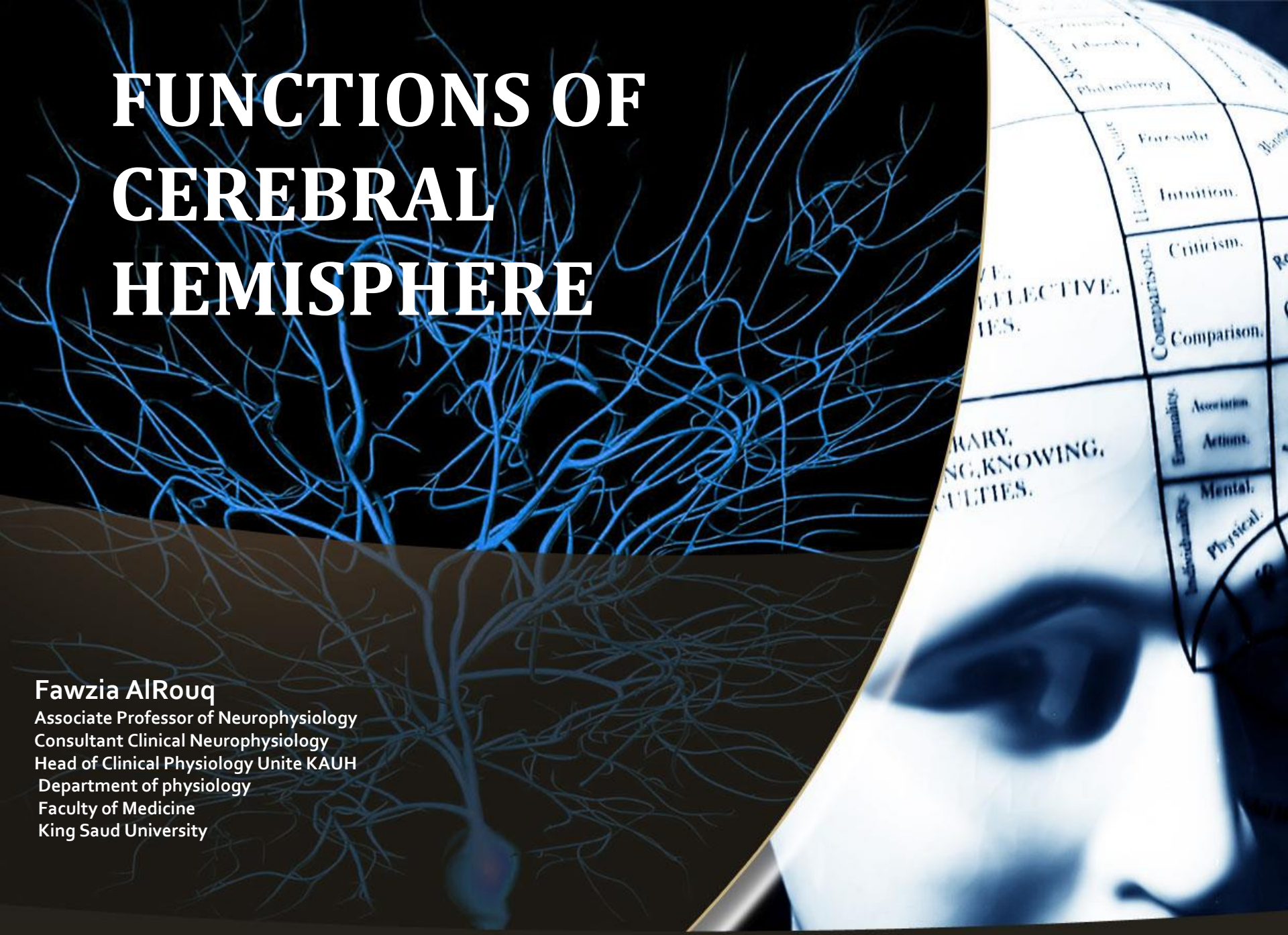
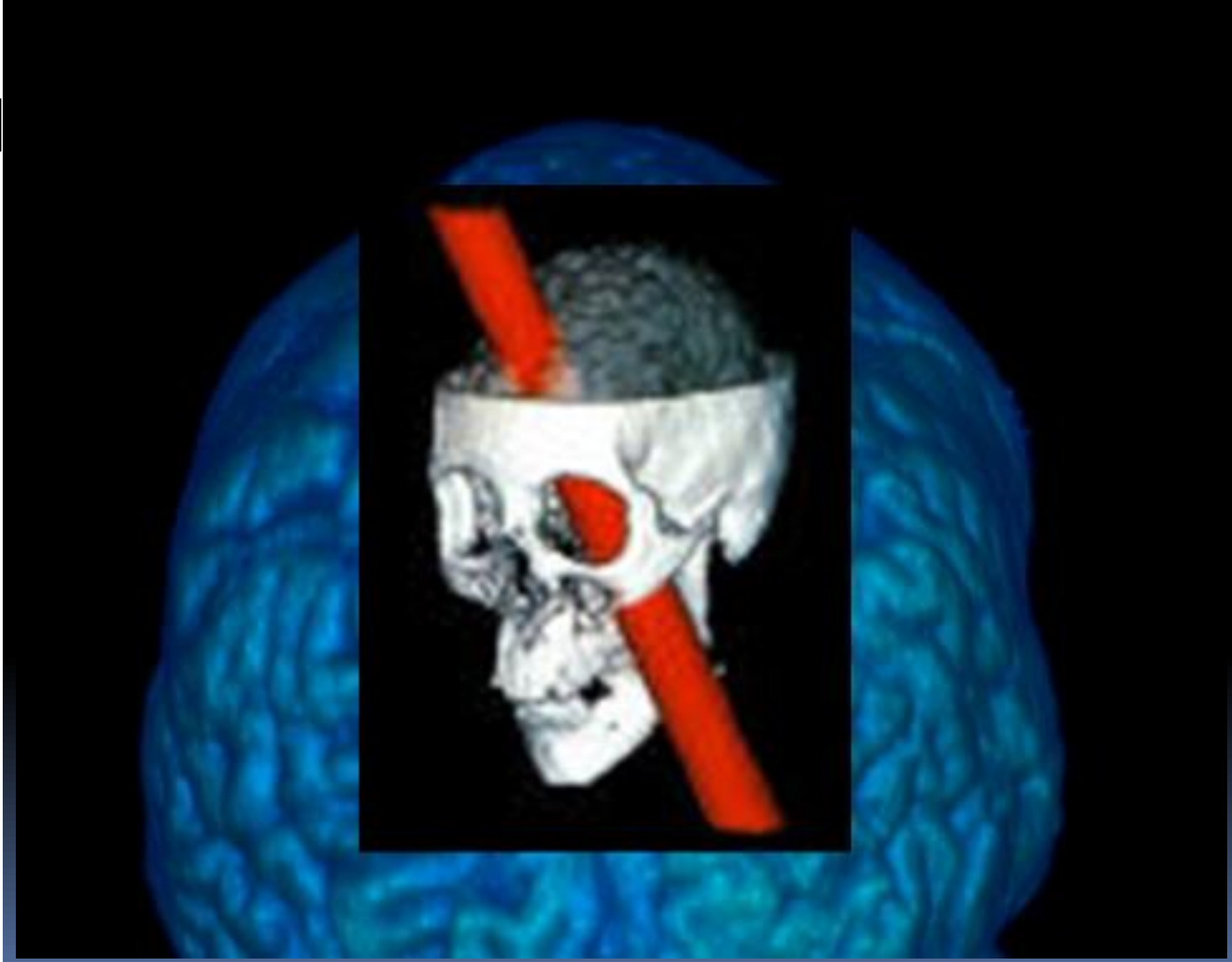
FUNCTIONS OF CEREBRAL HEMISPHERE



Fawzia AlRouq
Associate Professor of Neurophysiology
Consultant Clinical Neurophysiology
Head of Clinical Physiology Unite KAUH
Department of physiology
Faculty of Medicine
King Saud University

Objectives

- At the end of this lecture you should :
- understand that the nervous system can be classified in more than one way .
- Know Functional Anatomy of the CNS.
- Orientation of the cerebral cortex and spinal cord functions.
- know that much of human physiology can be learned from observing the consequences of human lesions & diseases .
- be able to explain what is meant by telencephalon , diencephalon ,brainstem , basal ganglia , cerebellum and spinal cord ; & outline their function .
- understand that the functions of the cerebral hemisphere
- Know Functional Anatomy and functions of Cerebral lobes .



- https://www.youtube.com/watch?v=NFO6ts6vZic

Phineas Gage

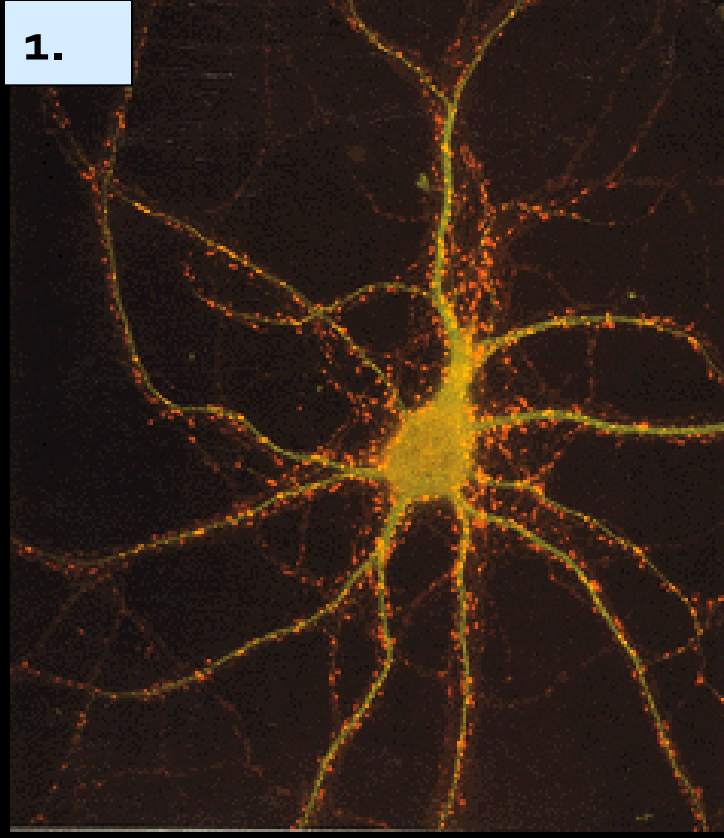
- Accident
  - Quick Recovery
- Months later: "No longer Gage"
  - Before: capable, efficient, best foreman, well-balanced mind
  - After: extravagant, anti-social, liar, grossly profane
- Stint with P.T Barnum
- Died 12 years later
- Watch Clip

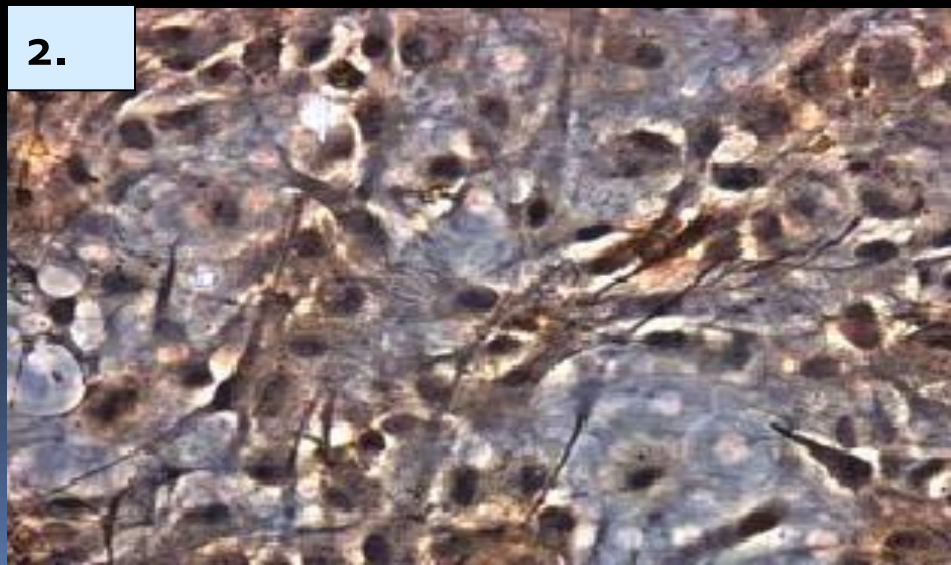
The Nervous System

- A network of billions of nerve cells linked together in a highly organized fashion to form the rapid control center of the body.
- Functions include:
  - Integrating center for homeostasis, movement, and almost all other body functions.

Nervous Tissue

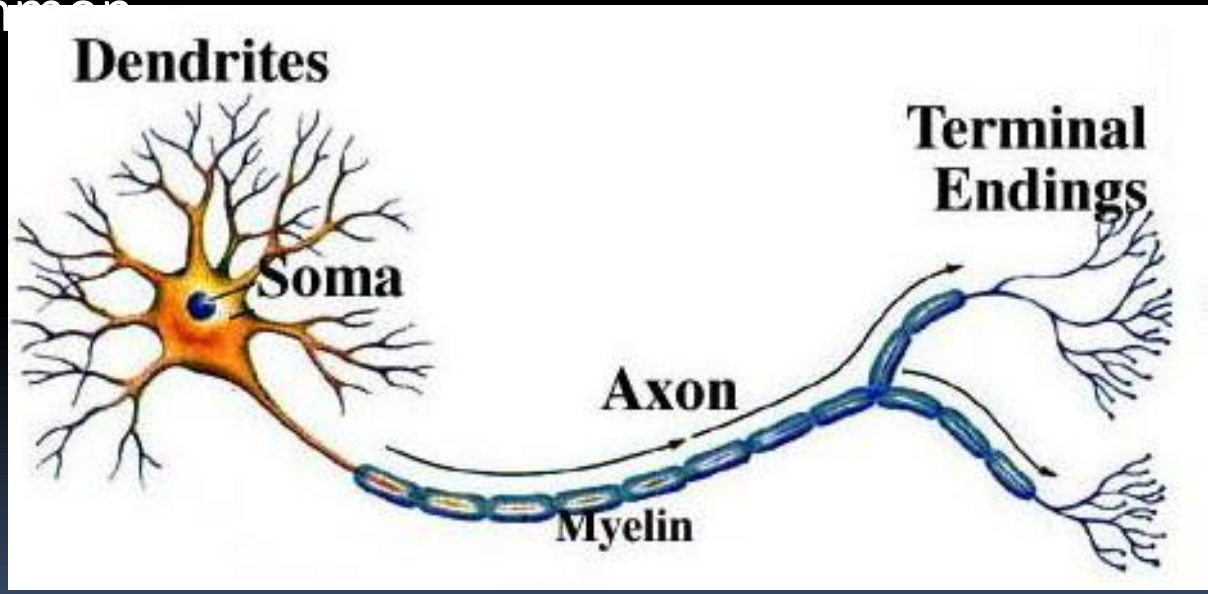
- Highly cellular
- 2 cell types
  1. Neurons
     - Functional, signal conducting cells
  2. Neuroglia
     - Supporting cells





