PHYSIOLOGY

SHEET NO. 2

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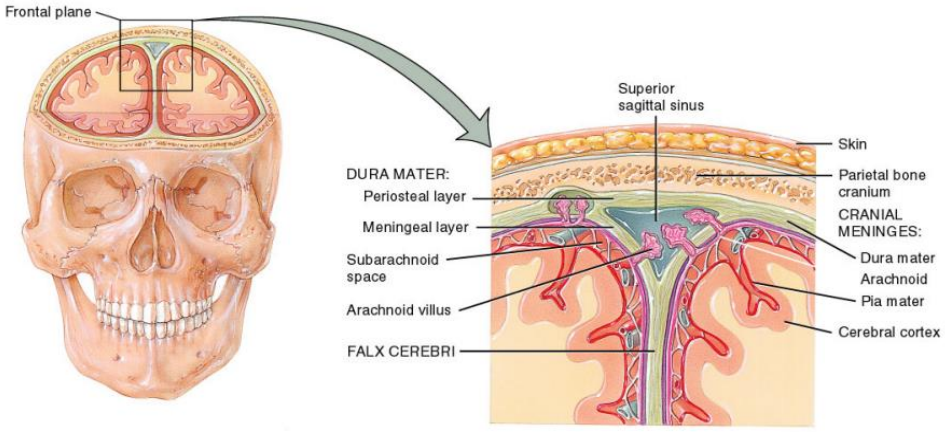
Cerebral Cortex; Intellectual Functions of the brain; Learning and Memory

Objectives

- Describe intellectual functions of the cerebral cortical areas.
- Explain memory and learning.
- Outline the dominant and non-dominant hemispheres.
- Delineate language areas of speech.

❖ Physiologic Anatomy of Cerebral Cortex

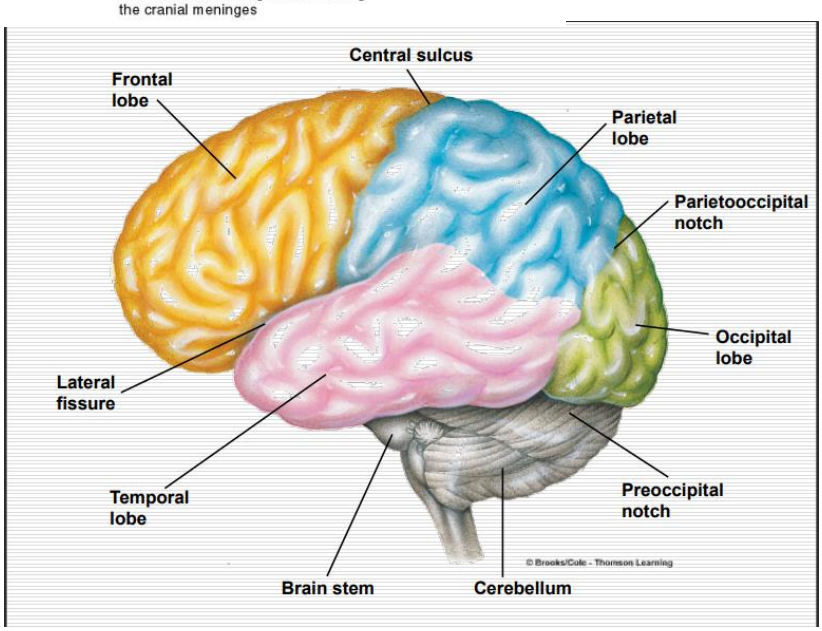
- Each area of the cortex is connected to a specific part of the thalamus.
- When thalamic connection is lost cortical function stops.
- All sensory pathways pass through the thalamus with the exception of some olfactory signals.



Frontal section through skull showing the cranial meninges

cerebral cortex is divided by sulci into gyri.

- **Sulcus** is a thin groove and there are 2 main sulci in the cerebral cortex: central sulcus and lateral sulcus, they divide the cerebral cortex into 4 lobes: frontal, parietal (posterior to the central sulcus), occipital, temporal (inferior to the lateral sulcus).

