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TABLE OF CONTENTS

1. Learning Outcomes

After studying this module, you shall be able to;

- Know about the location and general functions of different lobes of the cortex
- Learn about the functions of the temporal lobes in more details
- Identify various areas of the temporal lobes and their functions
- Learn about the temporal lobes dysfunctions and syndromes

2. Introduction

Billions of cells constitute the most complex structure of the brain. The connections between the cells are uncountable. The actions of survival are carried out as directed by the brain. The cells of the brain connect to every part of the body for receiving stimulation to act in the precise manner to ensure survival. Brain and the neural tube attached to it, called the spinal cord, constitute the central nervous system. It is the basic decision making center. The spinal and the cranial nerves, the nerves emanating from the spinal cord and the brain constitute the peripheral nervous system. The latter takes the message from the brain to the body and makes action possible.

Besides muscular activities, the mental and cognitive functions of thinking, problem solving, reasoning, having emotions and creativity are all carried out by various parts of the nervous system. The human brain is larger than that of any other primate. When corrected for body size, it is more than three times larger than that of a chimpanzee. An understanding of the basic structures of brain is required to connect the brain parts and the behaviors that they control. A picture of the brain is given below;

The total weight of a human brain is about one and a half kilograms. The earliest to develop in the fetus development is the neural tube, which later develops into the spinal cord. The brain develops an unlimited number of neurons, neuronal connections and the glial cells. The brain cells are highly supported and protected by the glial cells. It is the most protected organ of the body. Besides glial cells, the other supporting mechanisms of brain are ventricles, the hollow spaces filled with cerebrospinal fluid, the meninges, and the blood brain barrier system.

There are three major divisions of the brain are known as the forebrain, the midbrain, and the hindbrain. The brain is also divided into four lobes on the top called the cerebral cortex. Each part of the brain is specialized to perform specific functions.

3. The Four Major Lobes of the Cerebral cortex

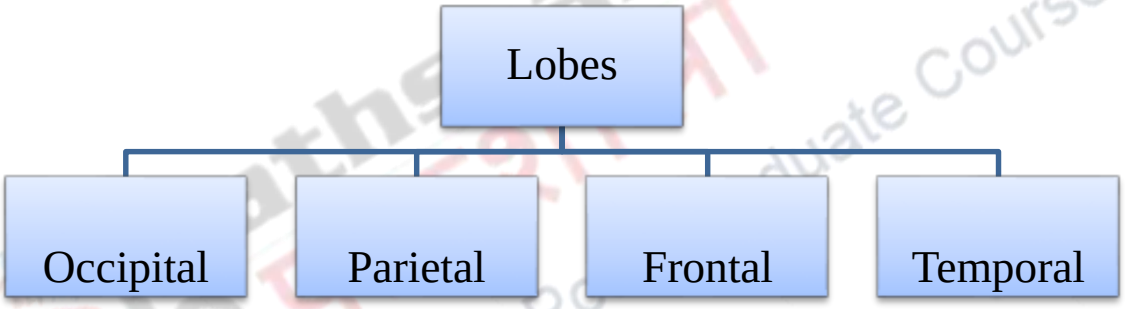
The outermost covering of the brain is called the cortex. Its thickness is about one tenth of an inch. It is about 3mm. It is a tightly packed tissue of neurons and other cells. It looks grayish pink under the microscope. It consists of blood vessels, militated fibers which look white and the cell bodies providing grey coloration.

The total area of the brain is much larger than the size of the skull. If it were a smooth surface on the skull, only two thirds of the area of the cerebral cortex could have been accommodated. There are several folds on thhe surface of the brain which have given rise to sulci (plural for sulcus), gyri (plural for gyrus), fissures (deep depressions) and convolutions (wrinkles) on the

brain. Sulci refer to slightly less deep depression whereas fissures are deeper than them. Gyrus is an elevation on the surface of the brain due to adjoining gyrus. Each of the sulci and gyri has been named. The areas thus divided by them have also been given specific names. The study of brain structures involves this regional classification of areas on the brain.

The development of brain has been maximum in t5he cerebral cortex rather than in other areas like the spinal cord. Therefore, maximum folds are seen on this only. This is known as the process of corticalization of the brain over thousands of years. This is an index of the development of intelligence and other cognitive and creative functions.

