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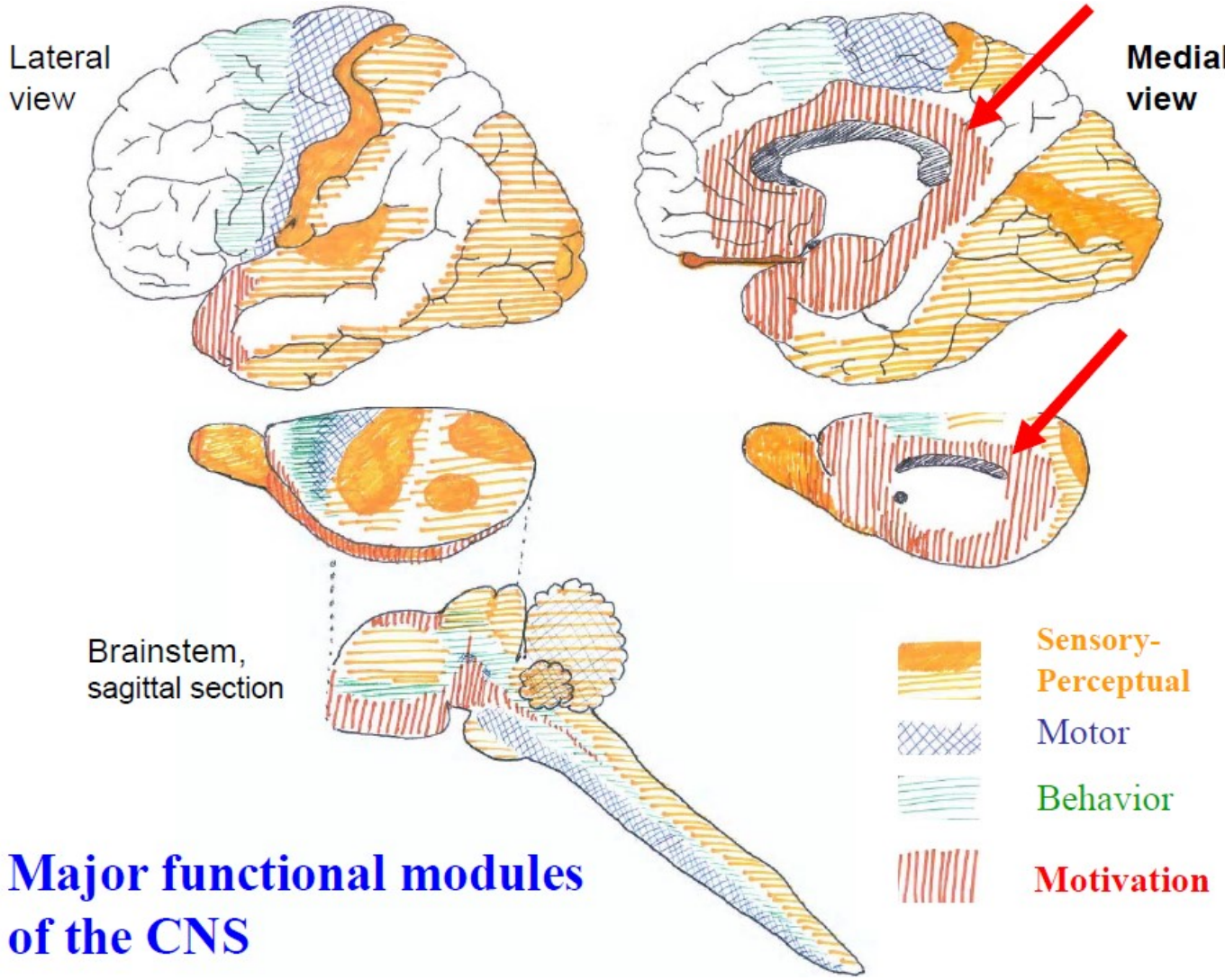
14

Limbic system

Limbic system

Limbus = border



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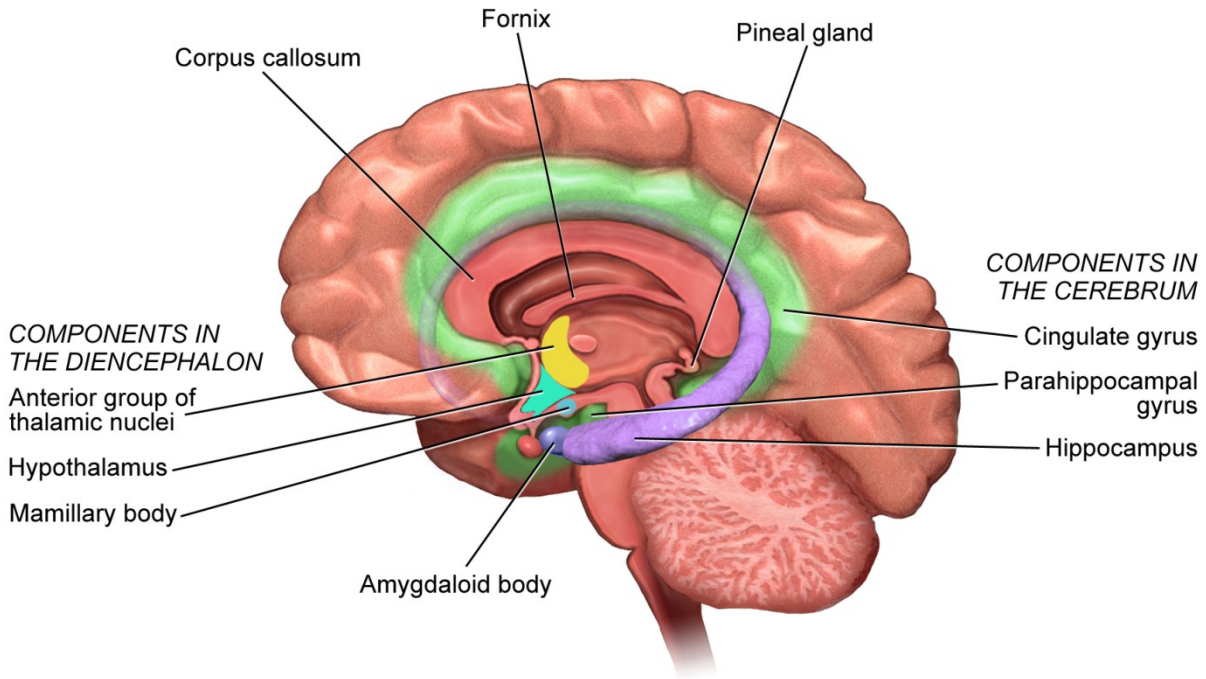
Concept of the limbic system

- 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



https://upload.wikimedia.org/wikipedia/commons/d/d1/Blausen_0614_LimbicSystem.png

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Concept of the limbic system

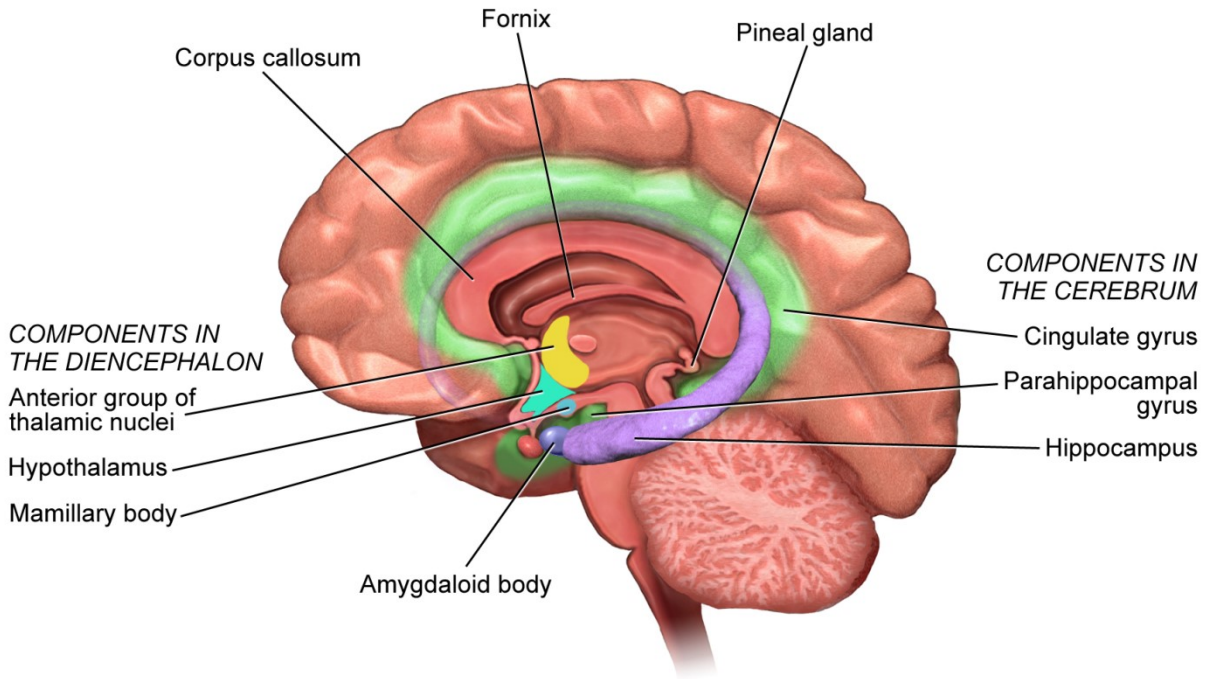
- Voluntary

↑

Potencial conflict

↓

- Automatic



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Concept of the limbic system

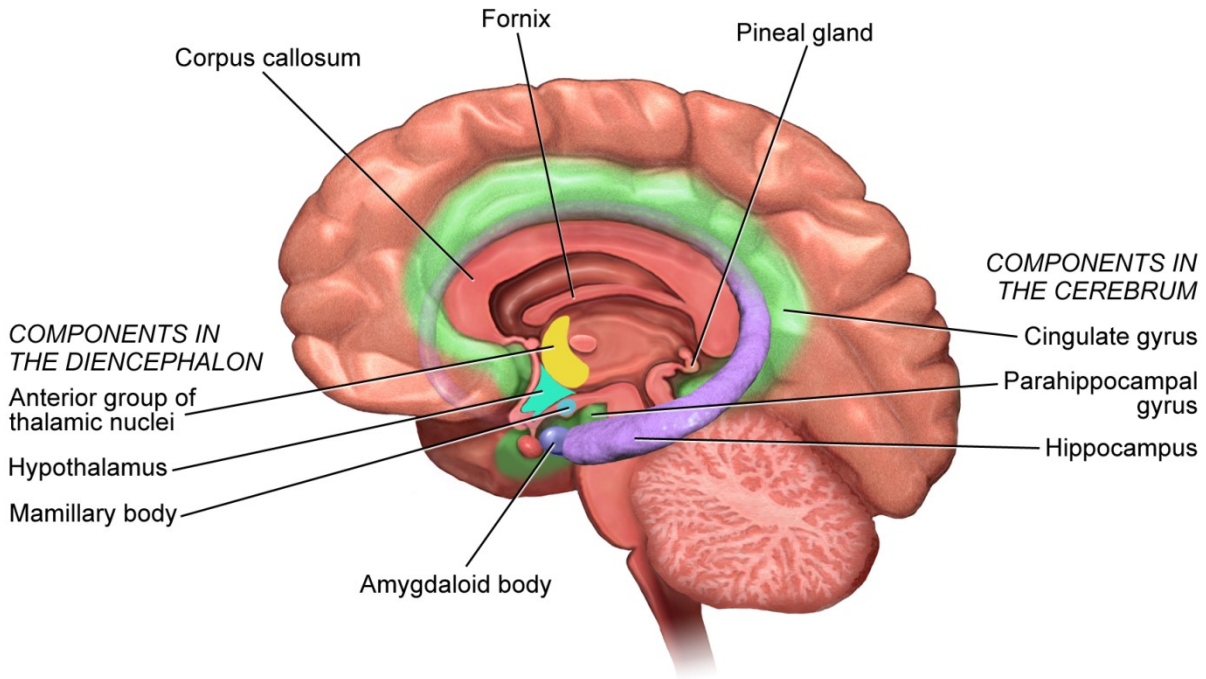
- Voluntary

↑ Modulation

Limbic system

↓ Control

- Automatic



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Concept of the limbic system

