Physiology of the Nerve & Muscle System(2)

Second Stage/ University of Anbar-College of Dentistry

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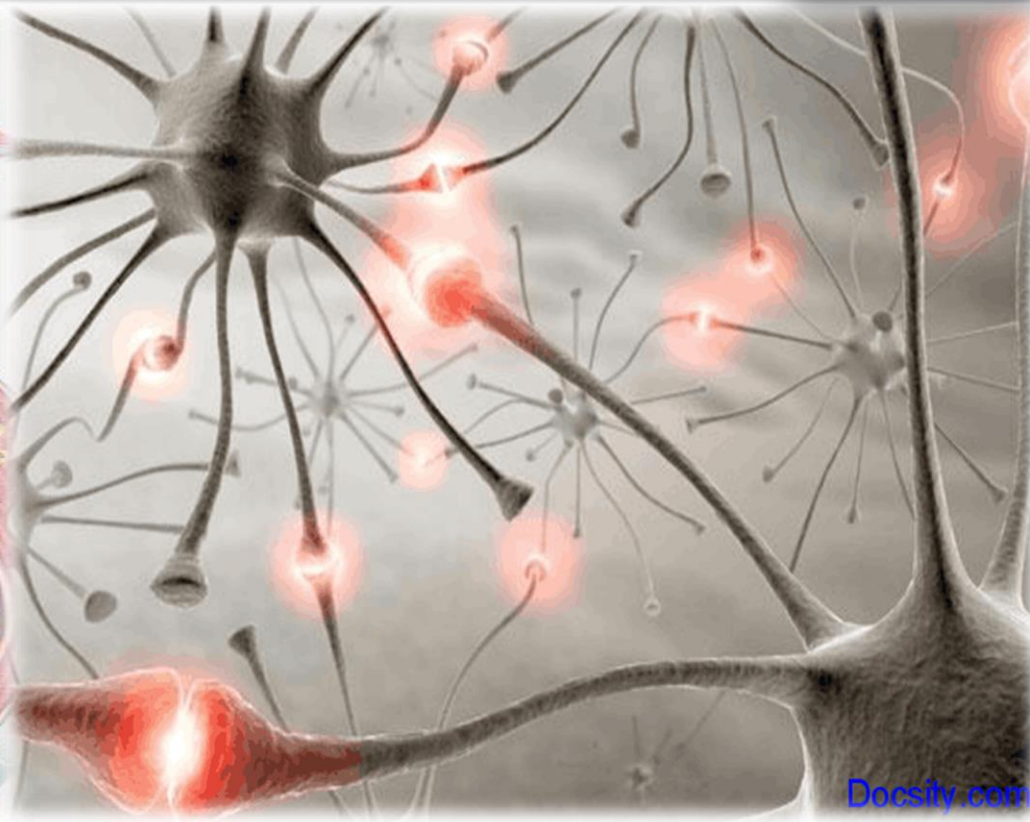
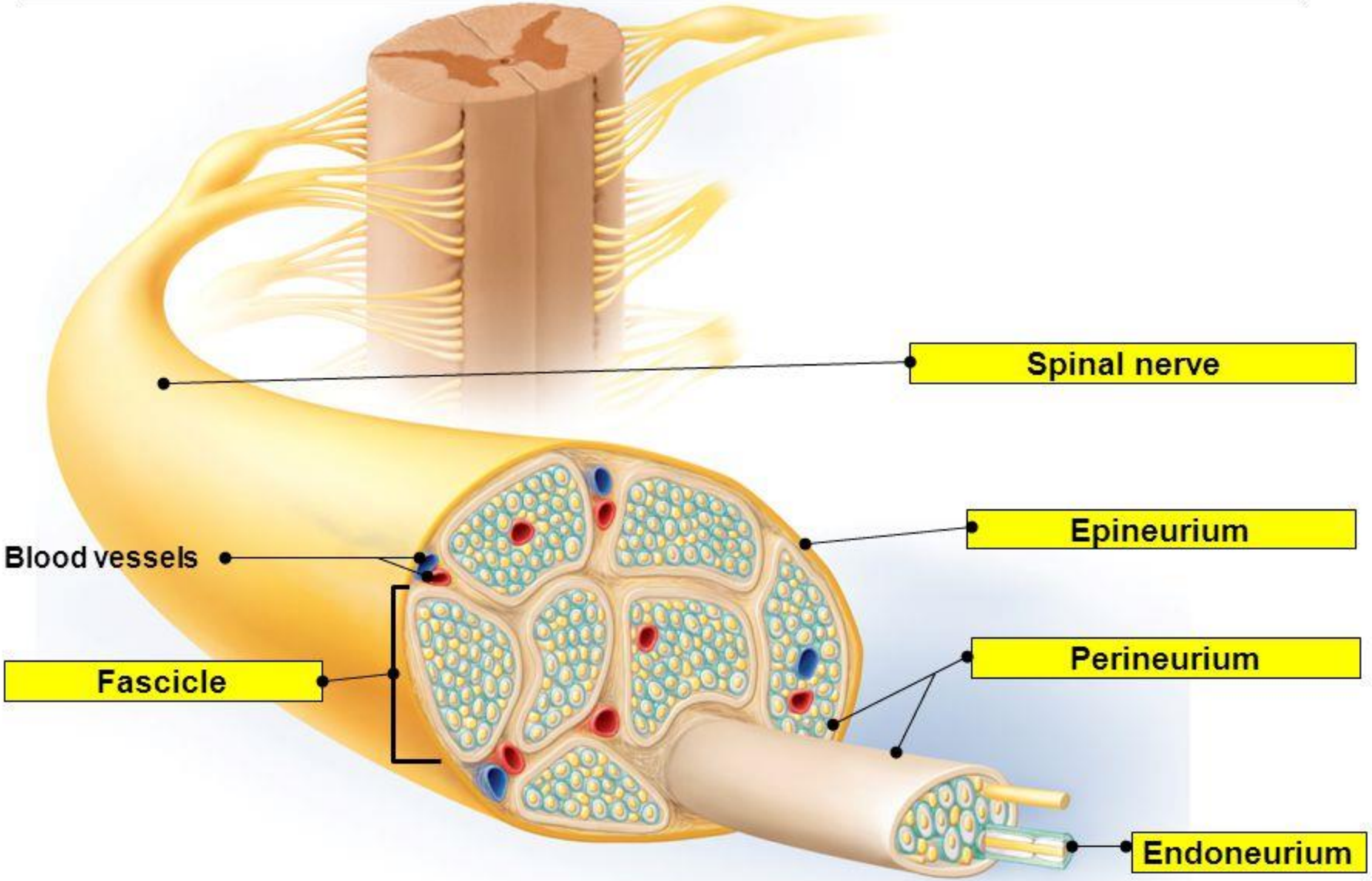


