بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

ANATOMY

وَلَقَدْ خَلَقْنَا الْإِنسَانَ وَنَعْلَمُ مَا تُوَسْوِسُ بِهِ نَفْسُهُ ۖ وَنَحْنُ أَقْرَبُ إِلَيْهِ مِنْ حَبْلِ الْوَرِيدِ

MID | Lecture 8

Nervous System

Written by : Ahmad Mohy
Khaled Abdalla
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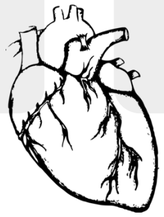

Color Code:

- Doctor's Slides
- Important Info on Doctor's Slide
- Doctor's words and explanation in lecture
- Addition information

Introduction to Anatomy

1st Year Medical Students

2025-2026
Second Semester

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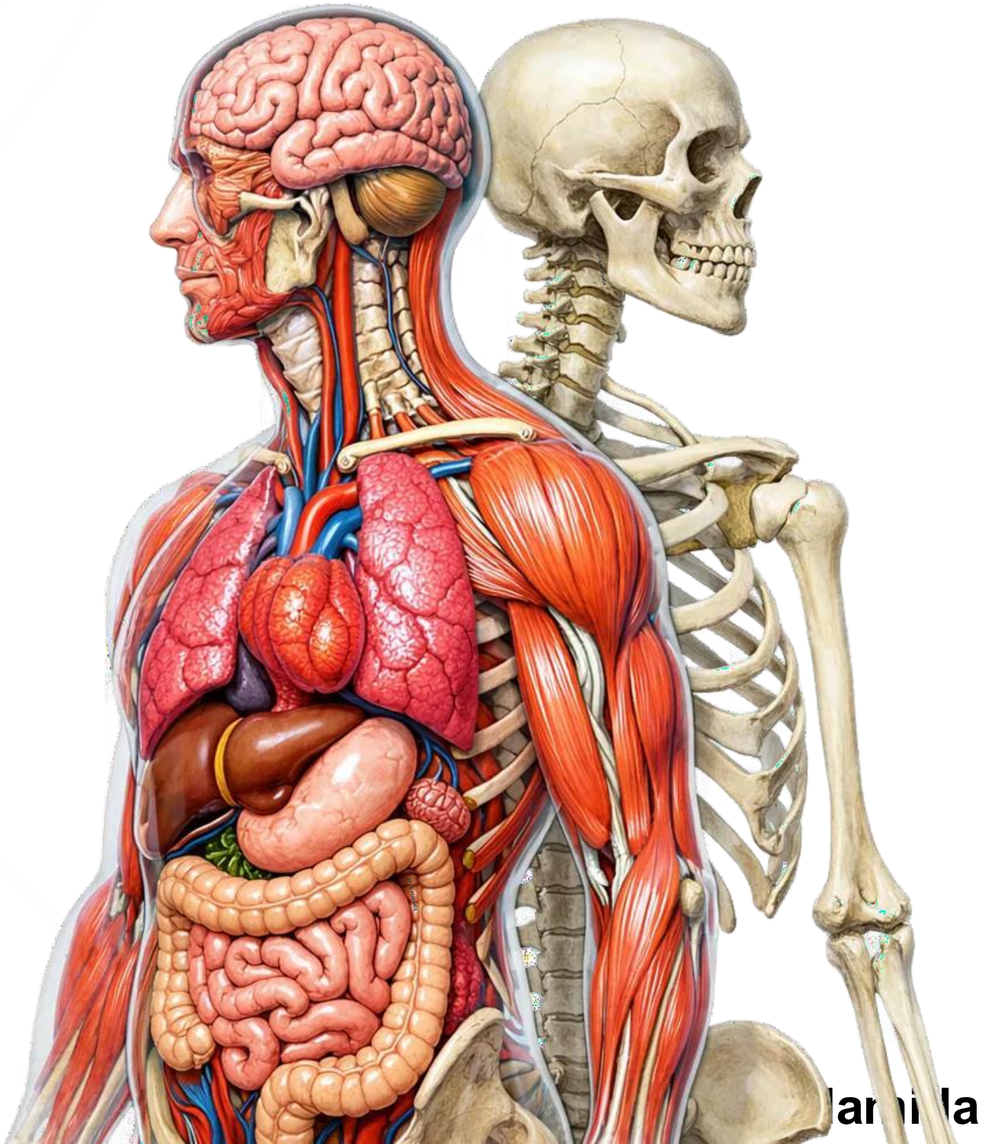
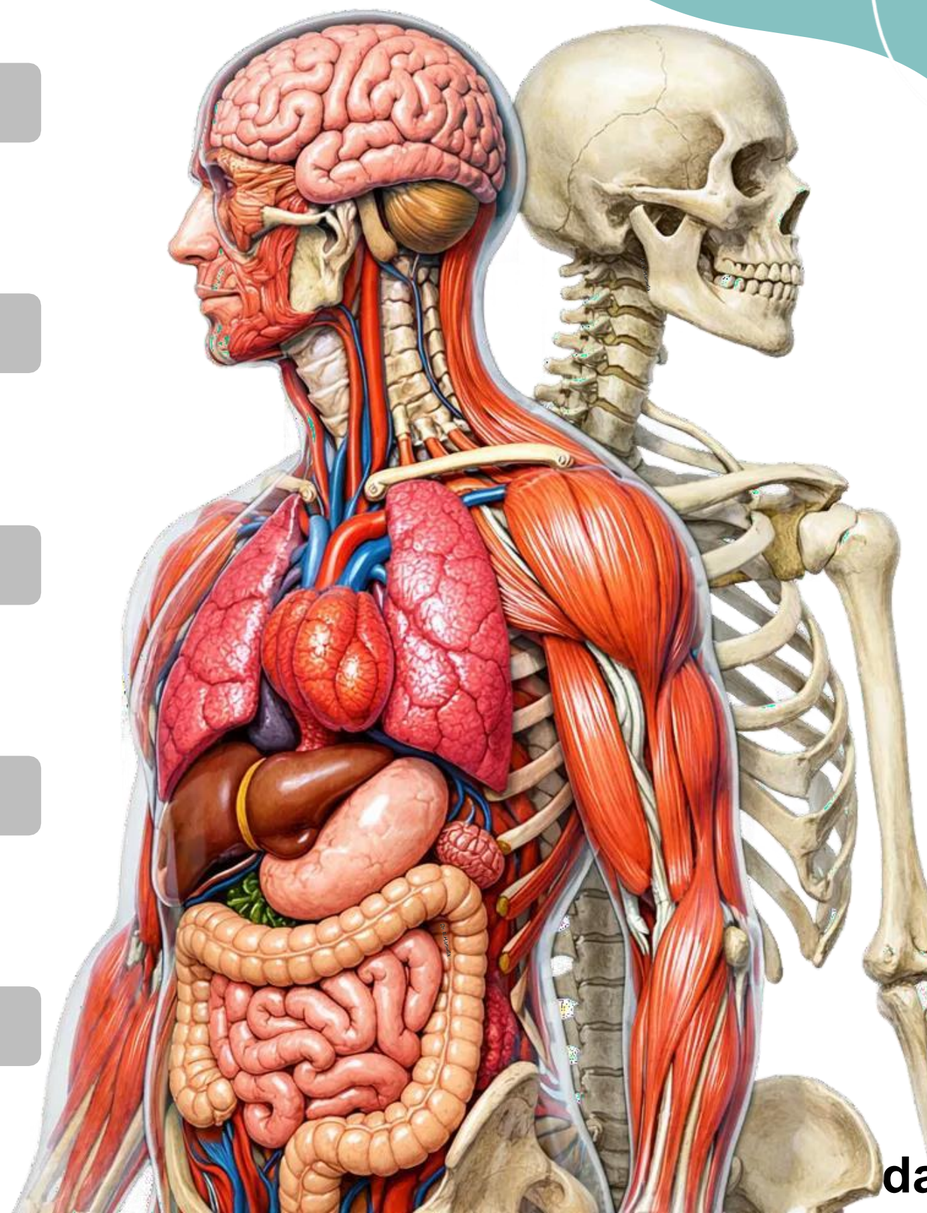


Course Outline:

1. Introduction and Terminology
2. Skeletal System
3. Cardiovascular System
4. Lymphatic System
5. Nervous System
6. Muscular System
7. Respiratory System
8. Digestive System
9. Urinary System
10. Endocrine System



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Gross lecture-7

Nervous System

Dr A.Hamida

Dr. Hamida

5 Nervous System

Action potential is basically about depolarization and repolarization. In resting state the inner part of the membrane is negatively charged and positively in the outer part. To do what so called action potential the membrane charge has to be changed by altering the charge in both sides of the membrane as the inner membrane becomes positive and the outer is negative (by sodium and potassium influx), and repeatedly the process occurs in successive segments of the membrane to deliver the electrical impulse.

Gross lecture-7

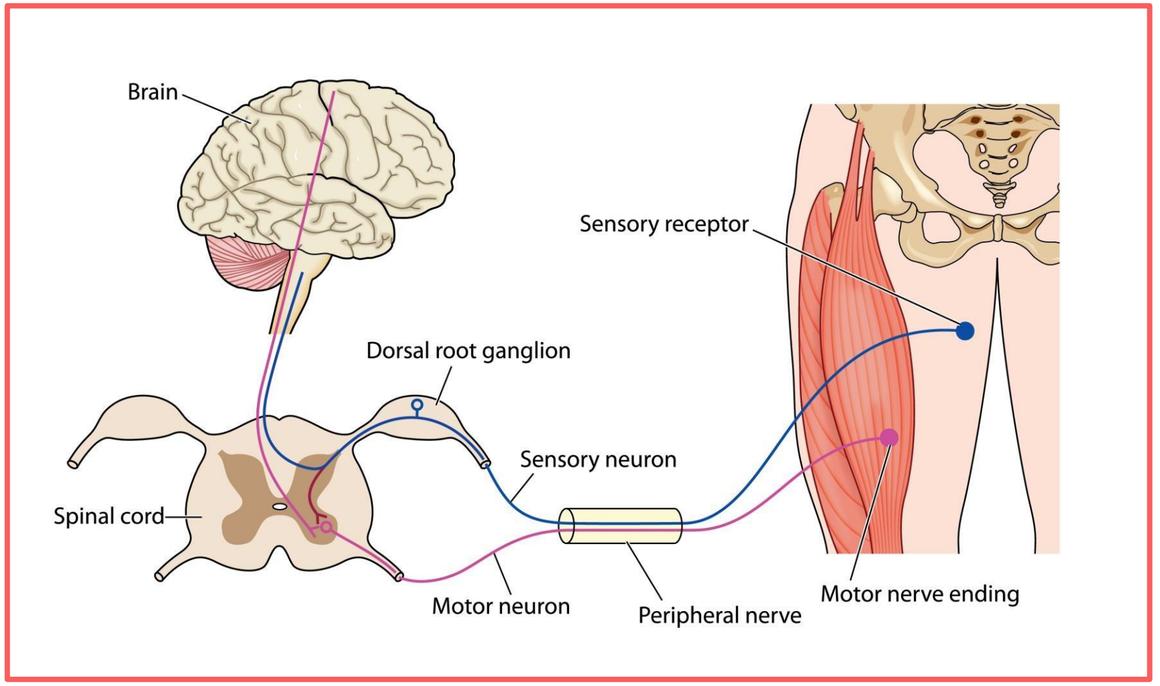
➢ **The nervous system, along with the endocrine system, regulates the functions of all other body systems.**

Generally, to control the function of any system in the body like respiratory, digestive or cardiovascular we have two ways, either the nervous system or the endocrine system.

Nervous System

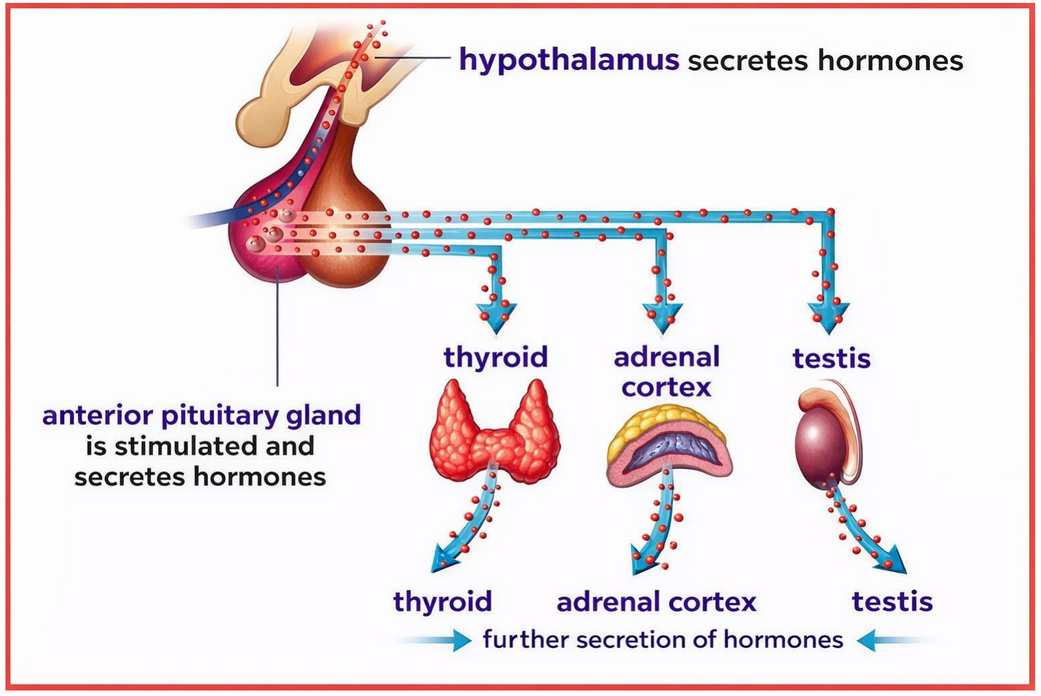
controls body activities by responding rapidly

through nerve impulses (electric impulses or action potential)



Endocrine System

responds more slowly by releasing hormones.



5 Nervous System

➢ The nervous system, along with the endocrine system, regulates the functions of all other body systems.

Nervous System

controls body activities by responding rapidly through nerve impulses

Needs less time, as the nerve is directly reaching the target system or organ transmitting electrical impulses.

Endocrine System

responds more slowly by releasing hormones.

These hormones need more time to reach the receptors of its target system (like cardiovascular or respiratory) , as they must be secreted in blood (by glands) then circulated passing through the heart and the systemic circulation.

