

The Brain, Biology and Cognition

Anatomy of the Nervous System and Neuron anatomy

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The Nervous system

A communication network consisting of nerve cells, both inside and outside the brain and spinal cord.

It transmits nerve impulses between parts of the body.

General Layout of the Nervous System

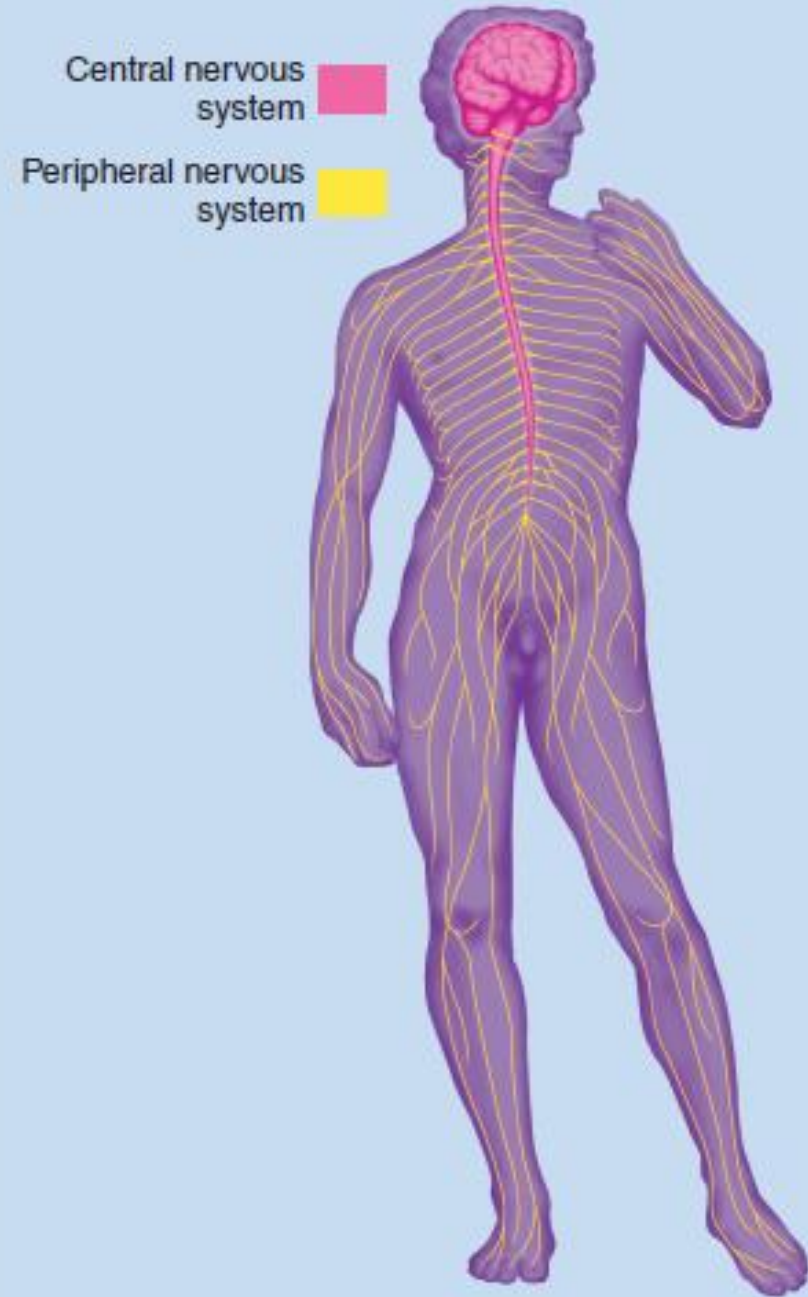


Central Nervous System (CNS)

- Brain (in the skull)
- Spinal Cord (in the spine)

Peripheral Nervous System (PNS)

- Located outside skull and spine
- Serves to bring information into and carry signals out of the CNS

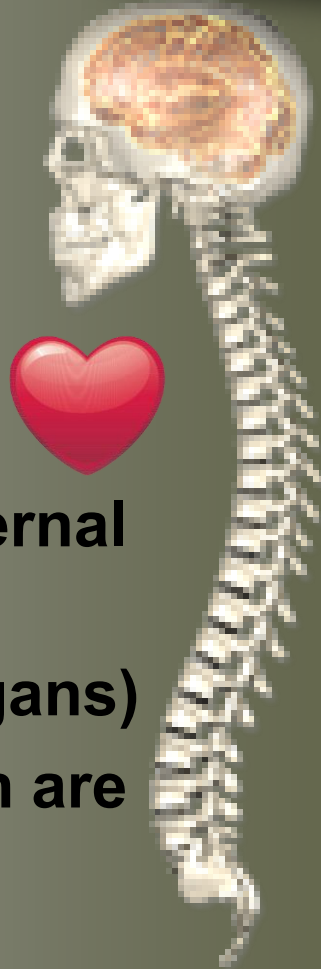


The Peripheral Nervous System (PNS):