Anatomy of a nerve



Internal structure of axon — Axis cylinder

- ✓ The axon has a long central core of cytoplasm called **axoplasm**.
- ✓ The axoplasm is covered by the tubular sheath like membrane called **axolemma** which is the continuation of the cell membrane of nerve cell body.
- ✓ The axoplasm along with the axolemma is called the axis cylinder of the nerve fiber (Fig. 1).
- ✓ Axoplasm contains mitochondria, neurofibrils and axoplasmic vesicles. But, Nissl bodies are absent in the axon

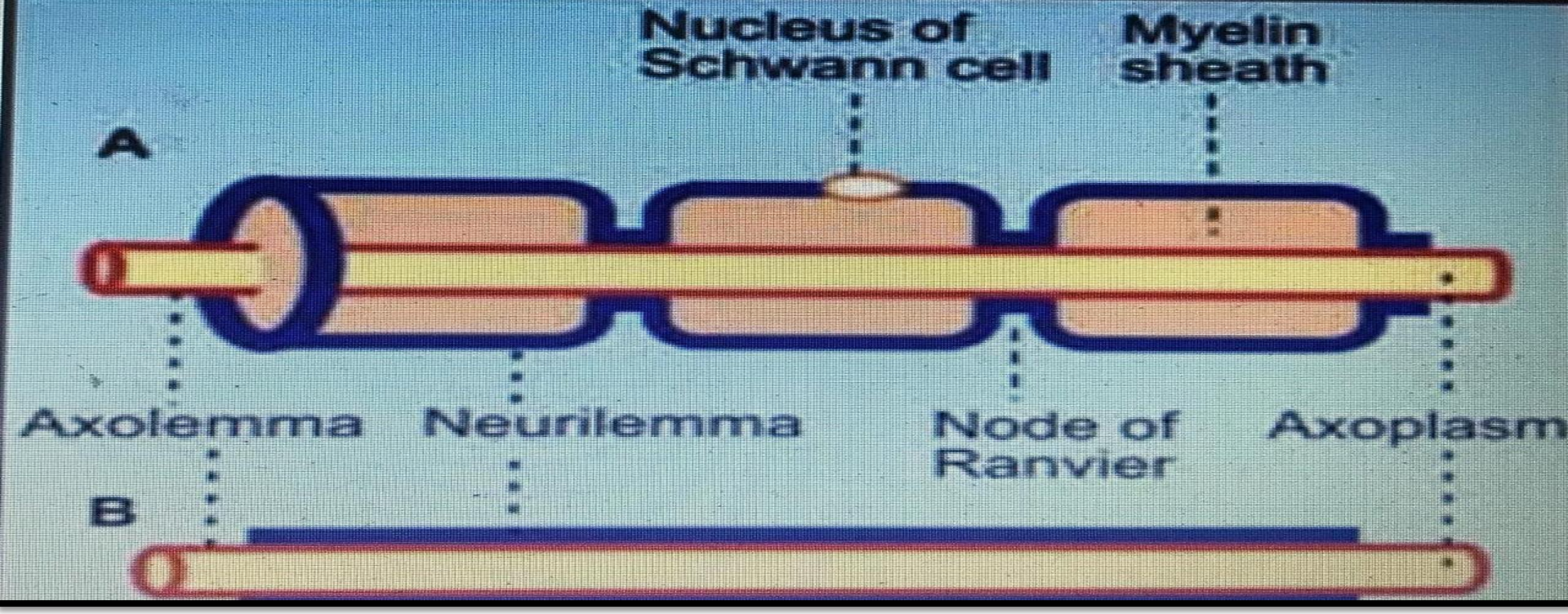


Figure (1) :- A- Myelinated never fiber B- Non- myelinated nerve

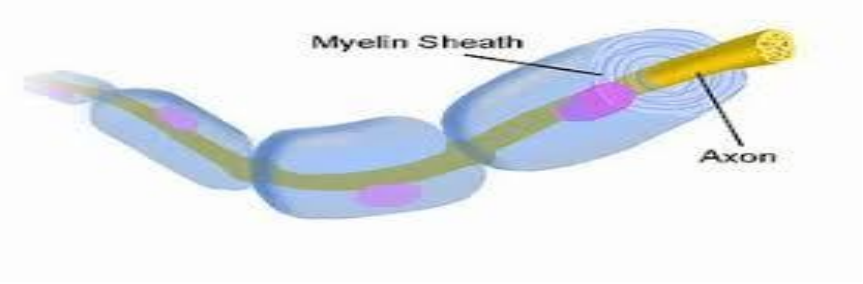
Myelinated nerve fiber

The nerve fibers which are insulated by myelin sheath are called myelinated nerve fibers.

Non - myelinated nerve fiber

The nerve fiber described above is the non-myelinated nerve fiber which is not covered by myelin sheath

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 the myelin sheath is absent is called node of Ranvier .
- The segment of the nerve fiber between two nodes is called internode.
- Myelin sheath is responsible for the white color of the nerve fibers.

Chemistry of Myelin Sheath

Myelin sheath is formed by concentric layers of proteins alternating with lipids. The lipids are cholesterol and lecithin.

Formation of myelin sheath — Myelinogenesis

The formation of myelin sheath around the axon is called the myelinogenesis. It is formed by Schwann cells in neurilemma.

Functions of myelin sheath

1- Faster conduction: Myelin sheath is responsible for faster conduction of impulse through the nerve fibers.