The longitudinal fissure runs in between the structure of the brain vertically. It divides the brain into two equalo halves. They are known as the left and the right hemispheres. However, they are joined by a thick band of fibers called the corpus callosium. Each of the two hemispheres of the brain consists of four major areas called the cerebral lobes ldue to the presence of various sulci and gyri .These four sections are called Lobes or Cortical areas of the brain. A brief description of the major functions of each lobe is given below;



Each of the two hemispheres of the brain contains all the four lobes of the brain. The brain is divided into two hemispheres due to the deep fissure called the longitudinal fissure. The central ring of interconnected neurons which touches almost all areas of the lobes in both hemispheres constitutes the limbic system which controls emotional and motivational processes in organisms.

3.1 Occipital Lobe

At the back of the brain towards the lower side, there is a small area called the occipital lobe. It is connected with the visual sensation. It consists of primary occipital areas to provide visual sensation as received from the thalamus, and emanating from the retina of the eye. The secondary area helps in making a meaning of that sensation, while the associative visual areas help integrate visual information with other sensory experiences, and to recognize complex visual patterns. This lobe is separated from the parietal lobe via the calcarine fissure. In each lobe of the cortex, there are association areas for sensory integration. Thus, primary areas in each lobe perform the sensory function whereas the association areas perform perceptual functions.

3.2 Parietal Lobe

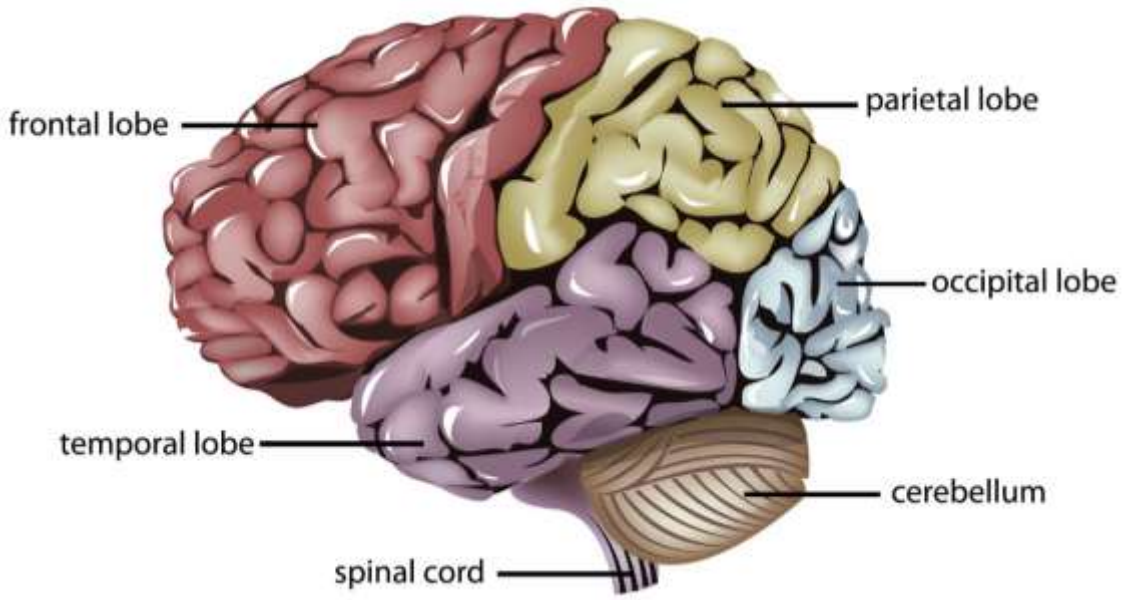
Under the large bone known as the parietal bone, there are the parietal lobes in each of the two hemispheres. It is also known as the somesthetic cortex. Sensations of tactile nature including touch, hot cold, pressure and pain are processed here. It is also the center for kinesthetic sensations, that is, the sensations of body position and movements. It is associated with the perception of the t5hird dimension, i.e., and visuo-spatial orientation.

3.3 Frontal Lobe

Just behind an individual's forehead, the frontal lobes are situated. This is the largest area in the cerebral cortex. It contains the primary motor areas to control voluntary movements of all the muscles of the body. It is also specialized for the higher cognitive functions including verbal, numerical, and abstract reasoning, decision making, and problem solving. It also has centers for the control of emotionality and impulse control. It is possible due to its connection with the limbic cortex which is the center for emotions. It provides a substrate for various personality characteristics, and has a great role in determining the intelligence level of the individual.

