Human Physiology, Motor System

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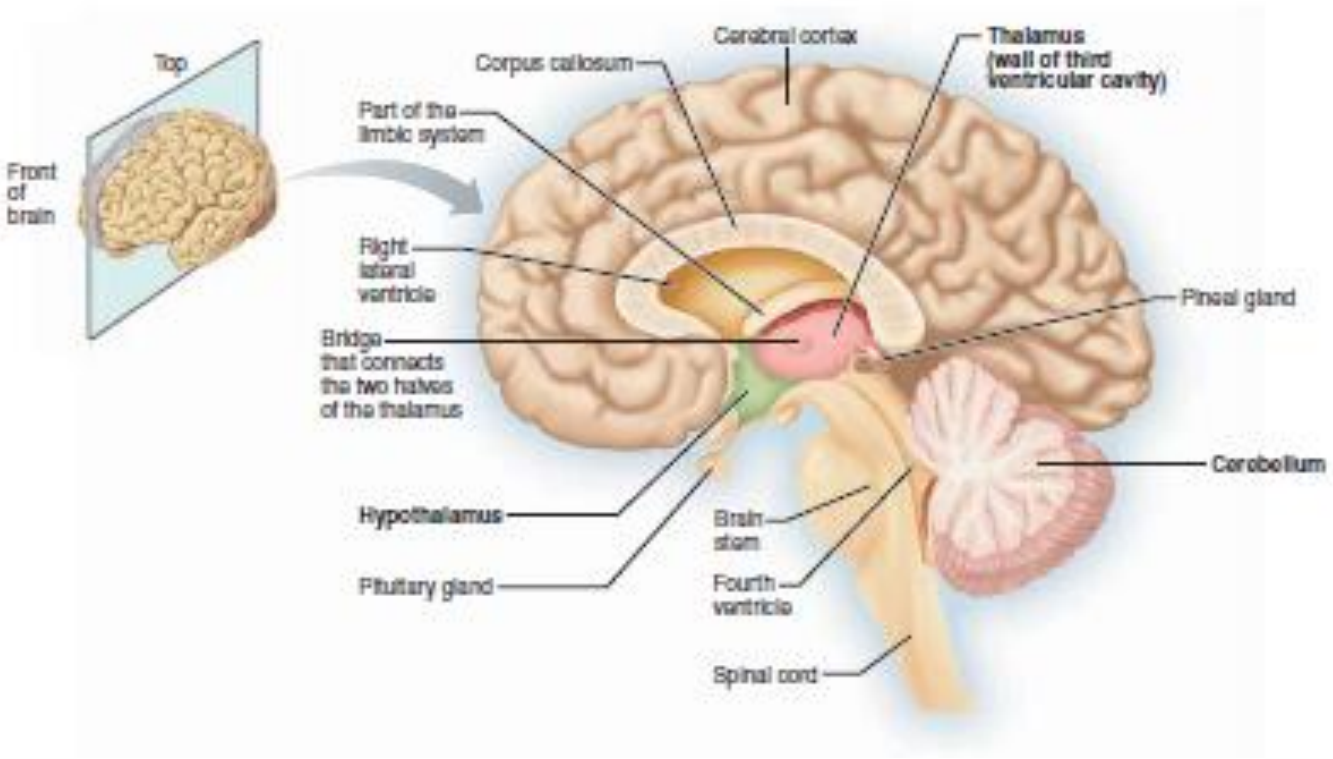
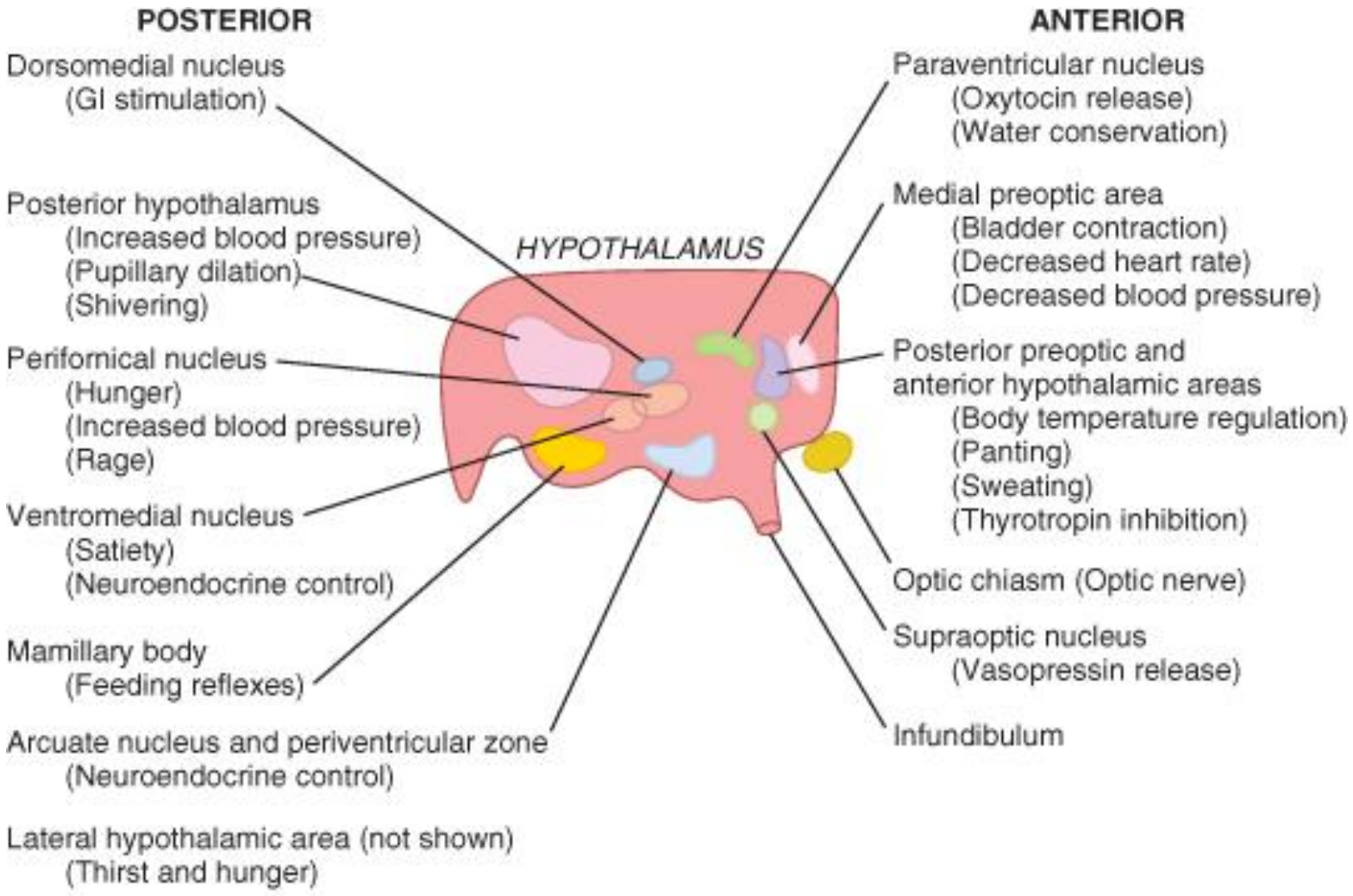
THE Thalamus & Hypothalamus

