Functions of Cerebral Hemispheres

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OBJECTIVES

At the end of this lecture the student should be able to:

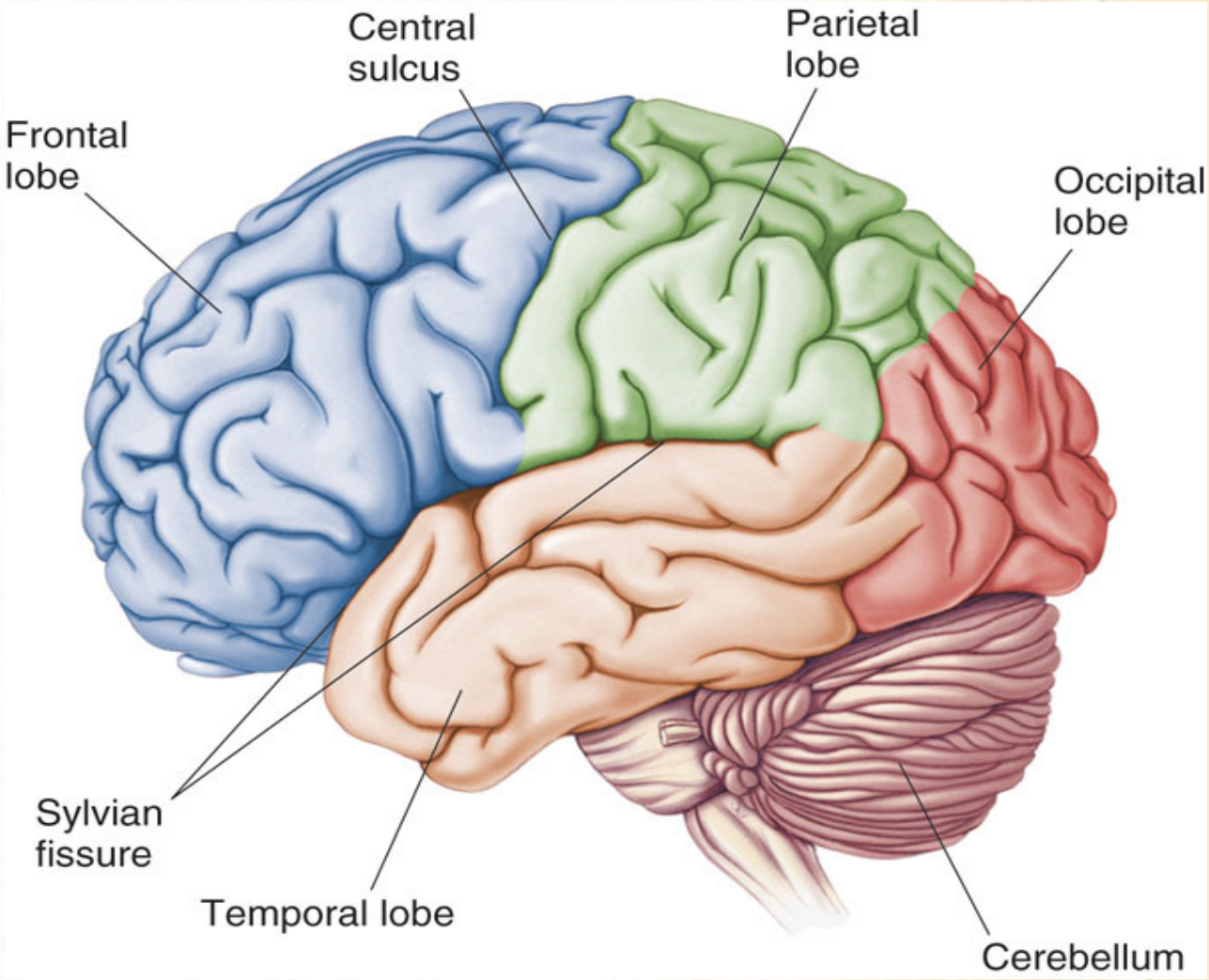
- **Enumerate the functions of brain**
- **List the cerebral cortex layers**
- **Explain the three main types of functional areas in the cerebral cortex**
- **Describe Broadmann's classification of cerebral cortex**
- **know the terms categorical hemisphere and representational hemisphere and summarize the difference between these hemispheres.**

INTRODUCTION

- The cerebrum is the largest part of the brain with two hemisphere, linked by commisural fibres of corpus callosum.
- Each cerebral hemisphere contains externally highly convulated cortex of grey matter and internal mass of white matter or medulla.
- The cerebral hemispheres contains motor and sensory areas and the limbic system.
- Each cerebral cortex is often divided phylogenetically into old allocortex, consisting of archicortex and paleocortex and a newer neocortex.

Lobes of the brain

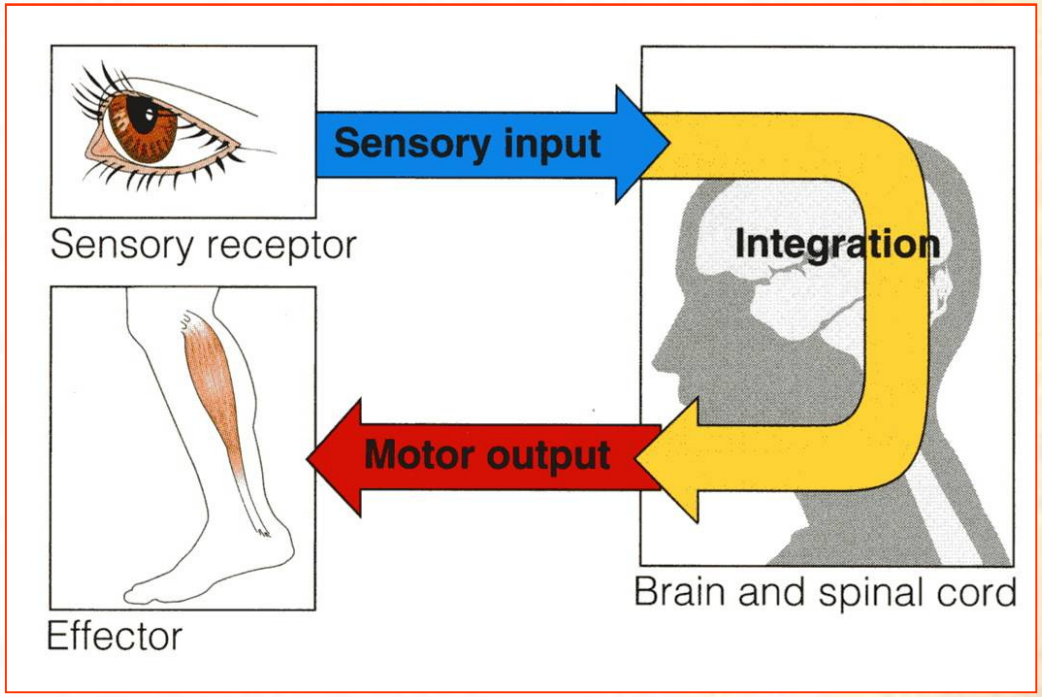
- **Four lobes are present**
  - **Frontal**
  - **Parietal**
  - **Occipital**
  - **Temporal**
- **Occasionally insula is considered as the fifth lobe**



The area of the cerebral cortex is 2200cm^2

HOW CNS FUNCTIONS?

- collection of sensory input
- integration
- motor output



There are 6 functions of the Brain

1. Thinking or Cognition
2. Perception or Sensing
3. Emotion or Feeling
4. Behaviour
5. Physical or Somatic
6. Signaling (being responsive and reacting to the environment)

Thinking (or cognition)
includes all of our internal mental processes and functions

