CENTRA NEURAL SYSTEM

Cerebrospinal – Fluid (CSF)

- This fluid is clear and alkaline in nature just like lymph.
- CSF is present in ventricles of brain, subarachnoid space of brain & spinal cord.
- C.S.F. is formed in choroid plexus found in the ventricles of the brain.

Functions of C.S.F.:

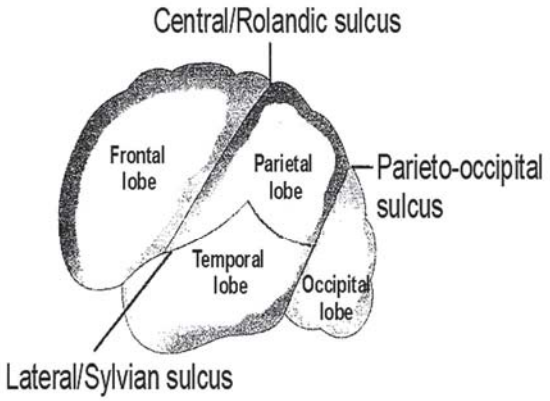
- Protection of Brain: It acts as shock absorbing medium and works as cushion.
- It provides buoyancy to the brain, so net weight of the brain is reduced from about 1.4 kg to about 0.18 kg.

(A) Fore Brain

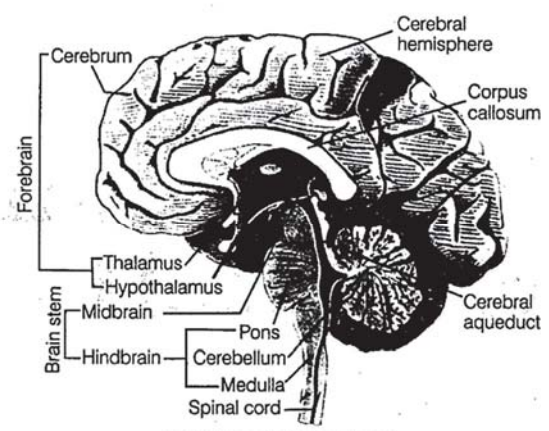
The fore brain consists of Cerebrum, Diencephalon (containing epithalamus, thalamus, hypothalamus) and off actor lobe.

(1) Cerebrum:

Cerebrum forms the major part of the brain which is most developed in human.



Dorso-lateral surface of cerebral hemisphere



Structure of human brain

- Cerebrum consists of two cerebral hemispheres; on the dorsal surface a longitudinal groove is present between two cerebral hemispheres called as median fissure. Both the cerebral hemispheres remain connected with each other by curved thick white nerve fiber called corpus callosum found in only higher mammals. (Largest commissure of brain)
- Each cerebral hemisphere is divided into 4 lobes-Anterior, Middle, Posterior and Lateral.
- Anterior lobe is also called frontal lobe (largest lobe) while middle lobe is called as parietal lobe. Frontal lobe is separated by central sulcus or Rolandic sulcus from parietal lobe.
- Posterior lobe is called as occipital lobe, it is separated from parietal lobe by a sulcus called parietal occipital sulcus.
- Lateral lobe or temporal lobe is separated from frontal lobe & parietal lobe by incomplete sulcus called lateral sulcus / sylvian sulcus.
- The outer part of cerebral hemisphere is called Cerebral cortex and thrown into prominent folds. These folds are found as ridges and grooves on dorsal surface of cerebral hemisphere. Ridge are known as Gyri while grooves are called sulci. Gyri and sulci increase the surface area of cerebrum and provide additional space for more neurons.

