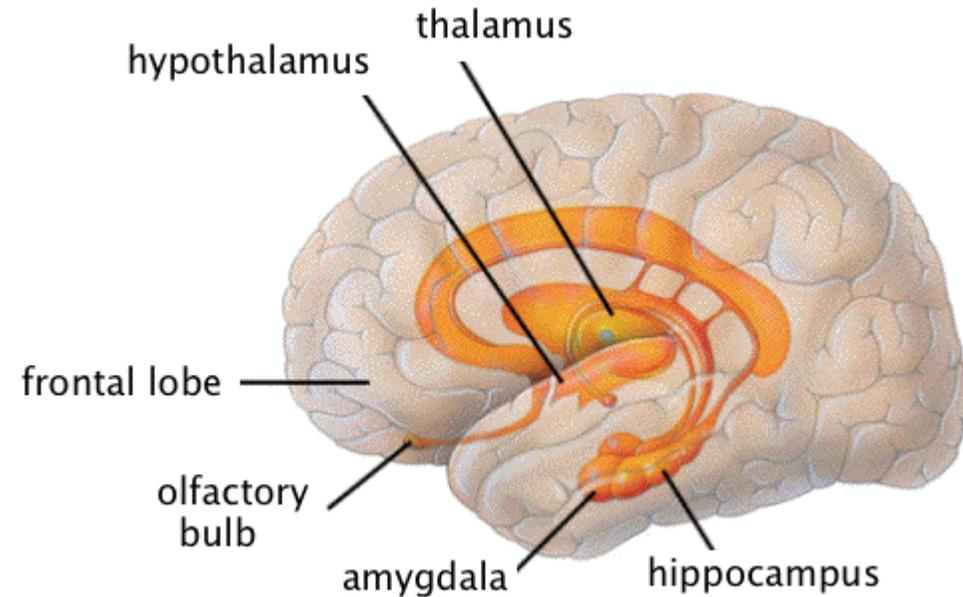


# EMOTION

2<sup>nd</sup> Semester CC4 TH

## The Limbic System

The limbic system is a complex set of structures that lies on both sides of the thalamus, just under the cerebrum. It includes the hypothalamus, the hippocampus, the amygdala, and several other nearby areas. It appears to be primarily responsible for our emotional life, and has a lot to do with the formation of memories. In this drawing, you are looking at the brain cut in half, but with the brain stem intact. The part of the limbic system shown is that which is along the left side of the thalamus (hippocampus and amygdala) and just under the front of the thalamus (hypothalamus):



## Limbic System

The word “limbic” means “border.” Originally, the term “limbic” was used to describe the border structures around the basal regions of the cerebrum, but as we have learned more about the functions of the limbic system, the term limbic system has been expanded to mean the entire neuronal circuitry that controls emotional behavior and motivational drives. A major part of the limbic system is the hypothalamus, with its related structures. In addition to their roles in behavioral control, these areas control many internal conditions of the body, such as body temperature, osmolality of the body fluids, and the drives to eat and drink and to control body weight. These internal functions are collectively called vegetative functions of the brain, and their control is closely related to behavior.