Communicating

Arithmetic

Insight

Planning

Judgement

Comprehension

Processing

Reading

Focusing

Attending

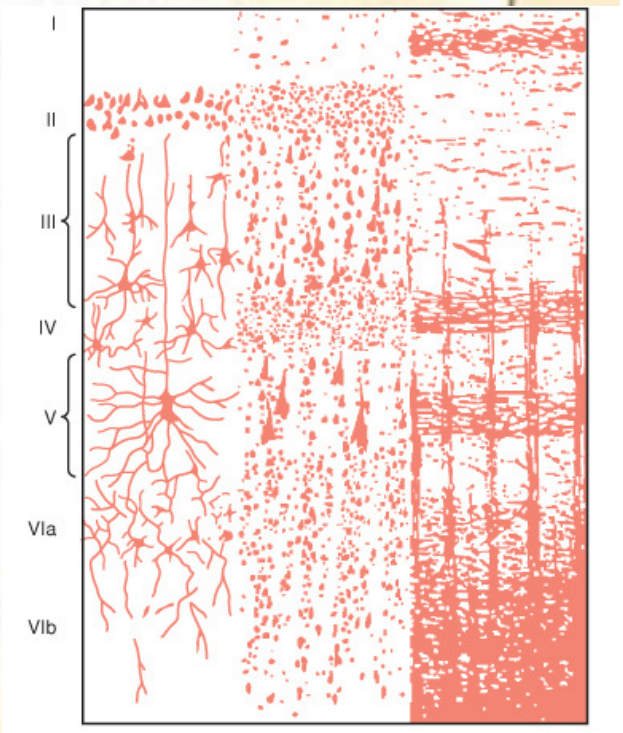
Memory

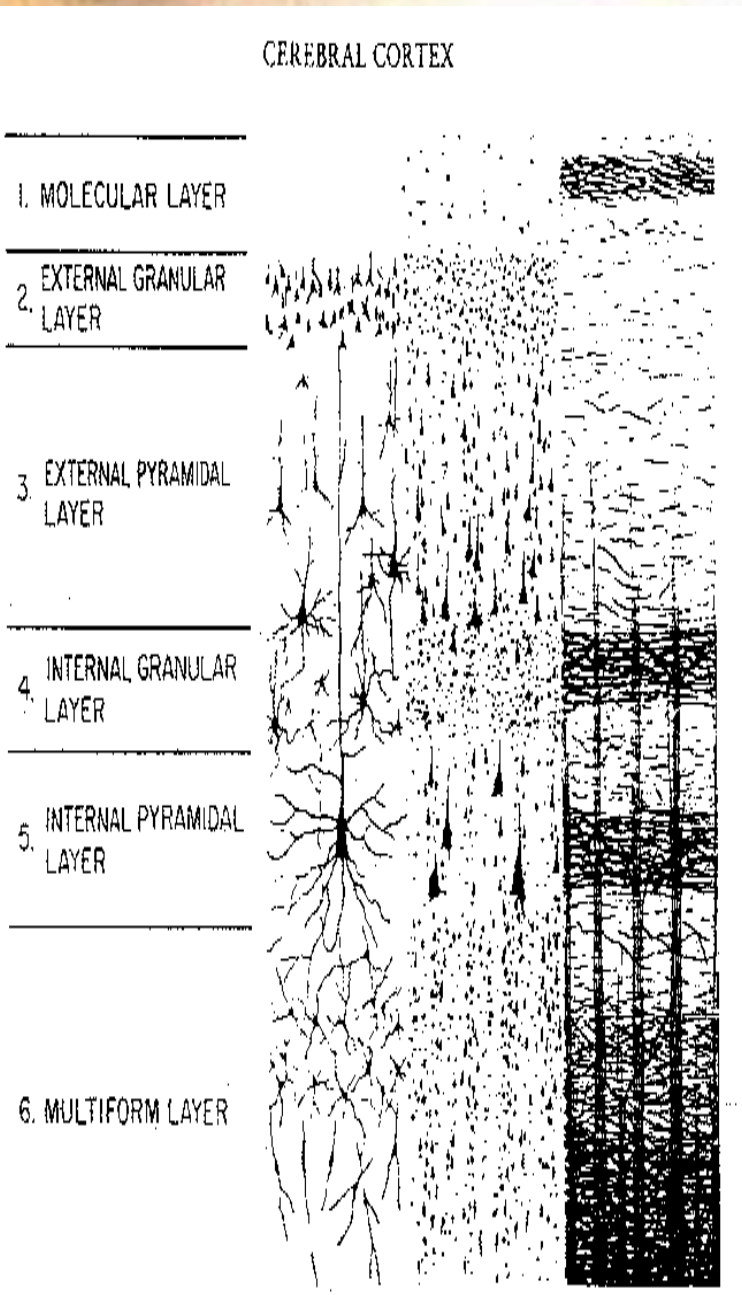
Contemplation

Cerebral Cortex

- Cerebral cortex is an intricate blend of nerve cells and fibres, neuroglia and blood vessels.
- Microscopically the cortex consists of six layers or laminae lying parallel to the surface.

- **From outside to inside the layers are:**
  1. **Molecular or plexiform layer**
  2. **The external granular layer**
  3. **External pyramidal lamina**
  4. **Internal granular layer**
  5. **Internal pyramidal cell layer**
  6. **Multiform or pleiomorphic layer**




CEREBRAL CORTEX
I. MOLECULAR LAYER
2. EXTERNAL GRANULAR LAYER
3. EXTERNAL PYRAMIDAL LAYER
4. INTERNAL GRANULAR LAYER
5. INTERNAL PYRAMIDAL LAYER
6. MULTIFORM LAYER

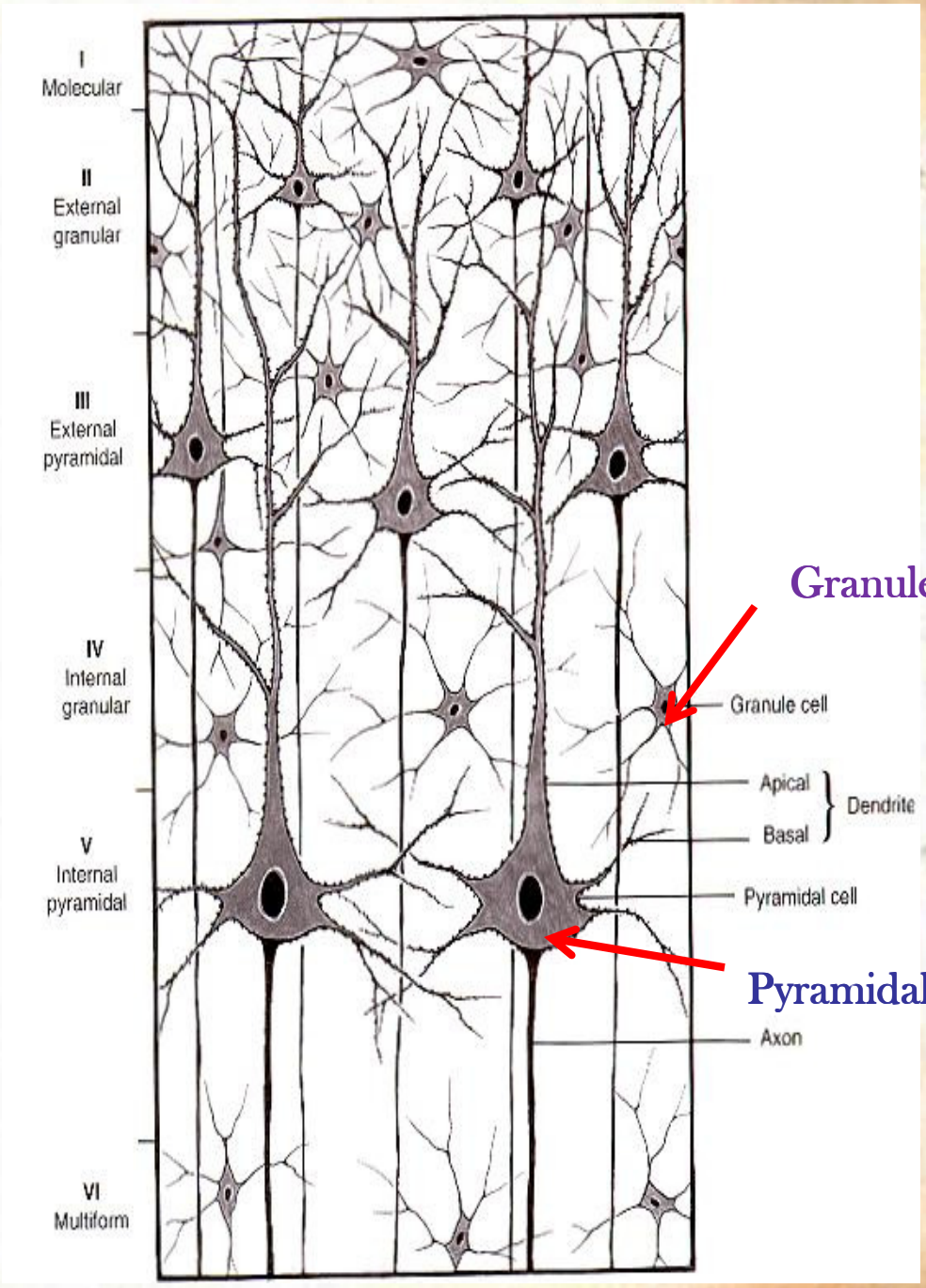

Pyramidal cells
cerebral cortex

Cerebral cortex

Neocortex has 6 layers designated I, II, III, IV, V, VI

Pyramidal cells predominate in layers III and V

Granule cells in layers II and IV



CEREBRAL CORTEX LAYERS

1.The incoming sensory signal excites neuronal layer IV first; then the signal spreads toward the surface of the cortex and also toward deeper layers.

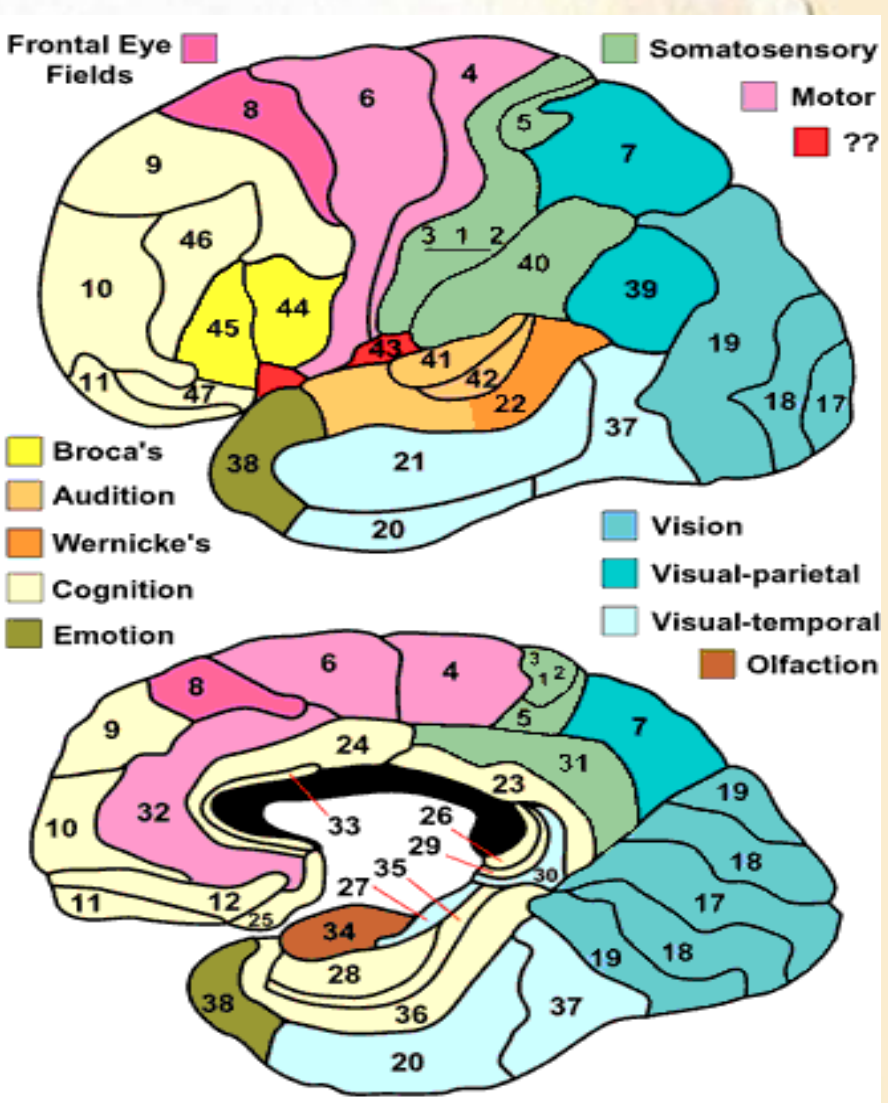
2.Layers I and II receive diffuse, nonspecific input signals from lower brain centers that facilitate specific regions of the cortex. This input mainly controls the overall level of excitability of the respective regions stimulated.

