

AGA 2110

THE NERVOUS SYSTEM

TERMINOLOGY

- ❑ **Neuro** – refers to the nervous system
- ❑ **Neurology** - The branch of science that studies the nervous system
- ❑ **Neuron** – Nerve cells (also called nerve fibers)
- ❑ **Afferent** – towards the CNS/cell body
- ❑ **Efferent** – Away from the CNS /cell body
- ❑ **Neurotransmitter** - endogenous substances that are released from neurons eg acetylcholine, dopamine that transmit an impulse from one cell to another

INTRODUCTION

- ❑ Function – coordination animals response to the environment
- ❑ the NS gathers, sorts & stores information & initiates movement/response

Examples

- ✓ Animals sense the temperature of the surroundings, for example, so they can avoid the hot sun.
- ✓ They must also be able to identify food and escape predators

INTRODUCTION

- ❑ An animals body is complex
- ❑ In order to maintain **homeostasis** & therefore health, all those cells, tissues, organs & systems have to be able to **communicate with each other & their functions have to be coordinated & controlled**.
- ❑ Fortunately the body has two communication & control systems that help keep things working properly
 - i. the nervous system
 - ii. the endocrine system
- ❑ Both use chemicals to carry their messages, but they do it by different means, and on different timescales.

❑ NERVOUS SYSTEM

- ✓ The nervous system's chemical messengers are called **neurotransmitters**
- ✓ Neurotransmitters are produced only by neurons (nerve cells).
- ✓ The neurotransmitters travel only very short distances, across spaces between nerve cells called **synapses**
- ✓ This allows the system to react quickly, but the limited supplies of neurotransmitters in the cells do not allow it to sustain individual activities for long periods of time.

❑ ENDOCRINE SYSTEM

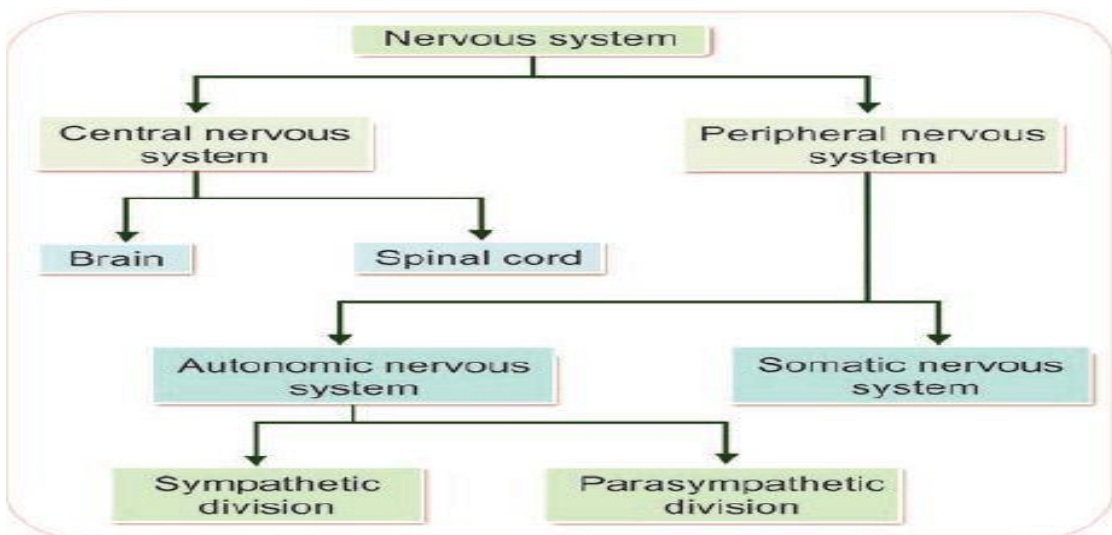
- ✓ The chemical messengers of the endocrine system are called **hormones**
- ✓ Hormones are secreted directly into the bloodstream, where they travel comparatively **long distances** to reach their targets.
- ✓ The hormone targets, therefore, react more slowly to changes, but hormones can be secreted for long periods of time, so they can sustain individual activities for long periods of time

THE NERVOUS SYSTEM

□ Structurally the nervous system (NS) has 2 major divisions

1. **The central nervous system (CNS)** - includes the brain & spinal cord.
2. **The peripheral nervous system (PNS)** - includes nerves found in all other regions of the body

SUBDIVISIONS OF THE NERVOUS SYSTEM



THE PERIPHERAL NERVOUS SYSTEM

- ❑ The [peripheral nervous system](#) consists of the nerves that branch out from the [brain](#) and [spinal cord](#).
- ❑ These nerves form the communication network between the [CNS](#) and the body parts.

THE PERIPHERAL NERVOUS SYSTEM

- ❑ The peripheral nervous system is further subdivided into the
 - i. [somatic nervous system](#) and
 - ii. [autonomic nervous system](#).
- ❑ The somatic nervous system consists of nerves that go to the skin and muscles and is [involved](#) in **conscious activities**.
- ❑ The autonomic nervous system consists of nerves that connect the CNS to the [visceral](#) organs such as the [heart](#), [stomach](#), and intestines. It mediates **unconscious activities**.

AUTONOMIC NERVOUS SYSTEM

- ❑ It is concerned with [heart rate](#), breathing rate, [blood pressure](#), body temperature, and other visceral activities that work together to maintain [homeostasis](#).
- ❑ The autonomic nervous system has two parts,
 - i. the [sympathetic division](#) and
 - ii. [parasympathetic division](#).
- ❑ Many visceral organs are supplied with fibers from both divisions. In this [case](#), one stimulates and the other inhibits. This antagonistic functional relationship serves as a balance to help maintain homeostasis.

FUNCTIONS OF THE NERVOUS SYSTEM

- ❑ The nervous system has three overlapping functions based on sensory input, integration, and motor output.
- ❑ Functionally, the nervous system's activities fall into 3 main categories:
 - (1) *sensory functions*
 - (2) *integrating functions and*
 - (3) *motor functions.*

FUNCTIONS OF THE NERVOUS SYSTEM

1. SENSORY FUNCTION

The NS senses changes from within the body or from outside the body & conveys this information to the spinal cord & brain.

What is sensory function?

it refers to the ability to detect any information from the senses that is

- ✓ Touch (Pressure, pain & temperature)
- ✓ Sight
- ✓ smell,
- ✓ hearing
- ✓ taste.

FUNCTIONS OF THE NERVOUS SYSTEM

2. INTERGRATING FUNCTION

In the brain & spinal cord, the sensory information is received, **analyzed**, stored, & integrated to produce an **appropriate response**

MOTOR FUNCTION

A motor response instructs the body to do something, such as contract a muscle or cause a gland to secrete its product

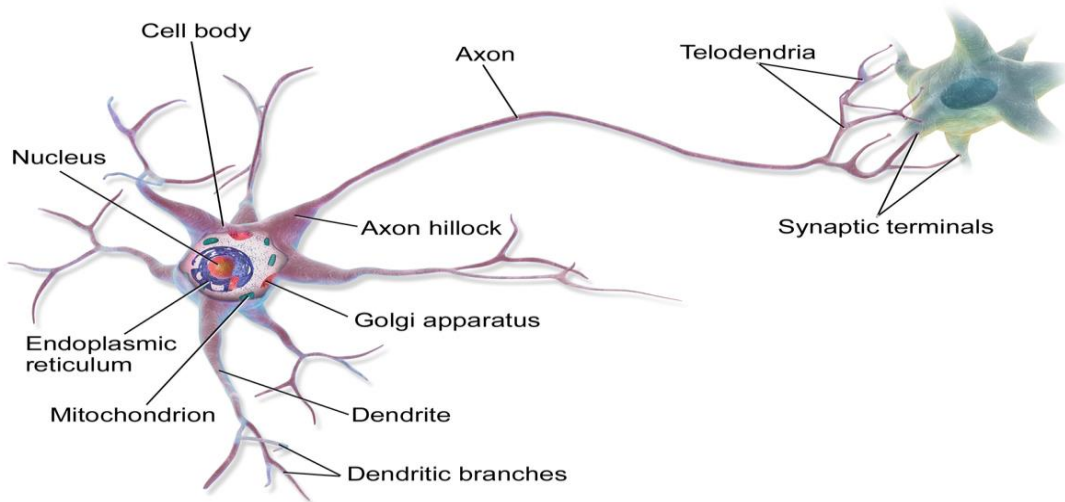
CELLS FOUND IN THE NERVOUS SYSTEM

- ❑ **Neurons** – sends & receive signals
- ❑ **Glial cells (neuroglial cells)** – support & protect the neurons

A NEURON

- ❑ The basic functional unit of the NS
- ❑ A neuron is a cell that have been adapted to carry nerve impulses
(sends & receives signals)
- ❑ Although neurons in different parts of the NS vary somewhat in appearance, their basic structure is the same.
- ❑ A basic neuron has a cell body (soma) – also called perikaryon and 2 types of processes
 - i. Dendrites
 - ii. Axon

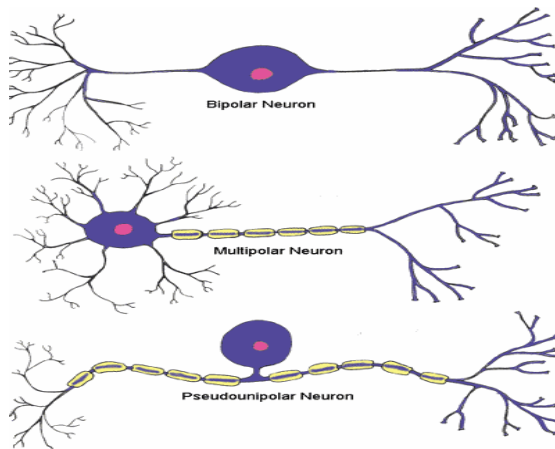
NEURON



POLARITY OF NEURONS

- ❑ The polarity of a neuron refers to the number of poles or processes that stem from its cell body.
- ❑ Mammalian neurons can be categorized as;
 - i. **bipolar** (1 axon, 1 dendrite) extending from the cell body
 - ii. **pseudounipolar** (in which the axon and dendrite of a bipolar neuron have fused near the cell body, giving the appearance of only one process),
 - iii. **multipolar** (many branching dendrites & 1 axon extending from the cell body)

POLARITY OF NEURONS



DENDRITES

- ❑ Receive messages (stimuli, impulses) from other nerves or organs & conduct this stimulation to the cell body.
- ❑ They can be referred to as **afferent** processes, because they conduct impulses toward the cell body.
- ❑ Dendrites also may be modified into sensory receptors that receive, or sense stimuli such as heat, cold, touch, pressure, stretch, or other physical changes from inside or outside the body.
- ❑ Dendrites tend to be short, numerous & have many branches

AXON

- An axon is another type of process from the neuron cell body.
- Axons conduct nerve impulses away from the cell body towards another neuron or an effector cell
- They can be called **efferent processes**, because they conduct impulses away from the cell body
- An axon is a single process that can be long
- Axons are sometimes referred to as nerve fibers
- When talking about the components of nerve cells, the term axon is usually used. When talking about the bundles of axons that make up cordlike nerves in the body, they are usually called nerve fibers

MYELIN SHEATH

- A sheath of fatty substance that covers the axon
- On gross appearance, is white in color
- Nervous tissue containing many myelinated axons is called WHITE MATTER
- Nervous tissue made up of largely cell bodies appears darker & is called GRAY MATTER
- Myelin sheath is made of cell membranes of specialised glial cells called
 - ✓ oligodendrocytes in the brain & spinal cord,
 - ✓ and Schwann cells in the nerves outside of the brain & spinal cord

LOCATION OF CELL BODIES

- ❑ The cell body of neurons is usually located in the brain or spinal cord
- ❑ while the axon extends the whole distance to the organ that it supplies.
- ❑ The neuron carrying impulses from the spinal cord to the hind leg or tail of a horse, for example, can be several cms long

3 TYPES OF NEURONS (BASED ON FUNCTION)

❑ **A sensory (afferent) neuron**

- ✓ is a nerve cell that transmits impulses from a sense receptor such as those in the eye or ear to the brain or spinal cord.