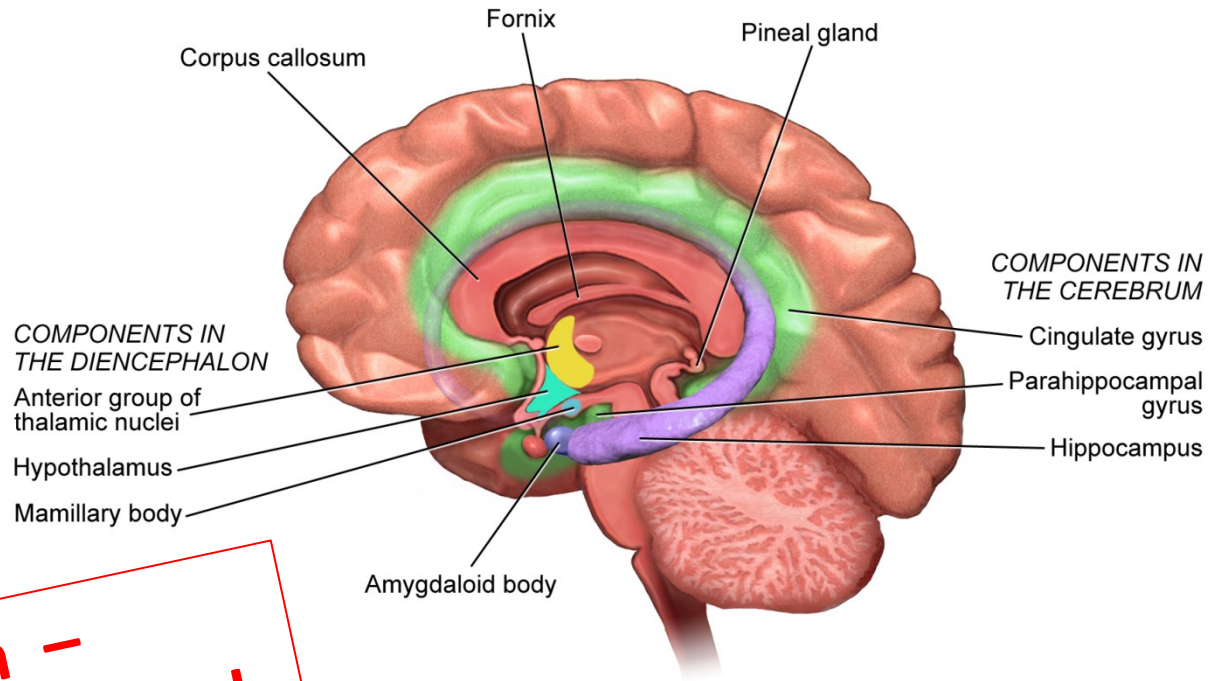
- Voluntary

Modulation

Limbic system

Control

- Automatic



Limbic system – hypothalamus and related structures

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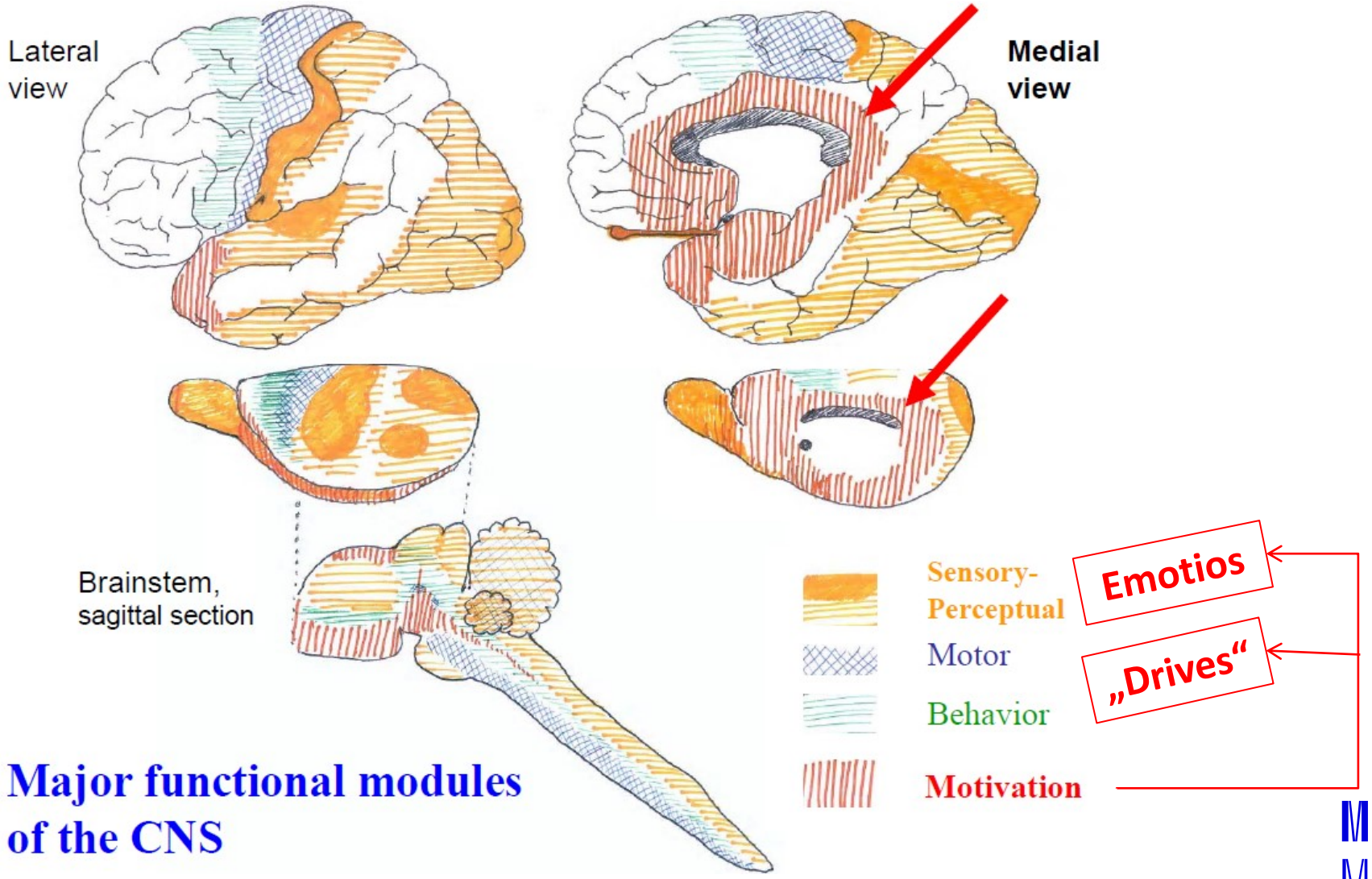
Limbic system

Limbus = border



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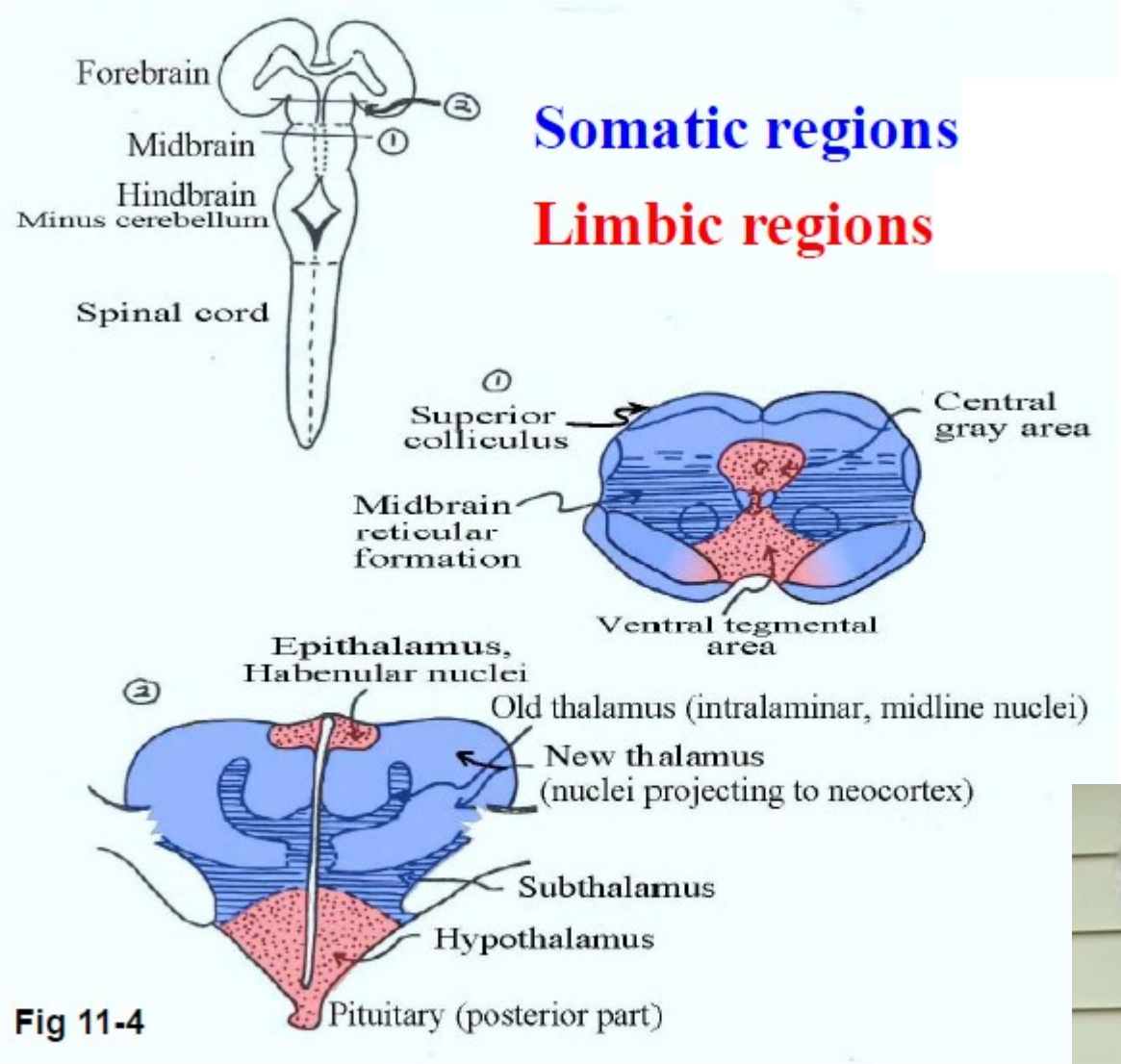

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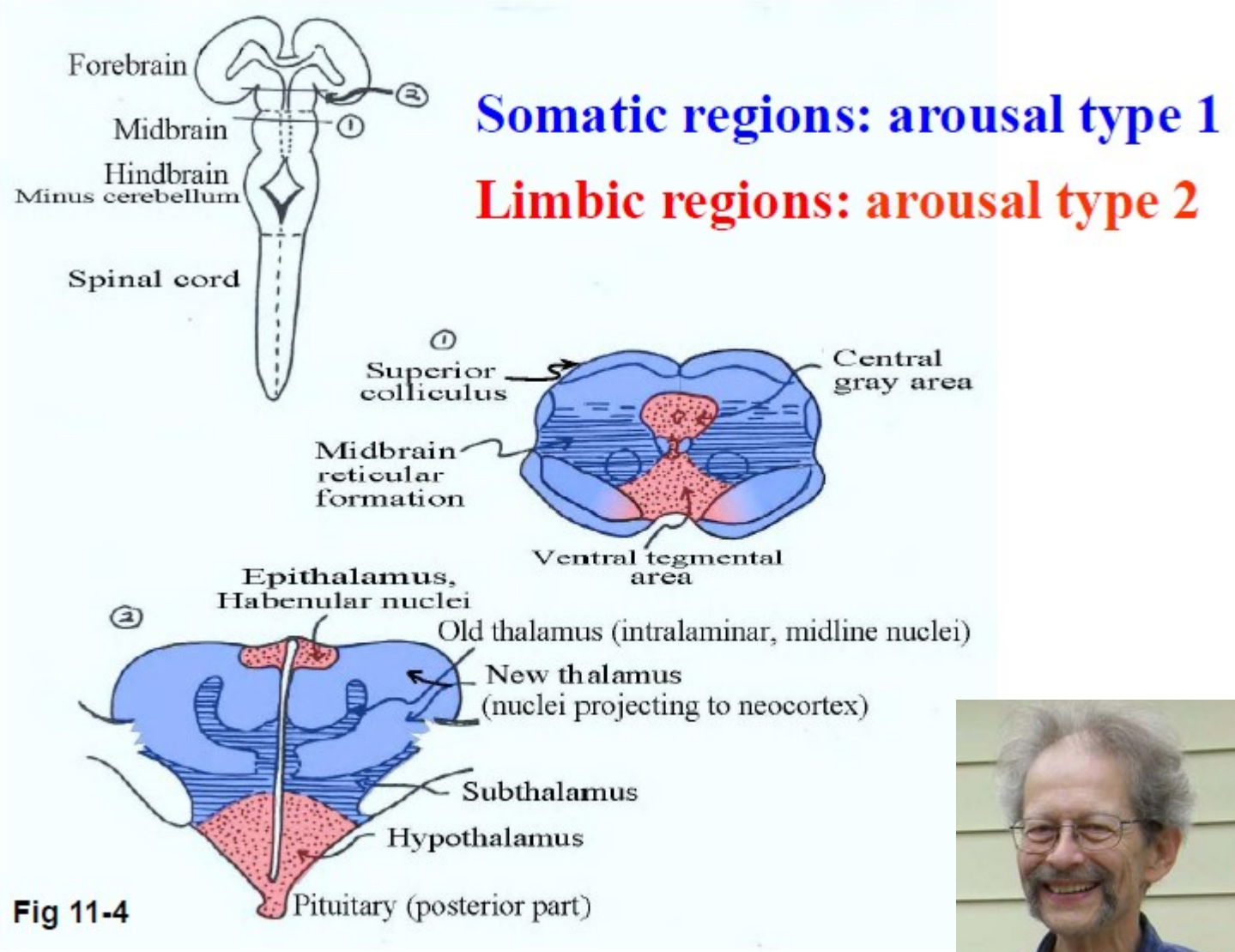

