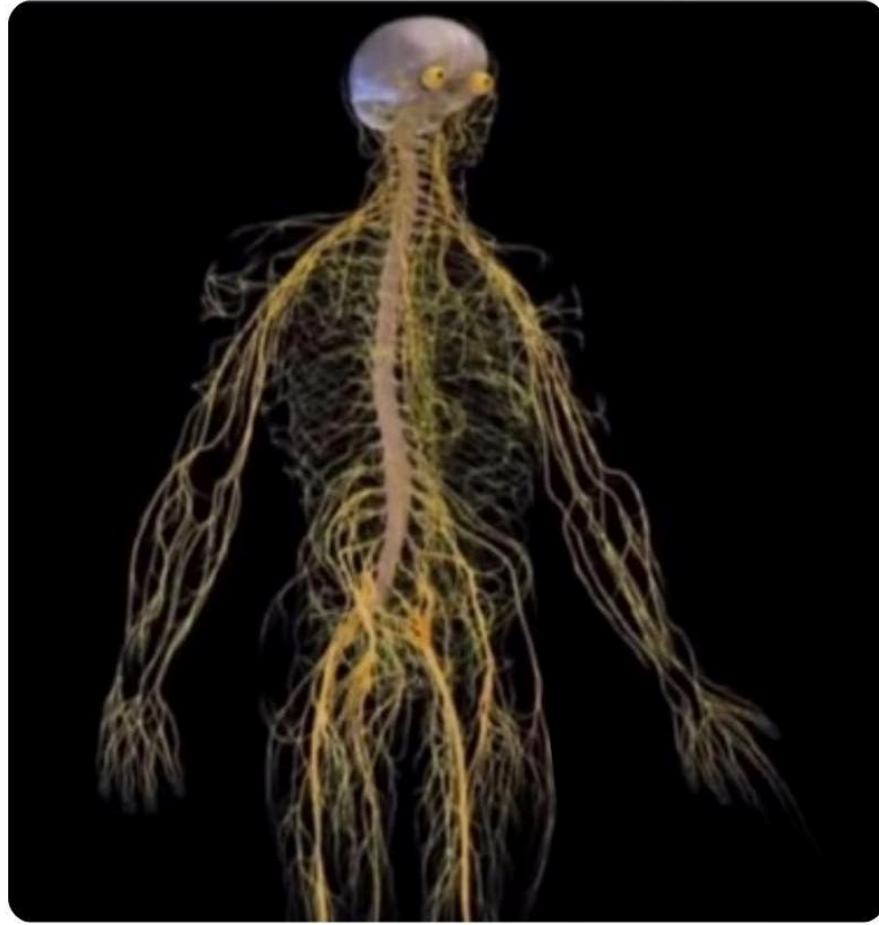


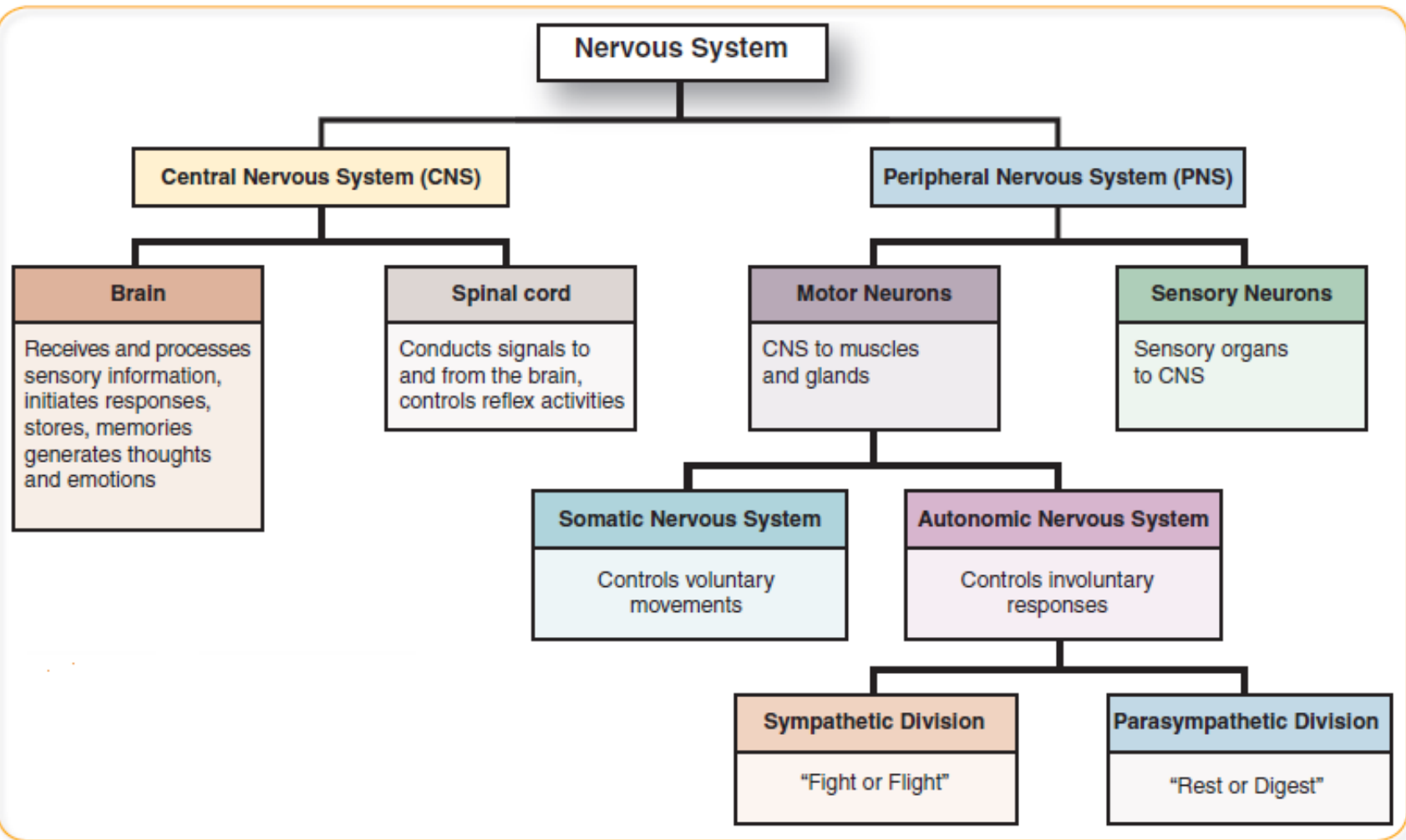
# RECAP OF MODULE 9



You look nervous

No way really





**HES 010**  
**HUMAN ANATOMY AND  
PHYSIOLOGY**  
**NERVOUS SYSTEM**  
**(PART II)**

**PERIOD 2 | WEEK 1 | MODULE 10**

# LEARNING OUTCOMES:

*At the end of the module, students will be able to:*

1. Distinguish the structures involved in somatic motor functions;
2. Describe other functions in relation to the communication between hemispheres, the speech, the brain waves & consciousness, the memory, and the emotions;
3. Define the structural and functional roles of meninges, ventricles, and cerebrospinal fluid in the CNS;
4. List the various types of cranial nerves with their functions;
5. Describe the structural and functional characteristics of autonomic nervous system and its divisions;



# LEARNING OUTCOMES:

*At the end of the module, students will be able to:*

7. Discuss how the enteric nervous system can act independently of the CNS;
8. Identify the different disorders and diseases associated with the nervous system with its description; and,
9. Enumerate the effects of aging on the nervous system.



# NERVOUS SYSTEM



**LABORATORY  
ACTIVITY 1  
NERVOUS  
SYSTEM**



Kindly find a pair, follow the instructions and do the task given in your **LABORATORY 1 – MODULE 10.**

**SCOPE OF THE LABORATORY ACTIVITY:**

**1.1 Anatomy of the Nervous System**

**1.2 Physiology of the Nervous System**

**OBJECTIVES:**

- At the end of the activity, you will be able to:
- Identify the structure and function of the nervous system.
- Appreciate the different reflexes in human
- Identify the organ(s), receptors involved, and the action elicited by selected reflexes

## **I. THE HUMAN REFLEX ARC**

Materials Needed:

- Reflex Hammer – (2 pencils, big eraser and rubber band)

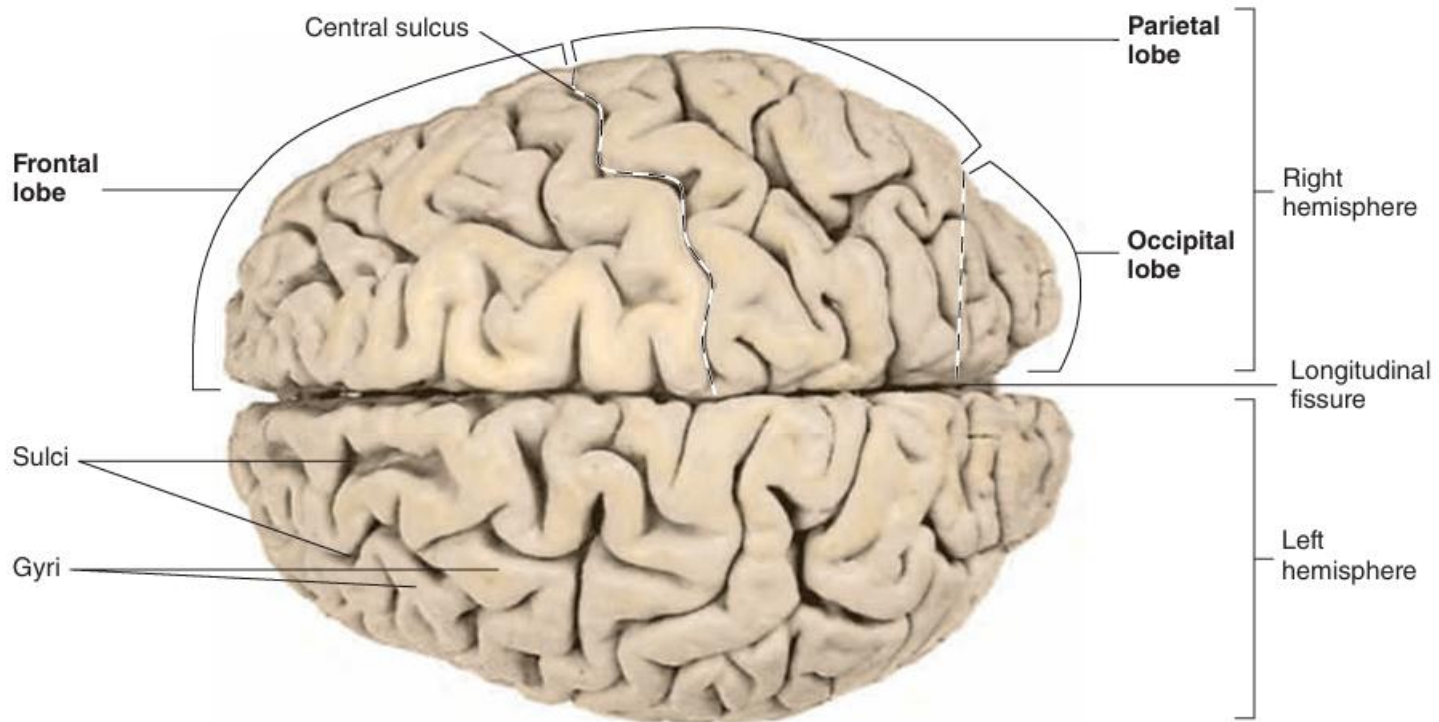
## **II. PUPILLARY REFLEX**

Materials Needed:

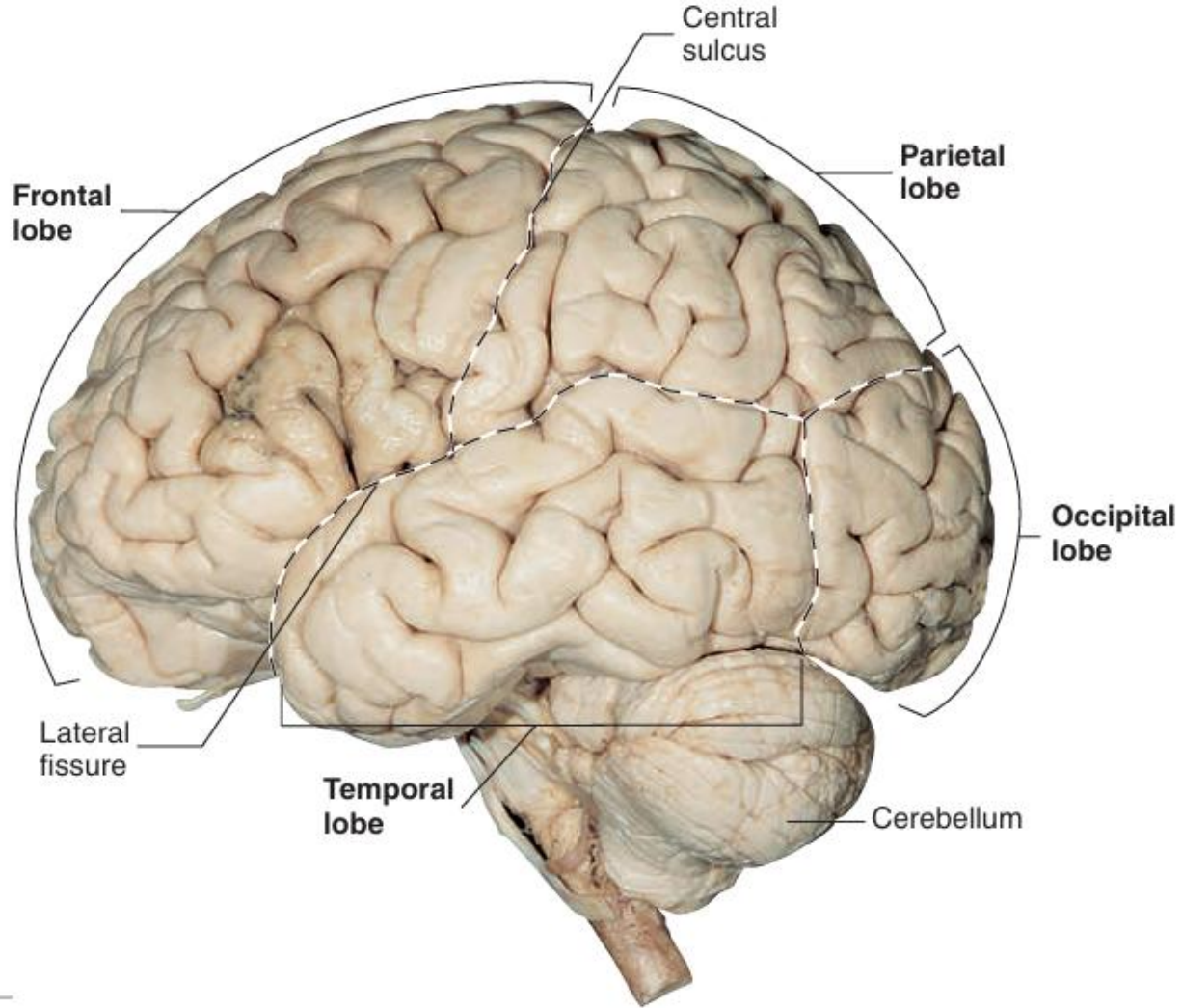
- Penlight – (Flashlight using phone)

# ASCENDING SENSORY FUNCTION





(a) Superior view



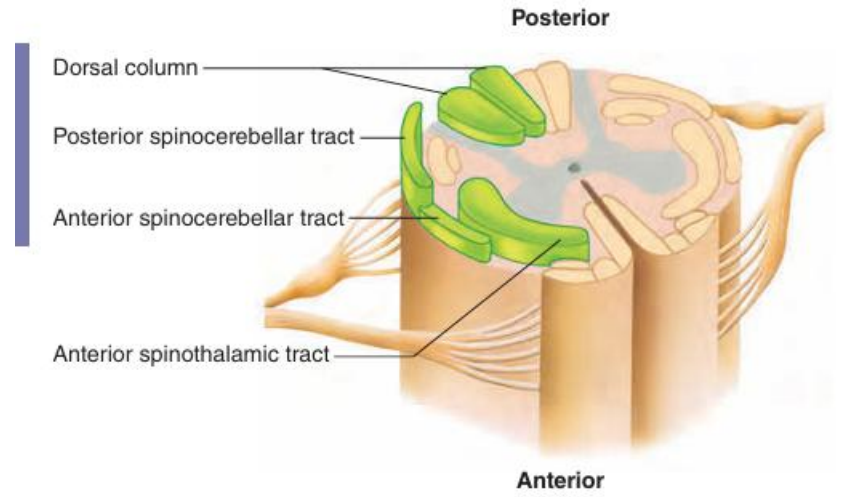
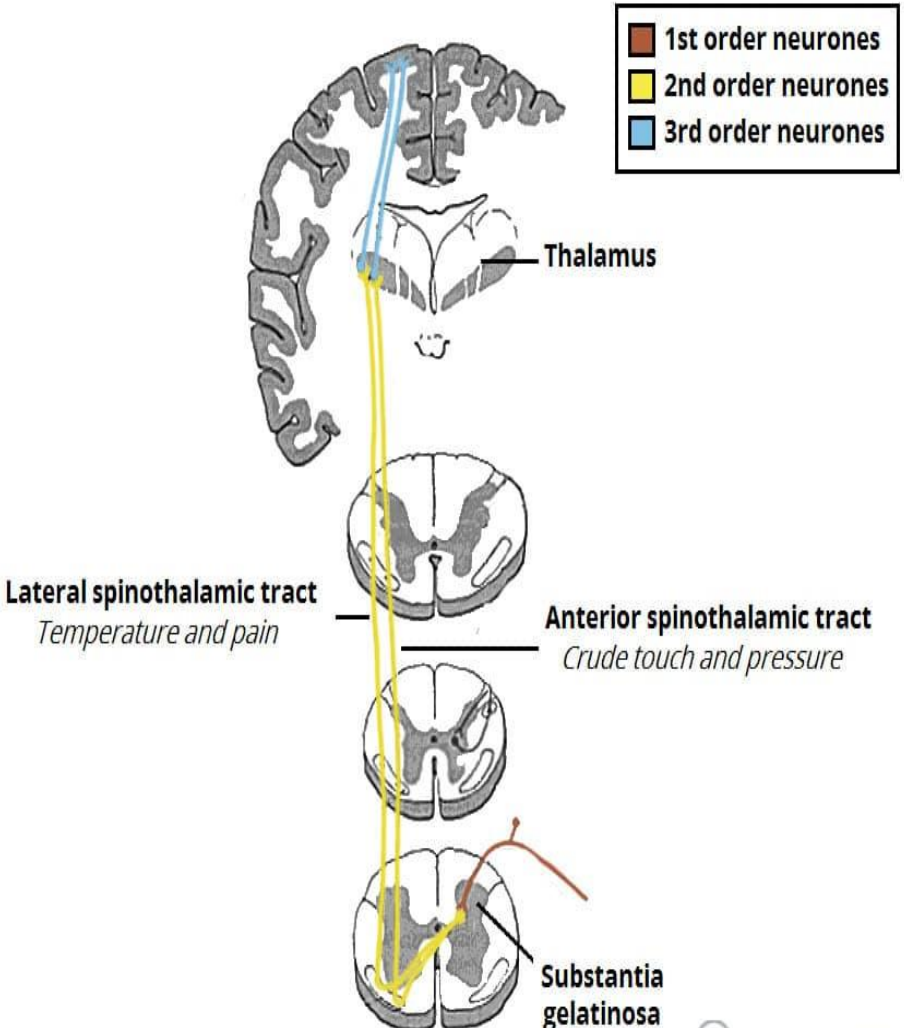
# SENSORY FUNCTION