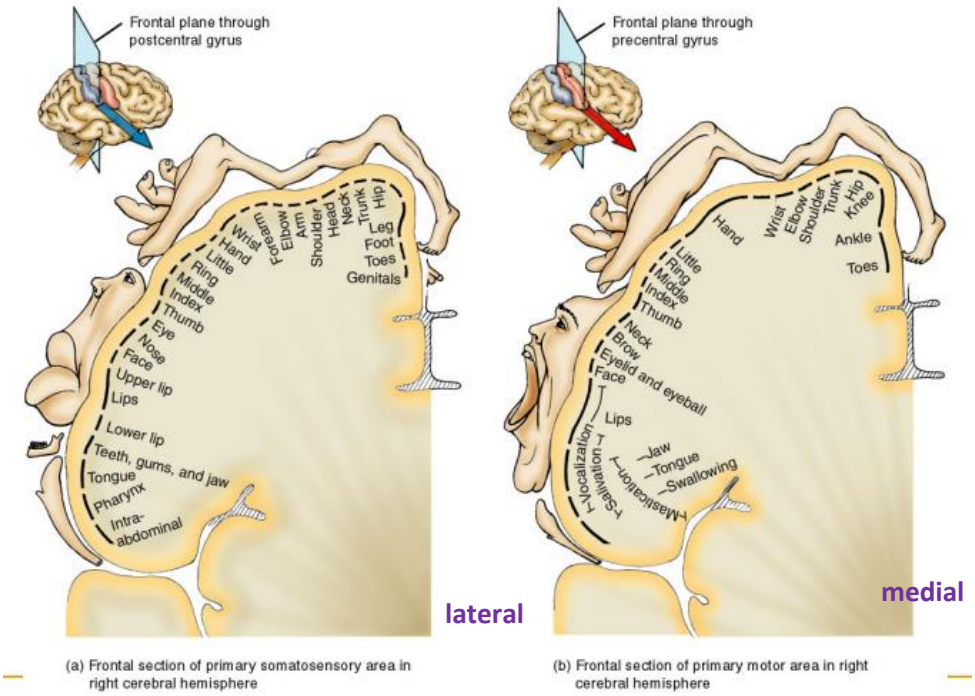


- **Gyrus:** is the area between two sulci.

2 major gyri: posterior to the central sulcus called post central gyrus and one anterior to the central sulcus called precentral gyrus.
Increase in the number of gyri, increases the surface area.

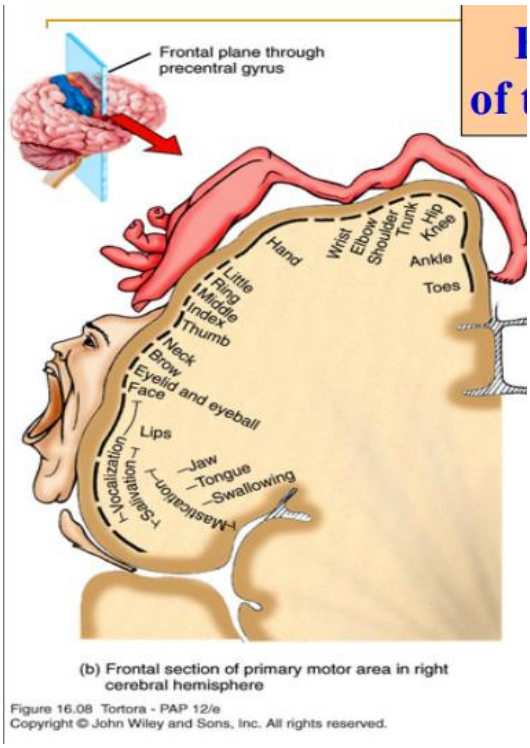
❖ Functional Organization of the primary Motor Cortex

- looking at the primary motor area of the precentral gyrus the body is represented upside down and contralateral.
- Primary sensory area: the area that will sense the somatic sensation (pain, touch…), but giving a meaning for the sensation happen in the secondary somato-association area (giving a meaning of the sensation).



  - for example:

Occipital lobe contains the primary visual sensors when you ask the patient if he can see and the answer is yes but he can't explain what he sees, the problem here is not on the eye or receptors (not primary) the problem is in the secondary center. (word blindness)



