

Control & coordination

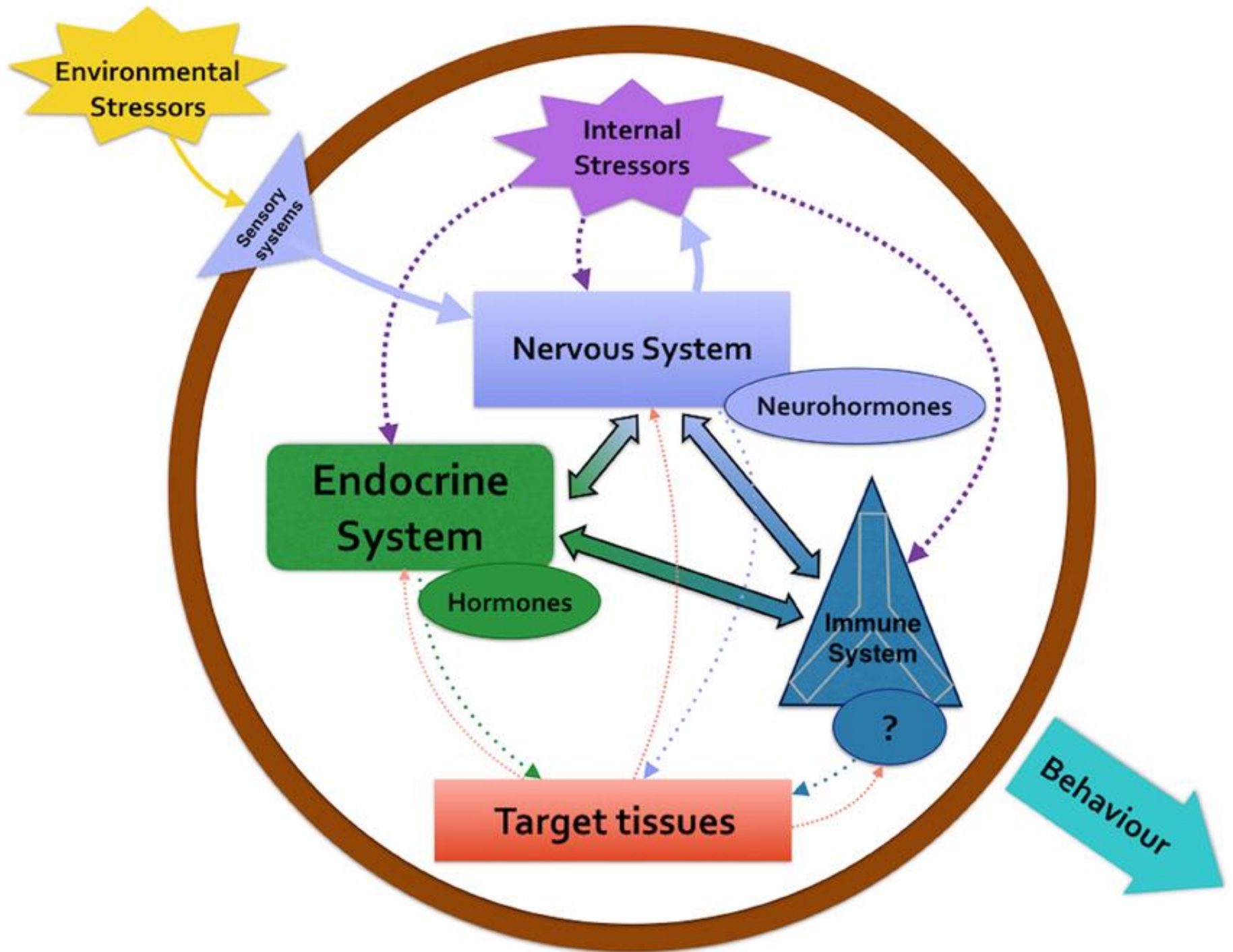
Chapter 9

Unicellular organism shows
simple
life processes.

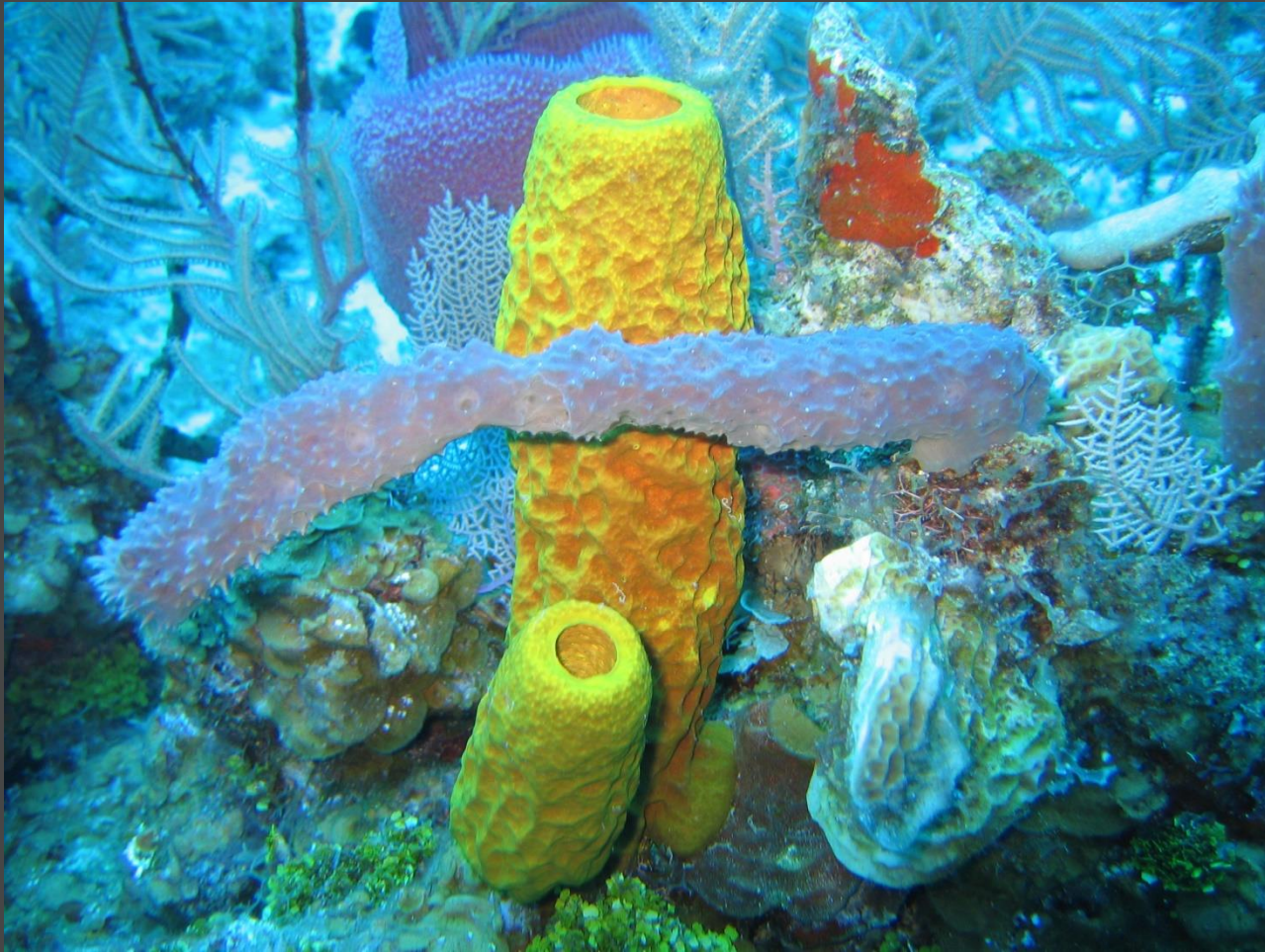
» Multicellular organism
shows complex life
processes.

Plants & Animals

- ▶ Plants shows chemical signals.
- ▶ Phototrophs are one of the good examples.
- ▶ Animals shows chemical and electrical signals.
- ▶ Reflex action is one of the good examples.



So these two systems nervous and endocrine goes hand in hand, & bring control and coordination with different cells, tissues, organs, and organ systems.



Guess what it is?

Yes, phylum Porifera.

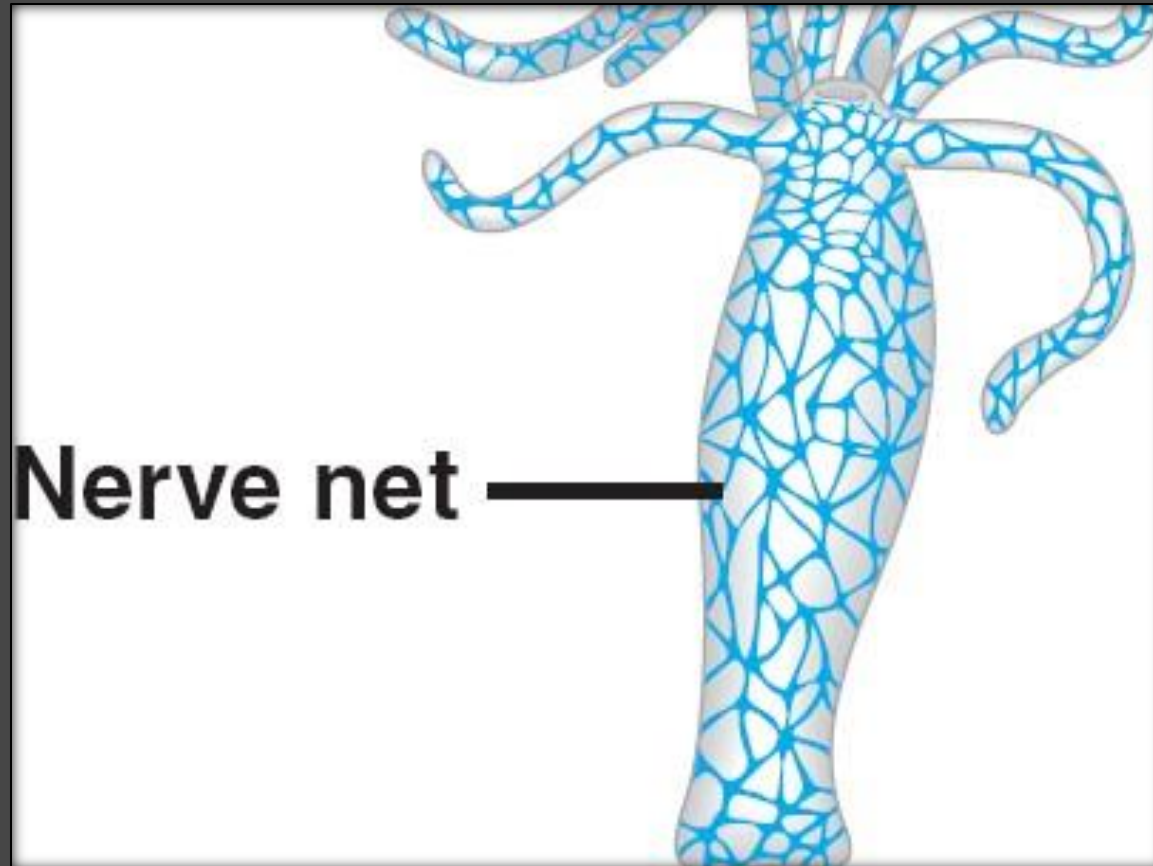


They show only cells, no tissues.
Various cells perform different functions,
like digestion, respiration, excretion etc.
But porifera lacking nervous system.
So they show least division of labour.

Phylum Cnidaria

Example: Hydra.

Primitive organism which shows nervous system. It consists of nerve cells & sensory cells. Nerve cells forms two nerve net.



Both the nerve net in hydra
present in mesoglea.

» One is in epidermis &
another is in gastrodermis.

Sensory cells are distributed all over the body wall & in the tentacles.

Neurons are not divided into sensory neuron or motor neuron. Activation of sensory cells can take place at any points and impulse can be carried through out the body in any direction.

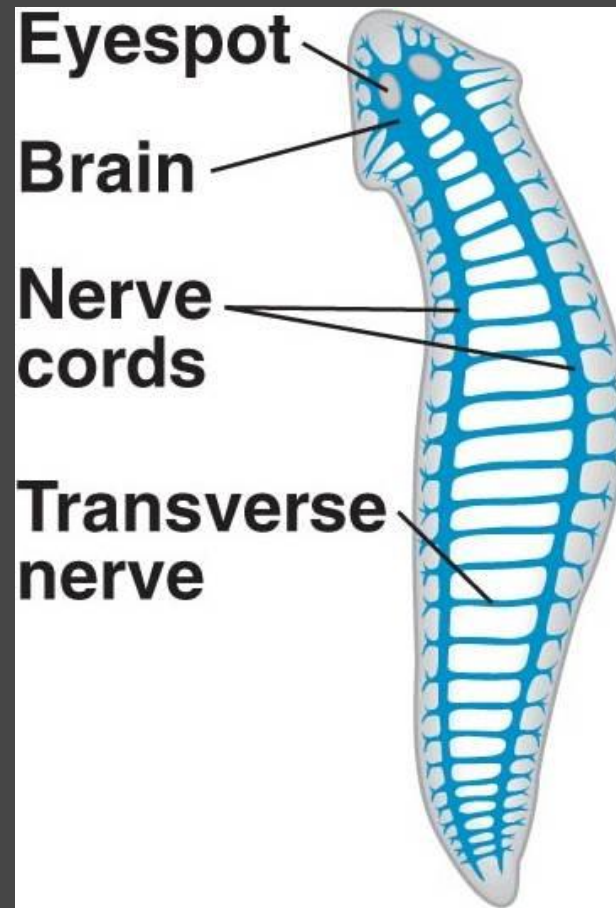
Example: Catching of the prey during feeding.

Phylum Ctenophora

»
Diffused type of nervous system is the landmark in the nervous system.

Planeria

Phylum : Platyhelminthes



The first primitive organism having central nervous system

- ▶ Cephalic or Cerebral ganglia lie in the anterior region of the body.
- ▶ From each ganglia arises nine branches.
- ▶ From below the ganglia arise a pair of Ventral nerve cord (VNC).
- ▶ VNC are interconnected with each other by transfer nerve or commissure.
- ▶ Peripheral nerve plexus arising from VNC.

A pair of photosensory structure , the eyes are located on dorsal side of the brain.

Neural tissue

Neurons

They are structural & functional cells of the nervous system.

Originate from embryonic layer ectoderm.

Lesser in numbers as compared to neuroglial cells.

Example: Sensory neuron, motor neuron, mixed neuron.

- ▶ **Neuroglial cells**
- ▶ They are supporting cells of the nervous system.
- ▶ Originate from embryonic layer ectoderm.
- ▶ Greater in numbers as compared to neurons.
- ▶ Example : Ependymal cell, schwann cells, microglia.

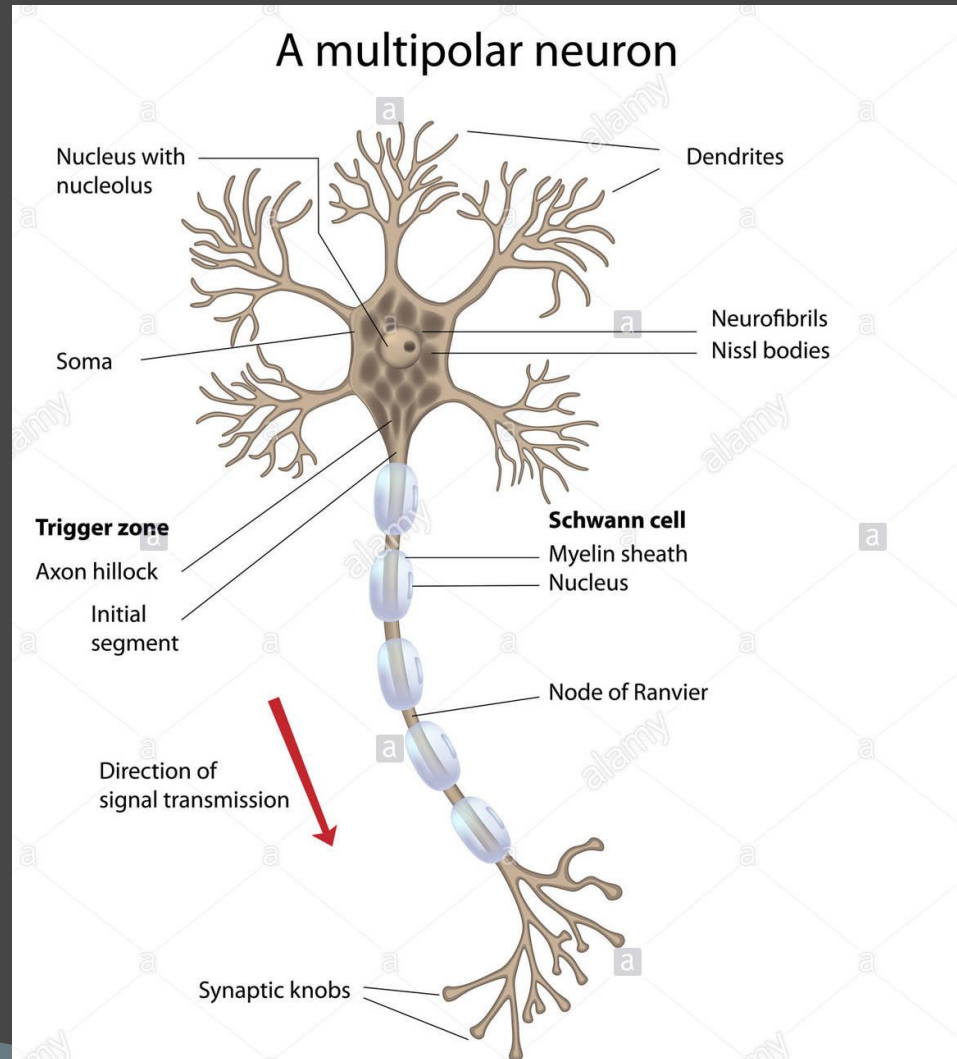
Types of neuron

Sensory neuron
Motor neuron
Mixed neuron

Types of neuroglial cells

Ependymal cell
Schwann cell
Microglia

Structure of multipolar neuron



Multipolar neuron has 3 parts

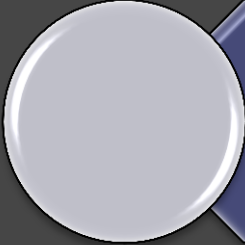
- ▶ Cyton or cell bodies : consists of neurofibrils, Nissl's granules & other cell organelles.
- ▶ Dendrons : small conical structures arising from cytons.
- ▶ Axon : single, long, unbranched processes, arising from cyton.

Synapse : Interconnection between two neuron or between neuron and motor organs.

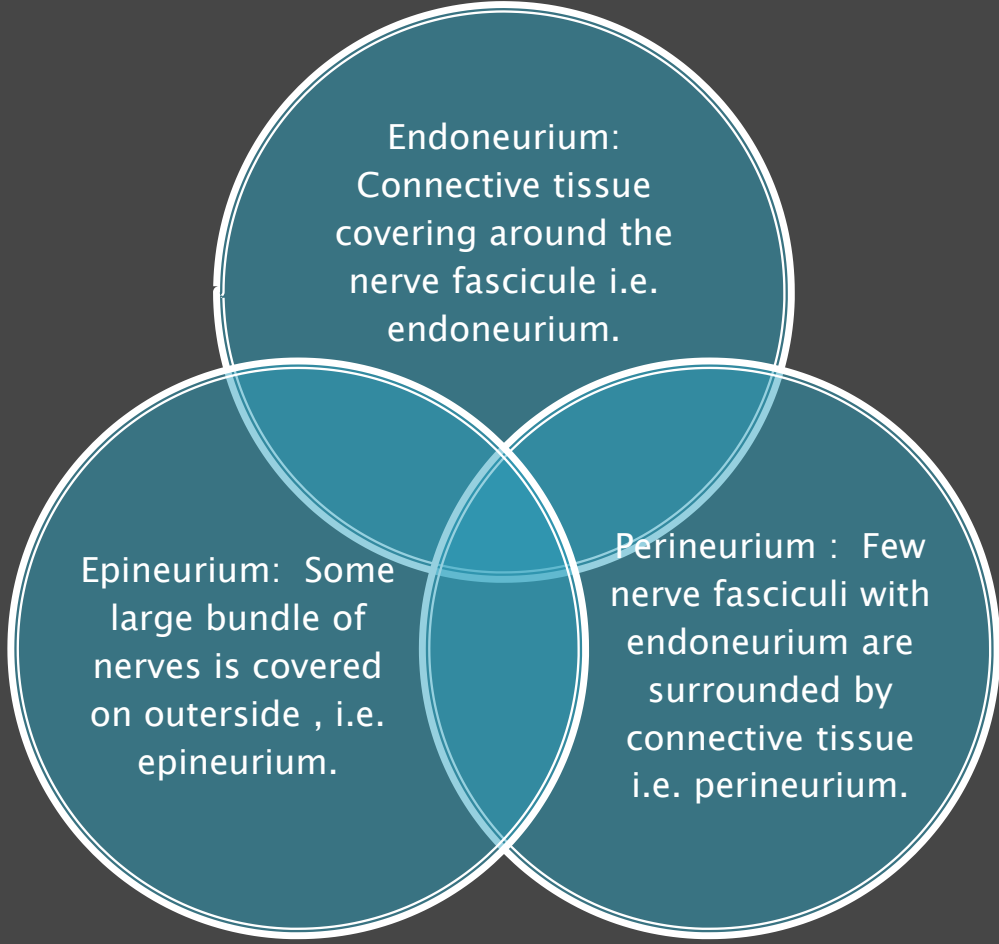
Synapse may be between axo-dendronic, or axo-axonic, or axo-somatic, or dendro-dendronic.

Medullated nerves: In which nerves are surrounded by medullary sheath and on outside surrounded by neurilemma.

Non medullated nerves: In which nerves are surrounded by only neurilemma.



Conduction of impulse is faster in medullated nerve fibres than non-medullated nerve fibres.



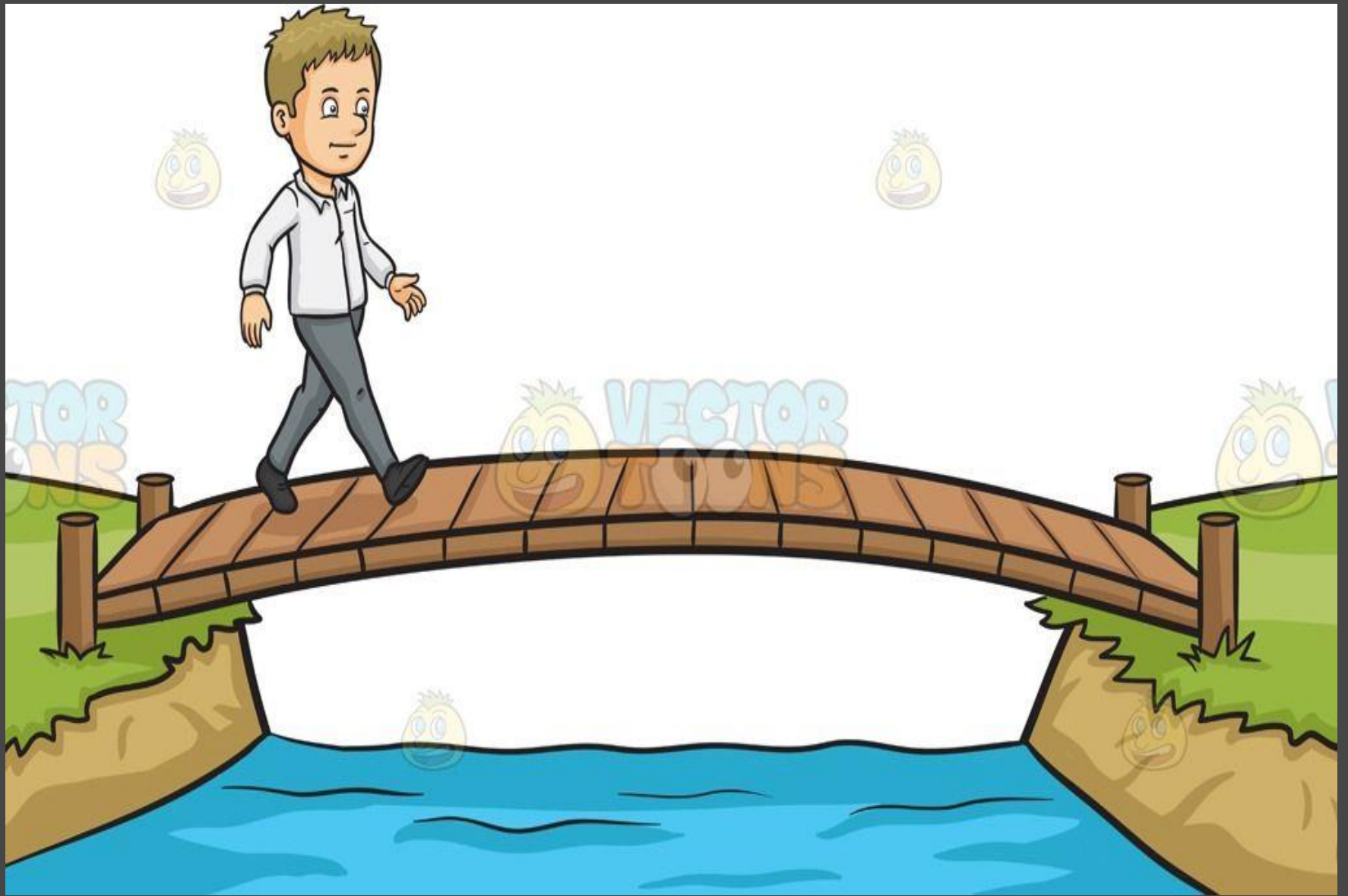
Endoneurium:
Connective tissue
covering around the
nerve fascicule i.e.
endoneurium.

Epineurium: Some
large bundle of
nerves is covered
on outside, i.e.
epineurium.

Perineurium : Few
nerve fasciculi with
endoneurium are
surrounded by
connective tissue
i.e. perineurium.

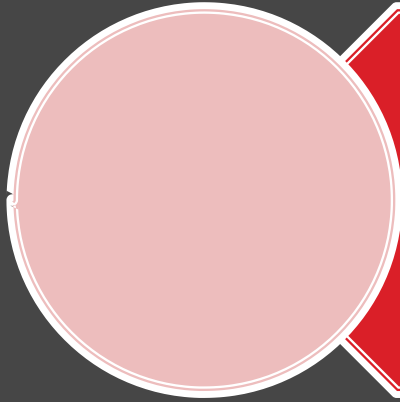
SYNAPSE : IT IS A JUNCTION
BETWEEN TWO NEURON WITH A
MINUTE GAP IN BETWEEN THEM
WHICH ALLOW TRANSMISSION OF
IMPULSE BY A NEUROTRANSMITTER
BRIDGE.





Properties of nerve fibres

- Excitability/ Irritability
- Conductivity
- Stimulus (Threshold, subliminal, supraliminal stimulus)
- Summation effect
- All or none law
- Refractory period
- Synaptic delay
- Synaptic fatigue
- Velocity



Presynaptic neuron:
The neuron which carry
impulse to the synapse.

Postsynaptic neuron : The neuron which
receiving impulse from the synapse.

Synaptic cleft: It is a small intercellular space lies in between two cells having a width of about 20–30nm between them.

Synaptic transmission: The process by which the impulse from the pre-synaptic neuron is conducted to the post-synaptic neuron.

Types of Synapse

Electrical synapse

Chemical synapse

Electrical synapse



Gap between two neuron is very narrow, about 3.8nm.

Synapse is mechanical.

Electrical conductive link is formed between presynaptic and postsynaptic neuron.

Transmission of impulse is faster.

Example : Defence reflexes.

Chemical synapse

These are specialized junctions through which one neuron send chemical signals to the another neuron or to the non-neuronal cells , such as glands, muscles.

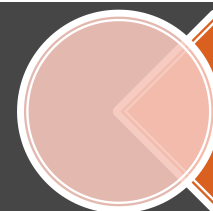
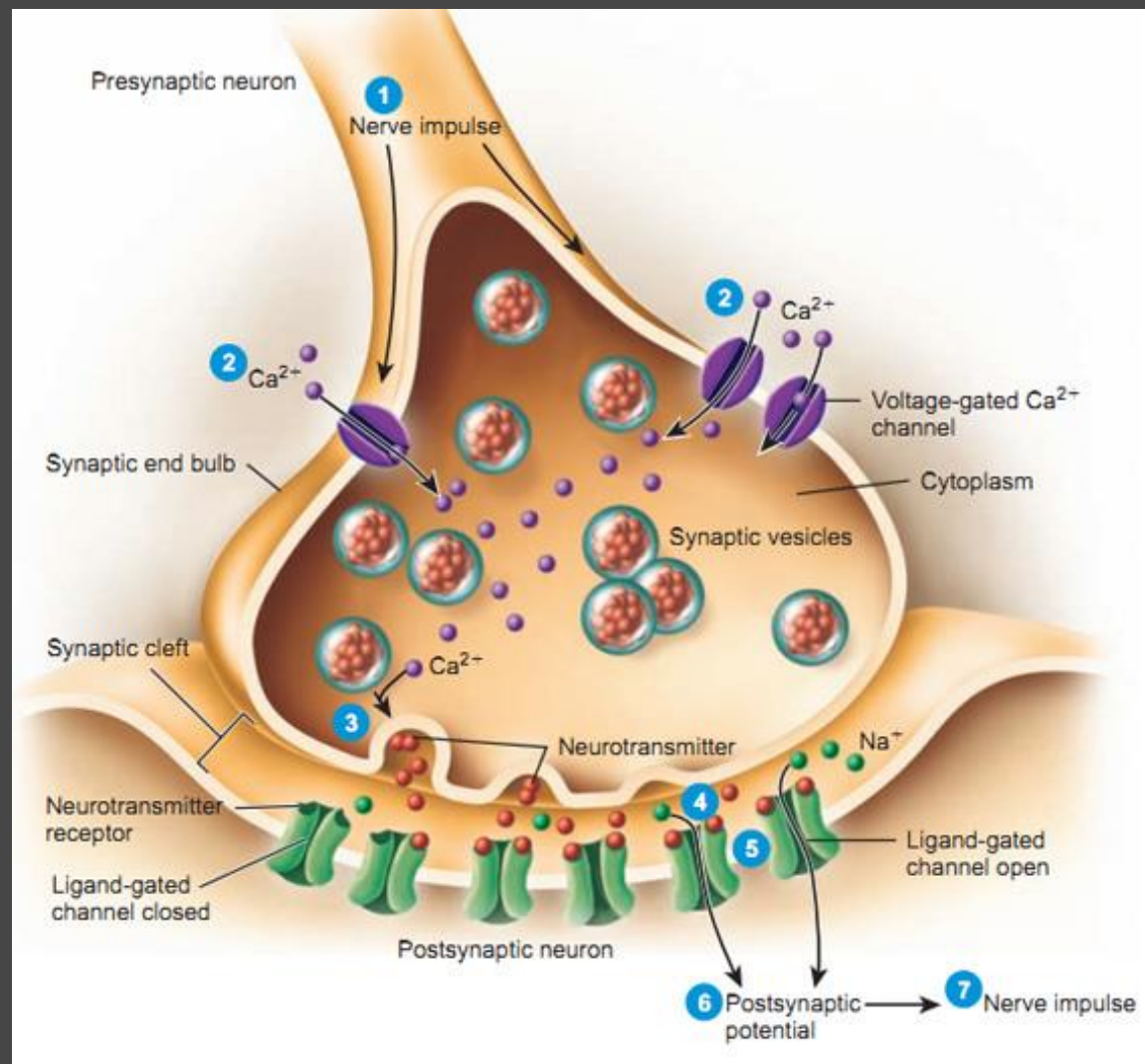
Gap between two adjacent neuron is 20–40 nm .