❑ **A motor (efferent) neuron**

- ✓ is a nerve cell that transmits impulses from the brain or spinal cord to a muscle or gland.
- ✓ ie begins in the CNS and ends in the PNS

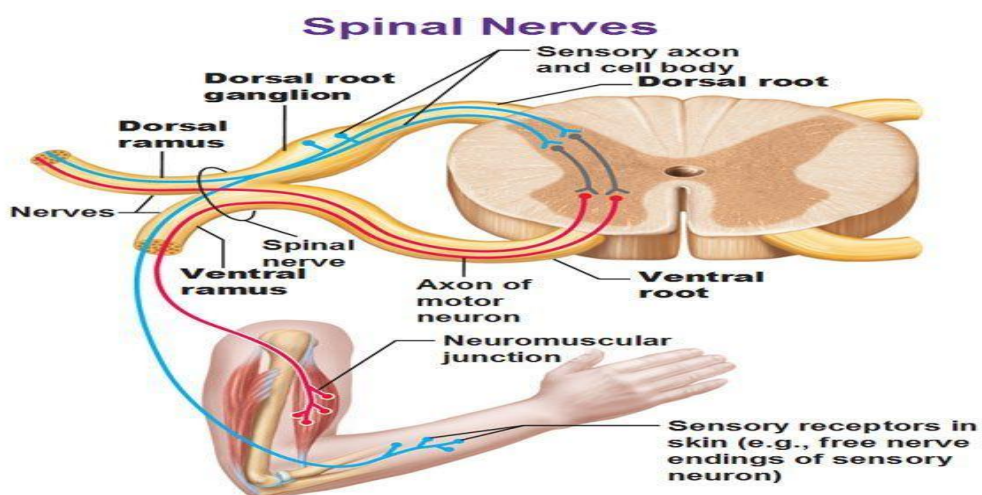
❑ **A relay neuron (interneuron)**

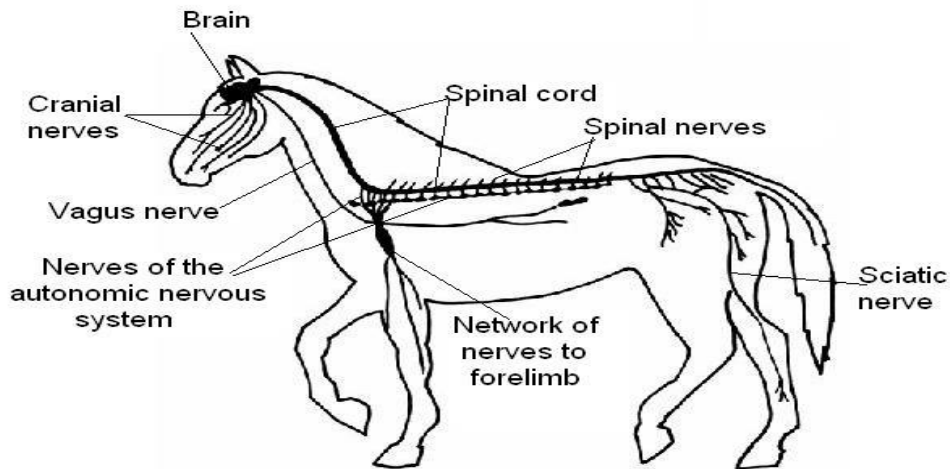
- ✓ connects sensory and motor neurons and is found in the brain or spinal cord

TERMINOLOGY

- ❑ **CNS** – Only has interneurons
- ❑ **PNS** – has afferent (sensory) and efferent (motor) neurons
- ❑ **NUCLEUS** - A collection of nerve cell bodies within the brain.
- ❑ **GANGLION** - A “nucleus” that occurs outside the brain is known as a ganglion
- ❑ Nerves occur as single neurons or in bundles, called nerve trunks.
- ❑ Ganglions are the nerve bundles that occur outside of the brain and spinal cord

SPINAL NERVES





NEUROGLIAL CELLS & MYELIN SHEATH

- Glial cells** are the non-neuronal cellular elements of the CNS.
- They are **10 to 1** ratio when compared to neurons in numbers
- Not involved in the transmission of impulses through the NS
- Main role is to **support & protect neurons**
- Glial cells include;
 - ✓ **Oligodendrocytes**
 - ✓ **Astrocytes**
 - ✓ **ependymal cells**
 - ✓ **and microglia.**
- The most significant role of oligodendrocytes is their involvement in myelin sheath formation in the CNS.

GLIAL CELLS & MYELIN SHEATH

- ❑ **Schwann cells** are involved in myelin sheath formation in the PNS.
- ❑ **Astrocytes**
 - ✓ are the most prominent glial cell
 - ✓ Star shaped
 - ✓ Are associated with neuronal synapses
 - ✓ They regulate transmission of impulses and provide neurons with nutrients.
- ❑ **Ependymal cells**
 - ✓ Form the epithelial lining of the the ventricles of the brain
 - ✓ Cerebral spinal fluid is formed in the ventricles

GLIAL CELLS & MYELIN SHEATH

- ❑ **The microglia**
 - ✓ have a phagocytic function.
 - ✓ They enter the CNS from blood vessels & increase in numbers during inflammatory processes or where neuron injury has occurred.

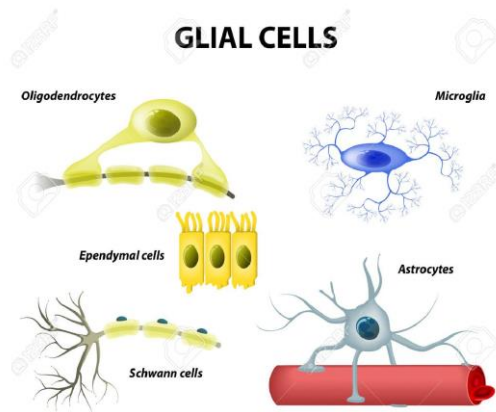
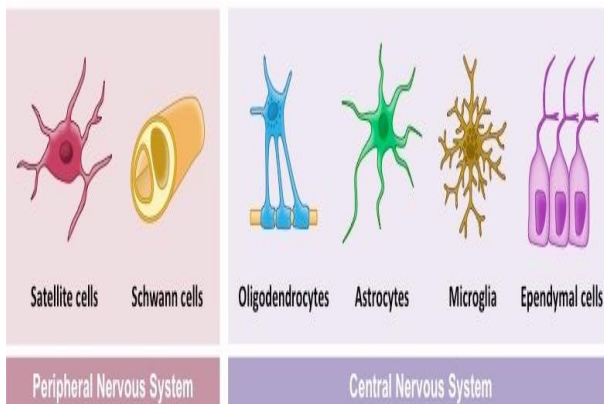
SUMMARY ROLES OF GLIAL CELLS (**SUPPORT & PROTECT**)

- i. **Formation of myelin sheath**
- ii. **Phagocytise/ digest debris**
- iii. **help supply nutrients of neurons by connecting them to blood vessels**
- iv. **Regulate transmission of impulses**

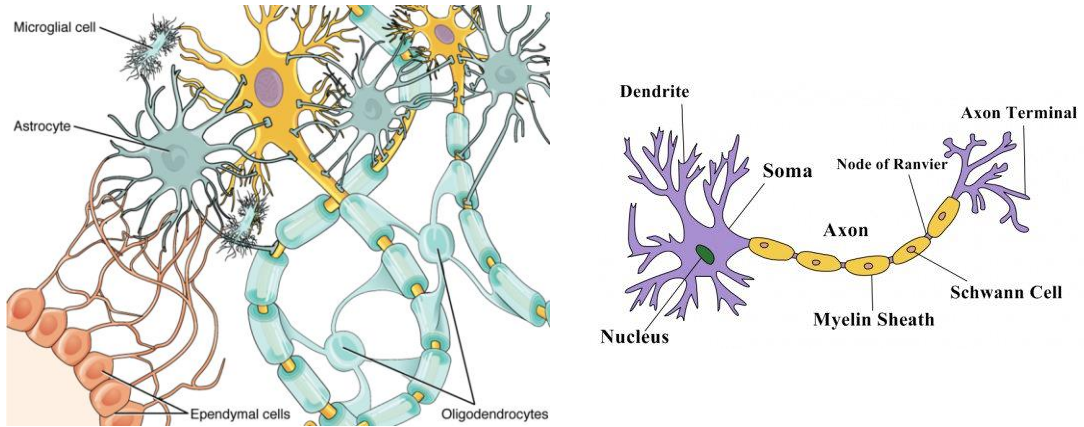
GLIAL CELLS & MYELIN SHEATH

- ❑ The special glial cells wrap themselves around the axon
- ❑ Because the axon of most neurons is fairly long, it takes multiple Schwann cells or oligodendrocytes lined up end to end to cover the entire length of the axon.
- ❑ Between adjacent glial cells are small gaps in the myelin sheath called nodes of Ranvier.
- ❑ The myelin sheath & nodes of Ranvier work together to enhance the speed of conduction of nerve impulses along the axon
- ❑ Myelinated axons conduct nerve impulses faster than unmyelinated axons

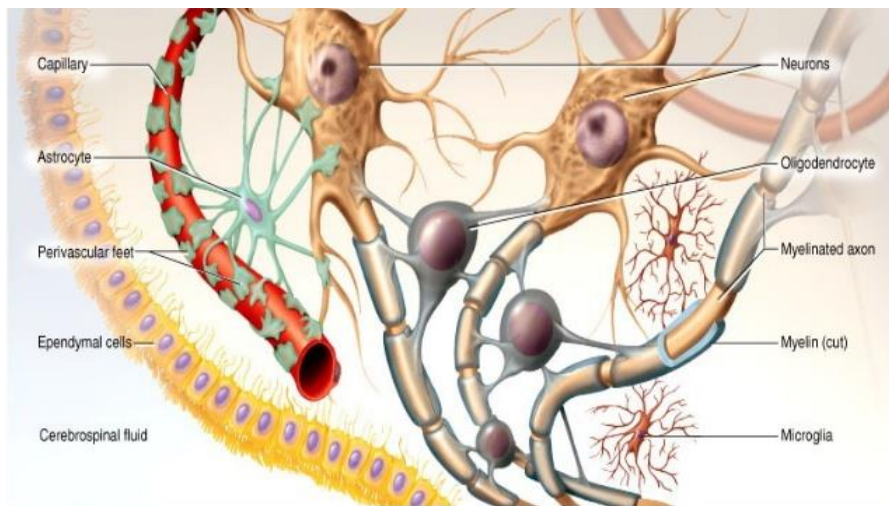
GLIAL CELLS – NEURON SUPPORT CELLS



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GLIAL CELLS – NEURON SUPPORT CELLS

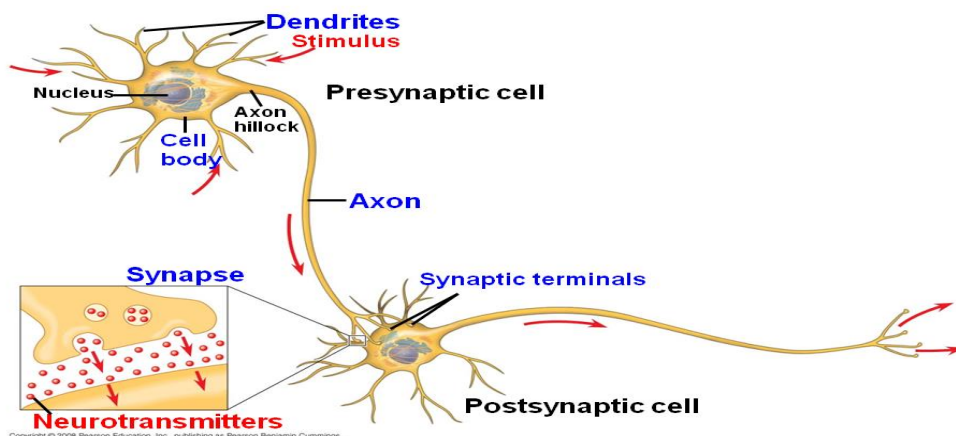


CONNECTION BETWEEN NEURONS (How neurons communicate)

- ❑ The connection between adjacent neurons is called a synapse.
- ❑ Nerve cells do not touch each other there is a space between them.
- ❑ The electrical impulse in the neuron before the synapse stimulates the production of chemicals called neurotransmitters (such as acetylcholine), which are secreted into the gap.
- ❑ The neurotransmitter chemicals diffuse across the gap & when they contact the membrane of the next nerve cell they stimulate a new nerve impulse
- ❑ After the impulse has passed the chemical is destroyed & the synapse is ready to receive the next nerve impulse

HOW NEURONS COMMUNICATE

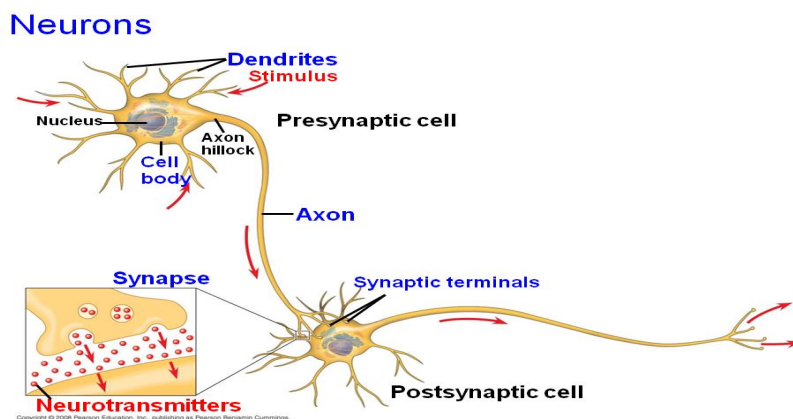
Neurons



TYPES OF NEUROTRANSMITTERS

- ❑ **Acetylcholine** is one of the most commonly studied neurotransmitter in the body
- ❑ **Norepinephrine** - is associated with arousal & fight-or flight reactions of the sympathetic nervous system.
- ❑ **Epinephrine** – Epinephrine is released from the adrenal gland & therefore plays more of a role as a hormone in the fight-or-flight reactions
- ❑ **Dopamine** - Dopamine is found in the brain, where it is involved with autonomic functions & muscle control.

HOW NEURONS COMMUNICATE



REFLEX ACTION

❑ A reflex is a rapid automatic response to a stimulus.

Examples of reflex actions

- ✓ when an animal touches a hot object & automatically jerk the limb away,
- ✓ Animals automatically blink when an object approaches the eye
- ✓ cats twist bodies in the air when falling so that they land their paws
- ✓ Swallowing, sneezing
- ✓ constriction of the pupil of the eye in bright light

REFLEX ACTION

❑ There are some stimuli that require an automatic, instantaneous response without the need of **conscious thought**. The diagram shows the reflex arc pathway.