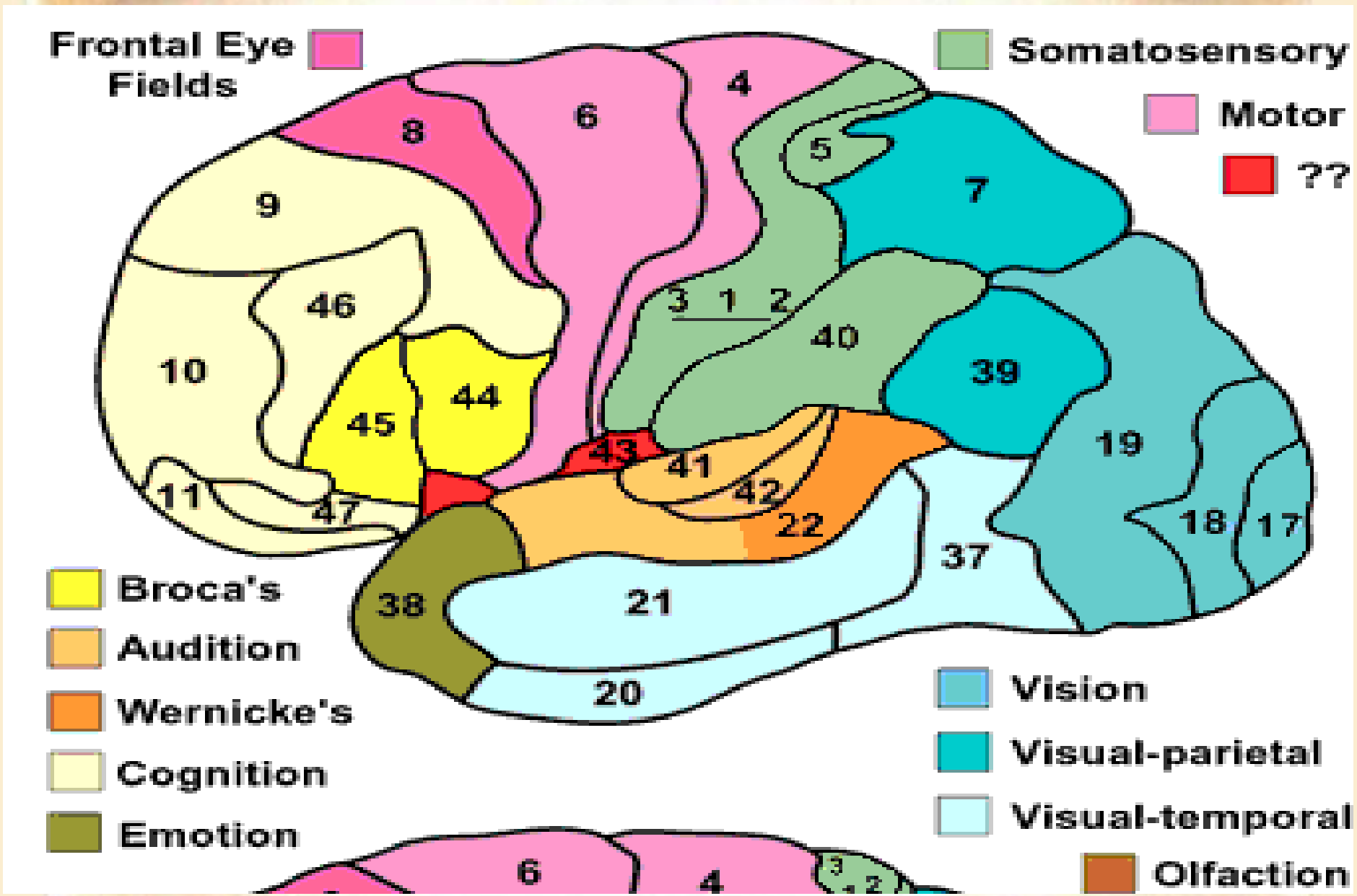
3.The neurons in layers II and III send axons to related portions of the cerebral cortex on the opposite side of the brain through the *corpus callosum*.

4.The neurons in layers V and VI send axons to the deeper parts of the nervous system. For eg to basal ganglia and thalamus

Broadmann's Areas

- These areas were defined and numbered by ***Korbinian Broadmann***
- The areas are based on the cortical cytoarchitectonic organisation of neurons
- Many of the broadmann's areas are defined on neurological function coorelated closely to diverse cortical functions.
- For example
  - Area 1,2,3 – primary somatosensory area
  - Area 4 – Motor area
  - Area 41,42 – Auditory area
  - Area 44,45 – Broca's area,etc




Frontal Eye Fields
Somatosensory
Motor
??
Broca's
Audition
Wernicke's
Cognition
Emotion
Vision
Visual-parietal
Visual-temporal
Olfaction
8
6
4
5
7
9
46
10
45
44
3 1 2
40
39
19
43
41
42
22
18
17
11
47
37
38
21
20

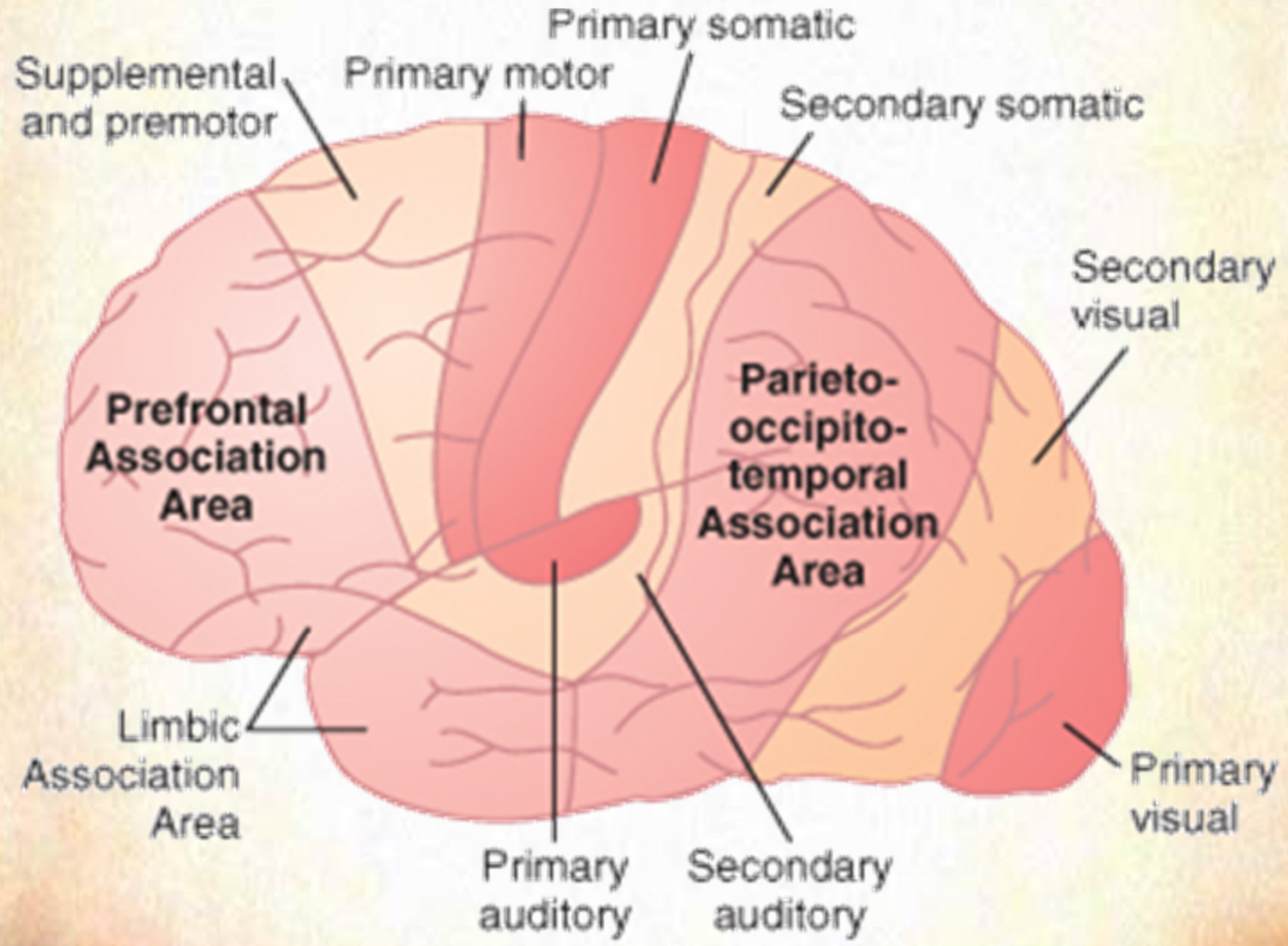
There are three main types of functional areas in the cerebral cortex:

The primary 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.