Neurons

- The functional and structural unit of the nervous system
- Specialized to conduct information from one part of the body to another
- There are many, many different types of neurons but most have certain structural and functional characteristics in common
  - Cell body (soma)
  - One or more specialized, slender processes (axons/dendrites)
  - An input region (dendrites/soma)
  - A conducting component (axon)
  - A secretory (output) region (axon terminal)



Nervous system organization

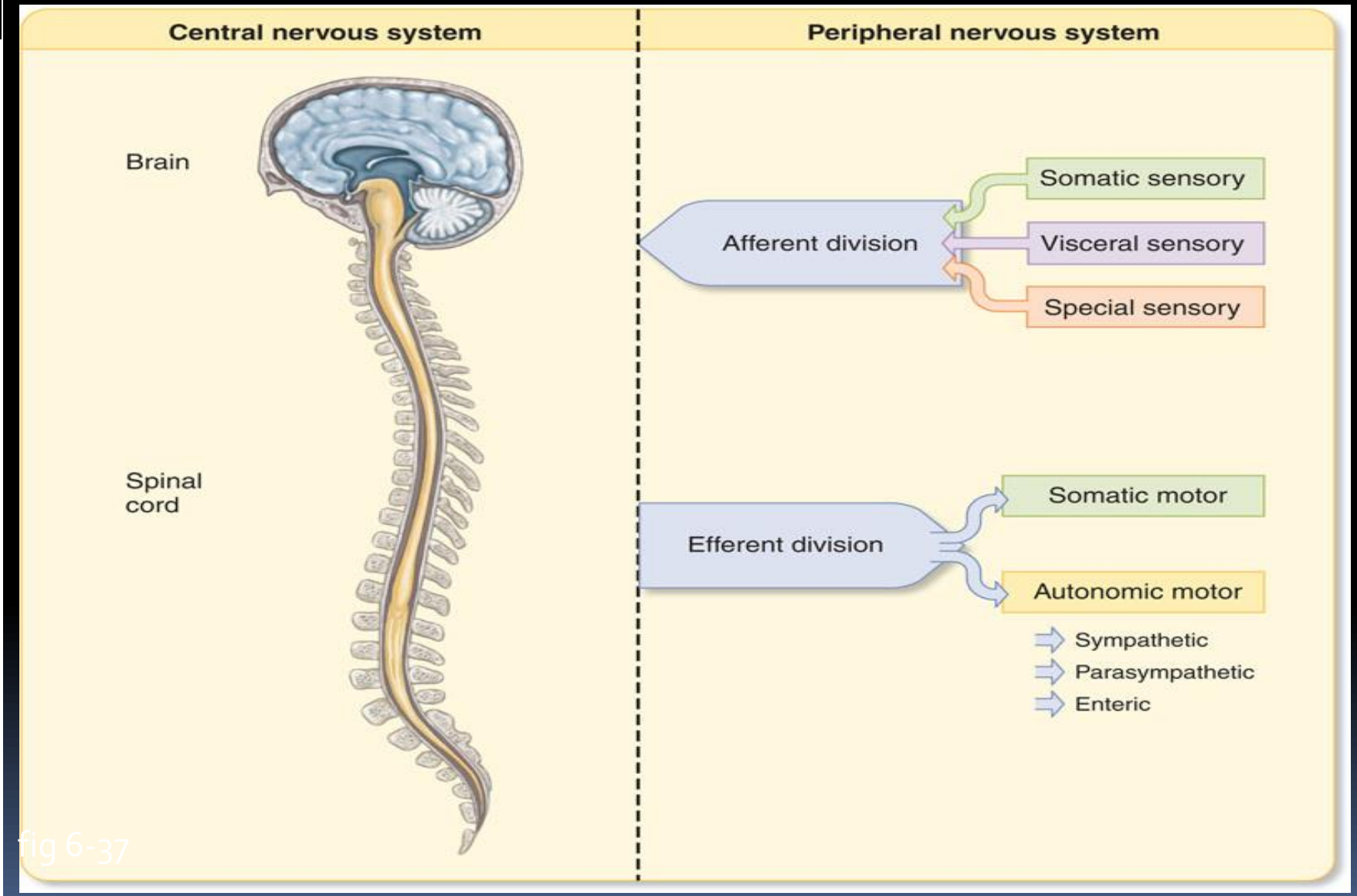


fig 6-37

Basic Functions of the Nervous System

1. Sensation
   - Monitors changes/events occurring in and outside the body. Such changes are known as *stimuli* and the cells that monitor them are *receptors*.
2. Integration
   - The parallel processing and interpretation of sensory information to determine the appropriate response
3. Reaction
   - Motor output.
     - The activation of muscles or glands (typically via the release of neurotransmitters (NTs))

Classification of the Nervous System

- The nervous system (NS) can be classified in more than one way :

(I) Central & Peripheral NS

(A) Central Nervous System (CNS) : consisting of the brain and spinal cord , and

(B) Peripheral Nervous System (PNS) : Fibers outside the CNS

(II) Sensory & Motor NS

(A) Sensory : includes (i) sensory (afferent) fibers , ascending (sensory) pathways , & brain sensory centers

(B) Motor : includes brain motor centers , descending (motor) pathways & motor (efferent) fibers .

(III) Somatic & Autonomic NS

(A) Somatic (Voluntary) Nervous System

(B) Autonomic (Inovluntary) Nervous System

Overview of the Brain

Brian

- **A/ Telencephalon →**

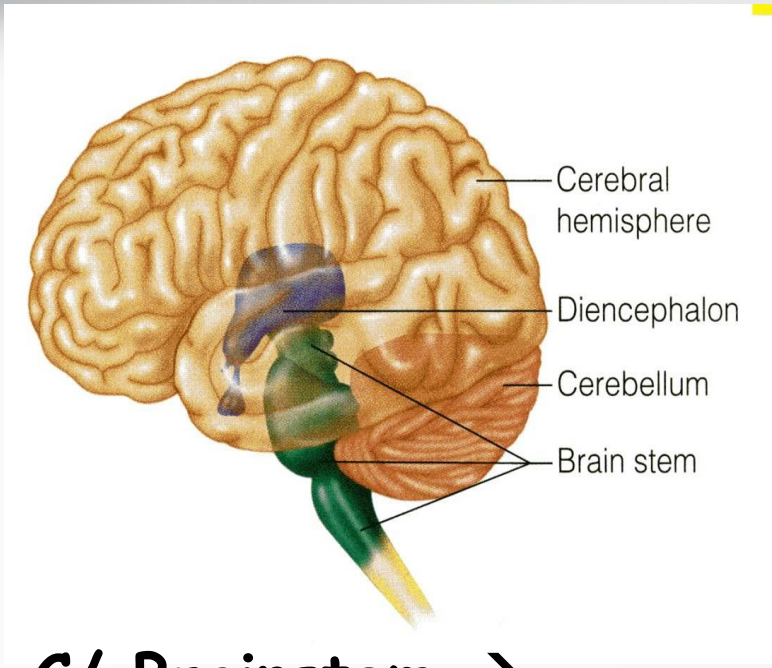
(1) Cerebrum and

(2) Basal Ganglia (collection of grey matter situated inside the cerebral hemispheres)

- **B/ Diencephalon →**
- Mainly :

(1) Thalamus (mainly a relay station for sensory pathways in their way to the cerebral cortex)

(2) Hypothalamus (contains cesnter for autonomic and endocrine control



- **C/ Brainstem →**

(1) Midbrain

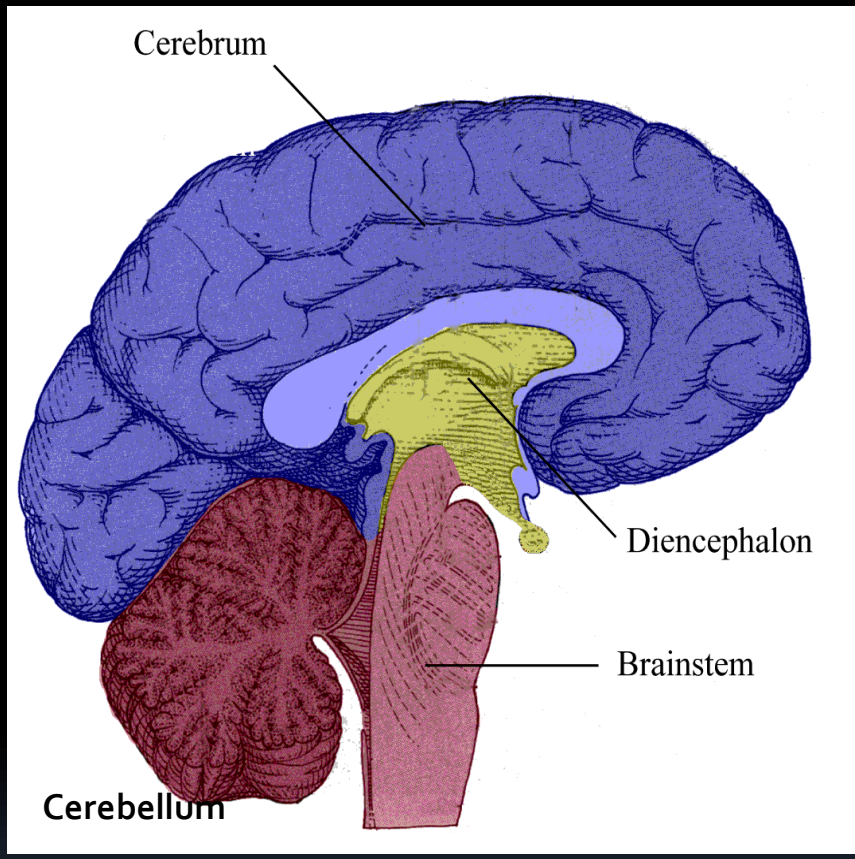
(2) Pons

(3) Medulla

- **E/ Cerebellum**

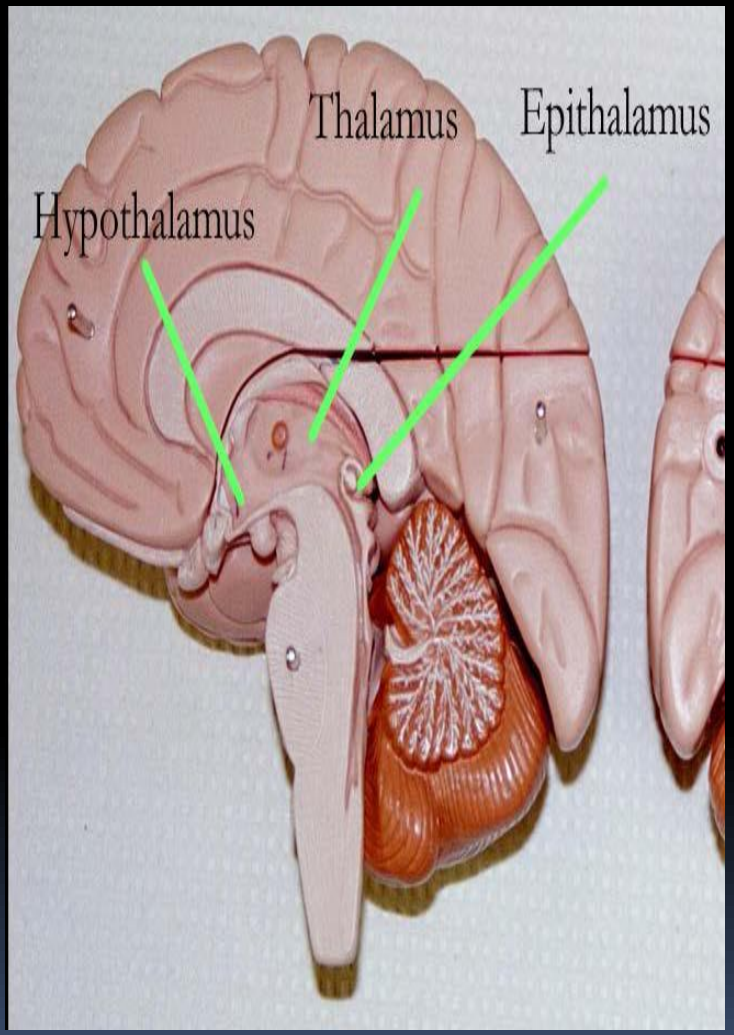
Brain Regions

- Cerebrum
- Diencephalon
- Brainstem
- Cerebellum



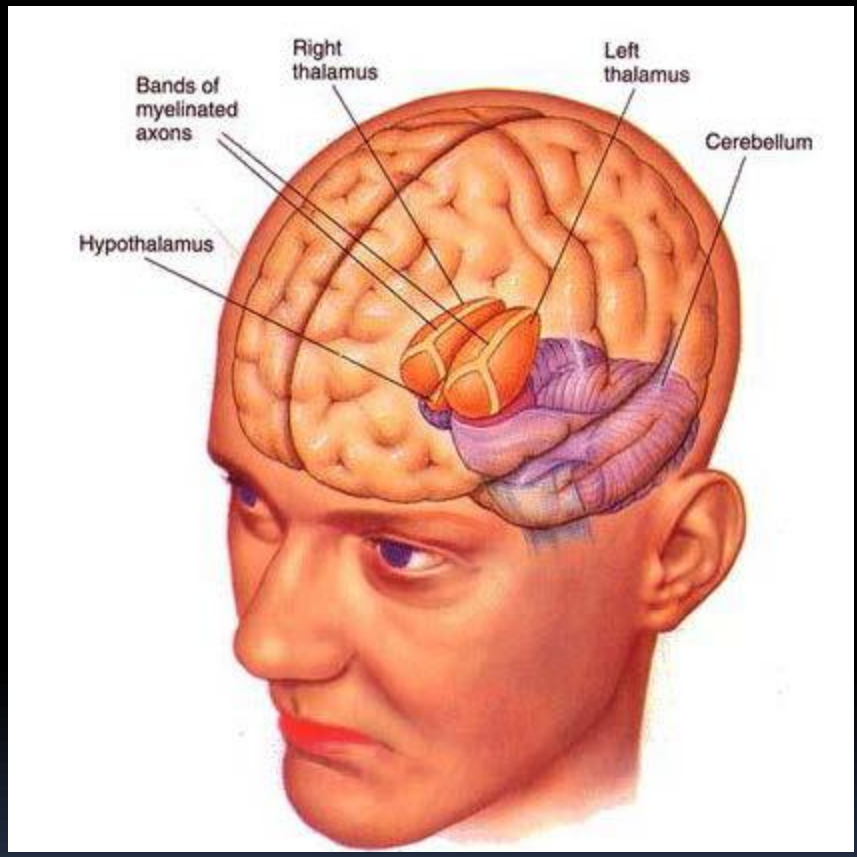
Diencephalon

- Forms the central core of the forebrain
- 3 paired structures:
- Thalamus
- Hypothalamus
- Epithalamus
- All 3 are gray matter



