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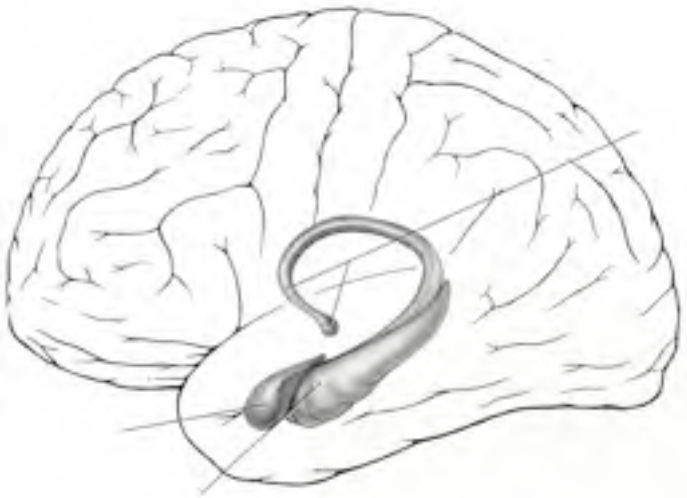
Limbic System



PD-INCL J.H. Martin. Neuroanatomy: Text and Atlas. McGraw-Hill, 2003. 3rd ed.

M1 CNS Head and Neck
March 18, 2009

Lecture Outline

- Brief Review of Cortical Function

- Neuroanatomy of Limbic System
  - Cortex
    - Hippocampus
    - Parahippocampal gyrus
    - Amygdala
    - Cingulate gyrus
    - Olfactory cortex
  - Diencephalon
    - Thalamus – Anterior nucleus, Mediodorsal nucleus
    - Hypothalamus - Medial Hypothalamus, Mammillary bodies

- Connections
  - Amygdala
  - Hippocampus – Papez Circuit

- Blood Supply

Important Terms

- Brodman Areas 4, 3, 17, 41, 42
- Primary Sensory Cortex
- Primary Motor Cortex
- Unimodal Association Areas
- Multimodal Association Areas
- Limbic Association Areas
- Limbic Cortex
- Cingulate Gyrus
- Amygdala
  - Centromedial Division
  - Central Nucleus
  - Basolateral Division
- Hippocampal Formation
  - Parahippocampal gyrus
  - Dentate
  - Subiculum
  - CA1, CA2, CA3
- Uncus
- Entorhinal Cortex
- Olfactory Bulb
- Olfactory Tract
- Forix
- Mammillary body
- Mammillothalamic Tract
- Anterior Nucleus of the Thalamus
- Mediodorsal Nucleus of the Thalamus
- Papez Circuit
- Neocortex
- Paleocortex
- Archicortex
- Stria Termialis

Functional Areas of the Cerebral Cortex

The cerebral cortex is divided into:

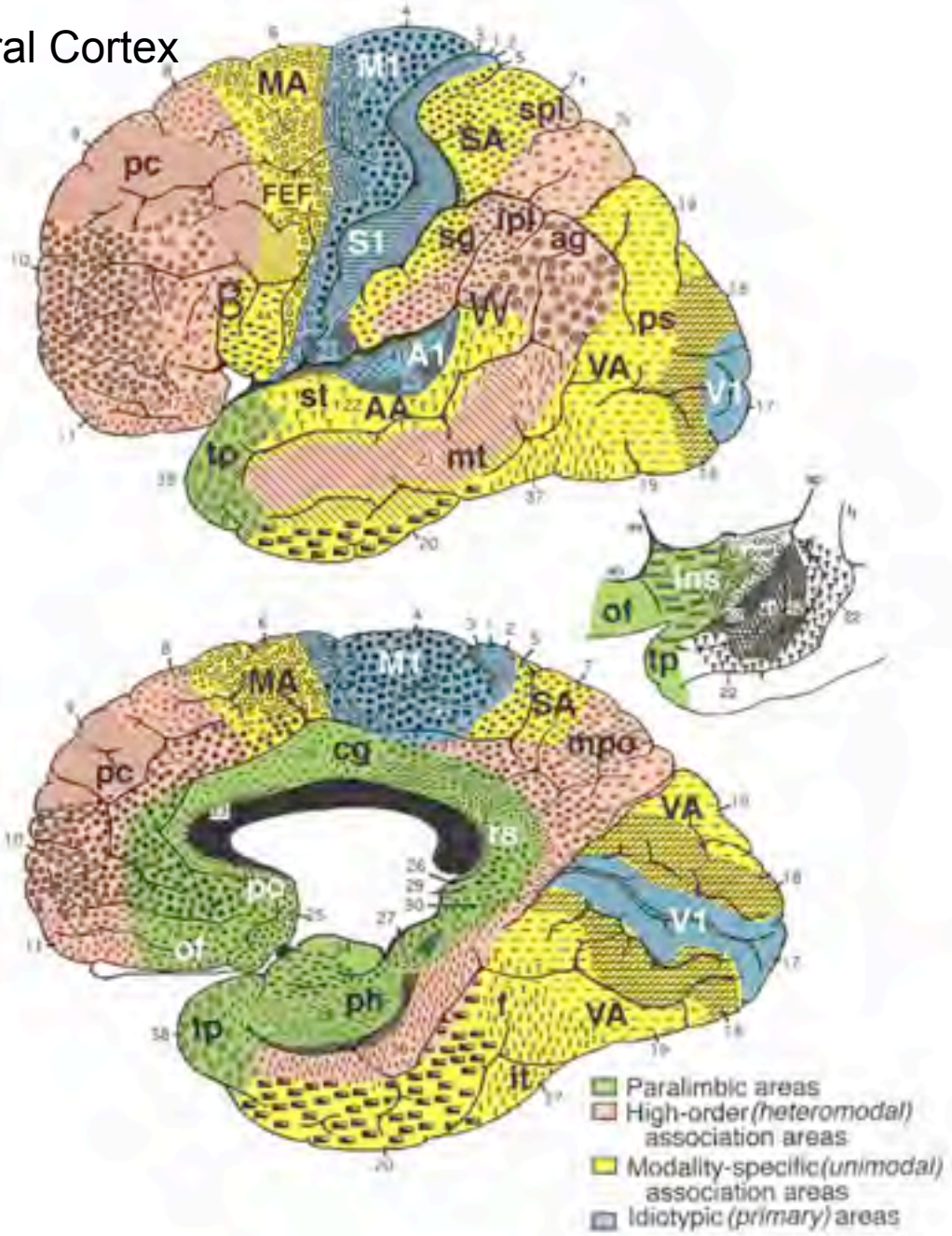
Primary motor & sensory areas
(M1, S1, A1, V1)
Brodman areas 4, 3, 41,42, 17)

Unimodal association areas
(MA, SA, AA, VA)

Multimodal association areas
(Posterior and anterior)

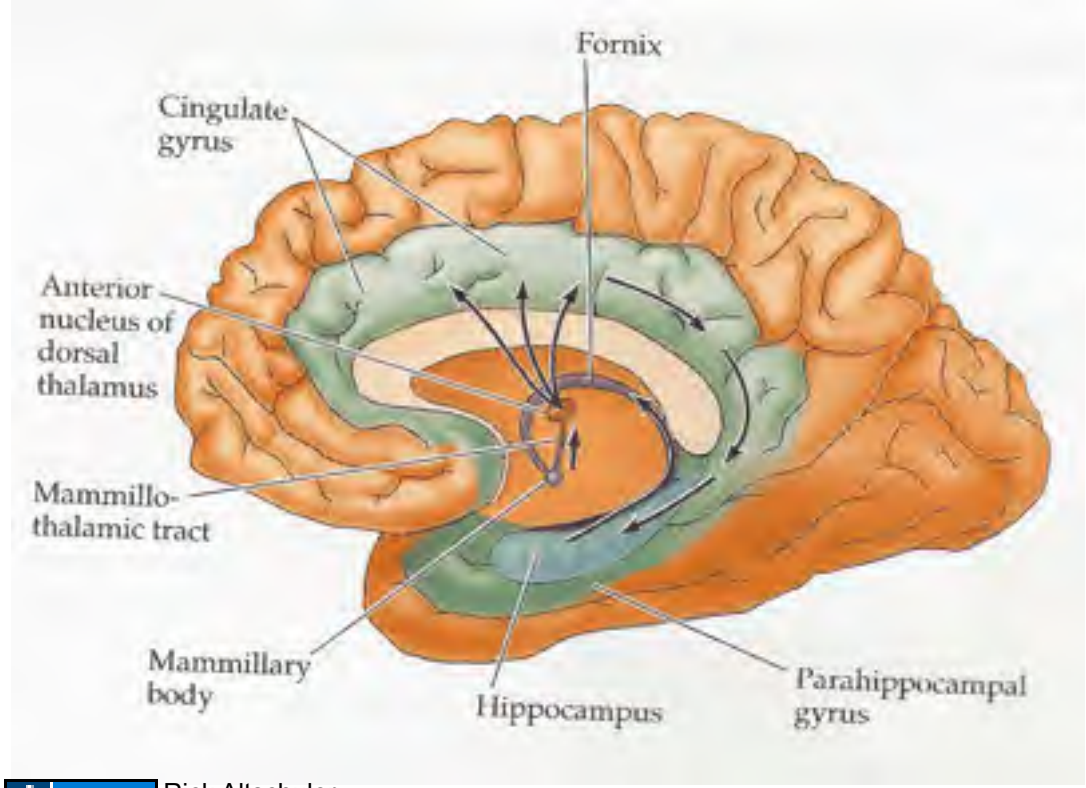
Limbic association areas
(Limbic lobe)

Limbic cortex
(Hippocampus & Amygdala)



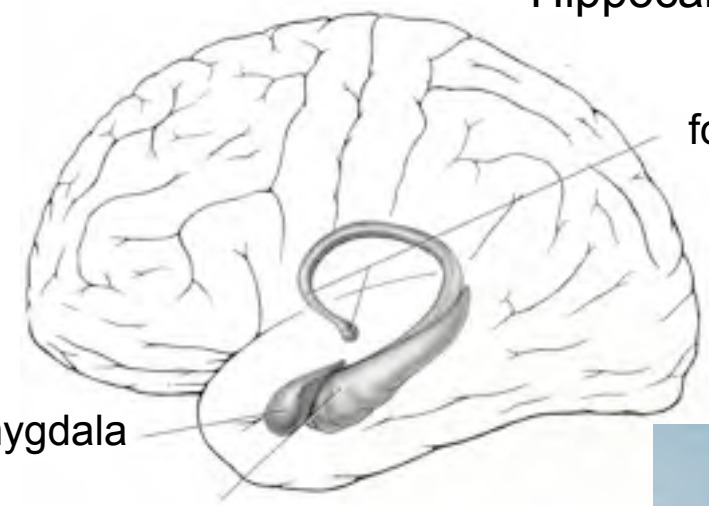
PD-INCL Mesulam, *Principles of Behavioral and Cognitive Neurology*, 2000

LIMBIC LOBE (Cortical Areas)	Cortex Type
Cingulate gyrus & Isthmus	Neocortex (six layers)
Subcallosal area	
Parahippocampal Gyrus	Paleocortex (3-5 layers)
Uncus	
Hippocampus	Archicortex (3 layers)
(Deep within parahippocampal gyrus)	



PD-INCL Rick Altschuler

Hippocampal Formation and Amygdala



PD-INCL J.H. Martin. Neuroanatomy: Text and Atlas. McGraw-Hill, 2003. 3rd ed.

