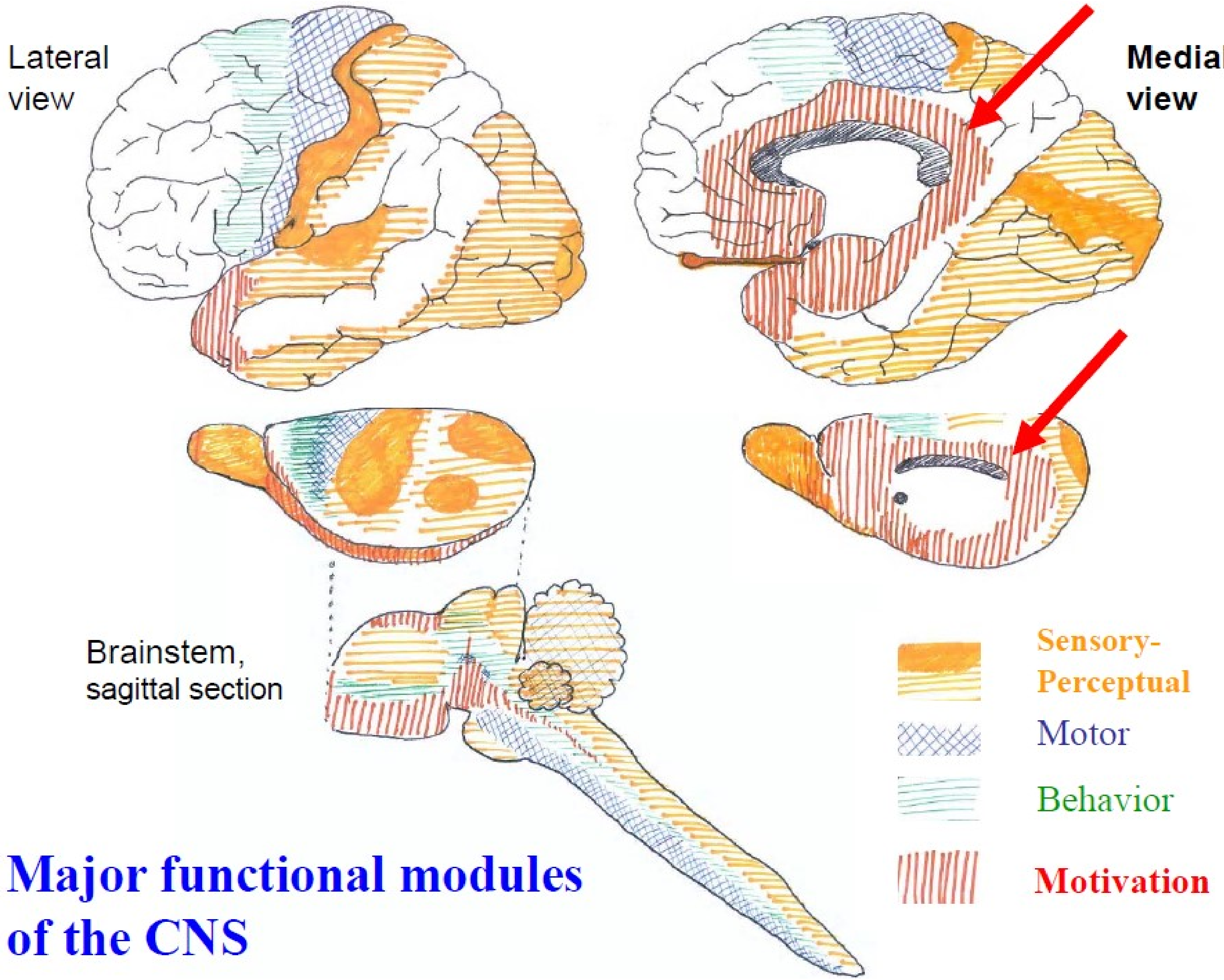
14

Limbic system

Limbic system

Limbus = border



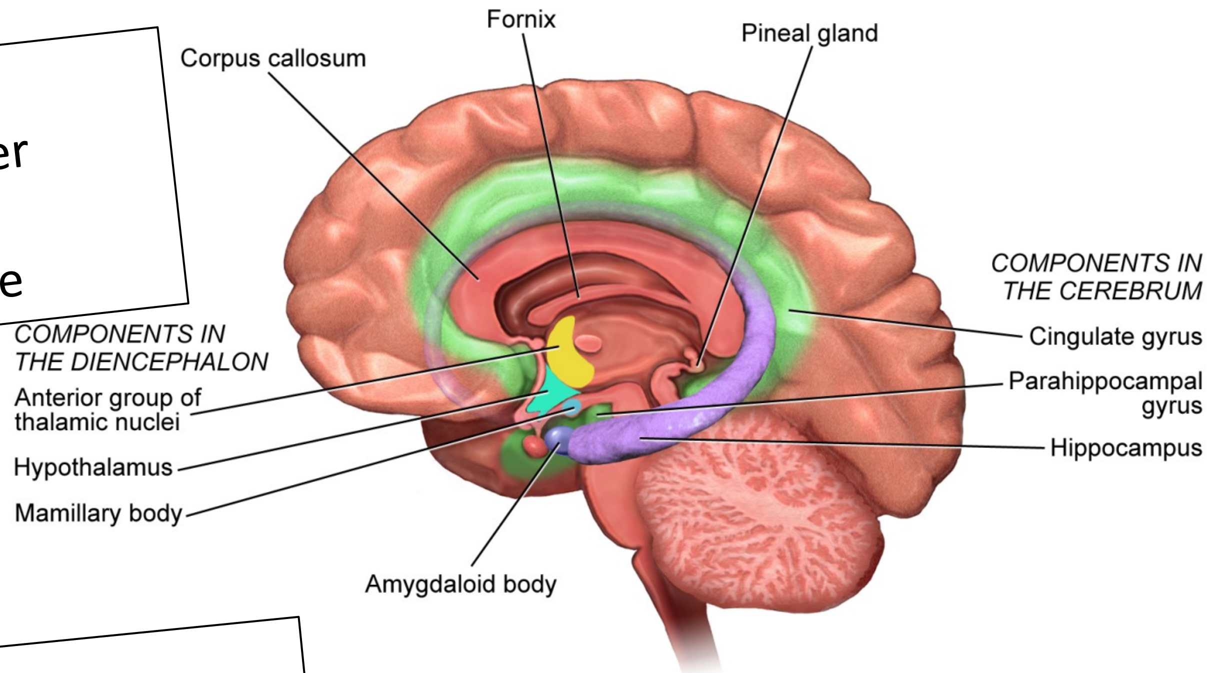
Concept of the limbic system

- Voluntary

Somatic nervous system
Inputs – mainly from outer environment
Control – skeletal muscle

- Automatic

Autonomic nervus system
Inputs – mainly inner environment
Control – smooth/cardiac m., glands



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Concept of the limbic system

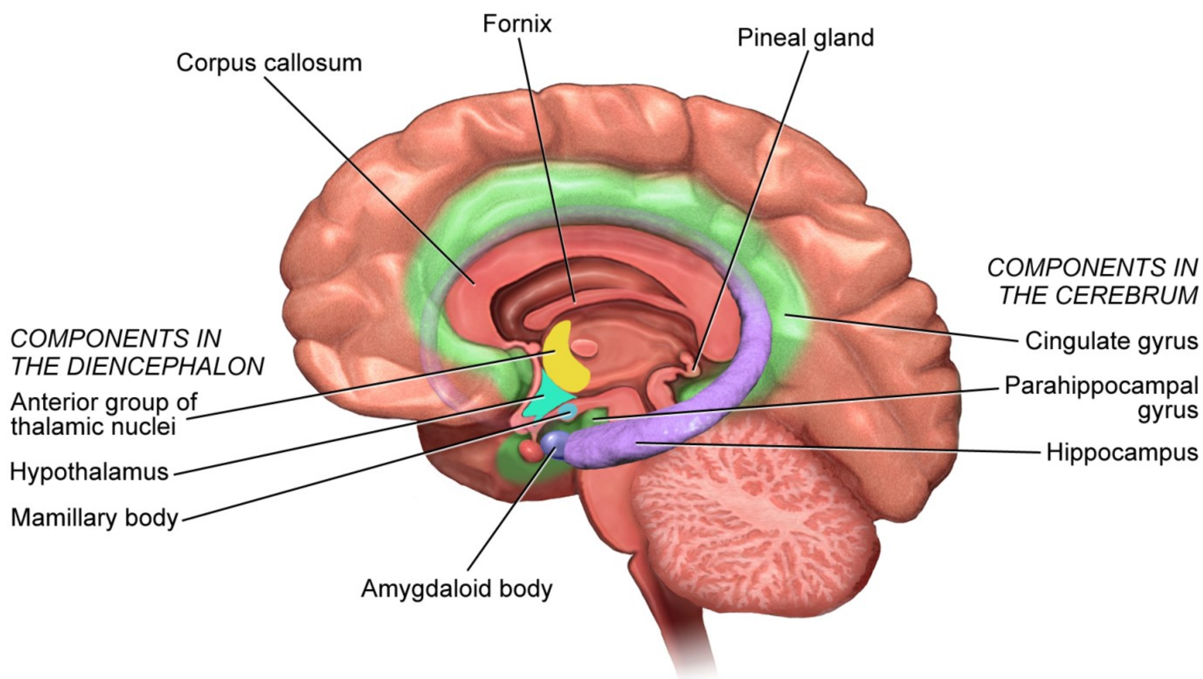
- Voluntary

↑ Modulation

Limbic system

↓ Control

- Automatic



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Concept of the limbic system

