NERVOUS SYSTEM

by

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INTRODUCTION

- The nervous system is the major controlling, regulatory and communicating system in the body.
- The nervous system is unique in the vast complexity of thought processes and control actions it can perform.
- It receives each minute literally millions of bits of information from the different sensory nerves and sensory organs and then integrates all these to determine responses to be made by the body.
- It is the center of all mental activity including thought, learning and memory.

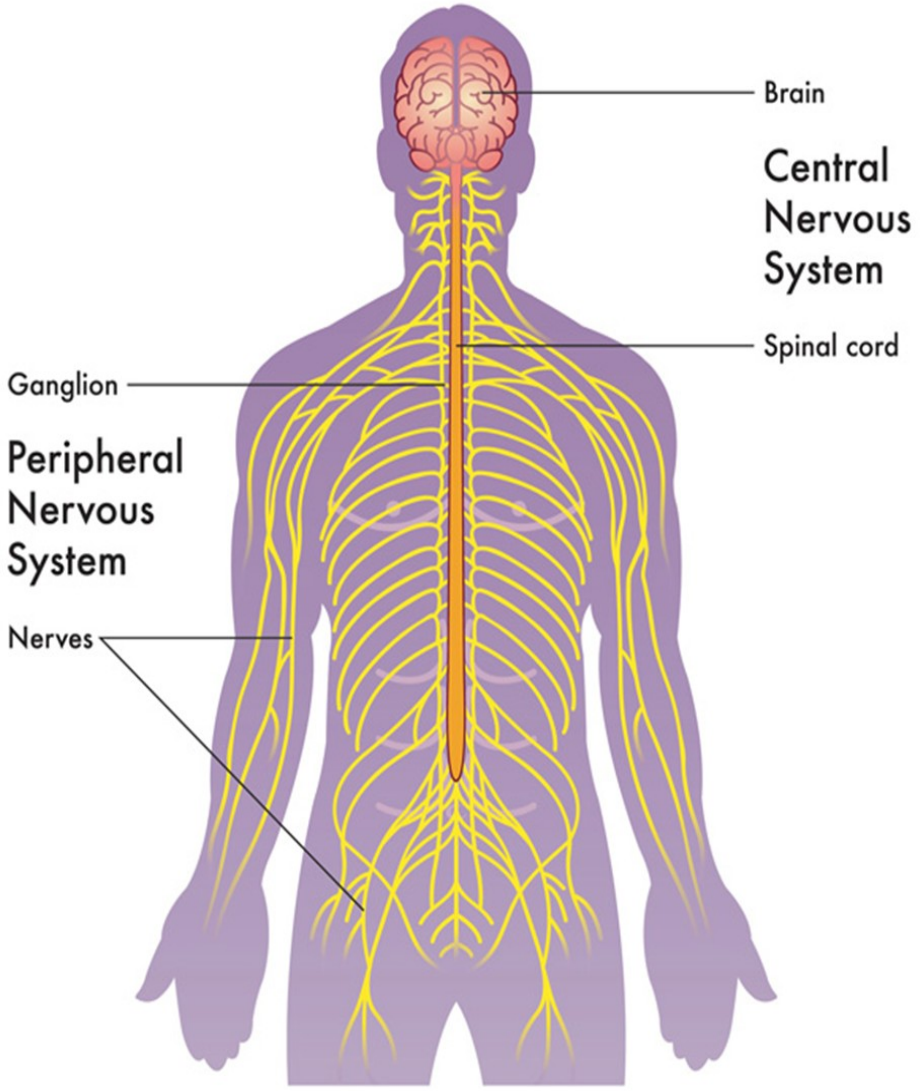
DIVISIONS OF NERVOUS SYSTEM

- Nervous system controls all the activities of the body.
- It is quicker than other control system in the body, namely endocrine system.

- Primarily, nervous system is divided into two parts:

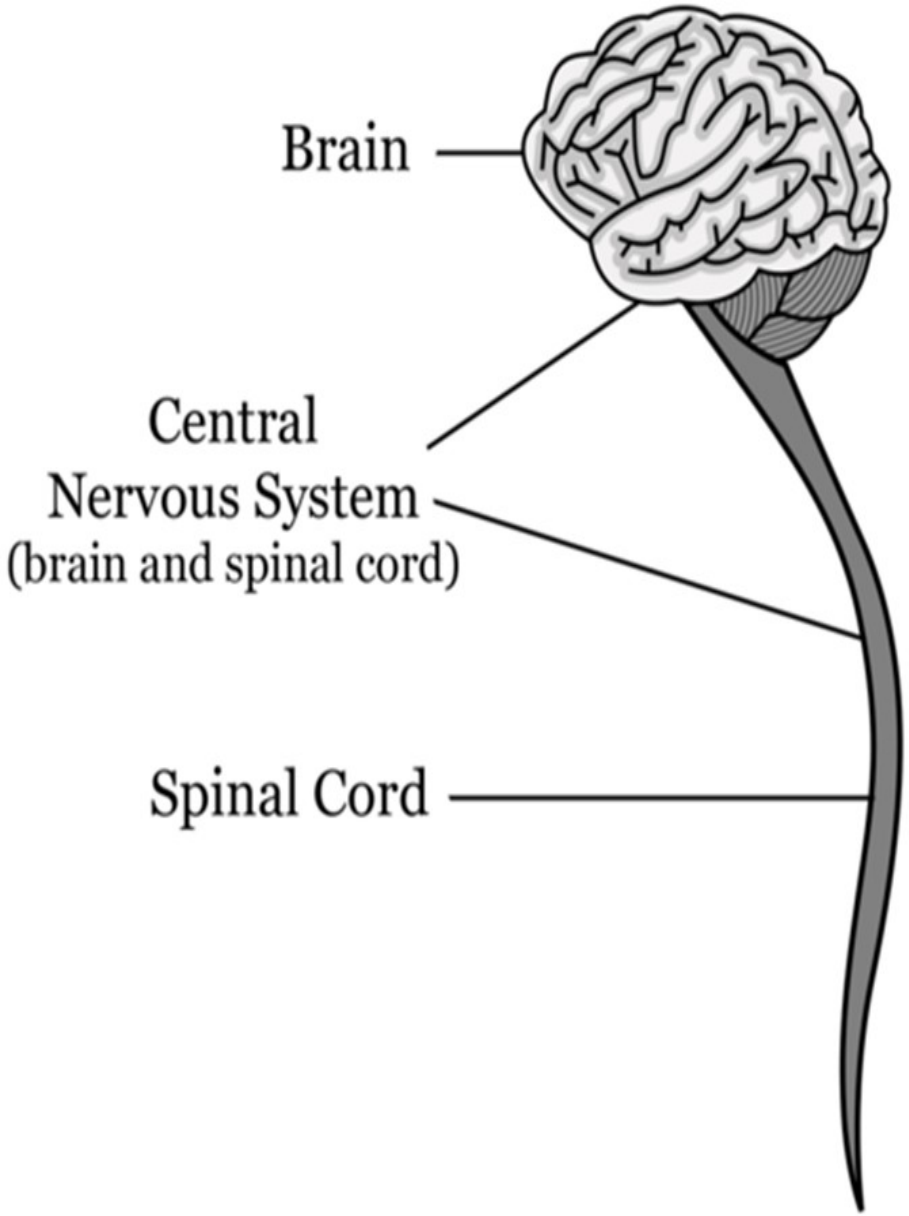
1. CENTRAL NERVOUS SYSTEM

2. PERIPHERAL NERVOUS SYSTEM



CENTRAL NERVOUS SYSTEM

- Central nervous system (CNS) includes **brain** and **spinal cord.**
- It is formed by **neurons** and supporting cells called **neuroglia.**
- Structures of brain and spinal cord are arranged in two layers, namely **gray matter** and **white matter.**
- Gray matter is formed by nerve cell bodies and the proximal parts of nerve fibers, arising from nerve cell body.
- White matter is formed by remaining parts of nerve fibers.