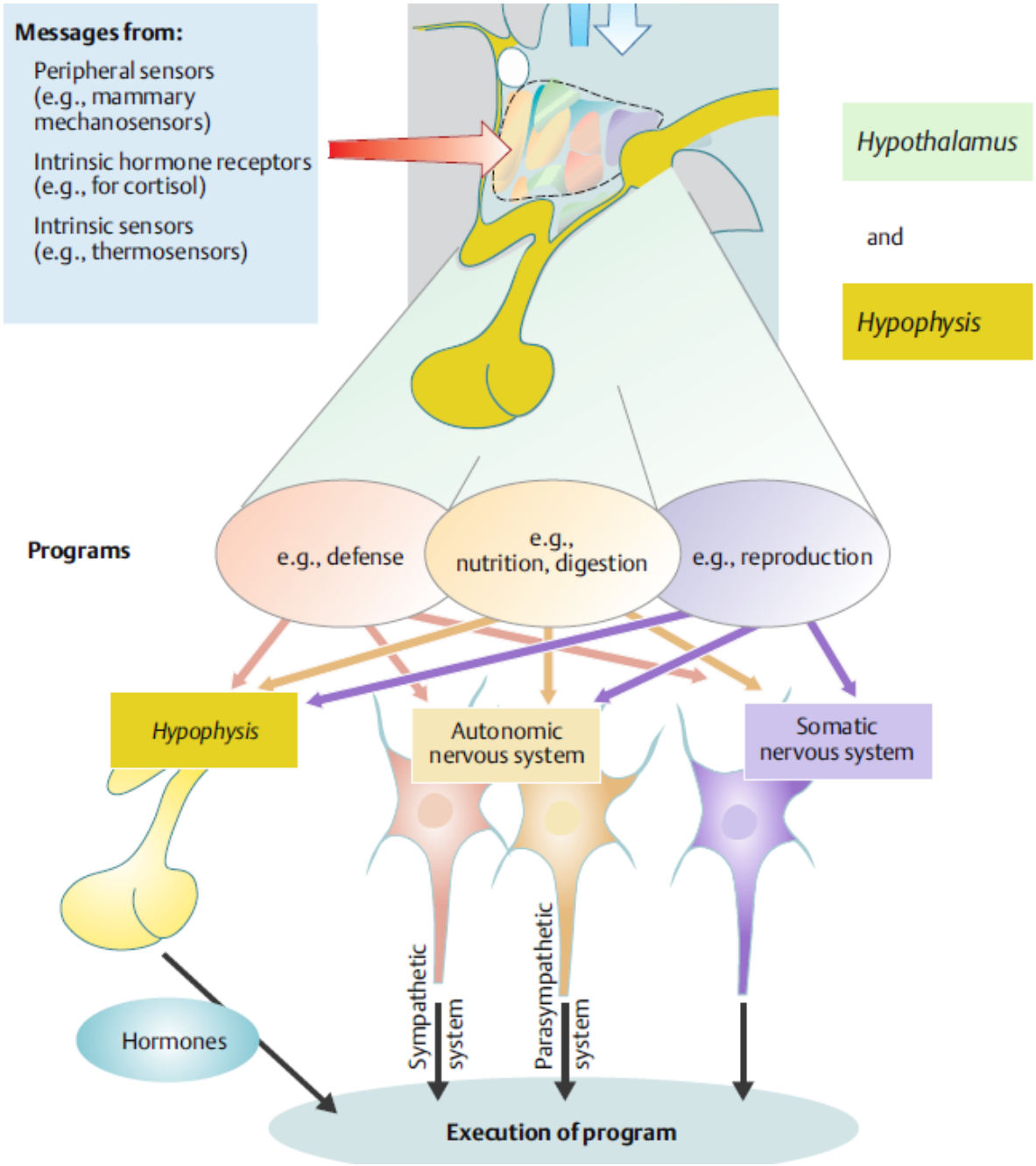


THE THALAMUS

- The thalamus is sensory relay station and is important in motor control
- Screen out insignificant signals and routes the important sensory impulses to somatosensory cortex
- Motor control by positively reinforcing voluntary motor behavior initiated by the cortex

Hypothalamus




Messages from:
Peripheral sensors (e.g., mammary mechanosensors)
Intrinsic hormone receptors (e.g., for cortisol)
Intrinsic sensors (e.g., thermosensors)
Hypothalamus
and
Hypophysis
Programs
e.g., defense
e.g., nutrition, digestion
e.g., reproduction
Hypophysis
Autonomic nervous system
Somatic nervous system
Sympathetic system
Parasympathetic system
Hormones
Execution of program

Cardiovascular regulation

- Stimulation of posterior and lateral hypothalamus increases the arterial pressure and heart rate
- Stimulating the pre optic area decreases both heart rate and arterial pressure
- These effects are transmitted through specific cardiovascular centers in reticular regions of pons and medulla

Regulation of body water

- Hypothalamus regulates body water in two ways

1- By creating the sensation of thirst. When fluid electrolytes in this center become too much concentrated, the animal develops an intense desire to drink water

