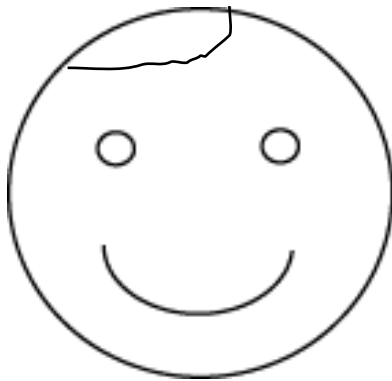


# Limbic System – Emotional Experience

Srdjan D. Antic, M.D.  
Department of Neuroscience

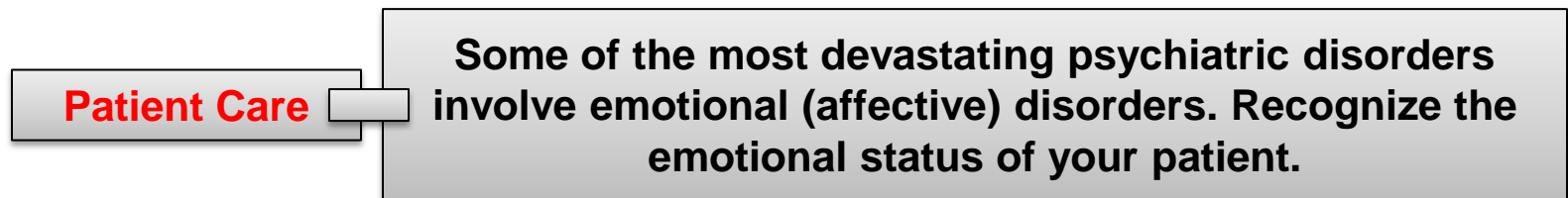
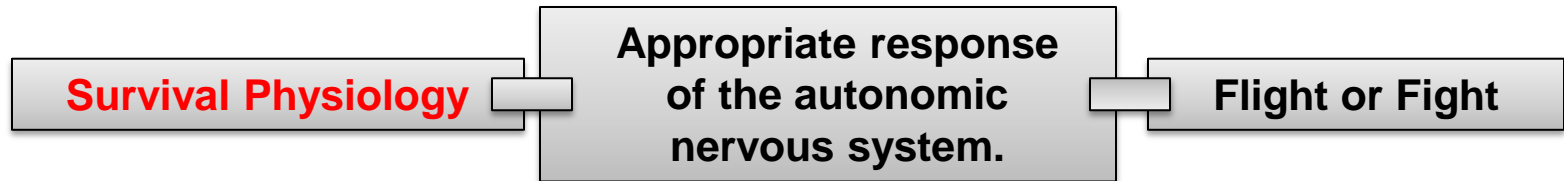


In preparation for the lecture I used four textbooks. They are listed by importance.

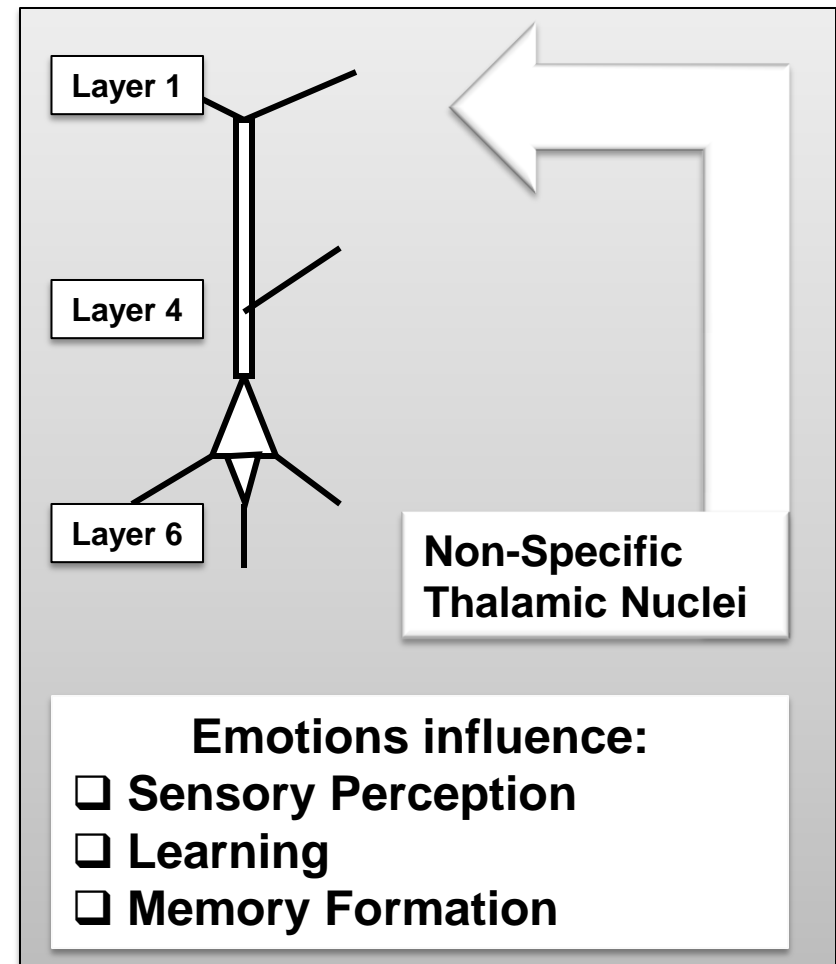
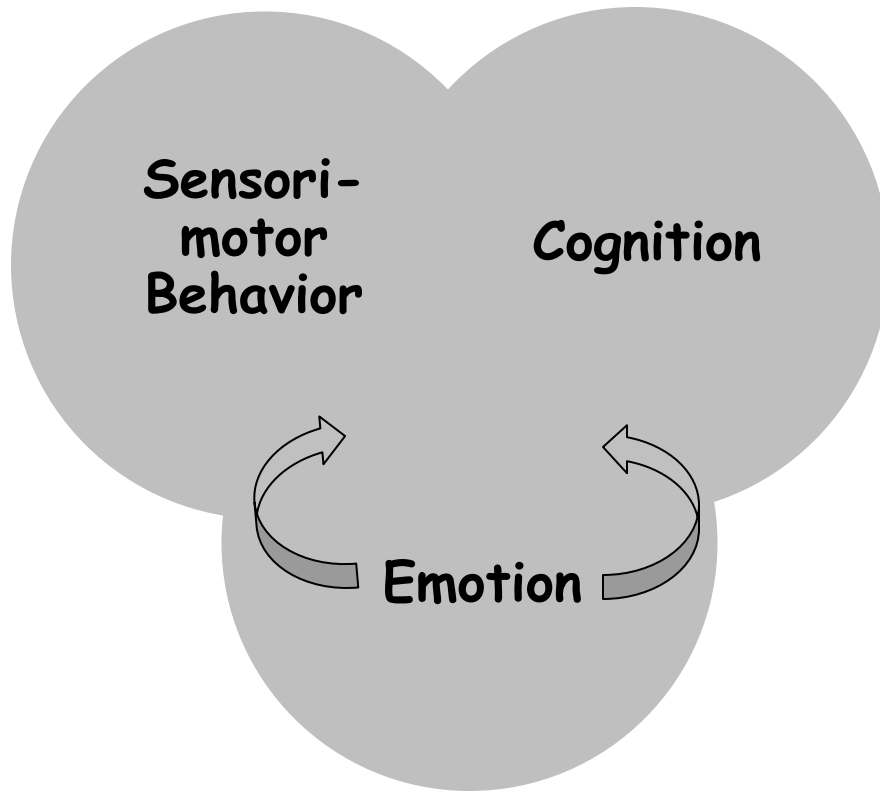
- (1) Purves *Neuroscience* (4th Ed);
- (2) Kandel and Schwartz *Principles of Neural Science* (2nd Ed);
- (3) Squire, Bloom et al., *Fundamental Neuroscience*, Academic Press (2nd Ed); and
- (4) Duane E. Haines *Fundamental Neuroscience also*, Churchill-Livingstone (2nd Ed).

There is no big pressure to purchase and study material beyond the Purves book and this slide presentation (+Lecture.PDF).