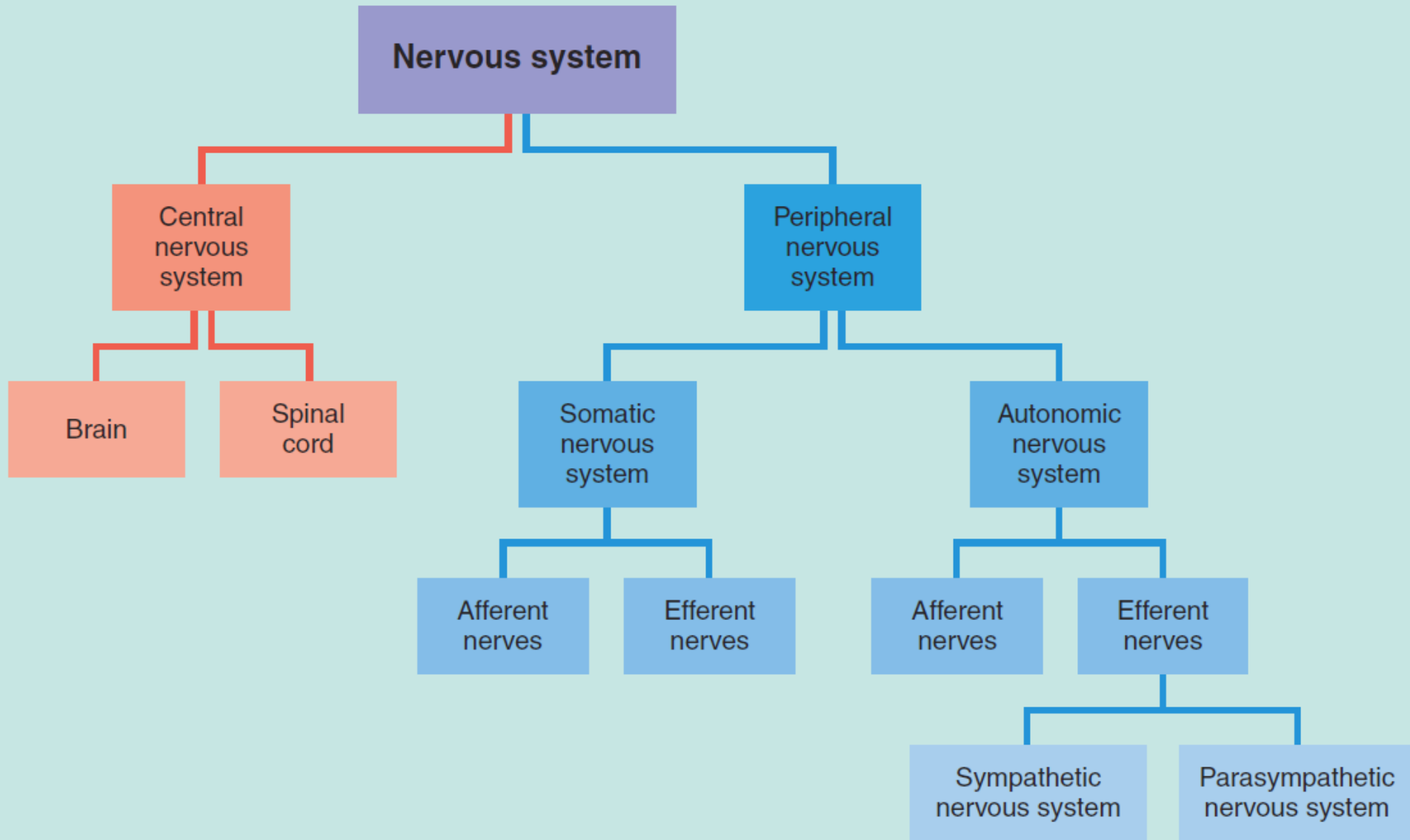


Functions of the sub-divisions of the PNS

- **Somatic Nervous System (SNS)** – interacts with external environment and made-up of:
 - Afferent nerves (carry sensory signals)
 - Efferent nerves (carry motor signals)
- **Autonomic Nervous System (ANS)** – regulates internal body environment
 - Afferent nerves (carry sensory info from organs)
 - Efferent nerves (motor info to organs) which are
 - Sympathetic and parasympathetic nerves



General Layout of the Nervous System



Major divisions of the nervous system.

Autonomic Nervous System



- **Sympathetic and parasympathetic nerves have Two-stage neural paths:**
 - **Project from CNS but only go certain length**
 - **They then synapse on a second-stage neuron before reaching target organ.**
- **Sympathetic neurons synapse a long distance from organ they intend to travel.**
- **Parasympathetic synapse close to target organ.**

See diagram in Core Text

Autonomic Nervous System



Opposite effects.

SYMPATHETIC

Project from CNS in Thoracic (chest) and lumbar (bottom of back) areas of spinal cord.

“Fight or flight”: stimulate, organize, & mobilize energy resources when in threat.

Second stage neurons are far from the target organ

PARASYMPATHETIC

Project from the Cranial (brain) and sacral (lower back area of spinal cord).

“Rest and restore”: conserve energy

Second stage neurons are near the target organ

See Appendix in Core Text



How is the brain protected?



