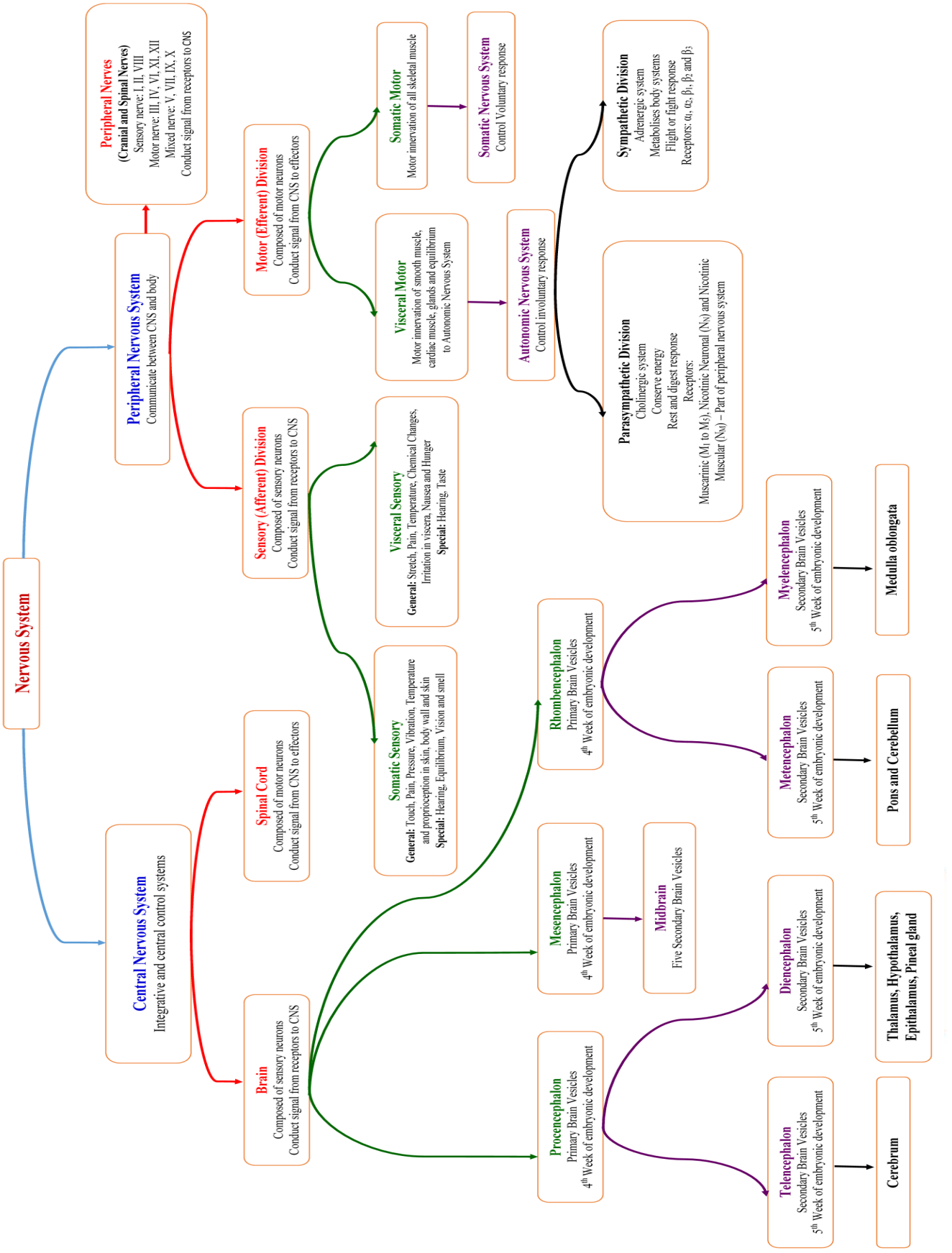
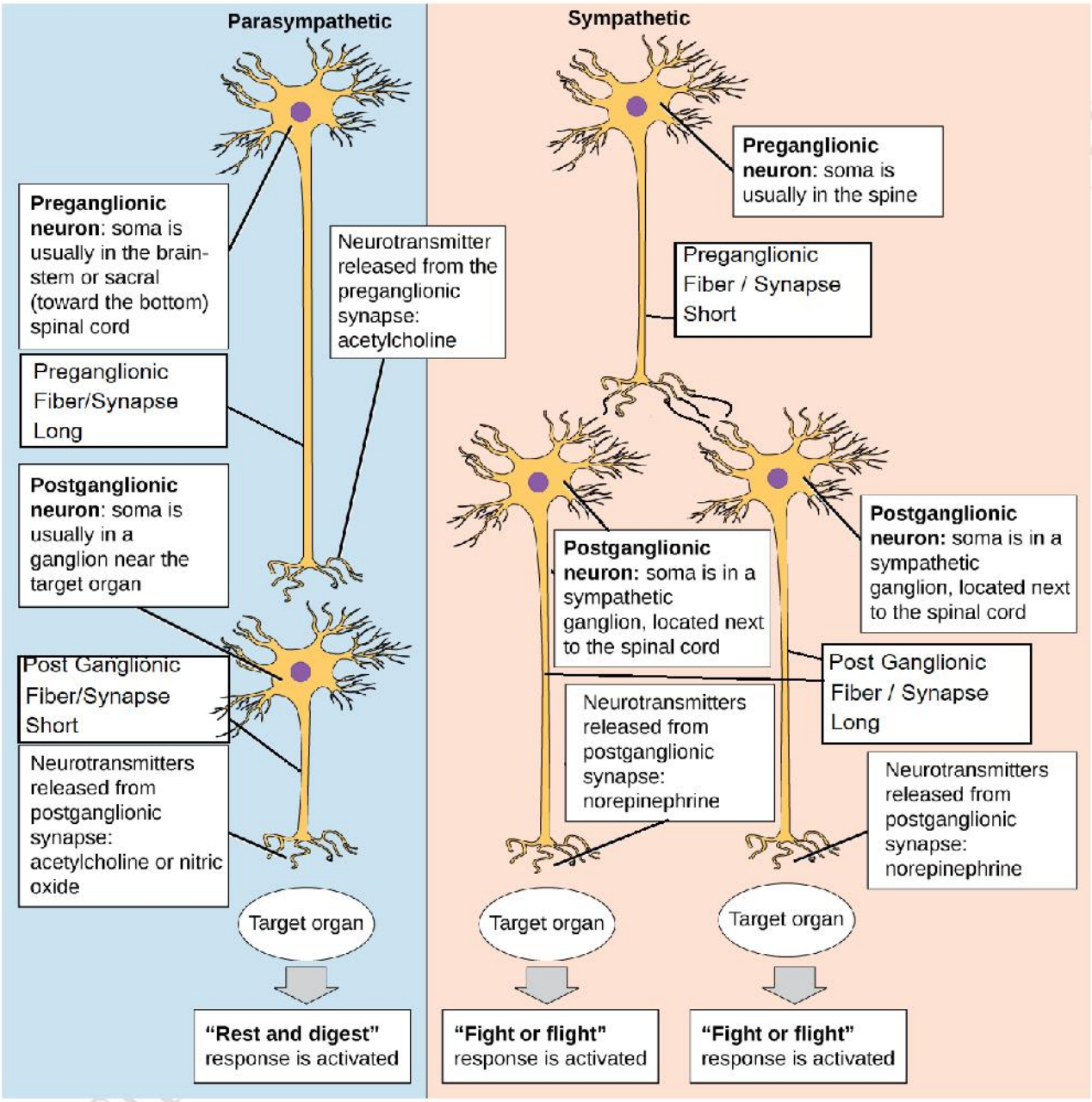
EXPERIMENT NO.: 14. g **DATE:**

AIM: TO STUDY THE NERVOUS SYSTEM USING SPECIMEN AND MODELS



REQUIREMENTS: Charts and Models of Human Brain, Spinal Cord, Autonomic Nervous system

AUTONOMIC NERVOUS SYSTEM



THEORY

Introduction of Autonomic Nervous System (ANS):

It is the part of nervous system that deals with the involuntary movements. It is also known as visceral nervous systems. It works under the conscious and unconscious conditions and maintain the involuntary functions. It control automatically, pumping of blood, beating of heart, contraction of blood vessel, lungs and GI tract, secretion of saliva, lacrimal fluid etc….