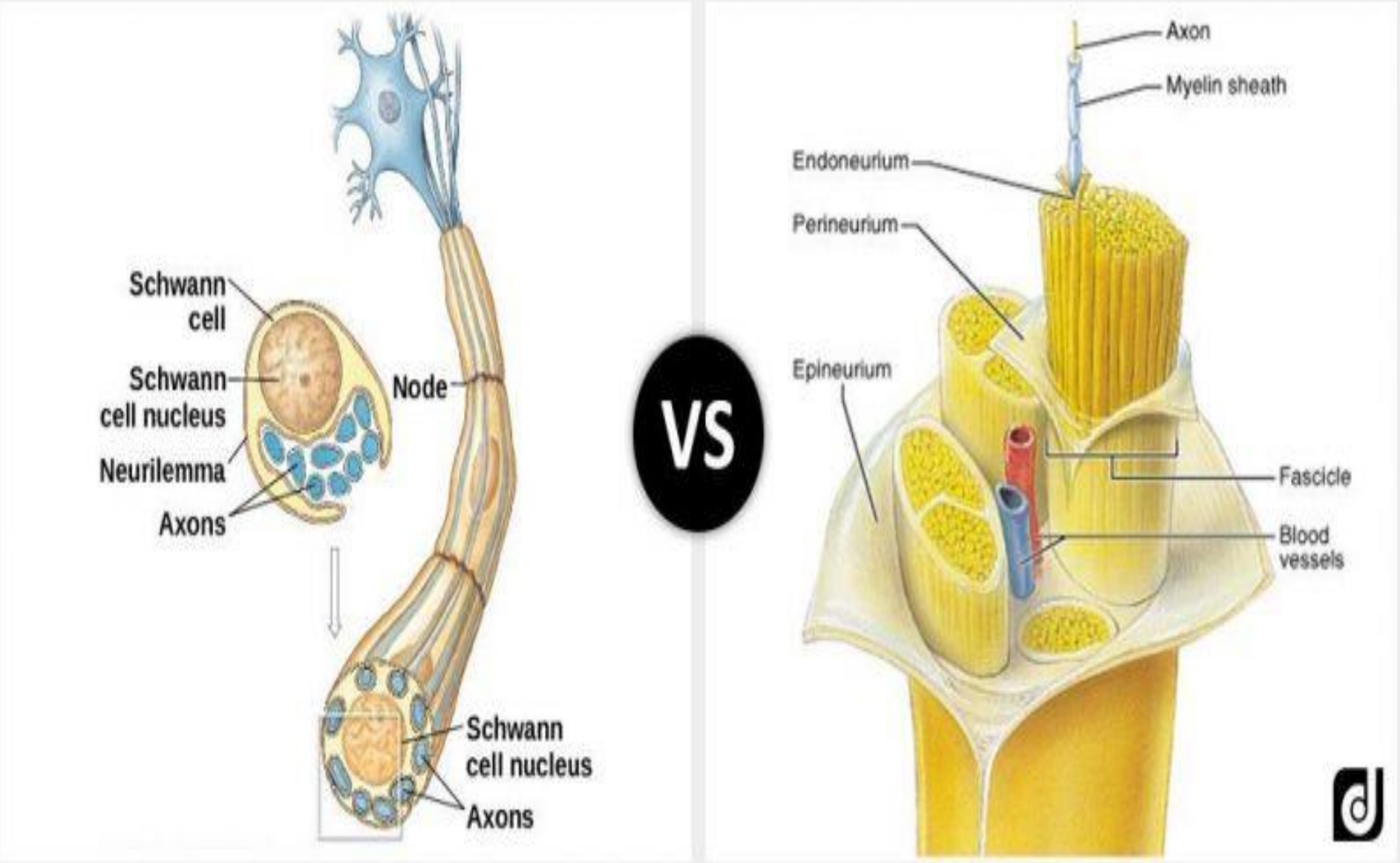
2- Insulating capacity: Myelin sheath has a high insulating capacity. Because of this quality, the myelin sheath restricts the nerve impulse within the single nerve fiber, and prevents the stimulation of neighboring nerve fibers.

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 nucleus.**
- **The cytoplasm is thin and modified to form the thin sheath of neurilemma.**

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 vs. Myelin Sheath

Neurotrophins — Neurotrophic Factors

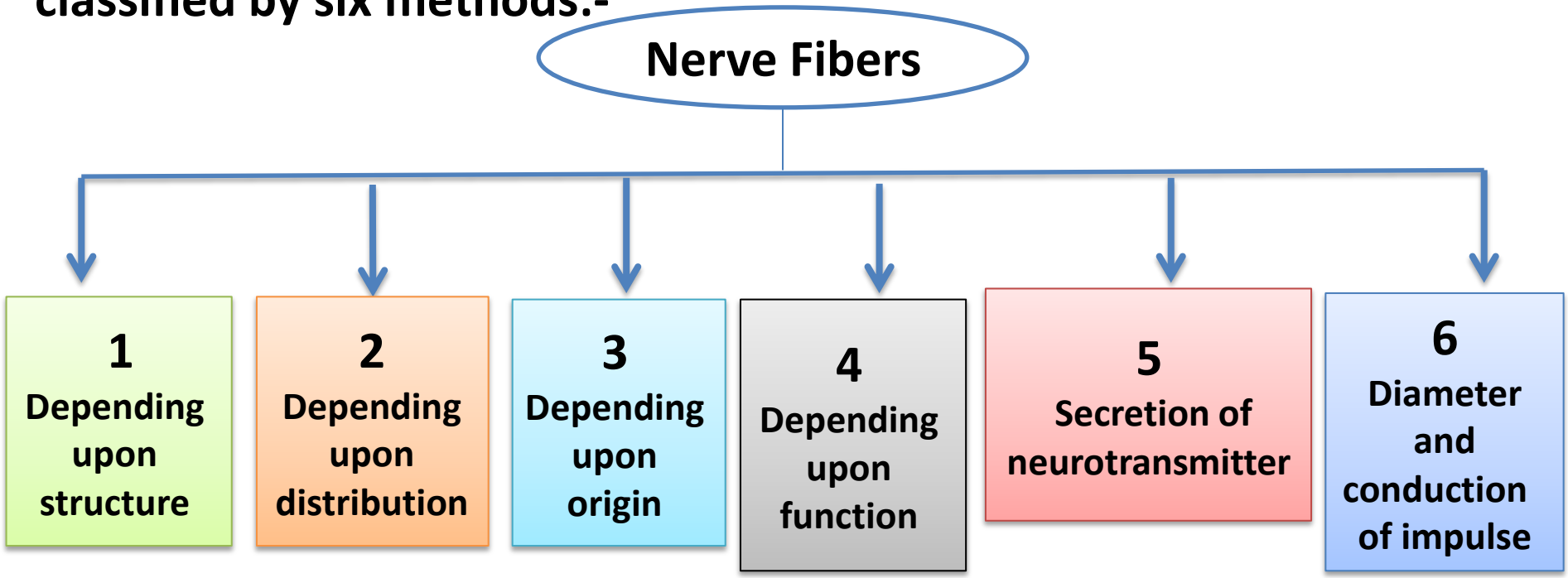
- Neurotrophins or neurotrophic factors are the protein substances, which play important role in growth and functioning of nervous tissue.
- Neurotrophins are secreted by many tissues in the body particularly muscles, neuroglial cells and neurons.