There are 3 components involved in the chemical synapse:

1. Pre synaptic neuron

2. Synaptic membrane of the postsynaptic neuron

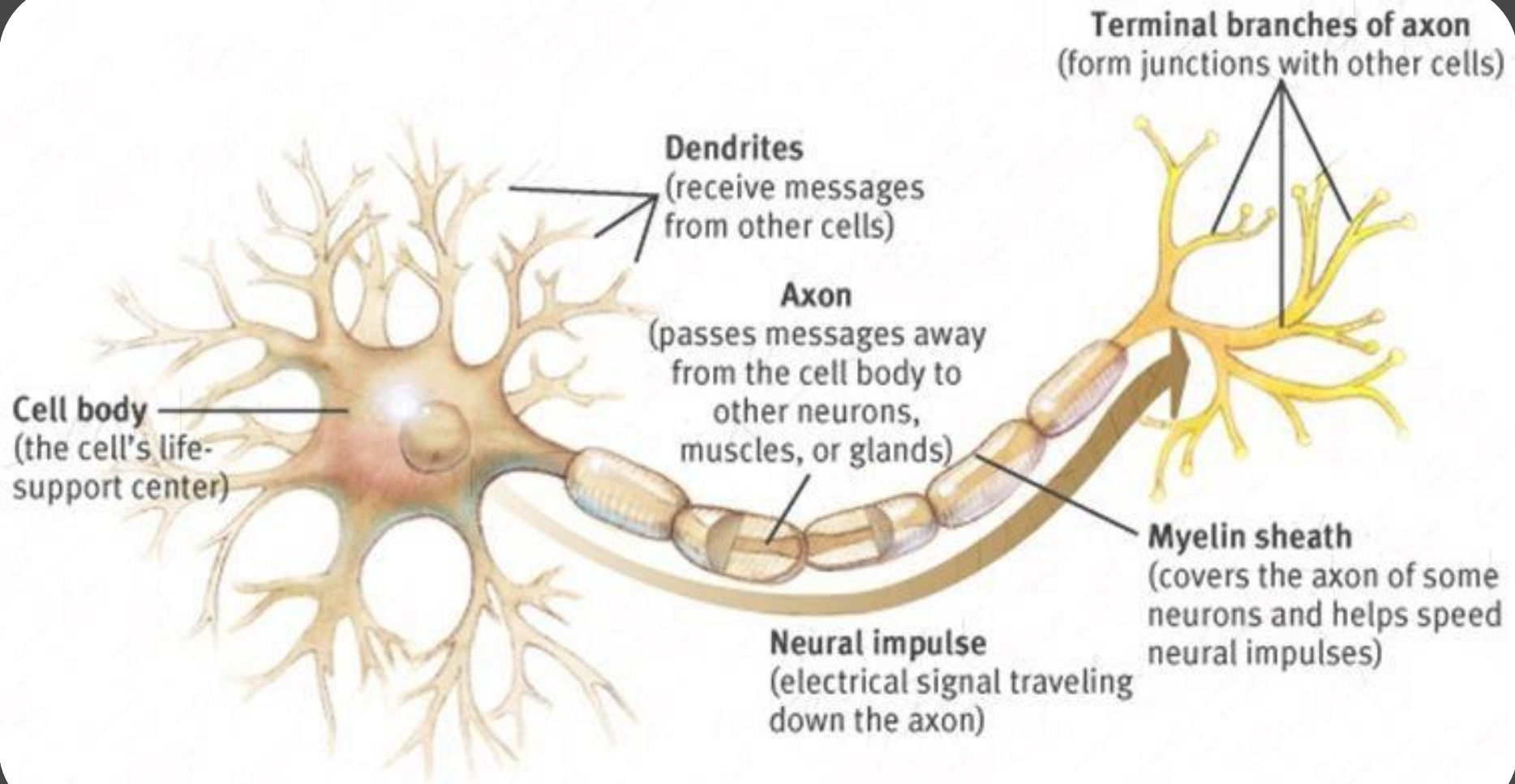
3. Post synaptic neuron.



Synaptic
transmission

Transmission of nerve impulse

- ▶ Neurons have the special features which shows excitation.
- ▶ Transmission of nerve impulse through out the length of long nerve fibres/axon is the way of conduction of excitation.
- ▶ Charges are different in inside or outside of the neuron.
- ▶ Predominance of Na^+ and Cl^- ions outside the cell or axon & predominance of K^+ ions inside of the axon.
- ▶ Sodium and potassium exchange pump.
- ▶ Resting nerve
- ▶ Once the stimulus is applied, rapid influx of Na^+ ion take place inside the axon.
- ▶ Not only leakage channels but also gated channels for Na^+ and K^+ ions are also present in the axon.



down the axon)

(electrical signal traveling

neural impulse)

neural impulse)

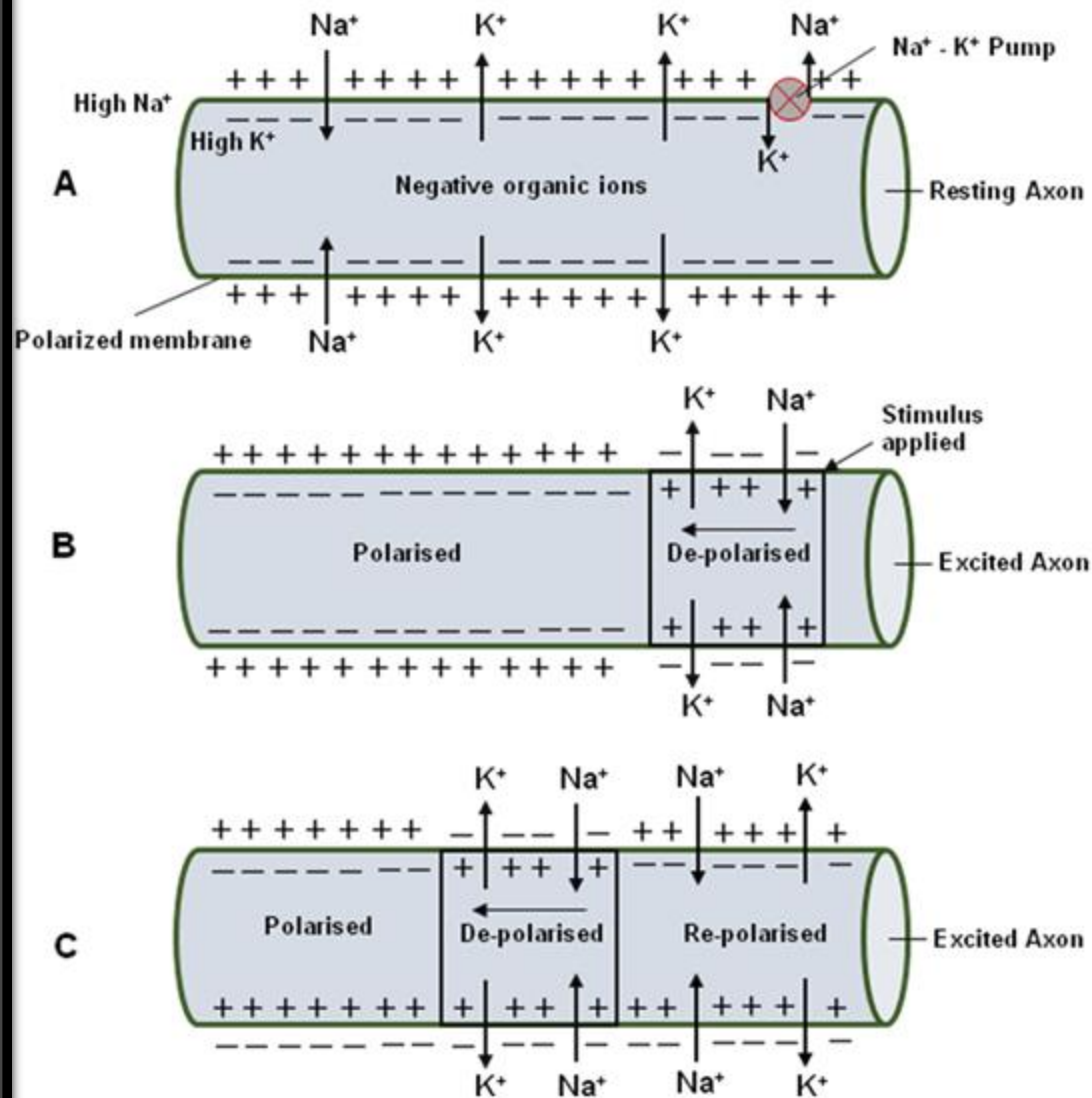
Generation of nerve impulse:



Depolarization : Any change or disturbance to the membrane will cause Na to enter into the membrane & lower the potential difference(lesser than -70 millivolts).

During depolarization the Na gates open but not the K gates.

Re-polarization : Change in the polarity from depolarized, back to the original state.



Steps in generation and conduction of nerve impulse :

Application of stimulus on a resting nerve



Permeability of membrane changes & it becomes more permeable to Na



Na ion diffuse into the neuron from the ECF



Number of positive ions inside axon increases



Membrane potential changes from -70mV to about $+30\text{ mV}$ (action potential)



Polarity has change from negative on outside and positive on inside (depolarization)



At the peak of action potential ($+30\text{mV}$), the Na channels close & K gates open (repolarization)



K ions diffuse out of the axon



Inside of axonal membrane now becomes negative again



ECF becomes positively charged

In medullated nerve fibres, the insulating myelin sheath prevents flow of ions between the axoplasm and ECF. The transport pump & gated channels can operate only in the region of nodes of Ranvier, where myelin sheath is absent.



The action potential cannot travel as a wave of membrane depolarization, it has to jump from node to node. This process is known as Saltatory conduction.

HUMAN NERVOUS SYSTEM

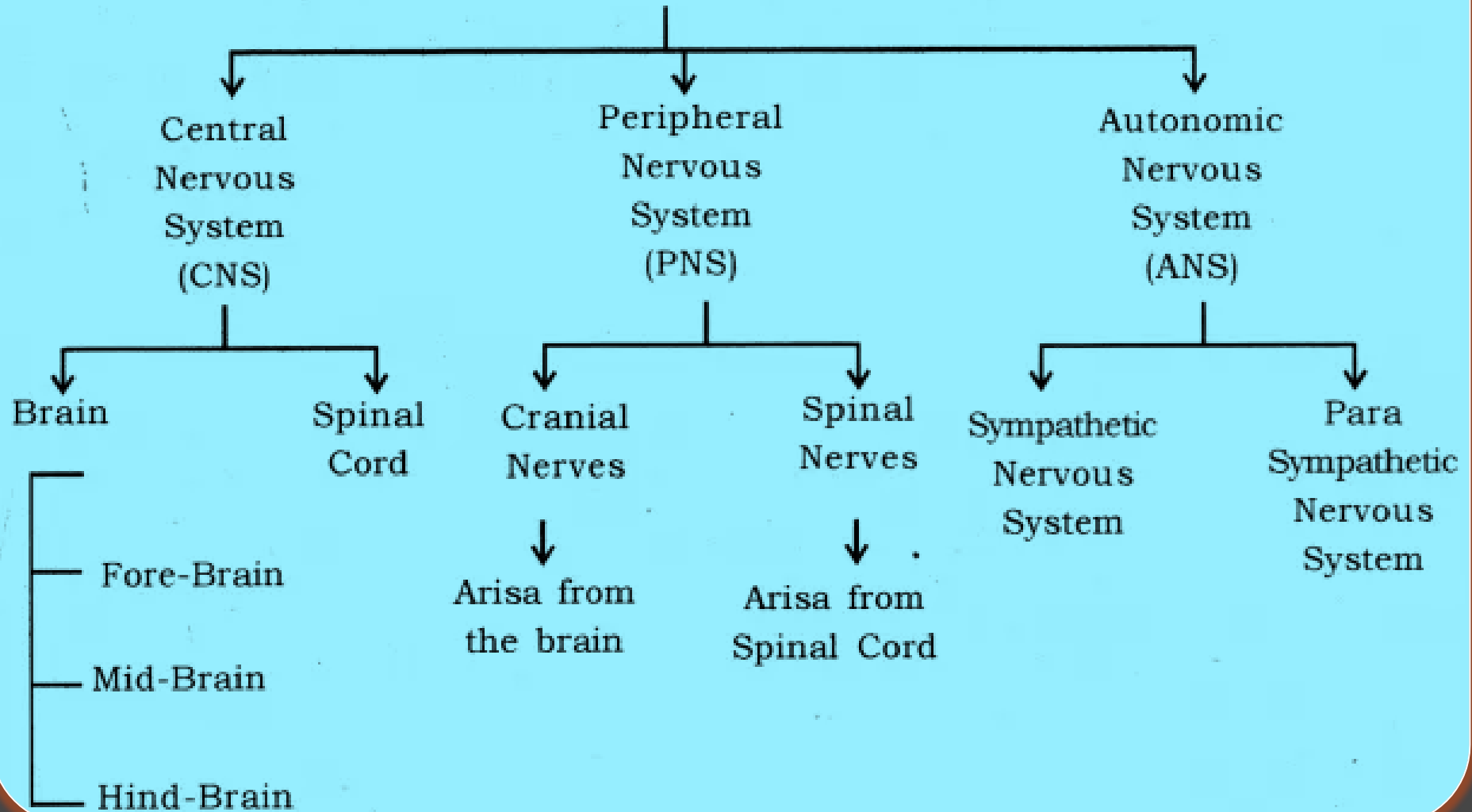
It is classified
into 3 parts

1. Central
nervous system

2. Peripheral
nervous system

3. Autonomous
nervous system

Human Nervous System

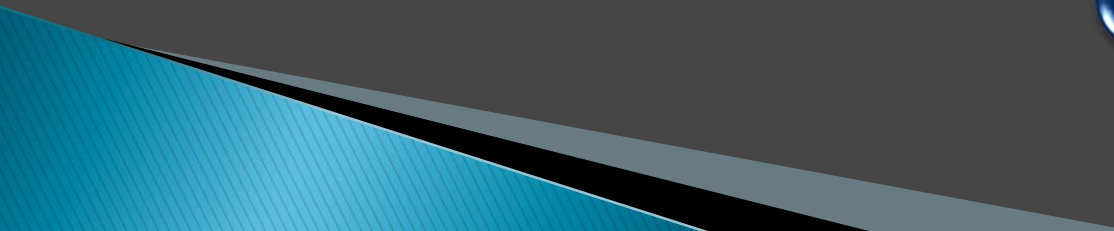


Central nervous system

It consist of
two main
parts:

1) Brain

2) Spinal
cord



Brain and Spinal cord are well protected by membranes known as Meninges.

**There are 3
membranous layers of
meninges:**

**1. Dura matter:
outermost, tough,
thick, non-vascular,
fibrous layer.**

**2. Arachnoid matter:
middle, thin, non-
vascular layer of
connective tissue.**

**3. Pia matter:
innermost, delicate,
highly vascular
membrane.**

Cerebrospinal fluid(CSF):

CSF is secreted by the pia matter, the choroid plexuses and the ependymal cells.

It is lymph like extracellular fluid.

CSF acts as a shock absorber.

Maintain constant pressure inside the brain.

Helps in exchange of nutrients and wastes between blood and brain.

Supply oxygen.

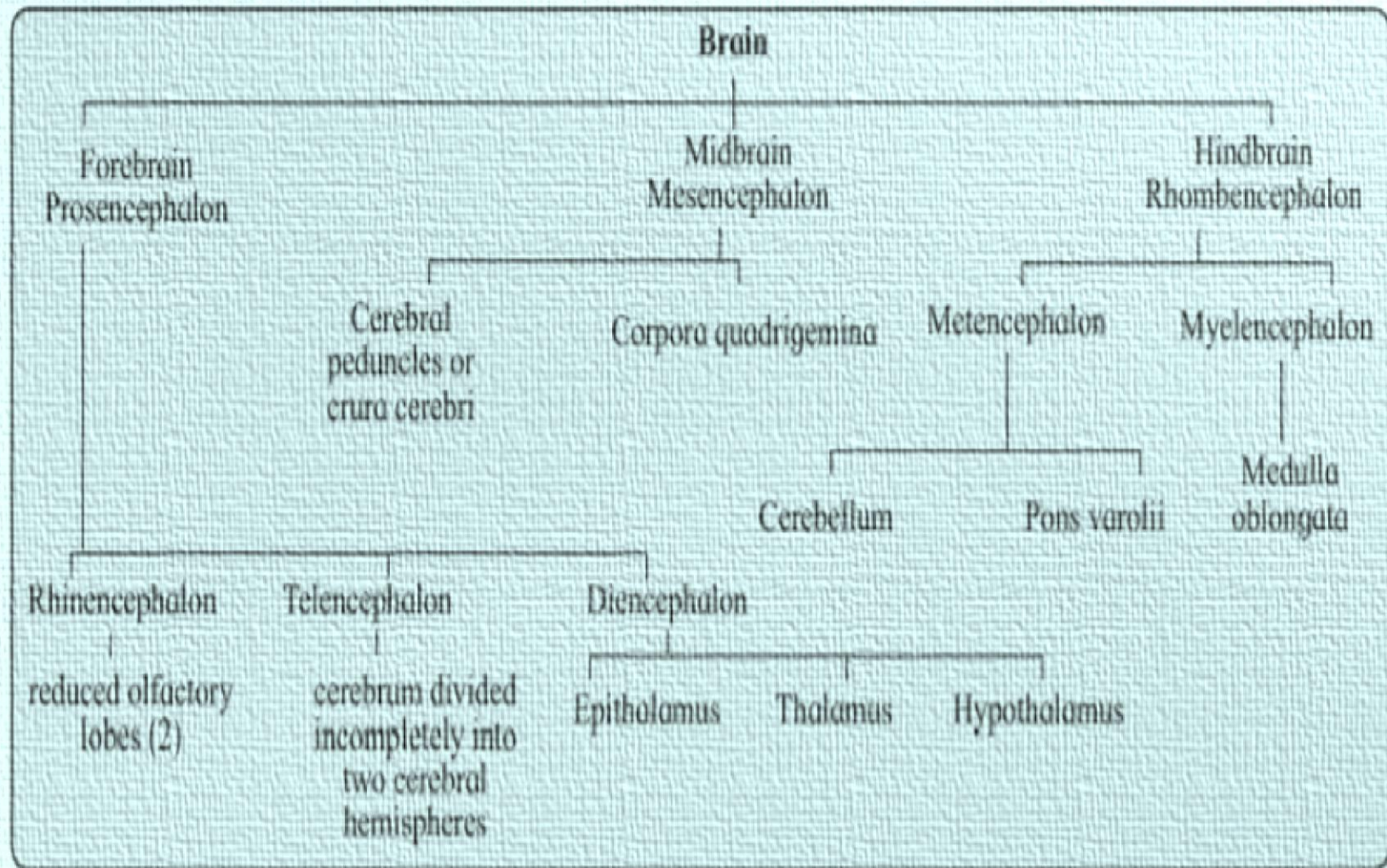
Prevent desiccation.

Human
brain

The study of all aspects of brain is called Encephalogy.

Brain is enclosed within the brain box known as Cranium.

Chart 9.8 Parts of Brain



Forebrain or Prosencephalon

It consist of 3
parts:

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graph TD; A[It consist of 3 parts:] --- B[Olfactory lobes or Rhinencephalon]; A --- C[Cerebrum or Telencephalon]; A --- D[Diencephalon]
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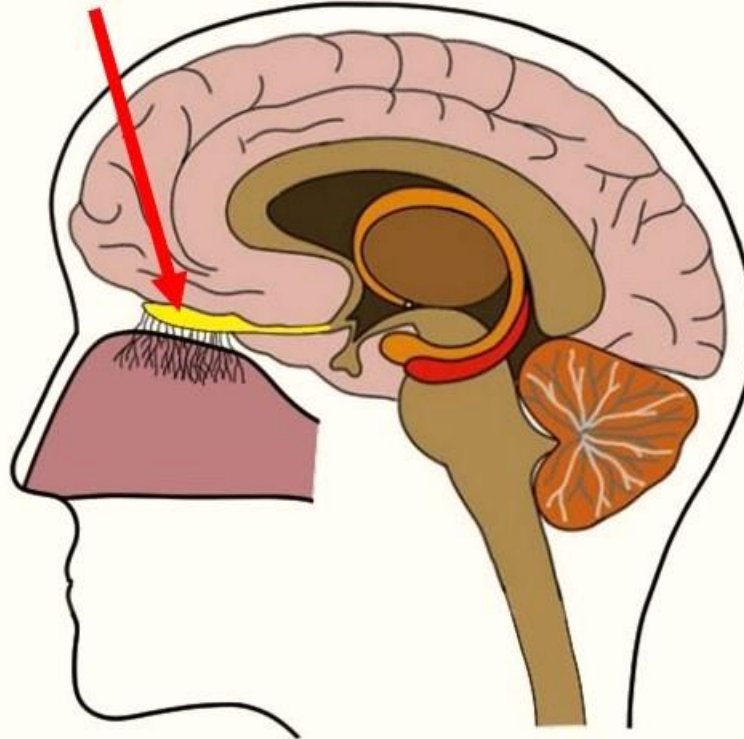
Olfactory lobes
or
Rhinencephalon

Cerebrum or
Telencephalon

Diencephalon

Olfactory lobe

OLFACTORY BULB



Cerebrum



Largest part of the brain

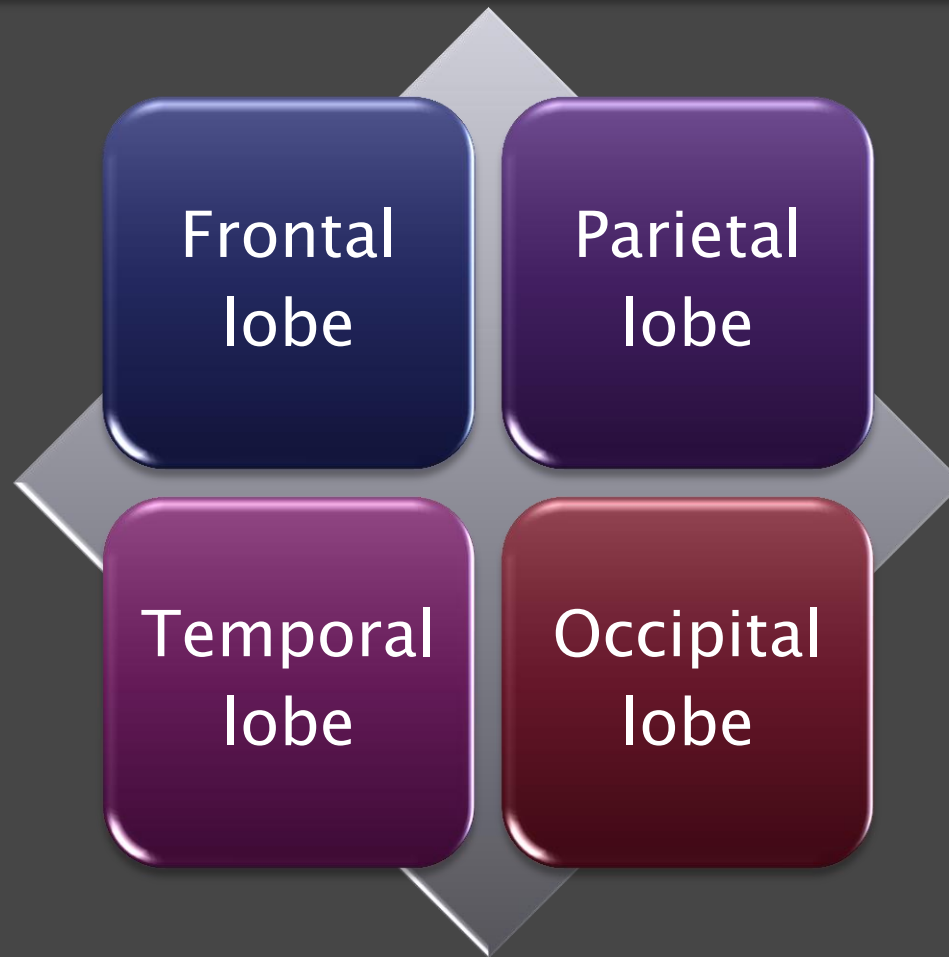
Divided into right & left cerebral hemisphere which connected with each other by thick band of nerve fibres known as corpus callosum.

Outer surface is cortex & inner surface is medulla.

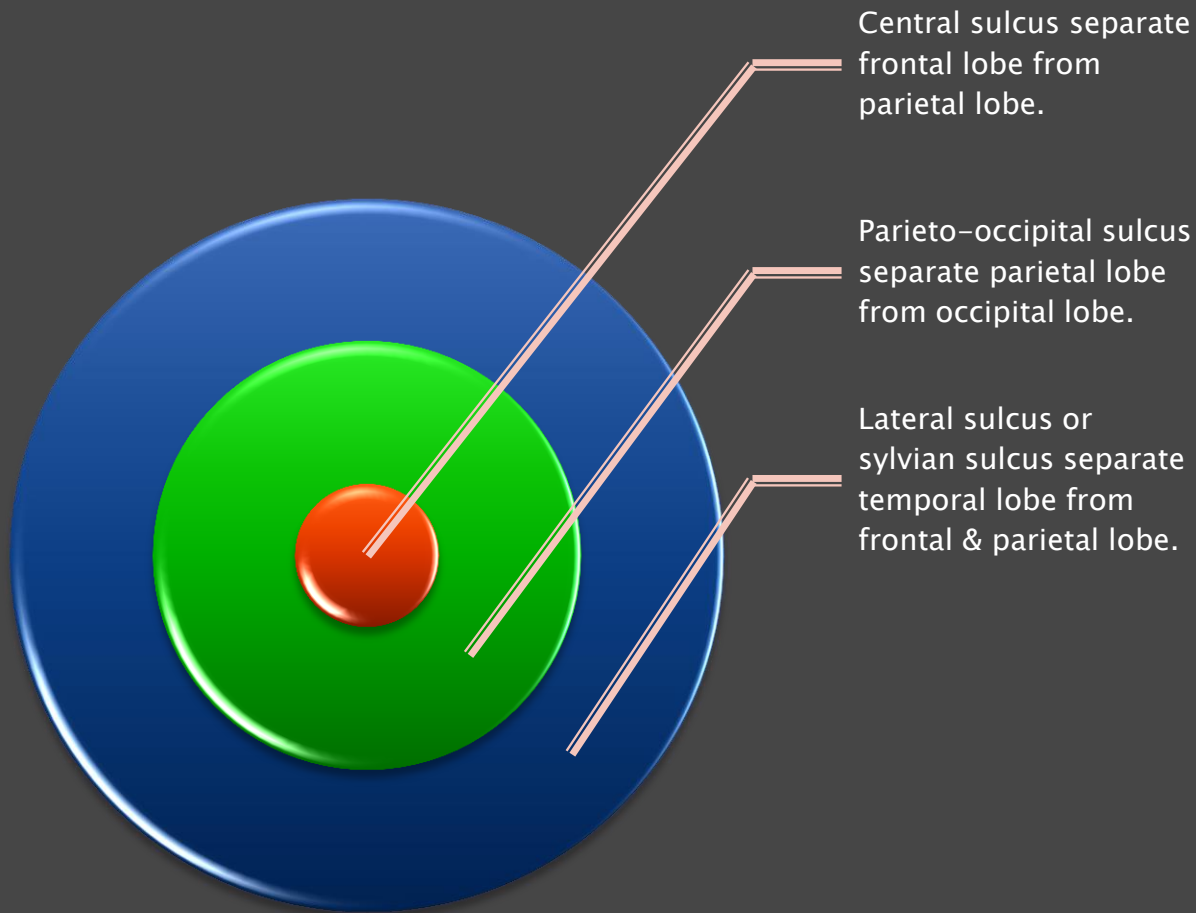
Cortex shows gyri and sulci

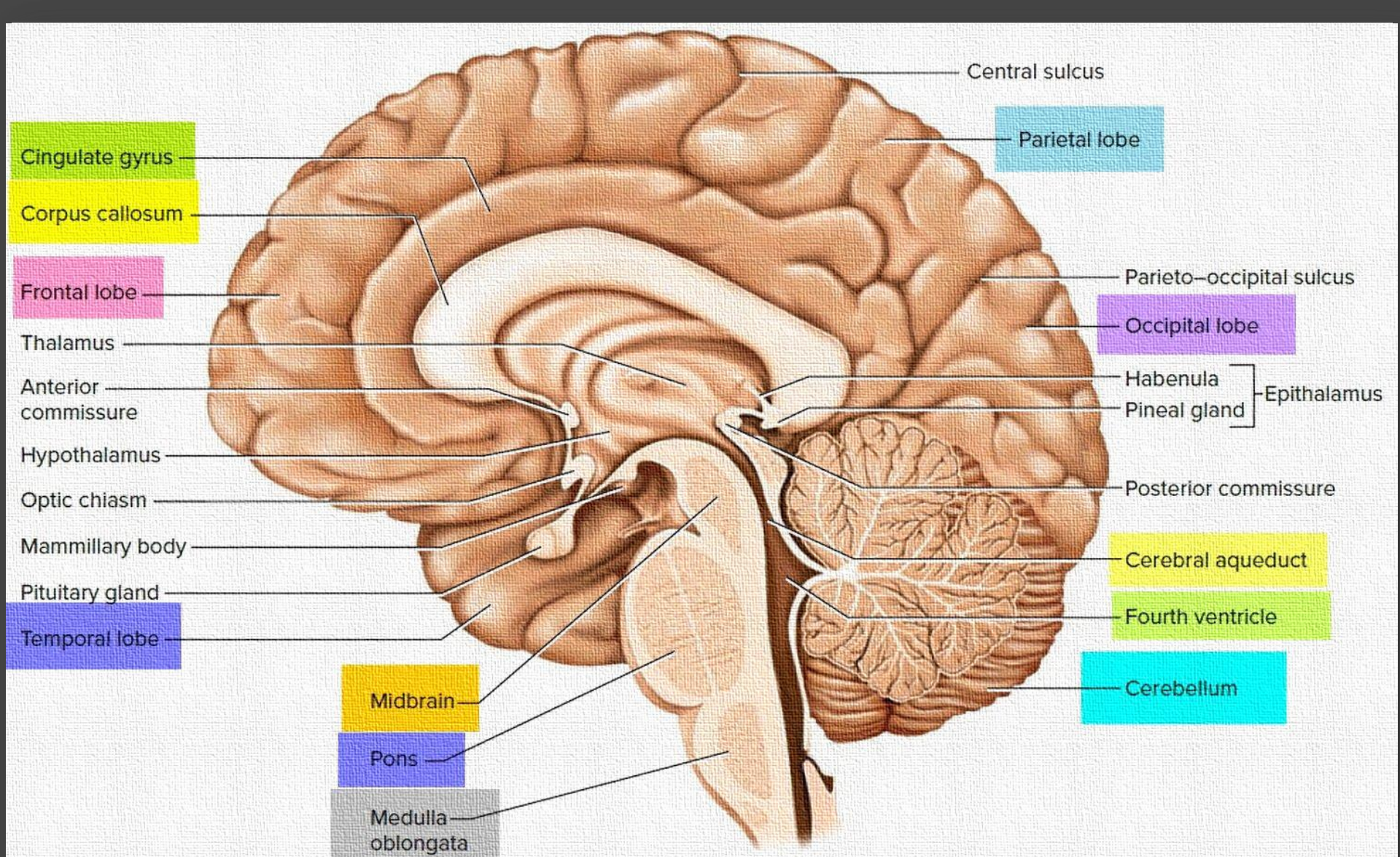


Each cerebral hemisphere is divided into ;