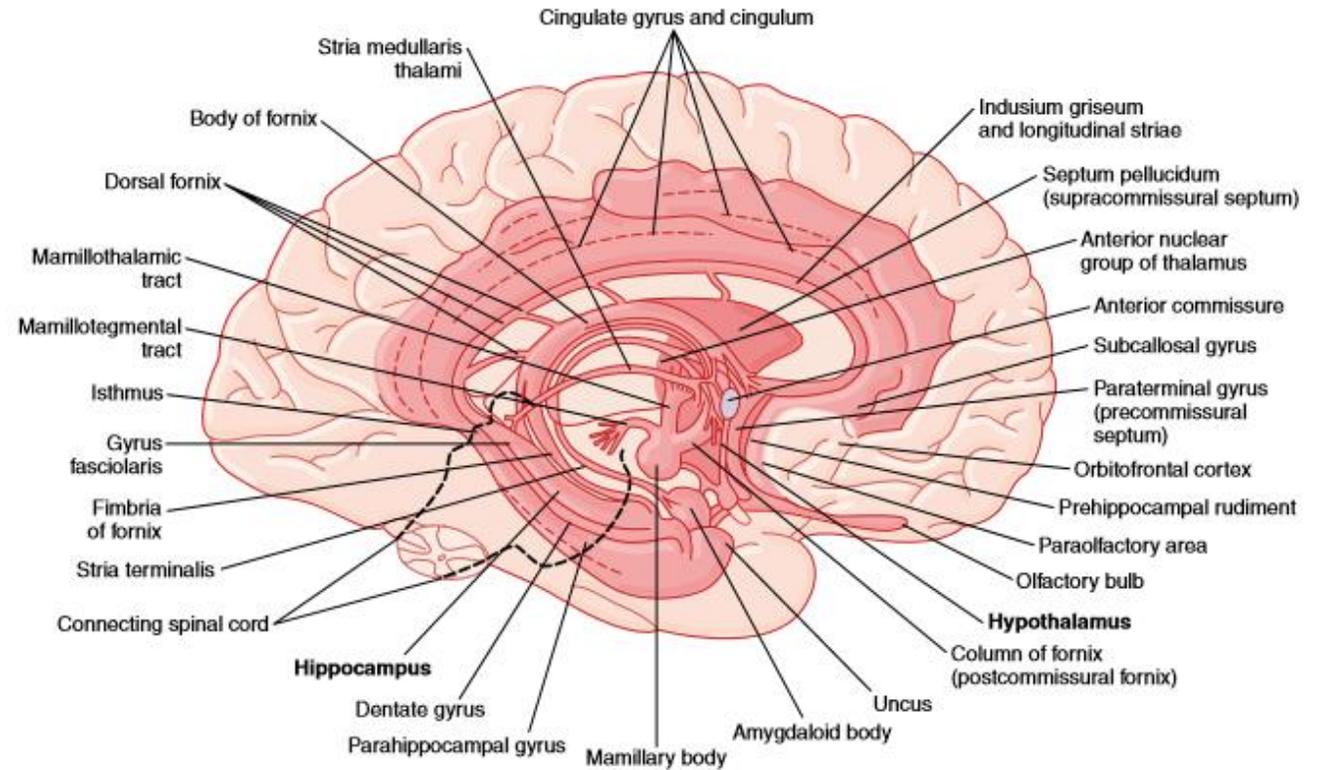
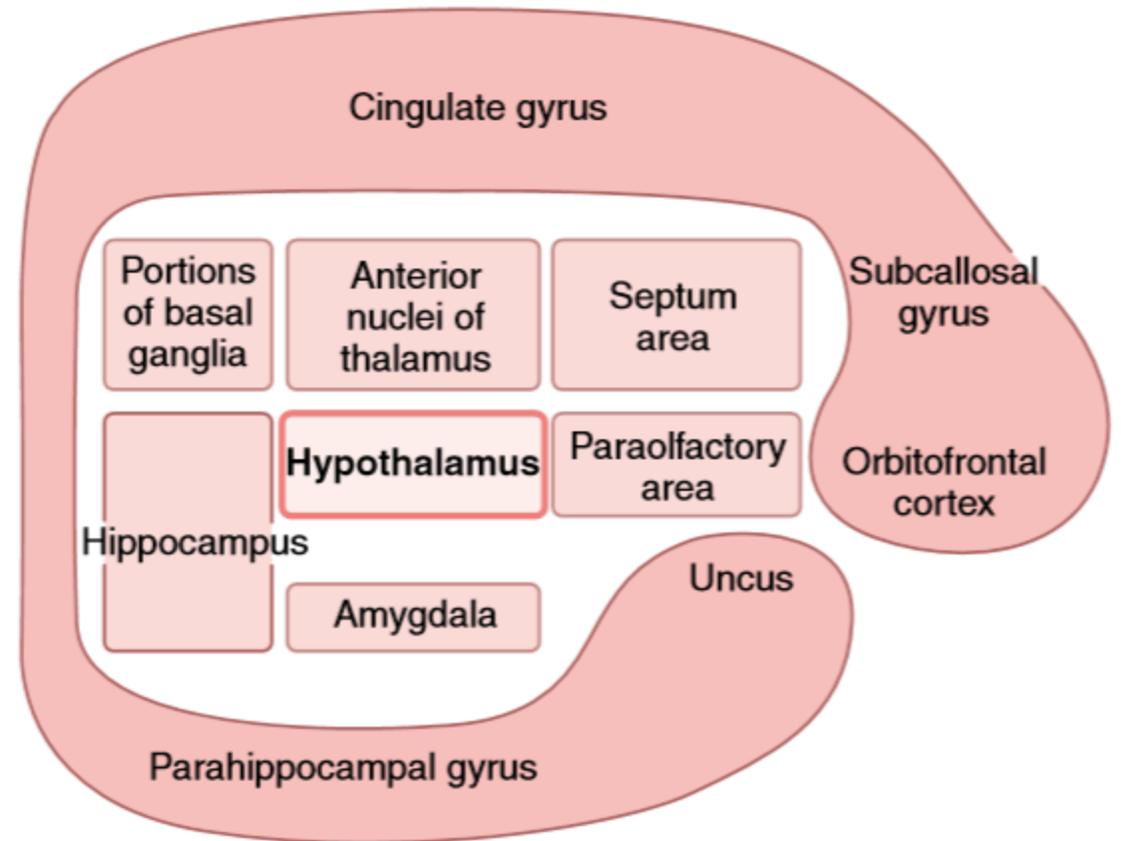


Figure 58-4 Anatomy of the limbic system, shown in the dark pink area. (Redrawn from Warwick R, Williams PL: Gray's Anatomy, 35th Br. ed. London: Longman Group Ltd, 1973.)

Figure shows the anatomical structures of the limbic system, demonstrating that they are an interconnected complex of basal brain elements. Located in the middle of all these is the extremely small hypothalamus, which from a physiologic point of view is one of the central elements of the limbic system. Figure 58-5 illustrates schematically this key position of the hypothalamus in the limbic system and shows surrounding it other subcortical structures of the limbic system, including the septum, paraolfactory area, anterior nucleus of the thalamus, portions of the basal ganglia, hippocampus, and amygdala. And surrounding the subcortical limbic areas is the limbic cortex, composed of a ring of cerebral cortex in each side of the brain (1) beginning in the orbitofrontal area on the ventral surface of the frontal lobes, (2) extending upward into the subcallosal gyrus, (3) then over the



**Figure 58-5** Limbic system, showing the key position of the hypothalamus.

## Definition:

In modern neurobiological terms, **emotions** are complex programs of actions triggered by the presence of certain stimuli, external to the body or from within the body, when such stimuli activate certain neural systems.

## Emotional Components:

- Cognition---Awareness of sensation
- Affect---Feeling inside
- Conation---Urge to take action

## Basis of Emotion:

- Physical responses: behavioural patterns for defence, attack. Faces (laughing, crying, blushing), Expressions emotional expression in animals---Standing at full height, Arched back. Hair standing on end, Ears drawn back, Teeth exposed, Spit, hiss, or growl
- Physiological responses: Hypertension, Tachycardia, sweating
- Mental: Feeling inside

Fear, anxiety, rage, punishment, avoidance: sense of displeasure

Reward, Motivation, Relaxed feeling, Joy: sense of pleasure

## Key Points of emotion:

The limbic system consists of evolutionary primitive structures so termed as Allocortex. It has 3 layers instead of 6 layers of Neo-cortex. Neurons exhibit prolonged after discharge. Neo-cortex has very less control over the Limbic cortex. So LC is like a horse with a rider(NC) without its reign.