The hippocampal formation and the amygdala are often described as being “inside” the telencephalon. The hippocampal formation can be viewed in the floor of the inferior horn of the lateral ventricle.

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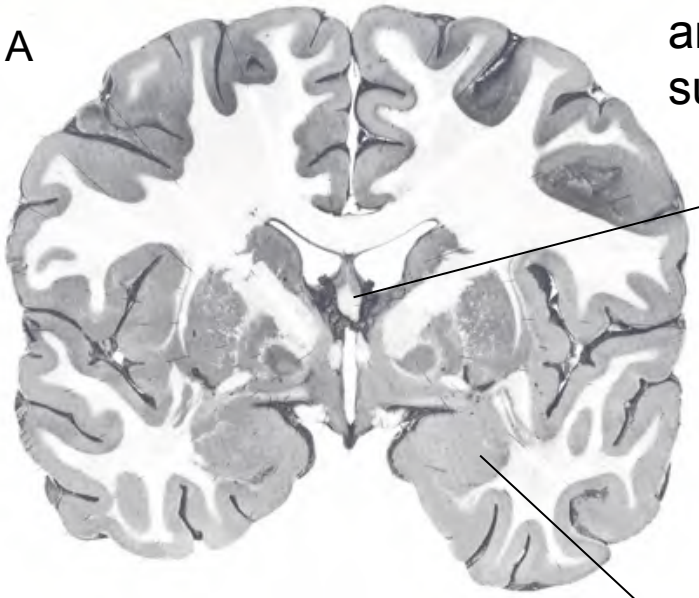
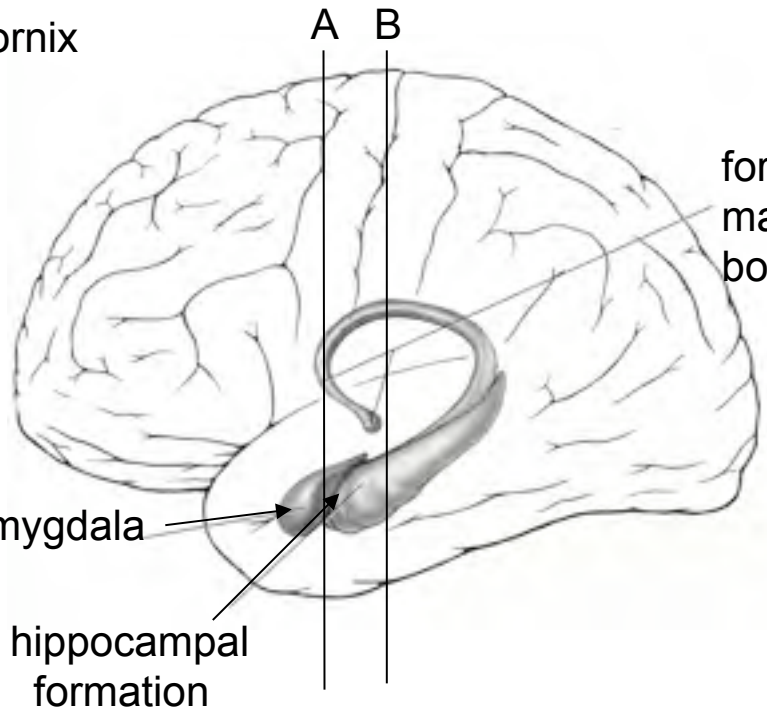
However, the amygdala and hippocampal formation are cortical areas that are continuous with surface cortical structures.





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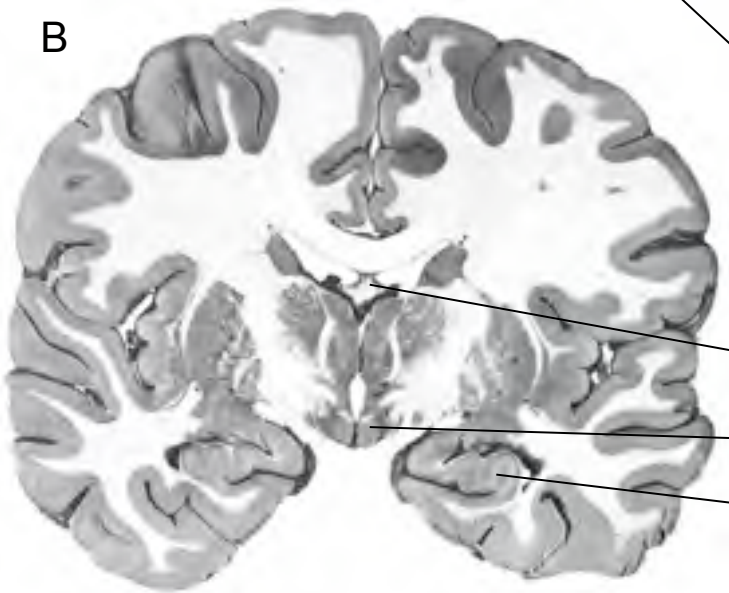

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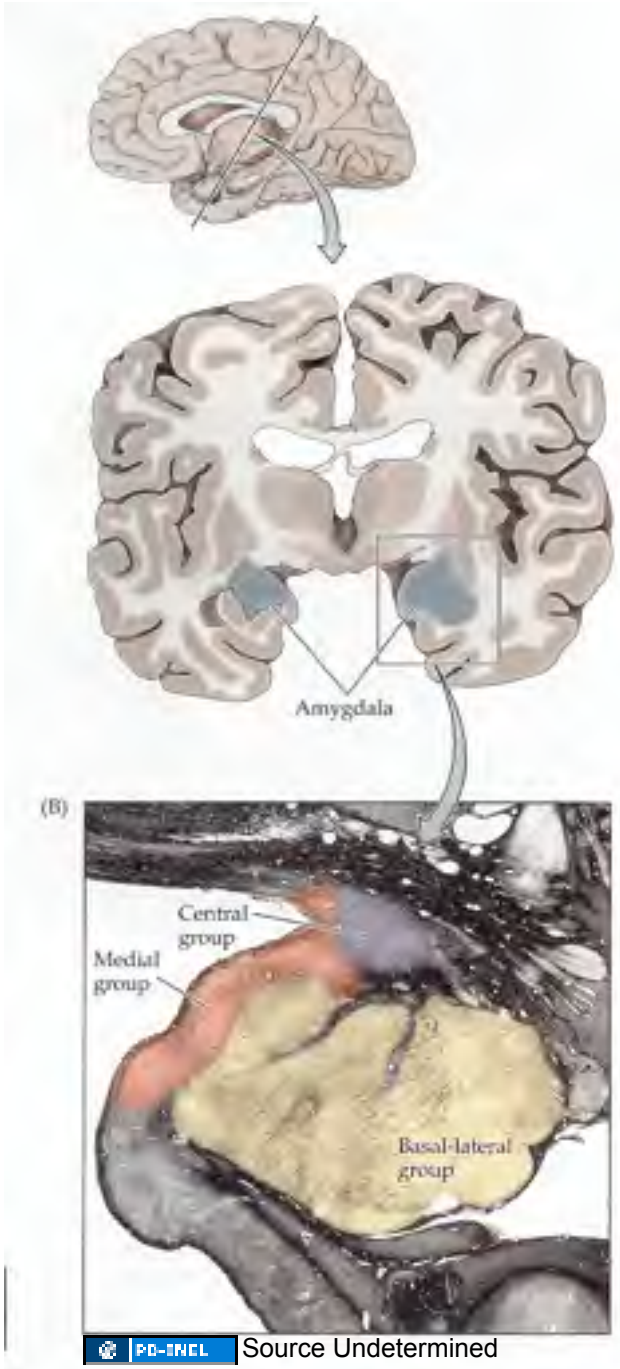

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AMYGDALOID COMPLEX:

Located in temporal lobe, rostral (forward) of the hippocampal formation, in the anterior end of the temporal horn of the lateral ventricle.