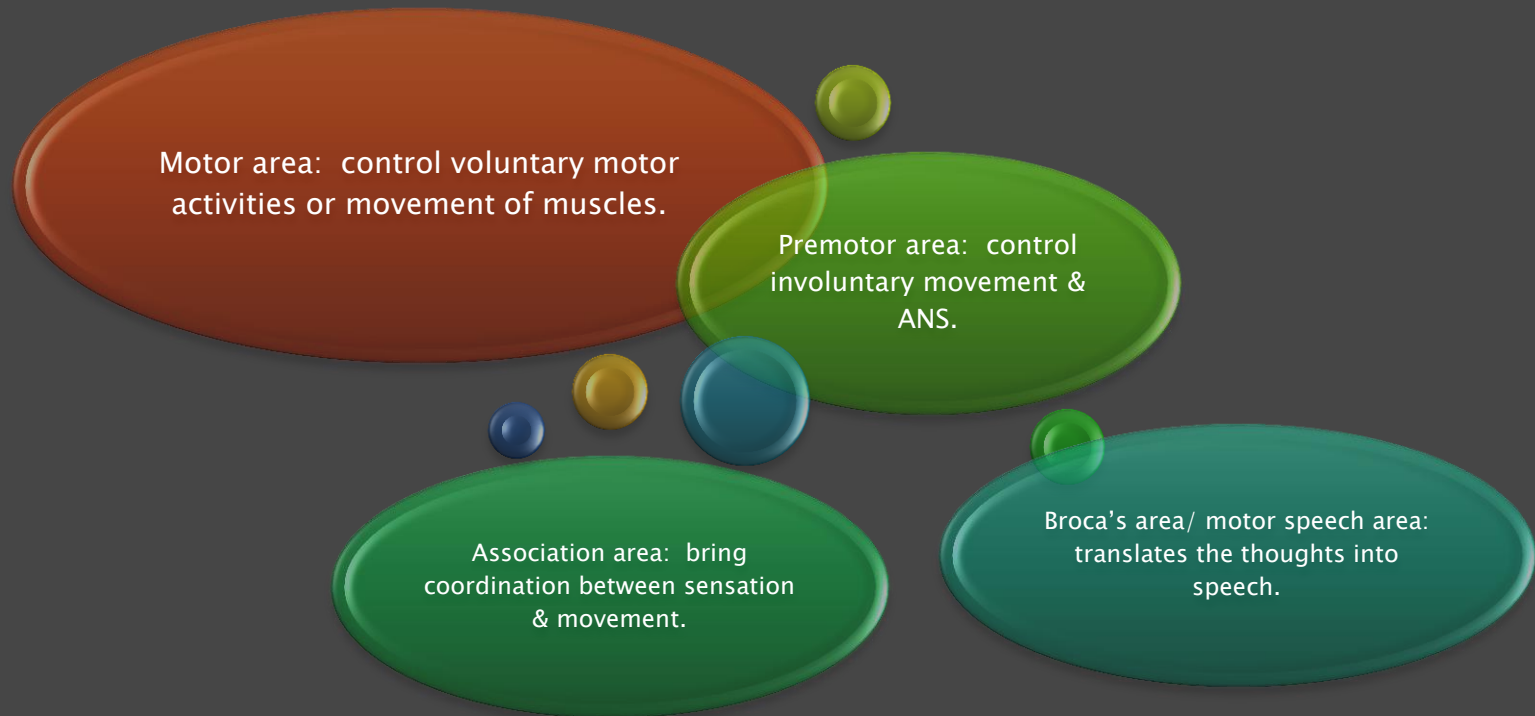


By three sulci





Functional areas of cerebrum:



Frontal lobes: They have 4 important areas such as,

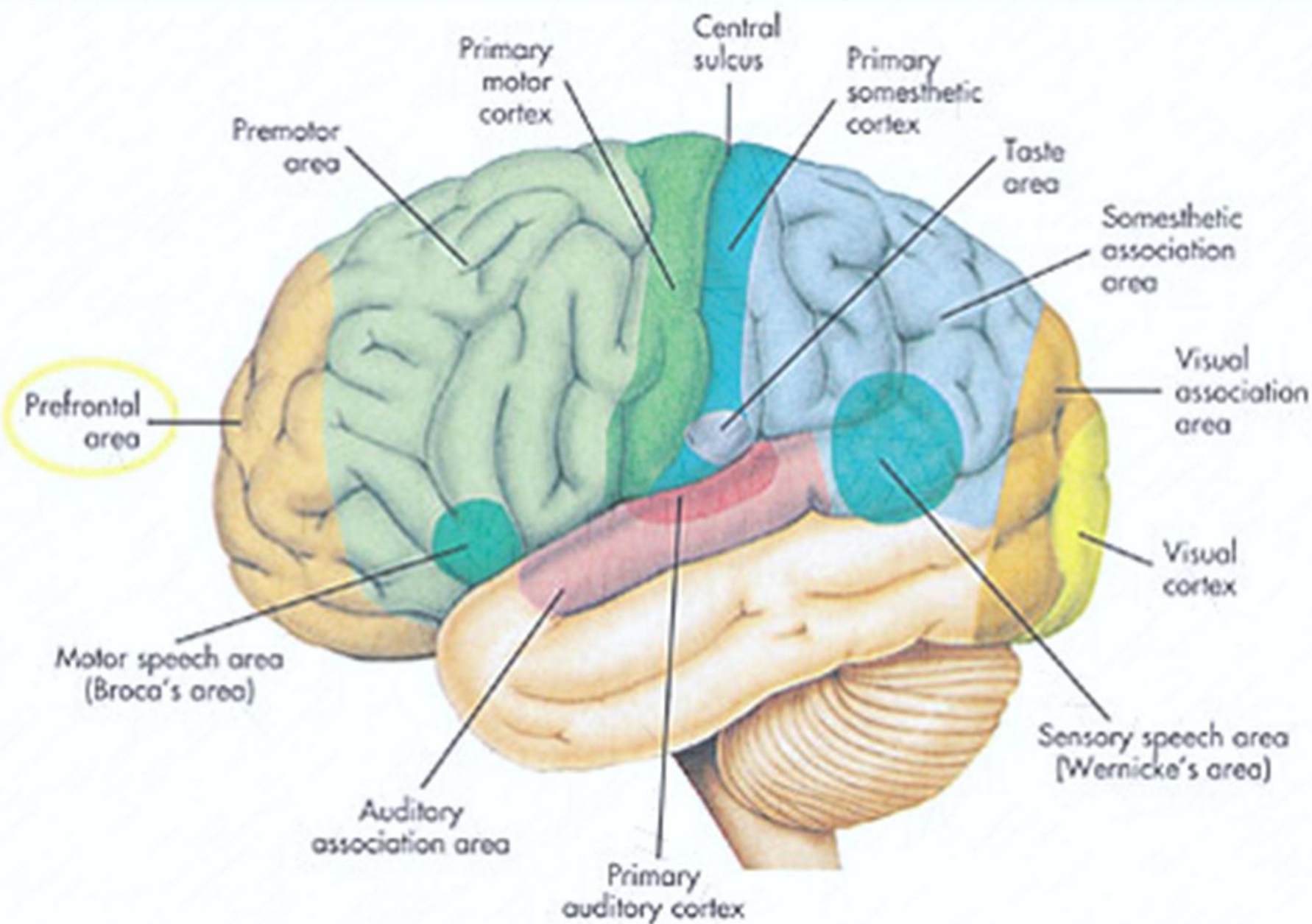
Parietal lobes: controls sensation of pain, pressure, temperature, taste(gustatoreceptor).

Temporal lobes: controls centres of smell,hearing, speech and emotions.

Occipital lobes: controls sense of vision.

In addition to all these areas there is one more area of intelligence i.e. Wernicke's area which helps in the understanding of spoken and written words.

Basal nuclei or basal ganglia are grey masses present in the white matter, help the cortex in the execution of activities at subconscious level. Corpus striatum the largest basal nucleus.



Diencephalon

It is the third part of the forebrain, present below the corpus callosum and above the midbrain.

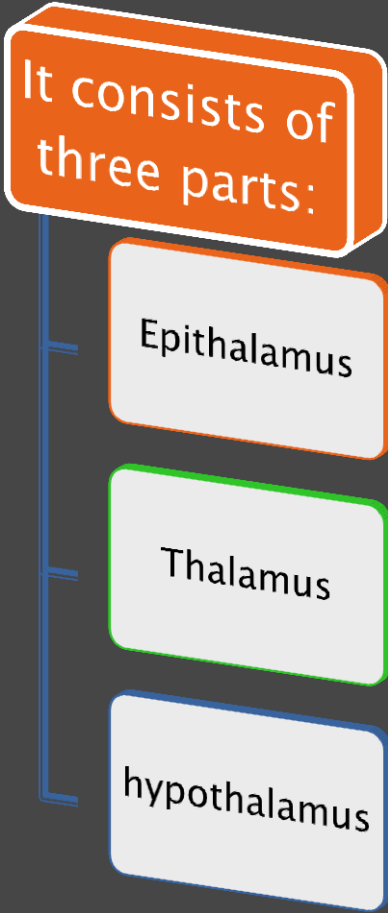
Encloses a cavity termed as third ventricle or diocoel which communicates with the two lateral ventricles of cerebrum by foramen of Monro.

Diencephalon



A large pink arrow pointing to the right, with a red box containing the word 'Diencephalon' in the center.

It consists of
three parts:

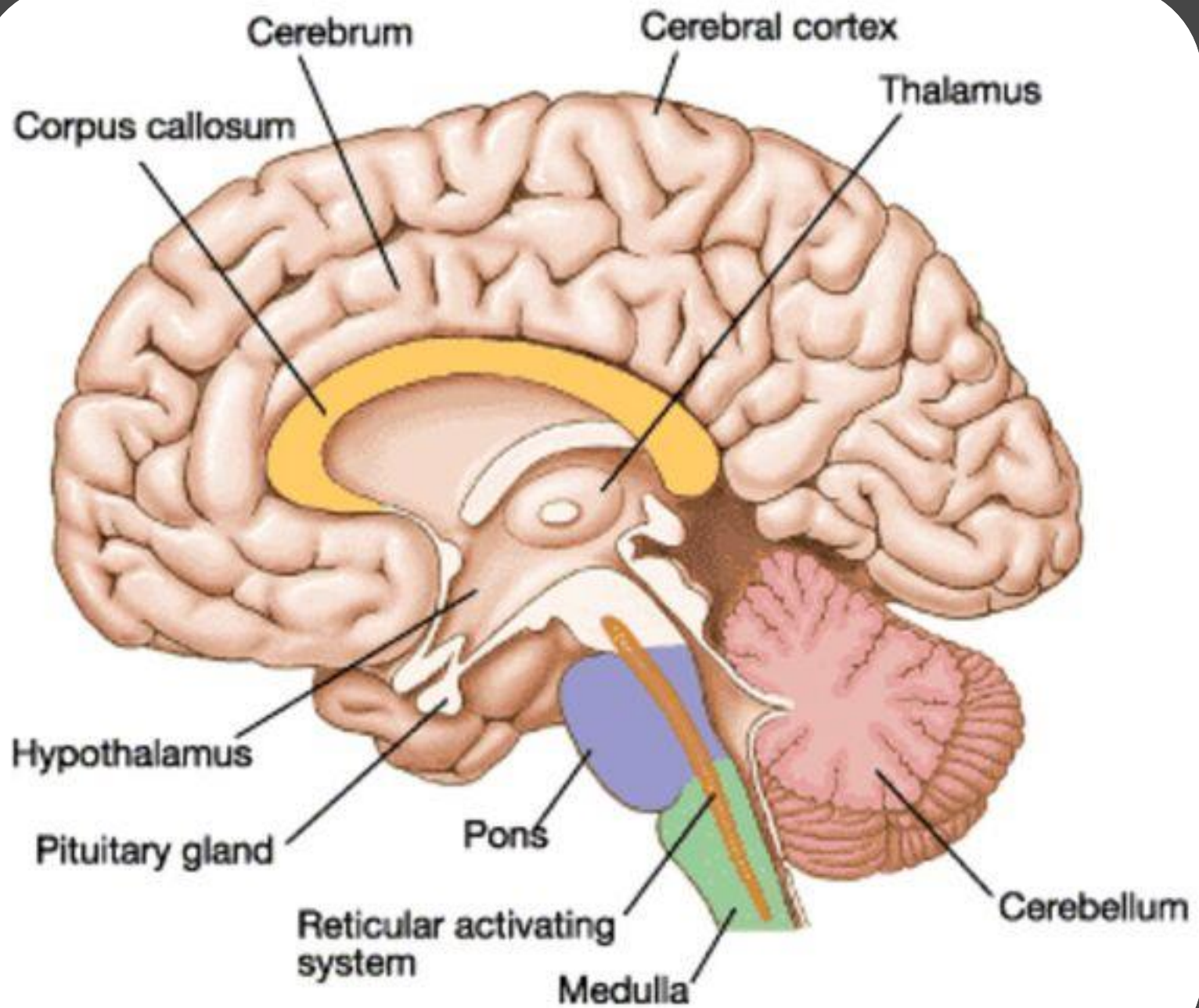


A vertical blue line with three horizontal tick marks, each connecting to a box representing a part of the diencephalon: Epithalamus, Thalamus, and hypothalamus.

Epithalamus

Thalamus

hypothalamus



Epithalamus

Roof of
diencephalon

Dorsal wall
connected to
pineal gland

Pineal gland
produces hormone
melatonin which is
sleep inducing
hormone & related
to reproductive
behaviour

Thalamus

They are lateral walls of the diencephalon, connected with each other by habencular commissure.



RAS of thalami interconnects all parts of the brain.



Acts as a relay centre.

Hypothalamus

Floor of diencephalon

Maintains homeostasis, internal equilibrium, & involuntary behaviour control.

Hypothalamic nuclei consists of neuro-secretary cells which produce hormones.

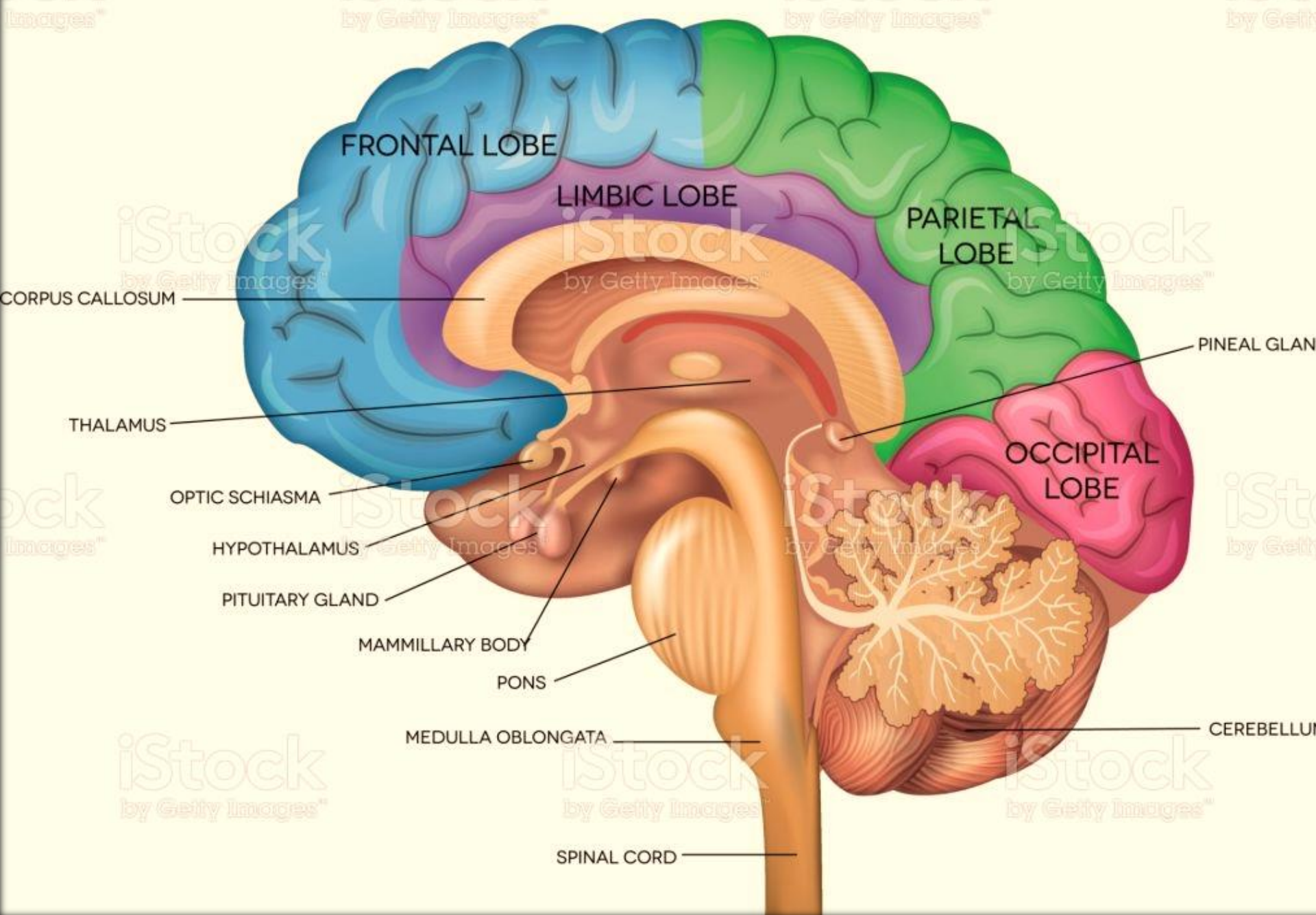
Hypothalamus is the link between nervous and endocrine system.

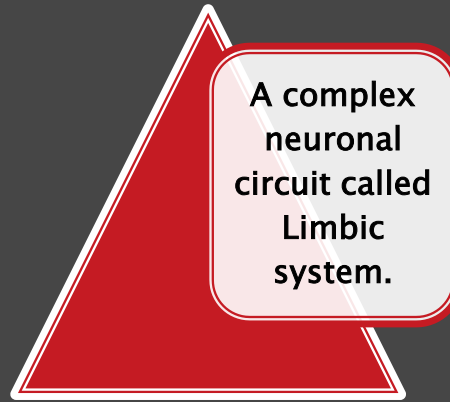
It regulates heart rate, respiration, B.P., body temperature, water & electrolyte balance.

It has centre for thirst, hunger, sleep, fatigue, satiety centre, secretion of glands of GI.

Floor of hypothalamus shows downward projection of pituitary gland.

On inferior surface it bears the optic chiasma & pair of mammillary bodies.





It is formed by the hypothalamic amygdala, epithalamus, thalamus, & hippocampus.

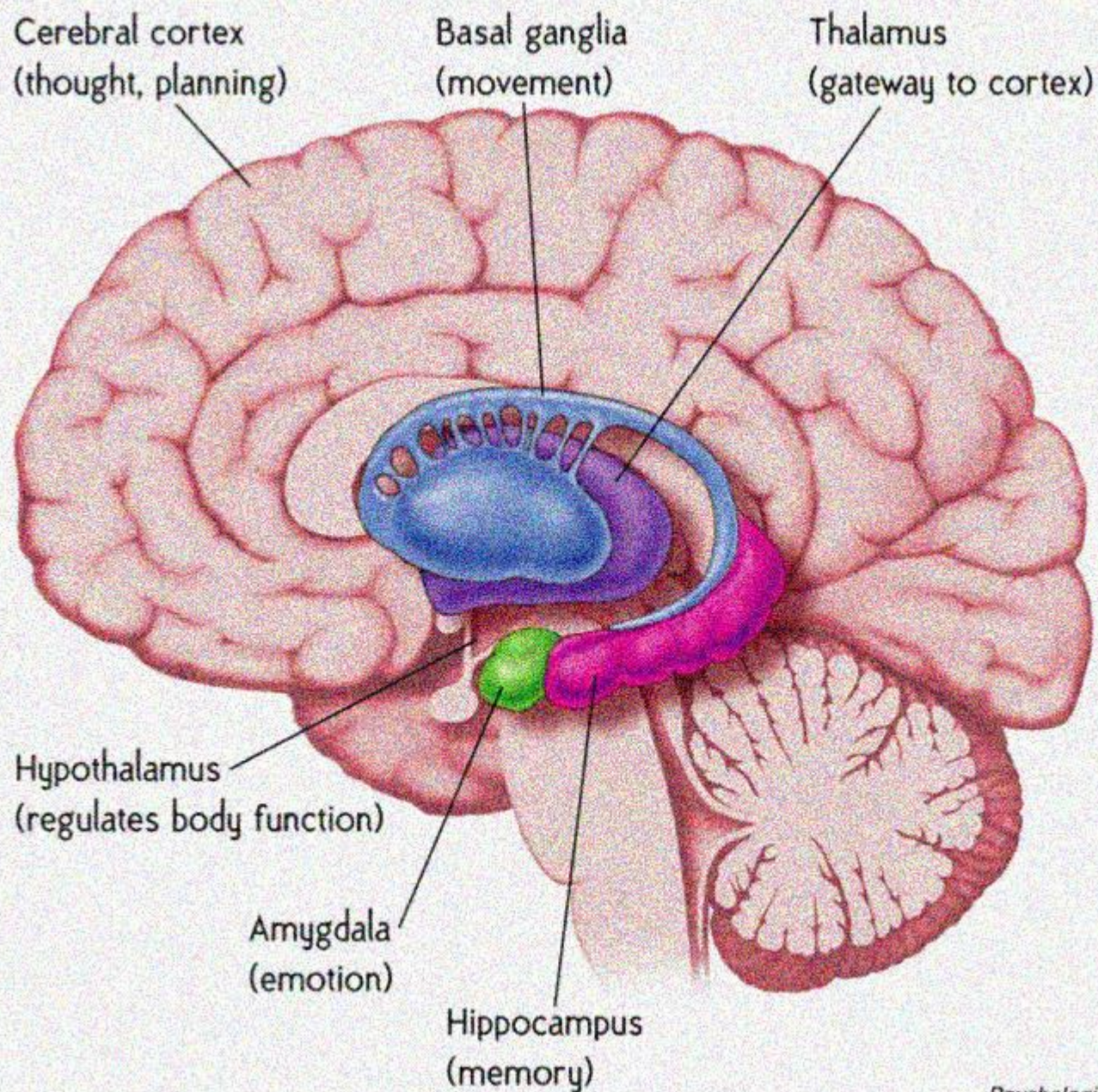


FIGURE 4.6



Mid Brain or Mesencephalon

Mid Brain

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graph TD; A[Mid Brain] --> B[Corpora quadrigemina]; A --> C[Crura cerebri];
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Corpora
quadrigemina

Crura cerebri

Corpora quadrigemina

They are four rounded elevations on the dorsal surface of the mid brain.

Upper two elevations are superior colliculi & lower two elevations are inferior colliculi.

Superior colliculi are involved in visual reflexes.

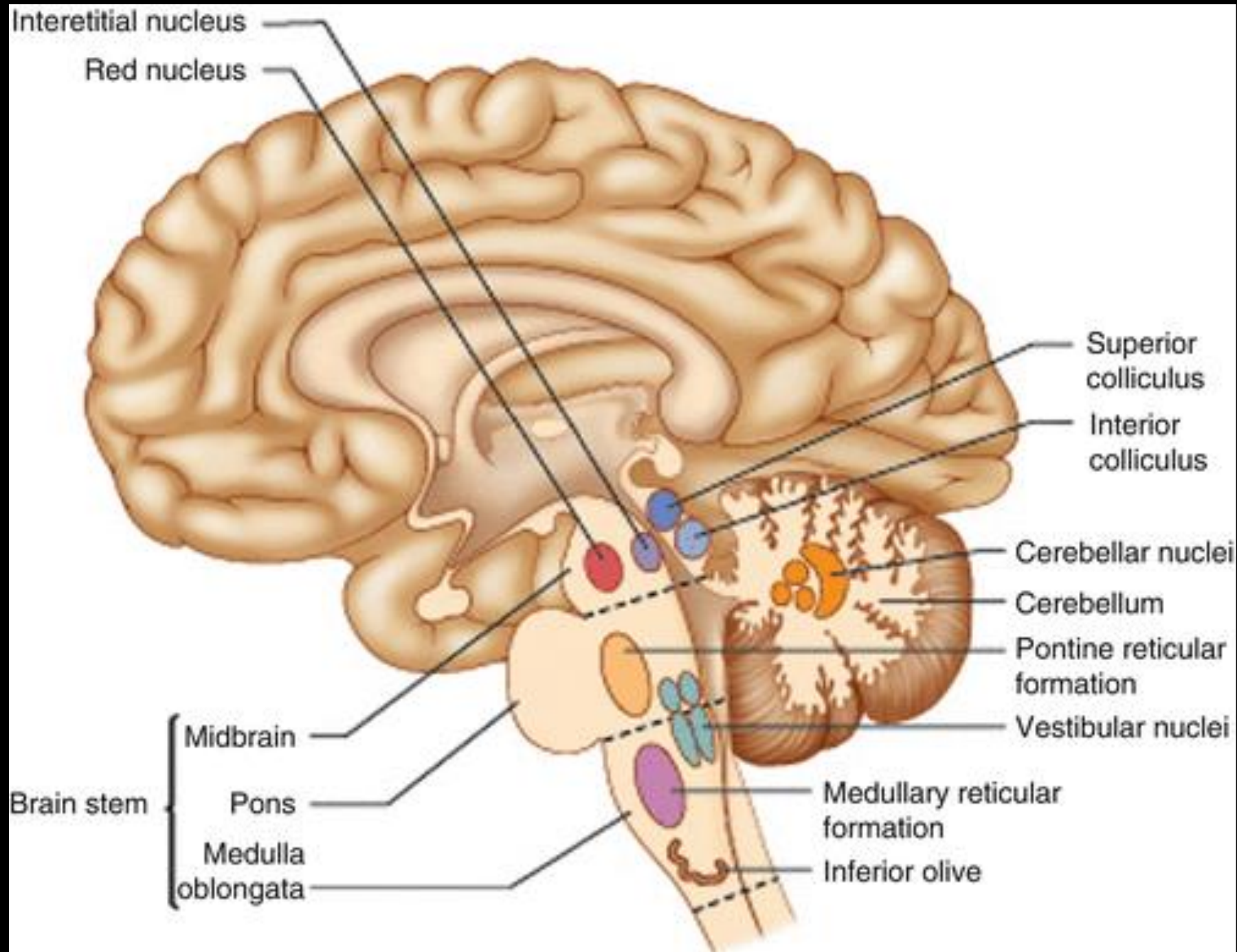
Inferior colliculi are involved in auditory reflexes.