The secondary areas make sense out of the signals in the primary areas.

Association Areas They receive and analyze signals simultaneously from multiple regions of both the motor and sensory cortices as well as from subcortical structures.

PRIMARY, SECONDARY AND 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

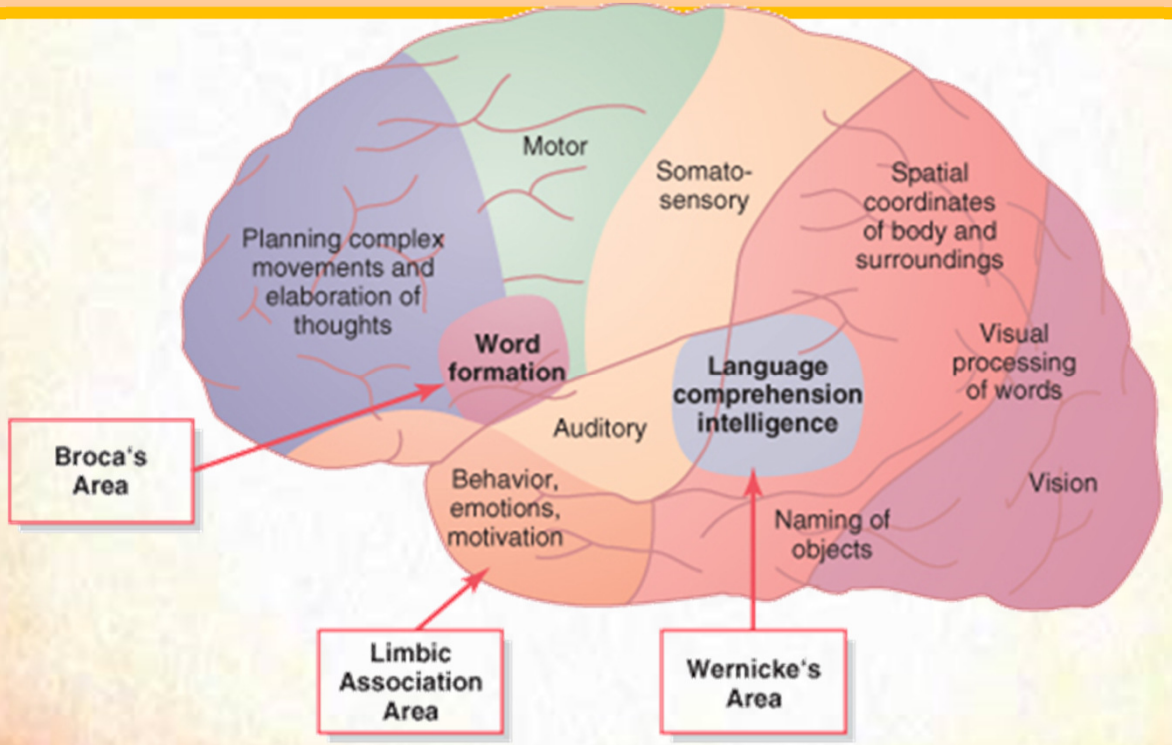
(1) Parieto-occipitotemporal association area

(2) prefrontal association area

(3) limbic association area.

PARIETO-OCCIPITOTEMPORAL ASSOCIATION AREAS

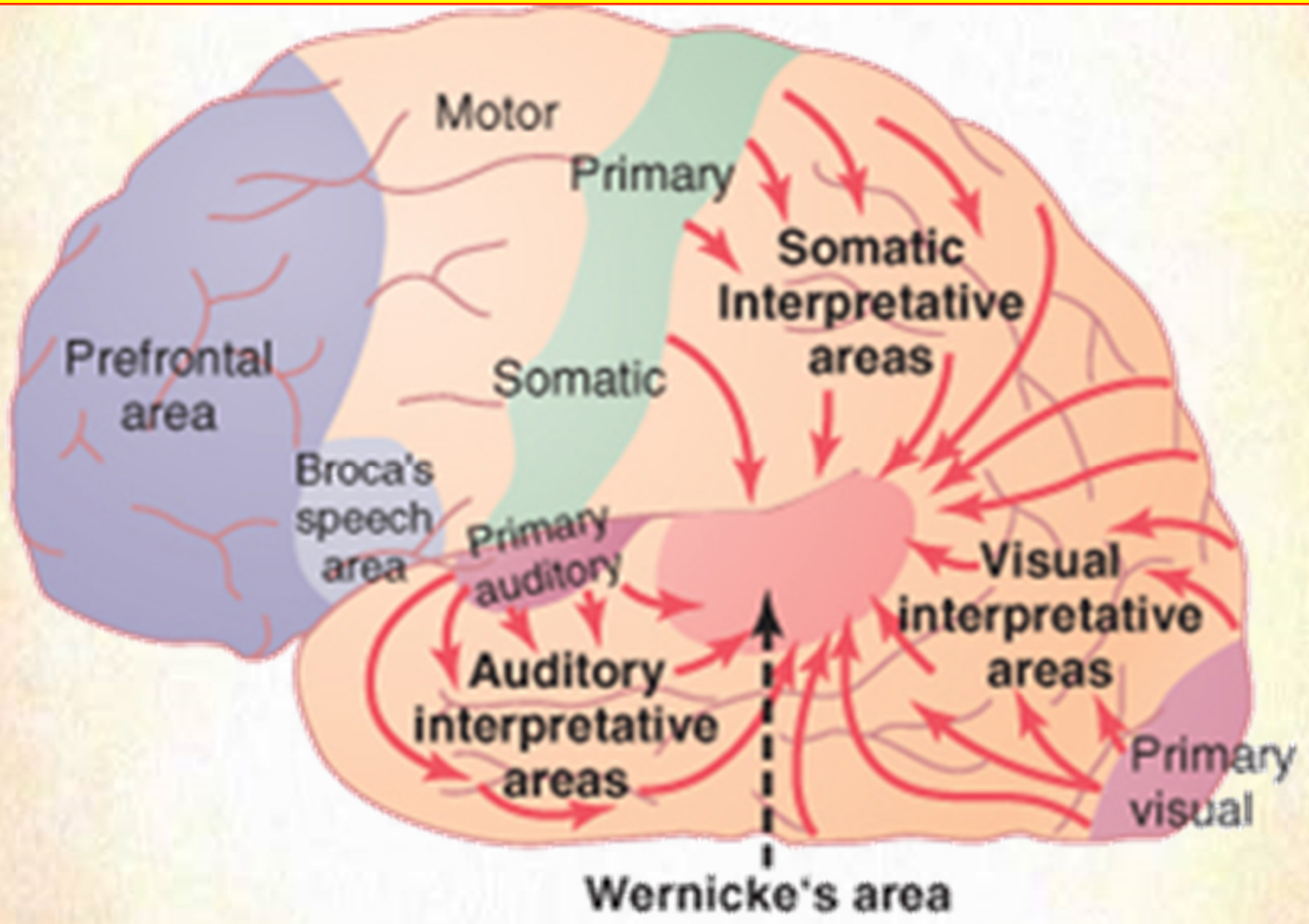
- 1. Analysis of the Spatial Coordinates of the Body.
- 2. Language Comprehension.
- 3. Initial Processing of Visual Language (Reading).
- 4. Area for Naming Objects.



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 Blindess)
Area for Naming Objects.	angular gyrus area	naming objects.