✓ Nerve growth factor (NGF) is an important neurotrophin found in many peripheral tissues. It promotes early growth and development of neurons.

Classification of Nerve Fibers

CLASSIFICATION OF NERVE FIBERS

The nerve fibers are classified by different method, Nerve fibers are classified by six methods:-



CLASSIFICATION OF NERVE FIBERS

1. Depending upon Structure

i. Myelinated nerve fibers that are covered by myelin sheath

ii. Non-myelinated nerve fibers which are not covered by myelin sheath

2. Depending upon Distribution

i. Somatic nerve fibers which supply the skeletal muscles of the body

ii. Visceral or autonomic nerve fibers which supply internal organs of the body

3. Depending upon Origin

i. Cranial nerves arising from brain

ii. Spinal nerves arising from spinal cord

CLASSIFICATION OF NERVE FIBERS

4. Depending upon Function

i. Sensory or afferent nerve fibers which carry sensory impulses from different parts of the body to the central nervous system.

ii. Motor or efferent nerve fibers which carry motor impulses from central nervous system to different parts of the body

5. Depending upon Secretion of Neurotransmitter

i. Adrenergic nerve fibers that secrete noradrenaline

ii. Cholinergic nerve fibers that secrete acetylcholine

6.Depending upon Diameter and Conduction of Impulses(Table 1)

1. Type A nerve fibers(are the thickest fibers)
2. Type B nerve fibers.
3. Type C nerve fibers (are the thinnest fibers)

all the nerve fibers are myelinated

Types of Nerve Fibers

The velocity of impulse through a nerve fiber is directly proportional to the thickness of the fibers (table 1)

Table 1 : Types of Nerve Fibers		
Type	**Diameter(m)**	**Velocity of conduction(meters/second)**
A alpha	**12 to 24**	**70 to 120**
A Beta	**6 to 12**	**30 to 70**
A gamma	**5 to 6**	**15 to 30**
A delta	**2 to 5**	**12 to 15**
B	**1 to 2**	**3 to 10**
C	**< 1.5**	**0.5 to 2**

Properties of nerve fibers

Properties of Nerve Fibers

1- Excitability

Excitability is defined as the physiochemical change that occurs in a tissue when a stimulus is applied.

The stimulus is defined as an external agent, which produces excitability in the tissues

((Action potential or nerve impulse))

The action potential in a nerve fiber is similar to that in a muscle, except for some minor differences (table 2).

The resting membrane potential in the nerve fiber is –70 mV. The firing level is at –55 mV.

Depolarization ends at +35 mV (Fig. 2). Usually, the action potential starts in the initial segment of nerve fiber

Differences between electrical potential in nerve fiber and muscle fiber (table2)

Event	Nerve fiber	Skeletal muscle fiber
Resting membrane potential	__ 70 mv	__ 90 mv
Firing level	__ 55 mv	__ 75 mv
End of depolarization	+ 35 mv	+ 55 mv