- ❑ **ASCENDING TRACTS** – pathways that transmit information via action potentials from the periphery to various parts of brain
- ❑ each tract carries **specific type of sensory information and is named before their origin & termination**
- ❑ The ascending tracts carry sensory information from the body, like pain, for example, up the spinal cord to the brain

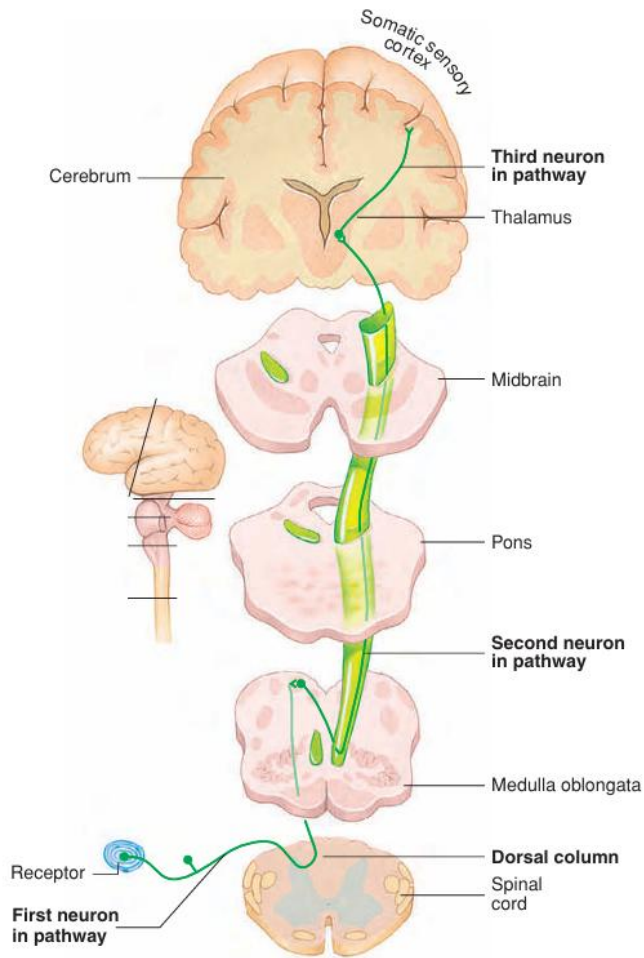
# TYPES OF ASCENDING TRACTS AND THEIR FUNCTION

TYPE OF ASCENDING TRACT	FUNCTION	PART OF THE BRAIN
<b>SPINOTHALAMIC</b>	pain, temperature, light touch, pressure, tickle, itch sensation	To the thalamus and on to the cerebral cortex
<b>DORSAL COLUMN</b>	proprioception, touch, deep pressure, vibration	Cross from one side of the body in the spinal cord or brainstem. The left side of the brain receives sensory input from the right side of the body, and vice versa.
<b>SPINOCEREBELLAR</b>	proprioception to the cerebellum	Transmit information about body position to the cerebellum





**Figure 8.25** Ascending Tracts of the Spinal Cord



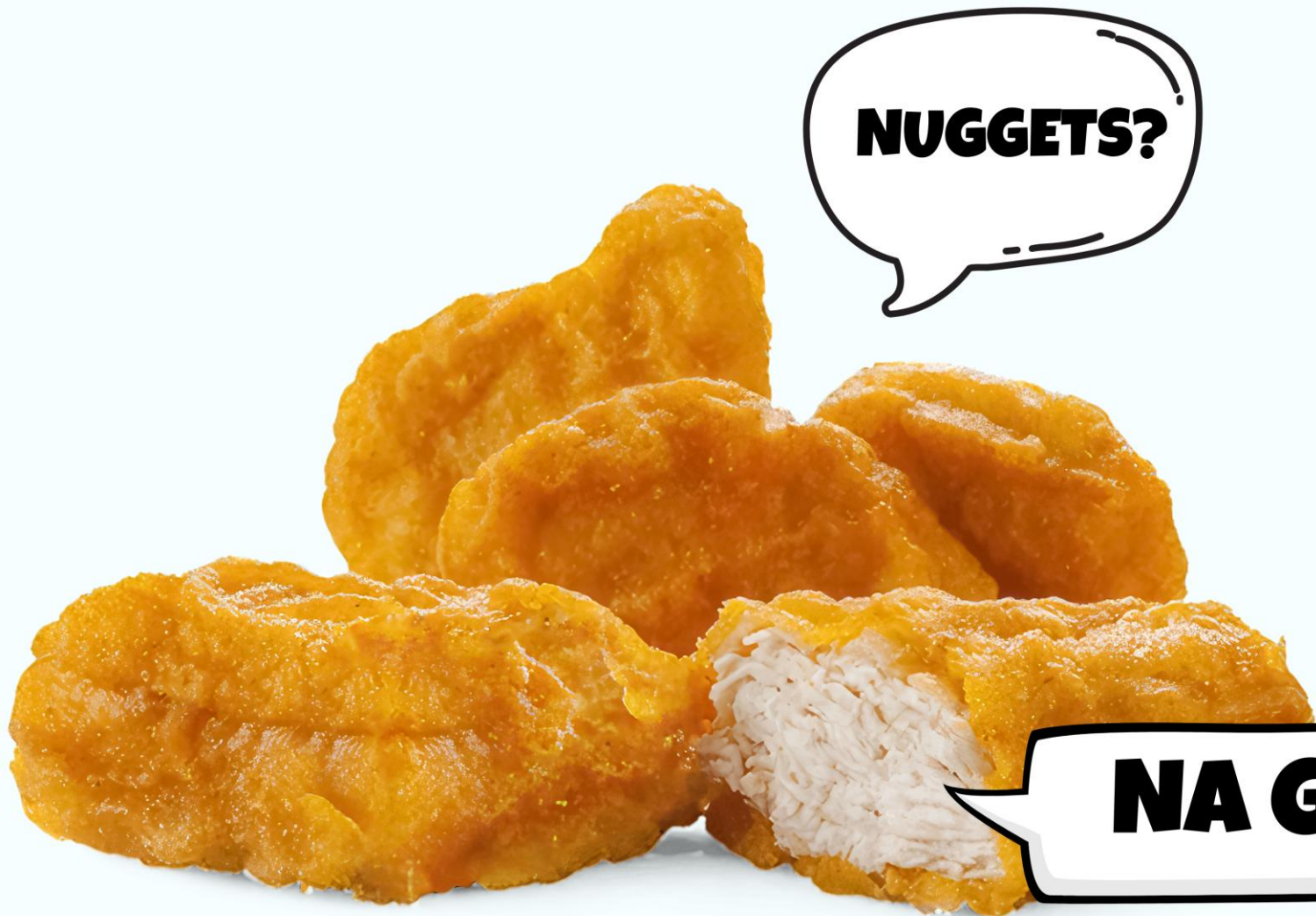
- **First neuron:** Begins at the sensory receptor (e.g., skin or muscle), enters the spinal cord, and ascends through the **dorsal column**.

- **Second neuron:** Located in the **medulla oblongata**, it crosses to the opposite side and travels upward through the **pons** and **midbrain**.

- **Third neuron:** Found in the **thalamus**, it relays the signal to the **somatic sensory cortex** in the **cerebrum**, where perception occurs.

**Figure 8.26** Dorsal Column

The dorsal column transmits action potentials dealing with touch, position, and pressure. Lines on the inset indicate levels of section.



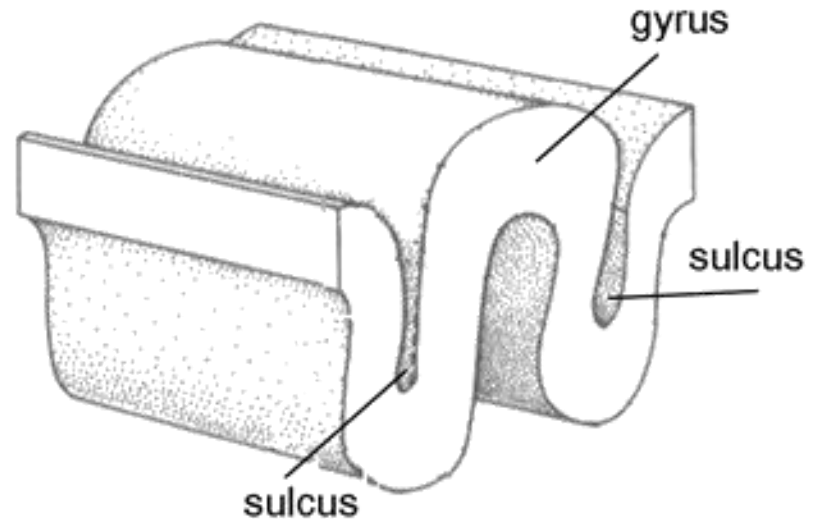
**NUGGETS?**

**NA GETS!**

# SENSORY AREAS OF THE CEREBRAL CORTEX

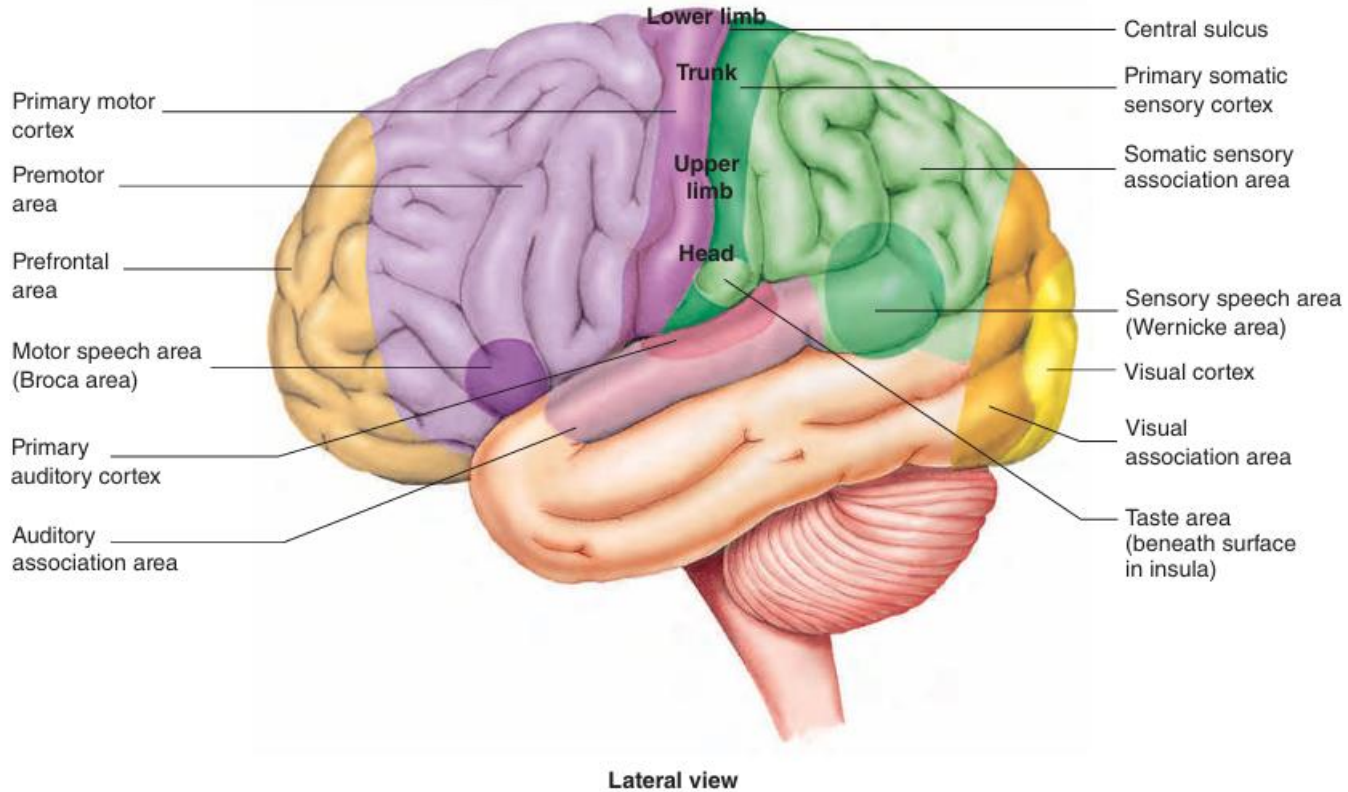


# CEREBRAL CORTEX



**outermost layer of your brain.** Its surface has many folds, giving it a wrinkled appearance. The folds consist of many **deep grooves called sulci** and **raised areas called gyri**. These folds add to the surface area of your cerebral cortex, allowing large amounts of information to be processed by more nerve cells. Your cerebral cortex makes up about half of your brain's total mass.

# SENSORY AND MOTOR AREAS OF CEREBRAL CORTEX



# SENSORY AND MOTOR AREAS OF CEREBRAL CORTEX

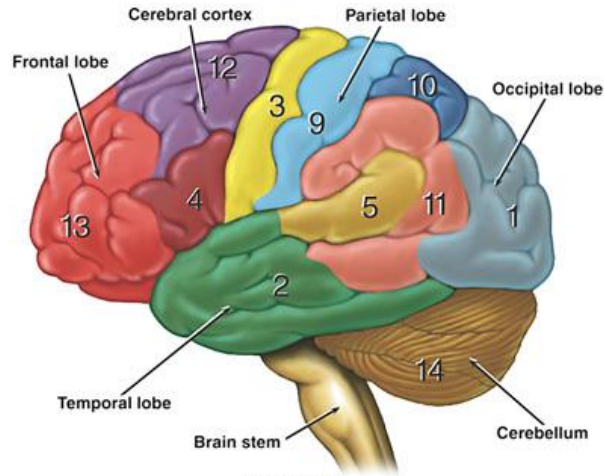
- **MOTOR REGIONS** (FRONT OF CENTRAL SULCUS):
  - **Primary motor cortex:** Controls voluntary movement (mapped from lower limb to head).
  - **Premotor area:** Plans movements.
  - **Broca's area:** Coordinates speech production.
  - **Prefrontal area:** Involved in decision-making and personality.
- **SENSORY REGIONS** (BEHIND CENTRAL SULCUS):
  - **Primary somatic sensory cortex:** Receives touch and body position signals.
  - **Somatic sensory association area:** Interprets sensory input.
  - **Wernicke's area:** Comprehends spoken and written language.
  - **Taste area:** Located deep in the insula.
- **AUDITORY AND VISUAL AREAS:**
  - **Primary auditory cortex and association area:** Process sound.
  - **Visual cortex and association area:** Handle visual input and interpretation.