Contains 3 groups of nuclei:

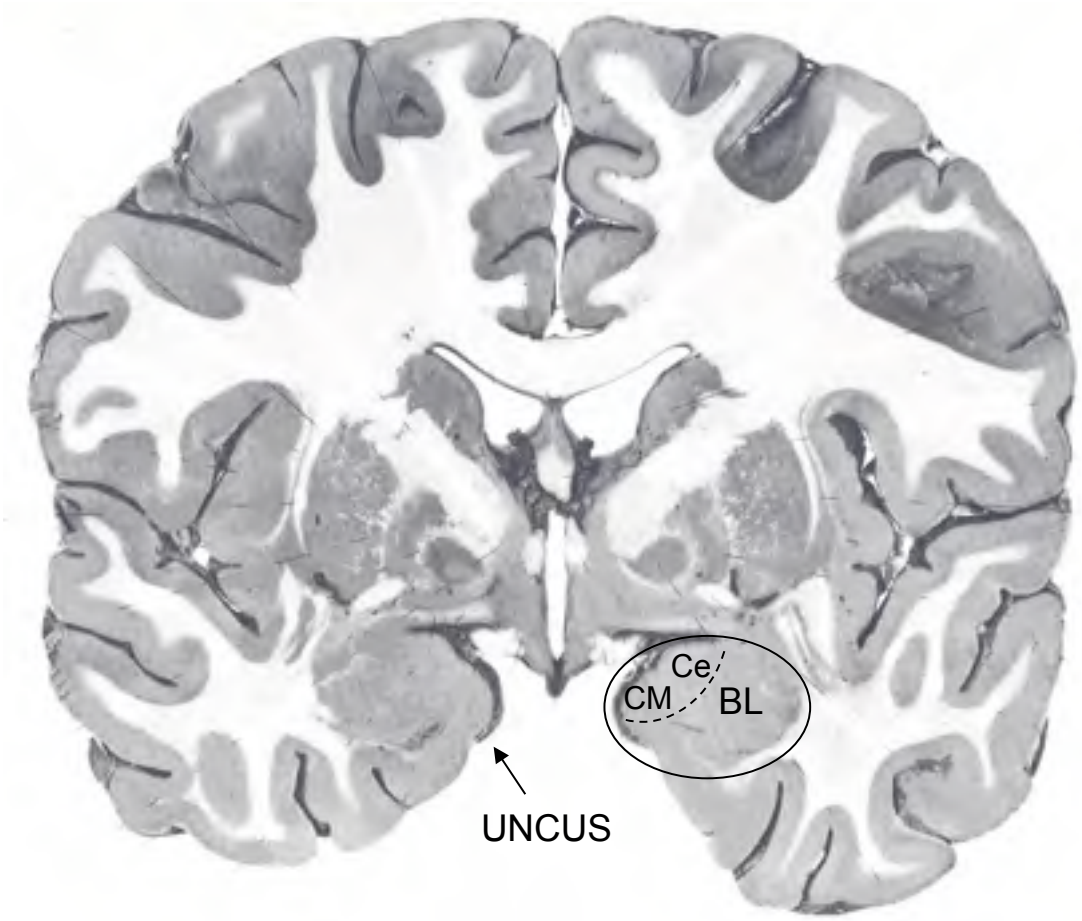
Basolateral Group – Connections to Cortical Structures

Corticomedial Group (smaller) – Receives large Olfactory Input

Central Nucleus – Connections to Reticular / Autonomic Regions of the Brain Stem

Function – General Limbic emotions & behaviors, fear, anger, satiety (eating), environmental context (reactions to environment)

The Amygdala



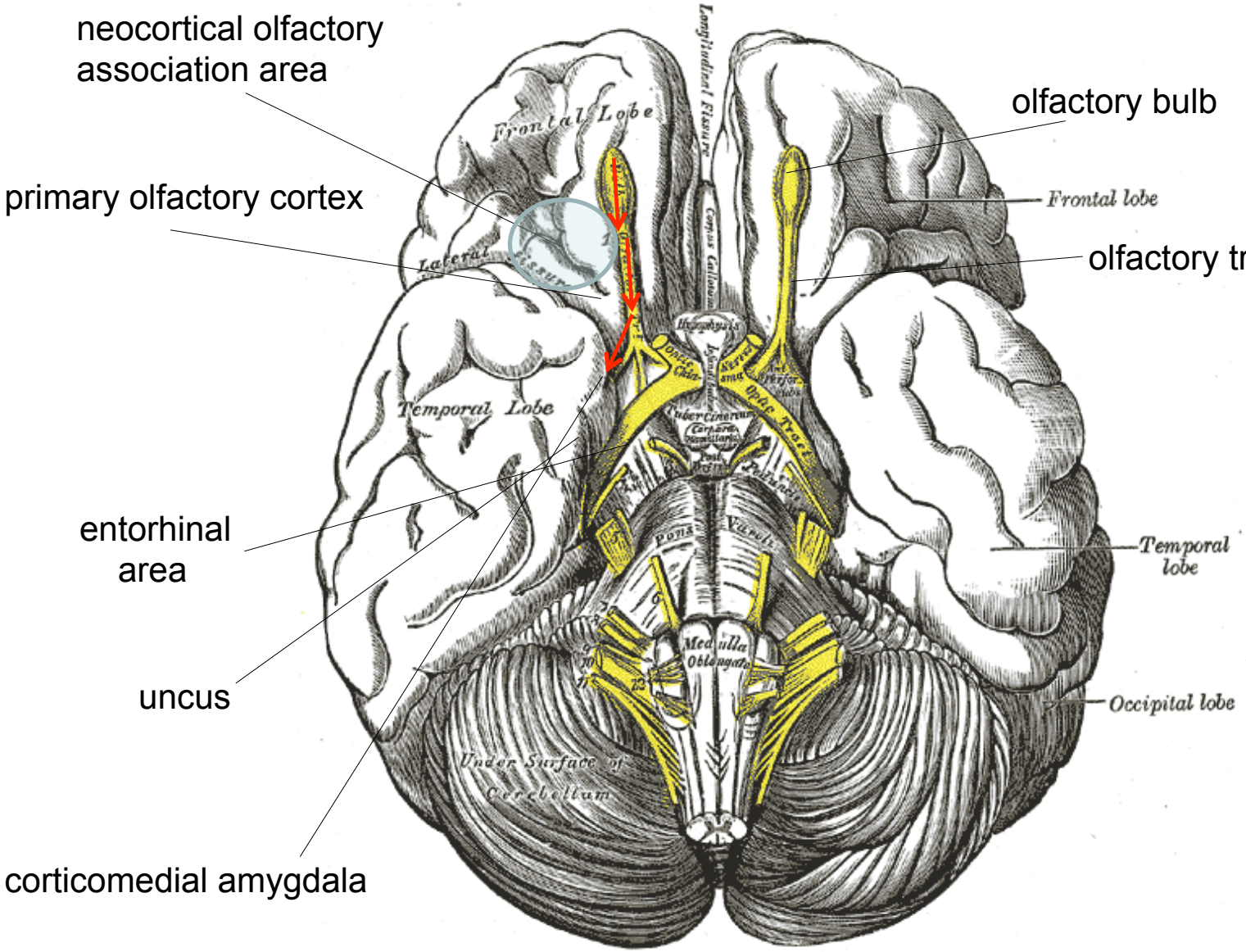
- A matrix of many nuclei
- Creates a bulge on the parahippocampal gyrus called the uncus
- Nuclei can be subdivided into:

Corticomedial division (CM) with connections to the olfactory system and the hypothalamus (social behavior modulation)

Central nucleus (Ce) with connections to the brain stem and hypothalamus (regulation of the autonomic nervous system)

Basolateral division (BL) with connections to the cerebral cortex (emotional memory, e.g., fear)

The Olfactory Bulb is the major input to the Corticomedial Amygdala



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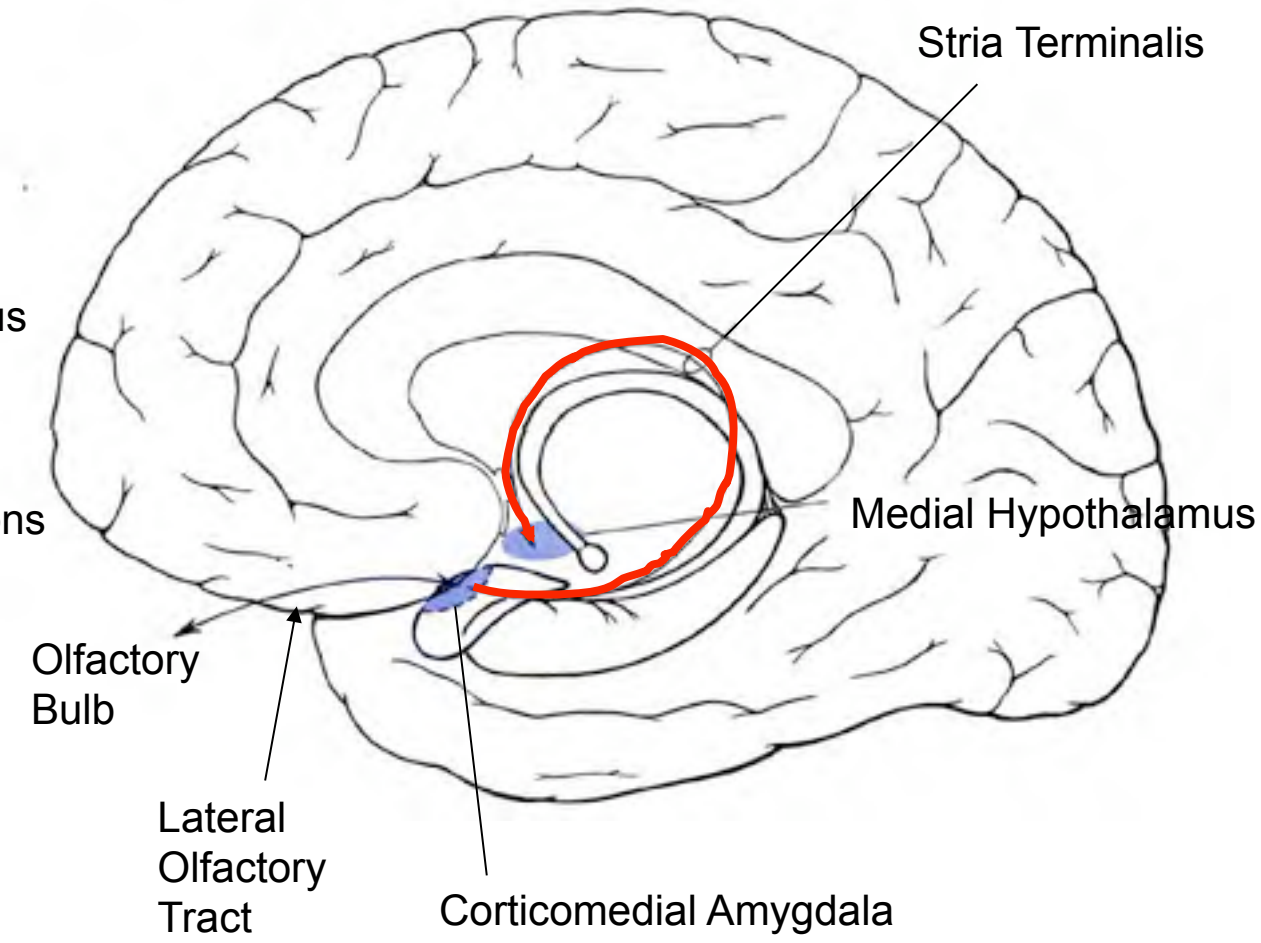
The Corticomedial Amygdala