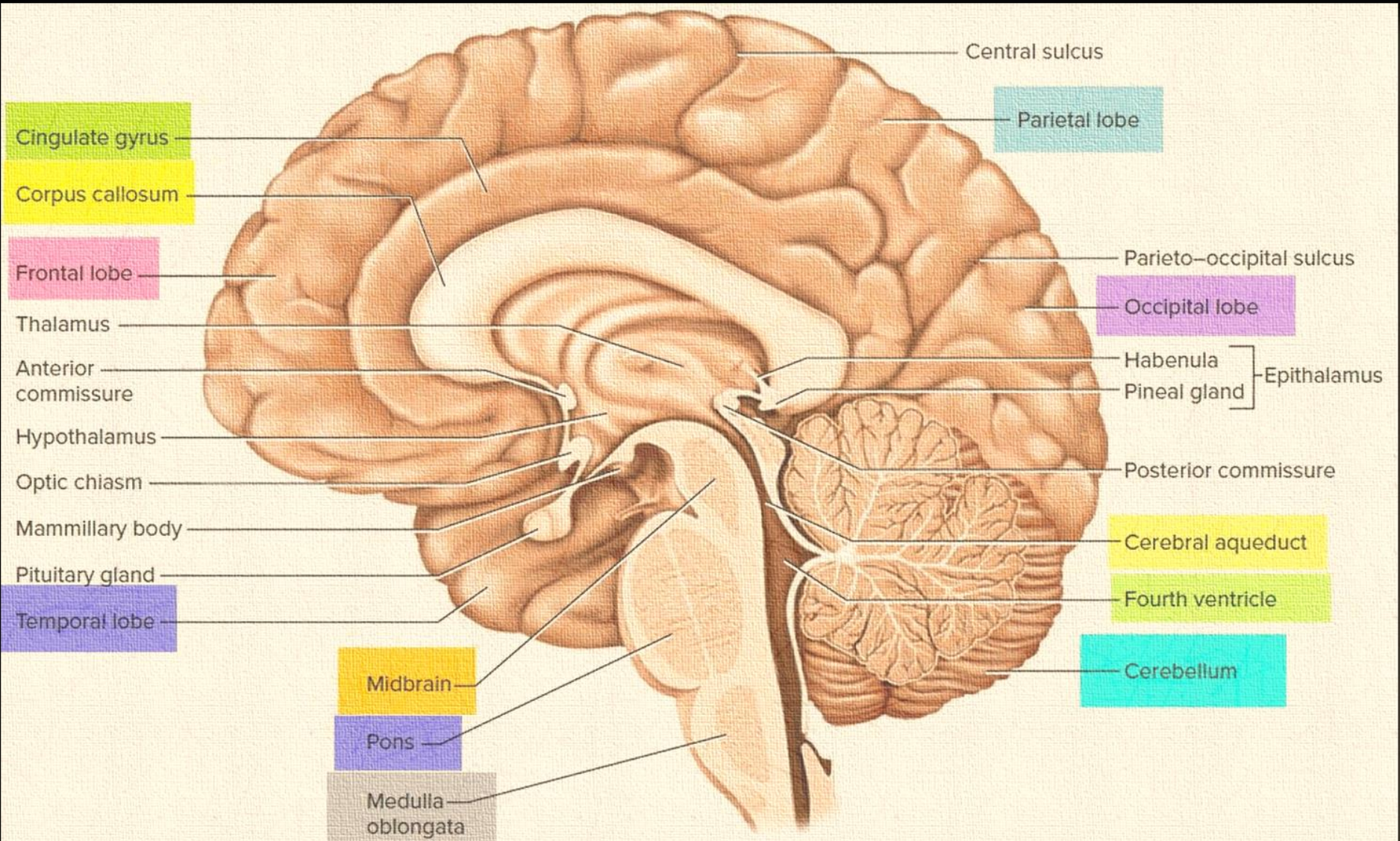
Crura cerebri

These are two thick fibrous tracks on inferior side of the mid brain.

These tracts are ascending and descending nerve fibres.

Near the centre of mid brain , red nucleus is present which is responsible for controlling posture and muscle tone, modifying motor activities, & motor coordination.





Hind brain or Rhombencephalon



It consists
of 3 parts:



Pons varolli



Cerebellum

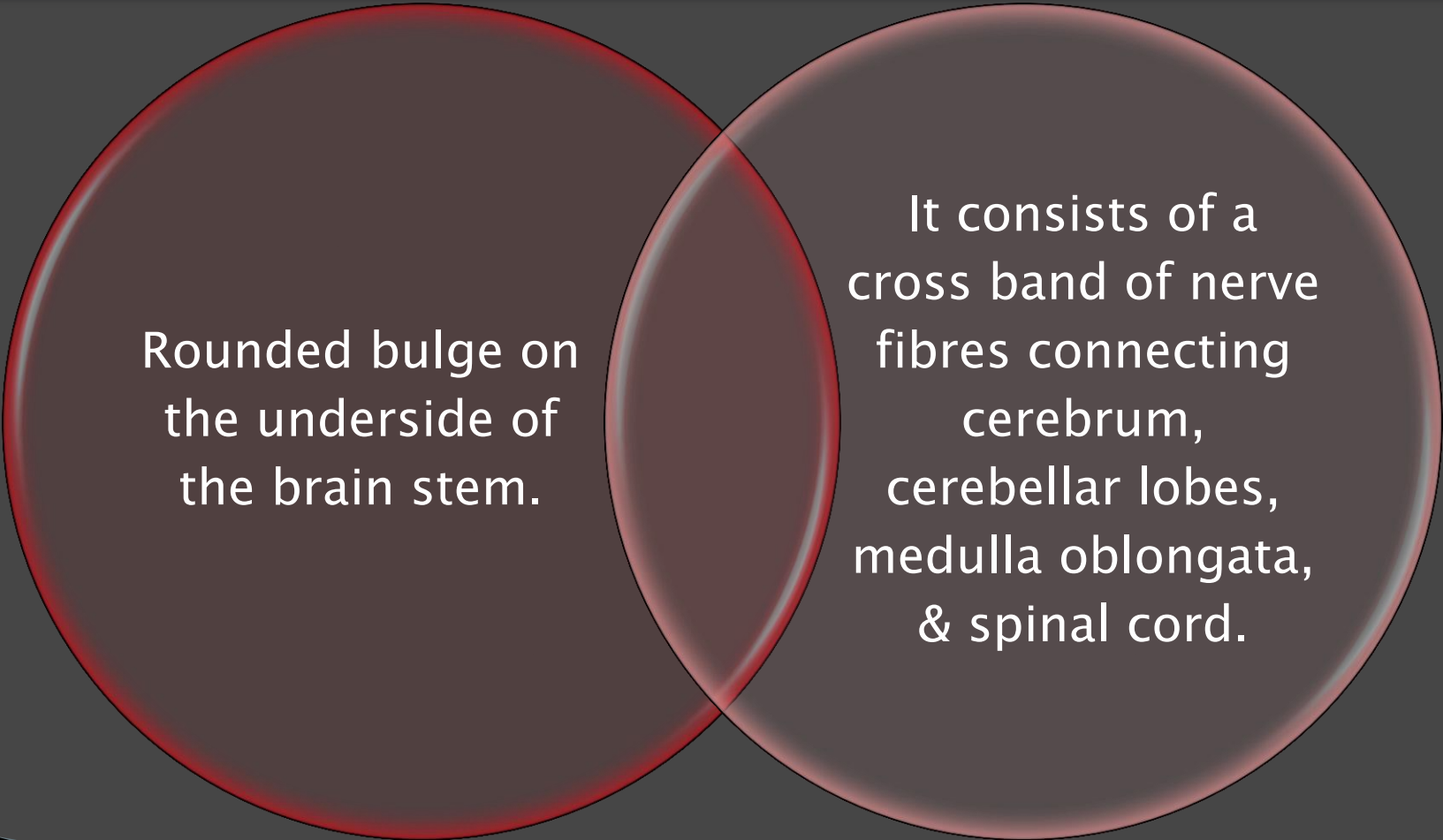


Medulla
oblongata



Pons varolli

A blue horizontal bar with rounded ends and a white dot in the center. Below the bar is a long white double-headed arrow.



Rounded bulge on the underside of the brain stem.

Two overlapping circles with a red-to-black gradient. The left circle contains the text 'Rounded bulge on the underside of the brain stem.' and the right circle contains the text 'It consists of a cross band of nerve fibres connecting cerebrum, cerebellar lobes, medulla oblongata, & spinal cord.'

It consists of a cross band of nerve fibres connecting cerebrum, cerebellar lobes, medulla oblongata, & spinal cord.

Cerebellum

A horizontal double-headed arrow is positioned below the title 'Cerebellum'.

Second largest part of the brain.

Consists of two lateral hemispheres & a central vermis.

White matter intermixes with the grey matter to show a tree like pattern called Arbor vitae.

Surface of cerebellum shows gyri & sulci.

Three pairs of myelinated bundles called cerebellar peduncles, connect cerebellum to other parts of CNS.

It maintains equilibrium, posture, balancing, orientation, moderation of voluntary movement, muscle tone.

It is centre for neuromuscular activities which is responsible for controlling activities like walking, running, speaking.

Medulla oblongata

Posterior most part of the brain, continues as the spinal cord.

Inner grey matter & outer white matter.

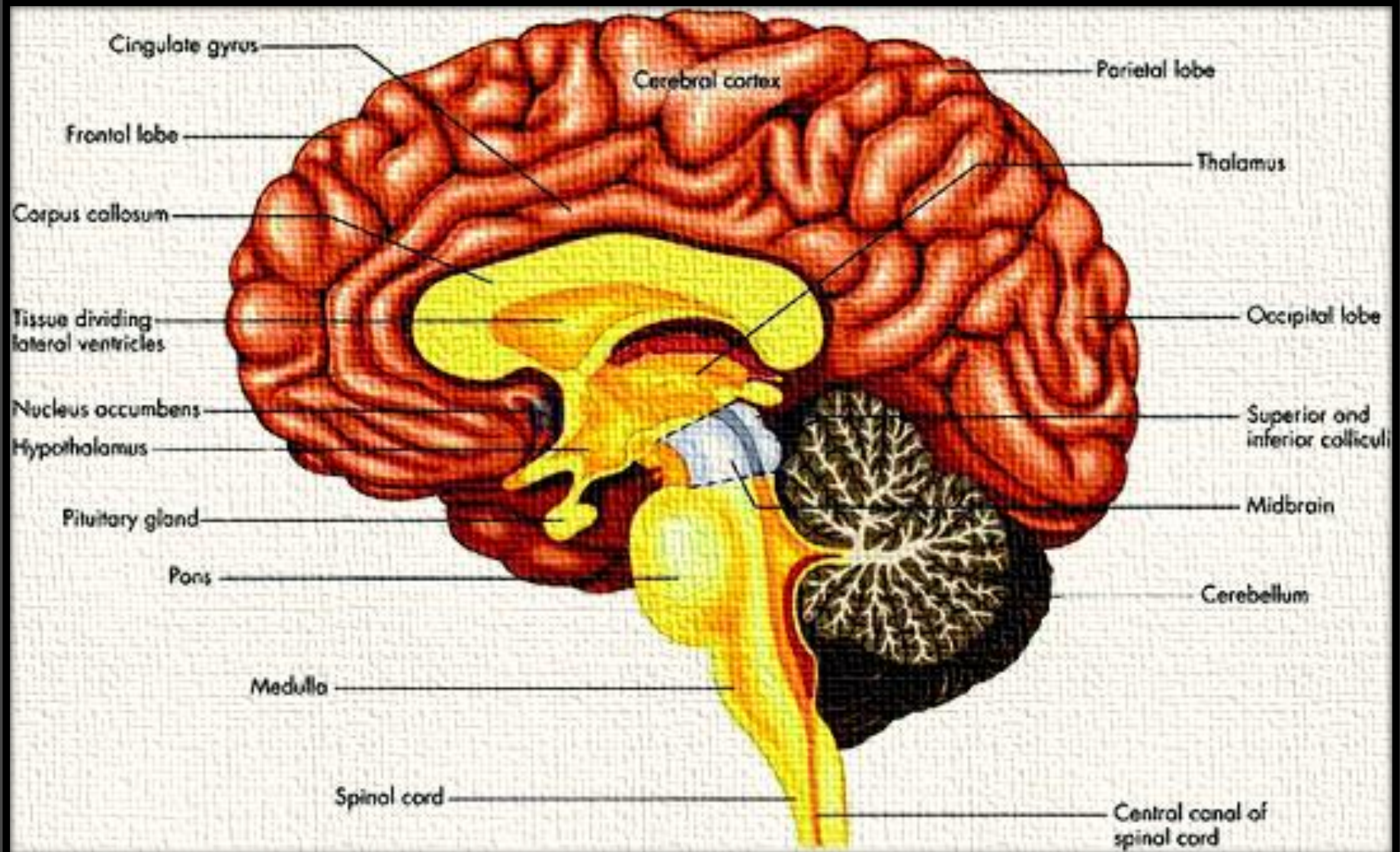
Controls involuntary vital functions such as heart beat, respiration, vasomotor activities, peristalsis.

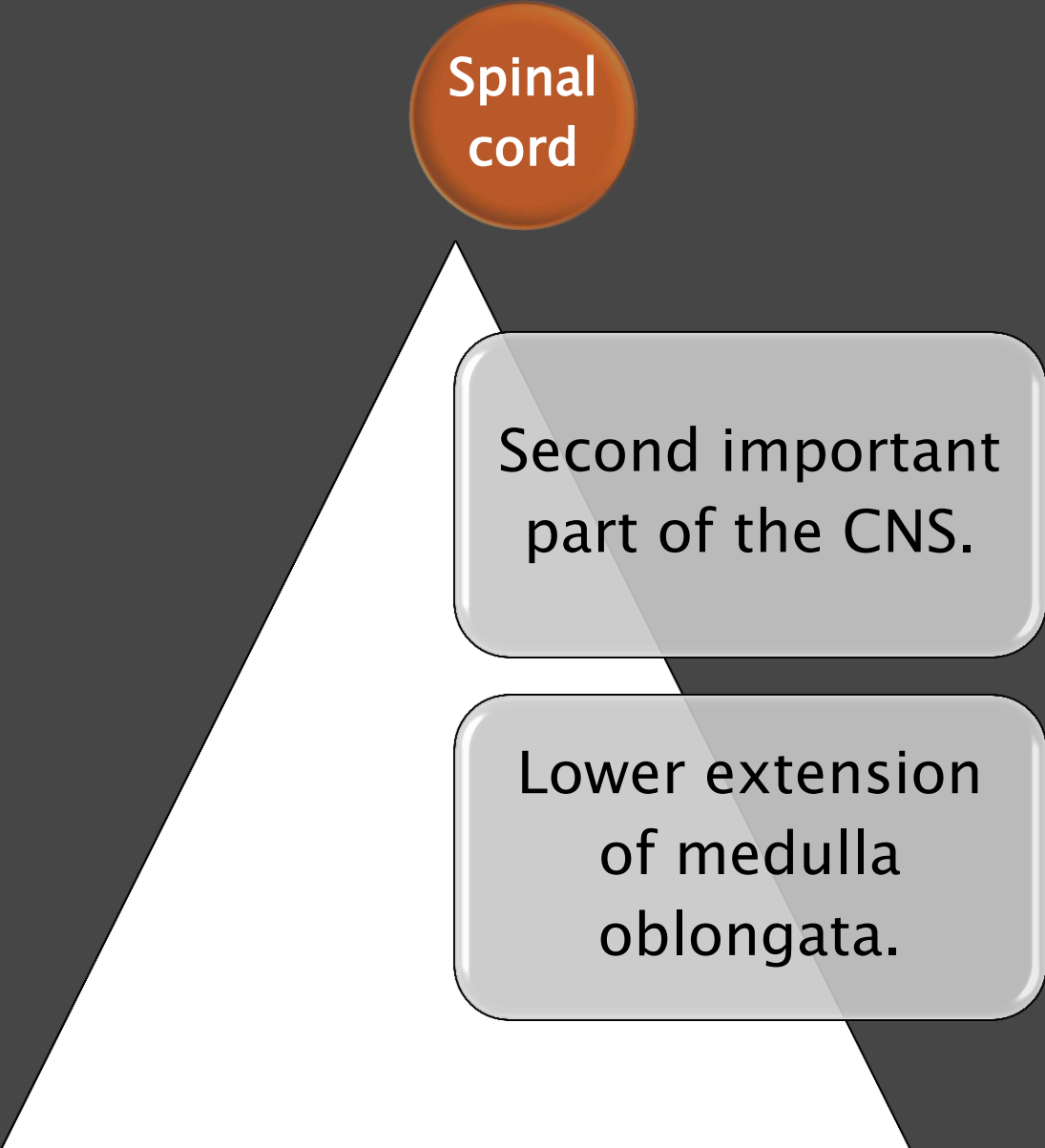
Controls non-vital activities like coughing, sneezing, swallowing, vomiting, yawning.

It encloses a cavity known as metacoel or fourth ventricle. Its roof has posterior choroid plexus for secretion of CSF.

Posterior choroid plexus has 3 opening–

- A pair of lateral foramen of Luschka,
- A median foramen of Magendie.

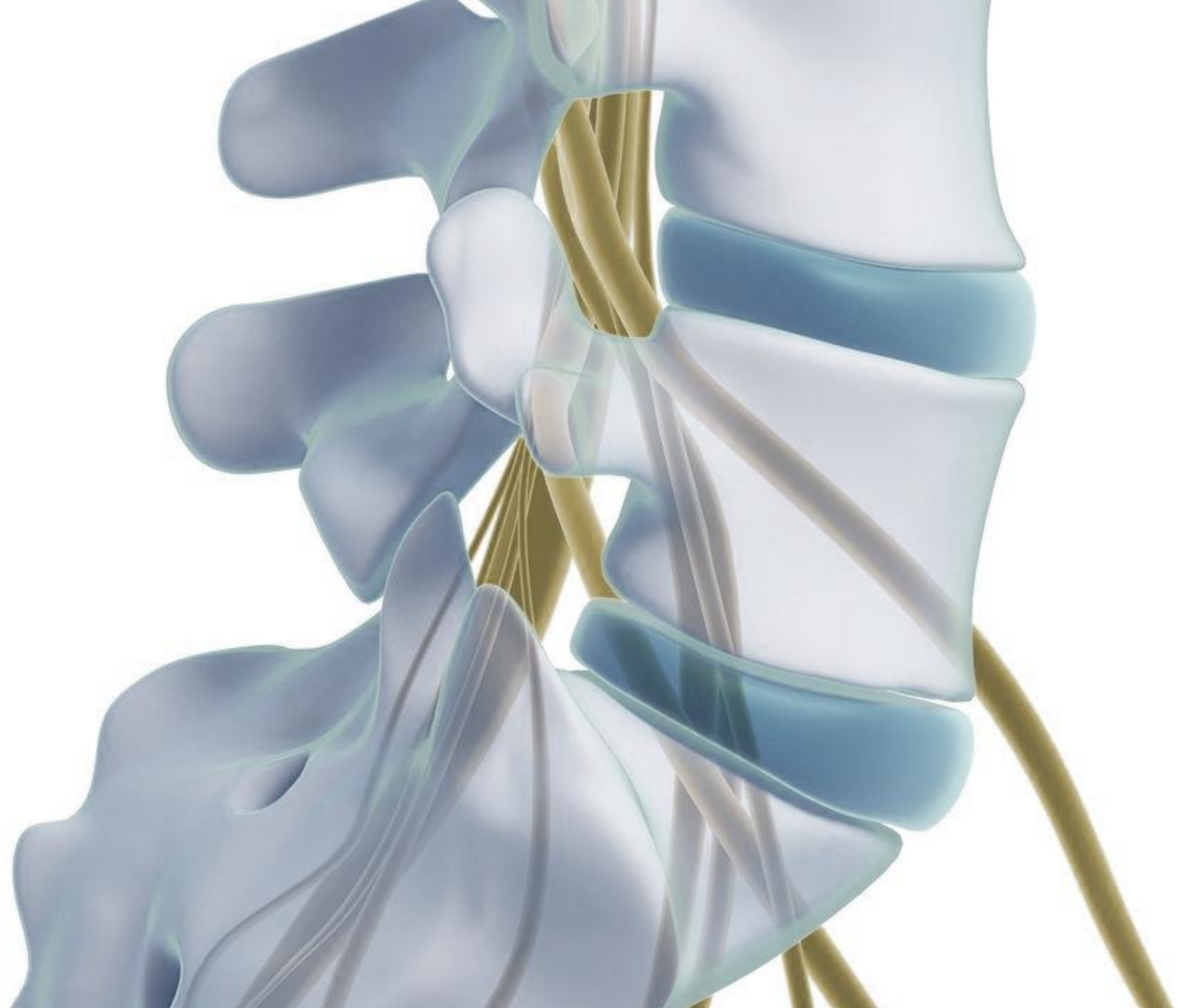




Spinal
cord

Second important
part of the CNS.

Lower extension
of medulla
oblongata.





Spinal cord



It lies within the neural canal of the vertebral column.

It is also surrounded by three meninges- dura matter, arachnoid matter,& pia matter.

CSF forms a fluid cushion around the spinal cord.

Structure of the spinal cord



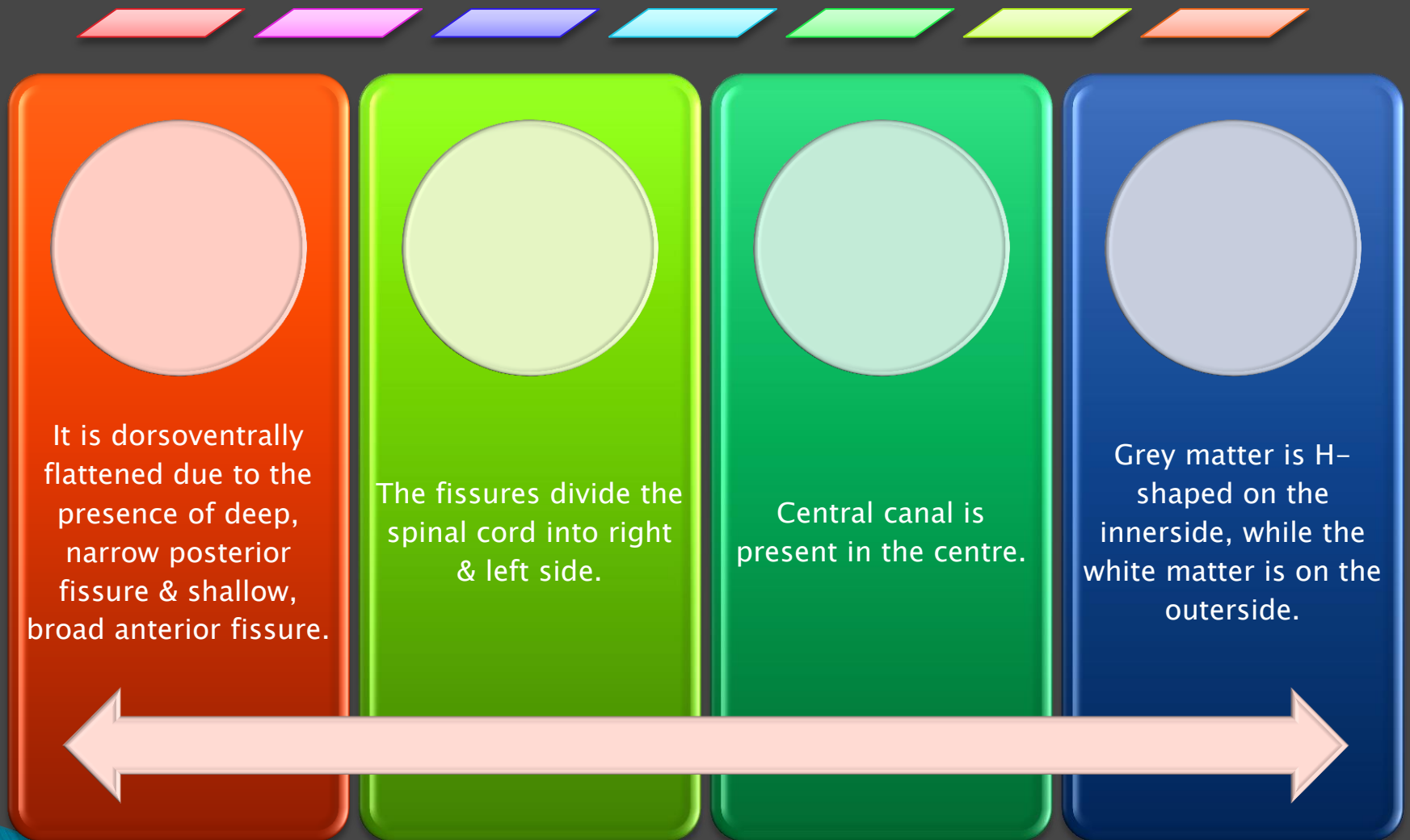
It is long cylindrical rod, 42 to 45 cm long & 2.0 to 2.5 cm broad.

Broadest at anterior end & tapers posteriorly into conus medullaris & further continues as a thread like filum terminale.

31 pairs of spinal nerves arise from lateral sides of the spinal cord. These nerves are concentrated in the region of cervical & lumbar shows swelling.

Bunch of nerve appear like a horse's tail along the filum terminale, known as Cauda equina.

T.S. of Spinal cord



It is dorsoventrally flattened due to the presence of deep, narrow posterior fissure & shallow, broad anterior fissure.

The fissures divide the spinal cord into right & left side.

Central canal is present in the centre.

Grey matter is H-shaped on the innerside, while the white matter is on the outside.

T.S. of Spinal cord

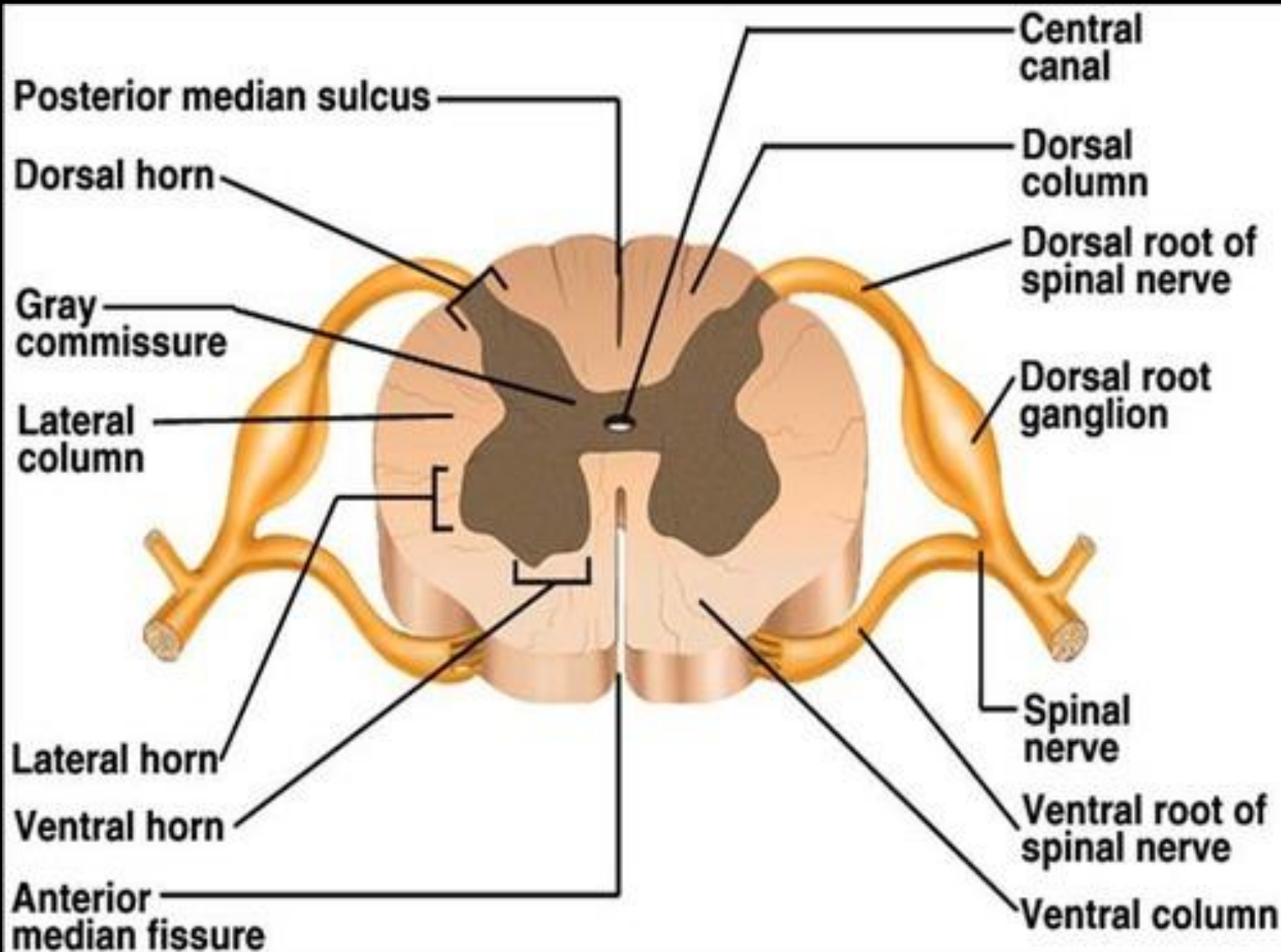


The fissures divide the grey matter into six horns, such as:

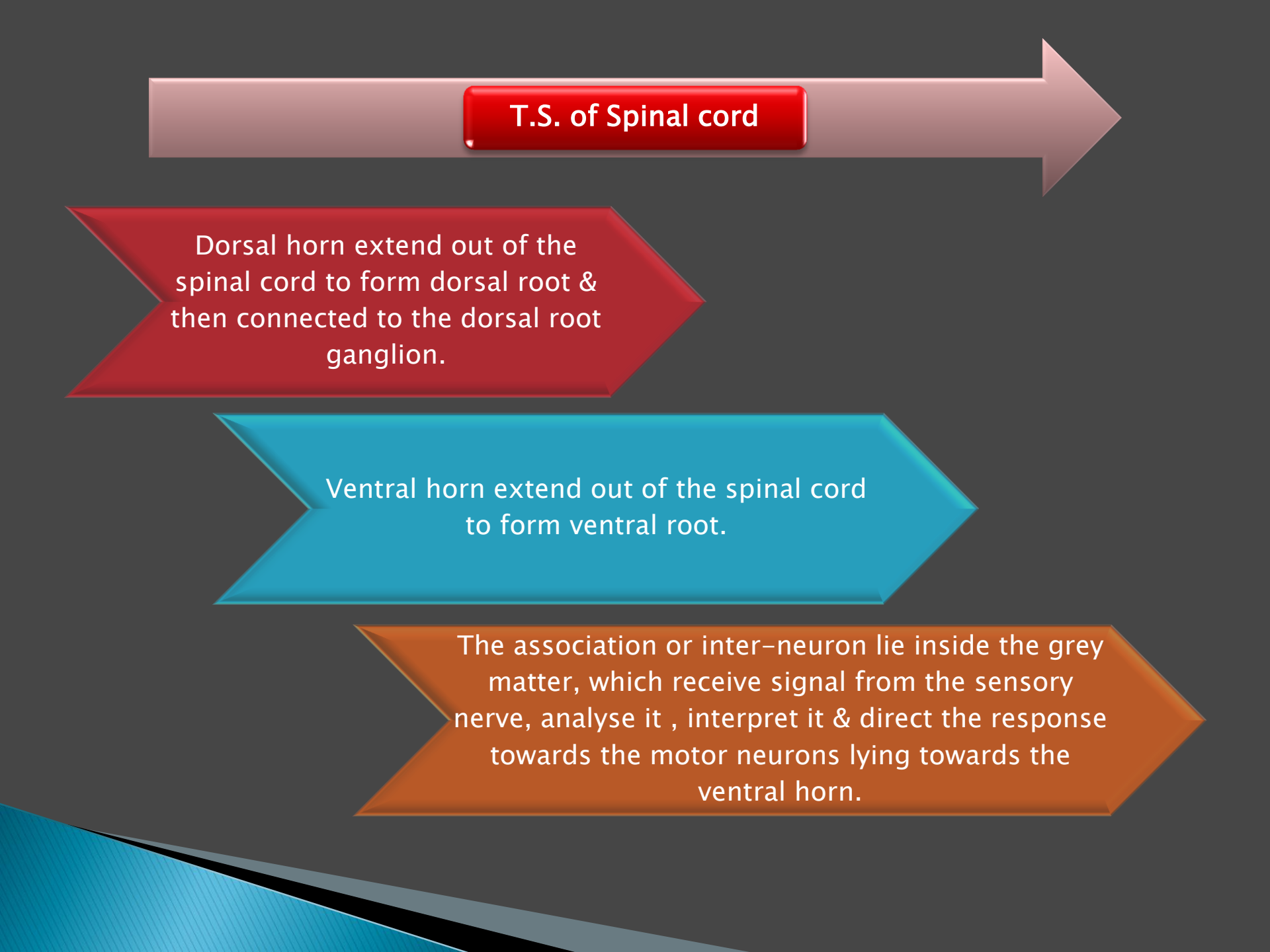
- Pair of dorsal horn
- Pair of lateral horn
- Pair of ventral horn

The fissures divide the white matter into six columns or funiculi, such as:

- Pair of dorsal funiculi
- Pair of lateral funiculi
- Pair of ventral funiculi



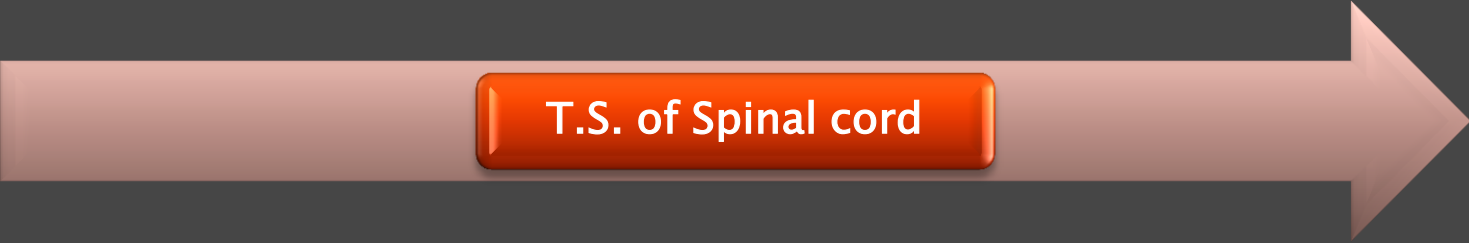
T.S. of Spinal cord



Dorsal horn extend out of the spinal cord to form dorsal root & then connected to the dorsal root ganglion.