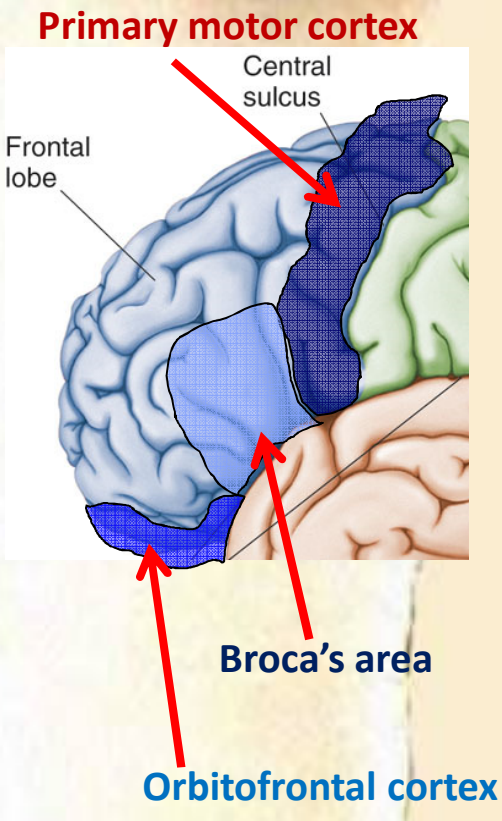
Comprehensive Interpretative Function of the Posterior Superior Temporal Lobe-"Wernicke's Area" (a General Interpretative Area)
GNOSTIC AREA, the KNOWING AREA, the TERTIARY ASSOCIATION AREA,

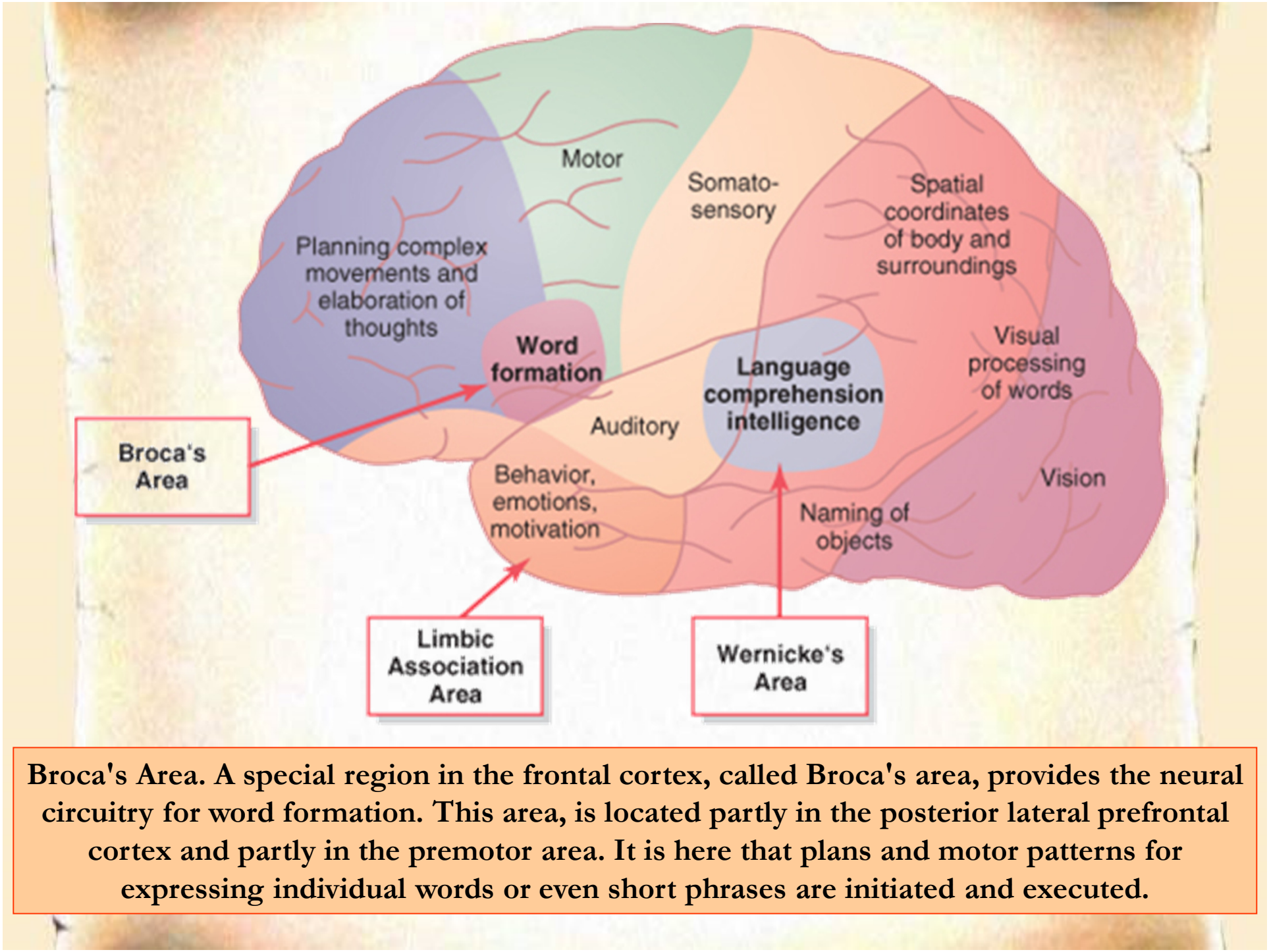


After severe damage in Wernicke's area, a person might hear perfectly well and even recognize different words but still be unable to arrange these words into a coherent thought.

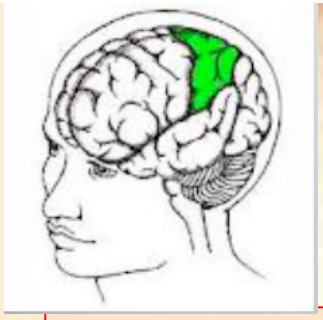
Frontal Lobe

- The **primary motor cortex** is at the back of the frontal lobes.
- **Broca's Area:** the "Speech Production Centre" is part of the association cortex. It is located in the **left** frontal lobe and is involved with the production of clear,fluent speech
- Other association cortex in the frontal lobes is involved in **Personality Reasoning, Planning & Thinking**



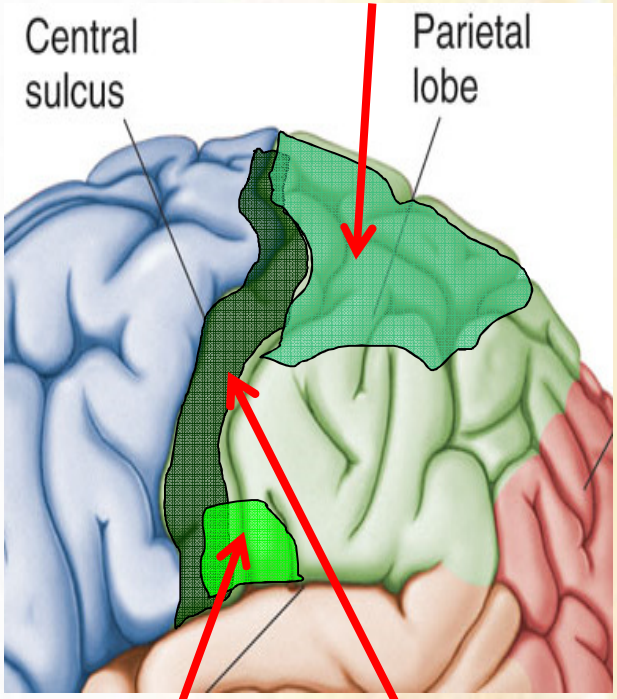


Broca's Area. A special region in the frontal cortex, called Broca's area, provides the neural circuitry for word formation. This area, is located partly in the posterior lateral prefrontal cortex and partly in the premotor area. It is here that plans and motor patterns for expressing individual words or even short phrases are initiated and executed.



Parietal Lobe

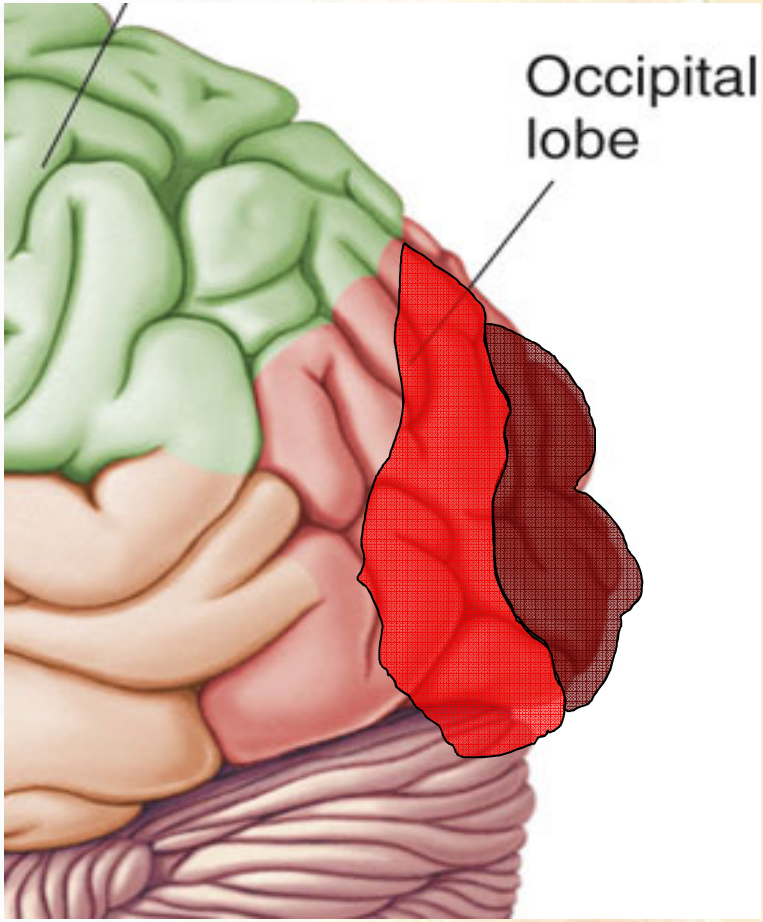
- **Primary Somatosensory Cortex (Postcentral Gyrus)** – Site involved with processing of tactile and proprioceptive information.
- **Somatosensory Association Cortex -** Assists with the integration and interpretation of sensations relative to body position and orientation in space. May assist with visuo-motor coordination
- **Primary Gustatory Cortex** – Primary site involved with the interpretation of the sensation of Taste.

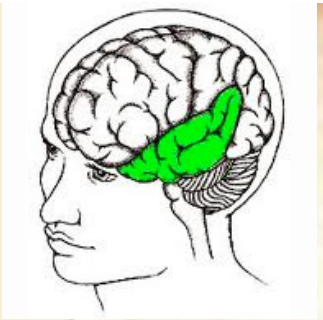


Occipital lobe

Primary Visual Cortex – This is the primary area of the brain responsible for sight -recognition of size, color, light, motion, dimensions, etc.