Connections of the Corticomedial Nuclei:

- the Olfactory Bulb through the Lateral Olfactory Tract
- the Medial Hypothalamus through the Stria Terminalis
- through these connections odors influence sexual and other social behaviors in mammals



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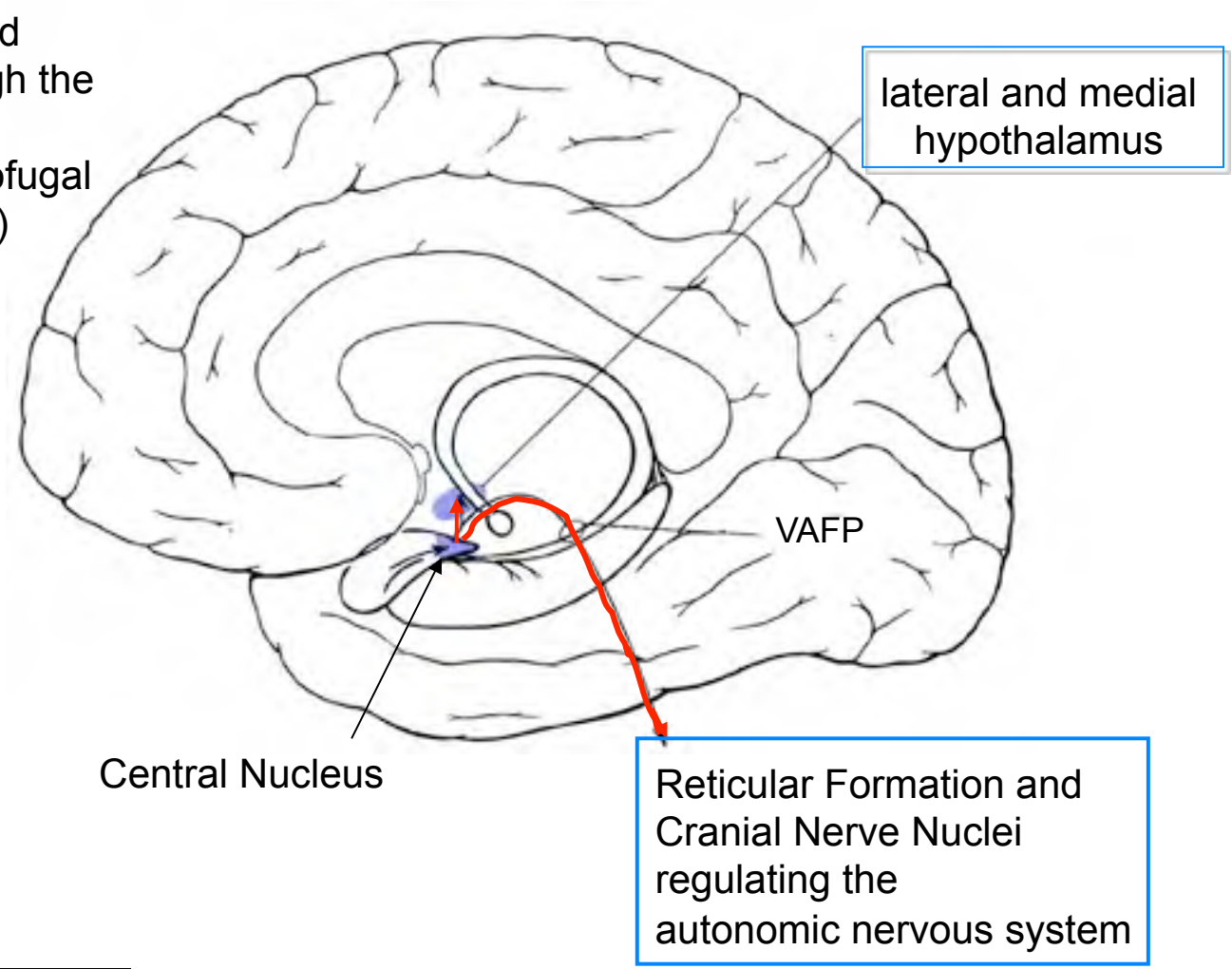
The Central Nucleus of the Amygdala

The Central Nucleus

connects to the hypothalamus and brain stem through the

Ventral Amygdalofugal Pathway (VAFP)



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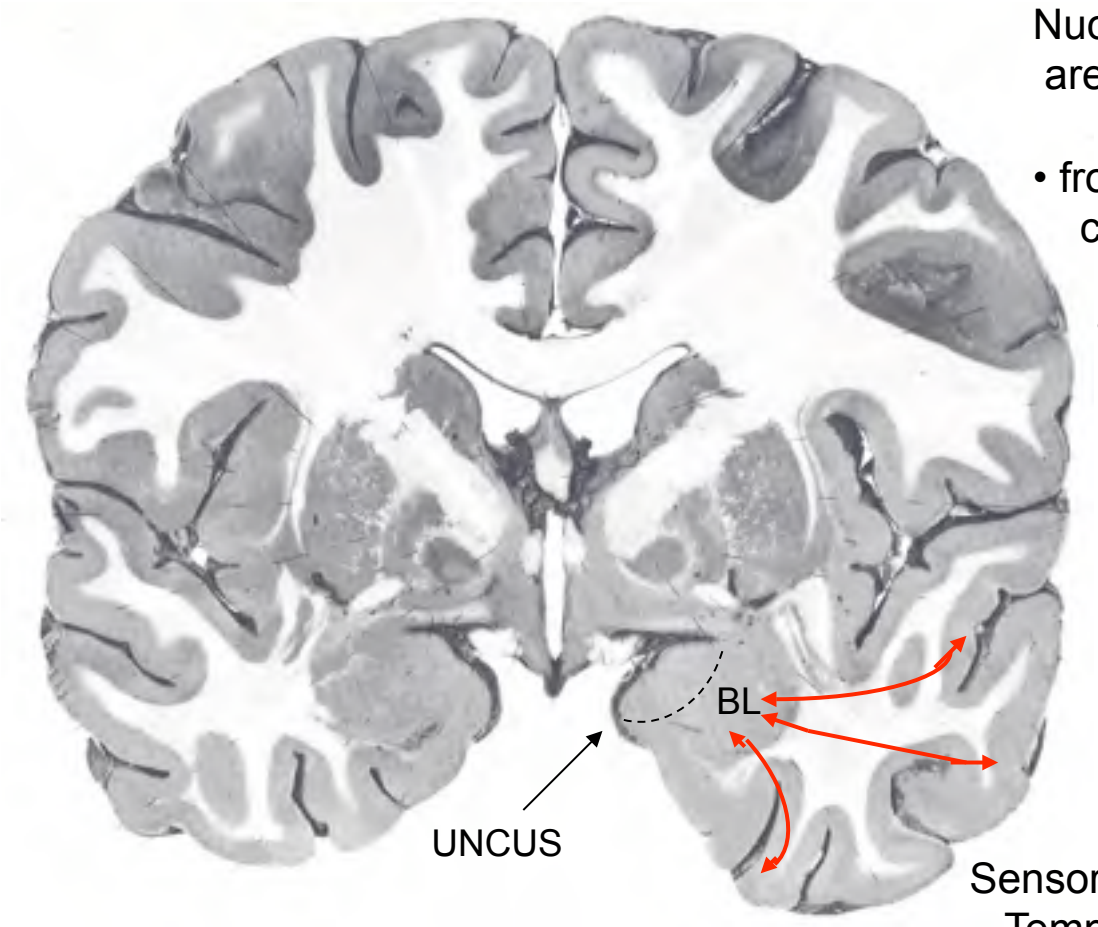
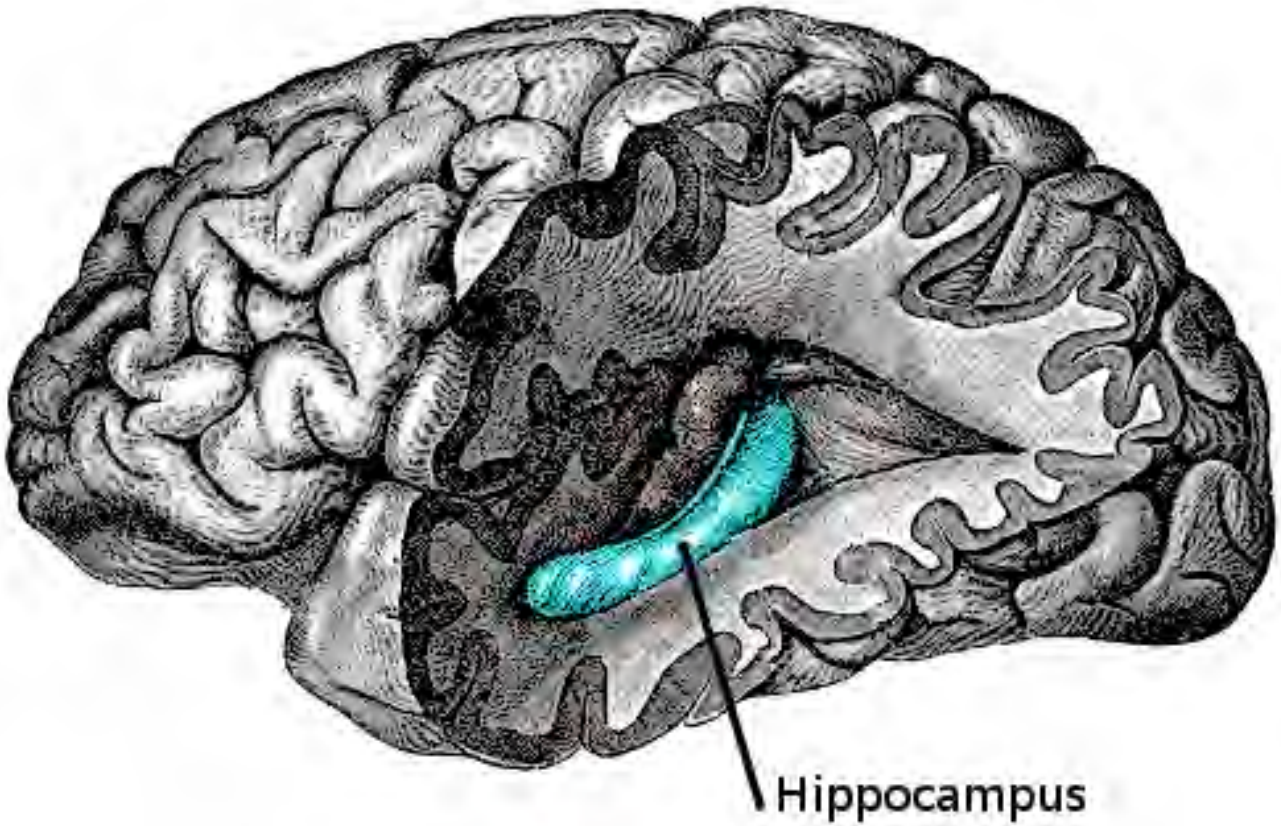
The Basolateral Amygdala



