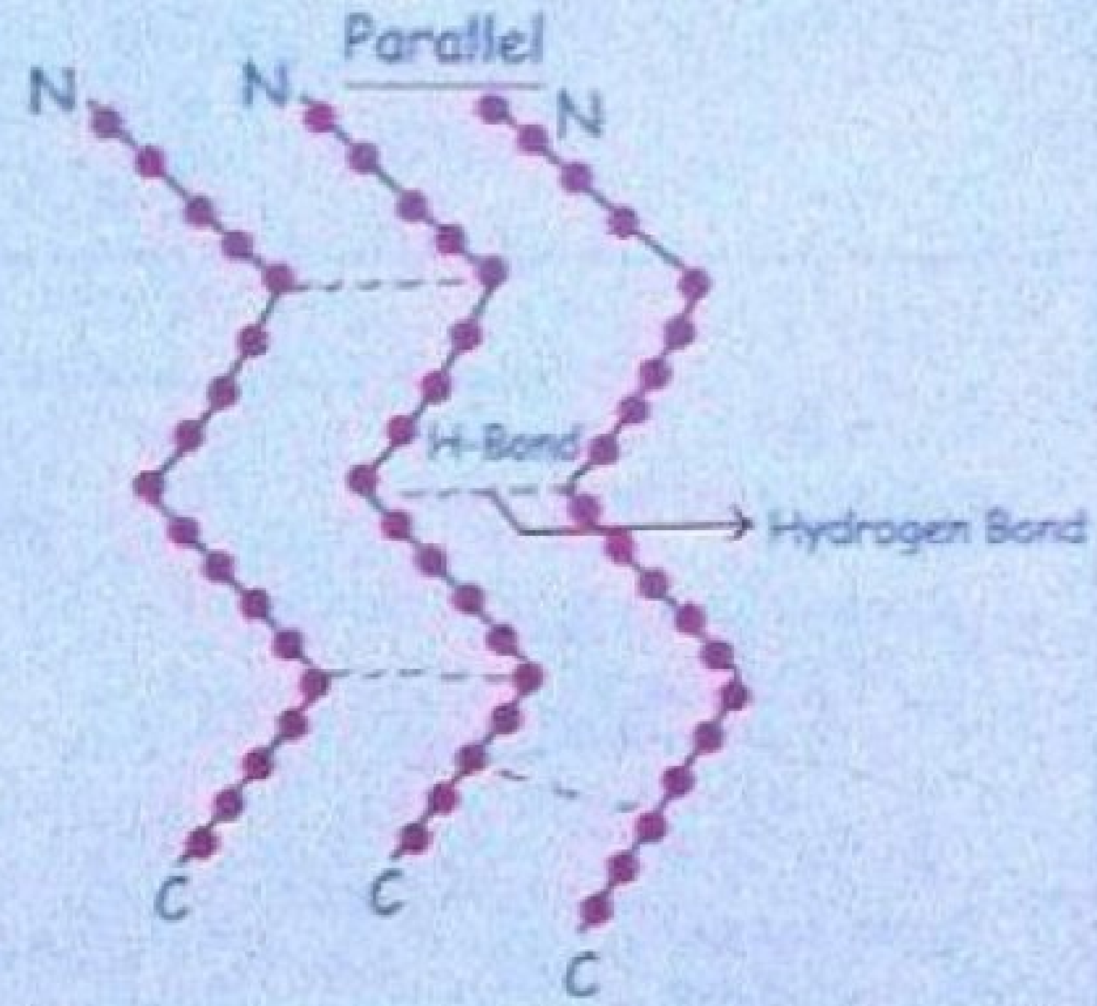
Anti parallel



'Hydrogen Bond'
Single polypeptide folded here

- C-terminal end of one segment is over N-terminal end of another segment

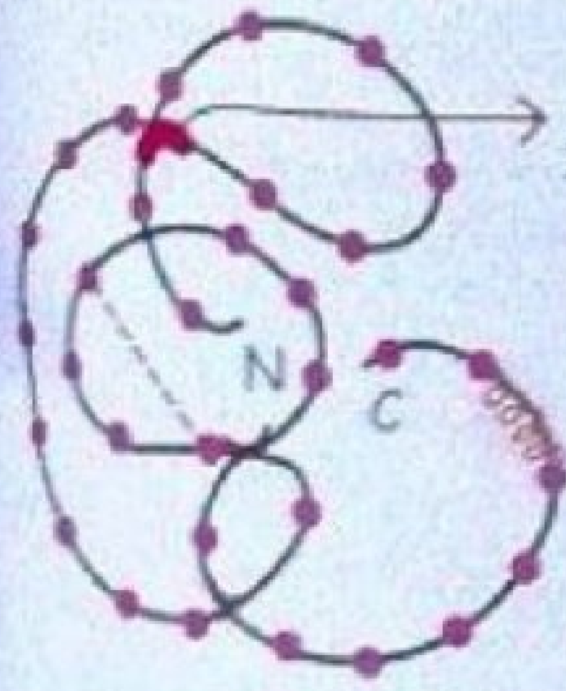
Parallel



- All bonded strands have same N to C direction

3. Tertiary structure:

- 3D Structure of protein
- A polypeptide chain is folded upon just like a hollow woollen ball.
- Mostly proteins are functional in this state.
- When polypeptide is folded cervices/grooves are formed called as ACTIVE SITES responsible for the activity of protein
- eg. Myoglobin (found in muscles)



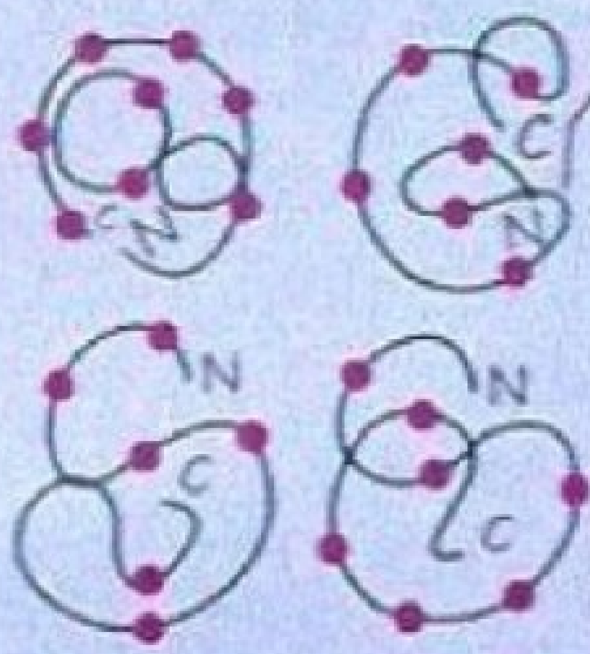
→ ACTIVE SITE

- It is absolutely necessary for many biological activites of proteins

Various interactions between amino acids occurs
→ H-Bond
→ Disulfide (Covalent)
→ Ionic
→ Hydrophobic
→ Van der Waal forces

4. Quaternary structure

- It is the characteristic of more than one polypeptide
- Polypeptides may arrange as linear string of sphere or spheres one upon each other in the form of a cube or plate



Each polypeptide: is known as ONE SUBUNIT

eg: Haemoglobin
- 2 α subunit/ 2 α chain
- 2 β subunit/ 2 β chain

Table: Some proteins and their function

Protein	Functions
Collagen	Intercellular ground substance
Trypsin	Enzyme
Insulin	Hormone
Antibody	Fights infectious agents
Receptor	Sensory reception (smell, taste, hormone, etc.)
GLUT-4 (Glucose Transport)	Enables glucose transport into cells

LIPIDS

- Waxy, greasy, oily substance generally insoluble in water.
- *NEVER POLYMERS
- Lipids are esters of fatty acids (ESTER BOND)

Lipids → Can be Fatty acid; Can be a Glycerol

LIPIDS

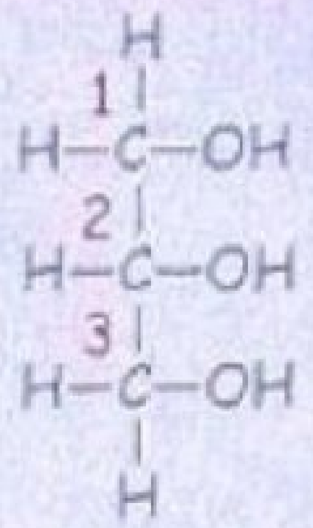
- **SIMPLE LIPIDS**
  - It could simply be a fatty acid & glycerol
  - *True fats/ neutral fats → Component: Fatty acid, Glycerol
  - Waxes
- **CONJUGATED LIPIDS**
  - ↓ Lipid + Non Lipid part
  - ↓ eg: Lecithin
  - ↓ Phospholipid
- **DERIVED LIPIDS**
  - ↓ These do not have a long chain of hydrocarbons instead have fused RINGS
  - eg: Cholesterol

- This flowchart is not in NCERT

1. Simple lipids:

Components: Glycerol + Fatty acid (FA)

GLYCEROL



'Trihydroxypropane'

FATTY ACID

- It is a 'Long chain of hydrocarbon'
- It can be represented as:

R—COOH

R → Maximum 19 Carbon

COOH → Carboxylic group

$CH_3-CH_2-CH_2-CH_2$ ------------ COOH

COOH → Carboxylic group

R → Saturated Fatty acid; Unsaturated Fatty acid

FATTY ACID

Saturated Fatty acid

- Presence of only SINGLE BOND in the 'R' group

eg: *Palmitic acid (16 C)

$CH_3 (CH_2)_{14} COOH$

Stearic acid (18 C)

$CH_3 (CH_2)_{16} COOH$

Arachidic acid (20 C)

$CH_3 (CH_2)_{18} COOH$

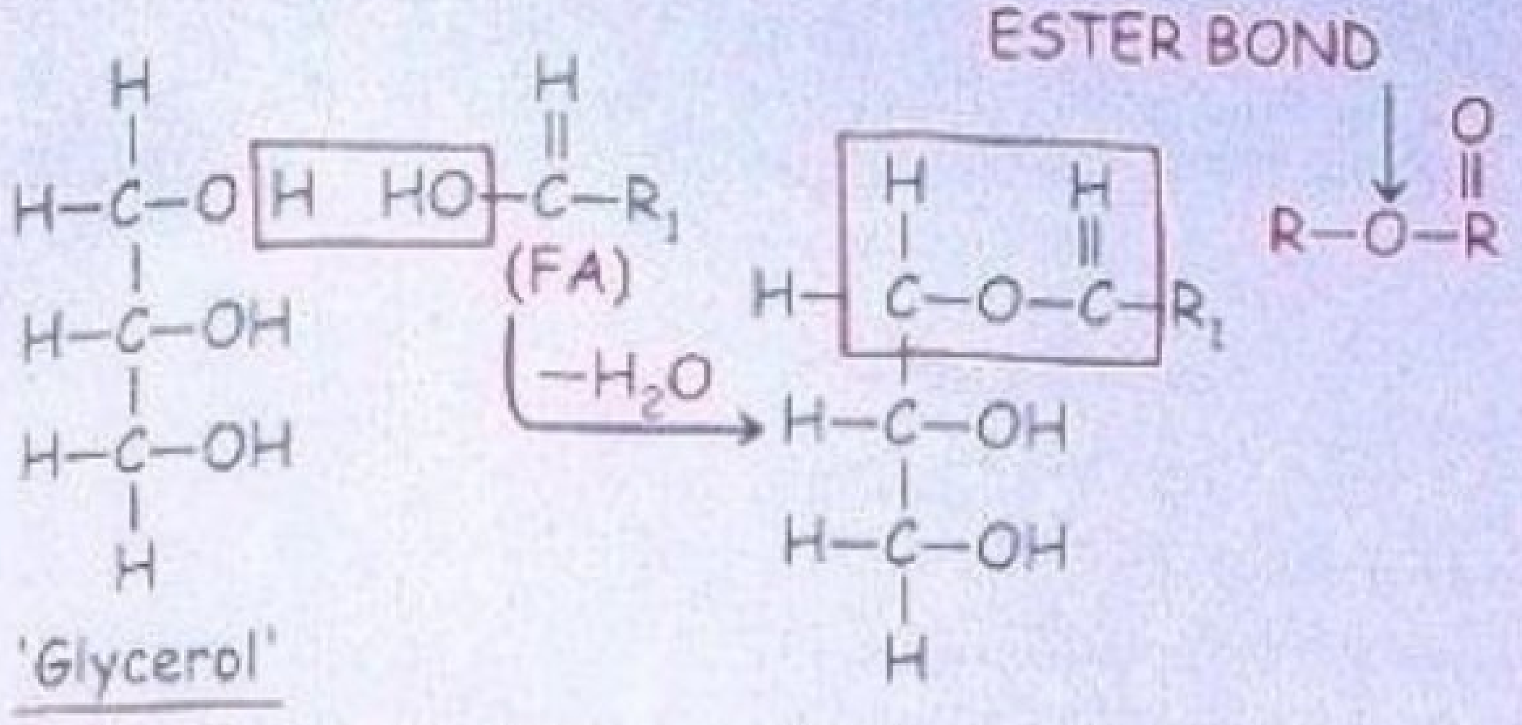
Unsaturated Fatty acid

- DOUBLE BOND present in the 'R' group
  - → Oleic acid (18 C) (1DB)
  - → Linoleic acid (18 C) (2DB)
  - → Linolenic acid (18 C) (3DB)
  - → Arachidonic acid (20 C)

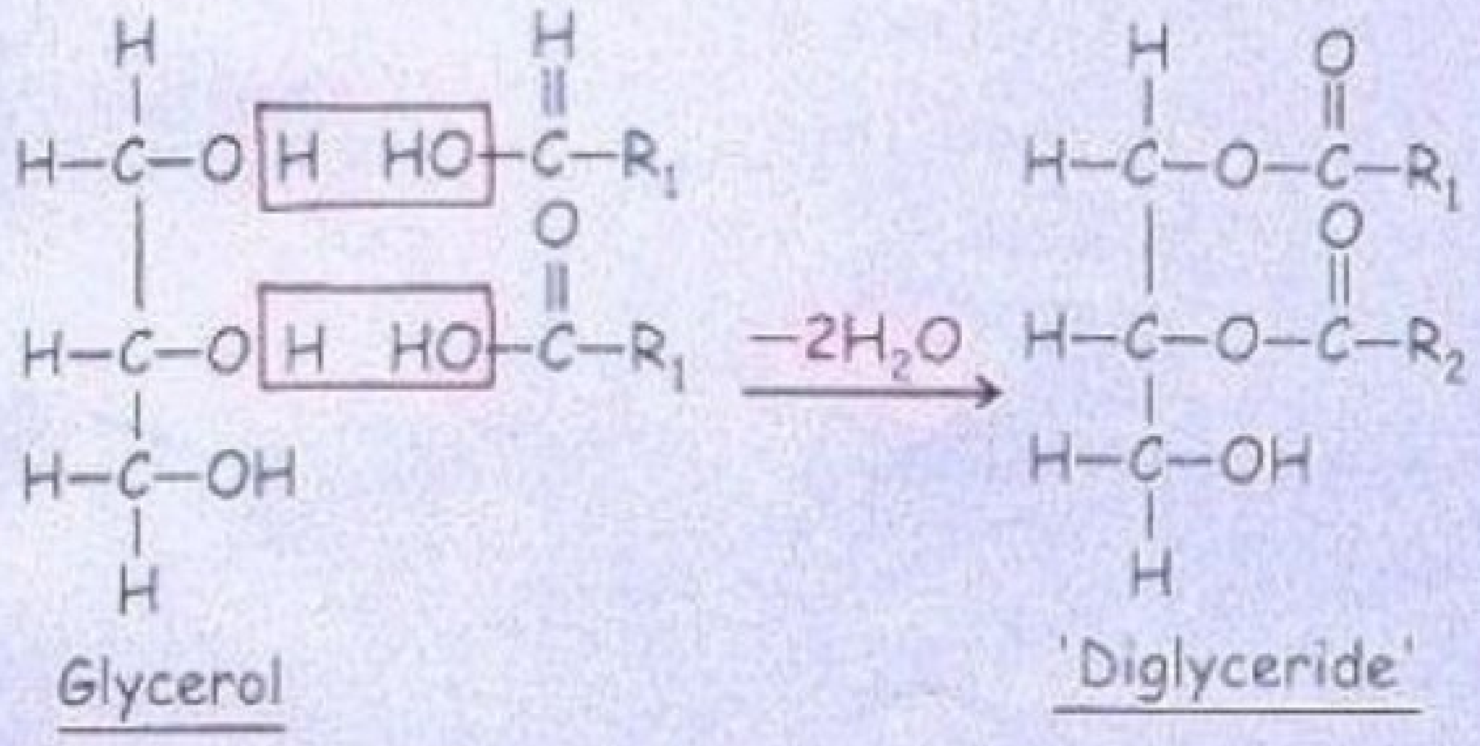
NOTE DB: Double Bond

○ True fats = Glycerol + Fatty Acid

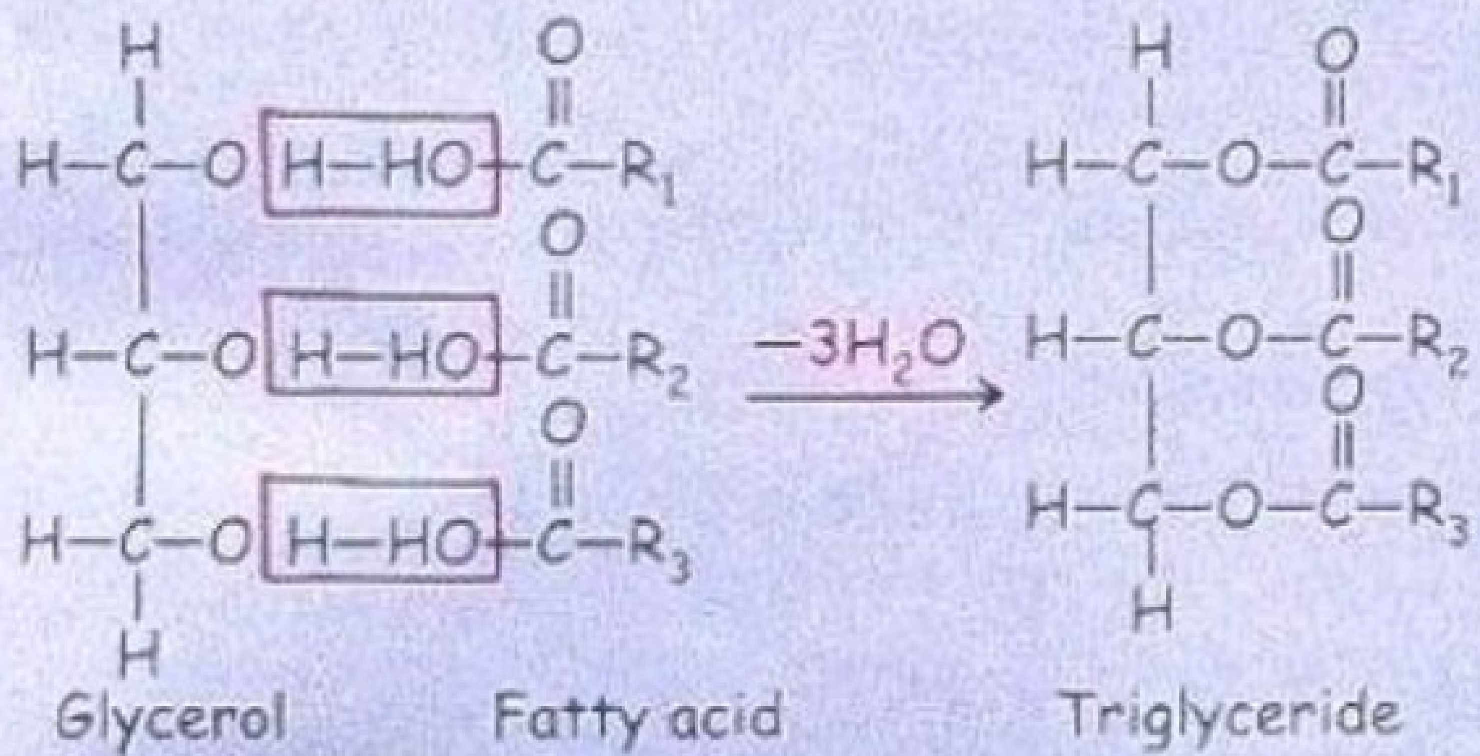
1. **Monoglyceride** (1 Glycerol + 1 Fatty Acid)



2. **Diglyceride** (1 Glycerol + 2 Fatty Acids)



3. **Triglycerides** (1 Glycerol + 3 Fatty Acids)



TRIGLYCERIDE

Fat
- Solid at room temperature
- High Melting point

eg: Butter, Ghee

Oil
- Liquid at room temperature
- Low Melting point

eg: Vegetable oil, gingelly oil

2. **Conjugated Lipid:** Has combination of lipid & non lipid part

eg: ** Lecithin (Phospholipid)

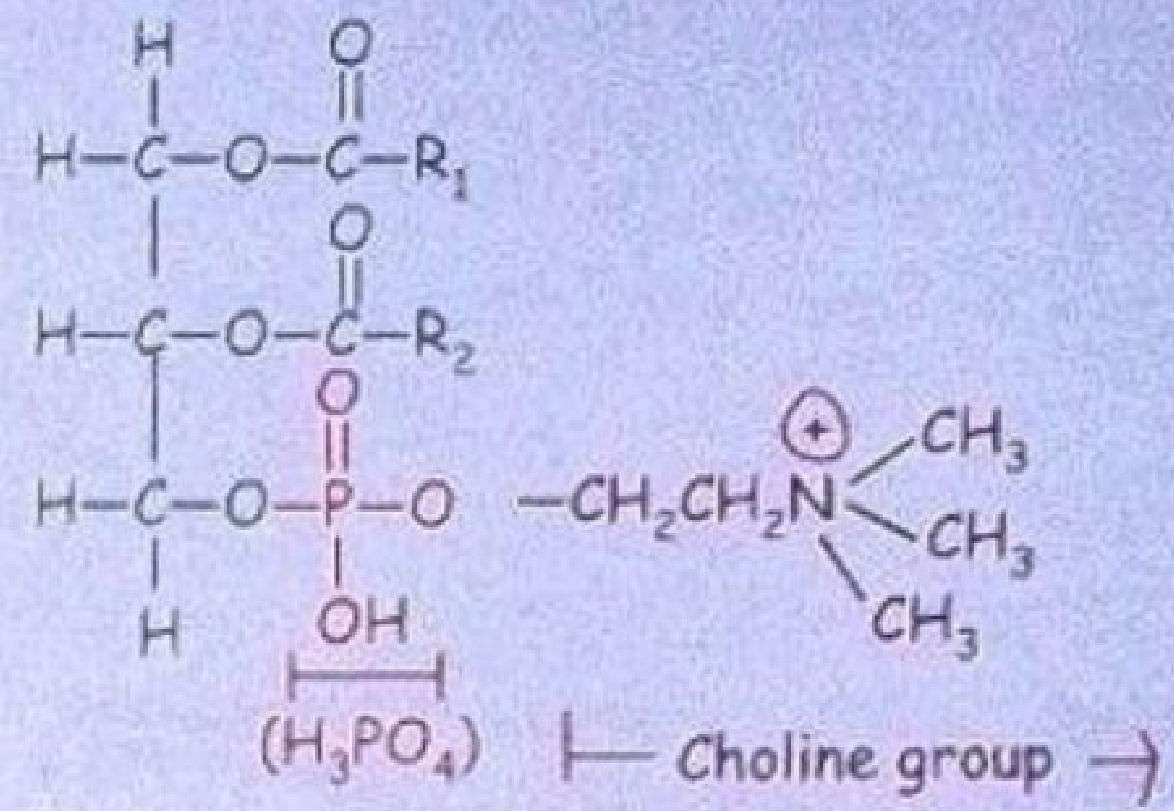


Figure: Lecithin

3. **Derived lipid**

eg: **Cholesterol**
- 27- Carbons
- Fused Rings
- Precursor of Cholesterol is ACETIC ACID
- Synthesised in LIVER

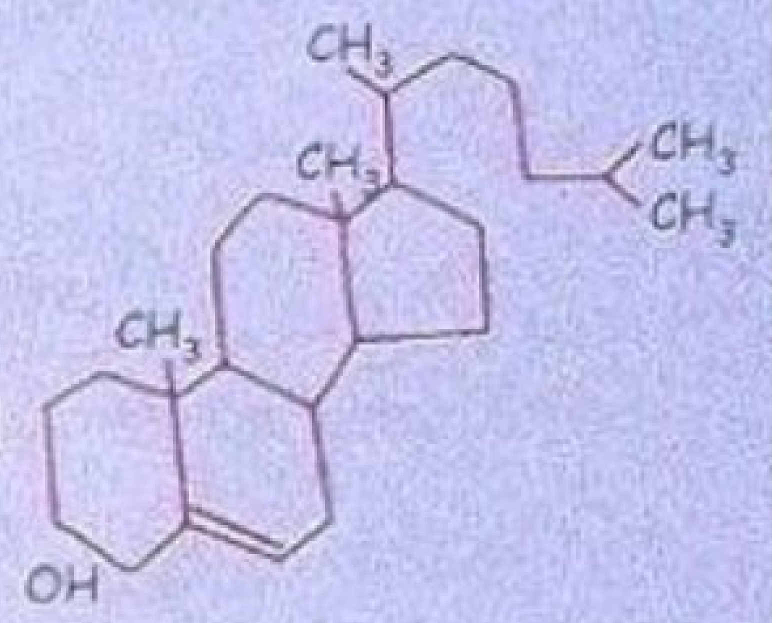


Figure: Structure of Cholesterol

NUCLEIC ACIDS

→ Found for the first time in → Pus cell (dead WBC)

↓

WITHIN NUCLEUS

Nucleic acid

'RNA' Ribonucleic acid

'DNA' Deoxyribonucleic acid

$\boxed{\text{Nucleic acid:}}$ Polymer of $\boxed{\text{'NUCLEOTIDE'}}$

COMPONENTS

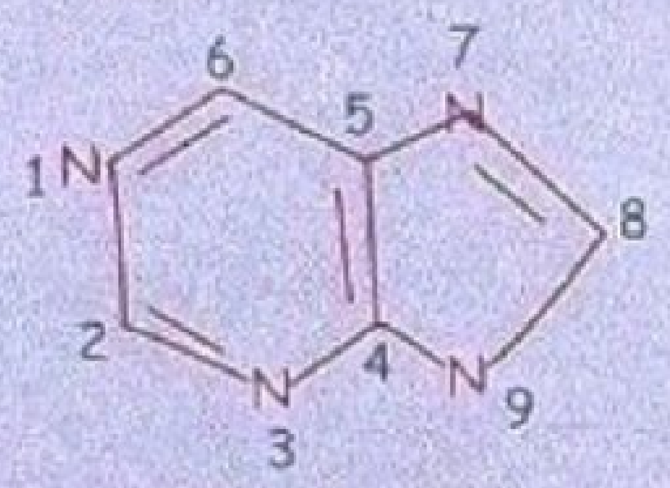
→ (i) β Sugar
- → Ribose sugar – In RNA
- → Deoxyribose sugar – In DNA

→ (ii) Phosphoric acid: H_3PO_4 → HO–P(=O)(–OH)–OH

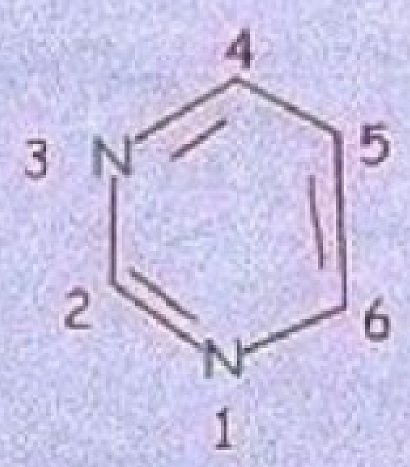
→ (iii) Nitrogenous Base/N_2 Base

- **Purines**
  - Adenine (A)
  - Guanine (G)
  - Both Found in RNA as well as DNA
- **Pyrimidines**
  - Uracil (U) – Found in RNA
  - Cytosine (C) – Both DNA & RNA
  - Thymine (T) – Found in DNA

Purine ⊢ Both Contain Heterocyclic Ring ⊣ Pyrimidine



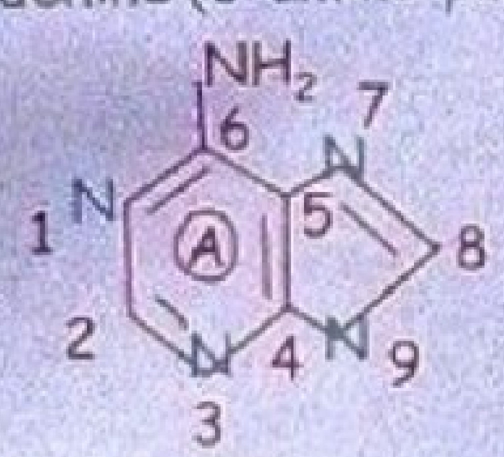
Standard structure of purine



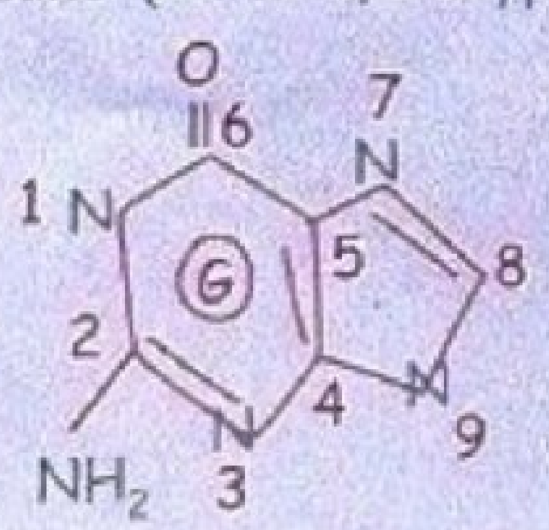
Standard structure of pyrimidine

PURINE

1. Adenine (6-amino-purine)

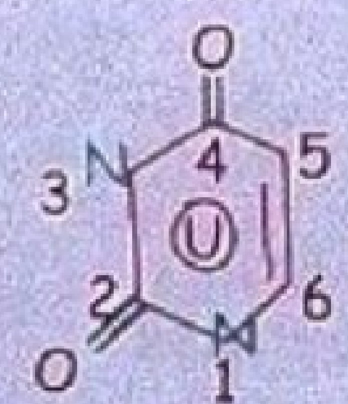


2. Guanine: (2 amino, 6 oxypurine)

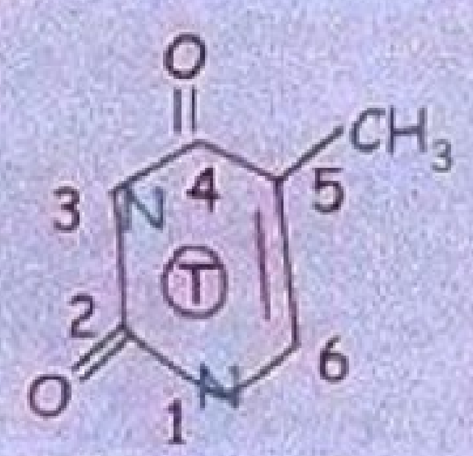


PYRIMIDINE

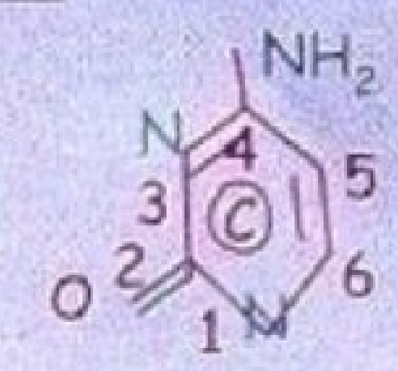
Uracil (2,4 dioxypyrimidine)



Thymine (5 methyl uracil/5 methyl, 2,4 dioxypyrimidine)



Cytosine (4 amino 2oxypyrimidine)



**

Nucleoside = Nitrogenous Base + Sugar
Nucleotide = Nucleoside + Phosphate

NITROGENOUS BASE	NUCLEOSIDE (N_2 Base + Sugar)	NUCLEOTIDE (N_2 Base + Sugar + P)
ADENINE	Adenosine	Adenylic acid
GUANINE	Guanosine	Guanylic acid
CYTOSINE	Cytidine	Cytidylic acid
URACIL	Uridine	Uridylic acid
THYMINE	Thymidine	Thymidylic acid

Nucleotide : N_2 Base + Sugar + Phosphate

Phosphoester bond → formed between sugar and phosphate within one Nucleotide.

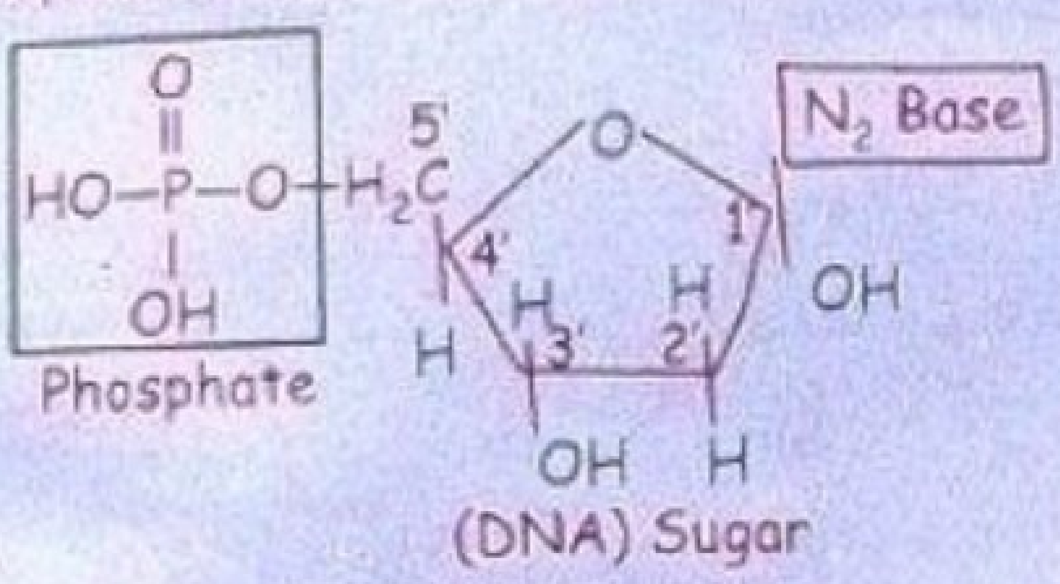


Figure: Nucleotide

Nucleic Acid : Polymer of Nucleotide

- When Nucleotides combines they form **phosphodiester bond** with a loss of water

ENZYMES

- Enzymes are biocatalysts that increases the rate of a chemical reaction within the body

ENZYMES	INORGANIC CARALYST
Found within Body (BIOCATALYST)	Found in laboratory
Organic (proteinaceous)	Inorganic
Thermolabile (High temperature → denature them; Low temperature → make them inactive) (Except Taq polymerase) Thermus aquaticus	Thermostable (work at HIGH temperature)
Highly specific	Less specific
More efficiency	Less efficient

PROPERTIES OF ENZYME

- Enzymes are proteinaceous except RIBONUCLEASE P & RIBOZYME (RNA containing)
- Enzymes has 1°/2°/3° structures but when you look at 3° structure, you will notice active sites formed due to chain criss-cross
- The ACTIVE SITE is the one to which the SUBSTRATE Binds
- They **speed up** the reactions without being utilised

eg: CA (Carbonic Anhydrase: fastest enzyme)

① $CO_2 + H_2O \xrightleftharpoons{\text{Without Enzyme}} H_2CO_3$ (only 200 H_2CO_3 formed in an Hour)

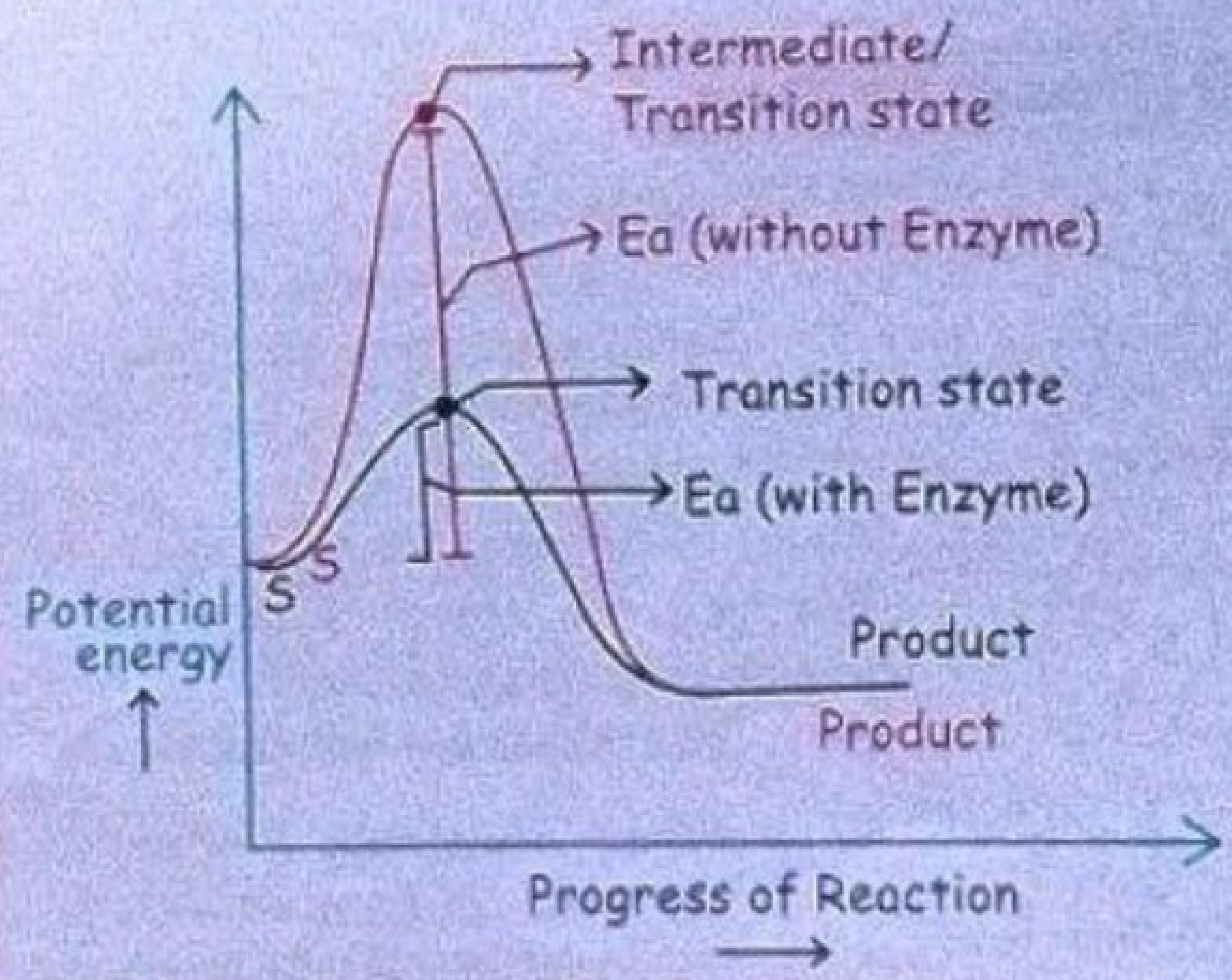
② $CO_2 + H_2O \xrightleftharpoons{CA} H_2CO_3$ (6 Lakh H_2CO_3 formed/Sec)

Working of Enzymes, Activation Energy

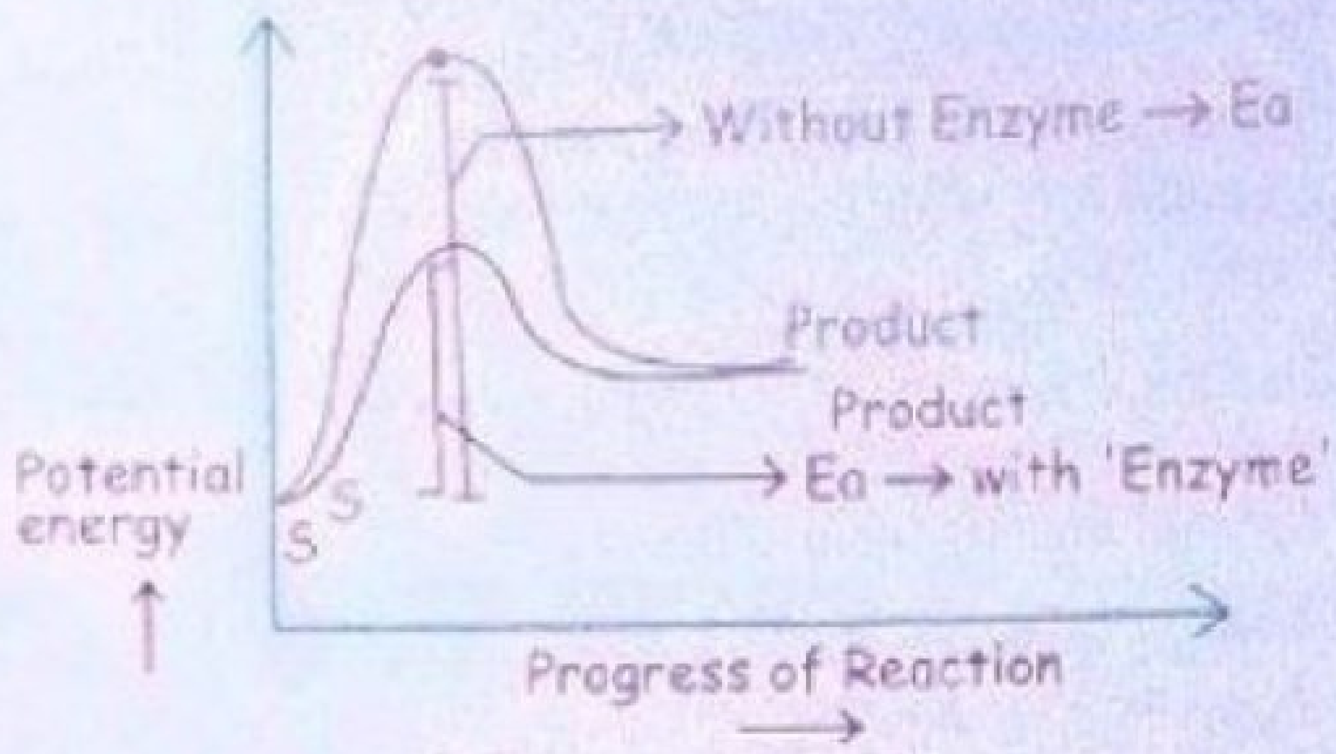
Activation energy (Ea): The energy needed by a Substrate to convert into the product

- Enzymes functions by $\boxed{\text{Lowering down}}$ this Ea

Transition state: Compulsory (1 or more than 1) unstable stage, formed in between before the substrate converts into product finally



This graph represents EXOTHERMIC reaction

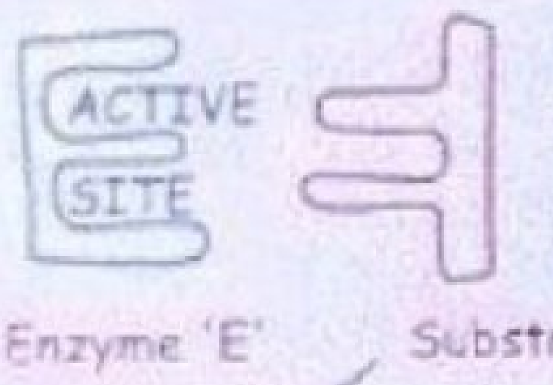


ENDOTHERMIC REACTION

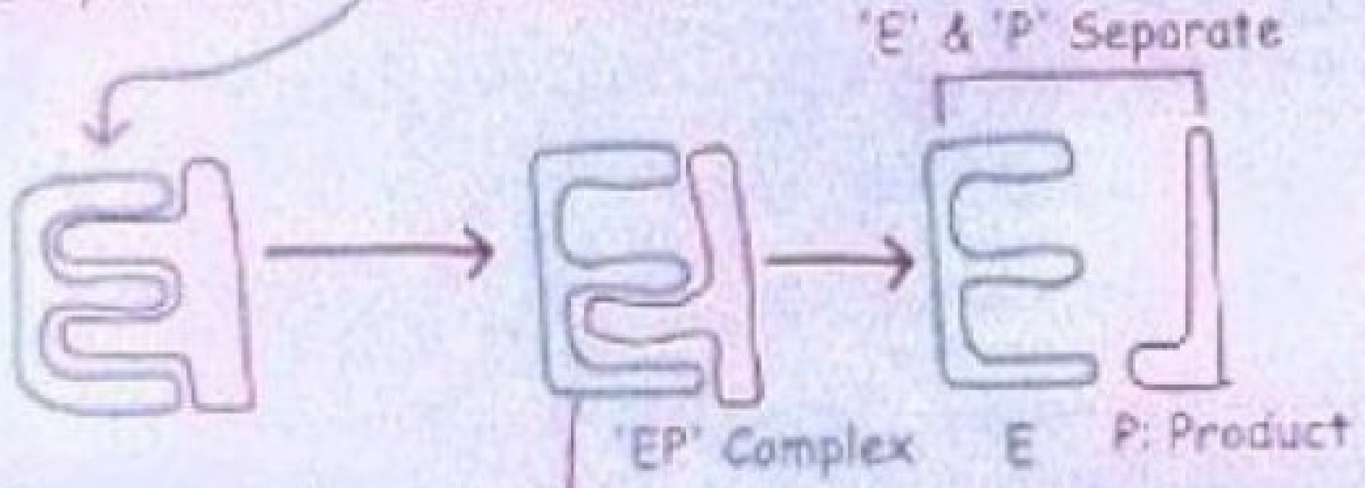
NATURE OF ENZYME ACTION

- 2 Theories explain the nature of enzyme action

① Lock & key Theory



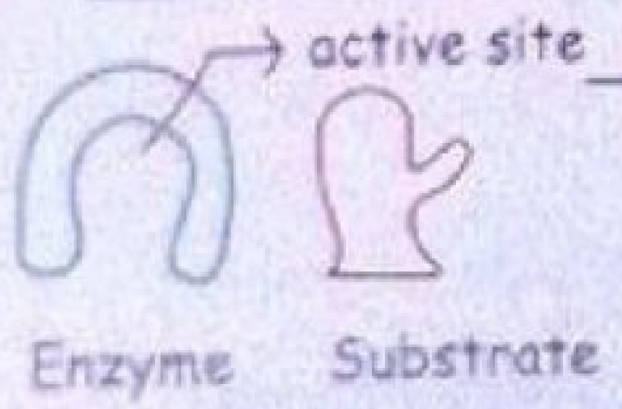
'Enzyme' & 'Substrate' are complementary to each other since the beginning just like lock & key



Enzyme-Substrate complex 'ES' complex

Slowly 'Enzyme' converts substrate into product

② Induced Fit Theory



'Enzyme' & 'Substrate' are not complementary to each other since the Beginning

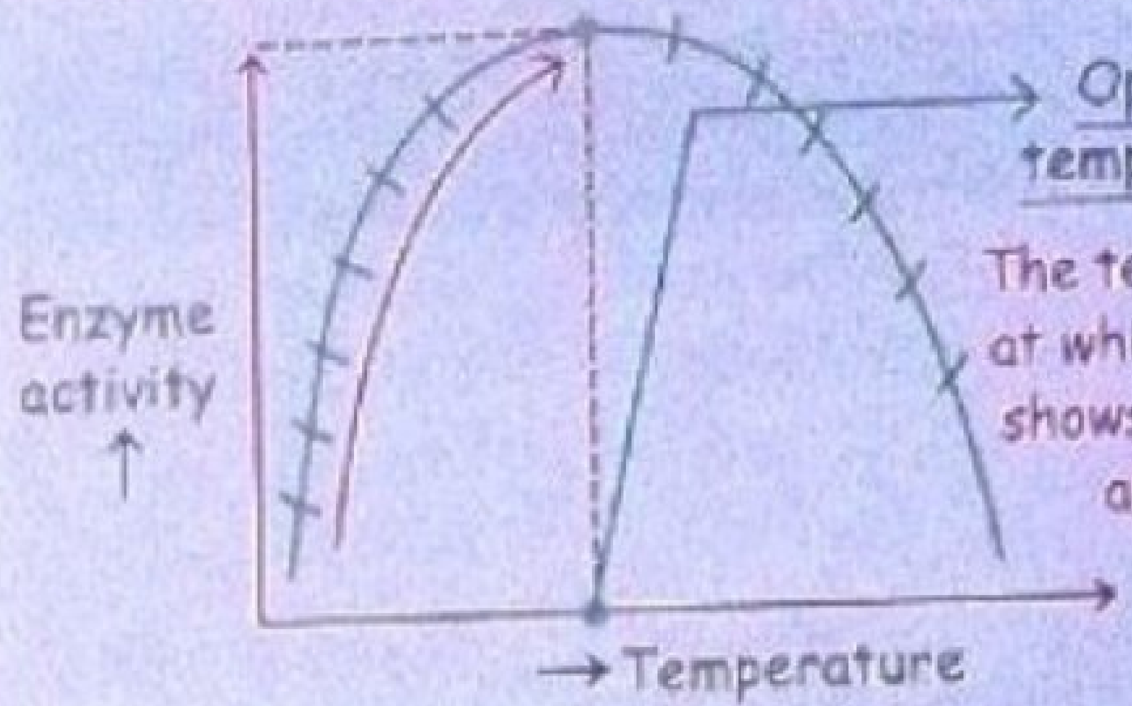
When 'Substrate' comes closer to 'Enzyme', the enzyme's active site gets altered (induced change) so that now it can complement the 'Substrate'

'ES' Complex
↓
EP Complex
↓
Enzyme + Product

When 'Substrate' Bind to 'Enzyme': Enzyme active site catalyses (makes & Break) some bond of Substrate & convert it into Product

FACTORS AFFECTING ENZYME ACTIVITY:

① Temperature:

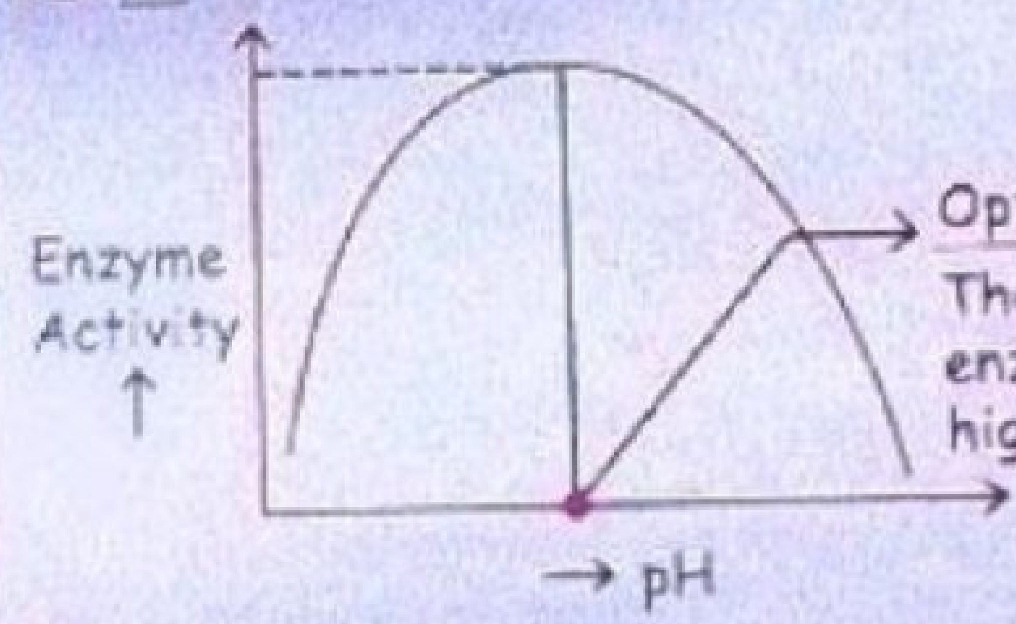


Optimum temperature: The temperature at which enzyme shows maximum activity

- *With every 10°C rise in temperature, enzyme activity either doubles or becomes half

Towards Optimum temperature | After Optimum temperature

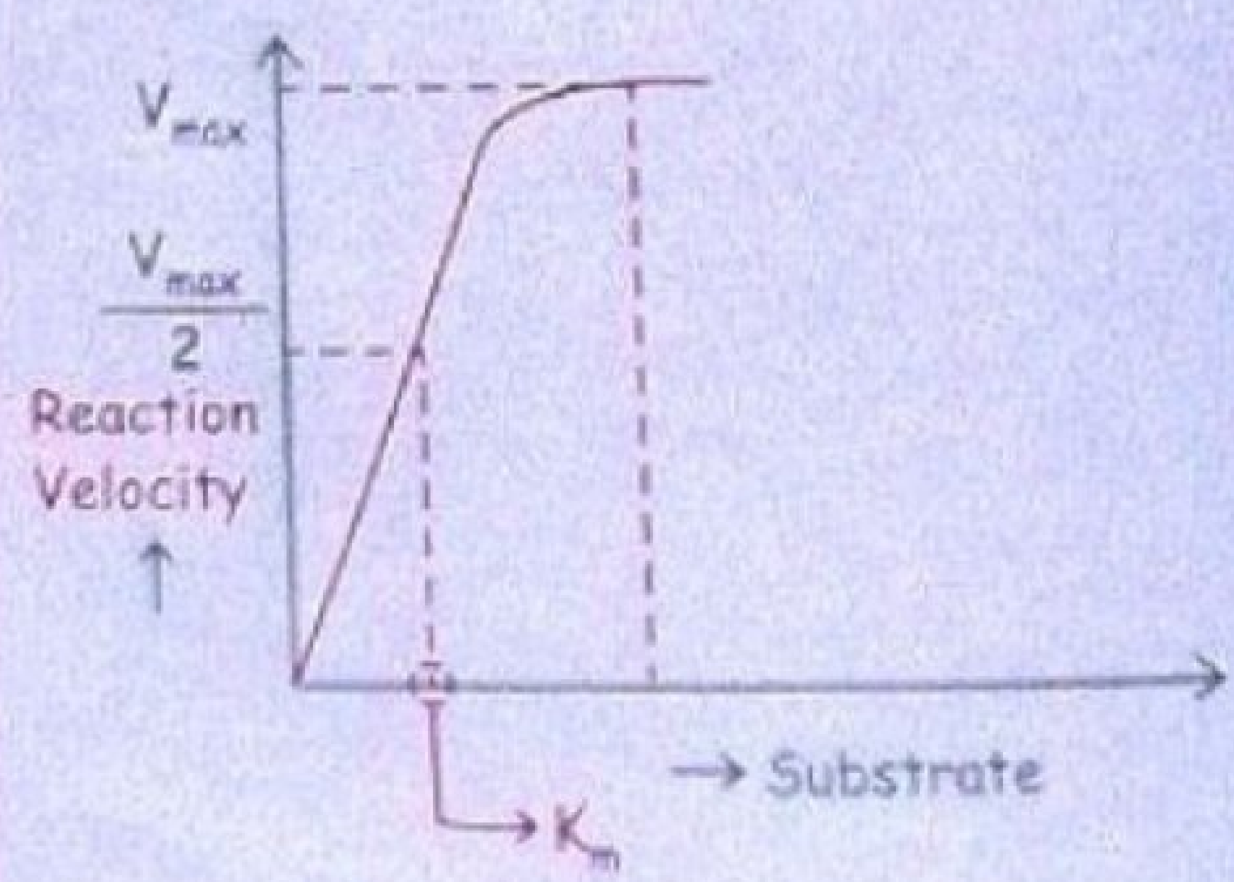
② pH



Optimum pH: The pH at which enzyme shows its highest activity

③ Substrate:

- With increase in the substrate concentration, reaction velocity increases till it reaches V_{max}: Reaction's maximum velocity
- Further increase in substrate concentration can't increases reaction velocity as all active sites of enzyme are occupied



- V_{max}: Max Velocity
- K_m: The substrate concentration at which half of the V_{max} is achieved

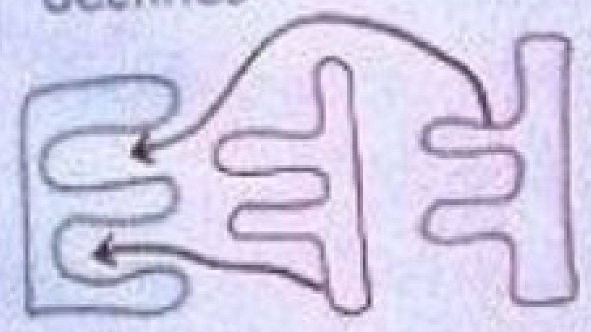
Michaelis Menten constant

- $K_m = [S]$, at which $V = \frac{V_{max}}{2}$
- $K_m \propto \frac{1}{\text{Efficiency enzyme}}$

(4) Inhibitors : Are the substances whose presence is responsible for decline in the reaction velocity

(i) COMPETITIVE INHIBITION

- When inhibitor closely resembles the substrate in its molecular structure and inhibits the activity of enzyme
- Consequently, both fights to bind to Active site
- Hence substrate unable to bind, enzyme action declines



Inhibitor (I) → look exactly the Substrate

'Enzyme' (E) 'Substrate' (S)

- 'S' & 'I' competes with each other to bind to the active site

(1) eg: **Malonate is a competitive inhibitor of Succinate for Enzyme Succinate dehydrogenase

(2) Often such competitive inhibitor used in control of bacterial pathogen

CLASSIFICATION OF ENZYMES

Enzymes are given: "EC" number : 4 digit Code:
→ Enzyme Classification

for eg:

(5) (4) (3) (1)

(5) → Class

(4) → Sub Class (4-13)
↑ Each Class further divided into

(3) → Sub Subclass

(1) → Enzyme reaction Catalyzed

CLASS of ENZYME (6)

Oxidoreductases → (I)
Transferase → (II)
Hydrolase → (III)
Lyase → (IV)
Isomerase → (V)
Ligase → (VI)

Oxidoreductase: Enzymes which catalyses oxidation as well as Reduction in a chemical reaction
→ Also known as 'DEHYDROGENASE'

S (oxidised) + S' (reduced) → S (reduced) + S' (oxidised)

Transferase: Enzymes Catalysing transfer of groups other than Hydrogen

$S-G + S' \longrightarrow S + S'-G$

NOTE

Transfer of 'H' is not transferase

Hydrolase: Enzymes catalysing hydrolysis of ester, ether, peptide, glycosidic, C-C, C-halide or P-N bonds.

eg *All DIGESTIVE ENZYMES Lipase, Protease, Sucrase

Lyase: Enzymes that catalyse removal of groups from substrates by mechanisms other than hydrolysis leaving double bonds

$$\underset{|}{\overset{X}{C}}-\underset{|}{\overset{Y}{C}} \xrightarrow{\text{Lyase}} C=C + X-Y$$

Isomerase: Includes all enzymes catalysing inter-conversion of optical, geometric or positional isomers.

Ligase: Enzyme which catalyses formation of bonds between compounds

C–S, C–O, C–N, etc.

Cofactors

Enzymes are composed of one or several polypeptide chains. However, there are a number of cases in which non-protein constituents called cofactors are bound to the the enzyme to make the enzyme catalytically active

Holoenzyme → It is a Complete Enzyme which consist of

- * Apoenzyme (Protein part)
  ↓
  requires the COFACTOR for its ACTIVITY
- * Cofactor (Nonprotein part)
  1. → COENZYME
  2. → PROSTHETIC group
  3. → METAL ION

COENZYME

- Organic part
- Coenzymes are the cofactors that are Loosely attached to the apoenzyme (Temporary)
- Vitamins are essential component of Coenzyme

eg NAD & NADP

NAD	NADP
Nicotinamide	Nicotinamide
Adenine	Adenine
Dinucleotide	Dinucleotide
	Phosphate

'Niacin' vitamin is the component

PROSTHETIC GROUP

- Prosthetic groups are the Cofactors that are tightly bound to apoenzyme
- 'Haem' is a prosthetic group of enzyme peroxidase and catalase

$$2H_2O_2 \xrightarrow{\text{peroxidase/catalase}} 2H_2O + O_2$$

METAL ION

- These are the Inorganic part which is not only attached to the apoenzyme but also to the side chain of 'Substrate'

eg: Zn^{+2} → Carboxypetidase, carbonic anhydrase

Cl^- : → Salivary amylase

NOTE

Catalytic activity is lost when the co-factor is removed from the enzyme which testifies that they play a crucial role in the catalytic activity of the enzyme.

4 Breathing and Exchange of Gases

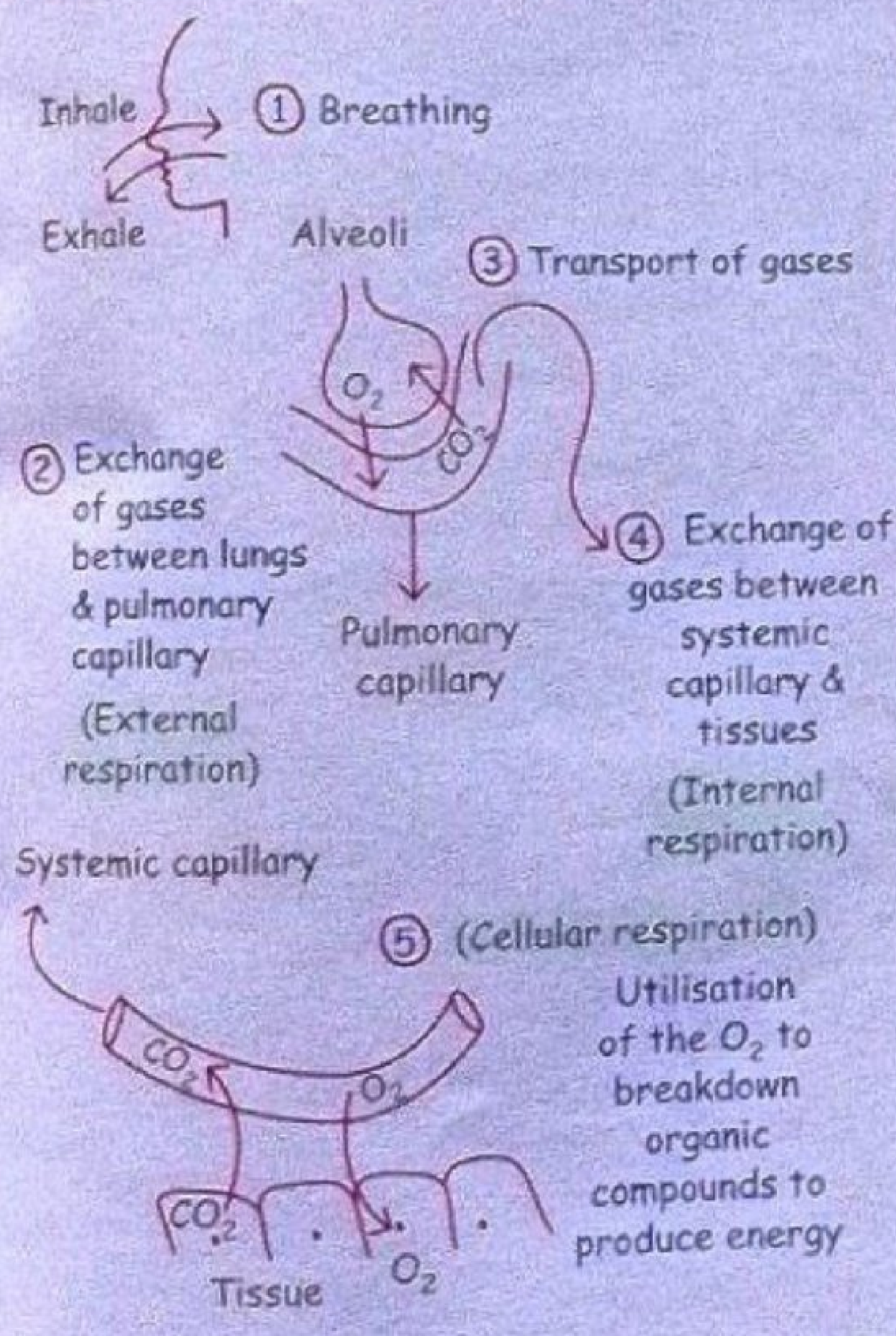
INTRODUCTION

Breathing
- → Inhalation/Inspiration: Intake of air
- → Exhalation/Expiration: Exhaling of air

Respiration: Breakdown of compounds like GLUCOSE, amino acid, etc. to produce energy.

Breathing is commonly known as respiration.

Steps Involved in Respiration



RESPIRATORY STRUCTURES

On the Basis of
- (I) Habitat
  - ① Aquatic
    - Uses gills for respiration
    - ↓ Known as **Branchial respiration**
  - ② Terrestrial
    - Uses lungs for respiration
    - ↓ Known as **Pulmonary respiration**
- (II) Level of Organisation

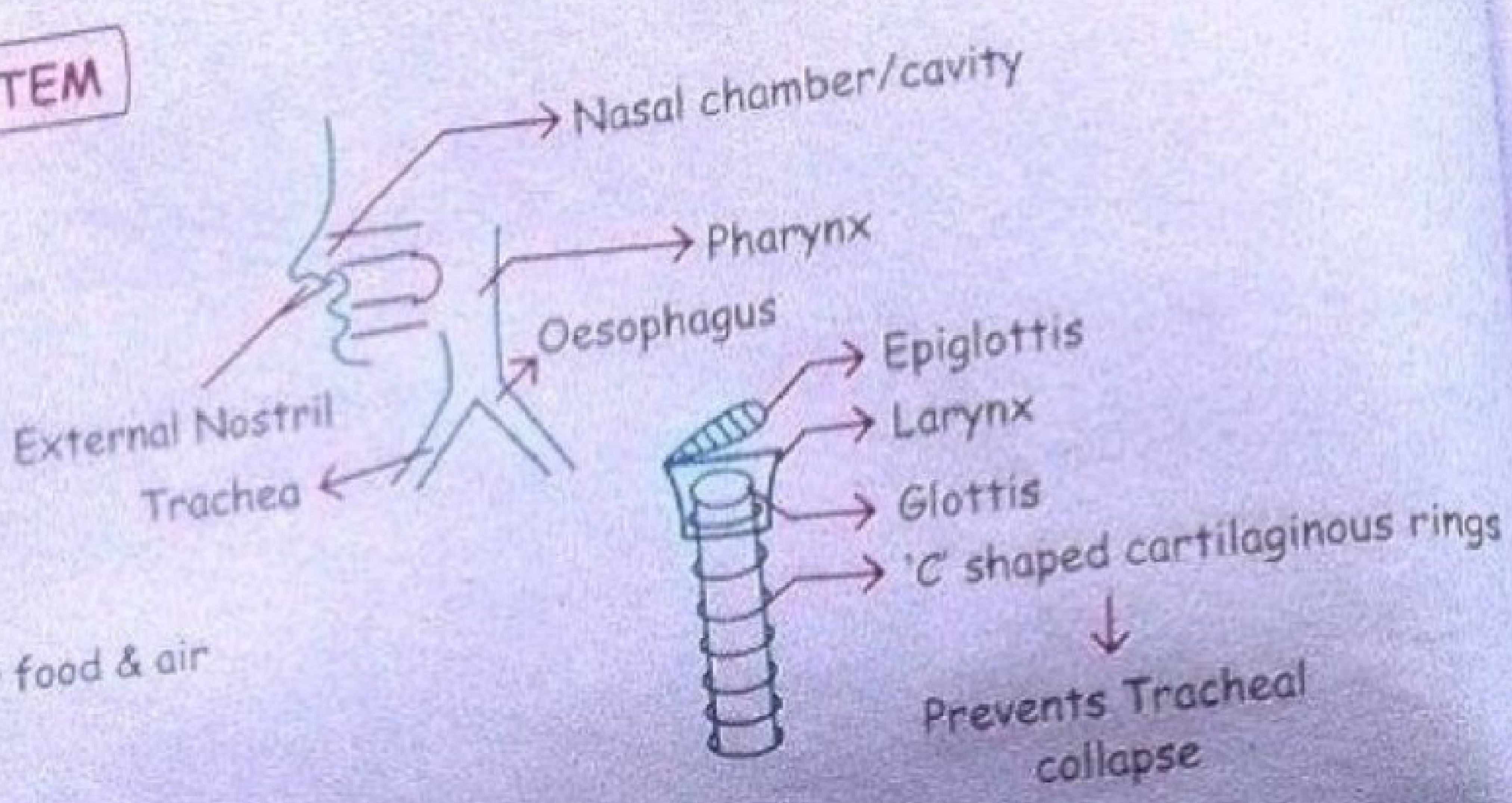
Level of Organisation:

- Cellular → Phylum Porifera
- Tissue → Coelenterata, Ctenophora
- Organ → Platyhelminthes
- Organ-system
  - → Aschelminthes

(Cellular to Aschelminthes: Simple diffusion across body wall)

  - → Annelids → Earthworm → *Moist cuticle
  - → Arthropoda → Gills, Book Gills, Book Lungs, Tracheal System
  - → Mollusca → Feather Like Gills
  - → Echinodermata → Tube feet
  - → Hemichordata → Gills
  - → Chordata
    - → Fish → Gills
    - → Amphibia → Gills, Buccopharynx, Skin, Lungs
    - → Reptilia, Aves, Mammal → Lungs

HUMAN RESPIRATORY SYSTEM



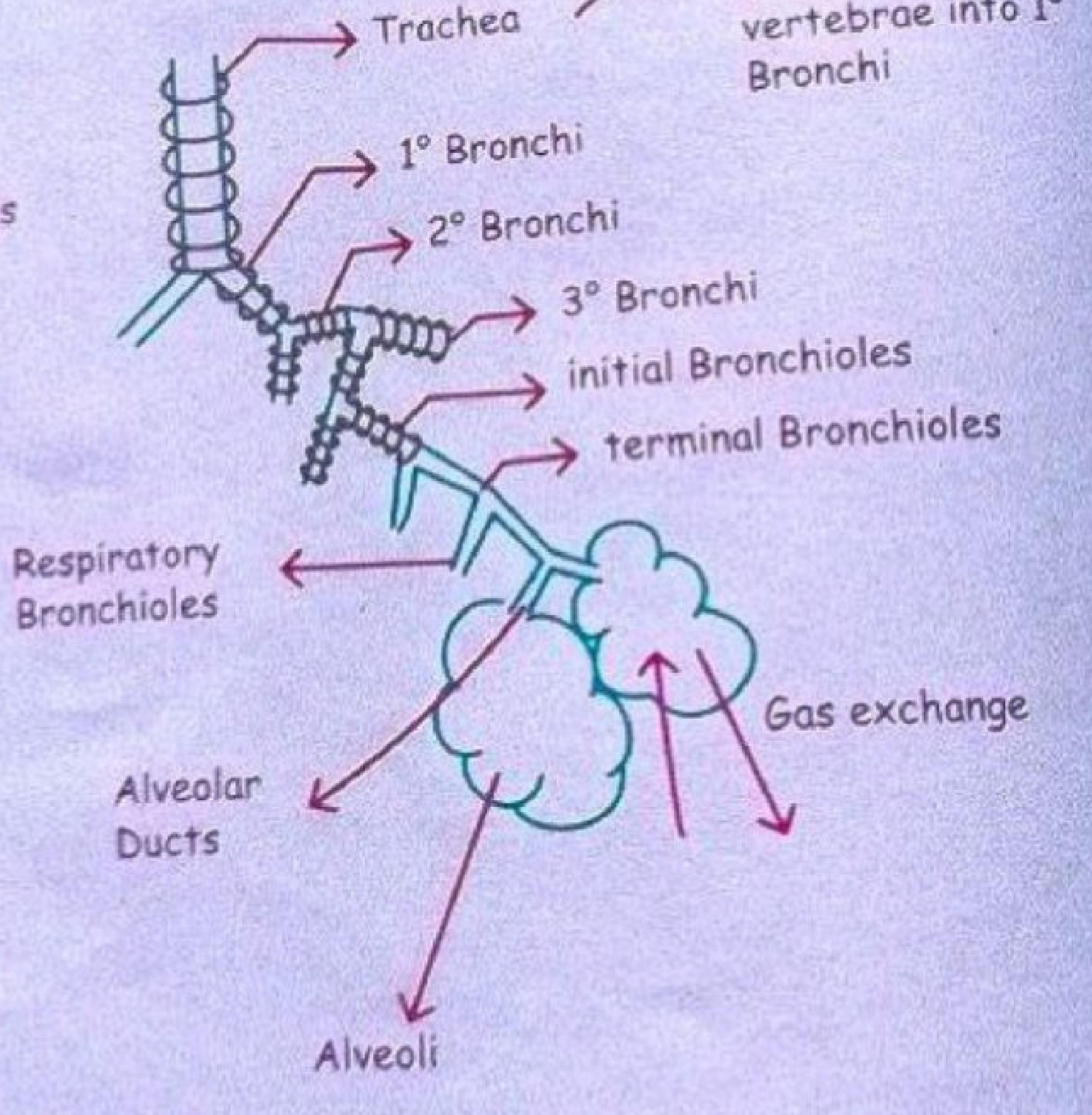
1. External Nostrils/Nares
↓
2. Nasal Chamber
↓
3. Internal Nostrils/Nares
↓
4. Pharynx → Common passage for food & air
↓
5. Larynx → Sound box/Voice box
→ Has vocal cords for sound production
→ It is made up of cartilages & one of its cartilages is 'Epiglottis' that covers the Glottis (Opening of Trachea) during swallowing of food.
↓
6. Trachea → Windpipe
→ Incomplete 'C' shaped Cartilaginous Rings.
→ Incomplete dorsally due to the presence of oesophagus dorsally.
↓
7. 1° Bronchi
↓
8. 2° Bronchi
↓
9. 3° Bronchi

(7–9: Supported by cartilaginous rings)

↓
10. Initial Bronchioles (→ Supported by cartilaginous rings)
↓
11. Terminal Bronchioles (No rings)
↓
12. Respiratory Bronchioles (No rings) (Not in NCERT)
↓
13. Alveolar duct
↓
14. Alveoli

(12–14: → Exchange zone/Respiratory zone)

*Divides at the level of 5th Thoracic vertebrae into 1° Bronchi



Respiratory System

I Conducting zone

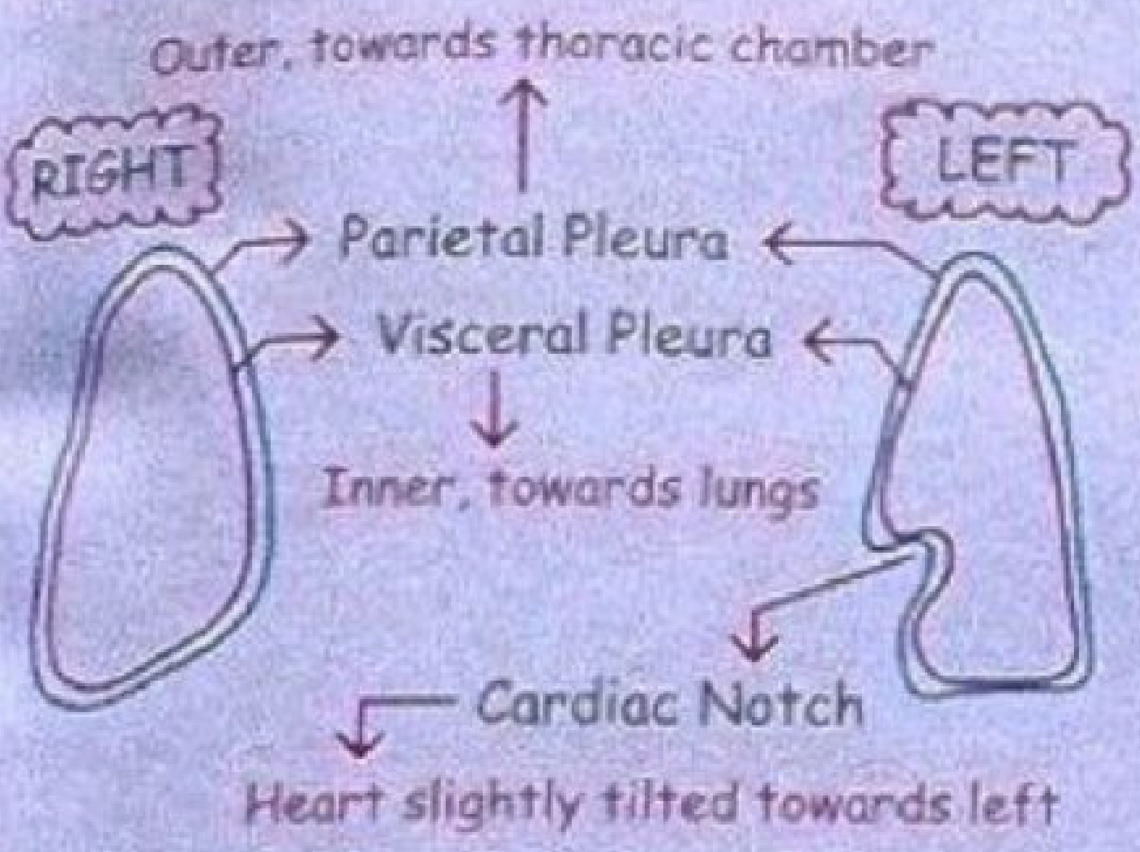
- External nostrils upto terminal bronchioles

Functions
- → humidification of Air
- → Bring the air to body temperature
- → traps the dust particles (MUCUS)
- → takes the air to the respiratory zone

II Respiratory zone/Exchange zone

- Alveolar ducts along with Alveoli
  (Respiratory Bronchioles
  +
  Alveolar ducts
  +
  Alveoli)
- Function: Exchange of gases

Lungs



NOTE

The double membranous, pleura has PLEURAL FLUID in between to prevent FRICTION.

ALVEOLI

- Both lungs in total has 300 million Alveoli (अतिरिक्त Gyaan)

→ Exchange of gases
↓ Occurs through
3 layer

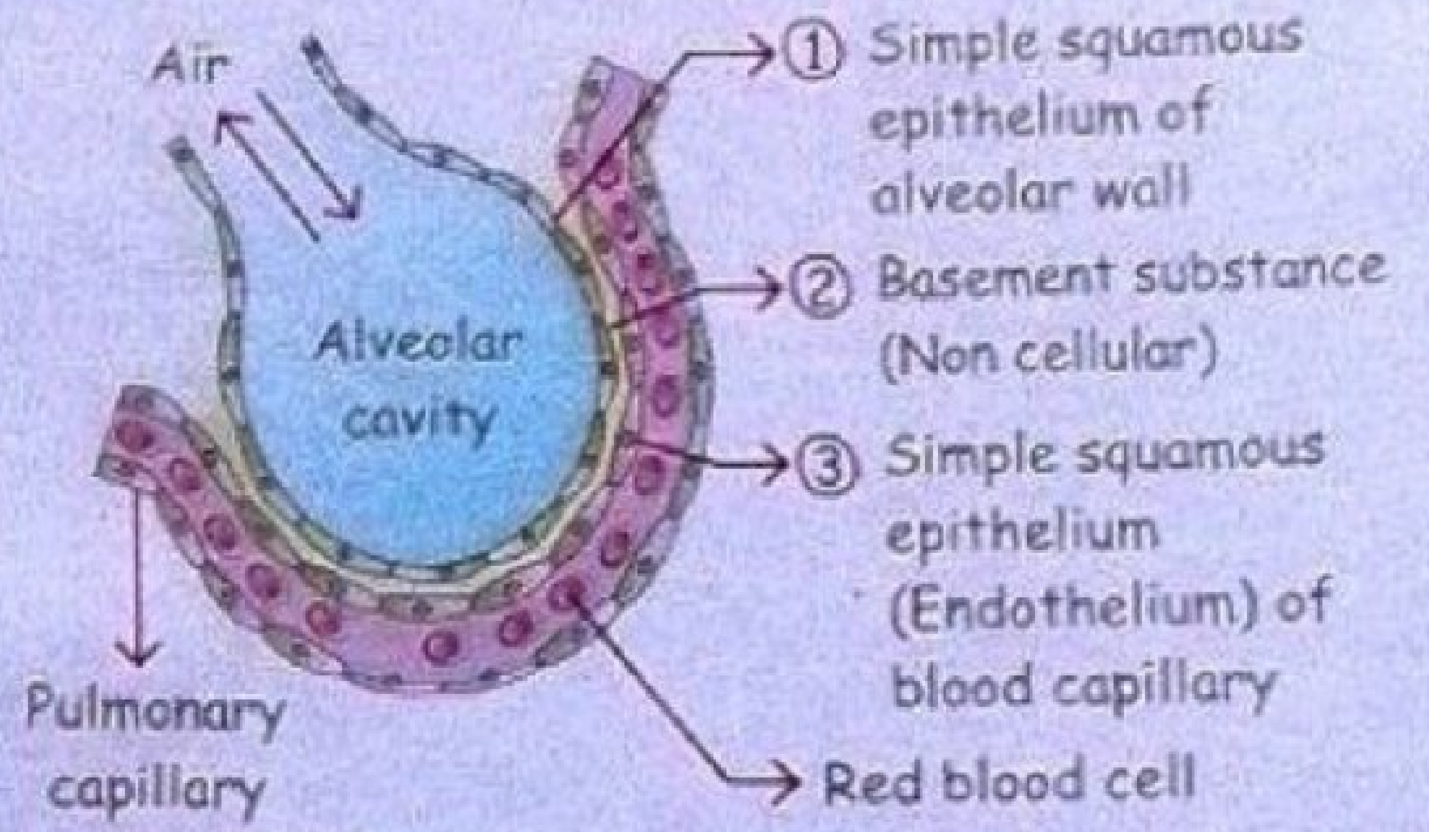


Figure: Sectional view of an alveolus with a pulmonary capillary.

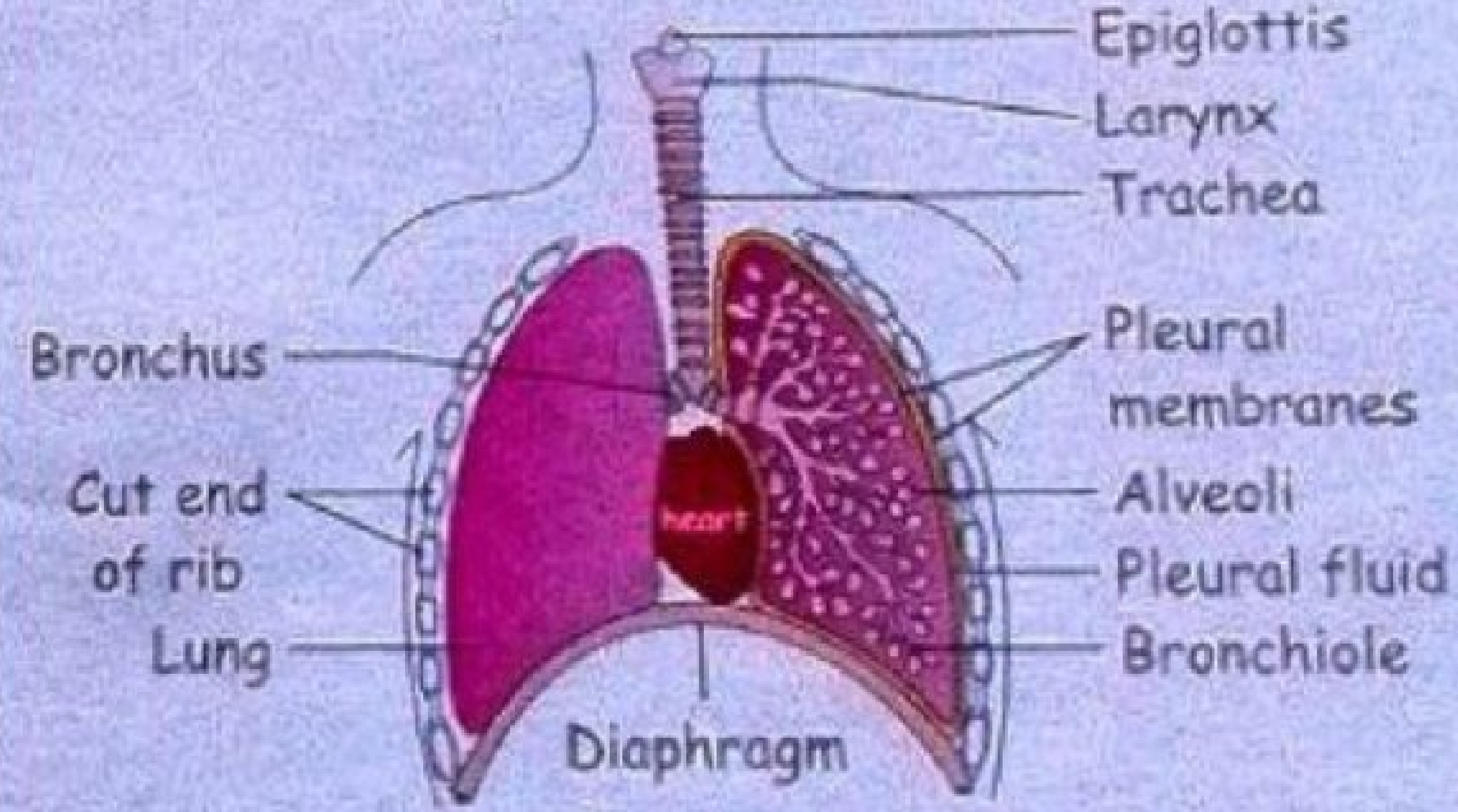


Figure: Diagrammatic view of human respiratory system (Sectional view of the left lung is also shown)

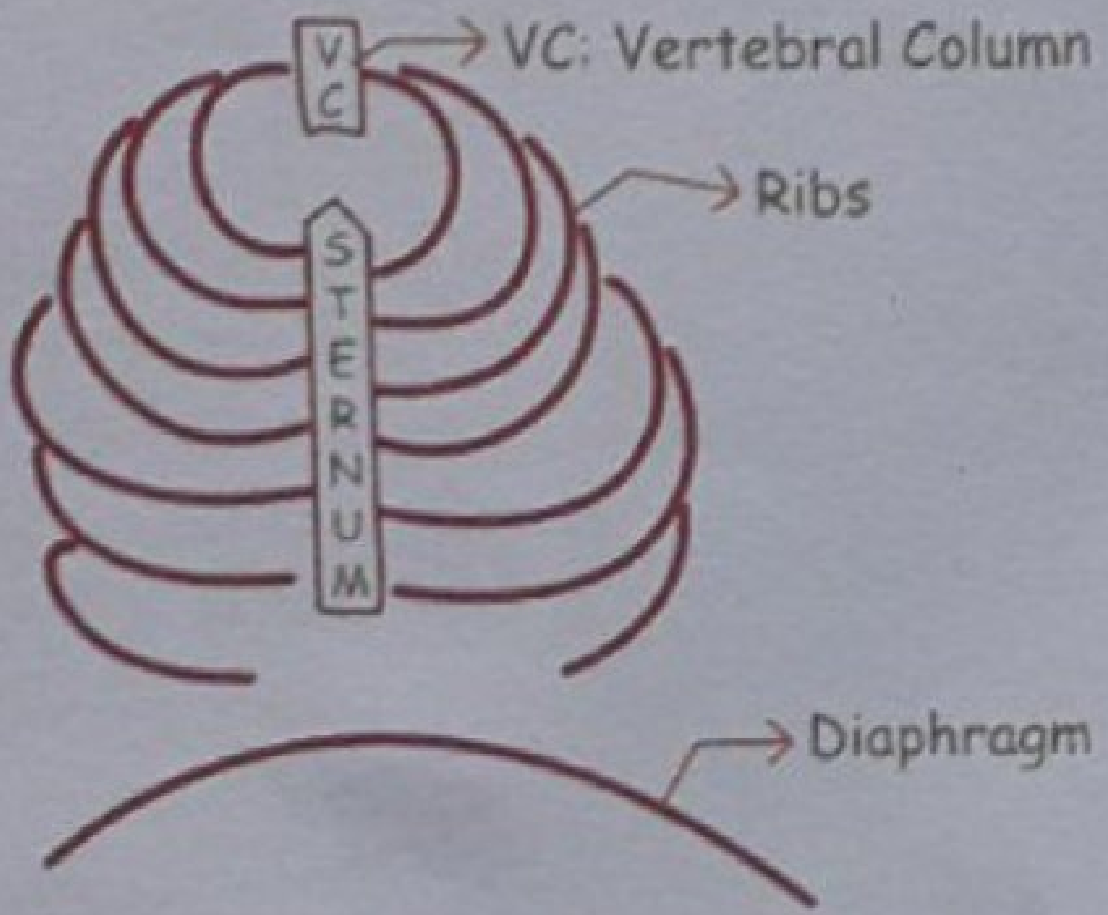
THORACIC CHAMBER

'Lungs' are situated in a air tight chamber:

THORACIC CHAMBER

- Dorsally → Vertebral column
- Ventrally → Sternum
- Laterally → Ribs
- Below → Diaphragm

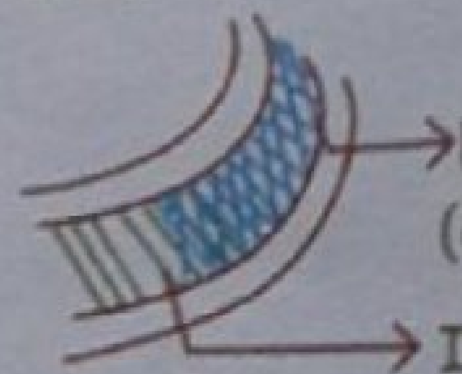
Any change in its volume is reflected in the pulmonary volume



MECHANISM OF BREATHING

Muscles involved in Breathing

- Diaphragm (major)
- ICM (Intercostal Muscle) — Located between Ribs
  - Internal ICM (IICM)
  - External ICM (EICM)



Relationship of Air Pressure and Volume

Air always moves from a region of high partial pressure to low partial pressure.

Air: High Partial Pressure → Low partial pressure

Basic Principle

- Pressure can be changed by changing the volume.

$$P \propto \frac{1}{V}$$

Normal Inhalation

For this to occur

Pout: (Atmosphere) → FIXED: 760 mmHg

(↑) Pout → Pins (↓)

NOTE
Pout : Pressure outside
Pins : Pressure inside
↑ : More
↓ : Less

Volume ↑

"Can be increased by"

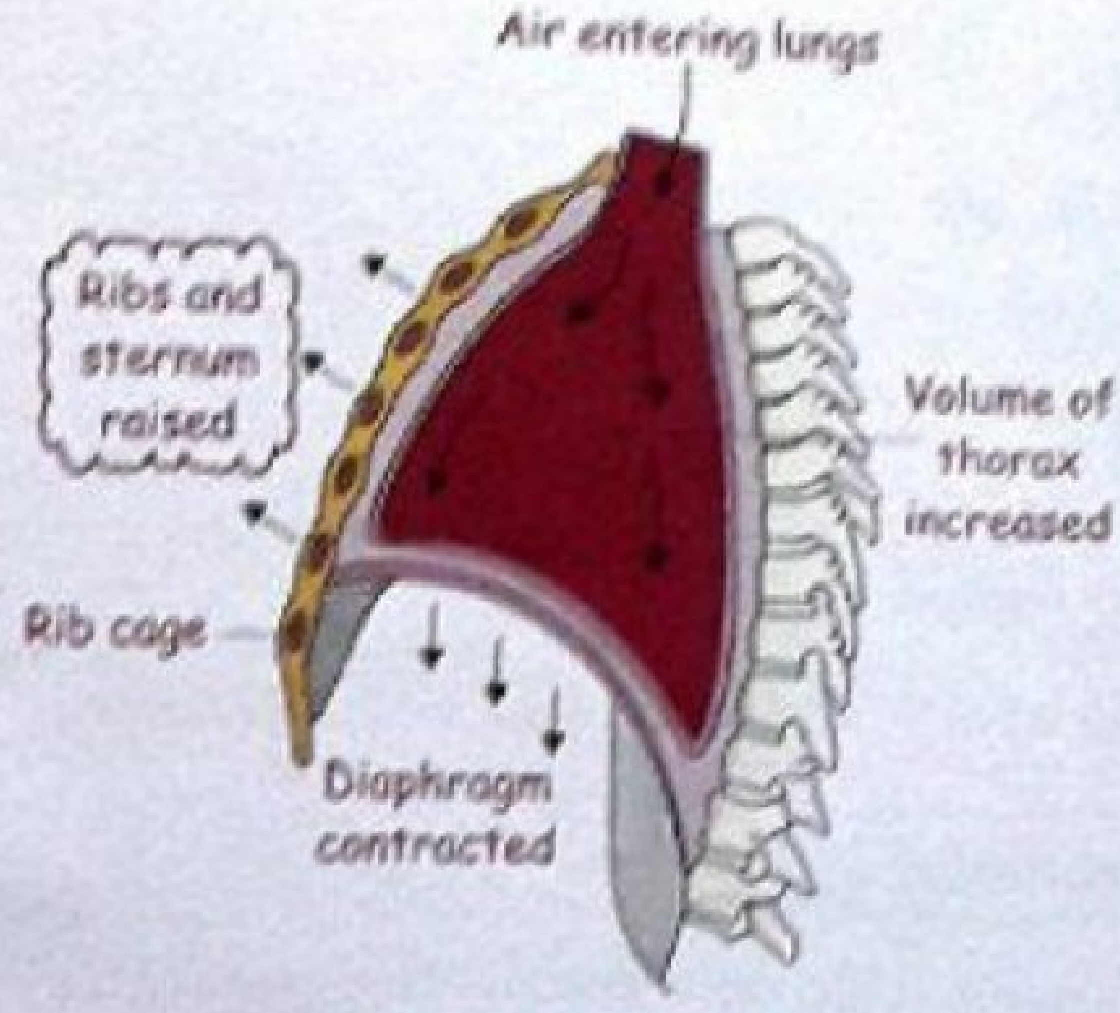
Diaphragm
↓
CONTRACTION
↓
It become FLAT from DOME-SHAPED
↓
Volume of thoracic chamber ↑ in Anterio-posterior direction
↓
Pressure ↓

External ICM
↓
CONTRACTION
↓
Ribs & sternum moves outwards & upwards
↓
Volume of the thoracic chamber & Lungs ↑ in Dorso-Ventral direction
↓
Pressure ↓

Pressure ↓ → Air comes in ← Pressure ↓

Normal Inhalation

- For normal inhalation to occur, P_{out} (outer pressure) should be more than P_{ins} as indicated in the flow chart
- To change P_{ins}, volume should be changed
- To ↓ P_{ins}: Volume should be ↑



Normal Inhalation

Normal Exhalation

↓ For this to occur

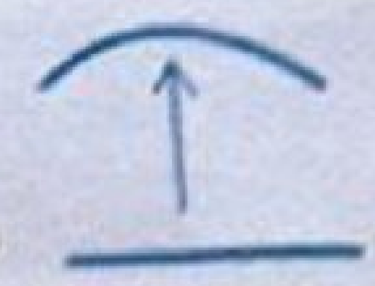
↑ Pinside → Pout ↓

↓

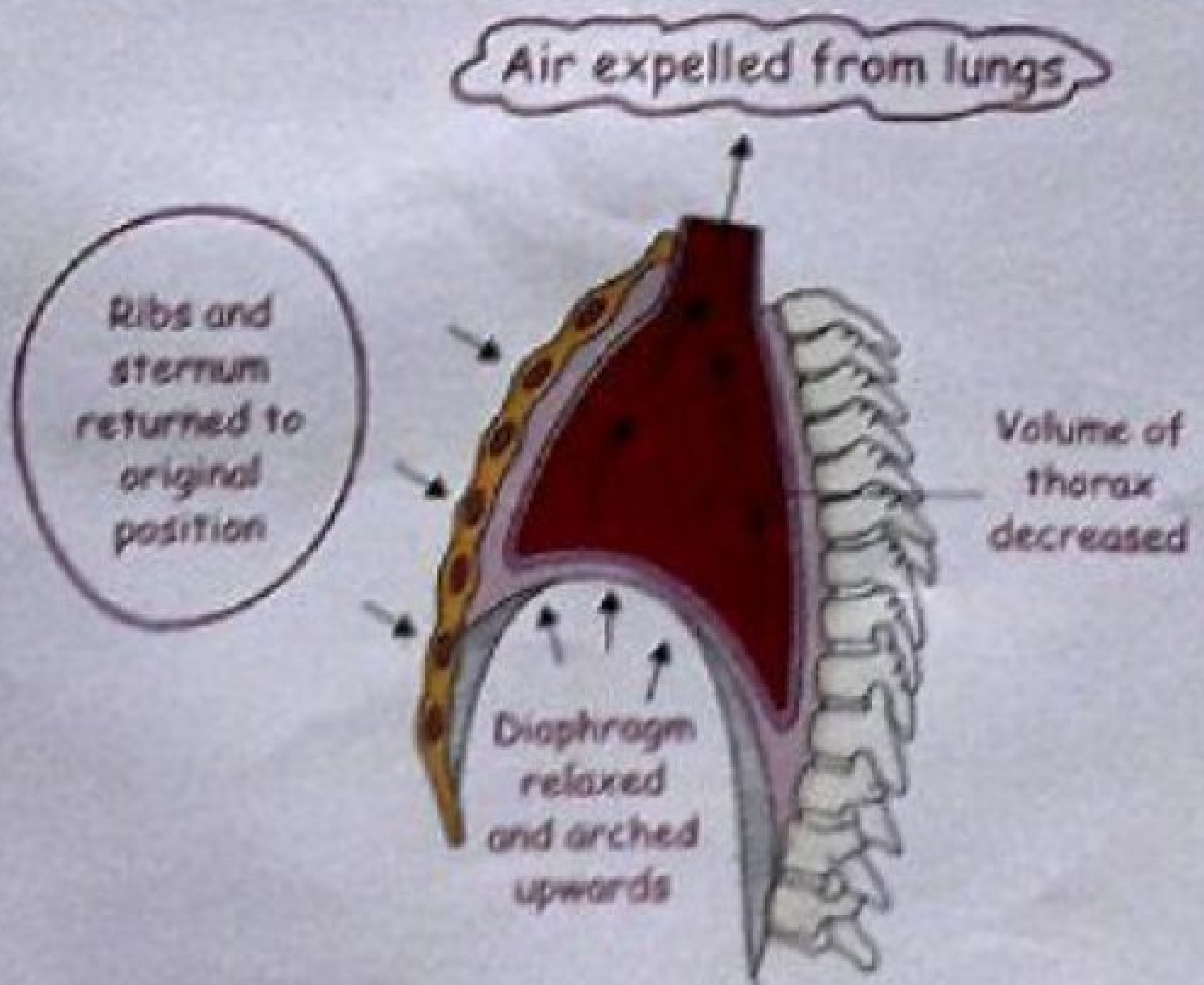
Volume ↓

"Can be decreased by"

Diaphragm	EICM
↓	↓
Relaxed	Relaxed
↓	↓
Becomes dome shaped again from FLAT	Ribs & sternum moves inwards, downward
↓	↓
Volume ↓ anterio-posteriorly	Volume ↓ dorso-ventrally
↓	↓
Pressure ↑	Pressure ↑



Pressure ↑ → Air goes outside ← Pressure ↑



Normal Exhalation

NOTE

We can use additional sets of muscles like IICM (Internal intercostal muscle), abdominal muscle for forceful Breathing.

Adult Breathing Rate = 12-16 times/min

Respiratory Volumes and Capacities

Spirometer

The device used to measure the respiratory volume (except residual volume)

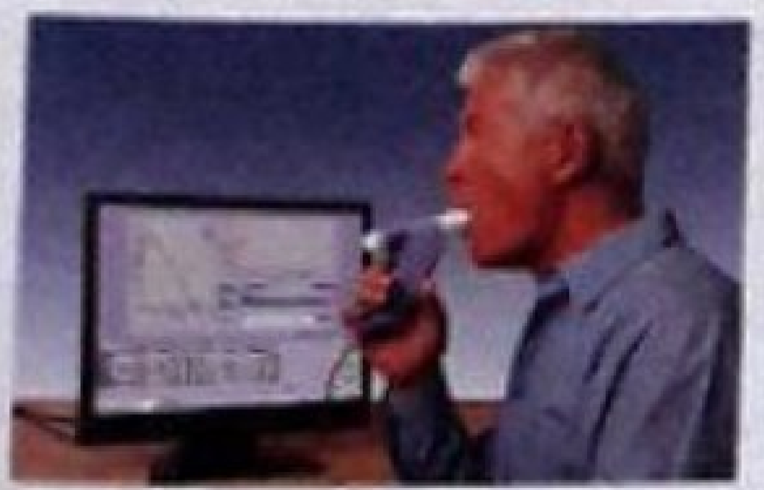


Figure: Spirometer Test

Respiratory Volume

The different volumes of air a person can breathe in or breathe out in different conditions

Tidal Volume (TV)

Amount of air that a person can normally inhale or exhale.

TV = 500 ml

Minute Respiratory Volume (Amount of air inspired per minute) = Tidal volume × Breathing rate

= 500 × (12 - 16) = (6000 - 8000) ml/min

Inspiratory Reserved Volume (IRV)

The additional amount of air that a person can inhale by a forceful inhalation.

IRV = 2500 - 3000 ml

Expiratory Reserved Volume (ERV)

The additional amount of air that a person can exhale by a forceful exhalation.

ERV = 1000 - 1100 ml

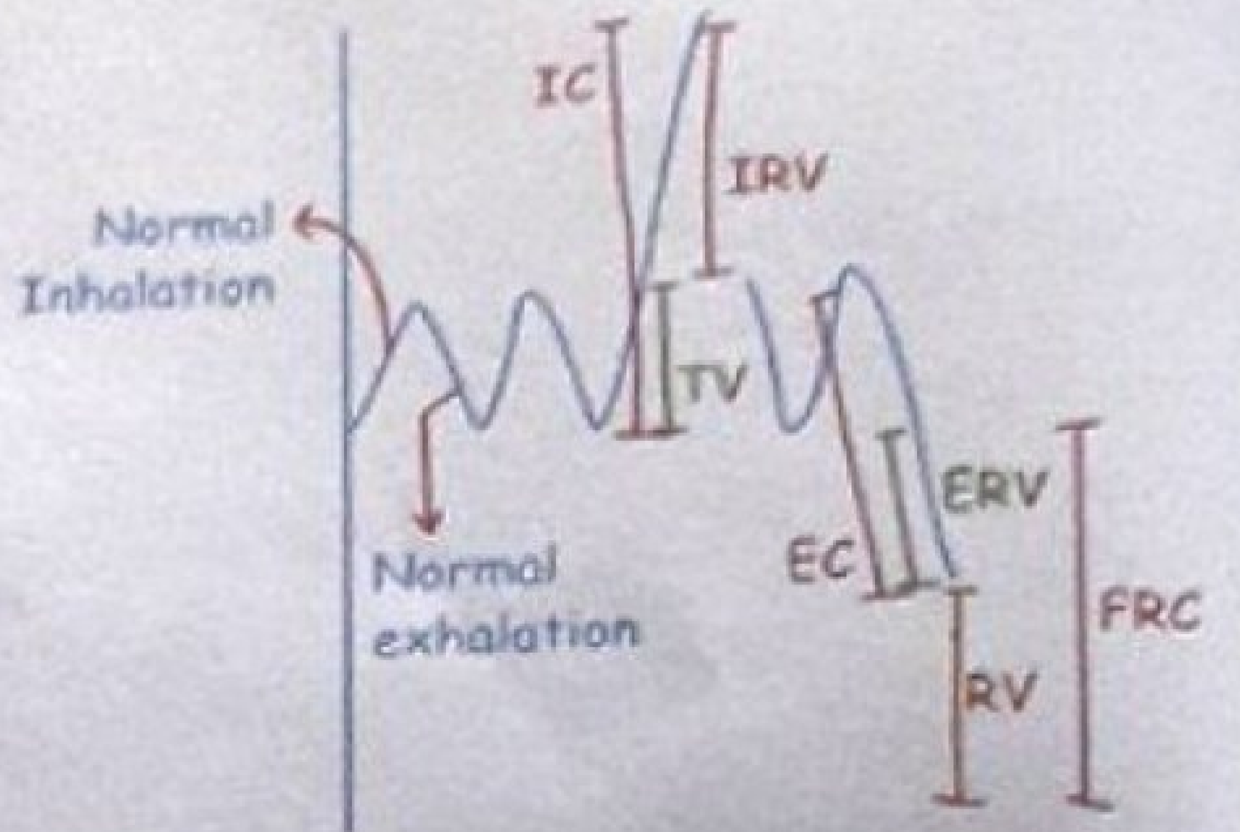


Figure: Spirometry: Lung volumes and capacities

Residual Volume (RV)

The amount of air which is always present in LUNGS even after a forceful exhalation.

RV = 1100 - 1200 ml

Respiratory Capacities:

By adding up a few respiratory volumes described above, one can derive various pulmonary capacities, which can be used in Clinical diagnosis.

Inspiratory Capacity (IC)

The total amount of air a person can inhale after a normal exhalation

IC = TV + IRV

Expiratory Capacity (EC)

The total amount of air a person can exhale after a normal inhalation.

EC = TV + ERV

Functional Residual Capacity (FRC)

The total amount of air that is present in Lungs after a normal exhalation.

FRC = ERV + RV

Vital Capacity (VC)

The total amount of air a person can exhale after a FORCEFUL INHALATION

OR

The total amount of air a person a can inhale after a FORCEFUL EXHALATION

$$VC = TV + IRV + ERV$$

Total Lung Capacity (TLC)

The total amount of air present in Lungs after a forceful inhalation.

$$TLC = TV + IRV + ERV + RV$$

OR

$$TLC = VC + RV$$

EXCHANGE OF GASES

Factors Affecting Exchange of Gases

1. Thickness of Diffusion Membrane:

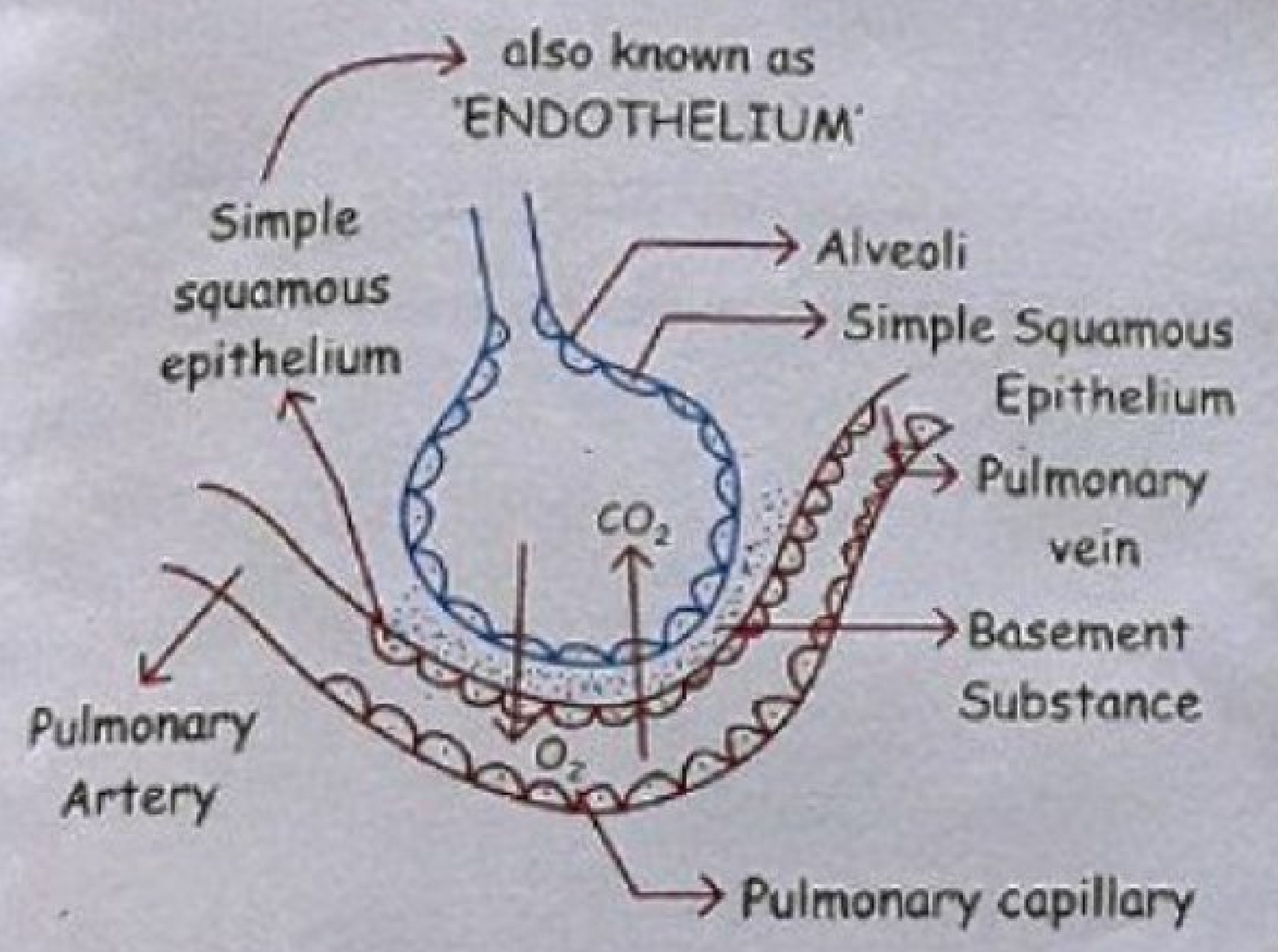
Alveoli → VASCULARISED

↓

Highly Vascular

↓

'Blood vessel' present



Diffusion Membrane:
- Thickness is less than 1 mm
- Very easy diffusion.

① → Simple Squamous Epithelium of ALVEOLI

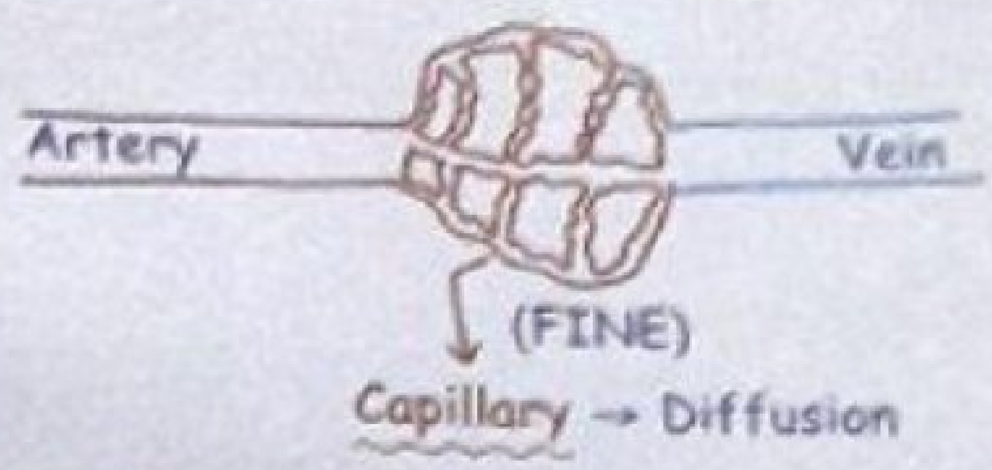
② → Basement Substance
- Non cellular

③ → Simple squamous epithelium of pulmonary capillary

NOTE

Artery: Carries Blood away from Heart

Vein: Carries Blood towards the Heart



2. Solubility of Gas:

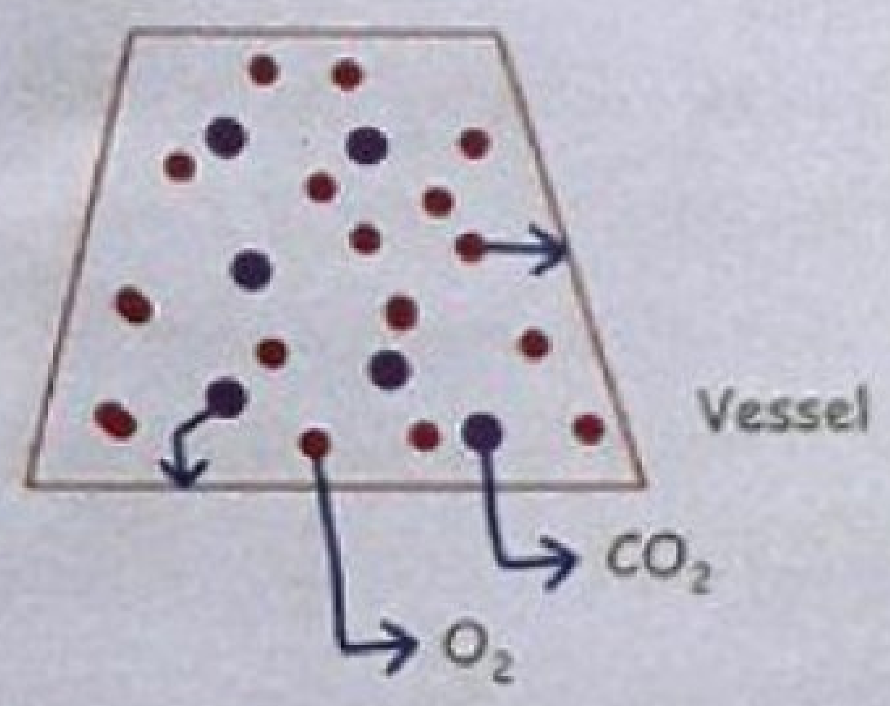
The more is the solubility of a gas, easier is the Diffusion

- CO_2 is 20-25 times more soluble than that of O_2

3. Partial Pressure:

pO_2: Partial pressure of O_2

pCO_2: Partial pressure of CO_2



Partial pressure: The pressure exerted by an individual gas in a mixture of gases.
- Air always move from a region of High partial pressure to a region of Low Partial Pressure.

Exchange of Gases

- Occurs at 2 sites:

  (1) Between Alveoli & $\underbrace{\text{pulmonary}}_{\text{Lungs}}$ capillary

  (2) Between Tissue & $\underbrace{\text{systemic}}_{\text{Tissue}}$ capillary

- Exchange of gases (O_2 and CO_2) occur by simple diffusion mainly based on pressure/concentration gradient.

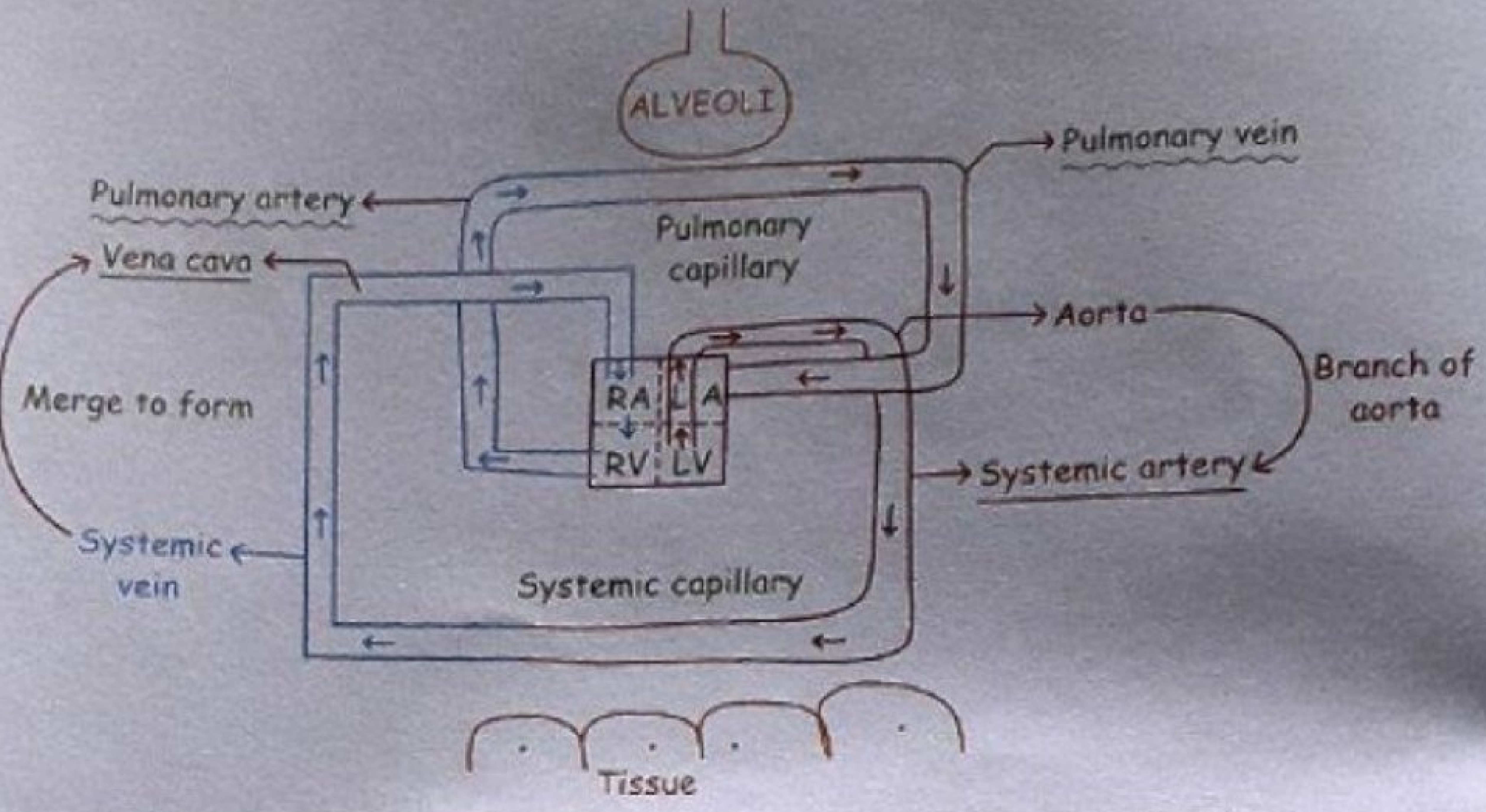
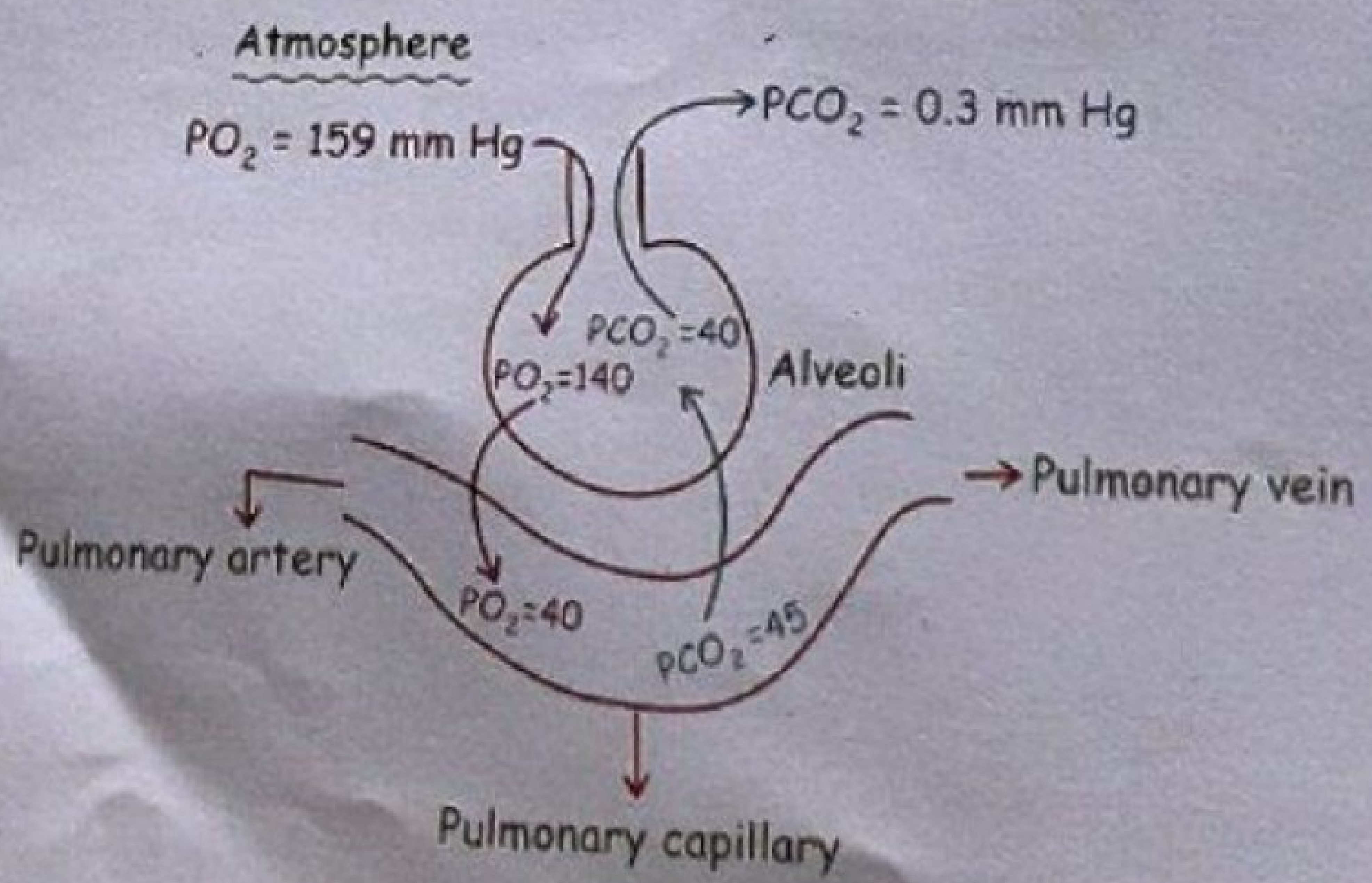


Figure: Blood circulation showing pulmonary and systemic circuit

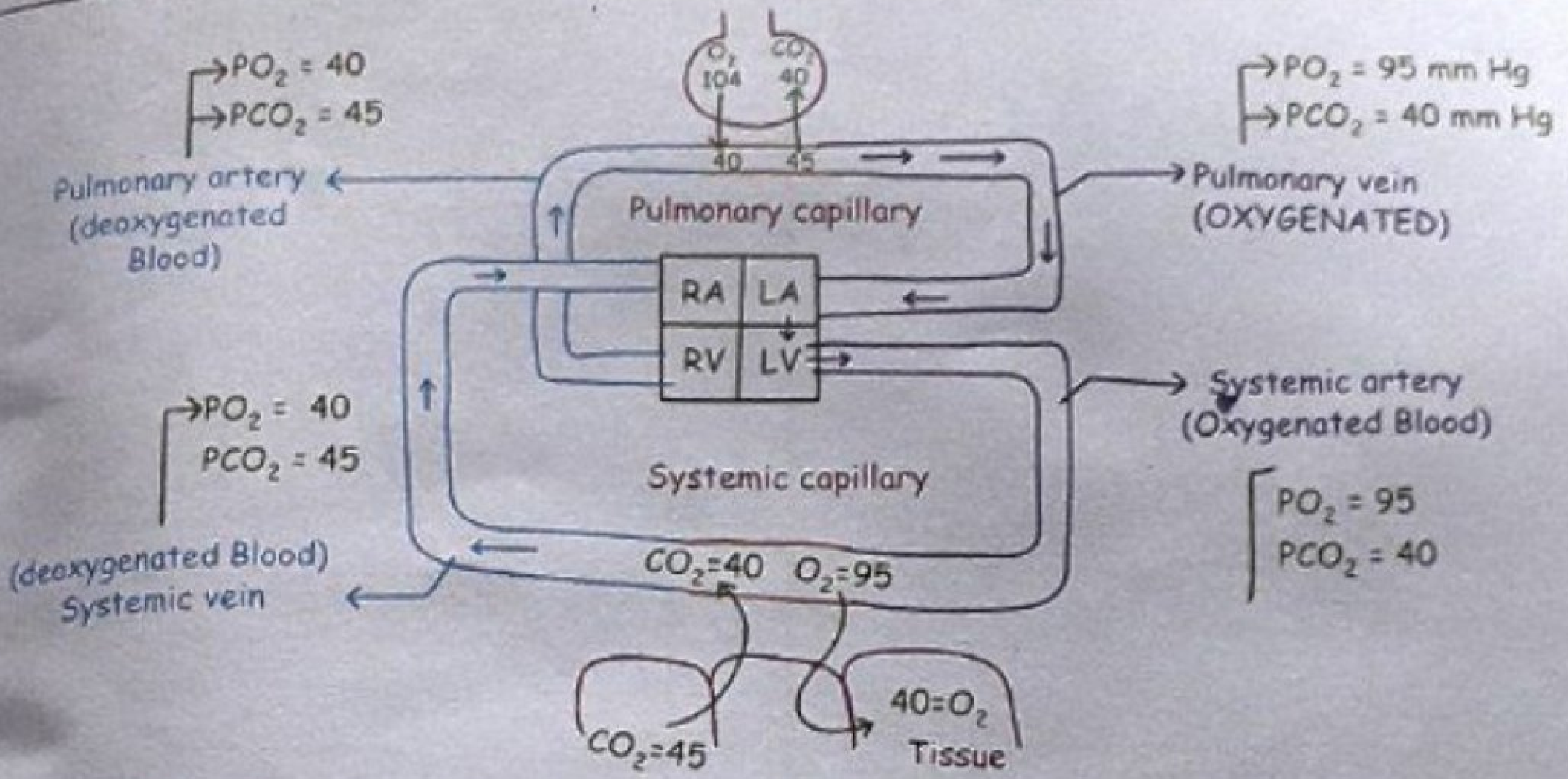
Basics

- Right Side Heart: Deoxygenated Blood ($CO_2 \gg O_2$)
- Left Side Heart: Oxygenated Blood ($O_2 \gg CO_2$)
- LA/RA: Left Atrium/Right Atrium
- LV/RV: Left Ventricle/Right Ventricle
- Aorta arises from LV to supply oxygenated blood to the Body & its Branch is ARTERIES
- VENA CAVA collects deoxygenated blood from Tissue, via different veins which Brings this deoxygenated Blood from Tissue & Merge to Vena Cava.

