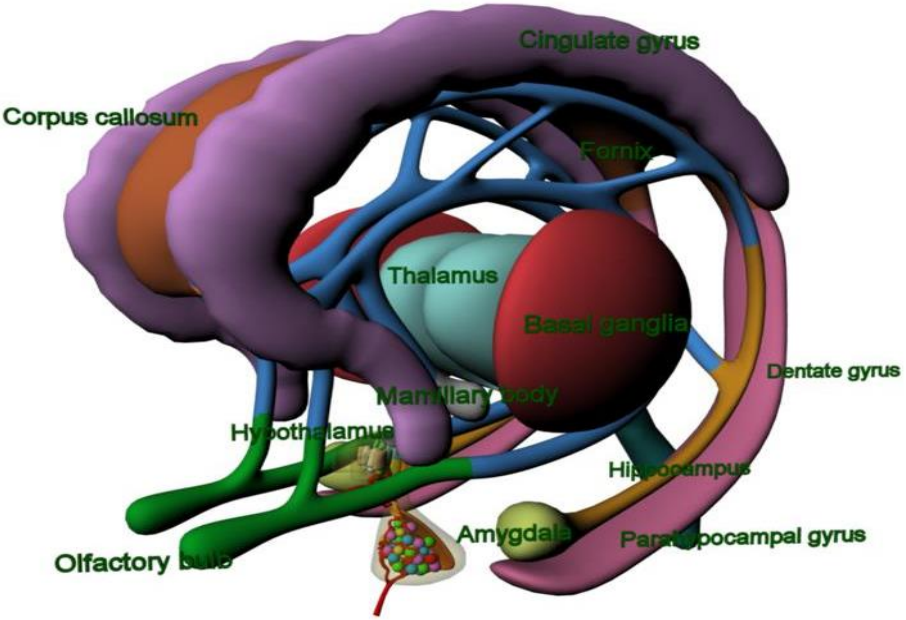
Limbic System



Mr. M. Banda

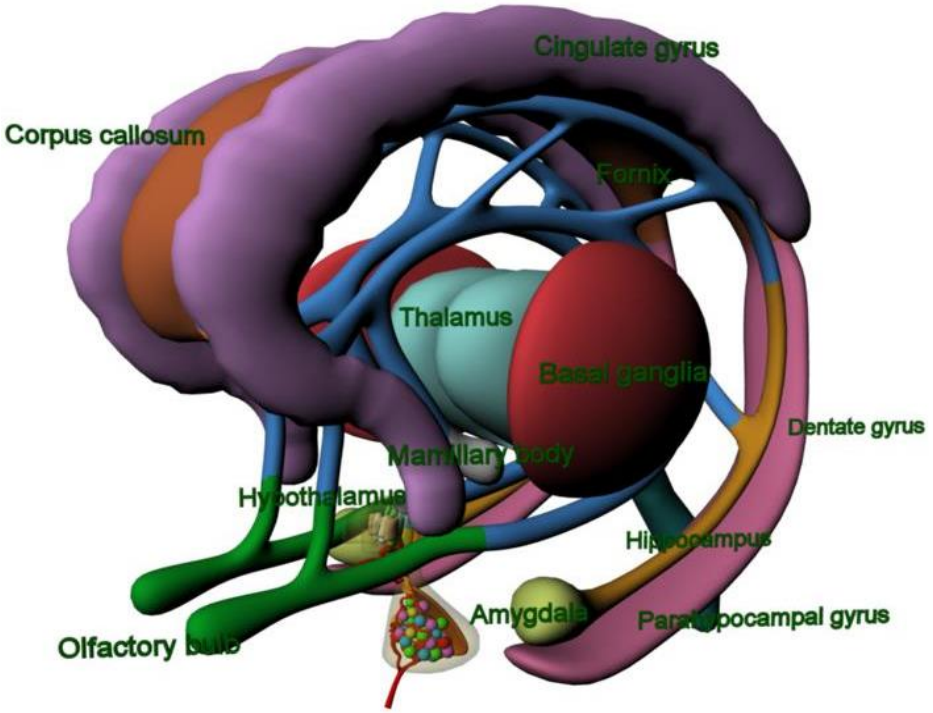
Limbic System

LEARNING OBJECTIVES:

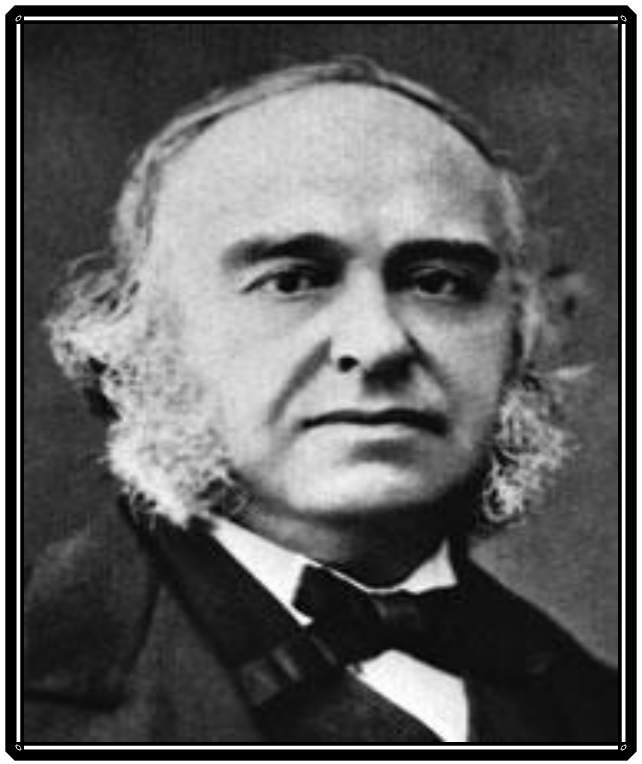
1. Knowledge about the various components of the Limbic system
2. Identify the exact function of the Limbic system
3. Explain the various functional circuitry of the Limbic system
4. Describe the dysfunctions associated with it.

INTRODUCTION: Limbic System

- The term “Limbic” comes from Latin Limbus, meaning **“border”** or **“edge”**
- Brain structures on the **medial** surface of the cerebral hemisphere
- Limbic system consists of interconnected cortical and sub cortical structures.
- Named by Paul Broca: limbic means names of structures forming a border between hypothalamus and cerebral cortex.



HISTORY OF CONCEPT OF THE LIMBIC SYSTEM



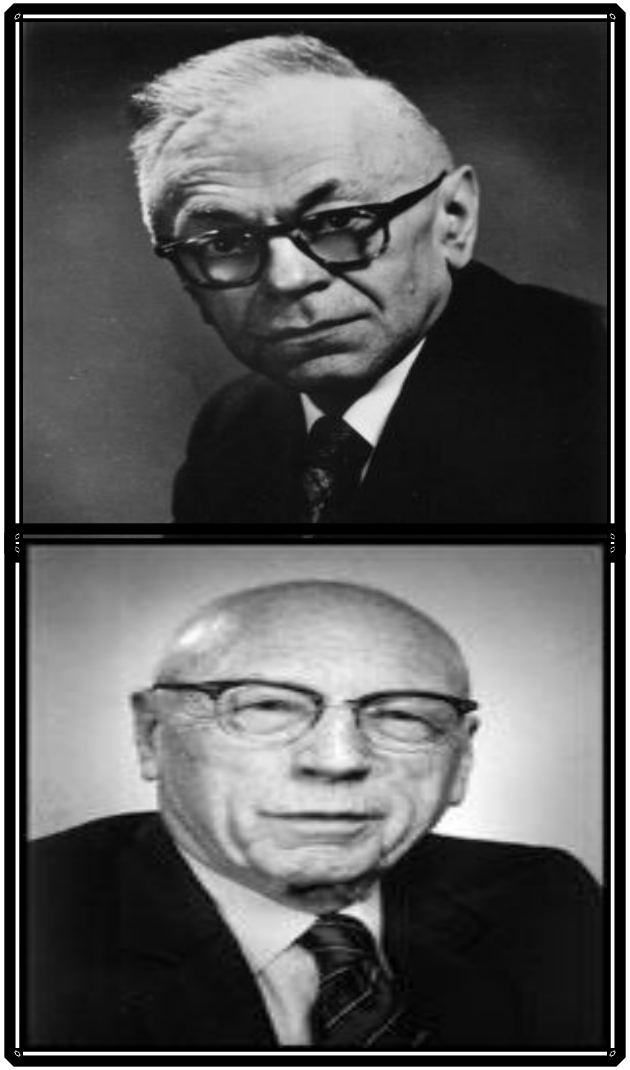
- Paul Broca– applied the term limbic to the curved rim of structures on the medial of cerebral hemispheres
- include cingulate and parahippocampal gyrus between diencephalon and cerebral cerebral hemispheres
- This cortex later shown to be composed of only three layers – labelled allocortex
- In order to distinguish it from the six layered Neocortex, that make up most of the cerebral mantle.

HISTORY OF CONCEPT OF THE LIMBIC SYSTEM

- James Papez (1937)– postulated these cortical regions(the cingulate gyrus and the parahippocampal gyrus) are linked to hippocampus, Mammillary body and anterior thalamus in circuit that mediated ***EMOTIONS (Papez circuit)***

- Emotions tend to go round and round in this circuit

HISTORY OF CONCEPT OF THE LIMBIC SYSTEM



- Heinrich Kluver and Paul Bucy(1939)—showed temporal lobes lesions in monkeys by disrupting of the circuit
- They found that **Amygdala of temporal lobe** has a role in ***taming and other basic instincts– fighting, fleeing, feeding and sex.***

HISTORY OF CONCEPT OF THE LIMBIC SYSTEM

Paul Maclean(1952)---coined the term **limbic system** to describe Broca's limbic lobe and related subcortical nuclei (Amygdalaoid body) in relation to ***Memory and Emotions.***

HISTORY OF CONCEPT OF THE LIMBIC SYSTEM

- Originally term limbic system encompassed only Broca's cortex and Papez's circuitry and later Amygdala is included.

- Further, the functions of Amygdala and Hippocampal system proved to have more to do with attention and formation of ***specific memories than with emotions.***