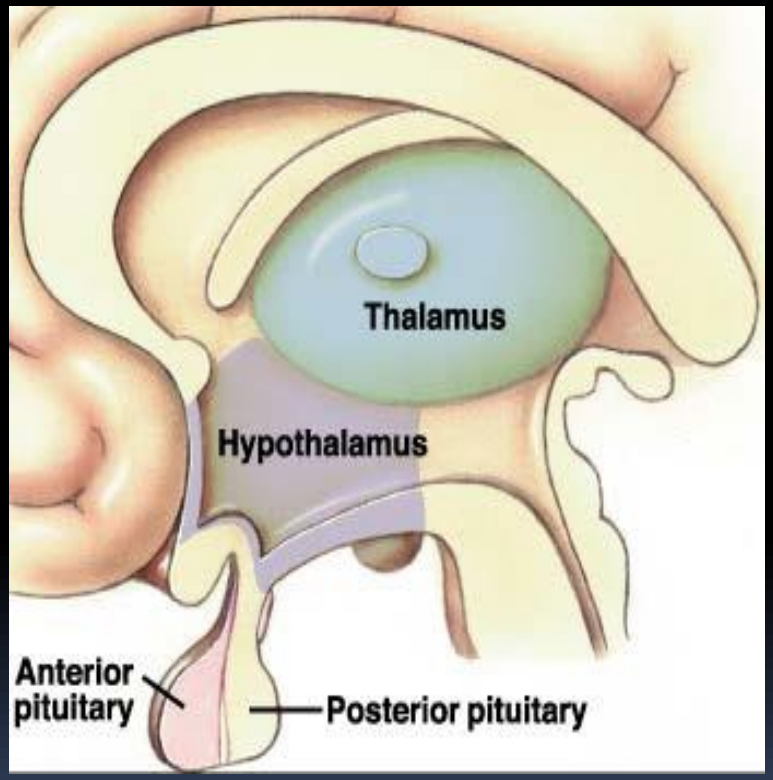
Thalamus

- 80% of the diencephalon
- Sensory relay station where sensory signals can be edited, sorted, and routed **except Olfaction.**



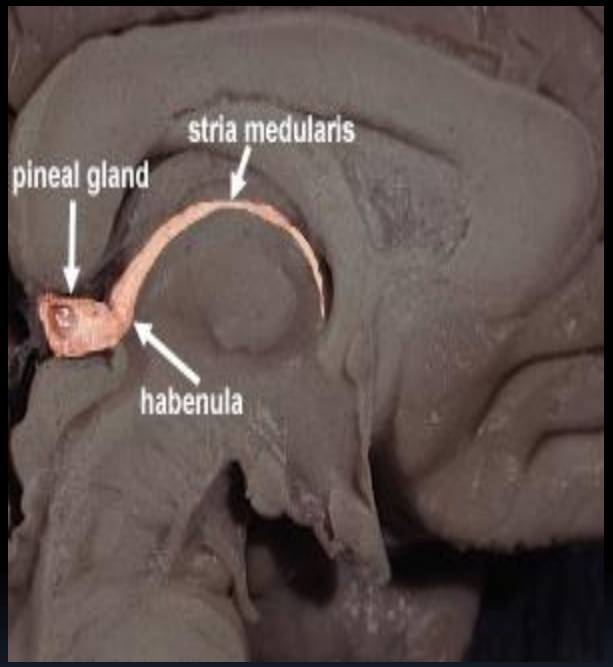
Hypothalamus

- Functions:
- 1-Autonomic regulatory centre
- Influences HR, BP, resp. rate,
- GI motility, pupillary diameter.
- 2-Emotional response
- Involved in fear, pleasure
- Drive centre: sex, hunger
- 3-Regulation of body temperature
- 4-Regulation of food intake
- Contains a satiety center
- 5-Regulation of water balance and thirst
- 6-Hormonal control
- Releases hormones that influence hormonal
- secretion from the anterior pituitary gland.
- Releases oxytocin and ADH.



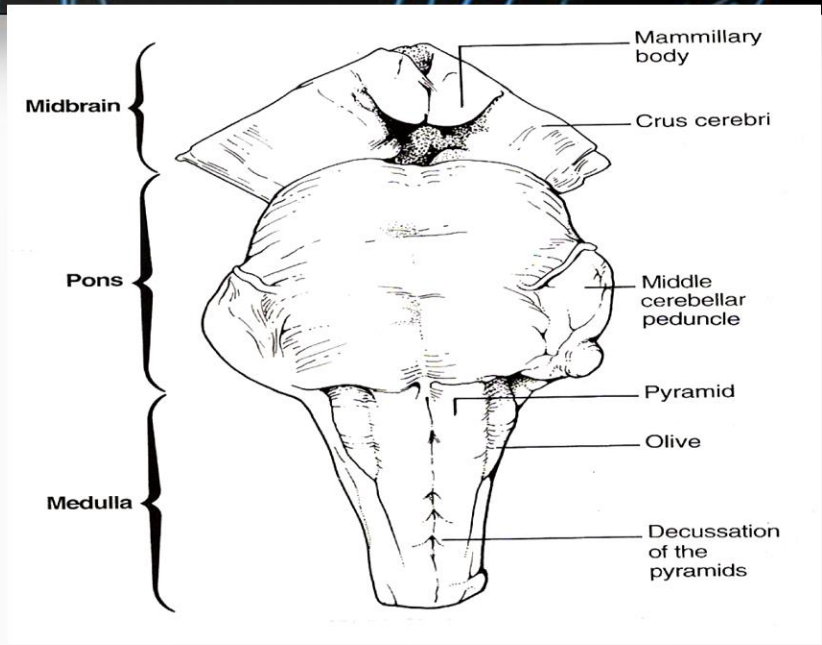
Epithalamus

- Above the thalamus
- Contains the pineal gland which releases melatonin(involved in sleep/wake cycle and mood).



The Brain Stem

- The term " brainstem " is, in terms of anatomy , to group " <u>all CNS structures that hang between the cerebrum and spinal cord " together .</u>

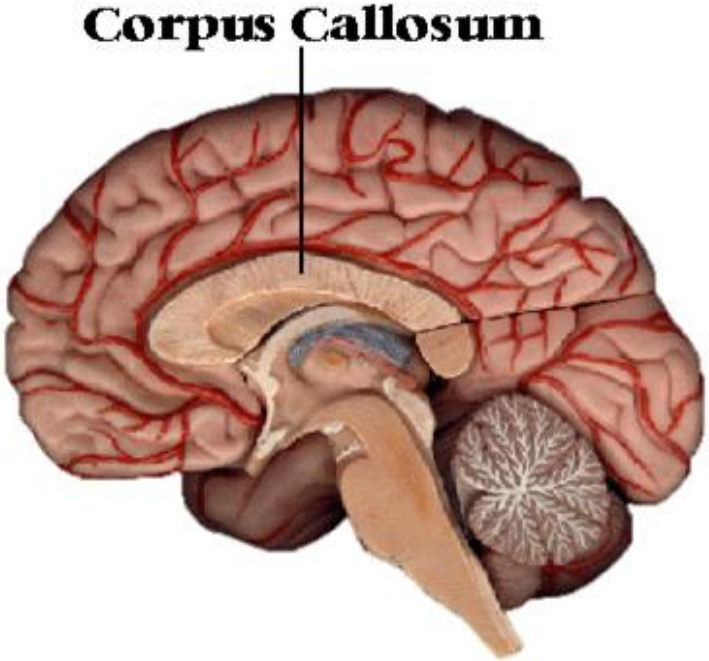


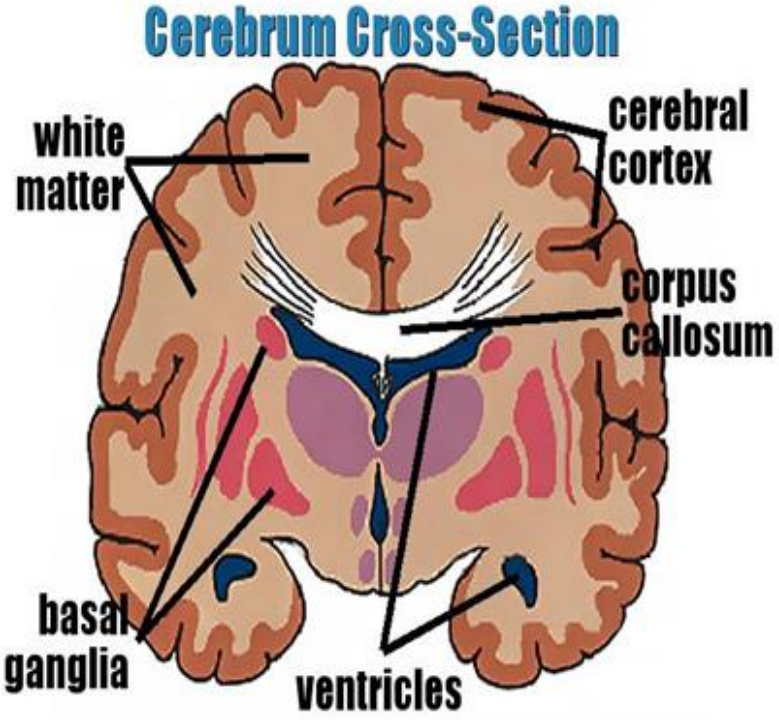
- The functions include
- (1) regulation of Consciousness , Wakefulness & Sleep ,
- (2) Respiratory , Cardiovascular and Gastrintestinal control ,
- (3) Balance (Vestibular nuclei) .
- (4) Moreover , it contain several Cranial Nerve nuclei .

Cerebrum

Cerebrum

- The largest, most conspicuous portion of the brain.
- 2 hemispheres connected by the **corpus callosum**.
- Has an outer cortex of gray matter surrounding an interior that is mostly white matter, except for a few small portions.
- The surface is marked by ridges called gyri separated by grooves called sulci.





The Cerebrum : Composed of 2 Cerebral Hemispheres , each of which controls functions on the opposite half of the body

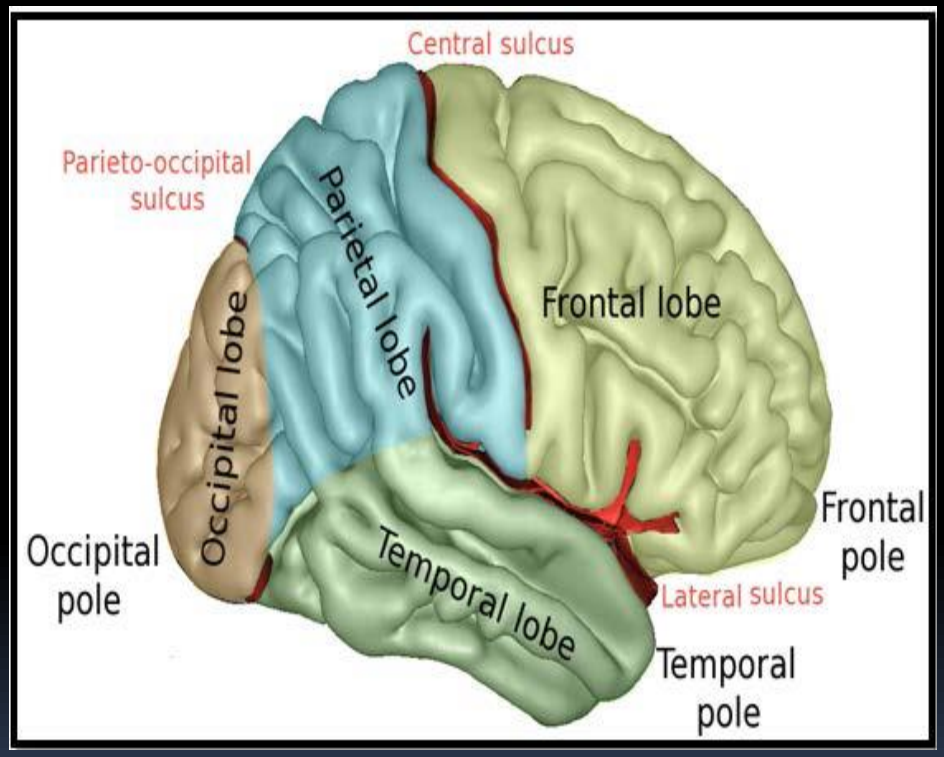
Lobes of the Cerebrum

The central sulcus separates the frontal lobe from the parietal lobe.

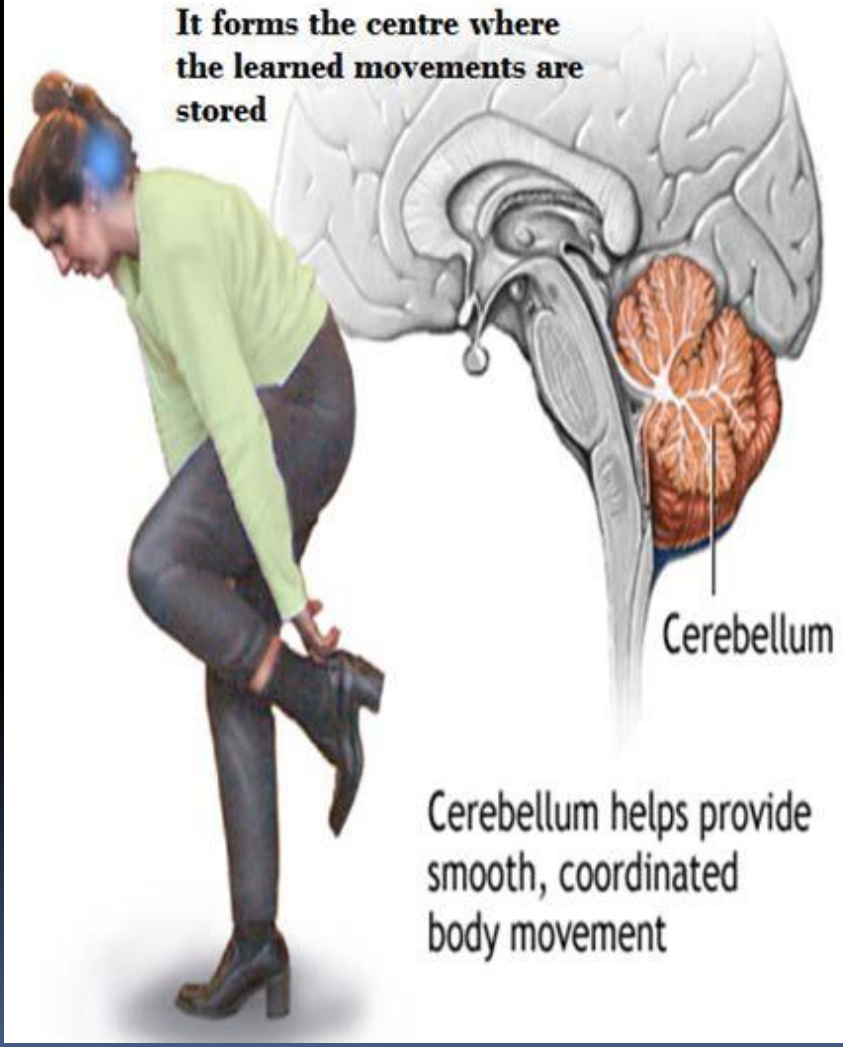
Bordering the central sulcus are 2 important gyri, the precentral gyrusand the postcentral gyrus.