Anatomy of Autonomic Nervous System (ANS):

Hypothalamus
↓ Coordinate with
Midbrain/Spinal Cord
↓
Stimulate Preganglionic Neuron/Fiber
↓ Release Neurotransmitter – I at Autonomic Ganglion
Stimulate Postganglionic Neuron/Fiber
↓ Release Neurotransmitter – II at Neuron Effector Junction
It stimulate various receptors of respective organs
↓
Produce various autonomic action

Autonomic nervous system is subdivided into the two portion:

1. Parasympathetic Nervous System (Cholinergic Nervous System)
2. Sympathetic Nervous Systems (Adrenergic Nervous System)

1. PARASYMPATHETIC NERVOUS SYSTEM (CHOLINERGIC NERVOUS SYSTEM):

Anatomy of Parasympathetic Nervous System (Cholinergic Nervous System)

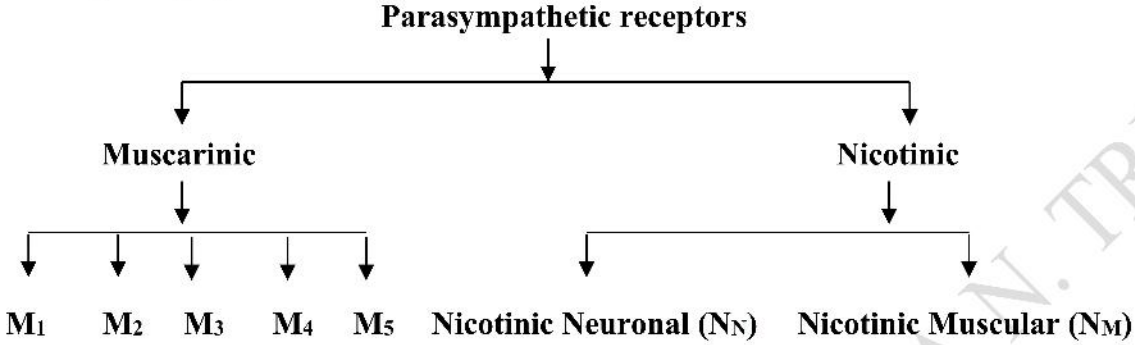
Superior control by anterior and middle part of hypothalamus
↓
Centre of III, VII, IX and X cranial nerve and sacral part of spinal cord
↓
Activate preganglionic neuron/fiber (Long)
↓
Release neurotransmitter-I (Ach) in Autonomic Ganglion/Junction (Junction-I)
↓ Stimulate (N_N) or (M_1) receptor
Activate postganglionic neuron/fiber (Short) after that Ach is destruct by Acetylcholine Esterase
↓
Release neurotransmitter-II (Ach) in Neuron Effector Junction (Junction-II)
↓ Stimulate (M_1), (M_2), (M_3) or (N_N) receptor
Produce various action after that Ach is destruct by Acetylcholine Esterase (AchE)

*Preganglionic neuron/fibers are long and post ganglionic neuron/fibers are short in parasympathetic nervous system.

* One preganglionic neuron/fiber, one or two post ganglionic neuron/fiber are originated except Auorbach's plexus - inner circular and outer longitudinal layers of the muscularis externa).

* Acetylcholine esterase (AchE) is the enzyme which destruct the Acetyl Choline (Ach) after their action.
* Parasympathetic system consist two types of receptors: 1) Muscarinic (M_1, M_2, M_3, M_4, M_5) and Nicotinic (N_N – Nicotinic Neuronal, N_M – Nicotinic Muscular).

Location of parasympathetic receptors and their functions:



- **M_1 receptors:**

Location	Function
Autonomic ganglion/junction (Junction – I)	Activation of post ganglionic neuron/fiber

- **M_2 receptors:**

Location	Function
Heart	Decrease force of contraction (Negative Inotropic) Decrease heart rate (Negative Chronotropic) Decrease conduction (Negative dromotropic)

- **M_3 receptors:**

Location	Function
GI smooth muscle	Contraction of GI smooth muscle
Bronchial smooth muscle	Contraction of bronchial smooth muscle (Lungs contraction)
Urinary tract	Contract detrusor – urinary bladder muscle which relax trigon of urinary bladder and produce micturition.
Salivary secretion	Increase secretion of saliva
Lacrimal secretion	Increase secretion of tear/lachrymal fluid
Gastric secretion	Increase secretion of HCl in GI tract
Eye	Produce meiosis (Contraction of pupils) Iris consist two types of smooth muscles 1) Sphincter pupillae 2) Dilator pupillae (Radial Muscle). Contraction of sphincter pupillae constrict pupil known as meiosis and contraction of dilator pupillae produce dilation of pupil known as mydriasis.

N_N receptors:

Location	Function
Autonomic ganglion/junction (Junction – I)	Activation of post ganglionic neuron/fiber
Adrenal medulla	Release of adrenalin and some nor adrenalin
CNS	Complex undefined action but inhibitory

N_M receptors:

Location	Function
Neuromuscular Junction	Contraction of skeletal muscle

Synthesis, storage, release and hydrolysis of Ach

Choline + Acetyl Co-A
↓ Choline acetylase
Ach (Store in vesicle)
↓ Release of Ach when needed
Ach produce various action through receptors
↓ Acetylcholine Esterase (AchE) destruct Ach
Ach convert in acetate and choline

2. SYMPATHETIC NERVOUS SYSTEMS (ADRENERGIC NERVOUS SYSTEM)

Anatomy of sympathetic nervous system (Adrenergic System)

Superior control by posterior and lateral part of hypothalamus
↓
Preganglionic fibers origenate from Thoracic 1 to Lumber 3 segments
↓
Activate preganglionic neuron/fiber (Short)
↓
Release neurotransmitter-I (Ach) in Autonomic Ganglion/Junction (Junction-I)
↓ Stimulate (N_N) or (M_1) receptor
Activate postganglionic neuron/fiber (Long) after that Ach is destruct by Acetylcholine Esterase
↓ Release neurotransmitter-II (Adr)
Stimulate (α_1), (α_2), (β_1), (β_2) or (β_3) receptor in Neuron Effector Junction (Junction-II)
↓
Produce various action

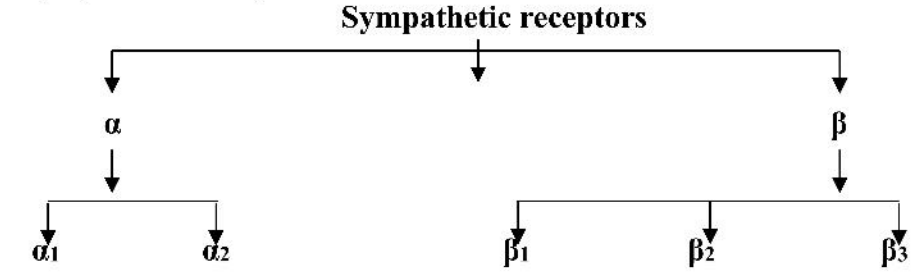
*Preganglionic neuron/fibers are short and post ganglionic neuron/fibers are long in sympathetic nervous system.

* One preganglionic neuron/fiber emerge out 20 to 100 post ganglionic neuron/fiber.

* Sympathetic nervous system consist both the neurotransmitter that is acetylcholine in autonomic ganglion/junction and noradrenalin in neuron effector junction.

* Parasympathetic system consist two types of receptors: α (α_1, α_2) and β (β_1, β2, β_3)

Location of sympathetic receptors and their functions:



- **α1 receptors:**

Location	Function
Blood vessels	Produce vasoconstriction
Iris	It contract radial muscles and dilate the pupil known as mydriasis
GI tract	Contract the GI sphincter and relax the the GI muscle
Urinary bladder	Contract the trigon and relax the urinary bladder
Glands	Increase the secretion of glands
Uterus	It produce contraction in nonpregnant uterus
Heart	Weak action on heart
Male sex organ	Penile erection and ejaculation
Skin	Contraction of pilomotor muscles.

- **α2 receptors:**

Location	Function
Presynaptic nerve ending	It reduce release of noradrenalin
Blood vessels	Produce constriction of blood vessels
CNS	Reduction in central sympathetic flow due to decrease of Noradrenalin level
Pancreas	Reduce insulin level so increase blood sugar level
Platelets	Aggregate platelets
GI muscle	Relaxation of GI muscle

- **β1 receptors:**

Location	Function
Heart	Increase force of contraction (Positive Inotropic) Increase heart rate (Positive Chronotropic) Increase conduction (Positive dromotropic)
Kidney	Release of renin, so renin activate angiotensinogen I which convert in angiotensinogen II by the help of angiotensinogen converting enzyme (ACE) and activate the aldosterone. Which retain the Na^+ and water and increase the blood volume as well as angiotensinogen act on AT-I and AT-II receptor and contract the blood vessels.

