

ZNZ Advanced Course in Neuroscience
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Limbic System I

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Limbic system – outline

① *Introduction*

- history
- definition

② *Review of anatomy*

- amygdaloid complex
- septal complex

③ *Theories of hippocampal function*

- declarative memory
- episodic memory
- cognitive map
- relational memory

④ *The amygdala and emotion*

- theories of emotion
- fear and fear conditioning

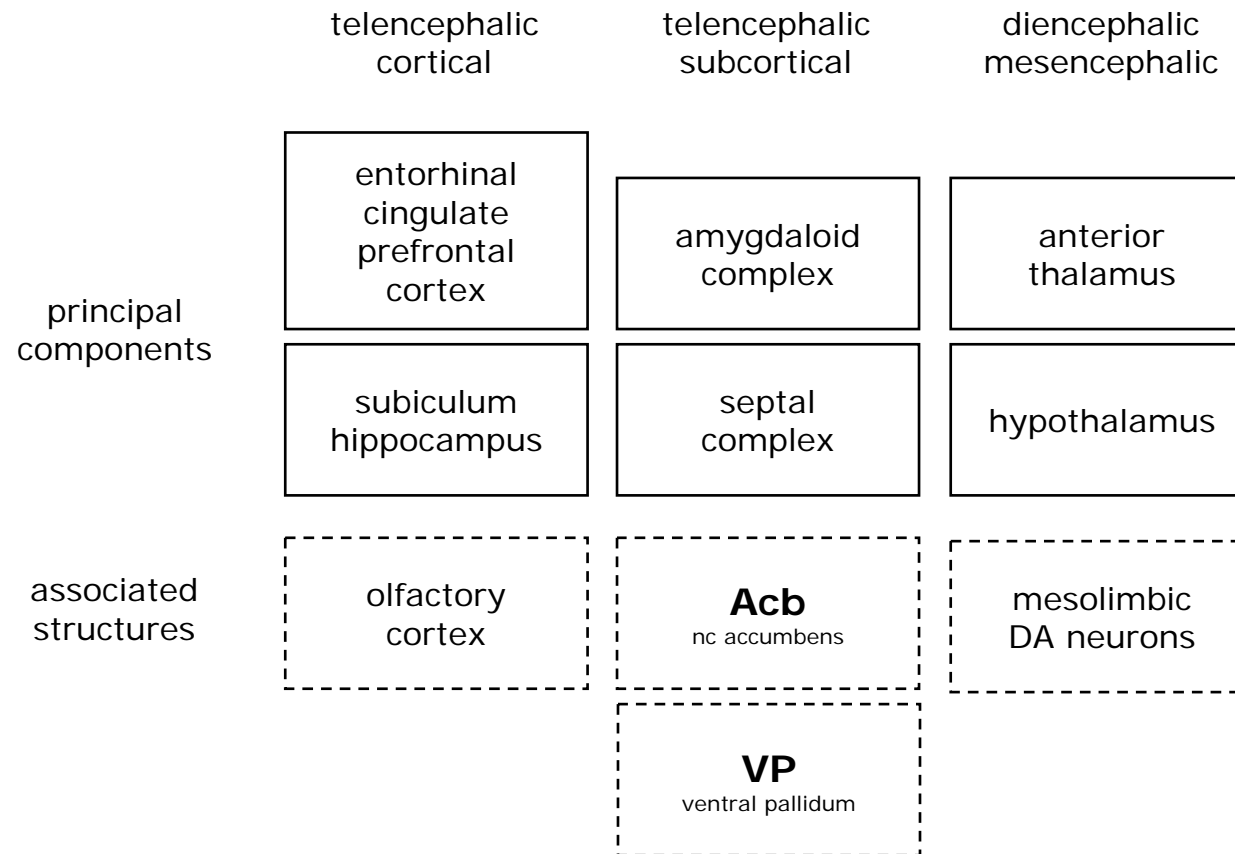
⑤ *The hippocampus beyond memory*

- exploratory behavior and anxiety
- species typical behaviors
- home cage behavior

