



Neuroanatomy

Dr. Maha ELBeltagy

Assistant Professor of Anatomy

Faculty of Medicine

The University of Jordan

2018

THE NERVOUS SYSTEM (NS)

It is divided into 2 major divisions:

1) Central Nervous System (CNS): found within bones & consists of:

- * The Brain: within the skull
- * The spinal cord: within the vertebral canal.

2) Peripheral Nervous System (PNS): Consists of:

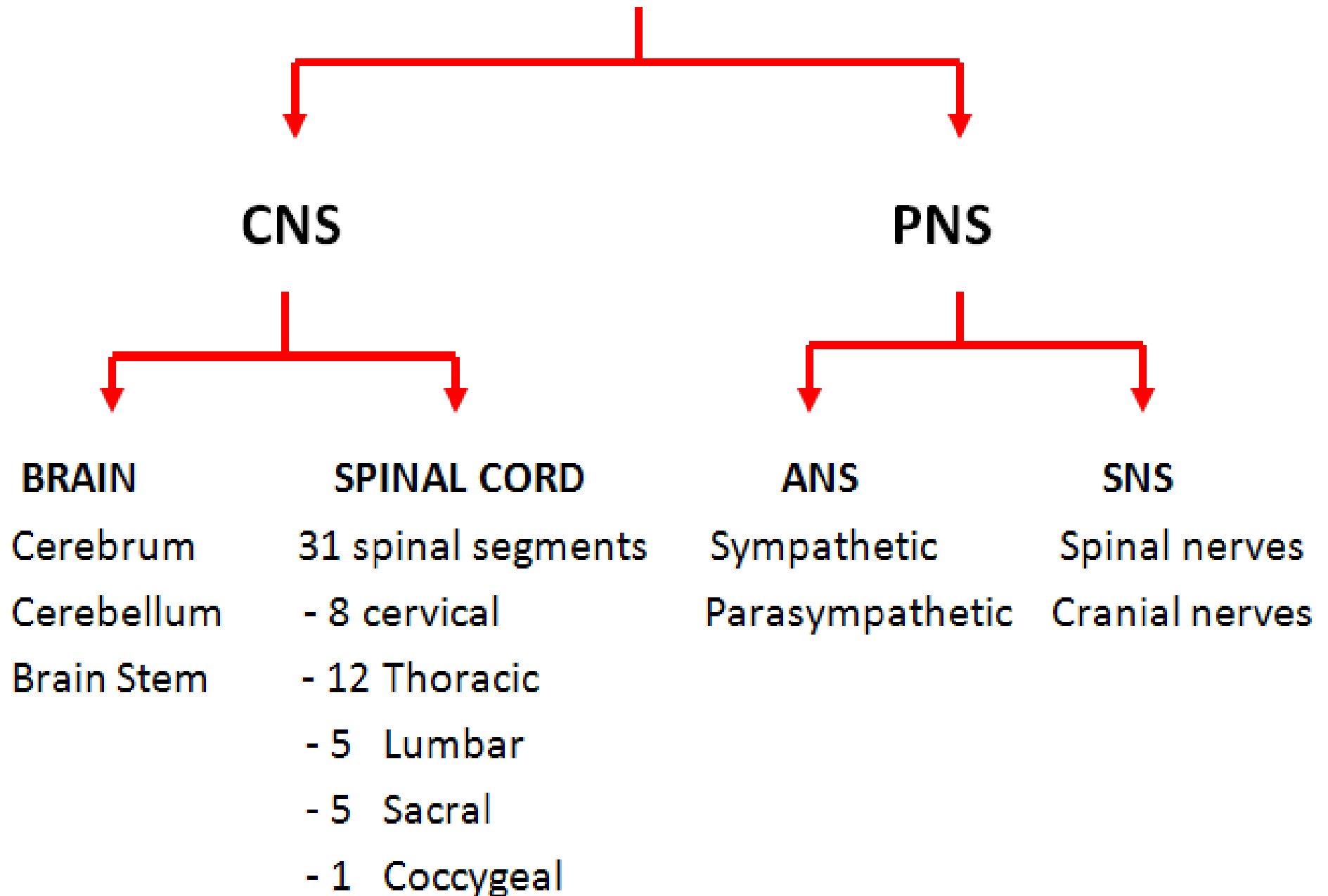
A) Autonomic nervous system: which is divided into:

- * Sympathetic nervous system.
- * Parasympathetic nervous system.

B) Somatic nerves:

- * Cranial nerves (12 pairs): Connected to the brain.
- * Spinal nerves (31 pairs): Connected to the spinal cord.

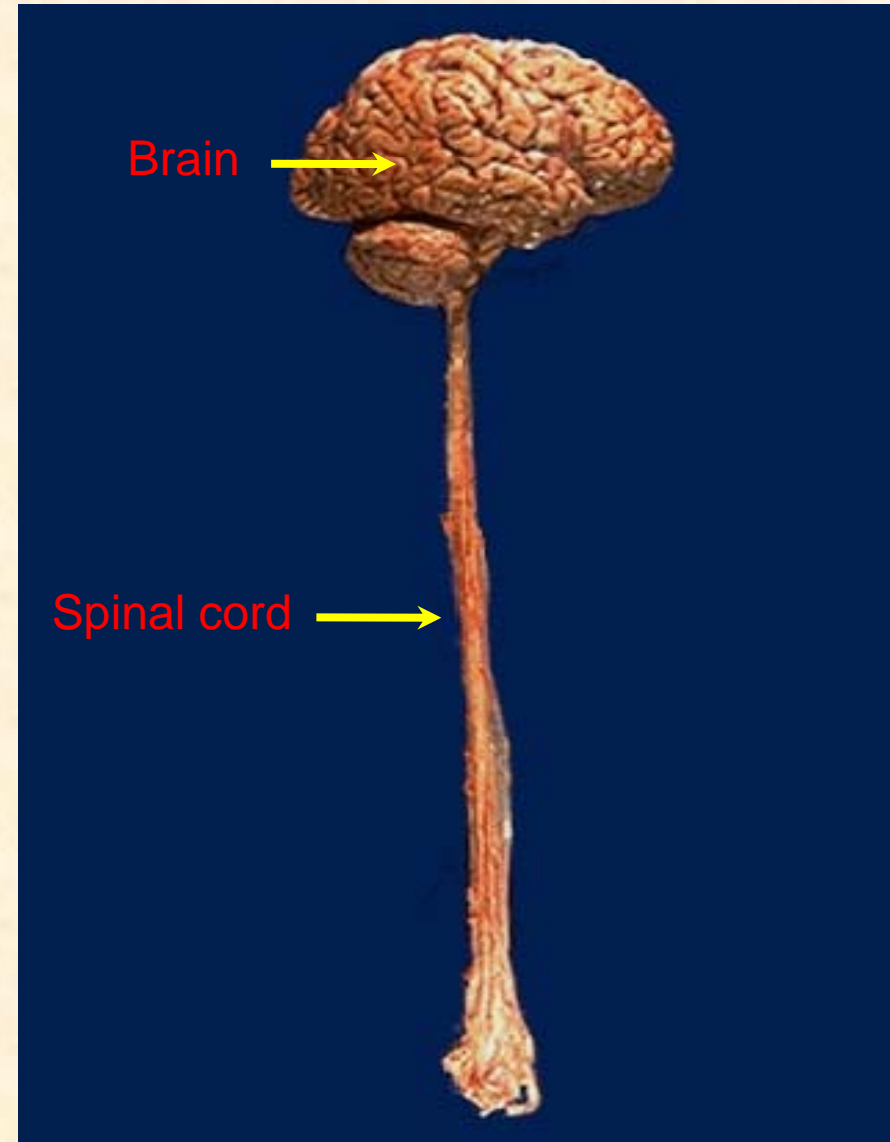
THE NERVOUS SYSTEM



THE CENTRAL NERVOUS SYSTEM

It consists of:

- 1) The brain: Within the skull.
- 2) The spinal cord: Within the vertebral canal.



THE BRAIN

It consists of:

1) Cerebrum:

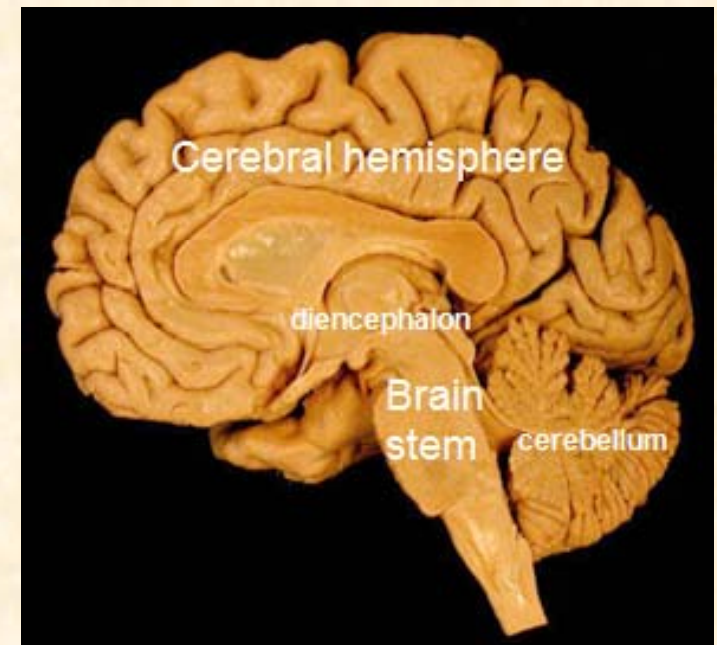
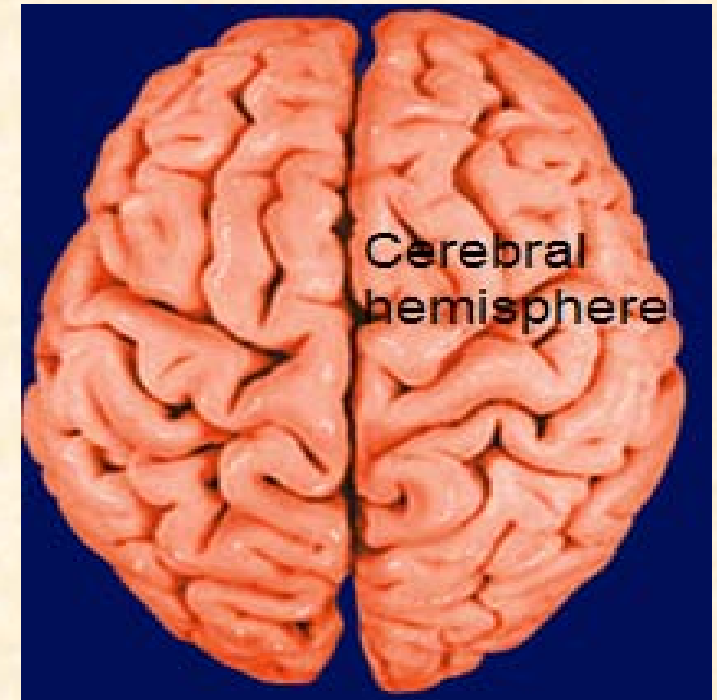
- 2 Cerebral hemispheres separated from each other by median fissure
- Diencephalon.

2) Brain Stem:

- Midbrain
- Pons
- Medulla

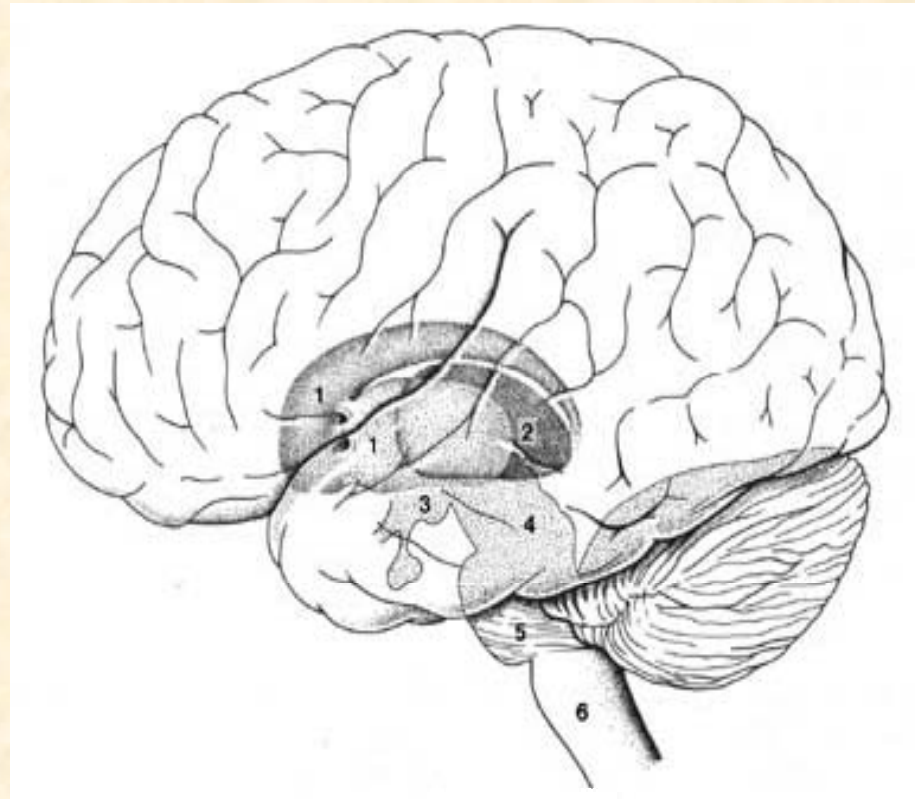
3) Cerebellum:

- 2 cerebellar hemispheres
- Vermis



Inner Structures of the Brain

- 1. Basal ganglia*
- 2. Thalamus*
- 3. Hypothalamus*
- 4. Midbrain*
- 5. Pons*
- 6. Medulla oblongata*

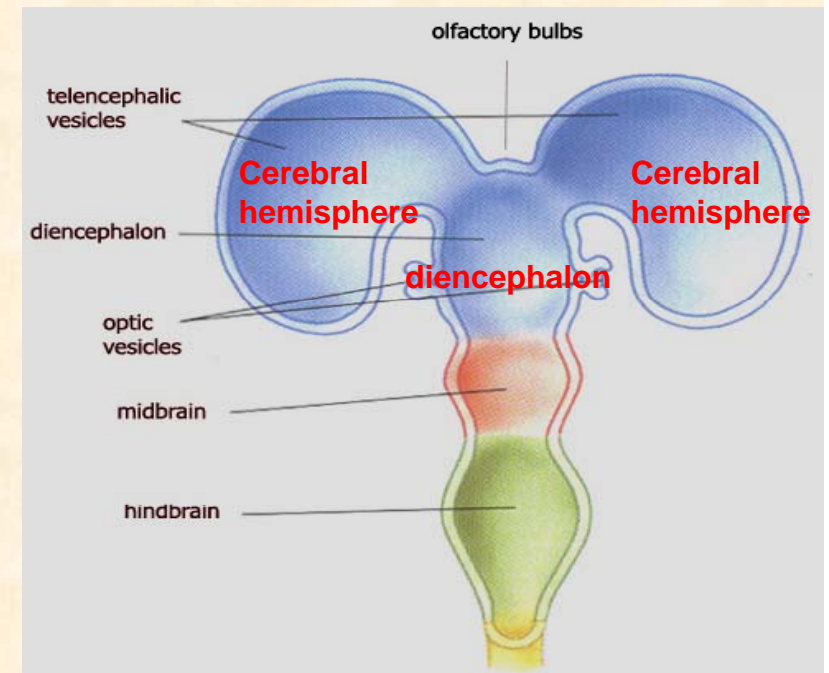
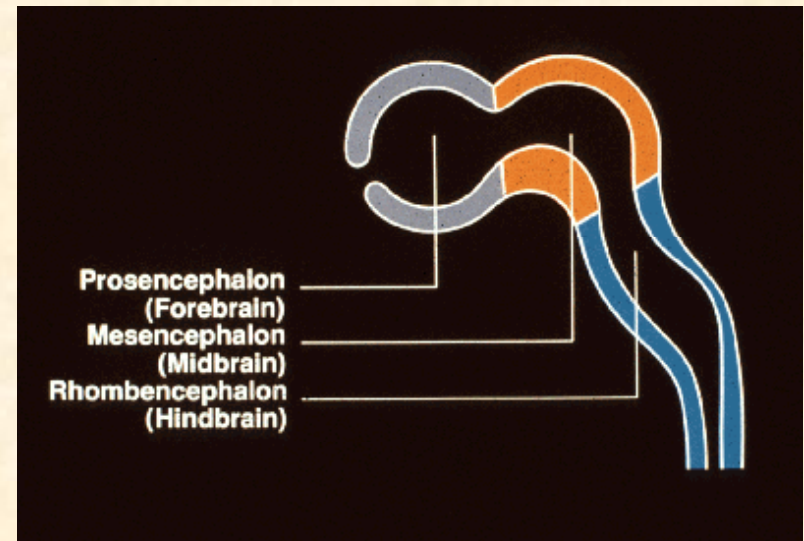


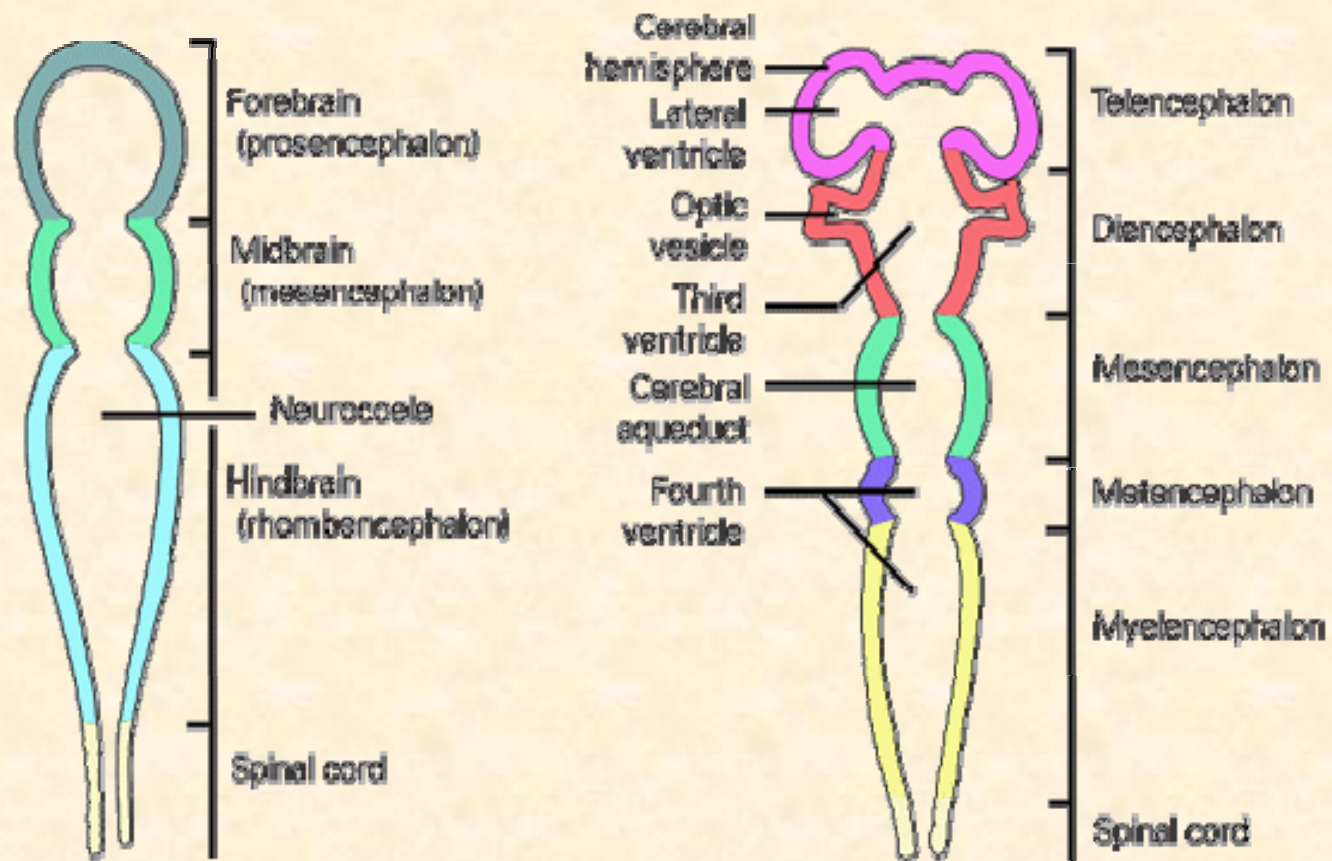
On embryological basis the brain is divided into:

- 1) Forebrain: Consists of
- * 2 Cerebral hemispheres.
 - * Diencephalon.