2- By controlling the excretion of water into the urine. Centers in the supra optic nuclei

- When the body fluids become too concentrated, the neurons of this area become stimulated
- Send fibers through infundibulum to posterior pituitary
- Nerve endings secrete ADH, absorbed into blood, transported to kidneys, increase absorption of water in collecting ducts

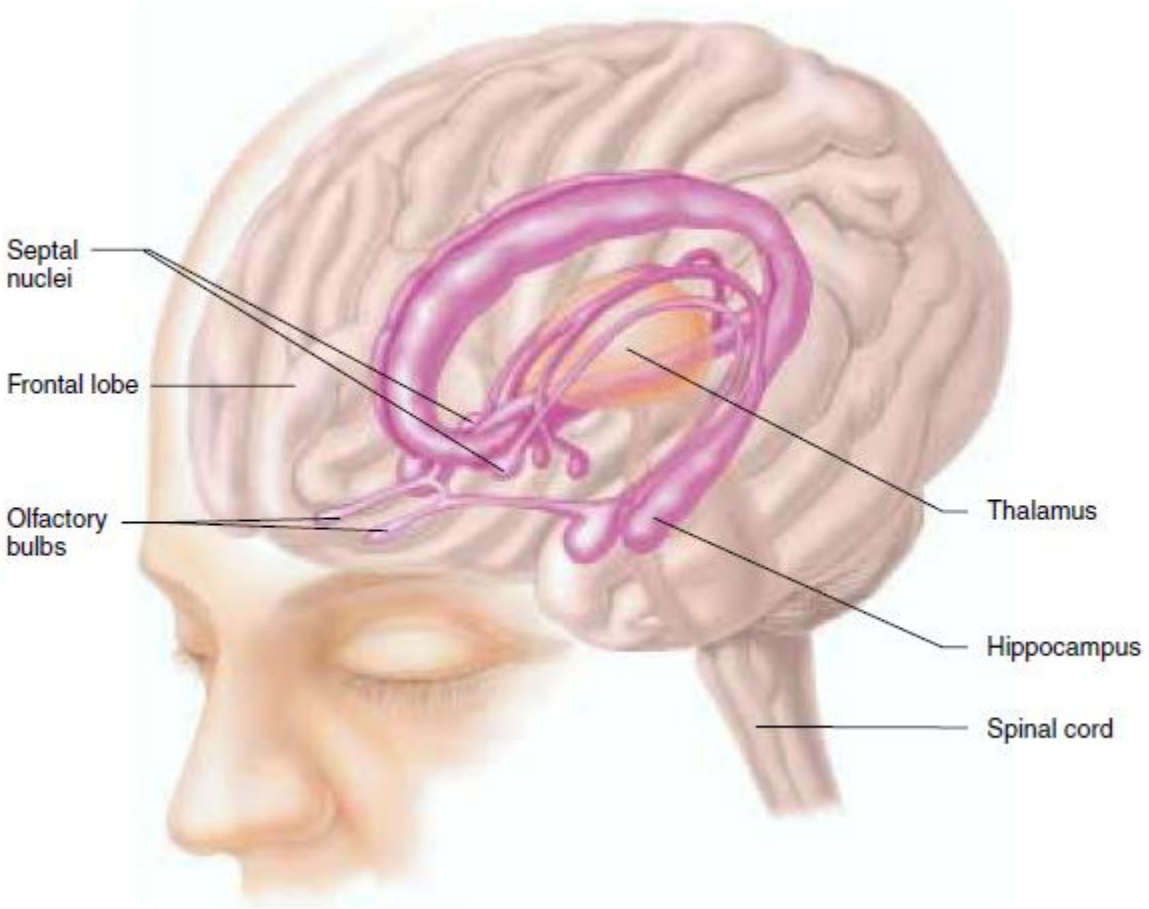
Regulation of uterine contraction and milk ejection

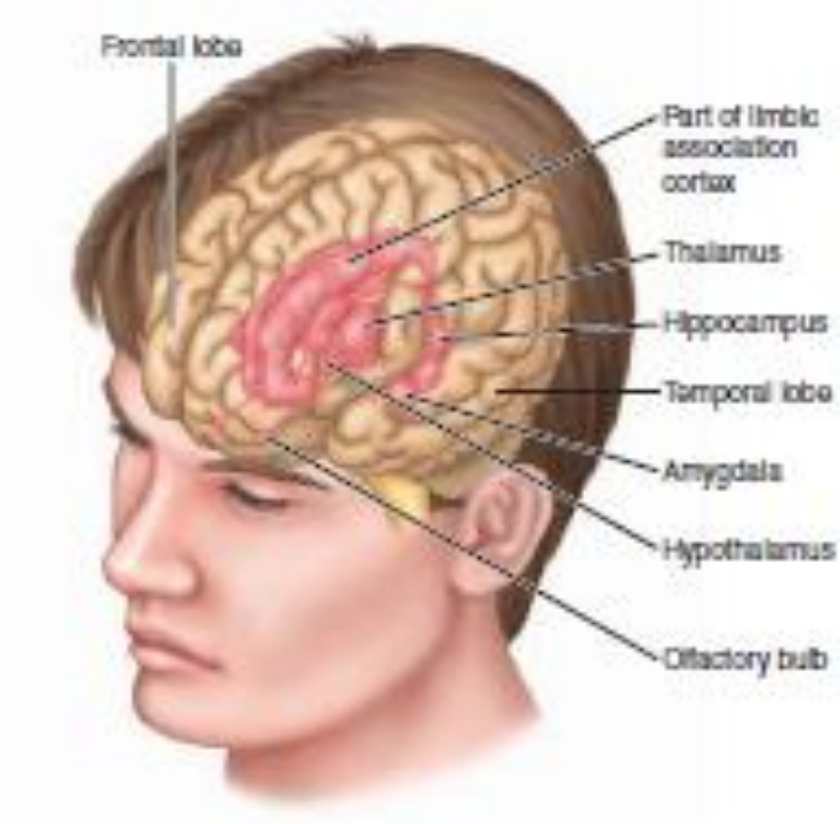
- Centers in paraventricular nuclei
- Secrete oxytocin in posterior hypothalamus
- Increase contractility of uterus
- Increase contractility of myoepithelial cells surrounding the alveoli of breast

