

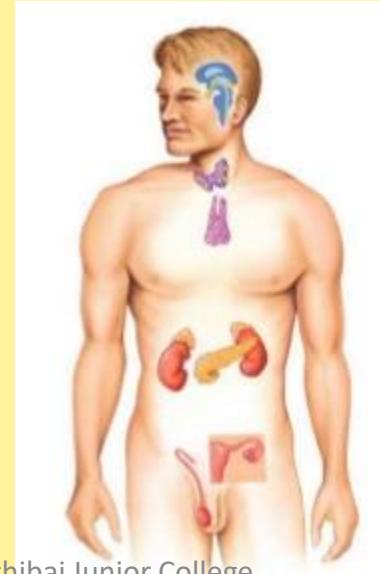
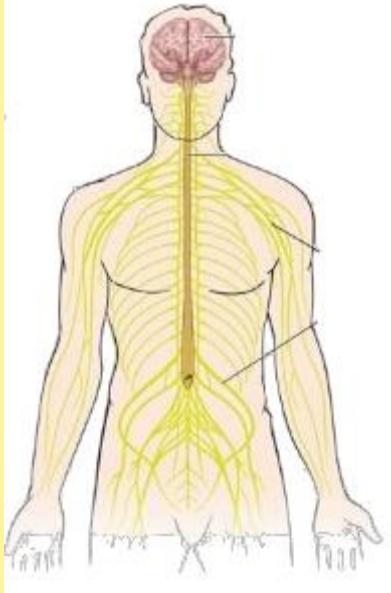


# Control and Coordination

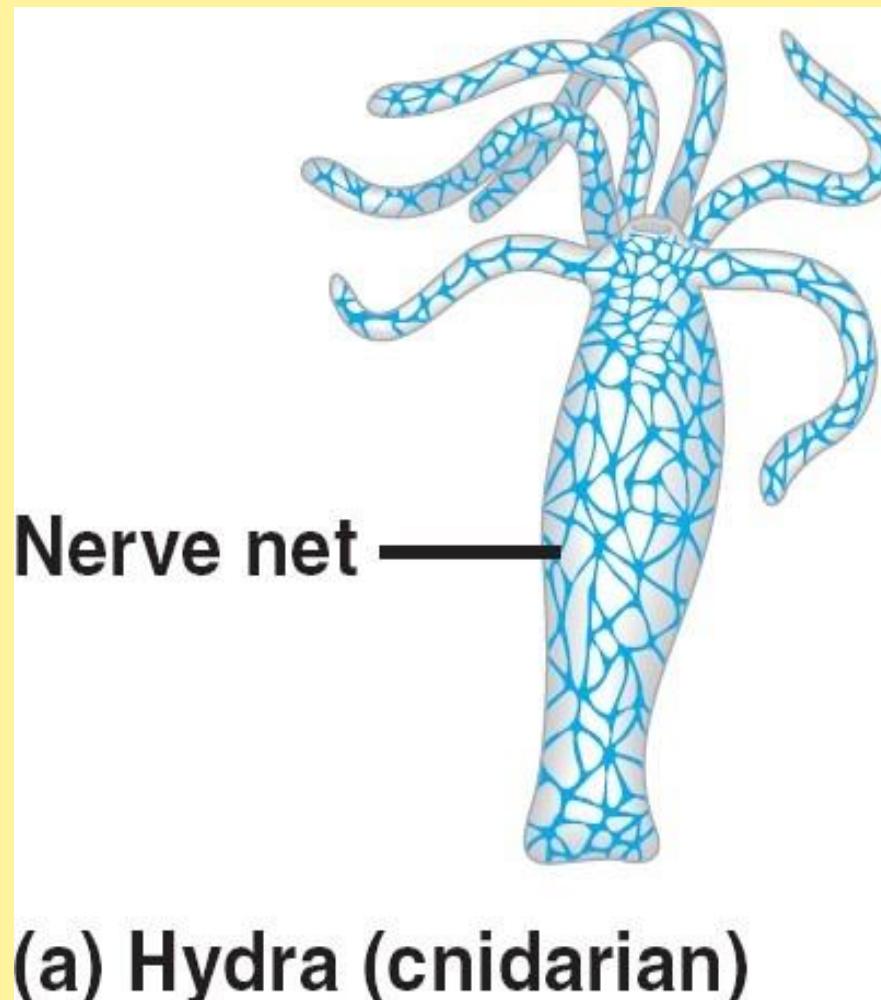
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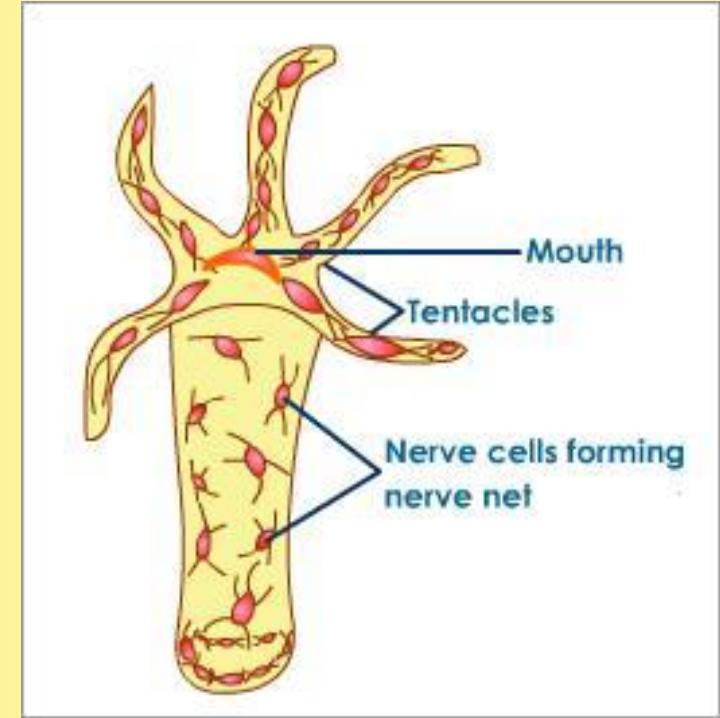
- Unicellular organism- simple organization
- Multicellular organism – control and coordination seen between various systems
- Lower forms- no proper nervous system
- Higher form- coordination of systems.  
(Nervous system[electrical] and endocrine system[chemical])



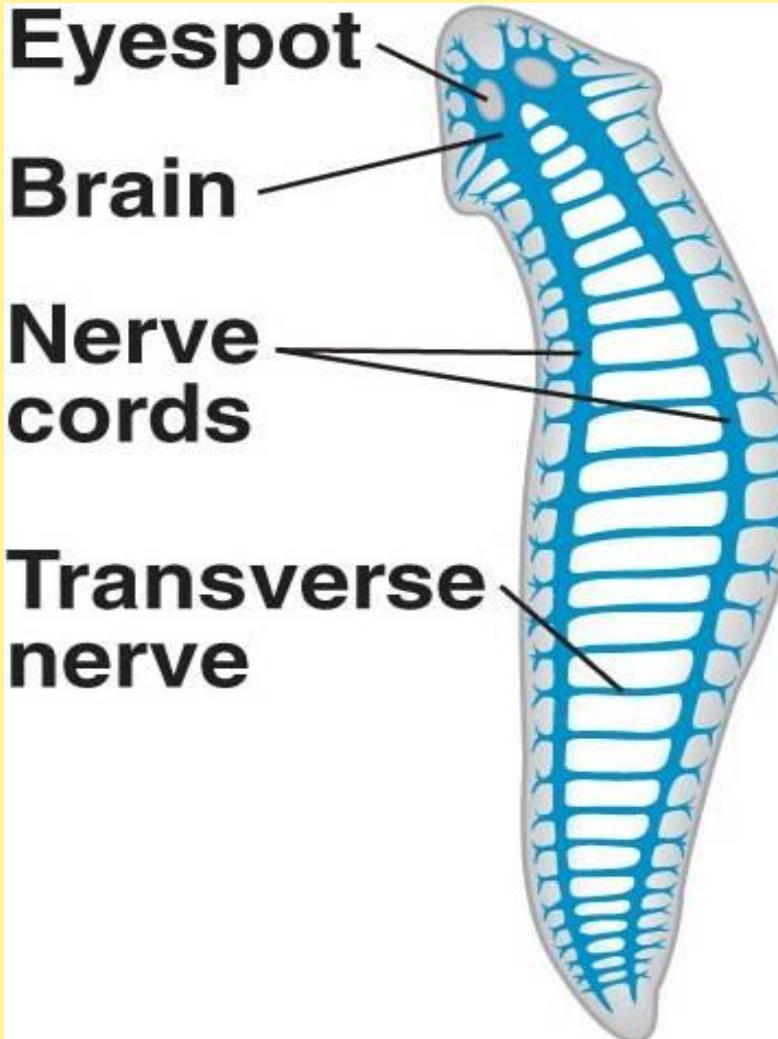
# UNIT 9.1 Nervous system in Hydra:



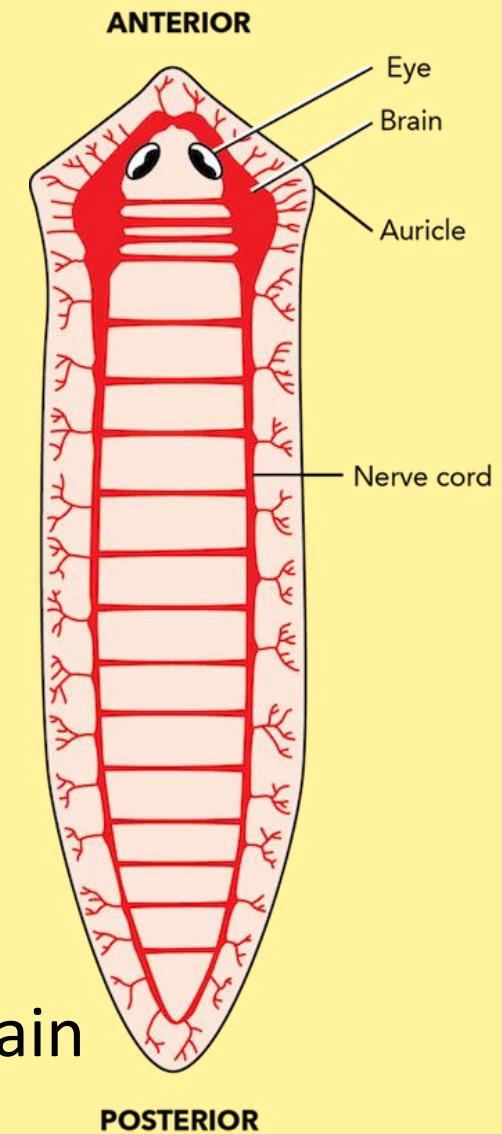
- Most primitive nervous system
- First animal group- true simple nervous system
- Diffused nervous system
- Form **nerve net**
- Two nerve nets(mesogloea) –connected to epidermis and gastrodermis
- Consists of sensory cells (body wall and tentacles) and nerve fibres (nor motor nor sensory , no direction)
- Any point activation, any direction.



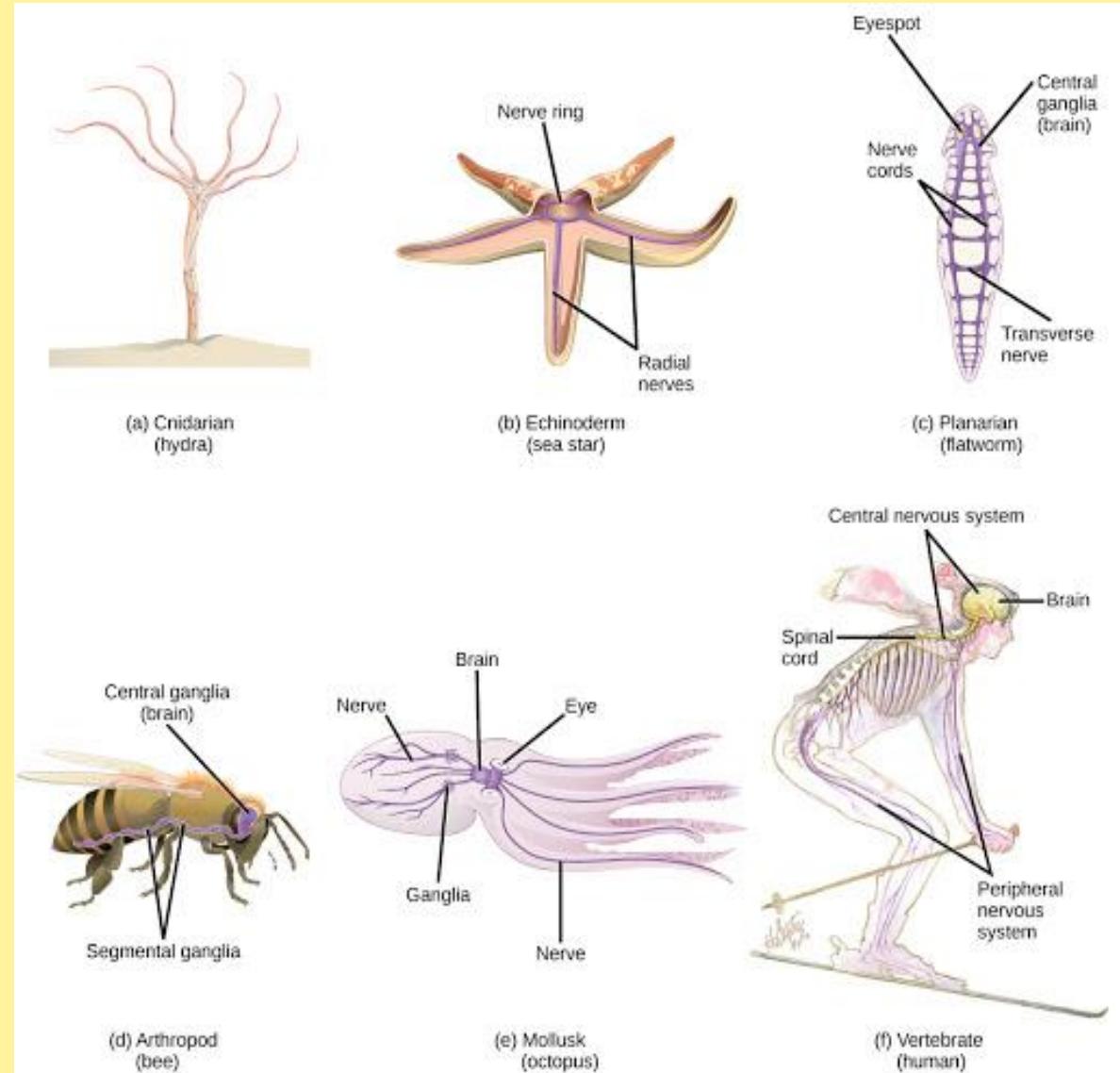
# UNIT 9.2 Nervous system in Planaria (flatworm)



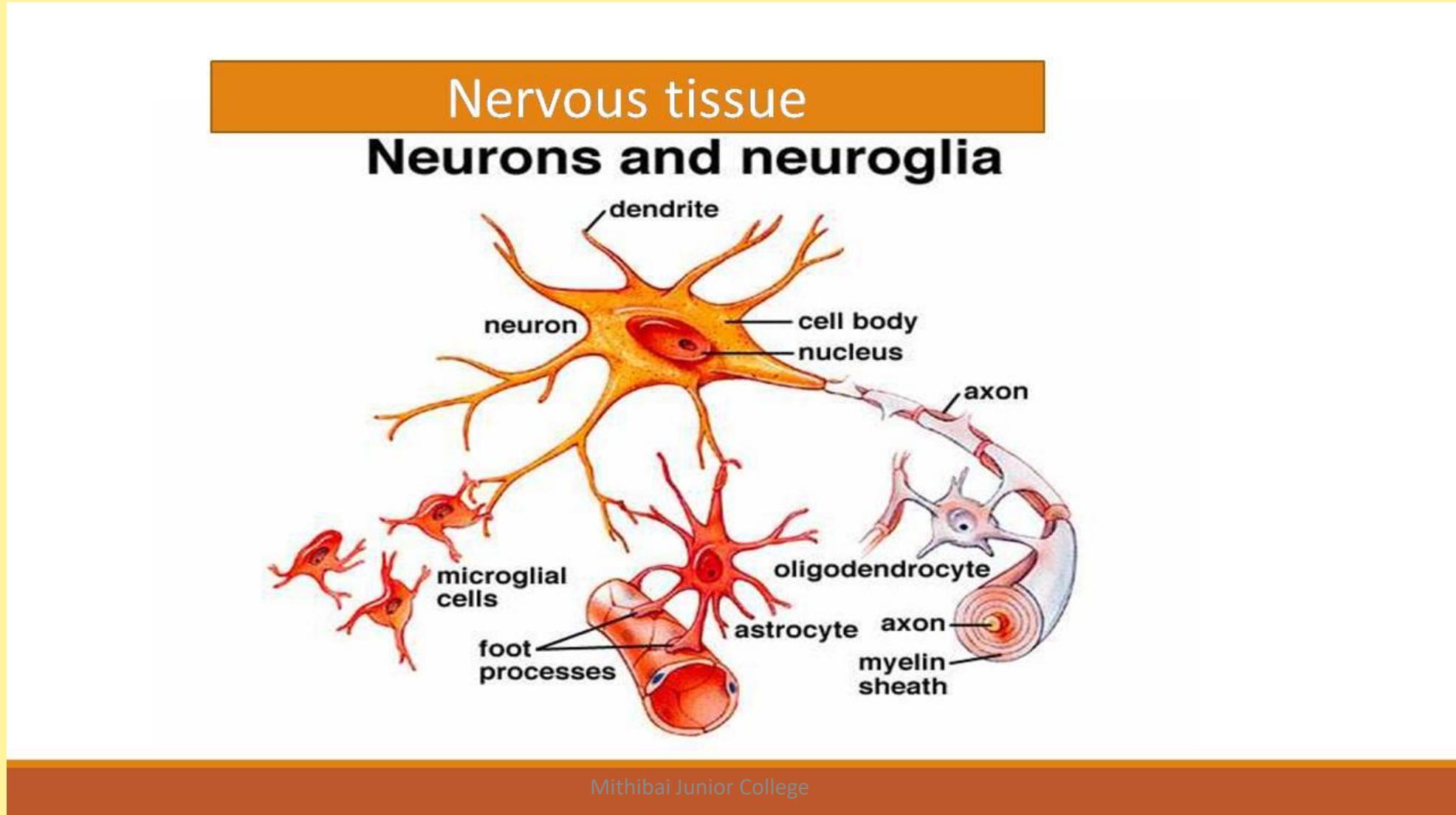
- Planaria-Platyhelminthes
- Most primitive type –C.N.S – ventral side.
- **Mass of cephalic /cerebral ganglion**
- **Inverted U shaped brain-** anterior region
- 9 branches arise from each ganglion
- Below ganglia – ventral side – pair of ventral nerve cord
- Transfer nerve/commissure (ladder like) (connection)
- Peripheral nerve plexus- arise lateral from ventral nerve cord
- P.N.S – **Sensory cells**
- (a pair) **Photosensory structure(eyes)** –dorsal side of brain
- Single sensory cells – scattered.



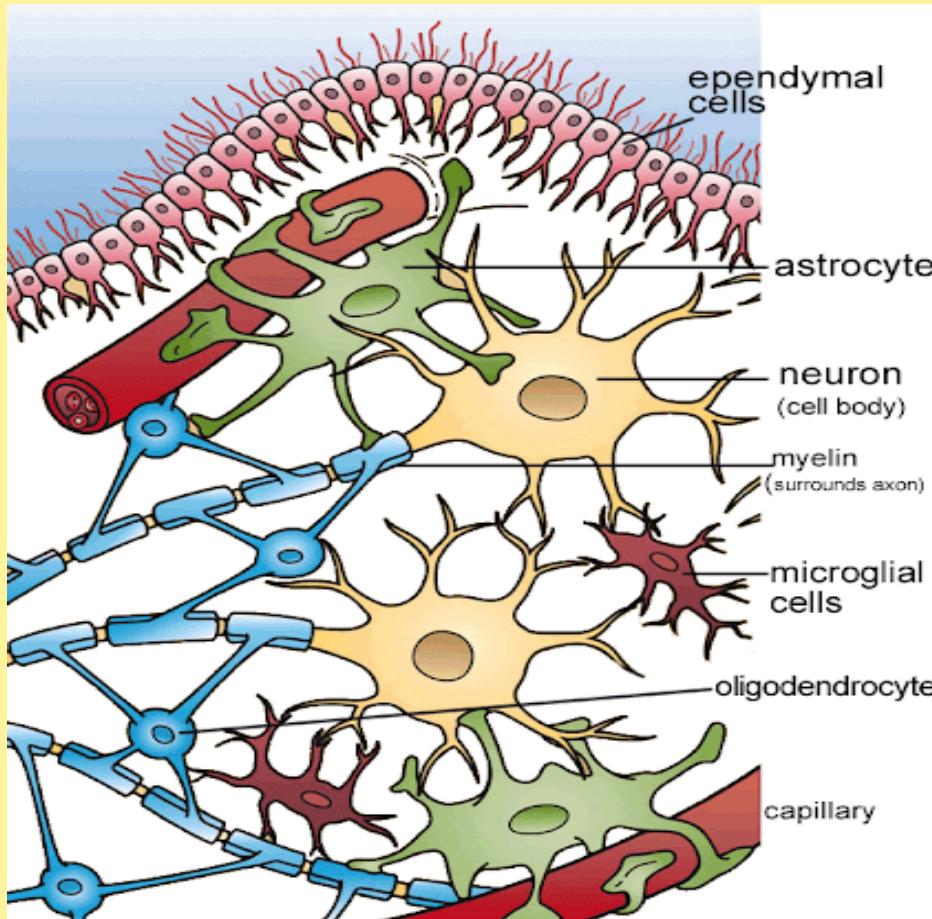
- Gradual evolution in nervous system
- High level of specialization in neurons
- **From diffused nervous system to centralized nervous system**
- **Centralization of sense organs-** coordinating internal environment with external environment.



# UNIT 9.3 Neural tissue

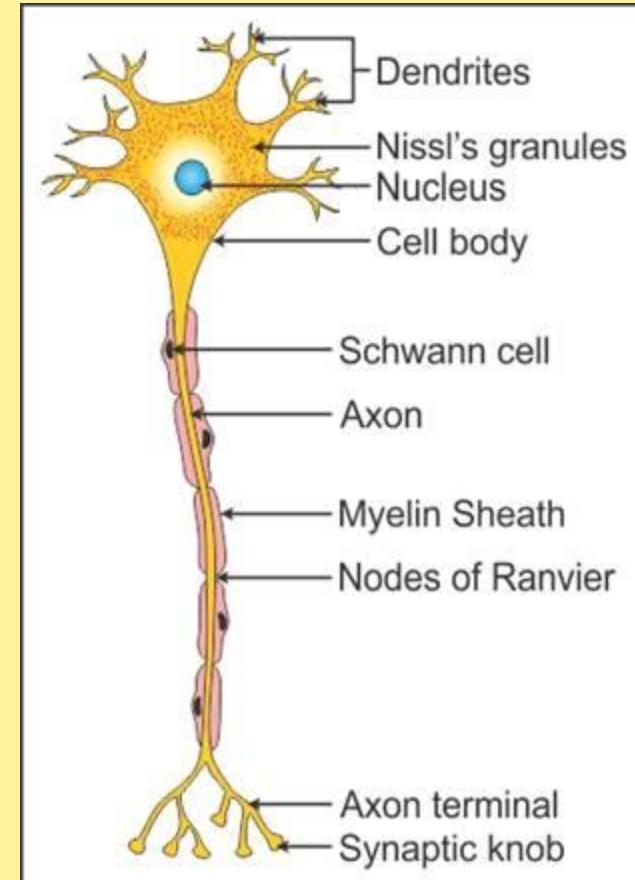


- Neural tissue- 2 types of cells
- Neurons and Neuroglial cells/ Glial cells.

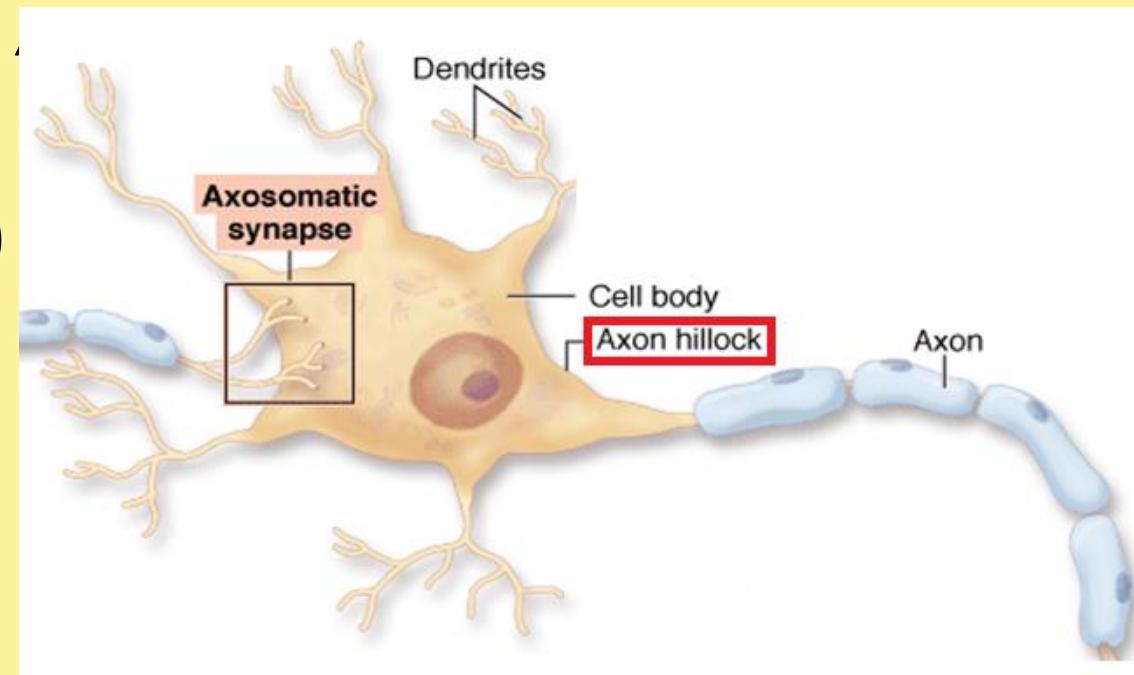


# NEURONS/NERVE CELLS:

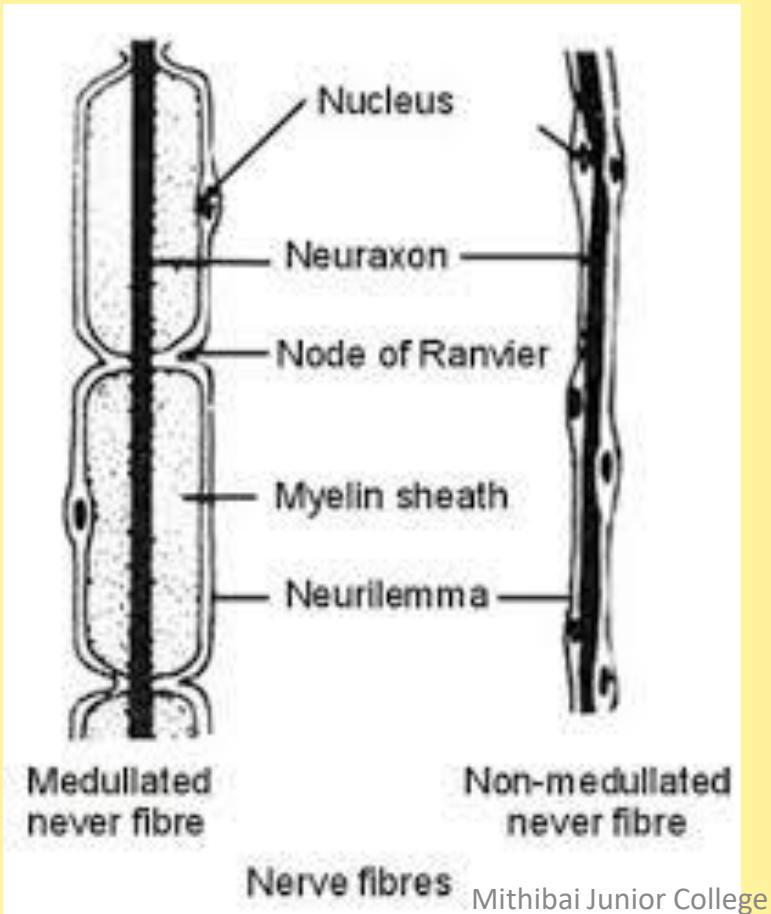
- Structural and functional unit of Nervous system
- Multipolar neuron: Cyton, Dendron and Axon
- **CYTON**: Central nucleus, nucleolus, nucleoplasm.  
Nissl's granules (enzyme for forming neurotransmitter)  
Neurofibrils present.  
Found in brain , spinal cord(CNS) and ganglia.  
Small group of cell bodies inside white matter  
of brain – **Basal nuclei**
- **DENDRON**: Process from cyton  
Branches- dendrites



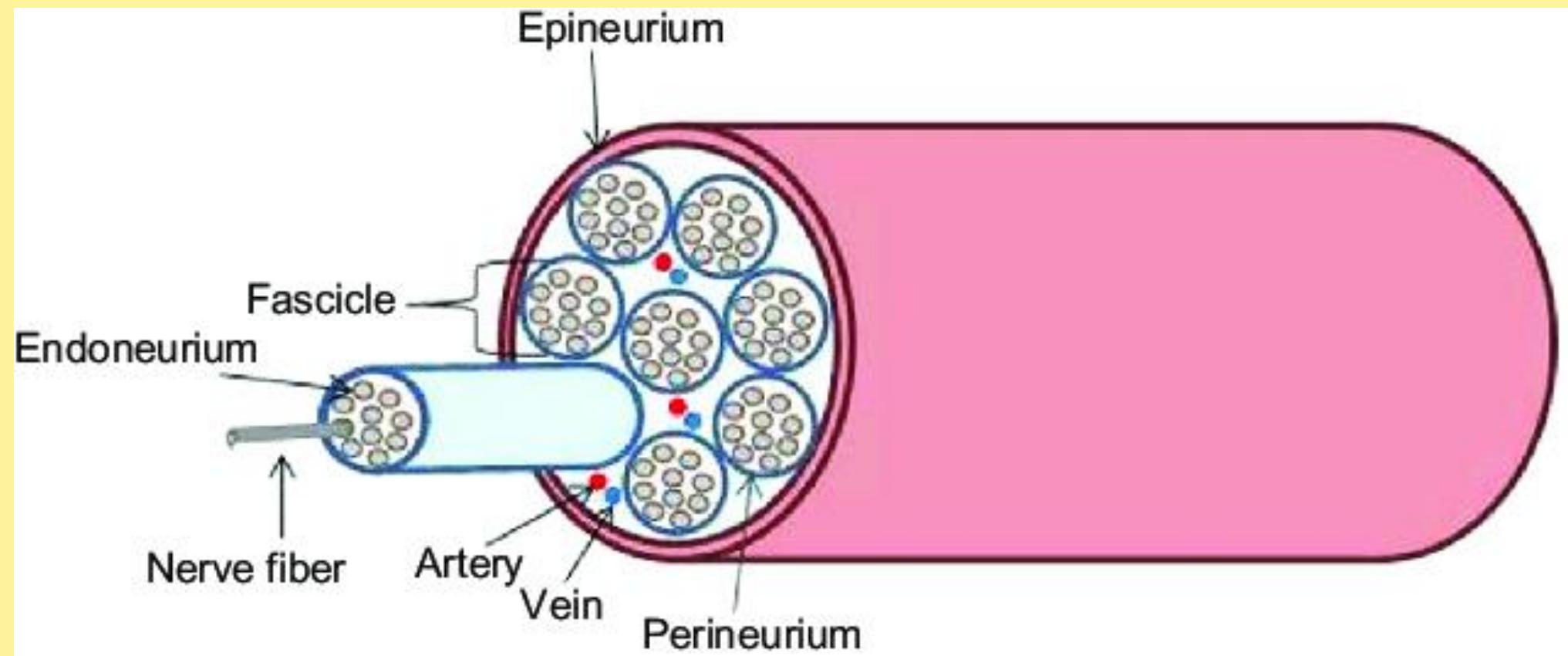
- **AXON**: Single, long process.  
Axon hillock, Bundle of neurofibrils  
Nissl's granule absent  
End- telodendrons , Lateral branches – collaterals  
Synapse- axo-dendronic or axo-axonic ,  
axo-somatic or dendro- dendritic.  
Bundle of axons- Nerve(outside C.N.S)  
- Tract (inside C.N.S)  
They are sensory, motor or mixed.



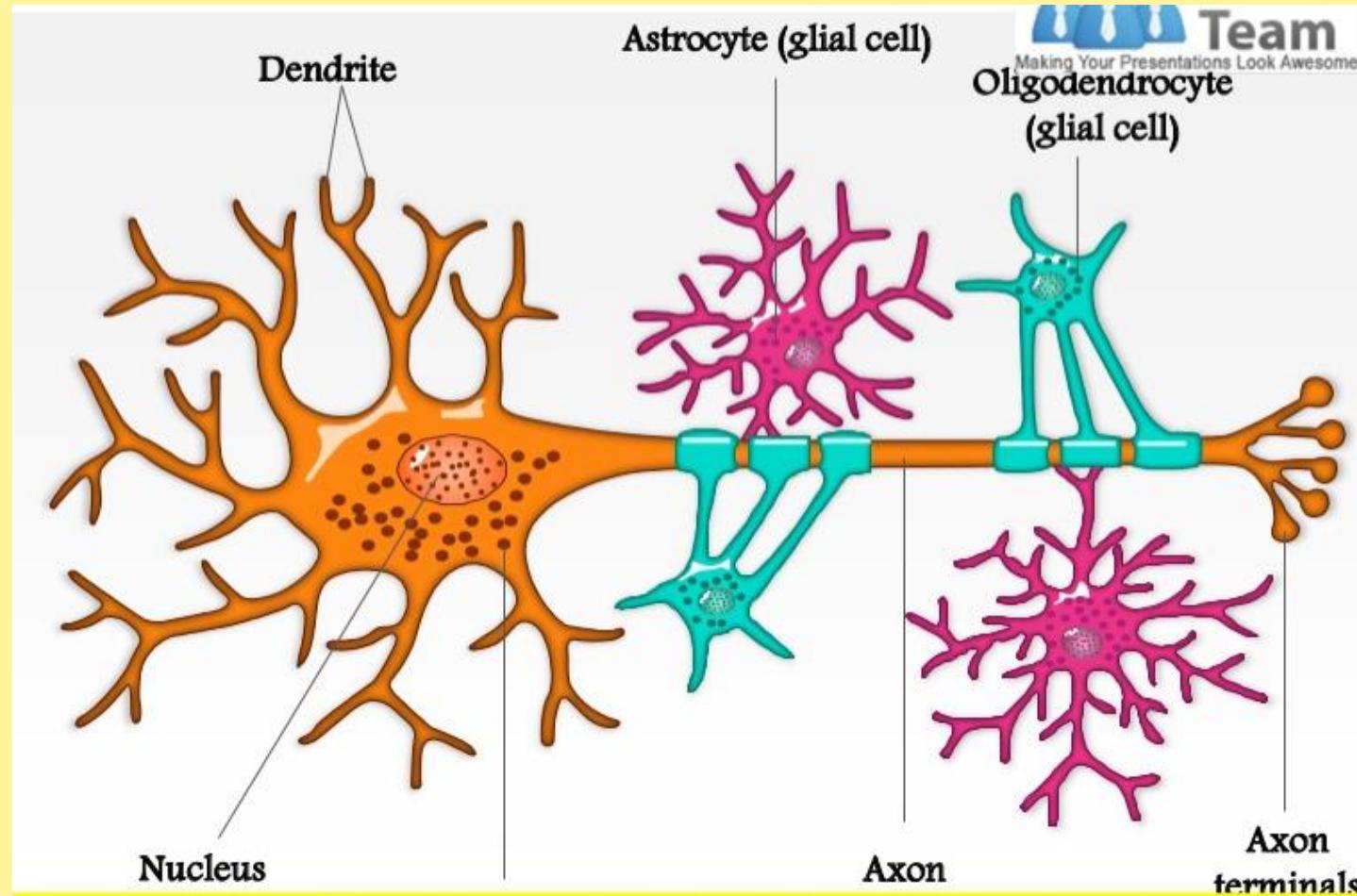
- Nerves: Medullated (medullary sheath) or Non- medullated ( only neurilemma)
- Conduction in medullated 50 times faster.



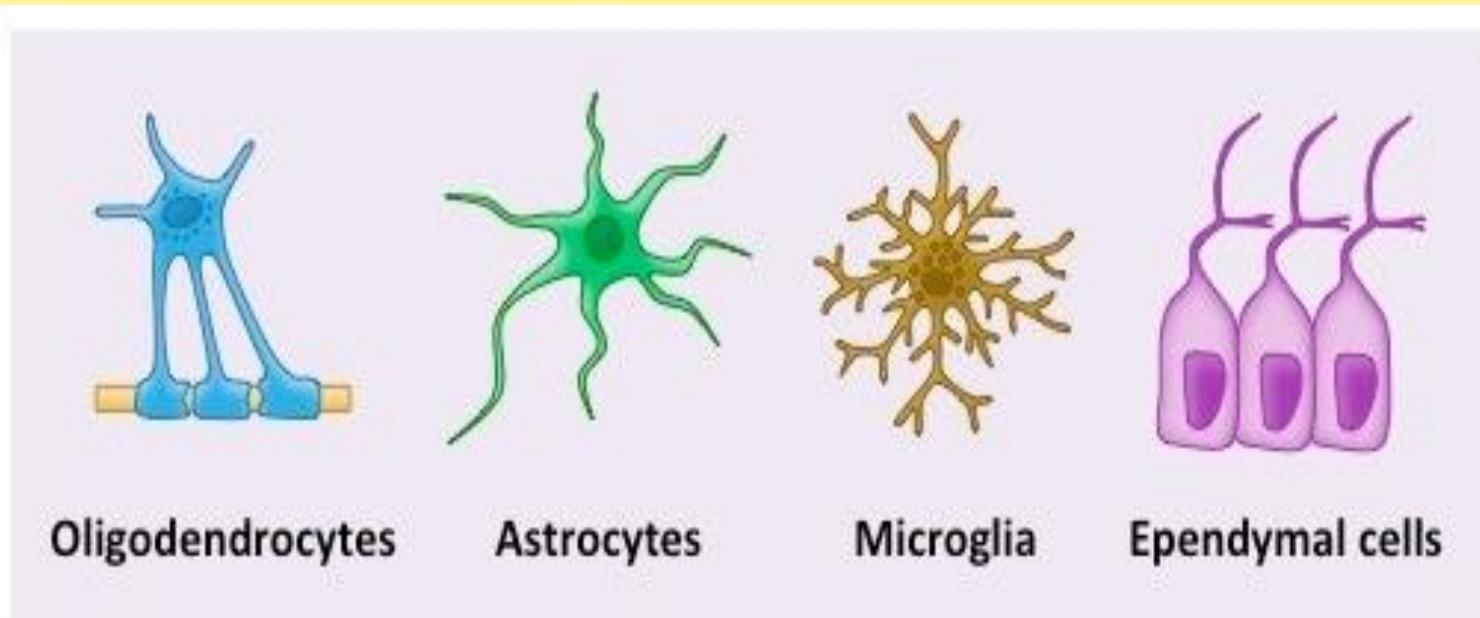
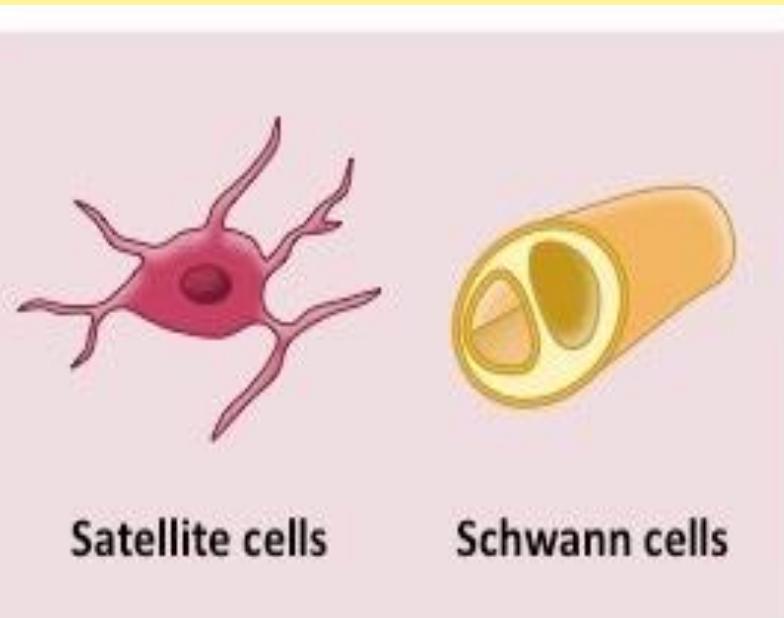
- Nerve fascicle ( Bundle of axons) – endoneurium – perineurium – epineurium



# NEUROGLIAL CELLS: supporting cells



- Supporting cells- P.N.S and C.N.S
- Derived- ectoderm
- More in number than neurons



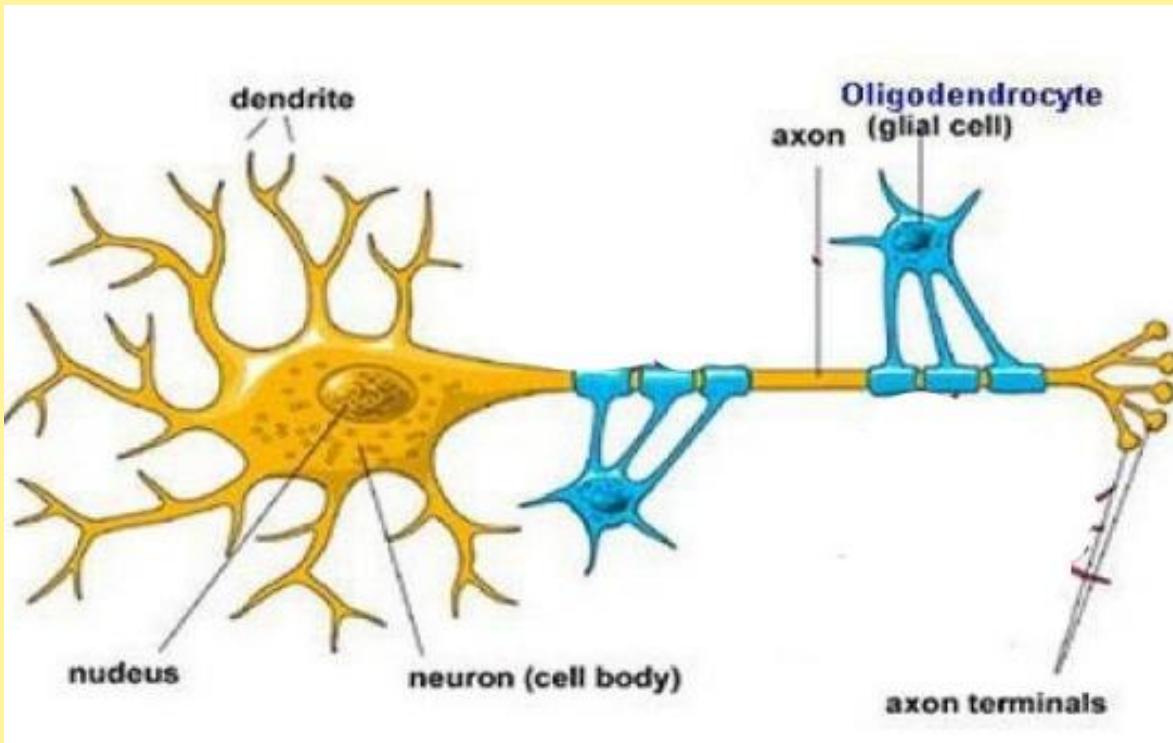
Peripheral Nervous System

Central Nervous System

# TYPES OF NEUROGLIAL CELLS:

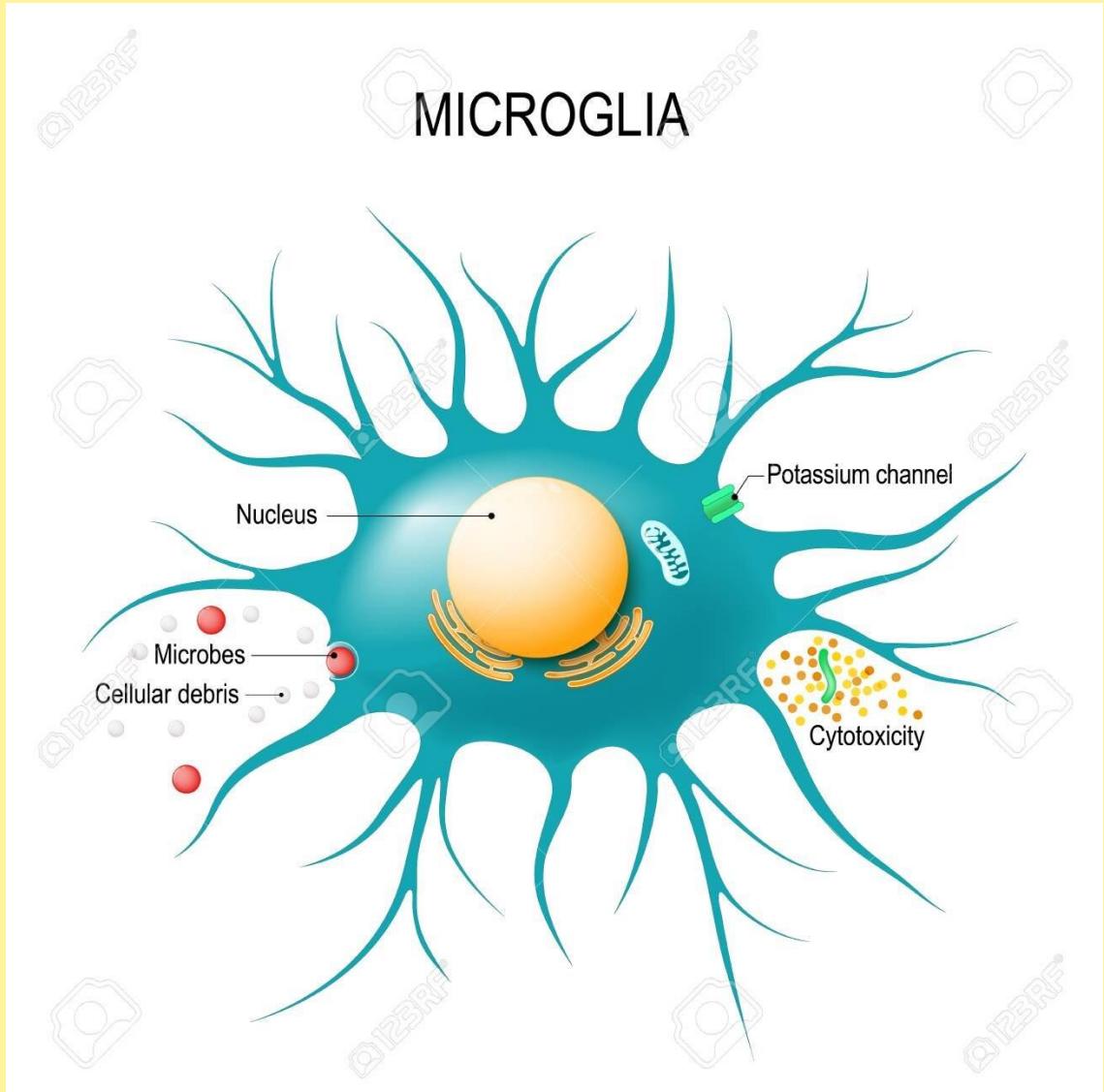
- CENTRAL NERVOUS SYSTEM:

1) Oligodendrocytes: few branches , form myelin sheath



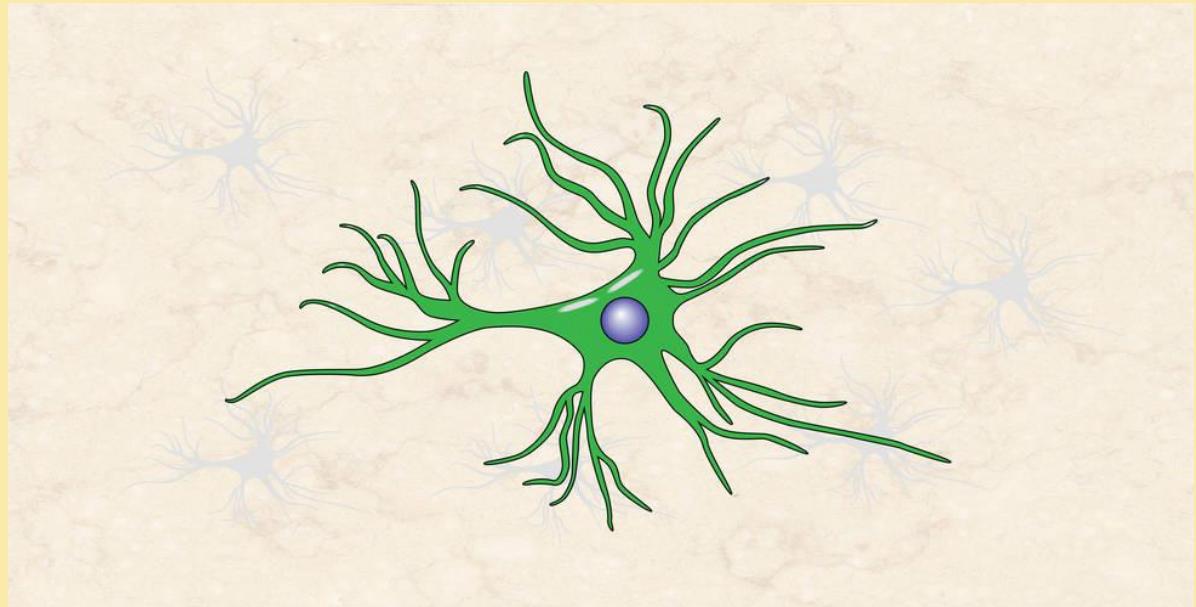
## **2) Microglia / brain macrophages:**

- Small branches
- derived from monocytes
- give immune response



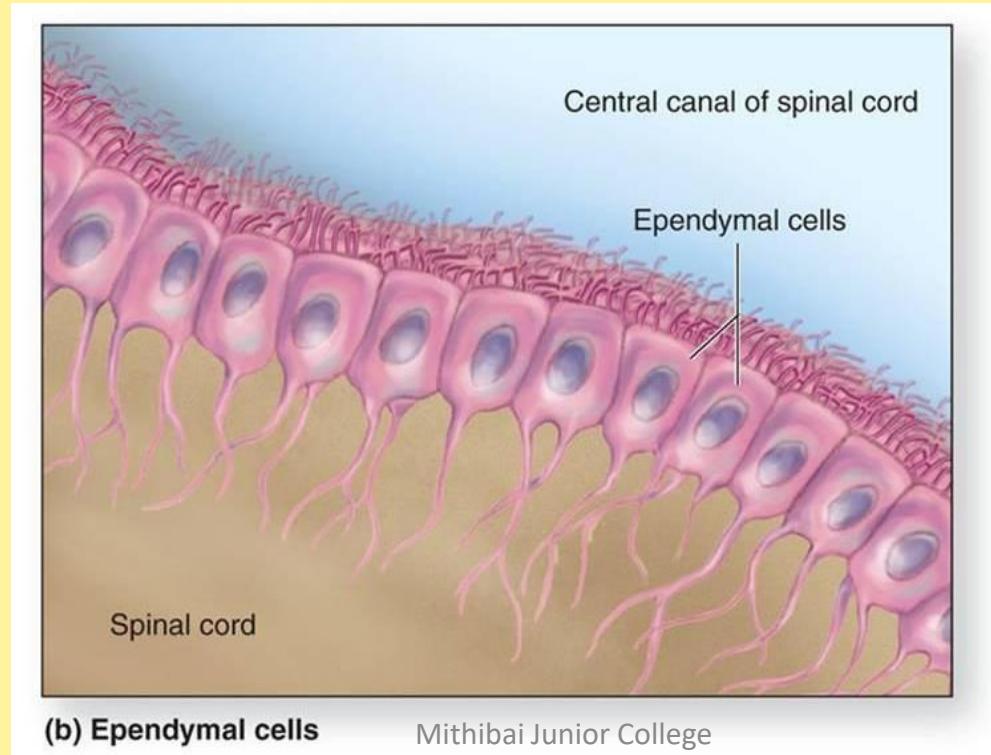
### **3) Astrocytes:**

- star shaped, most abundant
- secretion/absorption – neural transmitter
- maintainence of Blood - Brain – Barrier (BBB)
- regulation- electrical impulses



#### **4) Ependymal cells:**

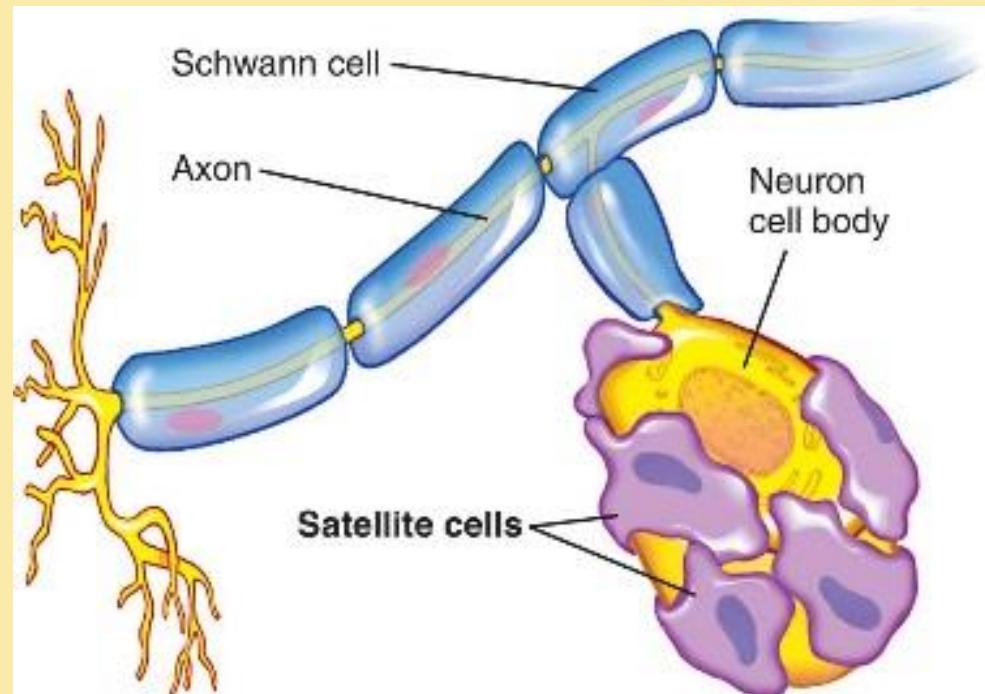
- single layer
- squamous / columnar , often ciliated
- line ventricles and central canal of spinal cord
- produce C.S.F



- **PERIPHERAL NERVOUS SYSTEM:**

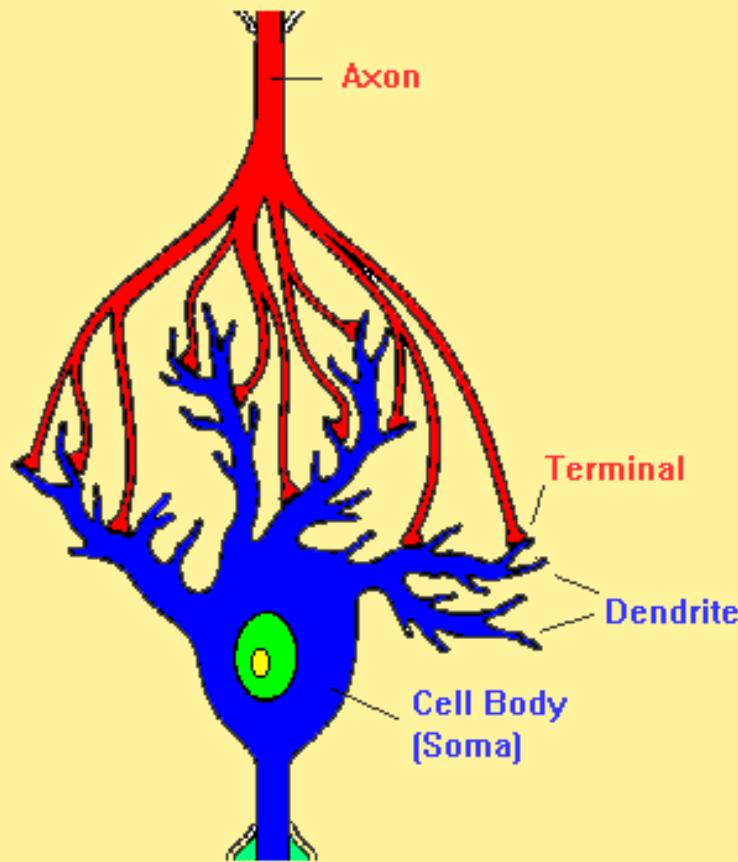
1) **Schwann cells:** most abundant , produce myelin sheath

2) **Satellite cells:** support functions of neurons



# UNIT 9.4 SYNAPSE

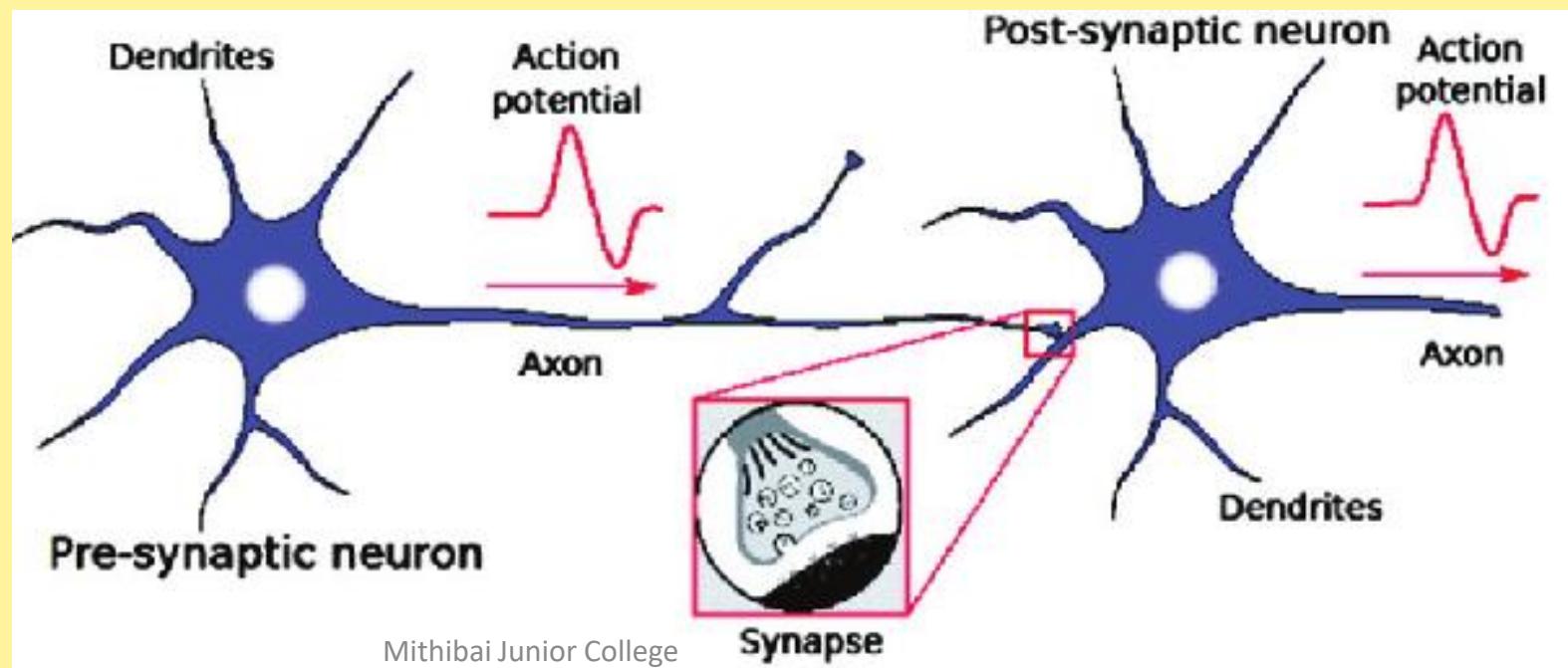
- Junction between two nerve cells with minute gap (synaptic cleft)



# 1) PROPERTIES OF NERVE FIBRES:

## a) Excitability/Irritability:

- perceive stimulus
- enter state of activity

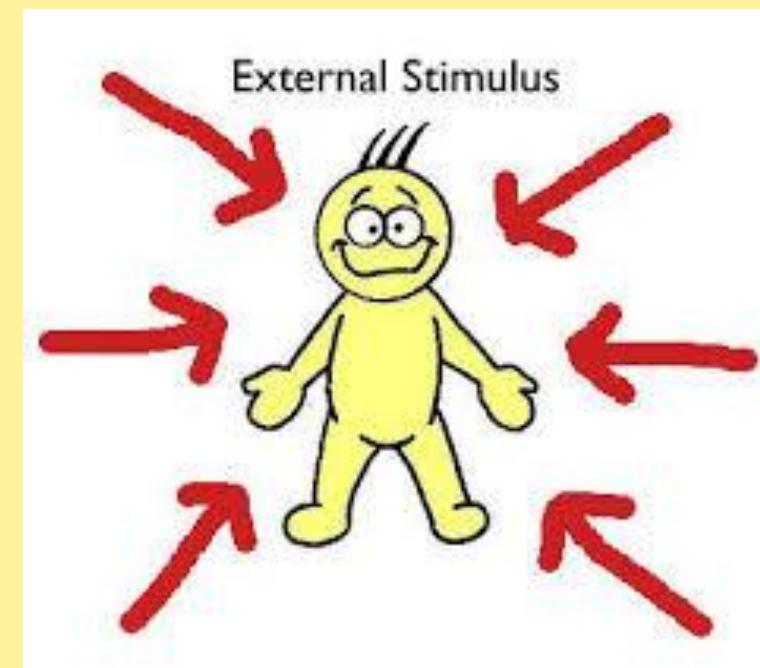
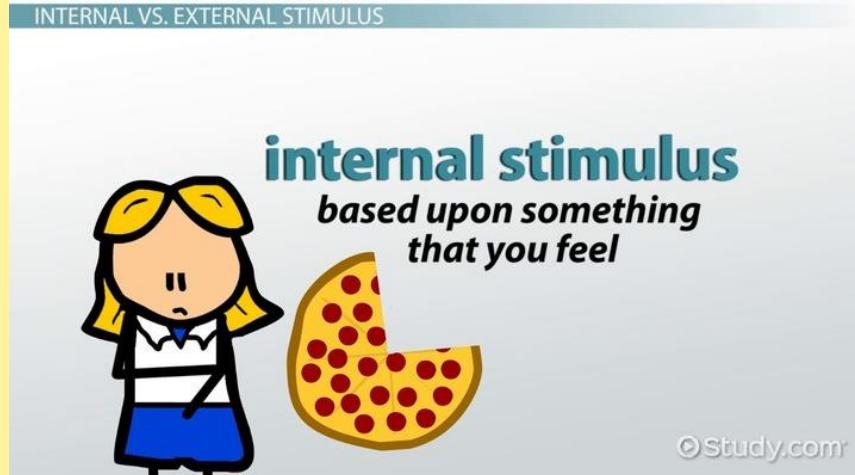


## b) Conductivity:

- transmit excitation

## c) Stimulus:

- change ( physical/chemical/electrical)
- external /internal
- threshold stimulus (minimum intensity)
- subliminal (weak) - no effect
- supraliminal (strong) –  
same effect as threshold stimulus



**d) Summation effect:**

- Subliminal stimulus – no effect
- many in succession (produce impulse)

**e) All or none law:**

- nerve conduct impulse along the entire length or not at all

**f) Refractory period:**

- Time interval (about millisec) nerve fails to respond to second stimulus (after depolarization)

**g) Synaptic delay:**

- about 0.3 -0.5sec - to cross synapse
- release of neurotransmitter
- excitation in Dendron of next neuron

## **h) Synaptic fatigue:**

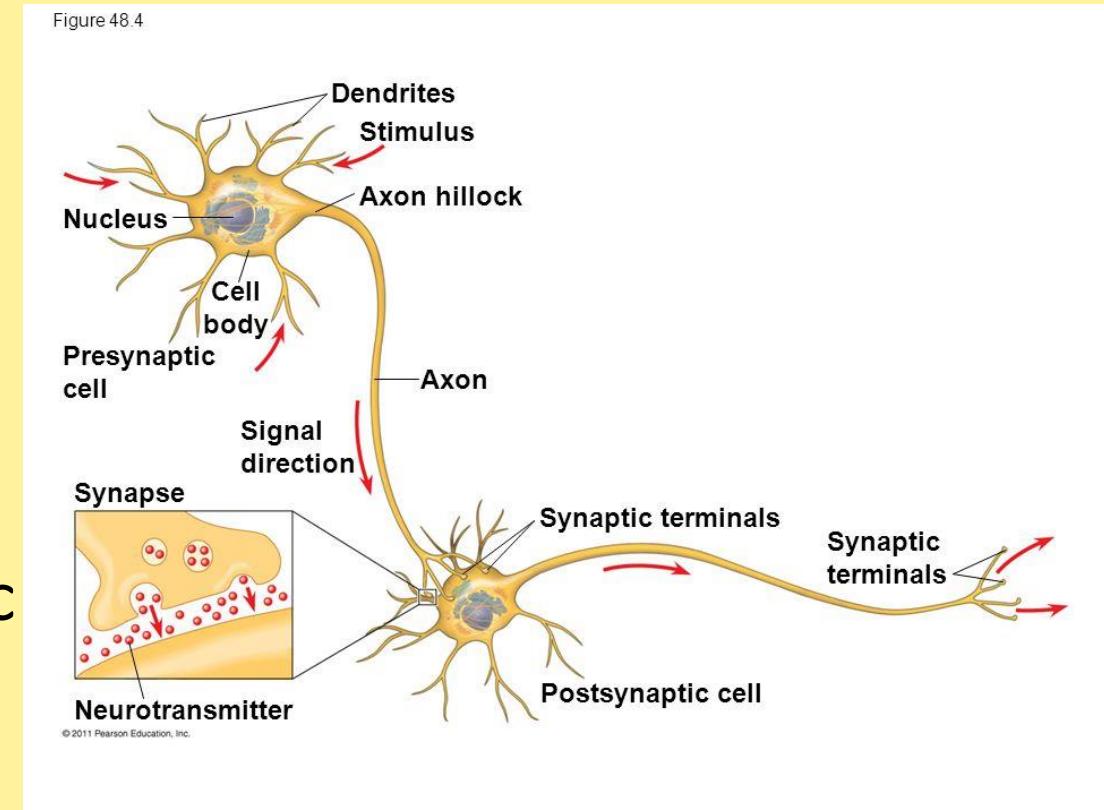
- Exhaustion of neurotransmitter
- temporary halt of impulse transmission

## **i) Velocity:**

- Rate of transmission of impulse(higher)
- long and thick nerves
- homeotherms than poikilotherms
- voluntary fibres (100-200m/sec in man) as opposed to involuntary (10-12m/sec)
- medullated nerves
- at synapse

# Terms to understand impulse transmission:

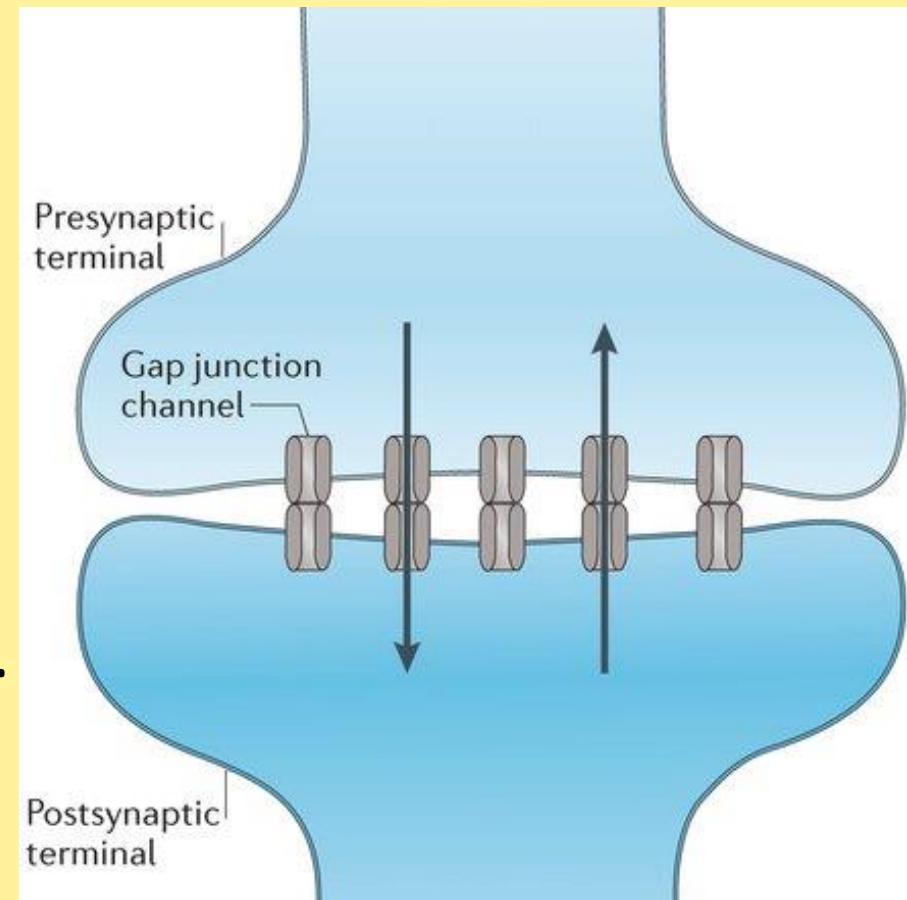
- Presynaptic neuron: carries impulse to synapse
- Postsynaptic neuron: receives input
- Synaptic cleft:
  - small intercellular space (20-30nm)
- Synaptic transmission:
  - one way process
  - impulse conduction from presynaptic to post synaptic neuron.