Ventral horn extend out of the spinal cord to form ventral root.

The association or inter-neuron lie inside the grey matter, which receive signal from the sensory nerve, analyse it , interpret it & direct the response towards the motor neurons lying towards the ventral horn.



T.S. of Spinal cord

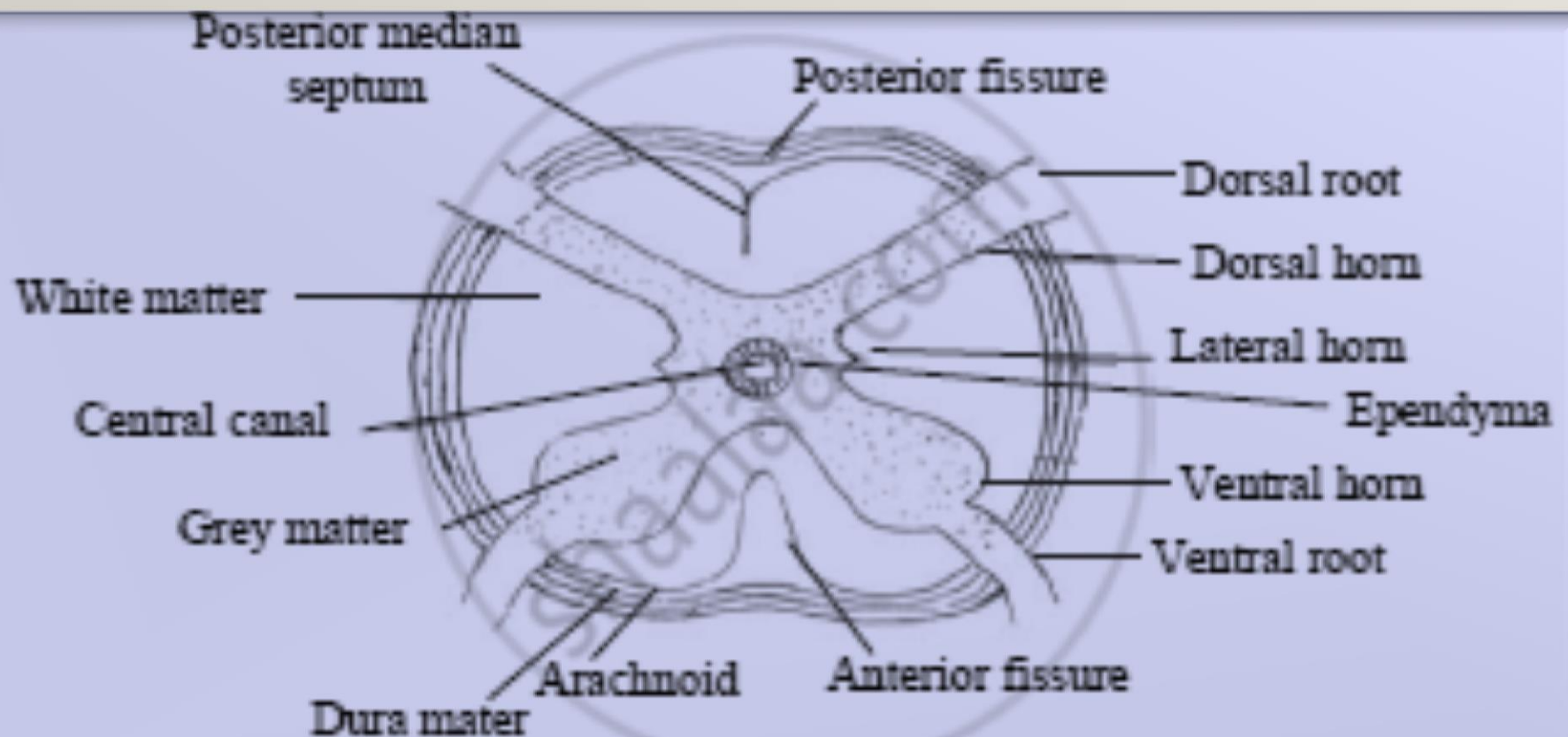
The lateral horns have neurons of ANS.

The nerves arising from these neurons, emerge out from the ventral root of spinal nerve.

White matter consists of myelinated ascending & descending tracts.

The ascending tracts conduct sensory impulses from spinal cord to the brain.

The descending tracts conduct motor impulses from brain to the lateral & ventral funiculi of spinal cord.



T.S. of Spinal Cord

Functions of spinal cord

Main centre for the most of the reflex actions.

It provides nervous connection to many parts of the body.

It provides pathway for conduction of sensory and motor impulses to and from the brain.

Peripheral nervous system

PNS connects
the CNS to
the different
parts of the
body through
receptors &
effectors.

Peripheral nervous system

It is classified into
two main types:

Cranial
nerves

Spinal
nerves

Cranial nerves

- Develop from brain
- 12 pairs of cranial nerves
- These nerves originate from or terminate into the brain.
- They may be sensory, motor, or mixed

Spinal nerves

- Develop from spinal cord
- 31 pairs of spinal nerves
- They provide two way communication between spinal cord and parts of the body.
- They all are mixed nerves.

No.	Name	Type
I	Olfactory	Sensory
II	Optic	sensory
III	Oculomotor	Motor
IV	Pathetic	Motor
V	Trigeminal a. Ophthalmic b. Maxillary c. Mandibular	Mixed
VI	Abducens	Motor
VII	Facial	Mixed
VIII	Auditory i. Vestibular ii. Cochlear	Sensory
IX	Glossopharyngeal	Mixed
X	Vagus	Mixed
XI	Spinal accessory	Motor
XII	Hypoglossal	Motor



Spinal nerves

Group	No. of pairs	Region of origin
Cervical	8 (C1–C8)	Neck
Thoracic	12 (T1–T12)	Thorax
Lumbar	5 (L1–L5)	Abdomen
Sacral	5 (S1–S5)	Pelvis
Coccygeal	1 (Co1)	Coccyx

Formation of typical spinal nerves

Each spinal nerve is formed inside the neural canal of vertebral column by the posterior or dorsal root & the anterior or ventral root.



Dorsal root receives the sensory nerve from the dorsal root ganglion.



Ventral root gives out the motor nerve.



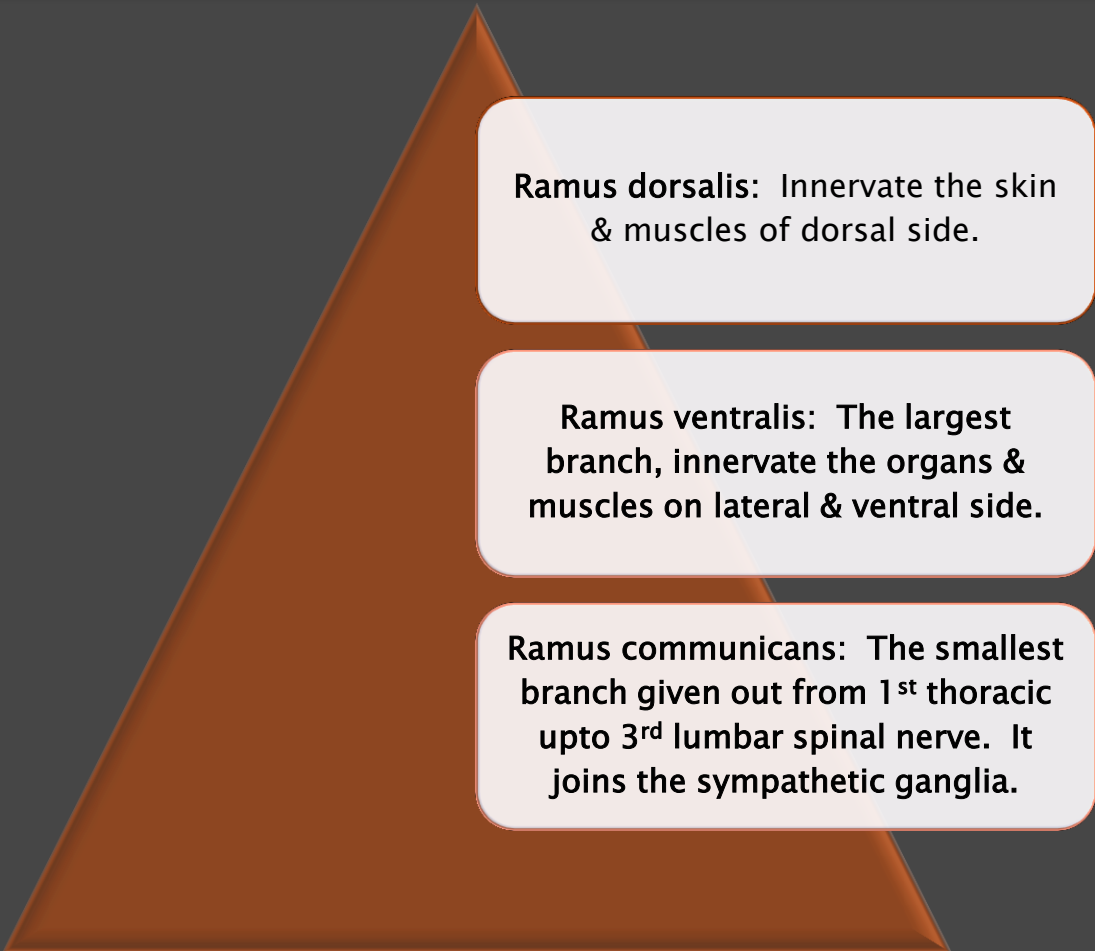
The dorsal sensory & ventral motor nerves together form the mixed spinal nerve.



Spinal nerve emerges out of vertebral column through intervertebral foramen & form three branches.



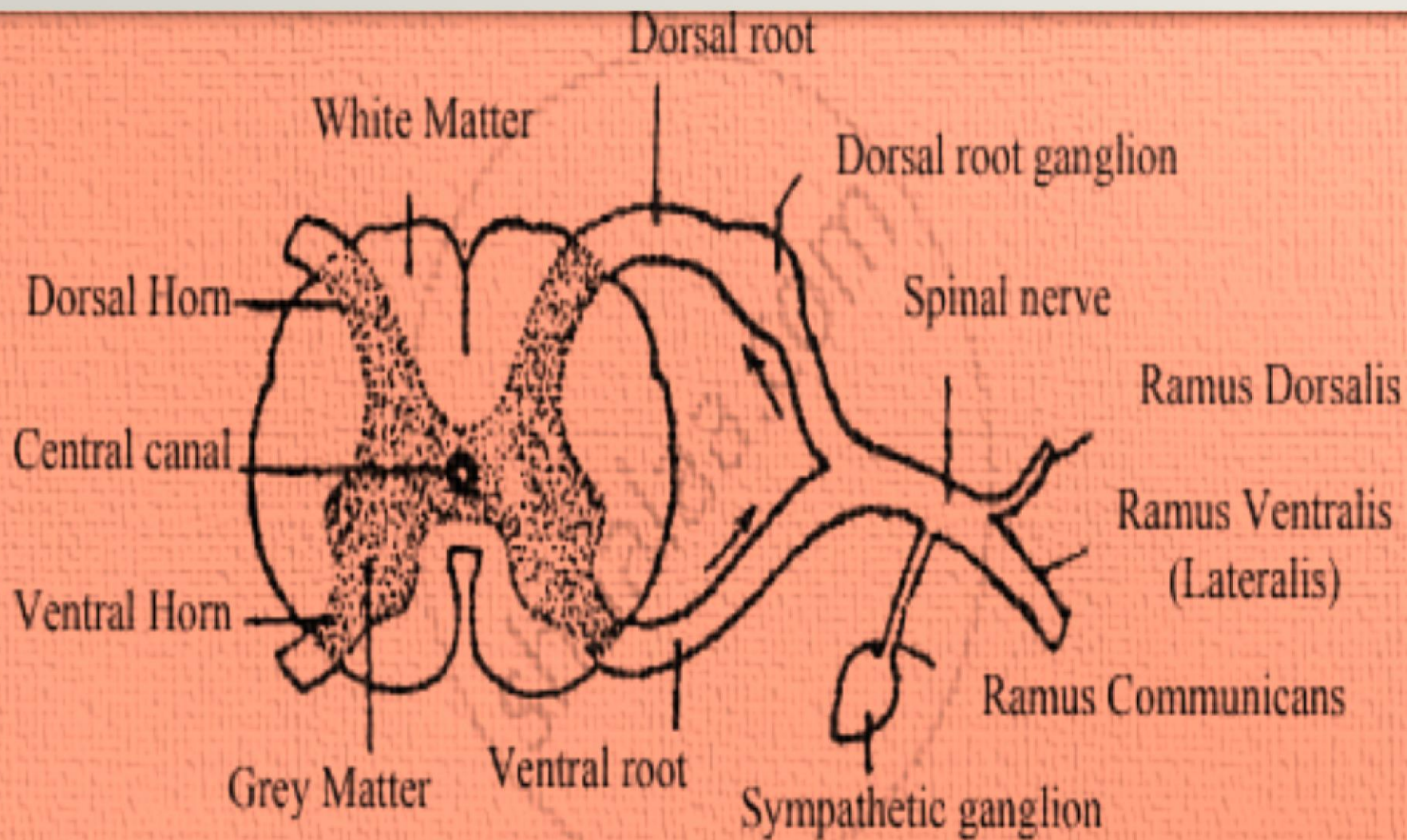
Three branches of spinal nerve



Ramus dorsalis: Innervate the skin & muscles of dorsal side.

Ramus ventralis: The largest branch, innervate the organs & muscles on lateral & ventral side.

Ramus communicans: The smallest branch given out from 1st thoracic upto 3rd lumbar spinal nerve. It joins the sympathetic ganglia.



Formation of Typical Spinal Nerve

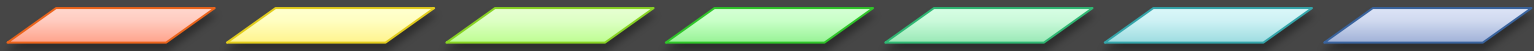
PNS consist of network of nerves arising from or going to the CNS

Accordingly peripheral
nerves are classified as

Afferent nerves: transmit
sensory impulse from
tissue or organ to the
CNS.

Efferent nerves: transmit
motor impulse from CNS
to the tissue or organ.

PNS is divided into :



Somatic nervous
system

Autonomic
nervous system

The somatic nervous system relays impulses from CNS to the skeletal or voluntary muscles of the body.

Autonomic nervous system transmits impulses from CNS to the smooth or involuntary muscles of the body.



Autonomous nervous system

ANS consists of a special set of peripheral nerves that regulate the involuntary activities of smooth muscles.

In ANS, impulses are conducted from CNS by an axon which form synapses with an autonomic ganglion, such neuron is called preganglionic neuron.

And the other neuron, which carry impulse from autonomic ganglion to the effector organ, is postganglionic neuron.

ANS consists of sympathetic & parasympathetic nervous system.

Sympathetic nervous system

- Thoraco-lumbar outflow.
- Originates in the thoracic & lumbar region of spinal cord.
- It consists of 22 pairs of sympathetic ganglia which lie on a pair of sympathetic cords on lateral sides of the spinal cord.

Parasympathetic nervous system

- Cranio-sacral outflow.
- Consists of branches of cranial nerves(III,VII,IX,X) & sacral nerves(II,III, IV).
- These ganglia are situated very close or within the wall of the effector organs.

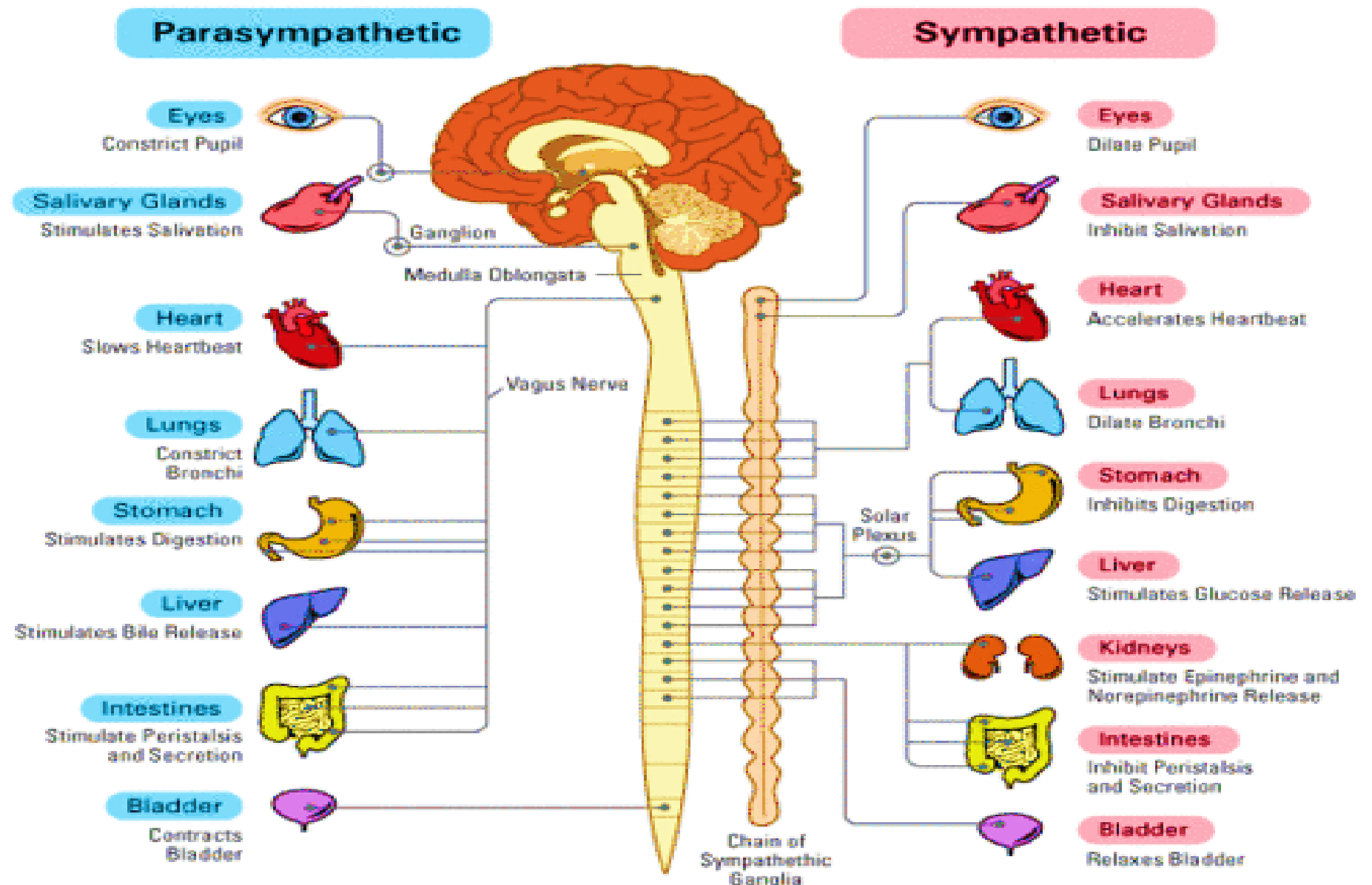
Sympathetic N S

- Pre-ganglionic nerve fibres are short & post-ganglionic nerve fibres are long.
- At the terminal ends of postganglionic nerve fibres, they produce adrenaline & noradrenaline at effector organ.
- Hence these nerve fibres are also called as Adrenergic fibres.
- SNS controls body activities during emergencies.
- It has excitatory or stimulating effect on most organs of the body except in the digestive & excretory organ.

Parasympathetic N S

- Pre-ganglionic nerve fibres are long & post-ganglionic nerve fibres are short.
- At the terminal ends of postganglionic nerve fibres, they produce acetylcholine at the effector organ.
- Hence these nerve fibres are also called as cholinergic fibres.
- PNS bring back to normal , all the activities which are stimulated by SNS. (Housekeeping system)
- It has inhibitory effect on most organs. But the activities associated with digestion, peristalsis & micturition, which are inhibited by SNS are accelerated by the PNS.

Schema Explaining How Parasympathetic and Sympathetic Nervous Systems Regulate Functioning Organs



DISORDERS OF NERVOUS SYSTEM.

Psychological disorders:

Mental disorder which affect the mood, thinking or behaviour, create distress for the person suffering from it.

Examples: Intellectual disability, Autism spectrum, Bipolar disorder, depression, stress related disorders, & ADHD(Attention Deficit Hyperactivity Disorder)

Parkinson's disease:

- Degeneration of dopamine-producing neurons in the CNS.
- Symptoms are tremors, stiffness, difficulty in walking, balance, and co-ordination.

Alzheimer's disease:

- Common form of dementia.
- Loss of cognitive functioning such as thinking, remembering, reasoning, & behavioral abilities
- It interferes with the persons daily life and activities.
- It occurs due to loss of cholinergic & other neurons in the CNS, accumulation of amyloid proteins.
- No cure, but treatment slows down the progression of the disease.

**Here nervous
coordination is over,
now let's learn about
chemical coordination.**

Chemical or Hormonal coordination



In higher animals due to complex body organization, in addition to the nervous coordination, there is need of chemical coordination.

The cells & organisms communicate with each other through chemical signals.

Depends on the chemical signals, they are divided into four types:

Autocrines : Cells release secretion to stimulate itself.

Endocrines : Cells release secretions to stimulate distant cells.

Paracrines : Cells release secretion to stimulate neighbouring cells.

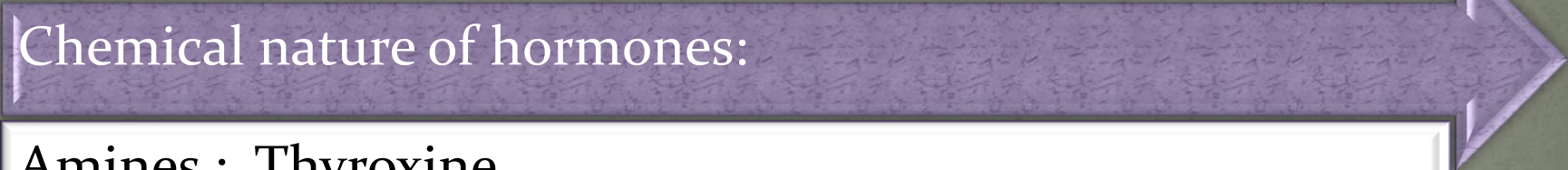
Pheromones : Organs release secretions to stimulate other organism.

Chemical coordination is carried out by ductless gland known as endocrine glands.

The endocrine glands constitutes endocrine system, which controls body activities by means of chemical messengers called hormones.



Hormones released directly into the blood & carried to all parts of the body . The message is relayed only to the target organs which get stimulated to carry out specific functions.



Chemical nature of hormones:

Amines : Thyroxine.

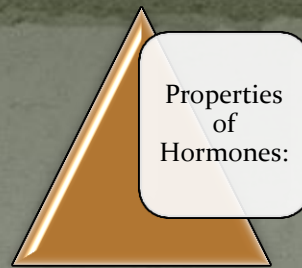
Peptide hormones : Oxytocin, ADH, GnRH.

Protein hormones : TSH, FSH, LTH, GH, insulin.

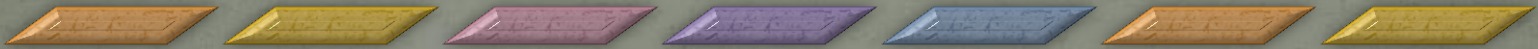
Fatty acid derivatives : Prostaglandin.

Steroid hormones : Estrogen, testosterone, aldosterone.

Gas : Nitric Oxide.



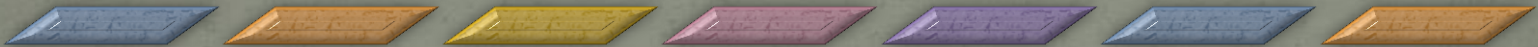
Hormones acts as chemical messenger.



Effective in very low concentration.



They are either stimulators or inhibitors.



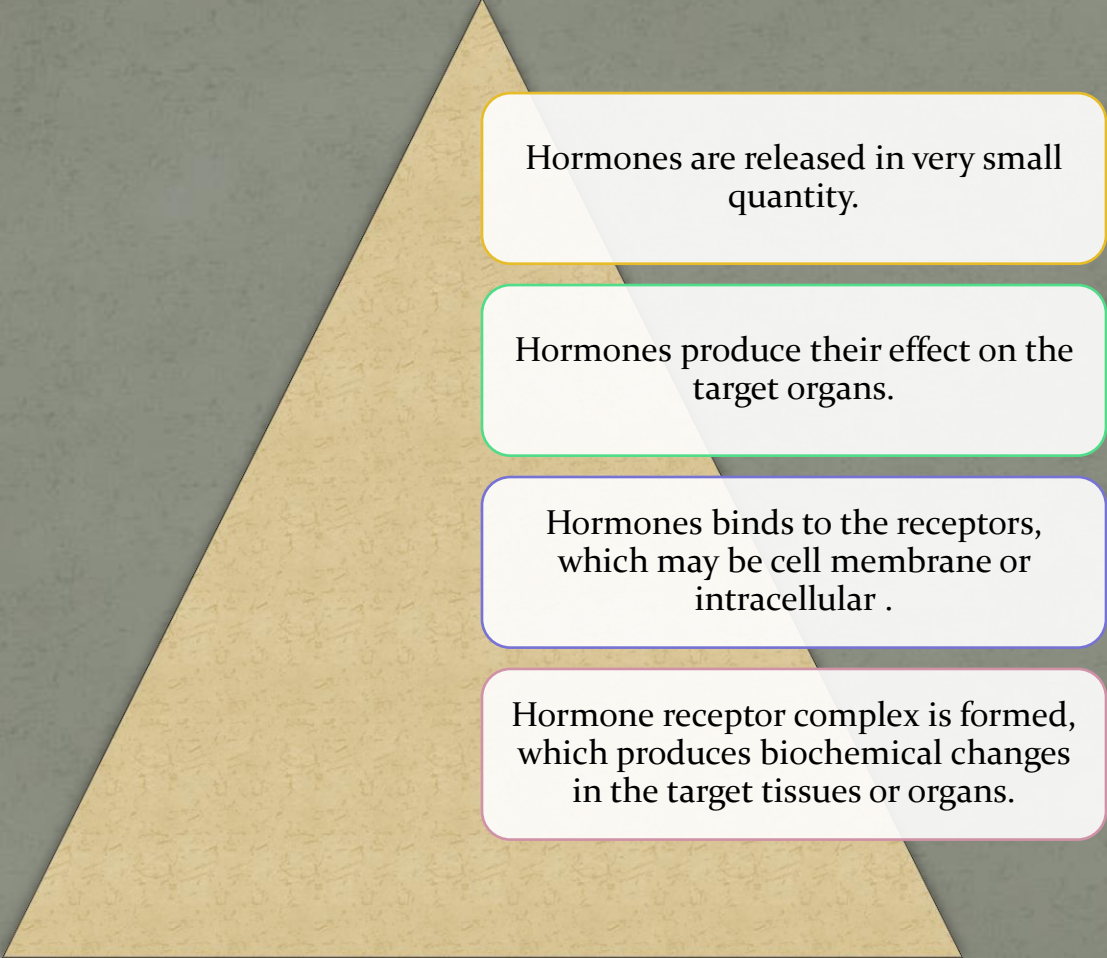
They are metabolized after their function is over, so cannot reuse.



Their secretion is regulated by positive or negative feedback mechanism.



Mechanism of hormone action



Hormones are released in very small quantity.

Hormones produce their effect on the target organs.

Hormones binds to the receptors, which may be cell membrane or intracellular .

Hormone receptor complex is formed, which produces biochemical changes in the target tissues or organs.

Mode of hormone action through membrane receptors:

Hormones such as catecholamines, peptide, polypeptide hormones are not lipid soluble, they are water soluble. So they cannot enter their target cells through plasma membrane, as it is having lipid coating.

These hormones interact with surface receptor, which initiate metabolic activity.