Visual Association Area – Interprets information acquired through the primary visual cortex. **Responsible for selection, organisation and integration of features of visual stimuli**





Temporal Lobe

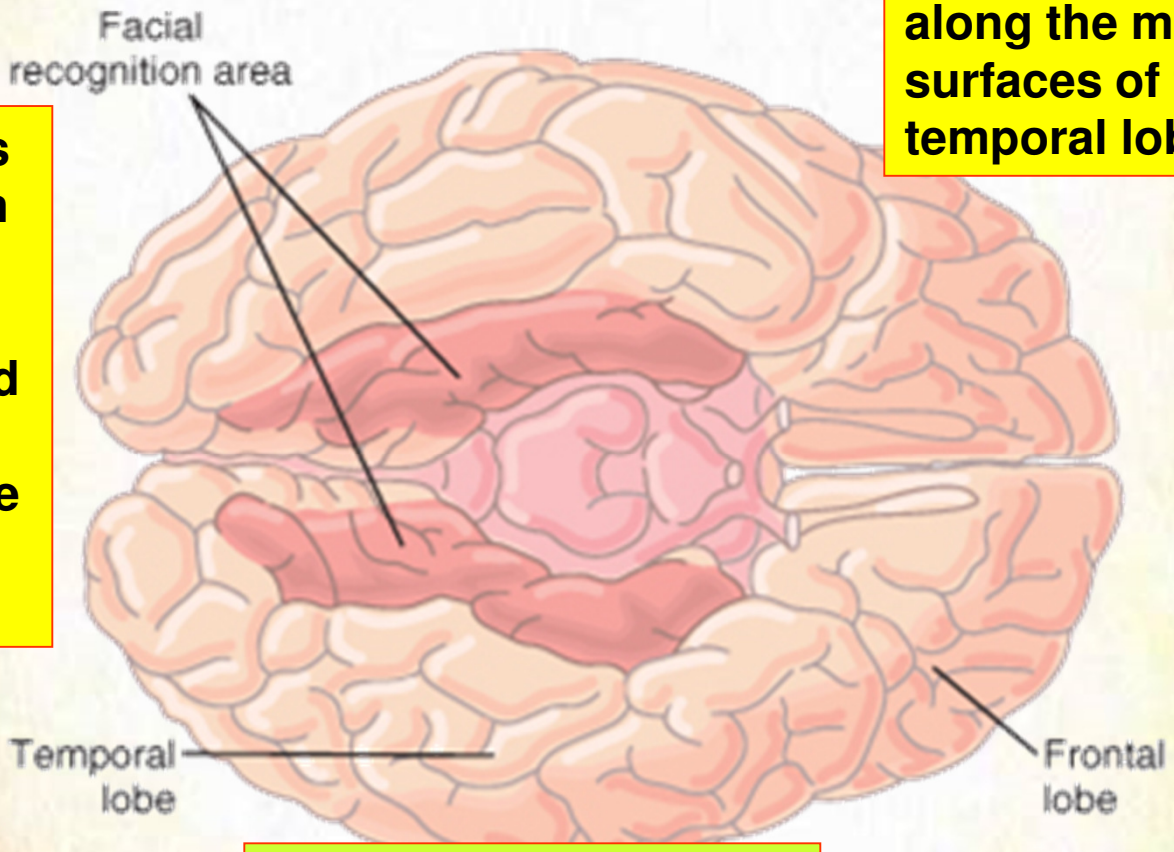
- **The Primary Auditory Cortex**
- **Association Areas**
  - Wernicke's area
  - Memory - Fascial Recognition Areas
  - Storing of episodic memories such as our first day at school or a particular holiday
  - Recognition of objects

-Wernicke's Aphasia – Language comprehension is lost. Words and sentences are not clearly understood, and sentence formation may be inhibited or non-sensical.

FASCIAL RECOGNITION AREAS

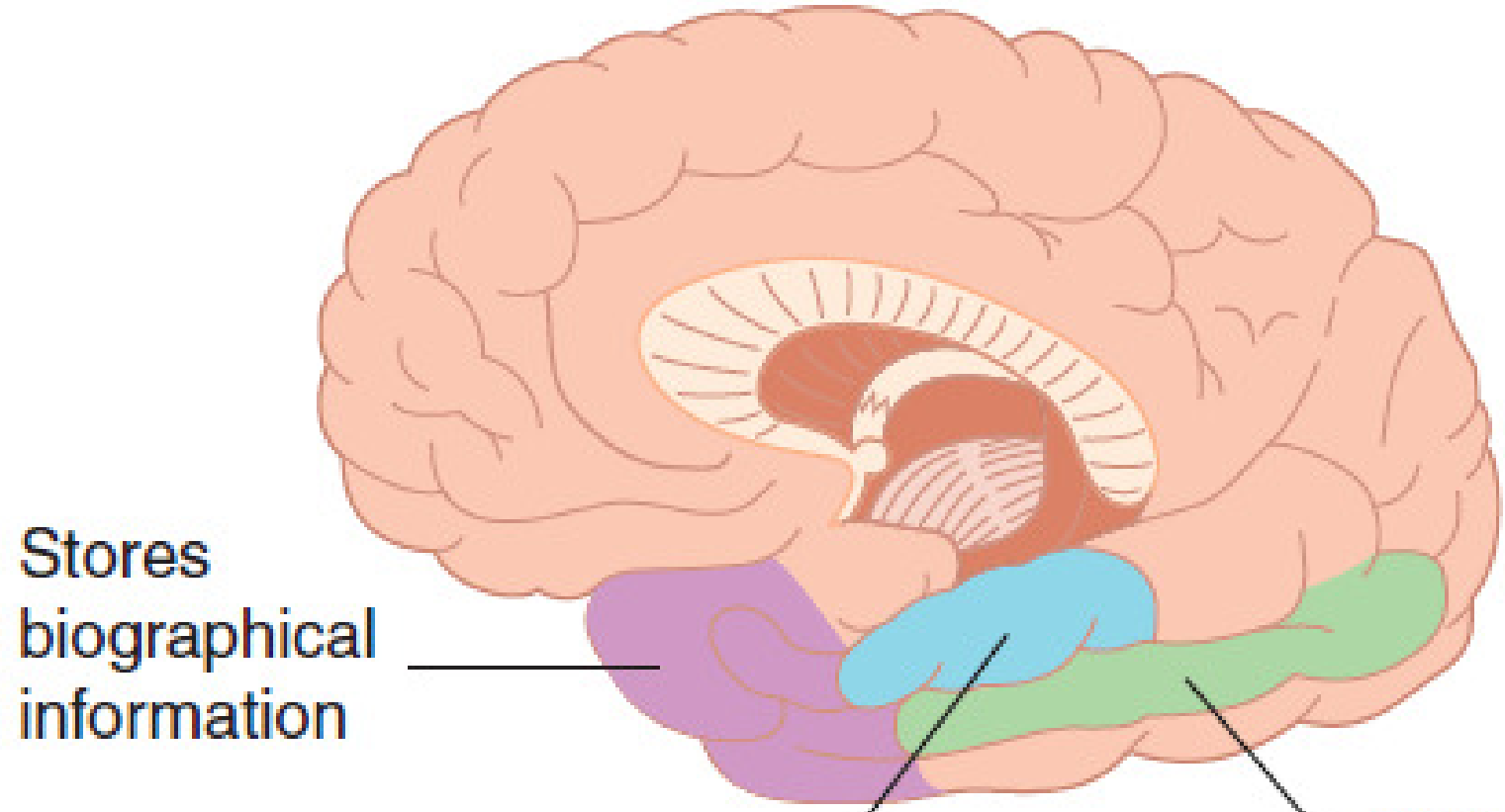
medial undersides of both occipital lobes and along the medioventral surfaces of the temporal lobes

One wonders why so much of the cerebral cortex should be reserved for the simple task of face recognition?