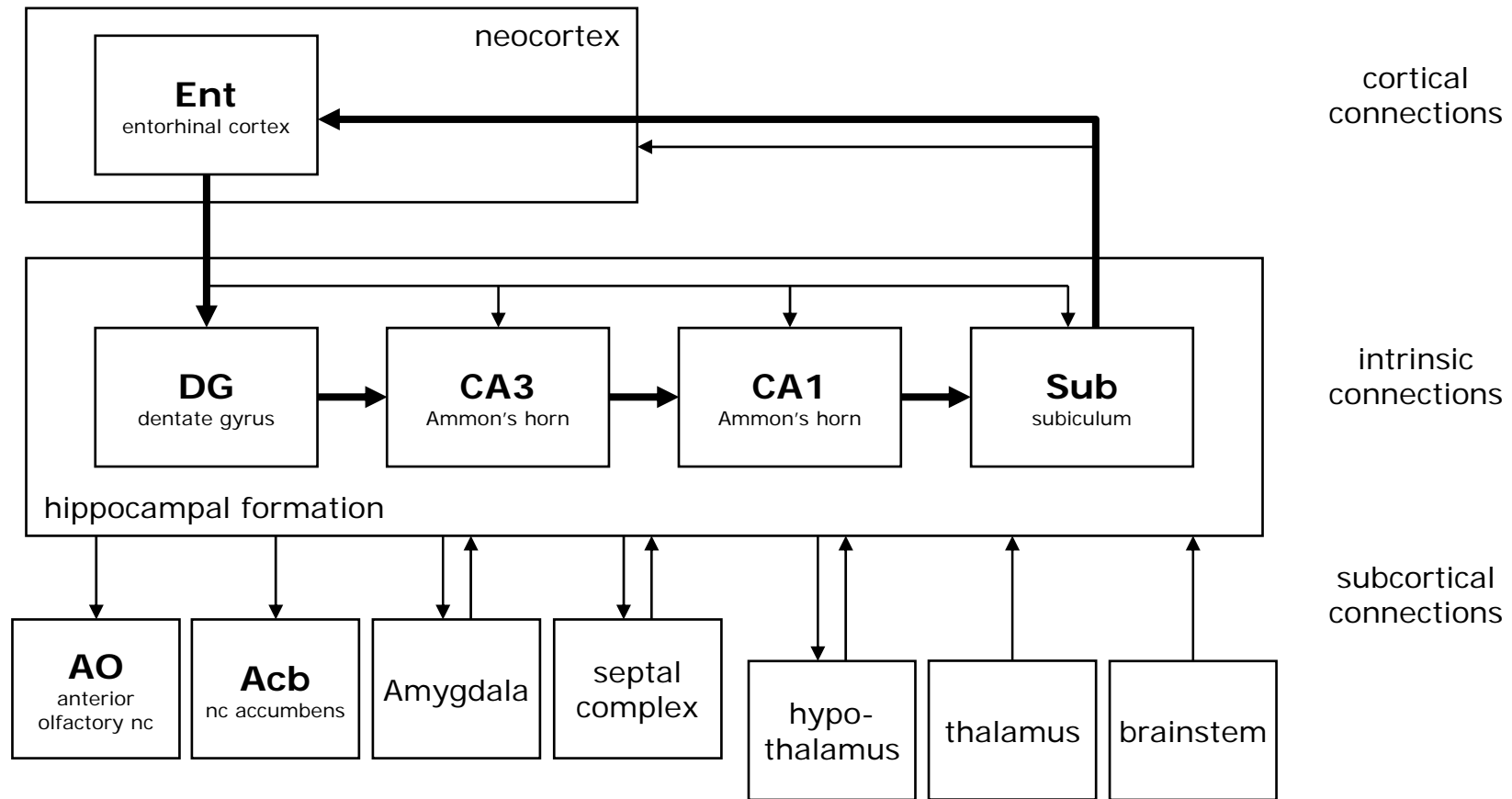
Limbic system components – history

1878	P. Broca	anatomical definition: grand lobe limbique (limbus = border, seam), structures at border between cerebral hemisphere and diencephalon: cingulate cortex, hippocampus and adjacent cortex, olfactory cortex and bulb
1928	P. Bard	hypothalamic theory of emotion: hypothalamus -> event evaluation, control of expression and experience of emotions
1929	W.B. Cannon	
1937	J. Papez	Papez circuit of emotion: cingulate cortex -> hippocampus -> hypothalamus (mammillary body) -> anterior thalamus -> cingulate cortex
1952	P. MacLean	Limbic system (old mammalian brain) as interface between reptilian brain and new mammalian brain, includes prefrontal cortex and amygdala.
1957	B. Millner W.B. Scoville	Patient H.M: identification of medial temporal lobe structures as substrate of declarative memory -> a core component of the limbic system becomes the major target of cognitive neuroscience.