(I) Exchange of Gases: Between ALVEOLI & pulmonary capillary



Partial pressure (respiratory gases)	Atmosphere	Alveoli	deoxygenated Blood	Oxygenated Blood	Tissue
PO_2 (mmHg)	159	104	40	95	40
PCO_2 (mmHg)	0.3	40	45	40	45



TRANSPORT OF GASES

Transport of gases → (i) Transport of O_2 ; (ii) Transport of CO_2

TRANSPORT OF O_2: (i) Bound with Haemoglobin ; (ii) Dissolved in Plasma

NOTE

Blood

- (i) $\boxed{\text{Plasma}}$ (Liquid part/ matrix)
- (ii) Formed elements (present in plasma)
  - Blood cells
    - $\boxed{\text{RBC}}$ Erythrocyte/ Red Blood Cell
    - WBC White Blood Cell/Leucocyte
  - Blood platelets

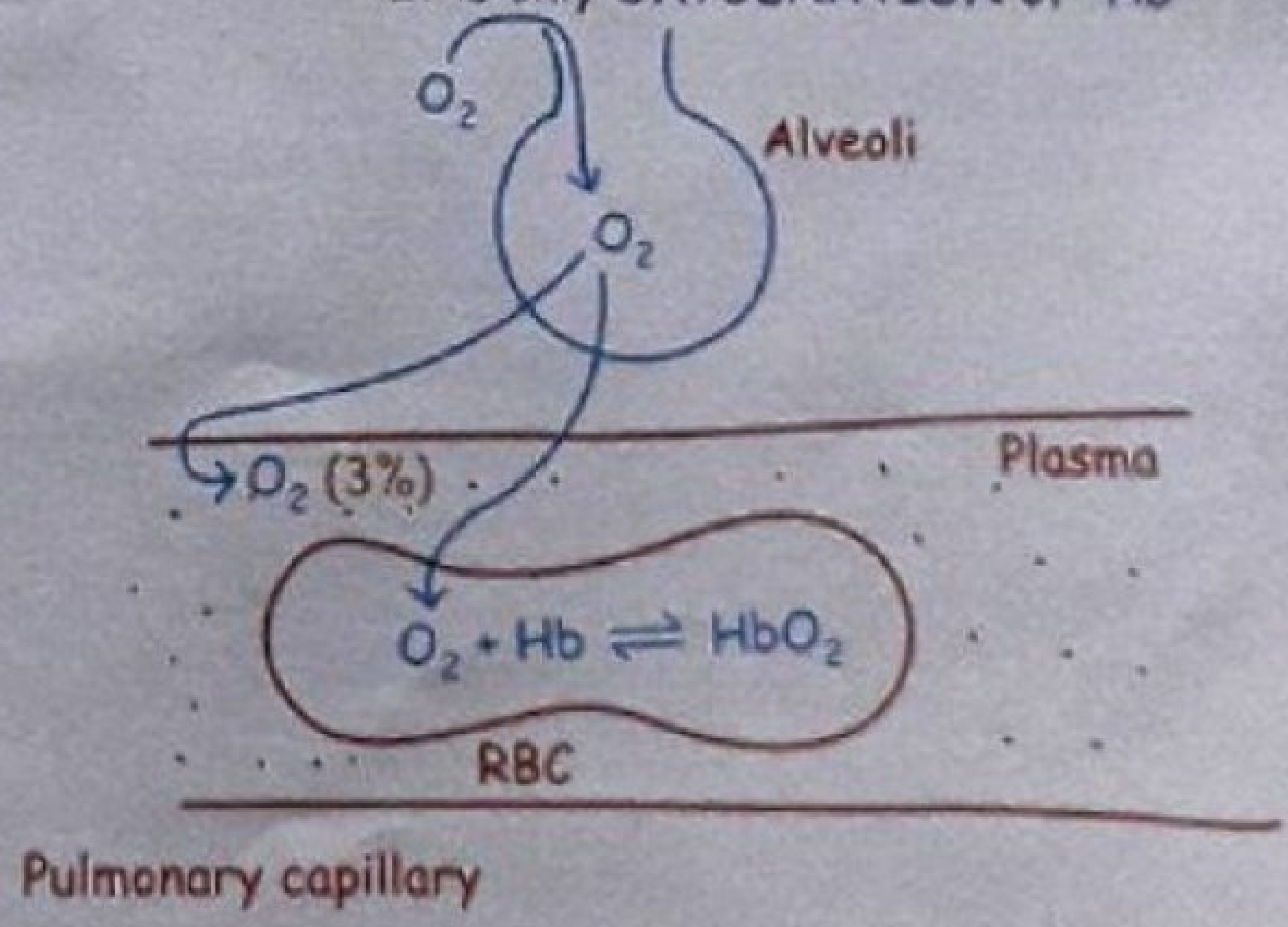
O_2

- (i) Dissolved in Plasma (3%)
- (ii) Bound with Haemoglobin (Hb) (97%)

O_2 is bound to "haem"/ "Fe^{+2}" part of Hb

$Hb + O_2 \rightleftharpoons \boxed{HbO_2}$ Oxyhaemoglobin

It is only OXYGENATION of "Hb"



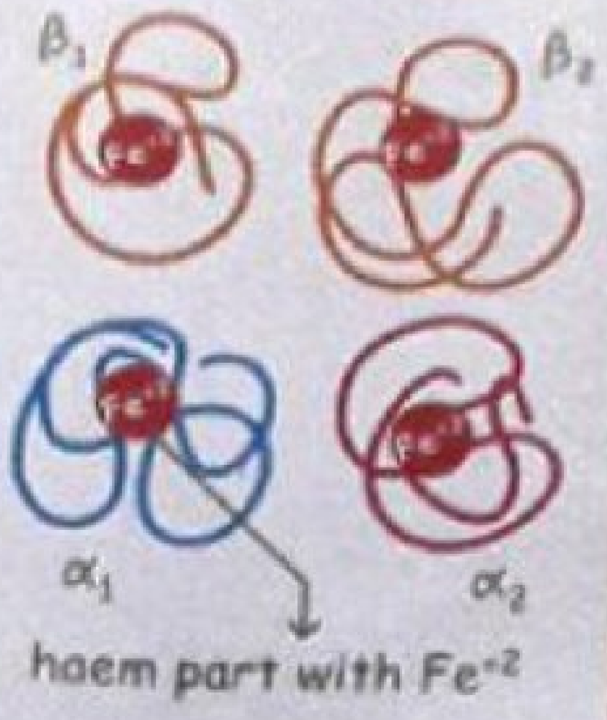
NOTE

→ RBC has "Hb"

① Haemoglobin

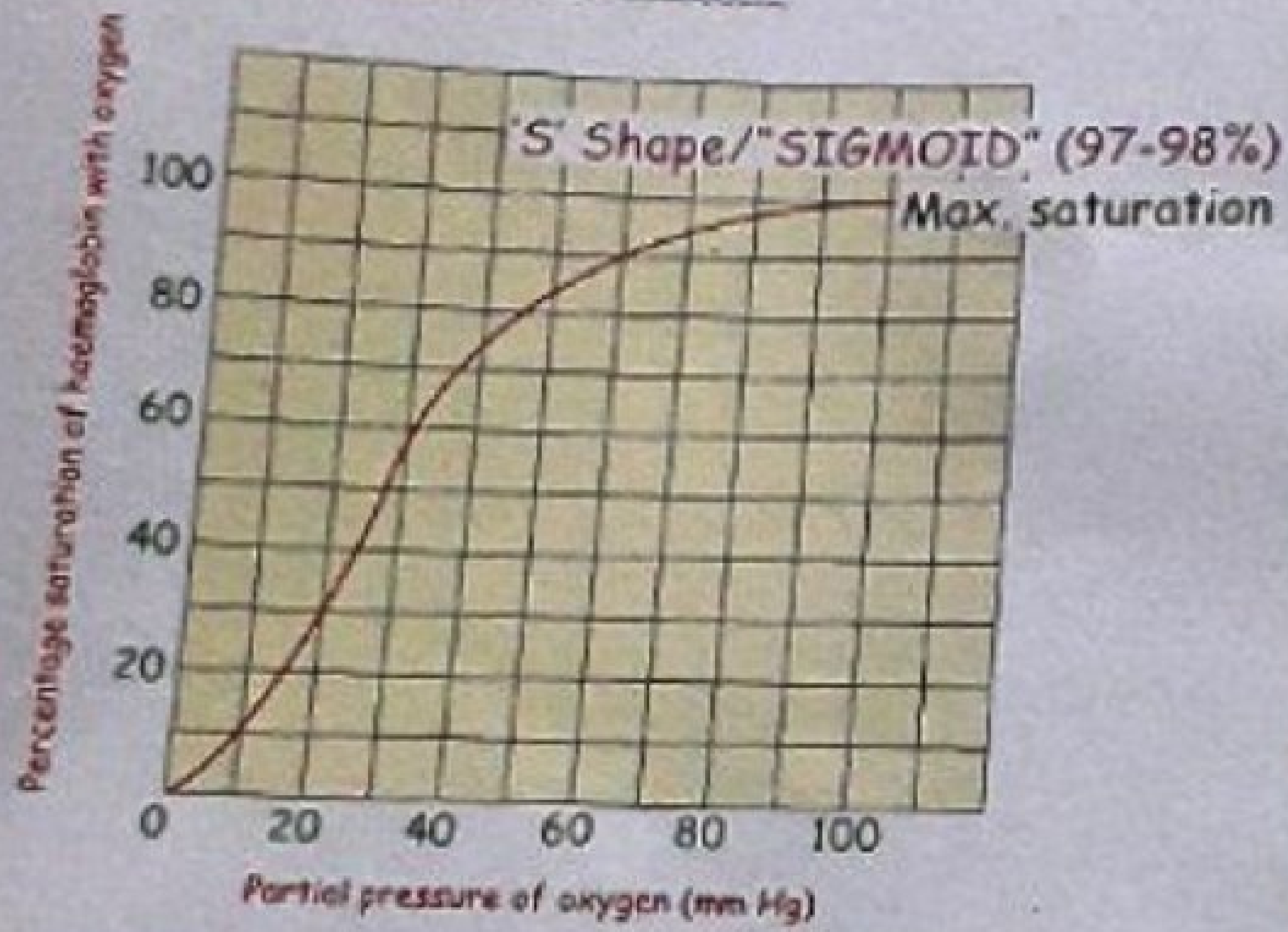
4 Haem (Non Protein) ↓ has "Fe^{+2}"

4 Globin ↓ Protein chain → 2α, 2β



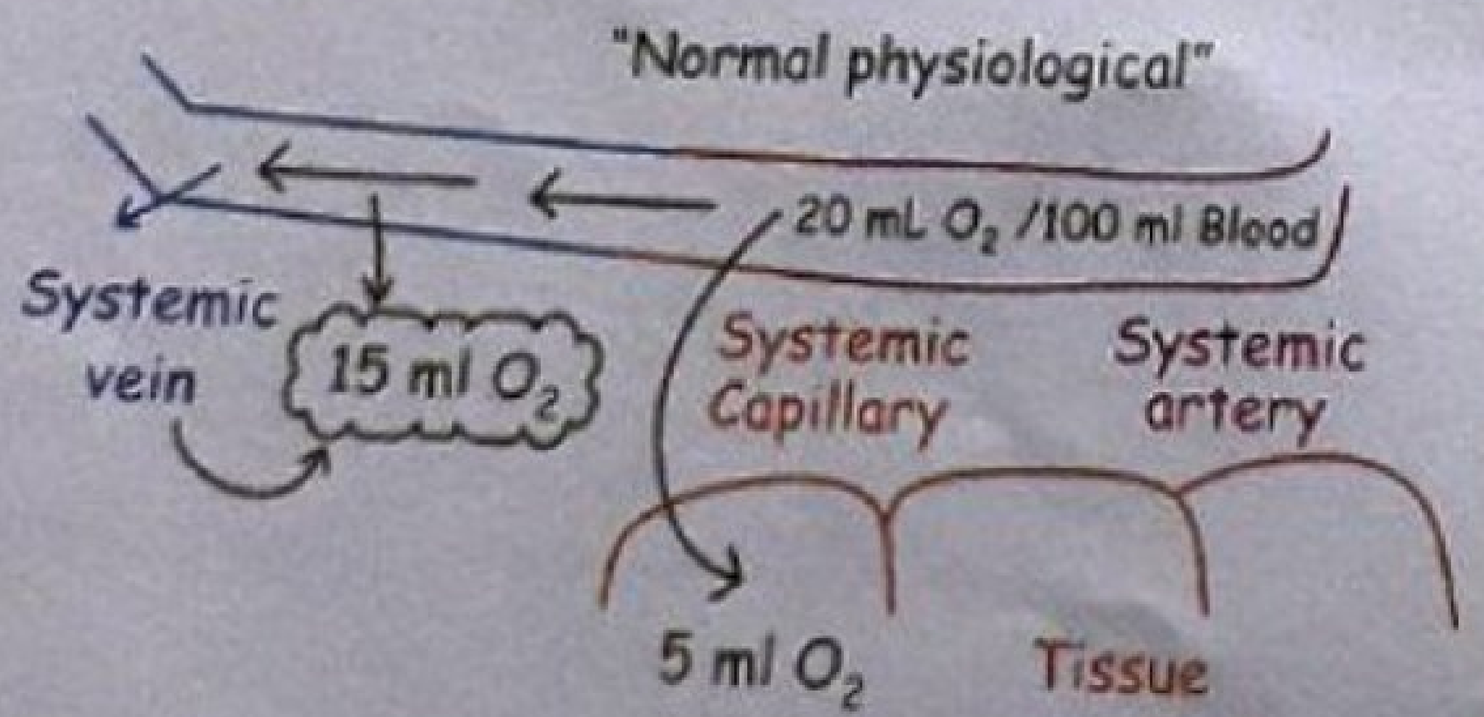
- 1 Hb can carry max. $4O_2$
- Every 100 ml of Blood has ⟶ 15 g Hb
- Every '1g' Hb can carry ⟶ 1.34 ml O_2
- Every 100 ml oxygenated Blood ⟶ 15 × 1.34 ml O_2
- Every 100 ml of oxygenated Blood ≃ 20 ml O_2

Oxygen Dissociation Curve



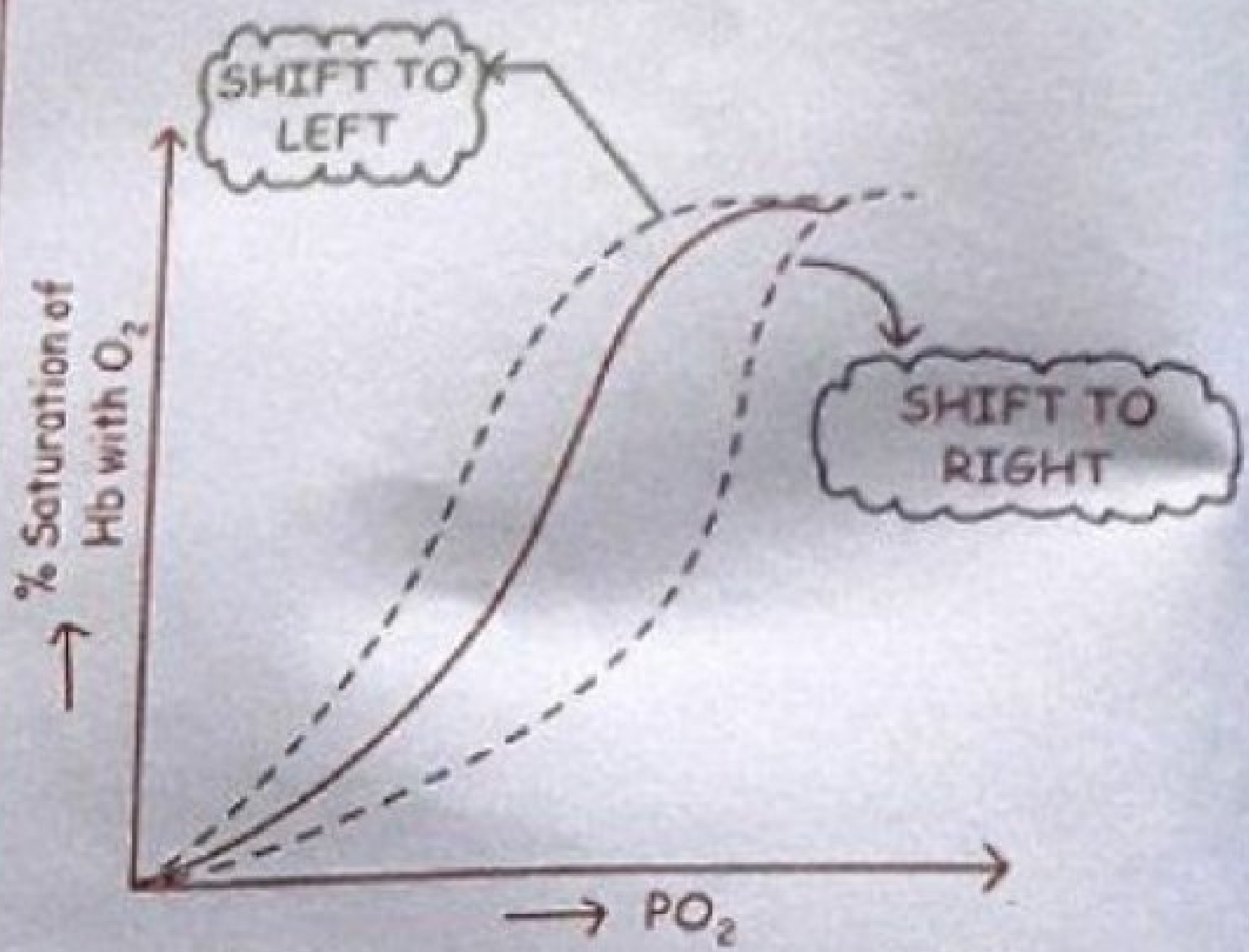
AT NORMAL PHYSIOLOGICAL CONDITION:

- Every 100 ml O_2 Blood delivers 5 ml O_2 to the tissue, rest 15 ml O_2 is still present in Blood (75% saturated)



Points to Remember

- *Binding of O_2 with Hb is primarily related to PO_2 but other factors like PCO_2, H^+, temp., pH may also affect the Binding.
- At different condition, this graph may either SHIFT to Right or Left.



RIGHT [Dissociation of HbO_2 (Tissue)]	LEFT [Association of Hb-O_2 (ALVEOLI)]
PO_2↓	PO_2↑
PCO_2↑	PCO_2↓
H^+↑, pH Low	H^+↓, pH High
Temperature ↑	Temperature ↓

Transport of CO_2

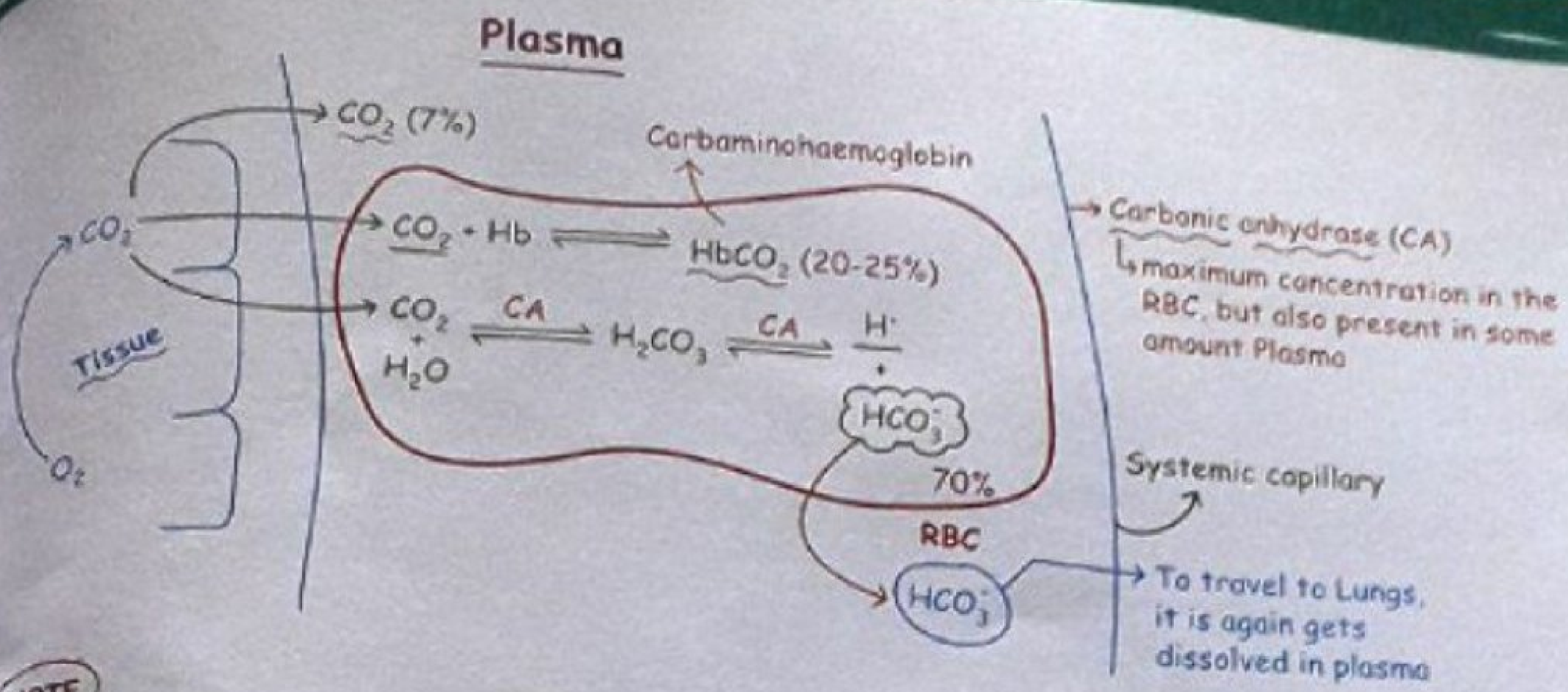
→ (i) Dissolved Plasma (7%)

→ (ii) Bound with Hb (20-25%)

$CO_2 + Hb \rightleftharpoons HbCO_2$: Carbaminohaemoglobin

↓ CO_2 Binds to the "globin" part Haemoglobin

→ (iii) As Bicarbonate (70%)



NOTE

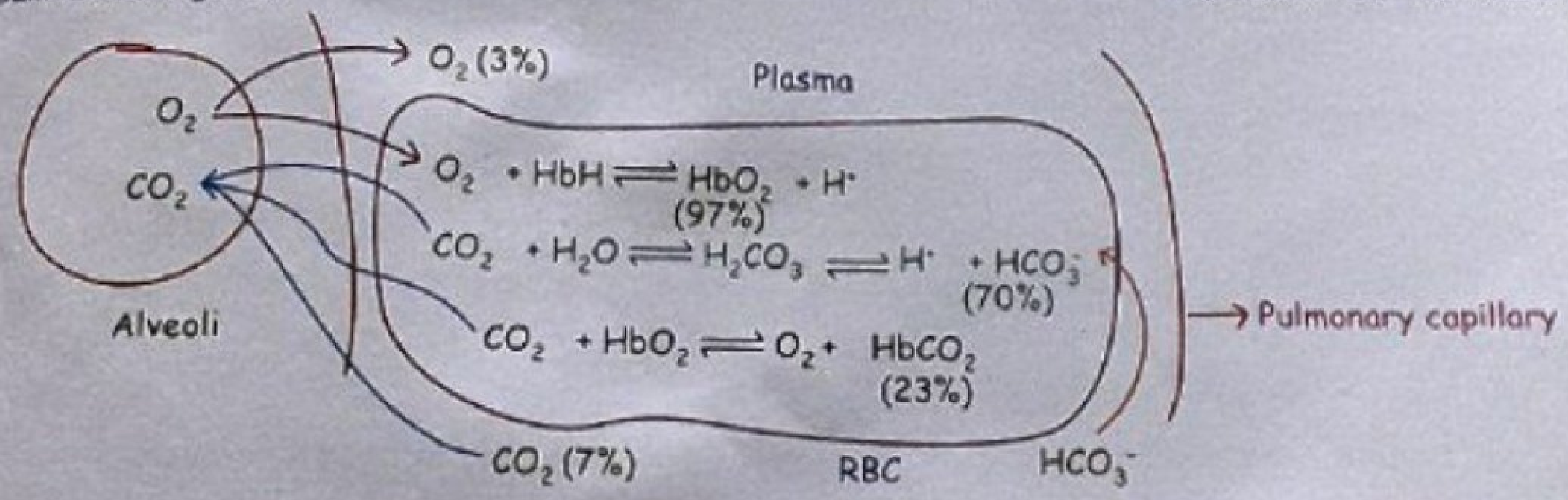
Every 100 ml of deoxygenated Blood delivers $\boxed{4 \text{ ml } CO_2}$ to the Lungs (Alveoli)

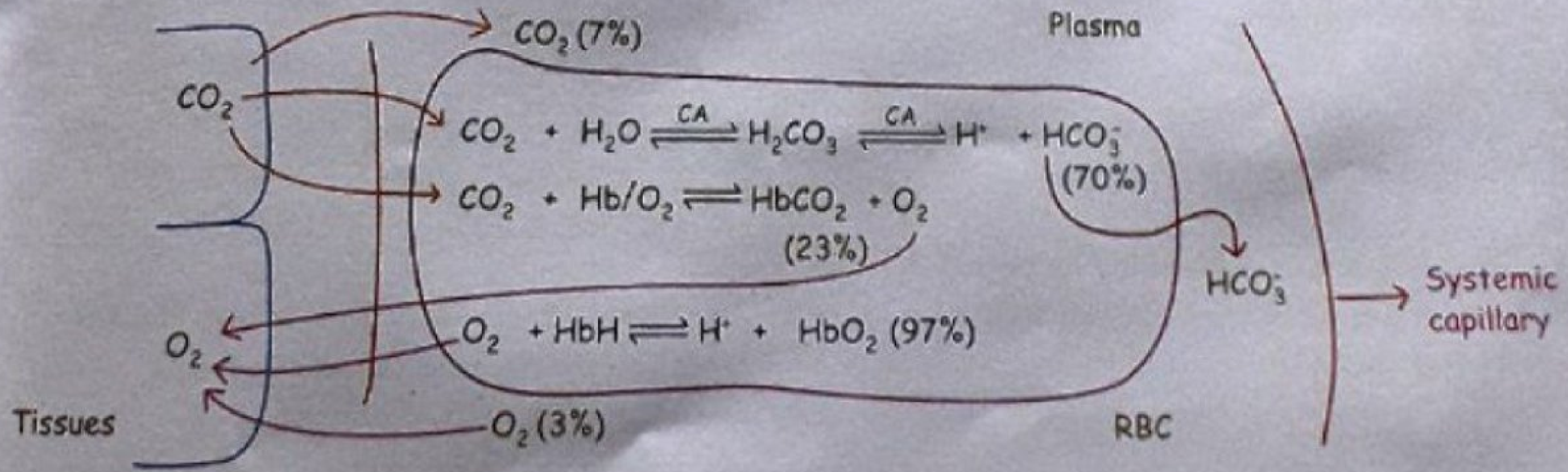
CONCLUSIVE DIAGRAMS OF O_2 & CO_2 TRANSPORT

NOTE

All factors in the Alveoli which is responsible for oxygen haemoglobin association will be responsible for dissociation of carbondioxide from Haemoglobin

All factors in the tissue responsible for oxyhaemoglobin breakup will be responsible for formation of carbaminohaemoglobin





REGULATION OF RESPIRATION

Regulation of Respiration

Nervous Regulation
- (i) By RRC
  RESPIRATORY RHYTHM CENTRE
- (ii) By PC
  PNEUMOTAXIC CENTRE

Chemical Regulation
↓
With the Help of chemoreceptors
(receptors that are sensitive to chemicals)
- (i) Central Chemoreceptors
- (ii) Peripheral Chemoreceptors
  - (a) Aortic Bodies
  - (b) Carotid Bodies

NERVOUS REGULATION

(i) By RRC (Respiratory Rhythm Centre)

- Location: In Medulla of Hind Brain
- This is the main centre that controls the RHYTHM OF BREATHING (Normal & forceful Breathing)
- Any changes in the Breathing pattern can be brought by signalling 'RRC'

(ii) By Pneumotaxic centre

- Location: In Pons of Hind Brain
- 'SWITCH OFF CENTRE'
  ↓
- Upon activation of this, it reduces the Duration of Inhalation By SIGNALLING RRC
  ↓
  That means faster Breathing

Chemical Regulation

↓

CHEMORECEPTORS
- NOT SENSITIVE FOR O_2
- Detects chemical like CO_2, H^+ ions the Body FLUIDS

Central Chemoreceptors

- Located Near RRC (Brain)

↓

Any change in 'H^+ & CO_2' in CSF (Cerebrospinal Fluid) is sensed by them.

↑ in H^+ & CO_2 in CSF & Blood will be sensed by these & eventually they SIGNAL RRC to ↑ BREATHING RATE

Peripheral Chemoreceptors

Aortic Bodies

Aorta
↳ Location

Carotid Bodies

- Location: Carotid artery

Any changes in the 'CO_2 & H^+' in the Blood is sensed by the Aortic & Carotid Bodies.

DISORDERS

Asthma

An allergic disorder, caused by "**Allergens**"

allergy causing agents

↓

eg: POLLEN

- Inflammation in the wall of '**Bronchi & Bronchioles**'

"Redness, Swelling"

Spasm in the smooth muscles of them

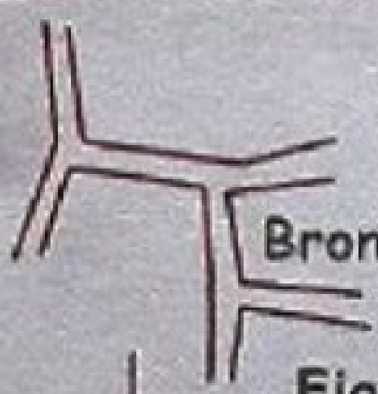
↓

"prolonged contracted" muscles

↓

BREATHING DIFFICULTY

- "WHEEZING" SOUND produced



Bronchiole

Figure: Normal case

↓

Diameter ⇒ ↓

Figure: Asthma case

Emphysema

Chronic disorder due to EXCESSIVE 'CIGARETTE SMOKING'

- Damage in **Alveolar wall**

↓

Alveolar elasticity Lost

↓

reduced surface area for diffusion

↓

Proper diffusion does not occur

↓

"Lungs/Alveoli remain filled with air"

↓

"FULL OF AIR" (Emphysema)

Occupational Respiratory Disorder

- People working in coal industry or stone breaking industry, etc., comes in contact with various pollutants in day to day life.
- Due to this, UPPER PART of their LUNGS show 'FIBROSIS'

deposition of fibrous tissue

- This results Breathing Difficulty
- For eg ✓ SILICON: 'SILICOSIS'
  ✓ ASBESTOS: 'ASBESTOSIS'
- Worker in such industries should wear protective mask

5 Body Fluids and Circulation

BLOOD: Main circulating fluid in higher organisms including humans.

BLOOD → Lymph, CSF (Cerebrospinal fluid) — These are other body fluids, formed from the blood itself

BLOOD

- It is a specialised Fluid Connective Tissue

Composition of BLOOD:

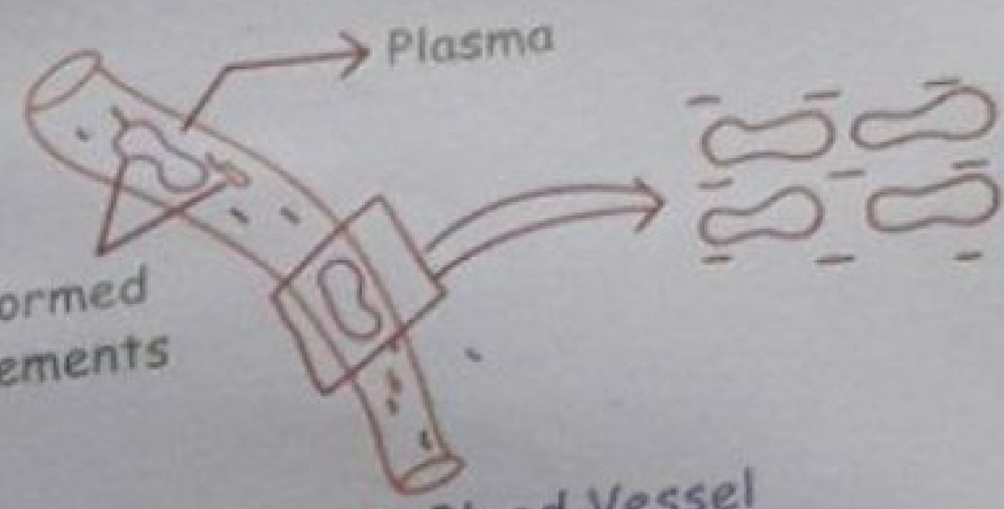
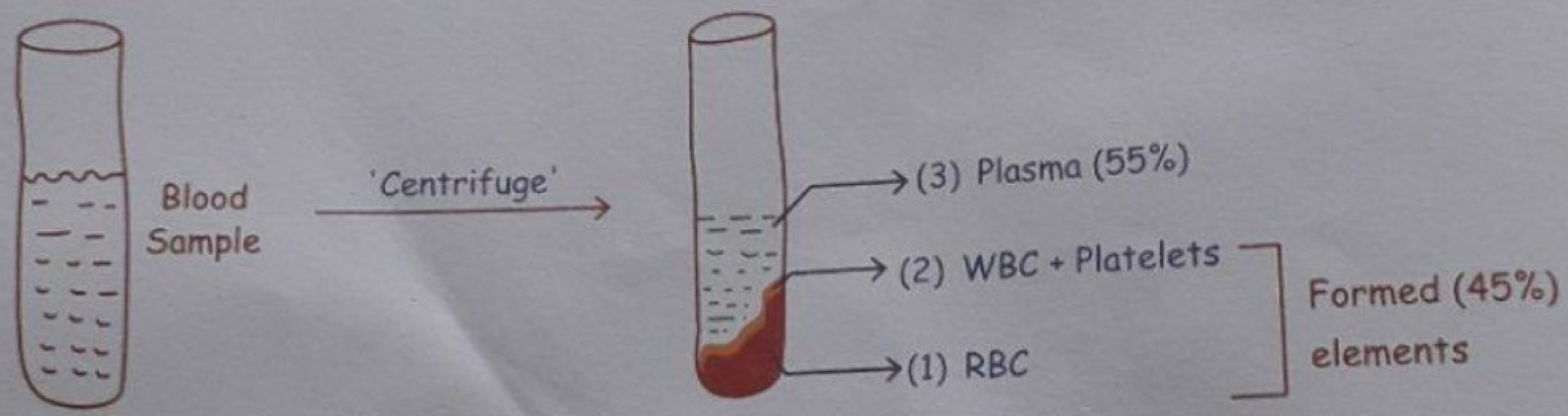


Figure: Blood Vessel

Blood
- Plasma (Fluid) (55%) → Outside cell (Extracellular Matrix/ Substance)
- Formed elements (45%)
  - Blood cells
    - RBC — Red Blood cell/ Erythrocyte
    - WBC — White Blood cell/ Leucocyte
  - Blood platelets/ Thrombocytes



Centrifuge tube

After centrifugation

1. **Plasma: (55%)**

- (i) Water: (90-92%)
- (ii) Proteins (6-8%) →
  - (a) Albumin: → Maintains Osmotic Balance
  - (b) Fibrinogens & Prothrombin
    - help in Blood Clotting
    - Present in Inactive form
  - (c) Globulins
    - α, β → transport of vitamins
    - γ → Antibody/Immunoglobulin
      - helps in defense mechanisms.
      - produced by a type of WBC : plasma B-cell
- (iii) Other Solutes:
  - Ions: Na^+, Cl^-, HCO_3^-, K^+, Mg^{2+}, Ca^{2+} etc
  - Excretory product: Urea
  - Gases: O_2 & CO_2
  - Nutrients: Glucose, amino acids etc present in transit state
  - Hormones

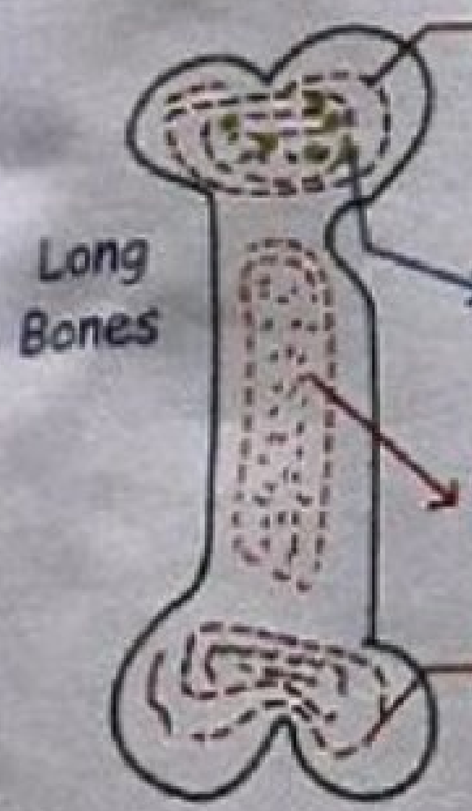
NOTE: * SERUM: Plasma - Clotting factor

2. **Formed elements** (45%): (A) BLOOD CELLS

(1) RBC/Erythrocytes:

(i) Number.: 5-5.5 Million/mm³ Blood

RBC		Platelets		WBC
5-5.5 million/mm³ blood	>	1.5-3.5 lakh/mm³ blood	>	6000-8000/mm³ blood



Long Bones

→ Red Bone Marrow (end)

→ Stem cells (capable of forming different formed elements)
- → RBC Formed
- → WBC Formed
- → Megakaryocyte → Platelets formed

→ Yellow Bone Marrow

→ Red Bone Marrow (end)

(ii) Formation:

ERYTHRO (RBC) POESIS (formation)

Early embryonic stage: Yolk sac

Late Embryonic stage: Liver, Spleen

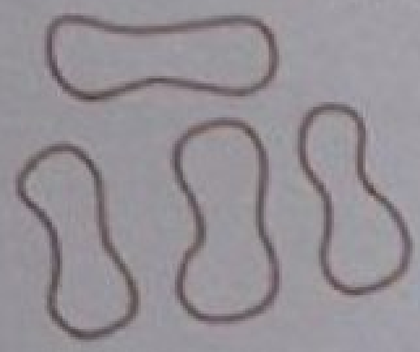
Adult: Red Bone Marrow

(iii) **Shape:** ○ Circular, Biconcave

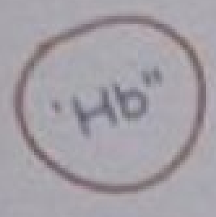
○ Enucleated : No Nucleus

→ Mature RBC

→ So that the entire space is available for 'Hb': Haemoglobin



'Side view'



'Top' view

○ No Cell organelles (Mitochondria X)

→ Hence, RBC show Anaerobic Respiration.

(iv) **Life span:** 120 days

→ Graveyard of RBC: SPLEEN

(v) **Function:** Transport of gases.

(2) LEUCOCYTES (WBC):

1. **Number:** 6000-8000/mm³ Blood
2. **Formation:** Red Bone marrow

→ $\underbrace{\text{Leuco}}_{\text{WBC}}\ \underbrace{\text{poesis}}_{\text{formation}}$

WBC/Leucocytes

→ $\underbrace{\text{A}}_{\text{absence}}\underbrace{\text{granulo}}_{\text{granule}}\underbrace{\text{cytes}}_{\text{cells}}$ (Agranulocytes)

→ Monocytes

→ Lymphocytes

→ No granules

→ $\underbrace{\text{Granulo}}_{\text{Granules}}\underbrace{\text{cytes}}_{\text{cells}}$ (Granulocytes)

→ Neutrophils

→ Eosinophils

→ Basophils

→ Presence of Granule

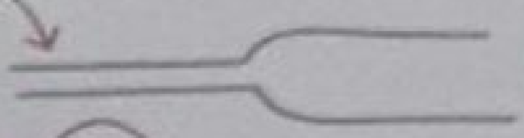
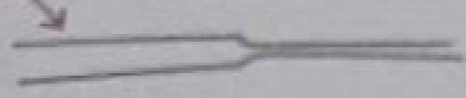
TYPES OF WBC:

○ **GRANULOCYTE**

Characteristic	Neutrophil	Eosinophil	Basophil
(i) Number	Maximum (60-65%)	(2-3%)	Least (0.5-1%)
(ii) Appearance	 → Nucleus ↓ multilobed Nuclei (3-5)	 → Headphone Shaped Nuclei	 'S' shaped Nuclei
(iii) Formation	←	Red Bone Marrow	→
(iv) Function	$\underbrace{\text{Phagocytic}}$ in Nature → perform Phagocytosis	○ Number increases during Helminths (worms) infection or parasitic infection ○ Number increases during Allergy (Antiallergic)	○ Involved in Inflammatory reactions just like mast cells

NOTE

- **Phagocytosis**: The process of engulfing the foreign agents & destroying them.
  → Neutrophils

- **Inflammation** (Basophils)
  → Involves 'Redness Swelling'
  → Secretes
  - ① HISTAMINE  Vasodilation
  - ② SEROTONIN  Vasoconstriction
  - ③ HEPARIN → Anticoagulant ($\underbrace{\text{Anti}}_{\text{Opposite}}\underbrace{\text{coagulant}}_{\text{Clotting}}$)

- **Antiallergic** (Eosinophil)

  Allergic reaction → Inflammation occurs
  ↓ during this
  Eosinophil (anti-allergic) → $\boxed{\text{Histamine} \uparrow}$
  ↓
  It secretes antihistamine substances like HISTAMINIDASE

- **AGRANULOCYTE**

Characteristic	Monocyte	Lymphocyte
(1) Number	6-8%	20-25%
(2) Appearance	 → horse-shoe shaped Kidney/Bean shaped Nuclei largest WBC	 → Round Nuclei
(3) Formation	← Bone Marrow	→
(4) Function	Phagocytic in Nature	Involved in providing Immunity

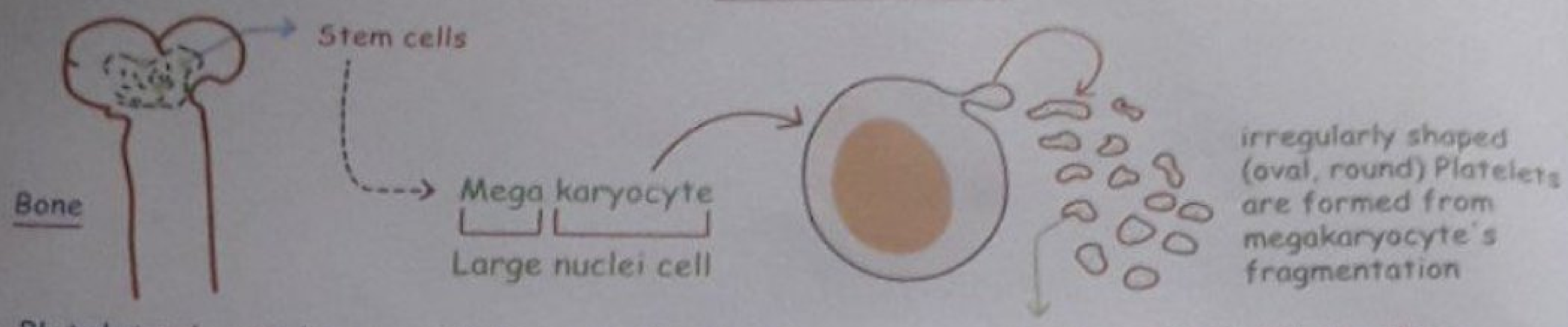
NOTE

Lymphocytes

- B-Lymphocyte/B-cell
  - Plasma B-cell → Secretes Antibody
  - Memory B-cell
- T-Lymphocyte/T-cell
  - killer T-cell /Tc (Cytotoxic T-cell)
  - T_H (Helper T-cell)
  - T_S (Suppressor T-cell)
  - Memory T-cell

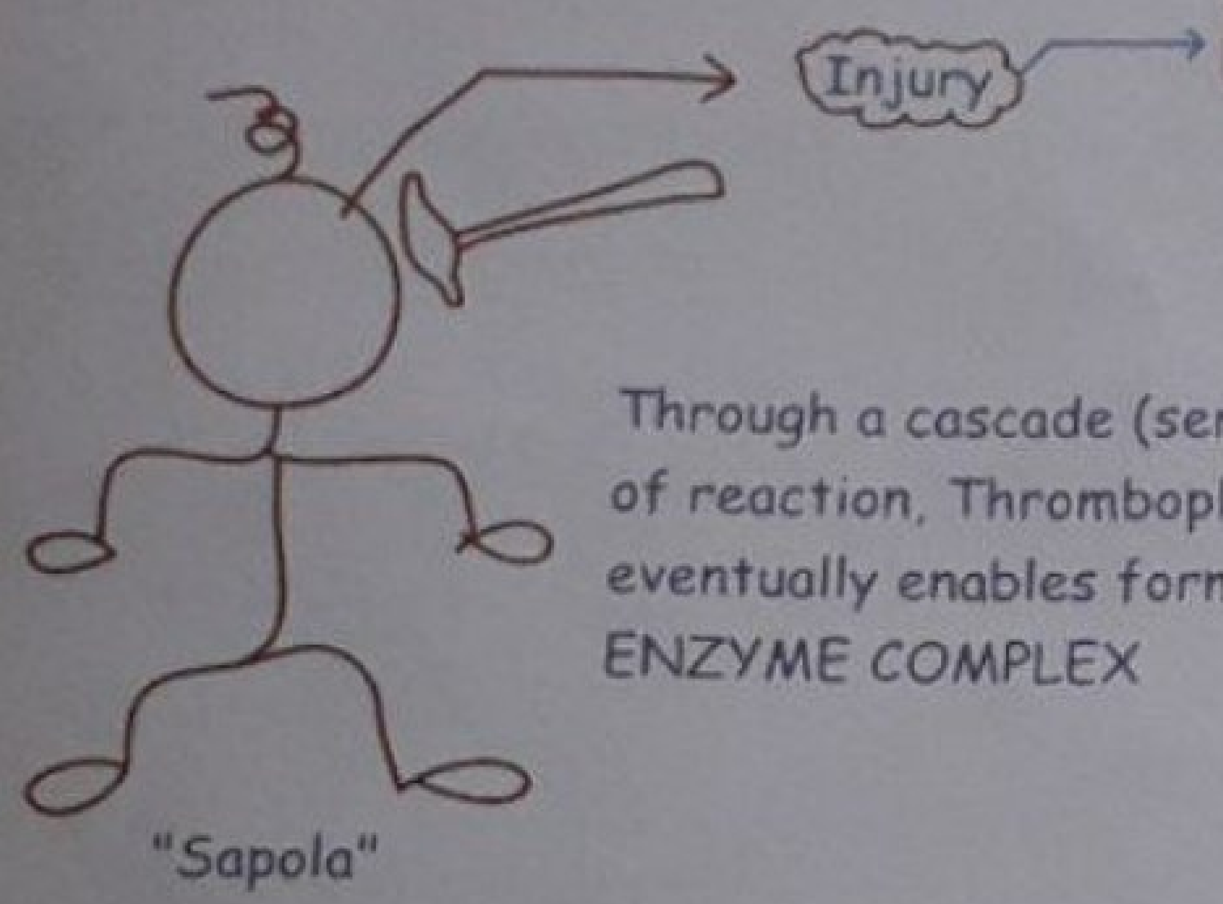
BLOOD PLATELETS/THROMBOCYTES

- Number: 1.5-3.5 Lakh/mm^3 Blood
- They are cellular fragments formed from MEGAKARYOCYTE



- Platelets do not have nuclei but are filled with THROMBOPLASTIN which helps in CLOTTING
- Lifespan : 1 week

BLOOD CLOTTING/COAGULATION OF BLOOD:



Injury → Tissue injured → Produce THROMBOPLASTIN

THROMBOPLASTIN → attract Blood Platelets → Secretes → More THROMBOPLASTIN

Through a cascade (series) of reaction, Thromboplastin eventually enables formation of ENZYME COMPLEX → THROMBOKINASE

$$\text{Prothrombin (Inactive)} \xrightarrow{Ca^{2+}} \text{Thrombin (Active)}$$

$$\text{Fibrinogen (Inactive)} \xrightarrow{Ca^{2+}} \text{FIBRINS (Active)}$$

Fibrin →

(dead Formed elements trapped)

It is the network of threads of FIBRIN: CLOT/COAGULUM.

BLOOD GROUPING

- ABO grouping
- Rh-grouping

(I) ABO grouping

BLOOD GROUP	ANTIGEN ON RBC	ANTIBODY IN PLASMA	DONAR
A	RBC — A-antigen, Surface	Anti-B (antibodies against B)	A, O
B	RBC — B-antigen	Anti-A	B, O
AB	RBC — A antigen, B-antigen	'No-Antibodies'	A, B, AB, O
O	RBC — no antigen	anti-A, anti-B	O

Q. HOW TO KNOW WHO CAN BE THE DONAR ?

Point to remember Donar (Check antigen) Recipient (Check antibody)

If they match: CLUMPING will Occur, So donation can't be done

NOTE

Antigens: Proteins, Glycoprotein substances.

- Foreign → against this Body produces Antibodies
- "Self antigens" → Present in our own body cells & body does not make antibody against it

NOTE

AB: universal Recipient
O: universal Donor

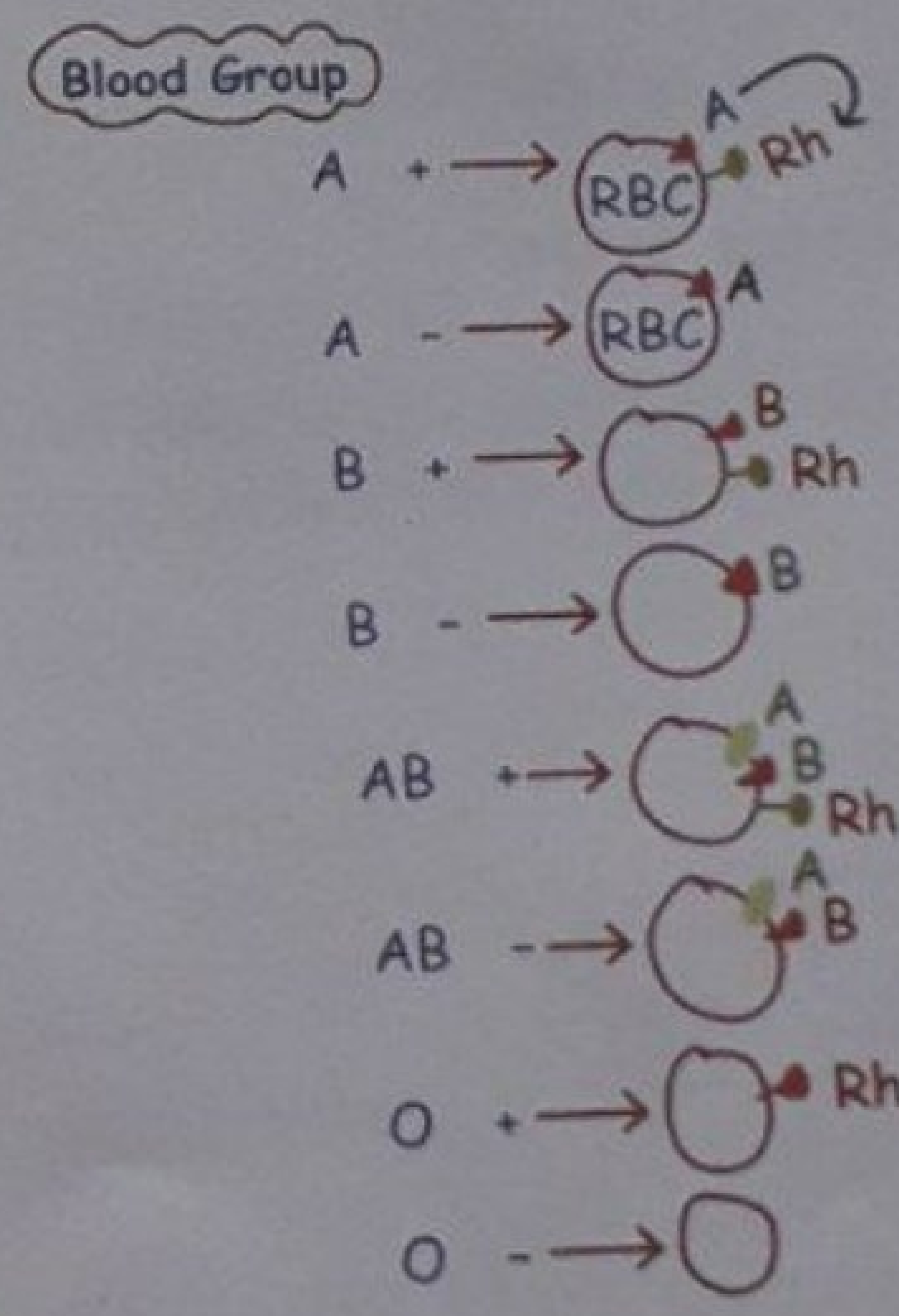
(II) Rh grouping:

→ similar to the one found in the rhesus monkeys.

'Rh': 'Rhesus' factor

Rh factor → It is also a surface antigen found on RBC (mostly) → 80% humans

- Present → Rh'+'
- Absent → Rh'-'



NOTE

- Unlike ABO grouping, 'Rh' antibodies are not pre-found in the 'Rh-' person's plasma. It is only developed when the person comes in contact with 'Rh-antigen'

- When you come in contact with 'FOREIGN ANTIGEN', body synthesises Antibodies against it to protect you.

Erythroblastosis Foetalis/Haemolytic Disease of Newborn

- A special case of Rh incompatibility is observed between Rh (-) mother and Rh (+) foetus

Mother (Rh-) ⟶ 1^{st} Pregnancy ⟶ Foetus (Rh+)

Placenta is there which act like a Barrier to prevent the mixing of Maternal & foetal Blood

↓

After Delivery

↓

Umbilical cord is cut (has foetal Blood)

↓

(Mother comes in contact with Rh+ Blood of foetus)

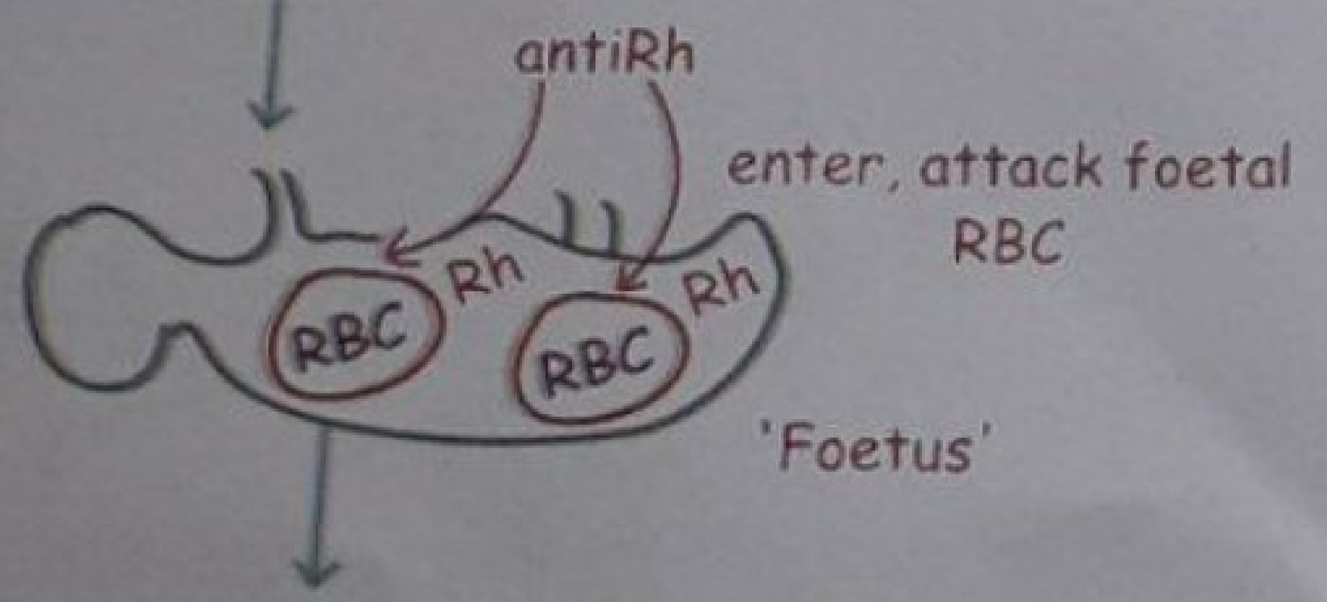
↓

She, now develops anti Rh antibodies

Mother Rh (-) ⟶ 2nd Pregnancy ⟶ Foetus Rh(+)

Now she has 'antiRh'

This time due to the small size of 'anti Rh' antibody in mother, it can easily cross placenta barrier & reach foetus



As the antiRh attack foetal RBC, it causes its destruction leading to Anaemia, Jaundice & in severe cases it can be fatal (DEATH)

NOTE

- How can Erythroblastosis be PREVENTED?

Mother (-) ⟶ After 1^{st} Delivery

If 'antiRh' antibodies are given to the mother from outside, this can be prevented

↓

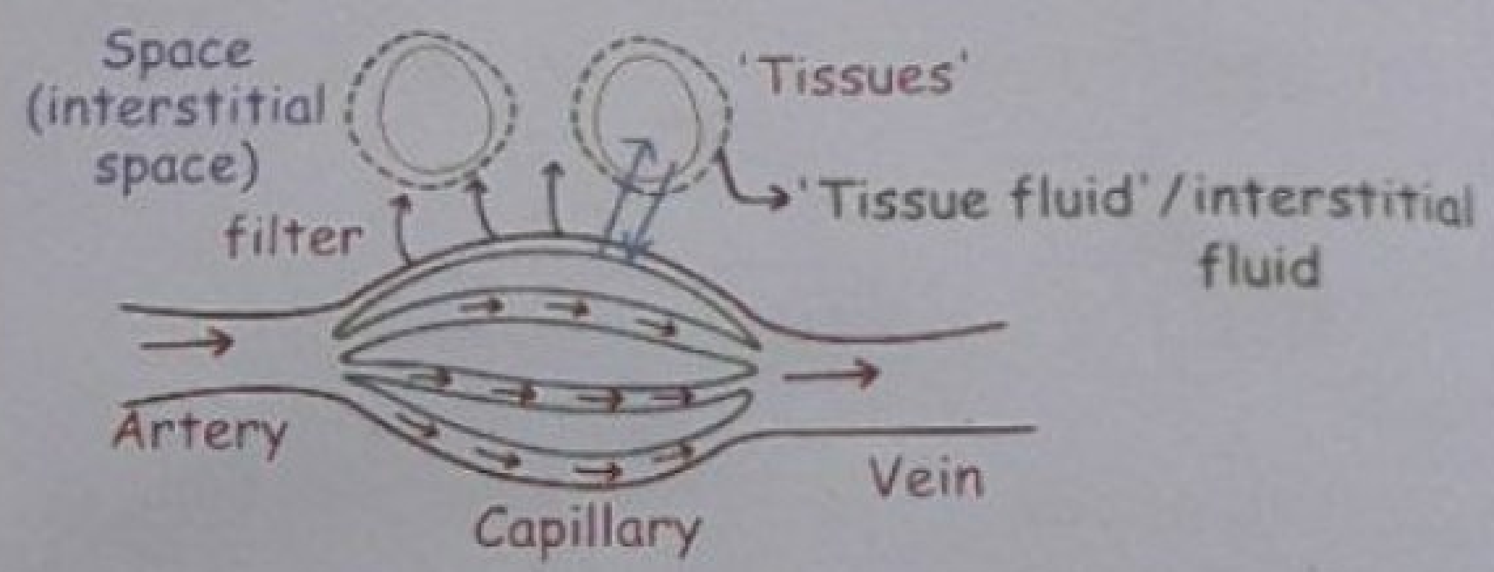
(1) If we do not allow the mother to come in contact with Rh-antigen of 1^{st} baby after 1^{st} delivery, mother will never generate anti Rh antibody on her own, so no MEMORY cells/antibodies will be present for future

(2) As soon as 1^{st} delivery occurs, we give 'antiRh antibody' to the mother so that these can kill all the Rh RBC of the first foetus & No contact occurs with mother's Blood, so no memory cells developed.

LYMPH (TISSUE FLUID)

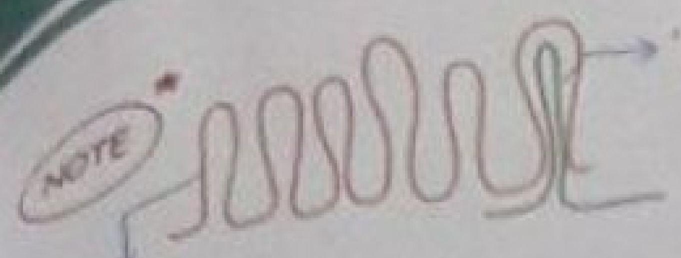
- As the blood passes through artery & then capillary, some portion of it gets filtered out to accumulate around tissue spaces: tissue fluid/lymph

Lymph = Blood- (Large Protein + RBC + Platelets)



Function

- Tissue fluid act as 'MIDDLE MEN' for the transfer of nutrients, gases from Blood to tissue & remova of wastes from Tissue to Blood
- Also an important carrier for Hormones, nutrient
- **Lymph** keeps on circulating with help of lymphati system which contains Lymphatic capillarie lymphatic vessels, ducts, lymph node etc, eventual it is drained back into blood.

NOTE


'Lacteal' lymphatic capillary of small intestine, here fatty acids are absorbed.

(villi) → finger Like projection → Small intestine

CIRCULATORY PATHWAYS

Circulatory System:

OPEN CIRCULATORY SYSTEM

- Here, Blood passes through Blood vessel not bounded by capillaries instead it is being dumped into open CAVITY OR SINUS
- eg: Arthropods, most of Molluscs, etc

CLOSED CIRCULATORY SYSTEM

- Here there is a closed network of blood vessels bounded by Capillary network
- eg: Chordates

Heart

- Heart → chambers → Atrium (Small) (A); → Ventricle (Large) (V)

I) 2 Chambered Heart → eg: fish

1 A
1 V

Circulation: SINGLE CIRCULATION OCCURS

Heart (Venous Heart) → deoxygenated Blood pump → 'GILLS'/Here Oxygenation occurs → OXYGENATED BLOOD → TISSUE

II) 3 Chambered Heart

dO_2 Blood → Right Atrium; O_2 Blood → Left Atrium

RA	LA
ventricle	

(MIXING)

eg: Amphibians, Reptiles Except Crocodile, Alligator (4)

- MIXED CIRCULATION/INCOMPLETE DOUBLE CIRCULATION OCCURS

dO_2 Blood → RA
O_2 Blood → LA
] Mixed into common VENTRICLE → MIXED BLOOD PUMP

III) 4 Chambered Heart → eg: Aves, Mammals

dO_2 Blood
O_2 Blood

RA	LA
RV	LV

2 Atria
2 Ventricle

DOUBLE CIRCULATION → Explained later

HUMAN HEART, CONDUCTING SYSTEM OF HEART

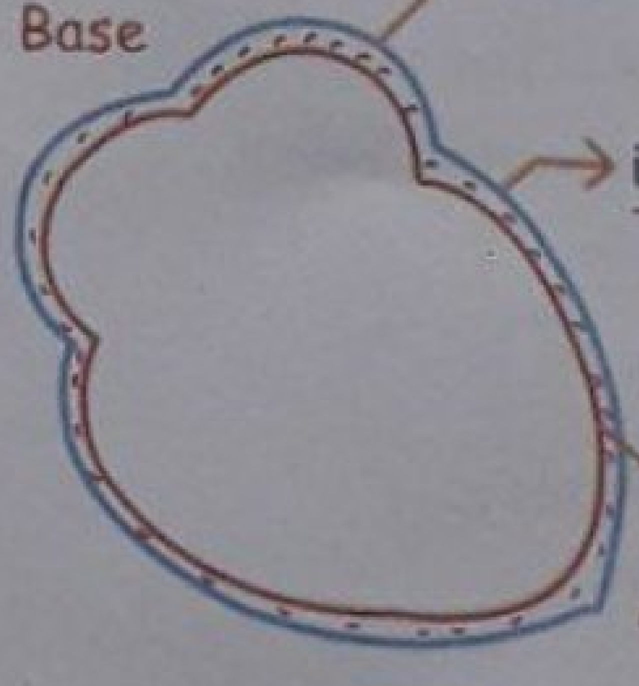
Human Circulatory System

- 4 Chambered Heart
- Double circulation

HUMAN-HEART

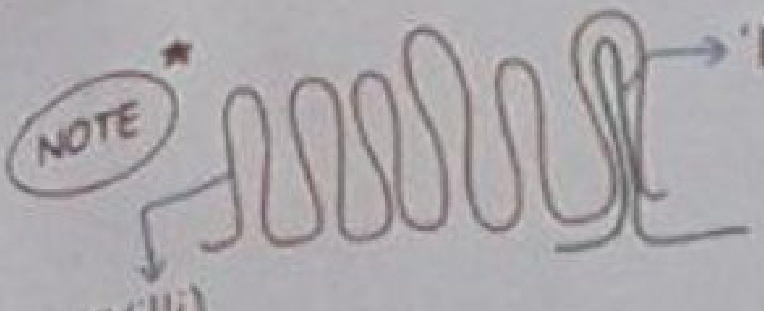
Origin: MESODERMAL

Location: Between lungs, slightly tilted towards left



Outer Layer: Parietal Pericardium
inner: Visceral Pericardium
→ Pericardial fluid (reduces friction)

NOTE*



'Lacteal' → lymphatic capillary of small intestine, here fatty acids are absorbed.

(Villi)
↓
finger Like projection
↓
Small intestine

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Heart (Venous Heart) → deoxygenated Blood pump
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'GILLS'/Here Oxygenation occurs
↓
OXYGENATED BLOOD → TISSUE

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ventricle	

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O_2 Blood → LA
Mixed into common VENTRICLE
↓
MIXED BLOOD PUMP

(III) 4 Chambered Heart → eg: Aves, Mammals

dO_2 Blood, O_2 Blood

RA	LA
RV	LV

- 2 Atria
- 2 Ventricle

DOUBLE CIRCULATION → Explained later

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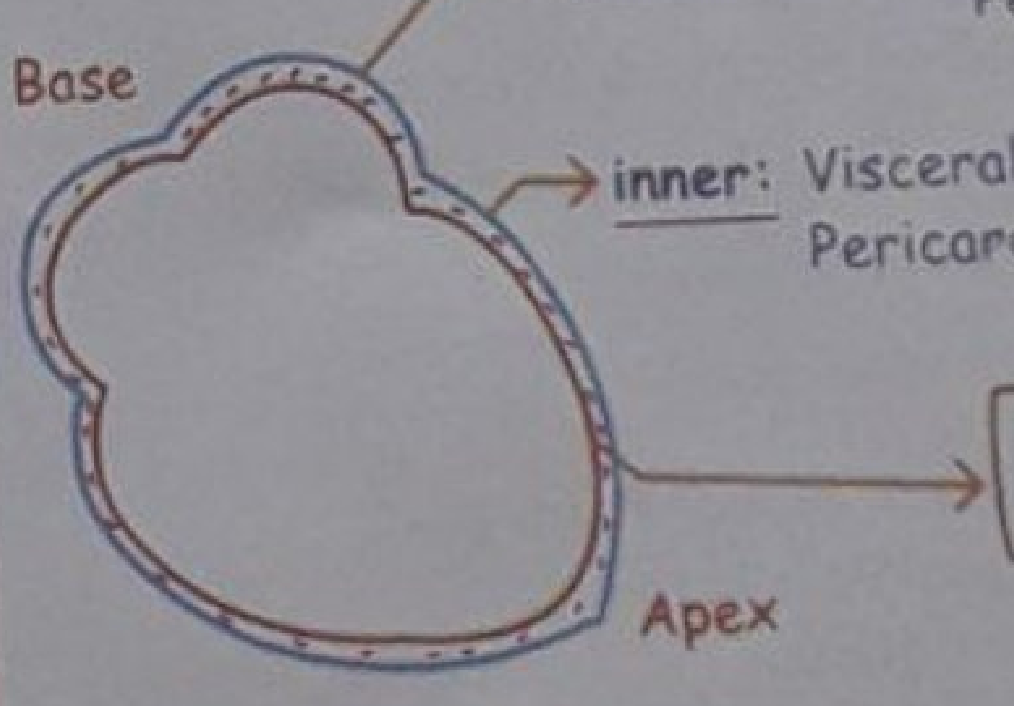
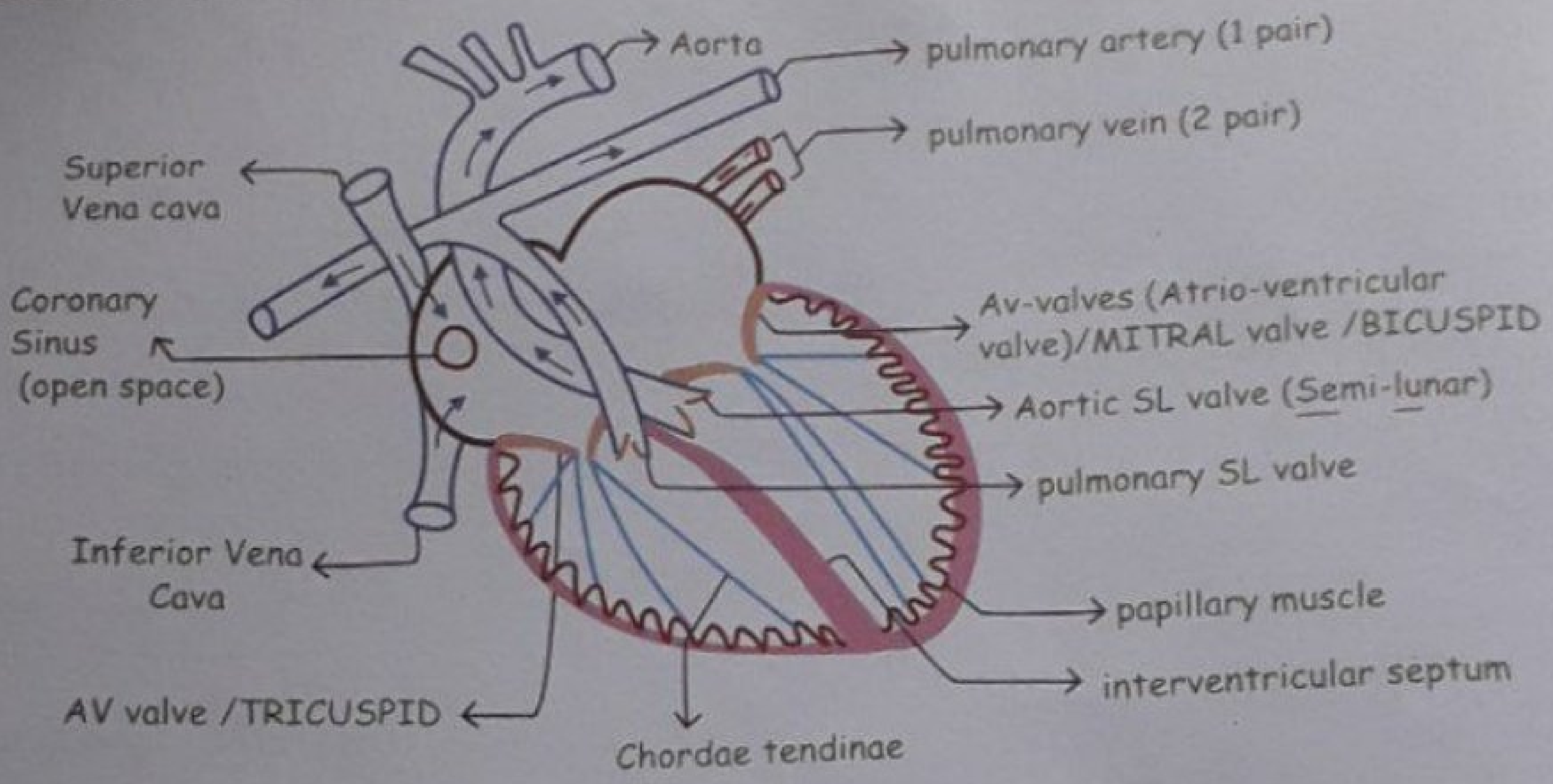


Outer Layer: Parietal Pericardium
inner: Visceral Pericardium
→ Pericardial fluid (reduces friction)

Internal Structure of Heart



Some Important points

- Chambers are separated by wall called 'SEPTA'

'SEPTA'
- → **BETWEEN ATRIA:** Interatrial
- → **BETWEEN VENTRICLES:** Interventricular
- → **BETWEEN ATRIA & VENTRICLES:** Atrioventricular

RA	LA
RV	LV

- → Inter atrial septa (THIN) → Muscular wall
- → atria-ventricular septum → Fibrous tissue — THICK
- → inter-Ventricular septum → Muscular — THICK

(1) RIGHT SIDE of Heart: deoxygenated Blood

(2) LEFT SIDE of Heart: oxygenated Blood

(3) SVC (Superior vena cava)
IVC (Inferior vena cava)

Collect deoxygenated Blood from upper & lower Body part respectively, dumps into the right atrium.

(4) Tricuspid valve ←

RA	LA
RV	LV

→ Bicuspid valve

(5) Papillary muscle: Wall of ventricle

(6) CHORDAE TENDINAE: Fibres attached to AV. valves & papillary muscles. It prevents backward movement of AV-valve.

(7) LEFT ventricle's wall is thicker as compared to RIGHT since it has to supply Blood to the whole body parts.

CONDUCTING SYSTEM OF HEART

- Heart is made up of CARDIAC MUSCLES (95%) along with some special muscle fibres (NODAL TISSUE) that are 'AUTOEXCITABLE'

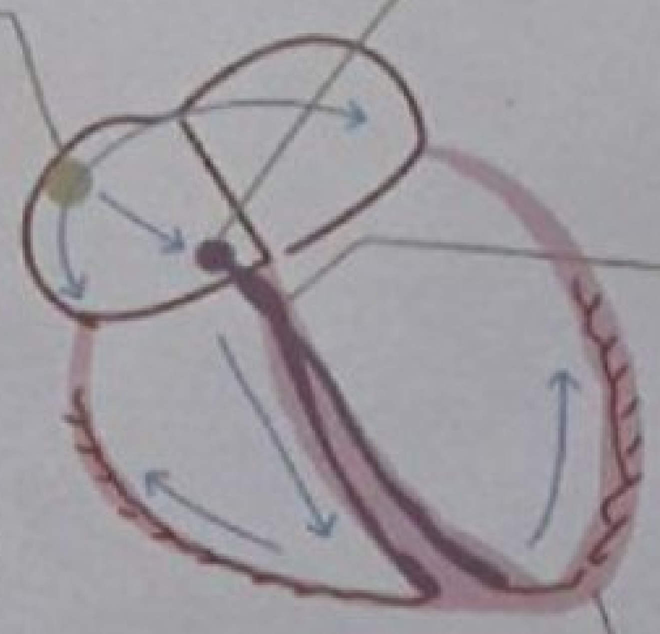
Beacuse these muscle fibers can excite (Depolarise), Repolarise on its own.

Human Heart: MYOGENIC HEART

Our heart can INITIATE the heart beat on its own without inputs from Nervous system

1. SAN

- Sino-atrial node
- Located: TOP RIGHT CORNER, of RA
- 'PACEMAKER'
  ↳ Maintains the pace of heart beat
- It can be depolarised 70-75 times/min means 70-75 times action potential/min



2. AVN

- Atrio-ventricular Node
- Lower left corner of RA
- generate action potential 60-65 times /min (अतिरिक्त Gyaan)

3. BOH/AV BUNDLE

- Arises from AVN & immediately divides into left & Right AV Bundle

→ AV Bundle Left & Right Bundle

Bundle of HIS (BOH)
↳ can generate Action Potential
↳ 40-50 times /min (अतिरिक्त Gyaan)

4. Purkinje Fibre (PF)

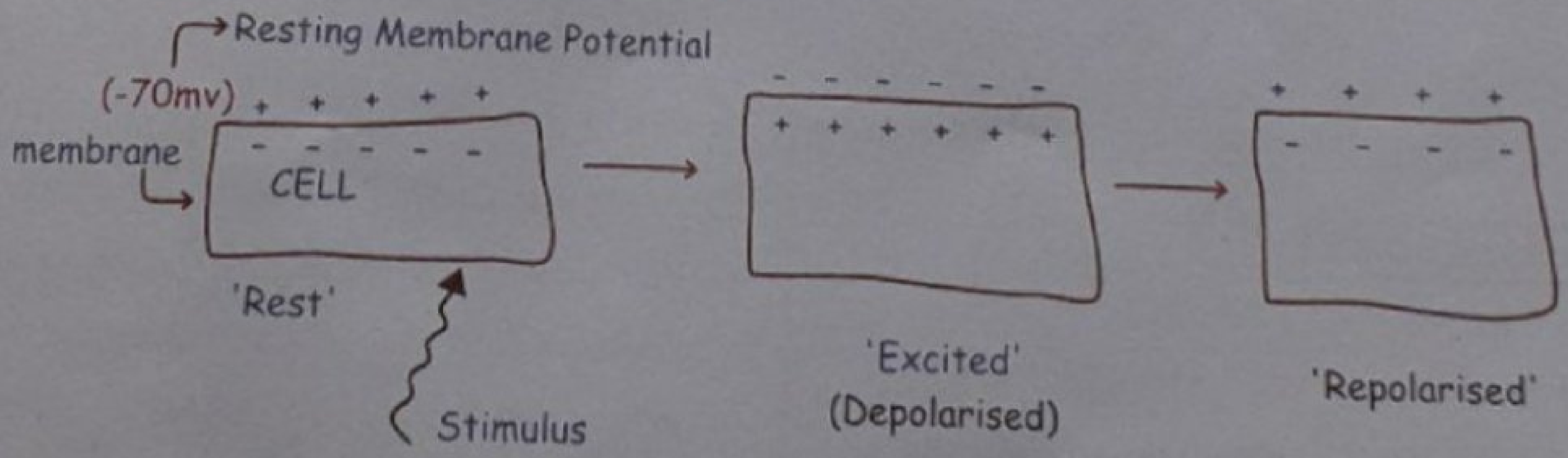
- Located: wall of ventricle
- can generate action potential: 20-25/ times (अतिरिक्त Gyaan)

SAN (depolarised) → Signals Both ATRIA
↳ Depolarisation of atria occurs

↓
AVN
↓
BOH
↓
PF → Signals BOTH VENTRICLES
↳ Depolarisation of ventricles occur

Basics (Explained in detail in Neural Control and Coordination)

Stimulus Given → Cell RESPONSE shown → Means → EXCITED



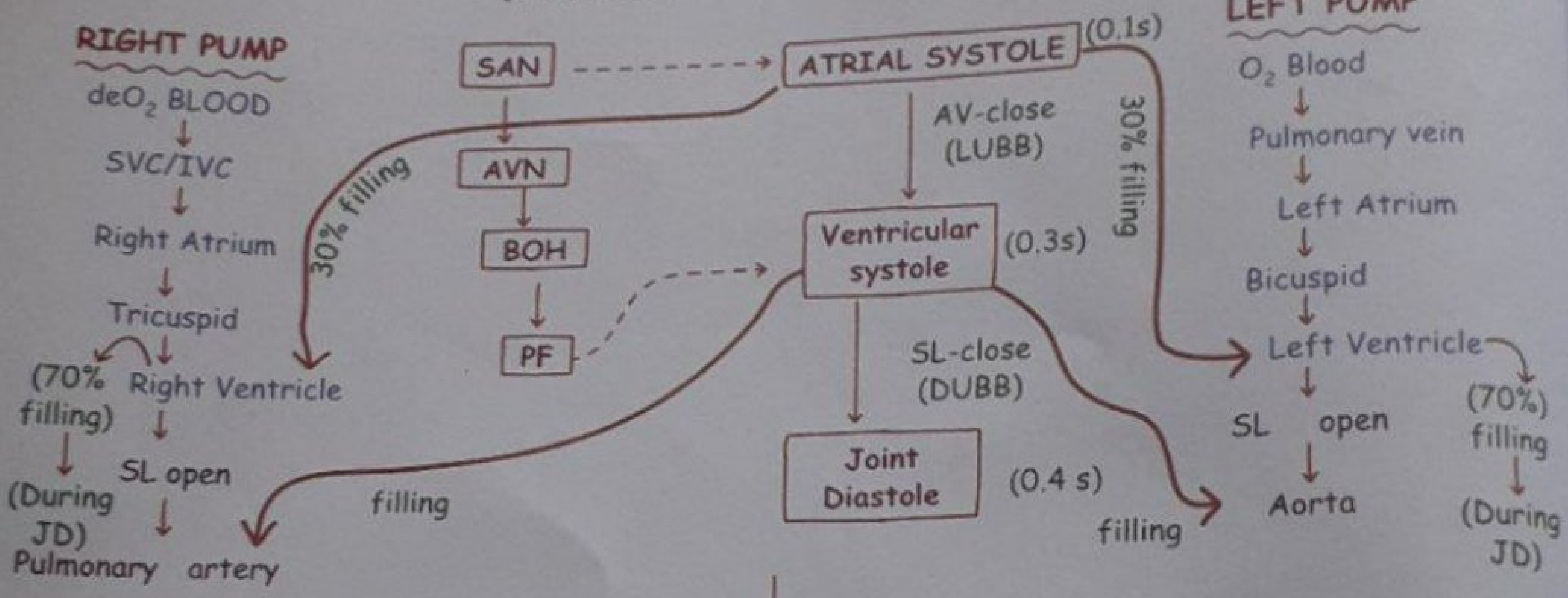
CARDIAC CYCLE

The alternating contraction & relaxation of the atria & ventricles as a sequence in order to pump blood throughout the body

NOTE

'Excited': Depolarise → Leads to CONTRACTION (SYSTOLE)

'Relaxed': Repolarisation → Leads to RELAXATION (DIASTOLE)



NOTE

- **Atrial Systole**: Atrial Contraction
- **Ventricular Systole**: Ventricular Contraction

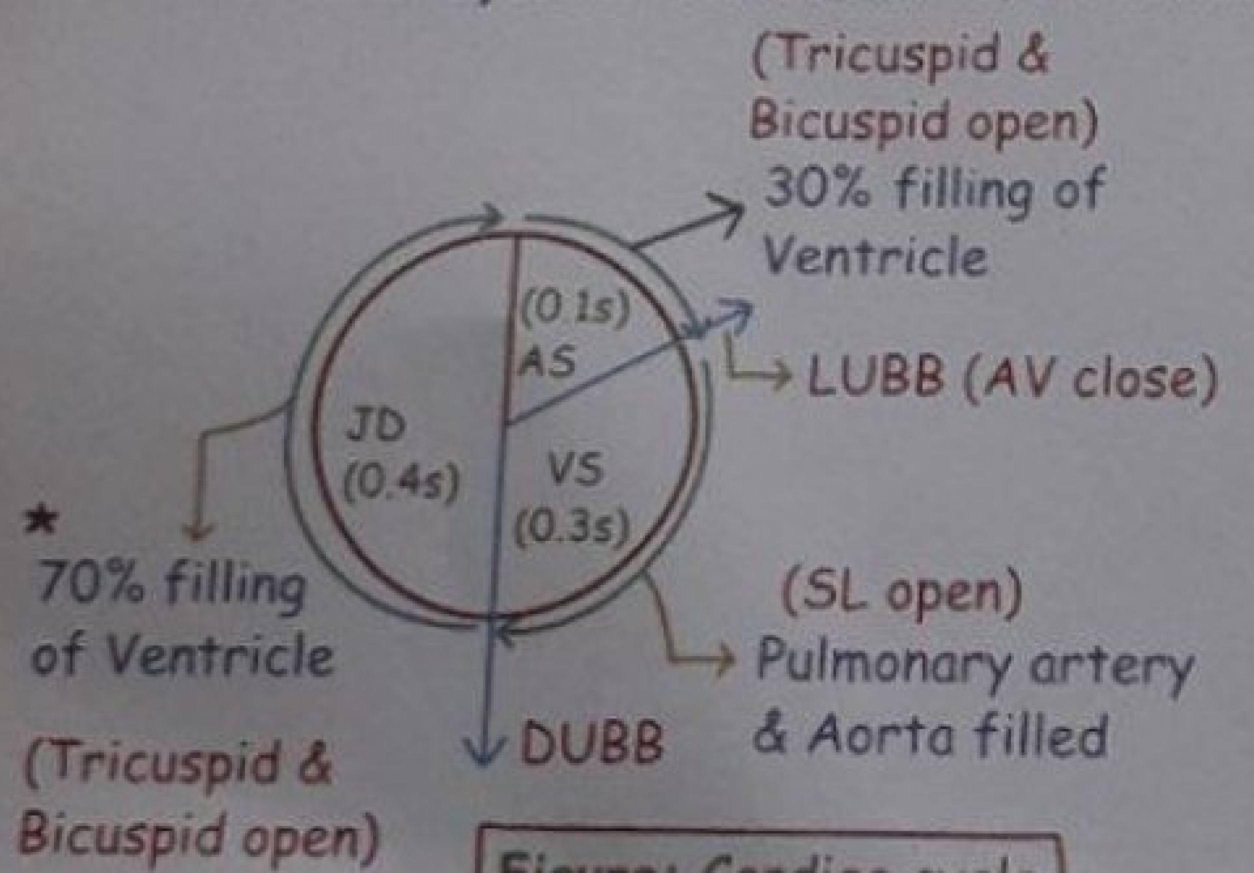


Figure: Cardiac cycle

1 Cardiac cycle = 0.8 s

AS + AD = 0.8s, VS + VD = 0.8s

AS: Atrial Systole AD: Atrial Diastole

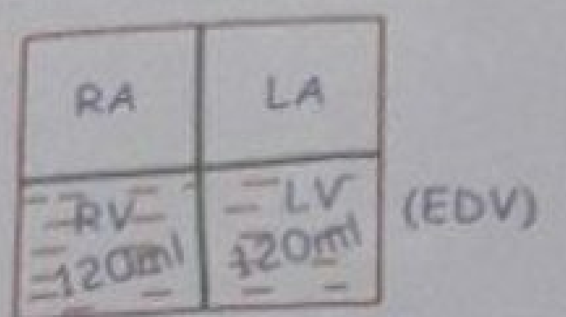
VS: Ventricular Systole VD: Ventricular Diastole

Some Important Points

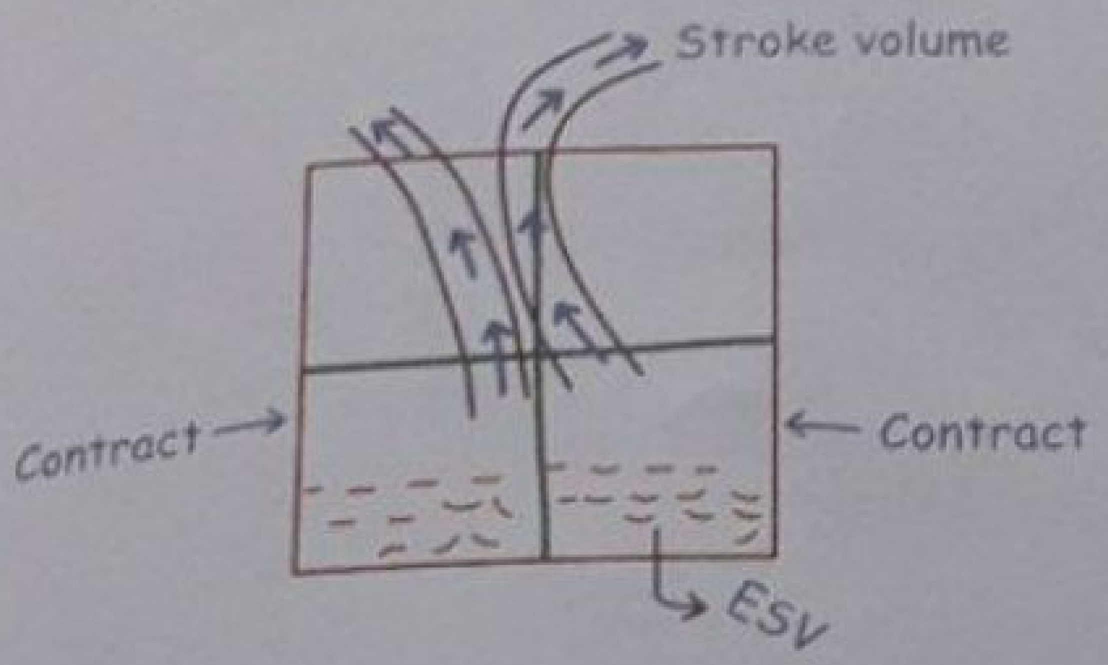
LUBB	DUBB
First heart sound	Second heart sound
Occur due to closure of AV- valve	Occur due to closure of SL- valve

- * When the VENTRICULAR SYSTOLE BEGINS, VENTRICULAR PRESSURE RISES, due to which FIRST CLOSURE of AV-Valve is seen and as the systole continues, further increase in pressure due to which SL-valves are forced OPEN.
- * After Blood moves into Aorta & Pulmonary artery, Ventricular diastole begins, decline in Ventricular Pressure first CLOSES SL Valves, Further decline in Pressure leads to OPENING of AV-valve.

○ EDV (End diastolic volume): The volume of Blood in each ventricle at the end of ventricular diastole (120ml)



○ ESV (End systolic volume): The volume of Blood in each Ventricle at the end of Ventricular systole (~50ml)



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○ SV (Stroke volume): The amount of blood pumped by each ventricle per beat (~70ml). It can vary.

1 Cardiac Cycle = 0.8S : 1 Heart Beat

Stroke volume (Amount of blood pumped by each ventricle /Beat)

Cardiac output (CO) = SV X HR → Heart rate (72 Beat/min)

CO= 70 ml/Beat X 72 Beat/Min

CO = (70 X 72) ml/min

CO = 5040 ml/min

CO = 5L /min → Amount of Blood pumped by each ventricle per minute.

NOTE

○ Body has ability to change stroke volume, also heart rate thereby cardiac output

○ Athletes have much higher cardiac output

ECG: ELECTROCARDIOGRAPH

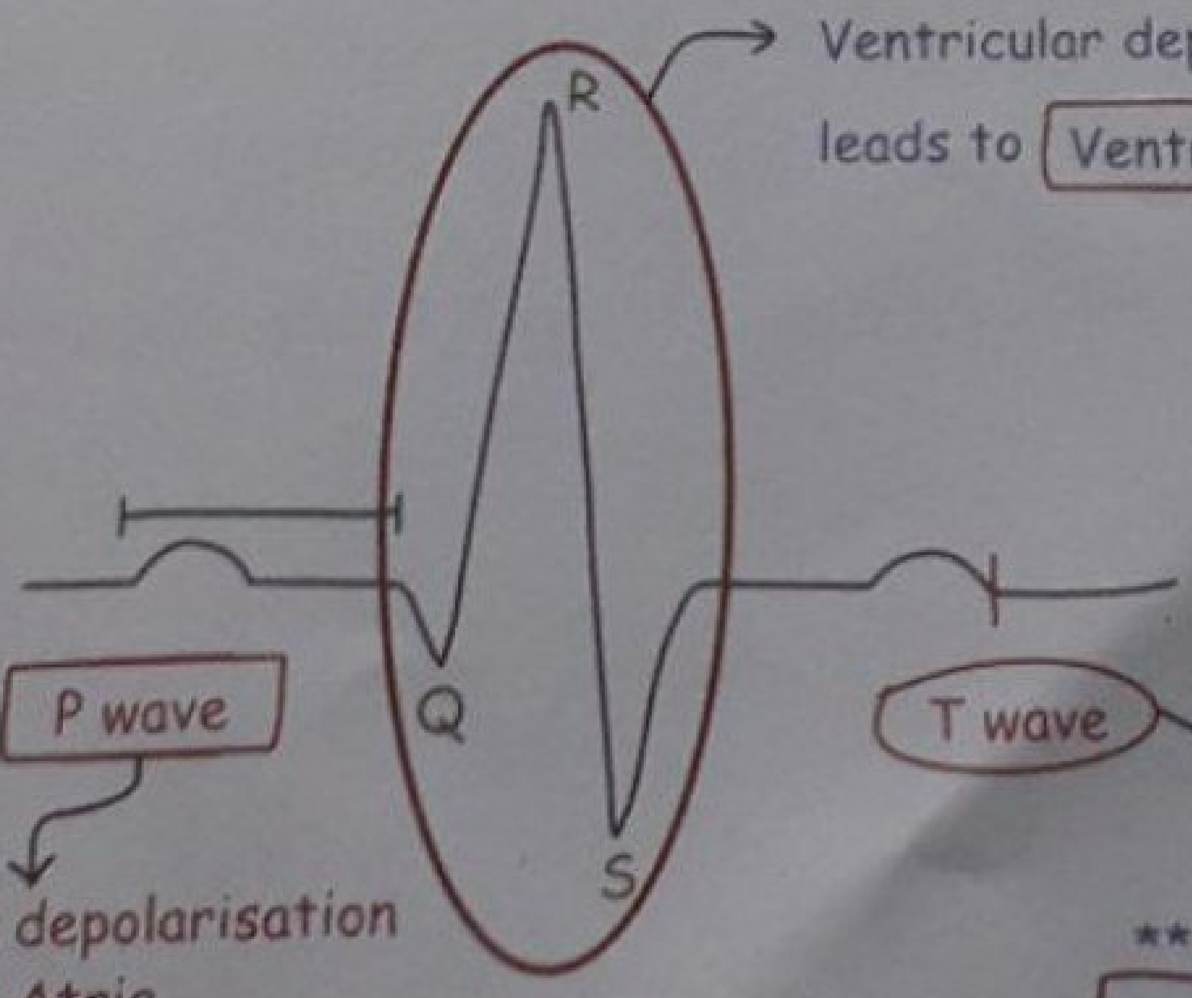
○ To obtain the electrical activity of the heart, there is a device called as 'ELECTROCARDIOGRAPH' which gives a graphical representation of cardiac activity 'ELECTROCARDIOGRAM'

○ To obtain a standard ECG:

3 electrodes used

- One connected to each wrist
- One connected to the left ankle

○ More electrodes can be used further depending upon the condition.



Ventricular depolarisation begins shortly after Q-wave that leads to Ventricular systole → QRS Complex

T wave → represents return of ventricles from excited to Normal state i.e., Repolarisation of ventricles

P wave → represents depolarisation of Atria → leads to ATRIAL SYSTOLE

**

○ End of T-wave represents end of ventricular systole

a

NOTE

- Number of 'QRS' waves in ECG gives the idea about the number of heartbeat of a person in a given time period.
- ECGs of different individuals have roughly same shape for a given lead configuration, any deviation from this may indicate abnormalities or disease

DOUBLE CIRCULATION

**Pulmonary Circulation

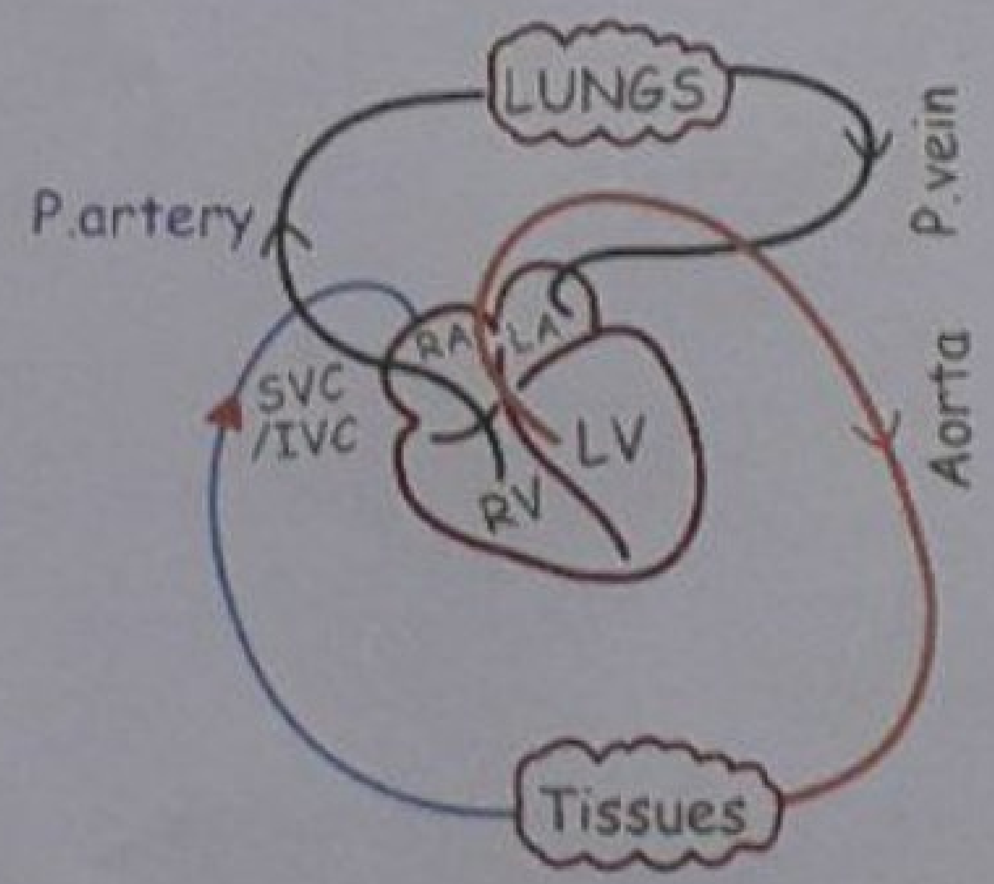
Flow of Blood

Right Ventricle
↓
Pulmonary artery
↓
LUNGS
↓
Pulmonary Vein
↓
Left Atrium

**Systemic Circulation

Flow of Blood

Left Ventricle
↓
Aorta
↓
Tissue
↓
Superior vena cava/
Inferior vena cava
↓
Right Atrium



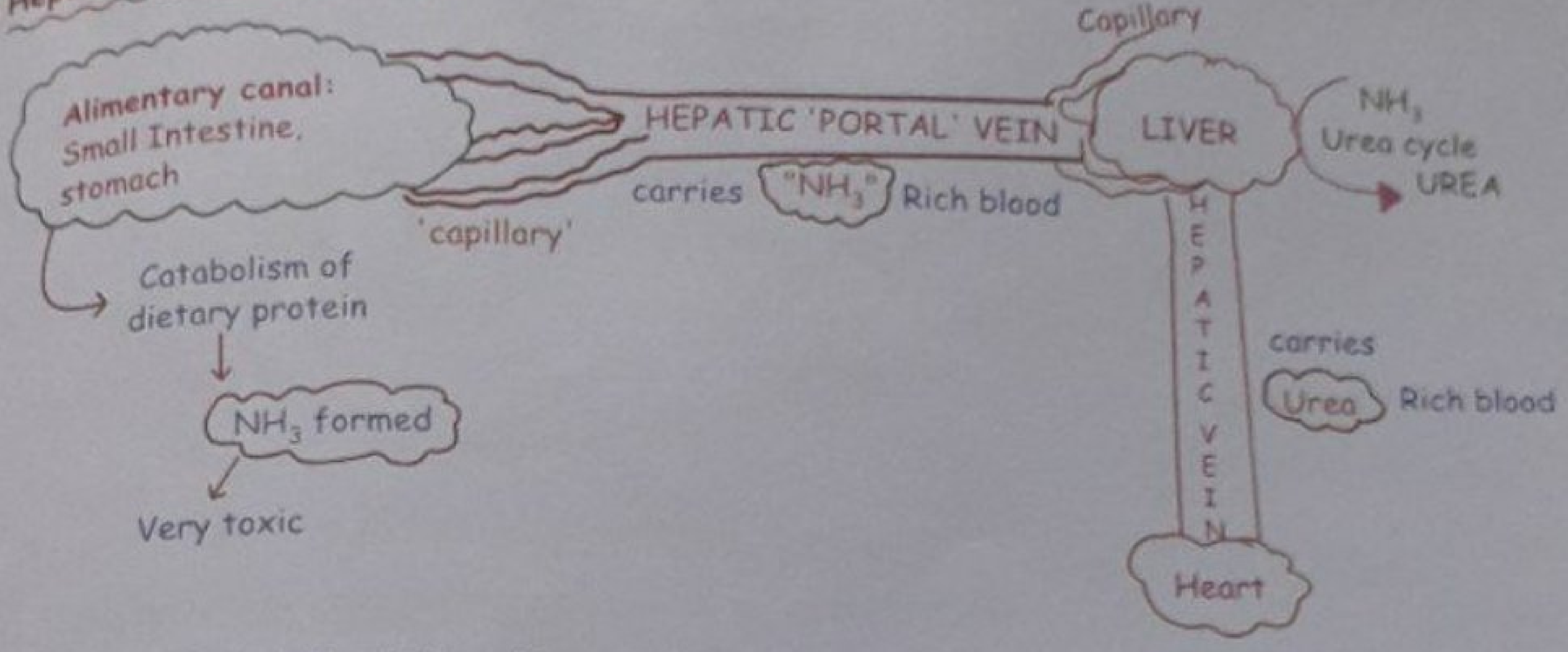
NOTE

Systemic circulation provide nutrients, O_2 & other essential substances to tissue & takes CO_2 & other harmful substances away for elimination

PORTAL CIRCULATION :

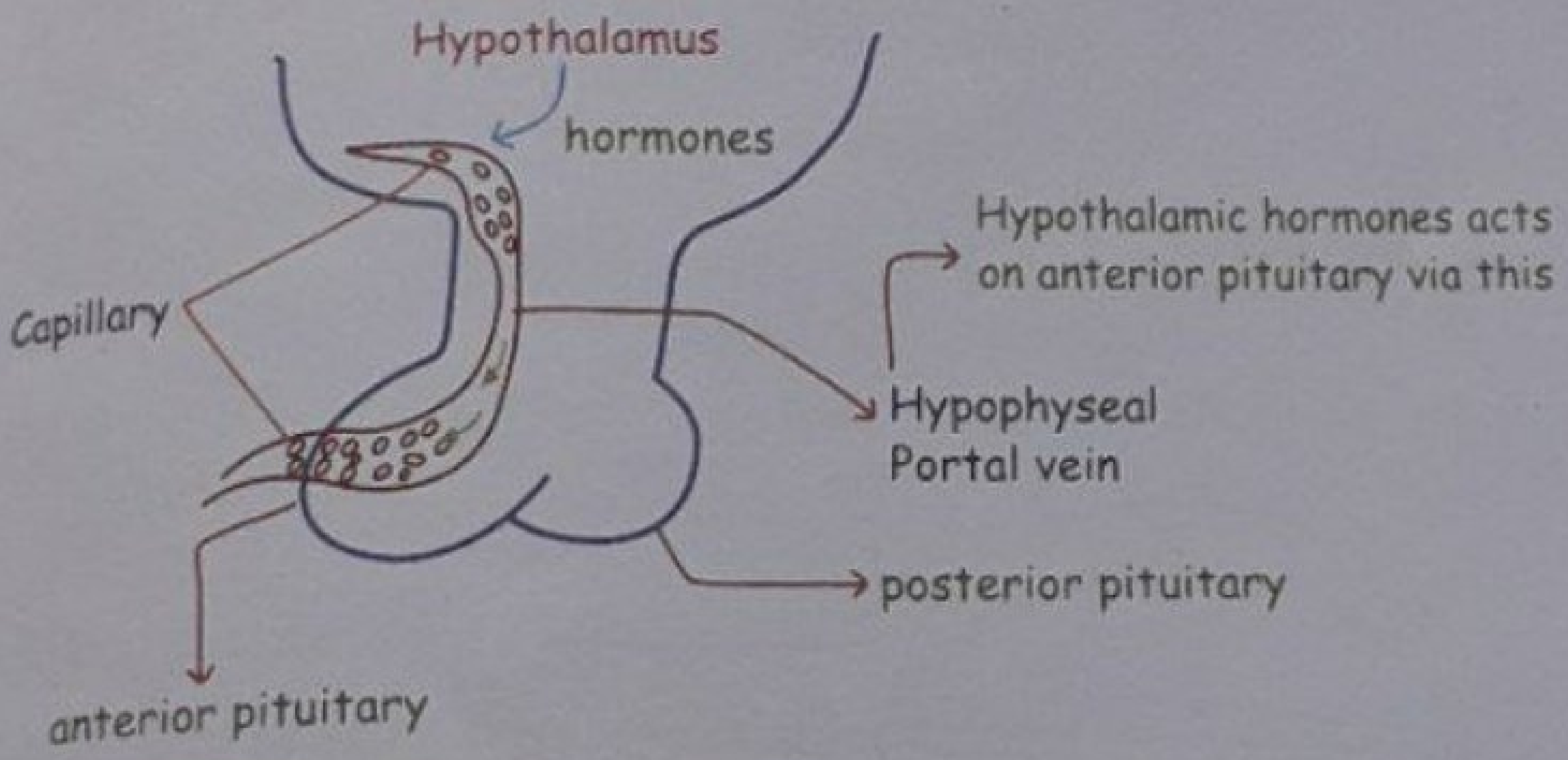
Special connection between 2 organs which starts from capillary & ends with capillary

(1) Hepatic portal circulation



(2) Hypophyseal Portal Circulation: (given in the Chapter-09, Chemical Coordination and Integration)

Hypophysis: Pituitary



CORONARY CIRCULATION: The circulation of heart

- About 10% of blood pumped by heart is required by heart itself

Aorta
↓
O_2 Blood
↓
Coronary Artery
↓
O_2 Blood
↓
Heart MUSCLE
↳ Coronary vein → deO_2 blood → Coronary SINUS

BLOOD VESSEL

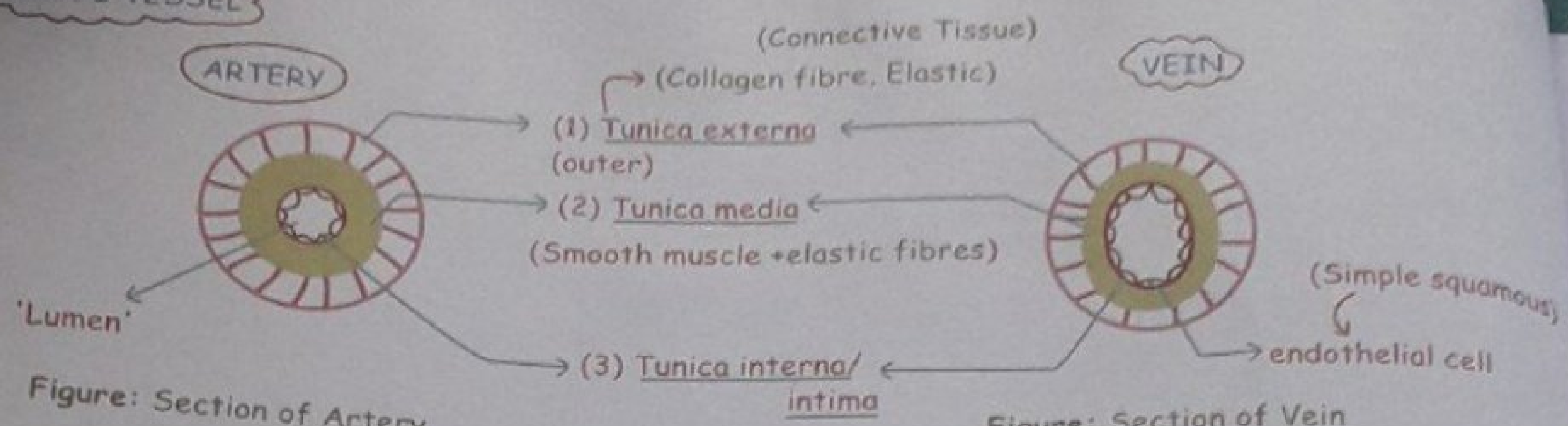


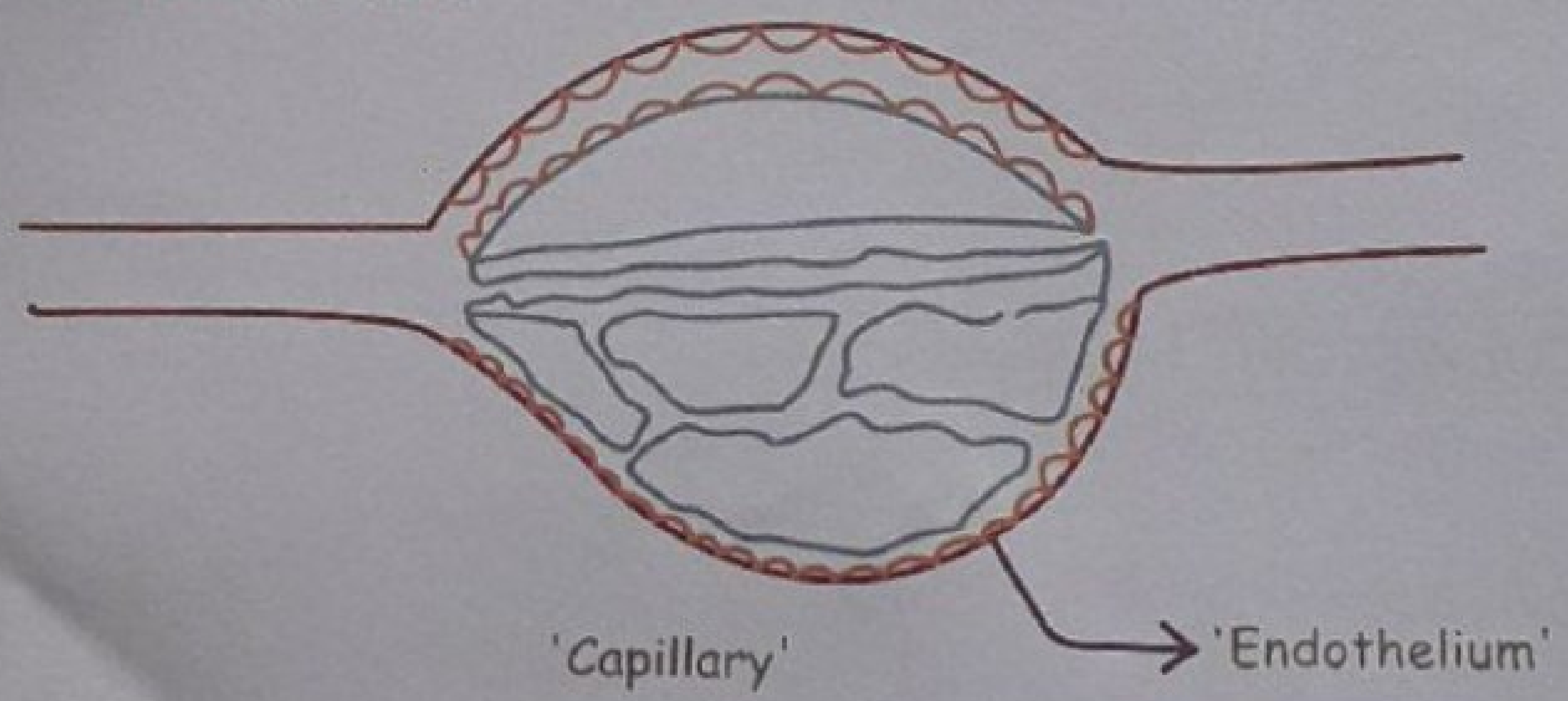
Figure: Section of Artery

Figure: Section of Vein

- Carries blood away from heart
- All artery except pulmonary artery carries O_2 blood
- Arteries deeply seated
- Wall thicker
- Under high pressure
- Lumen small
- No valves

- Carries blood towards heart
- All veins except pulmonary vein carry dO_2 blood
- Veins superficial
- Wall thinner
- Low pressure
- Lumen broad
- Valves are present

Capillary: It is lined by a single layer of Simple squamous epithelium → helps in filtration



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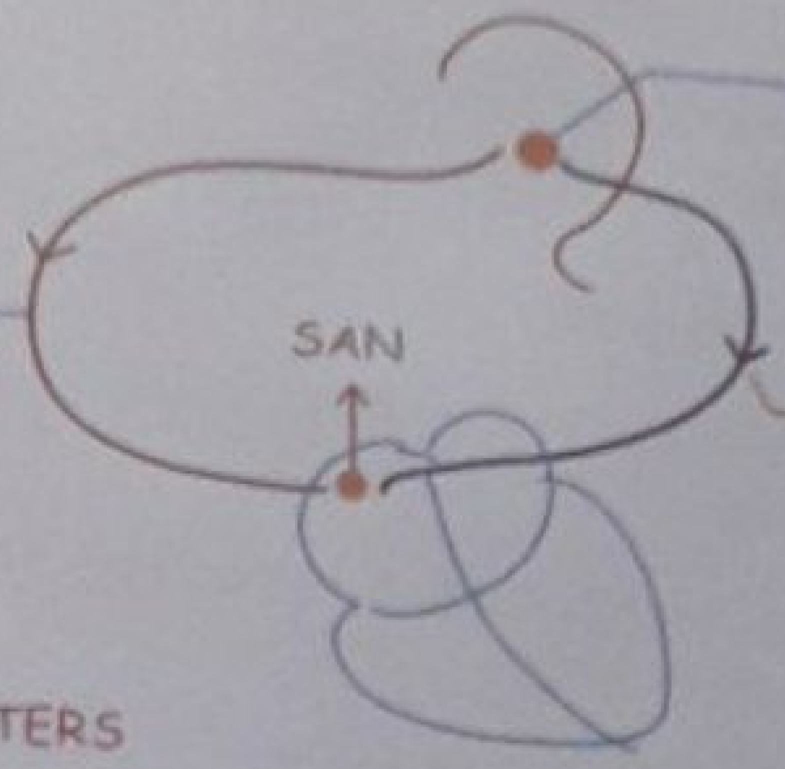
REGULATION OF CARDIAC ACTIVITY

→ Heart Beat regulated → by 'Nervous system'



Medulla (Centre for regulation of Cardiac Activity)

→ It acts via → 'ANS' (Autonomic Nervous System)

Sympathetic Nervous System

↓

acts on SAN

↓

Release NEUROTRANSMITTERS called as EPINEPHRINE/ADRENALINE & 'NOREPINEPHRINE'/'NORADRENALINE'

↓

↑HEART RATE, ↑ CO

Parasympathetic Nervous System

↓

act on SAN

↓

Releases ACETYLCHOLINE

↓

↓ Heart Rate, ↓CO

NOTE

- ANS has 2 branches → Sympathetic Nervous System, → Parasympathetic Nervous System
- Epinephrine & Norepinephrine are also known as EMERGENCY hormone released from Adrenal medulla: ↑ Heart Rate.

DISORDERS

High Blood Pressure (Hypertension):

- Hypertension is the term for blood pressure that is higher than normal (120/80).
- If repeated checks of blood pressure of an individual is $\boxed{140/90}$ or higher, it shows hypertension.
- (High blood pressure leads to heart diseases and also affects vital organs like brain and kidney)**

Normal B.P.= $\frac{120}{80}$ mmHg

120 → Systolic pressure → pumping pressure

80 → Diastolic pressure

- Sphygmomanometer
  → device to measure B.P.

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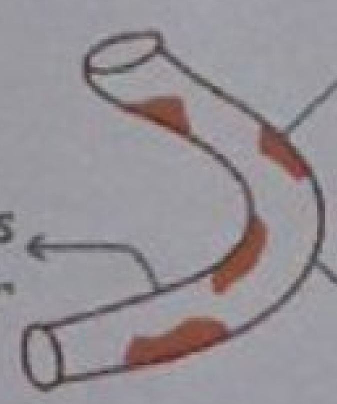
Coronary Artery Disease (CAD): Coronary Artery Disease, often referred to as atherosclerosis, affects the vessels that supply blood to the heart muscle.

- (It is caused by deposits of calcium, fat, cholesterol and fibrous tissues, which makes the lumen of arteries narrower.)



Angina: It is also called 'angina pectoris'.

- A symptom of acute chest pain appears when **no enough oxygen is reaching the heart muscle**. Angina is more common among the middle-aged and elderly.
- It occurs due to conditions that affect the blood flow.
- CAD can lead to Angina

Heart Failure: Heart failure means the state of heart when it is **not pumping blood effectively enough to meet the needs of the body**.

It is sometimes called congestive heart failure because congestion of the lungs in one of the main symptoms of this disease.

"accumulation of fluid" around lungs

Cardiac arrest: Complete stoppage of heart beat

Heart attack Heart not receiving enough blood ⟶ Heart muscles slowly dies

also known as MYOCARDIAL INFARCTION

6

Excretory Products and their Elimination

EXCRETION

Due to the metabolism or excess ingestion of certain substances, some Nitrogenous wastes like NH_3, Urea, Uric acid or even ions like Na^+, K^+, Cl^- etc., can be accumulated in EXCESS which needs to be constantly removed and the process in called as EXCRETION.