## Functional Areas of the Cerebral Cortex

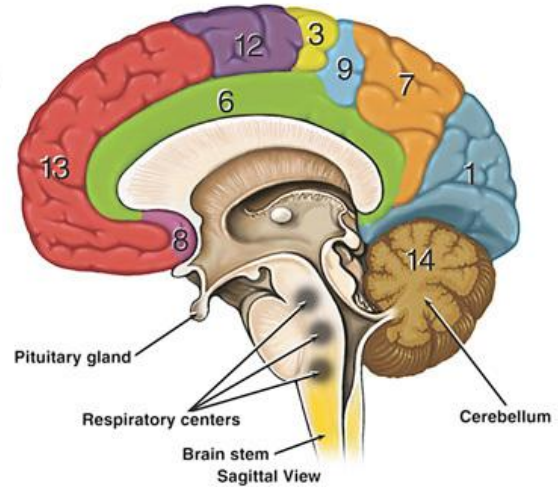
- 1 **Visual Area:**  
Sight  
Image recognition  
Image perception
- 2 **Association Area**  
Short-term memory  
Equilibrium  
Emotion
- 3 **Motor Function Area**  
Initiation of voluntary muscles
- 4 **Broca's Area**  
Muscles of speech
- 5 **Auditory Area**  
Hearing
- 6 **Emotional Area**  
Pain  
Hunger  
"Fight or flight" response
- 7 **Sensory Association Area**
- 8 **Olfactory Area**  
Smelling
- 9 **Sensory Area**  
Sensation from muscles and skin
- 10 **Somatosensory Association Area**  
Evaluation of weight, texture,  
temperature, etc. for object recognition
- 11 **Wernicke's Area**  
Written and spoken language comprehension
- 12 **Motor Function Area**  
Eye movement and orientation
- 13 **Higher Mental Functions**  
Concentration  
Planning  
Judgment  
Emotional expression  
Creativity  
Inhibition

## Functional Areas of the Cerebellum

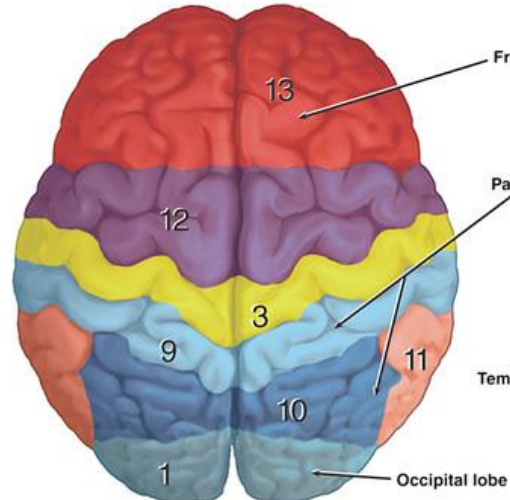
- 14 **Motor Functions**  
Coordination of movement  
Balance and equilibrium  
Posture



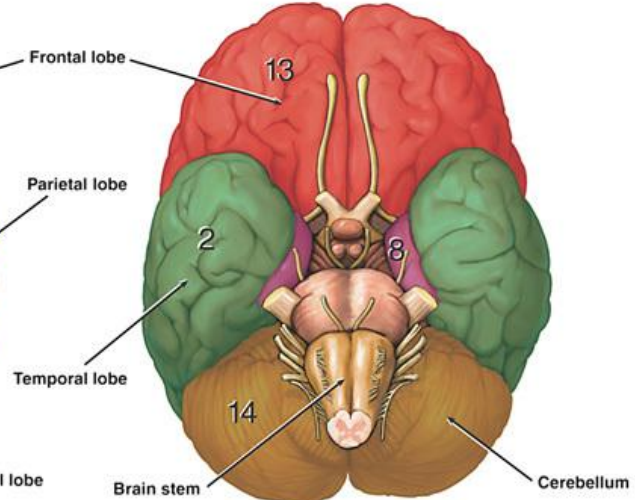
Lateral View



Sagittal View



Superior View



Inferior View

# Functional Areas of the Brain<sup>1</sup>

## Motor Area

- control of voluntary muscles

## Sensory Area

- skin sensations (temperature, pressure, pain)

## Frontal Lobe

- movement
- problem solving
- concentrating, thinking
- behaviour, personality, mood

## Broca's Area

- speech control

## Temporal Lobe

- hearing
- language
- memory

## Brain Stem

- consciousness
- breathing
- heart rate

## Parietal Lobe

- sensations
- language
- perception
- body awareness
- attention

## Occipital Lobe

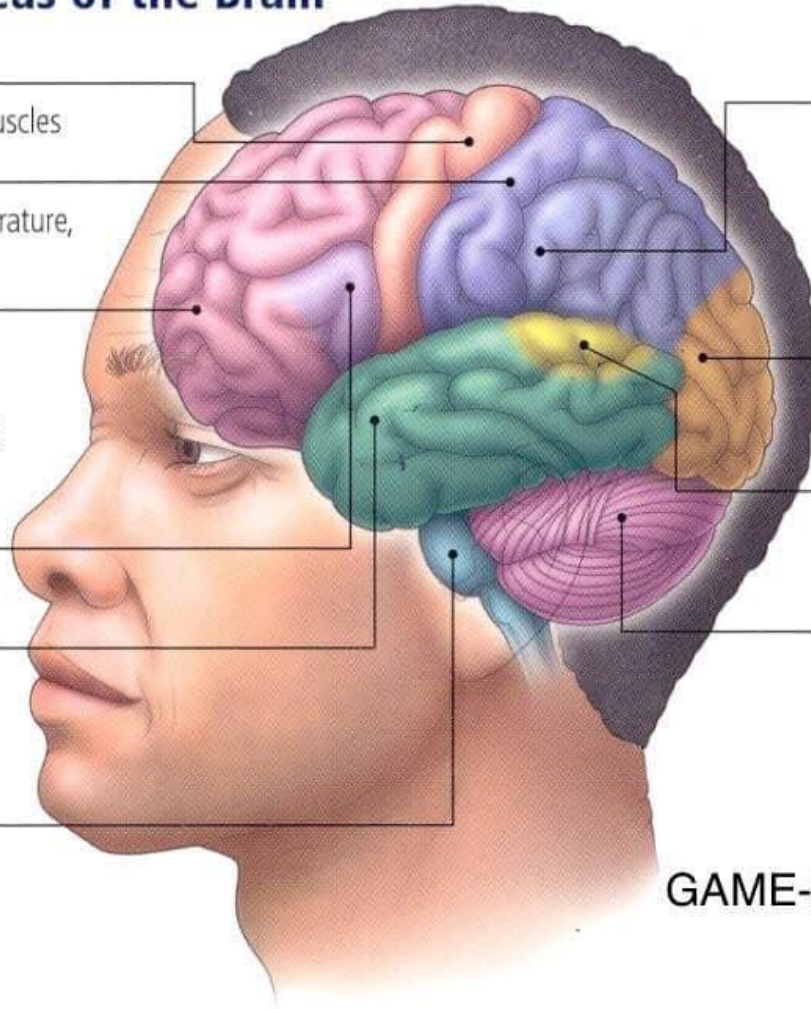
- vision
- perception

## Wernicke's Area

- language comprehension

## Cerebellum

- posture
- balance
- coordination of movement



GAME-ICC

# SENSORY AND MOTOR AREAS OF CEREBRAL CORTEX

- ❑ **PRIMARY SENSORY AREAS** – where **ascending tracts project** & sensations are perceived; this includes visual cortex in occipital lobe, primary auditory cortex in temporal lobe, & taste area

***These are the first cortical regions to receive sensory input from ascending tracts.***

Each type of sensation has a dedicated area:

- Primary somatic sensory cortex (parietal lobe): perceives touch, pain, pressure, and temperature.
- Visual cortex (occipital lobe): perceives visual input.
- Auditory cortex (temporal lobe): perceives sound.
- Taste area (insula): perceives gustatory signals.

# SENSORY AND MOTOR AREAS OF CEREBRAL CORTEX

- ❑ **ASSOCIATION AREAS** – cortical adjacent to primary sensory area; involved in the process of recognition.

***Located adjacent to primary sensory areas.***

*They compare new sensory input to past experiences to determine recognition and significance.*

Example:

- The visual association area helps you recognize familiar faces or objects.
- The auditory association area interprets sounds (e.g., recognizing a familiar voice).
- The somatic sensory association area helps interpret complex touch sensations.

# SENSORY AND MOTOR AREAS OF CEREBRAL CORTEX

**-PRIMARY SOMATIC SENSORY CORTEX / GENERAL SENSORY AREA –**  
located in **parietal lobe posterior to central sulcus**; receives information directly from sensory fibers or from thalamic neurons

**Somatic Motor Functions** include **involuntary** (no conscious thought) and **voluntary movements** (consciously activated).

## TWO MOTOR NEURONS INVOLVED IN VOLUNTARY MOVEMENTS:

- 1. Upper Motor Neurons** – have **cell bodies in cerebral cortex**; their axons form descending tracts that connect to lower motor neurons
- 2. Lower Motor Neurons** – have cell bodies in **anterior horn of spinal cord**; their axons leave the CNS & extend through spinal or cranial nerves to skeletal muscles

# TWO MOTOR NEURONS INVOLVED IN VOLUNTARY MOVEMENTS:



## UPPER MOTOR NEURON LESION

**CENTRAL NERVOUS SYSTEM**

CORTEX, BRAINSTEM, CORTICOSPINAL TRACT, SPINAL CORD

STROKE, TBI, SCI

**INCREASED:** HYPERTONIA/ SPASTICITY/RIGIDITY  
VELOCITY-DEPENDENT

**INCREASED:** HYPERREFLEXIA, CLONUS  
EXAGGERATED CUTANEOUS & AUTONOMIC REFLEXES: (+) BABINSKI RESPONSE

**MUSCLE SPASM:** FLEXOR & EXTENSORS

**IMPAIRED OR ABSENT:** OBLIGATORY SYNERGIES, DYSSYNERGIC PATTERNS

**DISUSE ATROPHY:** VARIABLE, WIDESPREAD DISTRIBUTION

**LOCATION OF LESION**

**STRUCTURES INVOLVED**

**DISORDERS**

**TONE**

**REFLEXES**

**INVOLUNTARY MOVEMENTS**

**VOLUNTARY MOVEMENTS**

**MUSCLE BULK**

## LOWER MOTOR NEURON LESION

**PERIPHERAL NERVOUS SYSTEM**

SPINAL CORD: ANTERIOR HORN CELL, SPINAL ROOTS, PERIPHERAL NERVES  
CRANIAL NERVES

POLIO, GBS, PNI, PERIPHERAL NEUROPATHY, RADICULOPATHY

**DECREASED OR ABSENT:** HYPOTONIA/ FLACCIDITY  
NON-VELOCITY-DEPENDENT

**DECREASED:** HYPOREFLEXIA  
CUTANEOUS REFLEXES: DECREASED OR ABSENT

**WITH DENERVATION:** FASCICULATIONS

**WEAK OR ABSENT** IF NERVE INTERRUPTED

**NEUROGENIC ATROPHY:** RAPID, FOCAL DISTRIBUTION, SEVERE WASTING

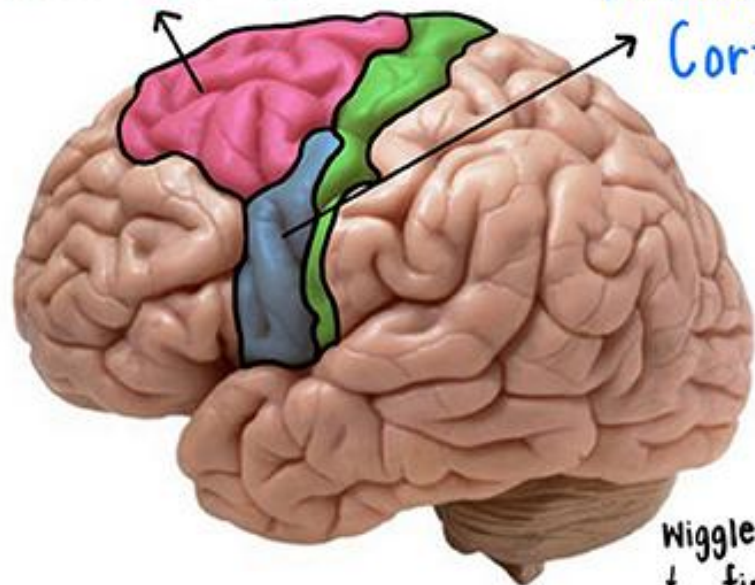
# MOTOR AREAS OF CEREBRAL CORTEX:

- **Primary Motor Cortex** – located in **posterior portion of frontal lobe**, anterior to central sulcus; **control voluntary motor movements**
- **Premotor Area** – located at **frontal lobe where motor functions** are organized before initiation
- **Prefrontal Area** – region of **association cortex** which involves in motivation & **regulation of emotional behavior and mood**; accounts for foresight to plan and initiate movement

## Functions: Premotor Cortex/SMC vs. Primary Motor Cortex

Supplementary  
Motor Cortex

Premotor  
Cortex

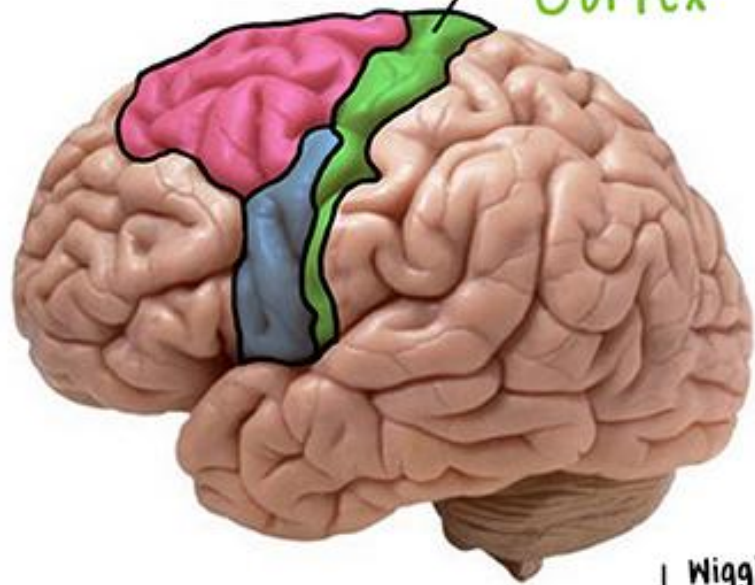


(A) Picks your body part



Wiggle this  
finger

Primary Motor  
Cortex



(B) Moves your body part



Wiggle  
Wiggle

# DESCENDING SENSORY FUNCTION



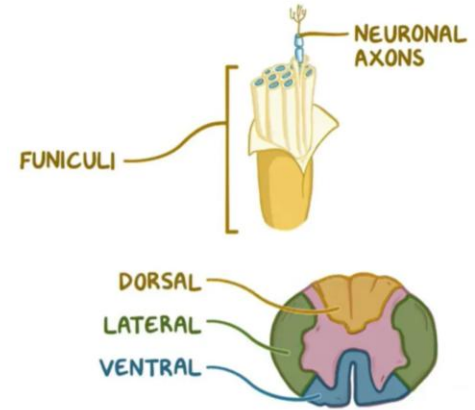
# DESCENDING TRACTS

**DESCENDING TRACTS** – pathways that control different types of movements

□ **CROSSOVER OF AXONS** in brainstem or spinal cord to the **opposite side** of the body is typical to this pathways

## SPINAL TRACTS

- 2 major pathways
  - Ascending (Afferent)
    - Carries sensory information from body → spinal cord → brain
  - Descending (Efferent)
    - Carries motor information from brain → spinal cord → body



# DESCENDING TRACTS

## **Naming principle:**

Tracts are identified by where they start and end (e.g., corticospinal = cortex → spinal cord).

## **Direct tracts (corticospinal):**

Extend straight from **upper motor neurons in the cerebral cortex** to lower motor neurons in the spinal cord.

Allow precise, voluntary control of movement.

A similar direct tract connects to motor neurons in the brainstem.

## **Indirect tracts (brainstem-originating):**

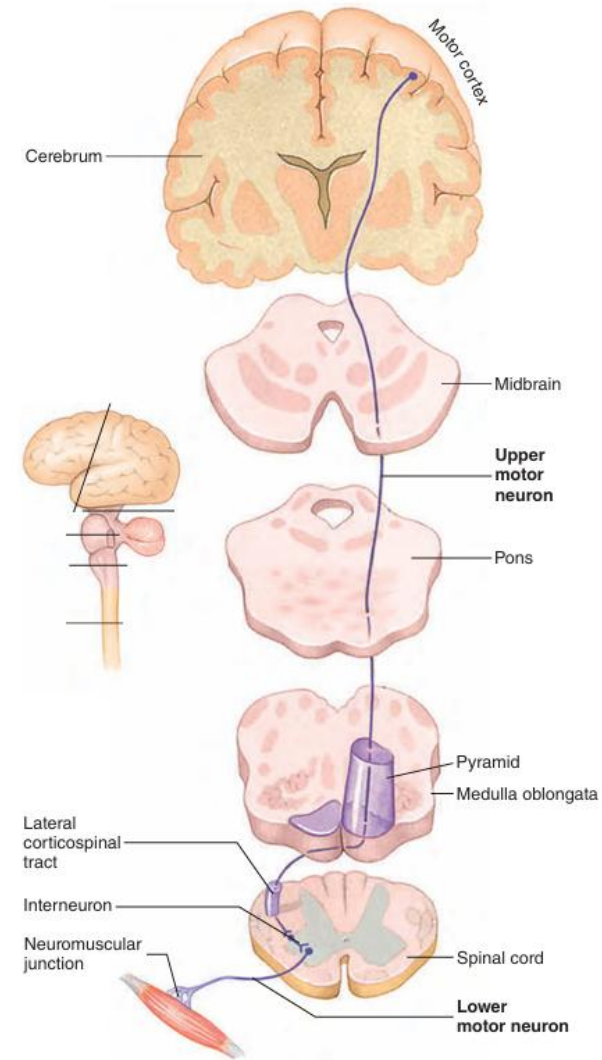
Begin in the **brainstem** but are influenced by the cerebral cortex, basal nuclei, and cerebellum.