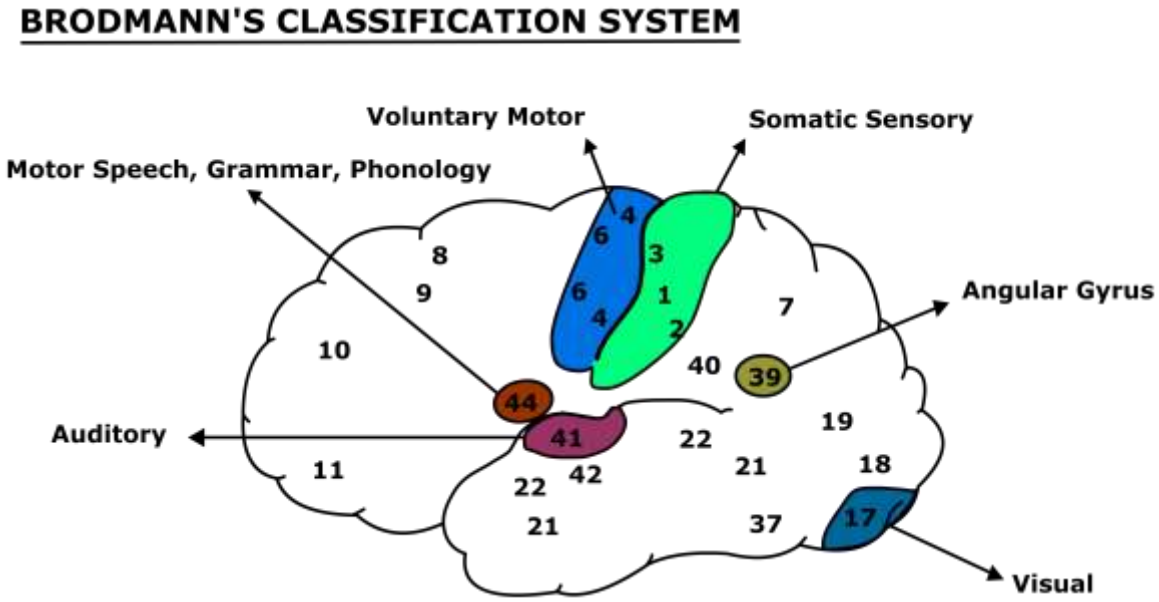
3.4 Temporal Lobes

The temporal lobes (temporal refers to the areas near the temples) are located behind the ears of an individual. It is separated from the frontal lobe via the lateral fissure. These lobes contain the primary area for the sensation of hearing and receive information from the thalamus emanating from the inner ear. It also contains the auditory association areas for sensory integration.. If a person receives a blow to the side of the head, he will probably hear a ringing sound. An important area located in the temporal cortex is Wernick's area which is associated with the comprehension of language.



4. Brodmann's Areas

Brodmann studied brain from a functional point of view to divide it into various areas, instead of their regional classification. Through the method of stimulation and other techniques, he recorded psychological and physiological changes connected with each area of the brain. In this manner, he divided the brain into 52 functional areas. It is known as the Broddman Classification



Major Brodmann areas in each lobe are described below;

The Parietal Lobes are comprised of areas that play a role in somato-sensory processes. They include;

- Areas 3, 2, and 1: Somasthetic areas, primary sensory areas for touch.
- Areas 5, 7, and 40: Somatosensory areas, presensory association areas
- Area 39: The angular gyrus.

The Occipital Lobes contain areas that process visual stimuli.

- Area 17: The primary visual area.
- Areas 18 and 19: The secondary visual (association) areas where visual processing occurs.

The Temporal Lobes are comprised of areas that are involved in the processing of auditory information and semantics as well as the appreciation of smell.

- Area 41: Heschl's gyrus, the primary auditory area.

- Area 42 immediately inferior to area 41 and is also involved in the detection and recognition of speech. The processing done in this area of the cortex provides a more detailed analysis than that done in area 41.

- Areas 21 and 22: The auditory association areas. Both areas are divided into two parts; one half of each area lies on either side of area 42**.** Collectively they can be called Wernicke'**s** area.

- Area 37 is found on the posterior-inferior part of the temporal lobe. Lesions here can cause anomia.

5. Major Areas of the Temporal Lobes

The Temporal Lobes are important structures for a number of functions.