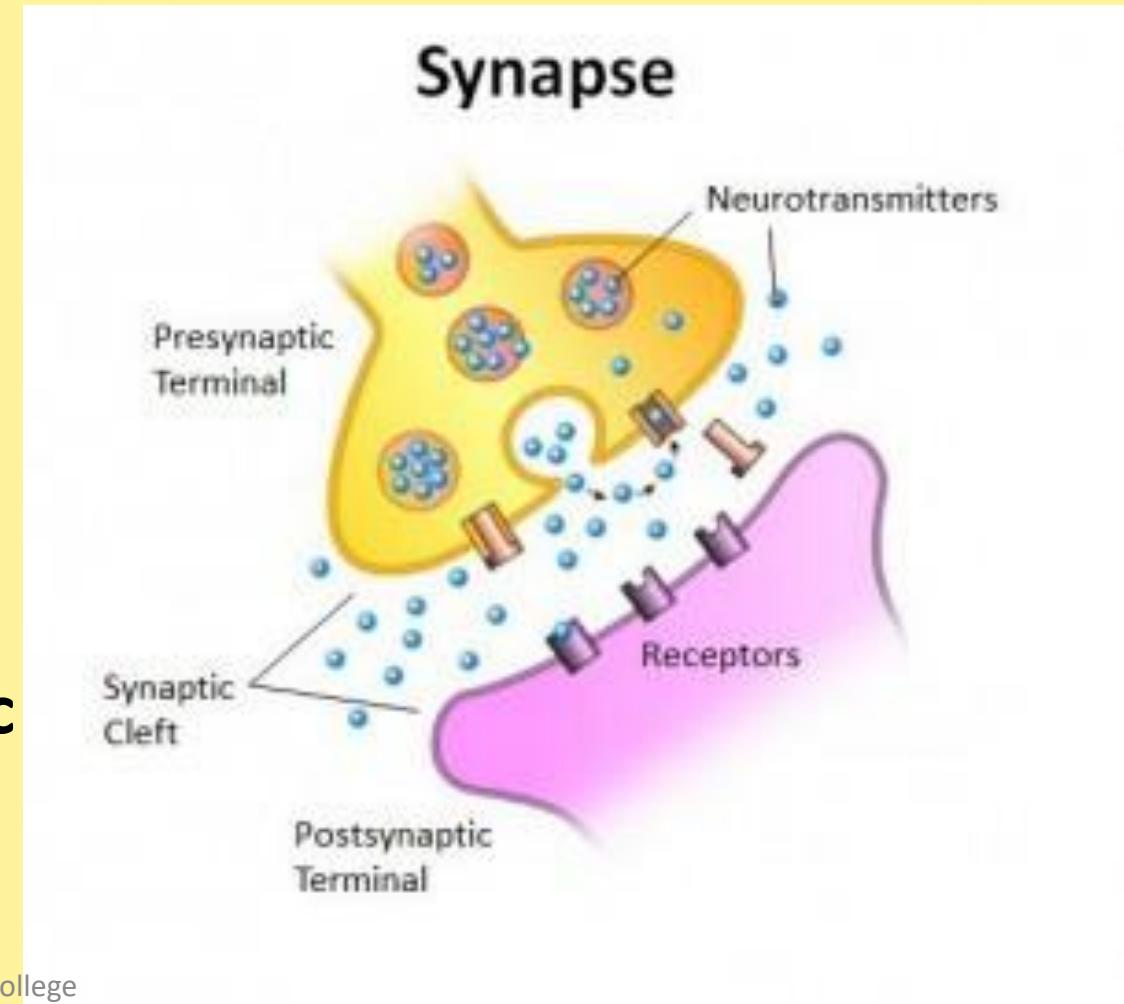
## 2) TYPES OF SYNAPSES:

### a) Electrical synapse:

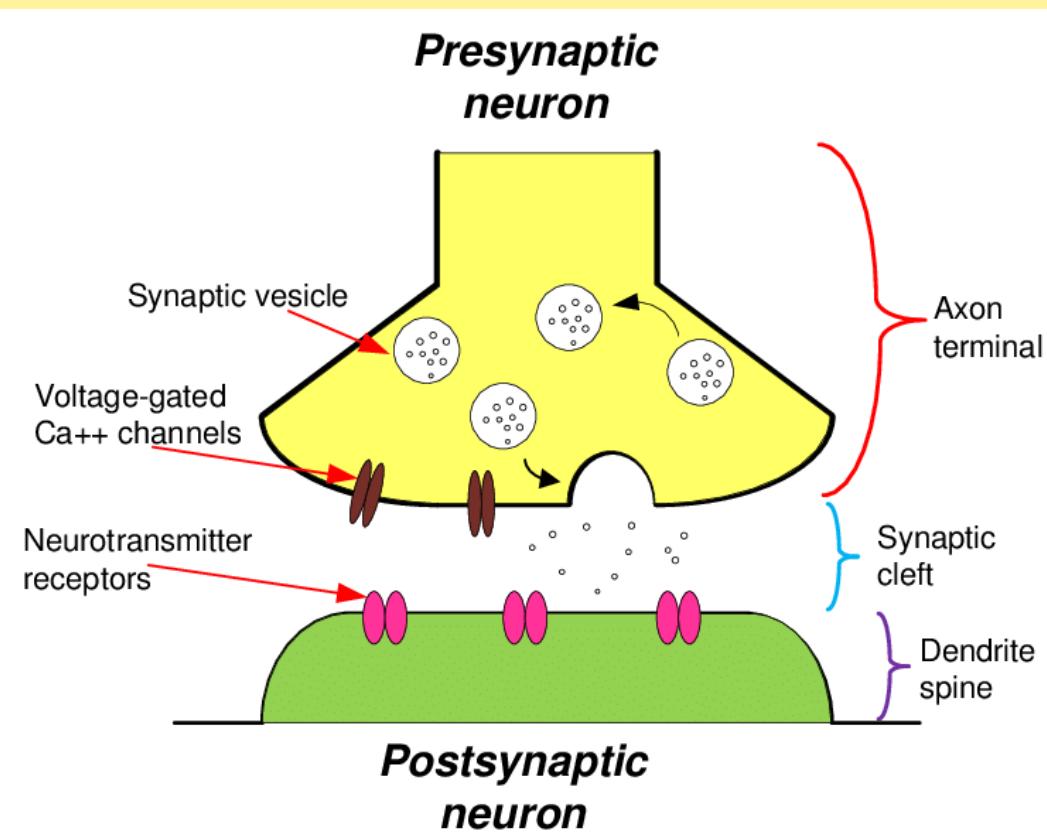
- Gap is narrow  
(between pre and post synaptic neuron)
- electrical conductive link formed
- 3.8nm distance (synaptic gap)
- transmission faster
- observed where faster response is required.  
(e.g. defense reflexes)
- unidirectional/bidirectional



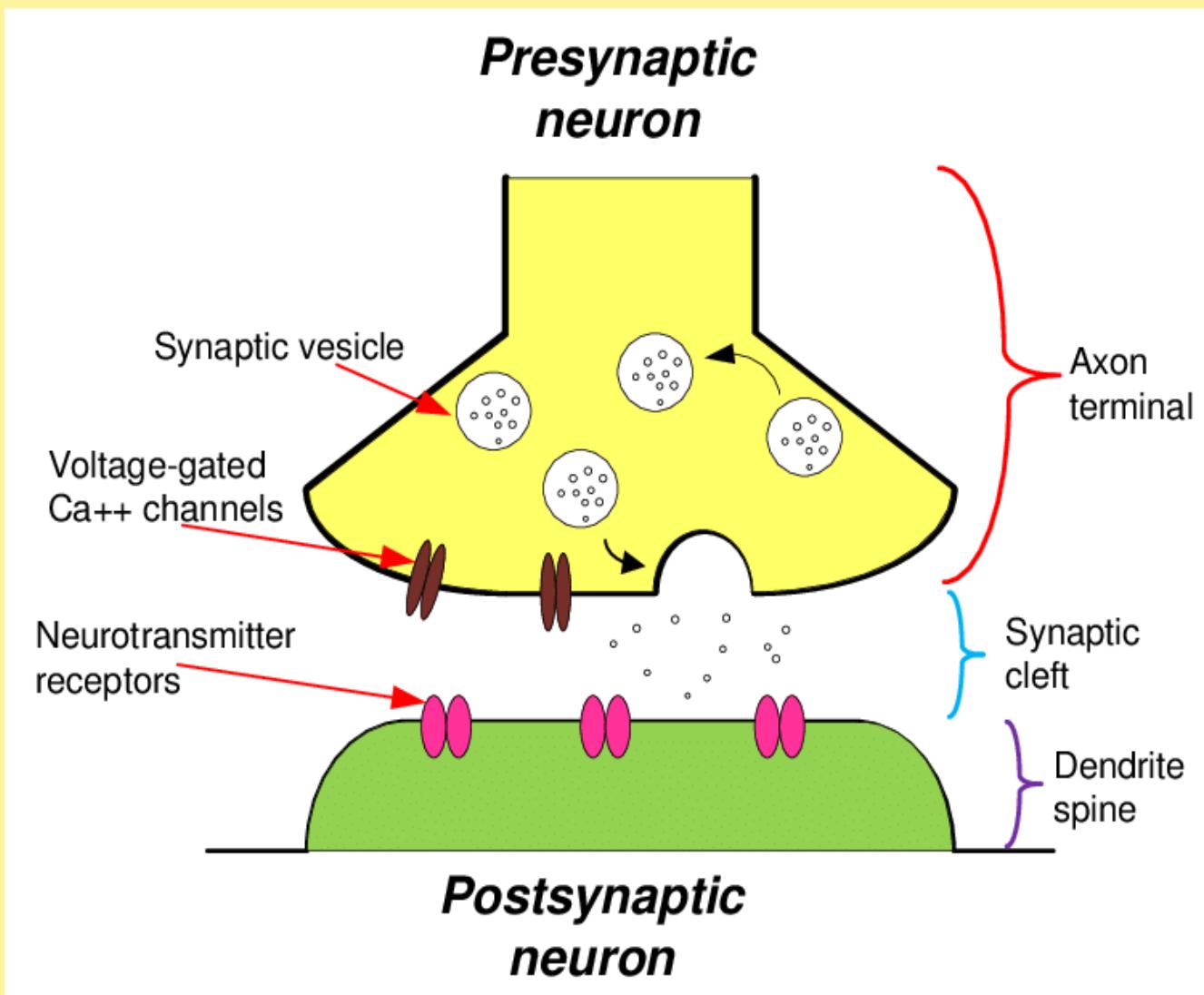
- b) Chemical synapse:
  - specialized junction(chemical signals are send)
  - synaptic gap is comparatively large (20-40nm)
  - **Three components** of a typical chemical synapse:
    - The **presynaptic terminal** (mostly axonic terminal)
    - **Synaptic membrane of post synaptic cell**( dendrite of next neuron)
    - **Post synaptic neuron**



- Impulse travels
- Presynaptic neuron-axon terminal- synaptic knobs- synaptic vesicles  
- contain neurotransmitters.
- When impulse reaches synaptic knob-  
 $\text{Ca}^{++}$  channels open and  
it diffuses inward from extracellular fluid
- Calcium conc increases
- Synaptic vesicles fuse
- Release of neurotransmitters (exocytosis)



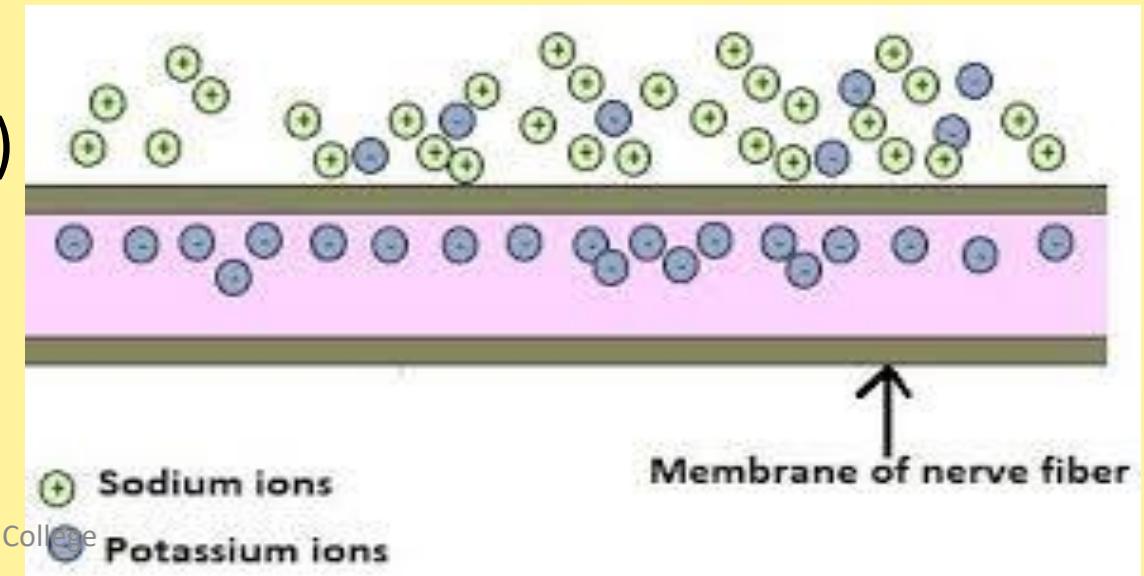
- Neurotransmitters bind to the receptors of post synaptic cells
- Action – excitatory or inhibitory
- After impulse transfer
  - destruction of neurotransmitter (cholinesterase)
  - Synapse ready to receive a new impulse.



# UNIT 9.5 Transmission of nerve impulse:

## Special features of neurons:

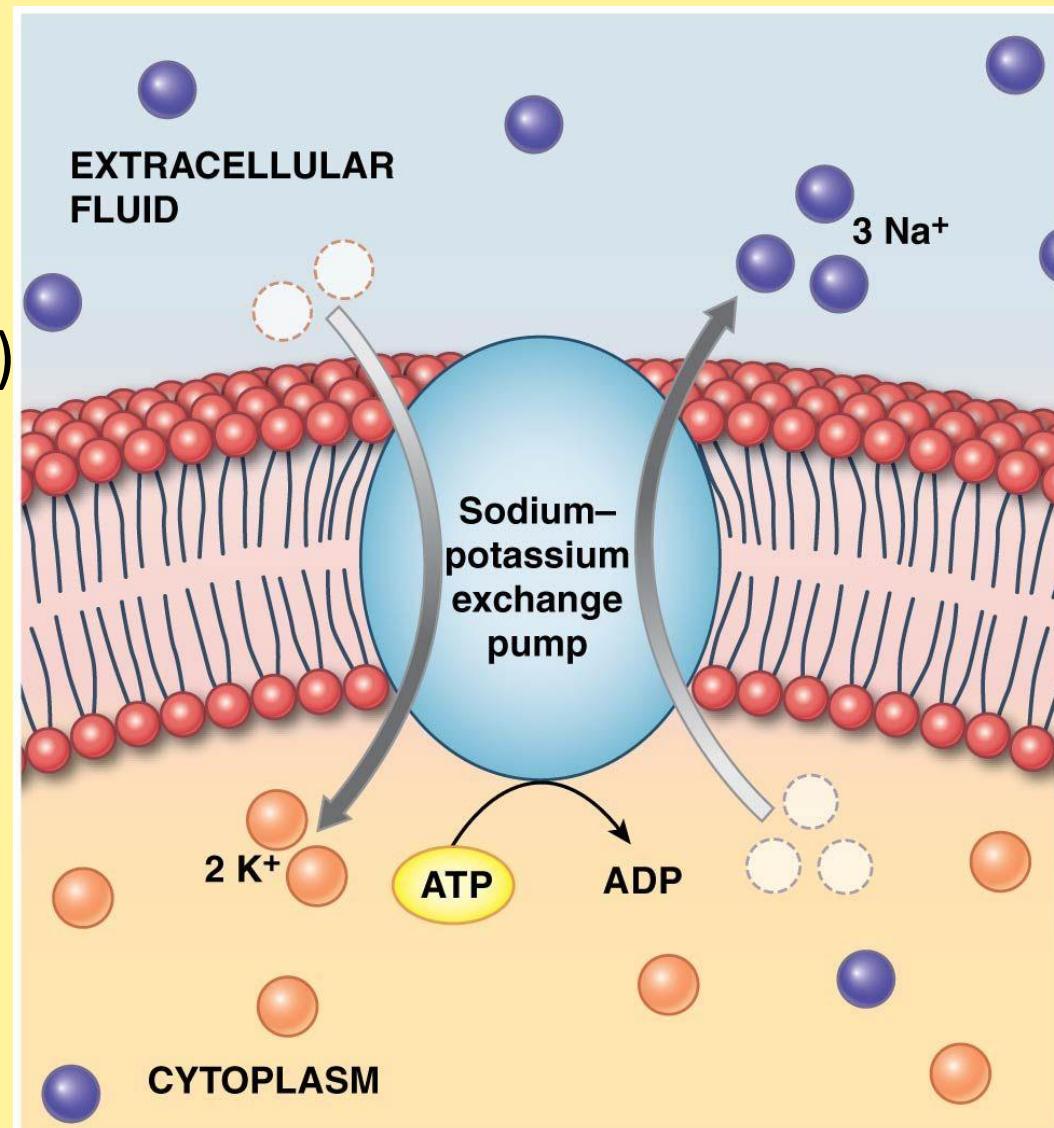
- Can be excited
- Generate impulse(bioelectrical/electrochemical)
- cellular charged membrane (difference in voltage –outside/inside)
- ECF – both  $\text{Na}^+$  and  $\text{K}^+$  but predominantly  $\text{Na}^+$  and  $\text{Cl}^-$
- Within fibre –  $\text{K}^+$  predominant as well as negative charged protein molecules , nucleic acid
- This is Polarised state(Resting nerve)



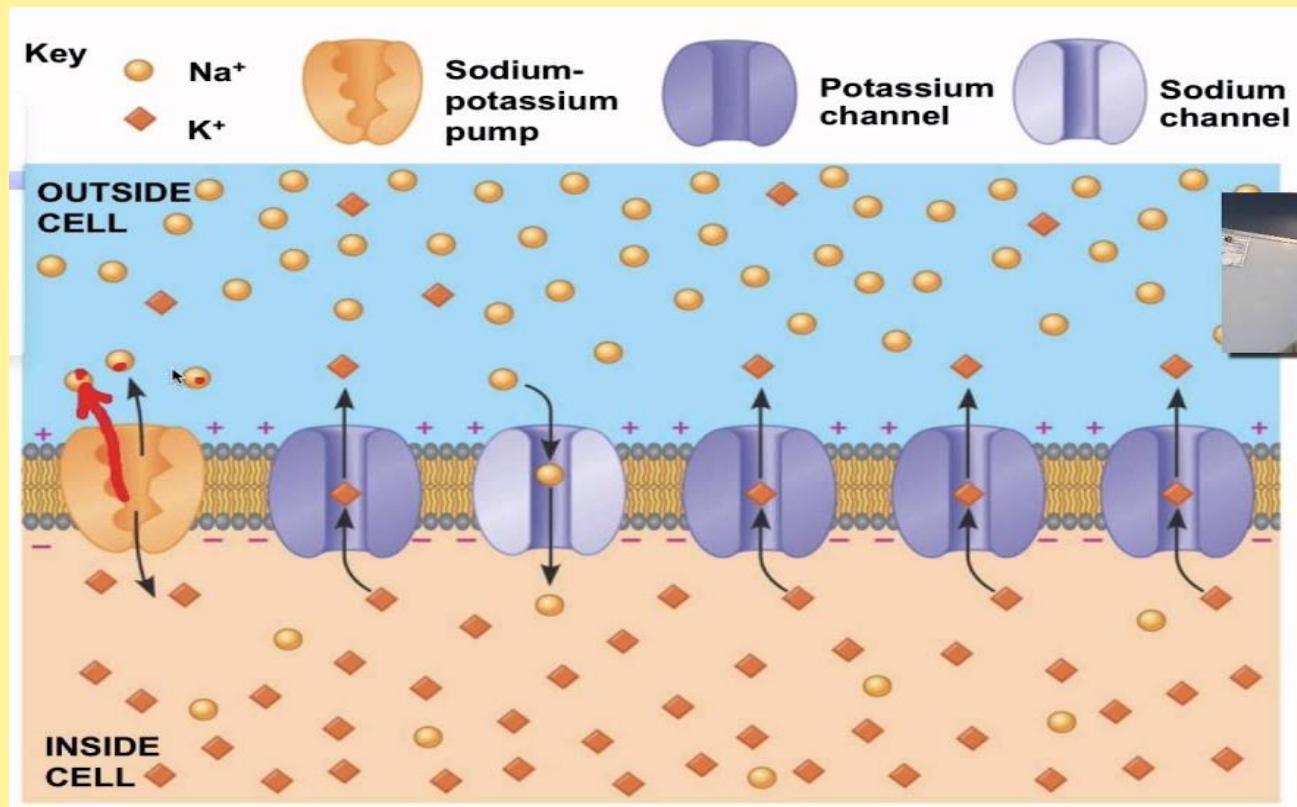
- $\text{Na}^+$  and  $\text{K}^+$  leaks
- Leakage channels
- $\text{Na}^+/\text{K}^+$  pump – restores ions actively
- (for every 3 $\text{Na}^+$  pumped out 2 $\text{K}^+$  pumped in)
- Against conc. and electrochemical gradient -  $\text{Na}^+$  forced out and  $\text{K}^+$  forced in

(Sodium pump or Na-K exchange pump)

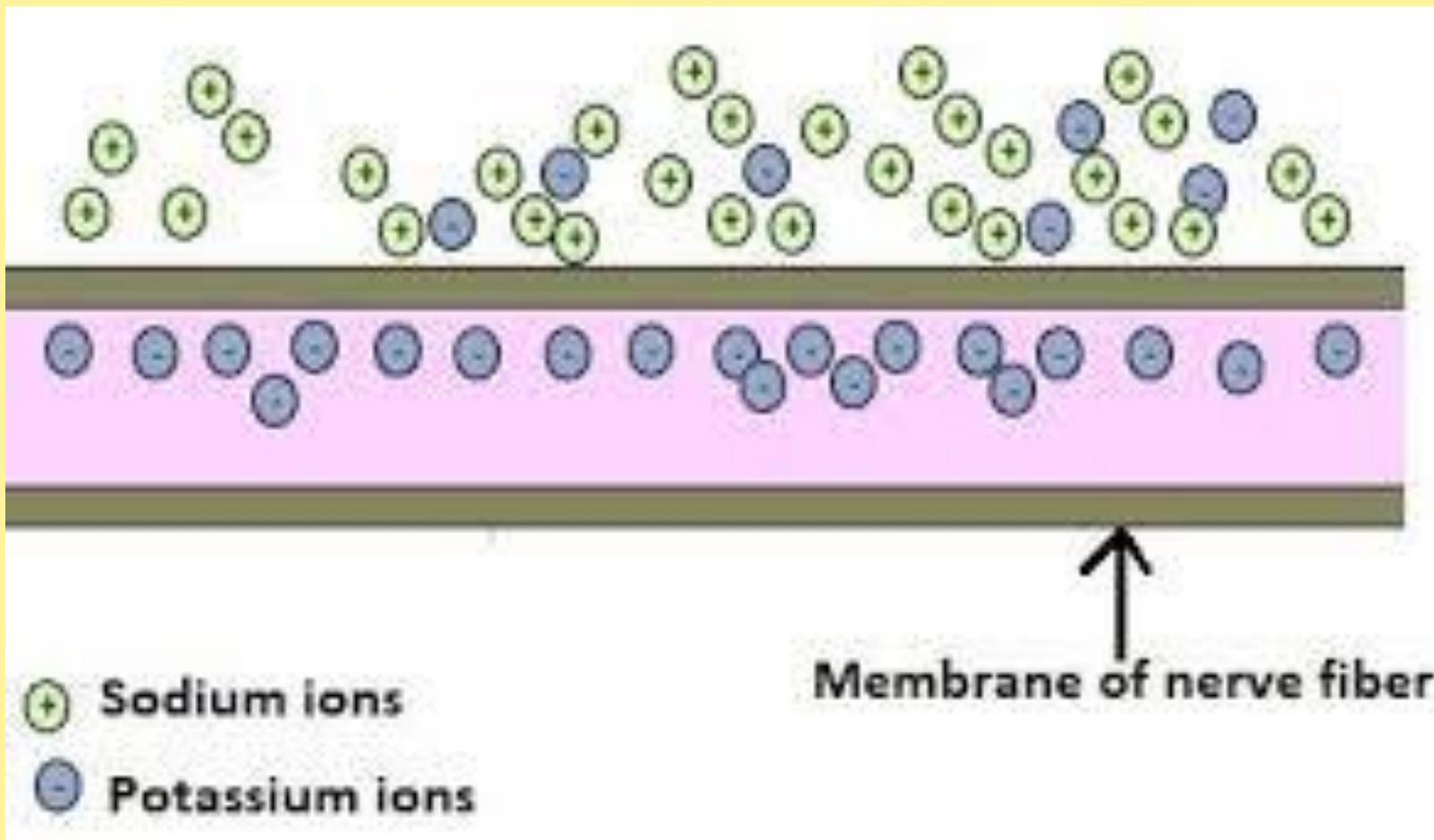
- Difference in distribution- produce potential difference(P.D) of -50 to -100 millivolts( Avg -70millivolts)  
i.e.P.D of resting nerve/resting potential



- Neurons at rest have more  $K^+$  Channels open than  $Na^+$
- More  $K^+$  diffuse out than  $Na^+$  moving in.
- Causes slight difference in polarity
- Also negative charged proteins and nucleic acid
  - negative inside, positive outside
- Gated channels for  $Na^+$  and  $K^+$  called **Voltage gated channels.**  
(Separate for both)
- Can change the P.D of the membrane as per stimulus
- Resting potential-both are closed and membrane resting potential is maintained.

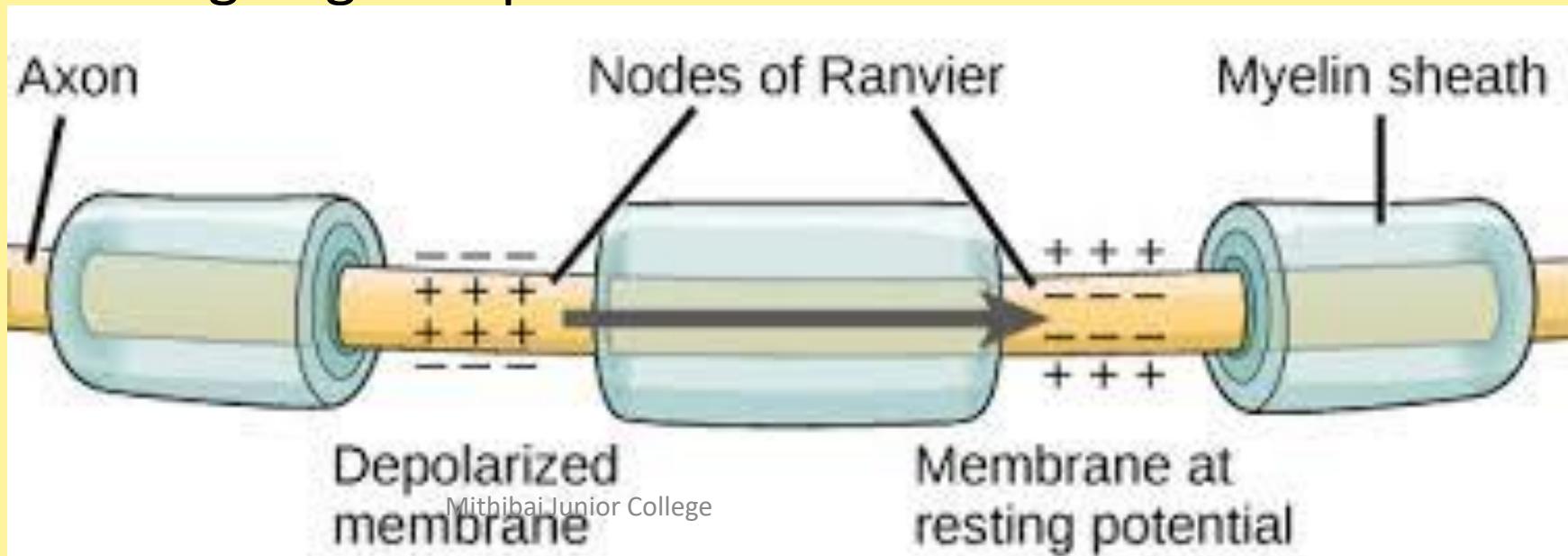


# Generation of nerve impulse: Resting potential



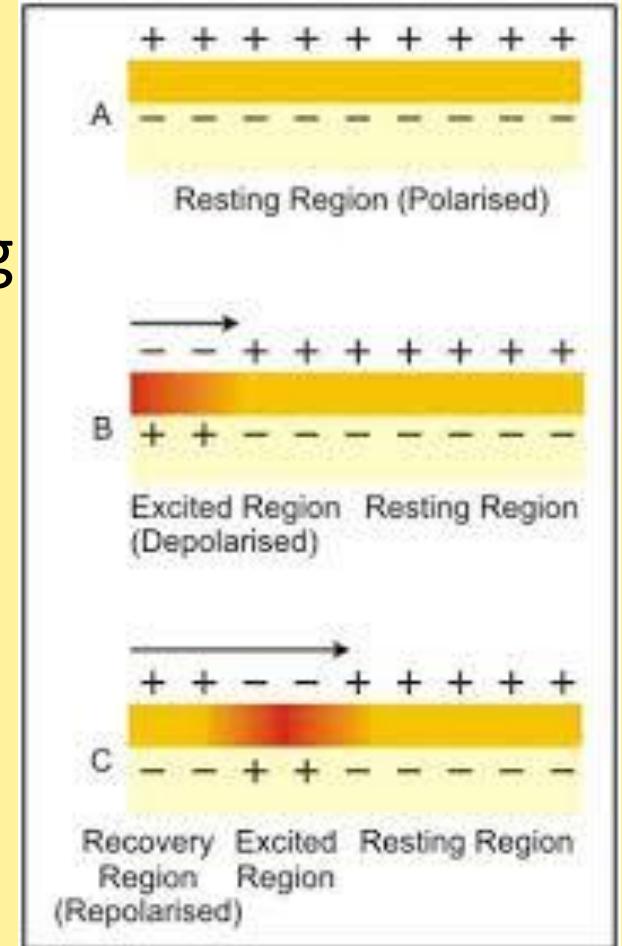
# Depolarization:

- Resting potential- both gates are closed, maintaining resting potential.
- During depolarization (stimulus received)- $\text{Na}^+$  gates open not  $\text{K}^+$
- $\text{Na}^+$  rush into axon, bring depolarization
- i.e. inner membrane electropositive
- outer (ECF) electronegative
- Action potential +30 to +60 millivolts, triggers depolarization in next part and itself starts going to repolarization



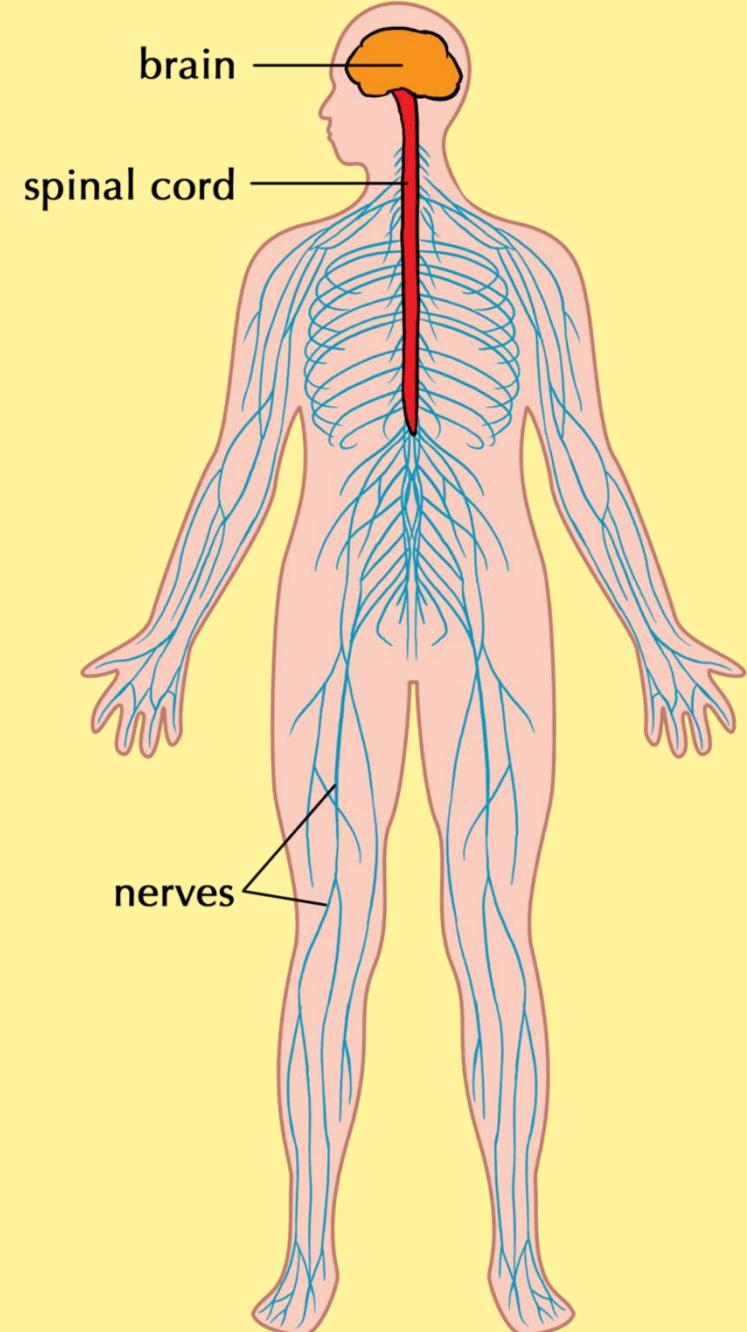
# Repolarization:

- Occurs after a short interval called refractory period.( about millisec)
- Repolarization is back to original state
- At the peak of action potential (+30 mv),
- K voltage gates open whereas Na gates start closing
- Rapid outflux of  $K^+$  (in ECF) and slow entry of  $Na^+$
- Later Na gates are closed
- $Na^+ / K^+$  pump becomes operational.
- Inside of membrane becomes negative once again.



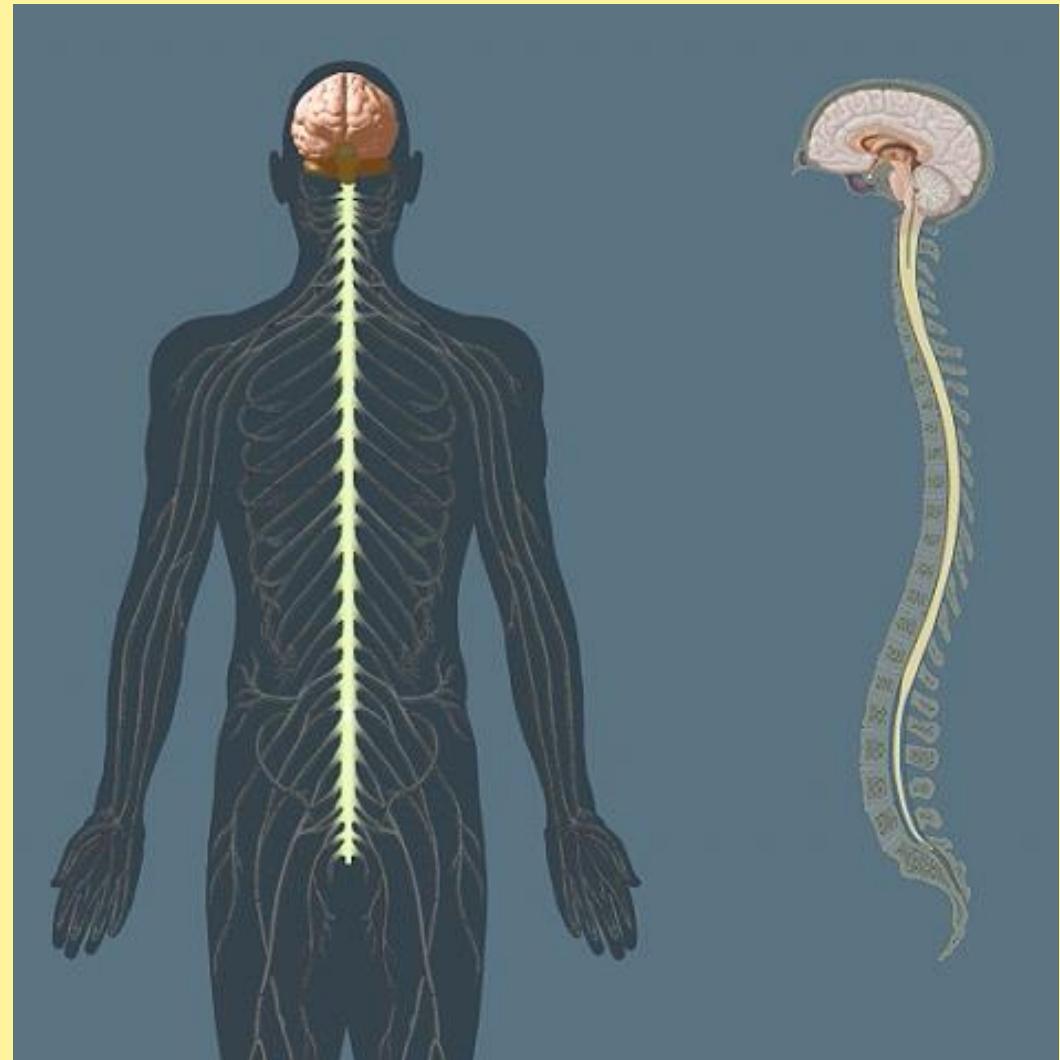
# UNIT 9.6 Human nervous system:

- Broadly classified into -
  - 1) Central nervous system
  - 2) Peripheral nervous system
  - 3) Autonomous nervous system



# 1) CENTRAL NERVOUS SYSTEM (CNS):

- Consists of:
  - **Brain and Spinal cord**
  - brain box/cranium (brain)
  - vertebral column (spinal cord)
  - **Meninges** ( protective membranes)



# Meninges: (Brain and Spinal cord)

## a) Dura mater

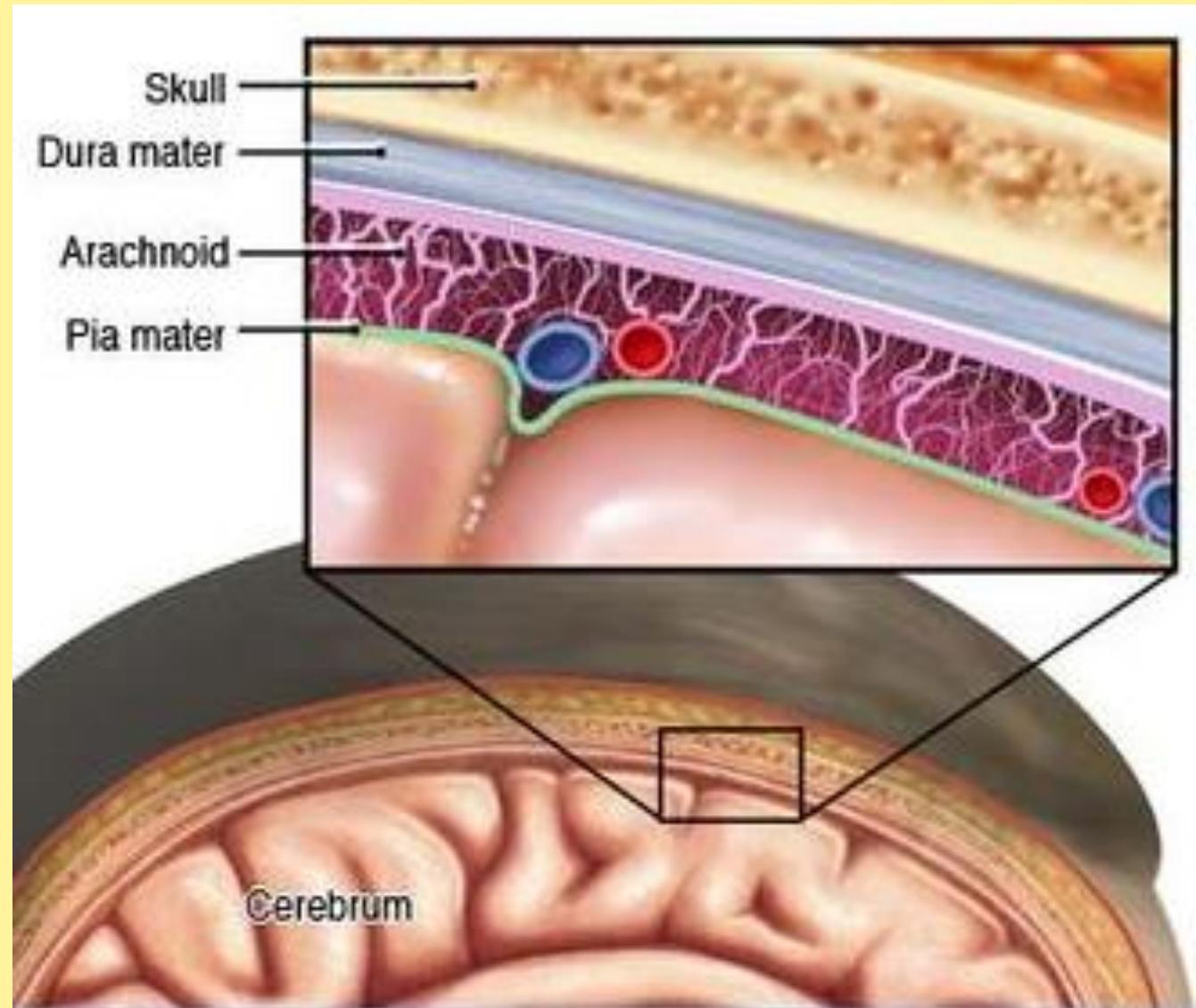
- outermost, tough, thick, nonvascular
- **subdural space(serous fluid)**

## b) Arachnoid mater

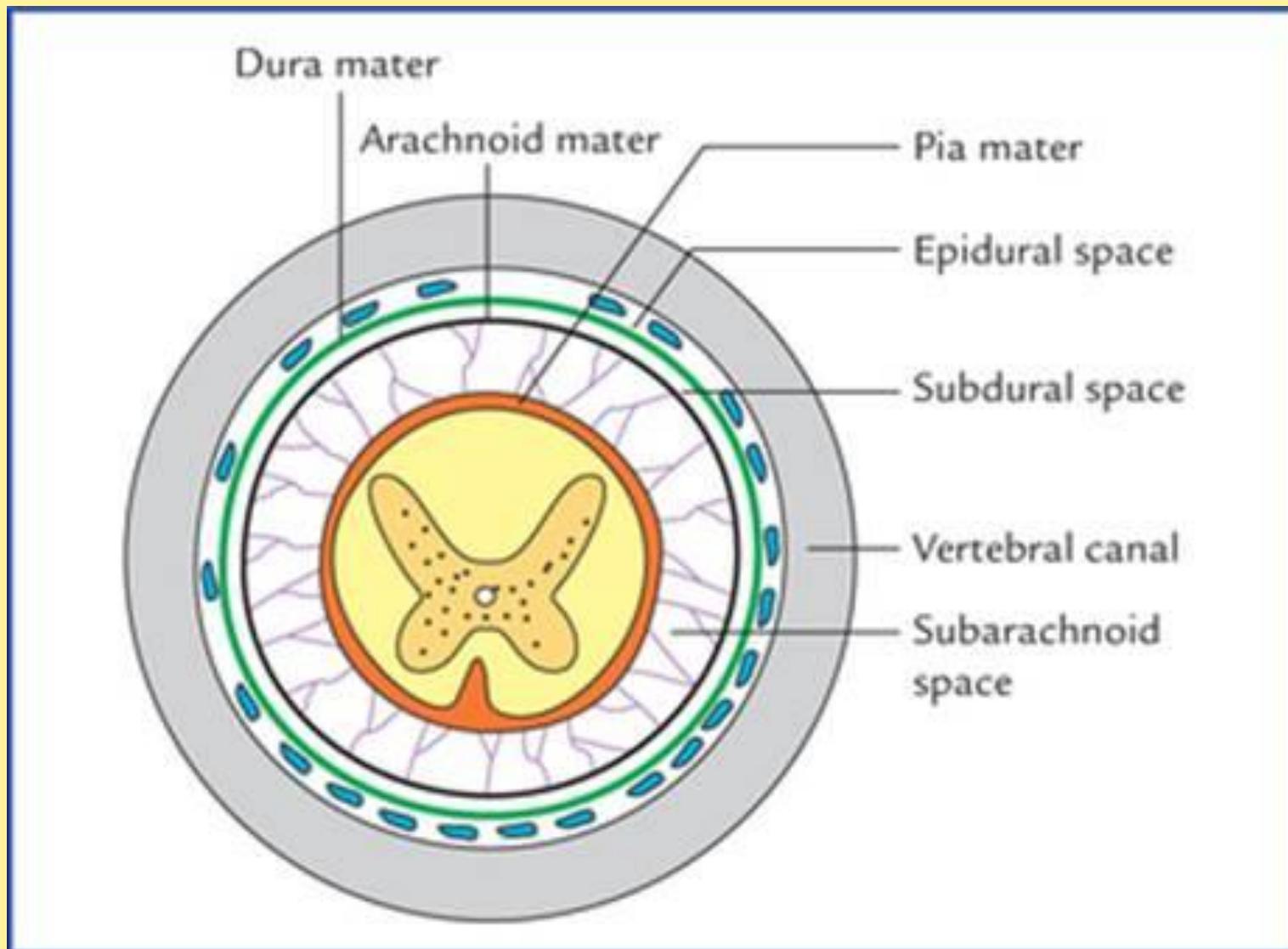
- middle, nonvascular, web like
- **subarachnoid space (C.S.F)**

## c) Pia mater

- innermost, highly vascular

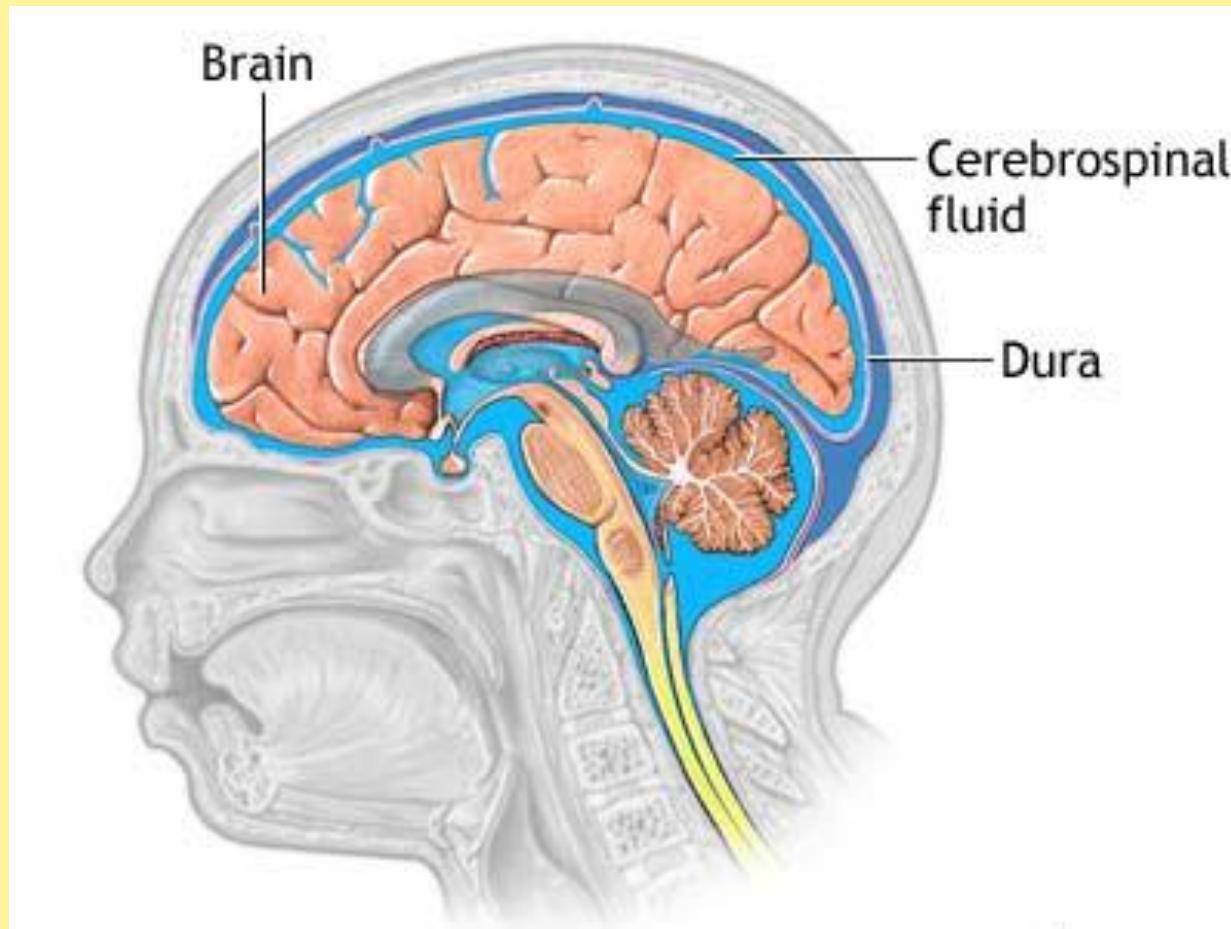


# Meninges of Spinal cord:



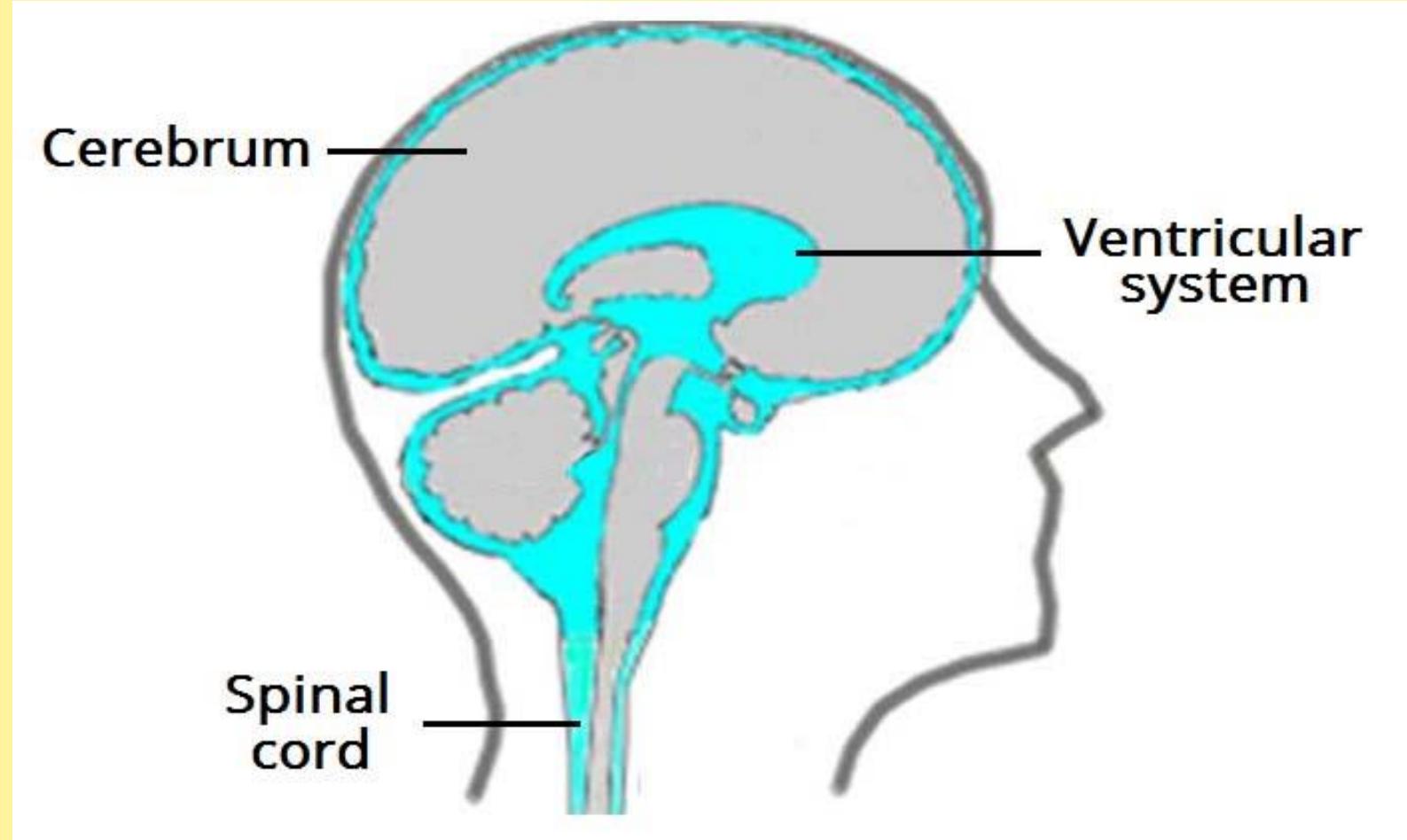
# CSF (Cerebrospinal fluid):

- Extra cellular alkaline fluid
- Specific gravity 1.005
- CSF 100-200cc in and around CNS
- Secreted - choroid plexus
  - (ventricles of brain)
  - ependymal cells
  - ( spinal cord)
- 3 openings - drain CSF out of brain
  - (present in roof of medulla)



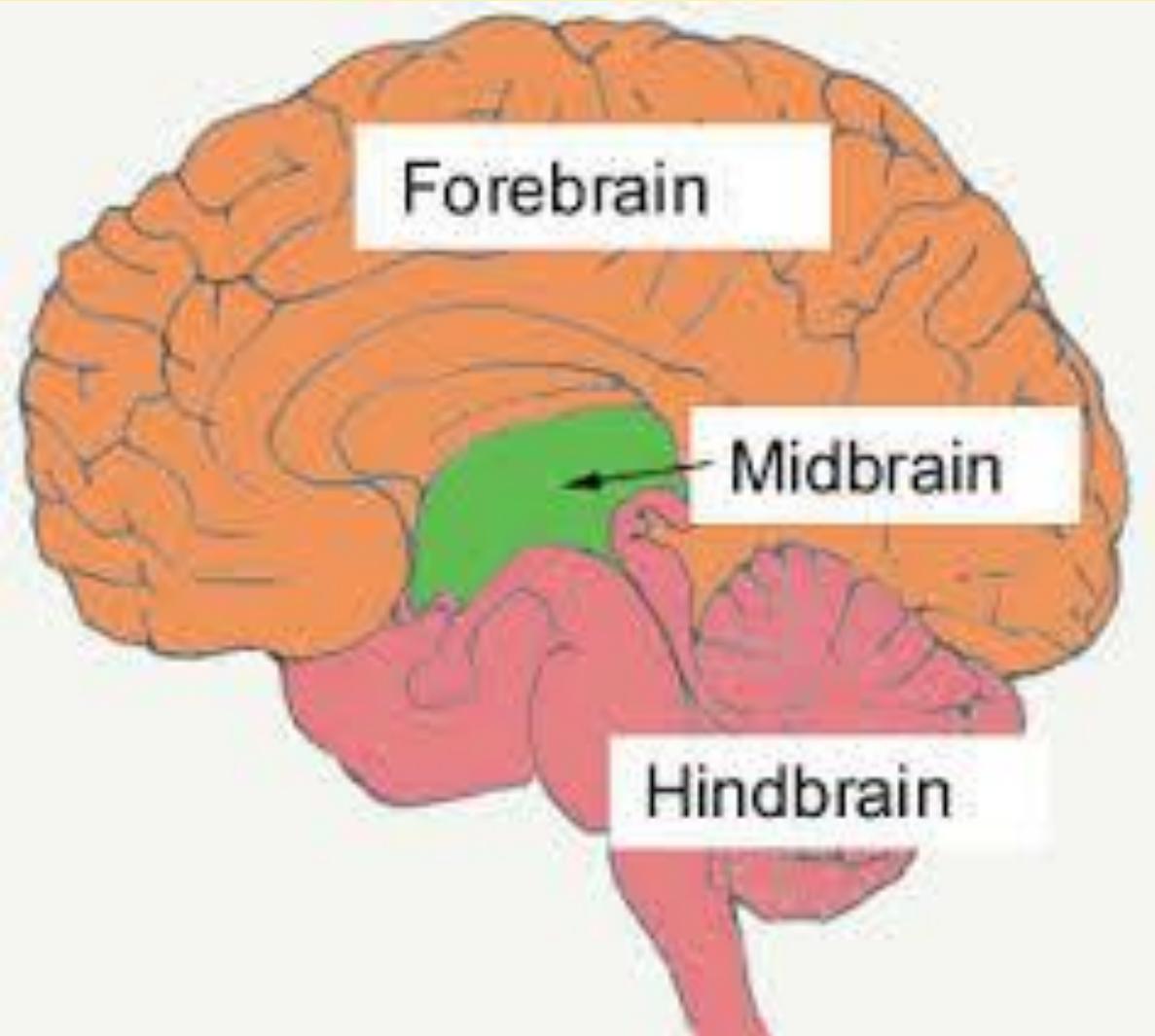
## Function of CSF:

- Shock absorber
- Protection- mechanical injuries
- Maintains pressure
- Exchange of materials
- Supply-oxygen
- Prevents dessication



## A) The human brain:

- **Encephalology.**
- **Three main parts:**
  - a) **Forebrain** (Prosencephalon)
  - b) **Midbrain** (Mesencephalon)
  - c) **Hindbrain** (Rhombencephalon)



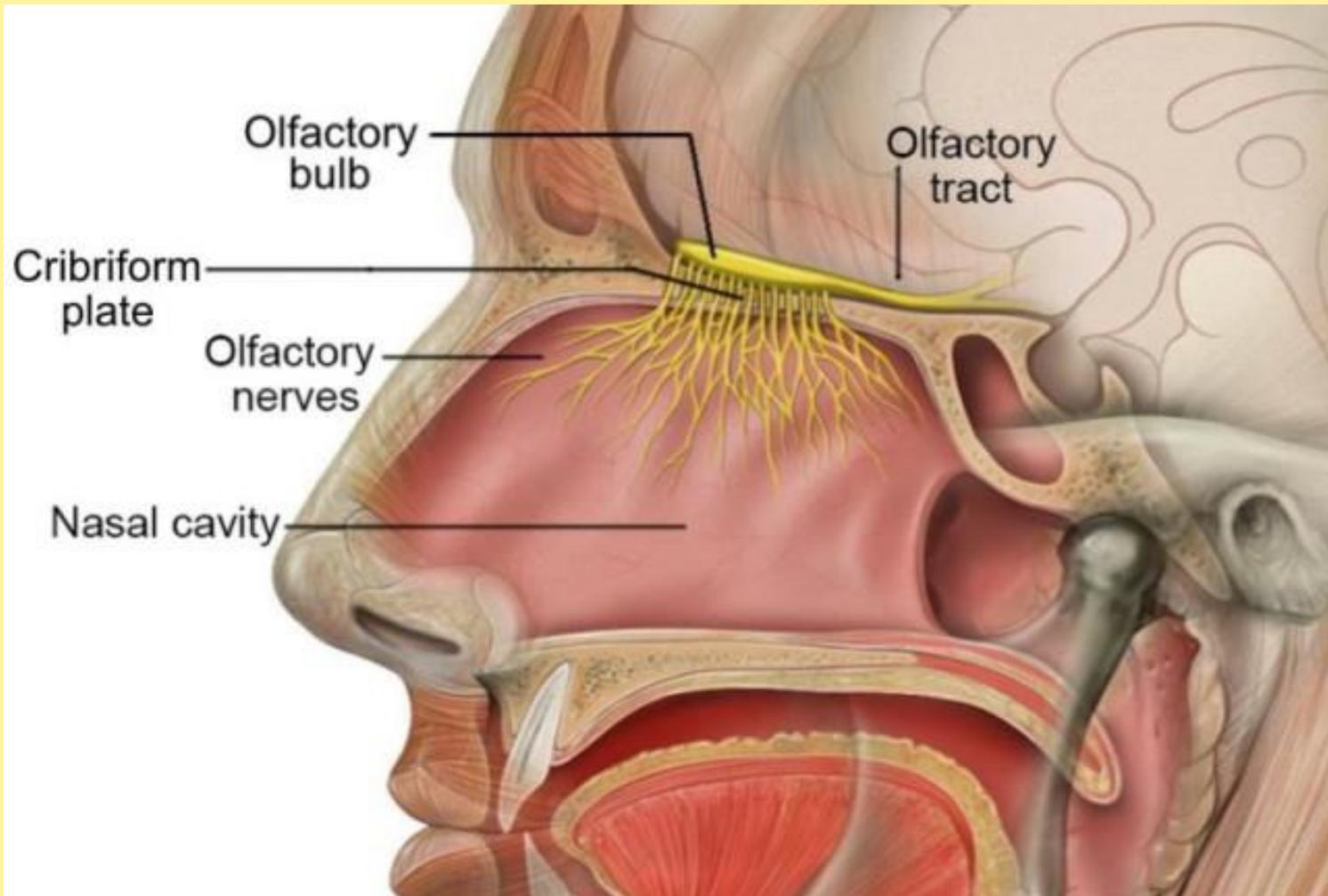
## a) Forebrain (Prosencephalon):

- **Consists of:**
  - i) Olfactory lobes
  - ii) Cerebrum
  - iii) Diencephalon



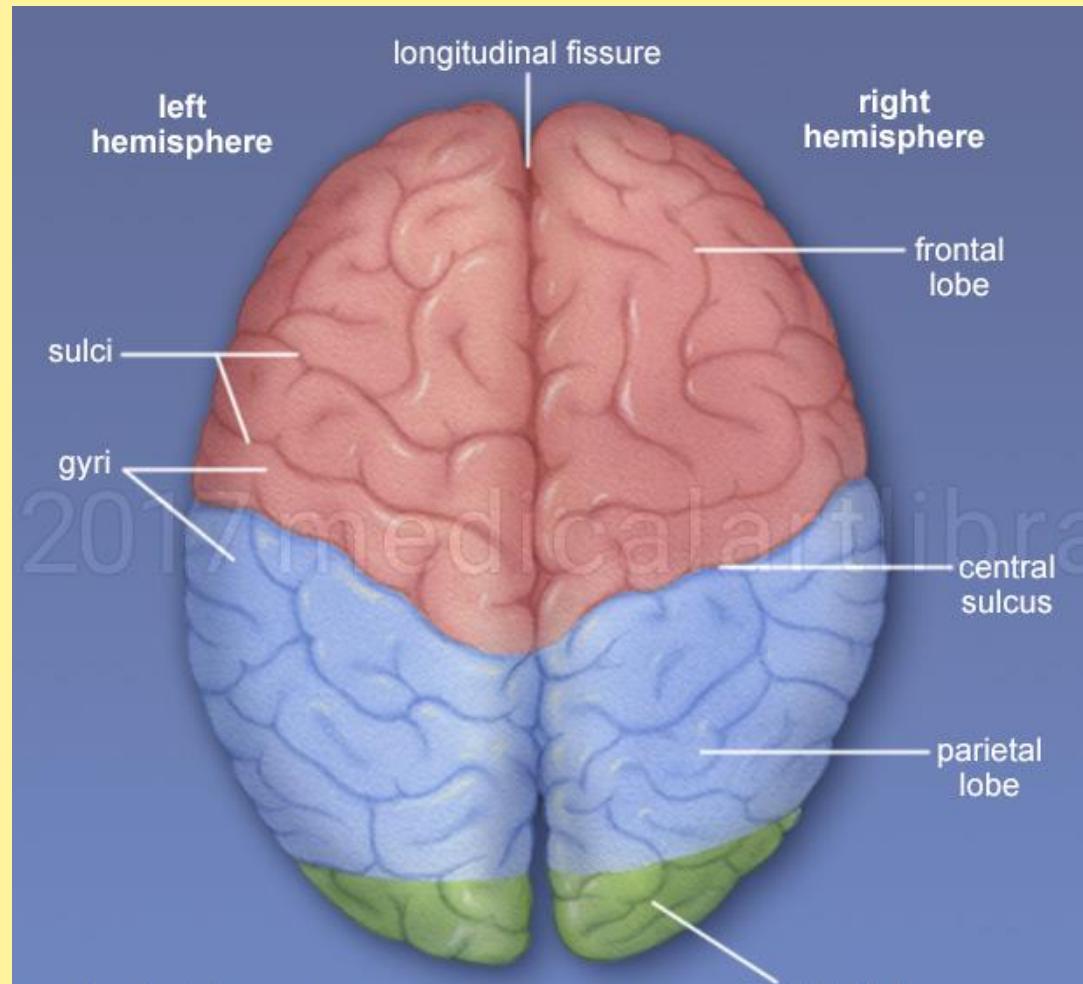
## i) Olfactory lobes:

- A pair
- Highly reduced (humans)
- Visible on ventral side
- consists : Olfactory bulb and olfactory peduncle
- Smell



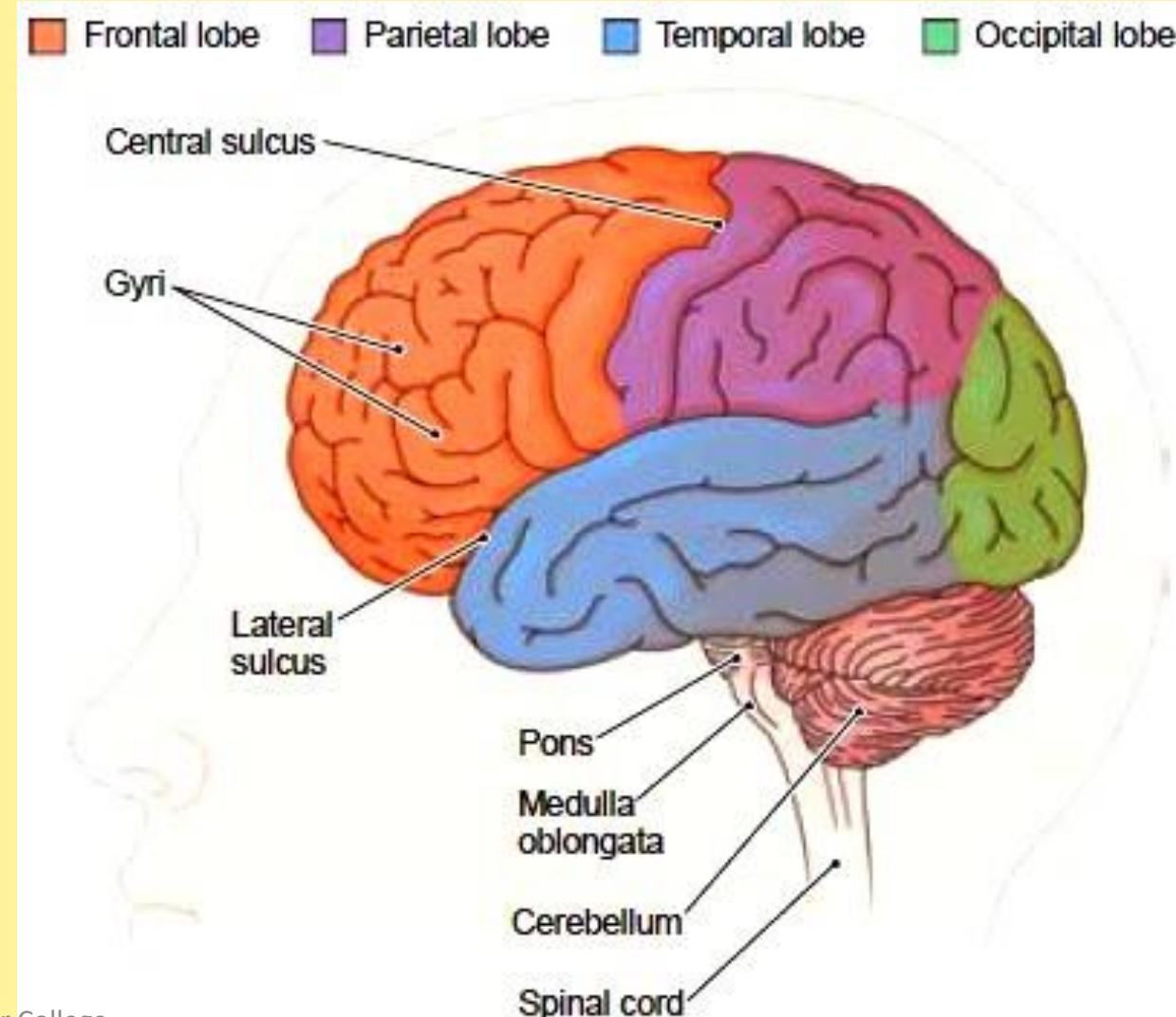
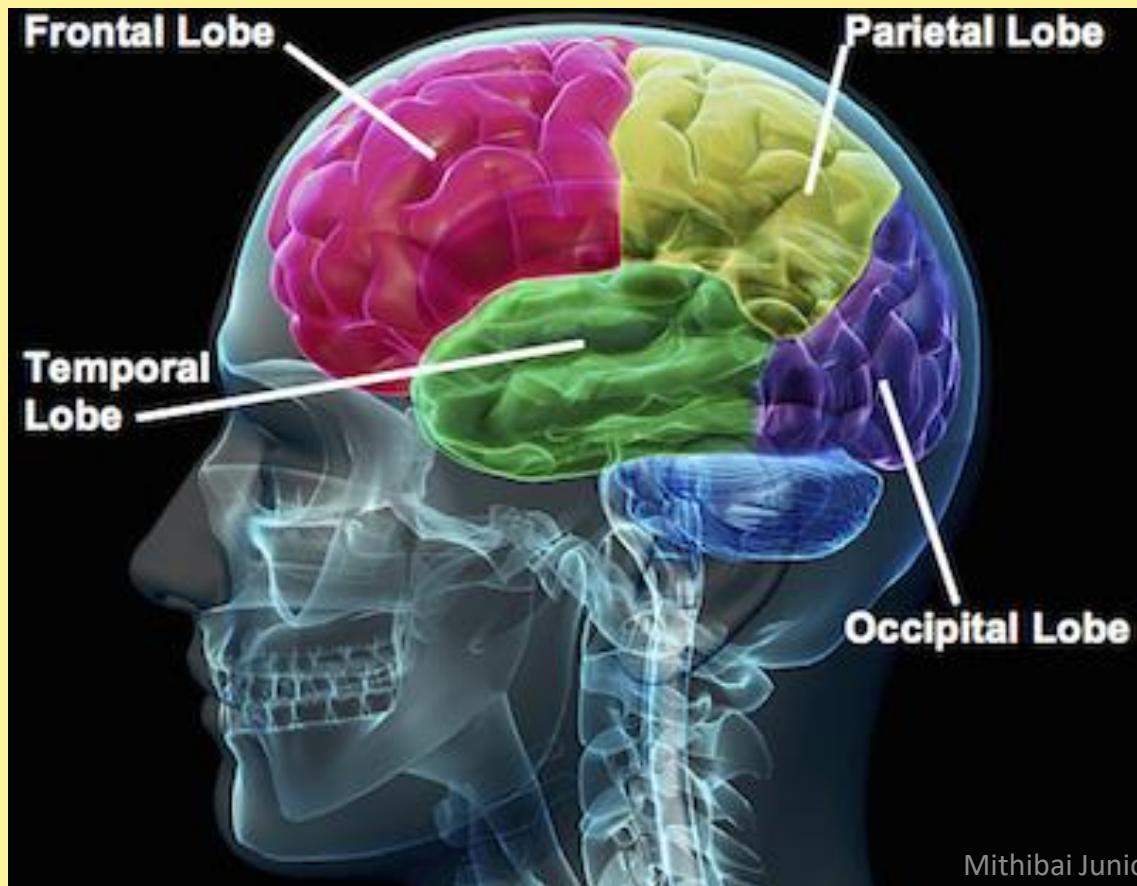
## ii) Cerebrum:

- Largest part (85%)
- Right and left cerebral hemisphere
- Band of nerve fibres – **corpus callosum**
- Outer – cerebral cortex (grey matter)
- Inner – cerebral medulla (white matter)
- Surface- folded
  - Convolutions- **gyri**
  - grooves - **sulci**



# Cerebral hemisphere:

- Each hemisphere:
  - Divided - **Four lobes**
  - by **three sulci**



a) Central sulcus –

Frontal from parietal

b) Parieto-occipital sulcus –

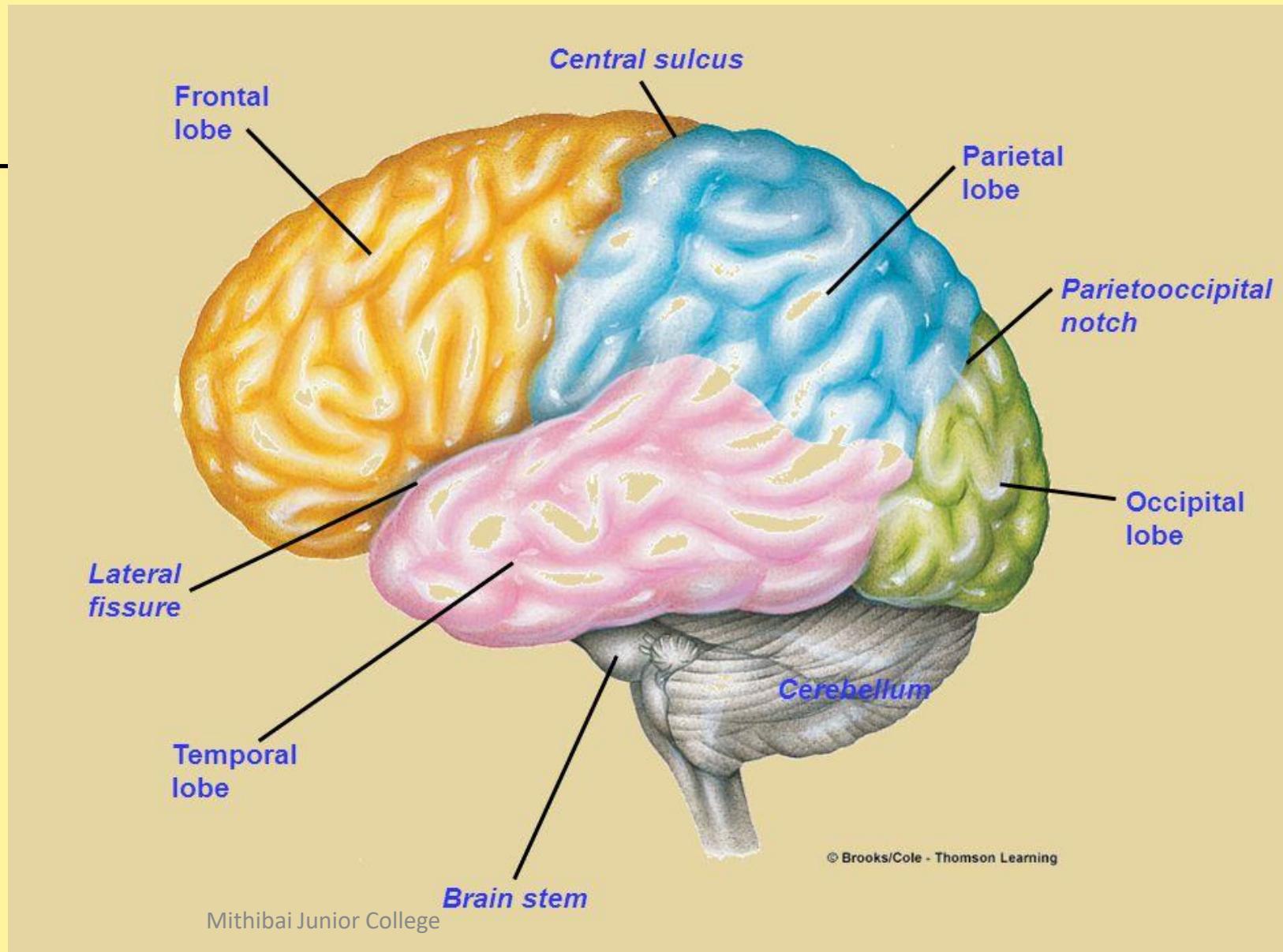
Parietal from occipital

c) Lateral / sylvian sulcus –

Temporal from frontal  
and parietal

d) Insula /insular cortex –

Folded deep within the  
lateral sulcus



# Functional areas of cerebrum:

- **FRONTAL:**

motor area (voluntary)

premotor area (involuntary and A.N.S)

Association area

( coordinates sensation and movements)

Broca's area

( translates thoughts into speech)

- **PARIETAL:**

Somaesthetic sensation

(pain/pressure/temp)

gustatoreceptor

- **TEMPORAL:**

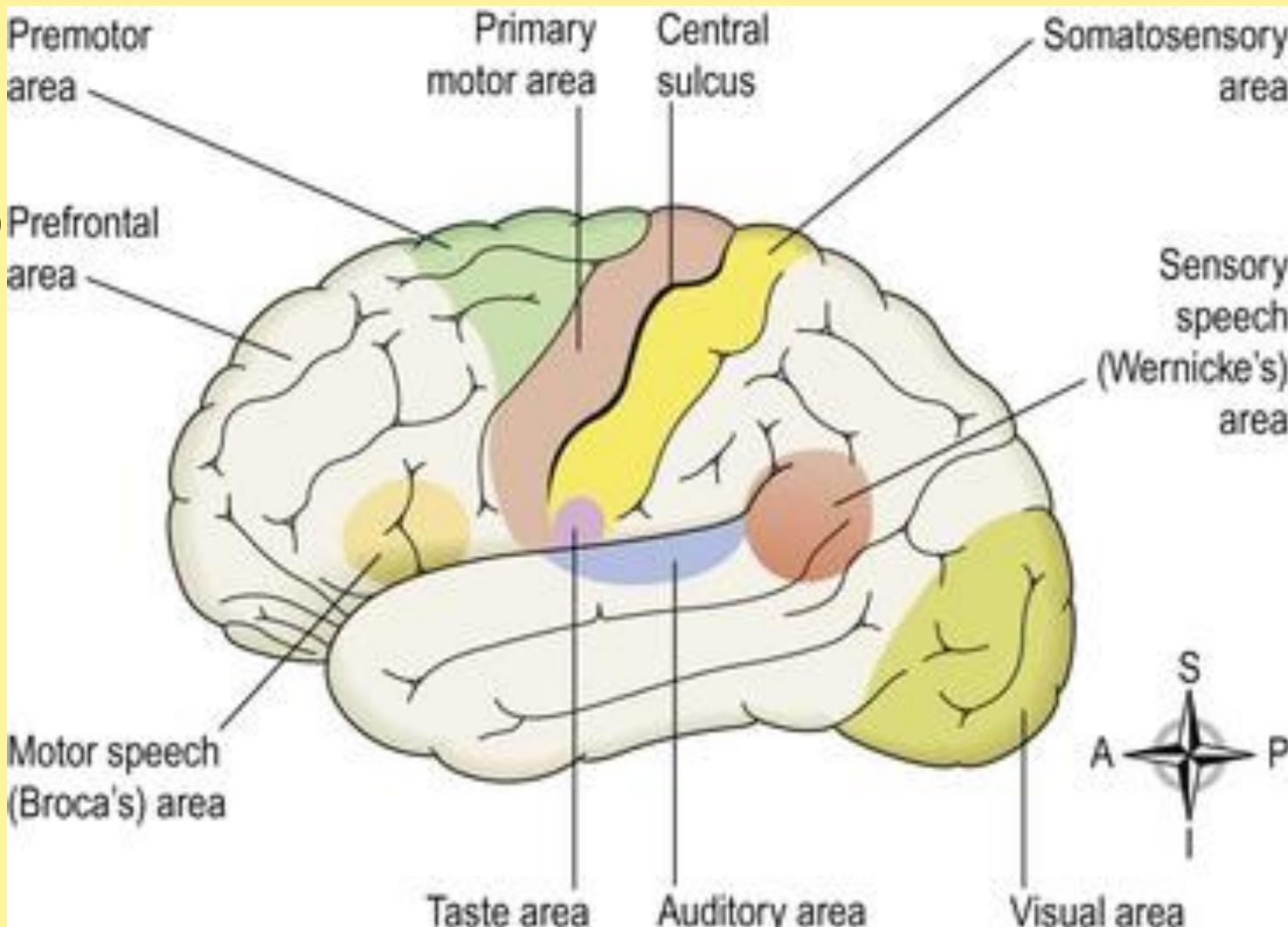
Olfactory , Auditory

- **OCCIPITAL:**

Visual

**At junction of Frontal,Parietal/Occipital**

**Wernicke's area( Understanding of written /spoken words).**



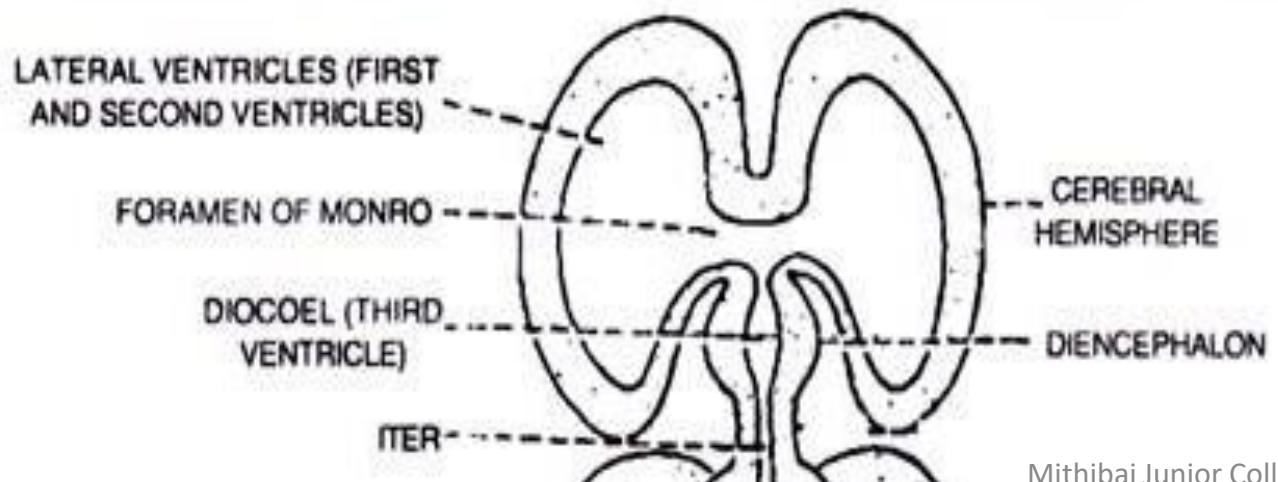
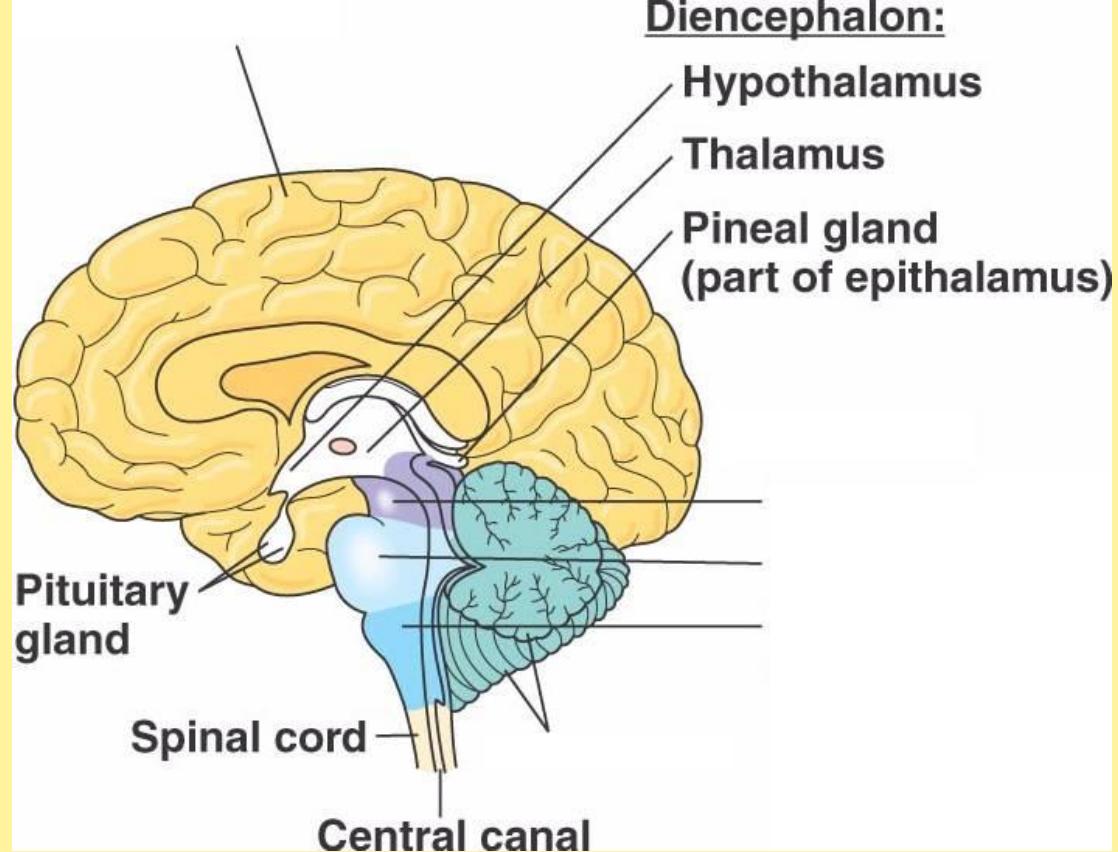
# Basal nuclei/ Basal ganglia:

- Grey matter within white matter
- Present –lateral sides of thalamus
- Receive neurotransmitters
- Execution of activities  
(subconscious)
- Corpus striatum  
(floor of cerebrum)
- Has largest basal nuclei



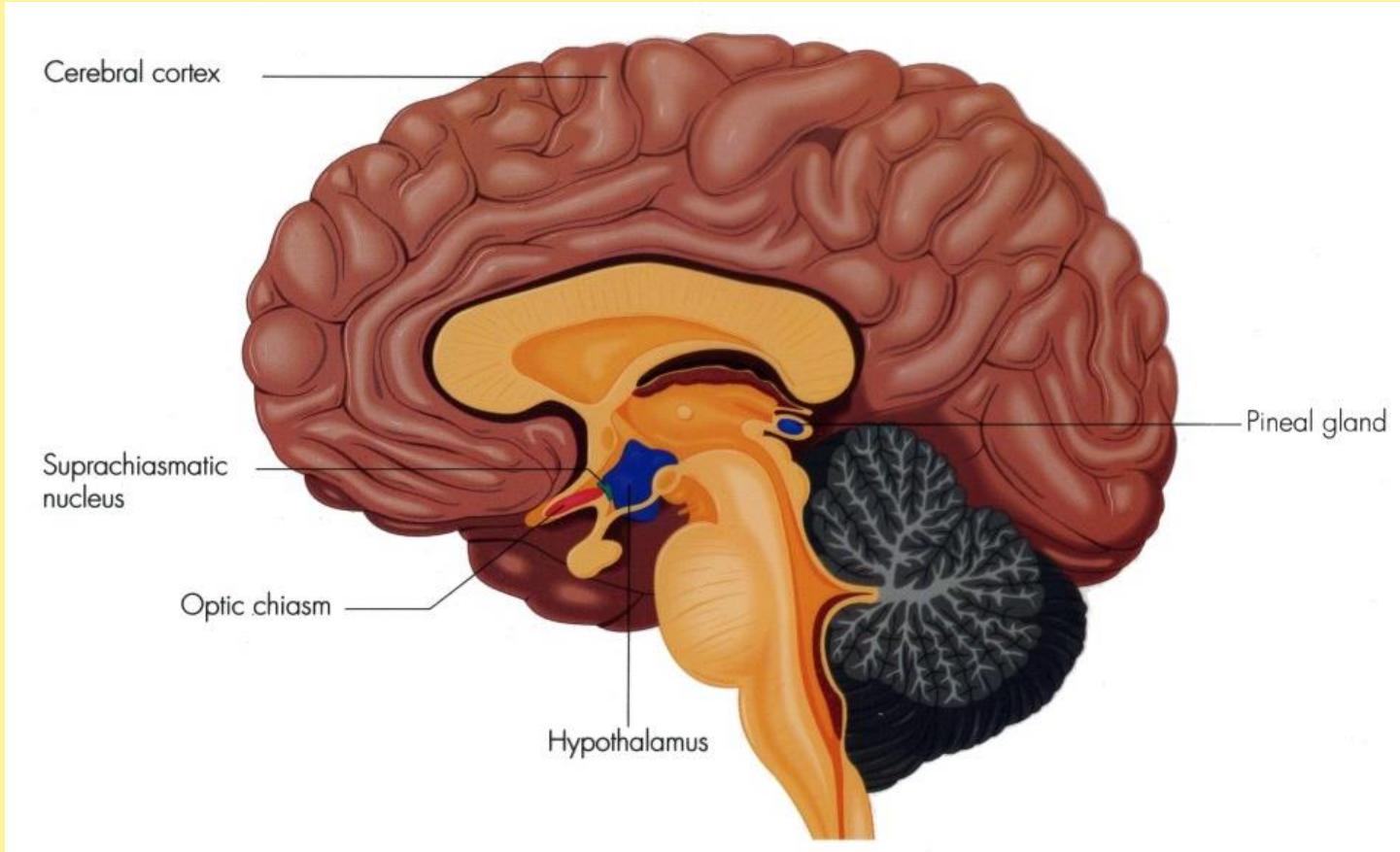
### iii) Diencephalon:

- Epithalamus, thalamus, hypothalamus
- Above midbrain
- **Third ventricle /Diocoel**
- **Foramen of monro**  
(connect to lateral ventricles)



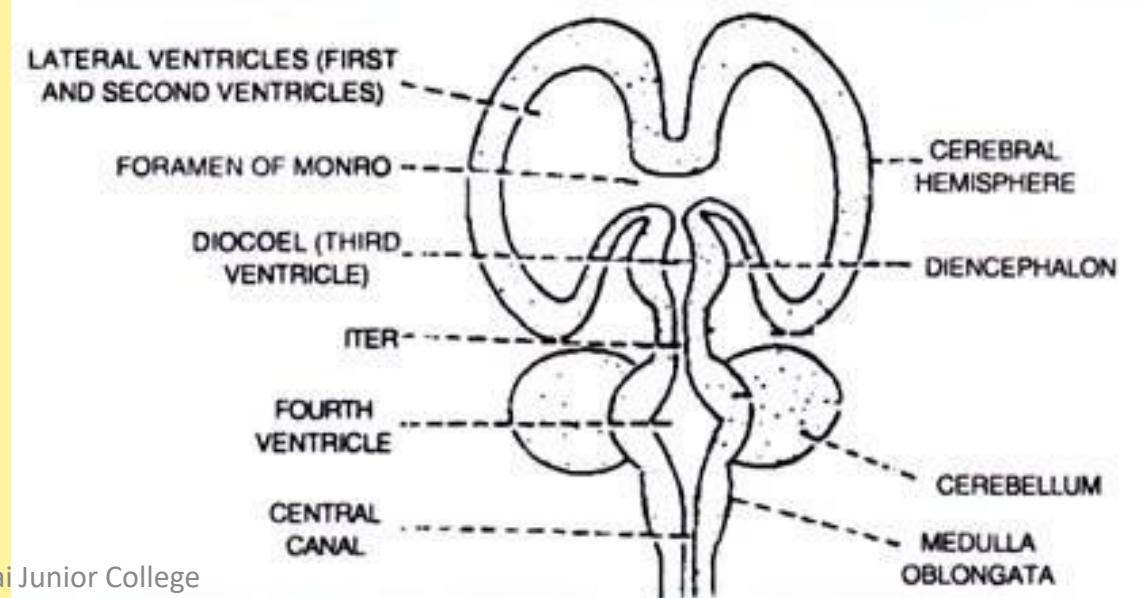
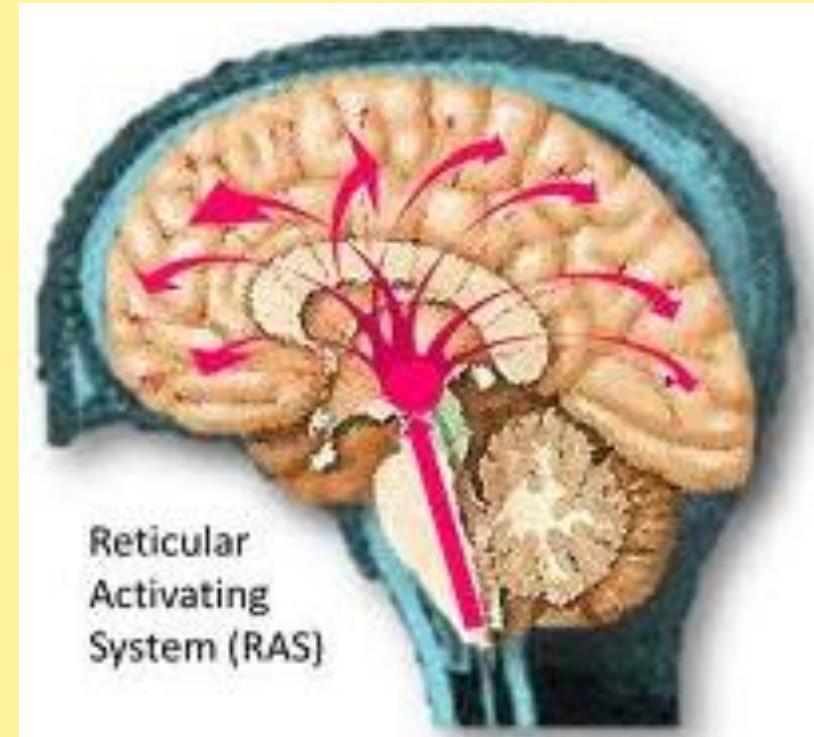
# Epithalamus:

- Thin , non nervous roof
- Anterior choroid plexus
- Dorsal wall- **pineal gland**  
**(melatonin- sleep inducing/reproductive behaviour)**



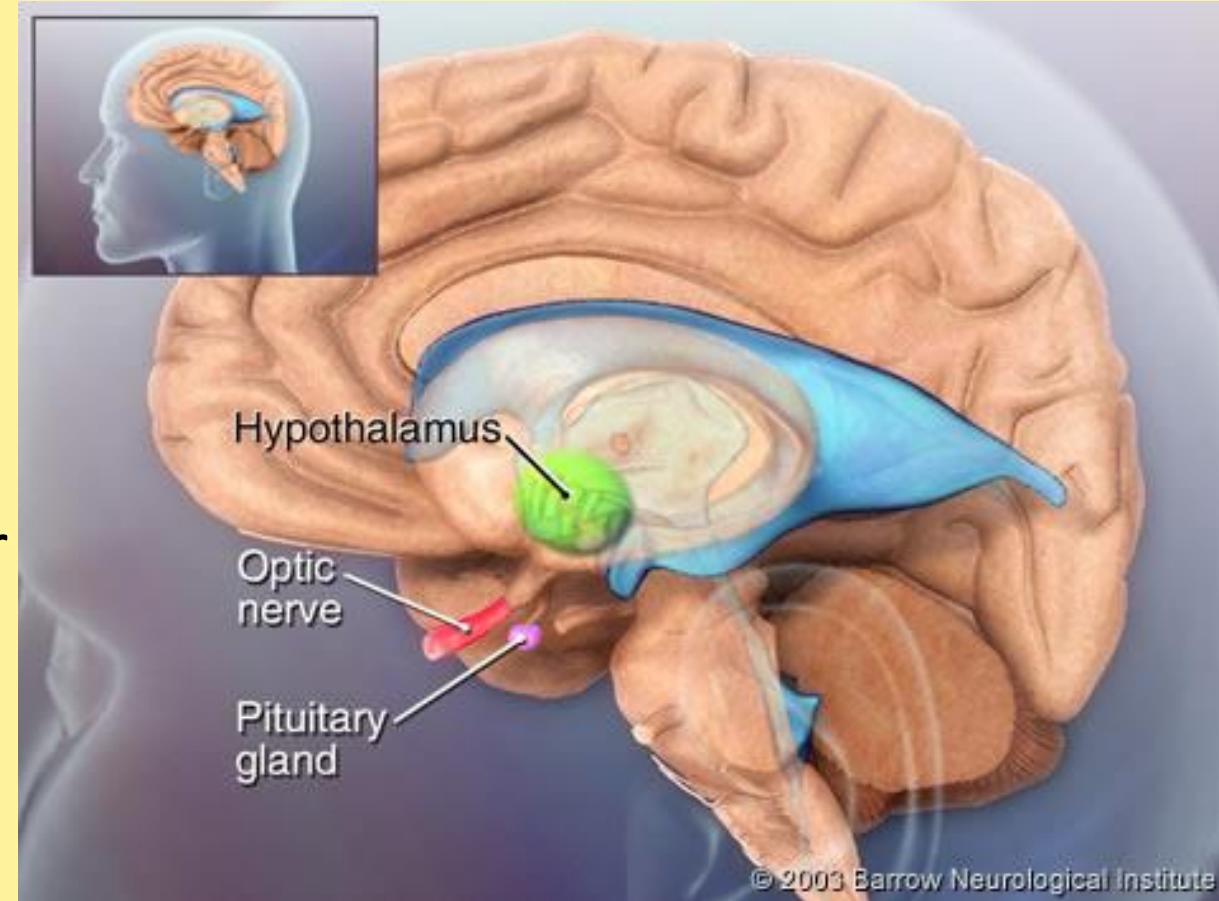
# Thalamus:

- Mainly grey matter
- Habencular commissure
- Parts of Brain-RAS-Thalami
- Relay centre (except olfactory)
- Gatekeeper to cerebrum
- Duct of sylvius/Iter  
(IV ventricle /metacoe)



# Hypothalamus:

- Floor of diencephalon
- Highly vascular
- Maintains homeostasis
- Involuntary behaviour control
- Hypothalamic nuclei – in white matter
  - hormone production(oxytocin and vasopressin)
- floor of hypothalamus- infundibulum-connect pituitary
- Optic chiasma
- Pair of mamillary bodies(recollective memory)
- Link – nervous and endocrine system



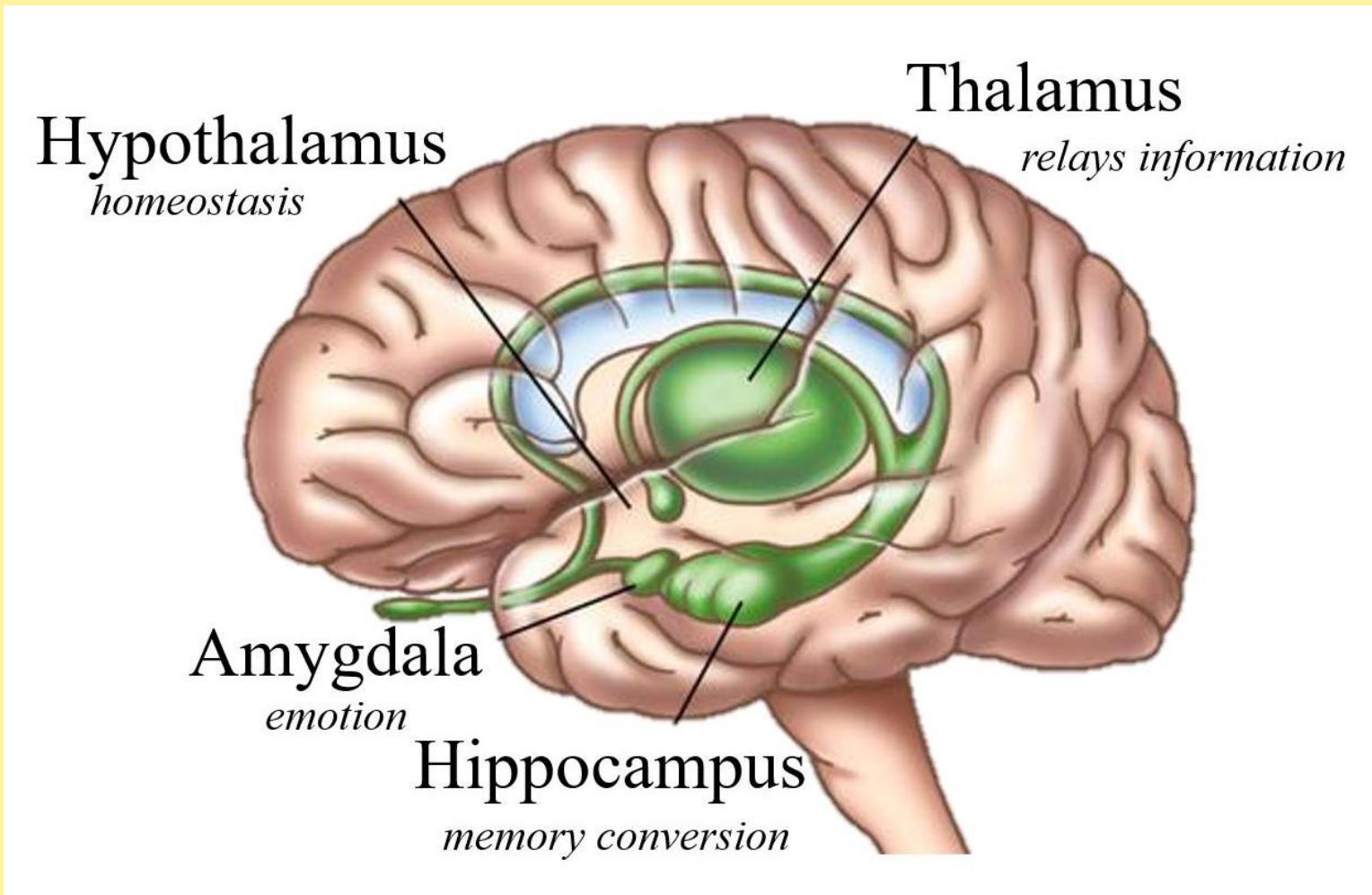
© 2003 Barrow Neurological Institute

## **Importance of hypothalamus:**

- Higher centres for endocrine system
- Regulates heart rate , respiration, B.P , temperature, Water electrolyte balance
- Centre for hunger, thirst,sleep, satiety , secretion of stomach and intestinal glands
- Produces neurohormones – pituitary gland

## Limbic system:

- Complex neuronal circuit
- Formed by
  - hypothalamus amygdala,
  - parts of epithalamus,
  - thalamus, hippocampus



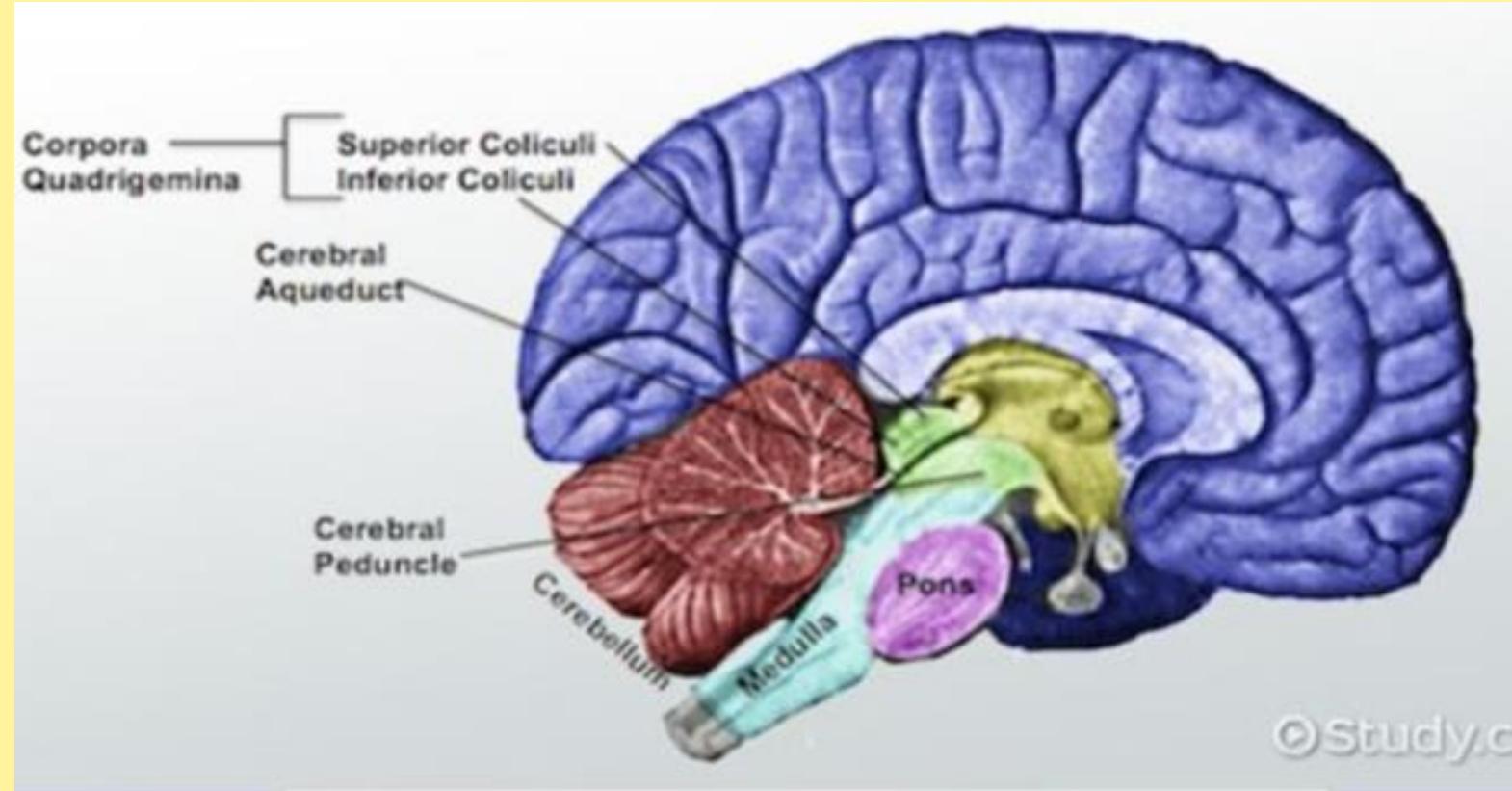
- Emotional reactions , motivation drives , memory.

## b) Mid brain:

- Between diencephalon and pons
- Cerebral aqueduct / iter (III to IV ventricle)
- Consists of:

### **a) Corpora quadrigemina**

- Four rounded elevations
- Two superior colliculi (visual reflexes)
- Two inferior colliculi (auditory reflexes)

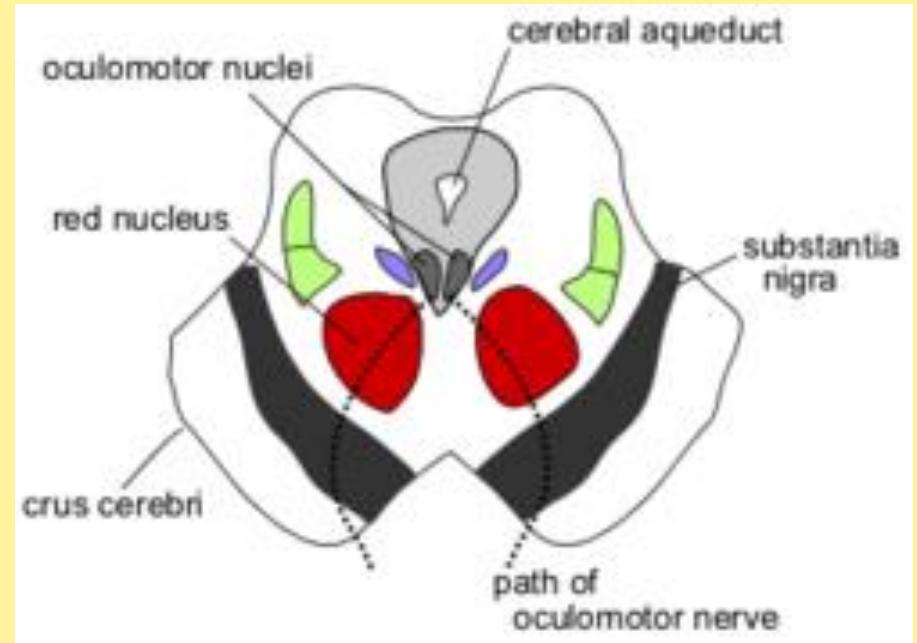


### **b) Crura cerebri/ cerebral peduncles**

- Two thick fibrous tracts
- Connect cerebrum to midbrain(RAS)

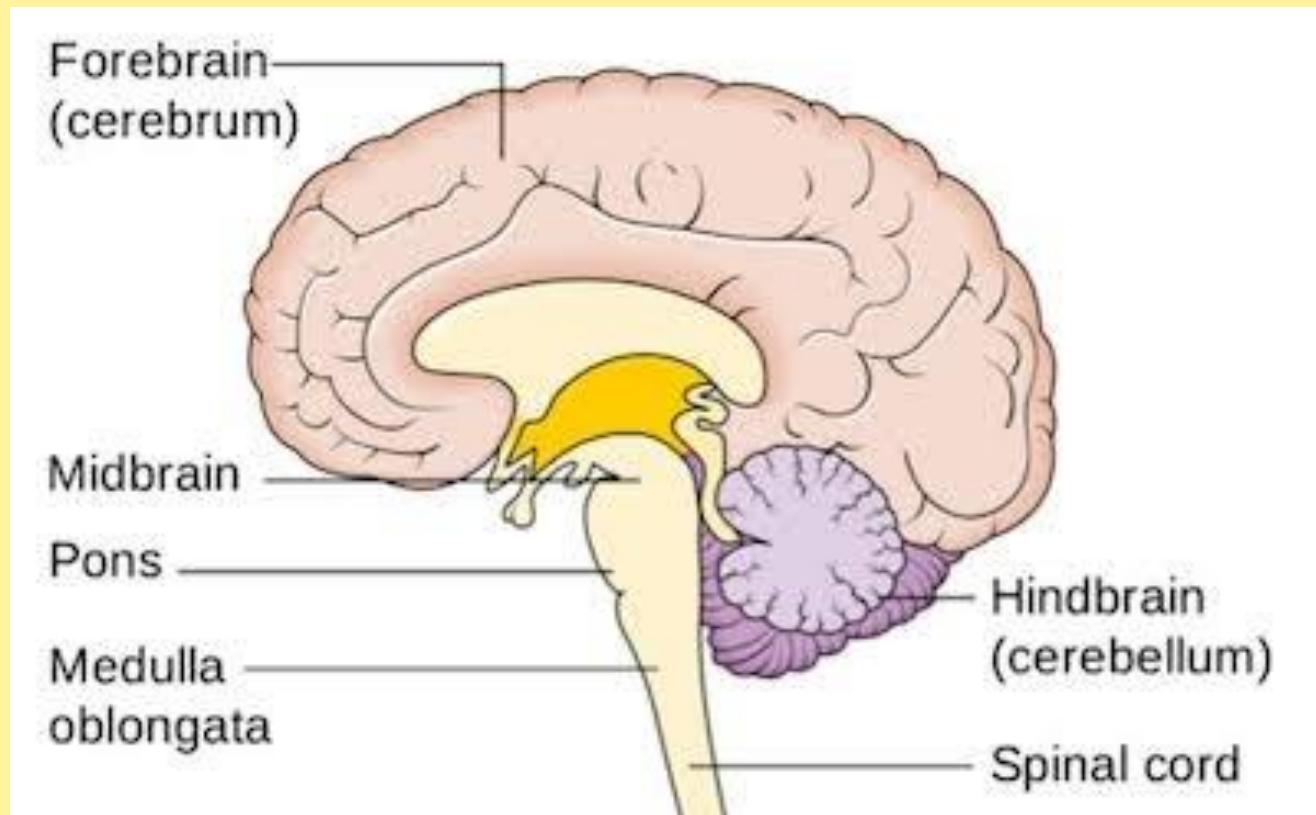
### **c) Red nucleus**

- Centre of mid brain
- Mass of grey matter within white matter
- Control posture
- Muscle tone
- Modify some motor activities.



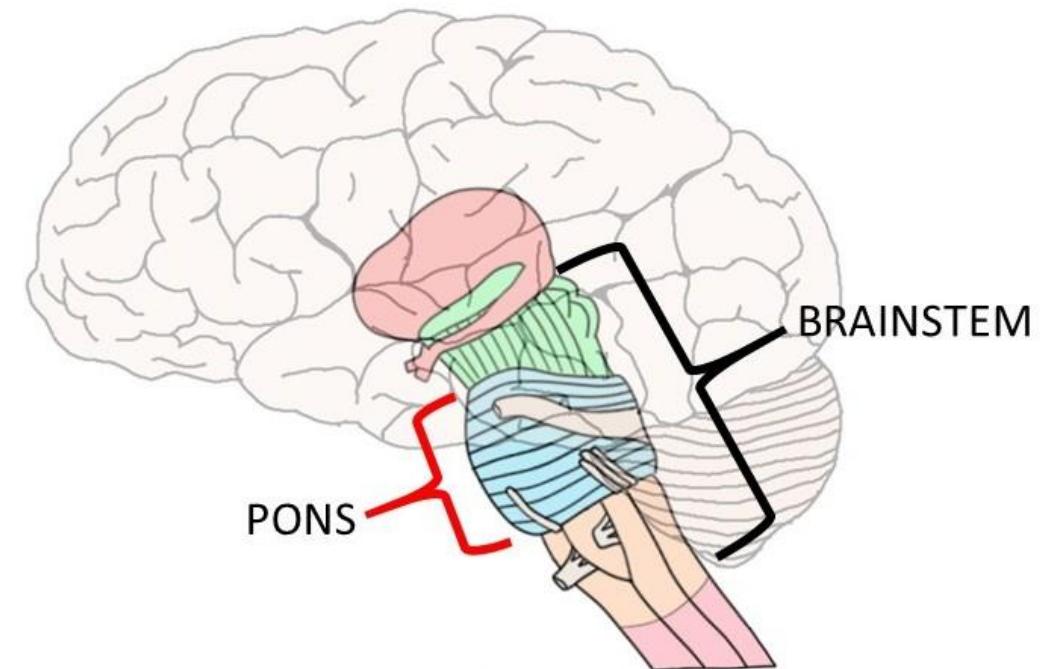
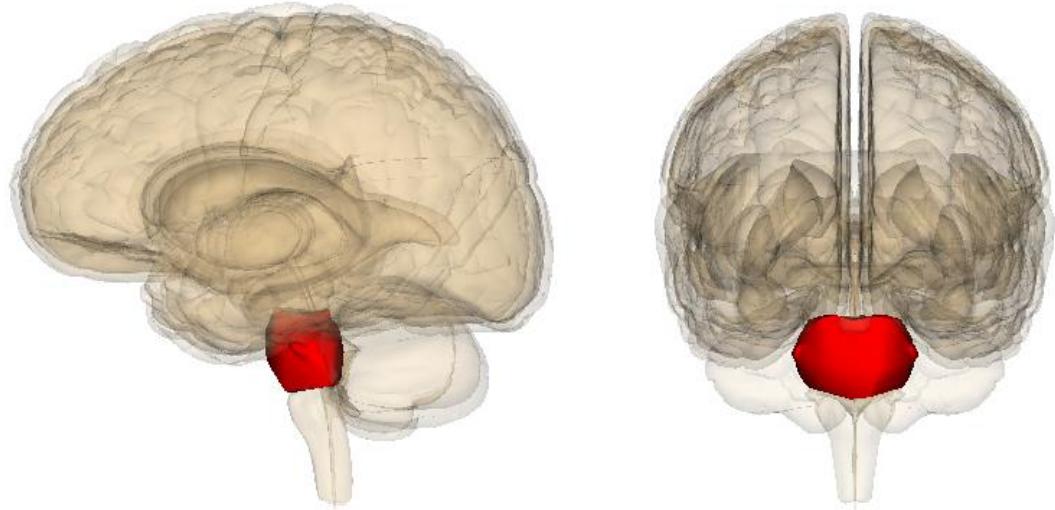
## c) Hindbrain( Rhombencephalon):

- Posterior region of brain
- Consists of:
  - a) Pons varolii
  - b) Cerebellum
  - c) Medulla oblongata



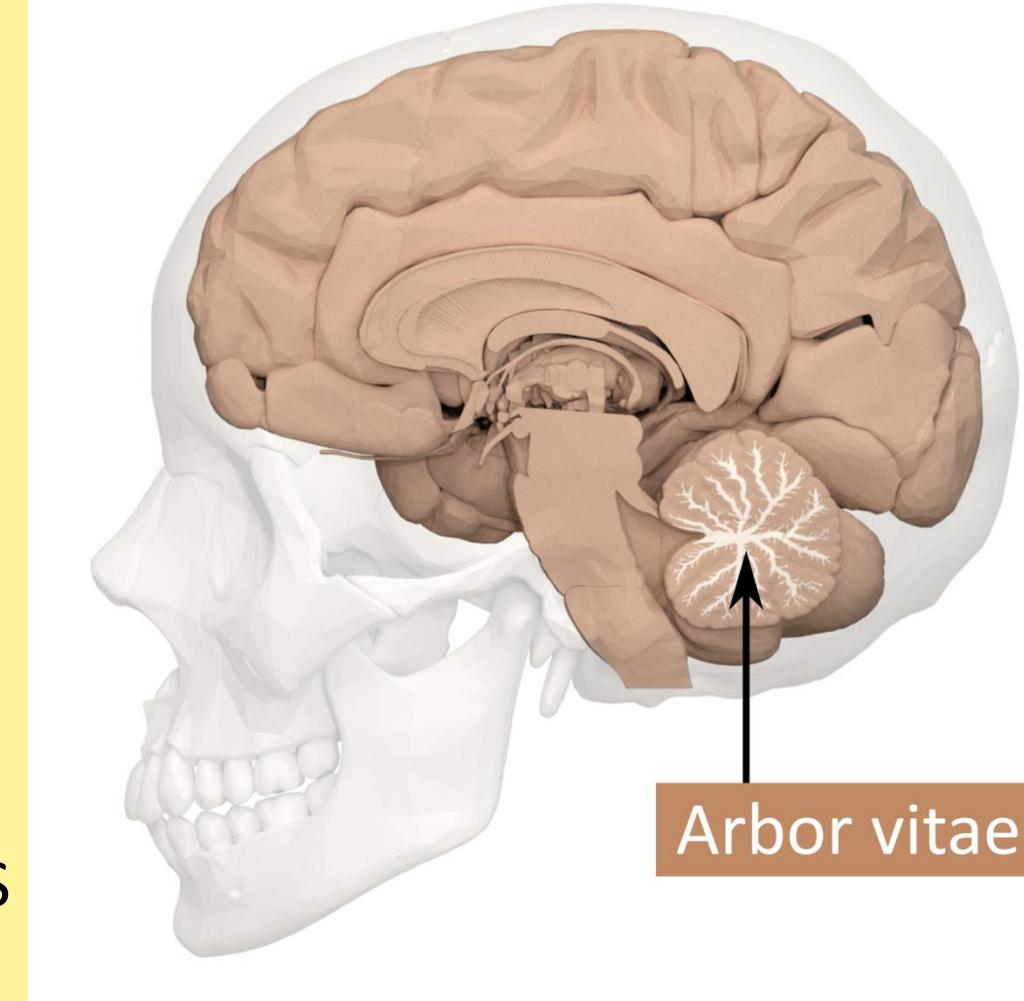
## a) Pons varolii:

- Part of brain stem (B.S)
- (B.S – Midbrain+ pons + medulla oblongata upto spinal cord)
- Cross band of nerve fibres
- Connect cerebellar lobes , medulla oblongata , spinal cord.



## b) Cerebellum:

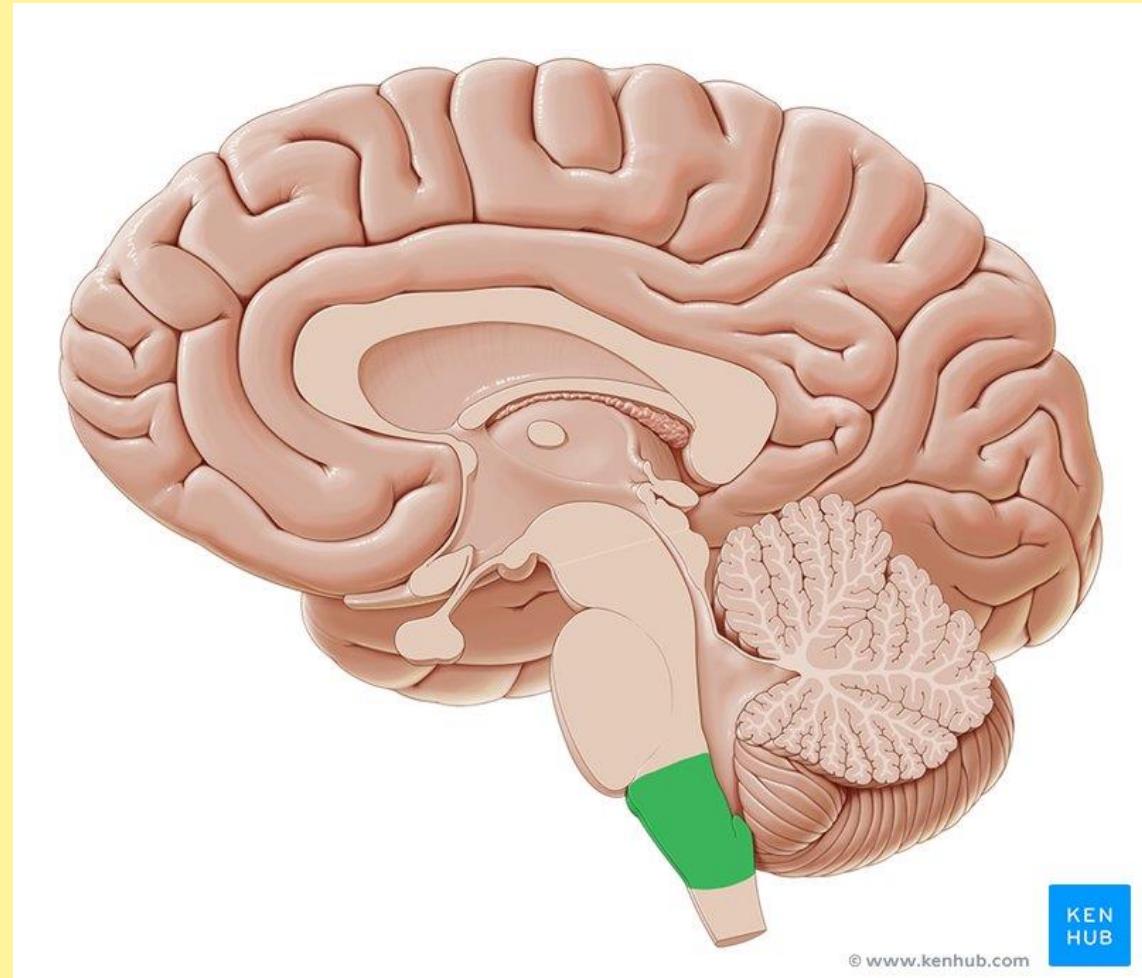
- Second largest part
- 2 lateral hemispheres and median vermis.
- Outer grey (thin) and inner white matter
- **Arbor vitae**
- Surface – gyri and sulci
- 30 million neurons in cortex
- Cerebellar peduncles- connect parts of C.N.S  
(3 pairs of myelinated nerve bundles)
- Maintains equilibrium ,posture , balance, voluntary movements
- Neuromuscular activities e.g walking



## c) Medulla oblongata:

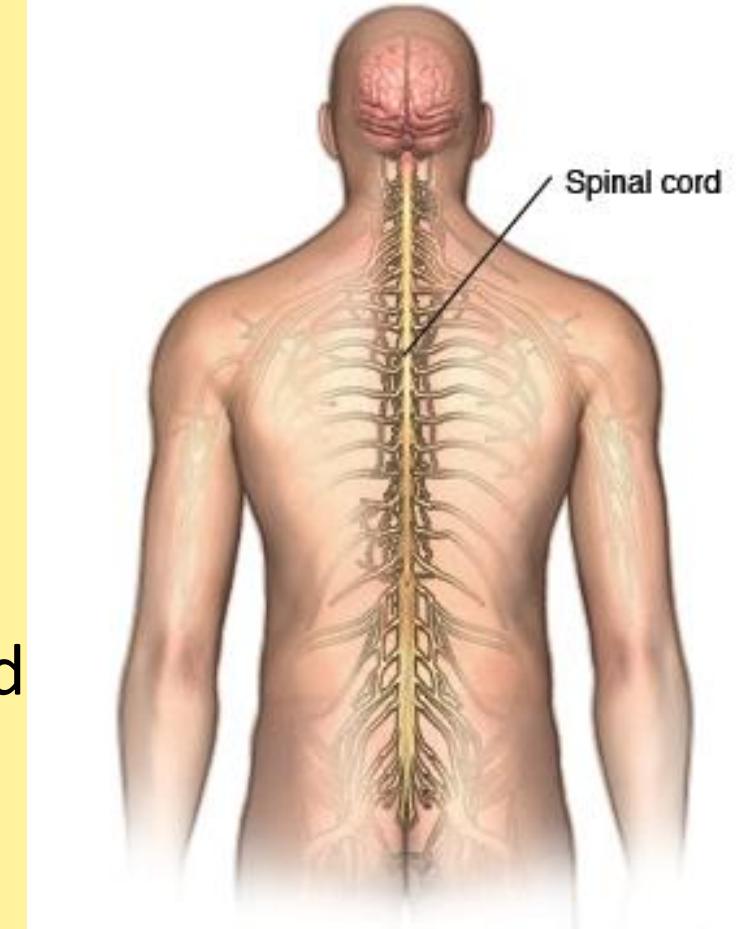
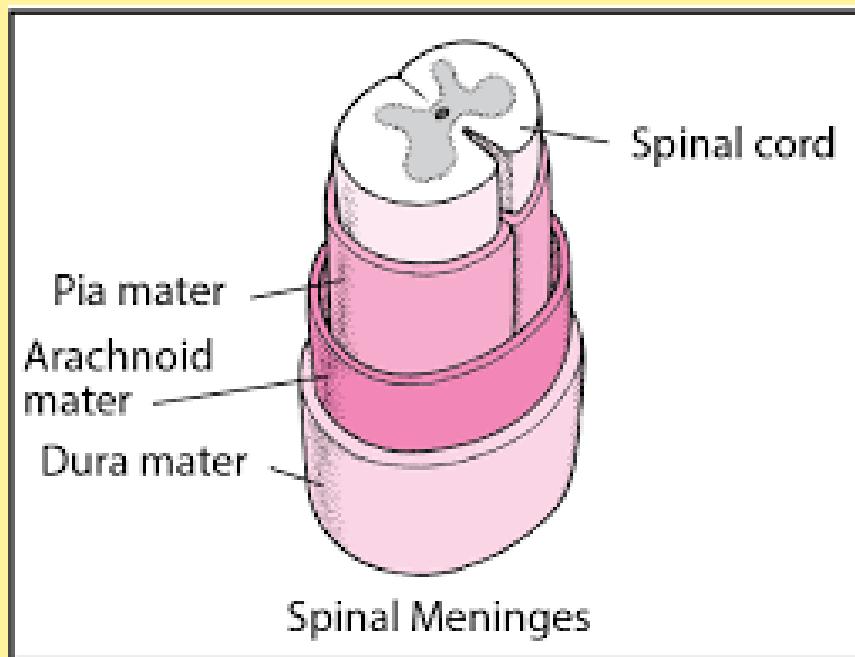
- Posterior part
- Continues as spinal cord
- Inner grey , outer white
- Involuntary vital functions  
e.g heartbeat
- Non vital reflex e.g coughing
- Metacoel/ IV Ventricle
- Roof – posterior choroid plexus
- Choroid plexus- 3 openings

( a pair of lateral foramen of luschka and median foramen of Magendie)



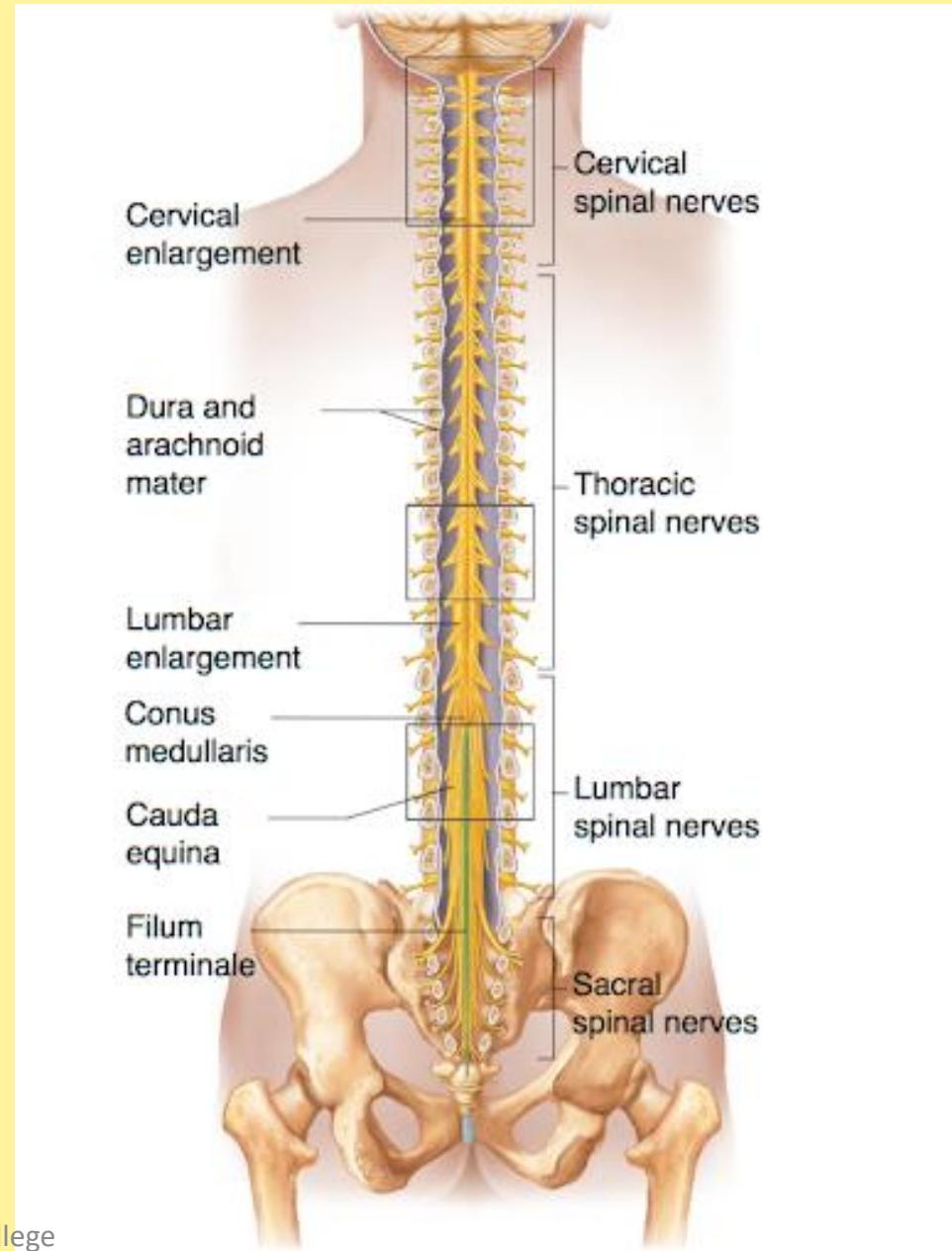
## B) Spinal cord:

- Medulla oblongata extension
- Neural canal of vertebral column
- Three meninges  
(same as brain)
- CSF – Around and within spinal cord



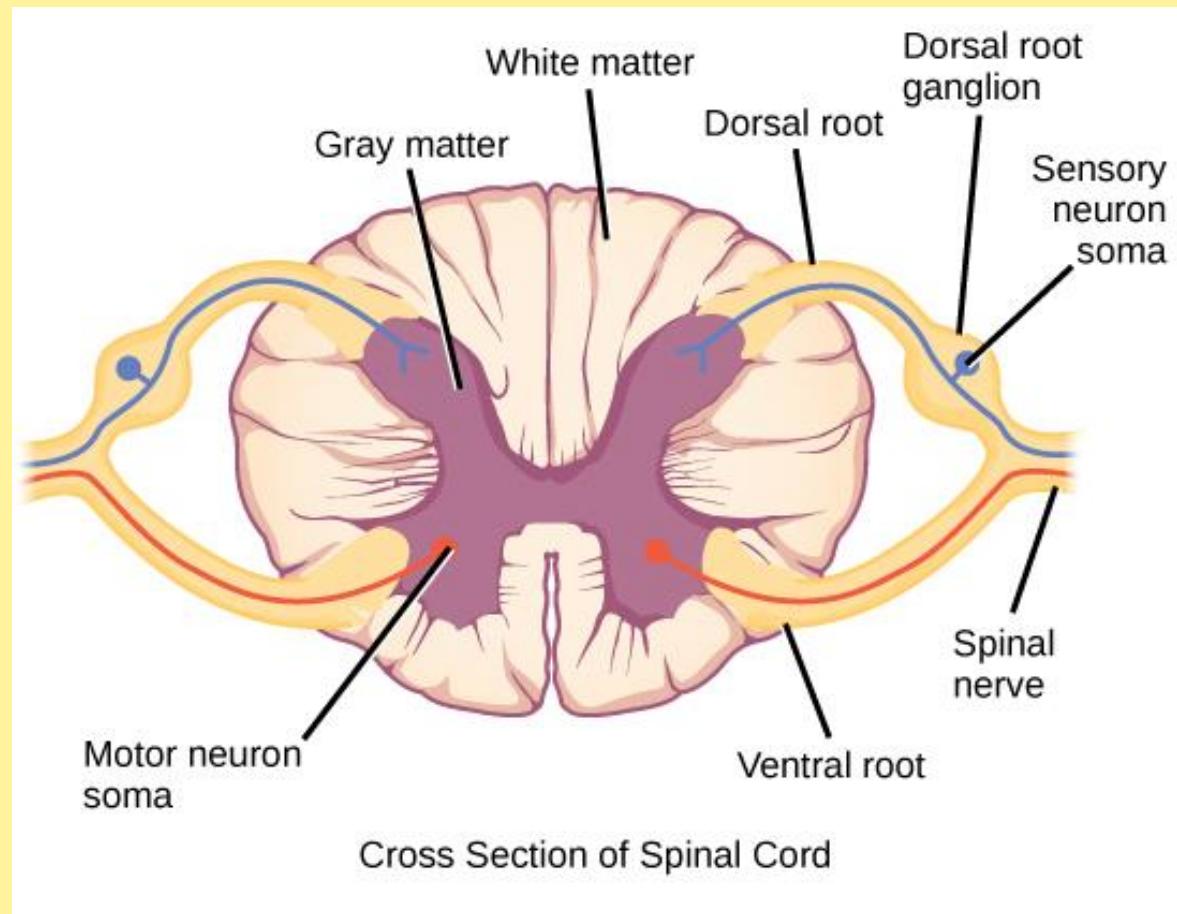
# Spinal cord:

- Long, cylindrical
- Length 42-45cm  
breadth 2- 2.5cm
- Anterior end –broad
- Posterior end- tapers- **conus medullaris**  
(L1 to L2) , thread like **filum terminale**
- **2 swellings** – cervical and lumbar
- **31 pairs**- spinal nerves( lateral)
- Nerves concentrated in swellings and around conus medullaris.
- Nerves in hindpart + filum terminale appear like horse tail ( **Cauda equina**)

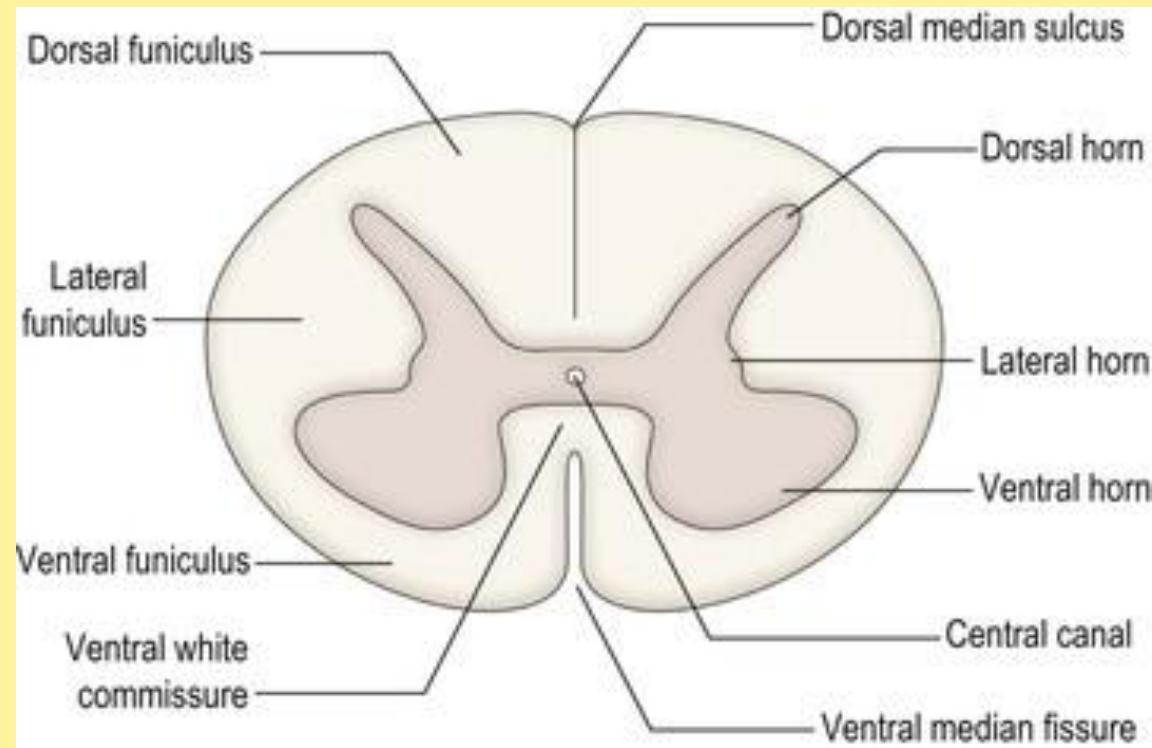


## T.S of spinal cord:

- Central canal
- **2 fissures**- deep posterior
  - shallow , broad anterior
- Outer- white matter
- Inner – grey matter
  - ( **H shaped/ butterfly shaped**)
- Fissures divide grey matter - **horns**  
divide white matter – **columns**
- Horns extend out- roots
- Dorsal root – **dorsal root ganglion** (unipolar sensory neurons)



- Within grey matter- Association/interneurons
- Ventral horn- motor neurons
- Lateral horn – neurons of ANS.
- White matter – bundles of myelinated nerve fibres  
( ascending and descending tracts)
- Ascending tracts (dorsal funiculi)-  
sensory impulses  
( from spinal cord to brain)
- Descending tracts- motor impulses  
(from brain to spinal cord [lateral and ventral funiculi])



# Functions of spinal cord:

- Main centre - reflexes
- Pathway - impulse conduction
- Nervous connection – many parts of the body



## 2) Peripheral nervous system (PNS):

- Connects CNS – Parts of body (receptors and effectors)
- Peripheral nerves – 2 main types(connection to CNS)

i) **Cranial nerves** ( to brain)

ii) **Spinal nerves** (spinal cord)