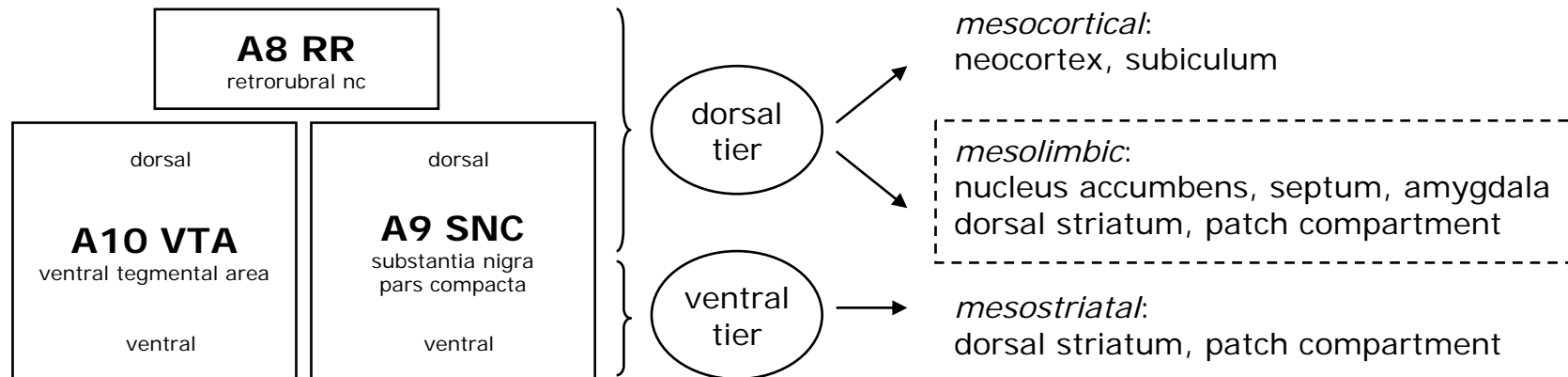
Components of the limbic system



Anatomy of the