Components of the limbic system

- **Limbic lobe**

- cingulate gyrus

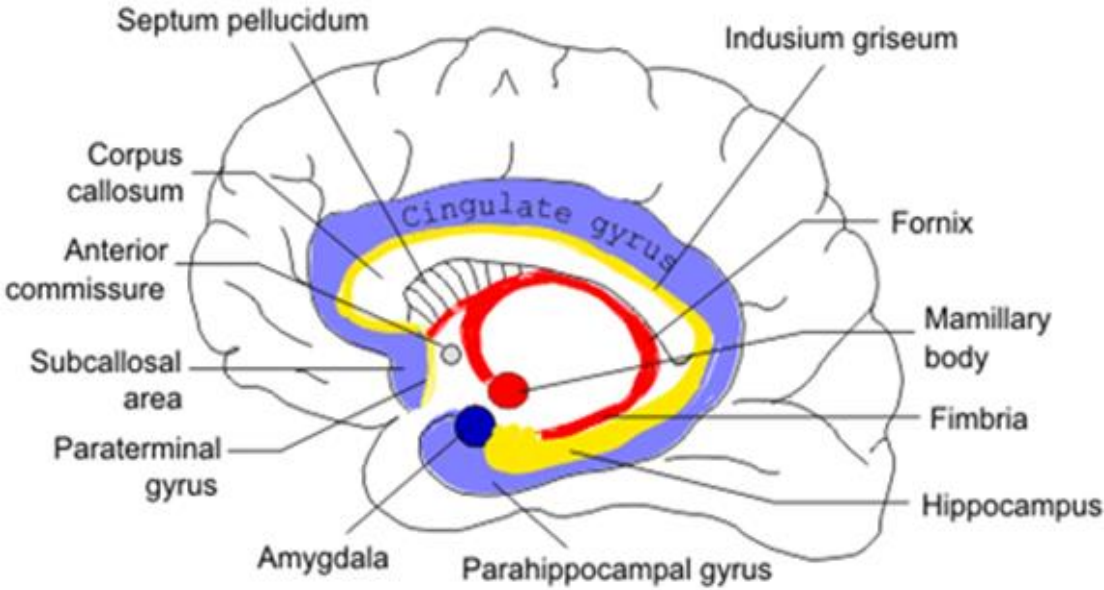
- parahippocal gyrus

- **Hippocampal formation**

- Dentate gyrus- afferent

- Sibiculum - efferent

-Hippocampus proper (cornu ammonis) - efferent

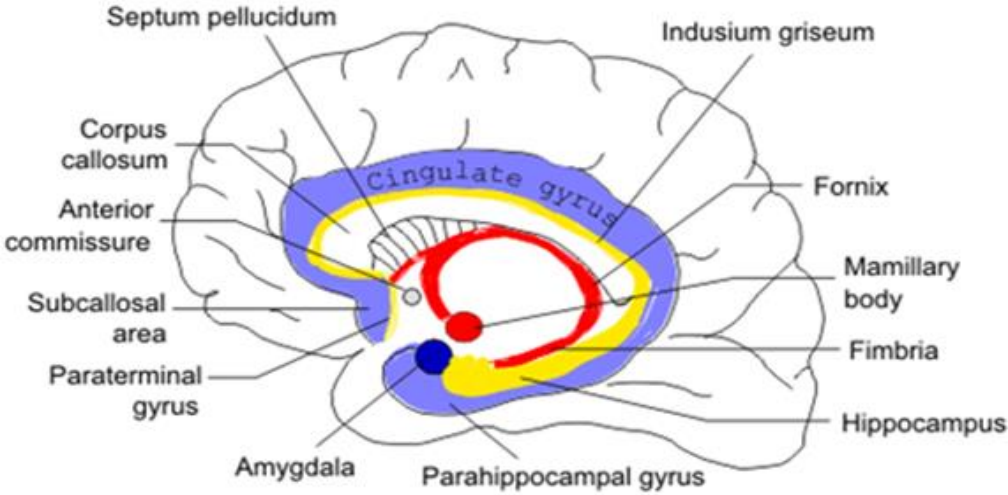


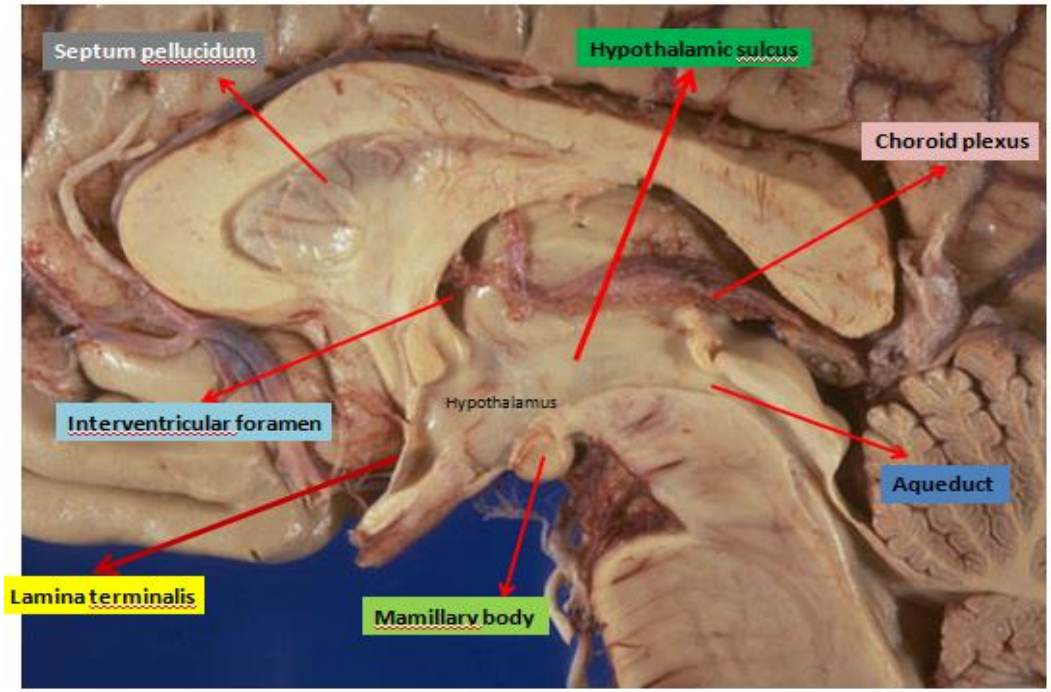
Components of the limbic system

- **Amygdala**
- **Hypothalamus**

- mammilary bodies

- Autonomic nervous system nuclei





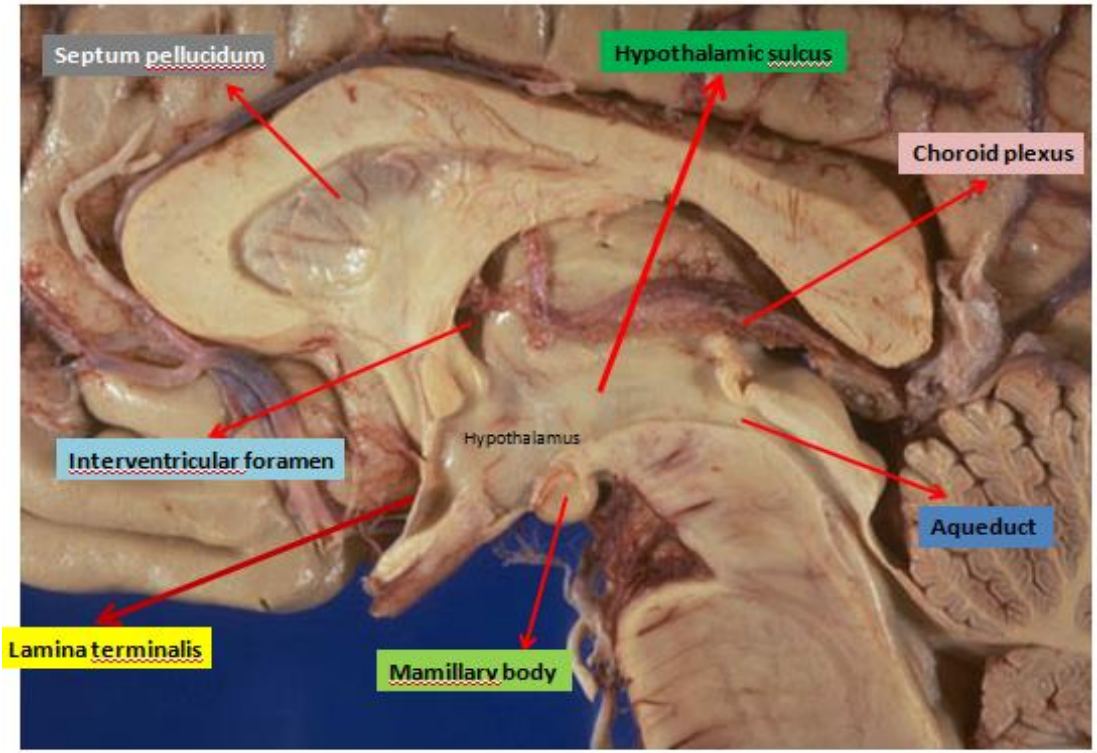
Components of the limbic system

- **Thalamus**

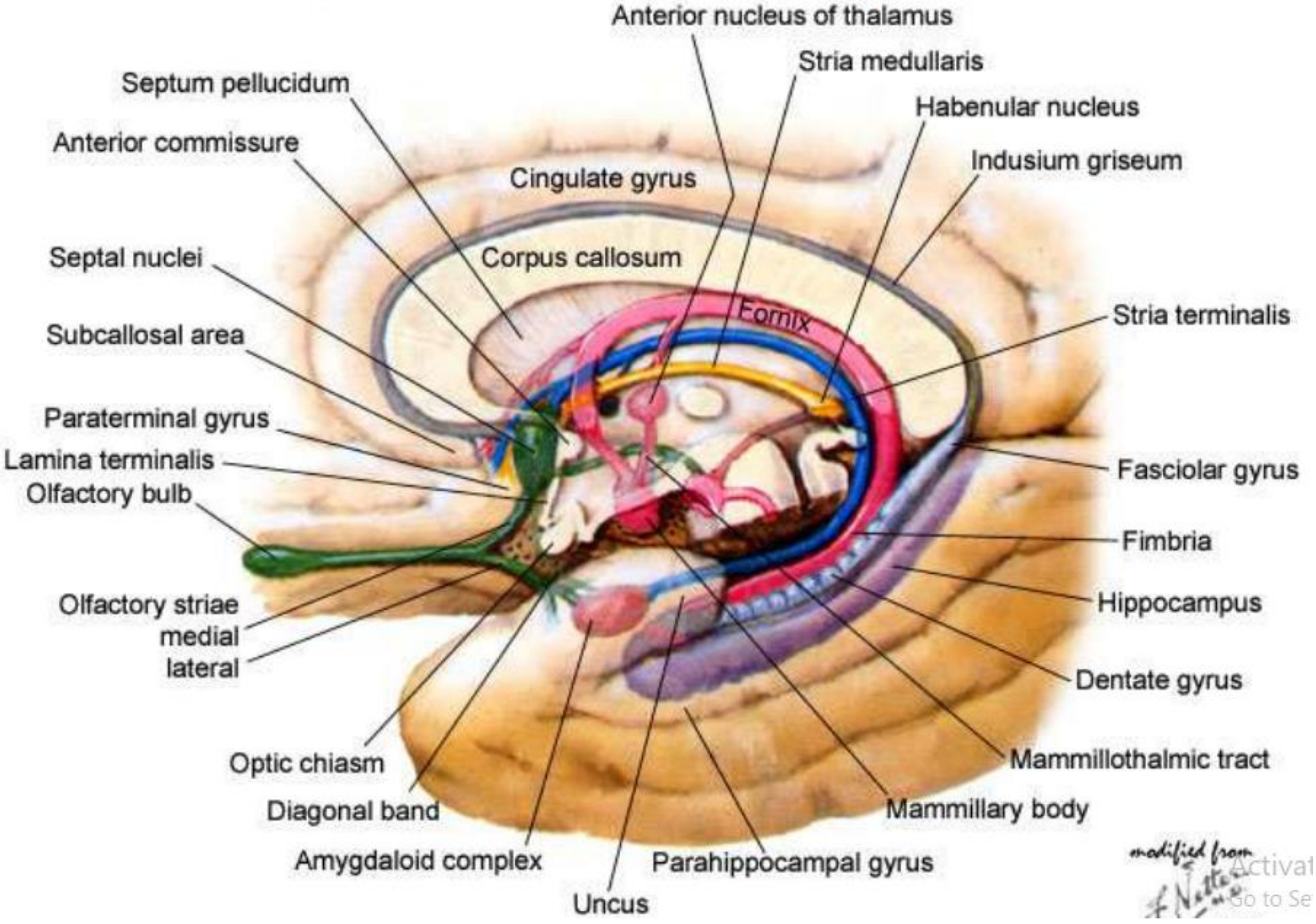
- Anterior nucleus

- Mediodorsal nucleus

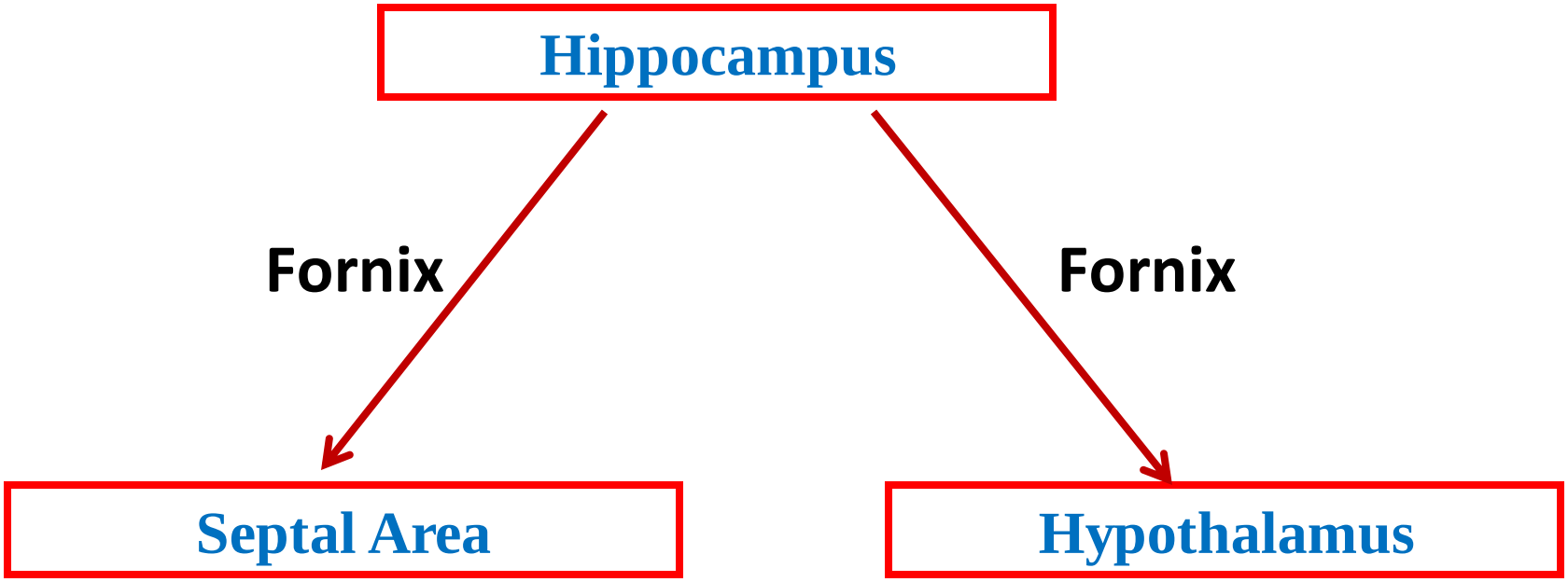
- **Septal area**
- **Habenula**



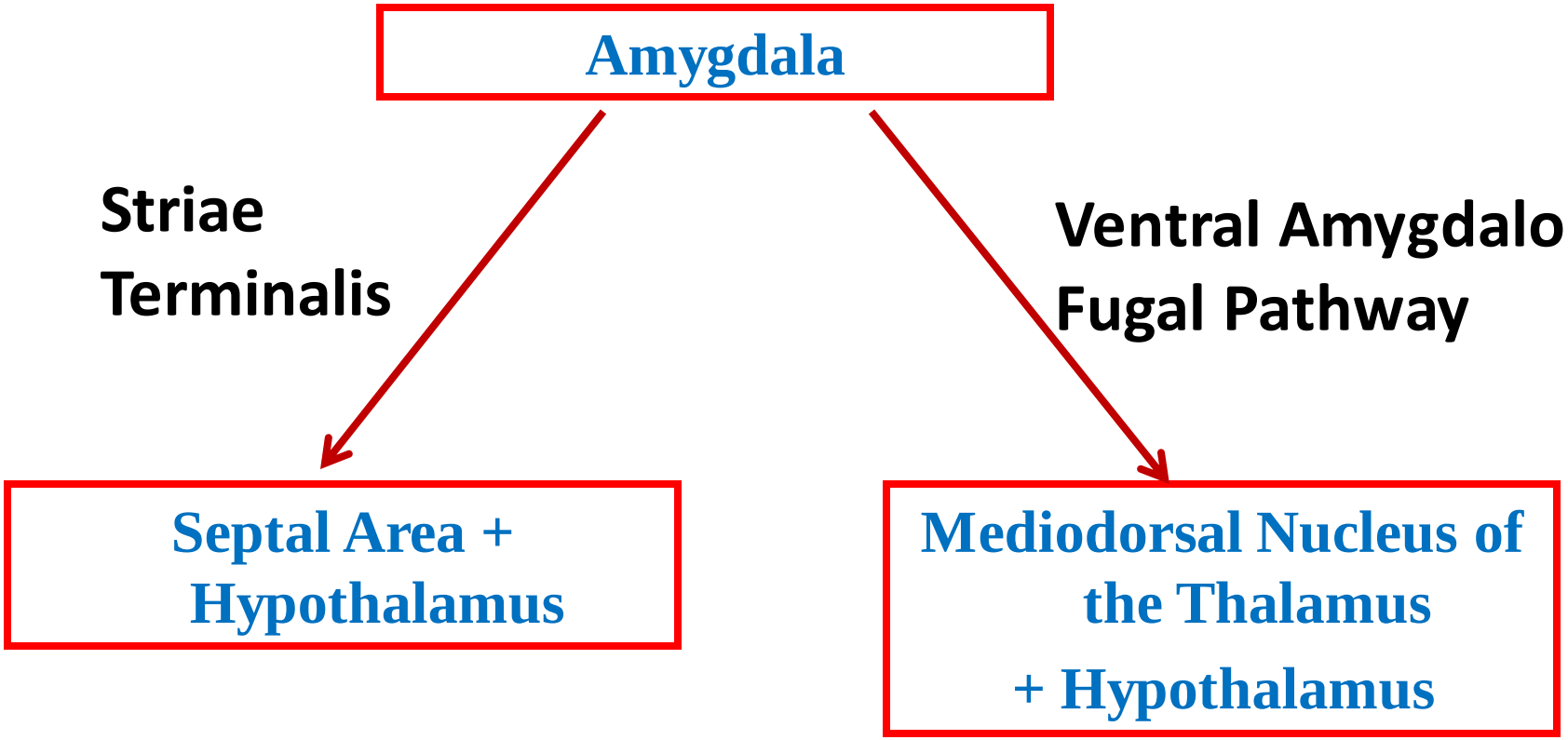
Components of limbic system



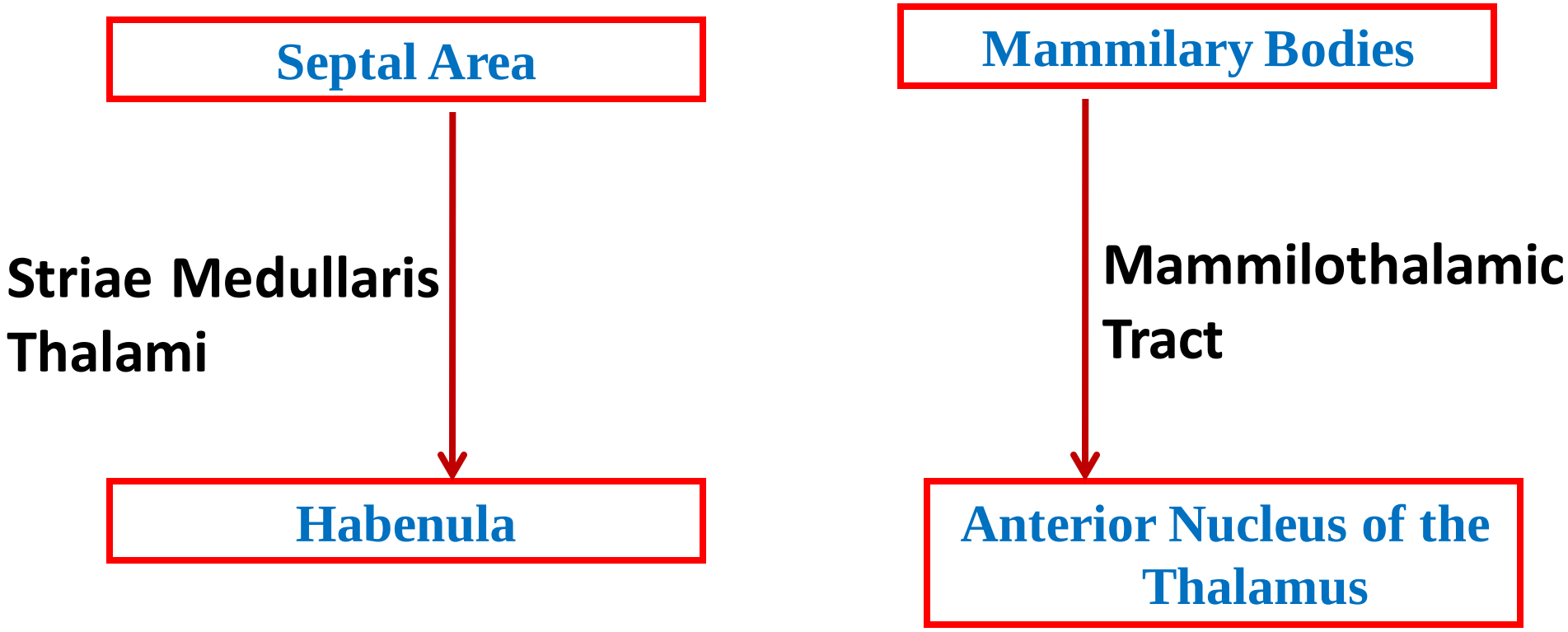
Connections of Limbic Components



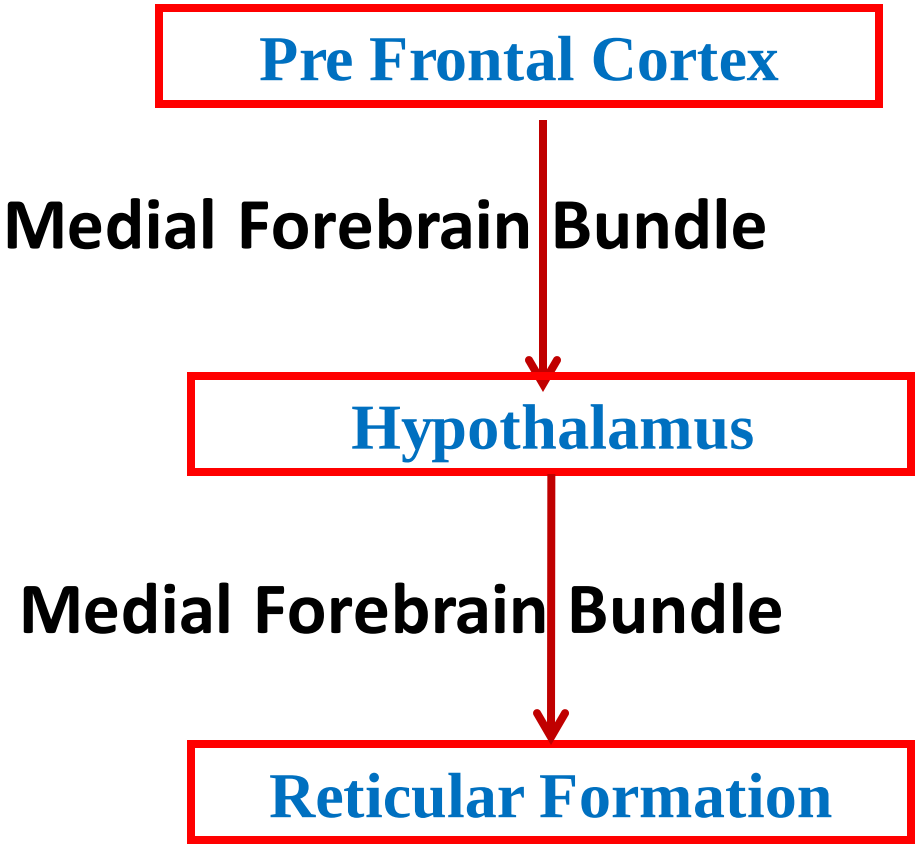