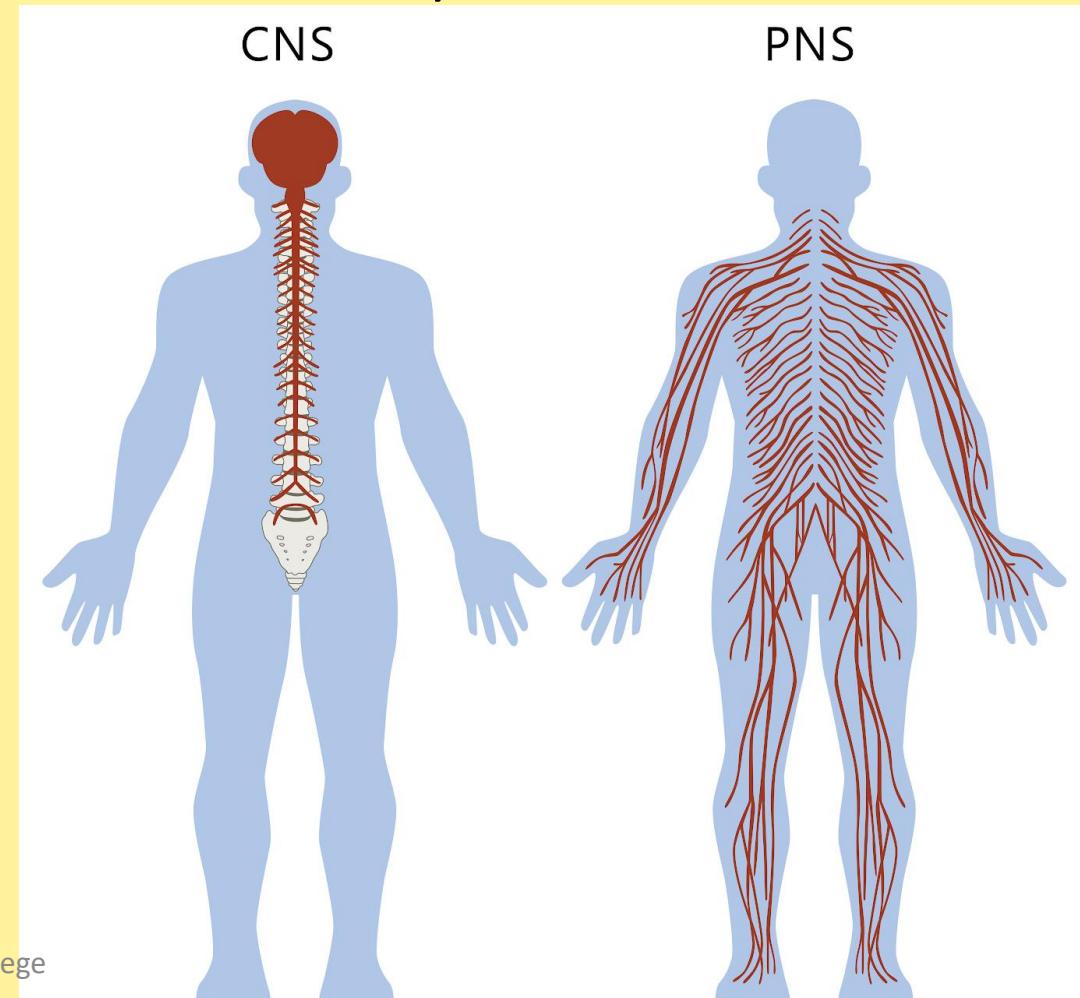
Peripheral nerves also classified as :

i) **Afferent nerves**

(sensory impulses towards CNS)

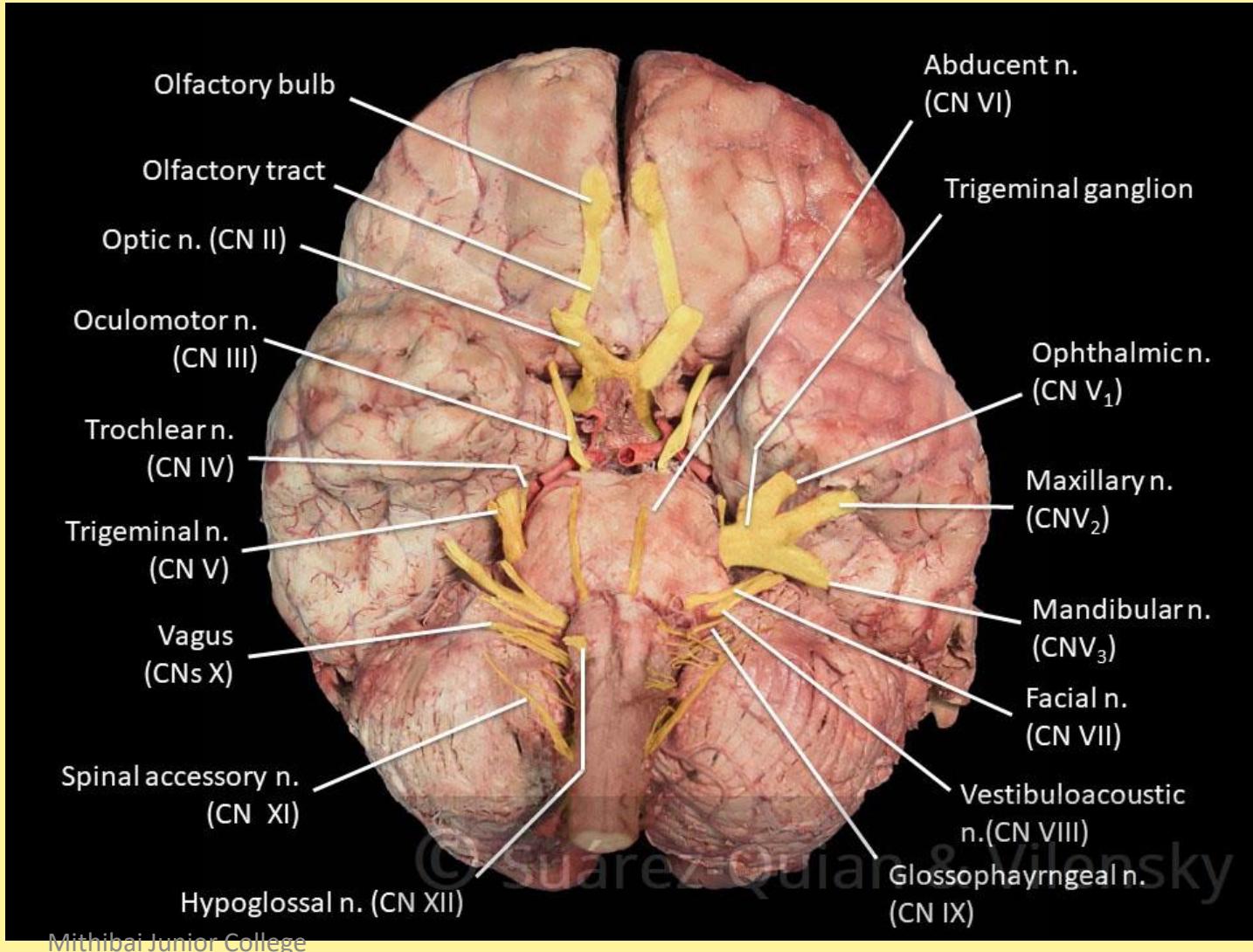
ii) **Efferent nerves**

(motor impulses away from CNS)



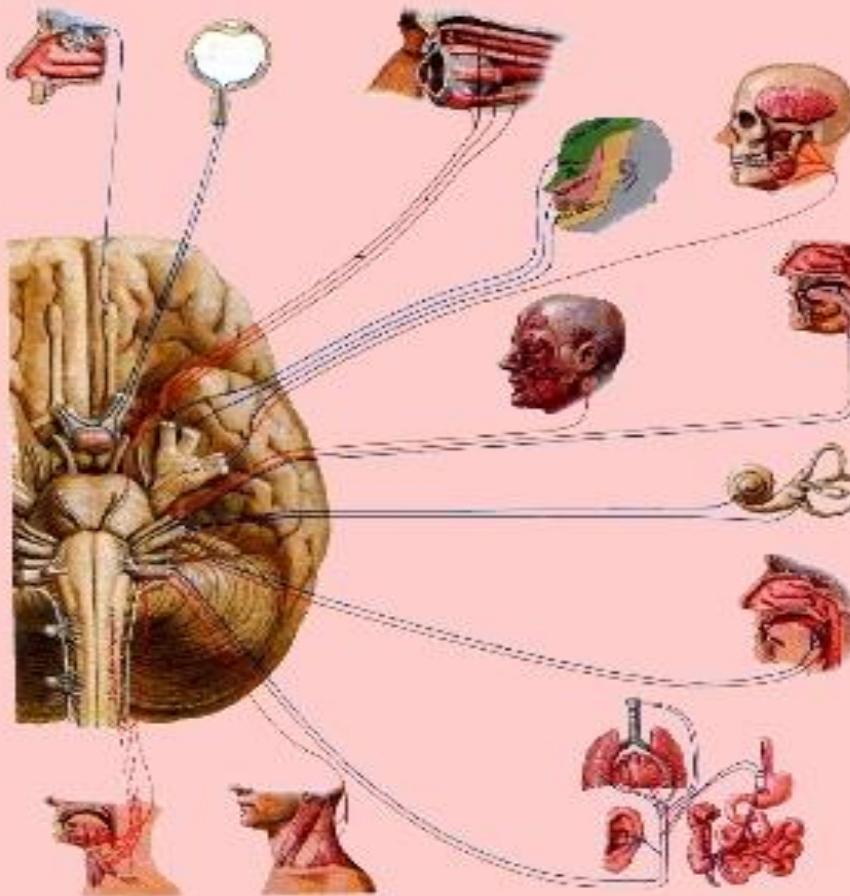
# i) Cranial nerves:

- Brain(all amniotes), originate or terminate
- **12 pairs**
- Roman number I to XII
- According to function
  - a) **Sensory ( I, II, VIII)**
  - b) **Motor (III, IV, VI, XI, XII)**
  - c) **Mixed ( V, VII, IX, X)**



# Names of cranial nerves

- I Olfactory nerve
- II Optic nerve
- III Oculomotor nerve
- IV Trochlear nerve
- V Trigeminal nerve
- VI Abducent nerve
- VII Facial nerve
- VIII Vestibulocochlear nerve
- IX Glossopharyngeal nerve
- X Vagus nerve
- XI Accessory nerve
- XII Hypoglossal nerve



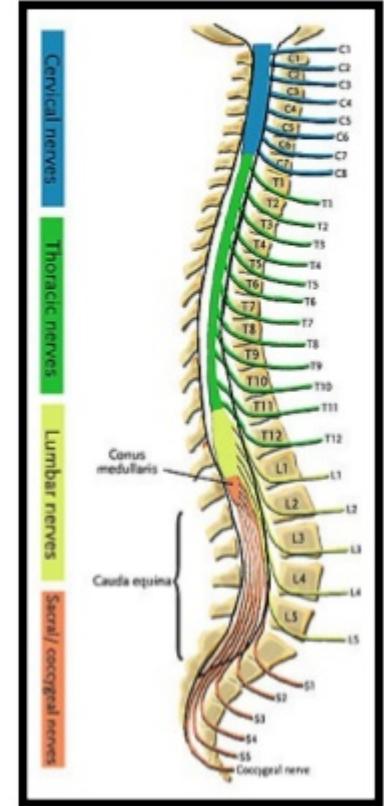
Sensory I
sensory II
Motor III
Motor IV
Mixed V
Motor VI
Mixed VII
sensory VIII
Mixed IX
Mixed X
Motor XI
Motor XII

## ii) Spinal nerves:

- Originate – spinal cord
- **31 pairs**
- **Mixed nerves**

### Spinal Nerve

- **Spinal nerves:**
  1. **8 pairs of cervical spinal nerves**
  2. **12 pairs of thoracic spinal nerves**
  3. **5 pairs of lumbar spinal nerves.**
  4. **5 pairs of sacral spinal nerves**
  5. **1 pairs of coccyx spinal nerves.**



# SPINAL CORD

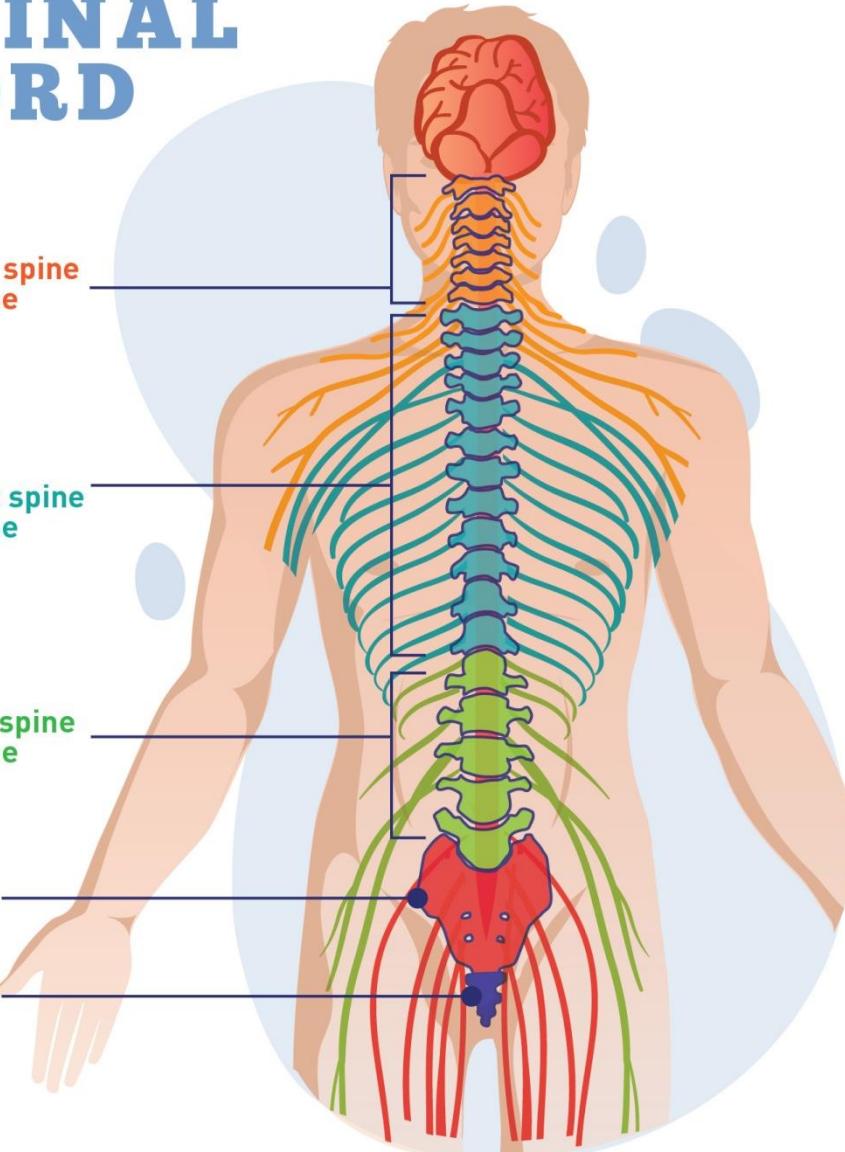
Cervical spine vertebrae

Thoracic spine vertebrae

Lumber spine vertebrae

Sacrum

Coccyx



## Cervical nerves

- C1 Head and neck
- C2 Diaphragm
- C3 Deltoids, Biceps
- C4 Wrist Extenders
- C5 Triceps
- C6 Triceps
- C7 Hand
- C8 Hand

T1

T2

T3

T4

## Thoracic nerves

T5

T6

T7 Chest muscles

T8 Abdominal muscles

T9

T10

T11

T12

## Lumber nerves

L1

L2 Leg muscles

L3

L4

L5

## Sacral nerves

S1

S2 Bowel, bladder

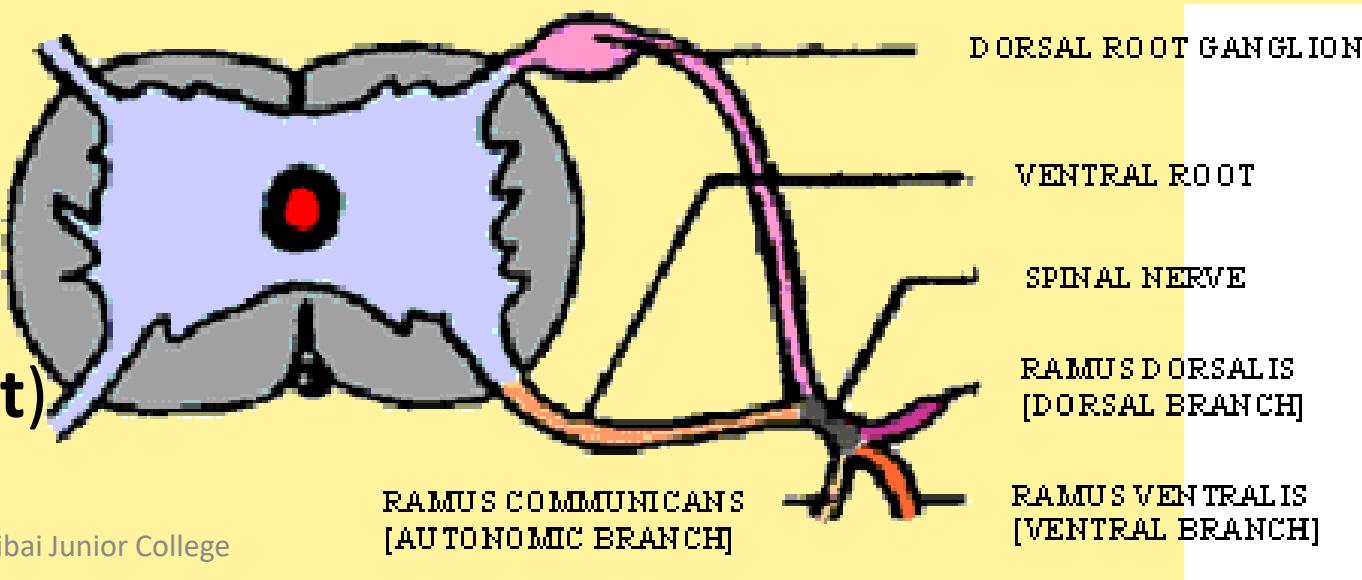
S3 Sexual functions

S4

Coccygeal

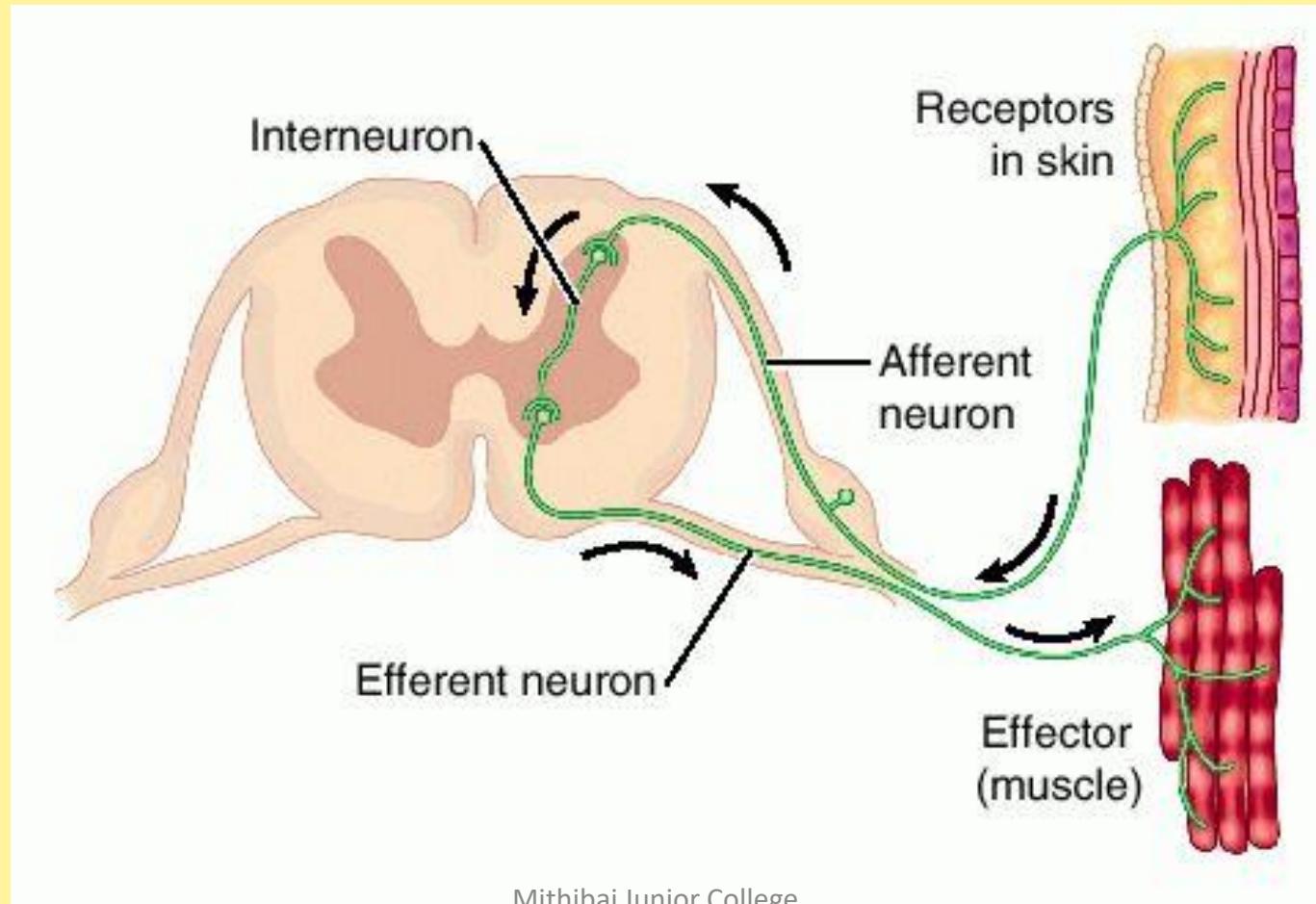
# Formation of a typical spinal nerve:

- Mixed type
- Spinal nerve- neural canal of vertebral column
- 2 roots- posterior/dorsal root(sensory nerve) and anterior/ventral root(motor nerve)
- Both nerves together- mixed spinal nerve.
- Emerges out- intervertebral foramen
- Shows – 3 branches
  - a) Ramus dorsalis
  - b) Ramus ventralis(**largest**)
  - c) Ramus communicans(**smallest**)



# Reflex action:

- Sudden, spontaneous , automatic , involuntary response
- Path- **Reflex arc**



# Types of reflex actions:

- **CRITERIAS:**

## **1) Control over the actions:**

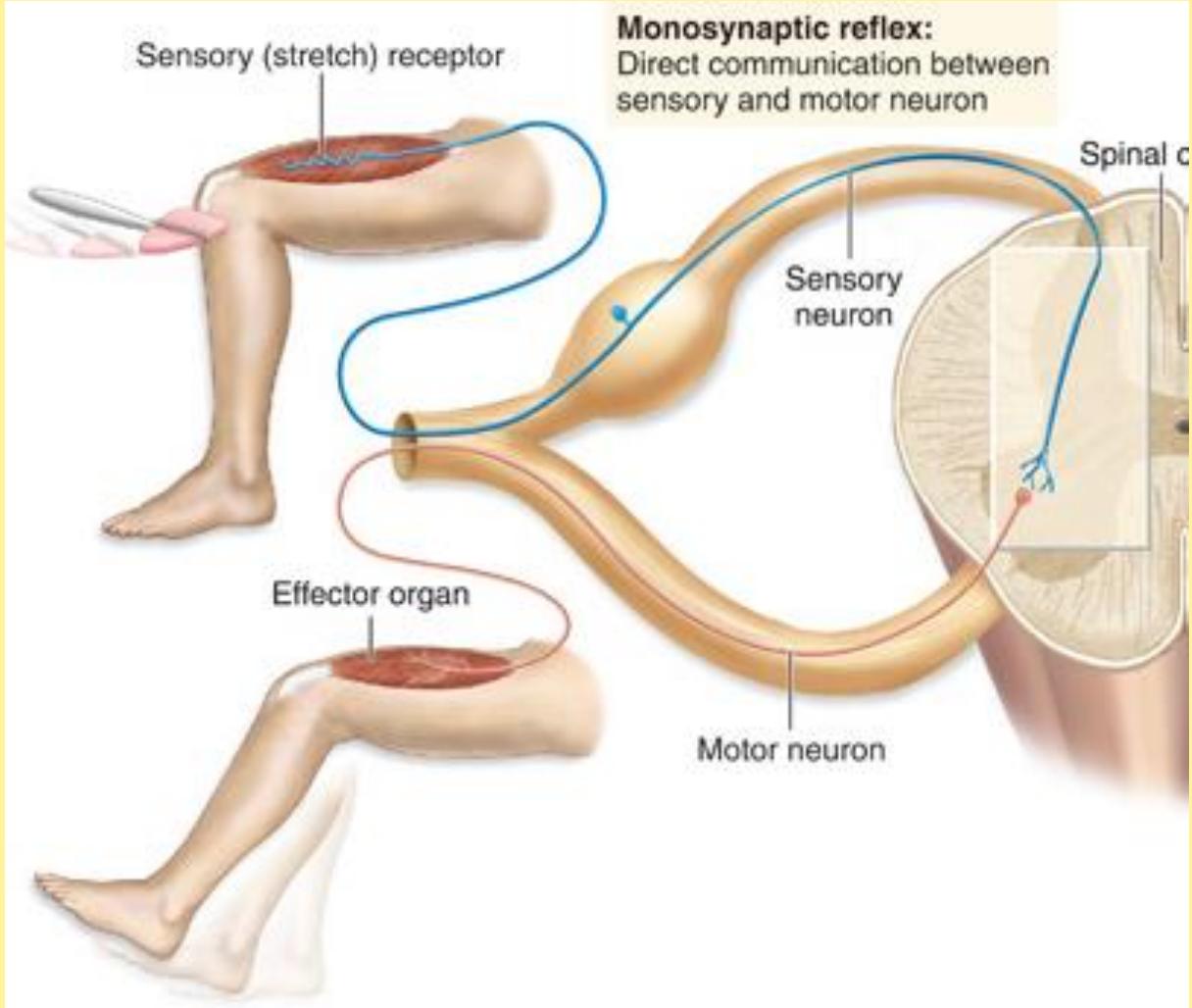
CRANIAL REFLEXES	SPINAL REFLEXES
- By brain	- By spinal cord
- Slow response	- Urgency of response
- Mouth watering	- Withdrawal of hand

## 2) Previous experiences:

UNCONDITIONED REFLEXES	CONDITIONED REFLEXES
No previous experience required	previous experience required
e.g. sneezing	e.g. cycling

### 3) Number of synapses:

SIMPLE MONOSYNAPTIC	COMPLEX POLYSYNAPTIC
Involves only sensory and motor neuron	involves sensory, interneuron, motor neuron
e.g. knee jerk reflex	e.g. swimming



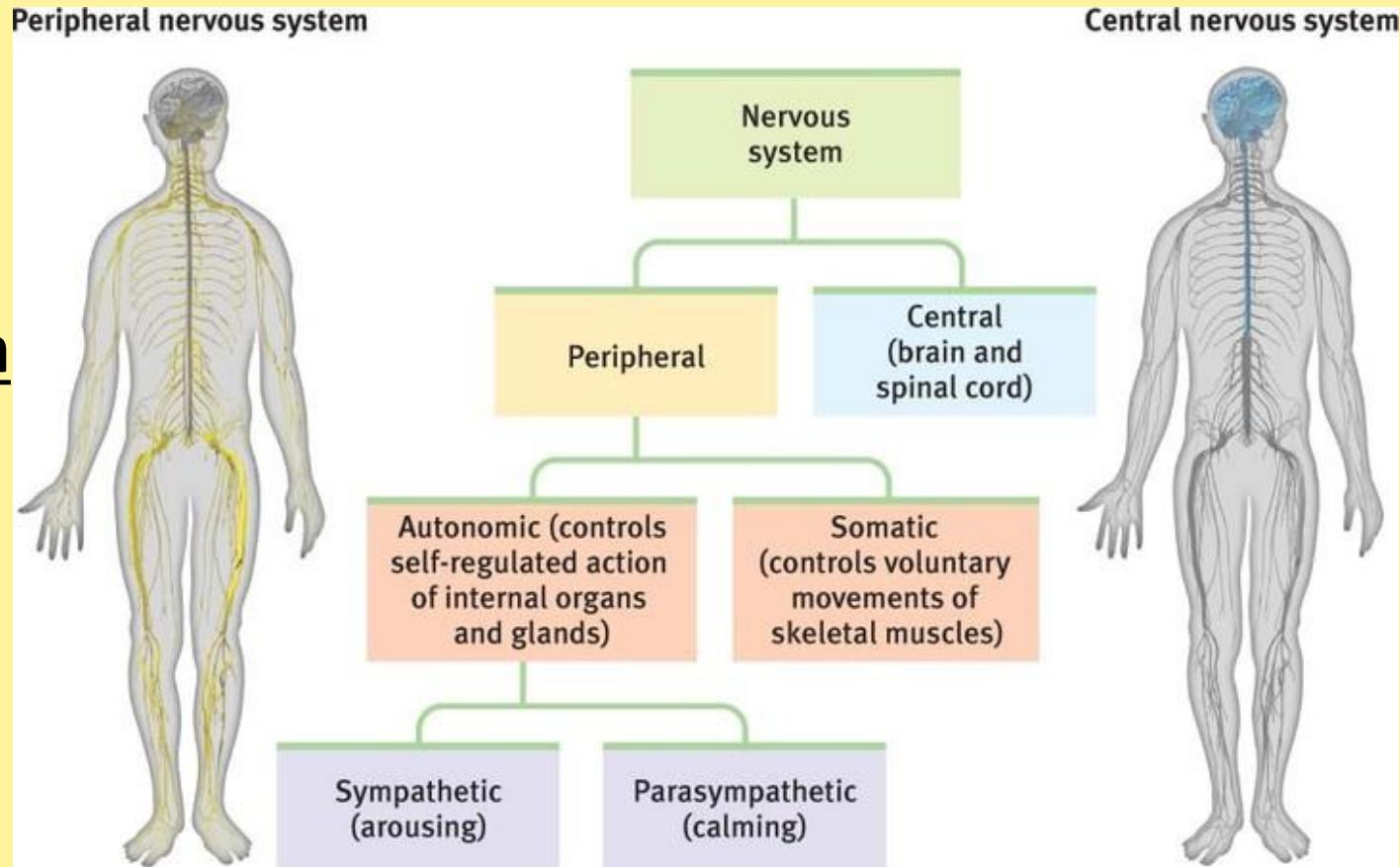
- **PNS is divided into**

- i) **Somatic nervous system**

( relays impulses from CNS  
to skeletal/ voluntary muscles)

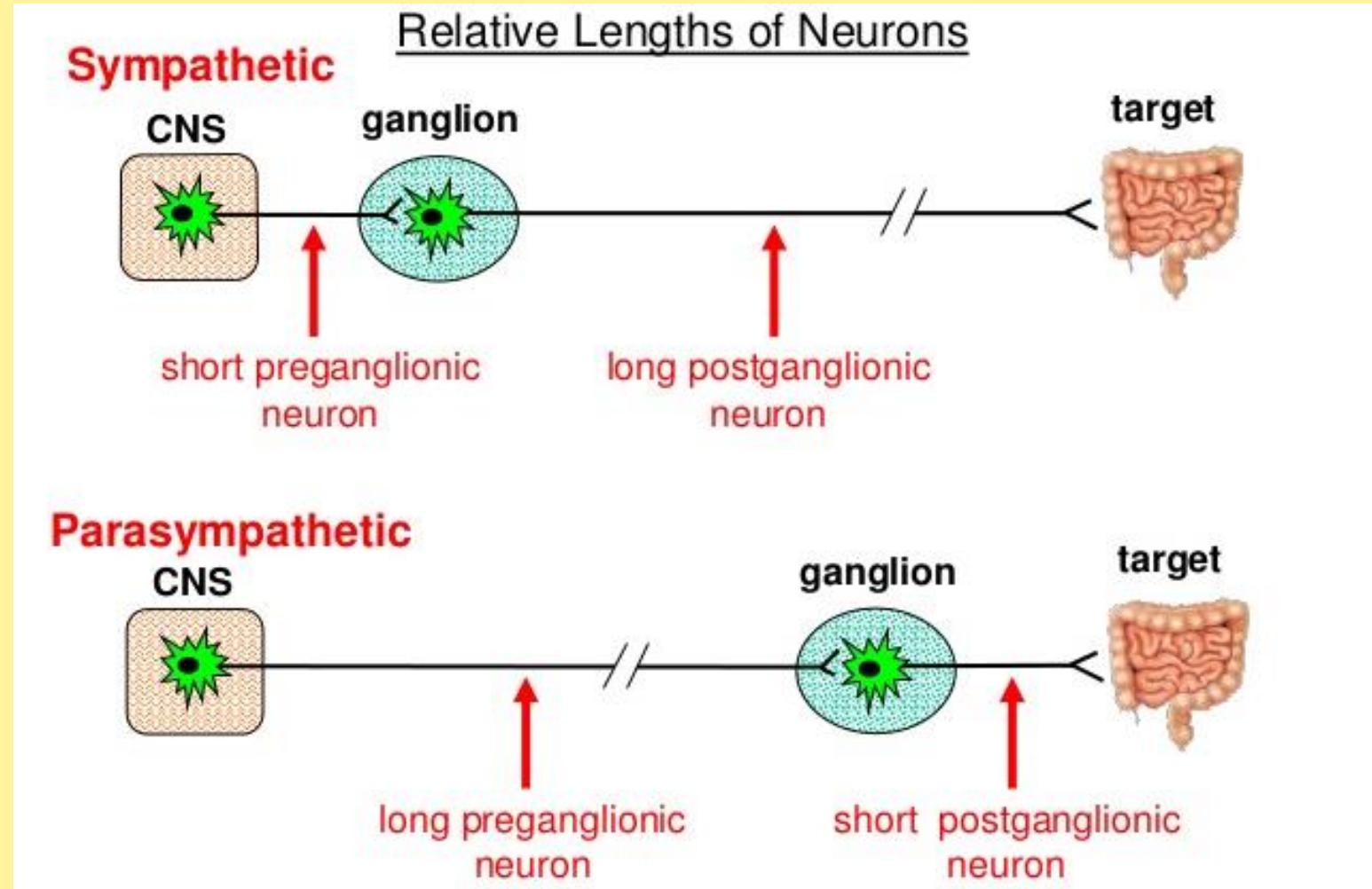
- i) **Autonomic nervous system**

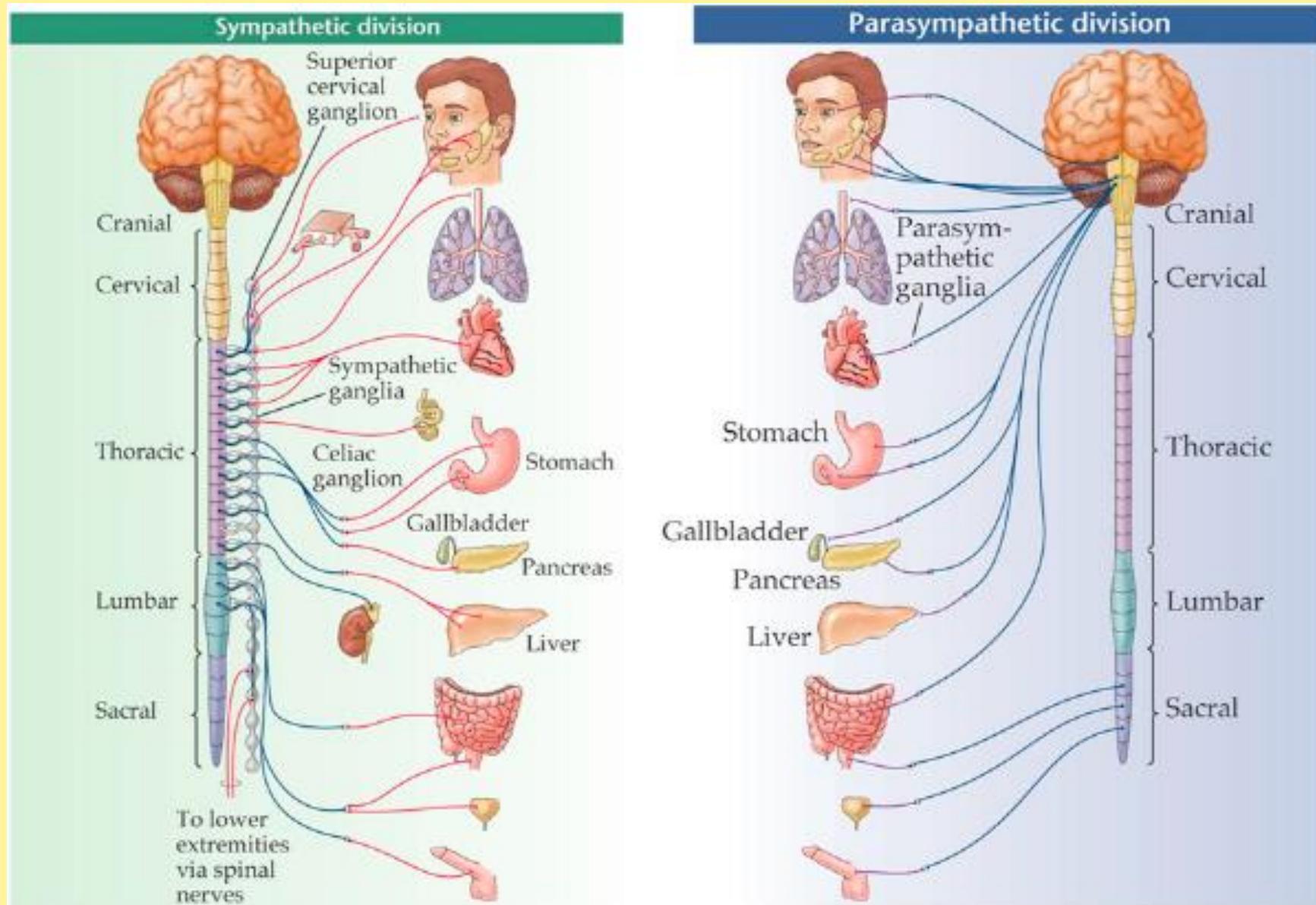
( relays impulses from CNS  
to smooth/involun-  
tary muscles)



# Autonomous nervous system:

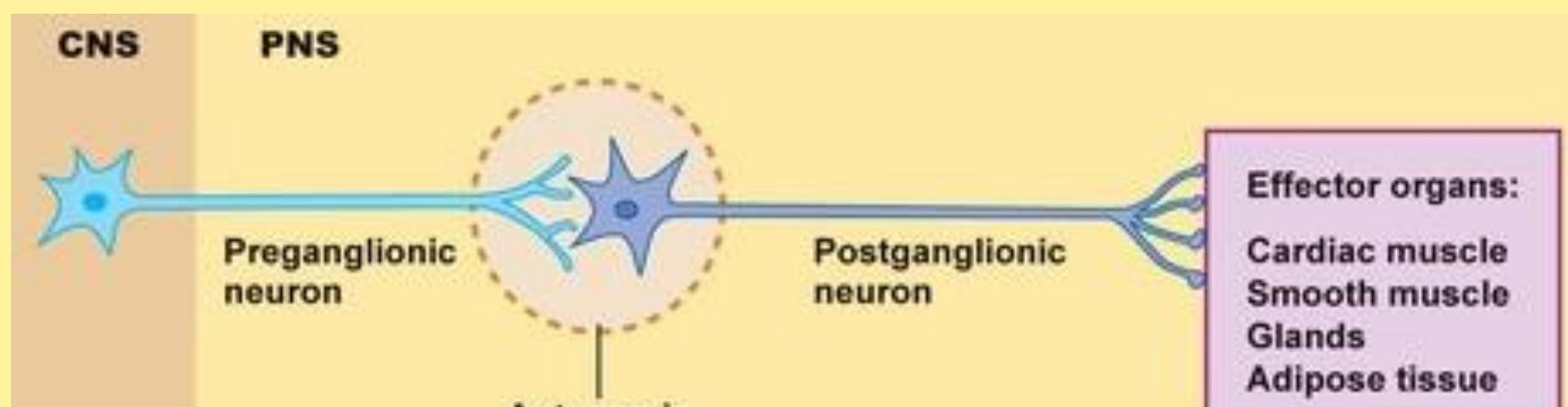
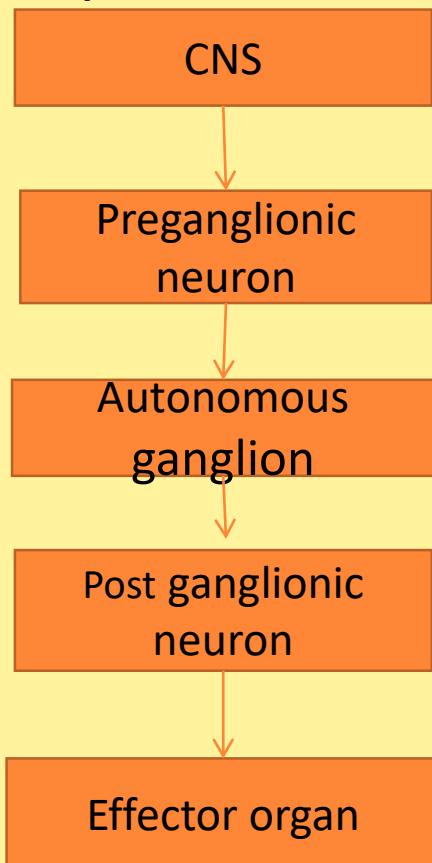
- Divided into –
  - a) Sympathetic Nervous System
  - a) Parasympathetic Nervous System





### 3) Autonomic Nervous System (ANS):

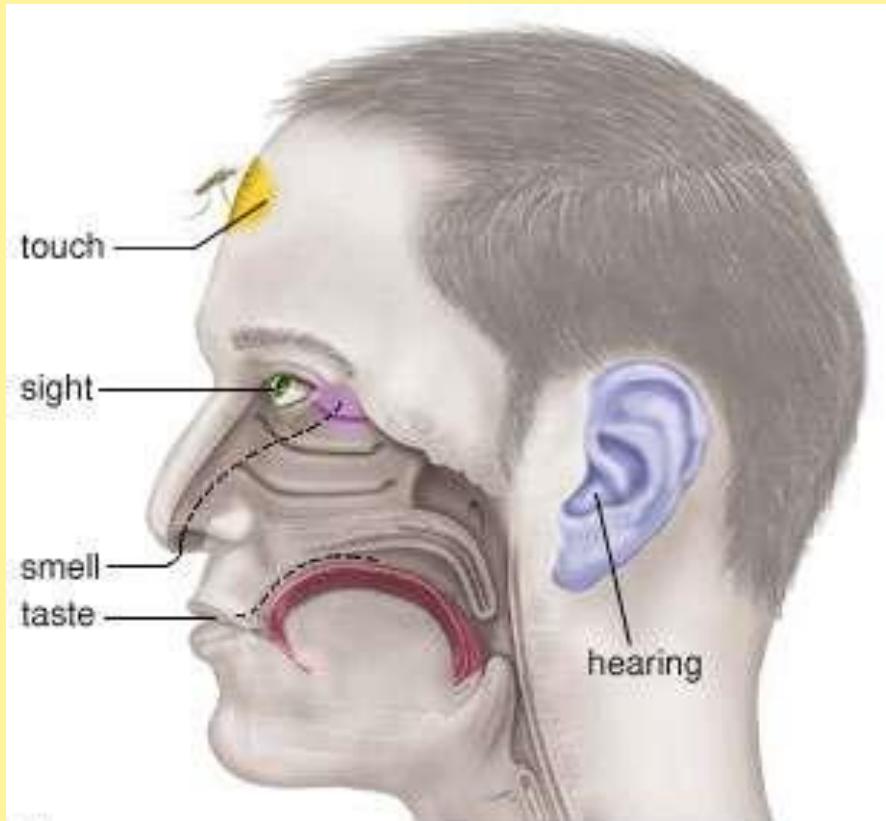
- Special set of peripheral nerves
- Regulates involuntary organs
- Impulses conducted from CNS



<b>SYMPATHETIC NERVOUS SYSTEM</b>	<b>PARASYMPATHETIC NERVOUS SYSTEM</b>
- Thoraco-lumbar outflow	- Cranio –sacral
- 22 pairs of sympathetic ganglia	-ganglia close or within wall of effector organ
- Preganglionic nerve fibres short and post ganglionic nerve fibres long.	- Preganglionic nerve fibres long and post ganglionic nerve fibres short
-Post ganglionic nerve fibres secrete Adernaline and Noradrenaline	- Post ganglionic nerve fibres secrete acetylcholine
- Adrenergic fibres	- Cholinergic fibres
- response- emergencies	- Antagonist to sympathetic , bring back to normal. Housekeeping system.
- Excitory effect except digestive and excretory organ	- Digestive and excretory activities accelerated.

# UNIT 9.7 Sensory receptors:

- Specialised structures
- Receive stimuli (external or internal)



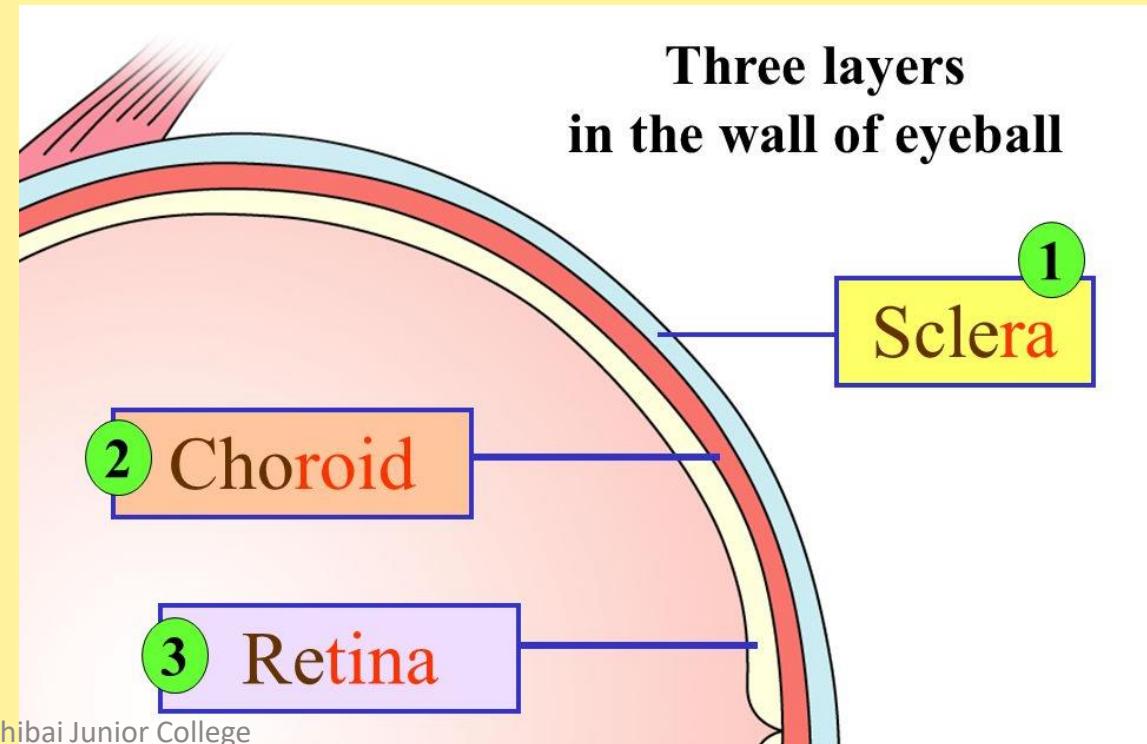
# Classification of receptors: Basis of location, function/sensitivity to specific stimuli.

## Types of receptors:

Name / Type of receptor	Location	Function
I) Exteroceptors:		Receives sensory stimuli for:
a) Phonoreceptors	Internal ear – organ of corti	sound
b) Statoreceptors	Internal ear- semicircular canals	Balance and equilibrium
c) Photoreceptors	Retina	vision
d) Thermoreceptors	Skin	Heat (caloriceptors) and cold (trigidoceptors)
e) Mechanoreceptors	Skin	Touch/pain/pressure
f) Chemoreceptors (Gustato/olfactory)	Taste buds/ olfactory epithelium	Taste/smell
II) Interoceptors		
a) Enteroceptors	Visceral organs	Hunger/thirst/pain
b) Proprioceptors	Joints/muscles/tendons	Tension/vibrations
c) Baroreceptors	Walls of atria, venae cavae, aortic arch	Changes in blood pressure

# EYE:

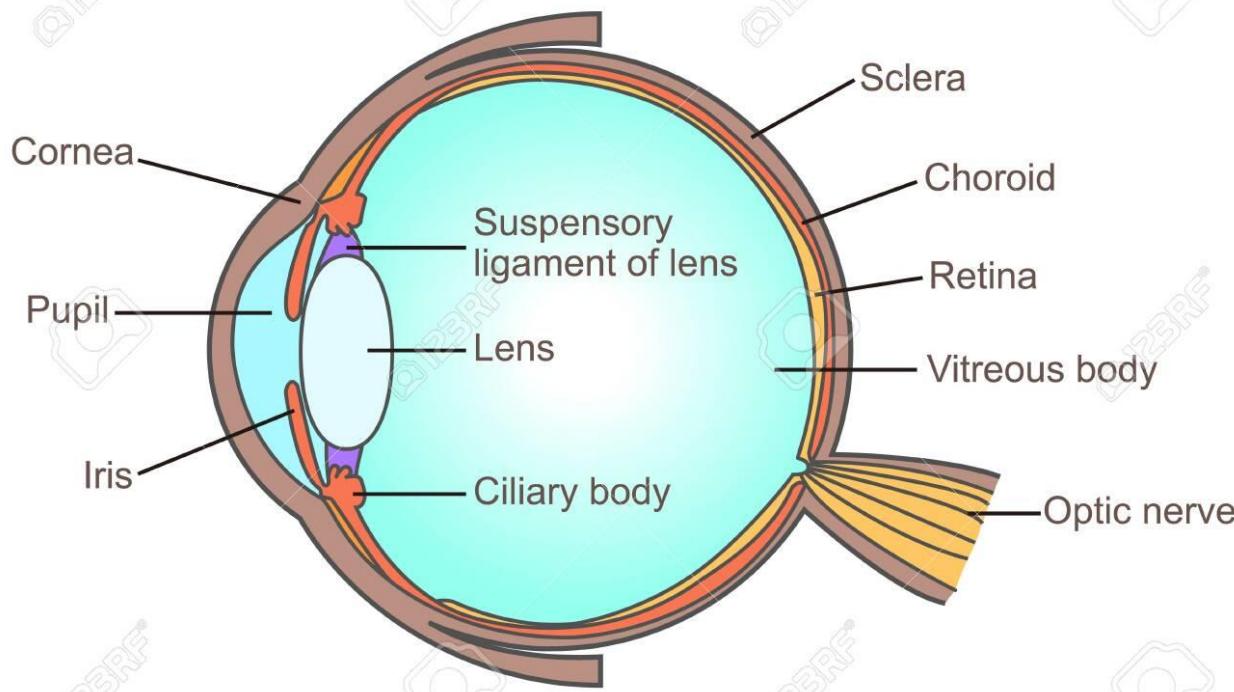
- Location : orbit of skull
- Each eye: spherical/rounded (EYEBALL)
- Movement of eyeball: controlled by 6 set of muscles
- Wall : **3 layers**
  - a) Sclera
  - b) Choroid
  - c) Retina



## 1) SCLERA:

- Outermost, fibroelastic (**collagen**)
- Anterior thick, transparent- **cornea**  
(lack blood vessels)
- Exposed sclera and entire cornea
- Transparent membrane
- **Conjunctiva**

Structure Of The Human Eye



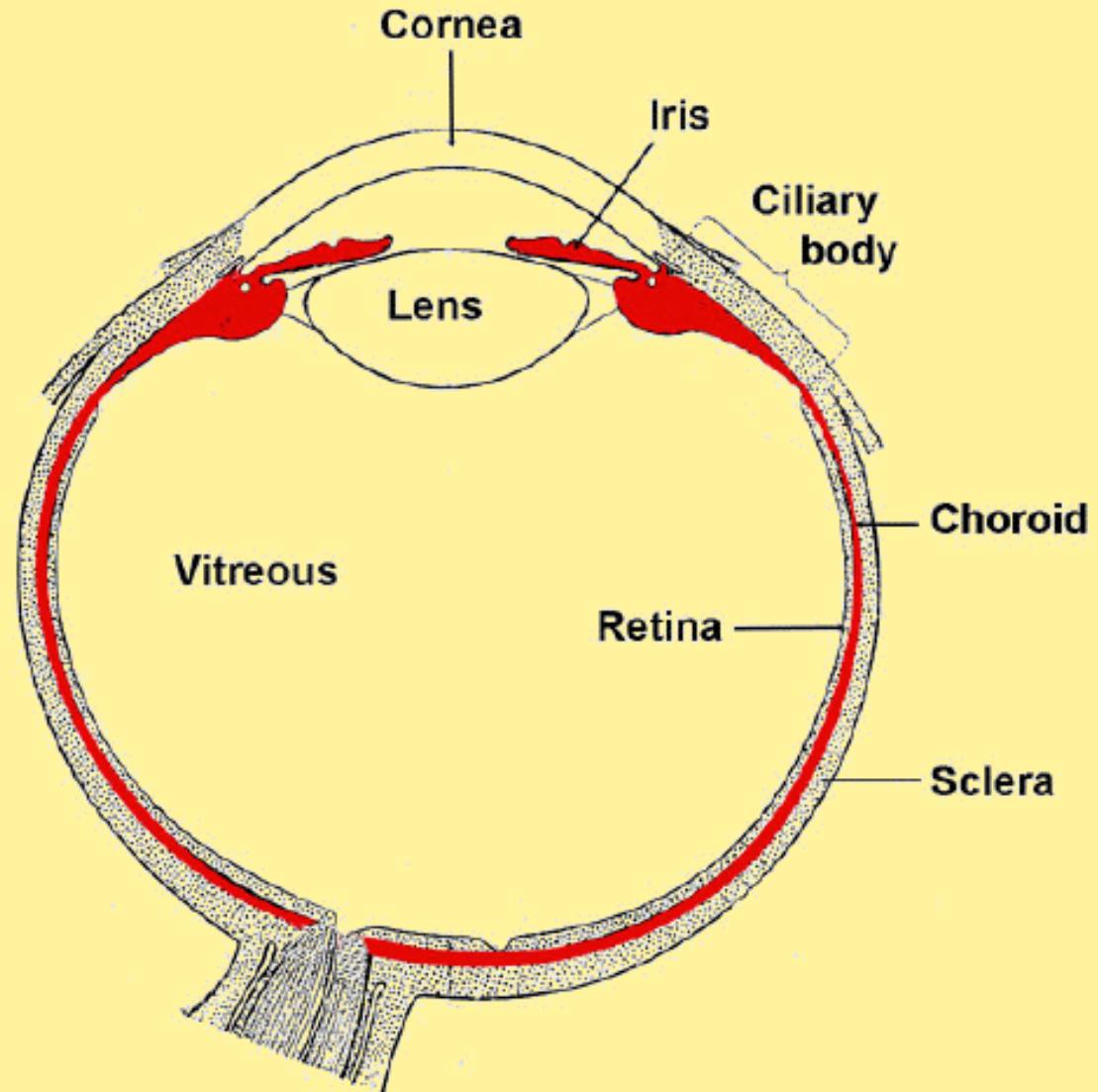
## **2) CHOROID/ UVEA:**

- Middle, vascular,pigmented

- 3 regions

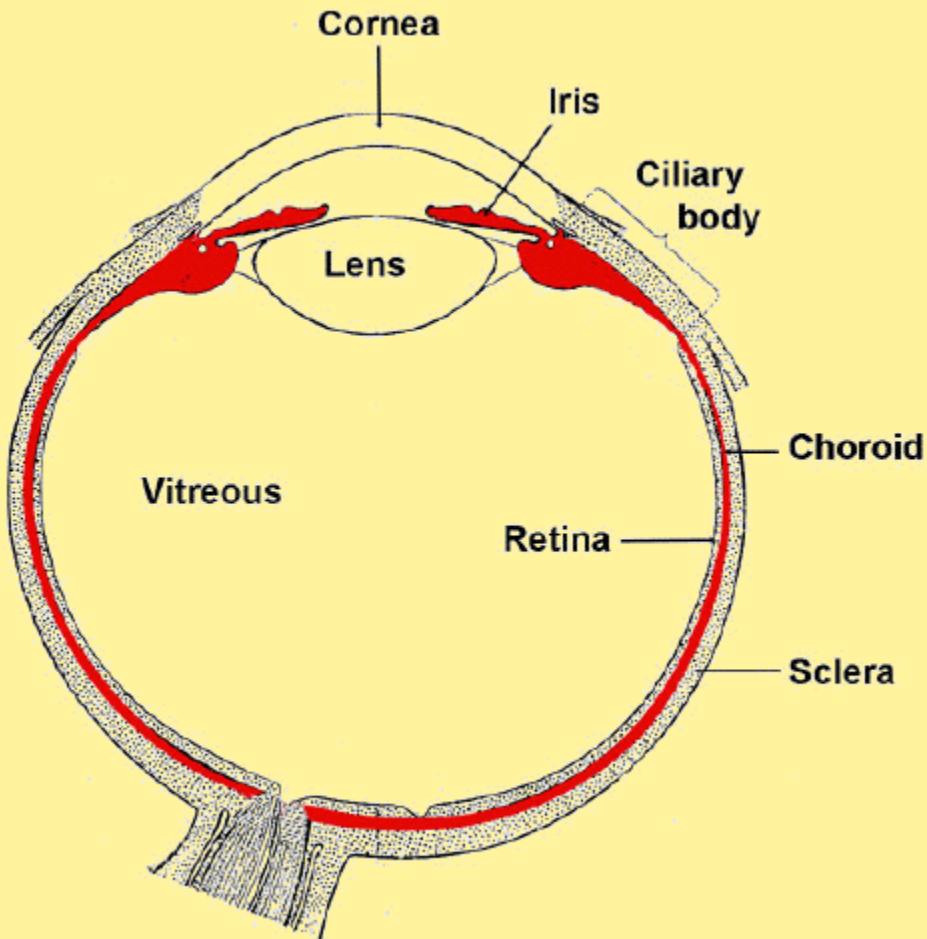
### **a) Choroid proper**

- Lines sclera
- Prevents internal reflection
- Bloodvessels present  
(nutrition and oxygen to retina)



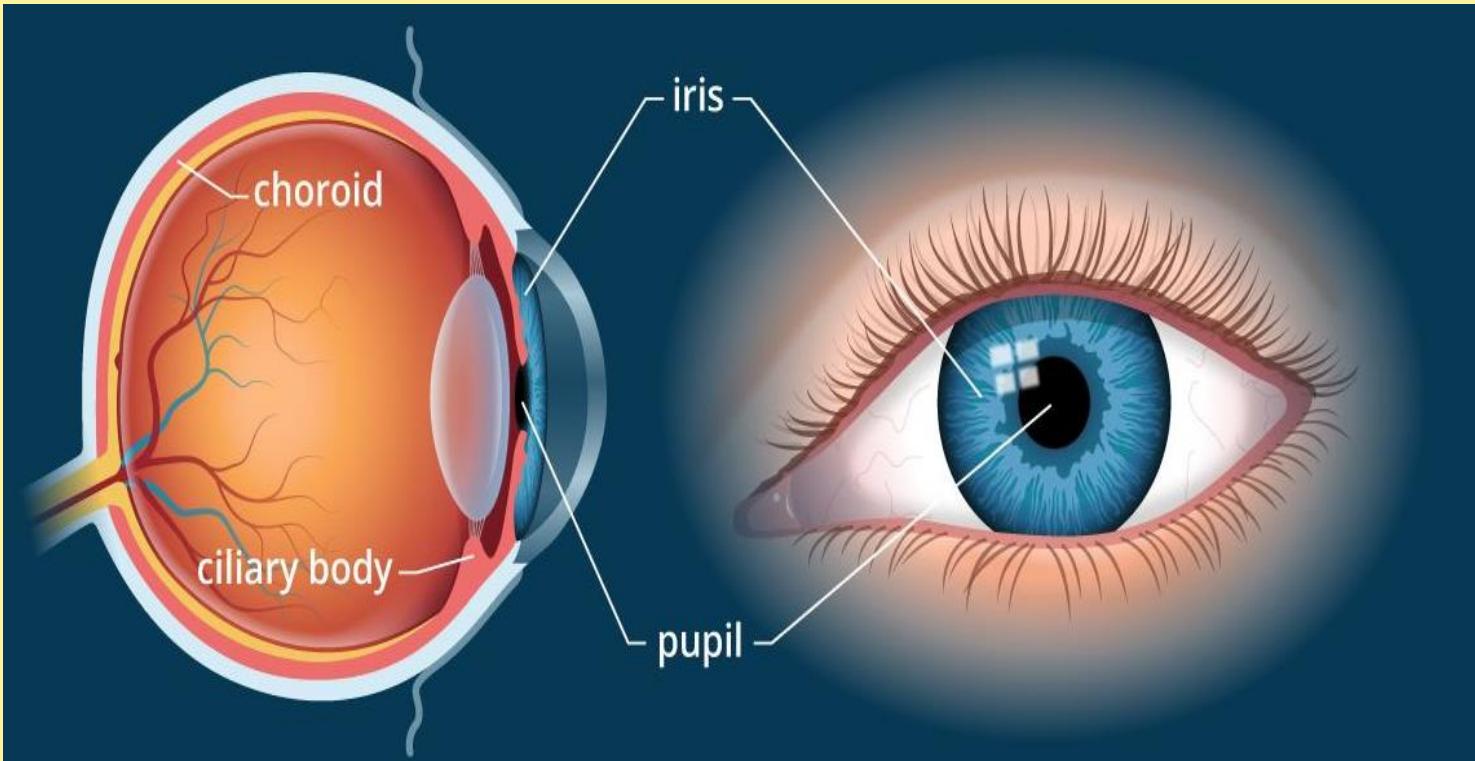
## b) Ciliary body

- thick, muscular , ring like
- Junction of choroid and iris
- Secretes aqueous humor
- Suspensory ligaments  
(holds lens)
- Ligaments and muscles  
(adjustment of size of lens)



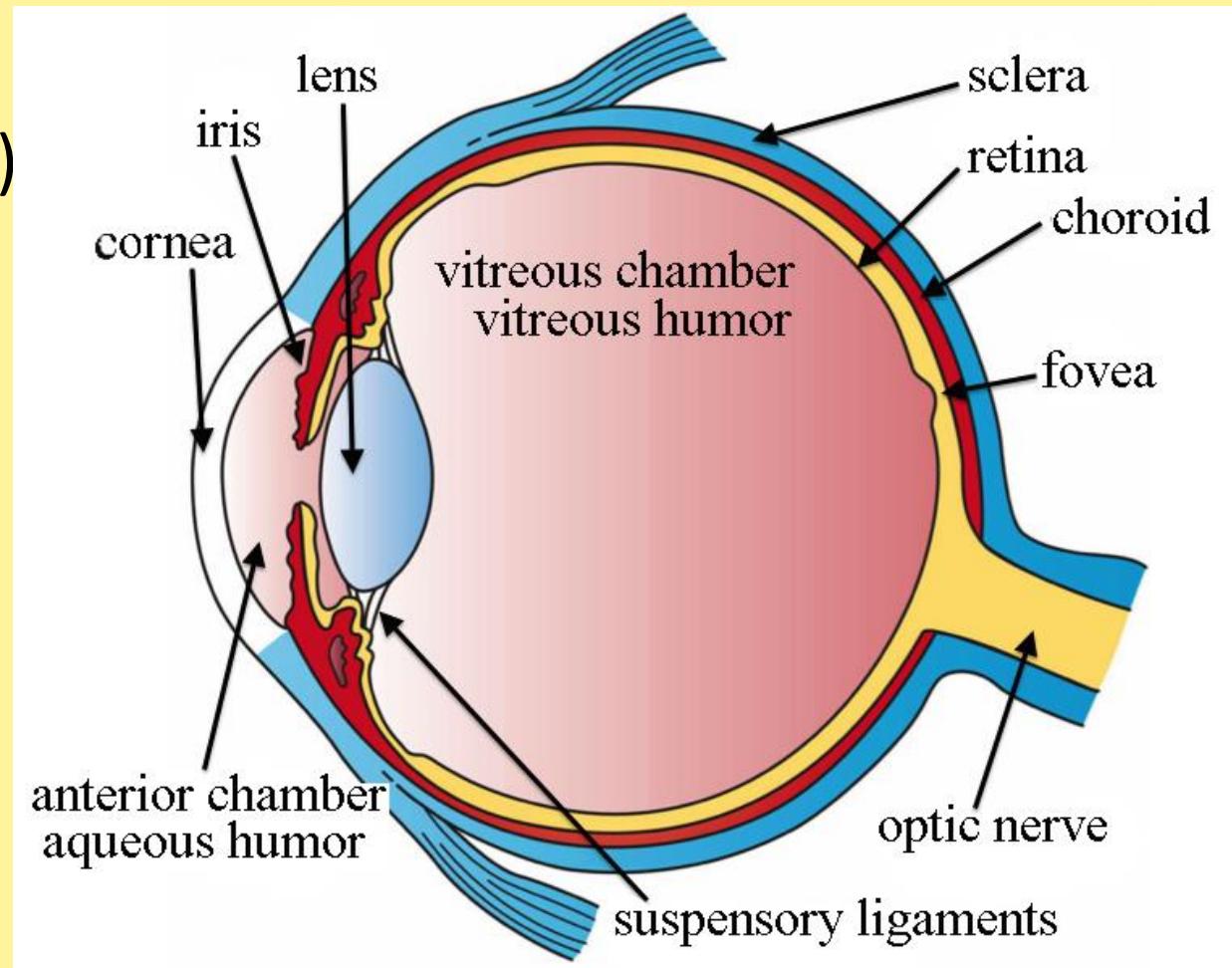
### c) Iris

- Thin coloured partition,
- Perforated in middle (**Pupil**)
- Smooth muscles  
(regulates size of pupil)
- Pigment in Iris  
(colour of eye)



# LENS:

- Transparent, elastic, biconvex
- Suspended (suspensory ligaments)
- Cavity of eyeball divided into:
  - i) Small aqueous chamber  
(clear watery fluid)
  - ii) Large vitreous chamber  
(jelly like vitreous humor)
- Maintains shape of eyeball
- Maintains pressure  
(lens in position)



### **3) Retina:**

- innermost, delicate, nonvascular, light sensitive
- Two regions:

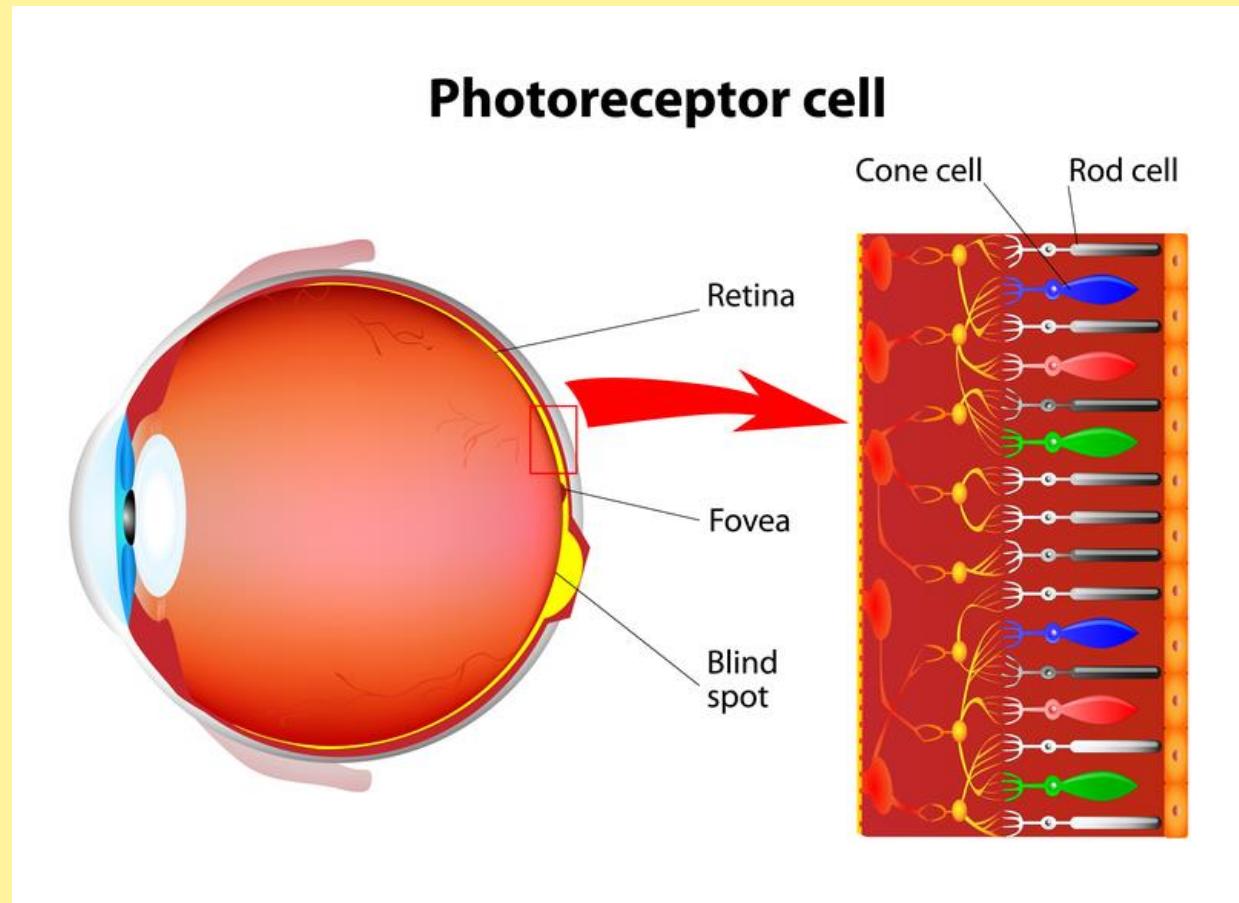
#### **a) Nonsensory part**

(lining iris and ciliary body)