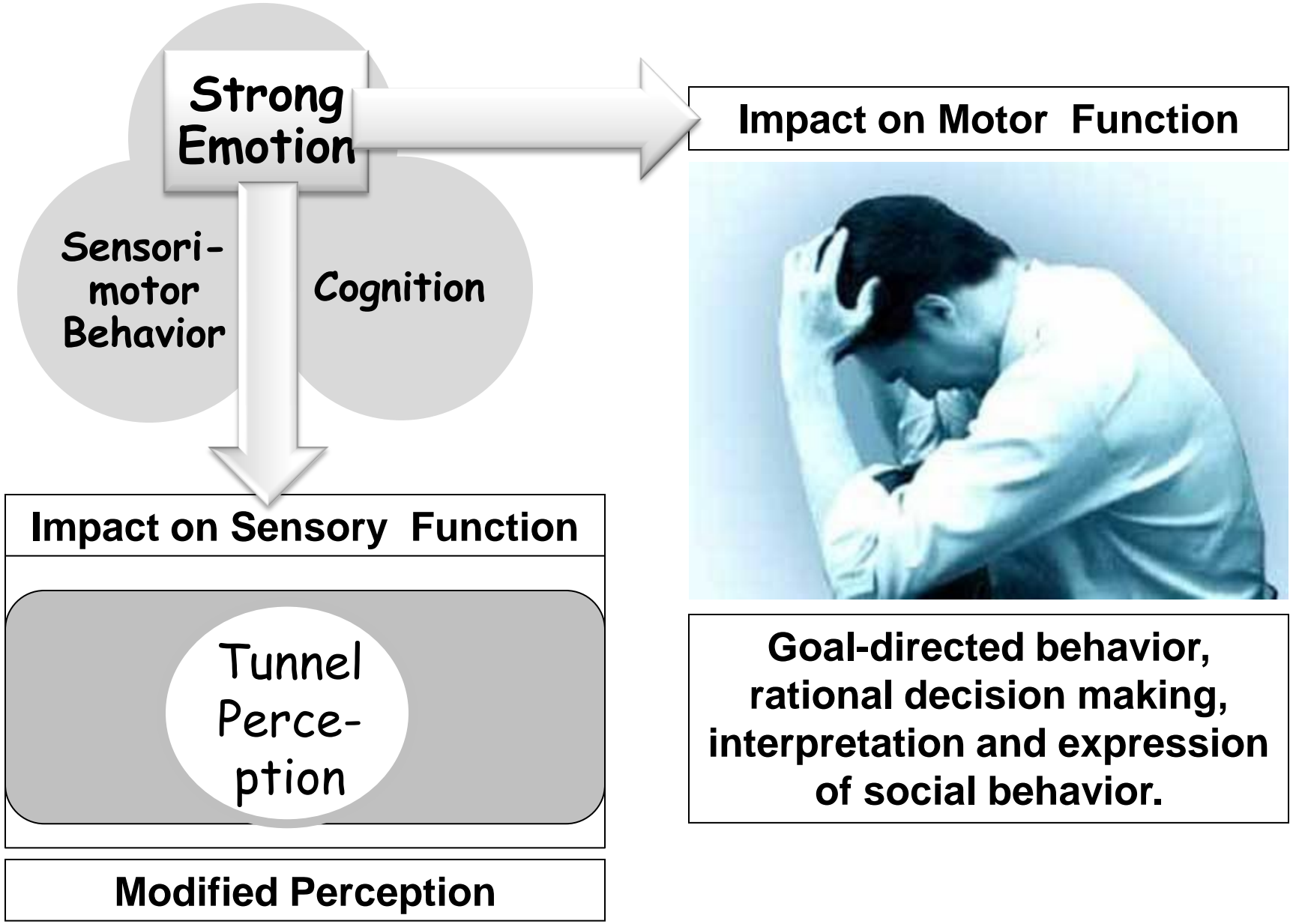
The subjective feelings and associated physiological states known as emotions are essential features of normal animal (human) experience.



The subjective feelings and associated physiological states known as emotions are essential features of normal human experience.



The same forebrain structures that process emotions participate in goal-directed behavior, rational decision making, interpretation and expression of social behavior, and even moral judgment.



**The subjective feelings and associated physiological states known as emotions are essential features of normal human experience.**

**Visceral changes**

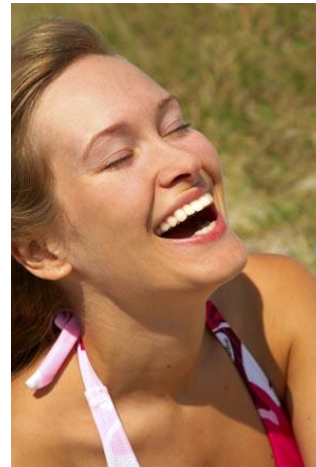
Emotions are expressed through visceral changes:

- Heart rate
- Cutaneous blood flow
- Piloerection
- Sweating
- Gastrointestinal motility

Intense sympathetic activity prepares the animal to fully utilize metabolic and other resources in challenging situations.

**Some of the most devastating psychiatric disorders involve emotional (affective) disorders.**

**Stereotyped somatic Motor response**



Gladness  
Pleasure  
Enjoyment  
Satisfaction  
Gratification  
Delight

***Happiness***

**Skeletal muscles**

**of the trunk, neck, shoulders and especially face,**

**broadcast important messages.**

Affect is a key part of the process of an organism's interaction with stimuli. A facial, vocal, or gestural behavior that serves as an indicator of emotion.

Anxiety  
Anger  
Sadness  
**Aggression**



The subjective feelings and associated physiological states known as emotions are essential features of normal human experience.

All emotions are expressed through both visceral changes and stereotyped somatic motor response, especially movements of the facial muscles.

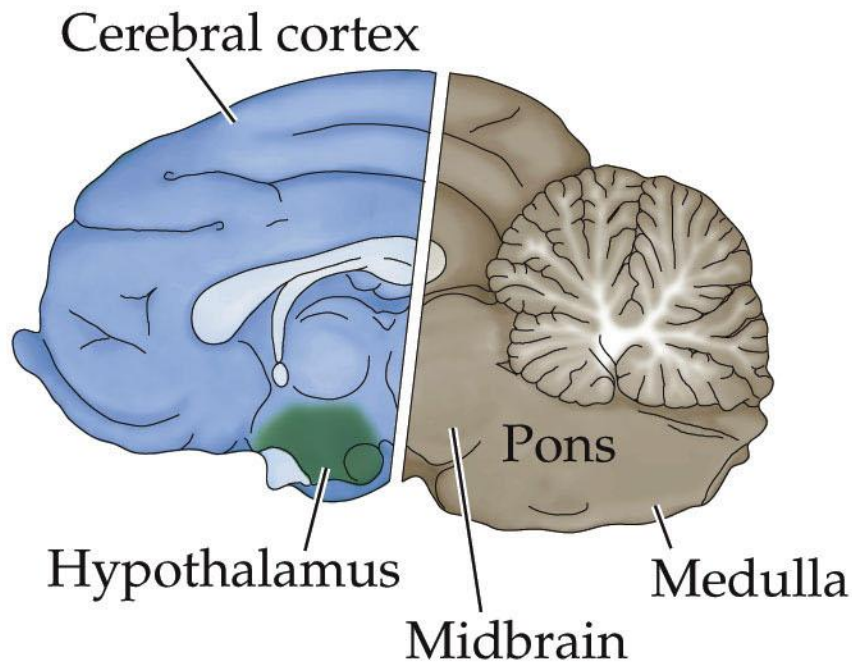
Physiological Roles of Emotions:

Mobilization of resources  
Communication with other animals  
Fast storing of important memories

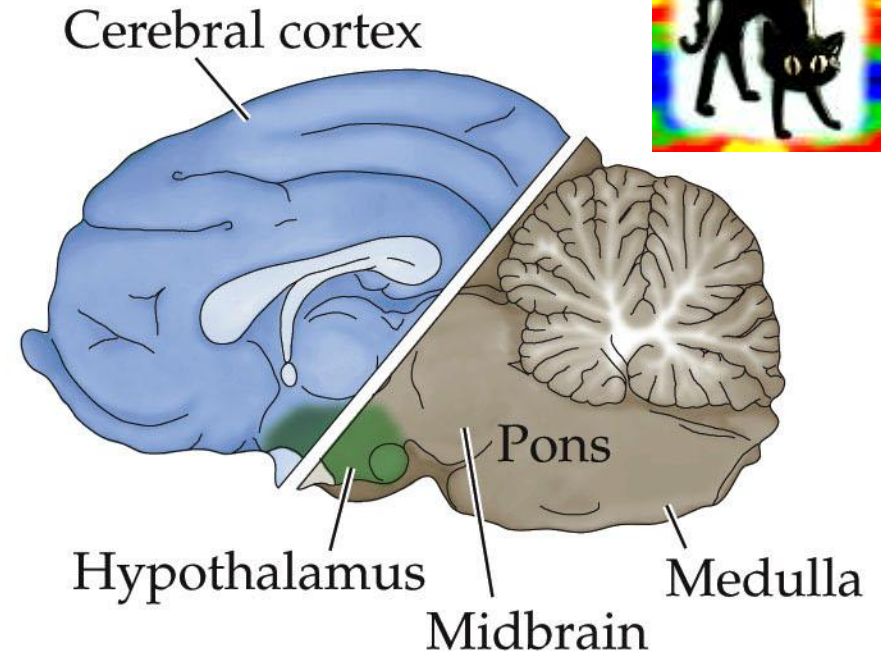
Affective reactions can occur without extensive perceptual and cognitive encoding, and can be made sooner and with greater confidence than cognitive judgments (Zajonc, 1980)

## Bard (1928) – surgery –spontaneous rage – visceral and somatic correlates.

(A) No “sham rage”