hippocampus - reminder



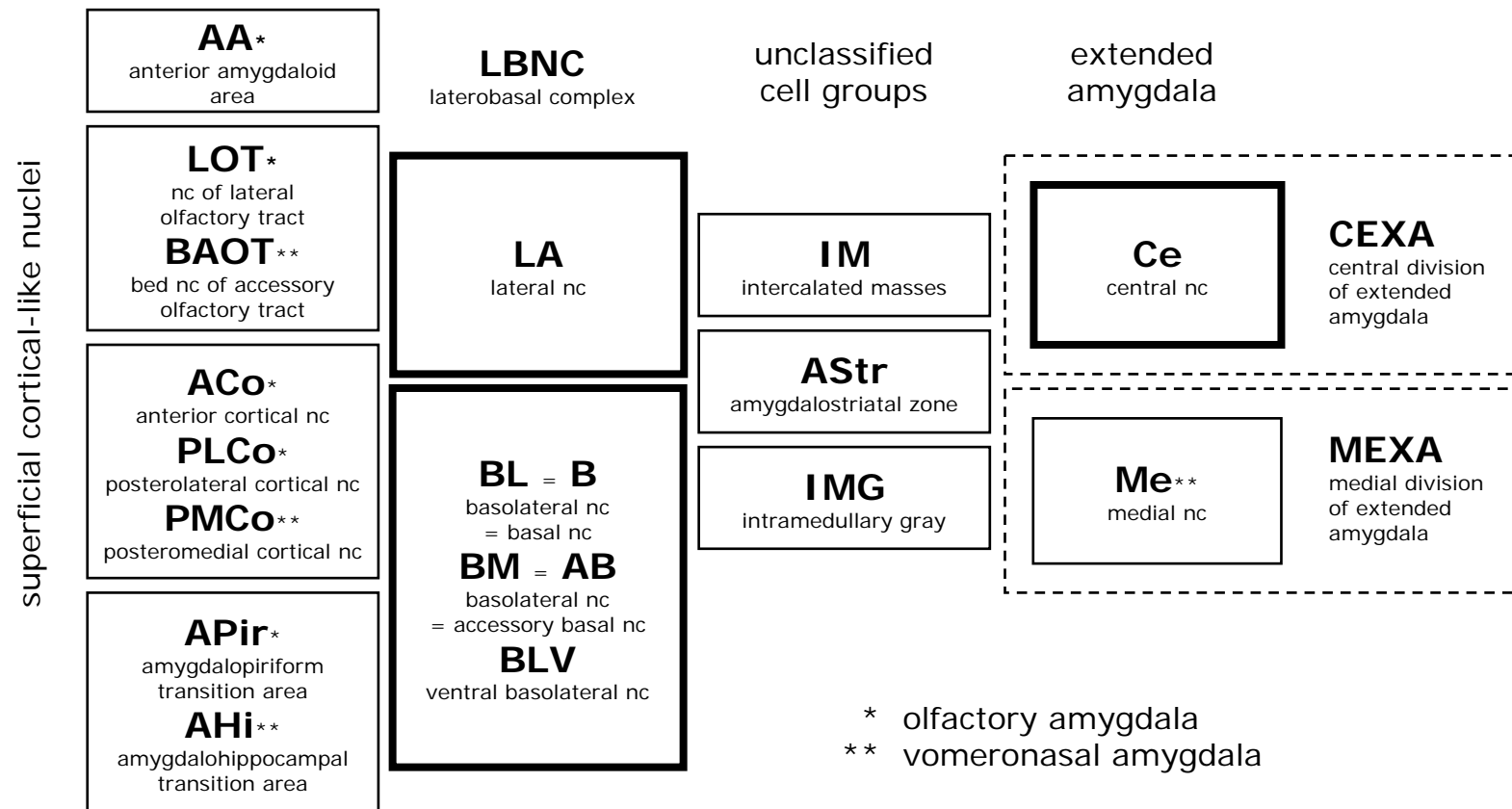
Mesolimbic dopamine system