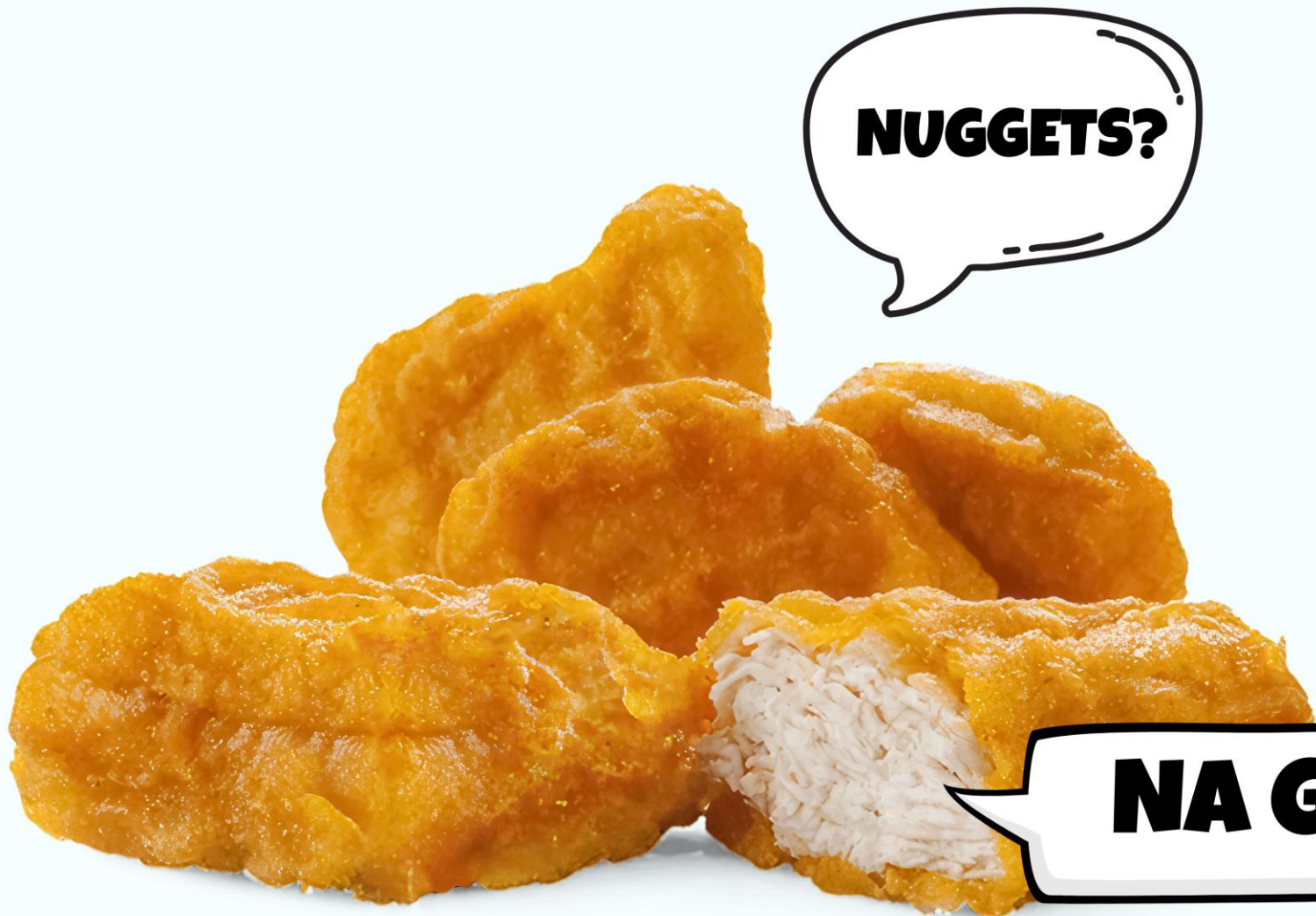
Called indirect because there is **no direct link between cortical neurons and spinal neurons.**

Important for posture, balance, and coordination.

# DESCENDING TRACTS

Pathway	Function
<b>Direct</b>	
Lateral corticospinal	Muscle tone and skilled movements, especially of hands
Anterior corticospinal	Muscle tone and movement of trunk muscles
<b>Indirect</b>	
Rubrospinal	Movement coordination
Reticulospinal	Posture adjustment, especially during movement
Vestibulospinal	Posture and balance
Tectospinal	Movement in response to visual reflexes





**NUGGETS?**

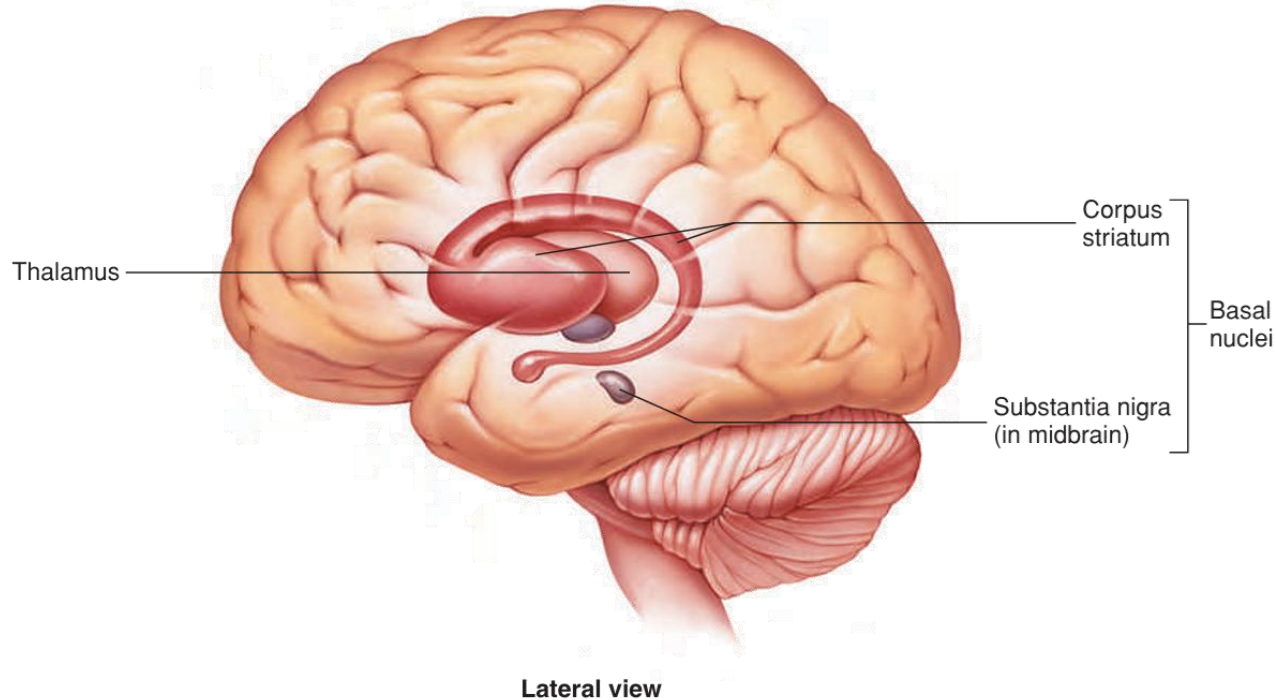
**NA GETS!**

# BASAL NUCLEI



# BASAL NUCLEI

The **basal nuclei** are interconnected brain structures that play a crucial role in **planning, organizing, and coordinating motor movements and posture**, with dysfunction leading to movement disorders.



# BASAL NUCLEI

## •Key Structures:

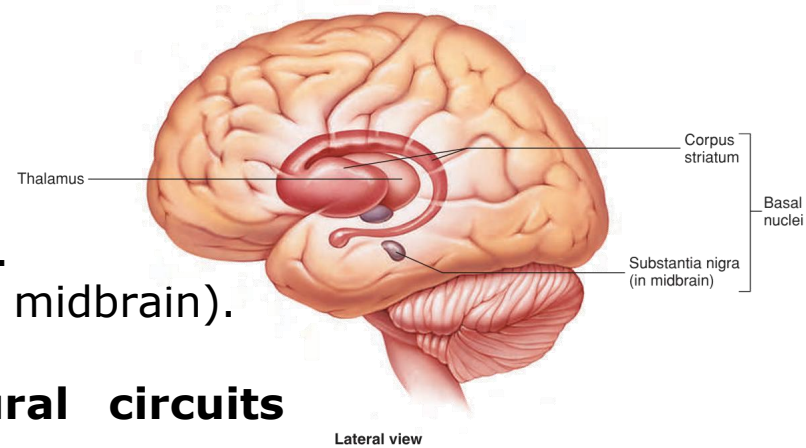
- Corpus striatum** (deep in the cerebrum).
- Substantia nigra** (pigmented cells in the midbrain).

## •Functions:

- Work together through **complex neural circuits** involving the thalamus and cerebral cortex.
- Create **feedback loops** that can either stimulate or inhibit motor activity.
- Stimulatory circuits help maintain muscle readiness, even when a person is not actively moving.

## •Feedback Loops / Circuits from Neural Circuits of Basal Nuclei:

- Stimulatory Circuit** – initiate an action, facilitate muscle activity such as **rising from a sitting position**
- Inhibitory Circuit** – inhibit random movements especially at **rest of the trunk and limbs**



# BASAL NUCLEI – FEEDBACK LOOPS

## **STIMULATORY CIRCUIT EXAMPLE (INITIATING ACTION)**

**EXAMPLE:** You're sitting in a chair and decide to stand up.

### **Process:**

The basal nuclei stimulatory circuit activates, sending signals that facilitate muscle activity in your legs and trunk. This ensures your quadriceps and gluteal muscles contract strongly enough to lift you smoothly.

**Outcome:** You rise from the chair in a controlled, coordinated motion.

## **INHIBITORY CIRCUIT EXAMPLE (PREVENTING RANDOM MOVEMENTS)**

**Scenario:** You're sitting quietly, reading a book.

### **Process:**

The basal nuclei inhibitory circuit suppresses unnecessary or random muscle contractions in your trunk and limbs. This prevents involuntary jerks or twitching that would interfere with your posture.

**Outcome:** You remain still and stable, conserving energy and maintaining focus.

# BASAL NUCLEI

## Clinical Relevance:

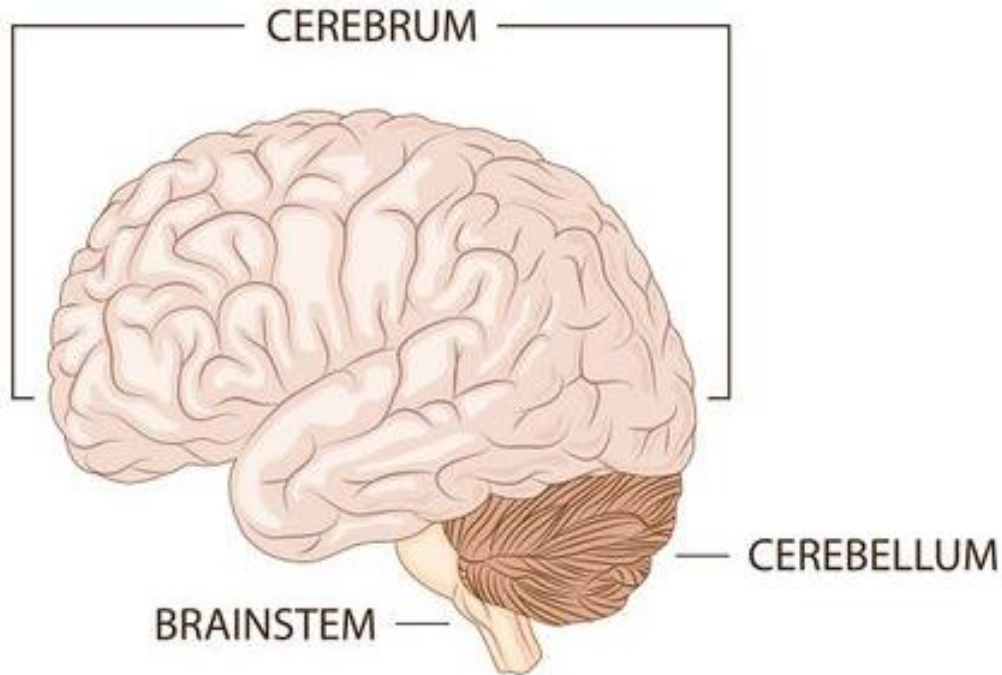
- Disorders such as **Parkinson's disease**, **Huntington's disease**, and **cerebral palsy** are linked to basal nuclei dysfunction, highlighting their importance in normal motor control.



# THE CEREBELLUM

# CEREBELLUM

The **cerebellum** is essential for **balance, muscle tone, coordination of fine motor movements, and motor learning**, functioning as a **comparator** that ensures smooth and accurate execution of voluntary actions.



# CEREBELLUM

## Structure:

- Attached to the brainstem via cerebellar peduncles.
- Composed of gray matter (cortex & nuclei) and white nerve tracts.
- Smaller gyri compared to the cerebrum.

## Functions:

- Balance & Muscle Tone: Maintains posture and readiness of muscles.
- Coordination: Ensures fine motor movements are smooth and precise.  
Damage leads to clumsy, uncoordinated actions.



**HOW MANY HEMISPHERE  
DOES OUR BRAIN HAS?**

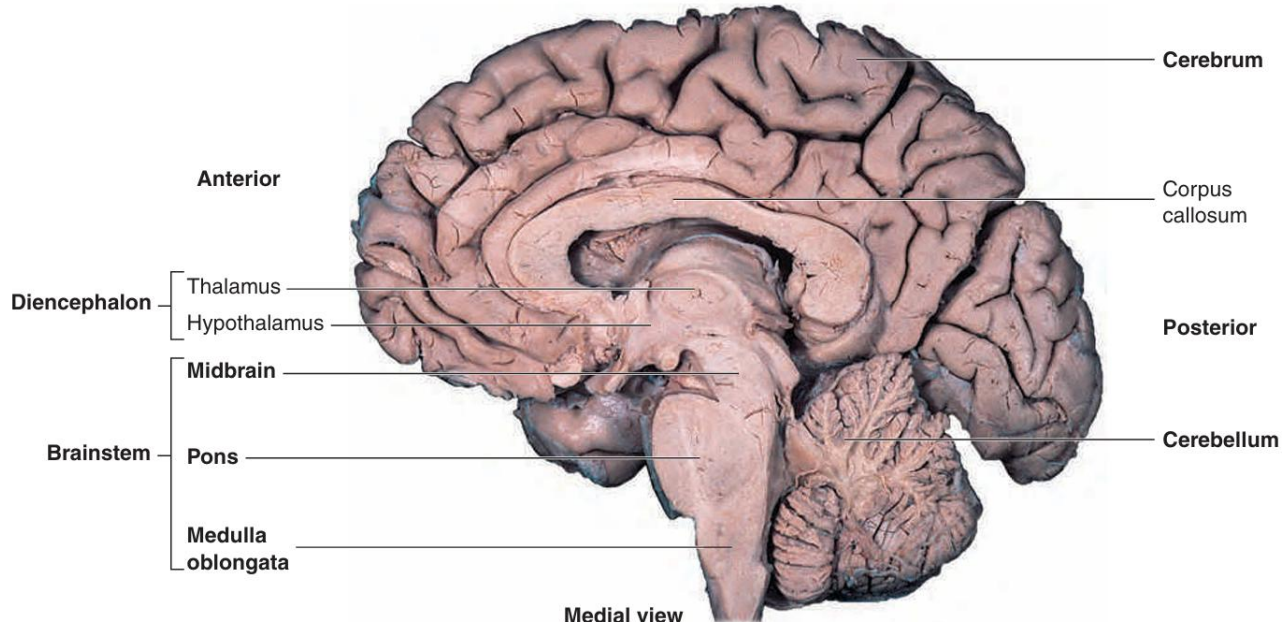


**COMMUNICATION  
BETWEEN  
THE RIGHT AND  
LEFT HEMISPHERES**

# COMMISSURES

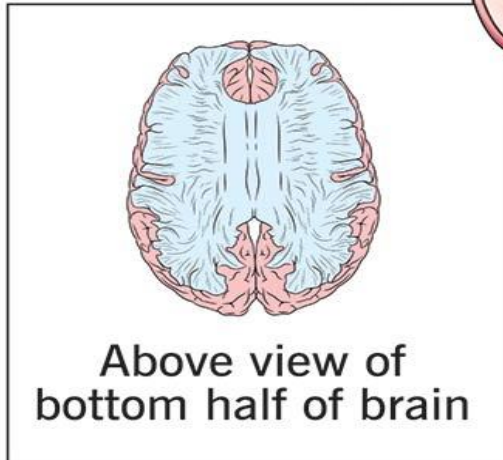
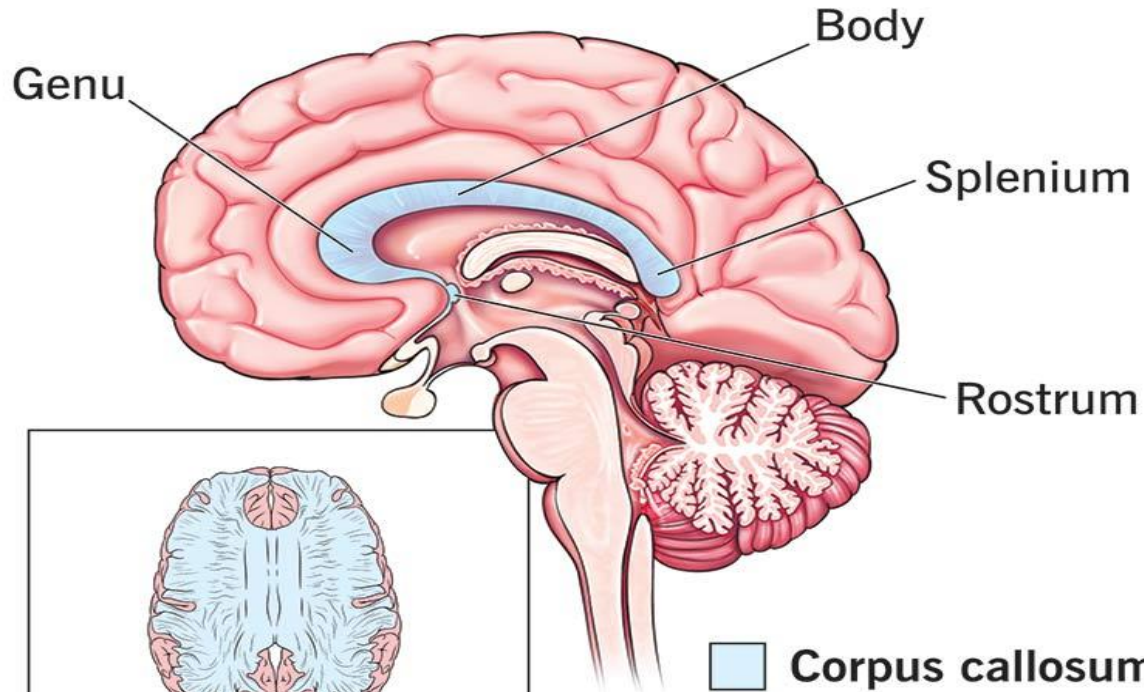
**Connections between two hemispheres intended to share the received sensory information.**

•**Corpus Callosum:** the largest of commissures; a broad band of nerve tracts at the base of longitudinal fissure; allow your brain's left and right hemispheres to communicate.