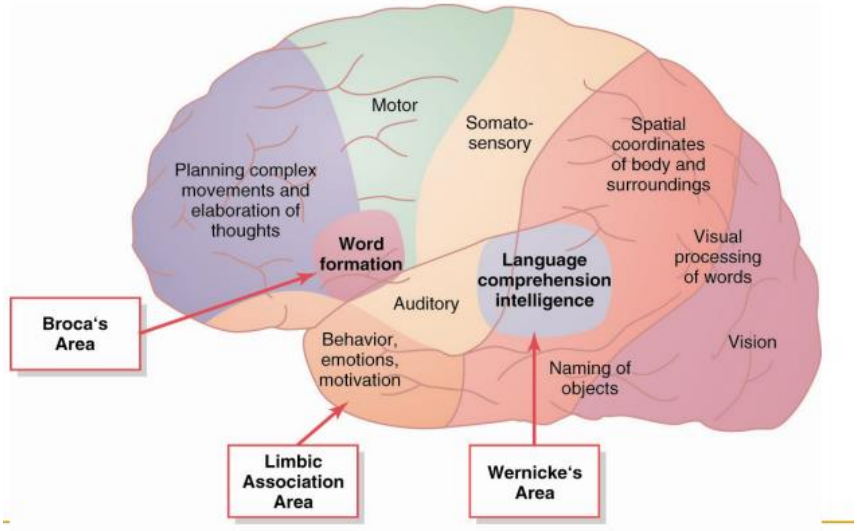
- The primary motor cortex is located in the precentral gyrus of the frontal lobe, while the primary sensory cortex is located in the post central gyrus.
- More cortical area is devoted to those muscles involved in skilled, complex or

delicate movements, that have more motor units i.e the cortical representation is proportional to the No of motor units.

- For example: the hand representation is taking space more than the whole lower limb because the area of any part is proportional to the prescience (how precise, exact, good) of the movement from that area.

The more the no. of motor units of one area the movement is more precise. The size of the represented part is proportional to the number of motor units supplying that organ, **not** to the actual size of the organ itself.

let's talk about the different functional areas of the cerebral cortex which are represented in the figure aside:
The secondary motor area is located in the premotor area.



- **Limbic association area**
  - This area is found on the most anterior part of temporal lobe.
  - It's concerned with behavior, emotions and motivation.

- **Somatosensory association area**
  - It's located posterior to the somatosensory area in the parietal lobe.
  - It interprets the sensory information and is concerned with spatial coordinates of the body and surroundings. By the function of this area you can feel the 3D shape of objects and localize different sensations and know their relations to other parts of the body.
  - If damaged → **Amorphosynthesis**: the person loses the ability to recognize the shape of the objects. Also he loses most of the sense of form of his own body on the opposite side (neglect it, forget that it's there).

- **Visual association area**
  - Located in the occipital lobe.
  - If damaged → word blindness.

- **Auditory association area**
  - Located in the temporal lobe.
  - Gives the meaning of what you hear.
  - If damaged → word deafness.

- **Wernicke's area** (language comprehension intelligence)
  - Located anterior to visual cortex, inferior and posterior to somatosensory association area, and posterior to auditory association area.
  - It's the **sensory area of speech** (responsible for understanding of speech).
  - It's where the ideas about what you feel (sensations), what you see, and what you hear are formed.
  - These ideas are then transmitted in the form of signals to **Broca's area**, and from there to the **primary motor area** to produce speech. (more on this is coming)

- **Prefrontal association area**
  - The most anterior part of frontal lobe.
  - This area is essential for planning complex movements and elaboration of thoughts, in fact this area is what forms your personality.
  - In the past it was believed that this area has no function, but how did they discover its function? This area was accidentally damaged in a railway worker named Phineas Gage, after which he became distracted, socially disinhibited, he lost the ability to prognosticate (foretell, predict). He lost the ability to do mathematical equations and make complex movements. His personality changed significantly and he acquired bizarre behavior.
  - **Intellectual functions of the prefrontal association area**
    - ✓ responsible for calling forth stored information and using it to obtain a goal. responsible for concerted thinking in a logical sequence.
    - ✓ elaboration of thought.
    - ✓ prognosticate, plan, consider consequences of motor actions before they are performed.
    - ✓ correlate widely divergent information, control one's activities.
    - ✓ Personality trait and behavior that confines to values and manners of the culture.
    - ✓ damage causes an inability to keep tract of simultaneous bits of information, easily distracted.