Regulation of body temperature

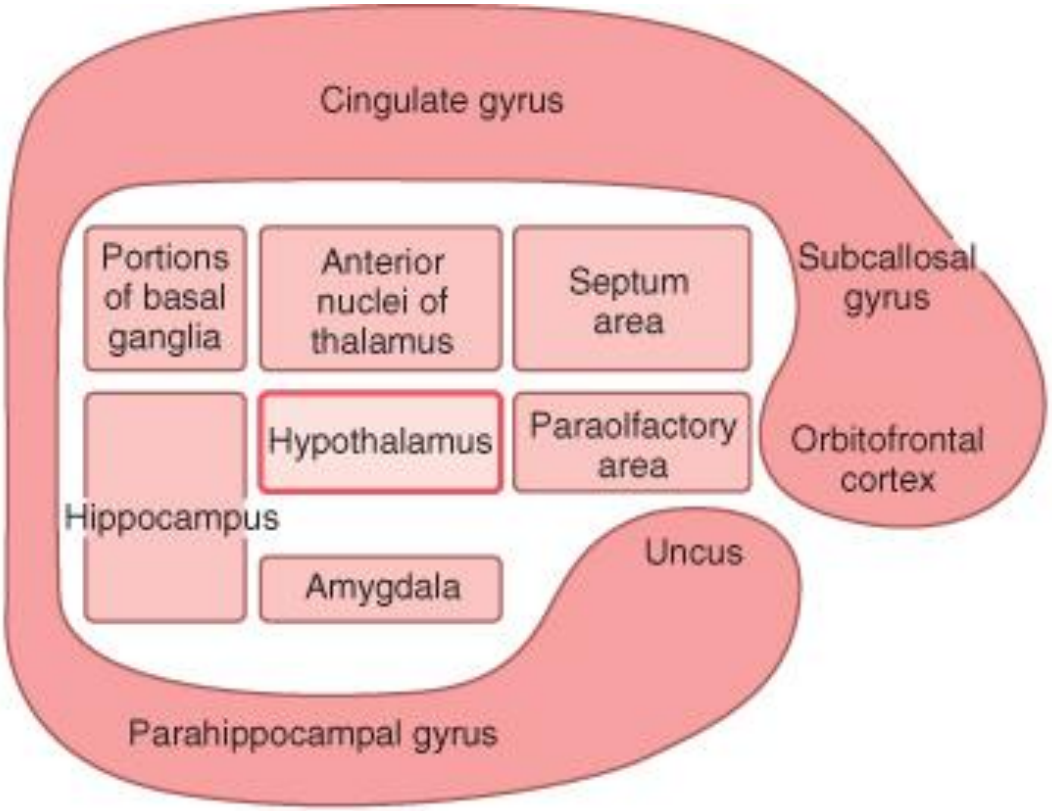
- Pre optic area of anterior hypothalamus regulates the body temperature
- Mechanism of temperature regulation

LIMBIC SYSTEM




Frontal lobe
Part of limbic association cortex
Thalamus
Hippocampus
Temporal lobe
Amygdala
Hypothalamus
Olfactory bulb

