Functional areas of cerebral cortex and its associated lesions

LEARNING OBJECTIVES
At the end of the lecture the student should be able to know:
- Different functional areas of cerebral cortex
- Motor areas
- Sensory areas
- Association areas
- Lesions associated with functional areas

Cerebral hemispheres
- Form the superior part of the brain and make up 83% of its mass
- Only 1/3 of surface area visible, 2/3 in banks of sulci
- Contain ridges (gyri) and shallow grooves (sulci)
- Contain deep grooves called fissures
- Are separated by the longitudinal fissure
- Have three basic regions: Cortex, White matter, Basal nuclei

Major Lobes, Gyri, and Sulci of the Cerebral Hemispheres
- Deep sulci divide the hemispheres into five lobes:
  - Frontal, parietal, temporal, occipital, and insula
- Transverse fissure - separates R and L hemispheres
- Central sulcus – separates the frontal and parietal lobes

2. Motor area
- Controls thin muscles of the body (fingers, mouth, feet, eye...)
- Coordinates movements
- Controls speech (articulation of words)

3. Somesthetic area
- Receives sensations, temperature and pain sensations from the body

Frontal lobe (1,2)

1. Prefrontal area
- Elaborates the thinking process
- Planning of complex movements

2. Motor area

Ocipital lobe (4)

4. Visual area
- Detects visual signals

Temporal lobe (5,6,7)

5. Auditory area
- Detects auditory signals

6. Wernicke’s area
- Interprets the signification of sentences as they are heard and written

7. Short-term memory area
- Stores short-term memory (that lasts few seconds)
- The precentral and postcentral gyri border the central sulcus
- Parieto-occipital sulcus – separates the parietal and occipital lobes
- Lateral sulcus – separates the parietal and temporal lobes

**Cerebral Cortex**
- The cortex – superficial gray matter
  - Contains cell bodies, dendrites, and short axons
- Folding of cortex triples its size
  - “Unity of structure and function”
- Enables us to:
  - Be aware of ourselves and our sensations
  - Initiate and control voluntary movements
  - Communicate, remember, and understand
- Each hemisphere acts contralaterally (controls the opposite side of the body)

**Functional Areas of Cerebral Cortex**
- Each lobe has several gyri
- Functionally the cortex is divided into numbered areas first proposed by Brodmann in 1909.
- Hemispheres are not equal in function
- No functional area acts alone; conscious behavior involves the...
Functional Areas of the Cerebral Cortex

- The three types of functional areas are:
  - Motor areas – control voluntary movement
  - Sensory areas – conscious awareness of sensation
  - Association areas – integrate diverse information

Cerebral Cortex: Motor Areas

- Primary (somatic) motor cortex. Precentral gyrus, area 4
- Premotor cortex, area 6, motor programs.
- Broca’s area, 44 & 45, production of speech

Primary Motor Cortex

- Located in the precentral gyrus (Area 4)
- Composed of pyramidal cells
  - Large neurons whose axons make up the corticospinal tracts
- Allows conscious control of precise, skilled, voluntary movements
  - i.e., controls skeletal muscle
- Motor homunculus – caricature of relative amounts of cortical tissue devoted to each motor function

Premotor Cortex

- Located anterior to the precentral gyrus
- Controls more complex movements
- Controls learned, repetitious, or patterned motor skills
  - Typing, playing a musical instrument
- Coordinates simultaneous or sequential actions
- Involved in the planning of movements
Broca’s Area
- Located in left cerebral hemisphere
  - Areas 44 and 45
- Manages speech production
  - A motor speech area that directs muscles of the tongue
  - Is active as one prepares to speak
- Corresponding region in right cerebral hemisphere
  - Controls emotional overtones to spoken words

Cerebral cortex: Sensory area
- Cortical areas involved in conscious awareness of sensation
- Located in parietal, temporal, and occipital lobes
- Distinct area for each of the major senses
  - Primary somatosensory cortex
  - Somatosensory association cortex
  - Visual and auditory areas
  - Olfactory, gustatory, and vestibular cortices

Primary Somatosensory Cortex
- Located in the postcentral gyrus (area 1-3)
- Involved with conscious awareness of general somatic senses
  - Receives information from the skin and skeletal muscles
  - Exhibits spatial discrimination
  - Precisely locates a stimulus
- Projection is contralateral
  - Receives sensory input from the opposite side of the body
- Somatosensory homunculus – a body map of the sensory cortex (same as Motor homunculus)

**Somatosensory Association Cortex**
- Located posterior to the primary somatosensory cortex
- Integrates sensory information
- Forms comprehensive understanding of the stimulus
- Determines size, texture, and relationship of parts.

**Visual Areas**
- Primary visual cortex (area 17)
  - Located on posterior part of occipital lobe
  - Receives visual information from the retinas
- Visual association area (area 18)
  - Surrounds the primary visual cortex
  - Interprets visual stimuli (e.g., color, form, and movement)

**Auditory Areas**
- Primary auditory cortex (area 41 and 42)
  - Located at the superior of the temporal lobe
  - Receives information related to pitch, rhythm, and loudness
- Auditory association area (area 22)
  - Located posterior to the primary auditory cortex
  - Stores memories of sounds and permits perception of sounds
  - Involved in recognizing and understanding speech Lies in the center of Wernicke’s area
Other Primary Sensory Areas

- **Vestibular Area**
  Area 3a and 2v of SI (superior temporal gyrus anterior to A I)

- **Gustatory Area**
  Area 43 (inferior end of postcentral gyrus)

- **Olfactory Area**
  Piriform Lobe - Limbic System

Association Areas

- Make associations between different types of sensory information
- Associate new sensory input with memories of past experiences
- New name for association areas – **higher order processing areas**
- Include:
  - Prefrontal cortex
  - Language area
Prefrontal Cortex
- Located in the anterior portion of the frontal lobe
- Performs cognitive functions
  - Involved with intellect, cognition, recall, and personality
  - Necessary for judgment, reasoning, persistence, and conscience
  - Also related to mood
  - Closely linked to the limbic system (emotional part of the brain)

Language Areas
- Surrounds the lateral sulcus in the left cerebral hemisphere
- Major parts and functions:
  - Broca’s area – (Motor Language Area) speech production
  - Wernicke’s area -- (Sensory Language Area) speech comprehension

Lateralization of Cortical Function
- The two hemispheres control opposite sides of the body
- Hemispheres are specialized for different cognitive functions – lateralization
  - Cerebral dominance – designates the hemisphere dominant for language
- Left hemisphere – more control over:
  - language, math, and logic
- Right hemisphere – more involved with:
  - Visual-spatial skills
- Emotion
- Artistic and musical skills

**Disorders of Association Cortex**
- **Agnosia** (loss of knowledge)
  - loss of ability to recognize objects, persons, sounds, shapes, or smells while the specific sense is not defective nor is there any significant memory loss
- **Apraxia** (disorder of motor planning)
- **Aphasia** (meaning speechless)
  - A defect in language processing caused by dysfunction of the dominant cerebral hemisphere
  - Wernicke’s (receptive) aphasia
  - Broca’s (Motor) aphasia

**HOMONYMOUS HEMIANOPIA**
- Type of partial blindness resulting in a loss of vision in the same visual field of both eyes.
- Caused by injury to the brain itself such as from stroke or trauma