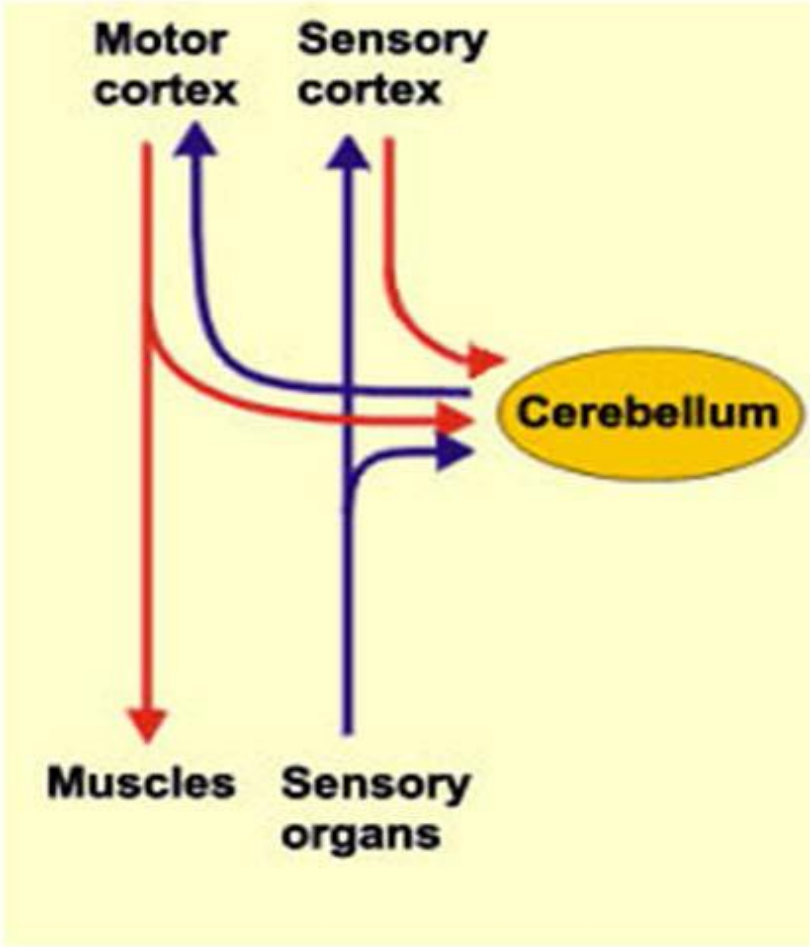
The occipital lobe is separated from the parietal lobe by the parieto-occipital sulcus.

The lateral sulcus outlines the temporal lobe.



CEREBELLUM

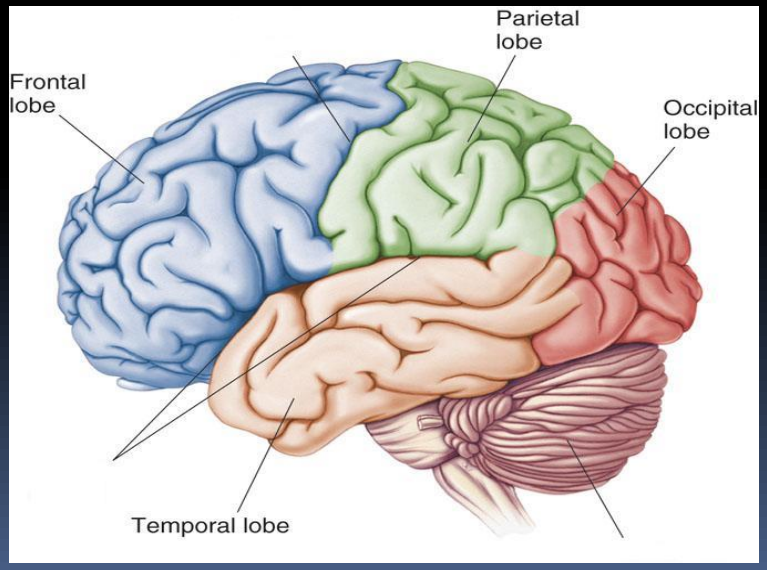

It forms the centre where the learned movements are stored
Cerebellum
Cerebellum helps provide smooth, coordinated body movement


Motor cortex
Sensory cortex
Cerebellum
Muscles
Sensory organs

Cerebellum

- Important for ccordination of body movements and balance .

FUNCTIONS OF CEREBRAL HEMISPHERE



The Cerebrum

Lobes, the Cerebral Cortex, and Cortical Regions of the Brain

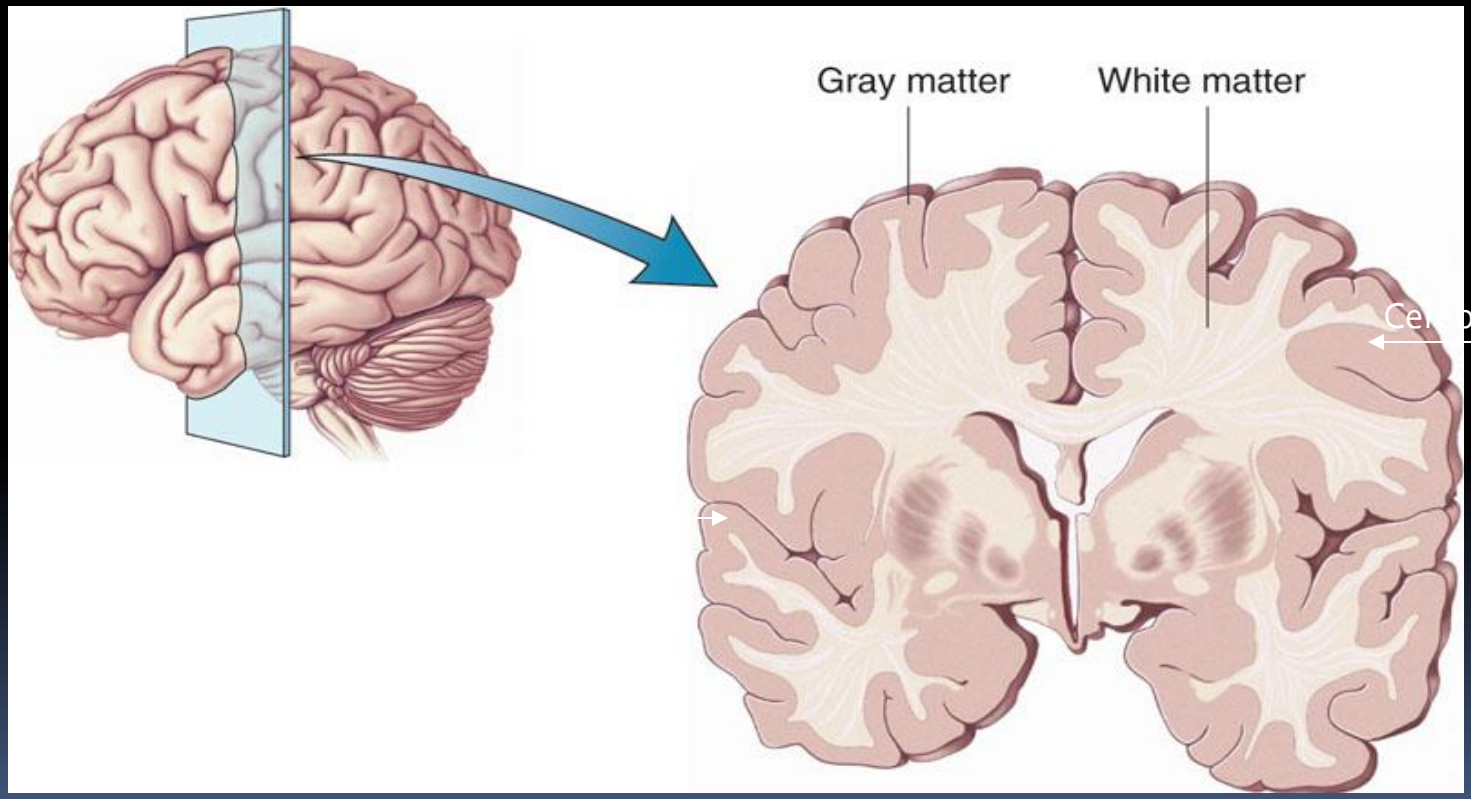
INTRODUCTION

- The cerebrum is the largest part of the brain with two hemisphere, linked by commissural fibres of corpus callosum.
- Each cerebral hemisphere contains externally

highly convoluted cortex of grey matter and internal mass of white matter or medulla.

- The cerebral hemispheres contains motor and sensory areas and the limbic system.

Cerebral Cortex - The outermost layer of gray matter making up the superficial aspect of the cerebrum.

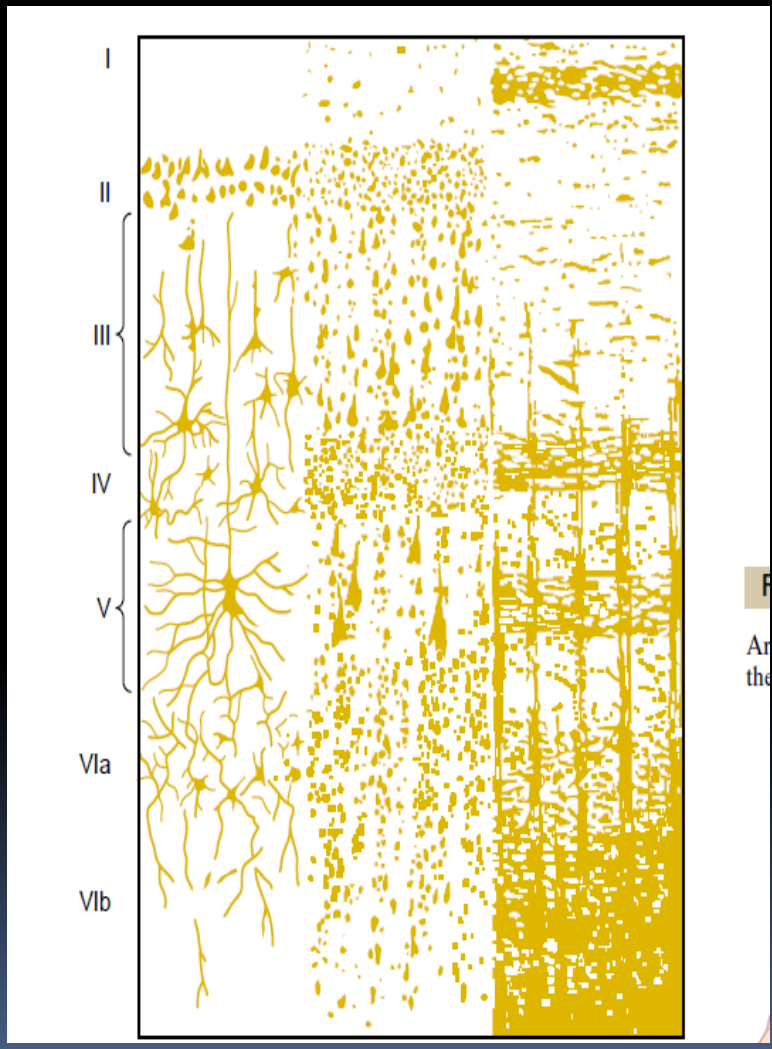


Cerebral Cortex

- Microscopically the cortex consists of six layers or laminae lying parallel to the surface

- From outside to inside the layers are:

I. Molecular layer
II. The external granular layer
III. Layer of pyramidal cell
IV. Internal granular layer
V. large pyramidal cell layer
VI. Layer of fusiform or polymorphic cells.



CEREBRAL CORTEX LAYERS

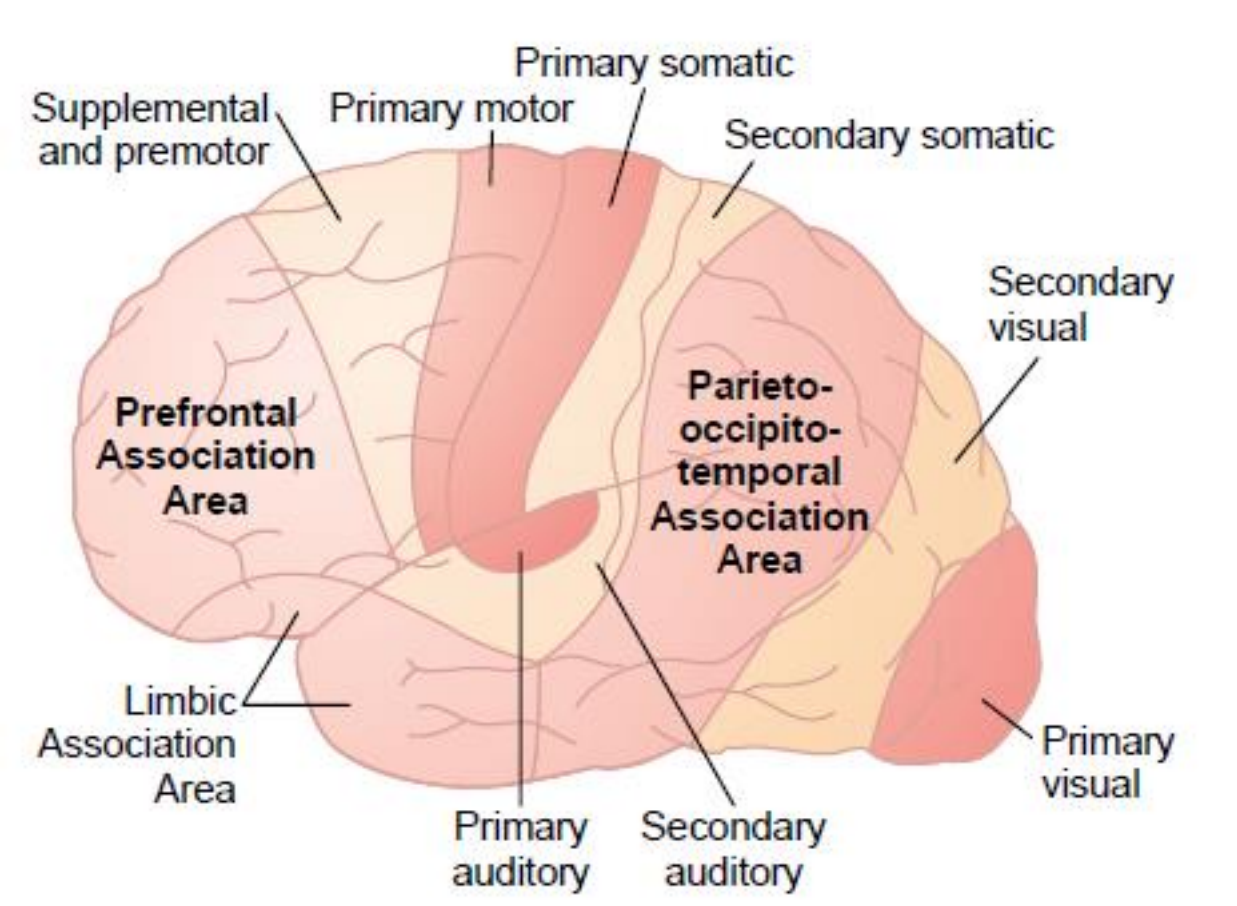
- The incoming sensory signal excites neuronal layer IV first; then the signal spreads toward the surface of the cortex and also toward deeper layers.
- 2.Layers I and II & III perform most of intracortical association function.
- 3.The neurons in layers II and III making short horizontal connections with adjacent cortical areas.
- 4.The neurons in layers V and VI send output signals to brain stem ,spinal cord (V) & thalamus (VI)

There are three main types of functional areas in the cerebral cortex:

- **Primary Areas:**
- **The primary motor areas have direct connections with specific muscles** for causing discrete muscle movements.
- The primary sensory areas detect specific sensations—visual, auditory, or somatic—transmitted directly to the brain from peripheral sensory organs.
- **Association Areas they receive and analyze signals**

simultaneously from multiple regions of both the motor and sensory cortices as well as from subcortical structures.