Components



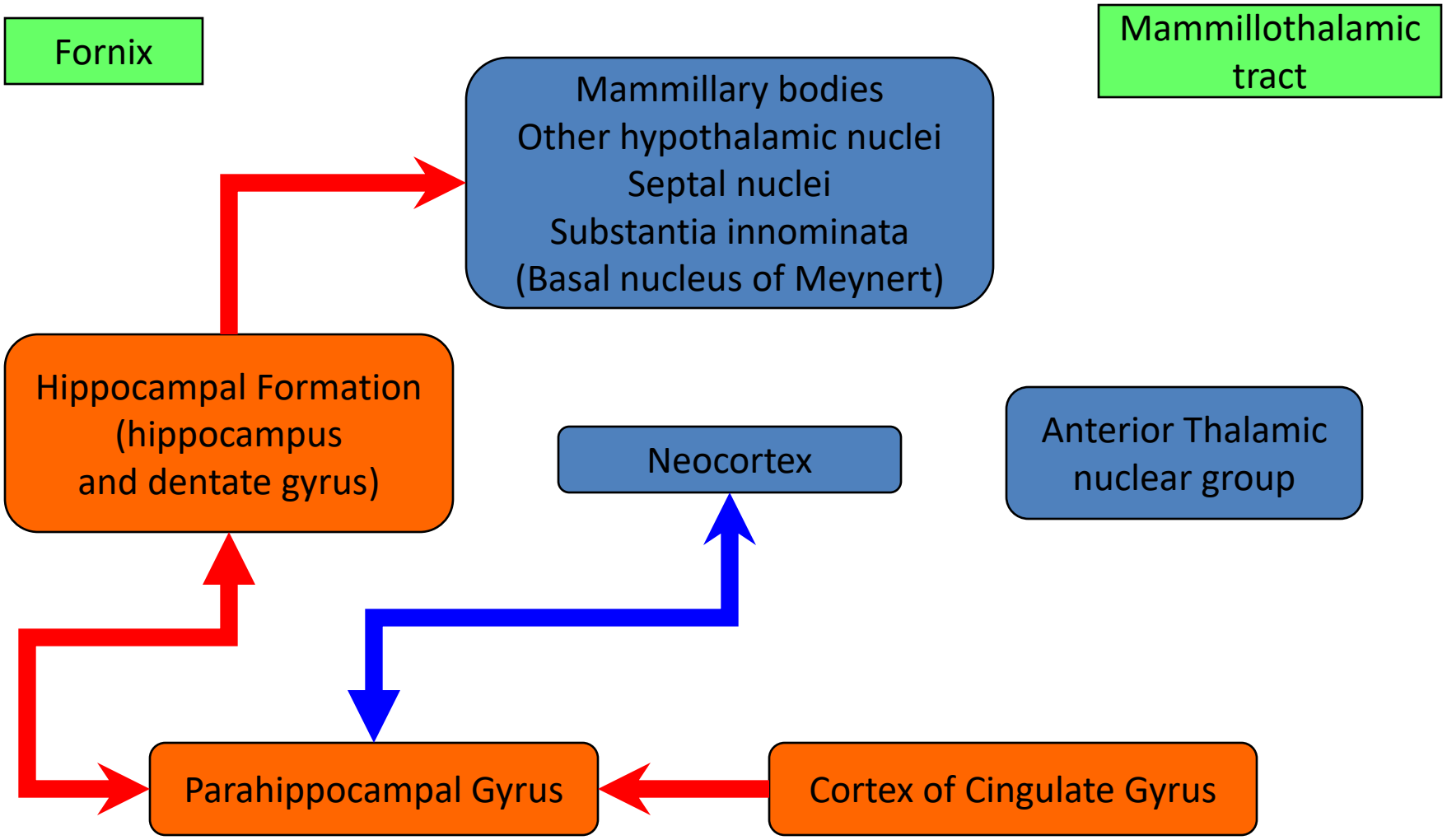
Functions

- “Emotional brain
  - Emotional and motivational aspects of behavior.
  - Provides emotional component to learning process:
    - Especially the amygdala.
- Associated with memory
  - Especially the hippocampus.
- Associated with pain/pleasure, rage

Emotions and Behaviour

- The limbic system plays a key role in emotions
- Love
- Hate
- Joy
- Shame
- Guilt
- Fear
- Anxiety

Papez Circuit (Emotions)



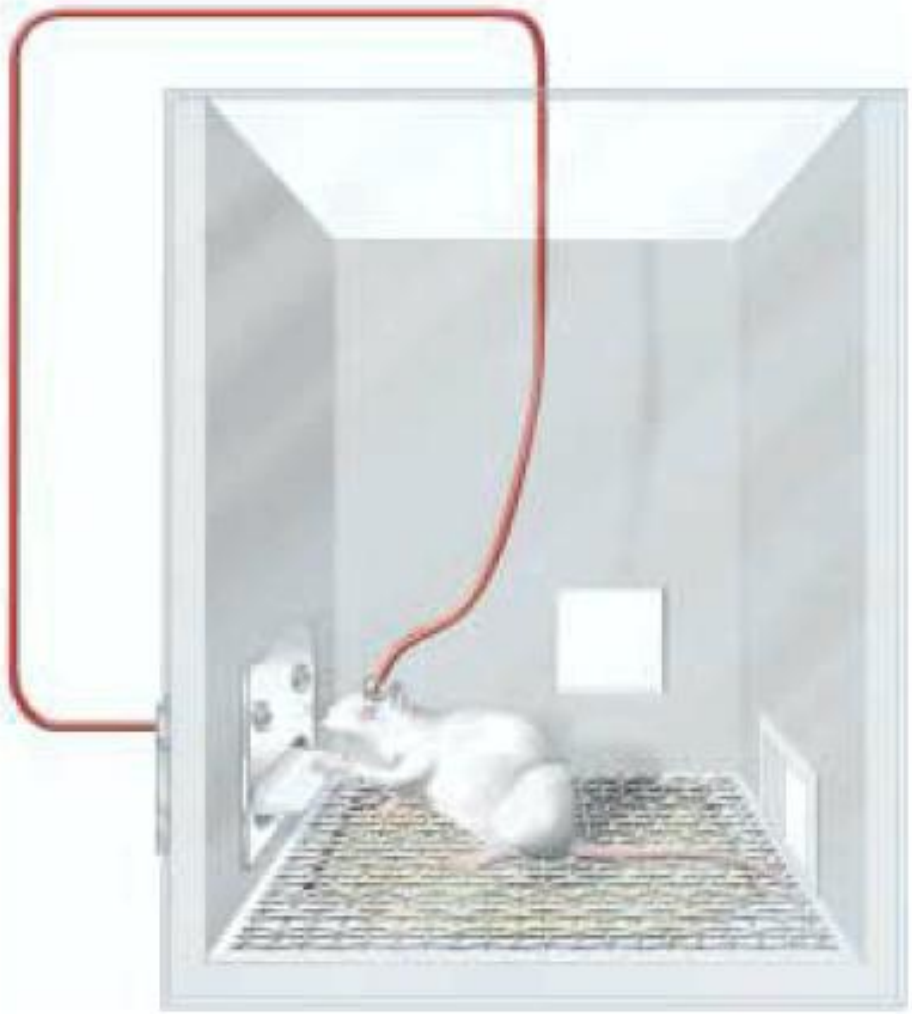
Reward and punishment functions of limbic system

- Whether the sensations are pleasant or unpleasant
- Major reward centers

→located along the course of the medial forebrain bundle,especially in lateral and ventromedial nuclei of hypothalamus

- Less potent reward centers

→septum, amygdala, certain areas of thalamus and basal ganglia



Punishment centers

- Most potent areas

→ central gray area surrounding the aqueduct of sylvius in the mesencephalon extending upward in the periventrivular zones of hypothalamus and thalamus

- Less potent punishment areas

→amygdala, hippocampus

Administration of a tranquilizer such as chlorpromazine, inhibits both reward and punishment centers

Functions of hippocampus

- Location
- Sensory experience → activation of some part of hippocampus → many out going signals to the anterior thalamus, hypothalamus and other parts of limbic system especially through the fornix→ Pleasure, rage, excess, sex drive etc
- Hyperexcitability of hippocampus

  → psychomotor effects including olfactory,visual, auditory, tactile and other types of hallucinations
- It's lesion leads to anterograde amnesia (unable to establish new long term memories)

Amygdala

- Large nuclear group in temporal lobe.
- Afferents:

Olfactory tract

Solitary nucleus

Parabrachial nucleus

Limbic neocortex:

Cingulate gyrus

Parahippocampal gyrus

- Large basolateral region:

  Provides direct input to basal ganglia and motor system.

