



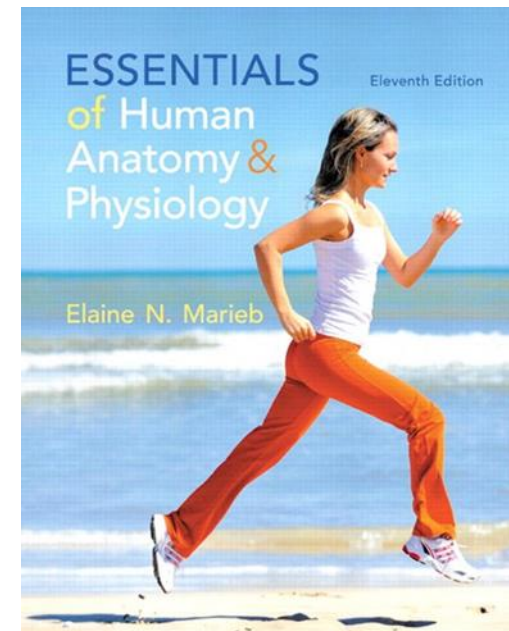
Human Anatomy and Physiology

CLS 224

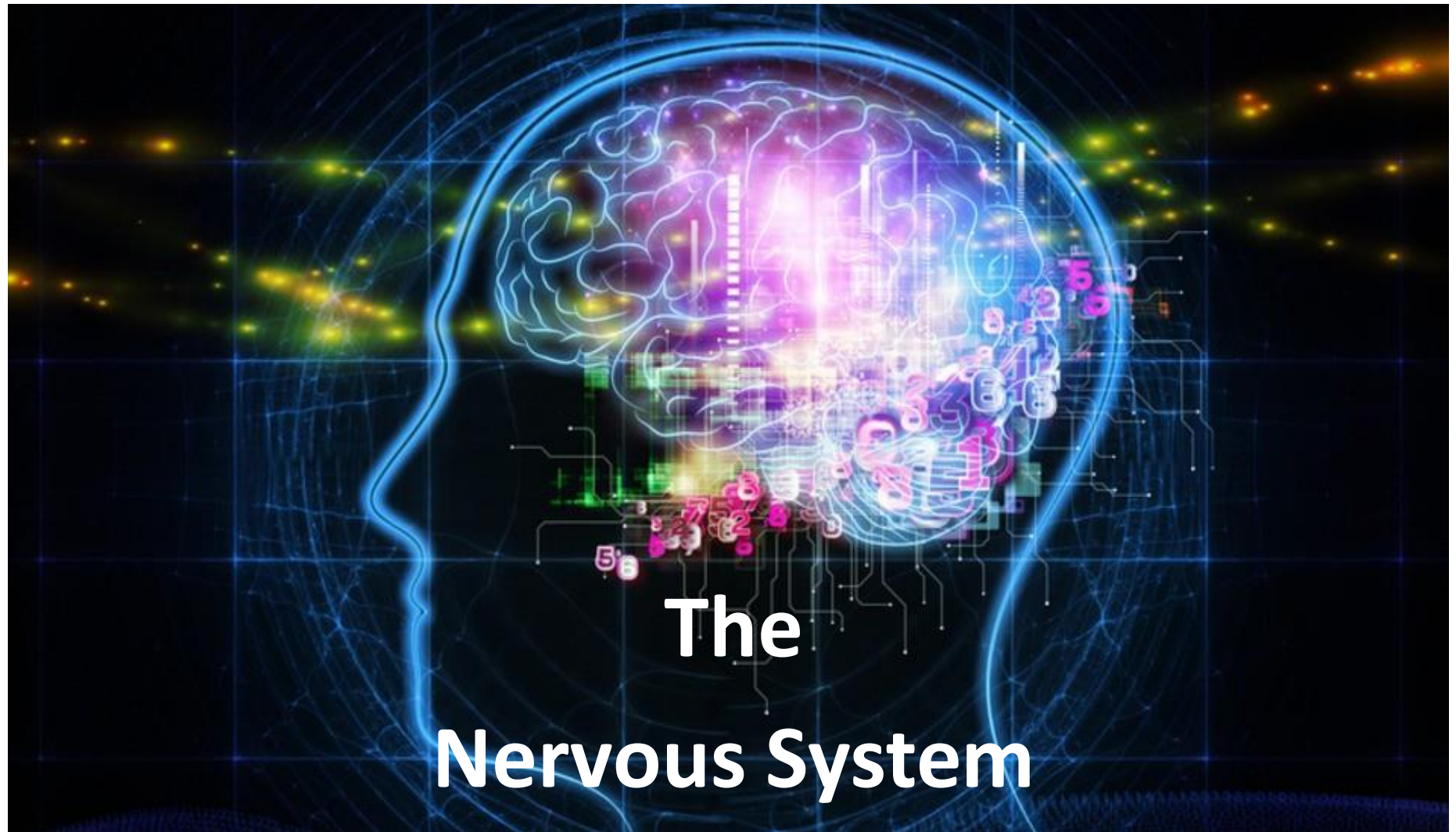
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Chapter 7



The Nervous System

1. Organization of the nervous system.
2. Nervous tissue: Anatomy and function.
3. Central nervous system.

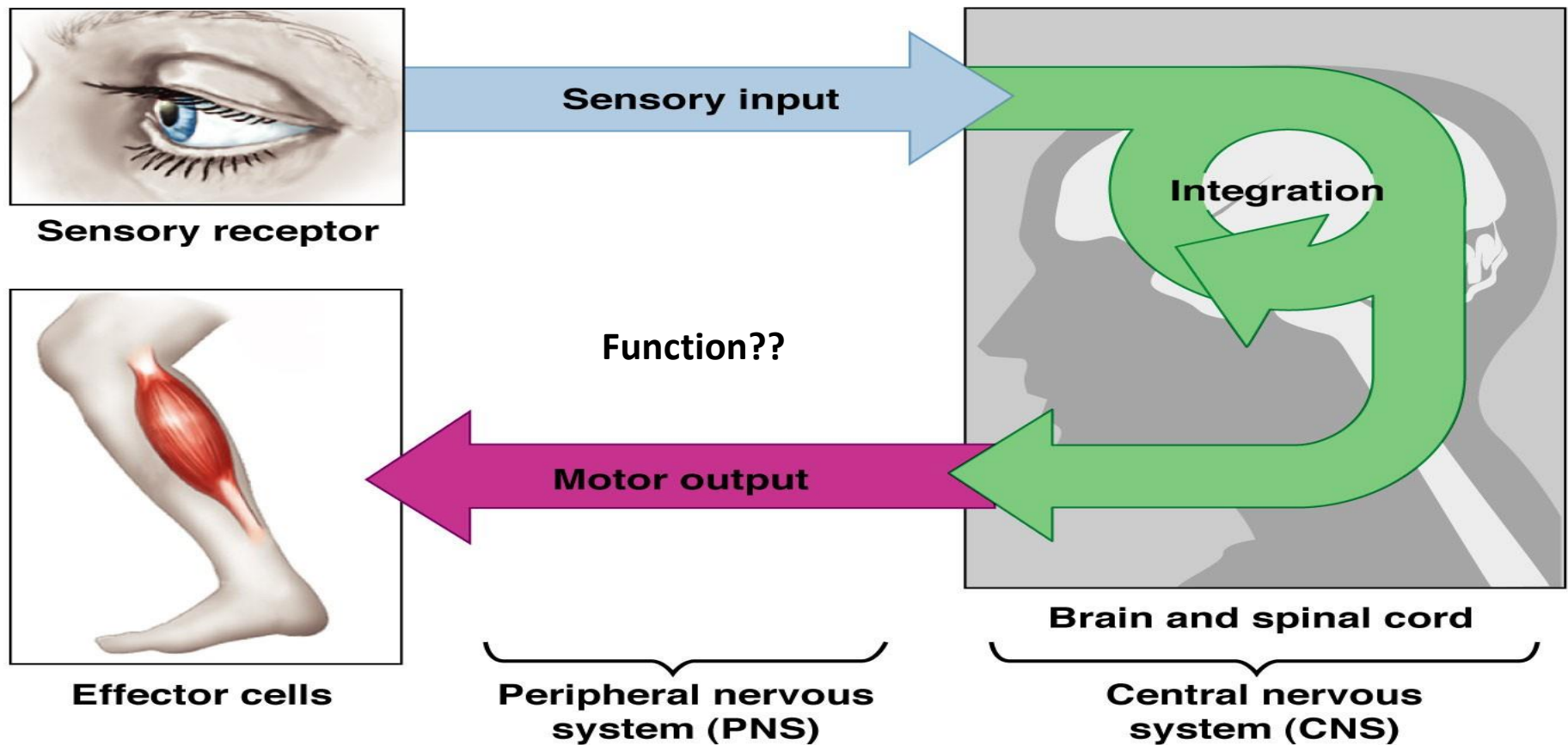
1. Organization of the nervous system.

Objectives:

- List the general functions of the nervous system.
- Explain the structural & the functional classifications of the nervous system.
- Define central nervous system & peripheral nervous system & list the major parts of each.

Introduction

- NS provides control functions of the body:
- 1- By detecting changes in internal and external environments >>> resulting in muscle, organ or gland response.
- 2- Higher functions : memory, learning and emotions.
- The NS doesn't work alone to **maintain body's homeostasis**, the endocrine system is a second important regulating system.



Mechanism of Functions

1- Sensory receptors monitor changes (stimuli) occurring both inside & outside the body. The gathered information is called **sensory input**.

2- The sensory input is then processed, interpreted & decisions are made about what should be done at each moment. This is called **integration**.

3- A response is made by activating muscles or glands via **motor output**.

1. Organization of the NS.

NS divided into:

1) Central nervous system (CNS)

- Brain.

- Spinal cord.

Act as the **integrating & command** centers of the NS. They interpret sensory input and make instructions based on past experience & current conditions.

2)Peripheral nervous system (PNS)

Nerves outside of the CNS:

- Act as a link between CNS and rest of the body
- These nerves link all parts of the body by carrying impulses from sensory receptors to the CNS & from the CNS to the gland or muscle.

It consists of:

- **12 pairs of Cranial nerves:** Carry impulses to & from the brain.
- **31 pairs of Spinal nerves:** Carry impulses to & from the spinal cord.

Functional classification of PNS:

1) Sensory neurons (afferent division):

Nerve fibers that deliver impulses to the CNS from sensory receptors.

–**Somatic sensory fibers:** Deliver impulses from the skin, skeletal muscles, joints and ligaments.

–**Visceral sensory fibers:** Deliver impulses from visceral organs.

2) Motor neurons (efferent division):

Motor Nerve fibers that carry impulses from the CNS to muscles & glands (away).

–**Somatic NS:** Allow voluntary control of skeletal muscle. (*voluntary NS*)

–**Autonomic NS:** Regulate events that are involuntary. (*involuntary NS*):

A) Sympathetic

B) Parasympathetic

Sympathetic NS

Mobilize the body during extreme situations (fear, rage, exercise, excited, threatened, stressed):

- Dilation of pupils.
- Dilation of skeletal muscle BV → run faster.
- Withdrawal of blood from digestive system → blood serve the heart, brain, skeletal muscles.
- Accelerate heartbeat, Increase BP,
- Rapid deep breathing → dilates the bronchioles of the lungs
- Cold, sweaty skin.
- Stimulate glucose production & release.

Parasympathetic NS

Allows us to conserve energy, most active when the body is at rest & not threatened in any way:

- Relaxed mode.
- Constrict pupils.
- Stimulate flow of saliva.
- Warm skin.
- Regulated BP, heart rate, respiratory rate.
- Promote normal digestion & elimination of feces & urine.

Key:
• = Structure
▪ = Function

Central Nervous System (CNS)

- Brain and spinal cord
- Integrative and control centers

Peripheral Nervous System (PNS)

- Cranial nerves and spinal nerves
- Communication lines between the CNS and the rest of the body

Sensory (afferent) division

- Somatic and visceral sensory nerve fibers
- Conducts impulses from receptors to the CNS

Motor (efferent) division

- Motor nerve fibers
- Conducts impulses from the CNS to effectors (muscles and glands)

Sympathetic division

- Mobilizes body systems during activity ("fight or flight")

Parasympathetic division

- Conserves energy
- Promotes "housekeeping" functions during rest

Autonomic nervous system (ANS)

- Visceral motor (involuntary)
- Conducts impulses from the CNS to cardiac muscles, smooth muscles, and glands

Somatic nervous system

- Somatic motor (voluntary)
- Conducts impulses from the CNS to skeletal muscles

2.Nervous tissue: Anatomy and function.

Objectives:

- State the function of neurons and neuroglia.
- Describe the general structure of a neuron & name its important anatomical regions.
- List two major functional properties of neurons.
- Classify neurons according to structure & function.
- Describe the events that lead to generation of a nerve impulse and its conduction from one neuron to another.