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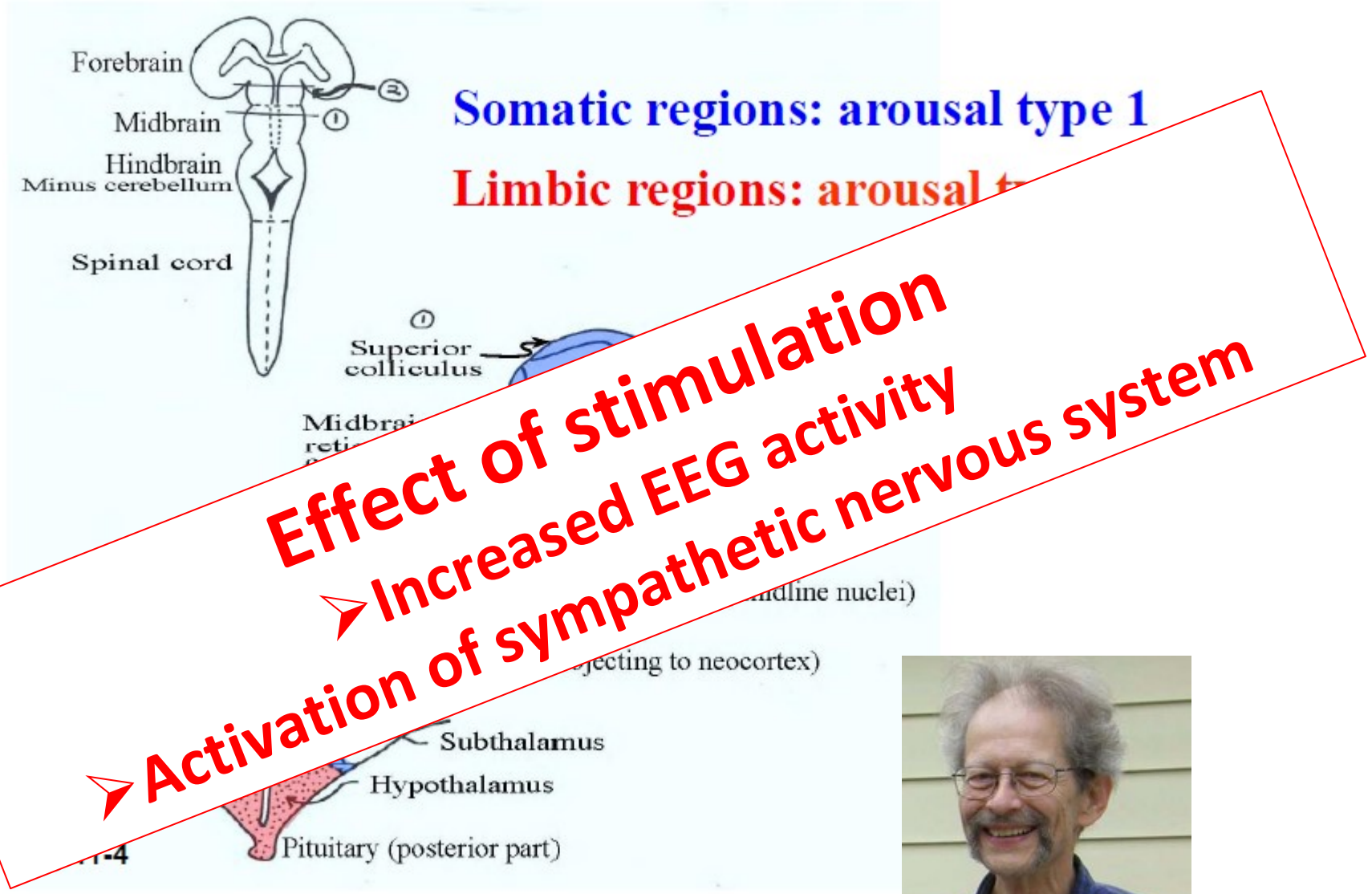

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Arousal type 1 (somatic)

ARAS (ascendent retikulation activation system)

- Effect of stimulation
  - Habituation
  - Minimal activation 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

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Arousal type 1 (somatic)

ARAS (ascendent retikulation activation system)

- Effect of stimulation
  - Habituation
  - Minimal activation 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

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Arousal type 1 (somatic)

ARAS (ascendent retikulation activati

- Eff
- ystem
- ong activation of
- „reward/ punishin
- ity, pain
- nections

Neocortex, corpus striatum, thalamus

- 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)

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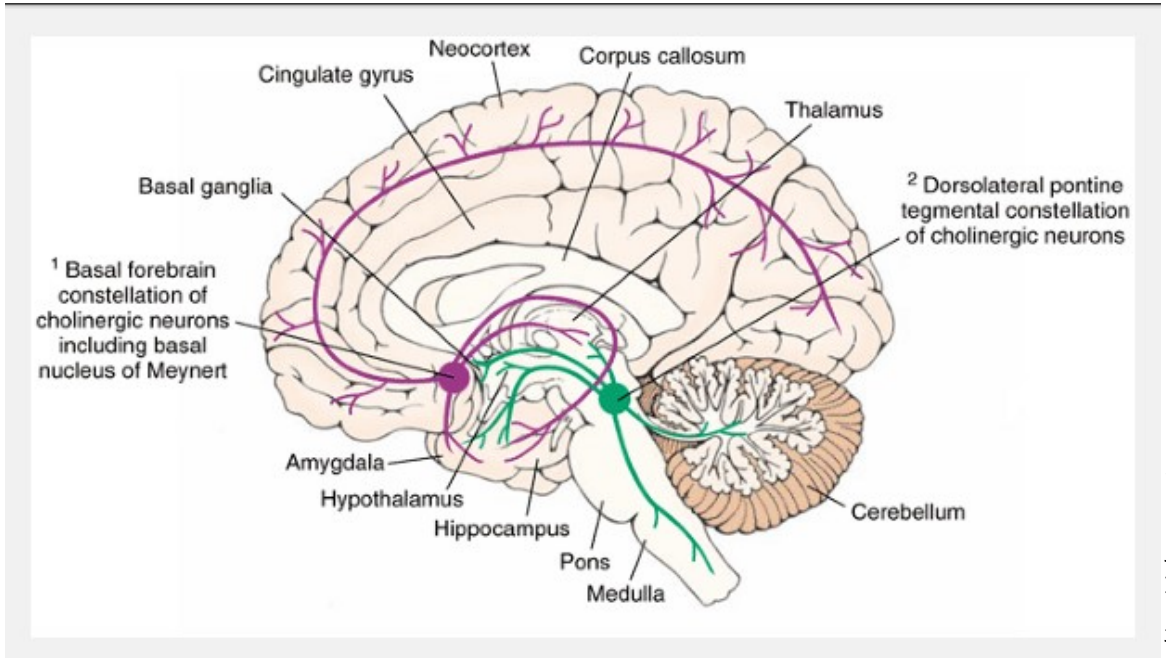
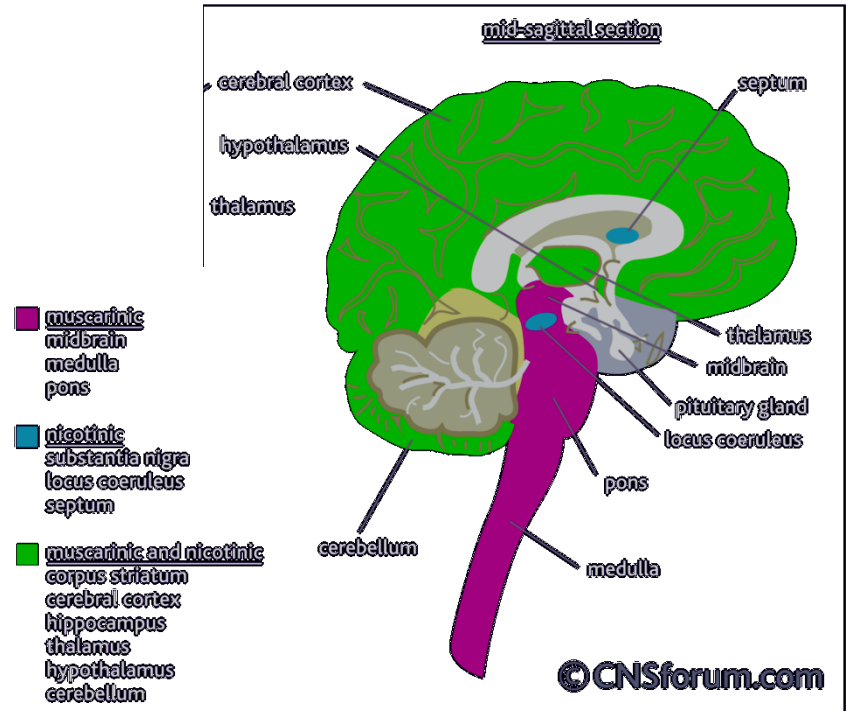
Acetylcholine

- Nucleus basalis (Meynerti) abd other nuclei
- Nicotin receptors
- Muscarin receptors

- Sleep/wake regulation
- Cognitive functions
- Behavior
- Emotions





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

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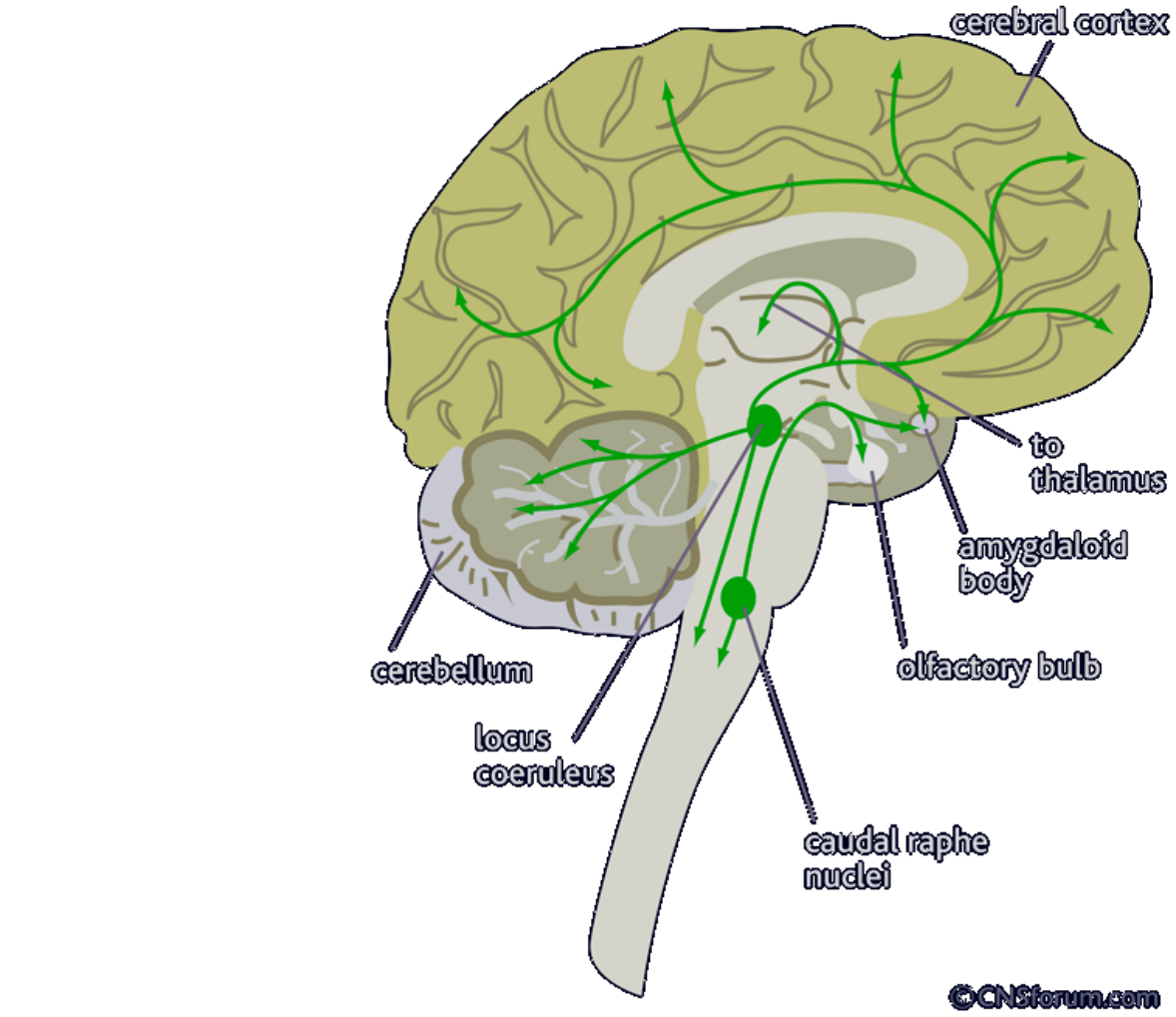
Norepinefrine