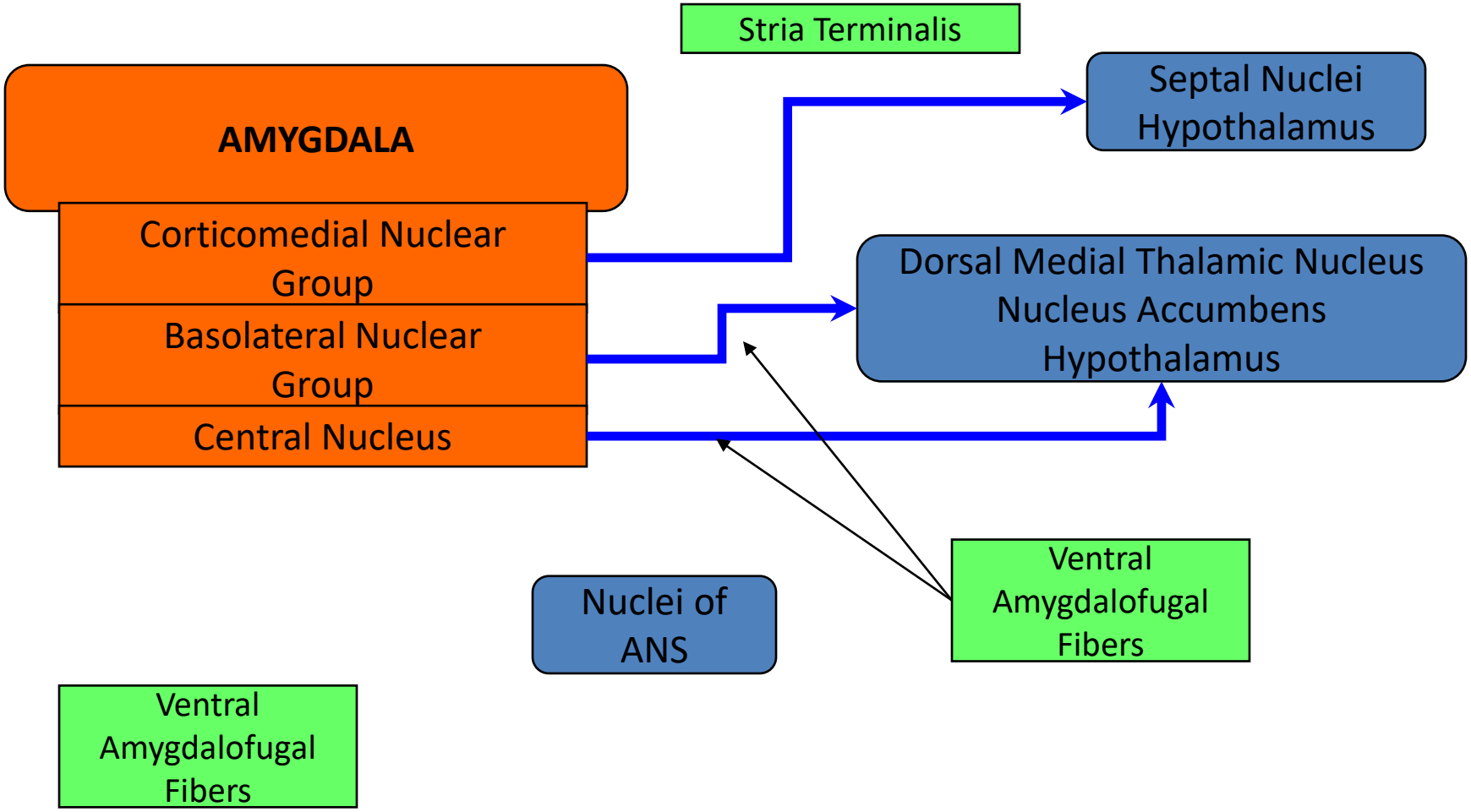
- Small corticomedial group of nuclei:

  Related to olfactory cortex.

- Medial and central nuclei:

  Connected to hypothalamus.

Amygdala Outputs



Functions

- Relate environmental stimuli to coordinated behavioral autonomic and endocrine responses seen in species-preservation.
- Responses include:

  Feeding and drinking

  Agnostic (fighting) behavior

  Mating and maternal care

  Responses to physical or emotional stresses.

Lesions

- Voracious appetite
- Increased (perverse) sexual activity
- Docility:
  - Loss of normal fear/anger response
- Memory loss:
  - Damage to hippocampus portion:
    - Cells undergoing calcium-induced changes associated with memory

Kluver-Bucy Syndrome:

- Results from bilateral destruction of amygdala.
- Characteristics:

Increase in sexual activity.

- Compulsive tendency to place objects in mouth.
- Decreased emotionality.
- Changes in eating behavior.
- Visual agnosia.

Learning & Memory

- Learning is the acquisition of knowledge as a result of experience
- Memory is laid down in stages
- Memory traces
- Consolidation
- Working memory (*function of prefrontal cortex)
- Short term memory→ that lasts for seconds or minutes unless they are converted into long term memory
- Intermediate long term memory → that lasts for days to weeks but then fade away
- Long term memory→ which once stored can be recalled up to years or even life time later

Functions of working memory

- Plan for the future
- Decision making
- Delay action in response to incoming sensory signals
- Considers the consequences of motor actions before they are performed
- Solve complicated mathematical, legal, philosophical problems

Consolidation of memory

- Short term memory if activated repeatedly will initiate chemical, physical and anatomical changes in the synapses
- Requires 5-10 min. for minimal and 1 hr. for strong consolidation
- Brain convulsions and deep general anesthesia can prevent consolidation
- Person can remember small amounts of information studied in depth far better than large amount of information studied only superficialy
- A person who is wide awake can consolidate memories far better than a person who is in a state of mental fatigue