#### **b) Sensory part**

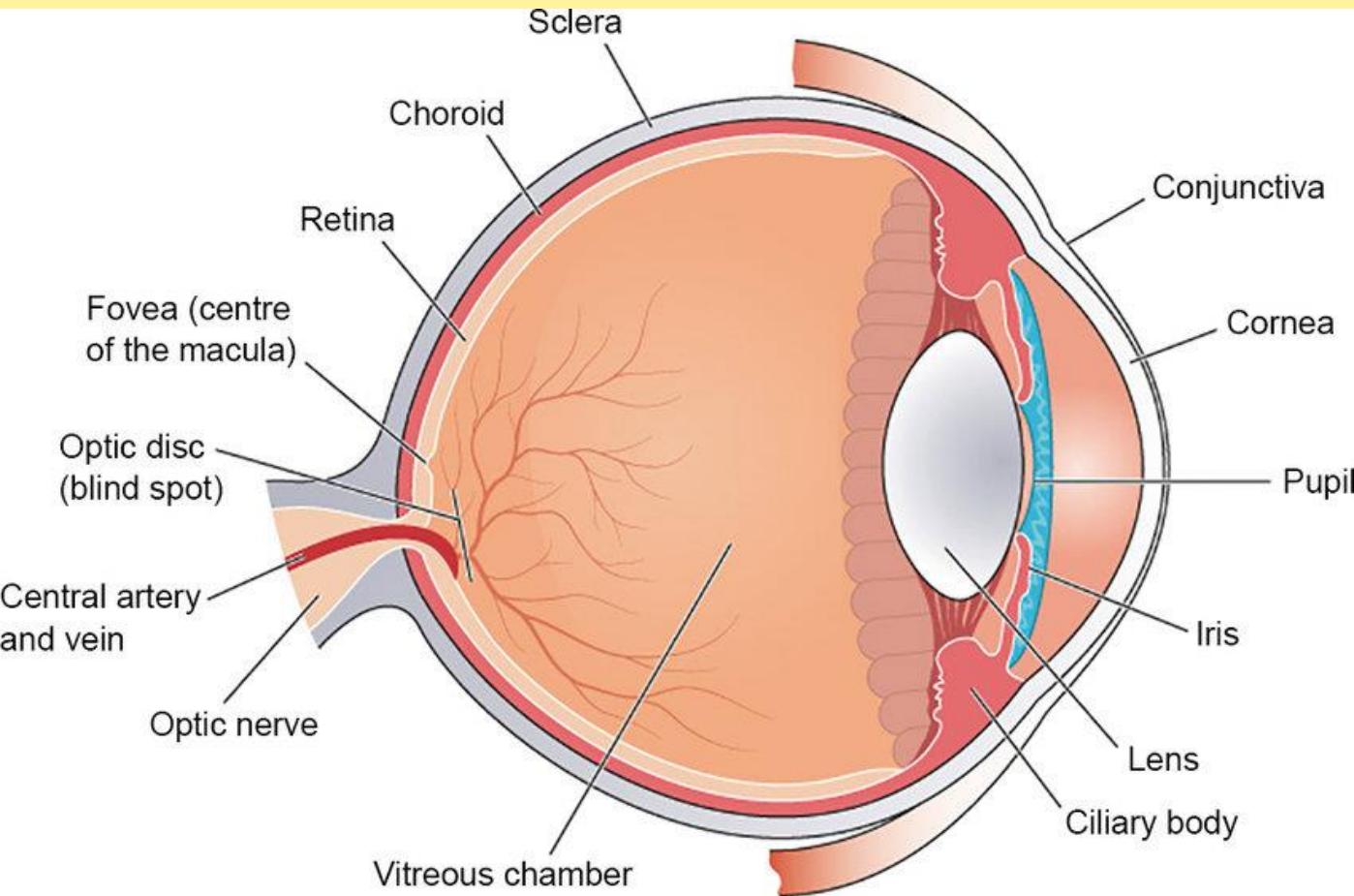
(lining the choroid)

- It has outer(pigmented)
- Inner (nervous part)



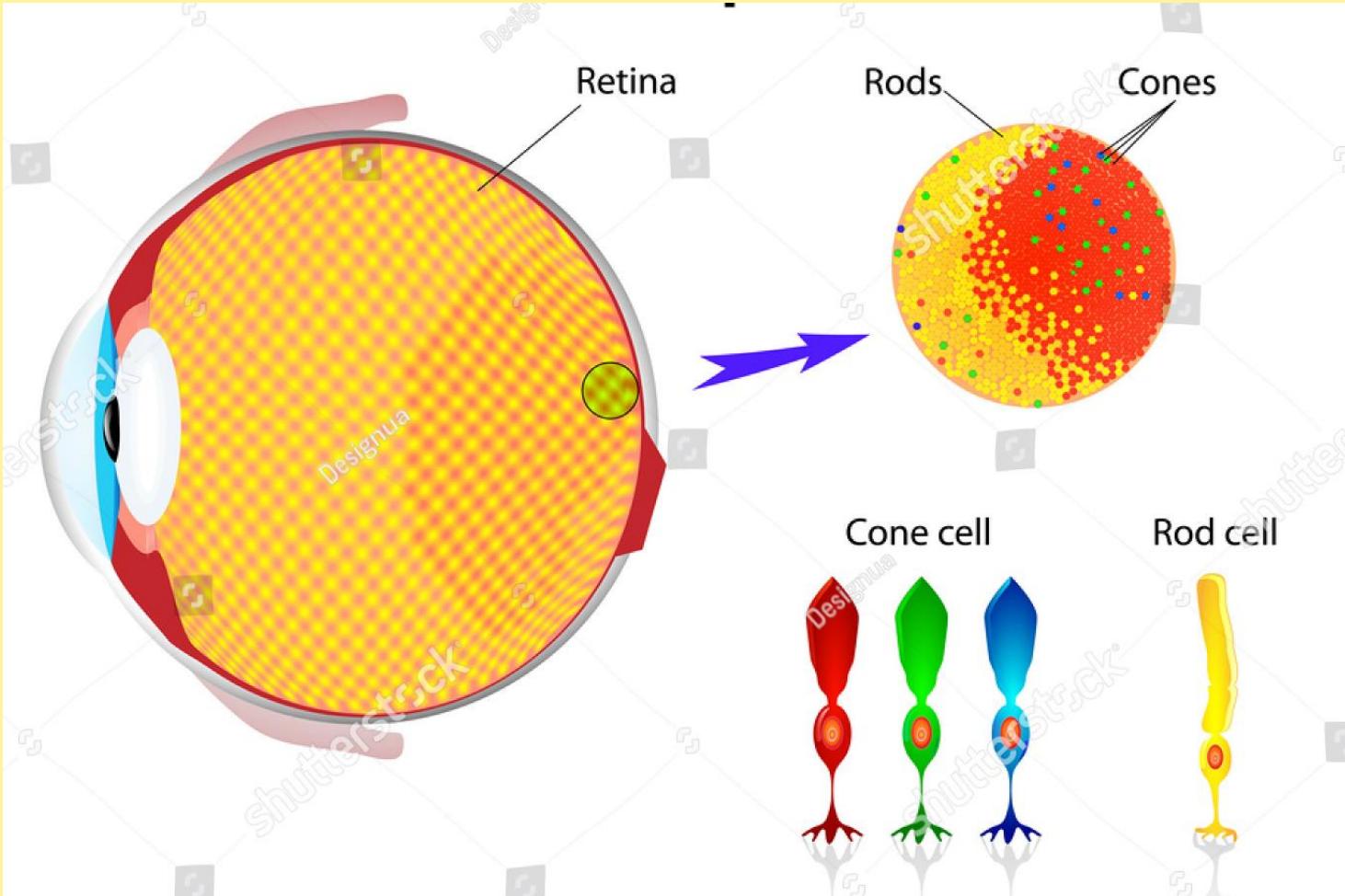
# Retina(Inner part):

- Transparent
- **3 layers**
- Outer- **photosensitive (rod and cones)**
- Middle- **bipolar nerve cells**
- Inner- **ganglion cells**
- **Optic nerves**  
(carries visual impulses from retina to brain)
- **Blind spot**- absence of rods and cones (optic nerves and blood vessels exit)
- **Macula lutea/yellow lutea** (above blind spot)
- Shows depression at centre – **fovea centralis**  
(maximum density of cones- sharpest vision)

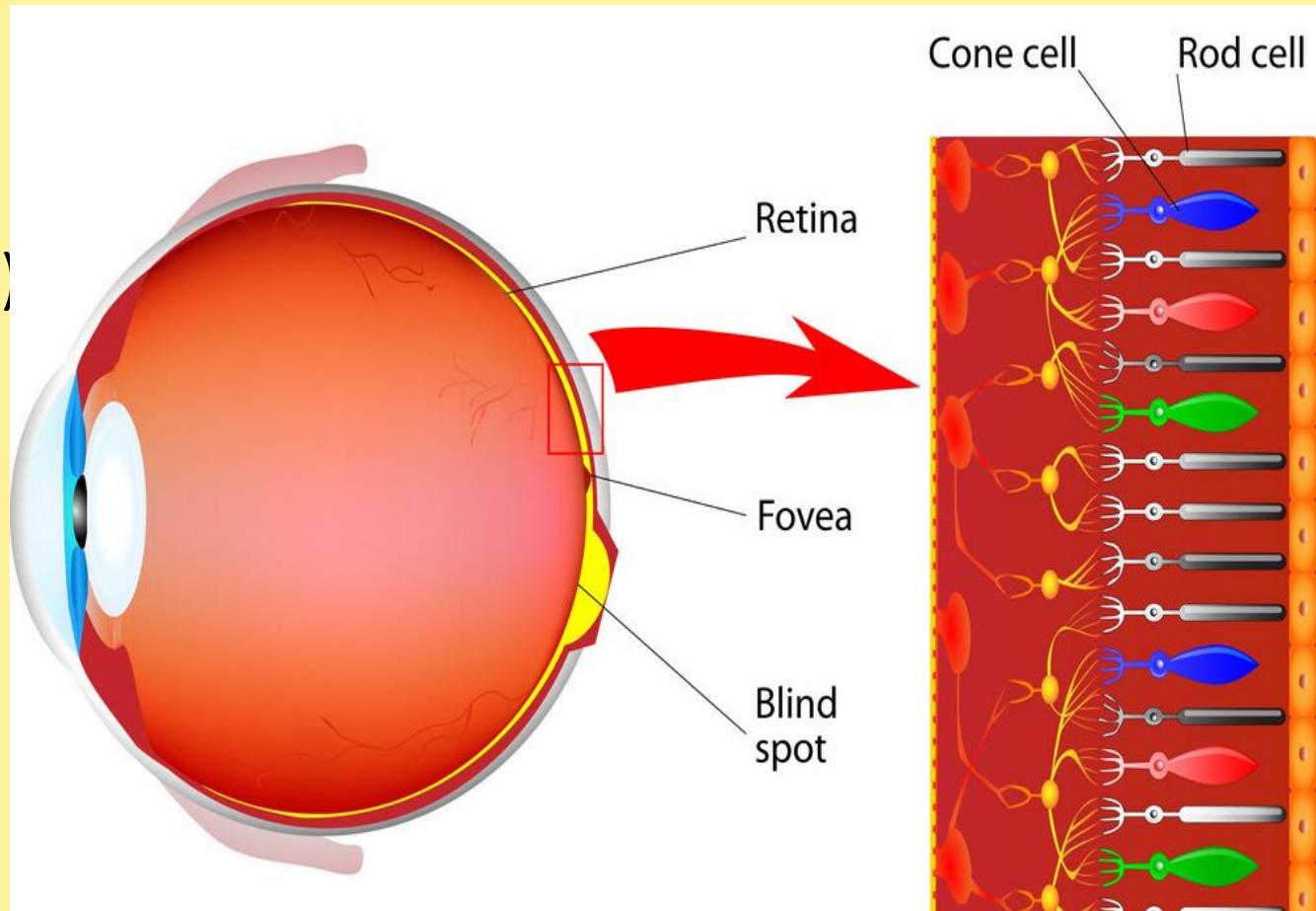


# Photoreceptor cells:

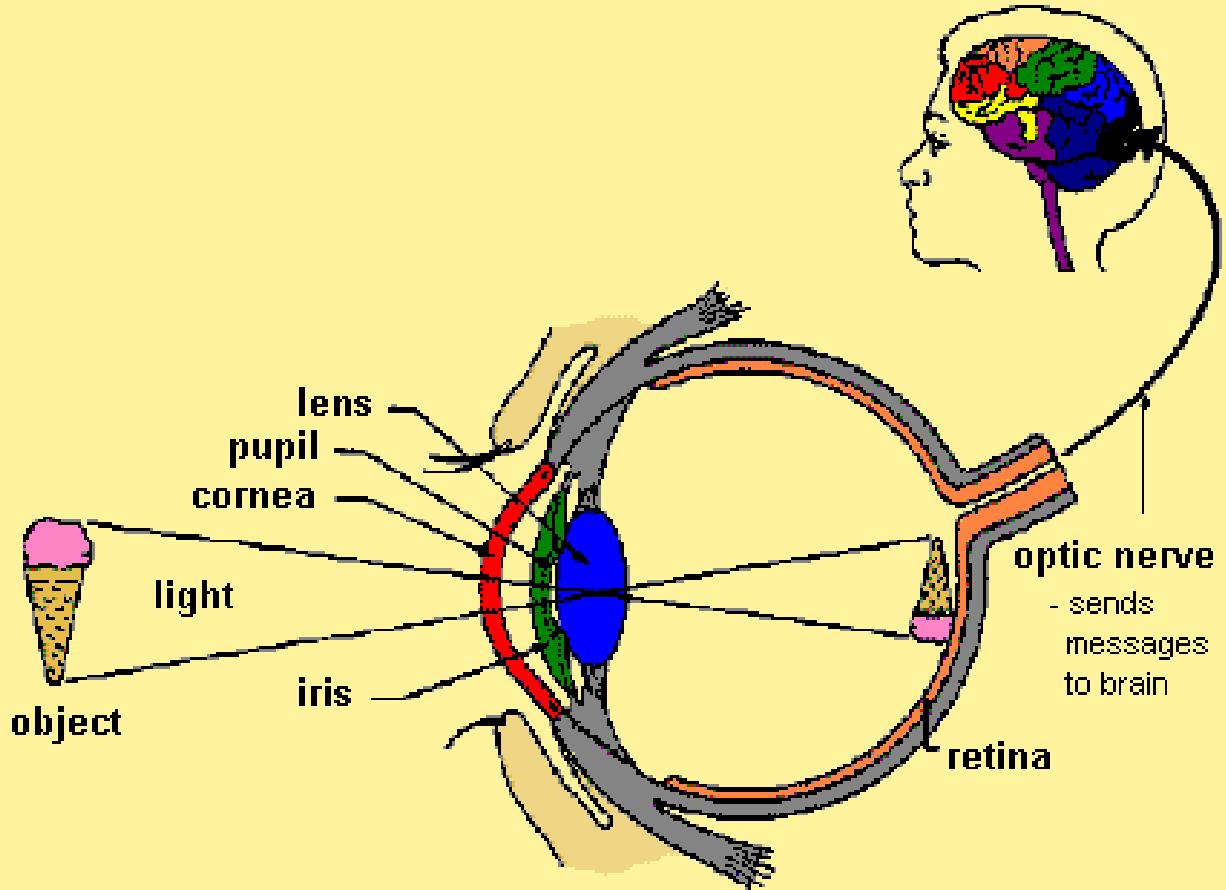
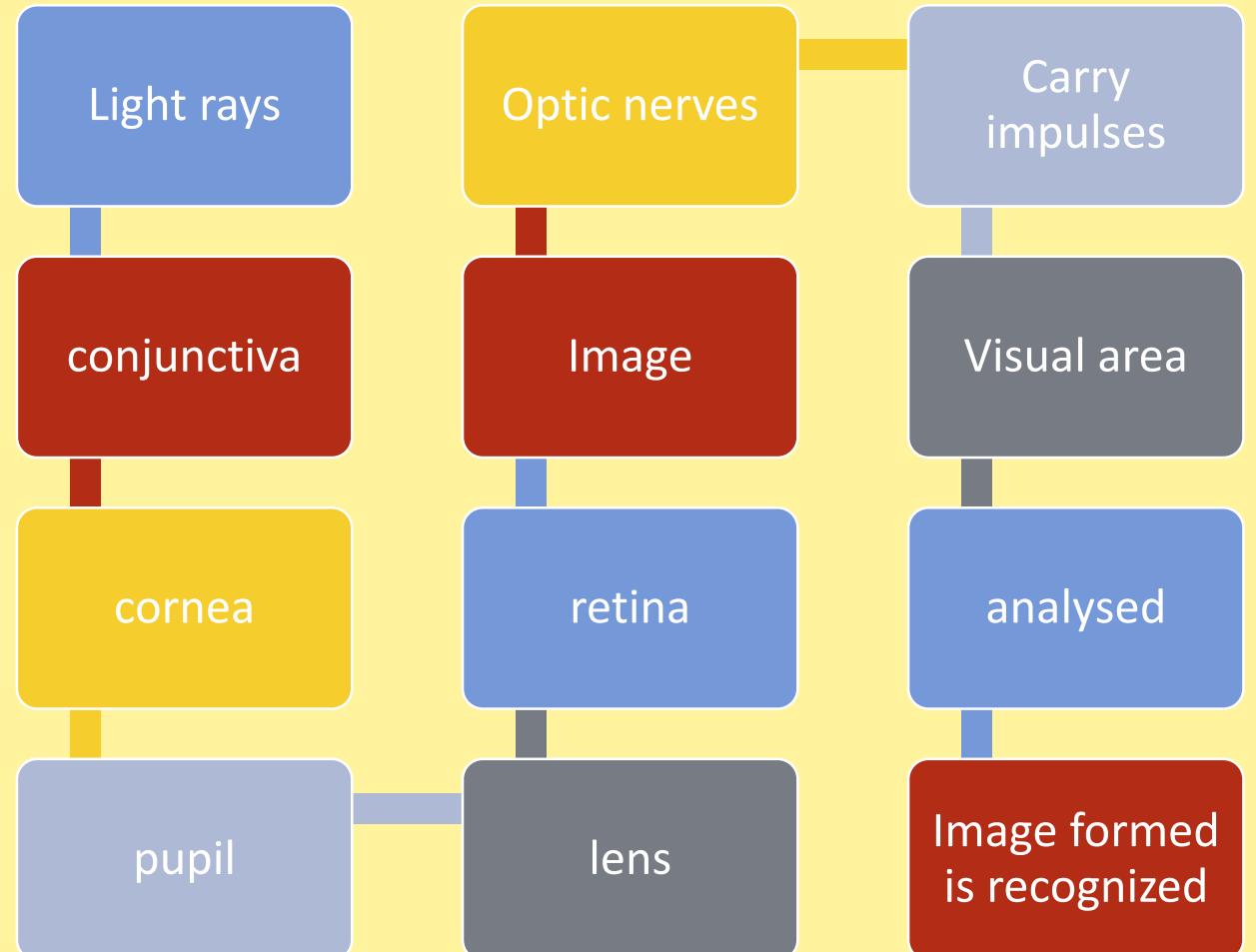
- 2 types:
  - a) Rod cells
  - b) Cone cells
- light sensitive proteins  
**(PHOTOPIGMENTS)**
- Cones (day light)  
- **photopic** vision, colour
- Rods (dim light)  
- **Scotopic** vision



- Rods – purple red protein (rhodopsins- Vitamin A derivative)
- Cones -Three types (own characteristic photopigments)
  - They respond to red , green and blue lights
- Combinations –cones and their Photopigments give sensation of different colours.
- White light sensation- Simultaneous equal stimulation of these three types of cones.

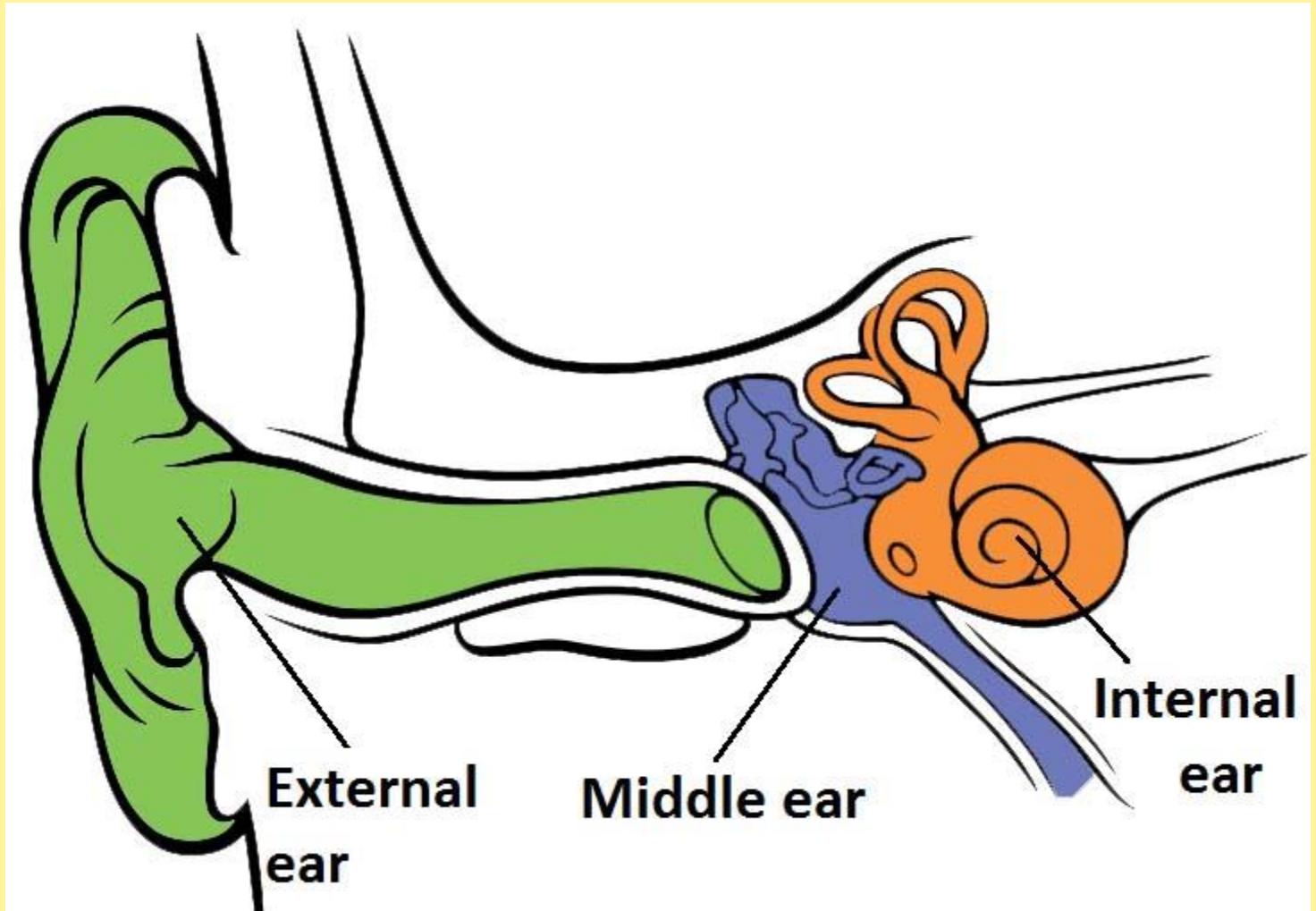


# Generation of image:



# EAR:

- Stato-acoustic organ
- Hearing and equilibrium
- Has 3 parts:
  - a) External ear
  - b) Middle ear
  - c) Internal ear



## a) External ear:

- Ear pinna

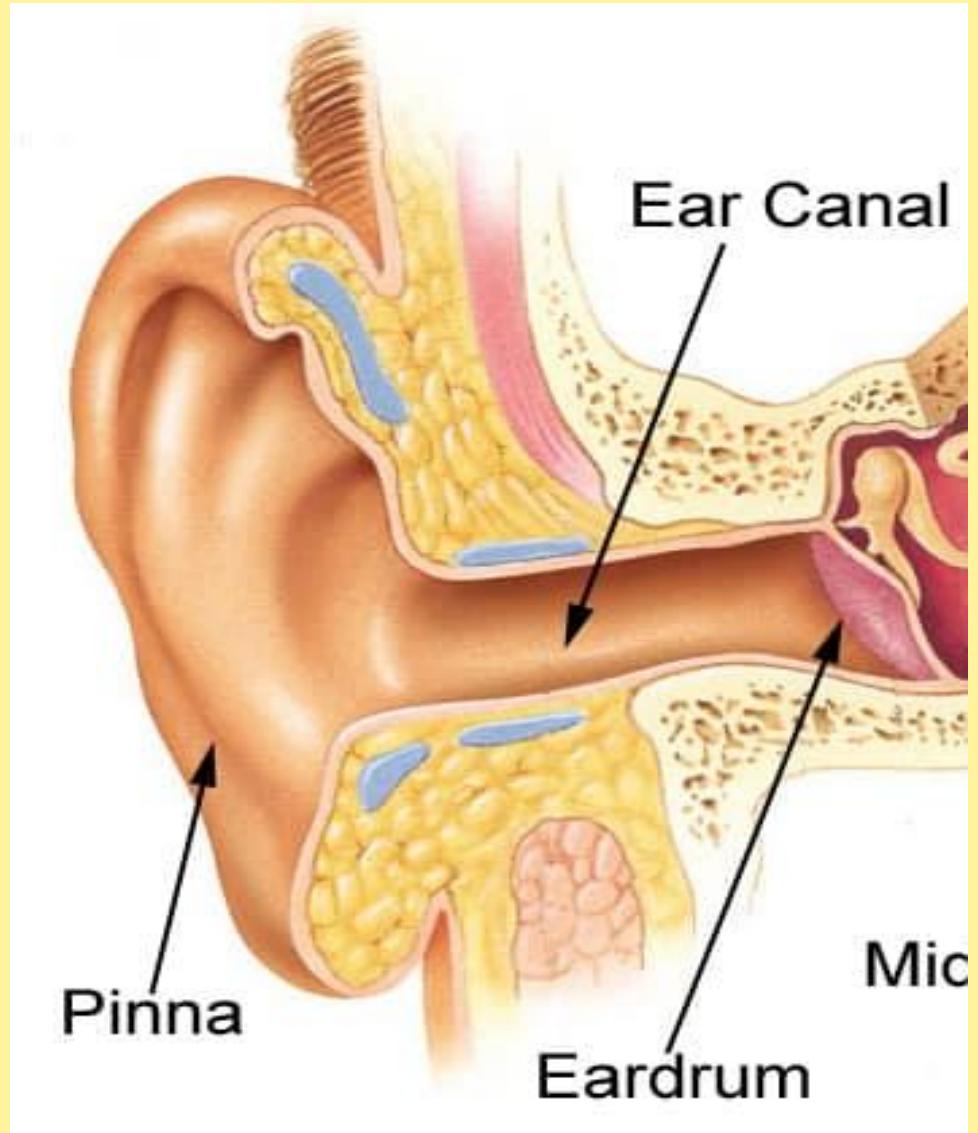
- immovable, Elastic cartilage,
- Presence of hair and sebaceous gland
- Collects and send soundwaves

- Auditory canal

- presence of hair and sebaceous glands
- Transfers sound waves to ear drum
- ends at tympanic membrane or ear drum

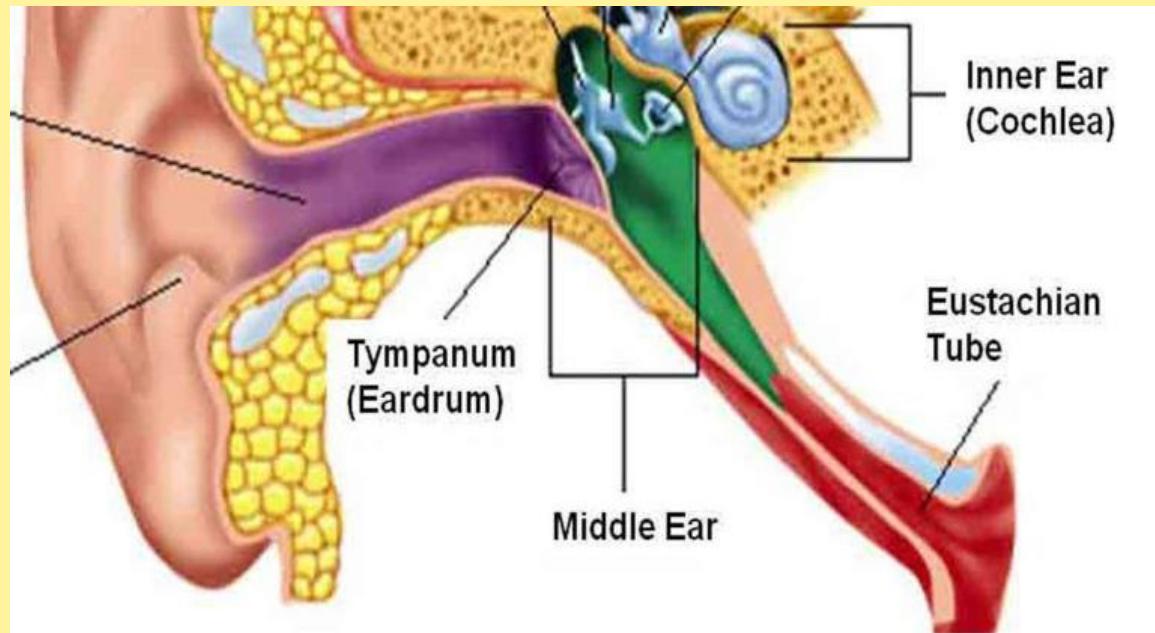
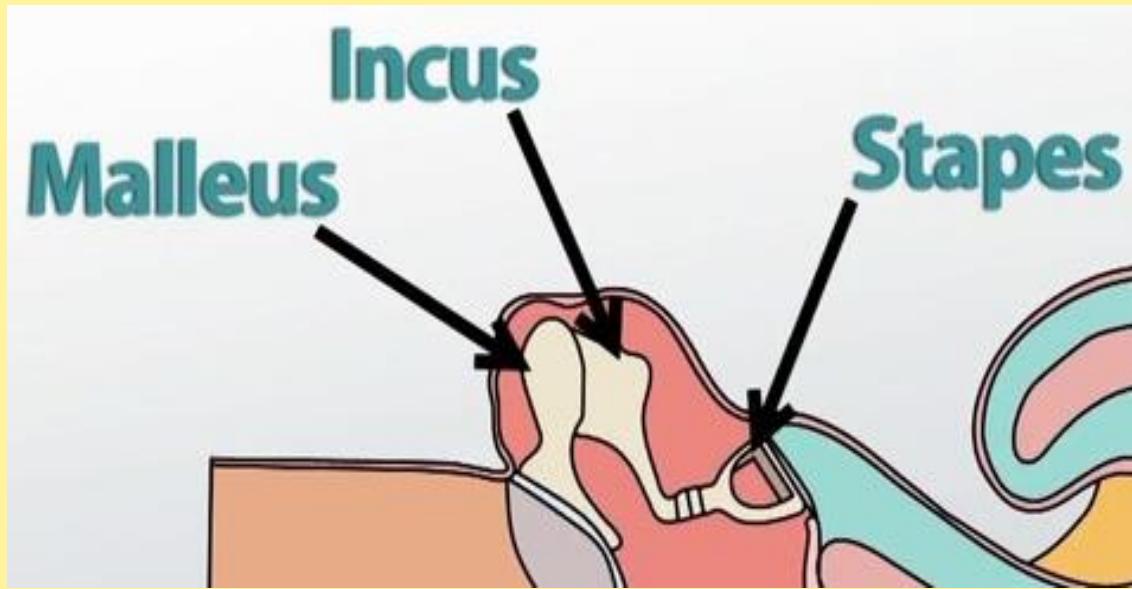
- Tympanic membrane / ear drum

- delicate,membranous
- Transfers soundwaves to middle ear



## b) Middle ear:

- Three ear ossicles
  - **Malleus** (hammer)
  - **Incus** (anvil)
  - **Stapes** (stirrup)
- They amplify vibrations and transfer to internal ear
- **Eustachian tube-**  
Equalizes air pressure.

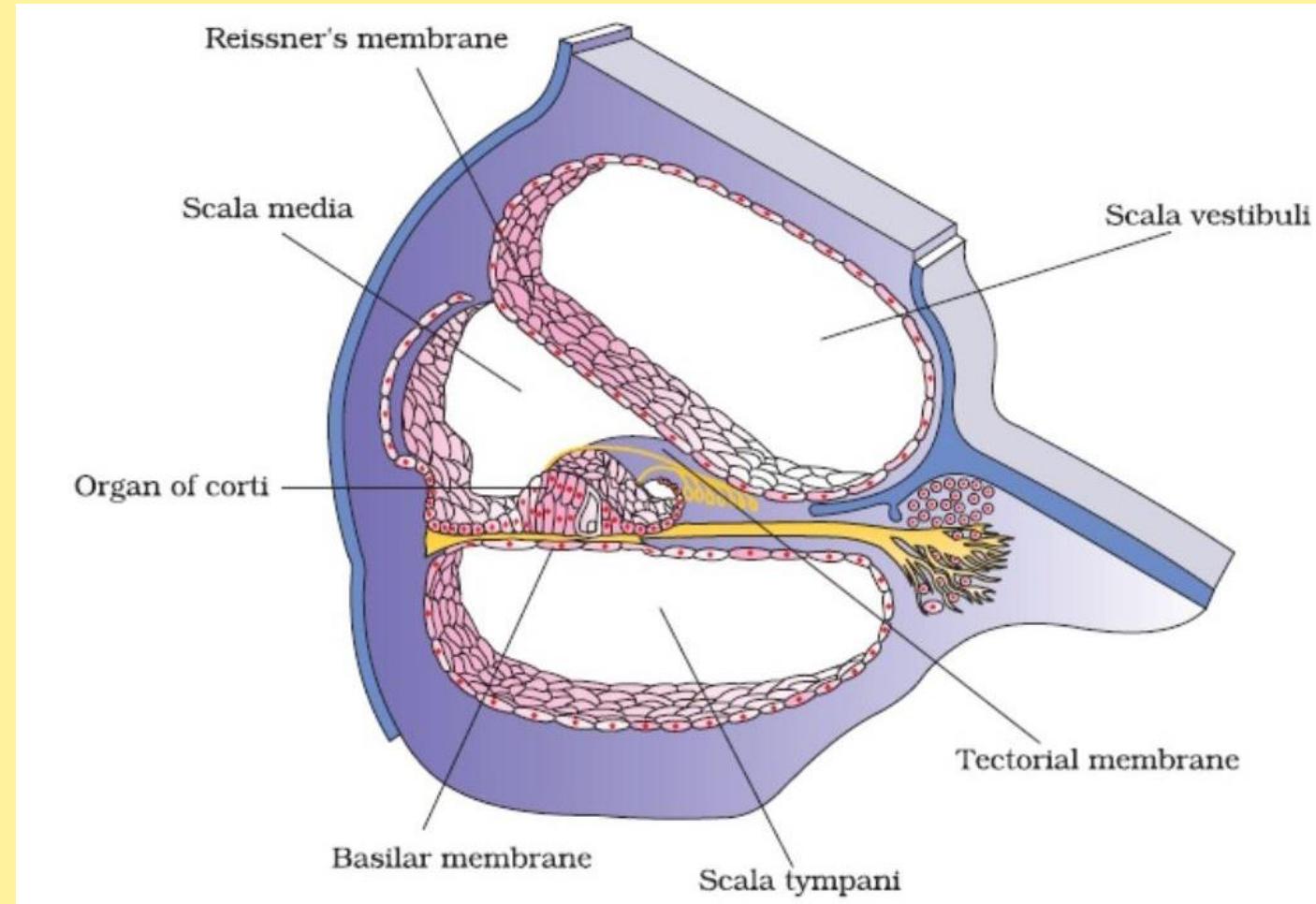


## c) Internal ear:

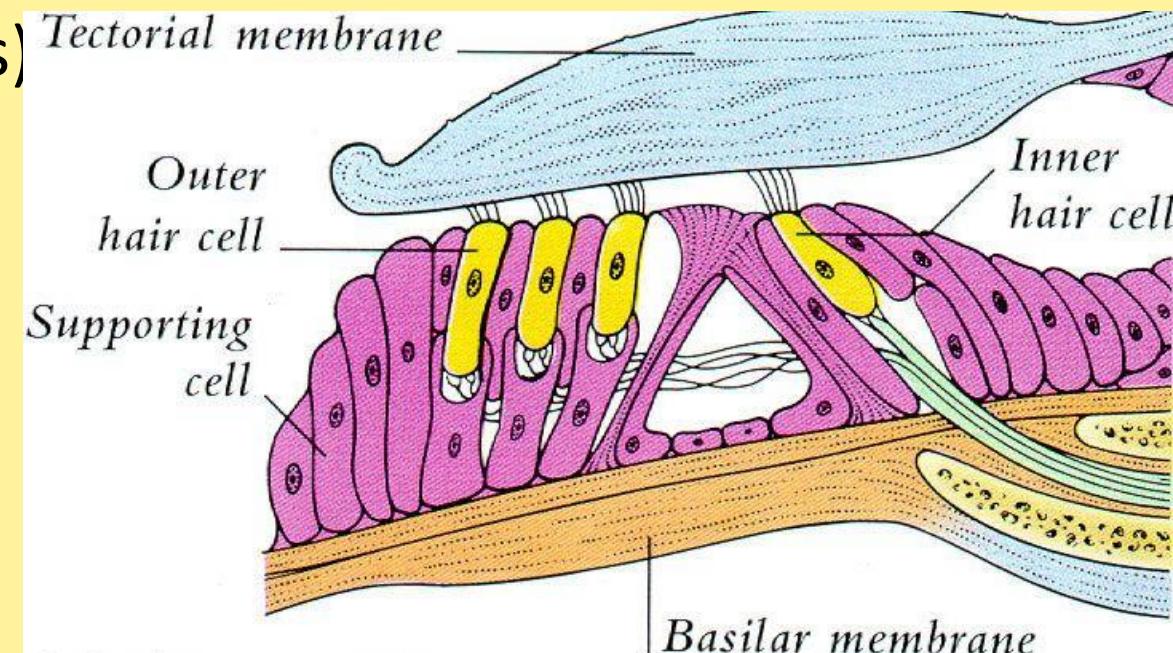
- Consists of:
  - i) labyrinth
  - ii) vestibular apparatus

### LABYRINTH:

- Consists of bony (perilymph) and membranous (endolymph)
- Coiled portion(**COCHLEA**)  
3 Chambered , fluid filled
- Separated by **Reissner's** and **basilar membrane**

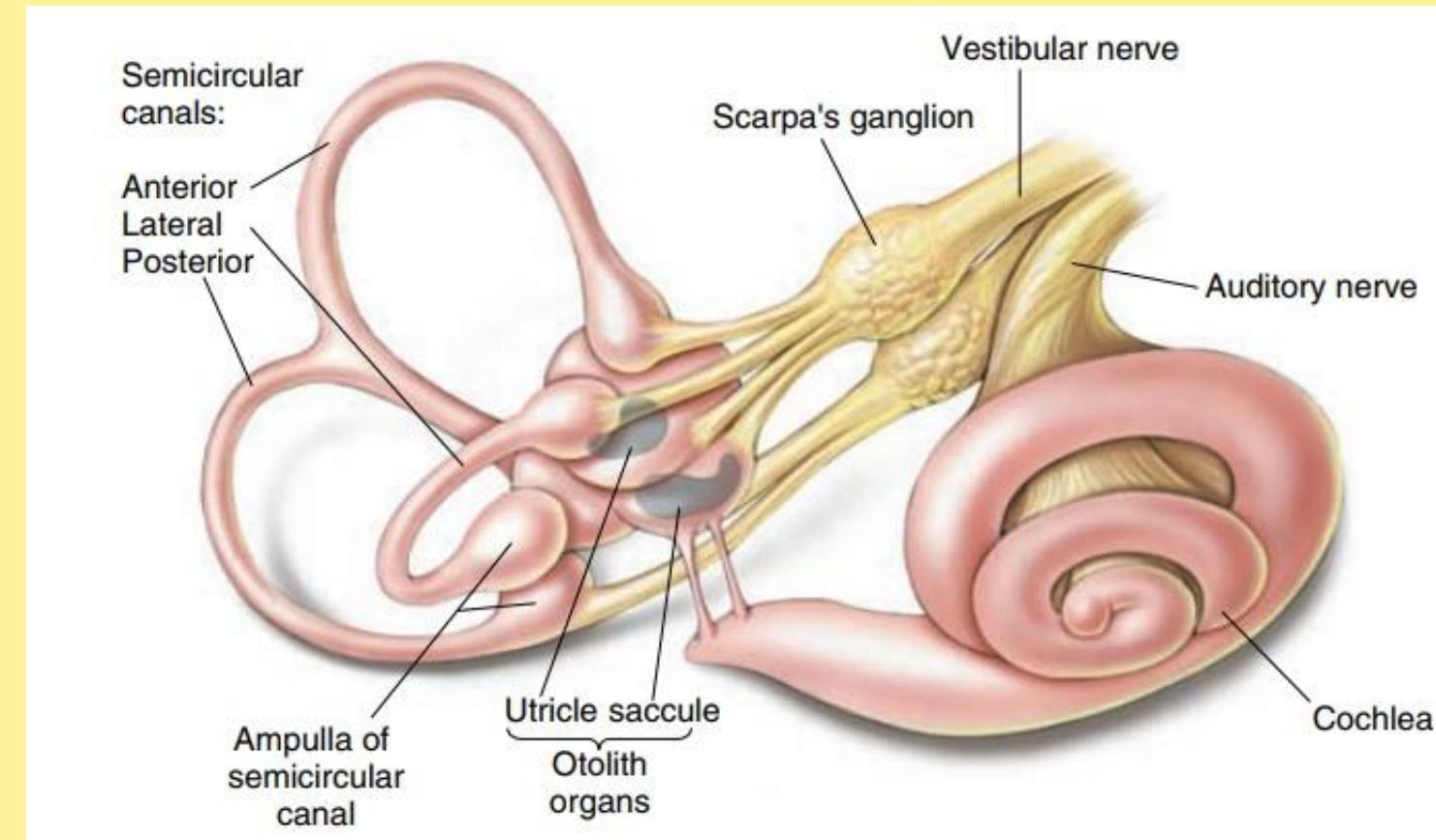


- Basilar membrane- presence of **Organ of corti**
- Organ of corti- sensory epithelium
- Sensory cells have sensory hair(**hair cells**)
- Hair cells- long, stiff microvilli( **stereo cilia**)
- Stereo cilia- in contact with **tectorial membrane**  
(Convert sound vibrations into impulses)

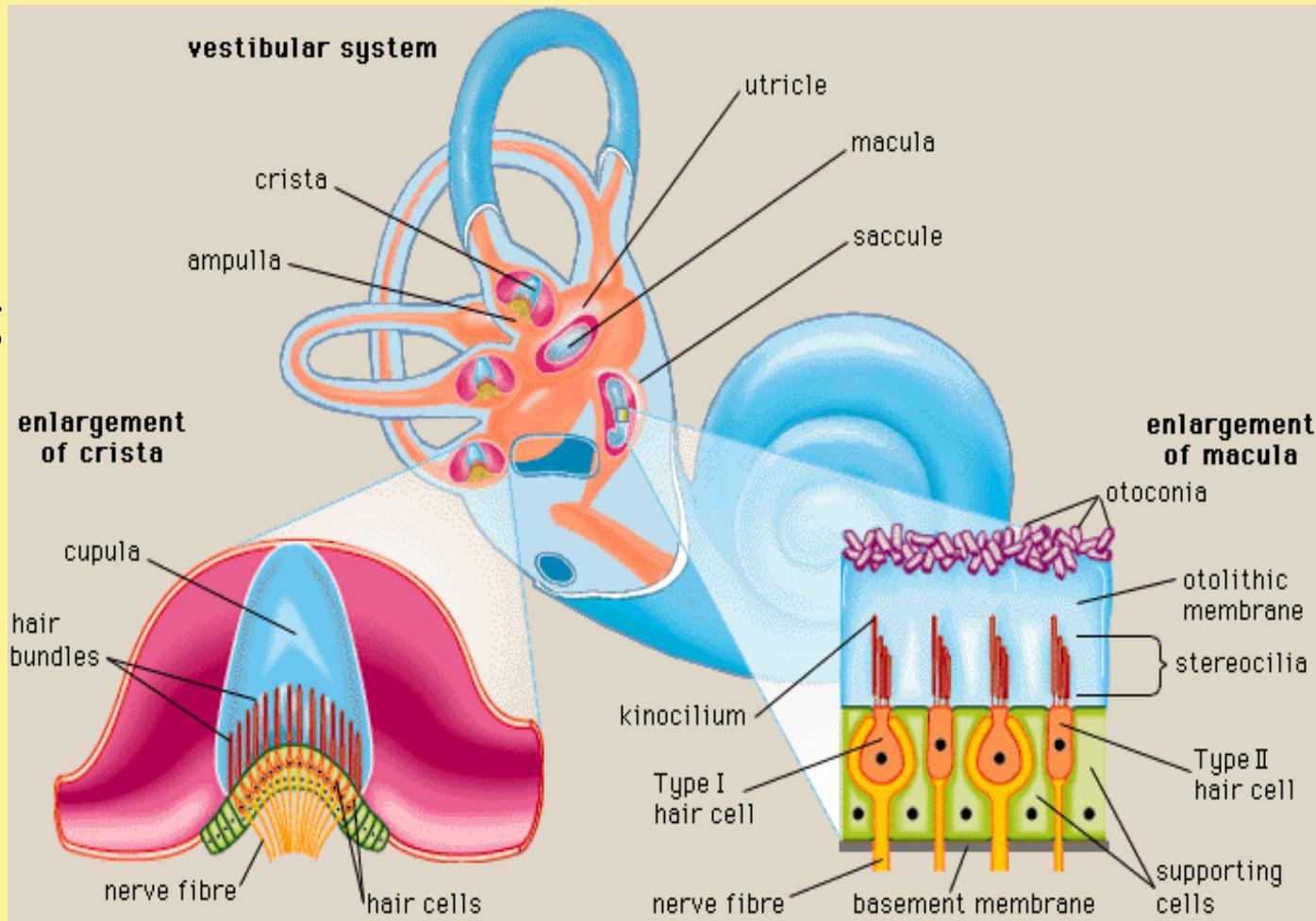


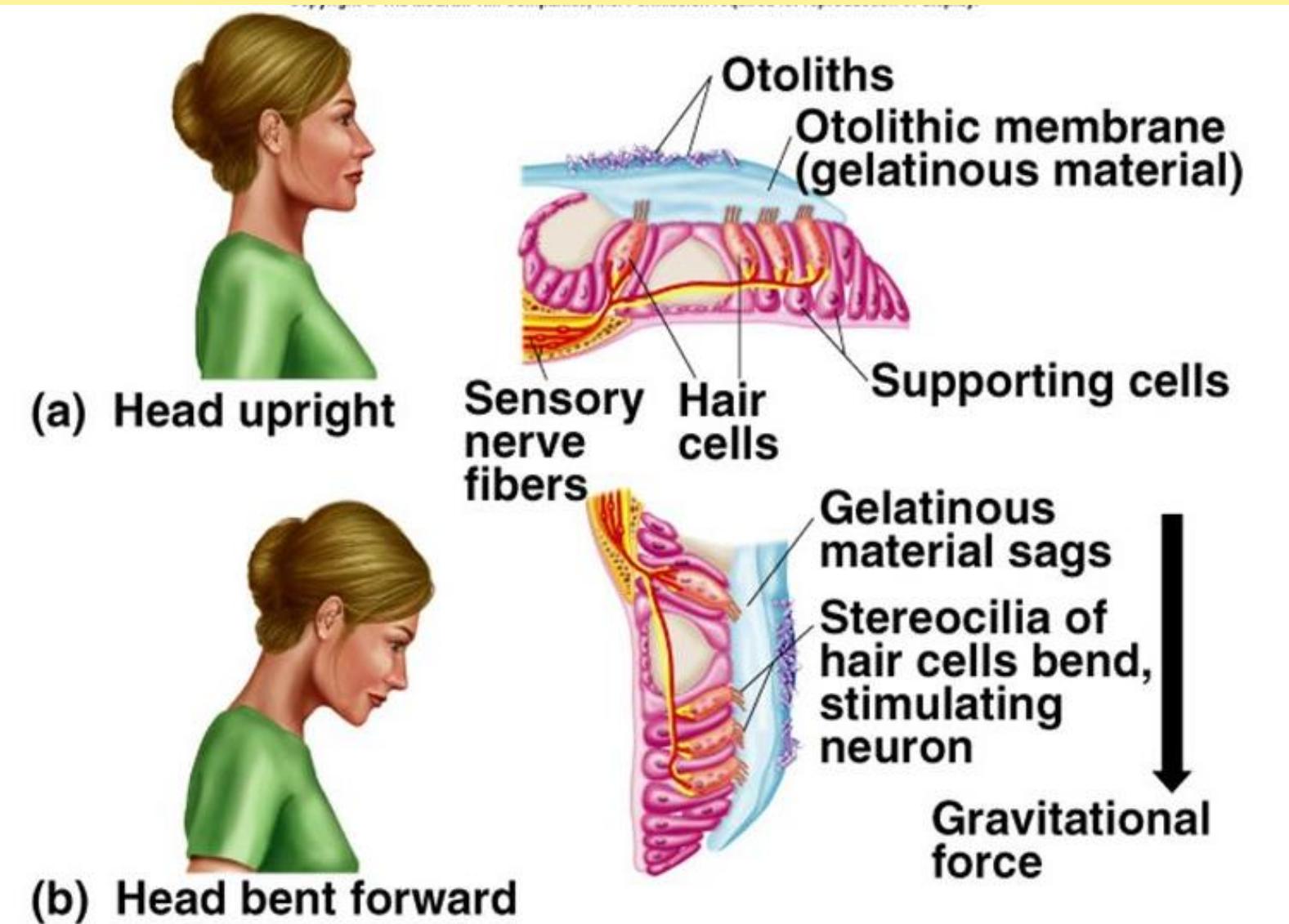
## VESTIBULAR APPARATUS:

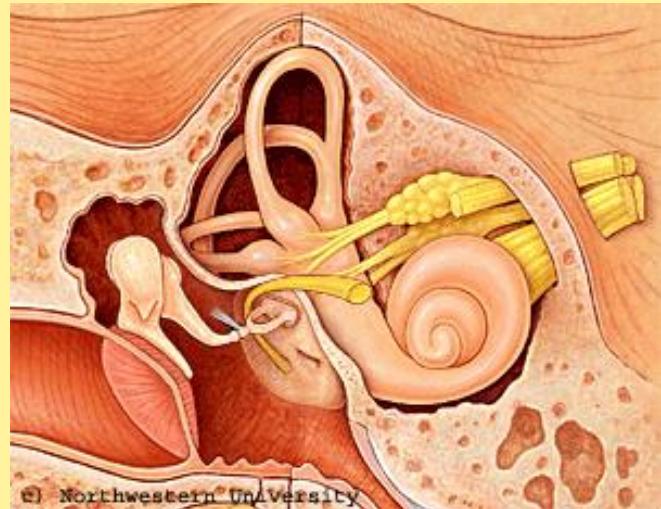
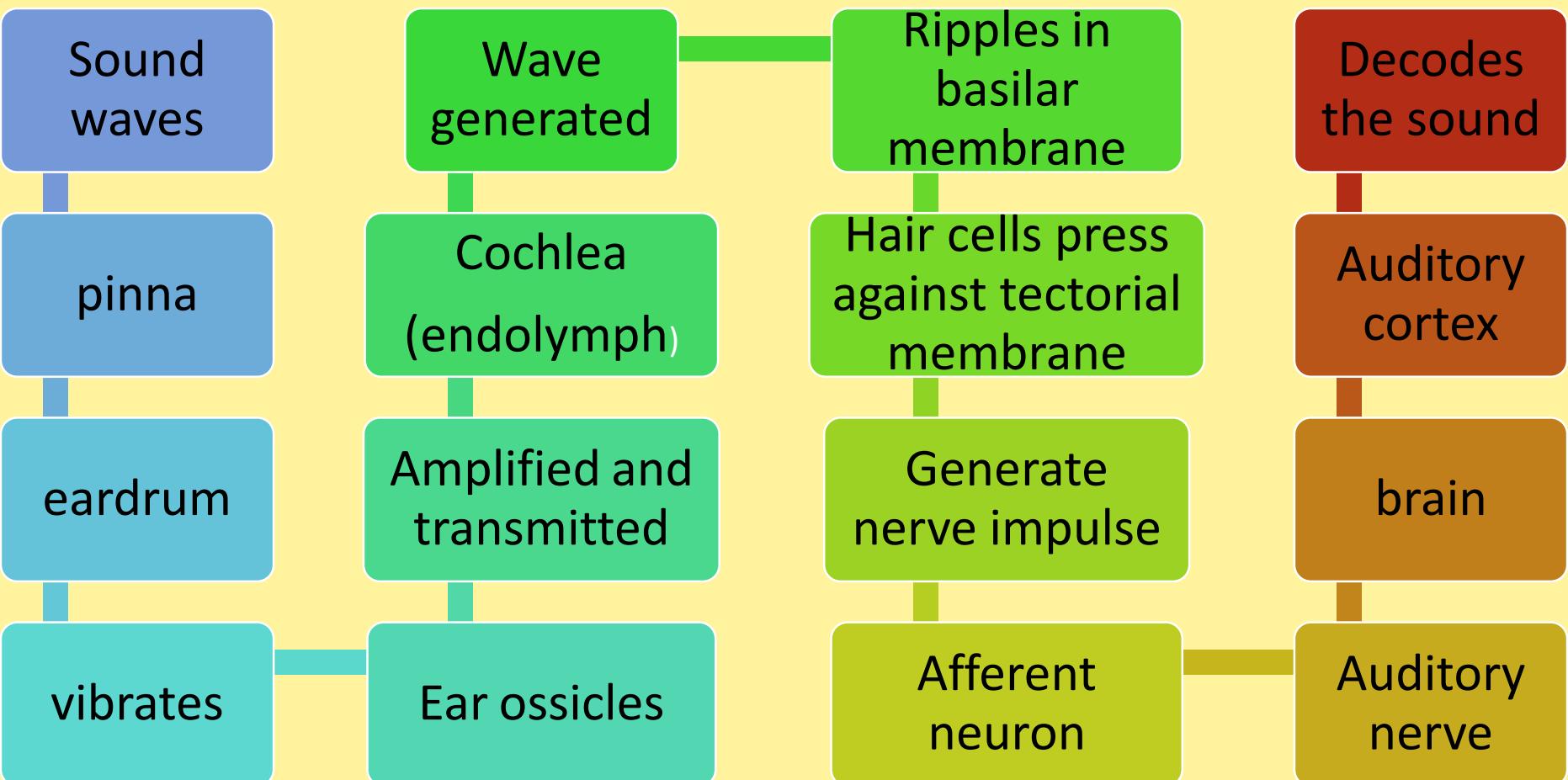
- Three semicircular canals and utriculo saccular region (otolith organ)
- Canals- endolymph
- Base of canal- ampulla - sensory spot called crista (maintain equilibrium)



- Vestibule:
  - Two sensory spots (macula of saccule and utricle)
  - Macula- hair cells and supporting cells
  - Tips of hair and cilium- project into otolithic membrane (secrete otoconia/otoliths)
  - Macula and crista sensitive to position of head w.r.t gravity
  - Maintain balance and posture
  - Maculae of utricle and sacculus (linear/static balance)



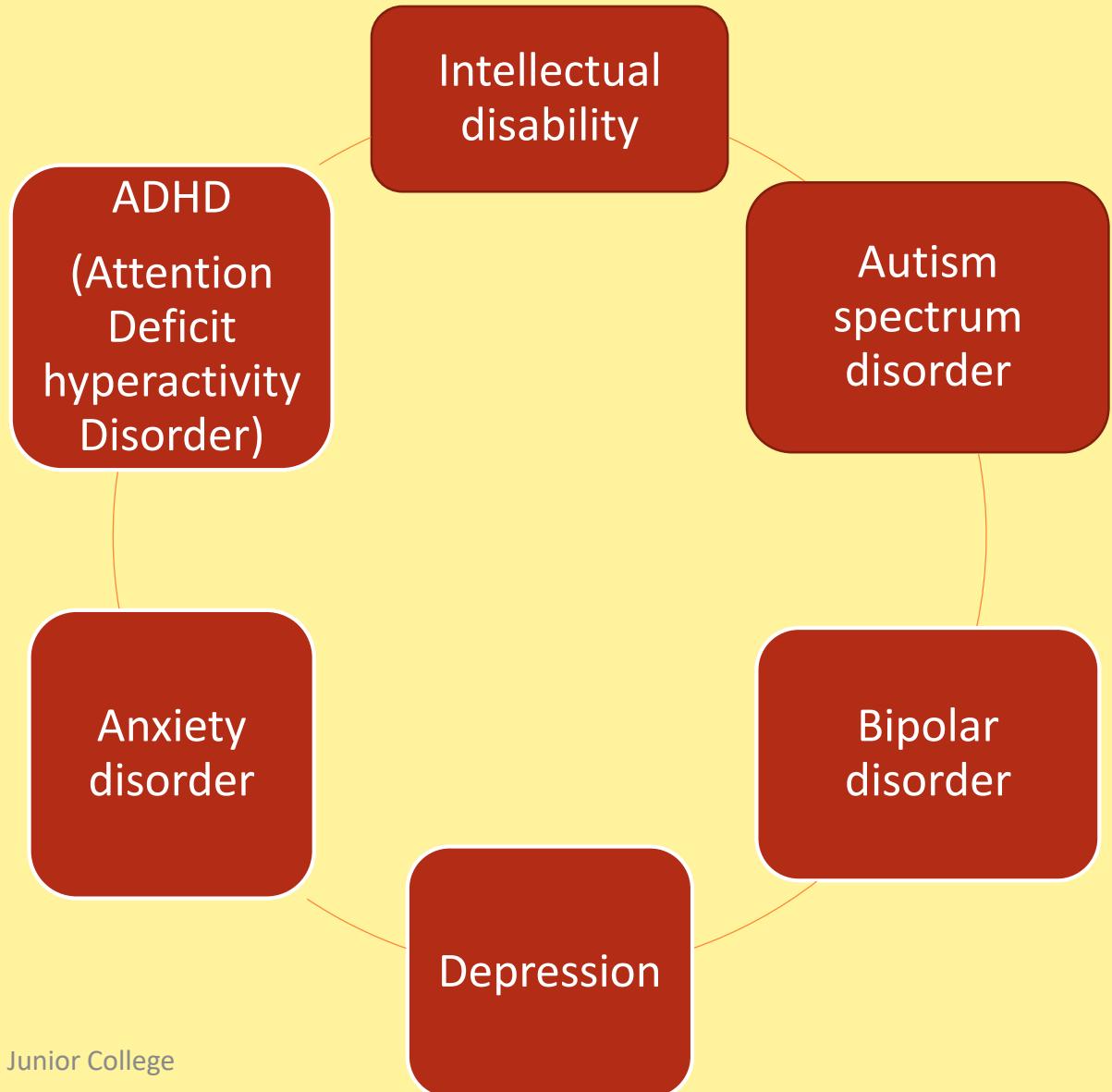




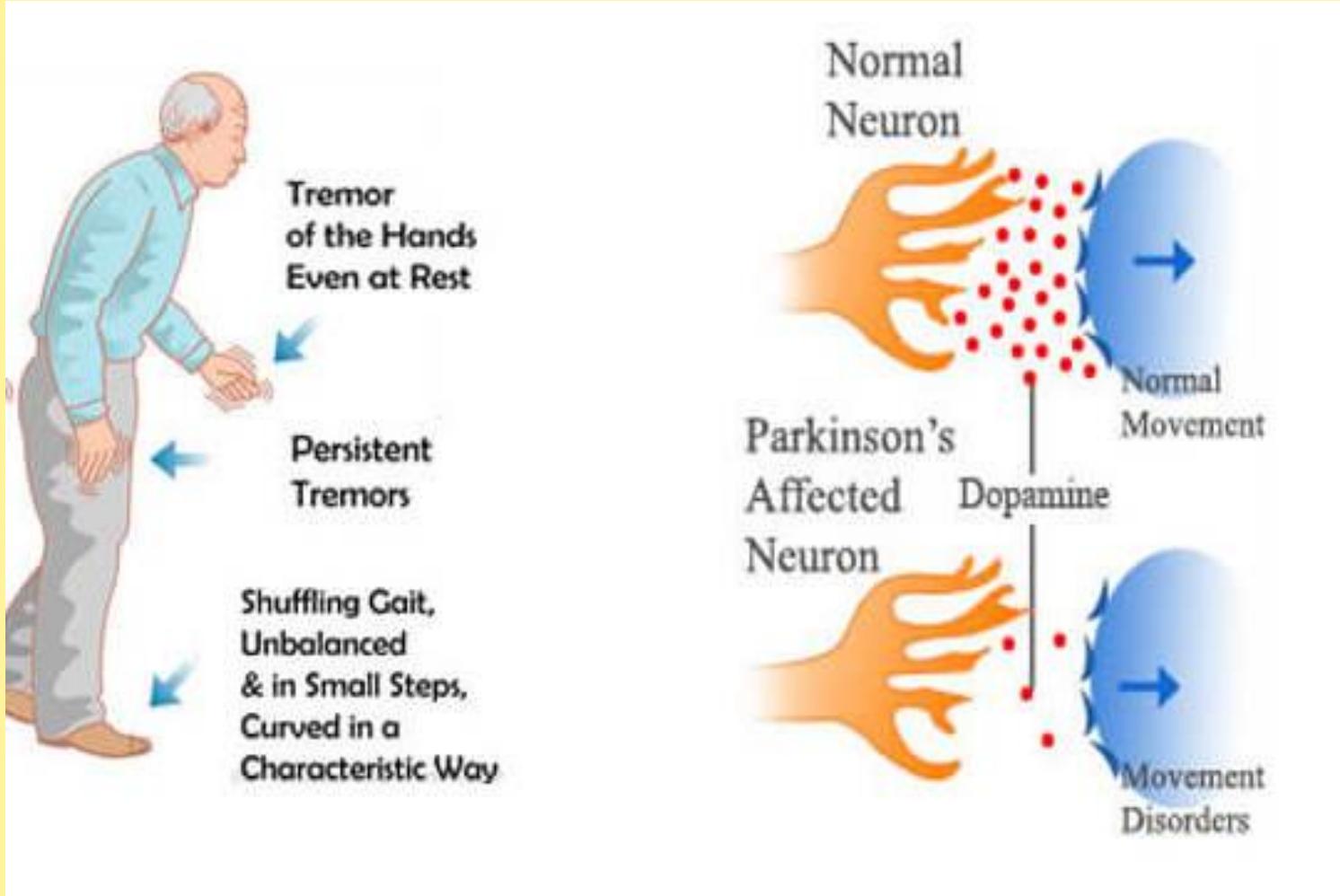
# Unit 9.8: Disorders of nervous system

## PSYCHOLOGICAL DISORDERS:

- Mental disorders
- Affect mood, thinking, behaviour
- Major categories include:

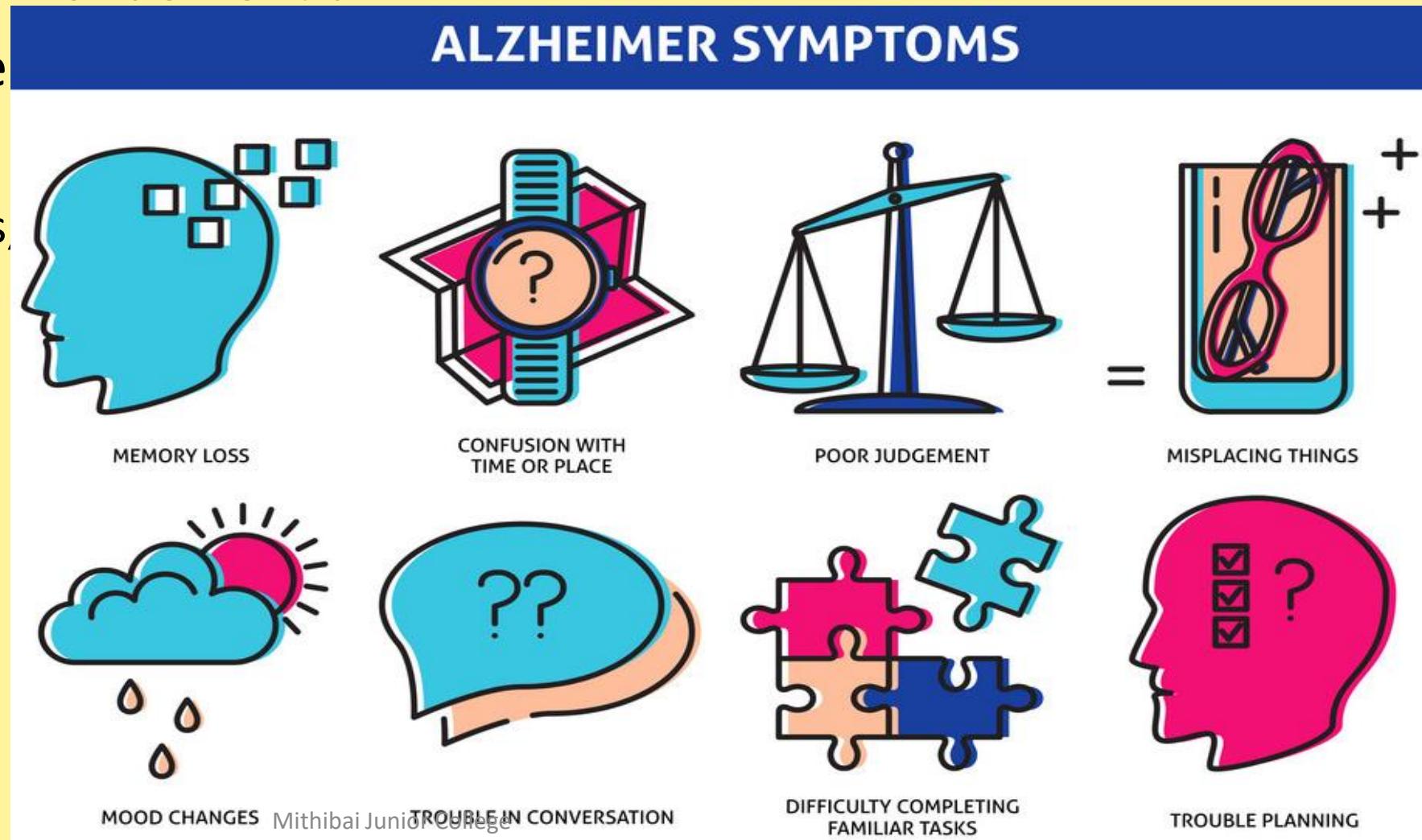


## PARKINSONS DISEASE:



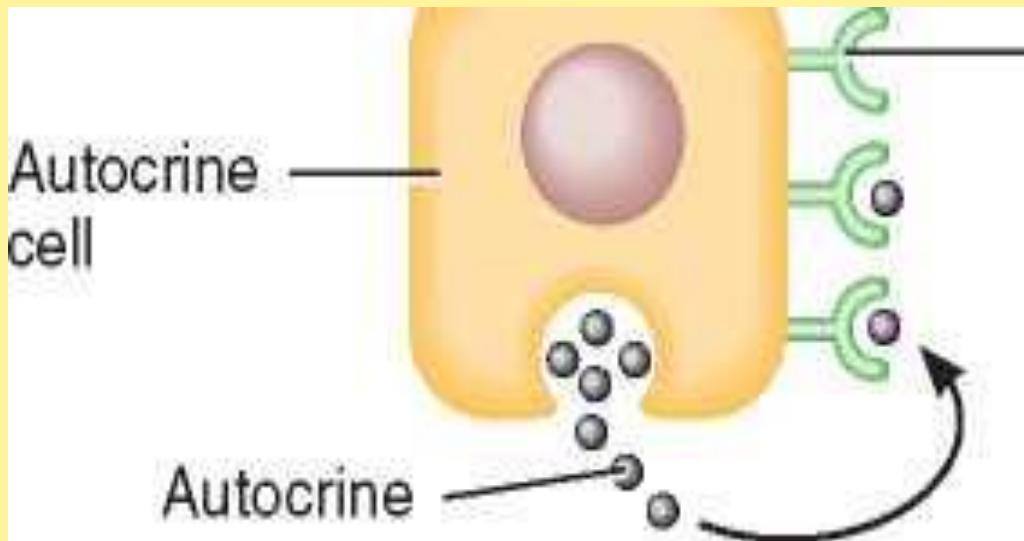
## Alzheimer's disease:

- Most common form of dementia
- Increases with age
- Occurs due to loss of cholinergic neurons, accumulation of amyloid proteins.