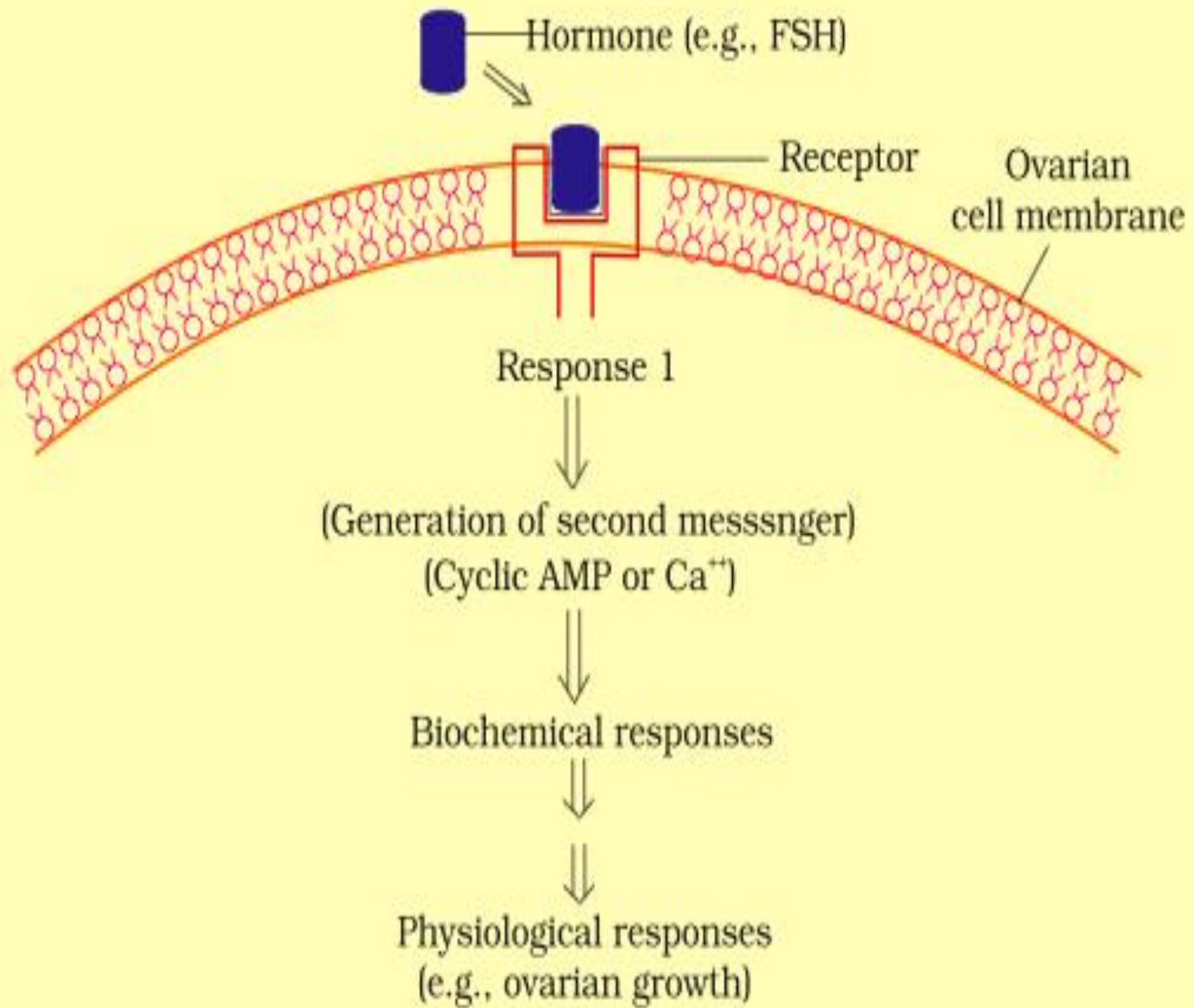
Molecules of amino acid, peptide hormones bind to specific receptor molecules located on the plasma membrane.

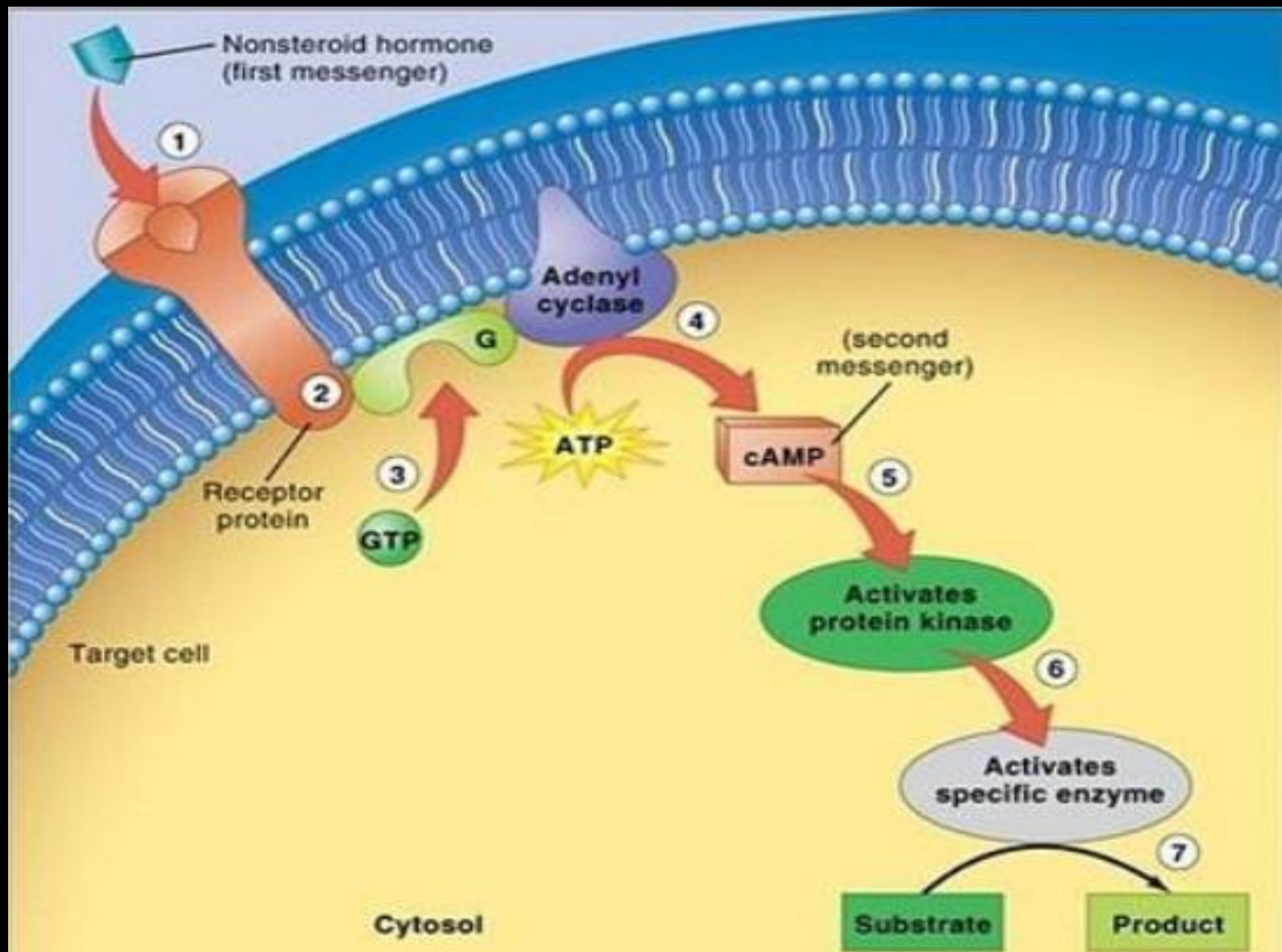
Hormone receptor complex causes the release of an enzyme adenylate cyclase from the receptor site. This enzyme forms cyclic AMP from ATP of the cell.

Cyclic AMP activates enzymatic actions.

Hormones acts as a first messenger & cAMP is the second messenger.

Other second messengers are Ca^{++} , cGMP, & IP_3 .





Mode of action through intracellular receptors:

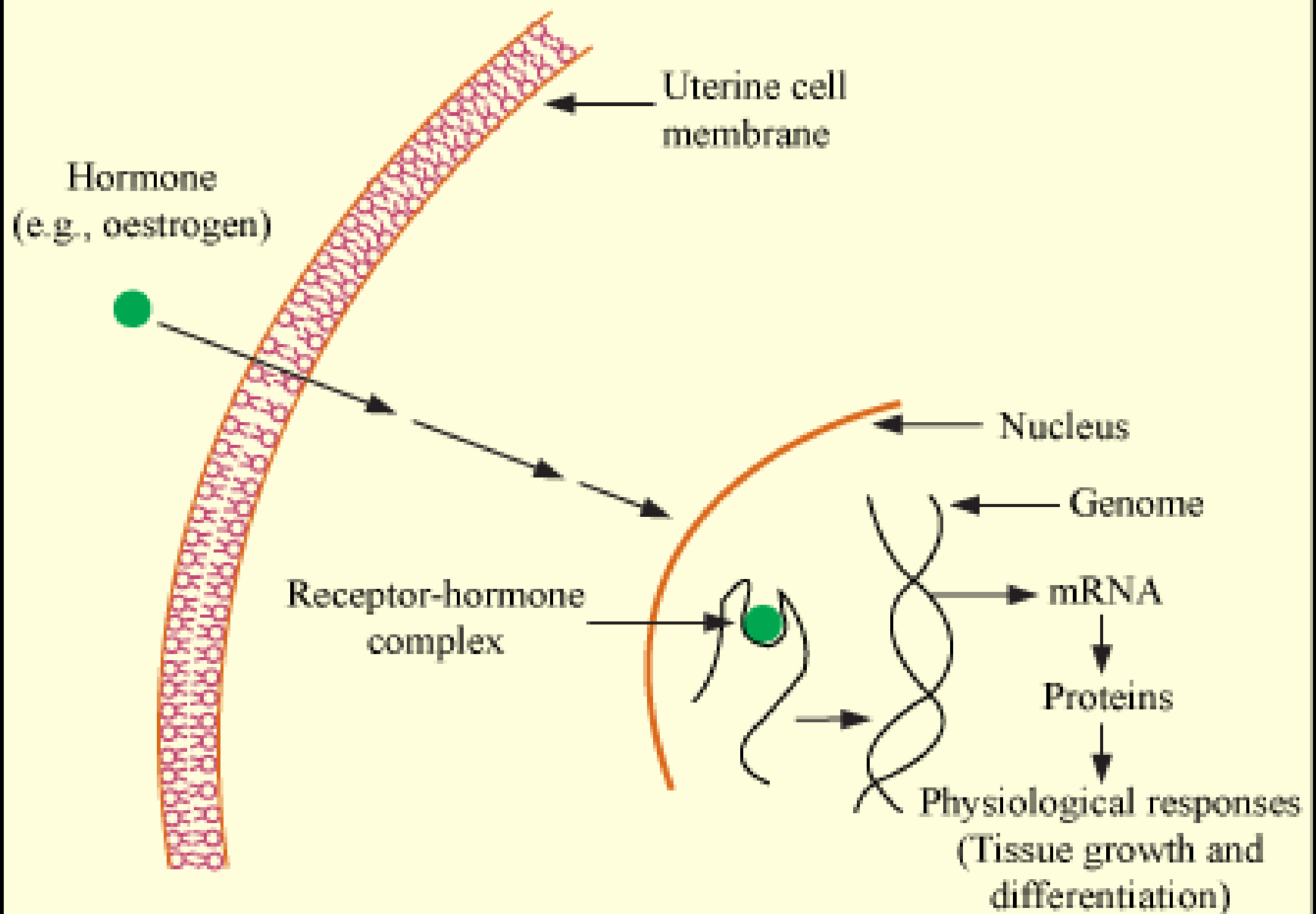
Steroid & thyroid hormones are lipid soluble, so they can easily pass through the plasma membrane of the target cell into the cytoplasm.

In the cytoplasm, they bind to the intracellular receptor protein forming a hormone receptor complex that enters the nucleus.

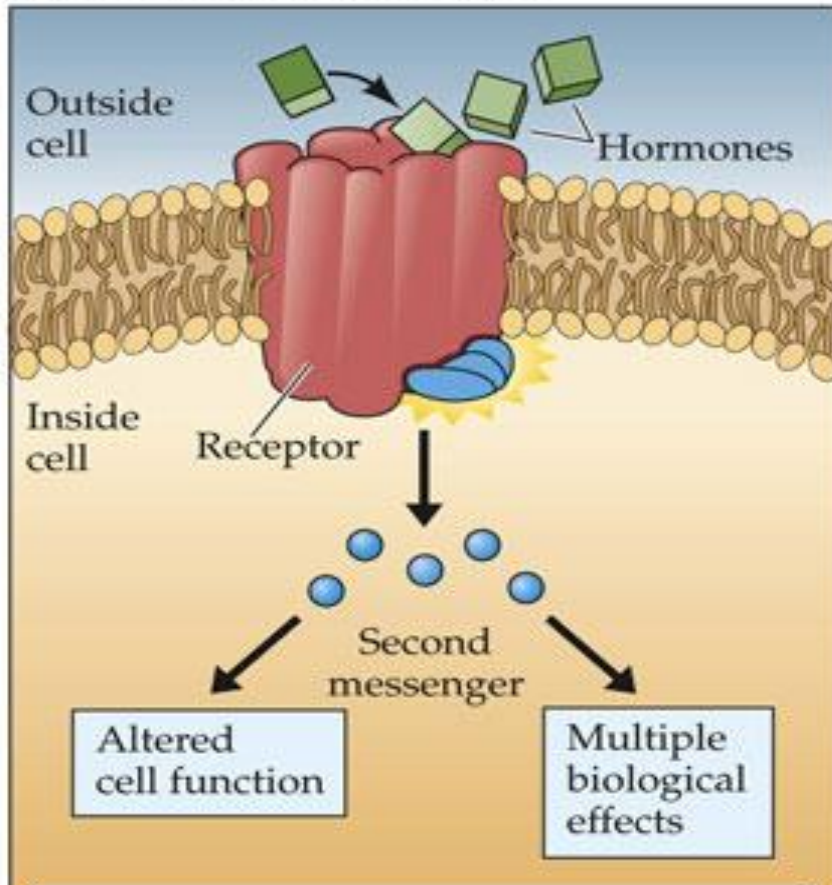
Hormone receptor complex binds to a specific regulatory site of DNA.

The activated genes transcribe mRNA which directs protein synthesis.

Action of lipid soluble hormones is slower but long lasting.

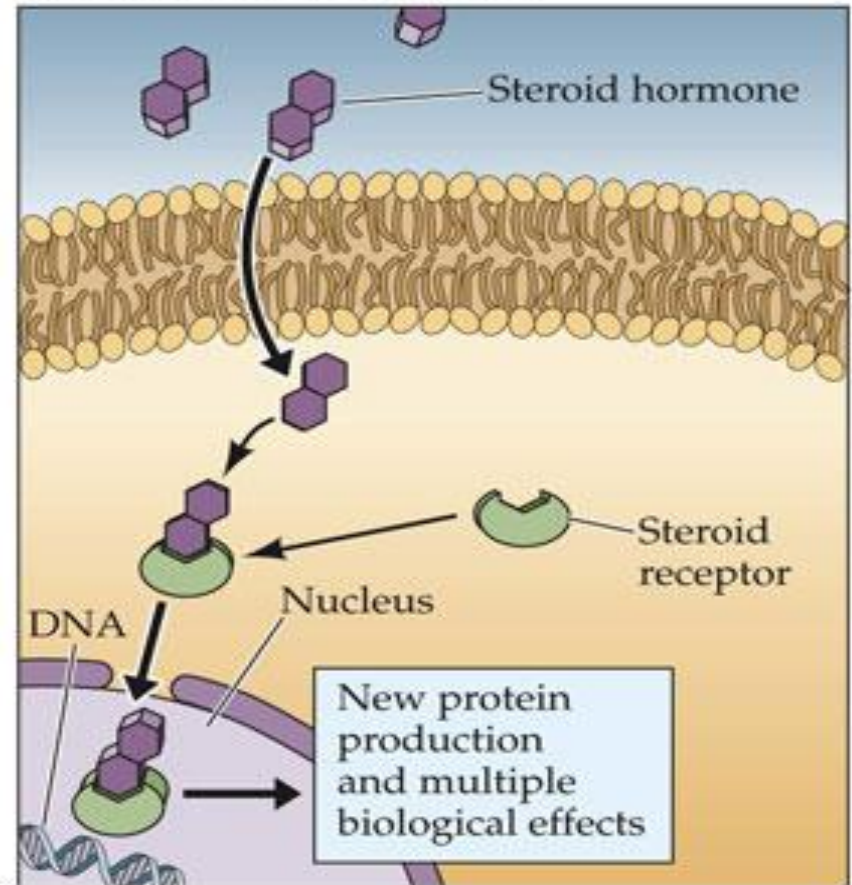


(A) Peptide hormone action



Peptide hormone receptors embedded in the cell membrane bind to the hormone, activating a second-messenger system that affects various processes inside the target cell.

(B) Steroid hormone action



Steroid hormones diffuse passively in, binding to large receptor molecules inside target cells. The steroid-receptor complex then binds to DNA, altering the expression of certain genes—a so-called genomic effect.

Major endocrine glands



Hypothalamus

Pituitary gland

Pineal gland

Thyroid gland

Parathyroid gland

Thymus gland

Adrenal gland

Pancreas

Gonads

Diffuse endocrine glands



Hypothalamus



- ❖ It is ectodermal in origin.
- ❖ Located at the floor of the diencephalon.
- ❖ Maintain homeostasis.
- ❖ Controls the secretory activity of the pituitary gland.
- ❖ Secret releasing & inhibiting hormones or factors.
- ❖ Neurosecretary cells of the hypothalamus secrete neurohormones which are peptide hormones.
- ❖ Example: ADH, Oxytocin.

Releasing or Inhibiting factors of hypothalamus:

- Adrenocorticotropin releasing hormone
- Thyrotropin releasing hormone
- Gonadotropin releasing hormone
- Prolactin inhibiting hormone
- Somatostatin
- Somatotropin
- Gastrin releasing peptide
- Gastrin inhibitory polypeptide

Hypophyseal portal system

This system carries various hormones secreted by hypothalamus to the pituitary gland. The portal vein collects blood from various parts of hypothalamus & open into anterior lobe of pituitary, & then finally to superior vena cava.

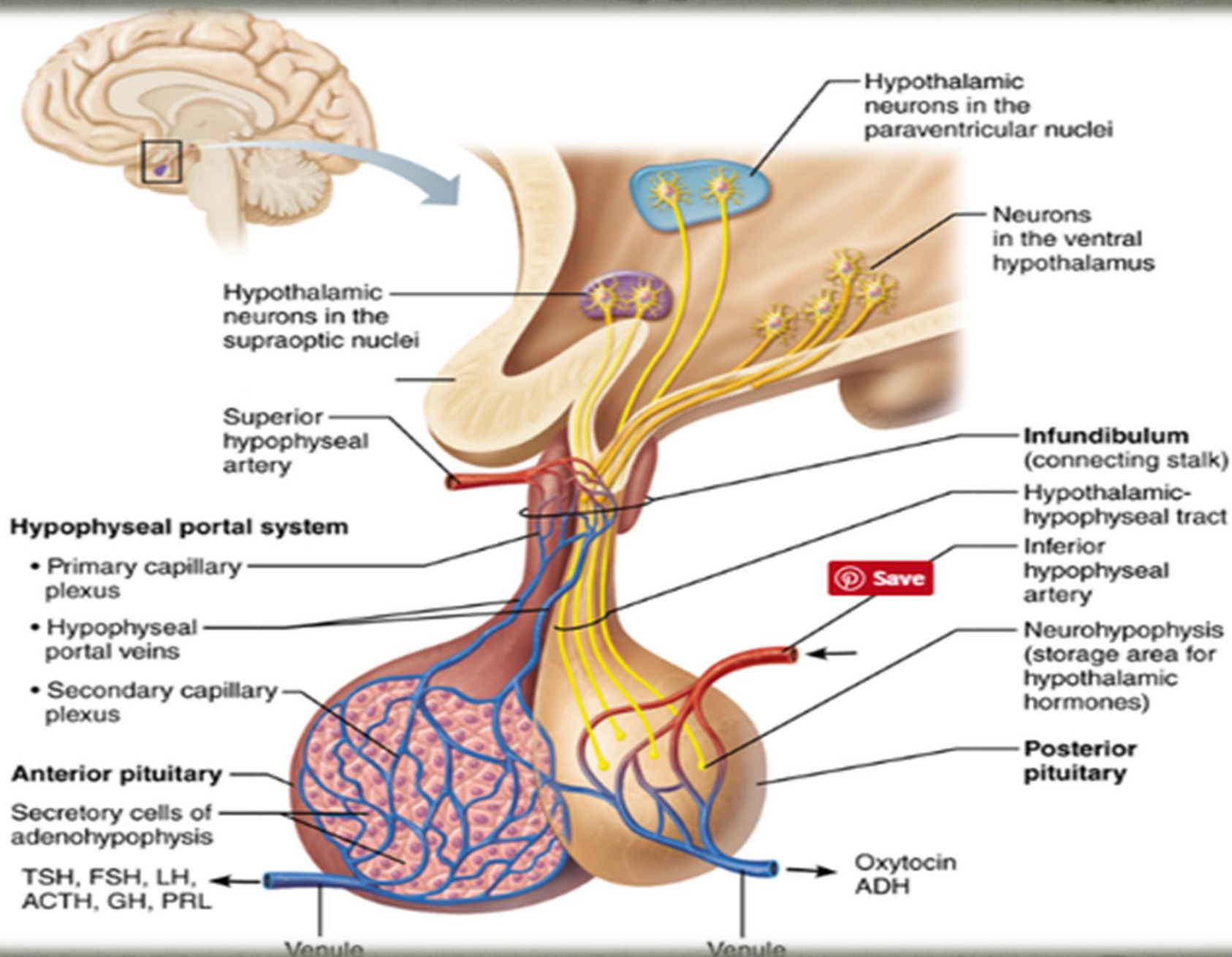
Pituitary gland or Hypophyseal gland

Location: It is located just below the hypothalamus & attached to it by infundibulum or hypophyseal stalk.

Pituitary gland is lodged in a bony depression called **sella turcica** of the sphenoid bone.

Structure: It is smallest, pea-sized, reddish-grey coloured gland.

It consists of two lobes, i.e. anterior lobe & posterior lobe.



Adenohypophysis or Anterior lobe

- It is an outgrowth from the roof of an buccal cavity. This outgrowth is called Rathke's pouch.
- It grows upward towards the brain.
- Adenohypophysis & intermediate lobes are connected to the hypothalamus through hypophyseal portal system.
- It is larger, highly cellular, & vascular part of pituitary gland.
- It consist of various types of epitheloid secretary cells, acidophils, basophils, chromatophores.
- It is diffentiated into 3 parts, such as pars distalis, pars intermedia, pars tuberalis.

Hormones of Adenohypophysis

Somatotropin/ Somatotropic hormone/ STH/ Growth hormone/ GH:

It stimulates growth & development of tissues by accelerating protein synthesis & cell division. It is continuously secreted through out life for repair & replacement of the body tissue or cell.

Hyposecretion of GH in children



- ✓ It causes stunted physical growth in child.
- ✓ This condition is known as **Pituitary dwarfism**.

Hypersecretion of GH in children



It causes abnormal growth in child.

This condition is called **Gigantism**.

Hypersecretion of GH in adults



- ❖ It causes disproportionate growth, disfigurement, enlargement of bones of lower jaws, hands, fingers, feet.
- ❖ This condition is called **Acromegaly**.

Thyrotropin/ Thyroid stimulating hormone/ TSH

Its primary action is to stimulate the thyroid gland to secrete its own hormone thyroxine.

Adreno corticotropic hormone/ ACTH/ Adrenocorticotropin

It stimulates adrenal cortex to produce & secrete its own hormones & maintains functioning of adrenal cortex.

Prolactin/ Luteotropin/ Mammotropin

- It is under predominant inhibitory control of hypothalamus.
- It activates growth of mammary gland during pregnancy (Mammotropin).
- It stimulates the milk production & secretion of milk by mammary gland after child birth(Lactogenic).

Gonadotropin

- a. Follicle stimulating hormone/FSH: In females, it stimulates growth of ovarian follicles and in males, it is concerned with the development of seminiferous tubules.
- b. Leutinizing hormone/LH: In females, the leutinizing hormone helps in ovulation. FSH & LH are responsible for stimulation of ovaries to produce oestrogen while LH induces the ruptured follicles to develop into corpus luteum and for production of progesterone.
- c. Interstitial cell stimulating hormone/ ICSH: In males, it stimulates the testes to produce testosterone, which is responsible for the development of secondary sexual characters.

Pars Intermedia

- Poorly developed in human beings.
- It secretes Melanocyte stimulating hormone(MSH) in some lower vertebrates.
- MSH stimulates the dispersion of melanin granules in menalocytes, which is responsible for skin pigmentation.

Neurohypophysis or posterior lobe

- It is differentiated into 3 parts:
 1. Pars nervosa/ neural lobe
 2. Infundibulum/ hypophyseal stalk
 3. Median eminence.

The pars nervosa acts as a storage area for neurohormones secreted by hypothalamus. It stores & releases oxytocin & vasopressin.

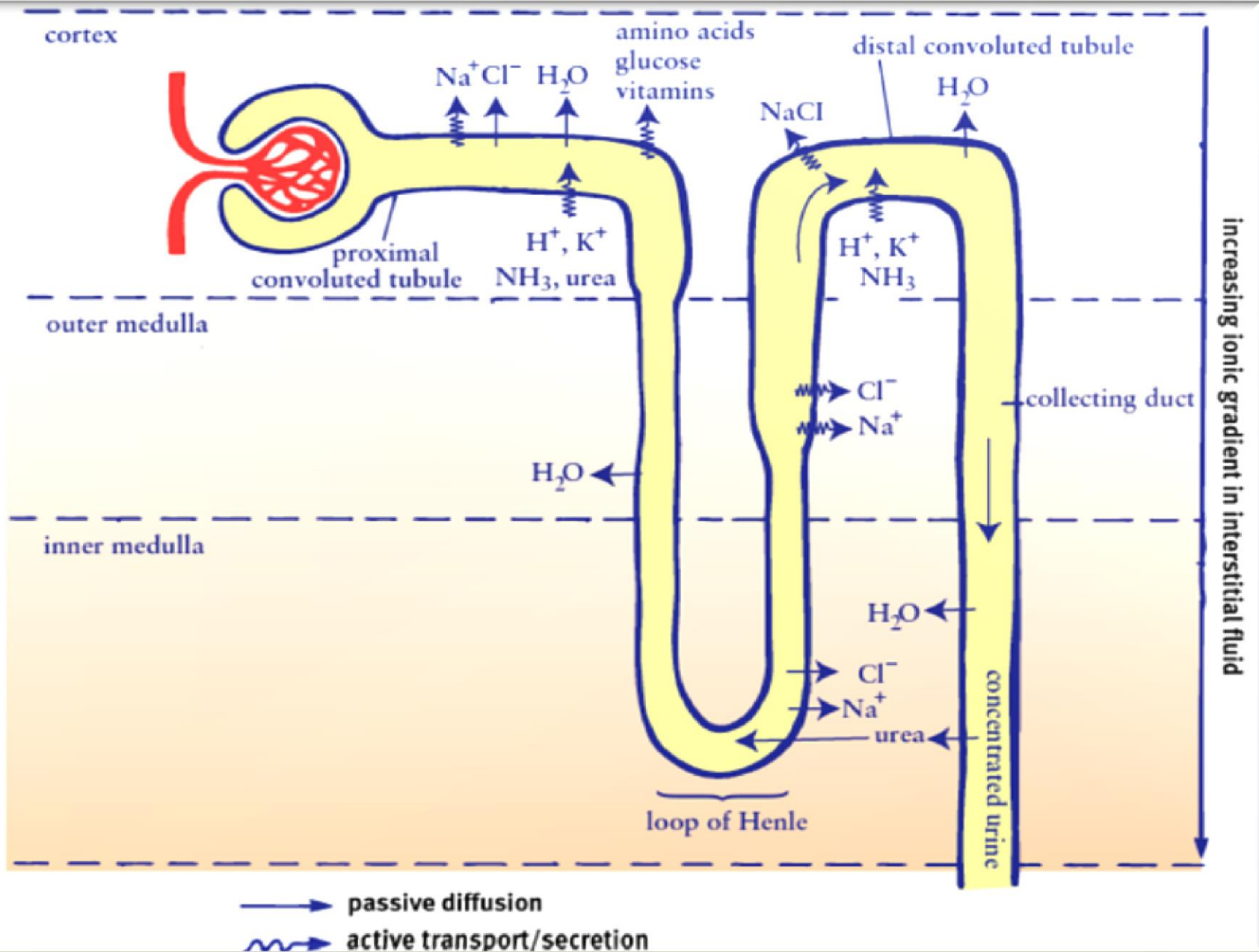
Hormones of Pars Nervosa

Oxytocin

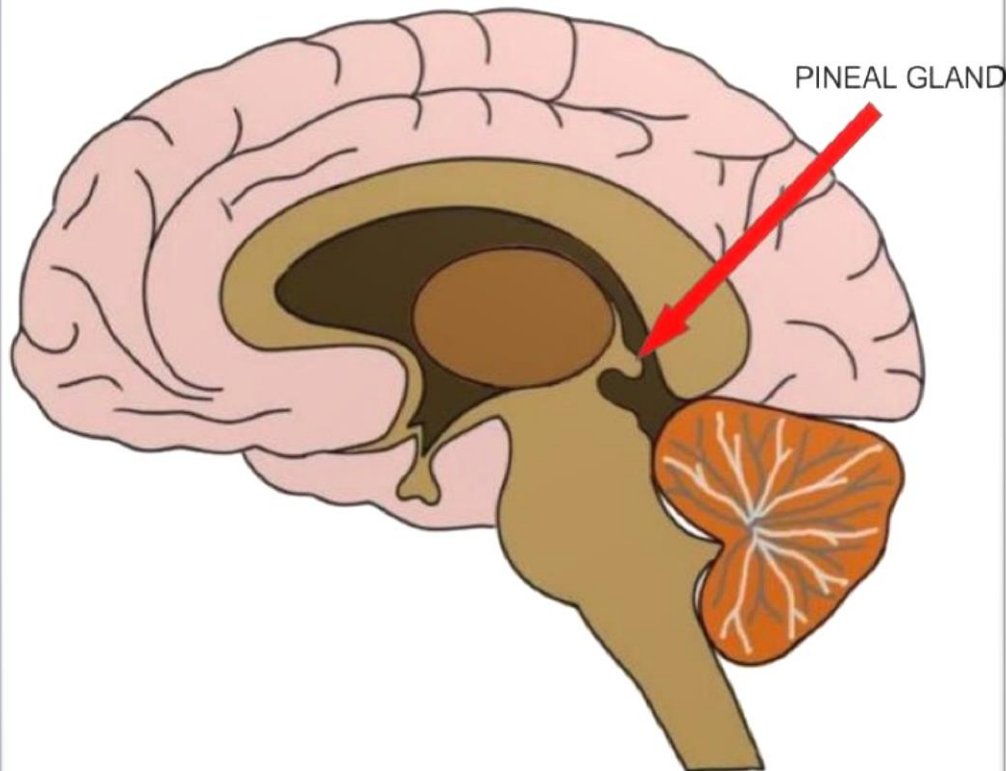
- ❑ It stimulates contraction of uterus during parturition.
- ❑ It stimulates the contraction of mammary glands to initiate ejection of milk.
- ❑ Therefore it is known as **Birth hormone.**

Antidiuretic hormone/ ADH/Vasopressin:

- ❖ It stimulates the re-absorption of water in distal convoluted tubule & collecting ducts of uriniferous tubules of the kidneys.
- ❖ It decreases loss of water by reducing the urine output.
- ❖ It increases blood pressure by causing vasoconstriction.
- ❖ Deficiency of ADH causes **Diabetes insipidus**.
- ❖ Excessive micturition causes excessive thirst, condition is known as **Polydipsia**.



