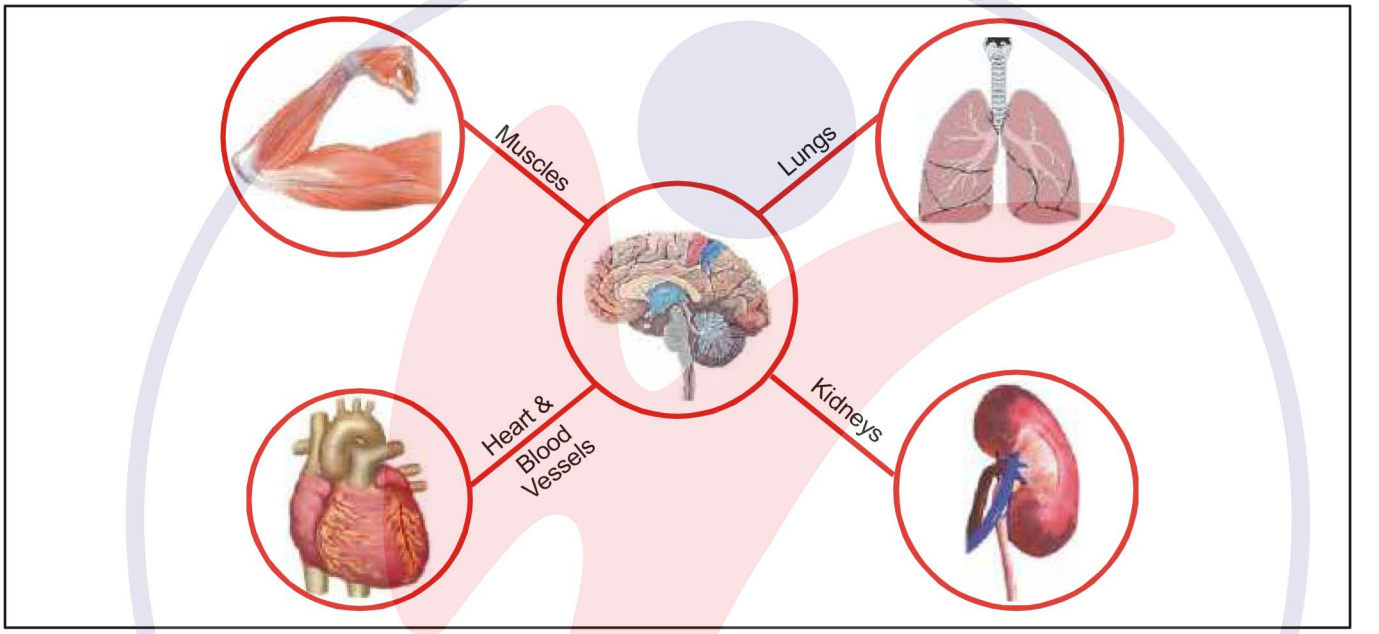
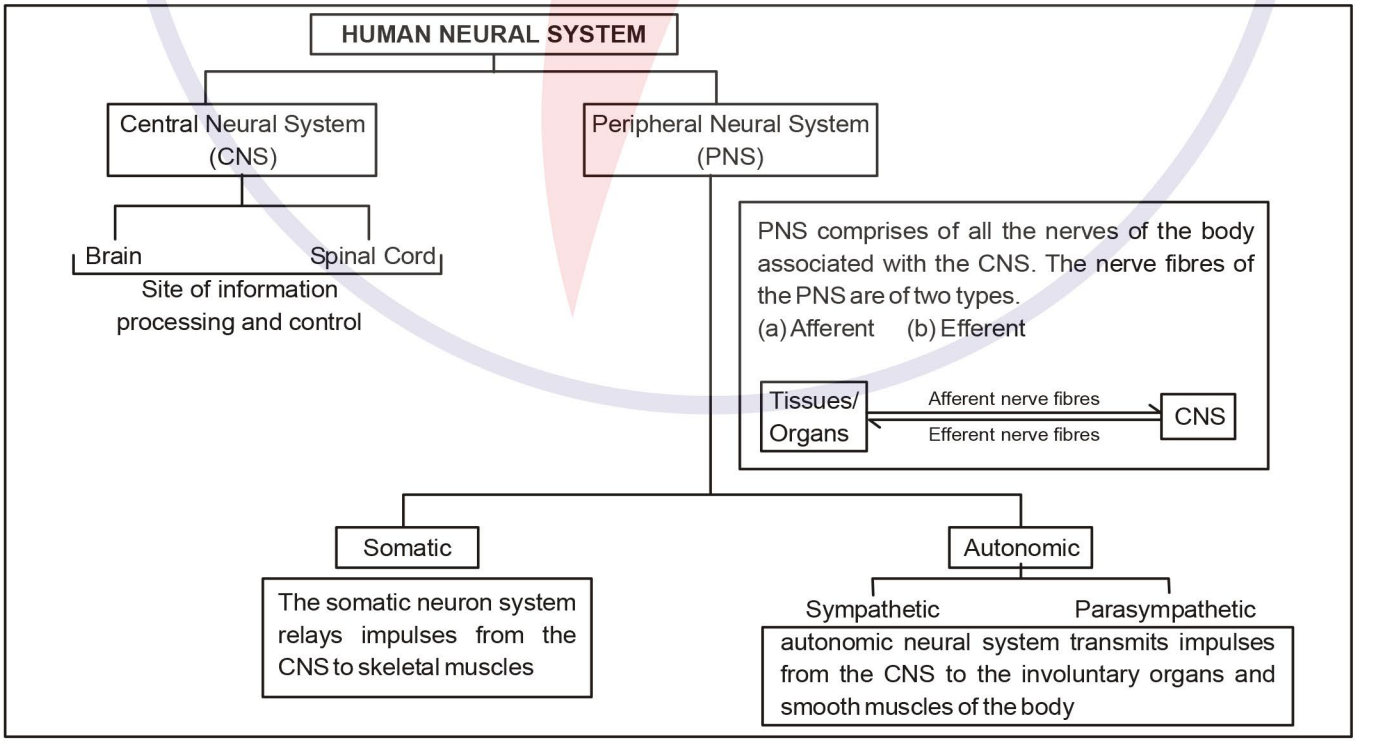
NEURAL CONTROL AND COORDINATION