2) Midbrain.

- 3) Hindbrain: Consists of:
- * Pons.
 - * Medulla Oblongata.
 - * Cerebellum.



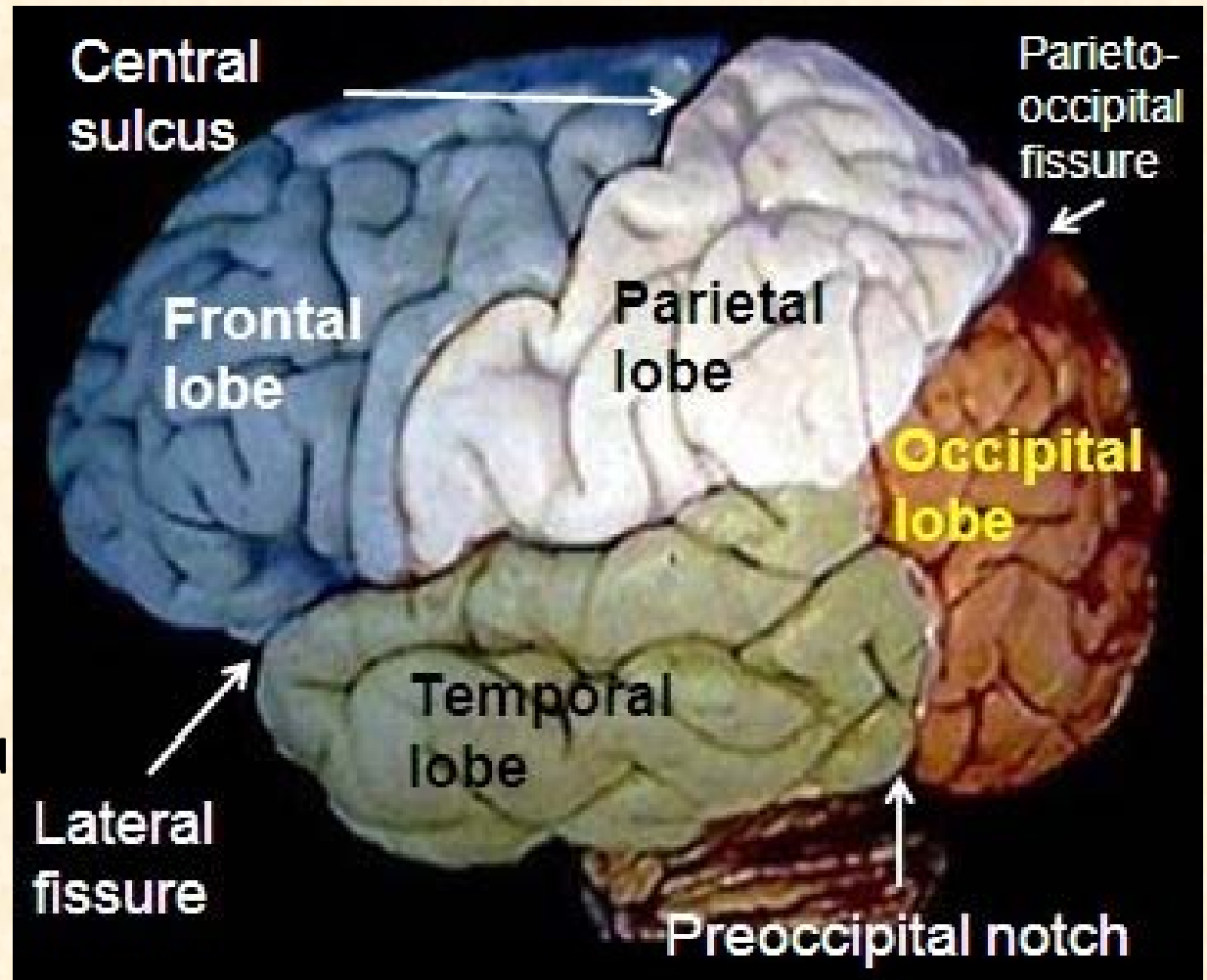


Embryonic (developmental) divisions of the Brain

Primary vesicle	Secondary vesicle	Derivatives
Prosencephalon	telencephalon	Cerebral cortex Cerebral white matter Basal ganglia
	diencephalon	Thalamus Hypothalamus Subthalamus Epithalamus
Mesencephalon	mesencephalon	Midbrain
Rhombencephalon	metencephalon	Cerebellum Pons
	myelencephalon	Medulla oblongata

THE CEREBRAL HEMISPHERES

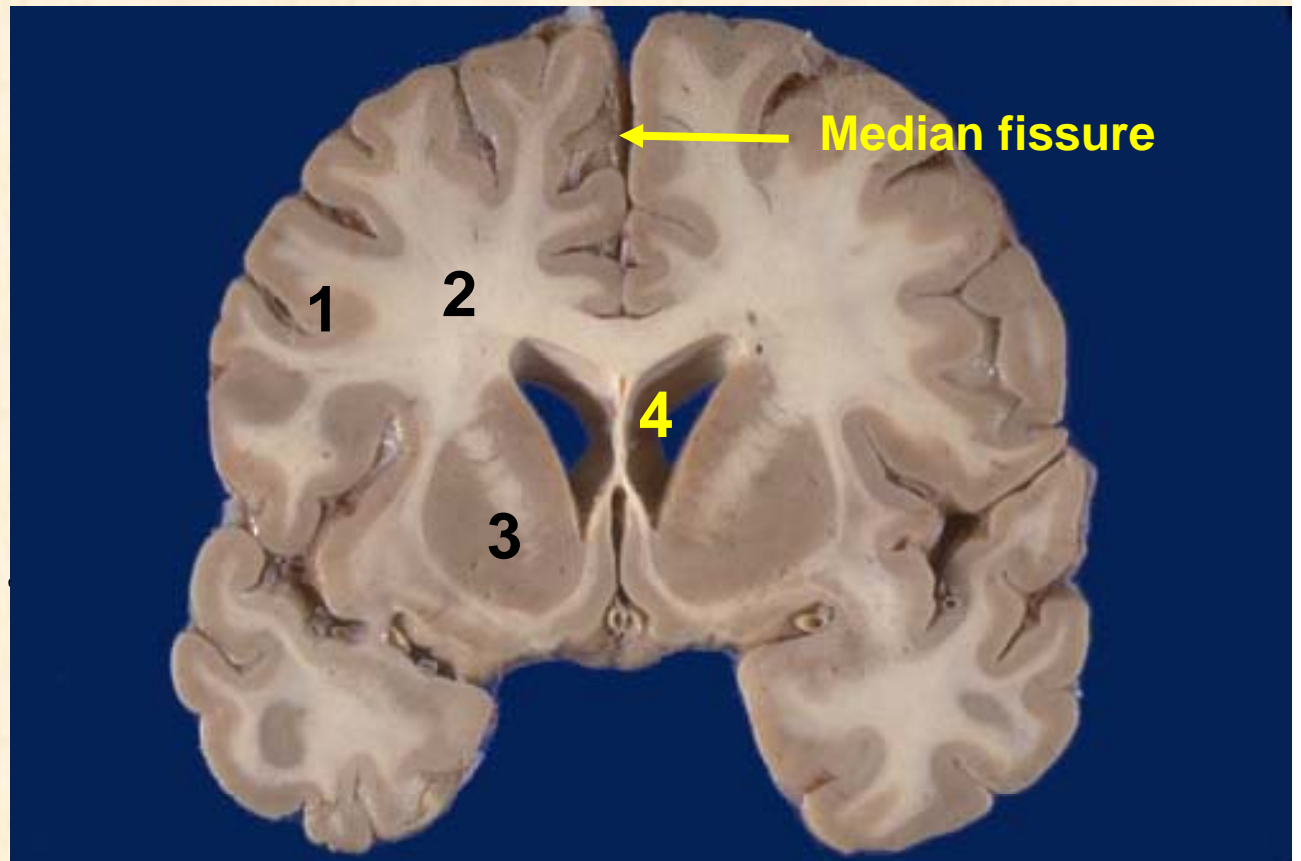
- 4 lines divide each hemisphere into 4 lobes:
 - The central sulcus.
 - Posterior ramus of lateral fissure.
 - Imaginary line between Parieto-occipital fissure & Preoccipital notch.
 - Imaginary line connecting the posterior ramus of lateral fissure to the previous line.
- Each hemisphere is divided into 4 lobes:
 - Frontal lobe.
 - Parietal lobe.
 - Temporal lobe.
 - Occipital lobe.



Components of the cerebral hemisphere

It consists of:

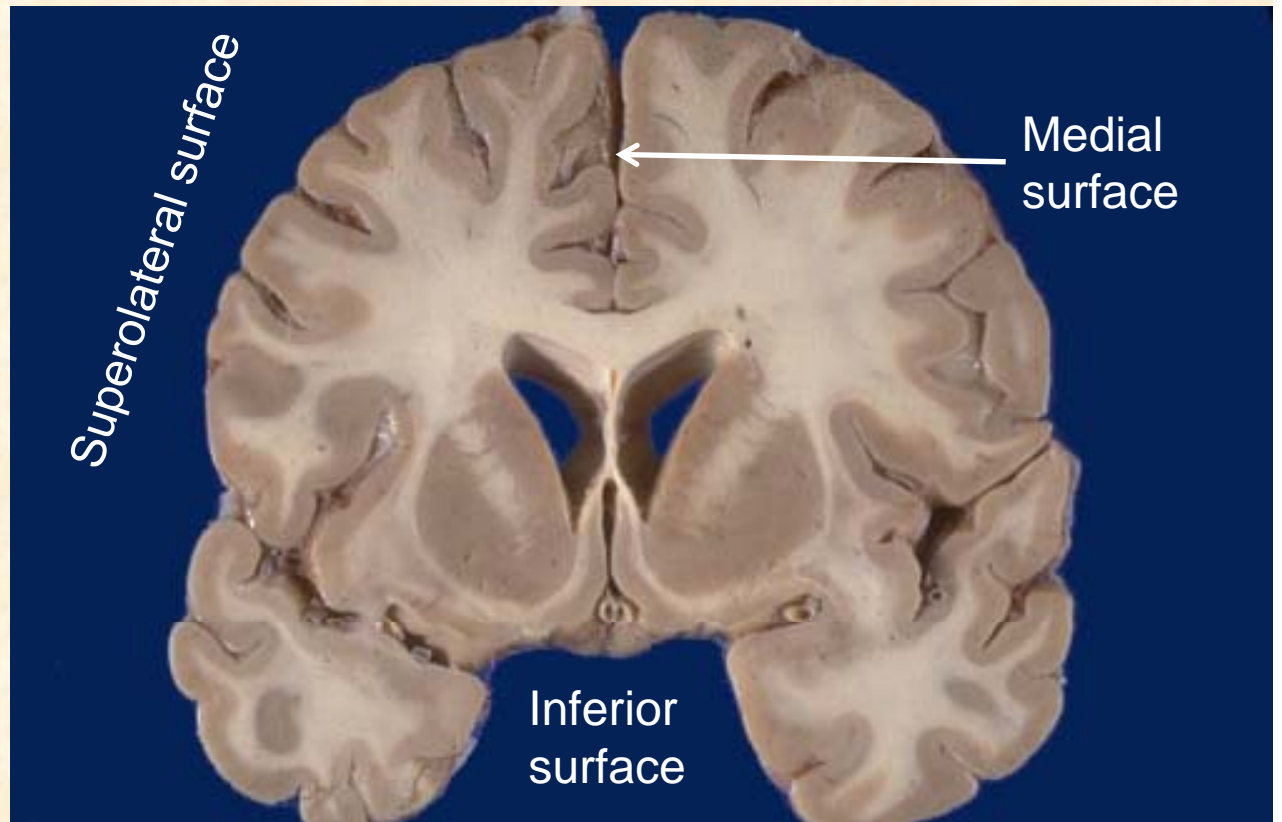
- 1) Grey matter.
- 2) White matter.
- 3) Basal nuclei.
- 4) Lateral ventricle.



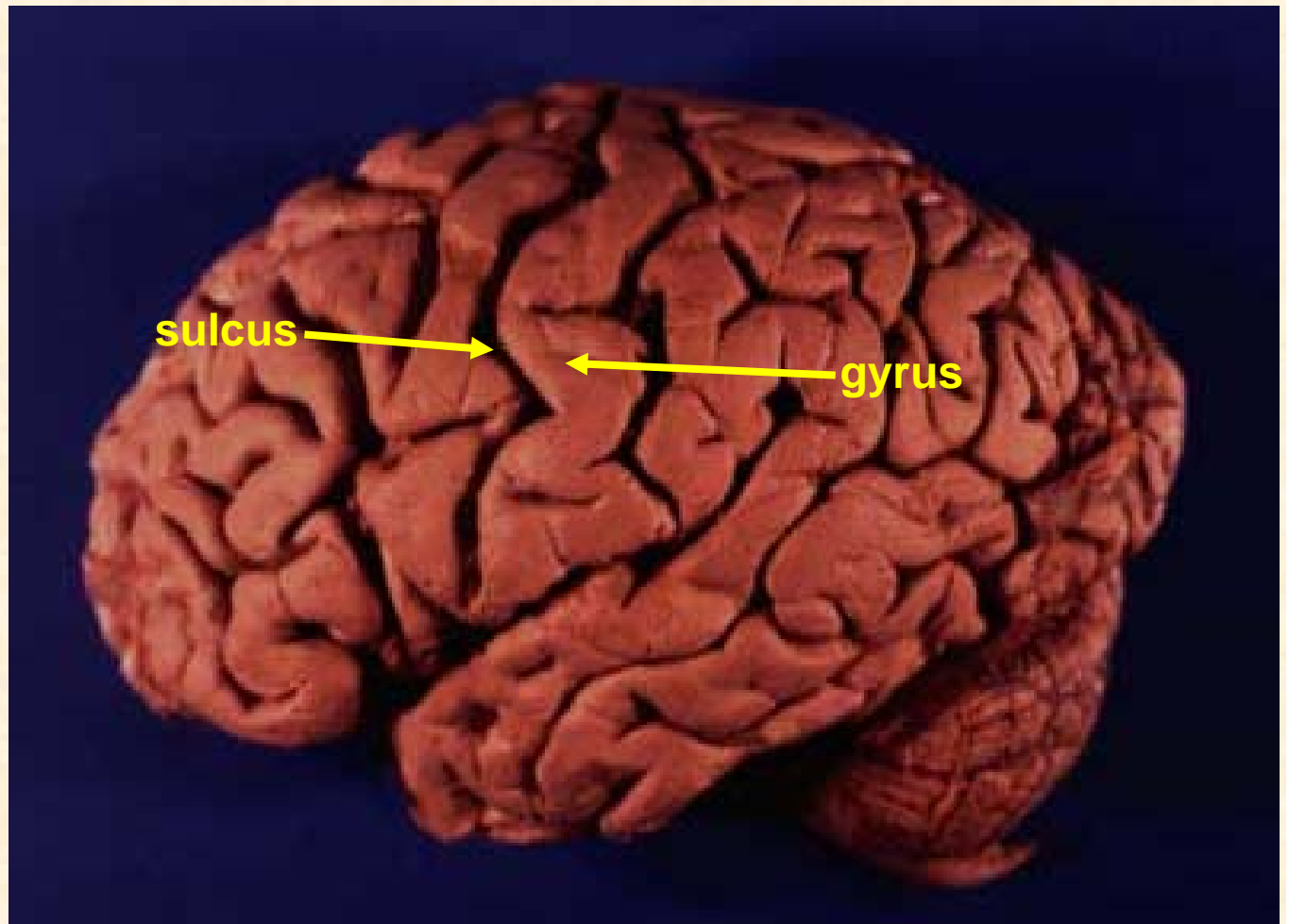
SURFACES OF THE CEREBRAL HEMISPHERE

Each hemisphere has 3 surfaces:

- Superolateral surface.
- Medial surface.
- Inferior surface.



- The surfaces of the cerebral hemisphere show elevations called **GYRI** & grooves called **SULCI**.
- Deep sulci are called fissures.
- The surface of the hemisphere is divided into different areas.
- Each area contains a group of cells that perform a specific function.