Association Areas



ASSOCIATION AREAS

- These areas receive and analyze signals simultaneously from multiple regions of both the motor and sensory cortices as well as from subcortical structures.

The most important association areas are

- (1) Parieto-occipitotemporal association area
- (2) prefrontal association area
- (3) limbic association area.

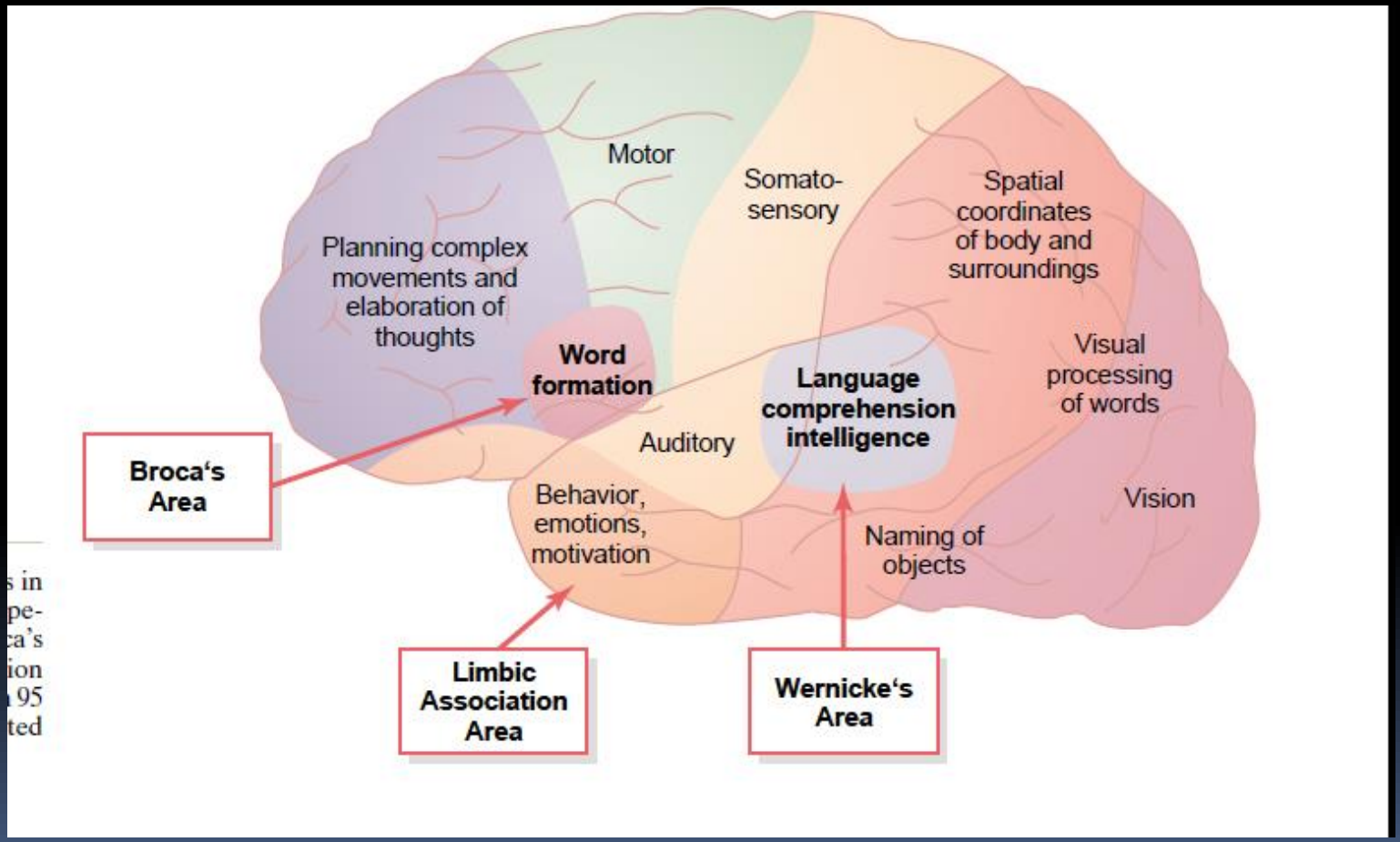
PARIETO-OCCIPITOTEMPORAL ASSOCIATION AREAS

- 1. Analysis of the Spatial Coordinates of the Body.
- 2. Language Comprehension.
- 3. Initial Processing of Visual Language (Reading).
- 4. Area for Naming Objects.

PARIETO-OCCIPITOTEMPORAL ASSOCIATION AREAS

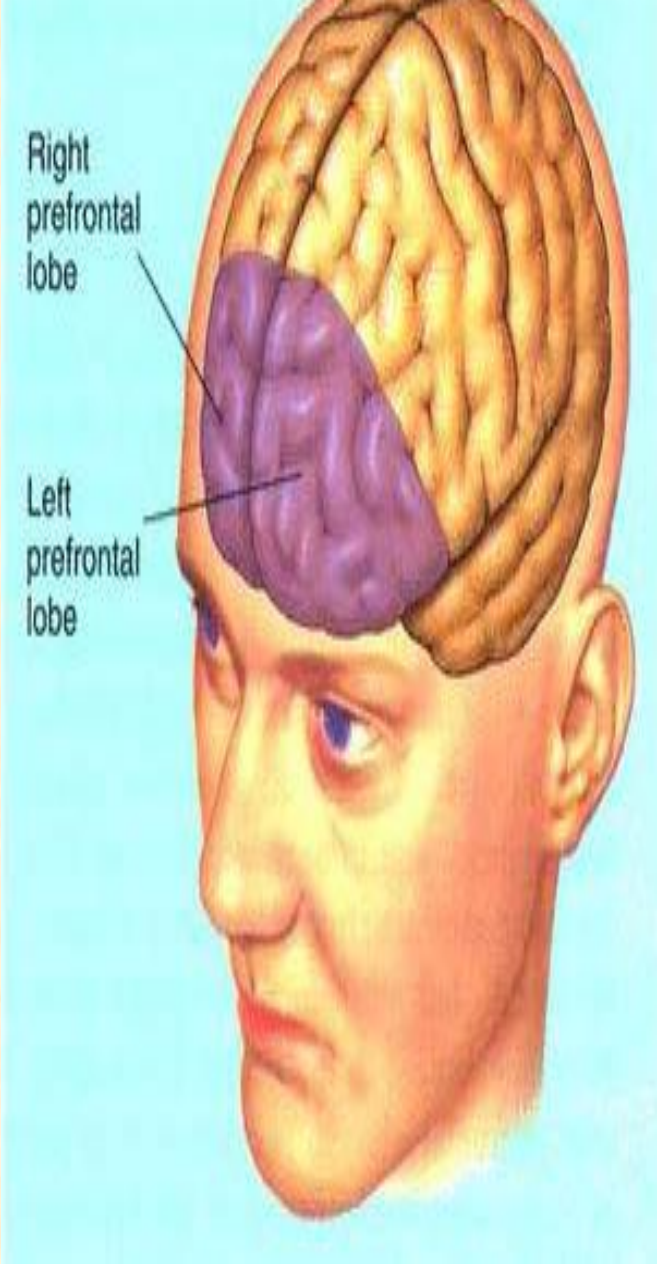
AREA	SITE	FUNCTION
Analysis of the Spatial Coordinates of the Body.	beginning in the posterior parietal cortex and extending into the superior occipital cortex	computes the coordinates of the visual , auditory, and body surroundings.
Area for Language Comprehension	Wernicke's area, lies behind the primary auditory cortex in the posterior part of the superior gyrus of the temporal lobe	higher intellectual function
Area for Initial Processing of Visual Language (Reading).	angular gyrus area	make meaning out of the visually perceived words (lesion causes Dyslexia or Word Blindness)
Area for Naming Objects.	Lateral portion of anterior occipital lobe	naming objects.

PARIETO-OCCIPITOTEMPORAL ASSOCIATION AREAS



Higher level: Prefrontal Cortex

- Most complicated region, coordinates info from all other association areas
- Important in intellect, planning, reasoning, mood, abstract ideas, judgement, conscience, and accuratley predicting consequences
- Phineas Gage?



Prefrontal Association Area

- Is the anterior pole of frontal lobe.
- It contributes in the following functions:

1. Planning of complex pattern of movements.
2. Personality characteristics and social relationship
3. Production of deep, more abstract and logically sequenced thoughts which enable attainment of goals
4. Working memory (ability to tie thoughts together in a logical sequence by comparing many bits of information with appropriate stored knowledge and be able to instantly recall this information for future planning)

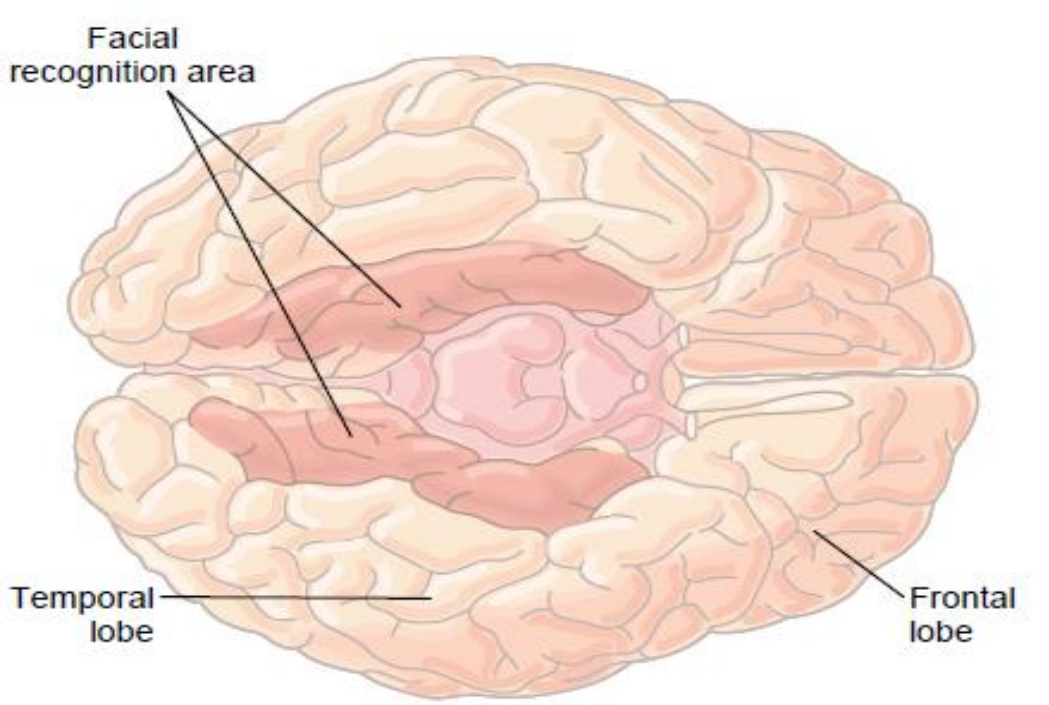
Lesions in this area lead to change in personality and behavior

Limbic Association Area

- Consists of anterior and inner portion of temporal lobe.
- Is primarily concerned with emotion , behavior and motivational drive for different tasks most importantly learning.
- *Lesion of this area may lead to decreased aggression , lack of emotion , hyper sexuality & hyperphagia*

Area of Recognition of Faces

- Located on the underside of the brain on the medial occipital and temporal lobes
- The occipital portion is contiguous with visual cortex , while the temporal one is closely associated with limbic system
- *Inability to recognize faces is called prosopagnosia*



Frontal Lobe - Cortical Regions

- **Primary Motor Cortex (Precentral Gyrus)** – Cortical site involved with controlling movements of the body.

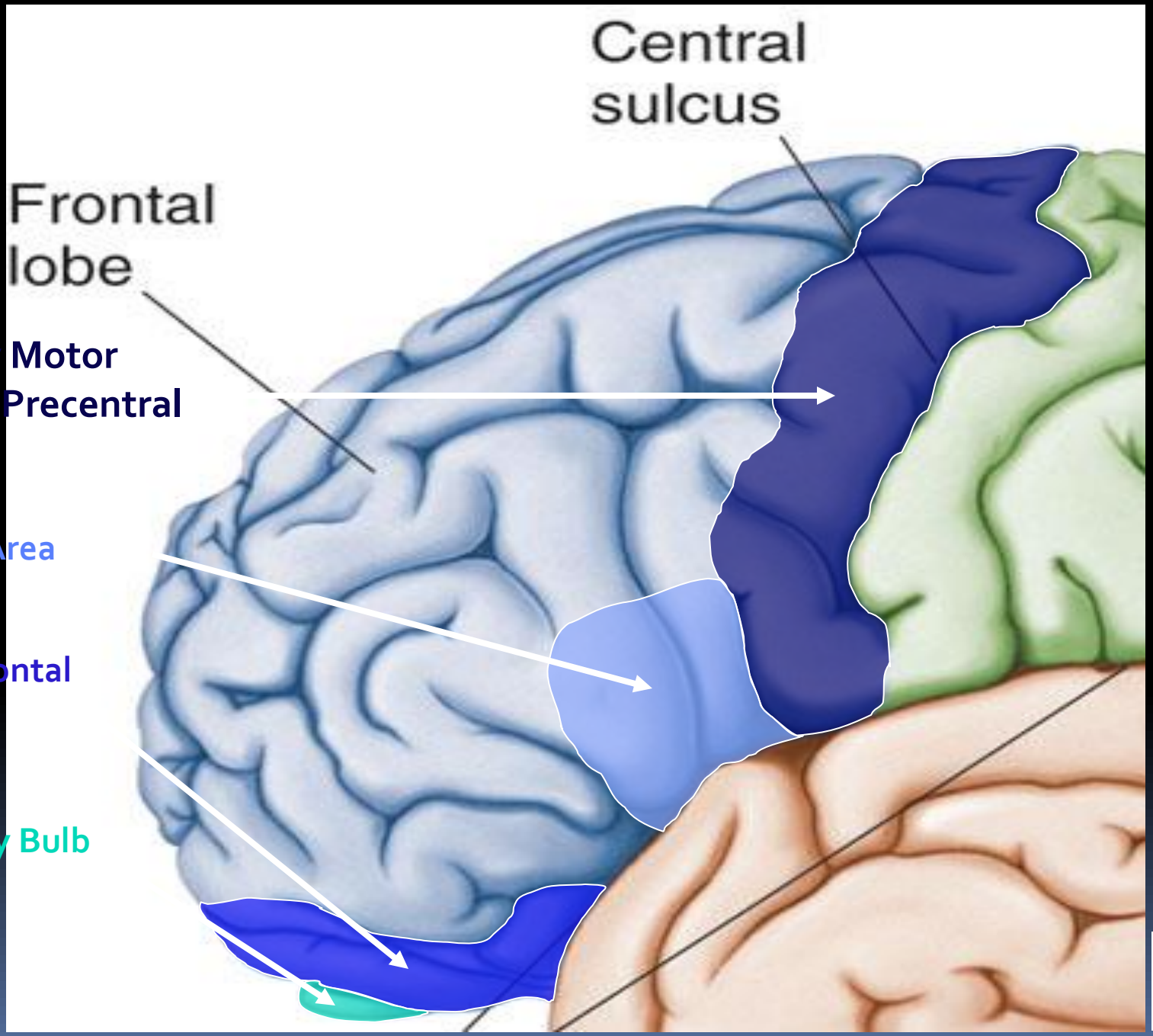
- **Broca's Area** –plan of motor pattern for expressing of individual words. Located on ***Left*** Frontal Lobe.