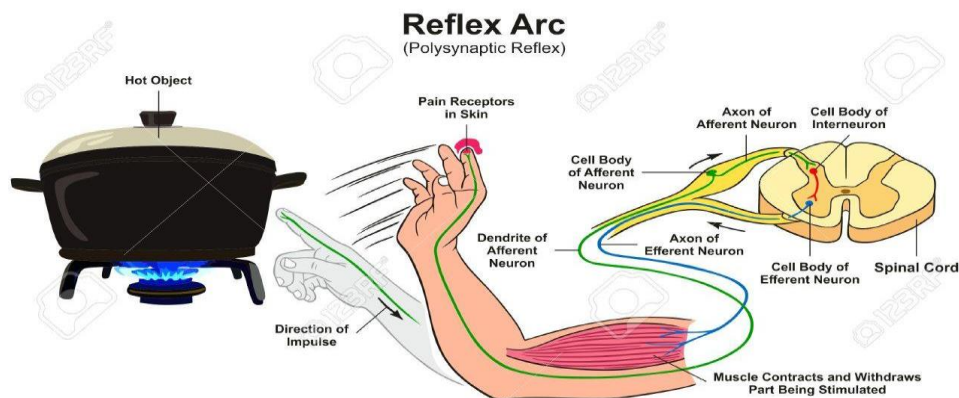
❑ The whole mechanism of reflex action occurs in such a fashion that there is no conscious control of the brain.

❑ Stimulation occurs through the peripheral nervous system and the response to this peripheral nerve stimulation is involuntary. In a reflex action, the spinal cord along with the brain stem is responsible for the reflex movement

REFLEX ARC

- ❑ The path taken by the nerve impulses in a reflex is called a **reflex arc**.
- ❑ Most reflex arcs involve only 3 neurons
- ❑ The stimulus (a pin in the paw) stimulates the pain receptors of the skin, which initiate an impulse in a sensory neuron. This travels to the spinal cord where it passes, by means of a synapse, to a connecting neuron called the relay neuron situated in the spinal cord. The relay neuron in turn makes a synapse with one or more motor neurons that transmit the impulse to the muscles of the limb causing them to contract & remove the paw from the sharp object.
- ❑ Reflexes do not require **involvement of the brain** although you are aware of what is happening and can, in some instances, prevent them happening. Animals are born with their reflexes.

REFLEX ARC



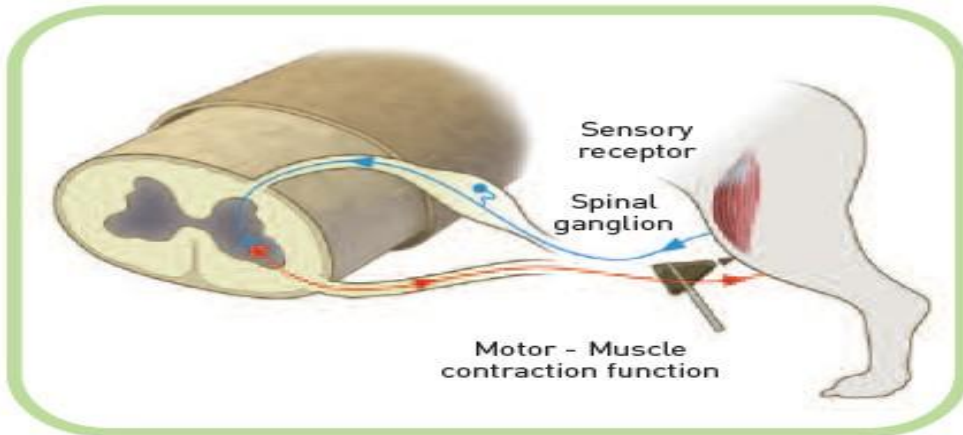
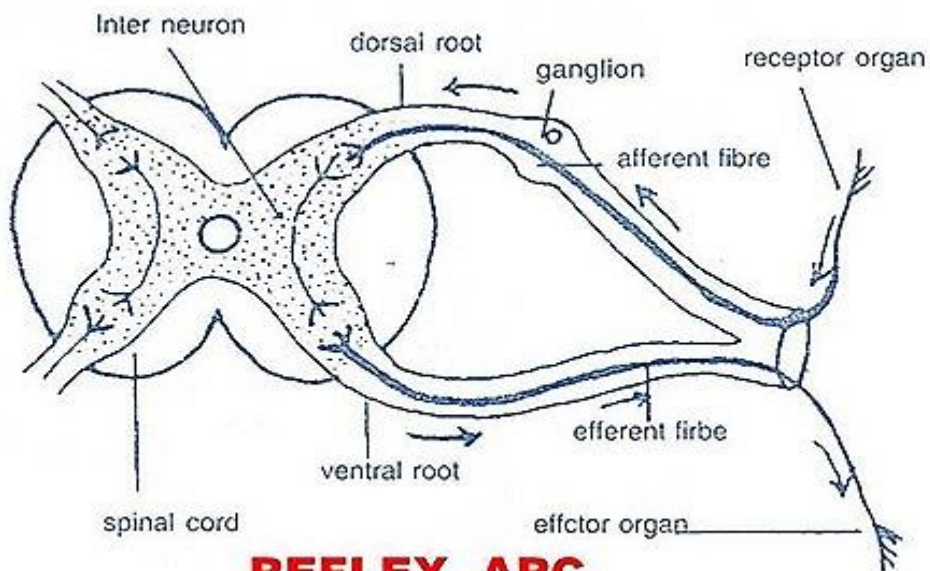


Fig 6. A simple reflex arc. The sensory fibre is stimulated by the tendon hammer. The impulse travels via the sensory nerve to the ventral horn of the grey matter where it synapses with the lower motor neurone which effects a muscular contraction.

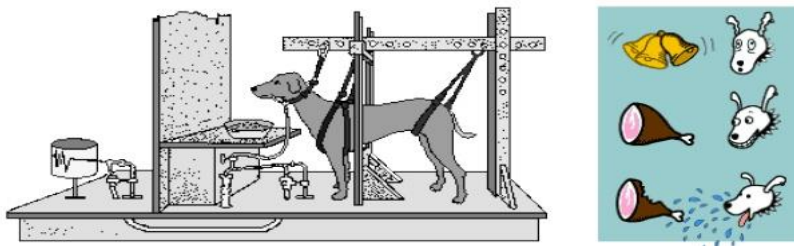


REFLEX ARC

CONDITIONED REFLEXES

- ❑ In most reflexes the **stimulus** and **response** are related.
- ❑ For example the presence of food in the mouth causes the salivary glands to release saliva.
- ❑ However, it is possible to train animals (and humans) to respond to different & often quite irrelevant stimuli. This is called a **conditioned reflex**.
- ❑ A Russian biologist called **Pavlov** carried out the classic experiment to demonstrate such a reflex when he conditioned dogs to salivate at the sound of a bell ringing.
- ❑ Almost every pet owner can identify reflexes they have conditioned in their animals. Perhaps you have trained your cat to associate food with the opening of the fridge door or accustomed your dog to the routines you go through before taking them for a walk.

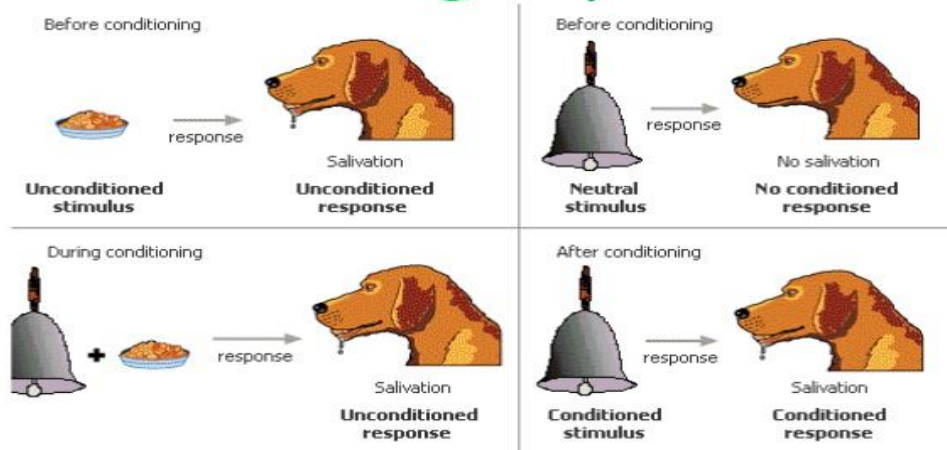
Pavlov's Experiment



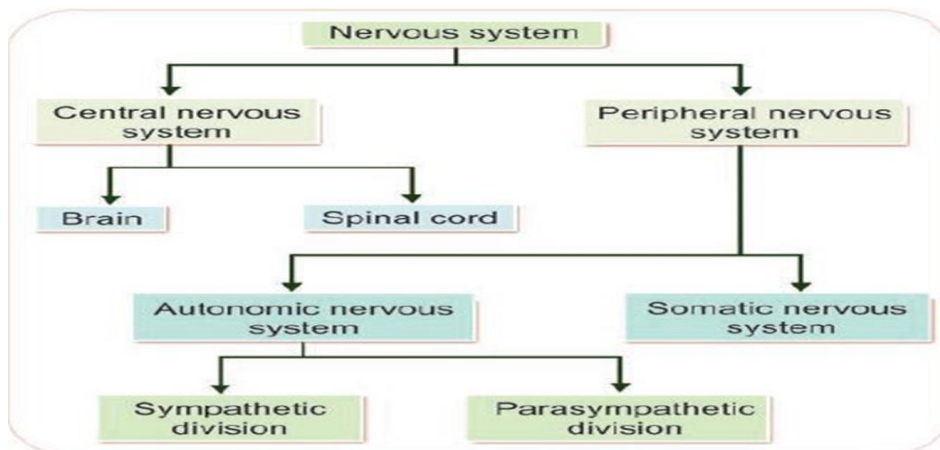
The dog's salivation to meat powder is an **unconditional reflex** (no learning is involved)

Over time, however, the dog comes to salivate at the sounding of the tone alone. When this occurs, a **conditional reflex** has developed

Pavlov's Dog Experiment



DIVISIONS OF THE NERVOUS SYSTEMS



CENTRAL & PERIPHERAL NERVOUS SYSTEMS

CENTRAL NERVOUS SYSTEM (CNS)

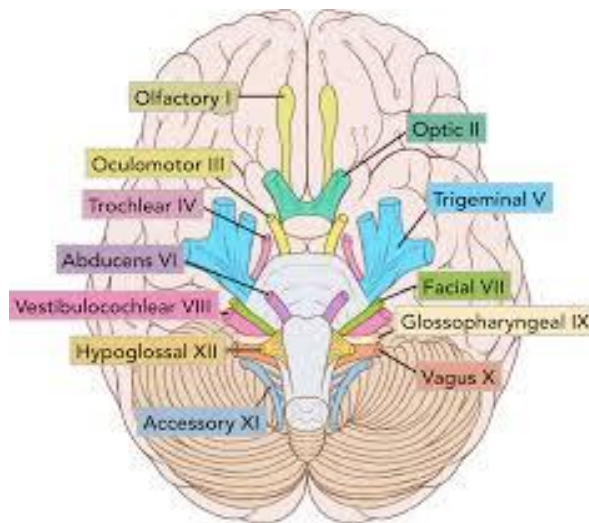
- Consists of brain & spinal cord
- Contains neural tissue, connective tissue & blood vessels
- Functions of CNS: To process & coordinate
- ✓ Receives sensory data
- ✓ Sends motor commands; control activities of peripheral organs eg skeletal muscles
- ✓ Higher functions of the brain: intelligence, memory, learning, emotions

CENTRAL & PERIPHERAL NERVOUS SYSTEMS

PERIPHERAL NERVOUS SYSTEM (PNS)

- Includes all neural tissue outside CNS
- Functions
- ✓ deliver sensory information to the CNS
- ✓ carry motor commands to peripheral tissues & systems
- PNS is made up of nerves called peripheral nerves
- Nerves carry sensory information & motor commands
- ✓ cranial nerves – connect to the brain
- ✓ spinal nerves – attach to the spinal cord

CRANIAL NERVES



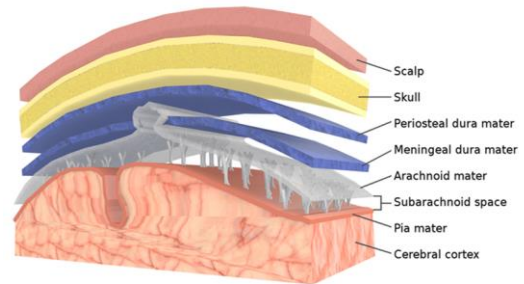
THE BRAIN – MENINGES

- Meninges are 3 protective layers of the brains;
- Function of the meninges
 - ✓ is to cover & protect the brain from mechanical injury
 - ✓ Provide blood supply to the skull and the brain
 - ✓ Provide space for flow of CSF between pia & arachnoid maters
- The 3 meninges are;
 - A. Dura mater
 - B. Arachnoid mater
 - C. Pia mater

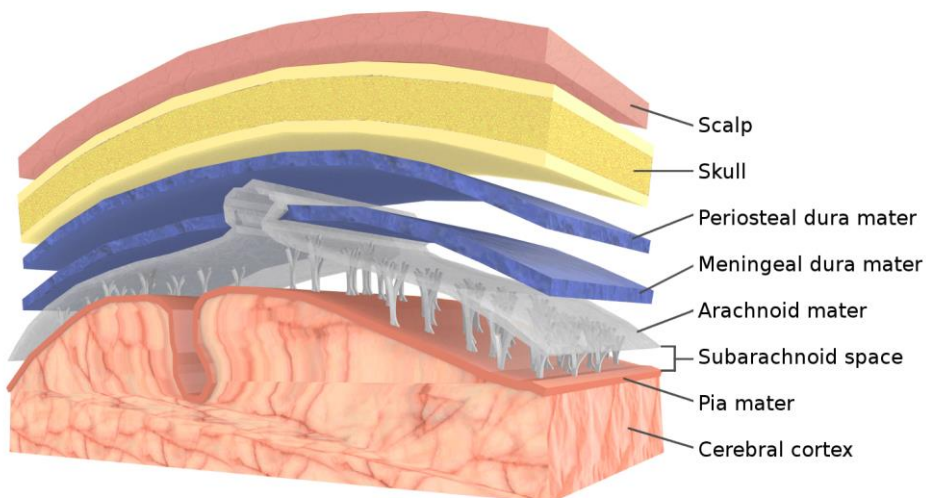
A . MENINGES

1. DURA MATTER

- Outermost of the 3 layers
- Tough, fibrous layer
- Closest to the skull
- Fused to the skull just as the periosteum is fused to the bone



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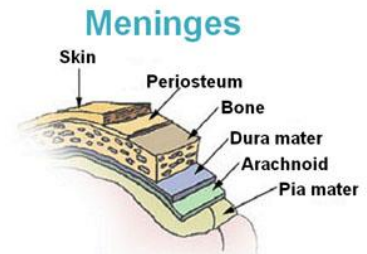


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A . MENINGES

2. ARACHNOID MATER

- ❑ Deep to the dura mater is the **subdural space**
- ❑ deep to which is the arachnoid membrane (**spiderweb like**)
- ❑ The space deep to it, the subarachnoid space, is where the **cerebrospinal fluid (CSF)** circulates around the brain.