As you know, the functions of the organs/organ systems in our body must be coordinated to maintain homeostasis. Coordination is the process through which two or more organs interact and complement the functions of one another. for example, when we do physical exercises, the energy demand is increased for maintaining an increased muscular activity. The supply of oxygen is also increased. The increased supply of oxygen necessilates an increase in the rate of respiration, heart beat and increased blood flow via blood vessels. When physical exercise is stopped, the activities of nerves lungs, heart and kidney gradually return to their normal conditions. Thus the functions of muscles, lungs, heart, blood vessels, kidney and other organs are coordinated while performing physical exercises in our body. The neural system and the endocrine system jointly coordinate and integrate all the activities of the organs so that they function in a synchronised fashion. (Integrated systems)



HUMAN NEURAL SYSTEM



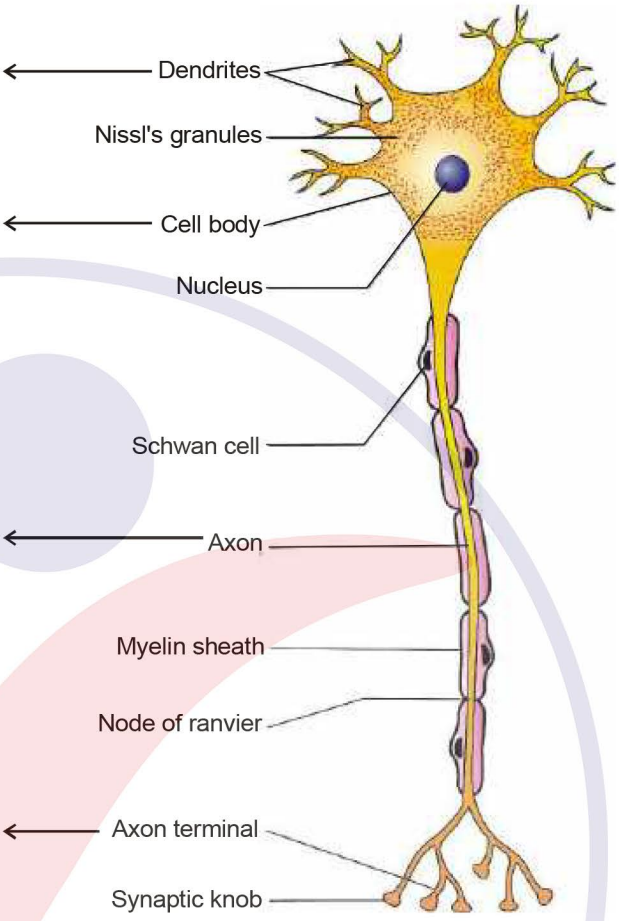
STRUCTURE OF A NEURON

Short fibres which branch repeatedly and project out of the cell body also contain Nissl's granules and are called dendrites. These fibres transmit impulses towards the cell body.

The cell body contains cytoplasm with typical cell organelles and certain granular bodies called Nissl's granules.

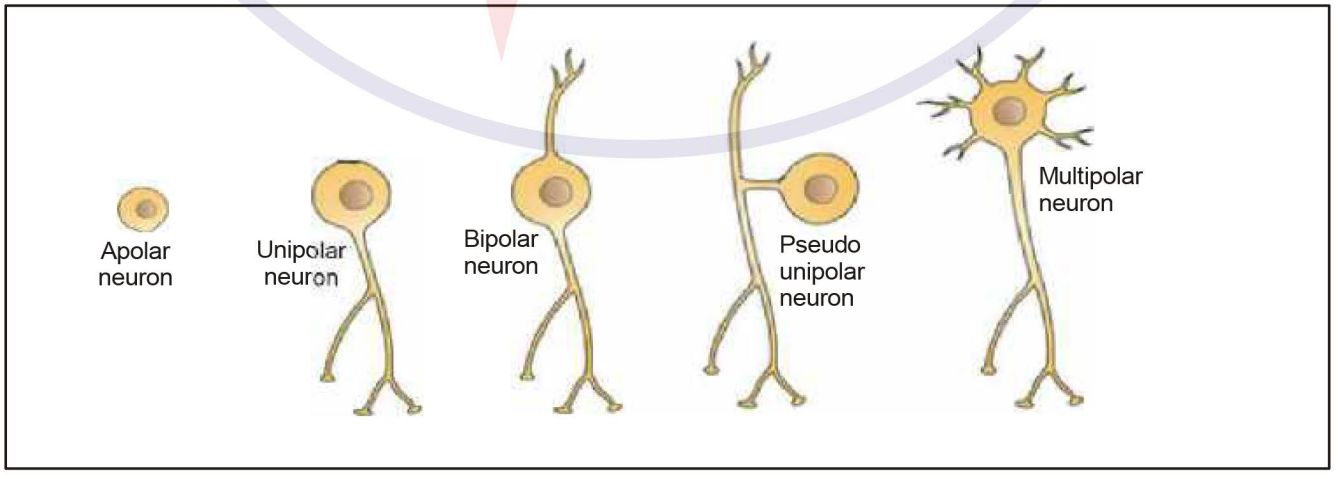
The axon is a long fibre, the distal end of which is branched.
The axons transmit nerve impulses away from the cell body to a synapse or to a neuro-muscular junction.
There are two types of axons, namely, myelinated and nonmyelinated.
The myelinated nerve fibres are enveloped with Schwann cells, which form a myelin sheath around the axon. The gaps between two adjacent myelin sheaths are called nodes of Ranvier.
Myelinated nerve fibres are found in spinal and cranial nerves.
Unmyelinated nerve fibre is enclosed by a Schwann cell that does not form a myelin sheath around the axon, and is commonly found in autonomous and the somatic neural systems.