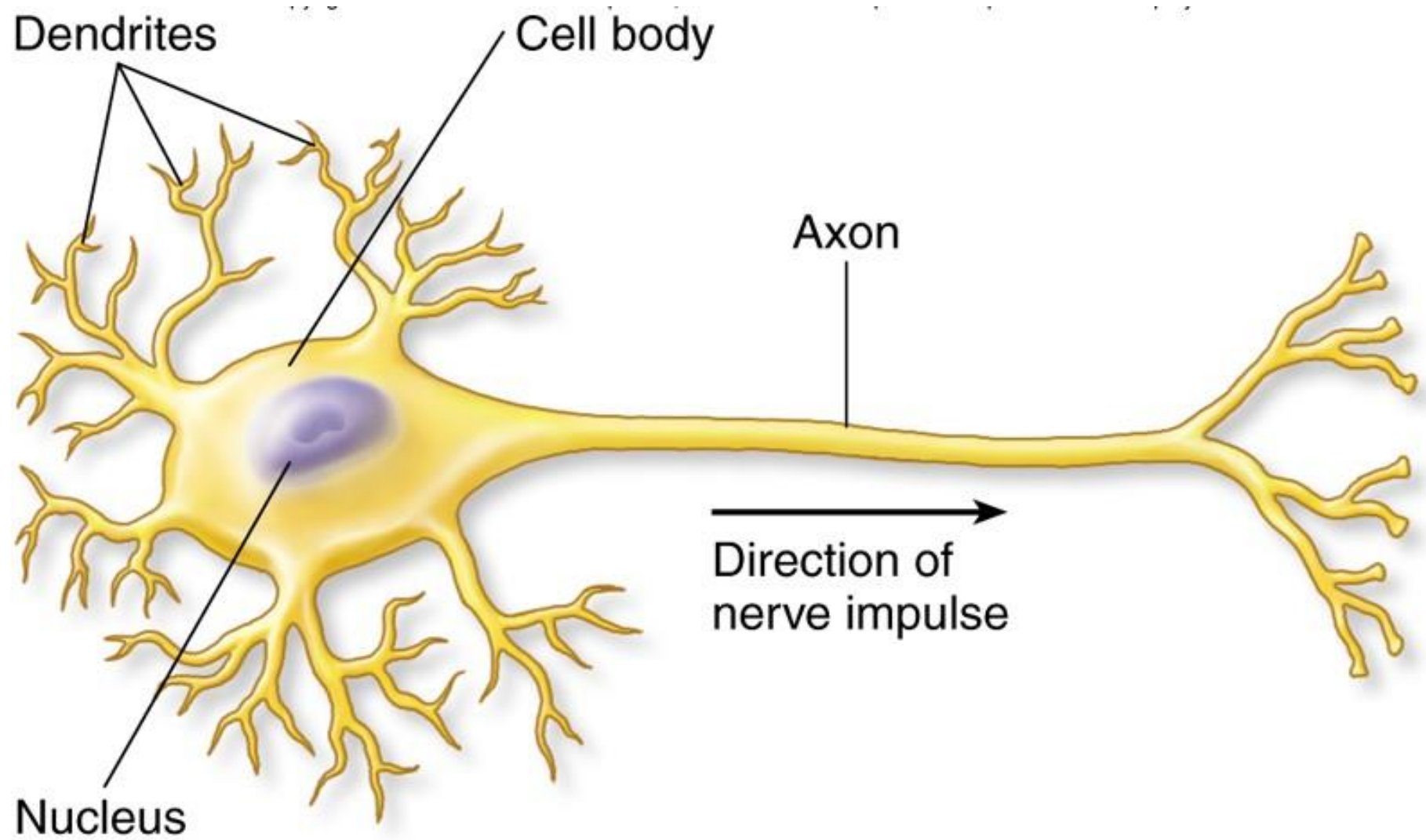
2. Nervous tissue: Anatomy & Function.

Structure:

- The nervous system is composed of two general types of cells:
 1. Neurons (nerve cells): Building blocks of the NS.
 2. Neuroglial cells (supporting cells).

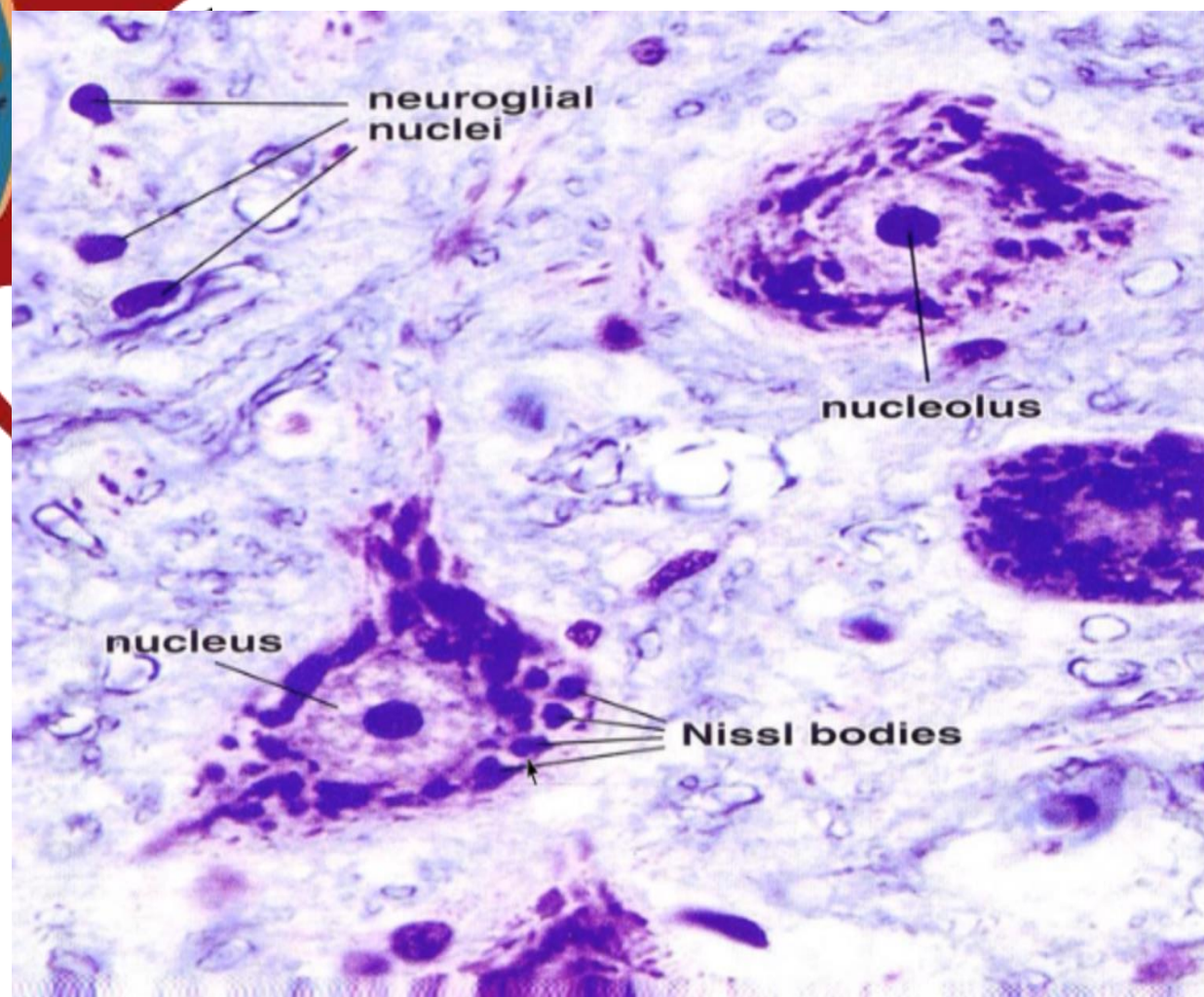
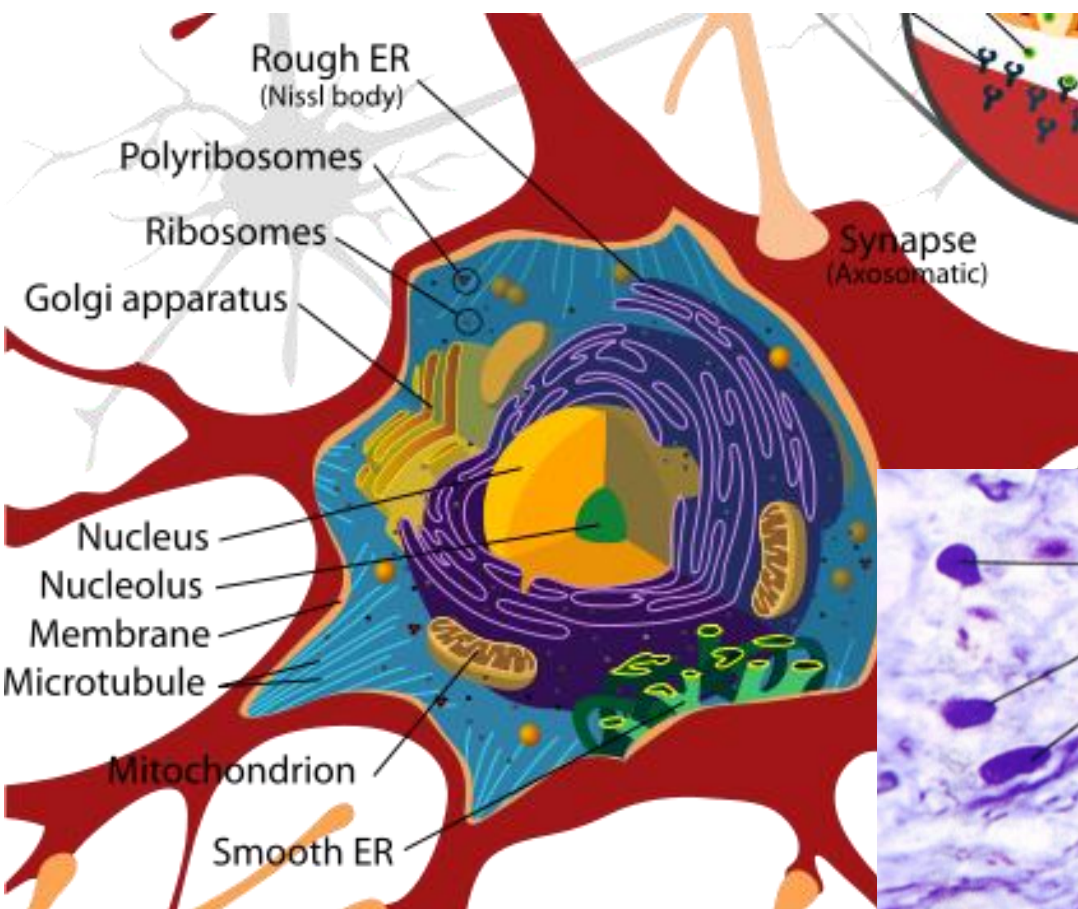
1.The Neuron

- Responsible for receiving & transmitting nerve impulses from one part of the body to another.
- Composed of:
 - A cell body (soma)
 - Dendrites
 - An axon

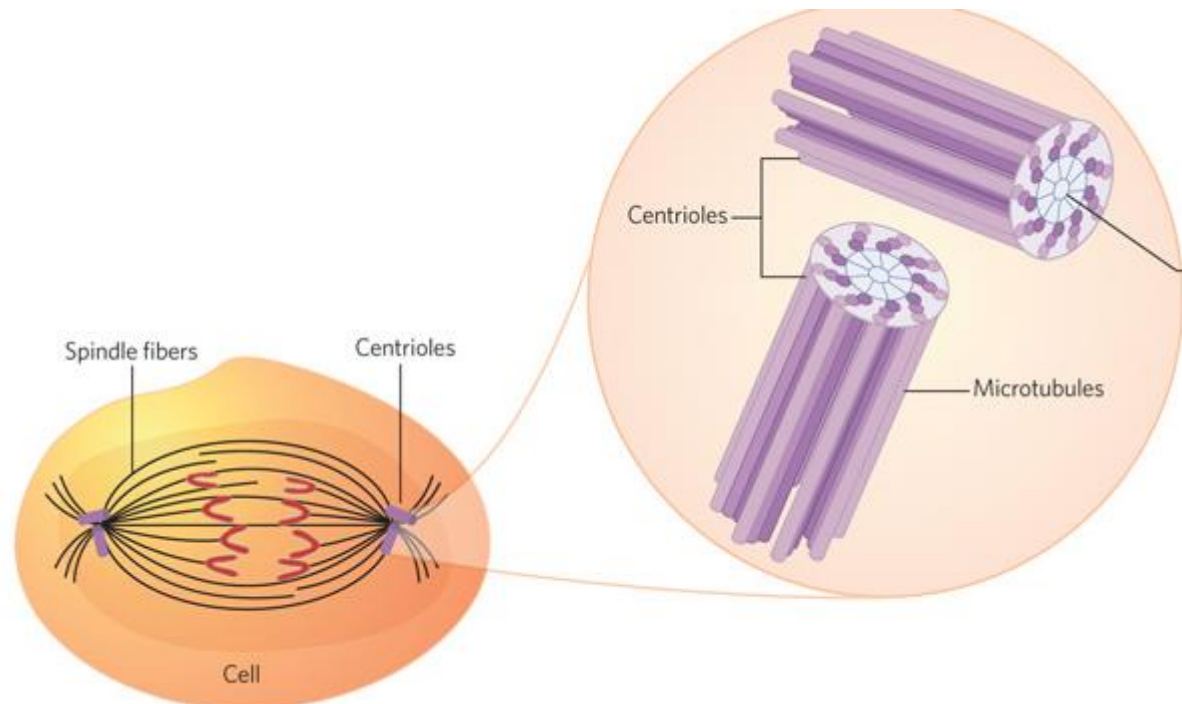


➤ Neuron Cell body (soma)

- The metabolic center of the neuron
- Contains:
 - single, centrally located nucleus with a large nucleolus.
 - a cytoplasm contains mitochondria, lysosomes, a Golgi complex, numerous inclusions, and an extensive rough endoplasmic reticulum and cytoskeleton.
 - The cytoskeleton consists of a dense mesh of microtubules and neurofibrils (bundles of actin filaments), which compartmentalize the rough ER into dark-staining regions called Nissl bodies.
 - Nissl bodies are unique to neurons and a helpful clue to identifying them in tissue sections with mixed cell types.
 - Nissl bodies are filled with ribosomes, and are the site of protein synthesis.