- Locus coeruleus
- Nuclei raphe caudalis

- Vigilance
- Responsiveness to unexpected stimuli
- Memory
- Learning



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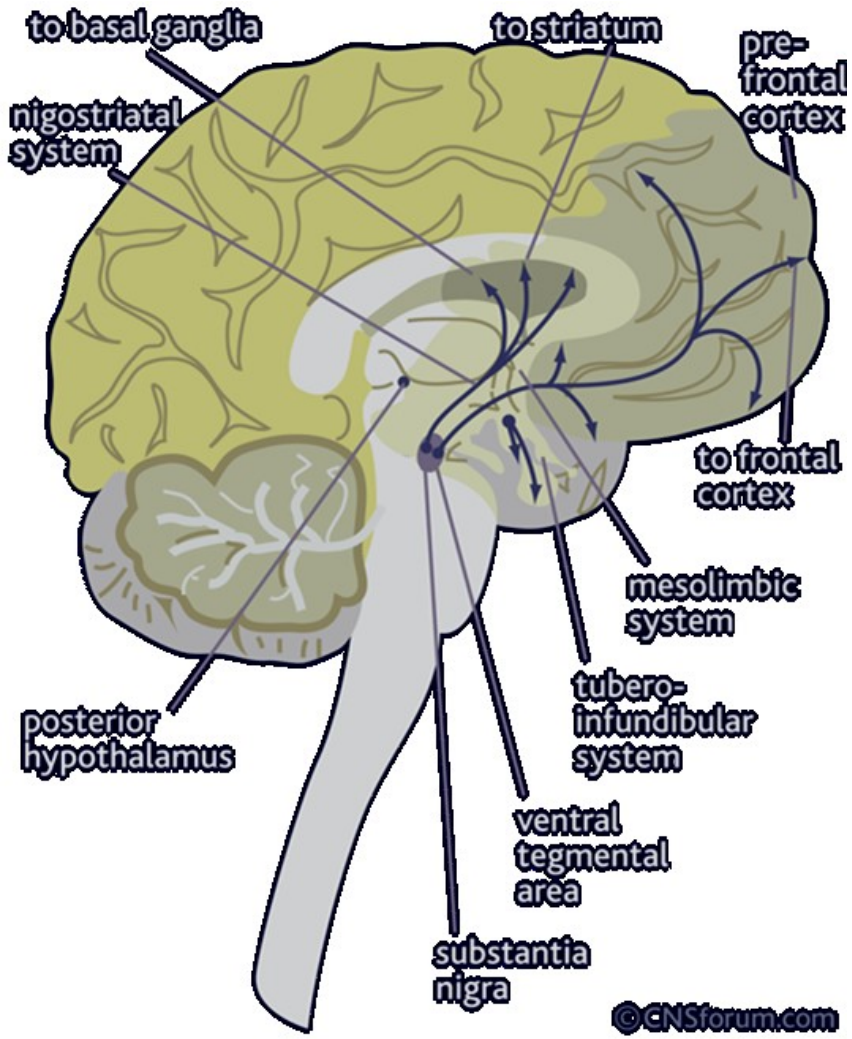
Dopamine

- 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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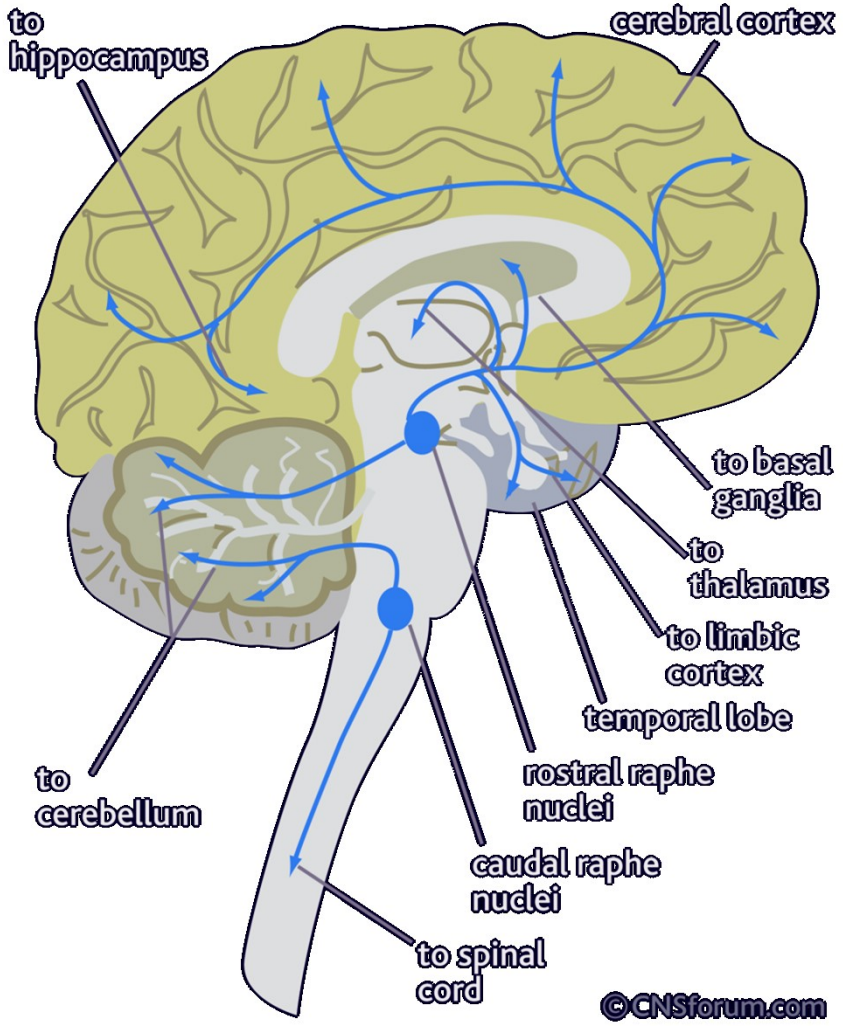
Serotonin

- Nuclei raphe rostralis
- Nuclei raphe caudalis

- Anxiety/relaxation
- Impulsive behavior
- Sleep



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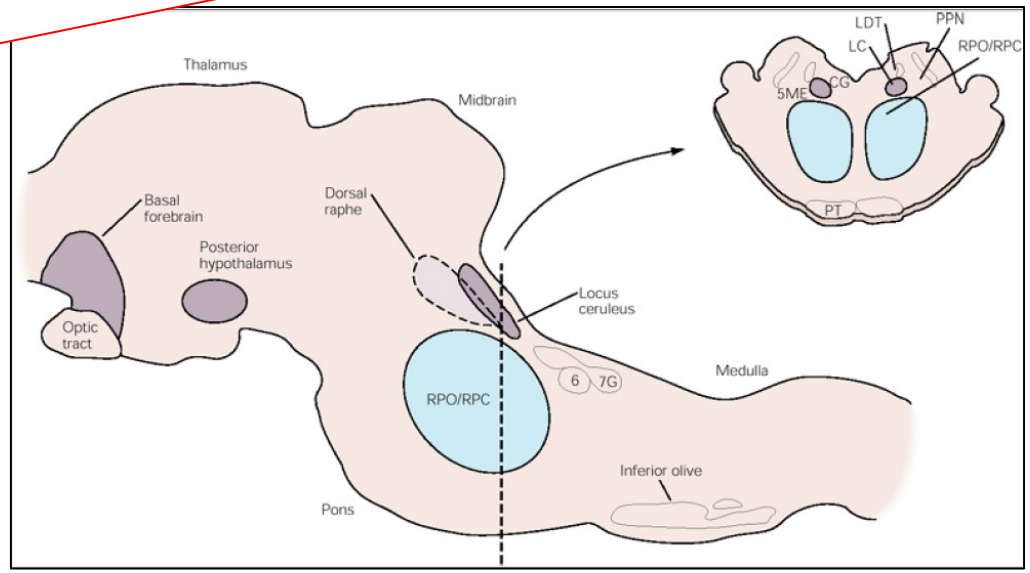
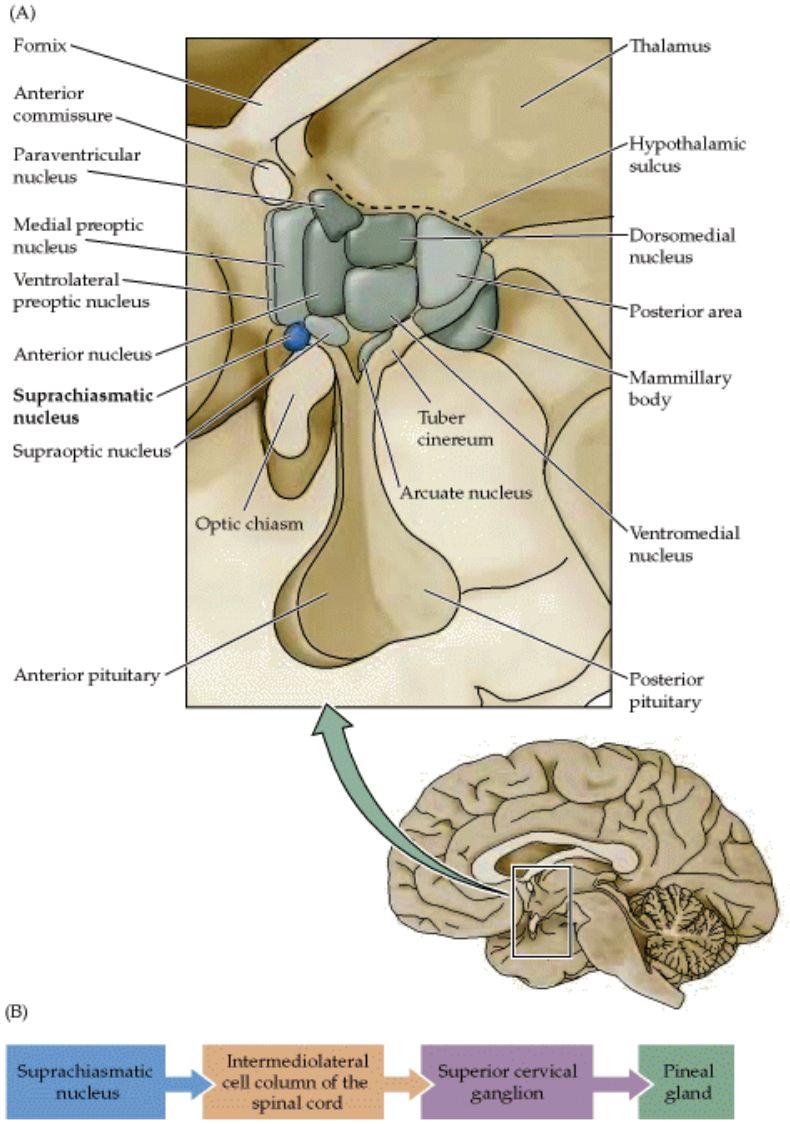
Sleep and wakefulness