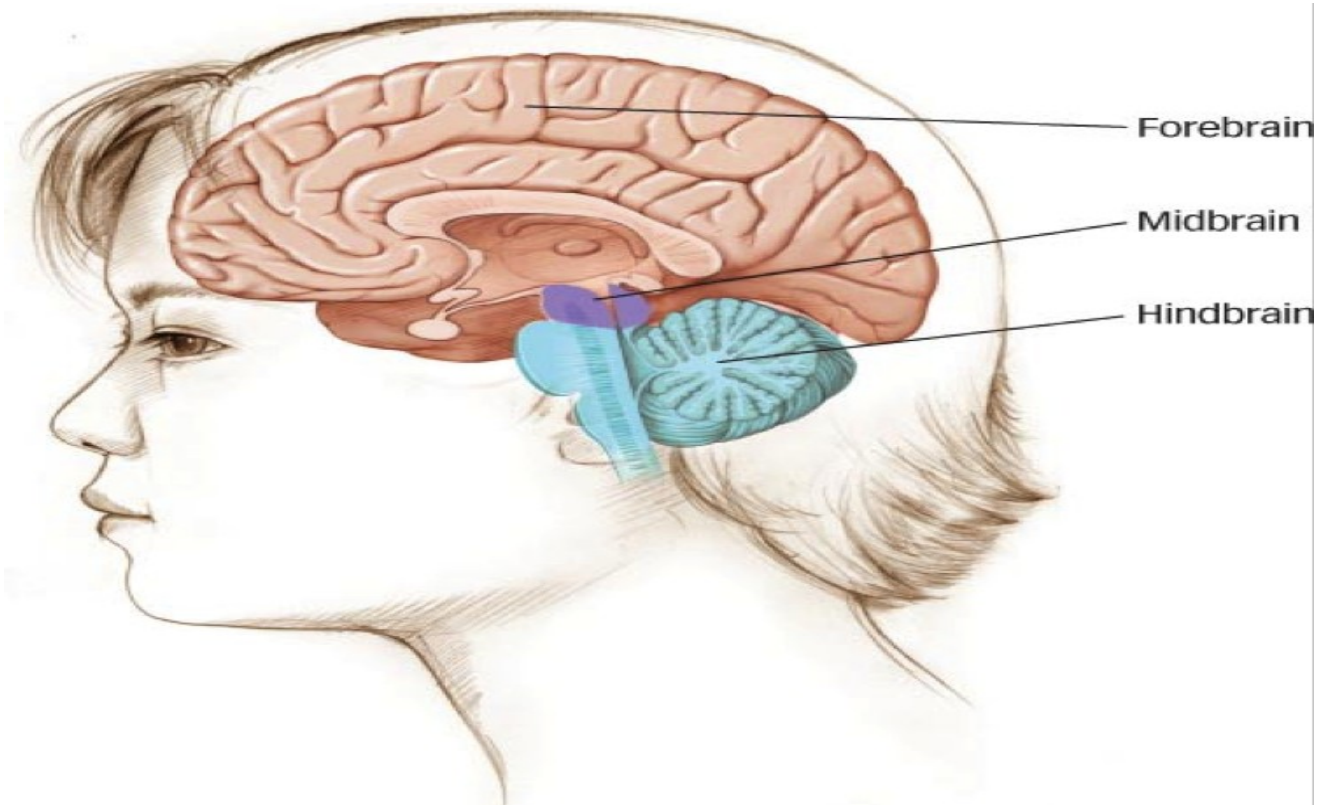


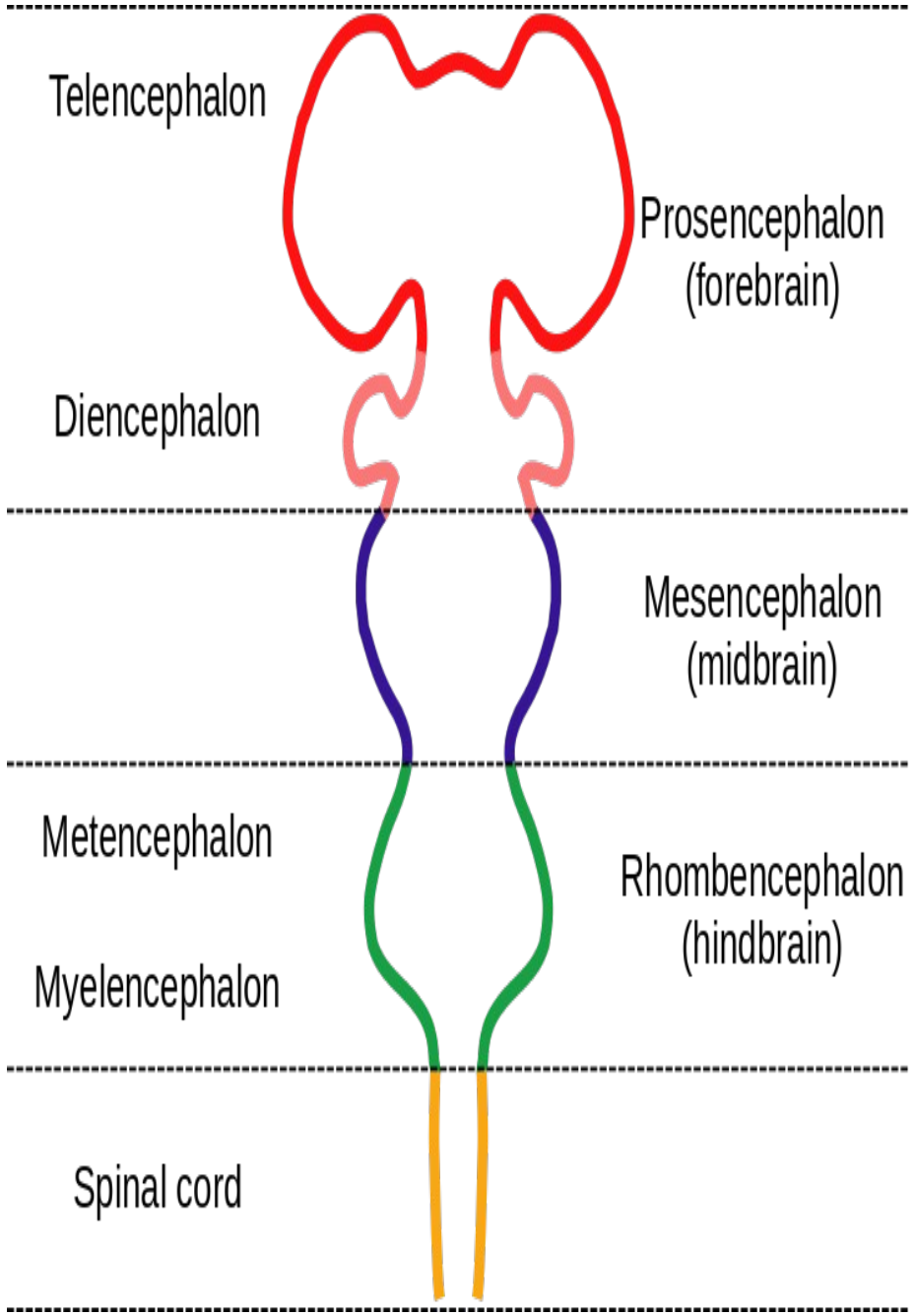
- In brain, white matter is placed in the inner part and gray matter is placed in the outer part.
- In spinal cord, white matter is in the outer part and gray matter is in the inner part.
- Brain is situated in the **skull.** It is continued as spinal cord in the **vertebral canal** through the **foramen magnum** of the skull bone.
- Brain and spinal cord are surrounded by three layers of **meninges** called the outer **dura mater,** middle **arachnoid mater** and inner **pia mater.**
- The space between arachnoid mater and pia mater is known as **subarachnoid space.**
- This space is filled with a fluid called cerebrospinal fluid.
- Brain and spinal cord are actually suspended in the **cerebrospinal fluid.**

PARTS OF BRAIN

- Brain consists of three major divisions:

1. PROSENCEPHALON
2. MESENCEPHALON
3. RHOMBENCEPHALON





1. PROSENCEPHALON

- Prosencephalon is otherwise known as **forebrain.**
- It is further divided into two parts:

i. Telencephalon, which includes cerebral hemispheres, basal ganglia, hippocampus and amygdaloid nucleus.

ii. Diencephalon, consisting of thalamus, hypo thalamus, metathalamus and subthalamus.

2. MESENCEPHALON

- Mesencephalon is also known as **midbrain.**

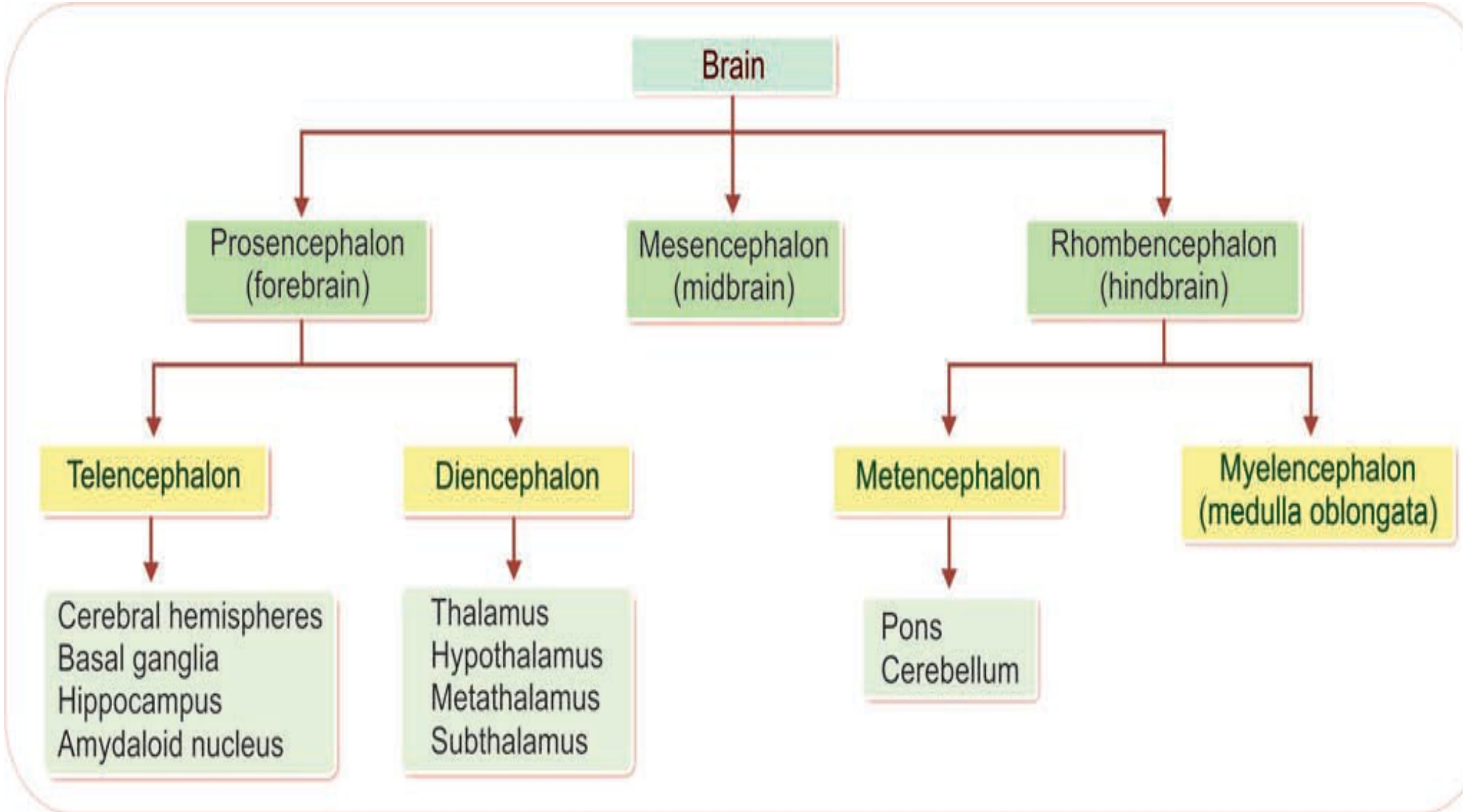
3. RHOMBENCEPHALON

- Rhombencephalon or **hindbrain** is subdivided into two portions:

i. Metencephalon, formed by pons and cerebellum.

ii. Myelencephalon or medulla oblongata.

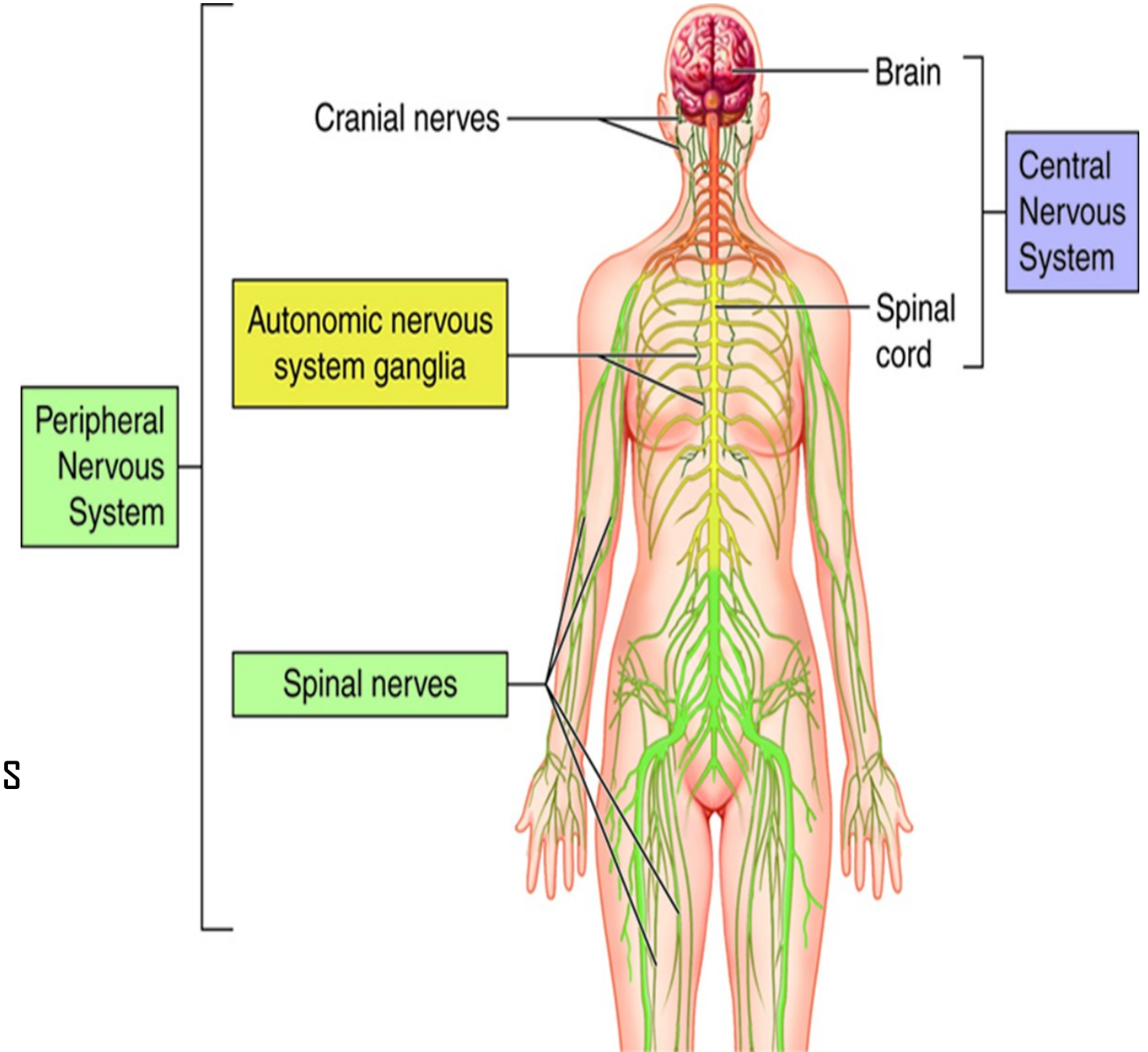
- **Midbrain, pons and medulla oblongata are together called the brainstem.**


Brain
Prosencephalon (forebrain)
Mesencephalon (midbrain)
Rhombencephalon (hindbrain)
Telencephalon
Diencephalon
Metencephalon
Myelencephalon (medulla oblongata)
Cerebral hemispheres
Basal ganglia
Hippocampus
Amydaloid nucleus
Thalamus
Hypothalamus
Metathalamus
Subthalamus
Pons
Cerebellum

PERIPHERAL NERVOUS SYSTEM

- Peripheral nervous system (PNS) is formed by neurons and their processes present in all regions of the body.
- It consists of cranial nerves, arising from brain and spinal nerves, arising from the spinal cord.
- It is again divided into two subdivisions