Major Nitrogenous wastes

Ammonia | Urea | Uric acid

On the basis of Excretory Products, animals are classified into:

"AMMONOTELIC"	"UREOTELIC"	"URICOTELIC"
○ Animals which eliminate ammonia	○ Animals that eliminate Urea	○ Animals that eliminate Uric Acid
○ Most toxic Nitrogenous waste	○ Moderately toxic	○ Least toxic
*(Ammonia 1 Lakh times more toxic than UREA)		
○ Requires lots of H_2O for its removal	○ Requires less H_2O for its removal	○ Requires least water for its removal
e.g.* Aquatic INSECTS, Aquatic Amphibian (Tadpole Larva-Frog), Bony Fish	e.g.* Terrestrial Amphibia (Frog), Cartilaginous Fish, Mammals	e.g.* Terrestrial Insect, Birds, Reptiles, Land snail

NOTE

1. Those animals which are Ammonotelic usually eliminate ammonia across Body surface or gill surface by diffusion as Ammonium ion.
2. Uric acid is usually eliminated in the form of 'PELLET' or 'PASTE' (waste)

EXCRETORY STRUCTURES

Excretory + Osmoregulatory
↓
Maintenance of water ionic balance

Usually the excretory structures are:

1. **Protonephridia/Flame-Cells:**

e.g. Phylum PLATYHELMINTHES (Flatworms: Planaria), Some ANNELIDS, Rotifers (Zooplanktons), Cephalochordate (Branchiostoma/Lancelet/Amphioxus)

2. Nephridia:* e.g: Earthworm (Phylum Annelida), Some other Annelids
3. Antennary glands/Green gland: e.g: Crustaceans like Prawn (Category under Arthropoda)
4. Malpighian Tubules: e.g: Insects like Cockroach (Category under Arthropoda)
5. Kidney: e.g: Amphibians
   Reptiles
   Aves
   Mammals

HUMAN EXCRETORY SYSTEM

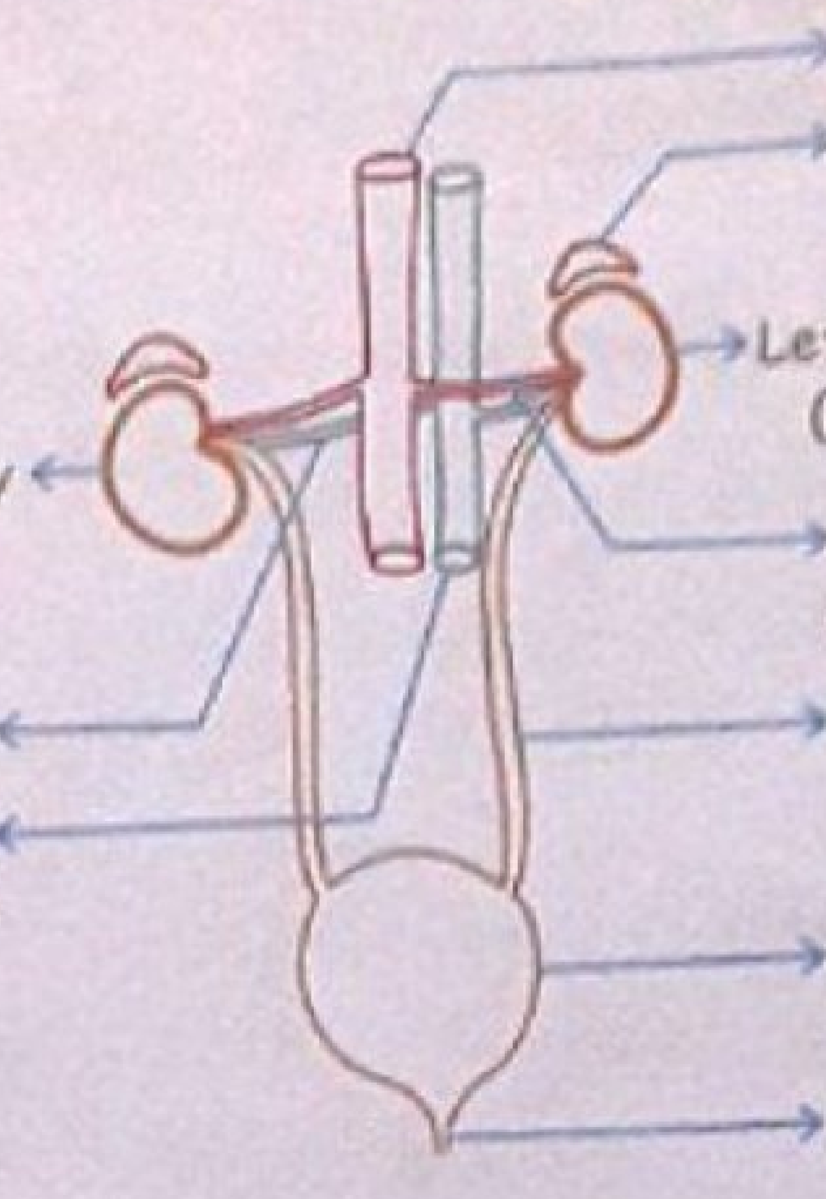


Fig: Human excretory system

Parts of Excretory Sytem

- Human excretory system consists of
  - A pair of KIDNEY
  - A pair of URETER
  - A urinary Bladder
  - A Urethra

1. Kidney:

- Close to dorsal wall
- Length = 10 - 12 cm
- Width = 5 - 7 cm
- Thickness = 2 - 3 cm
- Weight = 120 - 170 g
- Location: Between last thoracic vertebrate (T-3) and third lumbar (L-3)
- KIDNEY: OUTER COVERING = Renal Capsule: a layer of Connective tissue

INTERNAL STRUCTURE OF KIDNEY

KIDNEY

① OUTER CORTEX ② INNER MEDULLA

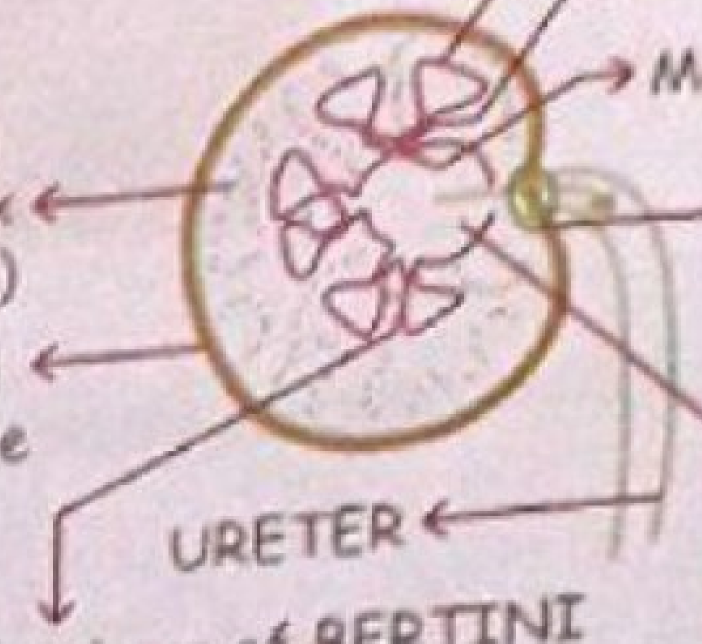
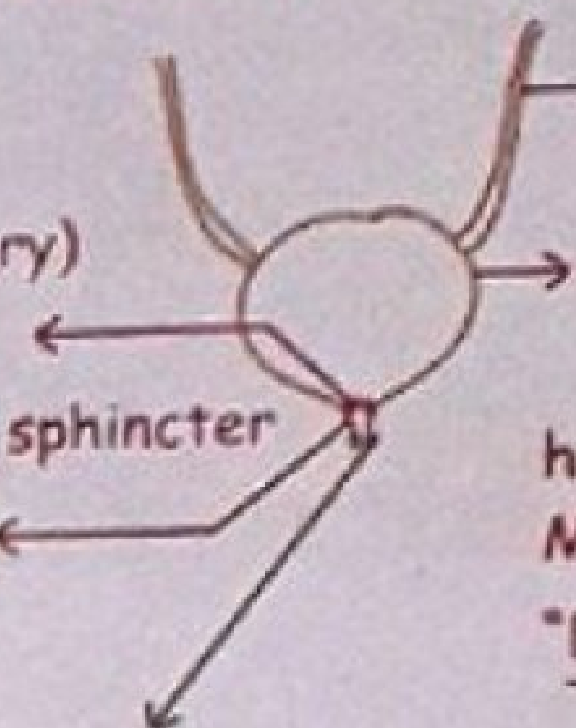


Fig: Inner structure of Kidney

2. Ureter:

Is a duct arising from KIDNEY to carry urine to the BLADDER

3. Urinary Bladder:



Urinary Bladder has SMOOTH MUSCLE called as "DETRUSOR MUSCLE" → Involved in Detrusion (Passage) of Urine

4. Urethra:

Male	Female
Longer (20-25 cm)	Short (2-4 cm)
Can carry both Urine + Semen ONE at a time (UROGENITAL DUCT)	Only carries Urine

- Each KIDNEY has approx **1 MILLION NEPHRON/URINIFEROUS TUBULE**

STRUCTURE OF NEPHRON (URINIFEROUS TUBULE)

- Structural and functional unit of KIDNEY

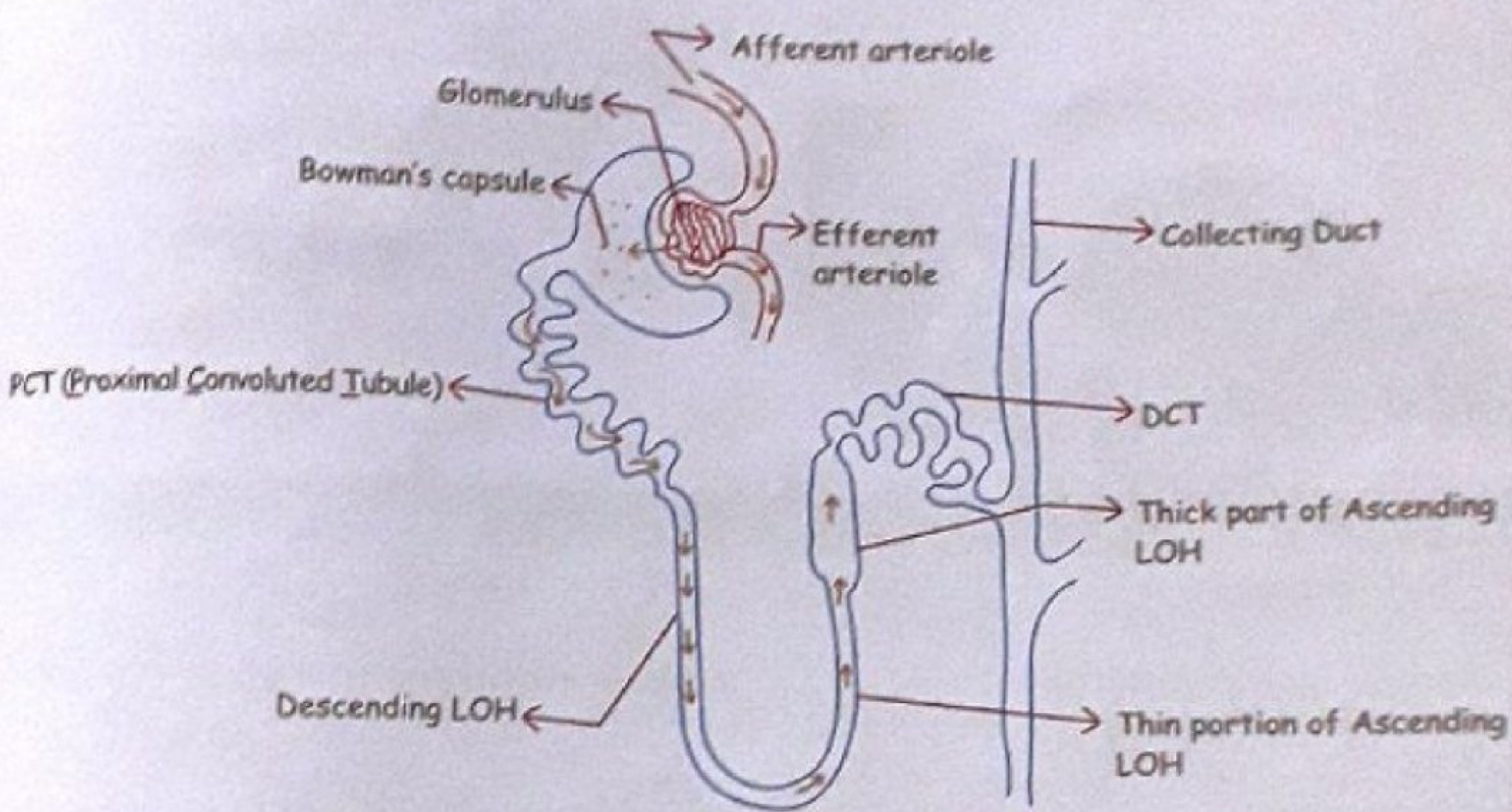
Nephron

1. GLOMERULUS
2. RENAL TUBULE
   - (a) Bowman's Capsule
   - (b) PCT (Proximal Convoluted Tubule)
   - (c) LOH (Loop of Henle)
   - (d) DCT (Distal Convoluted Tubule)
   - (e) Collecting Duct

GLOMERULUS + Bowman's Capsule together known as

★★ Malpighian Body or Renal Corpuscle

Structure of Nephron



- Afferent arteriole is a branch of Renal artery
- Afferent arteriole break into tuft of capillaries: GLOMERULUS
- LOH (Loop of Henle): hairpin like: 'U' shaped

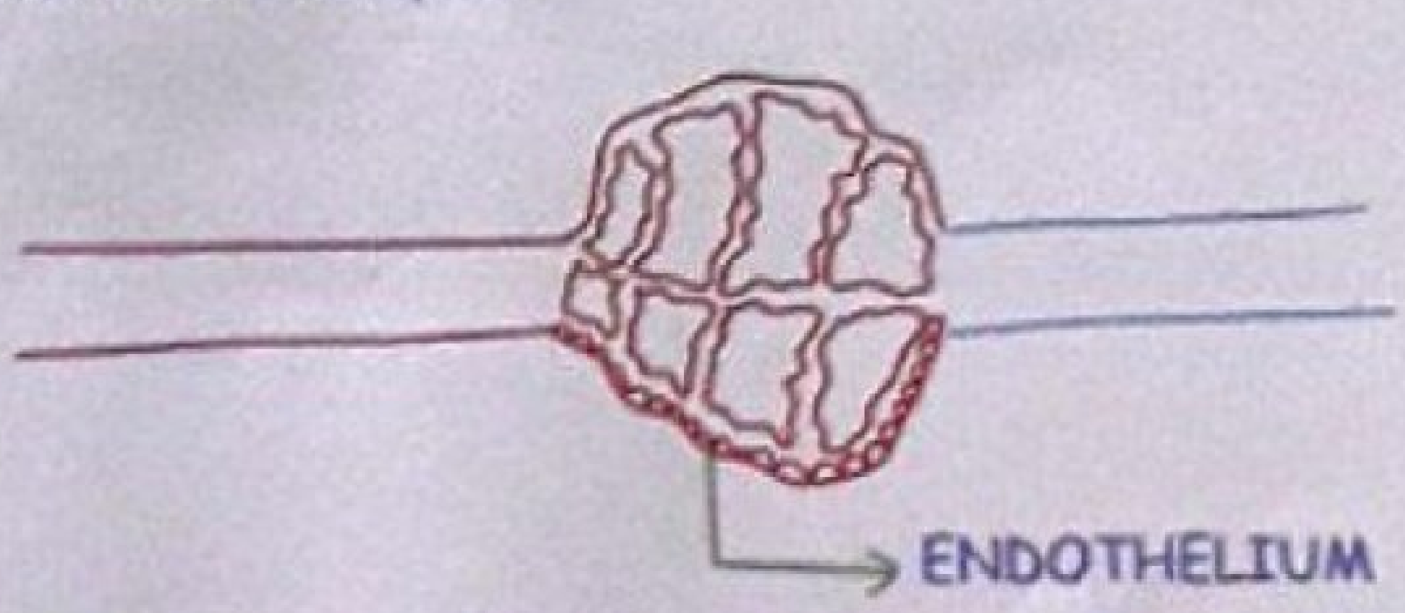


Fig: Glomerulus

Nephron

- Glomerulus
- PCT
- DCT

Located in Cortex

- LOH (Loop of Henle)
- Collecting duct

Located in Medulla

- BOWMANS CAPSULE: DOUBLE-WALLED
  - Outer wall → Parietal Layer
  - Inner wall → Visceral Layer

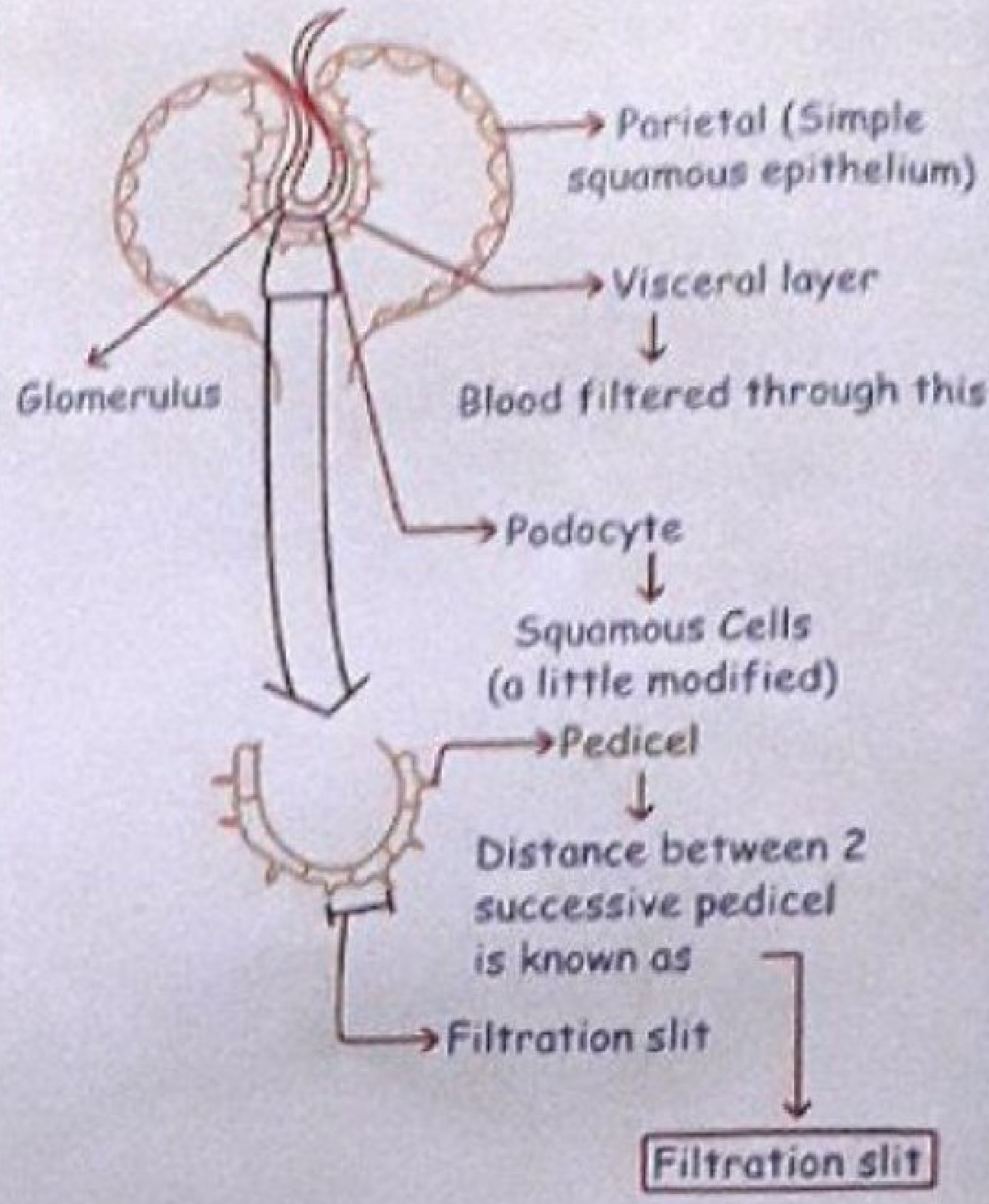
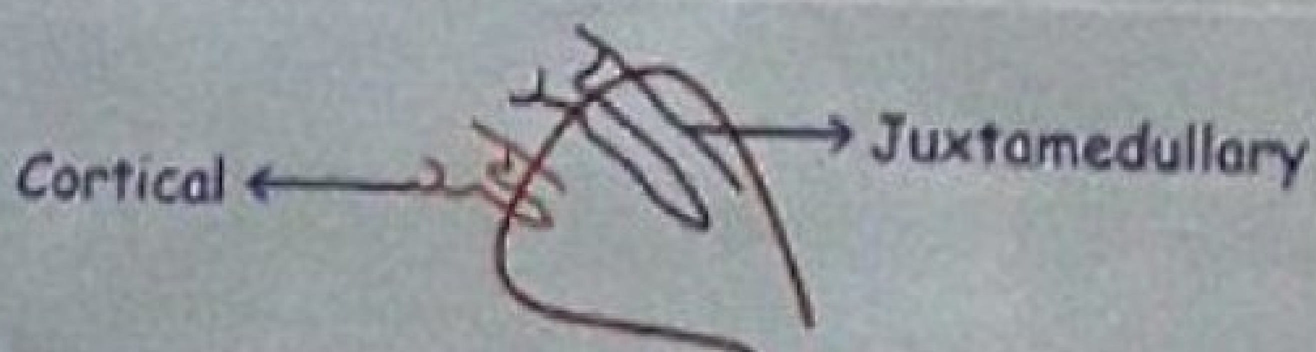


Fig: Bowman's Capsule

Types of Nephrons

Cortical Nephron	Juxtamedullary
85% of total Nephron	15% total Nephron
Loop of Henle is short and superficially penetrates medulla	Loop of Henle is long and deeply penetrates into medulla
	
Vasa Recta is either absent or poorly developed	Vasa recta is well developed
Excretory only	Excretory + OSMOREGULATORY

Vasa Recta:

Along with LOH (Loop of Henle) it is OSMOREGULATORY

- Efferent arteriole forms Network of capillaries around different parts of Nephron known as PERITUBULAR CAPILLARIES

↓

The capillary network around Loop of Henle is called as VASA RECTA

Vasa-Recta (VR)

- Descending VR → parallel to ALOH (Ascending limb of loop of Henle)
- Ascending VR → parallel to DLOH (Descending limb of loop of Henle)

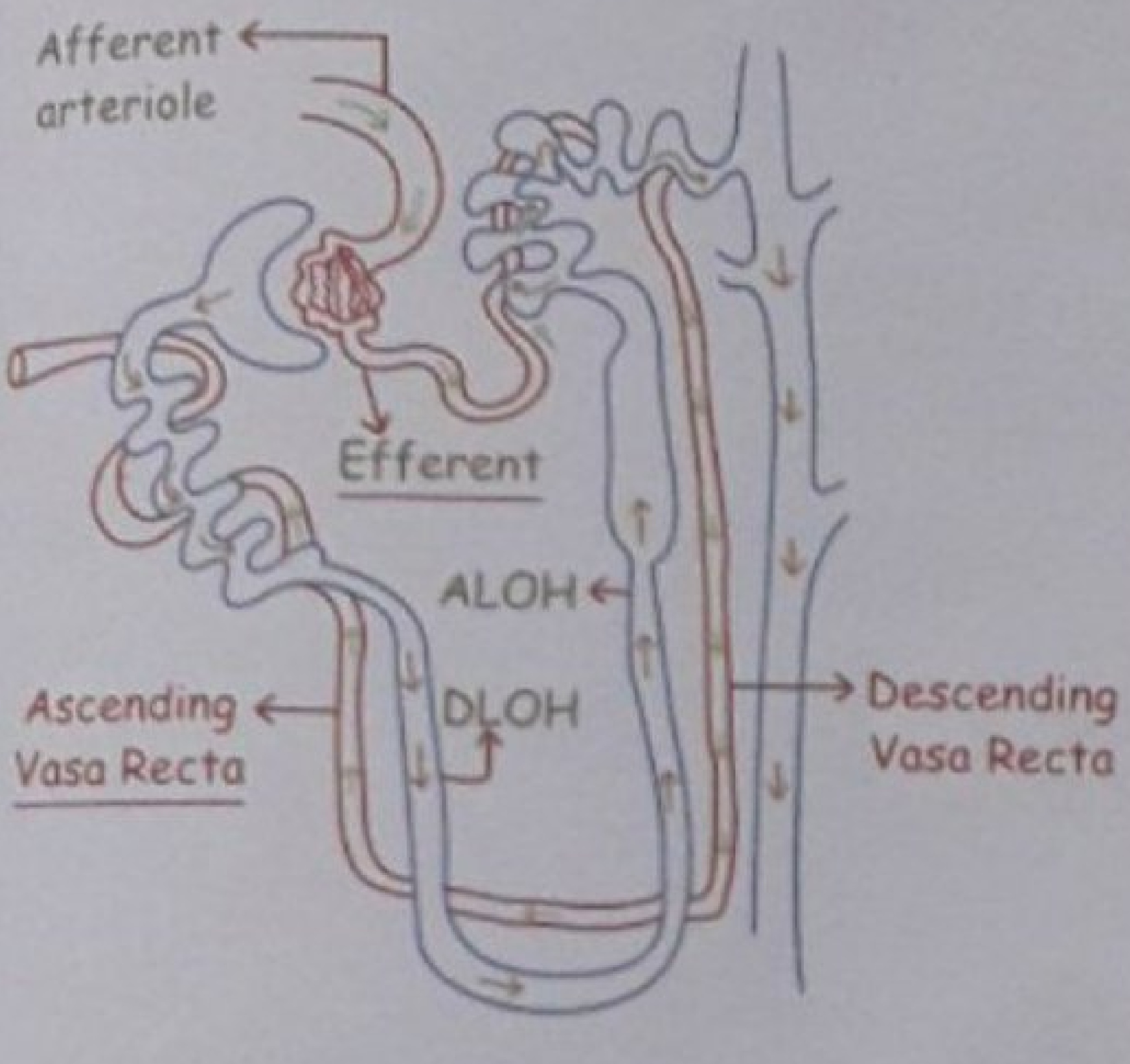


Fig: Vasa Recta

MECHANISM OF URINE FORMATION

- (i) Ultrafiltration
- (ii) Tubular reabsorption
- (iii) Tubular secretion

***

JGA (JUXTAGLOMERULAR APPARATUS)

Due to the proximity between Afferent arteriole and DCT, a sensitive area is formed: known as JGA

- At their point of contact

(1) Smooth muscle fibres of Afferent arteriole modified
↓
Now known as JG cells
↓
Juxtaglomerular cell
↓
Secretes Hormone "*RENIN"

(2) Cuboidal cells of DCT at contact point are also densely packed
↓
known as MACULA DENSA

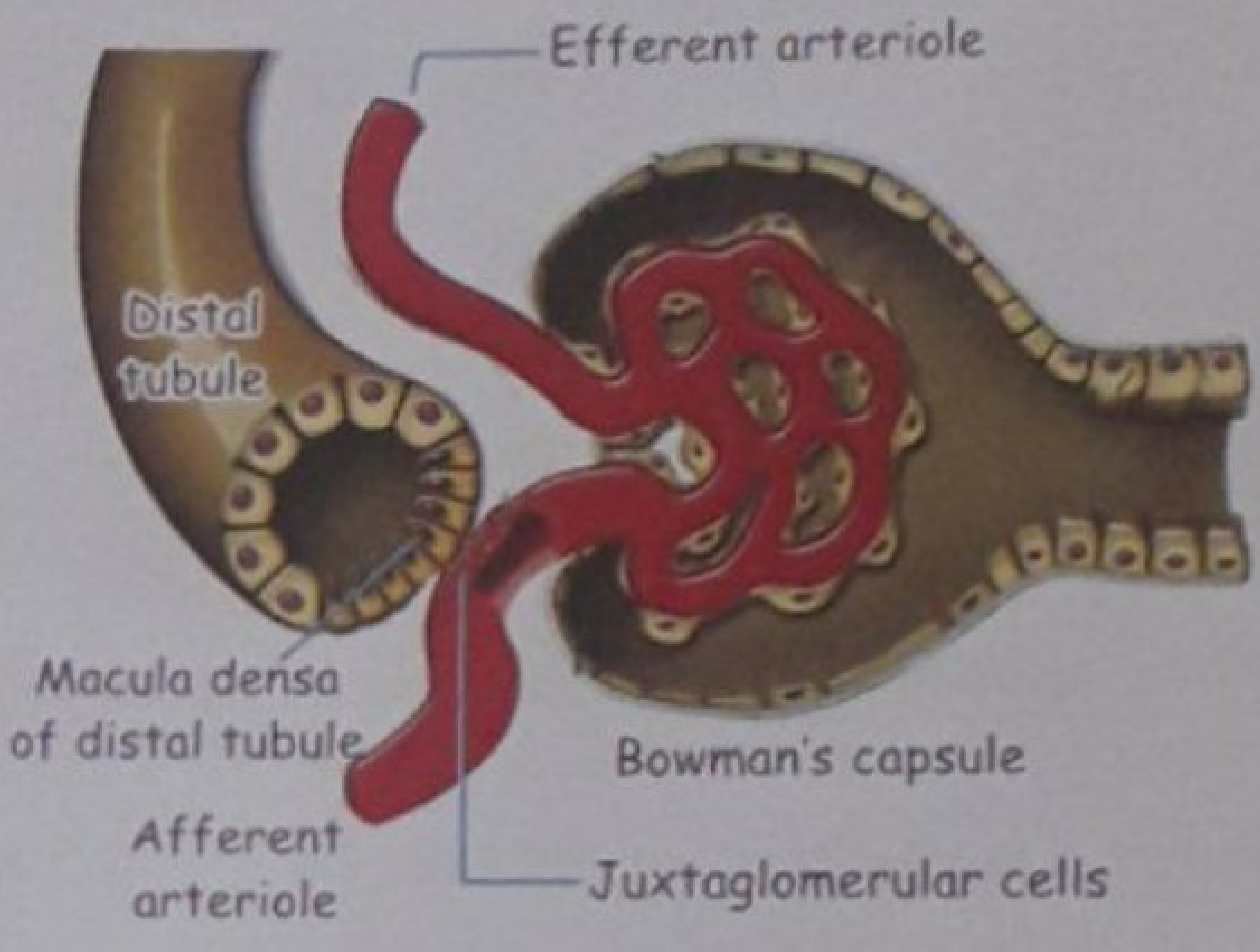
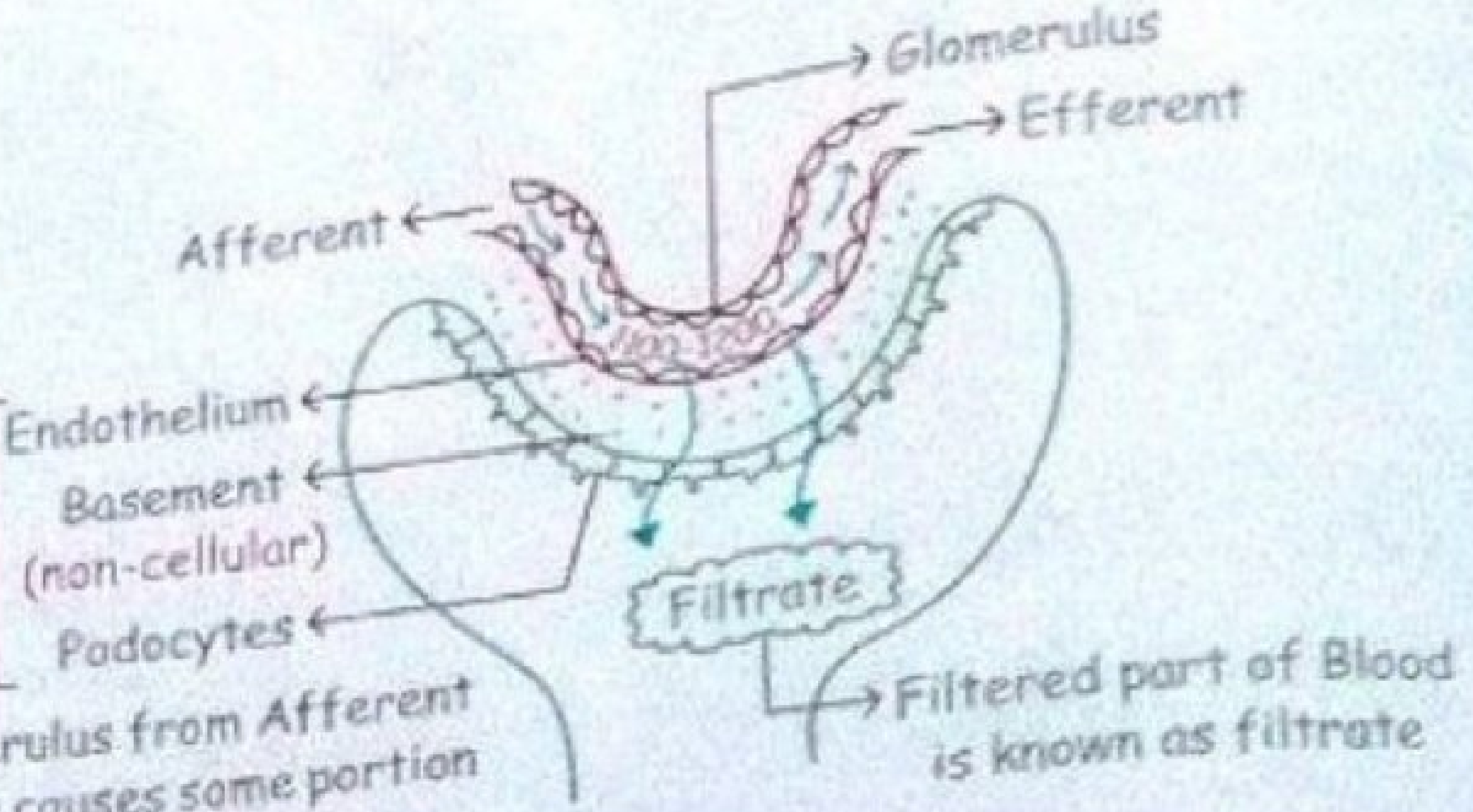


Fig: JGA (juxtaglomerular apparatus)

- JG cells along with macula densa is known as JGA which plays a very important role in Regulation of KIDNEY FUNCTION.

1. ULTRAFILTRATION



As the Blood passes through Glomerulus from Afferent arteriole, increase in pressure here causes some portion of Blood to filter out of it. (ONLY PLASMA PART)

- About 1/5th of Blood pumped by Heart i.e. approx 1100-1200 ml is undergoing Ultrafilteration.

NOTE

Cardiac output ∝ 5040 ml (Blood pumped by heart/min)
↳ 1/5th of this ∝ 1100-1200 mL

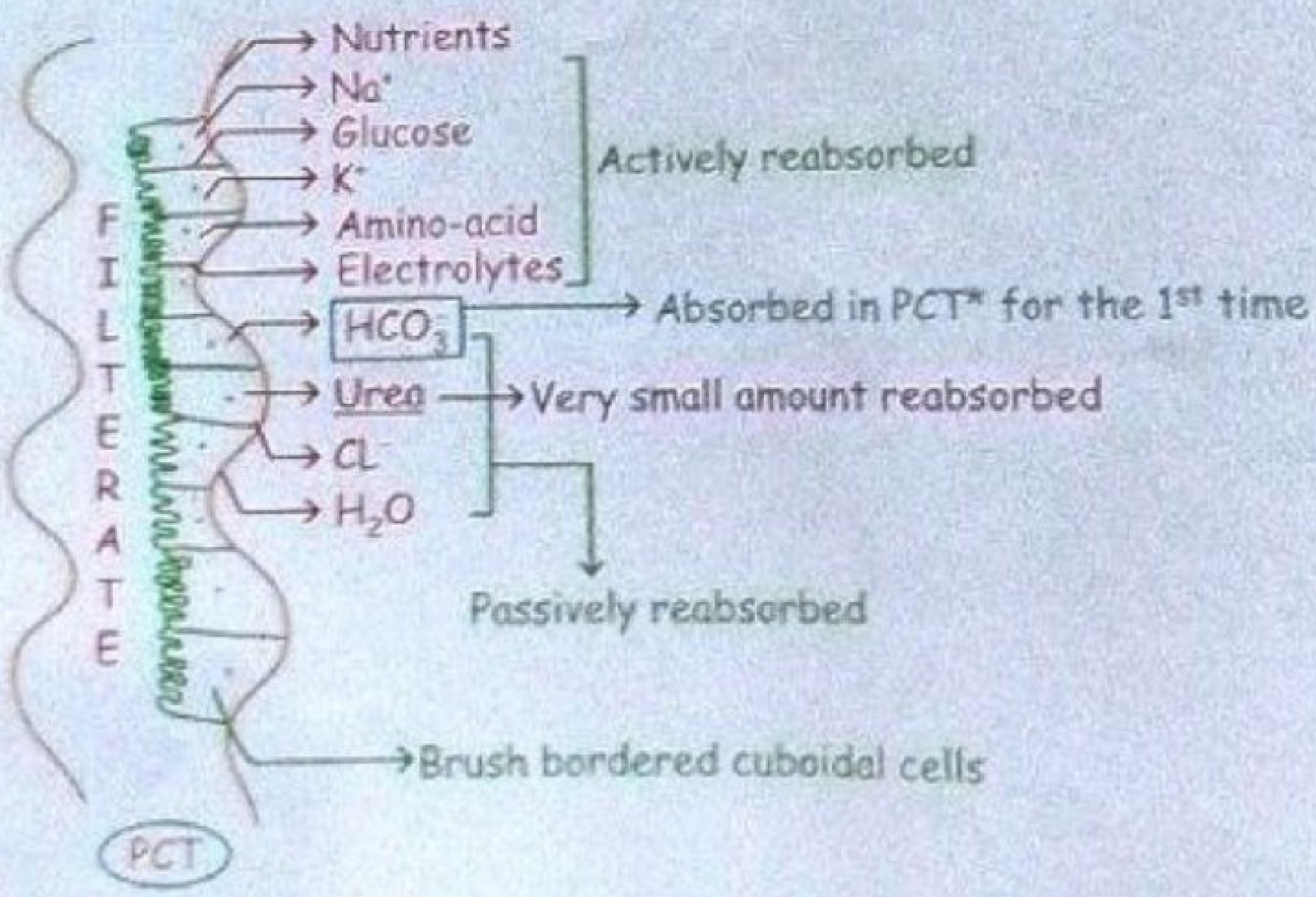
- Only the PLASMA PART get filtered leaving the proteins (Passive filtration)
- *GFR: Glomerular Filtration Rate: The amount of filtrate formed/unit time.

**GFR = 125 ml/min OR 180 L/day

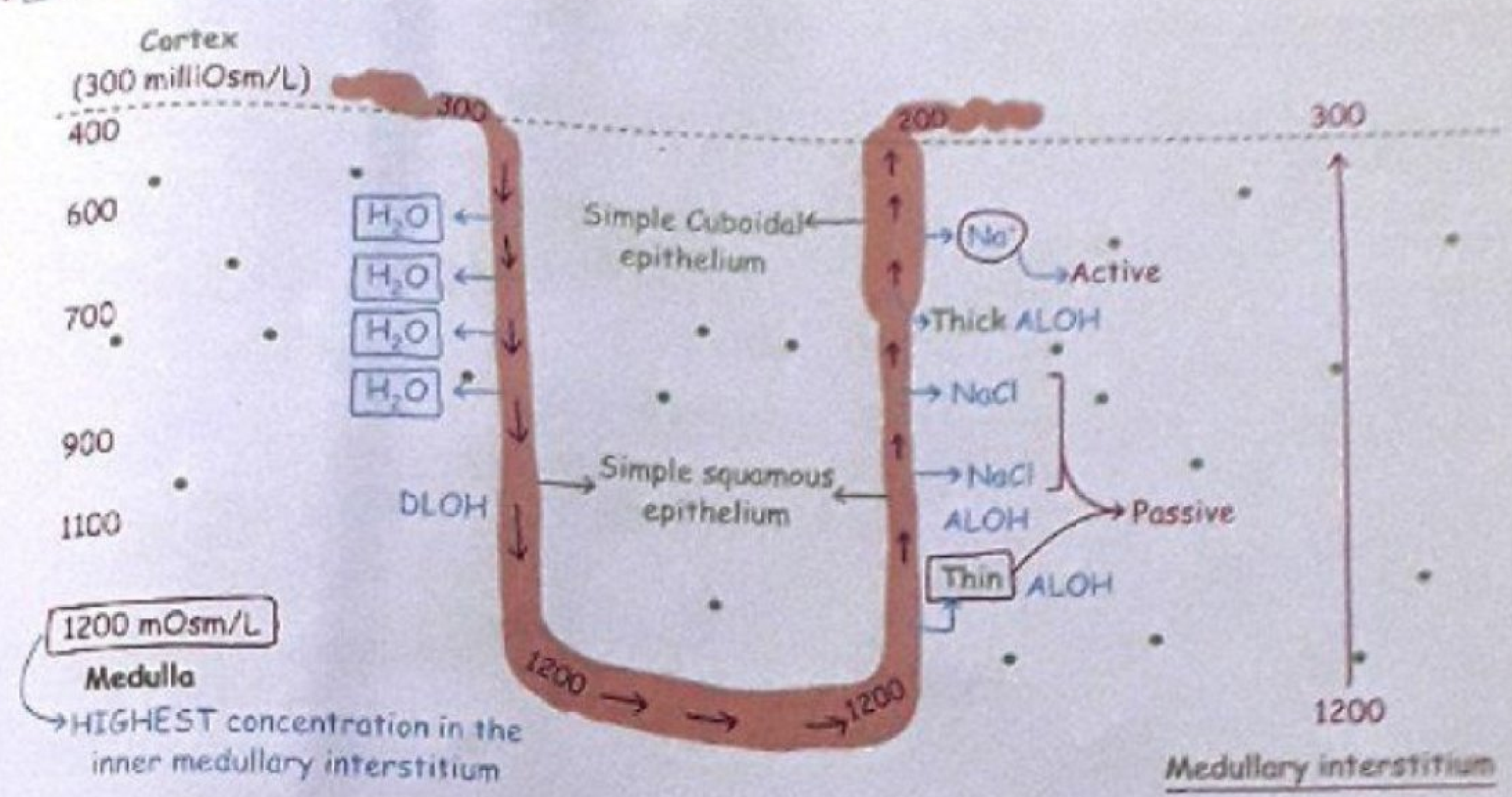
2. REABSORPTION

A comparison of the volume of filtrate formed per day (180 L) with that of urine released (1.5 litre), suggests that nearly 99% of filtrate has to be reabsorbed by renal tubules.

1. PCT: Lined by BRUSH-BORDERED (Microvilli) CUBOIDAL EPITHELIAL
   - 70-80% Water and electrolytes gets reabsorbed here
   - *Maximum reabsorption.



2. LOH: LOOP OF HENLE:



NOTE

1. Loop of Henle is penetrated into Medulla & the space within medulla is known as medullary interstitium having certain concentration measured in unit 'milliOsmoles/Litre' or 'mOsm/L'.
2. Outer cortex has concentration: 300 mOsm/L.
3. Inner medulla has concentration: 1200 mOsm/L

LOH (Loop of Henle)

DLOH (Descending limb of loop of Henle)

- Permeable for H_2O, nearly impermeable for electrolytes
- H_2O reabsorbed

As filterate goes down the DLOH, it becomes

HYPERTONIC → More concentrated filtrate

ALOH (Ascending limb of loop of Henle)

→ Reabsorption is minimum

→ Permeable for electrolytes, impermeable for H_2O

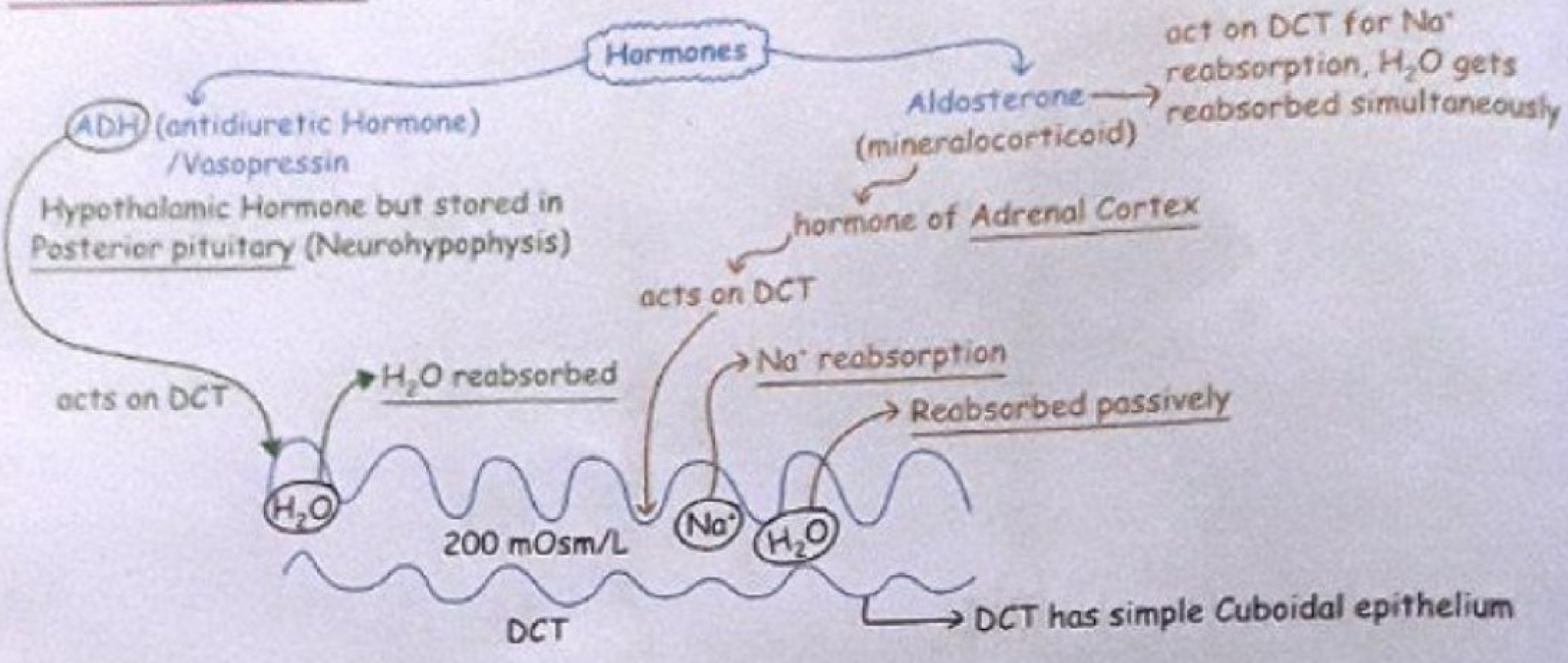
- Thin → Passive reabsorption of electrolyte
- Thick → Active reabsorption of electrolyte

As the filterate goes up in ALOH, it becomes

HYPOTONIC → Less concentrated filtrate as electrolytes gets reabsorbed

3. DCT:

Conditional reabsorption: Under certain situation in the influence of certain hormones.



NOTE

(I) ADH also act on collecting DUCT for H_2O reabsorption.

No ADH

↓

NO H_2O reabsorption from DCT and Collecting DUCT

↓

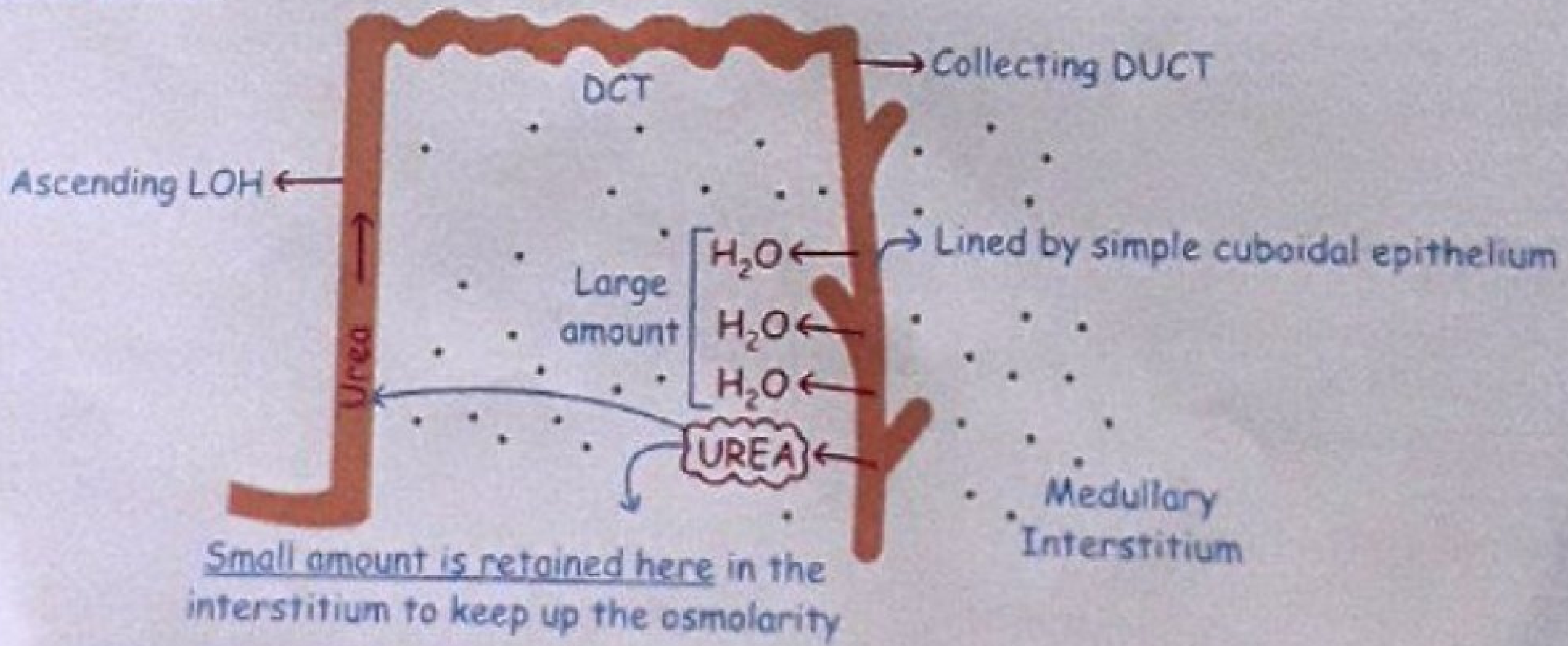
H_2O lost from URINE known as (DIURESIS)

↓

excessive loss of water through Urine leads to '**DIABETES INSIPIDUS**'

(II) HCO_3^- **reabsorbed** in DCT.

4. Collecting Duct

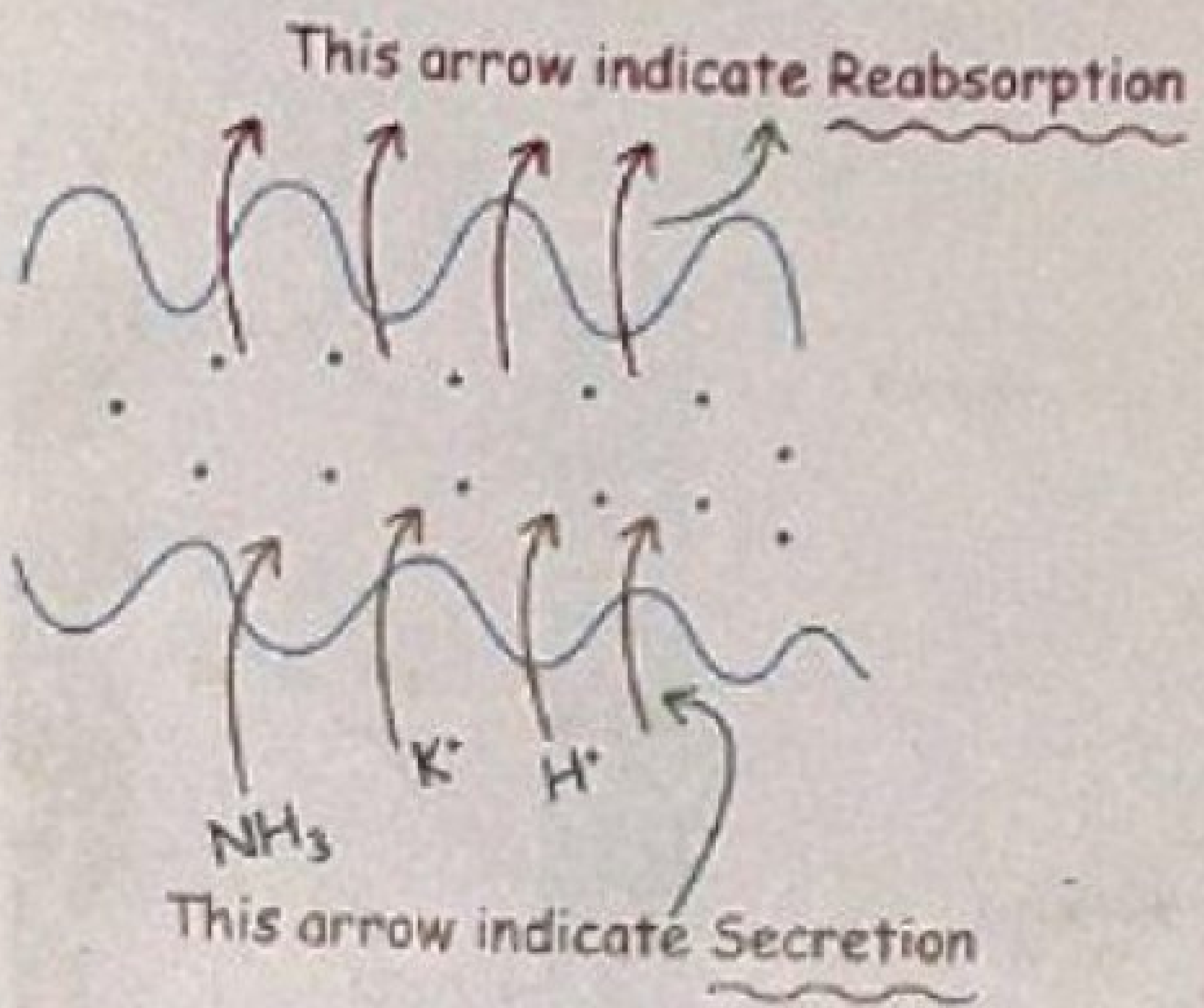


- Large amount of H_2O gets reabsorbed.
- Small amount of urea gets reabsorbed.
- Some urea again moves to ALOH as shown in the figure.

3. SECRETION

- Always an active process
- Its role is to maintain Acid-Base Balance (pH)

SECRETION
- → PCT : H^+, NH_3, K^+
- → DCT : H^+, NH_3, K^+
- → CD : H^+, K^+



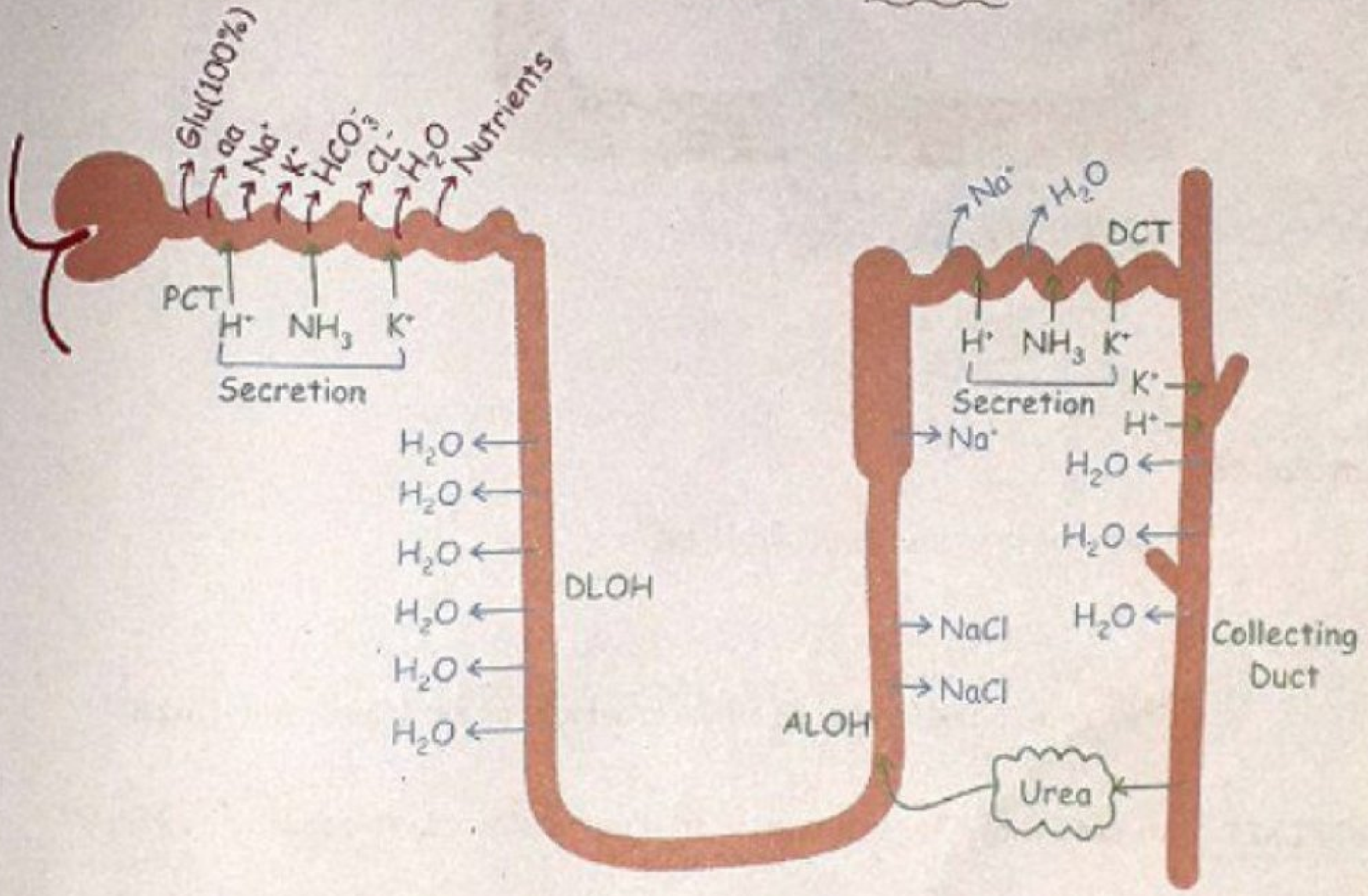


Fig: Conclusive diagram of reabsorption & Secretion.

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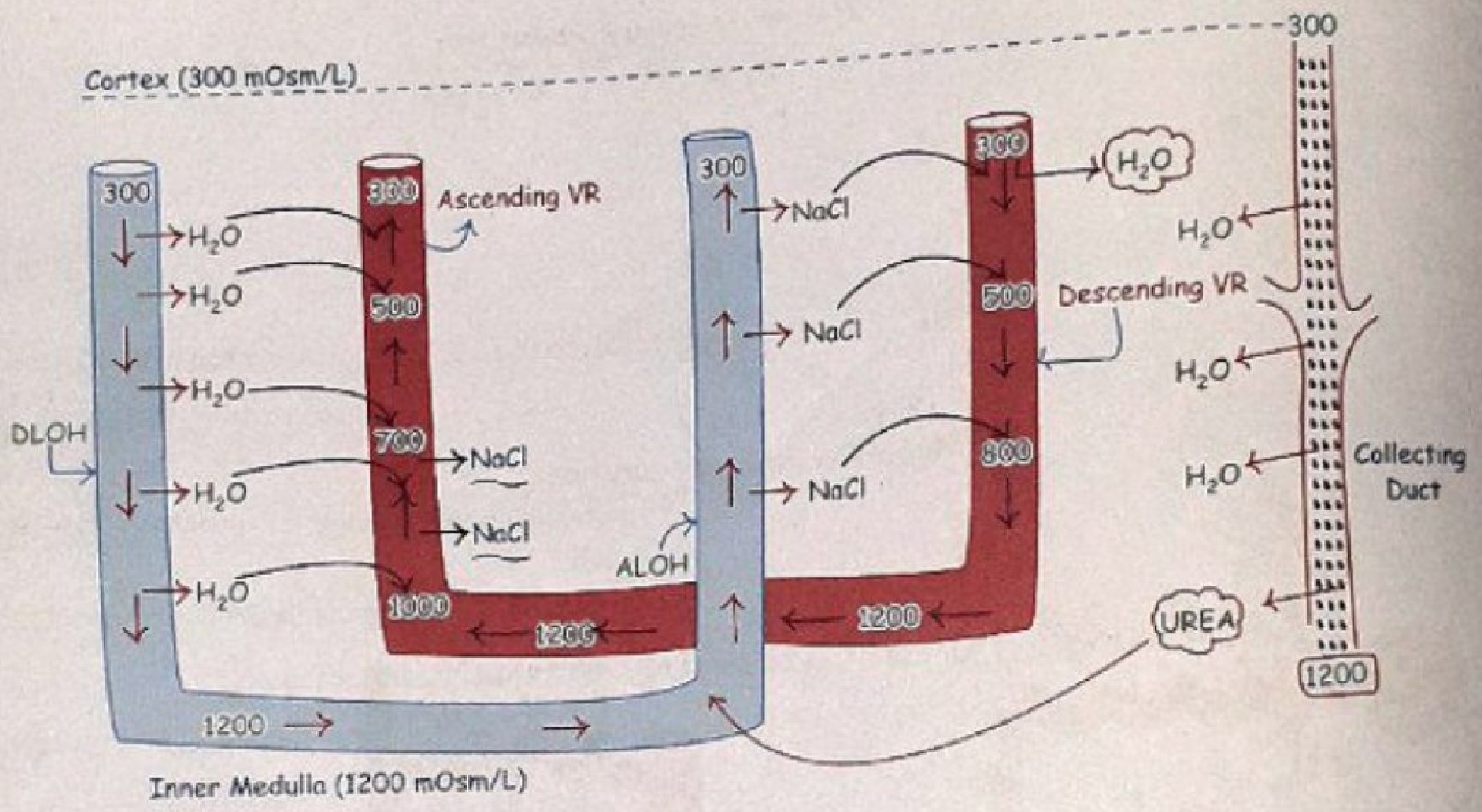
COUNTER CURRENT MECHANISM
Opposite Flow

- (i) The flow of filtrate in both the limbs of 'LOH' is in opposite direction
- (ii) The flow of blood in both limbs of vasa recta is in opposite direction
- (iii) The flow of filtrate in 'DLOH' & blood in ascending vasa recta, filtrate in ALOH & Blood in descending vasa recta is in opposite direction

- Mammals have the ability to produce a concentrated urine and Henle's loop and Vasa Recta plays a very significant role in this.



Some Important Points

- Counter Current Mechanism
  - Helps in concentration of Urine
  - *Maintain the increasing osmolarity towards medullary interstitium

- The CLOSE PROXIMITY between 'Loop of Henle & vasa recta' is responsible for this counter current.

- DLOH (Descending limb of loop of Henle) → reabsorb H_2O → Into AVR (Ascending vasa recta) → Ascendin[g] vasa recta release NaCl into interstitium → This is one of the electrolytes maintaining high osmolarity [of] the interstitium

- ALOH (Ascending limb of loop of Henle) → Reabsorb NaCl → Into DVR (Descending vasa recta) → Descending vasa recta Release H_2O in interstitium

→ UREA: From collecting duct, some amount of this is retained in interstitium to maintain high osmolarity

→ NaCl: From Ascending vasa recta

- ***2 ELECTROLYTES are responsible for maintaining increasing OSMOLARITY of interstitium

NOTE

Humans produce nearly **4 times** concentrated urine than the initial filtrate formed.

(300 mOsm/L → 1200 mOsm/L)

Initial filtrate ← 300 mOsm/L; 1200 mOsm/L → Final filtrate

REGULATION OF KIDNEY FUNCTION

Regulation occurs

→ 1. By HYPOTHALAMUS

→ 2. By JGA (juxtaglomerular apparatus)

→ 3. By ANF (Heart)

1. BY HYPOTHALAMUS:

- It operates when there is a Low GFR

Osmoreceptors

These are present in the hypothalamus & can detect the change in OSMOLARITY

↓

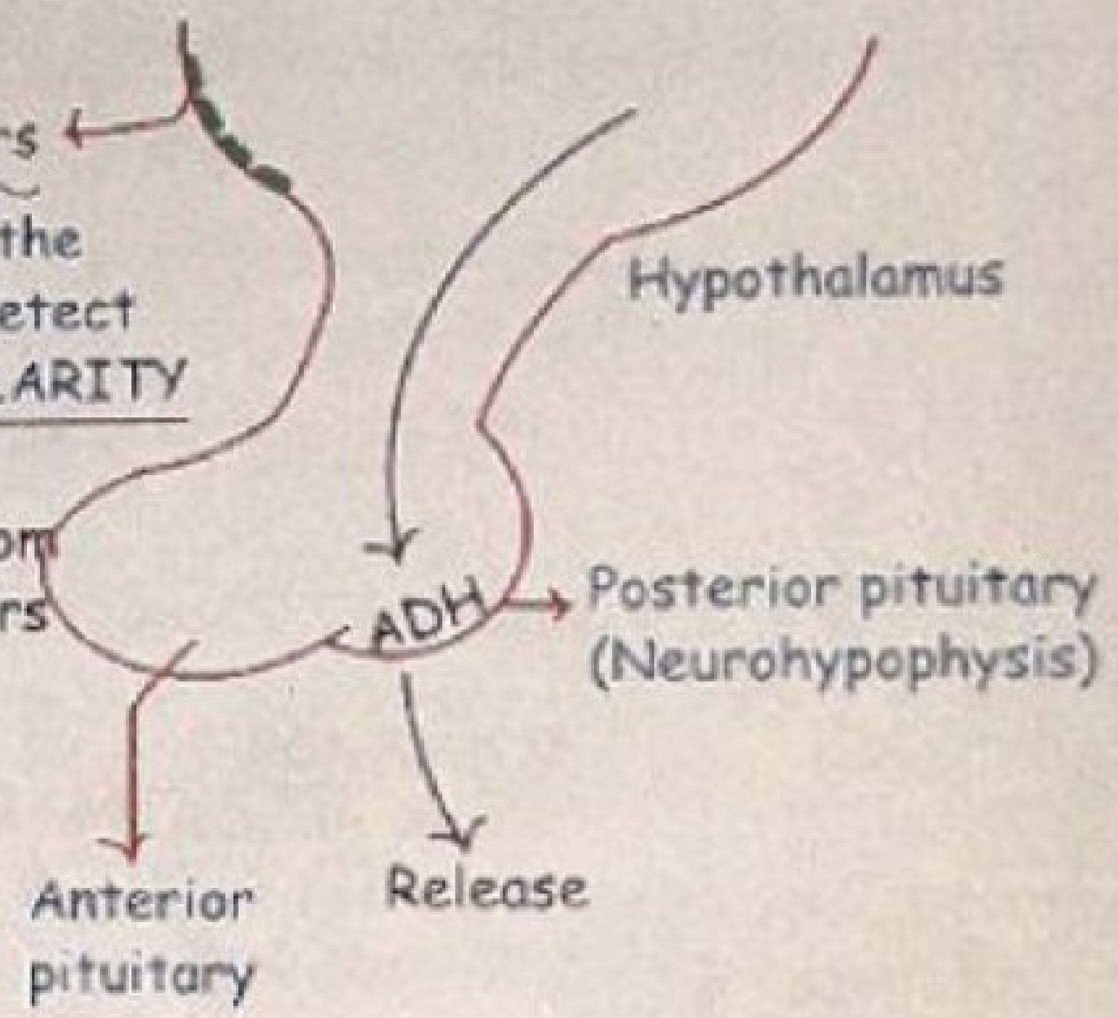
An excessive loss of fluid from body activate these receptors

↓

Signals the hypothalamus

↓

As soon as this happens it helps in release of VASOPRESSIN/ ADH (Antidiuretic Hormone) stored in Posterior Pituitary



Act on DCT | Act on Collecting duct

Causes H_2O reabsorption → Causes increase in the Blood Volume → Causes ↑ GFR

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VASOPRESSIN

$\underbrace{\text{Vaso}}_{\text{Blood}}\underbrace{\text{pressin}}_{\text{Press}}$

ADH has a *vasoconstrictory effect on Blood vessel to $\boxed{\uparrow \text{ the GFR}}$

→ Efferent arteriole

NOTE

- An ↑ in body fluid volume can switch off these receptors which in turn can stop the release of ADH via Neurohypophysis.

2. BY JGA (JUXTAGLOMERULAR APPARATUS)

OR

BY RAAS (RENIN-ANGIOTENSIN-ALDOSTERONE-SYSTEM)

Operates When: GFR is low

When GFR is low, Blood volume is low

↓

It signals JG cells

↓

JG Cells secretes RENIN $\xrightarrow{\text{Converts}}$ $\boxed{\text{Angiotensinogen}}$ (Produced in Liver)

↓

$\boxed{\text{Angiotensin I}}$

↓ By ACE (Angiotensin Converting Enzyme)

$\boxed{\text{Angiotensin II}}$

(i) Acts on ADRENAL CORTEX to release ALDOSTERONE which act on DCT for Na^+ & H_2O reabsorption

(ii) Directly action PCT: Na^+ & H_2O reabsorbed

(iii) Vasoconstriction: ↑ GFR

All these leads to increase in GFR

3. **BY HEART:** ANF

Operates when GFR is high

ANF

Atrial | Natri ($\nearrow Na^+$) | Uretic ($\nearrow$ Urine) | Factor

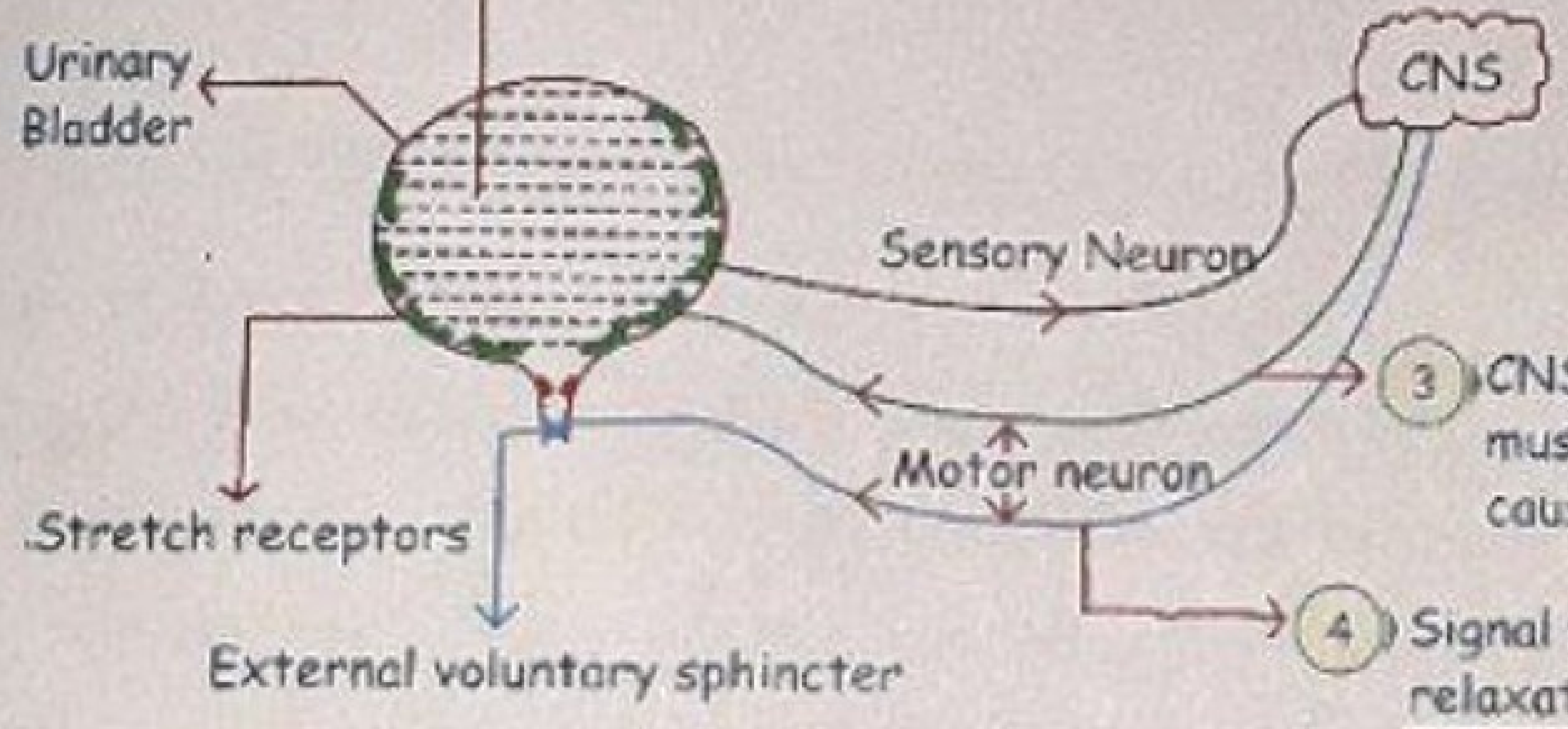
Atrial → Produced by Atrial wall of Heart

ANF secreted ← When GFR is high

- → Inhibit 'RAAS' (Check upons RAAS)
- → If RAAS inhibited, means Aldosterone not available
  ↓ Means
- → Na^+ not reabsorbed, instead released via URINE hence name is Natri-Uretic Factor
  ↓
  Na^+ released via Urine
- → Causes VASODILATION → leads to decrease in GFR

MICTURITION:

- Process of Release of Urine.



1. As soon as Bladder gets filled with urine, stretch receptor within bladder get activated & it signals CNS (Central nervous system) ↓
2. Sensory neuron carries signal to CNS
3. CNS Signals the DETRUSOR SMOOTH muscles of Bladder for its contraction & it causes DETRUSION (passing) of Urine.
4. Signal from CNS to urethral sphincter causes relaxation of SPHINCTER for their opening for release of urine

Fig: Micturition Reflex

URINE:

→ 1 - 1.5 L/day (Initially 180 L filtrate was present: 99% filtrate reabsorbed)

→ 25-30g Urea/day

→ pH → 6.0 (Slightly acidic)

a

→ Slightly yellowish: UROCHROME (derived BILE PIGMENT)

→ GLYCOSURIA: Glucose in Urine
→ KETONURIA: Ketone Bodies in Urine
] Patient of $\boxed{\text{Diabetes mellitus}}$

NOTE Diabetes Mellitus

When cells are unable to use glucose in diabetes mellitus, they end up breaking fat (β-oxidation) for energy making hence KETONE BODIES are produced too, excess of which is eliminated via URINE (Ketonuria) along with the Glucose in Urine (Glycosuria).

ROLE OF OTHER ORGANS IN EXCRETION:

1. **LUNGS**: It eliminates 200 mL/min CO_2 & some amount of water vapour

2. **LIVER**: **LARGEST GLAND**: Eliminates CHOLESTEROL, degraded STEROIDS, VITAMINS, DRUGS, BILE pigments: Bilirubin & Biliverdin, etc.

3. **SKIN**

→ Sweat glands/sudorific glands $\xrightarrow{\text{Secretion}}$ SWEAT → **Composition**: Water, Lactic acid, NaCl, Urea

→ Sebaceous glands/oil glands $\xrightarrow{\text{Secretion}}$ Oil/Sebum → **Composition**: wax, sterols, hydrocarbon

DISORDERS:

1 Glomerulonephritis

$\text{Glomerulone}\underbrace{\text{phritis}}_{\text{Inflammation}}$

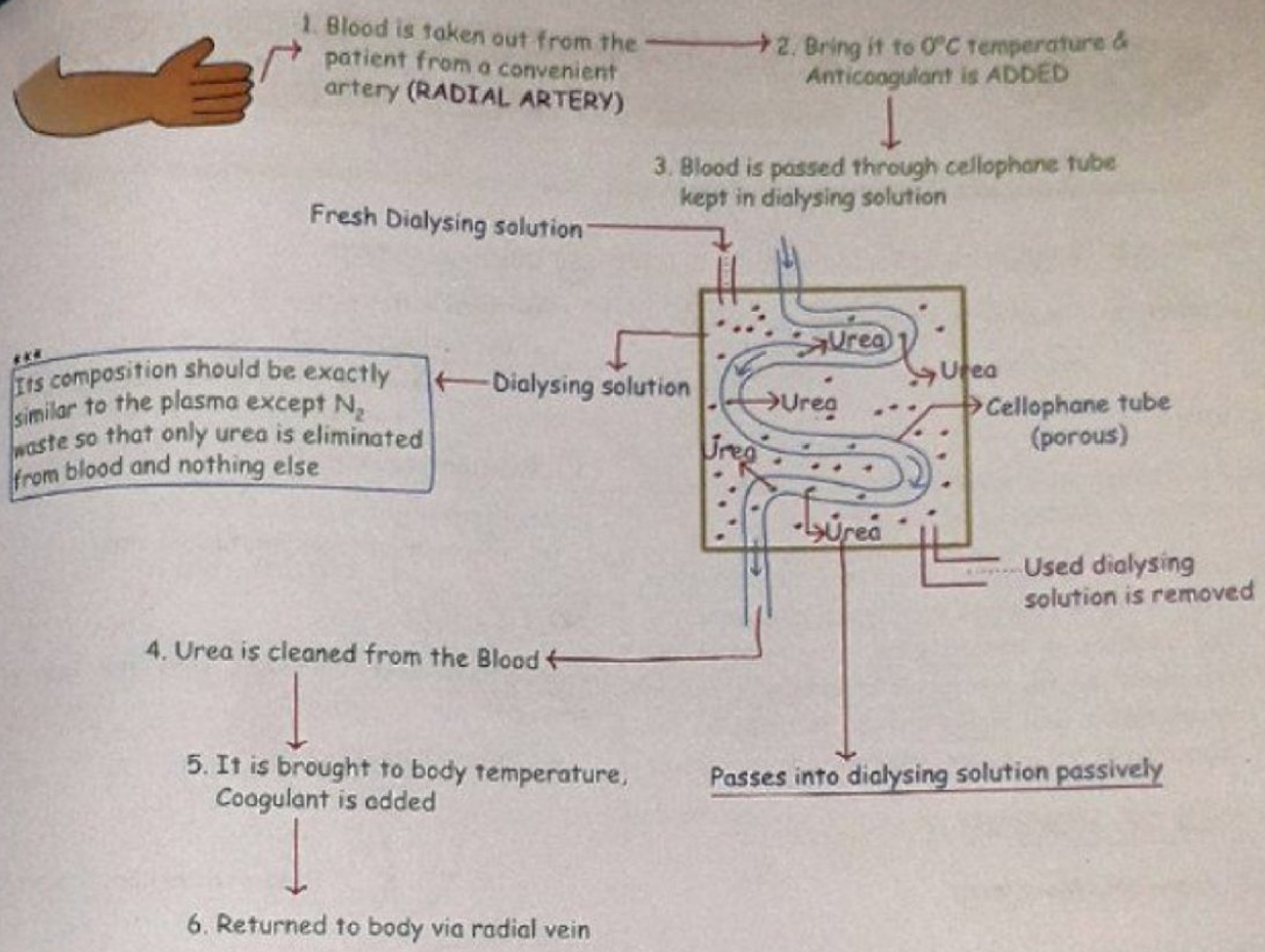
Inflammation in the filtration membrane.

2 Renal Calculi:

- Insoluble mass of crystalised salts of oxalate in KIDNEYS.
- Most common salt is calcium oxalate.

3 UREMIA: Presence of UREA in Blood.

'Haemodialysis' is performed to treat the patient in such case:



NOTE

From one end fresh dialysing solution is added & from another end used up dialysing solution is removed.

4 Acute Renal failure: (Kidney fail)

When the kidney fails to work, this is called Renal failure.

→ In such situation 'ORGAN TRANSPLANTATION' needs to be done.

→ A suitable donor is found with Maximum Tissue Matching & Blood group is also matched.

→ Often to stop unwanted immune response IMMUNOSUPPRESSANTS are given to the patient. e.g., Cortisol.

7 Locomotion and Movement

Movement: Change in posture

Locomotion: Movements that leads to change in position.

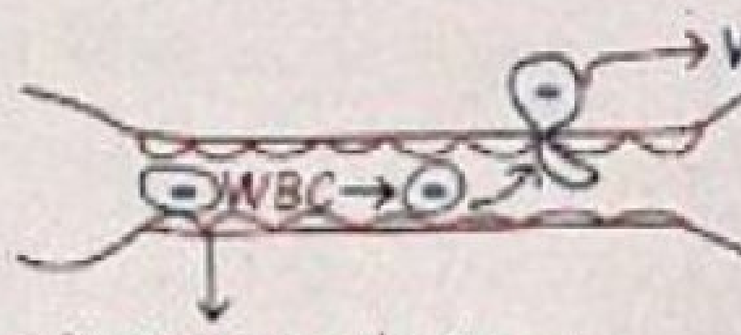
NOTE

- All locomotions are movement but all movements are not locomotion
- Locomotory structures need not be different from those affecting other types of movements. For example, in Paramoecium, cilia helps in the movement of food through cytopharynx and in locomotion as well. Hydra can use its tentacles for capturing its prey and also use them for locomotion.

TYPES OF MOVEMENT

1. Amoeboid Movement

Just like amoeba extends it protoplasm to form pseudopodial extensions, changing shape for its movement, WBCs and macrophage (Phagocytic cell) show this type of movement



- Cytoskeletal elements like microfilaments are also involved in amoeboid movement

2. Ciliary movement

Movement with the help of cilia

eg: In Trachea, oviduct/Fallopian tube

→ mucus movement → movement of ova

3. Muscular movement

Movement with the help of muscles

eg:, movement of limb, jaw, tongue, etc.

NOTE

Flagellar movement: Movement with the help of flagella

eg: Sperm/Spermatozoa

MUSCLES

- Comparises 40-50% of the body weight
- Origin: Mesodermal
- We have 3 types of muscles: **SKELETAL, SMOOTH, CARDIAC**, and we have read about it in the chapter Structural Organisation in Animals

Properties of muscle:

- Excitability
- Contractibility
- Extensibility
- Elasticity

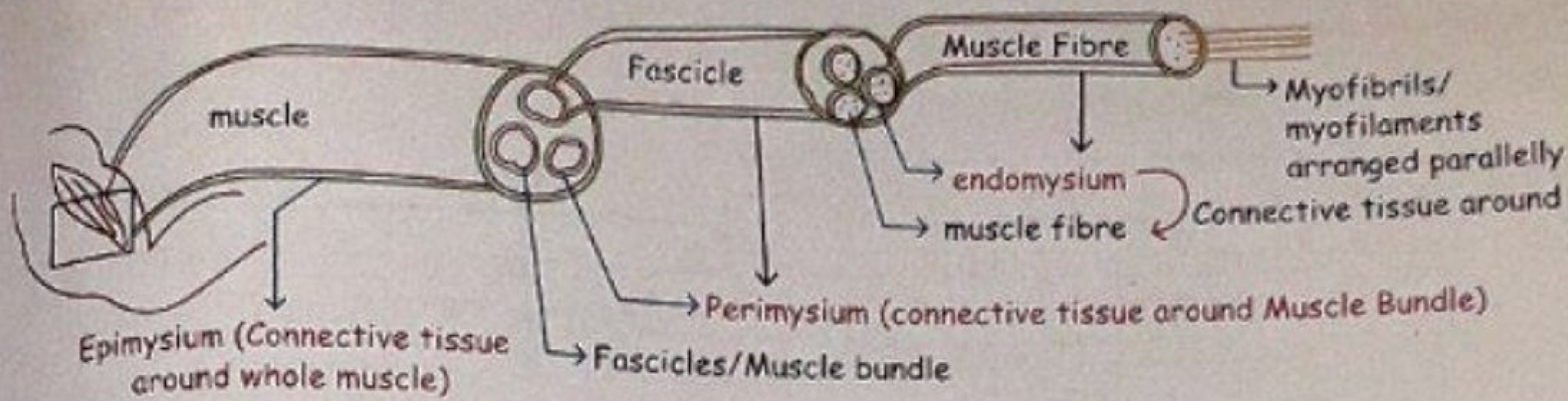


Figure: Section of muscle (Skeletal)

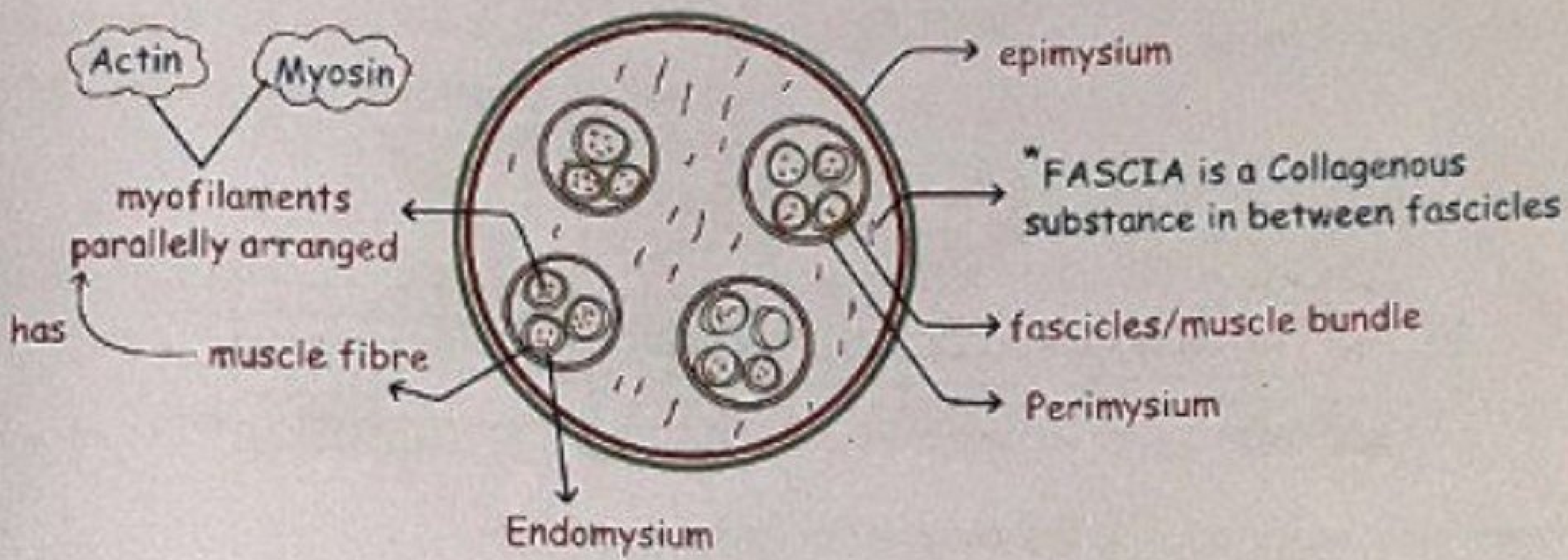
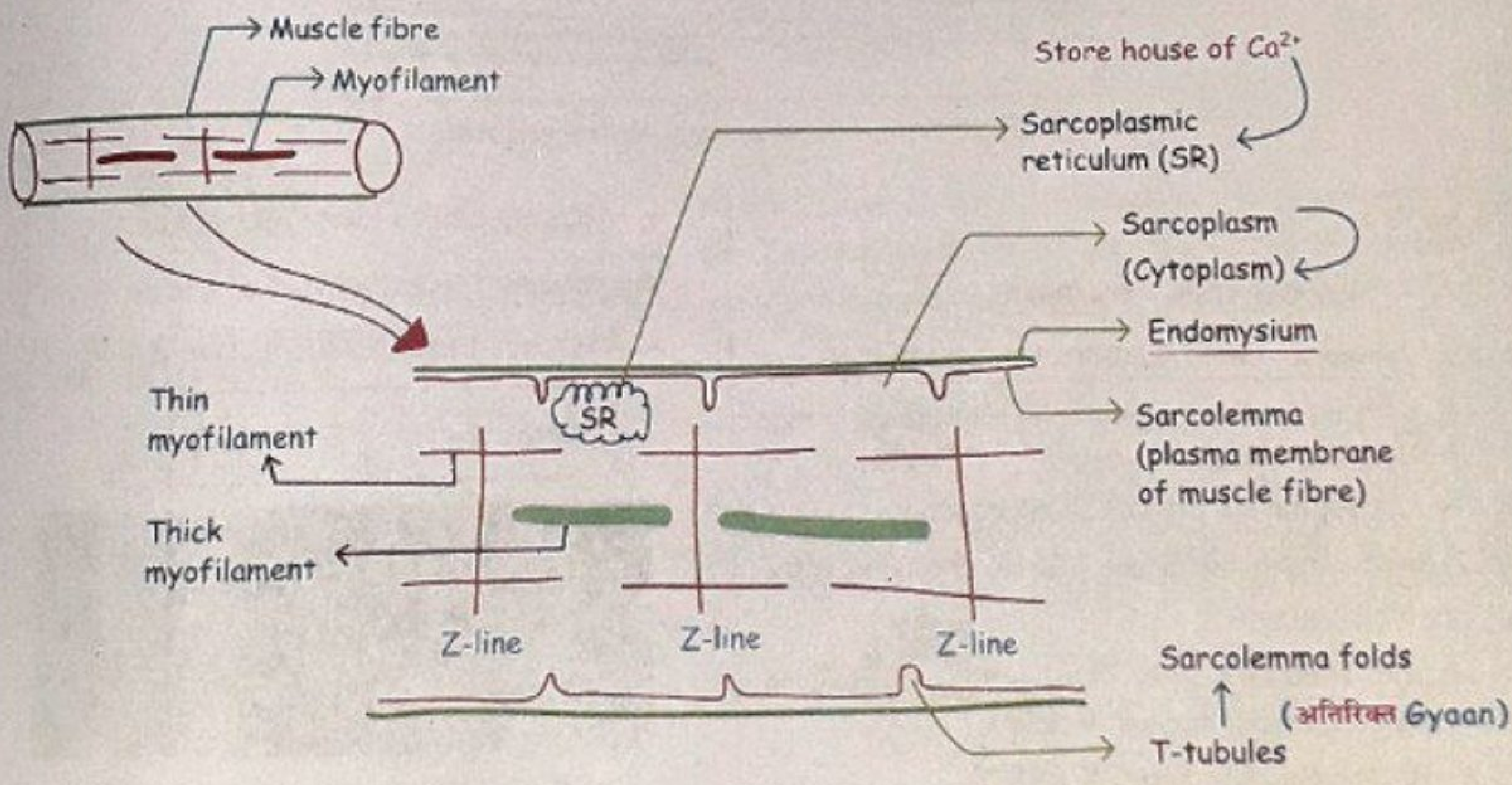


Figure: Section of muscle

Muscle fibre (Muscle cell)



Structure of Sarcomere

- Sarcomere is functional unit of contraction

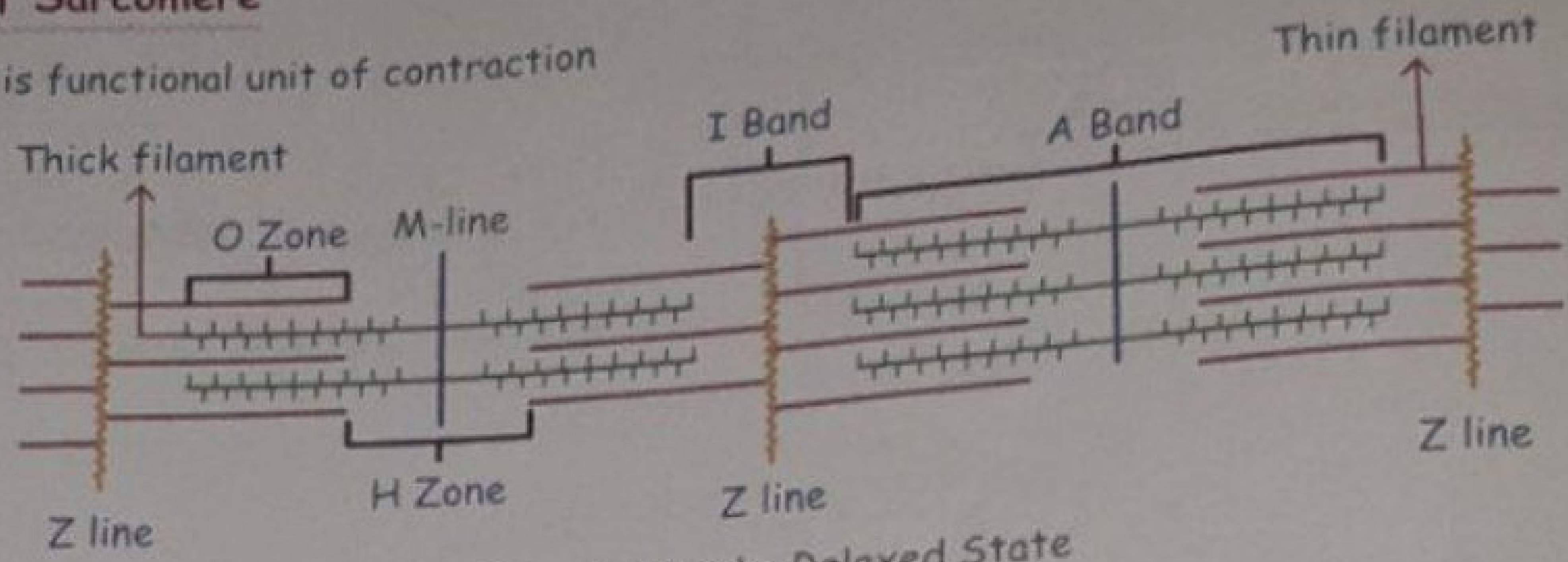


Figure: Muscle, Relaxed State

When muscle contracts, thin filament slides over thick filament

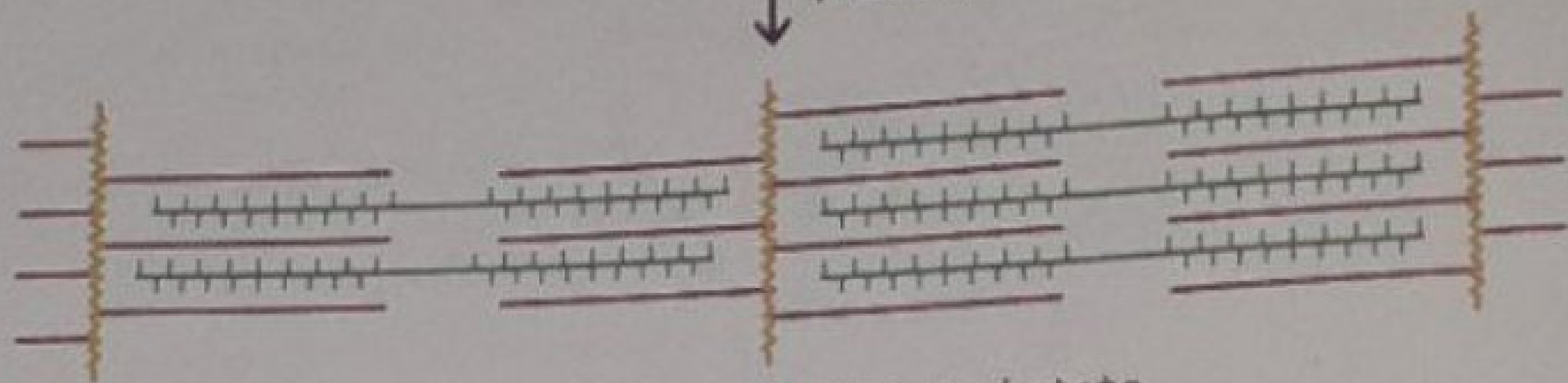


Figure: Muscle, Contracted state

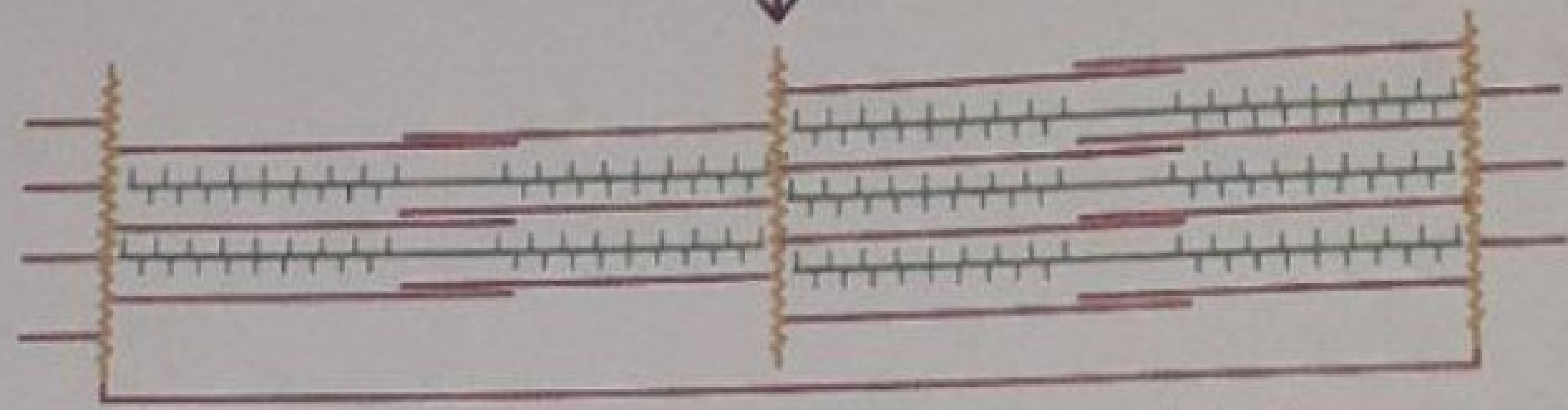


Figure: Muscle, Maximally contracted state

NOTE

- O-zone: **Overlapping zone/band**
- I : **Isotropic band (LIGHT BAND):** The position with in sarcomere where only thin filament is seen
  → 1/2 I on either of Z-line
  - It appears light under microscope
- Z line : elastic membrane passing through centre of thin filament
- H zone : **Hensen's zone:** The position in sarcomere where only thick filament is seen
- A : **Anisotropic band (DARK BAND)**
  → O + H + O
  - Appears dark under microscope
- **Sarcomere:** Functional unit of muscle.
  - Distance between successive Z-line

$$\text{Sarcomere} = \frac{1}{2}I + A + \frac{1}{2}I$$

Figure: Electron micrography image of a muscle fibre showing a sarcomere

During muscle contraction

- Thin filament slides over thick filament
- I Band shortens
- A Band remain same
  - (O ⟶ ↑, H ↓ (overall remains same)
    Maximum contraction: H zone Disappear)
- Sarcomere shortens

Structure of Contractile Proteins

MYOFILAMENTS

1. Thin myofilament
   - ① Actin
   - ② Tropomyosin
   - ③ Troponin
2. Thick myofilament
   - 'Myosin'

A THIN MYOFILAMENT:

① Actin Each actin filament is made of two 'F' (Filamentous) actins helically wound to each other.

- 'F' actin is a polymer of a 'G' (Globular) actin

② Tropomyosin: 2 Filamentous Structures wrapped around the F-actin called tropomyosin.

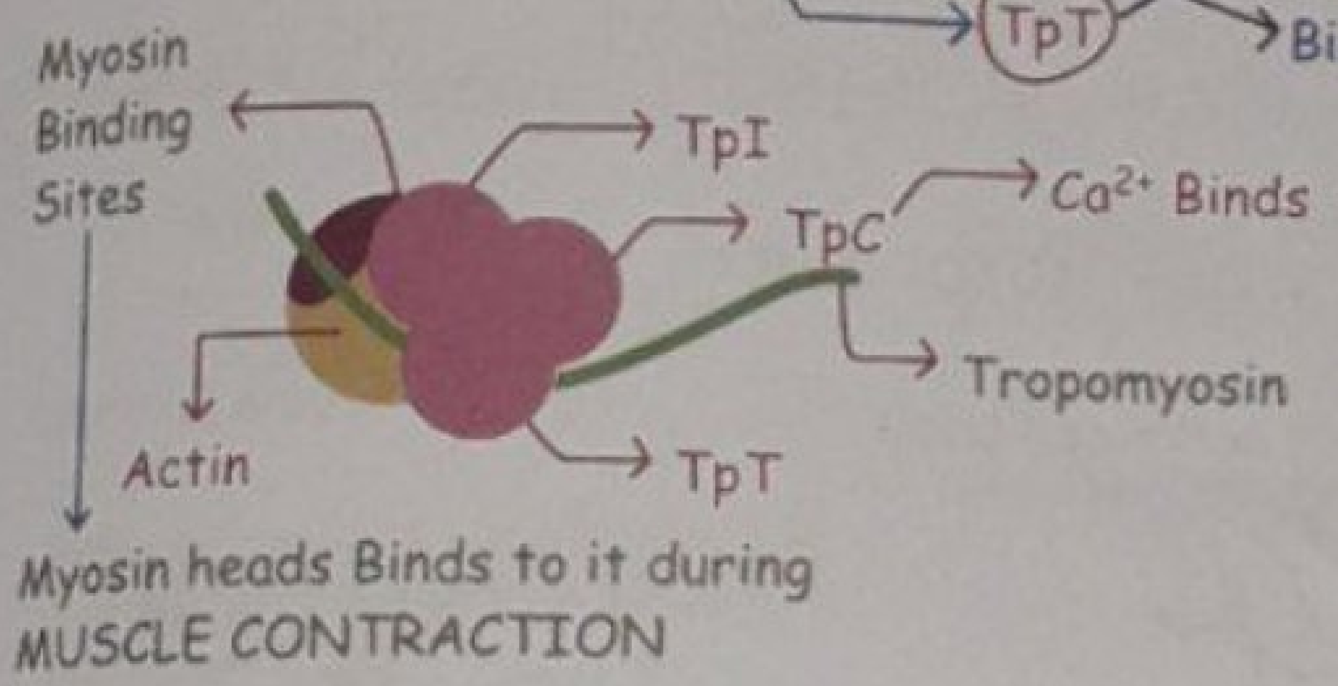
③ Troponin

↳ Trimeric Protein

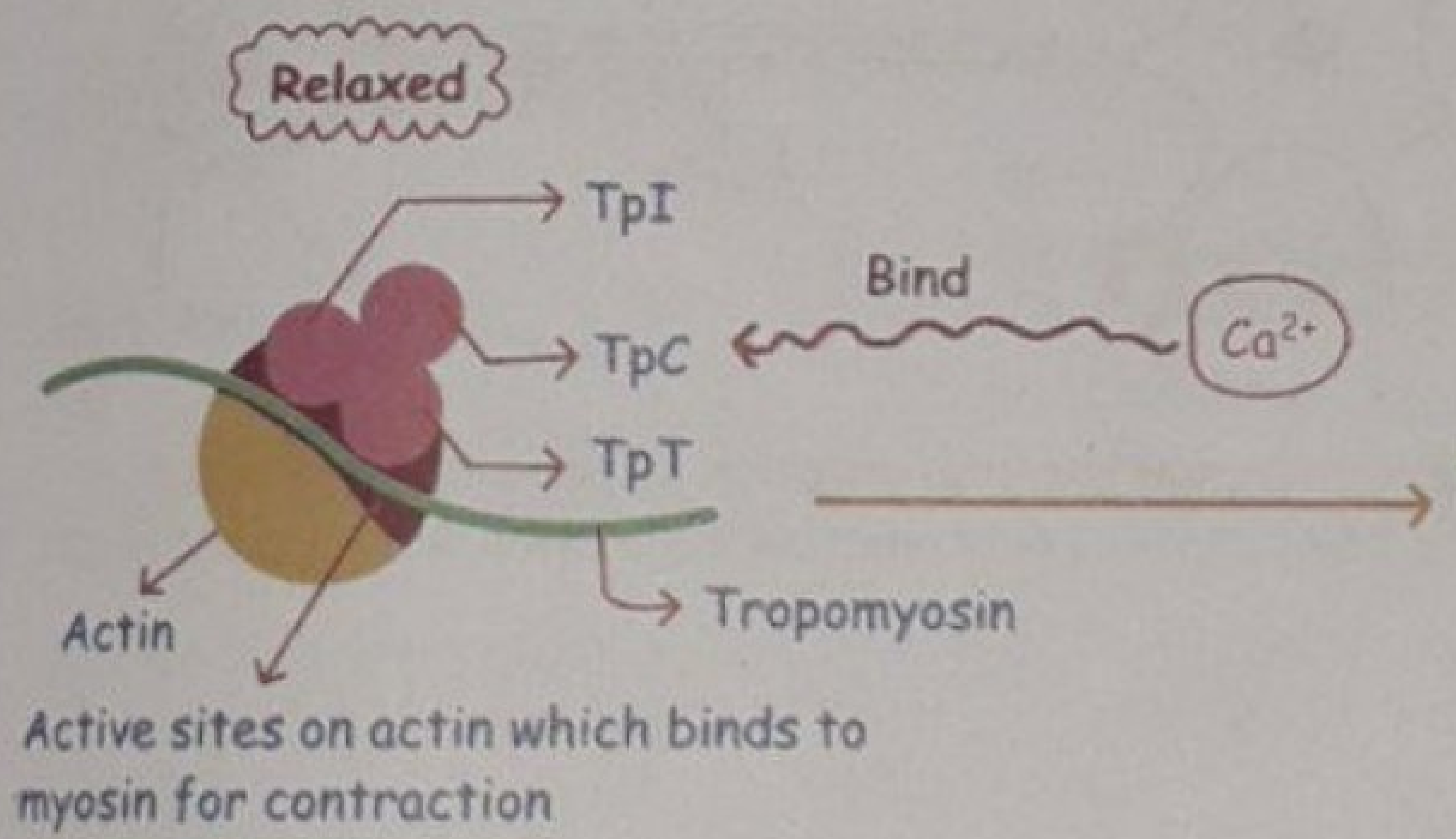
↓

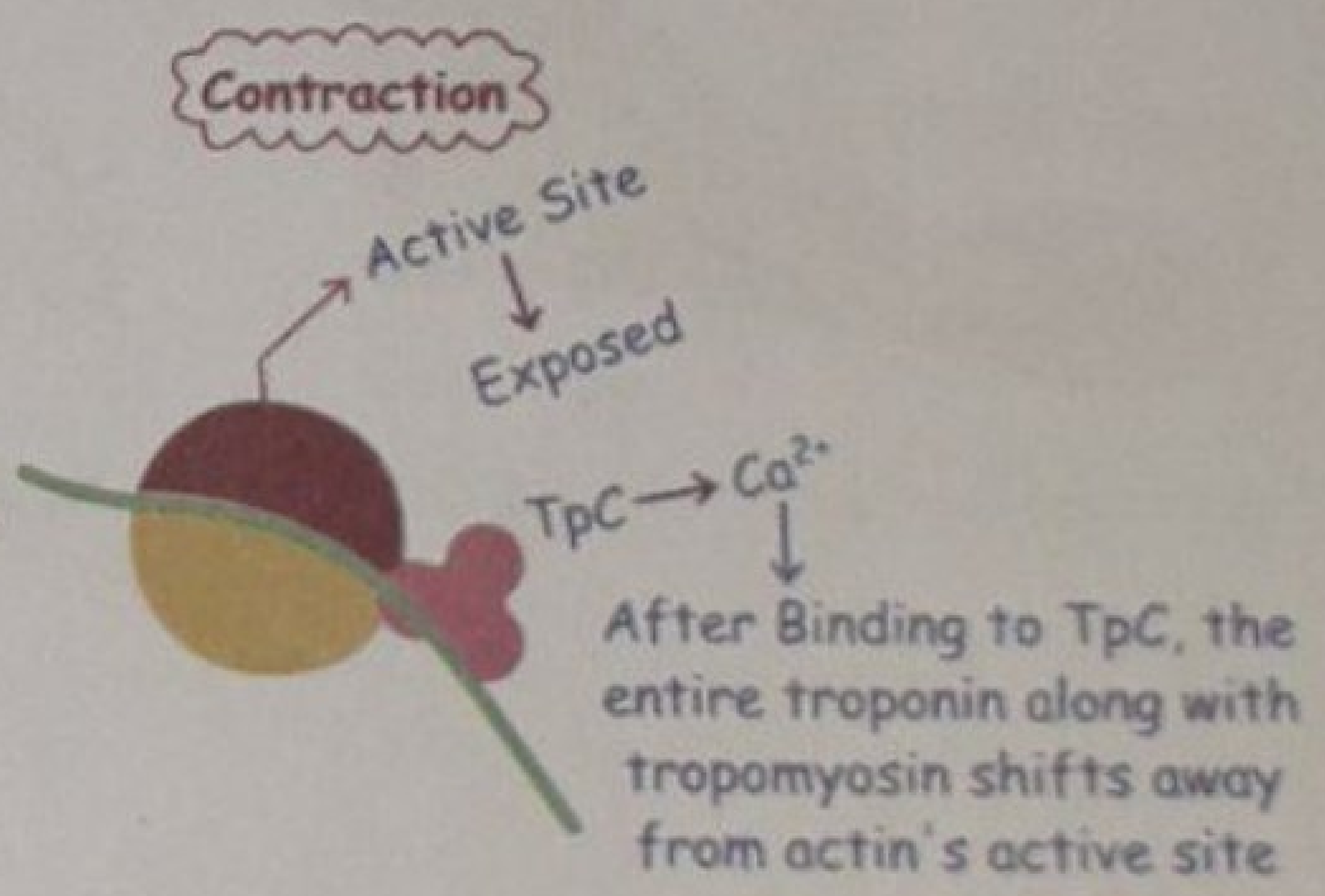
has 3 components

- TpC ⟶ It binds to Ca^{2+} & helps in shifting entire troponin along with tropomyosin from the actin's ACTIVE SITE during muscle contraction
- TpI ⟶ Inhibitory troponin, mask the active sites of actin when muscles are not contracting
- TpT ⟶ Binds to Tropomyosin



As the signals for muscle contraction come from neuron, Ca^{2+}↑ which binds to TpC & it leads to shifting of troponin along with tropomyosin from actin's active sites





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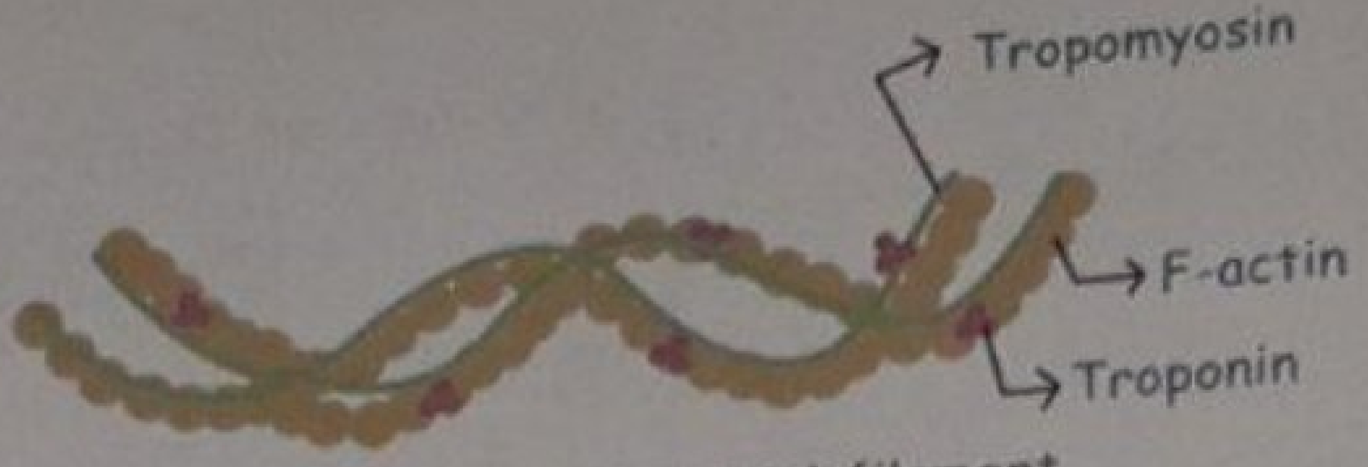


Figure: An actin (thin) filament

(B) THICK MYOFILAMENT

→ It is made up of 'Myosin' protein

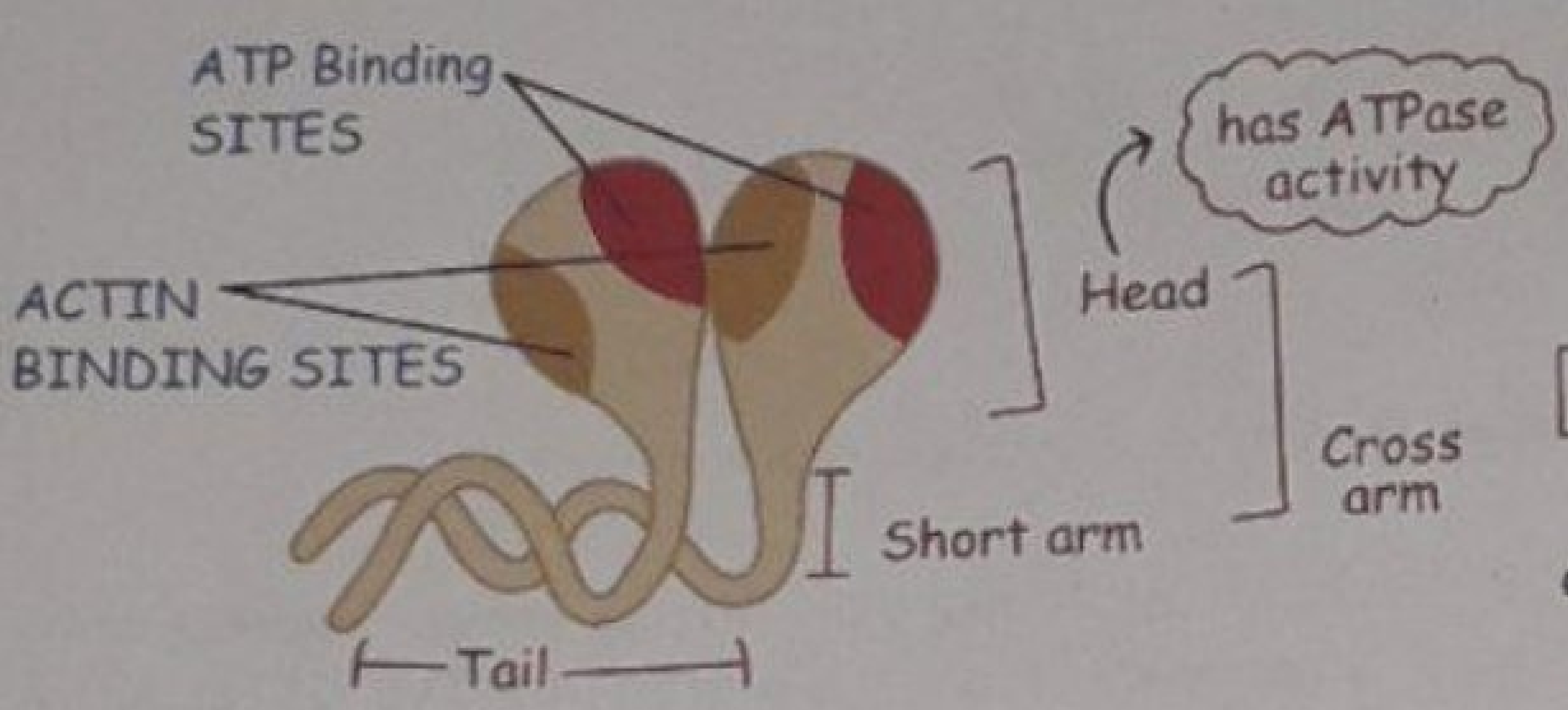


Figure: Myosin monomer (Meromyosin)

Meromyosin

- Heavy meromyosin (HMM) → Molecular weight ↑ → **Head + Short arm** → also known as **CROSS ARM**
- Light meromyosin (LMM) → Molecular weight ↓ → **Tail**

'Meromyosin' (Tadpole)

→ Polymerise - - → To form 'MYOSIN'

Muscle contraction:

- Motor neuron from CNS makes junction with muscle fibres, & this is called NMJ (neuromuscular junction)/ motor end plate.
- A motor neuron along with all its muscle fibres is known as **ONE MOTOR UNIT**

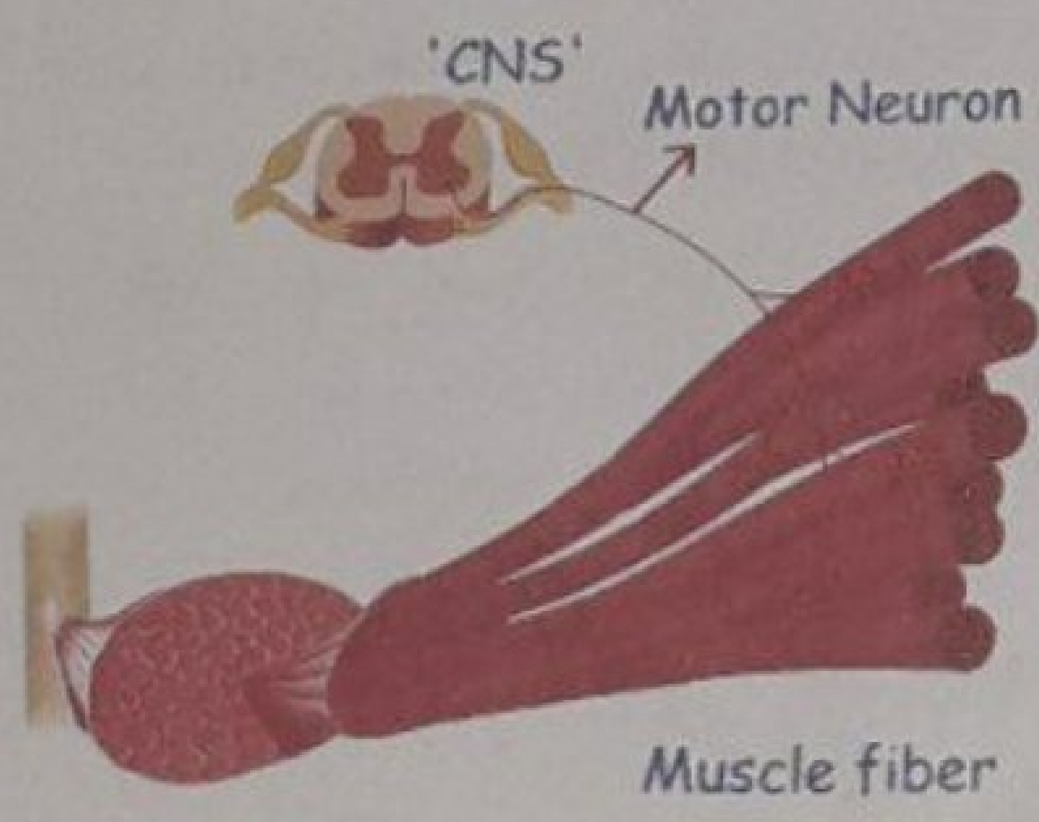


Figure: An illustration of a motor unit

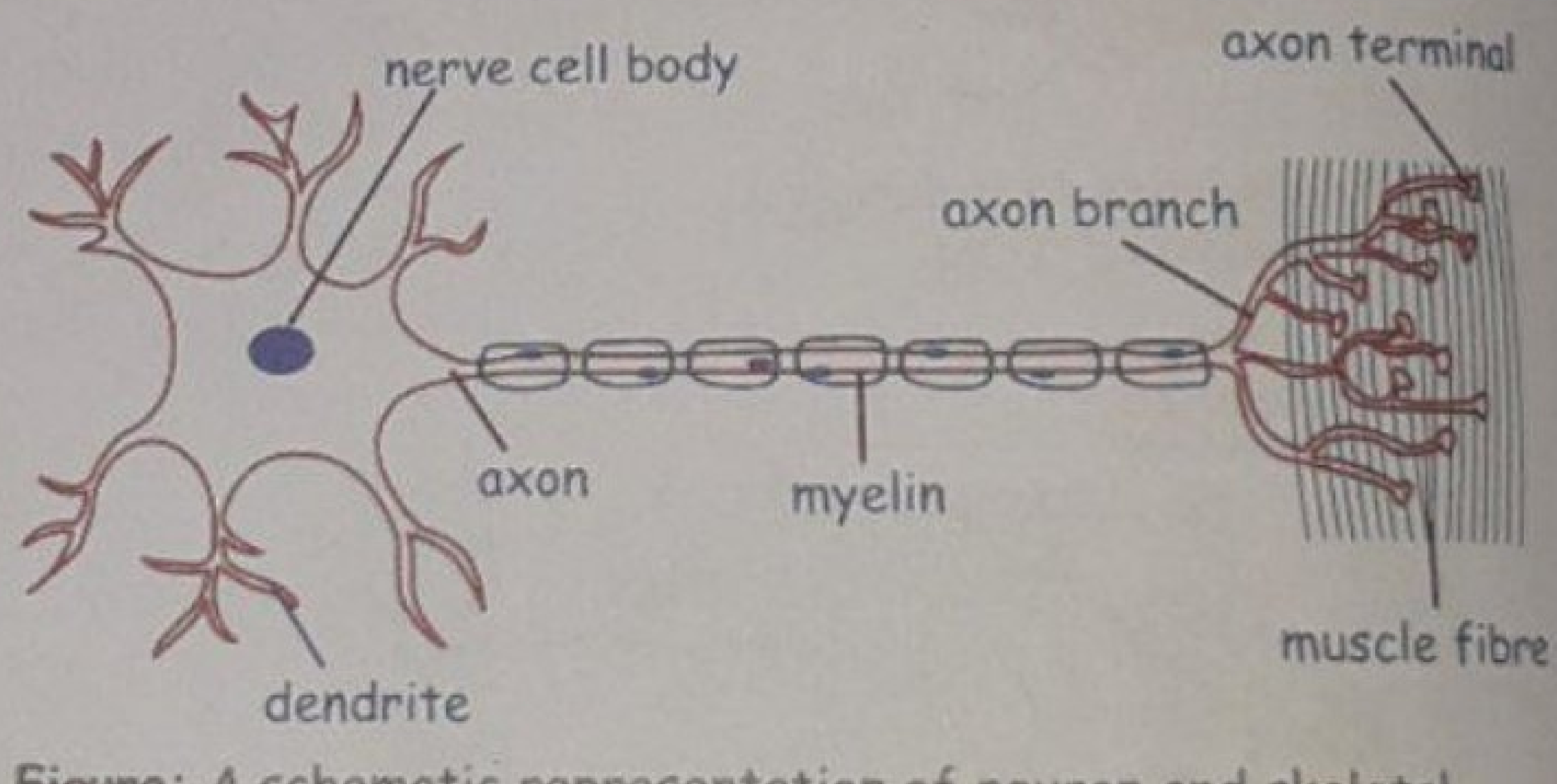
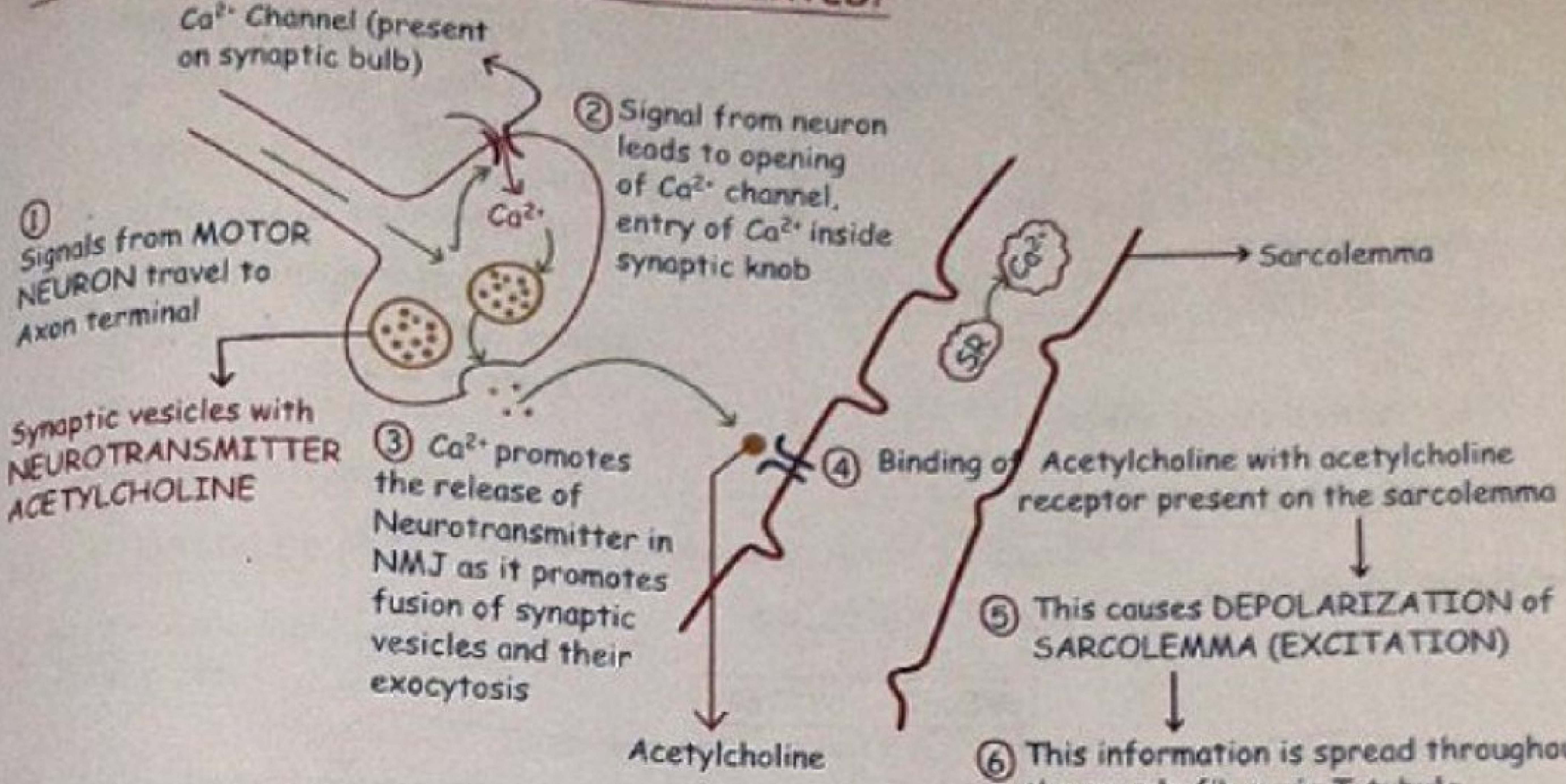


Figure: A schematic representation of neuron and skeletal muscle fibre showing neuromuscular junction & motor end plate

HOW IS MUSCLE CONTRACTION INITIATED?



④ Binding of Acetylcholine with acetylcholine receptor present on the sarcolemma

↓

⑤ This causes DEPOLARIZATION of SARCOLEMMA (EXCITATION)

↓

⑥ This information is spread throughout the muscle fibre via T-tubule

↓

⑦ This signals $\boxed{SR}$ to release Ca^{2+} into sarcoplasm

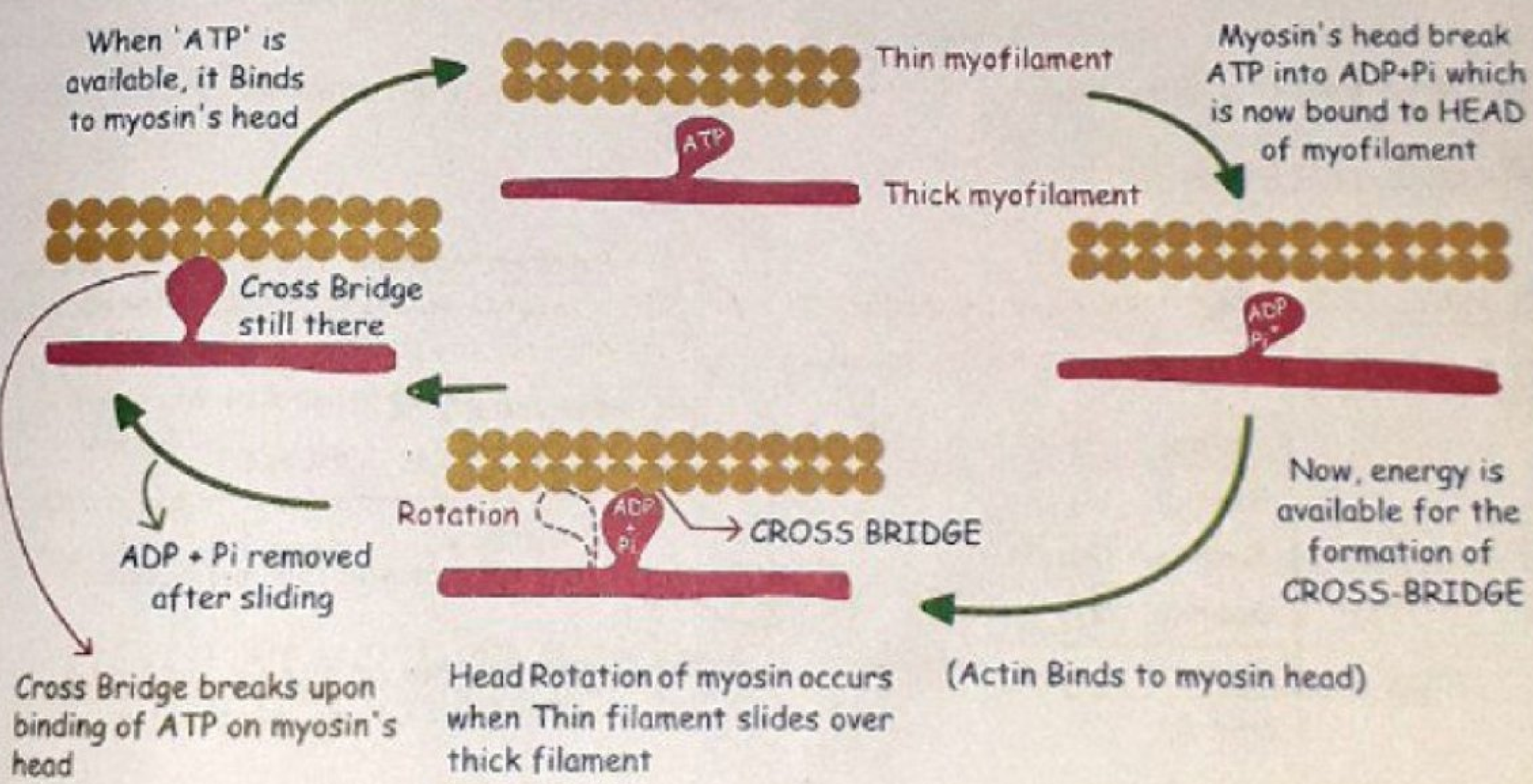
↓

⑧ Ca^{2+} Binds to TpC of Troponin

↓

⑨ Unmasking of actin occurs

SLIDING FILAMENT THEORY



Types of Muscle fibres

Red muscle fibre	White muscle fibre
Red in color	White in color
More blood vessel	Less blood vessel
More myoglobin (muscle protein)	Less Myoglobin
More Mitochondria → Aerobic respiration	Less Mitochondria → Anaerobic respiration
SR less ($Ca^{2+}\downarrow$)	SR More ($Ca^{2+}\uparrow$)
eg:- Pectoralis major Muscle	eg:- Eyeball muscle

HUMAN SKELETAL SYSTEM

→ Human Endoskeleton
- → Support & linkage (Specialised Connective tissue)
- → BONES + CARTILAGE

SKELETAL SYSTEM
206 Bones
↓
In adults

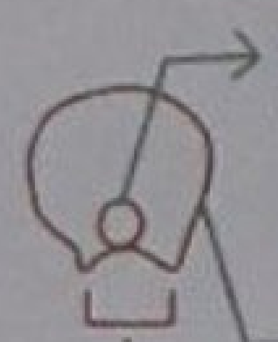
- Axial Skeleton (80)
  1. HEAD (29)
     - (a) → Cranium (8) } SKULL
     - (b) → Facial Bones (14) } SKULL
     - (c) → Hyoid (1)
     - (d) → Ear-ossicles (3X2)
  2. RIBS (24) + STERNUM (1)
  3. VERTEBRAL COLUMN (26)
- Appendicular skeleton (126)
  - Girdle Bone (6)
    - Pectoral girdle (4)
    - Pelvic girdle (2)
  - Limb Bones (30X4) (120)
    - Forelimb (30X2)
    - Hindlimb (30X2)

(A) AXIAL-SKELETON

(I) SKULL (22 or 23) Why? Explained later.

(1) Cranial Bones (8) → Forms Brain Box (Cranium)
↓
Protect Brain

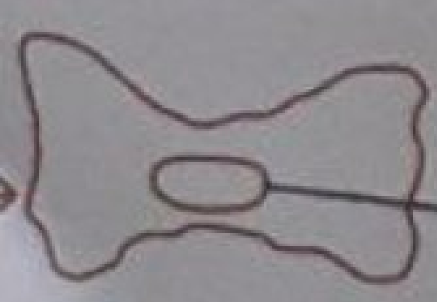
- Frontal (1)
- Parietal (2)
- Temporal (2)
- Occipital (1)
- Sphenoid (1)
- Ethmoid (1)



→ **Foramen Magnum:** There is a large opening present at the base of SKULL in the occipital bone for the passage of spinal cord

→ Occpital bone

→ 2 OCCIPITAL CONDYLES
↓
forms joint with first vertebrae



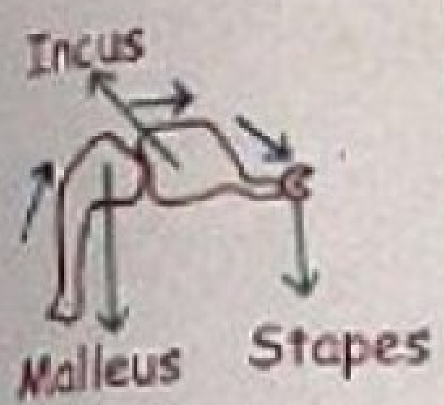
→ Sphenoid has cavity called as SELLA and TURSICA that encloses pituitary gland

(2) Facial Bones (14)

- Nasal (2) (Bridge of Nose)
- Maxillae (2) (Upper jaw)
- Zygomatic (2) (Prominence of cheek)
- Lacrimal (2) (Orbit)
- Palatine (2) (hard palate)
- Inferior Nasal conchae (2) (nasal cavity)
- Mandible (1) (Lowerjaw)
- Vomer (1) (Triangular)

(3) EAR OSSICLES (6)

Middle ear: each middle ear has 3 ear ossicles, so in total 6 bones



- Malleus (Hammer shaped)
- Incus (Anvil shaped)
- Stapes (Stirrup shaped)

Function: amplification of sound vibration

(4) Hyoid (1)

- Single 'U' shaped Bone
- Present at the base of Buccal cavity/Below the lower jaw
- Does not articulate with any other Bone

Very Important

NOTE

NCERT → *Facial & cranial Bones make skull (22)

→ *Hyoid also included in skull which makes skull bones 23

- बड़ी-बड़ी NCERT में ऐसे छोटे छोटे CONFUSION होता रहता है।

- 22 or 23 both are correct, both options never comes in NEET but you should know both.