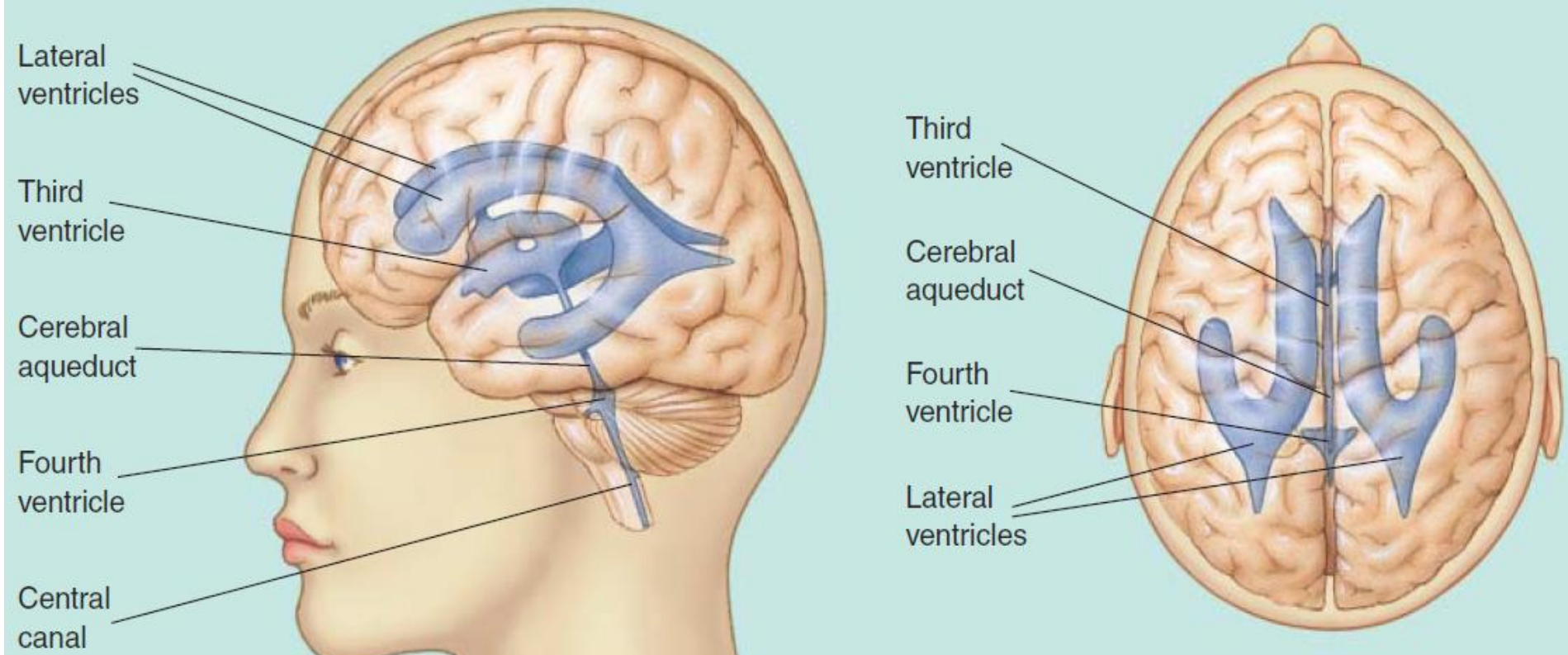
Physical Protection =

- **Skull – CNS encased in bone & covered by:**
- **Three Meninges**
 - **Dura mater – tough outer membrane**
 - **Arachnoid membrane – quite fine & web-like**
 - **Pia mater – inner delicate membrane that adheres to CNS surface**
- **Cerebrospinal fluid (CSF) - serves as cushion by filling space underneath arachnoid membrane, central canal of the spinal cord, and cerebral ventricles of the brain.**

The Cerebral Ventricles



4 large internal chambers of the brain