Connections of Limbic Components



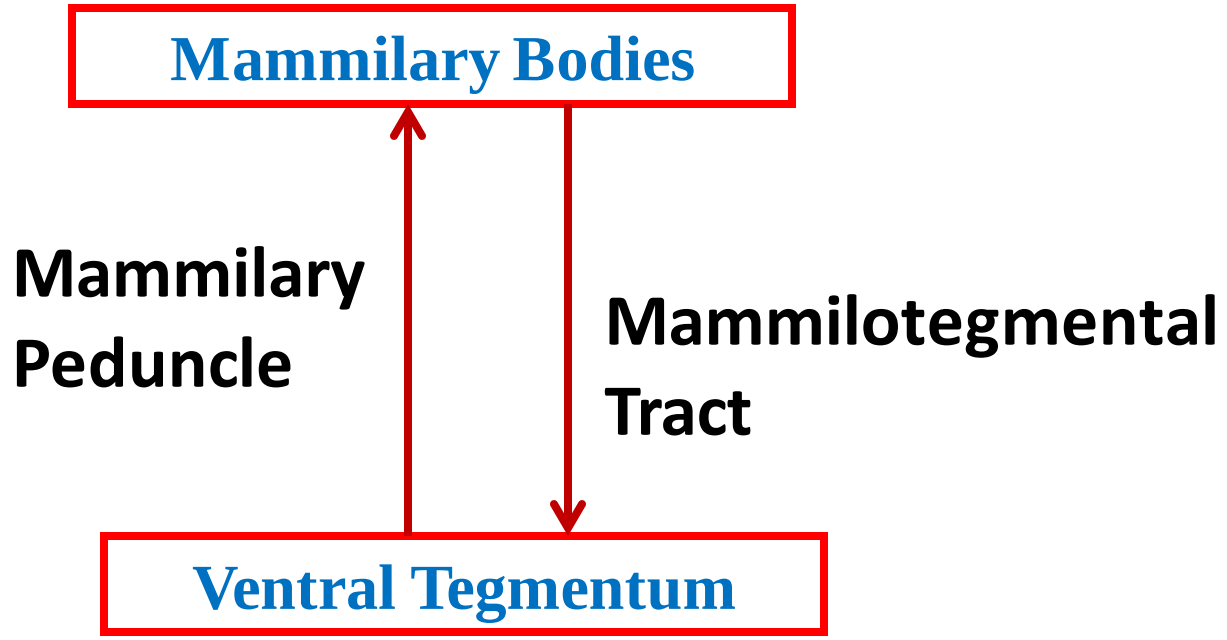
Connections of Limbic Components



Connections of Limbic Components

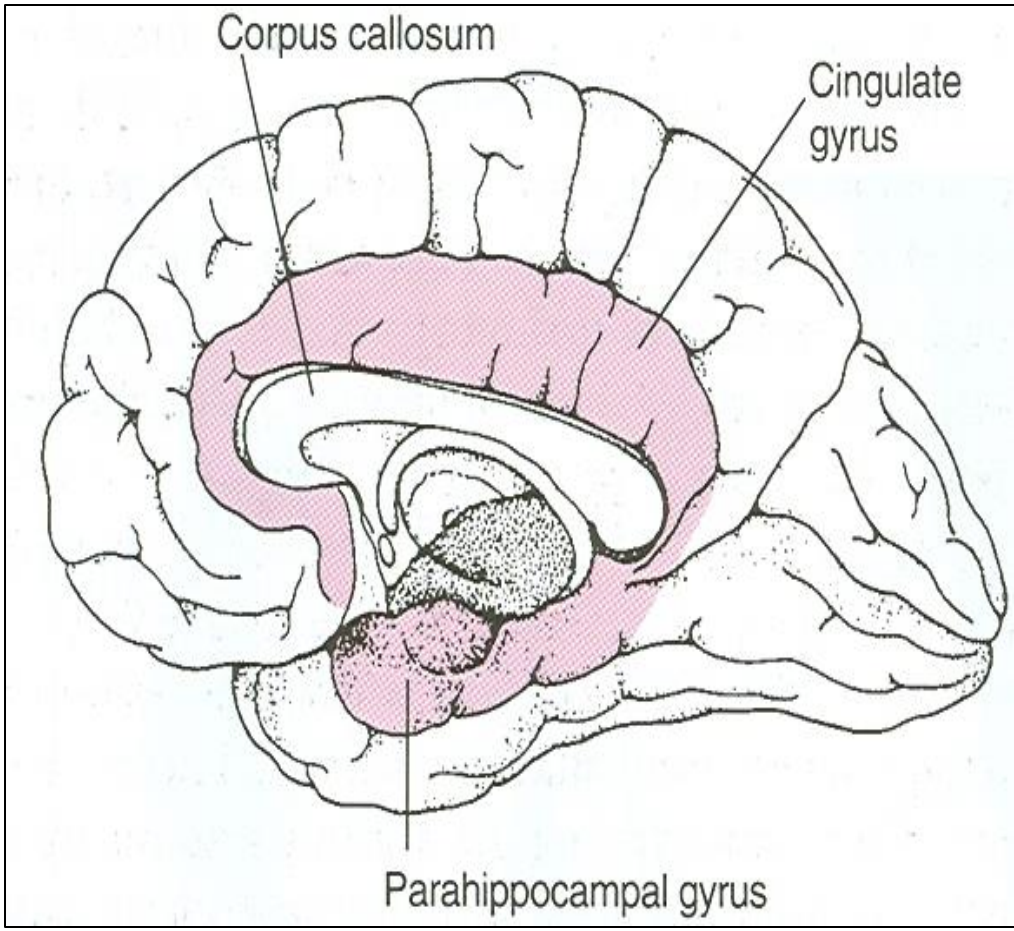


Connections of Limbic Components



Cingulate Gyrus

- Located abobe the corpus callosum
- Includes several cortical regions that are interconnected with the associated areas of the cerebral cortex
- Posteriorly, it becomes continuous with the parahippocampal gyrus
- It projects to the entorhinal cortex via the cingulum

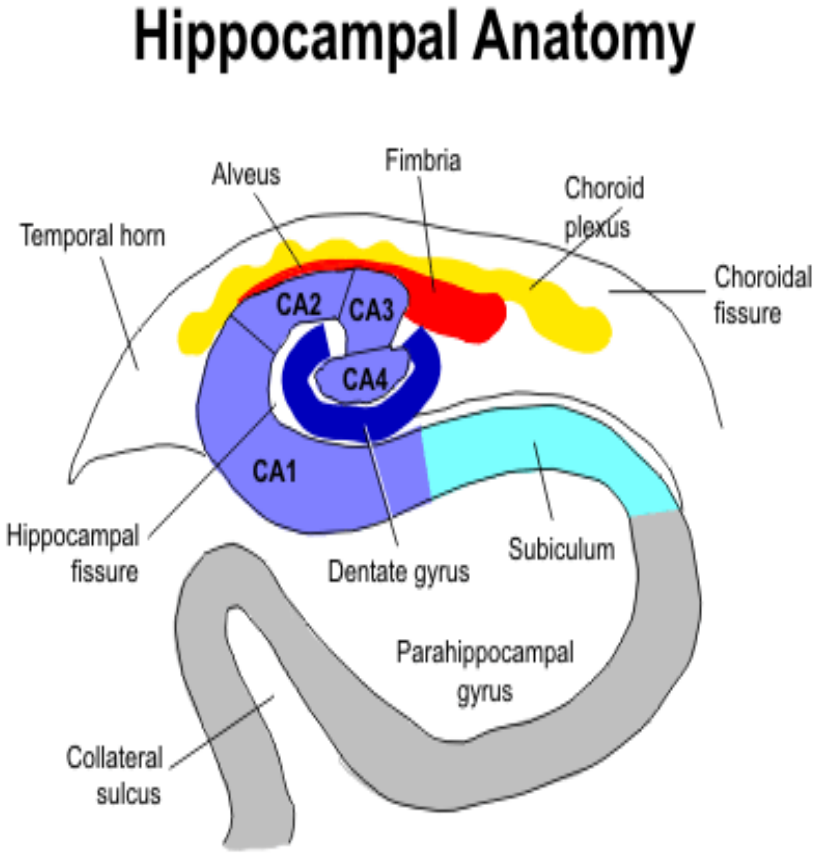


Cingulate Gyrus

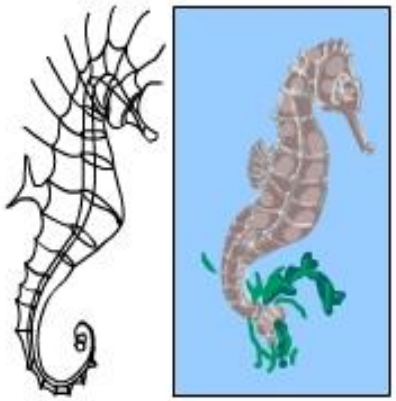
- Receives inputs from **the anterior nucleus of the thalamus and the neocortex**, **somatosensory areas of the cerebral cortex**
- Involved with **emotion formation and processing, learning, and memory ,central role in attention, feelings of safety and security**