5 Nervous System

Gross lecture-7

❖ Divisions of the Nervous System

➢ **Anatomically, the nervous system is divided into two parts:**

1. **Central Nervous System (CNS),**

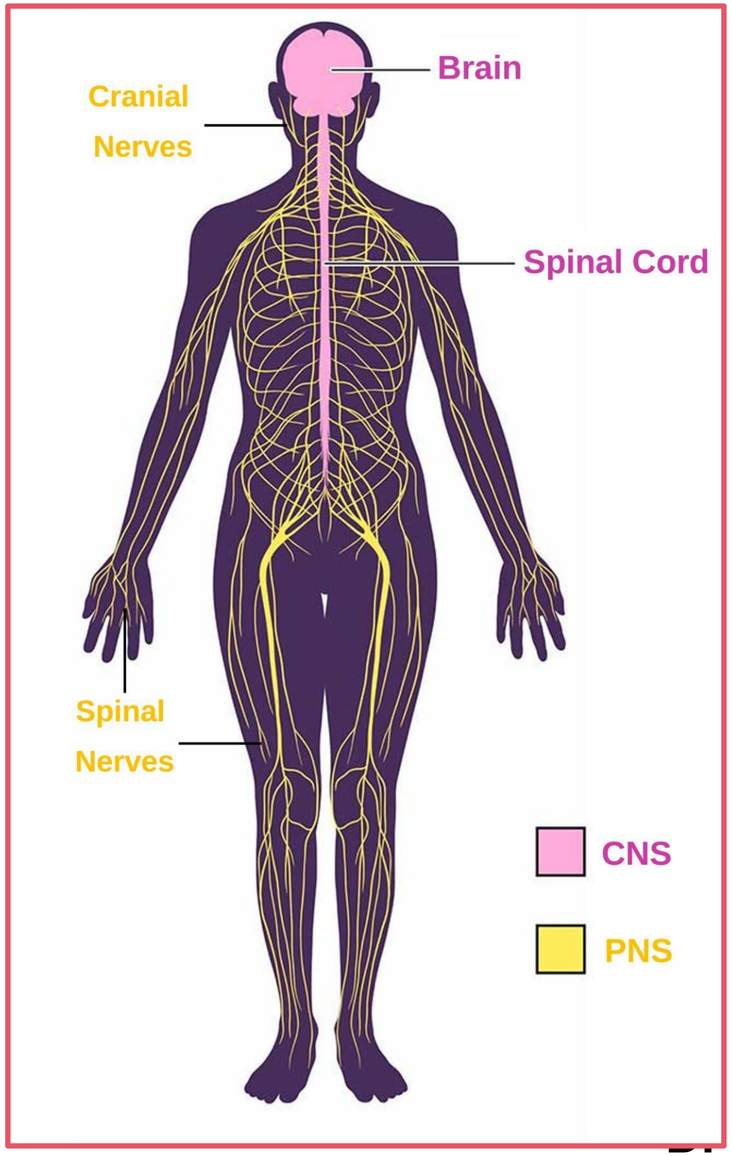
   consists of:

   In the central axis:
   - i. **Brain (located in the cranial cavity)**
   - ii. **Spinal Cord (located in the vertebral canal)**

2. **Peripheral Nervous System (PNS),**

   consists of nerves that exit from CNS:

   - i. **Cranial nerves (exit from the brain)**
   - ii. **Spinal nerves (exit from the spinal cord)**



5 Nervous System

Gross lecture-7

❖ Divisions of the Nervous System

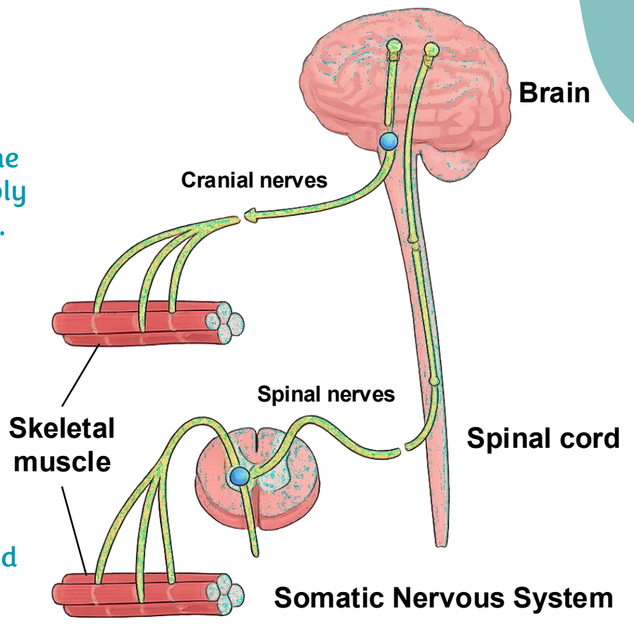
Based on the organ or the structure the nerve supply (either cranial or spinal).

➢ **Functionally, The PNS is divided into subsystems:**

1. Somatic Nervous System:

- **Provides the voluntary control of skeletal muscles.**

Like holding the microphone under your control causing the contraction of the muscles in your hand



2. Autonomic Nervous System:

In the digestive system like large and small intestines which do what's called "peristalsis : الحركة الدودية " to move the food .

- **Provides involuntary control of the smooth muscle (stomach), cardiac muscle (heart), and glands**

Like the endocrine glands (ex thyroid gland) and the exocrine glands secretes chemicals involuntary

- **The autonomic nervous system is further subdivided into:**

Based on the status or the time the nerve is activated in.

(Fight or flight actions)

a. Sympathetic Nervous System:

It increases the heart rate, respiratory rate and sweating to deal with the action, it decreases the secretion of saliva that's why the mouth becomes dry during these actions .

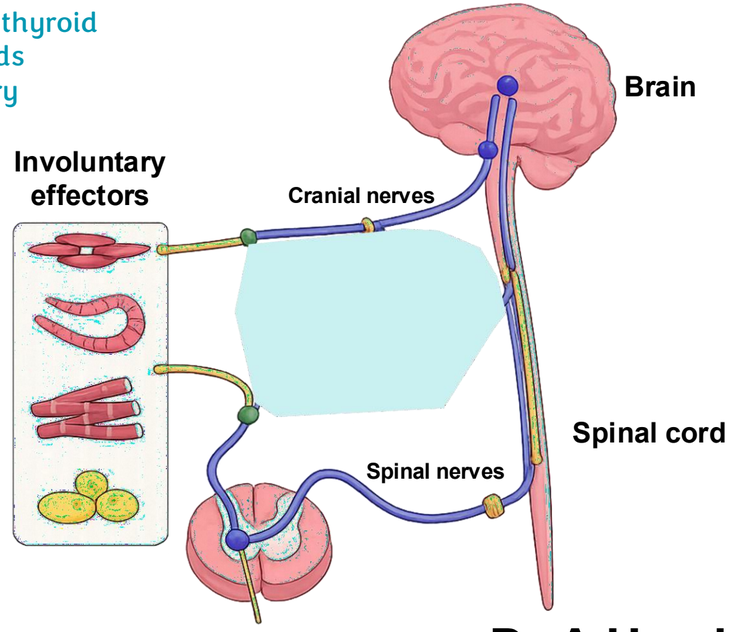
- **It is activated during stressful stimuli (e.g., fear, pain, exercise).**

(Rest and Digest actions)

b. Parasympathetic Nervous System:

Increase of the appetite to eat and increase of salivation , decrease in heart and respiratory rate.

It is activated during rest and relaxation (e.g., sleep).



Autonomic Nervous System

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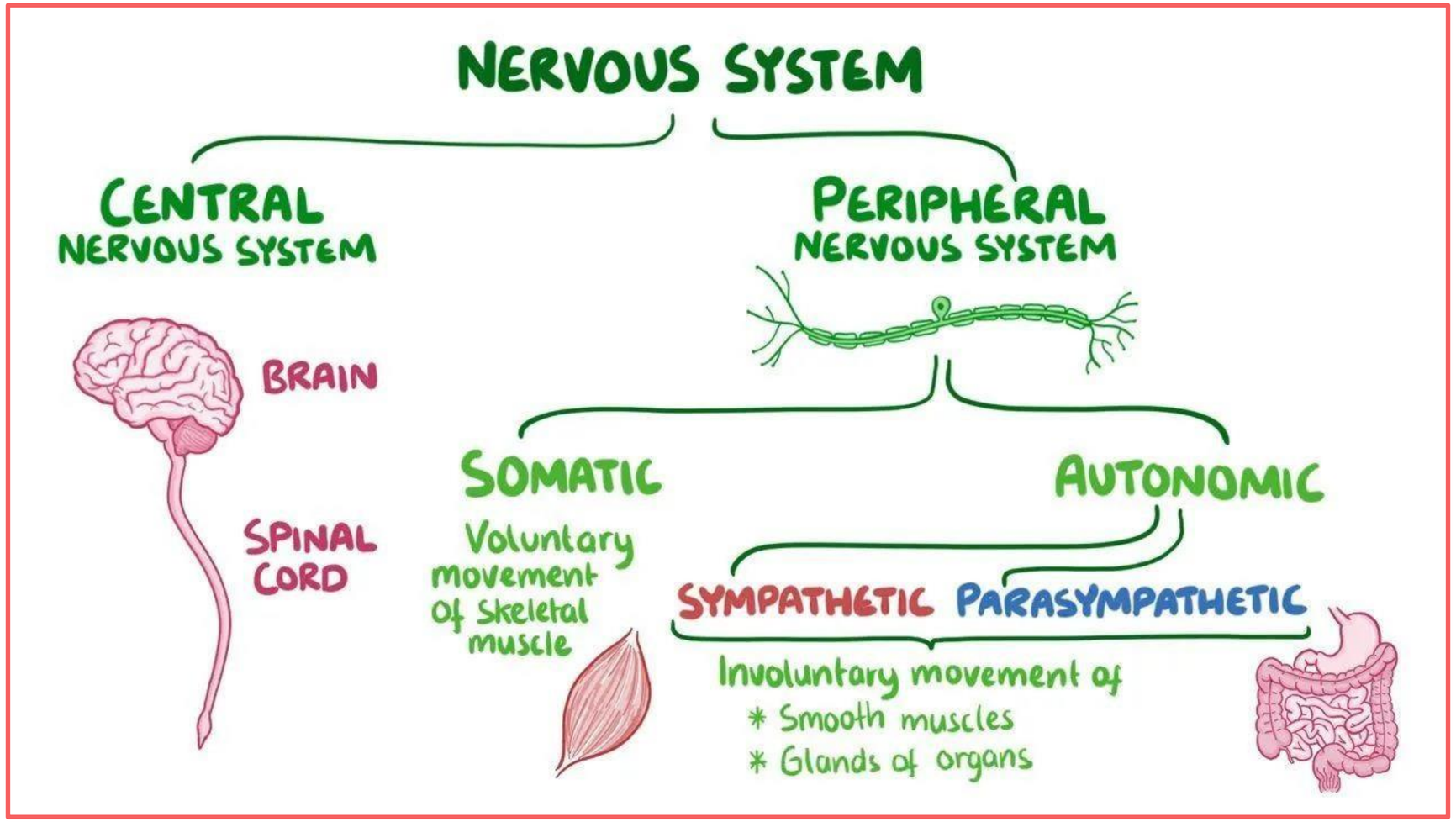
5 Nervous System

lecture-11

❖ Divisions of the Nervous System



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5 Nervous System

The whole process from the receptors to withdrawing the hand is called "reflex arc : رد الفعل المنعكس"

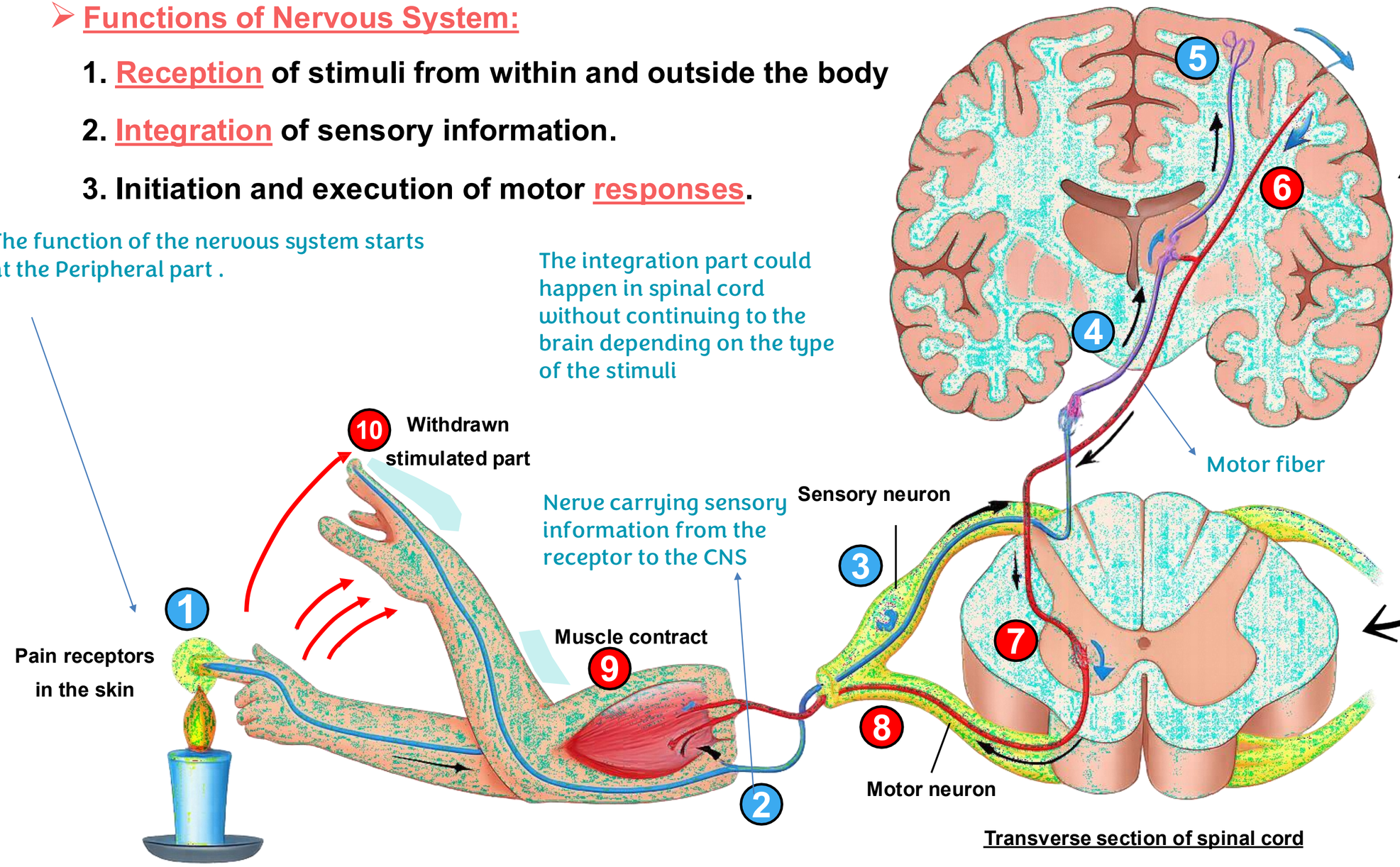
Gross lecture-7

➢ Functions of Nervous System:

1. **Reception** of stimuli from within and outside the body
2. **Integration** of sensory information.
3. Initiation and execution of motor **responses**.