Ventricles, subarachnoid space, & central canal interconnect by series of openings to form a single reservoir.

CSF continuously produced by choroid plexuses (network of small blood vessels) that stick to ventricles from the pia matter.

How is the brain protected?



Chemical protection

- **Blood-brain barrier:**
 - Blood contains toxins
 - Body must stop these getting to the brain.
 - Cells of blood vessel walls in the brain are tightly packed together to form a barrier stopping molecules passing through.



Spinal Cord

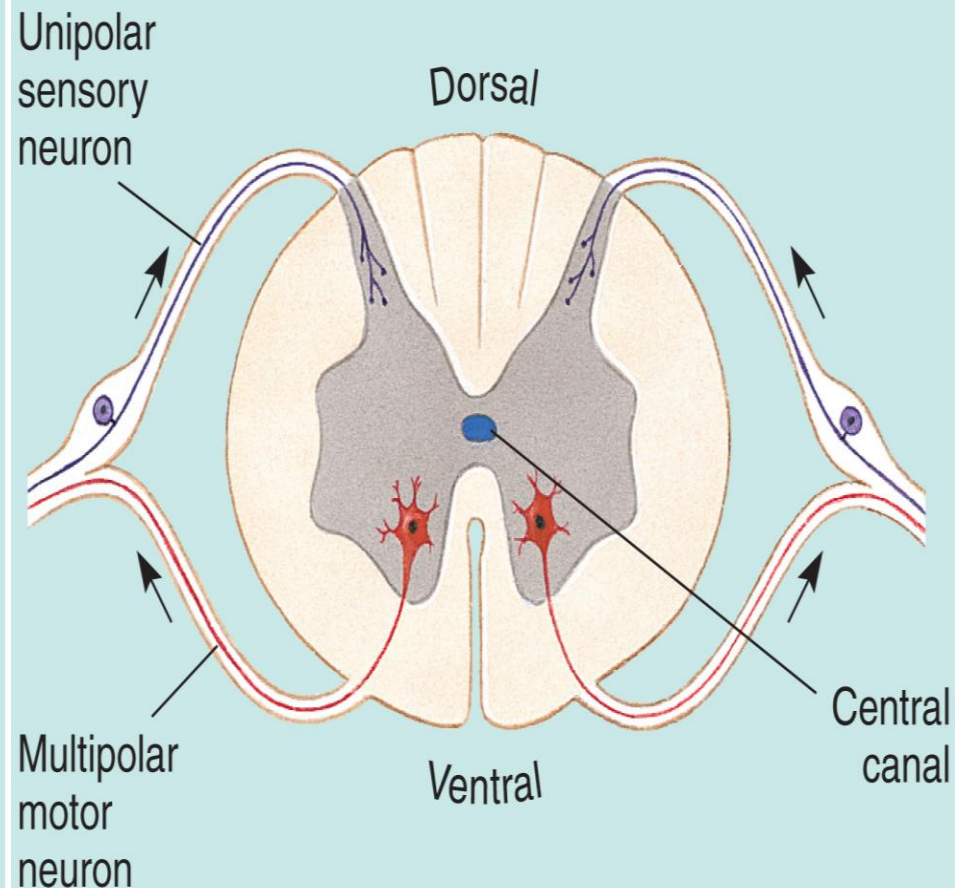
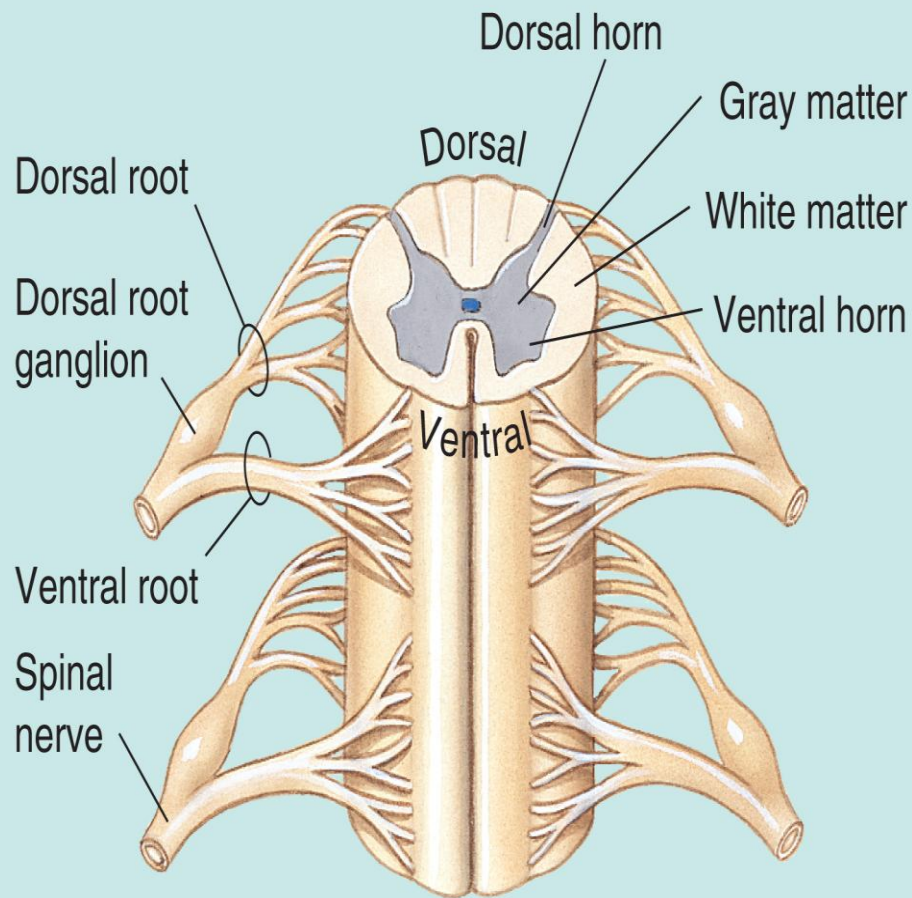