1. SOMATIC NERVOUS SYSTEM
2. AUTONOMIC NERVOUS SYSTEM

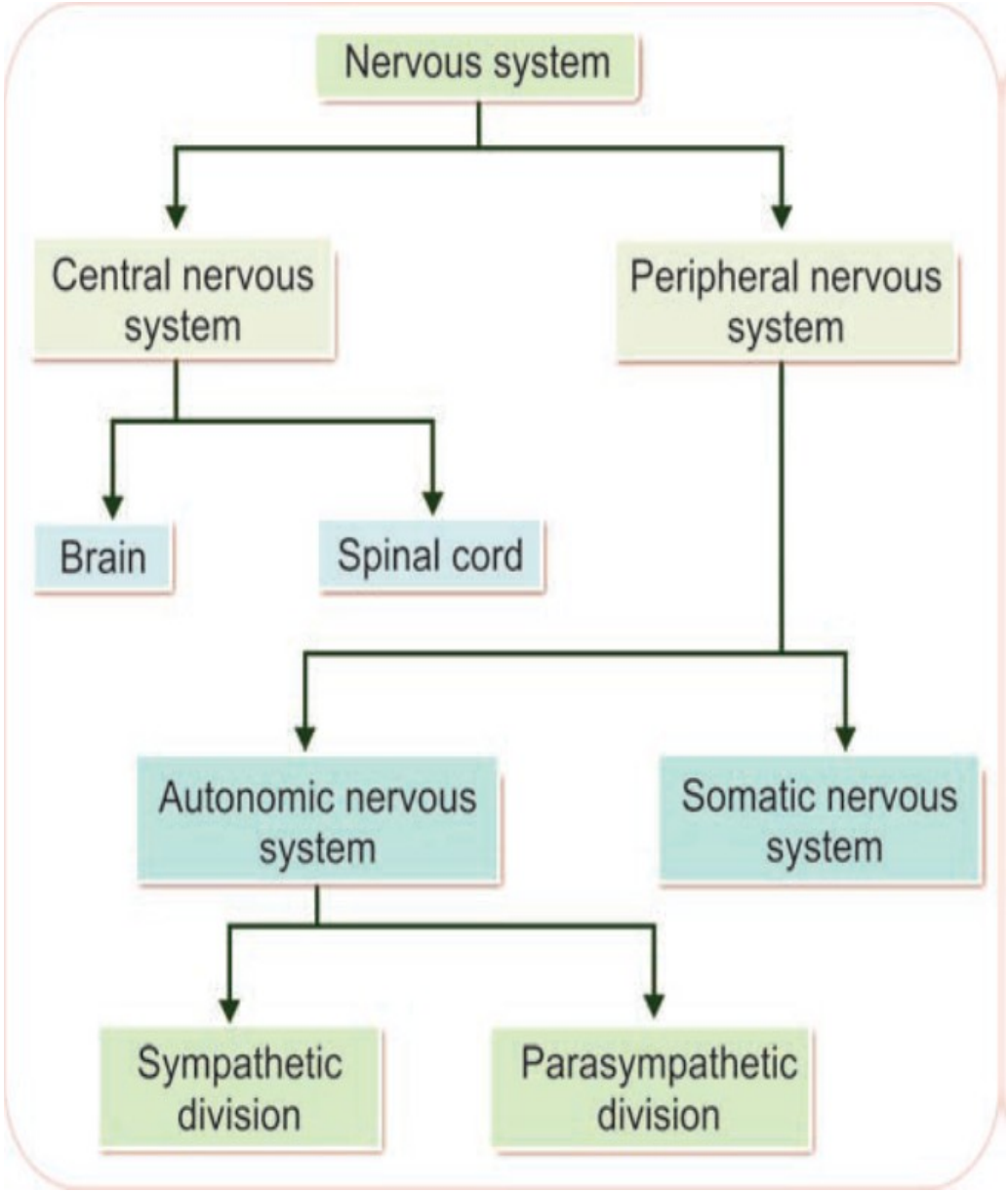


1. SOMATIC NERVOUS SYSTEM

- Somatic nervous system is concerned with **somatic functions.**
- It includes the nerves supplying the skeletal muscles.
- Somatic nervous system is responsible for muscular activities and movements of the body.

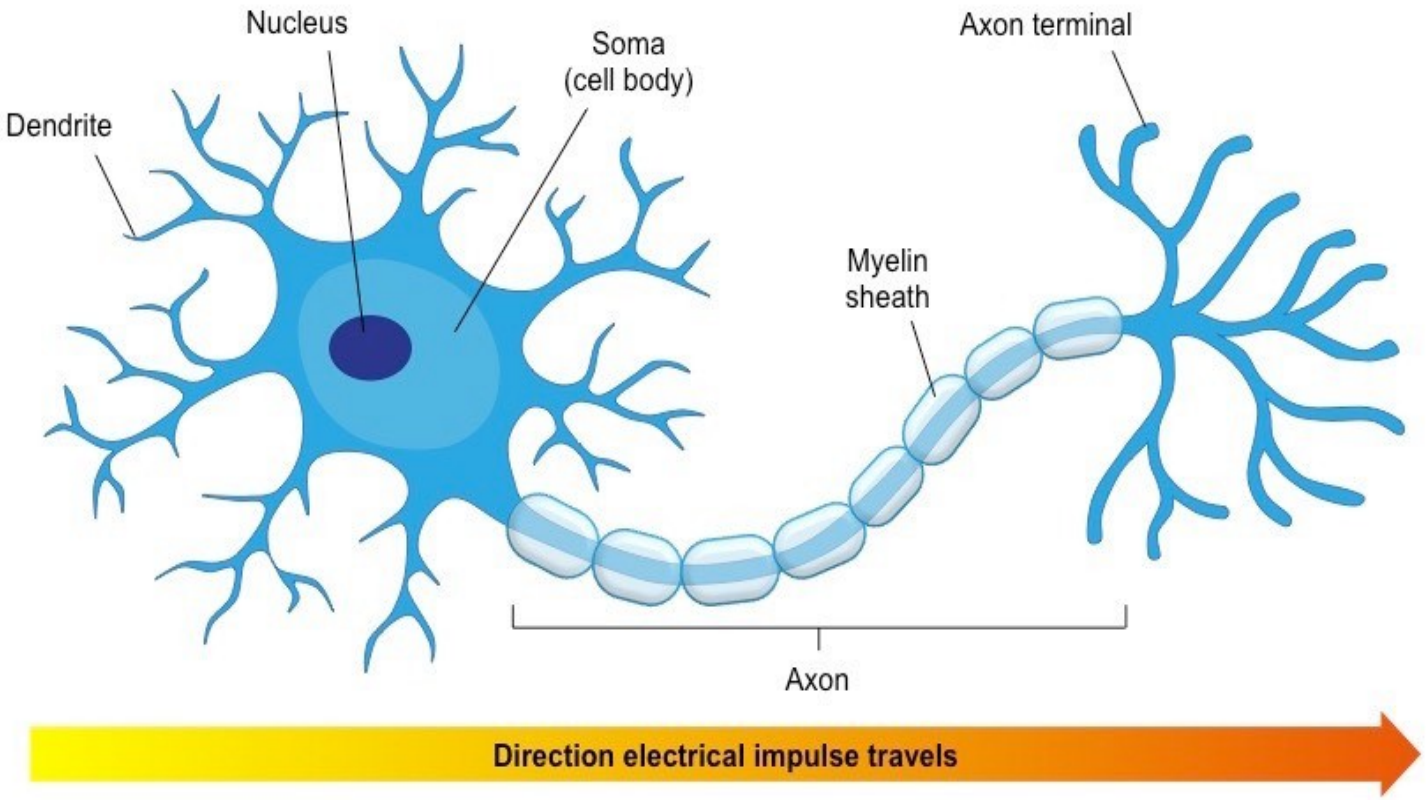
2. AUTONOMIC NERVOUS SYSTEM

- Autonomic nervous system is concerned with regulation of **visceral** or **vegetative functions.**
- So, it is otherwise called **vegetative** or **involuntary nervous system.**
- Autonomic nervous system consists of two divisions, sympathetic division and parasympathetic division.



NEURON

- **Neuron** or **nerve cell** is defined as the structural and functional unit of nervous system.
- Neuron is similar to any other cell in the body, having nucleus and all the organelles in cytoplasm.



- However, it is different from other cells by two ways:

1. Neuron has branches or processes called **axon** and **dendrites.**
2. Neuron does not have centrosome. So, it cannot undergo division.

CLASSIFICATION OF NEURON

- Neurons are classified by three different methods.

A. Depending upon the number of poles
B. Depending upon the function

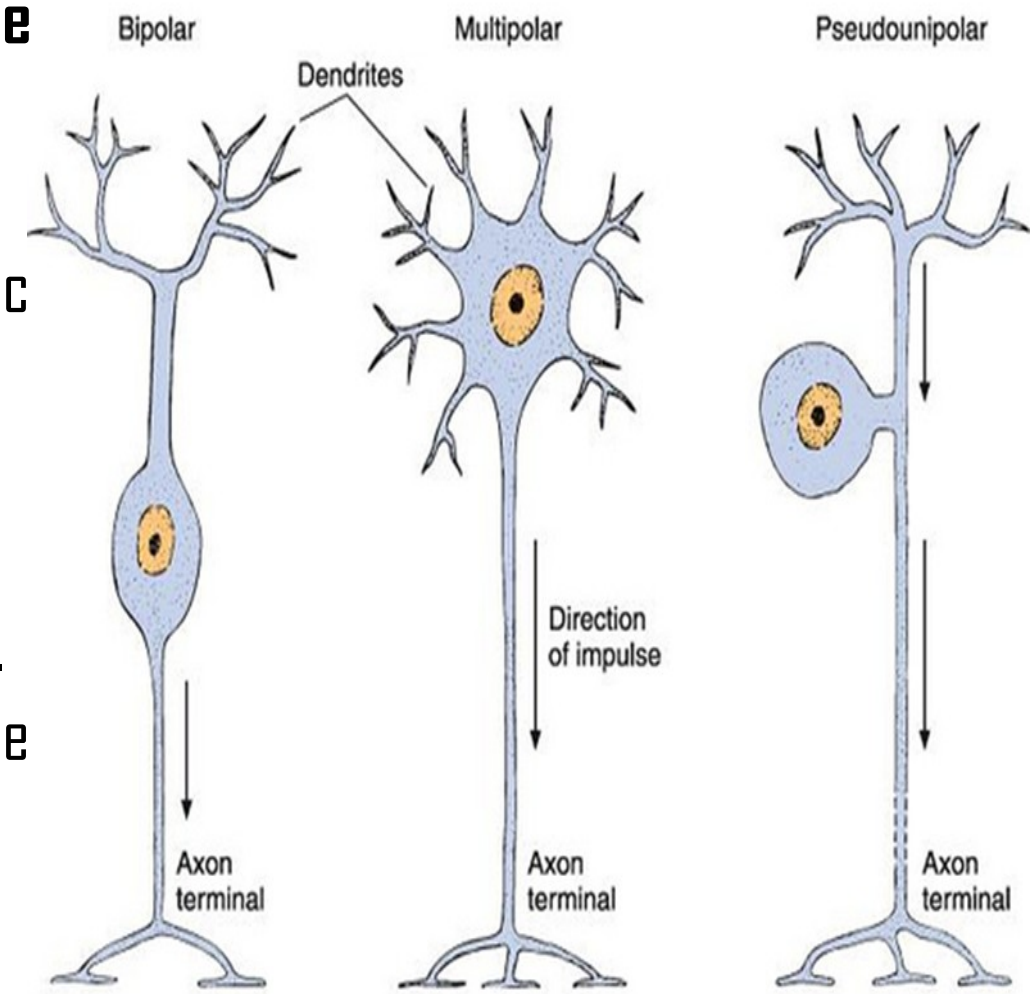
A. DEPENDING UPON THE NUMBER OF POLES

- Based on the number of poles from which the nerve fibers arise, neurons are divided into three types:

1. **UNIPOLAR NEURONS**
2. **BIPOLAR NEURONS**
3. **MULTIPOLAR NEURONS**

1. UNIPOLAR NEURONS

- Unipolar neurons are the neurons that have only **one pole.**
- From a single pole, both axon and dendrite arise.
- This type of nerve cells is present only in embryonic stage in human beings.



2. BIPOLAR NEURONS

- Neurons with **two poles** are known as bipolar neurons.
- Axon arises from one pole and dendrites arise from the other pole.

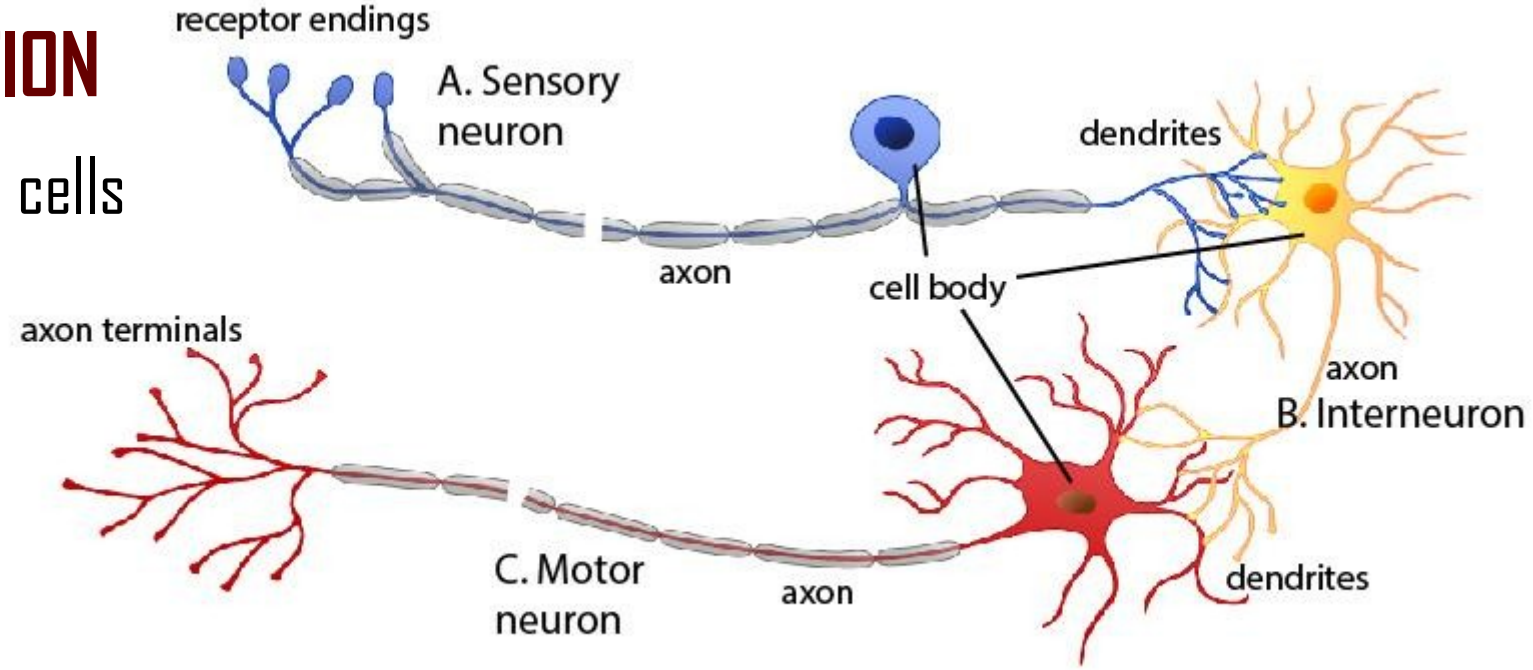
3. MULTIPOLAR NEURONS

- Multipolar neurons are the neurons which have **many poles.**
- One of the poles gives rise to axon and all other poles give rise to dendrites.