Branch of axon terminates as a bulb-like structure called synaptic knob which possess synaptic vesicles containing chemicals called neurotransmitters



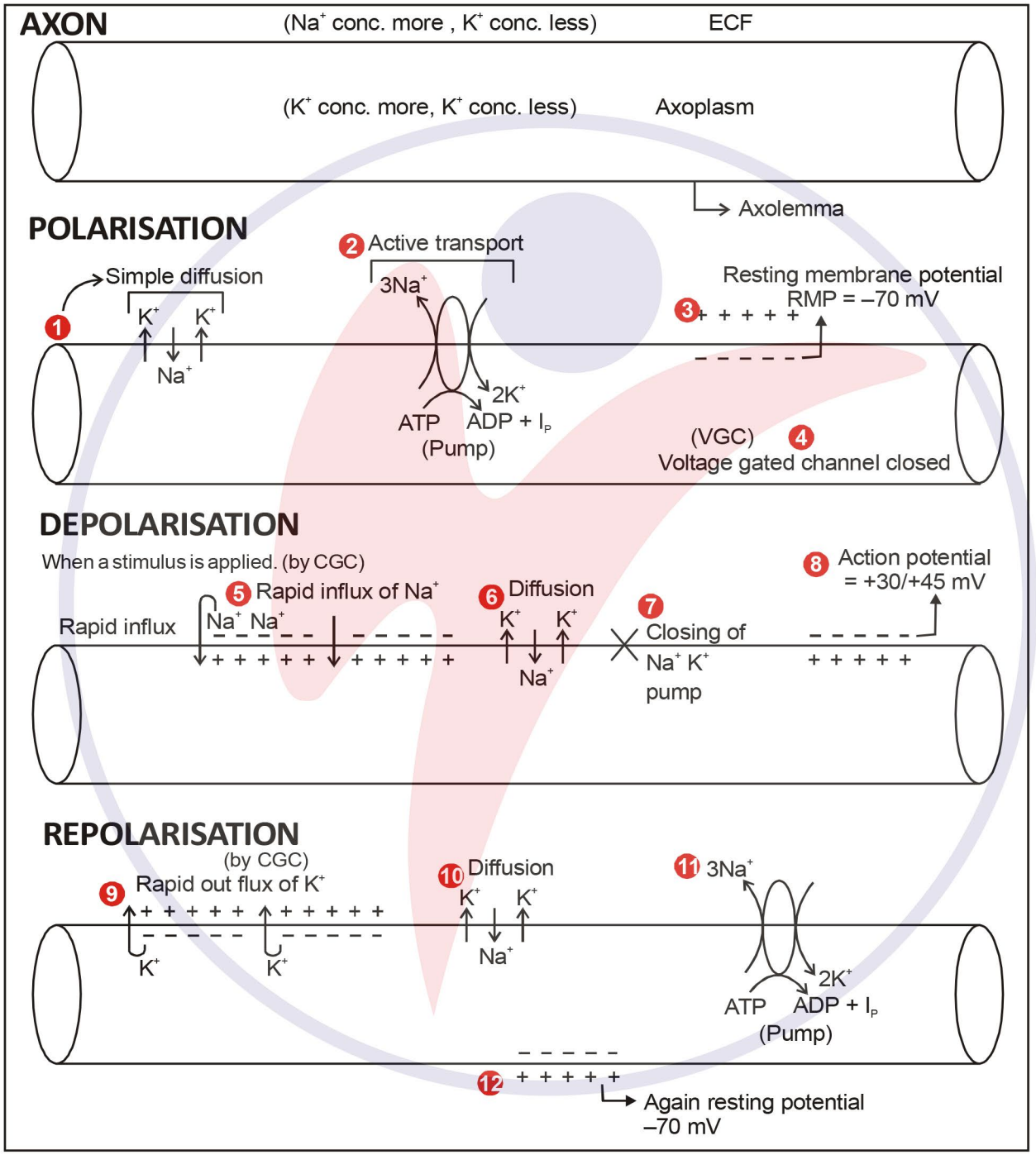
TYPES OF NEURONS

Based on the number of axon and dendrites, the neurons are divided into three types, i.e., multipolar (with one axon and two or more dendrites; found in the cerebral cortex), bipolar (with one axon and one dendrite, found in the retina of eye) and unipolar (cell body with one axon only; found usually in the embryonic stage). One more type of neuron are there - Apolar neurons (Only cell body is present) found in the Hydra.



GENERATION AND CONDUCTION OF NERVE IMPULSE

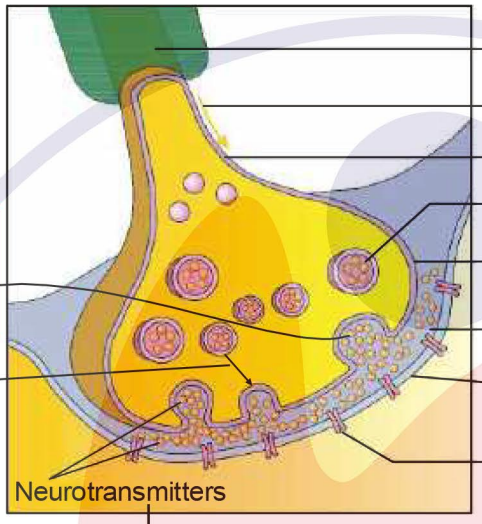
Neurons are excitable cells because their membranes are in a polarised state. Do you know why the membrane of a neuron is polarised? Different types of ion channels are present on the neural membrane. These ion channels are selectively permeable to different ions.