Gray matter – inner component, primarily cell bodies

White matter – outer area, mainly myelinated axons

Dorsal – afferent, sensory

Ventral – efferent, motor



How does the brain work?



- **Anatomy of neurons:**

- Cells receive and transmit electrochemical signals.
- Roughly 100 billion neurons arranged in complex array of around 100 trillion connections.

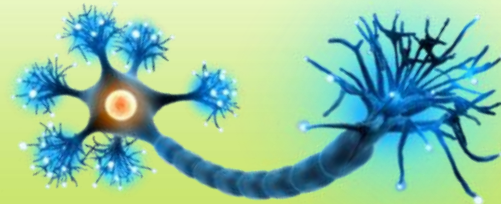
The human brain

An intricate network of neurons



Neurons

Cells that receive/transmit electrochemical signals



Anatomy of Neurons



Neurons:

Specialised cells for reception, conduction, and transmission of electro-chemical signals

Many sizes/shapes but many have typical structure

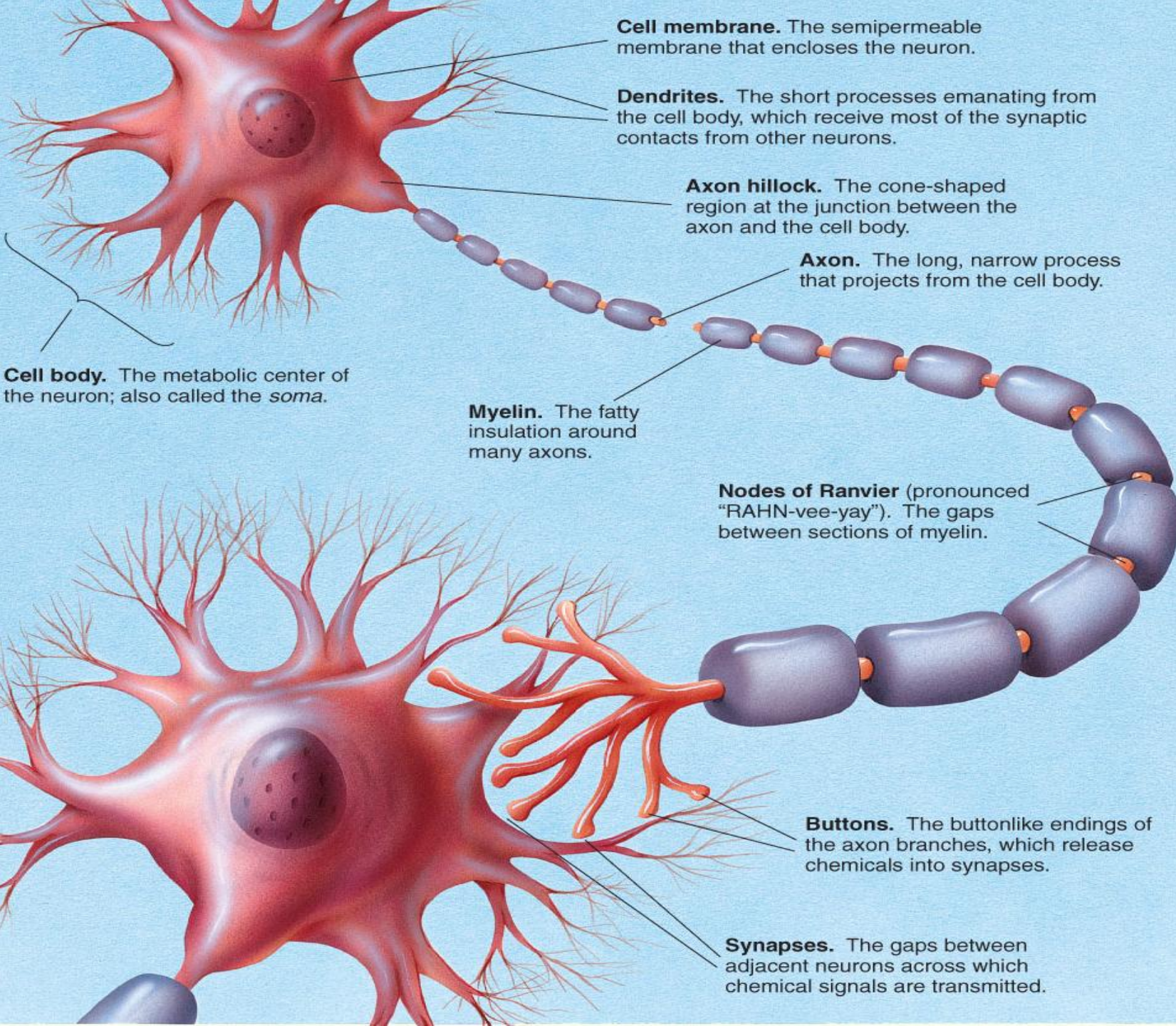




Interactive Task:

Work in small groups to identify the key:

- Internal features of a neuron
- External features of a neuron



Cell membrane. The semipermeable membrane that encloses the neuron.

Dendrites. The short processes emanating from the cell body, which receive most of the synaptic contacts from other neurons.

Axon hillock. The cone-shaped region at the junction between the axon and the cell body.

Axon. The long, narrow process that projects from the cell body.

Myelin. The fatty insulation around many axons.

Nodes of Ranvier (pronounced "RAHN-vee-yay"). The gaps between sections of myelin.

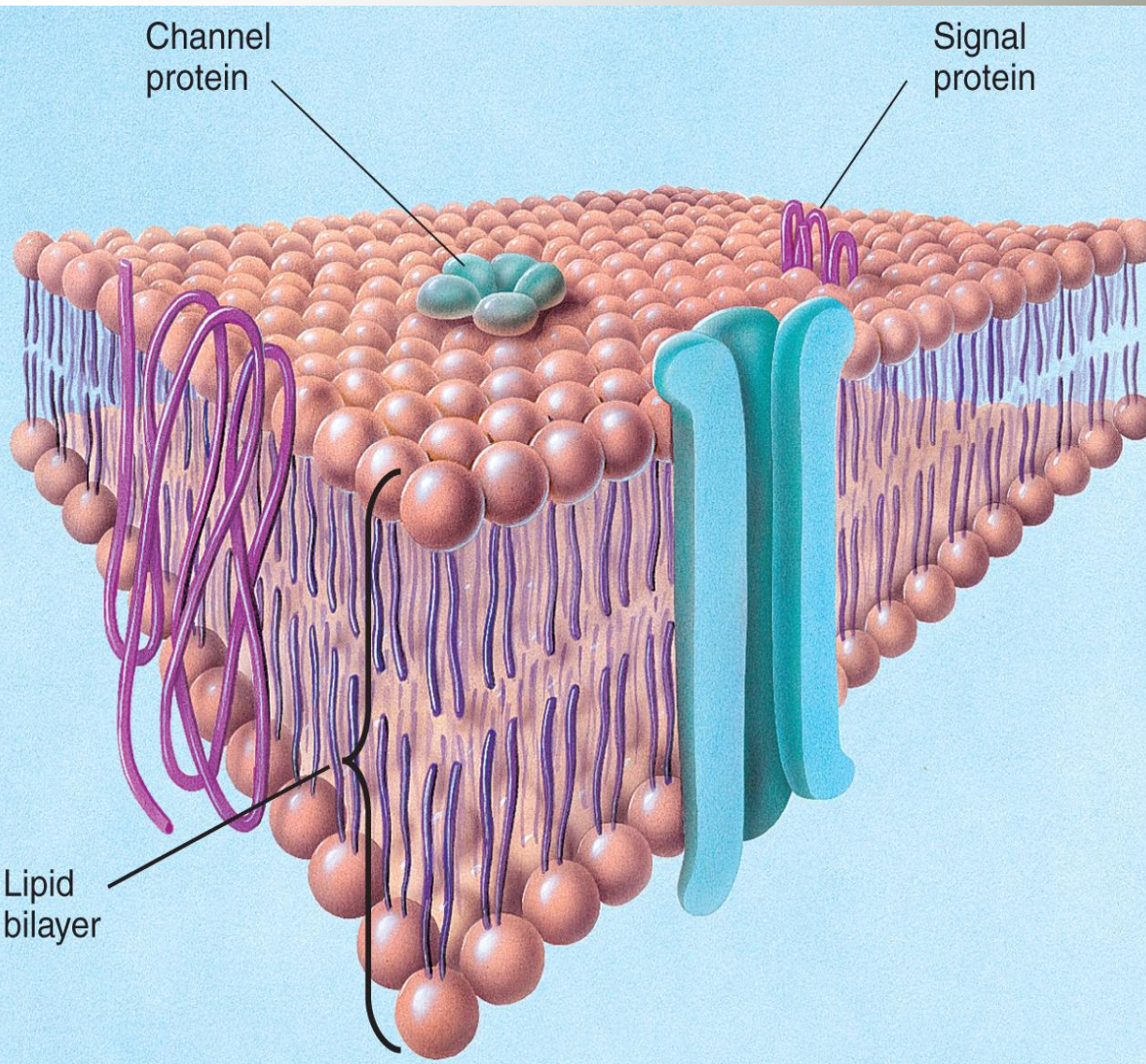
Buttons. The buttonlike endings of the axon branches, which release chemicals into synapses.