DEPENDING UPON THE FUNCTION

- On the basis of function, nerve cells are classified into two types:

1. Motor or efferent neurons
2. Sensory or afferent neurons.



1. MOTOR OR EFFERENT NEURONS

- Motor or efferent neurons are the neurons which carry the **motor impulses** from central nervous system to peripheral effector organs like muscles, glands, blood vessels, etc. Generally, each motor neuron has a long axon and short dendrites.

2. SENSORY OR AFFERENT NEURONS

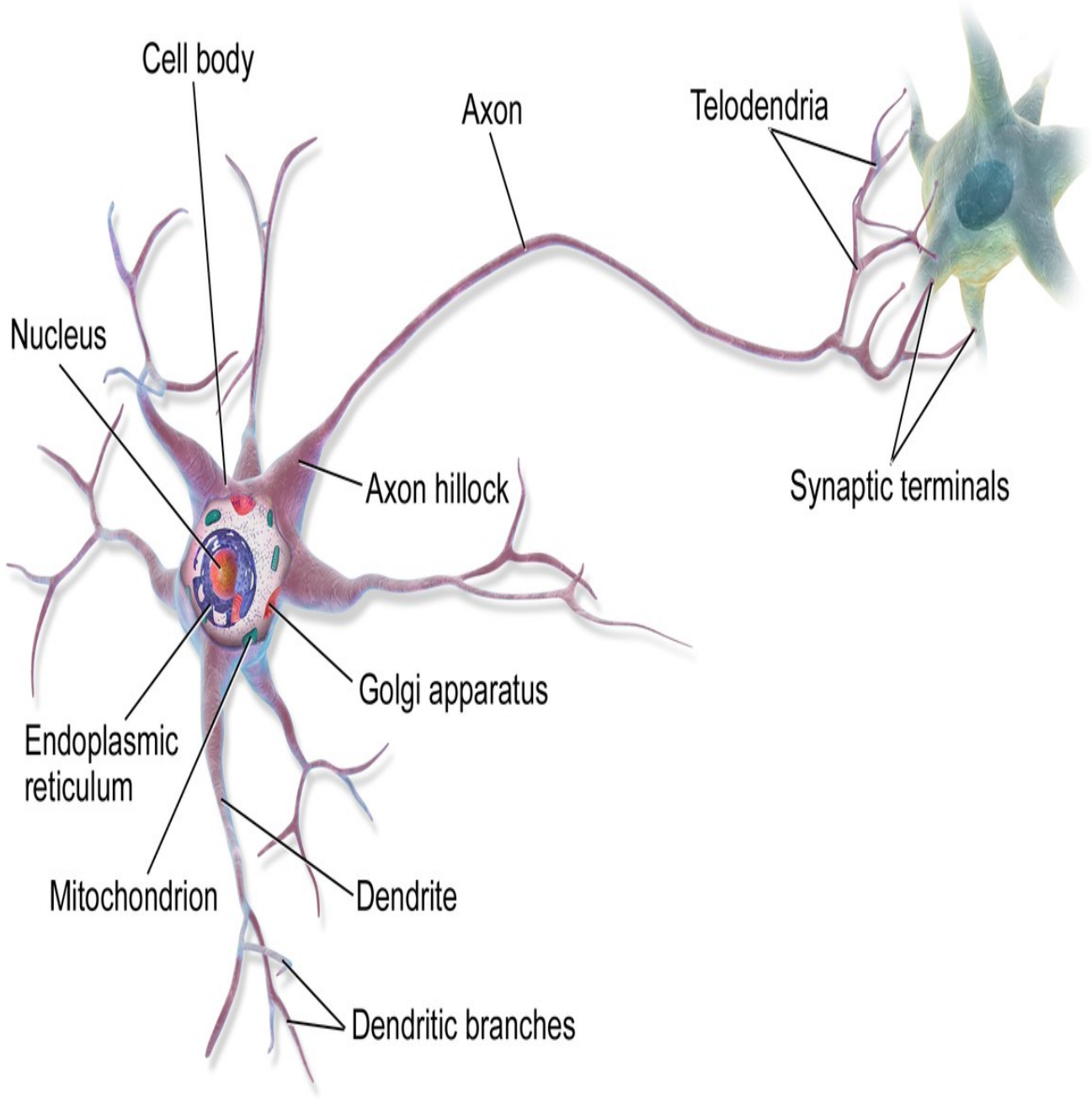
- Sensory or afferent neurons are the neurons which carry the **sensory impulses** from periphery to central nervous system.
- Generally, each sensory neuron has a short axon and long dendrites.

STRUCTURE OF NEURON

- Neuron is made up of three parts:

1. Nerve cell body
2. Dendrite
3. Axon.

- Dendrite and axon form the **processes** of neuron.
- Dendrites are **short processes** and the axons are **long processes**.
- Dendrites and axons are usually called **nerve fibers.**



1. NERVE CELL BODY

- Nerve cell body is also known as **soma** or **perikaryon.**
- It is constituted by a mass of cytoplasm called neuroplasm, which is covered by a cell membrane.
- Cytoplasm contains a large nucleus, Nissl bodies, neurofibrils, mitochondria and Golgi apparatus.
- **Nissl bodies and neurofibrils are found only in nerve cell and not in other cells.**

NUCLEUS

- Each neuron has one nucleus, which is centrally placed.
- Nucleus does not contain centrosome so nerve cell cannot multiply like other cells.

NISSL BODIES

- Nissl bodies or **Nissl granules** are small basophilic granules found in cytoplasm.
- These bodies are present in soma and dendrite but not in axon and **axon hillock.**
- Dendrites are distinguished from axons by the presence of Nissl granules.

- Nissl bodies are concerned with synthesis of proteins in the neurons.
- Number of Nissl bodies varies with the condition of the nerve.
- During fatigue or injury of the neuron, these bodies are disappears and reappear after recovery from fatigue or injury.

NEUROFIBRILS

- Neurofibrils are thread-like structures present in the form of network in the soma and the nerve processes.
- Presence of neurofibrils is another characteristic feature of the neurons.

MITOCHONDRIA

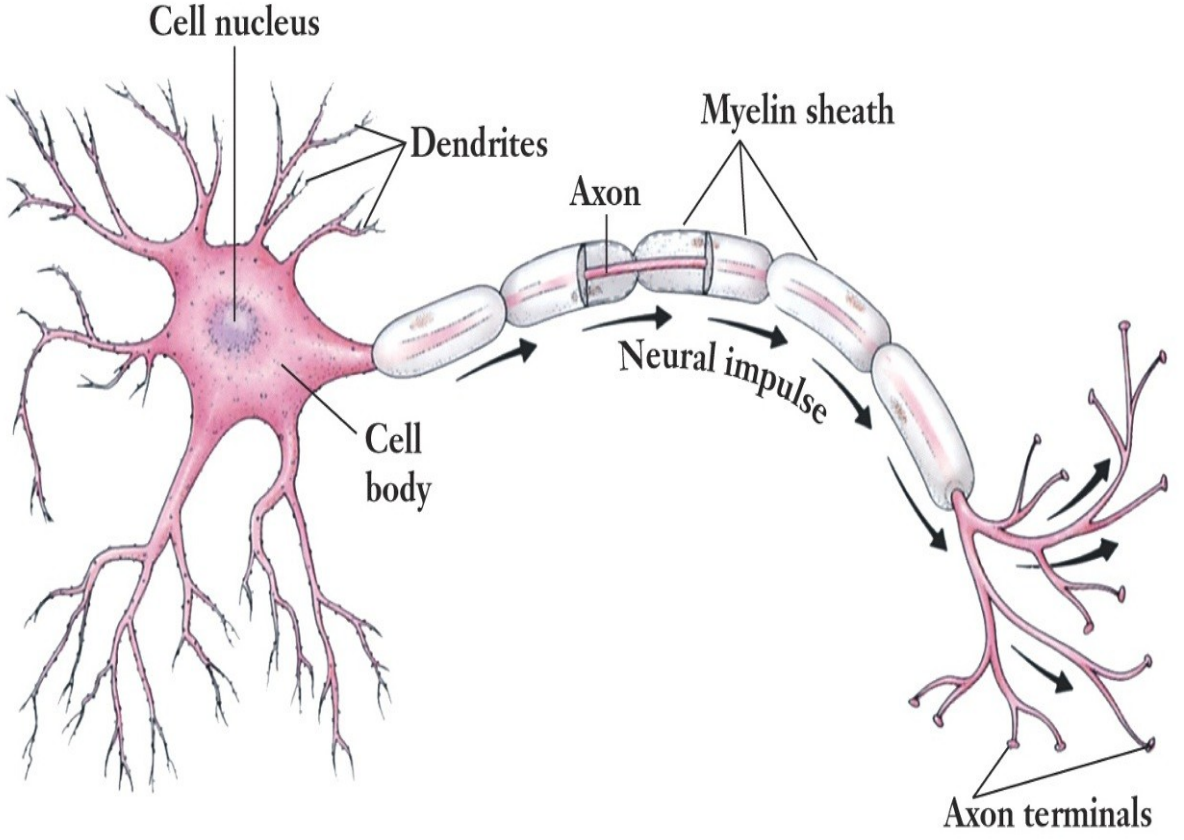
- Mitochondria are present in soma and in axon.
- It form the powerhouse of the nerve cell..

GOLGI APPARATUS

- Golgi apparatus of nerve cell body is similar to that of other cells.
- It is concerned with processing and packing of proteins into granules.

2. DENDRITE

- Dendrite is the **branched process** of neuron and it is branched repeatedly.
- Dendrite may be present or absent.
- If present, it may be one or many in number.
- Dendrite has Nissl granules and neurofibrils.
- Dendrite transmits impulses towards the nerve cell body. Usually, the dendrite is shorter than axon.



3. AXON

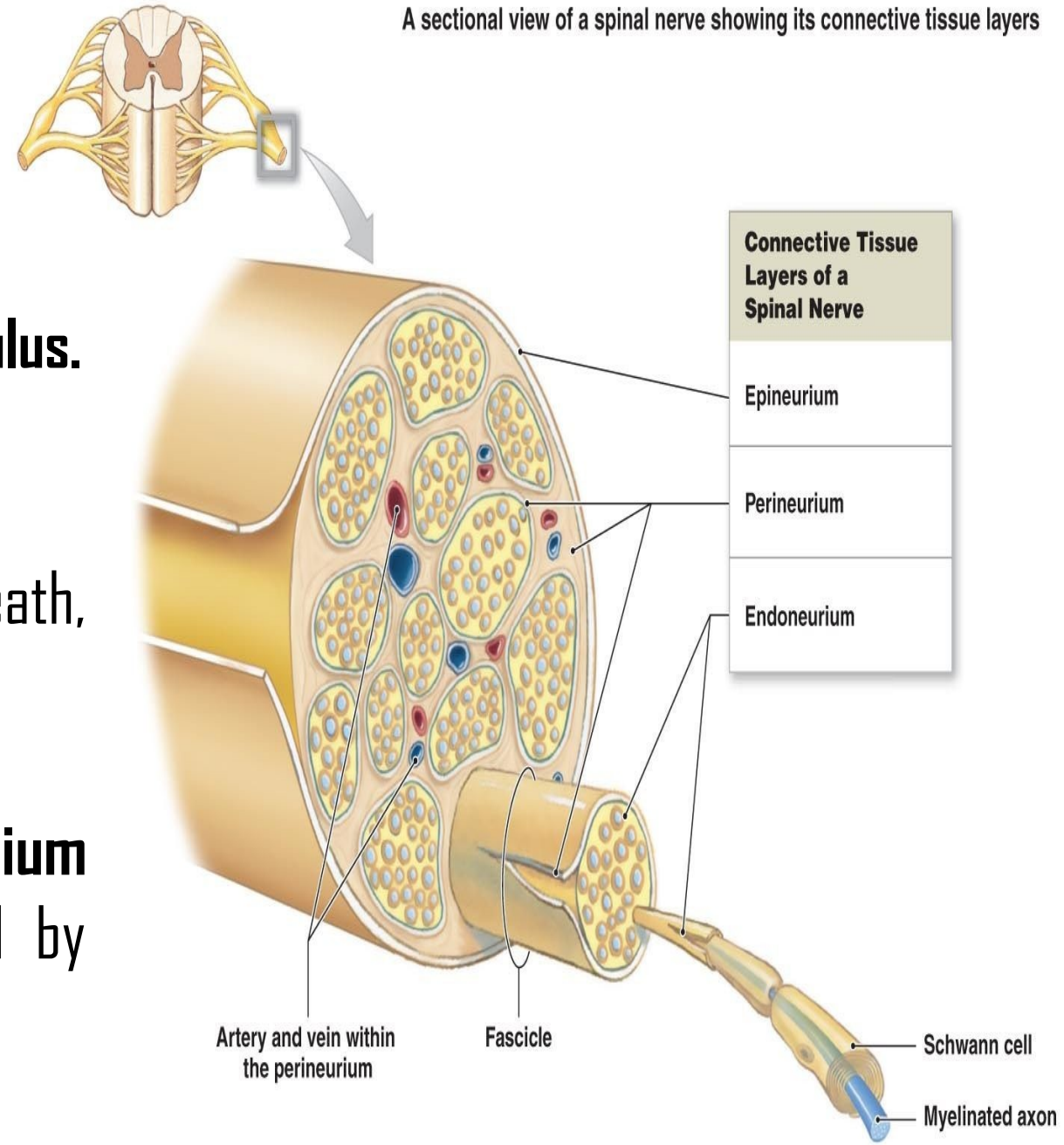
- Axon is the **longer process** of nerve cell. Each neuron has only one axon.
- Axon arises from axon hillock of the nerve cell body.
- Length of longest axon is about 1 meter.
- Axon transmits impulses away from the nerve cell body.