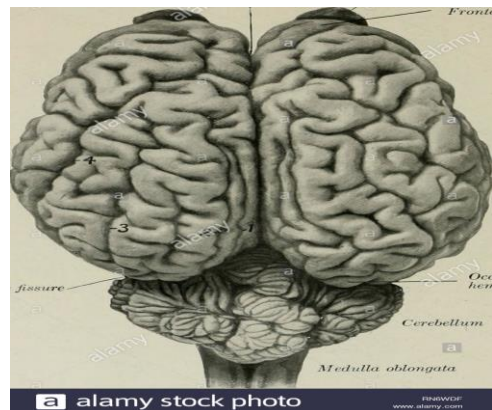
Dura mater -- outer layer lining skull
 Arachnoid (mater) -- contains blood vessels
 Subarachnoid space -- filled with CSF
 Pia mater -- covers brain

A . MENINGES

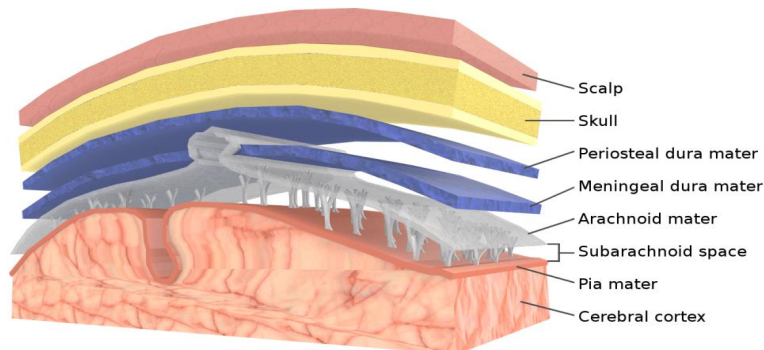
2. PIA MATER

The innermost layer, which sits directly on the brain, is called the pia mater

(lies directly on surface and spinal cord surface)



MENINGES

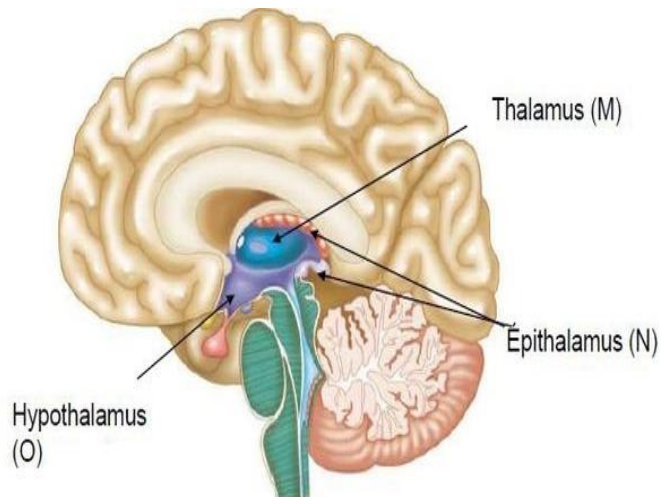


GYRI, SULCI

GYRI

- ✓ The surface of the mammalian brain is composed of a series of folds called gyri (singular: gyrus).
- ✓ the valleys between the gyri are called sulci (sulcus).
- ✓ The gyri help increase the surface area of the **brain & allow for more brain function**

THE folds of the brain



SUMMARY - HOW IS THE BRAIN PROTECTED

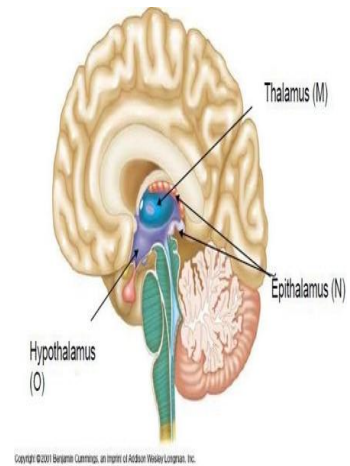
- The brain is protected by bones of the skull & a covering of 3 thin membranes called meninges
- The brain is also cushioned and protected by the CSF
- CSF is produced by special cells in the 4 hollow spaces in the brain called ventricles

THE BRAIN

□ is made up of 4 major parts:

- I. Cerebrum
- II. Cerebellum
- III. Pons
- IV. Medulla oblongata

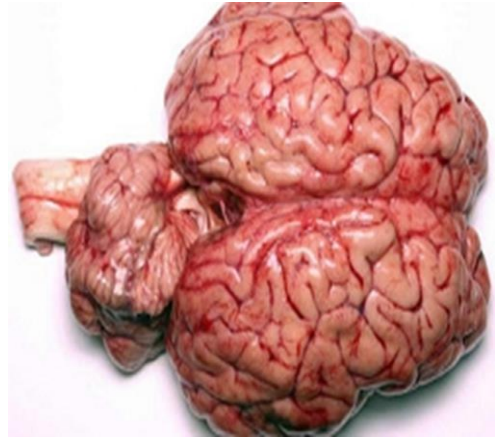
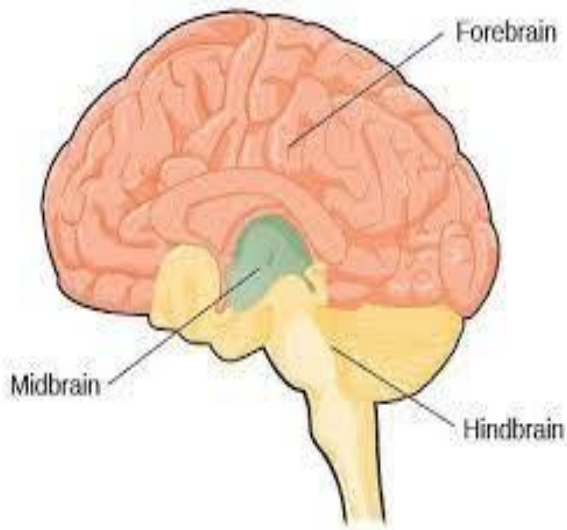
III & IV makeup the brainstem



THE BRAIN

□ Divided into 3 parts

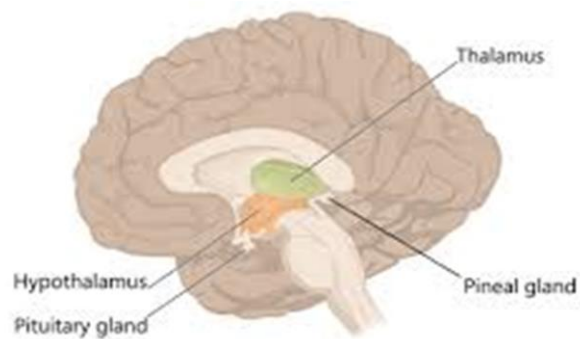
- i. The forebrain
- ii. Midbrain
- iii. Hindbrain



PARTS OF THE FOREBRAIN

☐ Made up of

- a) Cerebrum
- b) Thalamus
- c) Hypothalamus
- d) Pituitary gland



ROLES OF FOREBRAIN

- Thinking
- Speech
- language
- sensing
- Memory
- learning
- Emotions (happy, sad, fear, love)
- Feelings (hunger, fullness, sleepy)

THE BRAINSTEM –

THE THALAMUS

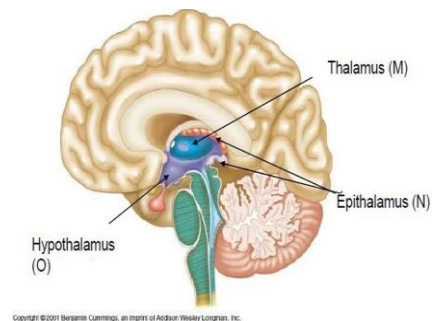
- ✓ Is a relay center
- ✓ A small structure above the brain stem bt cerebrum cortex & midbrain
- ✓ The thalamus contains many nuclei
- ✓ Has extensive nerve connections to both.
- ✓ The main function of the thalamus is to relay motor and sensory signals to the cerebral cortex.

FOREBRAIN

- ❑ Responsible for the voluntary functions
- ✓ EG Movement
- ❑ **MIDBRAIN & HINDBRAIN**
- ✓ Responsible for all the involuntary function
- ✓ heartbeat
- ✓ Digestion
- ✓ breathing

HYPOTHALAMUS

- ✓ located below thalamus
- ✓ contains the hypophysis (pituitary gland) an endocrine organ
- ✓ Pituitary gland – master gland – controls several hormone producing glands. It produces many hormones that travel throughout the body.
- ✓ Links the endocrine & nervous systems



HYPOTHALAMUS

Hormones released by the hypothalamus

- a. growth hormone releasing hormone (GHRH)
- b. Gonadotropin releasing hormone
- c. thyrotropin releasing hormone
- i. Also regulates body temperature, controls thirst, hunger & blood pressure and sleep

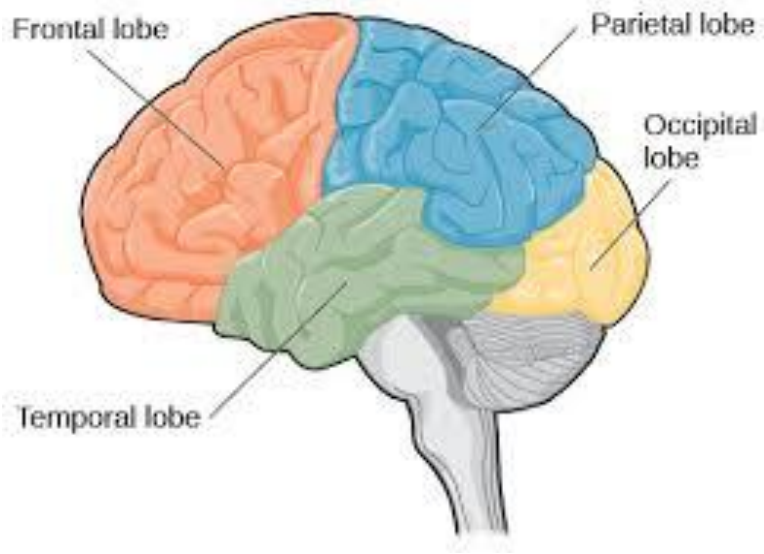
MIDBRAIN

- Beginning of the brainstem
- The midbrain is located below the cerebral cortex & cranial to the hindbrain placing it near the center of the brain.