Cooperation of ARAS and limbic activating system



RPO/RPC – nucleus reticularis pontis oralis/caudalis



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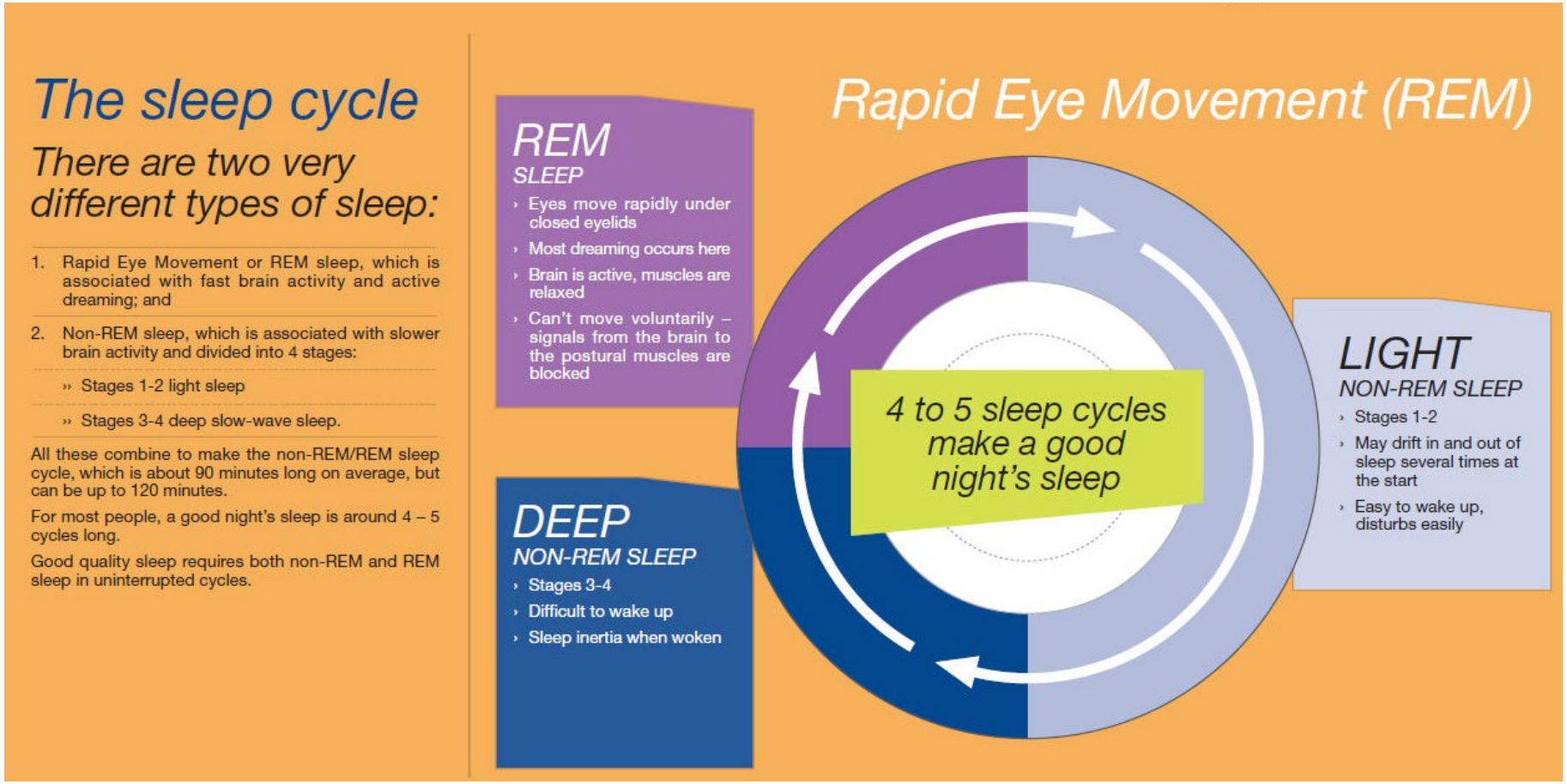
Sleep



http://anchortime.com/portal/images/stories/MNZ_sleep_cycles_1.jpg

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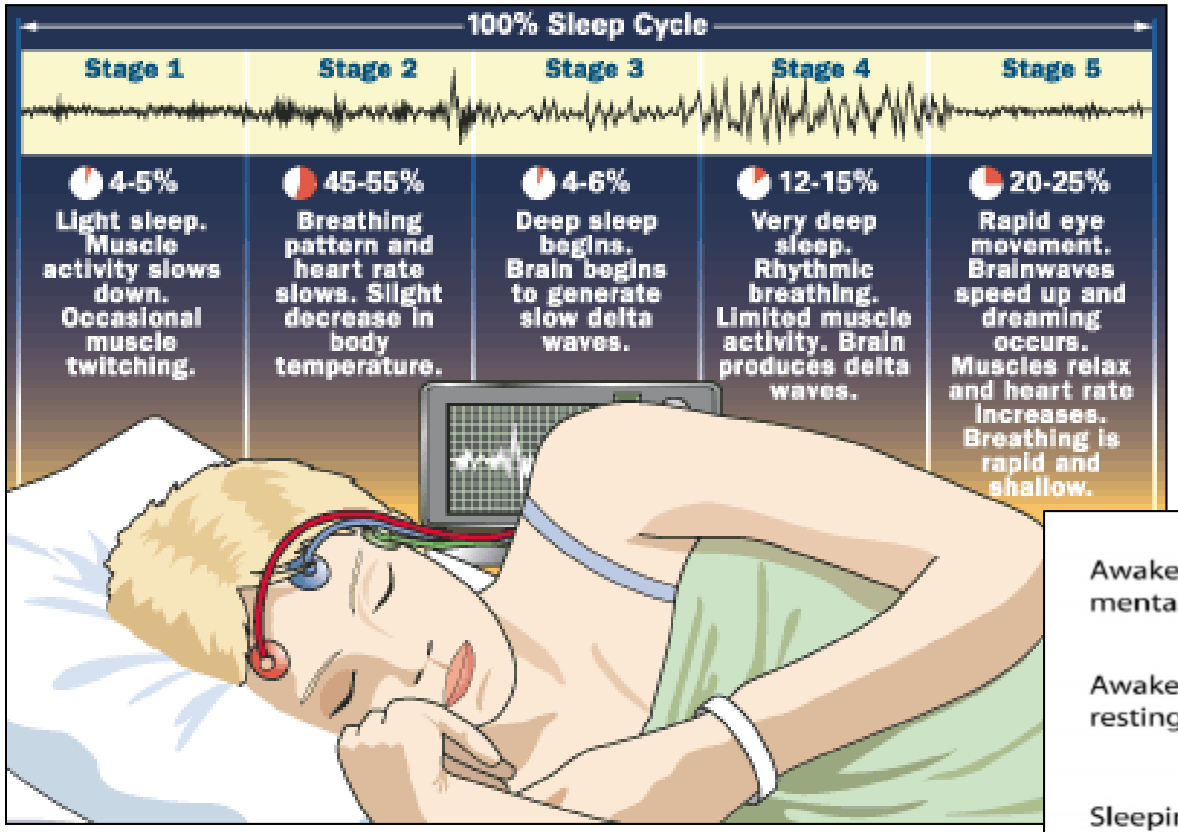
Sleep



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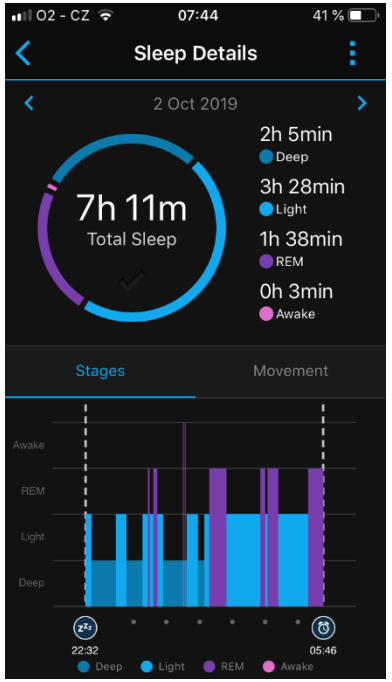
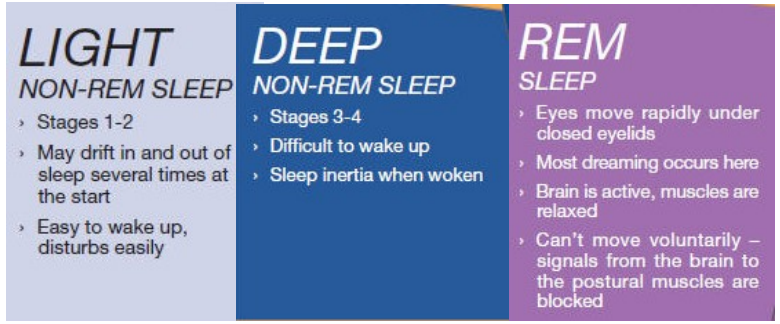
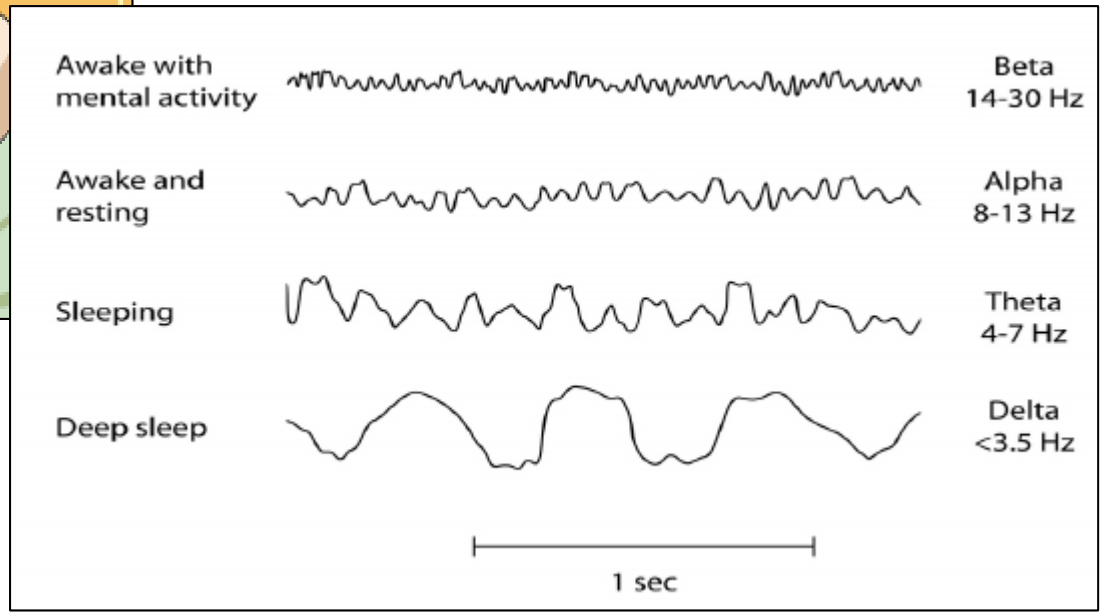


https://connect.garmin.com/modern/

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

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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

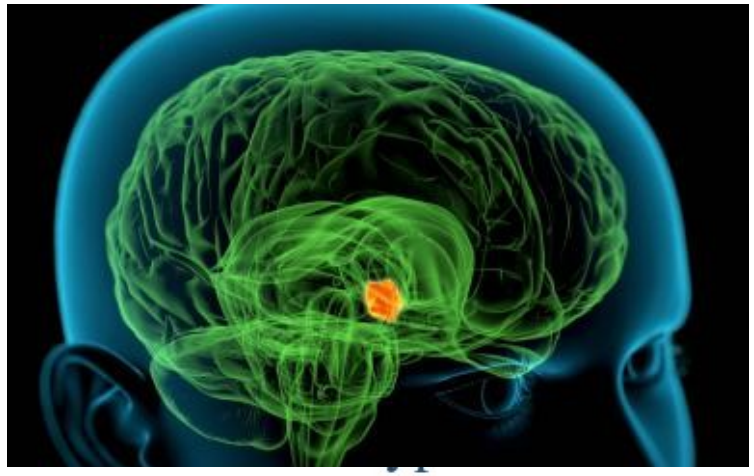
- Key center of autonomic regulations and coordination
- Integration of the information from inner and outer environment

↓

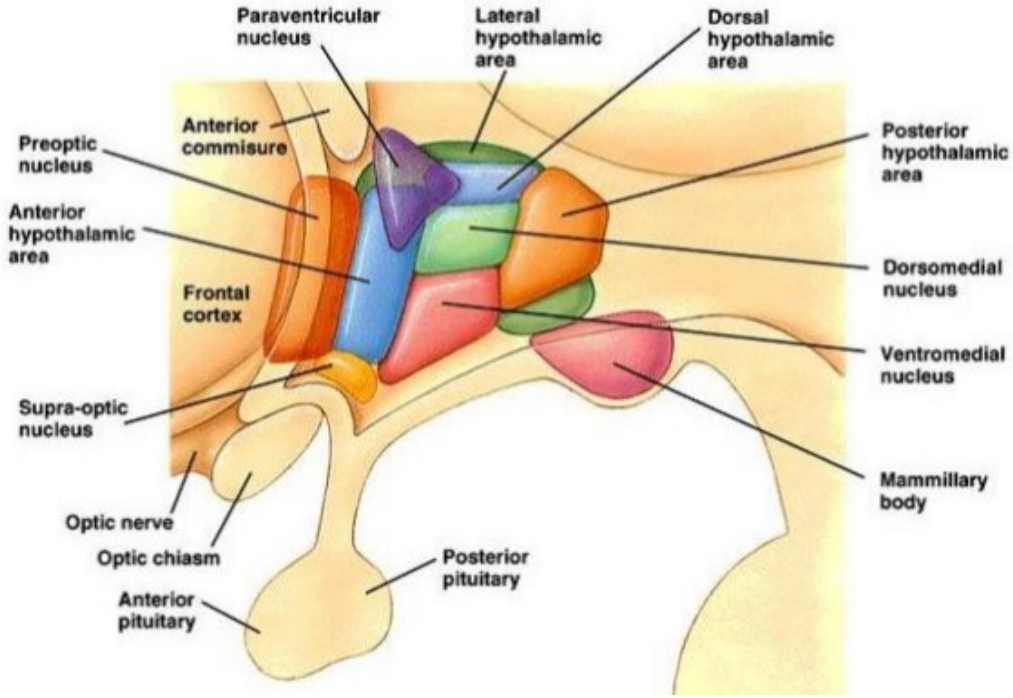
- Behavioral modulation
- Regulation of autonomic nervous system