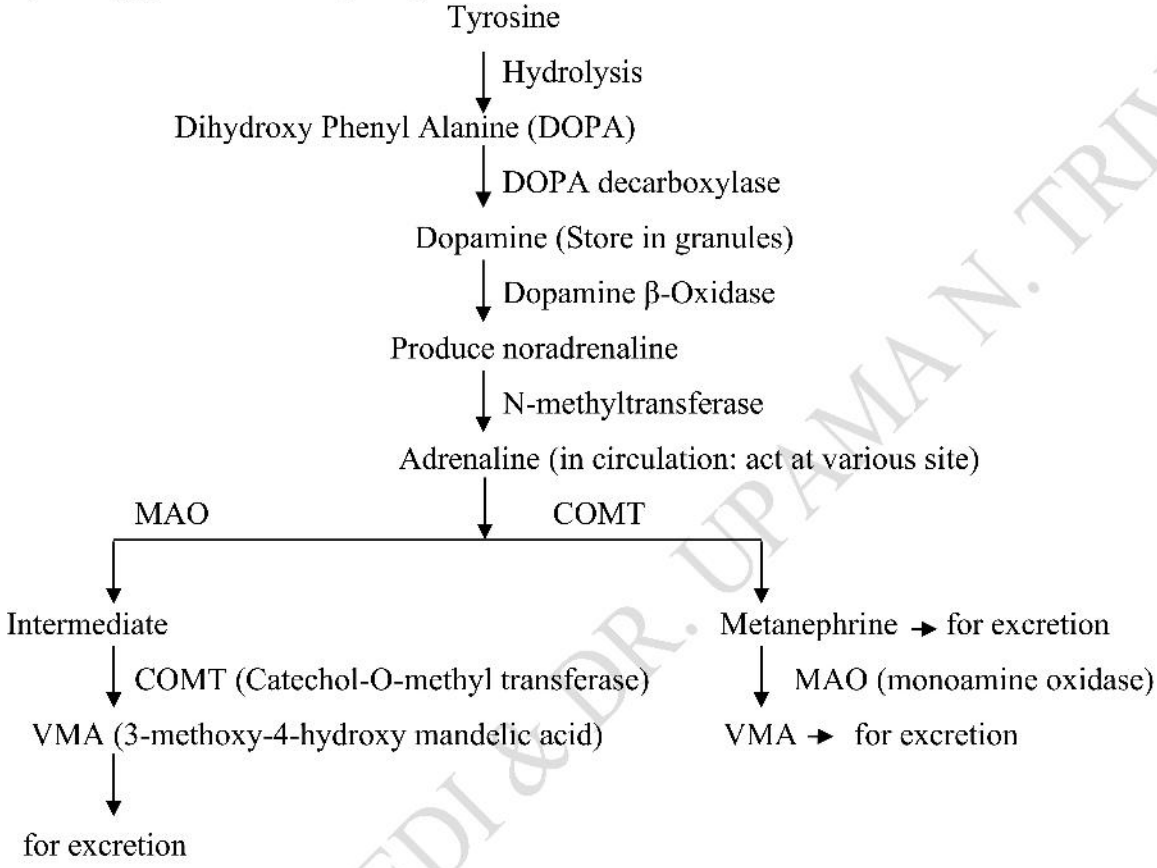
- **β2 receptors:**

Location	Function
Blood vessels	Dilation of blood vessels
Lungs	Dilation of bronchial smooth muscles and lungs
GI muscle	Relaxation of GI muscle
Bladder	Relaxation of detrusor produce relaxation in urinary bladder (contract the trigon)
Liver	Produce glycogenolysis means conversion of glycogen to glucose and increase blood sugar level
Pancreas	Increase glucagon secretion which increase blood sugar level

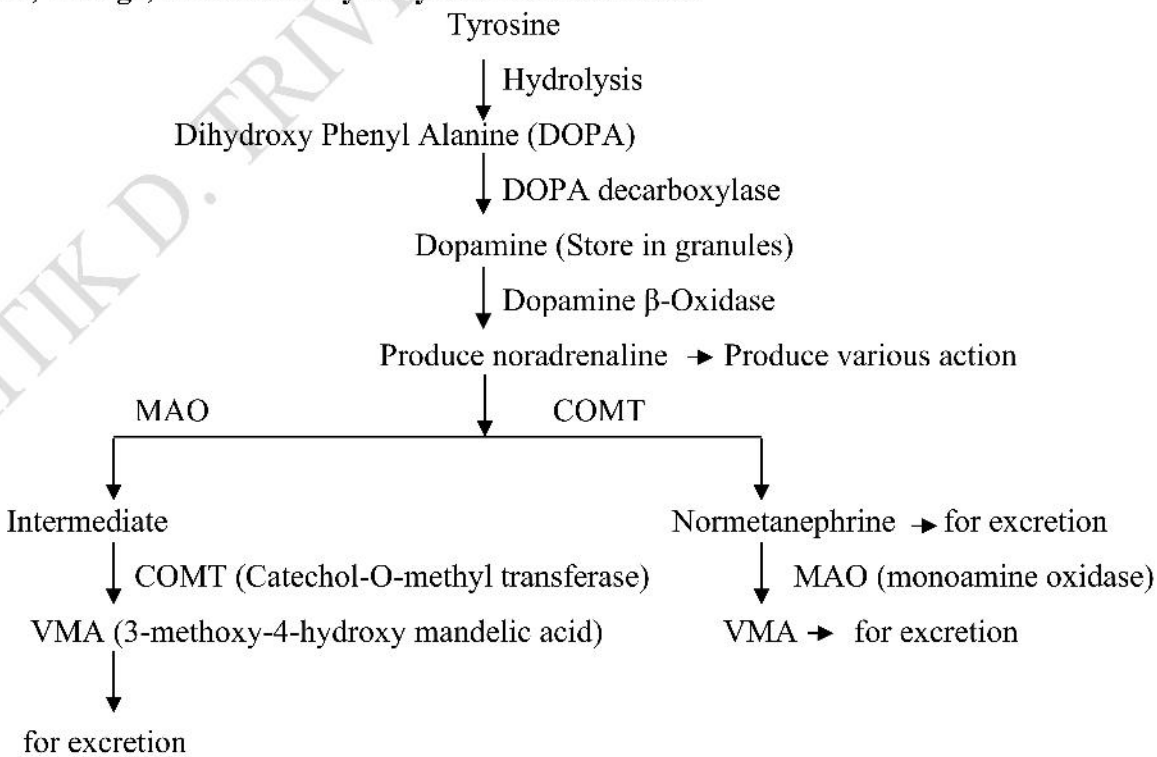
Adipose tissue	Lipolysis (Break down of fats)
Uterus	Produce relaxation in pregnant uterus

- **β_3 receptors:** Role and functions of β_3 receptors are not clearly defined.