The rise in the stimulus-induced permeability to Na^+ is extremely shortlived. It is quickly followed by a rise in permeability to K^+. Within a fraction of a second, K^+ diffuses outside the membrane and restores the resting potential of the membrane at the site of excitation and the fibre becomes once more responsive to further stimulation.

TRANSMISSION OF IMPULSES

A nerve impulse is transmitted from one neuron to another through junctions called synapses. Electrical current can flow directly from one neuron into the other across these synapses. Transmission of an impulse across electrical synapses is very similar to impulse conduction along a single axon.



Axon

Action Potential arrives at axon terminal

Axon terminal

Synaptic vesicles → Filled with neurotransmitters

Release of neurotransmitter from synaptic vesicles

Pre-synaptic membrane

Synaptic cleft

Post-synaptic membrane

Synapse → It is the junctional reason between two neurons where information is transfer from one neuron to another

Synapatic vesicles moves towards the membrane

Receptors

Neurotransmitters → Involved in transmission of impulses at these synapses

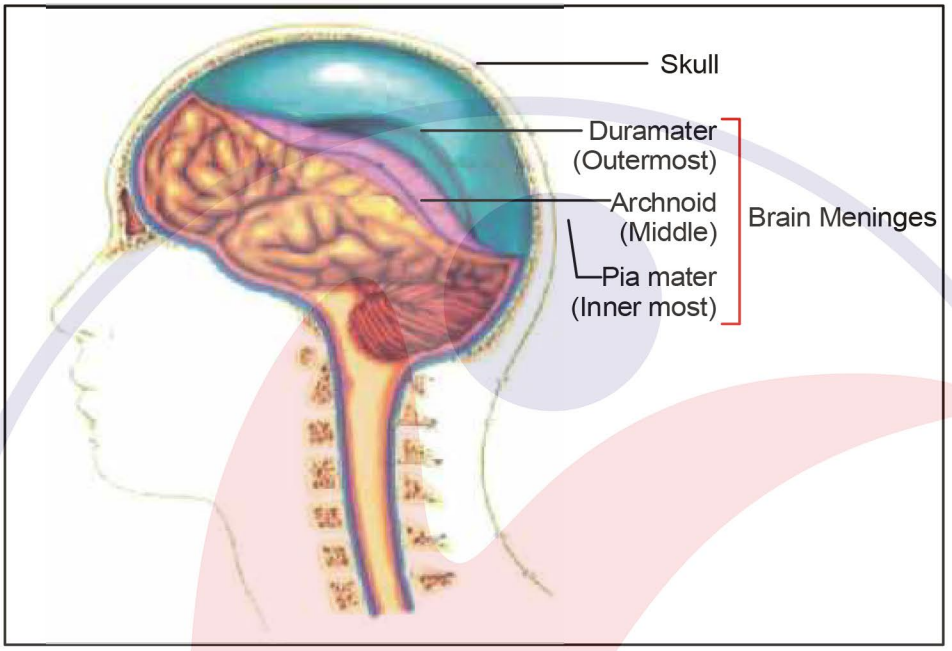
- Released neurotransmitters bind to specific receptors
- This binding opens ion channels allowing entry of ions which can generate a new potential in post synpatic neuron
- The new potential develope may be either excitatory or inhibitory.

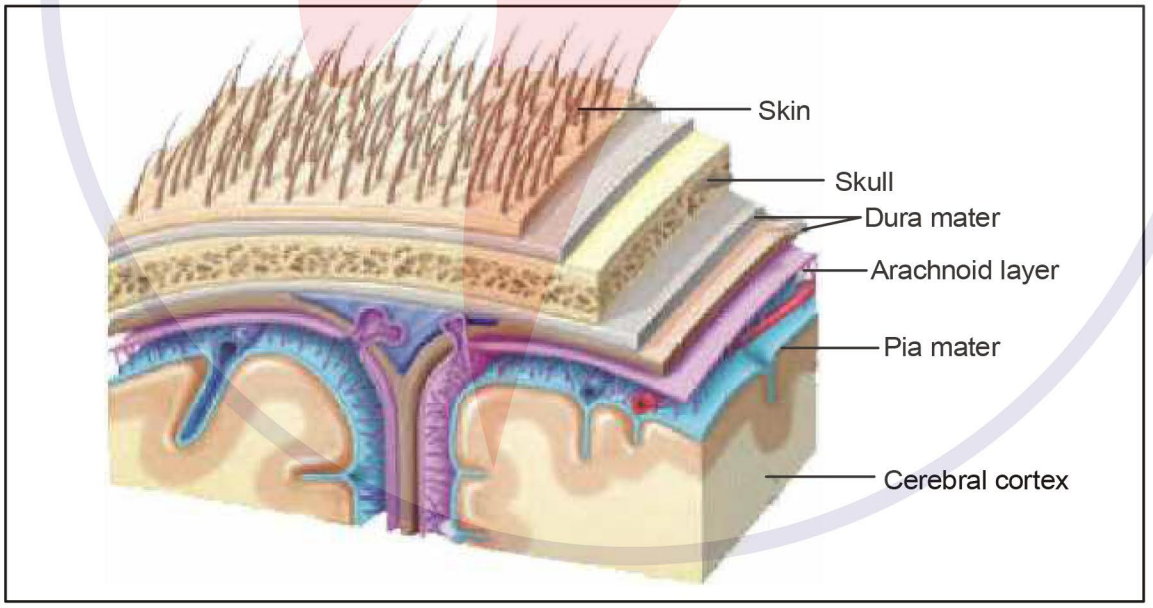
TYPE OF SYNAPSE			
		Electrical	**Chemical**
(I)	Conduction	Fast	Slow
(II)	Synaptic cleft	0.2 nm	> 20 nm
(III)	Neurotransmitter in synaptic cleft	Absent	Present
(IV)	Synaptic delay	Absent	Present
(V)	Blocking	Can not be controlled	Controlled by neurotransmitter