Parahippocampal Gyrus

- Located in medial temporal lobe
- Lies between the hippocampal fissure and the collateral sulcus
- Continuous with the hippocampus along with the medial edge of the temporal lobe
- Cortical structure of parahippocampal gyrus
- Important role in **memory encoding and retrieval**



Hippocampal Formation


Geneus Hippocampus

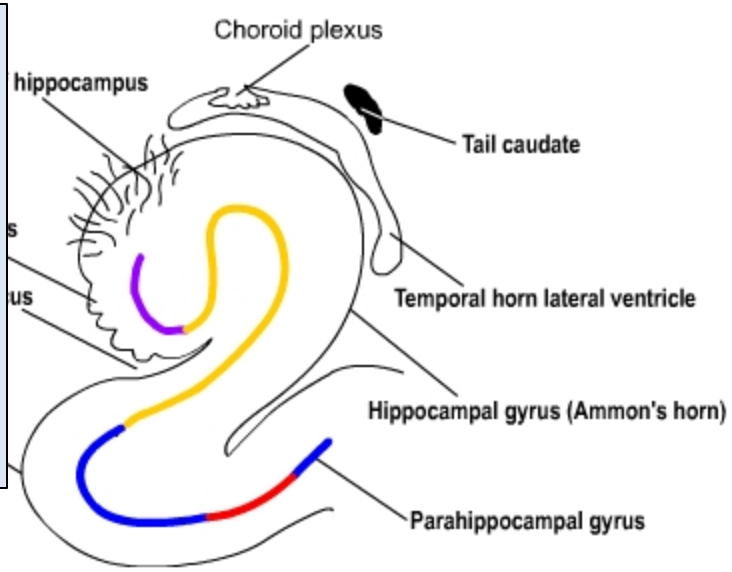
Is the inferomedial structure of the parahippocampal formation

Includes:

- Dendate nucleus (afferent)
- Subuculum (efferent)
- Hippocampus proper (cornu ammonis) - efferent

It is a C-shaped horseshoe paired structure, one in each temporal lobe.

It acts as a **memory indexer** by sending memories to the appropriate part of the **cerebral hemisphere** for long-term **storage** and **retrieving** them when necessary.



Hippocampal Formation

Hippocapal formation is involved in:

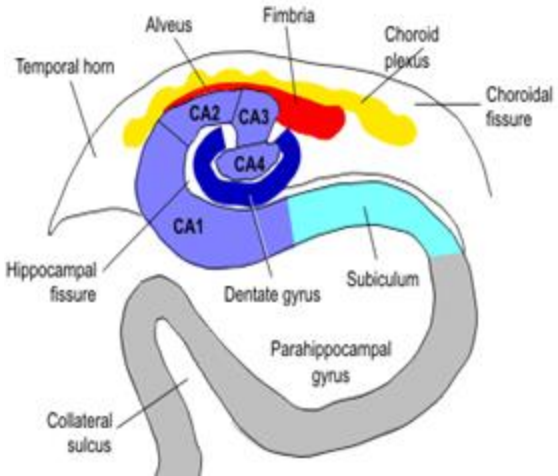
- F**ormation**
- **Organization**
- **Storage** of memories.

• It is important in forming new memories and connecting emotions and senses, such as smell and sound, to memories.

CA - Cornu Ammonis

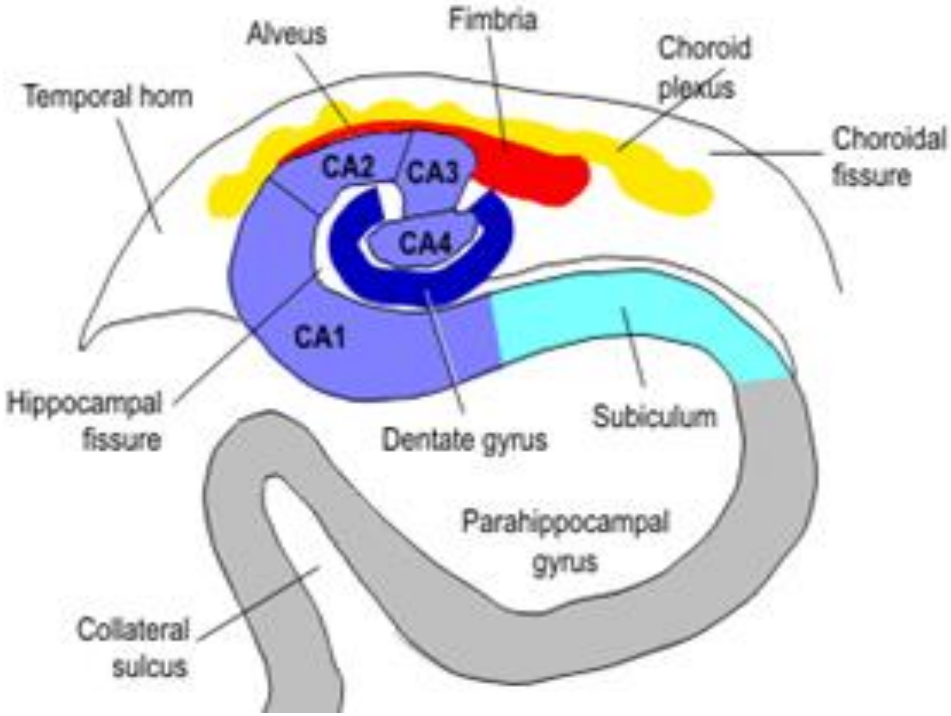
A Greek God with

"Ram's Horn"



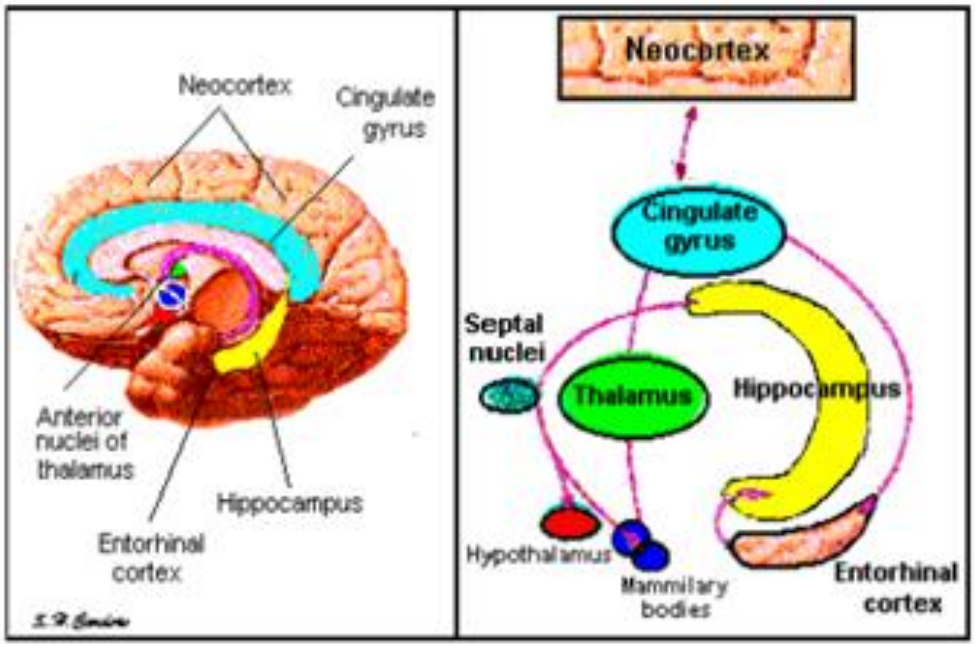
Dentate Gyrus

- Narrow notched band of gray matter
- Lies between the fimbria of the hippocampus and parahippocampal gyrus
- Anteriorly, continued into the uncus
- Posteriorly, continuous with indusium griseum



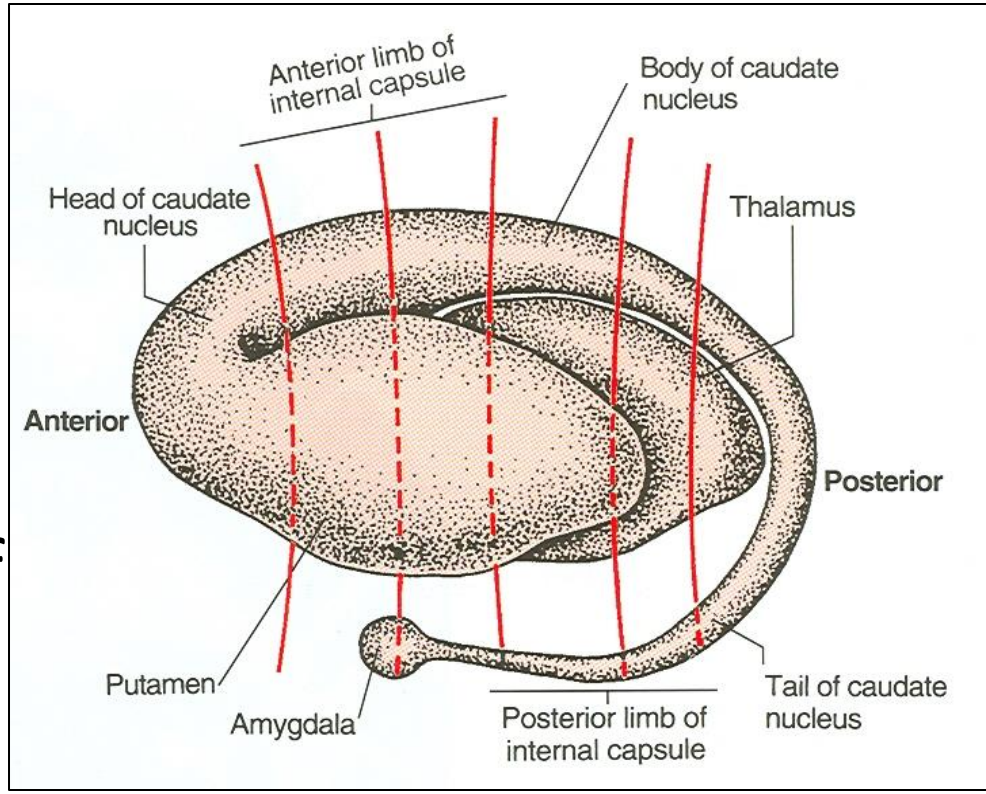
Entorhial Cortex

- Located in the anterior part of the parahippocampal gyrus, on medial surface of temporal lobe
- Transition zone between hippocampus and temporal neocortex



Amygdala

- Almond shaped mass of nuclei that
- Located in medial temporal lobe
- Just anterior to the hippocampal formation
- It is fused with the tip of the tail of the caudate nucleus

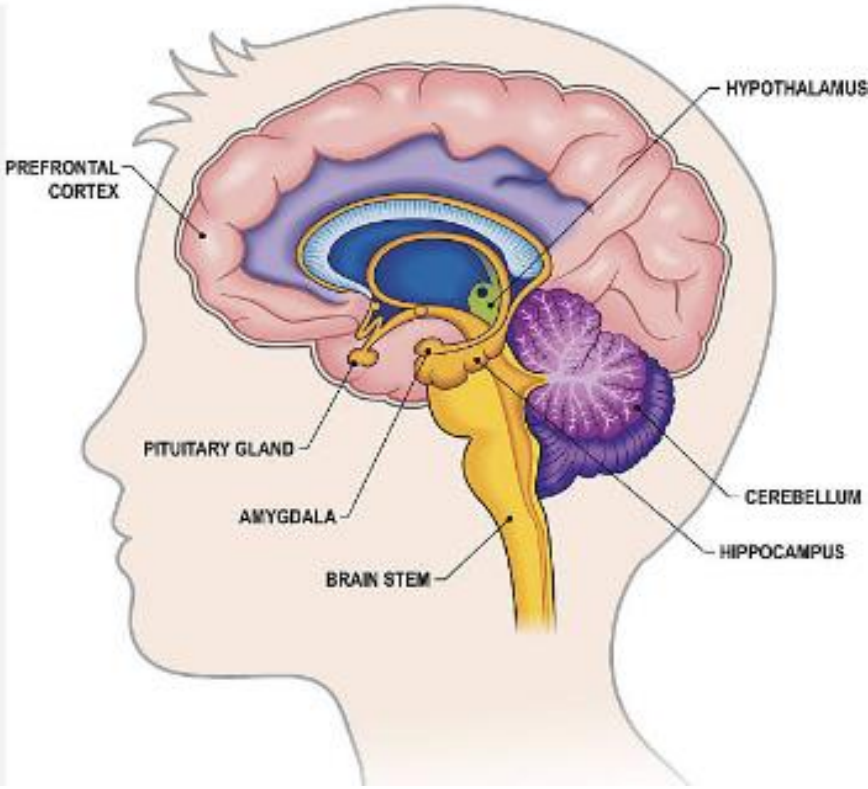


Amygdala

- It is a group nuclei; larger basolateral and smaller centromedial
- Stria terminalis emerges from its posterior aspect

Function:

- ❖ **Feeding and drinking**
- ❖ **Fighting behavior**
- ❖ **Mating and maternal care**
- ❖ **Fear**