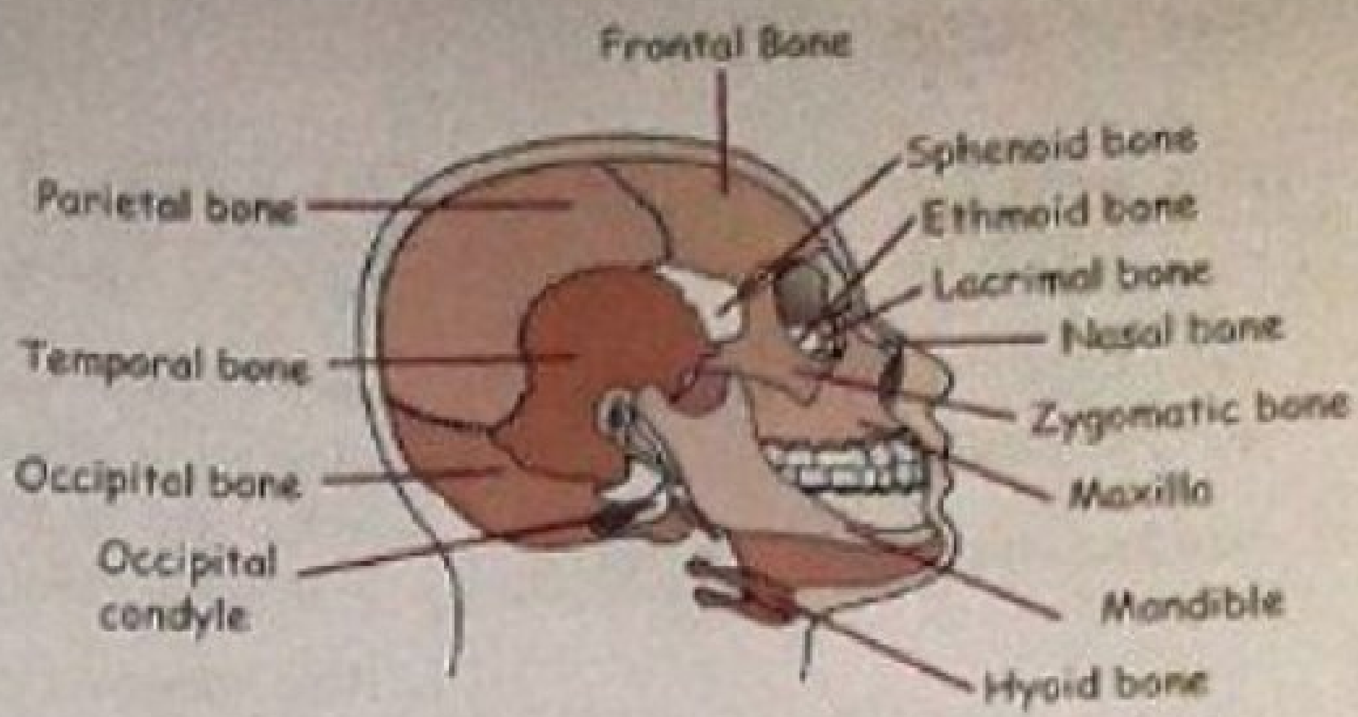


Figure: Diagrammatic view of human skull

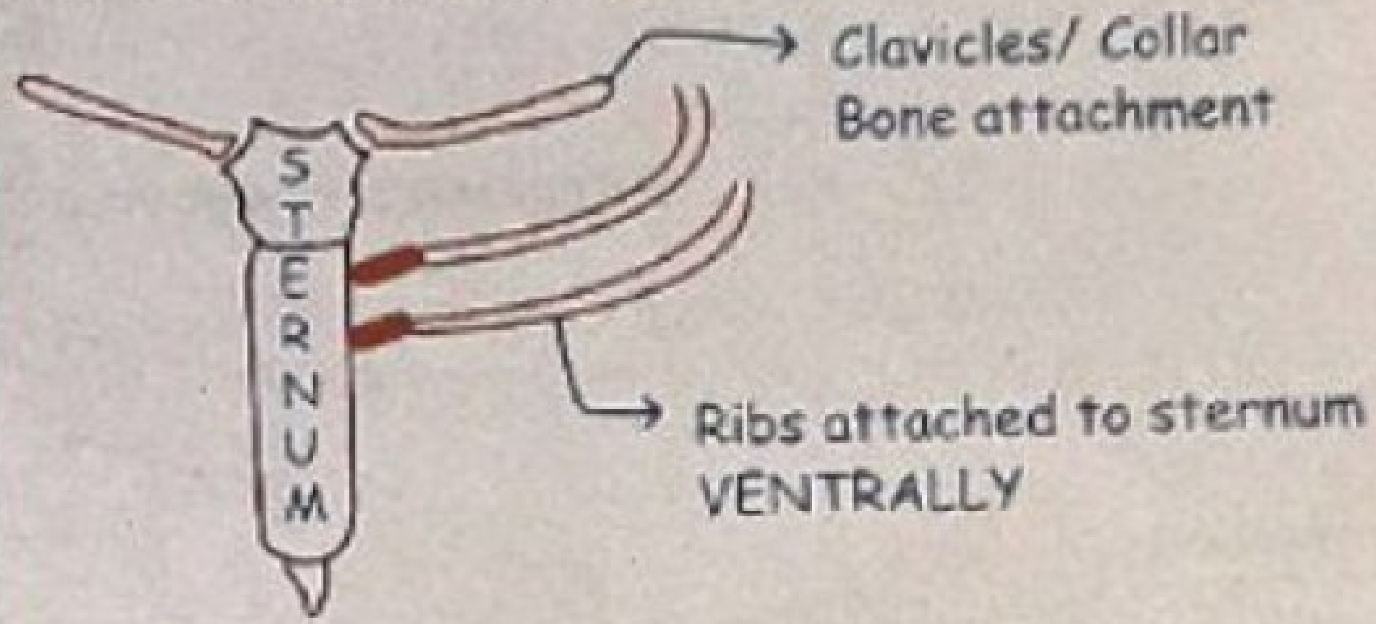
(II) Ribs & Sternum

→ 12 pair → '24'

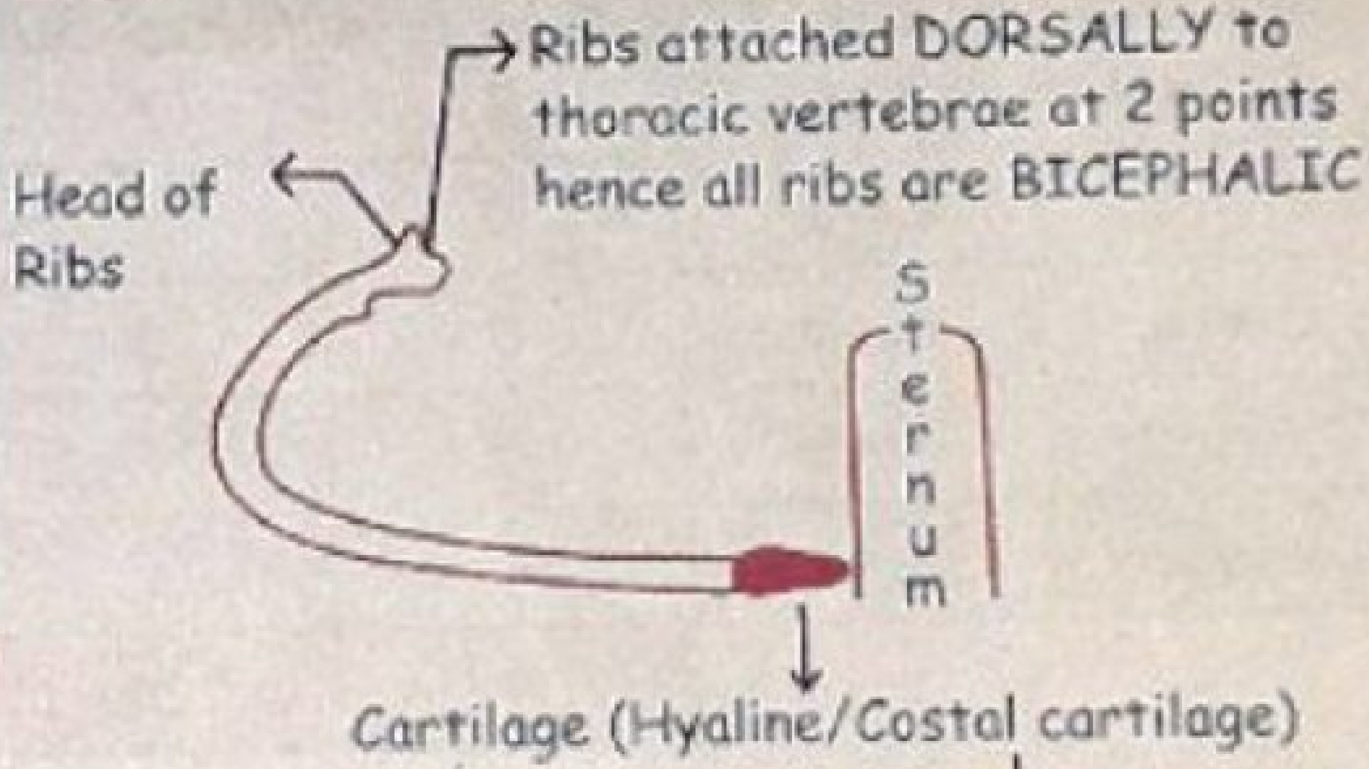
→ 1

STERNUM The breastbone, FLAT BONE

- Present on ventral side



RIBS 12 pair, flat Bones



Ribs attached via this to sternum

Ribs attached to

- Sternum (Ventrally)
- Vertebrae (Dorsally)

Types of RIBS

TRUE RIBS

- First 7 pair
- Attached both to sternum & vertebral column
- Also known as vertebrosternal Ribs

FALSE RIBS

- 8^{th}, 9^{th}, 10^{th} Pair
- Attached to vertebral column, indirectly attached to sternum. First attached to the cartilage of 7^{th} rib, indirectly attached to sternum.
- Also known as $\text{Vertebro}\underbrace{\text{Chondral}}_{\text{(Cartilage)}}$ RIBS

FLOATING RIBS

- 11 & 12^{th} pair
- Only attached dorsally to the vertebral column, free ventrally

(Protect the organs Like KIDNEY)

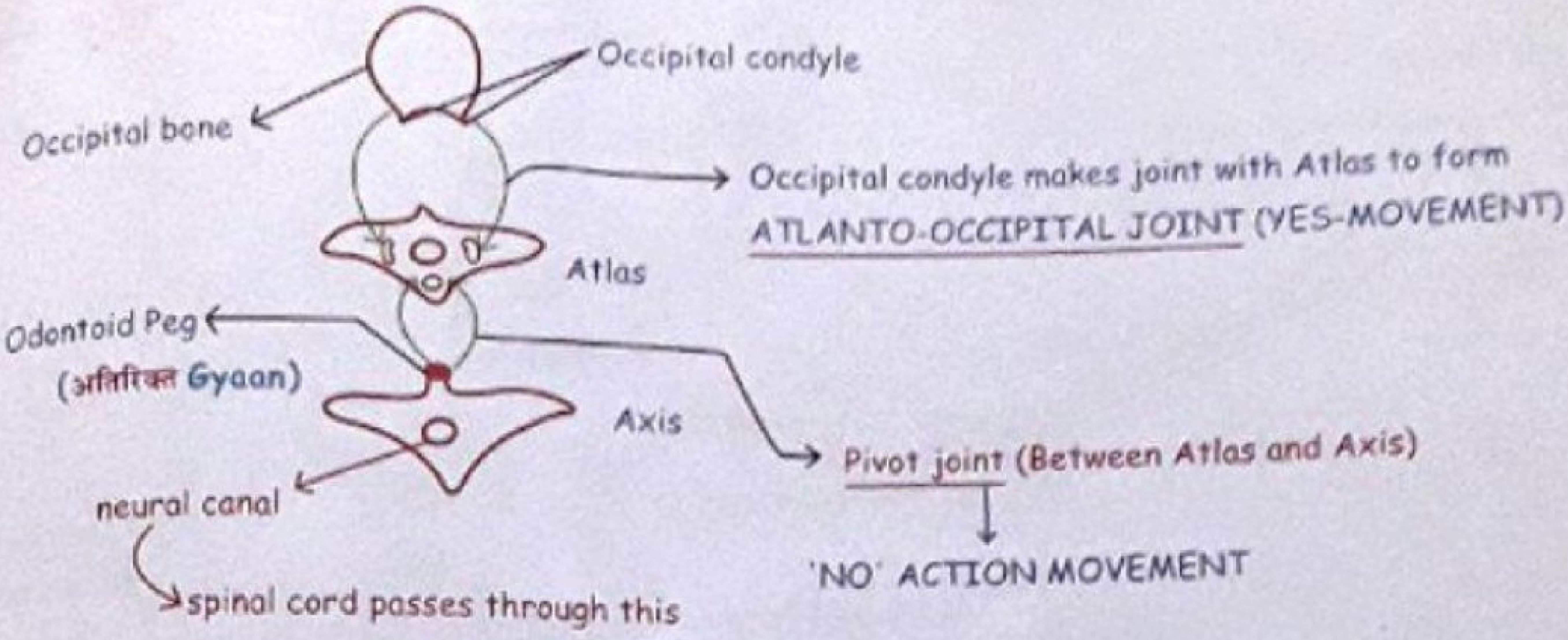
- Also known as VERTEBRAL RIBS

(III) VERTEBRAL COLUMN (26)

Vertebrae:

Name	Location	Embryonic Stage	Adult
Cervical	Neck	7	7
Thoracic	Chest	12	12
Lumbar	Abdomen	5	5
Sacral	Pelvis	5	1
Coccygeal	Pelvis	4	1
		33	26

- 1st cervical vertebra : ATLAS
- 2nd cervical vertebra : AXIS
- Thoracic Vertebra : Ribs Attached to this
- Lumbar : Holds the whole body weight
- Coccygeal : Tail Bone



Ⓑ APPENDICULAR SKELETON (126)

① GIRDLE BONES: (6)

Ⓐ PECTORAL GIRDLE: Each half of pectoral girdle has:

2 bones

1. CLAVICLE/ CollarBone
2. SCAPULA

- Each half is separate

Scapula:

- Triangular bone located between 2nd & 7th Rib
- Has GLENOID CAVITY into which head of humerus bone fit to form Ball & Socket joint.
- Has SPINOUS PROCESS DORSALLY, whose flat ACROMION PROCESS helps in ATTACHMENT of CLAVICLE

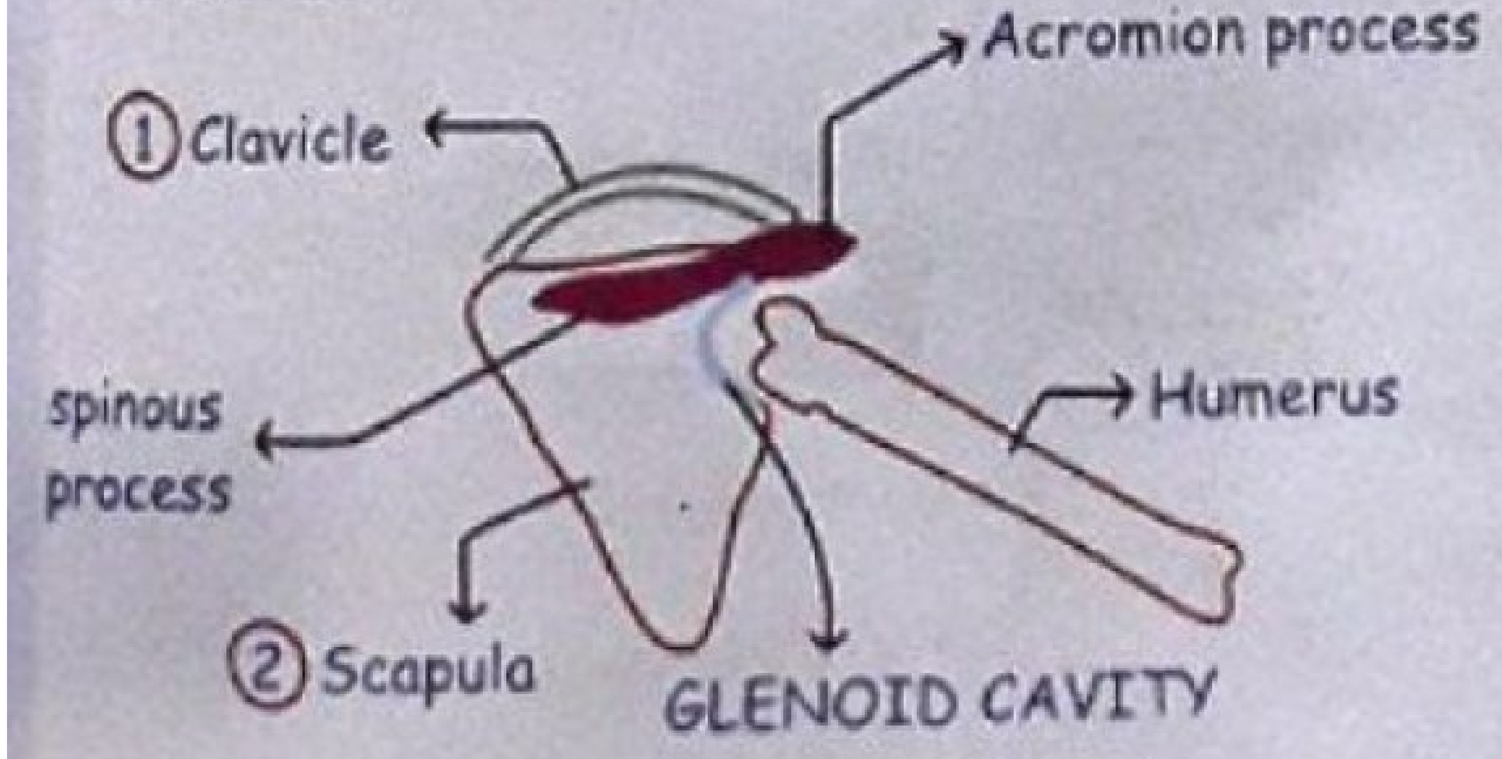


Figure: Dorsal view of Scapula

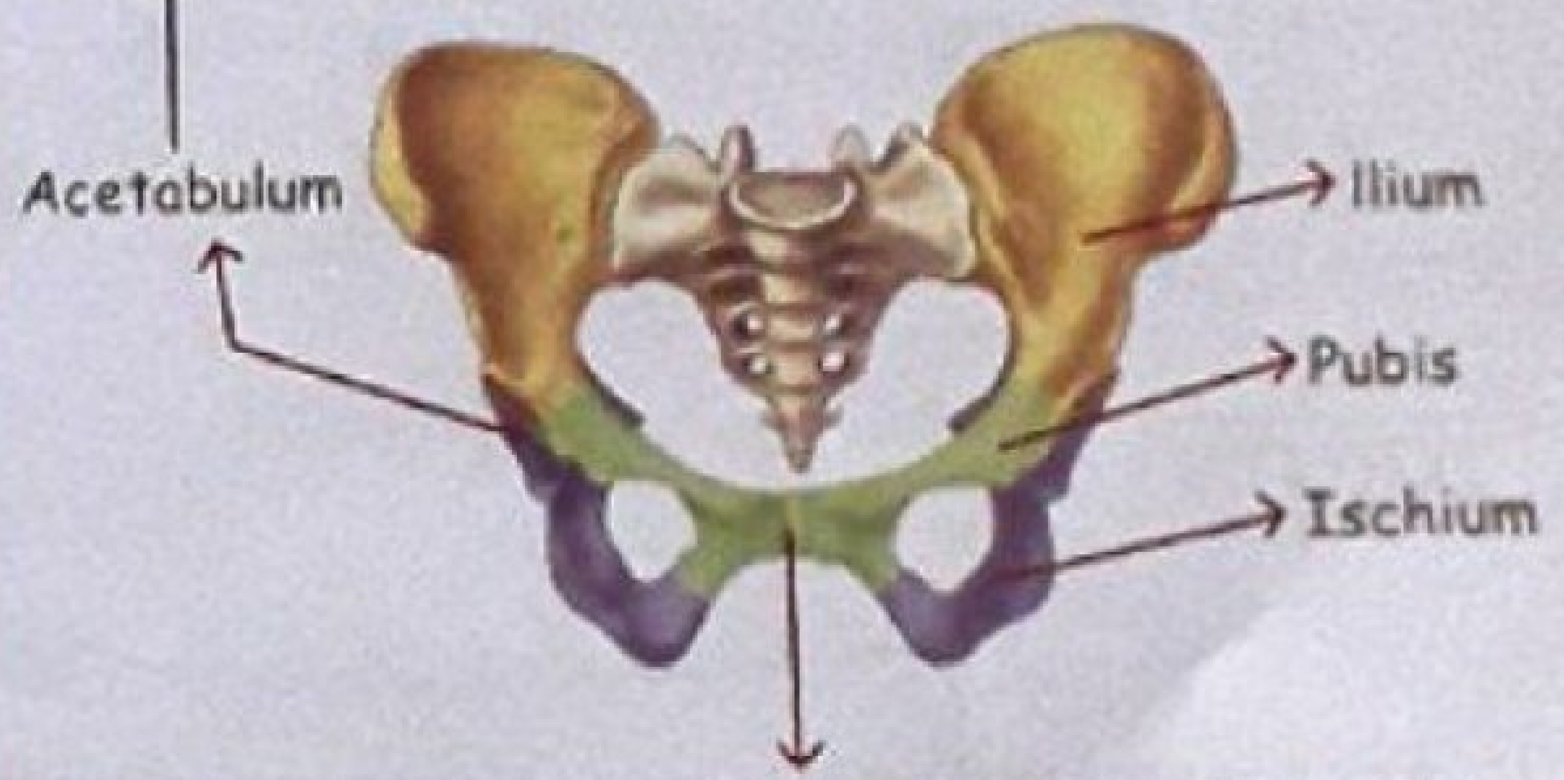
Clavicle:

- Clavicle/Collarbone: attached to SCAPULA and STERNUM

Ⓑ PELVIC GIRDLE (2)

- Each half of pelvic girdle: has 1 bone known as COXAL BONE which is actually formed by fusion of 3 bones: ILIUM, ISCHIUM, PUBIS

At the junction these 3 Bones, this cup like structure present for attachment of FEMUR

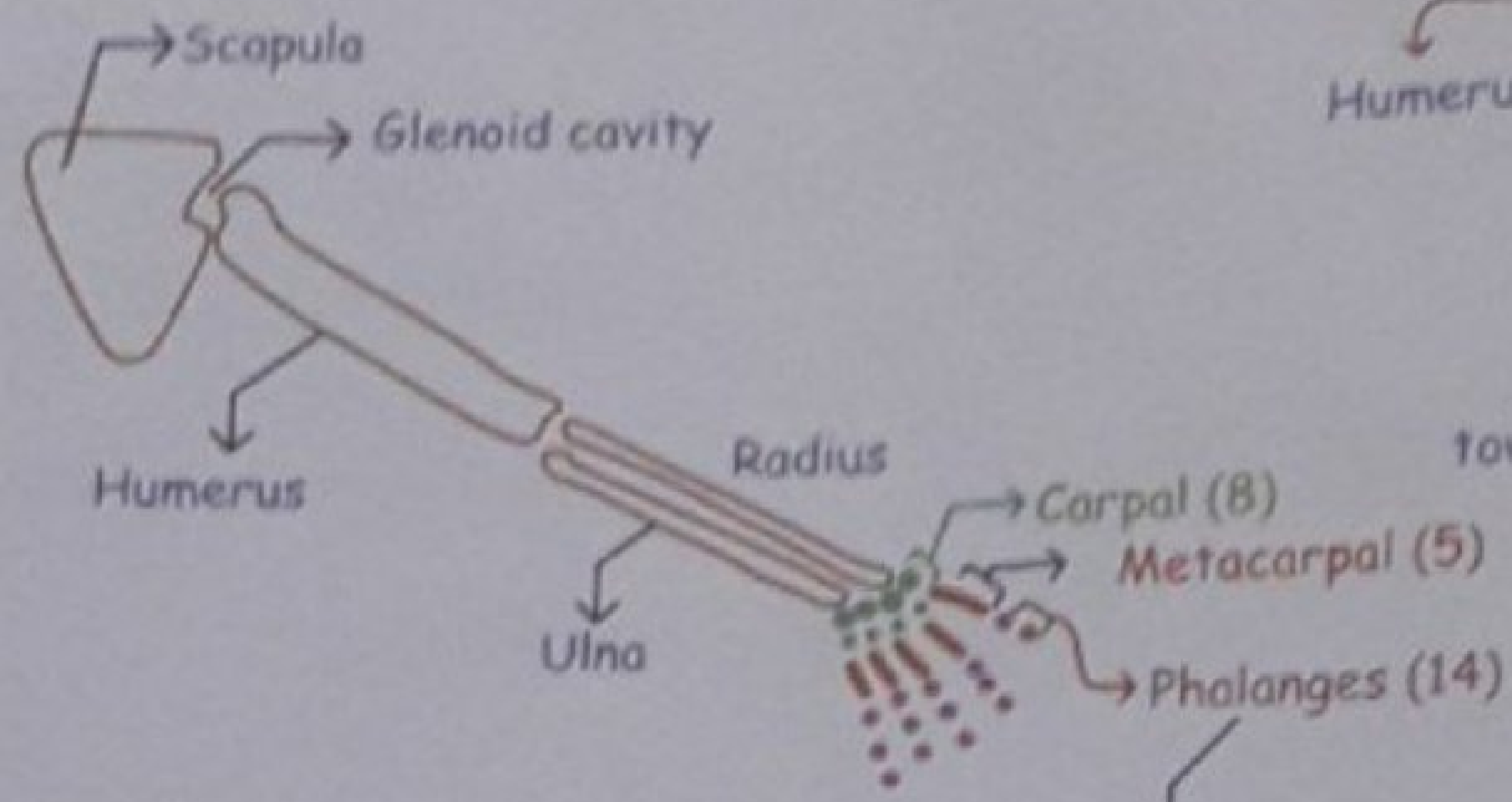


Each half of coxal bone is attached. Pubis bone of both side fused ventrally called as PUBIC SYMPHYSIS

② LIMB BONES (120)

Ⓐ Forelimb

- Each forelimb has 30 bones
- Total = 30 X 2 = 60 bones



Phalangeal formula

Thumb ← 2 3 3 3 3

Each Forelimb (30)
- Humerus (1)
- Radius & Ulna
  - (1) → towards thumb
  - (1)
- wrist → Carpal (8)
- Palm → Metacarpal (5)
- finger → Phalanges (14)

Ⓑ Hindlimb

- Each hindlimb has 30 bones
- Total = 30 X 2 = 60 bones

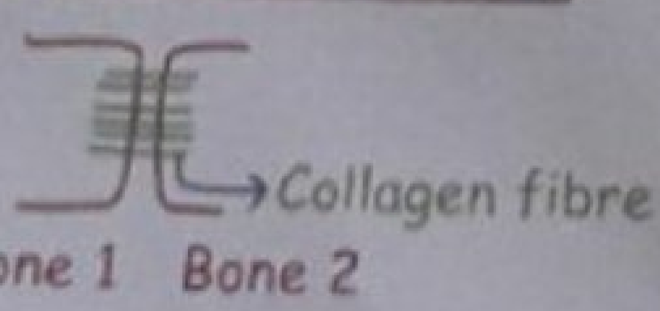
Each Hind limb
- Femur (1)
  - Longest Bone
  - Thigh bone
- Tibia (1), Fibula (1)
  - Tibia:
    - THICK
    - Present Medially
  - Fibula → present laterally
- Heel → Tarsal *(7)
- Sole → Metatarsal (5)
- Digits → Phalanges (14)

- 30th BONE: PATELLA: 'KNEECAP'

JOINTS

Joints

1. FIBROUS JOINTS



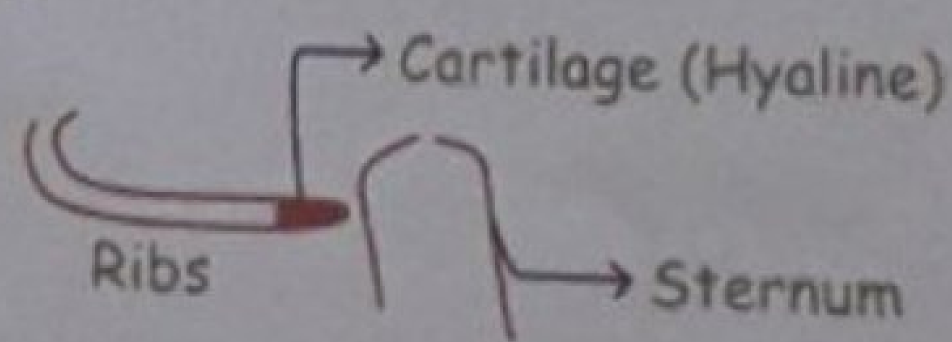
- Bones are joined via collagen fibres
- These are Immovable joints also called a SYNARTHROSE JOINTS

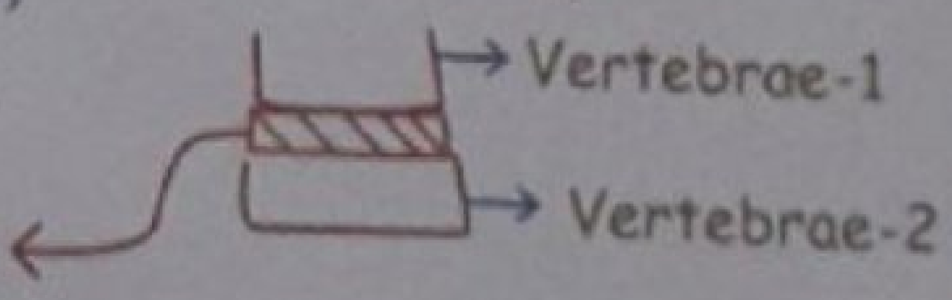
eg: Sutures of SKULL

2. CARTILAGINOUS JOINTS

- Joints formed with the help of CARTILAGE
- These are Slightly movable joints (AMPHIARTHROSE)

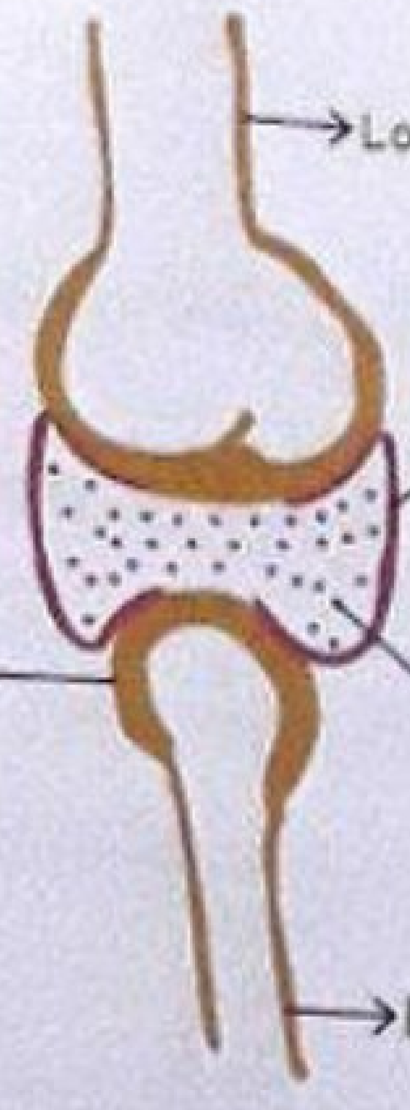
eg: Ribs & Sternum, Pubic Symphysis, Intervertebral disc





3. SYNOVIAL JOINTS

Synovial joints



Synovial joints

- Also known as Diarthrose joints
- Show Maximum movement
- Synovial fluid present between bones

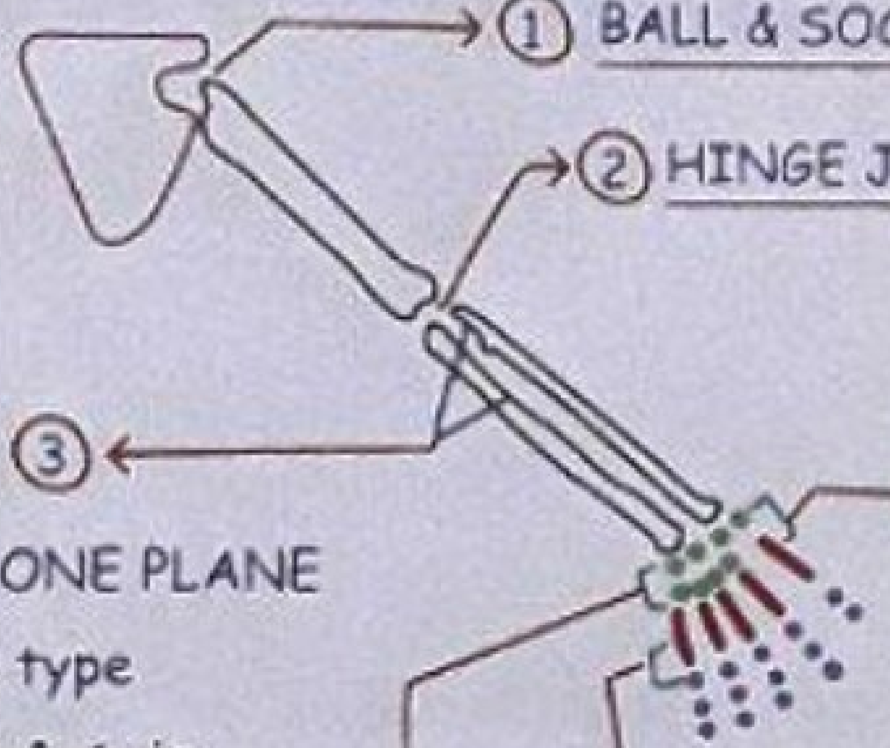


Figure: Types of synovial joints

DISORDERS

1. ARTHRITIS

$\underbrace{\text{ARTHR}}_{\text{joints}}\underbrace{\text{ITIS}}_{\text{inflammation}}$

→ ① **OSTEOARTHRITIS** (अतिरिक्त Gyaan) → Inflammation in the Cartilage present at the end of long Bones

→ ② * **RHEUMATOID ARTHRITIS** (Mentioned in class 12) → AUTOIMMUNE DISORDER → Body makes antibody for its own cells & start attacking them

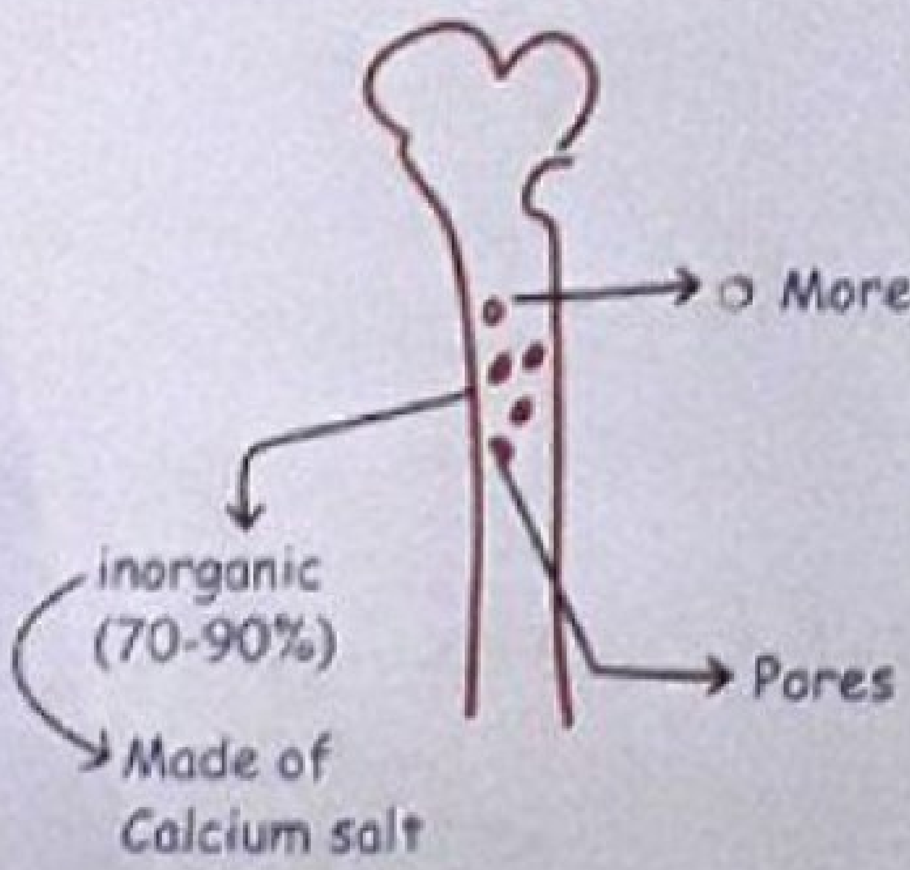
→ In this case, synovial membrane is inflammed, synovial fluid ↑, pressure on joints, causing joint pain

→ ③ ** **GOUT/GOUTY ARTHRITIS** → inflammation of joints due to accumulation of URIC-ACID CRYSTAL in joints

2. Osteoporosis

$\underbrace{\text{Osteo}}_{\text{Bone}}\underbrace{\text{porosis}}_{\text{pore}}$

- Age Related disorder
- Disbalance in Hormones like Calcitonin, Parathormone, Estrogen results in demineralisation of bone (loss of Ca^{2+}), creating pores in the Bones
  - creating pores → Bones: Become WEAK → Prone to fracture



- More common in females after MENOPAUSE due to drop in Estrogen Level

3. Tetany:
Spasm (Uncontrollable & fast contractions) in muscles due to low level of calcium in ** ECF (Extracellular fluid)

4. Muscular dystrophy:
It is a $\boxed{\text{GENETIC DISORDER}}$ → dystrophin gene damaged

↓

No dystrophin protein

↓

Structural stability of muscle is lost, communication between muscle fibre is lost

↓

Progressive degeneration of MUSCLE with time

Dystrophin gene Damaged → dystropin protein not produced

5. **Myasthenia gravis:** **AUTO-IMMUNE DISORDER

→ that affects NMJ

→ antibodies formed here attacks Acetylcholine receptors

↓

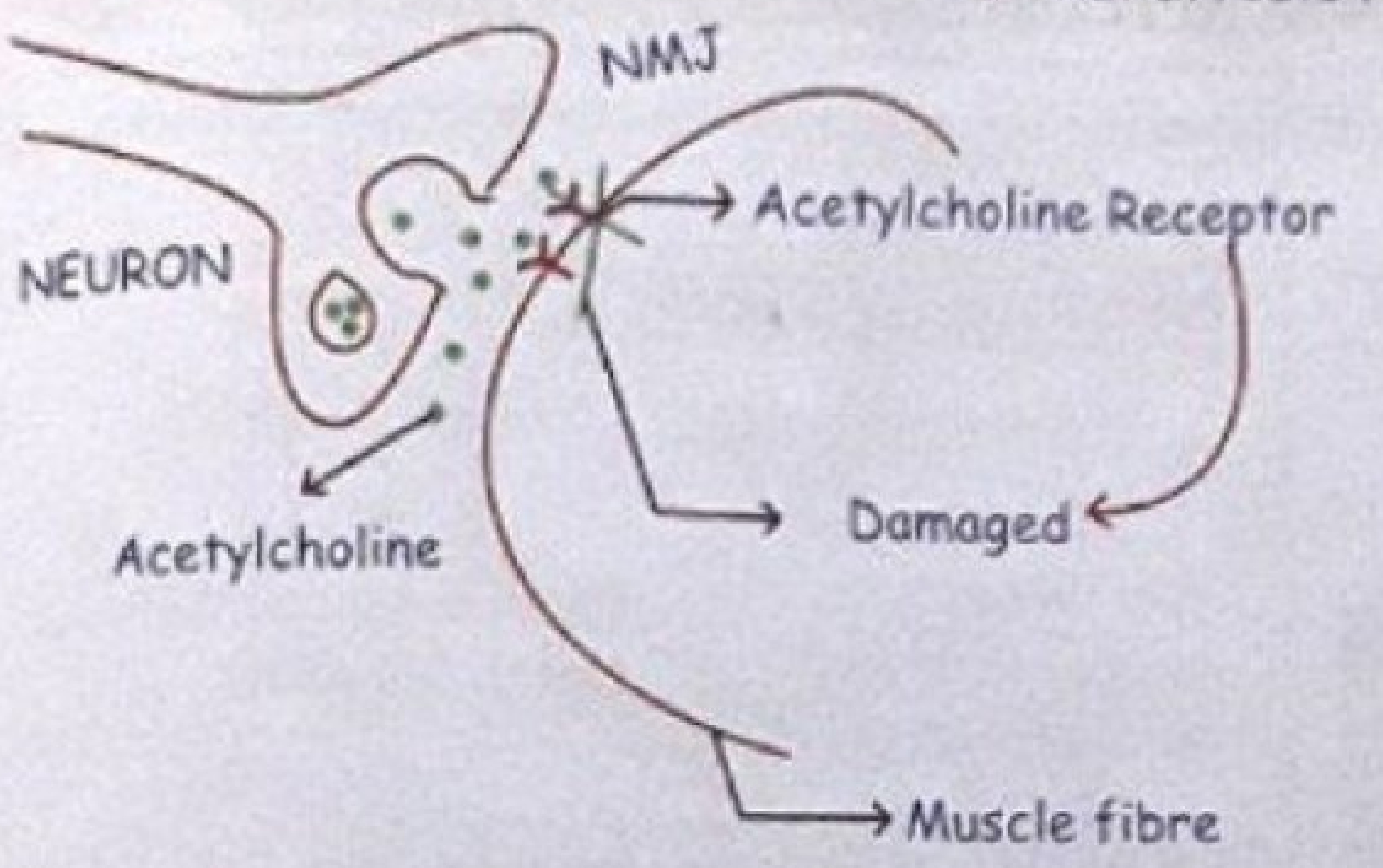
Acetylcholine will Not Bind to receptor

↓

MUSCLE do not contract

↓

Paralysis with time



8 Neural Control and Coordination

Coordination: Coordination is the process through which two or more organs interact and complement the functions of one another.

Table: Neural Control vs. Endocrine Control

Neural Control	Endocrine control
Here, the Neurons are involved and communicates with the help of NEUROTRANSMITTERS	Here, the glands work & communicate with the help of hormones
Quick response	Slower response
Not long lasting effect	Long lasting effect

NEURAL SYSTEM:

Primitive animals → They do not have a well organised Nervous System

eg: Hydra → I[st] time → APOLAR NEURON was seen

Advanced animals → (Well organised Nervous System is seen) → eg: Vertebrates (FISHES, AMPHIBIANS, REPTILES, AVES, MAMMALS)

Nervous system is made up of NEURAL TISSUE / NERVOUS TISSUE

(1) Neuron
- Excitable cell that will help in conduction
- Longest Cell

(2) Neuroglial cells
- Non excitable, non conductible
- Support & packaging of Neural tissue

eg: Schwann cell, oligodendrocyte

Neural/Nervous System

- CNS → Central Nervous System
  - Brain
  - Spinal cord
- PNS → Peripheral Nervous System
  - Somatic Nervous System → Control Voluntary Body parts
  - Autonomic Nervous System → Control involuntary parts
    - Sympathetic
    - Parasympathetic

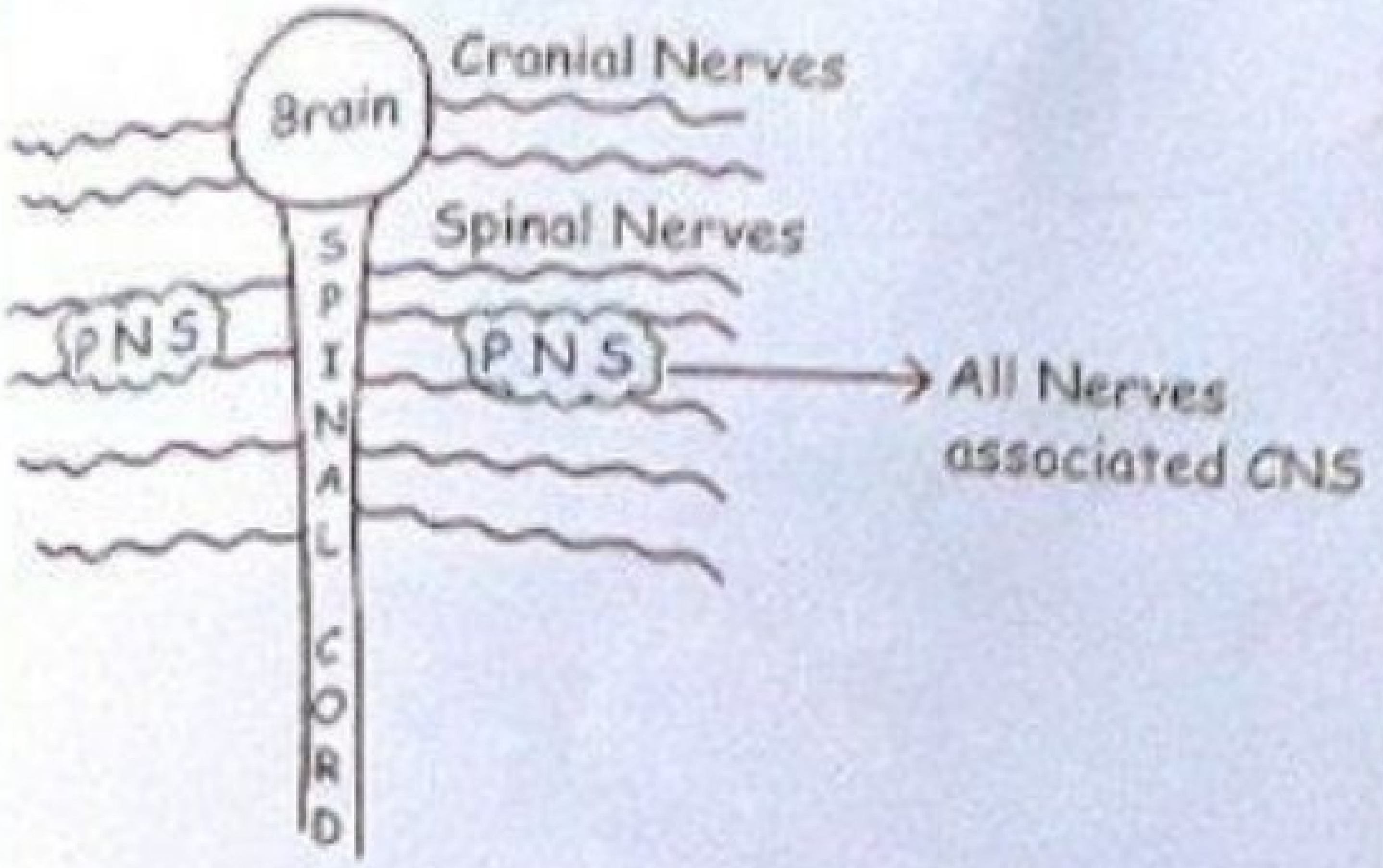


Fig: CNS and PNS

- CNS includes brain & spinal cord & is the information processing unit.
- PNS consists of all the nerves of body associated with CNS.

Nerve fibres of PNS are of 2 types

Afferent Fibres/Sensory Nerve Fibres
The afferent nerve fibres transmit impulses from tissues/organs to the CNS.

Efferent Fibres/Motor Nerve Fibres
The efferent fibres transmit regulatory impulses from the CNS to the concerned peripheral tissues/organs.

NOTE

Visceral Nervous System is a part of PNS that comprises the whole complex of nerves, fibres, ganglia and plexus from where impulse travel from CNS to viscera and vice versa.

		CNS	PNS
1.	Collection of Cell Body	NUCLEI	GANGLIA
2.	Collection of Axons	Tract	Nerve fibre

Plexus: जाल/Network

Neuron

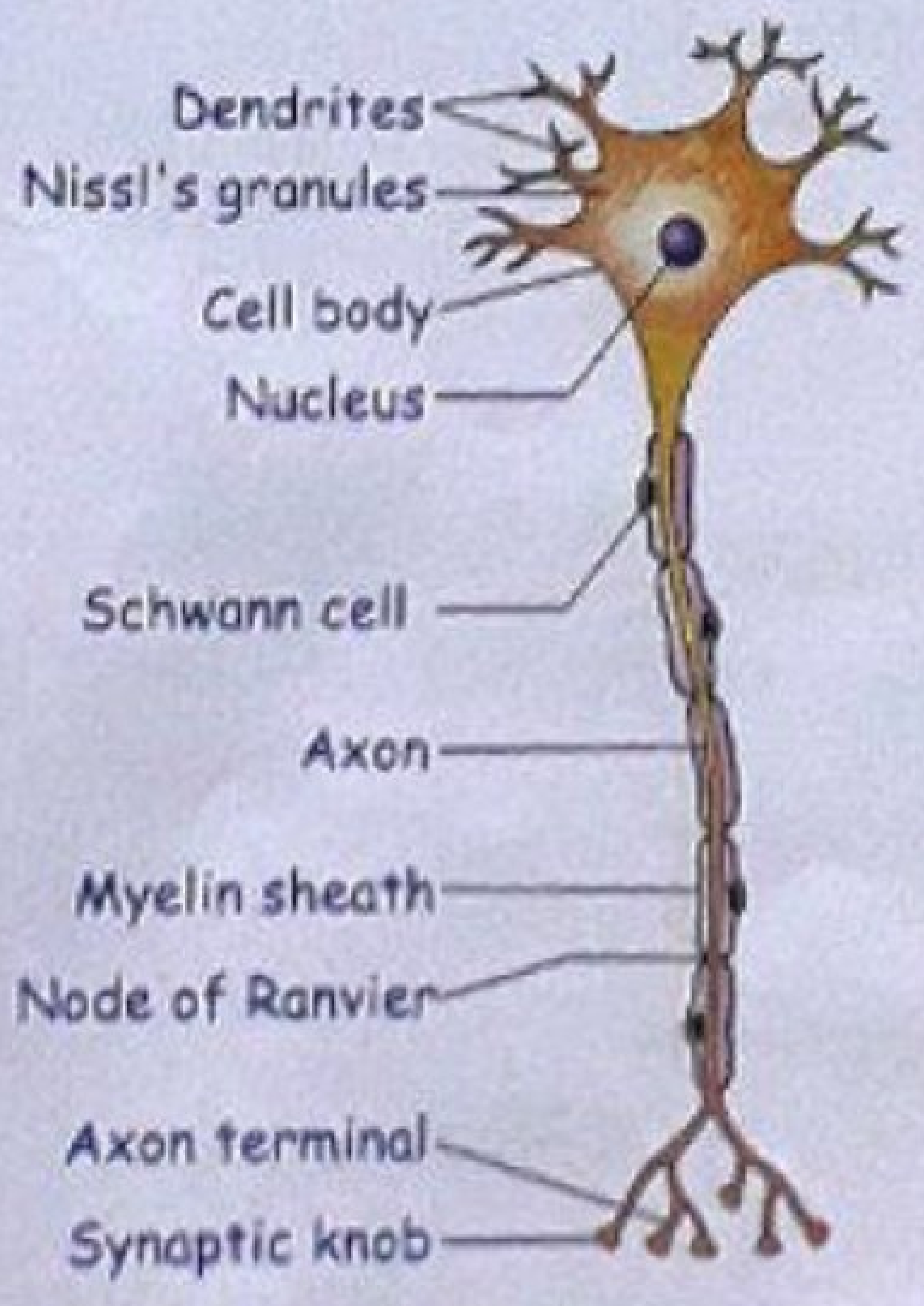


Figure: Structure of a neuron

Neurons

Myelinated
- Myelin sheath is present
- More commonly found in CNS

Unmyelinated/Non-myelinated
- Myelin sheath is Absent
- More commonly found in PNS

NOTE

Myelin sheath is LIPID enriched sheath which act as an insulator & hence no free conduction across them but there are gaps in between called NODES of RANVIER where free conduction is SEEN.

V.Imp

Myelinated Neuron

CNS
- Oligodendrocytes forms myelin sheath

PNS
- Schwann cell secretes myelin sheath

Types of Neurons

Type of Neuron

① Unipolar Neuron

Single polarity

eg: Embryonic Life

Only Axon is present

② Bipolar Neuron

e.g.: *Retina of eye, olfactory epithelium

1 Dendrite, 1 Axon present

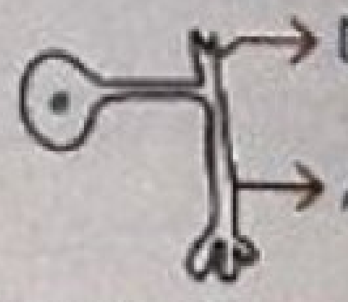
③ Multipolar Neuron

e.g.: Cerebral cortex of Brain

Many Dendrites, One axon present

Apolar: absence  Only cell Body is present
eg: Hydra

Pseudounipolar: false



- A single protoplasmic extension arise from cell body which later gets divided into 1 Dendrite and 1 axon.

eg: Dorsal Root of GANGLIA of SPINAL CORD

Dendrite receive information
↓
Send to
↓
Cell Body
↓ send it to
Axon

NOTE

Schwann cell enclosing a neuron may or may not secrete myelin, Schwann cell that does not form myelin around axon is common in autonomous and somatic neural systems.

GENERATION OF NERVE IMPULSE:

- When Neuron is at REST, the membrane of Neuron is known as RMP/RESTING MEMBRANE POTENTIAL or POLARISED STATE.
  - It is approx. -70 mV Potential
- This state is important for the Neuron for excitability.

RMP is maintained by

→ (i) Presence of more negatively charged Proteins inside the Axoplasm

→ (ii) Na^+ Leak channel & K^+ Leak channel (more leaky) working passively
- Through Na^+ Leak channel: Na^+ comes in.
- Through K^+ Leak channel: K^+ goes out.
- As compared K^+ channels are more in Number and more leaky

→ (iii) Na^+ K^+ Active pump
- Utilising 1 ATP: 3 Na^+ pumped out and 2K^+ comes into the axoplasm

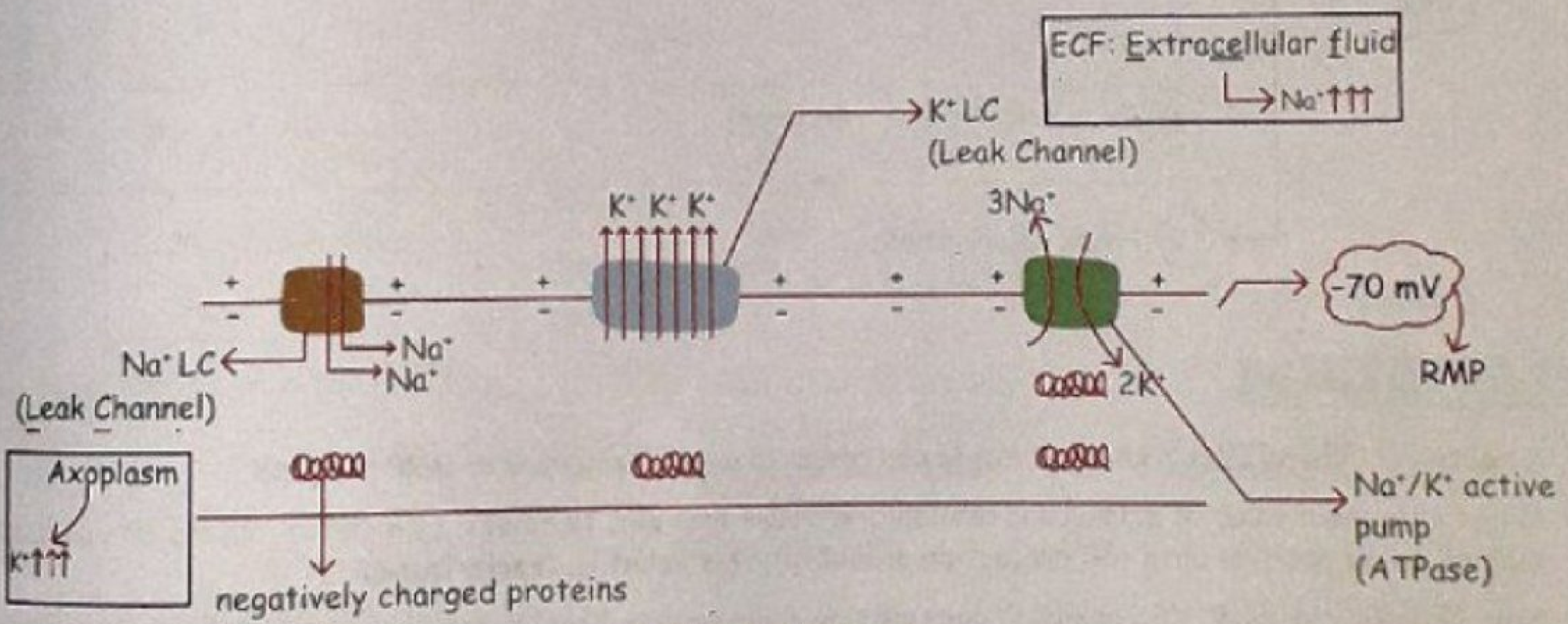
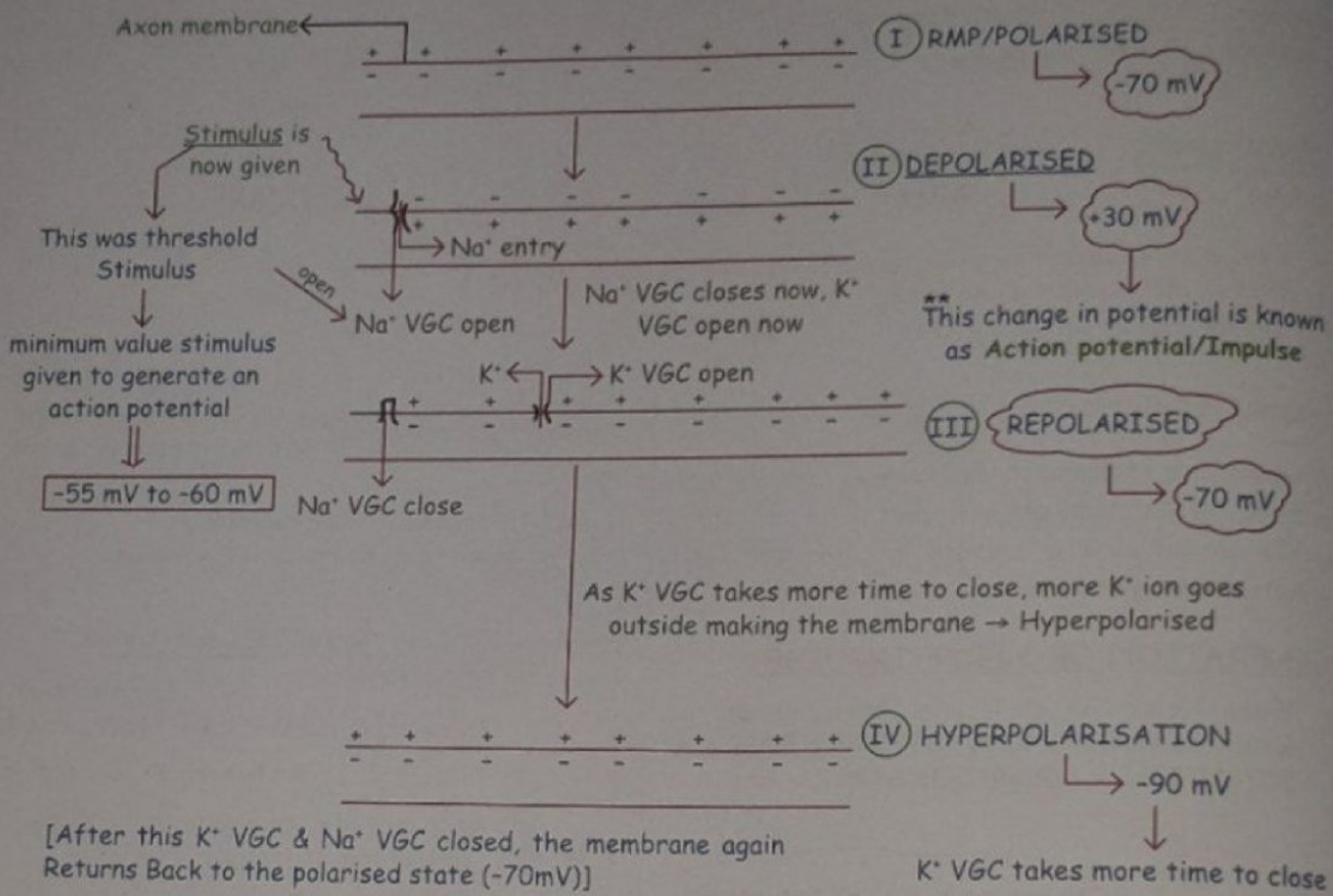


Fig: RMP explaination

NOTE Na^+ VGC(Voltage Gated Channel), K^+ VGC(Voltage Gated Channel) — Present on Axonal Membrane works during generation of impulse

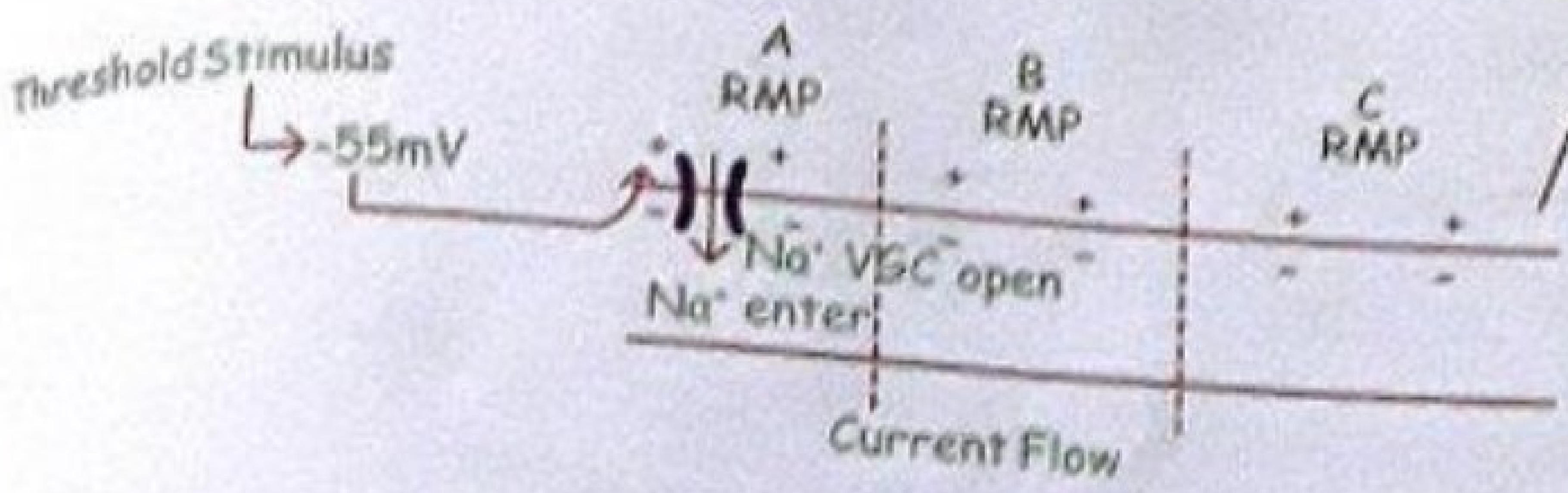


EVENTS
- (I) RMP/Polarised state
- (II) Depolarisation (Na^+ VGC/voltage gated channel) open
- (III) Repolarisation (K^+ VGC open)
- (IV) Hyperpolarisation

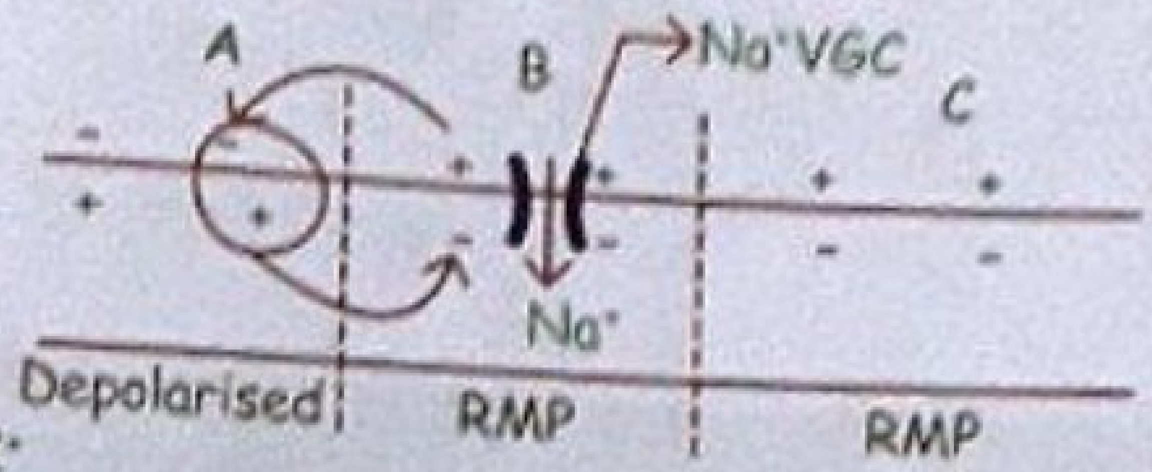
Points to Remember

1. A neuron is NEGATIVELY charged inside compared to outer membrane at RMP ~ 70 mV.
2. When threshold value of stimulus is available, it cause Na^+ VGC to open via which Na^+ enters into axoplasm making inside positive upto +30 mv (action potential), this event is **depolarisation**.
3. Now, Na^+ VGC closes, K^+ VGC opens, K^+ goes outside again making inside negative, event is **REPOLARISATION**.

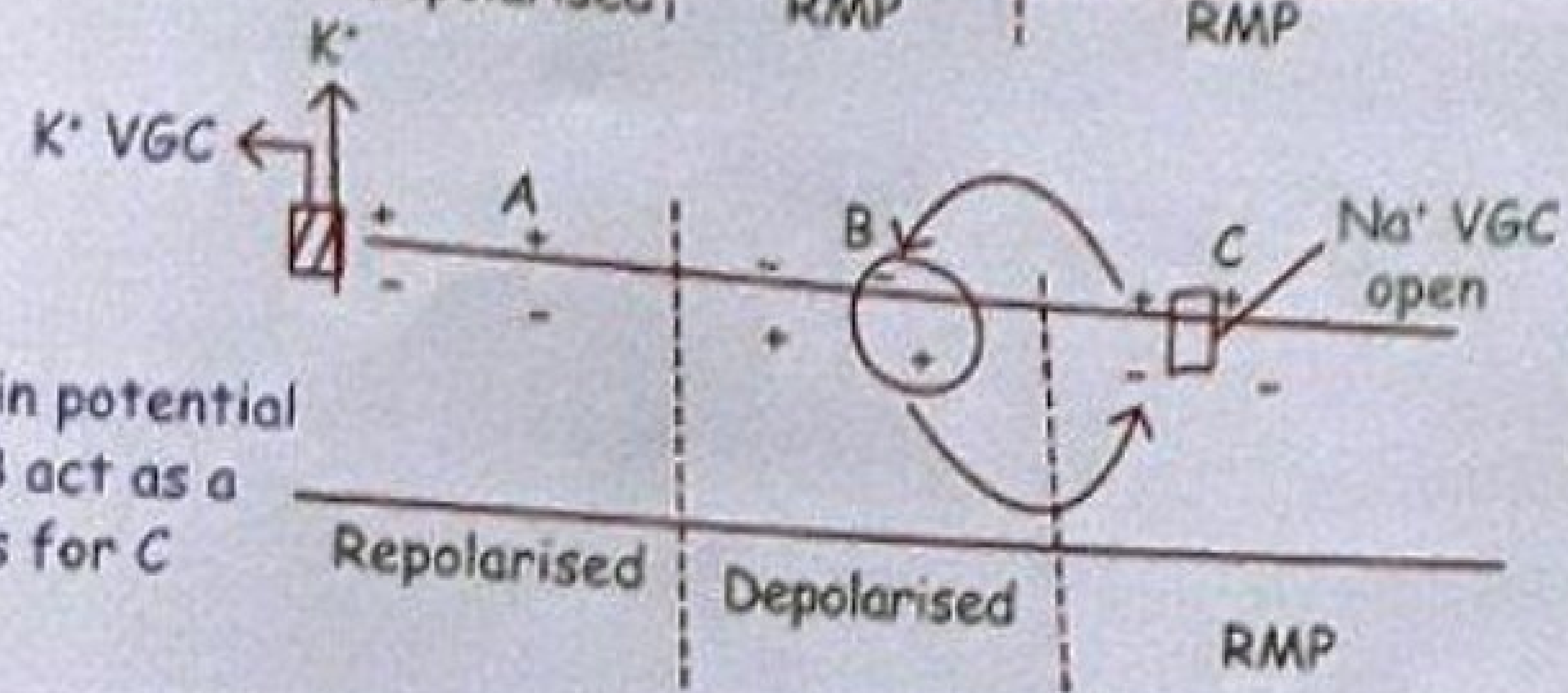
CONDUCTION OF IMPULSE:



→ When a threshold stimulus is applied at site A, on polarised membrane, the membrane at site A, becomes freely permeable to Na^+, Na^+ comes inside 'A' site DEPOLARISED



→ Change in potential across site A act as an Stimulus for nearest site (B) due to which, current flow occurs A ⟶ B (inside) B ⟶ A (outside), circuit complete



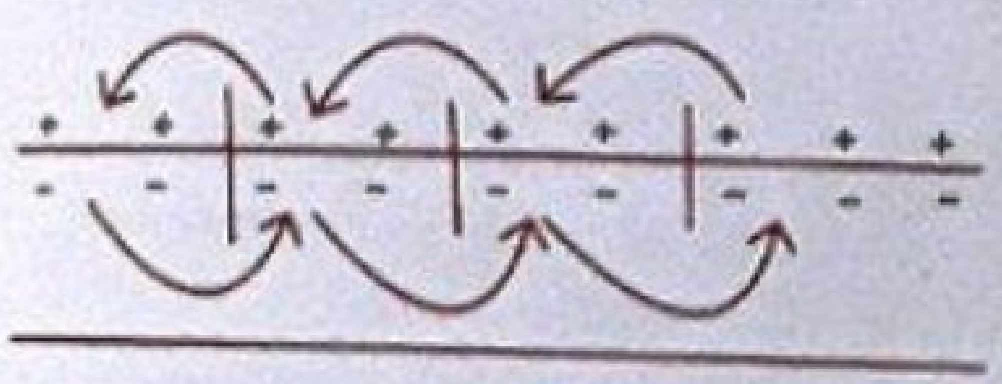
- Change in potential across B act as a Stimulus for C

1. Na^+ VGC opens at B
2. Polarity reversed
3. Action potential generated at site B, impulse arises at B from A and this sequence is repeated along entire axon

NOTE

Conduction across myelinated vs Non-myelinated

NON-MYELINATED

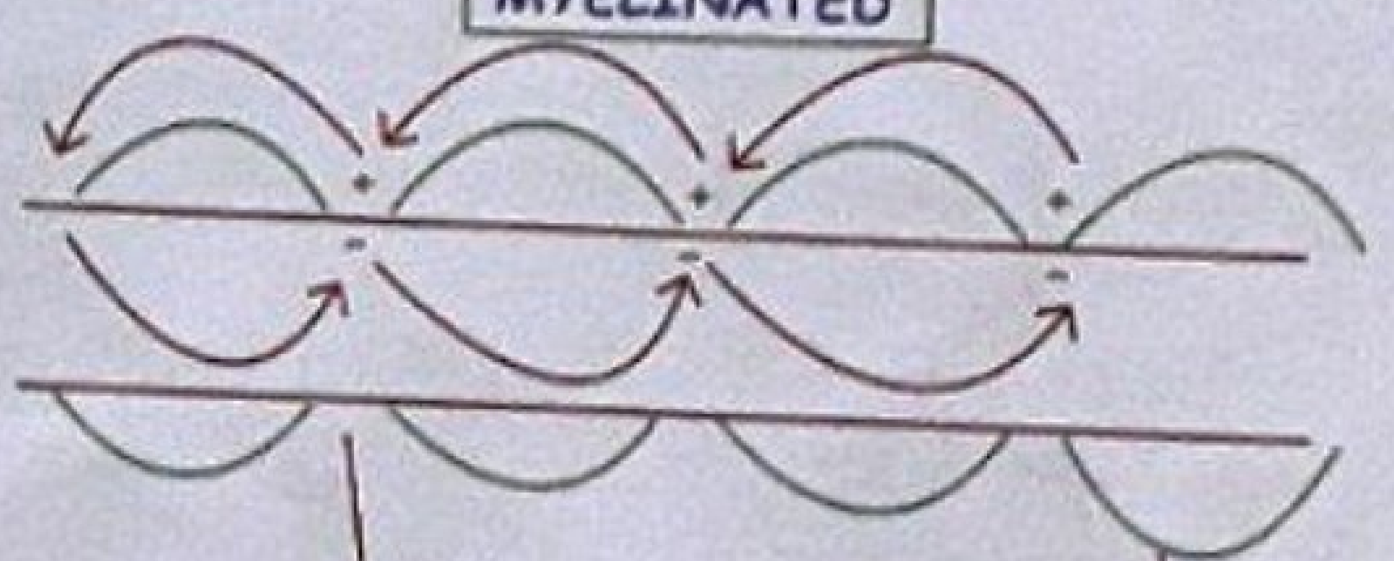


'Non-Myelinated'

↓

Slower Conduction as free conduction occurs throughout the neuron

MYELINATED



→ Nodes of Ranvier

↓

→ Conduction occurs only across Nodes of Ranvier

→ Jumping Conduction/ Saltatory conduction

→ Faster conduction

→ Myelin sheath

↓

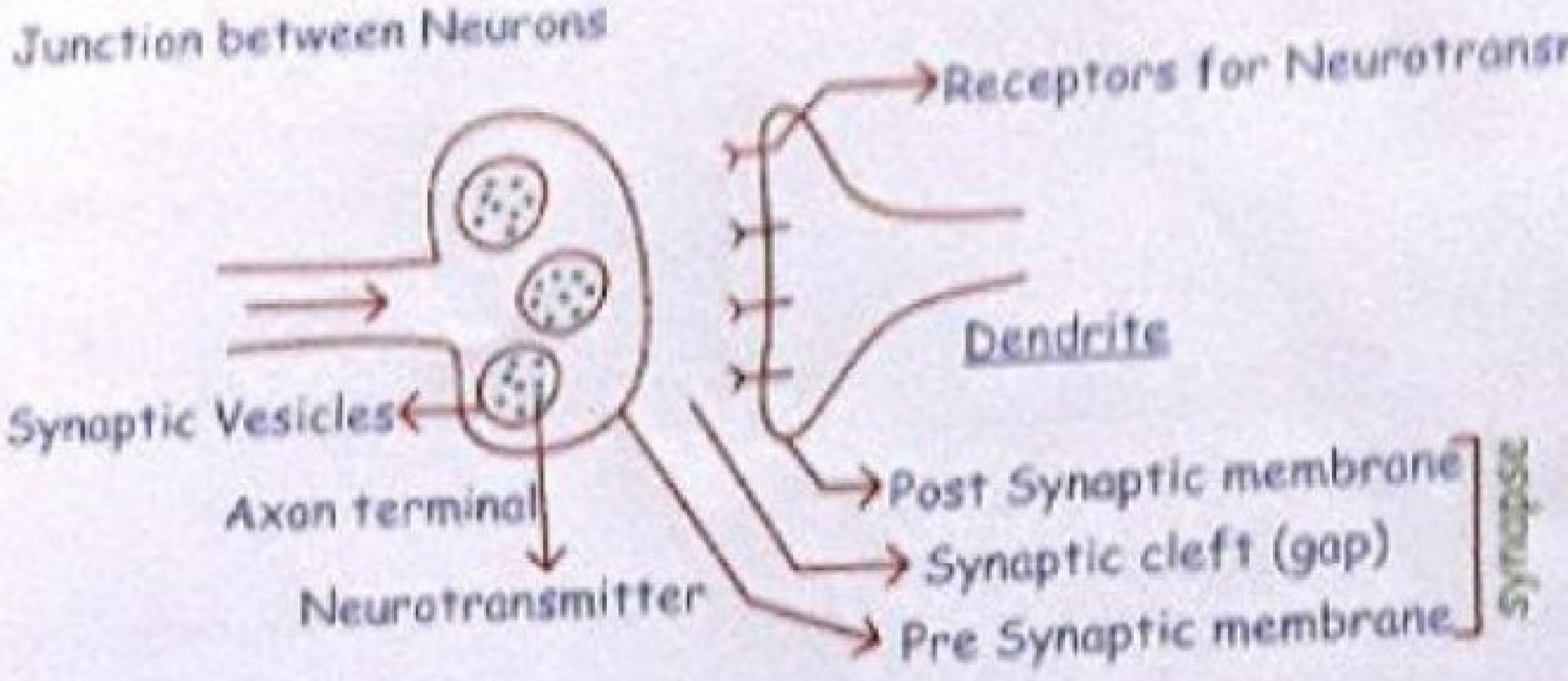
Insulated

↓

free conduction is not possible

SYNAPSES:

Junction between Neurons

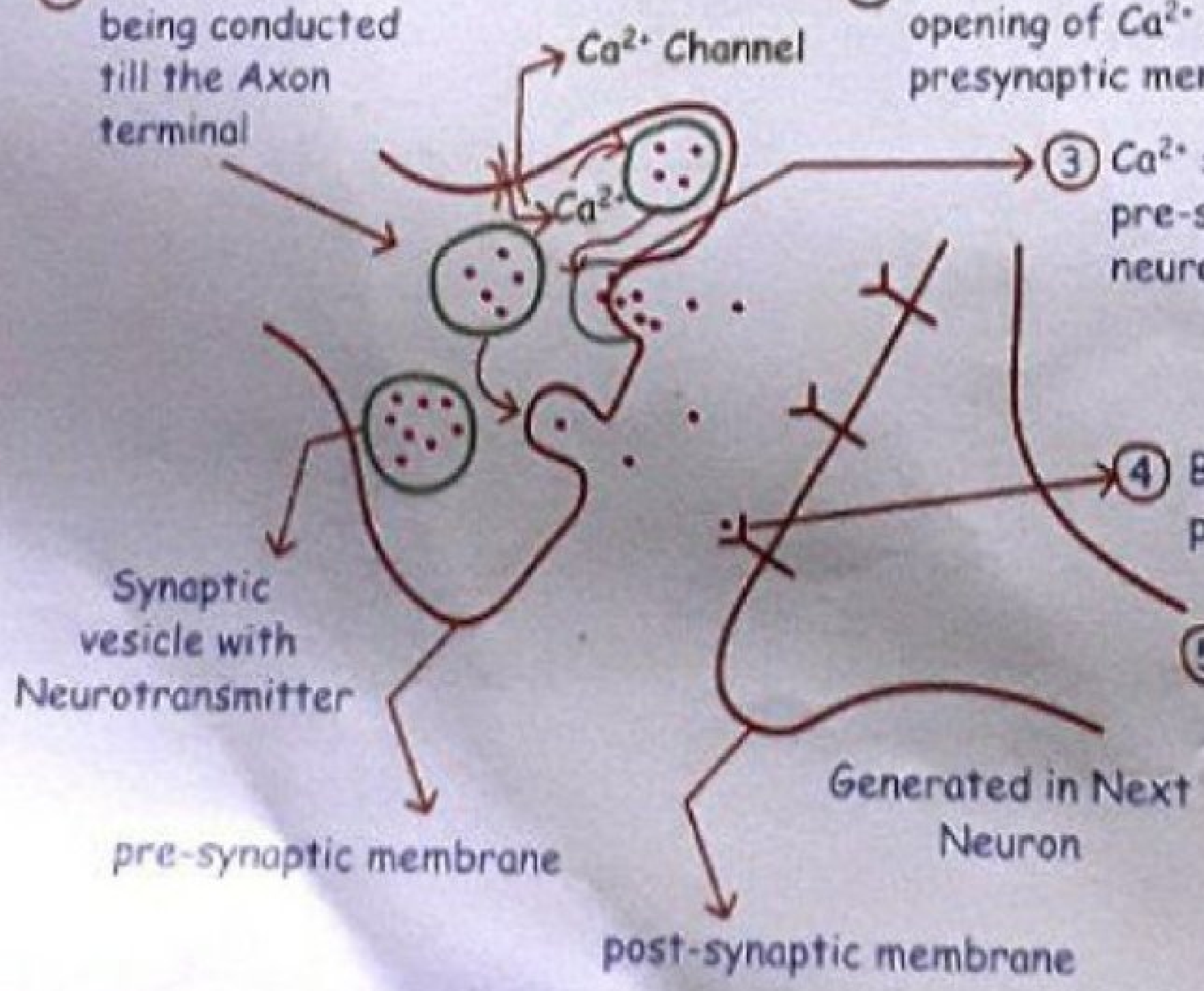


Types of Synapses

Electrical Synapse	Chemical Synapse
Rare in our System	Mostly these are present
Synaptic cleft is very very less	Synaptic cleft is present
Bi-directional transmission as ions are involved in transmission of impulse	Unidirectional, as Neurotransmitters are used for communication which is only present in Axon terminal
Gap junctions present between 2 Neurons	No gap junction
Faster conduction	Slower conduction

Transmission of Impulse across a Chemical Synapse

1. Information is being conducted till the Axon terminal



2. As the impulse arrives at the axon terminal, it leads to opening of Ca^{2+} channel, entry of Ca^{2+} occurs, located on presynaptic membrane
3. Ca^{2+} signals synaptic vesicles to fuse with pre-synaptic membrane & cause exocytosis of neurotransmitter in Synaptic Cleft
4. Binding of neurotransmitter to its receptor present on post-synaptic membrane.
5. Depending upon the nature of the neurotransmitter either of the two:
   EPSP (Excitatory Post Synaptic Potential) (other neuron is EXCITED)
   or
   IPSP (Inhibitory Post Synaptic Potential) is generated (other neuron inhibited)

NOTE

- Example of Excitatory Neurotransmitter – EPINEPHRINE, Acetylcholine etc.
- Example of Inhibitory neurotransmitter – Serotonin.

CENTRAL NEURAL SYSTEM (CNS)

CNS

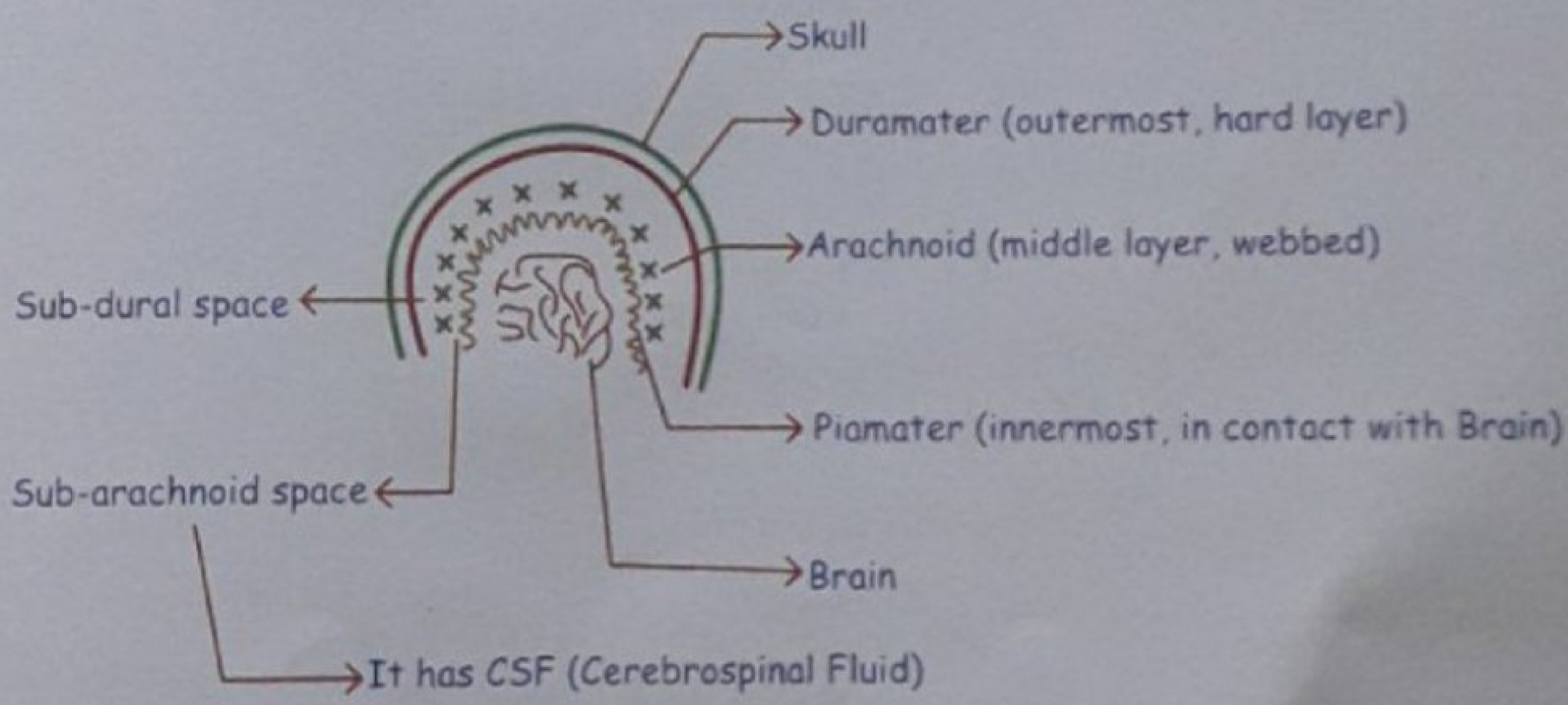
- Brain
- Spinal cord

Brain: (Command & Control)

- It is protected well inside the Skull specifically in CRANIUM (Brain Box)
- Walnut like
- Central information processing organ

Brain is also covered within the Cranial Meninges:

- Duramater (outer)
- Arachnoid (middle)
- Piameter (inner)



Parts of Brain →

- Forebrain
- Midbrain (No Further division)
- Hindbrain

Forebrain
- Cerebrum
- Hippocampus
- Amygdala
- Olfactory Lobes
- Epithalamus
- Thalamus
- Hypothalamus

Epithalamus, Thalamus, Hypothalamus: also known as DIENCEPHALON

Hindbrain
- Cerebellum
- Pons
- Medulla

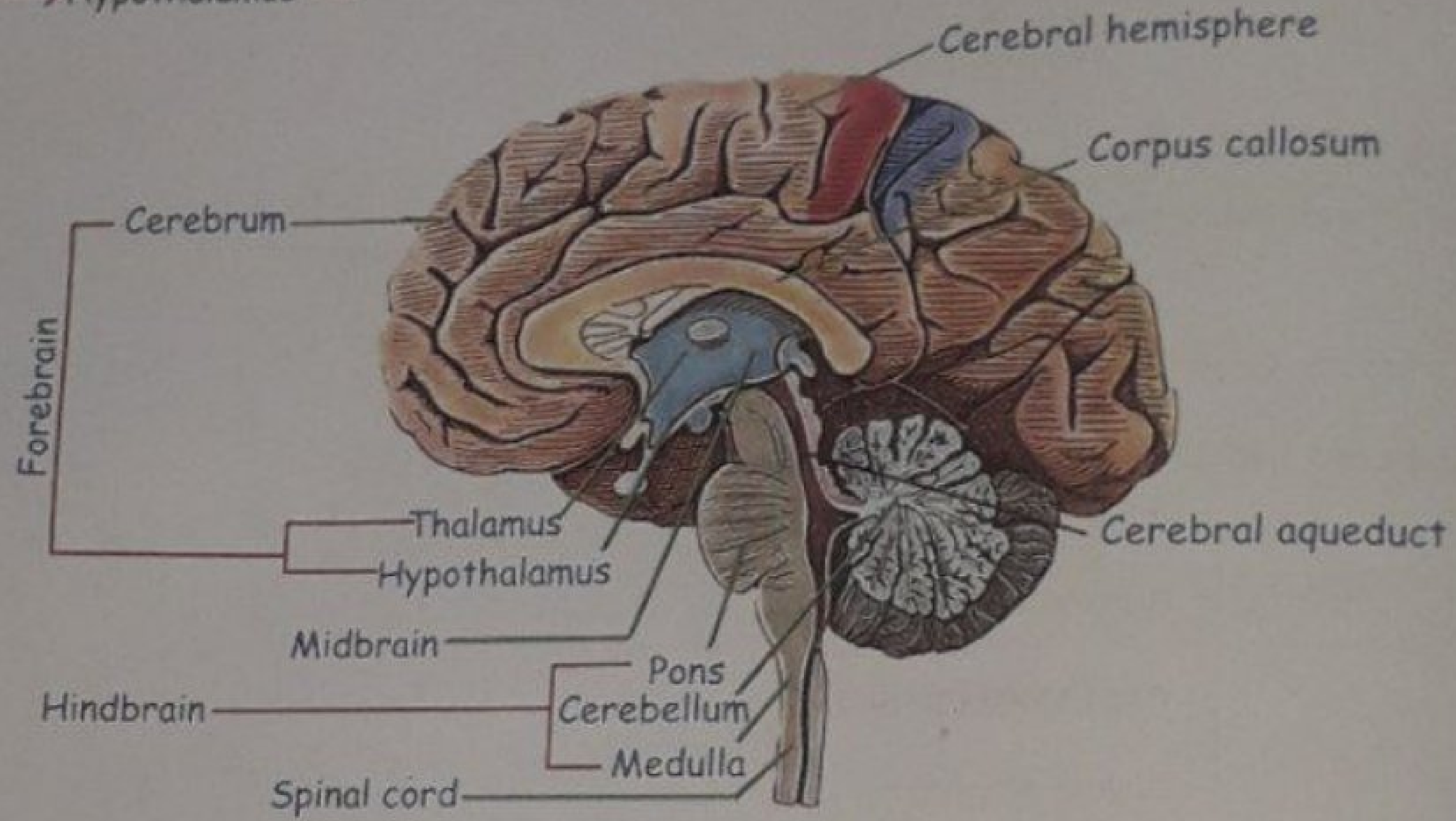
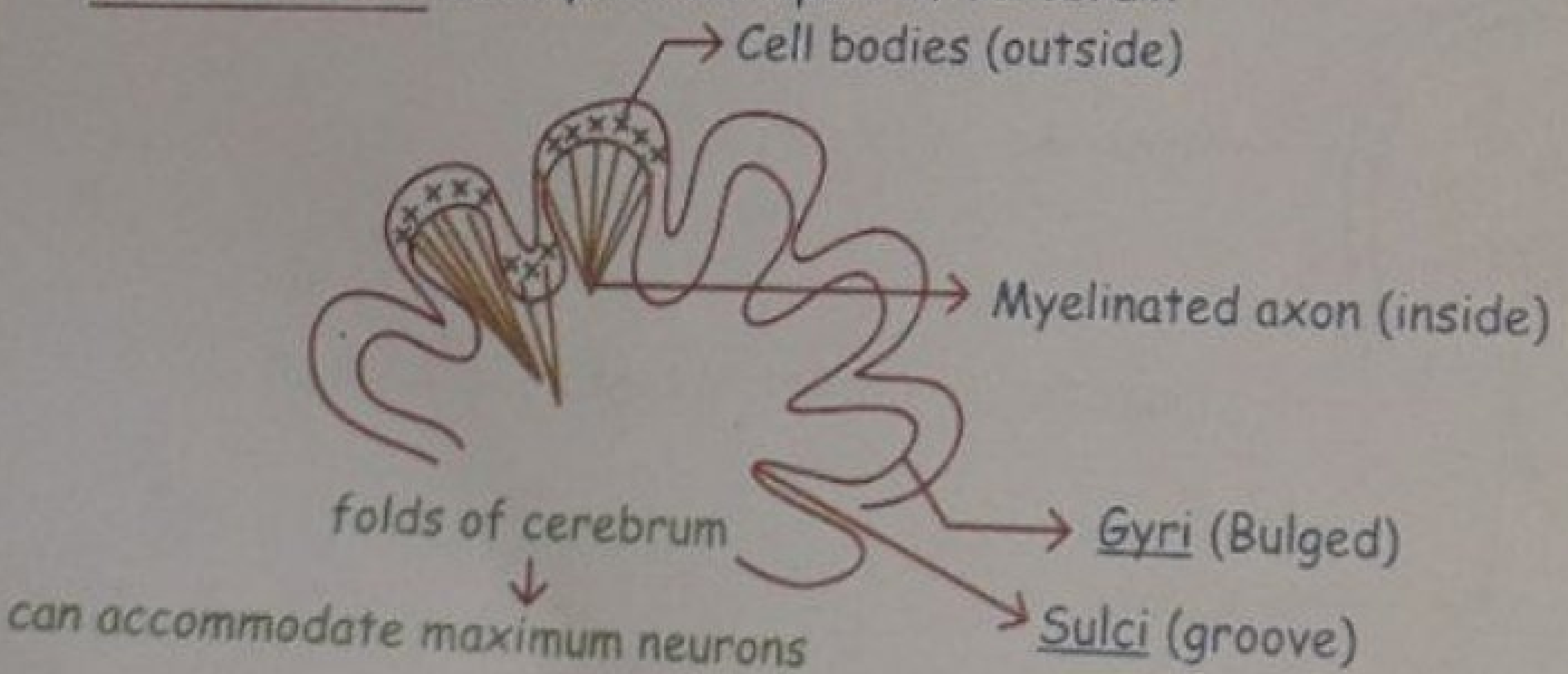


Figure: Diagram showing sagittal section of the human brain

A. Forebrain

(1) Cerebrum: Most prominent part of forebrain



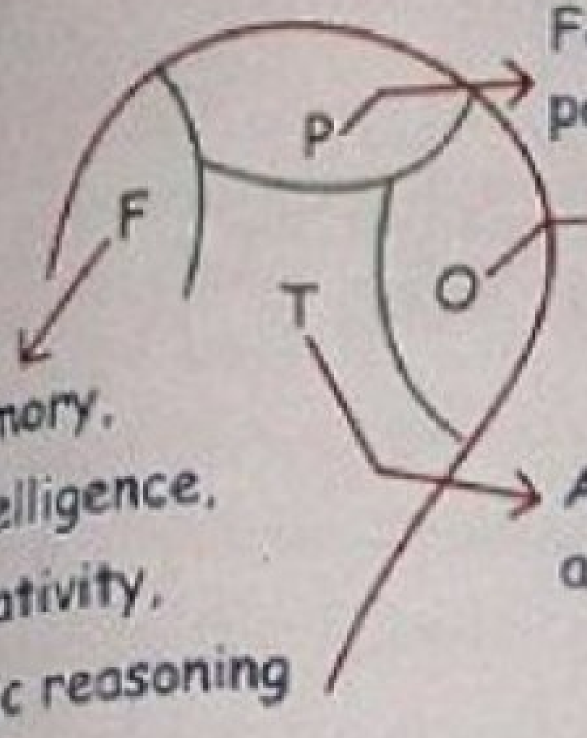
Brain has
- Outer gray matter → presence of cell bodies gives it this appearance
- Inner white matter → myelinated axon

NOTE

(अतिरिक्त Gyaan)

↓

Lobes of Cerebrum (8)
- → Frontal (2)
- → Parietal (2)
- → Temporal (2)
- → Occipital (2)



Important Points

1. A deep cleft divides cerebrum longitudinally into two halves which are Left and Right Cerebral hemispheres.

Cerebral cortex (outer part cerebrum):
- It has various areas

① **Sensory area** ② **Motor area** ③ **Association area**

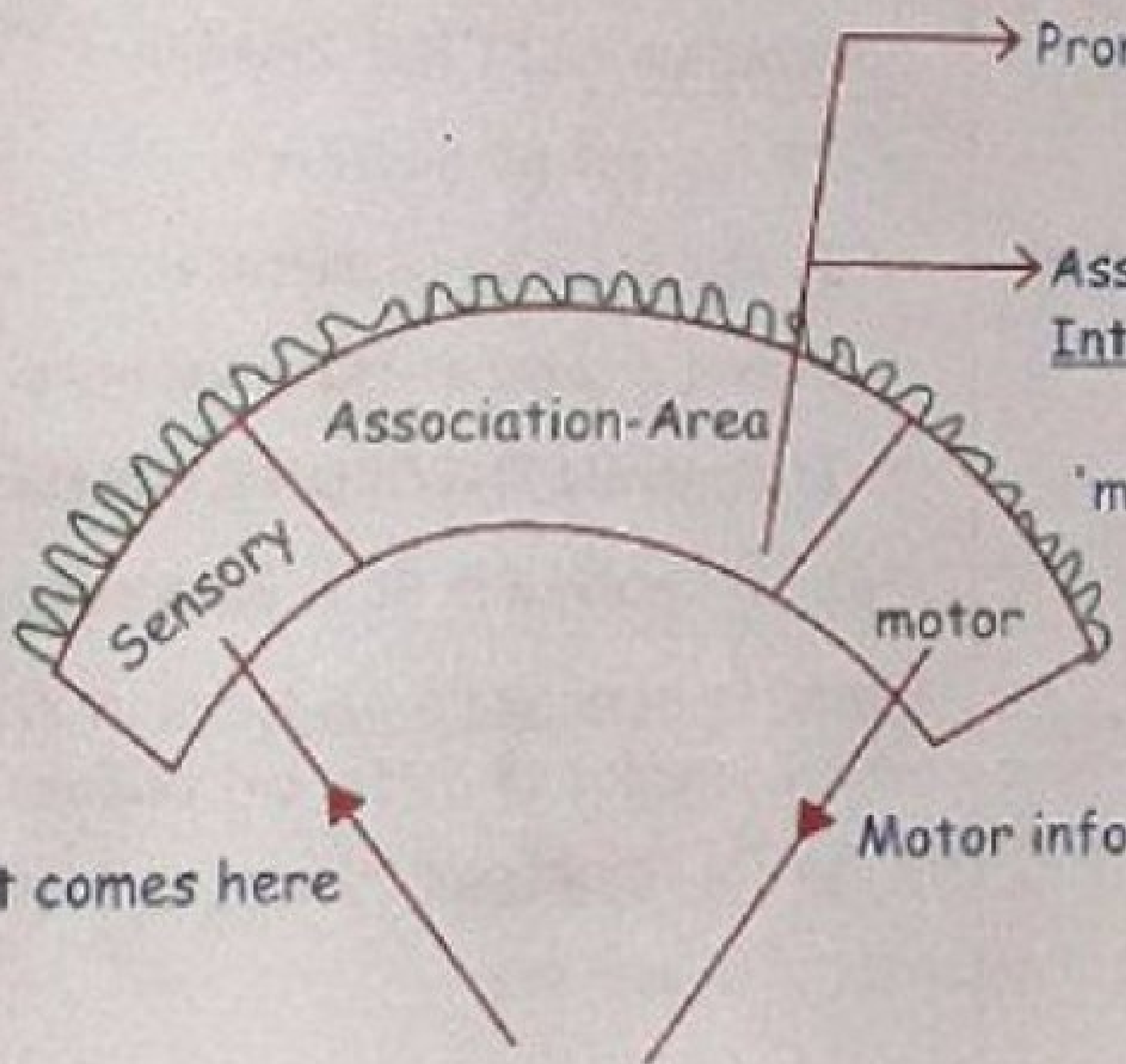


Fig: Various areas of cerebral Cortex

(2) Hippocampus & Amygdala

Amygdala → Almond shaped
Responsible for 'Anger & Rage'

Hippocampus → conversion of short term memory into long term memory

[Hippocampus + Amygdala] = **Limbic system**

[Limbic system + Hypothalamus] Forms **Emotional Brain** → Controls various aspects of human emotions like Happiness, sadness, fear, motivation, anger, pleasure, excitement, etc.

(3) Diencephalon: Thalamus + Epithalamus + Hypothalamus

Thalamus: Also known as 'RELAY CENTRE':

All the information to the cerebrum & from the cerebrum has to pass through thalamus.

- **Cerebrum WRAPS around THALAMUS**

Epithalamus: Pineal gland is present here.

Hypothalamus:

- Connection between endocrine & Neural system.
- Part of emotional brain.
- Has various hormones which controls growth, reproduction, thirst, hunger, etc.
- ****THERMOREGULATION centre.**

B. Midbrain:

It is located between the Thalamus/Hypothalamus of forebrain & Pons of HINDBRAIN.

On the Dorsal Side of Midbrain
↓
There are 4 Swellings/Lobes
↓
**CORPORA QUADRIGEMINA

- A canal called CEREBRAL AQUEDUCT passes through midbrain.

C. Hindbrain

→ Cerebellum
→ Pons
→ Medulla

Medulla

→ Connects to Spinal cord
→ It has various centres to control Heartrate, Breathing rate (RRC), Gastric juice secretion
→ Vomiting centre

Brainstem: Midbrain + Pons + Medulla

Cerebellum: LITTLE BRAIN

- 2nd largest part of Brain
- It has convoluted surface
- It has 2 cerebellar hemisphere
- It Controls INVOLUNTARY functions
- It is involved in Body Balancing

Pons: It acts like a bridge as it consists of Neurons which connect to different regions of Brain

- It has PNEUMOTAXIC CENTRE

9 Chemical Coordination and Integration

HORMONES:

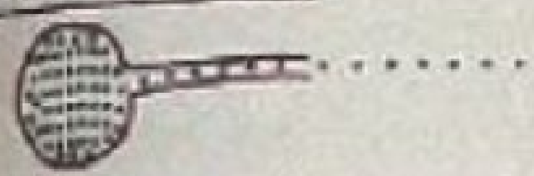
- Hormones are **non-nutrient** chemicals which act as **intercellular messengers** and are produced in **trace amounts**.
- Hormone always act via 'RECEPTORS'.

GLANDS: Organ which makes one or more substances like hormone, tears, sweat, etc.

Endocrine Gland: (DUCTLESS)

Secretions are directly poured into the bloodstream without any duct

Exocrine Gland:



Glands which pour their secretions via DUCT

e.g.: Sweat gland, salivary gland, mammary gland.

Heterocrine/mixed gland: Has both ENDOCRINE + EXOCRINE PARTS

e.g.: Pancreas

Gonads → Ovary
Gonads → Testis

HUMAN ENDOCRINE SYSTEM

The endocrine glands and hormone producing diffused tissues/cells located in different parts of our body constitute the endocrine system. Pituitary, pineal, thyroid, adrenal, pancreas, parathyroid, thymus and gonads (testis in males and ovary in females) are the organised endocrine bodies in our body.

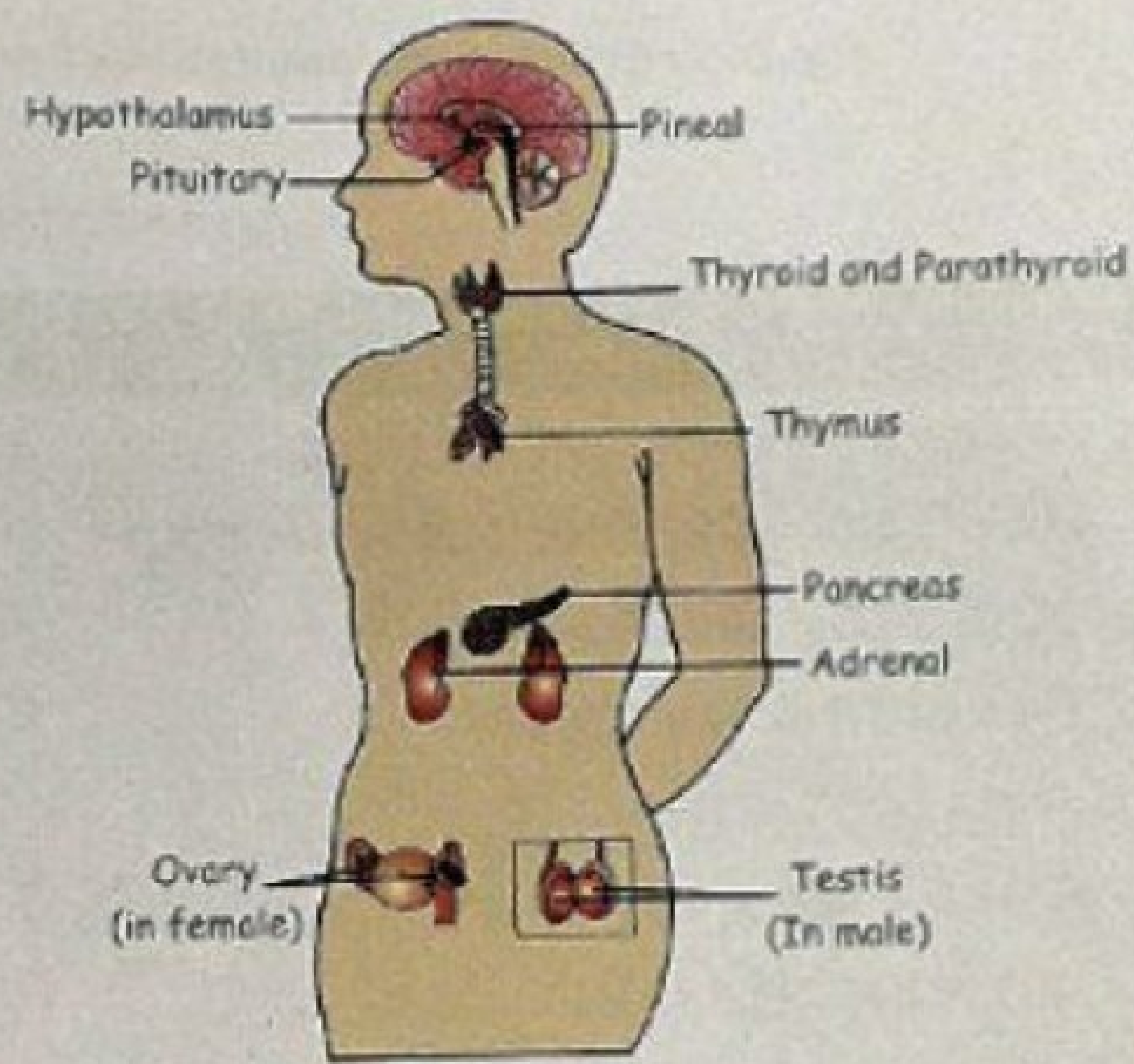


Figure: Location of endocrine glands

① HYPOTHALAMUS:

- Master of master gland
- Origin: ECTODERMAL

Hypothalamus
↓
It has Neurosecretory cells (NEURONS)
↓
Cell bodies of Neuron is known as NUCLEI
↓
It secrete hormones

- Hypothalamic neuron connected to Anterior pituitary via PORTAL SYSTEM
- Some Hypothalamic Neurons are directly connected to posterior pituitary.

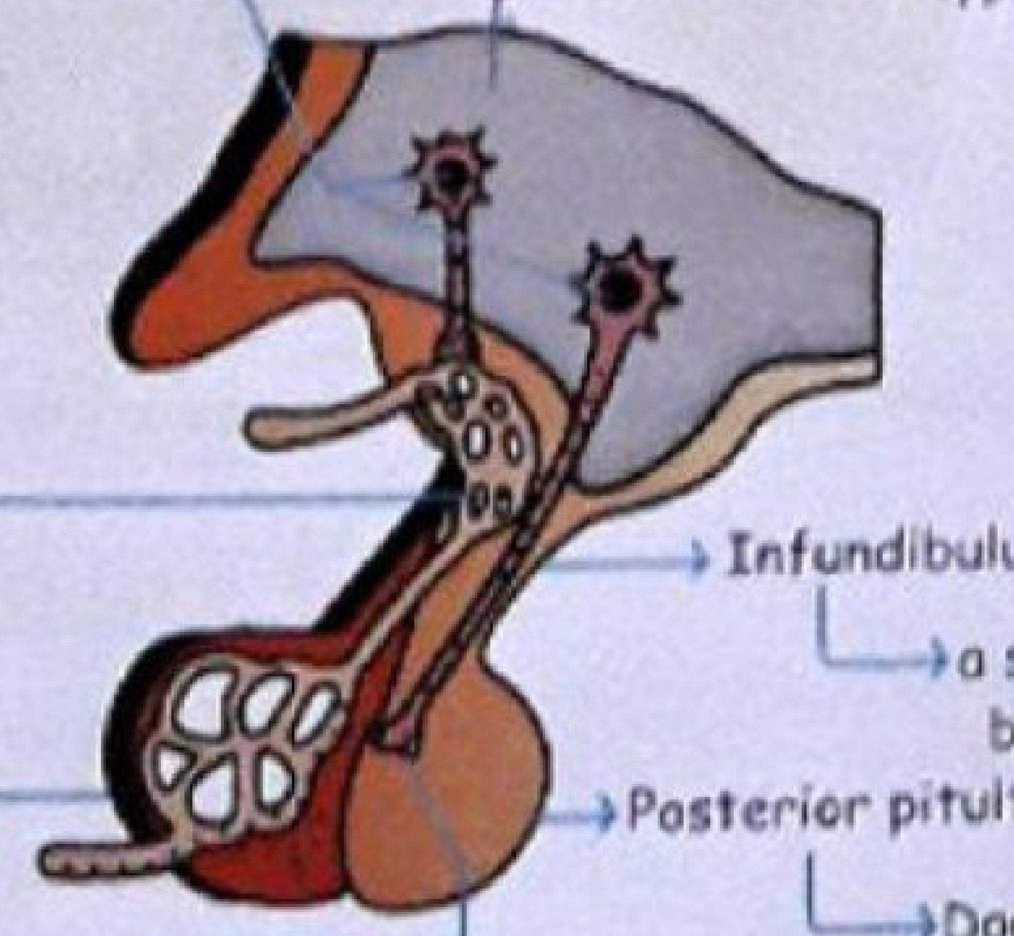


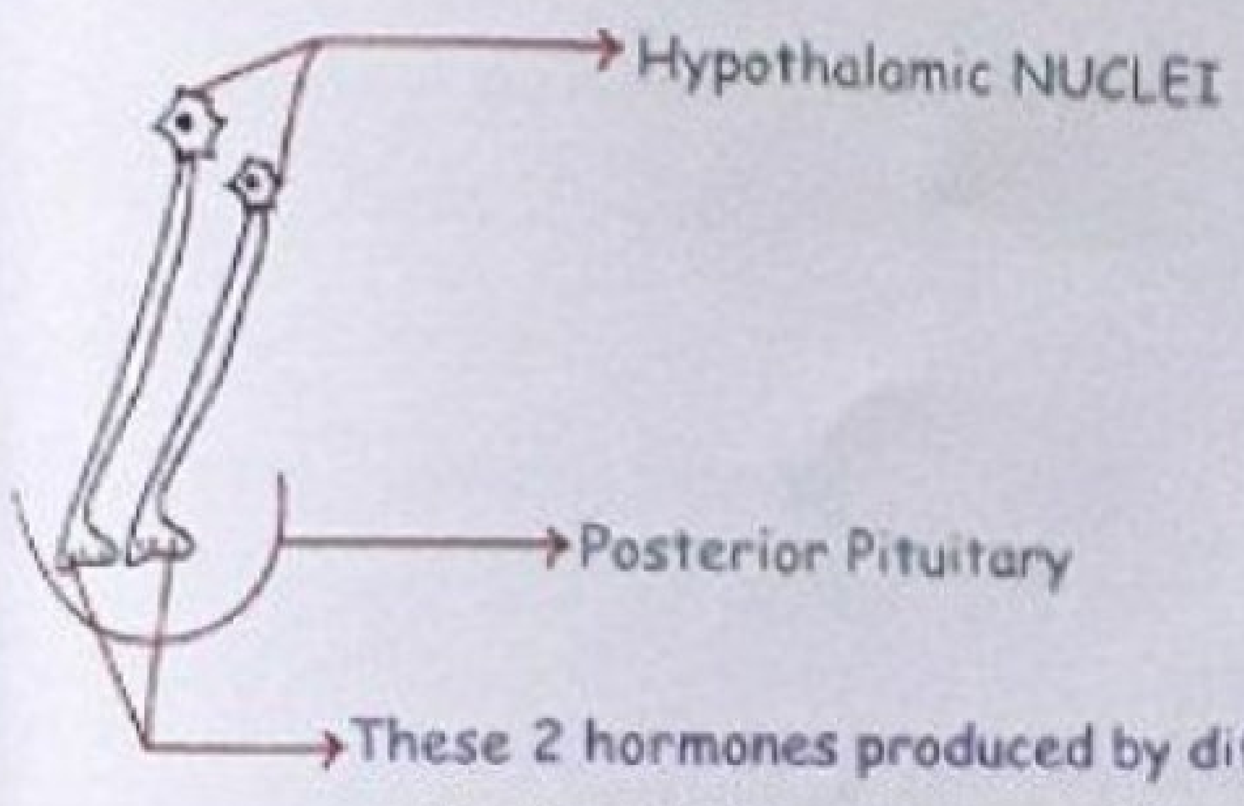
Fig: Diagrammatic representation of pituitary and its relationship with hypothalamus

Table: HYPOTHALAMIC HORMONES

Name	Target	Function
1. GH-RH/GRH: GROWTH HORMONE RELEASING HORMONE/SOMATOCRININ	Anterior Pituitary	Act on Anterior Pituitary for the secretion of Growth Hormone.
2. GH-IH/GIH: GROWTH HORMONE INHIBITING HORMONE/ SOMATOSTATIN	Anterior Pituitary	Act on Anterior Pituitary to inhibit the secretion Growth Hormone.
3. MSH-RH: MELANOCYTE STIMULATING HORMONE RELEASING HORMONE	Anterior Pituitary	Promote the secretion of Melanocyte stimulating Hormone.
4. MSH-IH: MELANOCYTE STIMULATING INHIBITING HORMONE	Anterior Pituitary	Inhibit the secretion of Melanocyte stimulating Hormone.
5. PRL-RH/PRH: PROLACTIN - RELEASING HORMONE	Anterior Pituitary	Promote the secretion of Prolactin.
6. PRL-IH/PIH: PROLACTIN - INHIBITING HORMONE	Anterior Pituitary	Inhibit the secretion of Prolactin.
7. ****Gn-RH: (GONADOTROPIN RELEASING HORMONE)	Anterior Pituitary	Acts on Anterior Pituitary to secrete the Gonadotropins. GONADOTROPINS: FSH (Follicle Stimulating Hormone); LH (Luteinising Hormone)

Name	Target	Function
8. ACTH-RH (ADRENOCORTICOTROPIC-HORMONE-RELEASING HORMONE)/ CRH (CORTICOTROPIN RELEASING HORMONE)	Anterior Pituitary	Promote the secretion of ACTH (Adrenocorticotropic Hormone).
9. **TSH-RH: (THYROID STIMULATING HORMONE-RELEASING HORMONE)	Anterior Pituitary	Promote the secretion of TSH.

OXYTOCIN AND VASOPRESSIN: Hypothalamic Hormone stored in posterior pituitary.



These 2 hormones produced by different NUCLEI are stored in the AXON TERMINAL in posterior pituitary known as [Herring's Bodies (अतिरिक्त Gyaan)]

1 **OXYTOCIN**

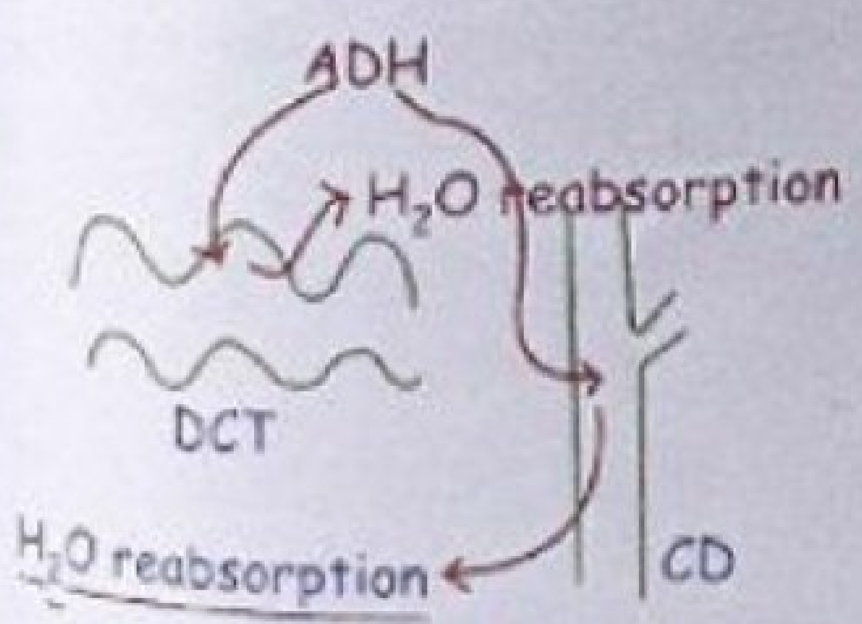
Birth Hormone

It acts on smooth muscles of uterus during the parturition (childbirth) & enables the delivery of Baby (Contraction of smooth muscle) of uterus

Milk ejecting Hormone

Helps in milk ejection during the Lactation

2 **Vasopressin/ADH (Antidiuretic hormone): Prevent DIURESIS:** It acts on DCT and collecting Duct for H_2O reabsorption.

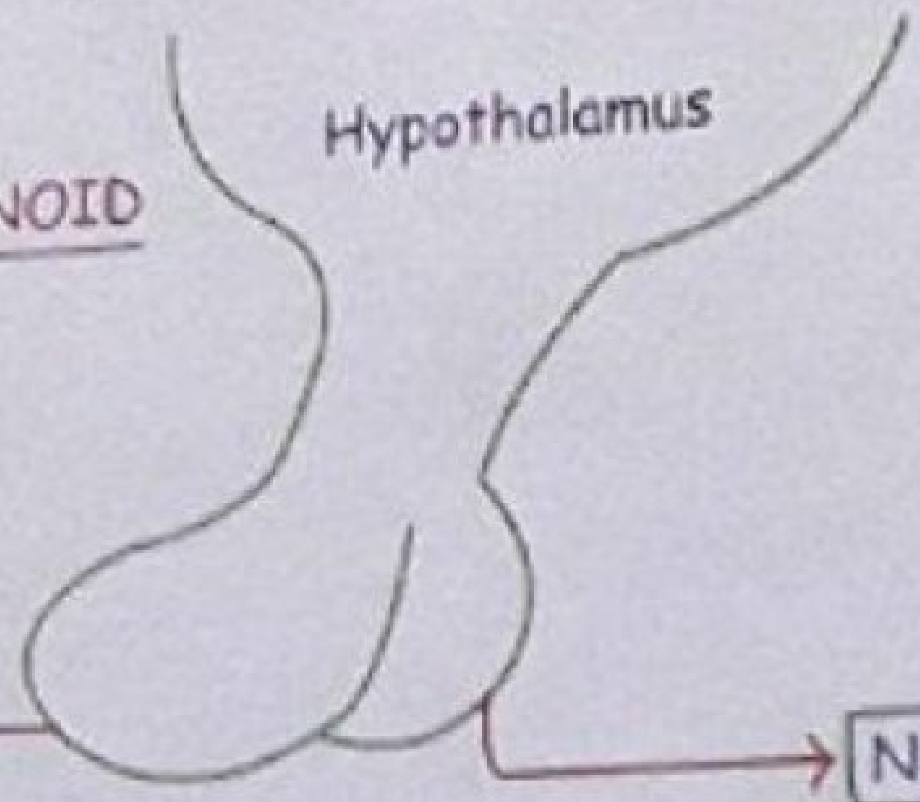


2) PITUITARY GLAND

Origin : ECTODERMAL

- Master gland
- Located in the cavity of SPHENOID bone called as Sella tursica
- Known as HYPOPHYSIS

Pituitary
- Anterior Pituitary
- Posterior Pituitary



Neurohypophysis
- Posterior pituitary
- 25%
- It has one lobe: pars nervosa

Adenohypophysis
- Anterior Pituitary
- 75%
- It is further having 2 lobes internally
  - Pars Distalis
  - Pars Intermedia

NOTE

- In humans, pars intermedia is almost merged with pars distalis so all hormones belong to Pars distalis.
- In animals where pars intermedia is separate: It only has 1 hormone: 'MSH'

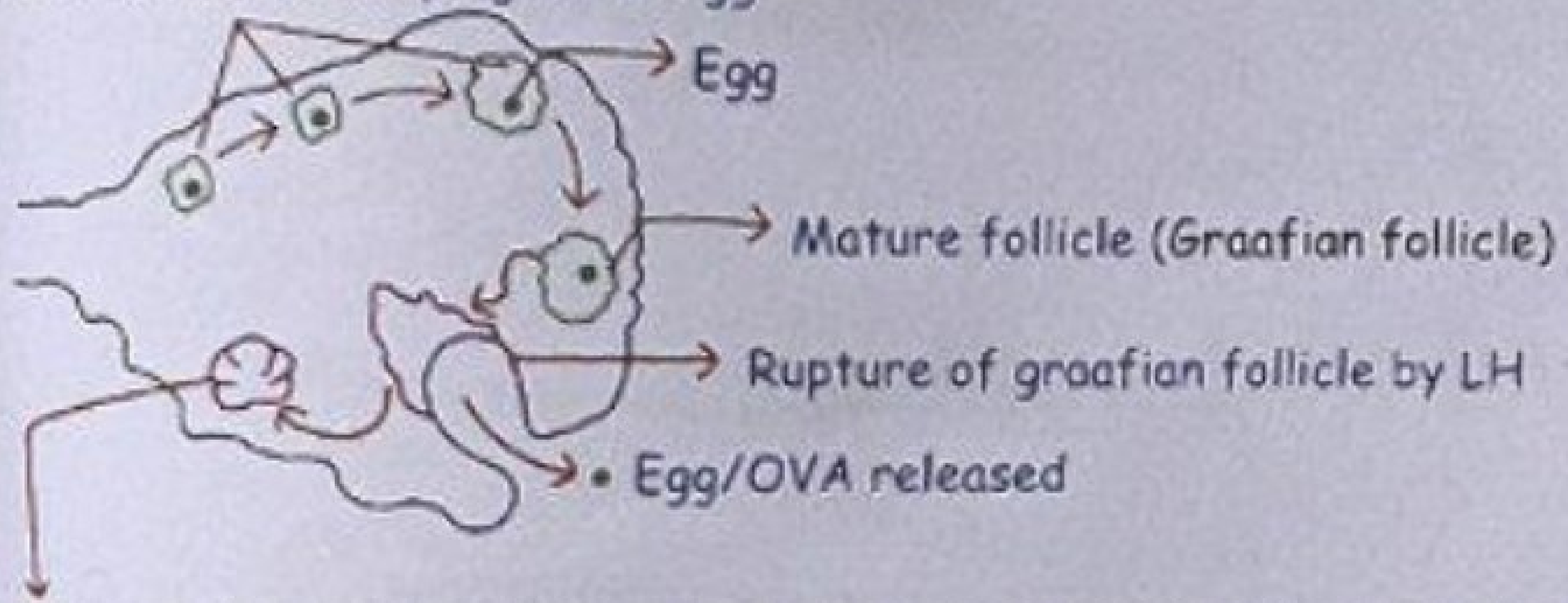
Table: HORMONES OF ANTERIOR PITUITARY

Name	Target	Function
1. GH/GROWTH HORMONE (also known as Somatotropin)	Generalised body parts	Helps in Growth of body by promoting Elongation of Bones. Helps in carbohydrate, Protein, Fat Metabolism.
2. MSH (Melanocyte Stimulating Hormone)	Melanocyte (melanin containing cells)	Distribution of Melanin Pigment in skin
3. PRL (Prolactin)	Mammary glands	→ Lactogenic: Helps in milk synthesis → Mammotropic: Helps in growth of mammary gland
4. TSH (Thyroid Stimulating Hormone)	Thyroid gland	Secretion of THYROID HORMONE (T_3 & T_4)
5. ACTH (Adrenocorticotropic hormone)	Adrenal gland (cortex)	Act on Adrenal cortex & helps in the secretion of corticoids hormone.

Name	Target	Function
6. FSH (Follicle Stimulating Hormone)	Ovary (♀)	Growth & development of Ovarian Follicles (OOGENESIS)
	Testis (♂)	Promotes $\underbrace{\text{SPERMATO}}_{\text{Sperm}}\underbrace{\text{GENESIS}}_{\text{generation}}$
7. LH (Luteinizing Hormone)	Ovary (♀)	Rupture the mature graafian follicle & cause ovulation. Formation of CORPUS LUTEUM.
	Testis (♂)	In Males, it is also known as ICSH (Interstitial Cell Stimulating Hormone) ↓ It acts on INTERSTITIAL CELLS/ LEYDIG CELLS to synthesise the male hormone TESTOSTERONE (Androgens)

NOTE

Follicles has developing OVA/egg



When graafian follicle ruptures, it release egg (ovulation) & convert into yellow Body called as CORPUS LUTEUM

Fig. Section of ovary

DISORDERS OF GROWTH HORMONE

Hyposecretion (Less secretion)

DWARFISM
- 'Hypo' secretion of GH before puberty
- Overall height short
- Often Referred to as 'MIDGETS'

ACROMICRIA
- 'Hypo' secretion of GH after puberty
- Specific parts like hand, feet, remains smaller

Hypersecretion (More secretion)

GIGANTISM
- ↑ GH before Puberty
- Overall height is more

ACROMEGALY (enlarged)
- ↑ GH after puberty
- Disproportionate body
  - → palm, feet, jaw enlargement
- It may cause premature death if unchecked

- From modification of Thyroglobulin → (T_3 & T_4) → Thyroid hormone are formed

T_3

- Tri-iodothyronine → 3 Iodine attached

T_4

- Tetraiodothyronine is also known as **THYROXINE** → 4 Iodine attahed

Together known as THYROID HORMONE

→ 1) Maintains BMR (Basal metabolic Rate) → Basic calories Burnt to do every day's activity
→ 2) Promotes ERYTHROPOESIS
→ 3) Stimulate adrenal medulla to produce epinephrine & Norepinephrine.
→ 4) ↑Heart rate
→ 5) Maintain H_2O, electrolyte Balance
→ 6) Affect SKIN PIGMENTATION
→ 7) Controls tissue differentiation

- **Calcitonin/TCT (Thyrocalcitonin)**

(HYPOCALCEMIC HORMONE)
$\underbrace{\text{HYPO}}_{\text{Less}}\underbrace{\text{CALCEMIC}}_{\text{Calcium}}$

- Reduces Blood Ca^{2+} level hence hypocalcemic.
- Along with PARATHORMONE of parathyroid gland, it regulates blood Ca^{2+} level.