The function of the nervous system starts at the Peripheral part .

The integration part could happen in spinal cord without continuing to the brain depending on the type of the stimuli



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Nervous System

Gross lecture-7

➢ Functions of Nervous System:

1. Reception of stimuli from within and outside the body

- **Sensory receptors detect internal stimuli (such as increased blood pressure) or external stimuli (such as heat or burning of the skin).**
- **This sensory information is carried to the brain and spinal cord through cranial and spinal nerves.**

In the skin we have different receptors that detects stimuli, like pain, temperature, pressure .

We have baroreceptors that detect the increase in the blood pressure and send that signal to the brain resulting in a motor order causing vasodilation of blood vessels and decrease in the heart rate.

2. Integration of sensory information.

- **The nervous system processes sensory input by analyzing it and making decisions for appropriate responses, an activity known as integration.**

3. Initiation and execution of motor responses.

- **After integration, the nervous system initiates a motor response by activating effectors (muscles or glands) via cranial and spinal nerves.**
- **Stimulation of these effectors causes muscles to contract and glands to secrete.**

5 Nervous System

Gross lecture-7

System Outline:

5.1 Nervous Tissue

5.2 Central Nervous System - Brain

5.3 Central Nervous System - Spinal Cord

5.4 Peripheral Nervous System

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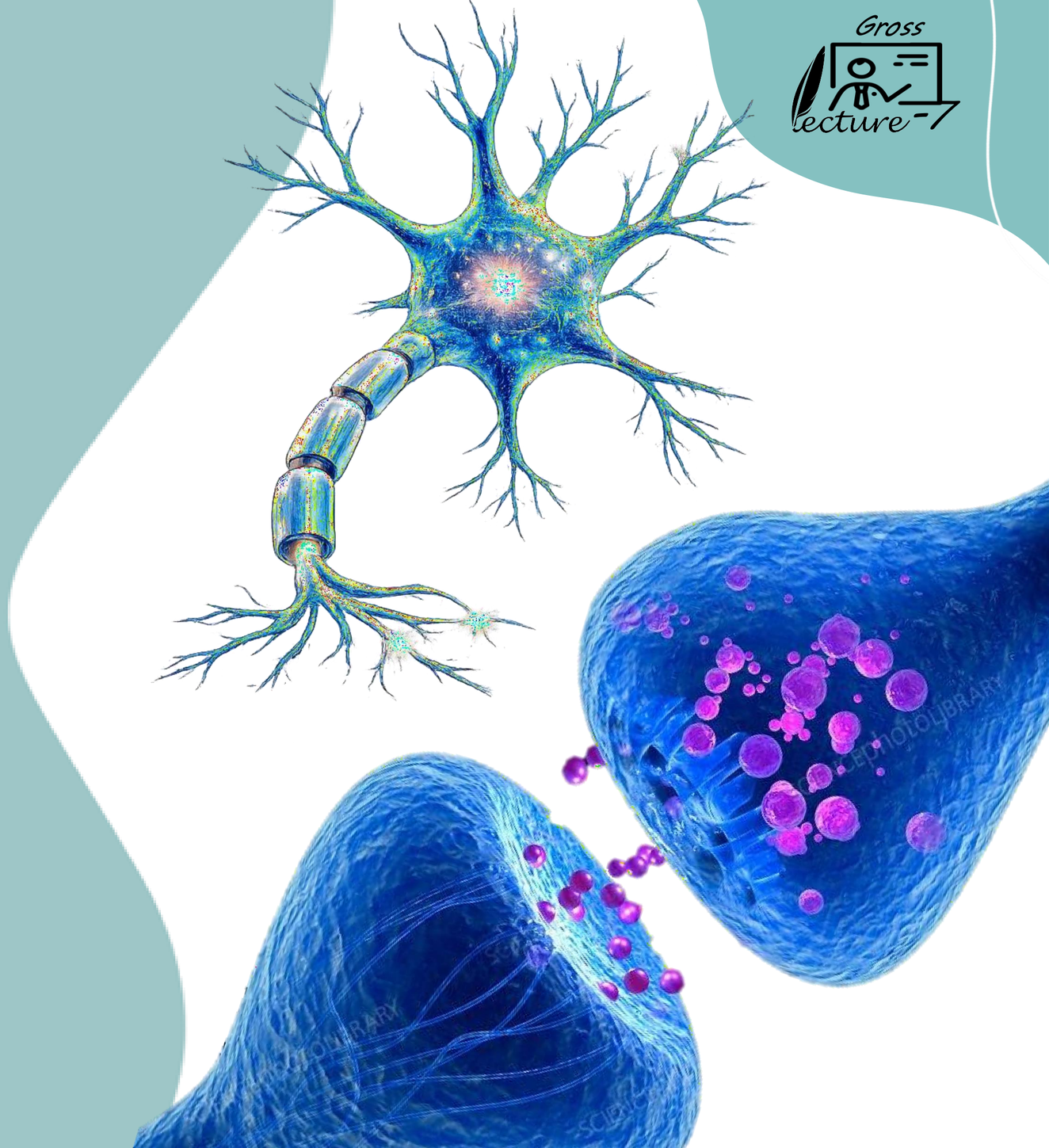
Gross lecture-7

Nervous System

1. Nervous Tissue



5.1 Nervous System- Nervous Tissue

Gross lecture-7

Lecture Outline:

- 5.1.1 Neurons (Nerve Cells)
- 5.1.2 Neuroglia (Glial Cells)
- 5.1.3 Nerve Fibers
- 5.1.4 Gray Matter
- 5.1.5 White Matter

5.1 Nervous System– Nervous Tissue

➢ **The nervous system consists of two principal types of cells:**

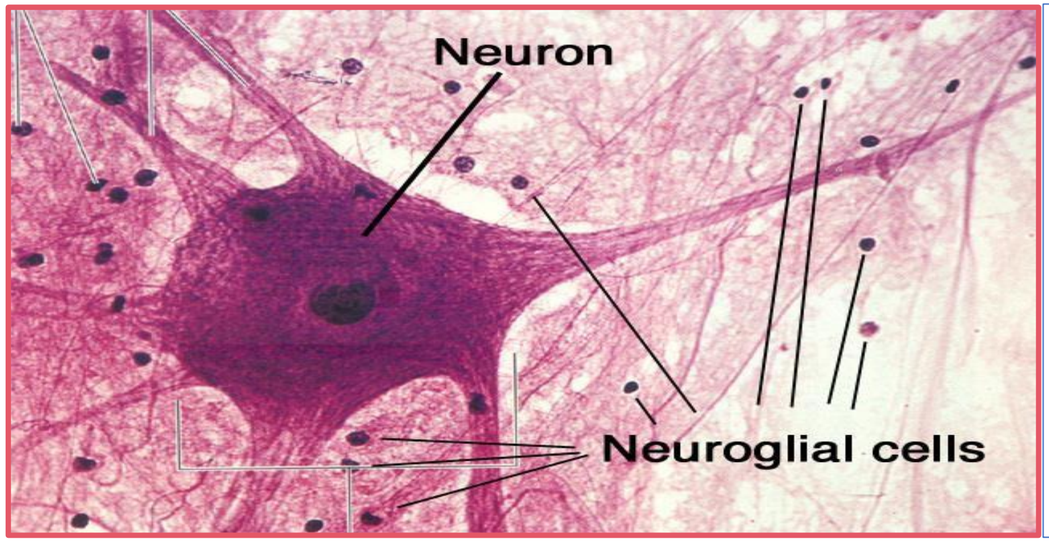
1. **Neurons (Nerve Cells):**
   - **The structural and functional units of the nervous system.**
   - **The two main properties of neurons are excitability and conductivity.**
   - **Highly differentiated cells that have lost their ability to divide.**

2. **Neuroglia (Glial Cells):**
   - **Supportive cells that assist neurons both structurally and functionally.**
   - **Non-conducting cells located near neurons.**
   - **Unlike neurons, neuroglia retain the ability to divide throughout life.**

Excitability: Generates action potential

Conductivity: The ability to move the action potential along the neuron

Cannot regenerate because it can't undergo cell division (so if a neuron is injured it'll be lost & won't recover)



Neuroglia doesn't generate action potential and cannot move the action potential (lacks excitability and conductivity). It only does structural and functional support

Can regenerate because it can undergo cell division (mitosis/miosis)

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5.1.1

Neurons (Nerve Cells)

Gross lecture-7

➢ **Each neuron consists of three parts:**

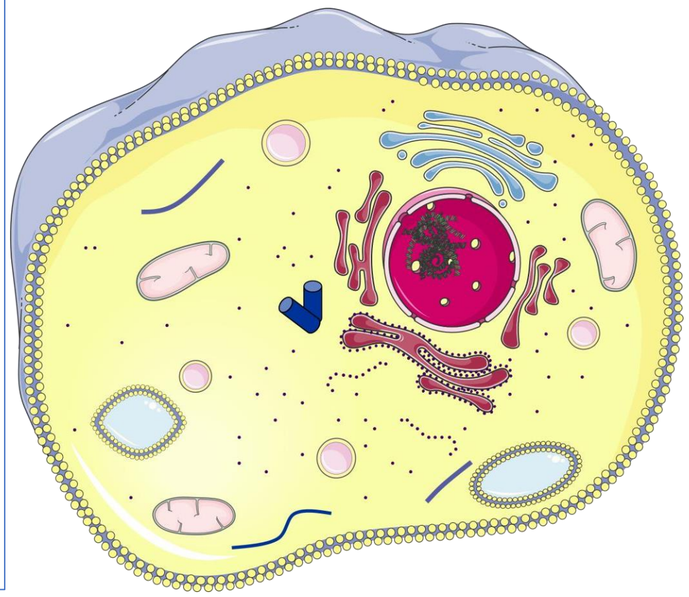
1. Cell Body (also called soma)
2. Dendrites
3. Axon

Typical cell contains nucleus, nucleolus, endoplasmic reticulum, golgi apparatus, mitochondria, etc.

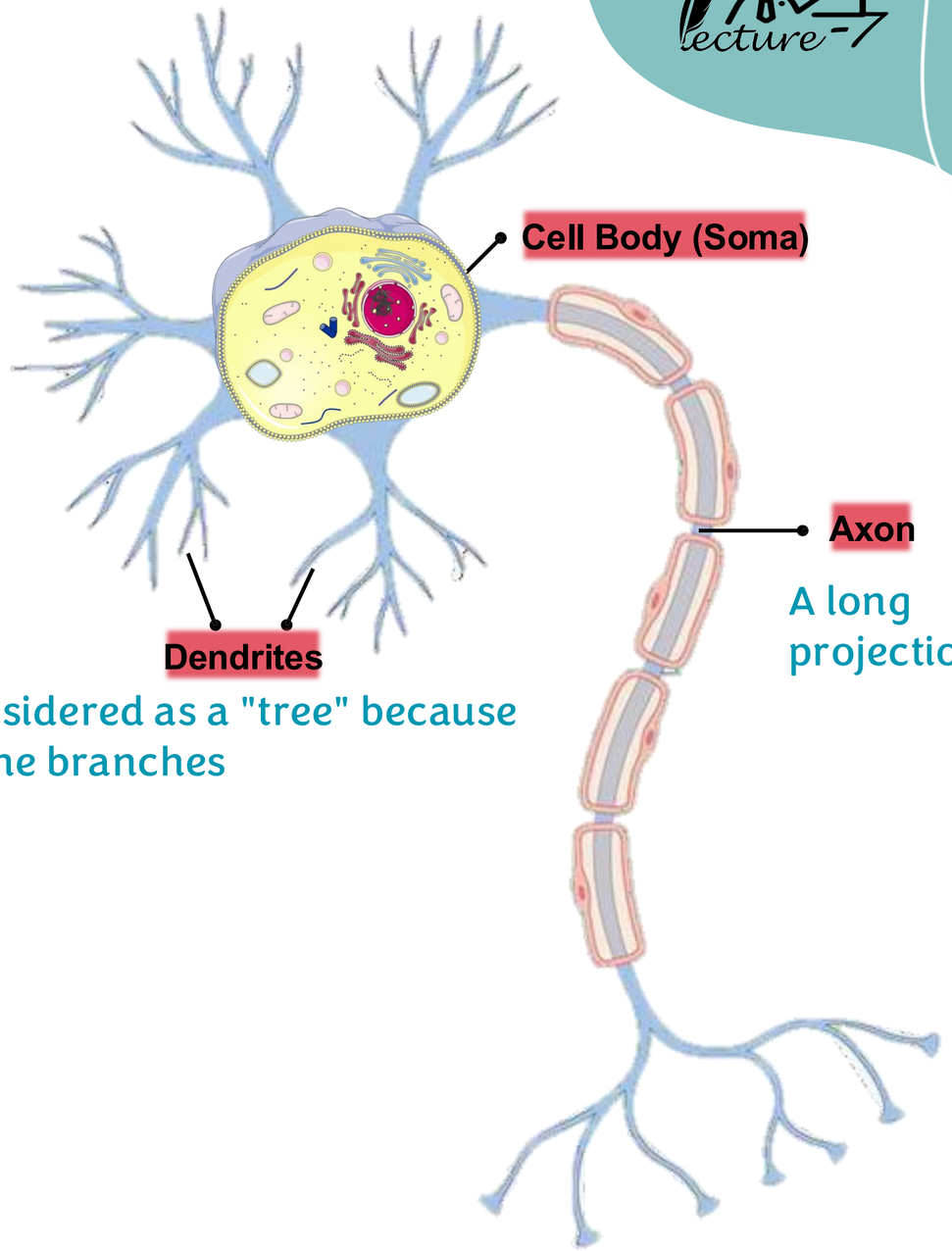
The cell body (soma) contains the typical cell.