HINDBRAIN

☐ Has 3 main parts

1. Pons
2. medulla oblongata
3. Cerebellum



ROLES OF THE HINDBRAIN

- Control Involuntary (reflex actions), such as blinking, vomiting, breathing, and swallowing
- act independently of the other two parts of the brain
- Medulla oblongata** - controls life giving involuntary processes
Eg Heartbeat, breathing, reflexes (sneezing, coughing)
- Cerebellum** - maintain balance & controls motor memory

3. THE BRAIN STEM (PART OF THE HINDBRAIN)

- is the connection between the rest of the brain & the spinal cord
- Controls flow of messages between the brain & the rest of the body
- composed of 3 parts
 - ✓ **medulla oblongata**
 - ✓ **pons**
 - ✓ **midbrain**
- does not have clear layers of gray and white matter

3. THE BRAIN STEM - FUNCTIONS

- Role is to maintain basic functions of the body. I.e. operates at the subconscious level
- Involved in autonomic control functions eg
 - ✓ Heartbeat
 - ✓ respiration (including coughing, sneezing & hiccupping),
 - ✓ blood vessel diameter (vasomotor control),
 - ✓ Swallowing & vomiting
- Cranial nerves originate from this area
- Damage to the area results in respiratory failure or cardiovascular collapse

1. THE CEREBRUM - HISTOLOGY

- The largest part of the brain
- is made up of;
 - i. gray matter - **cerebral cortex** (outer-most superficial layer of the brain)
 - ii. **And white matter** beneath the cortex,

1. THE CEREBRUM - HISTOLOGY

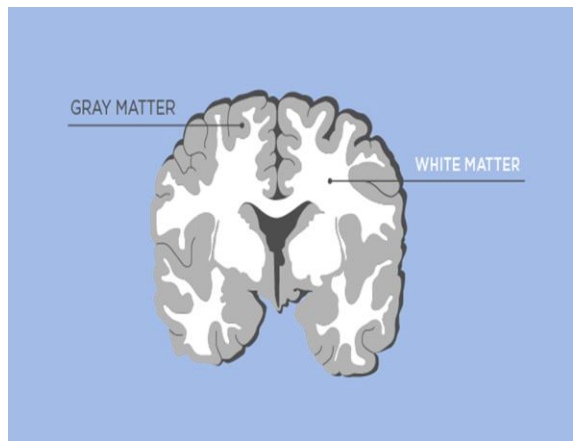
GRAY MATTER

- ✓ grey color in the living brain
- ✓ contains the cell bodies, dendrites & axon terminals of neurons, so it is where all synapses are

THE CEREBRUM

WHITE MATTER

- ✓ White matter is made of axons connecting different parts of grey matter to each other



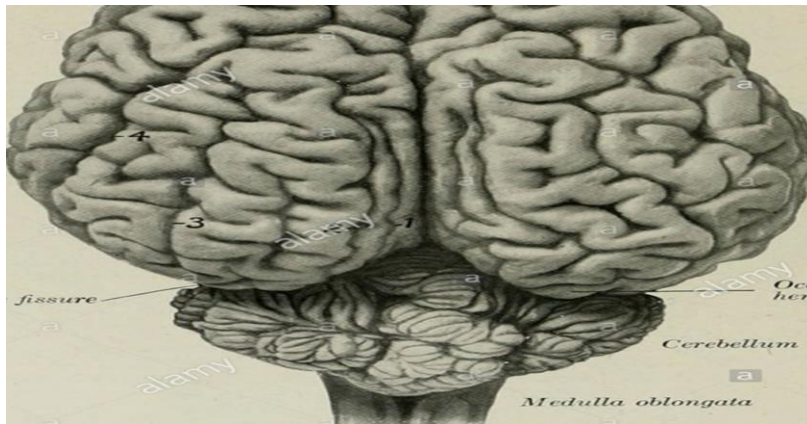
1. THE CEREBRUM -

- Constitutes the area of the brain responsible for those functions most commonly associated with higher-order behaviors, such as **learning, reasoning & intelligence**.
- ✓ receives & interprets sensory information
- ✓ initiates conscious (voluntary) nerve impulses to skeletal muscles
- ✓ integrates neuron activity that is normally associated with communication, expression of emotional responses, learning, memory & recall, & other behaviours associated with conscious activity

1. THE CEREBRUM -

- The cerebrum is divided into the left & right hemispheres
- Right hemisphere processes creative & emotional stimuli
- Left hemisphere processes actions & is involved in learning.
- The right side controls the left side of the body & the left side controls the right.

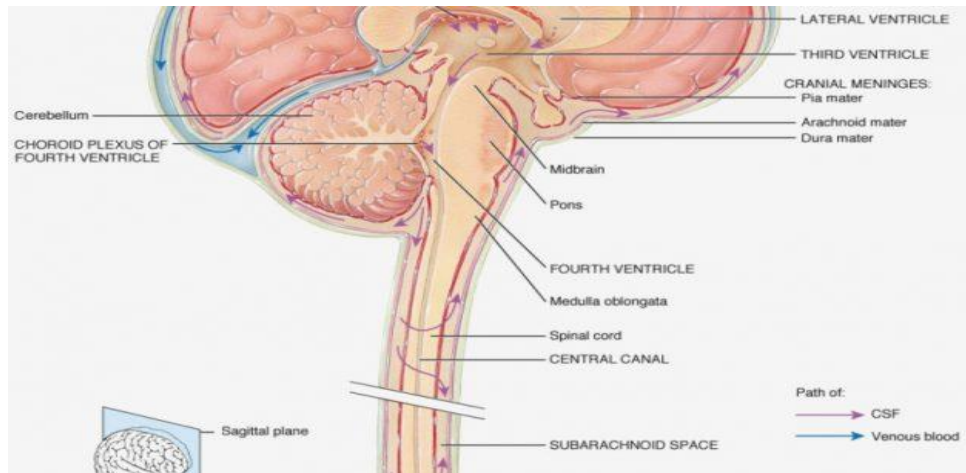
THE CEREBRAL HEMISPHERES



THE CEREBRUM - LOBES OF THE BRAIN

- Each cerebral hemisphere is divided into 4 lobes
- The lobes are areas named for their location relative to the skull.
- The 4 lobes are;
 - ✓ frontal
 - ✓ parietal
 - ✓ temporal
 - ✓ occipital lobes.
- The term cerebrum refers to the areas that overlap from the frontal into the parietal area.
- All of these lobes are paired (one on each side). There is no clear demarcation of each lobe when looking at the superficial brain surface

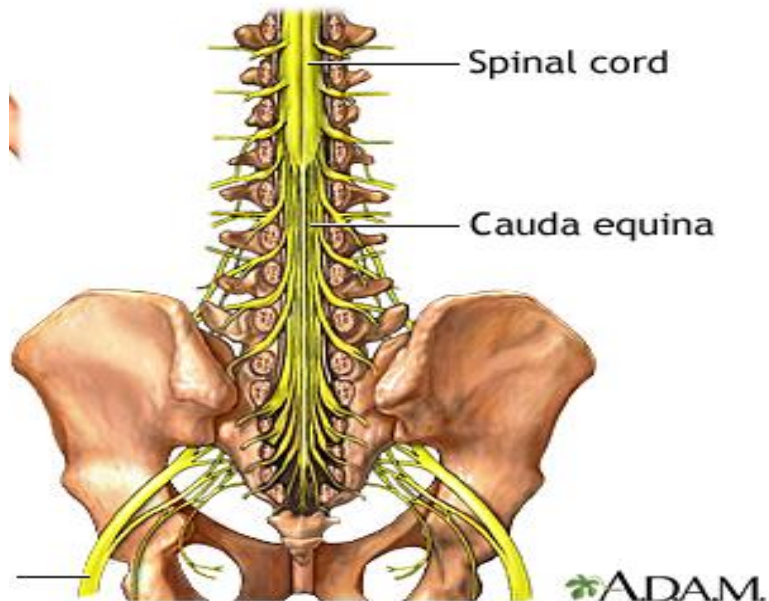
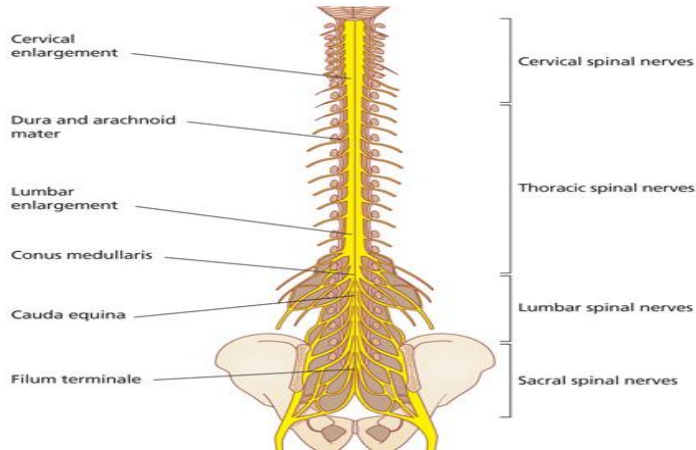
LOBES OF THE CEREBRUM



VENTRICLES

- The brain has 4 interconnected **cavities (ventricles)** where CSF is produced
- 2 lateral ventricles, 3rd ventricle & 4th ventricle
- Ventricles are continuous with the central canal of the spinal cord
- They are numbered & drain different areas of the brain depending on their location
- Another role is to cushion

THE VENTRICLES



CSF

- The cerebrospinal Fluid circulates from ventricles where it is produced to the subarachnoid space where it is resorbed

ROLE OF CSF

- Cerebrospinal fluid is a clear, colorless body fluid found in the brain and spinal cord.
- Role of CSF
 - ✓ providing basic mechanical protection (cushion) i.e shock absorber
 - ✓ CSF also circulates nutrients and chemicals filtered from the blood
 - ✓ Removes waste & toxic products from the brain
 - ✓ immunological protection to the brain inside the skull

2. THE CEREBELLUM

- ❑ Lies Caudal to the cerebrum
- ❑ It is a rounded structure also called “**little brain**”
- ❑ Also has gray mater cortex & white mater beneath it
- ❑ Serves as a **coordinator** of messages from other parts of the brain to the body.
- ❑ Coordinates the action of voluntary muscles in activities such as **walking, running, eating, and talking**.

2. THE CEREBELLUM

FUNCTIONS

- ❑ It is associated with regulation & coordination of movement, posture, balance and complex reflexes
- ❑ Essentially, the cerebellum compares the movement the body intends to make with the actual position of muscles & joints to determine whether the intentions of the cerebral cortex are actually being carried out.

THE SPINAL CORD

- ❑ The brain stem narrows as it runs caudally, but it widens again slightly as it approaches the foramen magnum
- ❑ This swelling is known as the **medulla oblongata** & is considered to be the cranial origin of the spinal cord.

CAUDAL EQUINA (horse's tail)

- ❑ At the base of the spinal column, near the **1st lumbar vertebra**, is a collection of nerves called the **cauda equina**.
- ❑ the roots of the lumbar & sacral spinal nerves, which form a bundle within the lowest part of the spinal column

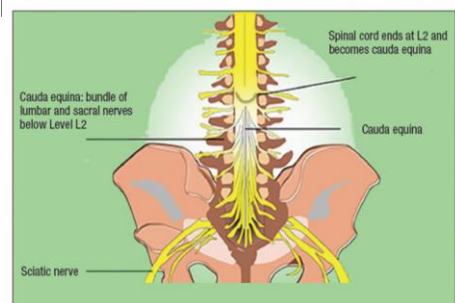
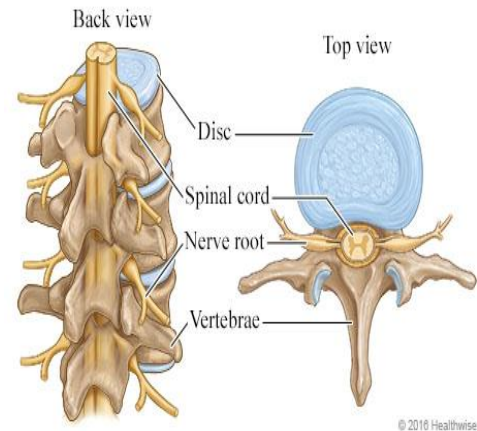
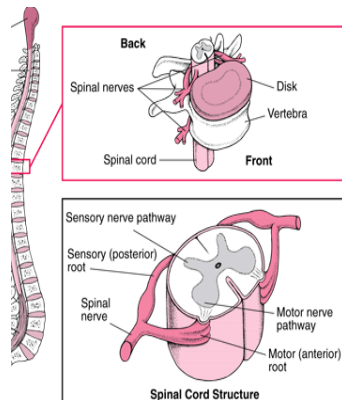


Figure 1. Illustration of the cauda equina ("horses tail").

THE SPINAL NERVES

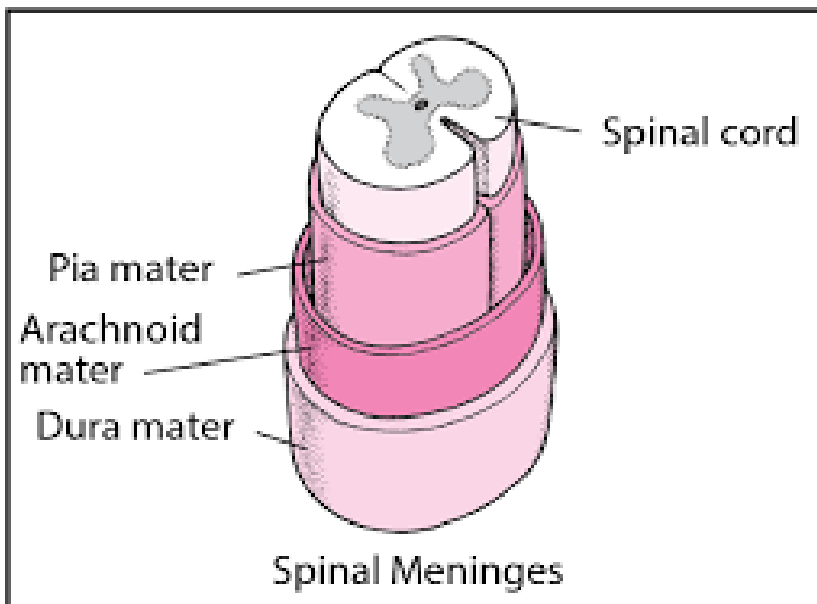


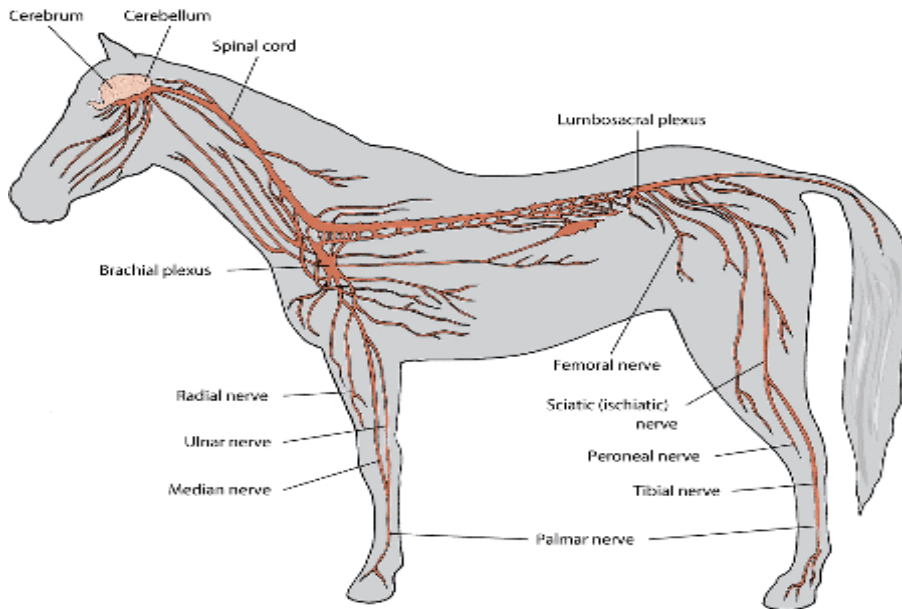
MENINGES OF THE SPINAL CORD

- Similar to the brain, the spinal cord is covered by meninges.
- They are the same as in the brain with one exception. Superficial to the dura, between the dura mater and the wall of the spinal canal, is a space. It is called the **epidural space**.
- The epidural space is an area in which local anesthetic is often injected prior to surgical procedures in the area.