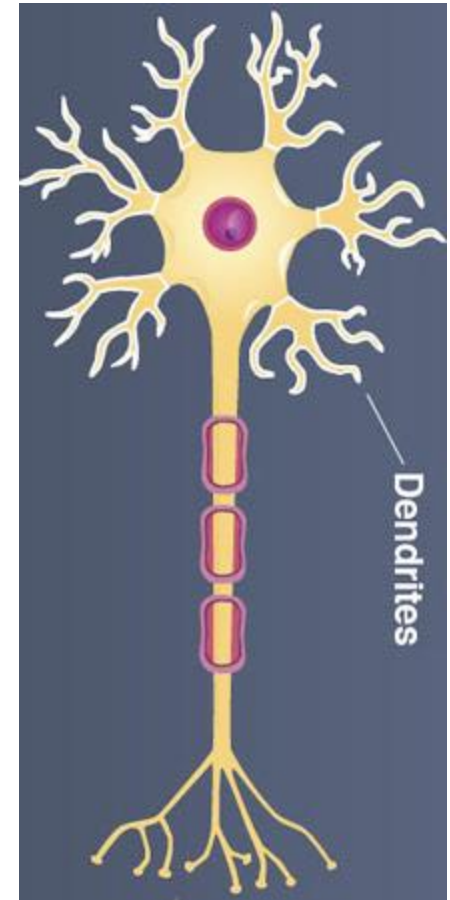


- Mature neurons have no centrioles (small set of microtubules), thus undergo no further mitosis (Amitotic) after adolescence; however, they are long-lived cells, capable of functioning for over a hundred years.



➤ Dendrites:

- Arm-like processes (branches) of the cell body.
- primary site for receiving signals from other neurons.
- Number of dendrites vary from one neuron to the other, the more dendrites a neuron has, the more information it can receive.

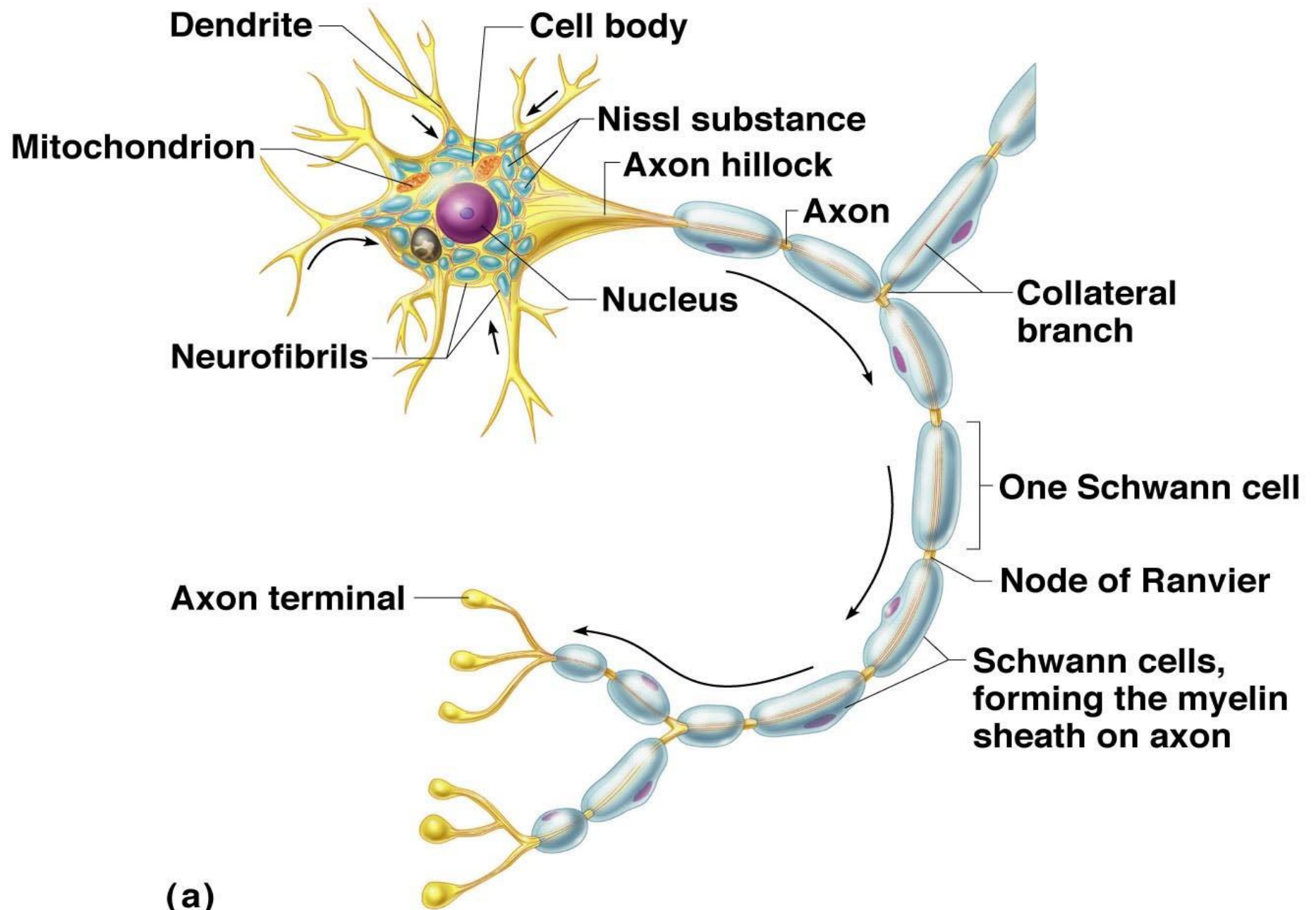


➤ Axon:

- Generate nerve impulses & conduct them **away** from the cell body **to** another cell.
- arises from a cone-like region of the cell body called **Axonal Hillock**.
- **May** give off a **collateral branch** along its length.
- Branches at their terminal ends forming thousands of **axon terminals** that contain **neurotransmitters** in tiny vesicles that are released into the extracellular spaces when impulses reach axon terminal.
- Each axon terminal is separated from the next neuron by a tiny gap called **synaptic cleft**.

Axon

- Long nerves are covered with a fatty material called **Myelin Sheath** that insulates & protects the fiber & increases the transition rate.
- **Schwann cells** form the myelin around nerve fibers in the **PNS**.
- **Oligodendrocytes** form the myelin around nerves fibers in the **CNS**.



The importance of the myelin insulation to nerve transmission is best illustrated by observing what happens when myelin is not there.

In people with multiple sclerosis (MS), the myelin sheaths around the fibers are gradually destroyed, converted to hardened sheaths called scleroses.

As this happens, the electrical current is short-circuited. The affected person may have visual and speech disturbances, lose the ability to control his or her muscles, and become increasingly disabled.

Multiple sclerosis is an autoimmune disease in which a protein component of the sheath is attacked.

Classification of Neurons

1. Based on their anatomy
2. Based on what they do

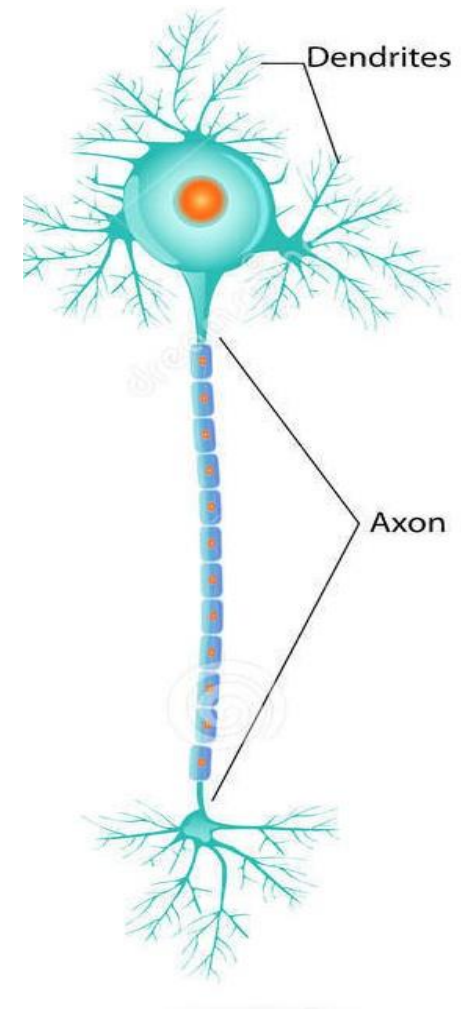
Anatomical Classification

is based on the number of processes extending from the cell body.

- Multipolar
- Bipolar
- Unipolar

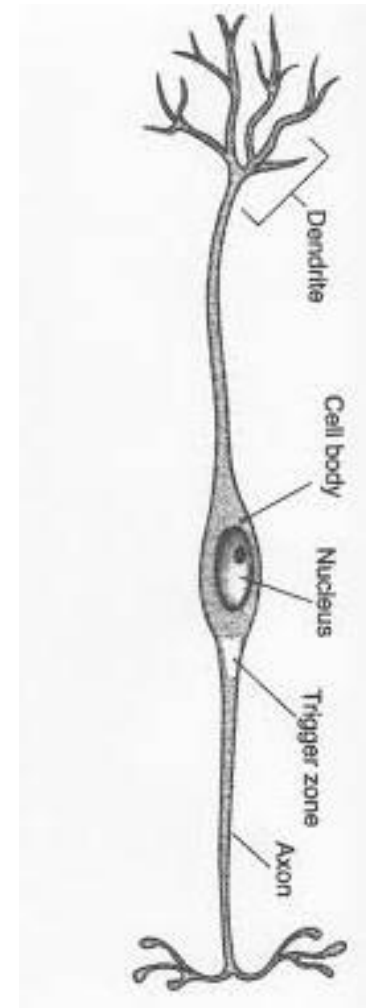
Multipolar Neuron

- Neuron with a cell body and 3 or more processes.
 - One process is the axon, and many other dendrites
- This is the most common type of neurons.

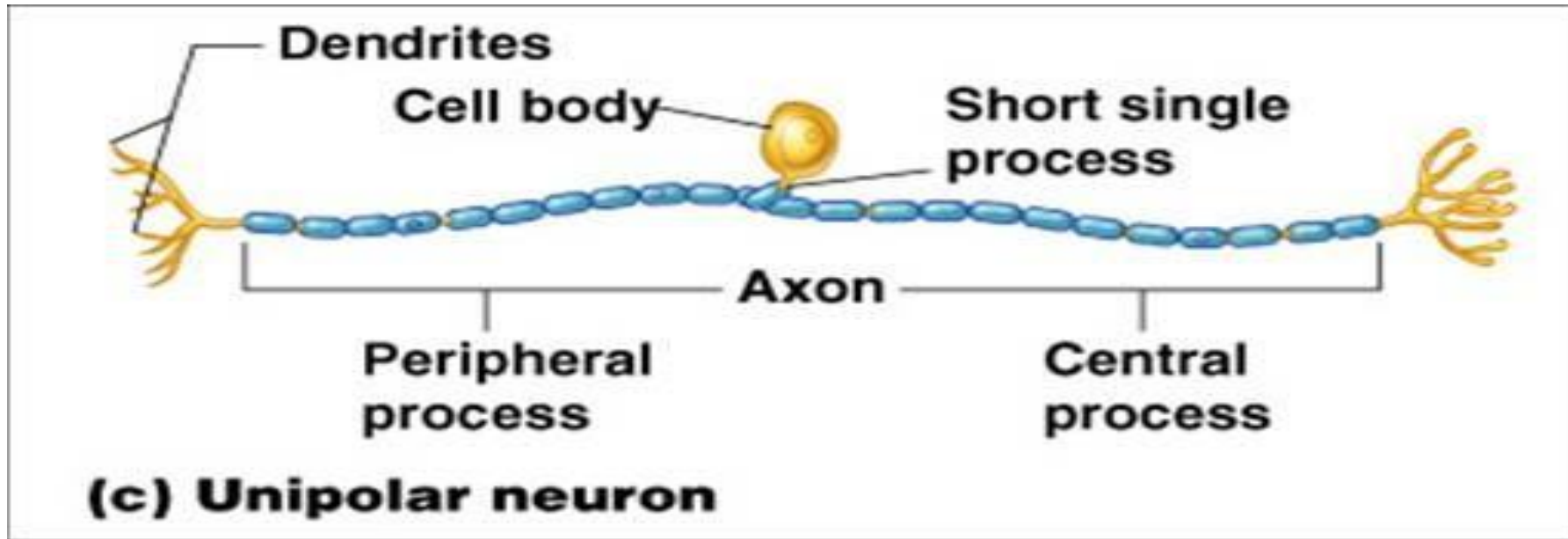


Bipolar Neuron

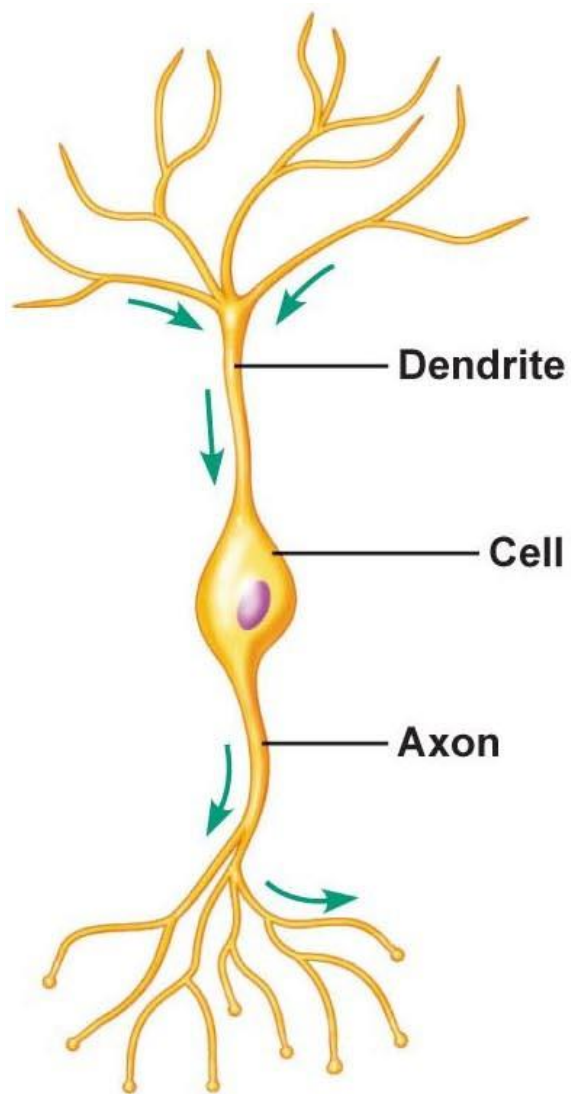
- Two processes protruding from cell body; one axon and one dendrite.
- transmit special senses, such as smell, sight and hearing
- Found in certain parts of eyes, nose and inner ear where they act in sensory processing as receptor cells.