However, in the cell body soma we do NOT have centrioles and centrosomes, this is the reason why neurons cannot divide

Typical Cell



Nerve Cells



A long projection

Considered as a "tree" because of the branches

Gross lecture-7

Neurons (Nerve Cells)

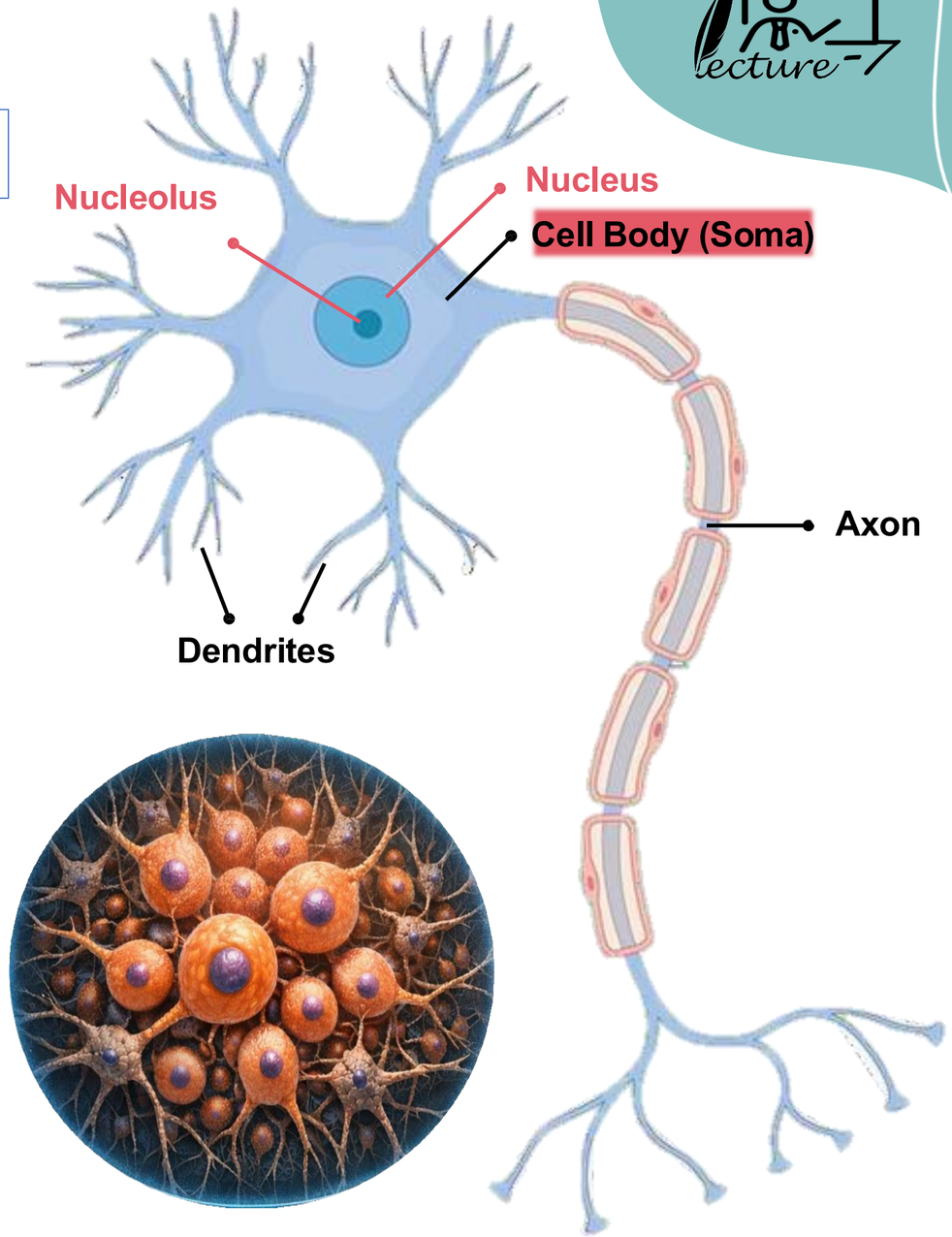
1. Cell Body (soma)

The cell body is responsible for the generation of action potential.

- **Contains a large nucleus with a prominent nucleolus, surrounded by cytoplasm that includes organelles such as lysosomes, mitochondria, and a Golgi complex.**

- **There are no centrioles and centrosome in the nerve cell body, which indicates that neurons cannot divide.**

The centrioles and centrosomes are responsible for cell division, they produce the mitotic spindle in order to divide a single cell into 2 cells and without them the cell loses its ability to divide.



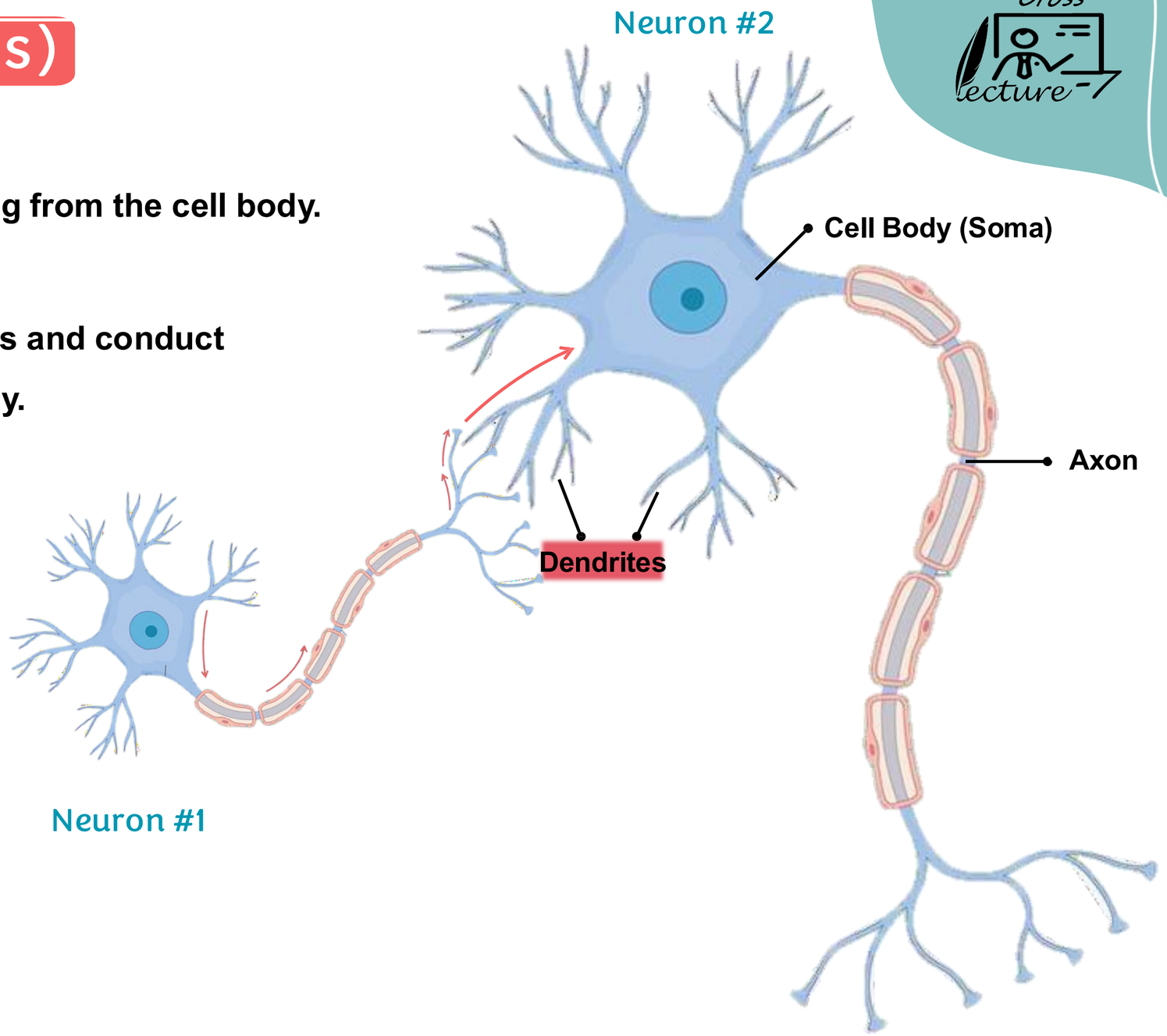
Clusters of cell bodies within the CNS are called Gray Matter

Clusters of cell bodies within the PNS are called Ganglion

Neurons (Nerve Cells)

2. **Dendrites** (dendron = tree):
   - **Short, branched processes projecting from the cell body.**
   - **Receive impulses from other neurons and conduct electrical signals toward the cell body.**

Neuron #1 has action potential that travels from the cell body (soma) to the axon to the axon terminal where it reaches the synaptic end bulbs. The synaptic end bulbs release the signal to the dendrites of Neuron #2 where it receives the signal



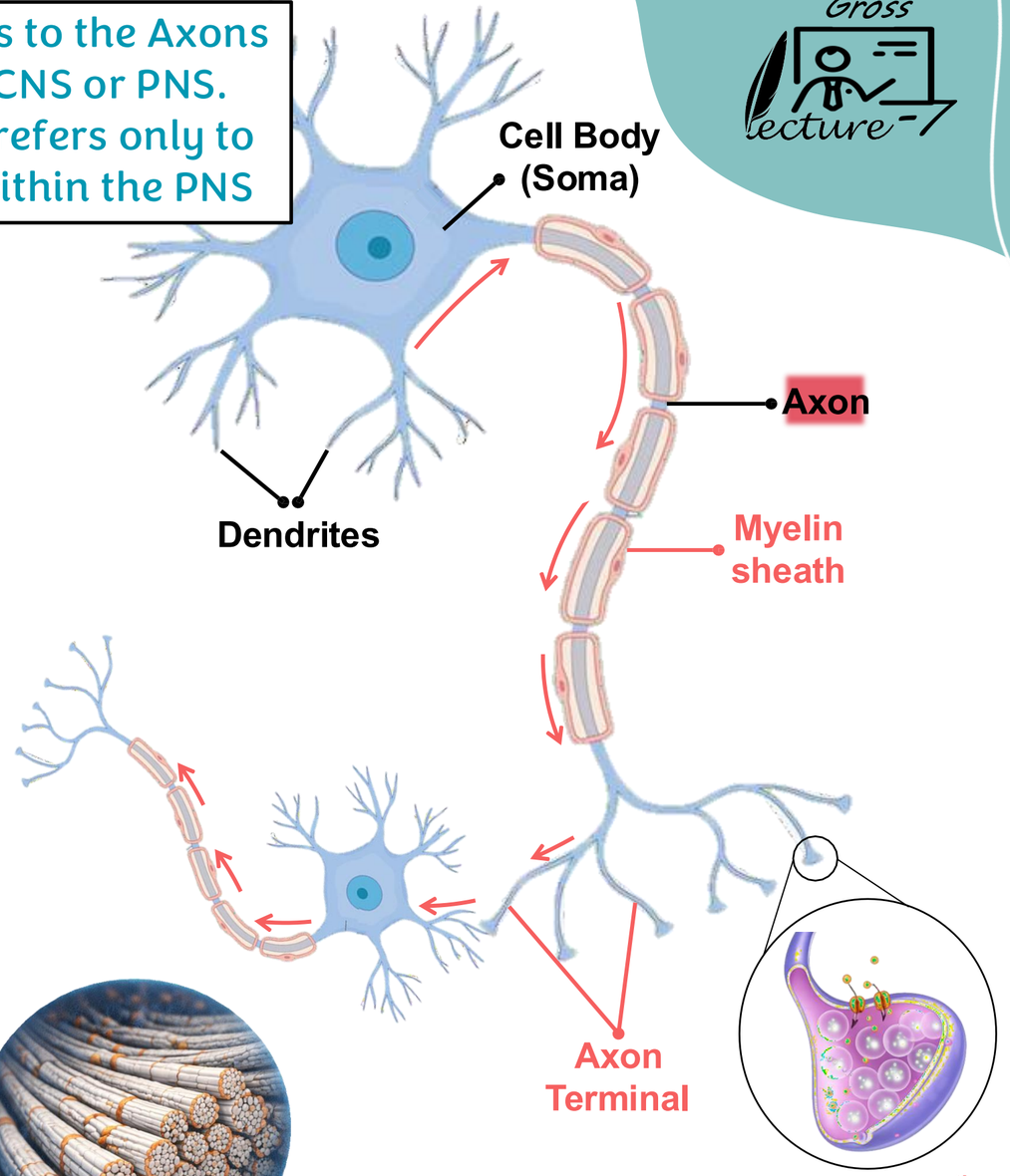
Neurons (Nerve Cells)

"Nerve fibers" refers to the Axons whether within the CNS or PNS. However, "Nerves" refers only to a bundle of axons within the PNS

3. Axon:

- **A long, cable-like projection that extends from the cell body.**
- **An axon is also referred to as a nerve fiber.**
- **Axon could be myelinated or unmyelinated.**
  Travels at a high speed Travels at a slow speed
- **The axon end dividing into many fine processes called axon terminals.**
- **The tips of some axon terminals expand into bulb-shaped structures called synaptic end bulbs.**
- **Axon conducts nerve impulses away from the cell body.**

Synaptic end bulbs contains neurotransmitters that are released towards the denderites of the next neuron to receive the signal



Bundle of axons within the CNS are called White Matter

Or Bundle of Nerve fibers

Bundle of axons within the PNS are called Nerve

Every nerve contains cell bodies located in the central nervous system (CNS). For example, in spinal nerves, the cell bodies are found in the spinal cord, while their axons extend to various parts of the body.