- Voluntary

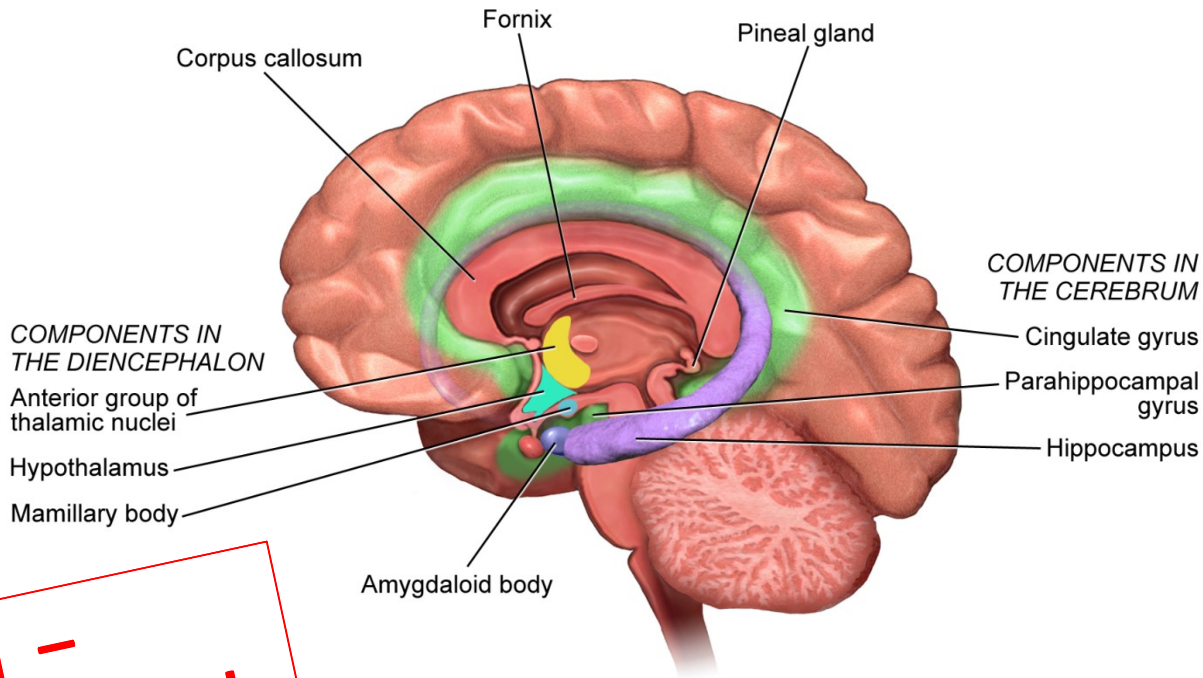
↑ Modulation

Limbic system

↓ Control

- Automatic

Limbic system – hypothalamus and related structures



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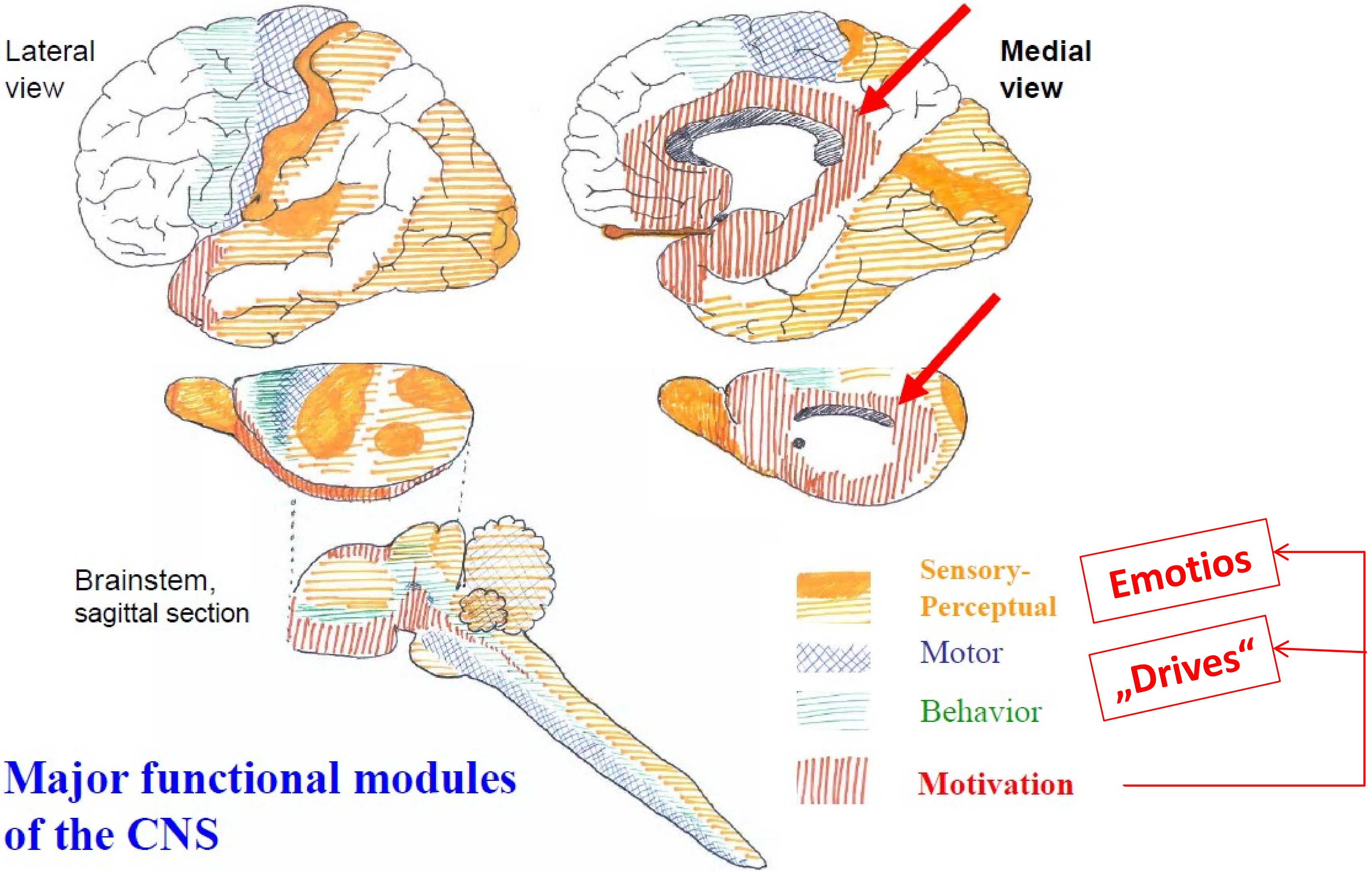
Limbický systém



Gerald Schneider. *9.14 Brain Structure and Its Origins, Spring 2014*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed). License:Creative Commons BY-NC-SA

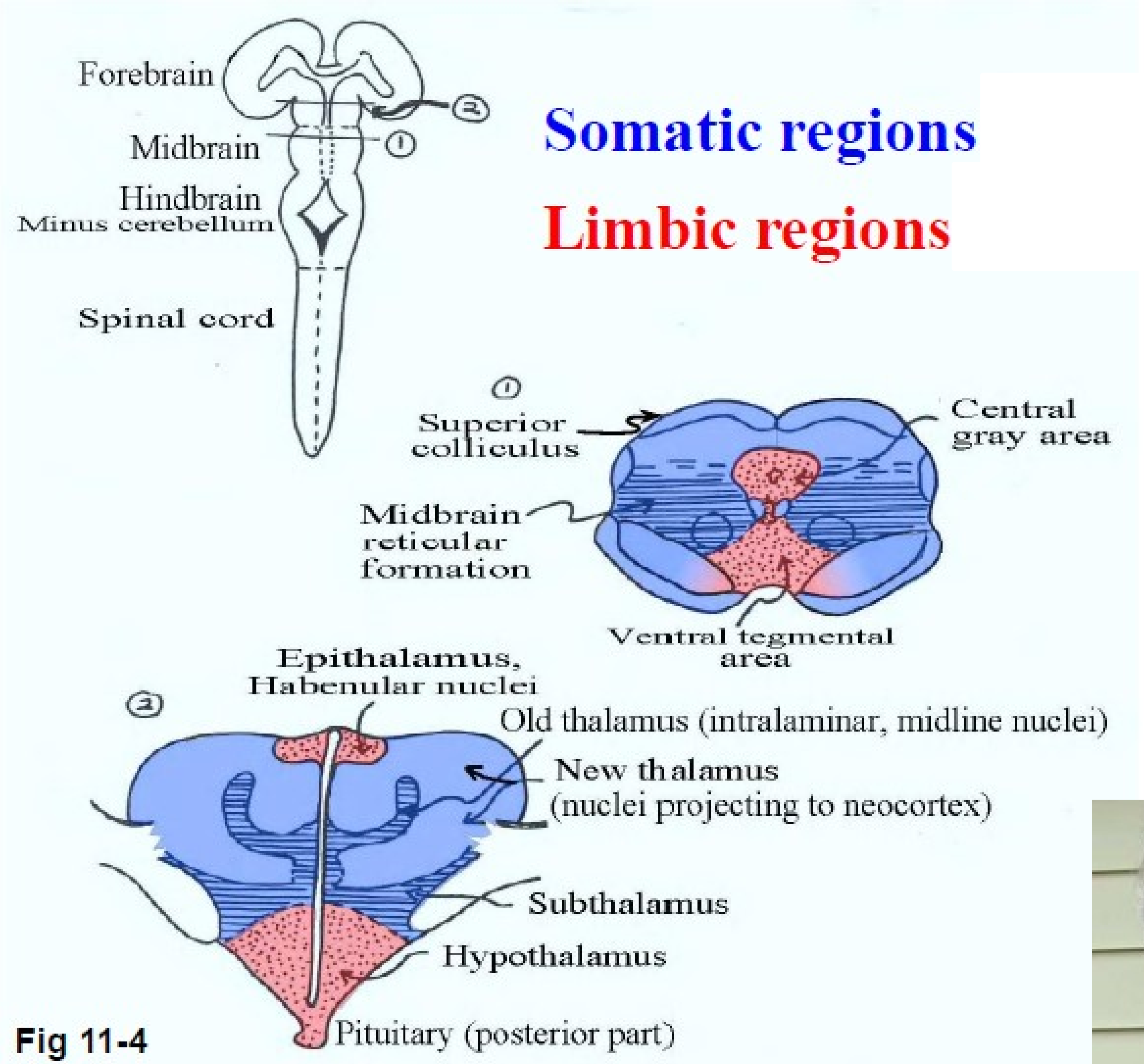


Fig 11-4

31

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Somatic regions: arousal type 1