❖ Language areas

- Located in large area surrounding the left (or language dominant) lateral sulcus.
- Wernicke's area is more developed in the left cerebral hemisphere, and very small on the right, that's why the left is called language dominant hemisphere.
- Major parts and functions:

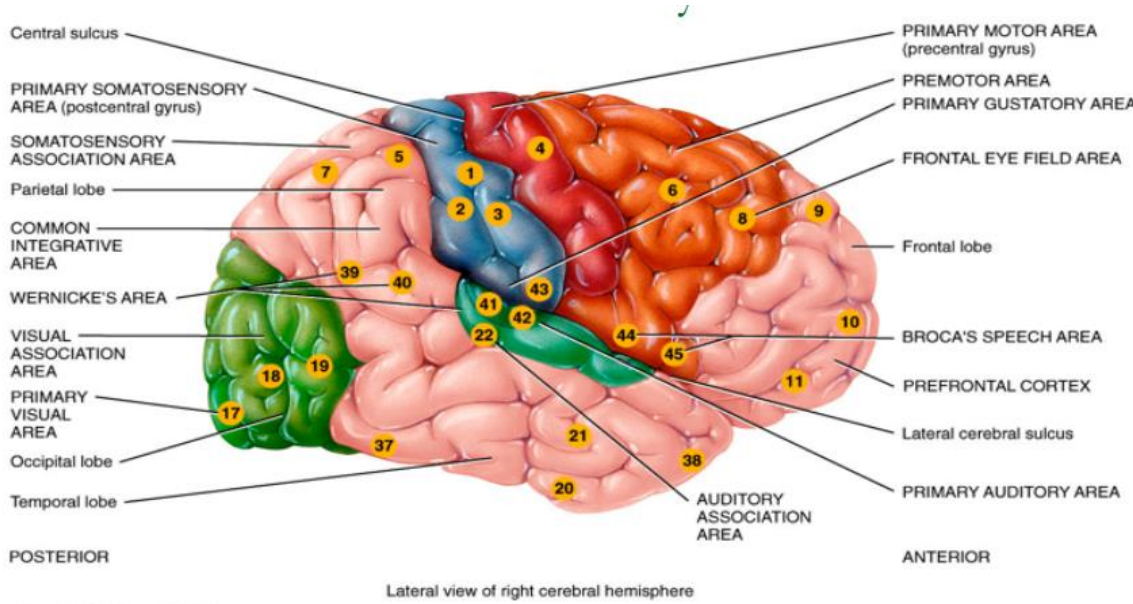
➢ Wernicke's area:

Damage → **sensory aphasia** (receptive aphasia), in which individuals have difficulty understanding written and spoken language. They demonstrate **fluent** speech, but their speech lacks content or meaning. (patient can vocalize but what he says doesn't make sense).

➢ Broca's area

Damage → **motor aphasia** (expressive aphasia), in which individuals can understand written and spoken language and form ideas, but they have difficulty expressing their ideas by speech and their speech is **non-fluent.**

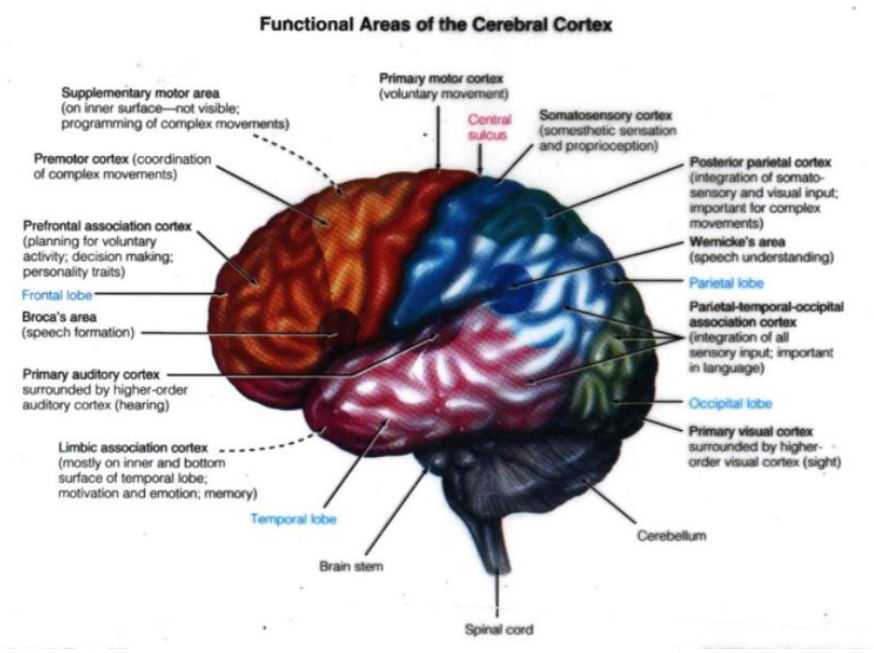
- If both Wernicke's and Broca's areas are damaged → **global aphasia** (both expressive and receptive language skills are reduced).
  - Lateral prefrontal cortex: for language comprehension and word analysis.
  - Lateral and ventral temporal lobe: coordinate auditory and visual aspects of language.