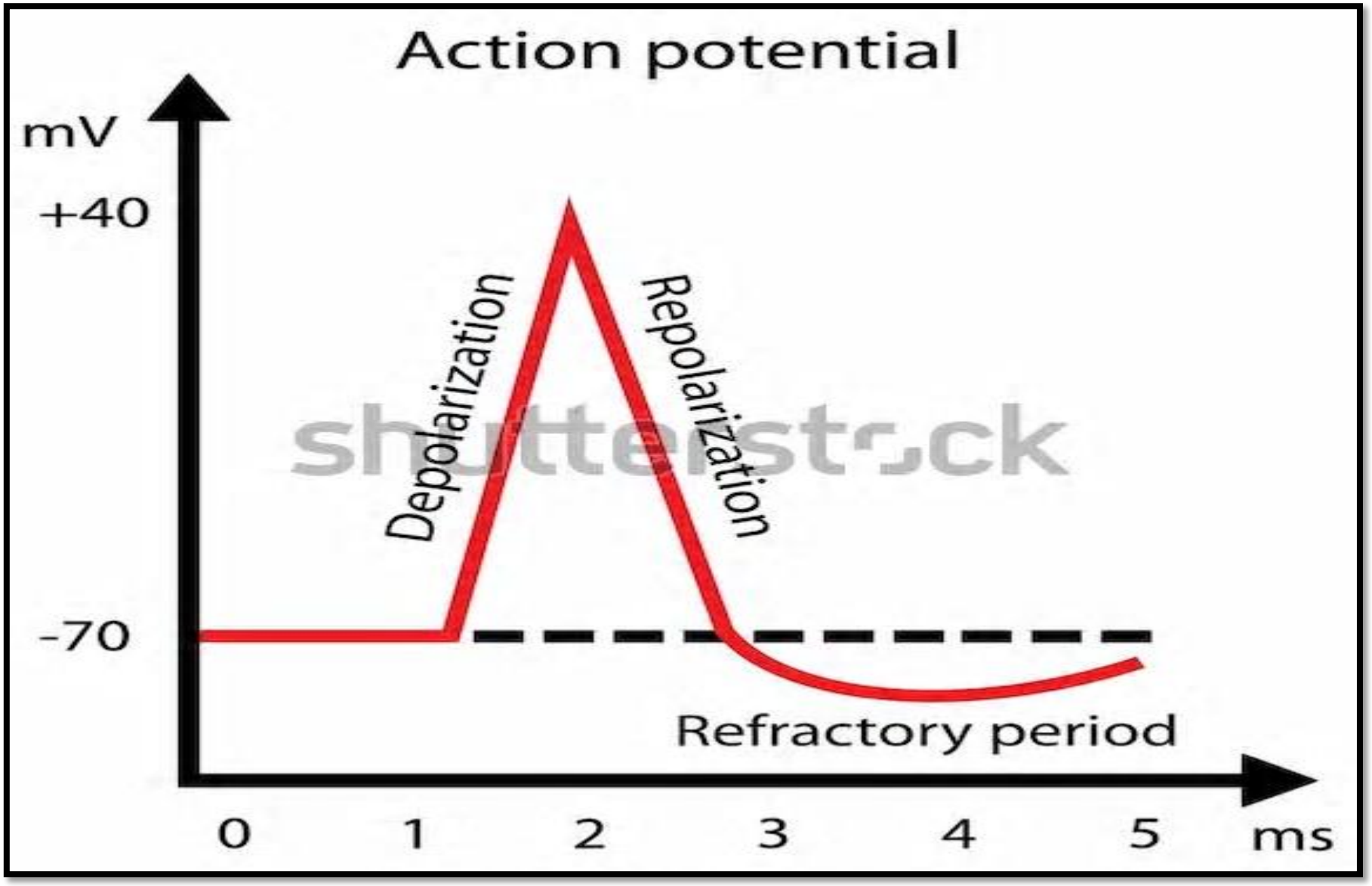


FIGURE 2: Action potential in nerve fiber

2- CONDUCTIVITY

- ✓ **Is the ability of nerve fibers to transmit the impulse from the area of stimulation to the other areas. The 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**

Mechanism of conduction of action potential

- The 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

- Saltatory conduction is the form of conduction of nerve impulse in which, the impulse jumps from one node to another.
- Conduction of impulse through a myelinated nerve fiber is about 50 times faster than through a non-myelinated fiber.

- It is because the action potential jumps from one node to another node of Ranvier instate of travelling through the entire nerve fiber (Fig. 3).

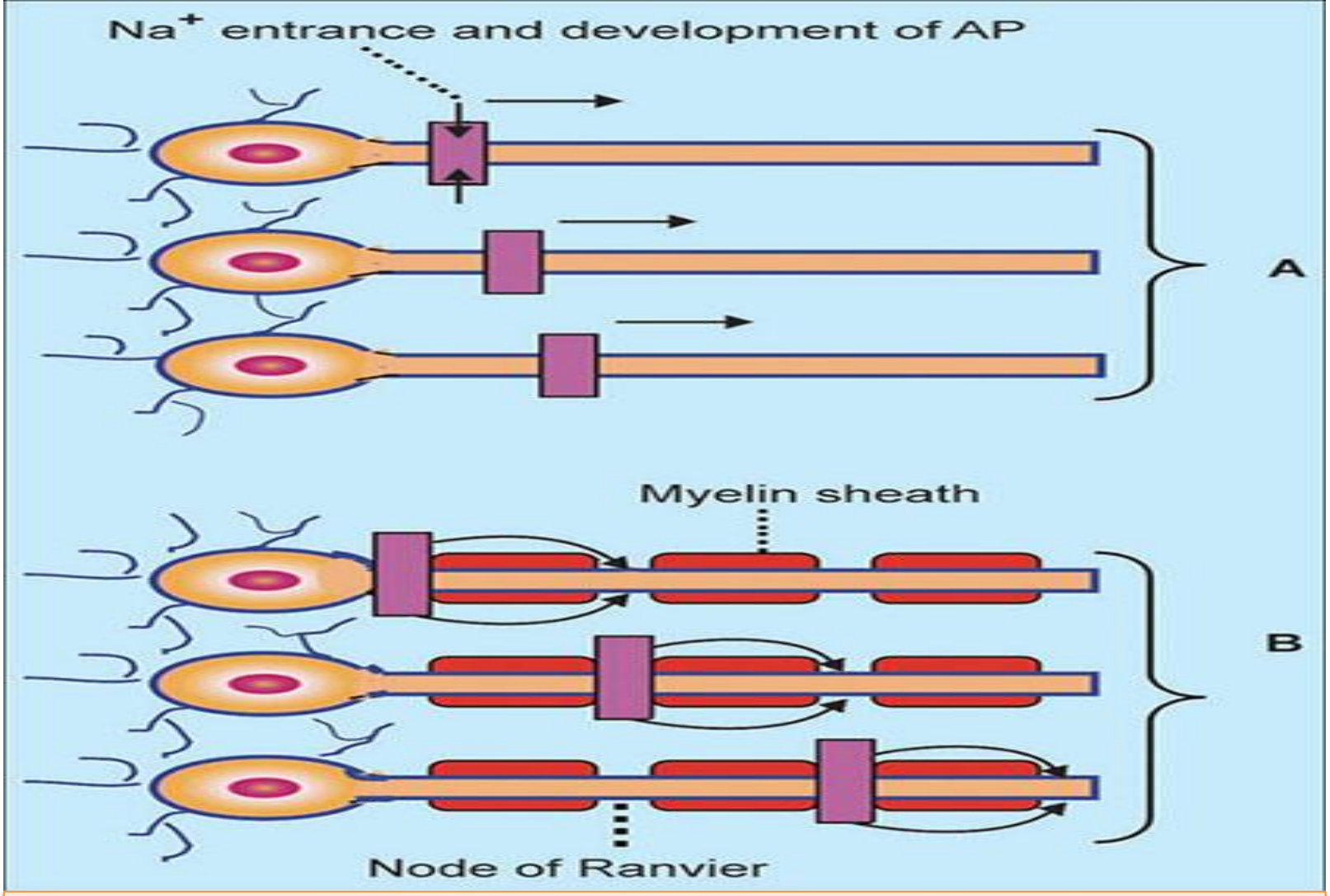


Figure 3: Mode of conduction through nerve fibers

A. Non-myelinated nerve fiber — Continuous conduction
B. Myelinated nerve fiber — Saltatory conduction: Impulse jumps from node to node. AP = Action potential

3- Refractory Period

Refractory period is the period at which the nerve does not give any response to a stimulus.