5.1.1

Neurons (Nerve Cells)

Gross lecture-7

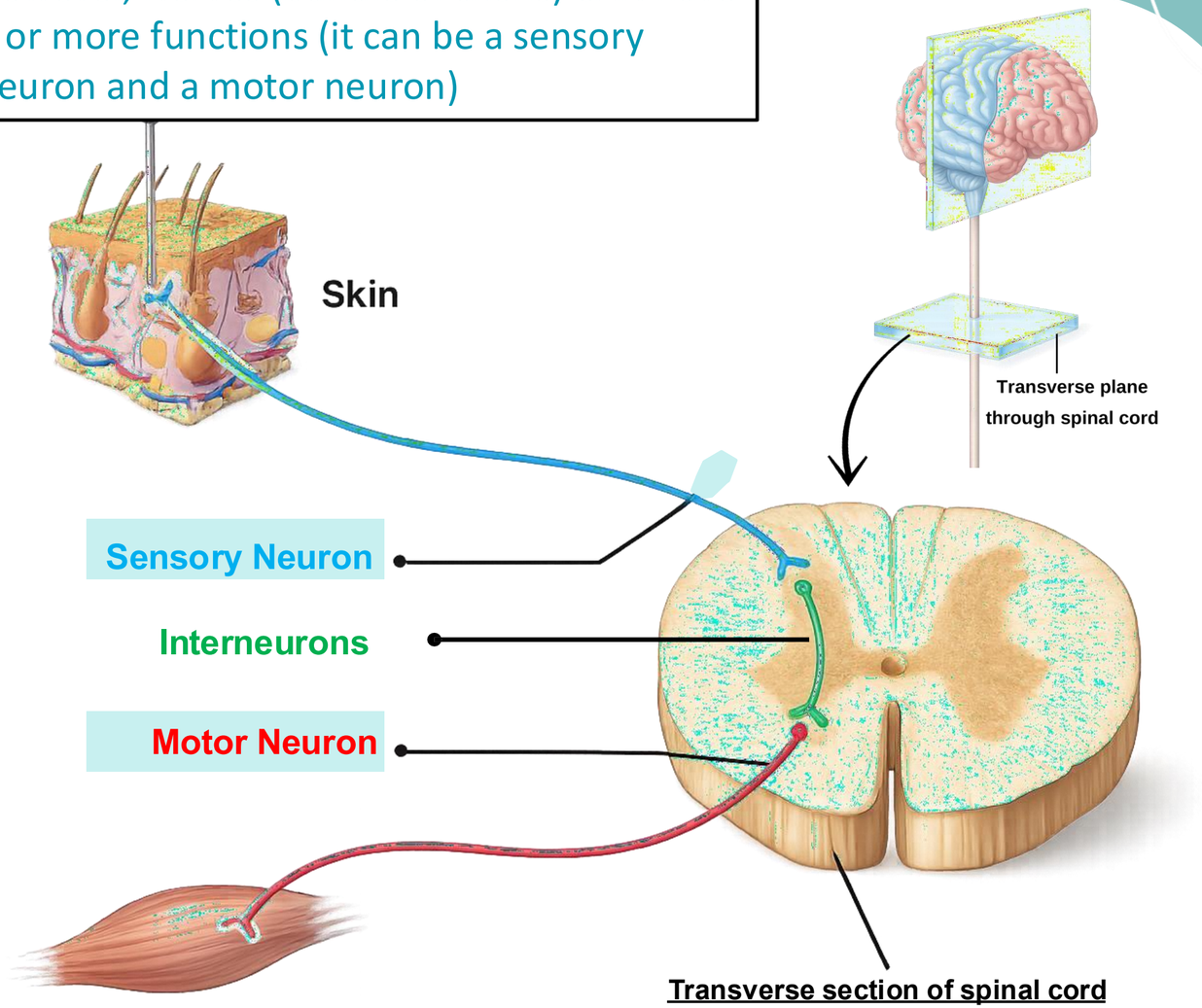
Neurons (a single cell) cannot have 2 functions at the same time (for instance, it cannot be a sensory neuron and a motor neuron at the same time)
However, Nerves (bundle of axons) CAN have 2 or more functions (it can be a sensory neuron and a motor neuron)

➢ Functional classification of neurons:

1. **Sensory Neurons (Afferent):** From PNS to CNS
   - **Carry sensory information from receptors throughout the body to the CNS.**

2. **Motor Neurons (Efferent):** From CNS to PNS
   - **Transmit impulses from the CNS to effector organs (muscles or glands) through cranial or spinal nerves.**

3. **Interneurons** Within the CNS
   - **Form communication and integration networks between sensory and motor neurons.**
   - **Mainly located within the CNS**



5.1.1

Neurons (Nerve Cells)

Gross lecture-7

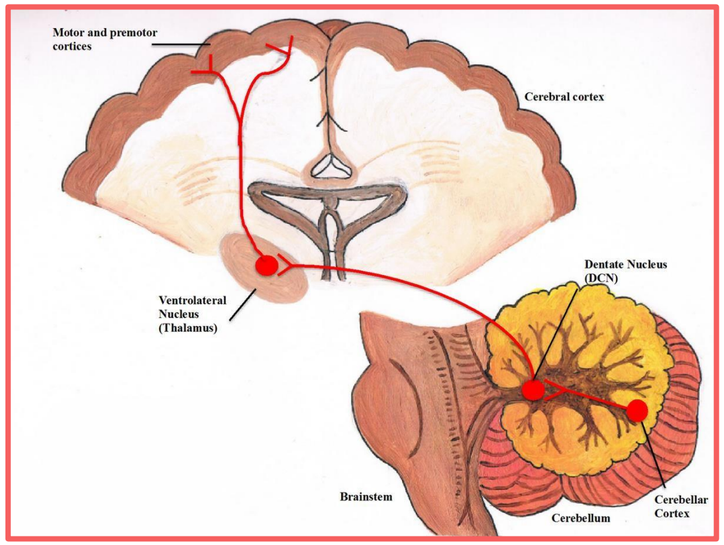
➢ Classification of neurons according to the length of axons

1. Golgi type I

- **These neurons possess long axons that project to distant regions of the nervous system, sometimes reaching lengths of up to 1 meter.**
- **Examples: Motor neurons whose axons extend from the spinal cord to the muscles of the foot (e.g., the big toe).**

2. Golgi type II:

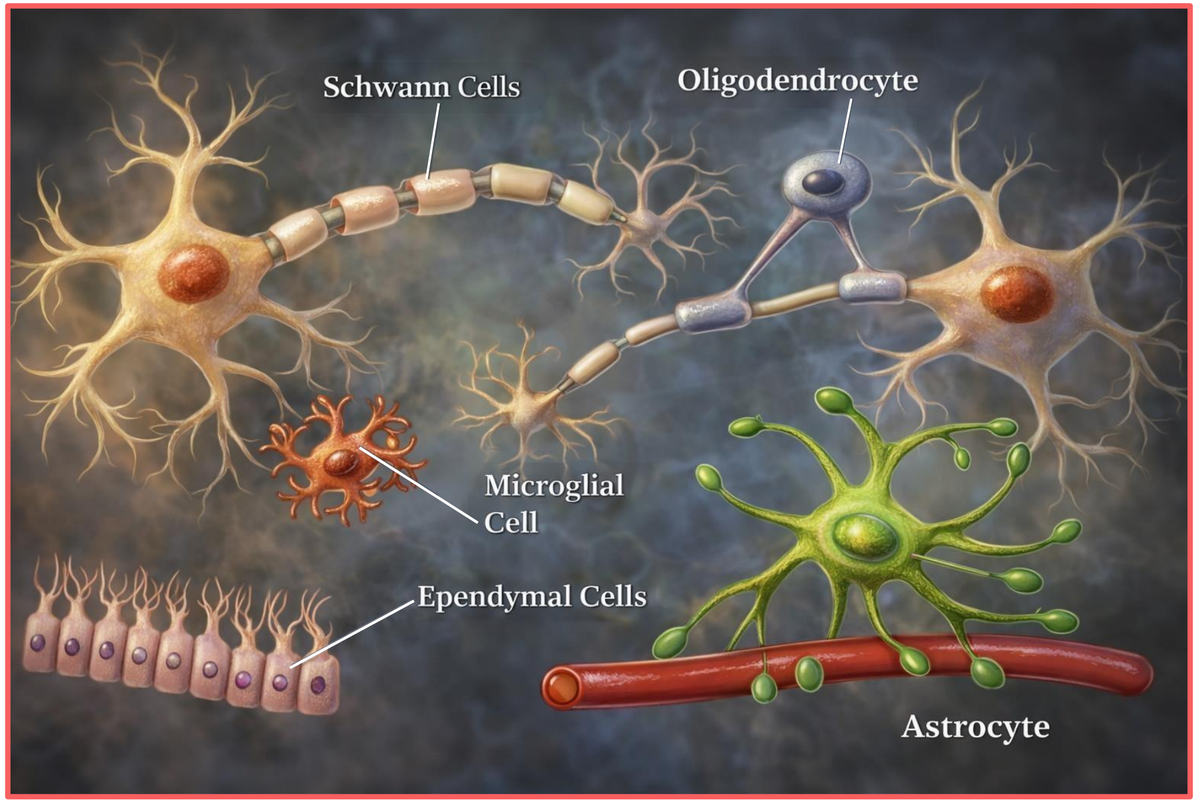
- **These neurons have short axons that terminate near the cell body.**
- **Examples: Interneurons that connect nearby neurons within the brain.**



5.1.2

Neuroglia (Glial Cells)

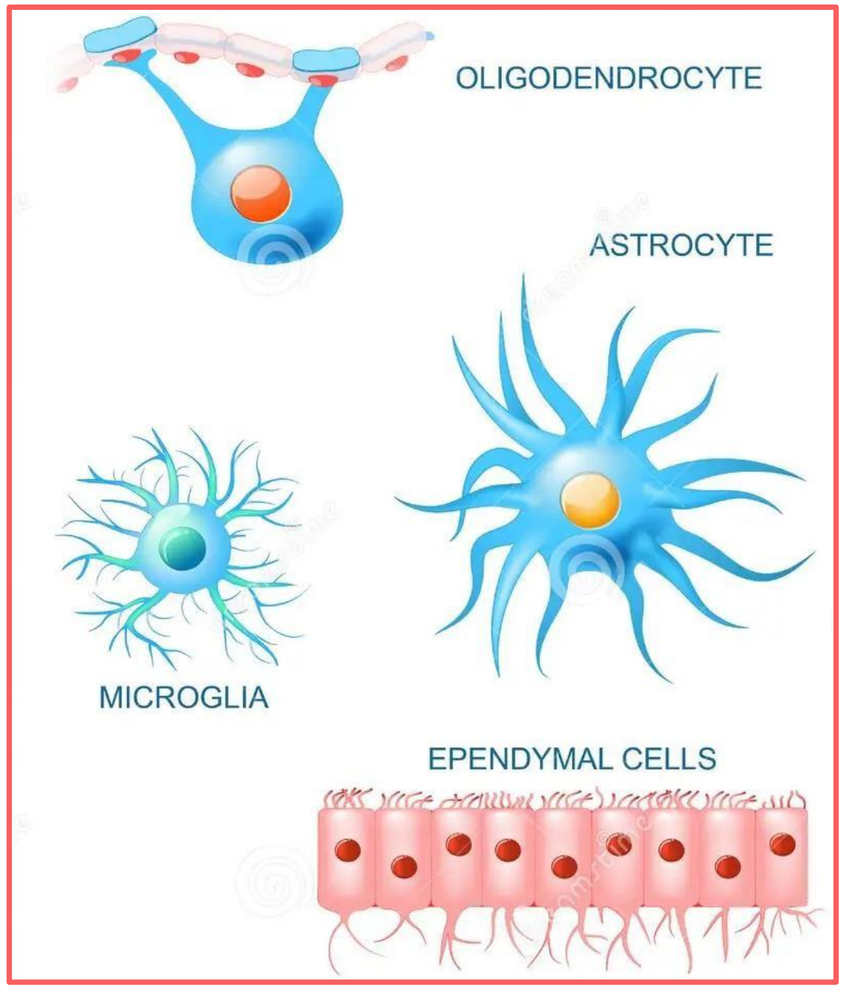
- Neuroglia are highly branched cells, smaller than neurons and are 5 to 25 times more numerous.
- They are the supporting cells of the nervous system.
- In contrast to neurons, **glia do not generate or propagate action potentials**, but they can **multiply and divide in the mature nervous system**.



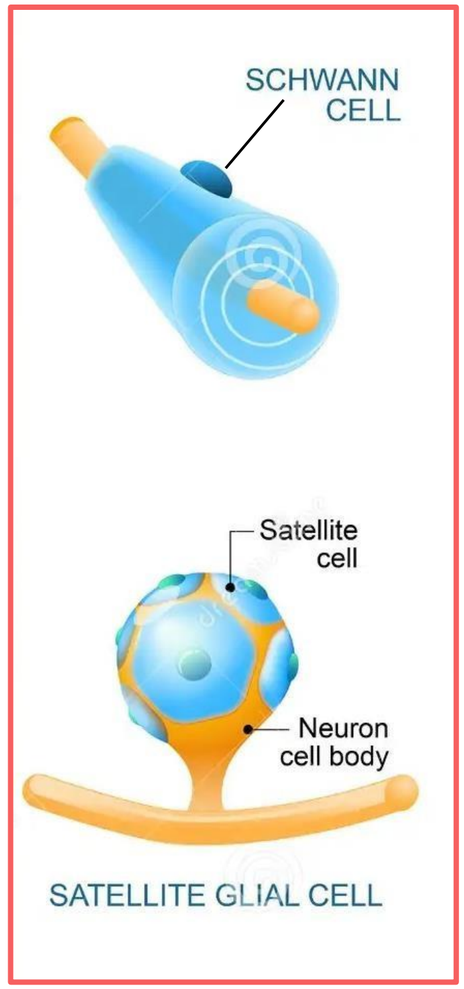
5.1.2

Neuroglia (Glial Cells)

➢ **There are four types of neuroglia in the CNS:**



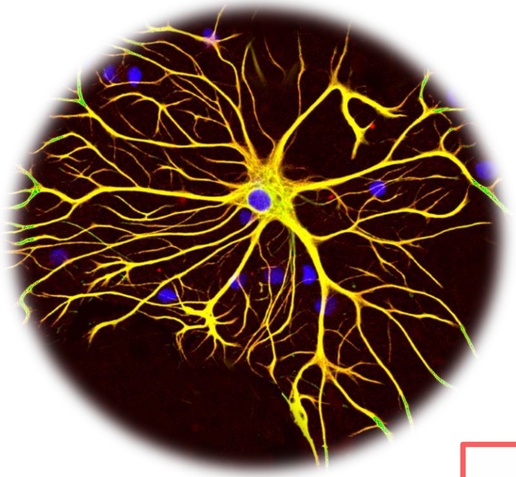
➢ **There are two types of neuroglia in the PNS:**



5.1.2

Neuroglia (Glial Cells)

Gross lecture-7

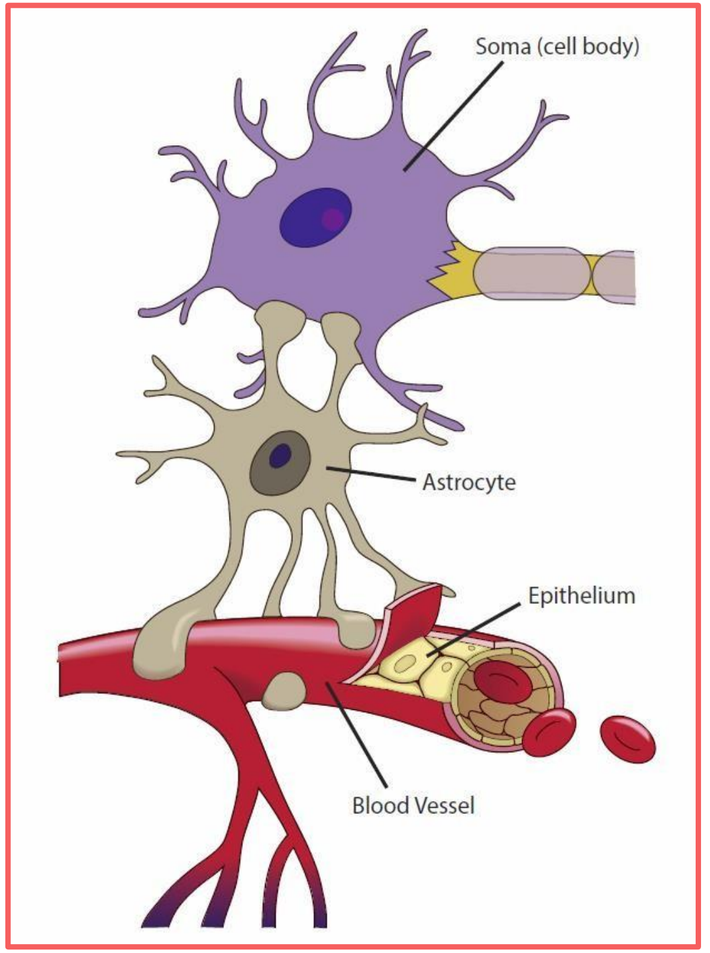


➢ **Types of neuroglia in the CNS:**

1. Astrocytes

- **The largest and most numerous type of neuroglia.**
- **Star-shaped cells with many processes.**