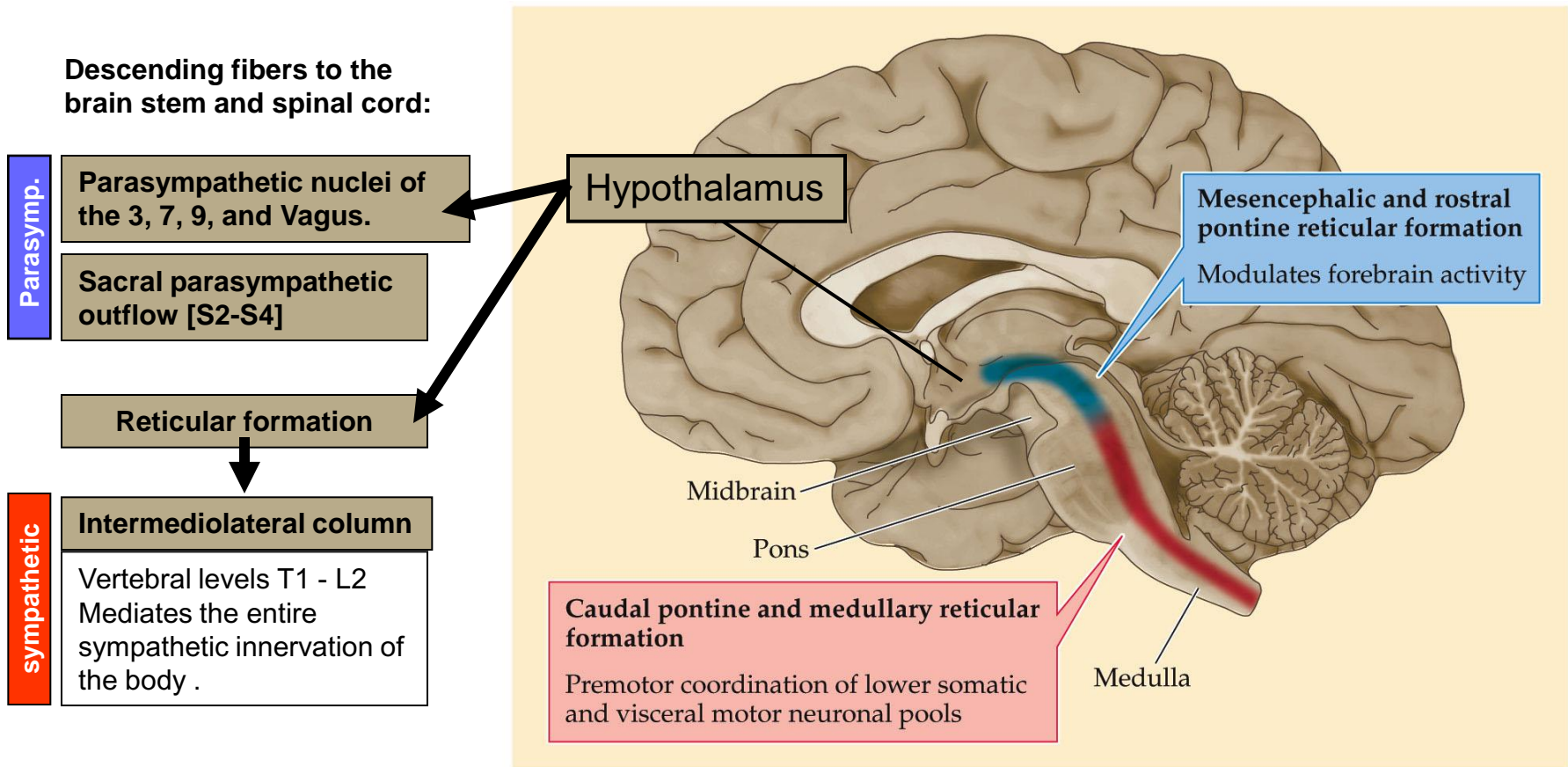


(B) “Sham rage” remains



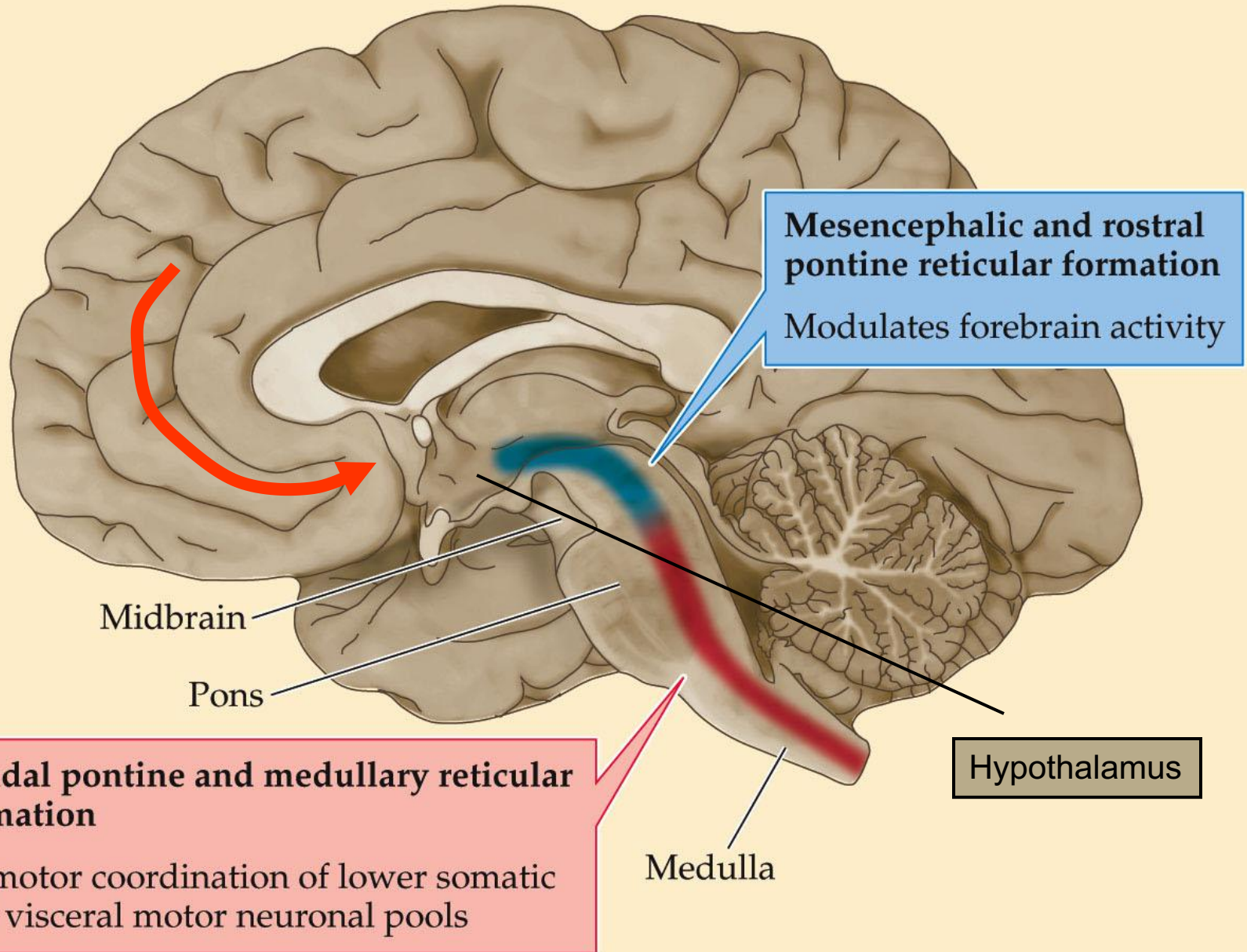
Whereas, the subjective experience of emotion might depend on intact cortex, the expression of coordinated emotional behaviors does not necessarily entail cortical processes.

# Hess Experiment – Hypothalamic Nucleus Stimulation - Reticular Formation





# Hypothalamic Nucleus Stimulation - Reticular Formation



# Hypothalamic Nucleus Stimulation - Reticular Formation

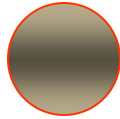
## Hypothalamus

Oculomotor



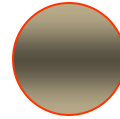
Edinger - Westphal

Facial



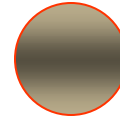
Sup. Salivatory Nuc.

Glossopharyngeal



Inf. Salivatory Nuc.

Vagus



Dorsal Vagal Nuc.