Limbic regions: arousal type 2

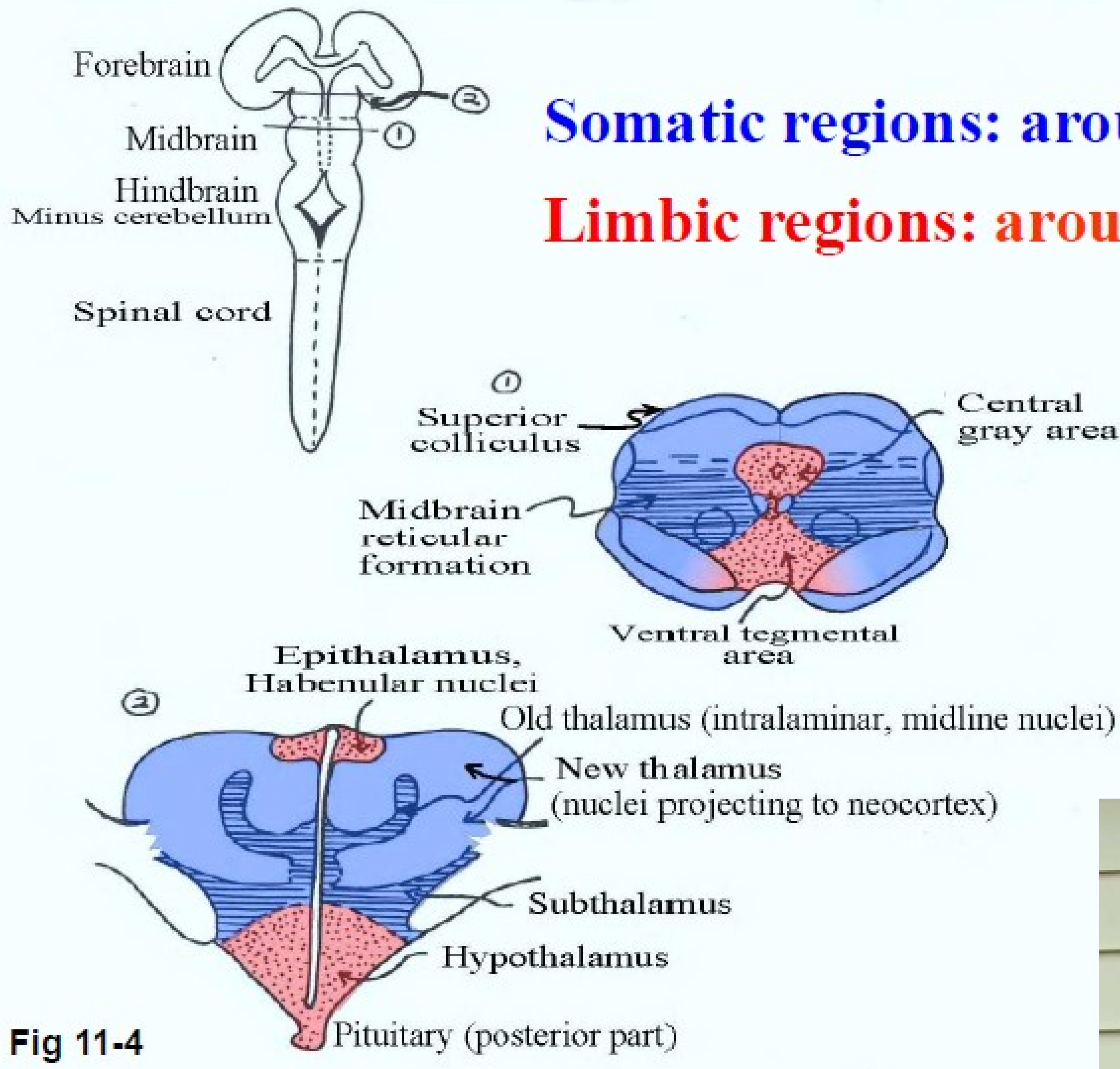

Fig 11-4

31

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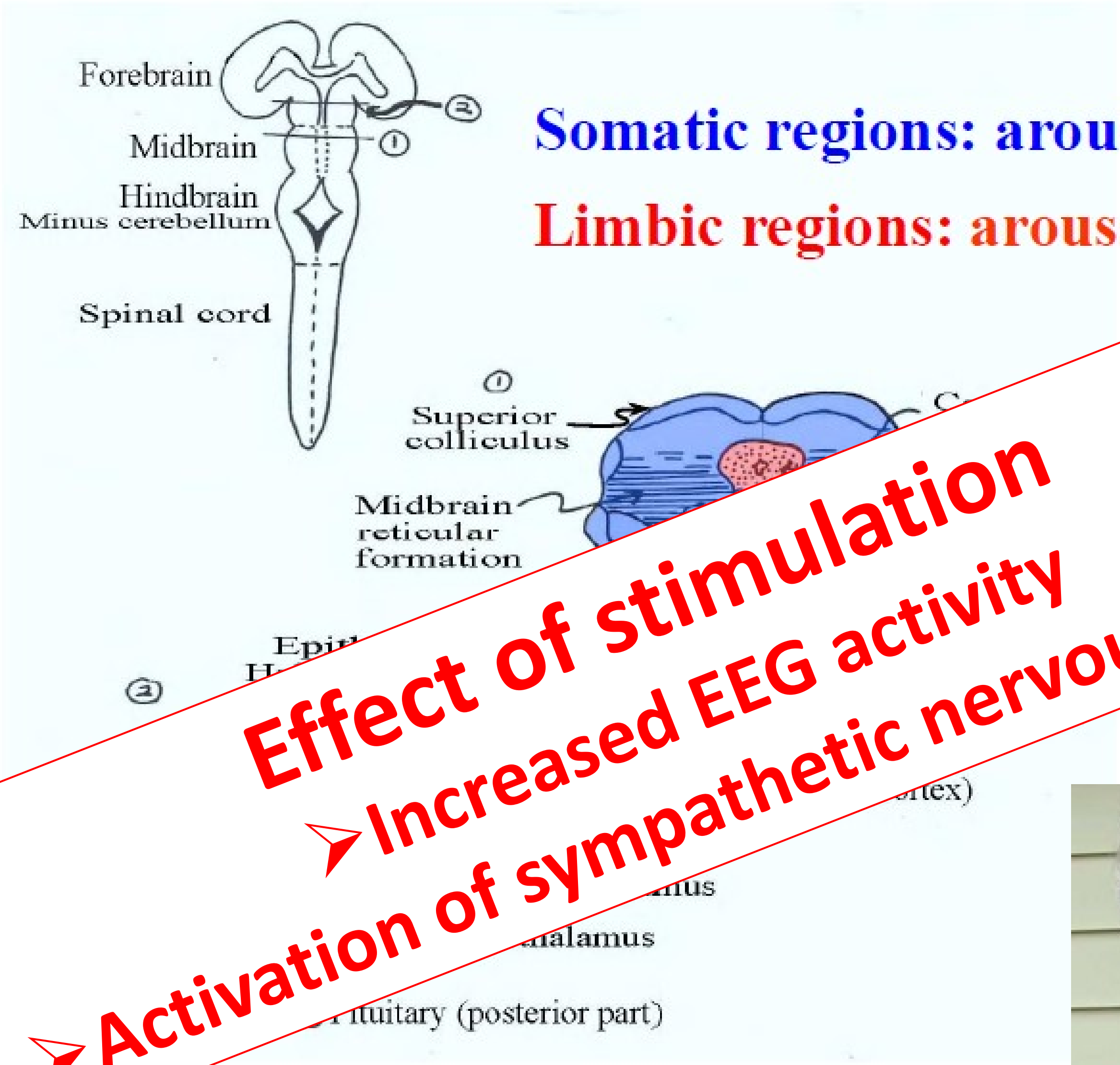

Courtesy of MIT Press. Used with permission.
Schneider, G. E. Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind. *MIT Press*, 2014. ISBN: 9780262026734.

Somatic regions: arousal type 1

Limbic regions: arousal type 2

Effect of stimulation
- Increased EEG activity
- Activation of sympathetic nervous system

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Arousal type 1 (somatic)

ARAS (ascendent retikulation activation system)

- Effect of stimulation
  - Habituation
  - Minimal ctivation of „reward/punishing“ system

Arousal type 2 (limbic)

- Effect of stimulation
  - Minimal habituation
  - Strong activation of „reward/ punishing“ system
    - Central gray area –CGA - negative
    - Ventral tegmental area – VTA – positive

Arousal type 1 (somatic)

ARAS (ascendent retikulation activation system)

- Effect of stimulation
  - Habituation
  - Minimal ctivation of „reward/punishing“ system
- Ascendent connections
  - Somatosensetivity, visual s., auditory s., vestibular s., cerebellum
- Descendent connections
  - Neocortex, corpus striatum, thalamus

Arousal type 2 (limbic)

- Effect of stimulation
  - Minimal habituation
  - Strong activation of „reward/ punishing“ system
    - Central gray area –CGA - negative
    - Ventral tegmental area – VTA – positive
- Ascendent connections
  - Mainly viscerosenzitivity, pain
- Descendent connections
  - Hypothalamus and other limbic areas, amygdala

Arousal type 1 (somatic)

ARAS (ascendent retikulation activation system)

- Effect of stimulation
  - Habituation
  - Mi...
- Ascendent co...
- ...pus striatum,
- ...alamus

Arousal type 2 (limbic)

- Eff...
  - ...
  - ...gray area –CGA - negative
  - Ventral tegme...
- Descendent connections
  - Hypothalamus and other limbic areas, amygdala

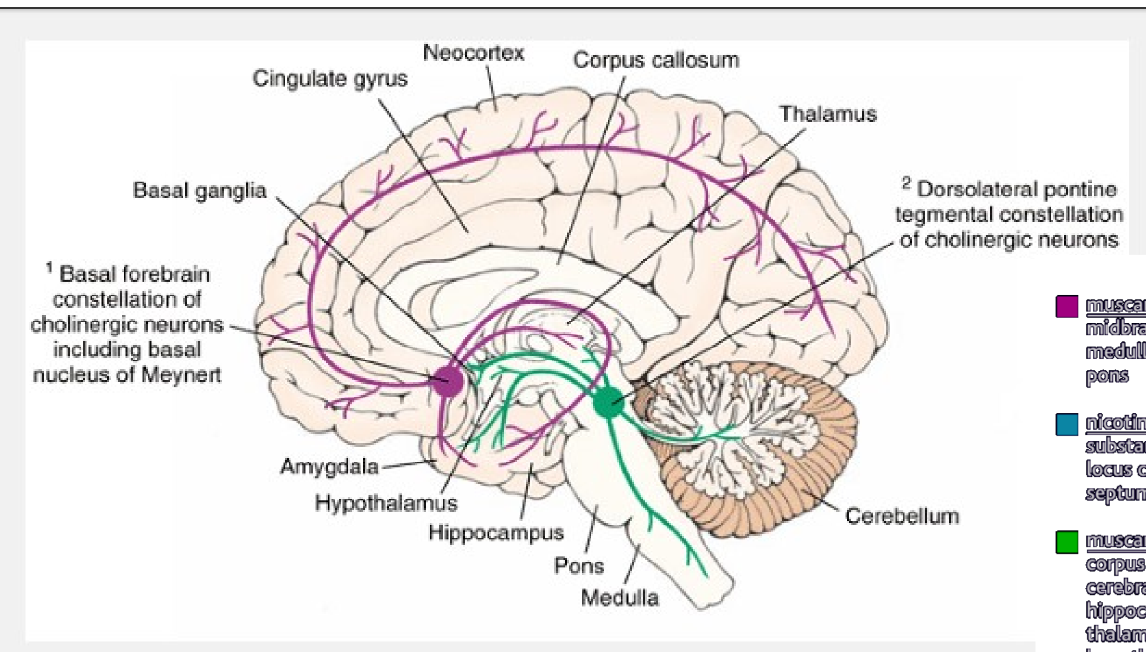
Effect of stimulation

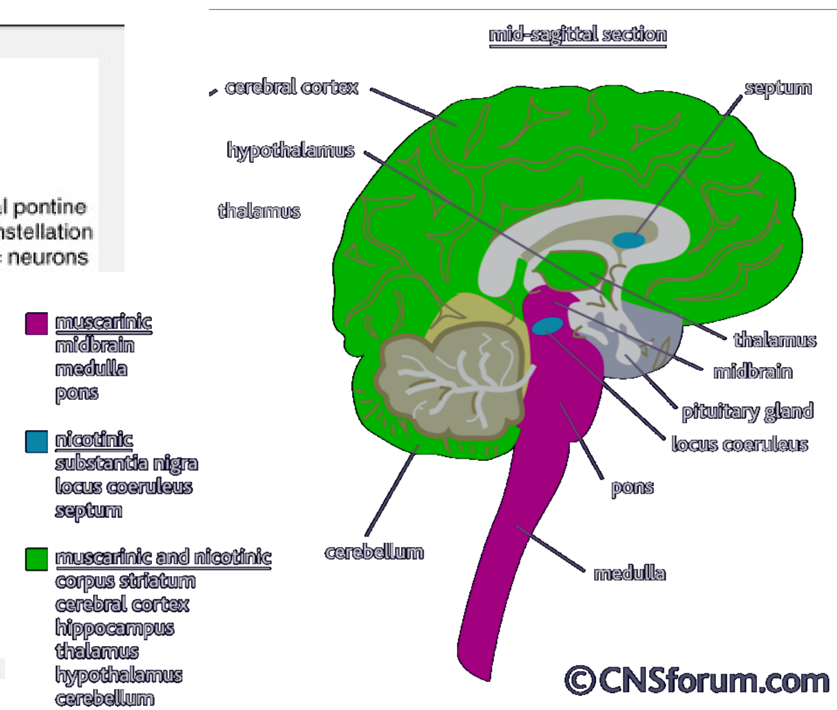
- ➢ **Increased EEG activity**
- ➢ **Activation of sympathetic nervous system**

Cooperation of both systems is a key to maintaining consciousness (through neuromodulation)

Acetylcholine

- Nucleus basalis (Meynerti) abd other nuclei
- Nicotin receptors
- Muscarin receptors
- Sleep/wake regulation
- Cognitive functions
- Behavior
- Emotions