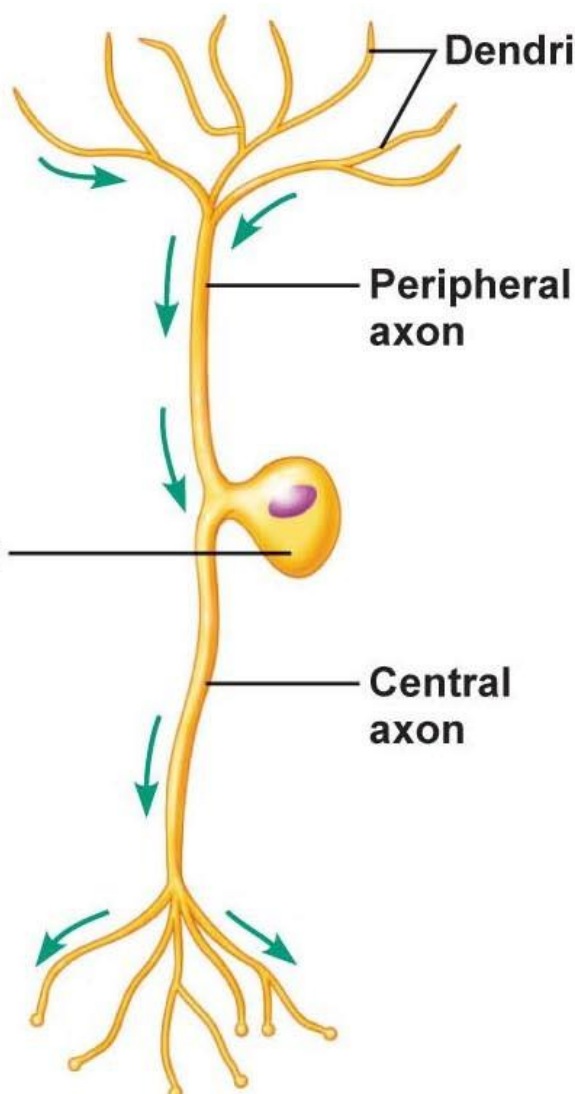
Unipolar Neuron



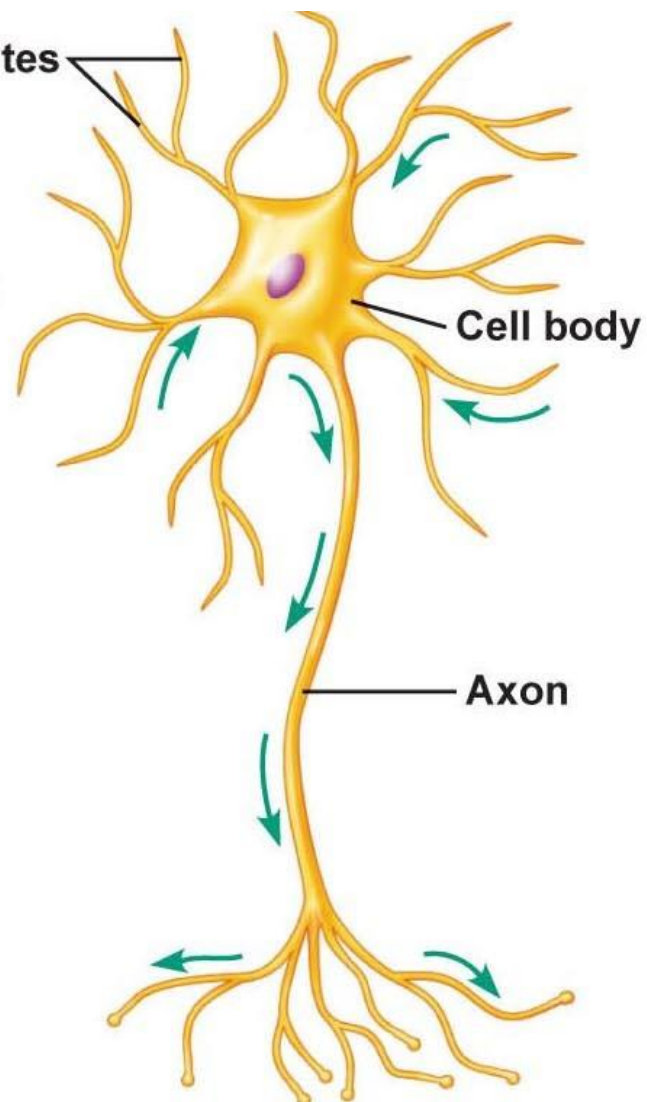
- A single process protruding from cell body
 - At a short distance from the cell body the process divides into two branches (central and peripheral)
 - no dendrites arising directly from the cell's soma
 - found in parts of central nervous system (brain and spinal cord).



(a) Bipolar



(b) Pseudo-unipolar



(c) Multipolar

Functional Classification of Neurons

According to the direction the impulse is traveling to the CNS.

- Sensory (afferent neurons)
- Motor (efferent neurons)

Nerve physiological

- Neurons have two major functional properties:
 1. **Irritability:** Ability to respond to a stimulus & convert it into a nerve impulse (e.g. change in environment).
 2. **Conductivity:** Ability to transmit the impulse to other neurons (pass it on to other cells).

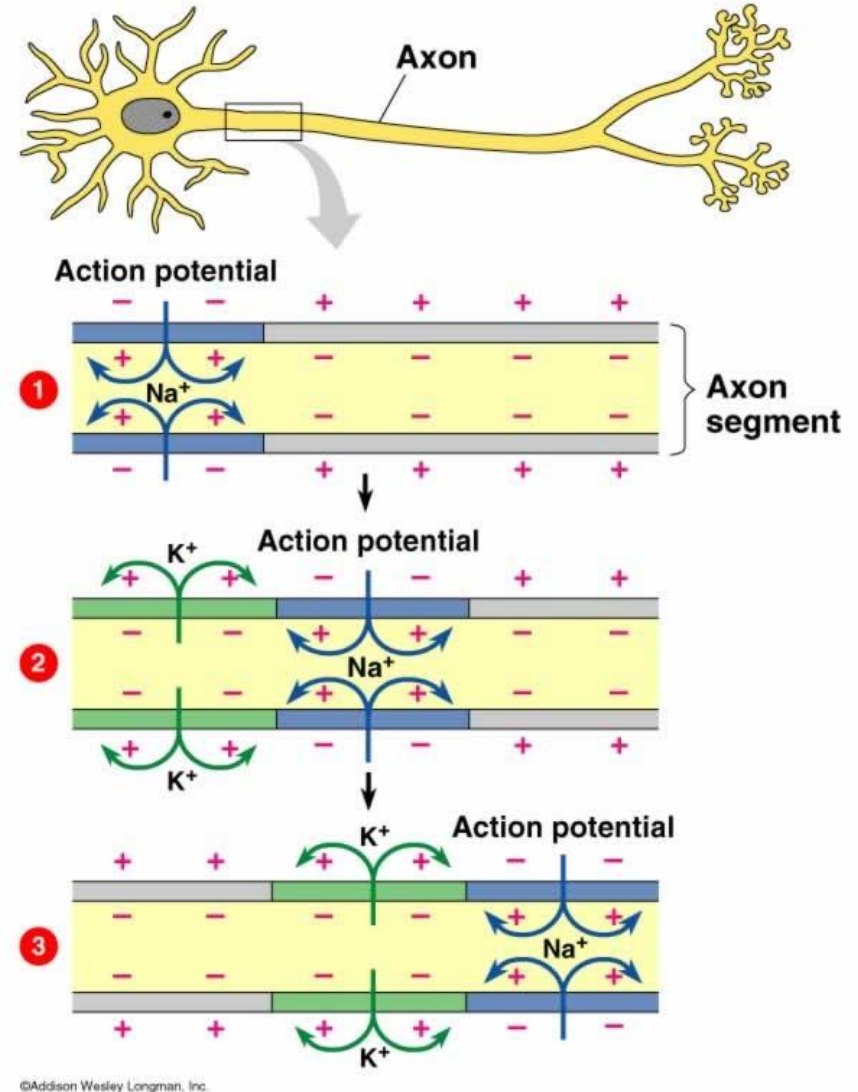
Inactive state

- **Resting, inactive** neuron has a **polarized membrane** = slightly more positive on the outer surface of the membrane.
- Polarized neuron has a potential of -70m volt.

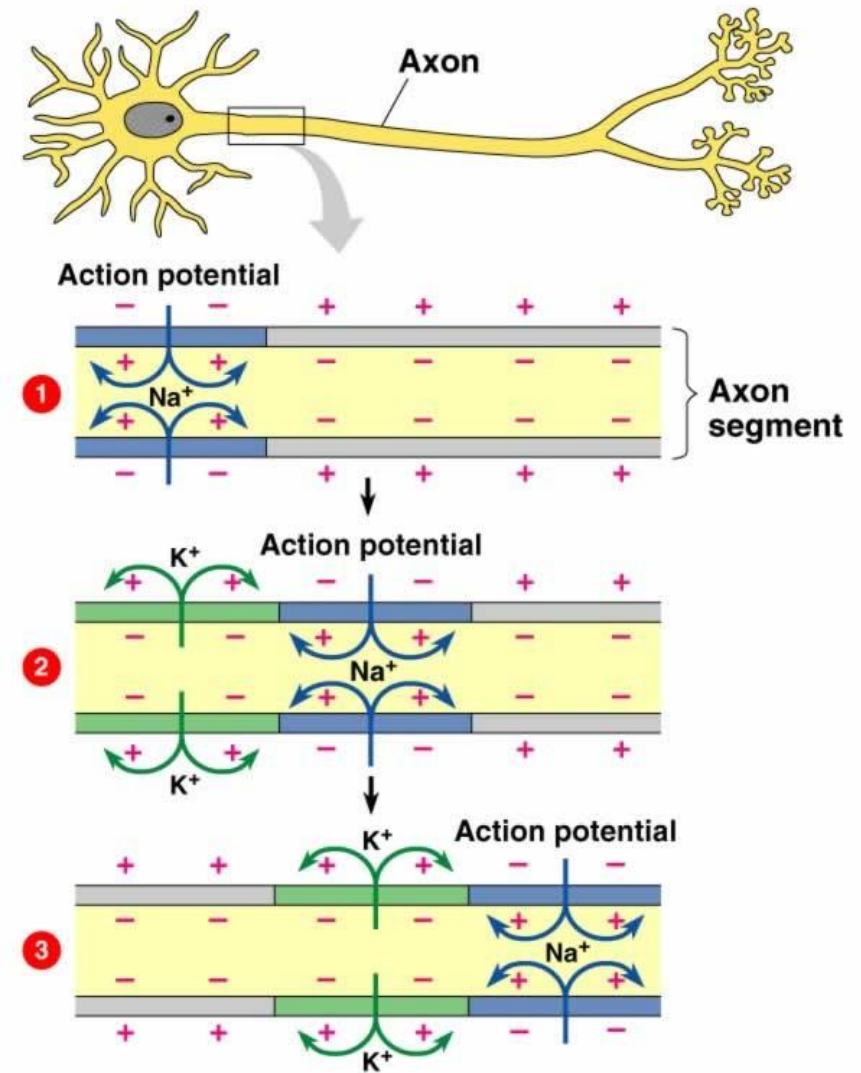
(maintained by stable concentrations of Na^+ outside the cell and K^+ inside the cell).

