

Unit VIII – Problem 11 – Neuroanatomy: Limbic System and Hypothalamus

- The four lobes of the cerebral hemisphere (frontal, parietal, temporal and occipital) are recognized easily. In contrast, the limbic system is located deep inside.

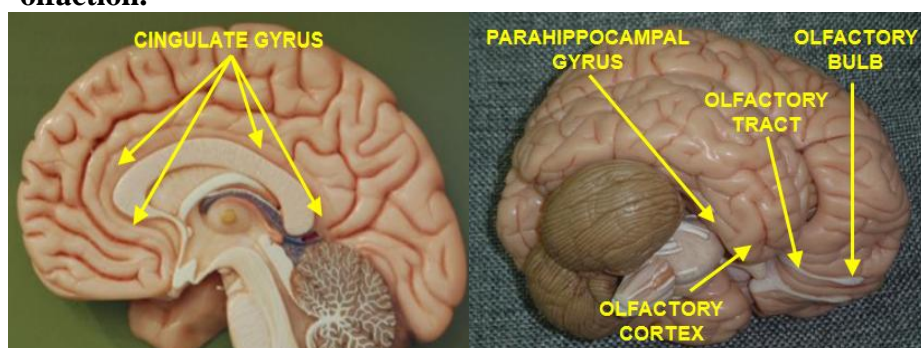
- History:

- **Thomas Willis** identified structures forming a border between cerebral hemispheres and the brainstem. He called this junction “limbus” (which means a border in Latin).
- **Broca** identified a motor center for speech in the inferior part of the left frontal lobe (Broca’s area: concerned with word formation). In addition, he noticed a collection of structures (grey matter) in the inferior medial aspect of cerebral hemispheres which was constant in many mammalian species → he called it “The Large Bordering lobe”.

✓ Broca included the following structures in his limbic lobe:

- ❖ *Cingulate gyrus.*
- ❖ *Olfactory bulb, olfactory tract and olfactory cortex.*
- ❖ *Parahippocampal gyrus and the underlying hippocampus.*

Note: he concluded that the main function of limbic system was olfaction.



- **James Papez:** he noticed that Broca’s limbic lobe was also concerned about emotion. He described a neural circuit (Circuit of Papez) which included the following structures:

- ✓ *Cingulate gyrus.*
- ✓ *Parahippocampal gyrus and the underlying hippocampus.*
- ✓ *Mamillary body.*
- ✓ *Anterior nuclei of the thalamus.*

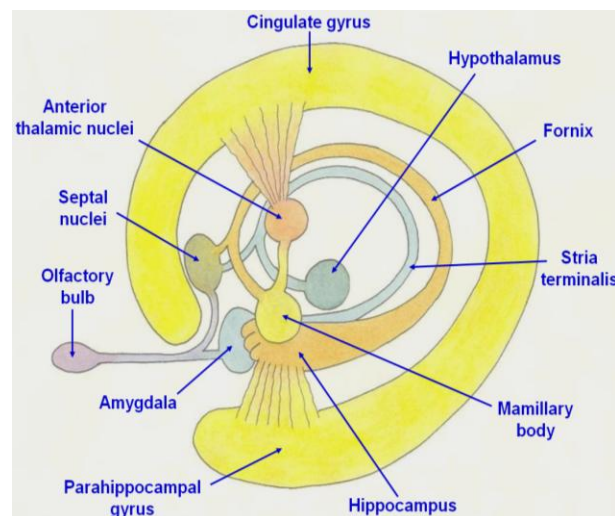
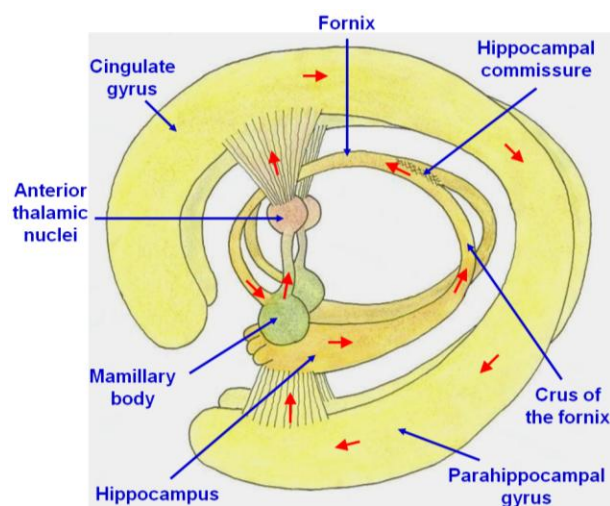
- **Paul D. Maclean:** he suggested that Broca’s lobe is better to be considered as a system “limbic system”. In addition, he extended the range of components which are constituting the limbic system to include the circuit of Papez and the following additional structures:

- ✓ *Amygdala.*
- ✓ *Hypothalamus.*
- ✓ *Prefrontal cortex.*
- ✓ *Thalamus.*

- Function of the limbic system: it has a major role in determining emotional responses. The hippocampus additionally is involved with memory.