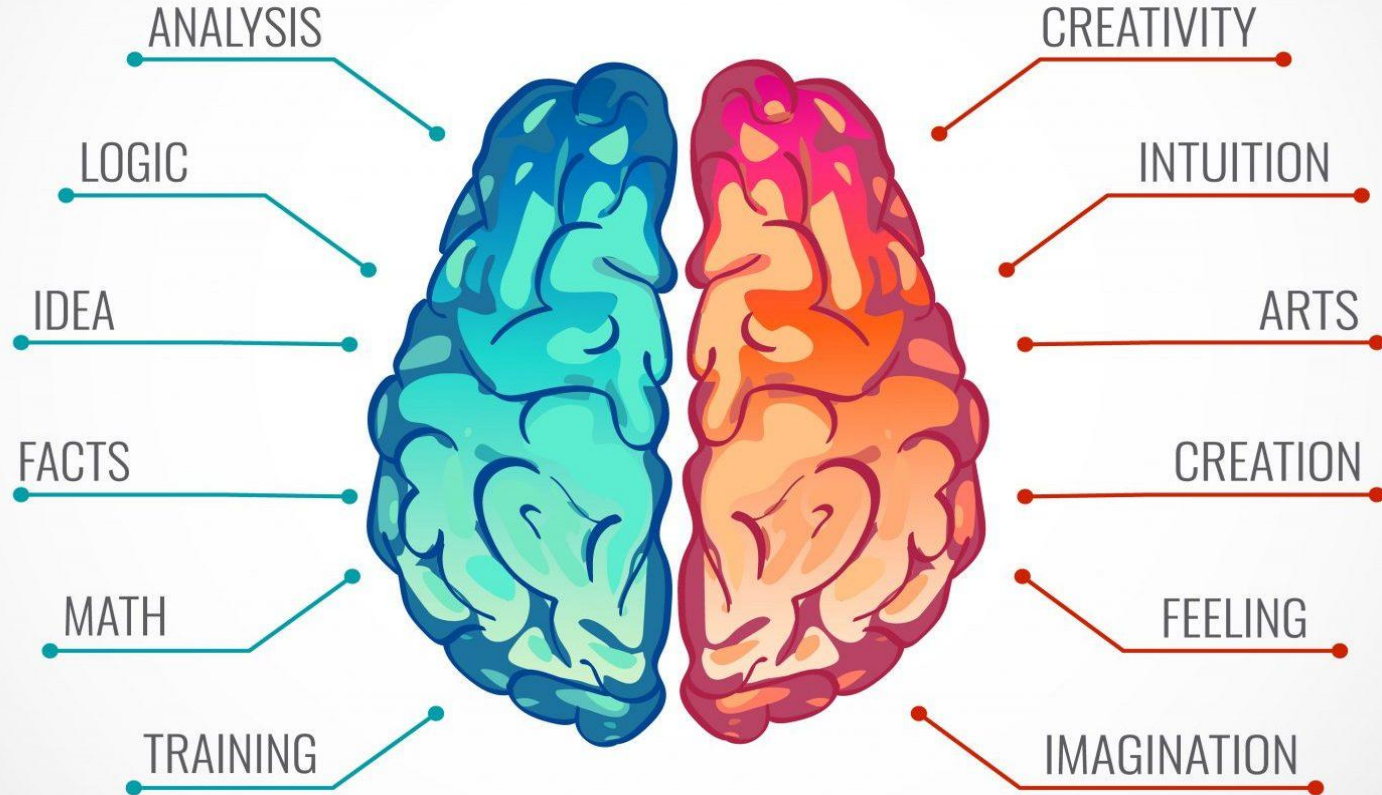


# Corpus callosum

Side view of inside of brain



# LEFT vs RIGHT BRAIN



# COMMISSURES

## RIGHT CEREBRAL HEMISPHERE

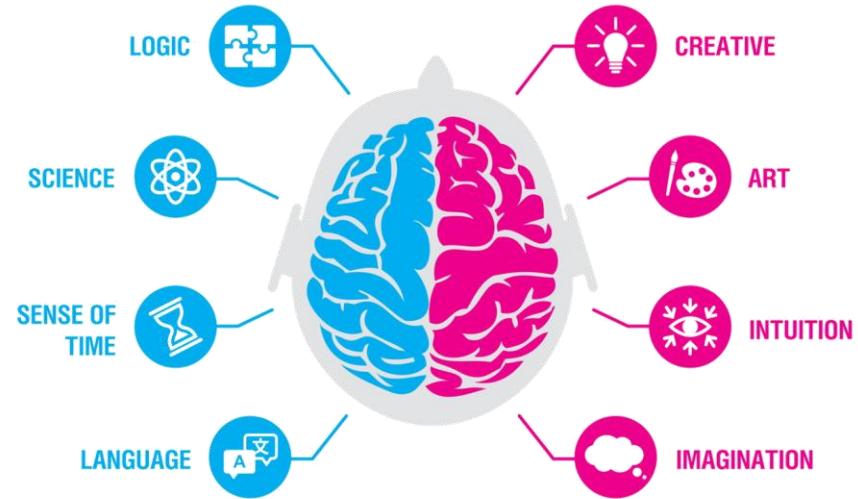
receives sensory input from and controls muscular activity in the *left half* of the body

more involved in functions such as 3D or spatial perception and music ability

## LEFT CEREBRAL HEMISPHERE

receives input from and controls muscular activity in the *right half* of the body

more analytics, emphasizing such skills as mathematics and speech



# THE SPEECH

# SPEECH

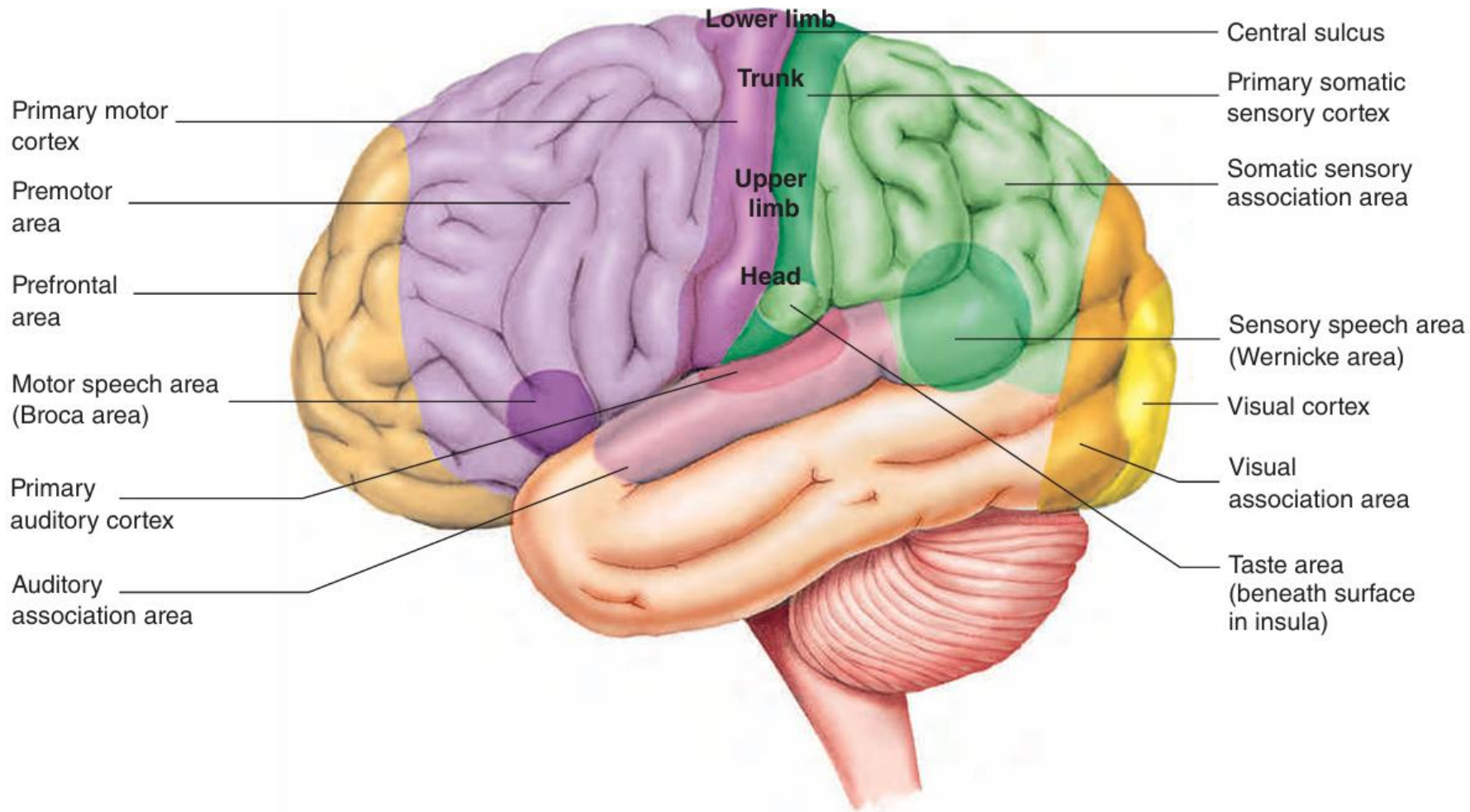
- In most people, the speech area is in the left cerebral cortex.

## TWO MAJOR CORTICAL AREAS INVOLVED IN THE SPEECH

- 1. Sensory Speech / Wernicke Area** – in parietal lobe; functions in **understanding & formulating** coherent speech
- 2. Motor Speech / Broca Area** – in frontal lobe; **controls movement** necessary for speech

Damage to these parts of the brain or to associated brain regions may result in **aphasia, absent or defective speech of language comprehension.** The most common cause is a stroke. It is estimated that 25–40% of stroke survivors exhibit aphasia.





# SPEECH

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# SPEECH

## TO REPEAT A WORD YOU HEAR:

Action potentials from ear is perceived to **primary auditory cortex**



Word recognition in **auditory association area** & comprehended in portions of **Wernicke area**



Conduct **action potentials through nerve tracts** in speech areas



**Broca area** determines the muscle activity needed to repeat the word



Send to **premotor area** for programming the movement



Action potentials conduct to **primary motor cortex** where specific movements are triggered



# SPEECH

## TO SPEAK A WRITTEN WORD

Word from eyes enters **visual cortex**



**Visual association area** for recognition



Continues to **Wernicke area** where it is **understood & formulated** as it is to be spoken



Conduct action potentials through **nerve tracts** in speech areas



**Broca area** determines the **muscle activity** needed to repeat the word



Send to **premotor area** for programming the movement



Action potentials conduct to **primary motor cortex** where specific movements are triggered



# BRAIN WAVES & CONSCIOUSNESS

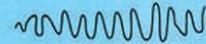


# BRAIN WAVES & CONSCIOUSNESS

- different levels of consciousness can be revealed by patterns of electrical activity in the brain.
- **Electroencephalogram (EEG)** – electrodes placed on a person's scalp to record brain's electrical activity; patterns can be detected as **wavelike patterns** known as **brain waves**.



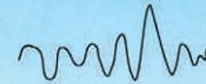
Alpha waves



Beta waves



Theta waves



Delta waves



(b)

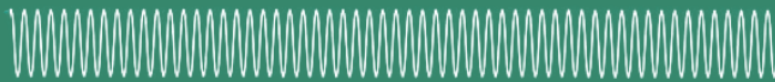
# BRAIN WAVES & CONSCIOUSNESS

TYPE OF BRAIN WAVE	DESCRIPTION
<b>Alpha Waves</b>	normal person is awake but in a quiet, resting state; eyes closed
<b>Beta Waves</b>	occur during intense mental activity; have higher frequency than alpha
<b>Delta Waves</b>	occur during deep sleep, in infants & patients with severe brain disorders
<b>Theta Waves</b>	common in children, may occur in adults with frustration or certain brain disorders

- In the beginning of sleep, a rapid transition takes place from a beta rhythm to an alpha. As sleep deepens, progressively more delta waves occurs.
- Neurologists use these patterns to diagnose and determine the treatment for the disorders.

## Gamma Waves

(30-100 Hz)



Insight  
Learning  
Problem Solving

## Beta Waves

(12-30 Hz)



Active thinking  
Alertness  
Scrolling

## Alpha Waves

(8-12 Hz)



Relaxation  
Meditation  
Lucid awareness

## Theta Waves

(4-8 Hz)



Daydreaming  
Intuition  
Creative thinking

## Delta Waves

(0.5-4 Hz)



Deep sleep  
Recovery  
Unconsciousness

# THE MEMORY



# MEMORY

- The storage of memory can be divided into three stages: ***working, short-term, and long-term.***

## 1. WORKING MEMORY

- ***task-associated memory*** that is required for **immediate performance of task**; lasts only a **few seconds to minutes**; occurs mostly in frontal lobe; storage limited to **about 7 bits of information at any one time.**
- When new information is presented, old information, previously stored in working memory, is eliminated.
- What happens to a telephone number you just looked up if you are distracted?



# MEMORY

## 2. SHORT TERM MEMORY

- can retain information for a **few minutes to a few days**; stored by mechanism involving increased synaptic transmission.
- **Consolidation:** a *gradual process* involving the formation of new & **stronger synaptic connections** transferring this memory into long-term; length of memory depends on how often the information is retrieved and used.



# MEMORY

## **3. LONG-TERM MEMORY – can store for only a few minutes or become permanent**

- **Declarative Memory / Explicit Memory** – involves retention of facts & related emotional undertones.
  - such as names, dates, and places, emotion and mood apparently serve as gates in the brain and determine what is stored in long-term
- **Procedural Memory / Reflexive Memory** – involves development of motor skills; only a small amount of this memory is lost over time
  - such as riding a bicycle. only a small amount of procedural memory is lost over time.

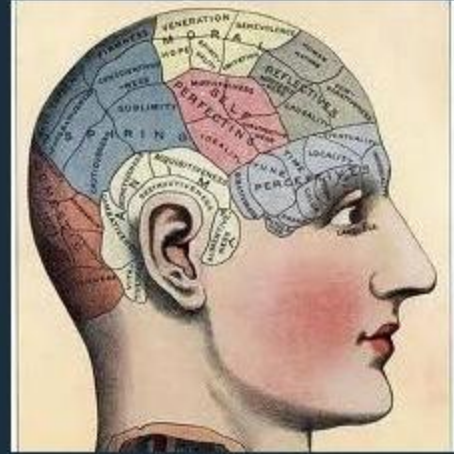
## **Memory Engrams / Memory Traces - involve in long-term retention of a given piece of information**

Repeating the information and associating it with existing memories help us transfer information from short-term to long-term memory



# MEMORY

Special people who can “remember everything” usually refers to individuals with **hyperthymesia**, also called Highly Superior Autobiographical Memory (HSAM).



There is a condition called hyperthymesia that allows a person to remember every single day of their life in great detail.

# LIMBIC SYSTEM & EMOTIONS



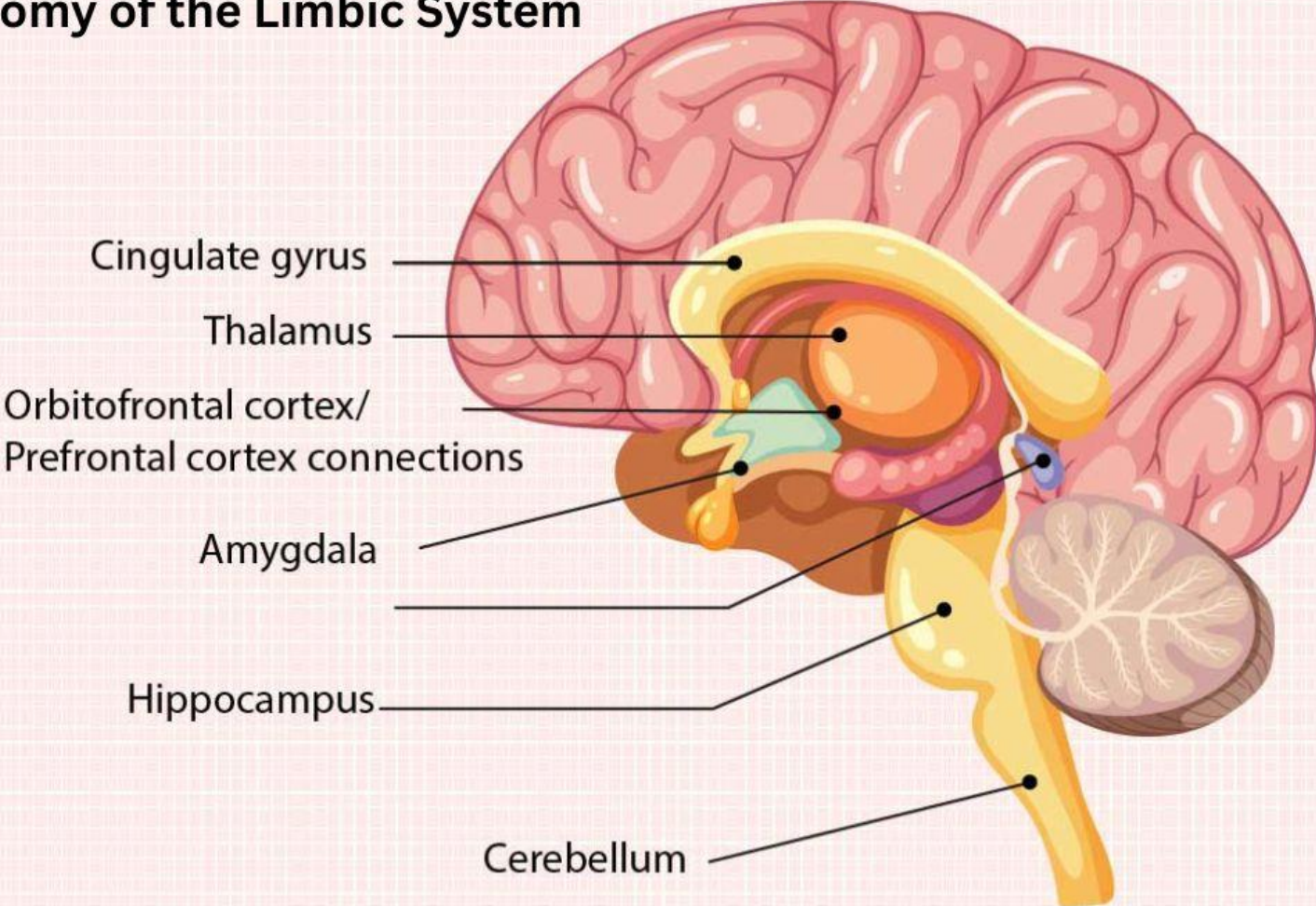
# LIMBIC SYSTEM & EMOTIONS

**LIMBIC SYSTEM** – includes the olfactory cortex, deep cortical regions, and nuclei of cerebrum, & diencephalon (emotional nervous system)