Sphincter pupillae

Ciliary muscle

Lacrimal gland

Nasal glands

Submandibular  
gland

Sublingual  
gland

Parotid gland

Dry mouth

Wet mouth

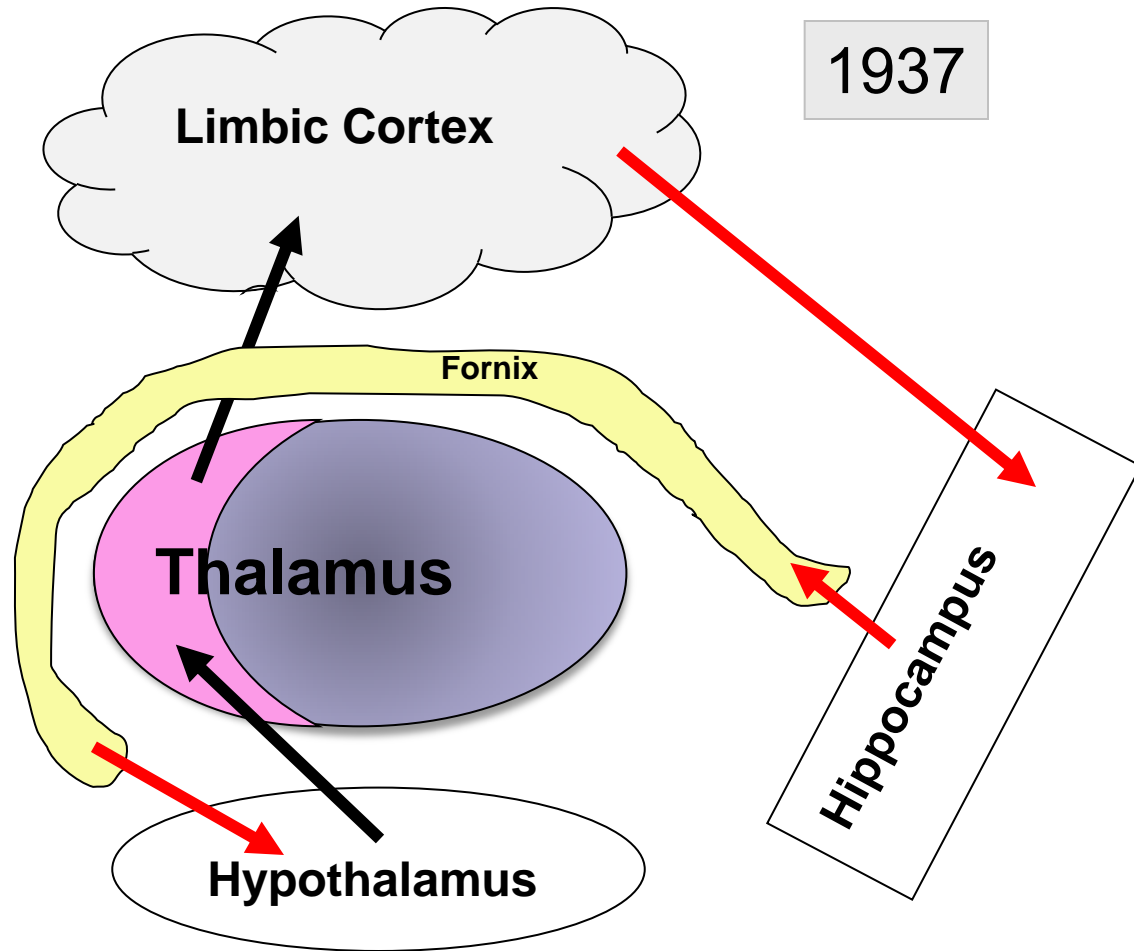
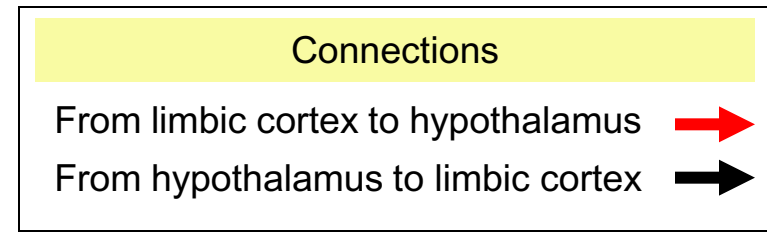
Cardiac cycle  
Bronchoconstriction  
Esophagus peristalsis  
Gastric secretion  
Intestine peristalsis  
Colon peristalsis

# ANAToMY oF THE IImbic SYStem

**Papez knew about Bard and Hess experiments.**

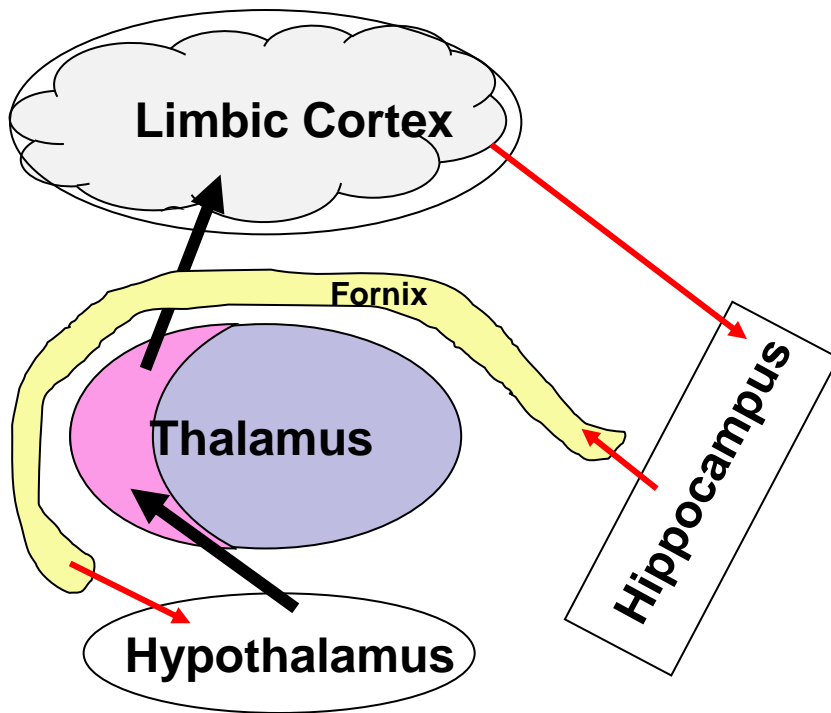
**Papez assembled a list of facts.**

- I. Hypothalamus influences the expression of emotions.**
- II. Emotions reach consciousness.**
- III. Higher cognitive functions modulate emotional behavior.**



## Original Papez Circuit

1. Limbic Cortex
2. Hippocampus
3. Fornix
4. Hypothalamus
5. Thalamus (ant. Nucl.)



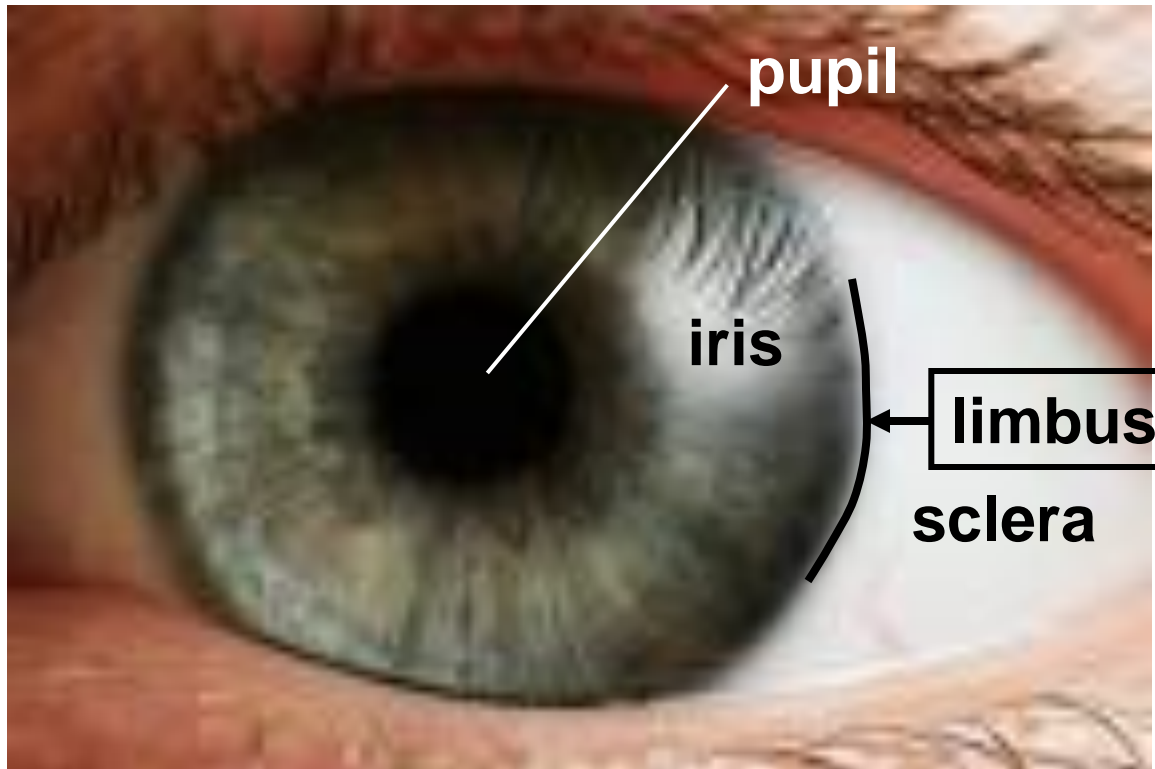
## Limbic System

1. Limbic Cortex
2. Hippocampus
3. Fornix
4. Hypothalamus
5. Thalamus (ant. Nucl.)

### New Additions:

6. Orbital and medial PFC
7. Ventral Basal Ganglia
8. MD Nucleus (Thalamus)
9. Pineal gland
10. Amygdala

A border or edge of any of various body parts distinguished by color or structure