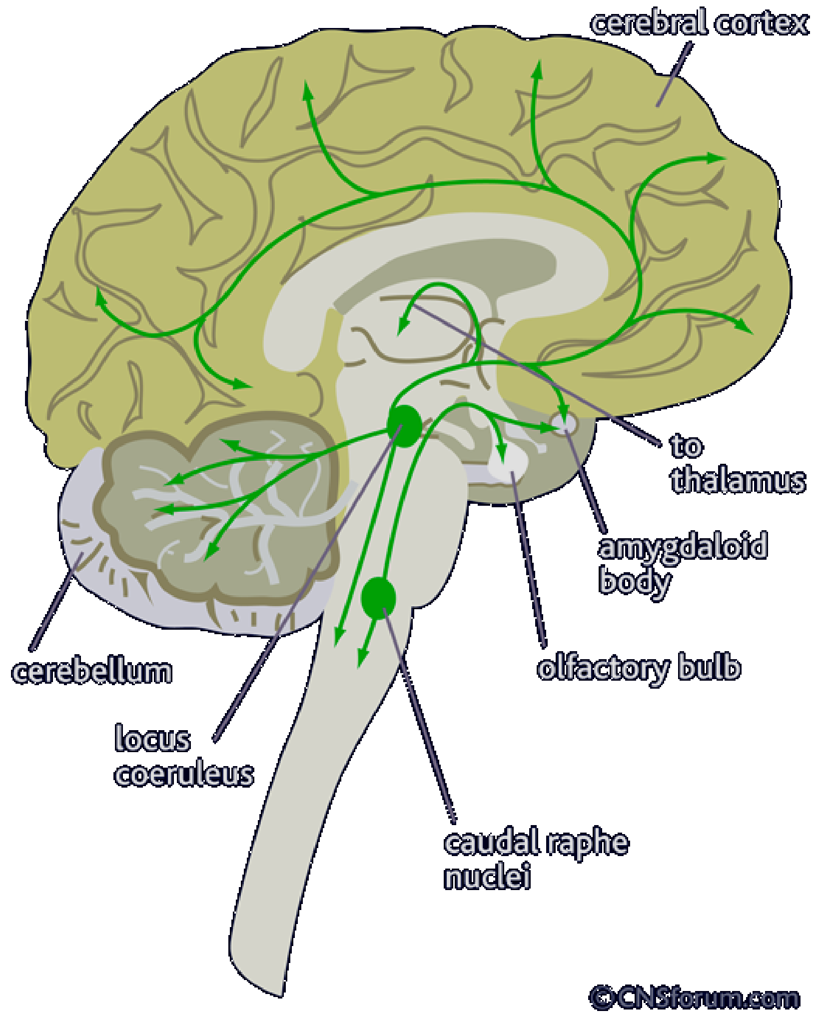


http://www.slideshare.net/drpsdeb/presentations

Norepinephrine

- Locus coeruleus
- Nuclei raphe caudalis

- Vigilance
- Responsiveness to unexpected stimuli
- Memory
- Learning



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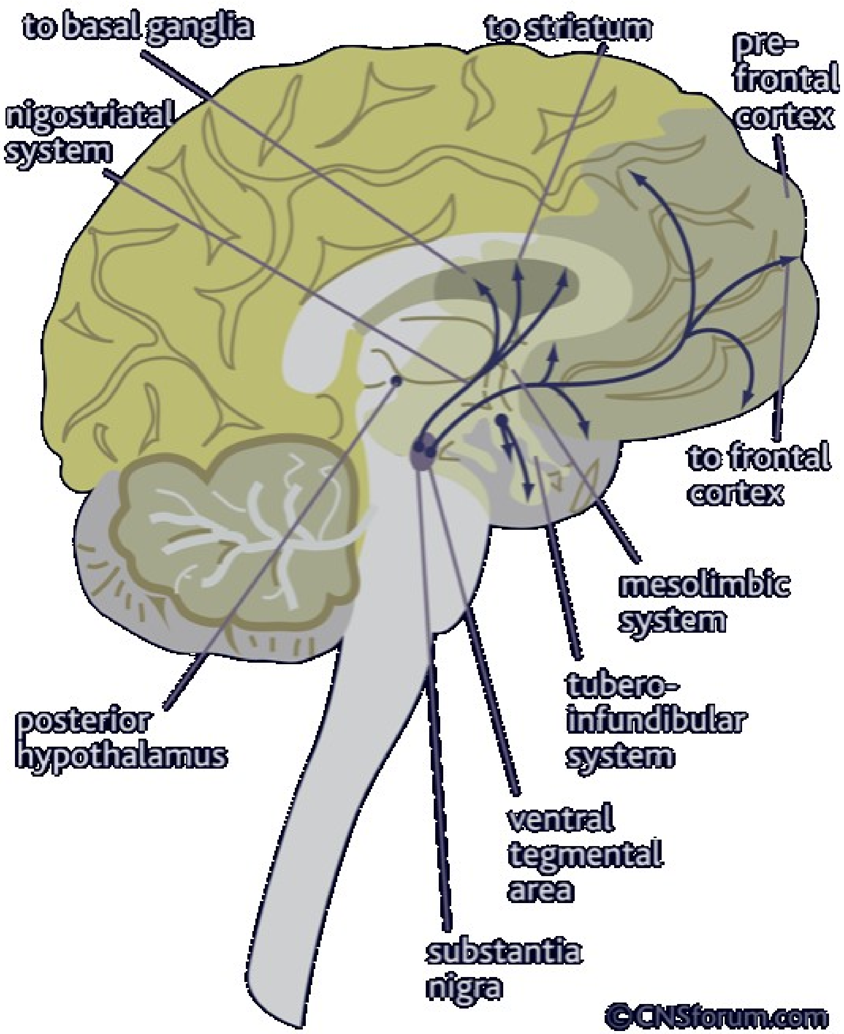
Dopamine

- Nigrostriatal system
  - Movement
  - Sensory stimuli
- Ventrotegmentno-mesolimbic-frontal system
  - Reward
  - Cognitive function
  - Emotional behavior
- Tubero-infundibular system
  - Hypotalamic-pituatory regulation
- D1 receptors – excitatory
- D2 receptors - inhibitory



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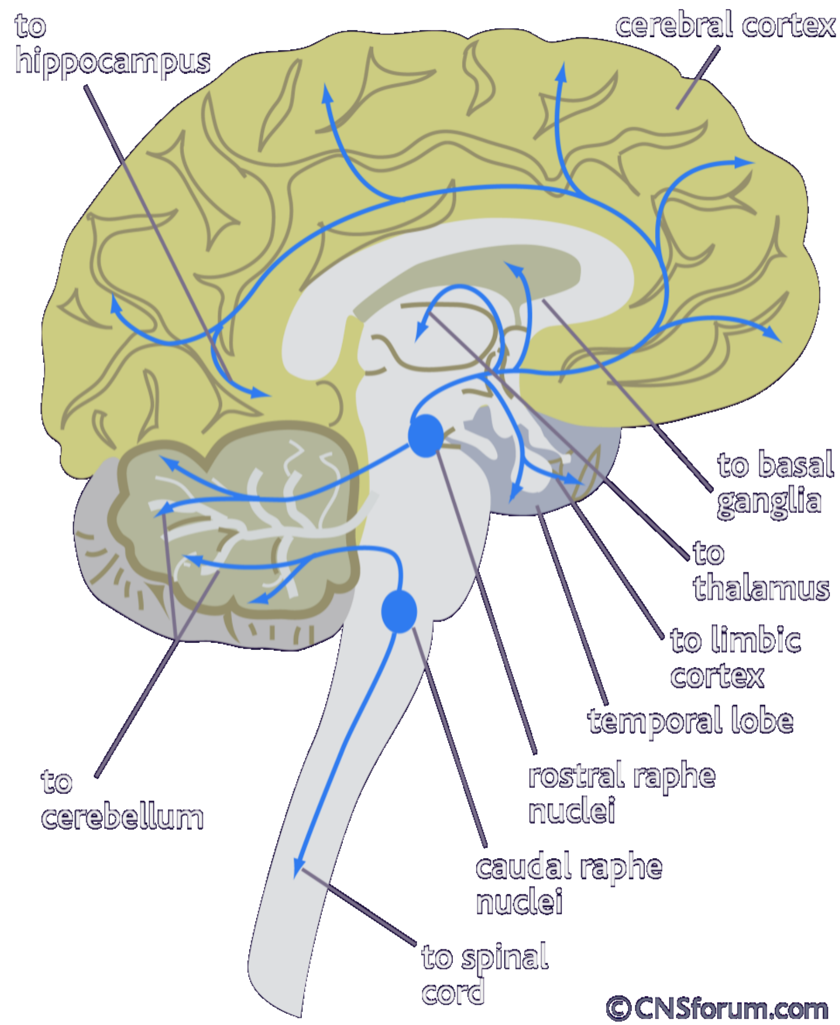
Serotonin

- Nuclei raphe rostralis
- Nuclei raphe caudalis

- Anxiety
- Impulsive behavior



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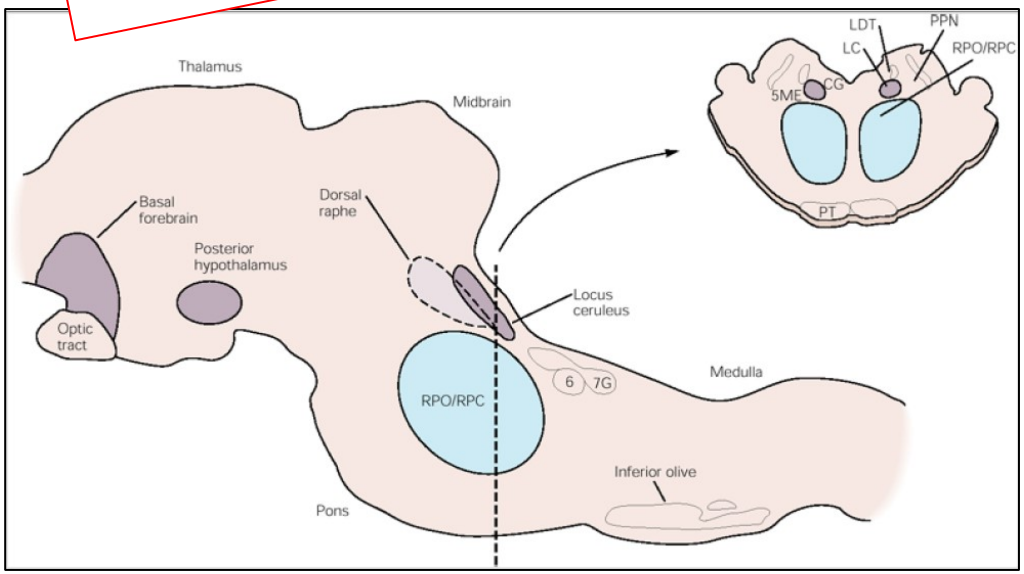
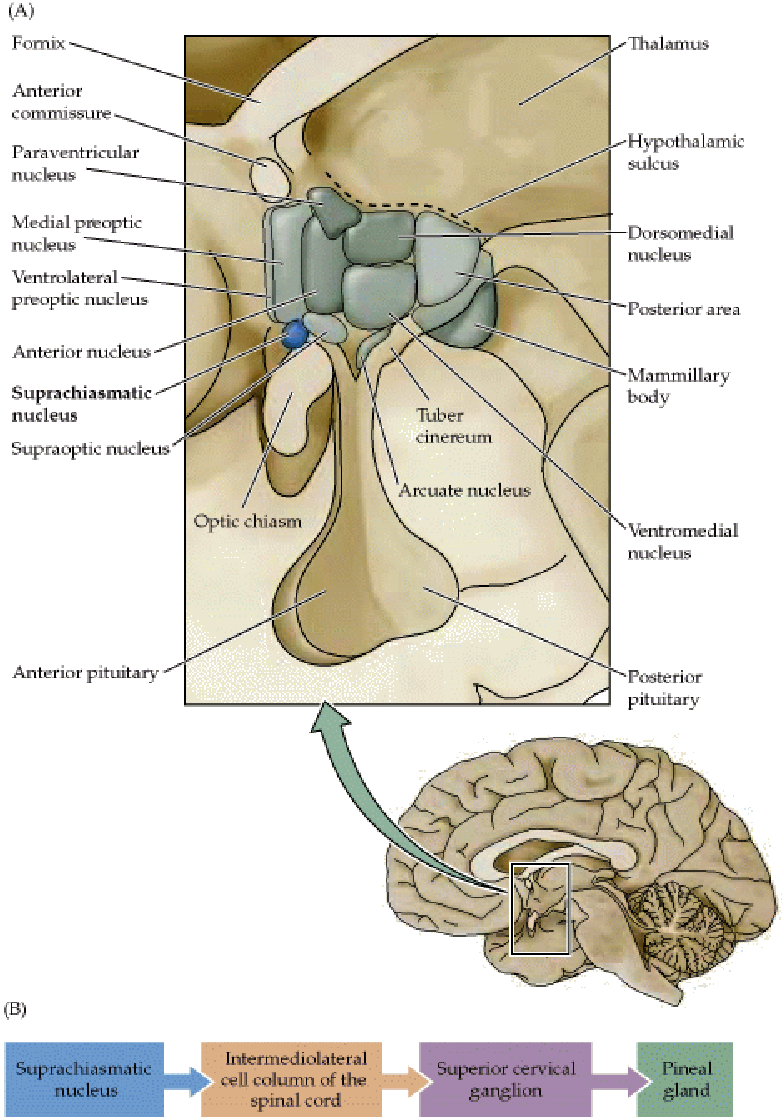
Sleep and wakefulness