Nuclei of the Basolateral Amygdala are reciprocally connected to:

- frontal lobe multimodal association cortex (connections not shown)
- unimodal and multimodal sensory association cortex of the:
  temporal lobe
  occipital lobe

Sensory Association Cortex
Temporal Lobe



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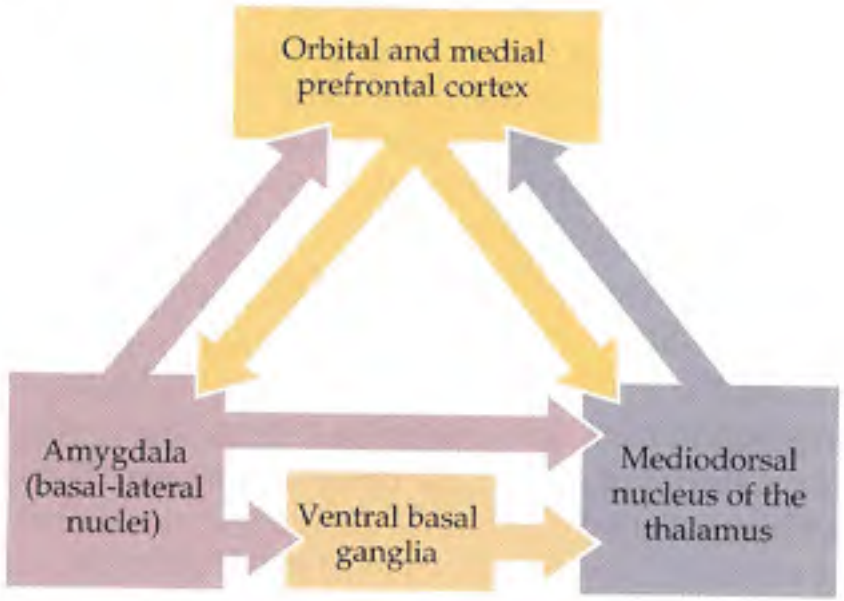

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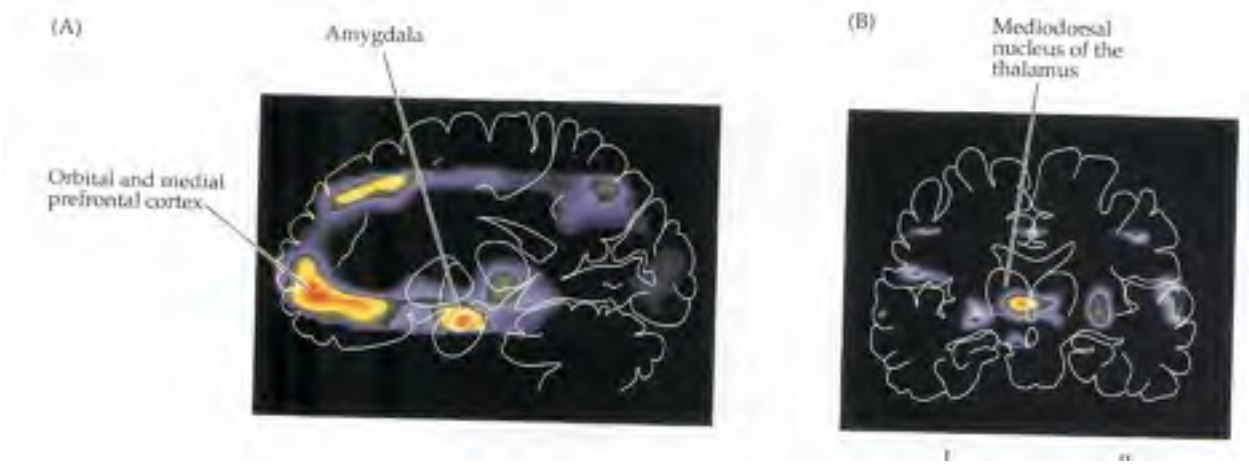
A "triangular" circuit links the Amygdala to the Orbital & Pre-Frontal Cortex, Basal Ganglia and to the Mediodorsal Nucleus of the Thalamus. This circuit is involved with the experience and expression of emotional responses including anger, fear, pleasure and depression.



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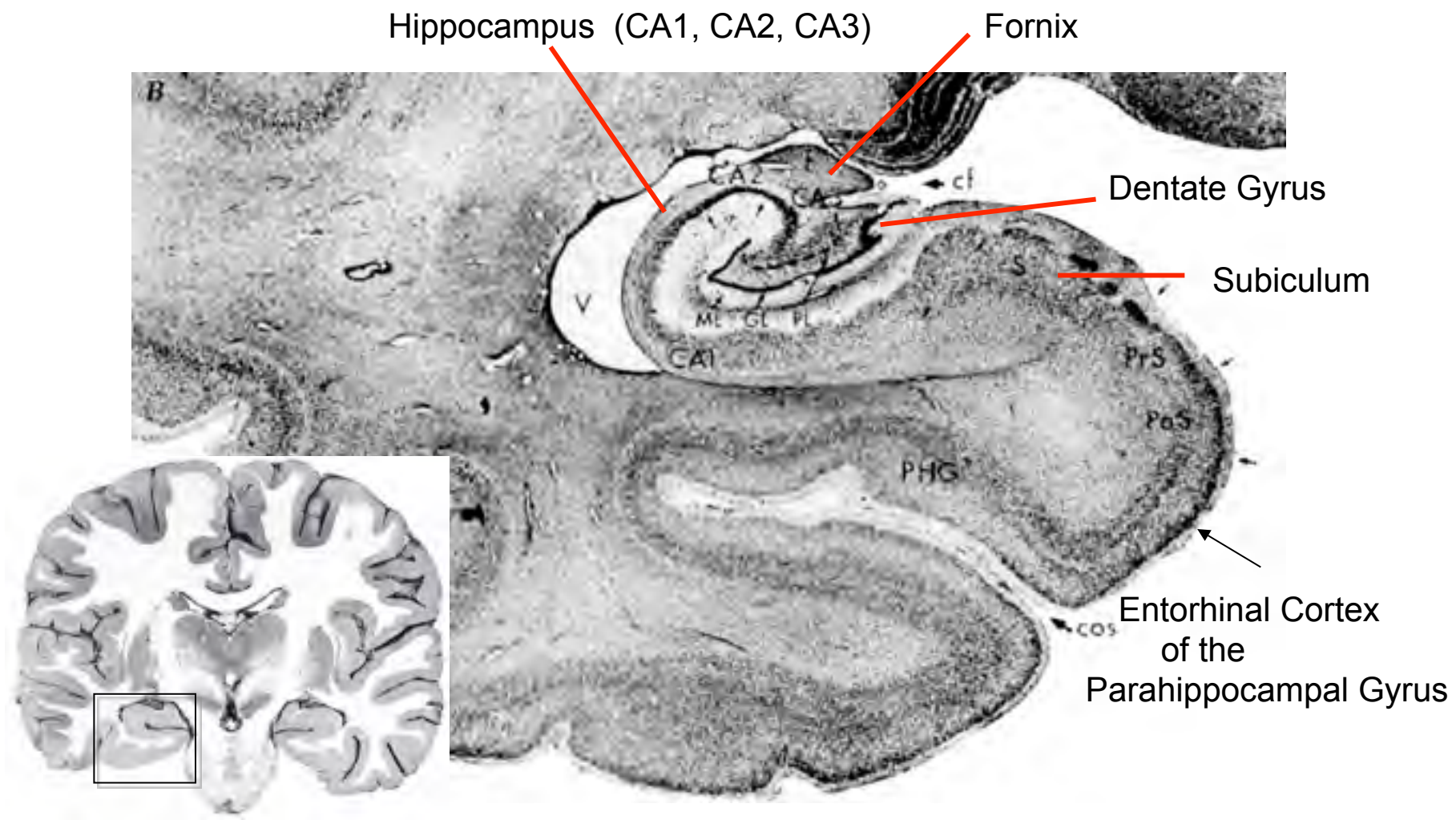
Imaging from subjects with clinical depression

The Hippocampal Formation:

1. Dentate Gyrus
2. Hippocampus
3. Subiculum



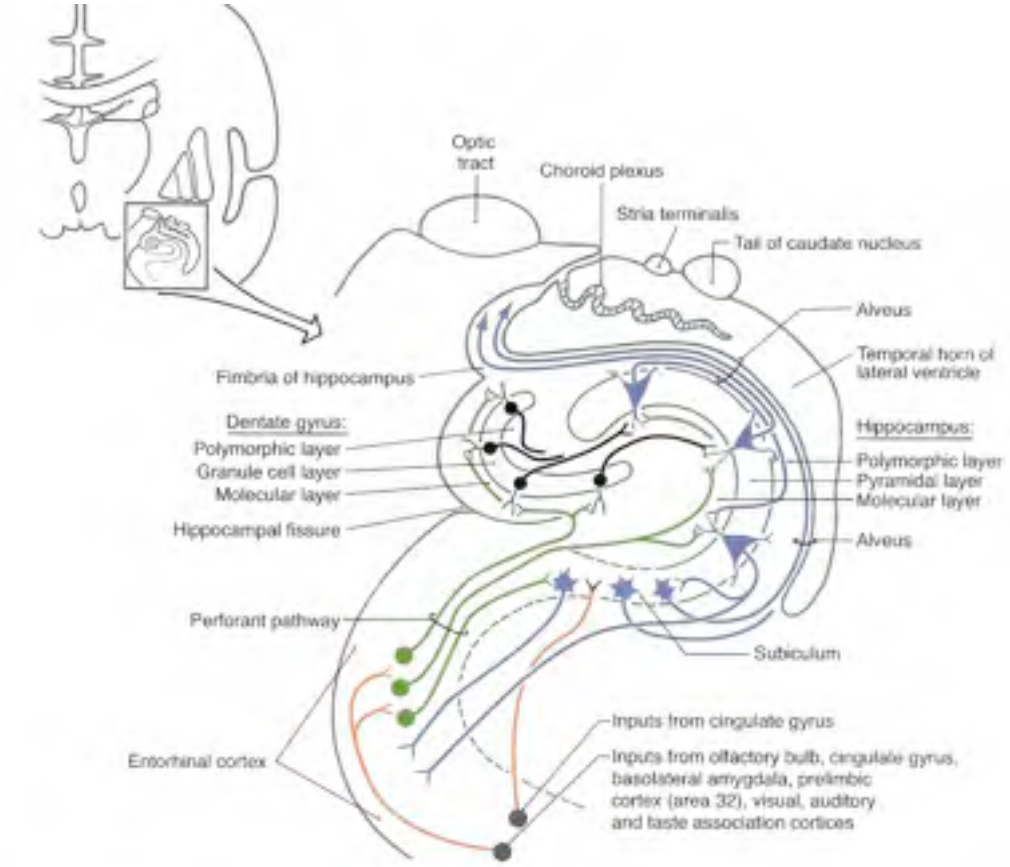
The hippocampus and the dentate gyrus are both archicortex with 3 layers.

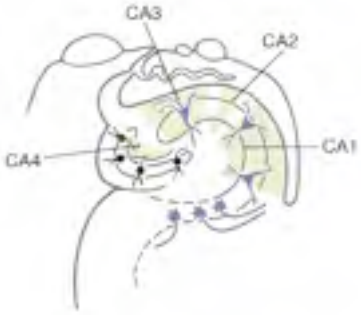
There are multiple inputs to entorhinal cortex, including fibers from the cingulate gyrus, basolateral amygdala, olfactory cortex and cortical association areas.

The Perforant pathway goes from entorhinal cortex to dentate gyrus.

Granule cells (middle layer) of dentate gyrus project (mossy fibers) to the hippocampus.

Pyramidal cells (middle layer) of hippocampus give rise to the fornix, the output tract of the hippocampal complex. The fornix projects to mammillary bodies of hypothalamus and septal nuclei.





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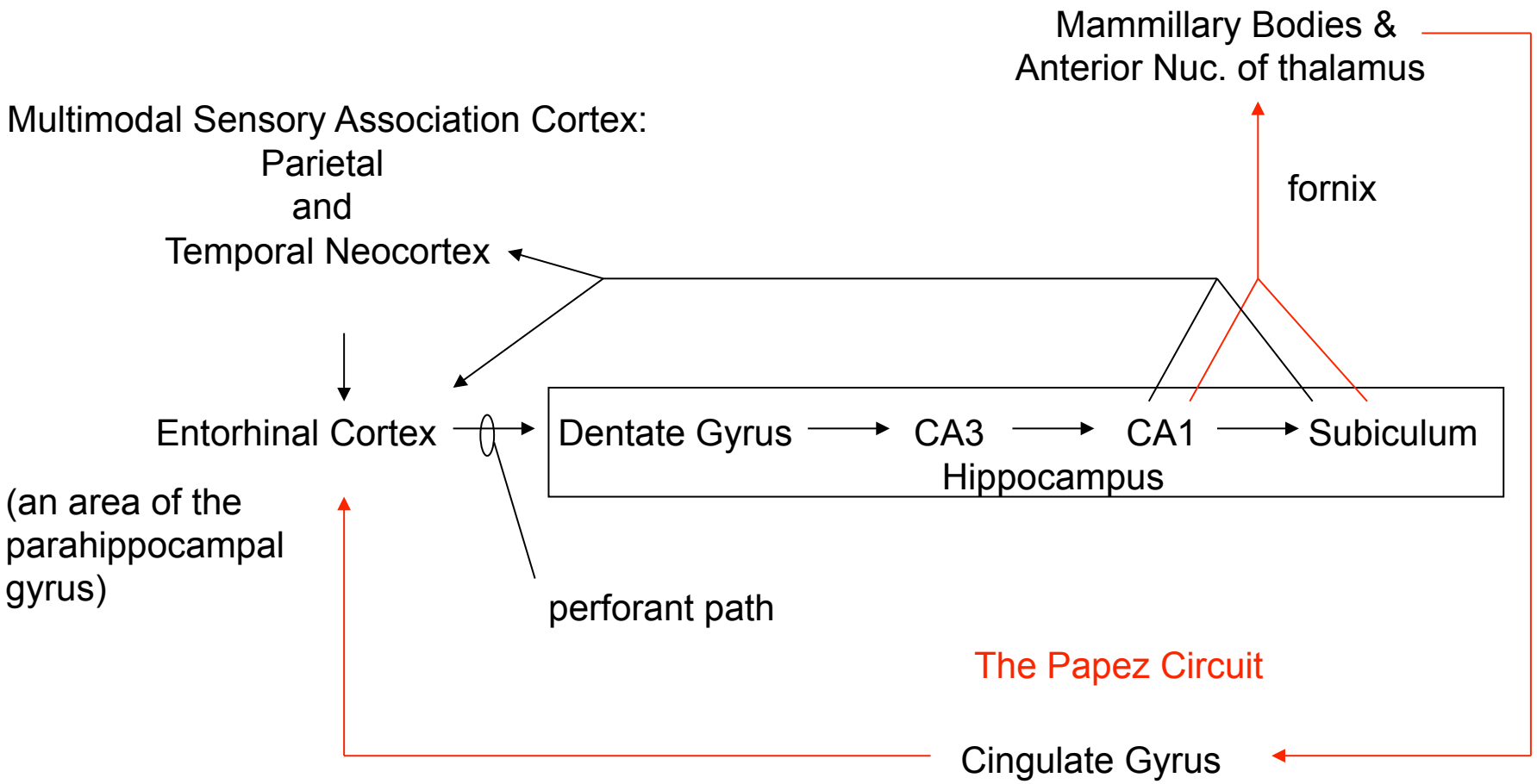
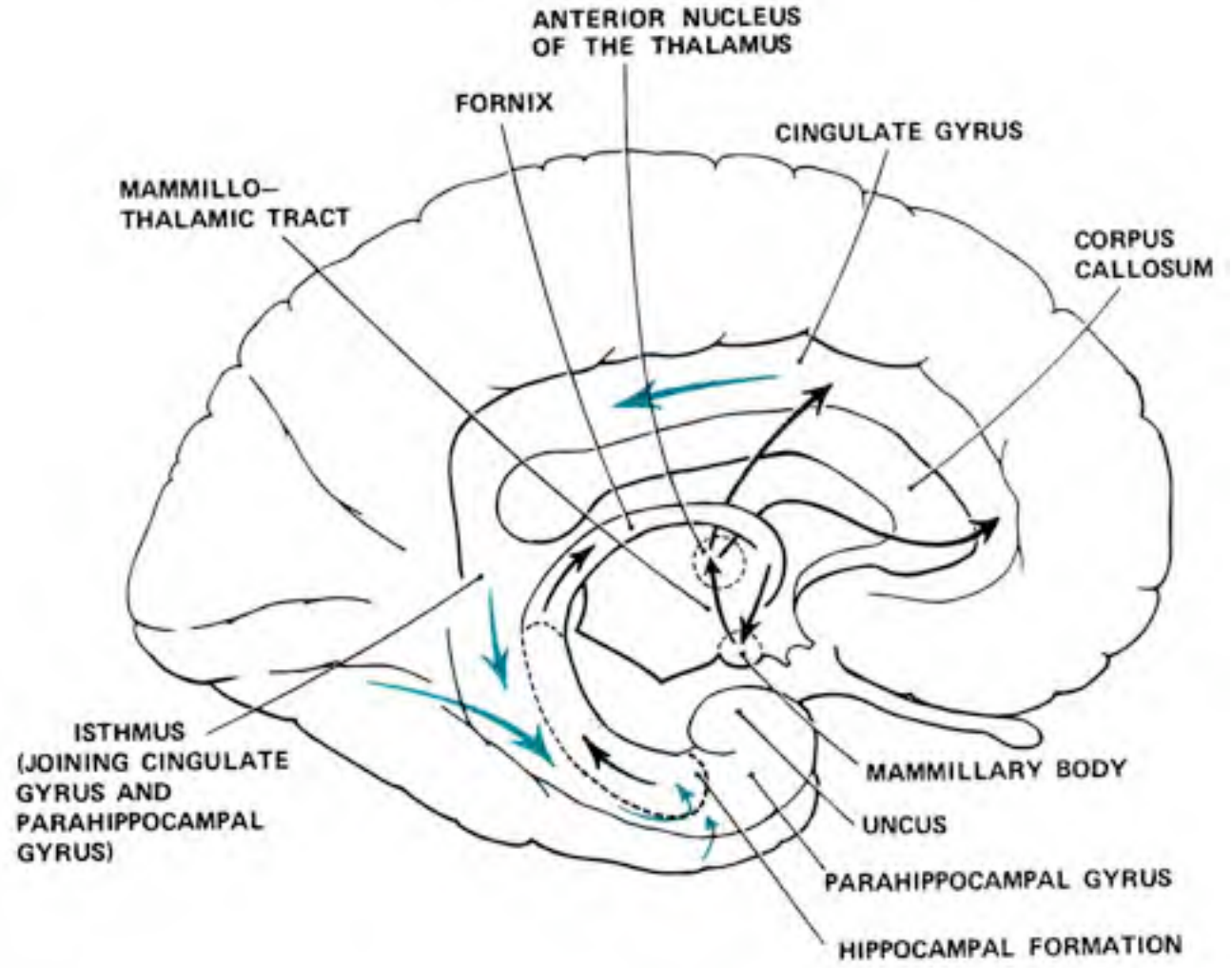
Basic neural circuits through the Hippocampal Formation