THE SUPEROLATERAL SURFACE

Important sulci & gyri:

Central sulcus (of Rolando):

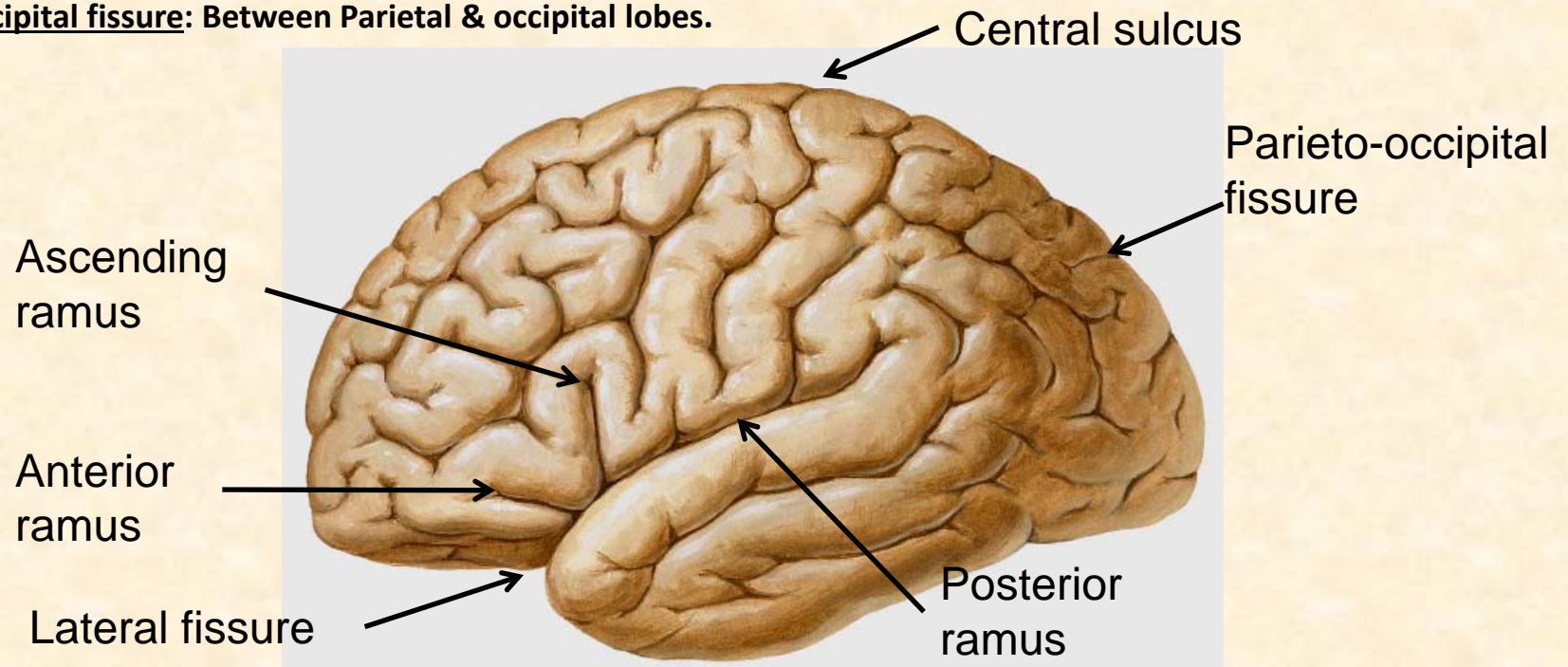
Extends from the superomedial border at a point a little behind the midpoint between the frontal & occipital poles. It ends slightly above the middle of the posterior ramus of lateral fissure. Begins on medial surface

Lateral fissure (of Sylvius):

It begins on the inferior surface (stem) lateral to the anterior perforated substance & extends laterally to reach the lateral surface where it divides into 3 branches:

- Anterior ramus: Runs forwards in the inferior frontal gyrus
- Ascending ramus: Ascends in the inferior frontal gyrus.
- Posterior ramus: Runs backwards & ends by turning upwards in the parietal lobe.

Parieto – occipital fissure: Between Parietal & occipital lobes.



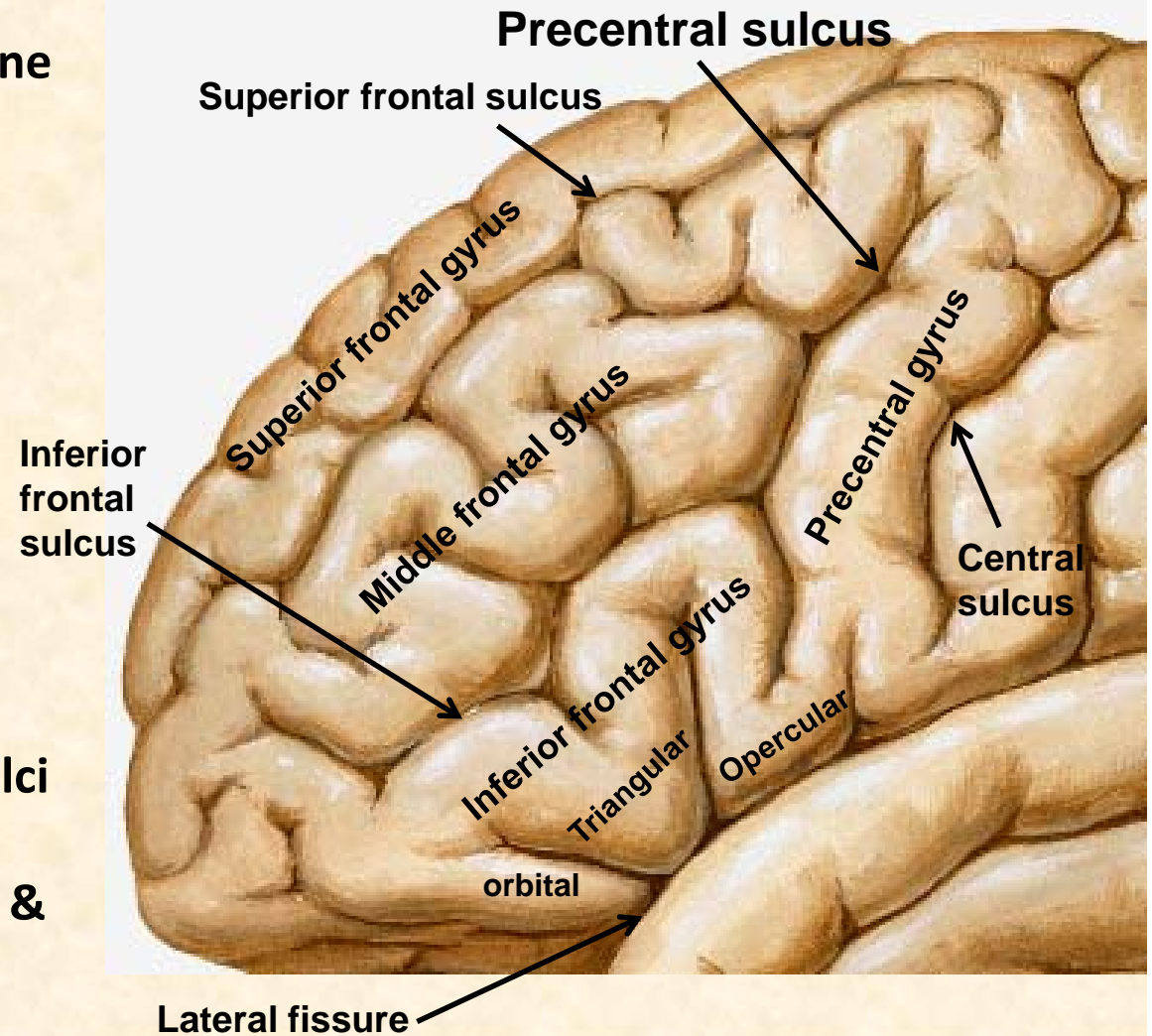
Sulci & Gyri of the frontal lobe

- Precentral sulcus: Parallel to & one finger in front of the central sulcus.
- Superior Frontal sulcus
- Inferior frontal sulcus

Gyri of the Frontal lobe:

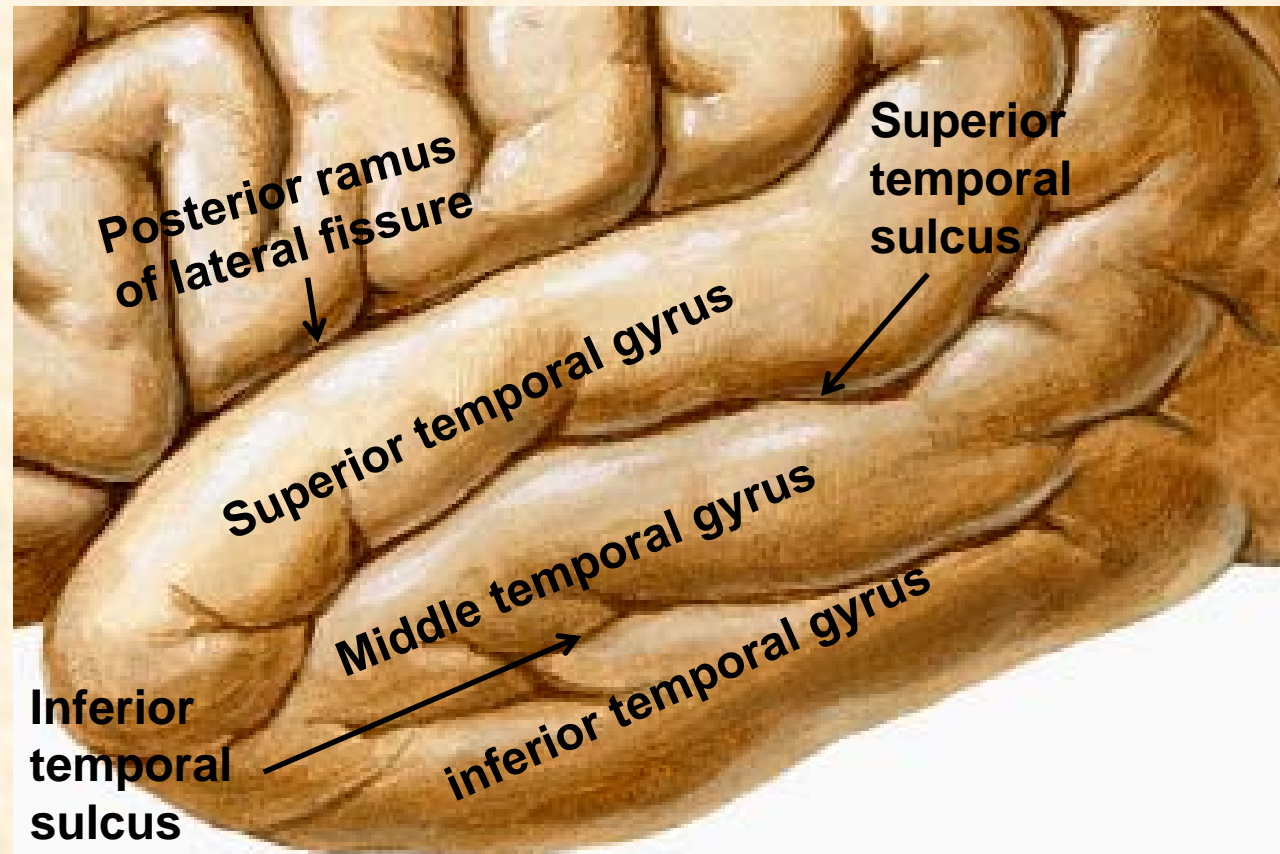
It is divided by the sulci of the frontal lobe into:

- Precentral gyrus: Between central & precentral sulci.
- Superior & inferior frontal sulci divide the remaining part equally into superior, middle & inferior frontal gyri



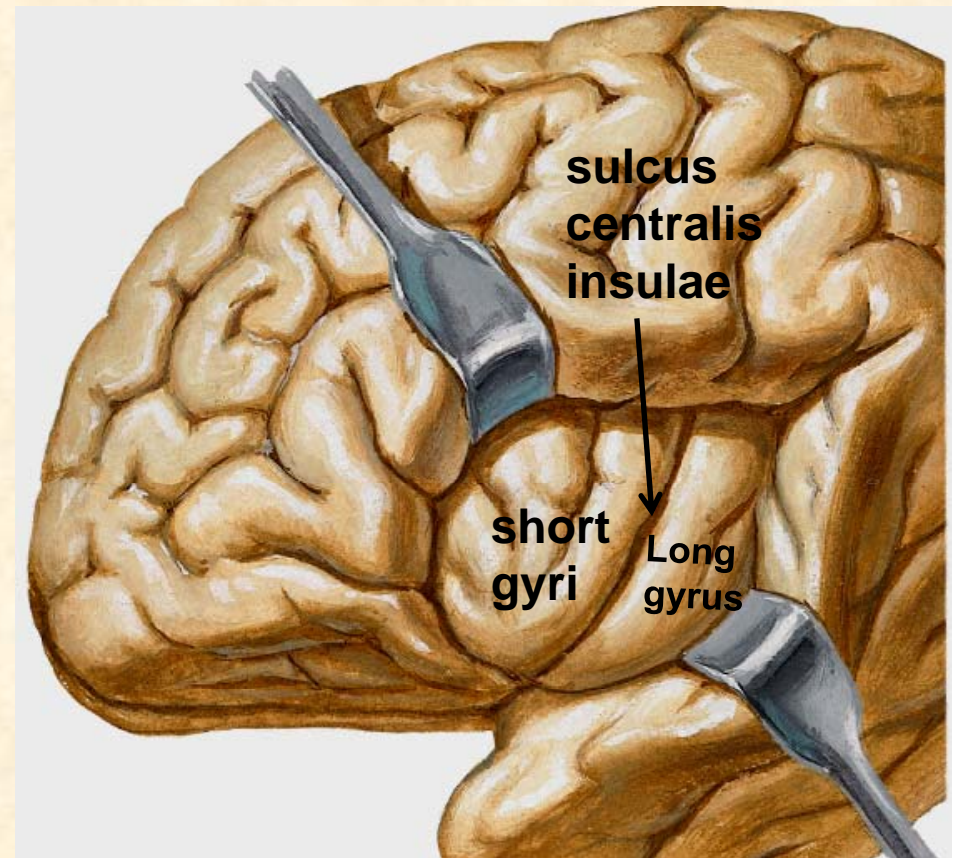
Sulci & Gyri of the Temporal lobe

- It contains 2 sulci : Superior & inferior temporal sulci.
- The 2 sulci divide the temporal lobe into 3 gyri: superior, middle & inferior temporal gyri.



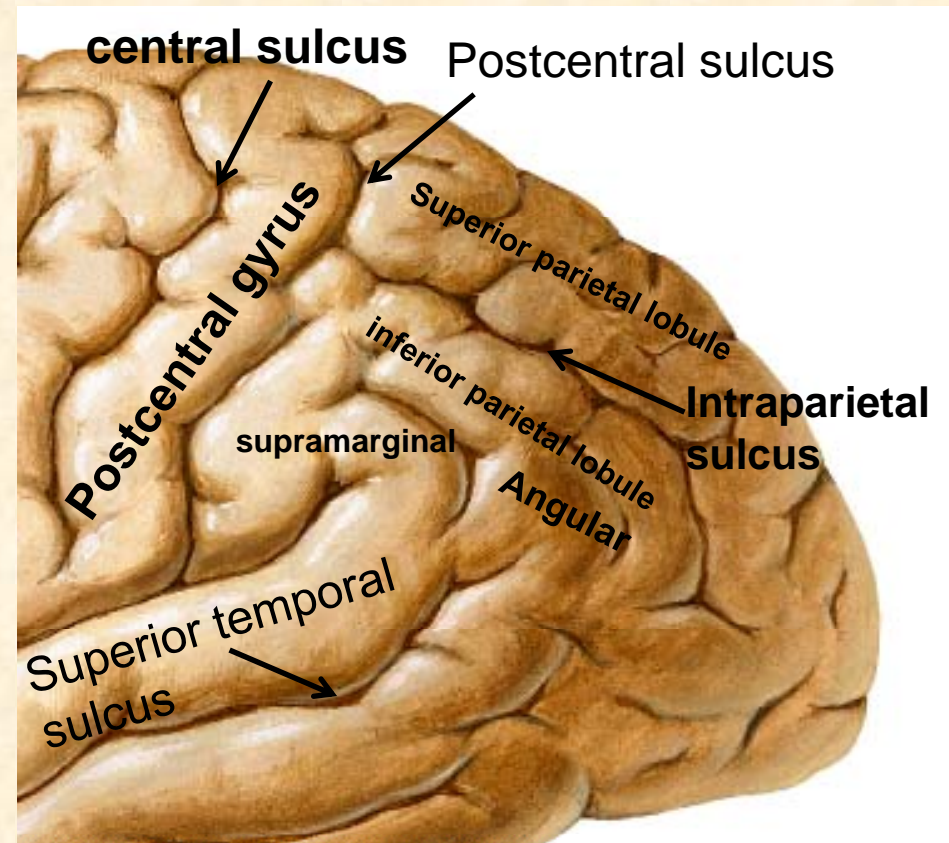
The insula (Island of Reil)

- It lies at the bottom of the lateral fissure. It is conical in shape having a base (surrounded by circular sulcus) & an apex directed inferiorly towards the anterior perforated substance.
- It is divided by sulcus centralis insulae into:
 - Anterior part divided into 3-4 short gyri.
 - Posterior part with one long gyrus which is usually divided near its upper part.
- Its function is related to taste (gustatory area)



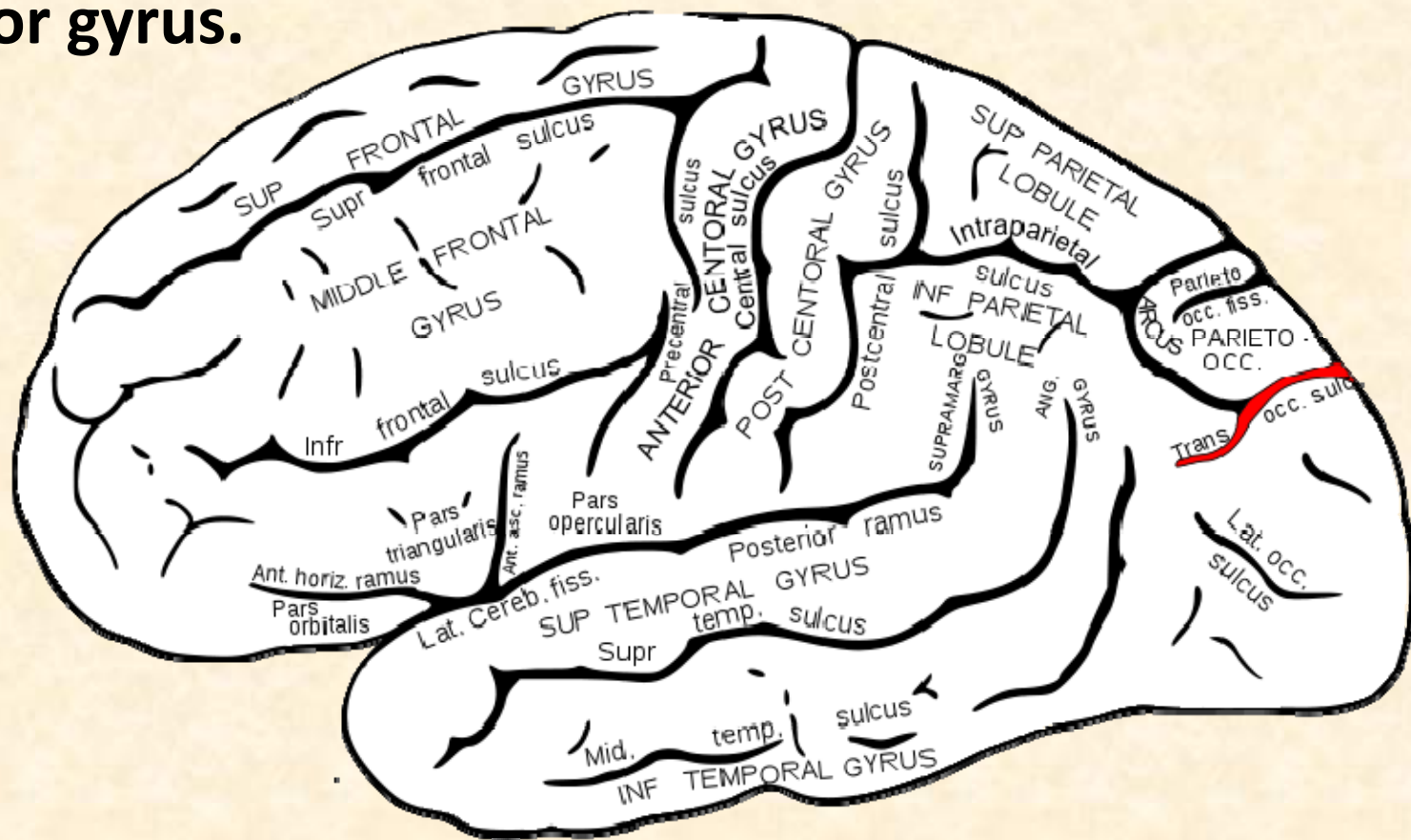
Sulci & Gyri of the Parietal lobe

- **Postcentral sulcus:** parallel to & one finger behind the central sulcus.
- **Postcentral gyrus:** Between the central & postcentral sulci.
- **Intraparietal sulcus:** Begins at the middle of the postcentral sulcus & divides the remaining part of the parietal lobe into:
 - **Superior parietal lobule.**
 - **Inferior parietal lobule:** Is further divided into:
- **Supramarginal gyrus:** Above the upturned end of the post ramus of lateral fissure.
- **Angular gyrus:** Above the upturned end of superior temporal sulcus area 39
- **Posterior part:** Above the upturned end of the inferior temporal sulcus




The Occipital Lobe

- Transverse occipital sulcus (lunate)
- Lateral occipital sulcus (horizontal): divides the lateral surface of the occipital lobe into a **superior** and an **inferior gyrus**.