Synthesis, storage, release and hydrolysis of adrenaline

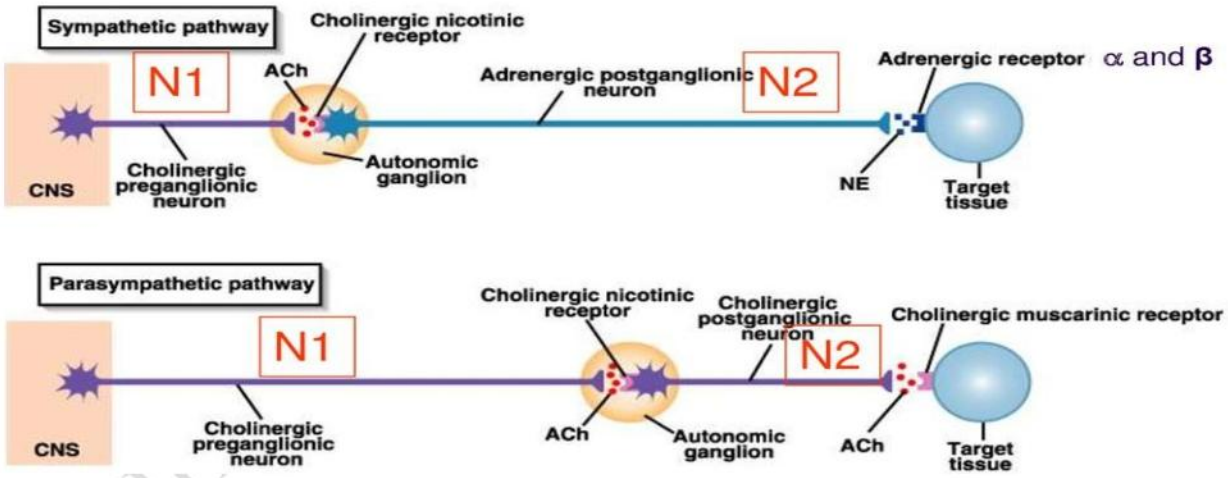


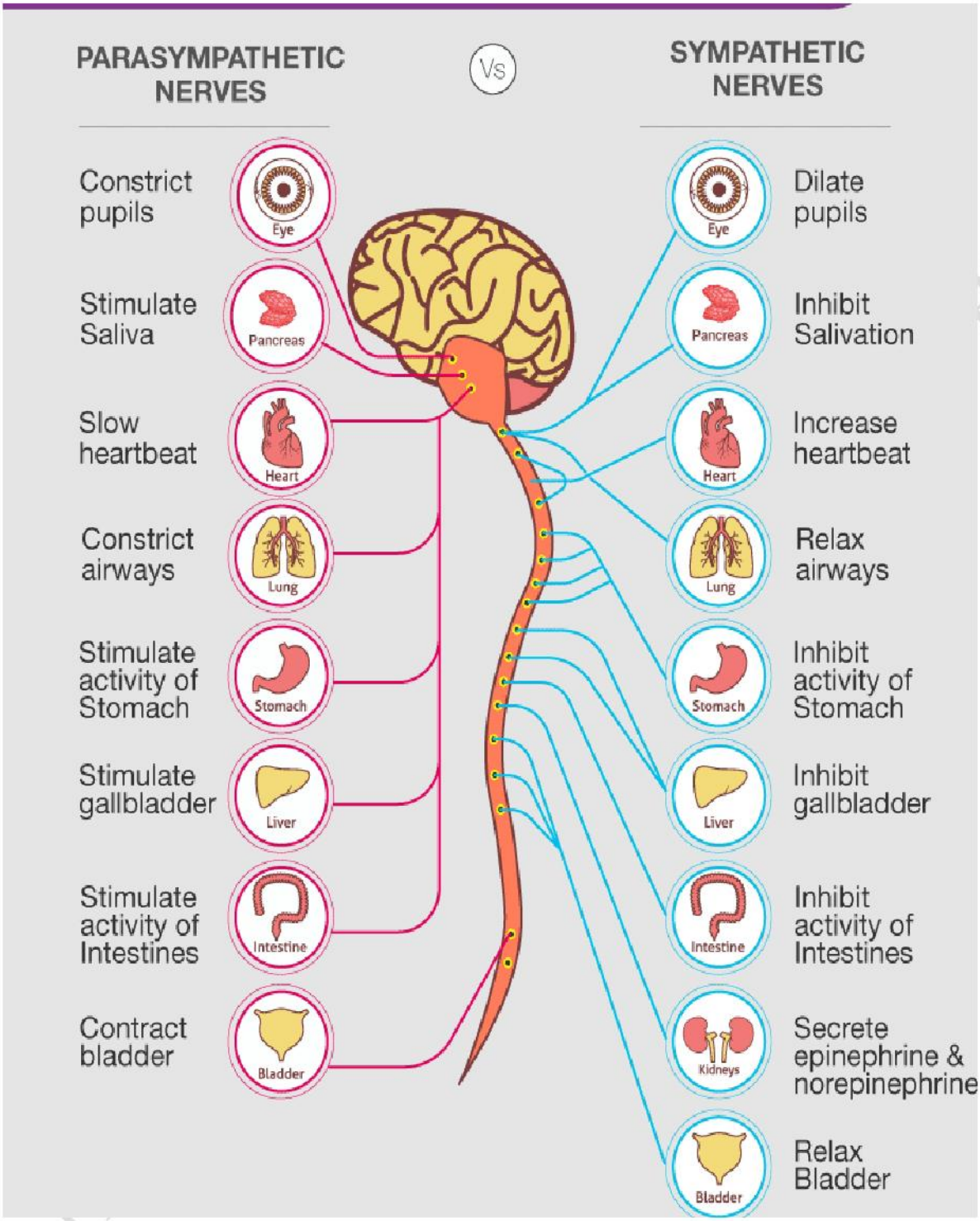
Synthesis, storage, release and hydrolysis of noradrenaline

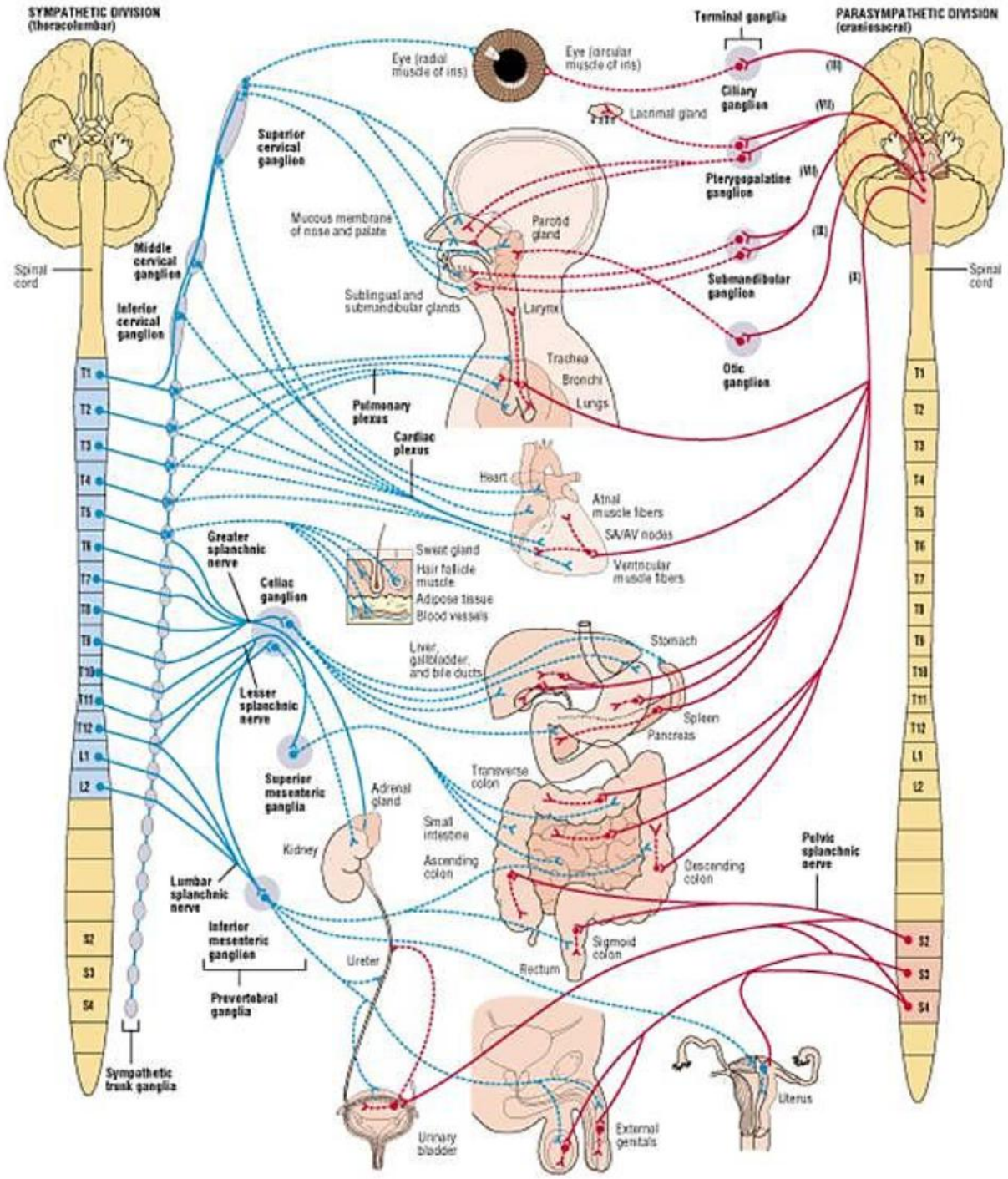


Sympathetic and Parasympathetic Effects		
Structure	**Sympathetic**	**Parasympathetic**
Eye (pupil)	Dilation	Constriction
Nasal Mucosa	Mucus reduction	Mucus increased
Salivary Gland	Saliva reduction	Saliva increased
Heart	Rate increased	Rate decreased
Arteries	Constriction	Dilation
Lung	Bronchial muscle relaxation	Bronchial muscle contraction
Gastrointestinal Tract	Decreased motility	Increased motility
Liver	Conversion of glycogen to glucose increased	Glycogen synthesis
Kidney	Decreased urine	Increased urine
Bladder	Contraction of sphincter	Relaxation of sphincter
Sweat Glands	↑Sweating	No change

Neurotransmitter	Neurotransmitter – I is acetylcholine and Neurotransmitter – II is Adrenalin	Neurotransmitter – I and II both are acetylcholine
Preganglionic fiber	Short	Long
Postganglionic fiber	Long	Short
Receptor	α and β	Muscarinic (M) and Nicotinic (N)