- Function:
  - **Contain microfilaments that provide strength and support to neurons.**
  - **Processes of astrocytes wrap around blood capillaries, forming part of the blood–brain barrier (BBB).**



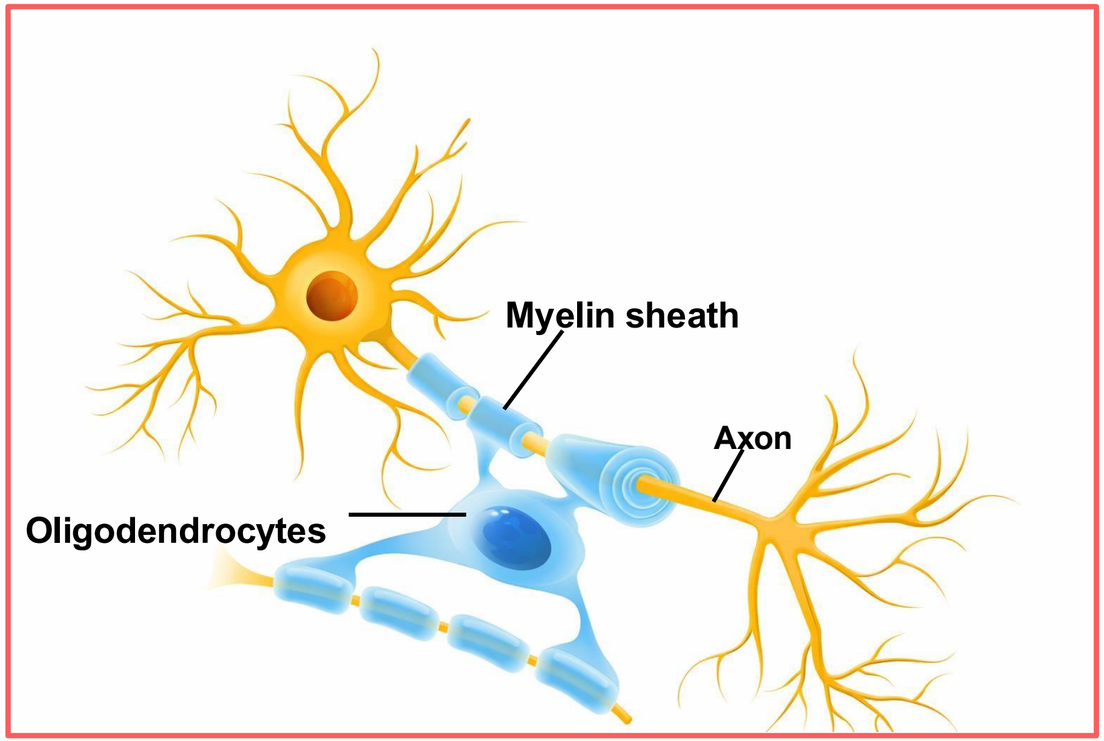
5.1.2 Neuroglia (Glial Cells)

➢ Types of neuroglia in the CNS:

2. Oligodendrocytes

- **Smaller than astrocytes and have fewer processes.**
- **Function:**
  - **Form and maintain the myelin sheath around CNS axons.**

Synthesis of myelin in the CNS



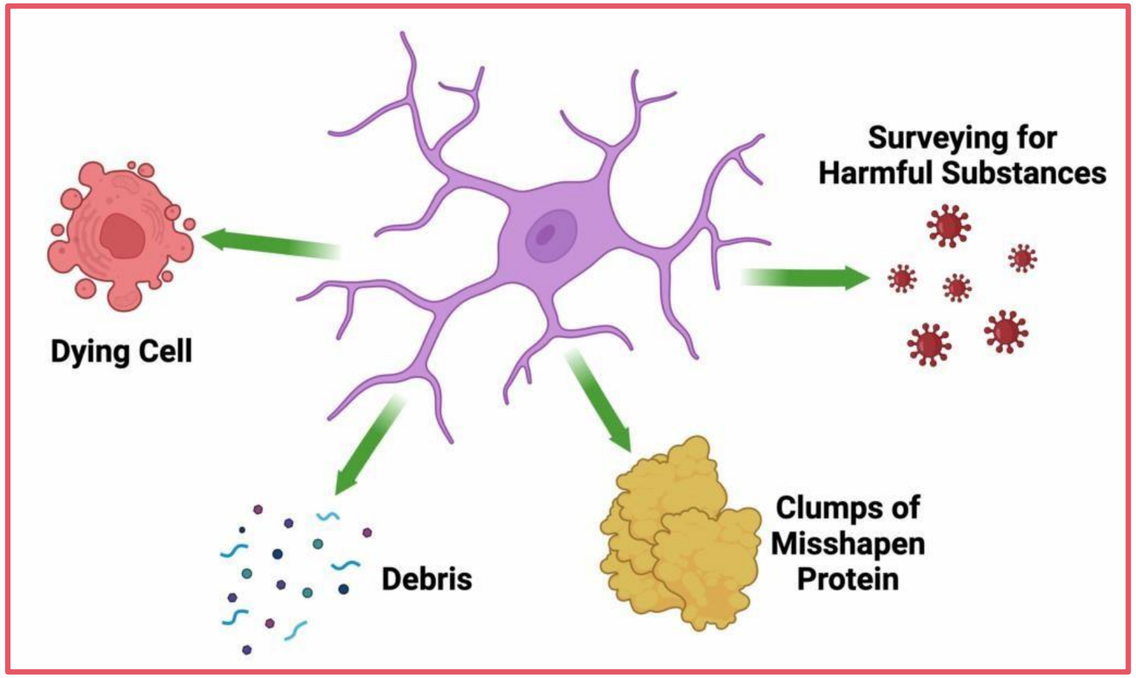
5.1.2

Neuroglia (Glial Cells)

➢ Types of neuroglia in the CNS:

3. Microglia

- **The smallest of the glial cells and phagocytic in nature.**
- **Function:**
  - **Act as phagocytes similar to tissue macrophages.**
  - **Remove cellular debris formed during normal nervous system development and engulf microbes and damaged neural tissue.**



5.1.2

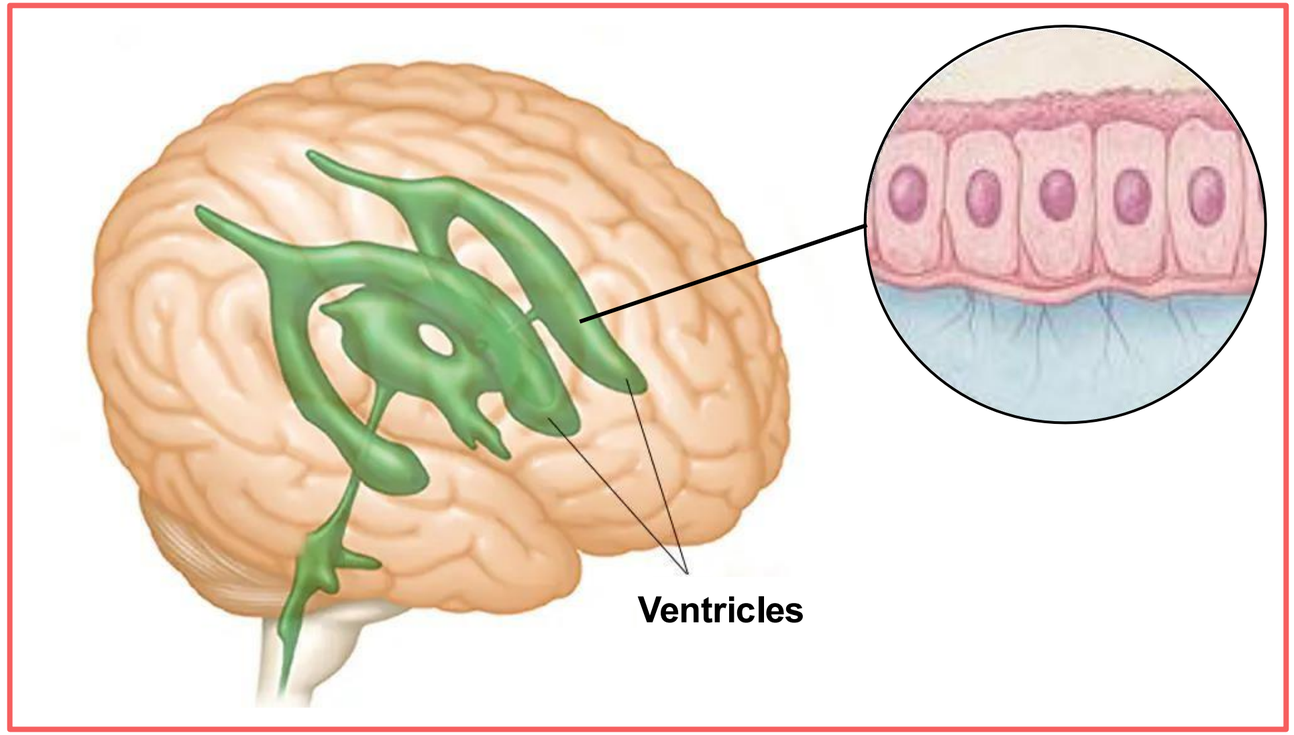
Neuroglia (Glial Cells)

➢ Types of neuroglia in the CNS:

4. Ependymal Cells

- **Form a single layer of cuboidal or columnar cells with microvilli and cilia.**
- **Line the ventricles of the brain and the central canal of the spinal cord.**
- **Function:**
  - **Produce and assist in the circulation of cerebrospinal fluid (CSF).**

Ventricles are cavities inside the brain where cerebrospinal fluid (CSF) is produced



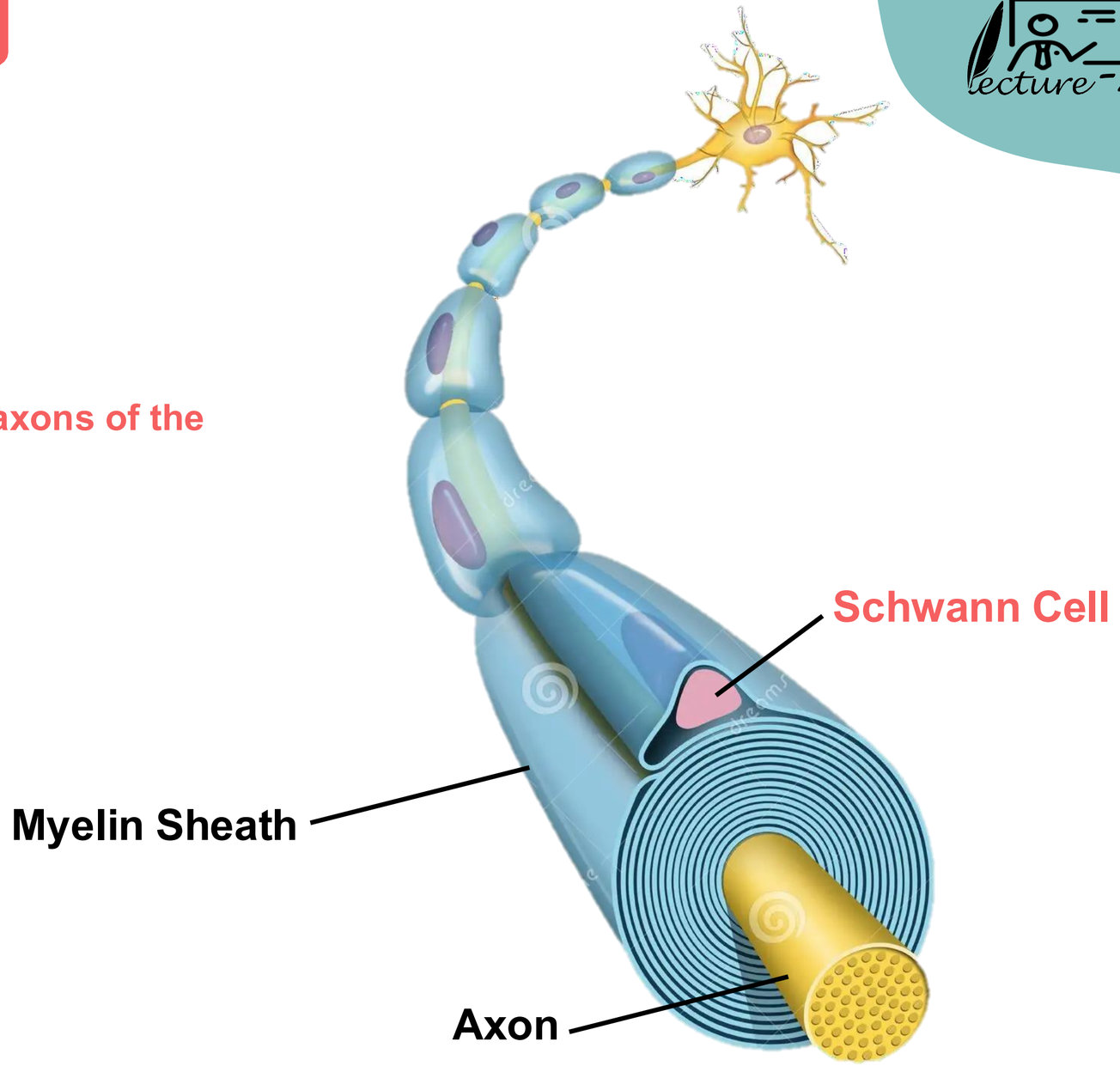
5.1.2

Neuroglia (Glial Cells)

➢ **Types of neuroglia in the PNS:**

1. Schwann cells

- **These cells encircle PNS axons.**
- **Function:**
  - **They form the myelin sheath around axons of the peripheral nervous system.**