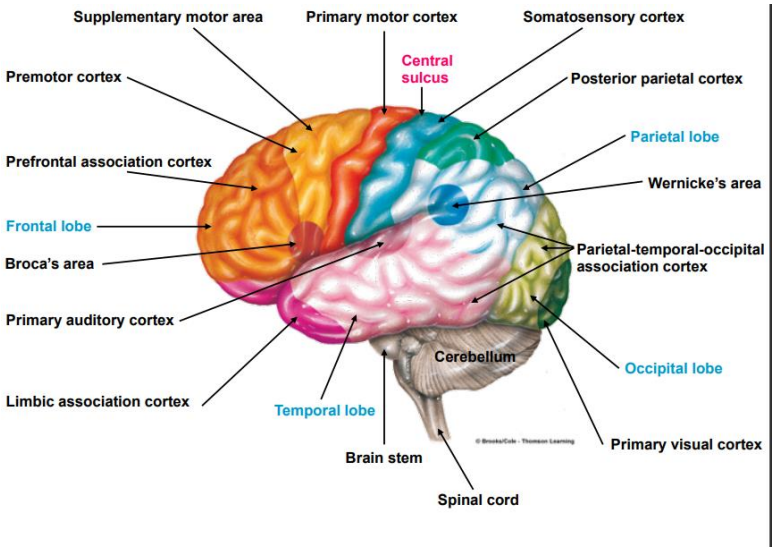


Lateral view of right cerebral hemisphere

Figure 14.15 Tortora - PAP 12/e

Not required to memorize numbers in physiology





❖ Dominant and non-dominant hemisphere

- When we say dominant and non-dominant we refer to the **language areas only**.
- Almost 95% of the right-handed people have a left dominant hemisphere.
- More than two thirds of left-handed people also have a left dominant hemisphere. The remaining third: half of them have right dominant hemisphere, and the other half have no dominant hemisphere.
- But what do we mean by a dominant hemisphere?

It means that the language areas are **larger** in the dominant hemisphere than the areas in the other non-dominant hemisphere, this is called **lateralization of the cerebral cortex.**
Wernicke's area can be as much as 50% larger in the dominant hemisphere.

- This doesn't mean that areas in the non-dominant side have no function. They are related to other forms of sensory intelligence (art, music, sensory, feelings).
- Damage to dominant Wernicke's area leads to **dementia** because it's also related to memory.
- Damage to language areas in the dominant hemisphere results in aphasia, whereas damage to the right hemisphere doesn't cause aphasia.
- Hemiplegia on the right side of the body is more likely to be associated with aphasia (damage to the left cerebral cortex that involves multiple areas), hemiplegia on the left side is less likely to be associated with aphasia.

- The dominance has no relation to handedness. **Handedness** means that right-handed individuals are born with the area that controls the movement of the right hand in the left cerebral hemisphere being larger than the opposite area, and as they grow up they tend to use the right hand, so this area grows and becomes dominant, and vice versa for the left-handed people.
- Left-handed individuals can convert to right-handed if they start to use their right hand instead, and the younger the individual the easier it will be because his/her brain is plastic. This applies to any learning skill (the younger the easier).
- Same applies for using the legs
- Close to 90% of people are right-handed and close to 10% are left-handed and a small number are ambidextrous (use both hands).
- 95% of right-handers process speech primarily in the left hemisphere.
    - Left handers: around 65% in the left hemisphere, 15-20% in right hemisphere, 15-20% in both.
- More than 90% of people are born with left the left hemisphere area that controls the movement of the right hand is bigger.
    - They tend to use the right hand, this area grows and become dominant.

TABLE 14.3

Functional Differences Between the Two Cerebral Hemispheres

LEFT HEMISPHERE FUNCTIONS	RIGHT HEMISPHERE FUNCTIONS
Receives somatic sensory signals from and controls muscles on right side of body.	Receives somatic sensory signals from and controls muscles on left side of body.
Reasoning.	Musical and artistic awareness.
Numerical and scientific skills.	Space and pattern perception.
Ability to use and understand sign language.	Recognition of faces and emotional content of facial expressions.
Spoken and written language.	Generating emotional content of language.
	Generating mental images to compare spatial relationships.
	Identifying and discriminating among odors.

Table 14.03 Tortora - PAP 12/e

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