Special point : Electrial synapses are rare in our body,

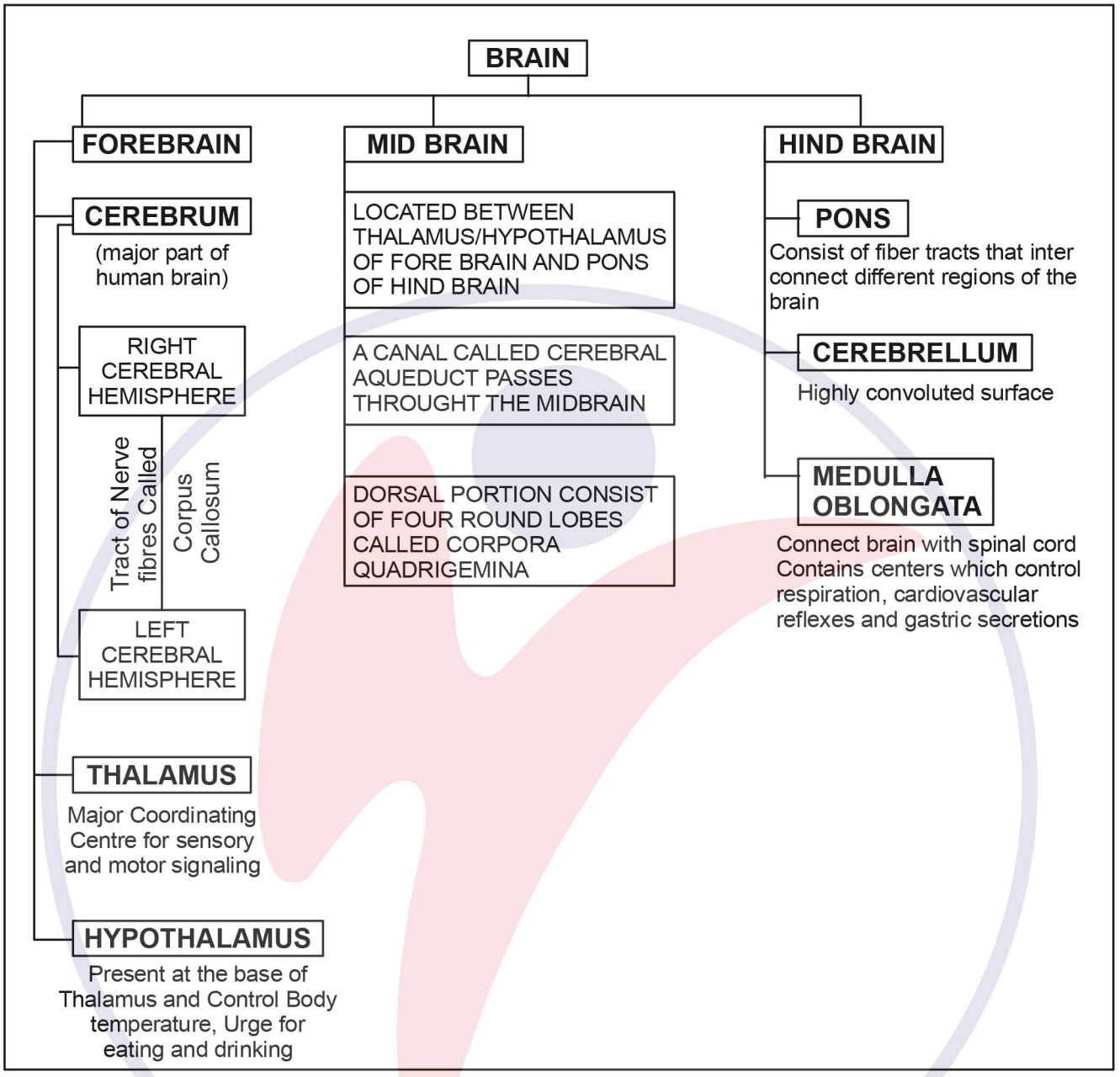
NEURAL CONTROL AND COORDINATION

The brain is the central information processing organ of our body, and acts as the 'command and control system'. It controls the voluntary movements, balance of the body, functioning of vital involuntary organs (e.g. lungs, heart, kidneys etc.) thermoregulation, hunger and thirst, circadian (24 hour) rhythums of our body, activities of several endocrine glands and human behaviour. It is also the site for processing of visin, hearing, speech, memory, intelligence, emotions and thoughts.