Action Potential (AP)

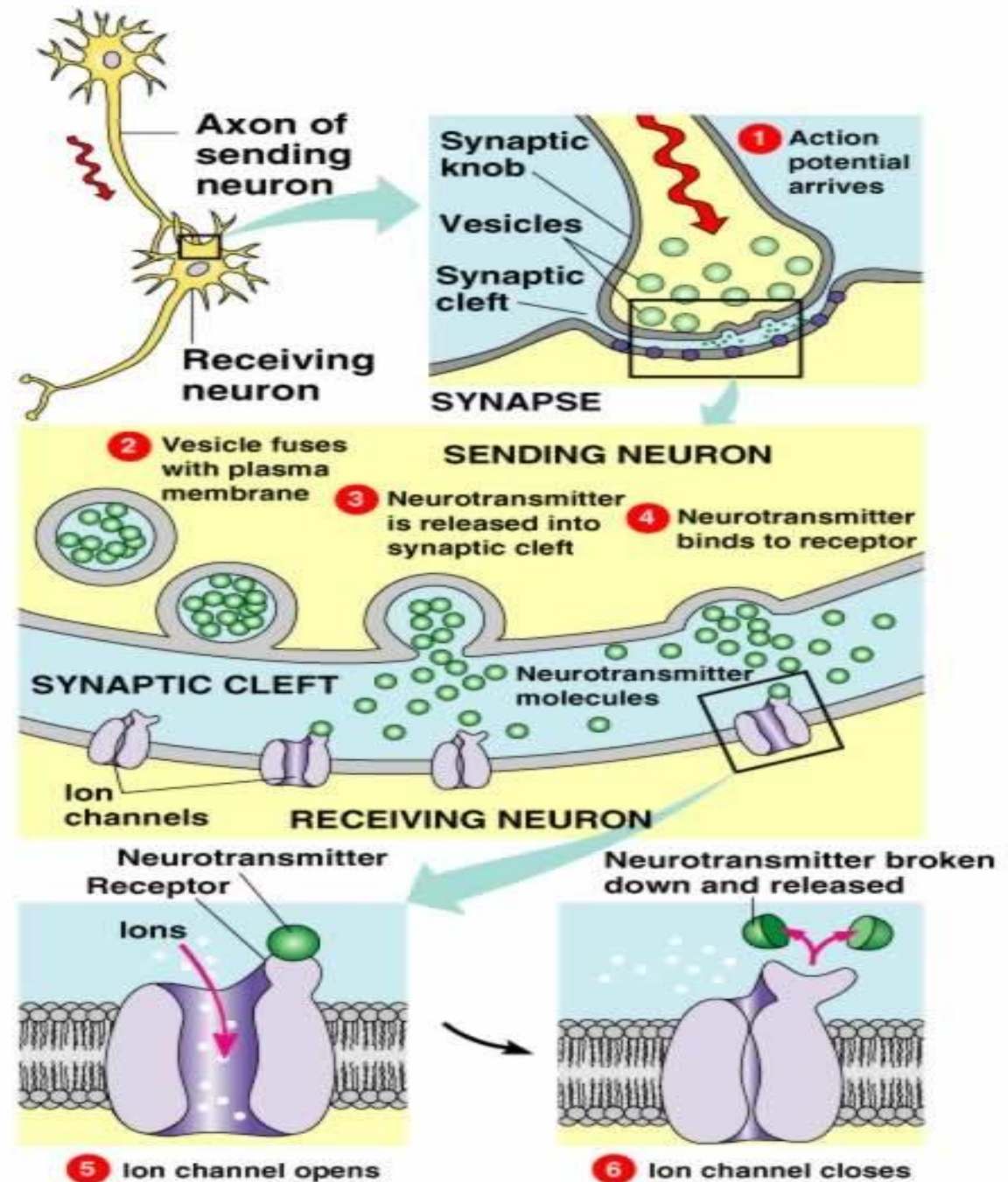
- Stimulus causes the permeability of the cell membrane to change. Na^+ channels open & Na^+ ions diffuse quickly into the neuron → Change polarity of the neuron's membrane (**Depolarization**).
- This creates an electrical potential = nerve impulse.



- The membrane permeability changes again, allowing K^+ ions to diffuse rapidly out of the neuron → **repolarization**, resting state.
- The initial conc. Of Na^+ & K^+ inside & outside the neuron are restored by activation of **Na-K pump**.
- Impulse propagates along the axon until it reaches the axonal terminal branches.
- Signal is then transmitted to the next neuron.



Transmission of signal from presynaptic neuron to post-synaptic neuron



2. Neuroglial Cell

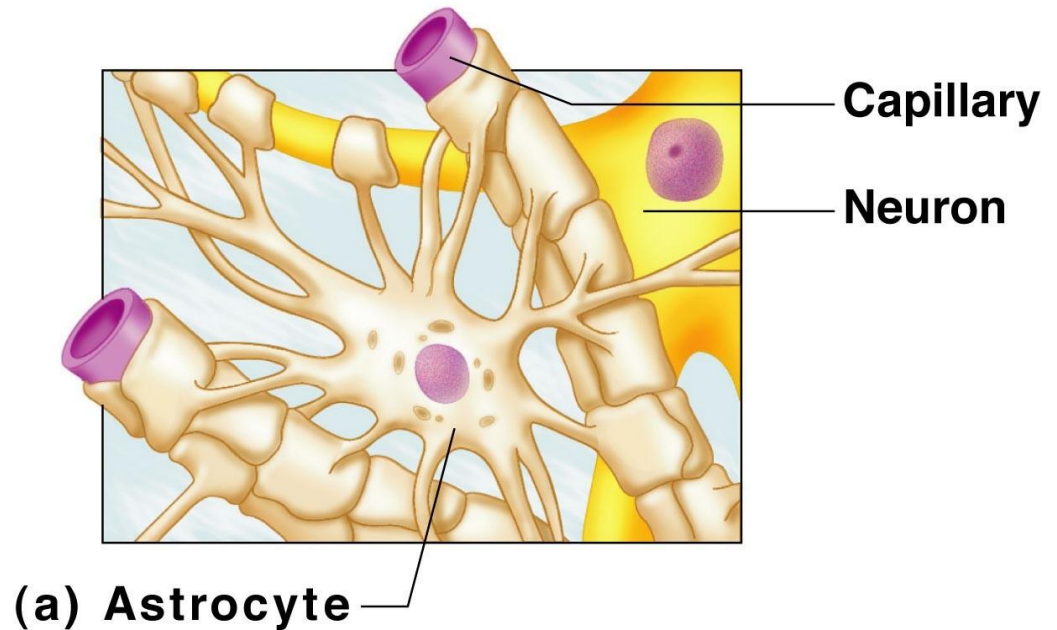
- Also known as
 - glia cell
 - Glia

Types of Neuroglial Cells in CNS:

- Astrocytes.
- Microglial cells.
- Ependymal.
- Oligodendrocytes.

Astrocytes

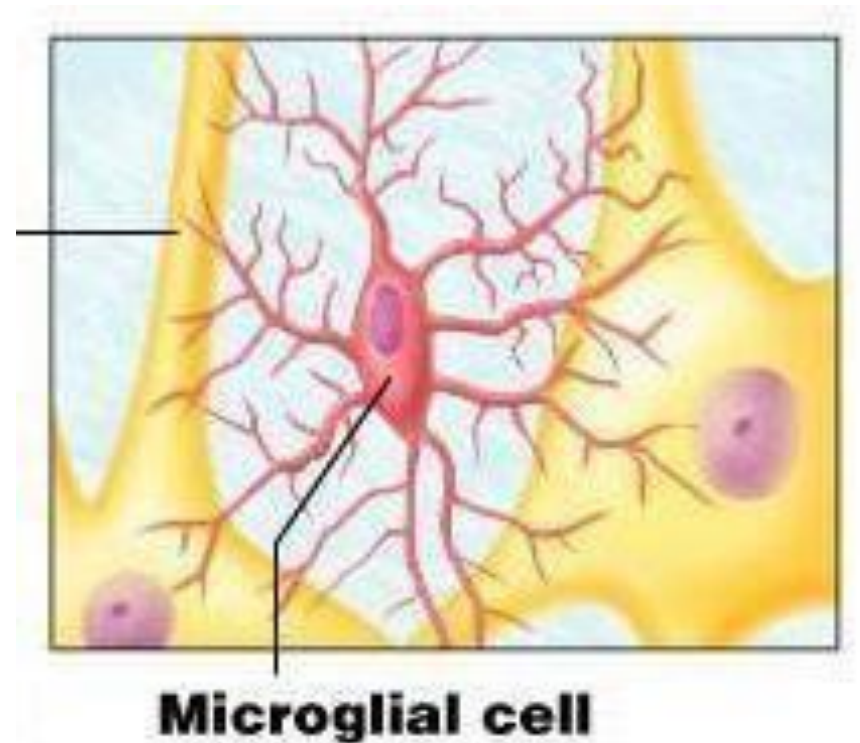
- Star-shaped cells.
- Most abundant.
- Swollen end projections that cling to neurons anchoring them to blood capillaries.
- Form a living barrier b/w neurons & capillaries.



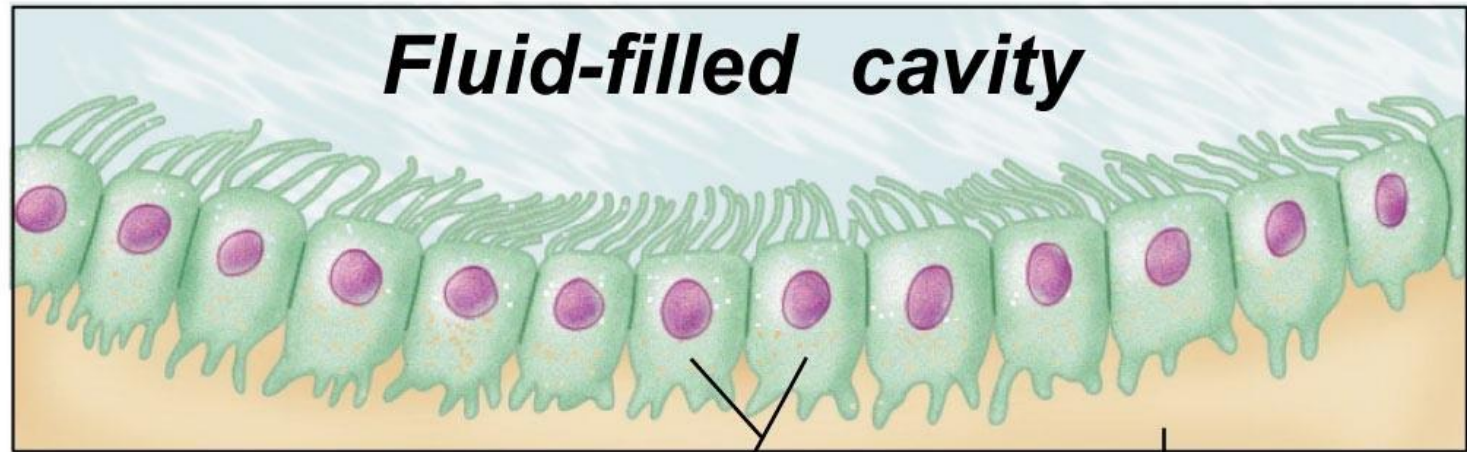
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Microglia cells

- Small Spiderlike phagocytes.
- Dispose of debris including dead brain cells & bacteria (protective cell of brain and spinal cord).
- They increase in number during infections



Ependymal Cells



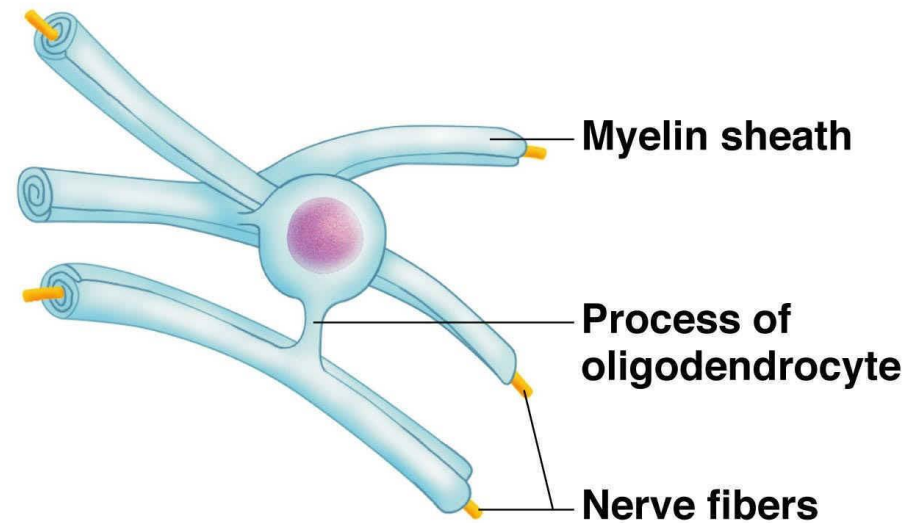
(c) Ependymal cells — **Brain or spinal cord tissue**

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- Line the cavities of the brain & spinal cord.
- Secret CSF that fills those cavities.

Oligodendrocytes

- Form myelin around nerve fibers in the CNS.

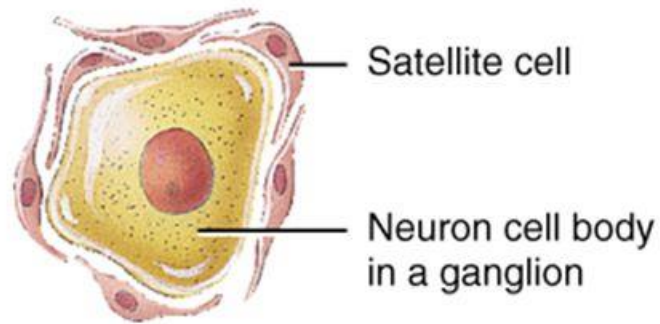


(d) Oligodendrocyte

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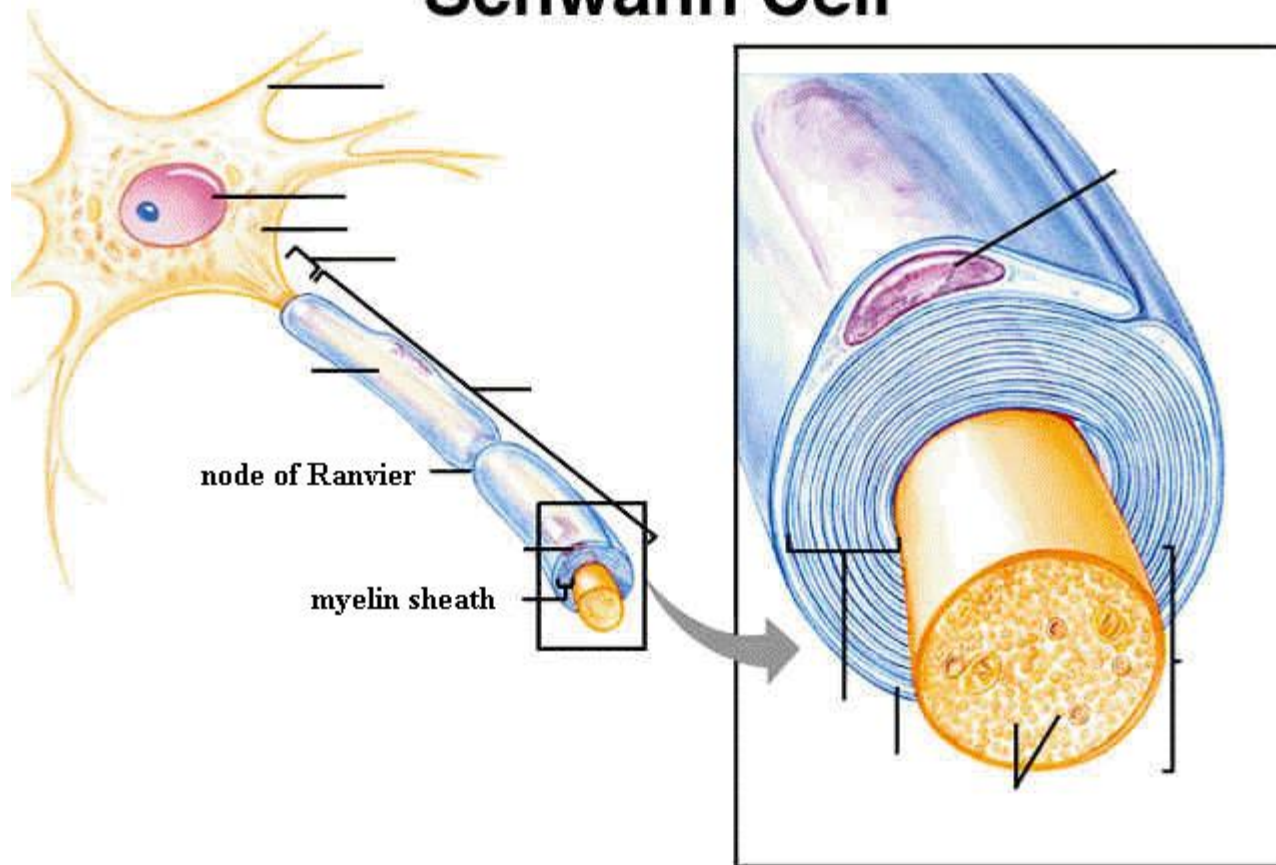
Types of Neuroglial Cells in PNS:

Satellite Cells



- Same as astrocytes function
- Surrounds and support neurons in PNS

Schwann Cell



- Same as Oligodendrocytes function
- Wrap axon of PNS

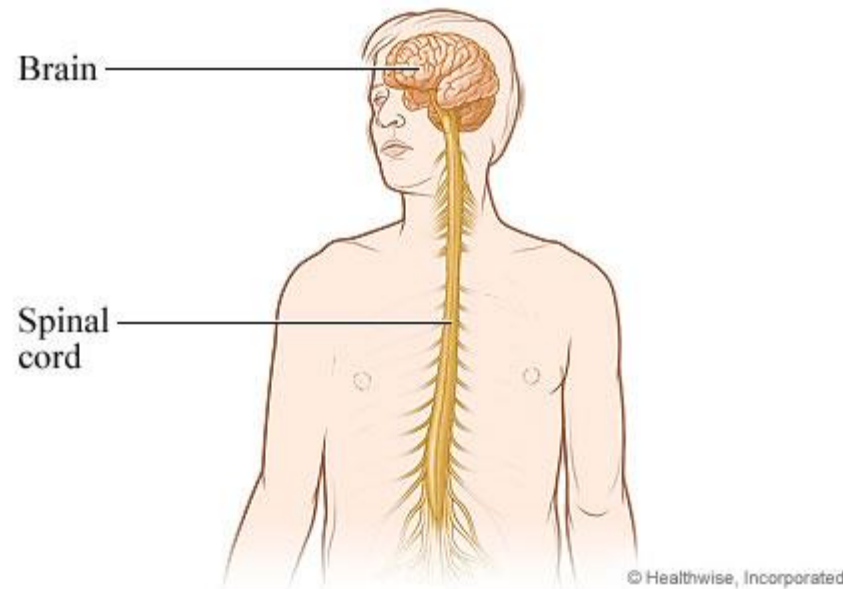
3. Central nervous system.

Objectives:

- Identify & indicate the functions of the major regions of the cerebral hemispheres, diencephalon, brain stem, & cerebellum.
- Name the 3 meningeal layers.
- Discuss the function of CSF and the BBB.

3. Central Nervous System.

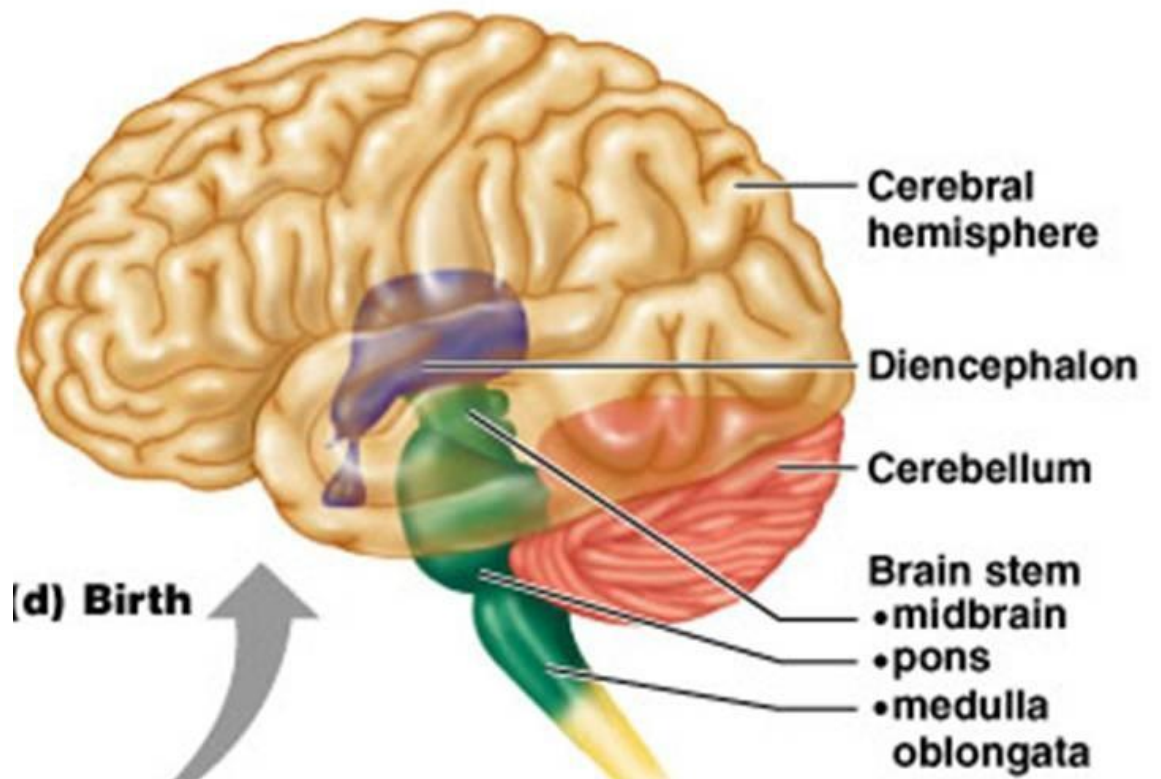
- The Brain
- Spinal Cord



The CNS has two kinds of tissue: grey matter and white matter, Grey matter, which has a pinkish-grey color in the living brain, contains the cell bodies, dendrites and axon terminals of neurons, so it is where all synapses are. White matter is made of axons connecting different parts of grey matter to each other.

The Brain:

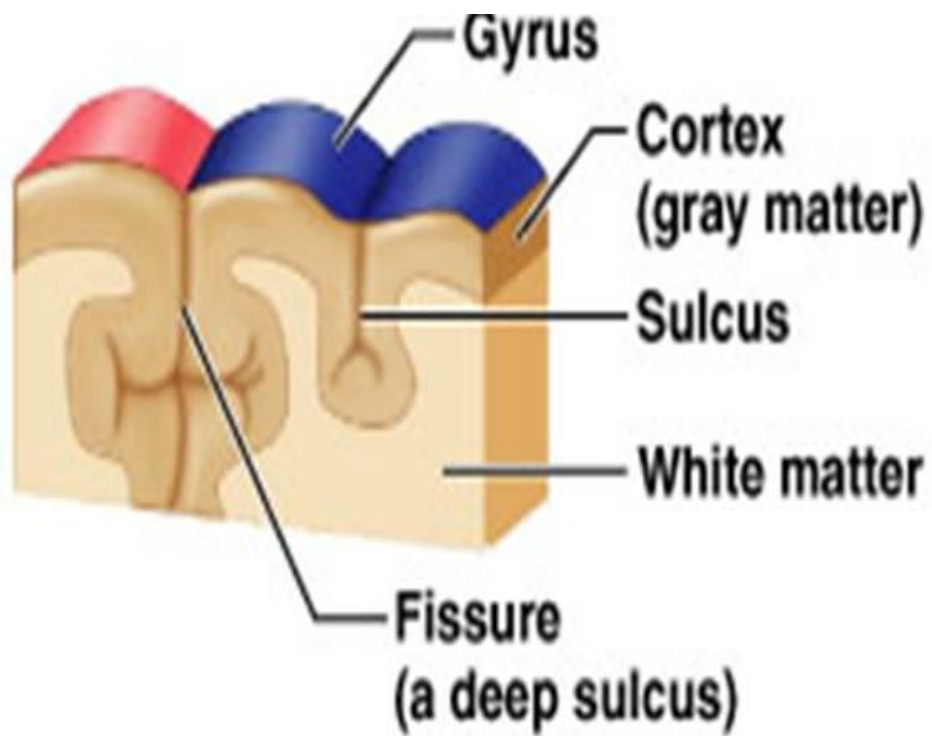
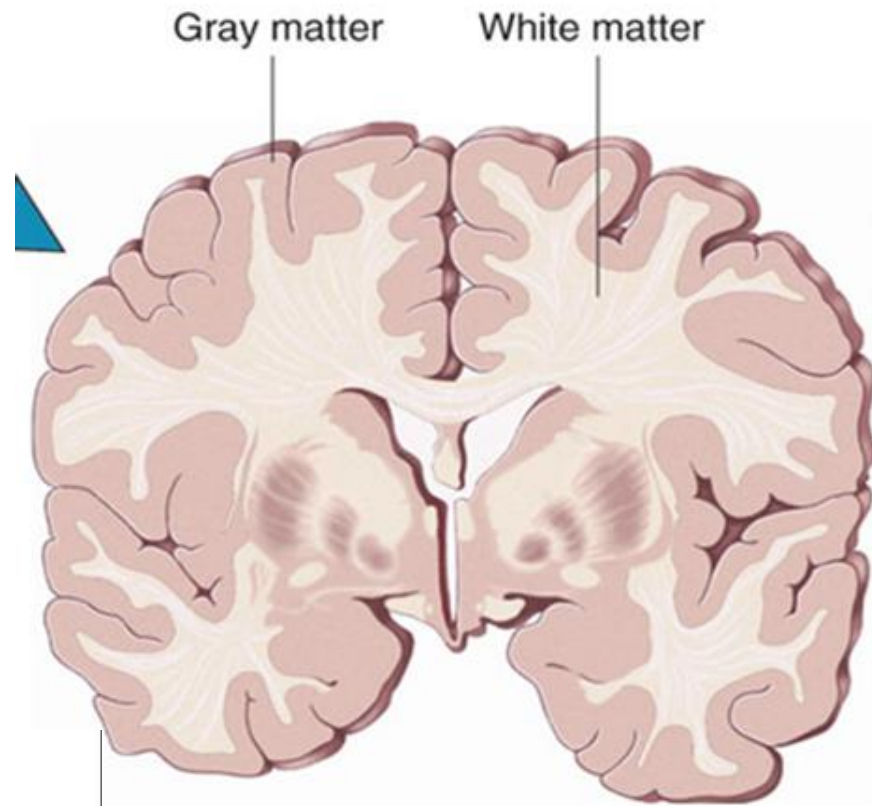
- Cerebral hemisphere
- Diencephalon
- Cerebellum
- Brain stem



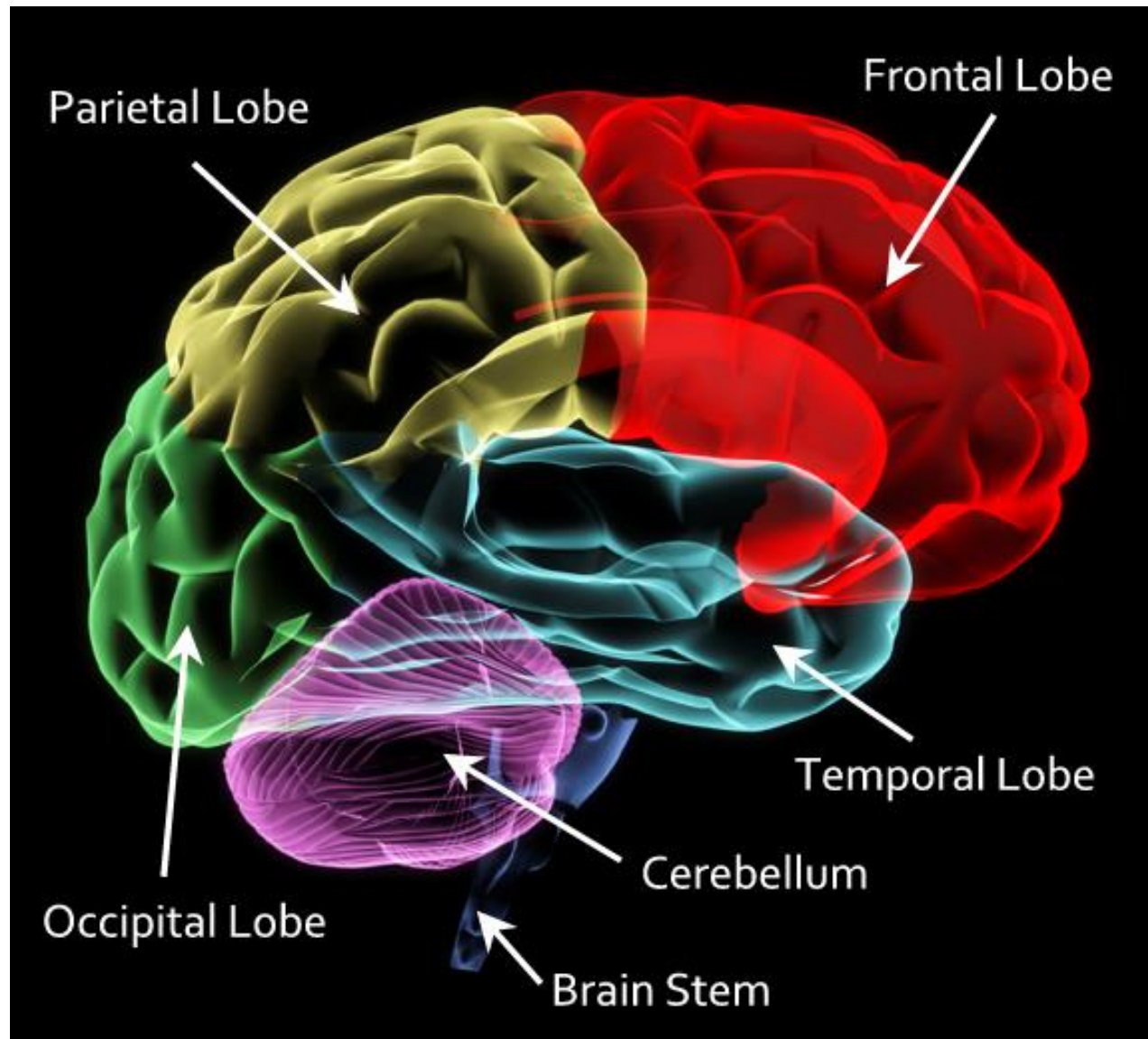
Cerebral hemispheres (Cerebrum):

- Most superior part.
- The largest part.
- The cerebrum is divided in to left and right hemispheres. The left half controls the right side of the body and the right half controls the left side of the body.
- A mass of nerve fibers known as the corpus callosum connects the two hemispheres and allows communication between the two.