Synapses. The gaps between adjacent neurons across which chemical signals are transmitted.



**Major
external
features
of typical
neuron**

Anatomy of Neurons



Cell membrane is a lipid (fat molecule) bilayer.

Channel proteins allow certain molecules to pass

Signal proteins transfer signal to the inside of the neuron when certain molecules bind to them on the outside of the membrane.

Cell membrane is semi-permeable.

Major internal features of typical neuron

Endoplasmic reticulum. A system of folded membranes in the cell body; rough portions (those with ribosomes) play a role in the synthesis of proteins; smooth portions (those without ribosomes) play a role in the synthesis of fats.

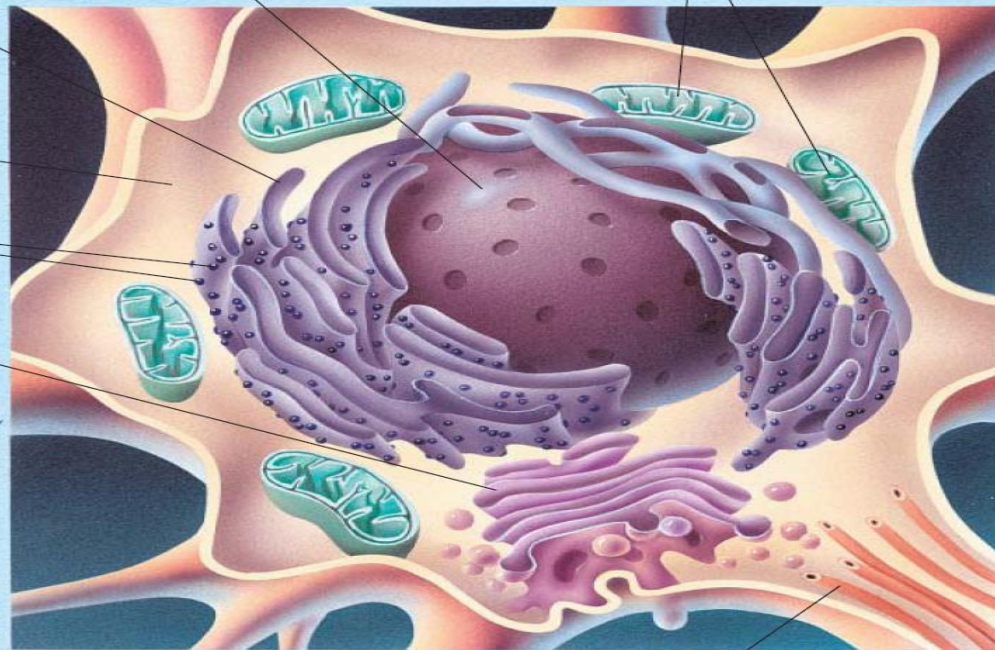
Cytoplasm. The clear internal fluid of the cell.

Ribosomes. Internal cellular structures on which proteins are synthesized; they are located on the endoplasmic reticulum.

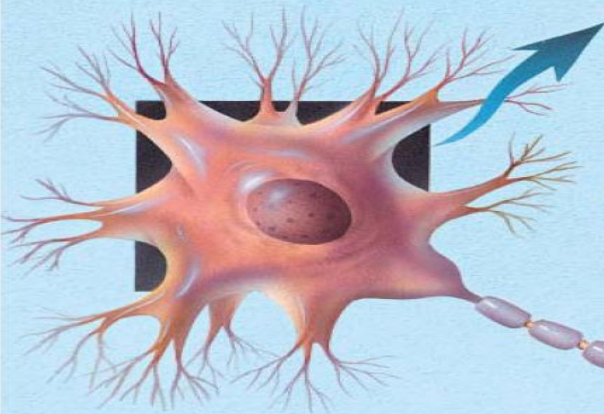
Golgi complex. A connected system of membranes that packages molecules in vesicles.

Nucleus. The spherical DNA-containing structure of the cell body.

Mitochondria. Sites of aerobic (oxygen-consuming) energy release.

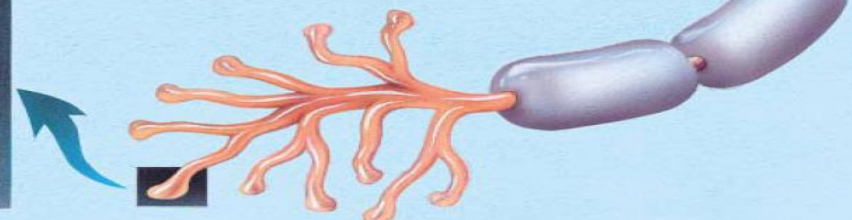
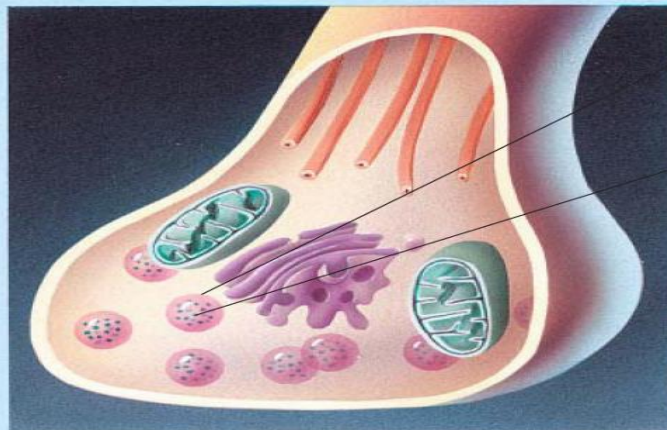


Microtubules. Tubules responsible for the rapid transport of material throughout neurons.



Synaptic vesicles. Spherical membrane packages that store neurotransmitter molecules ready for release near synapses.