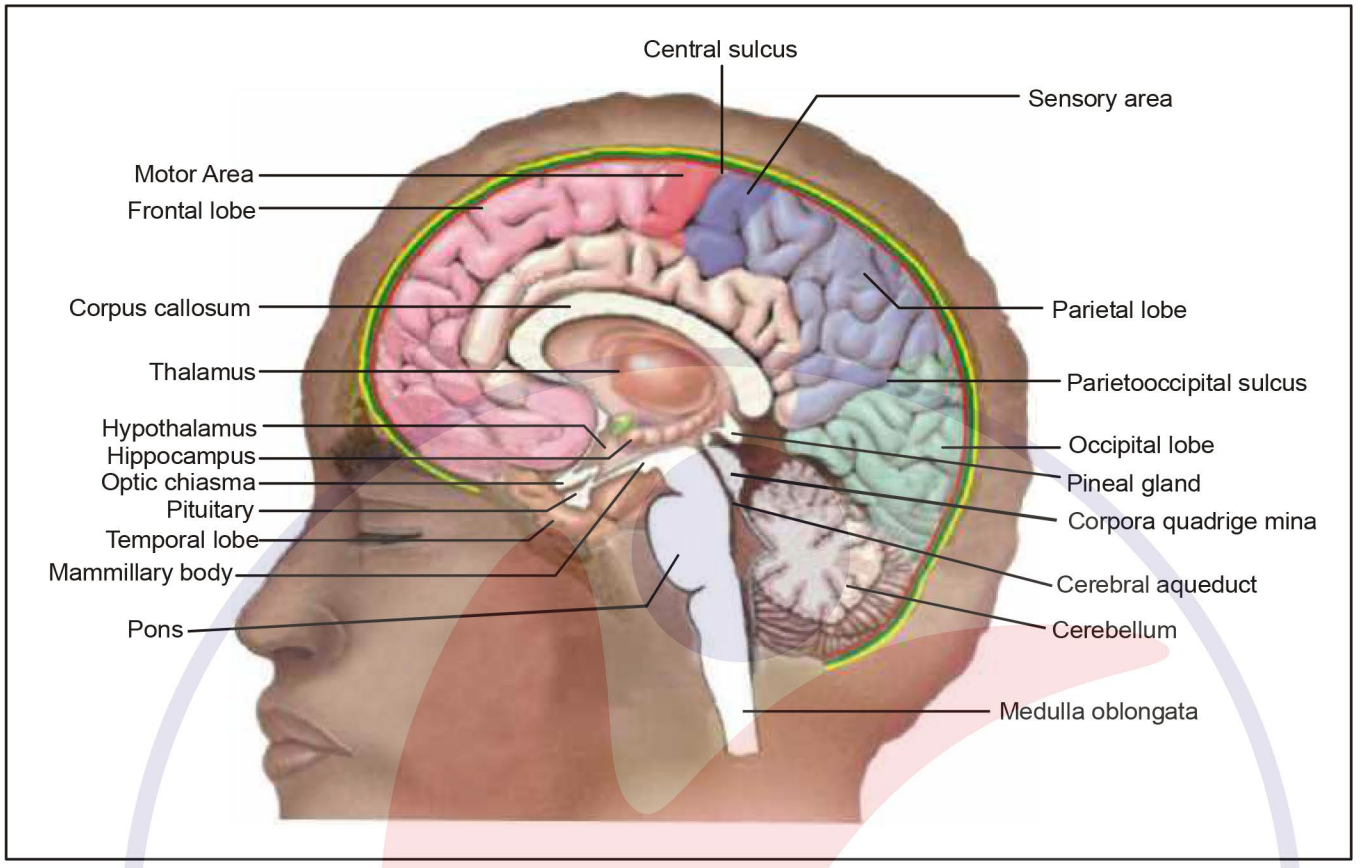
The human brain is well protected by the skull. Inside the skull the brain is covered by cranial meninges consisting of an outer layer called dura mater, a very thin middle layer called arachnoid and an inner layer (which is in contact with the brain tissue) called pia mater.



FOREBRAIN

The forebrain consists of cerebrum, thalamus and hypothalamus. Cerebrum forms the major part of the human brain. A deep cleft divides the cerebrum longitudinally into two halves, which are termed as the left and right cerebral hemispheres. The hemispheres are connected by a tract of nerve fibres called corpus callosum.

The layer of cells which covers the cerebral hemisphere is called cerebral cortex and is thrown into prominent folds. The cerebral cortex is referred to as the grey matter due to its greyish appearance. The neuron cell bodies are concentrated here giving the colour. The cerebral cortex contains motor areas, sensory areas and large regions that are neither clearly sensory nor motor in function. These regions called as the association areas are responsible for complex functions like intersensory associations, memory and communication. Fibres of the tracts are covered with the myelin sheath, which constitute the inner part of cerebral hemisphere. They give an opaque white appearance to the layer and, hence, is called the white matter.



Thalamus :- Relay centre, gate keeper of brain, pathway of sensory and motor signaling

Hypothalamus :- Regulation of temperature, urge of eating and drinking, biological clock.