ORGANIZATION OF NERVE

- Each nerve is formed by many bundles or groups of nerve fibers.
- Each bundle of nerve fibers is called a **fasciculus.**

COVERINGS OF NERVE

- The whole nerve is covered by tubular sheath, which is formed by a areolar membrane.
- This sheath is called **epineurium.**
- Each fasciculus is covered by **perineurium** and each nerve fiber (axon) is covered by **endoneurium**.

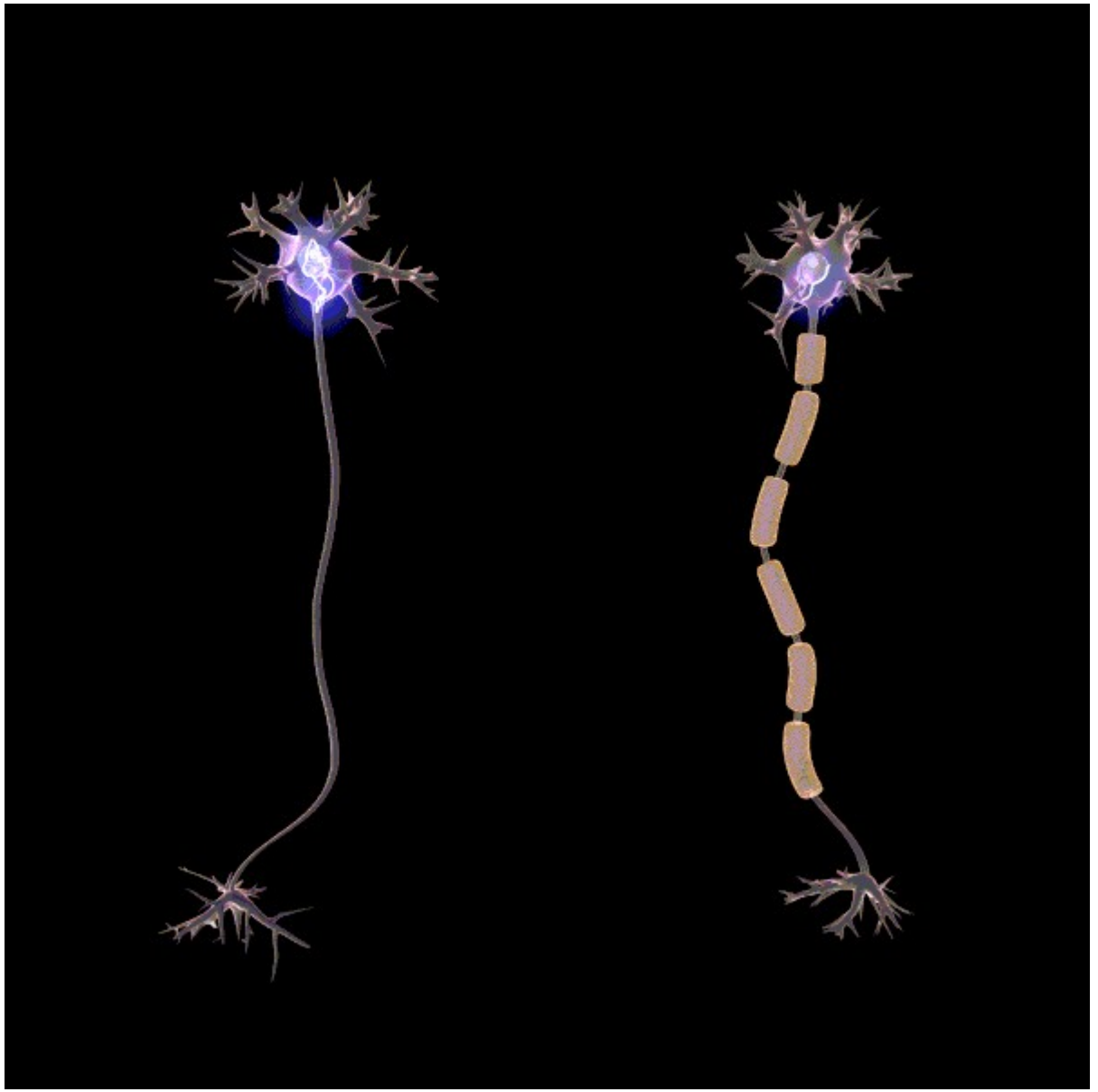


NON-MYELINATED NERVE FIBER

- Nerve fiber described above is the non-myelinated nerve fiber, which is not covered by myelin sheath.

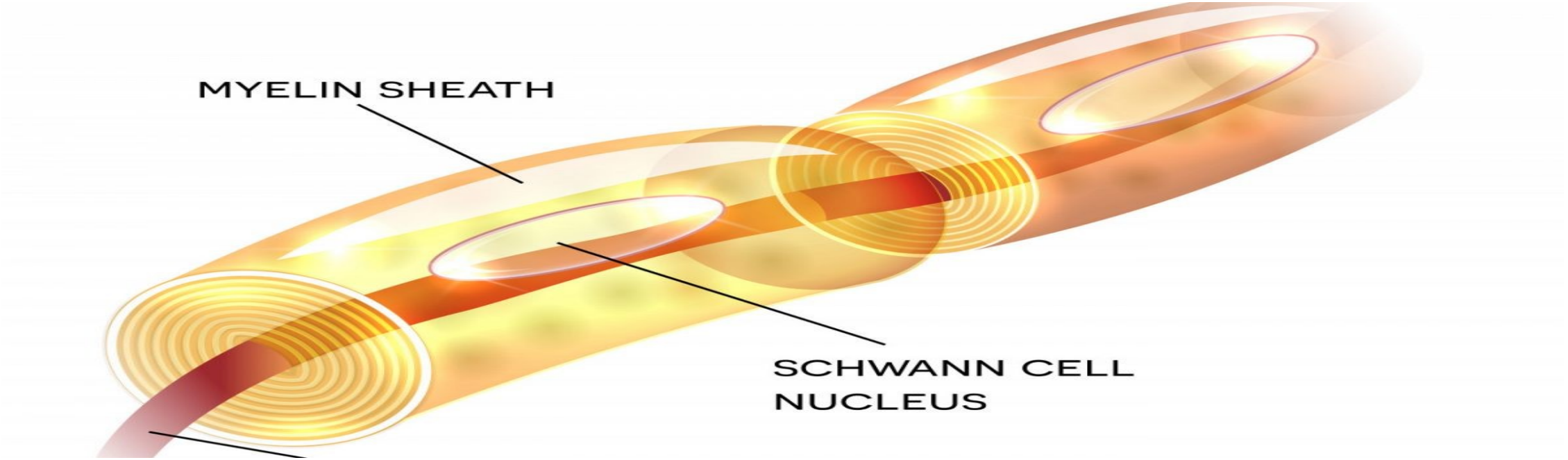
MYELINATED NERVE FIBER

- Nerve fiber which is insulated by myelin sheath is called myelinated nerve fibers.



MYELIN SHEATH

- Myelin sheath is a thick lipoprotein sheath that insulates the myelinated nerve fiber.
- Myelin sheath is not a continuous sheath.
- It is absent at regular intervals.
- The area where myelin sheath is absent is called **node of Ranvier.**
- Segment of the nerve fiber between two nodes is called **internode.**
- Myelin sheath is responsible for white color of nerve fibers.



FUNCTIONS OF MYELIN SHEATH

1. FASTER CONDUCTION

- Myelin sheath is responsible for faster conduction of impulse through the nerve fibers.
- In myelinated nerve fibers, the impulses jump from one node to another Node its called **saltatory conduction**.

2. INSULATING CAPACITY

- Myelin sheath has a high insulating capacity.
- Because of this quality, it prevents the stimulation of neighboring nerve fibers.

NEURILEMMA

- Neurilemma is a thin membrane, which surrounds the axis cylinder.
- It is also called **neurilemmal sheath** or **sheath of Schwann.**
- It contains Schwann cells, which have flattened and elongated nuclei.
- One nucleus is present in each internode of the axon.
- Nucleus is situated between myelin sheath and neurilemma.
- In non-myelinated nerve fiber, the neurilemma surrounds axolemma continuously.
- In myelinated nerve fiber, it covers the myelin sheath.
- At the node of Ranvier, neurilemma invaginates and runs up to axolemma in the form of a finger-like process.

FUNCTIONS OF NEURILEMMA

- In non-myelinated nerve fiber, the neurilemma serves as a covering membrane.
- In myelinated nerve fiber, it is necessary for the formation of myelin sheath (myelinogenesis).
- Neurilemma is absent in central nervous system.
- So, the neuroglial cells called **oligodendroglia** are responsible for myelinogenesis in central nervous system.

PHYSIOLOGY OF NERVE IMPULSE

EXCITABILITY

- Excitability is defined as the **physiochemical change** that occurs in a tissue when stimulus is applied.
- Stimulus is defined as an external agent, which produces excitability in the tissues.
- Nerve fibers have a low threshold for excitation than the other cells.

RESPONSE DUE TO STIMULATION OF NERVE FIBER

- When a nerve fiber is stimulated, based on the strength of stimulus, two types of response develop:

1. ACTION POTENTIAL OR NERVE IMPULSE

- Action potential develops in a nerve fiber when it is stimulated by a stimulus with adequate strength. Adequate strength of stimulus, necessary for producing the action potential in a nerve fiber is known as **threshold** or **minimal stimulus.**
- Action potential is propagated.
- Action potential in a nerve fiber is similar to that in a muscle, except for some minor differences.
- Resting membrane potential in the nerve fiber is –70 mV.

2. ELECTROTONIC POTENTIAL OR LOCAL POTENTIAL

- When the stimulus with **subliminal strength** is applied, only electrotonic potential develops and the action potential does not develop.
- Electrotonic potential or local potential is a non-propagated **local response** that develops in the nerve fiber when a subliminal stimulus is applied.
- It alters the resting membrane potential and produces **slight depolarization** for about 7 mV. This slight depolarized state is called electrotonic potential.

CONDUCTIVITY

- Conductivity is the ability of nerve fibers to transmit the impulse from the area of stimulation to the other areas.
- Action potential is transmitted through the nerve fiber as nerve impulse.
- Normally in the body, the action potential is transmitted through the nerve fiber in only one direction. However, in experimental conditions when, the nerve is stimulated, the action potential travels through the nerve fiber in either direction.