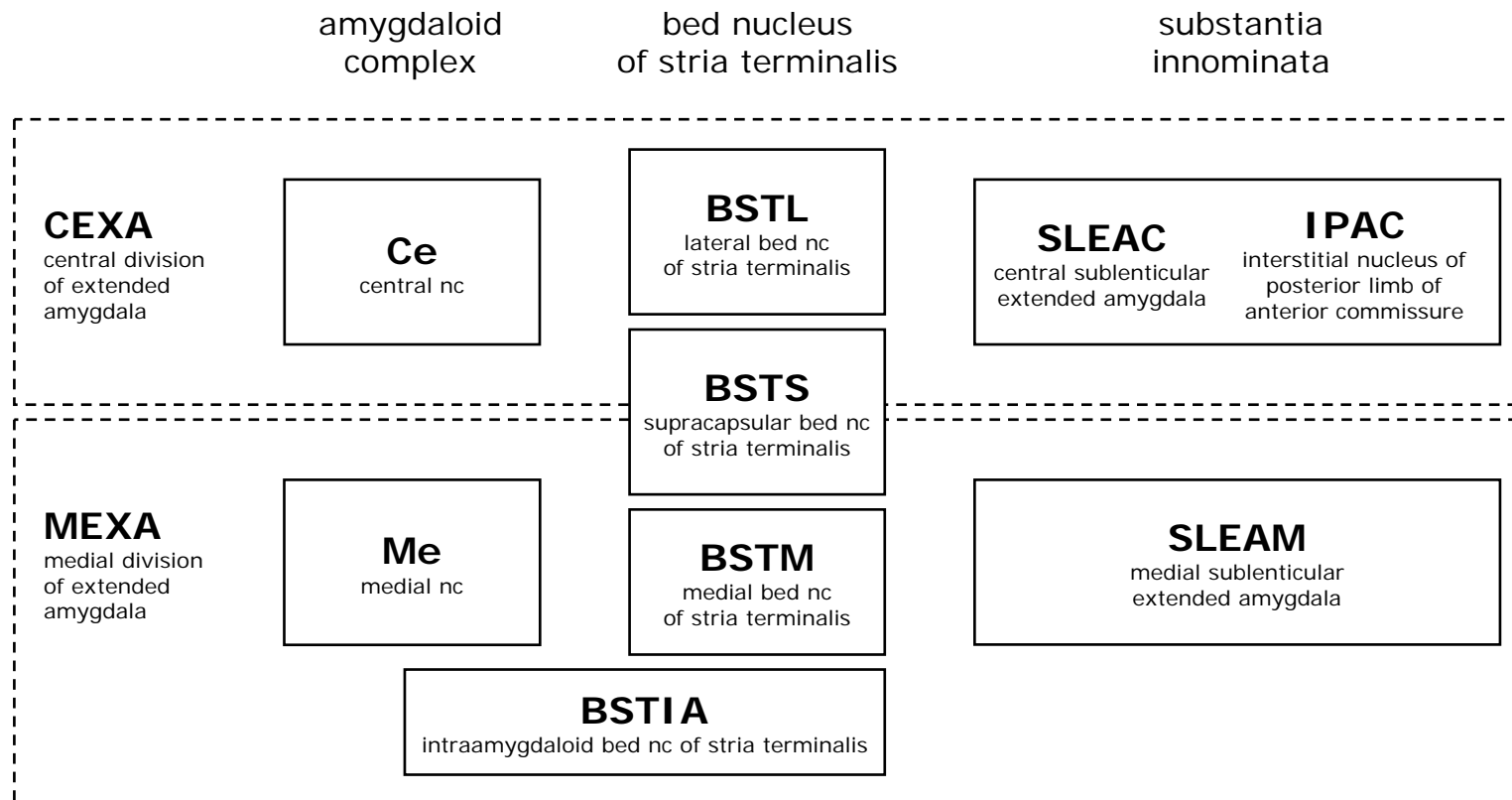
cortical innervation primates: entire cortical mantle