PARASYMPATHETIC NERVES
Vs
SYMPATHETIC NERVES
Constrict pupils
Eye
Dilate pupils
Eye
Stimulate Saliva
Pancreas
Inhibit Salivation
Pancreas
Slow heartbeat
Heart
Increase heartbeat
Heart
Constrict airways
Lung
Relax airways
Lung
Stimulate activity of Stomach
Stomach
Inhibit activity of Stomach
Stomach
Stimulate gallbladder
Liver
Inhibit gallbladder
Liver
Stimulate activity of Intestines
Intestine
Inhibit activity of Intestines
Intestine
Contract bladder
Bladder
Secrete epinephrine & norepinephrine
Kidneys
Relax Bladder
Bladder



Sympathetic and parasympathetic nervous system (Ref: Tortora)

CENTRAL NERVOUS SYSTEM

THE BRAIN

Anatomy of Brain:

Adult brain consist average 100 billion neurons and 1000 billion neuroglia. Weight of the adult brain is approximately 1.3-1.5 kg in human. Brain mainly divided into four parts:

1. Brain Stem: It is the superior portion and continuous with the spinal cord consist medulla oblongata, pons and midbrain.
2. Cerebellum: It located posterior to the brain stem.
3. Diencephalon: It is located superior to the brain stem. It consist thalamus, epithalamus, subthalamus, hypothalamus and pineal gland.
4. Cerebrum: It look like cap of mushroom. It occupies the most of the part of cranium and it is divided into right and left halves known as cerebral hemispheres.

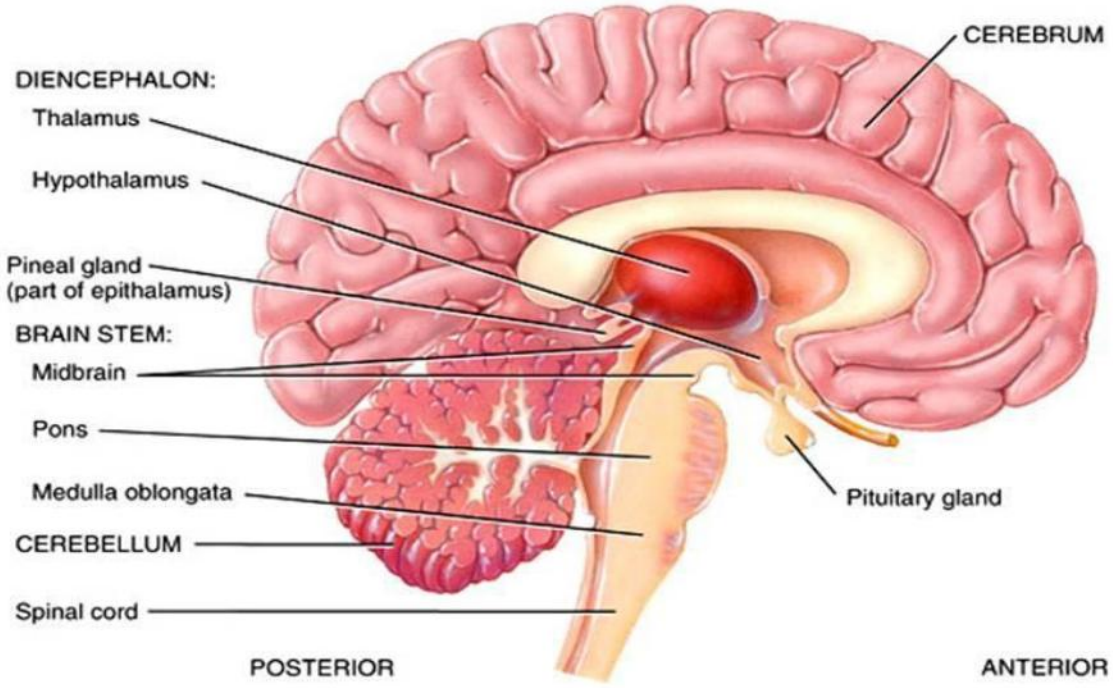


Diagram of brain

According to the embryonic development brain is divided mainly into the three parts at the third weeks of embryonic development which is also known as primary brain vesicles:

1. Prosencephalon – Forebrain
2. Mesencephalon – Midbrain
3. Rhombencephalon – Hindbrain

During the further development of the embryo primary vesicles is divided and form secondary vesicles at the 5th weeks of embryonic development.

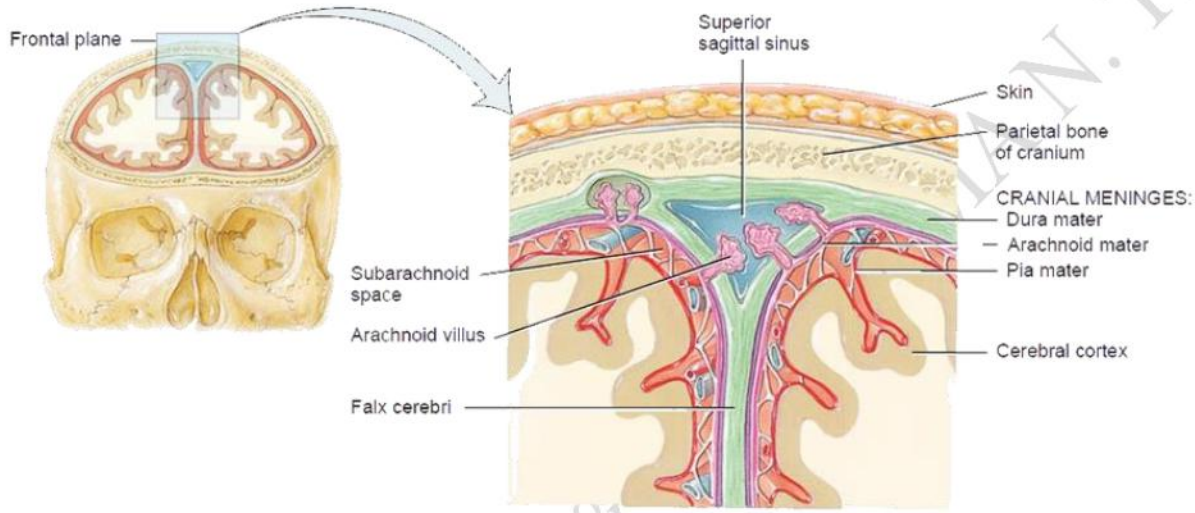
- Procencephalon develop telencephalon and diencephalon
- Mesencephalon develop midbrain
- Rhombencephalon develop metencephalon and myelencephalon

At the final stage of embryonic development:

- Telencephalon forms cerebrum
- Diencephalon forms epithalamus, hypothalamus, subthalamus, thalamus and pineal gland
- Metencephalon forms pons and cerebellum
- Myelencephalon forms medulla oblongata

The brain grow rapidly during the first few years of life (between the ages of 1-12 years).

PROTECTION AND COVERING OF THE BRAIN:

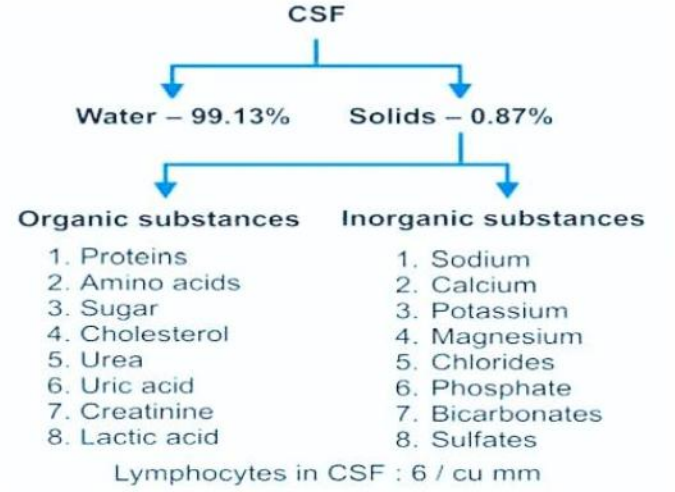


- Cranial bones and cranial meninges mainly protect the brain.
- Cranial bones produce the superficial layer of the brain.
- Cranial meninges surrounds the brain and continuous towards the spinal cord and known as spinal meninges.
- In the brain, outer portion of the cranial manages known as dura meter, middle portion known as arachnoid and inner portion is known pia meter.

CEREBROSPINAL FLUID (CSF):

The entire central nervous system contains between 80 – 150 mL of CSF, and about 500 mL is generated every day.