Cooperation of ARAS and limbic activating system



RPO/RPC – nucleus reticularis pontis oralis/caudalis



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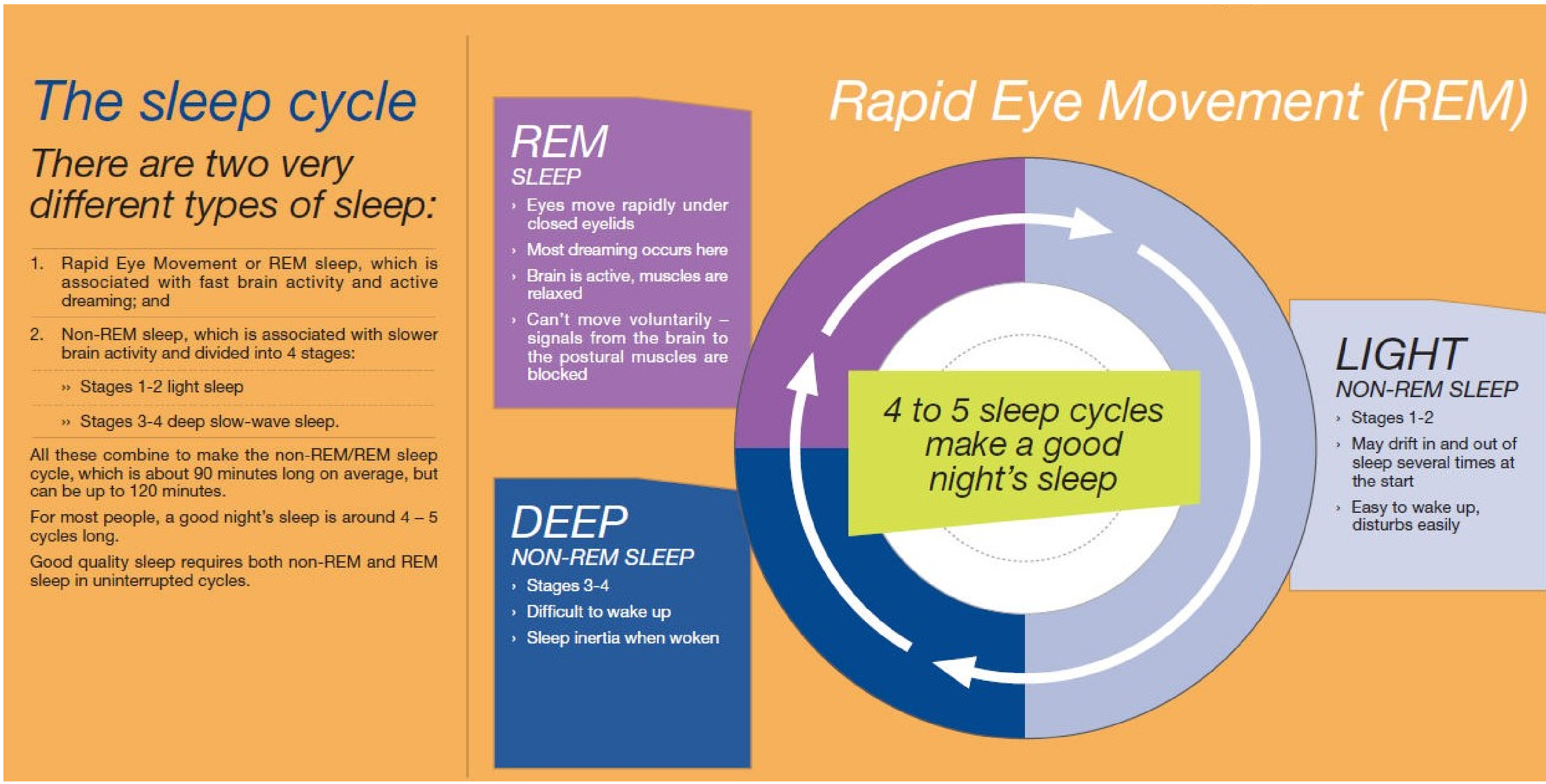
Sleep



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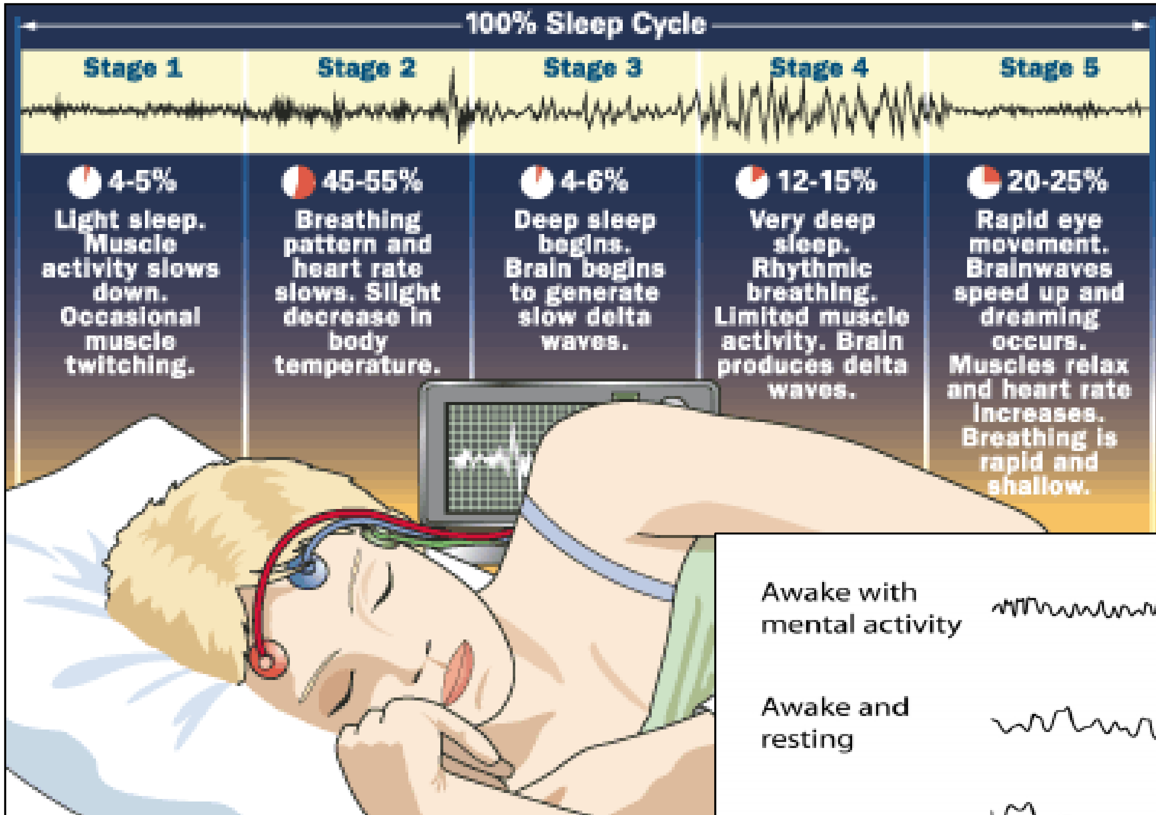
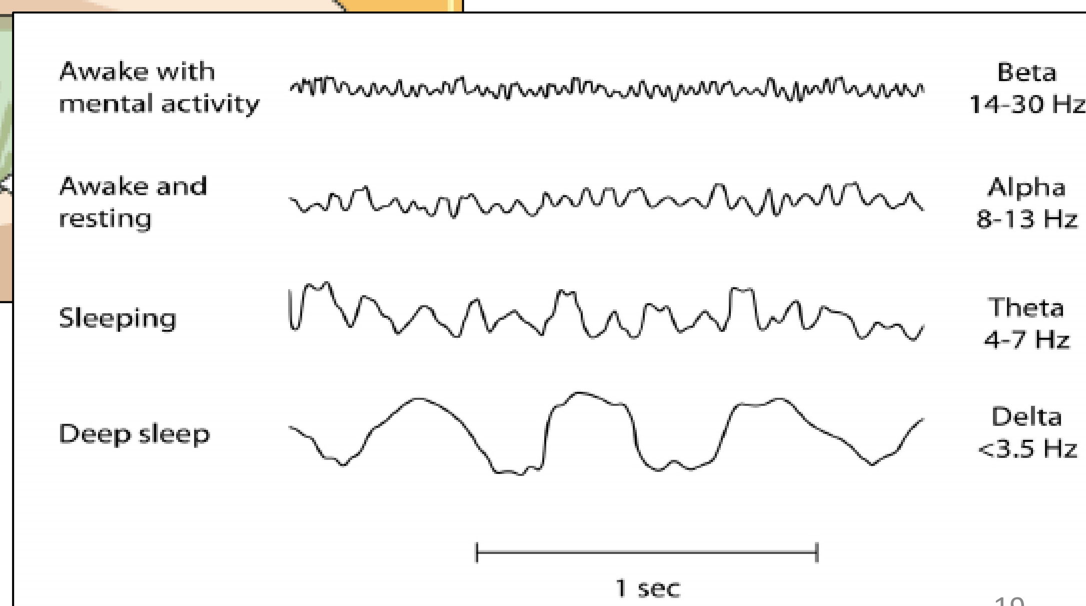
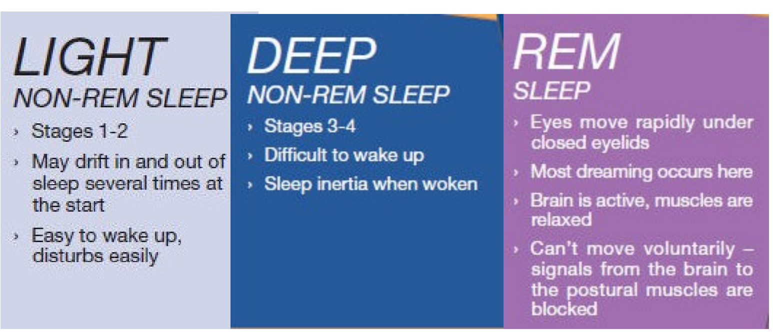
Sleep



http://www.slideshare.net/drpsdeb/presentations

http://www.dailymail.co.uk/sciencetech/article-3042230/Sleeping-habits-world-revealed-wakes-grumpy-China-best-quality-shut-eye-South-Africa-wakes-earliest.html





https://www.researchgate.net/profile/Priyanka_Abhang3/publication/281801676/figure/fig4/AS:305025248186371@1449735094401/Fig-4-EEG-waves-for-different-signals.png

Sleep and wakefulness

Brainstem nuclei responsible	Neurotransmitter	Activity state
WAKEFULNESS		
Cholinergic nuclei of pons-midbrain junction	**Acetylcholine**	**Active**
Locus coeruleus	**Norepinephrine**	**Active**
Raphe nuclei	**Serotonin**	**Active**
NON-REM SLEEP		
Cholinergic nuclei of pons-midbrain junction	**Acetylcholine**	**Decreased**
Locus coeruleus	**Norepinephrine**	**Decreased**
Raphe nuclei	**Serotonin**	**Decreased**
REM SLEEP ON		
Cholinergic nuclei of pons-midbrain junction	**Acetylcholine**	**Active**
Raphe nuclei	**Serotonin**	**Inactive**
REM SLEEP OFF		
Locus coeruleus	**Norepinephrine**	**Active**

Hypothalamus

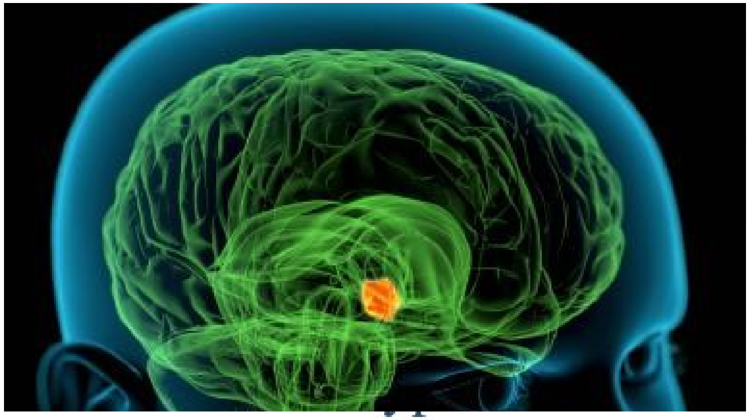
- Key center of autonomic regulations and coordination
- Integration of the information from inner and outer environment

