

FUNCTIONAL NEUROANATOMY OF THE MEDIAL TEMPORAL LOBES (MTL)

Norbert Fortin, PhD



NB209: Behavioral Neuroscience

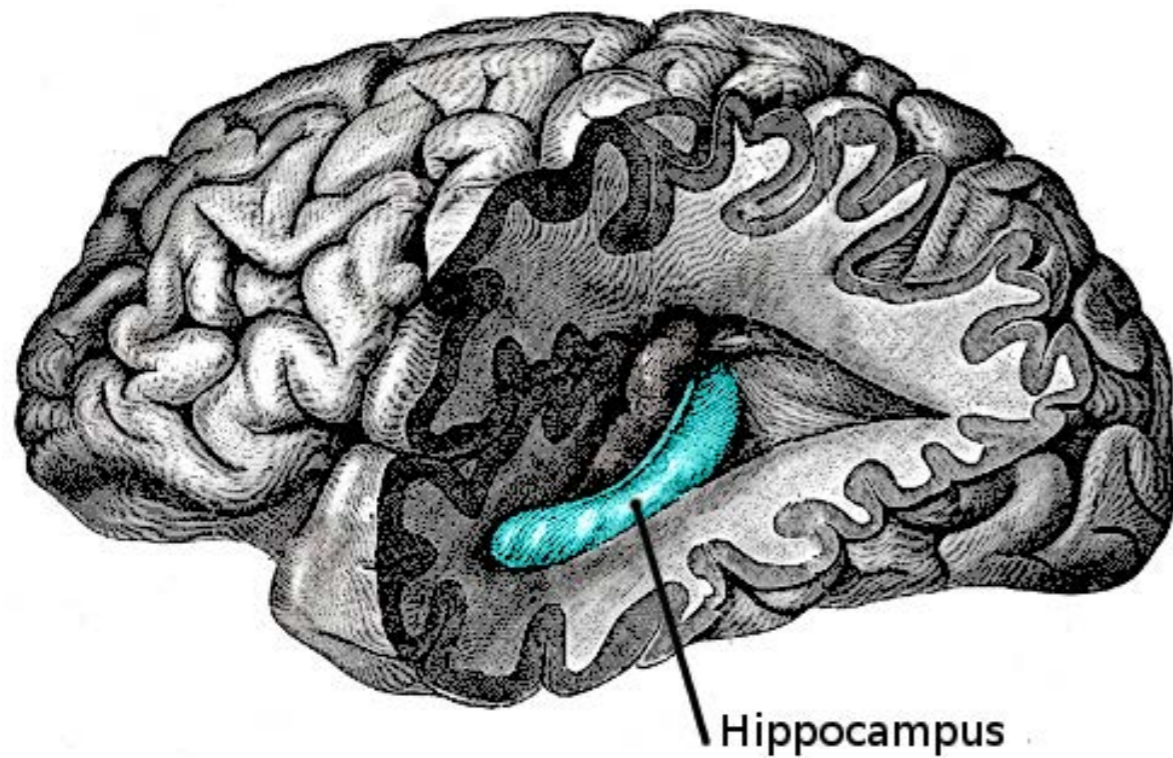
OVERVIEW

- Basic functional organization of the medial temporal lobes across species
- Detailed hippocampal-parahippocampal anatomical organization
- More anatomical resources

FUNCTIONAL ORGANIZATION OF MTL

BASIC ANATOMY OF THE HIPPOCAMPUS

Where is it in the human brain?



<http://en.wikipedia.org/wiki/File:Gray739-emphasizing-hippocampus.png>

Where does the name come from?