Pineal gland



Pineal gland is upward projection from the roof of diencephalon, between the two cerebral hemispheres.

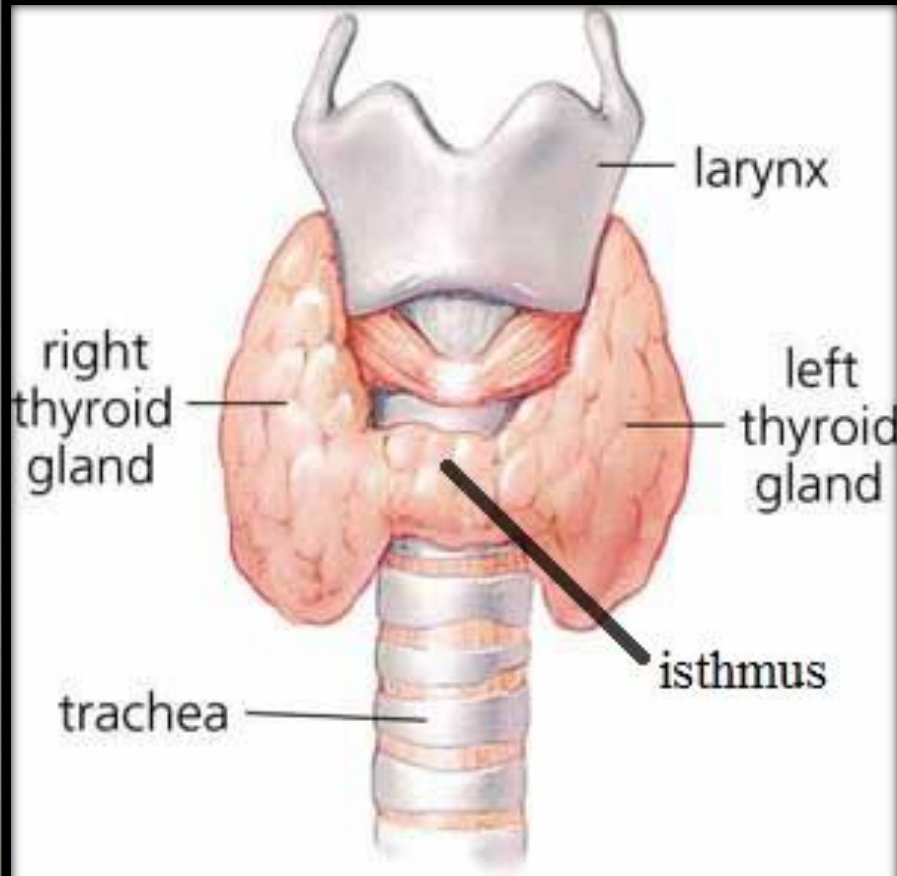
It is sensitive to the biochemical signals of light.

It secretes a hormone called **melatonin** which is sleep inducing hormone.

Melatonin derived from tryptophan & plays important role in the regulation of **Biological clock**.

It helps in maintaining the normal rhythm of sleep-wake cycle & influences body temperature, metabolism, & reproductive cycles.

Thyroid Gland



Thyroid gland is the largest endocrine gland.

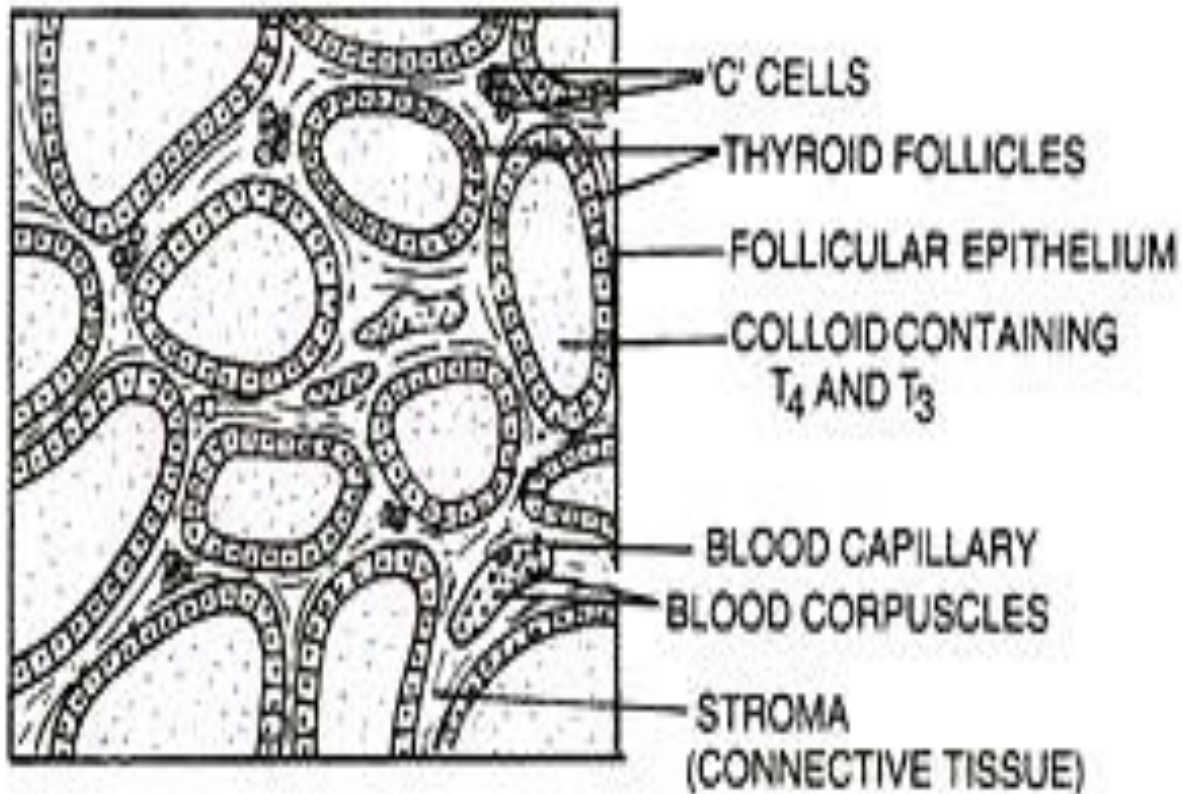
It is bilobed gland situated in front of the trachea just below the larynx.

It is richly supplied with blood vessels.

The two lobes of it connected with each other by non-secretory band called Isthmus.



T.S. of Thyroid Gland



T.S. Thyroid gland.

The thyroid lobes are composed of rounded follicles held together by interfollicular connective tissue called stroma.

Stroma contains blood capillaries & small group of parafollicular cell or 'C' cells (clear cells).

Thyroid follicles are composed of cuboidal epithelium resting on a basement membrane & is filled with a gelatinous colloid.

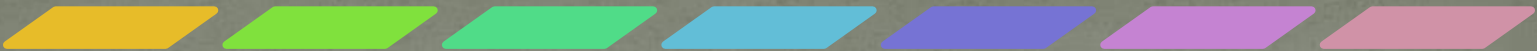
Physiological aspects of Thyroid Gland

- ❖ TSH stimulate thyroid gland to secret its own hormone Thyroxine.
- ❖ Thyroxine is present in two forms, T₄ & T₃.
- ❖ They are secreted by follicular cells.
- ❖ Calcitonin is another hormone produce by parafollicular or 'c' cells.
- ❖ T₄ is tetra-iodothyronine, made up of four atoms of iodine.
- ❖ T₃ is tri-iodothyronine, made up of three atoms of iodine.
- ❖ T₄ & T₃ are synthesized by attaching iodine to amino acid tyrosine by enzymatic action.

Physiological aspects of Thyroid Gland

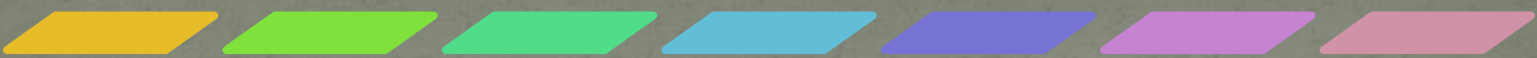
- 
- If one molecule of Iodine is attach to amino acid tyrosine, Mono-iodotyrosine(T₁) is produced.
 - If two molecules of Iodine is attach to amino acid tyrosine, Di-iodotyrosine (T₂) is produced.
 - T₁ & T₂ are bind to eachother end to end to form colloidal mass inside the follicle.
 - They metabolised to form T₄ & T₃.
 - T₃ is produced in small quantity than T₄, & more potent than T₄.
 - T₄ & T₃ stored before secretion & regulated by negative feedback mechanism of TSH of pituitary.

Functions of Thyroxine



1. Maintain Basal metabolic rate.
2. Stimulate protein synthesis & promotes growth of body tissues.
3. Helps in thermoregulation by increasing heat production.
4. Increases action of neurotransmitters-
adrenaline & nor adrenaline.
5. It supports the process of RBC production & maintenance of water & electrolyte balance.
6. Regulates reproductive cycles in females.

Functions of Calcitonin



1. It is secreted by 'C' cells.
2. Regulate the concentration of calcium & phosphorus in the blood.
3. Under the feedback control of plasma calcium concentration in blood.
4. It is secreted, when concentration of calcium in the plasma increases.
5. It lowers the concentration of calcium in the blood by decreasing their release from bone & accelerating the uptake of calcium & phosphorous by the bones.

Disorders related to Thyroid Gland

Hyperthyroidism

It is caused by increase in the levels of thyroid hormones. This increases metabolic rate, sensitivity, sweating, flushing, rapid respiration, bulging of eye balls, and affects various physiological activities.

Grave's disease



Grave's disease is also known as **Exophthalmic goitre**.

It is characterised by protruding eyeballs, increased BMR which produces increased heart beat, increased BP, higher body temperature, nervousness, irritability, tremor of fingers & bulging eyeballs.

Hypothyroidism

It is caused by deficiency of thyroid hormones or removal of thyroid gland(Thyroidectomy).

Cretinism



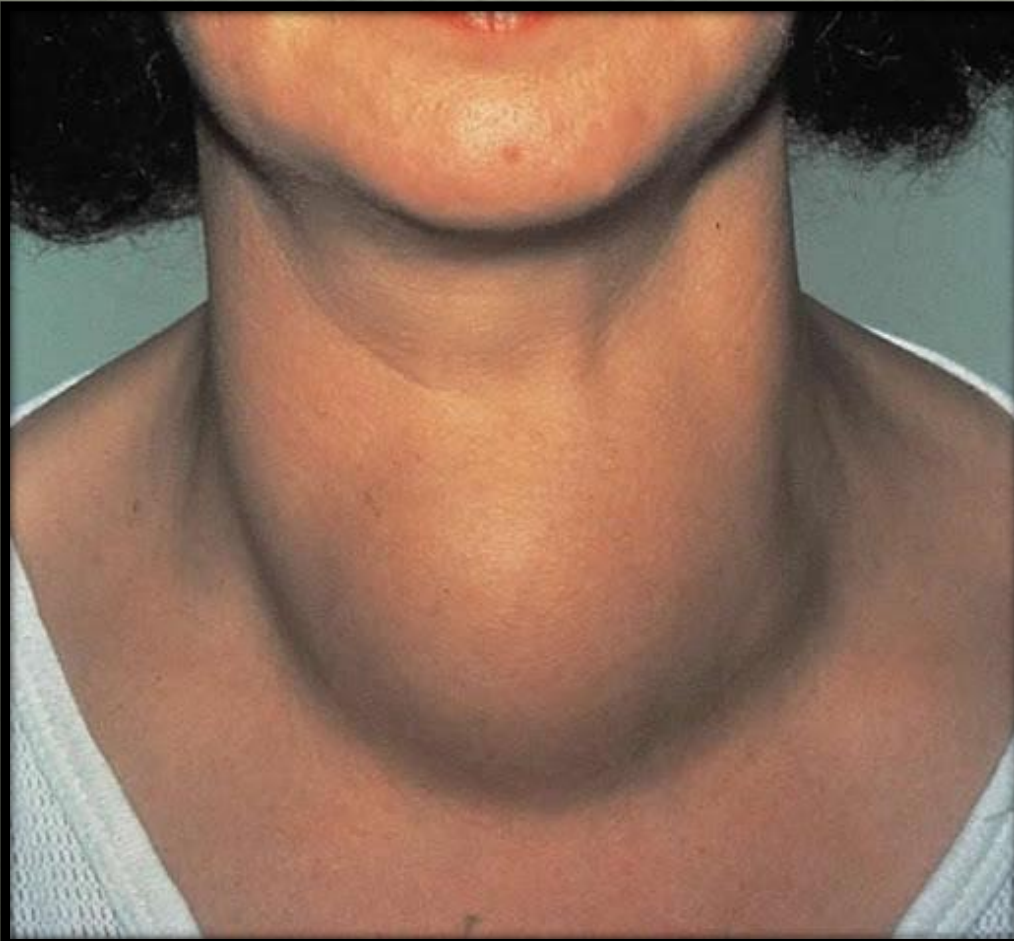
- Hyposecretion in infants leads to **cretinism**.
- Reduced BMR & low oxidation.
- They are short statured because skeleton fails to grow.
- Mentally retarded.
- They show dry skin, thick tongue, prolonged neonatal jaundice, lethargy, constipation.
- Delayed puberty.

Myxoedema



- ❖ It is found in adults.
- ❖ It is characterised by a peculiar thickening & puffiness of skin & subcutaneous tissue (face & extremities).
- ❖ Patients lack alertness, intelligence, low B.P., slow heart rate, low body temperature, retarded sexual development.

Simple Goitre



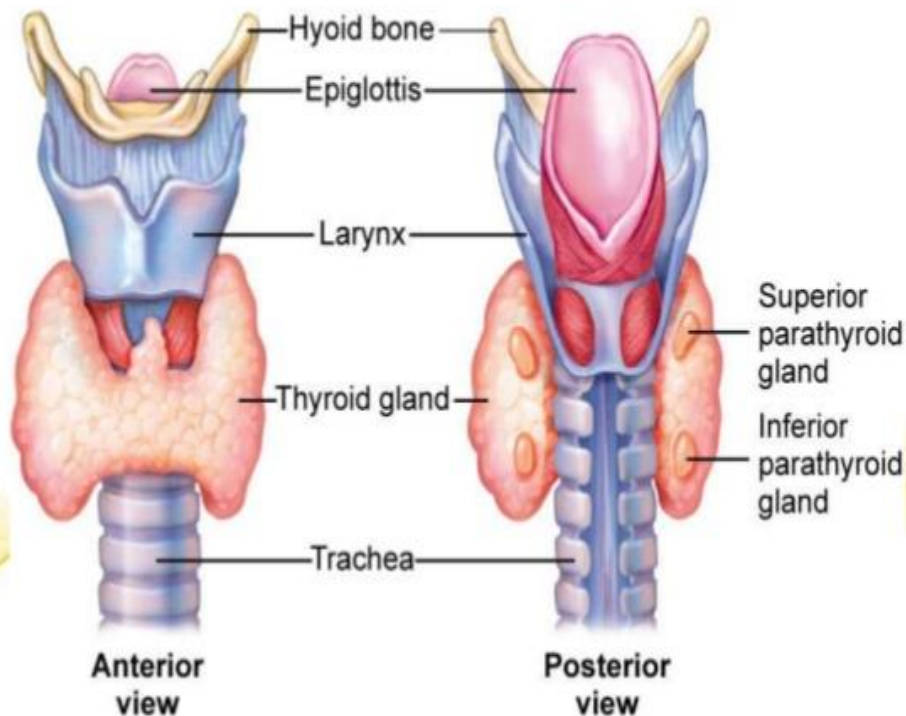
- ✓ Iodine deficiency goitre.
- ✓ Iodine is needed for synthesis of thyroid hormone, but if there is deficiency of iodine in diet, it causes enlargement of thyroid gland .
- ✓ So addition of iodine to diet prevents this disease.
- ✓ Size of thyroid gland increases & total output of thyroxine is decreases.

Parathyroid Gland

Parathyroid gland is situated on the posterior surface of the lobes of thyroid gland.

They are 4 in numbers, a pair of superior & a pair of inferior gland.

The cells of the parathyroid gland is arranged in a compact mass.



From Thiobodeau GA, Patton KT. The human body in health and disease, vol 4, 10 Loos, 2005, Mosby.

Physiological aspects of Parathyroid Gland

- ❑ Parathyroid Gland secretes a peptide hormone called **Parathormone(PTH)**, which is also known as **Collip's hormone**.
- ❑ It regulates calcium & phosphate level in blood & other tissues.
- ❑ It draws calcium from bones.
- ❑ Increases calcium absorption in the digestive tract.
- ❑ Reduces loss of calcium in the urine.
- ❑ Secretion of PTH is under feedback control of blood calcium level.
- ❑ Concentration of calcium & phosphate is maintained by PTH & calcitonin.

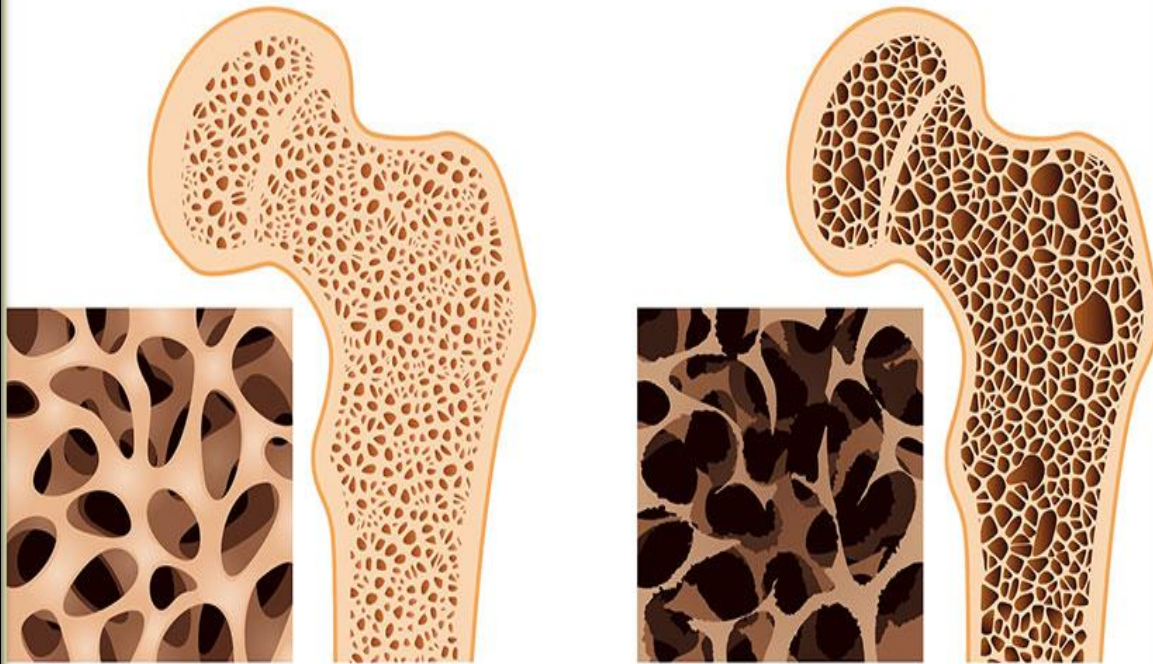
Hyposecretion of parathormone

- ✓ It lowers concentration of calcium in the blood.
- ✓ It increases excitability of nerves & muscles causing muscle twitch & spasm.
- ✓ This condition is called **parathyroid Tetany** or **Hypocalcaemic Tetany**.



Hypersecretion of parathormone

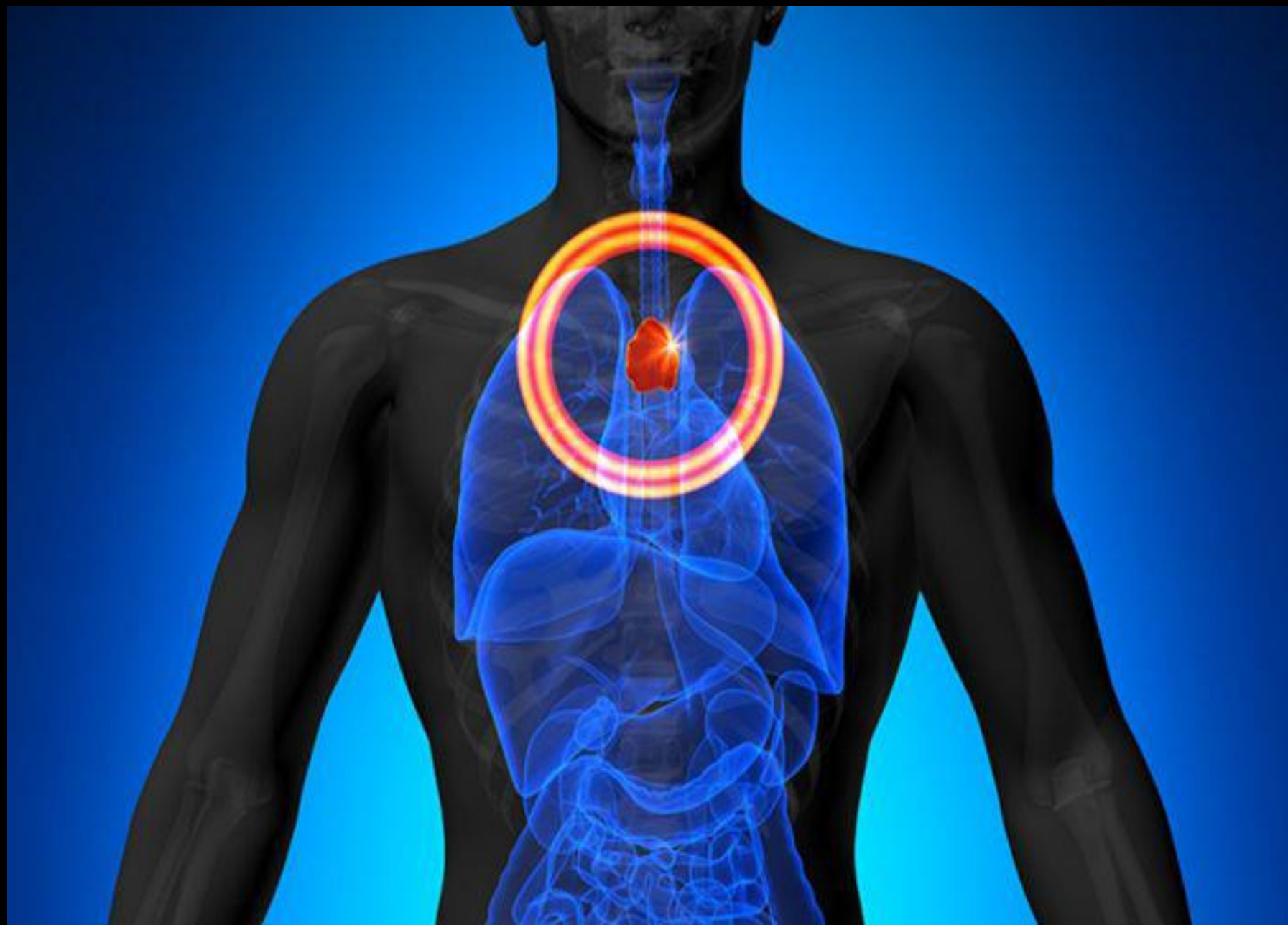
Osteoporosis



Healthy bone

Osteoporosis

- It is responsible for more absorption of calcium from bones, i.e., demineralization of bones resulting in softening, bending, & fracture of bone.
- This condition is called **Osteoporosis**.
- It is common in women with menopause.



Thymus Gland

Structure : It is located in the upper part of thorax on the dorsal side of the heart.

It is soft, pinkish, bilobed mass of lymphoid tissue. It is called temporary gland, because it is prominent at birth but gets atrophied in the adult.

Function : It secretes **Thymosin**.

It plays important role in the development of immune system by maturation of T-lymphocytes.

It also promotes production of antibodies by providing humoral immunity.



Adrenal Gland/ Suprarenal Gland

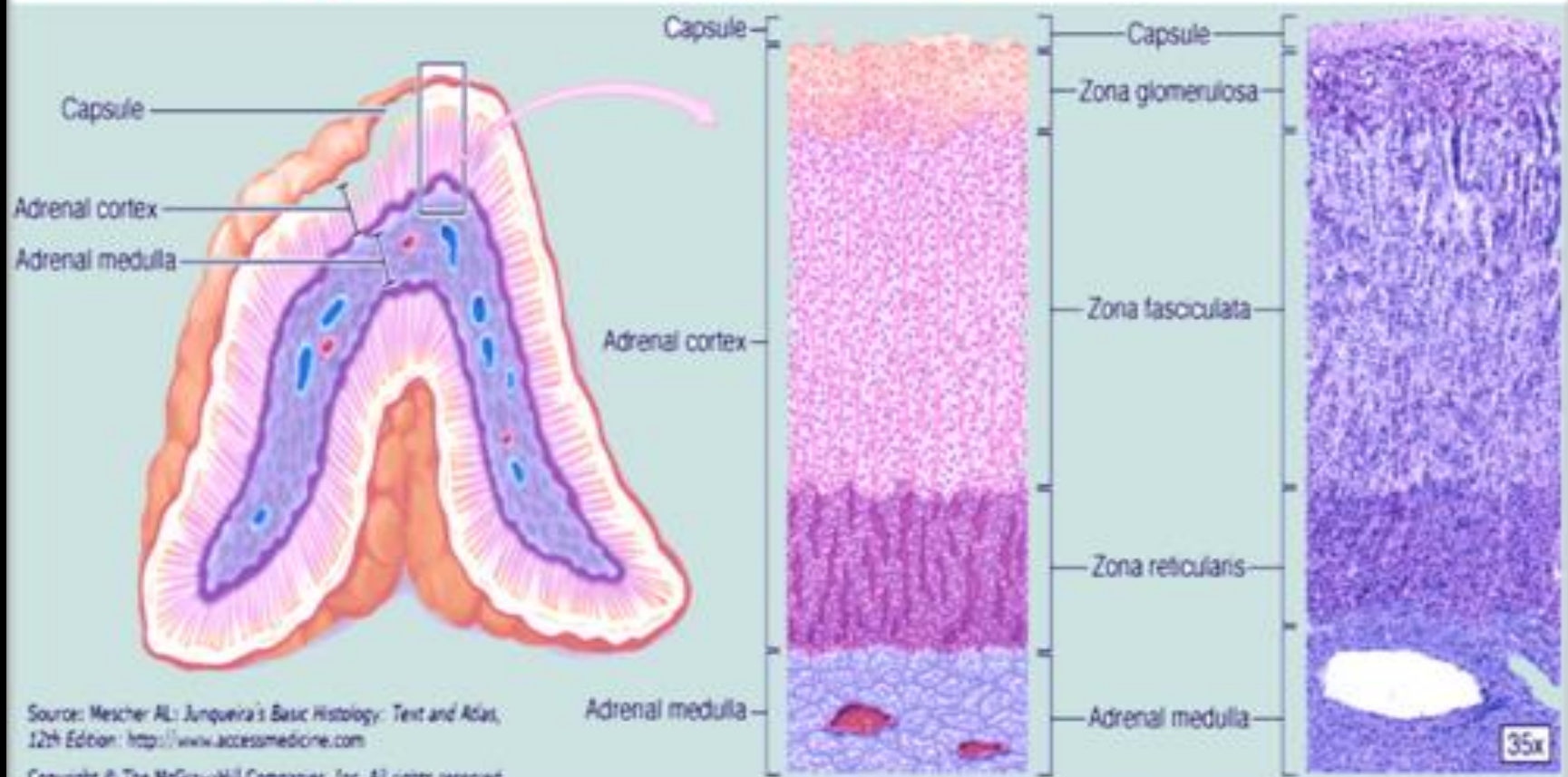
Origin: Dual origin, from mesoderm & ectoderm.

Location: On the upper border of each kidney, that's why adrenal gland is also known as **Suprarenal gland**.

Structure: It is small, conical, yellowish glands, show two distinct regions, i.e., outer cortex, & inner medulla.

Adrenal Gland

Histology of Adrenal Gland



Adrenal Cortex

It is derived from embryonic mesoderm. It secretes many hormones, together known as **Corticoids**. It is differentiated into 3 concentric regions.

Outer thin Zona glomerulosa

- It secretes **Mineralocorticoids**.
- Regulate sodium & potassium ion concentration.
- Regulate salt-water balance, blood volume, & blood pressure.
- **Aldosterone** is the main mineralocorticoid.

Middle thick Zona fasciculata

- It secretes **Glucocorticoids**.
- It regulate carbohydrate, protein, & lipid metabolism.
- It increases blood glucose level.
- It is immuno suppressive.
- It suppresses synthesis of antibodies.
- Used in the treatment of allergy.
- It prepares animals to face emergencies in nature.
- **Cortisol** is the main glucocorticoids.