MENINGES OF THE SPINAL CORD

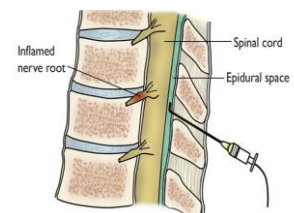
- ❑ Spinal cord has gray matter (**center**) and white matter surrounding it
- ❑ Central canal is in the center of the grey matter & contains CSF
- ❑ CSF helps to nourish nervous tissue & is a shock absorber
- ❑ Spinal nerves has 3 layers of membrane
 - i. **Pia matter**
 - ii. **Arachnoid**
 - iii. **Dura matter**



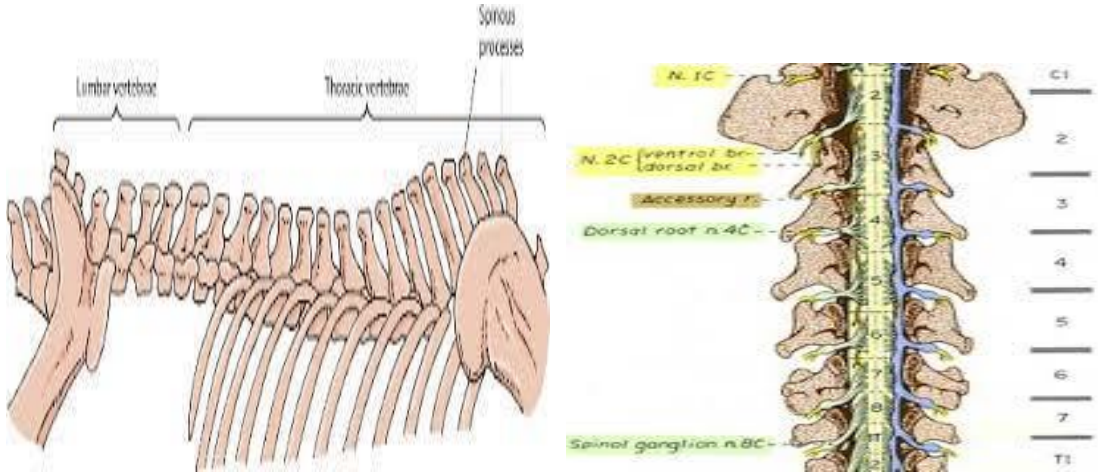


EPIDURAL SPACE

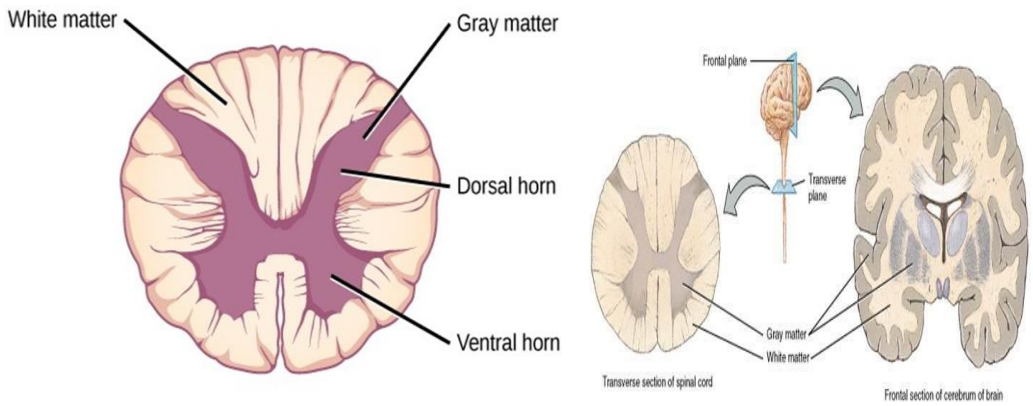
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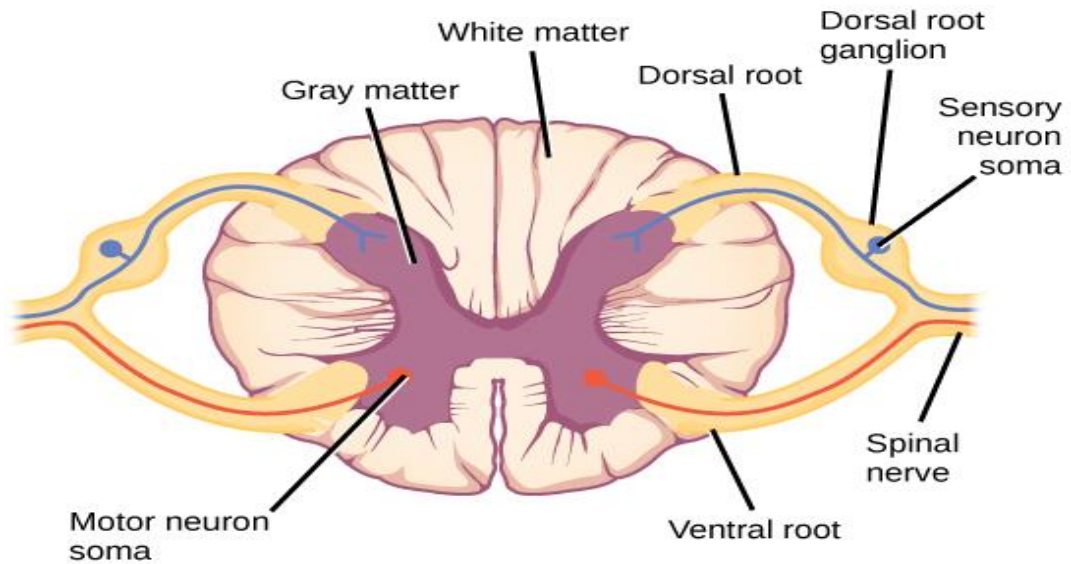


EPIDURAL SPACE

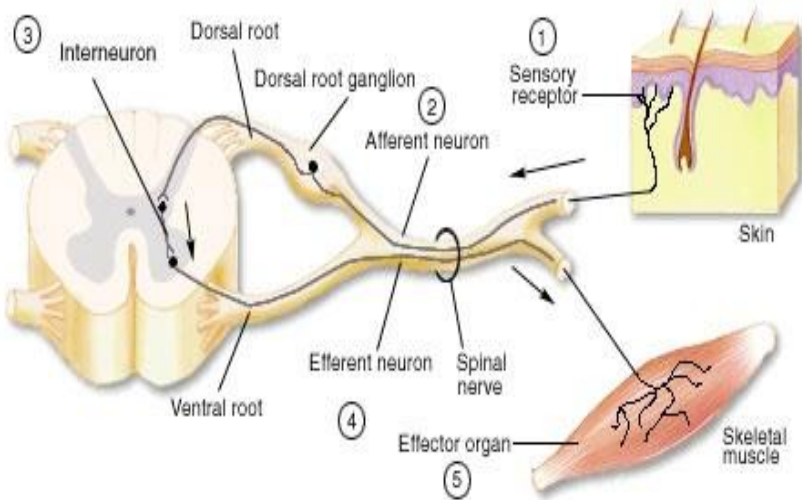


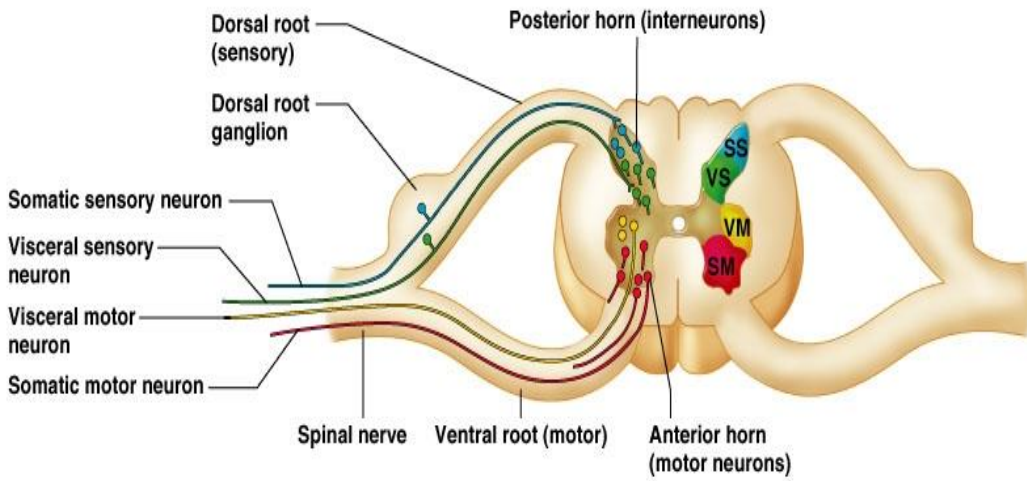
POSITION OF SPINAL CORD



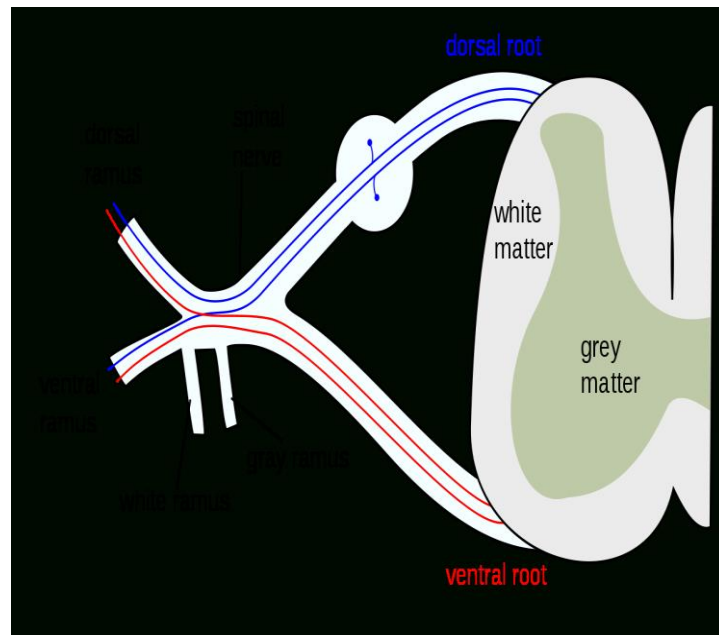


Cross Section of Spinal Cord



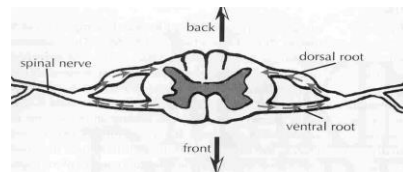


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SPINAL CORD - GRAY & WHITE MATTER

- ❑ Unlike in the cerebrum, the spinal cord's gray matter is found at the center of the cord, forming a butterfly shape on cross-section
- ❑ The white matter, surrounds the gray matter
- ❑ A spinal cord segment is defined by the presence of a pair of spinal nerves.



ROLE OF THE SPINAL CORD

- ❑ The spinal cord is located at the center of the vertebral column.
- ❑ The spinal cord is the main avenue for message transferal between the **brain & the other parts of the body**.
- ❑ The spinal cord is divided into **segments**; A pair of spinal nerves extends to the body from each segment
- ❑ The spinal cord receives messages from sensory nerve fibers in various parts of the body & transmits them to the brain.
- ❑ Motor nerve fibers in the spinal cord then transmit the response from the brain back to the body.

SPINAL NERVES

- Arise from the spinal cord
- Are paired
- There are approx 31 pairs in total
- ✓ 8 cervical
- ✓ 12 thoracic
- ✓ 5 lumbar
- ✓ 5 sacral
- ✓ 1 coccygeal (species differences)

SPINAL NERVES

- Each pair of spinal nerves connects the spinal cord with a specific region of the body.
- Near the spinal cord each spinal [nerve](#) branches into two roots.
- One, composed of [sensory fibres](#), enters the spinal cord via the dorsal root its cell bodies lie in a spinal [ganglion](#) that is outside the spinal cord.
- The other, composed of [motor fibres](#), leaves the spinal cord via the ventral root; its cell bodies lie in specific areas of the spinal cord itself.

SPINAL NERVES ARE MIXED NERVES

- ❑ Dorsal & ventral roots arise from the spinal cord & fuse, generally close to the intervertebral foramen
- ❑ Almost as soon as the spinal nerve emerges through the intervertebral foramen, it divides into a dorsal branch & a ventral branch. Both of these branches are mixed nerves, because each contains both sensory and motor fibers.