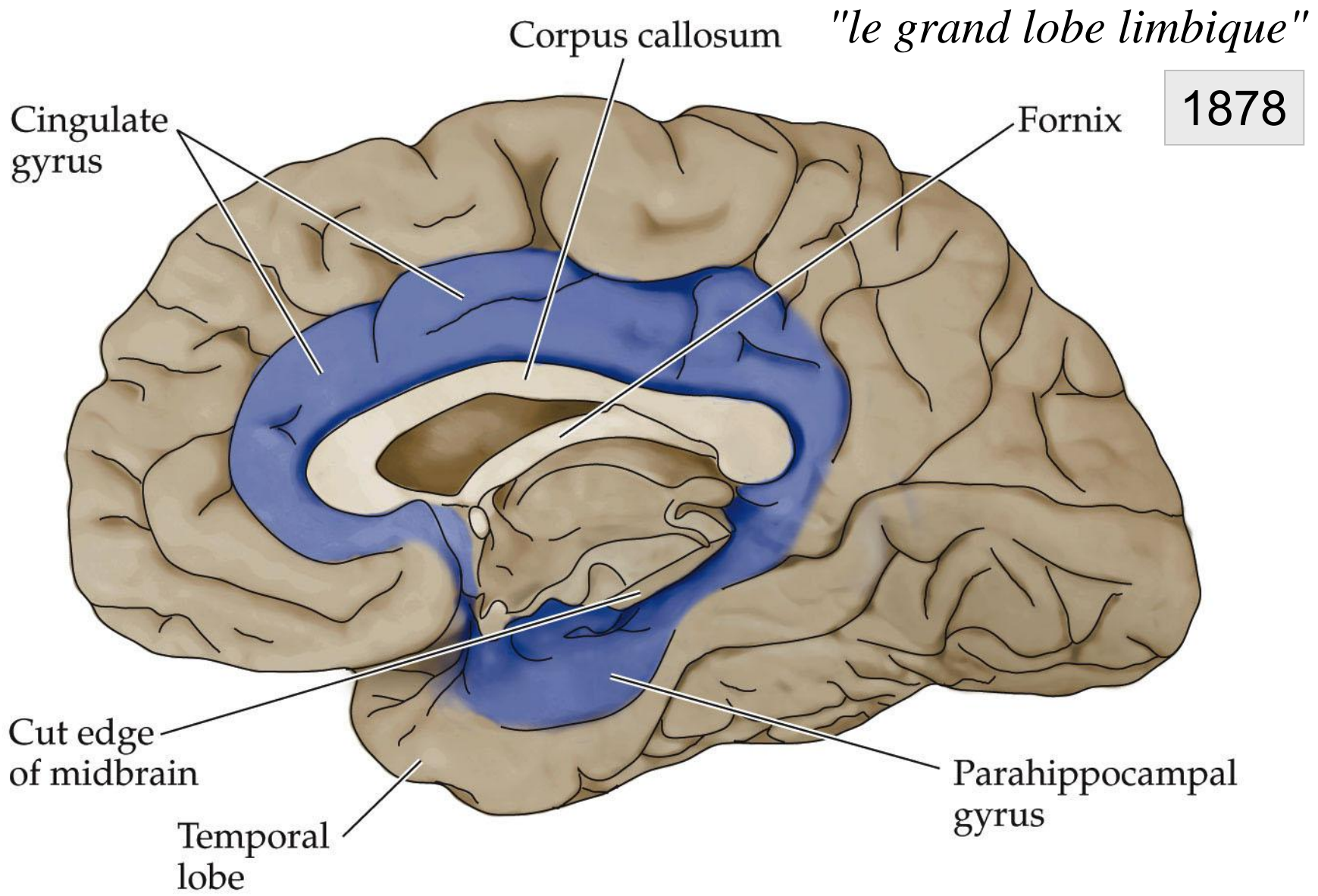


limbus = border

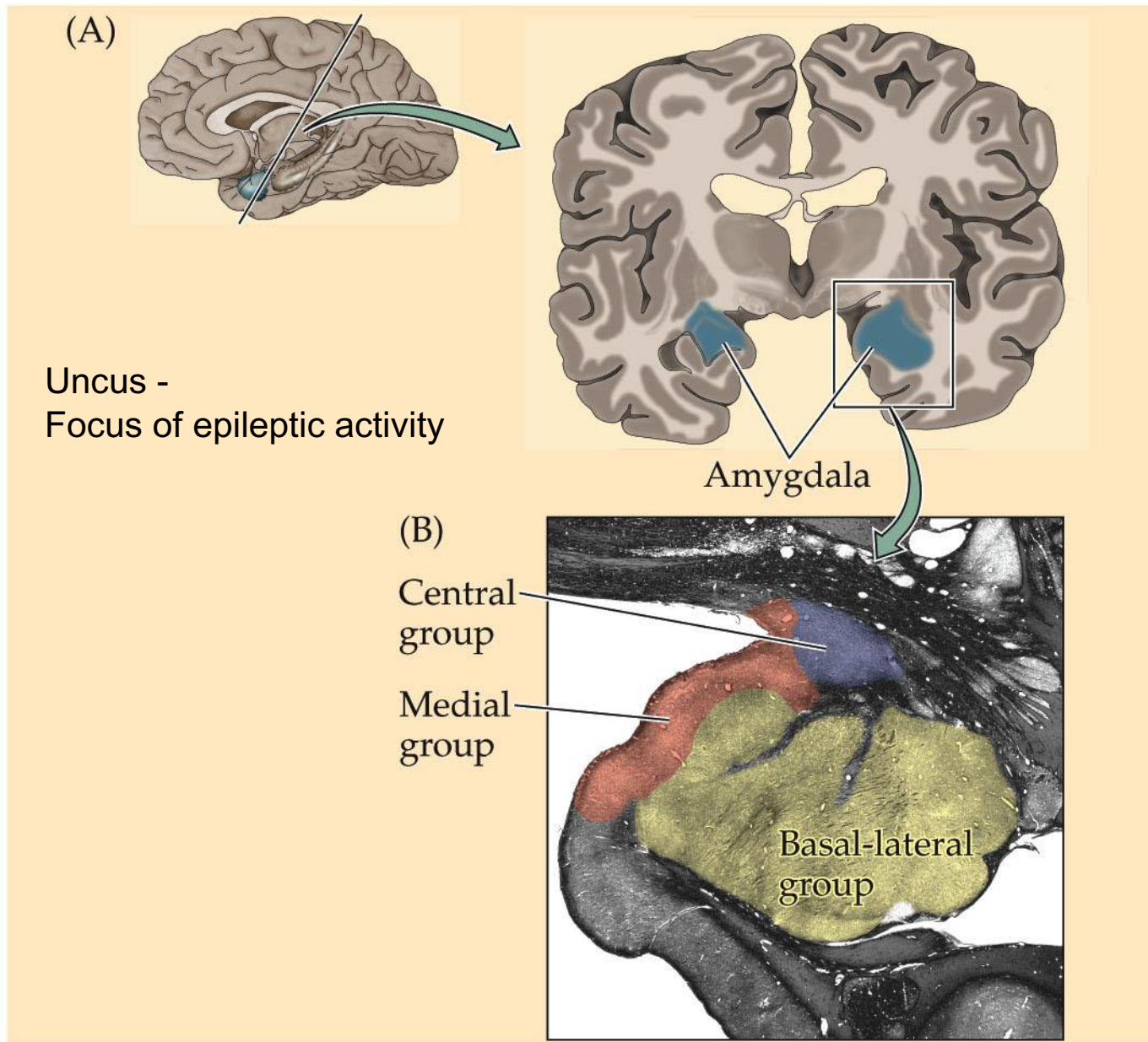
limbus = edge

limbus = rim

Limbus is a border between iris and sclera

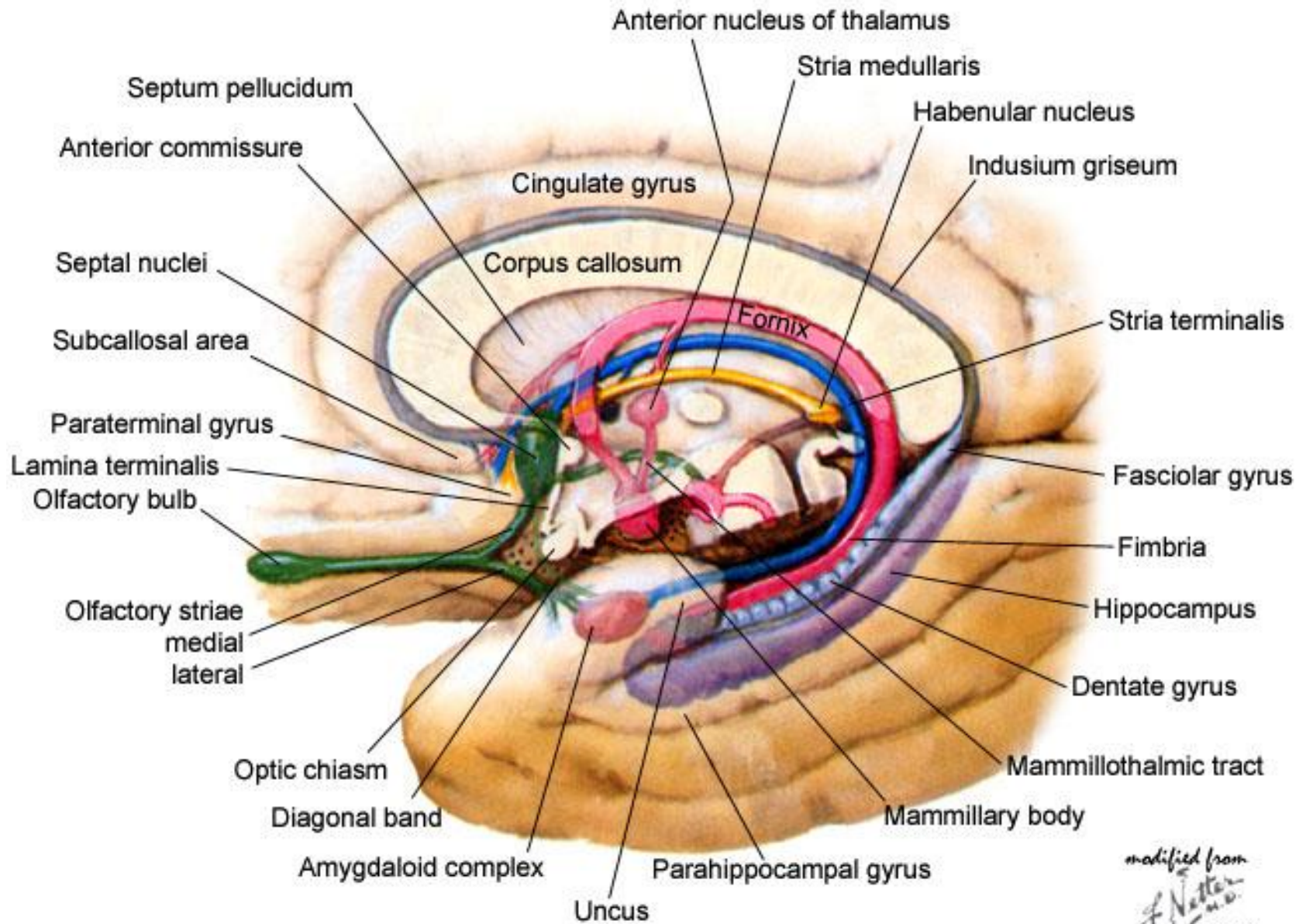


1878





# Connecting Pathways of the Limbic System



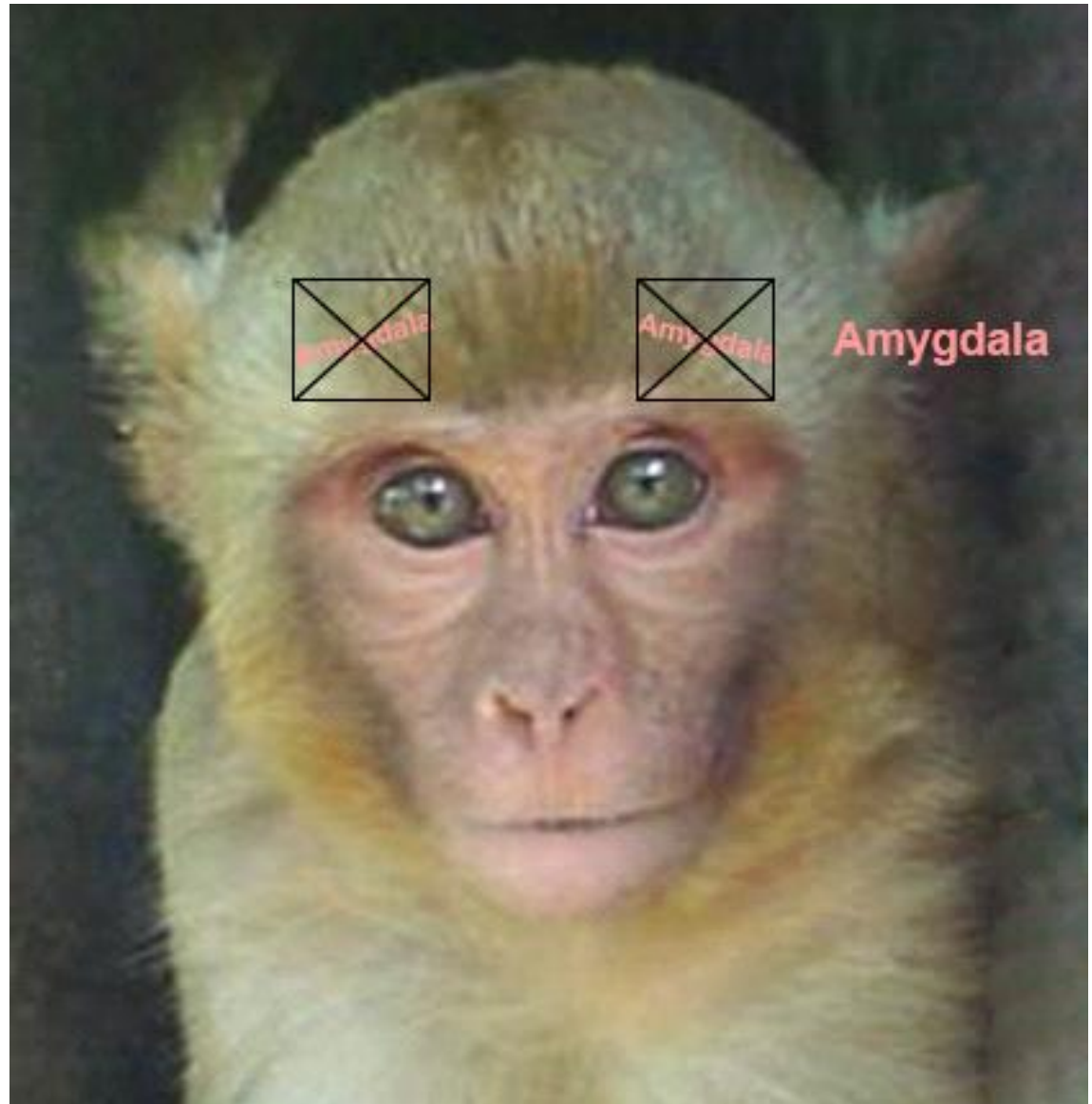
modified from  
F. Netter M.D.  
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Bilateral surgery  
Temporal lobes  
Visual agnosia  