Disorders of Thyroid gland

- Hyposecretion
  - Cretinism
  - Simple Goitre
- Hypersecretion
  - Grave's disease/exophthalmic goitre

Hyposecretion:

1. **Cretinism:** Low thyroid hormone during pregnancy or in CHILDHOOD result in cretinism & Child suffers from:
   - Mental retardation
   - Low IQ (Intelligence quotient)
   - Lack of alertness
   - Low BMR, Low Heart rate
   - Deaf-Mutism
   - Abnormal skin

2. **Simple goitre:** Hyposecretion of thyroid hormone due to iodine deficiency in diet.

- If iodine is deficient, normal hormone synthesis won't occurs and cause enlargement of Thyroid known as simple goitre.

II. **HYPERSECRETION:** $\underbrace{\text{Ex}}_{\text{Outside}}\underbrace{\text{ophthalmic}}_{\text{Eye}}$ $\underbrace{\text{GOITRE}}_{\text{Enlargement}}$

Outside Eye → Eye Bulged out

- Autoimmune Disorder

↓

Antibodies Produced here which mimics/copies the activity or action of TSH

ANTIBODIES (which copy TSH), means

→ Will Act on THYROID GLAND

↓

It $\boxed{\text{produces } T_3 \text{ \& } T_4}$

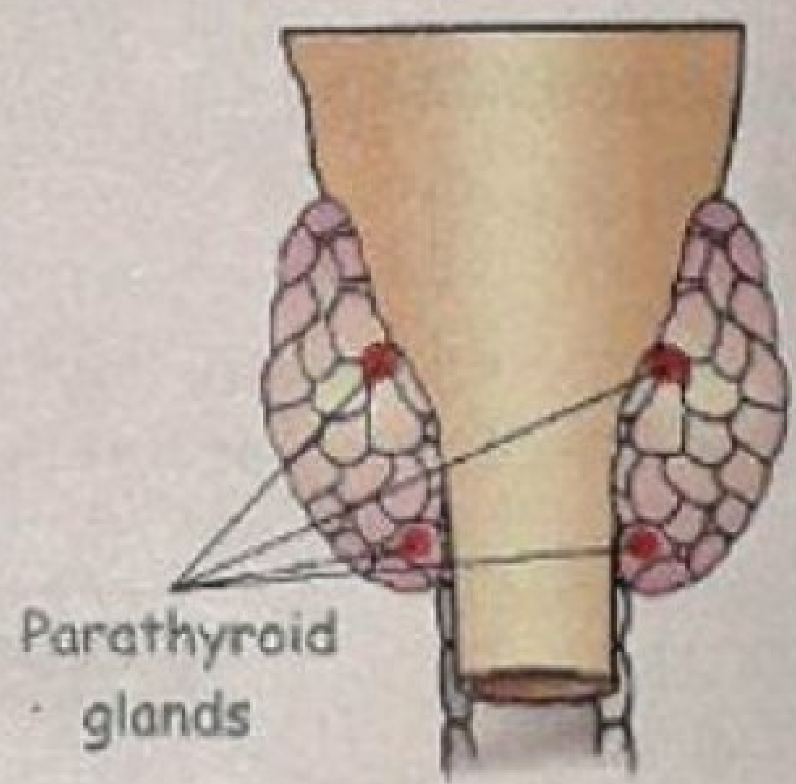
↓

More and more T_3 & T_4 produced i.e., 'HYPER' condition is developed

- These antibodies continue to stimulate Thyroid gland to produce more and more T_3, T_4, leading to enlargement of Thyroid gland and 'HYPER' condition of Thyroid hormone.

5. PARATHYROID GLAND

- Origin: Endodermal
- 4 parathyroid gland are present behind Thyroid



- Secretes a Hormone: PARATHORMONE/PTH/Collip's hormone

↓

$\underbrace{\text{HYPER}}_{\uparrow}\underbrace{\text{CALCEMIC}}_{\text{Calcium}}$ HORMONE

$\boxed{\uparrow \text{Blood calcium levels}}$ By different means

→ Causes dimineralisation of bones, takes Ca^{2+} from Bone to blood to increase blood Ca^{2+} level.

$\boxed{\text{Calcium HOMEOSTASIS}}$ → Regulation of Blood calcium level with the help of Calcitonin & PTH

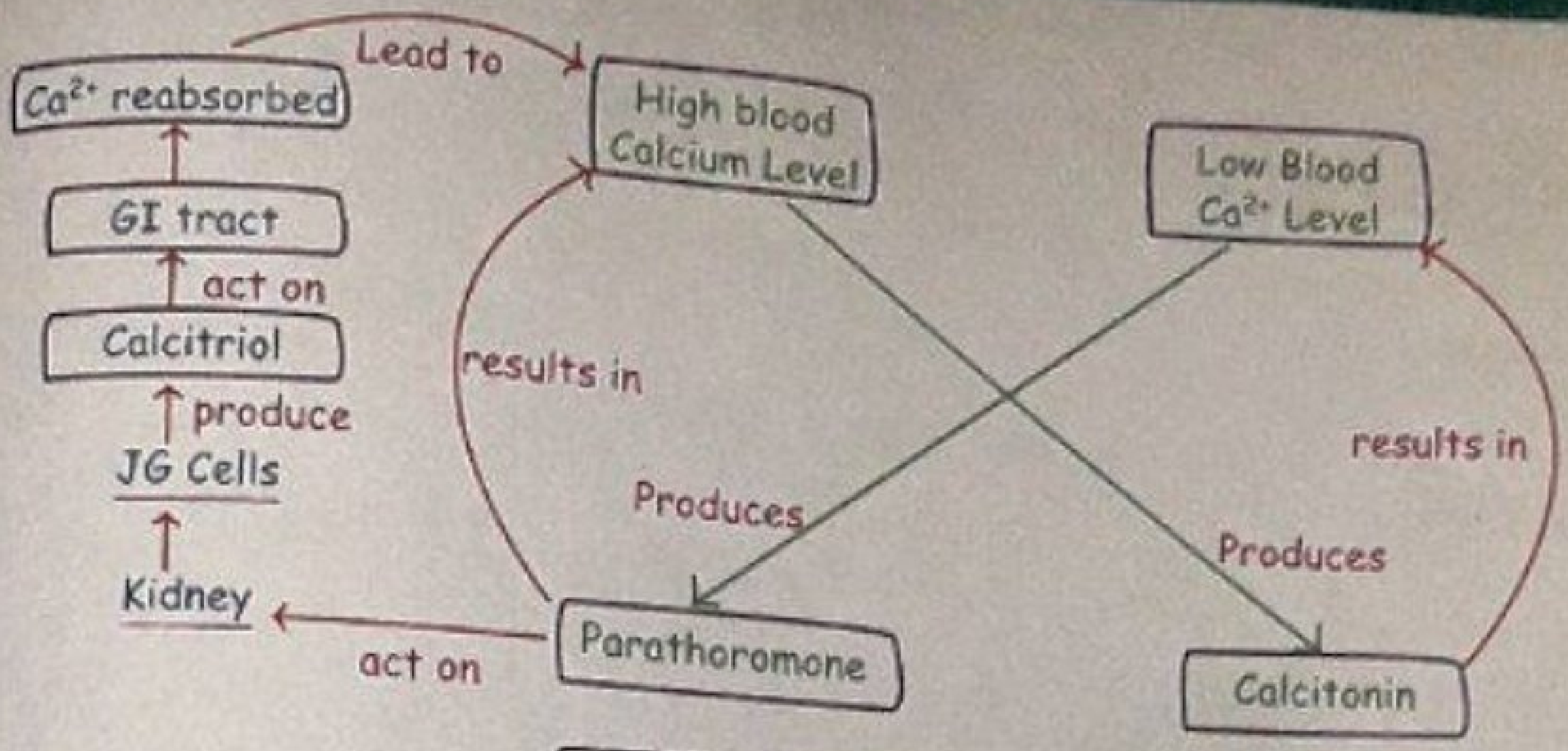
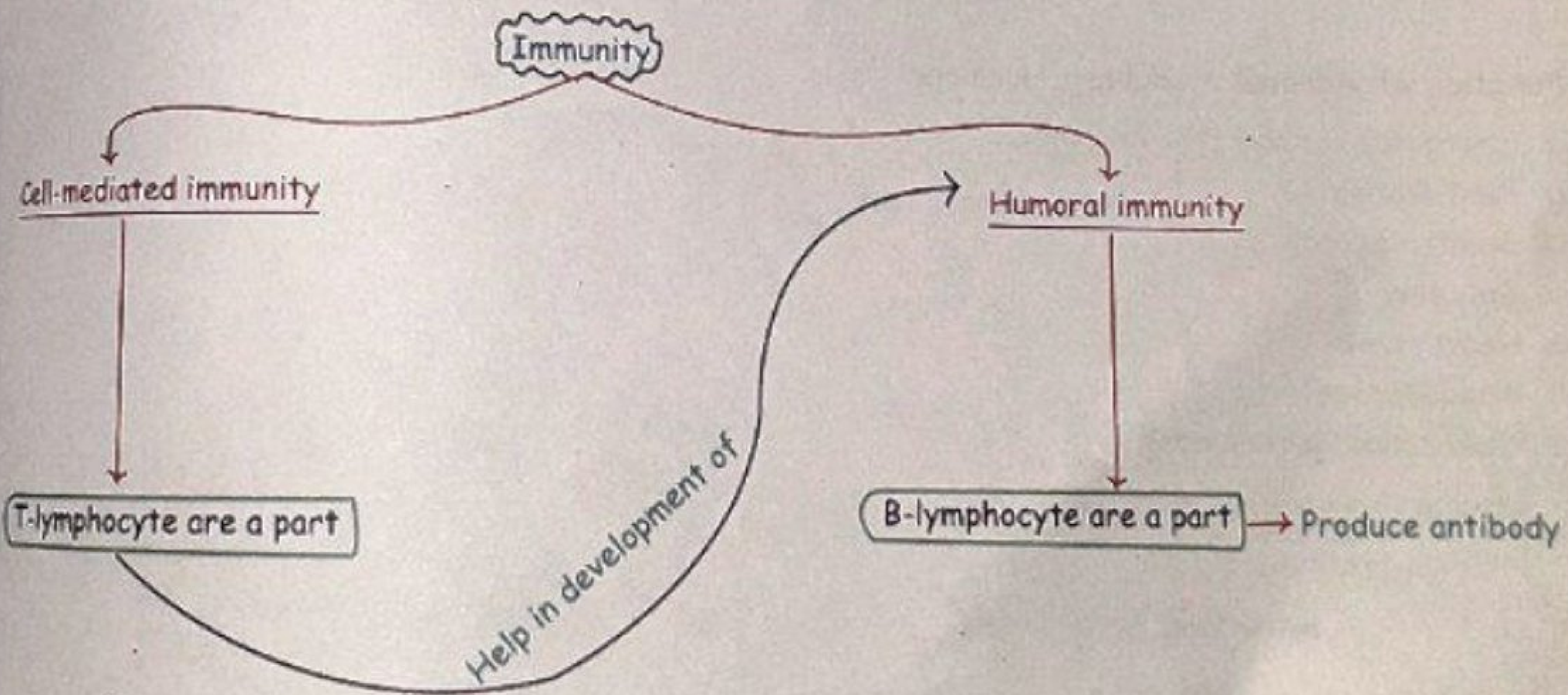


Fig. Ca^{2+} Homeostasis

6) THYMUS

- Origin: Endodermal
- Located behind the sternum between the Lungs, on the ventral side of AORTA.
- Hormone: 'THYMOSINS'

Helps in differentiation & maturation of T-cells which plays major role in cell mediated immunity & indirectly helps in humoral immunity



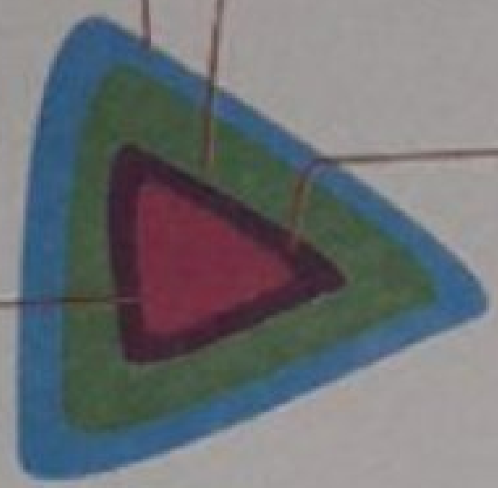
- Thymus is the only gland that shrinks or reduces in size with age hence, older people have weaker Immunity.

7) ADRENAL GLAND

ADRENAL GLAND → Outer Cortex, Inner Medulla

Above Kidney

- Located above Kidney.



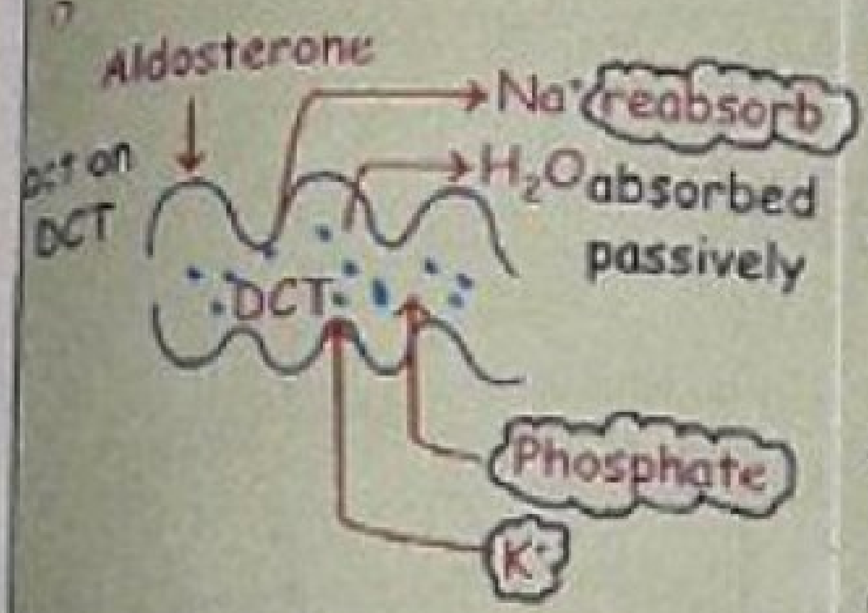
Adrenal cortex	Adrenal medulla
75%	25%
Outer	Inner
Mesodermal	Ectodermal
Further divided into 3 zones	No further division
Hormones are called as CORTICOIDS	Hormones are called as CATECHOLAMINE (Epinephrine + Nor epinephrine)

Function of Adrenal Medullary Hormone:

- Emergency hormones: 3F response → Fear, Fight, Flight
- Pupil dilation
- Breathing rate↑
- Sweating
- Heart rate↑
- Blood Glucose level↑
- Piloerection (goosebumps)
- It leads to $\underbrace{\text{Proteo}}_{\text{Protein}}\underbrace{\text{lysis}}_{\text{Breakdown}}$ & $\underbrace{\text{Lipo}}_{\text{Lipid}}\underbrace{\text{lysis}}_{\text{Breakdown}}$

Adrenal Cortex Hormones → also known as CORTICOIDS

1) Zona GLOMERULOSA → Secretes MINERALOCORTICOID
2) Zona FASCICULATA → Secretes GLUCOCORTICOID
3) Zona RETICULARIS → Secretes SEX CORTICOIDS

Mineralocorticoid	Glucocorticoid	Sex Corticoid
○ Hormone of Zona Glomerulosa ○ ALDOSTERONE is the major mineralocorticoid. ○ Under the CONTROL of RAAS ○  ○ Blood Na^+ ↑ ○ Blood Volume ↑ ○ Blood Pressure ↑ ○ K^+ & phosphate eliminated	○ Hormone of Zona Fasciculata ○ 'CORTISOL' is the main Glucocorticoid ○ Under control of ACTH of Pituitary ○ Promotes Gluconeogenesis ○ Promotes 'ERYTHROPOIESIS' ○ Suppresses WBC activity, hence act as Immunosuppressants ○ Promote Proteolysis & Lipolysis ○ Inhibit cellular uptake and utilisation of amino acids ○ Affects overall cardiovascular activity & Kidney Functions	○ Hormone of Zona Reticularis ○ Sex corticoids are: DHEA (DEHYDROEPIANDROSTERONE) & Estrogen ○ Under control of ACTH of Pituitary. ○ They control distribution of hair: PUBIC HAIR, AXILLARY HAIR, FACIAL HAIR, etc during puberty.

NOTE

- 'DHEA' is a type of Androgen.
- Gluconeogenesis: Formation of Glucose from a non-carbohydrate source.

Gluco → Glucose; genesis → Generation

Disorder:

(1) **Addison's Disease:** Hyposecretion (Hypo → Less) or underproduction of Adrenal cortex Hormone (→ Mainly Aldosterone, Cortisol) alters carbohydrate metabolism causing acute weakness and fatigue

- It may cause: Low level of blood Na^+.
- Blood Volume ↓, Pressure ↓
- Blood K^+, Phosphate Level ↑
- Blood Glucose ↓

8 PANCREAS

- Endodermal origin
- Heterocrine gland/mixed gland/composite gland.

Pancreas

Endocrine Part

→ This is also known as ISLETS OF LANGERHANS

→ Only1 %
- → α-Cell/A-cells → Secretes GLUCAGON
- → β-Cell/B-cells → Secretes INSULIN

Exocrine Part

→ This is also known as ACINAR cells/cell of ACINI

→ 99%

→ Secretes of pancreatic juice

- 'Glucogon & Insulin' Regulates Blood Glucose level or maintains GLUCOSE HOMEOSTASIS.

GLUCAGON HYPERGLYCEMIC HORMONE → increases Blood Glucose level.

- Mainly acts on HEPATOCYTE: Promotes the breakdown of GLYCOGEN (GLYCOGENOLYSIS).

  HEPATO = Liver, CYTE = Cell; GLYCOGENO = Glycogen, LYSIS = Breakdown

- Promotes GLUCONEOGENESIS
- Promote LIPOLYSIS, PROTEOLYSIS
- Inhibit CELLULAR UPTAKE of GLUCOSE

INSULIN HYPOGLYCEMIC HORMONE → decreases Blood Glucose level

- Mainly act on HEPATOCYTES, ADIPOCYTES, signals for storing GLUCOSE

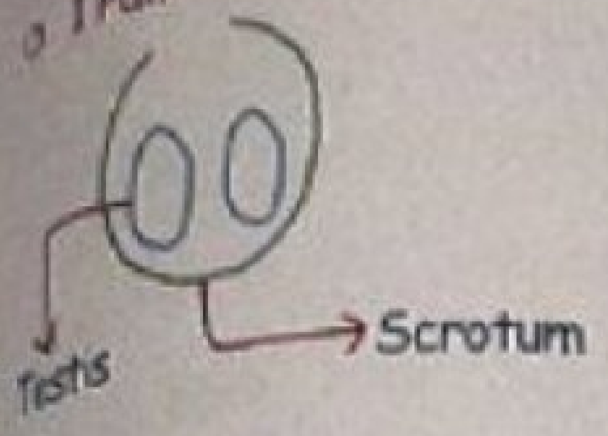
  ADIPO = Fat filled, CYTES = Cells

- Inhibits GLYCOGENOLYSIS
- Promote cellular UPTAKE of GLUCOSE

NOTE Prolonged hyperglycemia leads a complex disorder called DIABETES MELLITUS, they can be treated by insulin therapy.

5) TESTIS

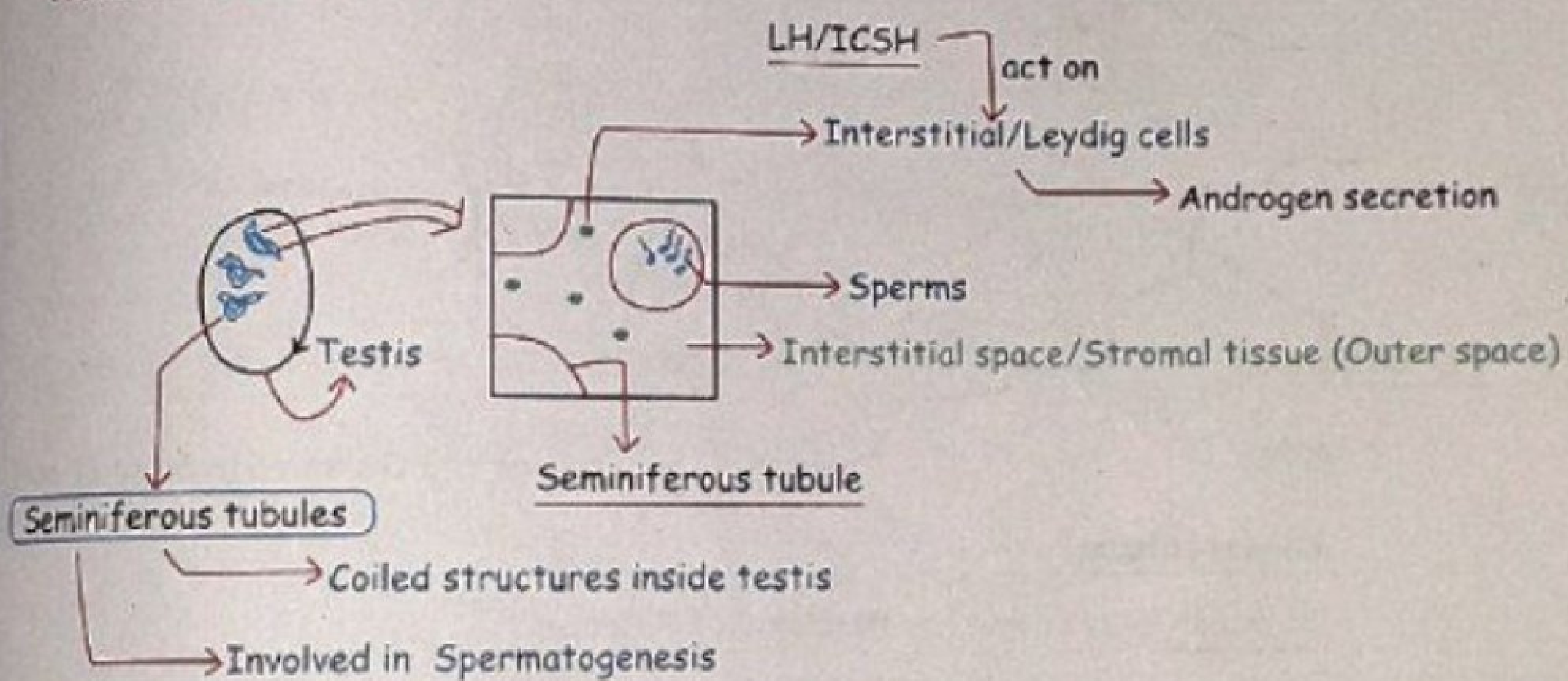
- Mesodermal origin.
- Location: Outside the abdominal cavity within a pouch called as SCROTUM.
- 1 Pair



Testis

- 1° Sex organ
  ↓
  Involved in SPERMATOGENESIS ($\underbrace{\text{SPERM}}_{\text{Sperm}}\underbrace{\text{ATOGENESIS}}_{\text{Formation}}$)
- Endocrine Gland
  ↓
  Production of Hormone
  ↓
  Androgens
  ↓
  Mainly testosterone

- Testis is composed of seminiferous tubules and stromal or interstitial tissue.
- Leydig cell/interstitial cells are present in intertubular spaces (space between seminiferous tubule): Produces ANDROGENS.



Function of Testosterone

- Responsible for low pitch voice
- Promotes Spermatogenesis
- Growth & development of male accessory glands/ducts (2°sex organ) like vas deferens, Seminal vesicle, Prostate, etc.
- Male pattern of hair distribution, appearance of beard, moustache.
- Male sexual behaviour (LIBIDO)
- Protein, Carbohydrate Anabolism
- Promotes Erythropoiesis
- Aggressiveness.

10) OVARY

- Mesodermal origin
- Location: Inside abdominal cavity
- 1 pair

Ovary

→ 1° sex organ → Oogenesis occur (Formation of ova)

→ Endocrine gland → Hormones → Estrogen, Progesterone (Mainly)

- Ovary consists of ovarian follicles and stromal tissues
- Ovary has growing follicles having developing oocytes inside it

FSH → Responsible for Growth of follicle

LH → Responsible for Rupture of Graafian follicle (Mature follicle)

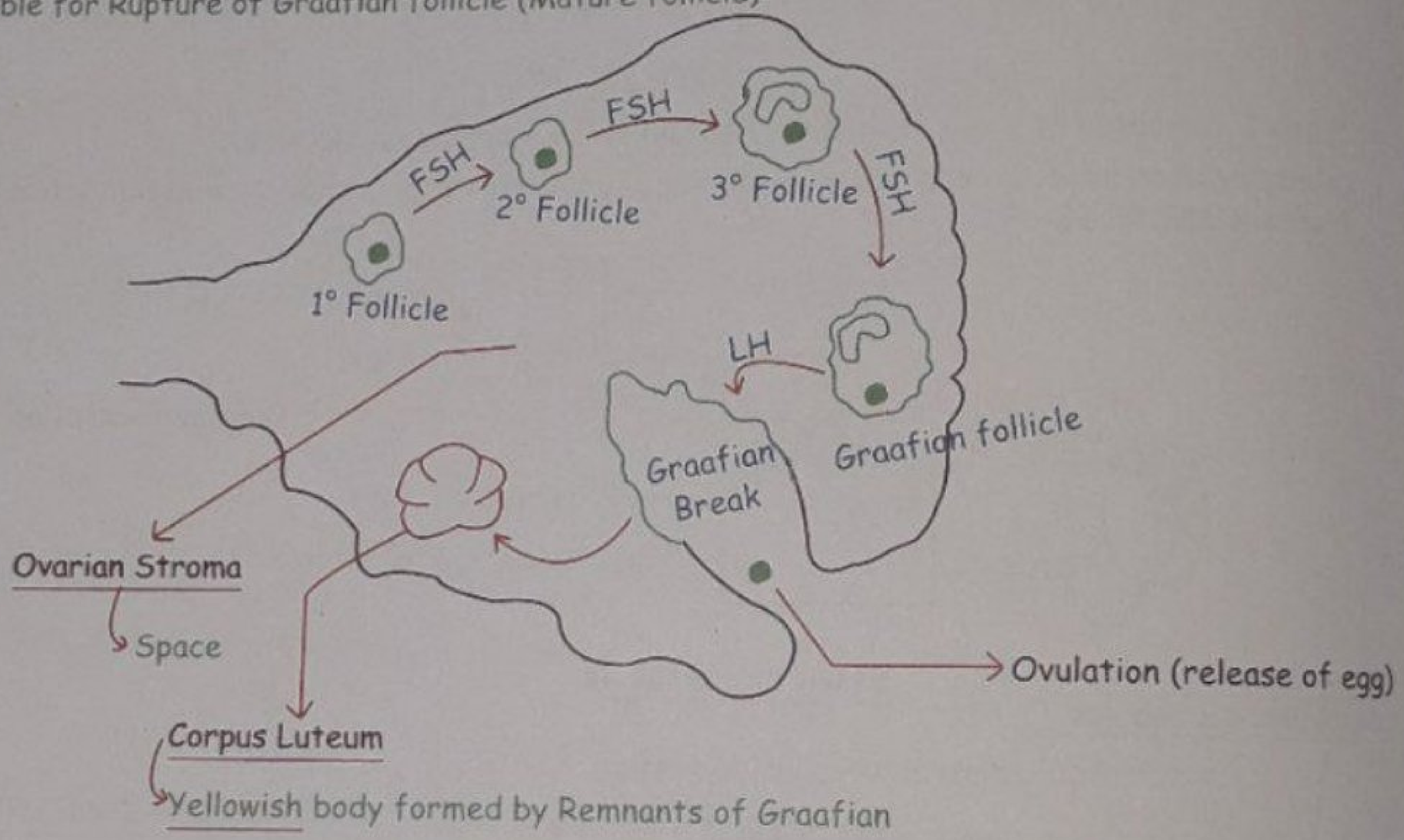


Fig: Section of Ovary.

Ovarian hormone: Estrogen, Progesterone

Progesterone → Main hormone of Corpus Luteum

Estrogen →
1) Mainly secreted by ovarian follicle
2) Some amount is also secreted by corpus luteum

Function of ESTROGEN

- Responsible for high pitch voice
- Mammary gland growth during Puberty
- Female pattern of hair distribution
- Growth & development of 2° sex organs in females: fallopian tube, uterus, etc.
- Female sexual behaviour
- Estrogen forms the ENDOMETRIUM wall of Uterus during Menstrual cycle.
- Influences → OOGENESIS

Progesterone ⟶ PREGNANCY HORMONE ⟶ Supports & Maintenance of Pregnancy

- Maintains the wall of Endometrium (Uterine wall) during pregnancy
- Growth of mammary gland during pregnancy & formation of ALVEOLI (milk forming structure) for lactation.

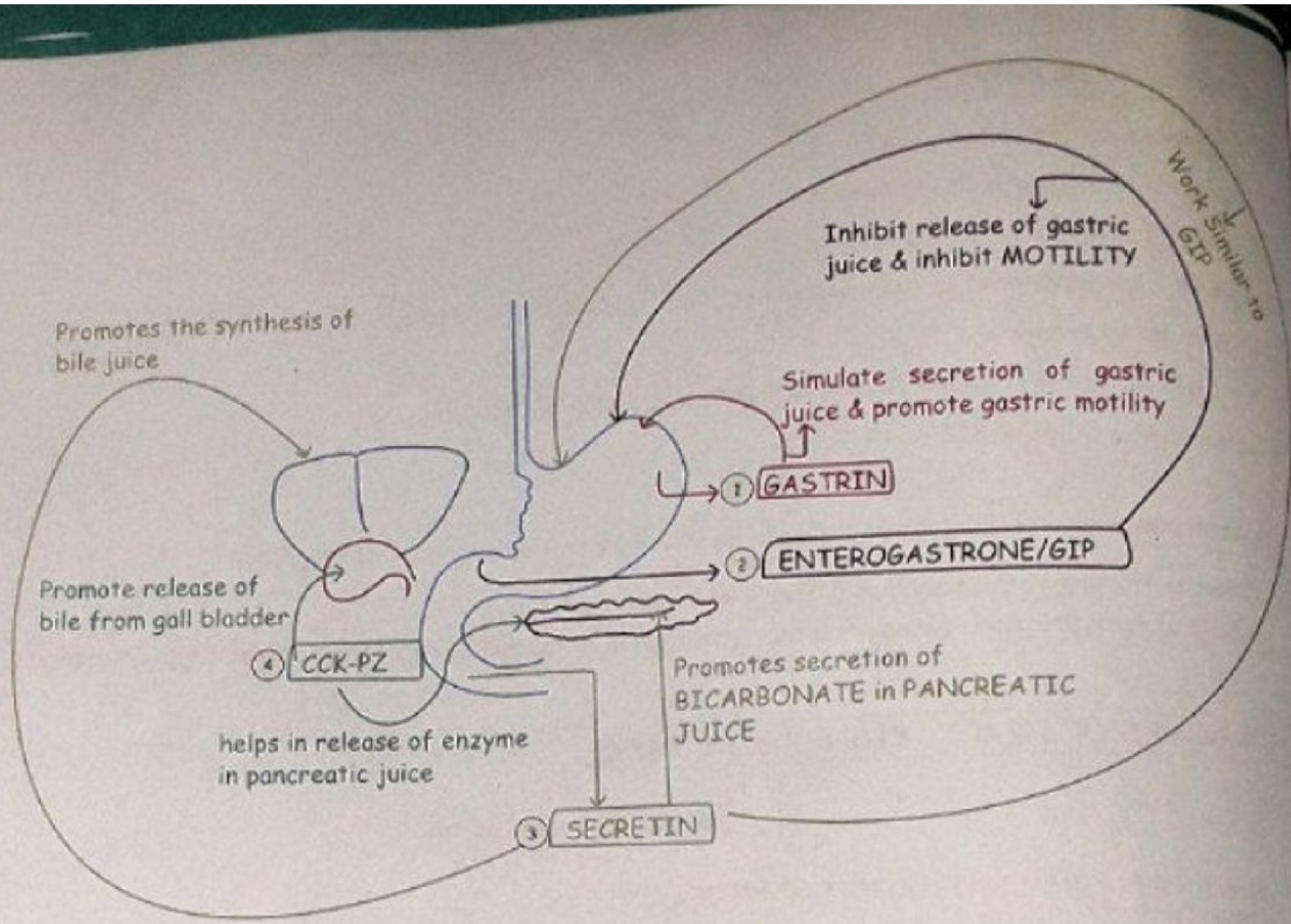
HORMONES OF HEART, KIDNEY & GI TRACT:

→ Gastro-intestinal tract

- Heart: ANF (ATRIAL NATRI-URETIC-FACTOR)
  - → By Atrial wall
  - → Produced when Blood pressure is high and it causes Vasodilation (dilation of blood vessels), hence reduces blood pressure

- Kidney: JG Cell: Produces ERYTHROPOIETIN
  - → Stimulates RBC production

- GI tract
  - → Gastrin
  - → Secretin
  - → CCK-PZ (Chole-cystokinin-Pancreozymin)
  - → ENTEROGASTRONE/(GIP) Gastric inhibitory peptide



Name	Source organ	Target organ	Function
1. Gastrin	Stomach	Stomach	Promote secretion of Gastric juices, gastric motility.
2. Enterogastrone/ GIP	Duodenum	Stomach	Inhibit gastric secretion and motility.
3. Secretin	Duodenum	Pancreas, Liver, Stomach	Releases bicarbonates in Pancreatic Juice. Increases secretion of bile. Decreases gastric secretion and motility.
4. CCK-PZ	Small intestine	Gall bladder and Pancreas	Promotes the release of bile from gall bladder Stimulates secretion of Pancreatic enzyme.

NOTE

- Several non endocrine gland produce hormone called as GROWTH FACTOR that enable the normal Tissue growth & differentiation.

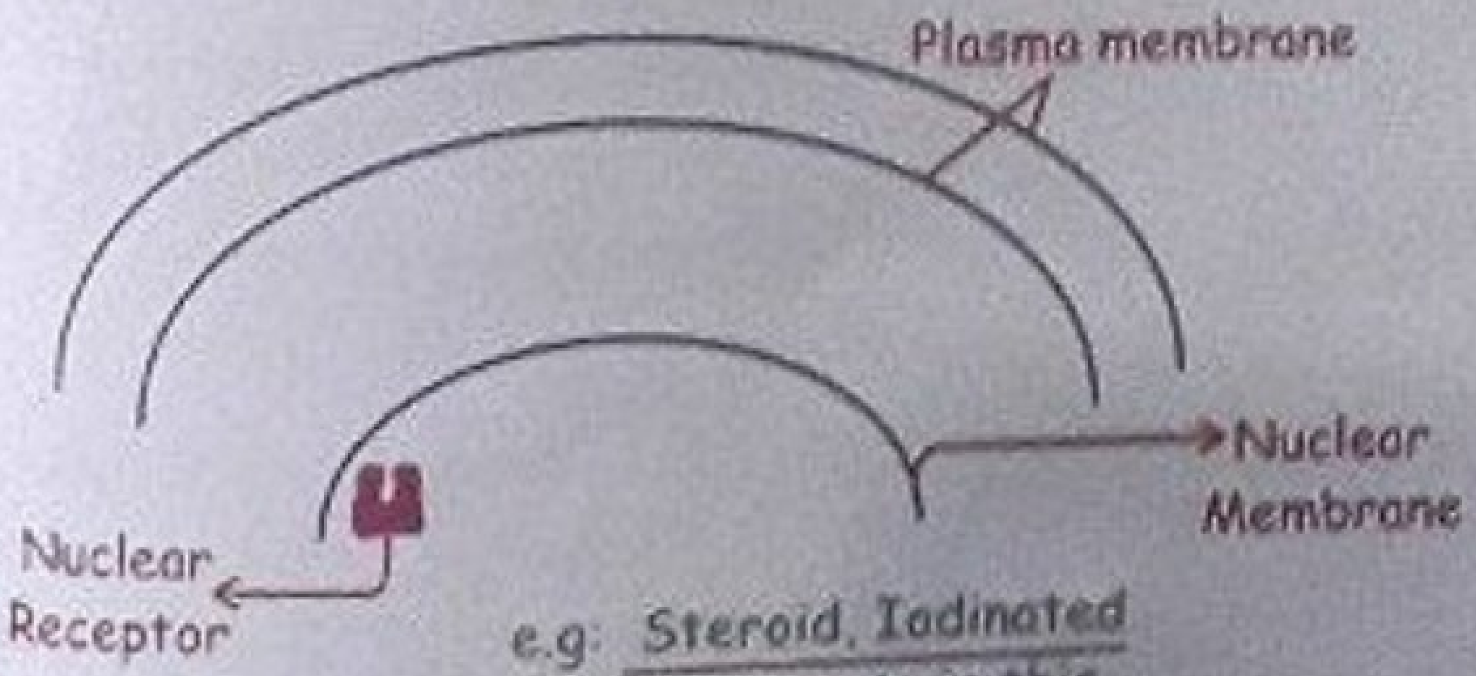
NATURE OF HORMONE

- i) **Proteinaceous/Peptide Hormone**
  - Hypothalamic hormone
  - Pituitary Hormone
  - Calcitonin, PTH
  - Thymosin, Insulin, Glucagon
- ii) **Amino acid-derivative:** Epinephrine + Norepinephrine (Adrenal Medulla), Melatonin
- iii) **Iodinated hormone:** T_3 & T_4
- iv) **Steroid:** Estrogen, Progesterone, Testosterone, Adrenal cortex

RECEPTORS OF HORMONE:

Receptors

1. Nuclear Receptors



e.g: Steroid, Iodinated hormones act via this

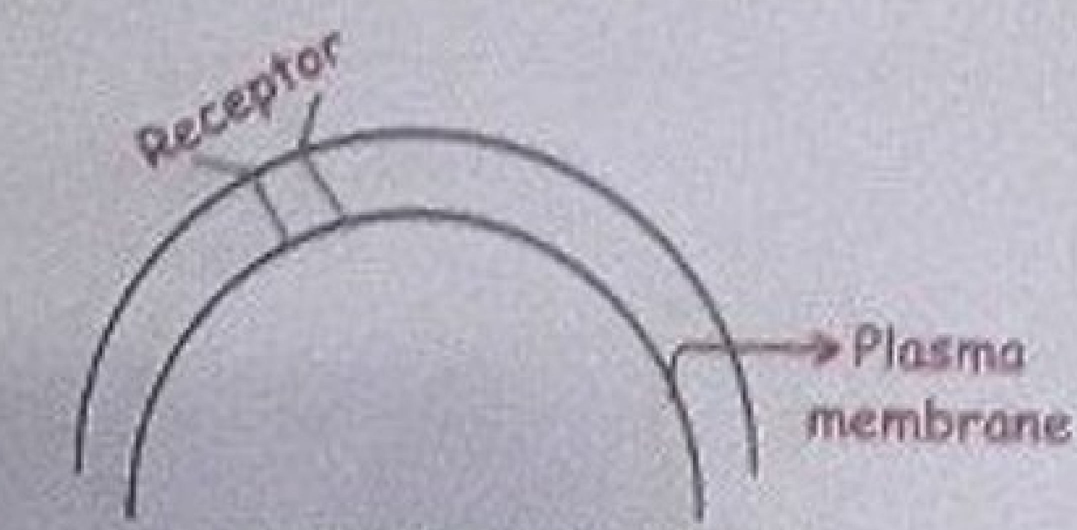
↓

Since these are LIPID SOLUBLE

↓

Can cross plasma Membrane

2. Membrane bound receptor/ extra-cellular receptors



eg: peptide, amino acid derivative hormone act via this

↓

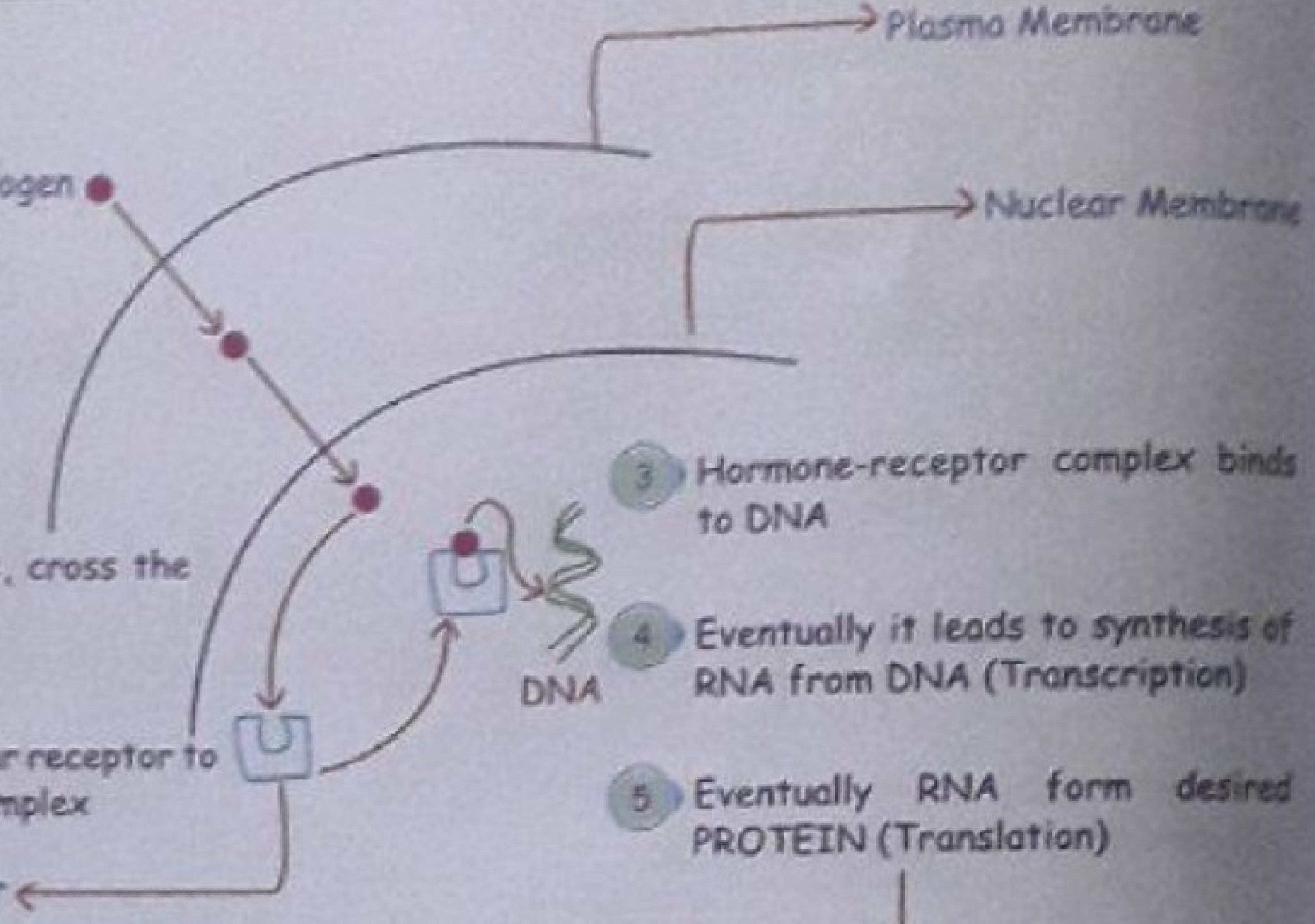
Since these are LIPID INSOLUBLE

↓

Can't cross plasma Membrane hence need extra-cellular receptor

MECHANISM OF HORMONE ACTION

1) Nuclear Receptors: (Intracellular)



1) Hormone being Lipid soluble, cross the plasma & nuclear membrane

2) Hormone binds to its nuclear receptor to form hormone-receptor complex

3) Hormone-receptor complex binds to DNA

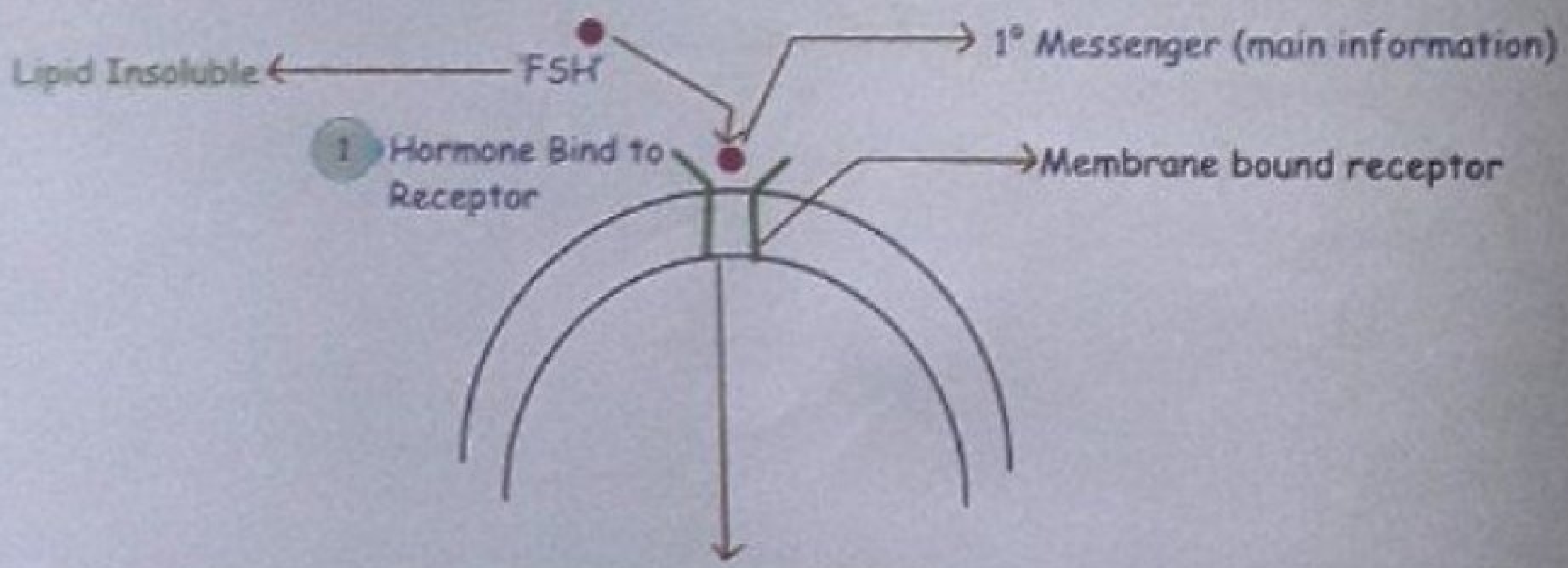
4) Eventually it leads to synthesis of RNA from DNA (Transcription)

5) Eventually RNA form desired PROTEIN (Translation)

↓

Physiological response

2) Extracellular receptors



1) Hormone Bind to Receptor

As soon as it binds to the receptor, it leads to formation of 2° messenger in the Cytoplasm

↓

Ca^{2+}, CAMP (Cyclic Adenosine Monophosphate)

↓

Biochemical response

↓

Physiological responses

10 Human Reproduction

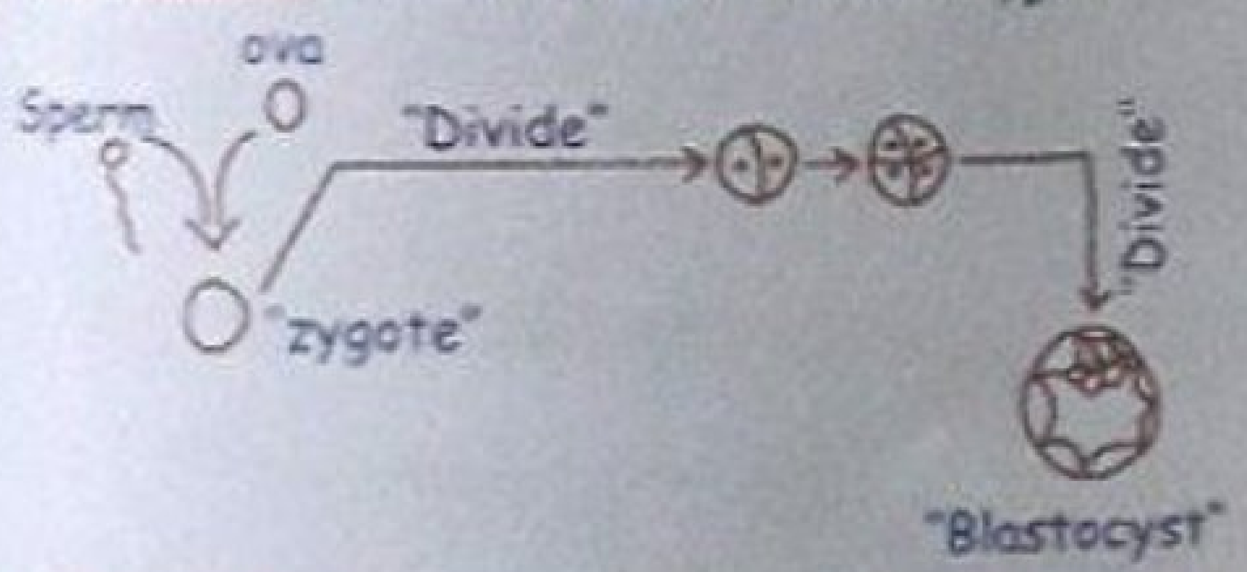
REPRODUCTION

↓

It is the production of OFFSPRING ⟹ For continuity of generation.

Events in Human Reproduction

1. **Gametogenesis:** Formation of Gamete
   - gamete | generation
   - SPERMATOGENESIS ♂ → SPERM
   - OOGENESIS ♀ → OVa
2. **Insemination**
   Transfer of Sperm into the female reproductive tract.
3. **Fertilisation:** Fusion of Gamete to from zygote.



4. **Implantation:** Attachment of the Blastocyst to the uterine Endometrium.
5. **Gestation:** Development of Embryo inside the uterus.
6. **Parturition:** Delivery of Baby

The Reproductive Events in a Male and Female

Spermatogenesis	Oogenesis
It start at the Puberty	It starts at the EMBRYONIC Stage
It continues even in Older Men	It stops at the "Menopause" (~ 50 age) → When Menstrual cycle stops

Types of Sex Organ

Primary Sex Organ

- Organs where production of gametes takes place as well as hormone production occurs.

♂ : Testis → Testosterone
♀ : Ovary → "Estrogen" and "Progesterone"

Secondary Sex Organ

- Support reproduction, storage, transfer and maturation of gametes.

♂ : Vas Deferens, epididymis etc.
♀ : Fallopian tube, Uterus etc.

The Male Reproductive System

The male reproductive system is located in the pelvis region.

- (1) Testes: 1° Sex organ
- (2) Male accessory ducts
  - Rete Testis
  - Vasa-efferentia
  - Epididymis
  - Vas deferens
- (3) Male accessory glands
  - (i) Seminal Vesicles
  - (ii) Prostate Gland
  - (iii) Bulbourethral Glands
- (4) External genitalia
  - Penis
  - Scrotum

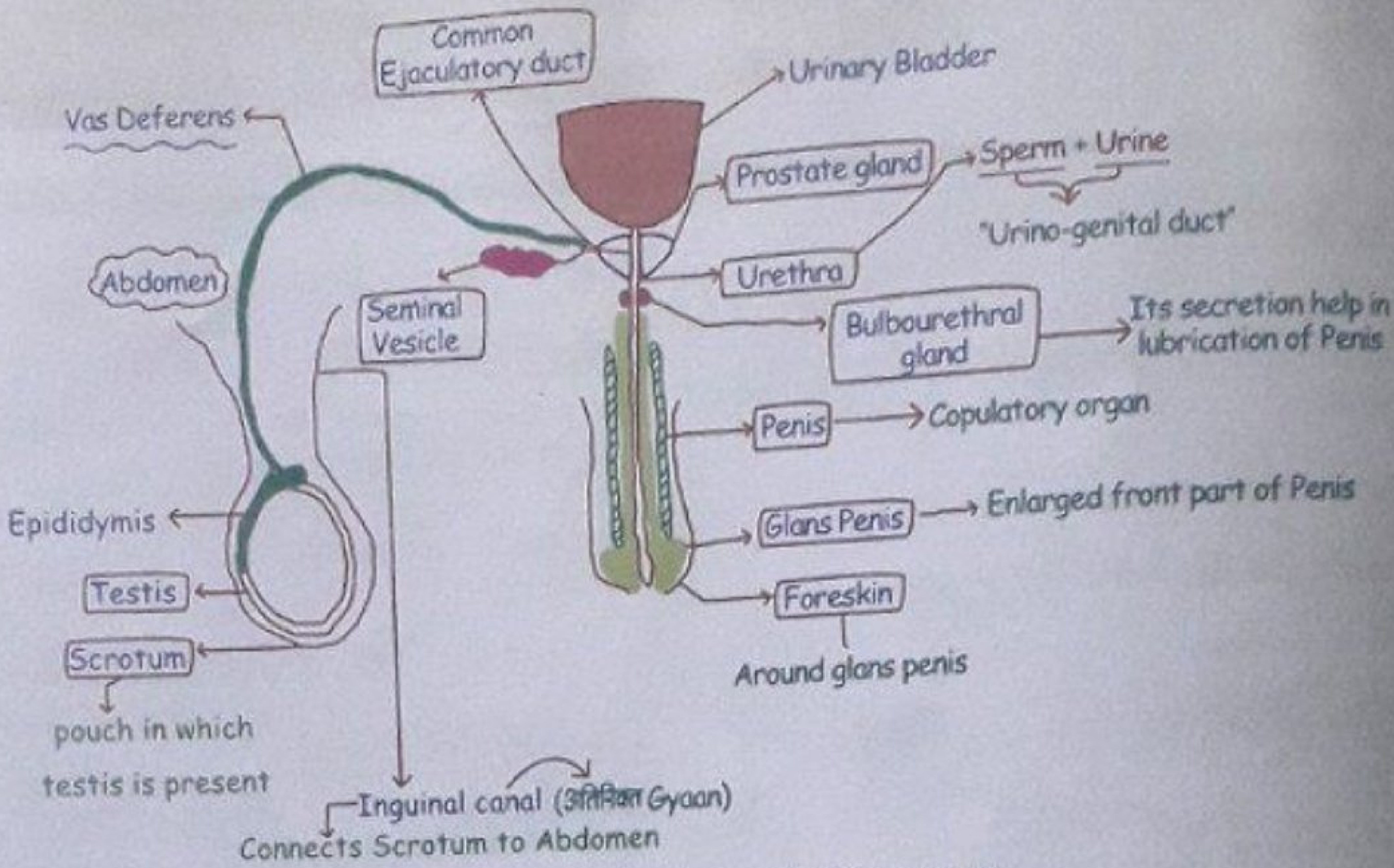


Fig: Section of male reproductive system

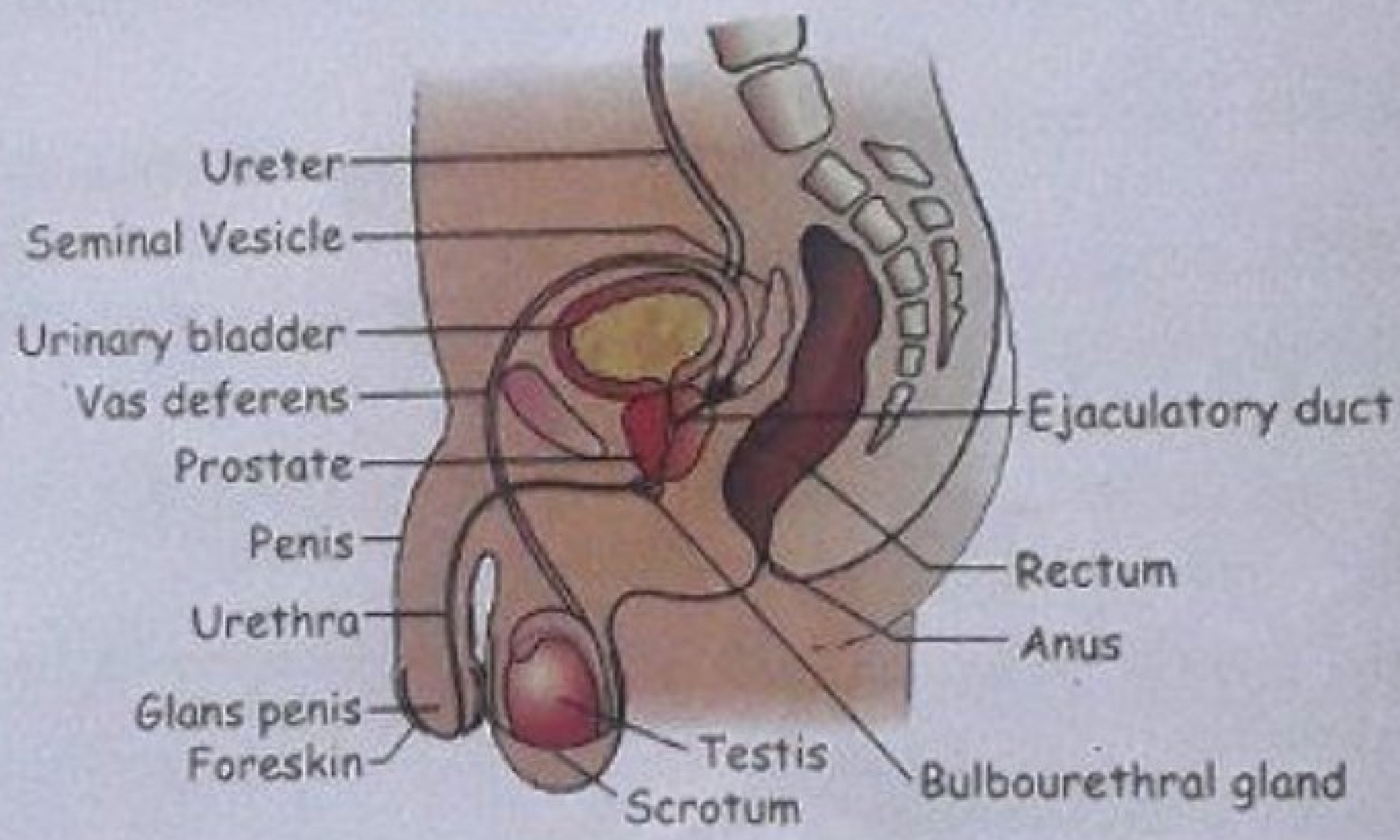


Fig: Diagrammatic sectional view of male pelvis showing reproductive system.

Male Reproductive System:

1. Testis

- Primary sex organ
- One pair
- Present outside the abdominal cavity with in scrotum as spermatogenesis requires **2-2.5°C lower temperatur** than body temperature.
- Testis → Length: 4-5 cm; → Width: 2-3 cm

Internal Structure of Testis:

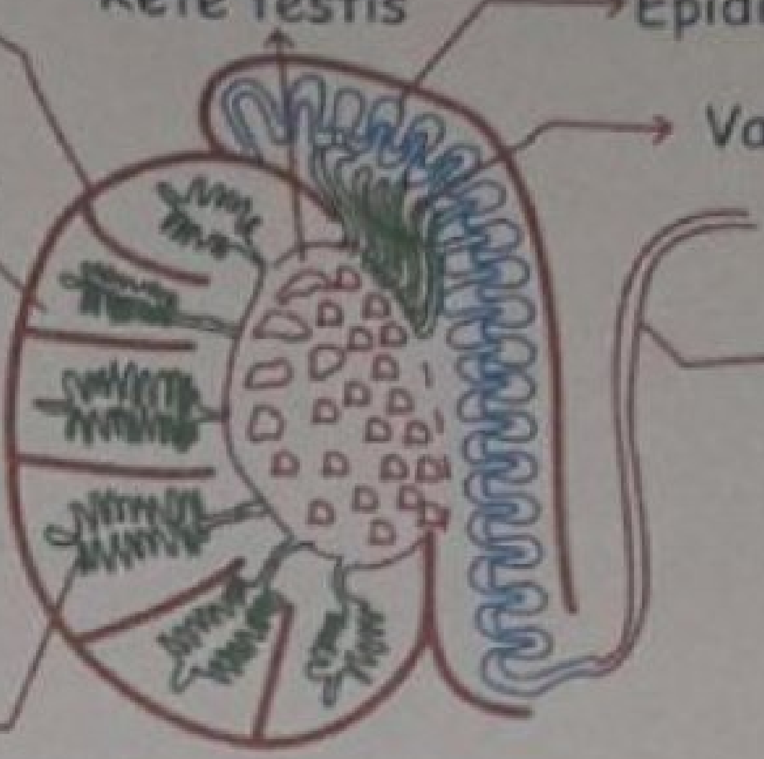


Fig: Section of testis

FLOW OF SPERMS:

Each Testis
↓
250 Testicular Lobules
↓
Each Lobule with 1-3 highly coiled SEMINIFEROUS TUBULE
↓
Sperm Formed
→ Rete Testis
↓
Vasa efferentia (10-12)
↓
Epididymis

It is a (highly coiled structure present along POSTERIOR SUFACE of each testis)

↓
Vas Deferens

Leaves the testis and (Loops over uninary bladder, recieves a duct from SEMINAL vesicle & Form Common EJACULATORY)

Male Accessory Duct

→ Its function is transport, storage & Maturation of sperm

Seminiferous Tubule:

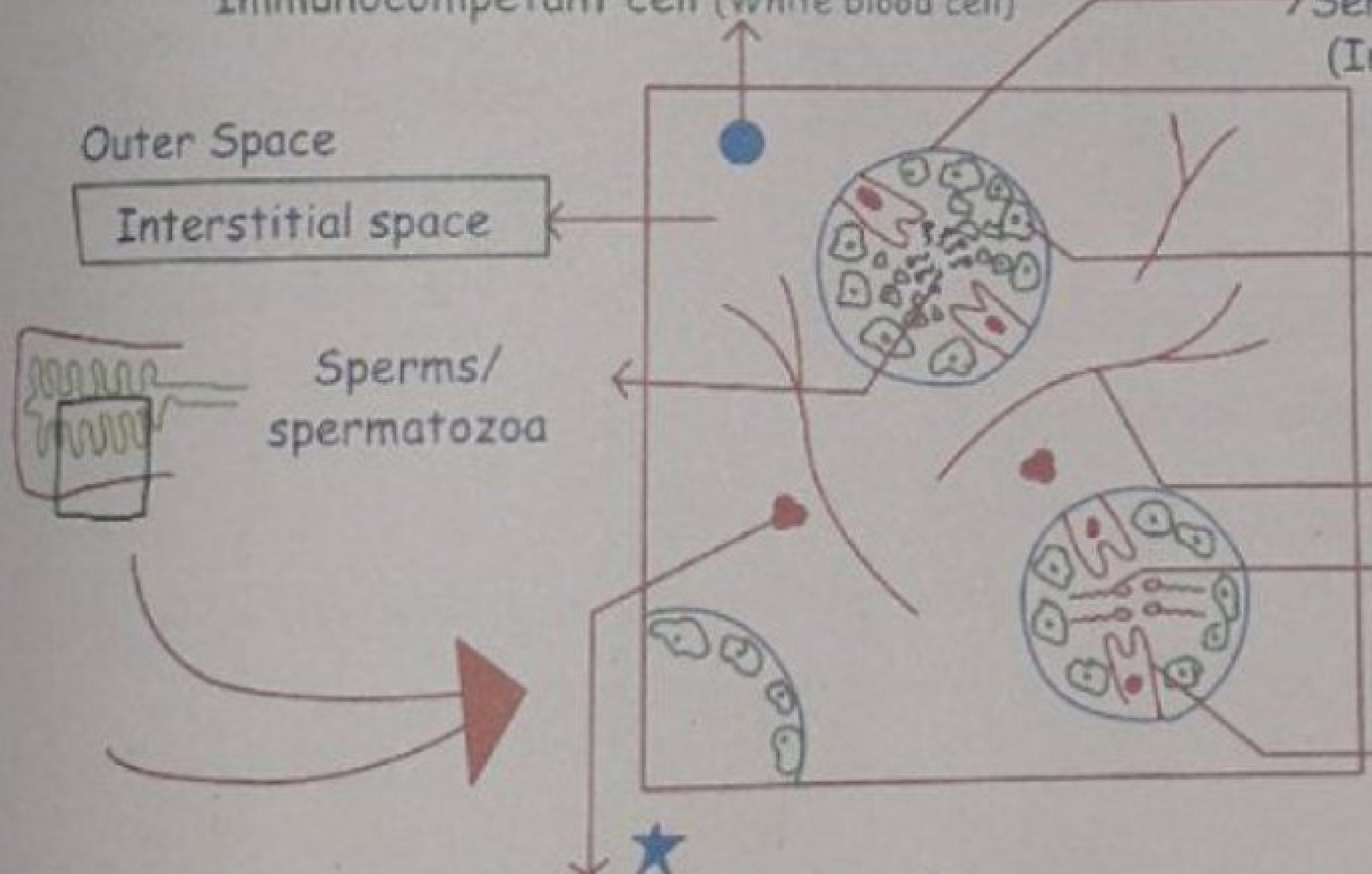


Fig: Section of seminiferous tubule

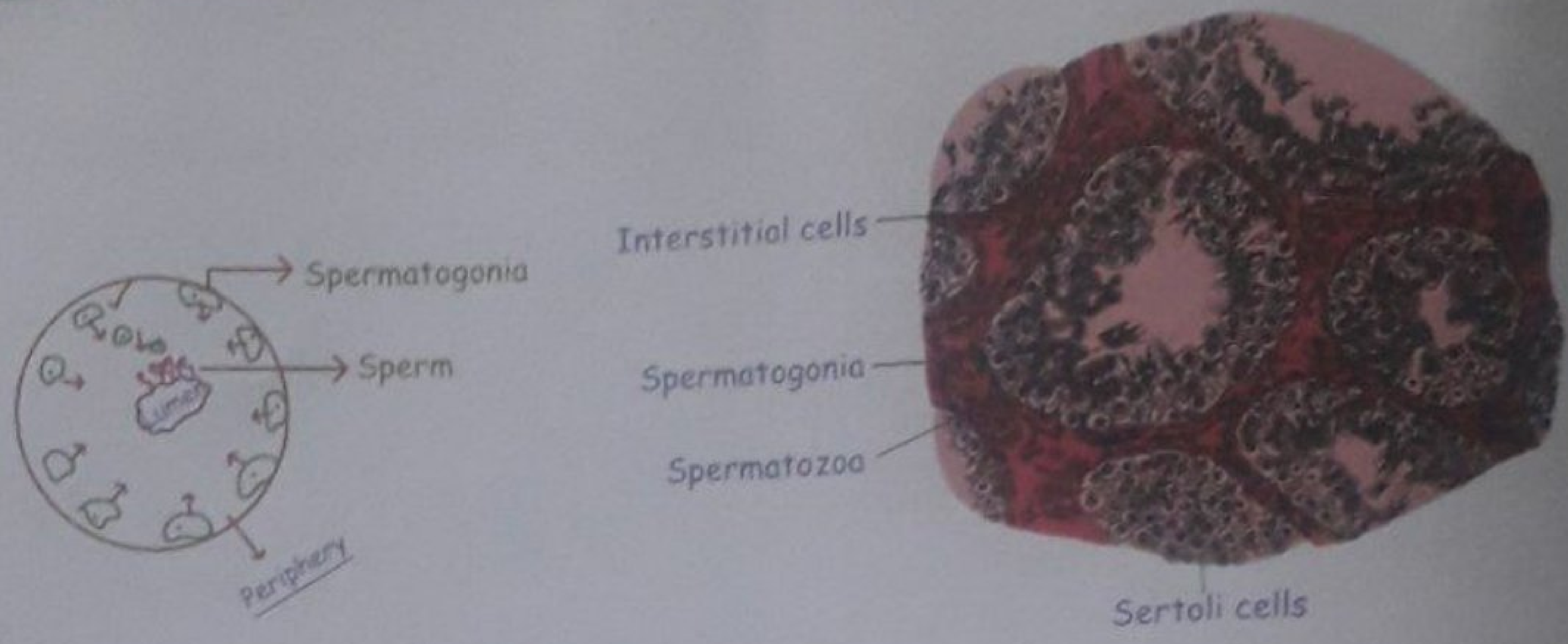


Fig: Digrammatic sectional view of seminiferous tubule

Seminiferous Tubules

- Internally lined by 2 Types of CELLS
  - **Sertoli cell**
    - Nourishment to the developing SPERM
    - Phagocytosis of excess residual cytoplasm of spermatids.
    - Secretes factors called **SPERM MATURATION FACTOR(SMF)** which helps in maturing sperms.
    - It also secretes **'ABP' Androgen Binding Protein** that Binds to Androgen & helps in its concentration in TESTIS
  - **Male germ cells or spermatogonia**
    - Divides to ultimately give rise to SPERM
- Outer Space is called as **INTERSTITIAL SPACE**
  - It has blood vessels
  - It has Interstitial cells Leydig cells.
  - Leydig cell synthesise and secrete testicular hormone called androgens (mainly testosterone).
  - Immunocompetent Cells (WBC) also present.

Accessory Glands: Their secretion is called "**SEMINAL PLASMA**"

	Seminal Vesicles	Prostate Gland	Bulbourethral/Cowper Gland
1. Number	Paired	Single	Paired
2. Location	Behind urinary Bladder	Below urinary Bladder	Sides of Urethra
3. Contribution/ secretion	60-70%	20-25%	5-10%

→ अतिरिक्त (Gyaan)

All of them secrete "SEMINAL PLASMA"

Seminal Plasma:

- Alkaline
- It contains, Fructose, prostaglandins, enzymes, ion like Ca^{2+}, Mucus from Bulbourethral glands helps in lubrication of Penis.

V.Imp

SEMEN = SPERMS + SEMINAL PLASMA

In a single Ejaculation during sexual intercourse / COITUS: 2.5-5 mL SEMEN is released having 200-300 million sperms.

External Genitalia:

(1) Penis: Copulatory structure having erectile tissues, whose enlarged front part is known as **GLANS PENIS**. Helps in insemination upon erection

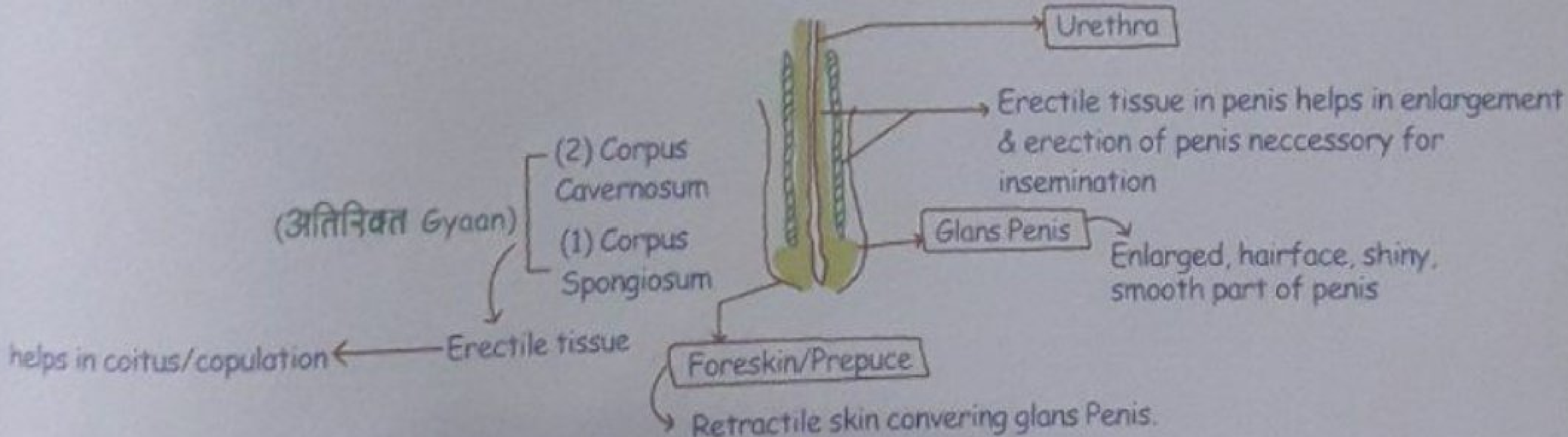


Fig: Section of Penis

(2) Scrotum: Sac like structure in which testis is enclosed. It is internally having 2 compartments to enclose 2 testis

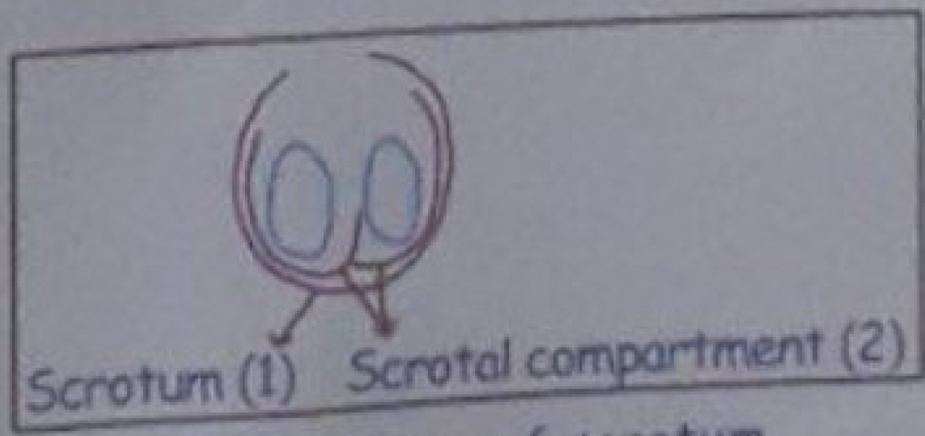


Fig: Section of scrotum

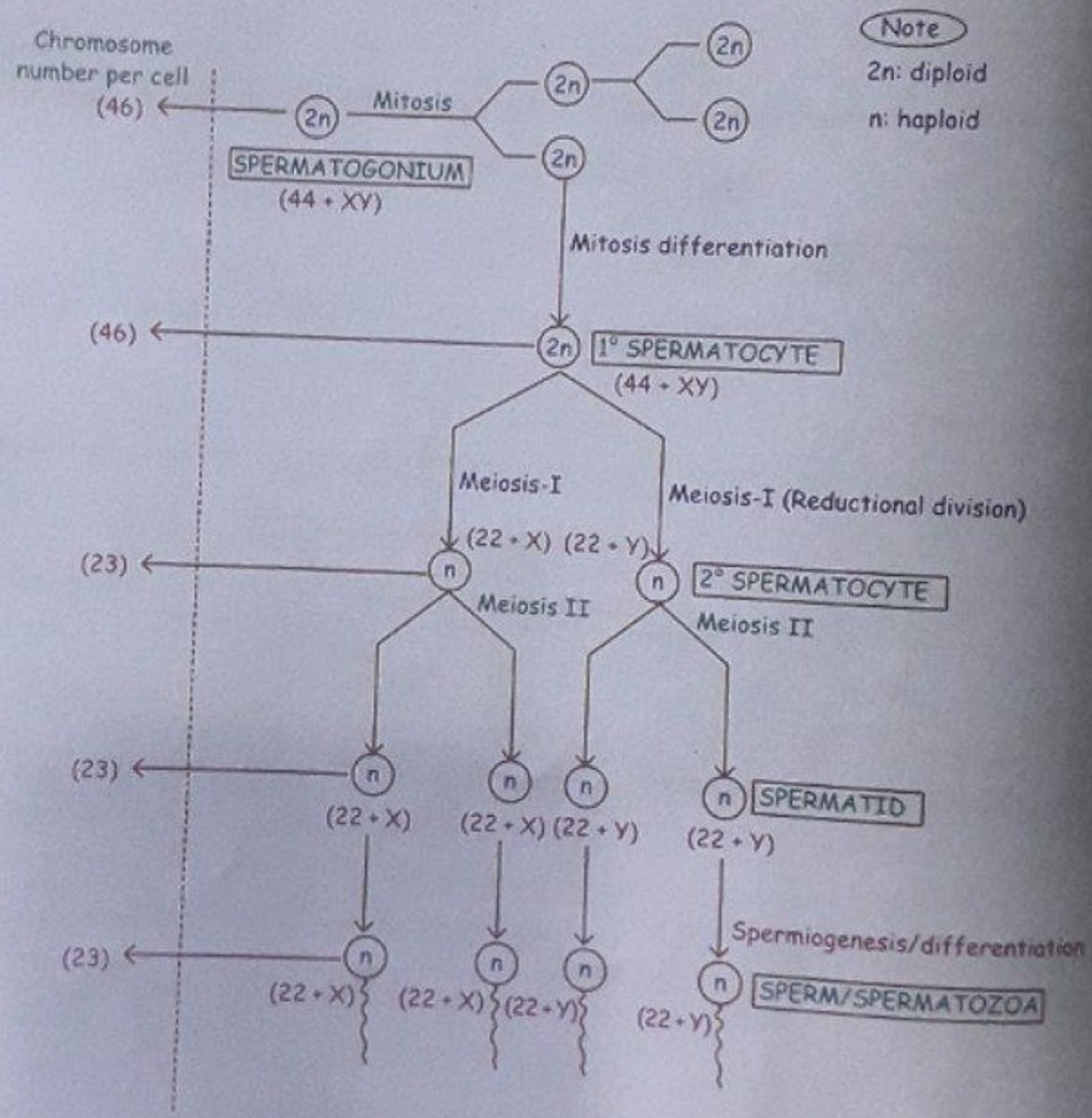
Gametogenesis:

Spermatogenesis → Start at Puberty

$\underbrace{\text{Sperm}}\ \underbrace{\text{Generation}}$ → In males

Continues even in older Men

Spermatogenesis: Process of formation of sperm



Important Note:

1. **Spermatogenesis**: The entire event of formation of sperm starting from spermatogonium.
2. **Spermiogenesis**: The generation of MOTILE sperm/spermatozoa from SPERMATID.
3. **Spermiation**:

NCERT: The release of sperm from seminiferous tubule

OR

Release of sperm into the lumen of seminiferous tubule

Fig: Diagrammatic sectional view of a seminiferous tubule (enlarged)

Structure of Sperm:

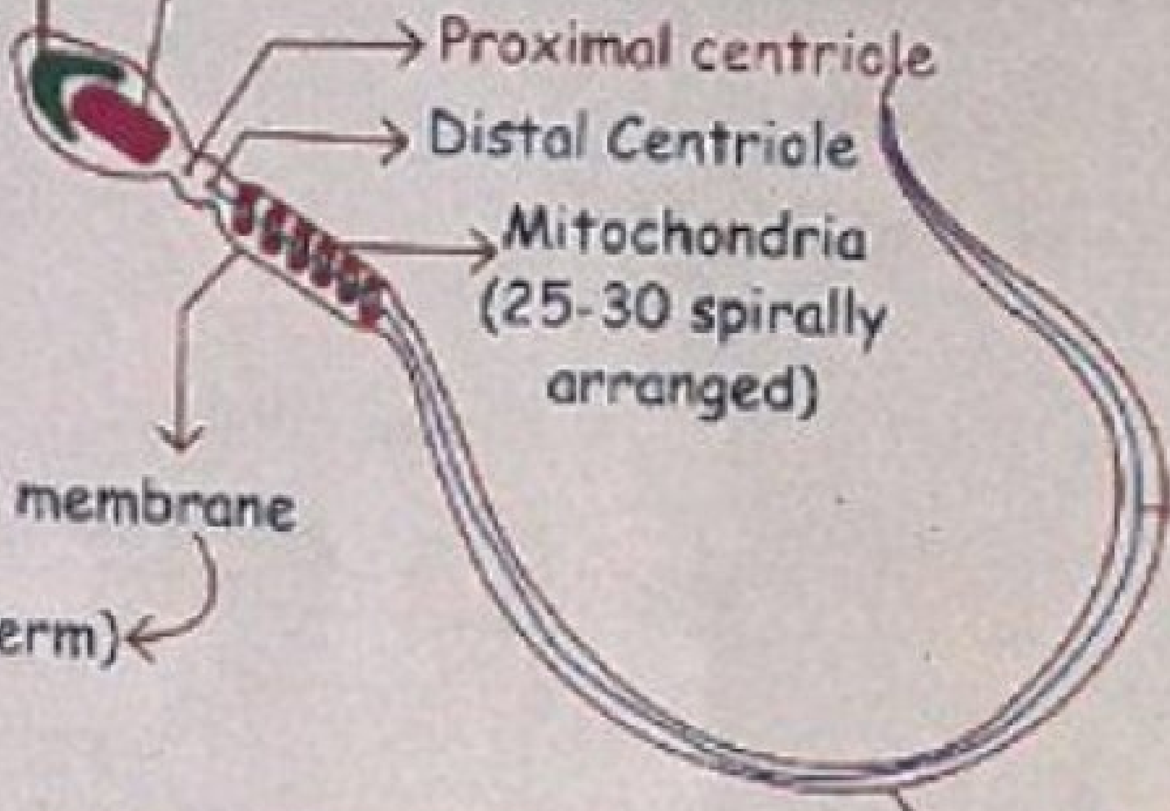
Sperm
- 1. Head
- 2. Neck
- 3. Middle Piece
- 4. Tail

Acrosome
- → Formed from Golgi
- → Cap like structure above nucleus filled with $\boxed{\text{ENZYMES}}$

called as SPERM LYSINS

↓

helps penetrating ovum



NOTE Sperm has very less Cytoplasm

Sperm
- 1. Head
  - Nucleus
  - Acrosome
- 2. Neck
  - Proximal & Distal Centriole
- 3. Middle Piece → 25-30 Mitochondria → "Energy"
- 4. Tail → motility

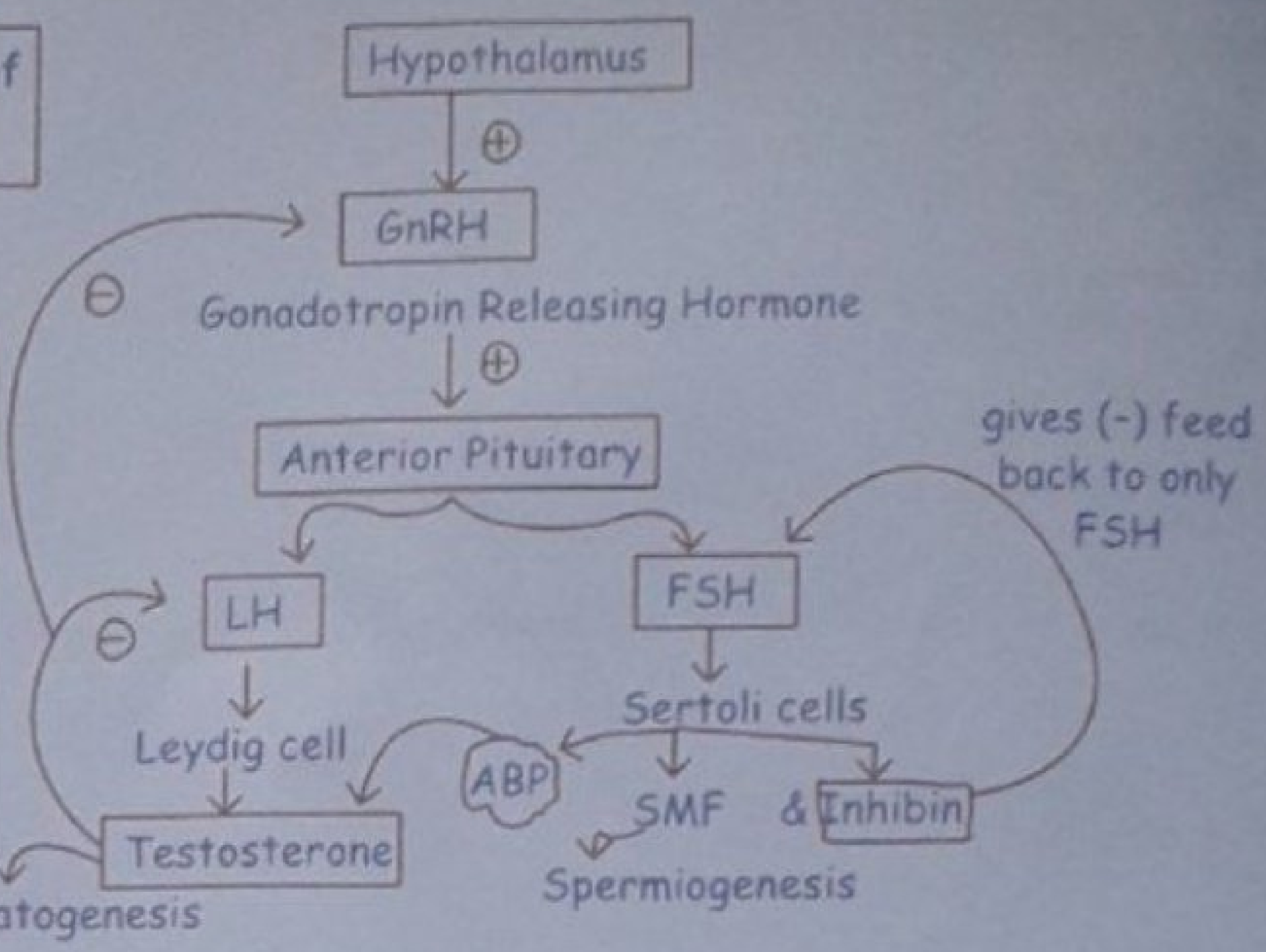
Semen: Seminal Plasma & Sperm

→ In one Ejaculation: '2.5-5 mL' Semen

200-300 Million sperms

- For normal fertility, atleast 60% should have normal shape & size & out of this 40% should show VIGROUS MOTILITY

Hormonal Control of Spermatogenesis



NOTE

SMF → Sperm Maturation factor

ABP → Androgen Binding protein

(-) Negative feedback

(+) Positive feedback

Important Points

- ABP binds to Testosterone to increase its concentration in Testis to promote Spermatogenesis.
- SMF helps in spermiogenesis

अतिरिक्तGyan Negative Feedback includes:

Inhibin $\xrightarrow{\ominus}$ FSH

Testosterone $\xrightarrow{\ominus}$ GnRH, LH

- Sperm: Survives upto 3 days in female body.

Female Reproductive System

- It consists of a pair of ovaries, paired oviduct/ fallopian tube, a uterus, cervix, vagina & external genitalia.
- Along with a pair of mammary gland, it structurally & functionally support ovulation (oogenesis), fertilisation, pregnancy, Child Birth and Care.

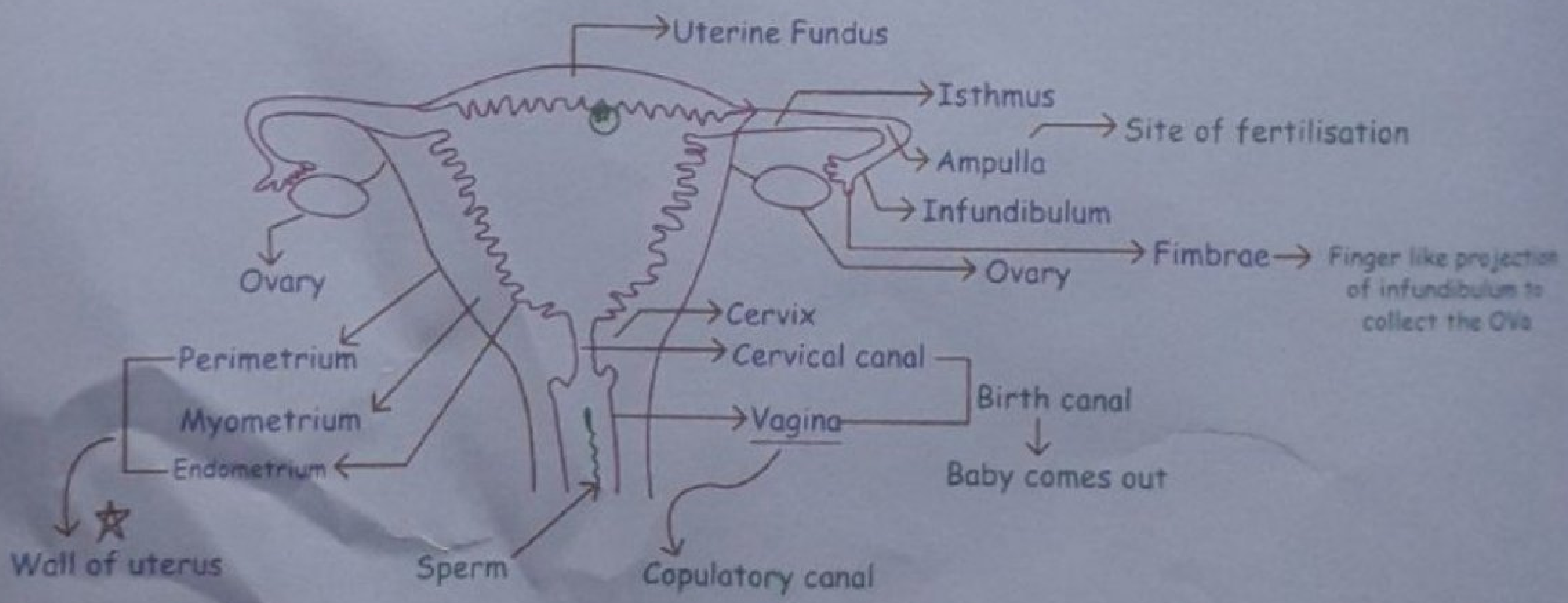
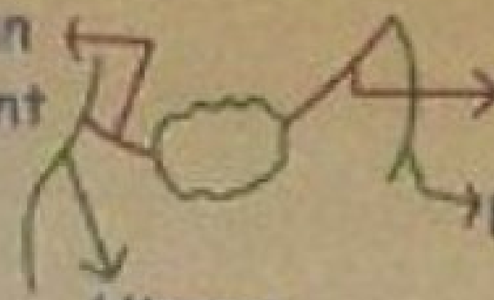


Fig: Female Reproductive System

Female Reproductive system

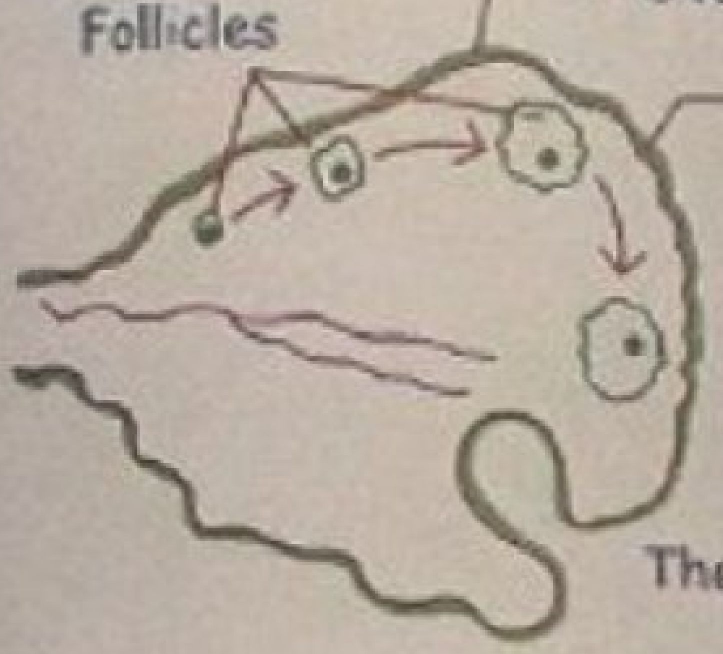
- Primary Sex organ: $\boxed{\text{Ovary}}$
- Accessory ducts: Fallopian tube, uterus, Cervix, Vagina
- Accessory glands: (अतिरिक्त Gyaan) Bartholin's glands & paraurethral glands
- Female external genitalia

1. $\boxed{\text{Ovary:}}$ 1° sex organ
   - Oogenesis
   - Hormone
     - Estrogen
     - Progesterone



○ Ovary is attached to the pelvic & Uterine wall with the help of ligament

Ovary: $\boxed{\text{Length = 2 - 4 cm}}$



$\boxed{\text{STROMA}}$
↓
The space with in the ovary
- Outer cortex → Developing follices
- inner medulla → Blood vessel

NOTE

Follicles
↓
(Gift wrap)

2. $\boxed{\text{Fallopian tube/oviduct}}$
   - Infundibulum → The portion which is closest to the ovary
   - Ampulla → Wider area where fertilisation occurs
   - Isthmus → Closest to Uterus

Length: 10-12 cm

Finger like projection
| Known as
↓
FIMBRIAE
↓
For the collection of Ovum

3. UTERUS/HYSTRA/WOMB

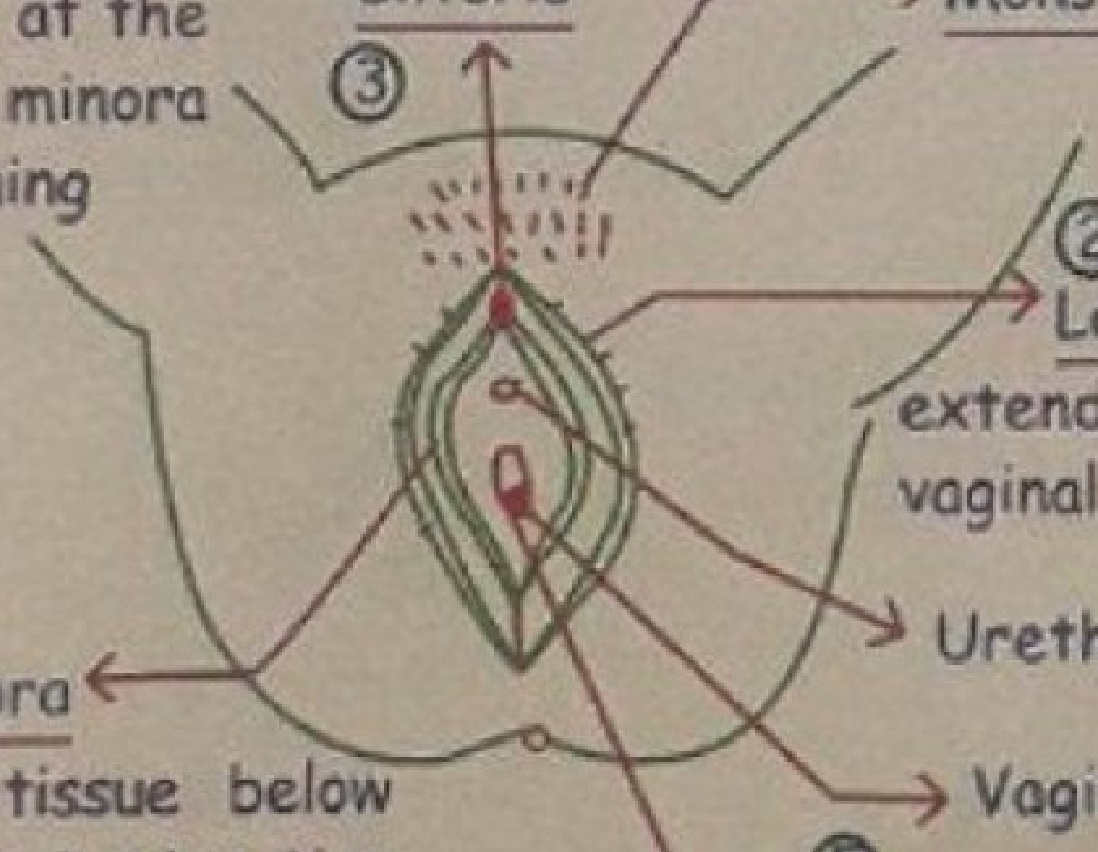
- Inverted pear shaped.
- 'Fundus' is the part of uterus where implantation occurs.
- Uterus opens into vagina via cervix.
- Cervix encloses cervical canal.
- Cervix + Vagina: Birth Canal
- Vagina: Copulatory Canal.

Wall of Uterus

- Perimetrium: Outer covering
- Myometrium: Has smooth muscle which undergoes vigorous contraction during child brith
- Endometrium:
  - Innermost, highly vascular.
  - Undergoes maximum changes during menstrual cycle.
  - It thickens to support pregnancy & if pregnancy does not occur it breaks down & Menstrual flow occurs.

Female External Genitalia:

- Also known as Vulva
- It consists of:
  - Mons pubis
  - Labia majora
  - Labia minora
  - Clitoris
  - Hymen (may or may not be a part)



NOTE
- Hymen may be torn during sexual intercourse/horse riding/heavy exercise etc.
- In some women hymen persist even after coitus.
- Hymen is not a reliable indicator of virginity or sexual experience.

Fig: Female External Genitalia

MAMMARY GLANDS:

→ Modified sweat gland

- Located on Pectoralis major muscle

Sagittal Section of Mammary Gland

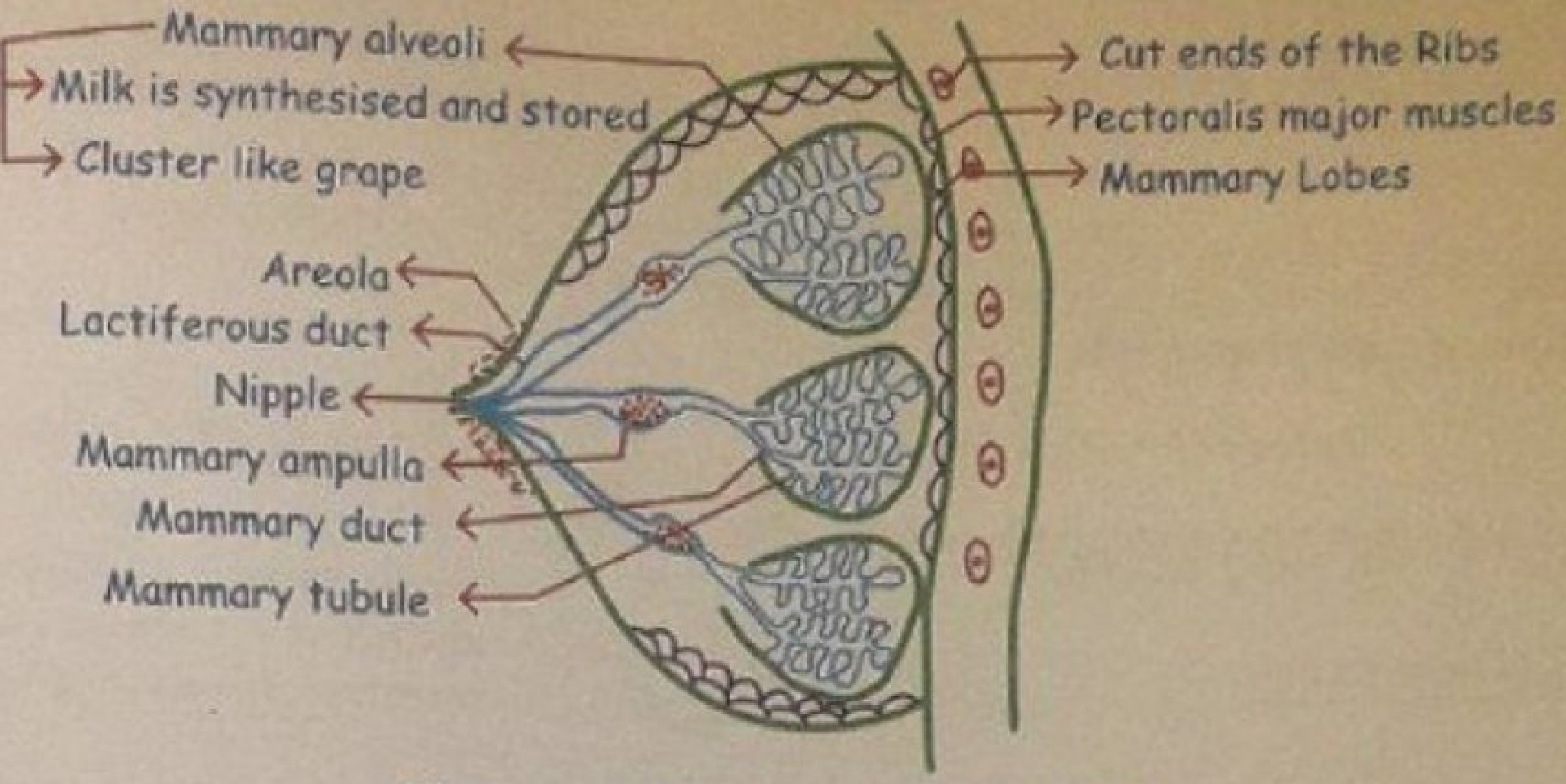


Fig: Sagittal section of Mammary gland

Each Mammary glands
↓
"15-20" mammary lobes
↓
Each lobes with cluster of milk forming structures called Alveoli where milk can also be stored
↓
From Alveoli, mammary tubule arises
↓
Mammary tubules joins to form mammary duct
↓
Mammary duct joins & forms a wider mammary ampulla
↓
Leads to Lactiferous duct that Opens into Nipple.

> **NOTE**
> Areola is the pigmented part around Nipples

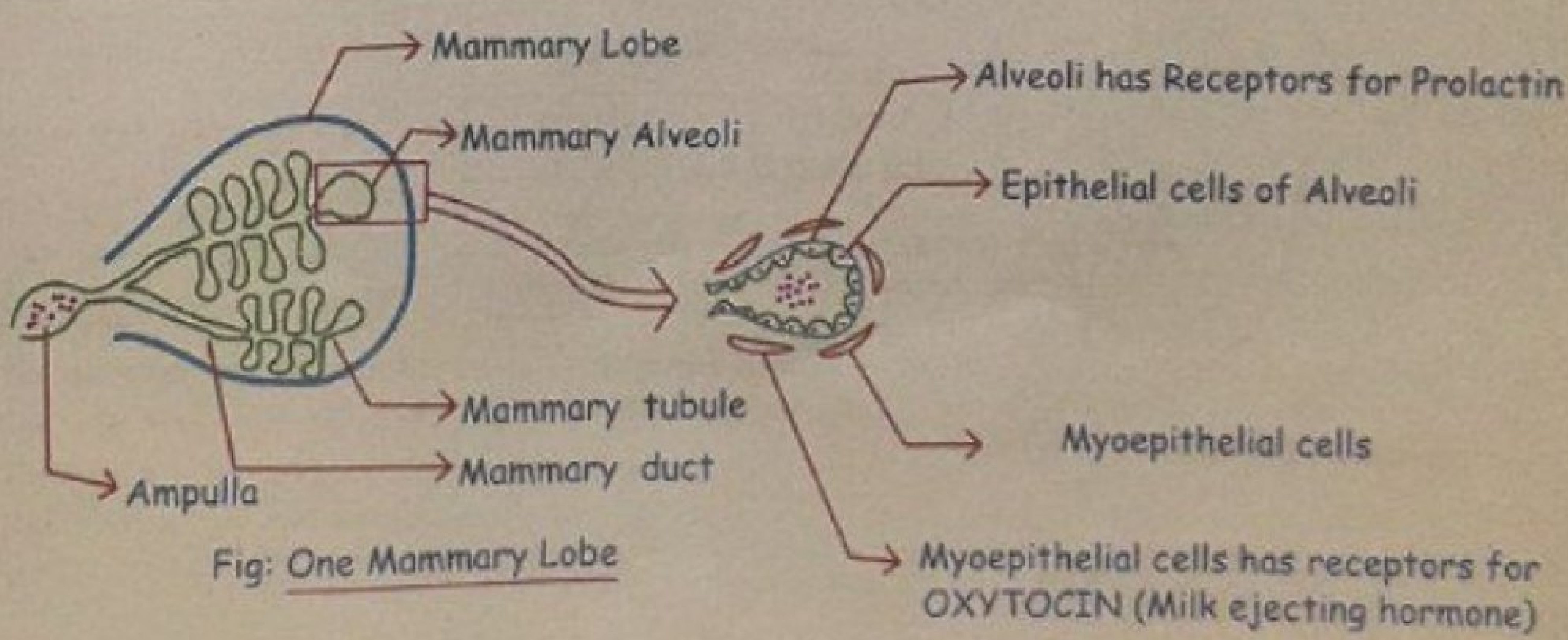


Fig: One Mammary Lobe

Lactation:

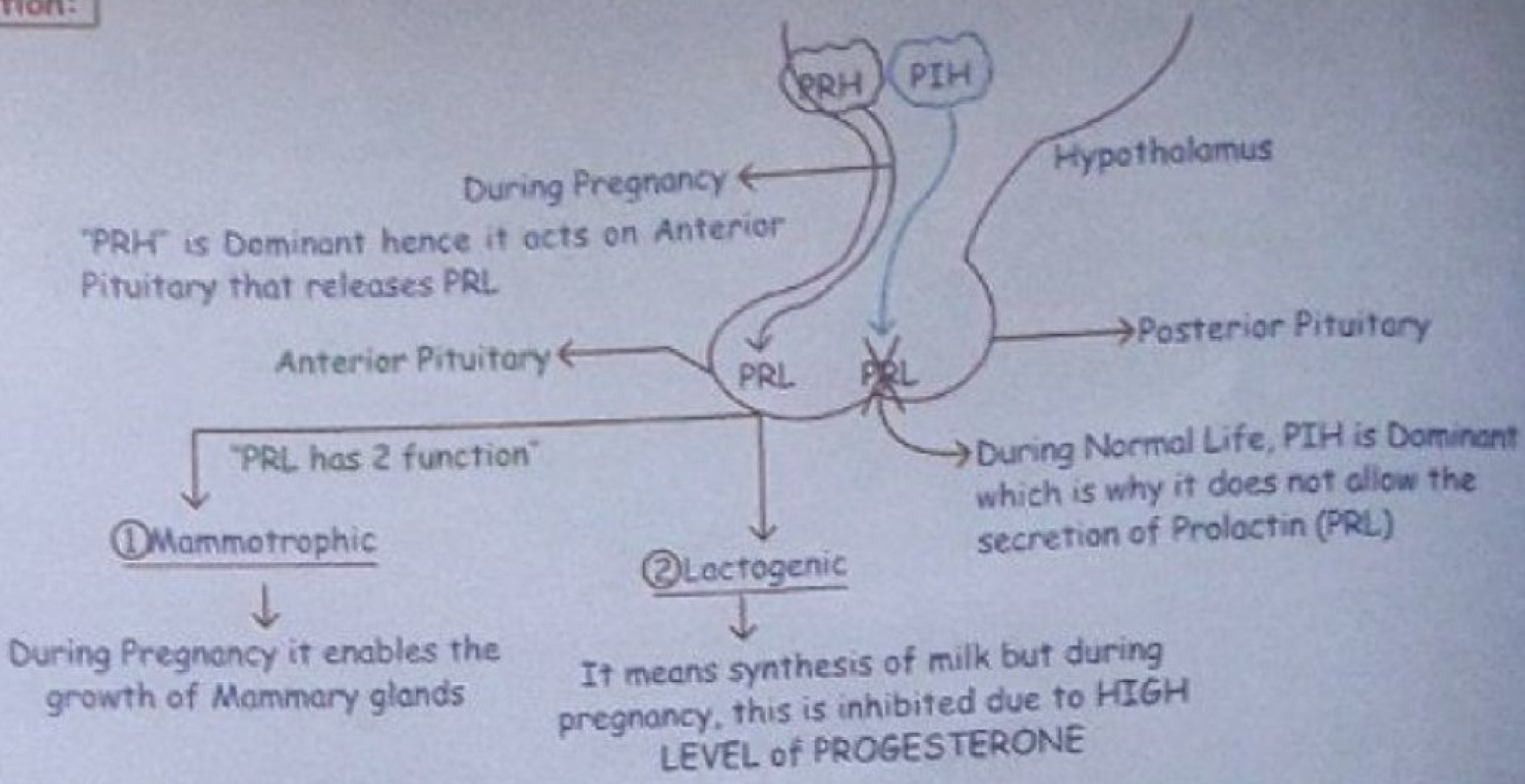


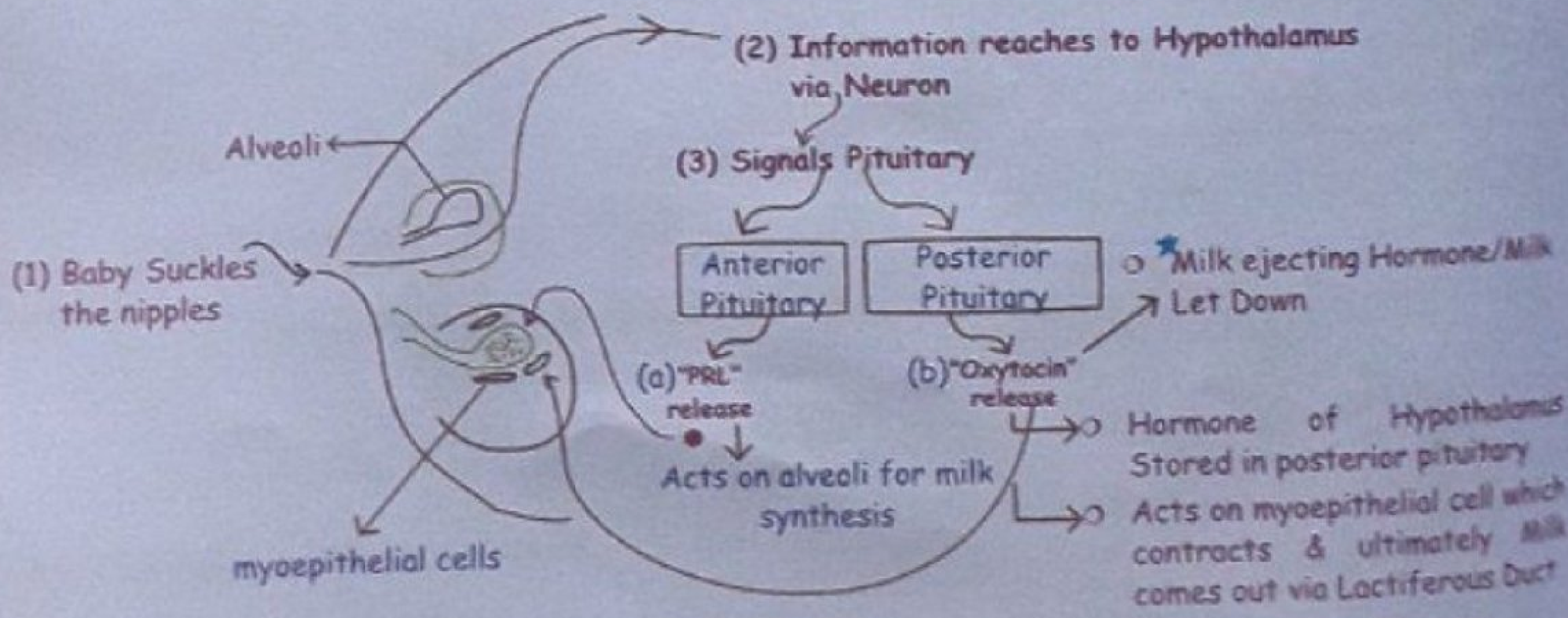
Fig: Hormonal control of lactation (Concept of 11th + 12th class)

NOTE

PRL: Prolactin → From Anterior Pituitary

PRH / PRL - RH: PRL releasing hormone ⎤
PIH / PRL - IH: PRL inhibiting hormone ⎦ From Hypothalamus

NEUROENDOCRINE MECHANISM OF LACTATION:



Milk Composition

Colostrum: The first Milk which is slightly Yellowish with high amount of Antibody /immunoglobulin (Ig): IgA

Milk contains

- Milk sugar (Lactose)
- Milk Proteins (Casein)
- IgA
- Electrolytes are high amount
- Poor in Iron and fat.

Oogenesis

- Gametogenesis in ♀ is start during embryonic Life

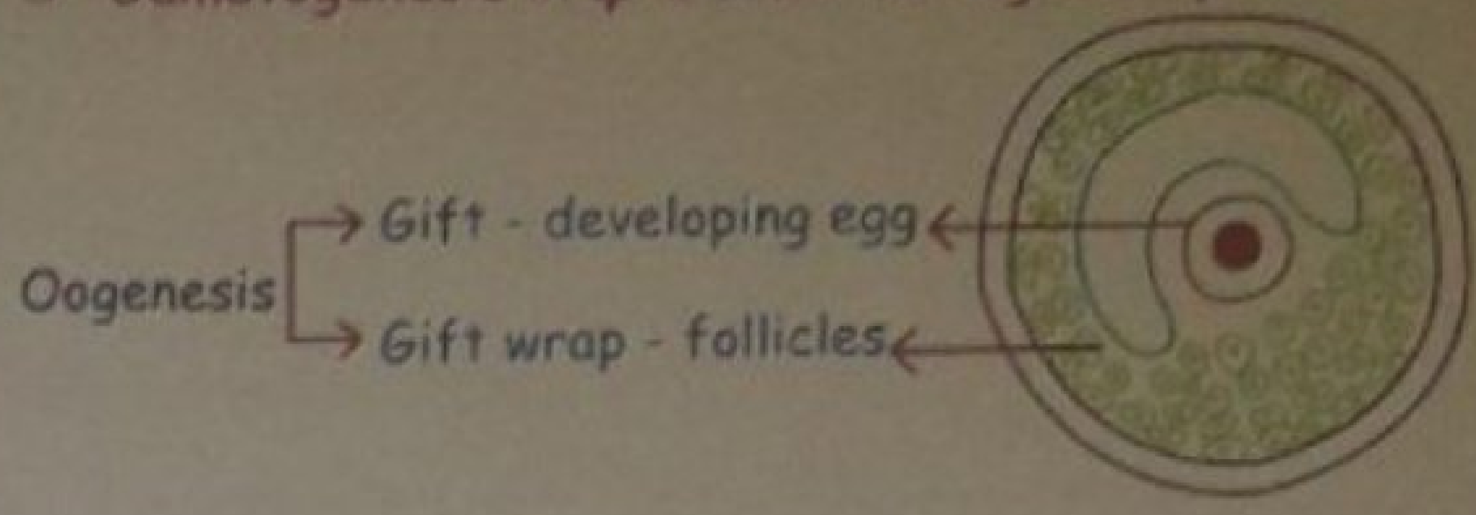
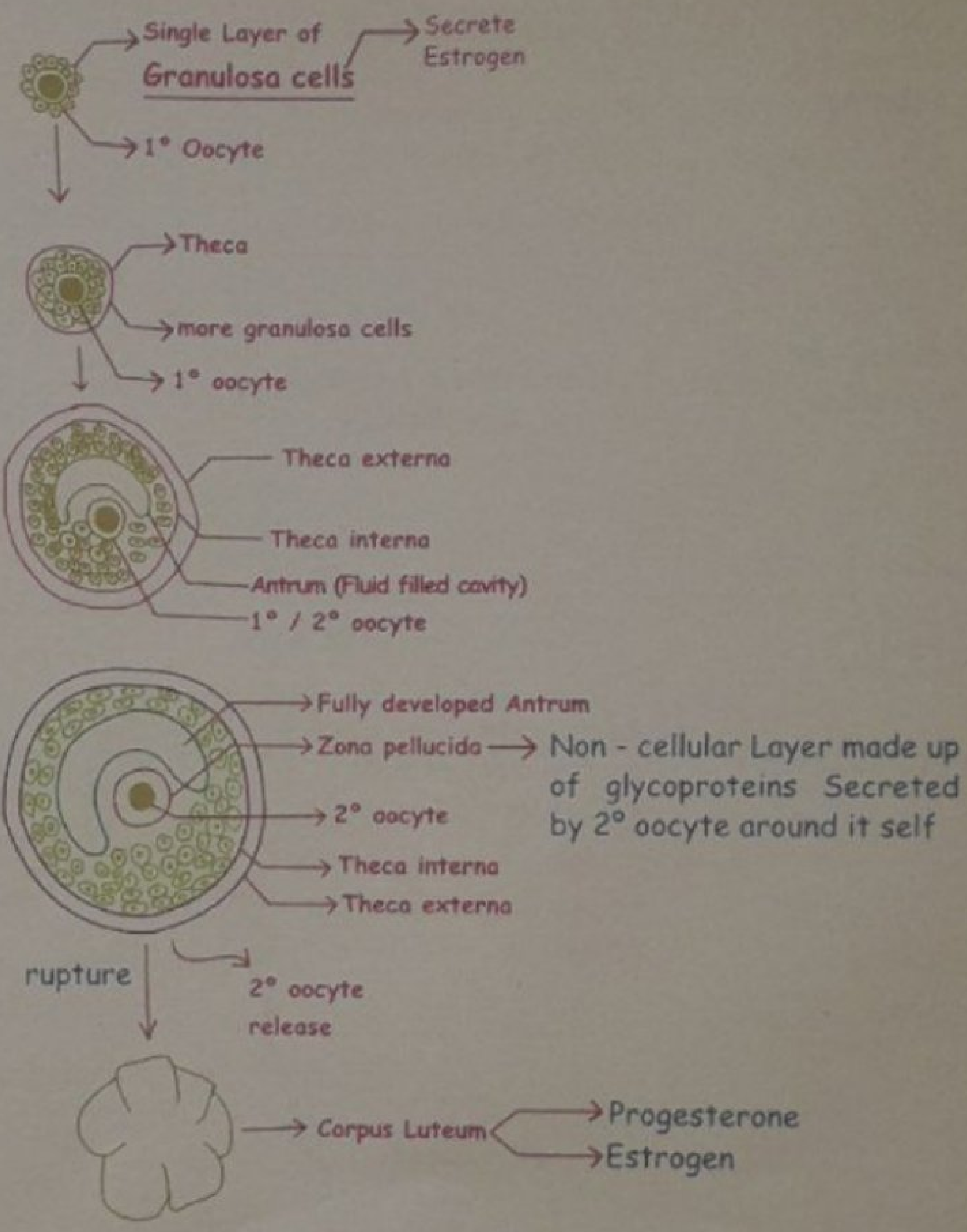


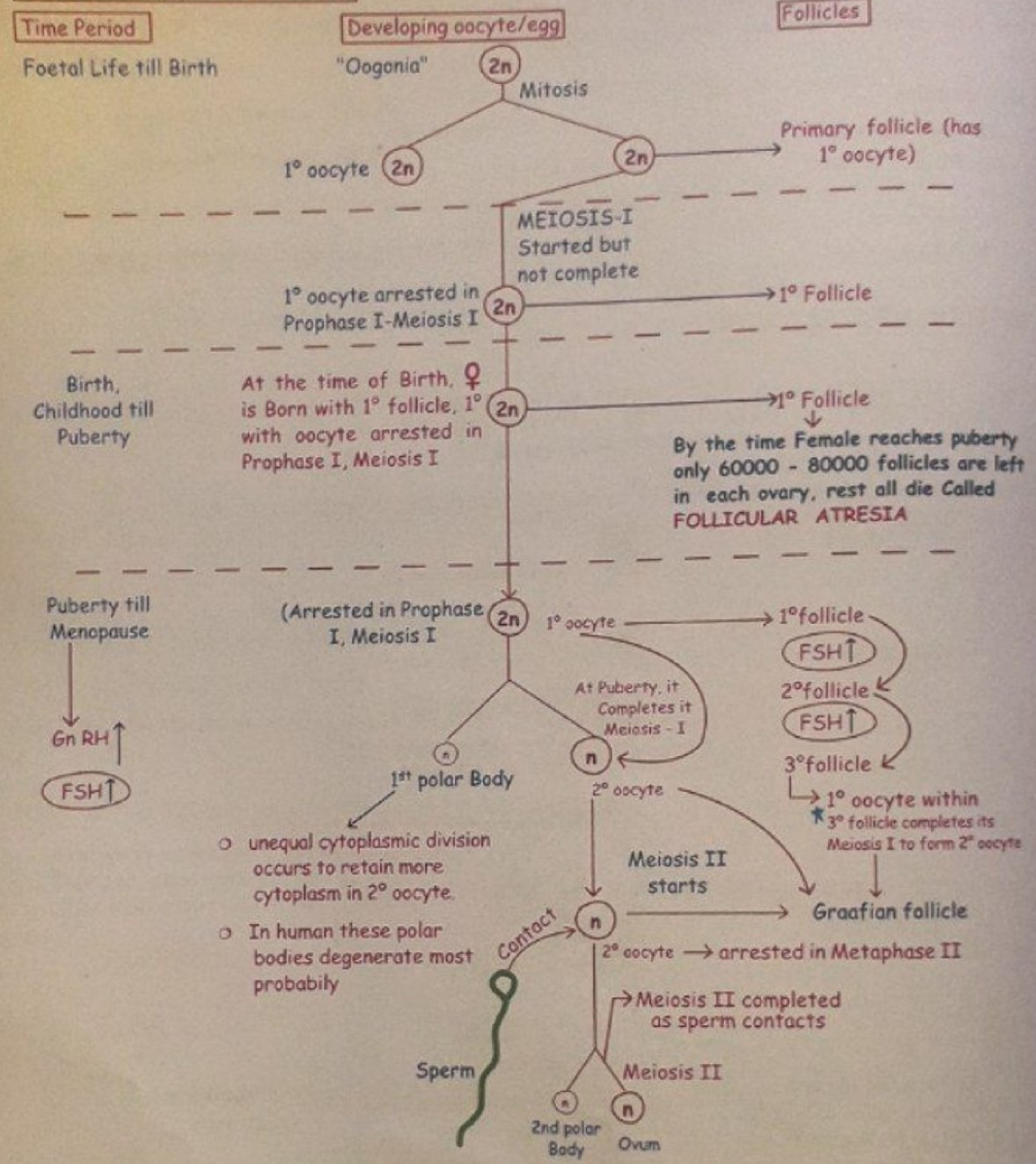
Fig: Reference image to understand egg and follicle

DEVELOPING FOLLICLES:

1° Follicle → 2° Follicle → 3° Follicle → Graafian follicle (mature) → It Ruptures to form a structure called CORPUS LUTEUM (Yellowish Body)



PROCESS OF OOGENESIS



Some Important Points: (OOGENESIS)

- Start → Embryonic Life
- Couple of million oogonia present at embryonic Life, no more added after Birth
- Meiosis I starts : 1° oocyte
- In Embryonic life: 1° oocyte: Arrested at Meiosis-I, Prophase-I

- $\boxed{\text{Meiosis I: Complete: At Puberty}}$
- 2° oocyte: $\boxed{\text{Meiosis II :started}}$
- 2° oocyte Arrested: $\boxed{\text{Meiosis II, Metaphase II}}$
- Meiosis II: Completed: Contact of sperm
- 2n: diploid (44 + xx)
- n: haploid (22 + x)

MENSTRUAL CYCLE:

Reproductive cycle in Primate mammals like Apes, monkey human.