SPINAL NERVES ARE MIXED NERVES

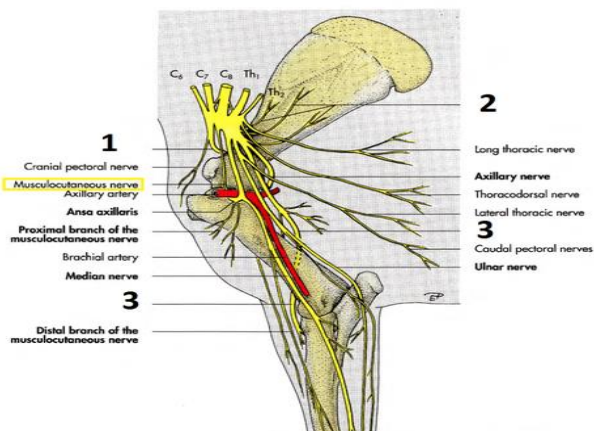
- ❑ **DORSAL BRANCHES** – of the spinal nerves innervate structures that are dorsal to the transverse processes of the vertebrae (**muscles & skin**)
- ❑ **VENTRAL BRANCHES** - The ventral branches supply structures ventral to the transverse processes & most of the thoracic and pelvic limbs.

****The spinal nerves tend to innervate the region of the body in the area adjacent to where they emerge from the vertebral column****

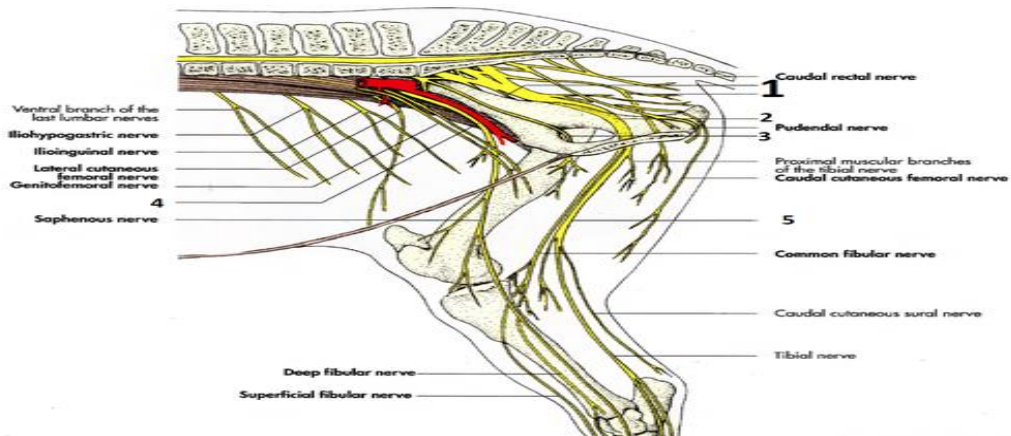
PLEXUS

- ❑ A network of nerves supply a particular region of the body
- ❑ Examples are Brachial plexus and Lumbosacral plexus
- ❑ Brachial plexus (C6 –C8, T1),
- ❑ LUMBOSACRAL PLEXUS (L4-L6, S1-S4)

BRACHIAL PLEXUS

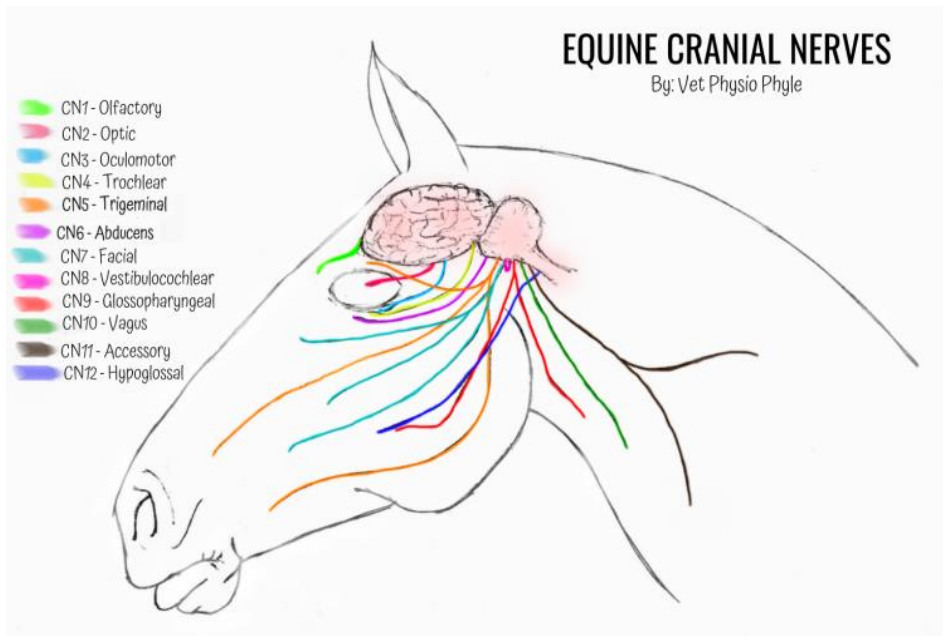


LUMBOSACRAL PLEXUS

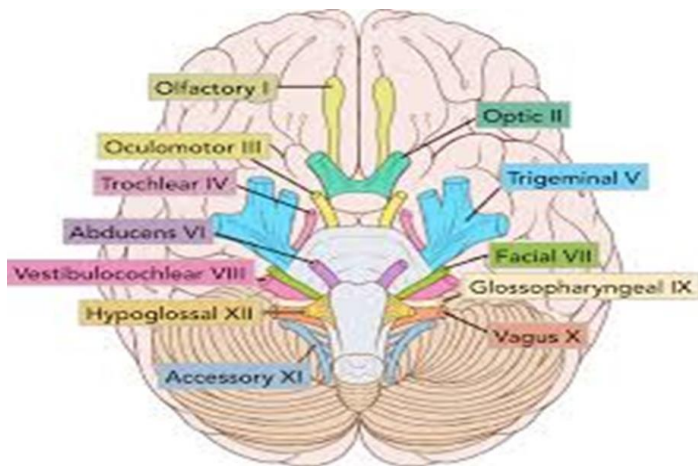


CRANIAL NERVES

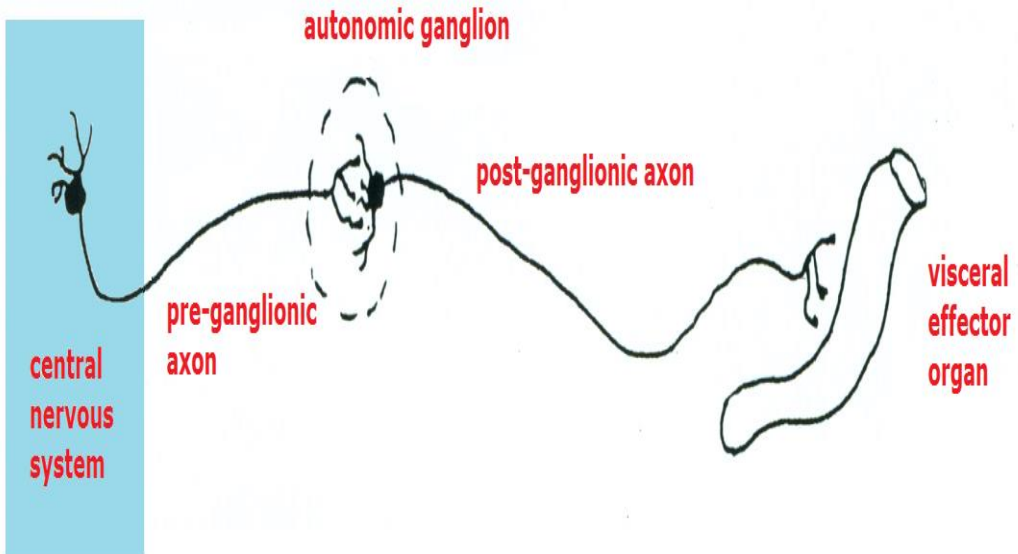
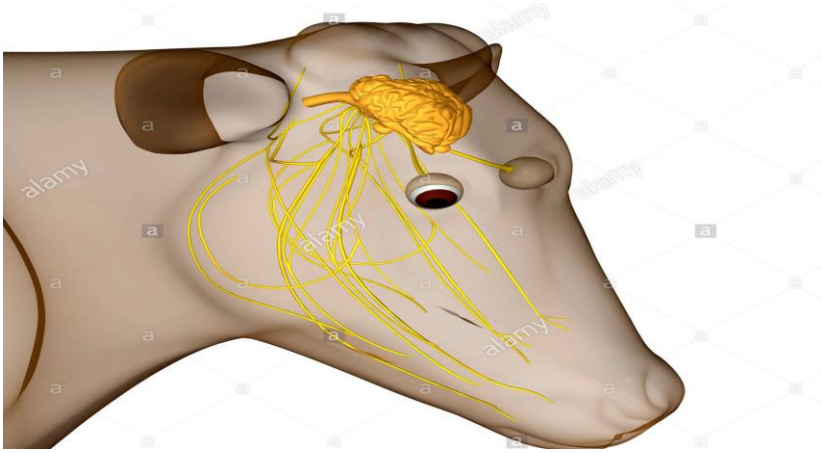
- 12 pairs arise from the brain
- Are designated by Roman numerals, numbered from most rostral (I) to most caudal (XII).
- Cranial nerves send electrical signals between the brain, face & neck
- Cranial nerves help animals to taste, smell, hear and feel sensations, make facial expressions, blink eyes and move the tongue.
- With the exception of cranial nerves I (olfactory) & II (optic), the cranial nerves arise from the midbrain, pons, & medulla oblongata and in general resemble ordinary spinal nerves.



CRANIAL NERVES



CRANIAL NERVES



CRANIAL NERVES

- ❑ Each nerve passes through a hole in the cranium (brain case). The most important of these are the olfactory, optic, acoustic & vagus nerves.
- ✓ **Olfactory nerves** - (smell) carry impulses from the olfactory organ of the nose to the brain.
- ✓ **Optic nerves** - (sight) carry impulses from the retina of the eye to the brain.
- ✓ **The auditory (acoustic) nerves** - (hearing) carry impulses from the cochlear of the inner ear to the brain.
- ✓ **vagus nerve** - controls the muscles that bring about swallowing. It also controls the muscles of the heart, airways, lungs, stomach and intestines

SPINAL NERVES

- ✓ Arise from the spinal cord
- ✓ **The sciatic nerve** is the largest spinal nerve in the body. It leaves the spinal cord as several nerves that join to form a flat band of nervous tissue. It passes down the thigh towards the hind leg where it gives off branches to the various muscles of this limb.

SPINAL CORD & SPINAL NERVES

☐ Spinal nerves consists of

✓ ventral root

✓ dorsal roots

☐ Both roots join the spinal cord

DORSAL ROOT

✓ Contains sensory neurons

✓ Contains a ganglion

✓ Ganglion – where cell bodies are located & also where synapse are located

✓ Sensory neurons bring sensory information to the spinal cord

SPINAL CORD & SPINAL NERVES

VENTRAL ROOT

✓ For the motor or efferent neuron

✓ The efferent neuron is can either be somatic or autonomic depending on the target organ/tissue

THE PERIPHERAL NERVOUS SYSTEM

- Consists of nerves that are connected to the brain (**cranial nerves**), and nerves that are connected to the spinal cord (**spinal nerves**).
- The **autonomic nervous system is also part of the peripheral nervous system.**

THE PERIPHERAL NERVOUS SYSTEM (PNS)

- The PNS is responsible for transmitting messages between the outer part of the body & the brain
- The PNS is made up of;
 - ✓ Somatic nerves
 - ✓ Autonomic nerves.

THE AUTONOMIC NERVOUS SYSTEM

☐ Has 2 divisions

- i. the **sympathetic nervous system**
- ii. the **parasympathetic nervous system**

☐ The 2 systems generally have **opposite effects** on organs or tissues, and whichever system dominates at any given moment determines how excited or relaxed things are in the body.

ORIGIN OF THE SYMPATHETIC & PARASYMPATHETIC NS

☐ Where the peripheral nerves of each system emerge from the CNS.

SYMPATHETIC SYSTEM

- ✓ Nerves emerge from the thoracic & lumbar regions
- ✓ referred to as the **thoracolumbar system**

PARASYMPATHETIC SYSTEM

- ✓ Emerges from the brain & the sacralvertebral regions
- ✓ therefore is called the **cranial–sacral** system.

THE SYMPATHETIC SYSTEM

- stimulates the “fight or flight” response
- So also called “flight or fight system”
- allows an animal to face up to an attacker or make a rapid departure.
- Effects
 - ✓ It increases the heart & respiratory rates,
 - ✓ It also causes the pupils of the eyes to dilate
 - ✓ Increases amount of blood flowing to the skeletal muscles
 - ✓ Reduces blood flow to less critical regions like the gut & skin

** Note that effects of the sympathetic system are similar to the effects of the hormone adrenaline**

THE PARASYMPATHETIC SYSTEM

- does the opposite to the sympathetic system
- also called “rest & restore system”.
- It maintains the normal functions of the relaxed body. These are sometimes known as the “housekeeping” functions.
- It promotes effective digestion, stimulates defaecation & urination
- maintains a regular heartbeat and rate of breathing.
 - ✓ decreased heart rate
 - ✓ pupil constriction
 - ✓ increased gastrointestinal activity.