↓

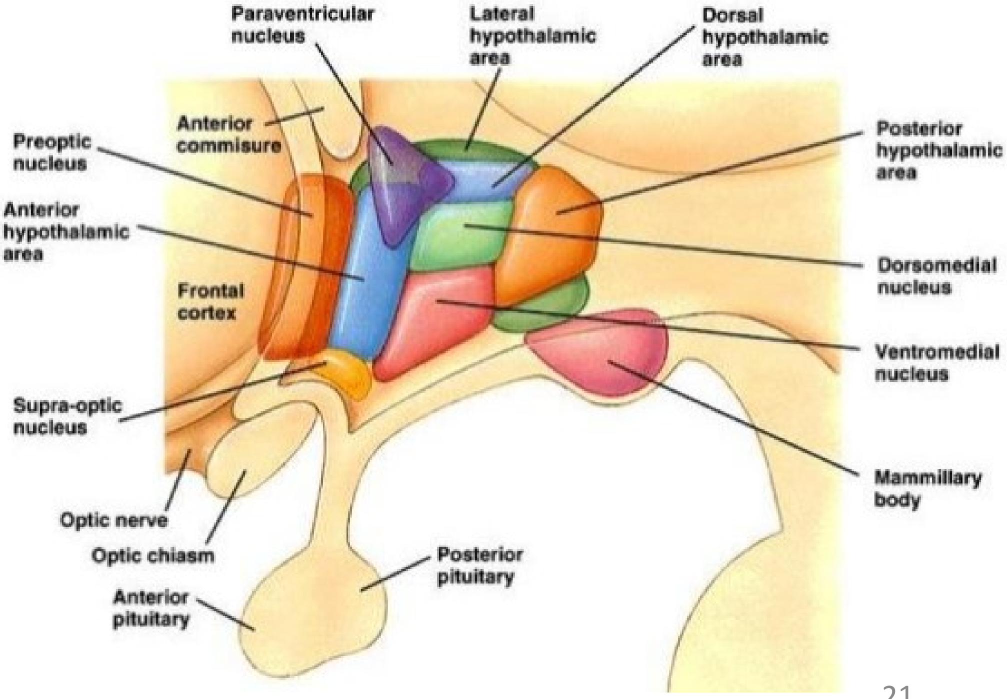
- Behavioral modulation
- Regulation of autonomic nervous system

↓

- **Maintenance of homeostasis**



http://biology.about.com/od/anatomy/p/Hypothalamus.htm



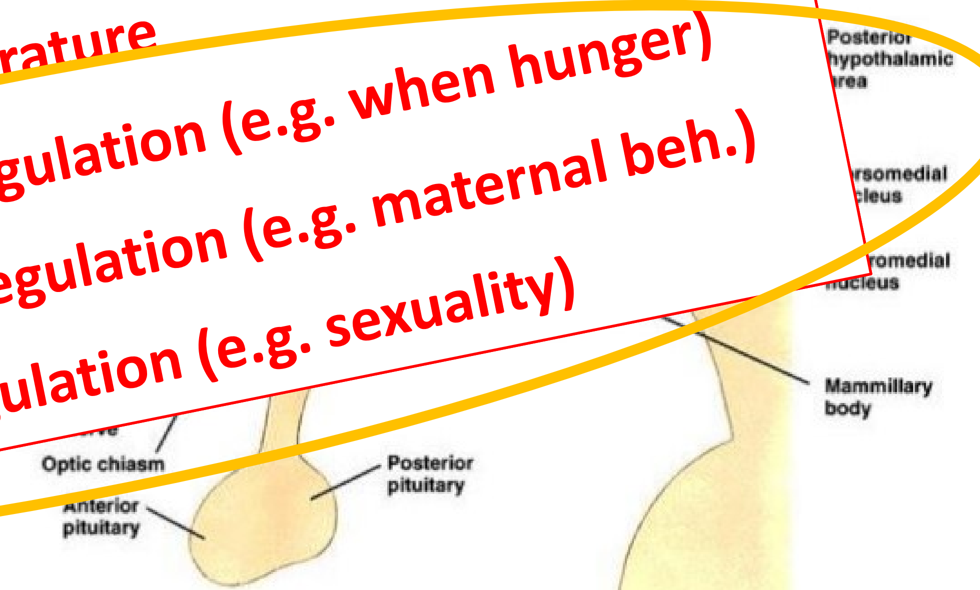
http://www.slideshare.net/physiologymgmcri/hypothalamus-15-apr-2016

Hypothalamus

- Key center of autonomic regulations and coordi
- Integ
  f
  e
- Be
- Reg
  nerv
- **Main**

✓ Biological clock – circadian /seasonal activity
✓ Autonomic nervous system regulation
✓ Endocrine system regulation
✓ Food and water intake regulation
✓ Regulation of body temperature
✓ „Immediate“ behavior regulation (e.g. when hunger)
✓ „Long-term“ behavior regulation (e.g. maternal beh.)
✓ Instinctive behavior regulation (e.g. sexuality)

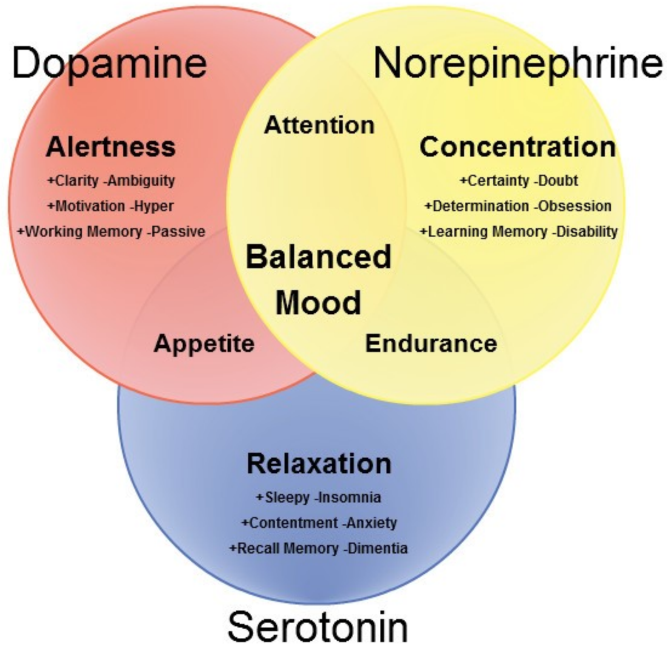
http://biology.about.com/od/anatomy/p/Hypothalamus.htm



http://www.slideshare.net/physiologymgmcri/hypothalamus-15-apr-2016

Influence of hypothalamus on neocortex

- Via neuromodulating systems
  - Consciuosness (sse above)
  - Mood
- Via thalamus
  - Via nucleus mediodorsalis to orbitofrontal cortex (influence on decision making)
  - Influence gating function of pther thalamic nuclei
- Papez circuit

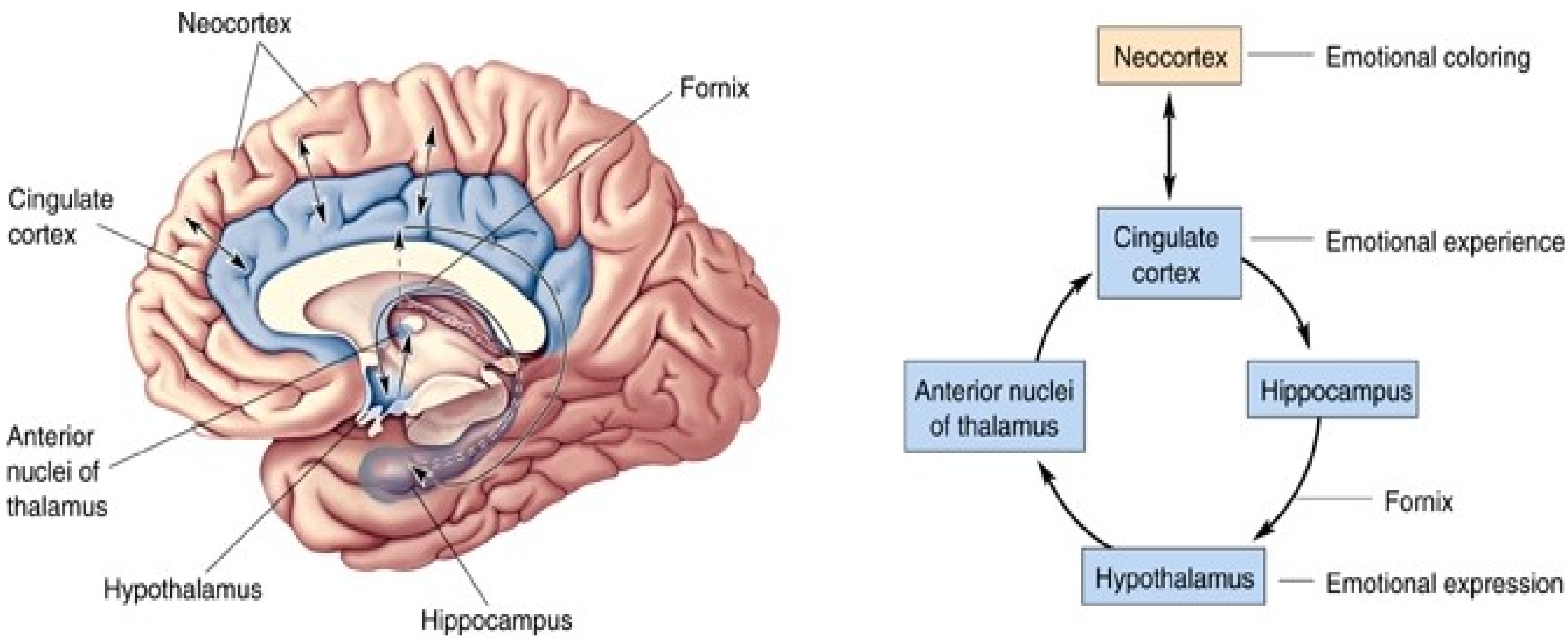


http://ausm.org.uk/wp-content/uploads/2015/02/Dopamine_Norepinephrine_Serotonin.jpg

Orbitofrontal cortex

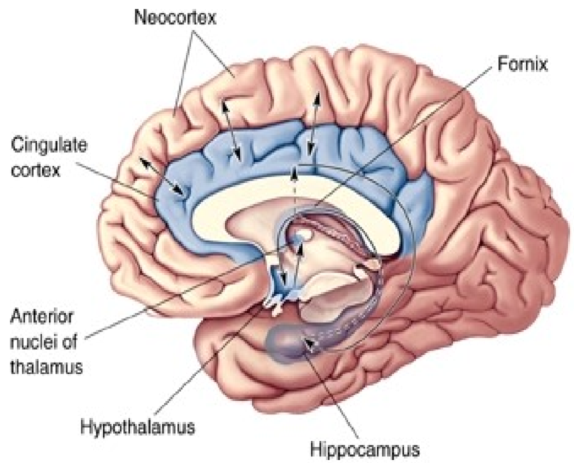
https://en.wikipedia.org/wiki/Orbitofrontal_cortex