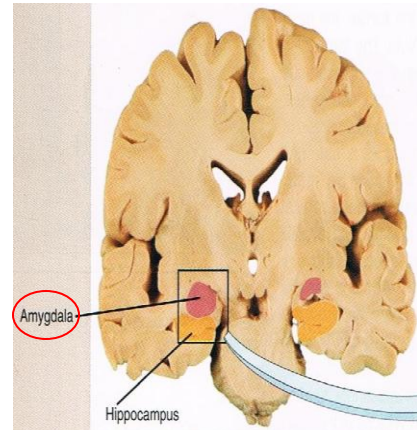
- The present concept of the limbic system is summarized in the image.

- Details about some components of the limbic system:



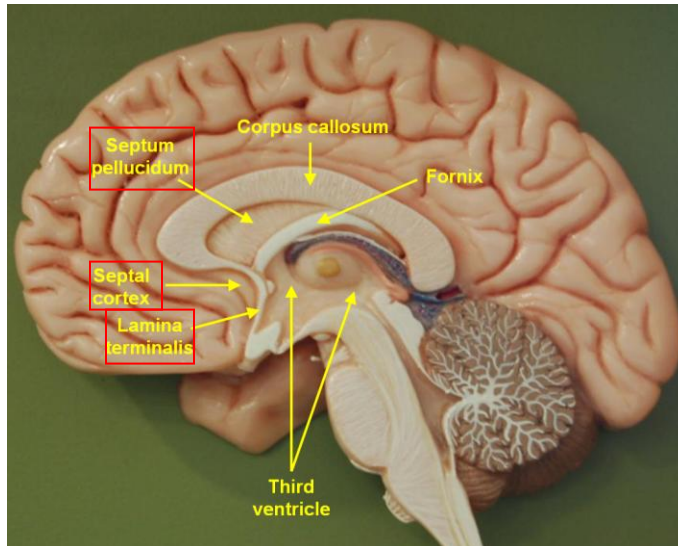
- **Amygdala:**

- ✓ Definition and location: it is an almond shaped collection of nuclei at the tip of the tail of caudate nucleus in close relation to the hippocampus in temporal lobe.
- ✓ Functions:
 - ❖ Emotional learning and memory.
 - ❖ Fear and fear conditioning.
 - ❖ Reward.
- ✓ Output: the main output from amygdala (stria terminalis) is going to hypothalamus which is responsible for expression of emotions.
- ✓ Damage: bilateral damage (rare) is caused by viral encephalitis and is leading to blunted emotional responses (becoming less sharp).



- **Septal area:**

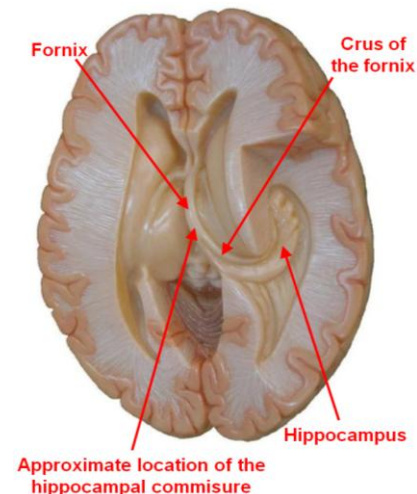
- ✓ Definition: it is the main (pleasure area) of the brain containing a group of nuclei known as septal nuclei. The septal area may include the following structures (see the image):
 - ❖ *Septum pellucidum:* it lies between the fornix and corpus callosum forming the medial wall of lateral ventricle.
 - ❖ *Lamina terminalis:* it forms the anterior border of the 3rd ventricle.
 - ❖ *Septal cortex:* with septal nuclei beneath it (stria-medullaris-thalami is a pathway between septal nuclei and habenula “the stalk of pineal gland”).



- ✓ Function: precise function remains largely unknown.
- ✓ Output: the main output is going to the hippocampus.