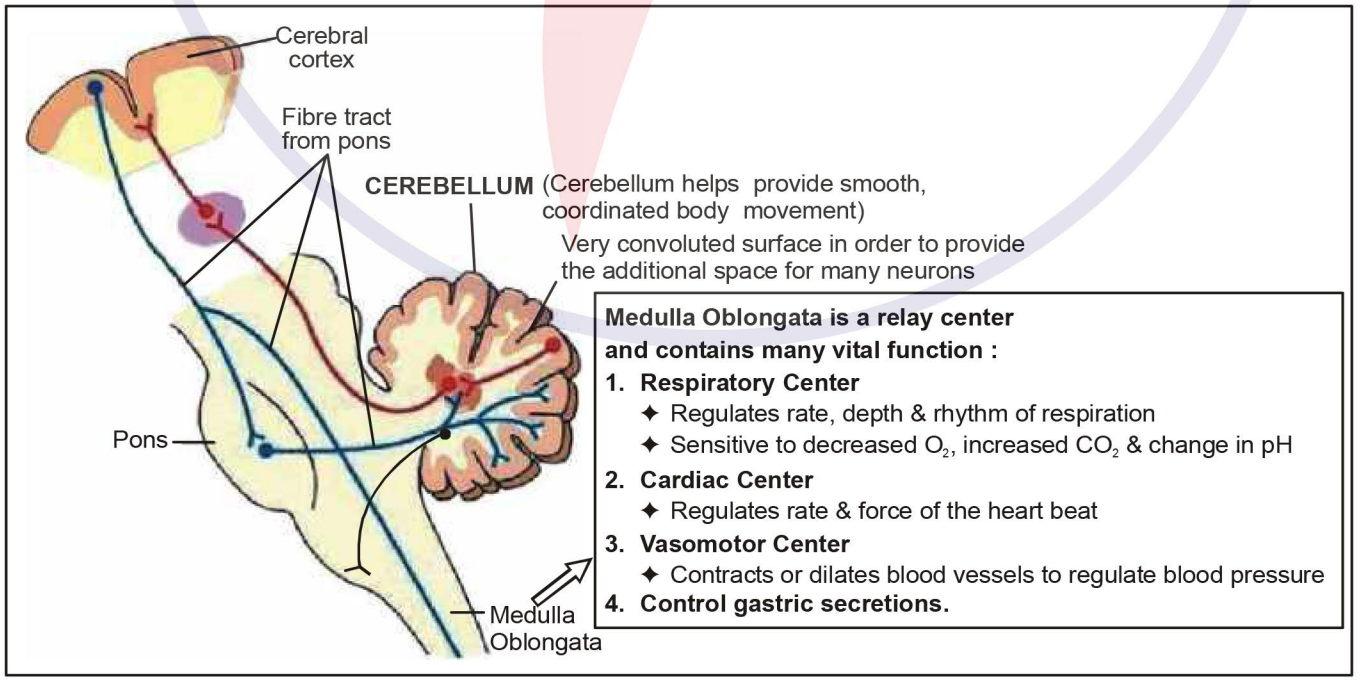
Hippocampus :- Part of limbic system, regulation of sexual behaviours, emotions pleasure, rage, excitement, fear and motivation.

Pons :- Fibres of tract which connects different region of brain.

Medulla oblongata :- Regulation of cardiovascular reflex respiration and gastric secretion.

HINDBRAIN

The hindbrain comprises pons, cerebellum and medulla (also called the medulla oblongata). Pons consists of fibre tracts that interconnect different regions of the brain.



PERIPHERAL NERVOUS SYSTEM

- All the nerves arising from brain and spinal cord are included in peripheral nervous system. Nerves arising from brain are called **cranial nerves**, and nerves coming out of spinal cord are called **spinal nerves**.
- **12-pairs** of cranial nerves are found in reptiles, birds and mammals but amphibians and fishes have only **10-pairs** of cranial nerves.

(A) CRANIAL NERVES

No.	Name	Nature	Function
I.	Olfactory	Sensory	Smell
II.	Optic	Sensory	Sight
III.	Occulomotor	Motor	Movement of eyeball
IV.	Trochlear	Motor	Movement of eyeball.
V.	Trigeminal (Dentist nerve)	Mixed	Teeth and Jaw muscles (mastication)
VI.	Abducens	Motor	Movement of eyeball
VII.	Facial	Mixed	Taste (antr 2/3 part of Tongue) Facial expression
VIII.	Auditory	Sensory	Hearing and equilibrium.
IX.	Glossopharyngeal	Mixed	Taste (Posterior 1/3 part of tongue) & saliva secretion
X.	Vagus (Pneumogastric)	Mixed	Visceral sensations and movements.
XI.	Accessory spinal	Motor	Movement of pharynx, larynx.
XII	Hypoglossal	Motor	Movement of tongue

(B) SPINAL NERVES

- In Human only **31 pairs** of spinal - nerves are found.
- Each spinal nerve is mixed type and arises from the roots of the horns of gray matter of the spinal cord. In dorsal root only afferent or sensory fibres and in ventral root efferent or motor fibres are found.
- Both the roots after moving for distance in the spinal cord of vertebrates combine with each other and come out from the Inter verterbal foramen in the form of spinal nerves.
- As soon as the spinal nerves come out of the inter vertebral foramen they divide into 3 branches :-

(i) **Ramus- dorsalis**
(ii) **Ramus ventralis**] S.N.S. (Somatic nervous system)

(iii) **Ramus communicans → A.N.S.** [Sympathetic nervous system / Parasympathetic nervous system

GOLDEN KEY POINTS

- Longest cranial nerve is **Vagus nerve.**
- Largest cranial nerve is **Trigeminal nerve.**

- Smallest cranial nerve is **Abducens nerve.**
- Thinnest Cranial nerve **Trochlear nerve.**
- I, II and VIII cranial nerves are pure sensory nerves.
- III, IV, VI, XI and XII are pure motor cranial nerves.
- V, VII, IX, X are mixed cranial nerves.

AUTONOMIC OR VISCERAL NERVOUS SYSTEM

- The autonomic nervous system. *Viseral nervous system is a part of peripheral nervous system that comprises the whole complex of nerves, fibres, ganglia and plexuses by which impulses travel from the central nervous system to the viscera and from the viscera to central nervous system.* It controls activities inside the body that are normally involuntary, such as heart beat, peristalsis, sweating etc.
- It consists of motor neuron passing to the smooth muscle of internal organs. Smooth muscles are involuntary muscles. Most of the activities of the autonomic nervous system is controlled within the spinal cord or brain by reflexes known as **visceral reflexes** and does not involve the conscious control of higher centres of the brain.
- Overall control of the autonomic nervous system is maintained by centres in the **medulla** (a part of the hind brain) and **hypothalamus**.
- The autonomic nervous system is composed of two type of neurons.

  (a) **preganglionic neuron** (myelinated)

  (b) **post preganglionic neuron** (non myelinated)

Sites of ANS –

Involuntary muscles, Exocrine glands, Blood vessels, skin (Pilomotor muscles, Blood vessels, Sweat glands)

Divisions of ANS : There are the two division of the autonomic nervous system :-

(a) sympathetic and

(b) parasympathetic

(i) Sympathetic system is related with such visceral reactions. which increase the protection of body in adverse atmospheric conditions along with calorie consumption (Causes loss of energy).