- involved in our **behavioral and emotional responses**, especially when it comes to behaviors, we need for survival: feeding, reproduction and caring for our young, and fight or flight responses.
- it influences **long-term declarative memory**, emotions, visceral responses to emotions, motivations & mood
- major source of sensory input is the **olfactory nerve & responds to olfactory** stimulation by initiating survival responses, such as hunger and thirst lesions in this area can result to voracious appetite, increased sexual activity, and docility



# Anatomy of the Limbic System



# MENINGES

Meninges (membrane) – **protective wrapping around the brain and spinal cord.**

## **3 TYPES OF MENINGES:**

**1. Dura Mater – superficial & thickest layer;** adheres tightly to cranial bone; consists of two layers which function as a single layer

• **Dural Folds:** help hold the brain in place within the skull

• **Dural Venous Sinuses:** collect blood from the small veins of brain & empty into internal jugular veins

**Epidural Space** – space of vertebral canal, between the dura mater & vertebrae which is clinically vital for injection of epidural anesthesia to spinal nerves, usually done in childbirth



# MENINGES

2. **Arachnoid Mater** – **very thin, wispy second layer**

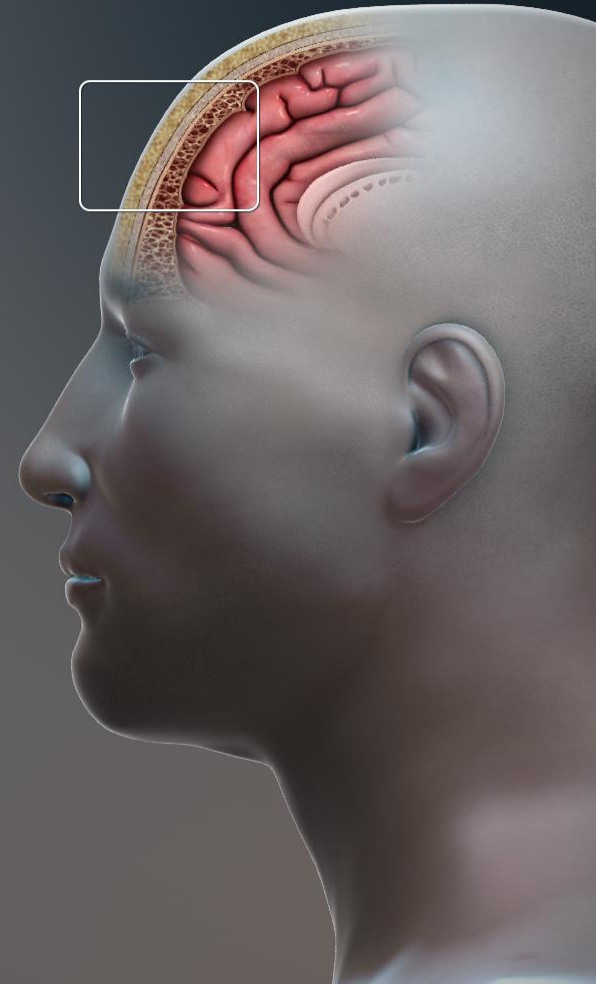
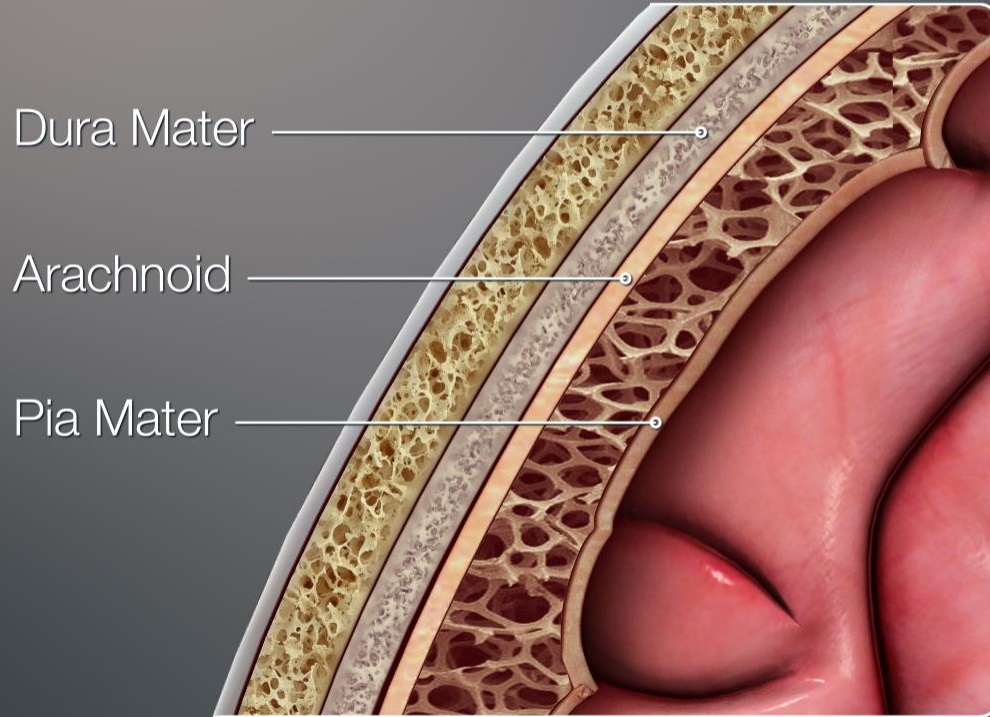
• **Subdural Space:** between the dura & arachnoid mater; contains a very small amount of serous fluid

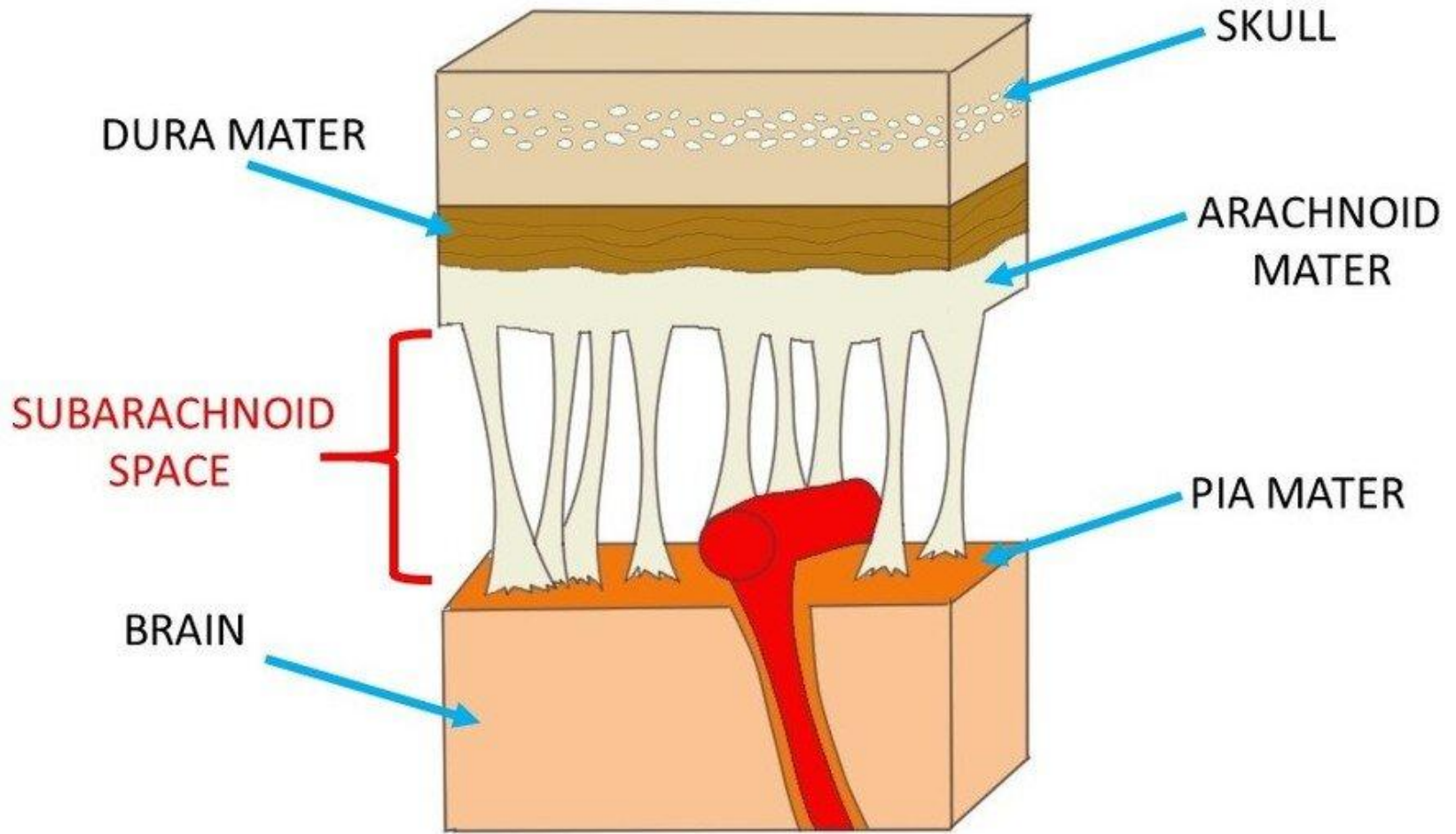
3. **Pia Mater** – **very tightly bound** to the surface of brain & spinal cord

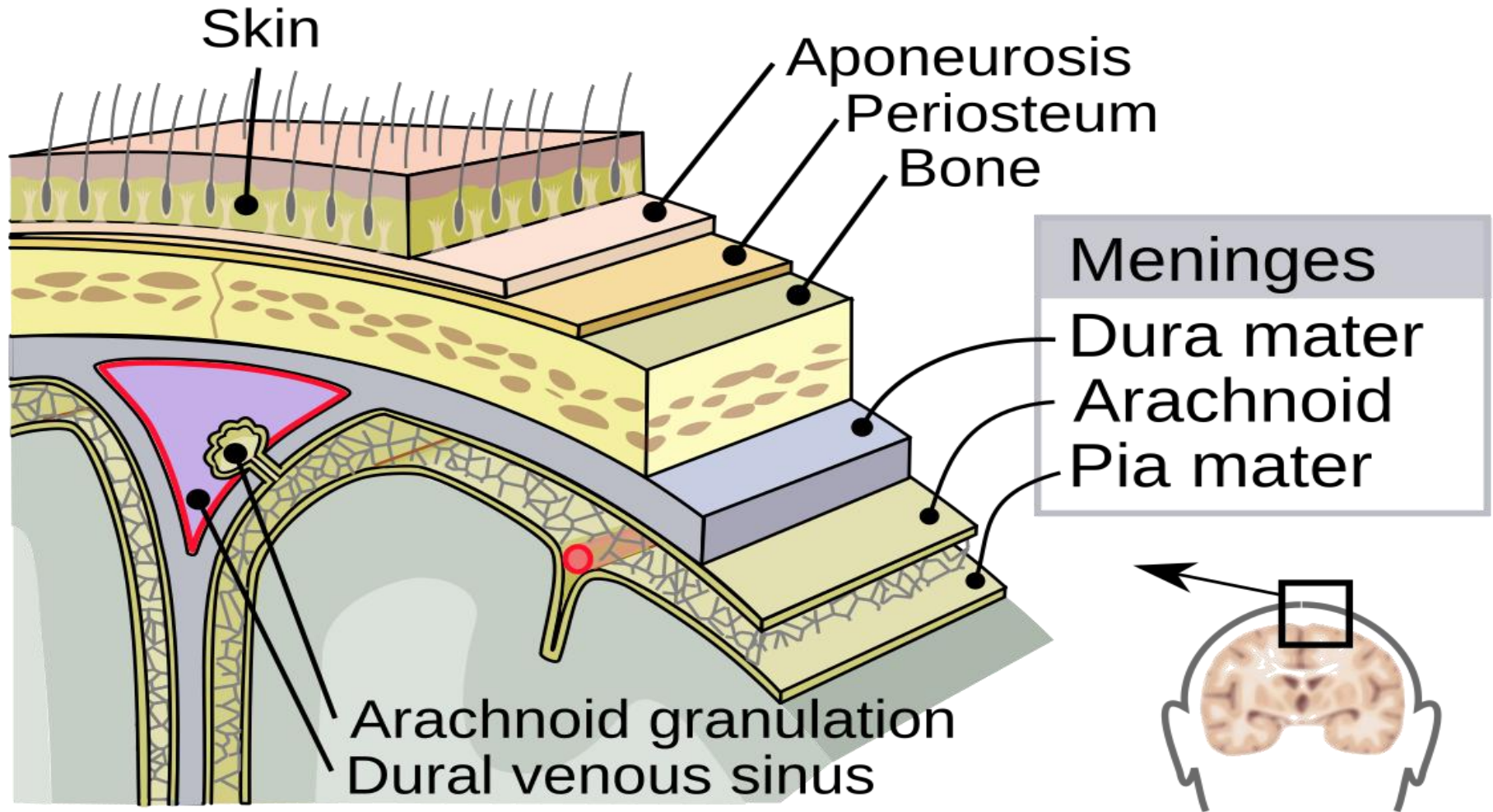
**Subarachnoid Space:** between the arachnoid & pia mater; filled with cerebrospinal fluid (CSF) & contains blood vessels; extends to the end of vertebral column & serves as a site of injection for spinal block (anesthesia) and spinal tap (to take sample of CSF)



# Meninges







# THE VENTRICLES

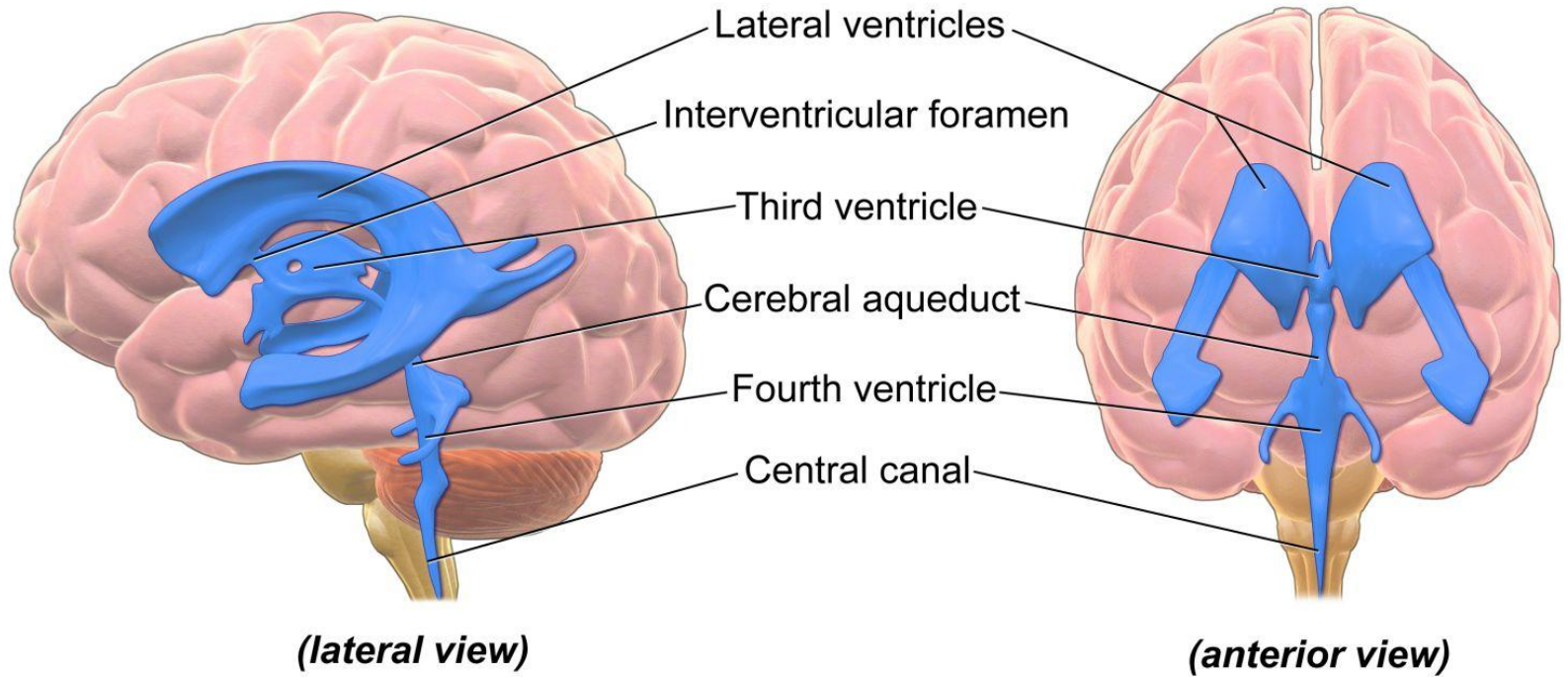


# VENTRICLES

The ventricles of the central nervous system (CNS) are **interconnected fluid-filled cavities** that circulate cerebrospinal fluid (CSF), linking the brain and spinal cord