Bizarre oral behaviors  
Hyperactivity  
Hypersexuality  
Tame  
Snakes

***Admonition: Have no Fear***

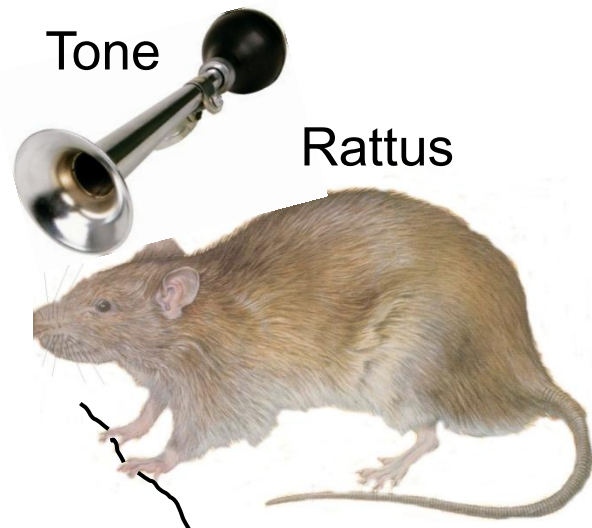
To truly live without fear is to be deprived of crucial neuronal mechanism that facilitates appropriate social behaviors, helps make right decisions, promotes survival.



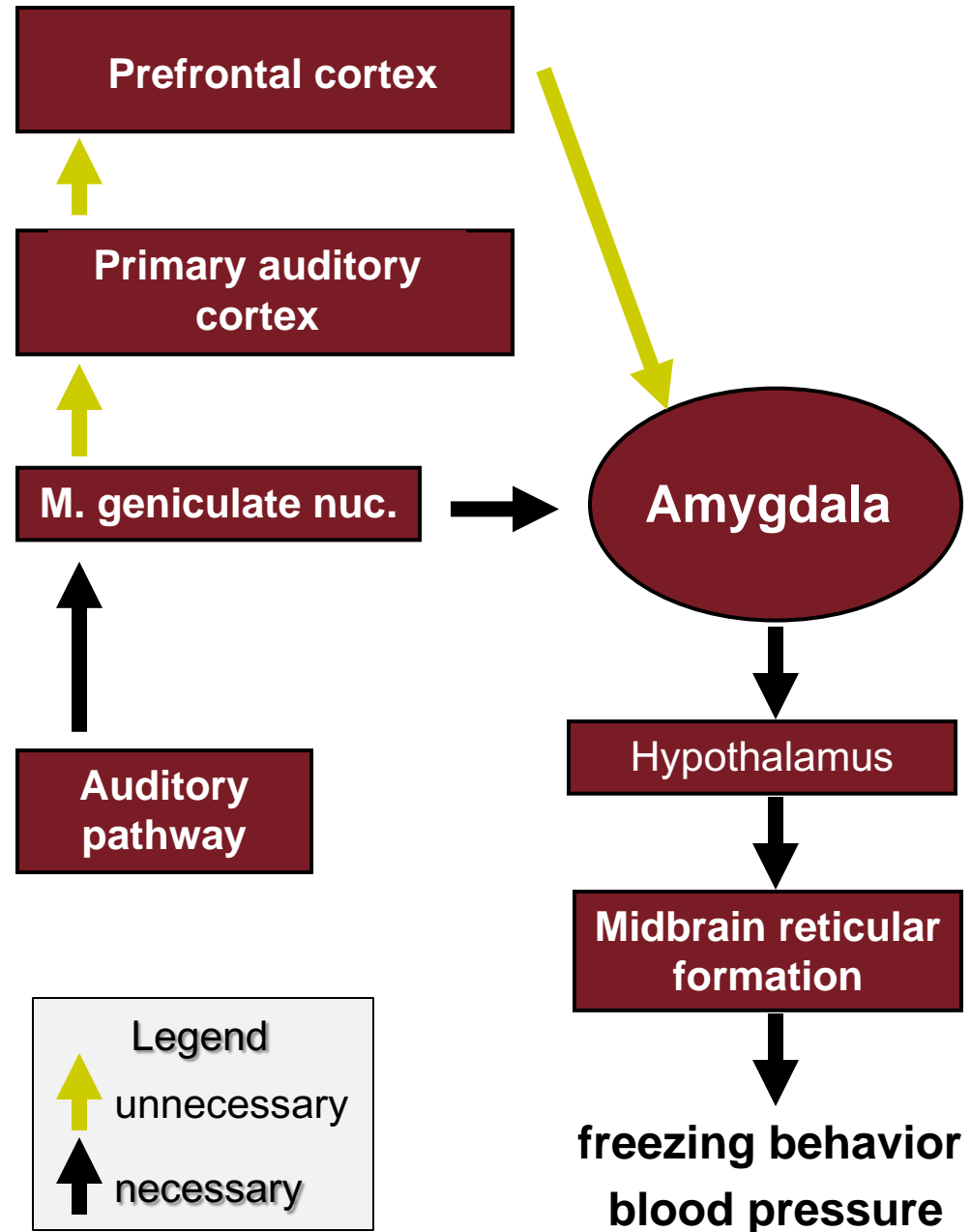
**I have no fear.**

Associate a tone with electric foot shock

Measure **freezing time** and **blood pressure**.