- The surface of the two hemispheres is covered by gray matter. Because of the area size of the gray matter, fitting it into the skull causes folds.
- The grooves in these folds are called sulci and the ridges are called gyri.
- The deeper grooves are called fissures.
- The cortex is a large mass of white matter.
- The left and right hemispheres look the same, but functions differently. Speech and language, reasoning and analysis, and certain communications are on the left side for most people.
- The right hemisphere is concerned with sensory input, auditory and visual awareness, creative abilities, and spatial awareness (aware of space and surroundings).
- **Cerebrum is divided into 4 main lobes.**



Cerebrum lobes

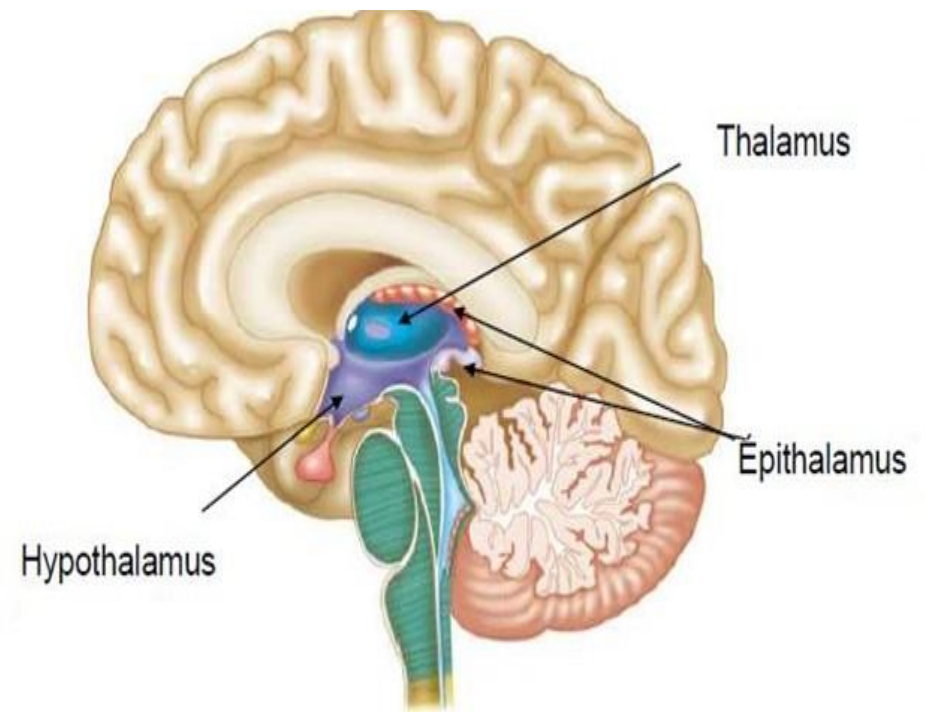


- Frontal lobe: Primary motor area: Conscious movement of all skeletal muscles, cognitive functions (concentration and planning), speech and language comprehension.
- Parietal lobe: Somatic sensory area: Allow you to recognize coldness, touch, pain and pressure).
- Temporal lobe: Auditory area and production of written and spoken language.
 - Medial temporal lobe has hippocampus region (short term memory)
 - Amygdala (sexual and social behaviour).
- Occipital lobe: Visual area.

Diencephalon:

Composed of:

1. Thalamus
2. Hypothalamus
3. Epithalamus



- **Thalamus:**

- Relay station for sensory impulses passing upwards to the sensory cortex.

- **Hypothalamus:**

- Regulates body temp, water balance, metabolism.
- Important part of the “limbic system” or emotional visceral brain (thirst, appetite, pleasure, pain..etc)
- Regulates the pituitary gland.

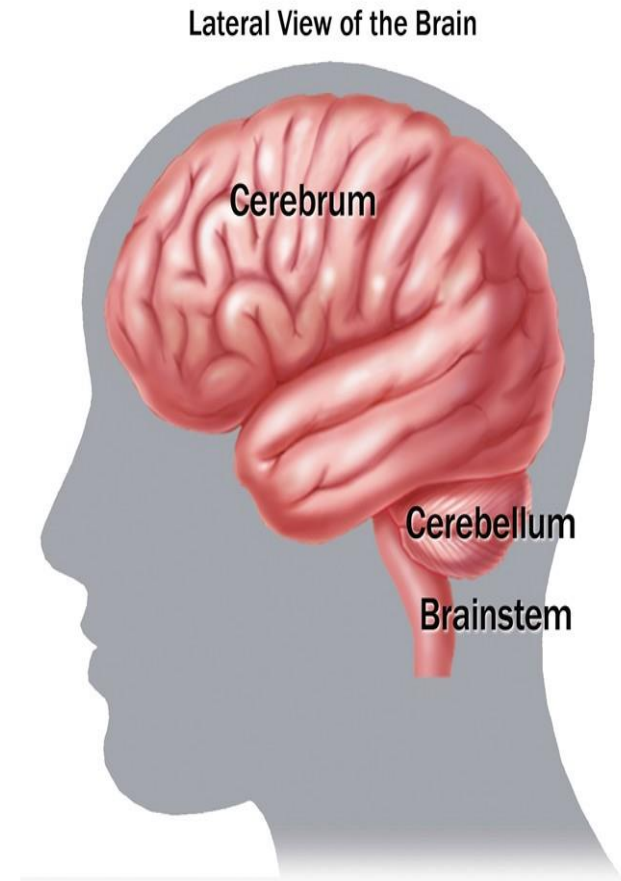
- **Epithalamus:**

Contains:

- pineal gland → melatonin (sleep hormone)
- Choroid plexus → forms CSF

Cerebellum:

- Located under the cerebrum.
- Functions:
 - Controls balance and equilibrium.
 - Provide the precise timing for skeletal muscle activity.



Brain Stem:

— Midbrain

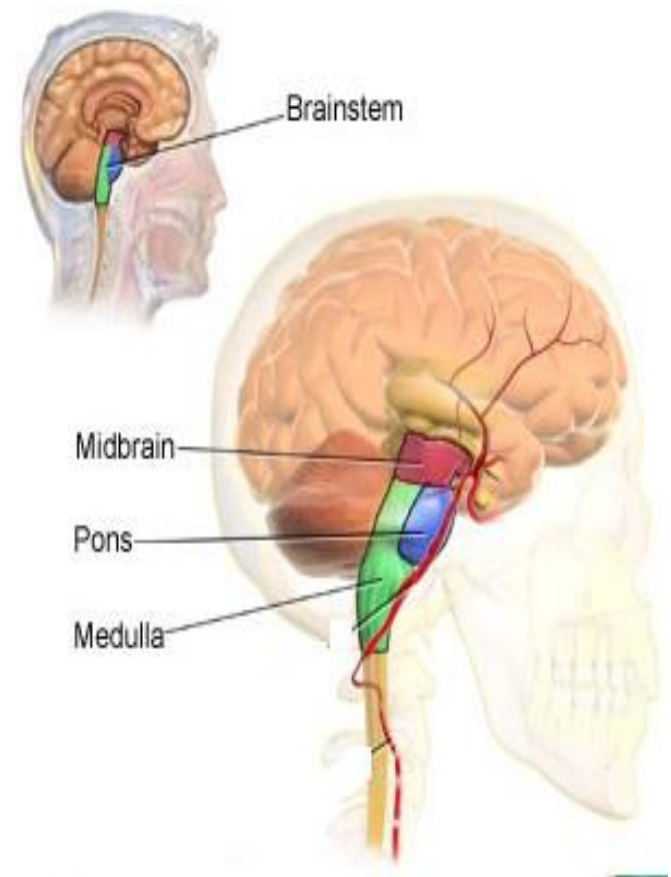
- Involved in vision & hearing.

— Pons

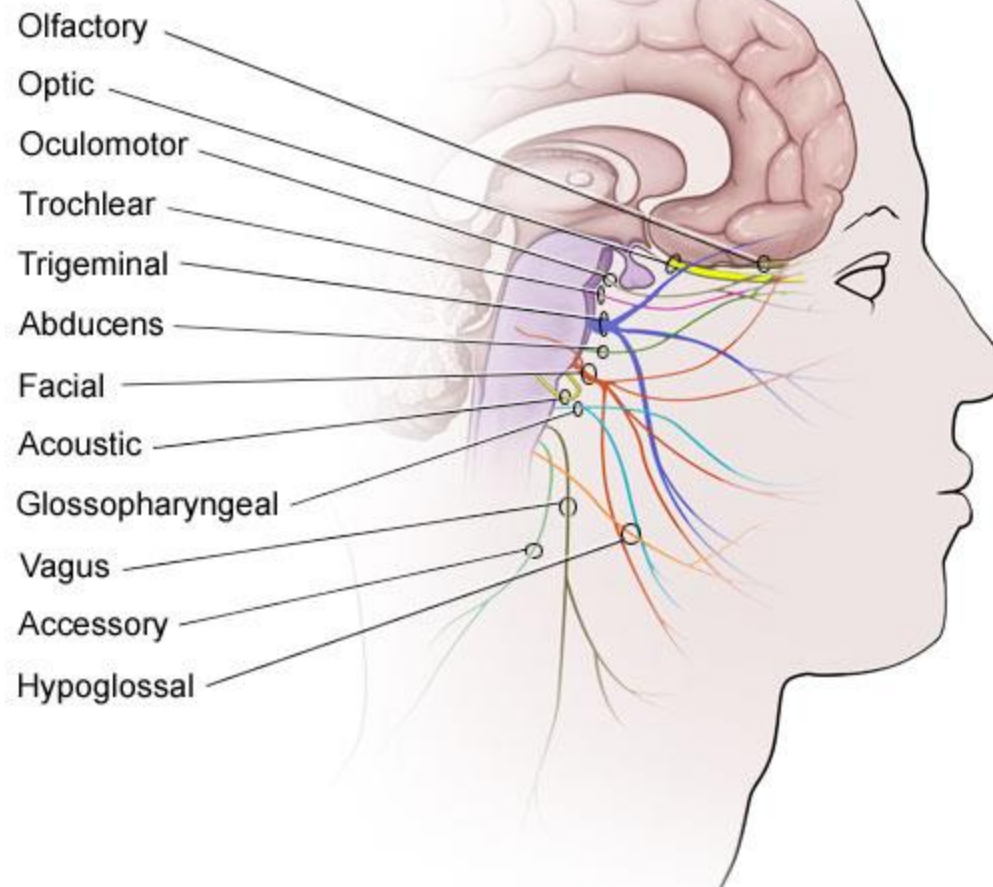
- Involved in the control of breathing.