- **Hippocampus:**

- ✓ Location: it lies in the floor of the inferior horn of lateral ventricle, near the parahippocampal gyrus in the inferior surface of temporal lobe.
- ✓ Function: formation of memory.
- ✓ Afferents: receiving fibers from septal area and olfactory cortex.
- ✓ Efferent: efferent fibers arch upwards and become crus of the fornix which is passing beneath corpus callosum → some fibers are exchanged across the midline between the two crura at the hippocampal commissure → the two



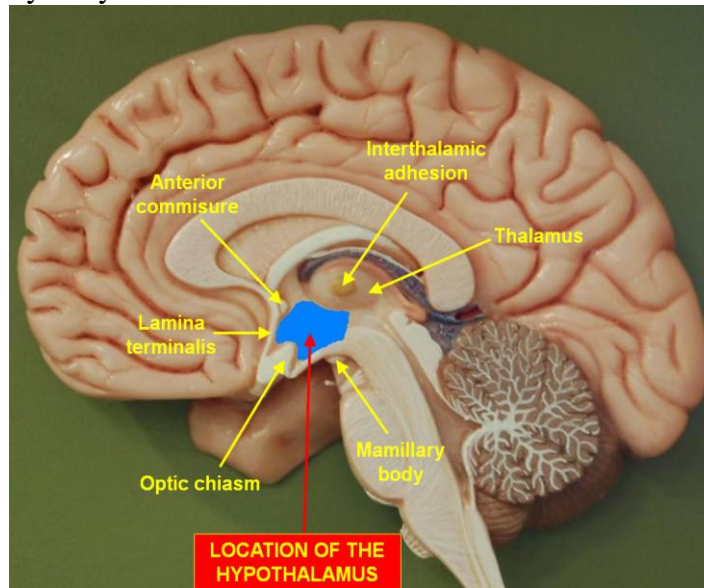
crura meet in the midline and become the body of the fornix → fornix ends in mamillary body of hypothalamus → then fibers will be sent to anterior thalamic nuclei → and from there to cingulate gyrus → and then to parahippocampal gyrus (completing circuit of Papez).

- ✓ Damage: bilateral damage to hippocampus or to fornix will result in inability to form new memory (anterograde amnesia).

- **Hypothalamus:**

- ✓ Location: it is part of diencephalon which lies in the side wall of the floor of the 3rd ventricle bordered by:

- ❖ Thalamus.
- ❖ Anterior commissure.
- ❖ Lamina terminalis.
- ❖ Optic chiasma.
- ❖ Tuber cinereum.
- ❖ Mamillary body.



- ✓ Functions:

- ❖ *It is regulating the hormones released by the pituitary gland:*

- ✚ Through releasing and inhibiting hormones in the portal venous system which is in connection with anterior pituitary gland. Hormones which are released from anterior pituitary gland include the following:

- Growth hormone (GH).
- Melanin stimulating hormone (MSH): going to melanocytes.
- Prolactin: going to mammary gland.
- ACTH: going to adrenal cortex.
- Thyroid stimulating hormone (TSH): going to thyroid gland.
- FSH and LH: going to testes and ovaries.

- ✚ Two hypothalamic nuclei are involved in production of hormones which will be stored and released from posterior pituitary gland:

- Supraoptic nucleus: producing vasopressin (ADH) which stimulates water retention in distal convoluted tubule of the kidney.
- Paraventricular nucleus: producing oxytocin in response to suckling thus resulting in lactation. It is also stimulating uterine contractions during labour.



- ❖ *Stimulating both sympathetic and parasympathetic nervous systems mainly to regulate temperature of the body (thermoregulation) and blood pressure.*
- ❖ *Regulation food intake through two main nuclei:*
 - ✚ **Lateral hypothalamus:** feeding center.
 - ✚ **Ventromedial nucleus:** satiety center.
- ❖ *Drinking:* thirst center monitors blood osmolarity and controls the release of antidiuretic hormones (ADH). A damage will result in diabetes insipidus which is characterized by polyuria and polydipsia.
- ❖ *Circadian rhythm.*
- ❖ *Expression of emotions:* especially anger, fear and sexual behavior.
- ✓ Outputs: the main outputs are going to:
 - ❖ Brainstem.
 - ❖ Autonomic nervous system.
 - ❖ Pituitary gland.
- ✓ Arterial supply:
 - ❖ Anterior cerebral and anterior communicating arteries.
 - ❖ Posterior cerebral and posterior communicating arteries.

- **Thalamus:**

- ✓ It is paired, containing several nuclei and divided into regions by the internal medullary lamina.
- ✓ There are two important nuclei in the thalamus:
 - ❖ *Lateral geniculate nucleus:* concerned with vision.
 - ❖ *Medial geniculate nucleus:* concerned with hearing.
- ✓ Other important relay nuclei of the thalamus:

| Relay nuclei | Input | Output |
|--|--|-------------------------|
| Anterior nucleus | Mamillary body | Cingulated gyrus |
| VPL nucleus | Medial lemniscus and spinothalamic tract. | Somatosensory cortex |
| VPM nucleus | Trigeminal lemniscus | Somatosensory cortex |
| Lateral geniculate nucleus | retina | Primary visual cortex |
| Medial geniculate nucleus | Inferior colliculus | Primary auditory cortex |
| Ventral lateral & ventral medial nuclei | Globus pallidus and substantia nigra pars reticulata | Motor cortex |