Papez circuit-- the circuit is related to emotion as well as memory

Major Neuro-transmitters in pathways of emotions include—Dopamine, Nor-epinephrine, Serotonin  
Over secretion by drugs/ stimulating brain areas

- Depression is characterized by deficiencies of serotonin and nor-epinephrine
- Size of hippocampus is smaller in depressed persons
- Serotonin uptake inhibitors(selective serotonin re-uptake inhibitor SSRI Fluoxetine) prolong the action of serotonin, thereby acting as anti-depressants
- NE uptake inhibitors(tricyclic anti-depressants) prolong the action of NE, thereby acting as anti-depressants
- Mono-amine oxidases breaks down NE, Serotonin, Dopamine blocking this enzyme by MAOIs decreases depression

The limbic system is an 'internal' brain controlling the viscerο-emotional responses.

Evidence--The structures of the system were identified by degeneration, ablation, stimulation experiments in monkeys and dogs as well as neurodegenerative diseases in humans

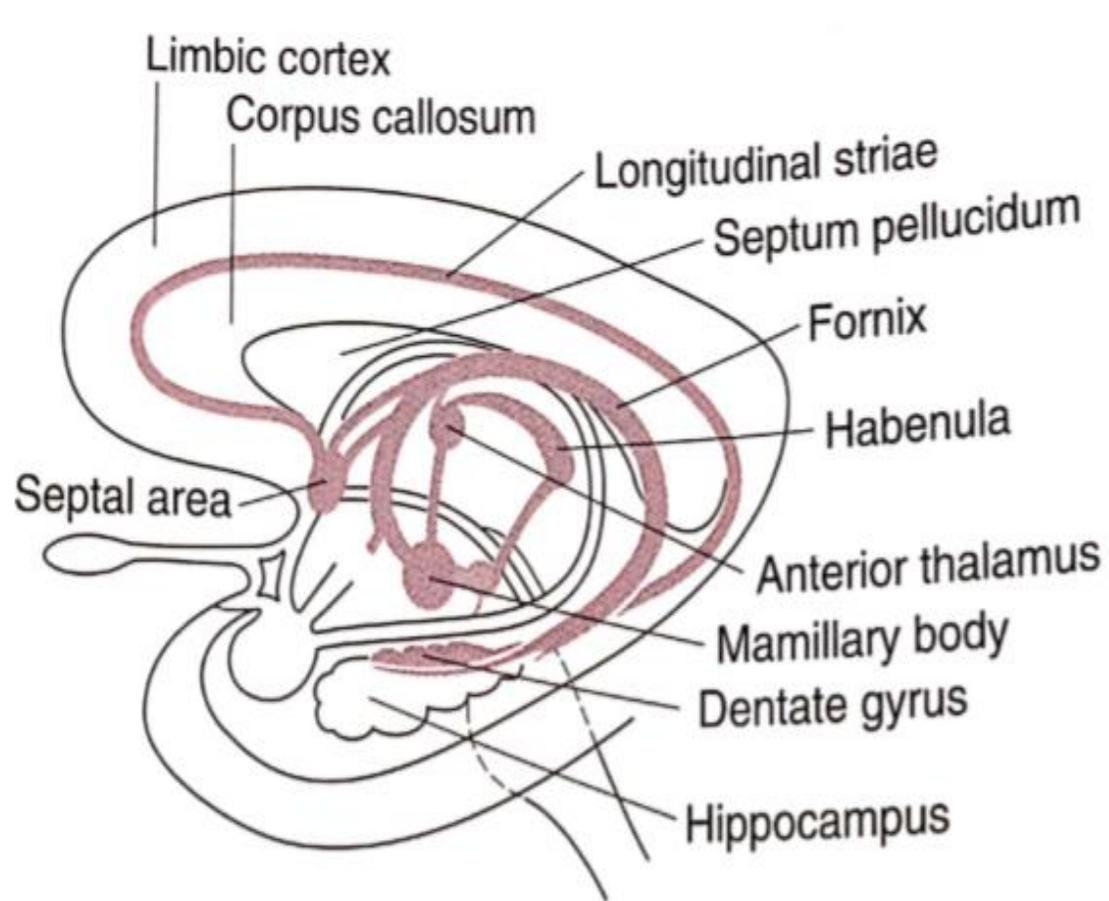
James Papez had been studying cases of rabies which is a disease that causes high levels of aggression.

He noticed that this heightened aggression correlated with damage to the hippocampus.