1. Menarche: Start of menstrual cycle (Puberty)
2. Menopause: End of menstrual cycle (≈45-50 yr)

Menstrual events

Ovarian events	Uterine events
1. Follicular phase	1. Menstrual phase
2. Ovulatory phase	2. Proliferative phase
3. Luteal phase	3. Secretory phase

Hormonal Control of Menstrual Cycle

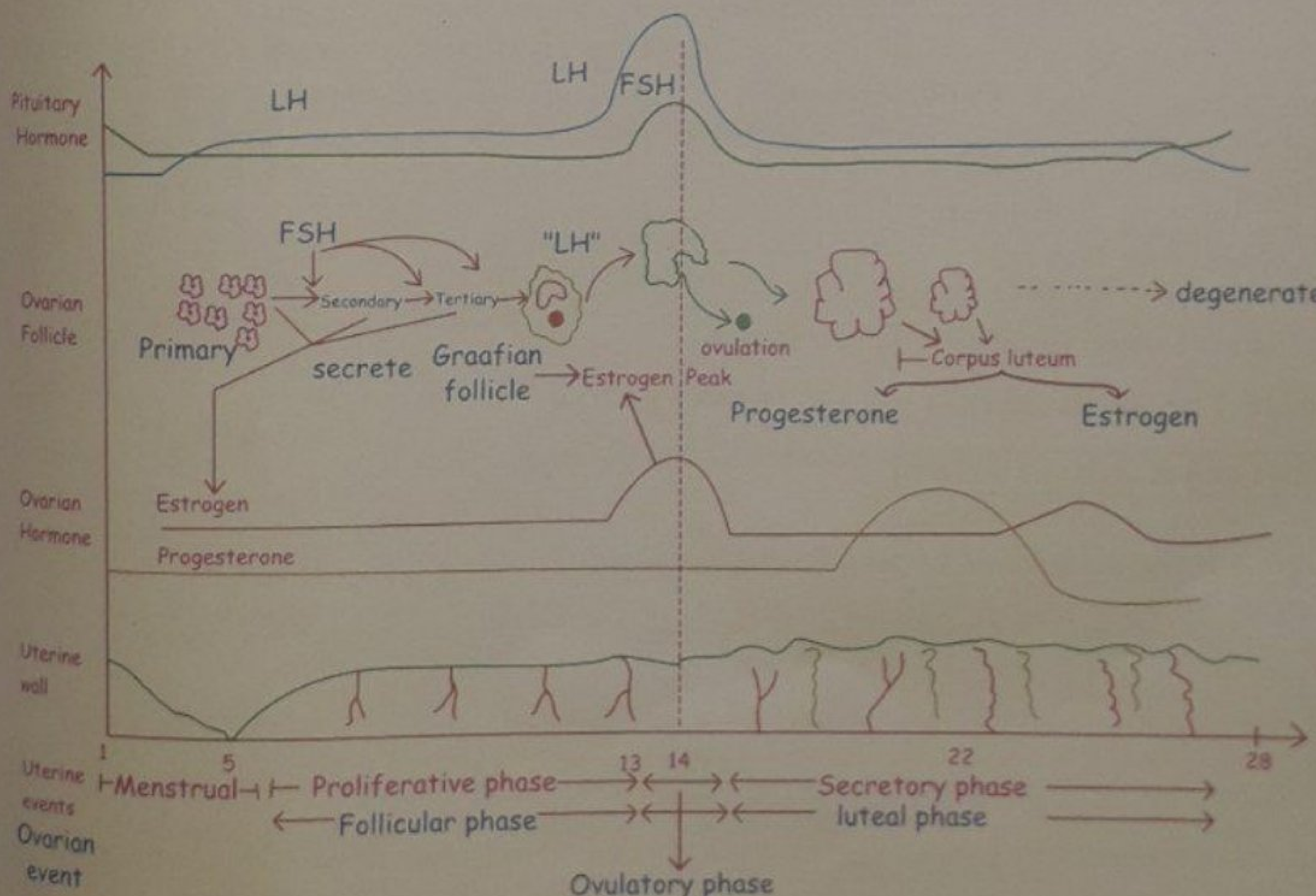
Hypothalamus
↓ GnRH
Ant. pituitary

FSH → growth of FOLLICLES → has GRANULOSA CELL → Secrete ESTROGEN → (+) Stimulate → FSH, LH, GnRH

LH → Ruptures Graafian follicle → Forms corpus luteum → Progesterone, Estrogen → (-) inhibit → GnRH, FSH, LH

Full form of GnRH, FSH, LH

- GnRH (Gonadotropins Releasing Hormone)
- FSH (Follicular Stimulating Hormone)
- LH (Luteinising Hormone)



IMPORTANT POINTS OF MENSTRUAL CYCLE:

1. MENSTRUAL PHASE:

- Can Vary female to Female
- Day1-5: BLEEDING Phase
- Corpus Luteum from Previous Cycle: DEGRADE
- No Corpus Luteum → No "Progesterone" & "Estrogen" → : No inhibition to FSH, LH, GnRH
- Endometrium Breaks
  ↓
  "Blood" comes out

2. PROLIFERATIVE/FOLLICULAR PHASE

- FSH ↑ → FOLLICLE GROW
- FOLLICLE secrete → ESTROGEN
  ↓
  UTERINE wall
  ↓
  Proliferation of Uterine Endometrium
- Mature Graafian Follicle → Maximum Estrogen
  ↓
  ESTROGEN peak (Prior to ovulation)
  ↓ ⊕
  FSH, LH
  ↓
  FSH & LH Surge

Corpus Luteum Life 14 days (If no pregnancy)

Note: Day of Ovulation = No of days of menstrual cycle-14

- Life span of ovum : 24 hr/1 day

Note: If pregnancy occurs, corpus Luteum is maintained

Fertilisation ✓⟶ Pregnancy ✓⟶ Corpus Luteum Maintain
↓ Progesterone, Estrogen
↳ Uterine wall maintain

- During Pregnancy ⟶ hCG Secreted

(HCG (Human Chorionic Gonadotropin) act as LH to Maintain Corpus Luteum during pregnance)

3. OVULATORY PHASE 'One Day'

Graafian follicle $\xrightarrow{LH}$ rupture
↓
Ovulation occurs (14th day)

4. SECRETORY/LUTEAL PHASE:

- Graafian follicle rupture: forms corpus Luteum (Yellow Body)
- "LH" forms & maintains Corpus Luteum (CL)
- Corpus Luteum ⟶ "Progesterone" & "Estrogen"

Uterine wall thick, secretory & maintained

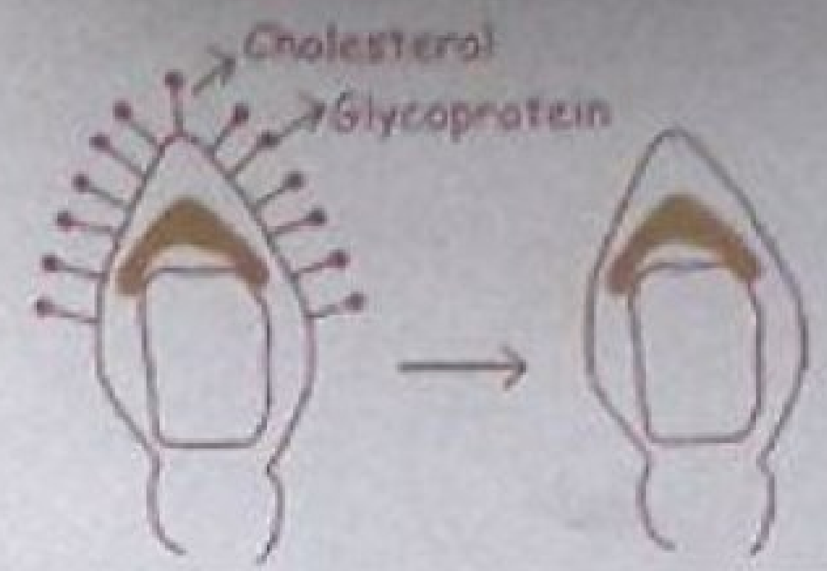
Corpus Luteum ⟶ "Progesterone" & "Estrogen": (Peak)
↓ ⊖
GnRH
FSH
LH

FERTILISATION

- During INTERCOURSE/COITUS "200-300 million" sperm → Only "200-300" reach viscinity of oocyte
- It involves a few steps as mentioned below.

① CAPACITATION"

When the sperms are deposited in the female reproductive tract they need to be "Capacitated" means become capable to be able to fertilise the ovum by process called as CAPACITATION.



NOTE

- Not all copulation leads to fertilisation or pregnancy because for fertilisation to occur simultaneous transport of sperm & ovum/2° oocyte to AMPULLA is needed.

अतिरिक्त (Gyaan)

How Capacitation Occurs?

- Removal of cholesterol, glycoproteins from surface of the sperm's membrane
- Entry of Ca^{2+} into sperm for fast movement of tail.

② Agglutination (Not given here but was given in REPRODUCTION in organism)

↓

recognition of sperm and ovum

"SPERM" has ANTIFERTILIZIN

"OVUM" has FERTILIZIN

ANTIFERTILIZIN – FERTILIZIN: RECOGNISE

③ Acrosomal reaction → release of Enzymes from Acrosome

- As the sperm binds to its receptors at zona pellucida (ZP-3), acrosomal reaction occurs.

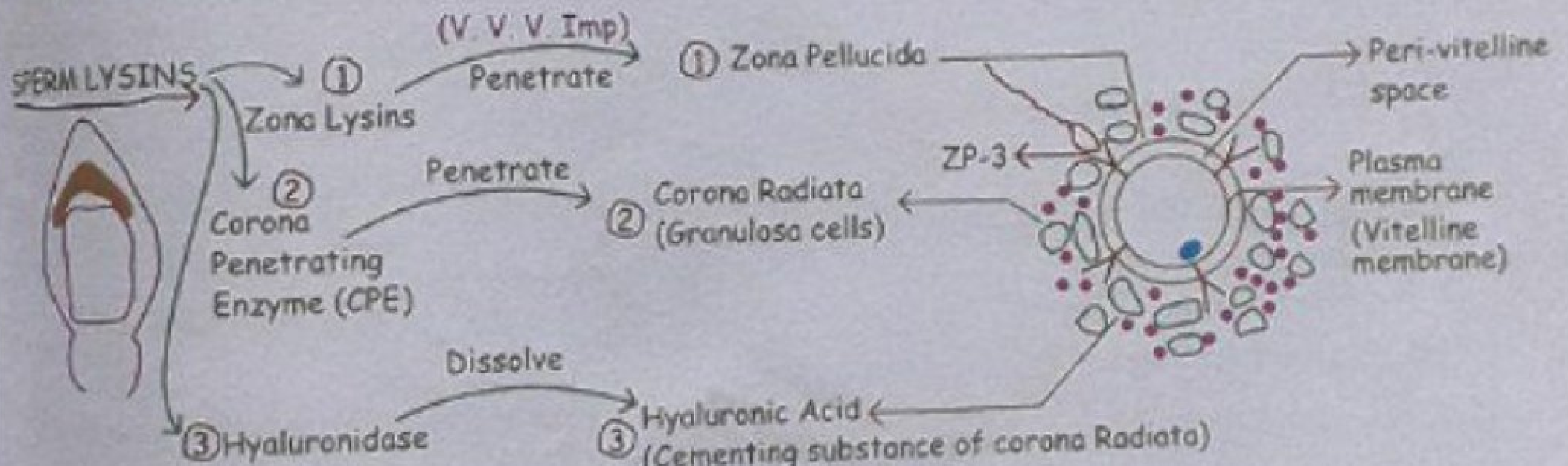
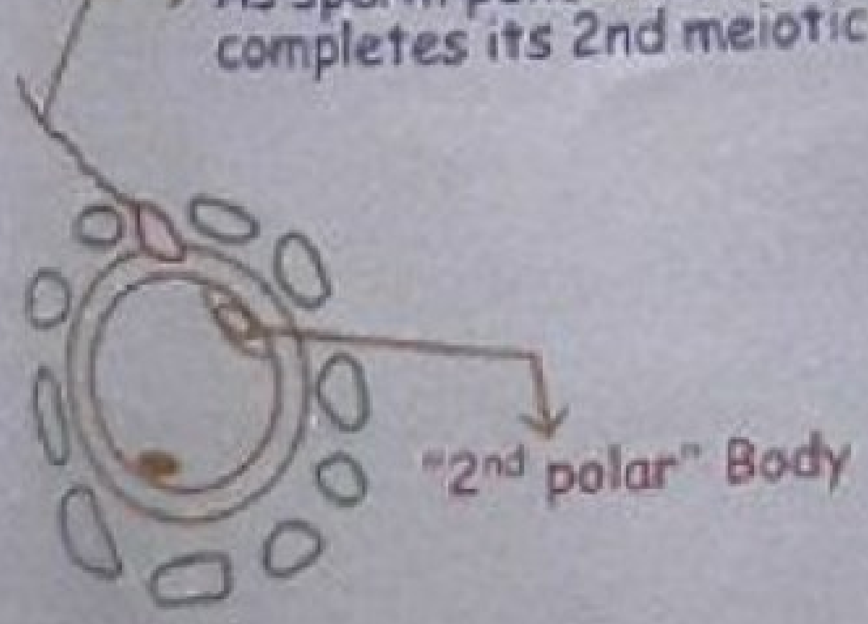


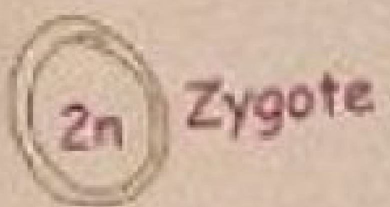
Fig: "Ovum"/2° oocyte

→ As sperm penetrates through zona pellucida & touches 2° oocyte's plasma membrane, the 2° oocyte completes its 2nd meiotic division & form large haploid ovum/ootid & small second polar body

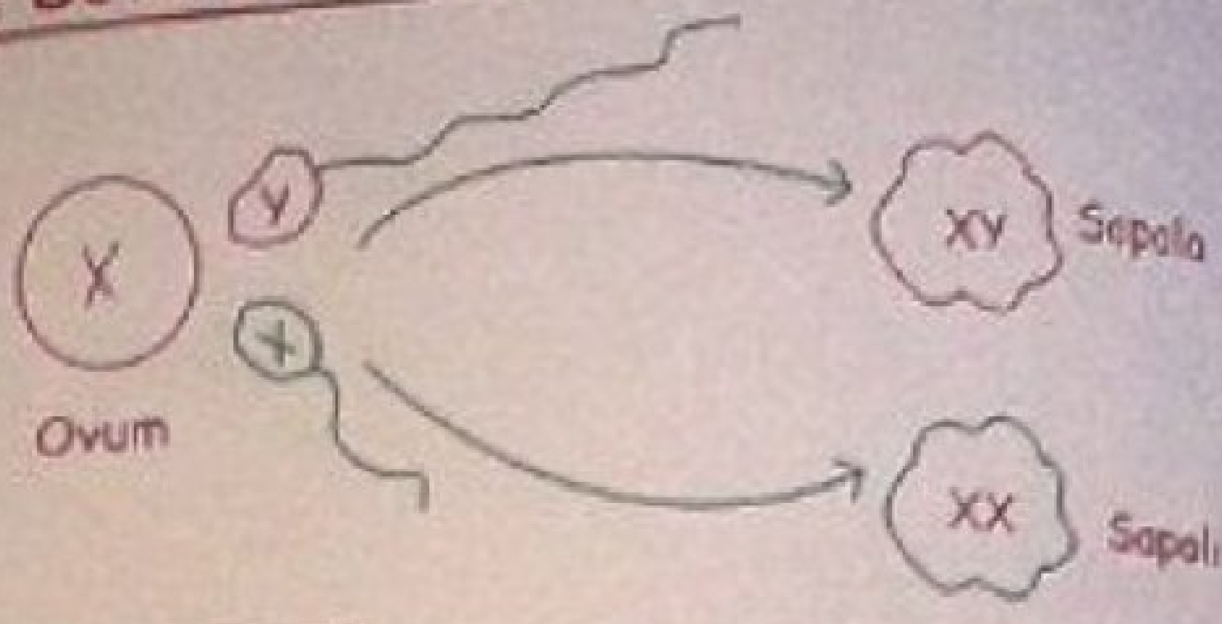


④ **Formation of fertilisation cone** (Not in NCERT)

⑤ Fusion of sperm nuclei & ovum's nuclei to form Diploid zygote

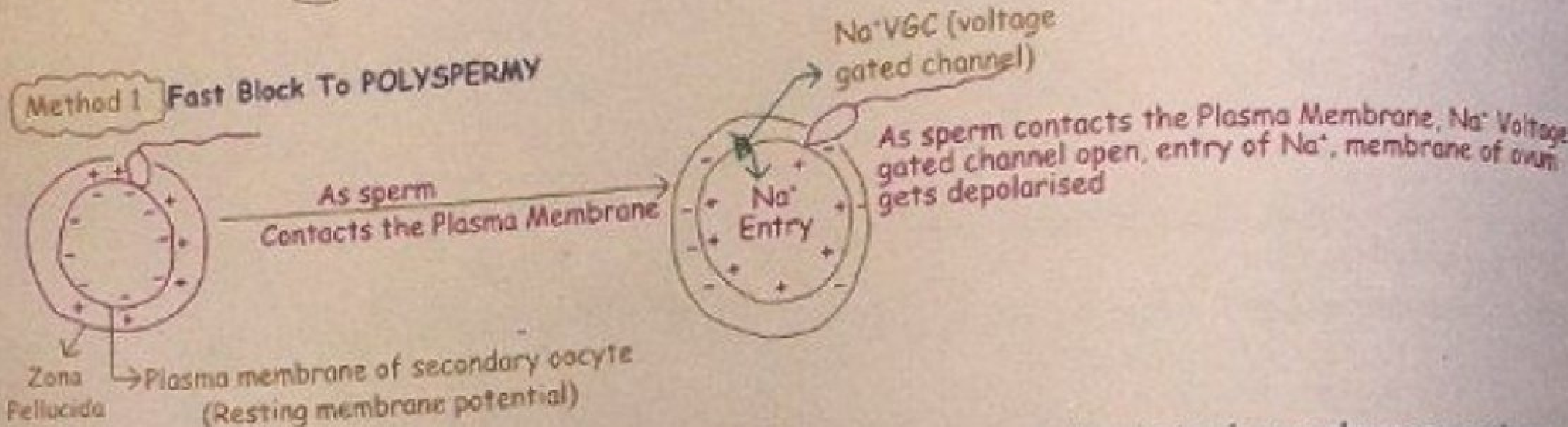


Sex Determination



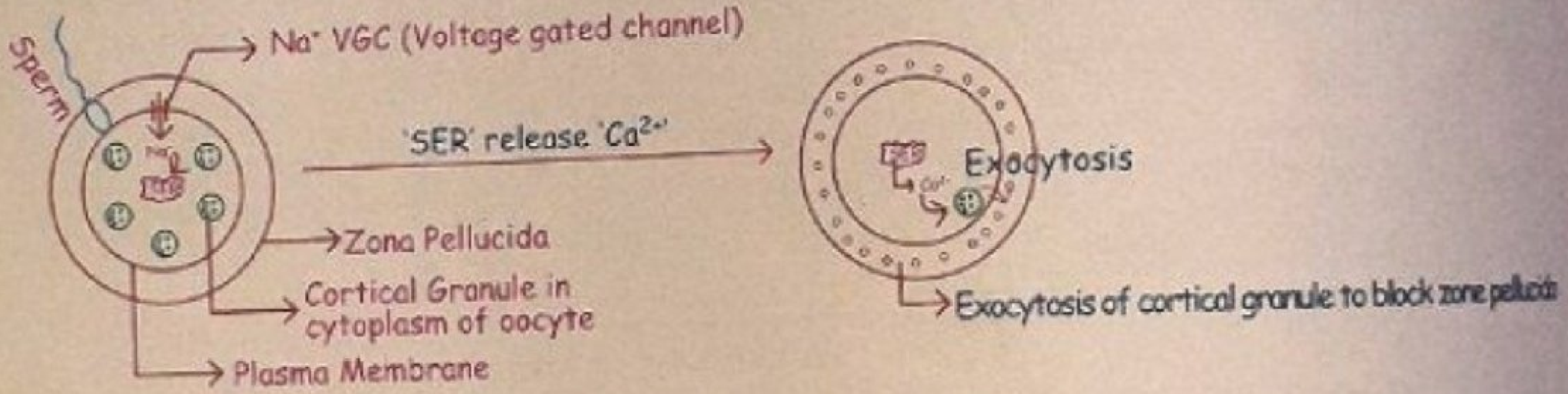
POLYSPERMY: Why many sperms don't fertilise the same ovum?
many Sperms
How polyspermy is prevented?

Method 1 **Fast Block To POLYSPERMY**



- We have read the concept of depolarisation in class 11, if the membrane gets depolarised, rare chances are there that another sperm can penetrate the same ovum. ∴ it is a temporary method.

Method 2



- Na⁺ signals smooth endoplasmic reticulum (SER) to release Ca^{2+} which further signals cortical granules to do exocytosis (release of its content in the PERIVITELLINE SPAC,. Blocking zona pellucida

TWINS
- Identical Twins (It is explained later)
- Non identical/Fraternal Twins

- Non identical twins are case of multiple ovulation if 2 follicle mature at the same time, 2 ova available fertilised by 2 different sperm.

Gender may be same or may be different

Cleavage: Rapid MITOTIC divisions.

- Here, G_1 (Growth phases) & G_2 Phases absent

NOTE MITOSIS: G1 S G_2 M

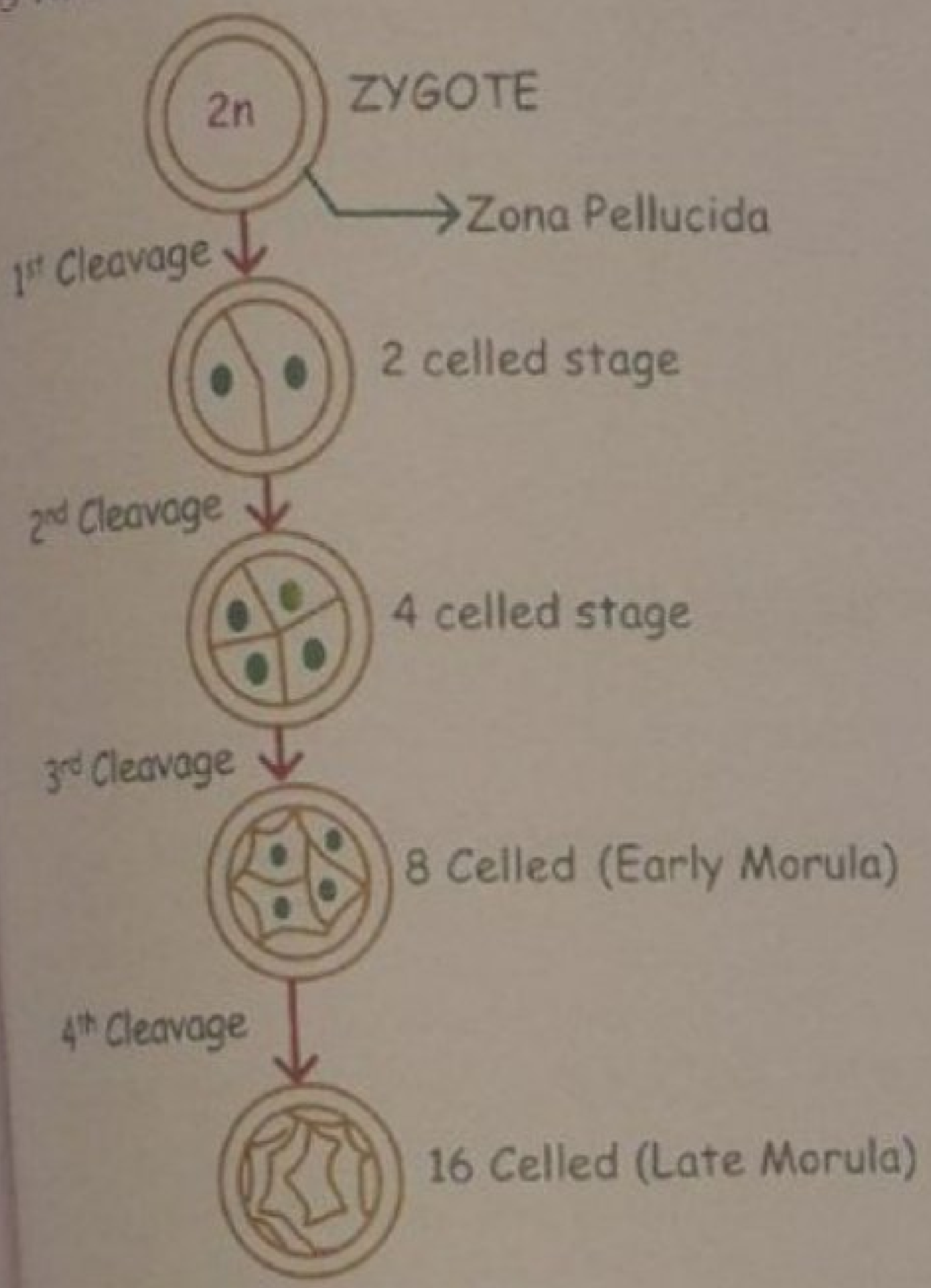
S → DNA double

2n → 2n → 2n, 2n

"Growth"

This is normal Mitosis, in cleavage Growth phase absent, only DNA doubles.

- After every division, individual cells formed are called Blastomere.



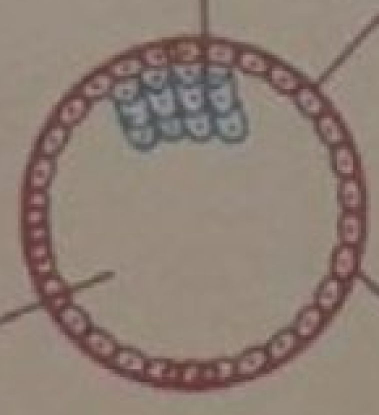
Morula: Mulberry Like

- 8 - 16 celled
- Early Morula = 8 celled → fallopion tube
- Late Morula = 16 celled → enters uterine cavity
- SOLID BALL LIKE

Blastula/Blastocyst V.imp

→ in which implantation occurs

- 32 celled stage
- ICM (Inner Cell Mass)
  - → It forms complete embryo
  - → It has Toti, Potent, STEM CELL
    - ↓ Total Potential



Blastocoel → Cavity inside Blastocyst

Trophoblast/ Trophoectoderm

1. → Secretes hCG (human Chorionic Gonadotropin) which act like LH to maintain corpus Luteum
2. → Secretes enzymes that helps coming out of Zona Pellucida
3. → Forms Foetal part of Placenta

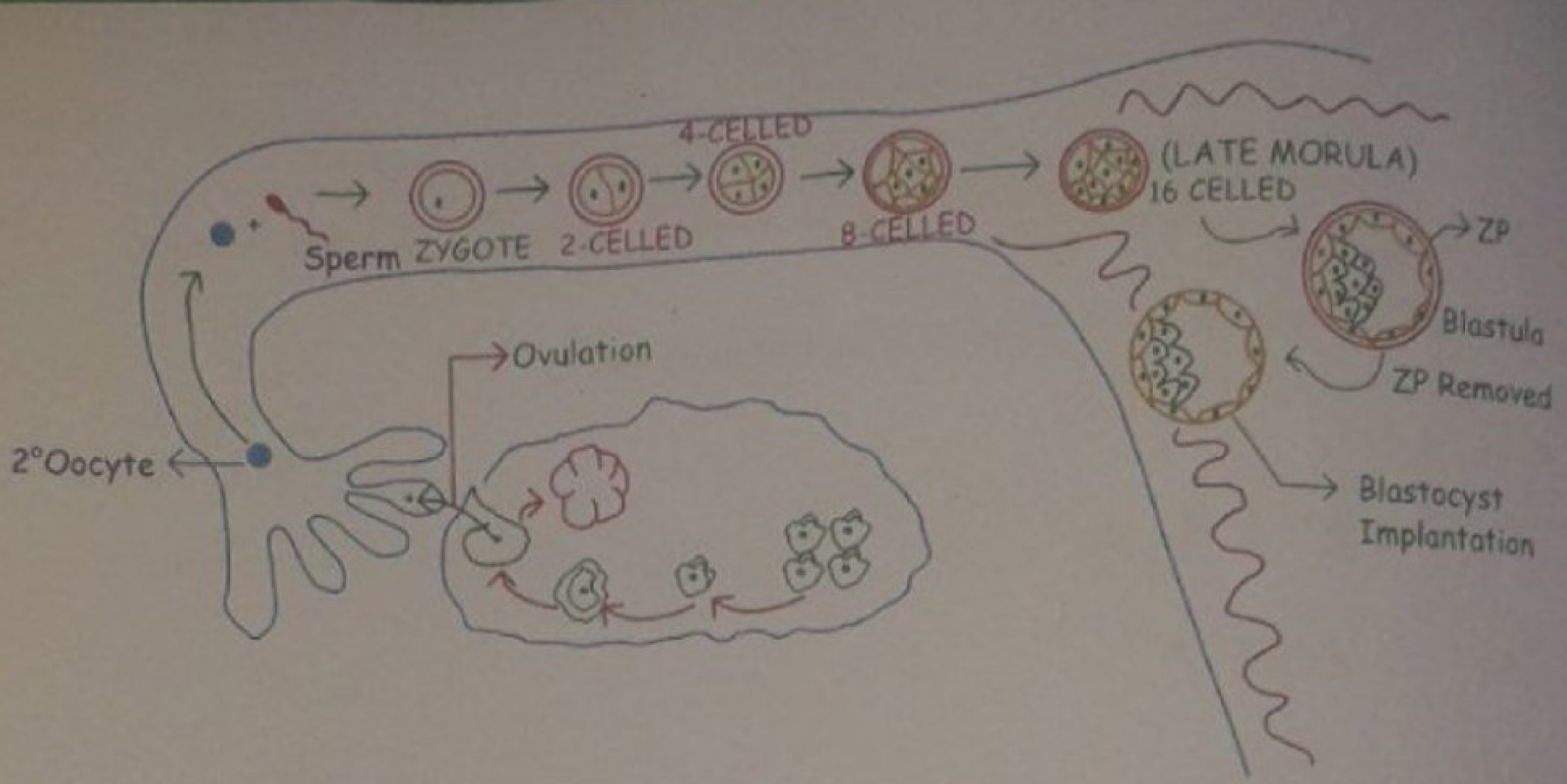


Fig: Transport of ovum, fertilisation and passage of growing embryo through fallopian tube.

NOTE

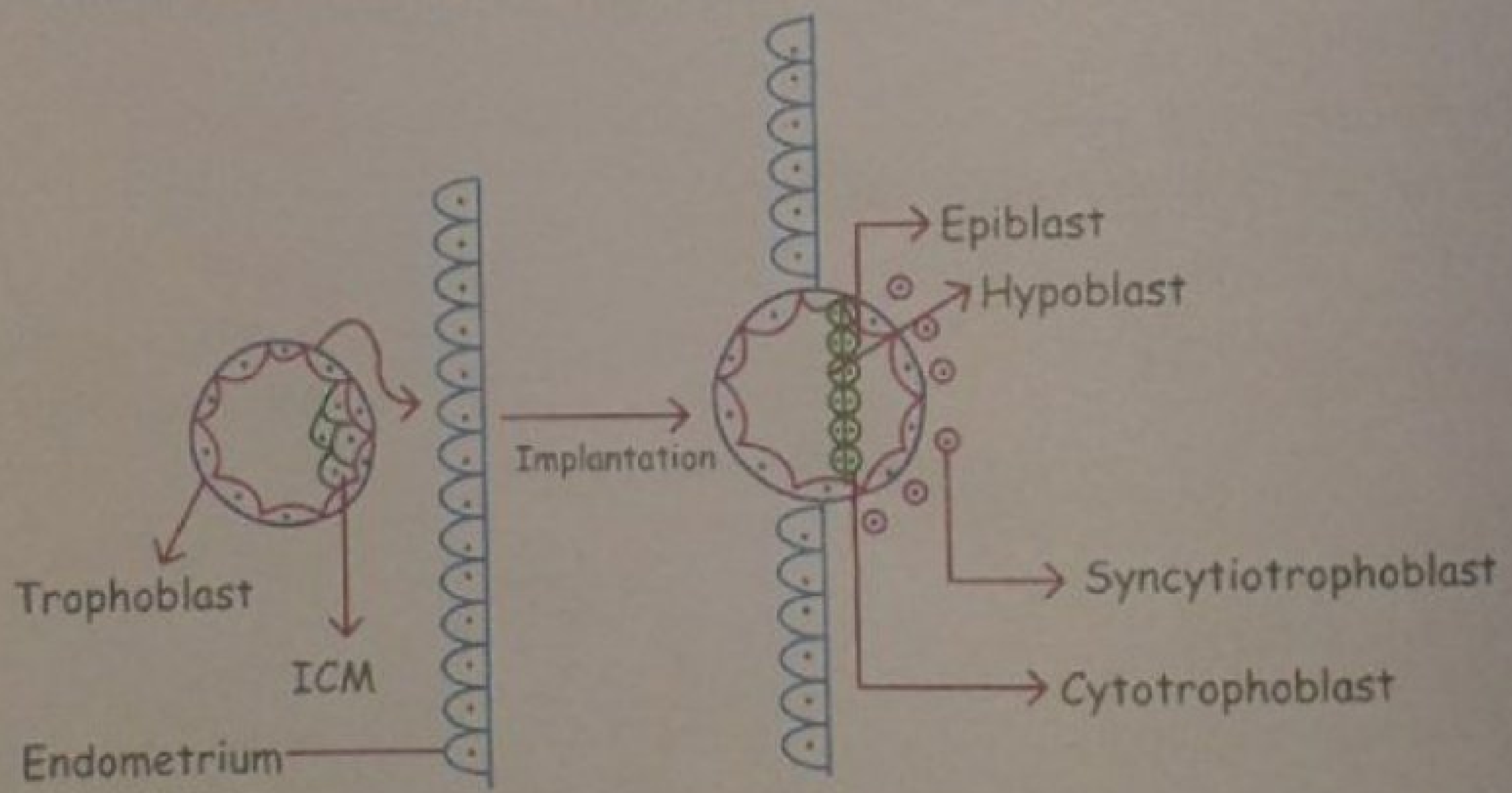
If implantation occurs anywhere other than uterine endometrium, this condition is called as ECTOPIC PREGNANCY

MONOZYGOTIC TWINS/IDENTICAL TWINS:

Sometimes when Blastocyst comes out of zona pellucida, it divides into 2 parts & as a result the twin formed are called MONOZYGOTIC TWINS.

- SEXES are same

Implantation Attachment of Blastocyst to uterine Endometrium.

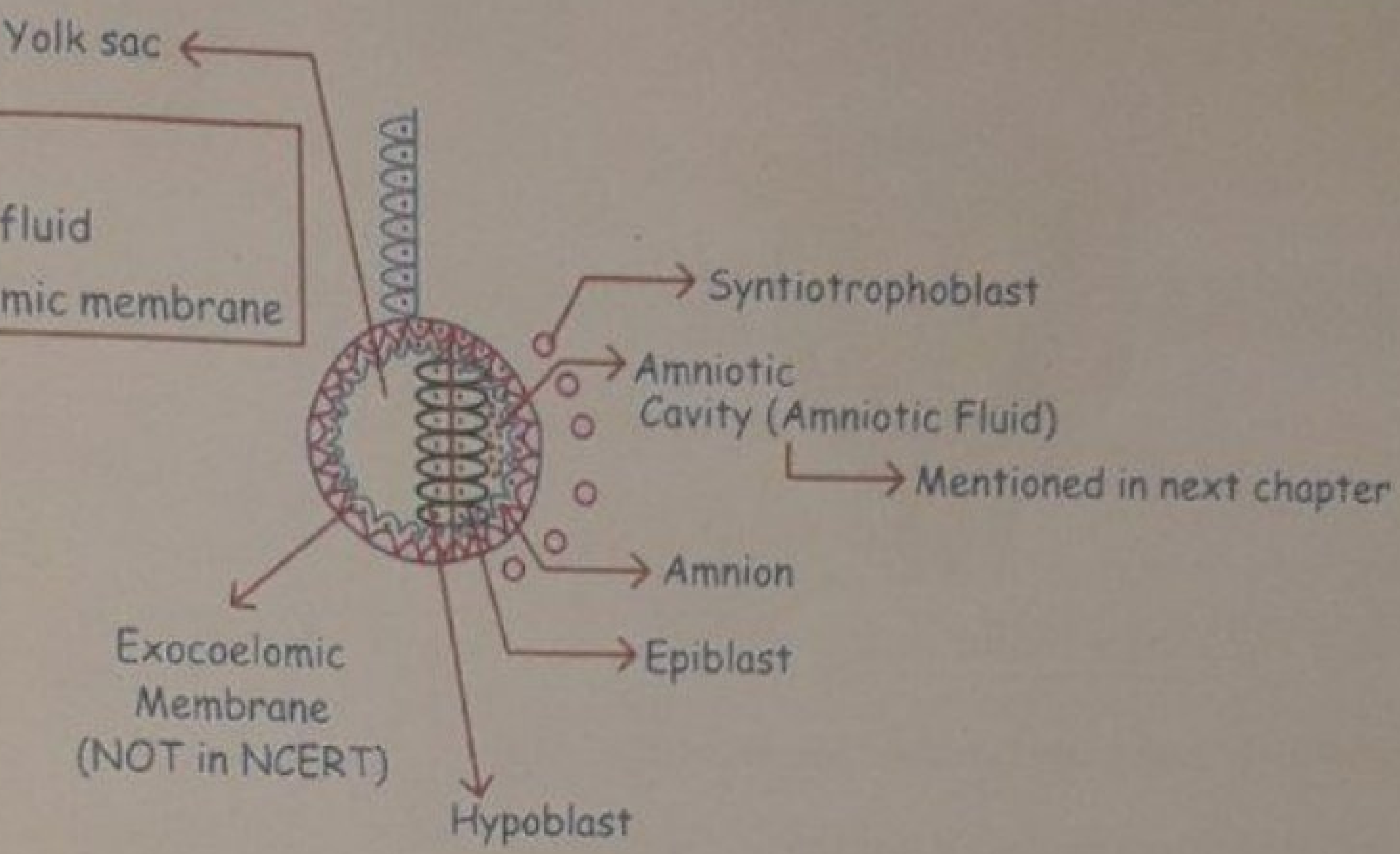


NOTE

ICM divides into → Epiblast, Hypoblast

Trophoblast divides into → Syncytiotrophoblast, Cytotrophoblast

Note
- Epiblast form Amnion
- Amnion secrete Amniotic fluid
- Hypoblast forms exocoelomic membrane



Gastrula:

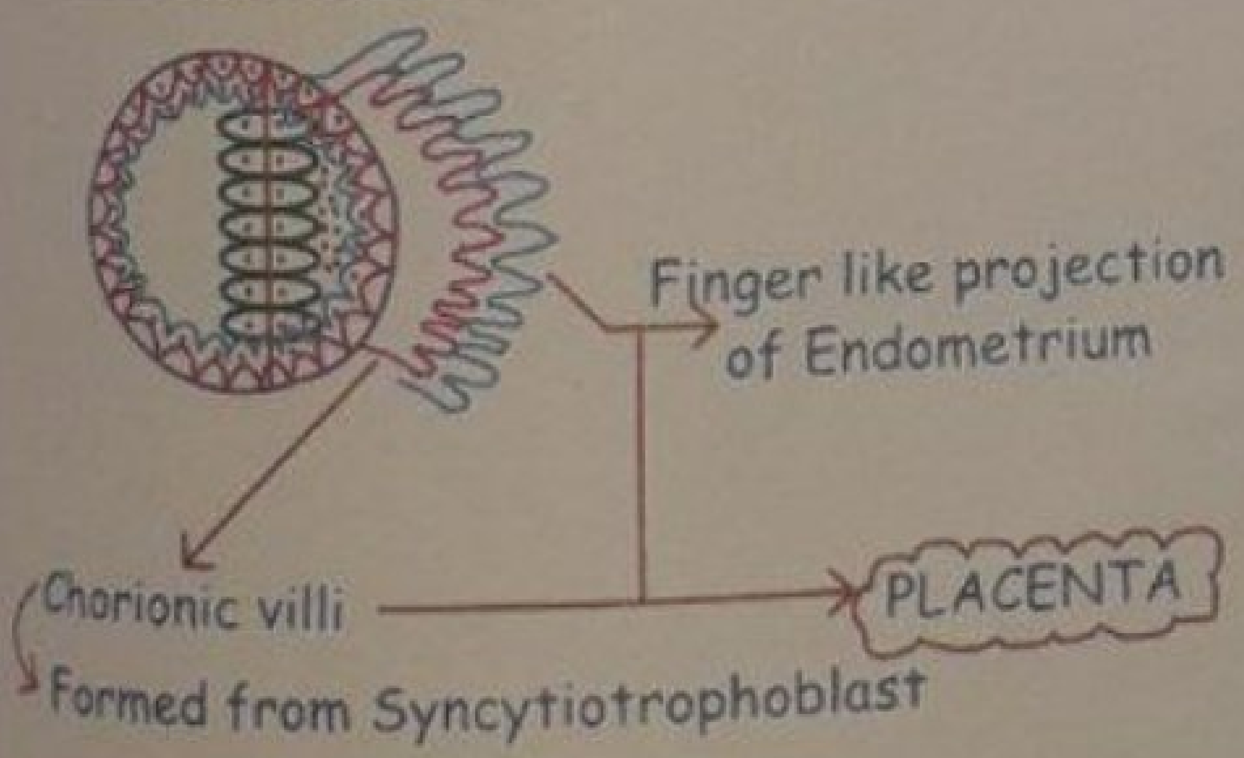
- After Blastula, Gastrula is formed & its formation is called as GASTRULATION.
- It is characterised by the presence of 3 GERM LAYER.
  → Endoderm → Mesoderm → Ectoderm

Placenta:

Structural & functional connection between foetus & mother

- Acts as a Diffusion membrane + Endocrine gland
- Diffusion of O_2, Nutrients from mother to foetus
- Removal of Nitrogenous waste from Foetus to mother.
- IgG cross placenta to provide immunity to foetus
- Both maternal (mother) & Foetal parts are involved in PLACENTA formation.

Placenta Formation



NOTE (अतिरिक्त Gyaan)

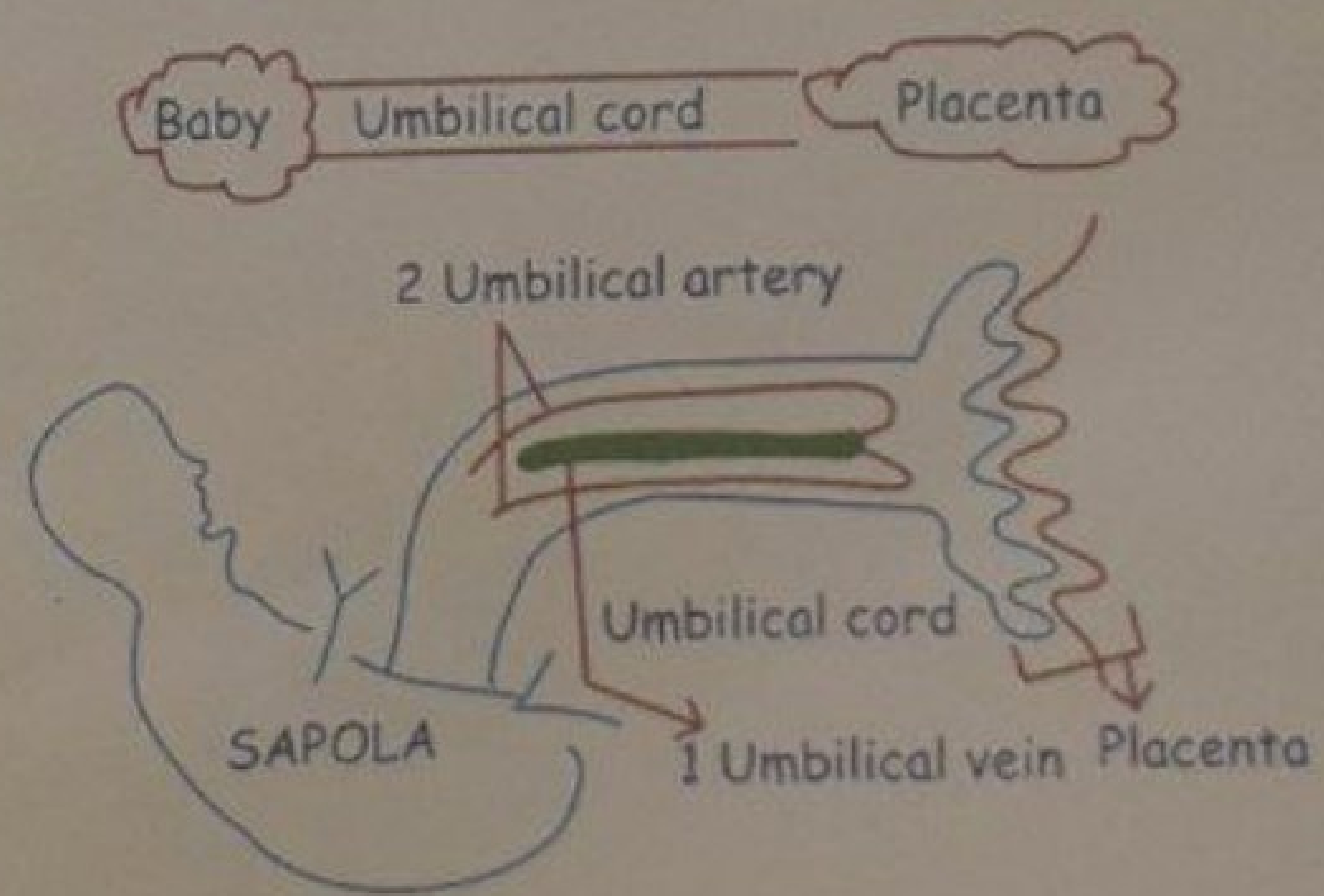
Aminion, Chorion] Ectomesodermal origin

Allantois, Yolk Sac] Endomesodermal origin

Hormones of Placenta:

- CRH: Corticotropin Releasing Hormone
- hPL: Human Placental Lactogen → Mammary gland growth during pregnancy.
- Chorionic thyrotropin (Metabolism)
- hCG: human Chorionic gonadotropin → Detected in URINE in PREGNANCY TEST/GRAVIDEX TEST.
- Estrogen
- Progesterone
- Relaxin → It is released during later stages in Pregnancy & also by Ovary to Relax Pubic Symphysis for easy delivery.

NOTE Let us remember hCG, hPL, relaxin are produced in women only during pregnancy.



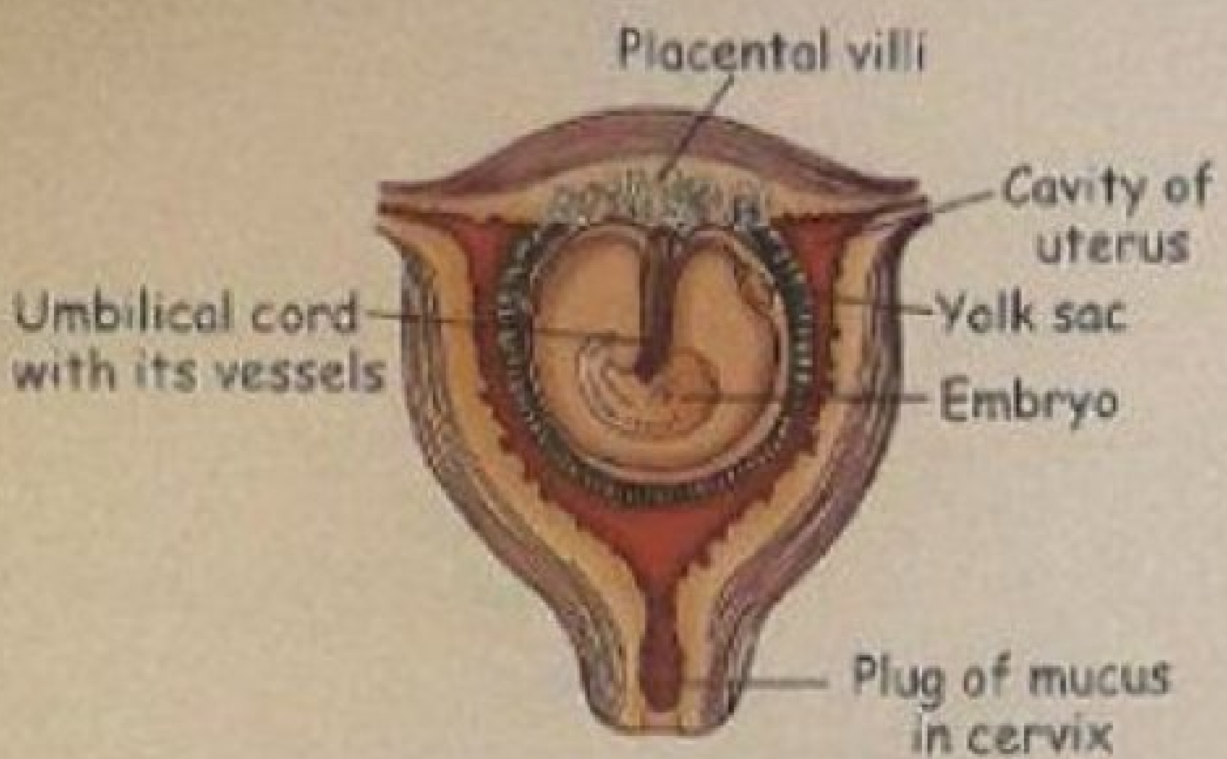


Fig: Human foetus with in Uterus

Gestation: The entire time duration of development of Baby.

- Human gestation period: 9 months.
- Cat and Dog: 52-65 days.
- Elephant: 18-22 months.
- Gestation period is divided into 3 trimester.
- Each trimester has 3 months

imp Embryonic Development

Time Period	Embryonic Development
1 Month →	Heart is formed
2 Month → (1st trimester)	Limbs & Digits are formed
3 Month →	External genitalia formed, most of the organ system formed
5 Month →	Hair appears on Head, First movement of foetus.
6 Month → (2nd trimester)	Hair all over the body, eyelashes formed, eyelids open.

Parturition:

→ Birth of Baby

→ "NEURO-ENDOCRINE" MECHANISM

Placenta is weak

↓

Progesterone level drop

↓

Placenta start secreting CRH(Corticotropin releasing Hormone)

↓ Act on

Adrenal Cortex of foetus

↓ Cortisol → Opening of Alveoli → Facilitate Breathing

↓ "DHEA" → "Dihydroepiandrosterone" → Converted by placenta into → Estrogen

Estrogen:
- → makes OXYTOCIN RECEPTOR
- → Act on Uterine wall to release prostaglandins from it

Foetal ejection Reflex

imp

Fully developed foetus

↓

SIGNALS Maternal Pituitary

↓

Releases "OXYTOCIN"

↓

Acts on Uterine Muscles (myometrium)

↓

"CONTRACTIONS"

↓

Further signal maternal Pituitary

↓

More Oxytocin

↓

Vigrous Contraction

↓

PARTURITION

NOTE

"PITOCIN" (artificial oxytocin) given to females to induce labour pain

11

Reproductive Health

REPRODUCTIVE HEALTH:

The term simply refers to healthy reproductive organs with normal functioning though has a broader perspective.

According to the World Health Organisation (WHO), reproductive health means total well being in all aspects of reproduction, i.e., physical, emotional, behavioural and social.

REPRODUCTIVE HEALTH: PROBLEMS AND STRATEGIES

Family Planning Programmes:

In the year 1951, India was amongst the first countries to introduce such programme to create a reproductively health society.

- Later on improved programmes called as 'RCH' (Reproductive & Child Healthcare Programmes) were introduced.

  RCH: Reproductive & Child healthcare Programme.

  Aim: To create awareness in the SOCIETY.

Major Role Played by:
- Family
- Teachers
- Friends
- Close Relatives

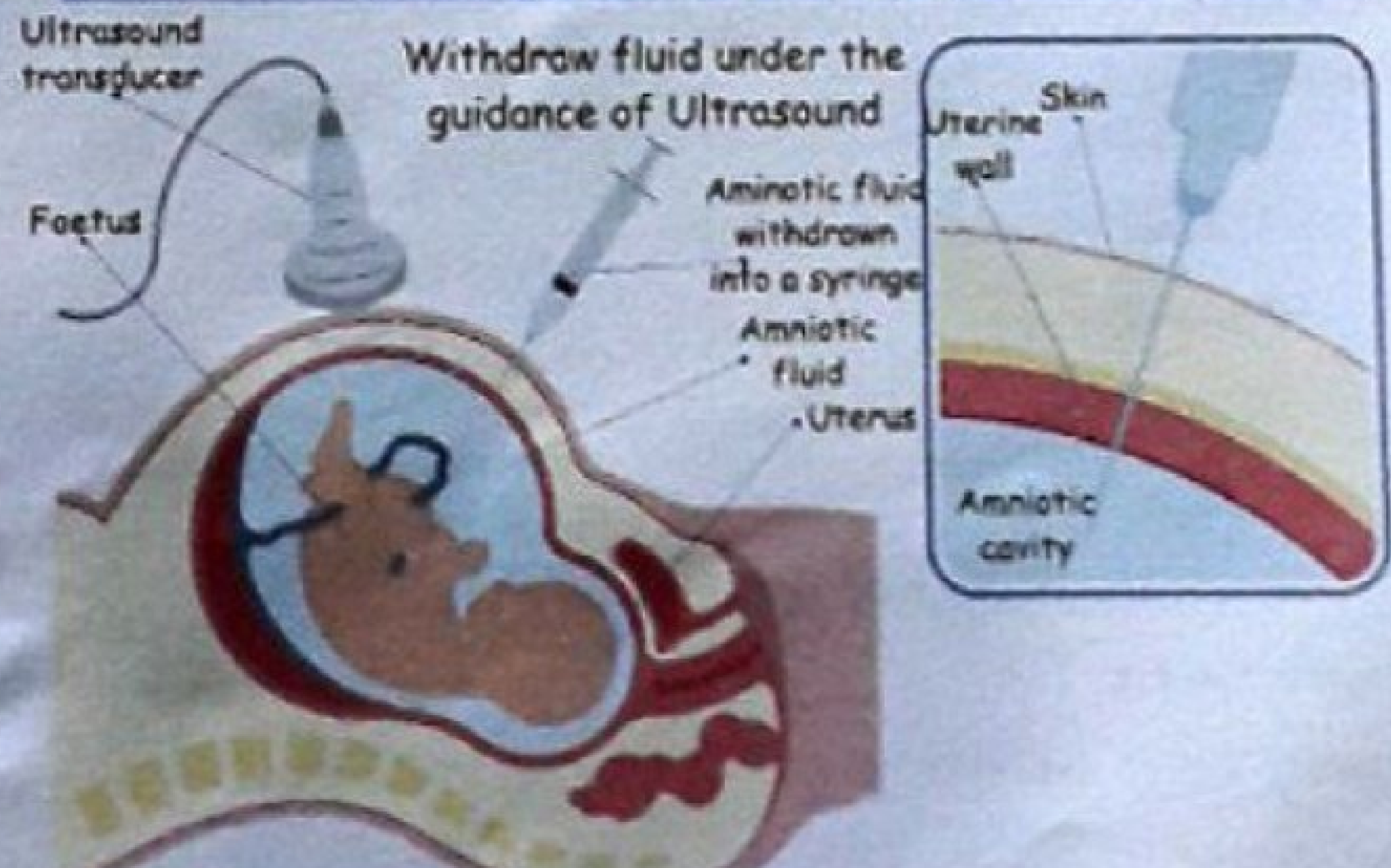
Strategies of RCH:

1. With the help of audio-visual and print media governmental and non-governmental agencies have taken various steps to create awareness.
2. Awareness about uncontrolled population growth, social evils like sex abuse, sex crimes etc.
3. People must be aware about STDs (SEXUALLY TRANSMITTED DISEASE)-AIDS, and sexual myth.
4. Equal rights to male and female (all gender).
5. Sexual hygiene, menstrual hygiene awareness.
6. Awareness about the use of CONTRACEPTIVE METHODS to avoid unwanted Pregnancies.
7. Research was also encouraged in this field: A new oral contraceptive for females "SAHELI" was developed by CDRI (Central Drug Research Institute), LUCKNOW.
8. Amniocentesis

   Amniotic fluid is withdrawn & used for understanding any kind of genetic disorders like Haemophilia, sickle cell anaemia, down syndrome etc in the developing foetus.

- Ban on Amniocentesis for sex determination as increased cases of female foeticide was reported.

AMNIOCENTESIS



9. Massive child Immunisation promoted.
10. Sex education should be promoted in school.
11. Better post natal care

NOTE

Successful implementation of the above mentioned point requires:

- Strong infrastrucural facilities
- Professional expertise
- Material support

Population Growth & Stabilisation

India's Population

At the time of independence →	350 million
2000 →	Close to 1 Billion
2011 →	1.2 Billion

Today ∝ 1.4 Billion

World's Population

1900 →	2 Billion
2000 →	6 Billion
2011 →	7.2 Billion

Today → 7.8 Billion

What is Population Explosion?

Rapid, drastic rise in population size.

Why Population Explosion?

- Population growth rate depends on:

1. Birthrate/Natality: No. of new born added/1000 year. Birth rate ↑ : Population size ↑.
2. Death rate/Mortality: No. of death/1000/year. Mortality ↑ : Population size ↓.
3. IMR(Infant Mortality Rate): Death rate of the new born. IMR ↑ : Population size ↓.
4. MMR(Maternal Mortality Rate): Maternal death rate. MMR ↑ : Population size ↓
5. If people of reproducible age are more in a population, Population size may ↑.
6. MIGRATION

Immigration $\xrightarrow{\text{added}}$ Population $\xrightarrow{\text{Left}}$ Emigration

Immigration → ↑Population size

Emigration → ↓Population size

NOTE

Growth Rate

- 2001 (old ncert) → 1.7 % → $\frac{17}{1000}$ / year (17 individual added/ 1000 individual)
- 2011 (new ncert) → Less than 2 % → $\frac{20}{1000}$ / year (20 individual added/ 1000 individual)

Steps to overcome population explosion:

- Incentives given to smaller families.
- Marriageable age raised → 21 Y → ♂ ; 18 Y → ♀
- Various slogan promoted
  - "Hum do Humare Do"
  - "Chota Pariwaar SUKHI Pariwaar"
- Use of Contraceptive Methods promoted to motivate smaller families.

Contraceptive Methods: These are the methods/ devices that are used to prevent unwanted pregnancy.

Ideal Contraceptive:

- Easily available.
- Cost effective.
- User-friendly.
- Reversible (when the couple wants to conceive, they should be able to conceive).
- Should not interfere with the sexual drive, desire or sexual act of user.
- Least side effect.
- Effective against Pregnancy.

CONTRACEPTIVE METHODS

- **Temporary Method (Easy Reversibility)**
  - I) Natural Methods
    - Safe Period/ Periodic Abstinence
    - Withdrawal/coitus interruptus
    - Lactational Amenorrhea
  - II) Barrier Methods
  - III) Chemical Methods
  - IV) IUDs/IUCDs
  - V) Oral contraceptive
  - VI) Implants, Injectables
- **Permanent Method (Poor Reversibility)**
  - Tubectomy
  - Vasectomy

TEMPORARY METHOD:

(I) Natural Methods: It works on the principle of avoiding chances of ovum and sperms meeting.

(i) Safe Period/Rhythm method/Periodic abstinence/ Calender Method

Couples should avoid/refrain coitus/sex from day 10-17 of the menstrual cycle as this is the highly fertile Period & Chances of ovulation during this period is high.

(ii) Withdrawal method/Coitus interruptus

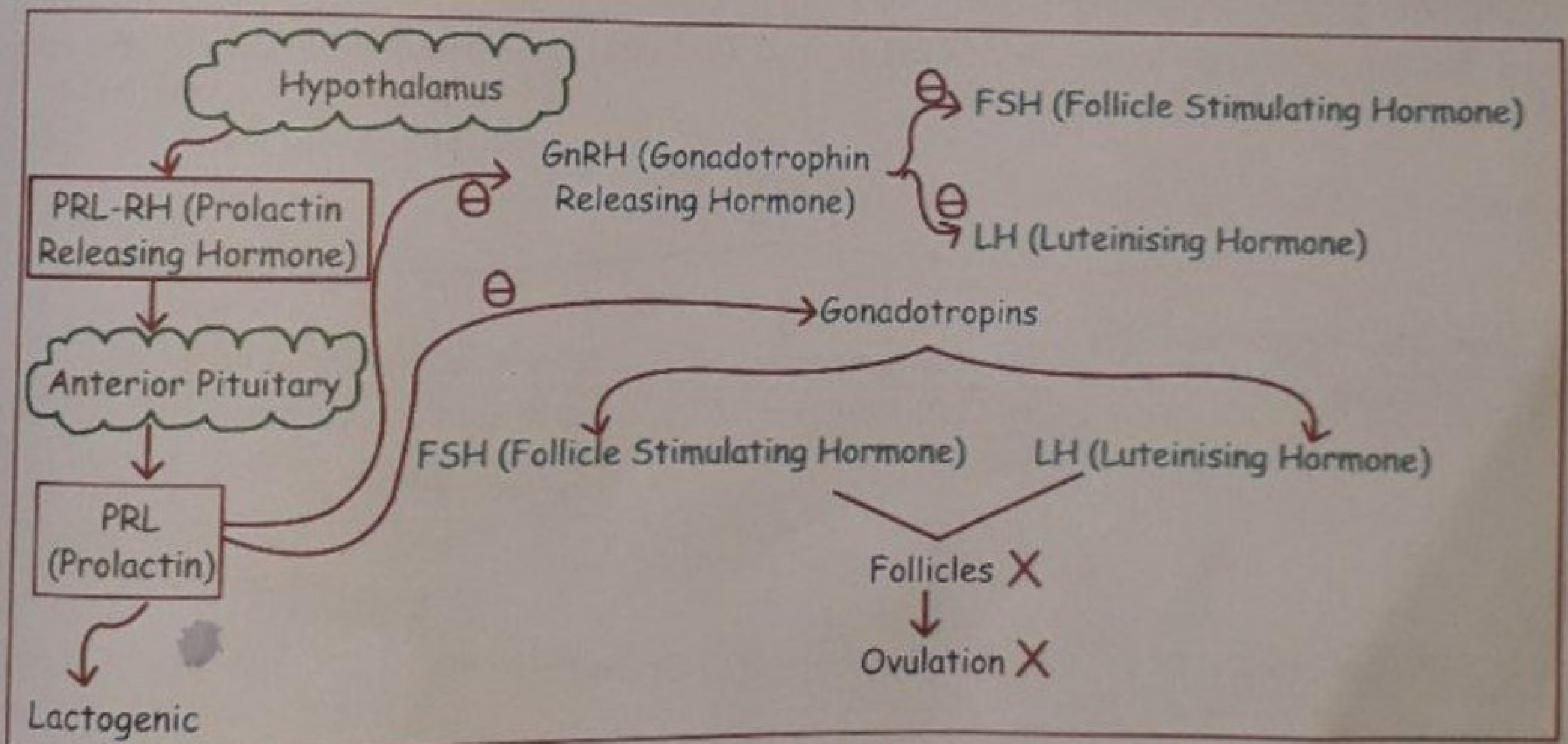
- This method has highest failure rate
- Male Partner should withdraw his penis before ejaculation to avoid insemination.

(iii) Lactational amenorrhea:

Lactation absence Menstrual cycle

- In a lactating mother, there is no menstrual cycle, hence no pregnancy
- Effective upto 6 month maximum.

CONCEPT OF LACTATIONAL AMENORRHEA



(II) Barrier Methods: In this method sperms and ovum are prevented from physical meeting.

eg: Condoms

(1) **Condom:**

These are made up of thin rubber or latex sheath and available for Both ♂ & ♀.

Condom are called as FEM-SHIELD for female

♂ (Male)	♀ (Female)
Used to cover the Penis	It is used to cover Vagina
Non-Reusable	Non-Reusable

Condom for male

Condom for female

Imp.

- Condoms prevent pregnancy as well as STDs (Sexually transmitted diseases)
- 'Nirodh' is a popular brand of condom for ♂ in India.

(2) **Diaphragms, Vaults, Cervical Caps:**

These are made up of rubber & used by females to cover the cervix.

- These are reusable.
- By using this method pregnancy is prevented but not STDs as vagina is still exposed.

(III) Chemical Method:

Chemicals which are spermicidal (Sperm Killing) are available in the form of cream, jellies, foams which if used along with barrier methods are highly effective against contraception.

(IV) IUCDs/IUDs: Intra Uterine Contraceptive Devices/Intra Uterine Devices

- It is one of the most widely used method of contraception in India.

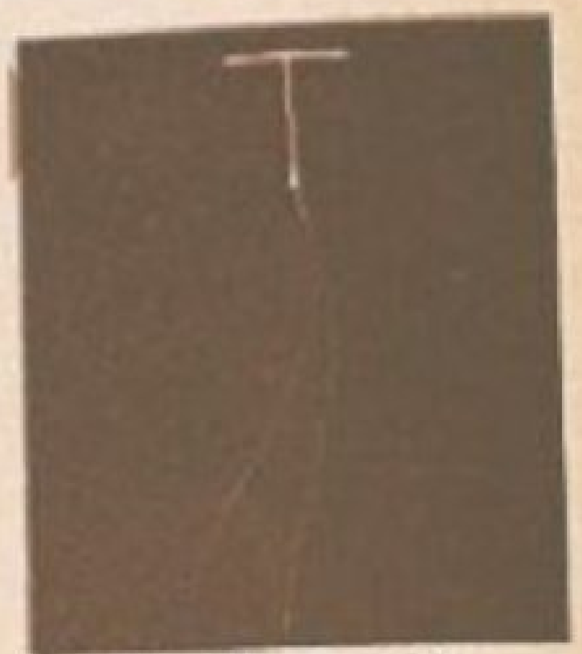


Fig: Copper T

- It is used for spacing between childrens.
- It is not self inserted, instead it is inserted by expert doctor & nurses.
- It is used by Female & placed in Uterus.

IUDs

1. Inert/Non Medicated IUDs
   eg: Lippes Loop
2. Copper releasing IUD
   eg: CUT, Multiload 375
3. Hormone releasing IUD
   eg: Progestasert, LNG-20
   levonorgestrel-20

IUDs:

(1) Inert/Non Medicated IUD: It increases phagocytosis of Sperm.

eg: Lippe's Loop

(2) ★ Cu^{2+} Releasing IUDs

The copper ions released Reduce the sperm moltility
↓
"Phagocytosis"
eg: CuT, Cu7, Multiload 375

The copper ion reduces the fertilising capacity of sperm
↓
Altering certain proteins on Plasma membrane of Sperm.

(3) ★ **Hormonal IUD:**

These are hormone containing devices (Progesterone)
eg: LNG-20 (levonorgestrel - 20), Progestasert

○ Working

→ Anovulation (absence of ovulation)
→ Reduces ciliary movement of fallopian tube
(अतिरिक्त Gyaan)
→ Makes Endometrium unsuitable for implantation
→ Makes cervix hostile (unfavourable) for sperm by thickening cervical mucus
NCERT

NOTE

IUDs
↓
Progesterone
↓
Inhibits GnRH(Gonadotropin releasing hormone), FSH(Follicle stimulating hormone), LH(Luteinising hormone)
↓
No Follicles
↓
Means no ovulation

(V) **Oral Contraceptives:** Popularly known as PILLS:

Hormone containing Tablets

Progesterone only pills (POP)/Minipills
↓
Progesterone only

Combined Pills
↓
Progesterone+Estrogen

DOSAGE: Pills have to be taken daily for a period of 21 days starting preferably within the first 5 days of menstrual cycle.
After a gap of 7 days (during which menstruation occurs) it has to be repeated in the same pattern till the female desire to prevent conception.

⇒ Tablet started from day 5 to day 25

5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	1	2	3	4

↓
Iron Tablets

⇒ **Working of Pills**

Progesterone estrogen
↓
⊖ GnRH (Gonadotropin Releasing Hormone)
⊖ FSH (Follicle Stimulating Hormone)
⊖ LH (Luteinising Hormone)

○ No ovulation
○ Thickening of cervical mucus to prevent entry of sperm.
○ For 21 days 'Estrogen' & 'Progesterone' make endometrium thick and inhibit ovulation but as soon as it is stopped, the wall breaks & Bleeding occurs.
○ Makes endometrium unsuitable for implantation

NOTE

In the gap of 7 days, Iron pills are consumed to compensate the blood loss.

Imp. Note

★ SAHELI Developed by CDRI, Lucknow
○ It is non steroidal oral contraceptive.
○ It is once in a week pill

NOTE

Nausea, irregular menstrual bleeding, breakthrough bleeding, abdominal pain, even breast cancer can be the ill effects/side effects of contraceptives.

MTP (Medical Termination of Pregnancy)

It is a voluntary or intentional termination of pregnancy before full term.

- World wide 45-50 Million MTPs are performed in a year all over the world.

  ↓

  This is 1/5th of the total pregnancy conceived & significantly controls population though it is not the aim of MTP.

- In 1971, in India, MTP was legalised & law was made as to which ground basis MTPs could be done.
- MTPs are relatively safer within first 12 weeks of Pregnancy.

According to MTP amendment act, 2017

MTP can be performed

- If pregnancy is upto 12 weeks, MTPs can be done under the opinion of 1 registered Medical Practitioner.
- If pregnancy is more than 12 weeks but less than 24, MTPs could be done under the opinion of atleast 2 registered medical practioner in good faith.

Ground Basis for Both

- If continuation of such pregnancy is a risk to both mother & child.
- If there are potential/chances of mental or genetic abnormality in developing baby as to be seriously handicapped.

NOTE

Another dangerous trend is the misuse of amniocentesis to determine the sex of the unborn child. Frequently, if the foetus is found to be female, it is followed by MTP- this is totally against what is legal.

STIs (Sexually Transmitted Infections)

Or

VD "VENEREAL DISEASES"

OR

RTI "REPRODUCTIVE TRACT INFECTIONS"

- Though all age person are vulnerable to this but age group most prone to STIs "15-24 year"

अतिरिक्तGyaan

	Name	Causative Agent
Bacterial	Chlamydiasis	→ *Chlamydia trachomatis*
	Gonorrohea	→ *Neisseria gonorrhoeae*
	Syphils	→ *Treponema pallidum*
Viral	Genital herpes	→ *Herpes simplex* virus
	Genital wart	→ HPV (Human papilloma virus)
	AIDS imp	→ HIV (Human immunodefiency virus)
	Hepatitis B	→ HBV (Hepatitis-B virus)
Protozoa	Trichnomoniasis	→ *Trichomonas vaginilis*

NOTE

AIDS: Acquired Immuno Deficiency Syndrome

Symptoms of STIs

Early Symptoms

- Itching
- Swelling of gonads
- Redness in gonds
- Fluid discharge

Later Symptoms

- Abortions
- Infertility
- Still Birth
- Ectopic pregnancy
- Pelvic inflammatory Diseases.

NOTE

★ Except Acquired Immuno Deficiency Syndrome (AIDS), Genital Herpes, Hepatitis-B, all other STDs are Completely curable if detected early.

- Early symptoms are minor hence can cause complication later.

Infected females may often be asymptomatic

Prevention

- Avoid unknown sexual partners.
- Avoid multiple sexual partners.
- Use of condoms during sexual intercourse.
- In case of doubt, go to qualified doctor for early detection and get complete treatment if diagnosed with disease.

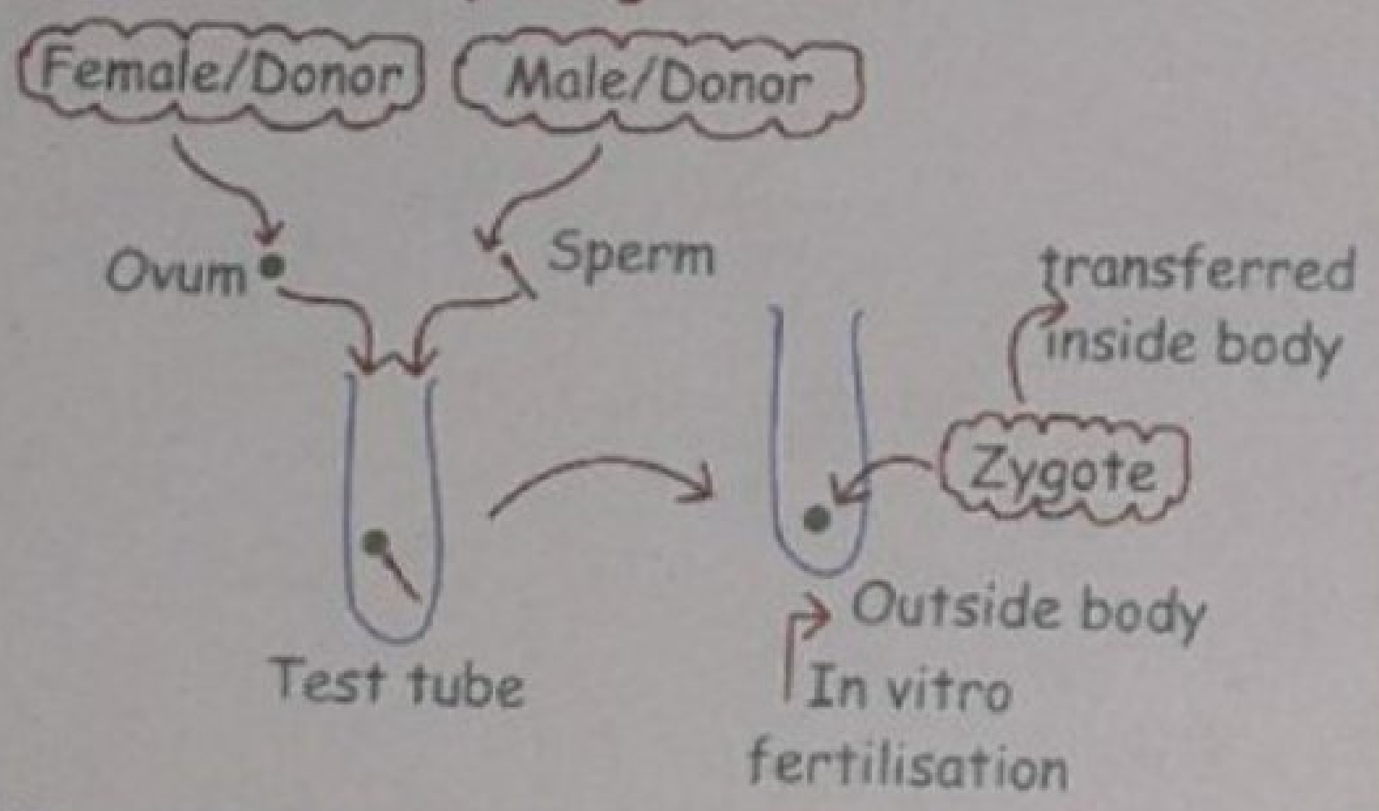
Infertility: Couples are unable to conceive even after unprotected coitus for 2 years.

A male as well as a female can be infertile.

Problems in Male	Problems in Female
→ Low sperm count (Oligospermia)	→ Irregular ovulation
→ Erectile dysfunction	→ Endometrium not favourable for implantation
→ Abnormal shape, size & motility of sperm	→ Egg not collected by fallopian tube

- The couples are helped by 'ART (Assisted Reproductive Technologies)'

Test-Tube Baby Programmes:



ART: ASSISTED REPRODUCTIVE TECHNOLOGIES

The techniques that are used to help infertile couples.

FERTILISATION
- In vitro (Fertilisation outside the body)
  - ZIFT (Zygote intra fallopian transfer)
  - ICSI (Intra cytoplasmic sperm injection)
- In vivo (Fertilisation inside body)
  - GIFT (Gamete intra fallopian transfer)
  - AI (Artificial insemination)

I In Vitro

A ZIFT

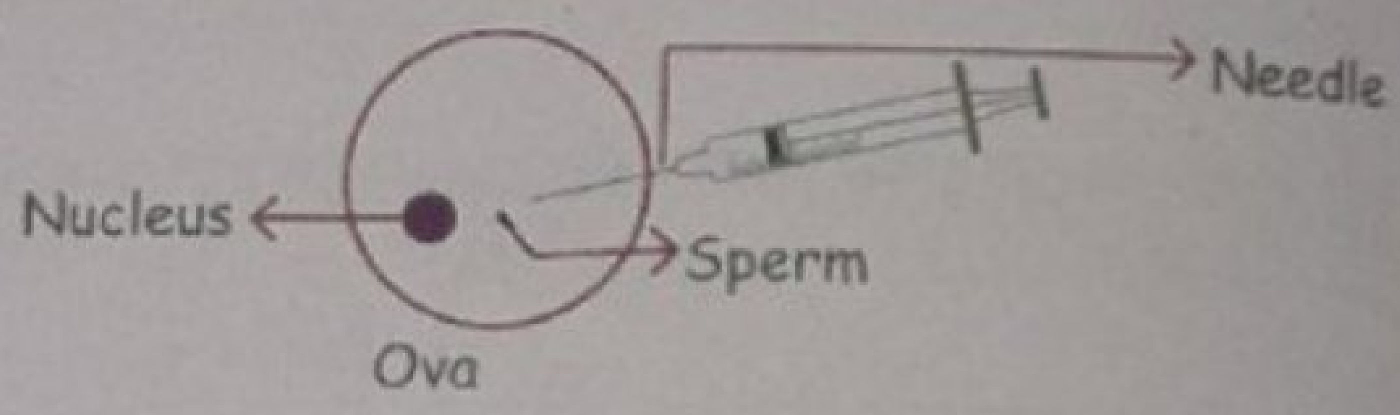
Female Partner/Donor → Ova
Male Partner/Donor → Sperm

In vitro Fertiliisation
↓
Zygote
↓
embryo upto 8 Celled stage, embryo transfer (ET) occur in fallopian tube.

NOTE If more than 8-celled stage is formed it is then transfered into uterus IUT **(Intra Uterine Transfer)**

B ICSI: Intra Cytoplasmic Sperm Injection

In this case, using needles, a sperm is directly injected into the cytoplasm of ovum.



II In Vivo:

In vivo

(A) Gamete Intra Fallopian Transfer

- A ♀ (female) who can't produce an ovum, in this case ova can be tranferred in fallopian tube & later fertilisation can be seen inside body

(B) Artificial Insemination

- If male has low sperm count or unable to inseminate ♀ (female) naturally, semen is artifically introduced into vagina or into Uterus, IUI (Intra Uterine Insemination)

NOTE

- These techniques are very expensive and require precise handling by professionals.
- These facilities presently are restricted to some countries only.
- In India, we have many orphaned and destitute children, our law permit legal adoption.

12 Evolution

EVOLUTIONARY BIOLOGY:

It is the history of life forms on earth.

Evolution means to "unfold" or "unroll"

- Changes in the Flora & 'Fauna' that took place gradually over million of years.
- These changes are important for the Survival of the particular organism.

ORIGIN OF UNIVERSE:

BIG BANG THEORY This theory explains the 'ORIGIN OF UNIVERSE'

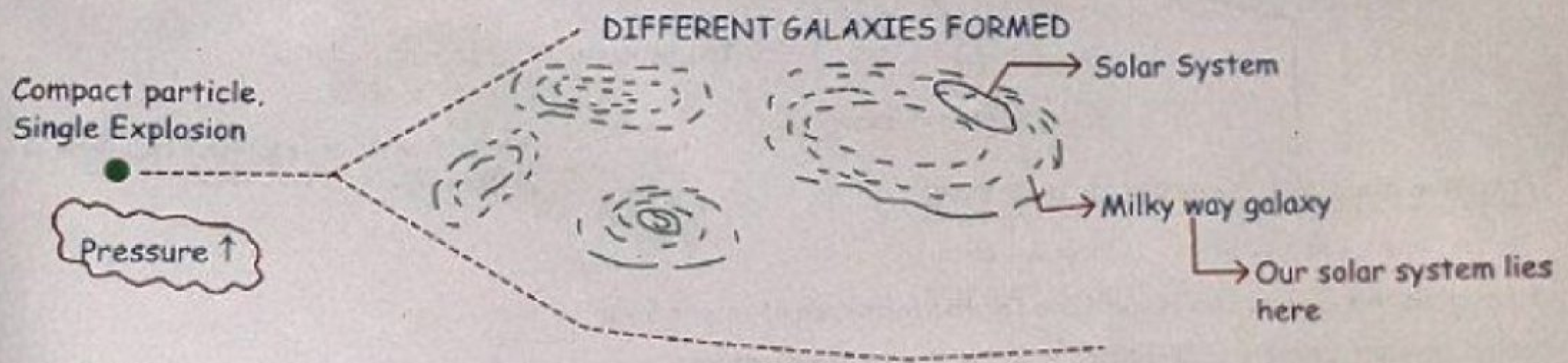
- Origin of Universe took place around 20 Bya (Billion years ago)

UNIVERSE → GALAXIES → SOLAR SYSTEM → EARTH

GALAXIES ↓ It contains star, clouds of gas and dust

EARTH ↓ Its just a 'speck' in the UNIVERSE

Single, Large, explosion took place in the space
↓
Unimaginable in Physical Terms
↓
Universe expanded and temperature came down
↓
* Helium and Hydrogen were formed sometime later
↓
UNIVERSE with different galaxies formed



NOTE

- 1 light year is the distance travelled by light in one year.
- Stellar distances are measured in light years.
- Distance between planets, stars and galaxies are called stellar distances.

ORIGIN OF EARTH

- 4.5 Billion years ago
- Life appeared 500 million years after formation of earth ~ 4 Billion years ago

NOTE

First non-cellular form of life: 3 Billion years ago

First cellular form of life: 2 Billion years ago

ORIGIN OF EARTH

Inside Temperature More → Due to difference in the temperature volcanic eruptions occurred. → Molten mass released & covered the earth surface — gases Like → CH_4, CO_2, NH_3 released; H_2O vapour

Earth ↓

Surface Temperature Less

- In the primitive atmosphere, there was no 'ozone layer', UV rays could easily enter.

'UV' rays from sun

$2H_2O \xrightarrow{\text{split water}} 2H_2 + \boxed{O_2}$

$NH_3 + O_2 \longrightarrow N_2 + H_2O$

$CH_4 + O_2 \longrightarrow CO_2 + H_2O$

→ It was never free as molecular O_2

→ It reacted with gases like CH_4, NH_3 & released CO_2, N_2, H_2O etc.

Being lighter it escaped

Primitive atmosphere was **REDUCING TYPE**

- Later on this O_2 was also responsible for the formation of 'ozone layer'
- Earlier Atomsphere was 'Reducing type', with high temperature.

- Slowly temperature came down → H_2O vapour $\xrightarrow{\text{Formed}}$ CLOUDS CLOUDS CLOUDS

↓ Condensation

↓ Rainfall

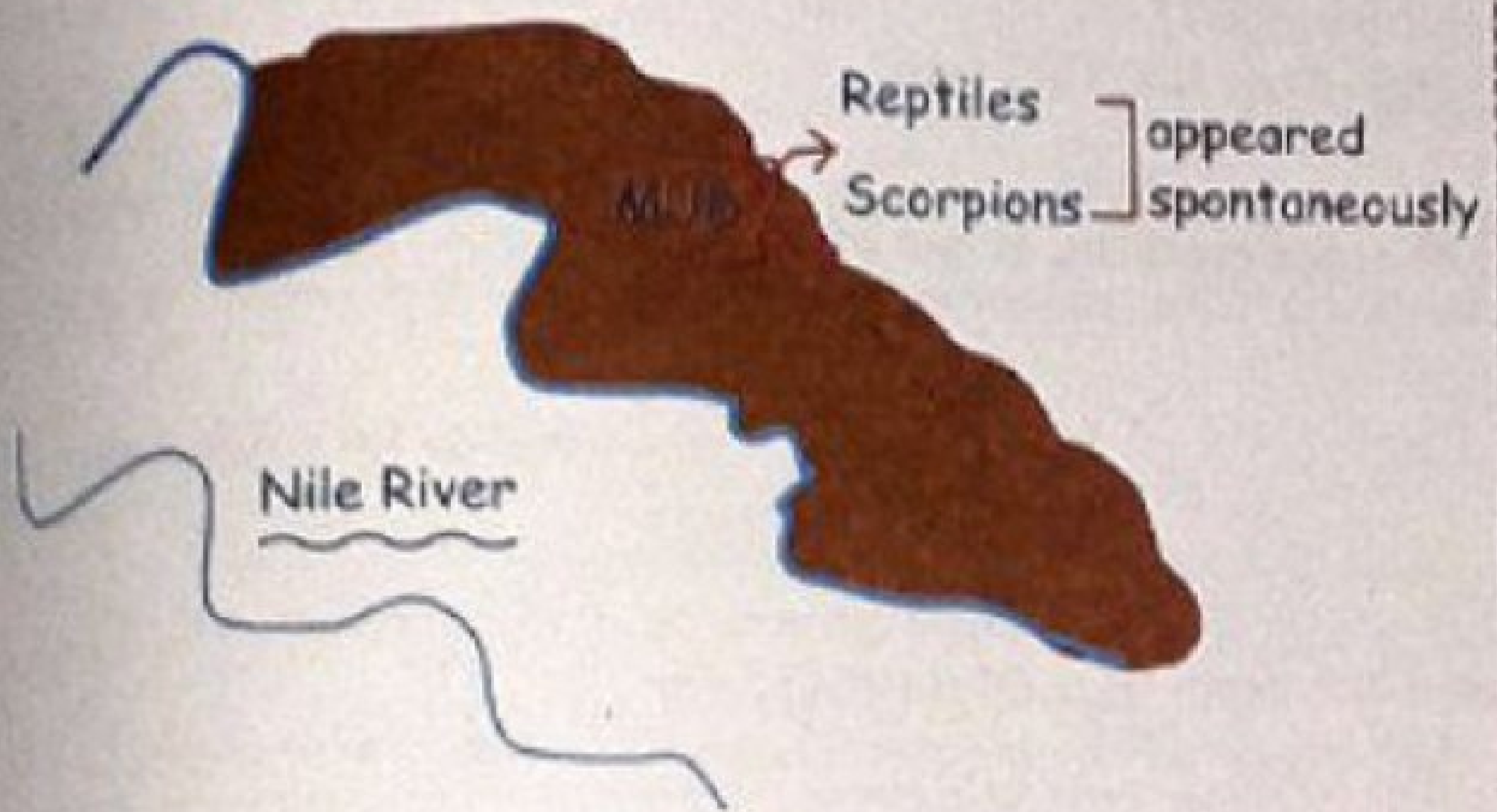
↓ Filled the "PITS" → Formed the OCEAN which we see today → Hot, with various Chemicals → Life appeared

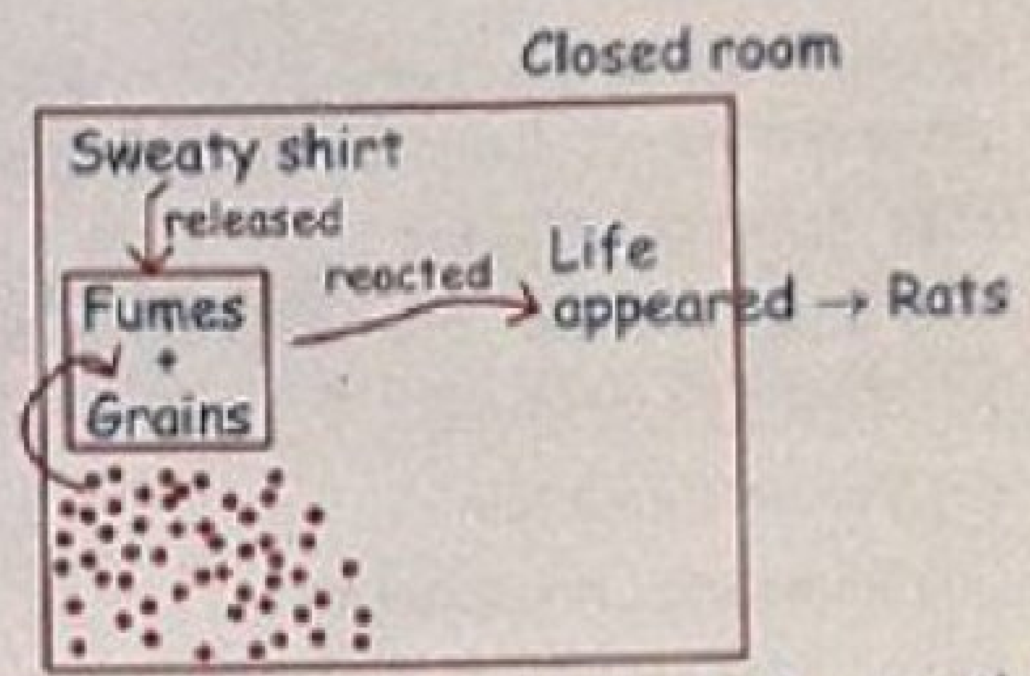
- 1st LIFE APPEARED IN WATER.

THEORIES TO EXPLAIN THE ORIGIN OF LIFE

1. Theory of special creation:
   - Life was created within 6 days by the supernatural power called as GOD.
   - Life is created 'as such'. Diversity was same since creation and will remain same in the future.
   - Earth is about 4000 years old.
2. (अतिविवत Gyan) Theory of Catastrophism: According to this, due to some catastrophic events, existing life disappears & new life come.
3. Theory of Panaspermia/Cosmozoic (Extra terrestrial theory)
   Life came on the Earth from other planet in the form of sperm, seed, spore etc.
4. Theory of Abiogenesis/Spontaneous Generation

A bio genesis : Life appears from non-living matters (decaying and rotting material) like straw and mud.
absent Life generation





It was believed by some that due to the fumes & grains in the closed room, rats appeared spontaneously.

(😂 मतलब कुछ भी)

5. Theory of BIOGENESIS:
   Living Generation
   Life comes from pre-existing life (Omne Vivum EX VIVO)

NOTE
- Theory of Biogenesis disproved the theory of abiogenesis.

Pasteur's Swan Neck Experiment:

- He took swan 's' neck flask with pre-sterilised condition having broth.
  - (A): It was broken
  - (B): It was kept as it 'is'

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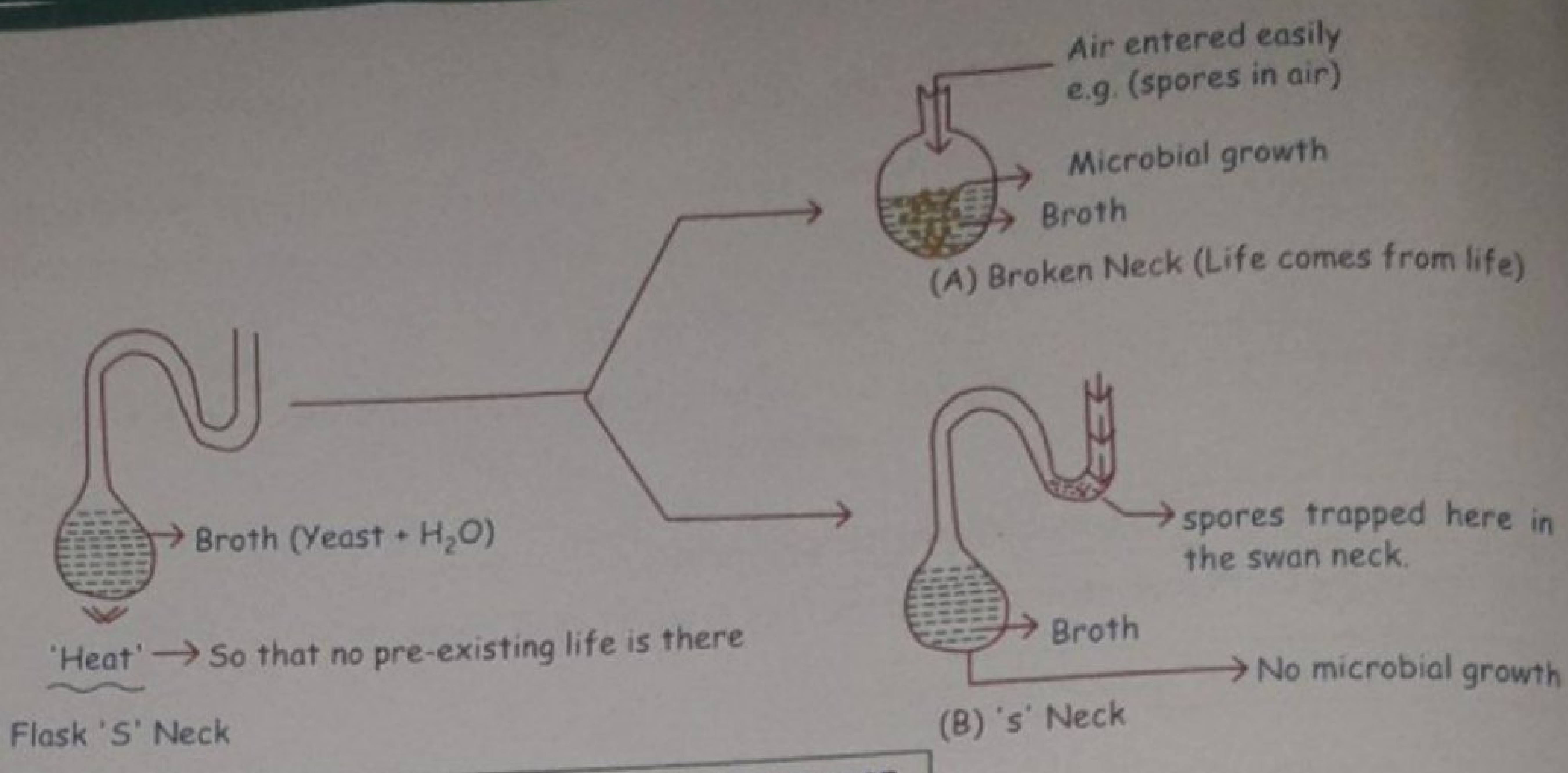
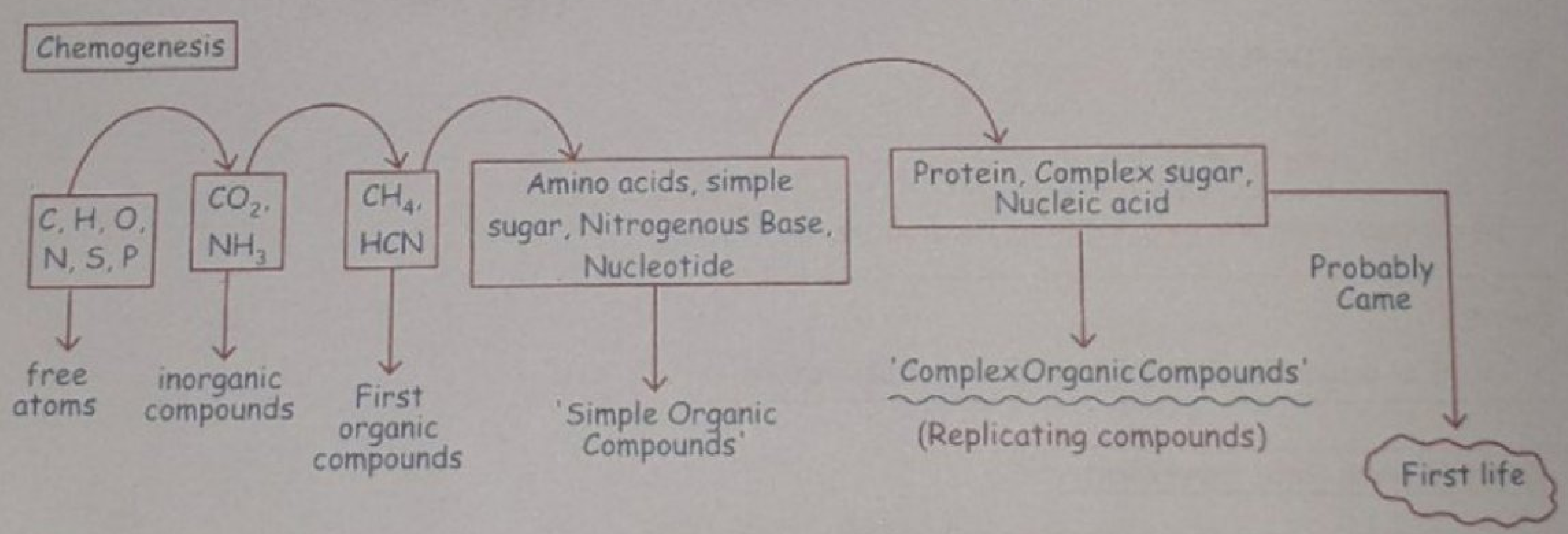


○ **HENCE, PROVED LIFE COMES FROM PRE-EXISTING LIFE.**

6. <u>THEORY OF CHEMICAL EVOLUTION (CHEMOGENESIS)</u> : <u>(OPARIN AND HALDANE THEORY)</u>:

- Oparin (Russian Biochemist) & Haldane (England Biologist) proposed that the first form of life come from pre existing non-living ORGANIC molecules LIKE RNA, PROTEIN etc.
- Most Accepted Theory
- They proposed that the condition on early earth supported the origin of life like:
  - (i) High temperature
  - (ii) Volcanic eruption
  - (iii) Reducing atmosphere
  - (iv) Lightening
- They said life originated in water, Haldane used the term "hot dilute soup" for 'OCEANS'



NOTE Exactly how the non-replicating components formed replicating is not yet clear.

MILLER & UREY'S EXPERIMENT

- They experimentally proved the theory of 'Chemogenesis' in favour of Oparin & Haldane theory in 1953.

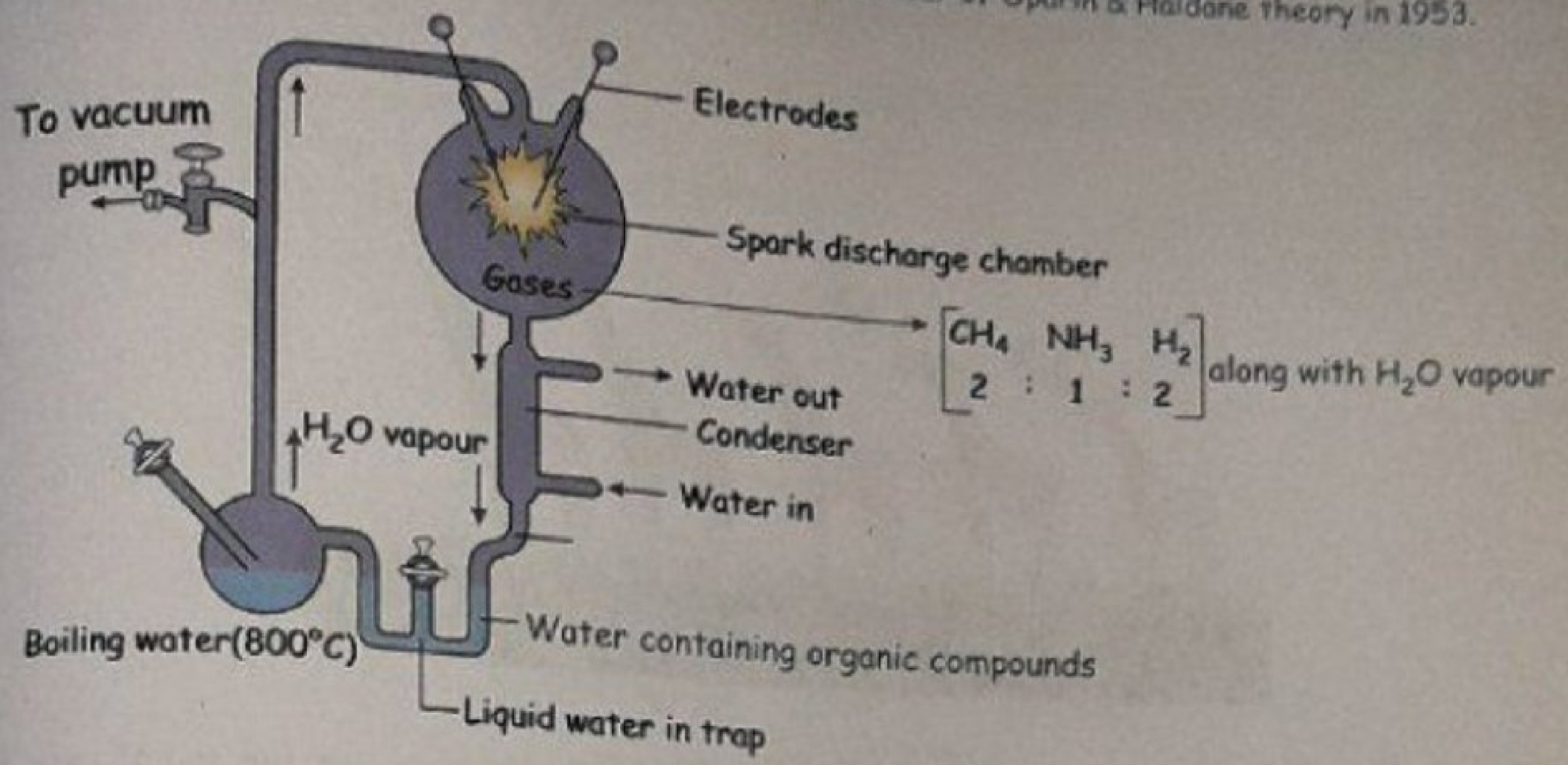


Fig: Diagrammatic representation of Miller's experiment

CONCLUSION

- After 18 days of his experiment, he obtained amino acid like glycine, alanine & aspartic acid.
- Similar experiments were performed by various other scientists to obtain other amino acid, sugar, pigments, fats etc.

NOTE अतिरिक्त gyaan

- 1^{st} Life appeared in deep oceans were chemoheteroptric anaerobes
- Chemoheterotrophs → Chemoautotrophs → Photoautotrophs

Theories of Evolution:

1. LAMARCKISM
2. DARWINISM
3. MUTATION THEORY
4. MODERN SYNTHENTIC THEORY

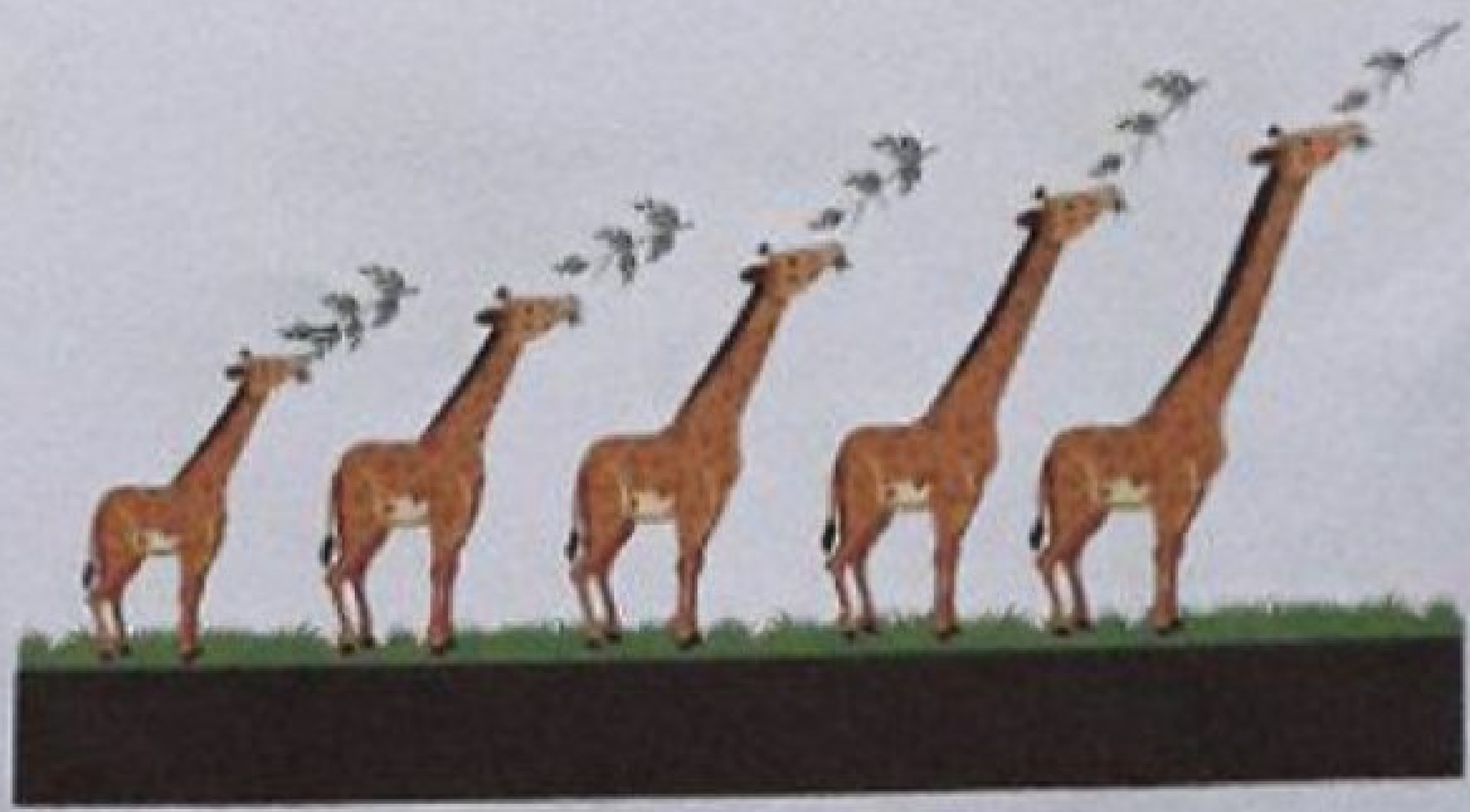
'Biological Evolution'

BIOLOGICAL EVOLUTION:

1. LAMARCKISM (Theory of use/disuse of organ or Theory of Inheritance of Acquired Characters)
   - Change in environment force the organism to either develop a new organ or modify the existing organ.
   - The more we use the organ, the more it develops and the less we use it, it dissapears.
   - These character that one acquires during the life time is also passed on to the next generation.

- He gave the examples of Giraffes who in an attempt to forage leaves on tall trees had to adapt by elongation of their necks.
- Slowly over years, they came to acquire long necks.

NOTE 'Lamarck was a French naturalist who gave lamarckism.



अतिरिक्त gyan Theory of germplasm by Weismann disproved this theory, he cut the tail of mice for 22 generation, still tails appeared next time.

- Weismann concluded that any change in germplasm of germ cell would pass on to the next generation not the changes in the somatoplasm.

2. DARWINISM/THEORY OF NATURAL SELECTION

Charles Darwin
↓
In his Sea Voyage
↓
H.M.S. Beagle (Her magesty ship)
↓
GALAPAGOS ISLAND
↓
Location: Pacific Oceans near South America

Alfred wallace at the same visited the
↓
Malay Archepelago ISLANDS
↓
Indian Oceans

IMP. NOTE

- Both Darwin & Alfred Wallace were influenced by Population theory of Thomas Malthus.

POPULATION THEORY:

According to this Theory

- Population have a tendency to grow exponentially but it does not as the NATURAL RESOURCES are limited.
- No two individuals are similar, they shows variations most of which are inheritable.
- Size of population is stable exept seasonal fluctuation.
- Considering these points, DARWIN PROPOSED DARWINISM which says.
- Differential reproduction: Different individual reproduce at different age and different rate.

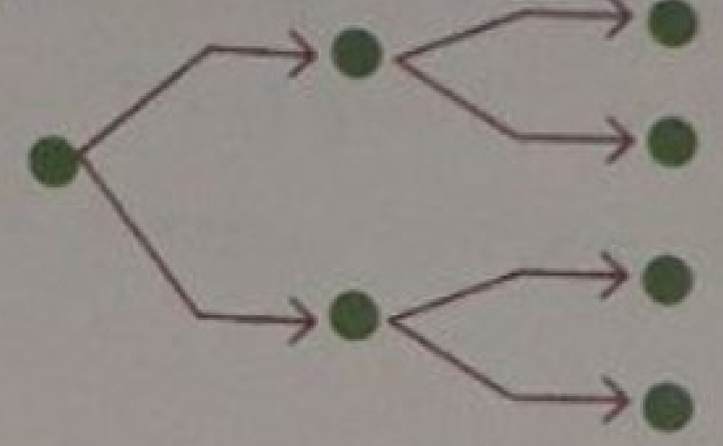
- Natural resources are limited:
- Struggle for existence "Competition" occurs → Intraspecific (within species) / → Interspecific (between species)
- ***Variation** according to Darwin are **small and directional** → Useful variations are adaptations.
- Natural selection: Nature selects the fittest individual with useful variation which leaves maximum progeny (REPRODUCTIVE FITNESS)
- Survival of the fittest: (Term was given by Herbert spencer)

NOTE

** 2 KEY CONCEPTS OF DARWINIAN THEORY

① NATURAL SELECTION — Defines → Mechanism of Evolution

② BRANCHING DESCENT — Defines → Pattern of Evolution



Examples of Natural Selection:

- Industrial melanism
- Antibiotic resistant microbes.
- Darwin Finches (explained later in the chapter)
- Evoution of pesticide Resistant mosquitoes.

① **Industrial Melanism: (England)**

Before industrialisation: (1850's)

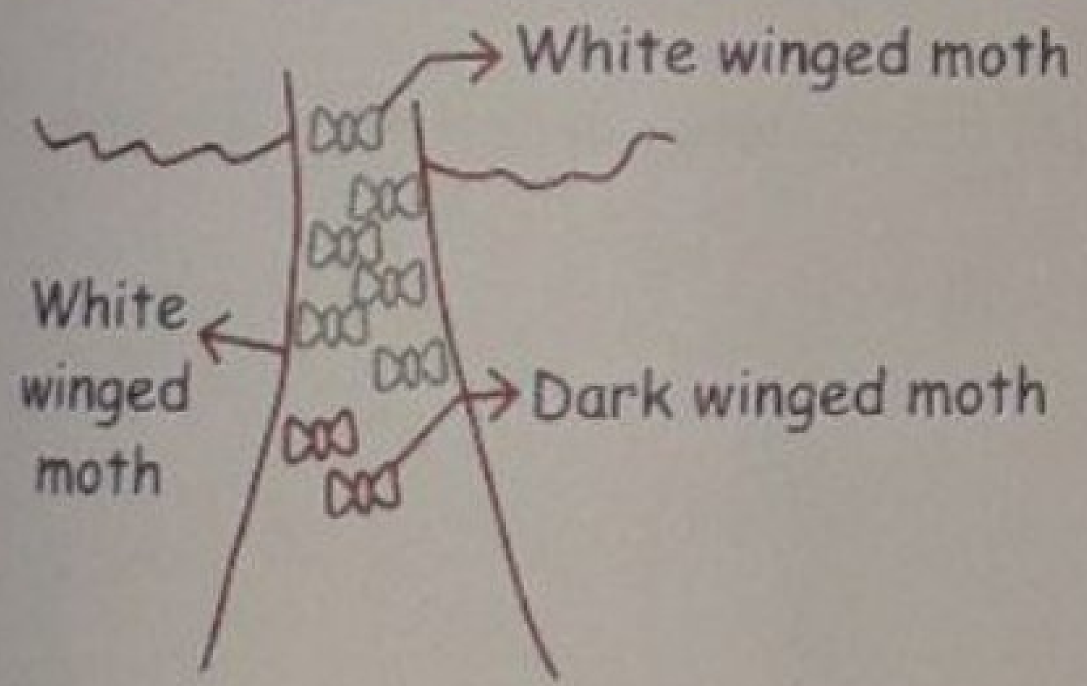
→ No pollution

↓

Lichens covered the bark of trees before industrialisation (No pollution)

↓

White -winged moth could easily camouflage in the Light background whereas the dark winged moth (melanised) were easily predated by birds



After Industrialisation (1920's)

↓

Pollution increased

↓

Lichens disappeared (lichens don't grow in polluted areas) & due to the pollution trees bark became Dark

↓

White winged moth easily predated this time & Dark winged could camouflage

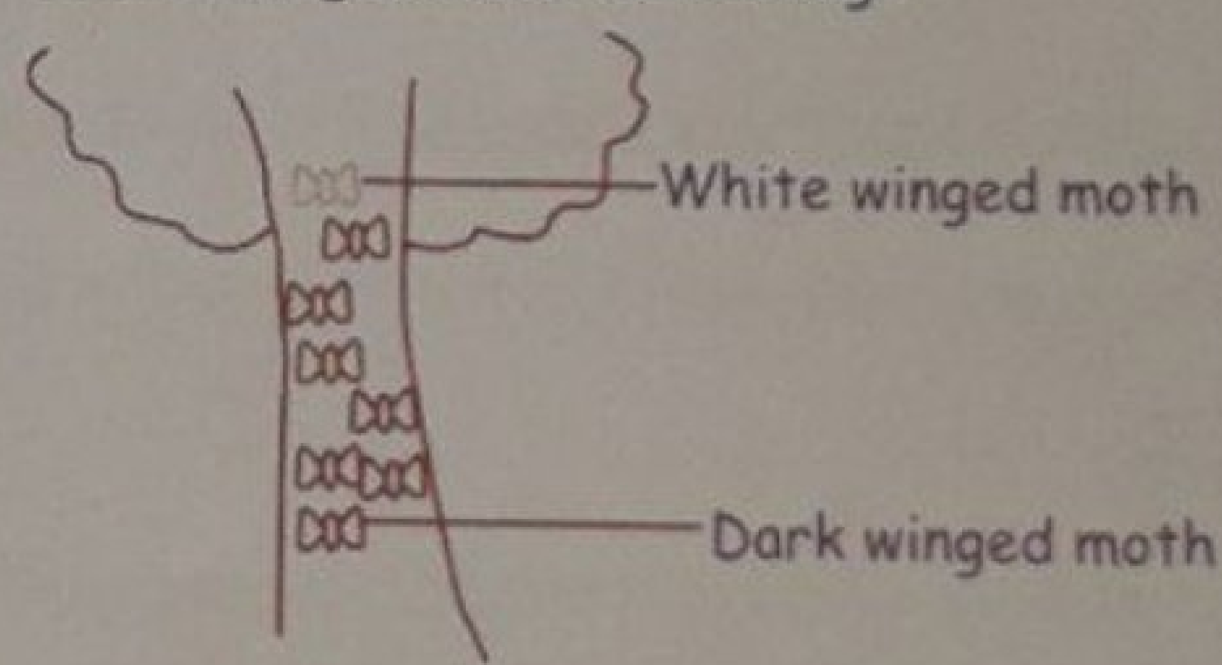


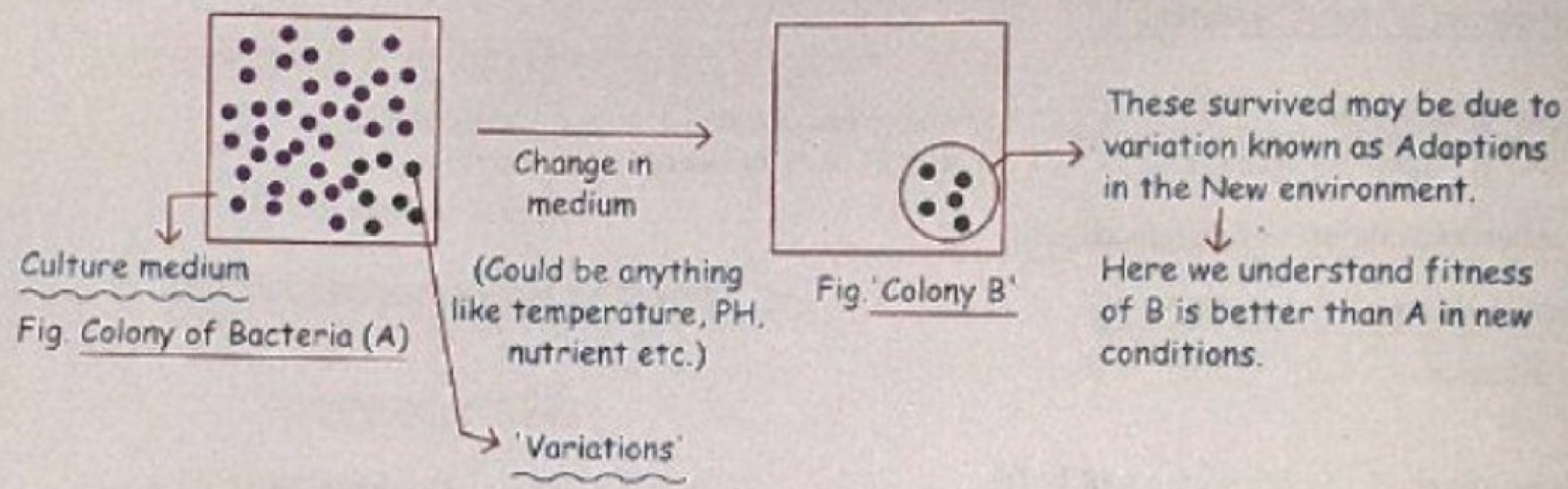
Fig. Figure showing white - winged moth and dark - winged moth (melanised) on a tree trunk
(a) In unpolluted area (b) In polluted area

NOTE

Before industrialisation → White winged moth increased
→ Dark winged moth decreased

After industrialisation → Dark winged moth increased
→ White winged moth decreased

2. <u>Microbial Experiment:</u>



NOTE The rate of appearance of new life forms is directly linked to the Life span/life cycle of organisms

- Microbial experiment occurs within days but the something to happen for fish or fowl would take million of years as life span of these are in years.

3. <u>Pesticide Resistance Mosquito</u>: Excess of use of herbicides, pesticides has resulted in resistant varieties in much lesser time.

   These are examples of evolution by anthropogenic action (human action)

NOTE

Evolution is not a directed process, it is a stochastic (random)

3. **Mutation Theory:**

- Huge deVries Proposed this theory
- He worked on 'Evening Primrose'

↓

Oenthera lamarckiana

- He said 'MUTATIONS' results in evolution.

*He gave the term 'SALTATION' for SINGLE STEP LARGE MUTATION: Large differences arising suddenly in a population

- Mutations are Large & Directionless

4. **Modern Synthetic Theory:**

Many factors collectively are responsible for formation of new species, → 'SPECIATION'

- Mutation
- Gene migration
- Genetic drift
- Genetic recombination
- Natural selection

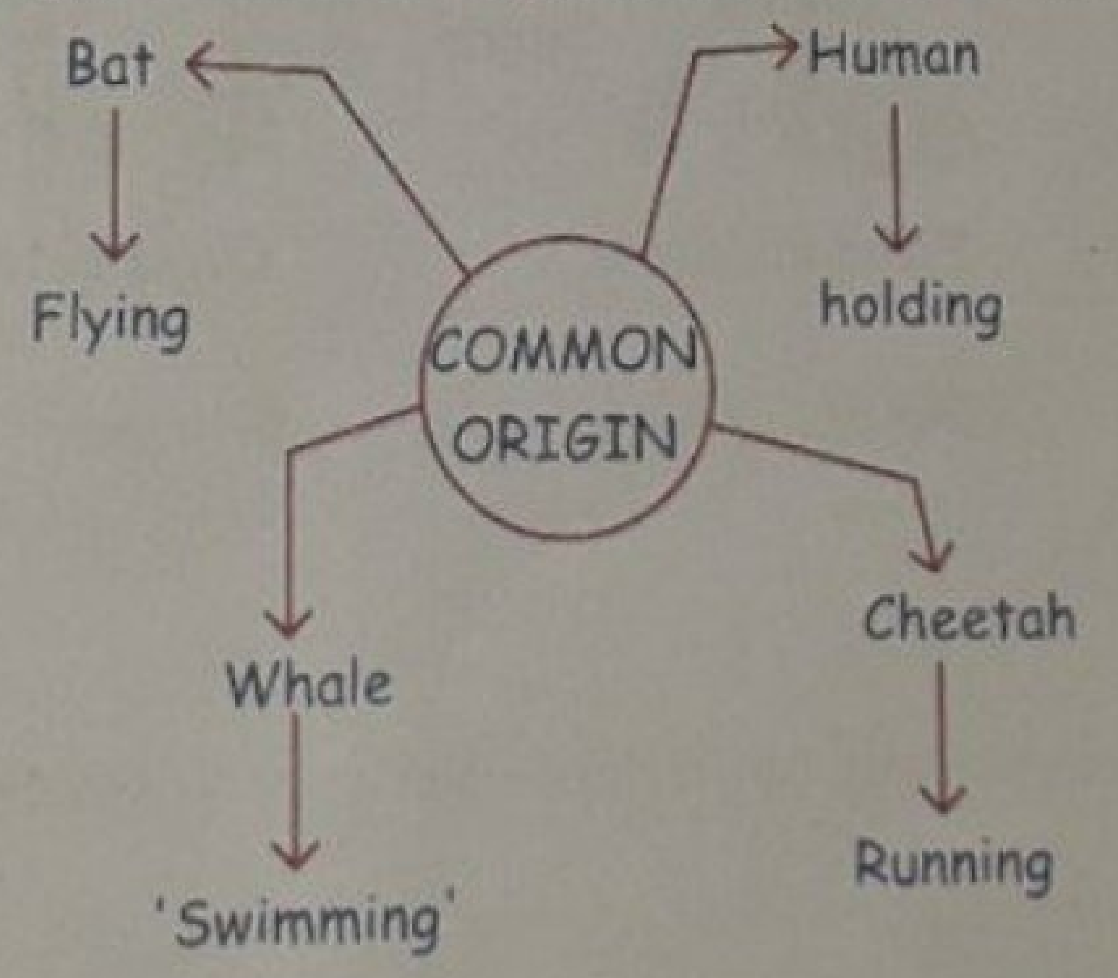
*EVIDENCES OF EVOLUTION:

1. Comparative anatomy and morphology → HOMOLOGY, ANALOGY
2. Palaeontological evidences
3. Embryological evidences
4. Biochemical evidences

1. MORPHOLOGICAL AND ANATOMICAL EVIDENCES:

(a) HOMOLOGOUS STRUCTURE

- Structures having common origin or similar basic plan but differs in functions like forelimbs of vertebrates.



- Homology explains 'DIVERGENT EVOLUTION'

Even after having similar origin, due to different needs adaptions were different hence they function differently.

Examples:

- Forelimbs of man, cheetah, whale, bat all have similarities in the pattern of bone like presence of humerus, Radius ulna, carpal, metacarpal, phalanges.

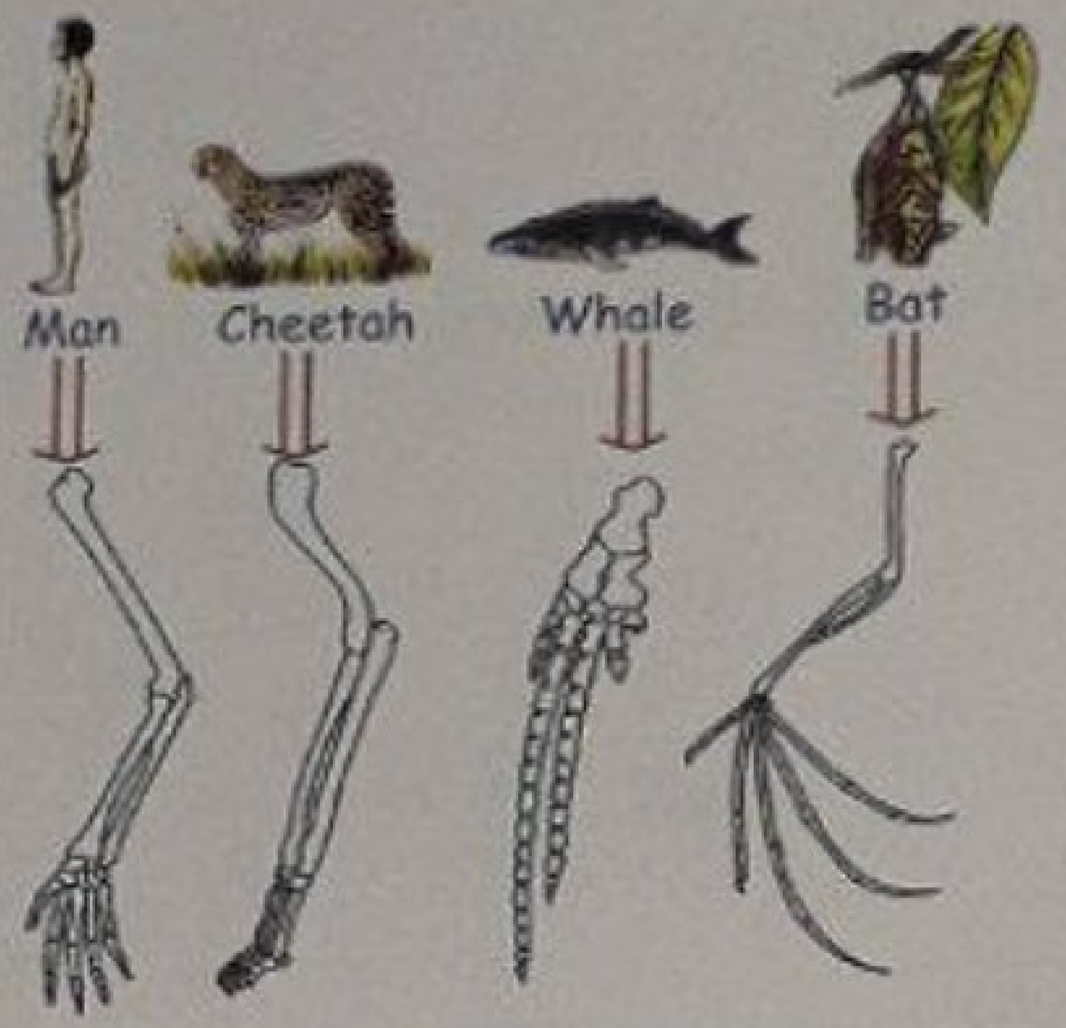


Fig. Example of homologous organ in Animal.

- Thorns (Protection) of *Bougainvillea* and tendrils (climbing) of *Cucurbita*.
  Both modified axilliary Bud.

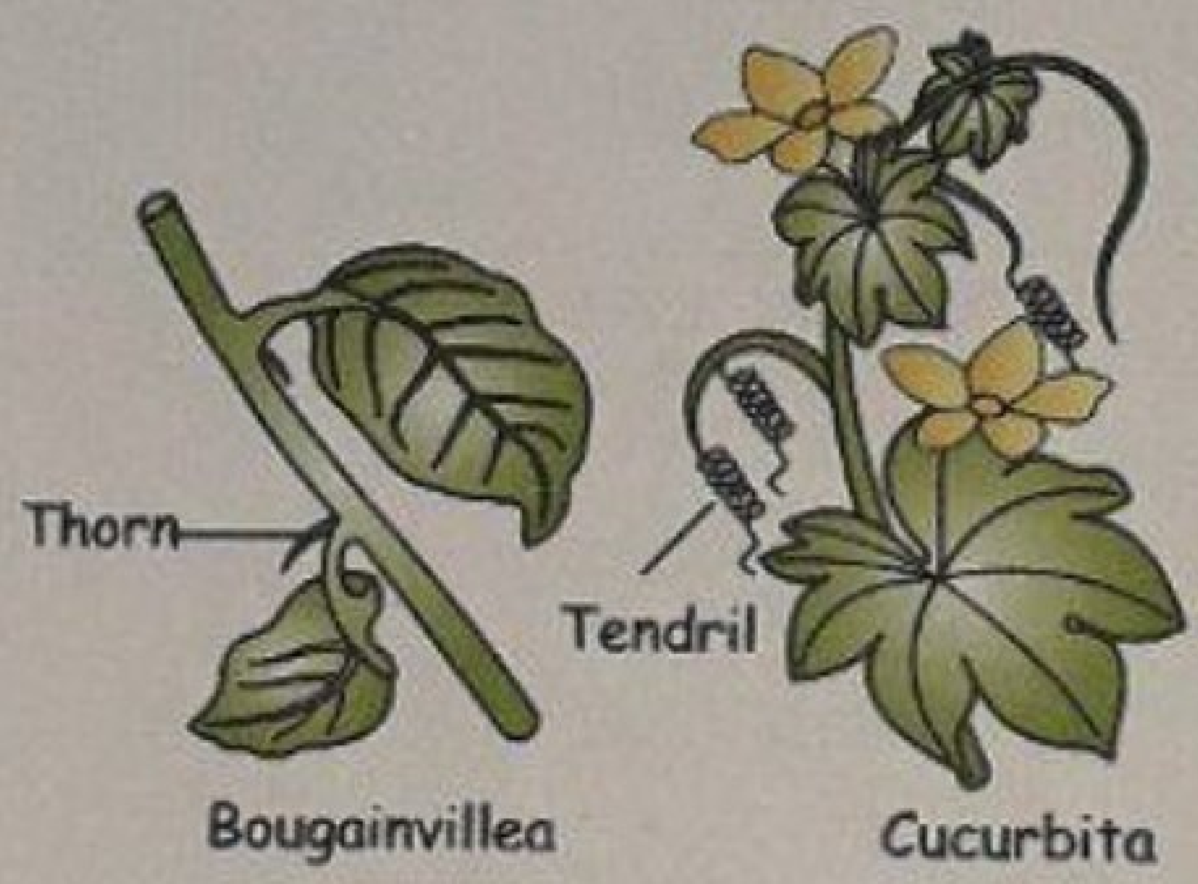


Fig. Example of homologous organ in plant.