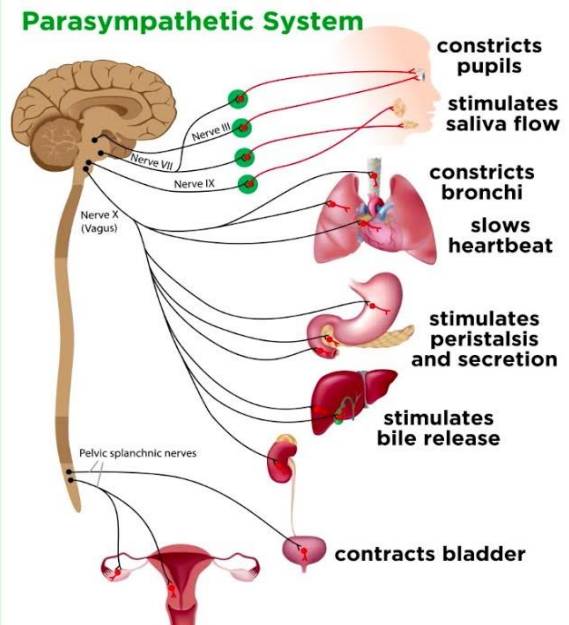
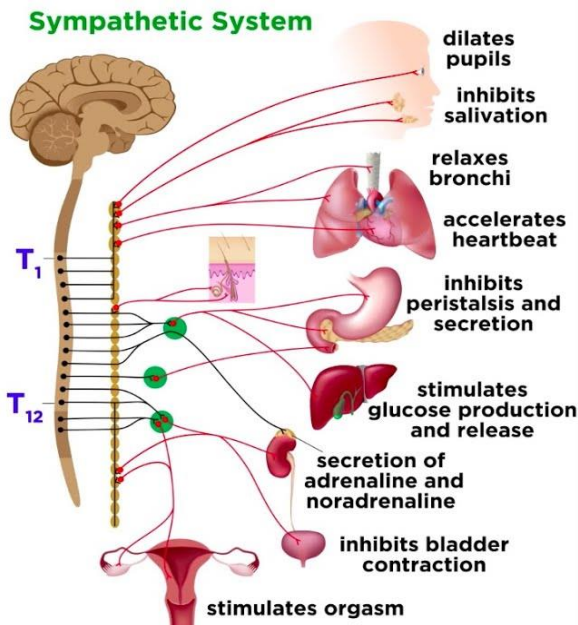
THE ANS IN PERSPECTIVE

- ❑ **In a fight-or-flight situation**, the animal needs to move rapidly
- ✓ the **bronchioles (airway passages)** increase in diameter (**bronchodilation**) to allow a greater exchange of O₂ & CO₂.
- ✓ Heart rate & force of cardiac contractions increase to increase the rate at which blood is moved around the body.
- ✓ Small blood vessels (arterioles) supplying the muscles dilate (vasodilation).
- ✓ Small blood vessels supplying the skin, GIT & kidney constrict → blood is redirected to the muscles
- ✓ The decreased blood supply to the skin also means that superficial wounds will bleed less.
- ✓ Pupils dilate – to increase peripheral vision

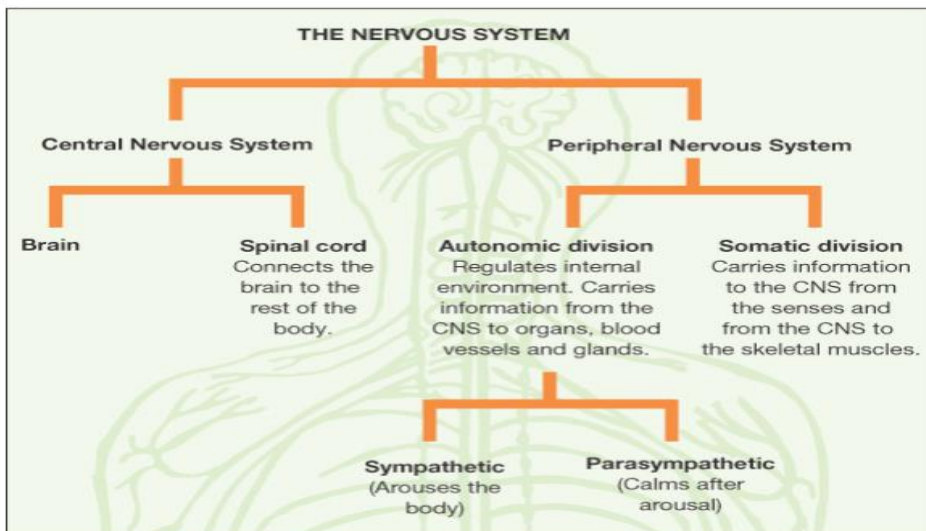
THE ANS IN PERSPECTIVE

The parasympathetic system causes following reactions;

- ✓ GI tract to increase its activity, thus digesting & absorbing nutrients that are needed to replenish the energy resources used during the fight-or-flight situation.
- ✓ reduces the heart rate and
- ✓ reduces the sympathetic system's dilation of the bronchioles.



SUMMARY – THE NERVOUS SYSTEM



BLOOD BRAIN BARRIER (BBB)

- ❑ Is a highly permeable border that separates the circulating blood from the brain.
- ❑ Separates the blood from the brain tissue

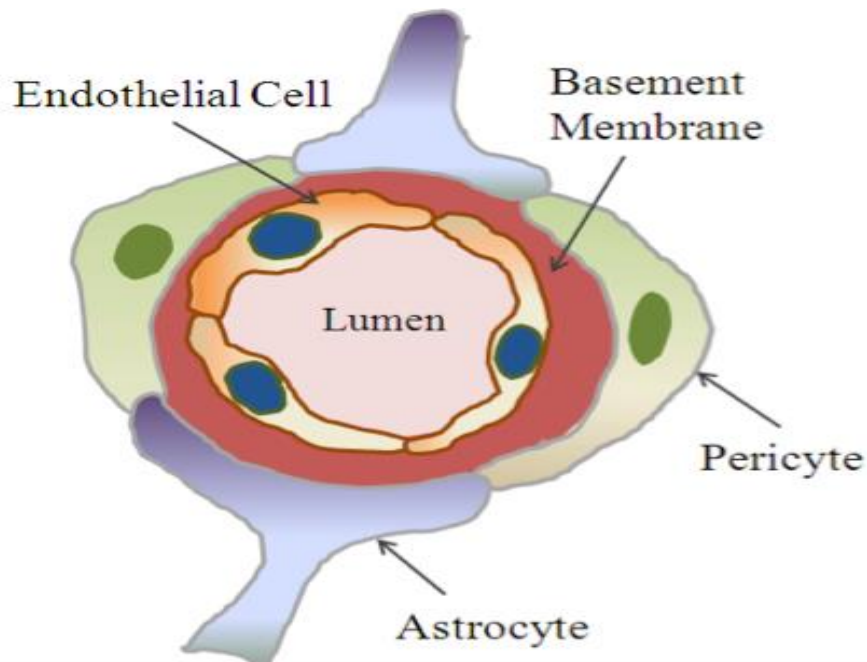
BLOOD BRAIN BARRIER (BBB)

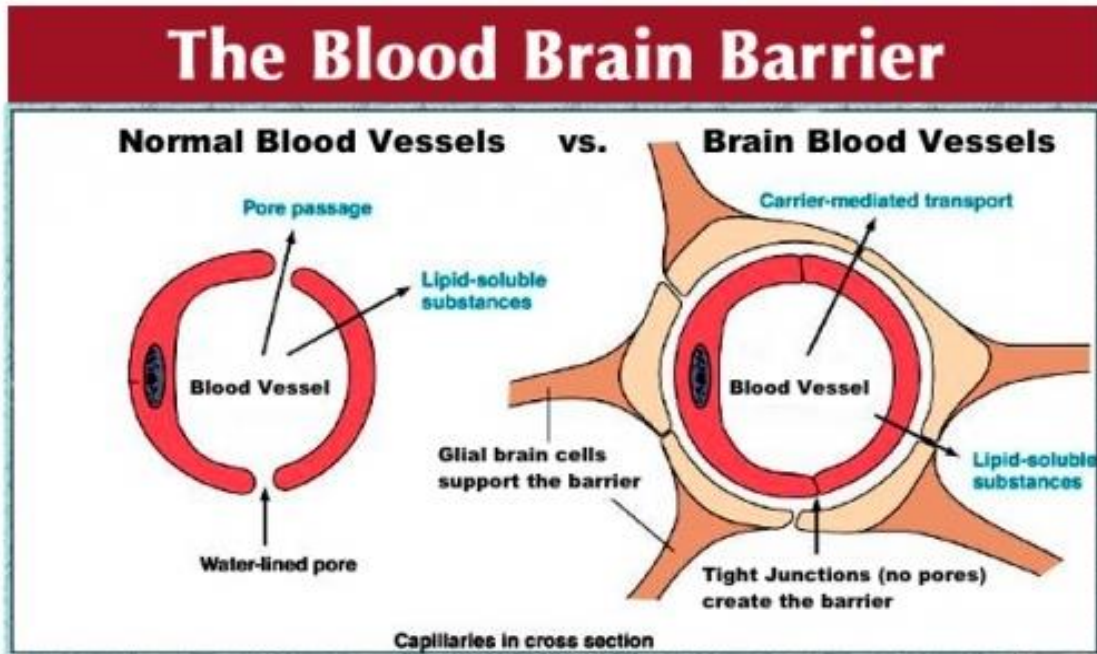
- ❑ Barrier is composed of 3 layers;
 - i. **Endothelial cells** (simple squamous cells) – have tight cell to cell junctions
 - ii. **Basement membrane** – found on the base of the endothelial cells
 - iii. **Glial cells** – surround the endothelial cells

BASEMENT MEMBRANE

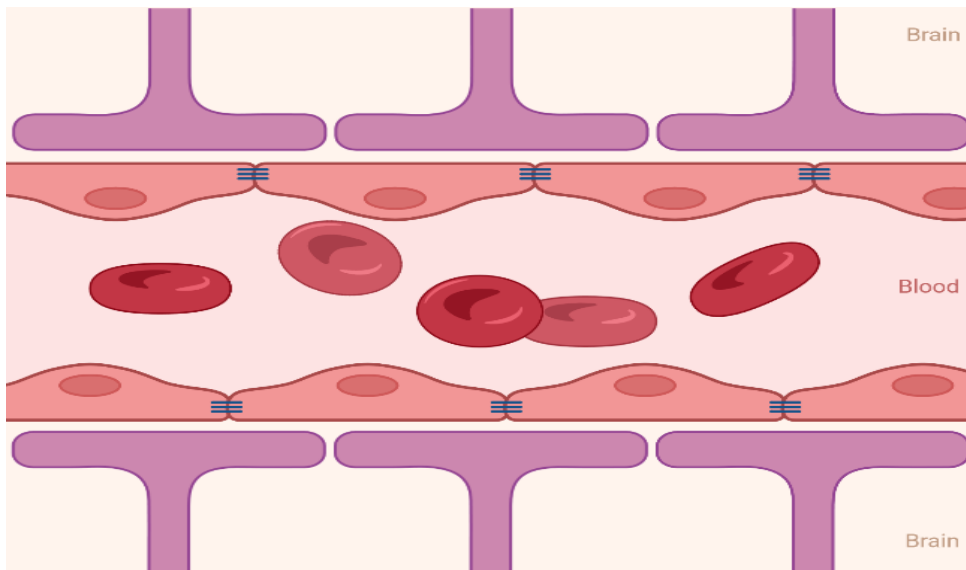
3 LAYERS OF THE BBB

- i. Endothelial cells
- ii. Basement membrane
- iii. Glial cells (astrocytes & pericytes)

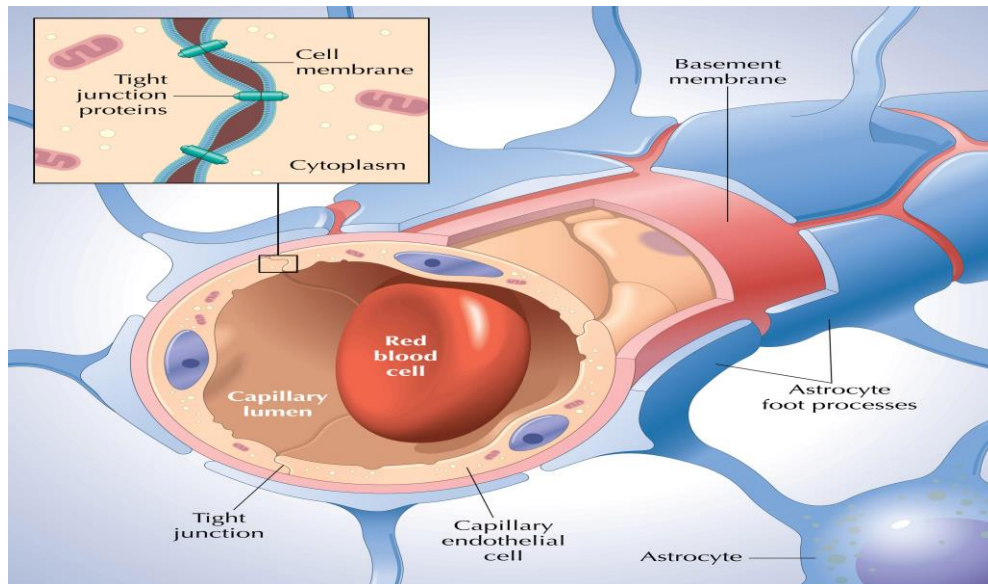




BLOOD BRAIN BARRIER



BLOOD BRAIN BARRIER



BLOOD BRAIN BARRIER (BBB)

- Is semipermeable membrane
- Basement membrane is composed of collagen and other proteins
- Pericytes & astrocytes envelop blood microvessels
- System allows passage of some molecules by passive diffusion
- System allows selective passage of some molecules such as glucose, water and amino acids that are crucial for neural function

BLOOD BRAIN BARRIER (BBB)

ROLES

- ✓ Mechanism for protecting the brain from fluctuations in plasma concentration, composition, & from circulating agents
- ✓ Prevents neurotoxic, blood cells & pathogens from entering the brain
- ✓ Regulates transport of molecules into and out of the CNS