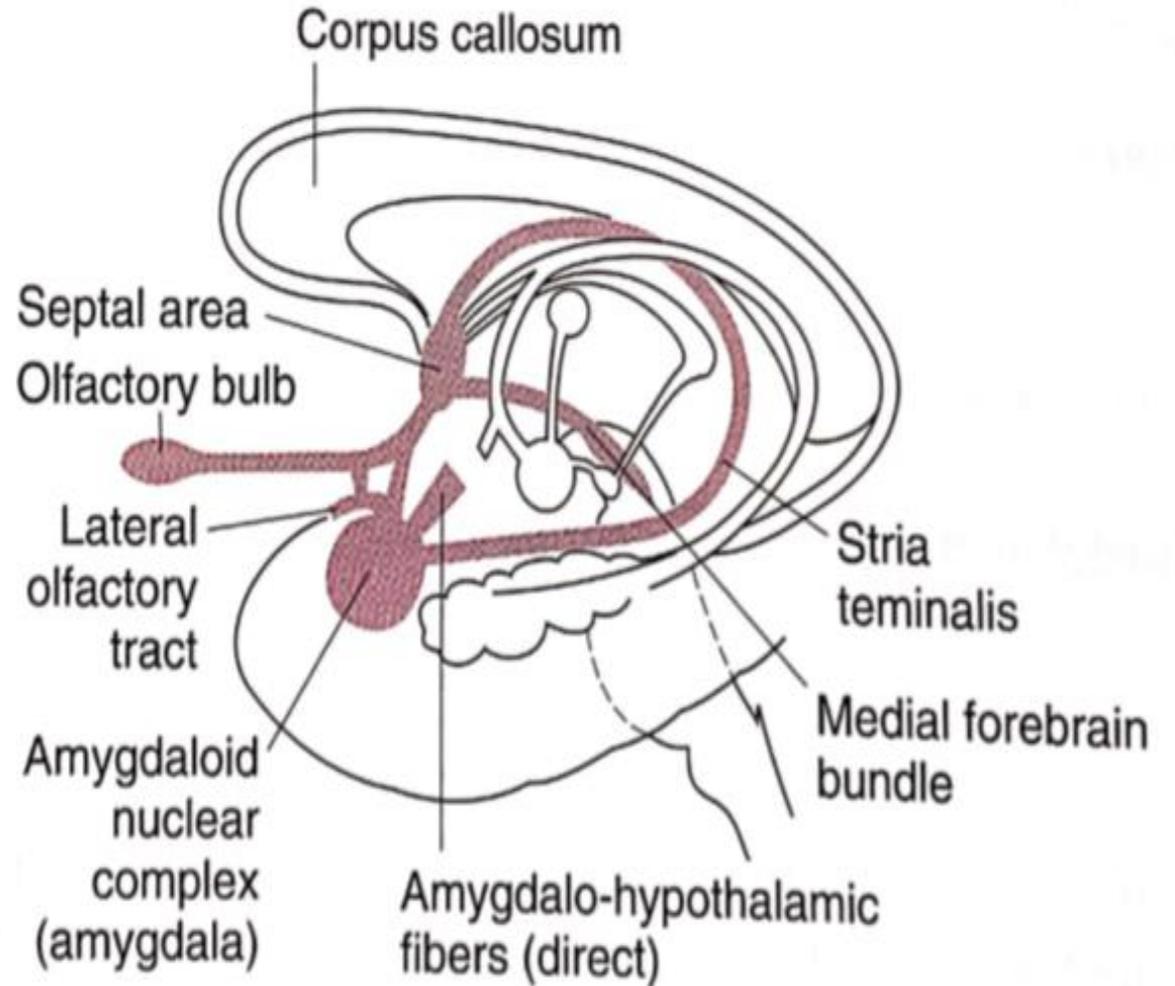
Theoretically, this made sense to Papez who asserted that the hippocampus is responsible for the expression of emotion because of its connection to the autonomic nervous system. He also noticed that in other cases, certain stimuli (taste, smell, pain, etc.) would cause strong emotional responses. These stimuli activated not only the hippocampus but also other brain structures. He theorized that these brain structures worked together as the emotional control center in the brain and consequently founded the Papez circuit.

Paul D. MacLean proposed a modified version of the Papez circuit, emphasizing not only the hippocampus, but also the amygdala and septum.

# Afferent & Efferent connections of the Limbic System



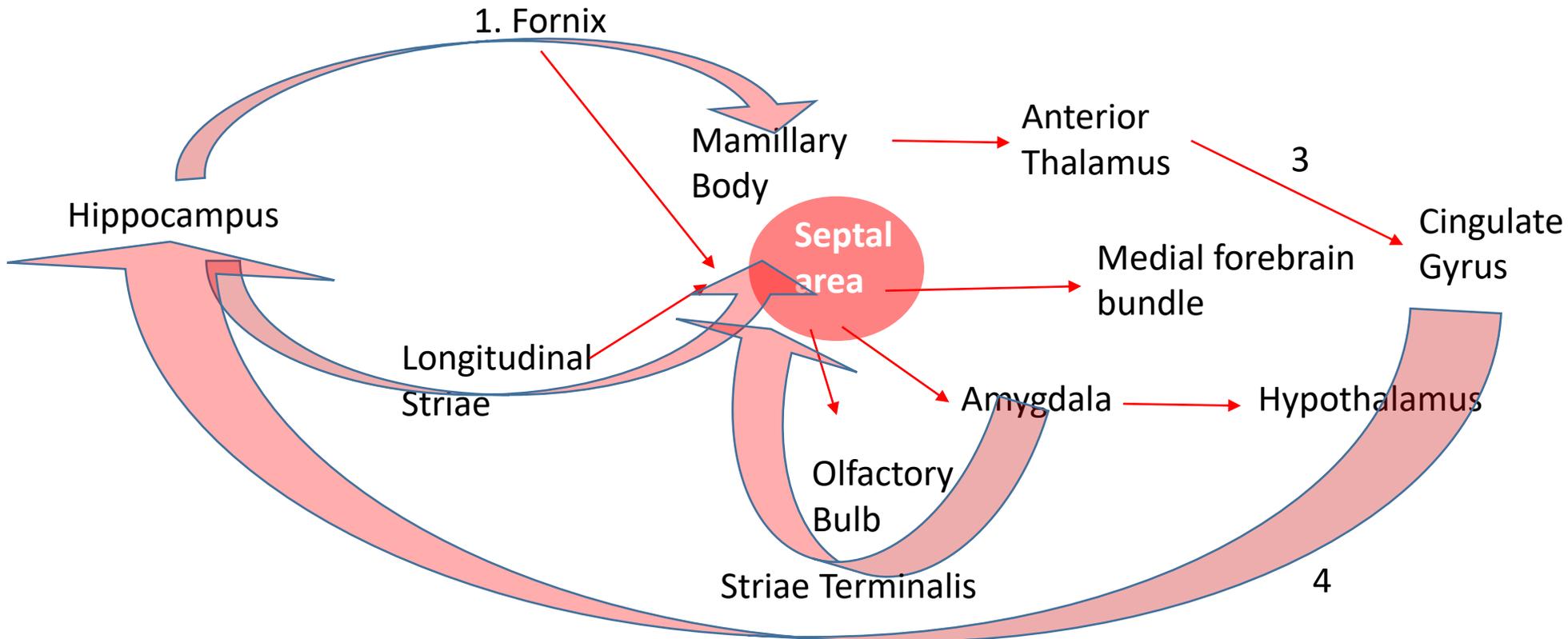
**Hippocampal Connections**



**Amygdaloid Connections**

# Papez circuit

1. Fornix connects the Hippocampus & the Mamillary body.
2. Mamilothalamic tract connects anterior thalamus and mamillary body
3. Anterior thalamus connected to cingulate cortex
4. Cingulate cortex connects to hippocampus