5.1. Wernicke's Area

There area is more active in the left temporal lobe. Wernicke's area was discovered when studies related to its damage were carried out. It was found that if this area got damaged due to injury, tumor or stroke etc., the person would lose capacity to understand language. The comprehension of the spoken word is adversely affected even though he will understand the written word. If he tries to speak, he may be using the wrong and random words. Such a condition is known as Wernicke's aphasia. Since it is located in the temporal lobe which is primarily concerned with hearing, it is the spoken aspect of language which is affected, and not the visual one, i.e., reading of language.

5.2 Hippocampus

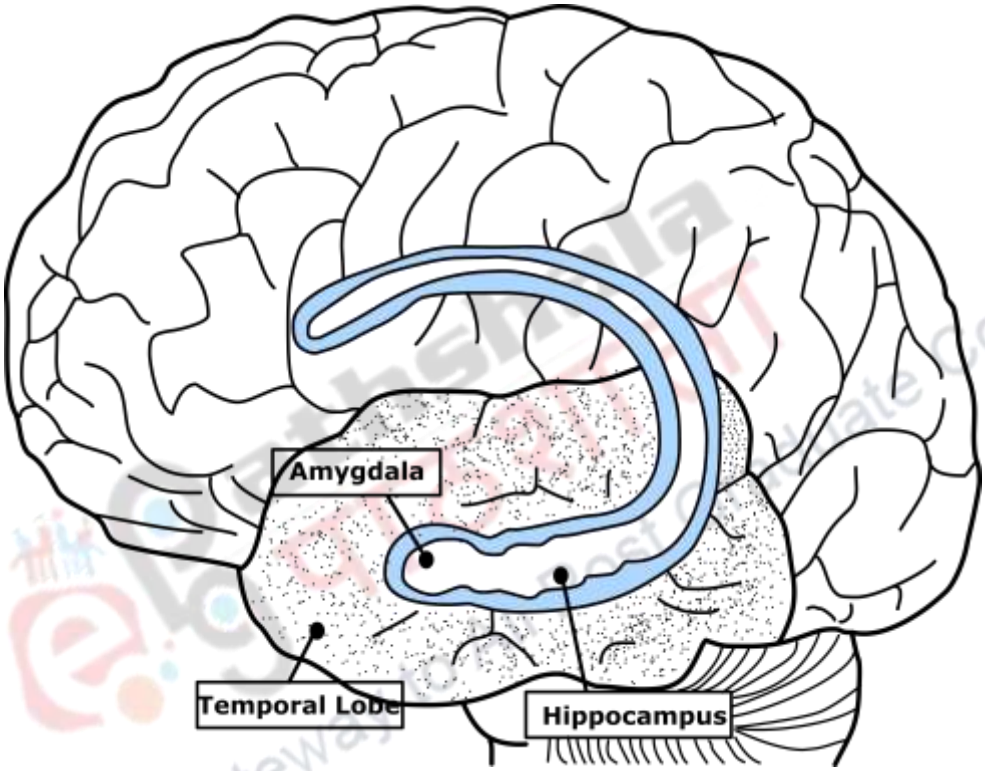
In the deep layers of the temporal cortex, the important structure called hippocampus is located, and electrical stimulation of the temporal lobe may produce memory like or dream-like experiences. Hippocampus has its name because the first scientists who discovered it thought that it looked like a seahorse. Hippocampus is connected with other parts of the brain via a bundle of fibers called the fornix. It is also connected to the mammillary bodied of the hypothalamus. It thus occupies a central place within the structure of the brain..

Researchers have found that hippocampus is involved with the storage of memories on a long term basis. Acetylcholine (Ach) is the main neurotransmitter which helps synaptic activity in these regions. The hippocampus may be located close to the area where the memories for location of objects are stored.

It has been found that the right para hippocampal gyrus, located to the right of hippocampus, is more active when the person is planning a travel route (Maguire et al., 1998). This might also explain why older people tend to forget where they live or have similar other location problems since their neurons begin to slow down/decay due to age. It may lead to the deterioration of the functioning of hippocampus. In the case of Alzheimer's patients, lower levels of Acetylcholine have been found in this region in comparison to the normal people and show severe deficits.

5.3 Amygdala

The deep layers of the temporal cortex also contain another important structure called amygdala .It is in the proximity of the hippocampus. Long term memory, particularly, emotion laden memories of fear responses in particular are stored in this area. Removal or damage to these areas results in an animal entering dangerous. It has also been found that they lose the discrimination between what is useful for them to eat and what may be harmful. Kluver and Bucy (1939) found that monkeys with damaged temporal cortices were eating even nuts and bolts in the laboratory. It was later described as the Kluver-Bucy syndrome.