The sea creature



http://en.wikipedia.org/wiki/File:Hippocampus_and_seahorse_cropped.JPG

The brain structure

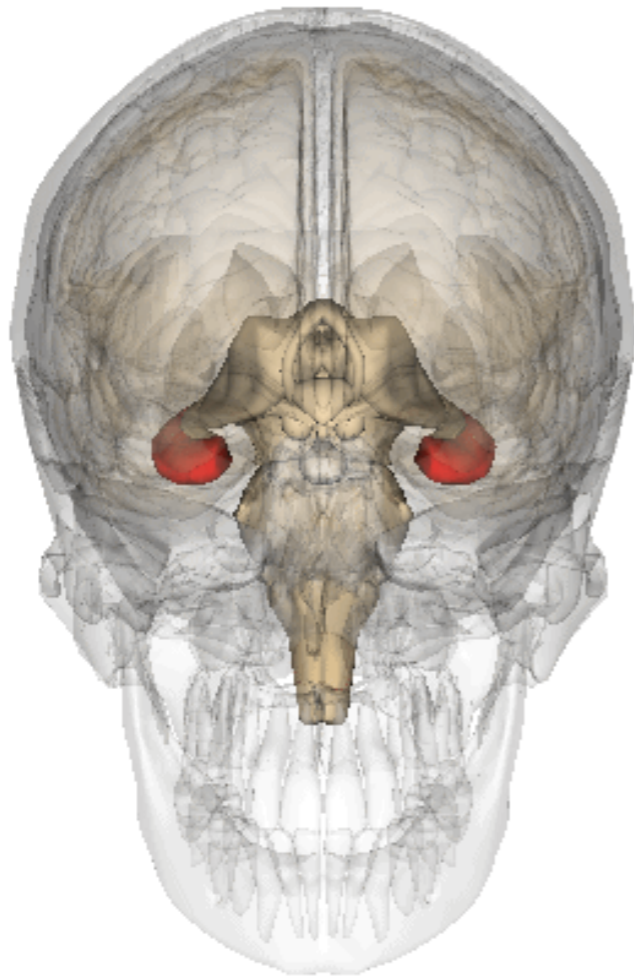


FUNCTIONAL ORGANIZATION OF MTL

BASIC ANATOMY OF THE HIPPOCAMPUS

It has a distinctive 3-D shape

Human