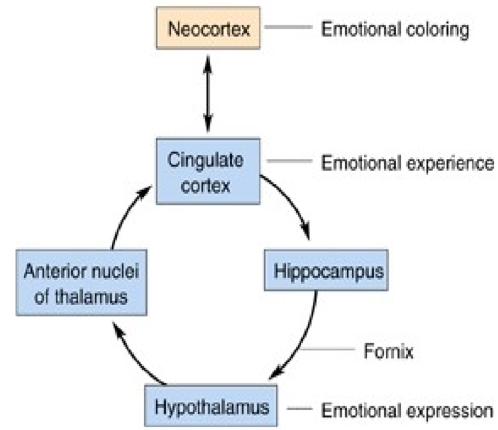
Papez circuit



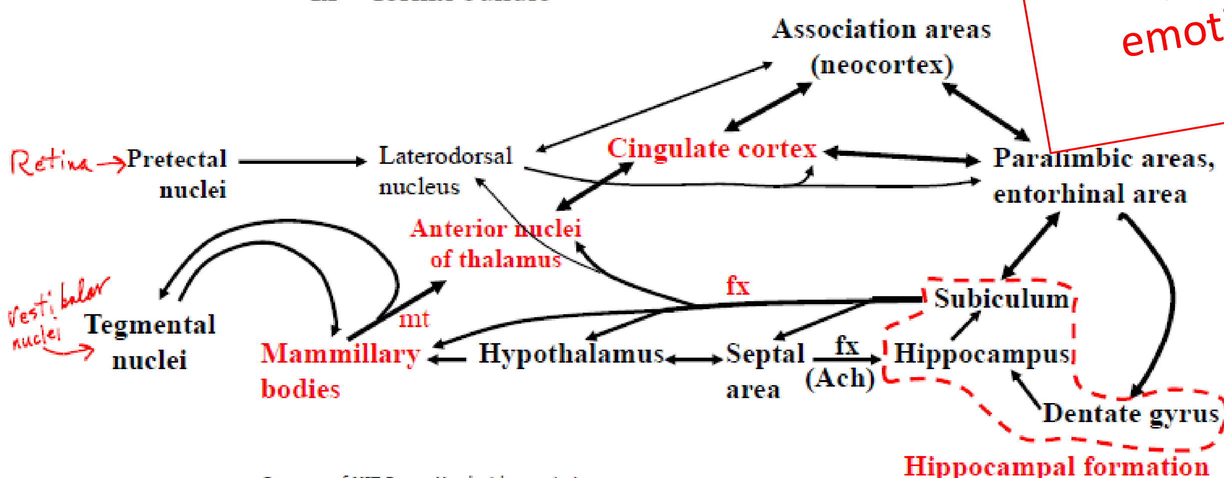
http://www.slideshare.net/drsunilsuthar/neurobiology-of-emotion

Papez circuit

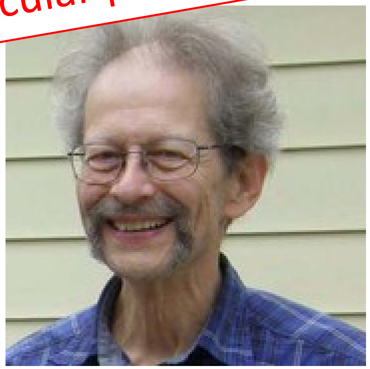




mt = mammillothalamic tract
fx = fornix bundle



Spatial orientation and emotions associated with particular place



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http://www.slideshare.net/drsunilsuthar/neurobiology-of-emotion

- ***Suggestion: the ascending axons of this circuit are continuously activating memories of places that lie ahead, in the direction indicated by the current direction of the head.***

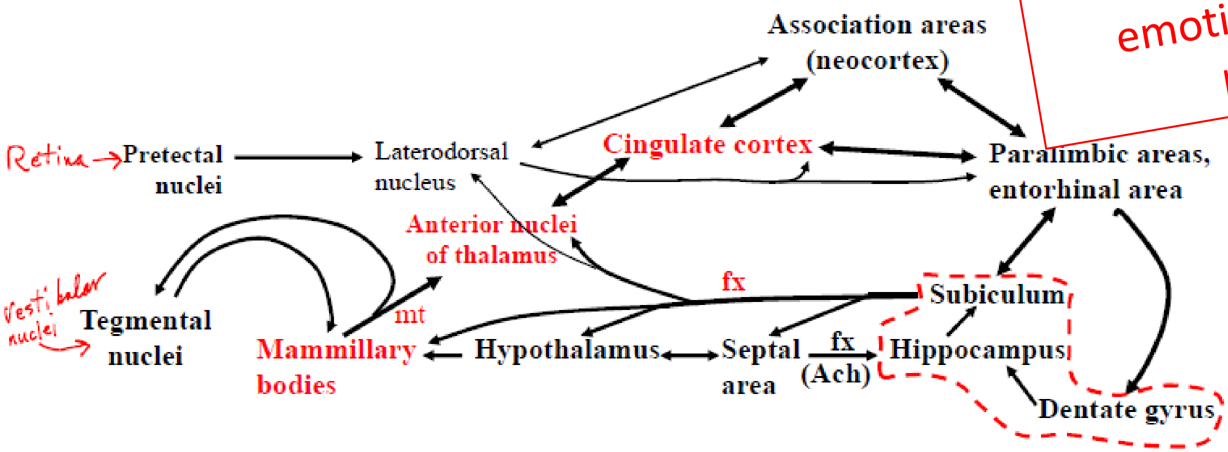
Thus, decisions about direction of locomotion are influenced by memories of those places, including their good or bad values.

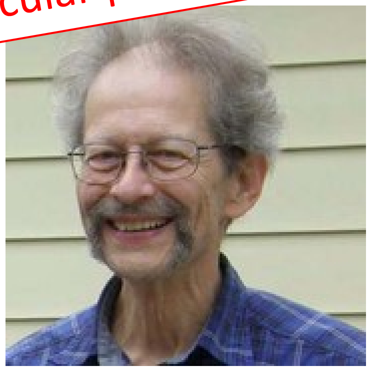
- ***Axons in the Papez circuit are of more than one type. Only the ones signaling head direction have been characterized.***

- ***What is the hippocampus sending to other parts of the hypothalamus? It may alter motivational levels according to remembered information about locations in the current frame of reference.***

Spatial orientation and emotions associated with particular place

mt = mammillothalamic tract
fx = fornix bundle

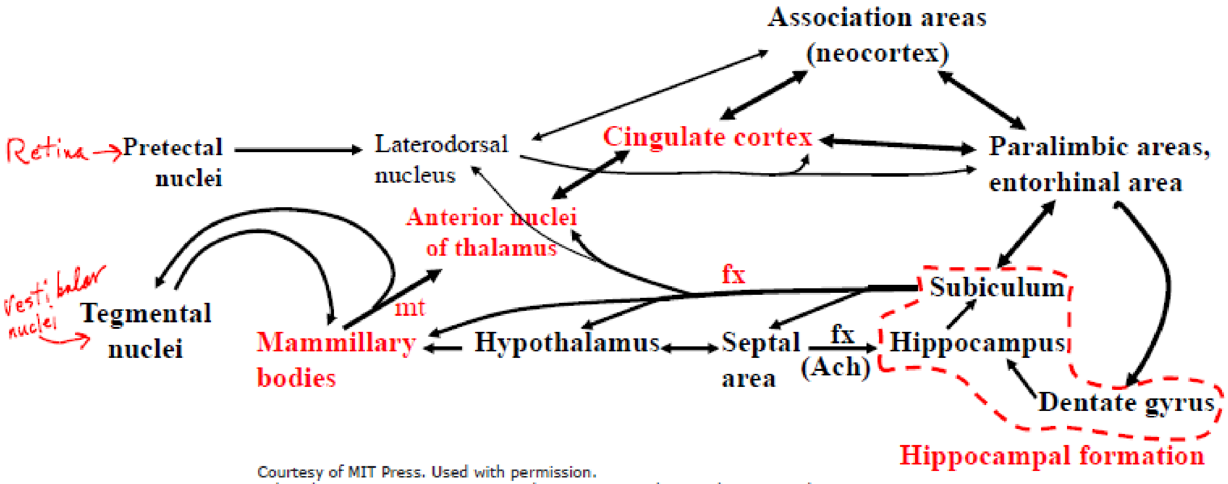




Prof. Gerald Schneider

- Origins of endbrain: Structures underlying olfaction
- Two major links between olfactory system and the motor systems of the midbrain
  1) Through the ventral endbrain, which became corpus striatum and basal forebrain (including much of the septal area)
     - Outputs to hypothalamus, (epithalamus, subthalamus), midbrain
     - These outputs affected locomotion and orienting movements
     - The links were plastic, so habits were formed according to rewarding effects mediated, e.g., by taste effects.
  2) **Through the medial part of the dorsal endbrain, which became medial pallium—the hippocampal formation**
     - **Outputs to ventral striatum, hypothalamus, epithalamus**
     - **The links were plastic, but the "habits" formed were different: The association of place with good or bad consequences of approach.**

mt = mammillothalamic tract
fx = fornix bundle



Prof. Gerald Schneider

- Origins of endbrain: Structures underlying olfaction
- Two major links between olfactory system and the motor systems of the midbrain

Object oriented…

1) Through the ventral endbrain, which became corpus striatum and basal forebrain (including much of the septal area)
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Location oriented…

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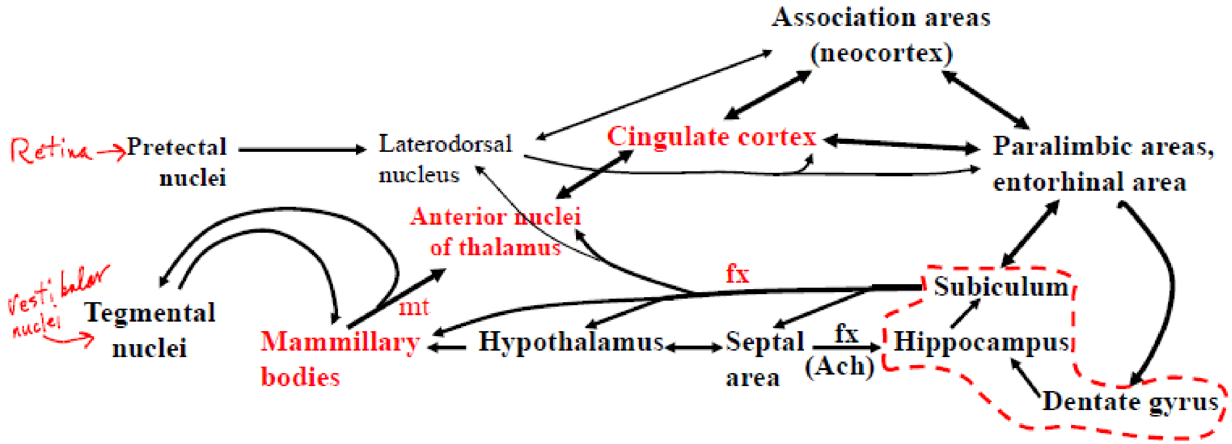


Prof. Gerald Schneider

Evolution of corpus striatum:

basic outline of a story

1. Beginnings: a link between olfactory inputs and motor control: The link becomes "Ventral striatum". **It was a <u>modifiable</u> link (capable of experience-induced change).**

2. Non-olfactory inputs invade the striatal integrating mechanisms (via paleothalamic structures).

3. Early expansions of endbrain: striatal and pallial.

4. Pre-mammalian & then mammalian expansions of cortex and striatum: For the striatum, the earlier outputs and inputs remain as connections with neocortex expand.