Experimental rats in the laboratory with damaged amydala show no fear in the group of even cats which they instinctively avoid. What is interesting in the functioning of amygdala is that information from the senses reaches amygdala even before it reaches upper parts of the brain. As a result, response to a dangerous situation comes up even before the organism becomes aware of it via the central nervous system in a normal condition.

6. Temporal Lobes Dysfunction and Syndromes

In a nutshell, besides auditory sensation and auditory perception, temporal lobes serve many more functions like those of memory and learning. It receives auditory messages, and some visual information, and contributes to the understanding of spoken language and rhythm. Moreover, it controls how things are categorized and ordered by an individual. There have been many problems associated with the malfunctioning of temporal lobes like aphasia, short-term memory loss, inability to categorize objects, increased aggressive behavior, among others. The major abnormalities associated with temporal lobes are as follows:

Prosopagnosia

Prosopagnosia is a neurological disorder which is characterized by an individual's inability to recognize faces. Prosopagnosia is thought to be the result of abnormalities, damage, or impairment in the right fusiform gyrus, a fold in the brain that appears to coordinate the neural systems that control facial perception and memory. Prosopagnosia can result from stroke, traumatic brain injury, or certain neurodegenerative diseases.

Wernicke's Aphasia

Wernicke's aphasia is characterized by difficulty in understanding spoken words. People with this abnormality tend to speak fluently, but their speech often becomes random, very hard to follow "streams of consciousness" constituting made up words, and is usually associated with lesions to Wernicke's area, a piece of cortical tissue at the boundary between the parietal and temporal lobes.

Disturbance of Selection of Visual and Auditory Input

Impairment in selection of auditory input is determined through dichotic listening. Ordinarily, normal subjects report more of the words presented in the right ear. However, left-ear advantage is maintained in people with left temporal lobe lesions. In case of visual input, damage to left temporal lobe results in impairment in recall of content in the right visual field. However, damage to right temporal lobe results in impairment in recall of content from both the fields.

Organization and Categorization

Patients with temporal lobe abnormality have difficulty in placing words or pictures into discrete categories. Patients with temporal lobe lesions may demonstrate dysphasic symptoms wherein they can work through broader classifications but have difficulty with the specific categorization process.

Memory

In 1950s, research including removal of medial temporal lobes, amygdala and hippocampus demonstrated instances of amnesia for all the events after the surgery (anterograde amnesia). Also, the damage to inferior temporal lobe results in interference of conscious recall of information that may be relevant to the individual.

Personality

Pincus and Tucker described several symptoms associated with the temporal lobe epilepsy which were reflected in the personality traits like egocentricity, paranoia, preoccupation with religion and proneness to aggressive outbursts.

A summary of such functions and dysfunctions is as follows:

Function	Observed Dysfunction	Lesion Site
▪ Memory and new learning ▪ Controls how things are ordered and categorized ▪ Receives auditory messages ▪ Some visual perception ▪ Understands spoken language and rhythm	▪ Prosopagnosia (difficulty in recognizing faces) ▪ Wernicke's Aphasia (difficulty in understanding spoken words) ▪ Short-term memory loss ▪ Disturbance with selective attention to what we see and hear ▪ Difficulty with identification of and verbalization about objects ▪ Interference with long term memory ▪ Increased or decreased interest in sexual behavior ▪ Increased aggression ▪ Difficulty in classification ▪ Nonstop verbalizations related to damage in the right hemisphere	▪ Superior Temporal Sulcus, Amygdala ▪ Area 22 left ▪ Area 28 ▪ Superior Temporal sulcus ▪ Superior temporal sulcus ▪ Area 28 ▪ Amygdala (Pincus & Tucker, 1974)

Source: http://www.health.qld.gov.au/abios/asp/btemporal.asp

7. Summary

- Each of the two brain hemispheres can be further divided into four areas or lobes due to the deeper wrinkles, or fissures, in its surface.
- Temporal lobes contain the primary area for hearing and its related associative areas. Functionally, Temporal Lobes are divided into several Brodmann areas.
- Temporal lobes include important structures like Wernicke's areas, hippocampus, and amygdale.
- Temporal lobes serve many functions like those of memory and learning.
- The malfunctioning or damage to Temporal Lobes causes disorders like prospagnosia, Wernicke's aphasia, short-term memory loss, inability to categorize and verbalize objects, increased aggressive behavior etc.