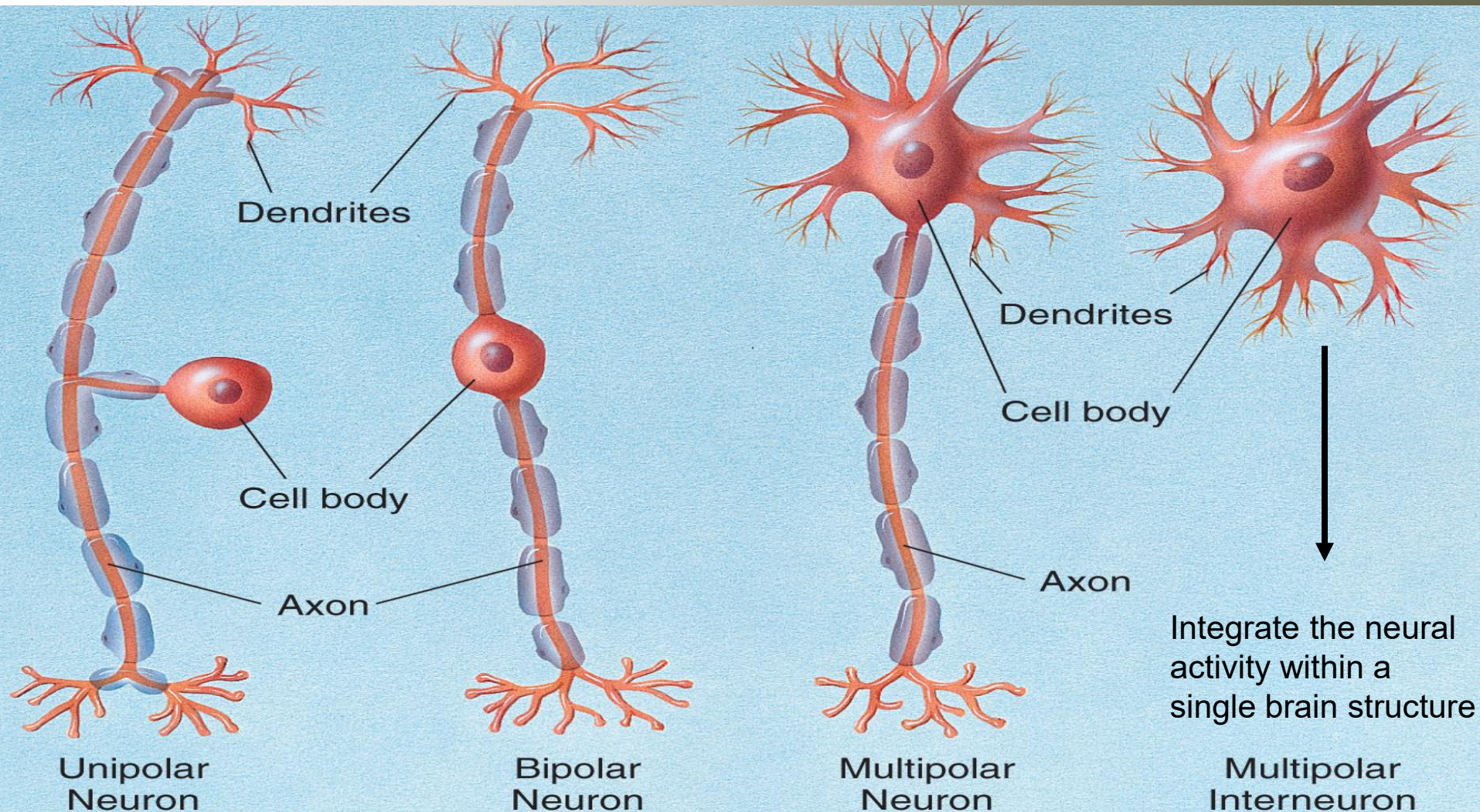
Neurotransmitters. Molecules that are released from active neurons and influence the activity of other cells.



Cells of the Nervous System: Anatomy of Neurons



Different classes of neurons based on number of projections (processes) that come out of the cell body.



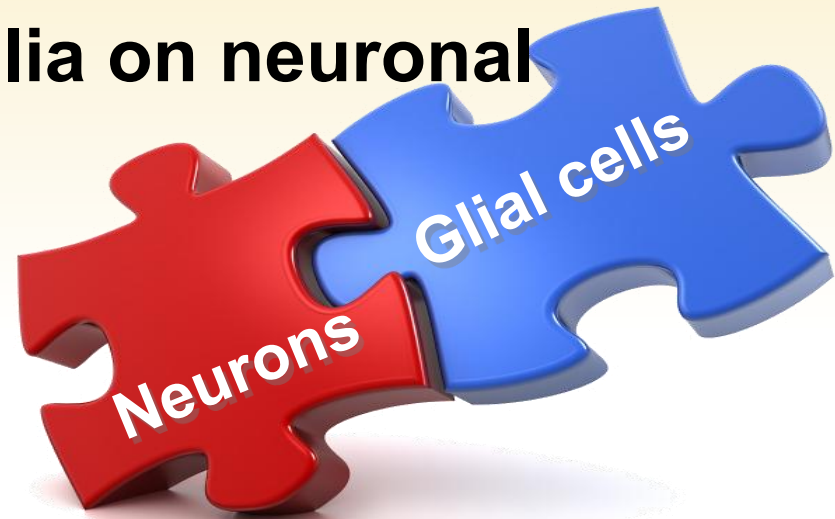
Glial Cells: The Forgotten Cells



Along with neurons, the system is also made of glial cells.

Glial cells

- **Support neurons**
- **Recent evidence for glial communication role and modulatory effects of glia on neuronal communication**



Four Classes of Glial Cells



1

Oligodendrocytes: extensions that wrap around axons rich in myelin to create myelin sheaths in CNS to increase speed & efficiency of conduction.