## **EMOTION FUNCTIONS:**

### **FEAR-**

Operant conditioning Fear learning • fear response – US: foot shock – UR: change in heart rate • pair tone (CS) with shock • tone (CS) by itself evokes fear response

The amygdala is a fear center • bilateral lesions – reduce fear and aggression • electrical stimulation – produce fear (as well as other emotions) • fMRI – activation when viewing fearful faces

• bilateral amygdala damage • impaired recognition of fear in others • impaired fear learning • impaired social judgments

Amygdala responsible for fear learning by auditory and visual stimulus. Faces with fearful expressions activate left amygdala. Long-term potentiation of neurons destroyed in pathways to amygdala – fear learning blocked.

Stimulations of lateral parts of posterior hypothalamus produces avoidance responses.

### **RAGE-**

Removal of neocortex, destruction of ventromedial hypothalamus, destruction of septal nuclei produces rage reactions, previously thought as sham rage. Placidity in amygdaloid animals is converted to rage if VMN of hypothalamus is subsequently destroyed.

35% of brain areas are pleasure evoking areas, 5% are response avoidance and 60% indifferent areas.

### **REWARD CENTER-**

ventral tegmentum → Band of tissue DOPAMINERGIC(MFB, medial forebrain bundles ) → nucleus accumbens → frontal cortex.

### **AVOIDANCE-**

Stimulation in Lateral parts of posterior hypothalamus, dorsal parts of midbrain and entorhinal cortex

### **MATERNAL BEHAVIOR-**

Lesion of cingulate and retrosplenial portions of limbic cortex – depression of maternal behaviour

### **SEXUAL RESPONSES-**

Bilateral limbic lesion in the pyriform cortex in cats and monkeys produces intensification sexual activity.

Bilateral amygdaloid lesions lead to hypersexuality in humans. Median forebrain bundle stimulation lead to increased sexual activity in male monkeys. Anterior hypothalamic lesions in sheep leads to diminished sexual activity.

**Klüver–Bucy syndrome** is a syndrome resulting from bilateral lesions of the medial temporal lobe (including amygdaloid nucleus). Klüver–Bucy syndrome may present with compulsive eating, hypersexuality, insertion of inappropriate objects in the mouth (hyperorality), visual agnosia, and docility.

The list of symptoms differs somewhat by source. Generally included are the following:

- Amnesia, characterised by an inability to recall memories. Its nature is both anterograde and retrograde, meaning new memories cannot be formed and old memories cannot be recalled. The level of amnesia is considered to be profound.
- Docility, characterized by exhibiting diminished fear responses or reacting with unusually low aggression. This has also been termed "placidity" or "tameness".
- Dietary changes and hyperphagia, characterized by eating inappropriate objects (**pica**), or overeating, or both.
- Hyperorality, described by Ozawa et al. as "an oral tendency, or compulsion to examine objects by mouth".
- Hypersexuality, characterized by a heightened libido or a tendency to seek sexual stimulation from unusual or inappropriate objects.

- Visual agnosia, characterized by an inability to recognize familiar objects or people.

While this cluster of syndromes is common to such sources as 1997's *The Neuropsychiatry of Limbic and Subcortical Disorders*, 2005's *Functional Neuroanatomy: Text and Atlas* and 1997's "Single-Photon Emission CT and MR Findings in Klüver-Bucy after Reye syndrome", an article in the *American Journal of Neuroradiology*, the three vary thereafter.