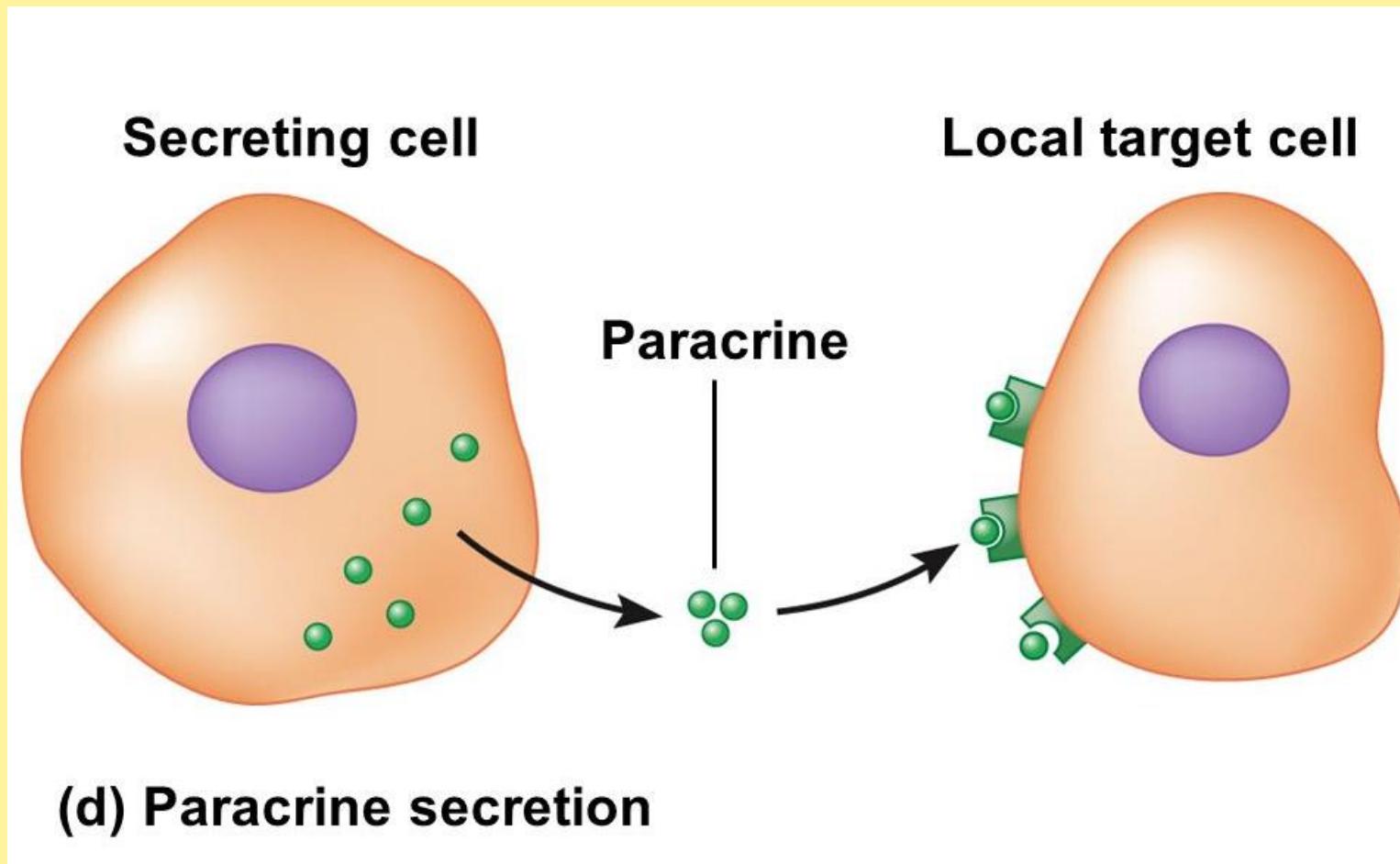


# Chemical coordination:

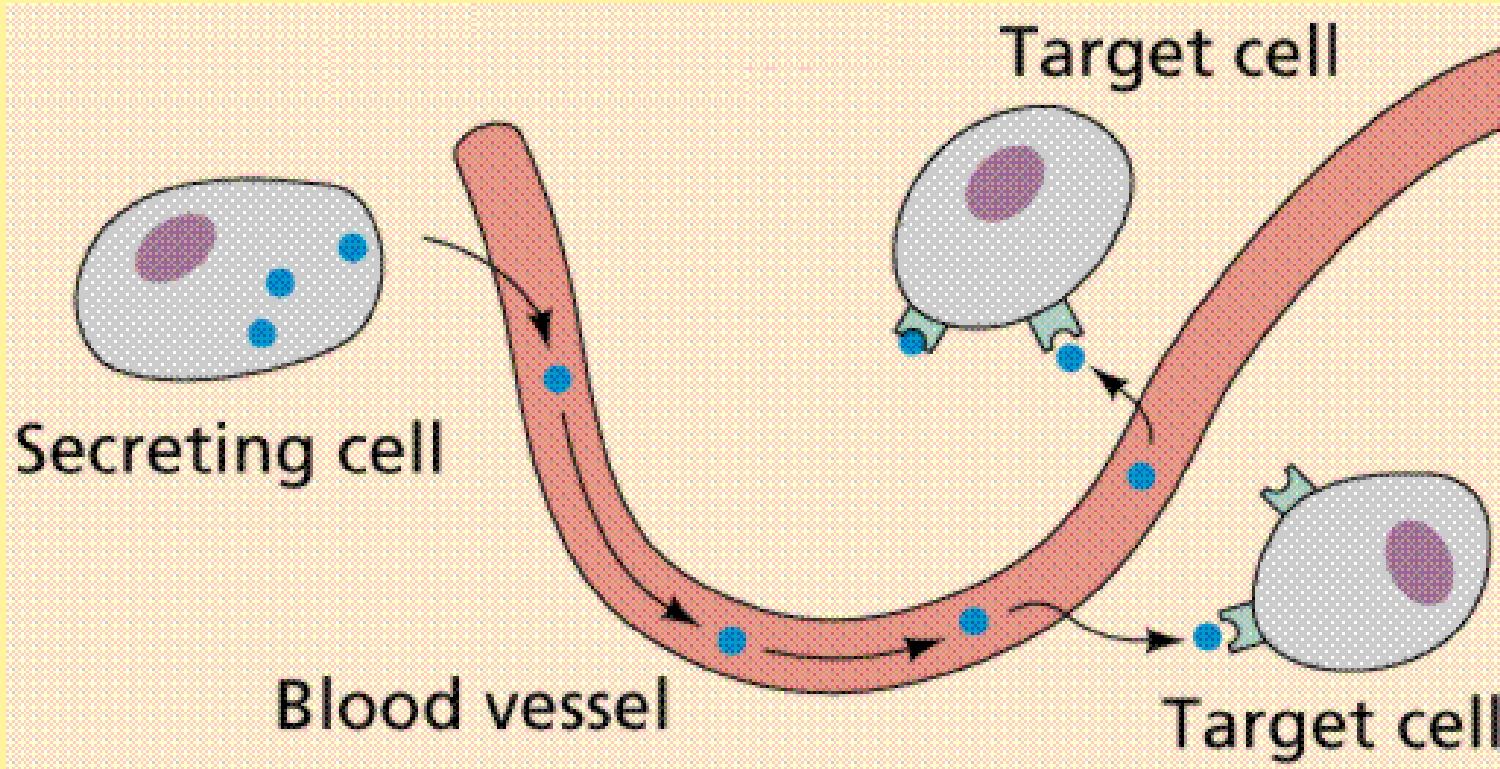
- Cells and organisms communicate with each other through signals.
  - Broadly of four types:
- 1) AUTOCRINES:



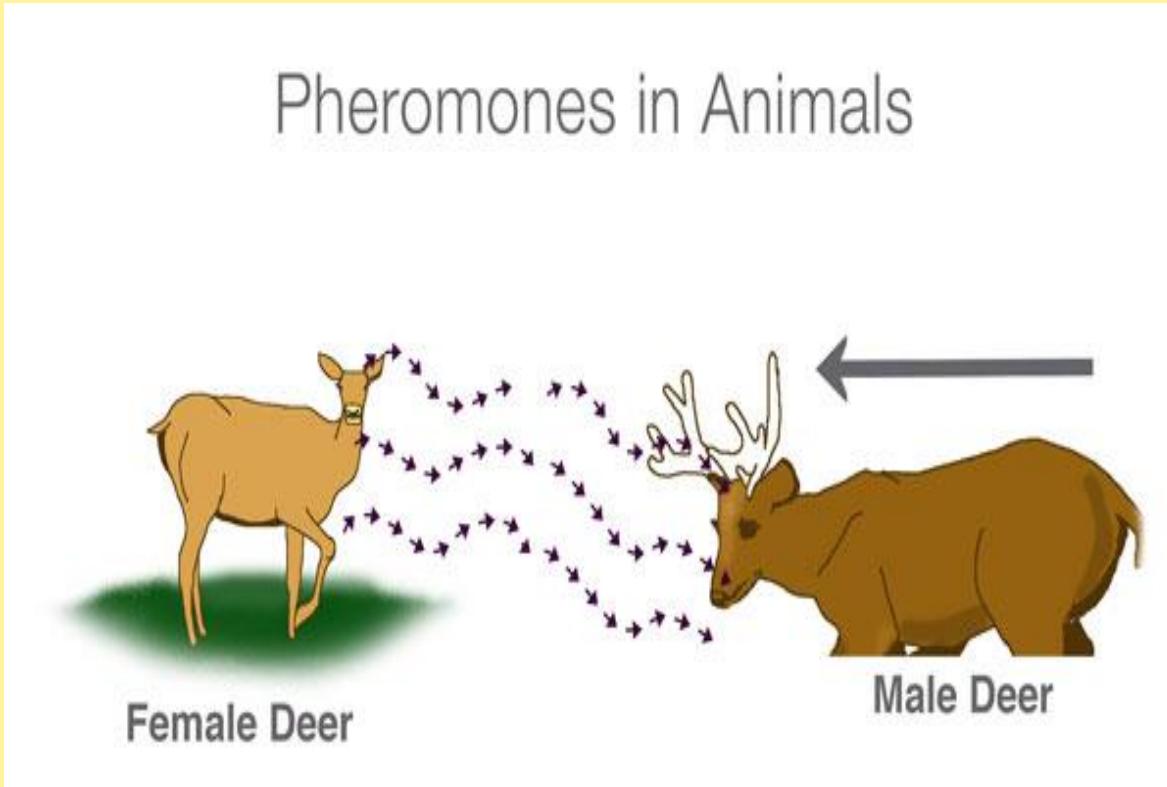
## 2) PARACRINES:



### 3) ENDOCRINES:

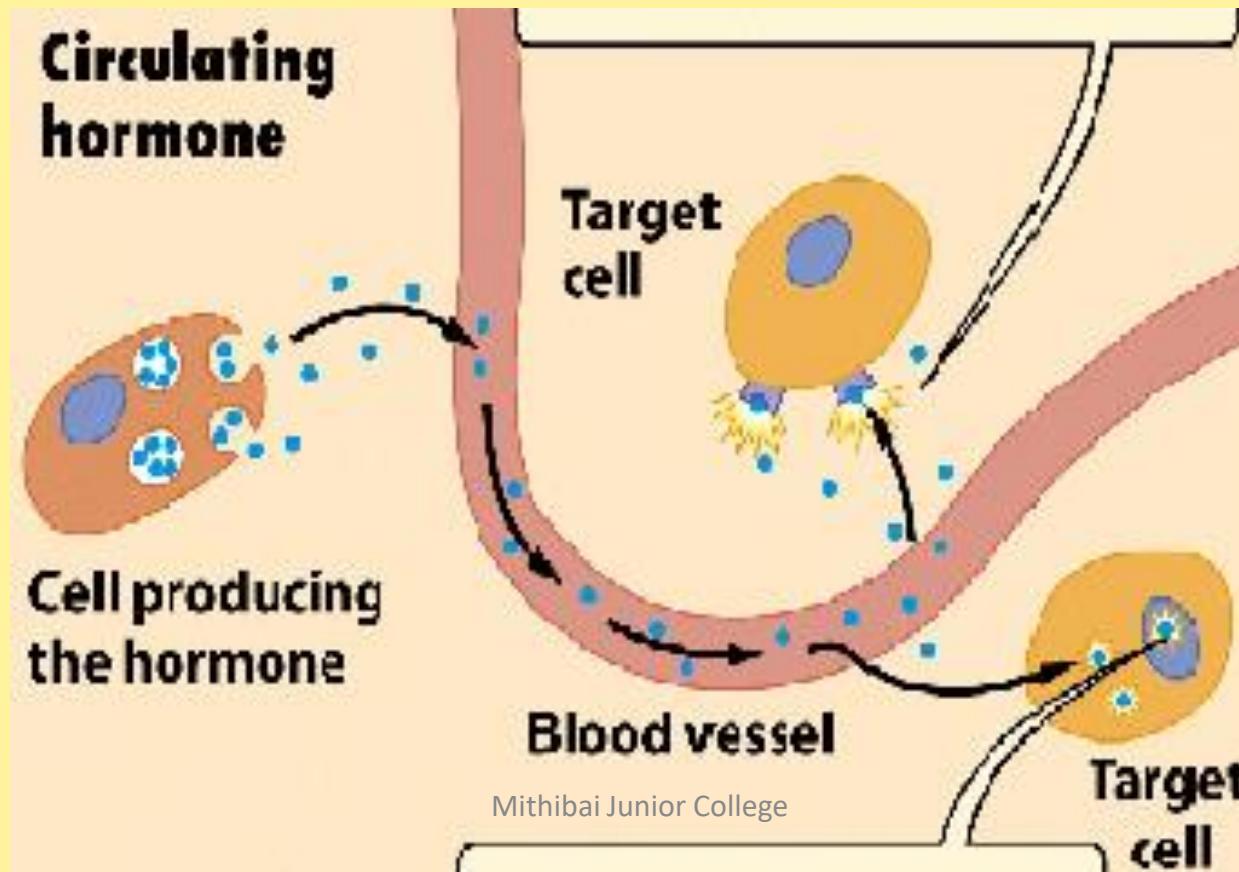


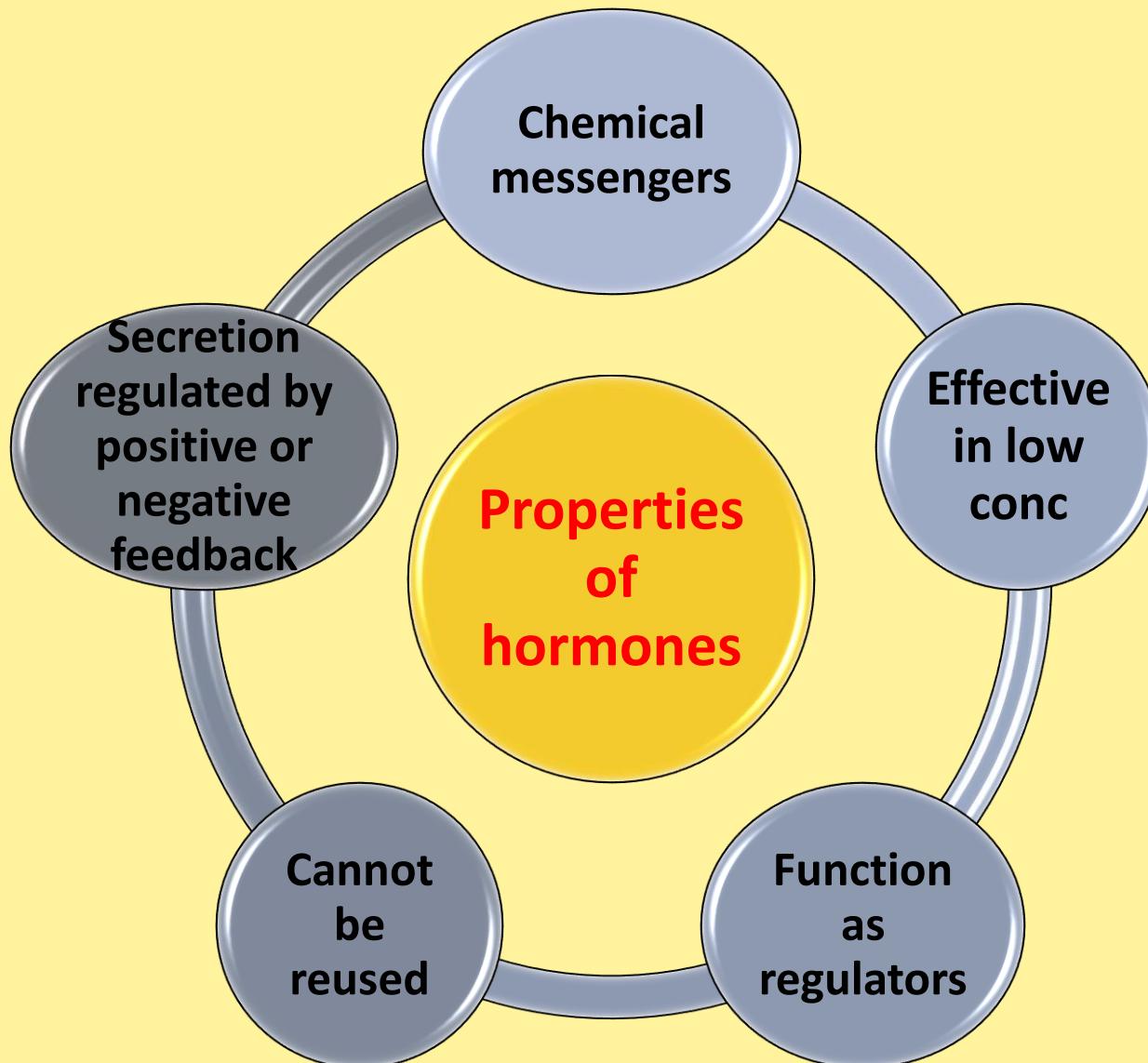
## **4) PHEROMONES:**



# Unit 9.9: Endocrine system

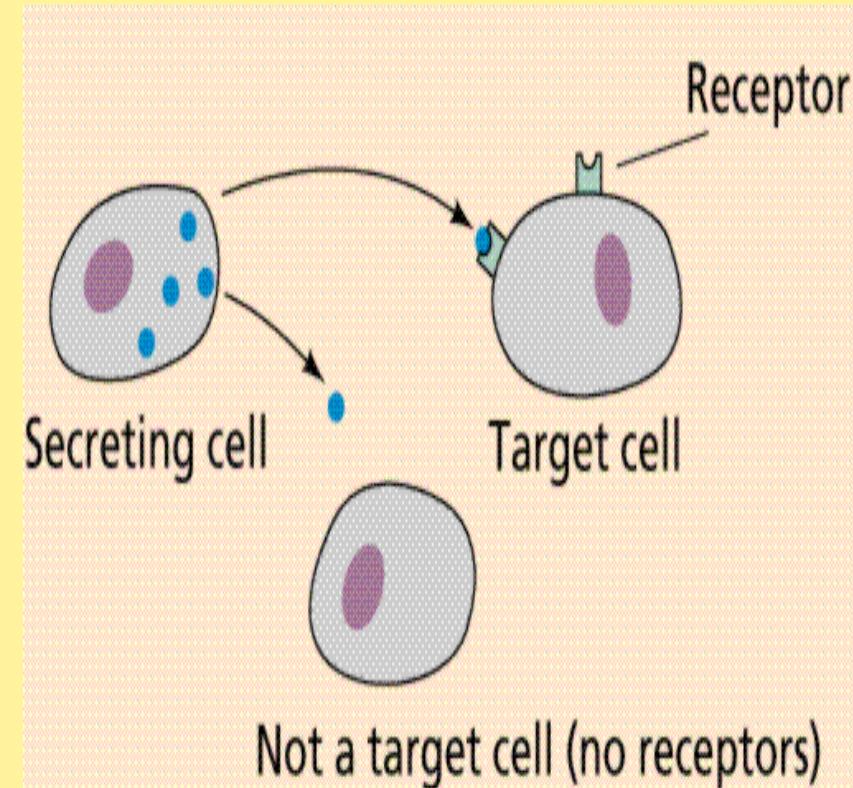
- Chemical messengers- ‘hormones’
- Released directly in blood
- Message relayed only to target organs



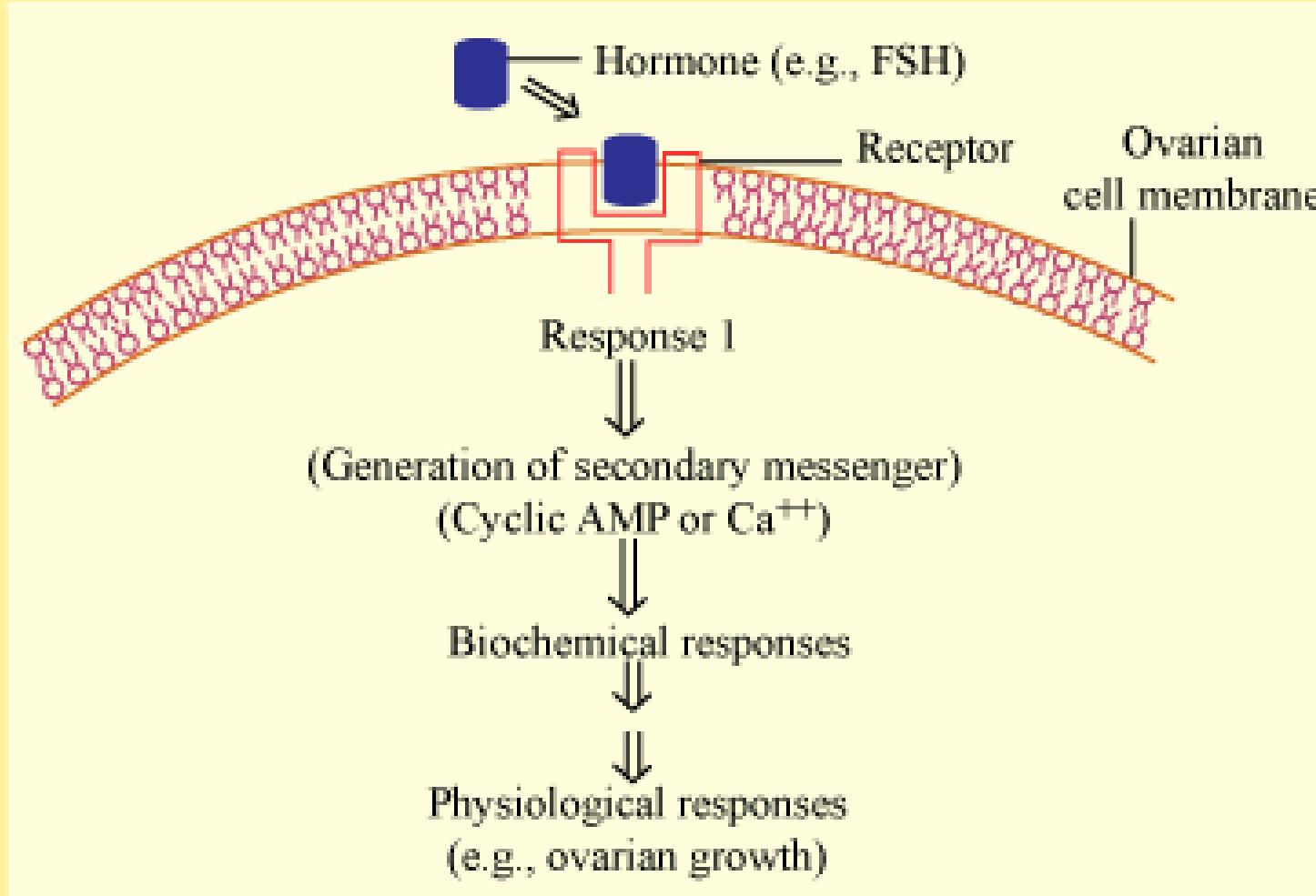


# Mechanism of Hormone action:

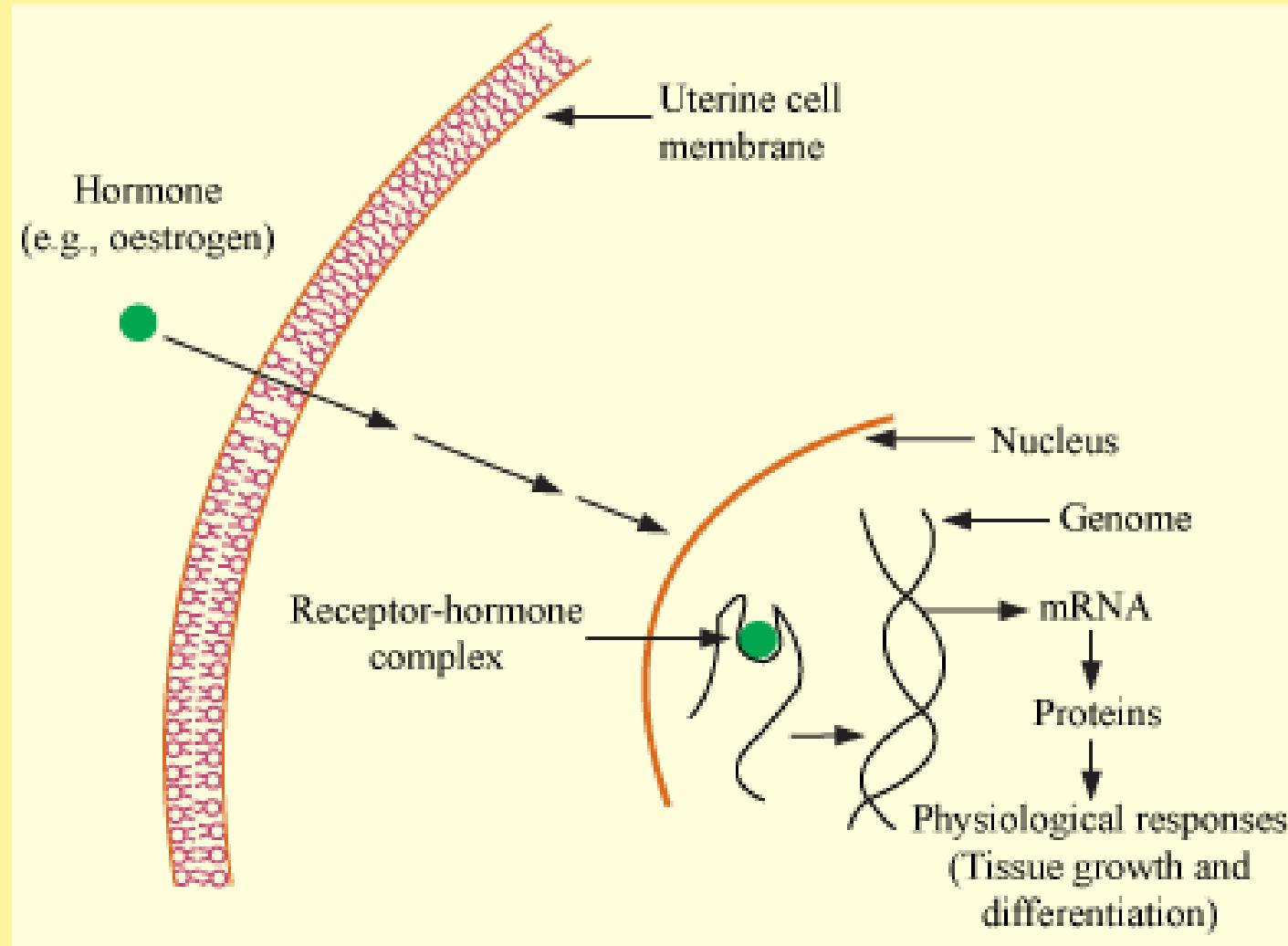
- Hormones produce effect by binding to hormone receptors
- Hormone receptors- on cell membrane or intracellular
- Hormone receptor complex formed
- Leads to biochemical change in target tissue.



# A) Mode of hormone action through membrane receptors:



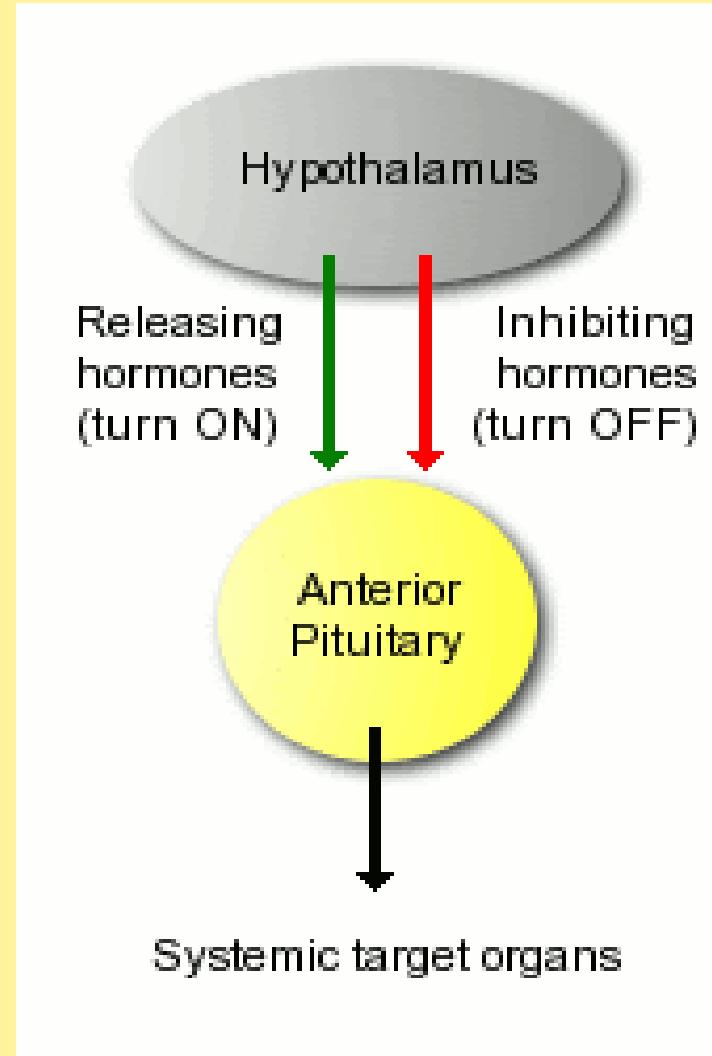
## B) Mode of hormone action through intracellular receptors:



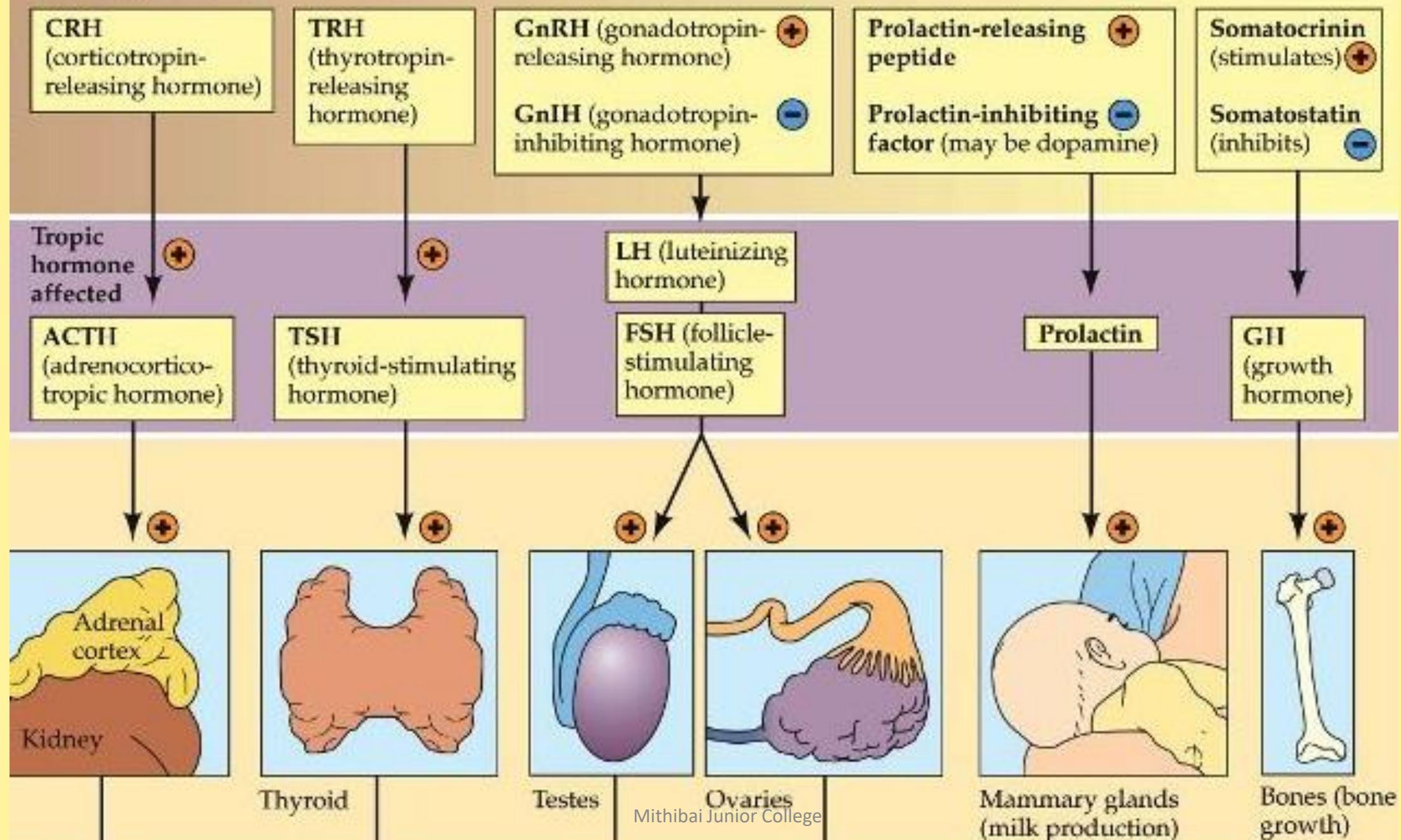
# Unit 9.13: Major endocrine glands

## A) Hypothalamus:

- Origin- ectodermal
- Location – floor of diencephalon
- Maintains homeostasis
- Controls secretory activities of pituitary by releasing and inhibiting hormones
- All are peptide hormones



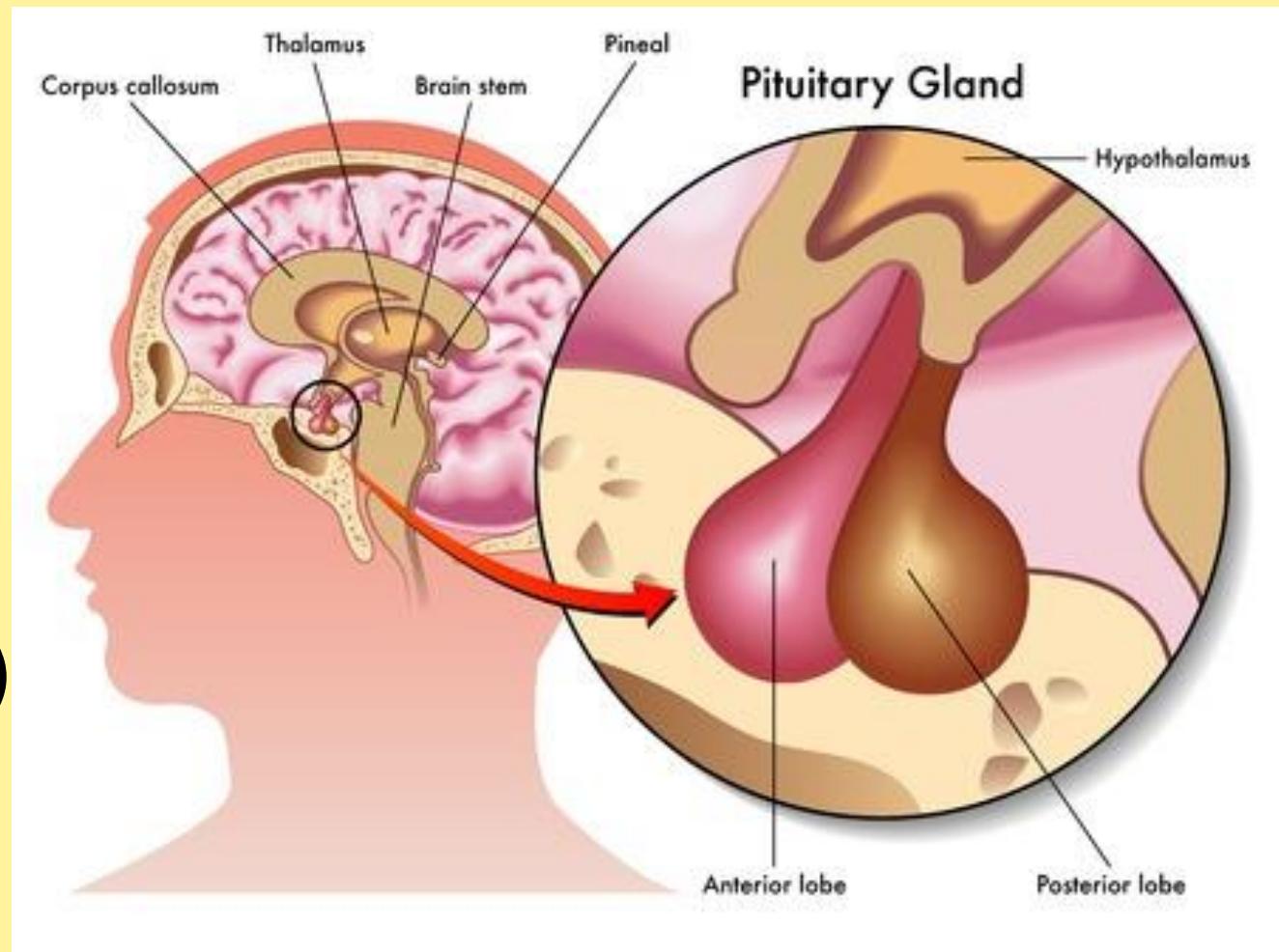
## Releasing hormones



- Other hormones include:
- Gastric Releasing Peptide (GRP)
- Gastric Inhibitory Polypeptide (GIP)

## B) Pituitary gland/ hypophysis gland:

- Smallest gland
- Below hypothalamus
- Attached by **infundibulum**
- **Sella turcica**( sphenoid bone)
- Consists of two lobes
  - a) **Adenohypophysis (anterior)**
  - b) **Neurohypophysis (posterior)**



- **ADENOHYPOPHYSIS**

- outgrowth, roof of buccal cavity  
**(Rathke's pouch)**

- Grows upwards

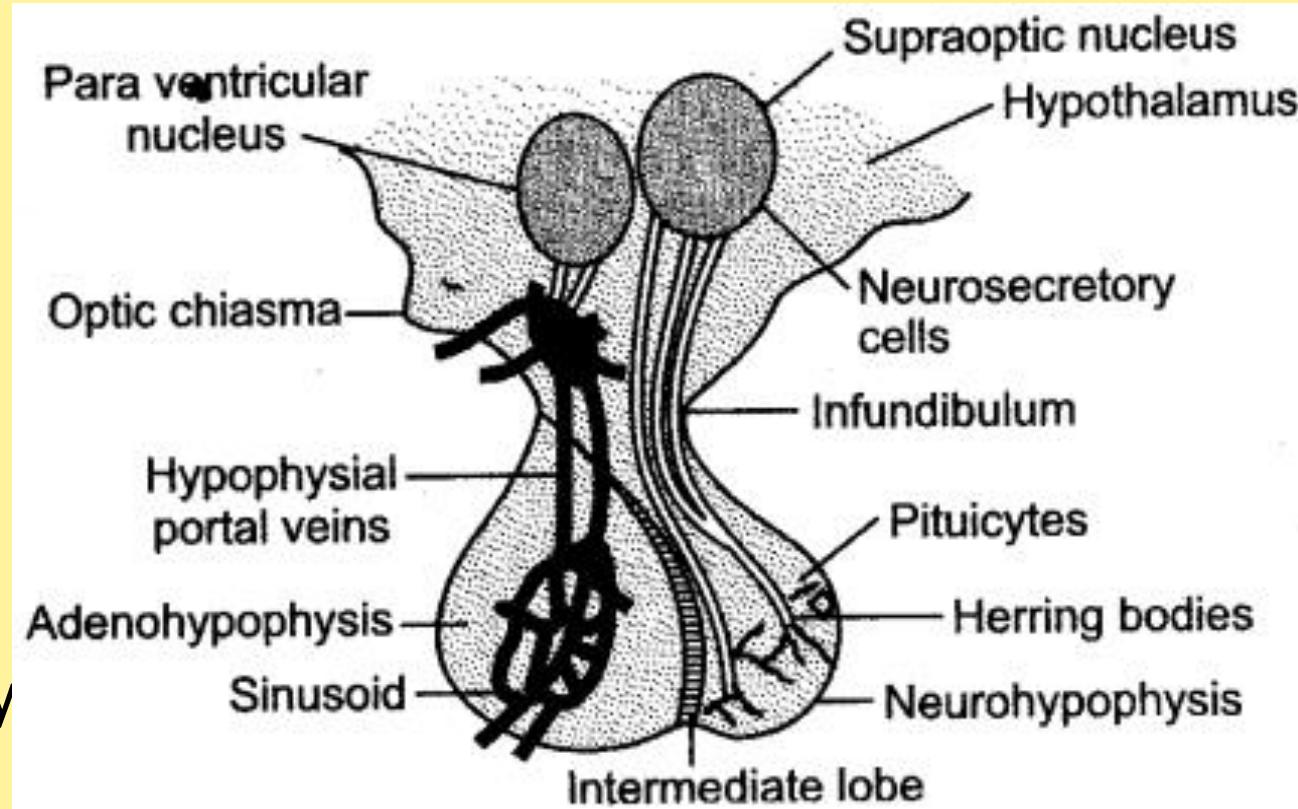
- Connected to hypothalamus by  
**hypophyseal portal system**

- **NEUROHYPOPHYSIS**

- Grows downward

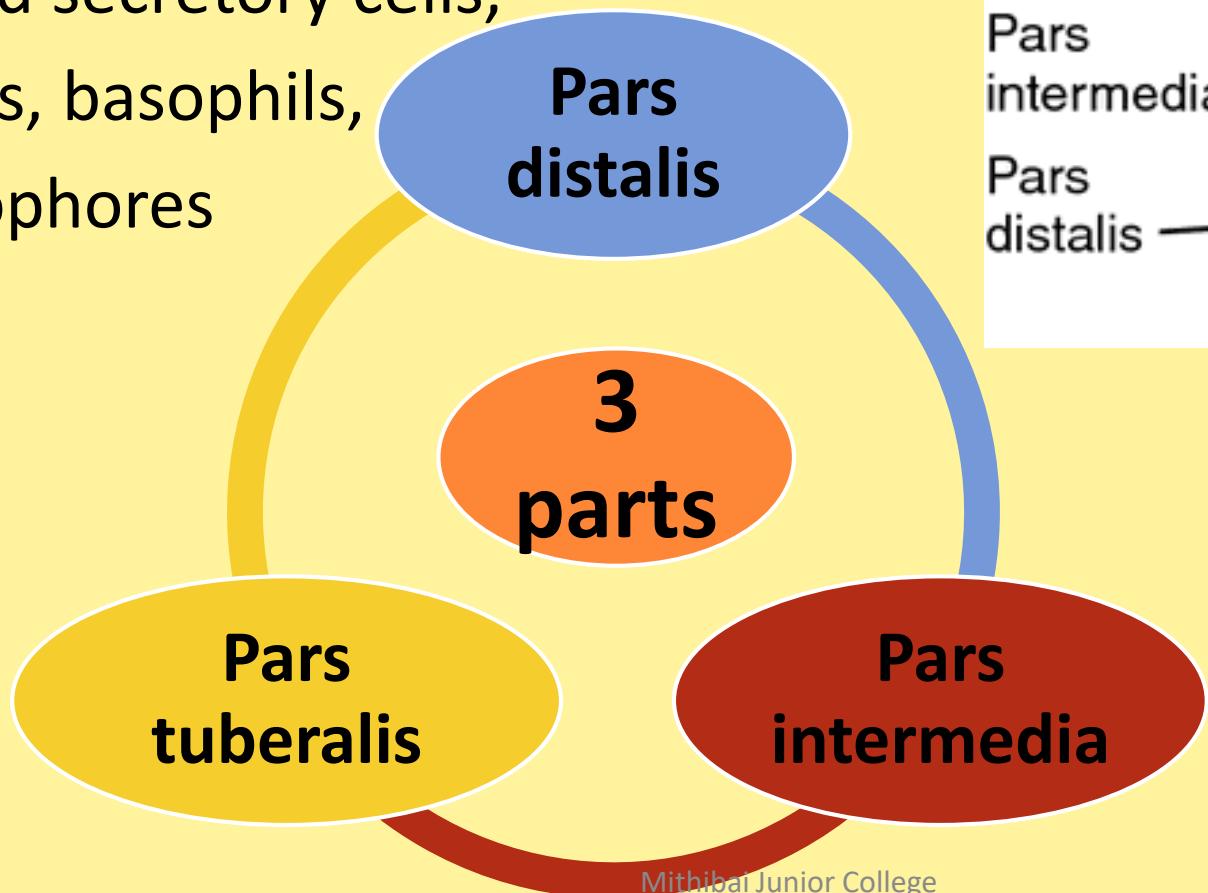
- Connected to hypothalamus directly  
**(axon fibres)**

- Adenohypophysis and neurohypophysis together form pituitary
- Inbetween them is **intermediate lobe**

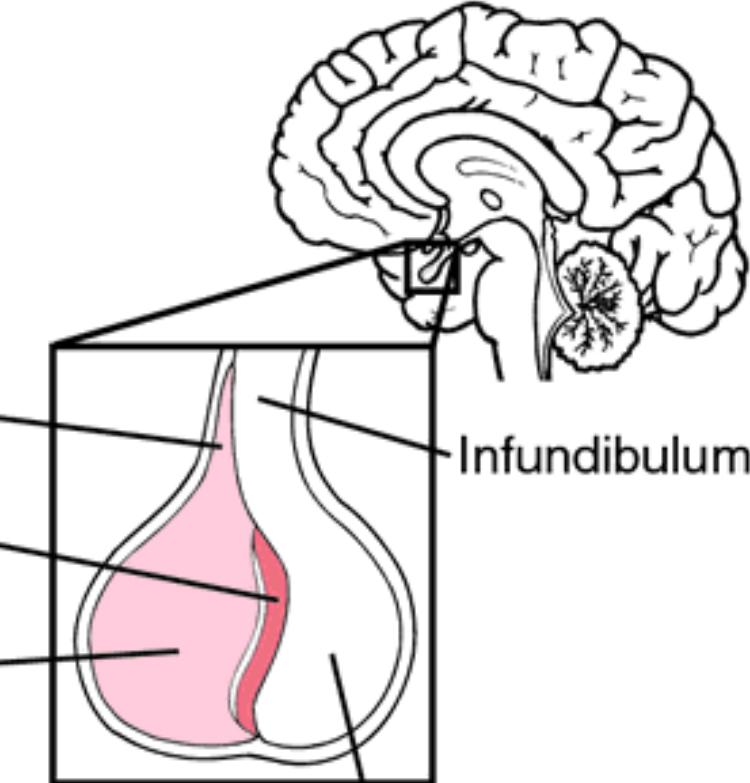


# ADENOHYPOPHYSIS:

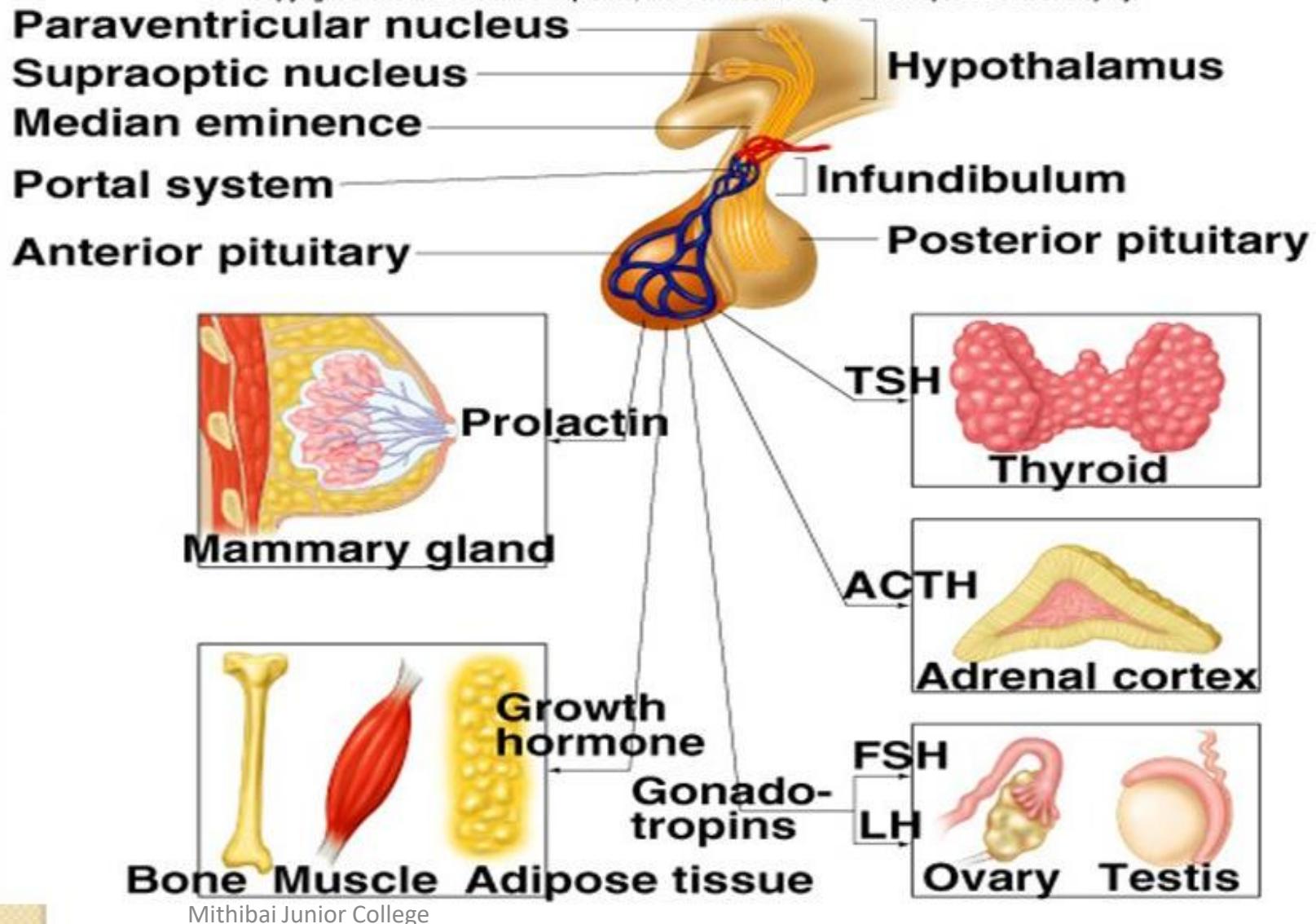
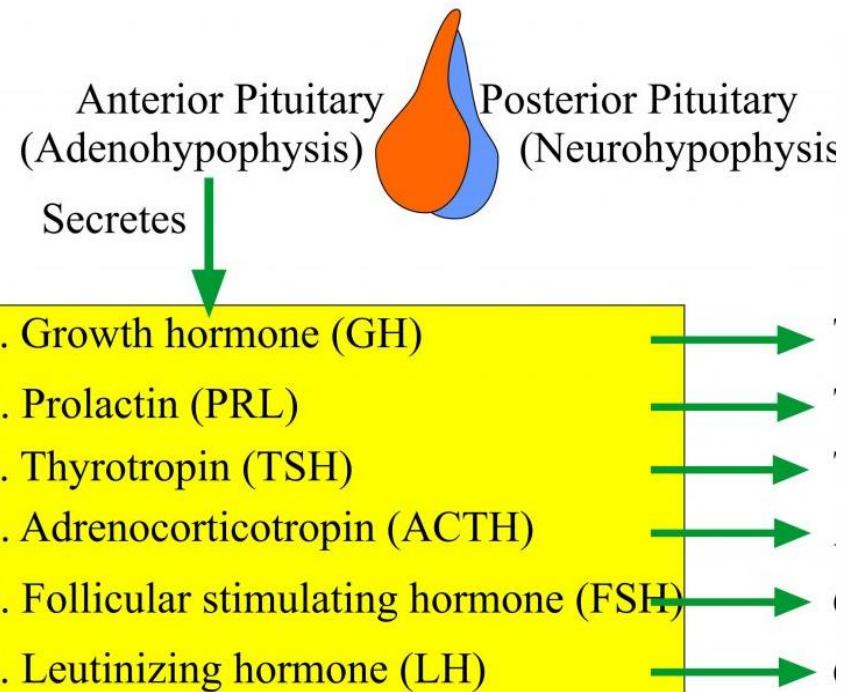
- Larger lobe, vascular
- Types of cells:
  - epitheloid secretory cells, acidophils, basophils, Chromatophores



Adeno-hypophysis:  
Pars tuberalis  
Pars intermedia  
Pars distalis

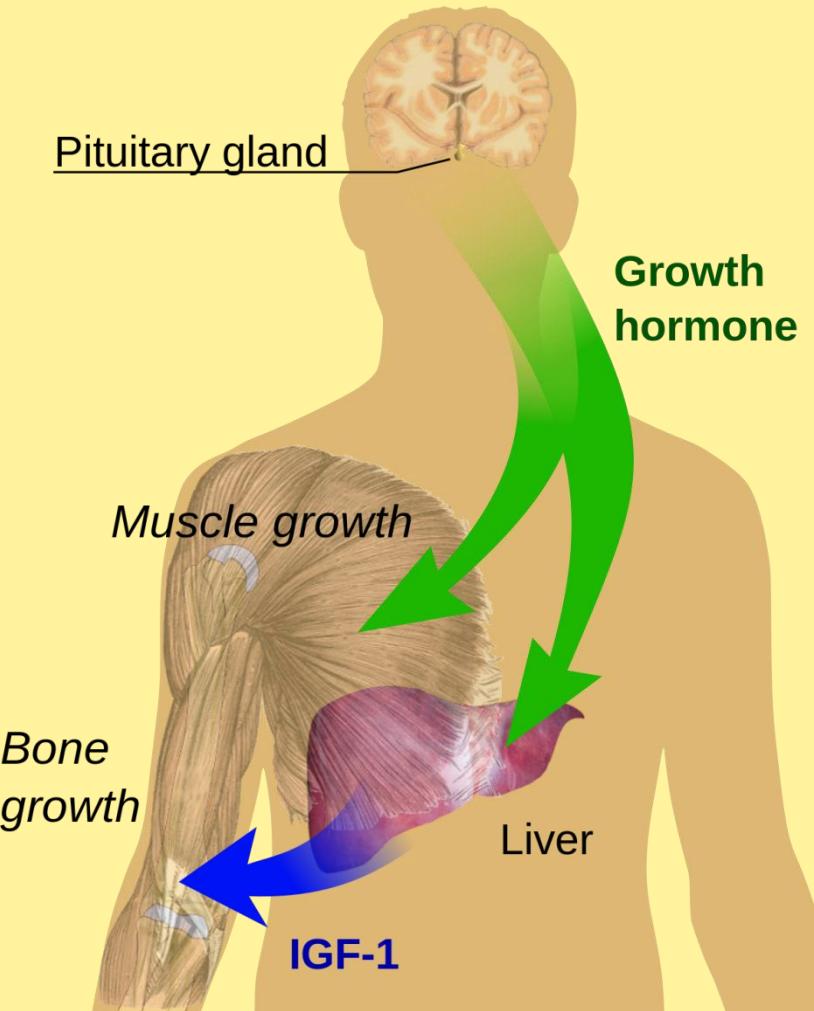


# HORMONES OF ADENOHYPOPHYSIS:



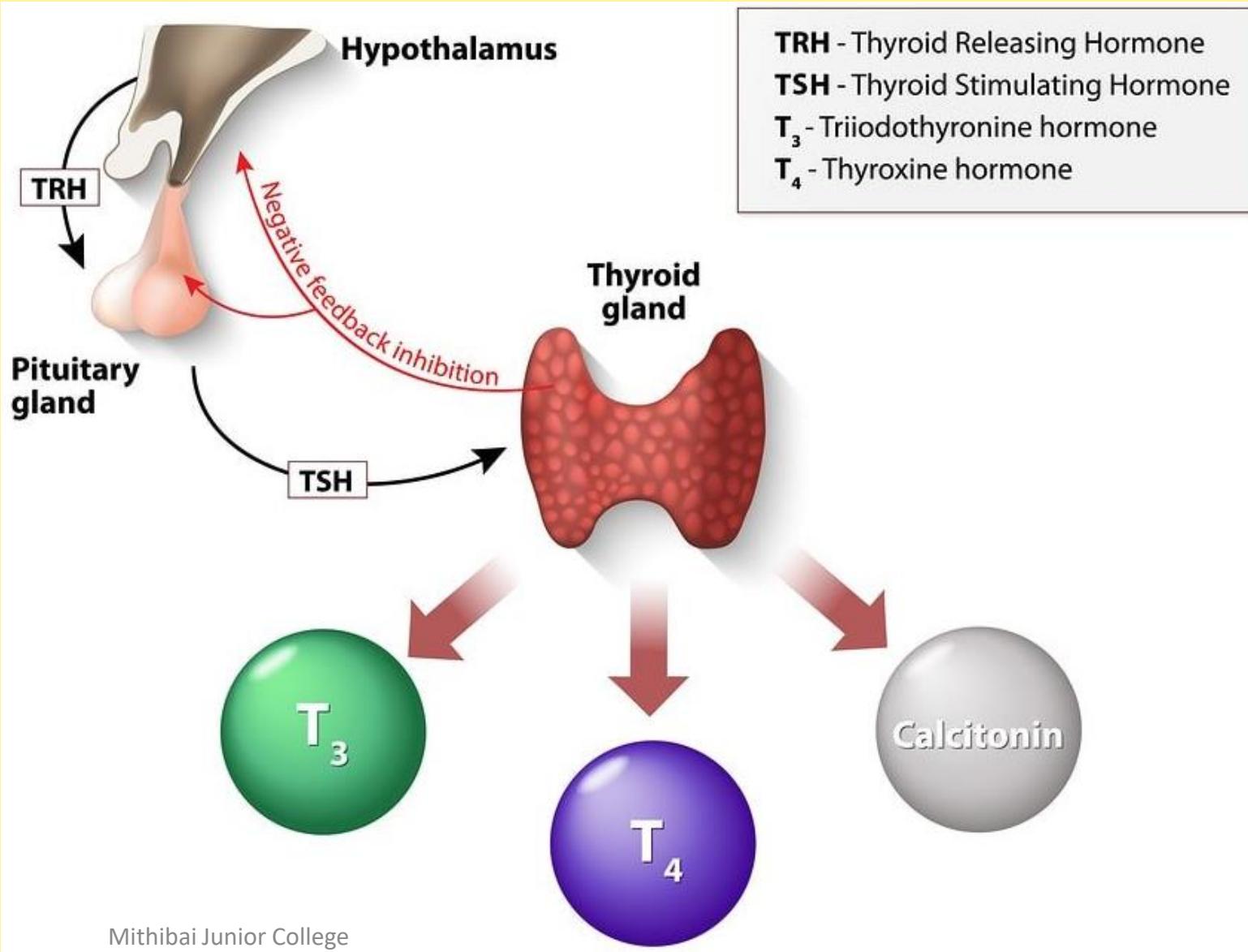
# 1) Somatotropin/Somatotropic Hormone/ STH/ Growth Hormone/GH:

- Stimulates growth and development
- Protein synthesis and cell division
- **HYPOSECRETION:** Pituitary dwarfism  
**(children)**
- **HYPERSECRETION:** Gigantism(**children**)  
**Acromegaly (Adults)**



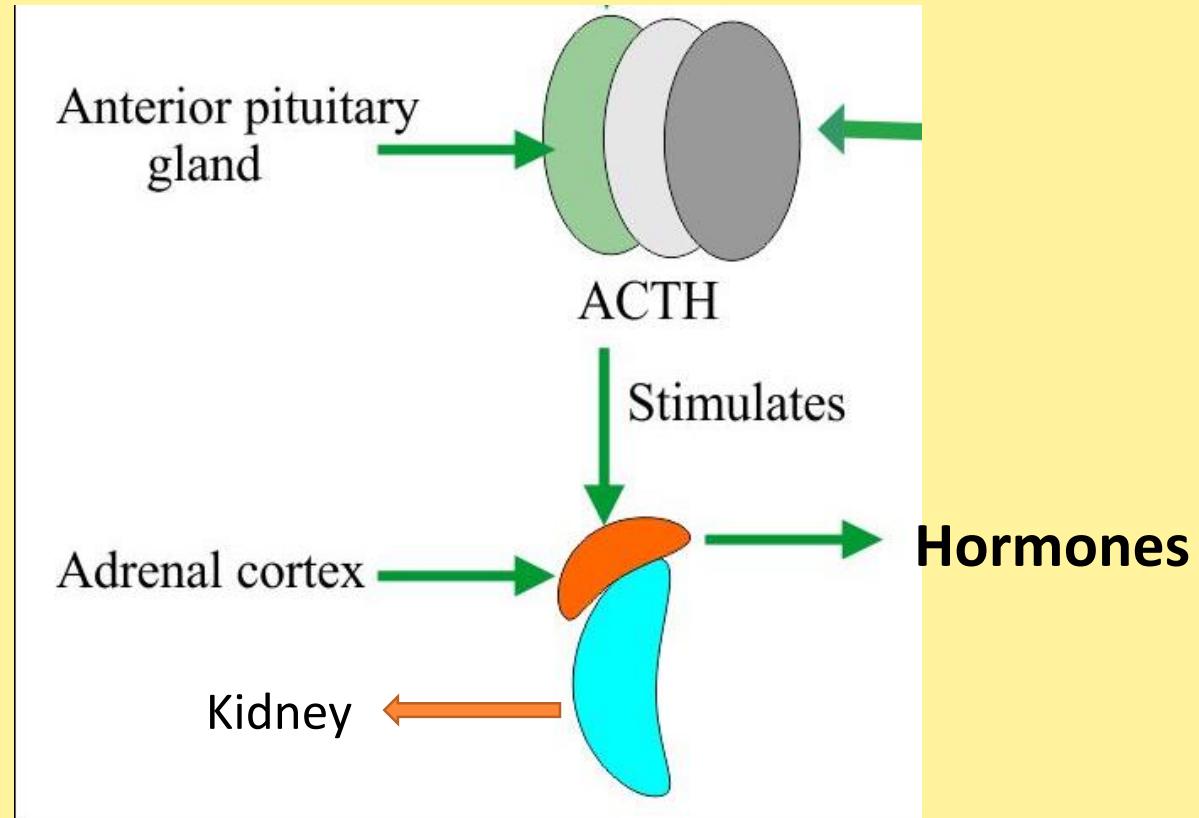
## 2) Thyrotropin/Thyroid Stimulating Hormone/TSH:

- Stimulate thyroid gland (secretion of thyroxine)



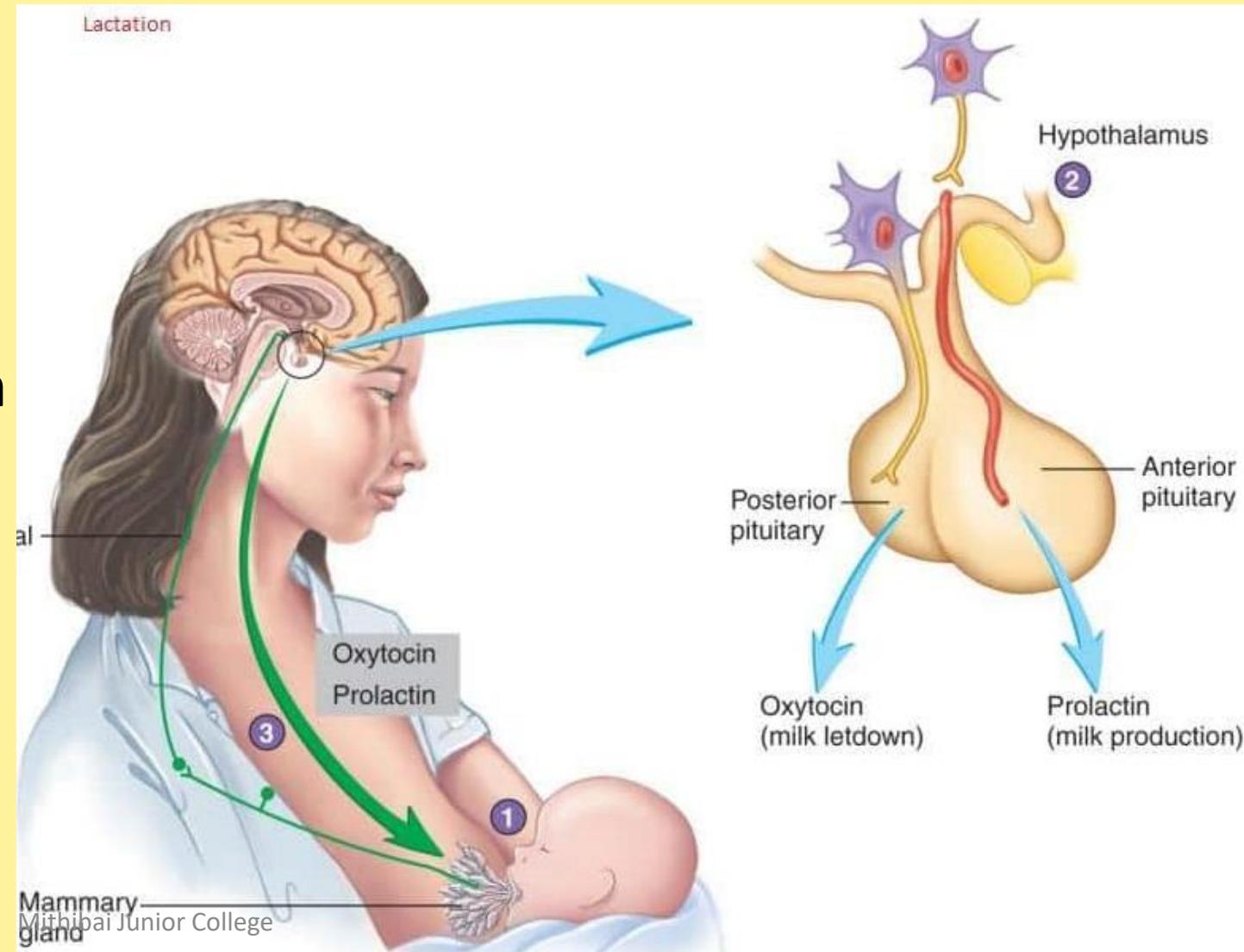
### 3) Adreno corticotropic hormone/ ACTH/Adrenocorticotropin:

- Stimulate adrenal cortex  
(to secrete its hormones)



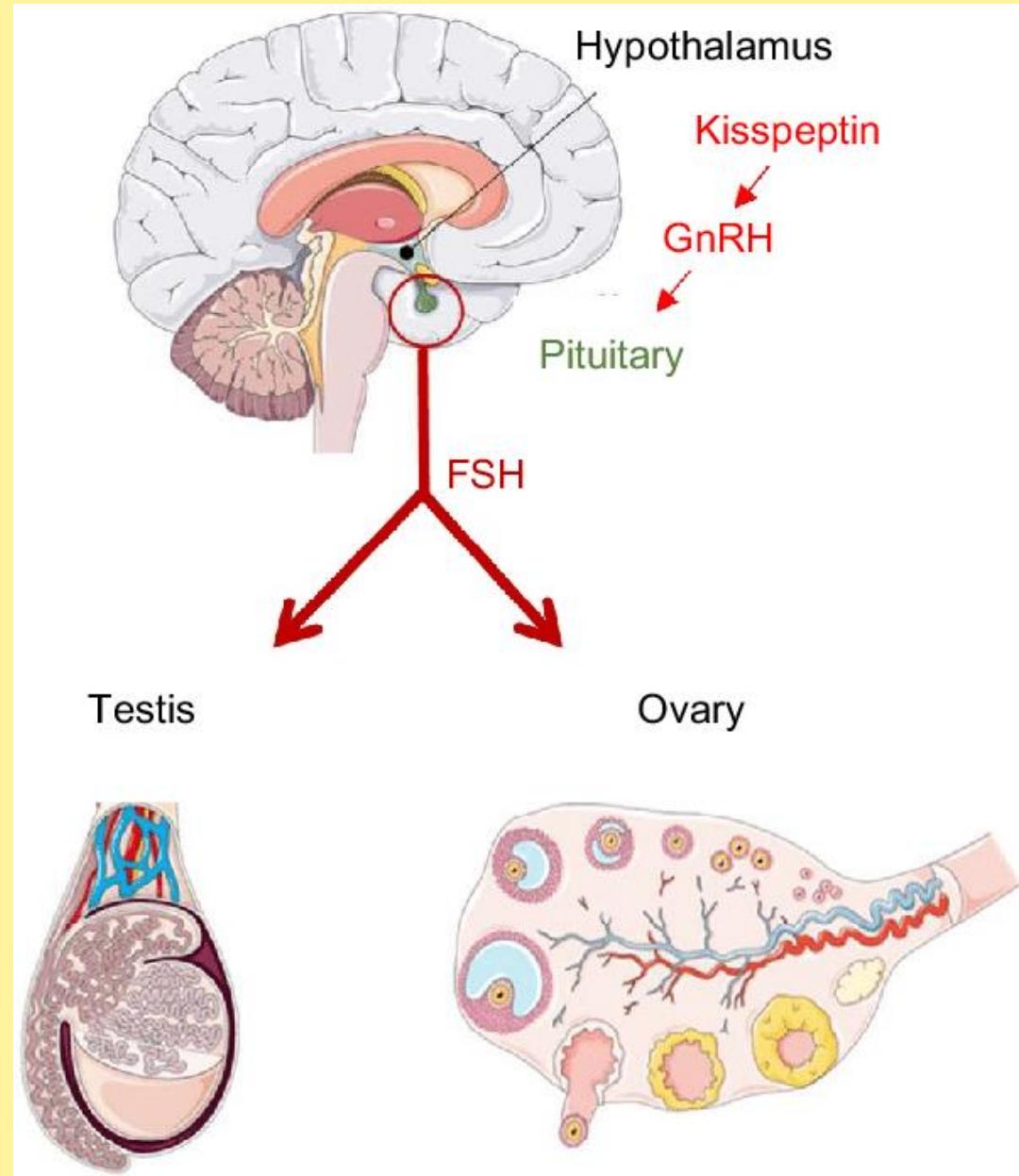
## 4) Prolactin/Luteotropin/Mammotropin:

- **Mammotropin** – growth of breast (during pregnancy)
- **Lactogenic** – milk production and secretion of milk (after child birth)