– **Broca's Aphasia** – Results in the ability to comprehend speech, but the decreased motor ability (or inability) to speak and form words.

- **Orbitofrontal Cortex** – Site of Frontal Lobotomies

* **Desired Effects:**	* **Possible Side Effects:**
- Diminished Rage - Decreased Aggression - Poor Emotional Responses	- Epilepsy - Poor Emotional Responses - Perseveration (Uncontrolled, repetitive actions, gestures, or words)

- **Olfactory Bulb** - Cranial Nerve I, Responsible for sensation of Smell


Central sulcus
Frontal lobe
Primary Motor Cortex/ Precentral Gyrus
Broca's Area
Orbitofrontal Cortex
Olfactory Bulb

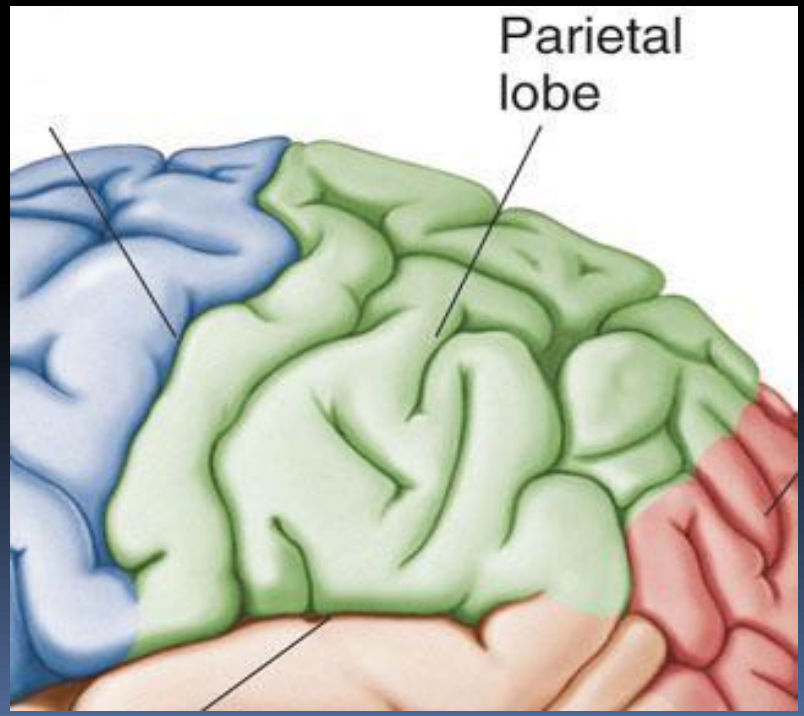
Regions

Lobes of the Brain - Parietal Lobe

- The Parietal Lobe of the brain is located deep to the Parietal Bone of the skull.

- It plays a major role in the following functions/actions:

  - Senses and integrates sensation(s)
  - Spatial awareness and perception (Proprioception - Awareness of body/ body parts in space and in relation to each other)

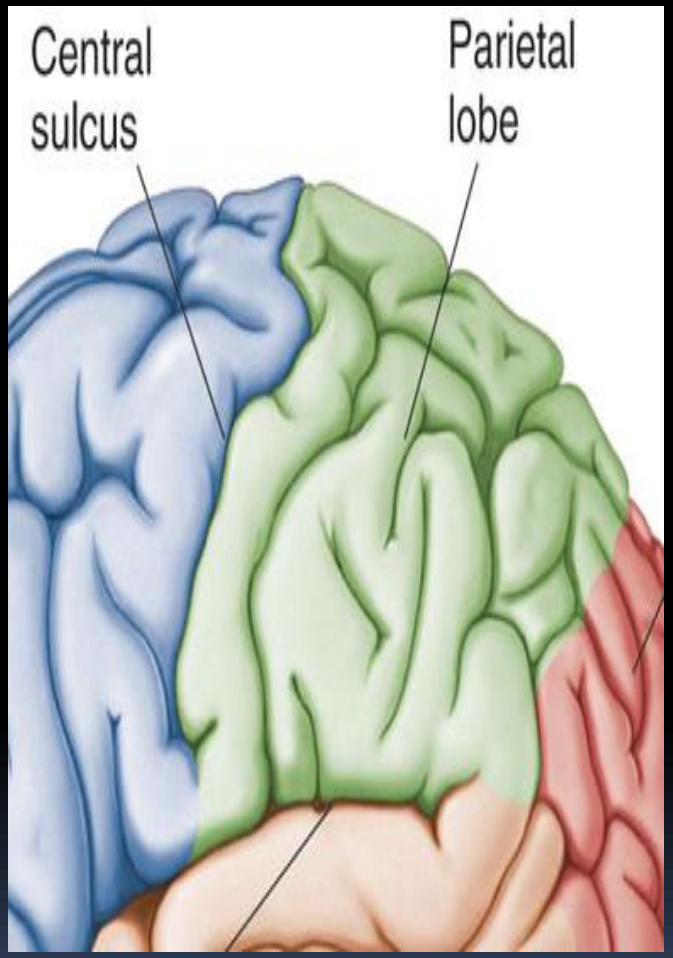


Parietal Lobe - Cortical Regions

- **Primary Somatosensory Cortex (Postcentral Gyrus)** – Site involved with processing of tactile and proprioceptive information.

- **Somatosensory Association Cortex** – Assists with the integration and interpretation of sensations relative to body position and orientation in space.

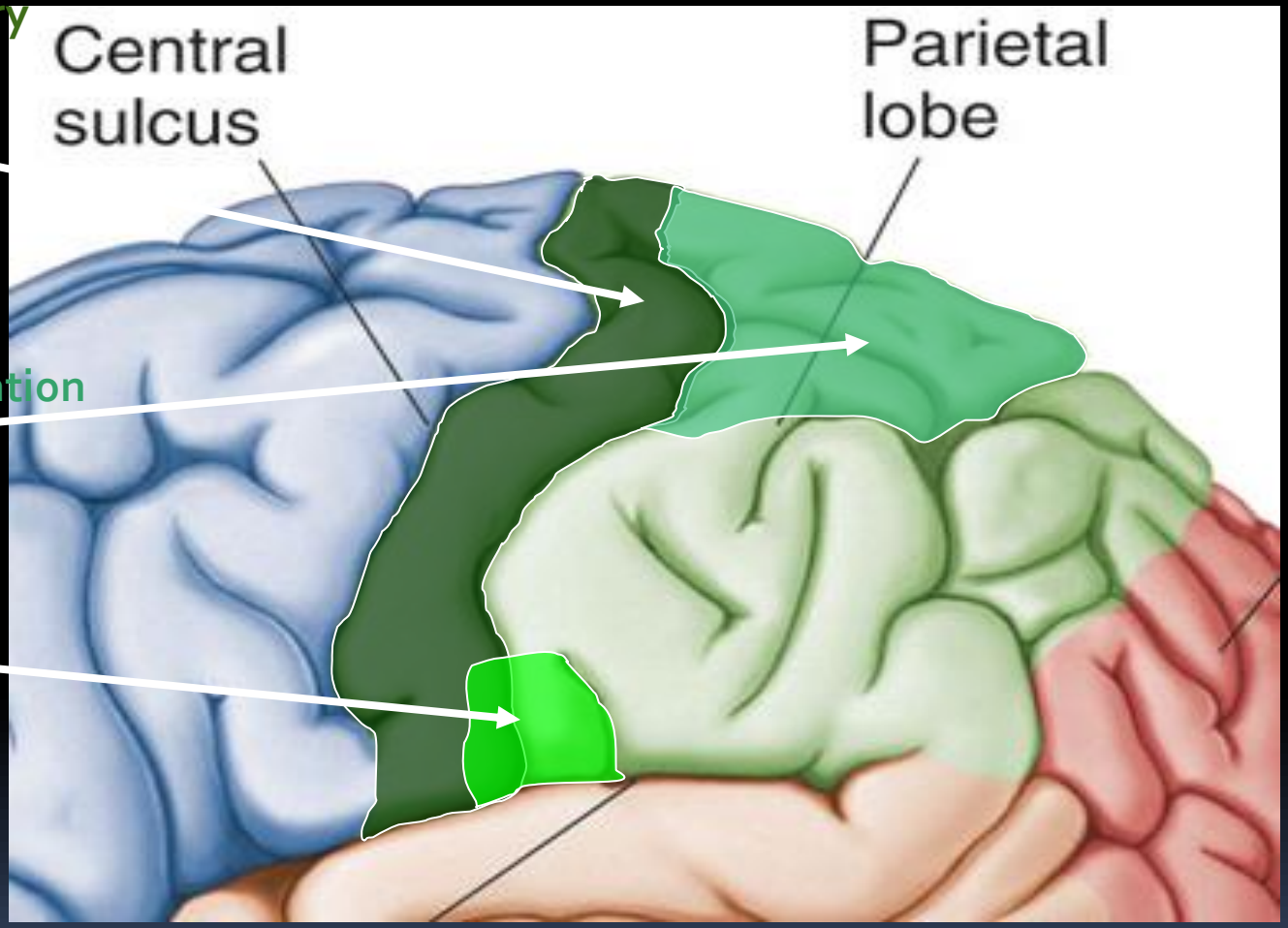
- **Primary Gustatory Cortex** – Primary site involved with the interpretation of the sensation of Taste.



Primary Somatosensory Cortex/ Postcentral Gyrus

Somatosensory Association Cortex

Primary Gustatory Cortex



Regions

Parietal Lobe Functions

- Parietal lobe is essential for our feeling of touch, warmth/heat , cold, pain , body position and appreciation of shapes of palpated objects .

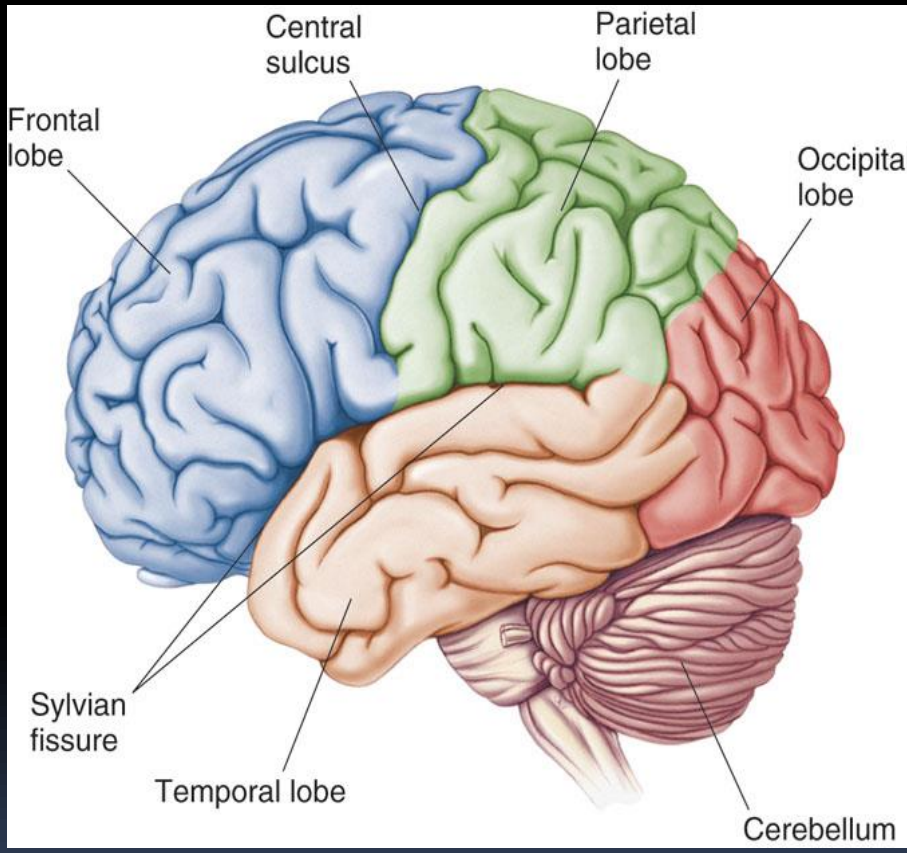
- *When damaged , the person loses the ability to recognize shapes of complex objects by palpation (palpation = examination of objects by touch)*
- *& also develops Sensory Inattention on opposite side*

(the inability to feel a tactile stimulus when a similar stimulus, presented simultaneously in a homologous area of the body, is perceived)

Lobes of the Brain – Occipital Lobe

- The Occipital Lobe of the Brain is located deep to the Occipital Bone of the Skull.

- Its primary function is the processing, integration, interpretation, etc. of VISION and visual stimuli.