Prosopagnosia

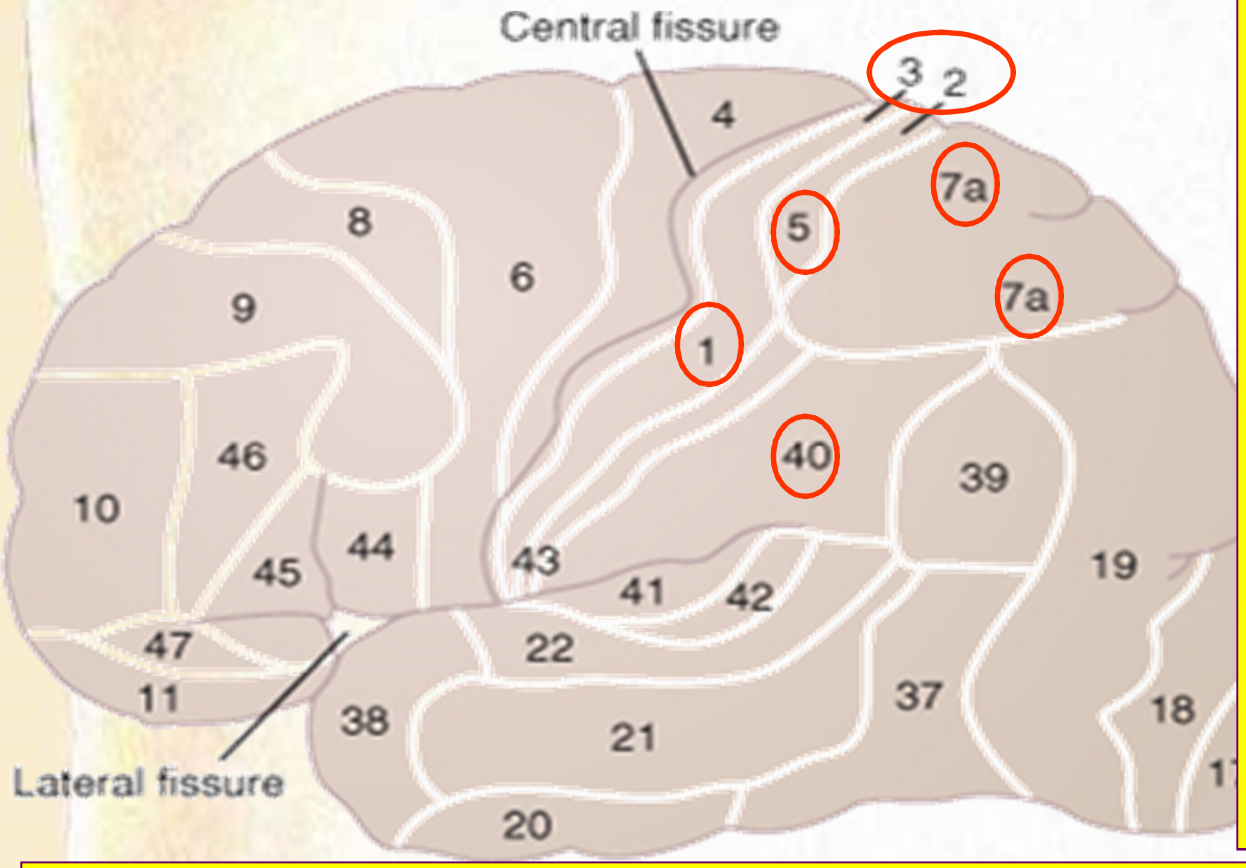
Areas in the right cerebral hemisphere, in right-handed individuals, that are concerned with recognition of faces.



Somatosensory Cortex (Cont.)

- The incoming sensory signal excites neuronal layer IV first and then the signal spreads both towards the surface of the cortex and towards the deeper layer.
- Functionally the neurons of the somatosensory cortex are arranged in vertical columns.
- Each of these columns severs a single specific sensory modality.
- Receives sensory information exclusively from the opposite side of the body.

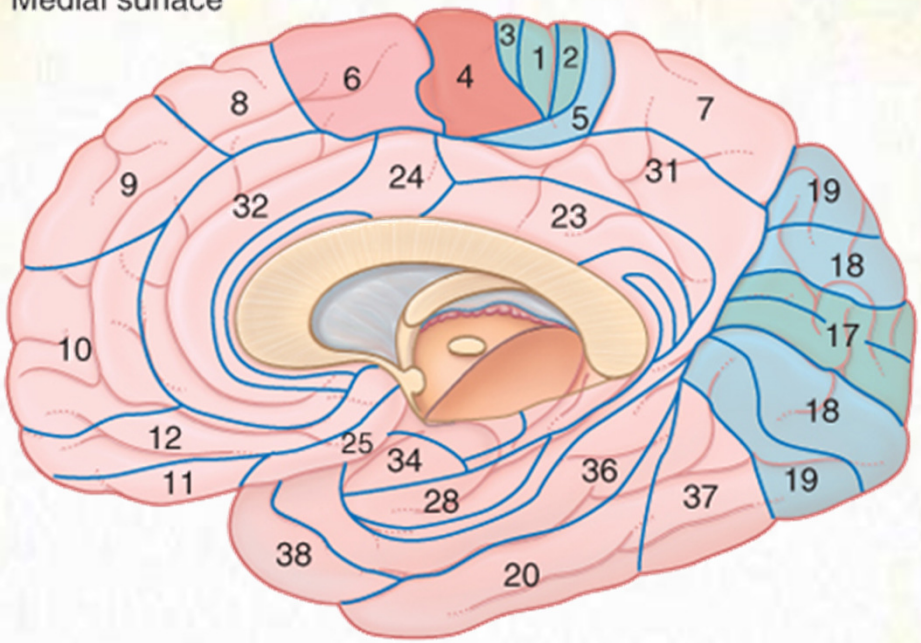
SOMATOSENSORY CORTEX



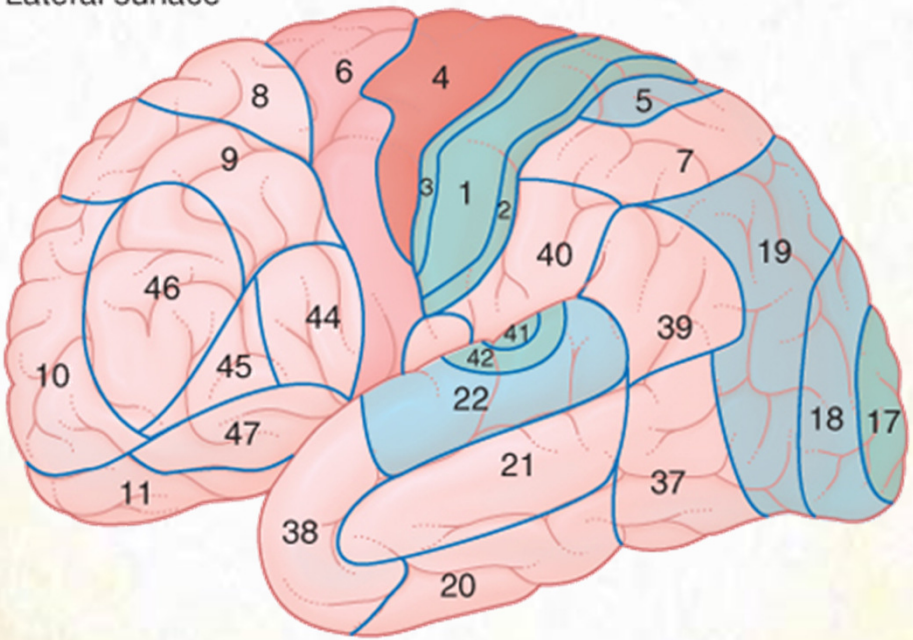
a map of the human cerebral cortex, that is divided into about 50 distinct areas called *Brodmann's areas* based on histological structural differences.

Areas 1, 2, and 3, which constitute PRIMARY SOMATOSENSORY AREA I, 40 is SECONDARY SOMATOSENSORY AREA II and areas 5 and 7, which constitute the SOMATOSENSORY ASSOCIATION AREA.

Medial surface



Lateral surface



What we know about somatic sensation appears to be explained by the functions of somatosensory area I.

- Somatosensory area II, although roughly, the face is represented anteriorly, the arms centrally, and the legs posteriorly.
- It is known that signals enter this area from the brain stem, transmitted upward from both sides of the body.
- many signals come secondarily from somatosensory area I as well as from other sensory areas of the brain, even from the visual and auditory areas
- removal of parts of somatosensory area II has no apparent effect on the response of neurons in somatosensory area I.

Functions of Somatosensory Area I

This area is used to localize sensations discretely and accurately.

1.If damaged the person can localize sensations crudely, such as to a particular hand, to a major level of the body trunk, or to one of the legs. The person is unable to judge critical degrees of pressure against the body.

2.The person is unable to judge the weights of objects.

3.The person is unable to judge shapes or forms of objects. This is called astereognosis.

4.The person is unable to judge texture of materials because this type of judgment depends on highly critical sensations caused by movement of the fingers over the surface to be judged.

SOMATOSENSORY CORTEX (AREA SII)

- Present in the wall of the sylvian fissure.
- The localization is poor as compared to SI.
- Face is represented anteriorly, the arm centrally and the leg posteriorly.
- Ablation of SI results in deficits in sensory processing in SII where as ablation of SII has no gross effect on the processing in SI.

SOMATOSENSORY ASSOCIATION AREAS

- Situated in Brodmann's area 5 & 7 of the central cortex located in the parietal cortex behind SI area.
- It plays an important role in translating the sensory information that enters the somatosensory areas.
- When damaged it loses the ability to recognize complex objects on the opposite side of the body.

e.g. Amorphosynthesis, Apraxia and sensory inattention.

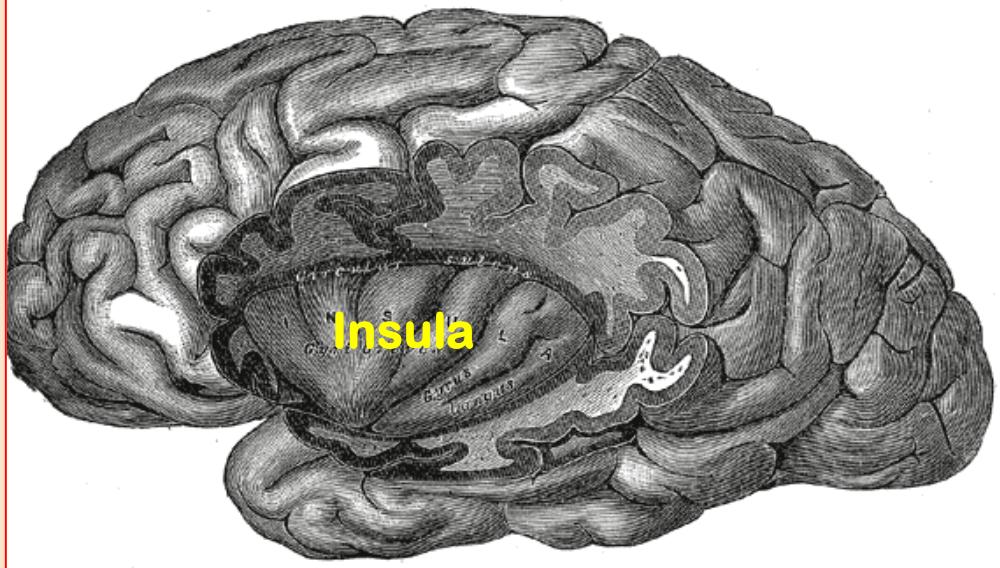
Insula

-Present within the lateral sulcus Between temporal and frontal Lobe.