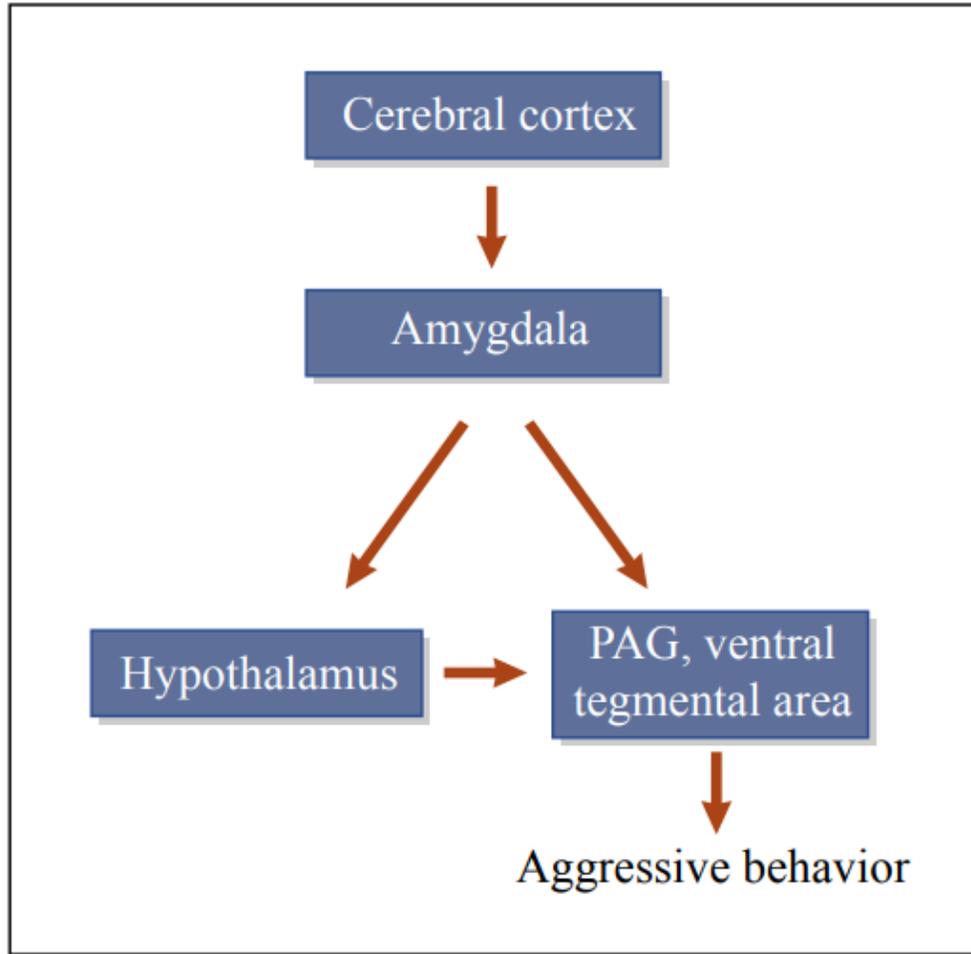
Inconsistent criteria include

- Hypermetamorphosis"an irresistible impulse to notice and react to everything within sight".

Klüver-Bucy

- Lack of emotional response, diminished emotional affect. This is a symptom under *The Neuropsychiatry of Limbic and Subcortical Disorders* and is included under "Single-Photon Emission CT and MR Findings in Klüver-Bucy" along with apathy under docility.

## A neural circuit for aggression



## Hypothalamus

The hypothalamus is a small part of the brain located just below the thalamus on both sides of the third ventricle. (The ventricles are areas within the cerebrum that are filled with cerebrospinal fluid, and connect to the fluid in the spine.) It sits just inside the two tracts of the optic nerve, and just above (and intimately connected with) the pituitary gland.

The hypothalamus is one of the busiest parts of the brain, and is mainly concerned with **homeostasis**. Homeostasis is the process of returning something to some “set point.” It works like a thermostat: When your room gets too cold, the thermostat conveys that information to the furnace and turns it on. As your room warms up and the temperature gets beyond a certain point, it sends a signal that tells the furnace to turn off.

The hypothalamus is responsible for regulating your hunger, thirst, response to pain, levels of pleasure, sexual satisfaction, anger and aggressive behavior, and more. It also regulates the functioning of

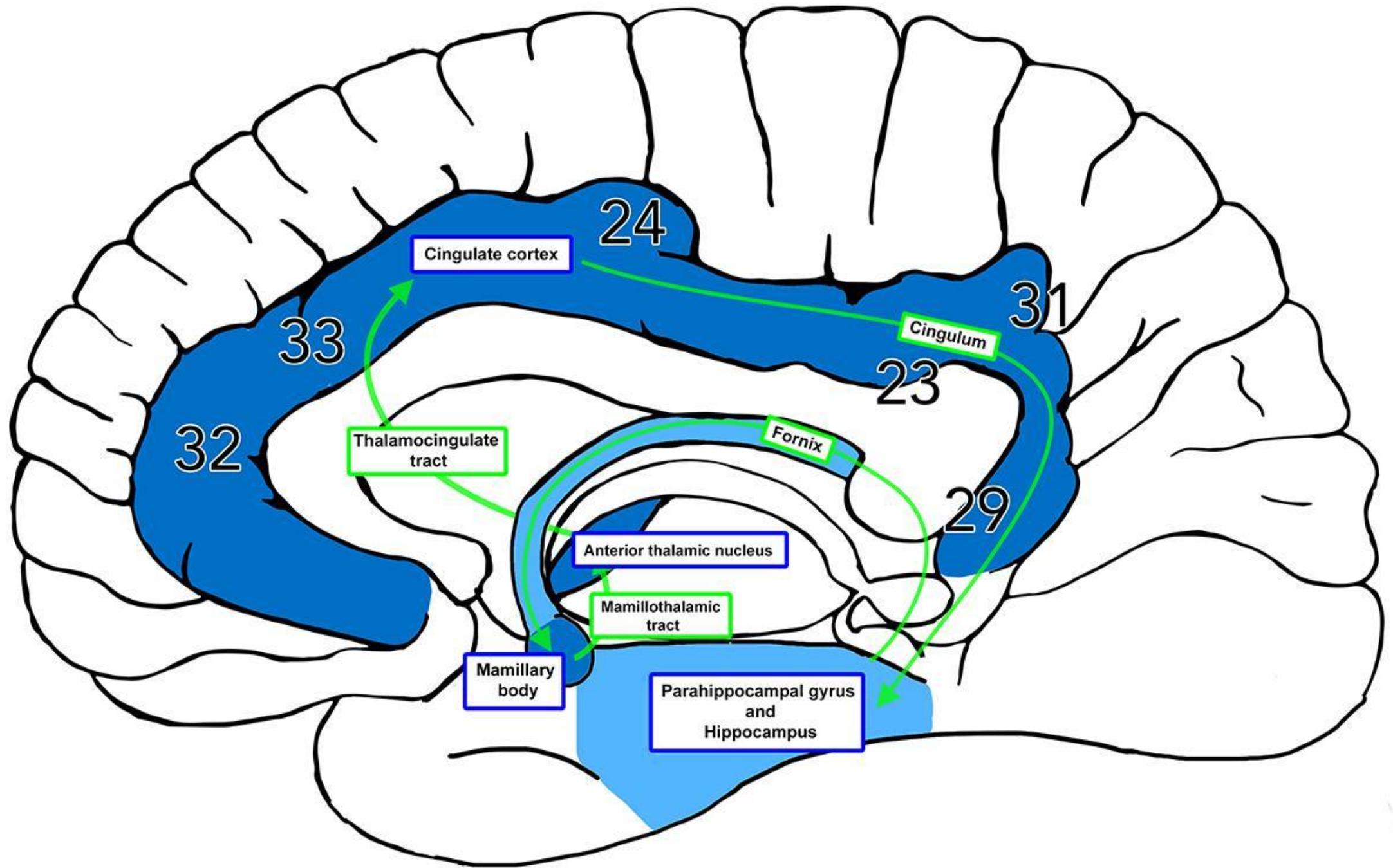
## Related areas

Besides the hypothalamus, hippocampus, and amygdala, there are other areas in the structures near to the limbic system that are intimately connected to it:

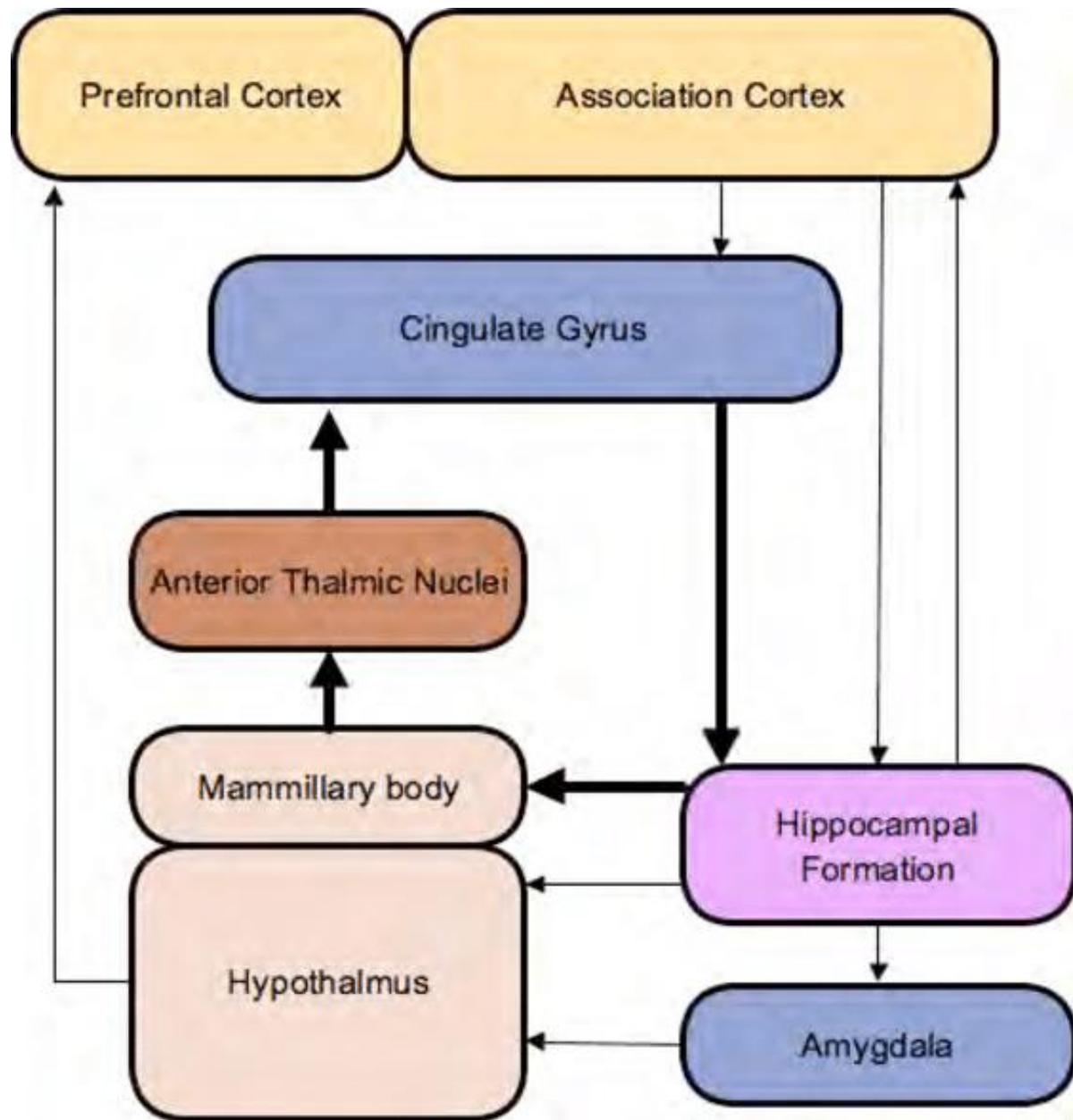
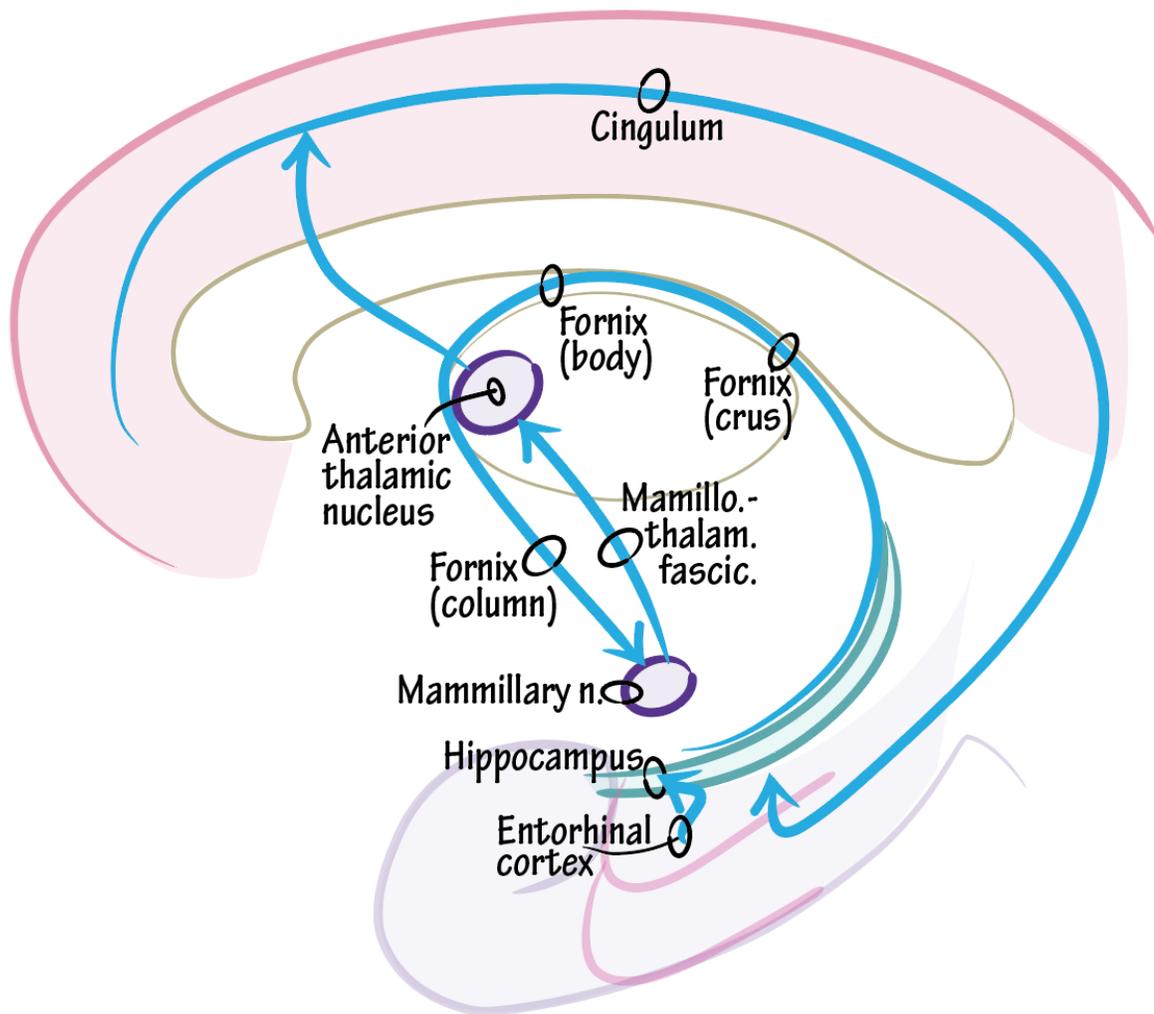
The **cingulate gyrus** is the part of the cerebrum that lies closest to the limbic system, just above the corpus callosum. It provides a pathway from the thalamus to the hippocampus, seems to be responsible for focusing attention on emotionally significant events, and for associating memories to smells and to pain.