MECHANISM OF CONDUCTION OF ACTION POTENTIAL

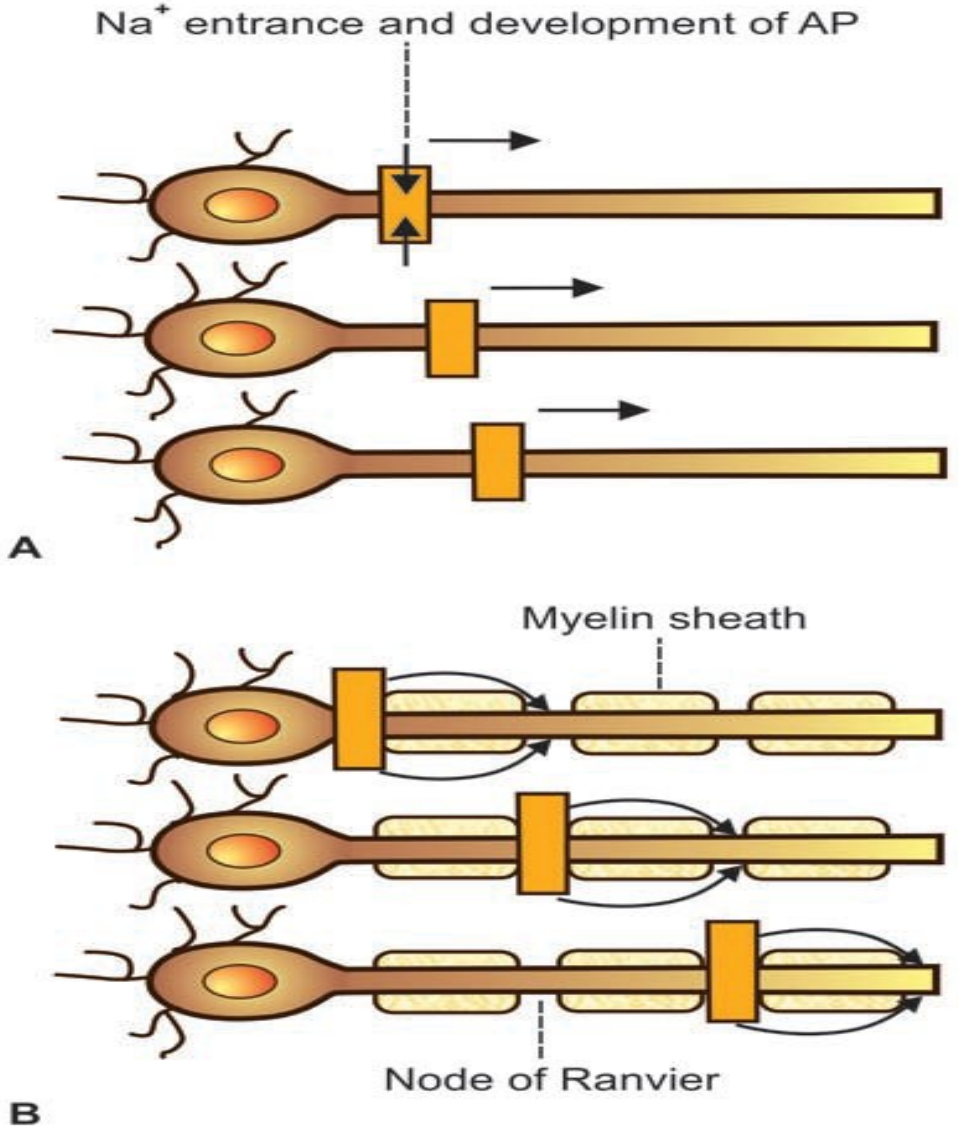
- Depolarization occurs first at the site of stimulation in the nerve fiber.
- It causes depolarization of the neighboring areas.
- Like this, depolarization travels throughout the nerve fiber.
- Depolarization is followed by repolarization.

CONDUCTION THROUGH MYELINATED NERVE FIBER – SALTATORY CONDUCTION

- In saltatory type of conduction, the impulse jumps from **one node to another.**
- Conduction of impulse through a myelinated nerve fiber is about 50 times faster than through a nonmyelinated fiber.
- It is because the action potential jumps from one node to another node of Ranvier instead of travelling through the entire nerve fiber.

MECHANISM OF SALTATORY CONDUCTION

- Myelin sheath is not permeable to ions. So, the sodium ions enters into nerve fiber only at the node of Ranvier.
- It causes depolarization in the node and not in the internode.
- Thus, depolarization occurs at successive nodes.
- So, the action potential jumps from one node to another. Hence, it is called saltatory conduction (saltare = jumping).



Mode of conduction through nerve fibers

A. Non-myelinated nerve fiber : continuous conduction.

B. Myelinated nerve fiber : saltatory conduction

SUMMATION

- When one subliminal stimulus is applied, it does not produce any response in the nerve fiber because, the subliminal stimulus is very weak.
- However, if two or more subliminal stimuli are applied within a short interval of about 0.5 millisecond, the response is produced.
- It is because the subliminal stimuli are summed up together to become strong enough to produce the response.
- This phenomenon is known as summation.

ADAPTATION

- While stimulating a nerve fiber continuously, the excitability of the nerve fiber is greater in the beginning.
- Later the response decreases slowly and finally the nerve fiber does not show any response at all.
- This phenomenon is known as adaptation or **accommodation.**

CAUSE FOR ADAPTATION

- When a nerve fiber is stimulated continuously, depolarization occurs continuously.
- Continuos depolarization inactivates the sodium pump and increases the efflux of potassium ions.

INFATIGABILITY

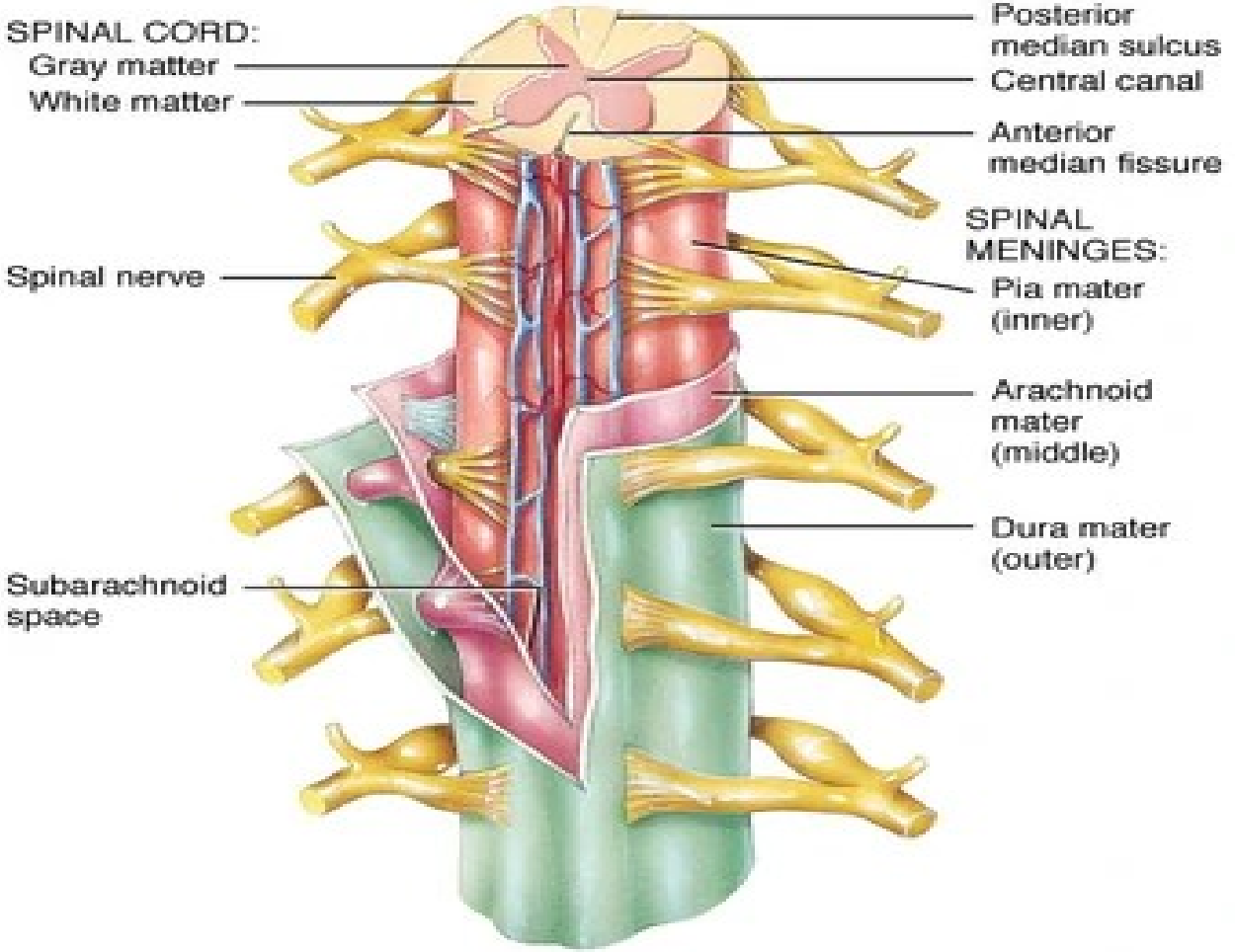
- Nerve fiber cannot be fatigued, even if it is stimulated continuously for a long time.
- The reason is that nerve fiber can conduct only one action potential at a time.
- At that time, it is completely refractory and does not conduct another action potential.

ALL-OR-NONE LAW

- All-or-none law states that when a nerve is stimulated by a stimulus it gives maximum response or does not give response at all.
- For example in cardiac muscle when a stimulus is applied, whatever may be the strength, the whole cardiac muscle gives maximum response or it does not give any response at all.
- Below the threshold level, i.e. if the strength of stimulus is not adequate, the muscle does not give response.
- But the amplitude of all contractions remains same, irrespective of increasing the strength of stimulus.
- This shows that cardiac muscle obeys all-or-none law.

SPINAL CORD

- Spinal cord lies loosely in the **vertebral canal.**
- It extends from **foramen magnum** where it is continuous with medulla oblongata, above and up to the lower border of first lumbar vertebra below.



COVERINGS

- Spinal cord is covered by sheaths called **meninges,** which are membranous in nature.
- Meninges are **duramater, pia mater** and **arachnoid mater.**
- These coverings continue as coverings of brain.
- Meninges are responsible for protection and nourishment of the nervous tissues.

SHAPE AND LENGTH

- Spinal cord is cylindrical in shape. Length of the spinal cord is about 45 cm in males and about 43 cm in females.

SEGMENTS

- Spinal cord is made up of 31 segments.
- In fact, spinal cord is a continuous structure.
- Appearance of the segment is by nerves arising from spinal cord, which are called spinal nerve.

SPINAL NERVES

- Segments of spinal cord correspond to 31 pairs of spinal nerves in a symmetrical manner.
- The spinal nerves are listed in the box.

Spinal segments/Spinal nerves		
1. Cervical segments/Cervical spinal nerves	=	8
2. Thoracic segments/Thoracic spinal nerves	=	12
3. Lumbar segments/Lumbar spinal nerves	=	5
4. Sacral segments/Sacral spinal nerves	=	5
5. Coccygeal segment/Coccygeal spinal nerves	=	1
Total	=	31

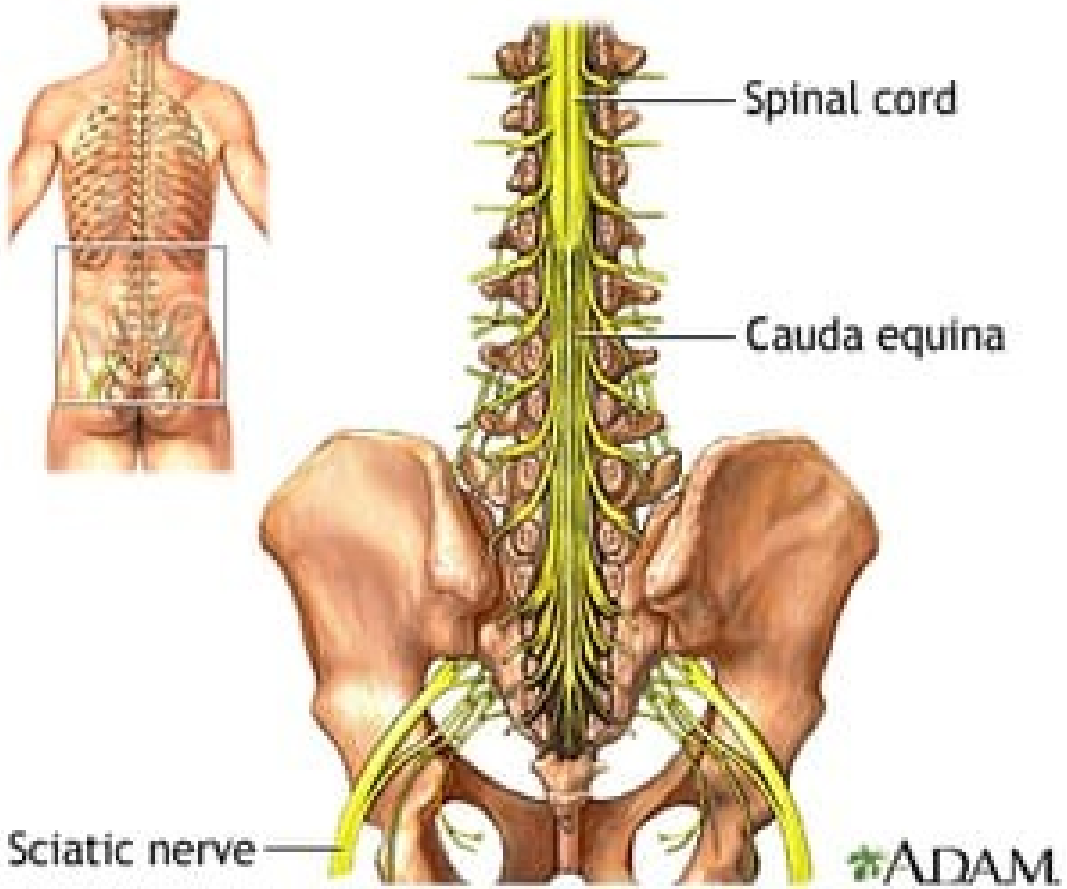
NERVE ROOTS

- Each spinal nerve is formed by an **anterior (ventral) root** and a **posterior (dorsal) root.**
- Both the roots on either side leave the spinal cord and pass through the corresponding **intervertebral foramina.**
- The Cervical and thoracic roots are shorter whereas, the lumbar and sacral roots are longer.
- The bundle of descending roots surrounding the filum terminale resembles the tail of horse. Hence, it is called cauda equina.