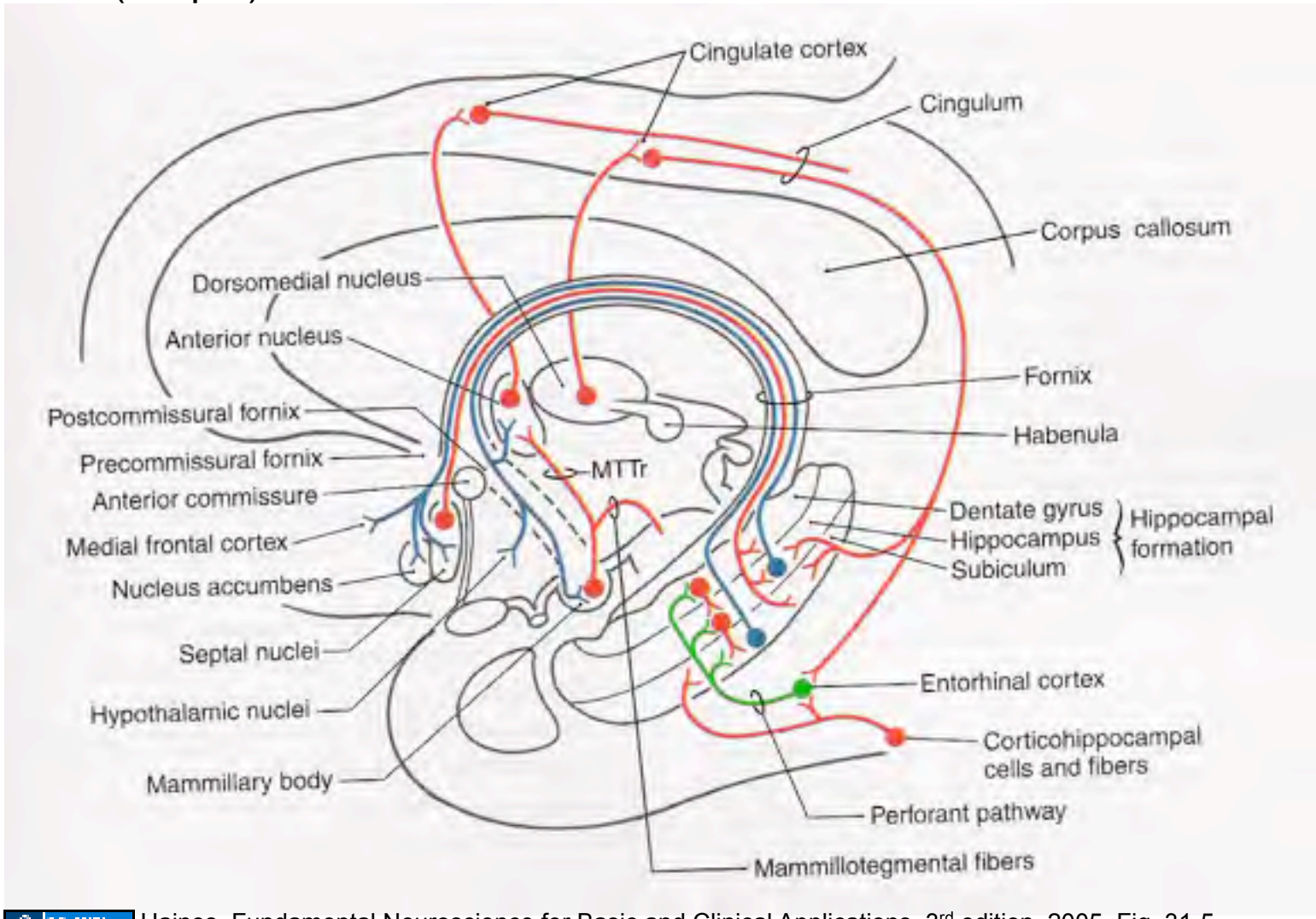
The Papez Circuit



PD-INCL Manter and Gatz's Essentials of Clinical Neuroanatomy and Neurophysiology, 8th ed

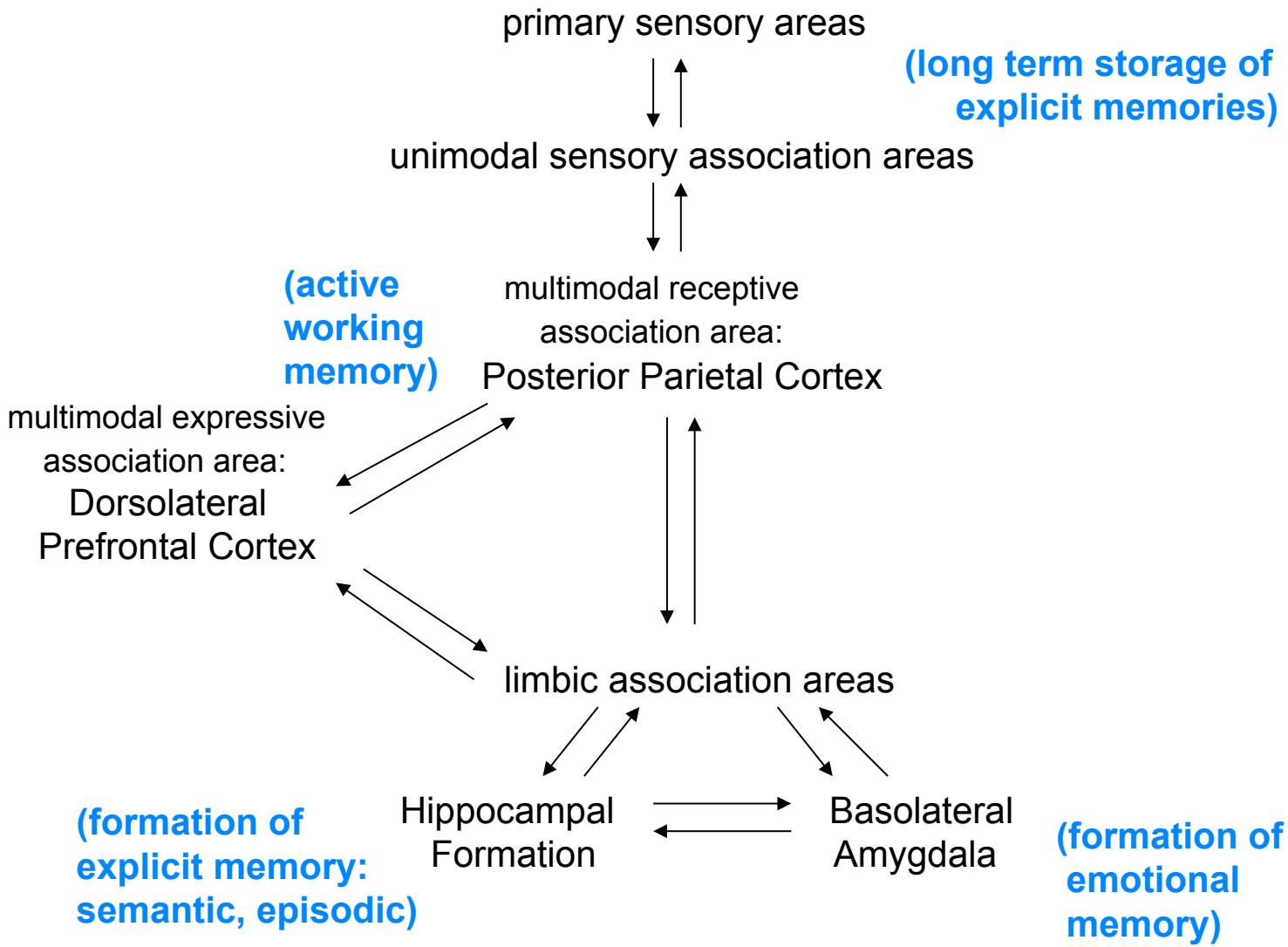
COMPONENTS OF HIPPOCAMPAL FORMATION:
Subiculum,Hippocampus, Dentate Gyrus