↓

- **Maintenance of homeostasis**



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



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

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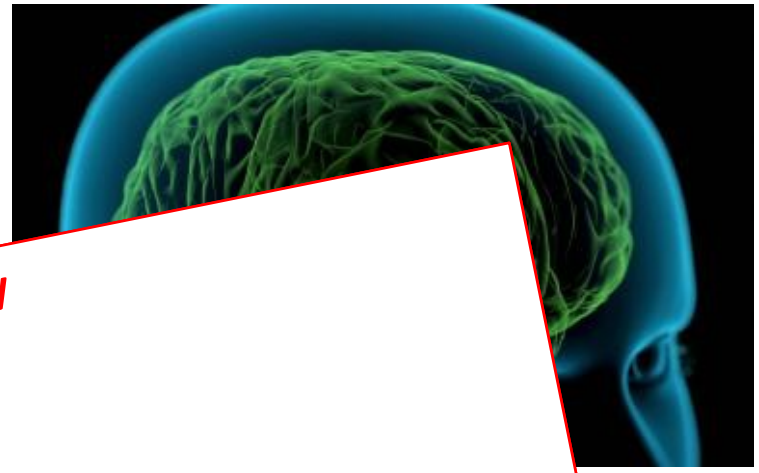
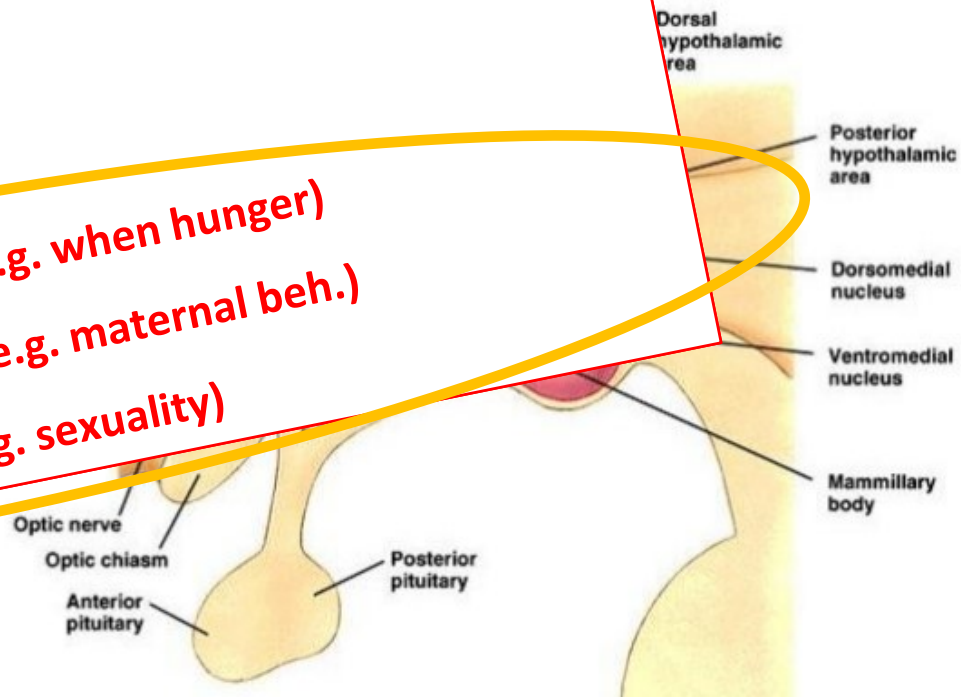
Hypothalamus

- Key center of autonomic regulations and coordination
- Integration of the inform… from inner… enviro…
- Behavic…
- Regulati… nervous …
- **Maintena…**



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

- ✓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)



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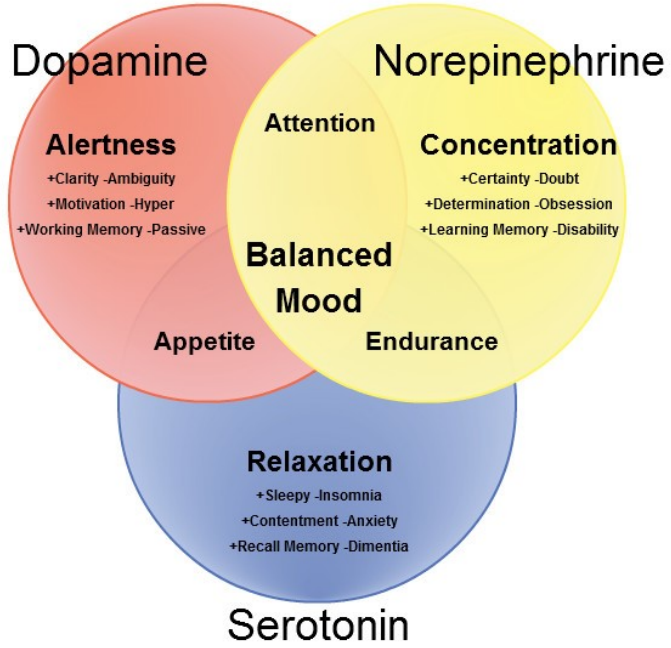
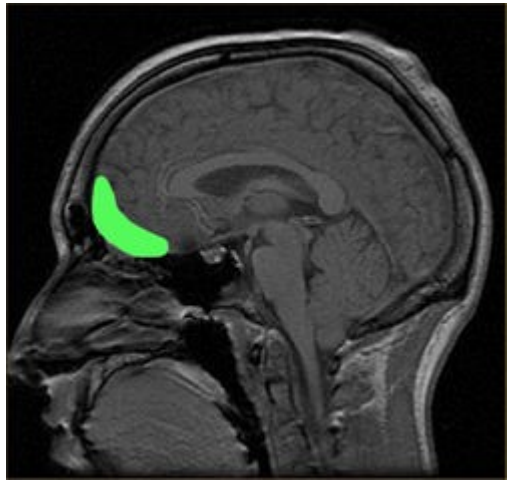
Influence of hypothalamus on neocortex

- Via neuromodulating systems
  - Consciuosness (see above)
  - Mood
- Via thalamus
  - Via nucleus mediodorsalis to orbitofrontal cortex (influence on decision making)
  - Influence gating function of other 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

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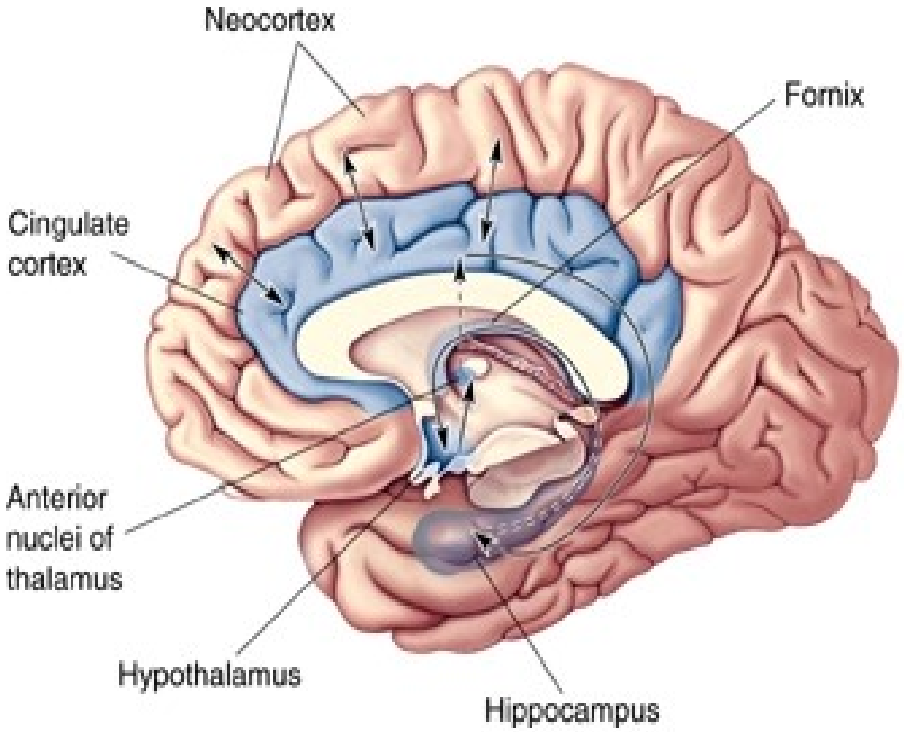
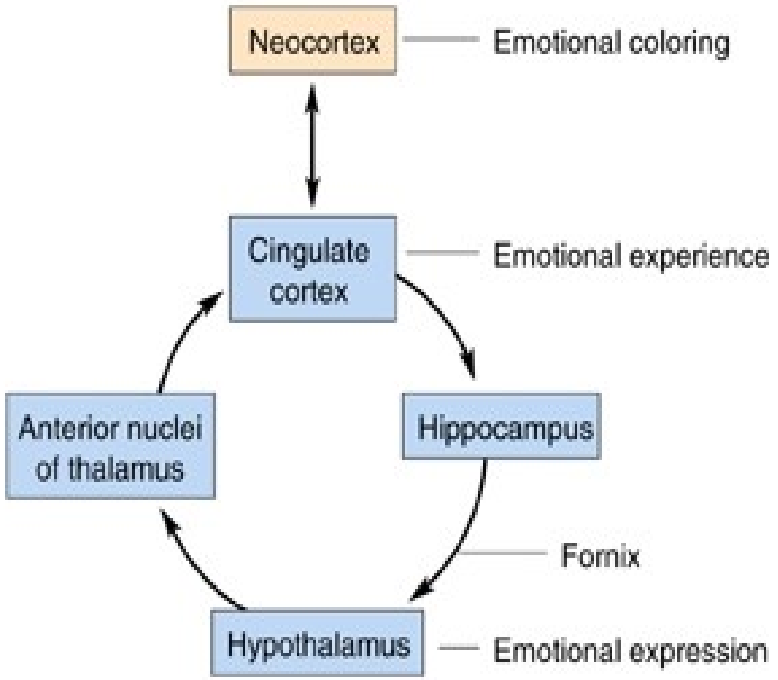
Papez circuit





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

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Papez circuit

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

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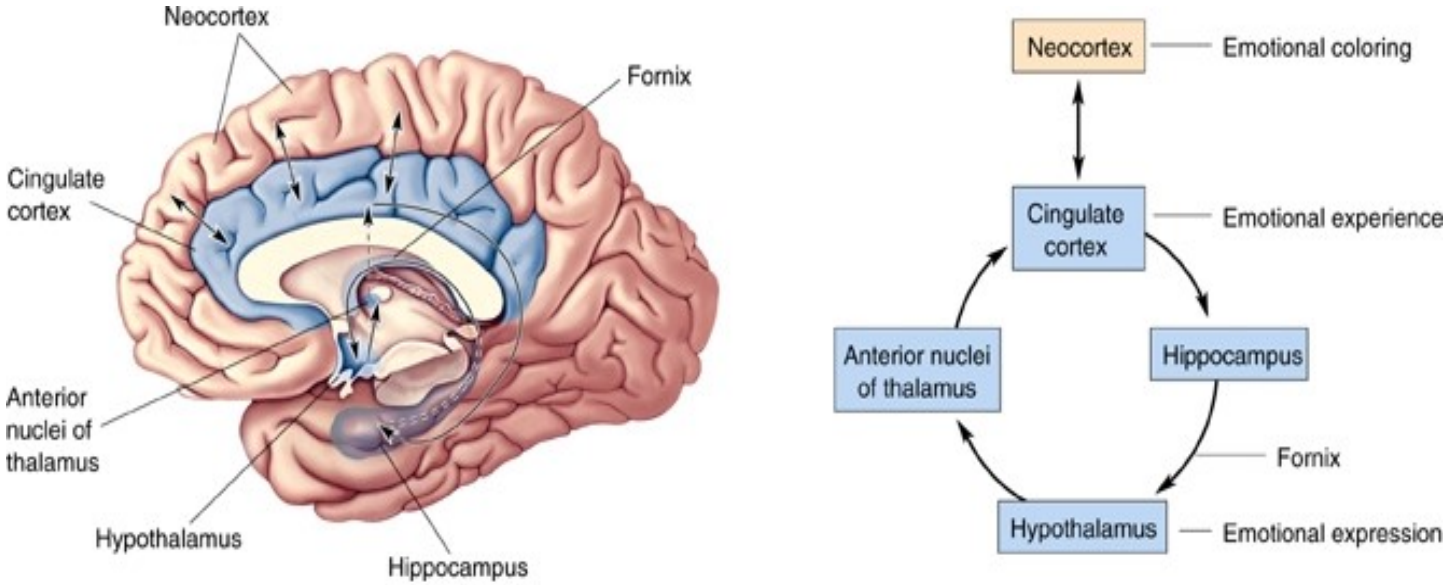