FISSURE AND SULCI

- On the anterior surface of spinal cord, there is a deep furrow known as **anterior median fissure.**
- Depth of this fissure is about 3 mm.
- Lateral to the anterior median fissure on either side, there is a slight depression
- called the **anterolateral sulcus.**
- It denotes the exit of anterior nerve root.
- On the posterior aspect, there is a depression called **posterior median sulcus.**

- This sulcus is continuous with a thin glial partition called the **posterior median septum.**
- It extends inside the spinal cord for about 5 mm and reaches the gray matter.
- On either side, lateral to posterior median sulcus, there is **posterior intermediate sulcus.**
- It is continuous with **posterior intermediate septum,** which extends for about 3 mm into the spinal cord. Lateral to the posterior intermediate sulcus, is the **posterolateral sulcus.** This denotes the entry of posterior nerve root.



INTERNAL STRUCTURE OF SPINAL CORD

- Neural substance of spinal cord is divided into inner gray matter and outer white matter.

1. GRAY MATTER OF SPINAL CORD

- Gray matter of spinal cord is the collection of nerve cell bodies and dendrites.
- It is placed centrally in the form of **wings of the butterfly** and resembles the letter 'H'.
- There is a canal at the center of gray matter called, **spinal canal.**
- Ventral and the dorsal portions of each lateral half of gray matter are called ventral (anterior) and dorsal (posterior) gray horns respectively.
- Part of the gray matter anterior to central canal is called the **anterior gray commissure** and part of gray matter posterior to the central canal is called **posterior gray commissure.**

2. WHITE MATTER OF SPINAL CORD

- White matter of spinal cord surrounds the gray matter.
- It is formed by the bundles of both myelinated and nonmyelinated fibers, but predominantly the myelinated fibers.
- Anterior median fissure and posterior median septum divide the entire mass of white matter into two lateral halves.
- Each half of the white matter is divided by the fibers of anterior and posterior nerve roots into three white columns or funiculi:

I. ANTERIOR OR VENTRAL WHITE COLUMN (FUNICULUS)

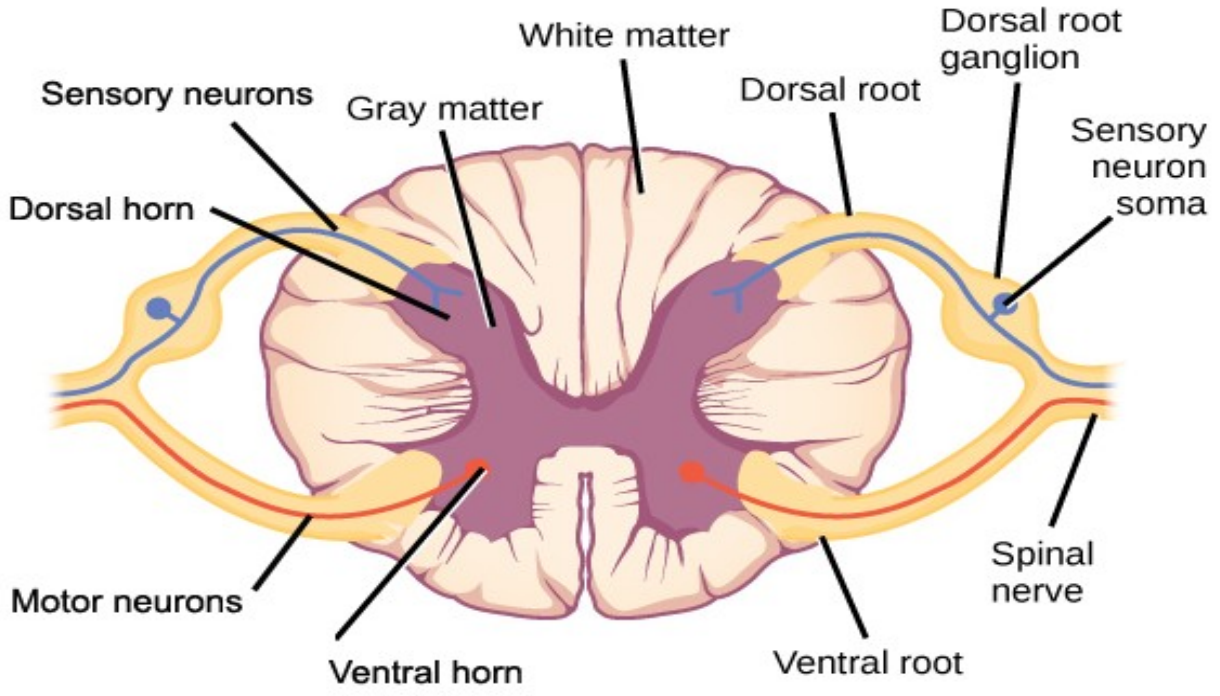
- Ventral white column lies between the anterior median fissure on one side and anterior nerve root and anterior gray horn on the other side.
- It is also called **anterior** or **ventral funiculus.**

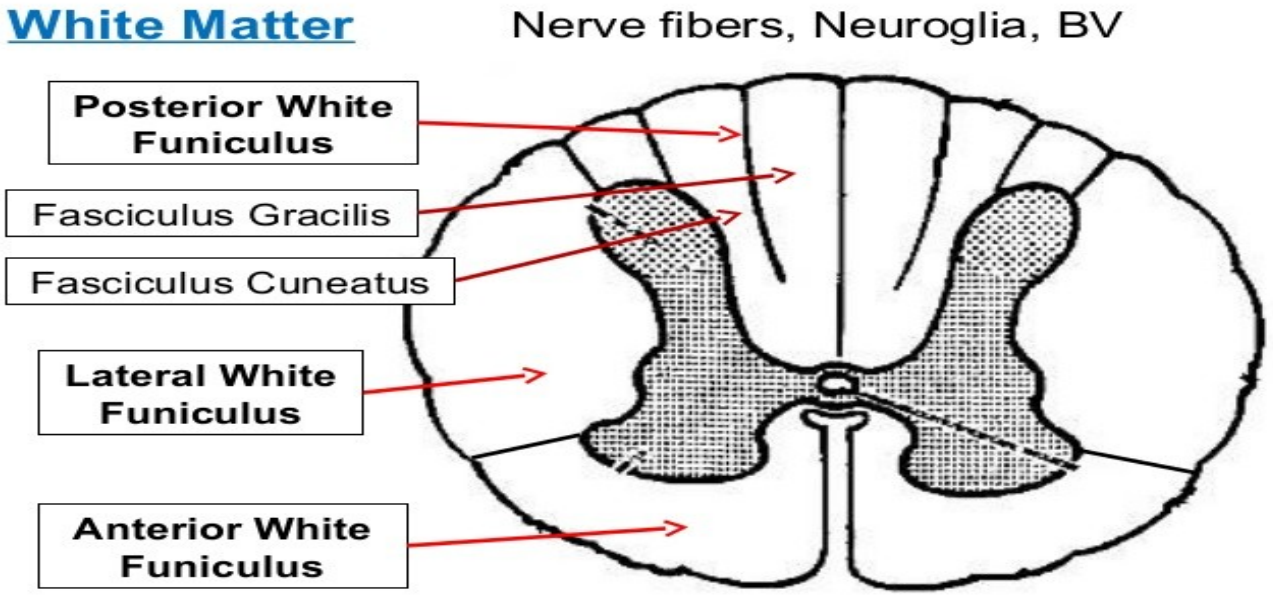
II. LATERAL WHITE COLUMN (FUNICULUS)

- Lateral white column is present between the anterior nerve root and anterior gray horn on one side and posterior nerve root and posterior gray horn on the other side.
- It is also called **lateral funiculus.**

III. POSTERIOR OR DORSAL WHITE COLUMN (FUNICULUS)

- Dorsal white column is situated between the posterior nerve root and posterior gray horn on one side and posterior median septum on the other side.
- It is also called **posterior or dorsal funiculus.**





TRACTS IN SPINAL CORD

- Groups of nerve fibers passing through spinal cord are known as tracts of the spinal cord.
- The spinal tracts are divided into two main groups.

1. SHORT TRACTS

- Fibers of the short tracts connect different parts of spinal cord itself.
- Short tracts are of two types:

i. **Association or intrinsic tracts,** which connect adjacent segments of spinal cord on the same side.

ii. **Commissural tracts,** which connect opposite halves of same segment of spinal cord.

2. LONG TRACTS

Long tracts of spinal cord, which are also called **projection tracts,** connect the spinal cord with other parts of central nervous system.

Long tracts are of two types:

i. **Ascending tracts,** which carry sensory impulses from the spinal cord to brain.

ii. **Descending tracts,** which carry motor impulses from brain to the spinal cord.

ASCENDING TRACTS OF SPINAL CORD

- Ascending tracts of spinal cord carry the impulses of various sensations to the brain.
- Pathway for each sensation is formed by two or three groups of neurons, which are:

1. FIRST ORDER NEURONS

- First order neurons receive sensory impulses from the receptors and send them to sensory neurons present in the posterior gray horn of spinal cord.
- Nerve cell bodies of these neurons are located in the **posterior nerve root ganglion.**

2. SECOND ORDER NEURONS

- Second order neurons are the sensory neurons present in the posterior gray horn.
- Fibers from these neurons form the ascending tracts of spinal cord.
- These fibers carry sensory impulses from spinal cord to different brain areas below cerebral cortex **(subcortical areas)** such as thalamus.

3. THIRD ORDER NEURONS

- Third order neurons are in the **subcortical areas.**
- Fibers of these neurons carry the sensory impulses from subcortical areas to cerebral cortex.
- Ascending tracts situated in different white funiculi are listed in Table.

White column	Tract
Anterior white column	1. Anterior spinothalamic tract
Lateral white column	1. Lateral spinothalamic tract 2. Ventral spinocerebellar tract 3. Dorsal spinocerebellar tract 4. Spinotectal tract 5. Fasiculus dorsolateralis 6. Spinoreticular tract 7. Spino-olivary tract 8. Spinovestibular tract
Posterior white column	1. Fasciculus gracilis 2. Fasciculus cuneatus 3. Comma tract of Schultze

TABLE: FUNCTIONS OF DIFFERENT ASCENDING TRACTS

Situation	Tract	Origin	Course	Termination	Function
Anterior white column	1. Anterior spinothalamic tract	Chief sensory nucleus	Crossing in spinal cord Forms spinal lemniscus	Ventral posterolateral nucleus of thalamus	Crude touch sensation
Lateral white column	1. Lateral spinothalamic tract	Substantia gelatinosa	Crossing in spinal cord Forms spinal lemniscus	Ventral posterolateral nucleus of thalamus	Pain and temperature sensations
	2. Ventral spinocerebellar tract	Marginal nucleus	Crossing in spinal cord	Anterior lobe of cerebellum	Subconscious kinesthetic sensations
	3. Dorsal spinocerebellar tract	Clarke nucleus	Uncrossed fibers	Anterior lobe of cerebellum	Subconscious kinesthetic sensations
	4. Spinotectal tract	Chief sensory nucleus	Crossing in spinal cord	Superior colliculus	Spinovisual reflex
	5. Fasiculus dorsolateralis	Posterior nerve root ganglion	Component of lateral spinothalamic tract	Substantia gelatinosa	Pain and temperature sensations
	6. Spinoreticular tract	Intermediolateral cells	Crossed and uncrossed fibers	Reticular formation of brainstem	Consciousness and awareness
	7. Spino-olivary tract	Non-specific	Uncrossed fibers	Olivary nucleus	Proprioception
	8. Spinovestibular tract	Non-specific	Crossed and uncrossed fibers	Lateral vestibular nucleus	Proprioception
Posterior white column	1. Fasciculus gracilis	Posterior nerve root ganglia	Uncrossed fibers No synapse in spinal cord	Nucleus gracilis in medulla	Tactile sensation Tactile localization Tactile discrimination Vibratory sensation Conscious kinesthetic sensation Stereognosis
	2. Fasciculus cuneatus	Posterior nerve root ganglia	Uncrossed fibers No synapse in spinal cord	Nucleus cuneatus in medulla	

DESCENDING TRACTS OF SPINAL CORD

- Descending tracts of the spinal cord are formed by motor nerve fibers arising from brain and descend into the spinal cord.
- These tracts carry motor impulses from brain to spinal cord.
- Descending tracts of spinal cord are of two types:

A. PYRAMIDAL TRACTS

- Pyramidal tracts were the first tracts to be found in man.
- Pyramidal tracts of spinal cord are the descending tracts concerned with voluntary motor activities of the body.
- These tracts are otherwise known as **corticospinal tracts.**
- There are two corticospinal tracts, the anterior corticospinal tract and lateral corticospinal tract.
- While running from cerebral cortex towards spinal cord, the fibers of these two tracts give the appearance of a **pyramid** on the upper part of anterior surface of medulla oblongata hence the name pyramidal tracts.