- The cerebral cortex referred to as the gray matter due to its greyish appearance. The neuron cell bodies are concentrated here giving the colour. This thick layer of gray matter is also known as Neopallium / Pallium in higher vertebrates.
- The cerebral cortex contains three types of functional areas:
- Sensory area: Analysis of sensory impulses eg. Somesthetic area for general sensation (Touch, Pain, Temperature etc.)
- Motor area: Generation of motor impulses eg. Broca's area for fine movement of tongue and speech. Motor area for voluntary movement of limb muscles.
- Association area: These are large regions that are neither clearly sensory nor motor in function. They are responsible for certain complex functions like:
- Intersensory association: As you are aware that all sensory inputs like touch, sound, light, smell are sent to brain. These different sensations require association and inter connection with each other for their proper interpretation.
- Memory: Memory of past events is recorded by the association areas also with the different lobes of the cerebrum. Memory is basically of two types: Short term memory and long-term memory.
- Communication: The ability of communication also controlled by the association areas of cerebral cortex.
- Function of cerebrum: It is the most important part of brain because it controls and regulates different part of brain. This is the centre of conscious senses, will power, voluntary movements, knowledge, etc.
- Different sense organs send impulse here and in this part of brain, analysis and coordination of impulse is done then messages are transferred to organs.

S.No.	Name of area	Location	Function
1	Prefrontal cortex	Frontal lobe	Seat of intelligence, knowledge, creative ideas, imagination, memory (organ of mind).
2	Motor area	Frontal lobe	Analysis of all type of voluntary muscle
3	Broca's area (Motor speech area)	Frontal lobe	Analysis for speech. If this area is injured, the person is unable to speak (aphasia), even though muscle concerned are not paralyzed.
4	Auditory area	Temporal lobe	Analysis of sound.
5	Olfactory area	Temporal lobe	Analysis of smell.
6	Wernicke's area (Sensory speech area)	Temporal lobe	Analysis of language. Sensory analysis of speech.
7	Gustatory area	Parietal lobe	Analysis of taste.
8	Somesthetic area	Parietal lobe	Analysis of touch, pain, pressure. knowledge about the body position and taking in the information from the surrounding environment.
9	Occipital area (Visual cortex area)	Occipital lobe	Analysis of vision.

2. Diencephalon

It is small chamber like posterior part of fore brain which is covered by cerebrum. It consists of 3 parts:

a. Epithalamus b. Thalamus c. Hypothalamus

a. Epithalamus:

It form the roof of diencephalon. Pineal body (Epiphysis cerebri) is found on epithalamus & control sexual maturity.

b. Thalamus:

It forms upper lateral wall of Diencephalon. It forms 80% of diencephalon. It acts as a relay centre. It receives all sensory inputs from all part of body & these impulses are send to the cerebral cortex. Cerebrum wraps around the thalamus. It is a major coordinating centre for sensory & motor signaling.

c. Hypothalamus:

It forms the lower or ventral part of diencephalon. It lies at the base part thalamus.

- The hypothalamus contains a number of centres which control body temperature. urge for eating and drinking (Hunger and thirst).
- It also contains several groups of neurosecretory cells. which secrete hormone called hypothalamic hormone.
- A cross like structure is found on anterior surface of hypothalamus called as optic chiasma, through Infundibulum pituitary body is attached to middle part of hypothalamus. Corpus mammillae or corpus albicans or mammillary body is found on the posterior part of hypothalamus. (Mammal are character)

Hypothalamus controls:

1. Thermoregulation
2. Behavior and emotion
3. Endocrine control
4. Biological clock system
5. ANS control.

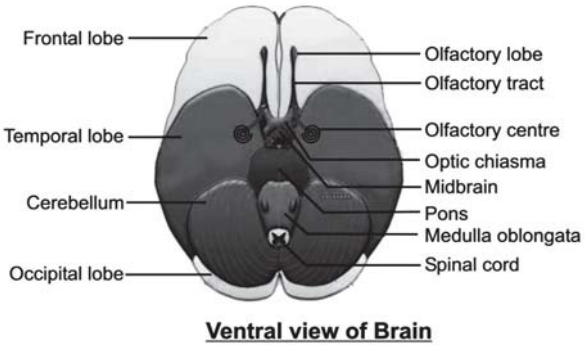
Limbic system:

The inner part of cerebral hemispheres and a group of associated deep structures like amygdala. Hippocampus etc. form a complex structure called Limbic system. Along with the hypothalamus, it is involved in the regulation of sexual behavior, expression of emotional reactions (e.g., excitement pleasure, rage, fear) and motivation, olfaction and autonomic responses.