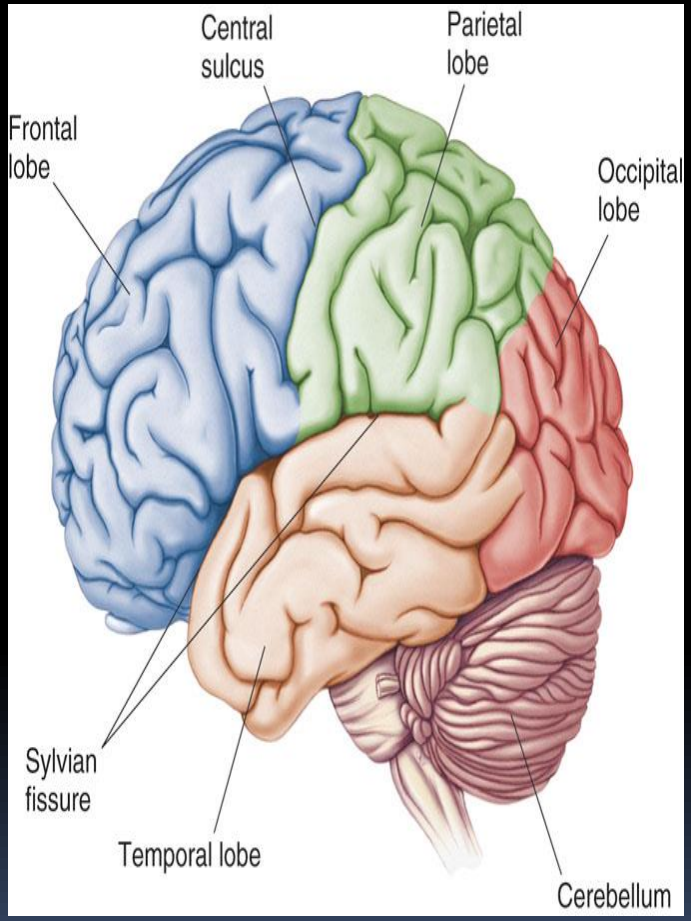
Occipital Lobe – Cortical Regions

- **Primary Visual Cortex**

This is the primary area of the brain responsible for detection of visual stimuli .

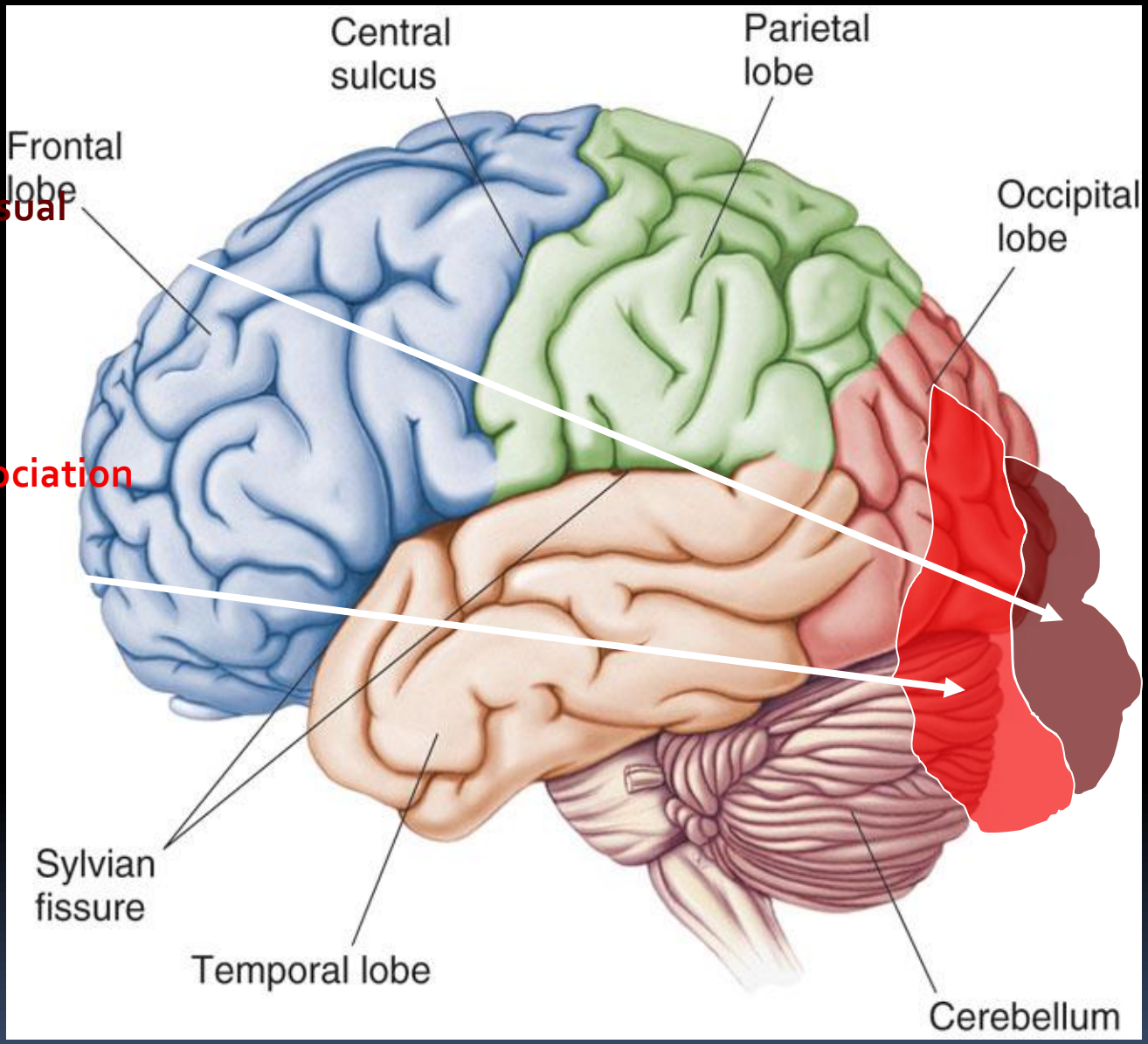
Visual Association Area

Interprets information acquired through the primary visual cortex.



Primary Visual Cortex

Visual Association Area



Lobes of the Brain – Temporal Lobe

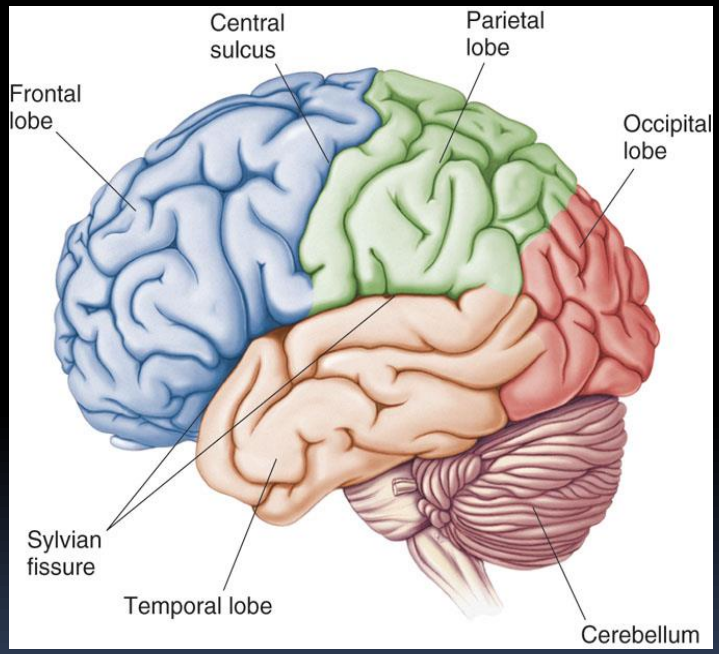
- The Temporal Lobes are located on the sides of the brain, deep to the Temporal Bones of the skull.

- They play an integral role in the following functions:

  - Hearing

  -Organization/Comprehension of language

  - Information Retrieval (Memory and Memory Formation)



Temporal Lobe Functions

- **Primary Auditory Cortex** – Responsible for hearing

- **Primary Olfactory Cortex** – Interprets the sense of smell once it reaches the cortex via the olfactory bulbs. (Not visible on the superficial cortex)

- **Wernicke's Area** – Language comprehension.
  - Located on the ***Left*** Temporal Lobe (dominant hemisphere).
  - Understand auditory and visual information and send them to Brocas area

- Information Retrieval (Memory and Memory Formation)

Temporal Lobe lesion

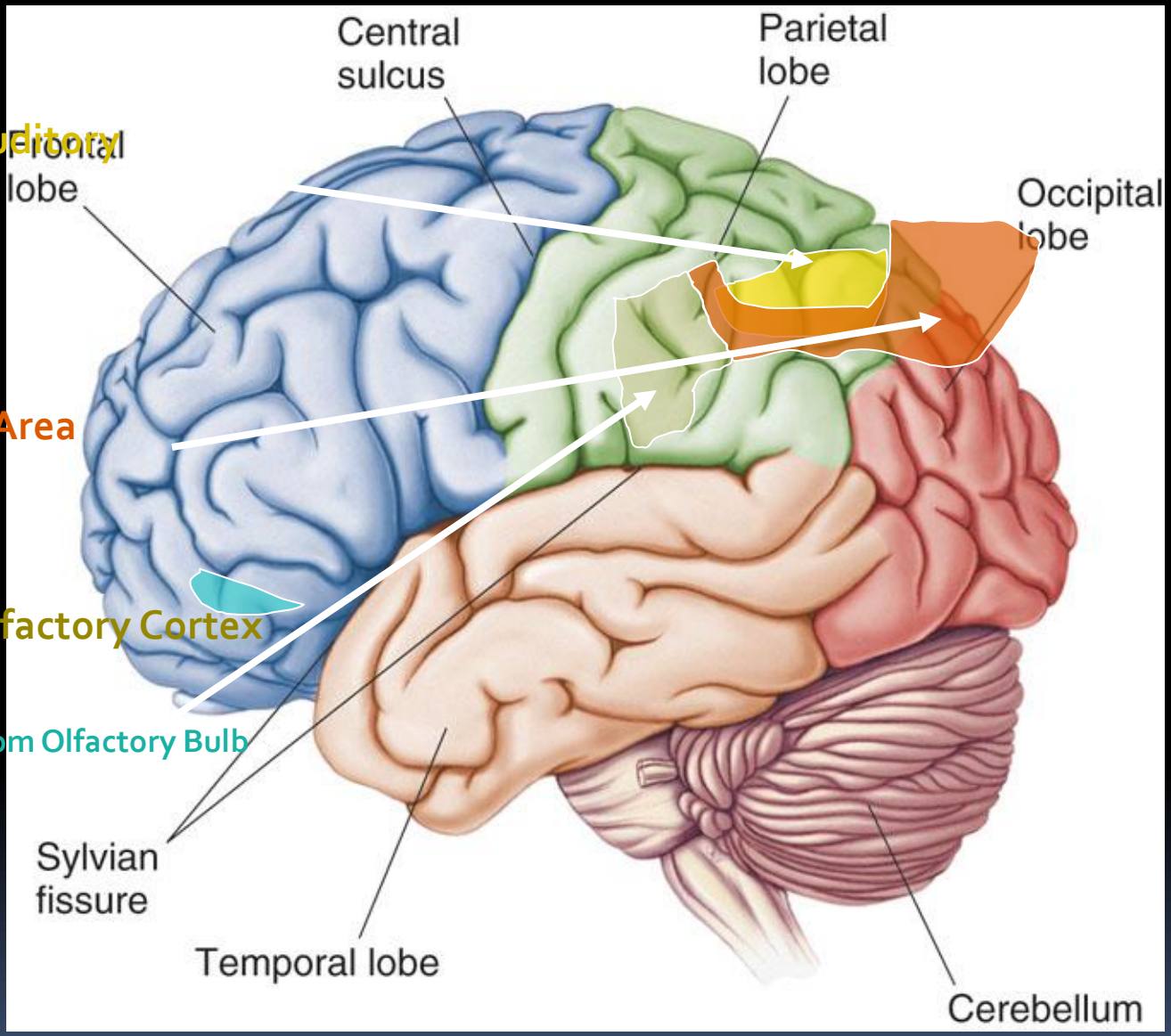
- Lesion → may lead to:
- ✓ - **Wernicke's Aphasia** – Language comprehension is inhibited. The individuals have difficulty understanding written and spoken language
- ✓ Memory impairment
- ✓ & can be associated with temporal lobe epilepsy

Primary Auditory Cortex

Wernike's Area

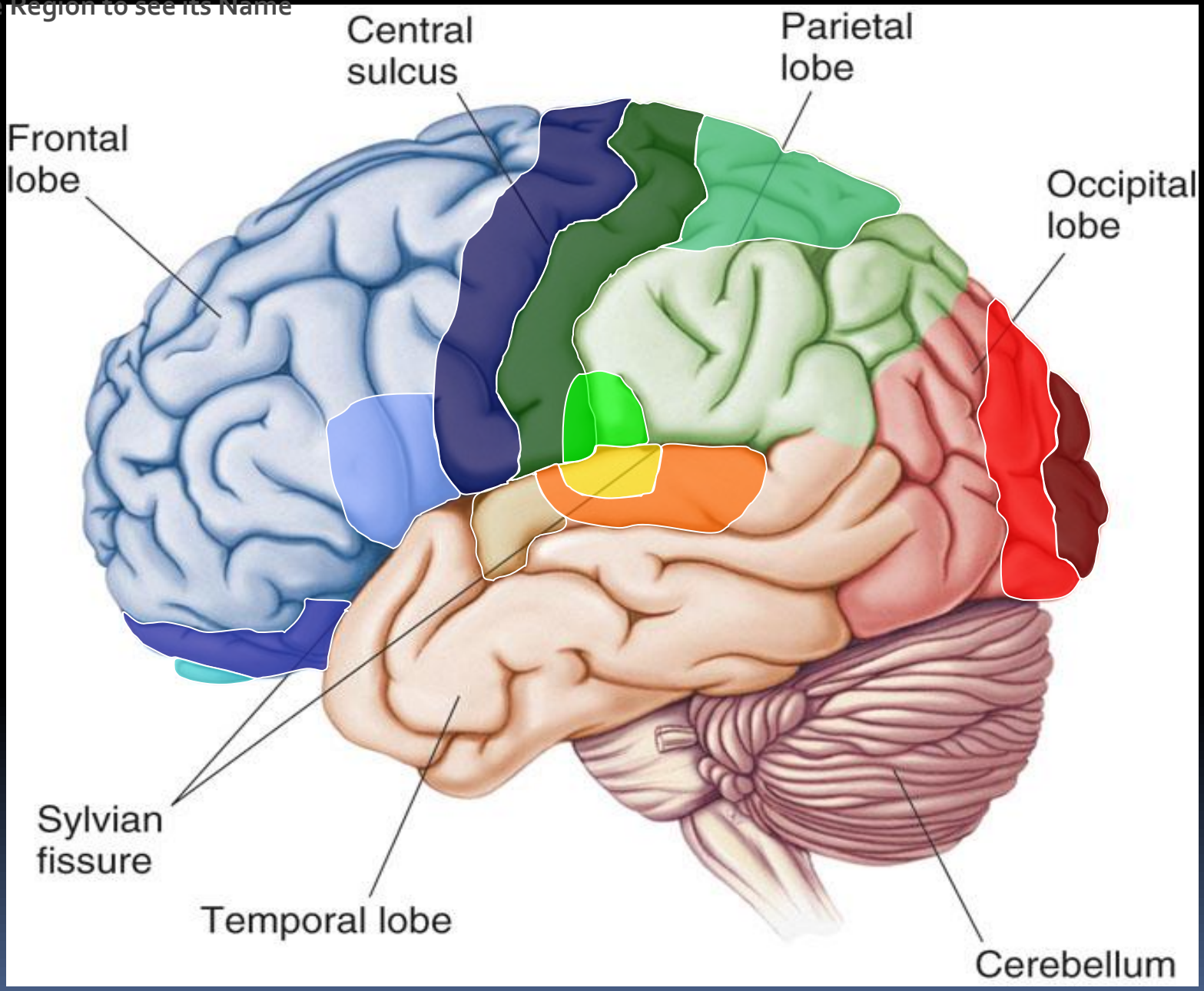
Primary Olfactory Cortex (Deep)