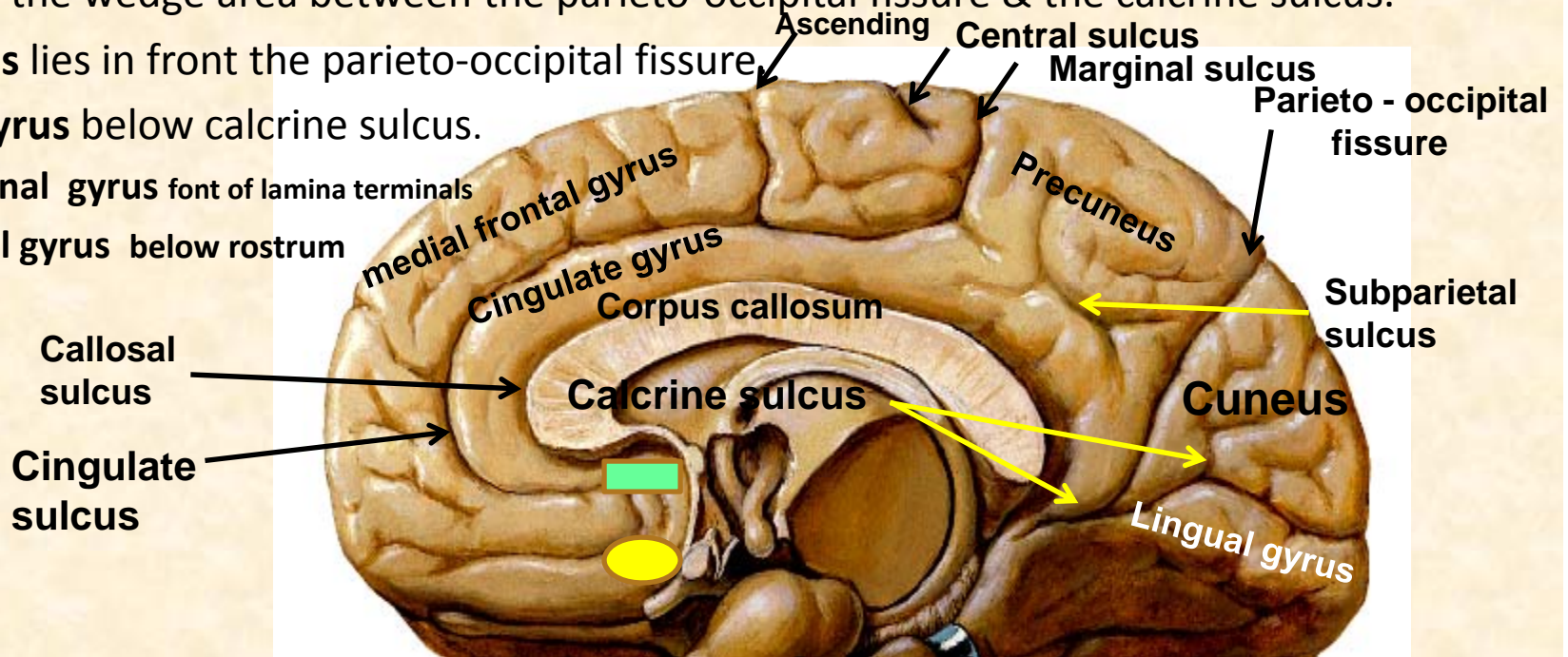


Sulci & Gyri of the medial surface

- **Callosal sulcus** surrounds CC.
- **Cingulate sulcus** runs parallel to CC & terminates by turning upwards to meet the superomedial border. It gives ascending branch above the middle of the body of CC which divides the area above cingulate sulcus into anterior part: medial frontal gyrus & paracentral lobule. Ends above as marginal sulcus.
- **Cingulate gyrus** lies between CC & cingulate sulcus.
- **Subparietal (suprasplenial) sulcus** appears as a continuation of cingulate sulcus.
- **Parieto-occipital fissure** between the parietal & occipital lobes.
- **Calcrine sulcus** begins near the occipital pole.
- **Cuneus** is the wedge area between the parieto-occipital fissure & the calcrine sulcus.
- **Precuneus** lies in front the parieto-occipital fissure.
- **Lingual gyrus** below calcrine sulcus.

 **Para terminal gyrus** font of lamina terminals

 **Subcallosal gyrus** below rostrum

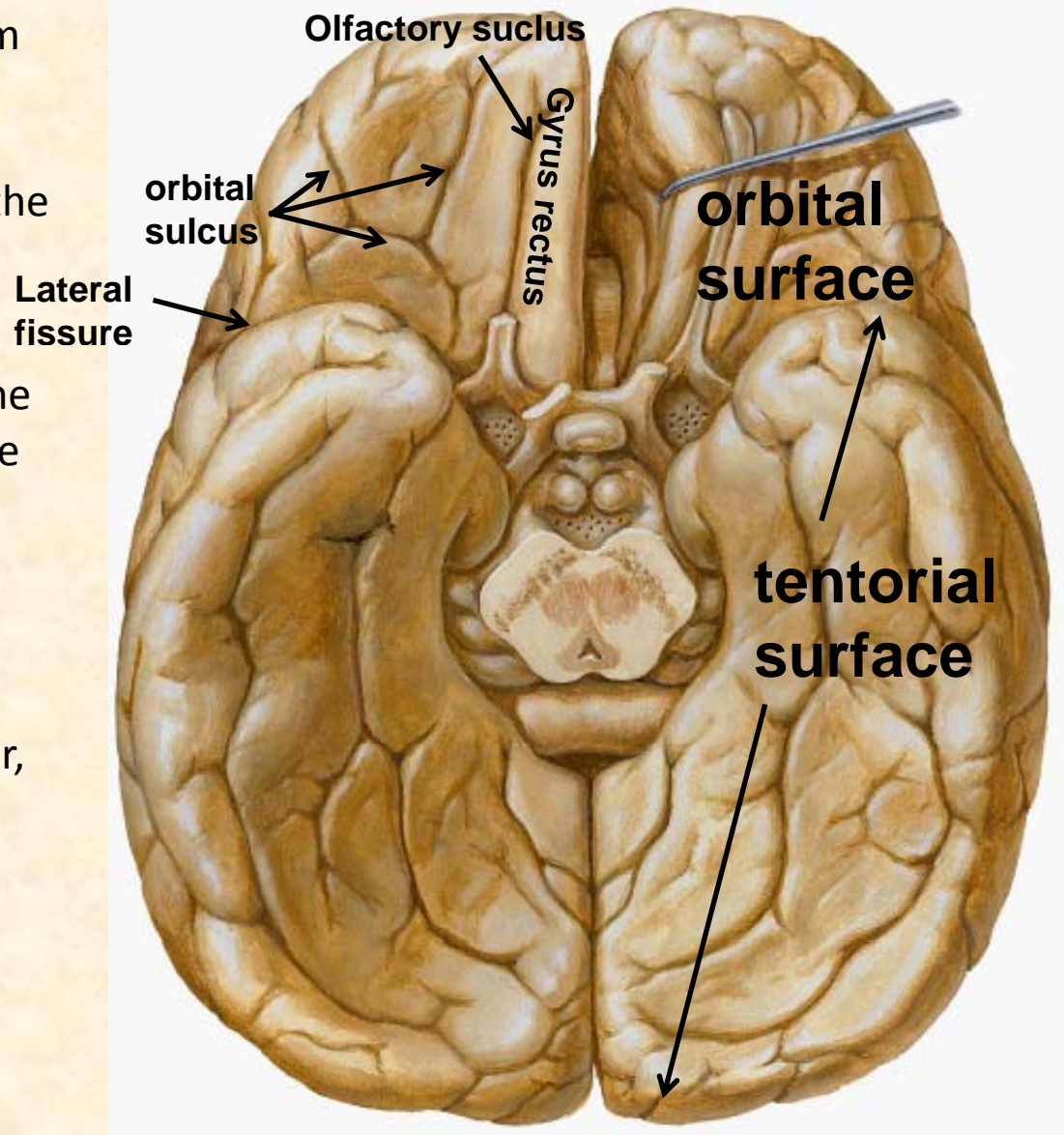


Sulci & Gyri of the inferior surface of the brain

The inferior surface is divided by the stem of the lateral fissure into a smaller anterior part known as the **orbital surface** & a posterior part known as the **tentorial surface**.

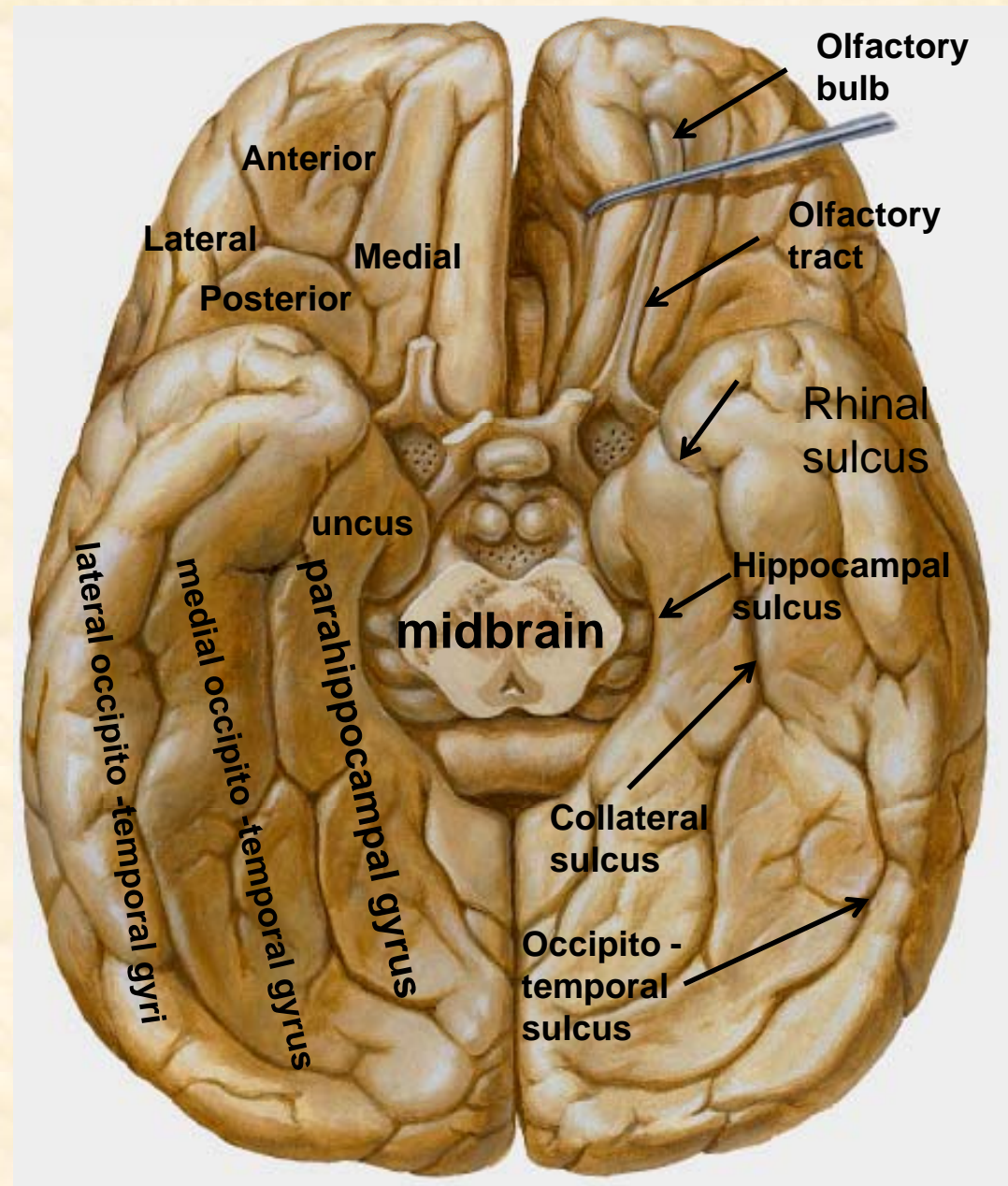
The orbital surface:

- **Olfactory suclus**; near & parallel to the median fissure. It is overlapped by the olfactory bulb & tract.
- **Gyrus rectus** lies medial to the olfactory suclus.
- H-shaped **orbital sulcus** divide the remaining part into anterior, posterior, lateral & medial orbital gyri.



The tentorial surface:

- **Hippocampal sulcus** separates the parahippocampal gyrus from the midbrain.
- **Collateral sulcus**: below & parallel to the calcarine sulcus.
- **Lingual gyrus** between the calcarine & collateral sulci.
- **Rhinal sulcus** separates the temporal pole from the uncus.
- **Occipito -temporal sulcus** lies between the medial occipitotemporal or fusiform gyrus & lateral occipito -temporal or inferior temporal gyrus.



Morphological Classification of Cortical Areas

- ❖ based on cytoarchitectonic studies
- ❖ Campbell (1905) ----- about 20 areas
- ❖ **Brodmann (1909) ----- 47 areas**
 - most popular
- ❖ Vogt and Vogt (1919) - over 200 areas
- ❖ von Economo (1929) -- 109 areas

Functional Localization of Cerebral Cortex

Sensory area

primary sensory area (post central gyrus)

Lesion : (Contralateral hemianesthesia)

secondary sensory area (no marked lesion)

Motor area

primary motor area 4 (precentral gyrus)

lesion : (Contralateral hemiplegia)

secondary (pre) motor area 6

controls trunk, shoulder and hip big muscles

supplementary motor area (SMA)

lesion (difficulty in coordination and planning of movement)

Association area

parietal, occipital and temporal cortex

prefrontal (frontal) cortex - thinking and learning

- judgment, foresight (lesion Alzheimer)

Motor Areas

primary Motor Area (M I) area 4

Premotor Area (PM) area 6

Supplementary Motor Area SMA

Frontal Eye Field area 8

Broca's area of speech area 44,45

Primary Motor Area

M I (area 4)

precentral gyrus of lateral surface

anterior part of paracentral lobule

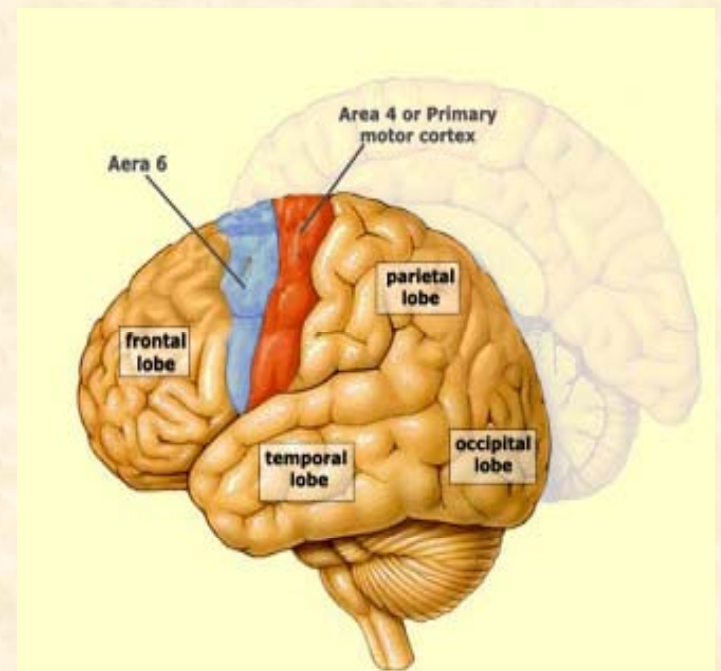
giant pyramidal cell of Betz (5th layer)

afferents: premotor area (40%), SMA, parietal sensory, VL, VPL of thalamus

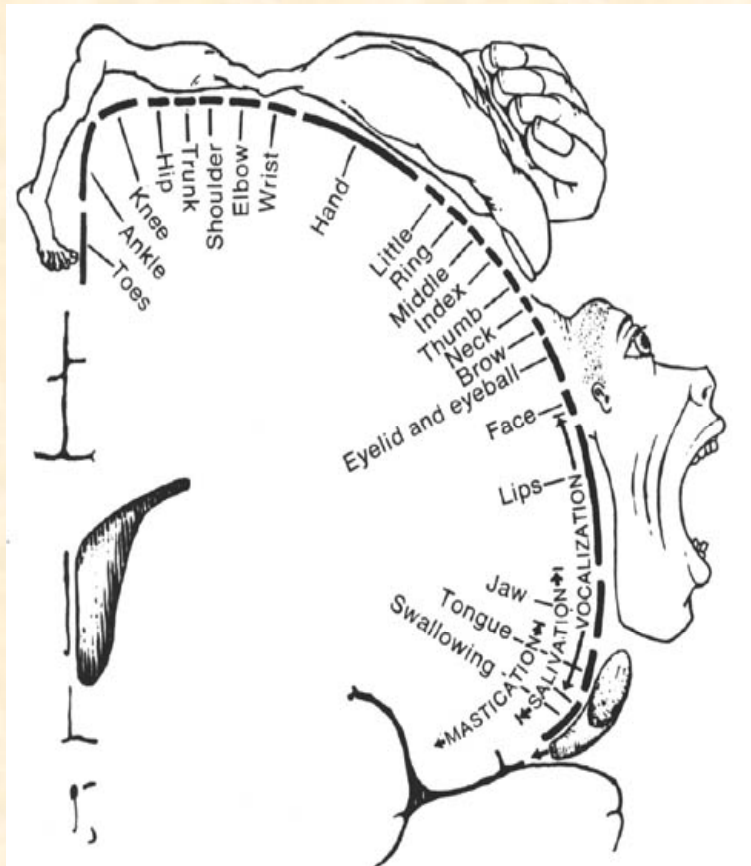
Motor Homunculus

Function: fine specific discrete movement mainly extremities

lesion Upper Motor Neuron (UMN) syndrome (contra lateral hemiplegia)



Motor Homunculus



Other Motor Areas

Premotor Area (PM) ----- area 6
(Extrapyramidal center)

afferents: VL, VPL thalamus ,from cerebellum, basal ganglia

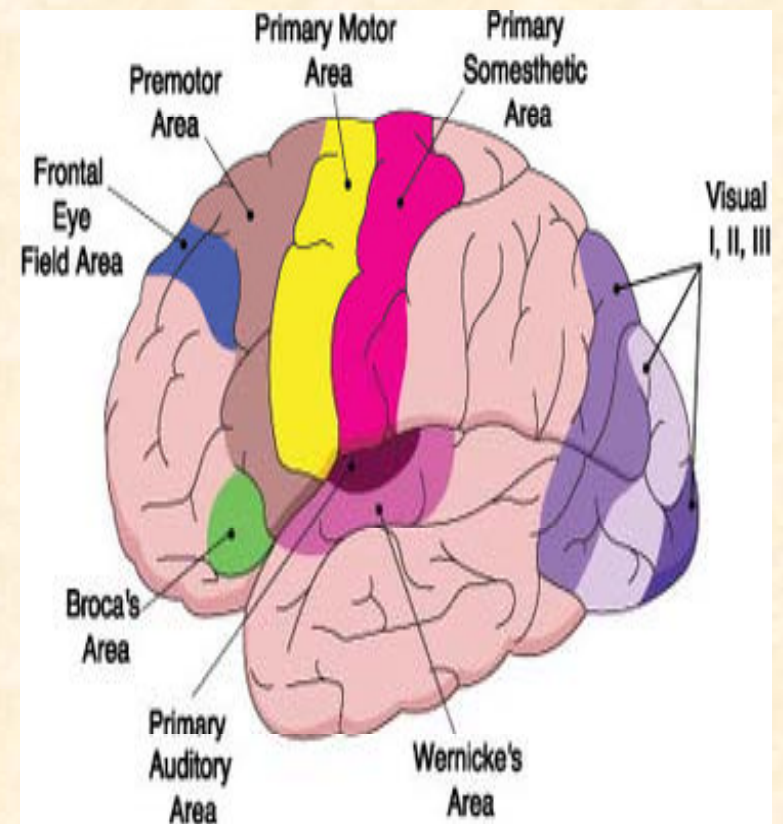
Site: in front of area 4 broad above narrow below

Function: storing motor programs ,coordination of coarse movement mainly trunk, shoulders and hip muscles.