rodents: subiculum, entorhinal cortex, cingulate cortex, frontal cortex

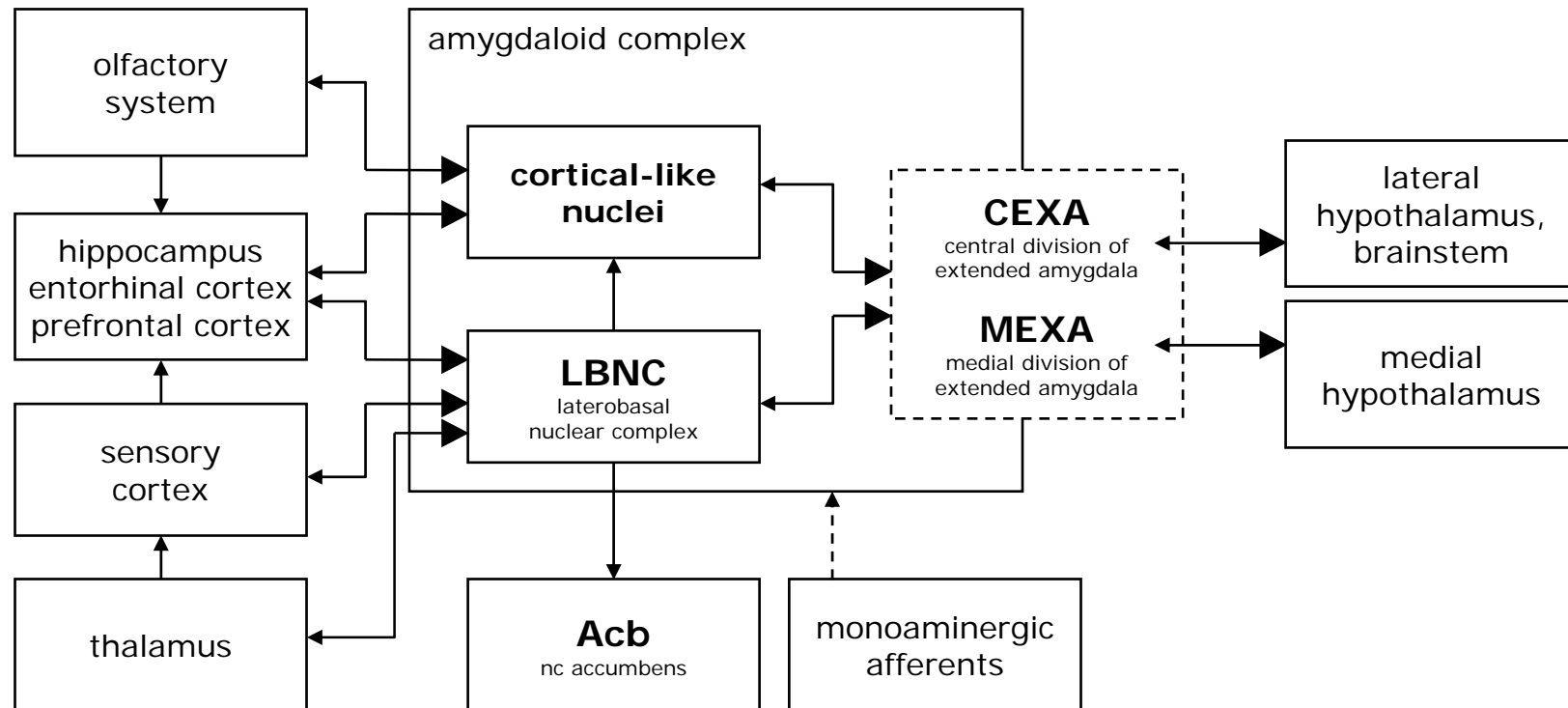
Amygdaloid complex - components



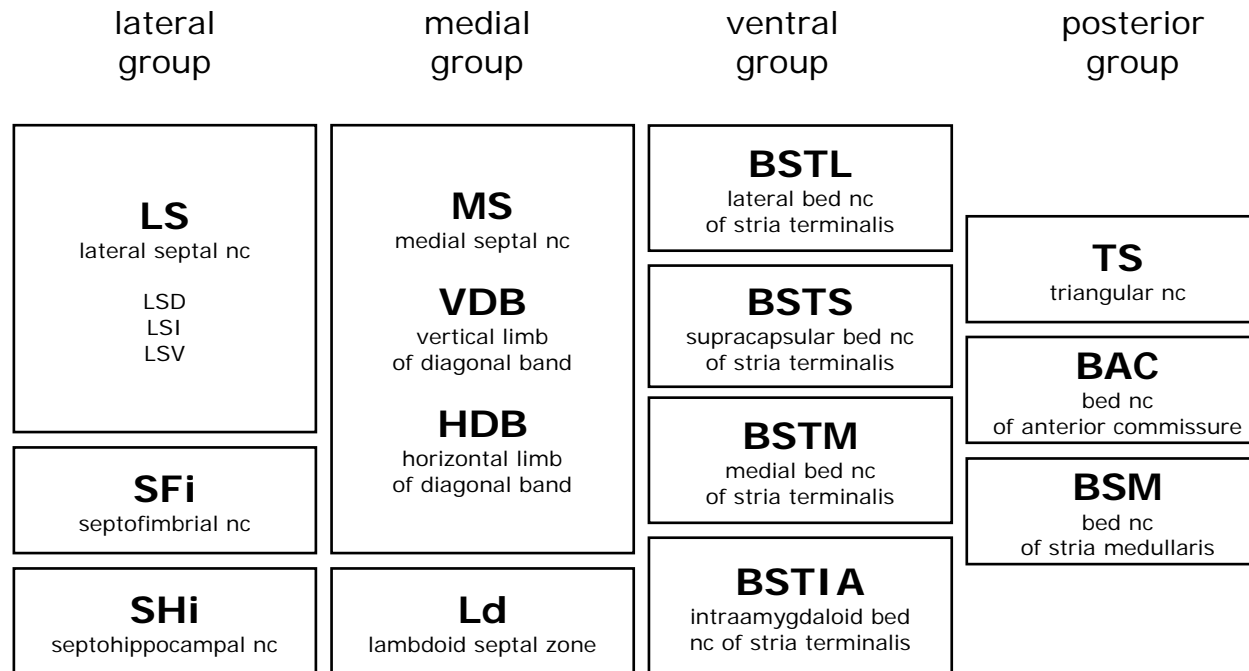
Extended amygdala



Amygdaloid complex - connections



Septal complex - components



Septal complex - connections

f
fornix

afferents (glutamate) from hippocampal formation to lateral and medial group, efferents (ACh) from medial group to hippocampus and neocortex

st
stria terminalis

afferents (glutamate and GABA) from amygdala to ventral and lateral group

sm
stria medullaris

efferents from posterior group to habenula

mfb
medial forebrain bundle

afferents to all components to hypothalamus, thalamus, brainstem. efferents from most components to hypothalamus, thalamus, brainstem

Theories of hippocampal function - history

1888	S. Brown H. Schäfer	early report of forgetfulness in a monkey with large bilateral temporal lobe lesions
until the 1930s		prevailing view of hippocampus as part of the olfactory system
1937	J.W. Papez	component of Papez circuit of emotion
1938	R. Jung A. Kornmüller	discovery of hippocampal EEG theta rhythm in rabbits, temporally linked to desynchronization of cortical EEG
1957	W. Scoville B. Milner	bilateral surgical lesions of medial temporal lobe associated with global amnesia in several patients including H.M.
1960s	R. Isaacson D. Kimble	lesion studies fail to model amnesia in monkey or rats, but show deficits of exploration and behavioral disinhibition.