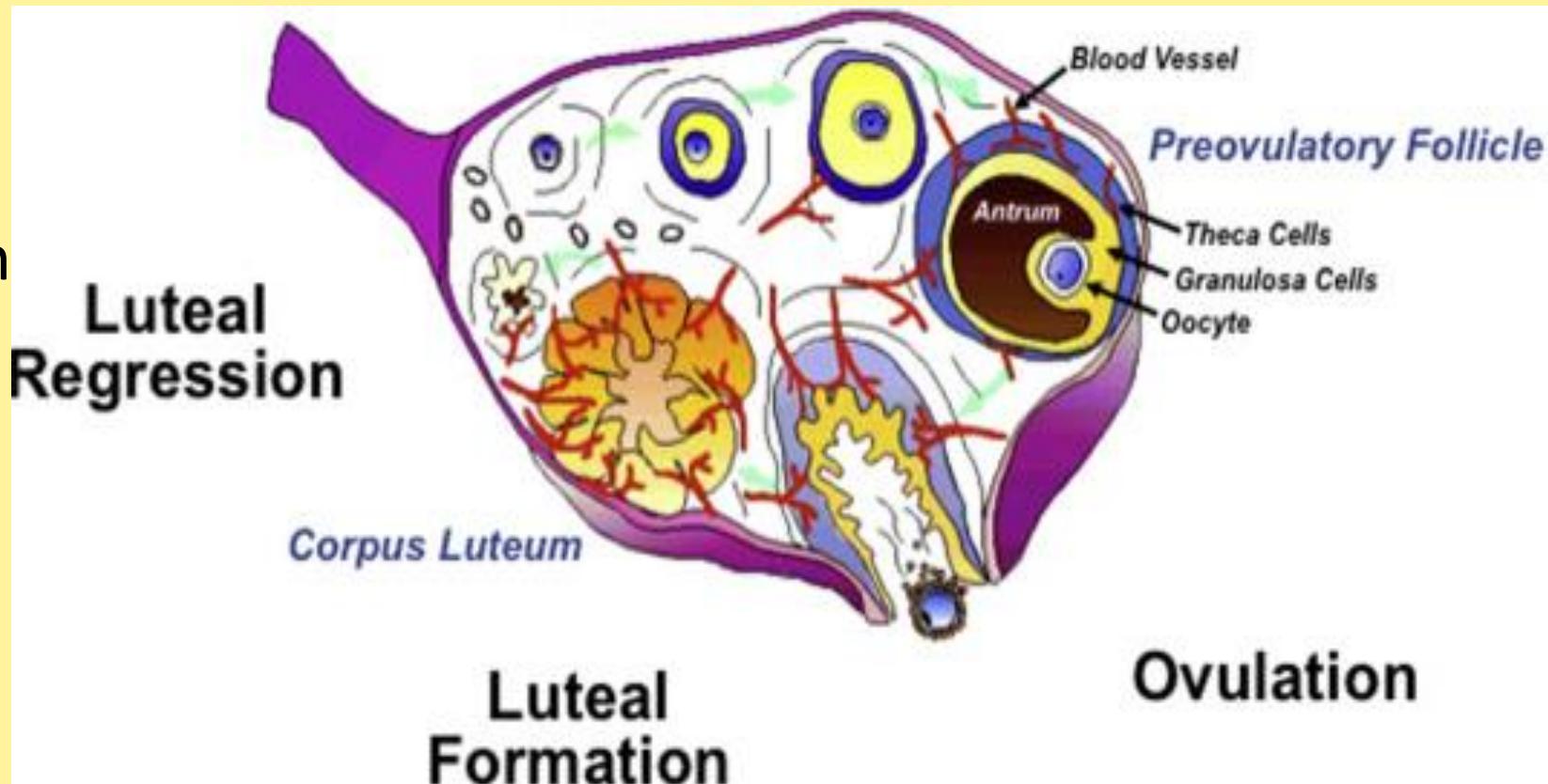
## 5) Gonadotropins:

- a) Follicle Stimulating Hormone / FSH:
- Development of ovarian follicles (females)
- Development of seminiferous tubules (males)



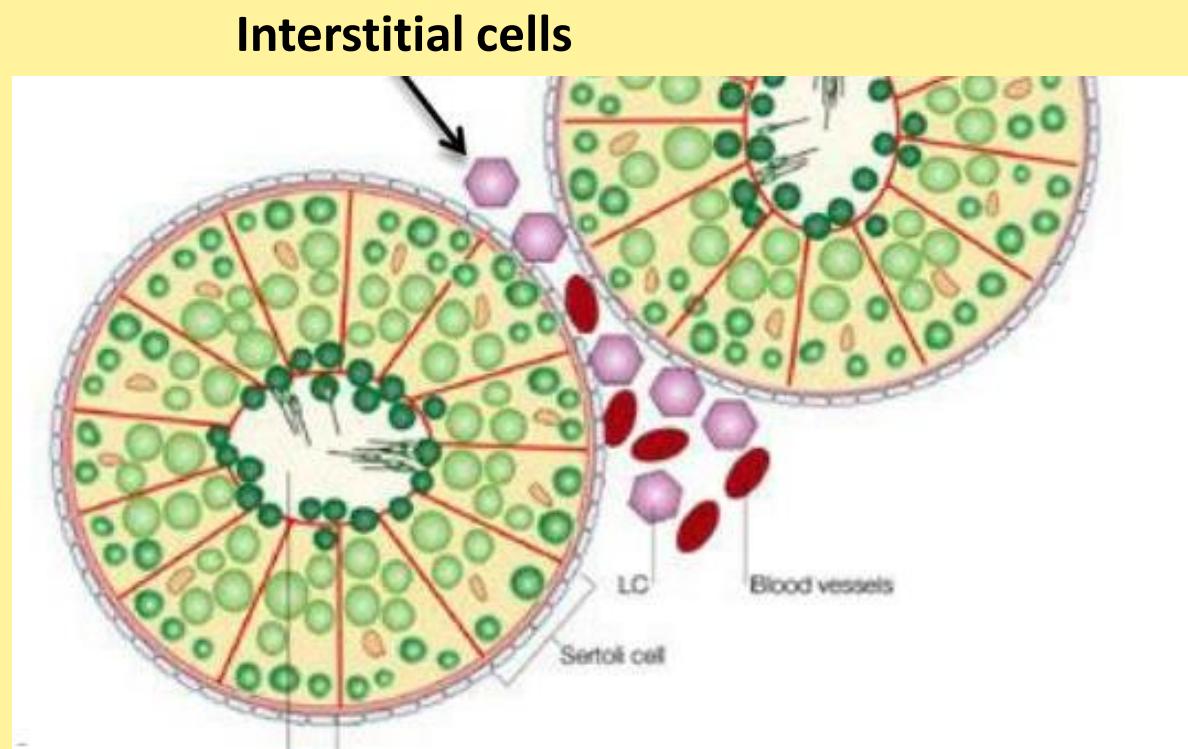
## b) Leutinizing Hormone/ LH:

- Helps in ovulation
- Stimulate ovaries to produce oestrogen
- Induce formation of corpus luteum
- Production of progesterone



### c) Interstitial cell stimulating hormone/ICSH:

- Stimulates testes to produce testosterone.  
(Sec. sexual characters-males)

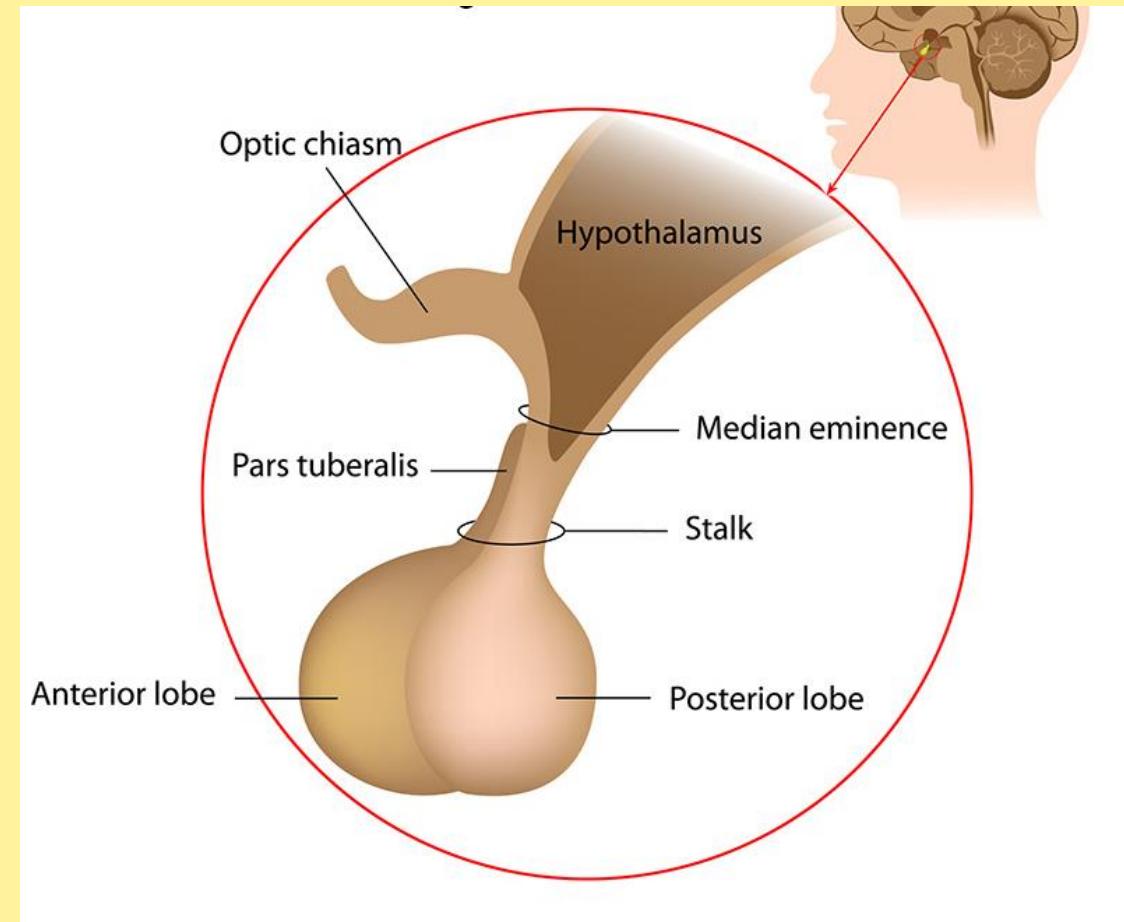
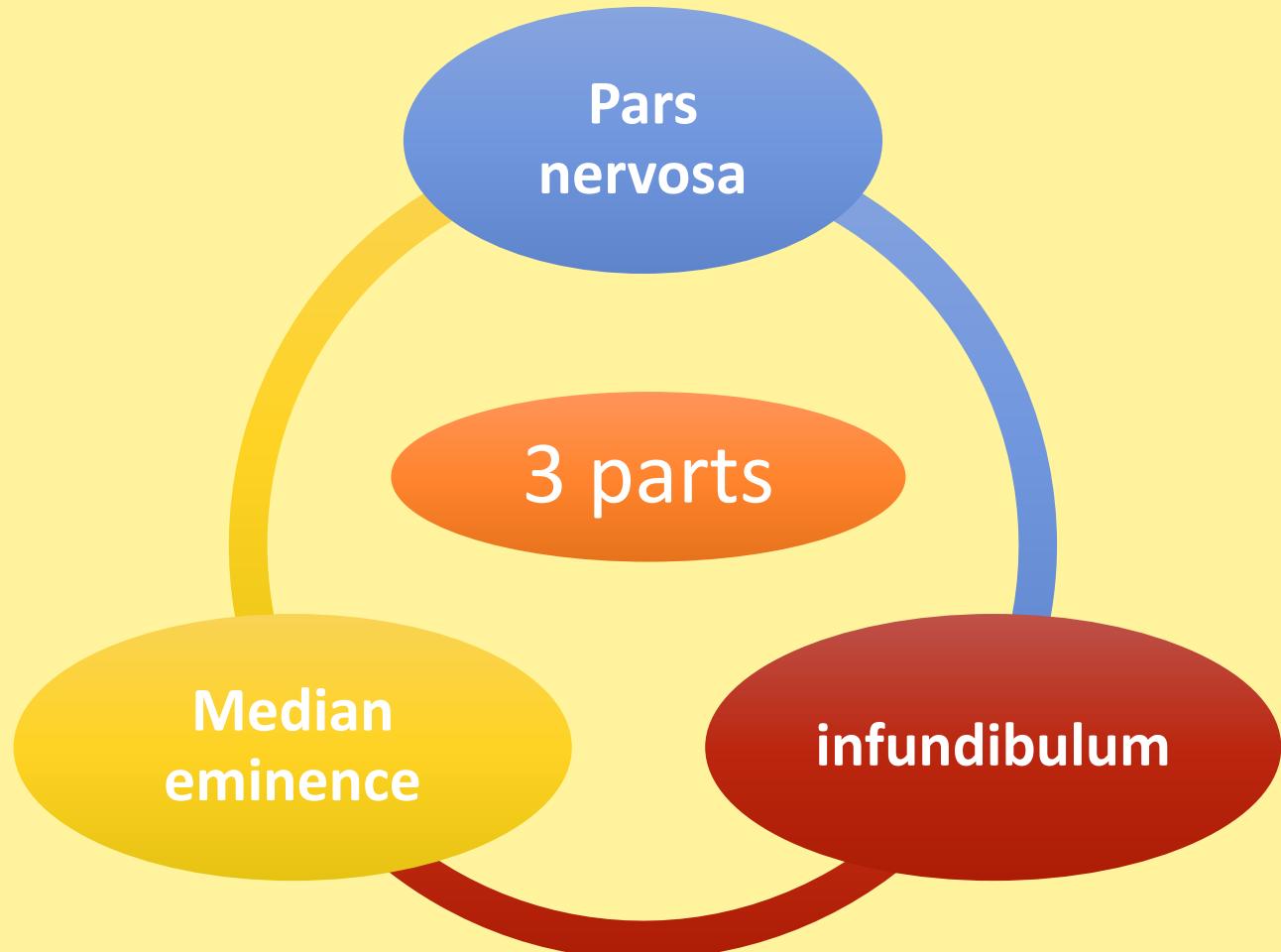


# Pars intermedia:

- Poorly developed in humans
- Secrete Melanocyte Stimulating Hormone (MSH)  
(in some lower vertebrates)
- Responsible for skin pigmentation  
(dispersion of melanin granules in melanocytes)



# Neurohypophysis



# HORMONES OF NEUROHYPOPHYSIS

- Pars nervosa- storage area for secretions of hypothalamus
- Stores and releases

## **1) Oxytocin**

**-Birth hormone**

**-milk ejecting hormone**

## **2) Antidiuretic hormone(ADH)/**

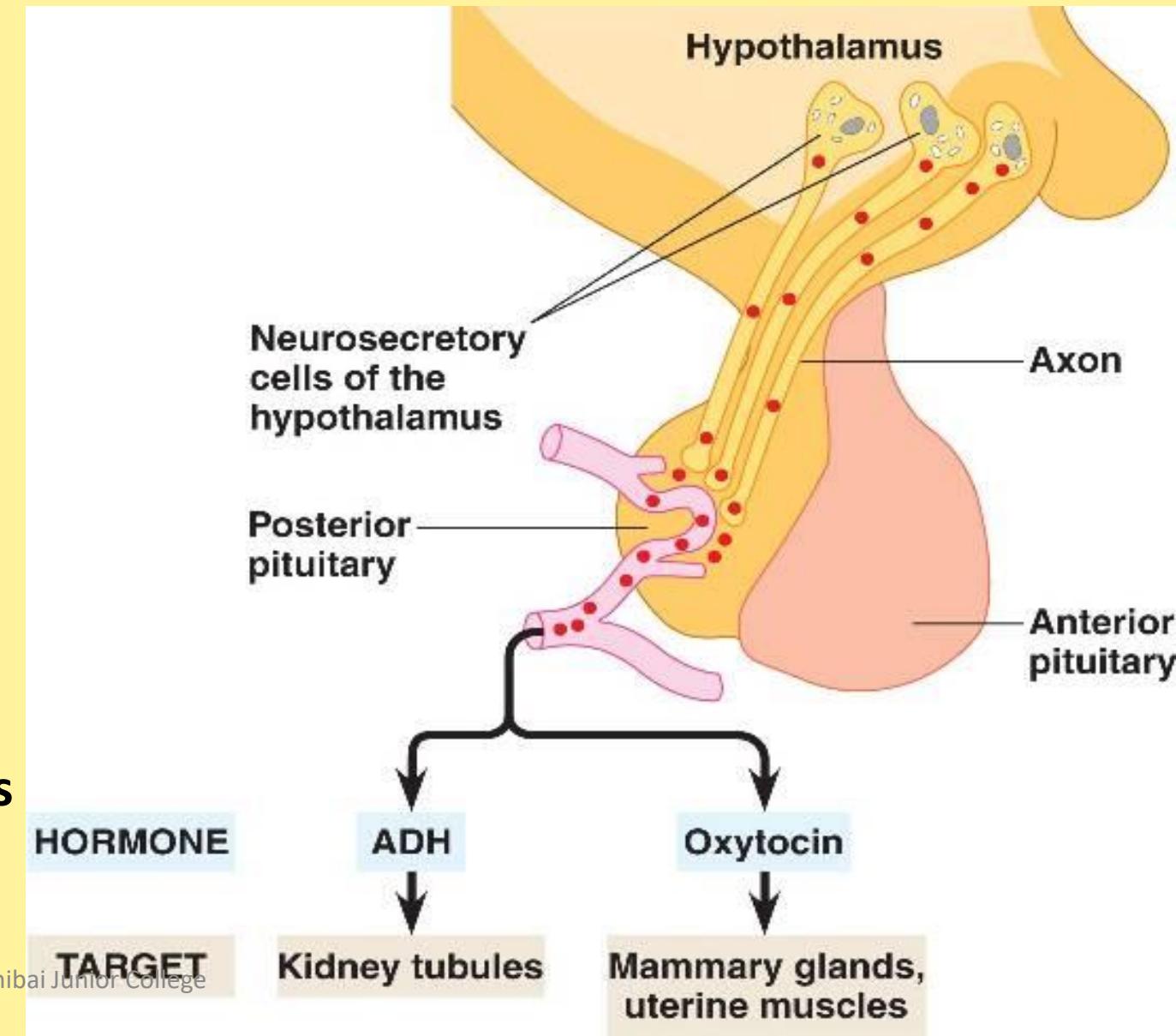
**Vasopressin**

**-stimulates reabsorption of water  
(DCT and CT)**

**-Vasoconstriction(decreases B.P)**

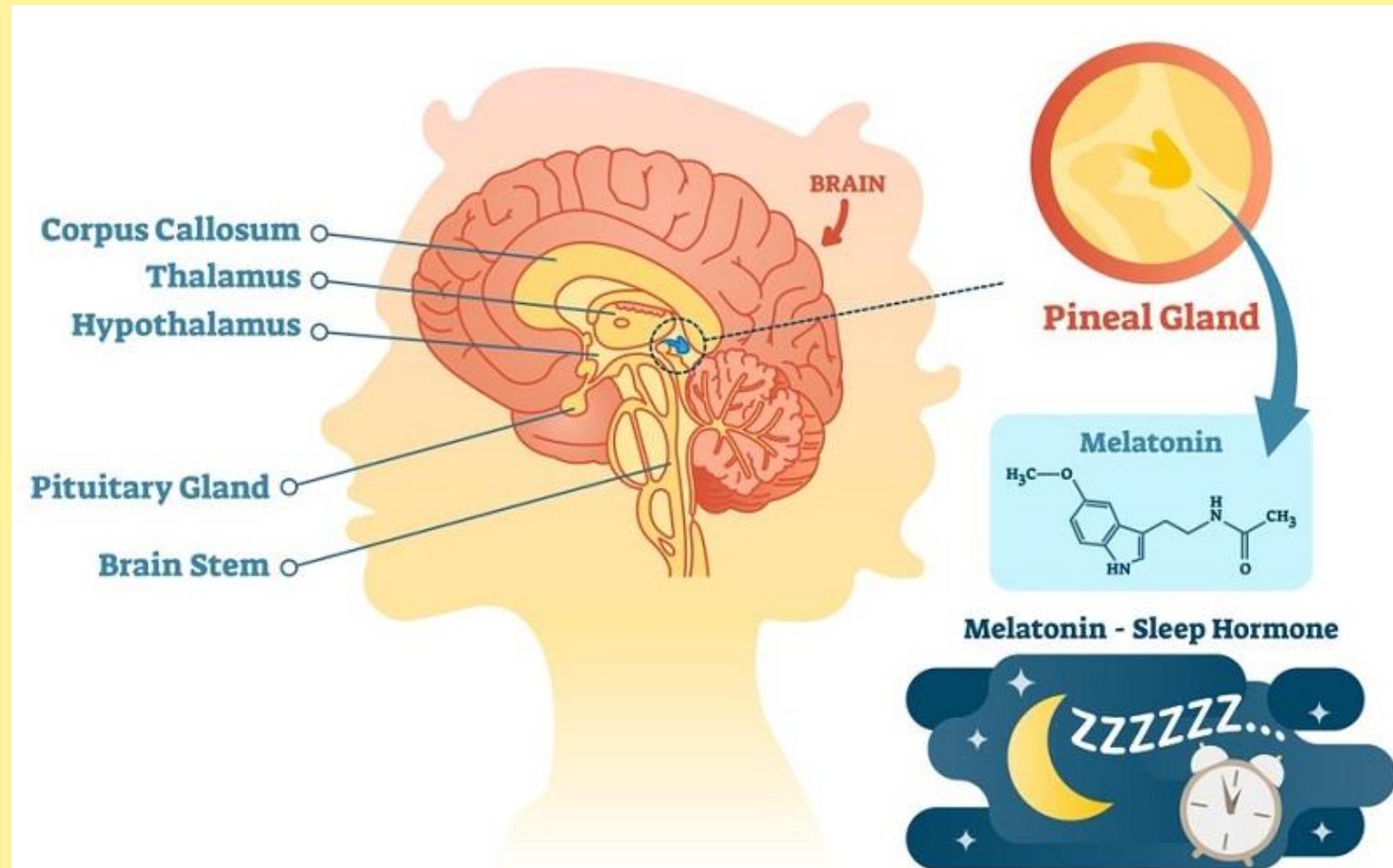
**-Deficiency of ADH- diabetes insipidus**

**-Polydipsia- Excessive thirst**



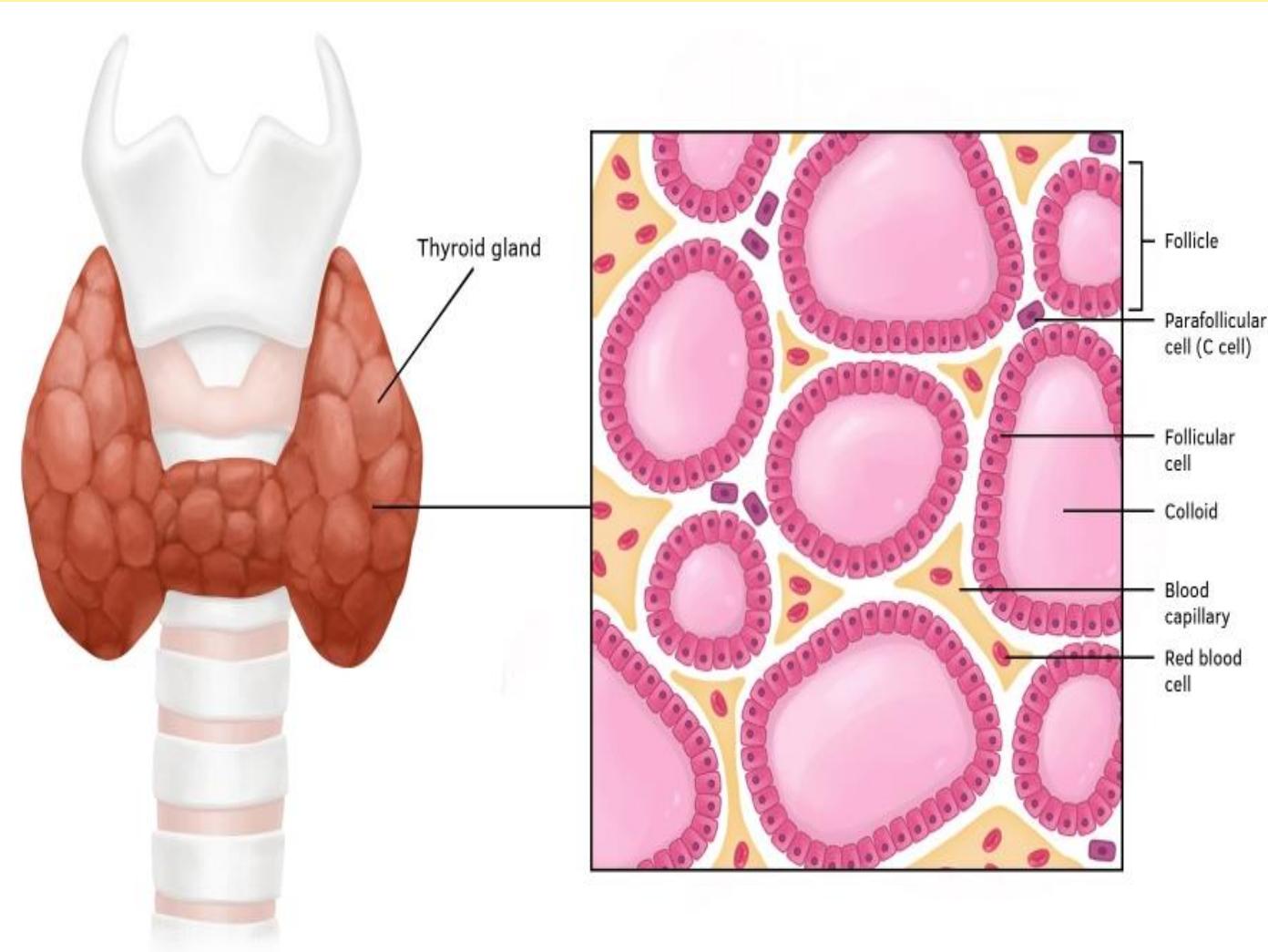
## C) Pineal gland:

- Given from roof of diencephalon
- Secretes- **melatonin** (sleep hormone)
- Tryptophan derivative
- Regulates biological clock
- Maintains sleep wake cycle



## D) Thyroid gland:

- Largest endocrine gland
- Only gland that stores its hormones
- Bilobed ,vascular
- Isthmus (connect 2 lobes)
- Thyroid lobes:
  - Follicles (cuboidal epithelium)
  - Colloid
  - Stoma-blood capillaries and parafollicular cells/ 'C' cells



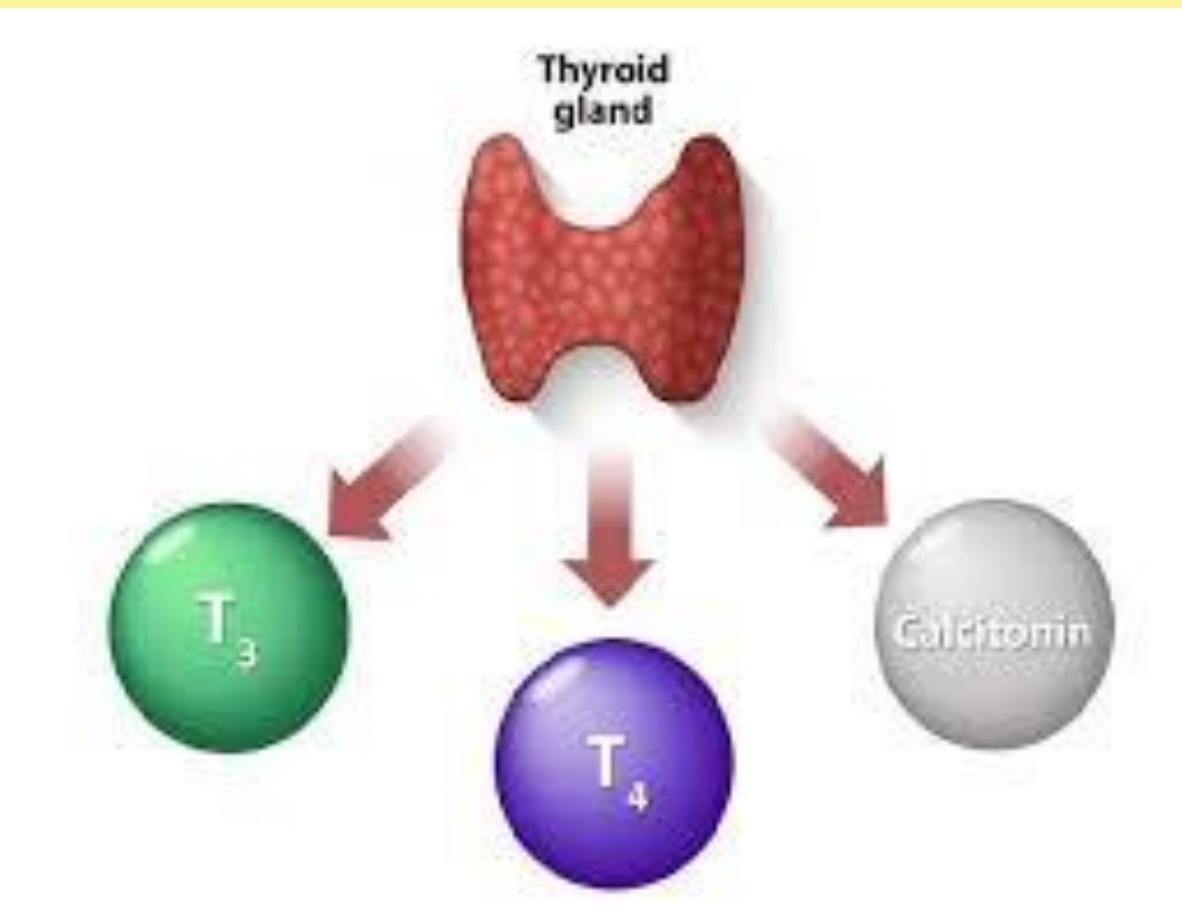
# Hormones of thyroid gland:

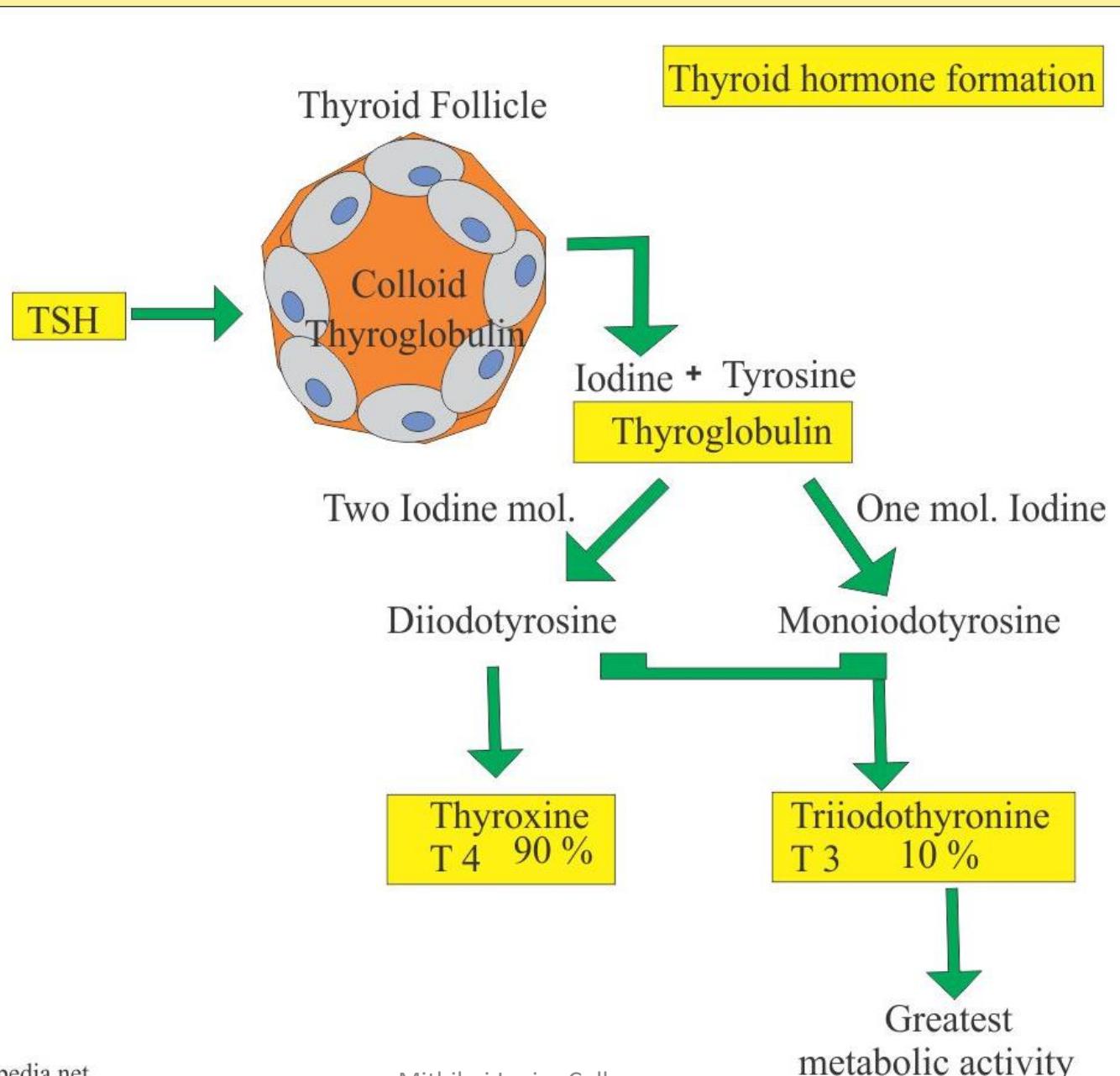
- **Follicular cells:**

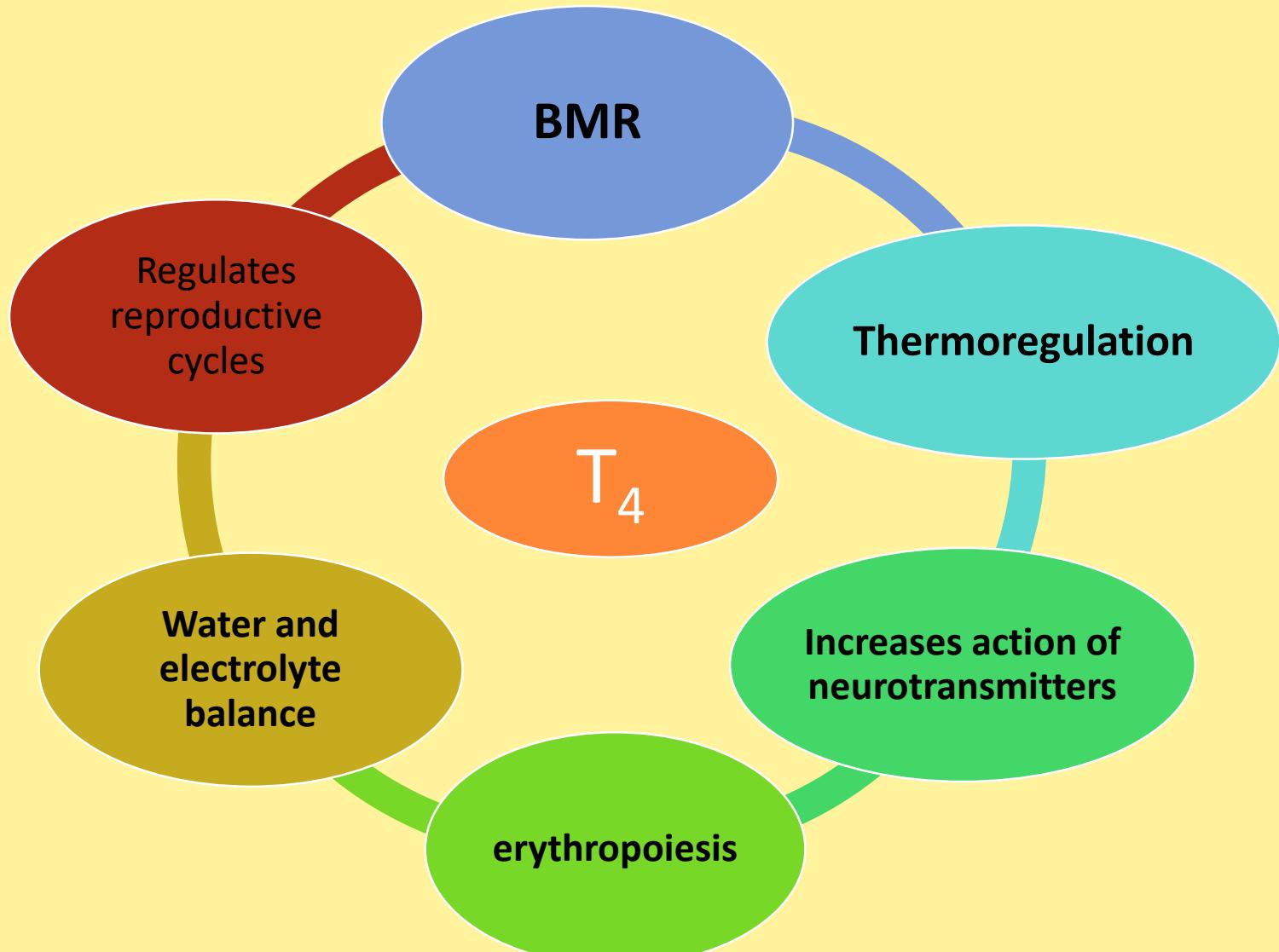
- Thyroxine/tetraiodothyronine/T<sub>4</sub>
- Triiodothyronine/T<sub>3</sub>

- **Parafollicular cells or 'C' cells:**

- Calcitonin

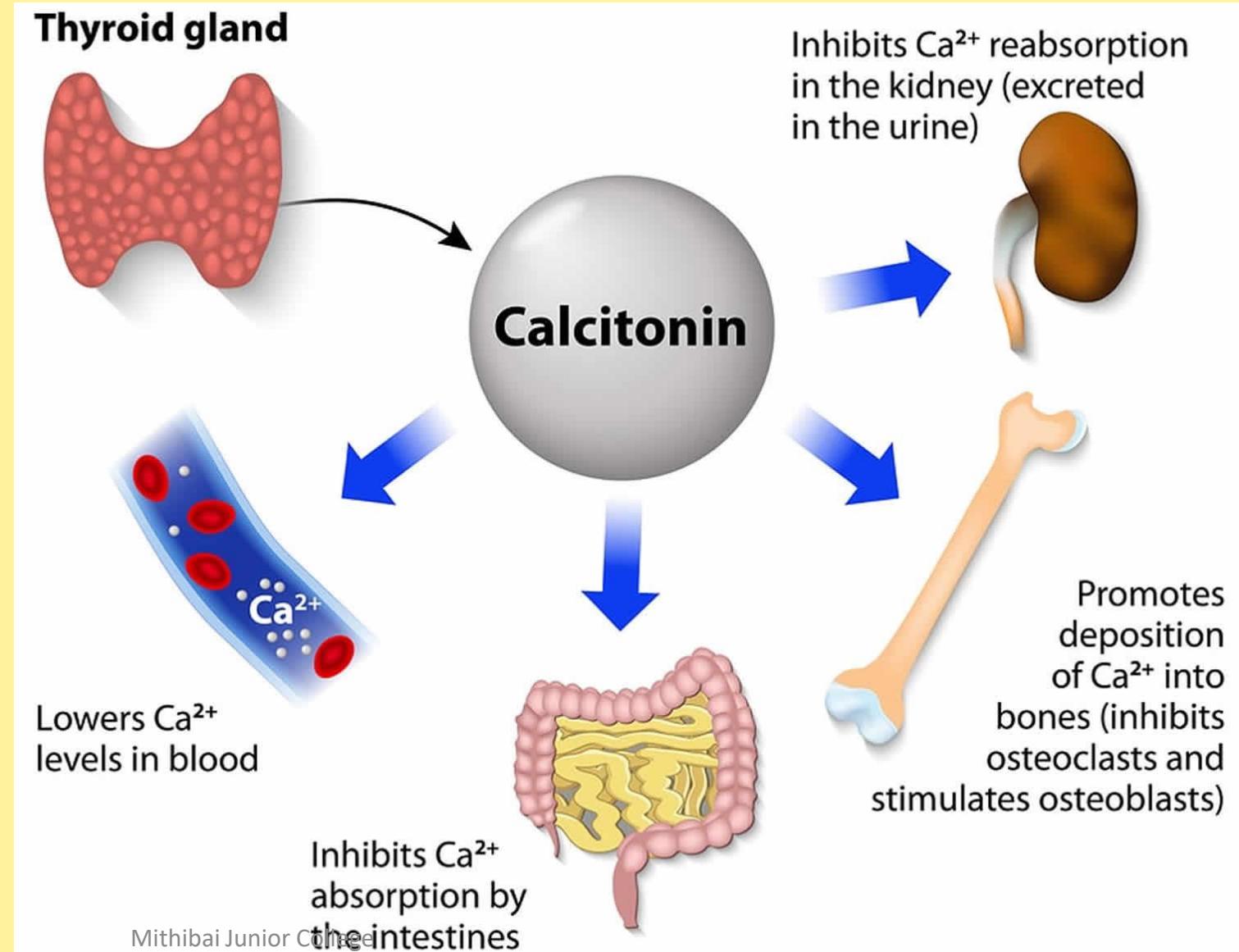






# Parafollicular cells/ 'C' cells:

- Secrete calcitonin
- Regulates calcium and phosphorus in blood



# Disorders related to thyroid gland:

## a) HYPERTHYROIDISM:

- Increase in levels of thyroid hormones
- Affects physiological activities

## Grave's disease:

- Hyperthyroidism in adults
- **Protruding eyeballs**
- Increase BMR



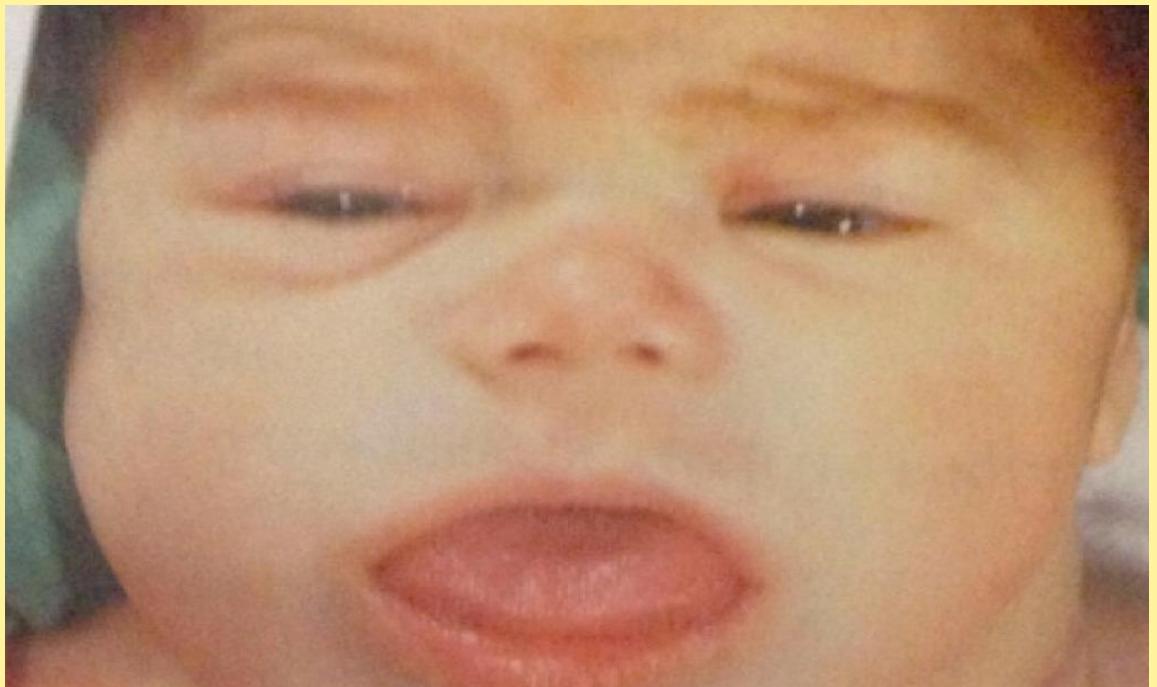
## **b) HYPOTHYROIDISM:**

- Deficiency of thyroid hormones
- Or removal of thyroid gland

**(thyroidectomy)**

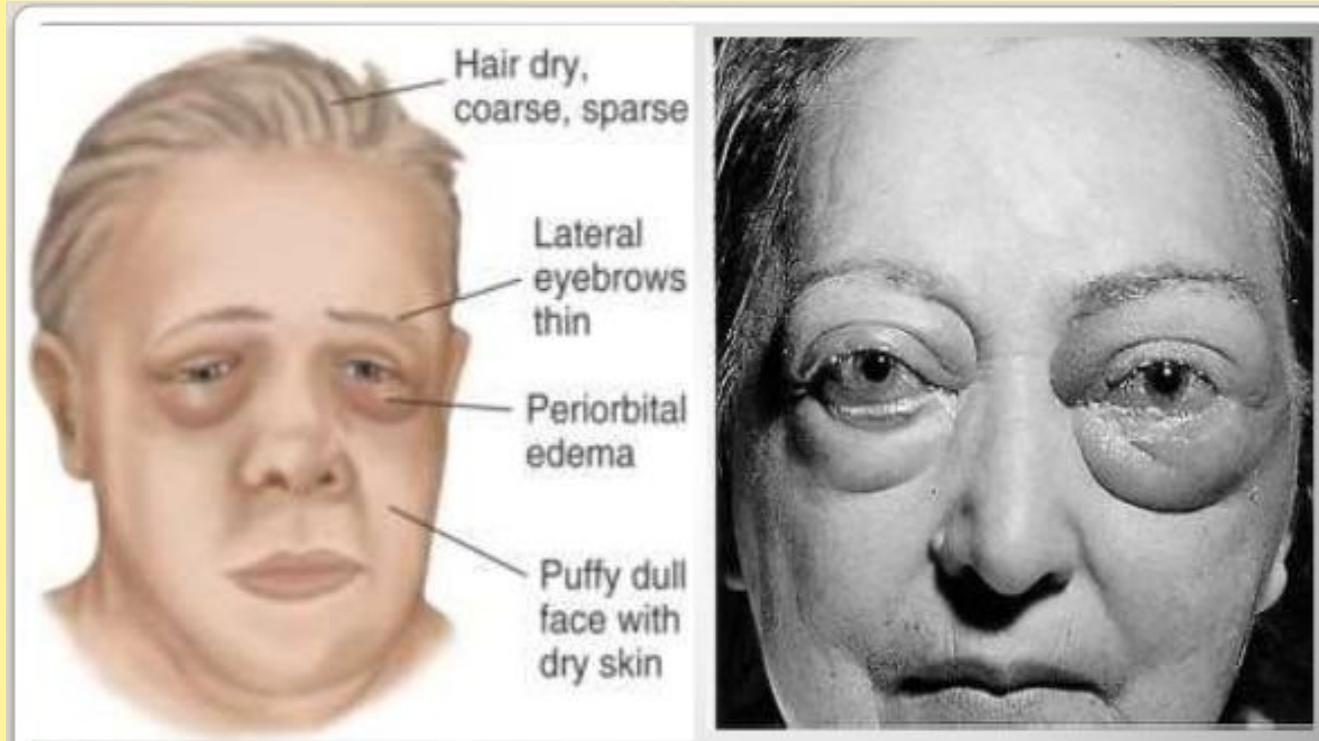
## **Cretinism:**

- In infants
- Low BMR , short stature
- Mental retardation
- Dry skin, thick tongue
- Treated by early administration of thyroid hormones



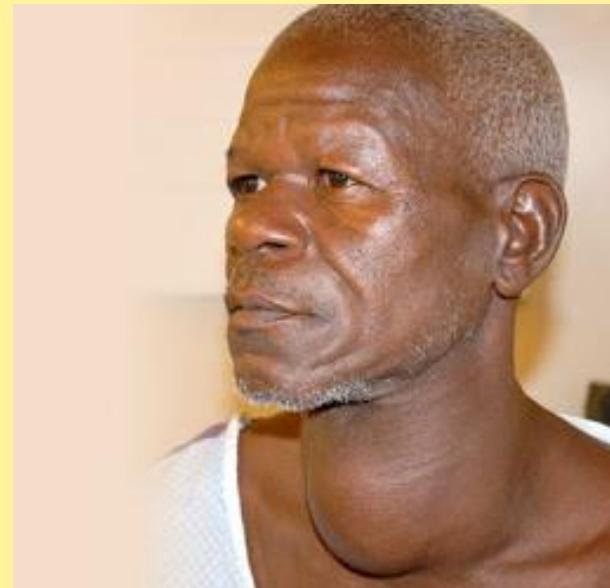
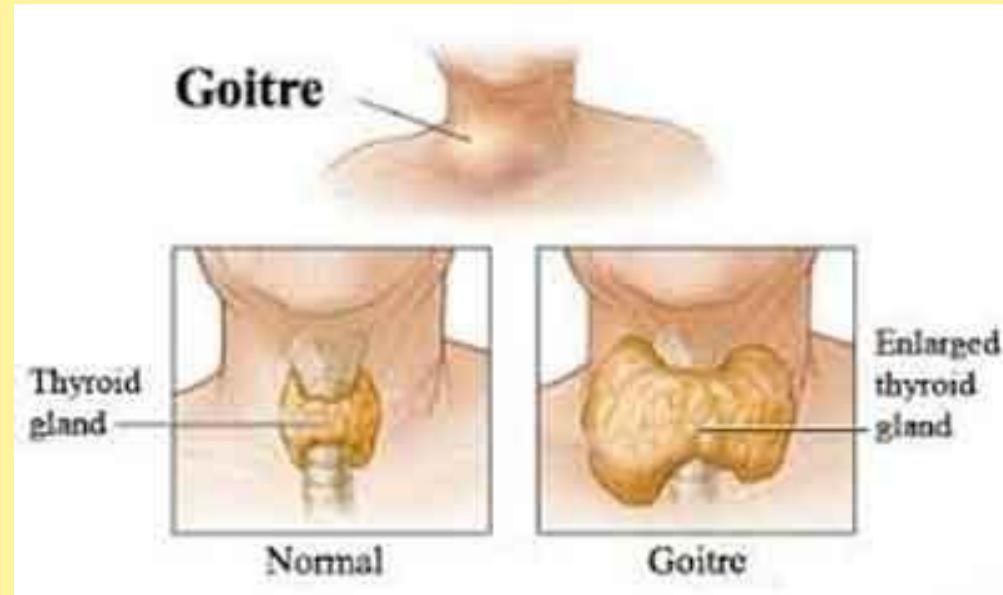
## Myxoedema:

- Deficiency in adults
- Thickening and puffiness
- Lacks alertness, intelligence
- Low B.P, Low body temperature
- Retarded sexual development



## Simple goitre:

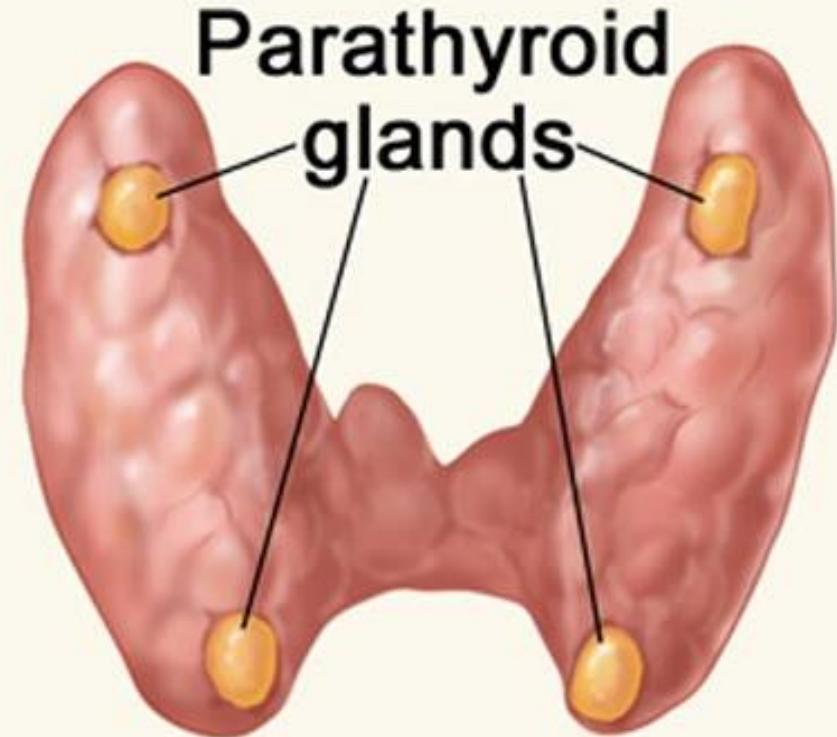
- deficiency of iodine in diet
- Enlargement of thyroid gland
- Common in hilly regions
- Use of table salt(iodized)



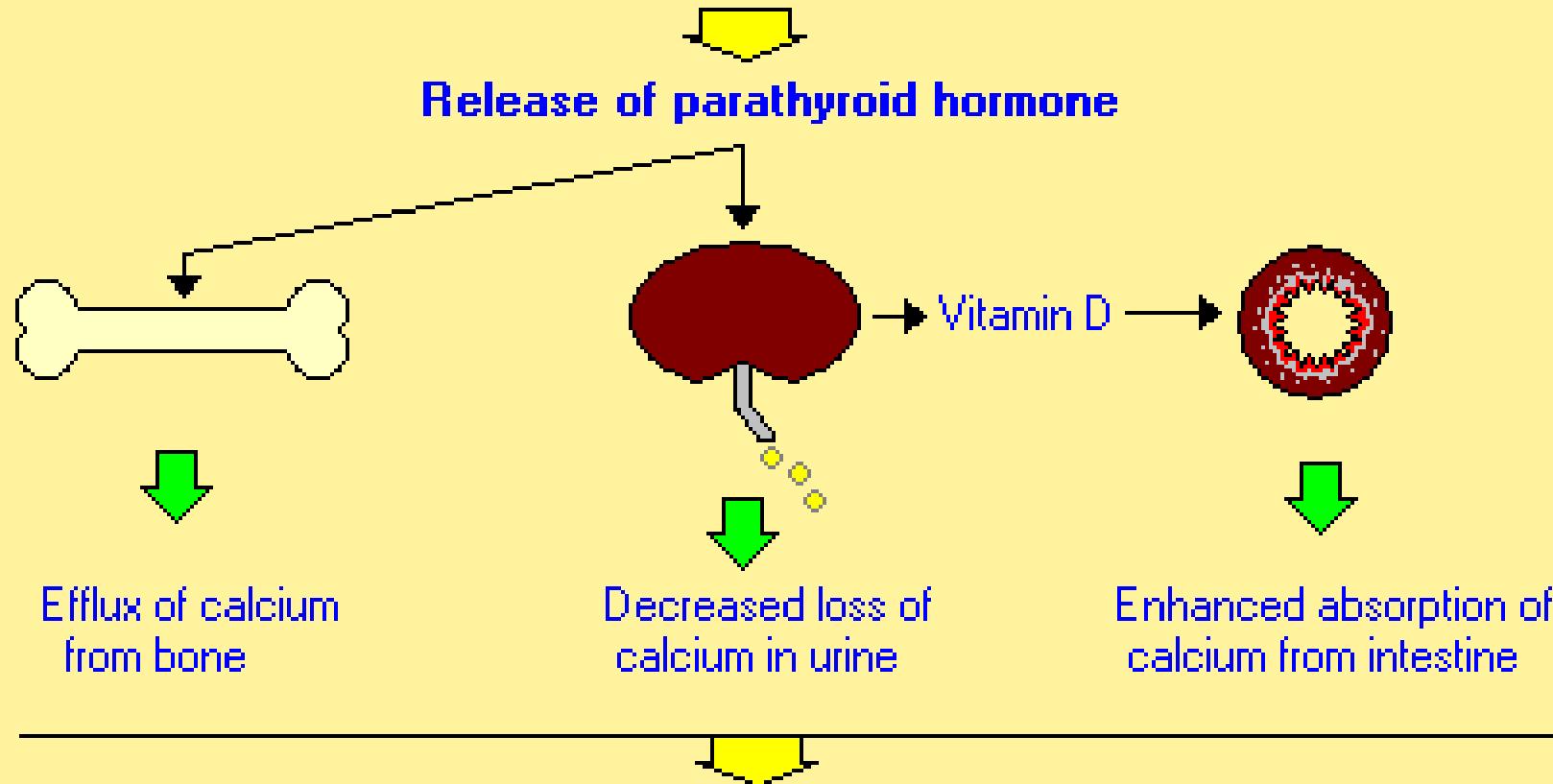
## E) Parathyroid gland:

- Four in number
- Two superior ,two inferior
- Posterior surface of thyriod gland
- Secrete **parathormone(PTH)**  
also called **Collip's hormone**
- It increases blood calcium level

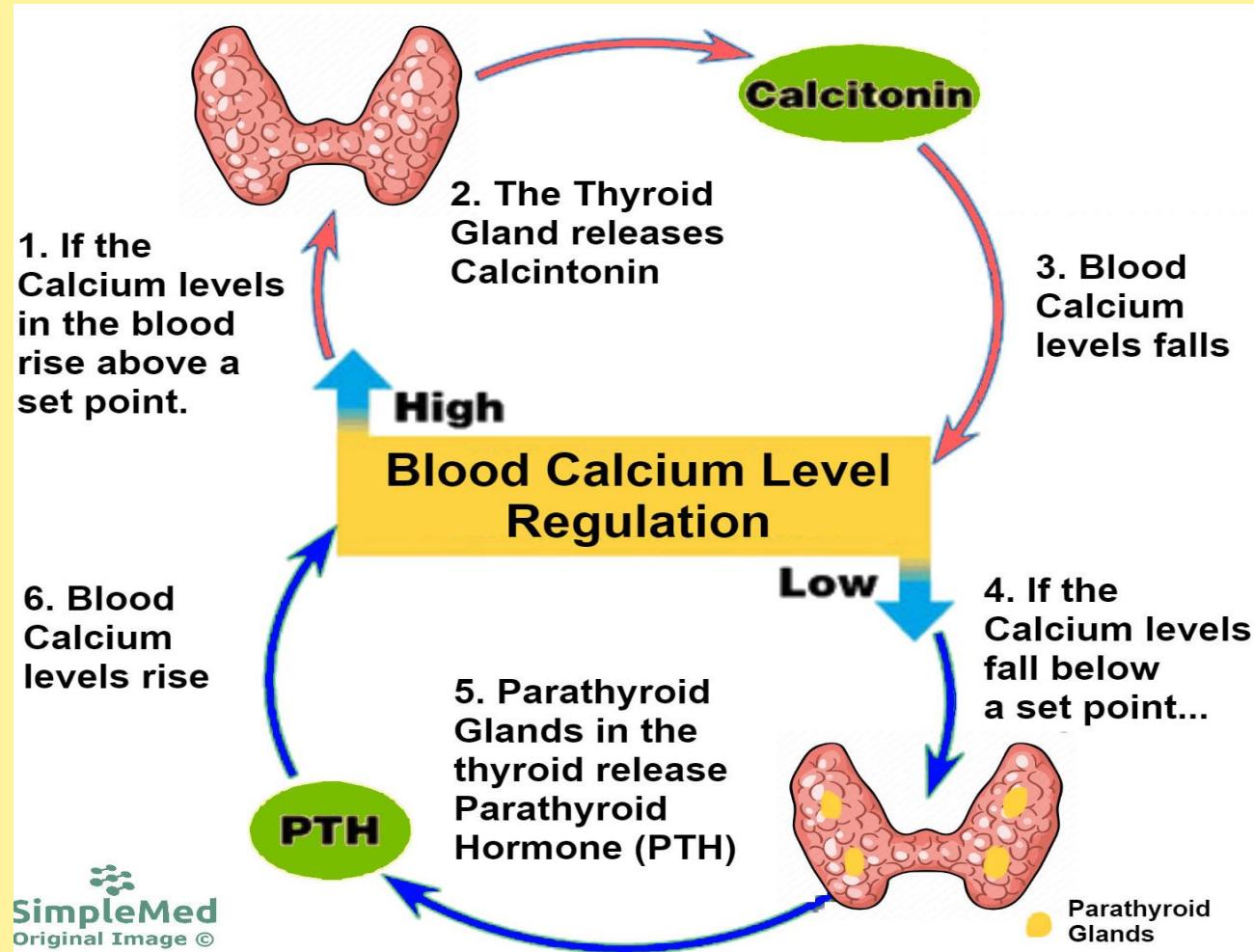
**Thyroid gland (back view)**



**Low concentration of calcium in blood**



# Calcitonin and parathormone maintain concentration of calcium and phosphate



- **HYPOSECRETION:**

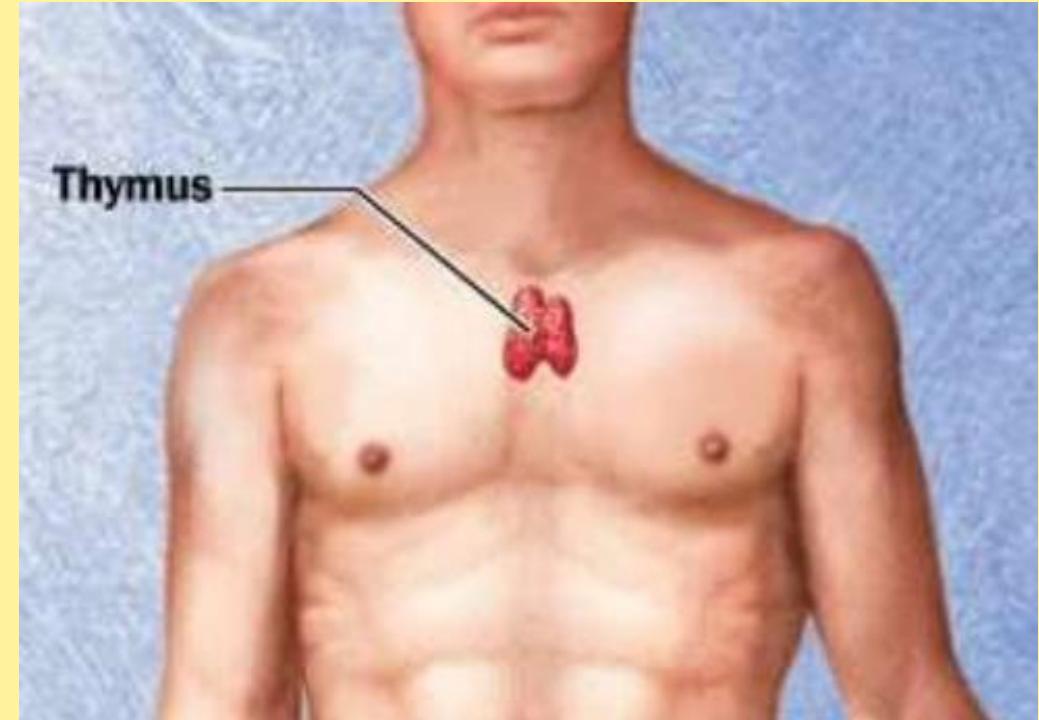
- Lowers concentration of calcium in blood
- Increases excitability of nerves and muscles
- **Parathyroid tetany or hypocalcaemic tetany.**

- **HYPERSECRETION:**

- Demineralization of bones (fracture)
- **Osteoporosis**
- Common in women (menopausal).