Compositions of cerebrospinal fluid:

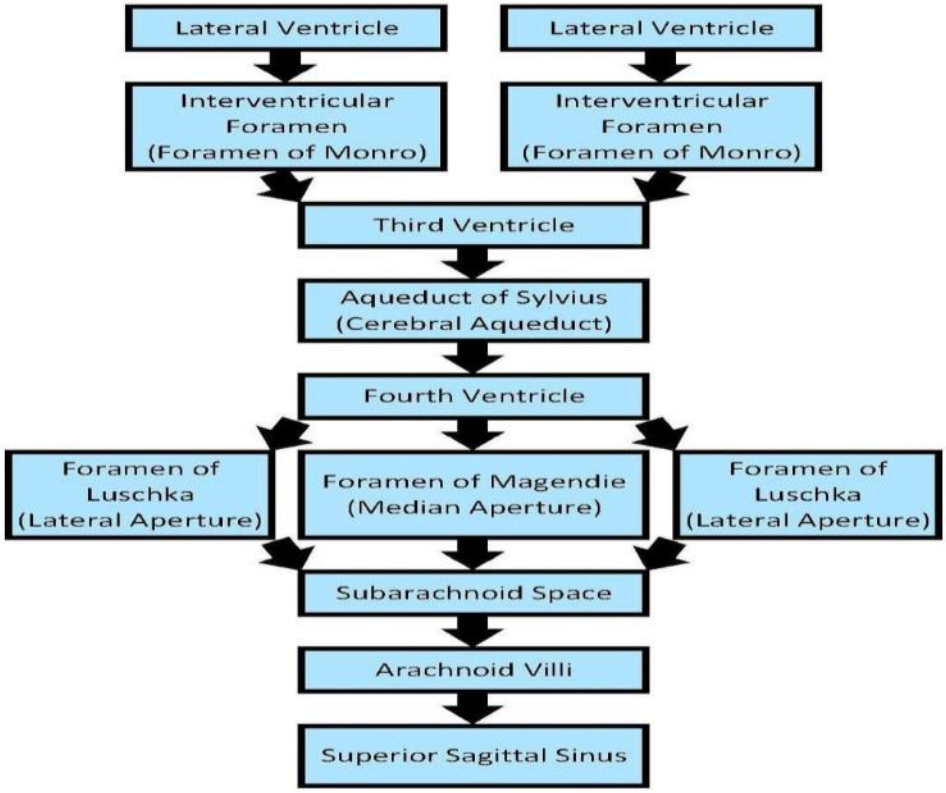


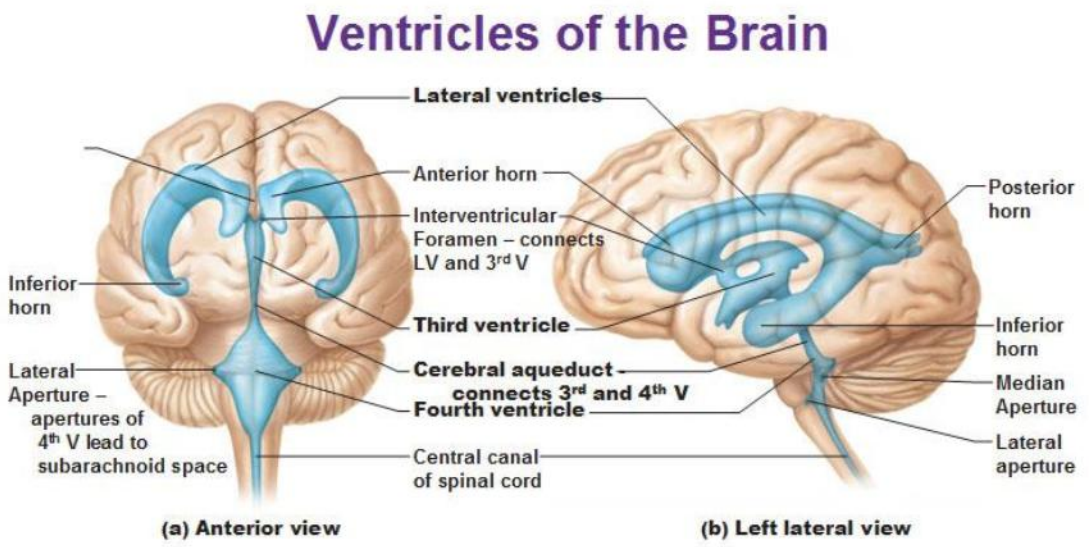
Composition of CSF

Substance	Plasma	CSF
Na^+ (mEq/l)	145.0	150.0
K^+	4.8	2.9
Ca^{++}	5.2	2.3
Mg^{++}	1.7	2.3
Cl^-	108.0	130.0
HCO_3^-	27.4	21.0
Lactate	7.9	2.6
PO_4^{---}	1.8	0.5
Protein	7000.0	20.0
Glucose	95.0	60.0

(protein and glucose expressed as mg/100 ml)

Flow/circulation of cerebrospinal fluid:

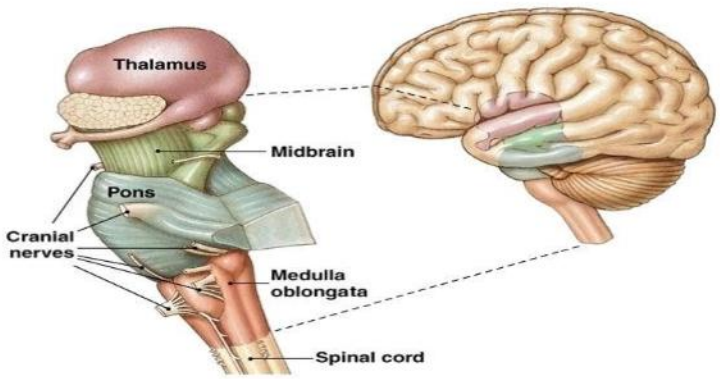




Functions of cerebrospinal fluid (CSF):

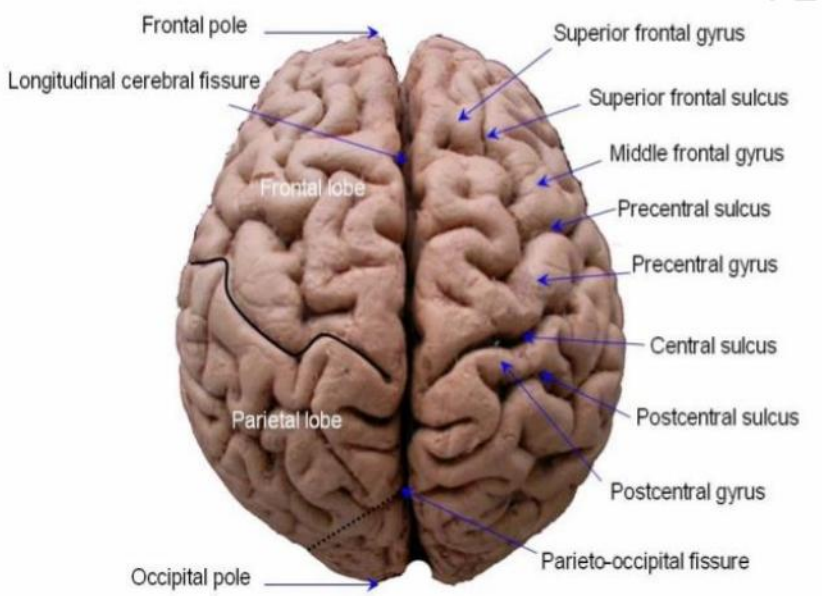
1. Mechanical Protection:
   - Cerebrospinal fluid absorb the shock and protect the delicate tissue of the brain and spinal cord.
   - It also act as a lubricating fluid and reduce the friction during the movement.
2. Chemical Protection:
   - It maintain the electrolytes and chemical balance which is required for regulation of post synaptic potential and action potential.
3. Provide nutrients:
   - It provide the essential nutrient through the circulation in brain and spinal cord.
4. Provide immunity:
   - It consist some amount of the WBCs which can fight against the harmful bacteria and virus.
5. Remove the toxin:
   - CSFs remove the metabolites, waste products and toxin from the brain and spinal cord through the circulation.

BRAIN STEM:



- The midbrain, pons and medulla oblongata of the hindbrain are collectively referred to as the "brain stem". These structures connects brain to the spinal cord.
- The midbrain coordinates sensory representations of the visual, auditory and somatosensory perceptual spaces.
- The pons is the main connection with the cerebellum. The pons and the medulla regulate several crucial functions, including the cardiovascular and respiratory systems.
- The cranial nerves connect through the brain stem and provide the brain with the sensory input and motor output associated with the head and neck, including most of the special senses.
- The major ascending and descending pathways between the spinal cord and brain, specifically the cerebrum, pass through the brain stem.