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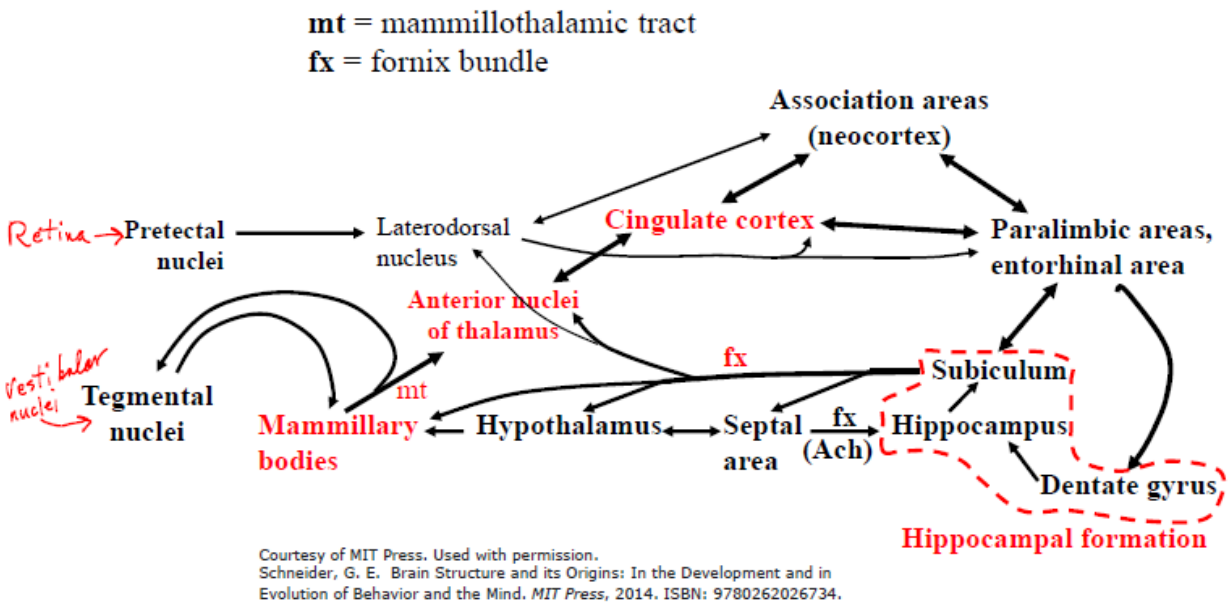

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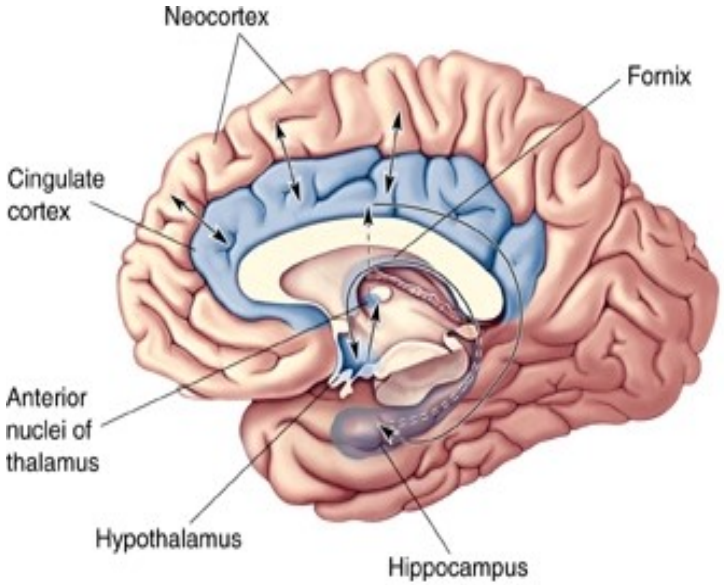

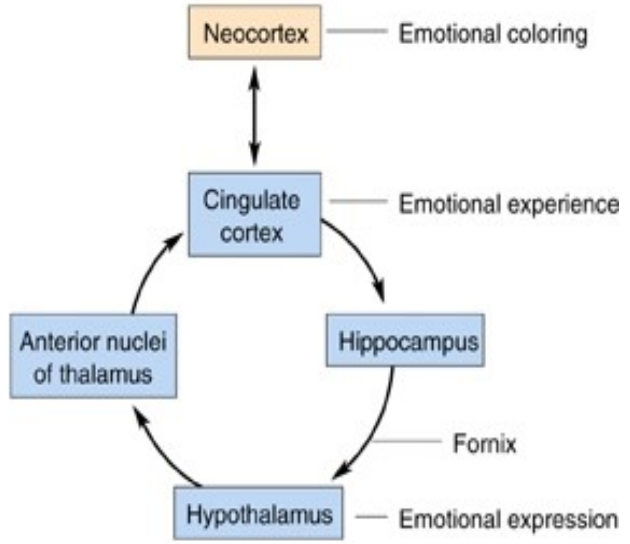

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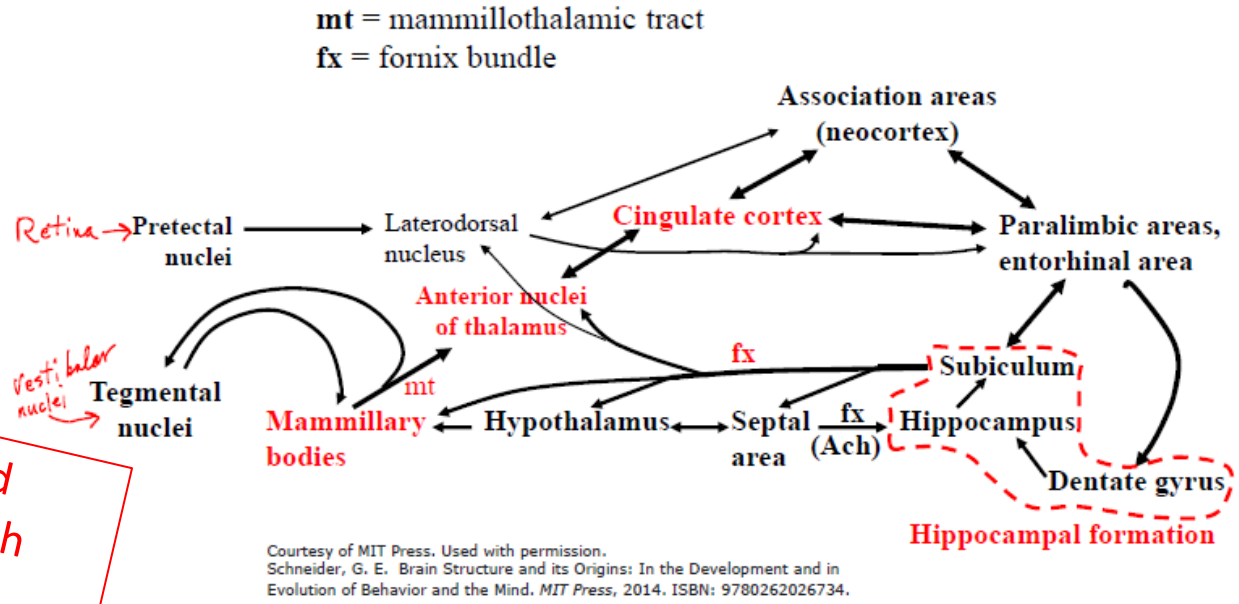

Spatial orientation and emotions associated with particular place

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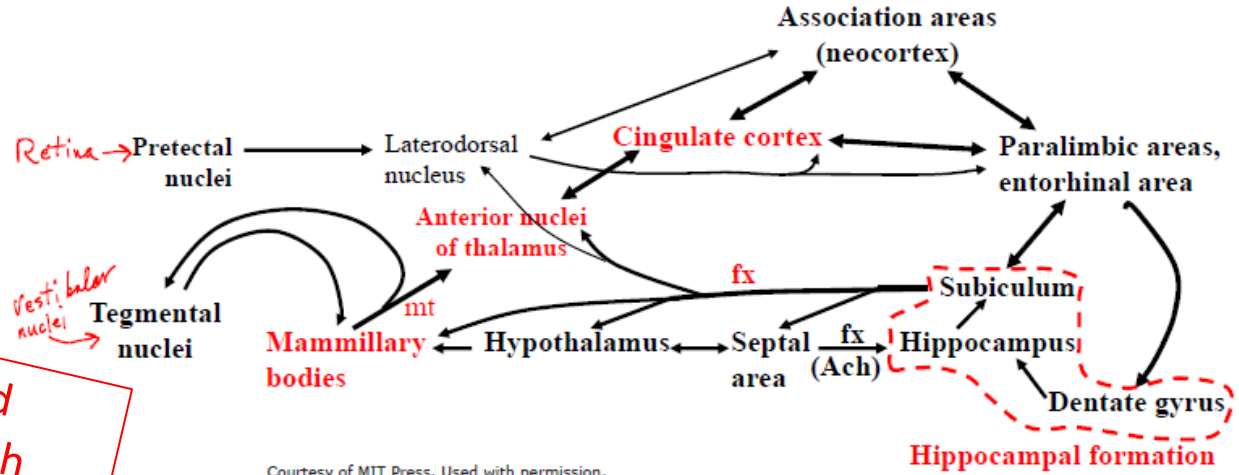
Papez circuit

Prof. Gerald Schneider

- ***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.***

mt = mammillothalamic tract
fx = fornix bundle



Spatial orientation and emotions associated with particular place

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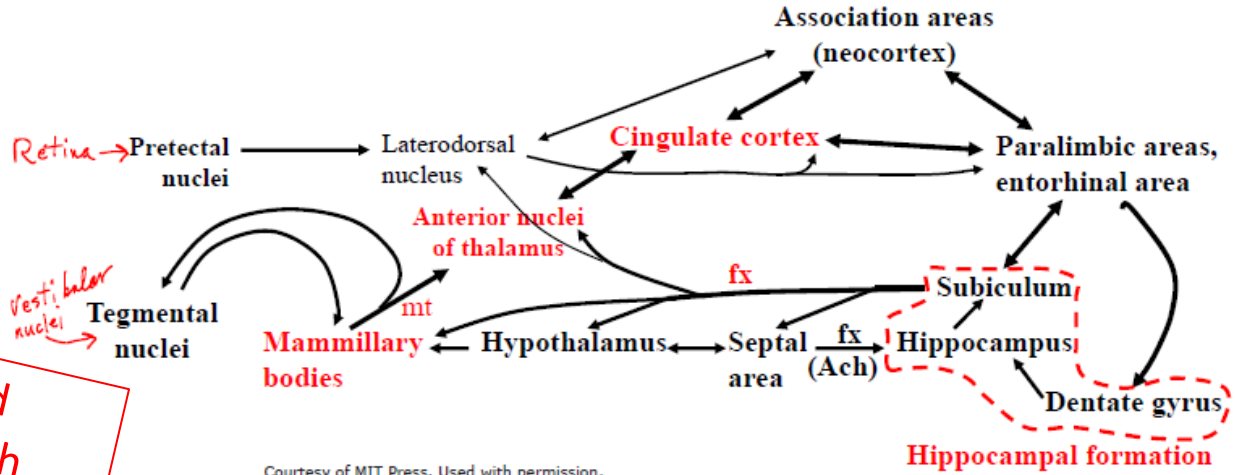
Papez circuit

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



Spatial orientation and emotions associated with particular place

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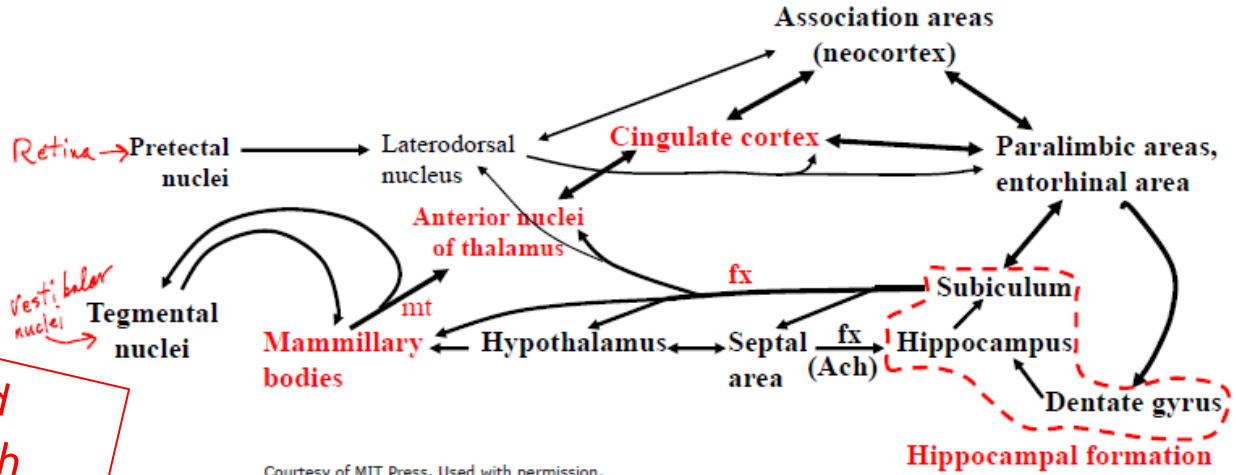
Object oriented...