## F) Thymus gland:

- Upper part of thorax
- Bilobed mass (lymphoid tissue)
- **Temporary gland**(atrophied in adults)
- Secretes **thymosin**  
**(maturation of T-lymphocytes)**
- Promotes antibody production



## G) Adrenal gland/ Suprarenal gland:

- Dual origin (mesoderm and ectoderm)
- Two distinct regions:

i) **Cortex** (outer)

ii) **Medulla** (inner)

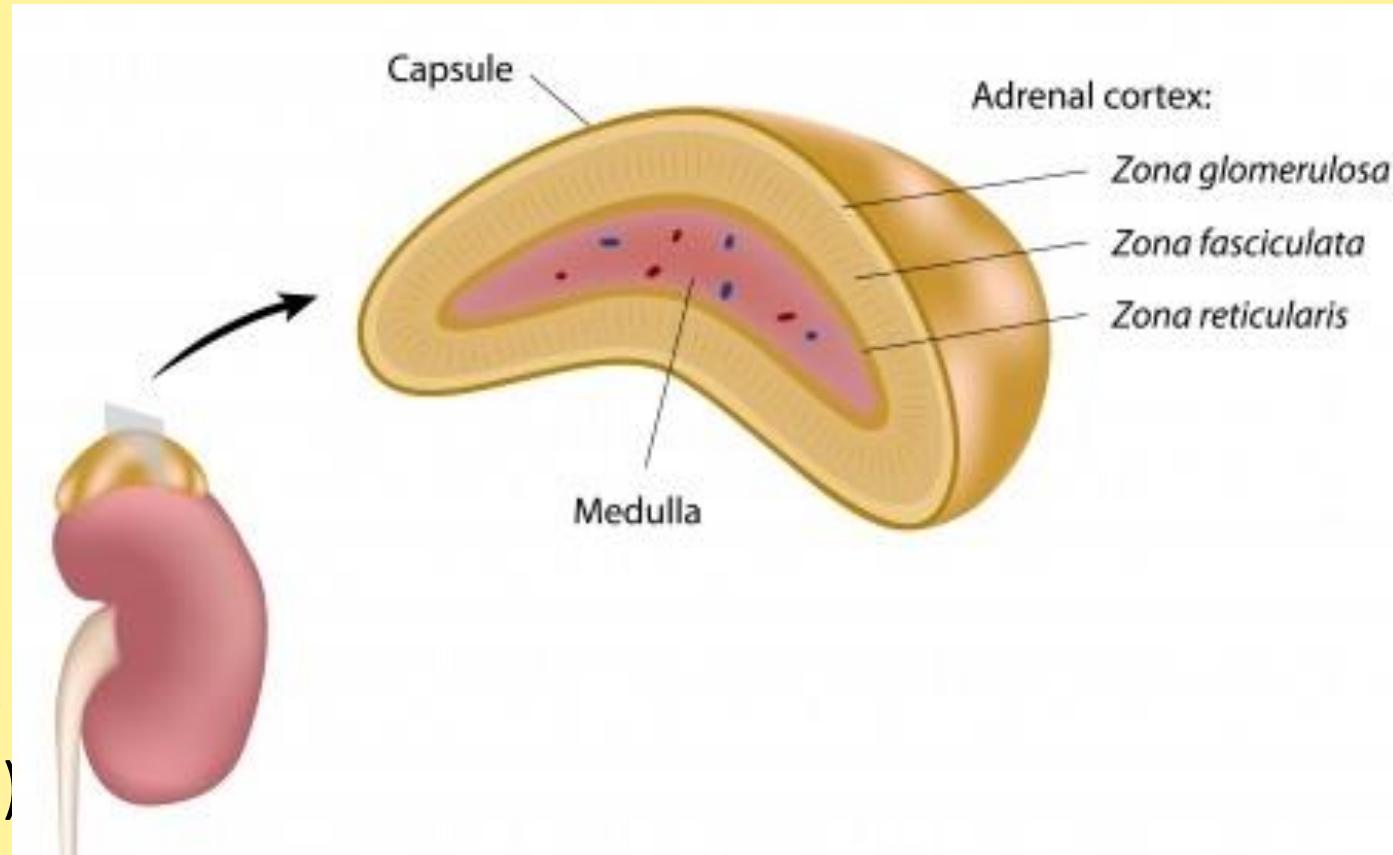
1) **Adrenal cortex:**

- origin: embryonic mesoderm
- Secrete hormones(**corticoids**)
- Differentiated into:  
(3 concentric regions)

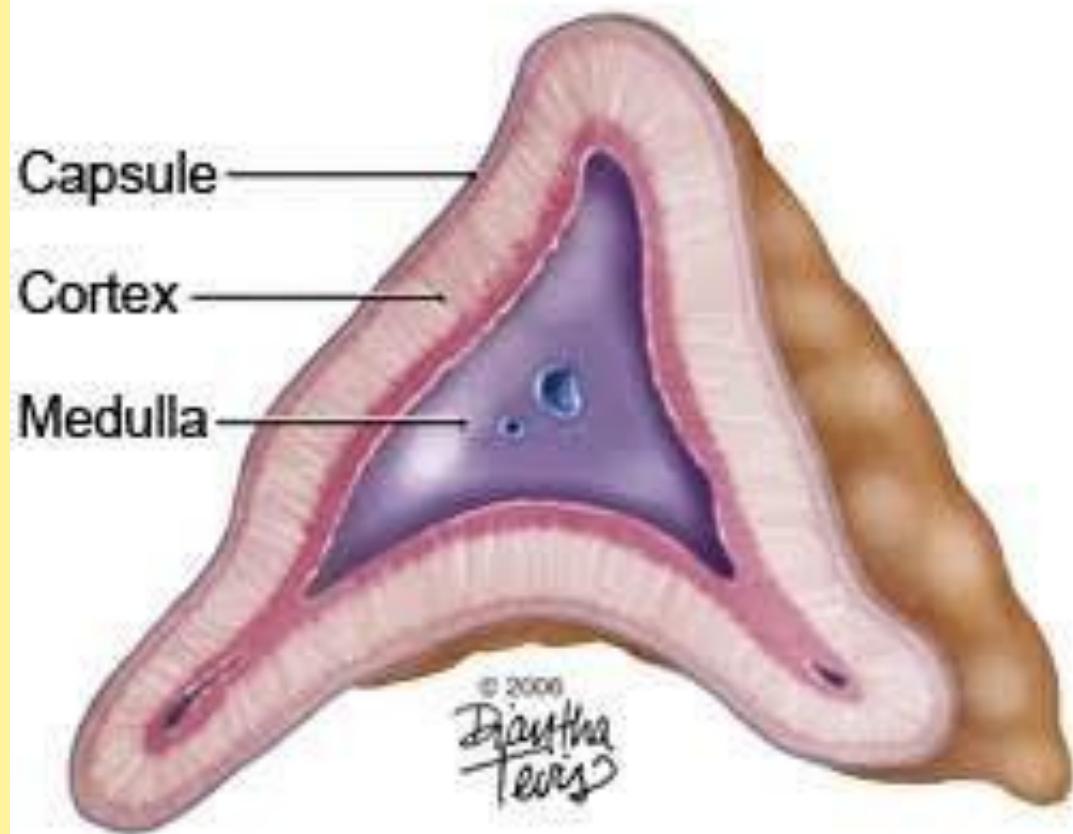
a) **Zona glomerulosa** (outer,thin)

b) **Zona fasciculata** (middle,thick)

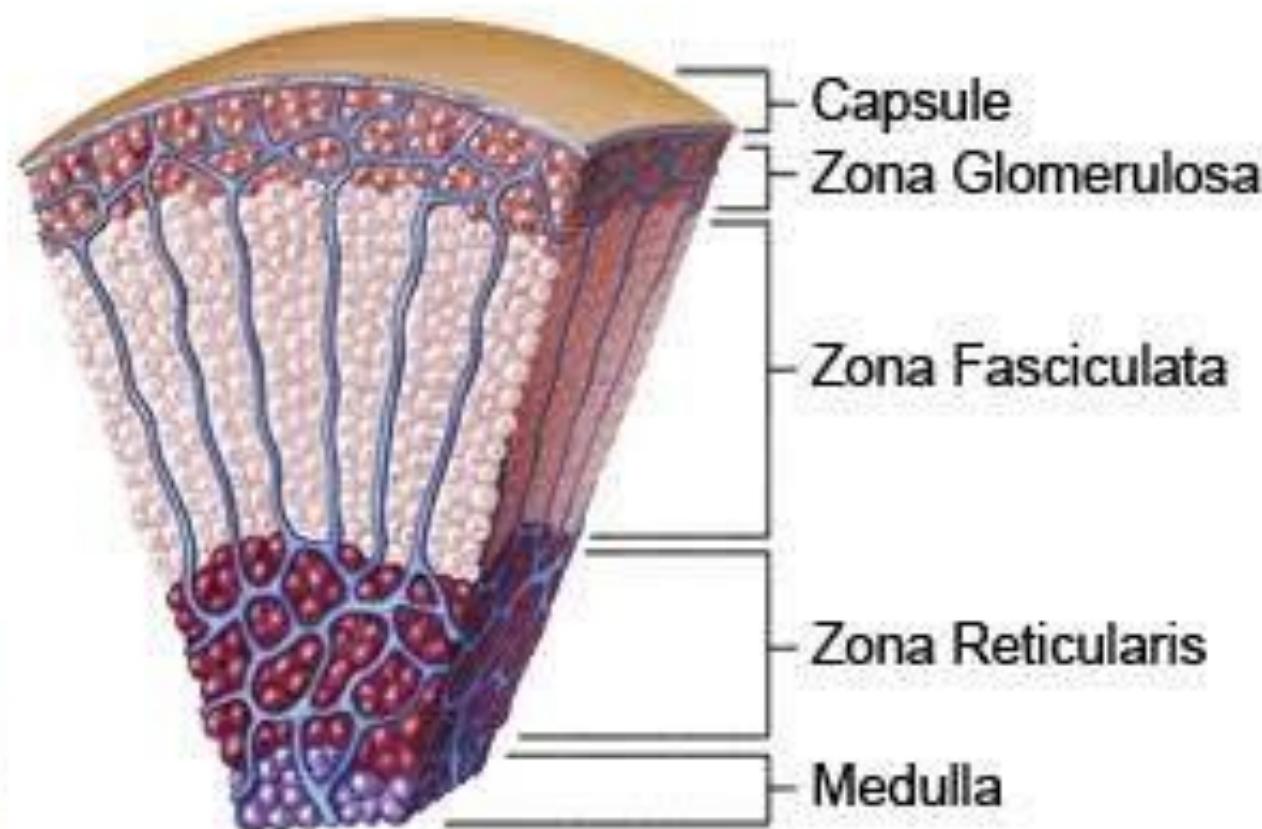
c) **Zona reticularis** (inner,thin)



## Transverse Section

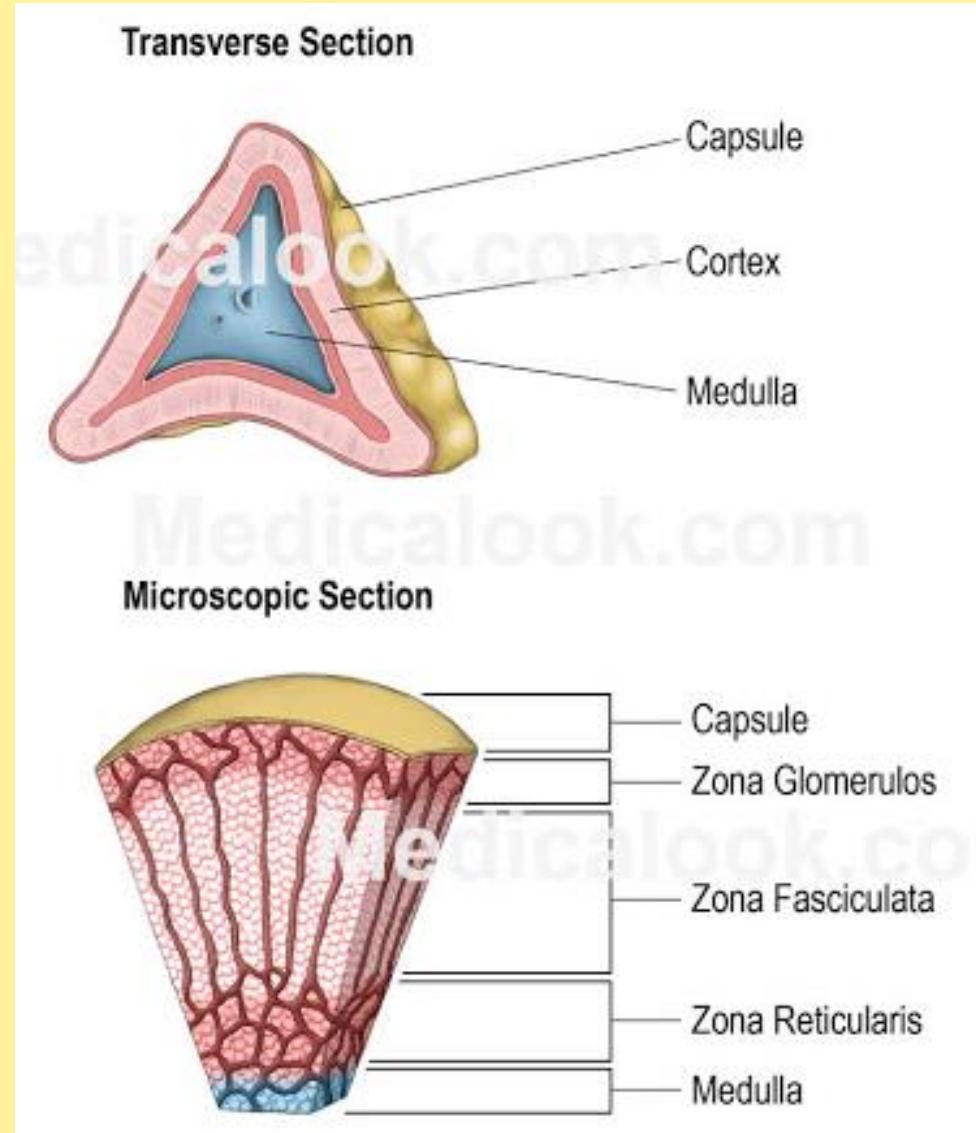


## Microscopic Section



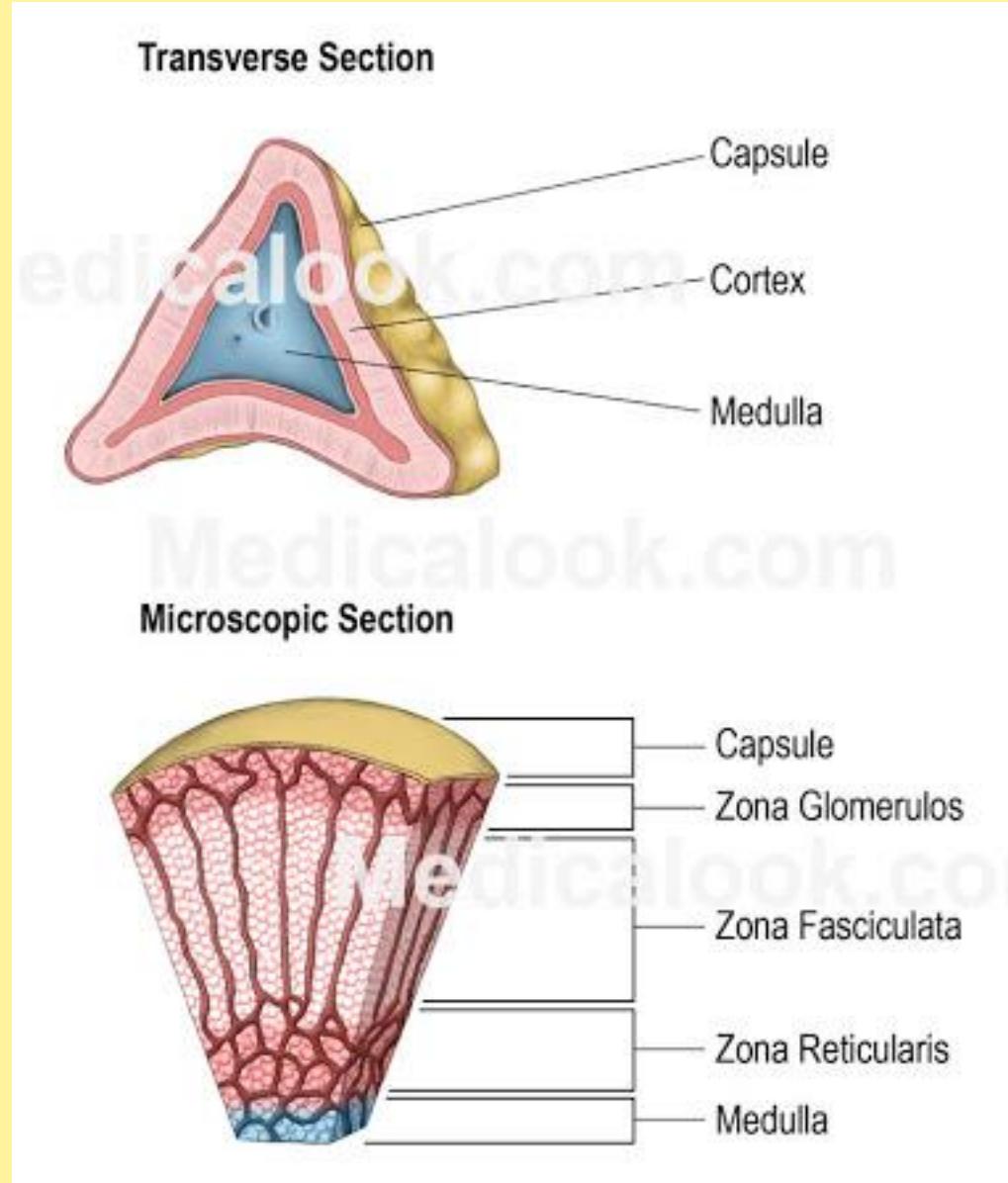
### a) Zona glomerulosa:

- Outer , thin
- Secretes **mineralocorticoids**
- Regulates:
  - sodium and potassium ion conc
  - Salt water balance
  - Blood volume/pressure
- **Aldosterone** main mineralocorticoid (salt retaining hormone)



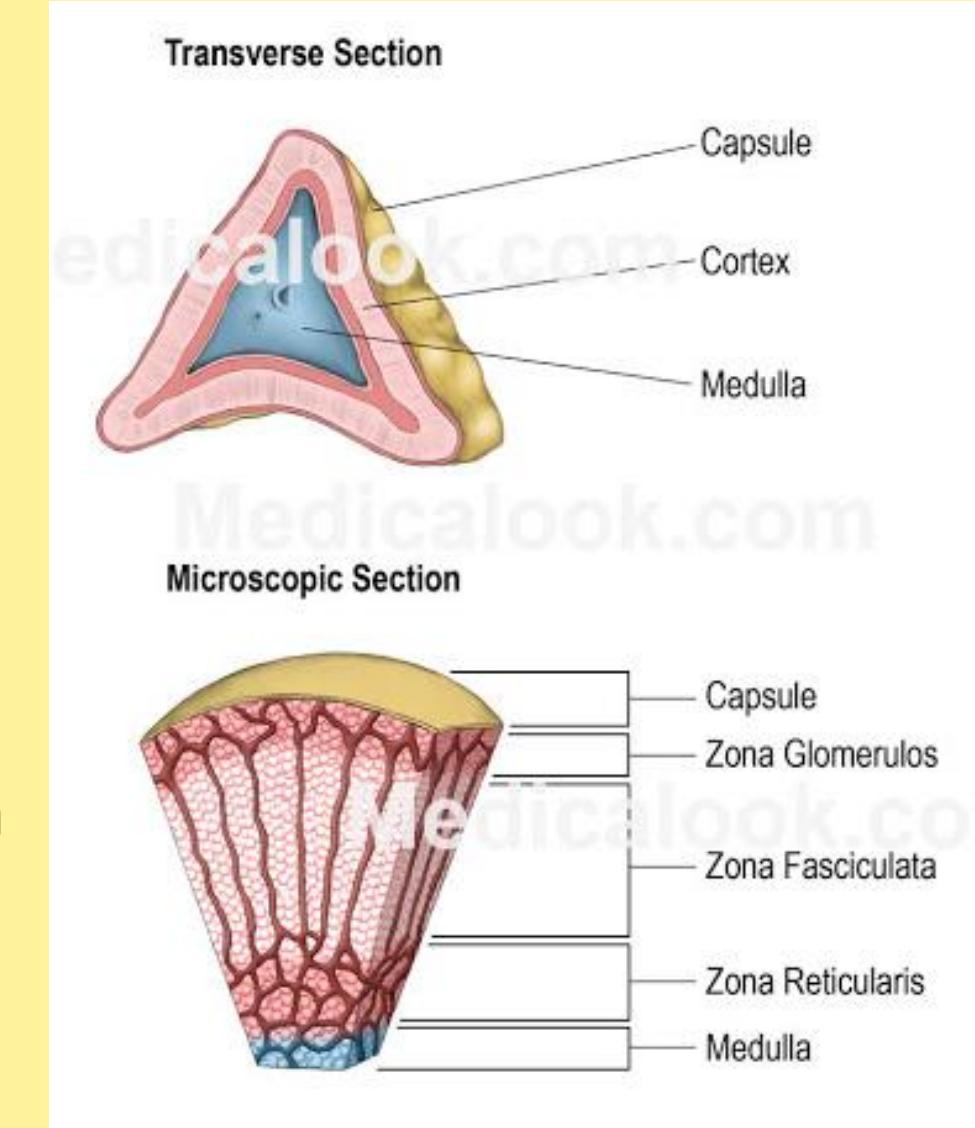
## b) Zona fasciculata:

- Middle, thick
- Secretes **glucocorticoids**
- Regulates carbohydrates, lipids, protein metabolism
- **Cortisol** is important glucocorticoid
  - Increase blood glucose level
  - It is immunosuppressive (treatment of allergy)



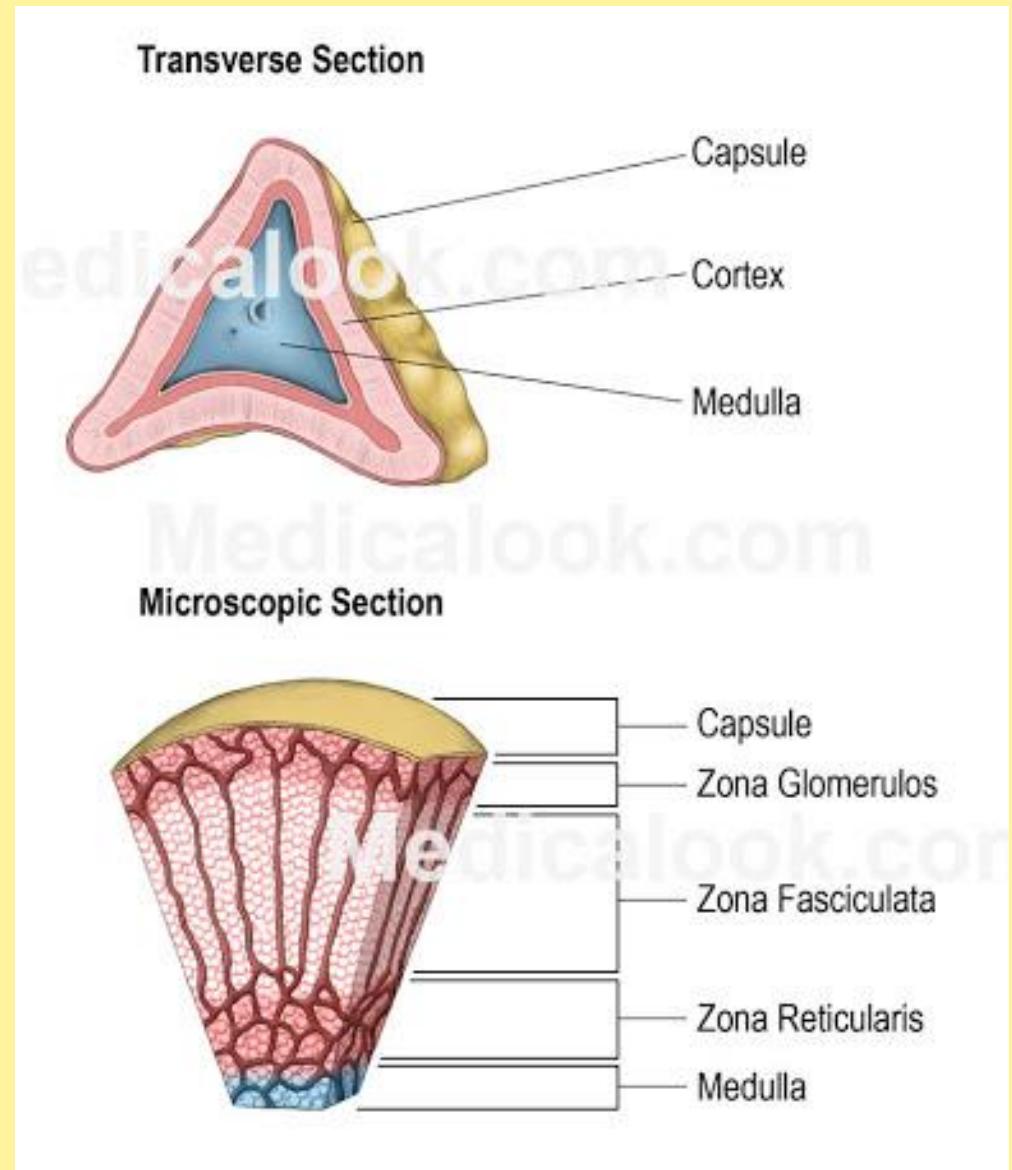
### c) Zona reticularis:

- Inner, thin
- Secretes sex corticoids  
**( gonadocorticoids)**
- **Androgens and estradiols**
- Males – development of external sex characters
- Excess hormones causes – **Adrenal virilism and hirsutism (Females)**  
**while Gynaecomastia (Males)**

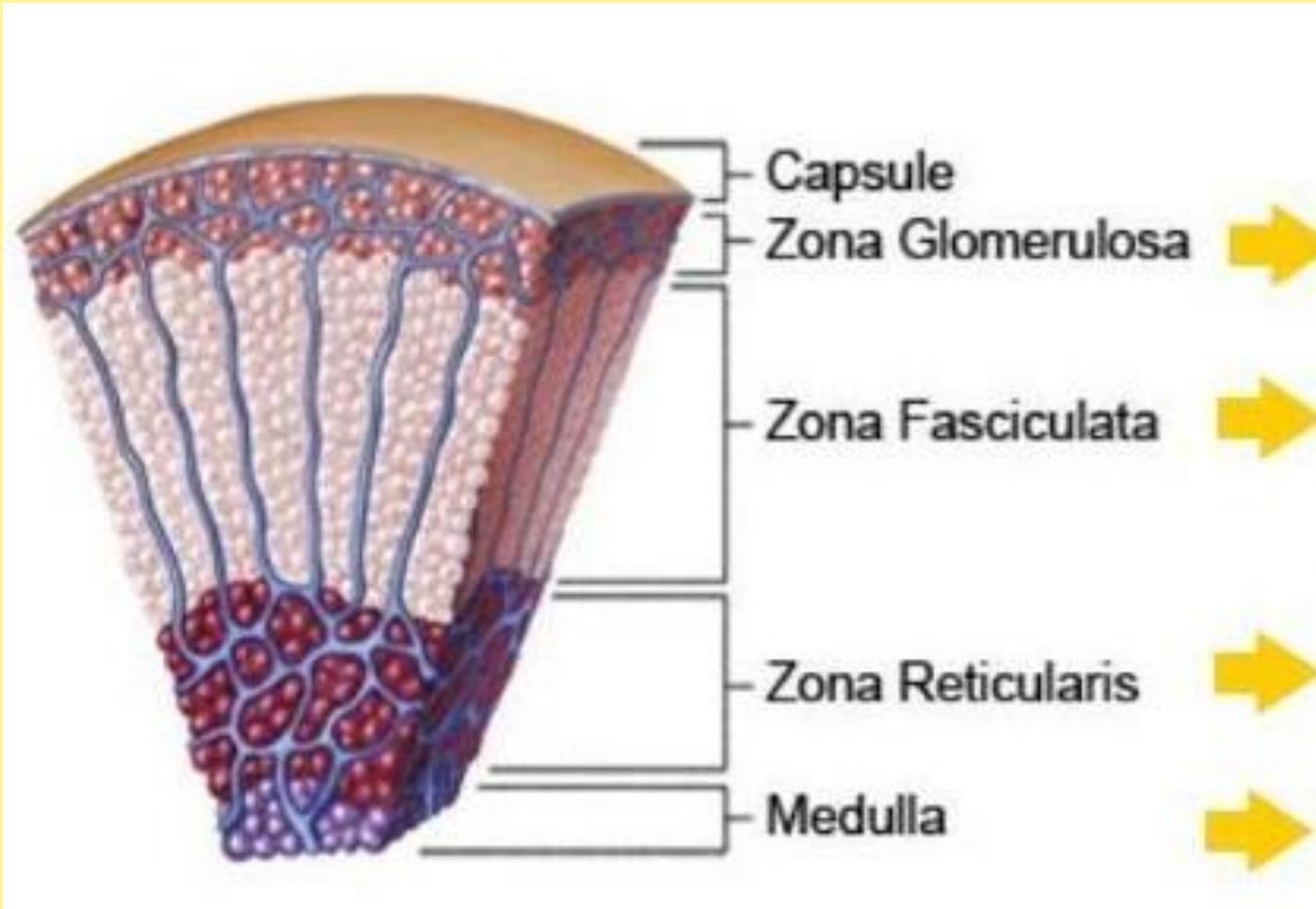


## 2) Adrenal medulla:

- Origin: ectoderm
- Secretes hormones-  
**adrenaline(epinephrine)**  
**and noradrenaline(norepinephrine)**
- Adrenaline:
  - **Emergency hormone / 3 F hormone**
- Noradrenaline:
  - Regulates B.P under normal conditions
  - Vasoconstrictor



# HORMONES OF ARENAL GLAND:



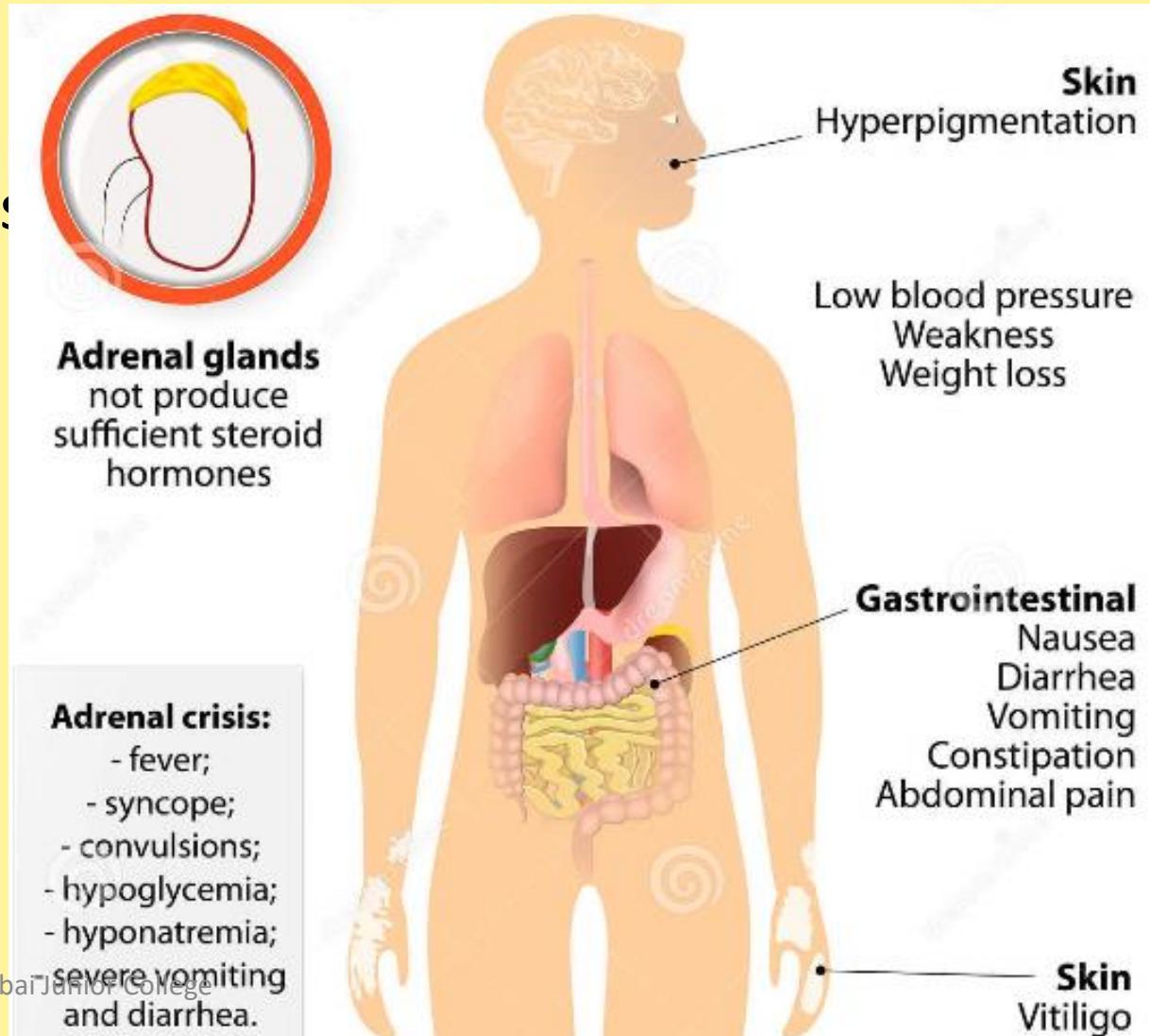
# DISORDERS RELATED TO ADRENAL CORTEX:

## a) Hyposecretion:

### - Addison's disease

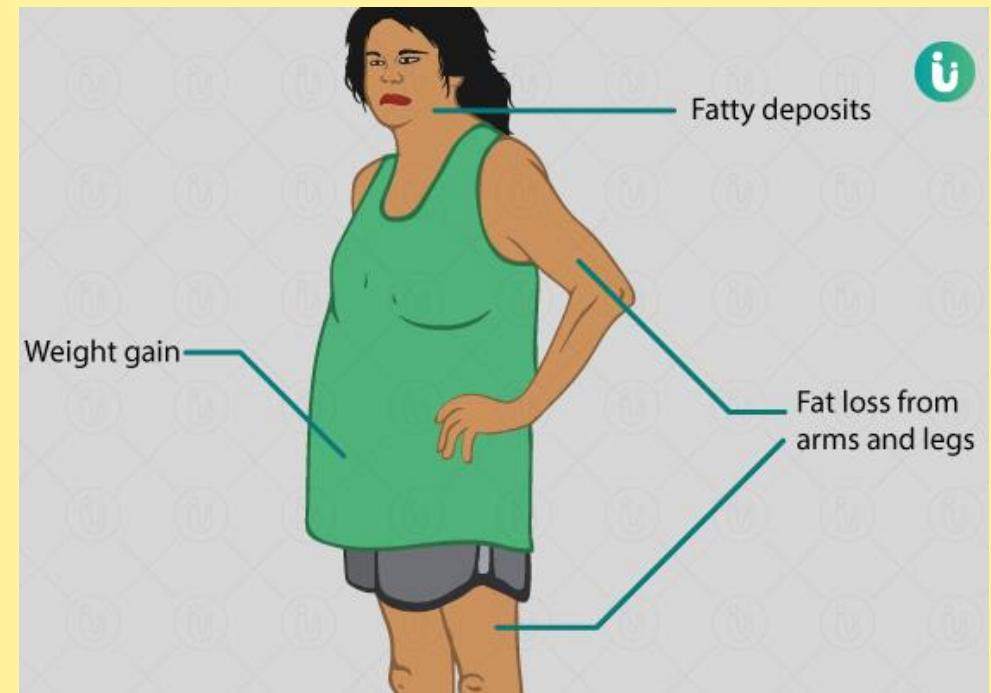
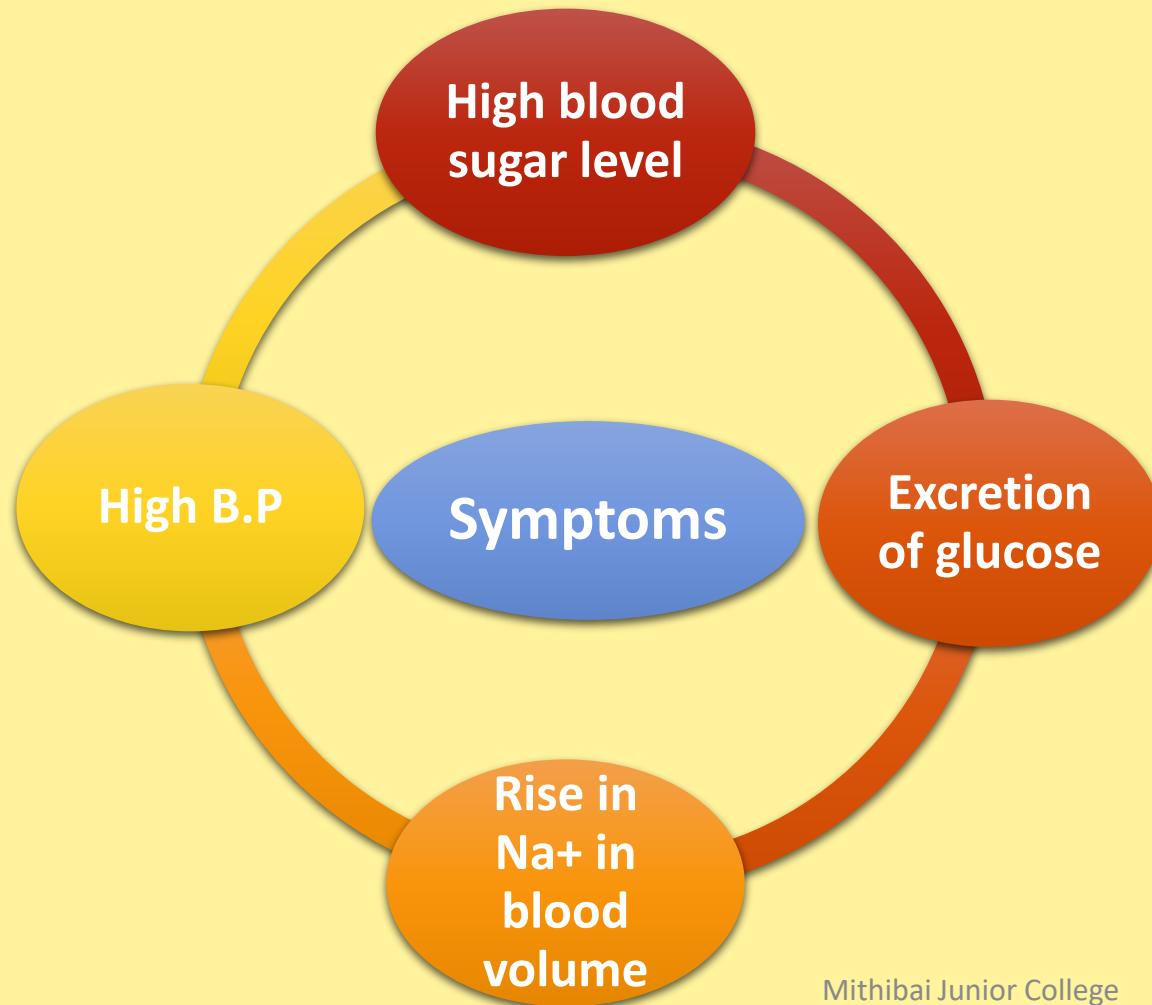
(less secretion- mineralocorticoids; glucocorticoids)

### Symptoms of addison's disease



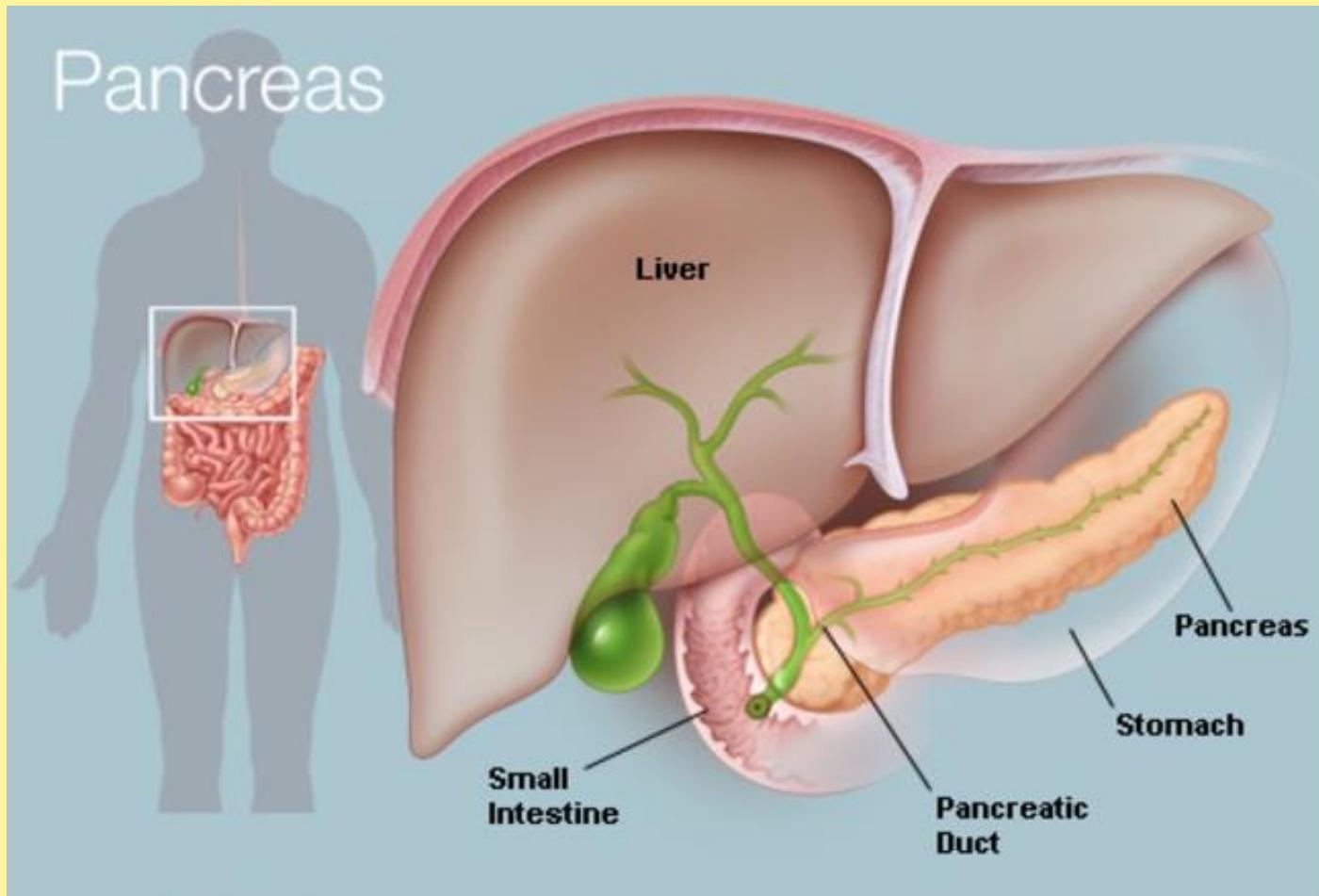
## b) Hypersecretion:

- **Cushing's disease** (increase secretion- glucocorticoids)



## H) Pancreas:

- Origin: endodermal
- Heterocrine gland
- Endocrine cells form group  
**(Islets of langerhans)**



- **Four types of cells:**

- I) **Alpha ( $\alpha$ ) cells:** (20%)

- Secrete **glucagon** (glucogenolysis)

- II) **Beta ( $\beta$ ) cells:** (70%)

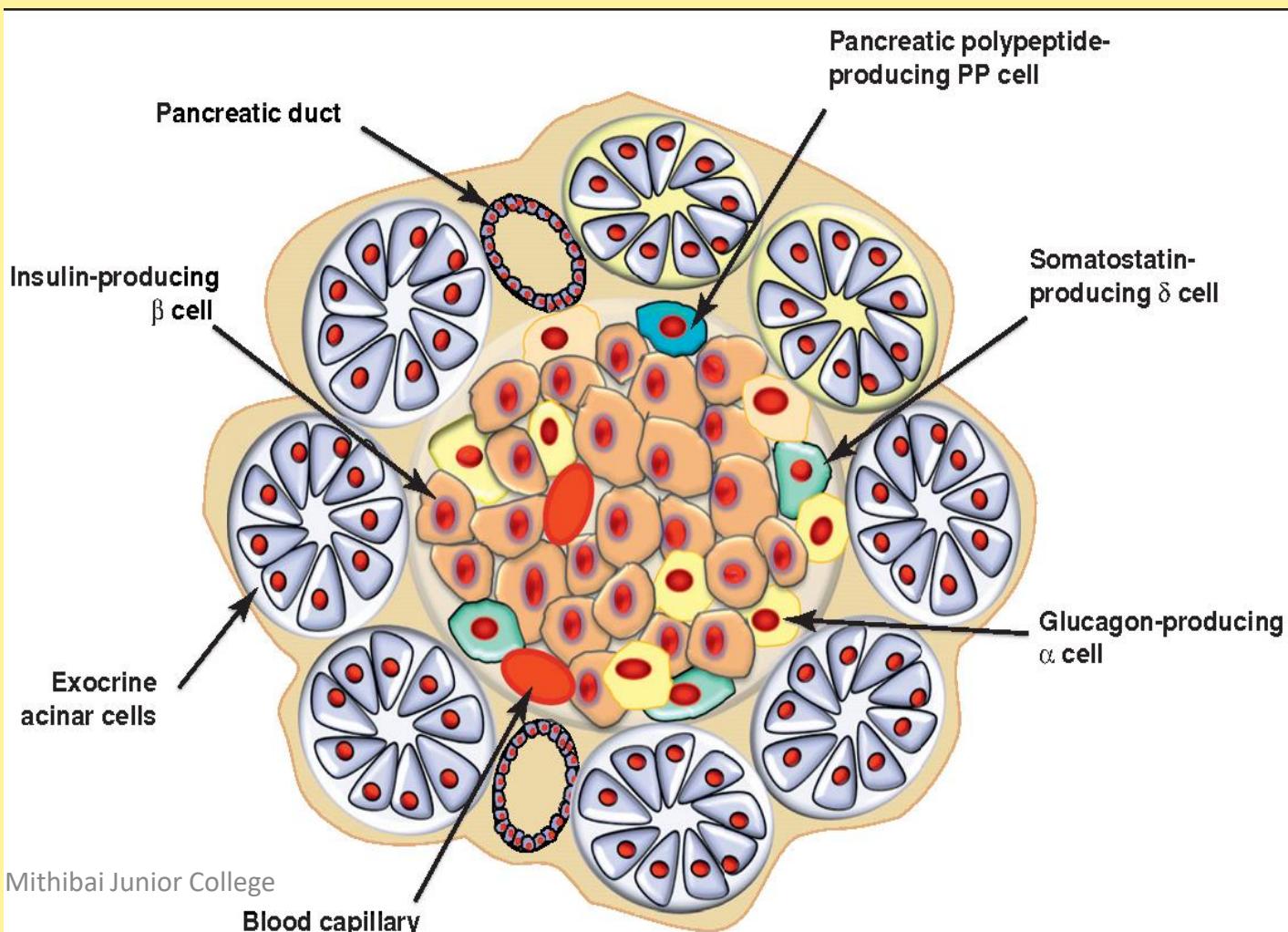
- Secrete **insulin** ( glycogenesis)

- III) **Delta ( $\delta$ ) cells:** (5%)

- Secrete **somatostatin**  
(inhibits both)

- IV) **PP cells or F cells:** (5%)

- Secrete **pancreatic polypeptide(PP)**
- Inhibits release of pancreatic juice



# Disorder related to pancreas:

## Diabetes mellitus(Hyperglycemia):

- Under activity of beta cells
- Reduced insulin secretion
- Increase in blood glucose level

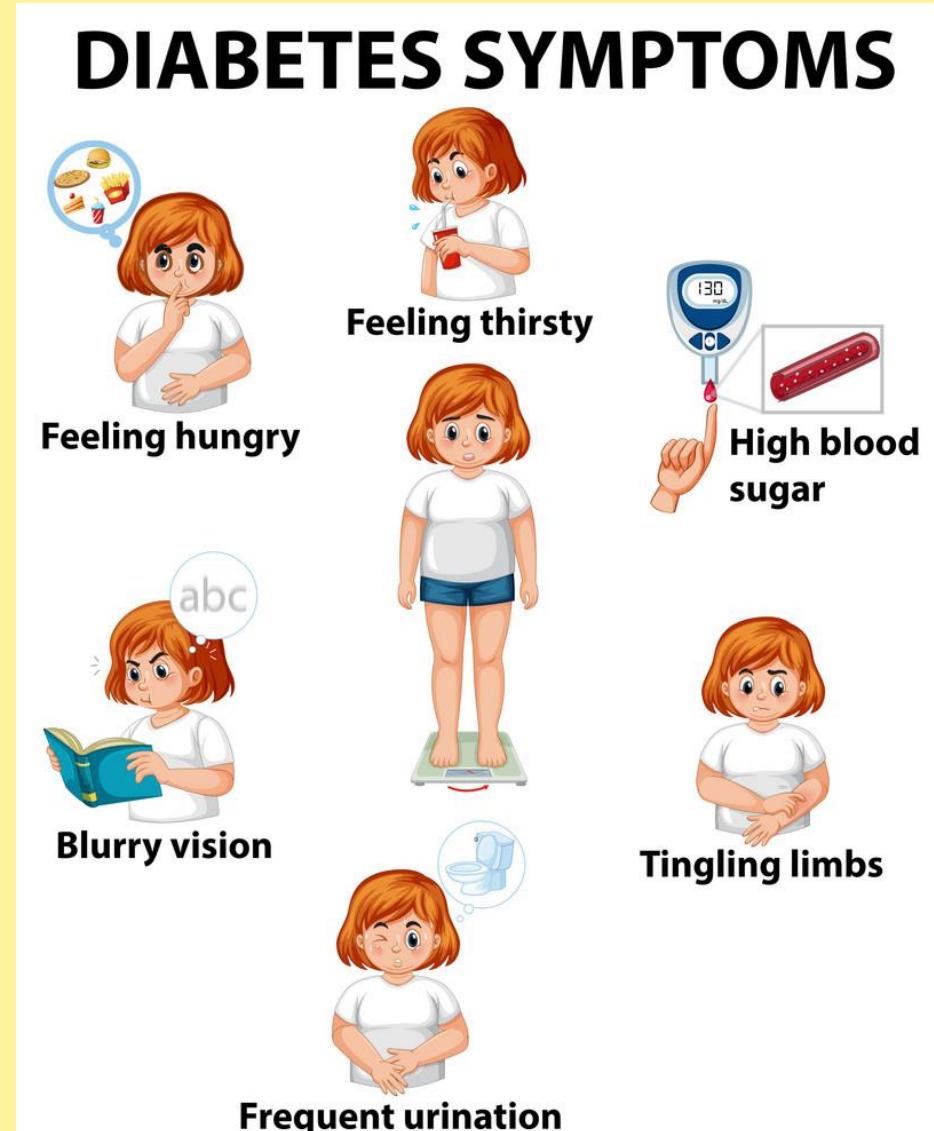
• Condition –

### **1) Insulin dependent diabetes mellitus**

**or Type I (IDDM)** – in children

### **2) Non insulin dependent diabetes mellitus or Type II (NIDDM)** – failure of insulin to allow movement of glucose into cells

- Insulin resistance(reduced sensitivity)
- Treatment: administration of insulin



## I) Gonads:

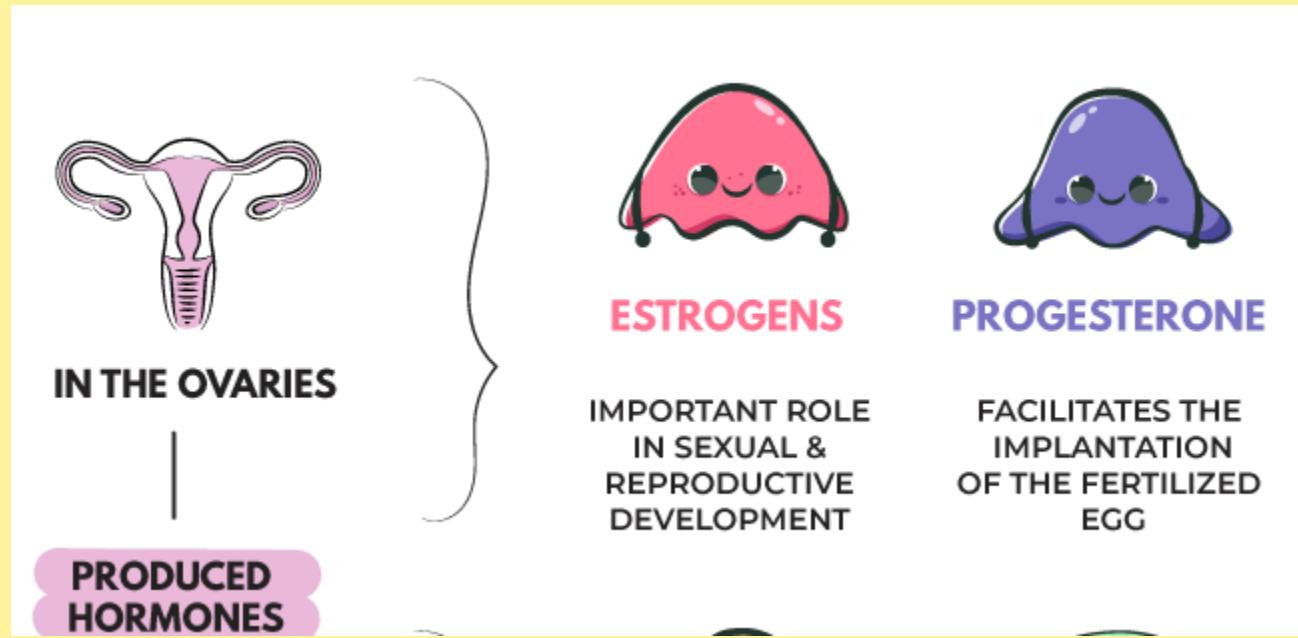
### i) Ovaries: (females)

#### 1) Estrogen:

- Secreted by developing follicles
- **Estradiol**(main oestrogen)
- Secondary sexual characters

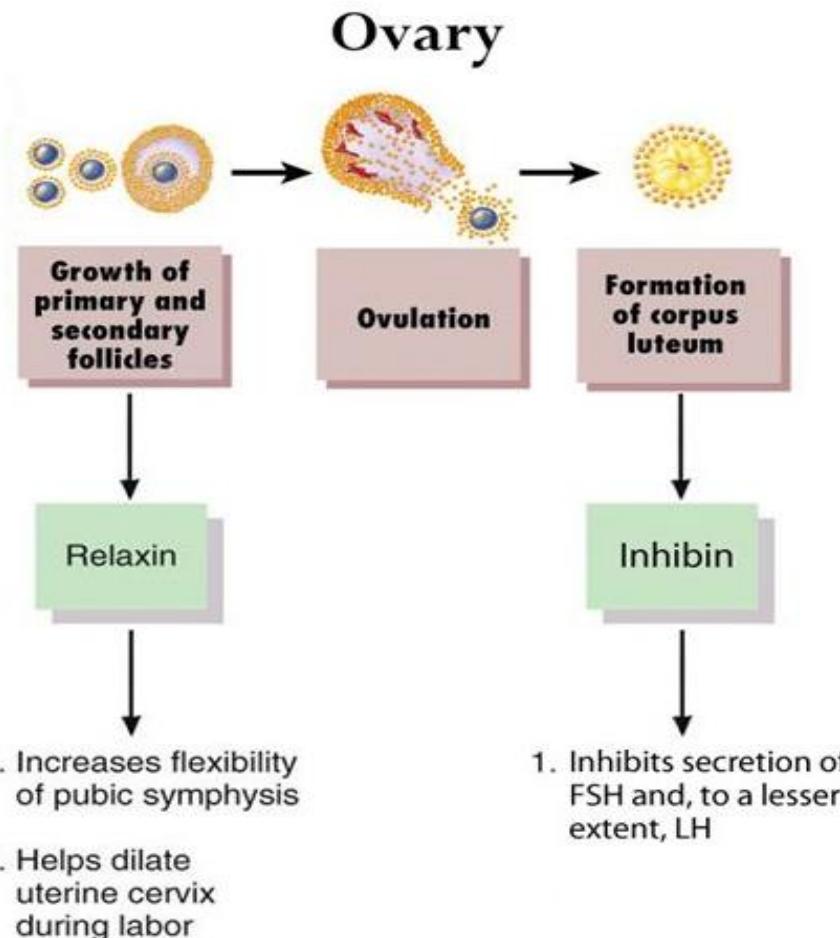
#### 2) Progesterone:

- Secreted by corpus luteum
- Prepares uterus (implantation)
- Development of mammary glands during pregnancy



3) **Relaxin** is released by the corpus luteum; it relaxes the myometrium and the pubic symphysis at the end of pregnancy

4) **Inhibin** is released by granulosa cells, and then in large amount by the corpus luteum; it inhibits FSH and LH



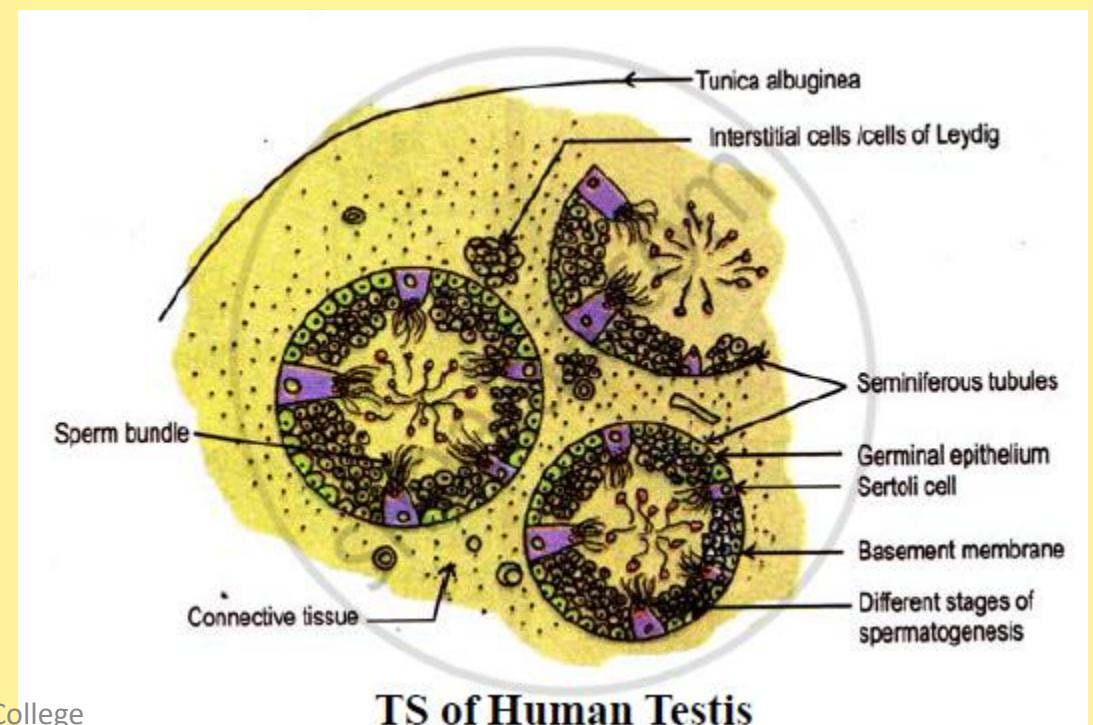
## ii) Testis : (Males)

- Secrete androgens e.g testosterone
- **Testosterone:**
  - Secondary sexual characters in males
  - Maintenance of testes

Leydig cells of testis



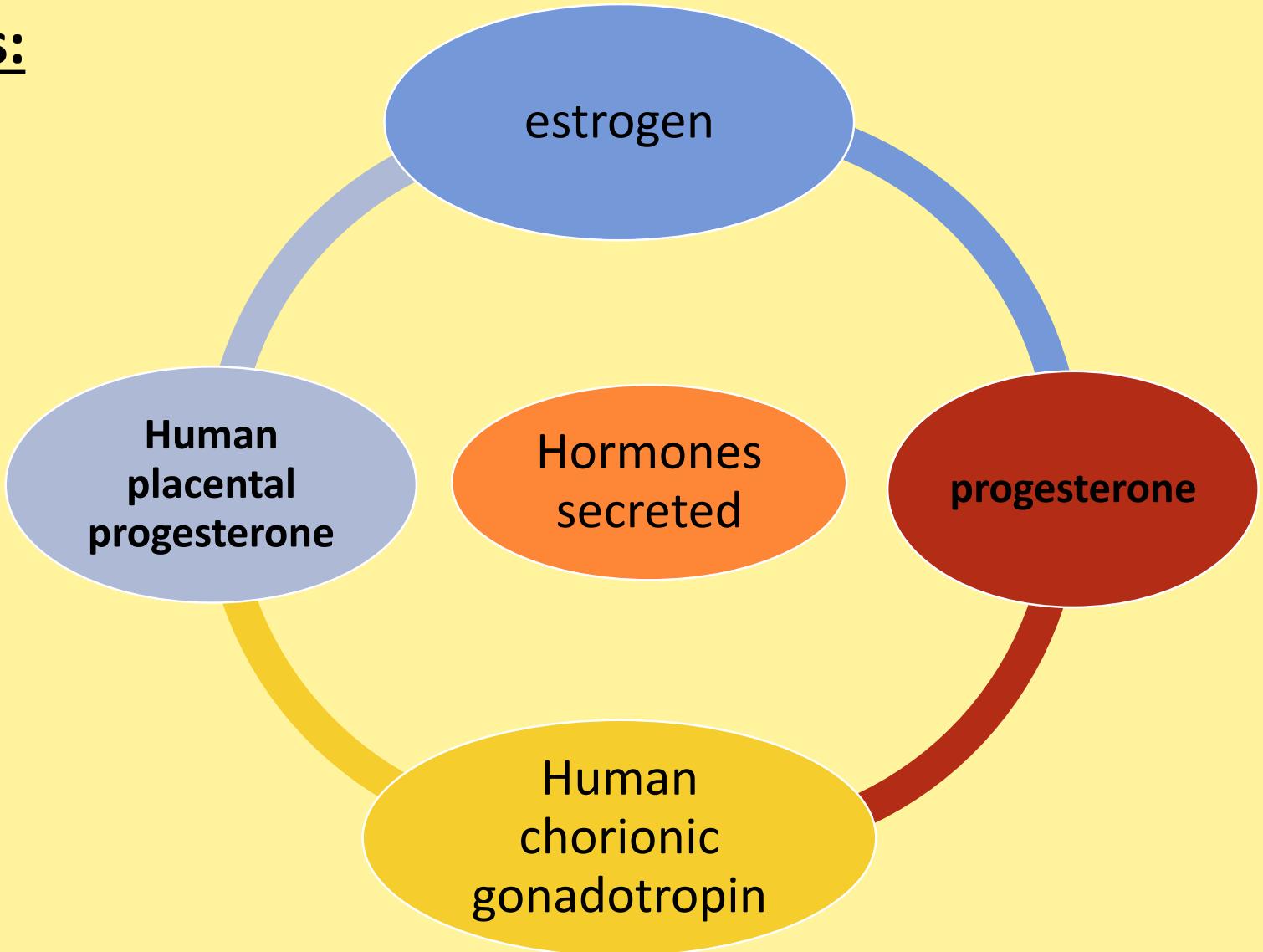
Testosterone



## J) Diffuse endocrine glands:

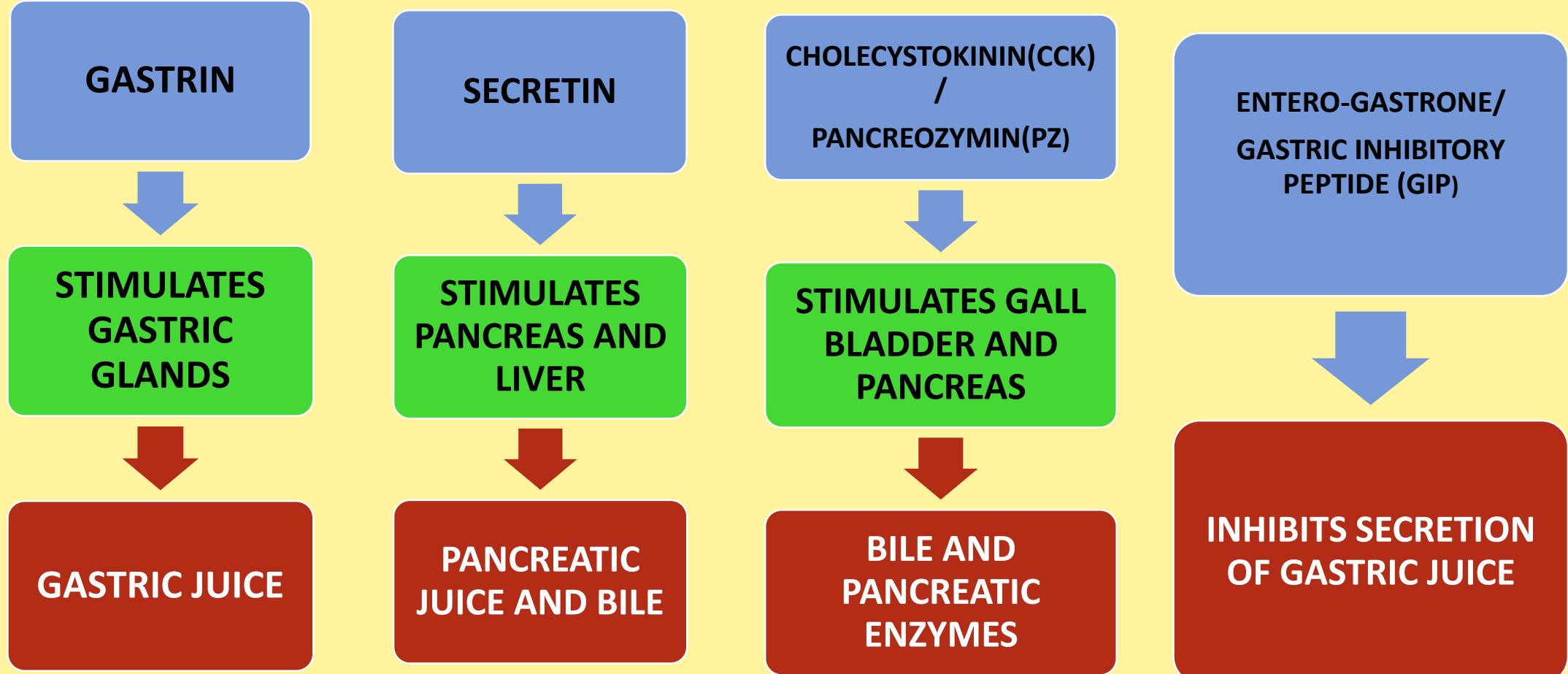
### Placenta:

- Temporary gland
- Connection  
(foetus and mother)
- Secreted hormones maintains pregnancy



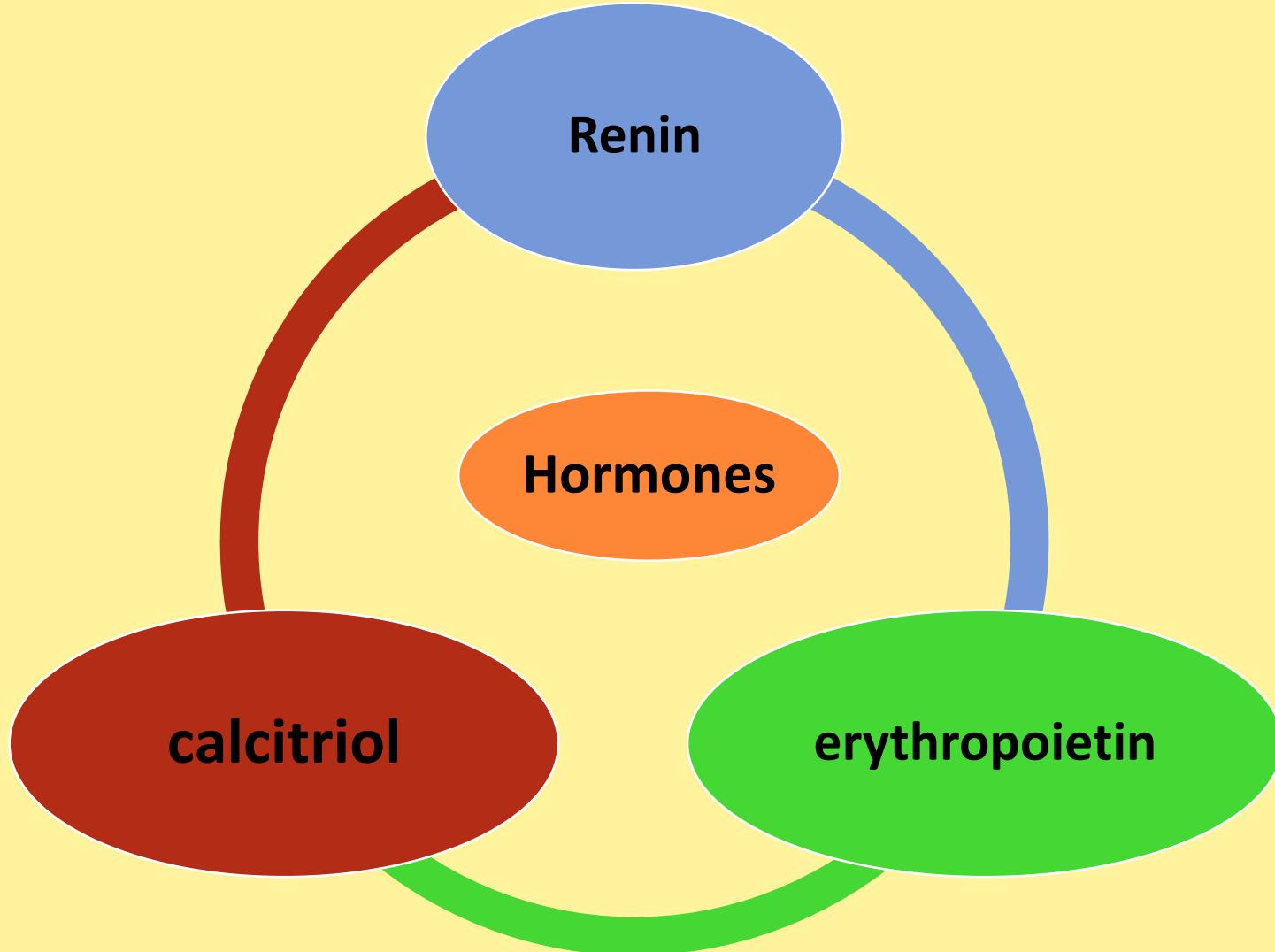
## Gastrointestinal tract:

- Gastrointestinal mucosa secretes-

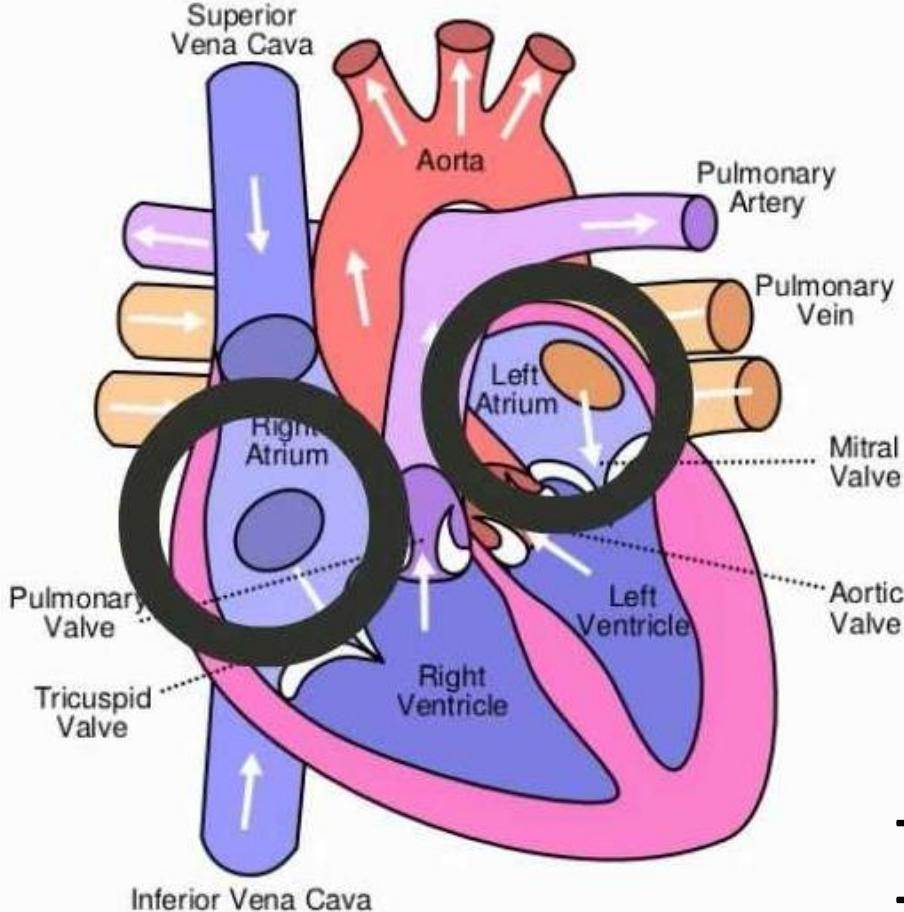


## KIDNEY:

- secretes-



## HEART:



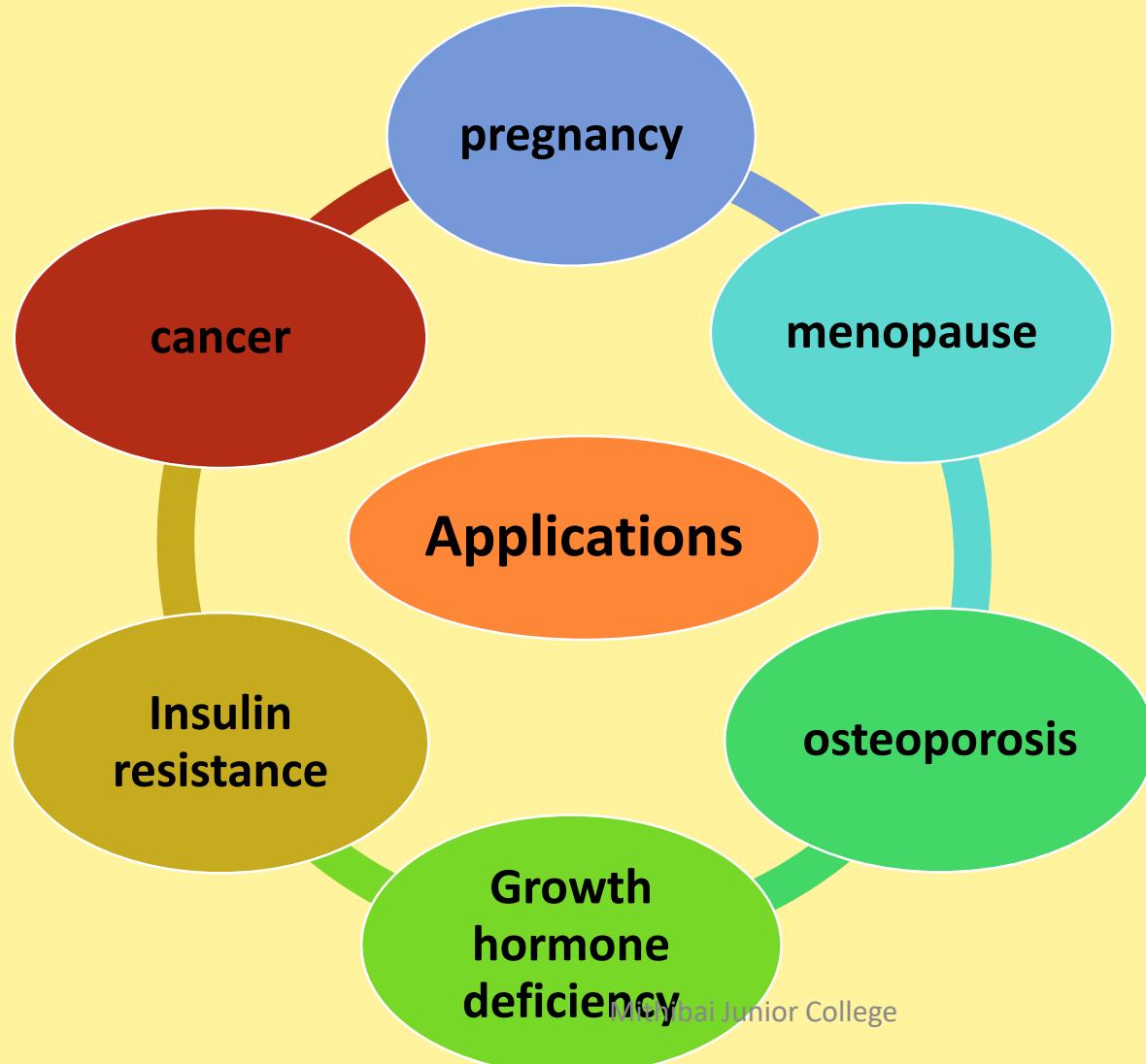
Atrial Natriuretic Peptide (ANP) is released by the atria of the heart

- Increase sodium excretion by kidneys
- Reduces B.P

# HORMONE THERAPY/HT:



- Use of hormones in medical treatment.



*That's all folks!*