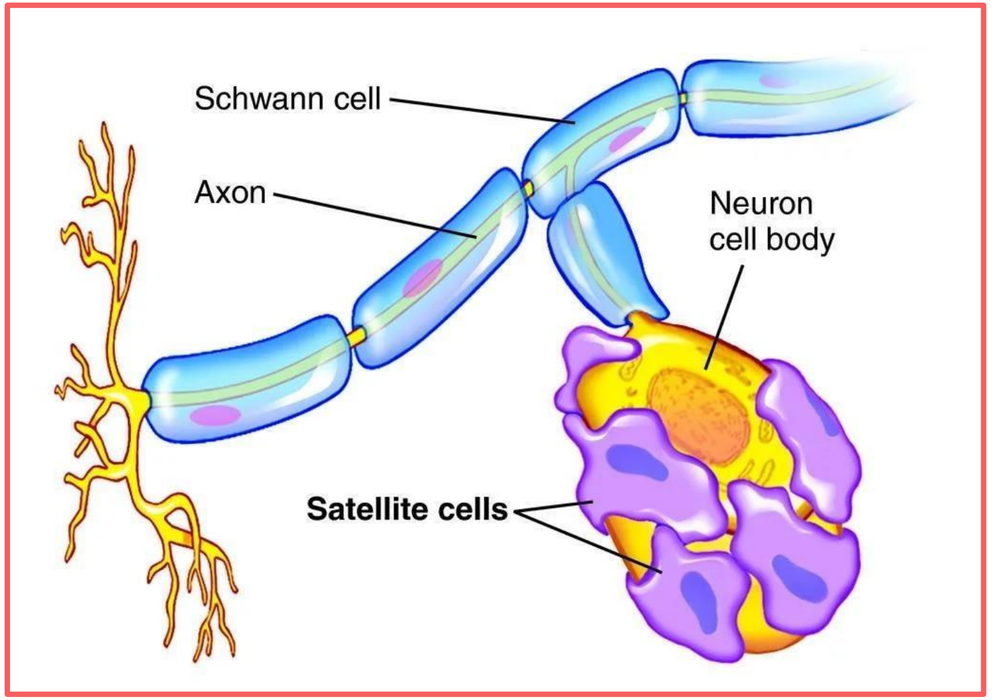
5.1.2

Neuroglia (Glial Cells)

➢ Types of neuroglia in the PNS:

2. Satellite cells

- **Flat cells that surround the cell bodies of neurons within PNS ganglia.**
- **Function:**
  - **Provide structural support.**



5.1.3

Nerve Fibers

❖ Myelin Sheath

➢ The myelin sheath is an insulating layer composed of proteins and lipids that forms around the axon.

➢ In the CNS, it is formed by **oligodendrocytes**.

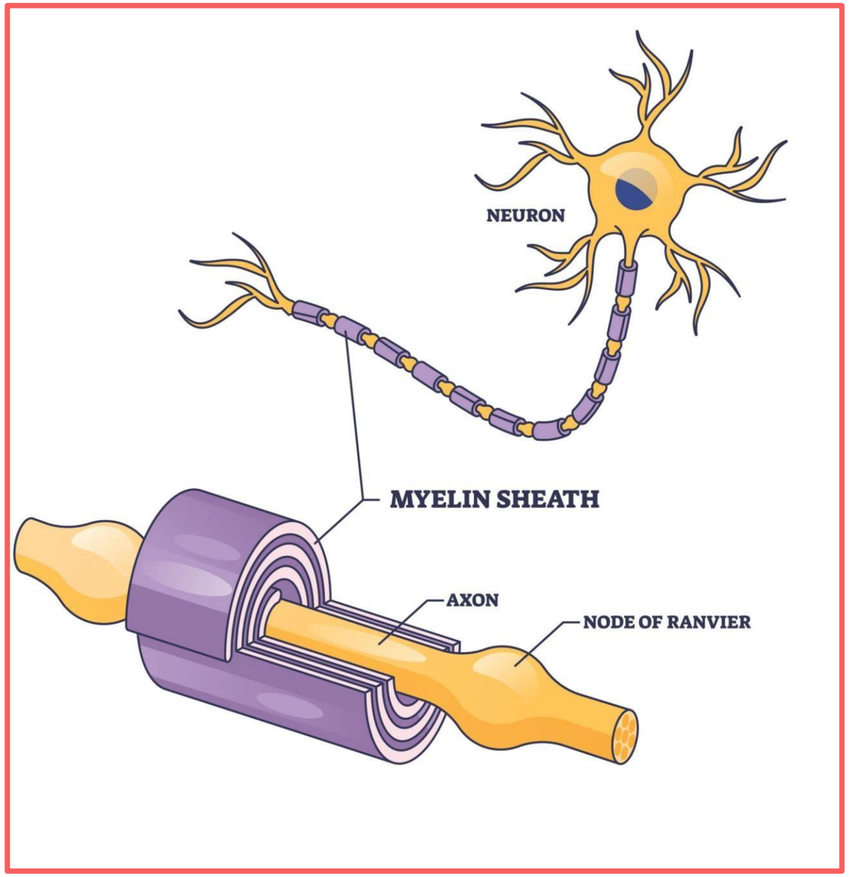
➢ In the PNS, it is formed by **Schwann cells**.

Myelin sheath is an insulator layer the covers(wraps) the axon

➢ Function:

- **Protects the axon.**
- **Enables rapid and efficient transmission of electrical impulses along nerve cells.**

Increases the speed of action potential



5.1.3

Nerve Fibers

Gross

➢ The axon of nerve cell is called nerve fiber.

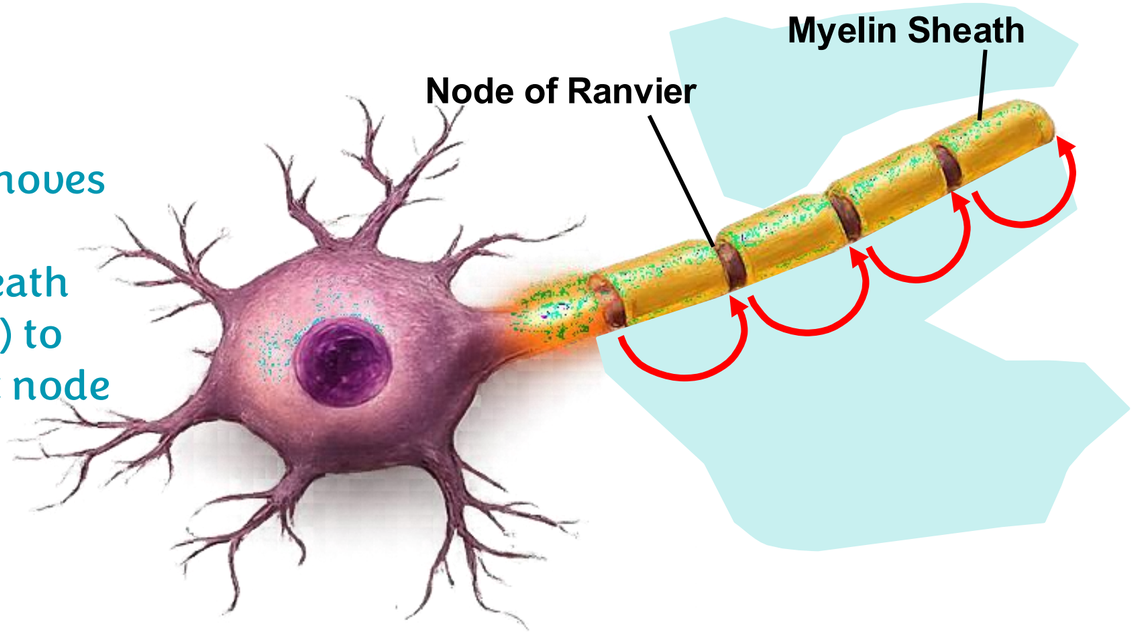
B12 is important because It enters in the formation of myelin sheath so it makes action potential moving quicker

➢ There are two types of nerve fibers:

1. Myelinated Nerve Fibers

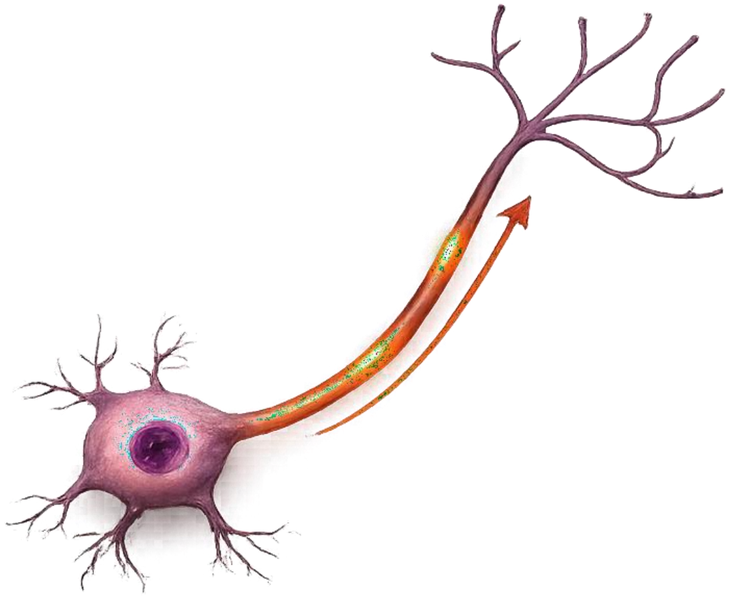
- Surrounded by a myelin sheath.
- The conduction of action potentials is faster, as impulses jump from one Node of Ranvier to the next.

The action potential moves under the myelin sheath (axoplasm) to the closest node



2. Unmyelinated Nerve Fibers

- Lack a myelin sheath.
- Conduction of impulses is slower, as the action potential travels continuously along the fiber.



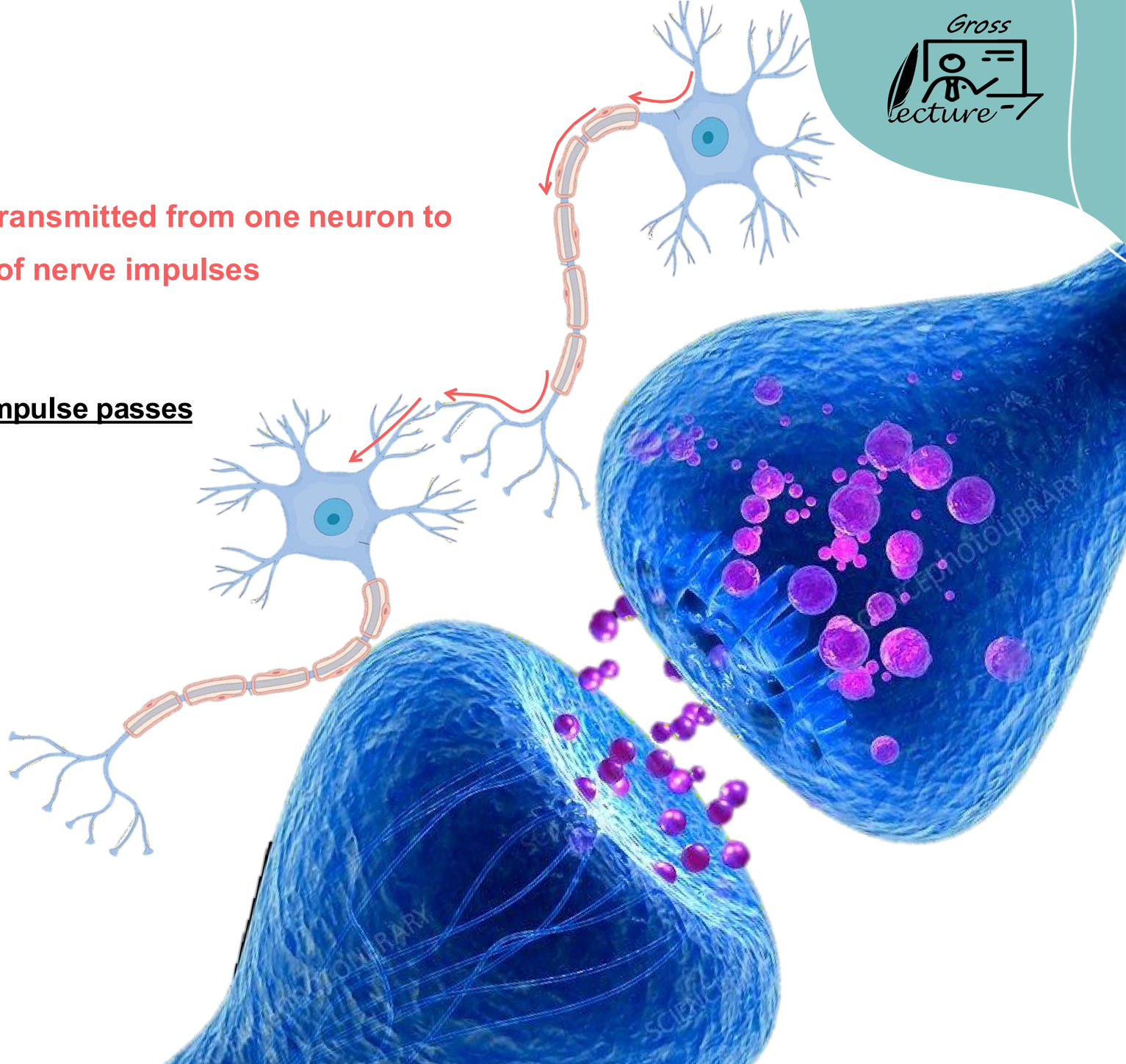
5.1.3

Nerve Fibers

Gross lecture-7

❖ Synapse

- In the nervous system, information is transmitted from one neuron to another through **synapses** in the form of nerve impulses (action potentials).
- A synapse is **the junction where a nerve impulse passes from one neuron to the next.**



5.1.3

Nerve Fibers

❖ Synapse

➢ Structure of Synapse

1. Presynaptic Neuron

- **Contains synaptic vesicles filled with neurotransmitters.**
- **The tips of its axon terminals form synaptic end bulbs containing these vesicles.**