-The overlying cortical areas are called opercula formed from the parts of frontal,temporal and parietal lobe

-Functions linked to emotion and body's homeostasis

-i.e perception, motor control, self awarness, congnitive functioning interpersonal experience



Insula is it the fifth lobe

?

Suppression or destruction of neurones and surrounding structures. This is the most common process part of the system fails to work.

Site of lesion	Disorder	L	R
Frontal, either	Intellectual impairment Personality change Urinary incontinence Monoparesis or hemiparesis		
Frontal, left	Broca's aphasia		
Temporo-parietal, left	Acalculia Alexia Agraphia Wernicke's aphasia Right–left disorientation Homonymous field defect		
Temporal, right	Confusional states Failure to recognize faces Homonymous field defect		
Parietal, either	Contralateral sensory loss or neglect Agraphaesthesia Homonymous field defect		
Parietal, right	Dressing apraxia Failure to recognize faces		
Pareital, left	Limb apraxia		
Occipital/ occipitoparietal	Visual field defects Visuospatial defects Disturbances of visual recognition		

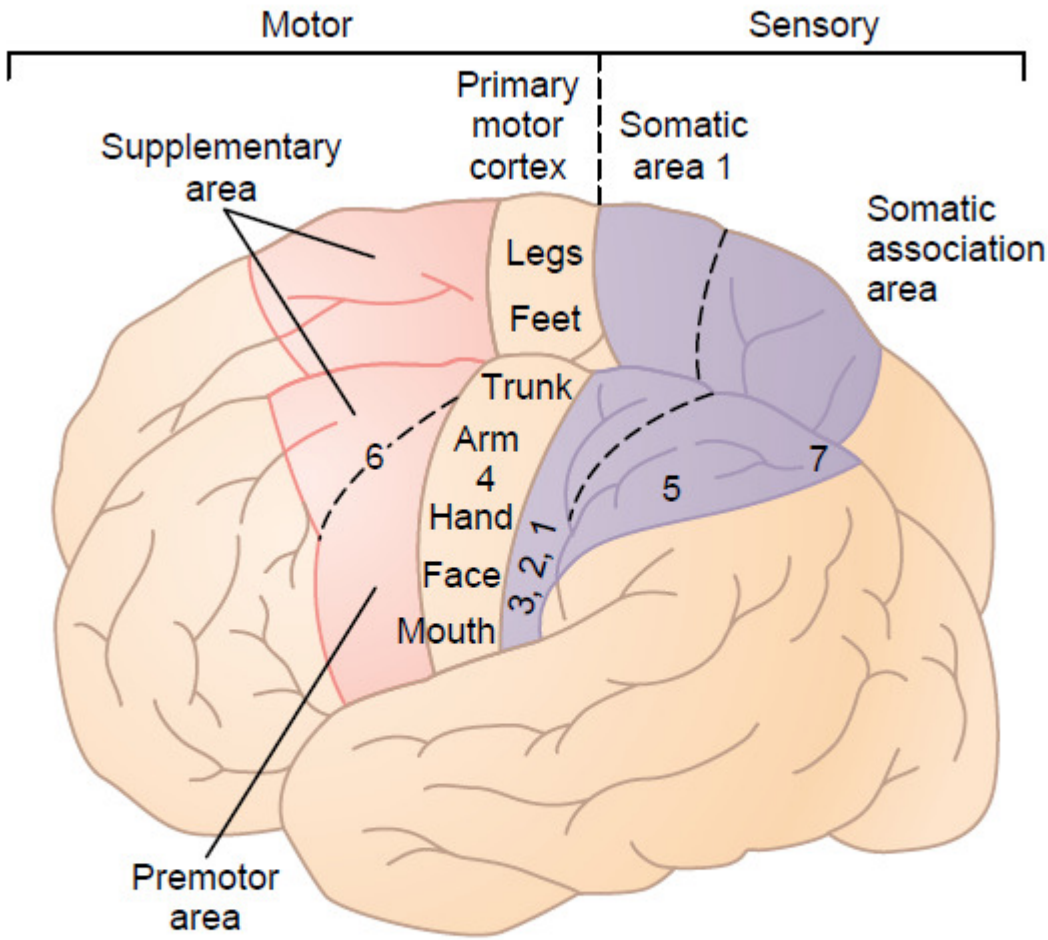


Figure 55–1

Motor and somatosensory functional areas of the cerebral cortex. The numbers 4, 5, 6, and 7 are Brodmann's cortical areas, as explained in Chapter 47.

Specialized Areas of Motor Control

Broca's Area and Speech

Voluntary" Eye Movement Field.

Head Rotation Area.

Area for Hand Skills.

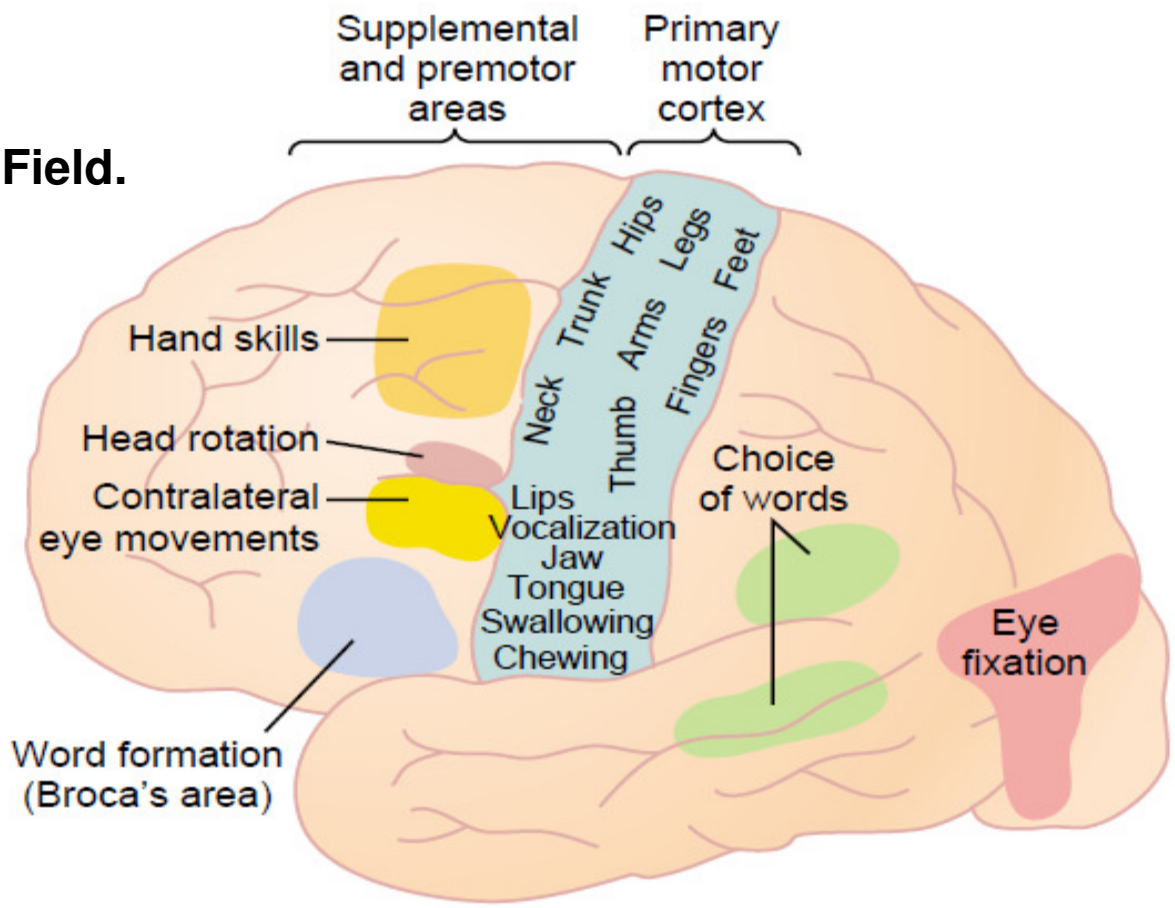


Figure 55–3

Representation of the different muscles of the body in the motor cortex and location of other cortical areas responsible for specific types of motor movements.

COMPLEMENTARY SPECIALIZATION OF THE HEMISPHERES VERSUS "CEREBRAL DOMINANCE"

- **Complementary specialization of the hemispheres, one for sequential-analytic processes (the categorical hemisphere) and one for visuospatial relations (the representational hemisphere).**
- **In 96% of right-handed individuals, the left hemisphere is the dominant or categorical hemisphere, and in the remaining 4%, the right hemisphere is dominant.**

THE NON-DOMINANT HEMISPHERE

REPRESENTATIONAL HEMISPHERE

- Understanding and interpreting music,
- Nonverbal visual experiences (especially visual patterns),
- Spatial relations between the person and their surroundings,
- The significance of "body language"
- Intonations of people's voices, and probably
- Many somatic experiences related to use of the limbs and hands eg;

  dressing or constructional apraxia