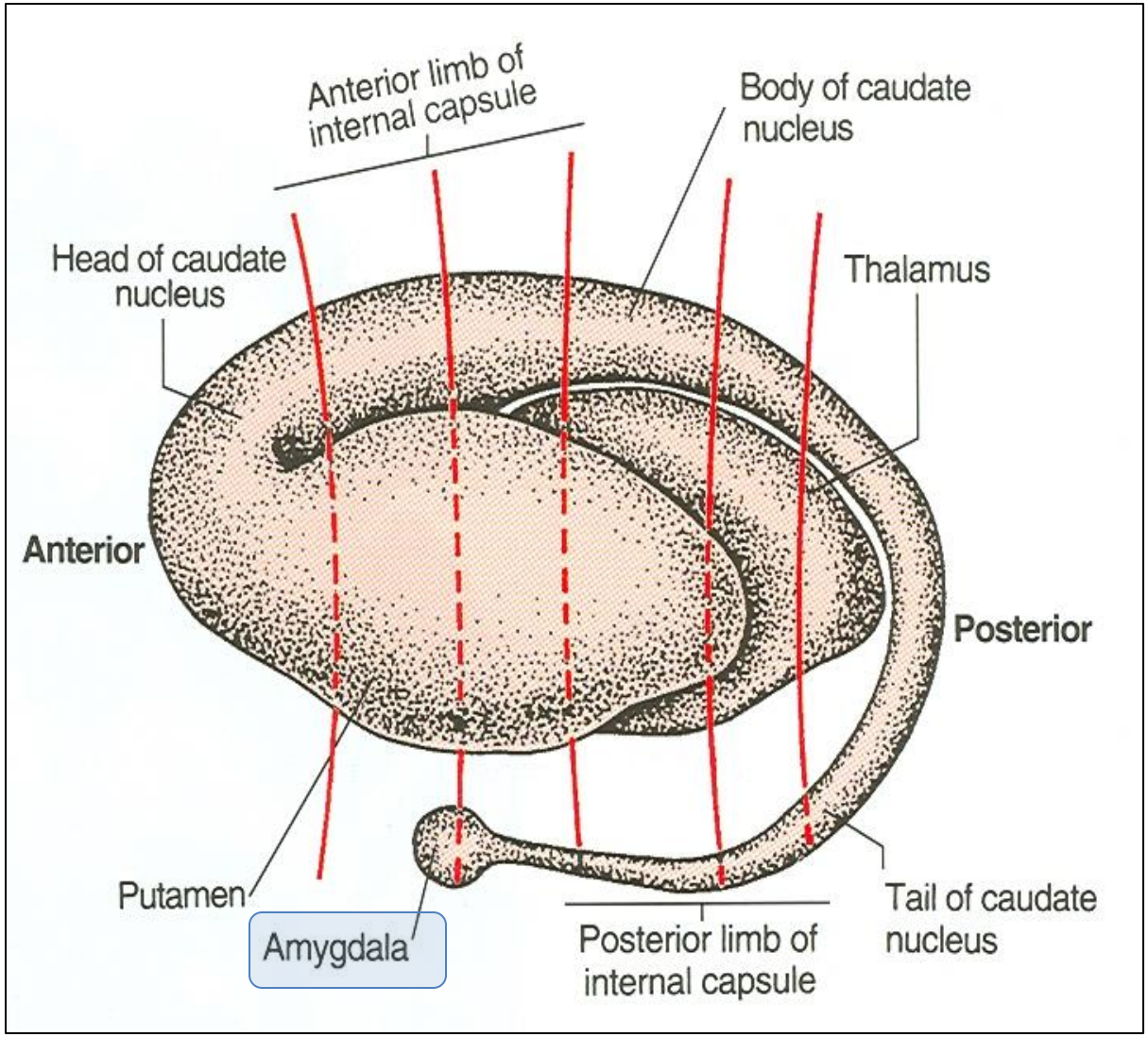
CONNECTIONS OF AMYGDALA

Inputs:

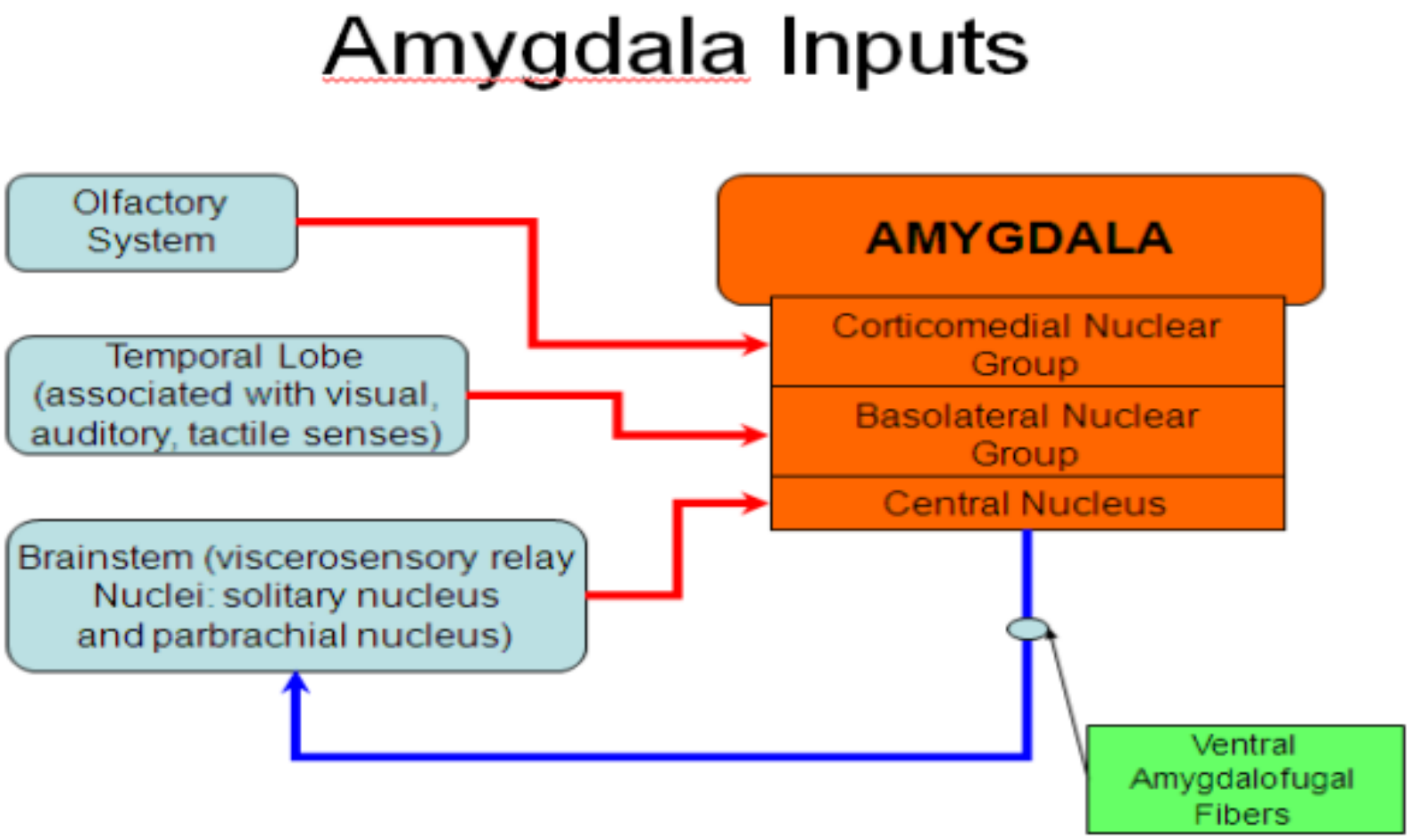
- **Association** areas of visual, auditory & somatosensory cortices.

Outputs:

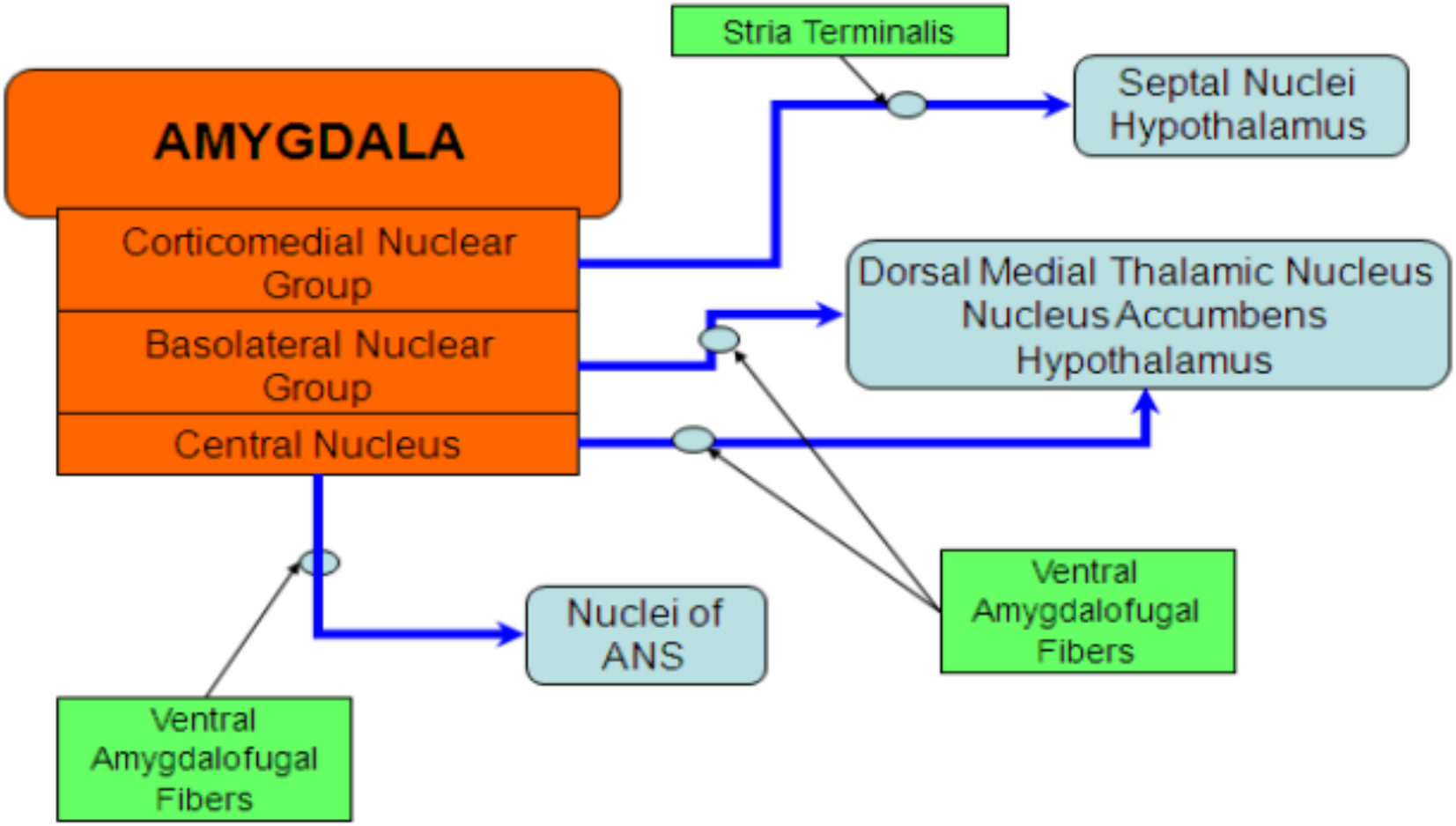
- Hypothalamus &
- Autonomic nuclei in the brain stem,
- **Lesion:**
- Lack of emotional responses & docility.



Circuits of amygdala



Amygdala Outputs



Septal Area

Site:

- **Gray mater** structure located immediately above anterior commissure

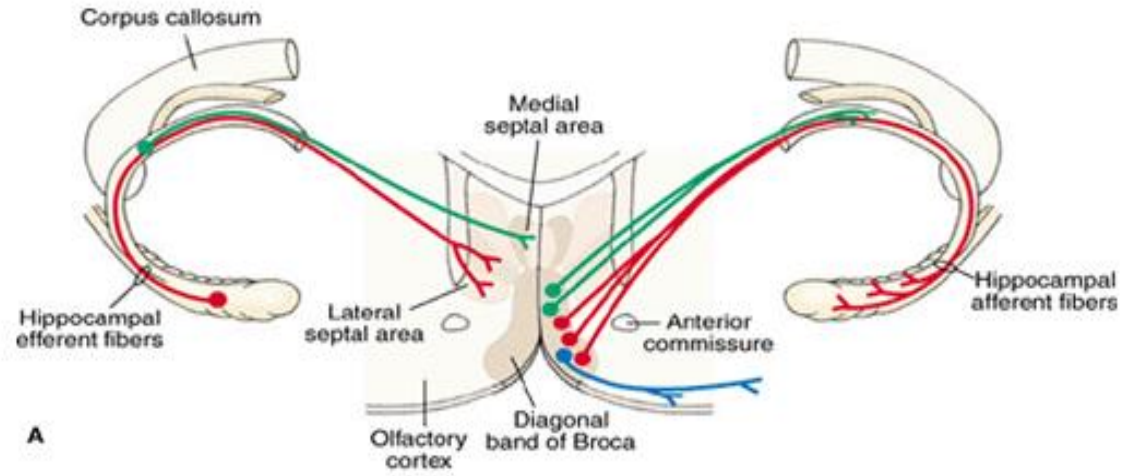
- Projects to the habenula nucleus via the stria medullaris thalami

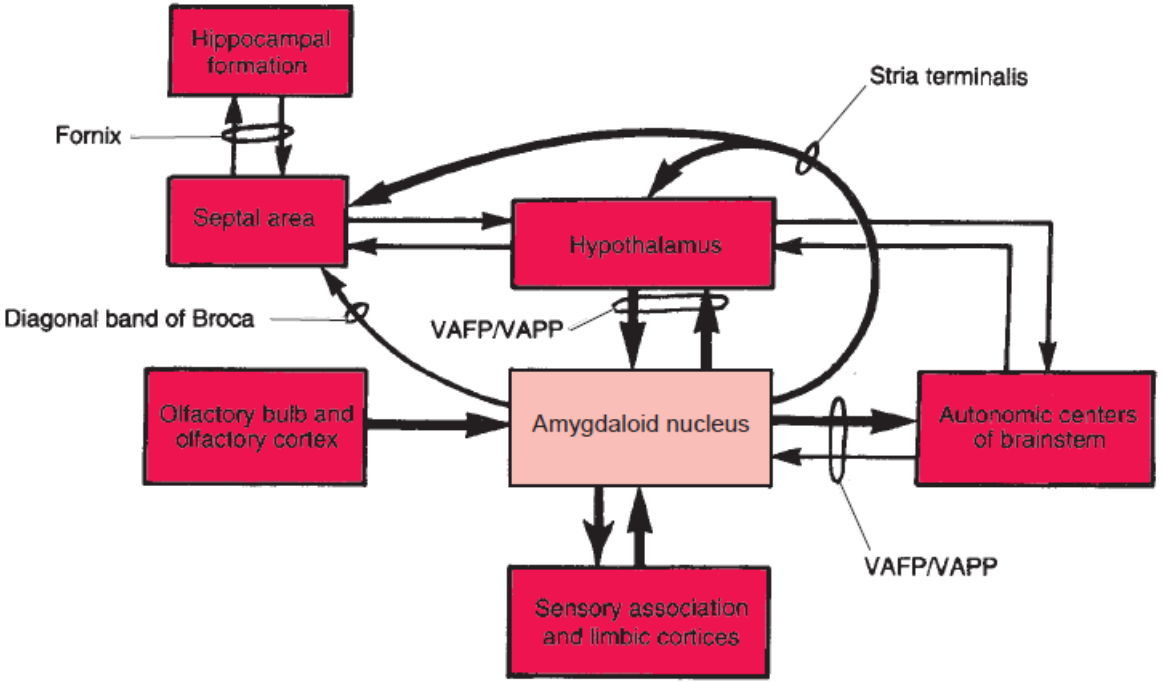
Main connections:

1. To Hypothalamus
2. To Habenular nuclei

Function:

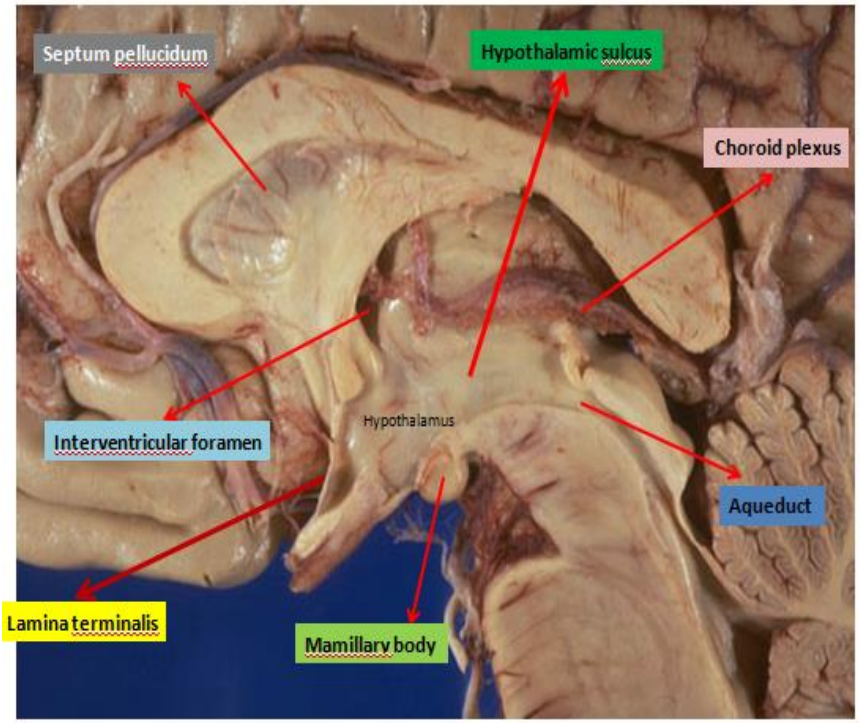
It is the **pleasure** zone.





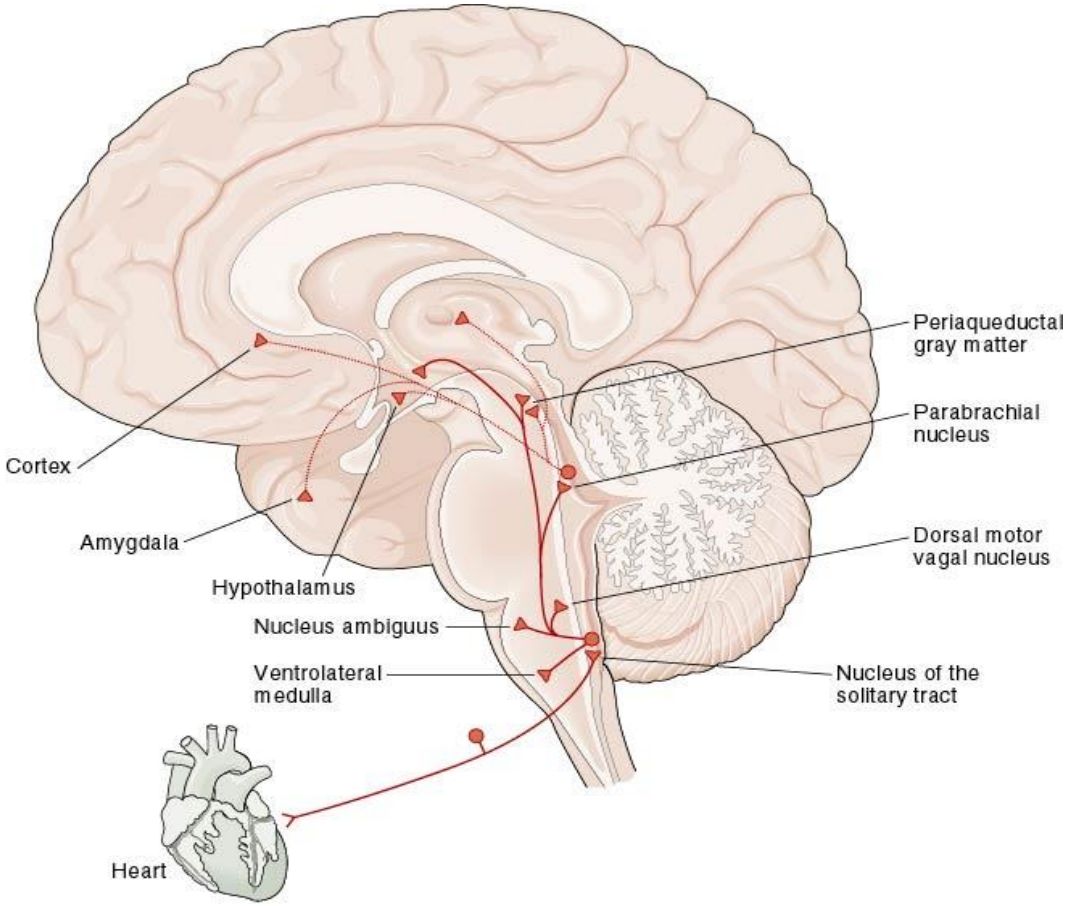
Hypothalamus

- Controls involuntary internal responses of various body systems in preparation for appropriate action to accompany a particular emotional state.
- For example, the hypothalamus controls the increase of heart rate and respiratory rate, elevation of blood pressure, and diversion of blood to skeletal muscles that occur in anticipation of attack or when angered.



Connections of the hypothalamus

- Hypothalamus is concerned with visceral function
- Connected to various parts of limbic system, reticular formation, autonomic centers in brainstem and spinal cord.
- It also releases secretions into the blood stream and into CSF.



Appleton & Lange
Kandel/Schwartz/Jessell
Principles of Neural Science
Fig. 49.09

Hypothalamus

- Stimulation in the lateral hypothalamus : thirst and eating, overt rage and fighting.
- Stimulation in the ventromedial nucleus and surrounding areas mainly causes effects opposite to those caused by lateral hypothalamic stimulation—that is, a sense of satiety and decreased eating

Hypothalamus

- Stimulation of a thin zone of periventricular nuclei, located immediately adjacent to the third ventricle (or also stimulation of the central gray area of the mesencephalon that is continuous with, this portion of the hypothalamus), usually leads to fear and punishment reactions.
- Sexual drive can be stimulated from several areas of the hypothalamus, especially the most anterior and most posterior portions of the hypothalamus

Anterior nucleus of thalamus

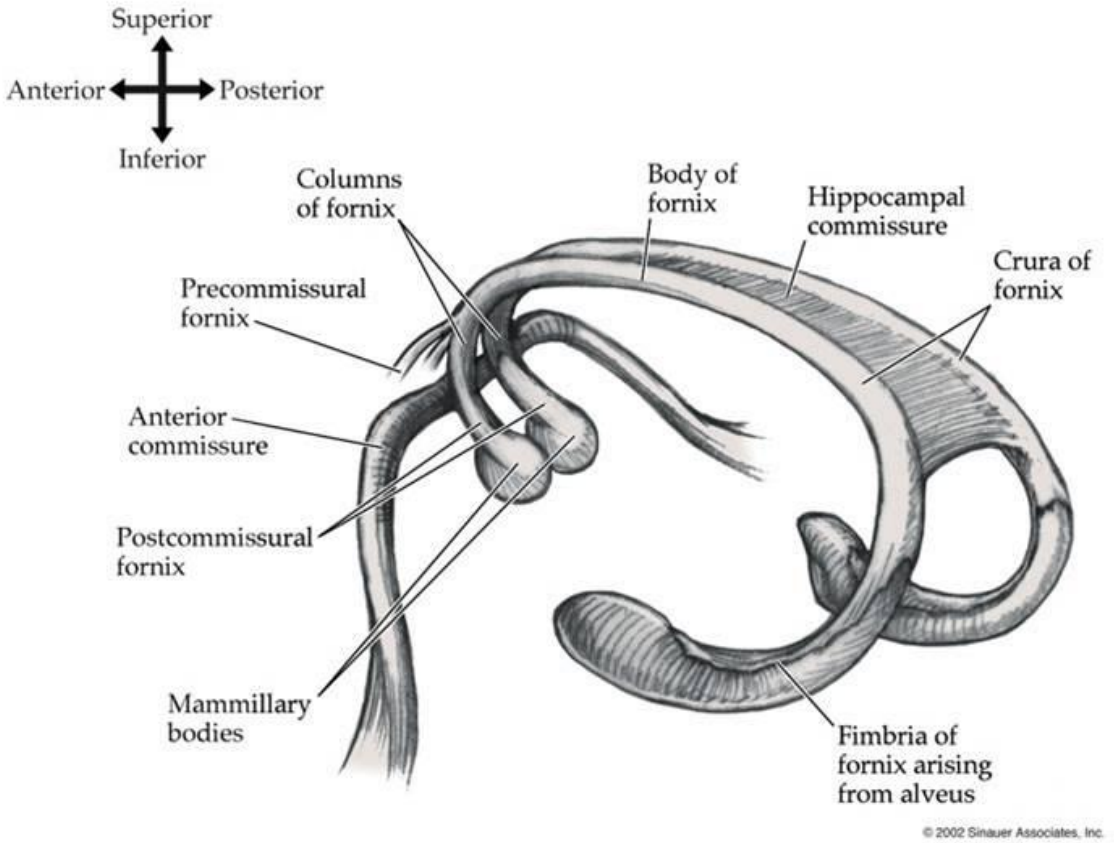
- Afferent connections:
  - Mammillothalamic tract, cingulate gyrus and hypothalamus
- Efferent connections:
  - Cingulate gyrus, hypothalamus
- Functions:
  - Emotional tone i.e. attitude, mechanism of recent memory.

Mammillary bodies

- They are connected to other parts of the brain
- Act as a **relay for impulses** coming from the **amygdalae and hippocampi**, via the **mamillo-thalamic tract** to the **thalamus**.
- This circuit, from **amygdalae to mammillary bodies**, and then on to the **thalamus, is part of the larger 'Papez circuit.**

Mammillary bodies

- Mammillotegmental tract: terminates in **reticular formation** of mid brain.
- They, along with the anterior and dorsomedial nuclei in the thalamus, are involved with the processing of memory.



Fornix

- **FORNIX** is principal efferent pathway

It is **C**-shaped group of fibers connecting the hippocampus with mammillary body.

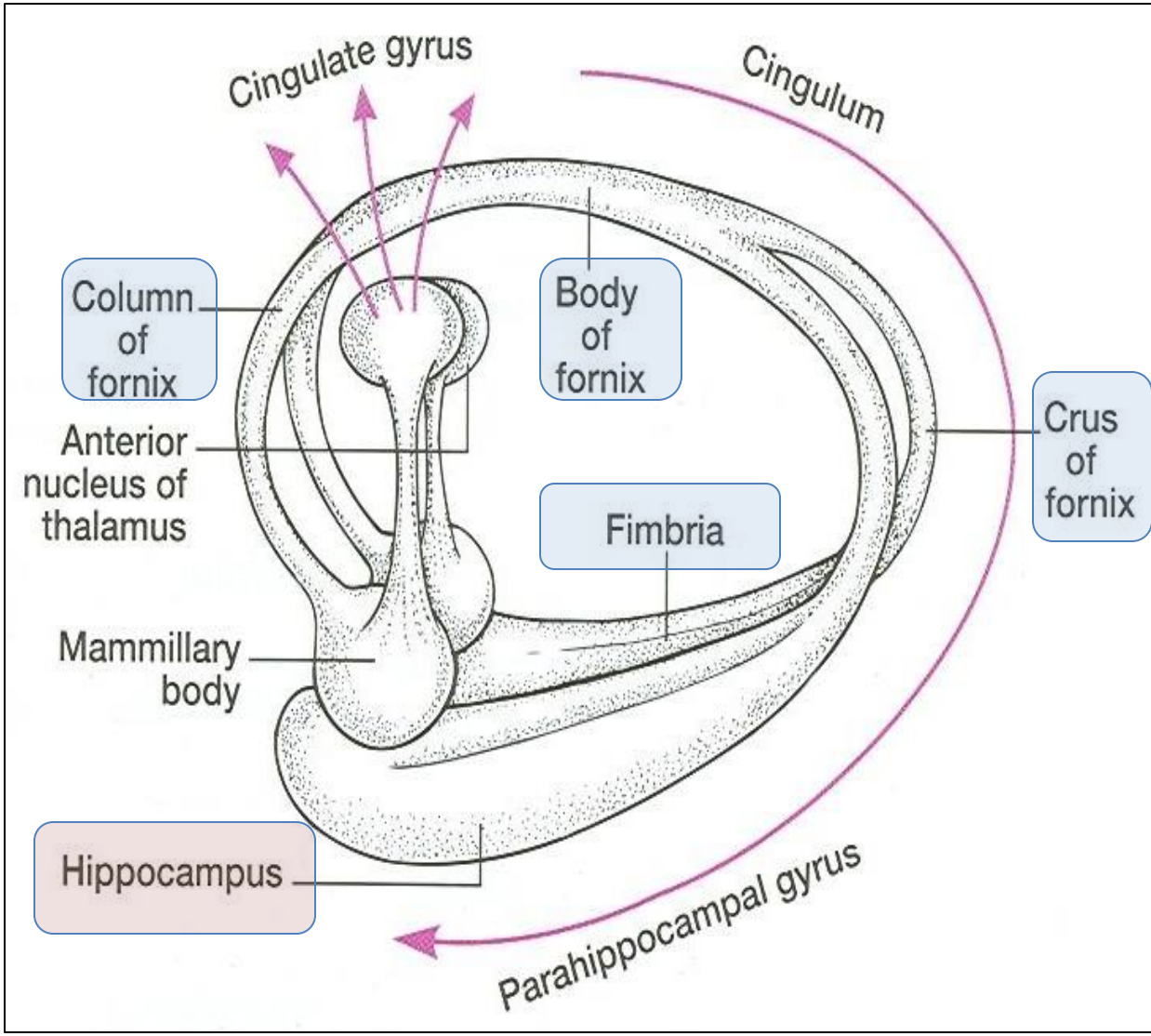
it consists of:

2 Fimbria,

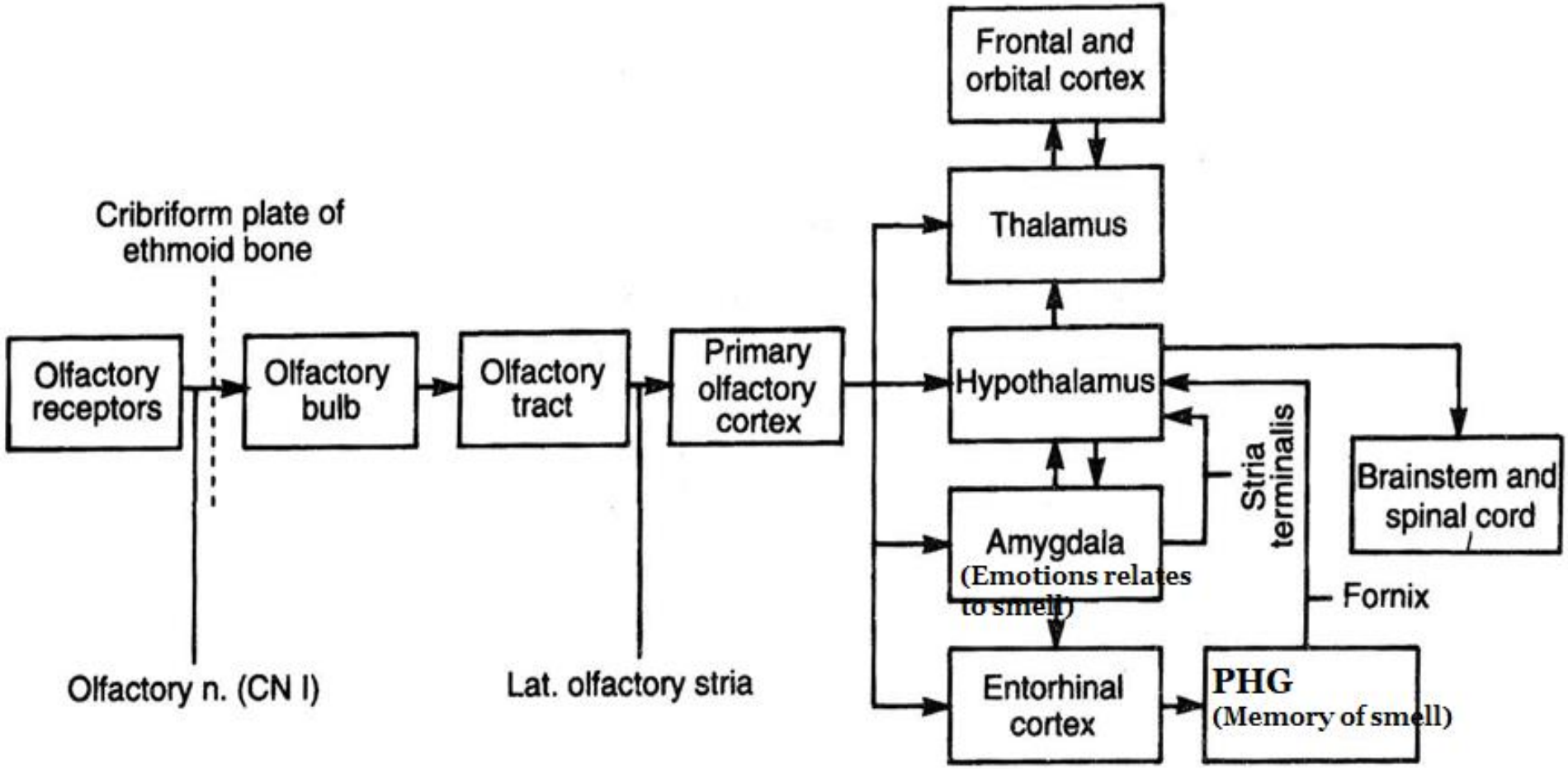
2 Crus,

1 Body &

2 Column.



Functions of the Limbic System: Olfaction



*Amygdala – involved in emotional response to smell

*Entorhinal cortex – involved in memories of smell

Appetite and eating behaviors

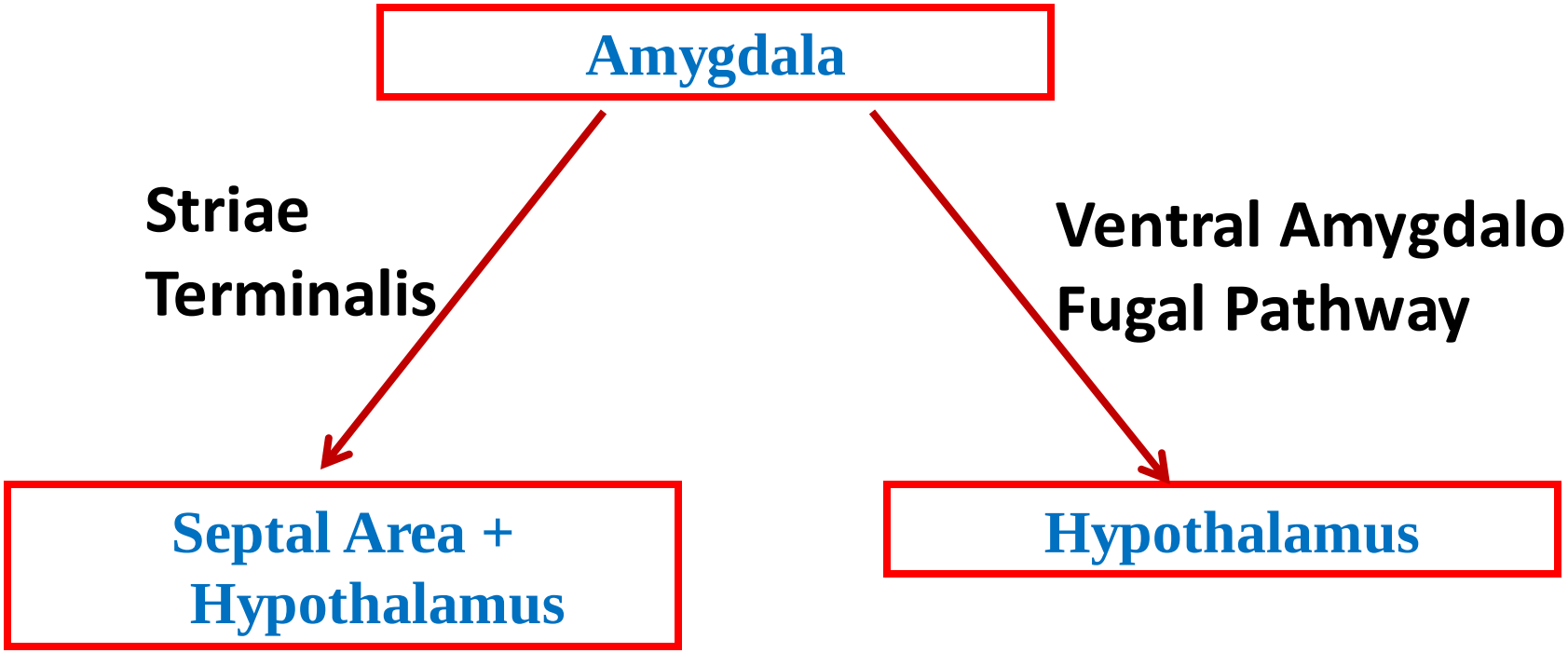
- Amygdala – food choice and emotional modulation of food intake
- Hypothalamus – LN – centre for control of feeding
- VMN – functions satiety centre

Emotional Response

Fear:

- Response – produced by stimulation of amygdala and hypothalamus
- Amygdala involved in fear learning

Appetite and eating behaviors

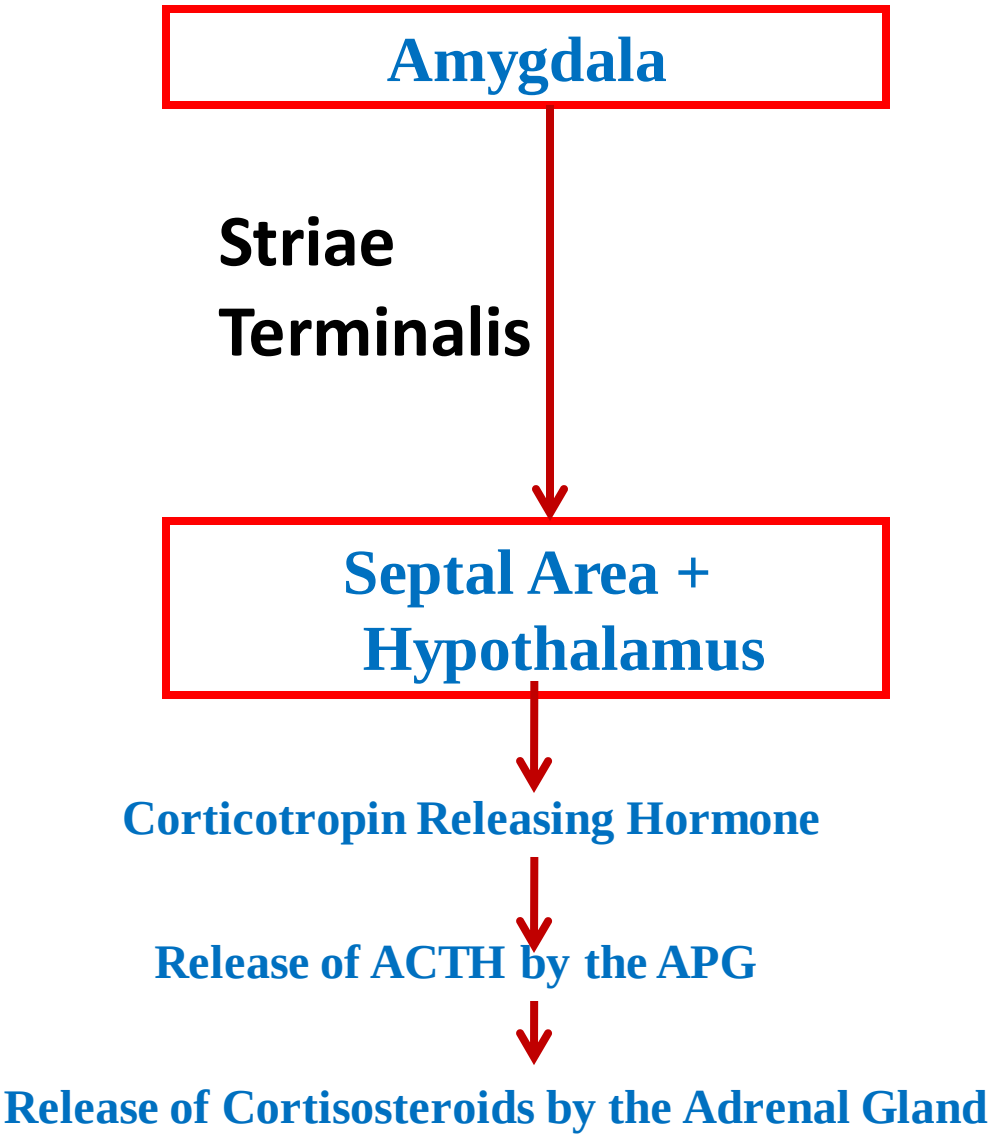


Ventromedial Nucleus → **Satiety**

Lateral Hypothalamus Nucleus → **Hunger**

Rage

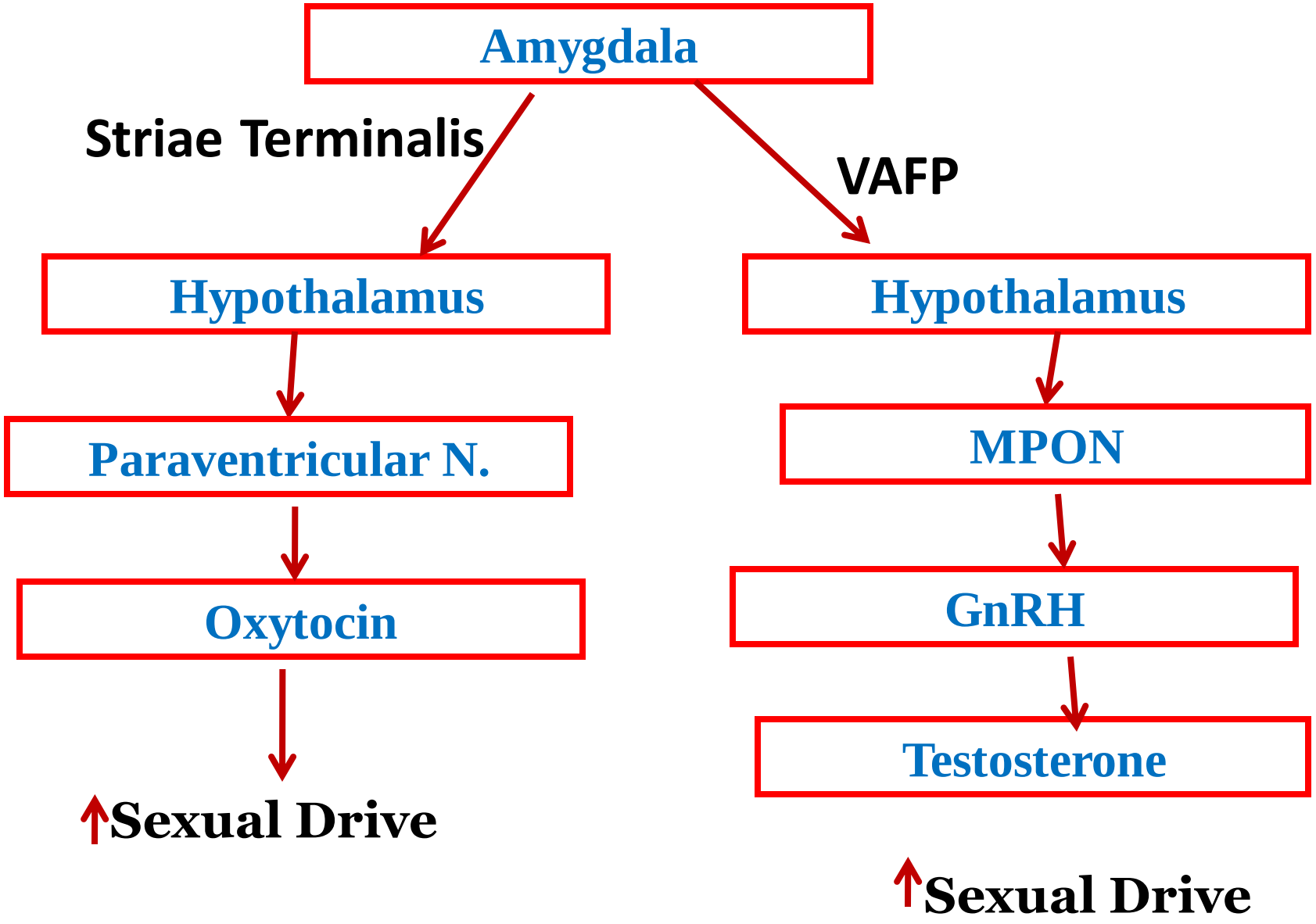
- Feeling of intense, violent or growing anger, associated with fight or flight response
- When faced with threatening situation, hypothalamus releases hormones rapidly