Conducted from Olfactory Bulb



Regions

Click the Region to see its Name



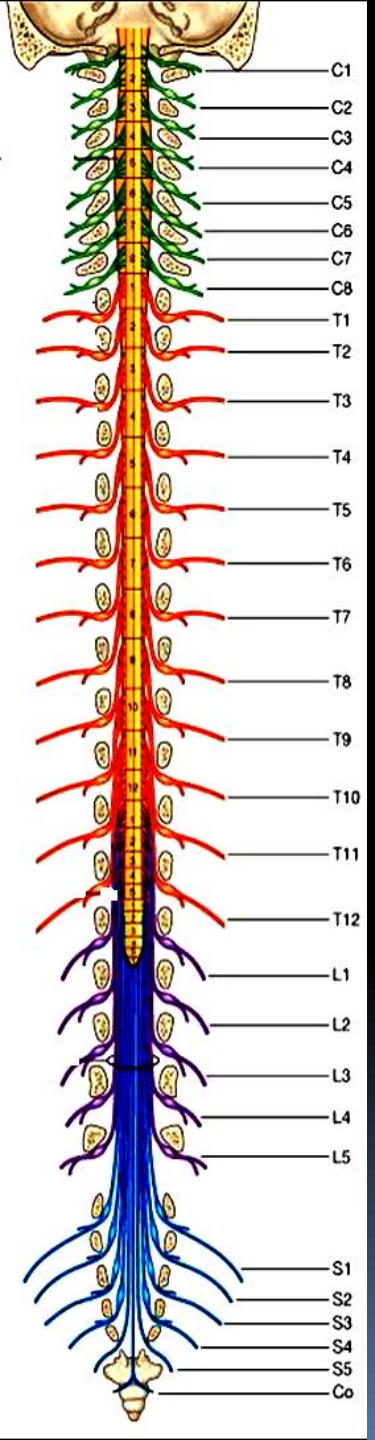
Functional Principles of the Cerebral hemispheres

1. Each cerebral hemisphere receives sensory information from, and sends motor commands to, the opposite side of body
2. The 2 hemispheres have somewhat different functions although their structures are alike
3. Correspondence between a specific function and a specific region of cerebral cortex is not precise
4. No functional area acts alone; conscious behavior involves the entire cortex

Dominant & Nondominant Hemisphere

- Functional differences between left and right hemispheres
- In most people, left hemisphere (dominant hemisphere) controls:
  - reading, writing, and math, decision-making, logic, speech and language (usually)
- Right cerebral hemisphere relates to:
  - ✓ understanding & interpreting music,
  - ✓ Non verbal visual Experience
  - ✓ Spatial relation between the person & their surroundings
  - ✓ Body language and intonation of peoples voices

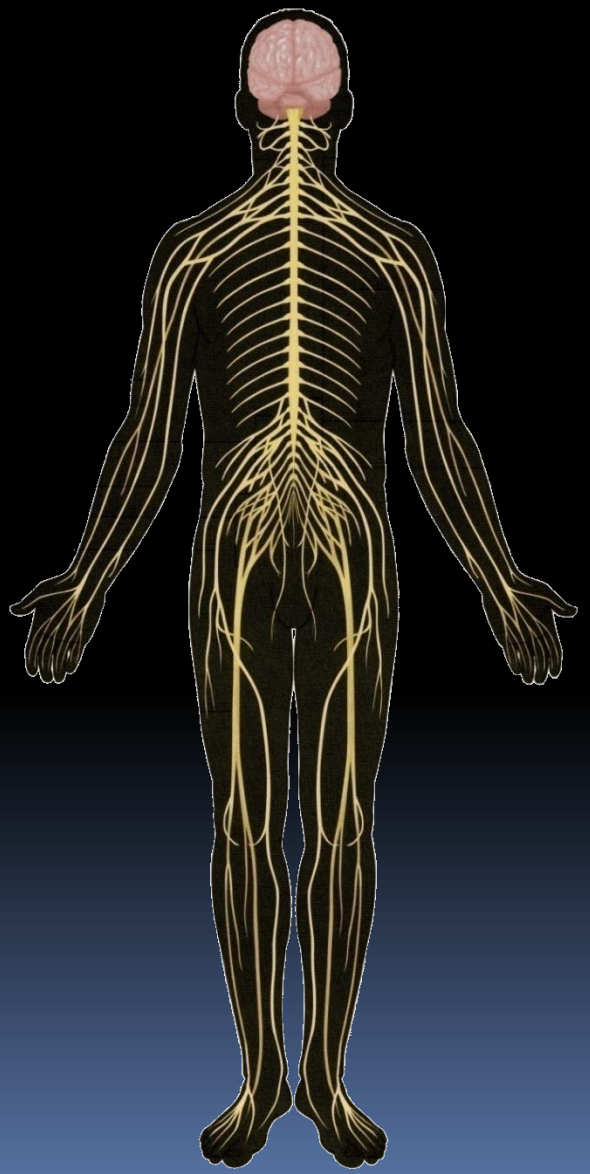
Spinal Cord and Spinal Nerves



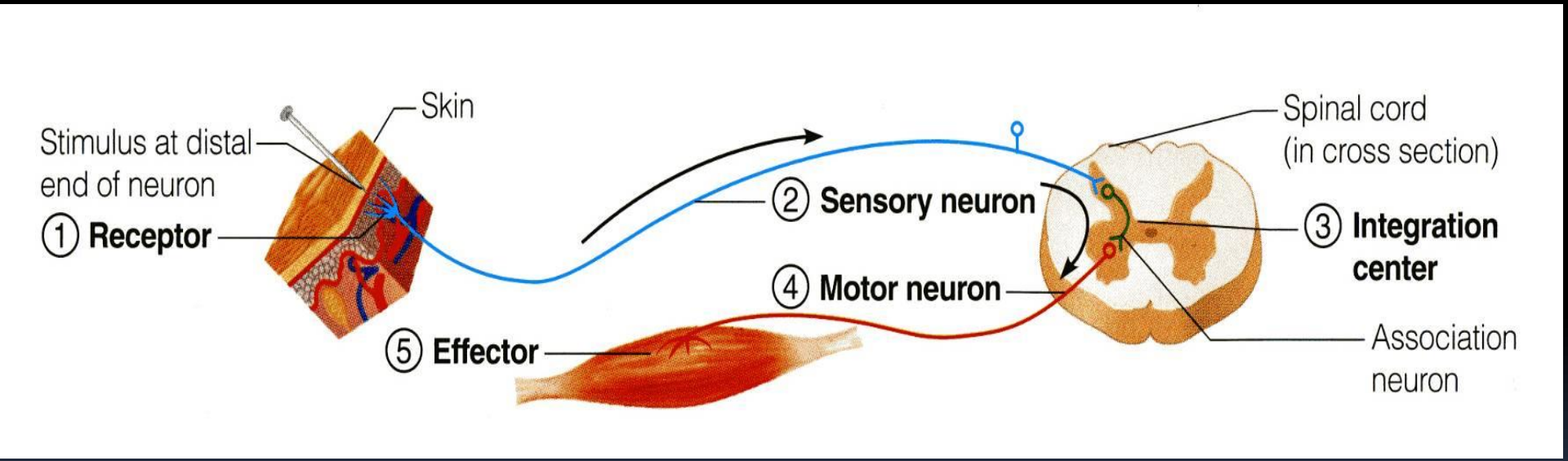
The spinal cord is generally cylindrical in shape

From it emerge 31 pairs of spinal nerves:

- 8 cervical,
- 12 thoracic,
- 5 lumbar,
- 5 sacral and
- 1 coccygeal.



The spinal cord , beside carrying sensory ✓ (ascending) and motor (descending) tracts , Also contains the centers of Spinal Reflexes ✓



Nervous system organization

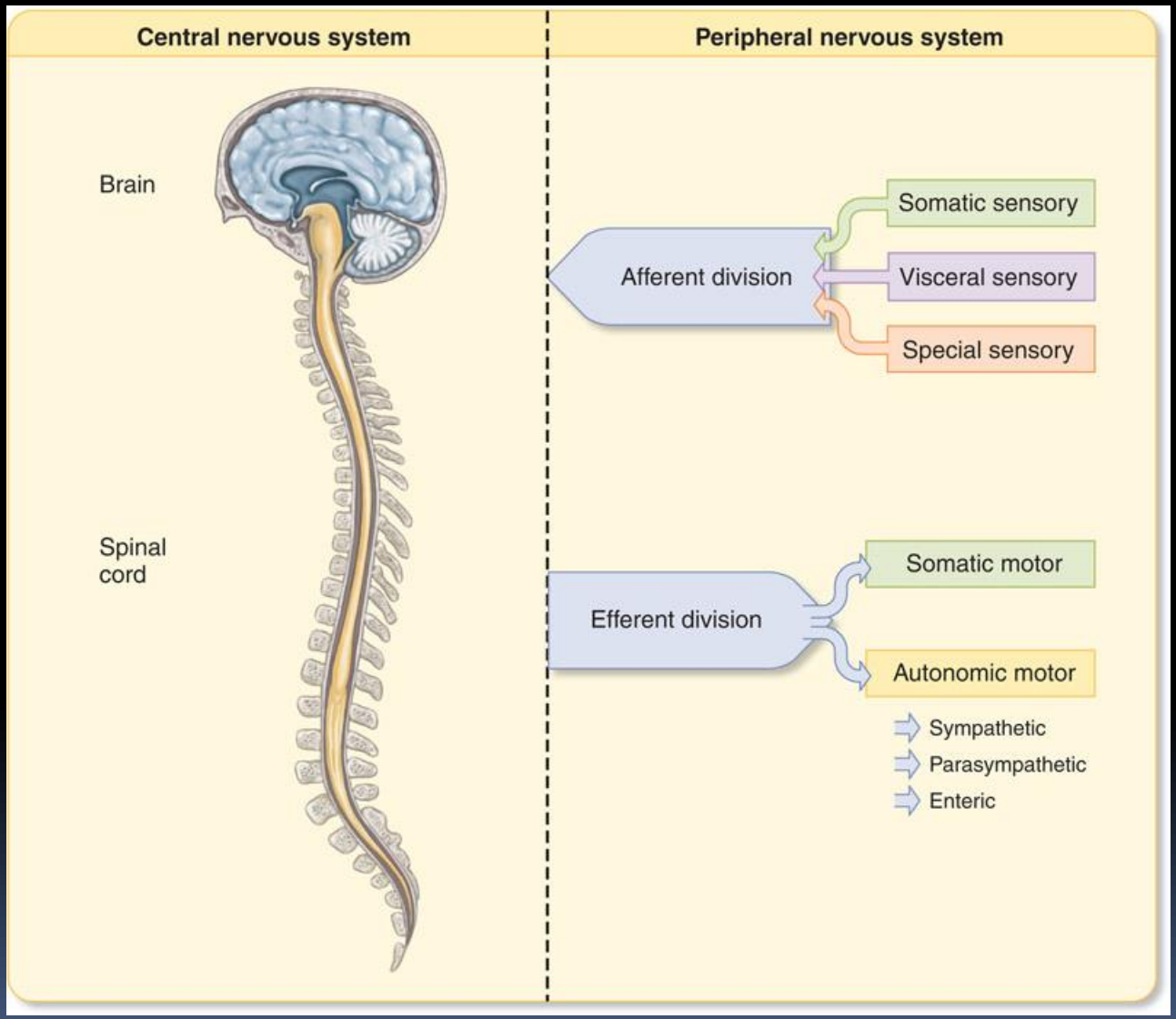


fig 6-37

Peripheral nervous system: efferent division

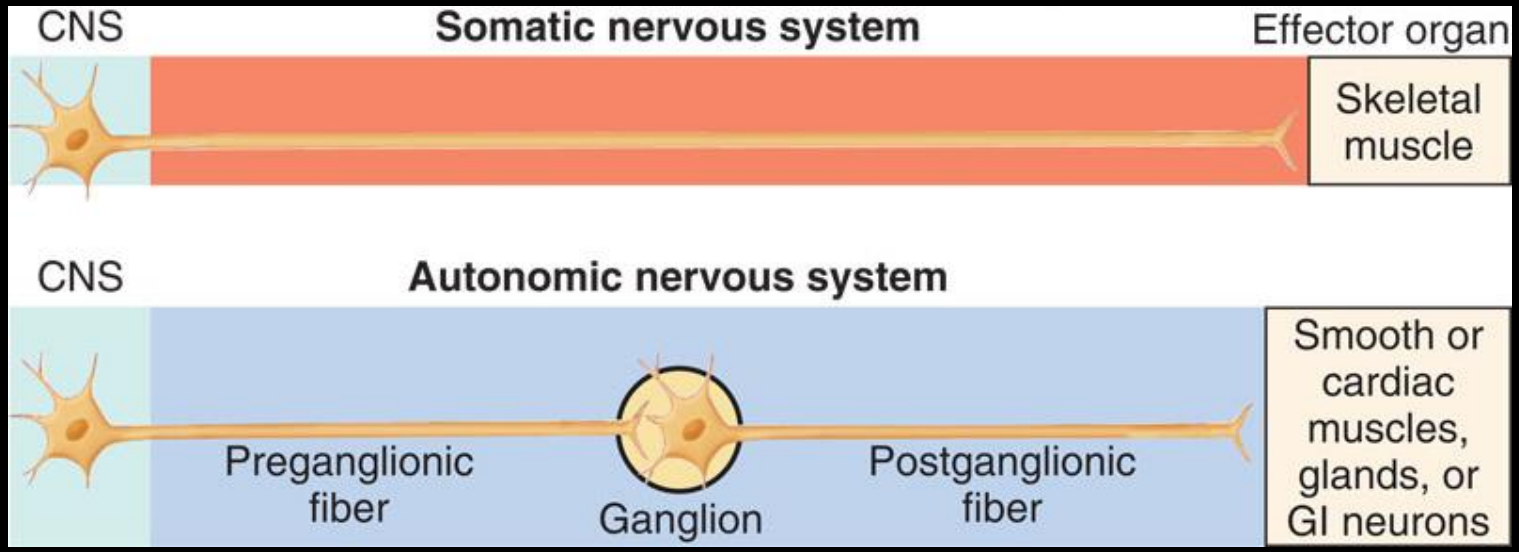


fig 6-43

Somatic: single neuron, innervates skeletal muscle, voluntary control

Autonomic: 2 neuron chain, innervates smooth, cardiac muscle, glands, largely involuntary control


THANK YOU