CEREBRUM:



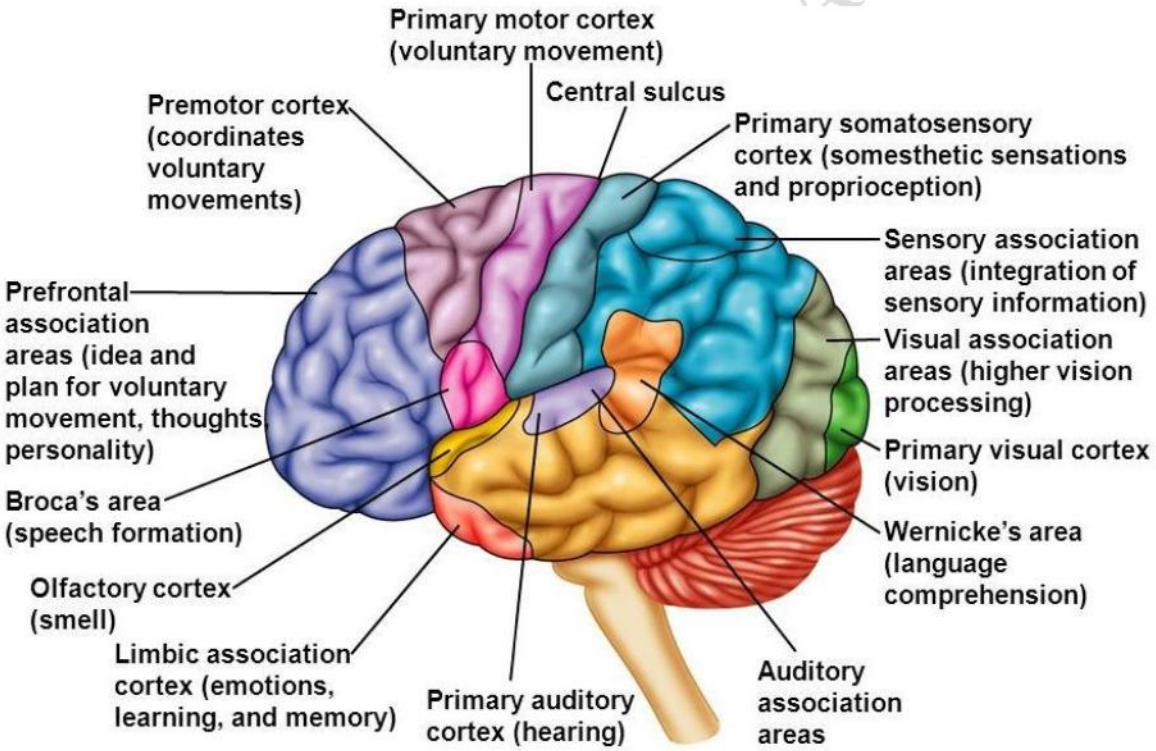
- Cerebrum support diencephalon and brainstem. It develop from the telencephalon.
- The superficial layer of the cerebrum is gray matter which is known as cerebral cortex.
- Cerebral cortex is 2-4 mm thick and consists billion of neurons.
- Deep to the cerebral cortex consist white matter.
- During the embryonic development when brain size increase rapidly the gray matter of the cortex enlarge much faster than the white matter so cortical region rolls and folds itself. The folds are known as gyri.
- The deepest grooves between folds are known as fissures and the narrower grooves between folds are known as sulci.
- The most prominent fissure is longitudinal fissure which separates cerebral in right and left hemispheres. These hemispheres are joined internally by the white matters.

- Each hemisphere controls the opposite side of the body. If a stroke occurs on the right side of the brain, your left arm or leg may be weak or paralyzed.
- Not all functions of the hemispheres are shared. In general, the left hemisphere controls speech, comprehension, arithmetic, and writing. The right hemisphere controls creativity, spatial ability, artistic, and musical skills. The left hemisphere is dominant in hand use and language in about 92% of people.

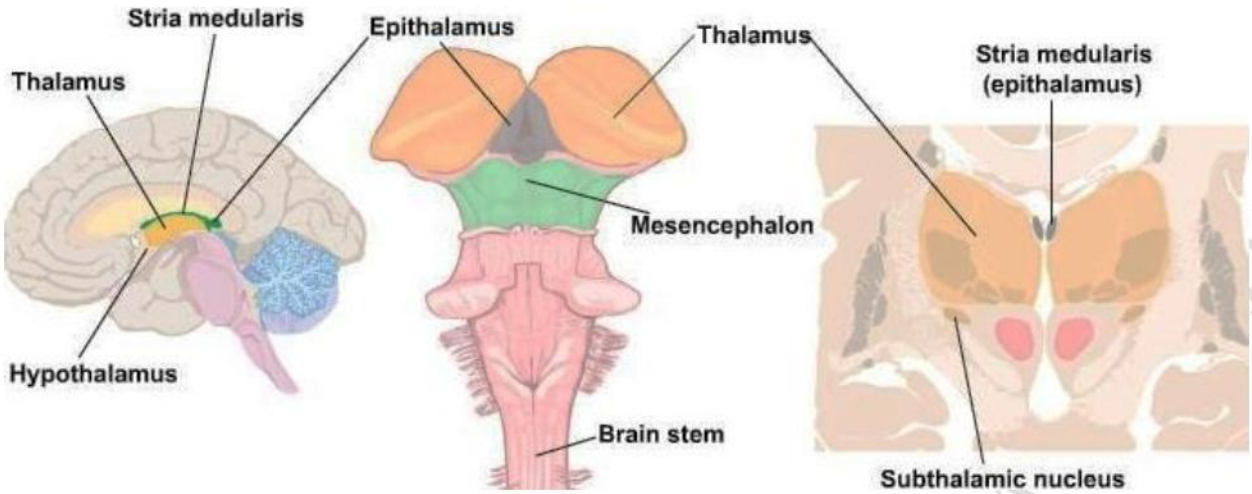
Functional area of the cerebral cortex:

Cerebral cortex consist mainly three kinds of functional areas.

1. Sensory areas: receives and interpret sensory impulses.
2. Motor areas: control muscular movements
3. Association areas: deals with more complex integrative functions such as memory, emotion, reasoning, will, judgment, personalities, intelligence etc.

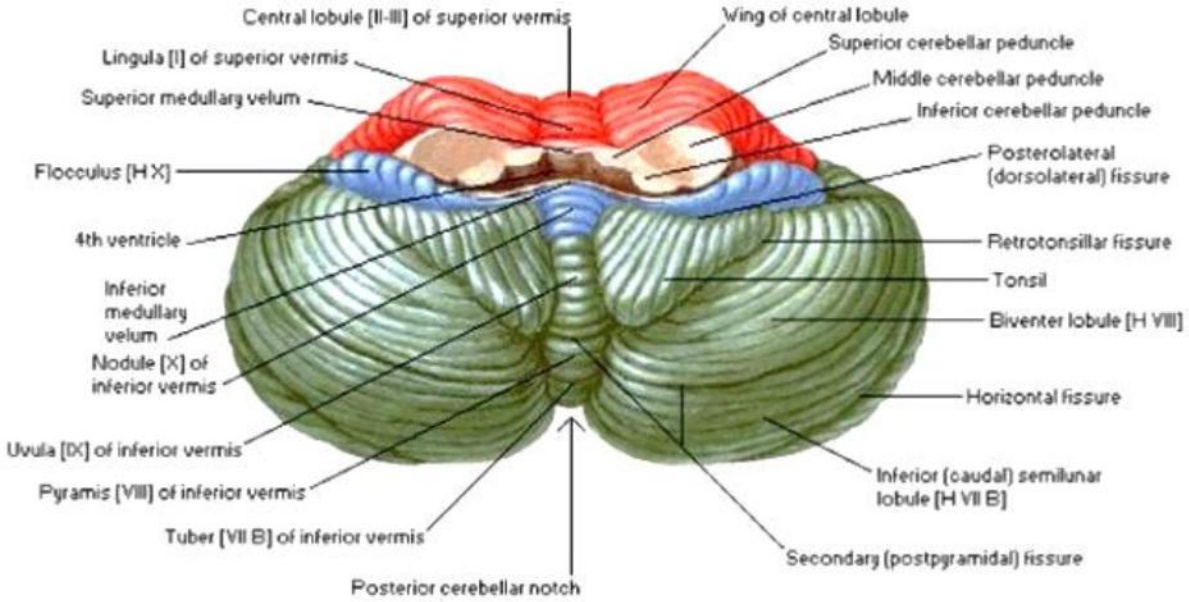


DIENCEPHALON:



- The diencephalon is the connection between the cerebrum and the rest of the nervous system, with one exception.
- The rest of the brain, the spinal cord, and the PNS all send information to the cerebrum through the diencephalon.
- Output from the cerebrum passes through the diencephalon. The single exception is the system associated with olfaction, or the sense of smell, which connects directly with the cerebrum.
- The diencephalon is deep beneath the cerebrum and constitutes the walls of the third ventricle. The diencephalon consists thalamus, hypothalamus, epithalamus, subthalamus and pineal gland.