Sexual behavior

- MPON – hypothalamus – key structure in control of male sexual behavior
- Dopamin triggers penile erection by acting on oxtocenergic neurons in the PVN of hypothalamus
- The inhibition of these neurons by GABA and its agonists, opiods like drugs inhibit sexual response
- MPON mediates female stimulate increase in dopamine – enhances copulatory ability

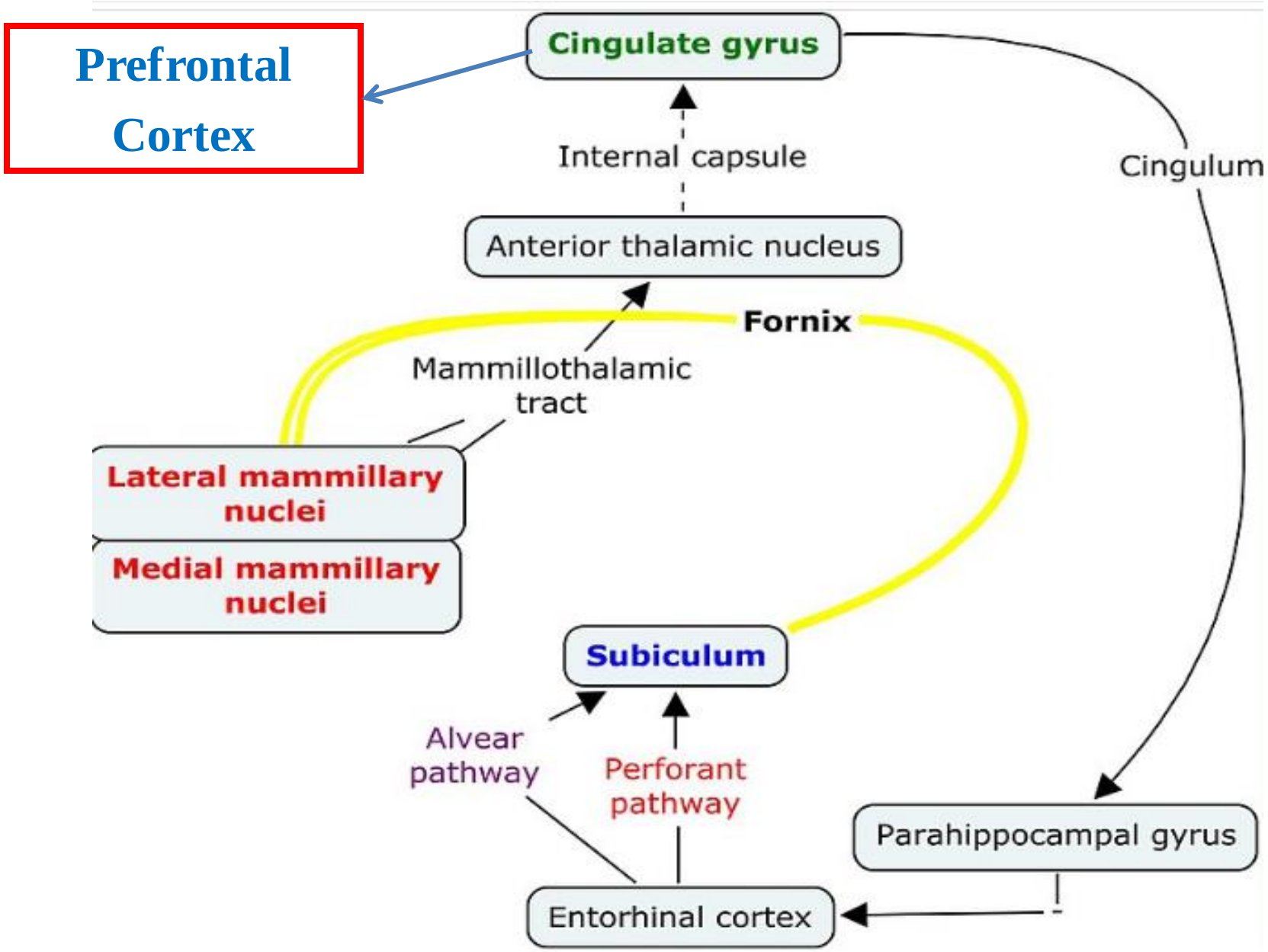
Sexual behavior



Memory and Learning (Papez Circuit)

- Emotional memory – emotions has a powerful influence on learning and memory
- Amygdala, prefrontal cortex, medial temporal lobe – consolidation, retrival of emotional memories
- Amygdala, prefrontal cortex, and hippocampus – acuisition, extinction and recovery of fears to cues
- Hippocampus - critical for recent memory

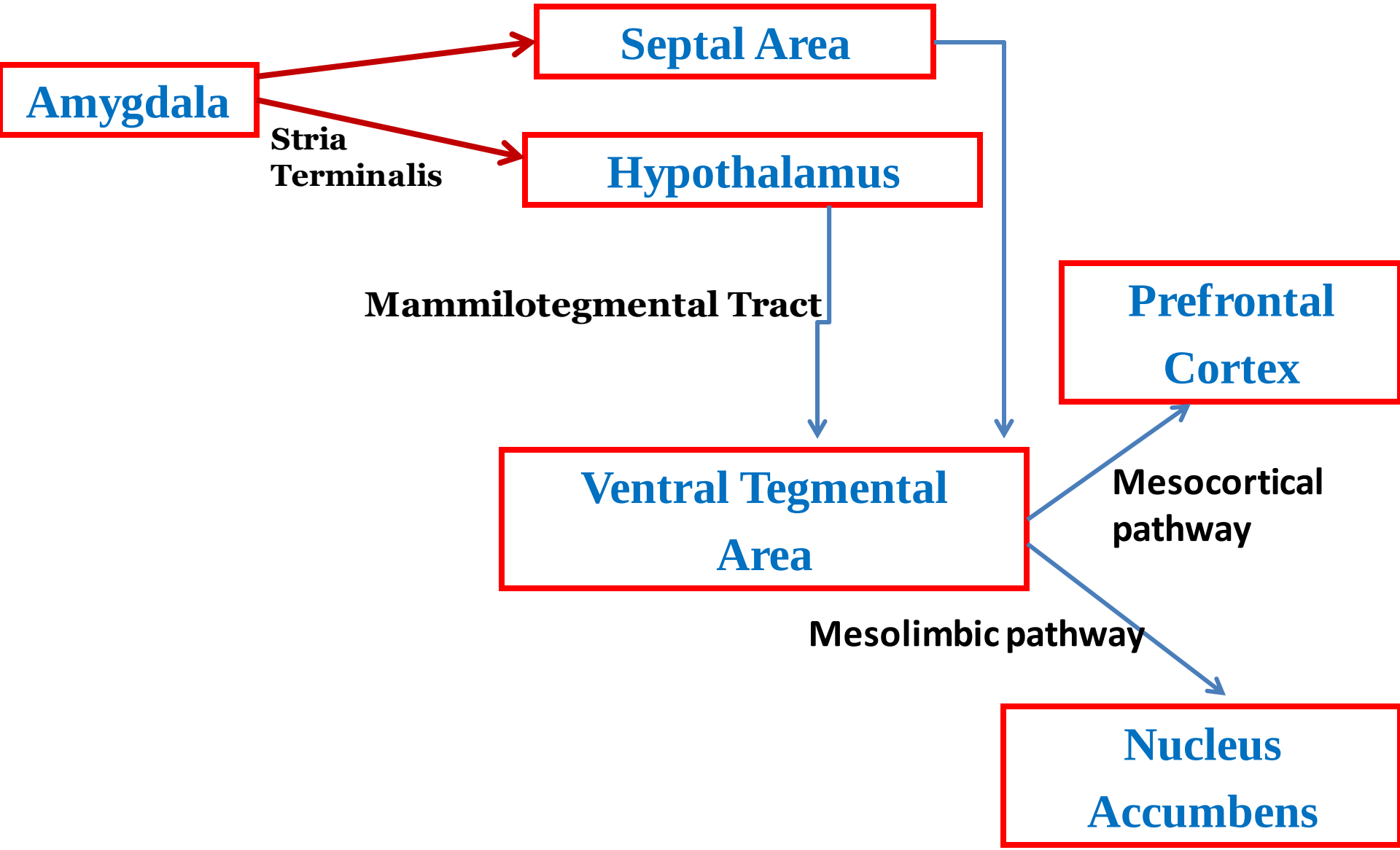
Papez Circuit: Memory and Learning



Addiction and Motivation

- Reward circuitry underlying addictive behavior include amygdala and nucleus accumbens
- Amygdala plays a central role in cue induced relapse, stress and drug abuse results in release of excitatory neurotransmitters in hippocampus and amygdala
- The pathway of motivated behavior involves the prefrontal cortex, ventral tegmental area, amygdala, nucleus accumbens

Addiction and Motivation

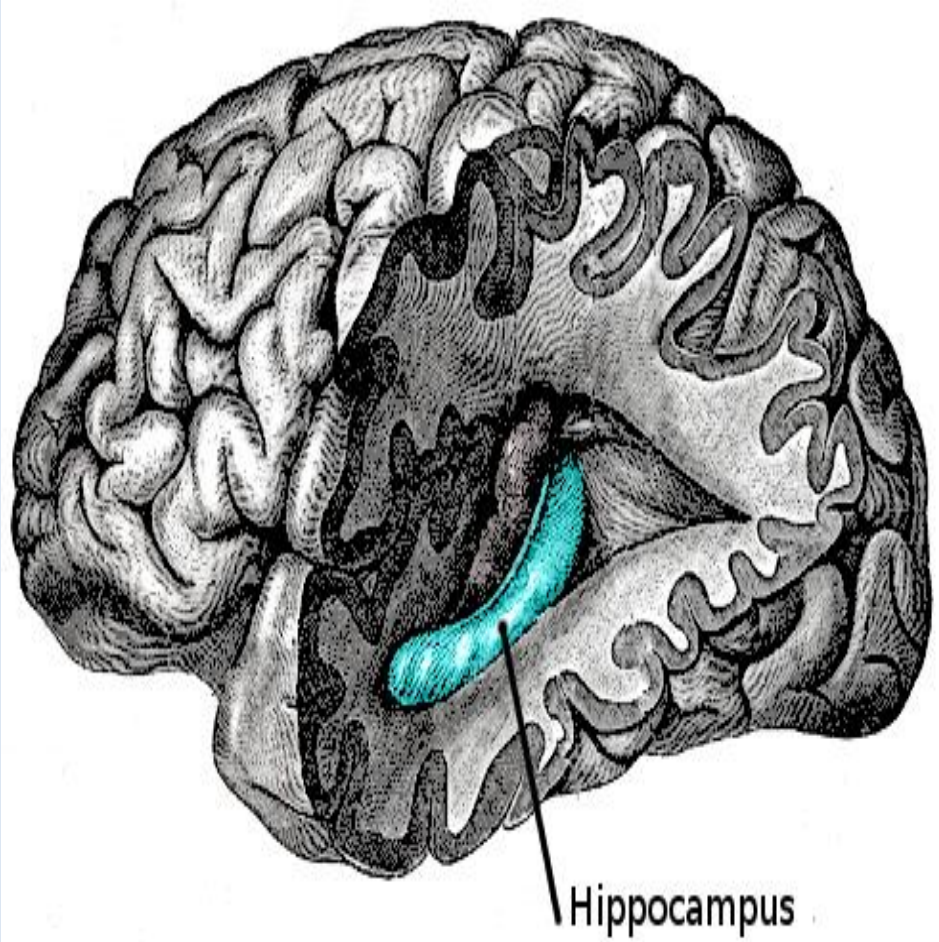


FUNCTIONS OF THE LIMBIC SYSTEM

Areas	Functions
Cingulate gyrus	Autonomic functions regulating heart rate and blood pressure as well as cognitive, attentional and emotional processing.
Parahippocampal gyrus	Spatial memory
Hippocampus	Long-term memory
Amygdala	Anxiety, aggression, fear conditioning; emotional memory and social cognition.
Hypothalamus	Regulates the autonomic nervous system via hormone production and release. Secondarily affects and regulates blood pressure, heart rate, hunger, thirst, sexual arousal and the circadian rhythm sleep / wake cycle.
Mammilary body	Memory
Nucleus accumbens	Reward, Addiction

Lesions associated with limbic lobe disorders

- **Korsakoff's psychosis (Retrograde** = loss of new memories at the time of lesion with retained old memories & **anterograde amnesia**= inability to gain new memories)
- **Temporal lobe epilepsy**
- The **hippocampus** is a common focus site in epilepsy, and can be damaged through chronic seizures.
- Alzheimer's disease: The hippocampus is one of the first brain areas to show damage in Alzheimer's disease
- **Schizophrenia.**



Wernicke-Korsakoff's psychosis

COAT RACK

Wernicke's encephalopathy

- C - Confusion
- O - Ophthalmoplegia
- A - Ataxia
- T - Thiamine deficiency

Korsakoff's psychosis

- R - Retrograde amnesia
- A - Anterograde amnesia
- C - Confabulation
- K - Korsakoff's psychosis

MEDCAMPUS.IO

Kluver-Bucy Syndrome

- Bilateral lesion of the medial temporal lobe

Manifestations:

- Hyperorality
- Psychic blindness
- Blunted emotions
- Hypersexuality
- Compulsive eating
- Docility (loss of fear and anger)
- Forgets rapidly
- Visual agnosia

The End

Thank you!