Electric foot shock

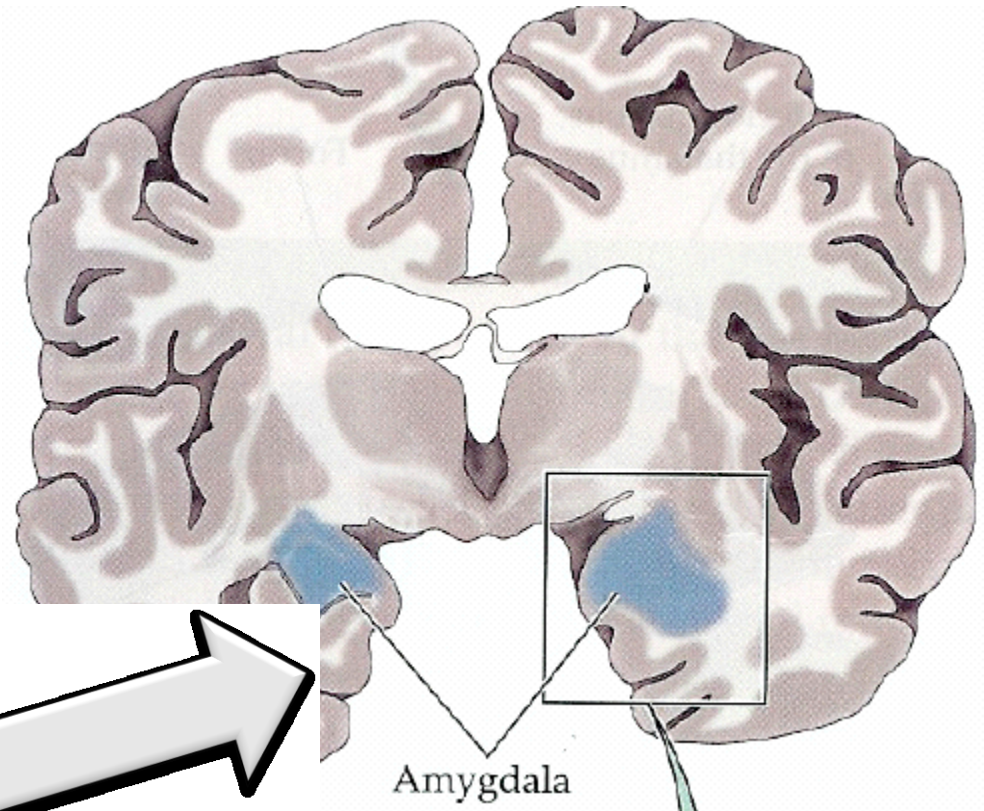


Amygdala is involved in regulating:

- Fear
- Emotions related to fear
- **Memory related to fear**
- Panic
- Anxiety

The bilateral damage to Amygdala results in inability to recognize the emotion of fear in the facial expressions of other people.

**Urbach-Wiethe** disease, bilateral calcification and atrophy of the anterior-medial temporal lobes.



**Fear conditioning – LTP - NMDA**

SM (woman, age 44) is the most studied patient with Urbach-Wiethe disease. She performs within the normal range on standardized tests of

1. IQ,
2. Memory,
3. Language, and
4. Perception

SM is impaired in recognizing fear in facial expressions and, and in some aspects of social behavior thought to be mediated by emotions related to fear.

None of the previous studies specifically assessed the induction and experience of fear in patient SM. The new study addresses **INDUCTION** of FEAR in SM.

Curr Biol. 2010 Dec 16. [Epub ahead of print]

**The Human Amygdala and the Induction and Experience of Fear.**

Feinstein JS, Adolphs R, Damasio A, Tranel D.

University of Iowa, Iowa City, IA 52242, USA.

Feinstein JS, Adolphs R, Damasio A, Tranel

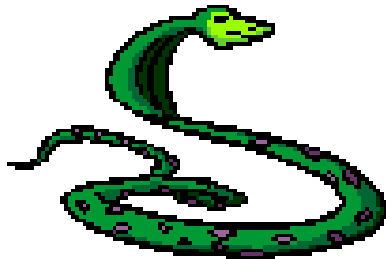
D. University of Iowa, Iowa City, IA 52242, USA. CurrBiol. 2010

Iowa Group conducted a new study in a rare human patient, SM, who has focal bilateral amygdala lesions (Urbach-Wiethe disease).

spider



Haunted house

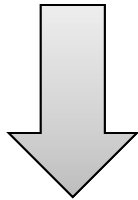
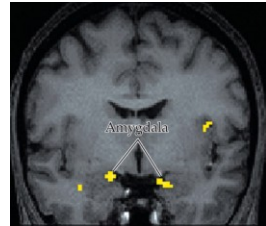


To provoke fear in SM, doctors exposed her to live snakes and spiders, took her on a tour of a haunted house, and showed her emotionally evocative films.

On no occasion did SM exhibit fear, and she never endorsed feeling more than minimal levels of fear.

Correlation between blood flow in the amygdala and the clinical severity of depression.

Increased blood flow  
in amygdaloid  
complex

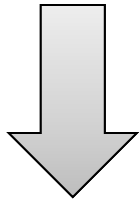


Patients report  
increased anxiety or  
anxiety attack



Speculation

Combat Induced  
Increase in the  
activity in the  
amygdaloid complex



Patients report  
increased anxiety or  
anxiety attack or post-  
traumatic stress  
disorder **PTSD**

Based on the analogy with loss of fear response caused by a **decrease** in the activity of the amygdaloid complex (Urbach-Wiethe disease), it is reasonable to **speculate** that a pathological **increase** in the activity (irritability) of amygdala complex is causing PTSD.



The National Institute of Mental Health estimates that over 7.7 million individuals are affected with PTSD in the USA. It has been predicted that approximately 300,000 military personnel would return from combat in Iraq/Afghanistan with PTSD.

Mental disorder characterized by dramatic changes of mood (Affect)



Affective disorders:

- Autism
- ADHD
- Bulimia nervosa
- Anorexia nervosa
- Social phobia

A large number of drugs that influence monoaminergic neurotransmission can alleviate depression.

MAOI  
TCA  
**SSRI**  
SNRI

What is the link between the PFC and monoaminergic neurotransmission? ★

The most severe affective disorders:

- General Anxiety Disorder
- Major Depression
- Manic Depressive Disord.

# Monoaminergic Modulation of Brain Function

## Physiology / Disease

**Sadness (Clinical Depression)**  
**Happiness (Mania)**  
**Arousal (Lethargy)**  
**Stress (PTSD)**  
**Panic (Panic Disorder)**  
**Anxiety (Depression)**