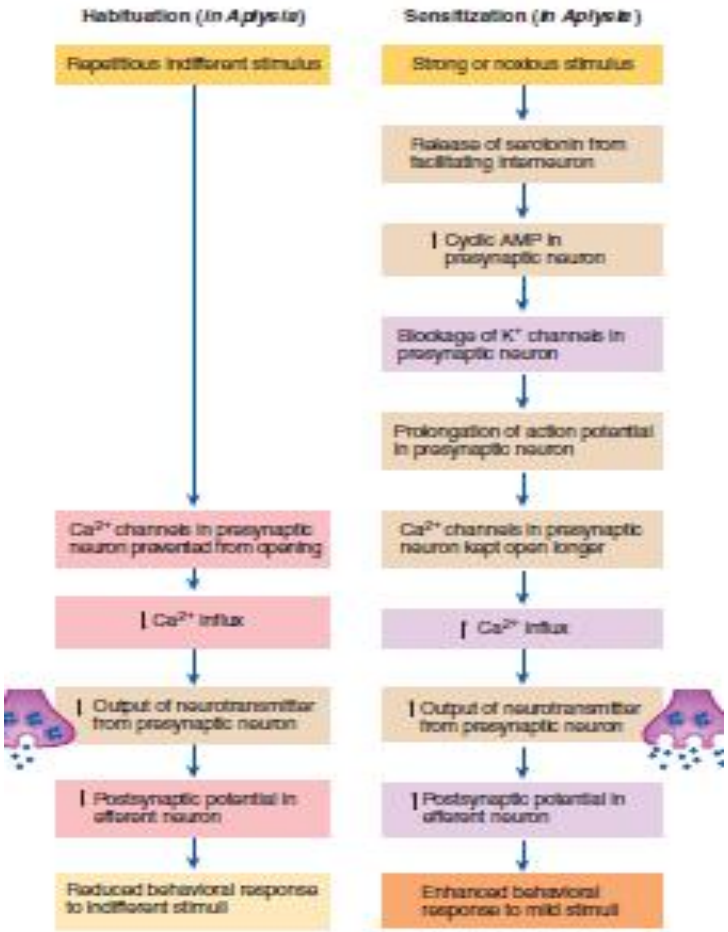
Comparison of short term and long tem memory

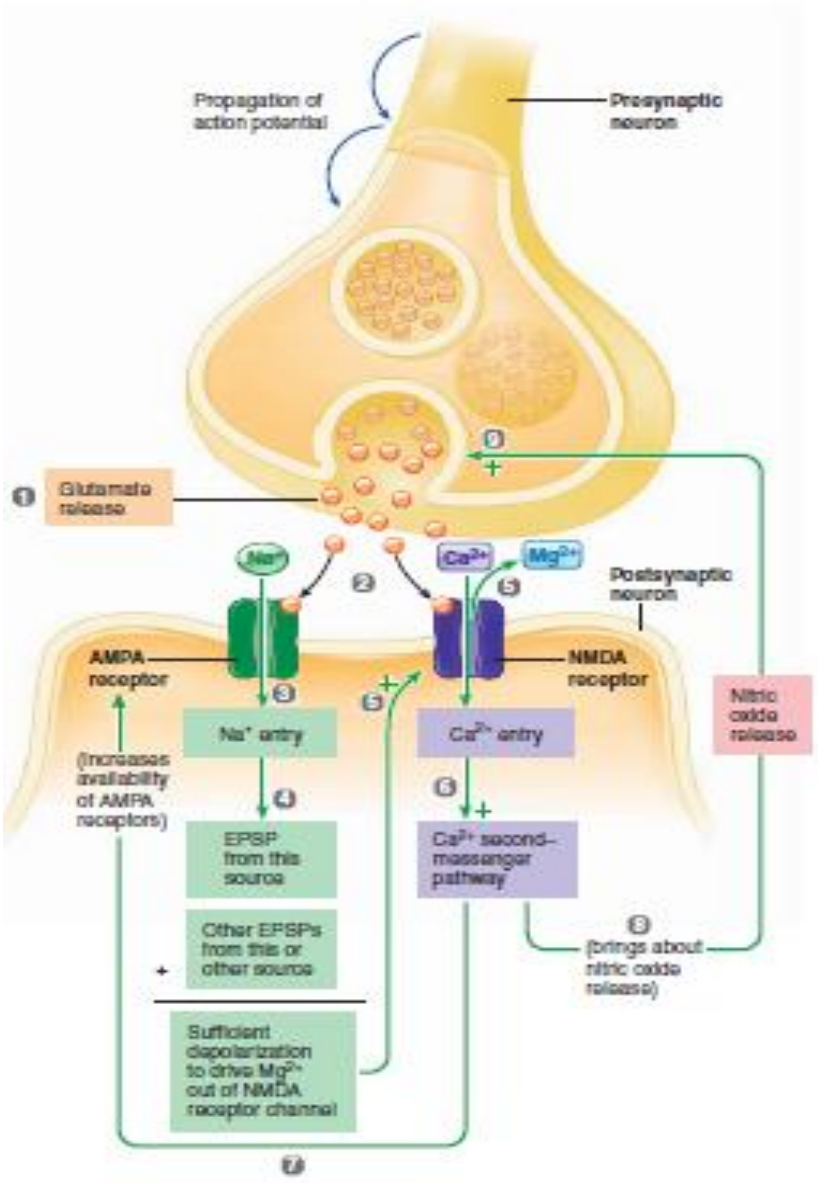
- Time of storage after acquisition of new information
- Duration
- Capacity of storage
- Retrieval time (remembering)
- Inability to retrieve (forgetting)
- Mechanism of storage
- Amnesia

Characteristic	Short-Term Memory	Long-Term Memory
Time of Storage after Acquisition of New Information	Immediate	Later; must be transferred from short-term to long-term memory through consolidation; enhanced by practice or recycling of information through short-term mode
Duration	Lasts for seconds to hours	Retained for days to years
Capacity of Storage	Limited	Very large
Retrieval Time (remembering)	Rapid retrieval	Slower retrieval, except for thoroughly ingrained memories, which are rapidly retrieved
Inability to Retrieve (forgetting)	Permanently forgotten; memory fades quickly unless consolidated into long-term memory	Usually only transiently unable to access; relatively stable memory trace
Mechanism of Storage	Involves transient modifications in functions of preexisting synapses, such as altering amount of neurotransmitter released	Involves relatively permanent functional or structural changes between existing neurons, such as formation of new synapses; synthesis of new proteins plays a key role

Short-term & Long-term memory involve different molecular mechanisms

- Short-term memory involves transient changes in synaptic activity
- Mechanism of habituation
- Mechanism of sensitization
- Mechanism of long term potentiation (LTP)
- Long-term memory involves formation of permanent synaptic connections
- Memory traces are present in multiple regions of the brain