- **Lateral Ventricle** – **large cavity** within each cerebral hemisphere
- **Third Ventricle** – smaller, **midline cavity** located in center of diencephalon
- **Cerebral Aqueduct** – **located in the midbrain**; connects the third & fourth ventricles
- **Fourth Ventricle** – **located at base of cerebellum**; continuous with central canal of spinal cord & opens into the subarachnoid space through foramina in its walls



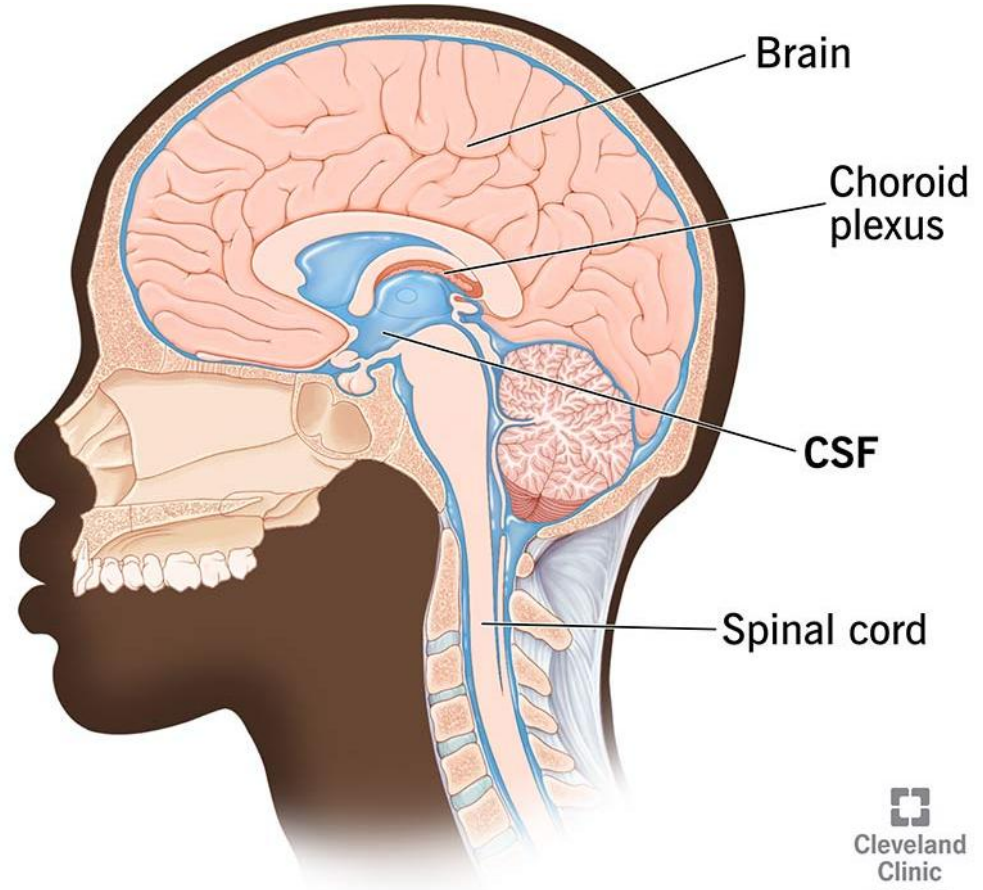


# THE CEREBRO- SPINAL FLUID



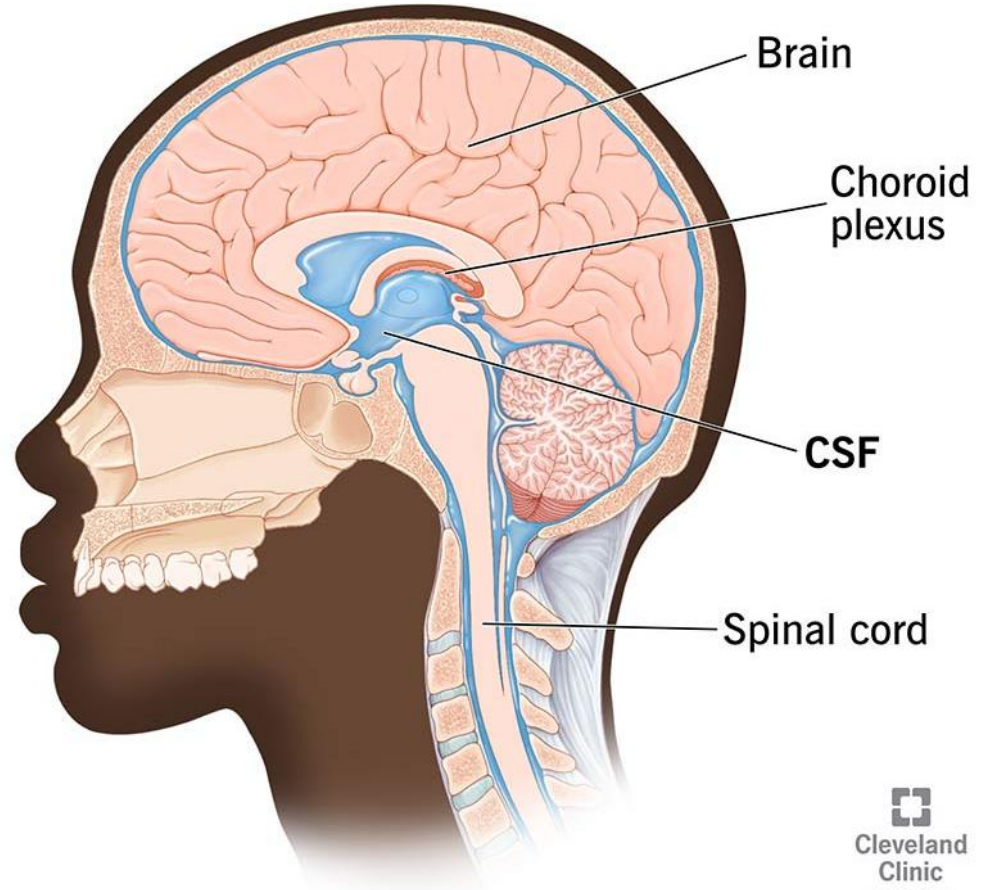
# CEREBROSPINAL FLUID

**Cerebrospinal fluid (CSF) cushions and protects the brain and spinal cord**, circulates through the ventricles and subarachnoid space, and is reabsorbed into the blood. Disruption of its flow can lead to hydrocephalus, a serious condition caused by fluid buildup and increased pressure in the brain.



# CEREBROSPINAL FLUID

- CSF is produced by **choroid plexuses** (ependymal cell structures) in the ventricles.
- It fills the ventricles, central canal of the spinal cord, and subarachnoid space.
- Flow pathway: **Lateral ventricles** → **Third ventricle** → **Cerebral aqueduct** → **Fourth ventricle** → **Central canal & subarachnoid space.**
- CSF is reabsorbed into the blood via **arachnoid granulations** in the superior sagittal sinus.



# THE CRANIAL NERVES



# CRANIAL NERVES

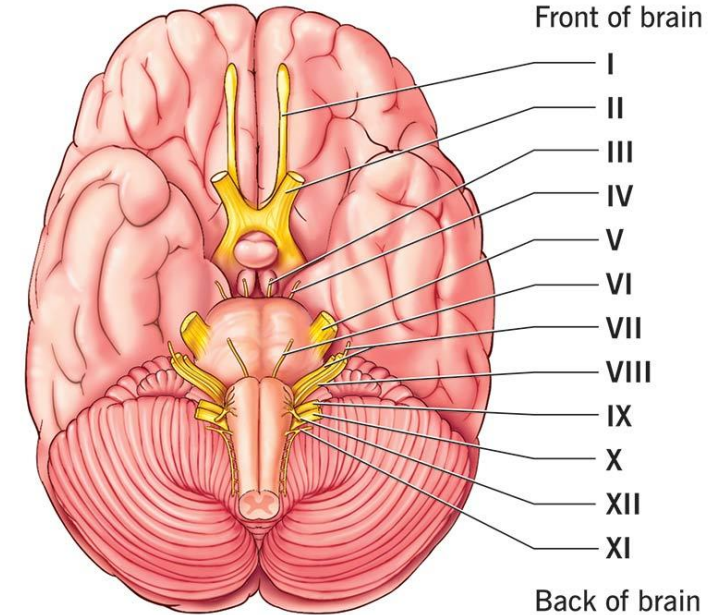
- Cranial Nerves have **12 pairs** which are divided into two general categories

- SENSORY FUNCTION** – divided into special senses (vision) & more general senses (touch, pain)

- MOTOR FUNCTION** – subdivided into somatic motor (voluntary) & parasympathetic (involuntary)

## Cranial nerves

Bottom view of brain



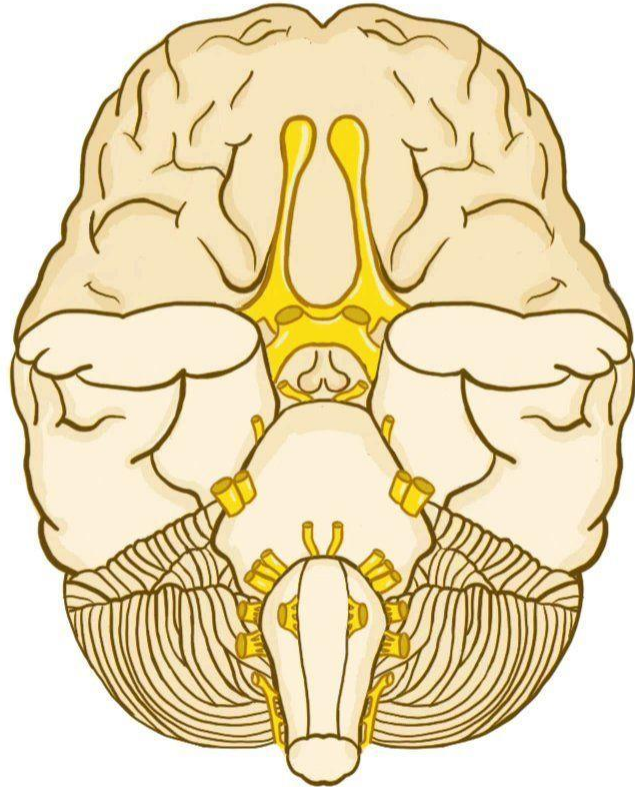
- |                      |                              |
|----------------------|------------------------------|
| I Olfactory nerve    | VII Facial nerve             |
| II Optic nerve       | VIII Vestibulocochlear nerve |
| III Oculomotor nerve | IX Glossopharyngeal nerve    |
| IV Trochlear nerve   | X Vagus nerve                |
| V Trigeminal nerve   | XI Accessory nerve           |
| VI Abducens nerve    | XII Hypoglossal nerve        |

Number	Name	General Function*	Specific Function
I	Olfactory	S	Smell
II	Optic	S	Vision
III	Oculomotor	M, P	Motor to four of six extrinsic eye muscles and upper eyelid; parasympathetic: constricts pupil, thickens lens
IV	Trochlear	M	Motor to one extrinsic eye muscle
V	Trigeminal	S, M	Sensory to face and teeth; motor to muscles of mastication (chewing)
VI	Abducens	M	Motor to one extrinsic eye muscle
VII	Facial	S, M, P	Sensory: taste; motor to muscles of facial expression; parasympathetic to salivary and tear glands
VIII	Vestibulocochlear	S	Hearing and balance
IX	Glossopharyngeal	S, M, P	Sensory: taste and touch to back of tongue; motor to pharyngeal muscles; parasympathetic to salivary glands
X	Vagus	S, M, P	Sensory to pharynx, larynx, and viscera; motor to palate, pharynx, and larynx; parasympathetic to viscera of thorax and abdomen
XI	Accessory	M	Motor to two neck and upper back muscles
XII	Hypoglossal	M	Motor to tongue muscles
*S, sensory; M, somatic motor; P, parasympathetic			

# CRANIAL NERVES

~ 12 PAIRS

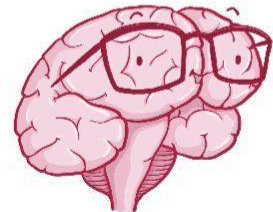
↳ NUMBERED BASED ON ORDER THEY ARISE FROM NUCLEI IN THE BRAIN → EXIT THROUGH FORAMINA  
(EXCEPT FOR XI & XII → INVERTED)



- (S) I - OLFACTORY
- (S) II - OPTIC
- (M) III - OCULOMOTOR
- (M) IV - TROCHLEAR
- (B) V - TRIGEMINAL
- (M) VI - ABDUCENS
- (B) VII - FACIAL
- (S) VIII - VESTIBULOCOCHLEAR
- (B) IX - GLOSSOPHARYNGEAL
- (B) X - VAGUS
- (M) XI - ACCESSORY
- (M) XII - HYPOGLOSSAL

"ON OLD OLYMPUS' TOWERING  
TOP, A FINN VAN GERMAN  
VIEWED A HOP"

"SOME SAY MARRY MONEY, BUT  
MY BROTHER SAYS BIG BRAINS  
MATTER MORE"



# THE AUTONOMIC NERVOUS SYSTEM



# AUTONOMIC NERVOUS SYSTEM

- consists of motor neurons that carry action potentials from CNS to periphery.

- BASIC STRUCTURE:**

- PREGANGLIONIC NEURON** – first neuron that innervates from CNS

- POSTGANGLIONIC NEURON** – second neuron that extends to effector organs

- AUTONOMIC GANGLIA** – point where the preganglionic neurons synapse with postganglionic neurons.

***The autonomic nervous system is composed of the sympathetic division and the parasympathetic division.***

# SYMPATHETIC DIVISION

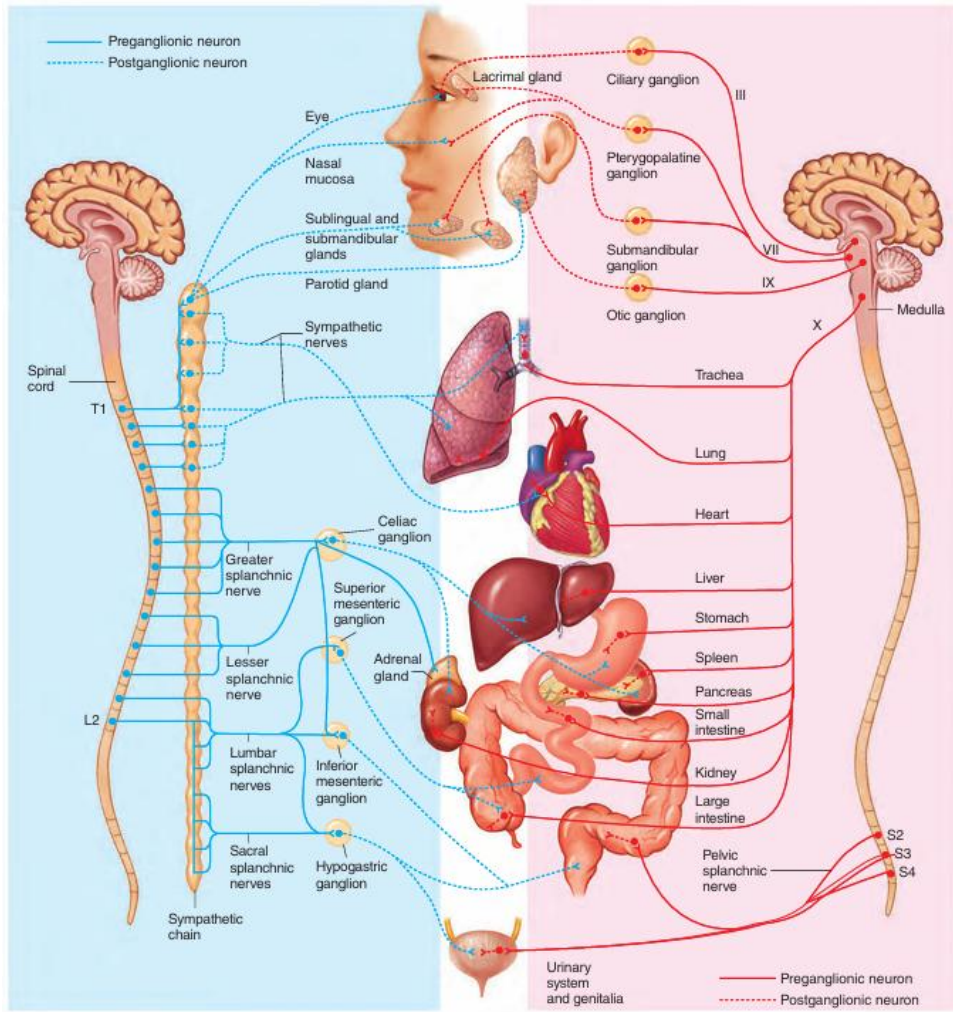
- **Origin: Preganglionic neurons in spinal cord (T1–L2)**
- Pathways:
  - Sympathetic chain ganglia → thoracic organs
  - Collateral ganglia (celiac, mesenteric) → abdominal & pelvic organs
- Function: Relay signals for fight-or-flight response

# PARASYMPATHETIC DIVISION

- **Origin: Cranial nerves (III, VII, IX, X) & spinal nerves (S2–S4)**
- Preganglionic axons → terminal ganglia near/within organs
- Postganglionic axons → short, connect directly to target organ
- Vagus nerve → major supply to thoracic & abdominal organs
- **Function:** Rest-and-digest responses (heart, lungs, liver, stomach, digestion)