- Heart and Brain of vertebrates

→ Heart of Vertebrates → presence of atria, ventricles, evolution of 2/3/4 Chambered heart
→ Brain of Vertebrates

a

(b) ANALOGOUS STRUCTURES

- Structure having different origin but common functions.
- Analogy explains 'CONVERGENT EVOLUTION'

Similar habitat that has resulted in selection of similar adaptive features in different groups of organisms but towards the same function.

Examples:

- Wings of bird (Vertebrate) and wings butterfly (Arthropoda): (Flying)
- Eye of Octopus and mammal: (Vision)
- Sweet potato and potato: (Stored food)

Modified Root — Modified shoot

- Flippers of Penguin & Dolphin

2. Palaentological Evidences: (Best Evidence):

Palaentology: Study of FOSSILS

Fossils: Whole organism or its part or excreta or foot print etc. preserved overs years.

found in 'Sedementary Rocks'

- Most accurate evidence

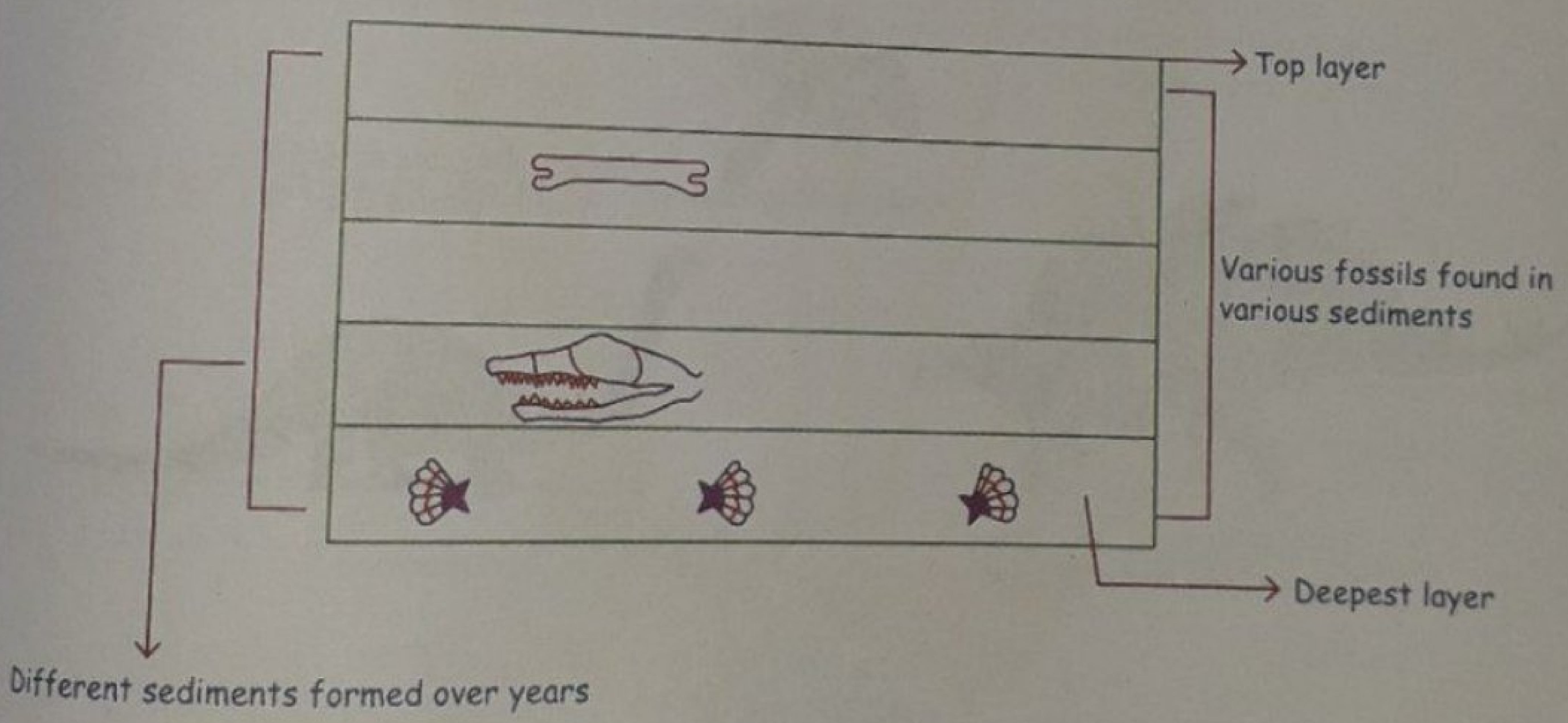


Fig. Different sediments layer over year

- Rock form sediments one over another.
- Different aged rock sediment
  ↓
  Contain fossil which died during formation of that particular sediment
- Deepest layer: OLDEST FOSSIL.
- Top layer: NEWEST FOSSIL.

NOTE Age of fossils can be determined by:

- Carbon dating
- Electron spin resonance
- Relative dating by comparision of deep & top layers.

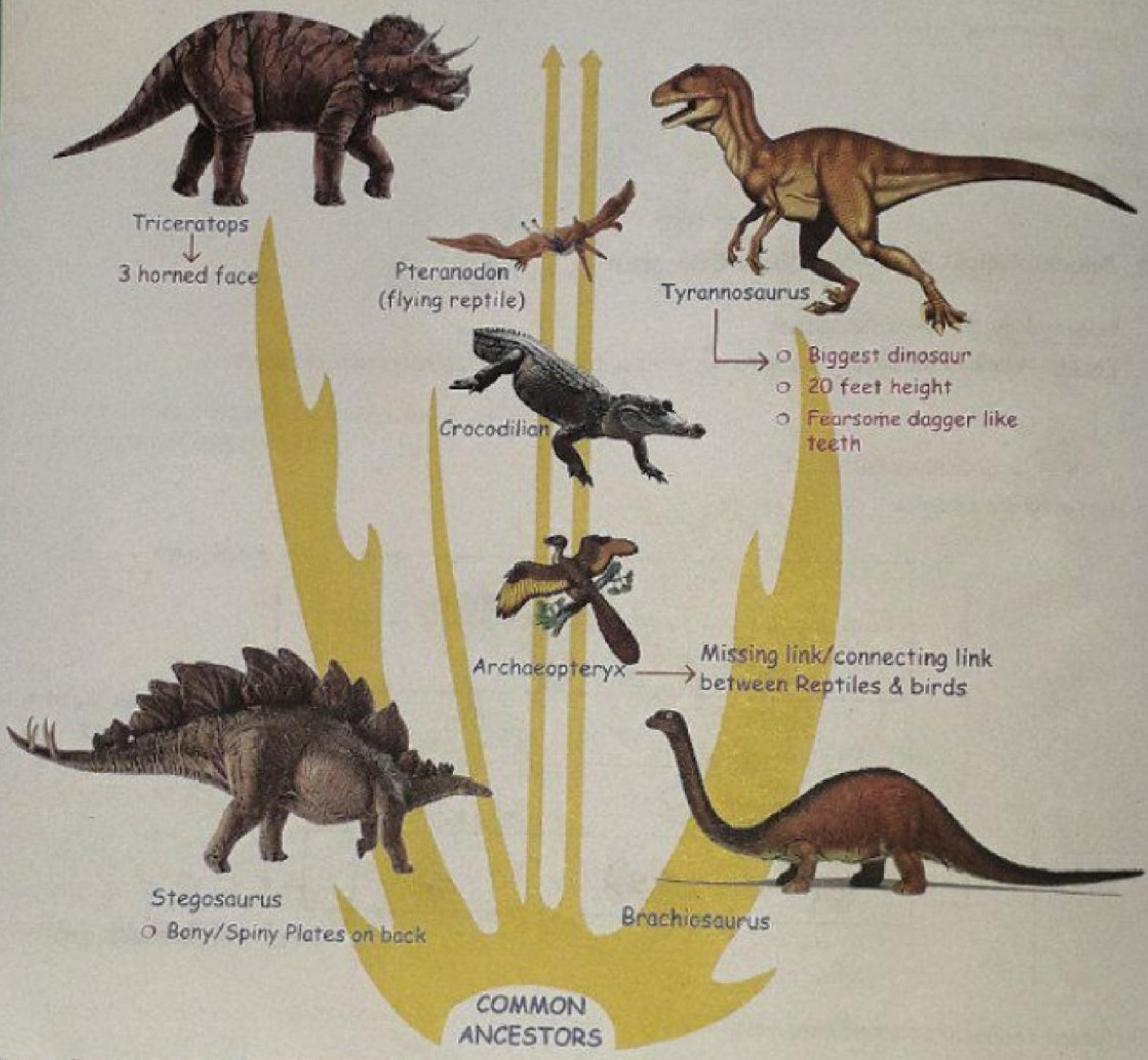


Fig. A family tree of dinosaurs and their living modern day counterpart organisms like crocodiles and birds

3. EMBRYOLOGICAL EVIDENCE:

BIOGENETIC LAW OR RECAPITULATION THEORY — By 'Ernst Haeckel'

ONTOGENY RECAPITULATES PHYLOGENY

Embryonic Stages — repeats — Evolutionary history

ACCORDING TO BIOGENETIC LAW

- Embryo's of all vertebrates have similar structures like gill slits behind head.

  gill slits → It is not functional in all adults, only funtional in fish adult

  → Indicates COMMON ANCESTORY

  * KARL ERNST VON BAER, rejected this theory & said:
- Initial stages common to all but later stages are not common → embryos never passes through adult stages of other animals.

4. BIOCHEMICAL EVIDENCE:

- Similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry.

e.g.:

- Trypsin is common for both vertebrates & invertebrates.
- Apes & human have similar proteins in blood.

ARTIFICIAL SELECTION:

- Man breeds Animals & Plant (Plant breeding and Animal breeding) for different purposes: Agriculture, Horticulture (Fruit & Vegetable), security and sports.
- It is said, if within 100 of years if man could create new breeds why could not nature have down this over million of years.

HW EQUILIBRIUM: (Hardy Weinberg Equilibrium)

Hardy Weinberg principle says that in a large randomly mating population: Allelic frequency remains constant or Stable generation after generation if population is free from:

1. Gene migration
2. Genetic recombination
3. Mutation
4. Natural Selection
5. Genetic drift

— Evolutionary forces

'Gene' alternate form of allele:

'T' : Dominant

't' : Reccessive

'genotype' →
- 'T t' : Heterozygote
- 'T T' : Homozygous Dominant
- 't t' : Homozygous Recessive

Mathematical Expression for Hardy-Weinberg Equation

$$\boxed{P + q = 1}$$

P → allelic frequency of Dominant allele

q → allelic frequency of recessive allele

frequency $\left[\begin{array}{l} f(A) = P \\ f(a) = q \end{array}\right.$

A: dominant allele a: recessive allele

AA - Homozygous dominant

Aa - Heterozygotes

aa - Homozygous recessive

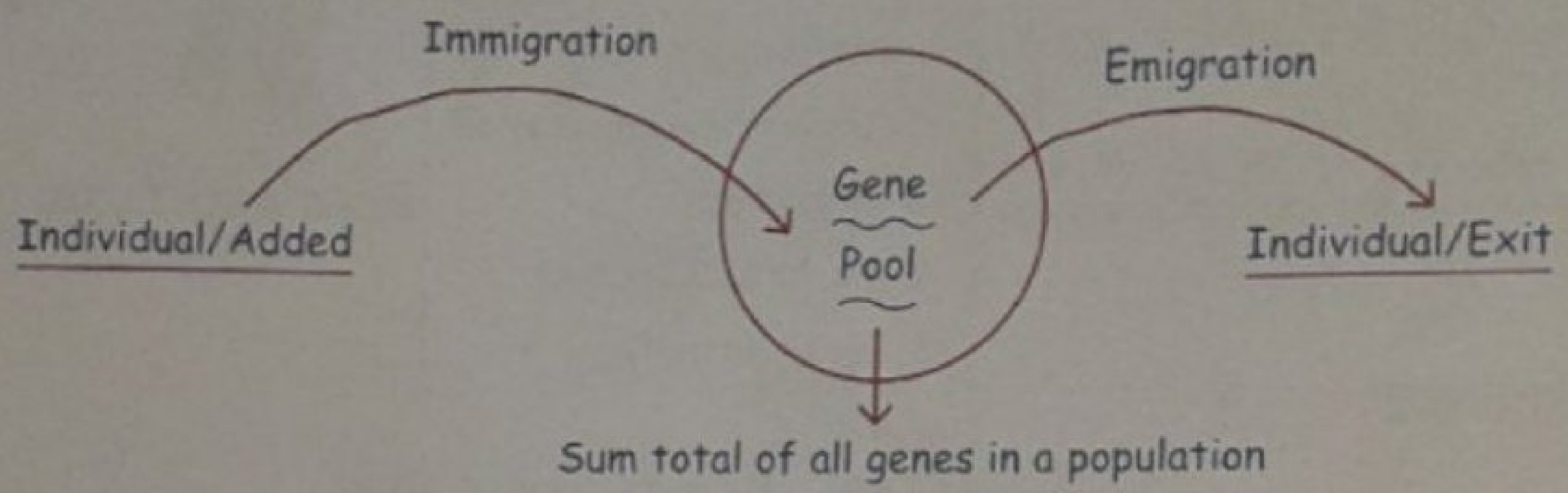
$$p^2 + 2pq + q^2 = 1$$

- p^2 → f(AA) → genotypic frequency of homozygous dominant
- $2pq$ → f(Aa) → genotypic frequency of heterozygotes
- q^2 → f(aa) → genotypic frequency of homozygous recessive

NOTE If $p + q \neq 1$, means evolution is taking place in the population & one or more factors are operating.

Factors affecting HW (Hardy-Weinberg) equilibrium

1. Gene flow or Gene Migration:



NOTE

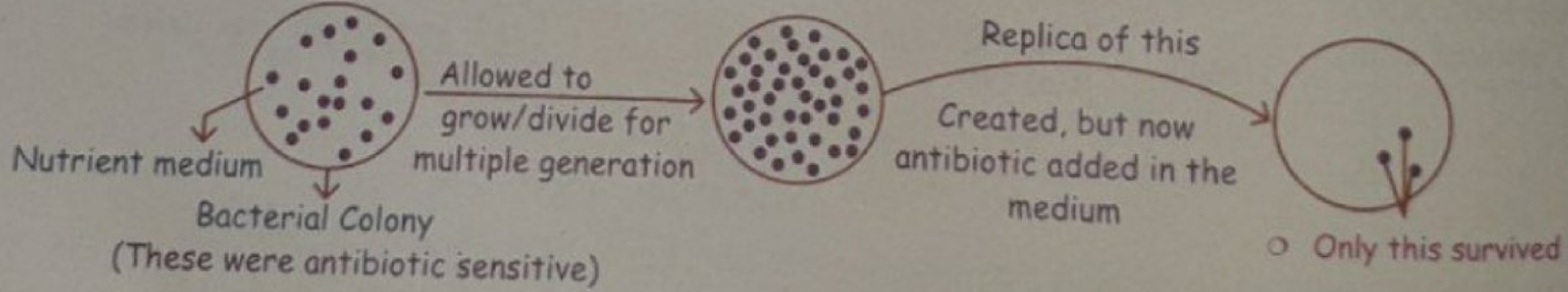
- If gene migration occurs multiple times: It is known as **GENE FLOW**

2. Genetic recombination: During gamete formation → Recombination occurs during meiosis → Change in gene frequency

3. **Mutation:**

Lederberg's Experiment:

- Microbial experiment performed to show pre-existing advantageous mutation when selected will result in new phenotypes.
- Over few generations new population will be formed.



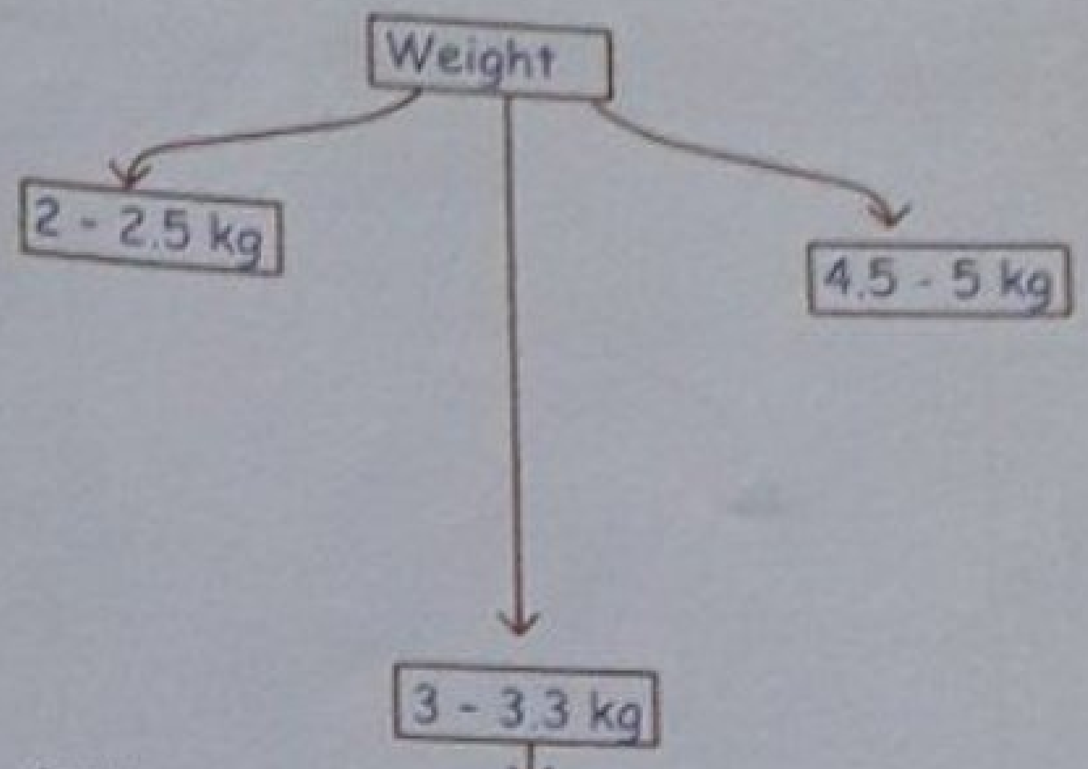
Conclusion: May be over generations, there might be some mutations in the members already but only showed up upon change in environment, will now form new species.

4. Natural Selection (Types of Natural selection)

- (1) Normal/Stabilising selection
- (2) Progressive/Directional selection
- (3) Disruptive Selection

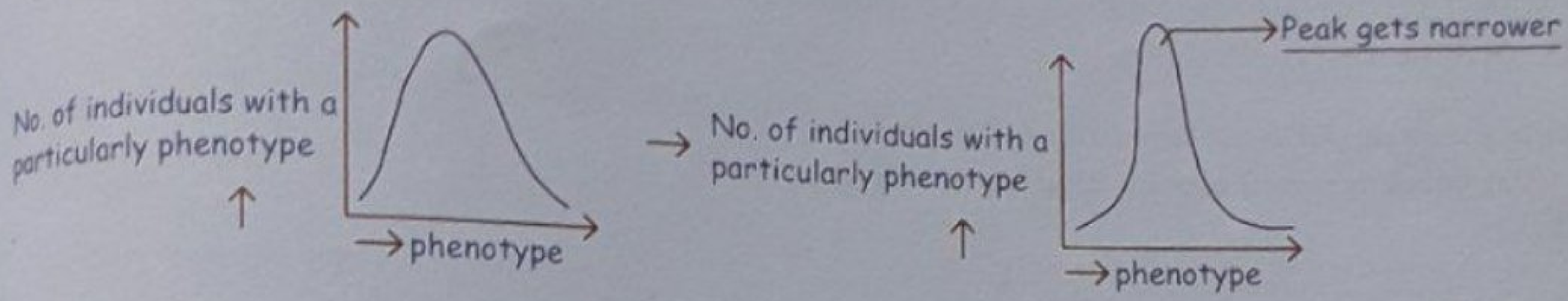
(1) Normal/Stabilising Selection: Nature selects individuals with mean character value.

e.g.: Birth weight of human babies.

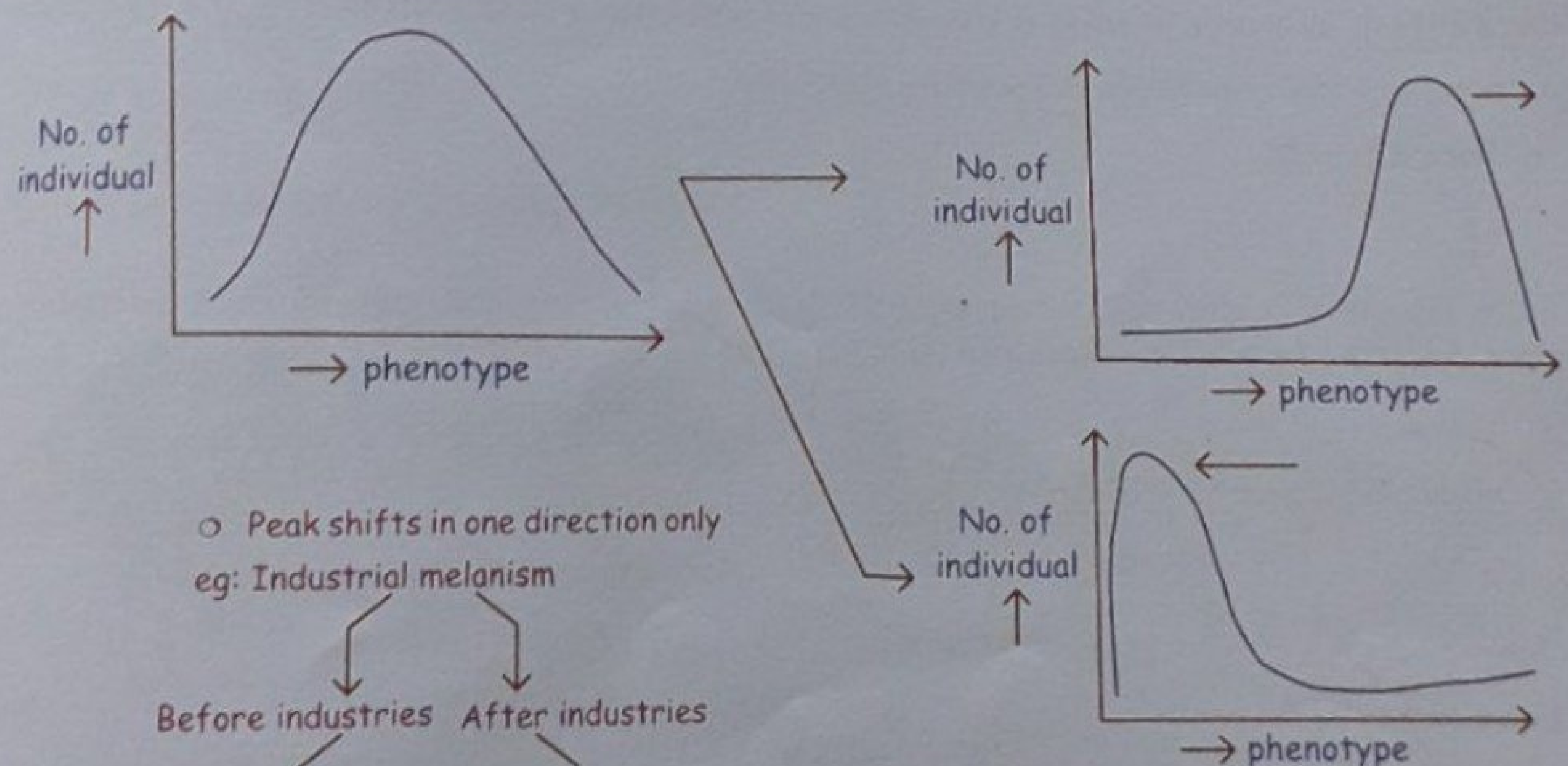


97% of new born with an aveage weight of this survives as compared to other infants.

- In this case, extreme low or extreme high baby weight is not favoured instead Average Baby weight is favoured by the nature.



(2) Progressive/Directional Selection: Nature selects one of the extreme phenotype not average mean value.



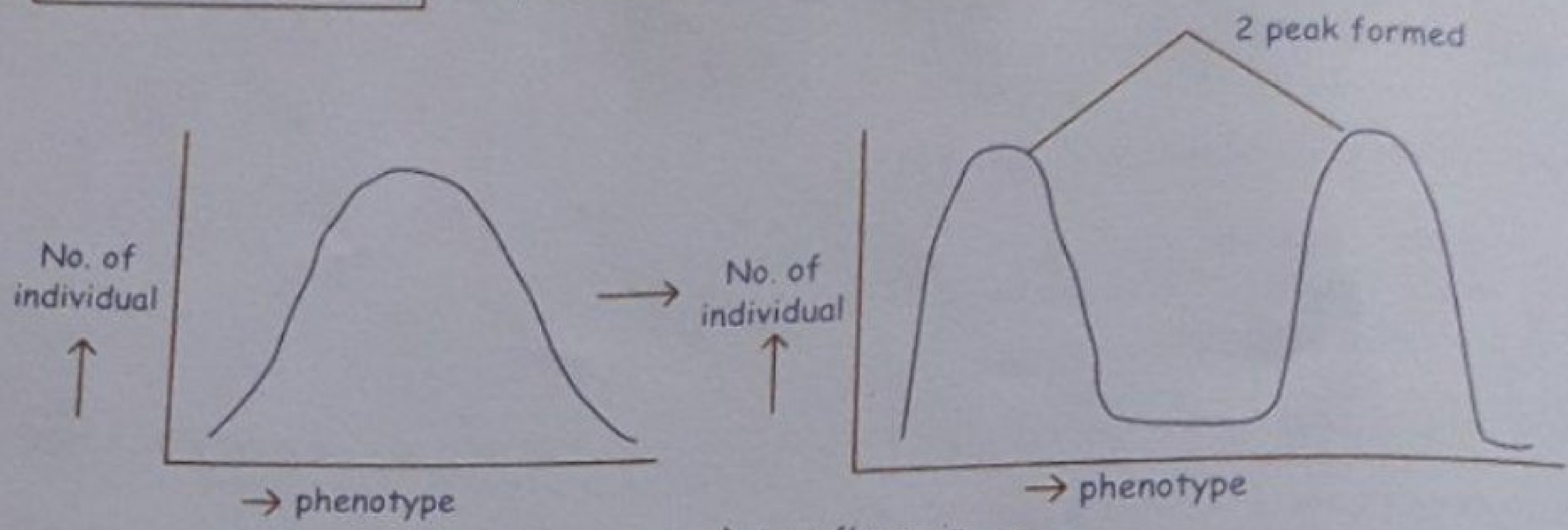
- Peak shifts in one direction only

eg: Industrial melanism

Before industries → White moth selected

After industries → Black moth selected

3 Discruptive selection: Both peripheral values are selected together.



अतिरिक्त gyan Snails
→ White shell → Camoflouge in white sand ← 'Selected'
→ GREY shell
→ Black shell → Camoflouge in rock ← 'Selected'

5. Genetic Drift:

- In a small population, random change in gene frequency.
- May be due to natural calamity, geographical isolation.

Genetic drift
1. Founder's effect
2. Bottleneck effect

Founder's Effect: By chance, if there is a small group of individual become isolated from the main population, forms a new population: now known as Founder's Population.

eg: Darwin Finches

↓

So, there was an original seed eating ANCESTOR BIRD in the main land, some of which drifted to a new place & formed a whole New population (species)

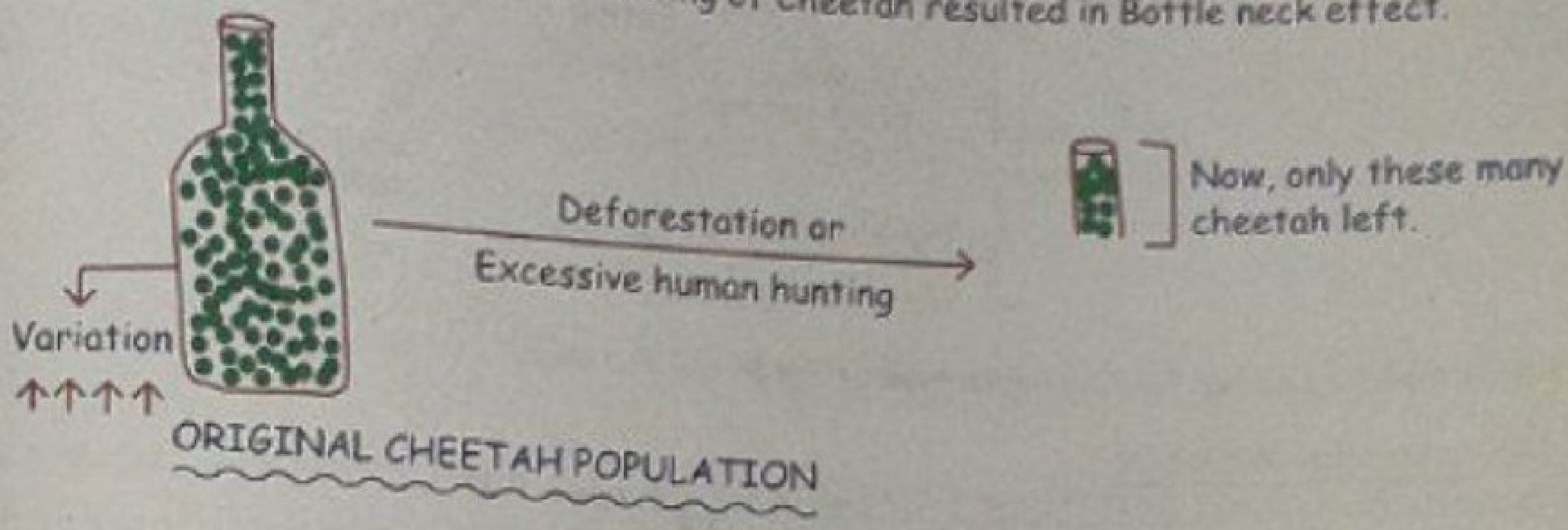
ORIGINAL SEED EATING BIRD → Some member moved → Founder's population → The whole new population is formed here. → More explanation in adaptive Radiation

Lived in Mainland
↓
"America"

GALAPAGOS ISLANDS
↓
(20-22 islands)

Bottleneck Effect: Initially population was enough to appear like filling complete bottle but due to some reason, only a few left which is comparable to the size of neck of the bottle.

→ e.g.: Excessive human hunting of Cheetah resulted in Bottle neck effect.



ADAPTIVE RADIATION : Evolution of different species in given geographical area starting from a common point.

e.g. Darwin finches, Australian marsupials and placental mammals in Australia.

(i) Darwin finches

Darwin during his sea voyage

↓

H. M. S Beagle

↓ went to

GALAPAGOS ISLAND

↓

Drawin observed small Black Birds over there

Fig: Variety of beaks of finches that Darwin found in Galapagos Island

Original ANCESTOR Bird: seed Eating

→ insect eating

→ Fruit eating

→ Nector eating

→ Cactus eating

eg: Darwin Finches

- Beak modified as per feeding habit, type of food they fed upon.

(ii) Australian Marsupial

(iii) Placental mammals in Australia

Placental mammal

PLACENTAL MAMMALS ANCESTORY → Mole, Anteater, Mouse, Lemur, Flying Squirrel, Bobcat, Wolf

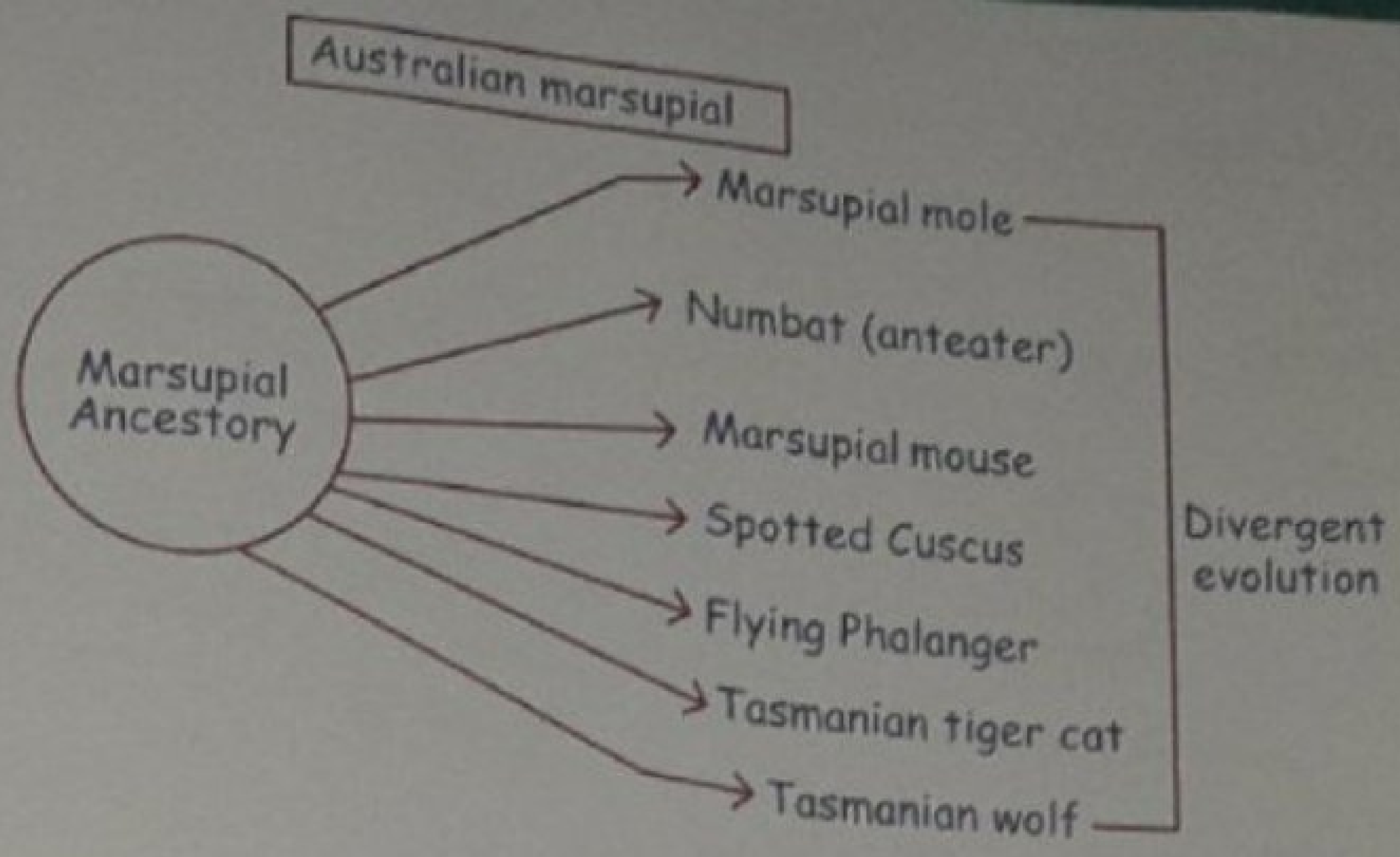
Divergent evolution

Mam let me fly slowly beyond world

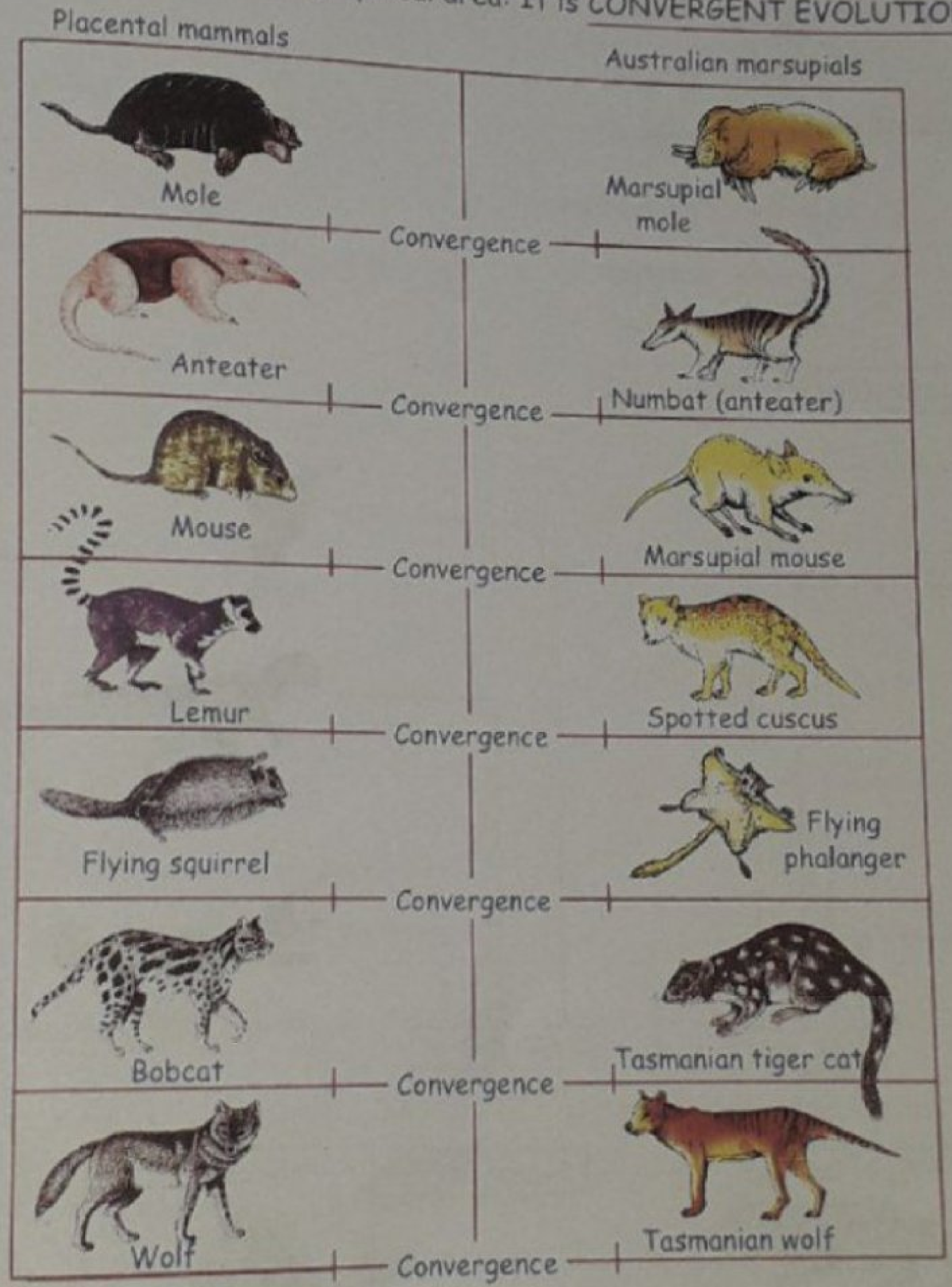
Mouse, mole, Anteater, Lemur, Flying Squirrel, Bobcat, Wolf

Trick

NOTE Just remember these placental mammals, rest all e.g. are Australian marsupial



NOTE *Adaptive radiation of a given species indicates DIVERGENT EVOLUTION but if more than one adaptive radiation occurs in an isolated geographical area: It is CONVERGENT EVOLUTION.



NOTE Members of placental mammals show convergence with Australian marsupials

GEOLOGICAL TIME SCALE

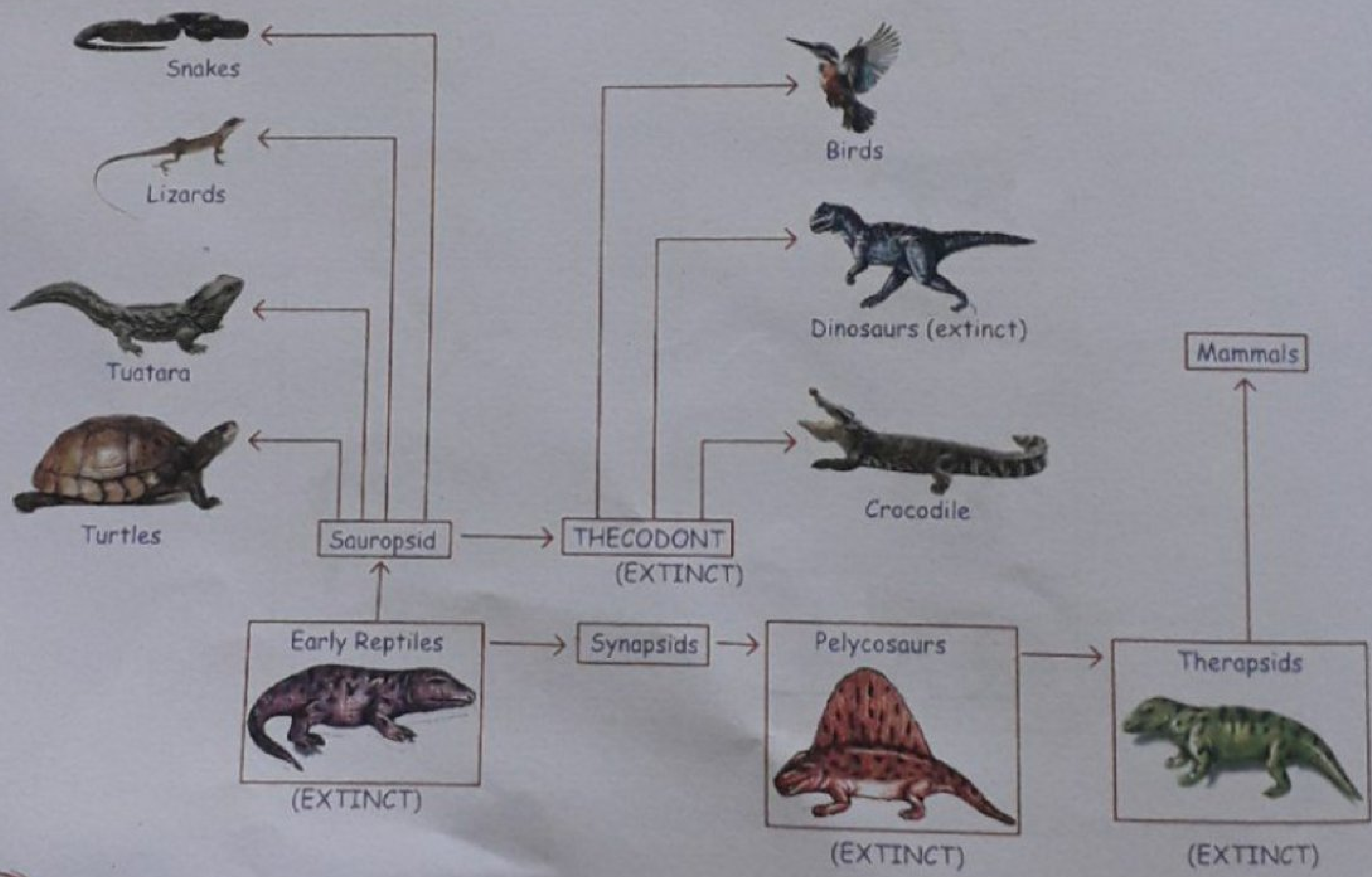
Era → Periods → Epochs

Era > Periods > Epochs

(Only as Per NCERT)

ERA	Period
COENOZOIC (NEW)	Quaternary
	Tertiary
MESOZOIC	Cretaceous
	Jurassic
	Triassic
PALAEOZOIC (OLDEST)	Permian
	Carboniferous
	Devonion
	Silurian

Evolutionary history of different vertebrates



Evolution of different life forms:

Origin of universe → 20 billion years ago

Origin of Earth → 4.5 billion years ago

Life appeared → 4 billion years ago (500 million years after formation of the Earth)

Non cellular form of life → 3 billion years ago

Cellular form of life → 2 billion years ago

Invertebrates → 500 million years ago

Jawless Fish → 350 million years ago

Fish with stout and Strong fin could move to land & back to water might have evolved into amphibians. → 350 million years ago

(In 1938, an organism coelocanth/Lobe Fin fish was caught in South africa which was though to be extinct, is a connecting link between Fish & AMPHIBIAN)

- Plant & sea weeds → 320 million years ago

  next 200 million years ago Reptiles dominated the earth
- Some land reptiles, moved to water & evolved into fish like reptiles (Ichthyosaurs) → 200 million years ago
- Dinosaurs disappeared (True Reason unknown) → 65 million years ago
- When reptiles came down mammals took over → First mammals were SHREW LIKE → Small fossils

HUMAN EVOLUTION:

Class Mammals → Order 'Primate' → Monkey

Class Mammals → Order 'Primate' → Apes → Gorilla, Chimpanzee

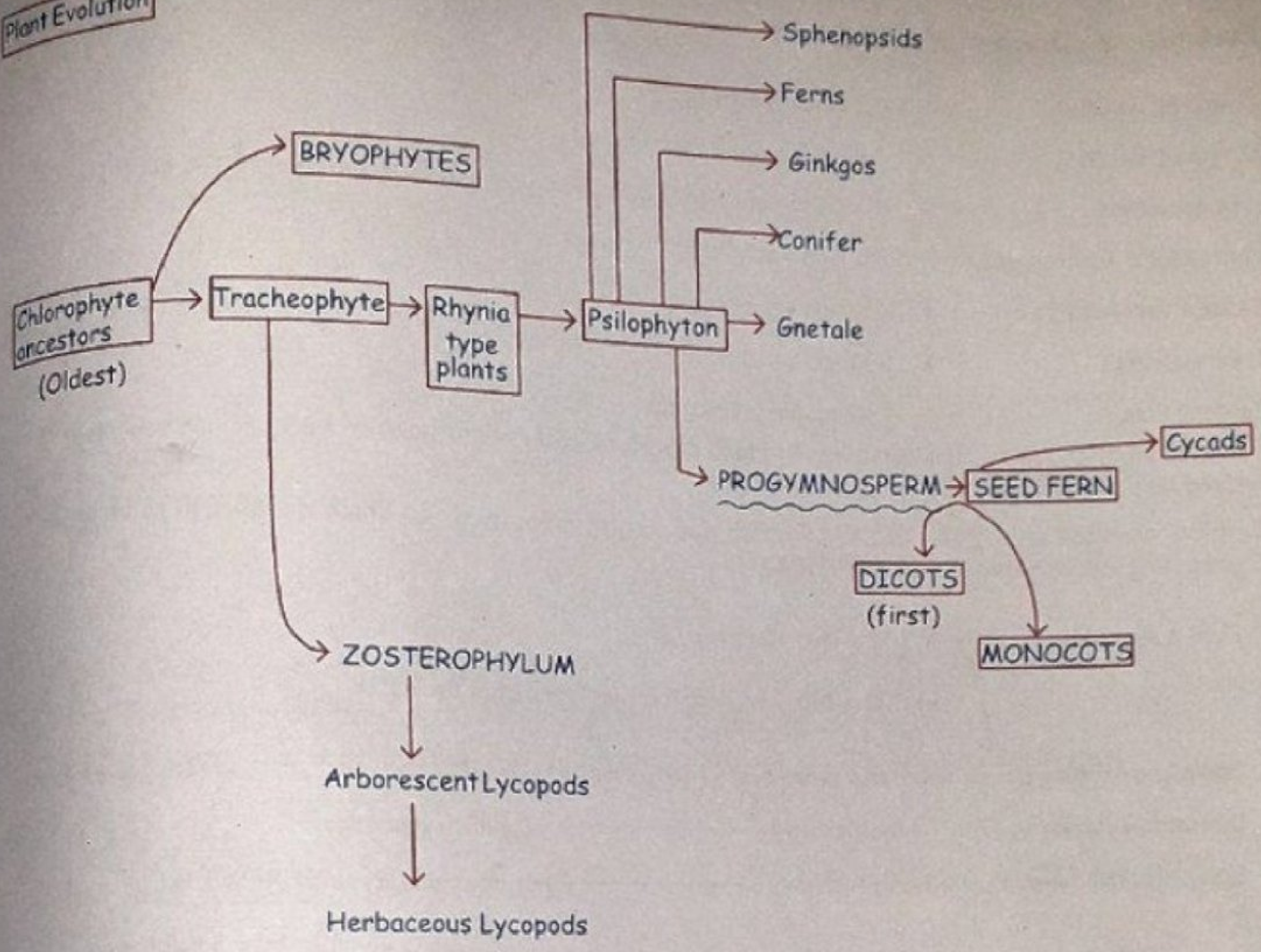
Class Mammals → Order 'Primate' → Human

Human → Closest → Gorilla, Chimpanzee

Doctor	Dryopithecus
Ram	Ramapithecus
Australia Se	Australopithecus
H	Homo habilis
E	Homo erectus
N	Neanderthal man
लाए	Cro-magnon (Not in NCERT)
	Modern man/Homo sapien sapien

Doctor Ram Australia से H E N लाए
(TRICK)

Plant Evolution



NOTE ① Land Reptiles: Dinosaurs

↓

Tyrannosaurus rex

↓

Biggest Dinausaur of the that time (20 feet the height)

↓

Huge fearsome, Dagger like Teeth

② Initially there was a common land (PANGEA) but due to continental drift, South America joined North America. Initally South America had mammals resembling horse, hippopotamus, bear, rabbit etc but now these animal were overridden by North America fauna.

③ Due to continental drift: pouched mammal/Australia marsupial survived in Australia due to lack of competition.

Dryopithecus
- 15 million years ago
- Walked on 4 feet, hairy
- More ape like

Ramapithecus (fossil obtained in SHIVALIK HILL) India
- 15 million years ago
- Walked on 4 feet, hairy
- More Man like

↓

Australopithecus
- Lived on East african grassland, 2 million years ago
- first time 'Bipedal movement'
- (Cranial Capacity): 500 cc (Cubic cm)
- Made stone weapon: fruit eating

↓

Homo habilis
- Hominid/Human Like
- Made perfect tool
- Cranial capacity: 650 - 800 cc
- They did not eat meat probably.

↓

Homo erectus
- Cranial capacity: 900 cc
- They had erect posture
- Lived ~ 1.5 myo
- The use fire for the first time
- They ate meat
- Fossil (Java man) was obtained in 1891

↓

Neanderthal
- Lived in Central & East Asia ∝ 1 lakh- 40000 year ago
- Cranial capacity 1400 cc
- For the first time covered their body. burdied Dead one, put flower

↓

Cro-magnon
- Cranial capacity: 1650 cc
- Made cave paintings (A cave painting was obtained, from Bhimbetka, Raisen District, Madhya pradesh, 18000 years ago)

↓

Homo sapien sapien
- Evolved during ICE AGE (75000 - 10000 yr ago)
- Cranial capacity 1350 cc
- 10000 years ago Agriculture, human settlement began.

NOTE
- A few fossils were obtained from Tanzania & Ethopia of East Africa revealing human like features indicating hominid like creatures probably lived 3-4 myo.
- They were probabily were not taller than 4 feet.

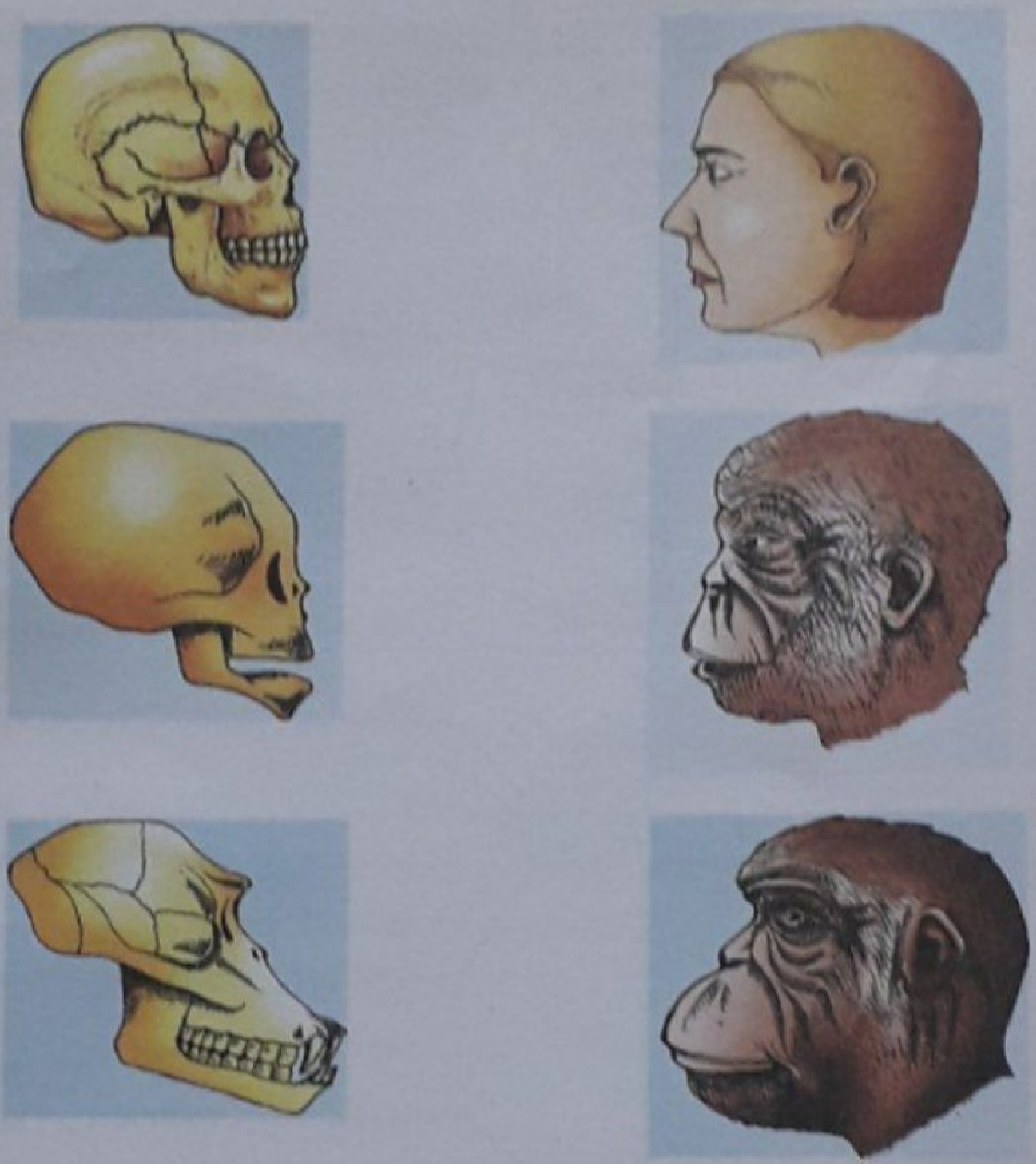


Fig. A comparison of the skulls of adult modern human being, baby chimpanzee and adult chimpanzee. The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull (Reveals about common ancestory)

13 Human Health and Disease

HEALTH

- Only absence of diseases is not considered as health.
- According to WHO complete physical, behavioural, mental & social well being of a person.

Good Humor Hypothesis:

Early Greeks like Hippocrates, Indian Ayurveda System of medicine considered health as a balance of certain 'Humors'.

Health means Balance of certain "HUMOR"

- Blood (Body fluid)
- Yellow Bile (By LIVER)
- Black Bile (By spleen & kidney)
- Phlegmn /Cough

It was thought that, people with BLACK BILE belonged to hot personality and would have fever.

NOTE William Harvey who discovered DOUBLE CIRCULATION DISPROVED THE GOOD HUMOR HYPOTHESIS, measured surface temperature using thermometer.

Health is affected by:

1. Genetic disorders - Deficiencies with which a child is born and inherits from their parents.
2. Lifestyle: Eating Habits, sleep, Personal Hygiene, Exercise, Yoga etc.
3. Infections: Disease causing agents: Bacteria, fungus, Protozoa etc.

DISEASES

Congenital Diseases
- Present since birth

eg: Down syndrome, sickle cell anemia

Acquired Diseases
- Gained during Life time

Communicable and infectious diseases
- Disease that spread from infected to healthy human beings & caused by various Biological agents. such as:
  - Bacterial disease: Typhoid, Pneumonia
  - Viral disease: Common cold, AIDS, Dengue, Chikungunya
  - Fungal disease: Ring worm
  - Helminth disease: Ascariasis, Elephantiasis
  - Protozoan disease: Malaria, Amoebiasis

Non-communicable and non-infectious diseases
- Disease which do not spread from infected to healthy person eg: Cancer, allergy etc.

NOTE

Vector: Carrier of Pathogens

Pathogen: Disease causing agents

Host: Where Pathogen lives & multiplies

1. BACTERIAL DISEASES:

NAME	CAUSATIVE AGENT	LOCATION	MODE OF TRANSMISSION	SYMPTOMS
1. Typhoid ○ Mary Mallon was a cook by profession and a carrier of typhoid & contaminated the food she cooked for several years, popularly Known as "TYPHOID MARY"	*Salmonella typhi* WIDAL Test : Confirmatory test for Typhoid	Small intestine	By contaminated food & water.	○ Sustained high fever of 39°C - 40°C. ○ Loss of Appetite ○ Weakness, weightloss ○ Headache, stomach pain and constipation ○ Intestinal perforation and death may occur in severe cases

NAME	CAUSATIVE AGENT	LOCATION	MODE OF TRANSMISSION	SYMPTOMS
2. Pneumonia	*Streptococcus pneumoniae, Haemophilus Influenzae*	Alveoli (air sacs of lung)	Infected droplets or Sharing things with infected person.	○ Fever, Headache, Breathing difficulty ○ Alveoli gets filled with fluid & proper exchange of air does not occur ○ Caughing, Chills ○ Lips, finger, nail may turn GREYISH to BLUISH (in severe cases)

NOTE

Plague, Diptheria, Dysentry are some other bacterial disease in human.

Causative agent

↓

- Plague: *Yersinia pestis*
- Diptheria: *Corynebacterium diptheriae*
- Dysentry: *Shigella* is a common bacteria causing this.

2. VIRAL DISEASES

NAME	CAUSATIVE AGENT	LOCATION	MODE OF TRANSMISSION	SYMPTOMS
1. Common cold (Rhinitis)	Rhinovirus	Upper Respiratory tract affected but not the infection of lungs	Infected droplets resulted from cough or sneezes or through contaminated objects	Headache, Fever, Running Nose, Tiredness, Sneezing, coughing, Hoarseness, Nasal congestion, nasal discharge The symptoms usually lasts for "3-7" days

2. DENGUE:

CAUSATIVE AGENT : Dengue Virus (RNA virus)
↓
'Arbo-virus'
↓
'Arthopod' Borne virus

VECTOR : (Mode of Transmission)
↓
Vehicle to carry the Pathogen

"♀ Aedes mosquito" bite infected person to take up the pathogen
↓
(Bites healthy human)

SYMPTOMS:

- → Headache
- → High fever
- → Joint pain, Body pain
- → Nausea, Vomiting
- → Pain around eye ball
- → Swollen Lymph nodes
- → Reduced Blood Platelets
- → Rashes appearence

Classical Dengue fever

Haemorrhagic Dengue Fever
↓ (Extreme)
Blood vessel rupture
↓
Internal bleeding

अतिरिक्त Gyaan

Treatment

- → Antipyretic (Painkiller suggested)
- → Fluid intake
- → Rest

Diagnosis:

1. Blood Test: Platelet count check
2. Torniquet test

3. CHIKUNGUNYA

CAUSATIVE AGENT: Chikungunya virus (RNA)
↓
(Arbo-virus)

VECTOR: (Mode of Transmission)
↓
'♀ Female *Aedes* mosquito'
↓
Bite infected person
↓
Pathogen taken up, then bites
↓
Healthy human

Symptoms:

- → Headache
- → Fever
- → Joint Pain (SEVERE)
- → Rashes

अतिरिक्त Gyaan

Diagnosis:

- → Blood test
- → RT-PCR (Real time reverse Transcriptase - Polymerase chain reaction)
- → Antibody-Antigen Test

Treatment

- ○ Painkiller
- ○ Fluids intake
- ○ Rest

PREVENTION OF MOSQUITO BORNE DISEASES LIKE DENGUE, CHIKUNGUNYA:

- ○ Avoid stagnant water
- ○ Wear full clothes
- ○ Mosquito-repellant cream application
- ○ Spread kerosene oil in the ponds, ***Gambusia*** fish is introduced that feeds on the mosquito larvae & prevent their breeding.

3. HELMINTH DISEASE

NAME	CAUSATIVE AGENT	LOCATION	MODE OF TRANSMISSION	SYMPTOMS
1. Ascariasis	*Ascaris* (Aschelminthes)	Small intestine	Eggs of parasite are released through the faeces & may contaminate the crops (sewage water agriculture), fruits, vegetable & then may infect a healthy person.	Muscular pain, fever, internal bleeding, Anaemic Condition, may cause blockage of intestinal passage.

NAME	CAUSATIVE AGENT	LOCATION	MODE OF TRANSMISSION	SYMPTOMS
2. Wuchereriasis/ Elephantiasis/ Filariasis	*Wuchereria bancrofti*, *Wuchereria malayi* (FILARIAL WORMS) (Aschelminthes)	Lymphatic vessel (Chronic inflammation over years)	Bite of (♀) Female *Culex* mosquito	○ Usually affects the lower body parts like leg, scrotum (Male) etc. ○ Inflammation of Lymphatic vessels & accumulation of lymph, blockage of lymphatic vessel ○ Swelling in the affected area ○ Dry, wrinkled skin like ELEPHANT

4. FUNGAL DISEASES

NAME	CAUSATIVE AGENT	LOCATION	MODE OF TRANSMISSION	SYMPTOMS
1. Ringworm	Many fungus belonging to genera *Microsporum*, *Epidermophyton*, *Trichophyton*	SKIN Specially groin (between skin folds), nail, hair	Using the towels, Clothes, Comb, Utensils of the infected person and can be acquired by soil as fungus is present in soil	○ Lesions (Damage) in the affected areas ○ Lesions followed by intensive itching ○ Dryness ○ Heat & moisture helps the growth of Fungus.

5. PROTOZOAN DISEASES

NAME	CAUSATIVE AGENT	LOCATION	MODE OF TRANSMISSION	SYMPTOMS
1. Amoebiasis (Amoebic dysentry)	*Entamoeba histolytica*	Large Intestine	Through contaminated food and water, HOUSEFLY act as a mechanical carrier	Abdominal pain, cramps, constipation stool with excessive MUCUS & Blood CLOTS

2. Malaria

Causative agent: *Plasmodium vivax*

Mode of Transmission: Bite of ♀ Female *Anopheles* mosquito (VECTOR)

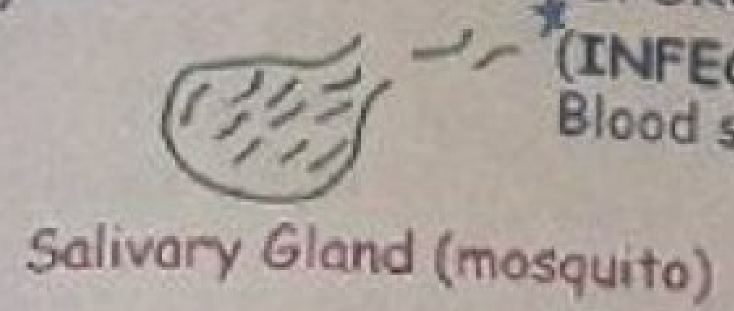
HOST: *Plasmodium* require two hosts to complete its life cycle (DIGENETIC PARASITE)

PRIMARY Host: Mosquito (sexual stage of Life cycle completed)

SECONDARY Host: Human (Asexual stage of life cycle completed)

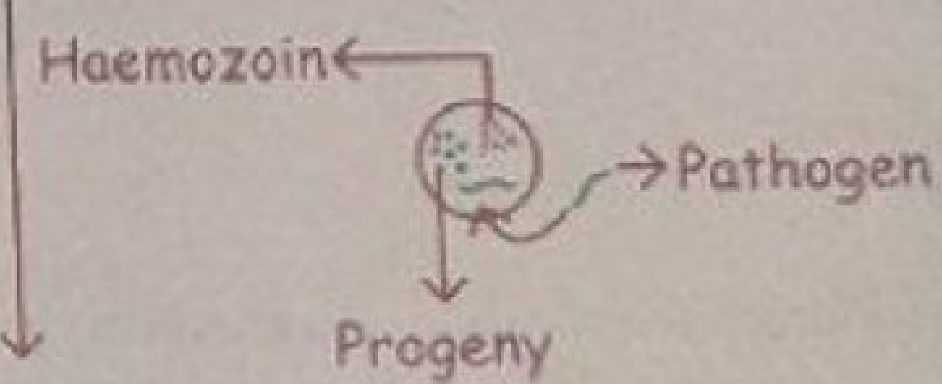
Life Cycle of Plasmodium

Mosquito bites healthy human → It releases 'SPOROZOITE' * (INFECTIVE STAGE) into Blood stream of Human → Through the blood stream, it enters into the "Liver" & Asexually divide (multiple fission), increase in number, Burst Hepatocyte, some re-enter Hepatocyte to infect again & mostly enter into the Blood stream



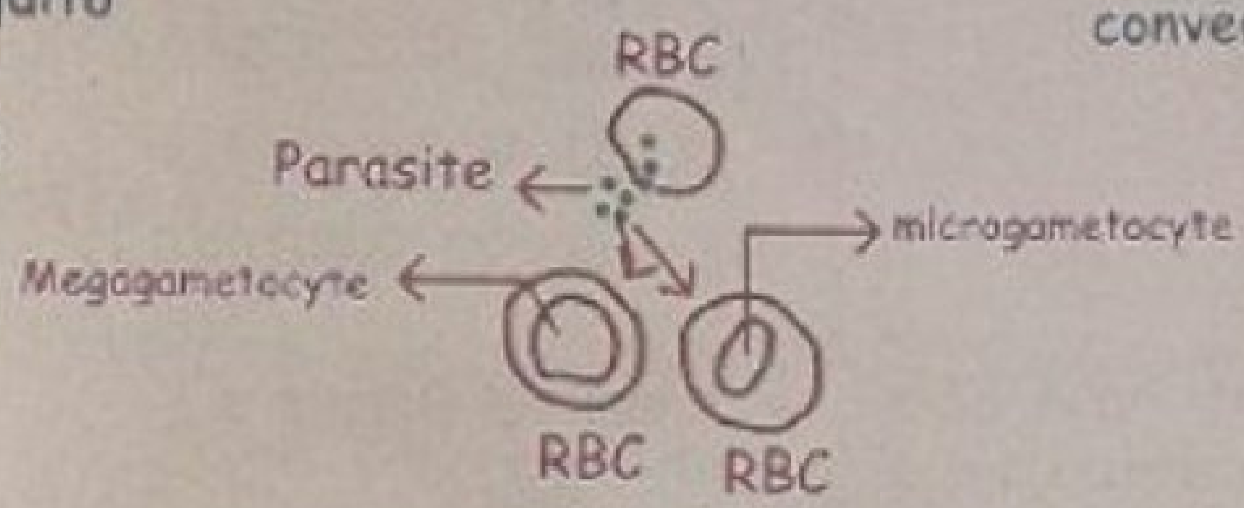
↓

It enters "RBC", asexually divides & ↑ progeny. Also, it feeds on haemoglobin, utilise the protein (globin) & "haem" converts into toxic "HAEMOZOIN"



↓

Now, it BURST RBCs, & parasite release into PLASMA, along with Haemozoin: responsible for "FEVER" ← It re-enters fresh RBC, & convert into 'MEGAGAMETOCYTE' & MICROGAMETOCYTE



← These Stages are uptaken upon bite of a Female *Anopheles* MOSQUITO

↑

Further inside the "MIDGUT", of mosquito "Megagametocyte" convert into ovum & 'microgametocyte' convert into sperm

↑

Sperm & ova fuses to form Zygote which further develops into Sporozoite stored in mosquito's SALIVARY GLAND

↑

Mosquito bites healthy human

a

Mosquito
↓
Sporozoites (Salivary gland)
↓
Blood (Human)
↓
Asexually divides ruptures hepatocytes (Liver)
↓
Released into blood
↓
(Enter RBCs) Asexually divides
↓
Ruptures RBC
↓
Haemozoin released (In blood plasma)
↓
Responsible for Fever
↓
Stages renters RBC
↓
Gametocytes formed (♀ and ♂)
↓
Uptaken by mosquito
↓
Zygote formed, that forms sporozoite
↓
Sporozoite reach salivary gland

NOTE

- *Plasmodium ovale, Plasmodium vivax, Plasmodium falciparum, Plasmodium malariae are various species of Plasmodium*
- *Plasmodium falciparum* causes deadliest 'MALIGNANT'/'CEREBRAL' Malaria which could be Fatal.

Prevention of the common diseases

- Keeping the body clean; consumption of clean drinking water, food, vegetables, fruits, etc. Public hygiene includes proper disposal of waste and excreta; periodic cleaning and disinfection of water reservoirs, pools, cesspools and tanks and observing standard practices of hygiene in public catering. These measures are particularly essential where the infectious agents are transmitted through food and water such as typhoid, amoebiasis and ascariasis. In cases of air-borne diseases such as pneumonia and common cold, in addition to the above measures, close contact with the infected persons or their belongings should be avoided.

IMMUNITY

- Ability of the body to fight the disease causing agents.

Immunity

① Innate immunity	② Acquired immunity
Present at the time of birth: Inborn Immunity	Gained during the life time: Adaptive immunity
Non-specific: Reacts in a similar way to all disease causing agents	Highly specific
No memory of previous encounter of infections	Has memory of previous encounter of infections

Innate Immunity: It is studied under 4 Barriers

- PHYSICAL BARRIERS ⎤ 1^{st} line of defence
- PHYSIOLOGICAL BARRIERS ⎦
- CELLULAR BARRIERS ⎤ 2^{nd} line of defence
- CYTOKINE BARRIERS ⎦

1. Physical Barriers

- Skin
- Mucus coating of GI tract (Gastrointestinal tract), Respiratory tract and urinogenital tract.
- Prevent Physical entry of disease causing agent.

2. Physiological Barriers:

- HCL in Stomach

- Lysozyme (ANTIBACTERIAL) in tears & SALIVA
- All these prevent microbial growth

3. Cellular Barriers:

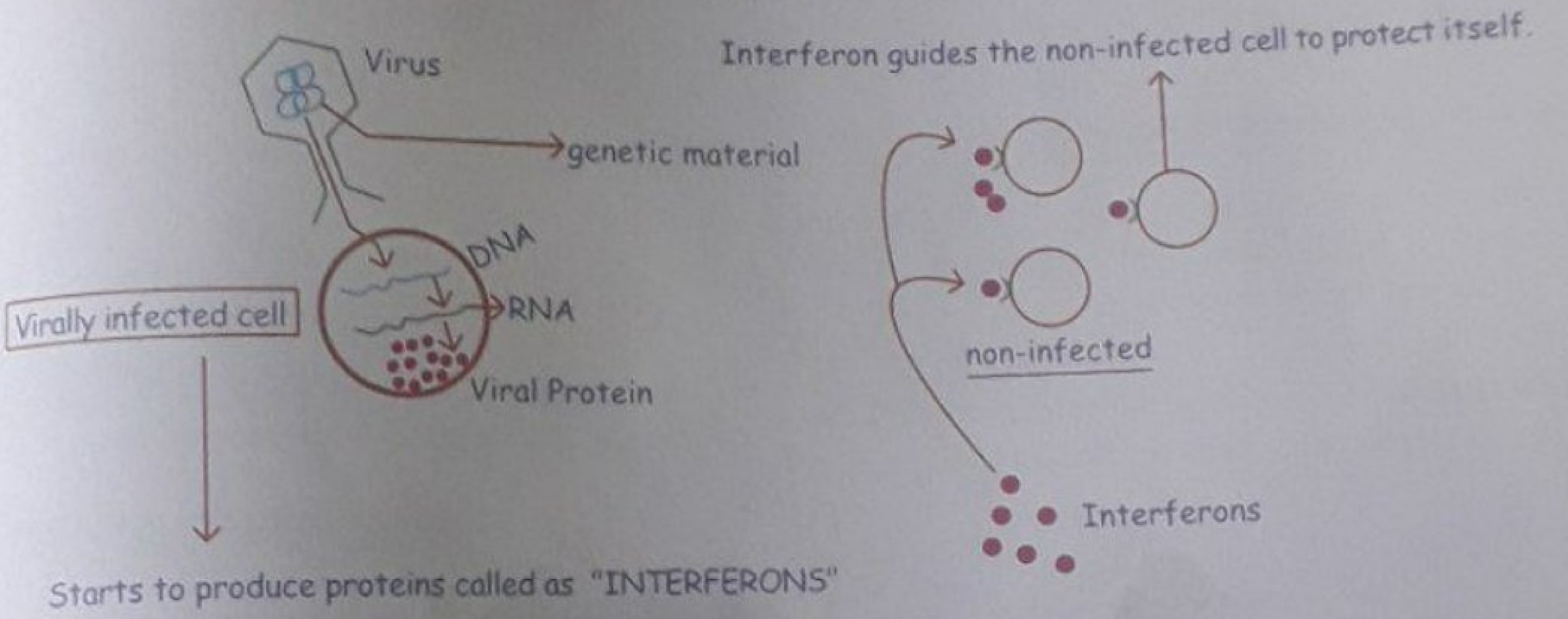
- Certain types of leucocytes (WBC) like Polymorpho-nuclear leucocytes (PMNL-neutrophils) and monocytes.
- Natural killer (NK) cells (type of lymphocytes)
- Macrophages (Phagocytose and destroy microbes)

4. Cytokine Barriers:

Some virally infected cell secretes **PROTEINS** called as interferons to protect the non-infected cell from viral infection.

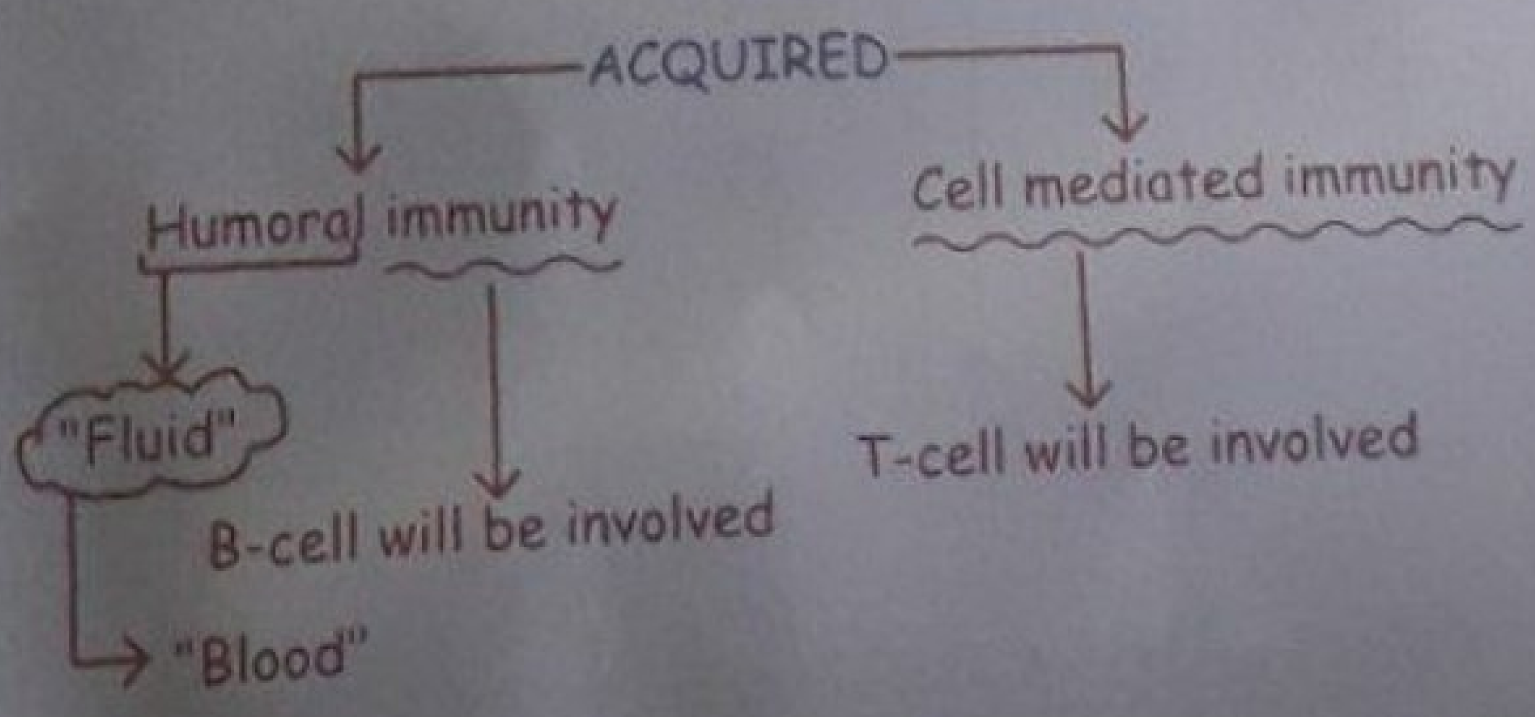
NOTE (Extra Gyaan) **CONCEPT OF INTERFERONS**

Interferons guides the non-infected cells to produce 'TIP' (translatory inhibitory protein) to stop translation (i.e. formation of viral protein) in normal cell, thus protect it.

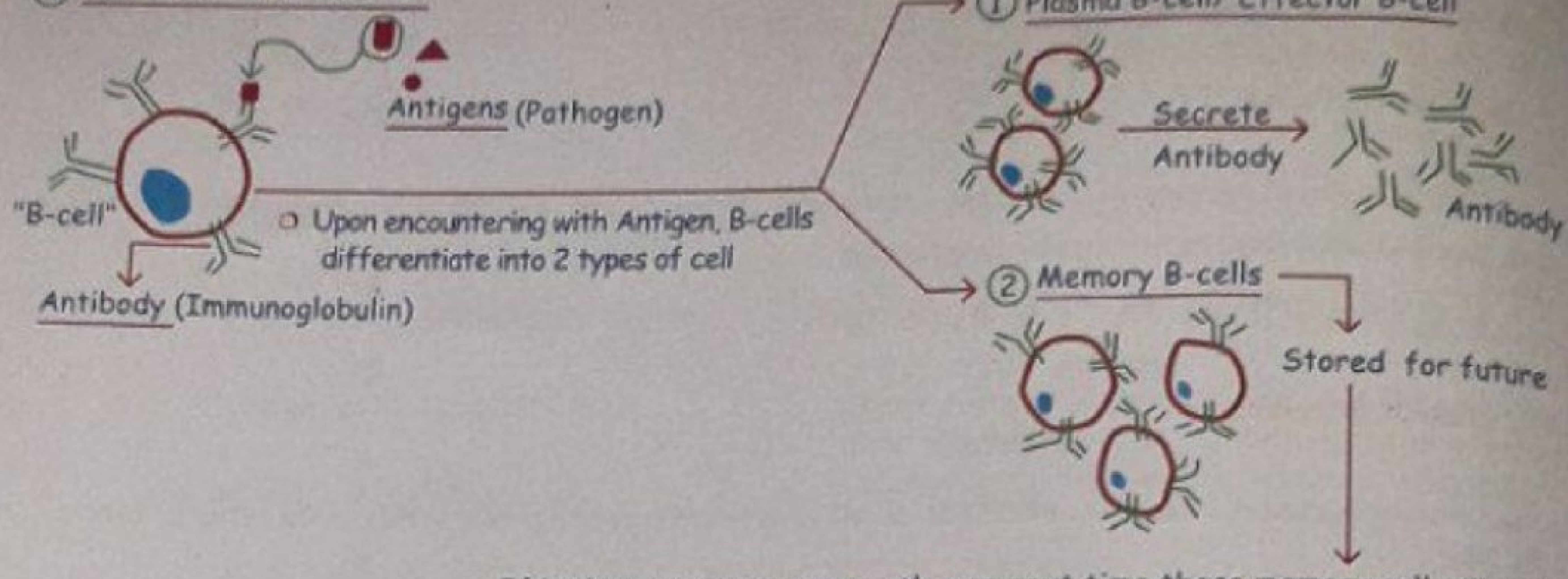


ACQUIRED IMMUNITY

- It is gained during the lifetime, highly pathogen SPECIFIC and characterised by MEMORY



① **HUMORAL IMMUNITY:**



If body encounters same pathogen next time these memory cell will work

Primary/ 1° Immune Response:

- When Body encounters pathogen for the first time, it takes time to respond & differentiate.
- Slow, Low intensity

Secondary/Anamnestic Response:

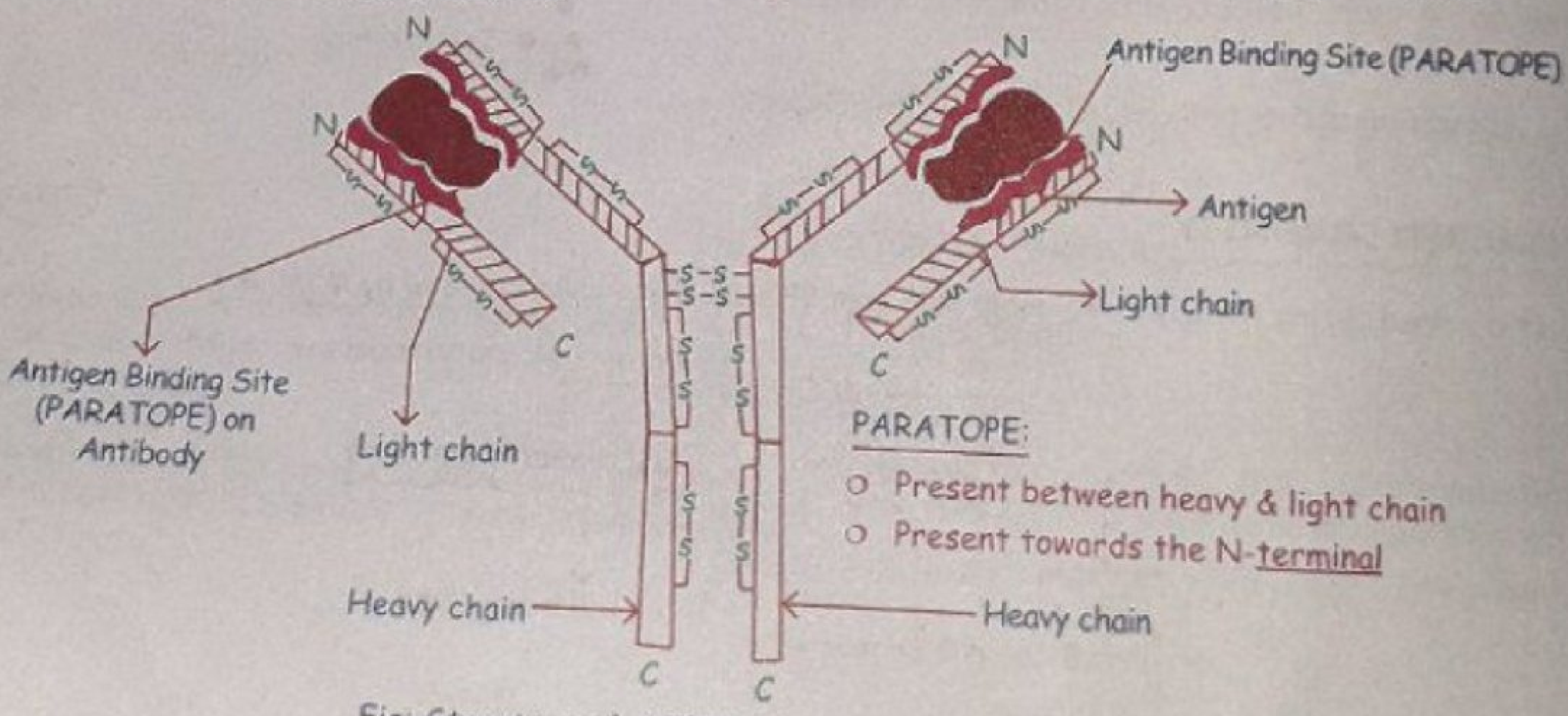
- Subsequent encounter with the same pathogen elicits a highly intensified response as it has memory of the first encounter.
- Fast, high intensity.
- **ANTIGEN:** Any foreign substance or particle which stimulate antibody production.

ANTIBODY:

- Antibody's nature is proteinaceous.
- Each Antibody is Represented by "H_2L_2"

H_2L_2
- 2 Heavy chains → Each weighing 50 KDa
- 2 Light chains → Each 25 KDa

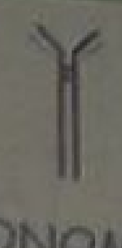
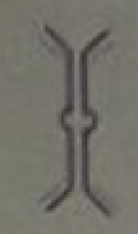
- Antibody is made up of 4 polypeptide chain



PARATOPE:
- Present between heavy & light chain
- Present towards the N-terminal

Fig: Structure of ANTIBODY/Immunoglobulins (Ig)

Types of Immunoglobulin

Name	Amount	Structure	Function
1. IgG	Maximum in amount ($\simeq$ 80%)	 MONOMER	Crosses placenta barrier
2. IgA	10 - 15%	 DIMER	Present in secretions like Saliva, mucus, colostrum
3. IgM	5 - 10%	 PENTAMER	Secreted in High amount during primary Immune response
4. IgE	(Less than 1%) ⟶ Least	 MONOMER	Secreted during Allergic reactions.
5. IgD	Less than 1%	 MONOMER.	Unknown function

② CELL MEDIATED IMMUNITY

T - cells

(i) T_H

- Helper T-cell
- These cell secretes chemicals which signals both B-cell to differentiate & T_C cells to perform

(ii) T_C

- Cytotoxic T-cell/Killer T-cell
- They have the potential to directly kill the pathogen

(iii) T_S

- Suppressor T-cell
- They suppress the T_C & T_H for regulated activity

(iv) Memory T - cell

- Stored for future

GRAFT REJECTION:

Before organ transplantation these must be matched

1. Blood group matching
2. Tissue matching/MHC matching (Major Histocompatibility complex)

Cells → On cells there are certain Glycoproteins called as MHC which of 2 types:

MHC → MHC I, MHC II

- Cell mediated immunity can recognize between self and non-self MHC
- ***When organ transplantation is done, MHC is matched.
- Once organ is transplanted, if there is any slight mismatching CELL MEDIATED IMMUNITY IS RESPONSIBLE for GRAFT REJECTION.

NOTE After graft transplant patient has to take immunosuppressant all his/her life

ACTIVE AND PASSIVE IMMUNITY

ACTIVE	PASSIVE
In Response to pathogen, body itself actively synthesise ANTIBODIES against it	Body Passively receives ANTIBODIES
Takes time to response	FAST response
EFFECT: Long lasting	EFFECT: Short term

ACTIVE IMMUNITY

Natural Active Immunity

When we naturally come in contact with disease causing agents, body synthesises antibodies against it.

Artificial Active Immunity

Vaccination is a good example of this, here inactivated and weakend pathogen are introduced into the body so that body makes antibody against it.

PASSIVE IMMUNITY

Natural Passive Immunity

- IgG crossing placenta, IgA in colostrum received naturally from mother to foetus/baby

Artificial Passive Immunity

- Ready made/preformed antibodies given to patients
  e.g., Anti-venom (Against snake venom), (required by SAPOLA BITE)
- ATS (Anti tetanus SERUM)

VACCINATION:

In vaccines whole organism either weakened or heat killed, protein of pathogen etc can be used in such a way that it does not cause disease but activates immune cells to produce antibodies. This results in **Immunisation**

Generation of Vaccines:

1st Generation vaccines

↓

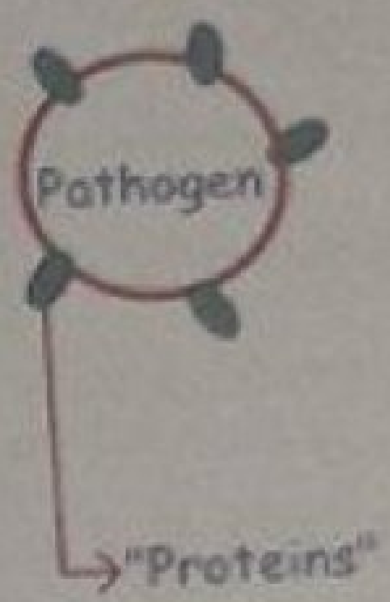
Whole Organism is used either
- → Killed
- → Live weak (Attenuated)

} eg: Small pox vaccine

2nd Generation vaccines

- → Recombinant Vaccine → The proteins toxin expressed on surface of pathogen is made using recombinant DNA technology inside yeast or Bacteria

  e.g. Hepatitis B Vaccine → In YEAST



- → **Toxoid**

  ↓

  Toxic substances secreted by pathogen is used as vaccine

3rd Generation vaccine : **DNA Vaccines**

Using recombinant DNA technology pathogen's DNA can be used as a vaccine

e.g., Hepatitis-B vaccine

ALLERGY:

The exaggerated **IMMUNE RESPONSE** towards ALLERGENS (allergy causing agents)

e.g., POLLEN, animal dander, mites in dust etc.

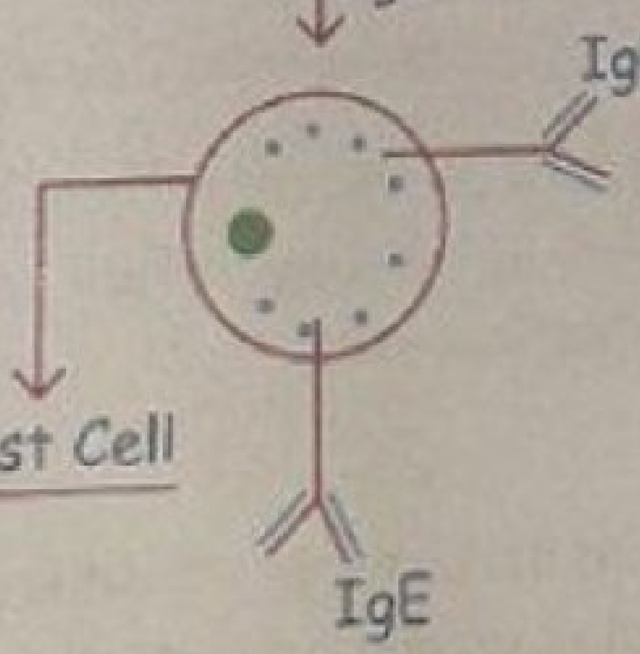
- During allergic reactions, "IgE" start to increase in number & is synthesised from plasma B-cell.
- When allergen enters for the first time, it binds to the Ig on B-cells & it produces IgE.
- IgE in turn Binds to **MAST CELL** as well as **BASOPHILS** to sensitise it

Allergen enters

↓

IgE from B-cell ↑

↓ IgE Bind



Sensitise mast cell

- Upon next exposure of allergen

  ↓

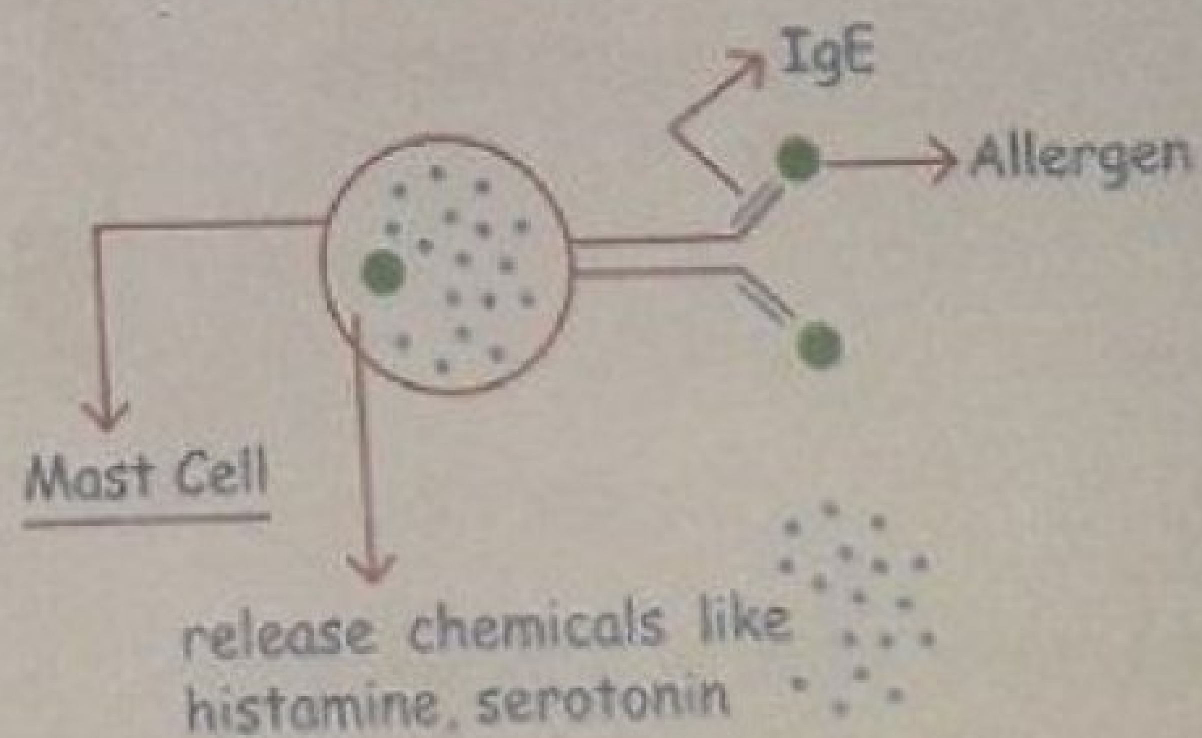
  Allergen reacts with sensitise mast cell

  ↓

  Mast cell release Histamine, Serotonin

  ↓

  Allergic reaction



Symptoms: Sneezing, watery eyes, running nose, difficulty in breathing

To reduce the symptoms of Allergy, drugs used are:

- Antihistamine
- Epinephrine/adrenaline
- Steroid (Cortisol)

Examples

- **Hay fever:** Allergic reaction due to pollen
- **Asthma:** It is spasm (wider contraction) in smooth muscles of bronchi & bronchioles

NOTE

Modern day life style has resulted in lowering immunity and more sensitivity to environment.

Autoimmunity

Our immune system (acquired) has the property to discriminate between self & non-self cells but when this power is lost due to genetic or other unknown reason & our immune cells start attacking own body cells, we suffer from AUTO-IMMUNE DISORDER.

e.g.: Myasthenia gravis, graves disease, Rheumatoid arthritis.

LYMPHOID ORGANS

Organ where origin and or maturation and proliferation of lymphocytes occur.

Lymphoid organs

Primary Lymphoid organs

- Lymphoid organs where production as well as maturation of Lymphocytes takes place.
  e.g. Bone marrow: B-cell & T cell produced & B-cell also matured
  Thymus: T-cell maturation

Secondary Lymphoid Organs

- These are the sites where lymphocytes encounter the pathogen.
  (ANTIGEN - ANTIBODY INTERACTION)

EXAMPLES

- Spleen
  - → Bean shaped
  - → Contain lymphocytes and phagocytes
  - → Acts as a filter of blood by trapping blood borne microorganism
  - → Reservoir of erythrocytes
- Tonsils,
- Appendix
- Peyer's patches (Lymph Nodes of Small Intestine)
- MALT (Mucosa-Associated Lymphoid Tissue)
  ↳ It makes up 50% of the entire lymphoid tissue present along mucus lining of Respiratory tract, GI-tract (gastro-intestinal etc).
- Lymph nodes
  - → Small solid structures at different point along Lymphatic system
  - → Trap pathogens present in lymph

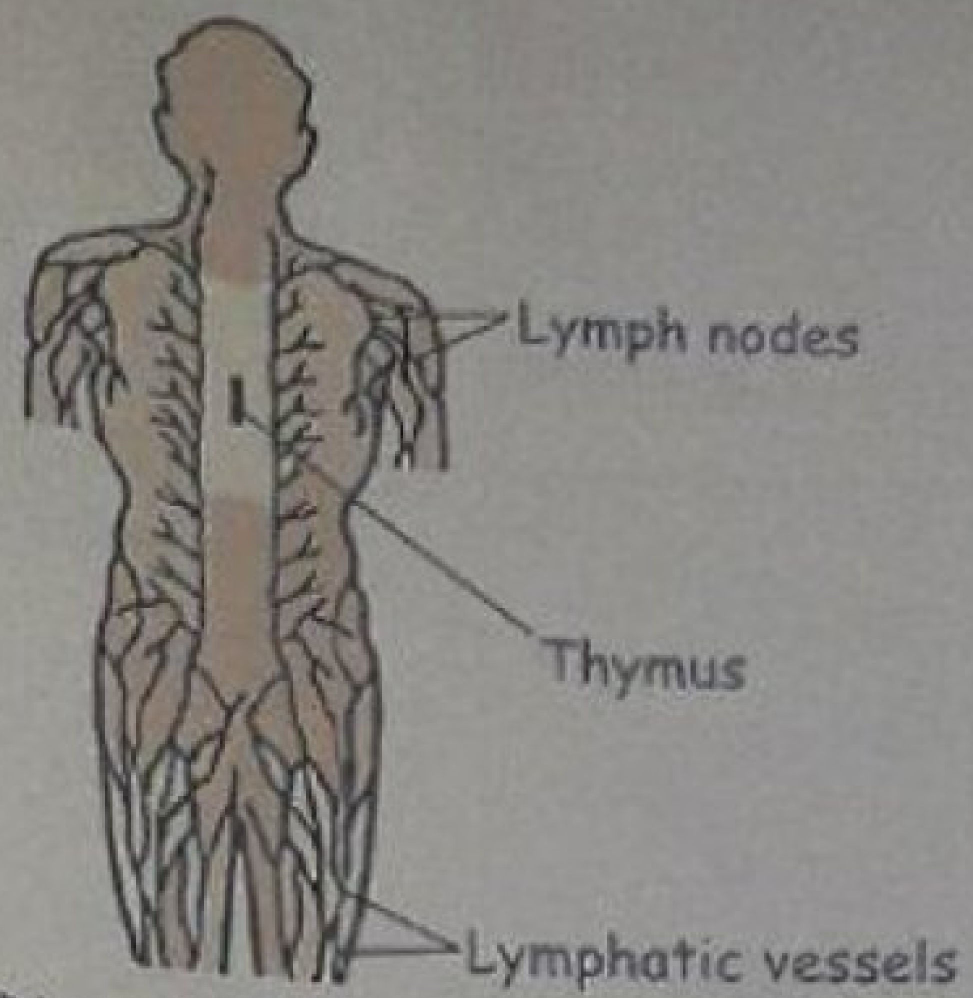


Fig: Diagrammatic representation of Lymph nodes

AIDS: (**Acquired** **Immunodeficiency** **Syndrome**)

- Acquired — gained during lifetime
- Immunodeficiency — Immune system weak
- Syndrome — Group of symptoms

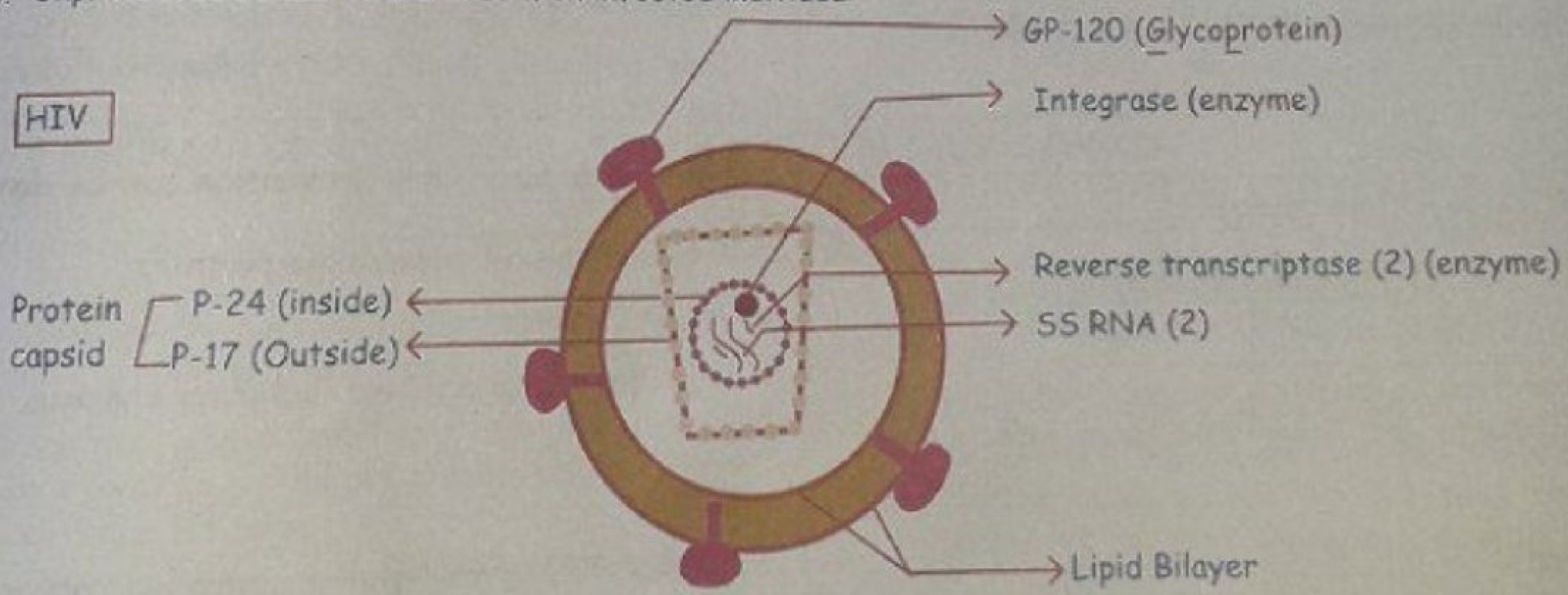
Causative Agent : HIV(Human Immunodeficiency virus)
→ RETROVIRUS (RNA)

- AIDS was first reported in 1981 in homosexuals.

Mode of Transmission :

1. From infected pregnant mother to foetus.
2. From infected Blood Transfusion.
3. From infected needles/syringes
4. Unprotected sexual intercourse with infected individual

HIV



NOTE GP-120 Binds to CD_4 (Cluster of Differentiation) on T_H and Macrophage to insert the genetic material

Replication of HIV

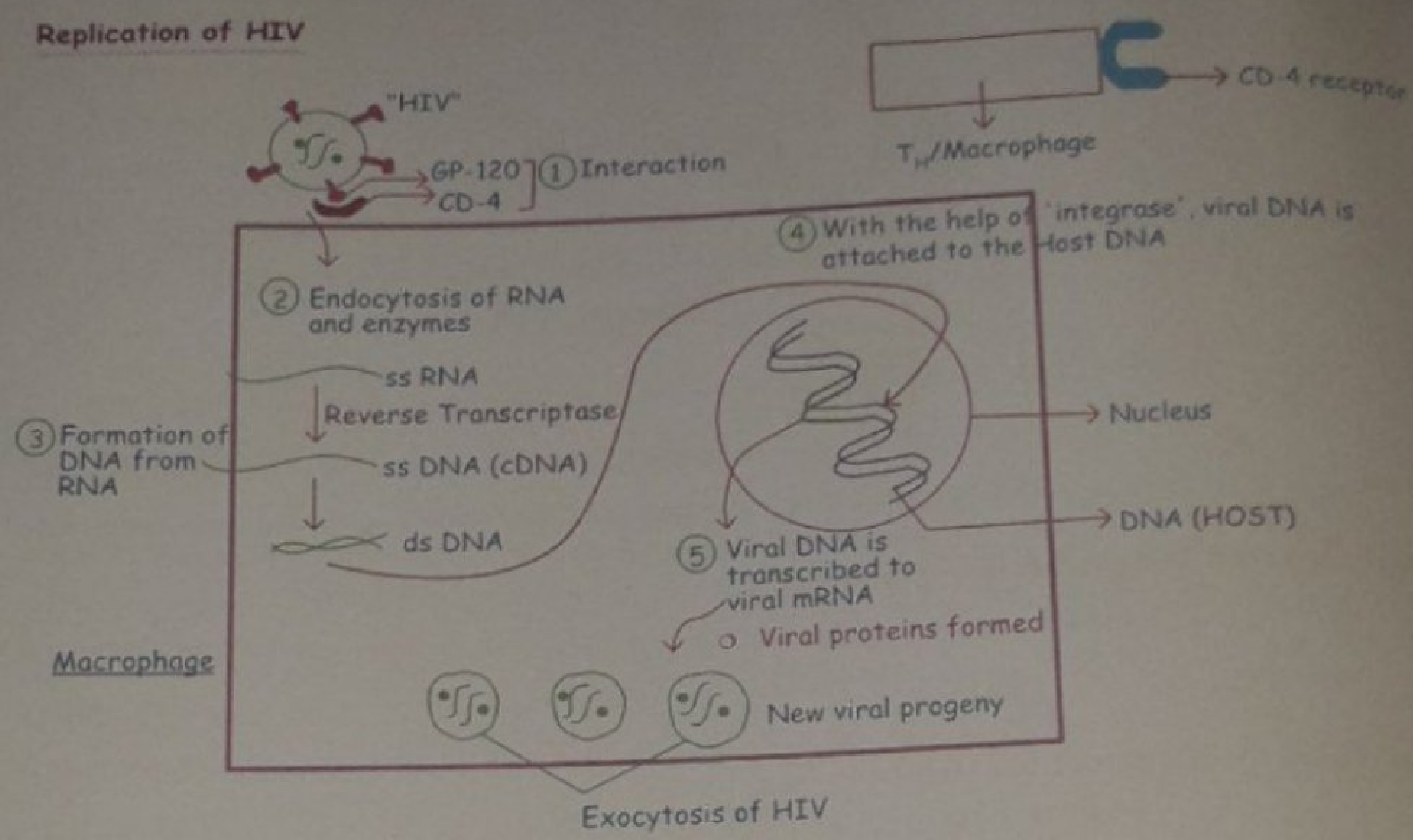


Fig: Macrophage (HOST Cell)

NOTE

- Macrophage acts as a factory of HIV where it replicates in HUGE amount.
- T_H (Helper T - Lymphocytes) cells are simultaneously attacked hence their number reduces from 1200/mm^3 Blood to 200/mm^3

T_H → Reduces → Immunodeficient →

Opportunistic infection may occur e.g., *Mycobacterium*, *Toxoplasma*, Fungal infection etc

NOTE

- World AIDS Day: 1 December.

अतिरिक्त Gyaan: Confirmatory test "Western Blotting".

Treatment:

- Treatment of AIDS with anti-retroviral drugs is partially effective
- They can prolong the life of the patient but cannot prevent death, which is inevitable.

Prevention & cure: Only prevention can be done

- Avoid multiple/unknown sexual partners
- Use of Condoms
- If in doubt go to qualified doctor for check up

NOTE

- Several NGOs (Non-Governmental organisations) & NACO (National AIDS Control Organisation) are doing a lot to educate people about AIDS

- WHO has started a number of programmes to prevent the HIV infection, which includes:
  - → Making blood (from blood bank) safe from HIV
  - → Use of disposable needles & syringes
  - → Free distribution of condoms
  - → Advocating safe sex and promoting regular checkup for HIV in susceptible population
  - → Controlling drug abuse

Diagnosis:

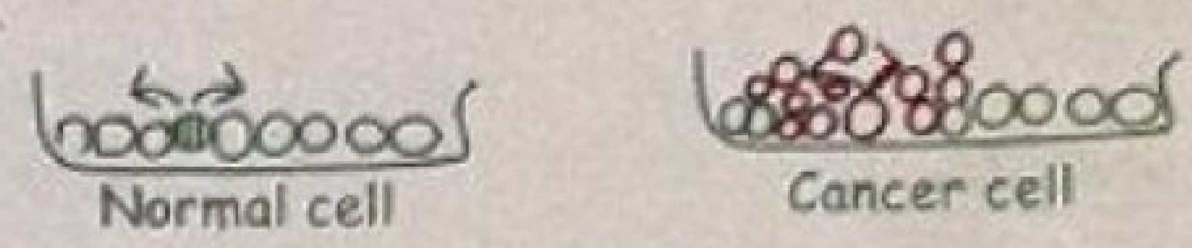
- There is a time lag between infection & appearance of symptoms which vary from a few months to years.
- A widely used diagnostic test for AIDS is 'ELISA' (Enzyme Linked Immuno Sorbant Assay).
- PCR can also be done when virus is less

CANCER

One of the most dreaded disease causing deaths all across the world.

PROPERTIES OF CANCER CELL:

1. Cancer cells shows uncontrolled, unregulated cell division
2. Cancer cells lose the property of contact inhibition: does not stop dividing upon contact with neighbouring cells.

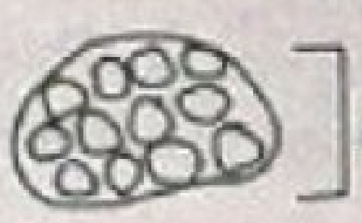


3. They are immortal: Natural cell death (apoptosis) is not seen.

Types of Tumor

BENIGN TUMOR

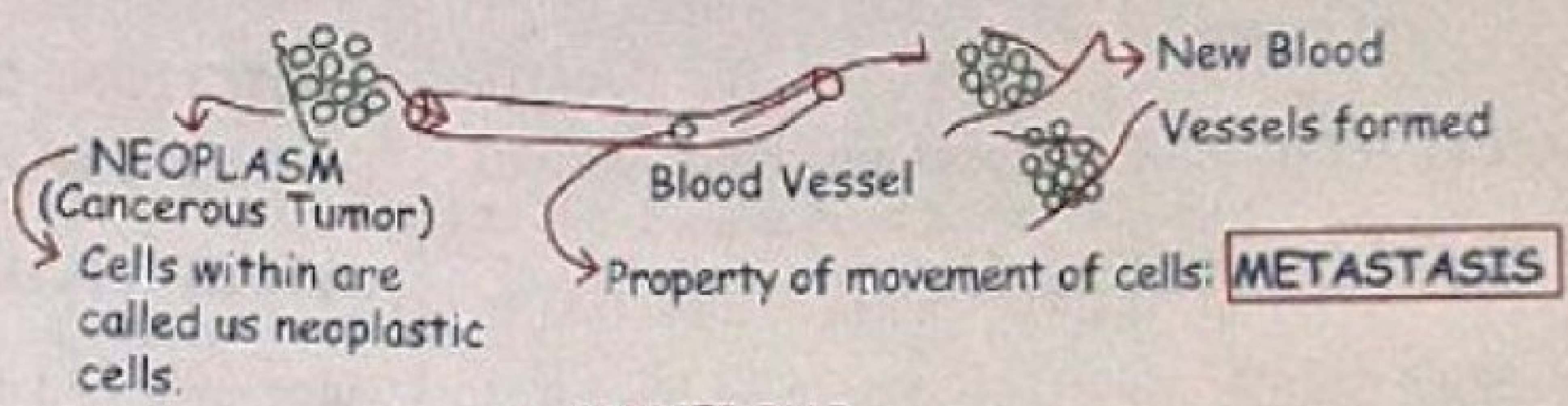
- Mass of cell localised at a place



- Non cancerous

MALIGNANT TUMOR

- The mass of cell which has the potential to move from one place to another



- CANCEROUS

NOTE **Cancerous cells enter new place where new blood vessels are formed & compete with normal cells for nutrition.**

BREAKDOWN OF WHICH REGULATORY MECHANISM CAUSES CANCER?

GENES

Cellular oncogene/c-oncogenes/ Proto-oncogenes

- These are the normal genes present in an individual that controls normal cell growth, cell division and cell differentiation
- C-oncogenes $\xrightarrow{\text{"Carcinogens"}}$ "Oncogenes" (activated) → Cancer causing

TUMOR SUPPRESSOR GENES

- They act as check points between $G_1 \rightarrow S \rightarrow G_2 \rightarrow M$ & if the cell are abnormal they donot further undergo division but once these genes are mutated, Cancer may develop

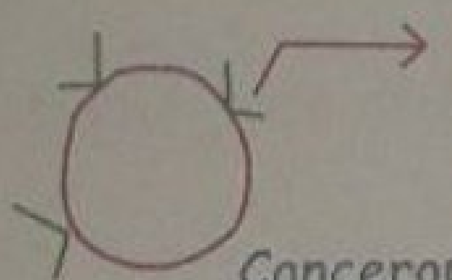
CAUSES OF CANCER:

Carcinogens: **Cancer causing agents**

1. Physical agents: Radiations like x-rays, y-rays (Ionising rays) & non-ionising (UV rays)
2. Chemical agents: Cancer causing chemical like the one present in tobacco etc.
3. Biological agents: Cancer causing viruses like HPV(Human papilloma virus), HBV contain viral oncogenes.

DIAGNOSIS

1. *Histopathology* & Biopsy: Tissue sections are taken & observed under microscope after staining to understand any abnormality.
2. CT SCAN: COMPUTED TOMOGRAPHY
   x-rays used to obtain 3D image of organs.
4. *MRI*: MAGNETIC RESONANCE IMAGING: Uses strong magnetic field to obtained 3D image of organs
   ↓
   SAFEST TECHNIQUE as it uses non ionising radiation
5. Blood & Bone marrow Test
6. Antibody test



Different protein expressed on cancer cell against which antibody is given for testing

Cancerous cell

7. Identification of genes: "Pre-diagnosis"
   If cancer runs in the family, genes of suspected person can be studied for pre-diagnosis.

Treatment:

1. Surgical method: Remove the tumor via surgery
2. Radiotherapy: Radiations are used to destroy the target cell.
3. Chemotherapy: Heavy chemicals/drugs are used for this treatment & it shows side effects like Hairloss, anaemia and weakness etc.
4. Immunotherapy: Sometimes our own immune system does not work against tumor/cancer. '**α-interferons**': Biological response modifiers are given to activate the Immune cell Like NK (natural killer) - cells to work against cancer.

DRUGS AND ALCOHOL ABUSE

It has been observed that the use of drugs has increased especially among youth. This is a matter of concern, as it could cause many harmful effects.

ADDICTION: Continuous presence of anything is needed in the body.

Children between '12-18' years are most vulnerable (Adolescence) to addiction

Drugs

1. Tranquilizers
2. Opiate Narcotics
3. Stimulants
   - Coca alkaloid
   - Amphitamines
   - Tobacco
4. Hallucinogens

a

1. TRANQUILIZER:

- Suppresses CNS (Central Nervous system)
- Bring Calmness
- Promotes sleep
- Anaesthetic

Example: Benzodiazepines, Barbiturates

CLINICAL IMPORTANCE

- Antianxiety
- Treat insomnia (sleeplessnes)
- Anaesthetics

2. OPIOIDS: (OPIATE NARCOTICS)

RECEPTORS: Specific opioid receptors are present in Central nervous system (CNS), GI tract (Gastrointestinal tract)

Examples

- 'Morphine' which is extracted from the latex of POPPY PLANT - *Papaver sominiferum*

Heroin:

- Commonly called as "SMACK"
- It is formed by diacetylation of morphine
- It is WHITE, CRYSTALLINE, BITTER, ODOURLESS
- It is usually taken intravenously or SNORTED.

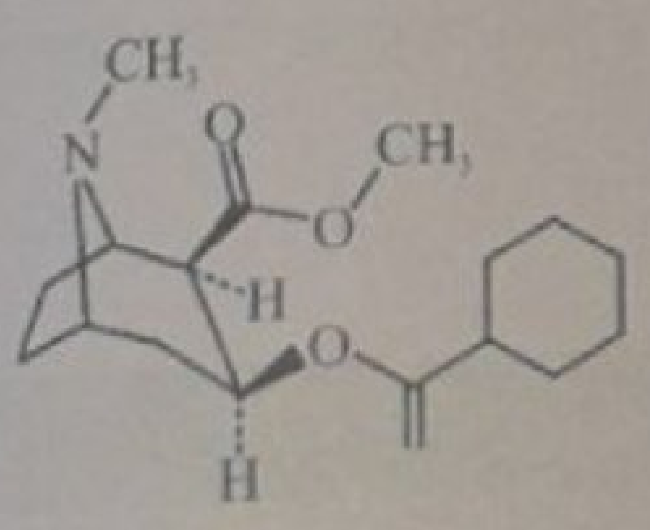


Fig. Chemical Structure of Morphine

Fig. *Opium poppy*

NOTE

- These Drugs are 'DEPRESSANTS'
- Used as SEDATIVE, analgesic (pain killer)
- Euphoric (Feeling of HAPPINESS)

3. STIMULANTS

(i) Coca alkaloid/cocaine

- Coca alkaloid or cocaine is obtained from *Exythroxylum coca*, native to South America
- Cocaine, commonly called "crack" or "coke" is usually snorted.
- It interferes with the transport of the "DOPAMINE" → Neurotransmitter

Functions

→ ↑alertness, ↑activity
→ Euphoric
→ Excessive dosage may cause "HALLUCINATION". (Distorted sense of reality)

(ii) Amphitamines:

- Synthetic Drugs → Artificially made
- Increases alertness, increases activity
- Cause SLEEPLESSNESS
- Commonly misused by SPORTSPERSON.

(iii) Tobacco

- It is been consumed since 400 years.
- It contains a chemical "NICOTINE"
- It is consumed in different ways: chewed, smoked or used as a SNUFF.
- Tobacco is the cause of various problems like:

  Emphysema, Bronchitis, Gastric ulcer, Lung cancer, Urinary bladder cancer, Oral cancer, CAD (coronary artery disease)
- Tobacco causes increased concentration of 'CO' in blood which has 200-250 times more affinity for 'Hb' than O_2 that is why in these people, 'OXYHAEMOGLOBIN' concentration reduces.
- Tobacco smoking stimulates Adrenal gland to release: Epinephrine, Norepinephrine: Heart Rate increase, Cardiac output increases.

4. HALLUCINOGENS

1. Cannabinoids : (Hallucinogenic): Causes Psycosis

Pscychosis
↳ DISTORTED SENSE of reality

- Receptors are principally present on "Brain"
- Obtained from the Plant '*Cannabis sativa*' (Flower tops, leaves and resins are combined in various way to obtained the drug)

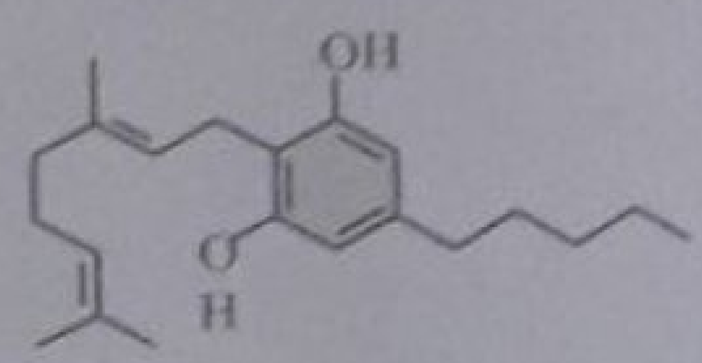


Fig: Skeletal structure of cannabinoid molecule

Fig: Leaves of canabis tannavis Staiva

Example:

Marijuana, Hashish, charas and ganja
↓

- Can be smoked or take orally

** Cannabinoids are well known for their effect on cardiovascular system (increases heart rate)

- Nowadays abused by sports person

NOTE

- Other well-known plants with hallucinogenic properties are *Atropa belladona* and *Datura*

Fig: Flowering branch of *Datura*

- LSD (lysergic acid diethyl amide) obtained from *Claviceps purpurea*: hallucinogen
  - *Claviceps purpurea* → "Fungus"
  - hallucinogen → most potent hallucinogen

ANABOLIC STEROIDS: (Synthetic Drugs)
↓
often misused by sportsperson are a testosterone derivative

Side Effects of anabolic steroids:

Females	Males
Masculinisation (features like males)	Acne
Increased aggressiveness	Increased aggressiveness
Mood swings	Mood swings
Depression	Depression
Abnormal menstrual cycles	Reduction of size of the testicles
Excessive hair growth on the face and body	Decreased sperm production
Enlargement of clitoris, deepening of voice	Potential for kidney and liver dysfunction
	Breast englargement
	Premature baldness
	Enlargement of the prostate gland

Alcohol:

- Absorbed from GI tract (mainly stomach).
- Depresses CNS.
- Excessive alcohol consumption may cause:

→ Cardivascular disorders

→ CIRRHOSIS

→ Chronic Liver Damage

↓

Liver tissues replaced by fibres (Fibrosis)

- During pregnancy, alcoholism may lead to abnormality in foetal developement.

WITHDRAWAL SYNDROME

- Once an addicted person is abruptly stopped from consuming drugs, they show symptoms like: Agressiveness, Sweating, Nausea, Shakiness. called as withdrawal syndrome

Prevention and control (Drugs and alcohol abuse)

- Avoid undue peer pressure
- Education and counselling
- Seeking help from parents and peers
- Looking for danger signs
- Seeking professional and medical help

14 Biotechnology: Principles and Processes

INTRODUCTION

Biotechnology: Living technique

Biotechnology: Techniques of using live organisms or enzymes from organisms to produce products and processes useful to humans.

The European Federation of Biotechnology (EFB) has given a definition of biotechnology that encompasses both traditional view and modern molecular biotechnology. The definition given by EFB is as follows:

'The integration of natural science and organisms, cells, parts thereof, and molecular analogues for products and services'.

Old Biotechnology	Modern Biotechnology
Conventional techniques of using living organisms for products.	Genetically modified organism (GMO) used for product and services
e.g., Curd, Dosa, Wine, Bread, etc.	e.g., IVF, gene therapy, Test tube baby, and vaccine, etc.

What is GMO?

- Genetically modified organism are those whose genes have been manipulated.

Principles of Biotechnology

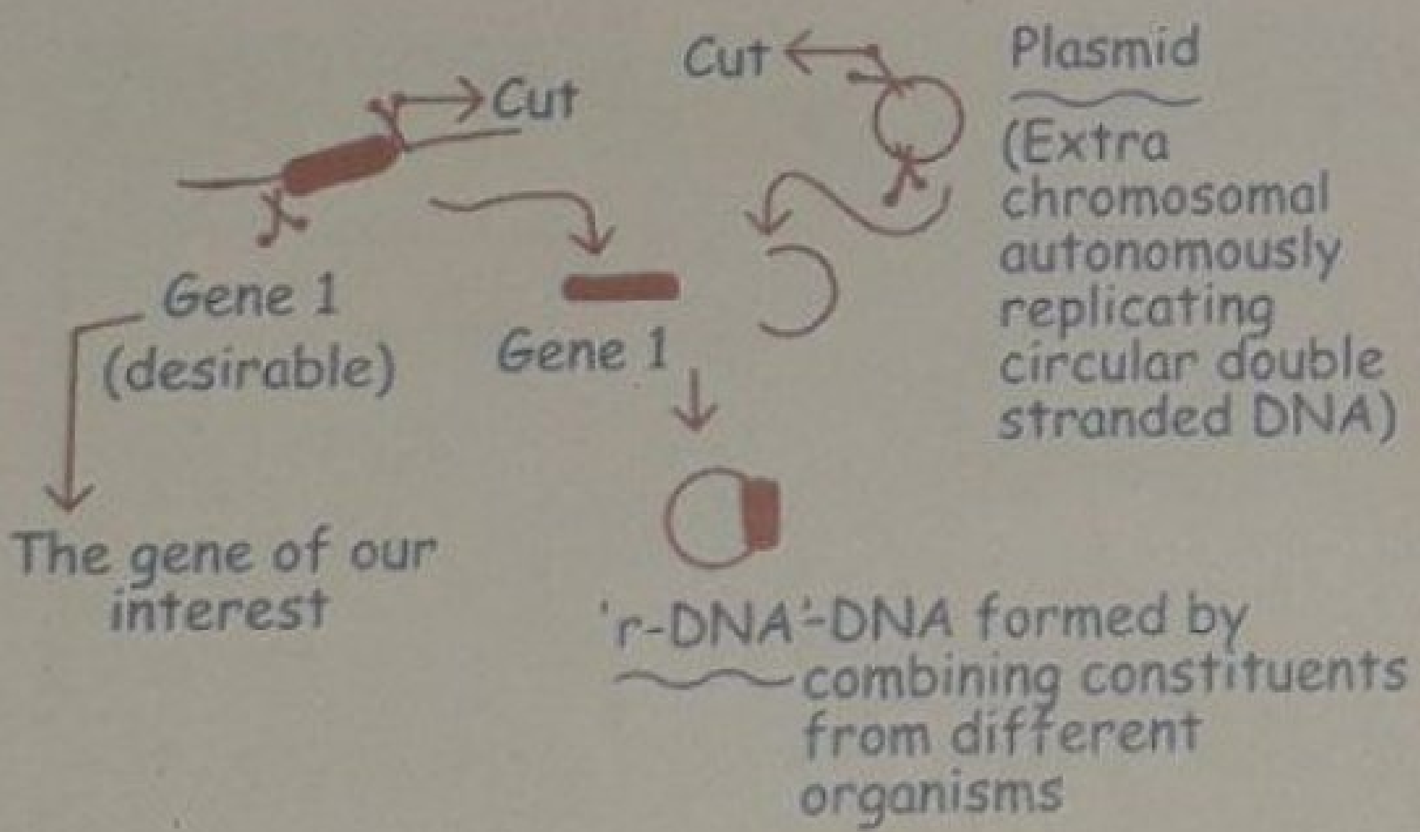
Genetic Engineering: Technique to alter the chemistry of genetic material, introduce into host.

Include creation of:
- Recombinant DNA (rDNA)
- Gene transfer
- Gene cloning

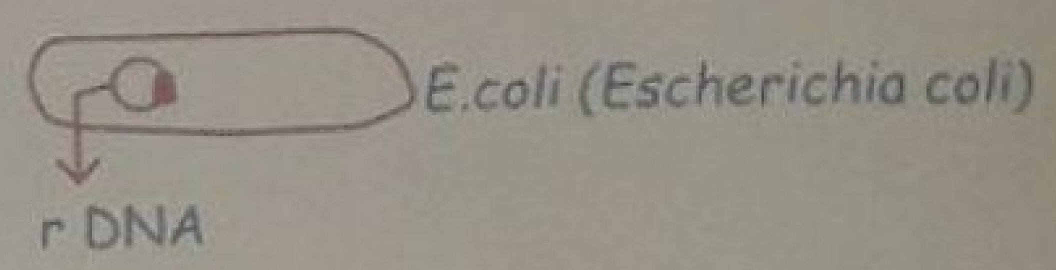
Bioprocess Engineering/ (Chemical enginnering)
- To maintain a STERILE Condition to avoid unnecessary contamination.