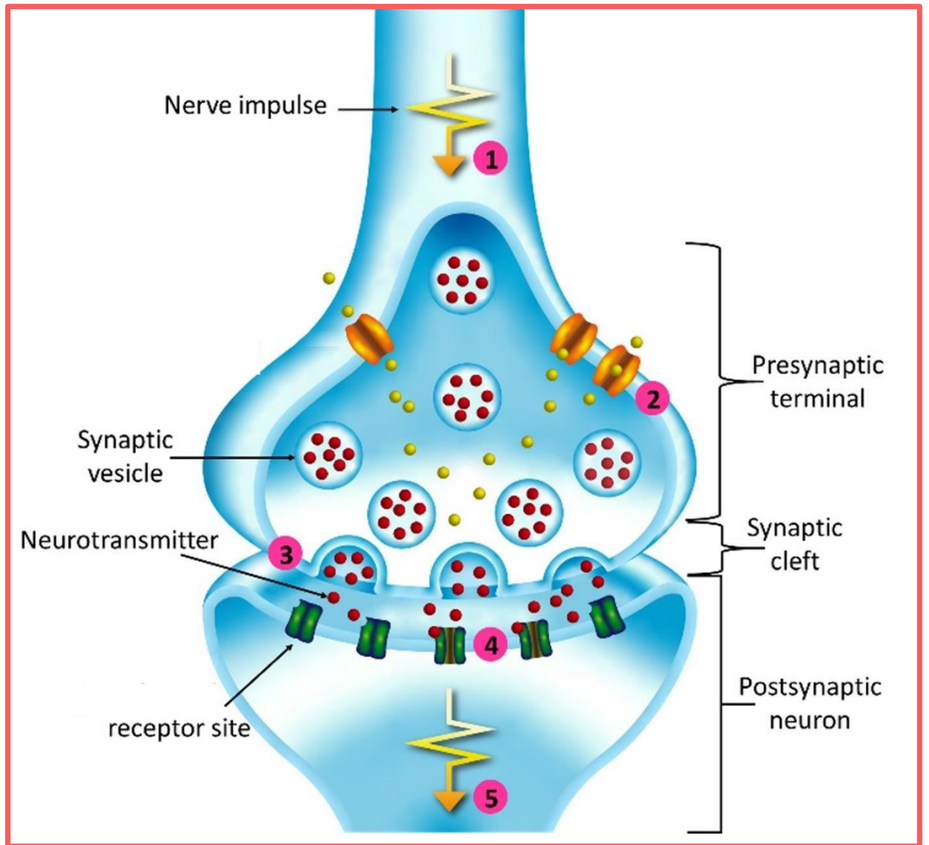
2. Postsynaptic Neuron

- **Contains receptor sites on its membrane that bind neurotransmitters.**

3. Synaptic Cleft

- **A small gap separating the presynaptic and postsynaptic membranes.**

Vesicles contain neurotransmitters when they are released by exocytosis it binds to the gated channels causing action potential to occur



5.1.3

Nerve Fibers

❖ Synapse

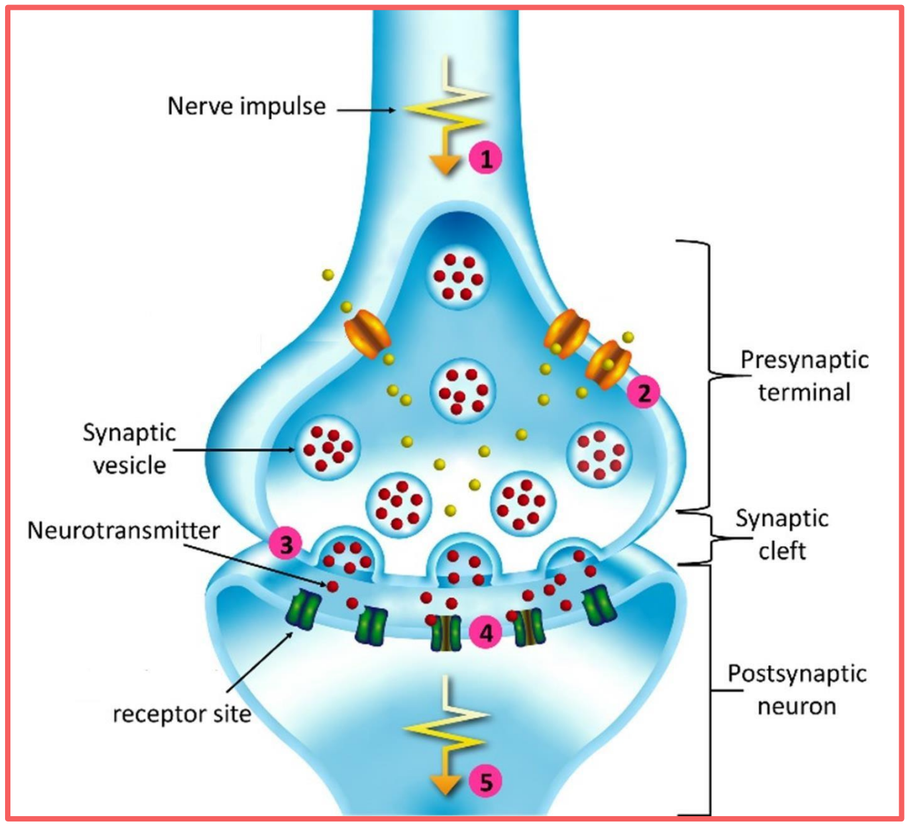
➢ Mechanism of Impulse Transmission Across a Synapse

1 2 3 **When a nerve impulse reaches the presynaptic terminal, neurotransmitters are released into the synaptic cleft.**

4 **The neurotransmitters bind to receptors on the postsynaptic membrane.**

5 **This binding causes depolarization of the postsynaptic membrane, generating a new nerve impulse.**

Thus, impulses are transmitted from one neuron to another.



Dr A. Hamida

5.1.4

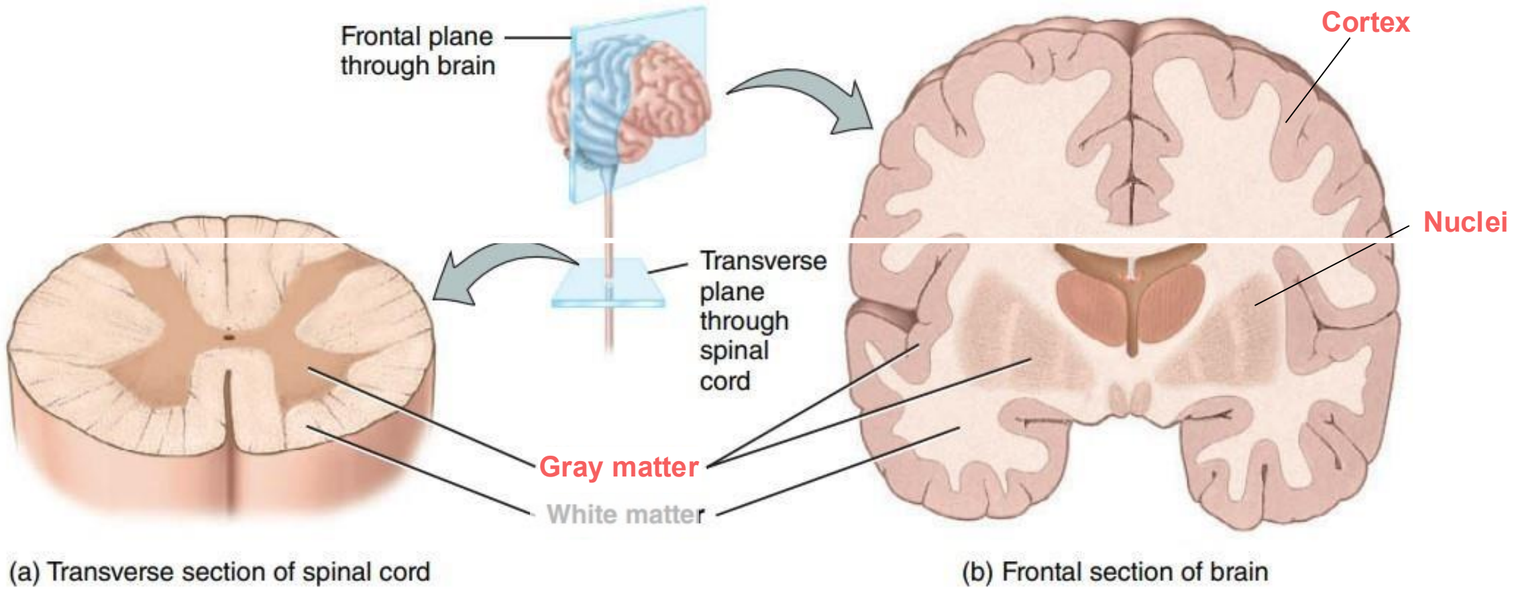
Gray Matter

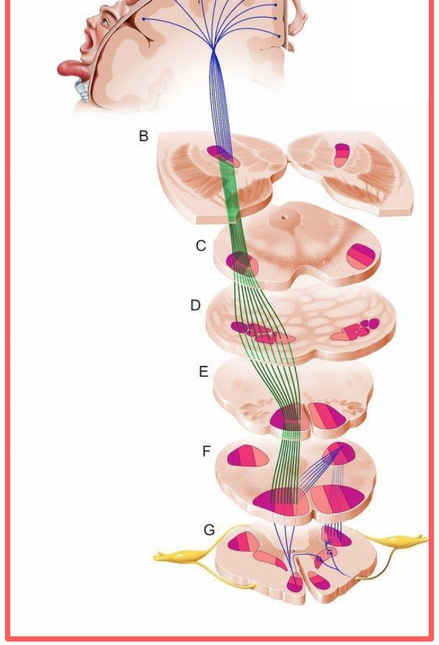
Gross lecture-7

- It is a collection of neuron cells bodies in the CNS.
- It is called gray because the cell body contain **DNA/RNA which make the dark color.**
- In the brain, gray matter located on the outer surface is known as the **cortex**, while gray matter located deeper within the brain forms **nuclei**.
- In the spinal cord, gray matter is located centrally.

Nucleus and nuceleolus contain DNA/RNA which are dark in colour that's why a bundle of neuron cells bodies appears dark in colour

The center appears whitish due to myelin sheath which is white in colour





Dr. Ahmida

5.1.5

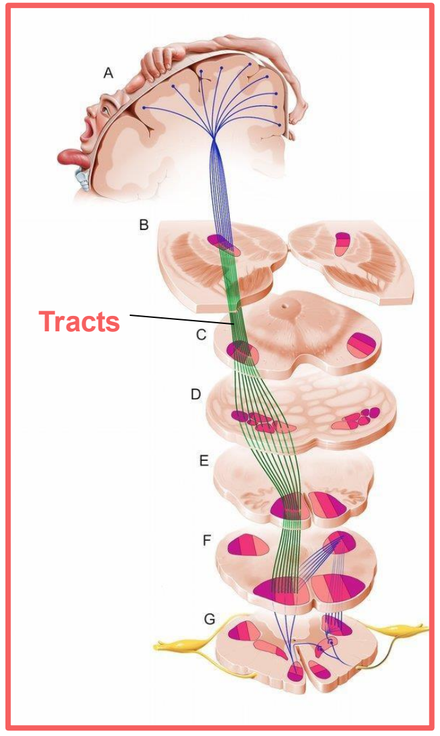
White Matter

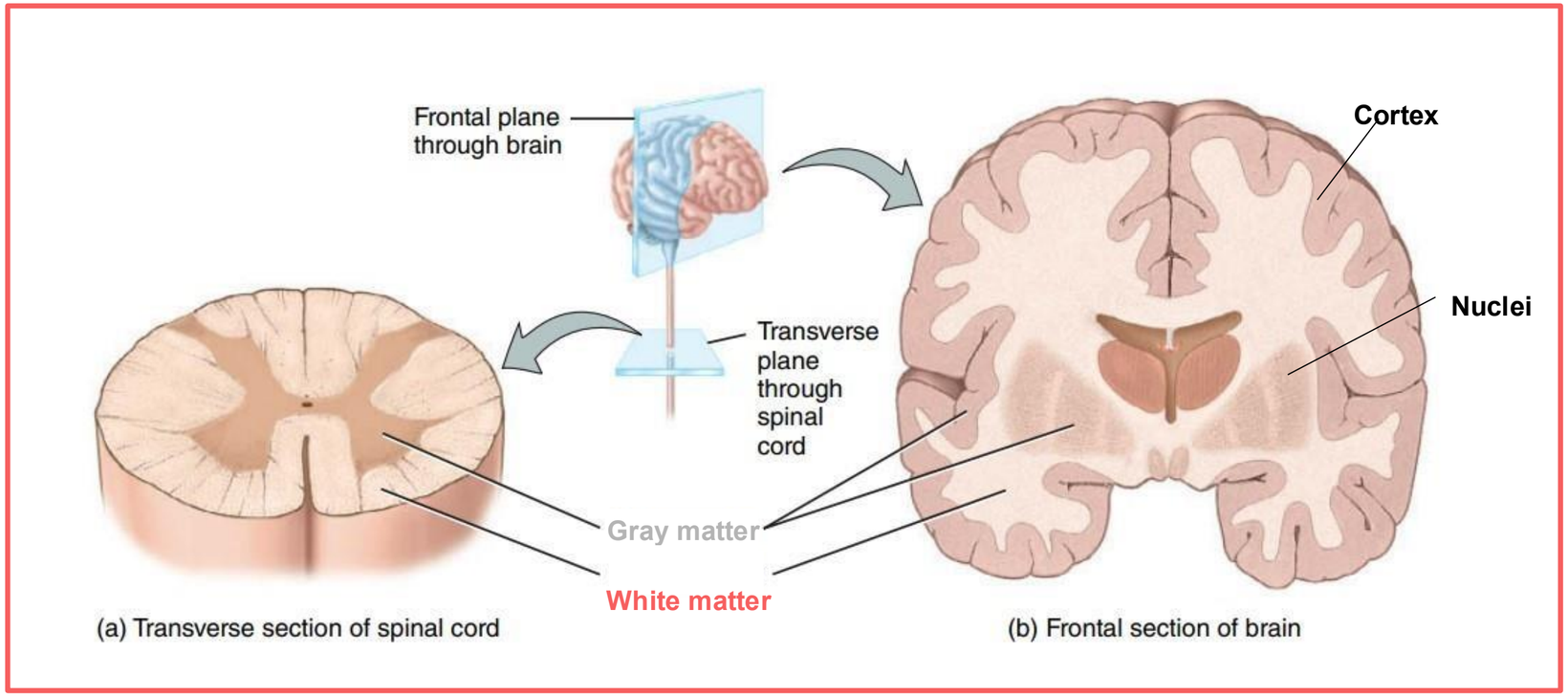
Gross lecture-7

- It is a collection of myelinated axons in the CNS
- It is called white because the axons are **covered by myelin sheath which is white in color.**
- **In the brain**, white matter present in the **center**, whereas **in the spinal cord**, it lies at the **periphery**.
- Bundles of white matter fibers in the spinal cord are known as **tracts**.

White matter fibers are myelinated axons

A Nerve is a bundle of axons within the PNS while a tract is a bundle of axons within CNS





Test your knowledge!

https://forms.gle/sZ1akqeqtJ2SFpQLA

رسالة من الفريق العلمي:

قال رسول الله –صلى الله عليه وسلم-: " مَنْ سَلَكَ طريقًا يلتمسُ فِيْهِ علمًا، سَهَّلَ اللهُ لهُ بِهِ طريقًا إلىٰ الجنَّةِ".

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	Slide 5 Text on the top right	the outer is "positive"	The outer is "negative"
V1 → V2			