(ii) Parasympathetic system is related with those reactions in which energy is conserved.

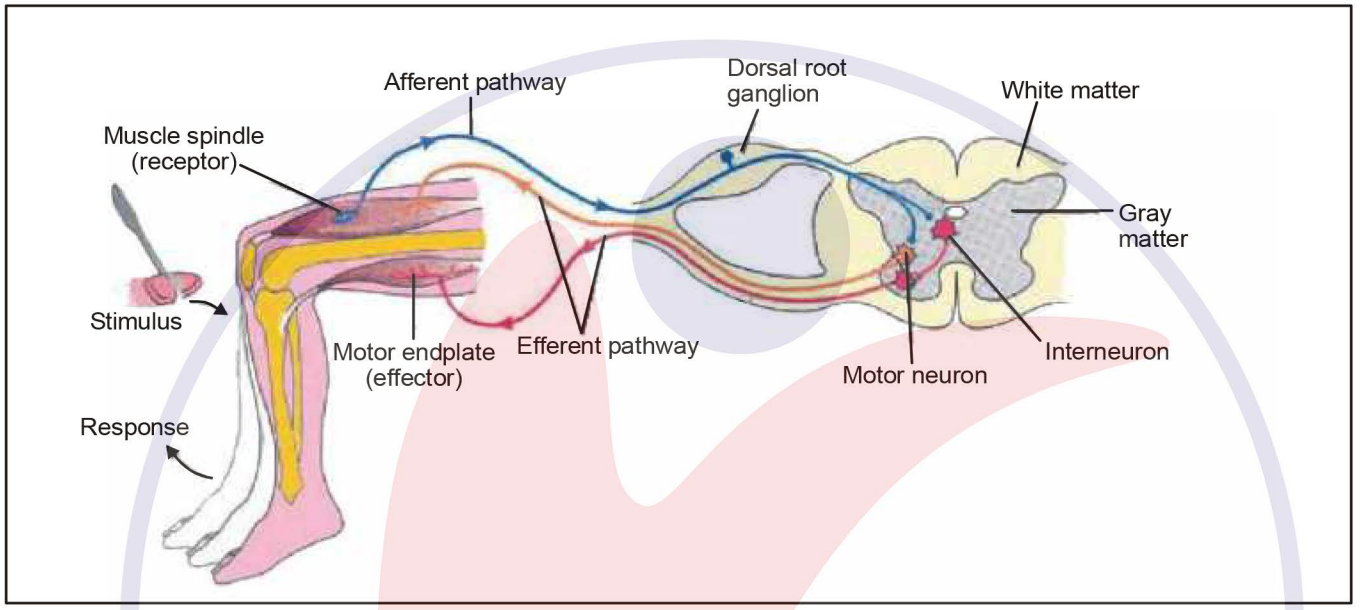
In this way, autonomic nervous system controls the activites of visceral organs double sided i.e. antagonistic to each other.

Autonomic Nervous Control of Visceral Organs

S. No.	Name of Visceral Organs	Affect of sympathetic nervous system	Affect of parasympathetic nervous system
1.	Secretion	Acetyl choline + sympathetin	Only acetylcholine
2.	Iris of eye	Dilates pupils	Constricts pupils
3.	Heart	Increases the rate of cardiac contraction	Inhibits the rate of cardiac contraction
4.	Secretion of adrenal gland	Stimulates adrenal secretion	Inhibits adrenal secretion
5.	Salivary secretion	Inhibits the secretion of saliva	Stimulates the secretion of saliva
6.	Lungs, trachea and bronchi	Dilates trachea bronchi & lungs for easy breathing	Constricts these organs during normal breathing.
7.	Alimentary canal	Inhibits peristalsis of alimentary canal.	Stimulates the peristalsis of alimentary canal
8.	Digestive glands.	Inhibits the secretion of these glands	Stimulates the secretion of the glands
9.	Sweat glands	Stimulates secretion of sweat.	Inhibits secretion of sweat.
10.	Arrector pilli muscles	Stimulates contraction of these muscles of skin, causing goose flesh	Relaxes Arrector pilli muscles.
11.	Urinary bladder	Relaxes the muscles of urinary bladder. **(Inhibits Micturition)**	Contracts the muscles for ejaculation of urine (Micturition).
12.	Anal sphincter	Closes anus by contracting anal sphincters. **(Inhibits Defaecation)**	Relaxes anal sphincter and opens the anus (Defaecation).
13.	External genitalia of male (penis)	Ejaculation	Erection

REFLEX ACTION AND REFLEX ARC

The entire process of response to a peripheral nervous stimulation, that occurs involuntarily, i.e., without conscious effort or thought and requires the involvment of a part of the central nervous system is called a reflex action.



REFLEX ACTION AND REFLEX ARC

You must have experienced a sudden withdrawal of a body part which comes in contact with objects that are extremely hot, cold pointed or animals that are scary or poisonous. The entire process of response to a peripheral nervous stimulation, that occurs involuntarily, i.e., without conscious effort or thought and requires the involvment of a part of the central nervous system is called a reflex action. The reflex pathway comprises at least one afferent neuron (receptor) and one efferent (effector or excitor) neuron appropriately arranged in a series (Figure 21.5). The afferent neuron receives signal from a sensory organ and transmits the impulse via a dorsal nerve root into the CNS (at the level of spinal cord). The efferent nueuron then carries signals from CNS to the effector. The stimulus and response thus forms a reflex arc as shown below in the knee jerk reflex. You should carefully study Figure 21.5 to understand the mechanism of a knee jerk reflex.