  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.**

Location oriented...

mt = mammillothalamic tract
fx = fornix bundle



Spatial orientation and emotions associated with particular place

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Papez circuit

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

Prof. Gerald Schneider

Review

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 modifiable 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

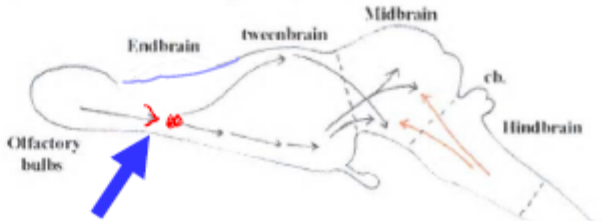


Figure 2. **Other inputs reached the striatum**

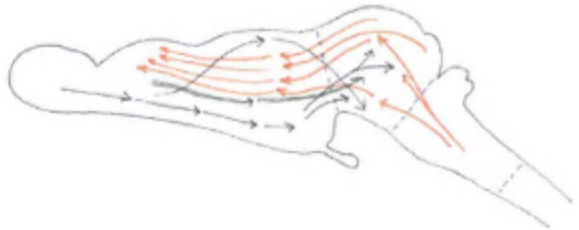


Figure 3. Early expansion of striatal and adjacent " limbic" areas

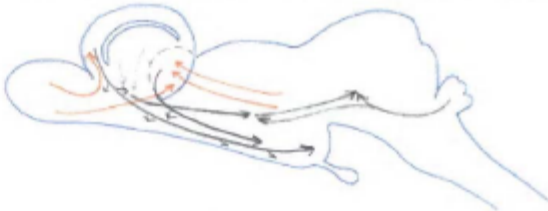
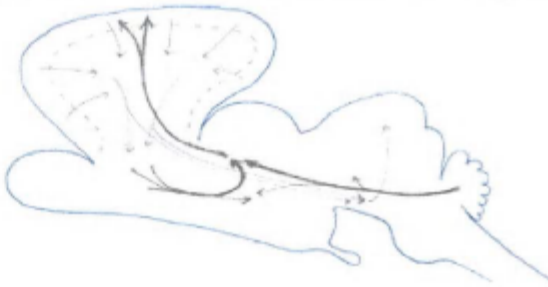


Figure 4. Pre-mammalian, and then mammalian expansions



Learning and memory

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

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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

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

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  - Habitual learning – motor skills, but also social habits
  - „Construction of the algorithms“

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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?

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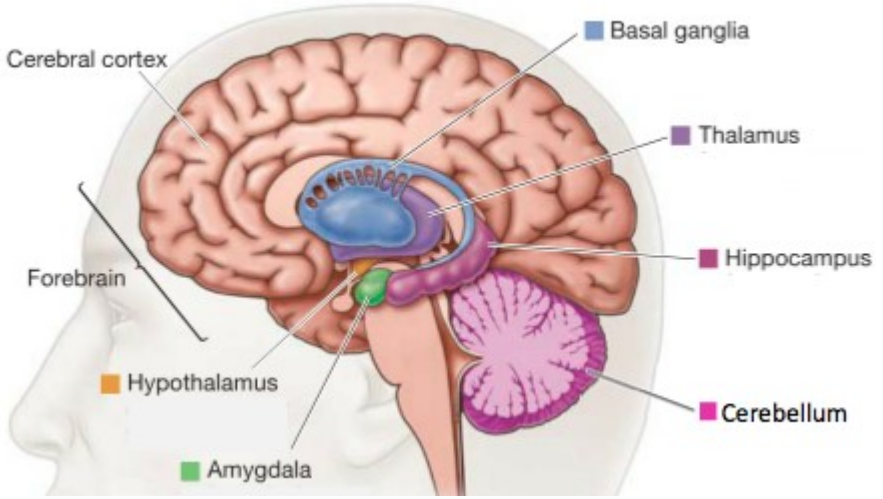
Amygdala

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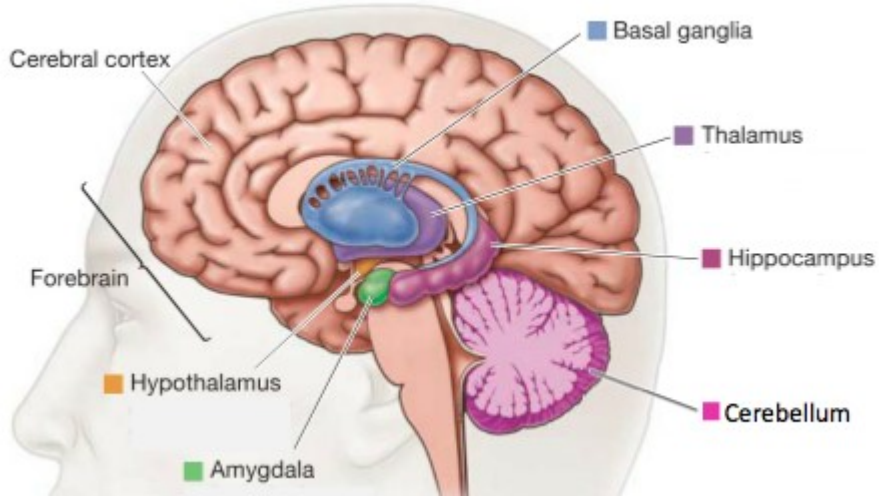
- Connections to all major cortical and subcortica lstructures
- Modiffied corpus striatum
- Plasticity – memory formation
- „Influence of information from outer environment on limbic system“
- „Amygdala hijack“
- „Affective tags“
  - Both possitive and negative
  - Higher responsiveness to negative



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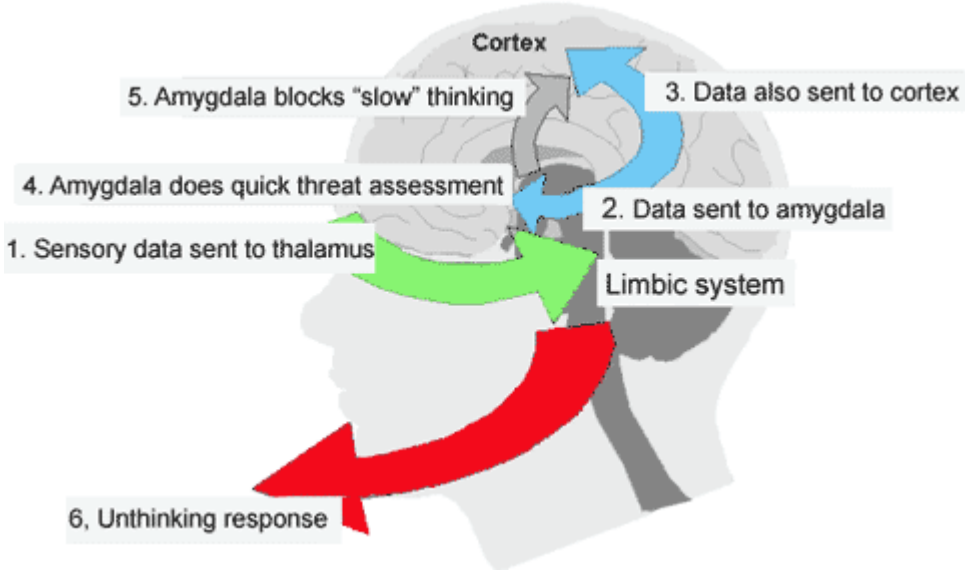

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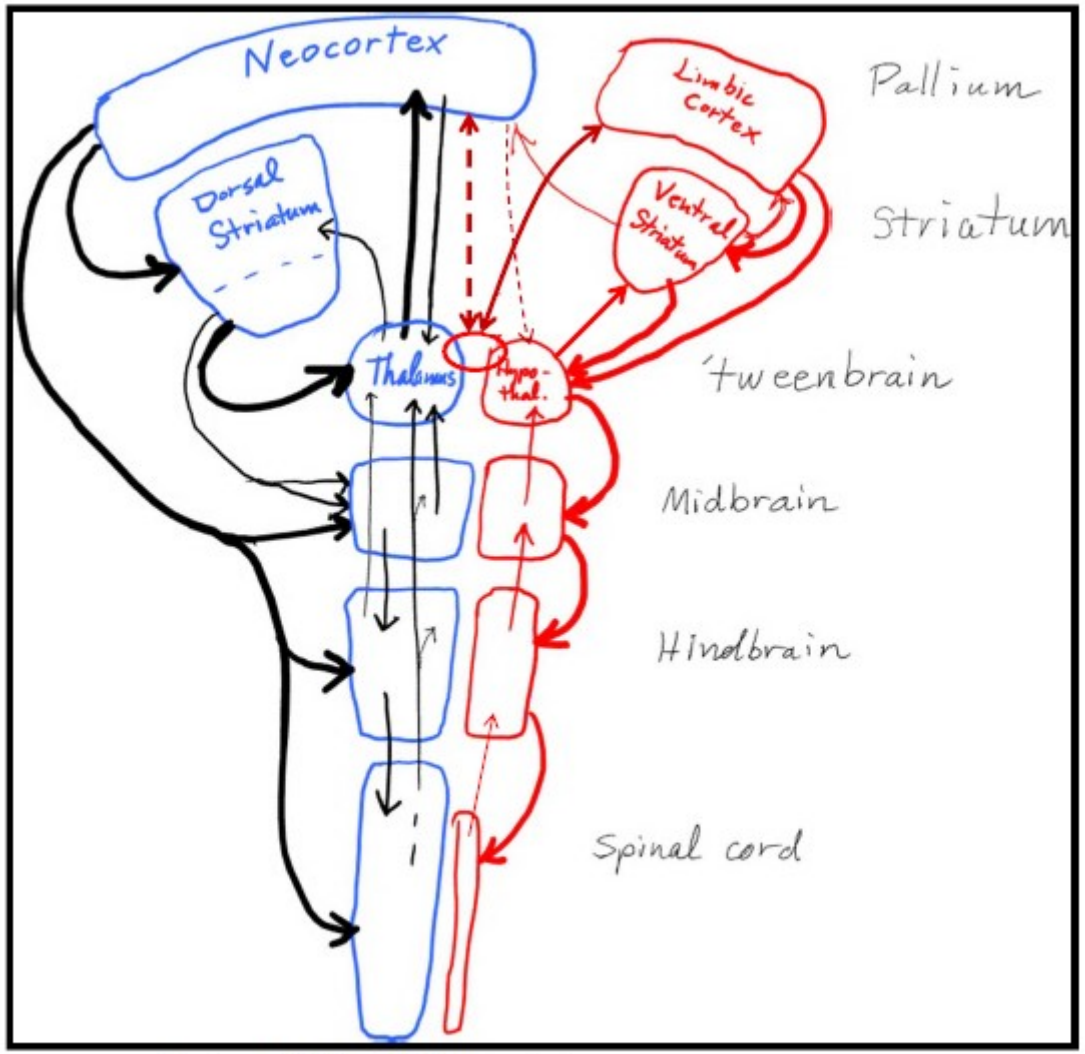
Gerald Schneider. *9.14 Brain Structure and Its Origins, Spring 2014*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed). License:Creative Commons BY-NC-SA



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83. The importance of limbic system and brief characterization of basic functions – somatic and limbic arousal systems, sleep and wakefulness

- Concept, definition and structures of limbic system
  - Integration of information from inner and outer environemnt
  - Hypothalamus is a central structure…
- Somatic vs. limbic arousal system
- Habituation, association with reward punishing system, connections…
- Sleep/wakefulness – cooperation of somatic and limbic activation system via neuromodulation
- Phases of sleep, basic EEG characteristics

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84. The importance of limbic system and brief characterization of basic functions – learning and memory, the influence of hypothalamus on neocortex, the role of amygdala

- Concept, definition and structures of limbic system
  - Integration of information from inner and outer environemnt
  - Hypothalamus is a central structure…
  - Brief overview of hypothalamic functions
  - Influence of hypothalamus on neocortex
- Learning and memory
  - Learning is based on plasticity, learning is forming of long-term memory
  - Explicit memory – hippocampus
  - Implicit memory - striatum
- Amygdala
  - Influence of information from outside (neocortex) on limbic system
  - Amygdal hijack, affective tags

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