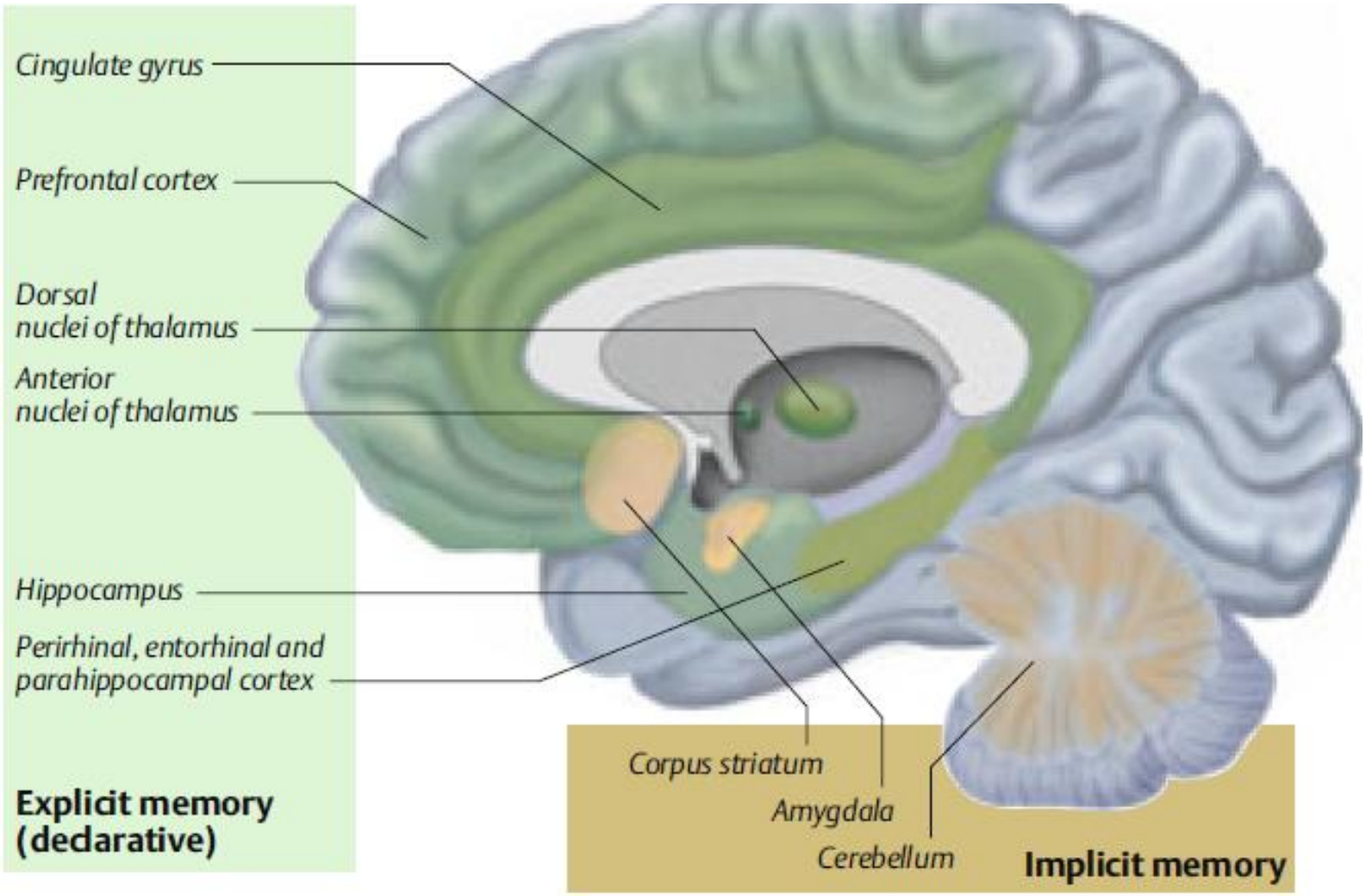

Habituation (*in Aplysia*)
Repetitious indifferent stimulus
Ca^{2+} channels in presynaptic neuron prevented from opening
↓ Ca^{2+} influx
↓ Output of neurotransmitter from presynaptic neuron
↓ Postsynaptic potential in efferent neuron
Reduced behavioral response to indifferent stimuli
Sensitization (*in Aplysia*)
Strong or noxious stimulus
Release of serotonin from facilitating interneuron
↑ Cyclic AMP^2 in presynaptic neuron
Blockage of K^+ channels in presynaptic neuron
Prolongation of action potential in presynaptic neuron
Ca^{2+} channels in presynaptic neuron kept open longer
↑ Ca^{2+} influx
↑ Output of neurotransmitter from presynaptic neuron
↑ Postsynaptic potential in efferent neuron
Enhanced behavioral response to mild stimuli


Propagation of action potential
Presynaptic neuron
1
Glutamate release
Na+
Ca2+
Mg2+
2
5
Postsynaptic neuron
AMPA receptor
NMDA receptor
3
Na+ entry
Ca2+ entry
6
+
Nitric oxide release
(Increases availability of AMPA receptors)
4
EPSP from this source
Ca2+ second-messenger pathway
Other EPSPs from this or other source
+
8
(brings about nitric oxide release)
Sufficient depolarization to drive Mg2+ out of NMDA receptor channel
7

Neural changes in long-term memory

- Structural changes occur in synapses instead of chemical changes

1. Increase in vesicle release sites
2. Increase in number of vesicles
3. Increase in number of presynaptic terminals
4. Changes in structures of dendritic spines
5. Number of neurons and their connections often change during learning →soon after birth, a principle, use it or lose it


Cingulate gyrus
Prefrontal cortex
Dorsal nuclei of thalamus
Anterior nuclei of thalamus
Hippocampus
Perirhinal, entorhinal and parahippocampal cortex
Explicit memory (declarative)
Corpus striatum
Amygdala
Cerebellum
Implicit memory

Amnesia

- **Anterograde amnesia:**
- Hippocampal lesion
- Unable to establish new long term memories
- **Retrograde amnesia:**
- Inabilities to recall memories from the past
- Damage to thalamic areas
- May be related to hippocampal lesions

Hippocampus damage: Alzheimr's disease

- Symptoms
- Characteristic brain lesion:
- Underlying pathology
- Possible causes
- Treatment