CEREBELLUM:



Anatomy of Cerebellum:

- The cerebellum, which stands for "little brain", is a structure of the central nervous system. It has an important role in motor control.
- In particular, it is active in the coordination, precision and timing of movements, as well as in motor learning.
- The cerebellum is located at the back of the brain, immediately inferior to the occipital and temporal lobes, and within the posterior cranial fossa. It is separated from these lobes by the tentorium cerebelli, a tough layer of dura mater.
- It lies at the same level of and posterior to the pons, from which it is separated by the fourth ventricle.
- The cerebellum consists of two hemispheres which are connected by the vermis, a narrow midline area. Like other structures in the central nervous system, the cerebellum consists of grey matter and white matter:
- Grey matter – located on the surface of the cerebellum. It is tightly folded, forming the cerebellar cortex.
- White matter – located underneath the cerebellar cortex. Embedded in the white matter are the four cerebellar nuclei (the dentate, emboliform, globose, and fastigi nuclei).
- There are three ways that the cerebellum can be subdivided – anatomical lobes, zones and functional divisions
- There are three cerebellar zones. In the midline of the cerebellum is the vermis. Either side of the vermis is the intermediate zone. Lateral to the intermediate zone are the lateral hemispheres. There is no difference in gross structure between the lateral hemispheres and intermediate zones

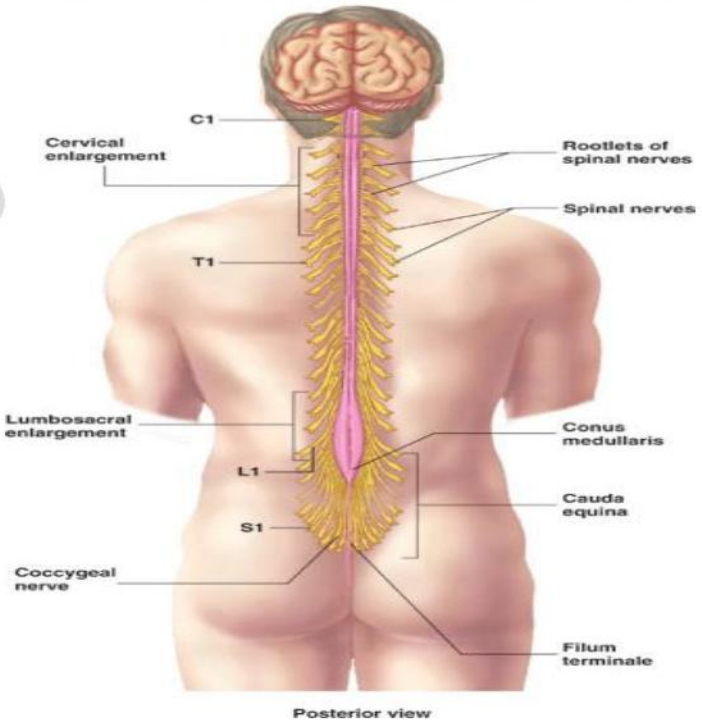
THE SPINAL CORD

FUNCTIONS:

- The spinal cord with its 31 pairs of *spinal nerves* serves two important functions.
- It is the connecting link between the brain and most of the body.
- It is involved in spinal reflex actions, both somatic and visceral.

BASIC EXTERNAL ANATOMY OF THE SPINAL CORD:

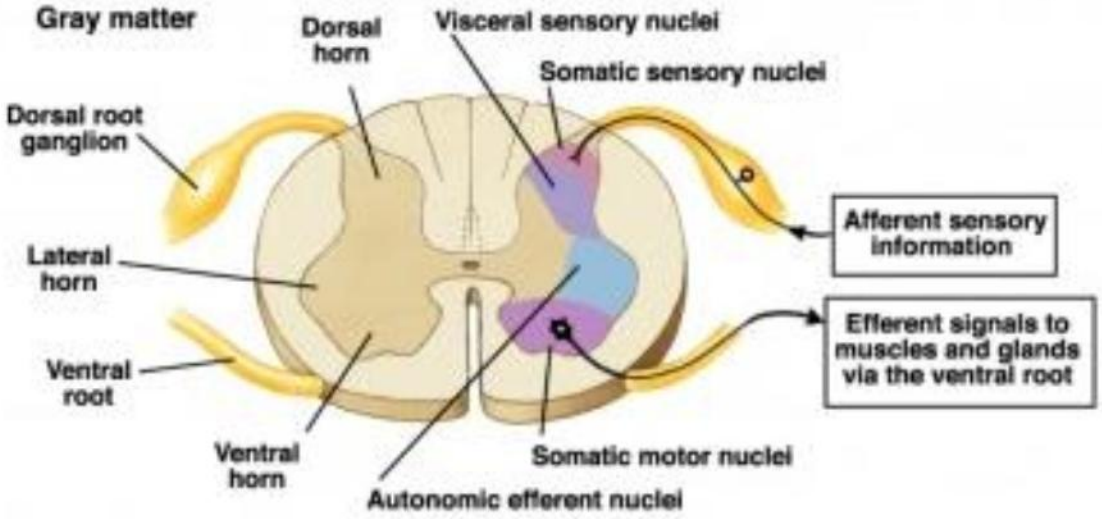
- The spinal cord extends caudally from the brain for about 45 cm and has a width of ~14 mm. Its upper end is continuous with the brain (medulla oblongata). The cord is slightly thicker than a pencil.
- There are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and coccygeal. The roots of the lumbar and sacral are called *cauda equina*.
- Surrounding and protecting the spinal cord is the vertebral column.
- The spinal cord is slightly flattened dorsally and ventrally, with two enlargements-cervical and lumbosacral from which the spinal nerves emerge that innervate the upper and lower limbs.
- The cervical enlargement supplies nerves to the pectoral girdle and upper limbs.
- The lumbar enlargement supplies nerves to the pelvis and lower limbs.
- Inferior to the lumbar enlargement, the spinal cord becomes tapered and conical-conus medullaris.
- Filum terminale-slender strand of fibrous tissue that extends from conus medullaris.



Posterior view

Basic Internal Anatomy of Spinal Cord:

- If the spinal cord is cut in X.S., a tiny central canal is observed, which contains CSF.
- There is a dark portion of H-shaped or butterfly shaped "gray matter", surrounded by a larger area of "white matter".
- The spinal cord is divided into more or less symmetrical halves by a deep groove called the anterior (ventral) median fissure and a median septum called posterior (dorsal) median sulcus.
- Extending from the spinal cord are the ventral and dorsal roots of the spinal nerves.



GRAY MATTER:

- The gray matter of the spinal cord consists of nerve cell bodies, dendrites and axon terminals (unmyelinated) and neuroglia. It is pinkish-gray color because of a rich network of blood vessels.
- The gray matter forms an H shape and is composed of three columns of neurons-posterior, anterior and lateral horns. The projections of gray matter toward the outer surface of spinal cord are called horns.
- The two that run dorsally-posterior horns which function in afferent input. The two that run ventrally-anterior horns which function in efferent somatic output. The two that extend laterally-lateral horns.
- The nerve fibers that form the cross of the H are known as gray commisure-functions in cross reflexes.

WHITE MATTER:

- The white matter gets its name because it is mainly composed of myelinated nerve fibers, and myelin has a whitish color.

- The white matter is divided into three pairs of columns or funiculi of myelinated fibers- anterior, posterior, lateral and a commisure area.
- The bundles of fibers within each funiculus are divided into tracts called fasciculi.
- Ascending tracts-sensory fibers carry impulse up the spinal cord to the brain.
- Descending tracts-motor neurons transmit impulse from the brain down the spinal cord.

CRANIAL NERVES

- The brain communicates with the body through the spinal cord and twelve pairs of cranial nerves.
- Ten of the twelve pairs of cranial nerves that control hearing, eye movement, facial sensations, taste, swallowing and movement of the face, neck, shoulder and tongue muscles originate in the brainstem. The cranial nerves for smell and vision originate in the cerebrum.
- The Roman numeral, name, and main function of the twelve cranial nerves:

Number	Name	Function
I	Olfactory	Smell
II	Optic	Sight
III	Oculomotor	Moves eye, pupil
IV	Trochlear	Moves eye
V	Trigeminal	Face sensation
VI	Abducens	Moves eye
VII	Facial	Moves face, salivate
VIII	Vestibulocochlear	Hearing, balance
IX	Glossopharyngeal	Taste, swallow
X	Vagus	Heart rate, digestion
XI	Accessory	Moves head
XII	Hypoglossal	Moves tongue

SIGNATURE OF TEACHER