3. Olfactory Lobe:

One pair of broad bean size organ called olfactory lobe / bulb are found on the ventral surface of frontal lobe of cerebral hemisphere. It is a small, spherical and solid structure in human brain. It is connected to olfactory area / center (temporal lobe) through olfactory tract and are extensions of the brain's limbic system.

Function: It is supposed to be the center of smelling power. Some animal like are sharks and dogs have well developed olfactory lobes.



Ventral view of Brain

MID BRAIN

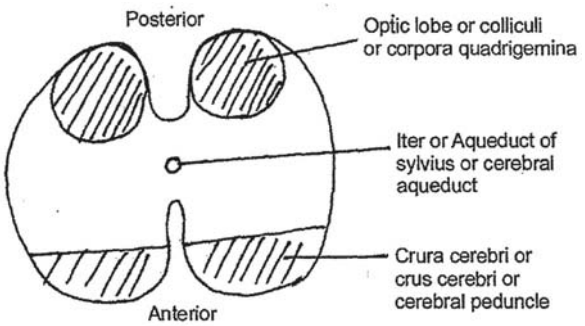


FIG : T. S. OF MID BRAIN

- It is a small part of brain. The midbrain is located between diencephalon of the fore brain and pons of the hind brain. A canal called Cerebral aqueduct/Aqueduct of Silvius passes through the midbrain.
- Anterior part of midbrain contains two longitudinal myelinated nerve fiber called cerebral peduncles or crus cerebri or crura cerebri.
- On posterior part of mid brain four spherical projections are found called colliculus or optic lobe. Four colliculi are collectively called as corpora quadrigemina. (2 upper & 2 lower) (Mammalian character)
- Mid brain and hind brain (except cerebellum) form the brain stem.
- The mid brain receives and integrates visual. tactile and auditory inputs.
- Crura cerebral controls the muscle of limb while superior and inferior colliculus are related with pupillary (light) reflex and acoustic (Sound) reflex action respectively.

(B) Midbrain

Situated between the thalamus/hypothalamus of the forebrain and the pons of the hindbrain, the dorsal section of the midbrain is predominantly characterized by four rounded swellings collectively known as the corpora quadrigemina. These four lobes within the midbrain are organized, with two positioned on the upper side called the superior colliculi and two on the lower side termed the inferior colliculi. The superior colliculi, receiving sensory impulses from the eyes and head muscles, oversee visual reflexes, orchestrating concurrent movements of the head and eyes to focus on an object.

In contrast, the inferior colliculi receive sensory impulses from the ears and head muscles, overseeing auditory reflexes associated with the ears. The inferior colliculi manage and synchronize head movements to pinpoint and recognize the source of sound.

(C) Hind Brain

The hind brain comprises cerebellum, pons and medulla (also called the medulla oblongata).

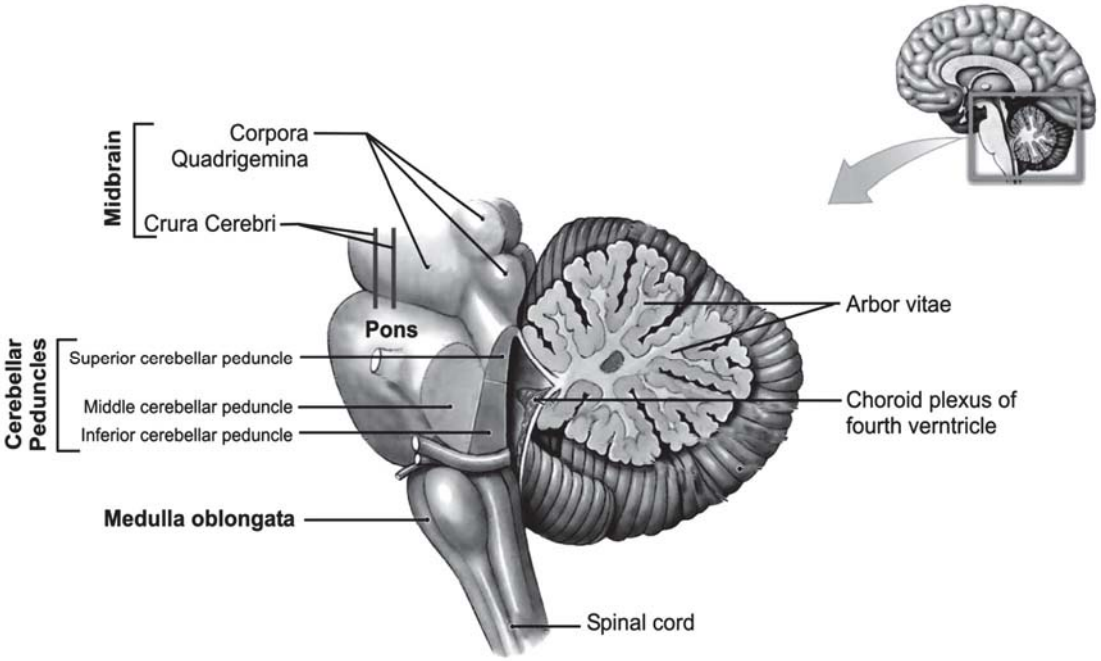
1. Cerebellum:

- It is made up of 3 lobe (2 large lateral lobe and 1 small middle lobe-vermis). Both lateral lobes become enlarged and spherical in shape. so lateral lobe of cerebellum is also called as cerebellar hemisphere. Cerebellum has very convoluted surface in order to provide the additional space for many more neurons.
- Outer part of cerebellum is made up of gray matter while inner part is of white matter. White matter projects outside & forms a branched tree like structure known as Arbor Vitae / Tree of life.

Functions:

It helps in maintaining body balance and posture. The cerebellum integrates information received from the receptors for balancing which are located in - joints, muscles, tendons and semicircular canals of internal ear.

- Coordination of voluntary muscle through involuntary regulation is done by cerebellum. (body balancing)
- It is also related with fine and skillful voluntary movements.
- Consumption of alcohol in excess adversely affects the cerebellum, as a result the person is unable to maintain the balance and so the walking is disturbed.



Lateral view of Midbrain & Hindbrain

2. Pons:

It is a small spherical projection, which is situated between the midbrain and medulla oblongata. It consists of many transverse and longitudinal nerve fibres. Transverse nerve fiber connects with cerebellum while longitudinal nerve fiber connect cerebrum to medulla oblongata.

Function: It regulates the breathing reaction through pneumotach centre.

3. Medulla Oblongata:

- Posterior part of hind brain and is tubular and cylindrical in shape. Medulla of brain is connected to spinal cord.
- Mid brain, pons and medulla are situated in one axis and it is called as Brain stem.

Functions: It is the most important part of brain which controls the involuntary activities of internal organs of the body e.g., cardiovascular reflex, respiration, metabolism, gastric secretion etc. As well as this act as conduction path for all impulses between spinal cord and remaining portions of brain.

- It is also concerned with simple reflex action like sneezing, salivation, coughing, swallowing, vomiting, yawning etc.

Spinal Cord

- Medulla oblongata comes out from foramen of magnum & continues in neural canal of vertebral column, the continued part of MO is known as Spinal cord. It extends from base of skull to (L_1) lumbar vertebra.
- Its upper part is wide while lower most part is known as conus-medullaris.
- Conus medullaris present up to L1 vertebra. Terminal part of conus medullaris extend in the form of thread like structure called filum terminal.
- Filum terminal is non-nervous part. Met acoel also continues in spinal cord where it is known as neurocoele or central canal.
- The group of spinal nerve at the terminal end (L_1) of spinal cord form taillike structure called cauda equina (horse tail).

- Spinal cord is also covered by Duramater, Arachnoid & Piamater. A narrow space is found between vertebra & Duramater known as Epidural space.