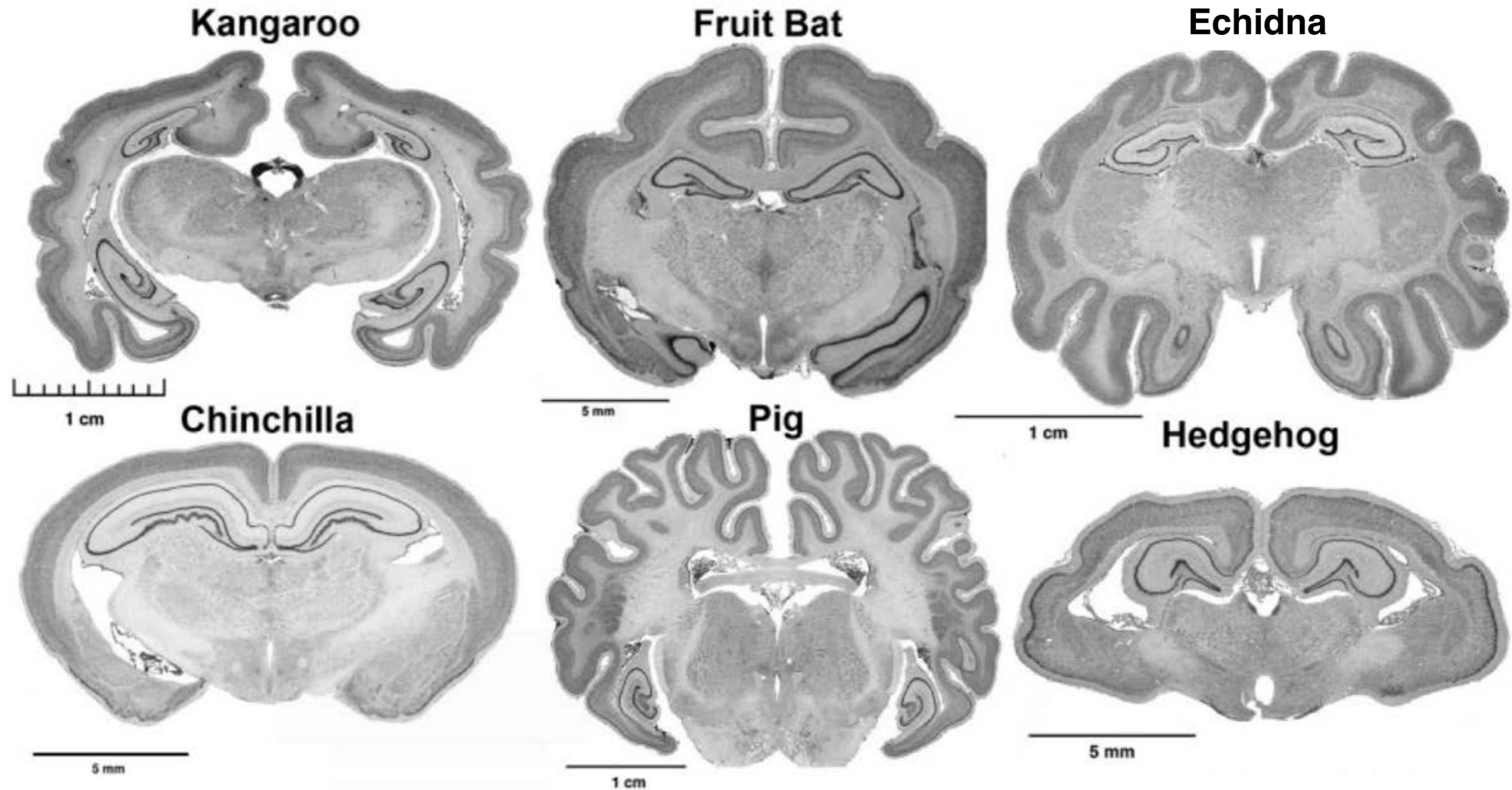
Rat



FUNCTIONAL ORGANIZATION OF MTL

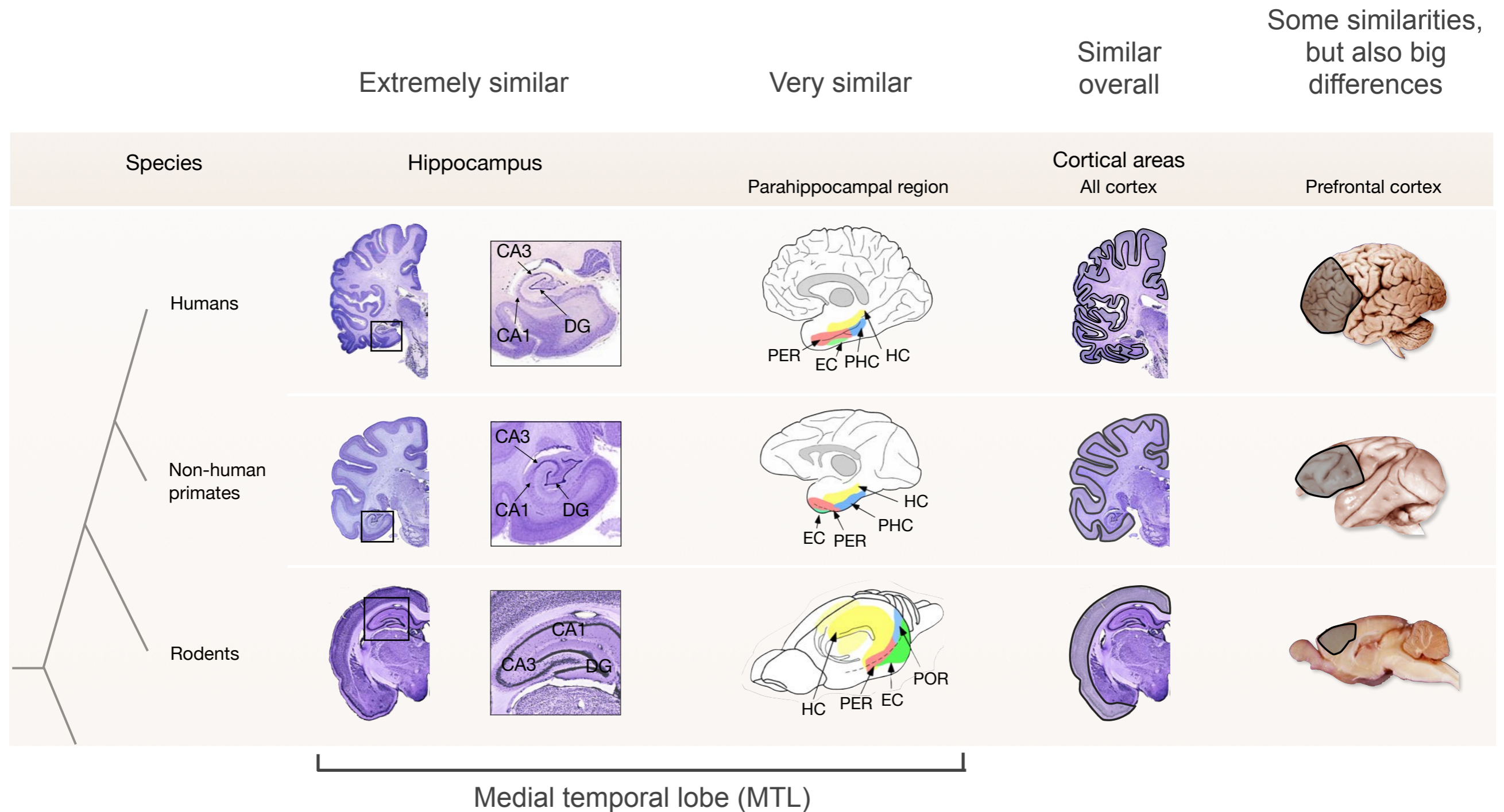
THE HIPPOCAMPUS IS VERY SIMILAR ACROSS SPECIES

Other mammals



FUNCTIONAL ORGANIZATION OF MTL

THE HIPPOCAMPUS AND CORTEX ACROSS MAMMALS