Inhibitory to muscle tone

Send inputs to M4

Lesion: motor apraxia, spasticity, loss of postural stability



Supplementary Motor Area (SMA)

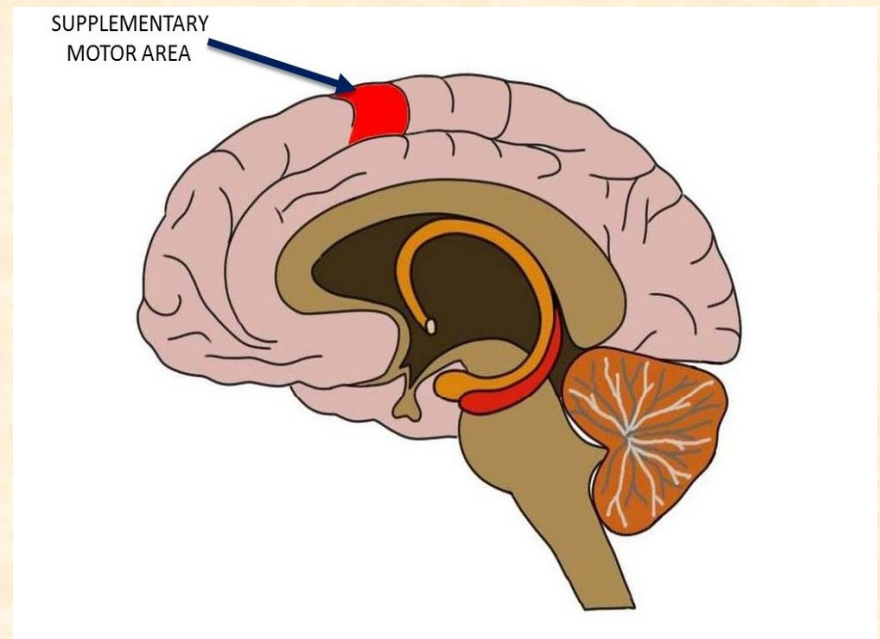
Extrapyramidal centre

afferents: VL of thalamus, from basal ganglia

Site: (mostly on the medial frontal gyrus anterior to paracentral lobule)

Function: postural stabilization of the body, the coordination of both sides of the body and the control of sequences of movements.

Lesion: not definite



Frontal Eye Field ----- 8

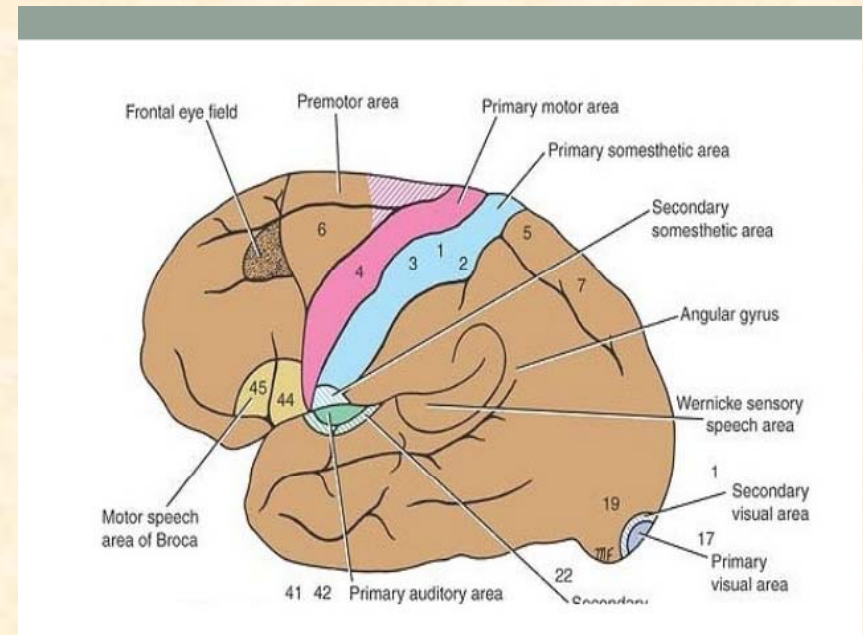
Site: in front of premotor area

mainly middle frontal gyrus

Connected to visual area in
occipital lobe.

Function: voluntary tracking
movement (conjugate
movement) to the opposite side

lesion :(deviation of both eyes to
same side of lesion)



Motor (Broca's) area of speech 44

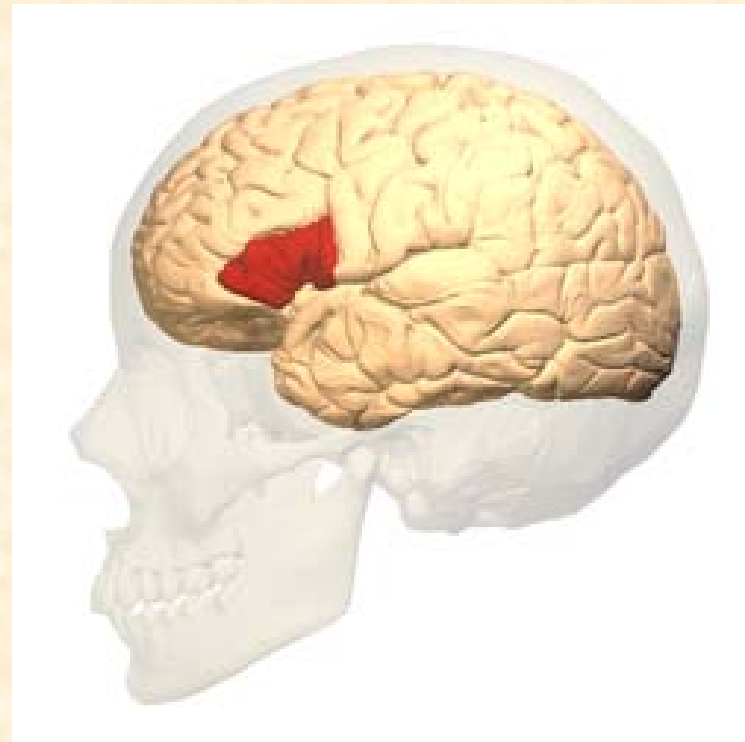
Site: inferior frontal gyrus

Mainly on the left dominant hemisphere

Function: coordination of muscles of larynx, mouth, tongue and palate.

Connected to wernicke's area through arcuate fasciculus

Lesion: (motor aphasia) non flueunt aphasia



Sensory areas

Primary sensory area (3,1,2)

Site: post central gyrus

Extends on the paracentral lobule
Representation of the body as motor area.

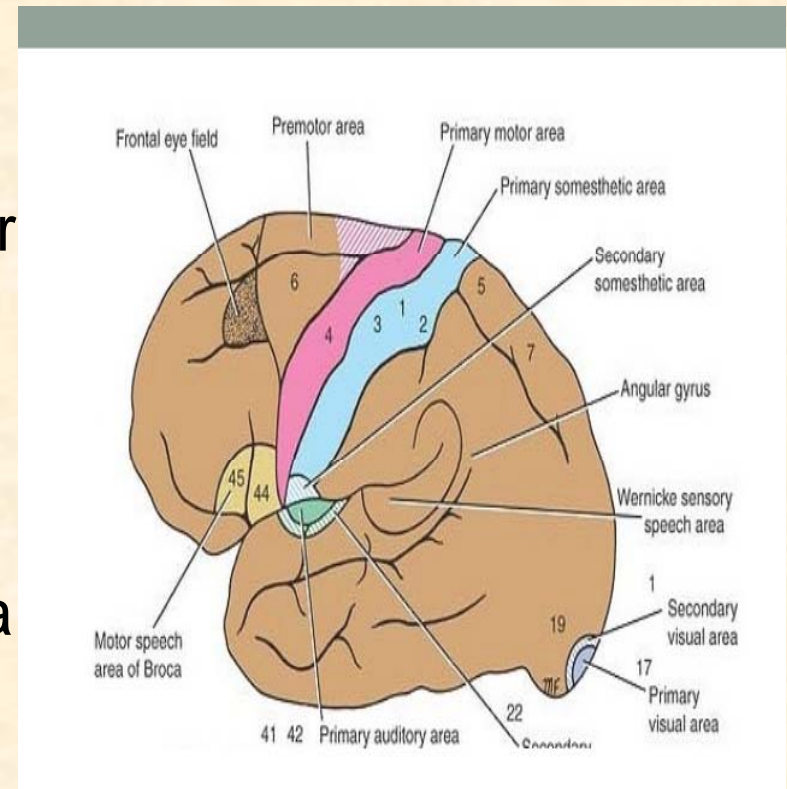
Function: localize, discriminates different sensations.

Gives 20% of pyramidal tract

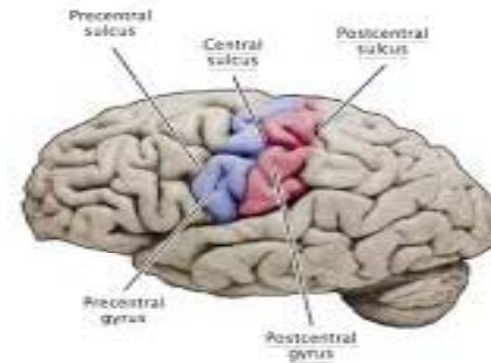
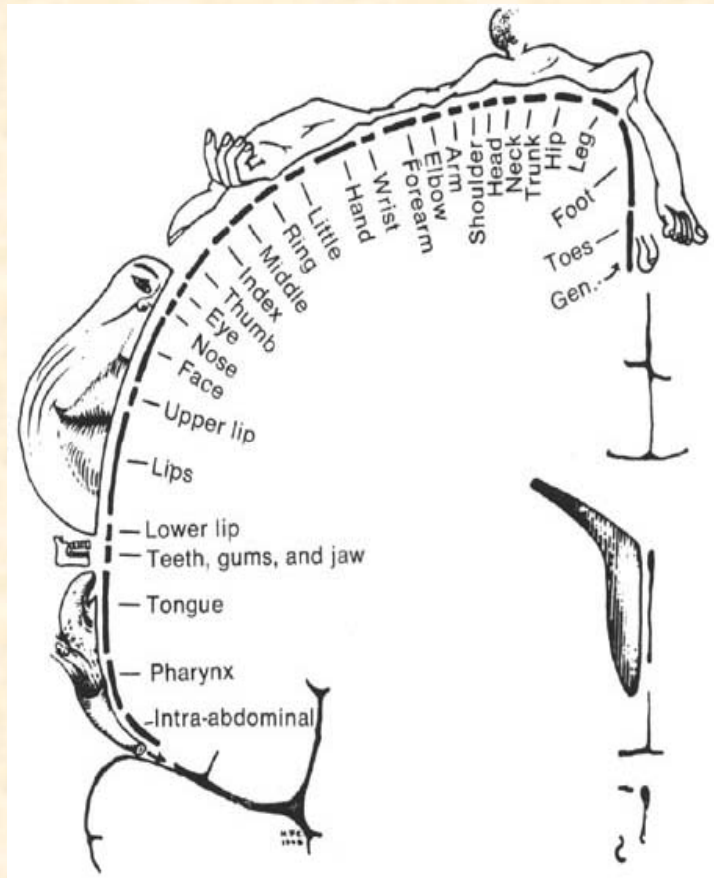
Lesion: contralateral hemianesthesia

Secondary sensory area

Lowermost part of postcentral gyrus (depth of lateral sulcus)



*Primary sensory area
3,1,2 (general
sensations)*



Postcentral gyrus

Lesion: contralateral hemianesthesia

Other Sensory Areas

Visual Area (vision)	V I, V II
Auditory Area (Hearing)	A I, A II
Vestibular Area (Equilibrium)	
Gustatory Area (Taste)	
Olfactory Area (Smell)	

Visual Cortex

V I ----- 17 (striate cortex)

site: around calcarine sulcus lips (cuneus above and lingual below)
receive visual radiations from LGB

Function: visual perception

lesion: contralateral homonymous hemianopia with macular sparing.

V II ---- 18, 19 (visual association area)

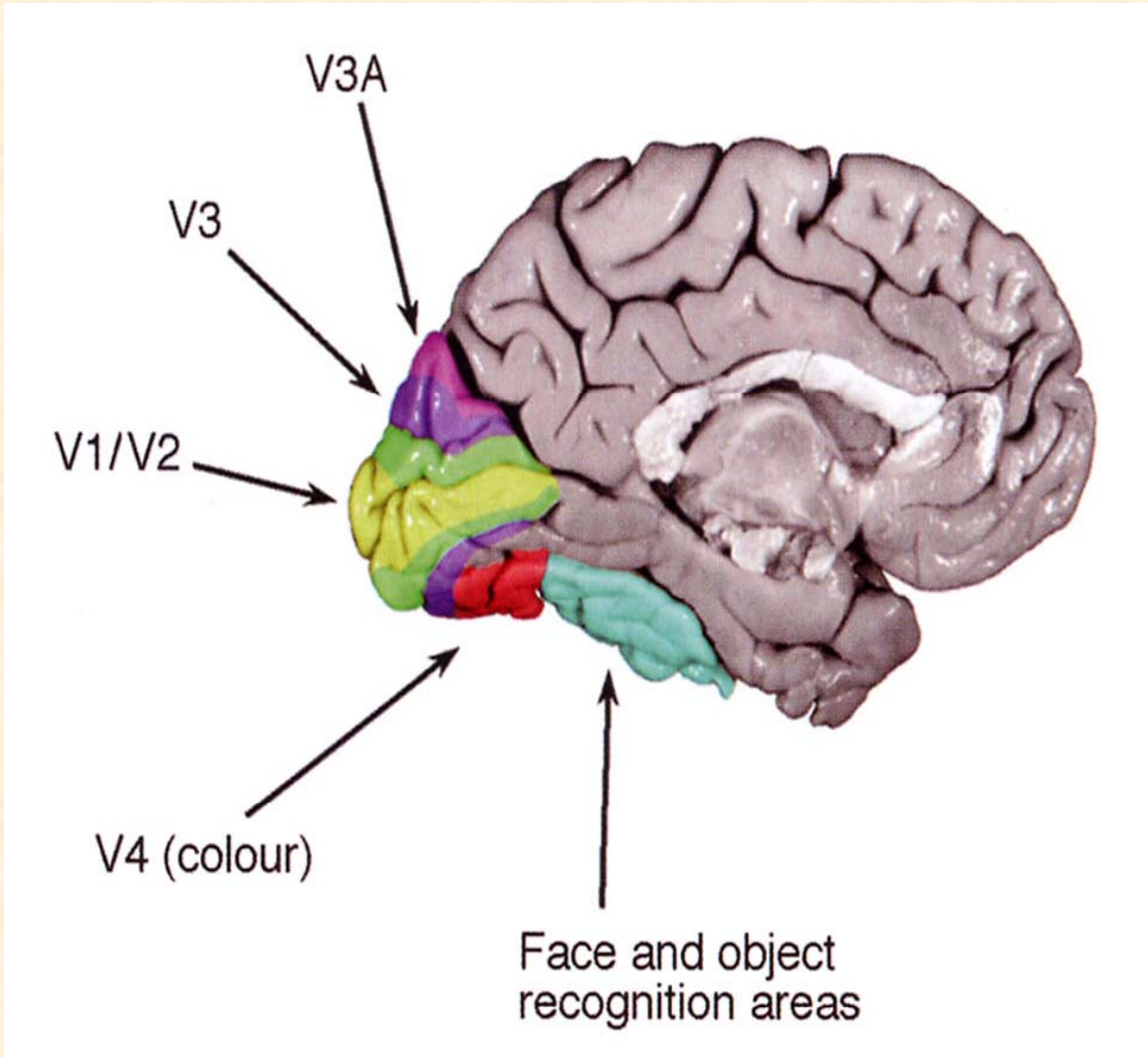
Site: remainder of cuneus and lingual gyri