Genetic Engineering

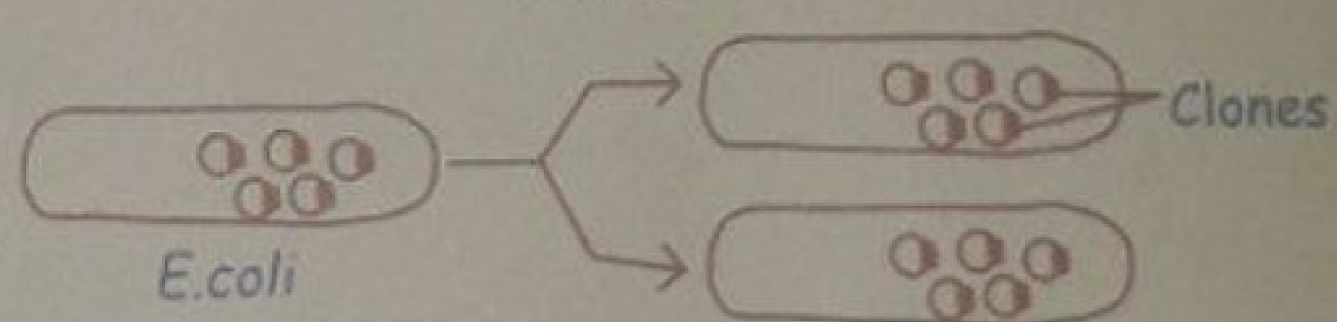
(1) Constructing a rDNA (Recombinant DNA)



(2) Gene transfer : DNA is now transferred into the host → for e.g. E.coli (Escherichia coli)



(3) Gene Cloning: Multiple copies of the gene are formed



- All this is explained in detail later in this chapter.

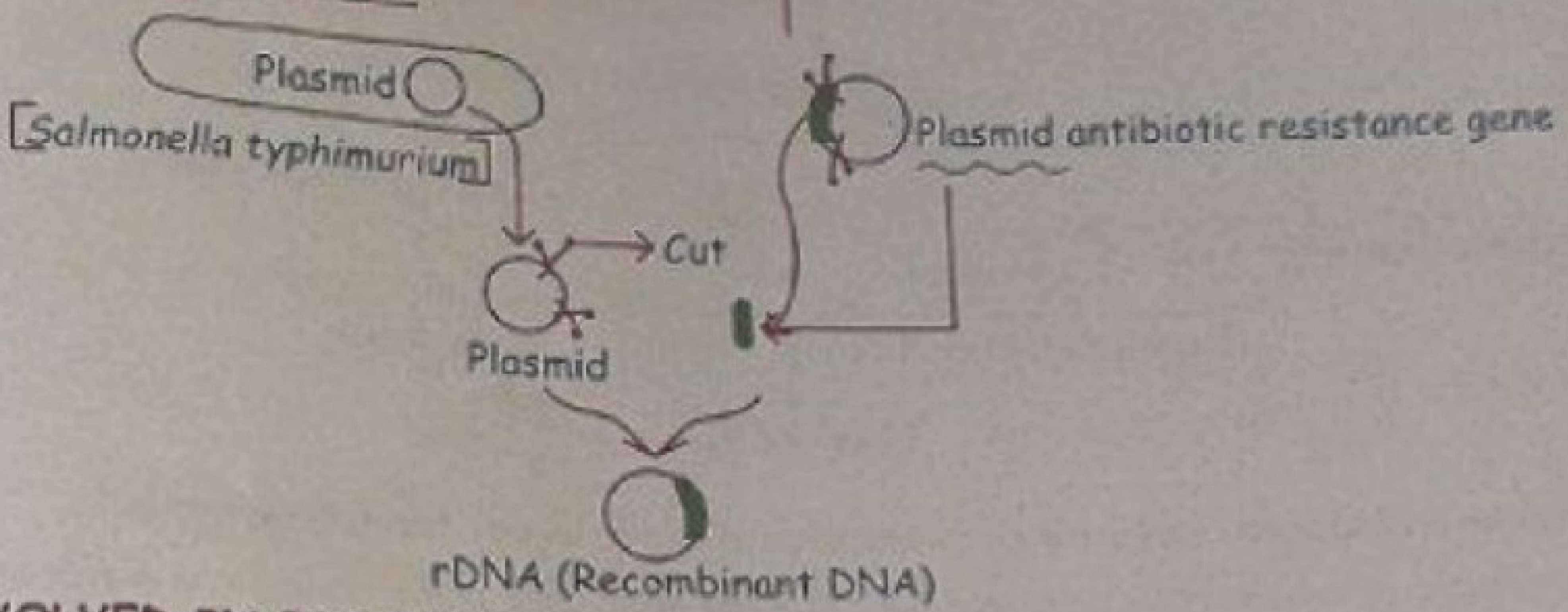
Traditional hybridisation vs Genetic Engineering

- In traditional hybridisation, DESIRABLE as well as NON-DESIRABLE genes were included unlike genetic engineering where only desirable genes can be utilised.
- This became feasible with the discovery of Restriction enzyme (molecular scissor)

How the first rDNA was constructed?

- In the year **1972**, first rDNA was constructed by **Stanley Cohen & Herbert Boyer.**
- They achieved this by:

Linked the native Plasmid of *Salmonella typhimurium* + An antibiotic resistance gene from a different plasmid → rDNA (Recombinant DNA)



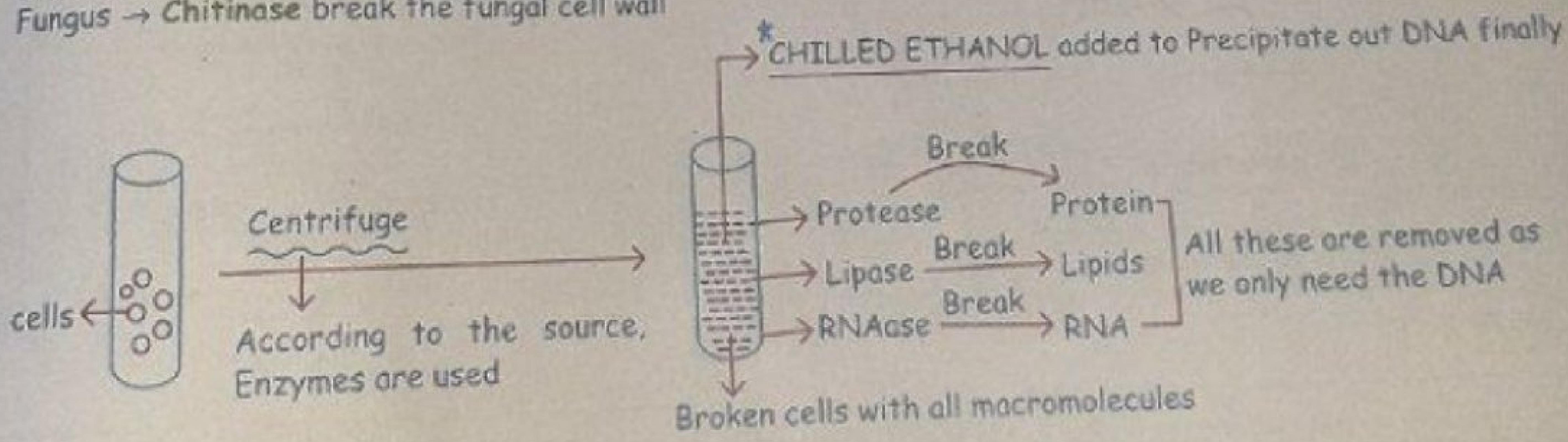
STEPS INVOLVED IN BIOTECHNOLOGY

1. Identification & isolation of GENE/DNA
2. Cutting/Fragmentation of DNA using restriction enzyme
3. Separation of the desirable fragments using GEL ELECTROPHORESIS
4. Amplification of the gene using PCR (Polymerase Chain reaction)
5. Linking of gene with vector
6. Transfer into the host
7. Culture of the host cells in medium on a large scale (By using bioreactors).
8. Downstream processing of products

1. ISOLATION OF GENETIC MATERIAL:

To isolate the DNA, first the cell needs to be broken.

Plant → **Cellulase** is required to break cellulose in the cell wall.
Bacteria → **Lysozyme** break the bacterial cell wall
Fungus → **Chitinase** break the fungal cell wall



NOTE

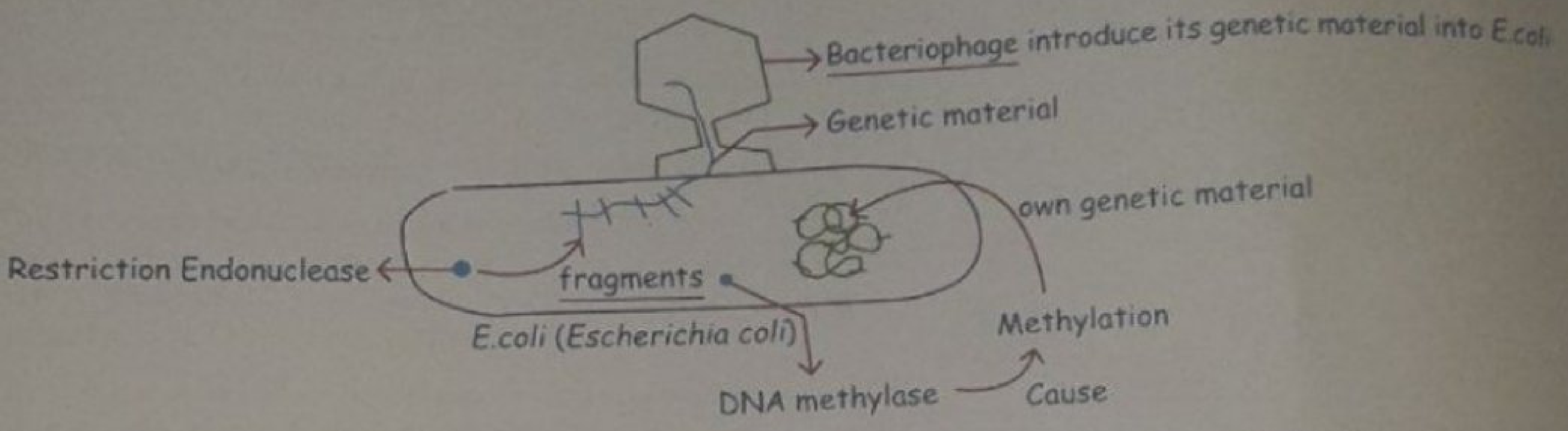
- From the solution, after adding chilled ethanol, DNA ultimately precipitates out and seen as fine threads called as SPOOLING.

2. FRAGMENTATION of DNA using restriction enzyme

Restriction enzymes:

History: In 1963, 2 enzymes were discovered from *E. coli* (*Escherichia coli*).

1. One which added methyl group to its own DNA to protect itself: DNA methylase.
2. Restriction endonuclease that cleaves the DNA of the Bacteriophage



- Basically, restriction endonuclease cleaves the genetic material of bacteriophage, basically restricting it.
- But *E.coli*'s own genetic material is protected using DNA methylase which adds methyl group to its own DNA.

NOTE

Till date, more than **900 restriction enzymes** have been isolated from **230 strains** of bacteria.

Restriction Enzymes (RE): Belongs to a larger classes of enzymes called **Nuclease** → cleave nucleic acid

- ENDONUCLEASE
- EXONUCLEASE

NAMING OF THE RESTRICTION ENZYME:

E co R I

- E → First letter → genus name → *Escherichia*
- co → Next 2 letter → Species → *coli*
- R → Strain
- I → Roman no : Represents ORDER of Isolation

NOTE

The first restriction endonuclease **Hind II** was isolated & characterised 5 year later

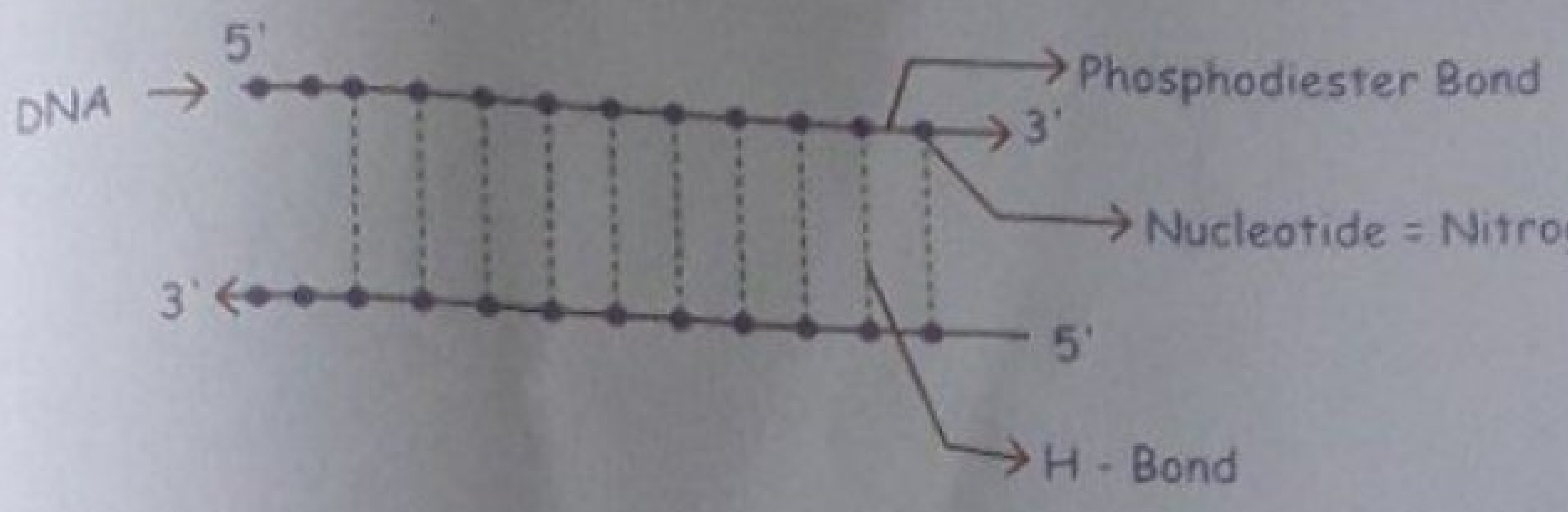
- H → *Haemophilus*
- in → *Influenzae*

Working of Restriction Enzyme (RE):

Each restriction enzymes functions by 'inspecting' the length of the DNA sequence but by recognising PALINDROMIC sequences' (4-8 long nucleotide) (e.g. MALAYALAM)

Palindromic sequences: These are the sequences which reads the same from 5' ⟶ 3' on both the strands of DNA. Restriction enzyme always recognises their own palindromic sequence, which is very specific & cut between specific nucleotide, between the same base pairs (same on both strands)

Basics

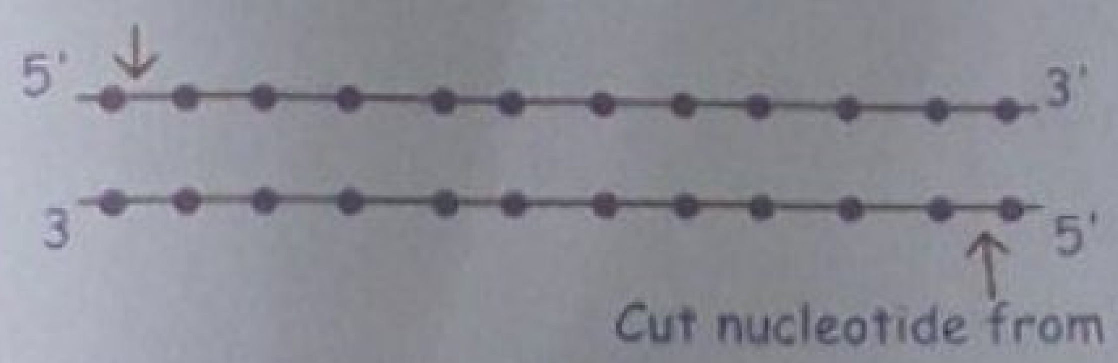


A = T, G ≡ C — Base pairing

Restriction Enzymes

Exonuclease — These enzymes remove the nucleotides from the ends of the strands

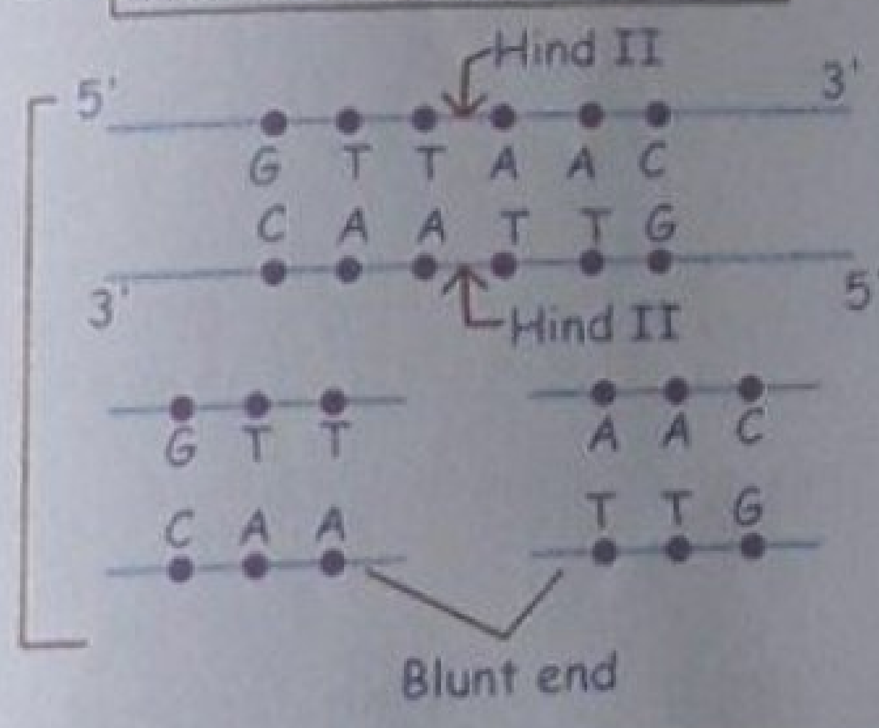
Endonuclease — These remove the nucleotide from the centre & is actually useful in biotechnology.



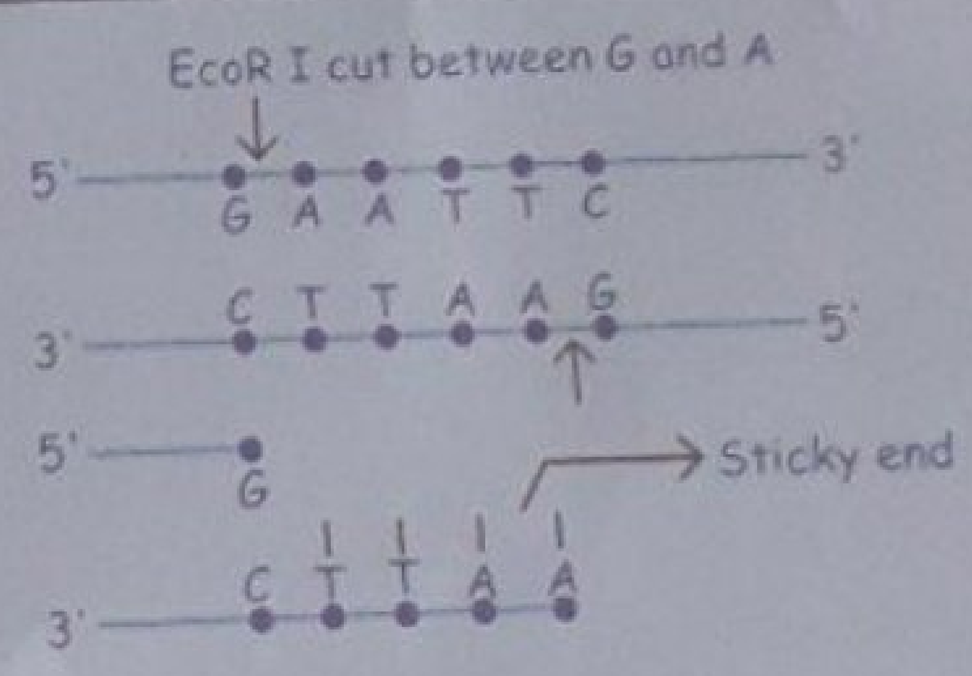
अतिरिक्त Gyaan

Restriction endonucleases produces 2 types of ends

BLUNT ENDS/FLUSH ENDS



STICKY/COHESIVE/STAGGERED/OVERHANGING ENDS

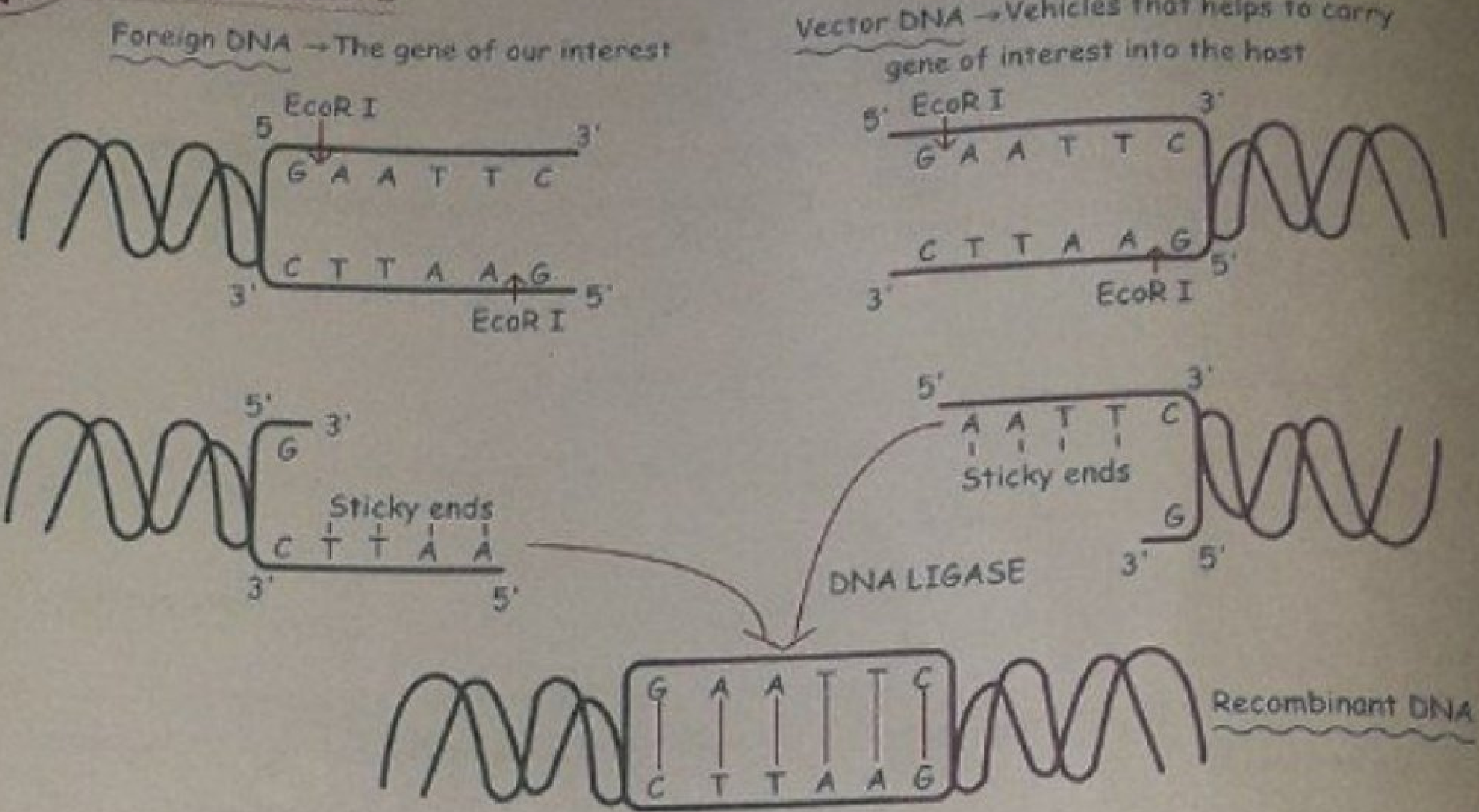


NOTE For Hind II, recognition site is 5' GTPyPuAC 3' 3' CTPuPyTG 5'

- Py: Any pyrimidine
- Pu: Any Purine

NOTE These are named so because they form hydrogen bond with their complementary cut counterparts. The stickiness of the ends facilitates the action of the enzyme DNA ligase.

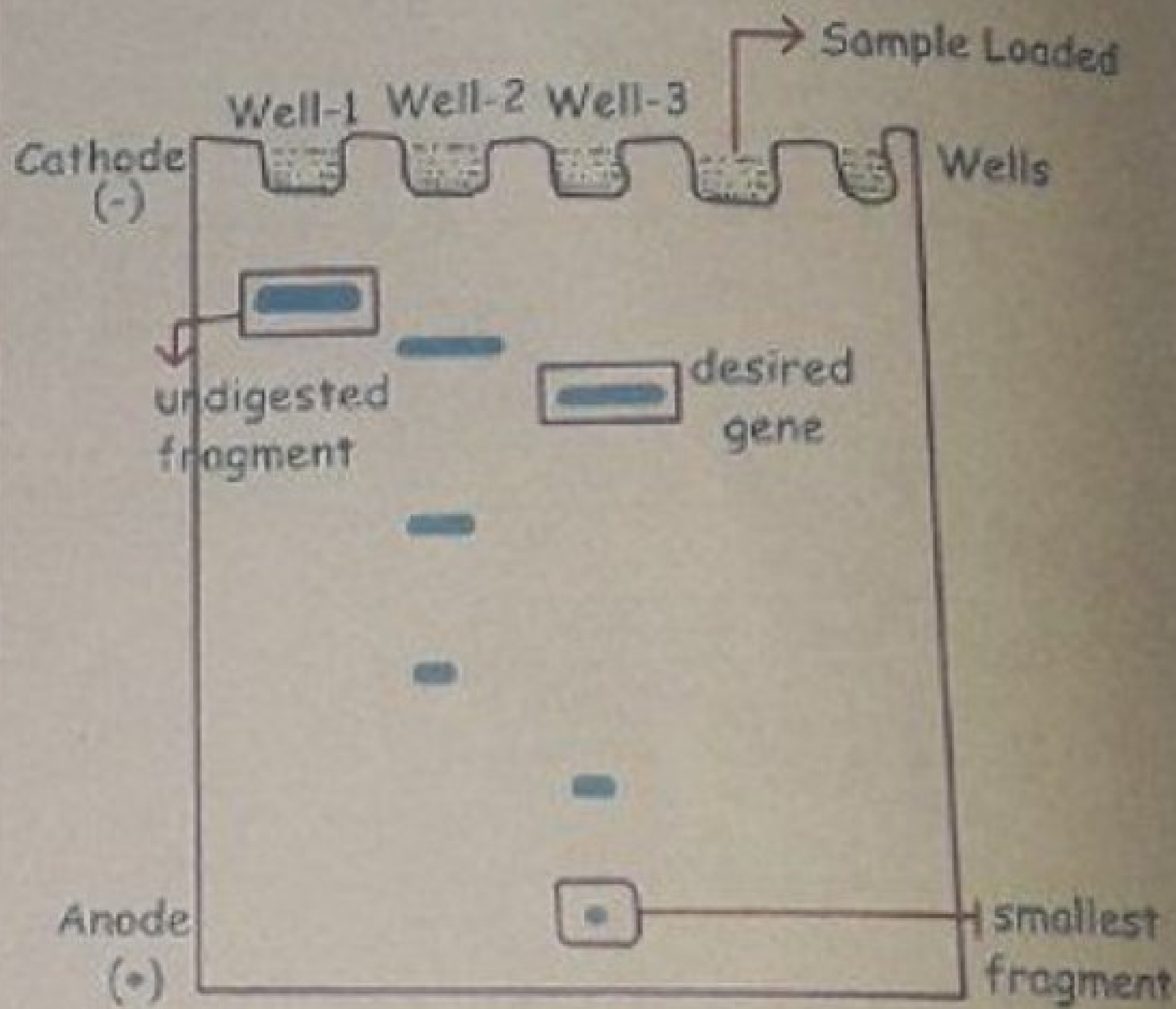
V.IMP Working of EcoR I



> **NOTE**
> - DNA ligase is also known as MOLECULAR glue.
> - To cut the vector & foreign DNA, same restriction enzymes are used to produce similar kind of complementary sticky end.

3. GEL ELECTROPHORESIS

- It is a technique used for separation and isolation of desired fragment.



Principle

- DNA fragments get separated on the basis of molecular weight (size).
- The most commonly used matrix is agarose gel extracted from sea - weeds.
- 'Wells' in the gel is to load the sample to be separated.
- The DNA fragments separate (resolve) according to their size through seiving effect provided by agarose gel.

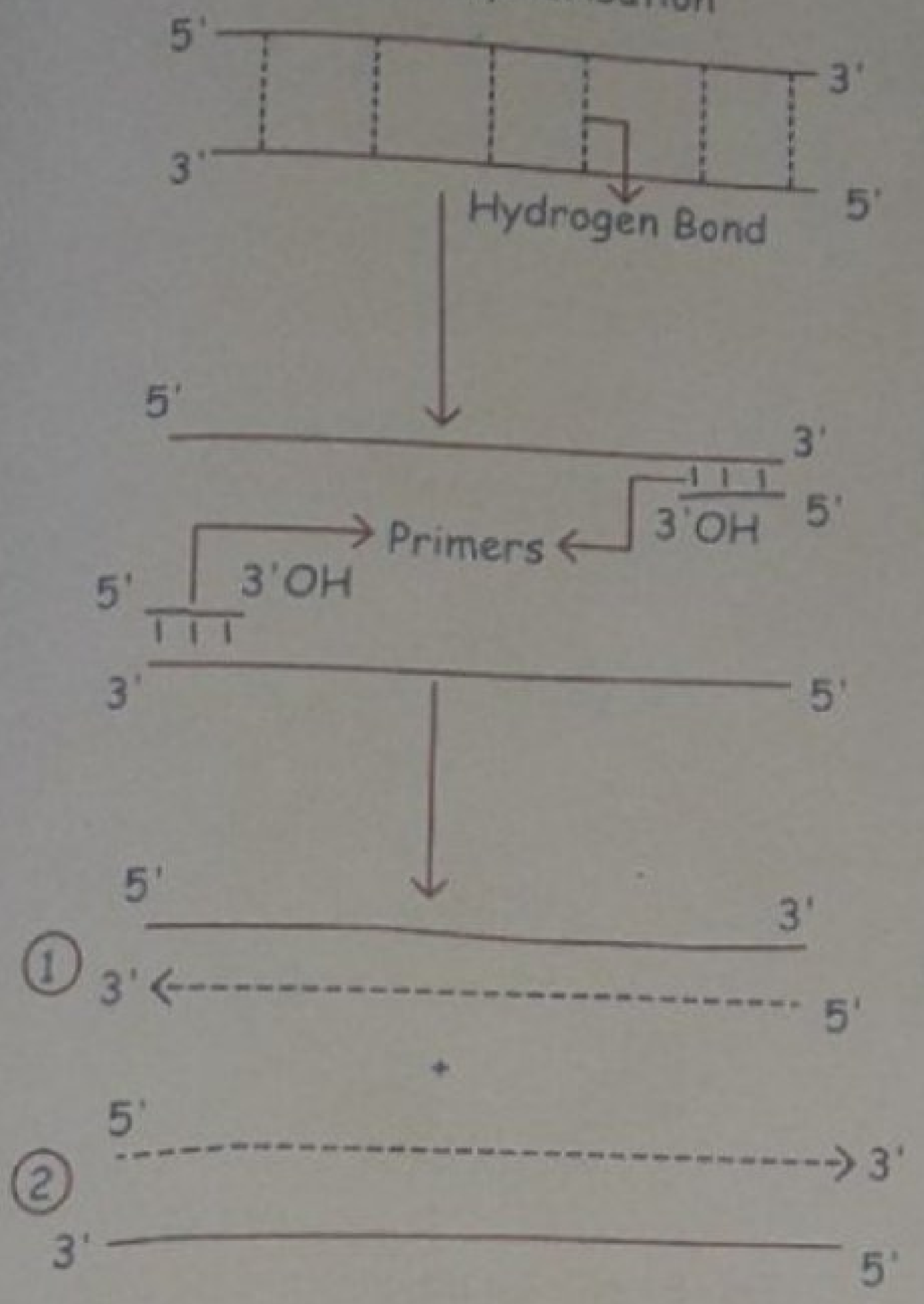
★ Separation
- Smaller is the fragment: farther it moves
- Larger is the fragment: slower it Runs

DNA being negatively charged run towards: Anode (+)

- To visualise the fragments we use **'ethidium bromide'** stain & bright orange colour bands can be seen under UV rays only.
- Once you locate the position of the desired gene, we cut the gel with DNA to extract, this step is known as ELUTION.

4. PCR (POLYMERASE CHAIN REACTION)

- It is the technique for the amplification of the gene. (Just like we have xerox machine)
- 3 steps are involved in PCR:
  - → Denaturation
  - → Annealing/Primer annealing
  - → Extension/Polymerisation



(1) Denaturation:

- High temperature provided (90-94°C)
- Hydrogen bond between the bases of the 2 strands broken
- Strands are now separated

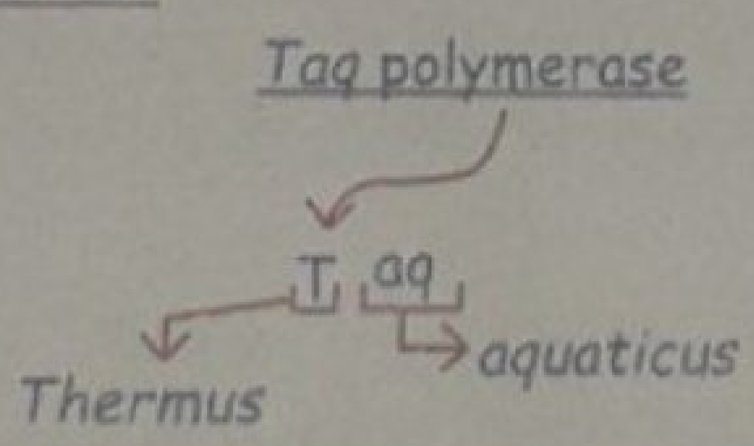
(2) Annealing: (50-60°C)

- OLIGONUCLEOTIDE (small nucleotide sequence) known as primers are provided to attach to respective strands to provide free 3'OH end for the polymerase to act.
- Polymerase can't make a new strand without these primers.

(3) Polymerisation / Extension : (72°C) By using *Taq* (*Thermus aquaticus*) Polymerase

Important points

- Polymerisation: In this step, the polymerase used is *Taq polymerase*



- *Taq* polymerase is obtained from *Thermus aquaticus* bacteria & is thermostable

THERMOSTABLE

Works at high temperature

- *Taq* uses the nucleotides to polymerise & make a new chain.

NOTE After running approximately 30 cycles of PCR, one can achieve approximately 1 billion copies of the original sample.

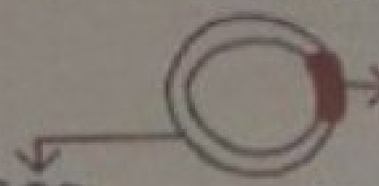
5. The Ligation of the gene of interest (GOI) with vector:

Vector: It is the vehicle that is used to carry the gene of interest.

Characteristic of vectors:

1. Size: Should be small (Easy to handle)
2. Ori: Origin of Replication: This is a sequence from where replication starts.

- Any piece of DNA linked to this sequence can be made to replicate within the host cells.



- It also controls the copy number

The number of copies of genes that are present in the host in future

NOTE

- Some plasmid may have low copy number (only one or two) and some may have as high as 15 - 100 copy number per cell
- Bacteriophage have high copy number.

- pBR 322

Plasmid

the order of synthesis

Bolivar & Rodriguez → They constructed this plasmid in the lab.

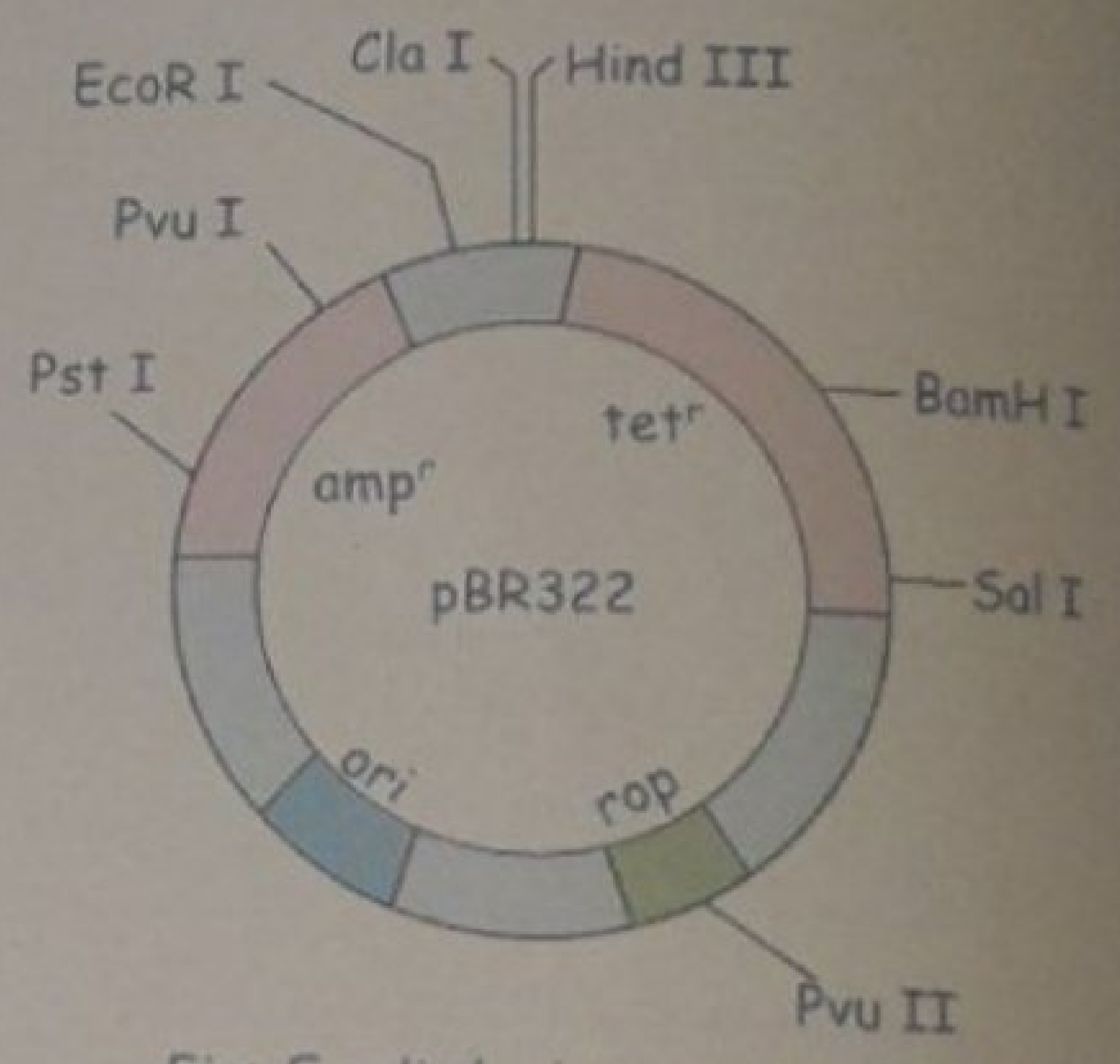


Fig: *E.coli* cloning vector pBR 322

3. Cloning sites: In order to link the alien DNA, there should be recognition sites for various restriction enzymes but MCS (MULTIPLE CLONING SITES) for a single restriction enzyme should be avoided.

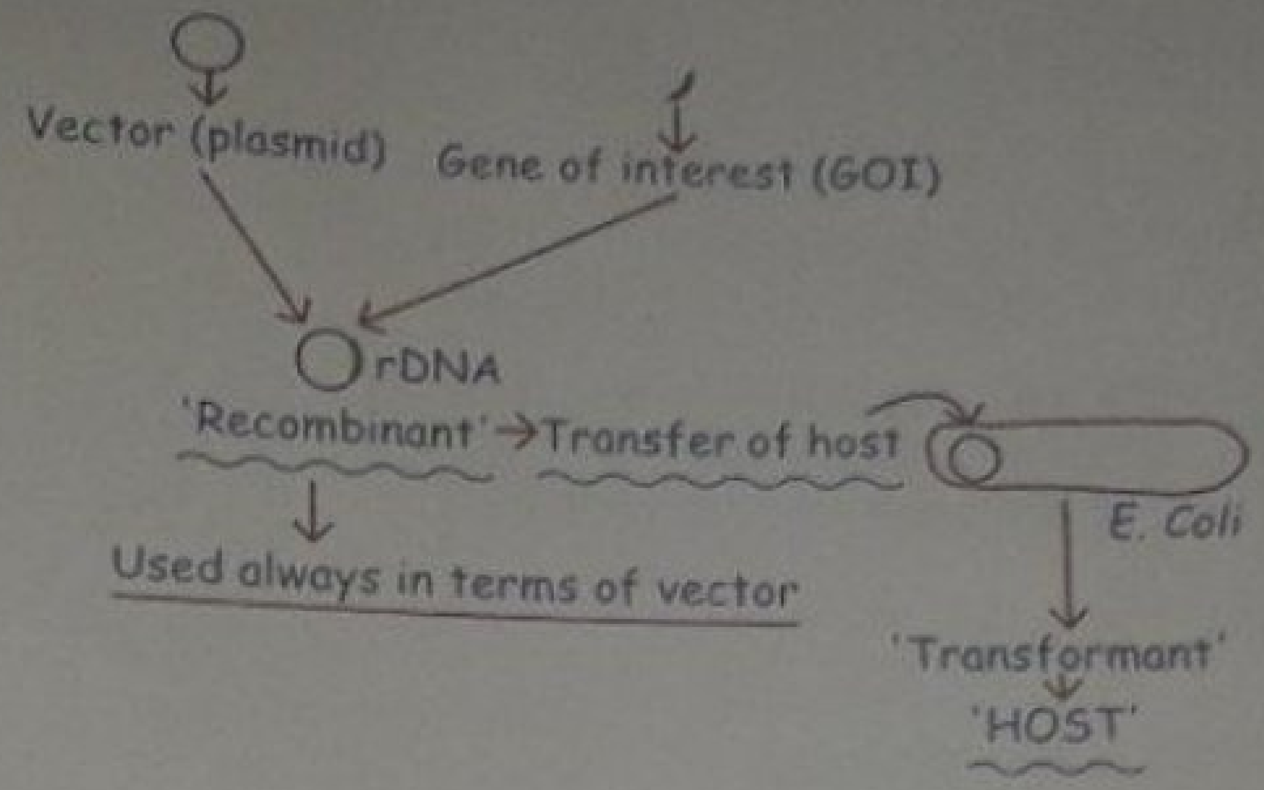
As, if a single restriction enzyme recognises multiple sites, it creates multiple cuts → That will create confusion

4. SELECTABLE MARKERS: Selectable markers are usually ANTIBIOTIC RESISTANT GENES which enables in the selection of Recombinant (R) from Non-Recombinant (NR) & Transformants (T) from Non-Transformants (NT)

- TRANSFORMATION is a procedure through which a piece of DNA is introduced into a host.

ANTIBIOTIC RESISTANT GENES:

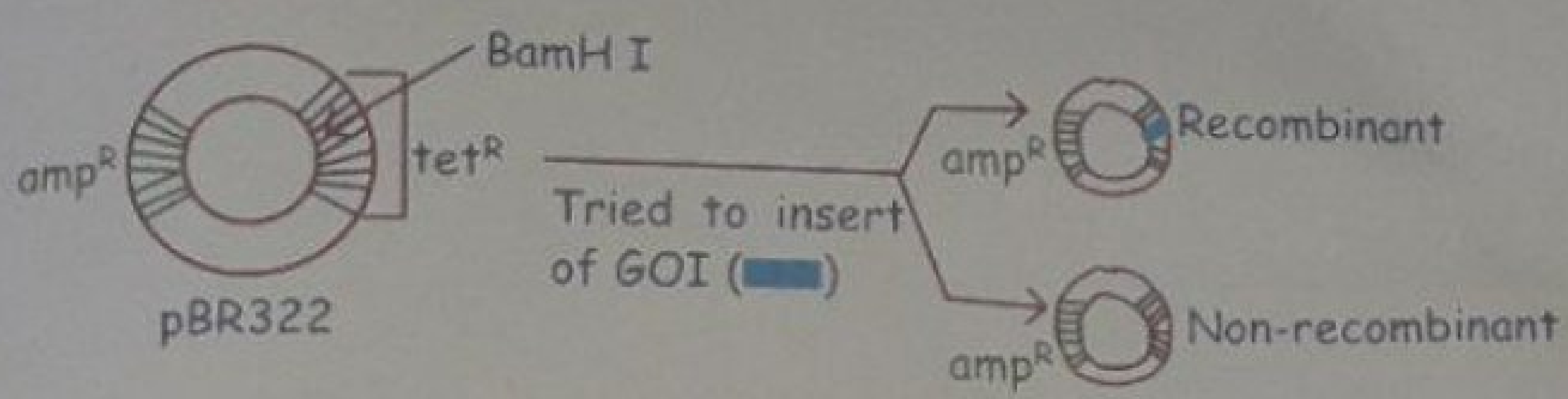
- Amp^R : Ampicillin resistant gene
- Tet^R : Tetracycline (Kanamycin) Resistant gene
- Chloramphenicol Resistant gene is another example



Example of Vectors:

- PLASMIDS (extra-chromosomal circular ds DNA)
- Retroviruses
- Ti plasmid (Tumor inducing plasmid) of *Agrobacterium tumefaciens*

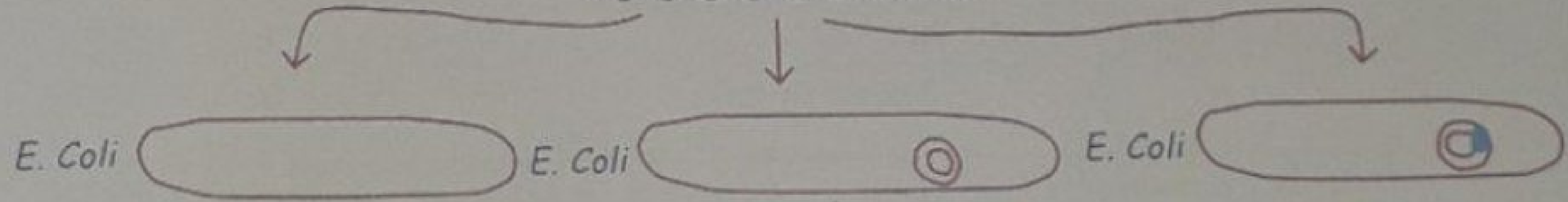
Using BamH I Cutting is done



- We still do not know which plasmid is recombinant & which one is non-recombinant.
- We will now try to insert these into the Host *E.coli* (*Escherichia coli*)
- *E.coli* (*Escherichia coli*) is a very good host as it does not have any antibiotic Resistant gene mentioned above.

↓ Transformation of Host

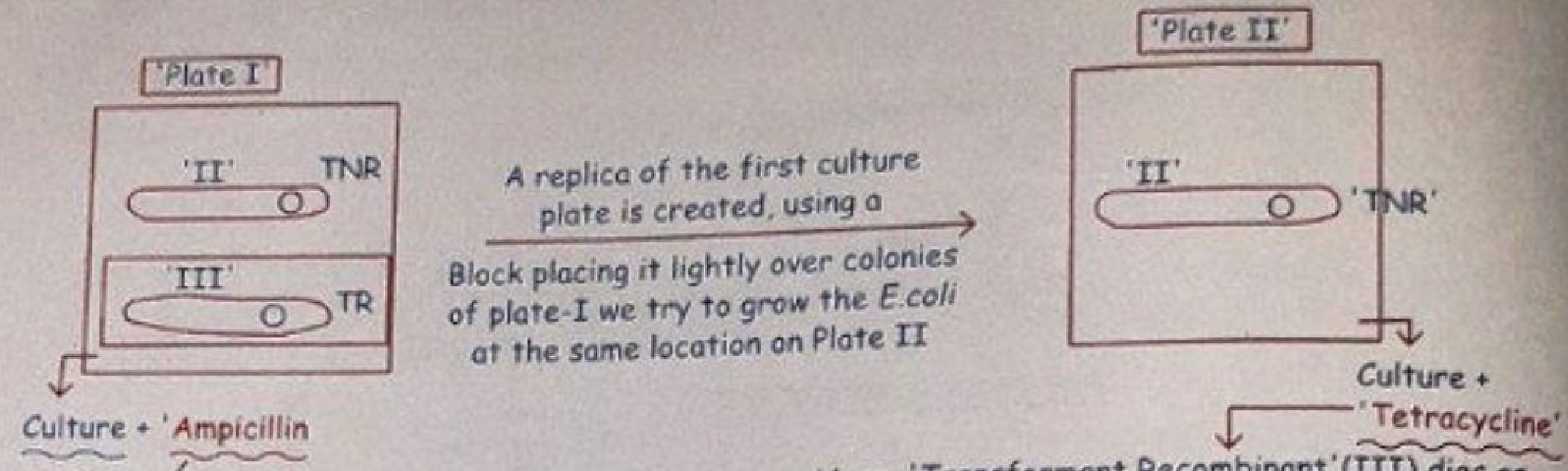
There are 3 possibilities



'I'	'II'	'III'
Non transformant (NT)	Transformant, Non Recombinant (T, NR)	(TR) Transformant Recombinant

Selection of T/NT (Transformant/Non-Transformant), R/NR (Recombinant/Non-Recombinant):

- Growing all of these first in Ampicillin medium.

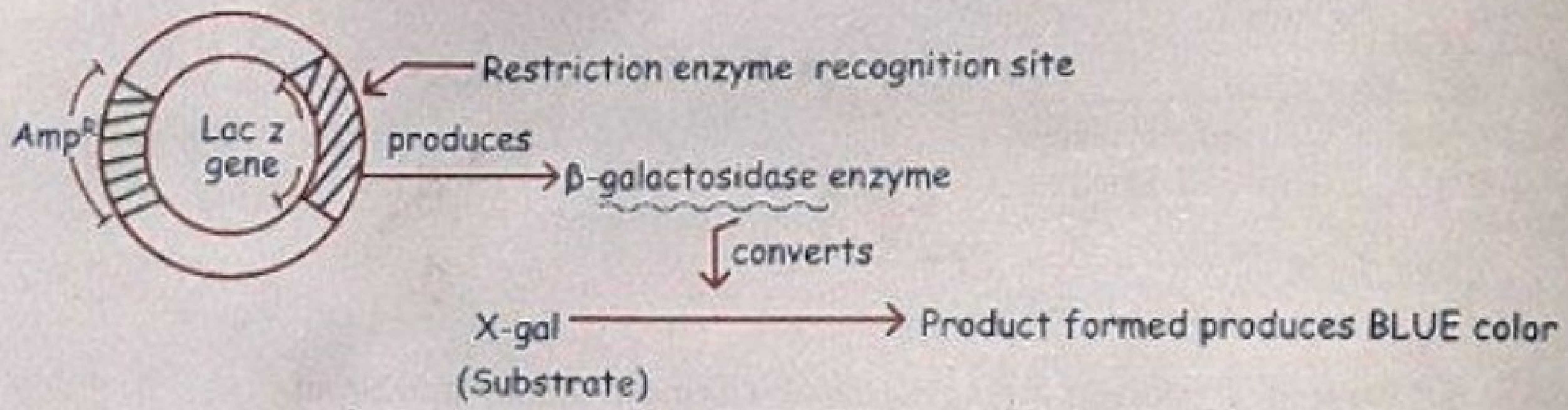


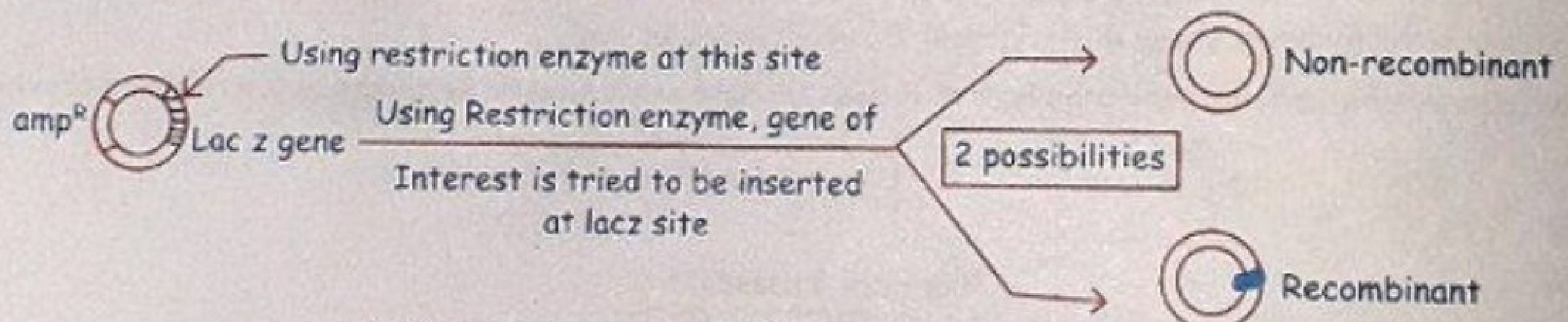
In this medium, selection of Transformant from Non-Transformant occurs as Non-Transformant donot have any antibiotic Resistant gene, hence can't survive, so (I) non-transformant colony doesnot grow here.

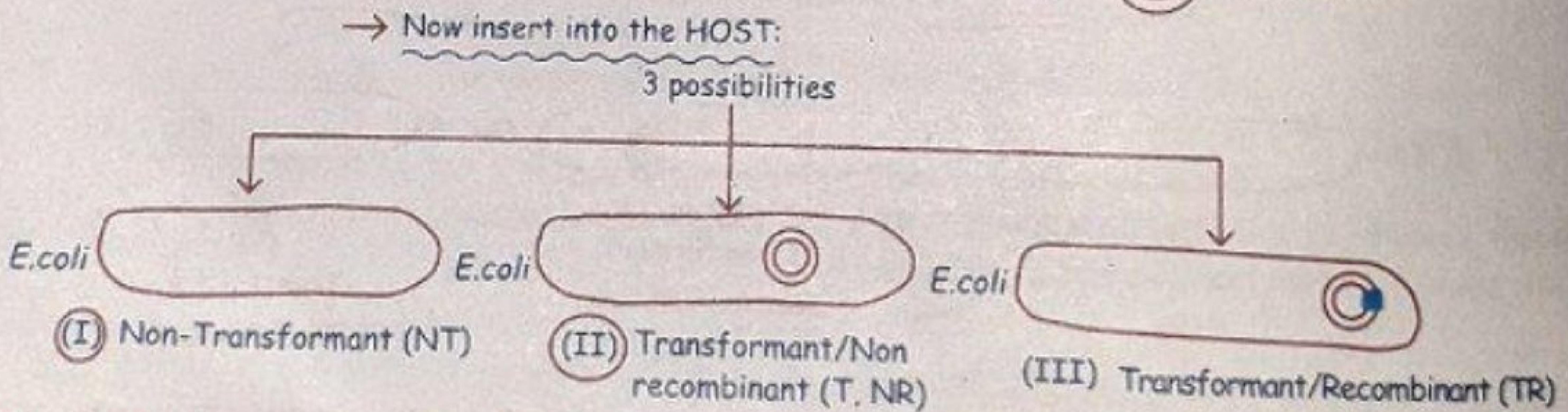
Here, 'Transformant Recombinant'(III) dies as their 'Tet^R' was cut to introduce the foreign gene hence provided no resistance for tetracycline to *E. Coli*, only transformant non-recombinant (II) survived

NOTE Since, TR die in Replica plate II but we can recognise its position from Plate-I, take them out & Culture separately.

- PUC - 8 : This vector makes the selection process easier and less time consuming

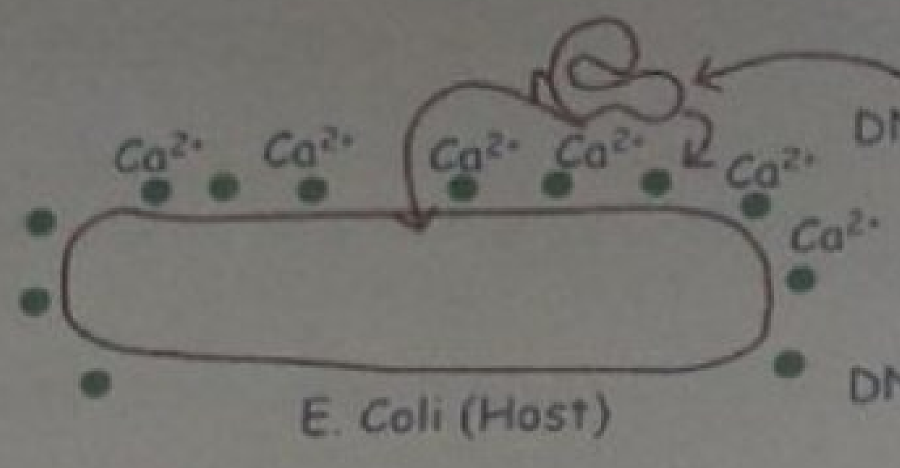






Selection of Transformant/Non-Transformant and Recombinant/Non-Recombinant

- Growing them in Ampicillin medium with x-gal substrate.



DNA (Hydrophillic) hence it cannot cross the Bacterial cell wall.

↓

Solution is to treat the *E. coli* with divalent cation like 'Ca^{2+}'

↓

DNA binds to Ca^{2+} which increases the efficiency with which DNA enter

↓

'Heat shock treatment'

↓

Treat *E.coli* by placing them on

↓

$\boxed{\text{ICE} \rightarrow \text{Heat } (42°C) \rightarrow \text{ICE}}$

↓

Now, *E. coli* takes up the DNA

2. <u>Biolistic/Gene gun</u>: (Plants)

- Gold & tungsten is coated with DNA & is bombarded with high velocity directly into the Plant cells.

Fig: Biolistic/Gene gun

3. <u>Microinjection</u>: (Animal Cell)

- Using a microneedle, DNA is directly injected into the nucleus of animal cell.

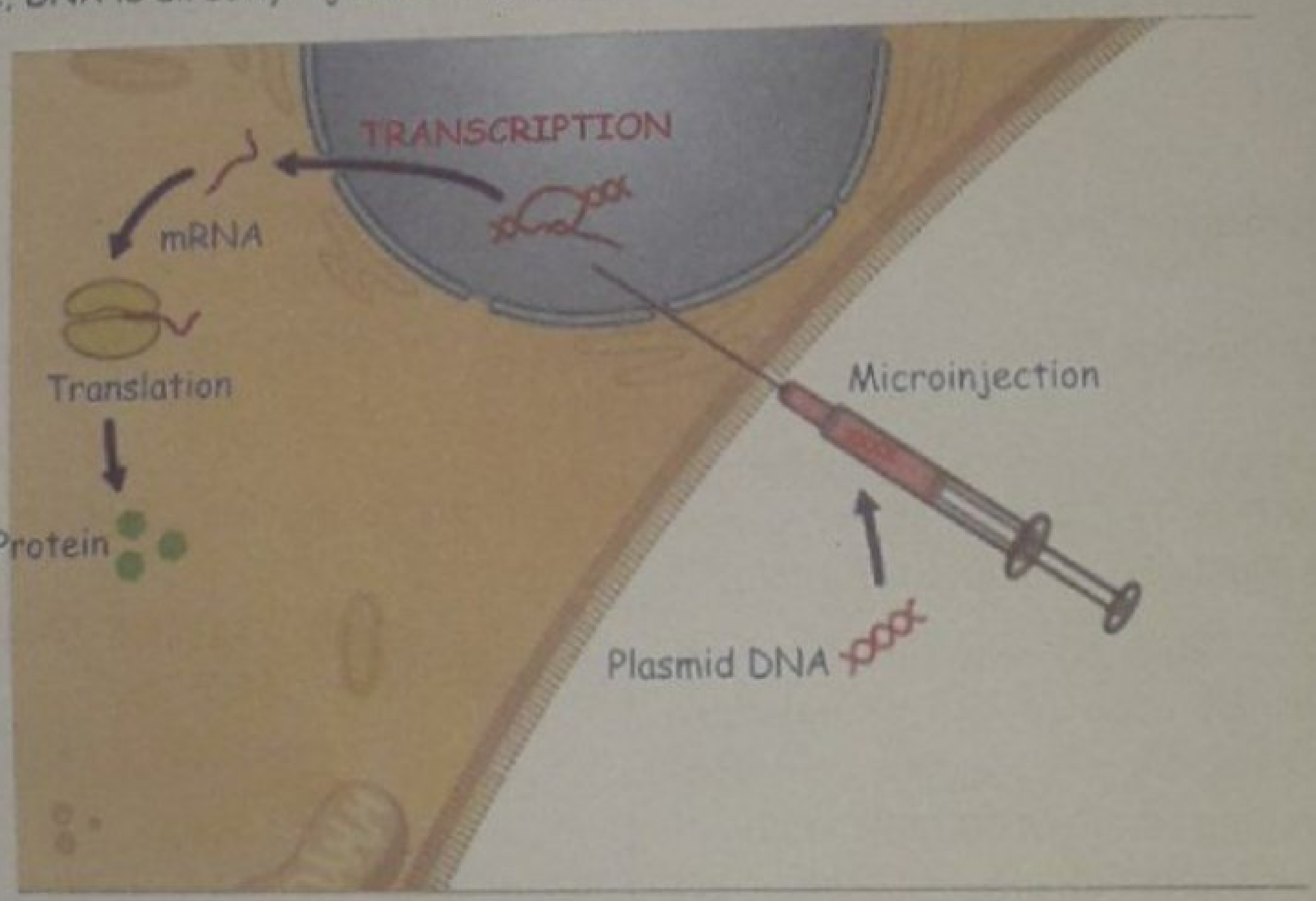


Fig: Insertion of rDNA by using microinjection into host

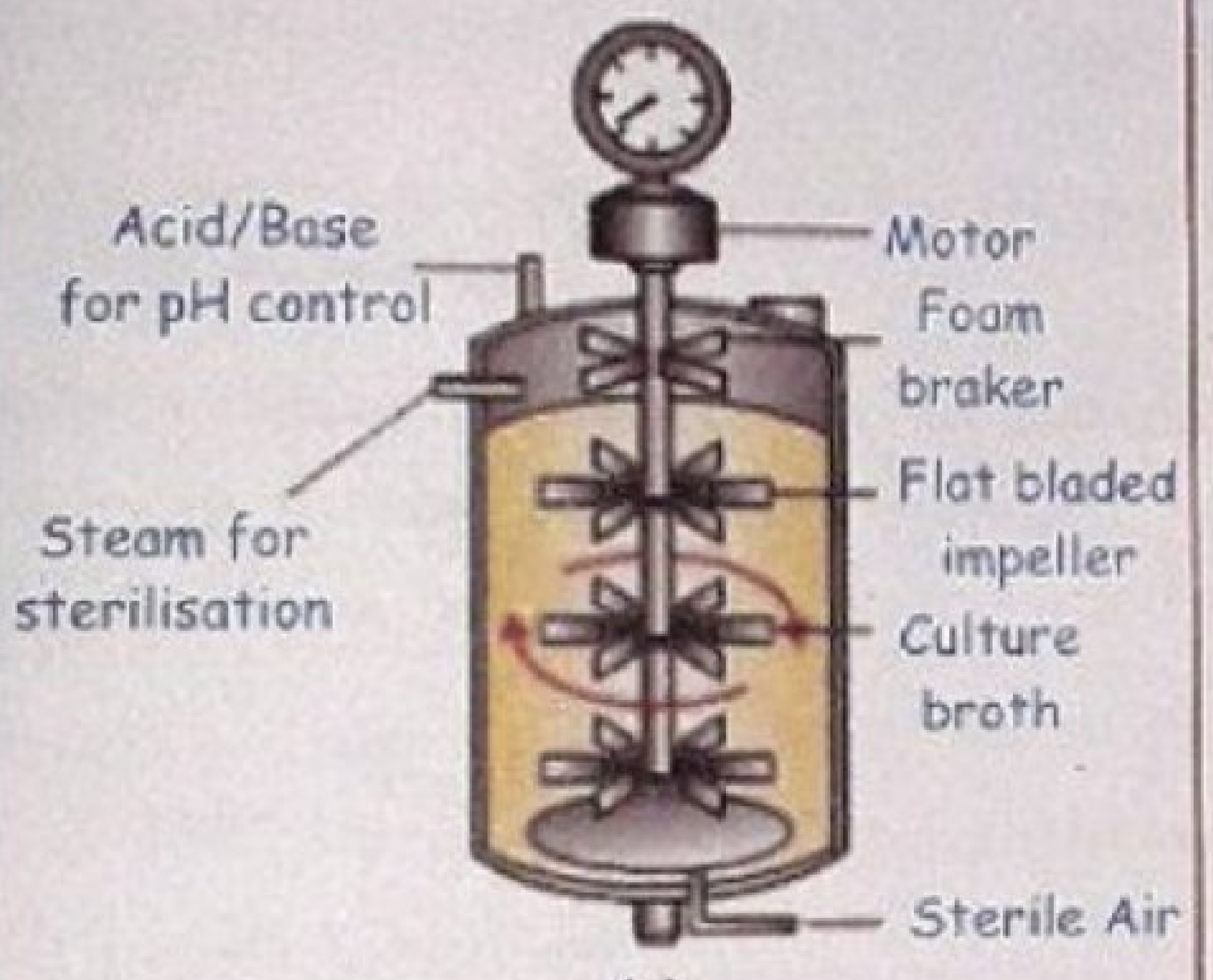
7. Bioreactors

- Large tanks where great amount of raw materials can be biologically converted into products.
- Capacity: '100L - 1000L'
- Properties
  - → Great capacity for the culture
  - → Proper aeration
  - → Sterile conditions maintained
  - → Acid-Base (pH) control system
  - → Temperature control system
  - → Foam Breakers
  - → Sampling ports

Most commonly used **Bioreactors**
↓
STIRRED TYPE BIOREACTORS → It is usually cylindrical or with a curved base to facilitate mixing of content

SIMPLE STIRRED BIOREACTOR

→ Tank Base: Curved

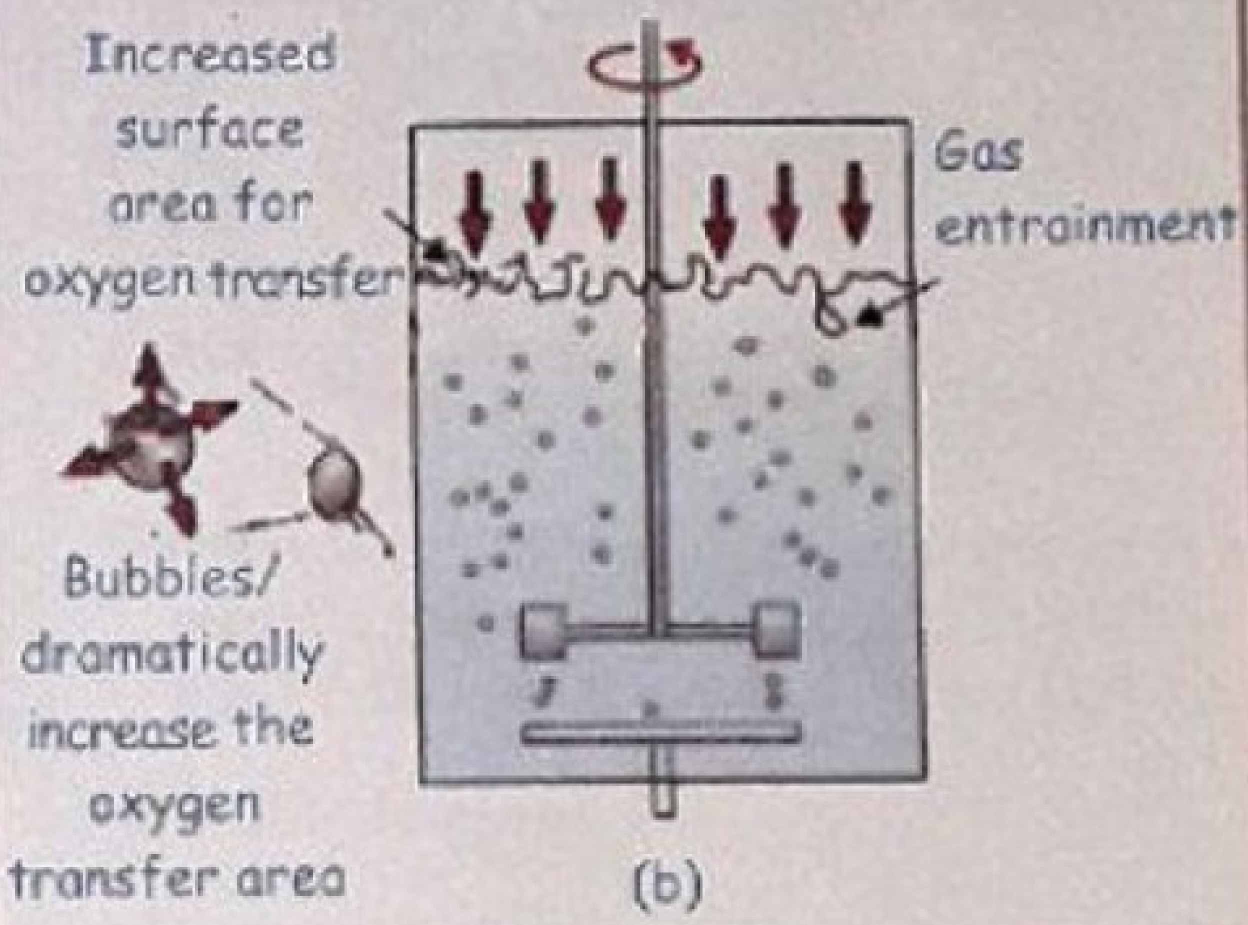


(a)

SPARGED STIRRED BIOREACTOR

→ Base : Flat

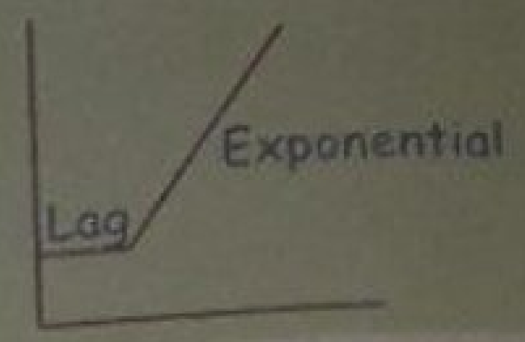
→ It has additional Sparged Tube for extra O_2 availablity in the culture



(b)

Types of Culture

Batch Culture	Continuous Culture
CLOSED SYSTEM	OPEN SYSTEM
Here with in Bioreactors, all the content required to grow the culture is added at once & closed.	Here while the process is ONGOING, in between new additions of fresh culture could be done & used culture can be withdrawn

○ In between, no new additions can be done.	○ Culture/Host is maintained in the EXPONENTIAL/ LOG PHASE 

NOTE If any protein encoding gene is expressed in a heterologous host, it is called as a recombinant protein.

8. DOWNSTREAM PROCESSING

- Extraction of the desired protein: SEPERATION & PURIFICATION
  Before marketing preservative added
- Strict quality control testing for each product is also required.

Explant

If any part of plant is taken out & grown in a test tube under sterile condition used in Tissue culture e.g., Root, Stem, Leaf etc.

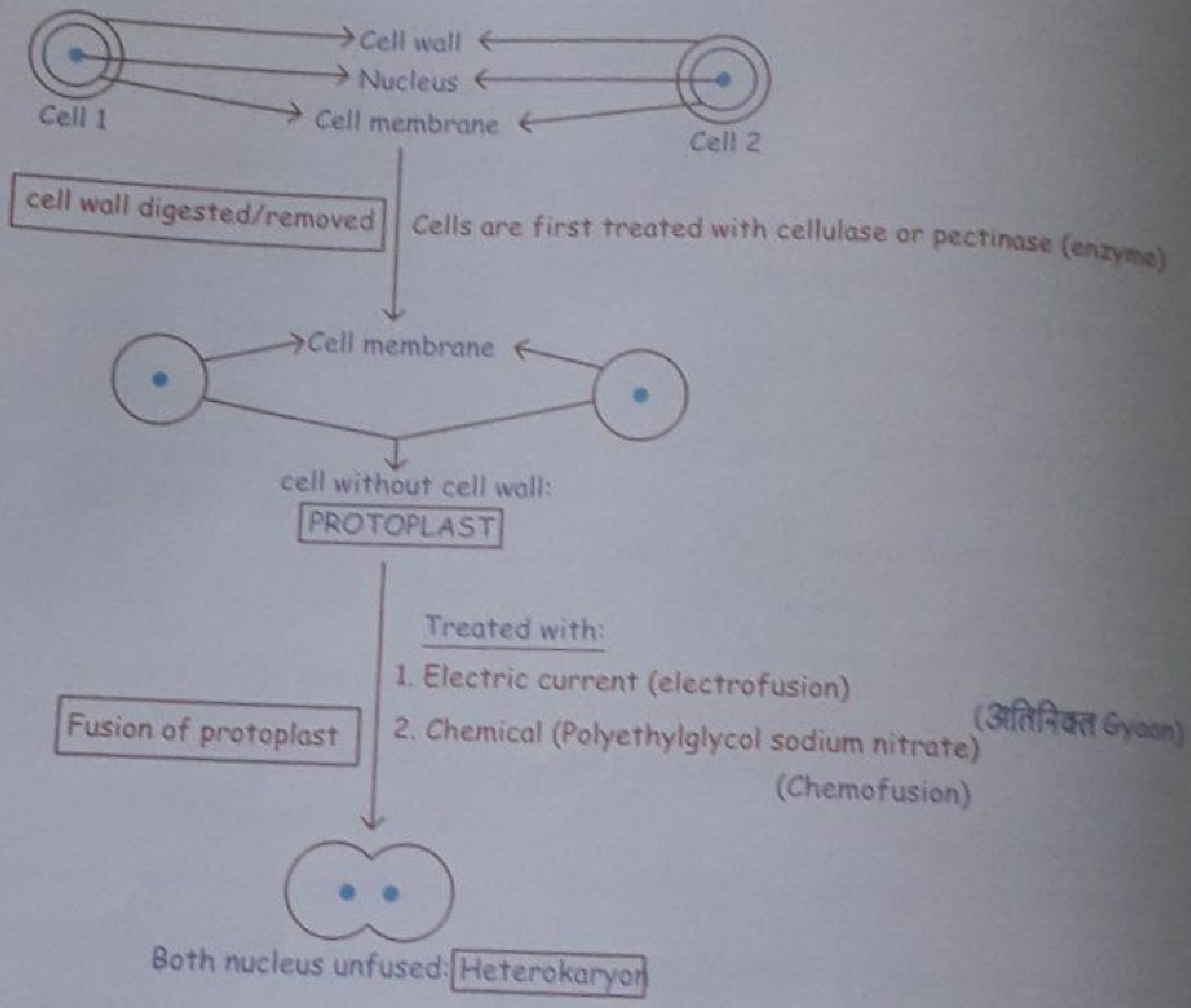
METHODS OF PLANT TISSUE CULTURE

1. Meristem culture (virus free culture)

- Pathogen free clones of plants can be obtained from this.
- Meristem (apical and axillary) is free of virus due to high concentration of auxin & rapid rate of cell division.
- Hence, we can remove meristem → grow in vitro → Virus free plant obtained.
- Scientists have succeeded in culturing meristems of banana, sugarcane, potato etc.

2. Protoplast Fusion or Somatic Hybridisation

- Fusion of protoplast of 2 plants belonging to different varieties species and even genera.
- Protoplast: Cell without cell wall.
- Root, Stem, Leaf: Somatic cell.



NOTE

- These are hybrid protoplasts, can be further grown to form a new plant.
- These hybrids are somatic hybrid & the process is somatic hybridisation.

○ Somatic hybrid → Synkaryon (fused Nuclei)
→ Heterokaryon (unfused Nuclei)

e.g., Pomato: Potato × Tomato

does not contain all character of potato & tomato

Somatic cell used (Root, stem leaf)

Leaf → Leaf part

↓

$\boxed{\text{No Variation}}$ Tissue culture Technique

↓

Plant Produce

Leaf Leaf Leaf Leaf

→ All are same
(Asexual Reproduction)

→ All are clone

IMPORTANT POINT TO REMEMBER

1. Micropropagation

Thousand of plant produced with the help small/ micro-part of leaf (Vegetative propagation or asexual reproduction)

2. Somaclone

Soma = Same

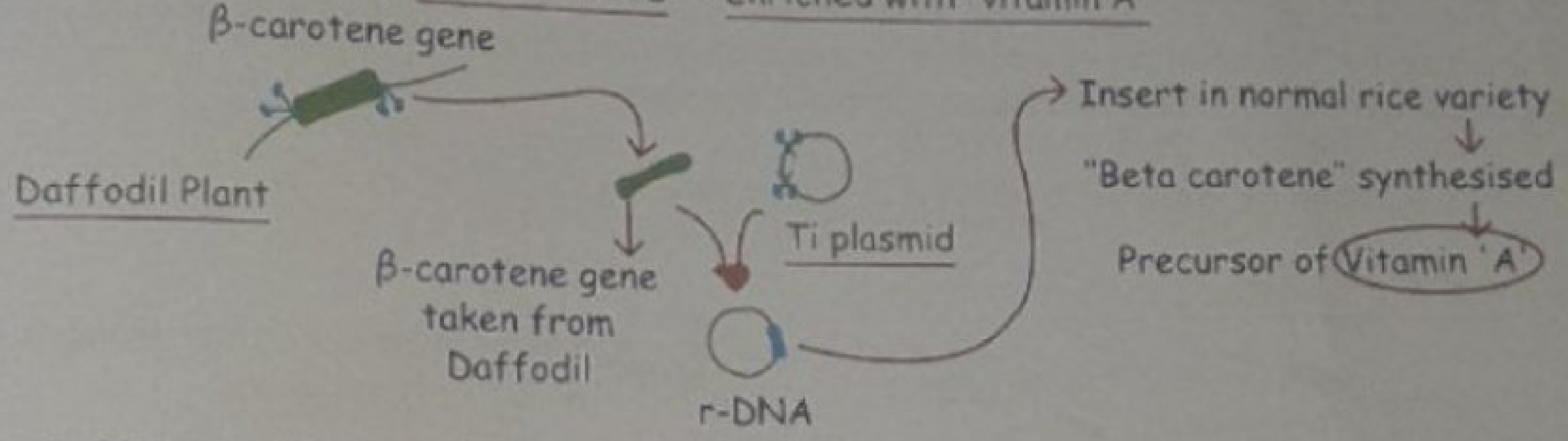
3. Somaclonal variation

Sometime we observe very minute variation during tissue culture called somaclonal variation

Advantage of GM Plants:

→ Increase in the productivity.
→ Enhanced nutritional value.

eg: GOLDEN RICE → Enriched with 'vitamin A'



→ Increased efficiency of mineral usage by Plants.
→ Reduced reliance on chemical pesticide:
→ Can tolerate abiotic stress like salinity, high/low temperature dry or moist conditions etc.
→ Help to reduce post harvest losses.

Biotechnology: Application in Agriculture

1. Bt Cotton (PEST-RESISTANT PLANT)

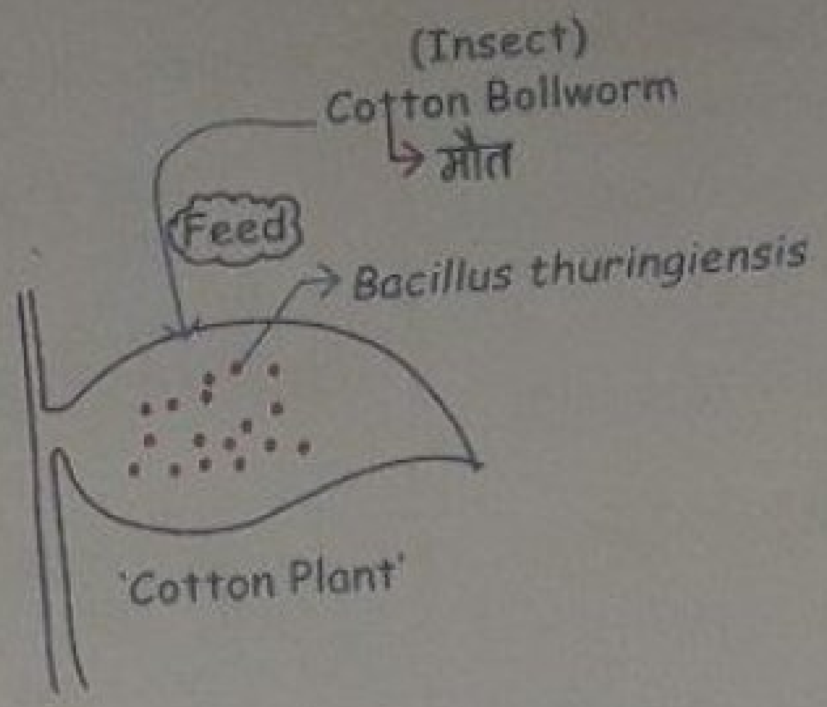
Bt → *Bacillus thuringiensis*

Cotton Bollworm → Damage Cotton Balls
Cotton Bollworm → (PEST)

OBSERVATION:

→ Occationally while the insect feeds on plants this bacteria also becomes the diet of the insect & when fed upon the bacteria, eventually the insect dies.

Scanned with OKEN Scanner



'*Bacillus thuringiensis*' had certain genes

↓

'Genes'

cry gene

↓

Encodes for a protein 'Cry' (Endotoxin)

↓

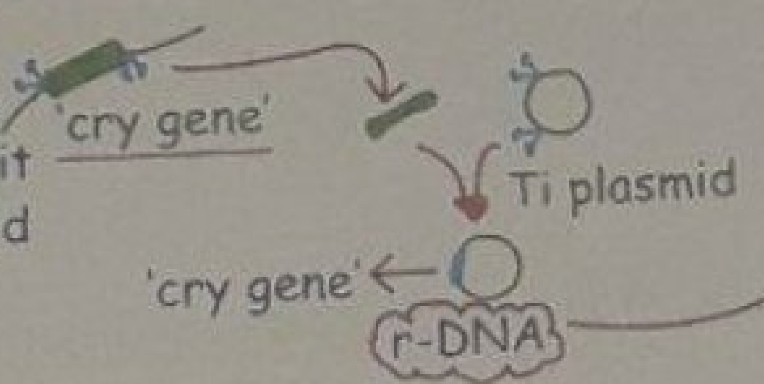
It is formed in the bacteria at a particular stage of growth, these CRYSTALLISED PROTOXIN, are inactive within the Bacteria hence not toxic for them.

↓

Once ingested by insects, it ACTIVATES (but how ??)

How did we make Bt Cotton?

We took the cry genes of bacteria and linked it with a vector Ti plasmid to form a r-DNA



Insert/introduce the recombinant DNA within cotton plants

↓

Now when the cotton bollworm feeds: these 'Cry proteins' are also ingested by them

↓

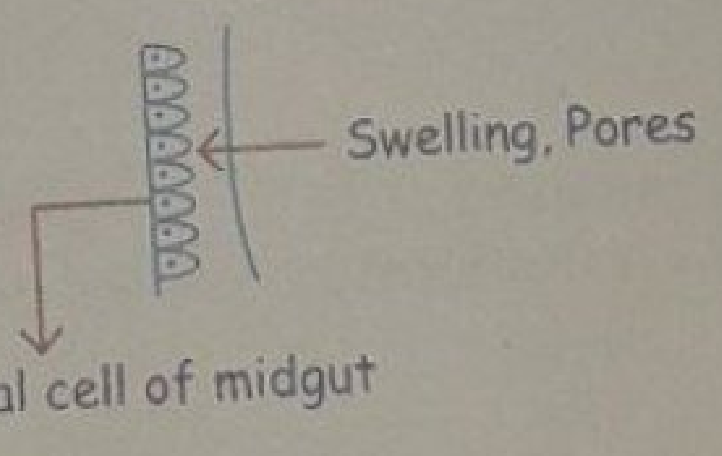
Inside the MIDGUT of the insect these Cry proteins gets activated due to the Alkaline pH of the gut.

↓

It causes swelling and lysis of the epithelial cells of the midgut

↓

INSECT KILLED



NOTE

INSECT
- Lepidopterans: Tobacco budworm, armyworm, cotton bollworm, corn borer
- Coleopterans: Beetles
- Dipterans: Flies, Mosquito

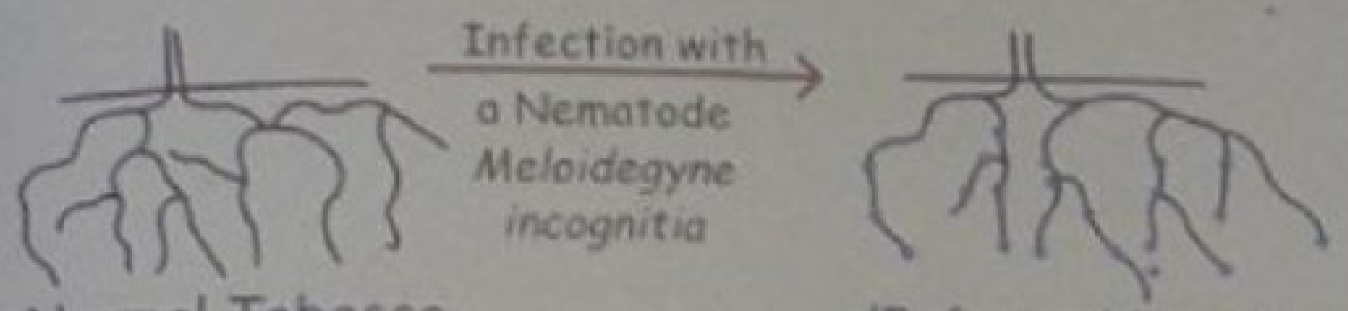
→ Some strains of *Bacillus thuringiensis* are toxic for specific insects mentioned above.

★ The choice of gene depends on
- The CROP
- the PEST

★ Cotton Bollworms → *cry I Ac, cry II Ab* (Protein encoded by these are toxic for cotton bollworm)
Corn Borer → *cry I Ab* (Proteins encoded by this is toxic for corn borer)

2. RNAi: (RNA interference)/ mRNA silencing/ Gene Silencing:

Pest Resistant Plant: Tobacco plant



Normal Tobacco plant root

'Infected Roots' (Root-Knot Diseases)

ds DNA
↓ Transcription
mRNA
↓ Translation
PROTEIN

CENTRAL DOGMA

If some how we donot allow this sense mRNA to transcribe (Silence This)

↓

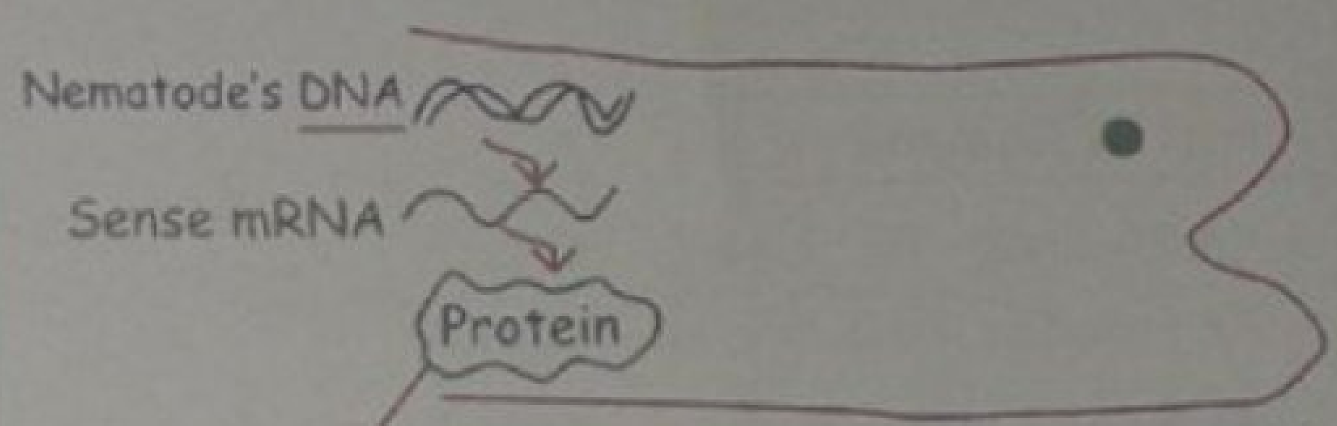
No proteins will be formed

↓

We acheive this by formation of ds RNA

NOTE Important NCERT Points

- RNA silencing is due to the formation of dsRNA.
- RNAi is a natural cellular defense mechanism in all Eukaryotes.
- We use RNAi to kill this Nematode: *Meloidegyne incognitia* causing ROOT KNOT DISEASE in tobacco plants.



'Nematode': *Meloidegyne incognitia*

↓

helps in feeding of Nematode & further growth

↓

→ If we silent this mRNA, eventually this protein will not be formed

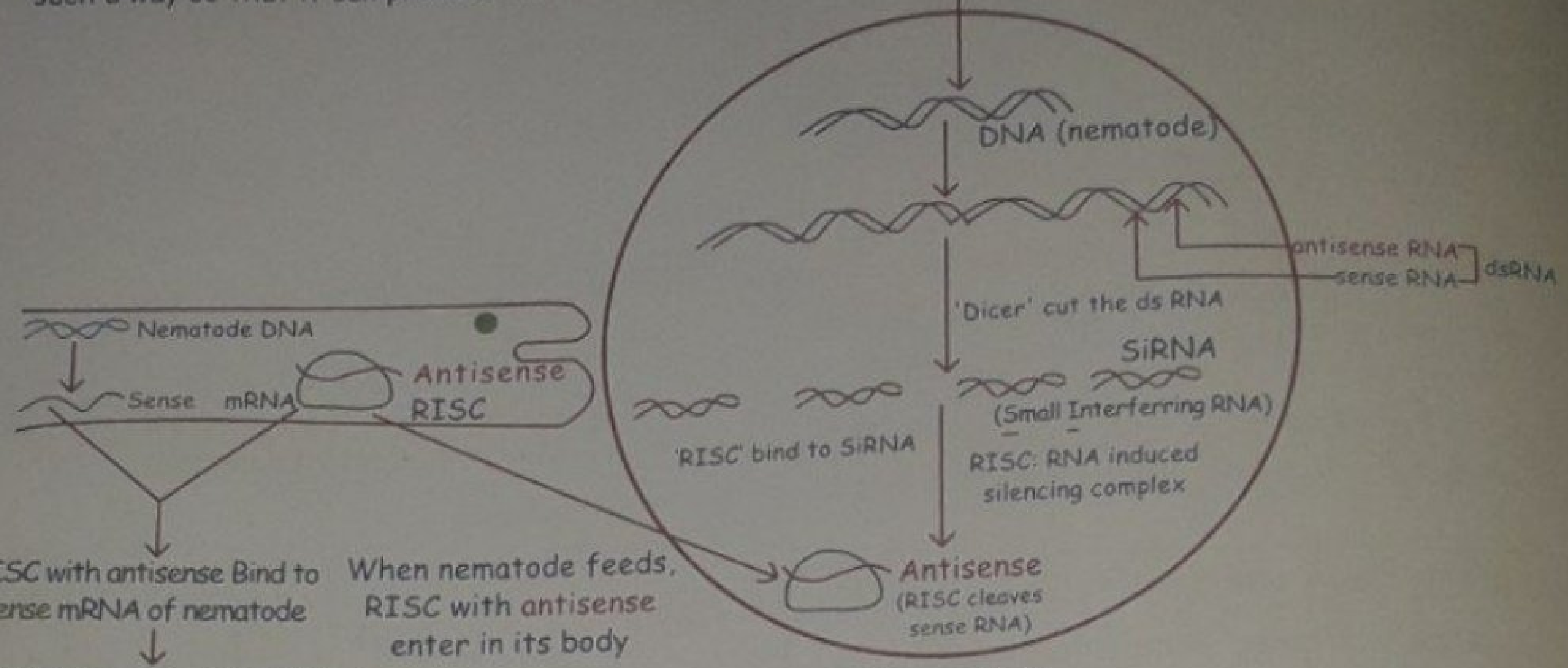
↓

Nematode will be unable to feed & grow

↓

nematode will die

Using *Agrobacterium tumefaciens* Ti plasmid, Nematode specific gene is introduced in the tobacco plant in such a way so that it can produce both SENSE as well as ANTISENSE mRNA into the host



RISC with antisense Bind to sense mRNA of nematode
↓
RISC Cleave sense mRNA
↓
No Protein formed
↓
No feeding, No growth of nematode
↓
Nematode dies eventually

When nematode feeds, RISC with antisense enter in its body

Tobacco plant

Fig: Mechanism or RNAi in Tabacco Plant (diagram not in NCERT but important to understand the concept)

Point to Remember

→ Root - Knot - DISEASE : Tobacco

→ Nematode : *Meloidegyne incognitia*

→ Vector : *Agrobacterium tumefaciens*

→ Silencing by dsRNA

→ In normal cells, the source of complimentary RNA could be from viruses having RNA genome or Mobile genetic elements called Transposons/ Jumping genes.

Biotechnological Application in Medicine:

→ Genetically modified insulin

→ Gene Therapy

→ Molecular Diagnosis

→ At present 30 recombinant therapeutics is being used world wide, out of which 12 recombinant therapeutics are marketed in India

GENETICALLY MODIFIED INSULIN (HUMULIN)

In diabetes mellitus, insulin is injected in the patient

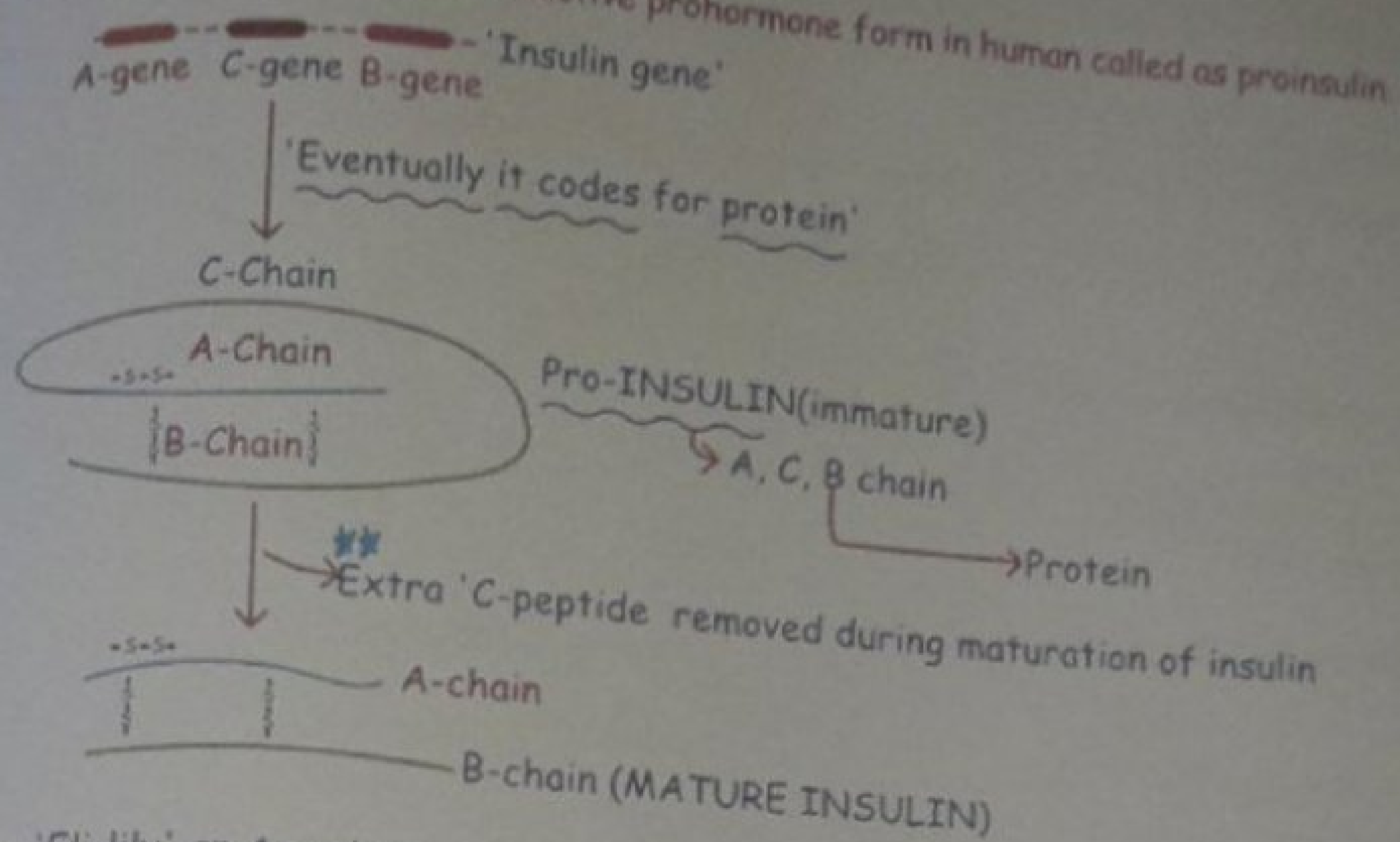
Pancreas
- Exocrine Part
- Endocrine Part: Islets of langerhans
  - α-cells
  - β-cells → Produces → Insulin

→ Earlier 'INSULIN' was extracted from slaughtered cattles & Pigs for human usage but it caused ALLERGIES, hence alternative method was thought to produce insulin for human usage. For that first we need to understand structure of insulin.

a

Structure of Insulin

- Insulin is synthesised as inactive prohormone form in human called as proinsulin.

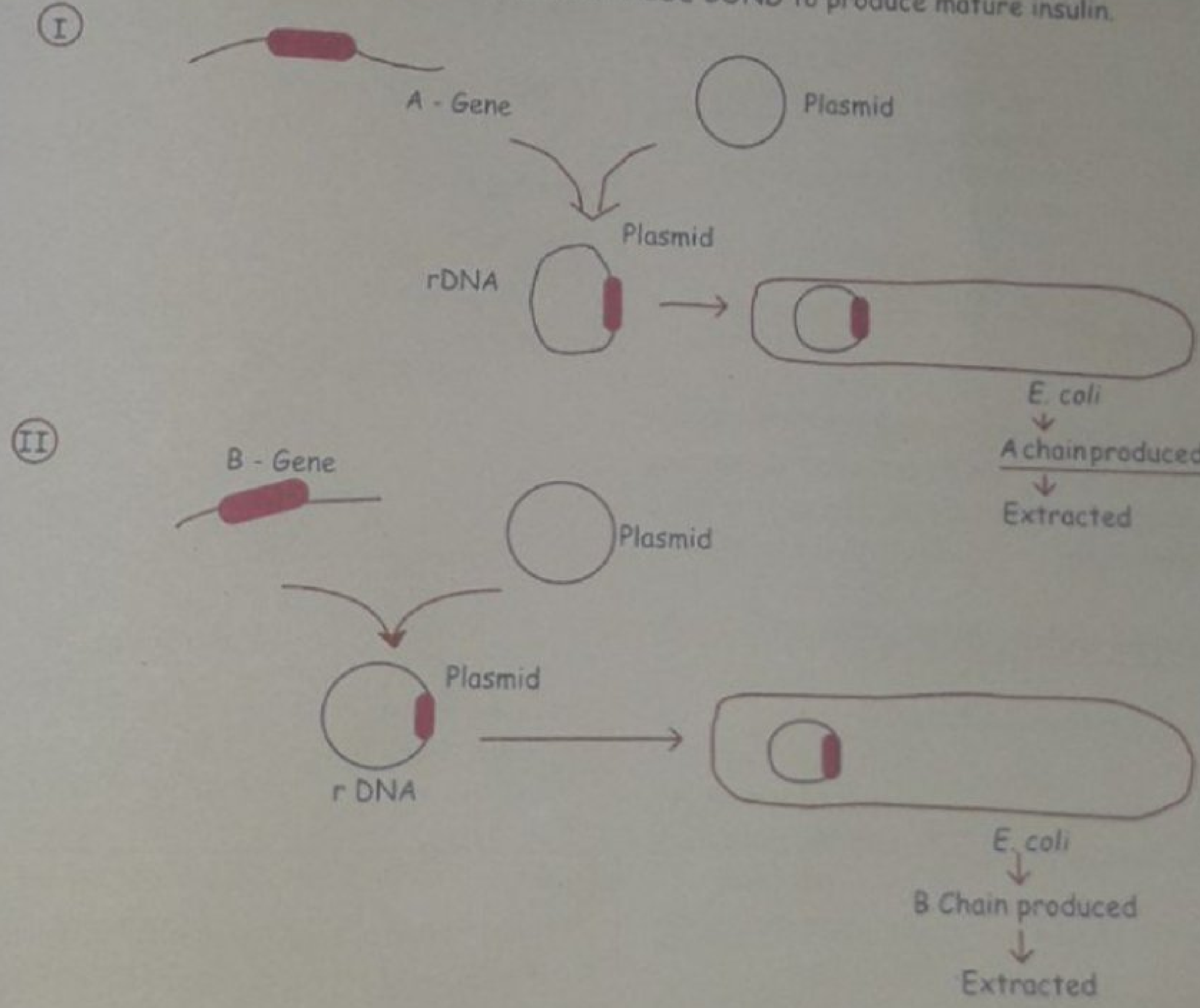


→ 'Eli-lily' an American company in 1983, constructed the first genetically modified 'INSULIN'.

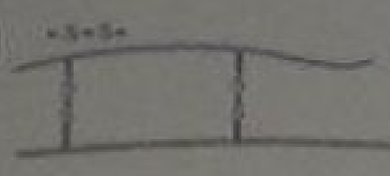
→ Major challenge was 'Maturation of insulin' was solved by Eli lily

→ They separately synthesised A & B chain in separate *E. coli*

→ In the Lab both chains were then joined by DISULPHIDE BOND to produce mature insulin.



Both the chains joined later by disulphide bond.

(III) 

GENE THERAPY:

→ Replacement of Defective gene with correct set of gene.

→ 1st time performed for a '4 year old girl child' in the year 1990

↓

Was suffering from 'SCID'

Severe combined immuno deficiency

In this

'ADA' gene was Defective → 'Congenital disease'

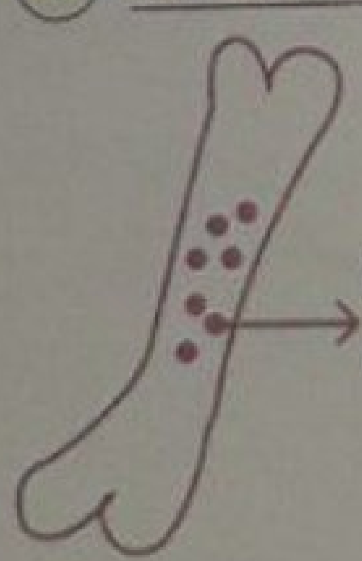
ADA: Adenosine deaminase

'Lymphocyte' ADA gene → forms ADA (adenosine deaminase) enzyme —helps in the→ Proliferation of Lymphocytes

Treatment of Severe Combined immunodeficiency:

1) Enzyme Replacement Therapy (ERT): Injection of 'ADA' could be given directly to the patients but needs to be done time to time as it is not a permanent cure.

2) Bone marrow transplantation:



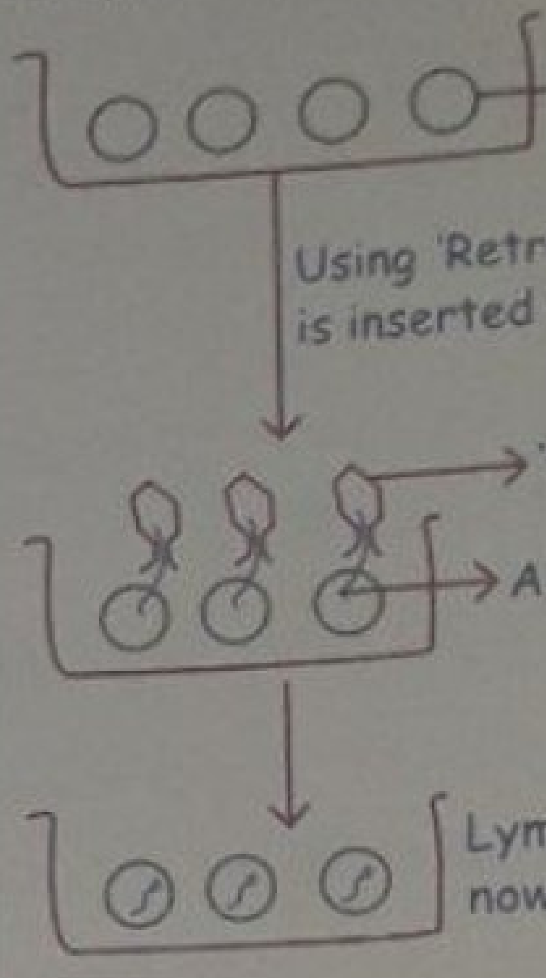
Normal bone marrow cells → Used to transplant into the defective individual

o Needs to be done periodically

3) Gene therapy: Defective gene replaced by correct gene.

First Clinical Gene Therapy:

→ Lymphocytes of the patient is taken out & cultured.



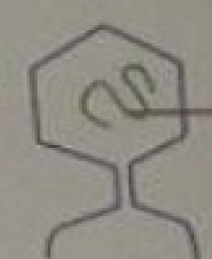
How ADA cDNA is made?

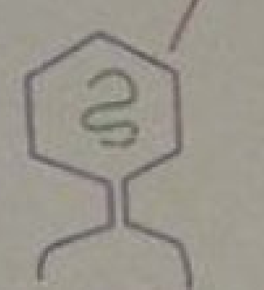
In lab.

'ADA DNA'

↓ Transcription

mRNA (ADA) → inserted into





ADA RNA

↓ Reverse transcriptase

cDNA Formed

Complementary

★★★

→ Gene therapy is also not a permanent solution as Lymphocytes are not immortal (अमर) Periodic infusion of such lymphocytes is required for the patient

NOTE 'Gene therapy' if performed at early embryonic stage can be a permanent solution.

MOLECULAR DIAGNOSIS:

Conventional Diagnosis	Modern Diagnosis (Genetic engineering)
○ Small amount of pathogen cannot be detected. ○ Early diagnosis is not possible e.g.: Serum Analysis, Urine analysis etc	○ Small amount of pathogen can be detected. ○ Early diagnosis possible → PCR → ELISA → Autoradiography

Molecular Diagnosis:

(i) PCR:

- ○ Small amount of pathogen can be detected in the sample by an attempt to amplify them
- ○ 'HIV' in the sample can be detected, 'gene mutation' in cancer patient can also be detected via this.

(ii) ELISA: ENZYME LINKED IMMUNO SORBANT ASSAY

- ○ In the patient, 'Antigen' or 'Antibody' corresponding to a particular disease can be detected.
- ○ Based on 'Ag'-'Ab' interaction

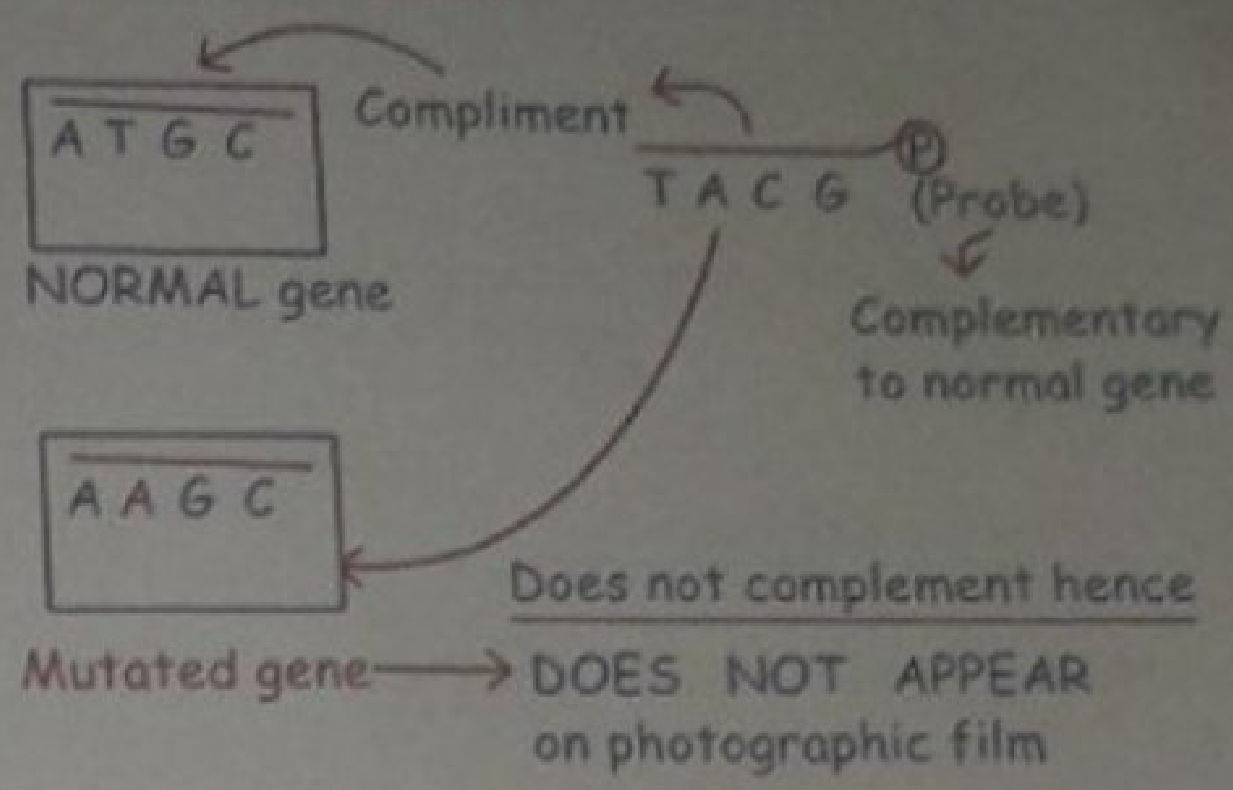
(iii) Autoradiography:

→ Any mutations in the gene can be detected using this technique.

→ Here, a ssDNA or RNA which is radiolabelled called as 'PROBE' is allowed to form complimentary Bond with the gene suspected to be mutated.

→ If complementary binding happens & X-rays passed through them, it appears on the photographic film which means the gene is NORMAL:

→ How this is done?



Transgenic Animals

→ Animals whose gene have been manipulated.

→ 95% of the transgenic animals are mice.

→ Transgenic rabbit, fish, sheep, pig, cow etc also produced.

Why Transgenic Animals Created?

(i) Normal physiology and development:

To study:

- ○ Normal body functions & growth.
- ○ How genes are regulated
- ○ Study of complex factors like: Insulin like growth factor.

(ii) Study of disease:

- ○ To know about the disease & find suitable treatment.
- ○ Models for CANCER, CYSTIC FIBROSIS, RHEUMATOID ARTHRITIS, ALZHEIMER'S exists today.

(iii) Biological products:

○ Rosie: Transgenic cow: Protein enriched milk

↓

2.4 g/Litre human α-Lactalbumin

↓

Nutritionally more Balanced than natural cow milk

○ Tracy: Transgenic sheep → produced α-1-antitrypsin

↓

treat EMPHYSEMA

(iv) Vaccine safety: Testing on 'transgenic mice' before human trials.

NOTE Transgenic mice used to test the safety of Polio vaccine: if successful: they could replace use of monkeys to test batches of vaccine.

(v) Chemical safety testing:

↓

Also known as TOXICITY/SAFETY TESTING

↓

Transgenic animal: MORE SENSITIVE to toxic substances

↓

hence give FASTER results

ETHICAL ISSUES

The manipulations in the gene of animals cannot go beyond a certain level or ethics considering human emotions, Safety etc without regulation

GEAC: Genetic Engineering Approval Committee

→ Makes decision regarding validity of GM research & safety of introducing GM organisms for public services

→ **By the Indian government**

Biopatent & Biopiracy:

→ A biopatent is a patent granted by the government to the inventor for biological entities and for products obtained from them.

→ It allows the patent holder to prevent others from making, using, selling, or importing the protected invention for a limited period of time.

→ BIOPIRACY: Illegal, unauthorised use of biochemicals or genetic materials.

e.g., BASMATI RICE, In 1997. US company got patent to use our Indian basmati by US patent & trademark. They crossed our Indian basmati with semi dwarf, variety of rice to produce a new variety & claimed to be their own.

Basmati rice × Semi dwarf variety rice

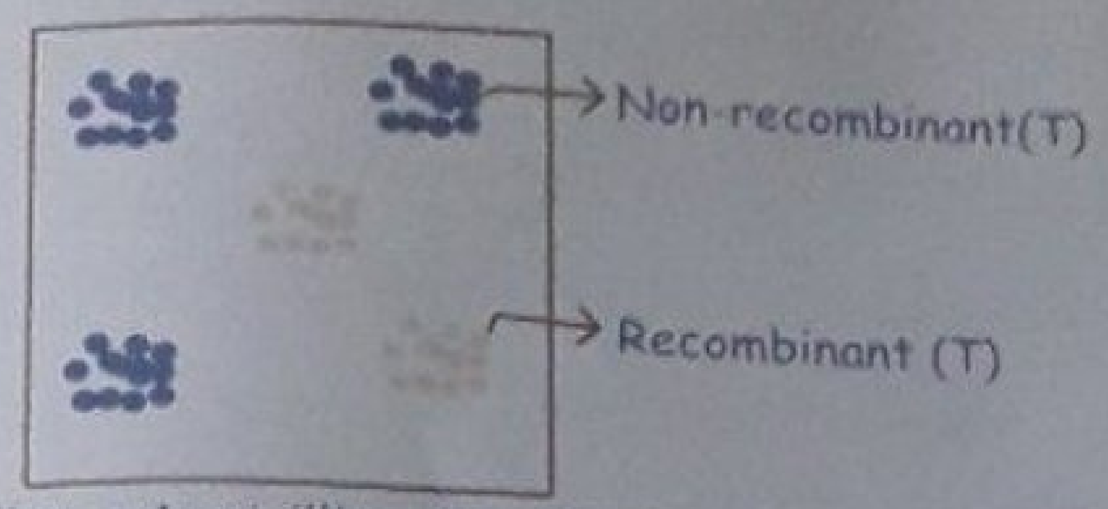
↓

Made a new Variety → Claimed to be their own

NOTE

- Several attempts have been made for Neem & Turmeric
- India has: 2 lakh variety of RICE
  → 27 documented variety of Basmati

Blue White Colony Selection:



Medium + Ampicillin + X gal (Substrate)

↓

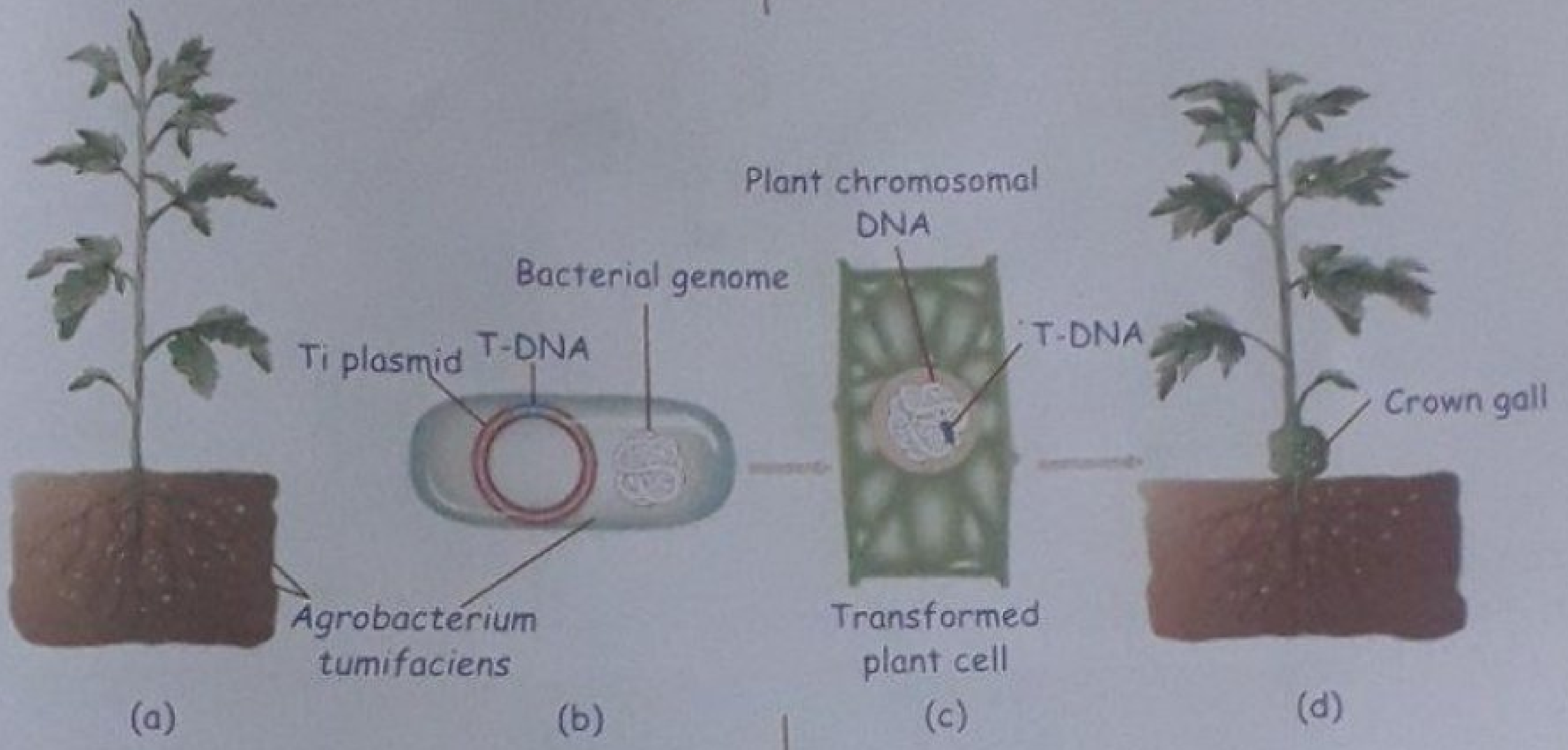
Non-transformant Die

- Those colonies which are 'NR' will have intact lac z gene means will produce β-galactosidase means will utilise the substrate to produce <u>BLUE COLOUR</u> in the medium
- White colonies indicates recombinants as their lac z gene is damaged & has a foreign gene, so no β-galactoridase, hence no <u>BLUE COLOUR</u>

INSERTIONAL INACTIVATION: Due to insertion of an alien piece of DNA at the particular sites/ genes, those genes gets inactivated.

Vectors for cloning genes in plant and animals:

For example, *Agrobacterium tumefaciens*, a pathogen of several dicot plants is able to deliver a piece of DNA known as 'T-DNA' to transform normal plant cells into a tumor and direct these tumor cells to produce the chemicals as required by the pathogen.



T-DNA (transfer DNA)

Ti plasmid(Tumor inducing Plasmid)

- We can use them as a vector for Transforming plants by **DISARMING THEM**, so that are no more Pathogenic to the Plants but can be useful to us.
- Similarly, **RETROVIRUSES** have also been disarmed and are now used to deliver desirable genes into animal cells. So, once a gene or a DNA fragment has been ligated into a suitable vector it is transferred into a bacterial, plant or animal host (where it multiplies).

NOTE

Bacteria	→	Plasmid	Vectors
Animal	→	Retroviruses	
Plant	→	Ti plasmid	

6. Transformation of Host

1. <u>Heat Shock Treatment</u>: (Bacteria - HOST)
   Host is made 'Competent'
   → Capable to take up the foreign gene.

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15 Biotechnology and its Applications

Biotechnology Application
- In waste treatment
- In energy production and processed food
- In agriculture
  - Pest Resistant Plant
    - Bt. Cotton
    - RNAi
- In medicine
  - Genetically modified insulin
  - Gene therapy
  - Diagnostic

○ Three critical research areas of biotechnology are:

(i) Providing the best catalyst (Microbe/organism/ pure enzyme).

(ii) Creating optimal conditions for a catalyst to act.

(iii) Downstream processing: Purify the protein/ organic compound.

Biotechnological Applications in Agriculture

Three ways to increase the food production

(i) Agro-chemical based agriculture;

Use of harmful chemicals → PESTICIDES & FERTILIZERS { Insecticides, Herbicides

(ii) Organic agriculture

(ECO-FRIENDLY) → Biopesticides, Biofertilizers

(iii) Genetically engineered crop-based agriculture

→ Use of Genetically modified crops

NOTE

The Green Revolution (1960's-1970's) succeeded in TRIPLING the food supply but yet it was not enough to feed the growing human population.

Increased yields have been due to:

○ The use of improved crop varieties.

○ Mainly due to the use of better management practices & use of agro-chemicals (fertilisers and pesticides)

GMO (Genetically Modified Organisms)

Plant, bacteria and animals whose genes have been altered by manipulation.

PLANT BREEDING

What is Tissue Culture ?

As traditional breeding techniques failed to keep pace with demand and provide sufficiently fast and efficient systems for crop improvement: Tissue culture was developed.

- → Plant Hormones: Auxin, cytokinin
- → Inorganic salt
- → Carbon source (sugar) sucrose
- → Vitamin, amino acid
- → Beaker
- → Plant cell/Tissue/organ (leaf)

(Plant hormones, inorganic salt, carbon source, vitamin: Nutrient media or culture media)

○ When plant cell/tissue/organ is grown in a culture medium, then this cell is able to form the complete plant & technique is called Tissue Culture.

How this happens ?

Because in plant we have Totipotency condition

Cell placed in nutrient media

↓

Cell divide

↓

Plant

↓

The capacity to generate a whole plant from any cell/explant

↓

Totipotency

○ Somatic hybrid → Synkaryon (fused Nuclei) / → Heterokaryon (unfused Nuclei)

e.g., Pomato: Potato × Tomato

does not contain all character of potato & tomato

IMPORTANT POINT TO REMEMBER

1. Micropropagation

Thousand of plant produced with the help small/ micro-part of leaf (Vegetative propagation or asexual reproduction)

2. Somaclone

Soma – Same

Somatic cell used (Root, stem leaf)

Leaf → Leaf part

↓

No Variation | Tissue culture Technique

↓

Plant Produce

Leaf Leaf Leaf Leaf

⇒ All are same (Asexual Reproduction)

⇒ All are clone

3. Somaclonal variation

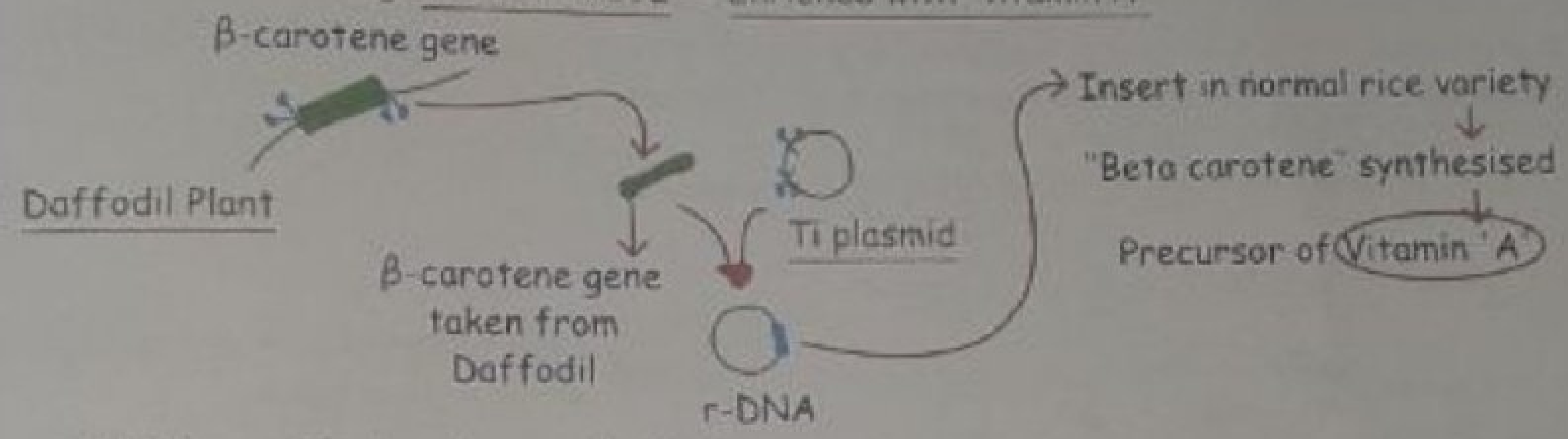
Sometime we observe very minute variation during tissue culture called somaclonal variation

Advantage of GM Plants:

→ Increase in the productivity.

→ Enhanced nutritional value.

eg: GOLDEN RICE → Enriched with 'vitamin A'



→ Increased efficiency of mineral usage by Plants.

→ Reduced reliance on chemical pesticide.

→ Can tolerate abiotic stress like salinity, high/low temperature dry or moist conditions etc.

→ Help to reduce post harvest losses.

Biotechnology: Application in Agriculture

1. (Bt) Cotton (PEST-RESISTANT PLANT)

→ *Bacillus thuringiensis*

Cotton Bollworm → Damage Cotton Balls
→ (PEST)

OBSERVATION:

→ Occationally while the insect feeds on plants this bacteria also becomes the diet of the insect & when fed upon the bacteria, eventually the insect dies.