Length of spinal cord is 45 cm.
Length of filum terminal is 20 cm.
Weight of spinal cord is approximately 35 gm

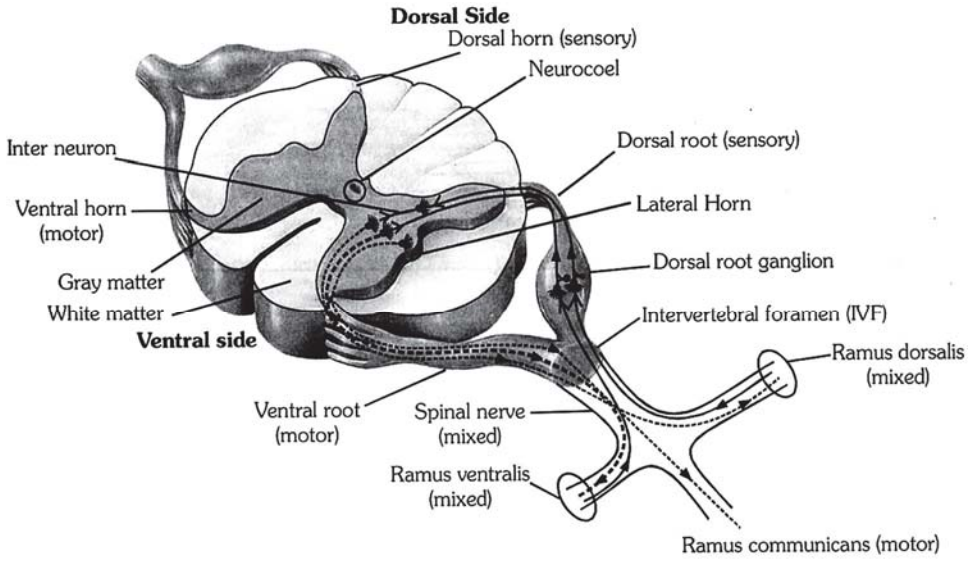


Fig. :- Section of spinal cord, showing the origin and branching of a spinal nerve

The outer-part of spinal cord is of white matter while inner-part contain gray matter.

- On the dorsa-lateral & ventro-lateral surface of spinal cord, the gray matter (butter fly shaped) projects outside & forms the one pair dorsal & ventral horn.
- Due to formation of dorsal & ventral horn white matter is divided in 4 segments & segment is known as Funiculus or white column.
- Dorsal & ventral horn continue in a tube like (bundle of never fibres) structure known as Dorsal root and Ventral root. In root of dorsal horn, ganglia are present called Dorsal root ganglia.
- Sensory neurons are found in the dorsal root ganglia which is pseudo unipolar in nature. Its axon extend & gets embedded into gray matter of spinal cord & make synapse with ventral root neuron.
- Multipolar motor neurons are found in the ventral root. Its Cyton and dendron are embedded into gray matter of spinal cord where they make synapse with axon of sensory neuron.
- Both sensory & motor nerve fibers combinedly come out from intervertebral foramen & form spinal nerve.
- In some part of spinal cord on both side lateral horns are also found. Motor neurons are found in this horn. There nerve fiber follows the ventral root & comes out through intervertebral foramen. This fiber called Ramus communicans.
- Ramus communicans forms ANS.
- Spinal nerve & its branches are mixed type (except ramus communicans).

Functions of spinal cord:

1. It acts as a bridge between brain & organs of the body.
2. It also provides relay path for the impulses coming from brain
3. Spinal cord regulates and conducts most of the reflex action.

Peripheral Nervous System

(A) Cranial nervous (12 Pairs)
(B) Spinal nervous (31 Pairs)

- 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 (aves) and Mammals but Fishes and Amphibians have only 10-pairs of cranial nerves.