Function: Interpretation of visual stimulus with past experience

lesion: visual agnosia and colour blindness

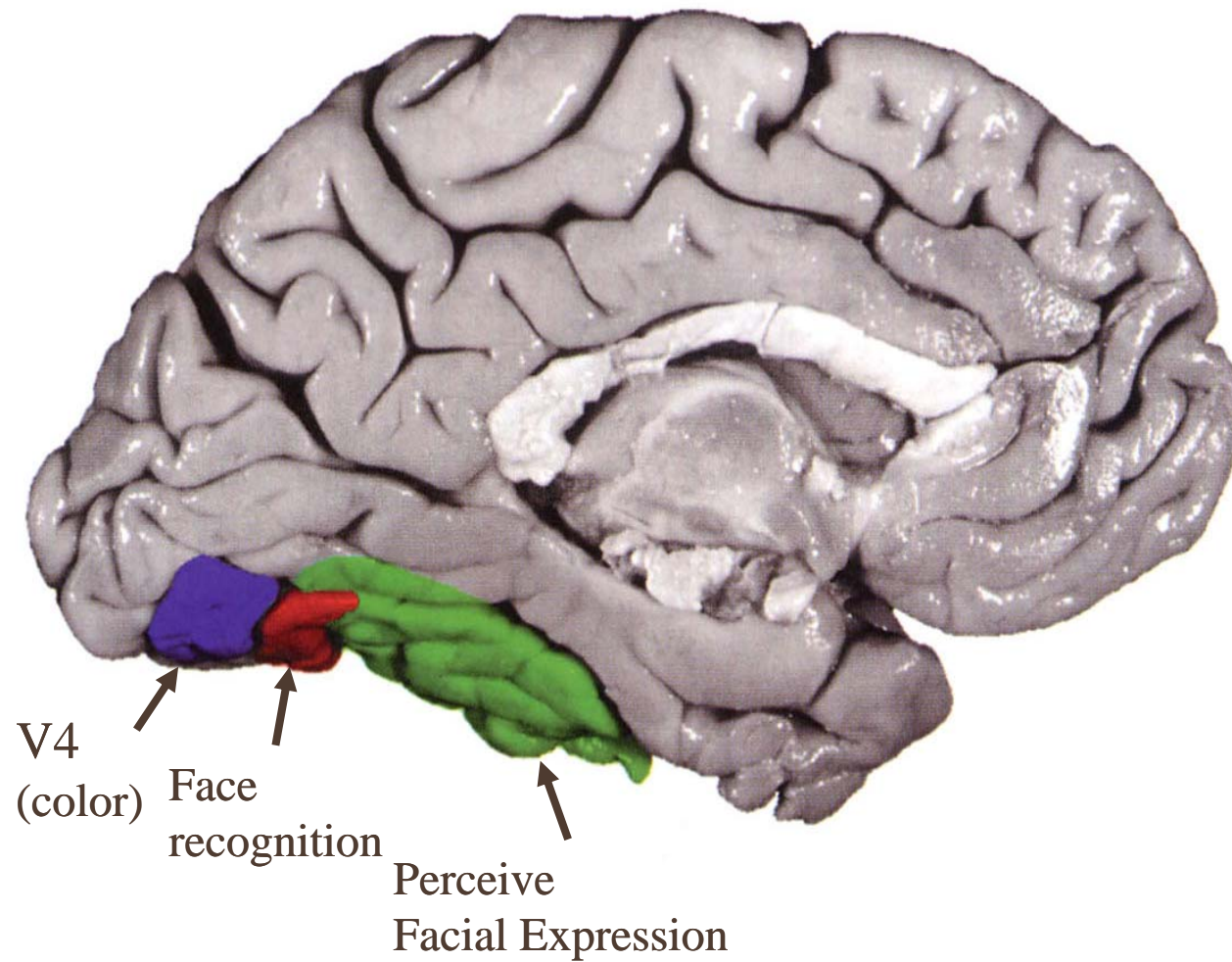
Occipital eye field area (rest of occipital lobe)

Function: reflex conjugate movement of both eyes to opposite side

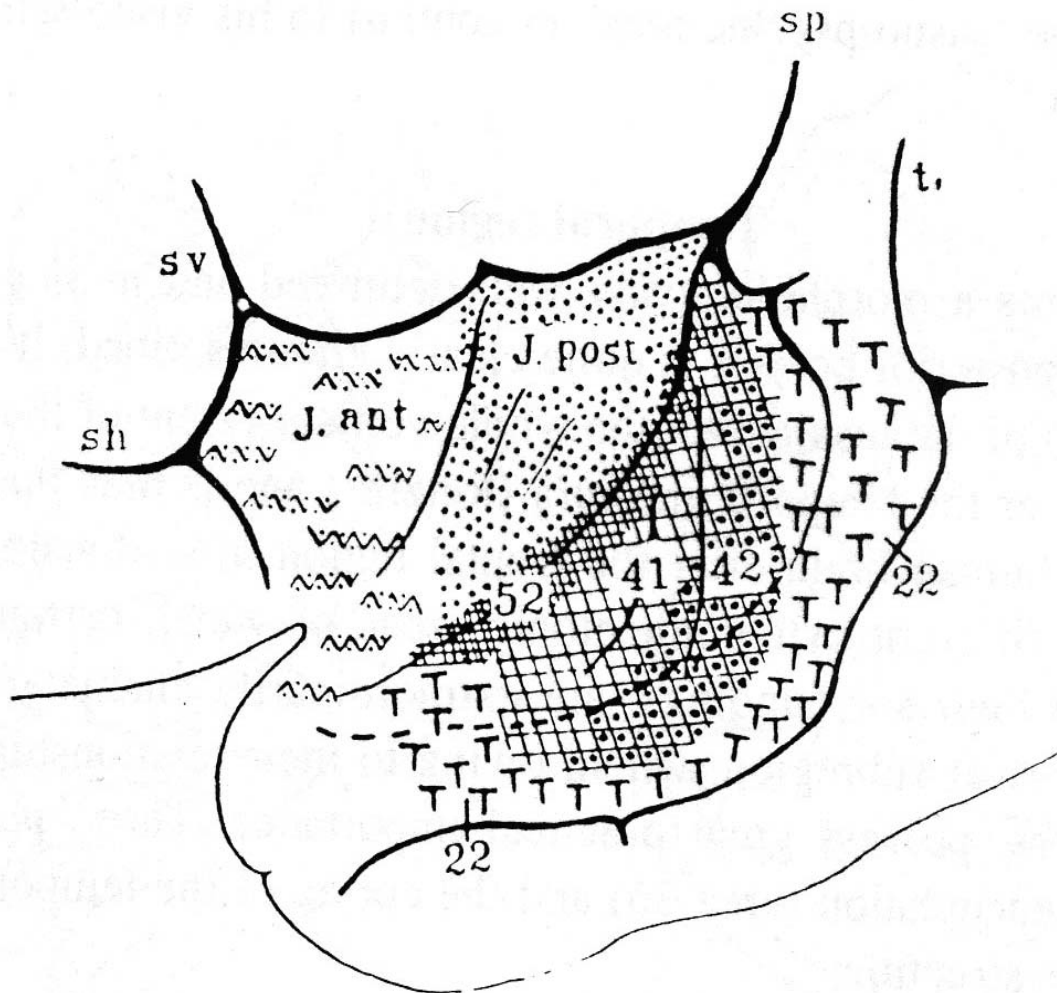


Visual
Areas

Visual association areas



Auditory Areas (SUPERIOR TEMPORAL GYRUS)



A I primary auditory
----- 41, 42

Lesion: hearing
defect

A II auditory
association----- 22

Lesion : auditory
agnosia

Auditory Areas (SUPERIOR TEMPORAL GYRUS)

Primary auditory area 41,42

Site: middle of the superior temporal gyrus

Function: perception, analysis of pitch, intensity of sound

Lesion: reduction of hearing acuity on both ears mainly on opposite side.

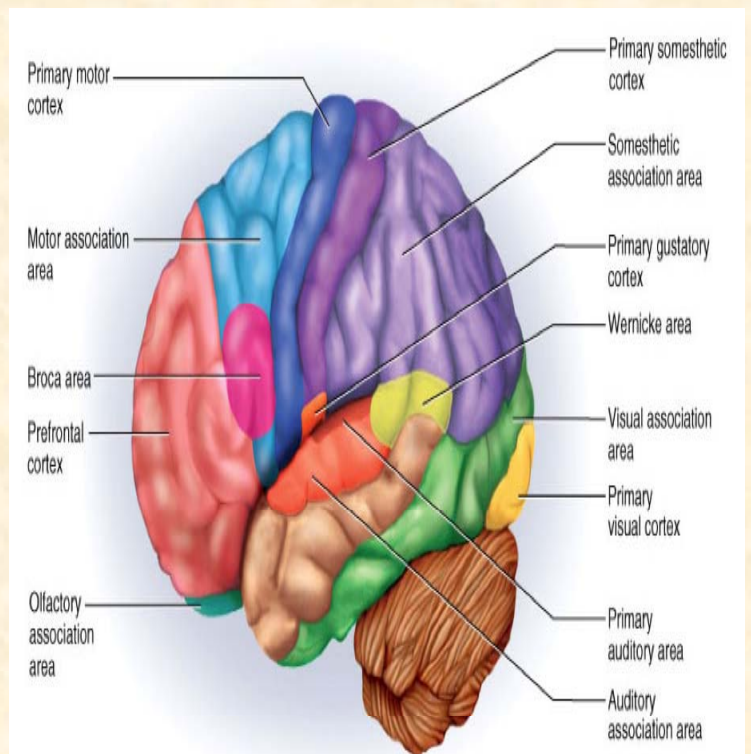
auditory association---- 22

Site: back of superior temporal gyrus along with wernicke's area

Function: interpretation of auditory stimulus

Lesion: auditory agnosia

Rest of temporal lobe -----memory



Other Primary Sensory Areas

Vestibular Area

[superior temporal gyrus posterior part]

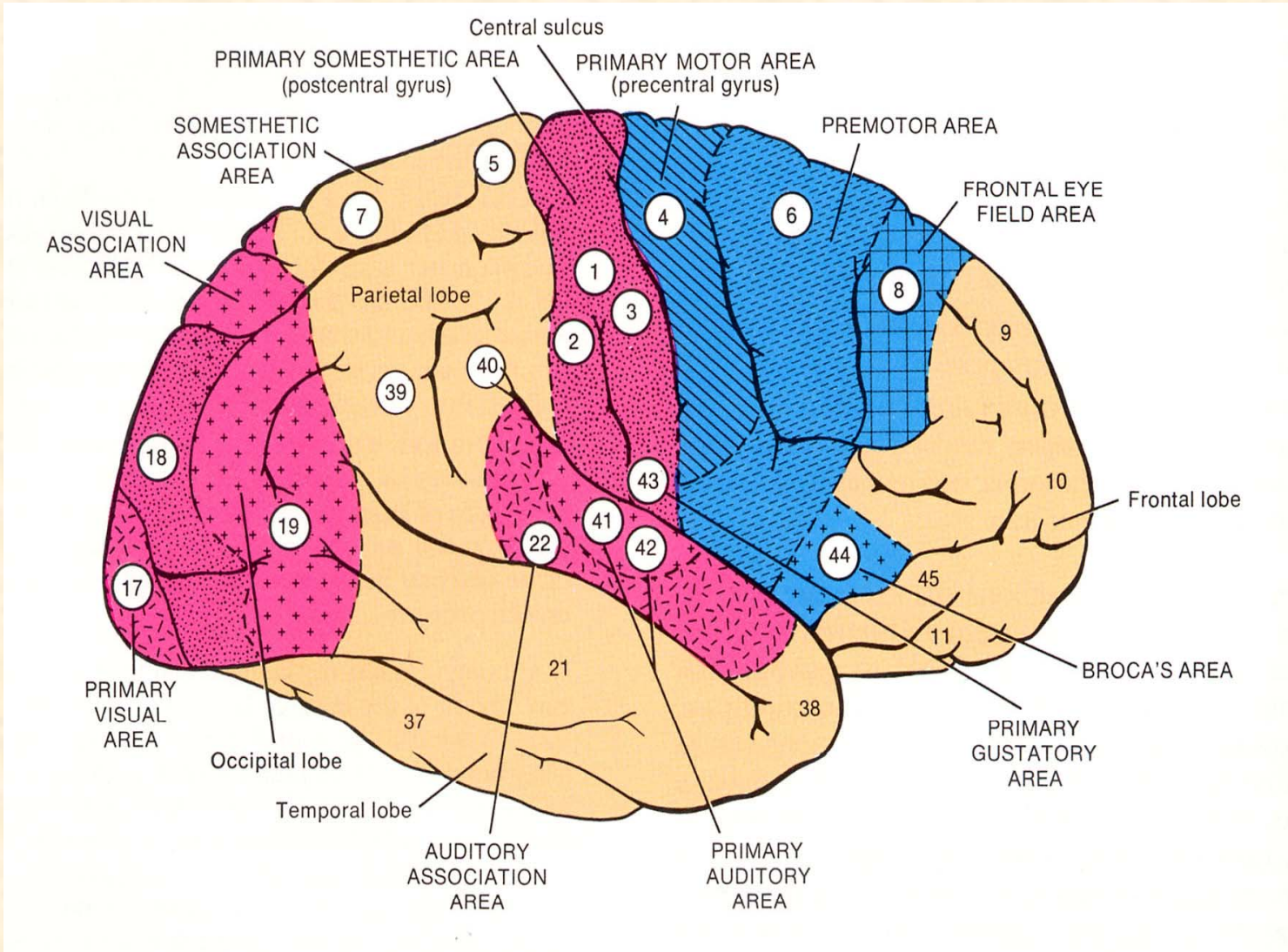
Gustatory Area

Area 43 (inferior end of postcentral gyrus)

+Insula

Olfactory Area

Uncus- piriform area= uncus and adjoining hippocampal gyrus (rhincephalon), smell center



Association Areas

1- Language Areas ----- 22, 39, 40, 44, 45 (discussed later)

2- Posterior Parietal Association Area + supramarginal and angular gyri
5, 7 (39, 40)

body image know object by feeling it **lesion (Asterognosis)**

3- Temporal Association Area (22)

multisensory integration

lesion (acoustic or verbal agnosia)

4- Visual association area agnosia (19) **lesion visual agnosia**

5- Prefrontal Association Area 9, 10, 11, 12

Site: greater part of frontal cortex

connected with thalamus, hypothalamus, corpus striatum

Function: judgment, foresight, personality (Alzheimer?) amyloid degeneration and schizophrenia (low dopamine)

Disorders of Association Cortex

❖ Agnosia

Tactile agnosia (Asterognosis)

Visual agnosia

Auditory agnosia

❖ Apraxia (posterior parietal damage and or premotor area 6), CC

❖ Aphasia

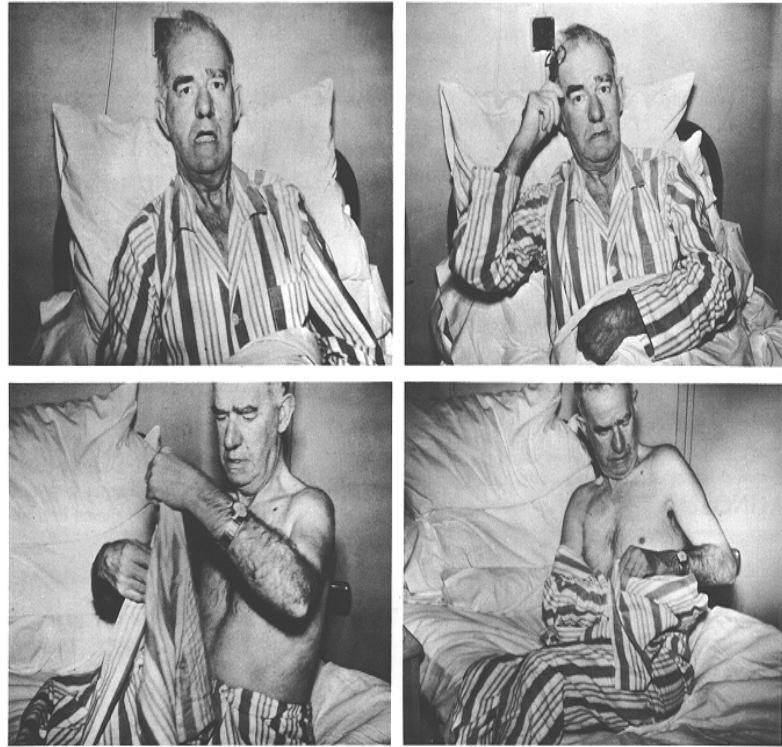
1- Wernicke's (receptive) aphasia (2ND language)

→ 2- Broca's (Motor) aphasia (expressive)

1+2 global aphasia

3- Conduction aphasia

Apraxia



The inability to execute a voluntary motor movement despite being able to demonstrate normal muscle function. Lesion is mainly due to injury of posterior parietal area or the split brain syndrome due to corpus callosum injury.

Language Areas

Motor Language Area (Broca's area) --- 44, 45

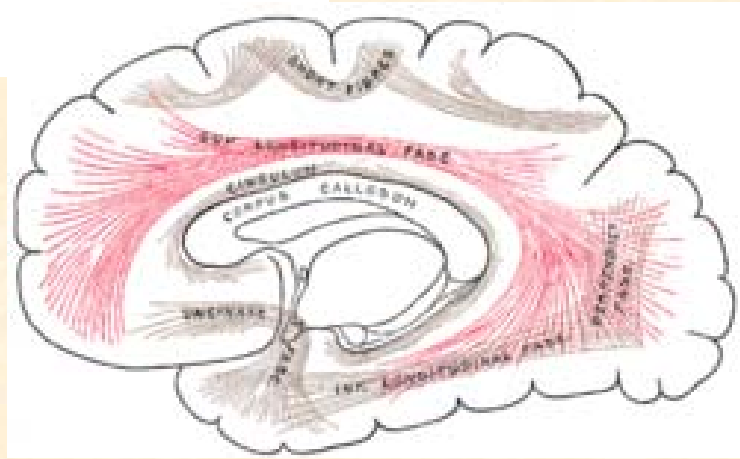
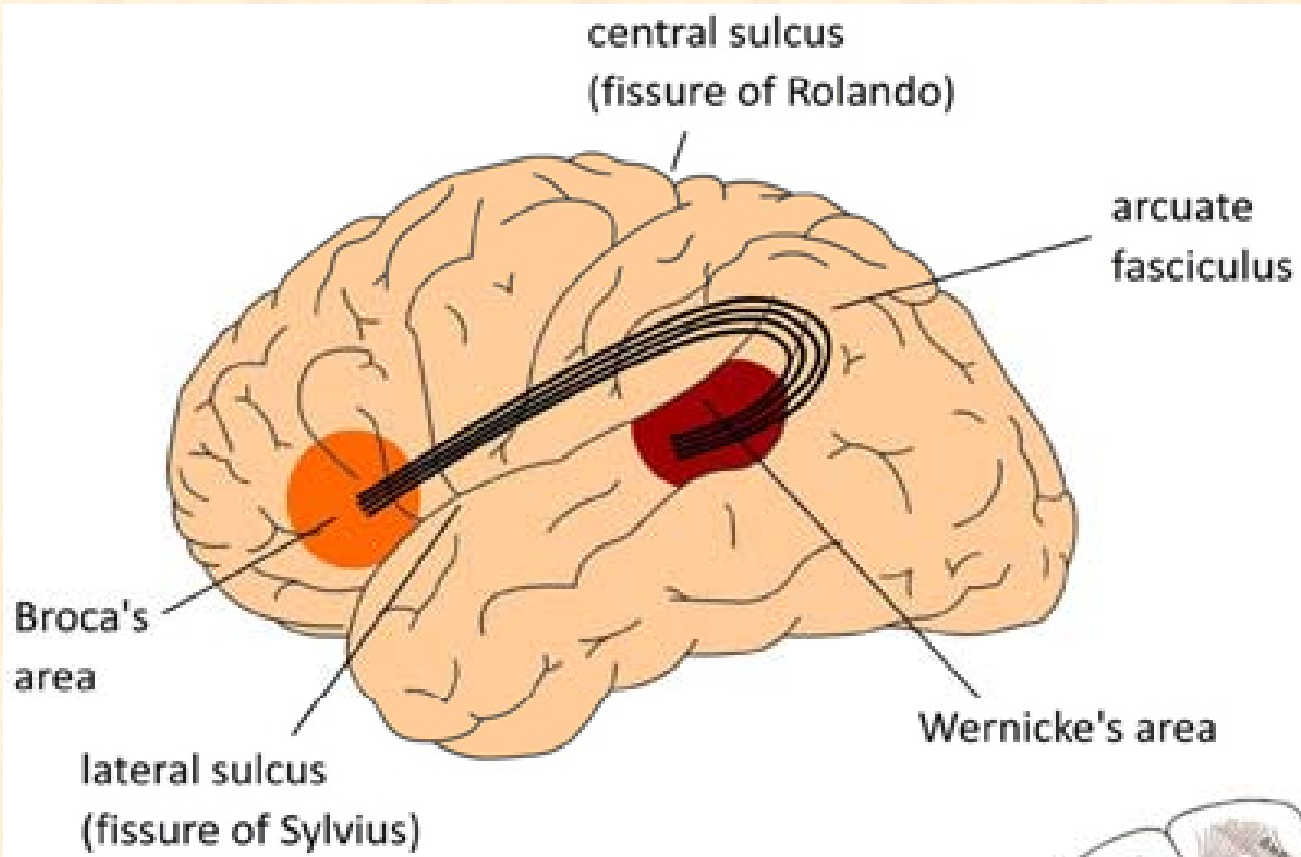
lesion Motor Aphasia (non-fluent aphasia)
good comprehension, poor speech

Sensory Language Area (Wernicke's area) ---- 22, 39,40

Site: left dominant hemisphere of superior temporal gyrus
extending into posterior end of lateral sulcus into parietal lobe
Connected to Broca's area by arcuate fasciculus
Receives fibers from visual and auditory areas.