B. EXTRAPYRAMIDAL TRACTS.

- Descending tracts of spinal cord other than pyramidal tracts are called extrapyramidal tracts.
- Descending tracts are listed in Table.

Type	Tract
Pyramidal tracts	1. Anterior corticospinal tract 2. Lateral corticospinal tract
Extrapyramidal tracts	1. Medial longitudinal fasciculus 2. Anterior vestibulospinal tract 3. Lateral vestibulospinal tract 4. Reticulospinal tract 5. Tectospinal tract 6. Rubrospinal tract 7. Olivospinal tract

TABLE : FUNCTIONS OF DIFFERENT DESCENDING TRACT

	Tract	Situation	Origin	Course	Function
Pyramidal Tracts	1. Anterior corticospinal tract	Anterior white column	Betz cells and other cells of motor area	Uncrossed fibers	i. Control of voluntary movements ii. Form upper motor neurons
	2. Lateral corticospinal tract	Lateral white column	Betz cells and other cells of motor area	Crossed fibers	
Extrapyramidal tracts	1. Medial longitudinal fasciculus	Anterior white column	Vestibular nucleus Reticular formation Superior colliculus and cells of Cajal	Uncrossed fibers Extend up to uppercervical segments	i. Coordination of reflex ocular movements ii. Integration of movements of eyes and neck
	2. Anterior vestibulospinal tract	Anterior white column	Medial vestibular nucleus	Uncrossed fibers Extend up to upper thoracic segments	i. Maintenance of muscle tone and posture ii. Maintenance of position of head and body during acceleration
	3. Lateral vestibulospinal tract	Lateral white column	Lateral vestibular nucleus	Mostly uncrossed Extend to all segments	
	4. Reticulospinal tract	Lateral white fasciculus	Reticular formation of pons and medulla	Mostly uncrossed Extend up to thoracic segments	i. Coordination of voluntary and reflex movements ii. Control of muscle tone iii.Control of respiration and diameter of blood vessels
	5. Tectospinal tract	Anterior white column	Superior colliculus	Crossed fibers Extend up to lower cervical segments	Control of movement of head in response to visual and auditory impulses
	6. Rubrospinal tract	Lateral white column	Red nucleus	Crossed fibers Extend up to thoracic segments	Facilitatory influence on flexor muscle tone
	7. Olivospinal tract	Lateral white column	Inferior olivary nucleus	Mostly crossed Extent – not clear	Control of movements due to proprioception

DISEASES OF SPINAL CORD

1. SYRINGOMYELIA

- Syringomyelia is spinal cord disorder characterized by the presence of **fluid-filled cavities** in the spinal cord.
- Gray matter around the central canal is the most affected part. So the sensory disturbances are more pronounced than the motor disturbances.

2. MULTIPLE SCLEROSIS

- Multiple sclerosis (MS) is a chronic and progressive inflammatory disease characterized by demyelination in brain and spinal cord.
- It affects the myelinated nerve fibers of brain, spinal cord and optic nerve and causes gradual destruction of myelin sheath **(demyelination).**
- When the disease progresses, there is transection of axons in patches throughout brain
- and spinal cord.
- The term sclerosis refers to scars (scleroses) in the myelin sheath.

3. TABES DORSALIS

- Tabes dorsalis is another disease of the spinal cord.
- It is a slowly progressive nervous disorder affecting both the motor and sensory functions of spinal cord.

4. DISK PROLAPSE

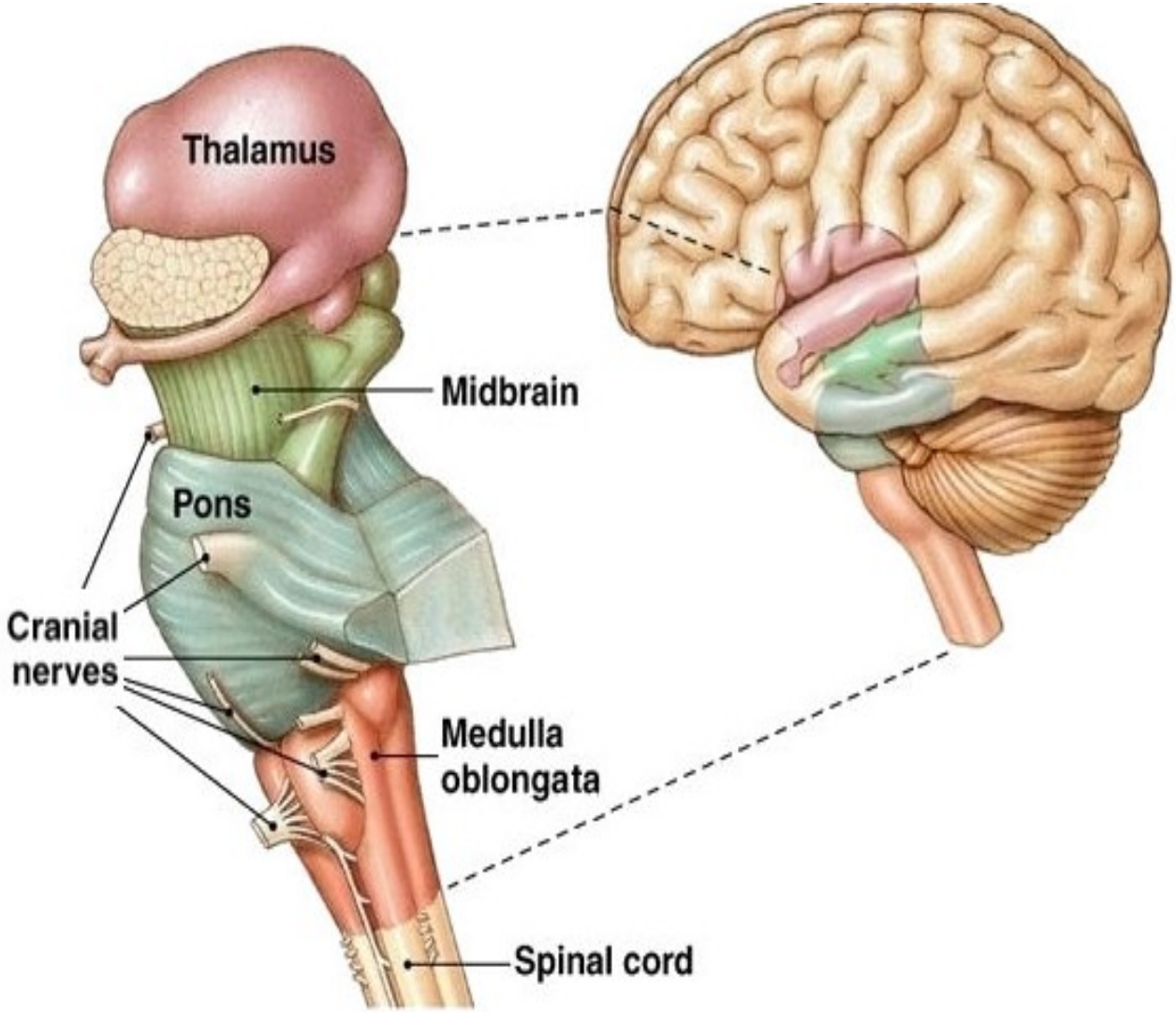
- Intervertebral or **spinal disk** is the cartilaginous structure of vertebral column that separates each vertebra.
- It is made up of a tough outer fibrous layer and a soft inner part.
- Inner part acts as a shock absorber and cushions the vertebrae while moving.
- A small gap in between the adjacent vertebrae allows nerve roots to enter or leave the spinal cord.
- Rupture of disk is called disk prolapse.
- During disk prolapse, the soft inner material bulges out through a weak area in the hard outer layer.

- The bulged disk material may irritate or compress or damage the nerve root that passes through the gap between the vertebrae.
- Severity of the condition depends upon the degree of bulging.

BRAINSTEM

INTRODUCTION

- Brainstem is the part of brain formed by medulla oblongata, pons and midbrain.
- Brainstem contains ascending and descending tracts between brain and spinal cord.
- It also contains many centers for regulation of vital functions in the body



MEDULLA OBLONGATA

- Medulla oblongata or medulla is the lowermost part of brain.
- It is situated below pons and is continued downwards as spinal cord.
- Medulla forms the main pathway for ascending and descending tracts of the spinal cord.
- It also has many important centers which control the vital functions.

1. **RESPIRATORY CENTERS**

   Dorsal and ventral group of neurons form the medullary respiratory centers, which maintain normal rhythmic respiration.

2. **VASOMOTOR CENTER**

   Vasomotor center controls blood pressure and heart rate.

3. **DEGLUTITION CENTER**

   Deglutition center regulates the pharyngeal and esophageal stages of deglutition.

4. VOMITING CENTER

- Vomiting center induces vomiting during irritation or inflammation of gastrointestinal (GI) tract.

5. SUPERIOR AND INFERIOR SALIVATORY NUCLEI

- Salivatory nuclei control the secretion of **saliva.**

6. CRANIAL NERVE NUCLEI

- Nuclei of 12th, 11th, 10th and some nuclei of 8th and 5th cranial nerves are located in the medulla oblongata.
- 12th cranial (hypoglossal) nerve controls the movements of **tongue.**
- 11th cranial (accessory) nerve controls the movements of **shoulder.**
- 10th cranial (vagus) nerve controls almost all the **vital functions** in the body, viz. cardiovascular system, respiratory system, GI system, etc.
- 8th cranial nerve (the cochlear division of this nerve), which has the relay in medulla oblongata, is concerned with the auditory function.

- All the medullary centers and nuclei of cranial nerves are controlled by higher centers, situated in cerebral cortex and hypothalamus.

PONS

- Pons forms a bridge between medulla and midbrain.

FUNCTIONS OF PONS

1. Pons forms the pathway that connects cerebellum with cerebral cortex.
2. Pyramidal tracts pass through the pons.
3. Medial lemniscus is joined by the fibers of 10th, 9th, 7th and 5th cranial nerves in pons.
4. Nuclei of 8th, 7th, 6th and 5th cranial nerves are located in pons.
5. Pons contains the pneumotaxic and apneustic centers for regulation of respiration.
6. It also contains the vestibular nuclei, which are already mentioned in medulla oblongata.

MIDBRAIN

- Midbrain lies between pons and diencephalon.
- It consists of two parts:

A. Tectum
B. Cerebral peduncles.

A. TECTUM

- Tectum is formed by two structures:

1. SUPERIOR COLLICULUS

- Superior colliculus is a small structure and is an important center for reflexes.
- Superior colliculus controls the **movements** of the eyes, head, trunk and limbs, in response to visual impulses.

2. INFERIOR COLLICULUS

- Inferior colliculus consists of single layer of neurons to which the lateral lemniscus (auditory fibers) synapses.
- Inferior colliculus is the center for auditory reflexes.
- Stimulation of this also produces reflex vocalization.

B. CEREBRAL PEDUNCLES

- Cerebral peduncles include:

1. BASIS PEDUNCULUS

- Basis pedunculus consists of pyramidal tract fibers in the middle, temporopontine fibers laterally and frontopontine fibers medially.

2. SUBSTANTIA NIGRA

- Substantia nigra is situated below the red nucleus.
- Substantia nigra is considered as one of the components of basal ganglia.

3. TEGMENTUM

- Tegmentum lies dorsal to substantia nigra and is actually the upward continuation of the reticular formation in pons.
- Tegmentum comprises three decussations and red nucleus.

RED NUCLEUS

- Red nucleus is a large oval or round mass of gray matter, extending between the superior colliculus and hypothalamus.
- Red nucleus has two parts:

1. **NUCLEUS MAGNOCELLULARIS,** which is formed by large cells. Fibers from this form the rubrospinal and rubrobulbar tracts.
2. **NUCLEUS PARVOCELLULARIS,** which is formed by smaller cells. Fibers from this form mainly the rubroreticular tract.

FUNCTIONS OF RED NUCLEUS

1. **CONTROL OF MUSCLE TONE:** Because of its connections with cerebellum, vestibular apparatus and skeletal muscle, the red nucleus plays an important role in facilitating the muscle tone.
2. **CONTROL OF COMPLEX MUSCULAR MOVEMENTS:** Red nucleus controls the complex muscular movements. It plays an important role in the integration of various impulses received from many important areas of brain.
3. **CONTROL OF RIGHTING REFLEXES:** Red nucleus is the center for all righting reflexes except optical righting reflexes.
4. **CONTROL OF MOVEMENTS OF EYEBALL:** Through its efferent connections with nuclei of 3rd, 4th and 6th cranial nerves, red nucleus plays an important role in the control of ocular movements.
5. **CONTROL OF SKILLED MOVEMENTS:** Red nucleus plays an important role in controlling the skilled muscular movements by its connections with spinal cord and cerebral cortex.

THANK YOU