# SYMPATHETIC VS. PARASYMPATHETIC

DIVISIONS OF ANS	LOCATION OF PREGANGLIONIC CELL BODY	LOCATION OF POSTGANGLIONIC CELL BODY	PROMINENT FEATURE	GENERAL FUNCTION
<b>Sympathetic</b>	T1 to L2	<p><b>Sympathetic Chain Ganglia</b> – along both sides of spinal cord</p> <p><b>Collateral Ganglia</b> – located nearer target organs; include celiac, superior &amp; inferior mesenteric ganglia</p>	<p><b>Splanchnic Nerves</b> – axons of preganglionic fibers that do not synapse in sympathetic chain ganglia that extend to collateral ganglia</p>	<p><b>“Flight-or-Flight”</b>; prepares the body for physical activity</p>
<b>Parasympathetic</b>	Cranial nerves III, VII, IX, X; Spinal nerves S2 to S4	<p><b>Terminal Ganglia</b> – located near or embedded in walls of target organs in thorax, abdomen, &amp; pelvis</p>	<p><b>Vagus Nerve</b> – extends from brainstem where its preganglionic neurons supply most of thoracic &amp; abdominal organs</p>	<p><b>“Read-and-Digest”</b>; stimulates involuntary activities of body at rest</p>



→ Sympathetic (thoracolumbar)

← Parasympathetic (craniosacral)

# AUTONOMIC NEUROTRANSMITTERS

- Neurotransmitter release in the autonomic nervous system differs between divisions, with acetylcholine used widely and norepinephrine primarily in the sympathetic division—this chemical signaling can be influenced by drugs to alter body functions.
- **Acetylcholine:** Used by all preganglionic neurons + parasympathetic postganglionic neurons
- **Norepinephrine:** Used by most sympathetic postganglionic neurons
- **Drugs:** Can stimulate or inhibit body functions by mimicking or blocking these neurotransmitters

Target	Sympathetic Effects	Parasympathetic Effects
Heart	Increases rate and force of contraction	Decreases rate
Blood vessels	Constricts and dilates	None
Lungs	Dilates bronchioles	Constricts bronchioles
Eyes	Dilates pupil, relaxes ciliary muscle to adjust lens for far vision	Constricts pupil, contracts ciliary muscle to adjust lens for near vision
Intestinal and stomach walls	Decreases motility, contracts sphincters	Increases motility, relaxes sphincters
Liver	Breaks down glycogen, releases glucose	Synthesizes glycogen
Adipose tissue	Breaks down lipids	None
Adrenal gland	Secretes epinephrine, norepinephrine	None
Sweat glands	Secretes sweat	None
Salivary glands	Secretes thick saliva	Secretes watery saliva
Urinary bladder	Relaxes muscle, constricts sphincter	Contracts muscle, relaxes sphincter
Pancreas	Decreases secretion of digestive enzymes and insulin	Increases secretion of digestive enzymes and insulin

# THE ENTERIC NERVOUS SYSTEM



# ENTERIC NERVOUS SYSTEM

- specialized subdivision of the peripheral nervous system that controls digestive tract activity through local reflexes, functioning independently of the CNS but also integrated with the autonomic nervous system (ANS).

Structure:

Located in **plexuses within the wall of the digestive tract.**

Contains three types of neurons:

- **Sensory neurons** → connect digestive tract to CNS.
- **Sympathetic & parasympathetic neurons** → connect CNS to digestive tract.
- **Enteric neurons** → located entirely within the plexuses.

# ENTERIC NERVOUS SYSTEM

## STEP-BY-STEP EXPLANATION OF THE ENS PATHWAY:

### 1. STIMULUS DETECTION

**Enteric sensory neurons** detect changes in the digestive tract, such as **stretching** when food enters.

These neurons are embedded in the gut wall and monitor internal conditions.

### 2. SIGNAL PROCESSING

The sensory input is sent to **enteric interneurons**, which process the signal.

These interneurons can act independently or be influenced by the **vagus nerve (parasympathetic)** or **splanchnic nerve (sympathetic)**—allowing the brain to override local reflexes when needed.

### 3. MOTOR RESPONSE

Interneurons activate **enteric motor neurons**, which then stimulate **effector organs** in the digestive tract.

These effectors include **glands (for secretion)** and **smooth muscles (for motility)**.

### 4. OUTCOME

The result is a **local reflex** that adjusts digestion—like increasing enzyme secretion or moving food along the tract.

# DISEASES & DISORDER OF NERVOUS SYSTEM

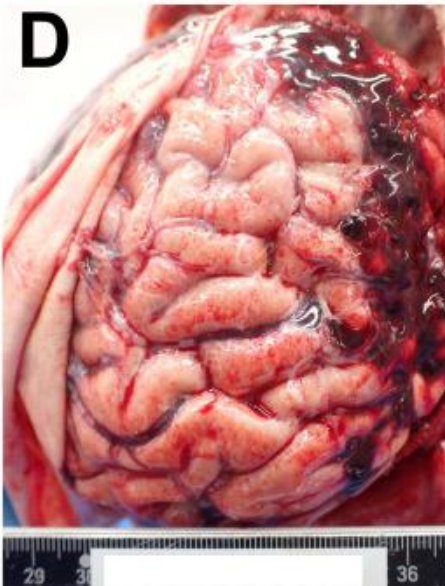
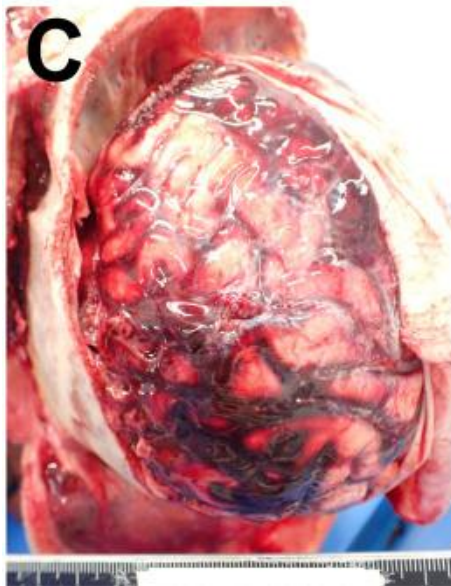
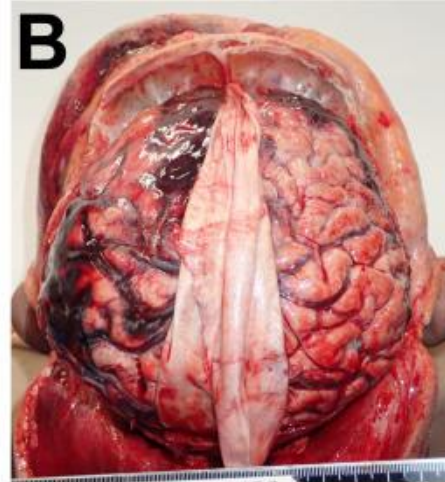
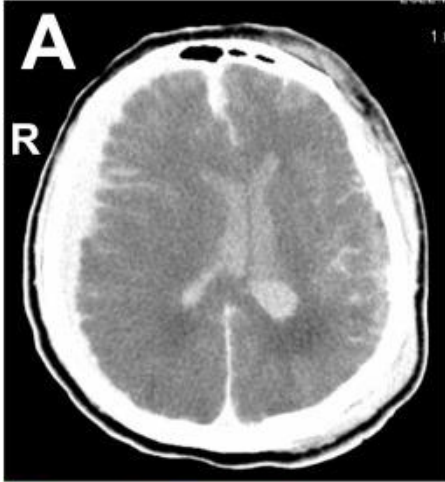


<b>CONDITION</b>	<b>DESCRIPTION</b>
<b>Spinal Cord Injury</b>	damage to spinal cord that can interrupt ascending and/or descending tracts where the sensations and/or motor functions & reflex modulation may be disrupted
<b>Aphasia</b>	<b>absent or defective speech</b> or language comprehension associated with the damage to Wernicke and/or Broca areas
<b>Subdural Hematoma</b>	<b>bleeding into the subdural space</b> caused by the damage to the veins crossing between the cerebral cortex & dural venous sinuses
<b>Hydrocephalus</b>	<b>accumulation of CSF in the ventricles</b> due to the blockage in openings of fourth ventricle or the cerebral aqueduct
<b>Stroke</b>  <b>✓ Ischemic Stroke</b> <b>✓ Hemorrhagic Stroke</b>	known as <b>cerebrovascular accident (CVA)</b> that results to the death of brain tissue due to disruption of its vascular supply  results when <b>arteries supplying brain tissue are blocked</b> results from <b>bleeding of arteries supplying the brain tissue</b>

**SPINAL  
CORD  
INJURY**



# SUBDURAL HEMATOMA



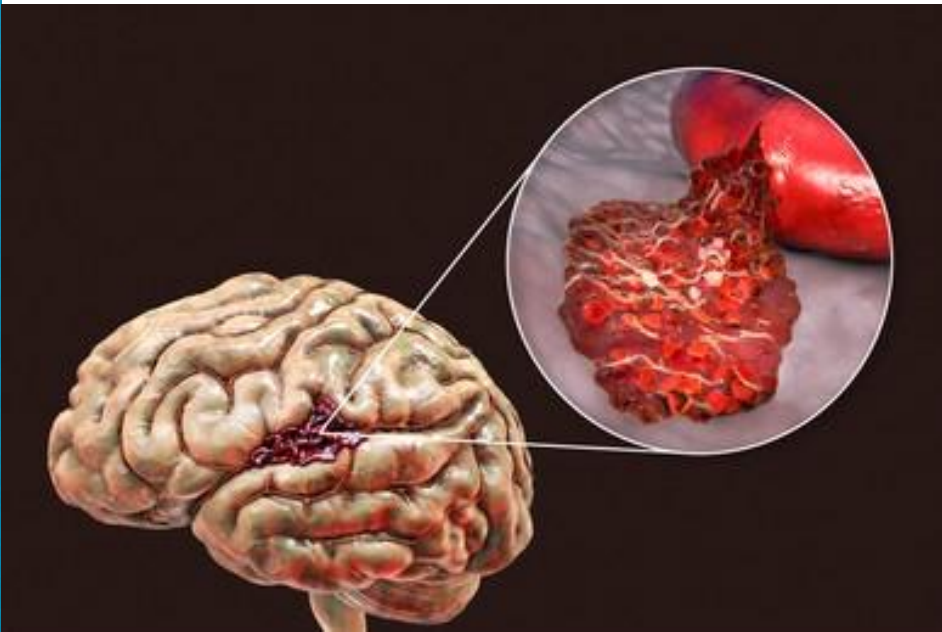
# HYDROCEPHALUS



# ISCHEMIC STROKE

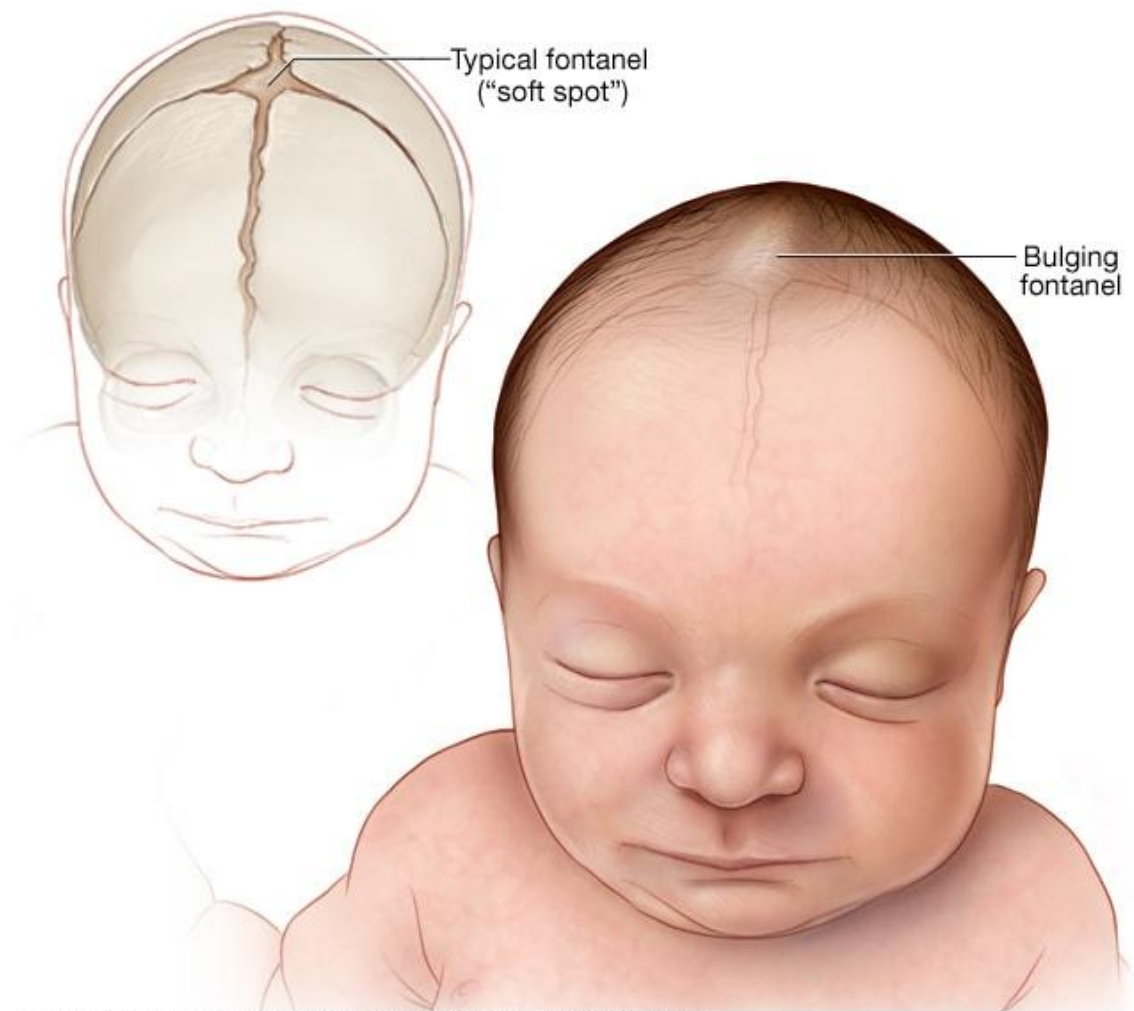


# HEMORRHAGIC STROKE



<b>CONDITION</b>	<b>DESCRIPTION</b>
<b>Encephalitis</b>	<b>inflammation of the brain caused by a virus</b> and less often by bacteria or other agents; symptoms include fever, coma, and convulsions
<b>Meningitis</b>	<b>inflammation of meninges</b> caused by viral/bacterial infection; symptoms include stiffness in neck, headache, & fever; severe cases cause paralysis, coma, or death
<b>Multiple Sclerosis</b>	<b>autoimmune;</b> may be initiated by viral infection; inflammation in brain & spinal cord with demyelination & sclerotic sheaths results in poor conduction of action potentials; symptoms include exaggerated reflexes, tremor, and speech defects
<b>Parkinson Disease</b>	<b>caused by a lesion in basal nuclei;</b> characterized by muscle rigidity, resting tremor, general lack of movement, and slow, shuffling gait
<b>Alzheimer Disease</b>	<b>mental deterioration, or dementia;</b> usually affects older people; involves loss of neurons in cerebral cortex; symptoms include general intellectual deficiency, memory loss, short attention span, moodiness, disorientation, and irritation

# ENCEPHALITIS



# PARKINSON'S DISEASE



# ALZHEIMER DISEASE



Normal

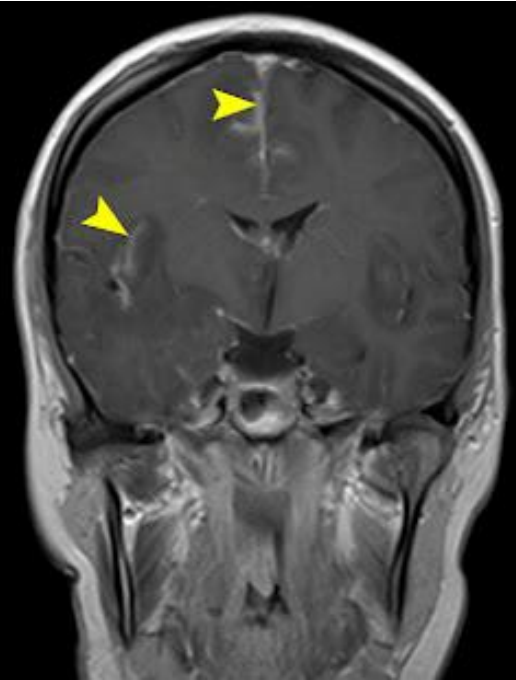
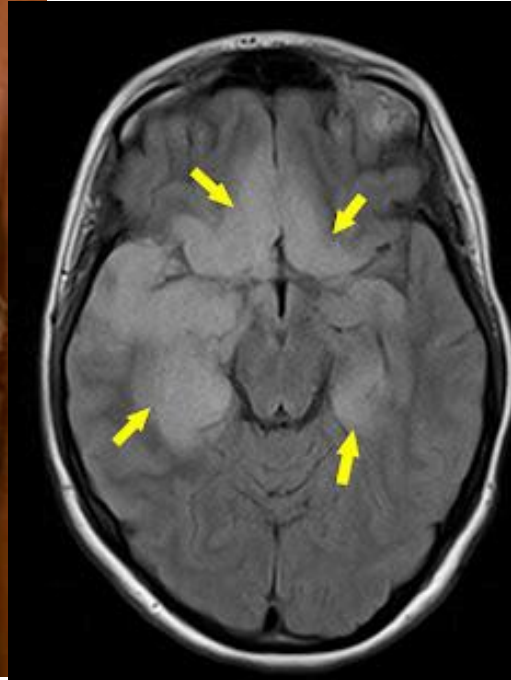


Alzheimer



# HERPES

family of diseases characterized by skin lesions due to herpes viruses in sensory ganglia; different viruses cause oral lesions (*cold sores*), STD with lesions on genitalia, or chickenpox in children (shingles in adults)



**ANY  
QUESTIONS?**



# ***SHORT QUIZ***

**STUDY TIME: 15 MINUTES  
IDENTIFICATION  
10 POINTS**



*"The nervous system is the bridge between perception and action—turning signals into the story of life."*