Efferents (Output): FORNIX

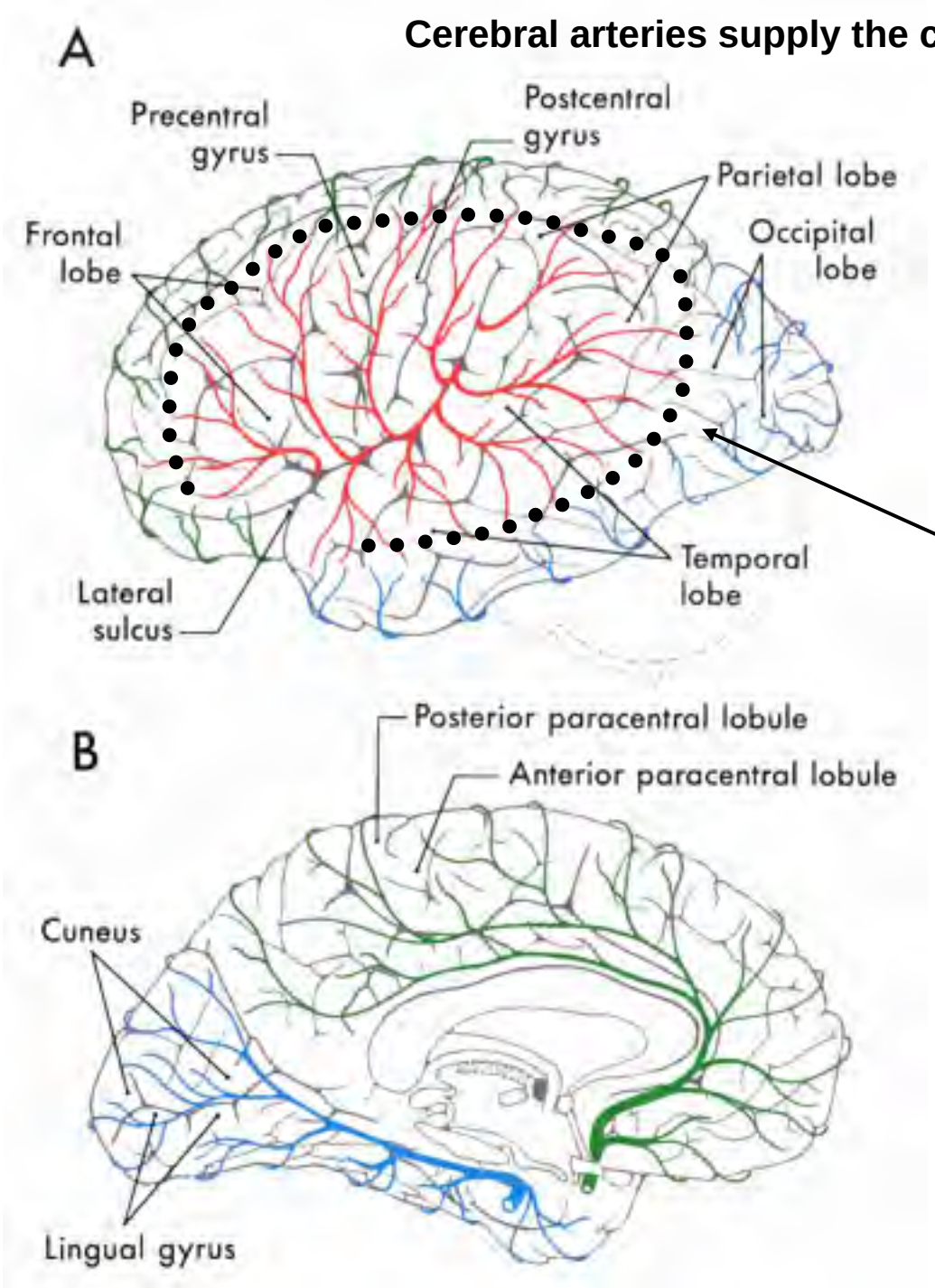


Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 31-5

Cortical Network Subserving Memory



Cerebral arteries supply the cortex and superficial white matter



middle cerebral artery

anterior cerebral artery

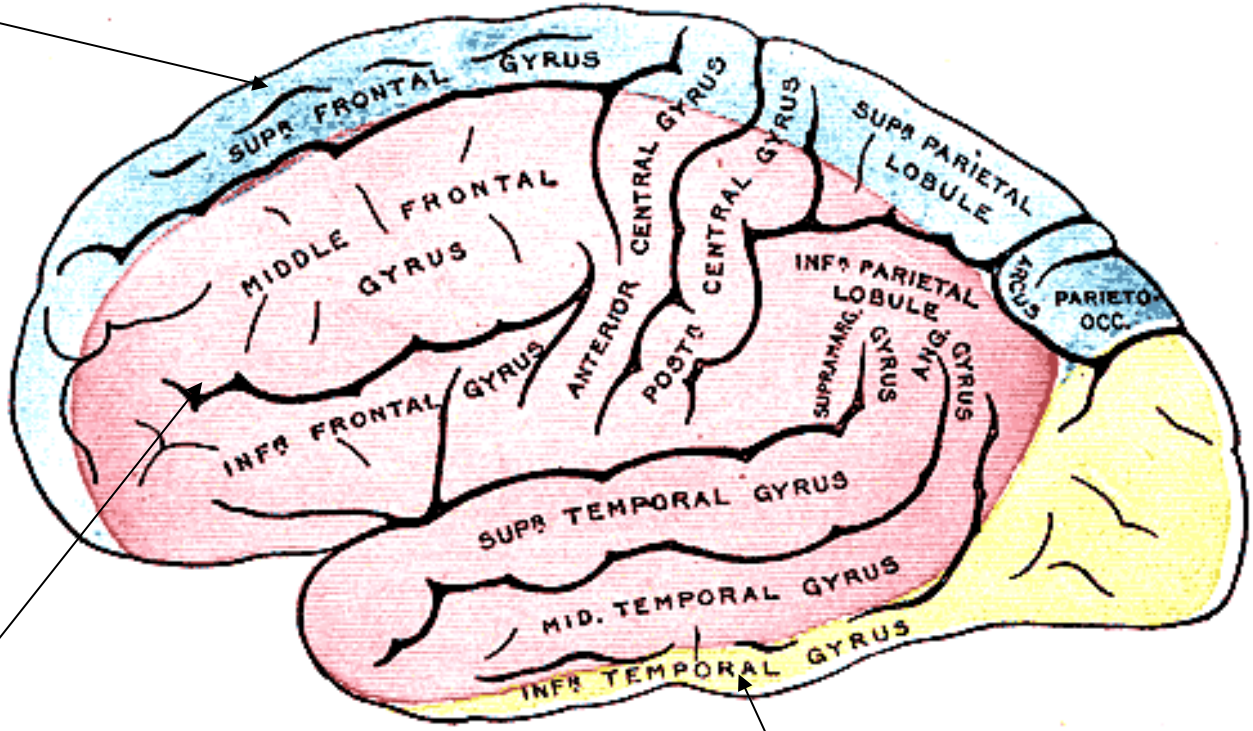
posterior cerebral artery

border zones

Modified From Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Figs. 8-7, 8-9

Anterior Cerebral Artery
includes leg and foot areas of the somato-sensory and motor cortices

Territories of the Anterior, Middle, and Posterior Cerebral Arteries



Middle Cerebral Artery
includes hand and face areas of the somatosensory and motor cortices

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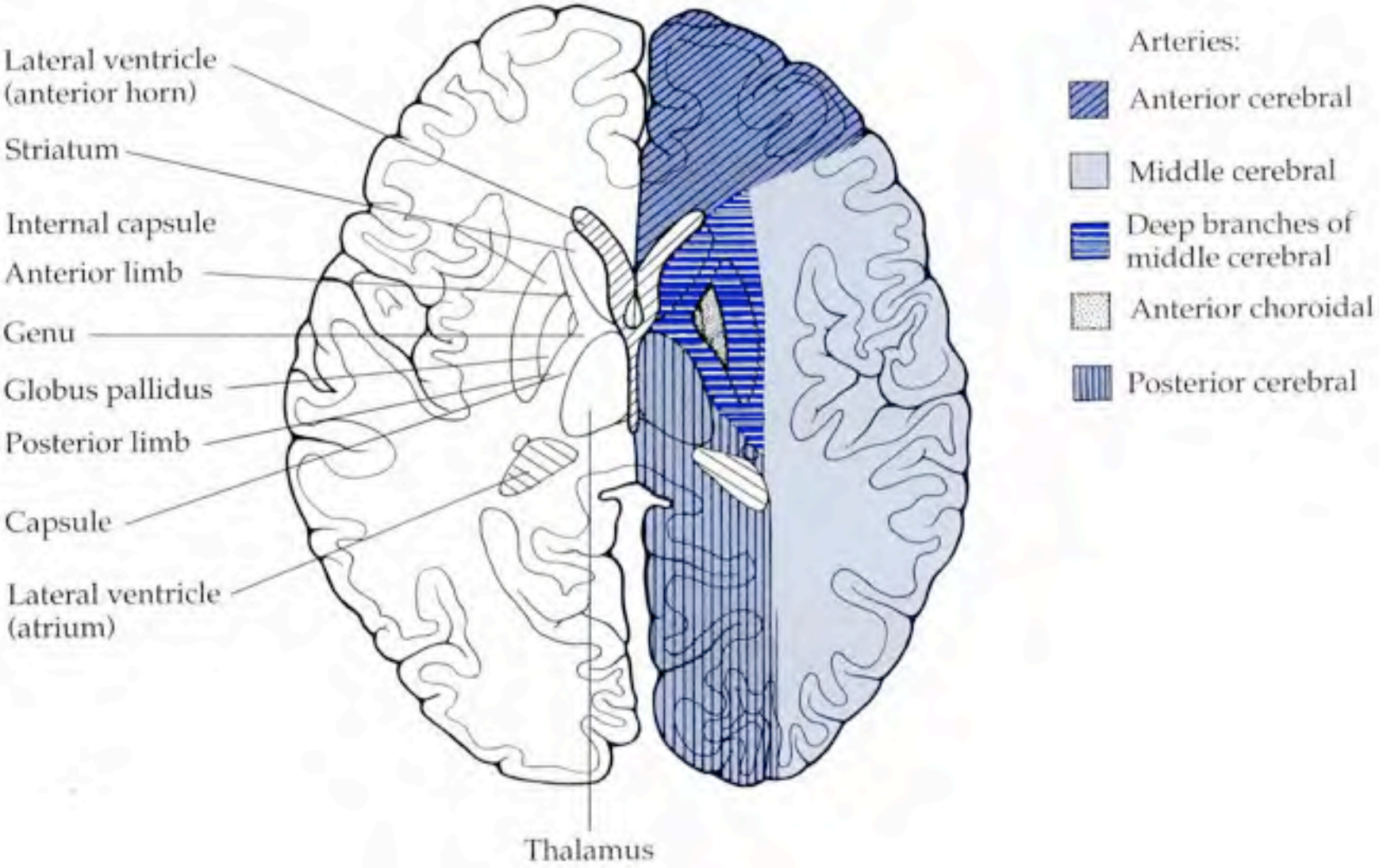
Posterior Cerebral Artery
includes visual cortex

Distribution of the Cerebral Arteries to Internal Structures of the Cerebral Hemispheres



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