2

Schwann cells – like oligodendrocytes but in PNS, can guide axonal regeneration

3

Astrocytes: largest/star-shaped, some cover outer surface of blood vessels in brain, can contact neural cell bodies, play role in allowing passage of some chemicals from blood and into CNS neurons.

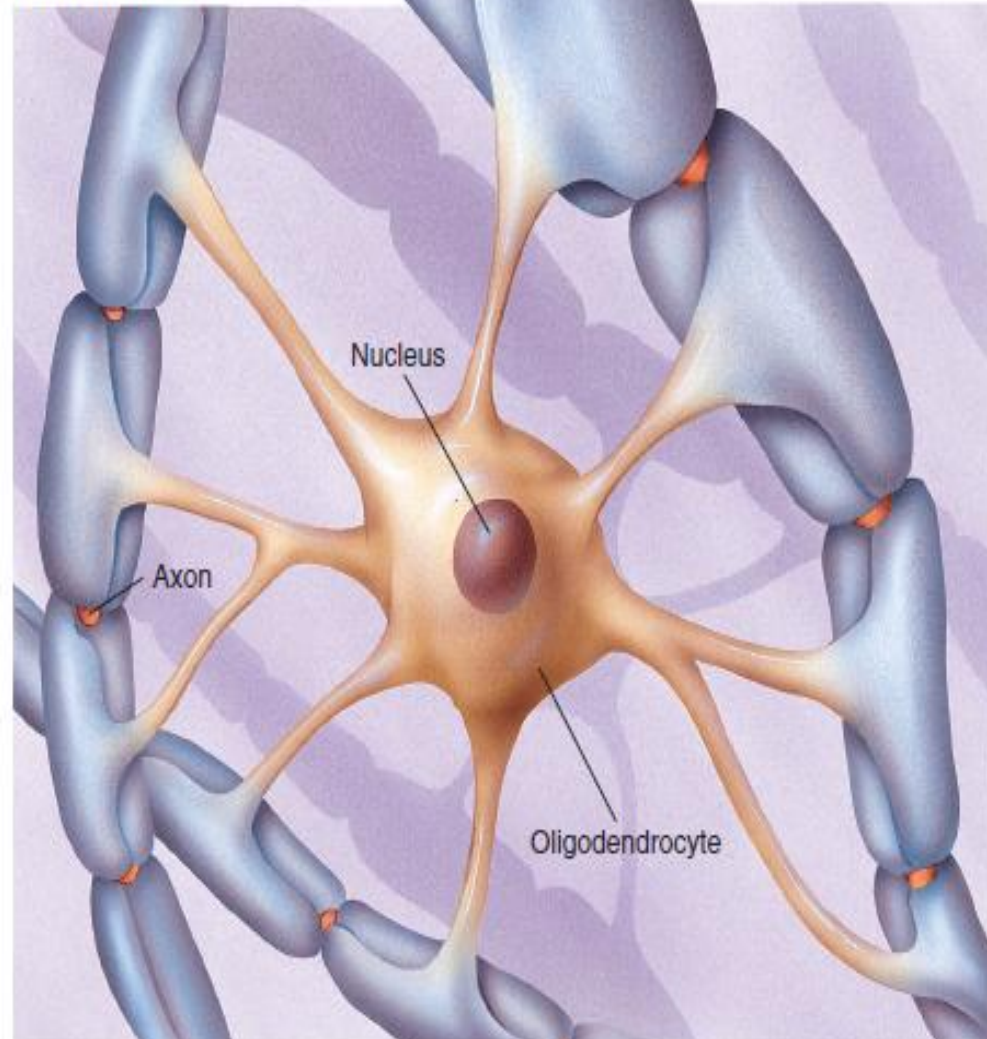
4

Microglia: involved in response to injury/disease, trigger inflammatory responses.

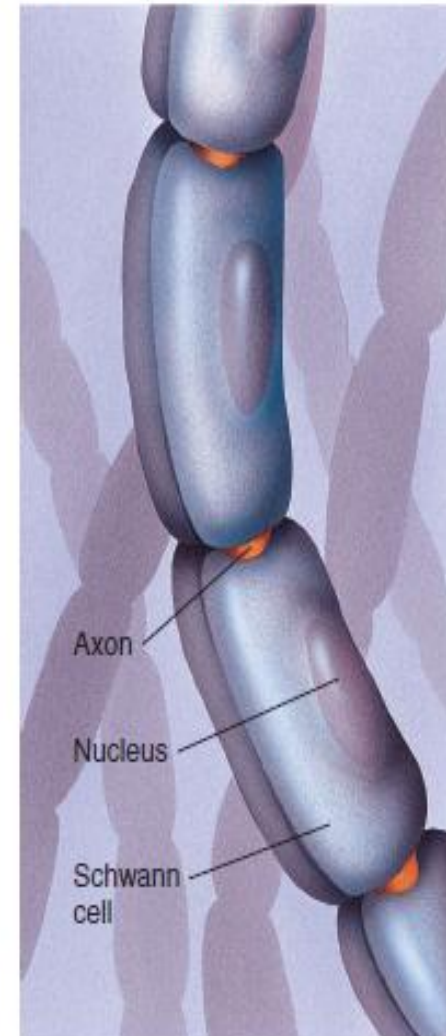
Glial Cells: The Forgotten Cells



Myelination in the Central Nervous System



Myelination in the Peripheral Nervous System



The myelination of CNS axons by oligodendrocyte & myelination of PNS axons by Schwann cells.

Each Schwann cell makes-up 1 myelin segment.

Each oligodendrocyte gives a number of myelin segments.

Glial Cells: The Forgotten Cells



Terminology

	CNS	PNS
Myelin-providing glia	Oligodendrocytes	Schwann cells
Clusters of cell bodies	Nuclei (singular nucleus)	Ganglia (singular ganglion)
Bundles of axons	Tracts	Nerves