## 3 Levels of Emotional Processing

Cortical

sadness

Subcortical

fear, aggression

Brain Stem

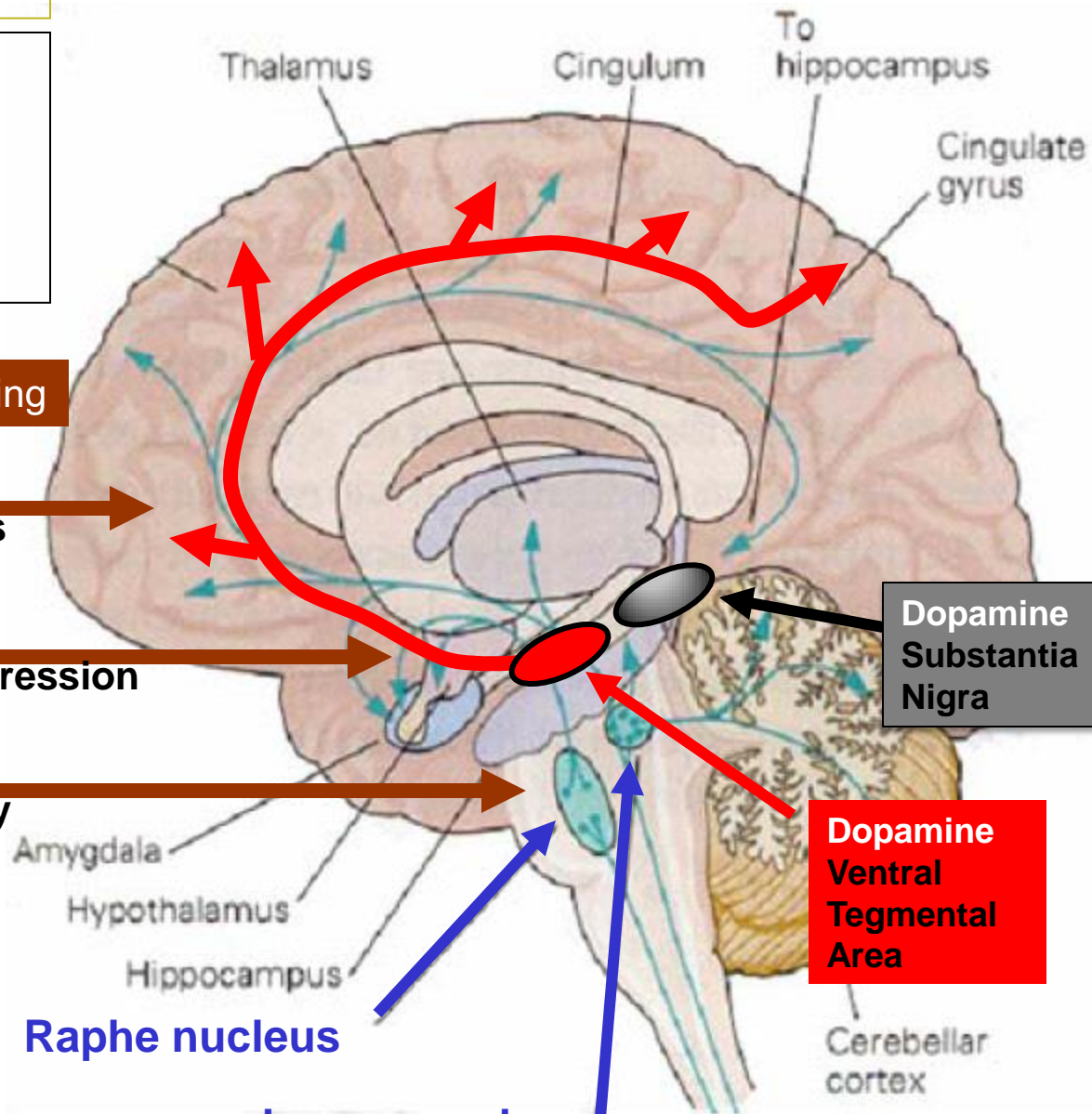
irritability

serotonin

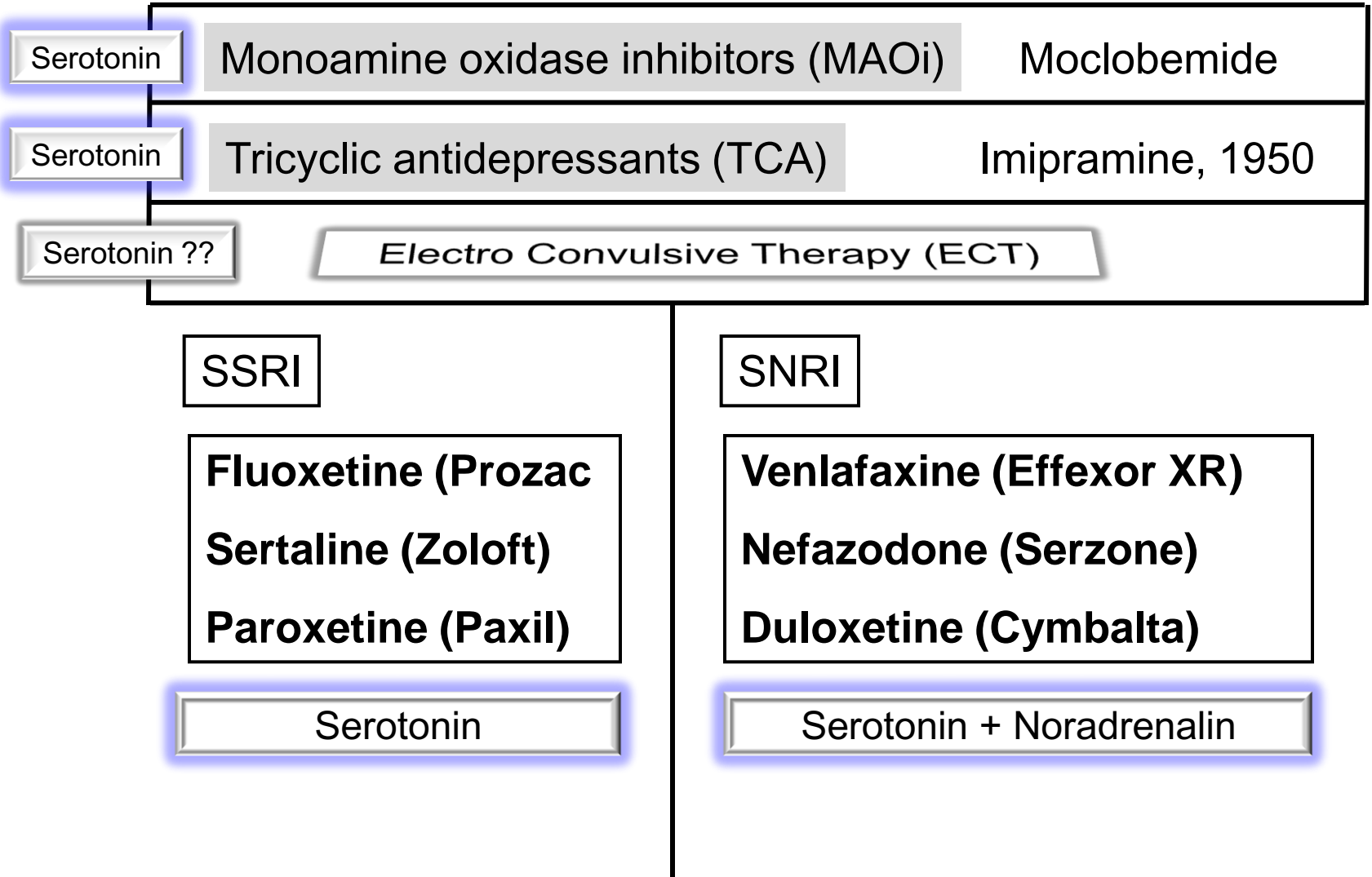
Raphe nucleus

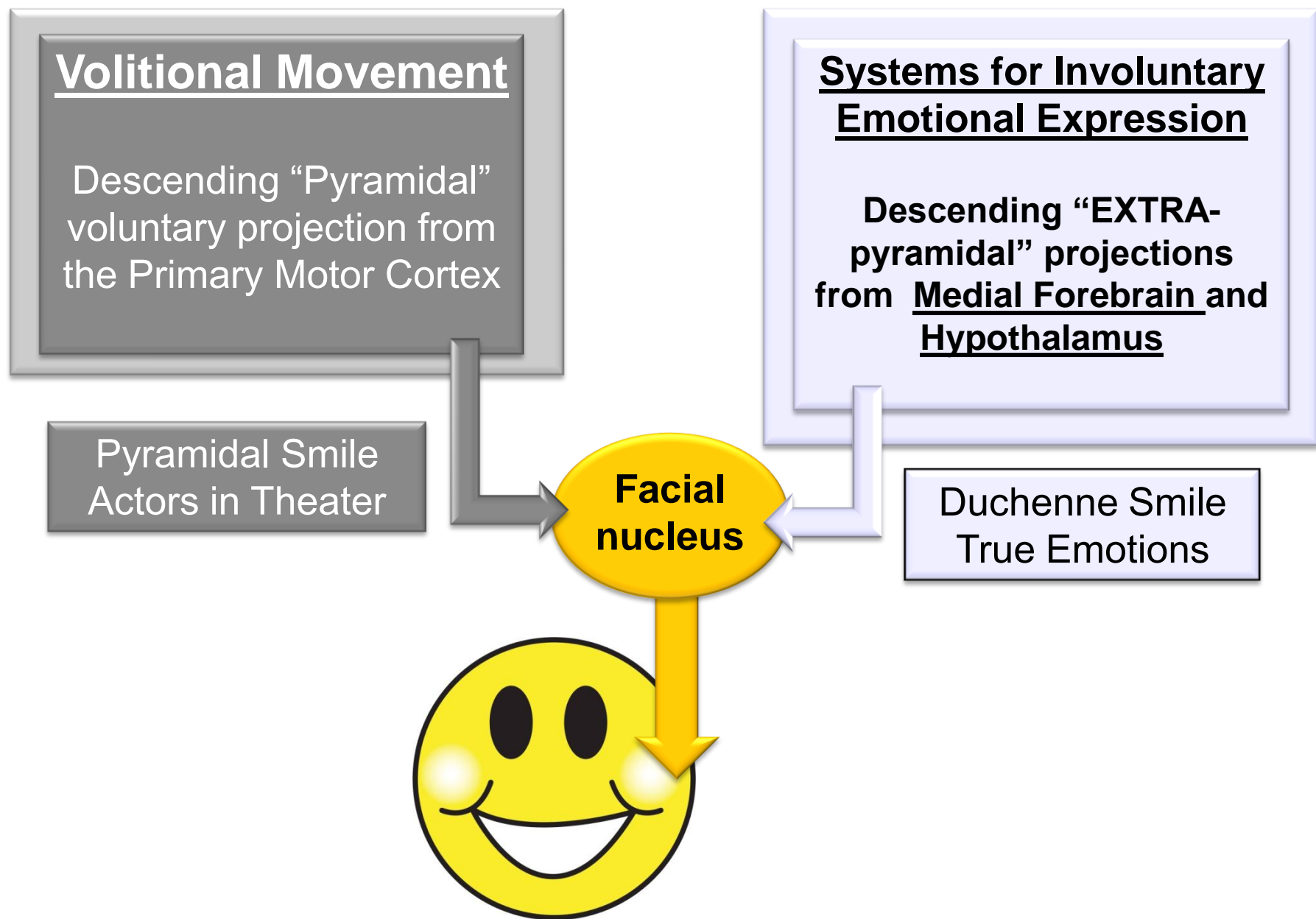
norepinephrine

Locus ceruleus



# Antidepressants – Dominance of Serotonin





**Volitional Movement**

Descending "Pyramidal" voluntary projection from the Primary Motor Cortex

Pyramidal Smile Actors in Theater

**Facial nucleus**

**Systems for Involuntary Emotional Expression**

Descending "EXTRA-pyramidal" projections from Medial Forebrain and Hypothalamus

Duchenne Smile True Emotions