Refractory period is of two types :-

1. Absolute refractory period:

Absolute refractory period is the period during which the nerve does not show any response at all, whatever may be the strength of stimulus

2. Relative refractory period:

It is the period, during which the nerve fiber shows response, if the strength of stimulus is increased to maximum.

4- 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 incident is known as adaptation or accommodation.

5- Infatigability

A nerve fiber cannot be fatigued, even if it is stimulated continuously for a long time.

The reason for this is the 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.

Neuroglia

Neuroglia :- is the supporting cell of the nervous system. The neuroglial cells are non-excitable and do not transmit nerve impulse (action potential). So, these cells are also called non-neural cells or glial cells.

Classification of Neuroglial Cells

the neuroglial cells are distributed in

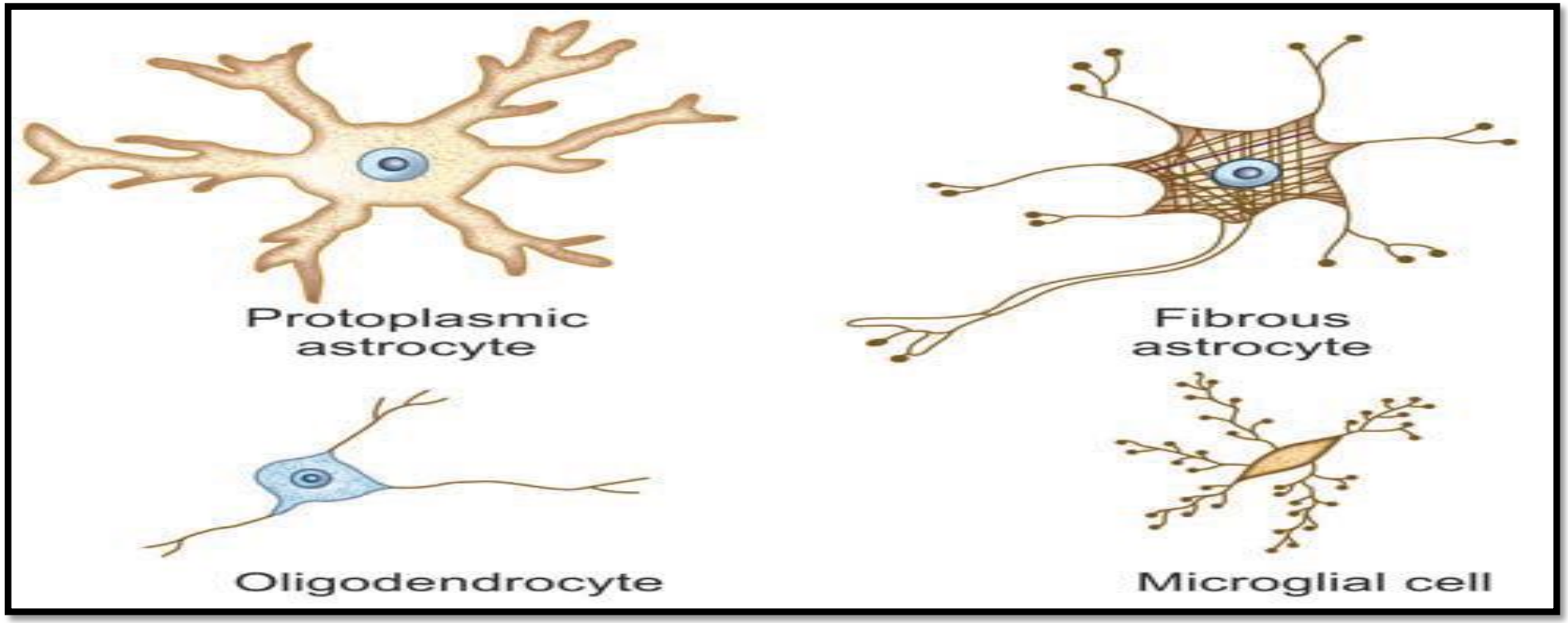
1- central nervous system (CNS) .

2- peripheral nervous system (PNS).

Central Neuroglial Cells

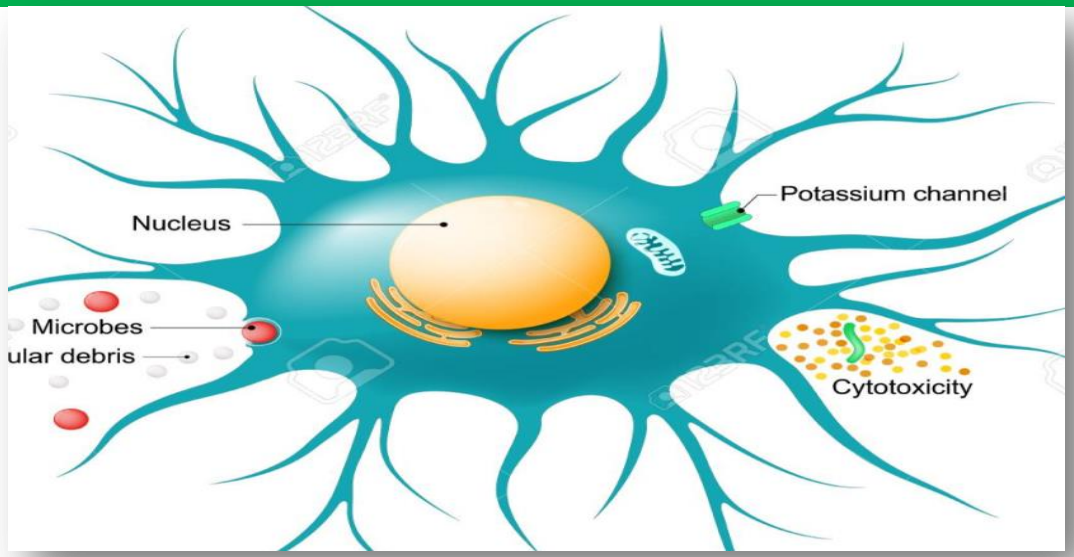
The neuroglial cells in CNS are of **three types**:

1. Astrocytes are star shaped neuroglial cells present in all the parts of the brain. Astrocytes are of two types, fibrous astrocytes and protoplasmic astrocytes.