The **ventral tegmental area** of the brain stem (just below the thalamus) consists of dopamine pathways that seem to be responsible for pleasure. People with damage here tend to have difficulty getting pleasure in life, and often turn to alcohol, drugs, sweets, and gambling.

The **prefrontal cortex**, which is the part of the frontal lobe which lies in front of the motor area, is also closely linked to the limbic system. Besides apparently being involved in thinking about the future, making plans, and taking action, it also appears to be involved in the same dopamine pathways as the ventral tegmental area, and plays a part in pleasure and addiction.



## Extra-Hippocampal Circuitry The Papez Circuit



## Sham rage

- Bard, a student of Cannon's, made serial transections, essentially disconnecting the cerebral cortex from outflow pathways in cats.

When transection just included the forebrain (a), a range of behaviors constitutive of rage was observed when a cat was presented with innocuous stimuli.

- These behaviors included: – Arching of the back – Extension of claws – Hissing – Spitting – Pupil dilation – Increased blood pressure, heart rate and adrenal secretion
- This rage was called “sham rage” because animals retained emotional responses, but the responses lacked aspects of emotional behavior that was normally observed during rage. Besides being elicited by innocuous stimuli, sham rage subsided rapidly upon stimulus removal and was undirected; animals even bit themselves.
- When Bard performed progressive transections (b and c), when the posterior hypothalamus was disconnected, no coordinated rage response was observed. Two theories of emotion Hypothalamus and emotion
- The sham rage experiments established the hypothalamus as playing a prominent role in coordinating emotional behavior.
- Further studies by Stephen Ranson in the 1930s and by Walter Hess in the 1940s extended these findings. These investigators placed electrodes in the hypothalamus (Ranson in anaesthetized animals, and Hess in unanaesthetized animals) and applied stimulation. Hess found that stimulating different parts of the hypothalamus produced characteristic reactions that appeared to correspond to specific emotional states. For example, stimulation of the lateral hypothalamus caused autonomic and somatic responses consistent with anger: increased blood pressure, raising of the body hair, pupillary constriction, etc.

## Summary

- old theories of emotion, the basic purpose of the limbic system, and the basic anatomy of the limbic system.
- The hypothalamus plays an important role in generating emotional behaviors...but
  - The amygdala has been implicated in playing a prominent role in integrating information and coordinating emotional behaviors in response to sensory stimuli, events, and memories. These findings were demonstrated in: – Fear conditioning studies in rodents – Monkey studies (Kluver-Bucy) – Human neuroimaging and lesion studies – Studies of memory modulation by hormones in lower animals.
- Reward processing occurs in distinct brain circuits. – Stimulation of these circuits can provide powerful reinforcement signals. – Dopaminergic neurons in the ventral tegmental area provide a learning signal that reflects a computation comparing the reward received to the reward expected. – Drugs of abuse act on reward circuits.
- Psychiatric disorders such as depression, anxiety disorders, and addiction, all involve limbic system neural circuitry.