(A) Cranial Nerves:

No.	Name		Nature	Function
1.	Olfactory	O	Sensory	Smell or olfaction
2.	Optic	O	Sensory	Sight or vision
3.	Oculomotor	O	Motor	Movement of eyeball
4.	Trochlear (Thinnest)	T	Motor	Movement of eyeball
5.	Trigeminal or Dentist Nerve (Largest)	T	Mixed	Teeth and Jaw muscles (mastication)
6.	Abducens (Smallest)	A	Motor	Movement of eyeball
7.	Facial	F	Mixed	Taste (antra 2/3 part of Tongue) Facial expression
8.	Auditory	A	Sensory	Hearing and body balancing
9.	Glossopharyngeal	G	Mixed	Taste (Posterior 1/3 part of tongue) & Saliva secretion
10.	Vagus or Pneumogastric (Longest)	V	Mixed	Visceral sensations and movements
11.	Spinal accessory /Accessory spinal	A	Motor	Movement of pharynx, larynx,
12.	Hypoglossal	H	Motor	Movement of tongue

- Sensory nerves - i, ii and viii, motor nerves - iii, iv, vi, xi and xii, mixed nerves - v, vii, ix and x.

Spinal nerve = Ramus doesalis + Ramus ven tentralis + Ramus communicans

S. N. S. A.N.S.

(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 vertebral 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:

$$\left.\begin{matrix}\text{(i) Ramus} - \text{dorsalis}\\ \text{(ii) Ramus ventralis}\end{matrix}\right] \text{S.N.S. (Somatic nervous system)}$$

$$\text{(iii) Ramus communicans} \rightarrow \text{A.N.S.} \left[\begin{matrix}\text{Sympathetic nervous system}\\ \text{Paraympathetic nervous system}\end{matrix}\right.$$

- 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. Visceral 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 types of neurons.
- Preganglionic neuron (myelinated)
- Postganglionic neuron (non myelinated)

Autonomic Nervous System (Ans)

- The autonomic or Visceral nervous system (ANS) is a part of PNS that comprises the whole complex of nerves, fibres, ganglia and plexuses by which impulses travel from the CNS to the visceral organs and from the visceral organs to CNS. It controls activities inside the body that are normally involuntary, such as heart beat, peristalsis, sweating etc.
- All visceral motor neurons constitute ANS which regulates involuntary activities of visceral organs (Cardiac, smooth muscles and glands). 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 and hypothalamus.
- The autonomic nervous system is composed of two type of visceral motor neurons.
- **pre-ganglionic neuron** (myelinated)
- **post-ganglionic neuron** (non myelinated)
- ANS has two antagonistic divisions to regulate visceral activities automatically.
  (a) sympathetic and **(b)** parasympathetic division

(i) Sympathetic system is related with such visceral reactions, which increase the protection of body in adverse or emergency 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 activities of visceral organs bidirectionally i.e., antagonistic to each other.

Sites affected by ANS: Smooth muscles, Exocrine glands, Blood vessels, Skin (Pilomotor muscles, Sweat glands).

Autonomic Nervous Control of Visceral Organs

S. No.	Name of Visceral Organs	Effect of sympathetic nervous system	Effect of parasympathetic nervous system
1.	Secretion	Acetyl choline + sympathetin (E and NE)	Only acetylcholine
2.	Iris of eye	Dilates pupils	Constricts pupils
3.	Heart	increases the rate of cardiac contraction	Inhibits the HBR
4.	Secretion of adrenal gland	Stimulates adrenal secretion	Inhibits adrenal secretion
5.	Lungs, trachea and bronchi	Dilates trachea, bronchi & increases breathing rate	Constricts these organs and decreases breathing rate.
6.	Sweat glands	Stimulates secretion of sweat.	Inhibits secretion of sweat.
7.	Arrector pili Muscles (skin)	Stimulates contraction of these muscles causing goose flesh	Relaxes Arrector pili muscles.
8.	Alimentary canal	Inhibits peristalsis of alimentary canal.	Stimulates the peristalsis of alimentary canal
9.	Digestive glands and saliva secretion	Inhibits the secretion of these glands including saliva	Stimulates the secretion of all digestive juices
10	Urinary bladder	Relaxes bladder muscles and contracts Urethral sphincter (Inhibits Micturition)	Contracts bladder muscles and relaxes sphincter (Micturition)
12.	Anal sphincter	Closes anus by contracting anal sphincters. (Inhibits Defecation)	Relaxes anal sphincter and opens the anus (Defecation).
13.	Genitalia organs (penis)	Ejaculation of semen (decreases libido)	Erection of penis (enhances libido)