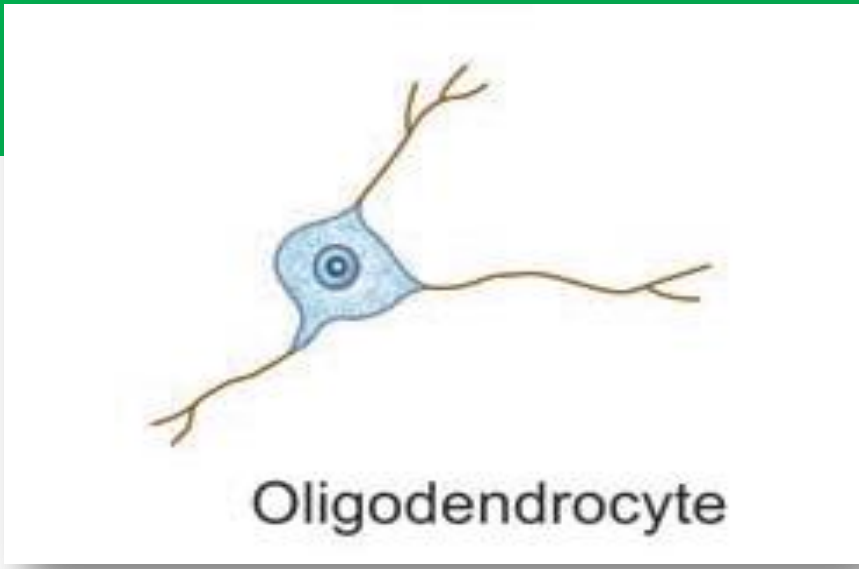
Central Neuroglial Cells

2- Microglia



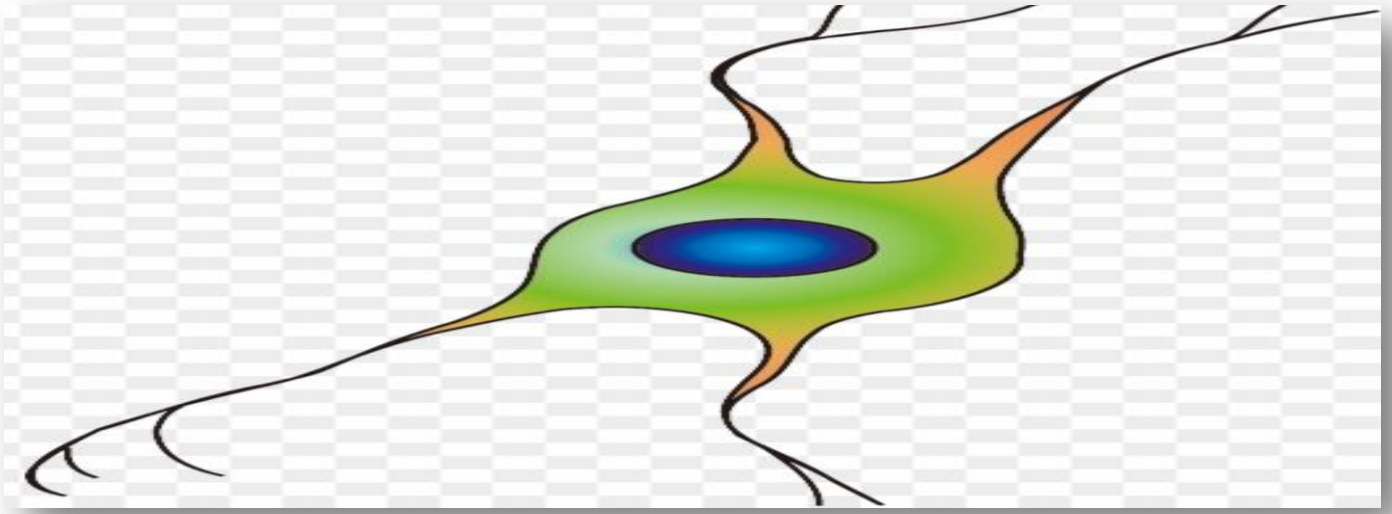
- Are the smallest neuroglial cells. These cells are derived from monocytes and enter the tissues of nervous system from blood.
- These phagocytic cells migrate to the site of infection or injury and are often called the macrophages of CNS.

Central Neuroglial Cells



3- **Oligodendrocytes**

- **Are neuroglial cells which produce myelin sheath around nerve fibers in CNS.**
- **Oligodendrocytes provide myelination around the nerve fibers in CNS where Schwann cells are absent**