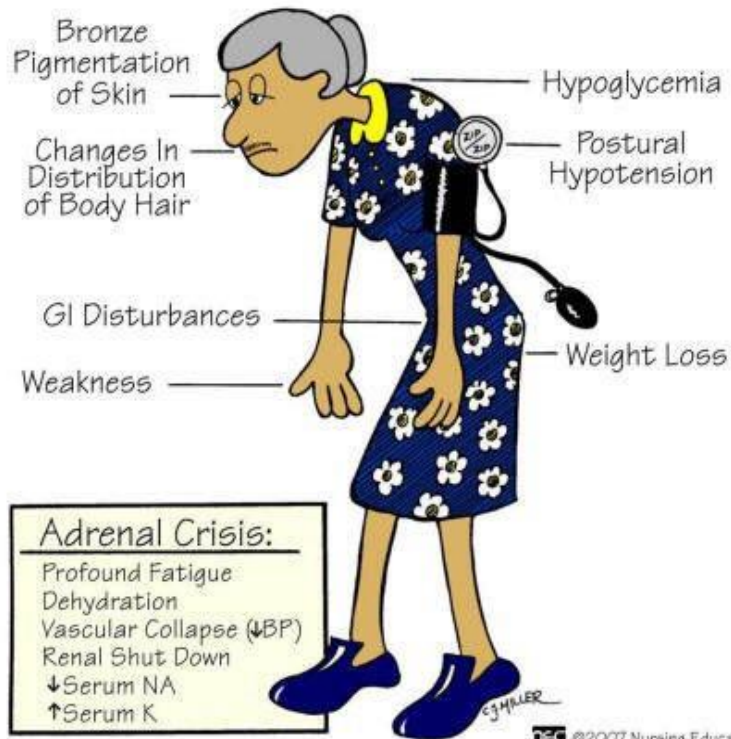
Inner thin Zona reticularis

- It secretes **Gonadocorticoids**.
- Play a role in the development & maintenance of external sexual characters in male.
- **Androgens** & **estradiols** are main gonadocorticoids.
- Excess sex corticoids causes adrenal virilism & hirsutism in female, while it causes **Gynaecomastia** i.e. enlarged breast, in male.

Disorders related to Adrenal cortex

Hyposecretion of Mineralocorticoids & Glucocorticoids

ADDISON'S DISEASE

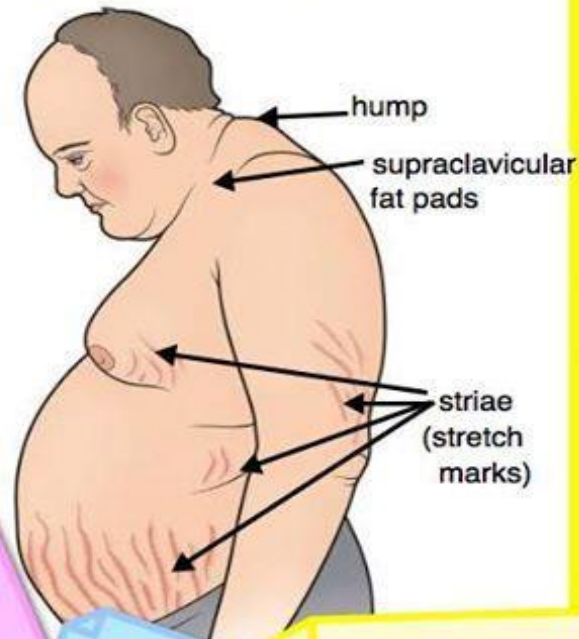
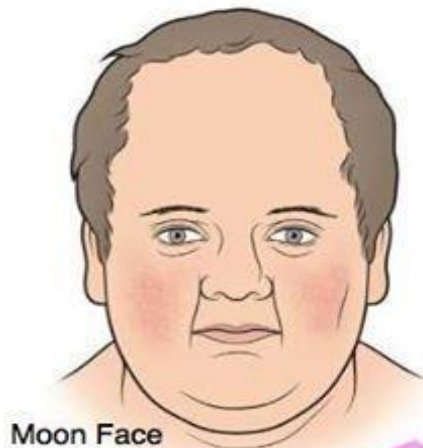


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- It is responsible for **Addison's** disease.
- It is characterised by low blood sugar, low Na^+ & high K^+ in plasma.
- Increased loss of Na^+ & water in urine.
- It leads to weight loss, weakness, nausea, vomiting & diarrhoea.

Hypersecretion of Mineralocorticoids & Glucocorticoids

Cushing's Disease/Syndrome in Men



Sweaty/Hot
Upper body obesity
Difficulty when drawing blood

Muscle Weakness
Low Testosterone
Loss of Libido
Low Vitamin D

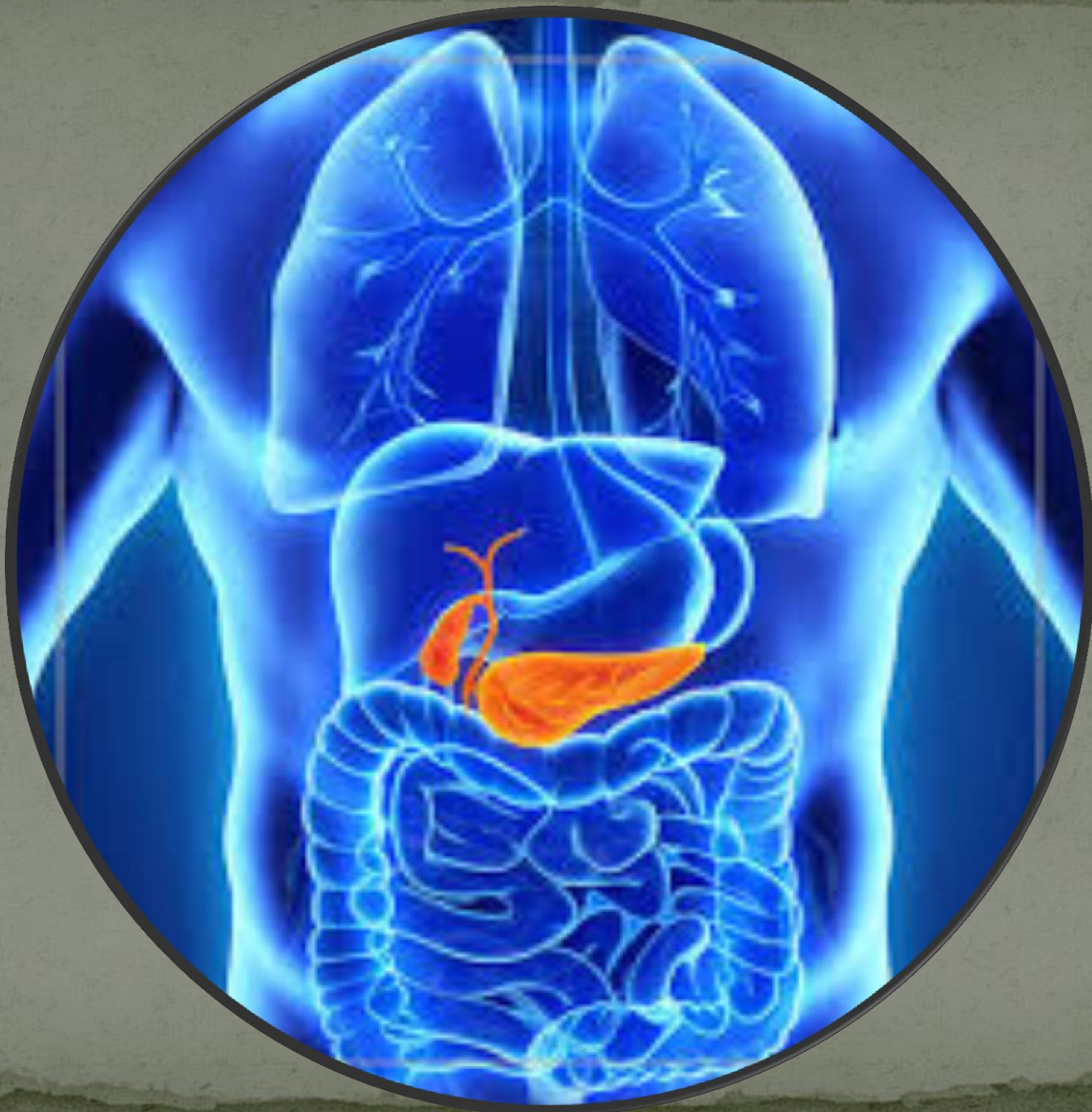
High Blood Sugar
Bruising
Insomnia

High Blood Pressure
Secondary Hypothyroidism
Fatigue
Low Ferritin

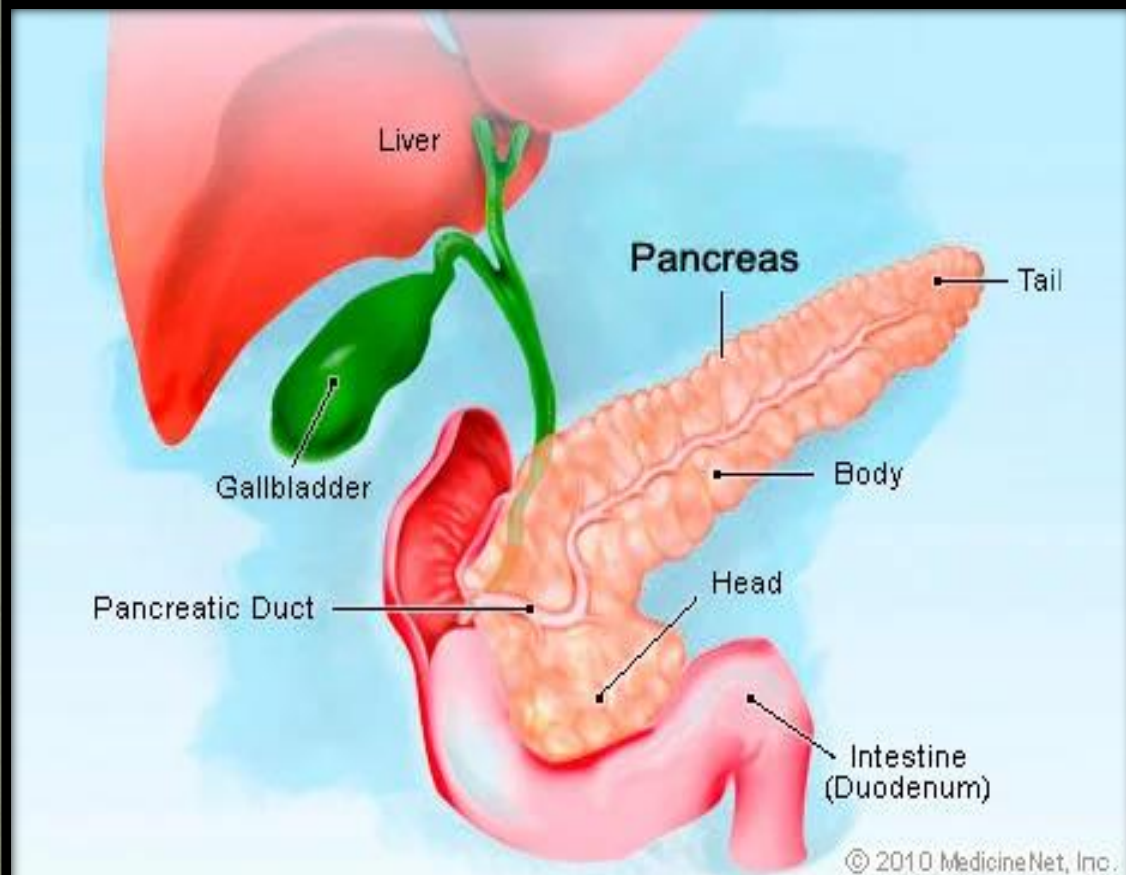
- It causes **Cushing's disease**.
- Leads to high blood sugar level.
- Excretion of glucose in urine.
- Rise of Na^+ in blood, & high B.P.
- Obesity & wasting of limb muscles.

Adrenal medulla

- It develops from ectoderm.
- It secretes Adrenaline (epinephrine) & noradrenaline (norepinephrine).
- Adrenaline is emergency hormone, known as **3F hormone**.
- Noradrenaline regulates blood pressure & acts as a vasoconstrictor.



Pancreas



- It develops from endoderm.
- It is exocrine as well as endocrine in function.
- Exocrine part helps in digestion.
- Endocrine part is known as **Islets of Langerhans**.

Islets of Langerhans

It consists of four types of cells:

- **Alpha cells** (20%) secrete **Glucagon**. It stimulates liver for glycogenolysis to increase blood glucose level.
- **Beta cells** (70%) secrete **Insulin**. It stimulates liver & muscles for glycogenesis. This lowers the blood sugar.
- **Delta cells** (5%) secrete **Somatostatin** which inhibits the secretion of glucagon & insulin. It also decreases the gastric secretions, motility & absorption in digestive tract.
- **PP cells or F cells** (5%) secrete **Pancreatic polypeptide** which inhibits the release of pancreatic juice.

Disorder related to Pancreas

Diabetes mellitus (Hyperglycemia)

- ❖ Metabolic endocrine disorder of pancreas.
- ❖ This is due to reduced activity of Beta cells, results in reduced secretion of insulin, leads to increase in blood glucose level.
- ❖ There are two types of Diabetes, Type I & Type II.
- ❖ Type I is **Insulin dependent diabetes mellitus (IDDM)**, found in children.
- ❖ Type II is **Non insulin dependent diabetes mellitus (NIDDM)**, due to failure of insulin to facilitate the movement of glucose into cells.
- ❖ Reduced sensitivity to insulin is called **Insulin resistance**.



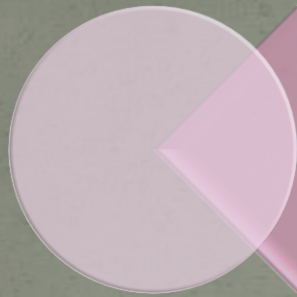
In both the type, blood glucose increases & appears in the urine.



It causes excessive urination & dehydration of body tissues.



Degradation of fats leads to ketosis.



Gonads

They are sex organs, i.e. Testes & Ovaries

Ovaries

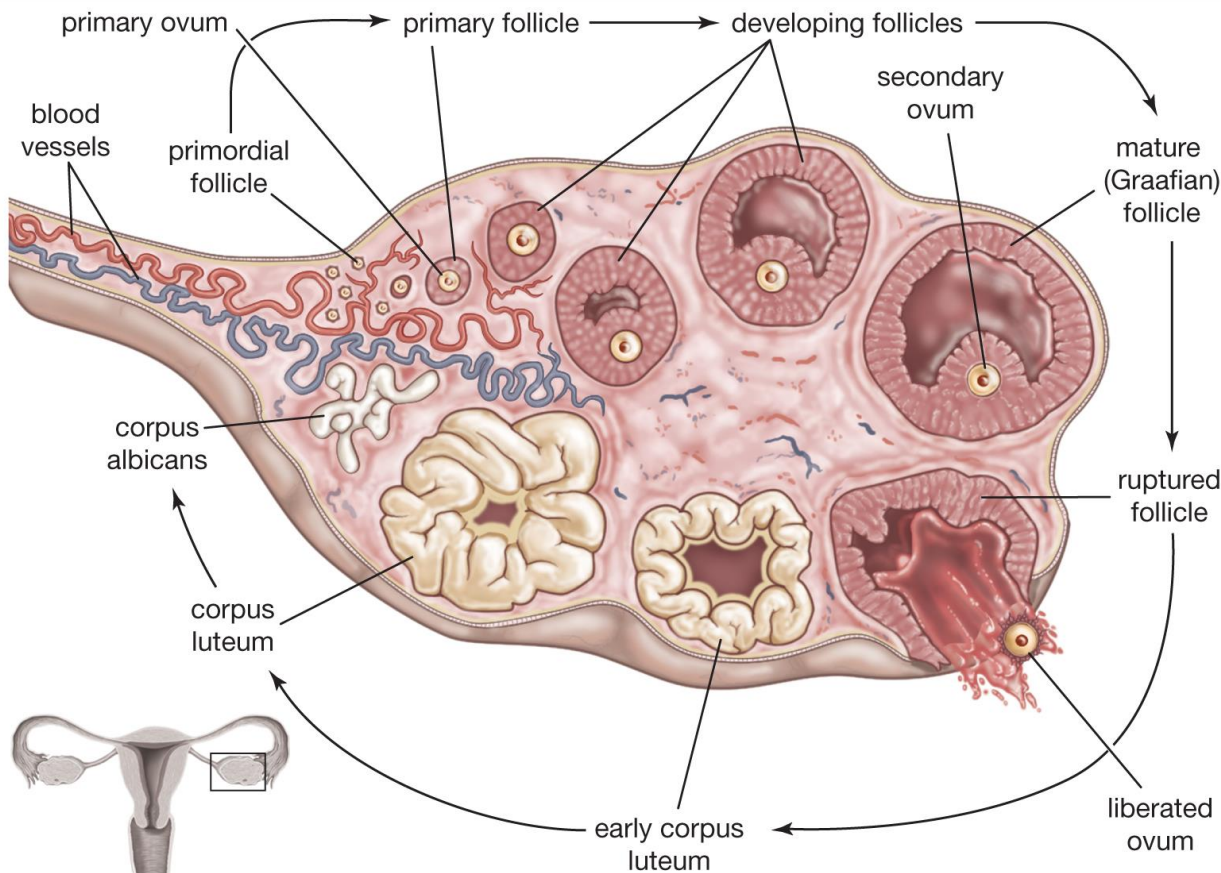
They produce,

Estrogen

Progesterone

Relaxin

Inhibin



Estrogen

:

- Secreted by developing follicle.
- **Estradiol** is the main oestrogen.
- Responsible for secondary sexual characters in female.

Progesterone

:

- Secreted by corpus luteum after ovulation.
- Essential for thickening of uterine endometrium for implantation of fertilized ovum.
- Development of mammary gland.
- Inhibits uterine contraction during pregnancy.

Relaxin

:

- Secreted by the corpus luteum, at the end of gestation period.
- It relaxes the cervix of the pregnant female & ligament of pelvic girdle for child birth.

Inhibin

:

- Secreted by the corpus luteum.
- Inhibits FSH & GnRH production.

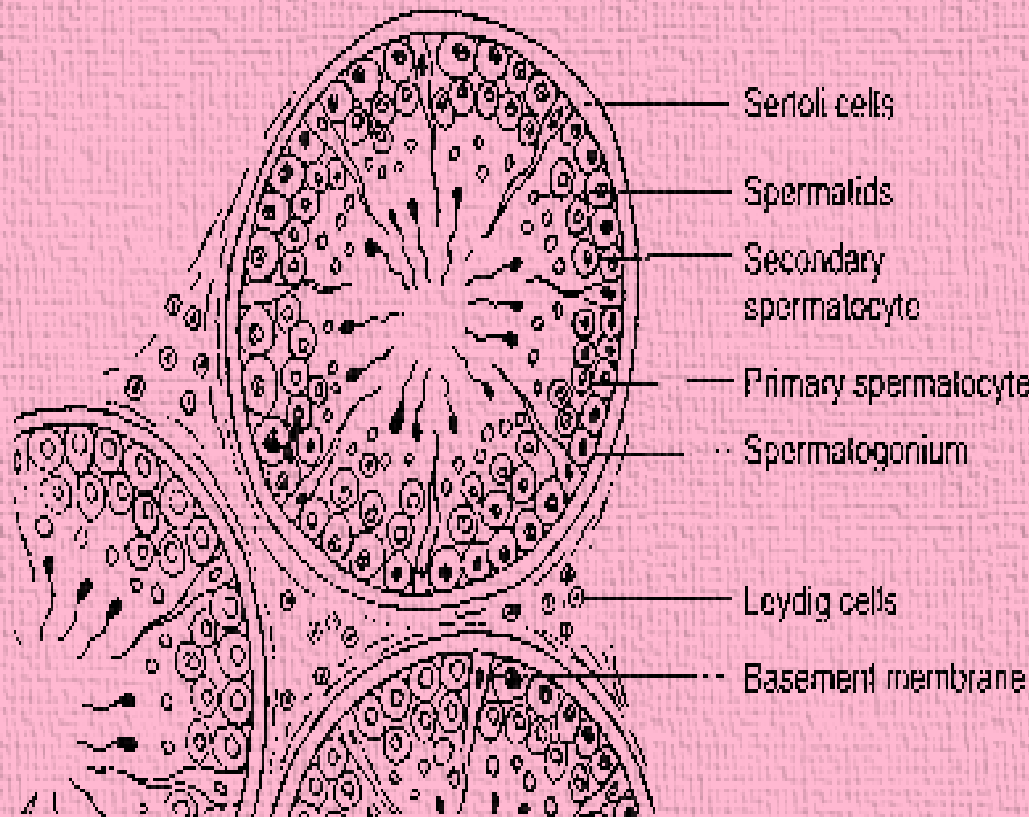
Testes

Testes secrete male sex hormone, i.e.

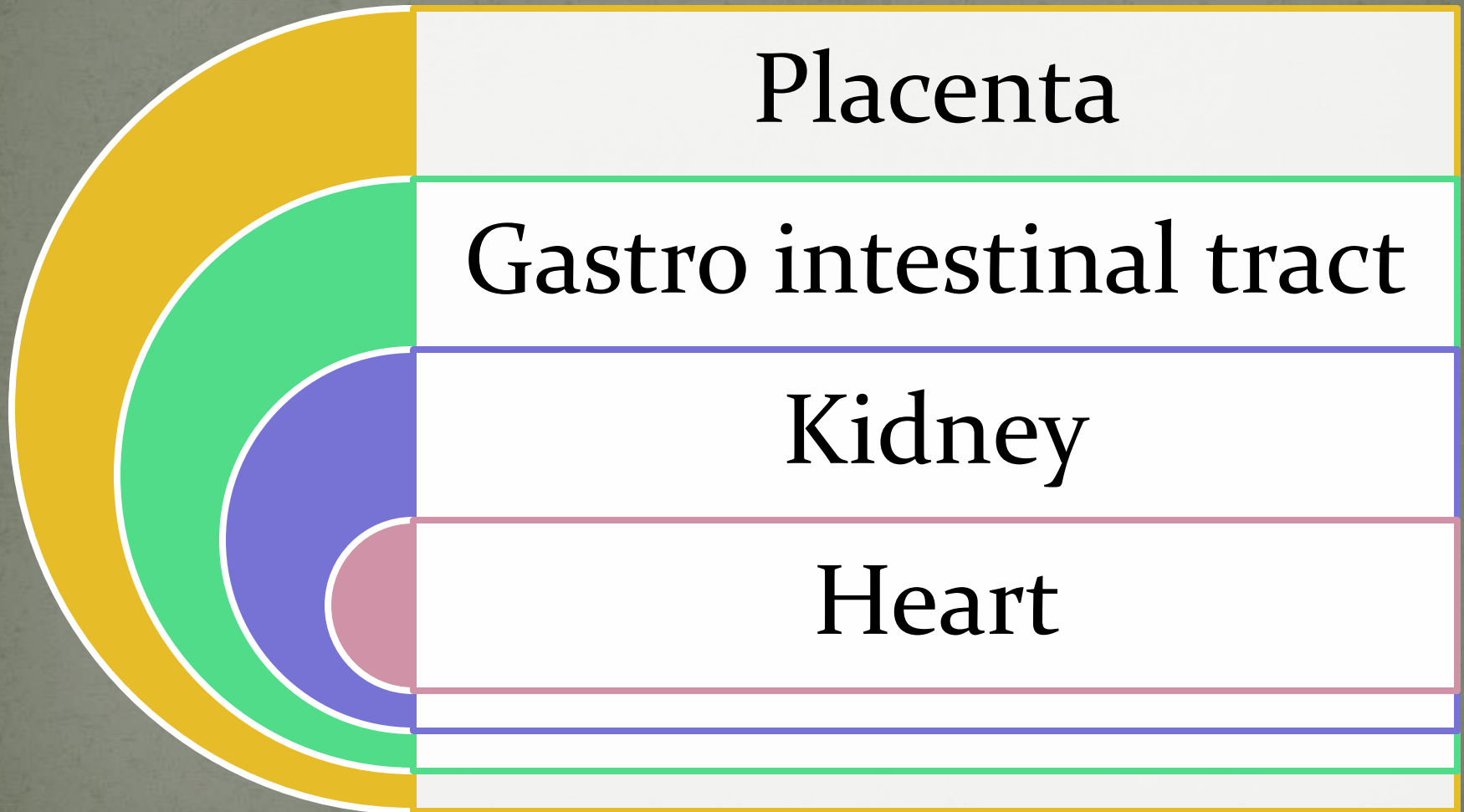
Testosterone, responsible for secondary sexual characters, such as facial & pubic hair, deepening of voice, broadening of shoulders, aggressiveness.

Testosterone is secreted by Leydig cells or interstitial cells by the influence of LH/ICSH.

Rise in testosterone in blood, inhibits LH/ICSH.



Diffuse endocrine glands



Placenta

It is temporary endocrine gland.

It is a connection between foetus & uterine wall of the mother for physiological exchange of material.

During pregnancy, placenta secretes hormones such as estrogen, progesterone, HCG (Human Chorionic Gonadotropin) & human placental progesterone.

This hormones check the uterine contraction.

Maintain the thickness of uterine endometrium to maintain the pregnancy.

Gastro intestinal tract

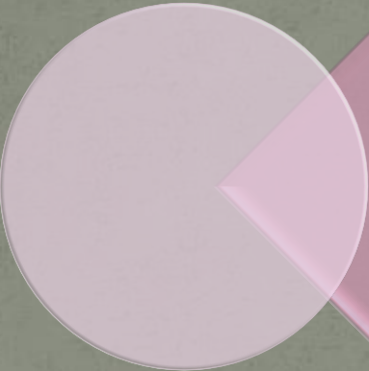
In gastro intestinal mucosa, endocrine cells are present, which produce hormones & play vital role in digestive processes & flow of digestive juices.

1. **Gastrin** : It stimulates gastric glands to produce gastric juices.
2. **Secretin** : It is responsible for secretion of pancreatic juice & bile from pancreas & liver.
3. **Cholecystokinin CCK/ Pancreozymin PZ** : It stimulates the pancreas & gall bladder to release enzymes & bile, respectively.
4. **Entero-gastrone/ Gastric inhibitory peptide (GIP)**: It slows gastric contractions & inhibits the secretion of gastric juice.

Kidney

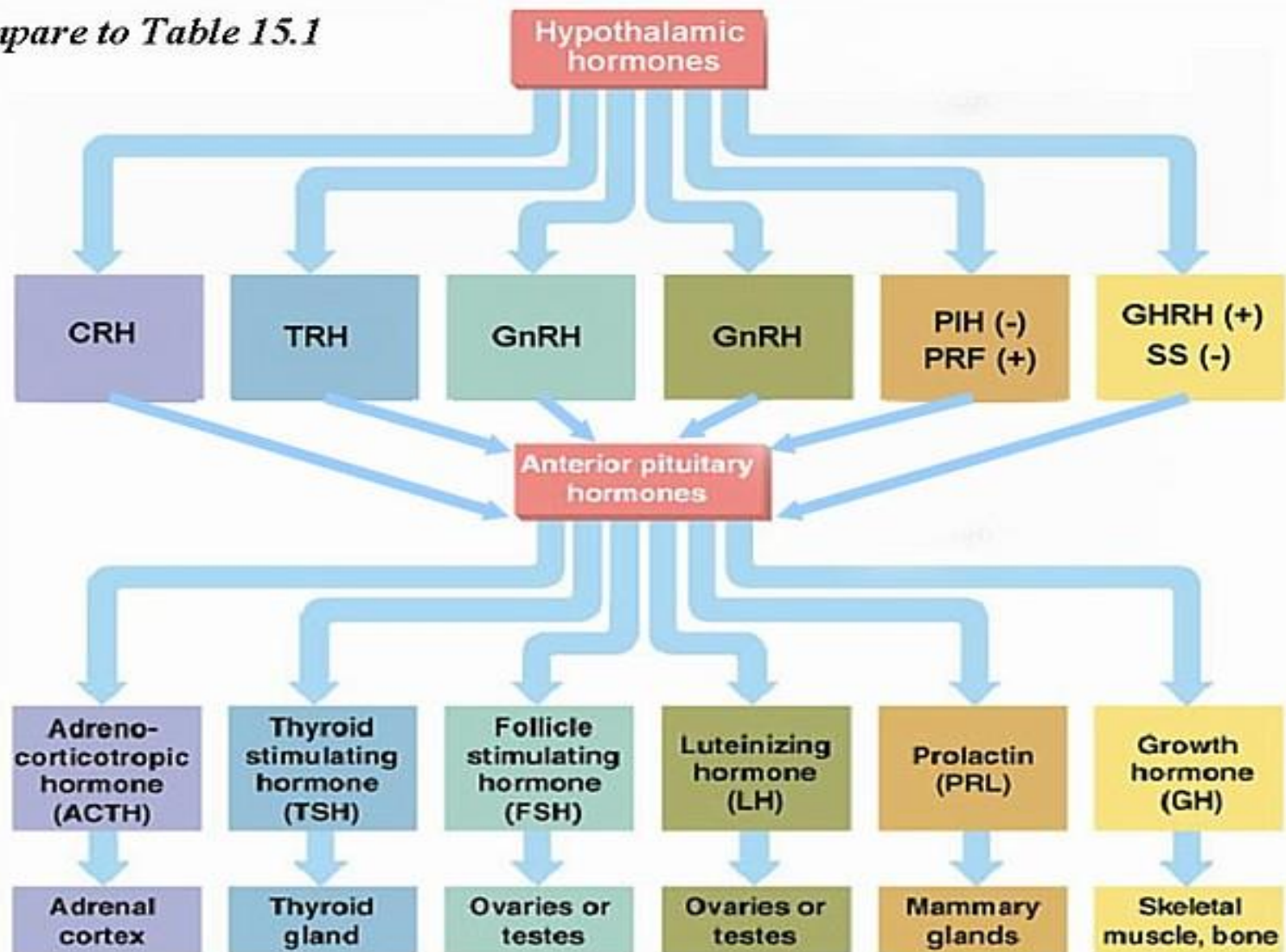
It produces Renin, Erythropoietin, & Calcitriol.

Heart

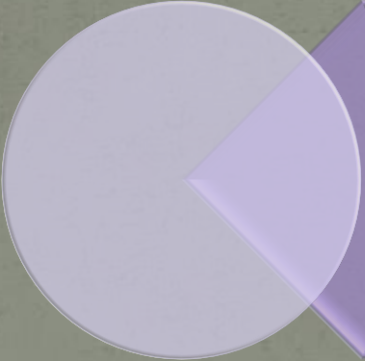


Atrial wall of heart produces
Atrial natriuretic hormone/
ANF, which increases sodium
excretion by kidneys & reduces
blood pressure.

compare to Table 15.1



Hormone therapy / HT



HT is applied in Pregnancy,
Menopause, Osteoporosis,
Growth hormone deficiency,
Insulin resistance, Cancer, etc.



Here Nervous & Chemical
coordination chapter is
over.

Thank you