Figure 1. Postulated beginnings in primitive chordates

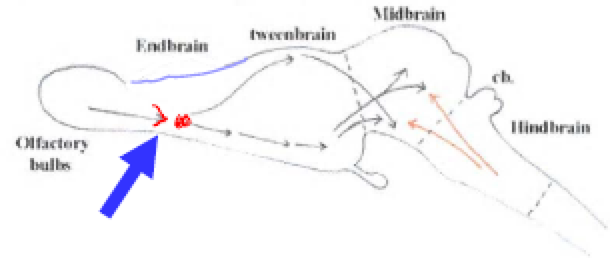


Figure 2. Other inputs reached the striatum

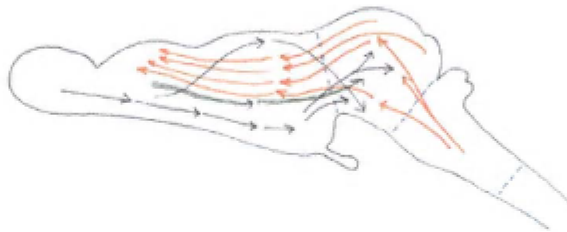


Figure 3. Early expansion of striatal and adjacent " limbic" areas

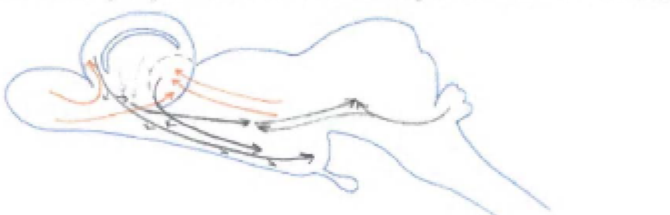
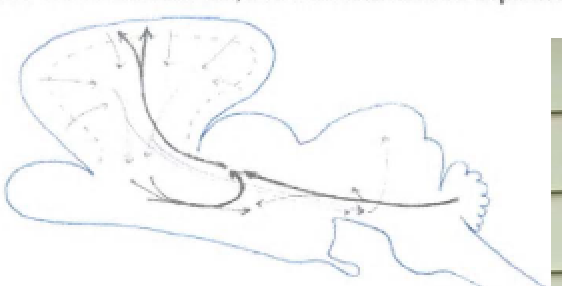


Figure 4. Pre-mammalian, and then mammalian expansions



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Learning and memory

- Connections of striatum and hippocampus are plastic
- Plasticity is a base of learning
- Learning is a forming of long- term memory

Working/Short term memory
– „RAM“
Long term memory
– „Hard disk“

Learning and memory

- Connections of striatum and hippocampus are plastic
- Plasticity is a base of learning
- Learning is a forming of long- term memory

Working/Short term memory
– „RAM“
Long term memory
– „Hard disk“

- Declarative memory (explicit)
  - Based on hippocampus
  - Explicit information is stored and later recollected
  - „Construction of the maps (relationships)“ – spatial or abstract
- Procedural memory (implicit)
  - Based on striatum
  - Habitual learning – motor skills, but also social habits
  - „Construction of the algorithms“

Learning and memory

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- Learning is a forming of long- term memory

- Declarative memory (explicit)
  - Based on hippocampus
  - Explicit information is stored and later recollected
  - „Construction of the maps (relationships)“ – spatial or abstract

Location oriented:
Where am I and what has happened here?

- Procedural memory (implicit)
  - Based on striatum
  - Habitual learning – motor skills, but also social habits
  - „Construction of the algorithms“

Object oriented:
Can I eat it and how to eat it?

Amygdala

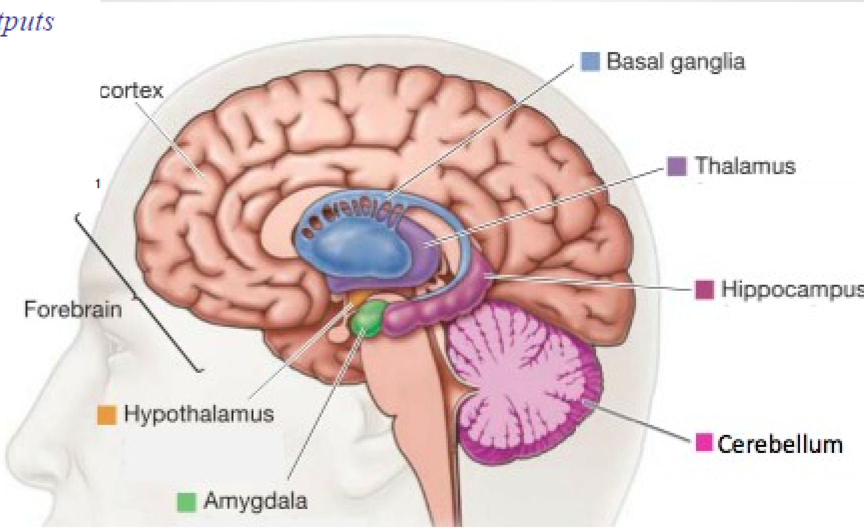
http://proprofs-cdn.s3.amazonaws.com/images/FC/user_images/1406217/9806788916.png

Corticomedial: *Inputs from olfactory bulbs, hypothalamus & lateral amygdala; outputs to hypothalamus, amygdala, ANS*

Basolateral: *Inputs from thalamus, neocortex, hippocampus; outputs to prefrontal cortex, ventral striatum, other amygdala nuclei*

Central: *Intra-amygdalar inputs; outputs through stria terminalis (see later slides)*

- Connections to all major cortical and subcortica lstructures
- Modiffied corpus striatum
- Plasticity – memory formation



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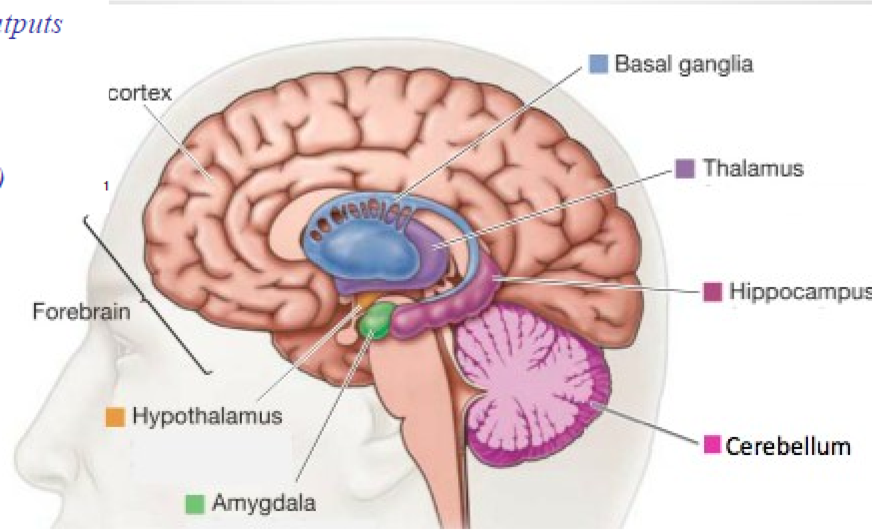
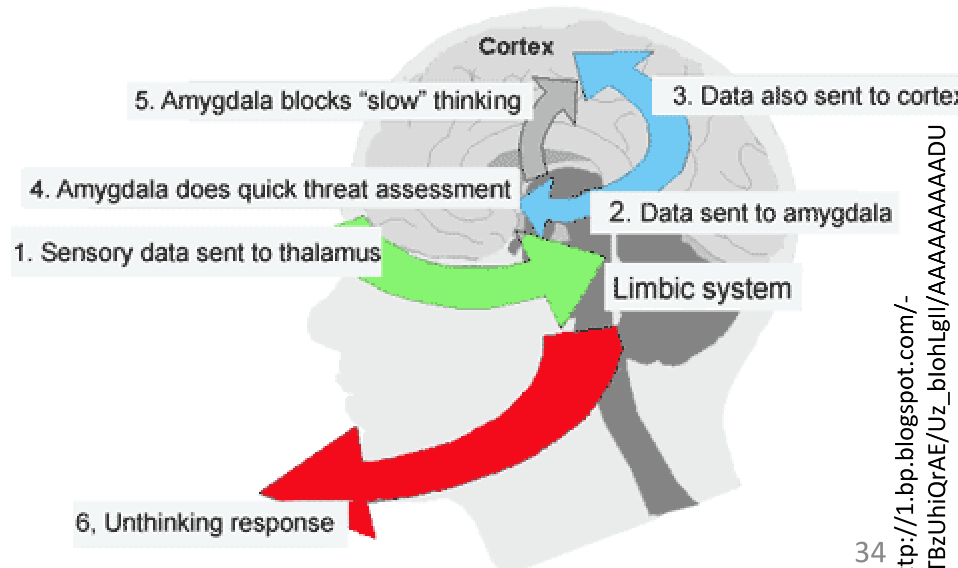


- Connections to all major cortical and subcortica lstructures
- Modiffied corpus striatum
- Plasticity – memory formation
- „Influence of information from outer environment on limbic system“
- „Amygdala hijack“
- „Affective tags“
  - Both possitive and negative
  - Higher responsiveness to negative



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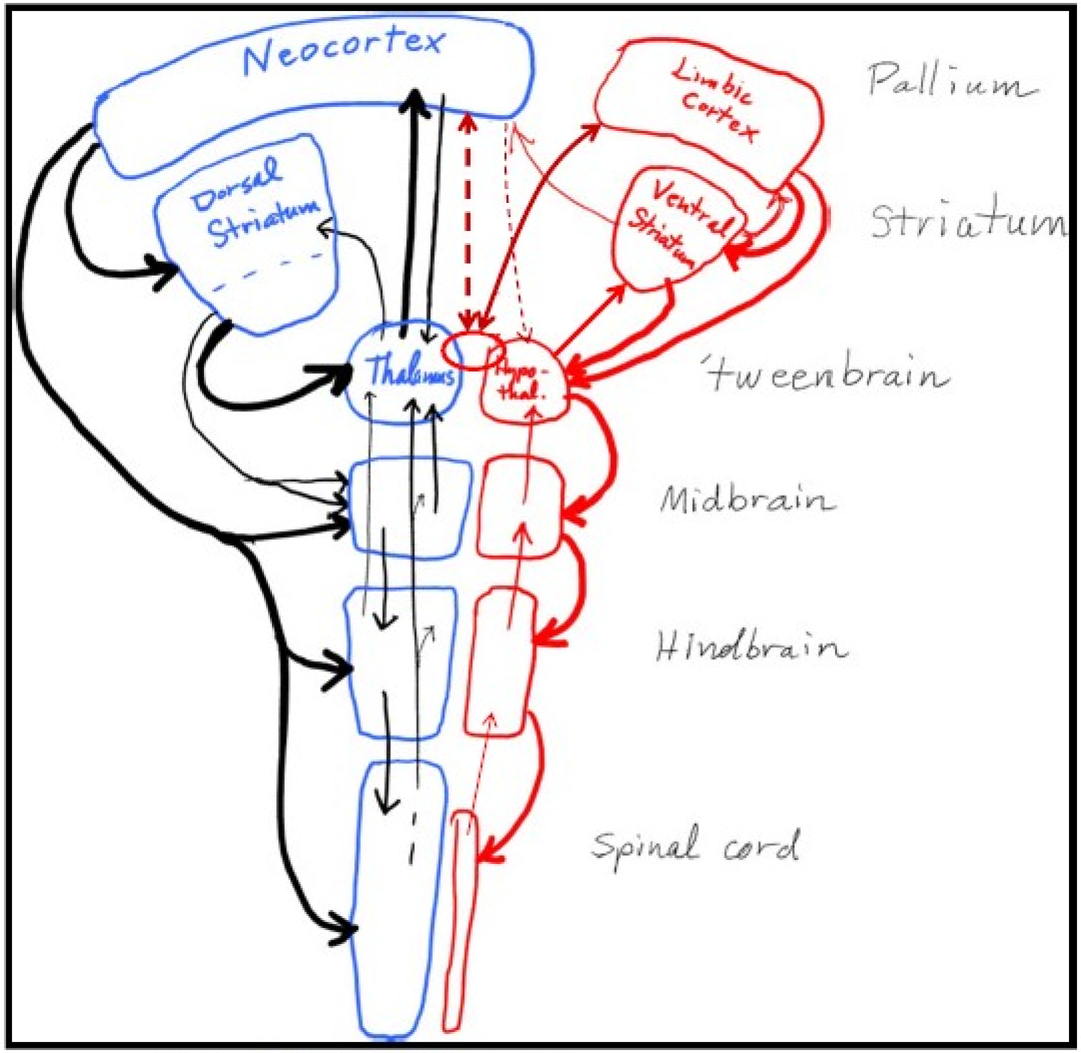

Schneider, G. E. *Brain structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN: 9780262026734.