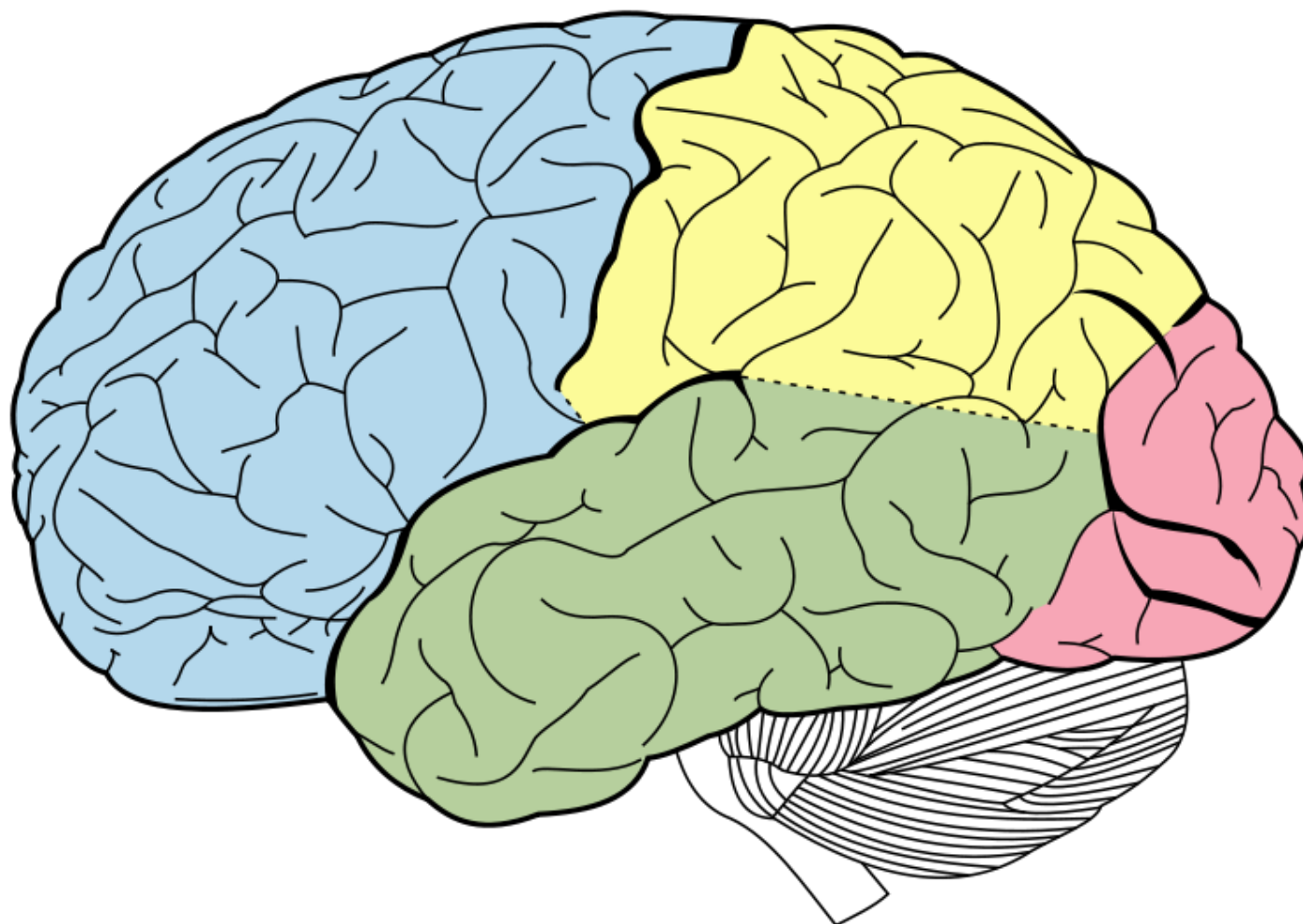
— Medulla oblongata

- Regulate vital visceral activities (heart rate, blood pressure, vasoconstriction, Breathing, swallowing, vomiting).



Cranial Nerves





Protection of CNS

In addition to Skin and skull ;

- Meninges
- CSF
- Blood Brain barrier

Meninges

- Three C.T. membranes surround and protect the brain:
 1. Dura matter (outer most)
 2. Arachnoid matter (middle)
 3. Pia matter (inner most)

The Meninges

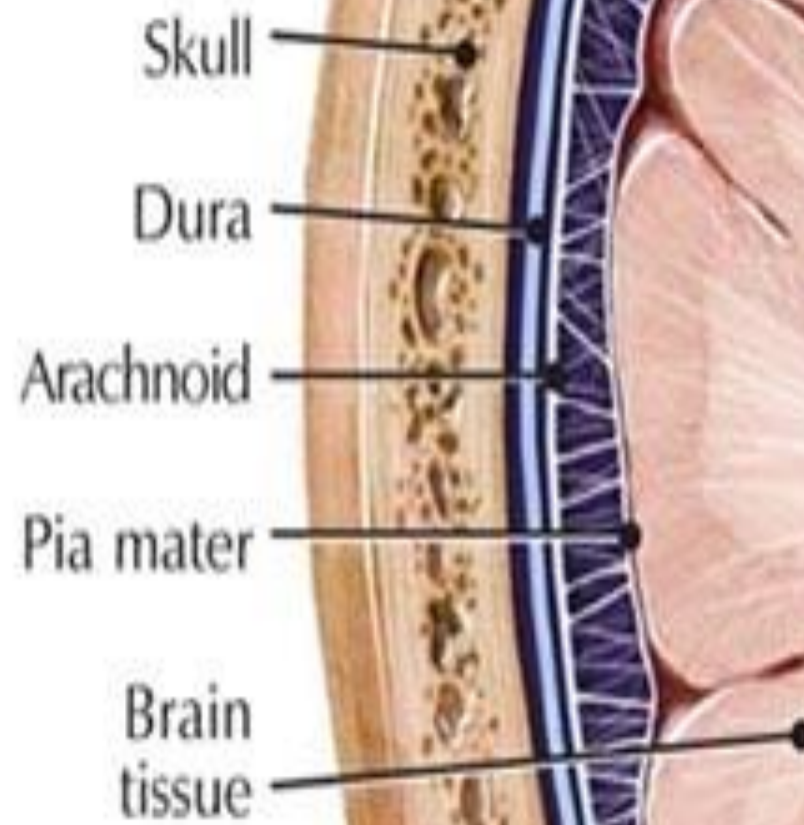
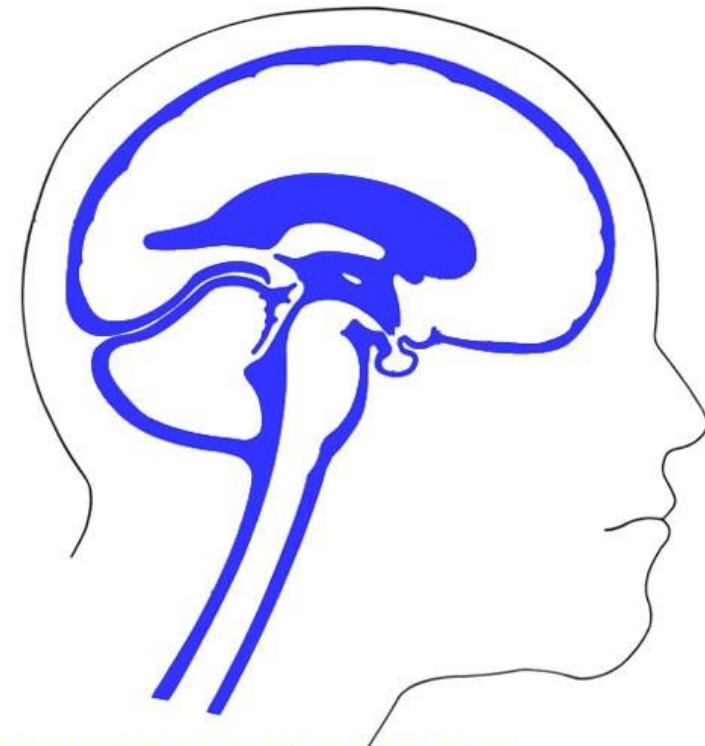


Fig. 2

Cerebrospinal fluid

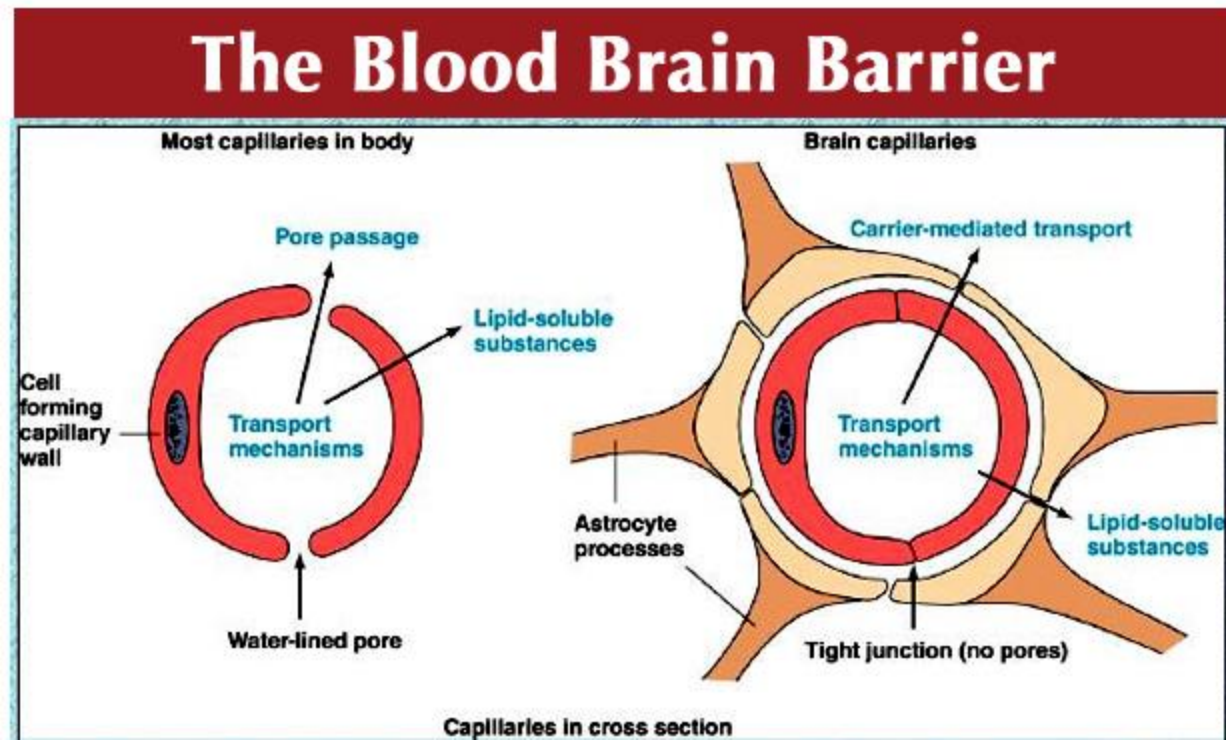
- Around the brain & spinal cord forming a watery cushion that protects the nervous tissue from blows and trauma.
- If something obstructs its drainage (tumor), CSF begins to accumulate and exert pressure on the brain. This condition is hydrocephalus.



CSF in ventricles and meninges

Blood Brain Barrier (BBB)

- Keeps the brain separated from bloodborn substances that might affect neural activity.
- Composed of the least permeable capillaries in the body.
- Only water, glucose and essential a.a's can pass through its capillary walls.
- Metabolic wastes; urea, toxins..etc are prevented from entering brain tissue.



Spinal Cord:

Structure:

- Cylindrical in shape.
- lies within the vertebral canal of the vertebral column.
- it is a continuous of the brain stem.
- it provides a two-way conduction pathway to and from the brain.
- Like the brain, the spinal cord is cushioned and protected by meninges
- The spinal cord is 40 to 50 cm long and 1 cm to 1.5 cm in diameter.
- Two consecutive rows of nerve roots emerge on each of its sides. These nerve roots join to form 31 pairs of spinal nerves.

- Like the brain; it is composed of white and gray matter.
- in cross section; each segment shows central H-shaped area of grey matter and peripheral zone of white matter.
- Is uniformly organized and is divided into four regions:
 - cervical
 - thoracic
 - lumbar
 - sacral

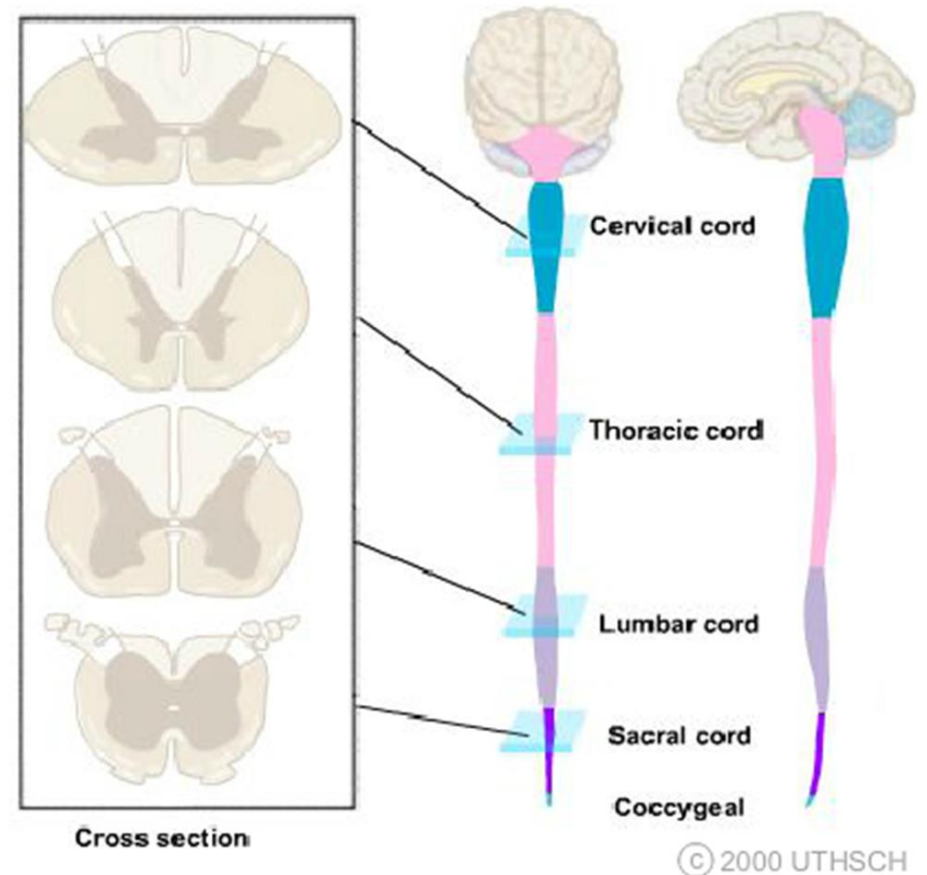


Figure 3.1
Schematic dorsal and lateral view of the spinal cord and four cross sections from cervical, thoracic, lumbar and sacral levels, respectively.