1971	Hirano O. Vinogradowa	first implantations of microelectrodes to record single unit activity in the hippocampus of freely moving animals
1978	J. O'Keefe L. Nadel	the hippocampus as a cognitive map
1982	J. Gray	septo-hippocampal theory of anxiety

Theories of hippocampal function

Declarative memory theory

Hippocampus is part of a medial temporal lobe memory system that selectively mediates declarative memory in a time-limited manner.

- founded on global amnesia syndrome in human patients
- primate models of amnesia: DMTS and DNMTS tasks

Episodic memory theory

The hippocampus is a structure that mediates episodic memory, the recall of discrete events via mental time travel. Episodic-like memory in animals is the memory of "what", "when" and "where".

- founded on global amnesia syndrome in human patients
- bird model: caching of perishable and non-perishable food

Cognitive map theory

The hippocampus harbors the locale system, a memory system that represents stimuli as a cognitive map with respect to an allocentric spatial framework and permits navigation in space.

- founded on single unit recordings in freely moving animals
- rodent models: radial maze, water maze, Barnes maze

Configural, relational, contextual theories

The hippocampus is a learning system that deals flexibly with overlapping sets of stimuli in which the meaning of each stimulus may depend on temporal sequence or presence of other stimuli.

- roots in instrumental and classical conditioning
- rodent models: contextual fear conditioning, transitive inference tasks