Function: Understanding written and spoken words
enables person to read and understand

**Works in coordination with angular gyrus (39) and supra
marginal gyrus (40)**



Lesions:

(Fluent aphasia)

Receptive Aphasia - area 22 defect in comprehension, good spontaneous speech (inability to understand spoken, written)

Anomic Aphasia - word finding difficulty

Jargon aphasia - fluent, but unintelligible not understood

Global aphasia: both Broca's and Wernicke's.

Superior Longitudinal Fasciculus

lesion: Conduction Aphasia

good comprehension, good spontaneous speech poor repetition, poor response

Angular gyrus (39)

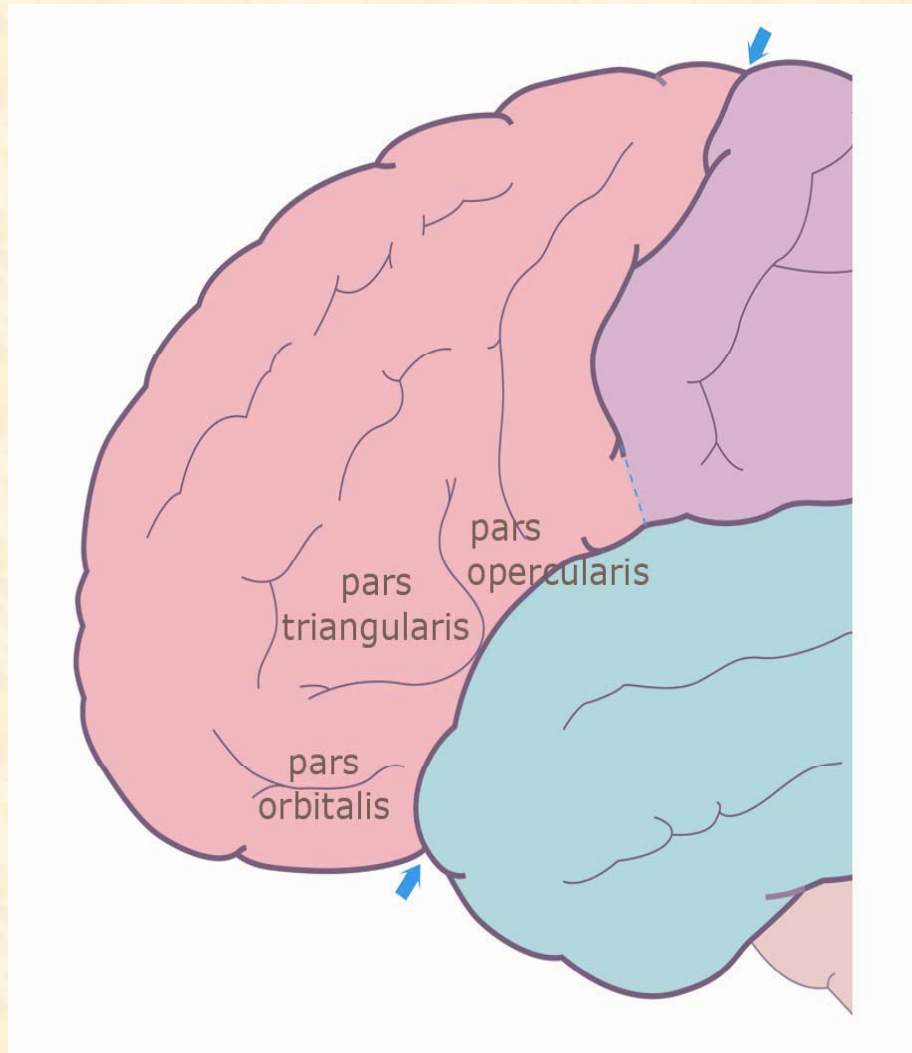
Site: around posterior end of superior temporal gyrus

Lesion: Agraphia : inability to write or identify drawn objects

Alexia: inability to read

Acalculia: inability to solve small calculations

Speech area

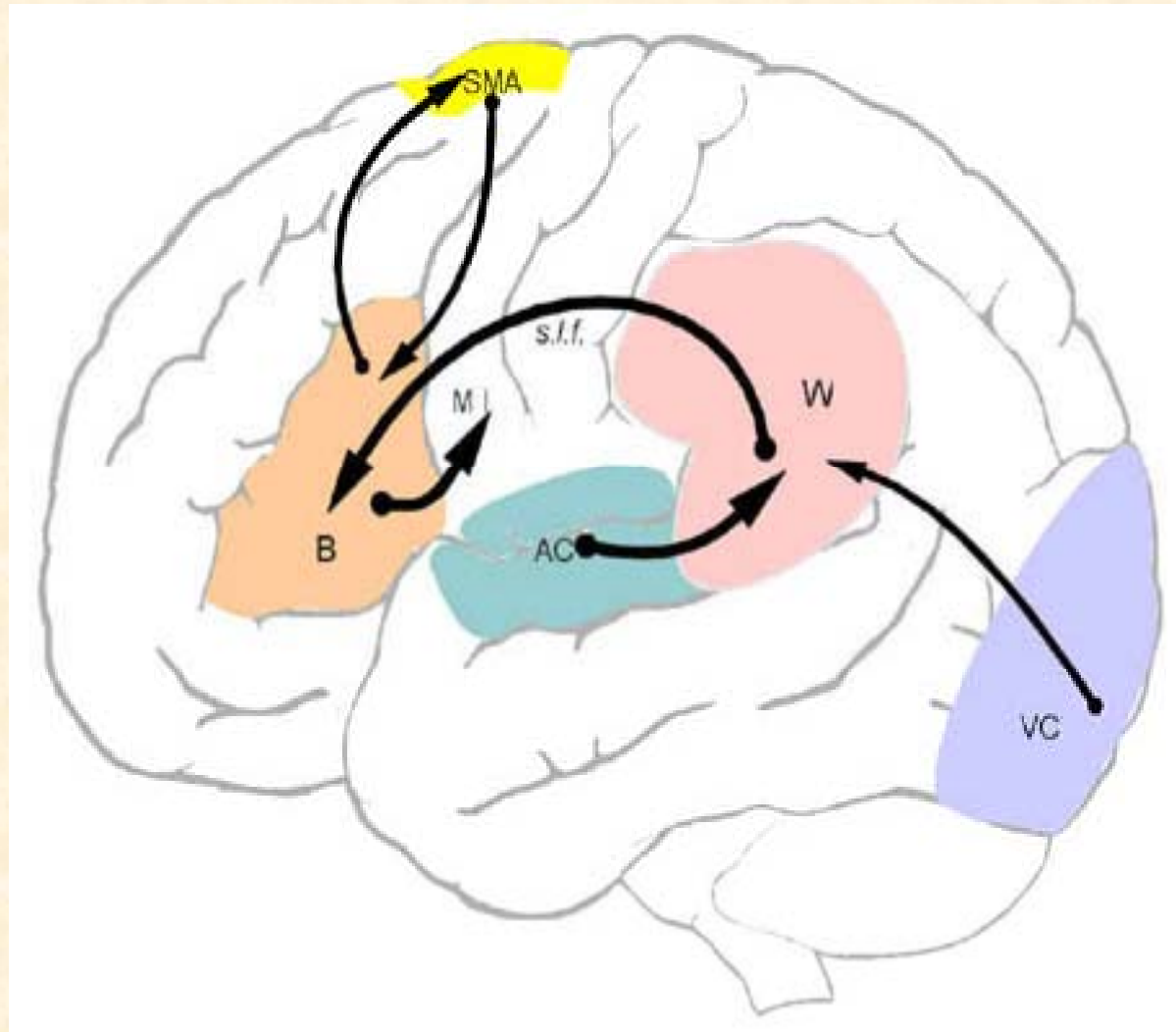


Broca's area

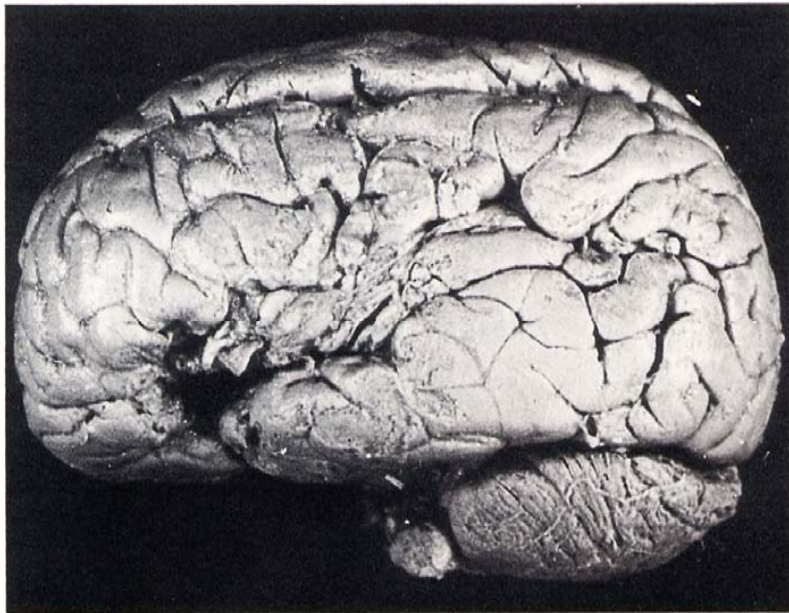
Pars Opercularis

Pars Triangularis

Pars Orbitalis

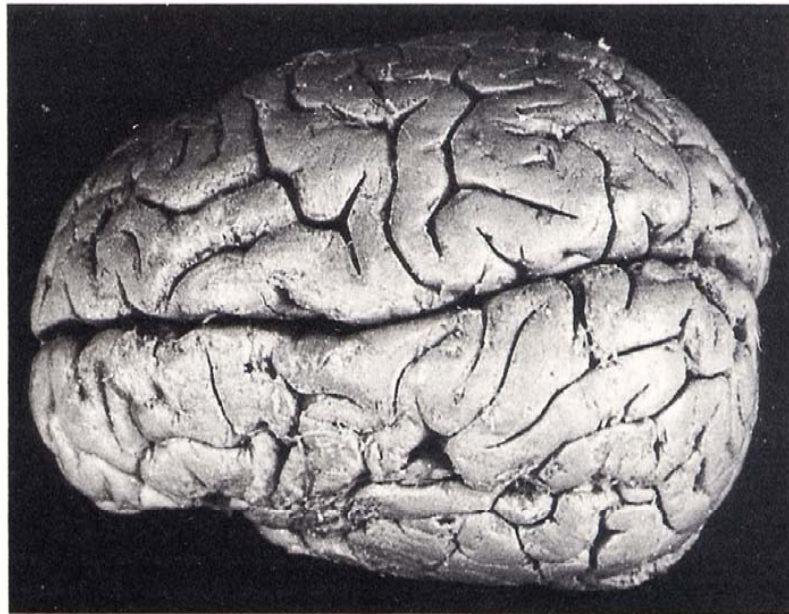


Language Areas

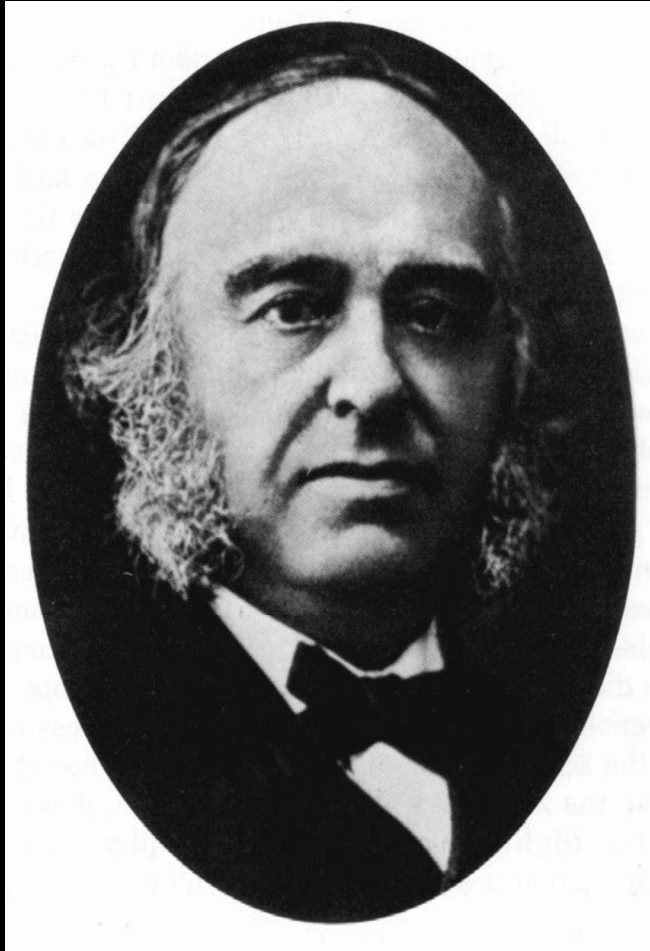


Broca's Area

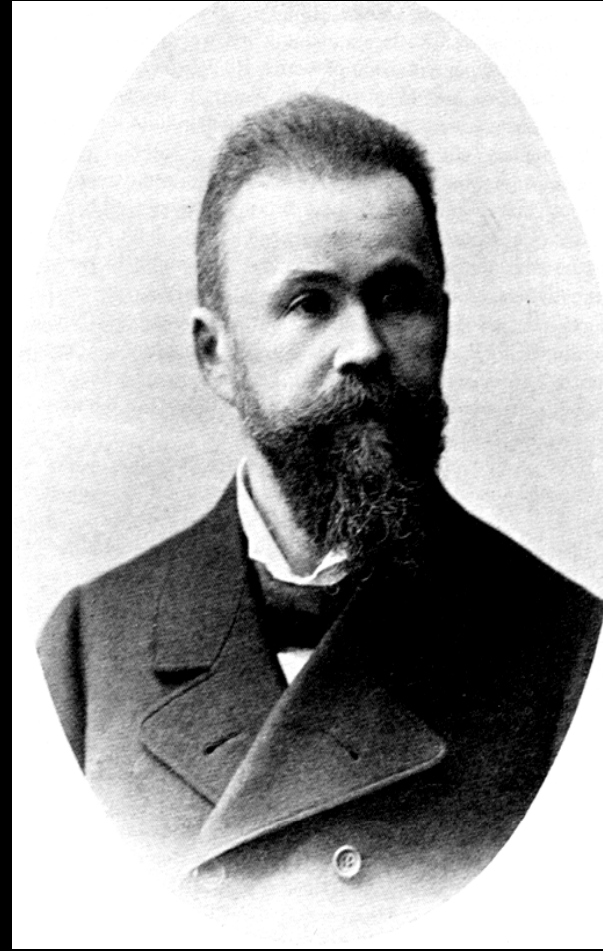
*Pars triangularis and
pars opercularis of the
inferior frontal gyrus of
dominant hemisphere*



*Photograph of the brain of
Broca's patient.*



Paul Broca (1824-1880)



Carl Wernicke (1848-1905)

THE MAIN FUNCTIONAL AREAS OF THE DIFFERENT LOBES OF THE BRAIN

The Frontal lobe:

- Contains motor area (4) which controls muscles of the opposite half of the body. Premotor area (6), Frontal eye field (8) & Broca's (motor) area for speech (44,45)

The parietal lobe:

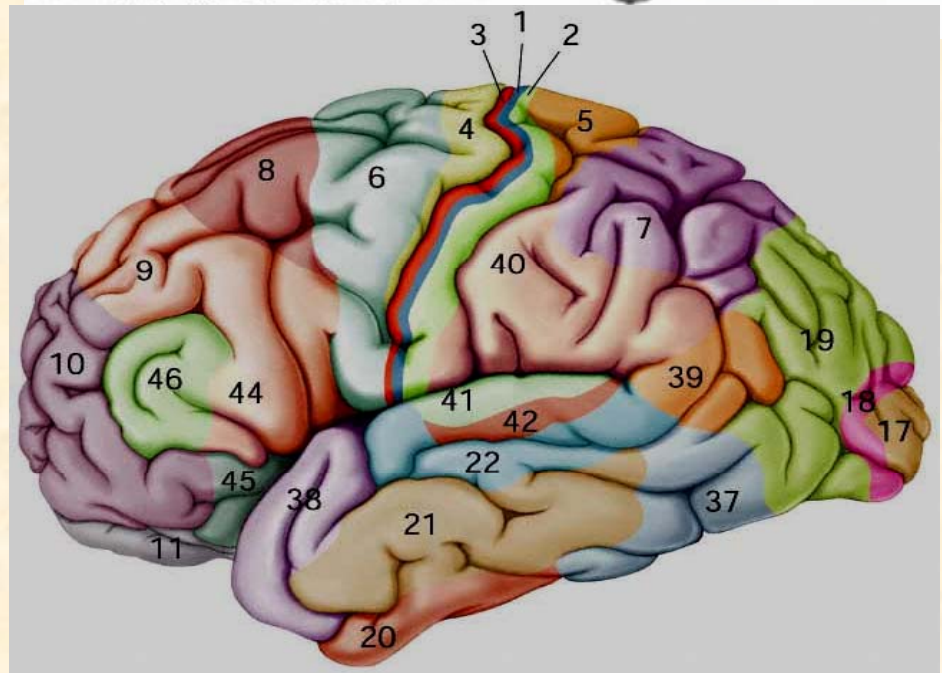
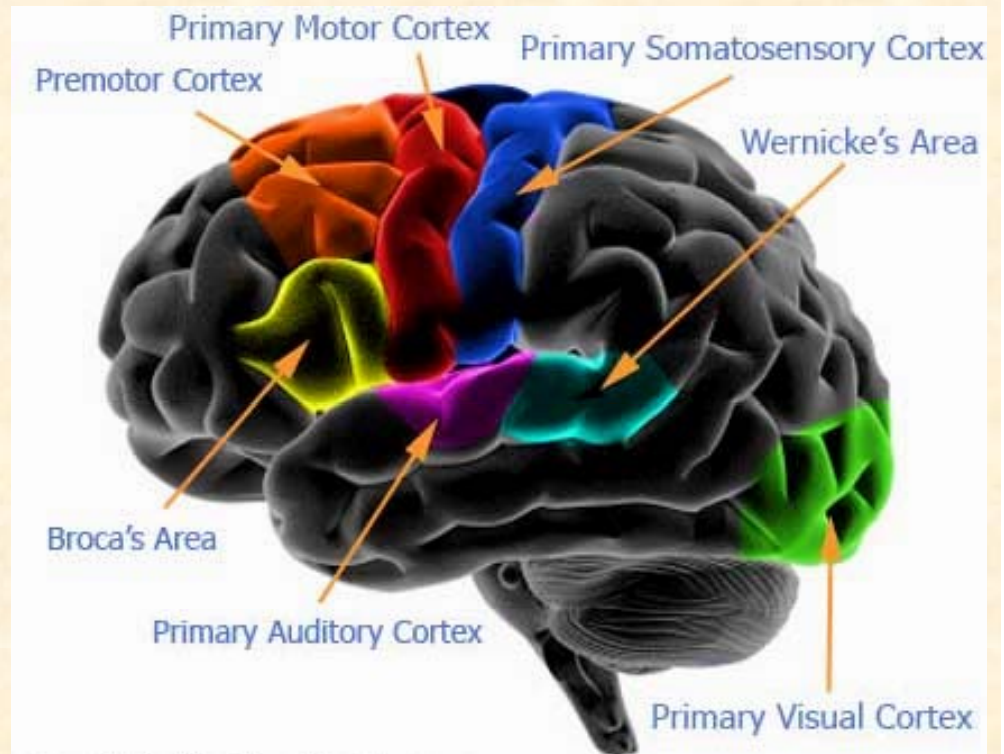
- Contains the sensory area (3,1,2) for the opposite half of the body.
- Wernicke's area (39,40,22)

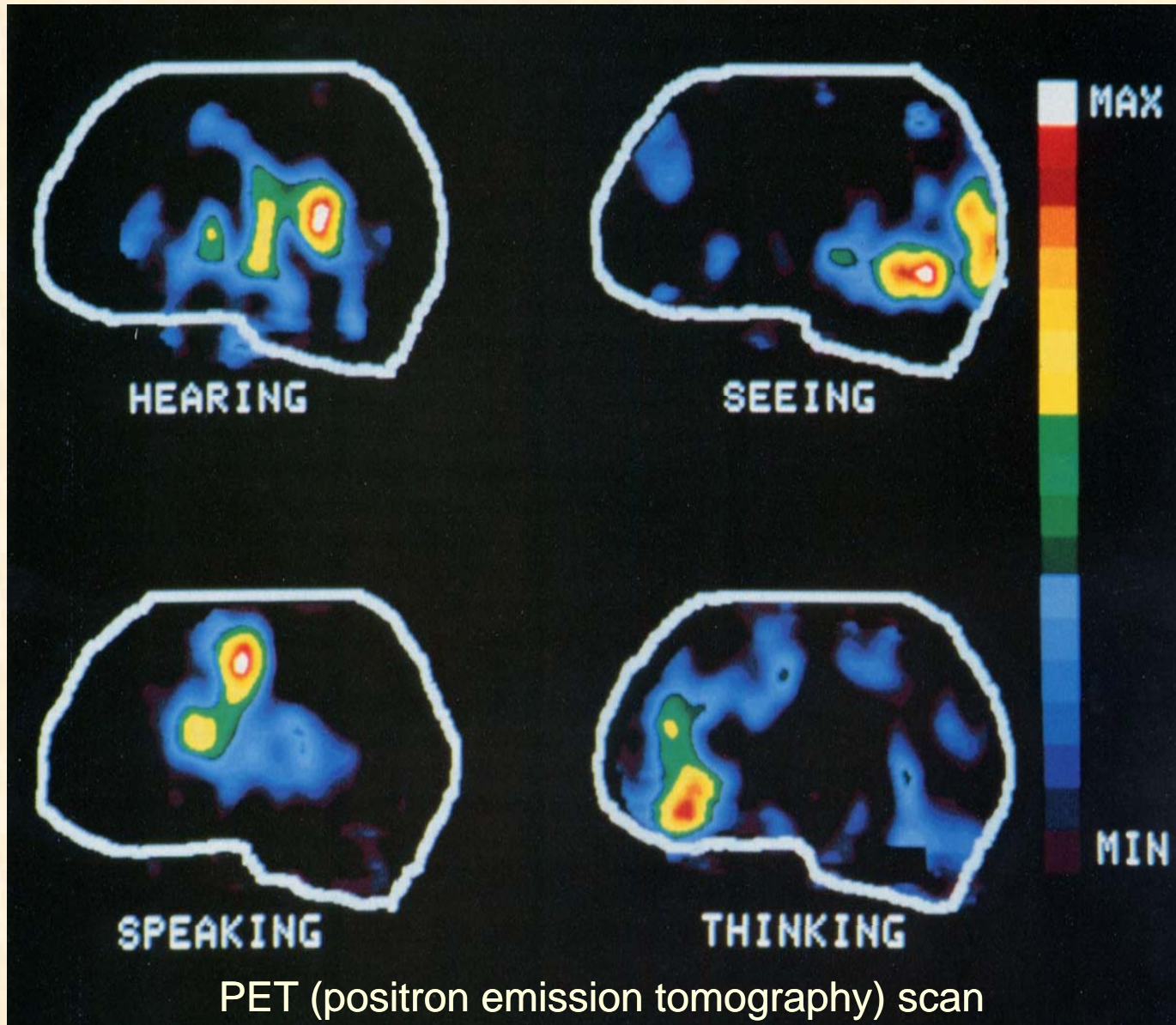
The temporal lobe:

Contains hearing center (41,42,22).

The occipital lobe:

Contains center for vision (17,18,19).





Cerebral Dominance (Lateralization, Asymmetry)

Dominant Hemisphere

Language
speech, writing

Calculation

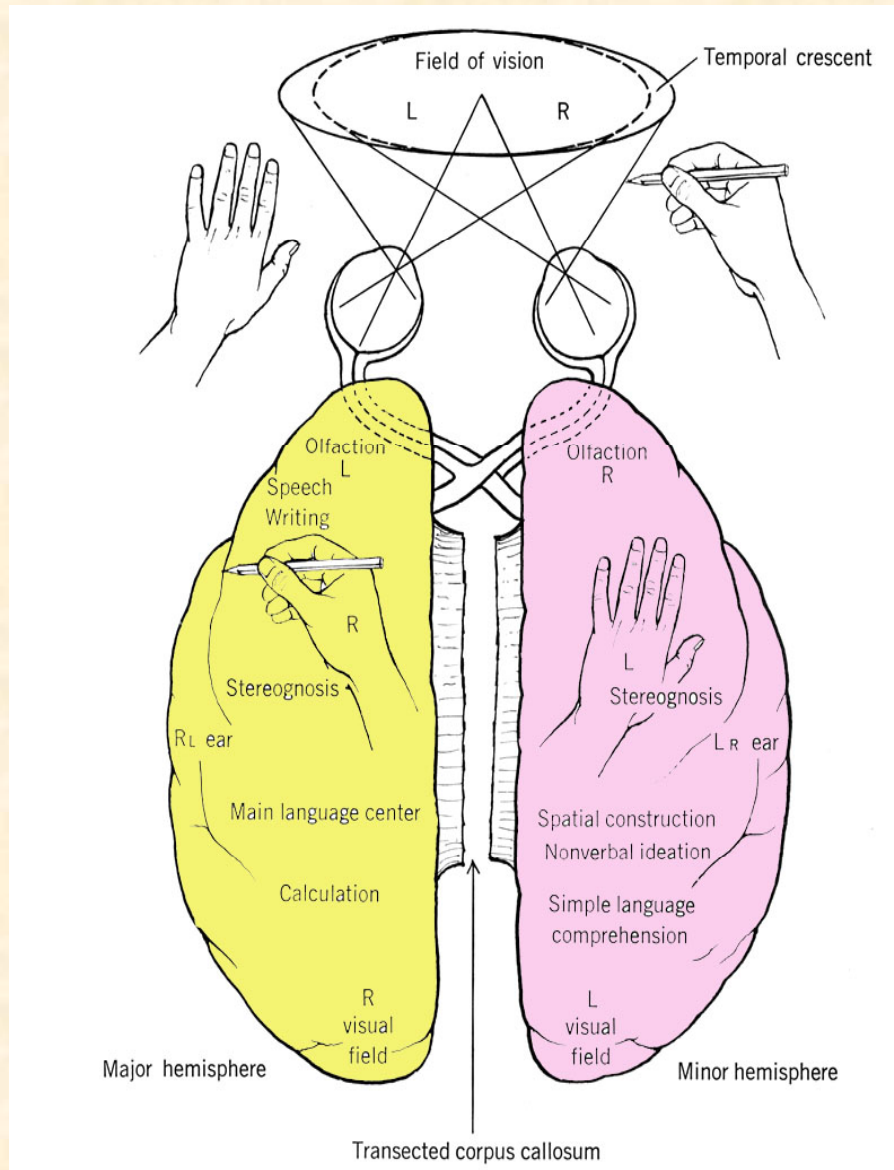
Non-dominant Hemisphere

Spatial Perception (3D subject)

Singing

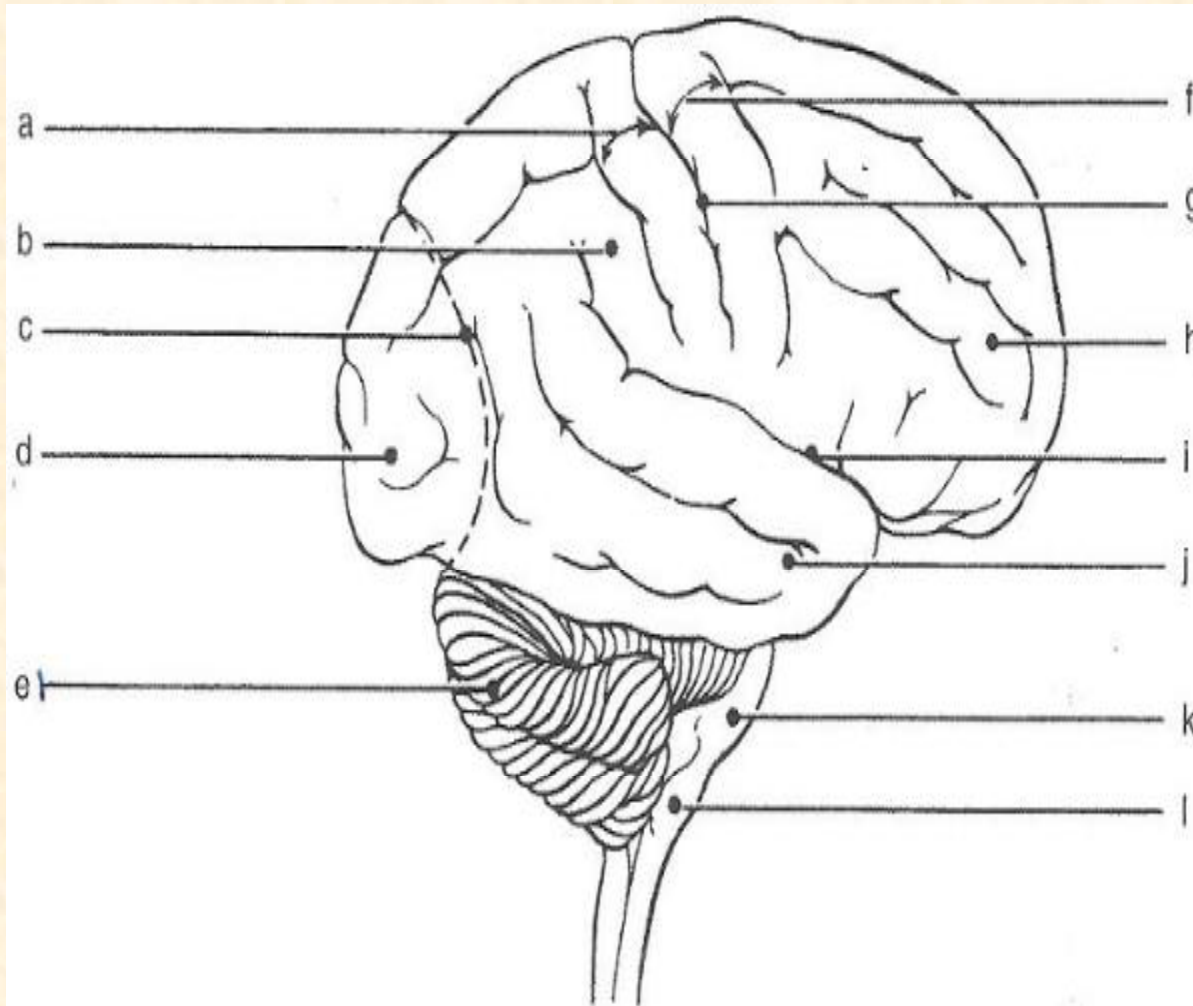
Playing musical instrument

Language
Speech
Writing
Calculation



3D perception
Singing
Playing Musical
instrument

Now test yourself



- A- post central gyrus
- B- inferior parietal lobule
- C- imaginary line
- D- occipital lobe
- E- cerebellum
- F- precentral gyrus
- G- central sulcus
- H- inferior frontal gyrus
- I- posterir ramus (lateral fissur
- J- middle temporal gyrus
- K- pons
- L- medulla oblongata

Label Key: Insert the correct brain term into the picture's label boxes.

...

LOBE TERMS

1. Occipital Lobe
2. Parietal Lobe
3. Temporal Lobe
4. Frontal Lobe

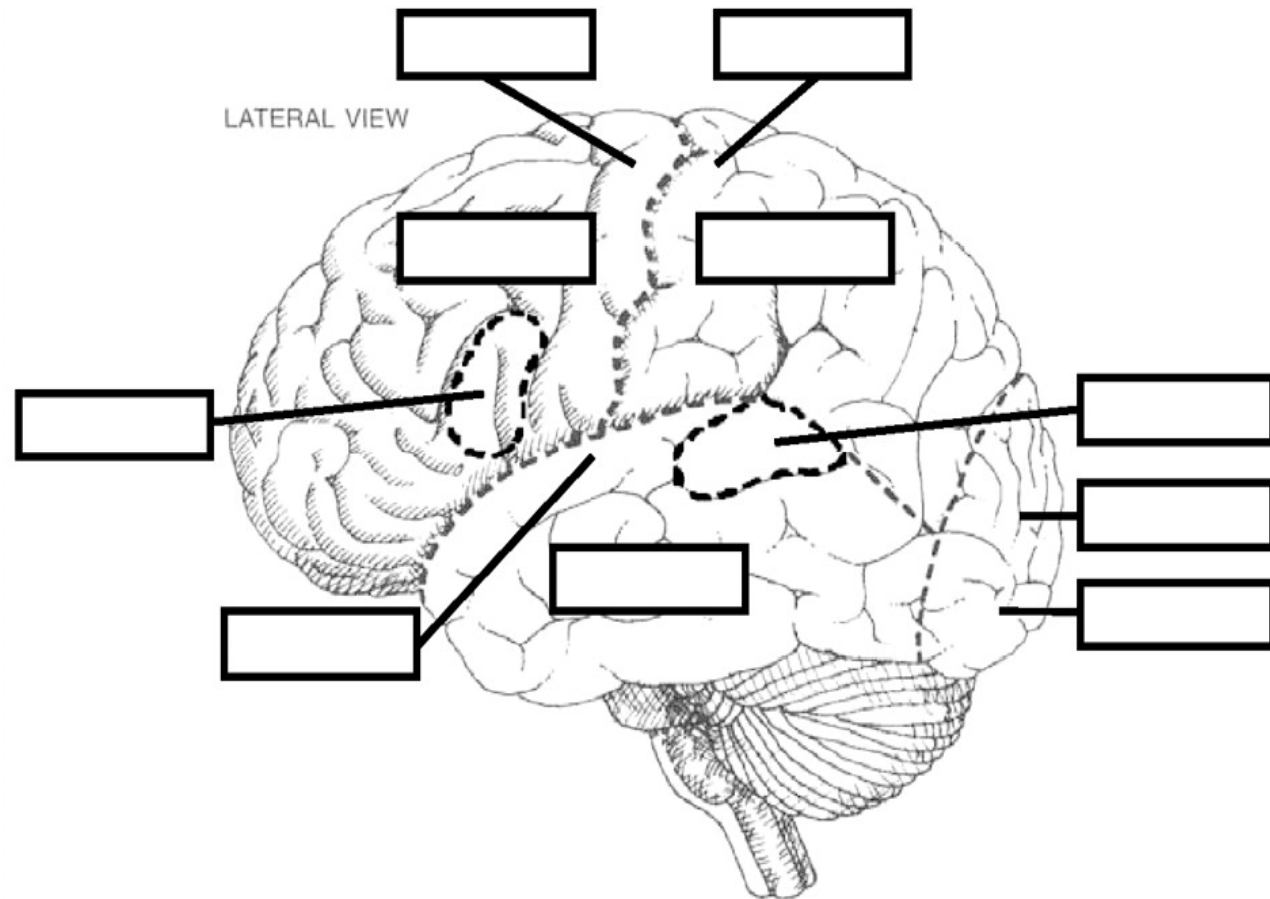
SENSORY CORTEX TERMS

7. Visual Cortex
8. Auditory Cortex
9. Somatosensory Cortex
10. Motor Cortex

SPECIAL FEATURE

TERMS

5. Wernicke's Area
6. Broca's Area



Brain diagram adapted from Pinel, J. P. J. & Edwards, M. (2008, p.113). *A colorful introduction to the anatomy of the human brain: A brain and psychology coloring book*. Boston, Massachusetts: Pearson Education.

THANK YOU