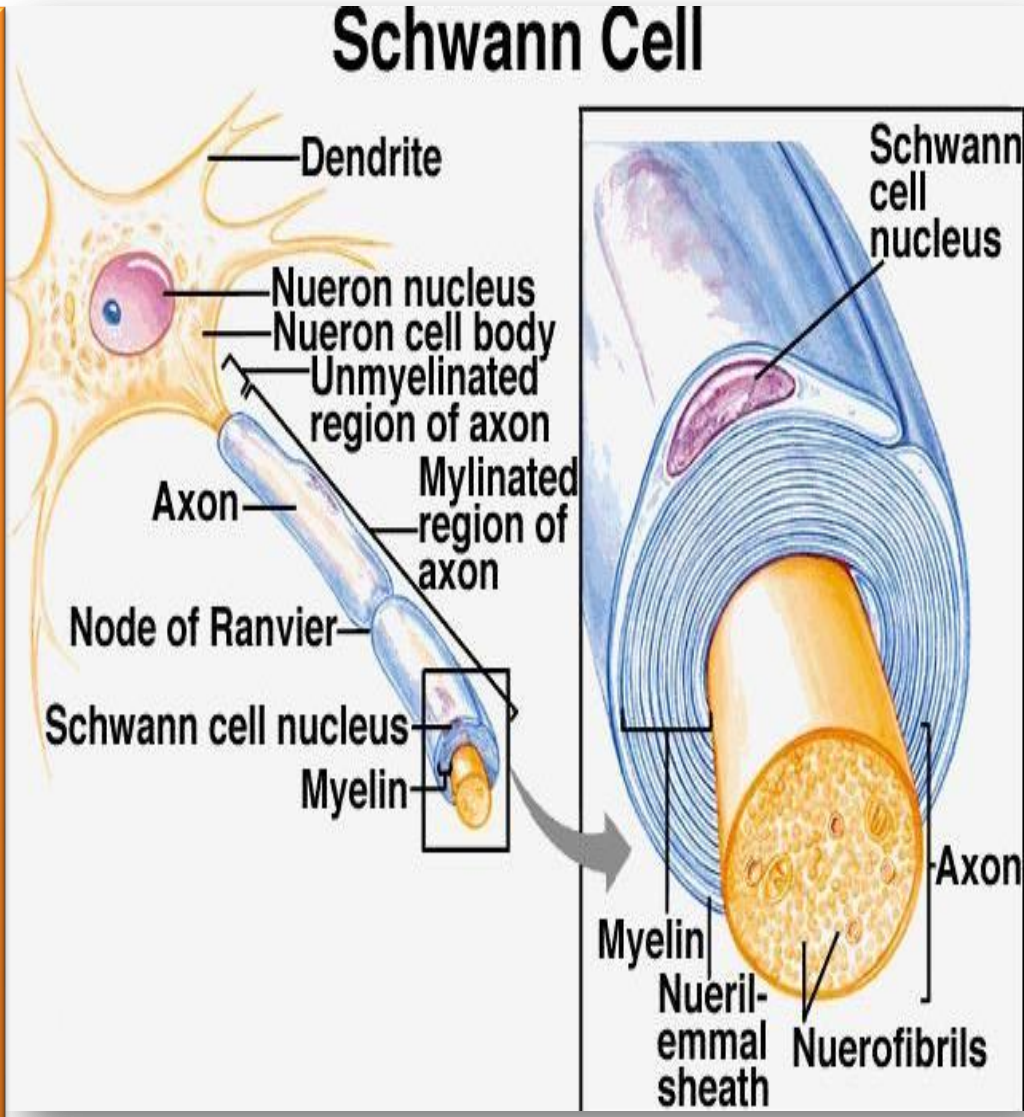
Peripheral Neuroglial Cells

The neuroglial cells in PNS are of two types:

1- Schwann cells:

are the major glial cells in PNS. Schwann cells provide myelination (insulation) around the nerve fibers in PNS.

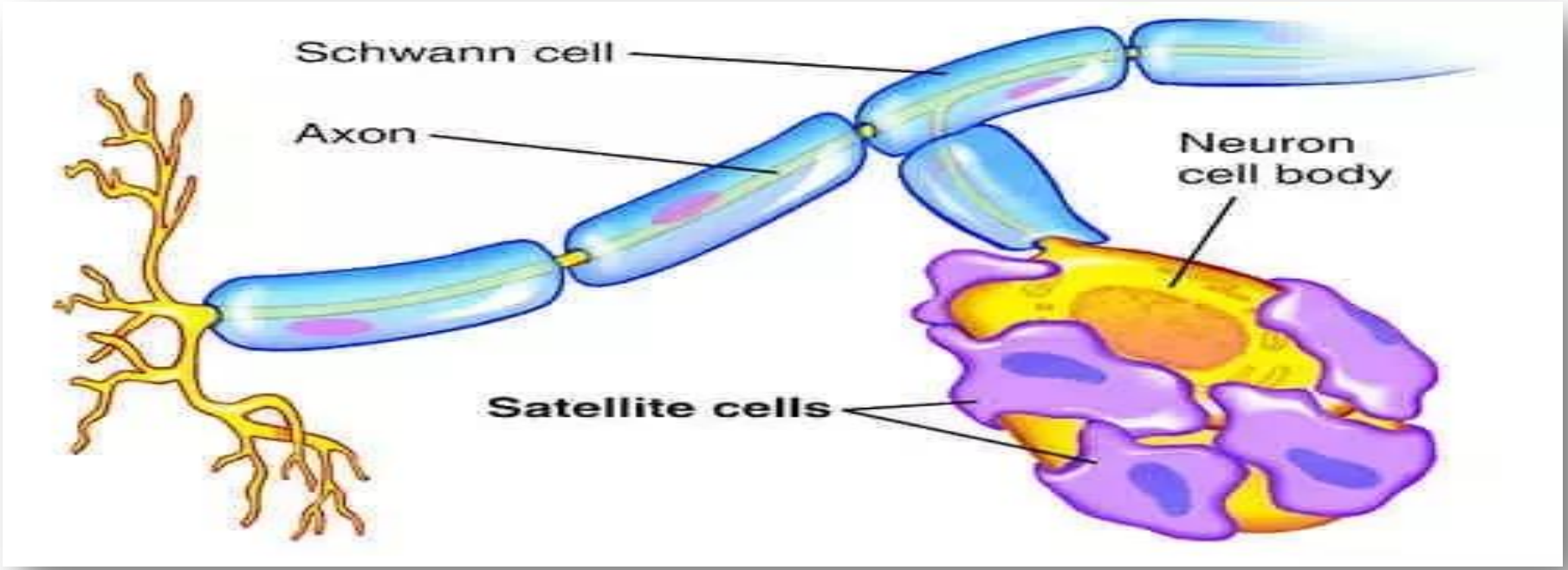
These cells remove cellular debris during regeneration by their phagocytic activity.



Peripheral Neuroglial Cells

2- Satellite cells:

are the glial cells present on the exterior surface of PNS neurons. Satellite cells provide physical support to the PNS neurons.



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Thank you