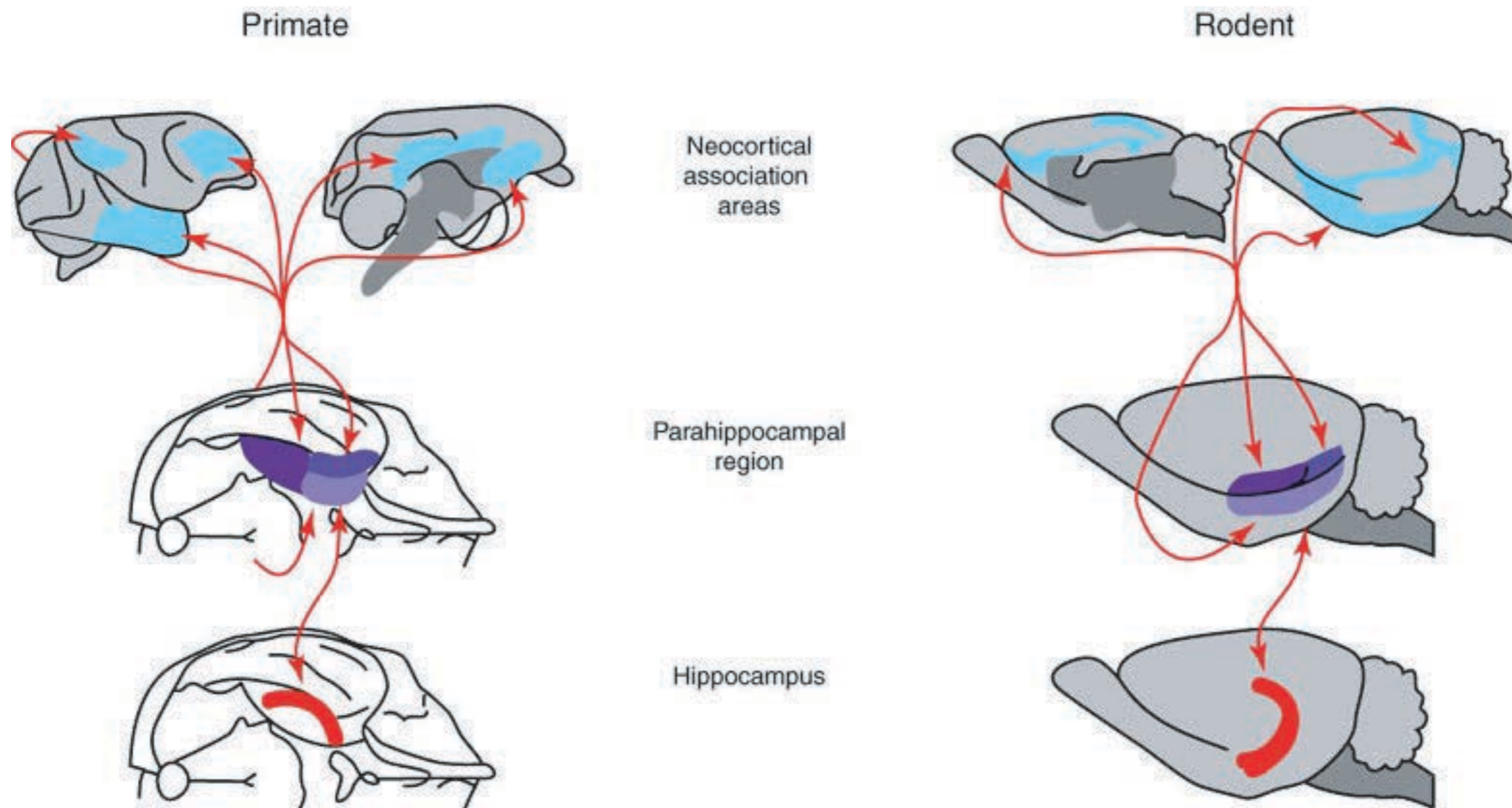
Allen & Fortin (2013) PNAS

Abbreviations: Entorhinal cortex (EC), Hippocampus (HC), Perirhinal cortex (PER), Parahippocampal cortex (PHC) (PHC is called postrhinal in rodents, or POR)

FUNCTIONAL ORGANIZATION OF MTL

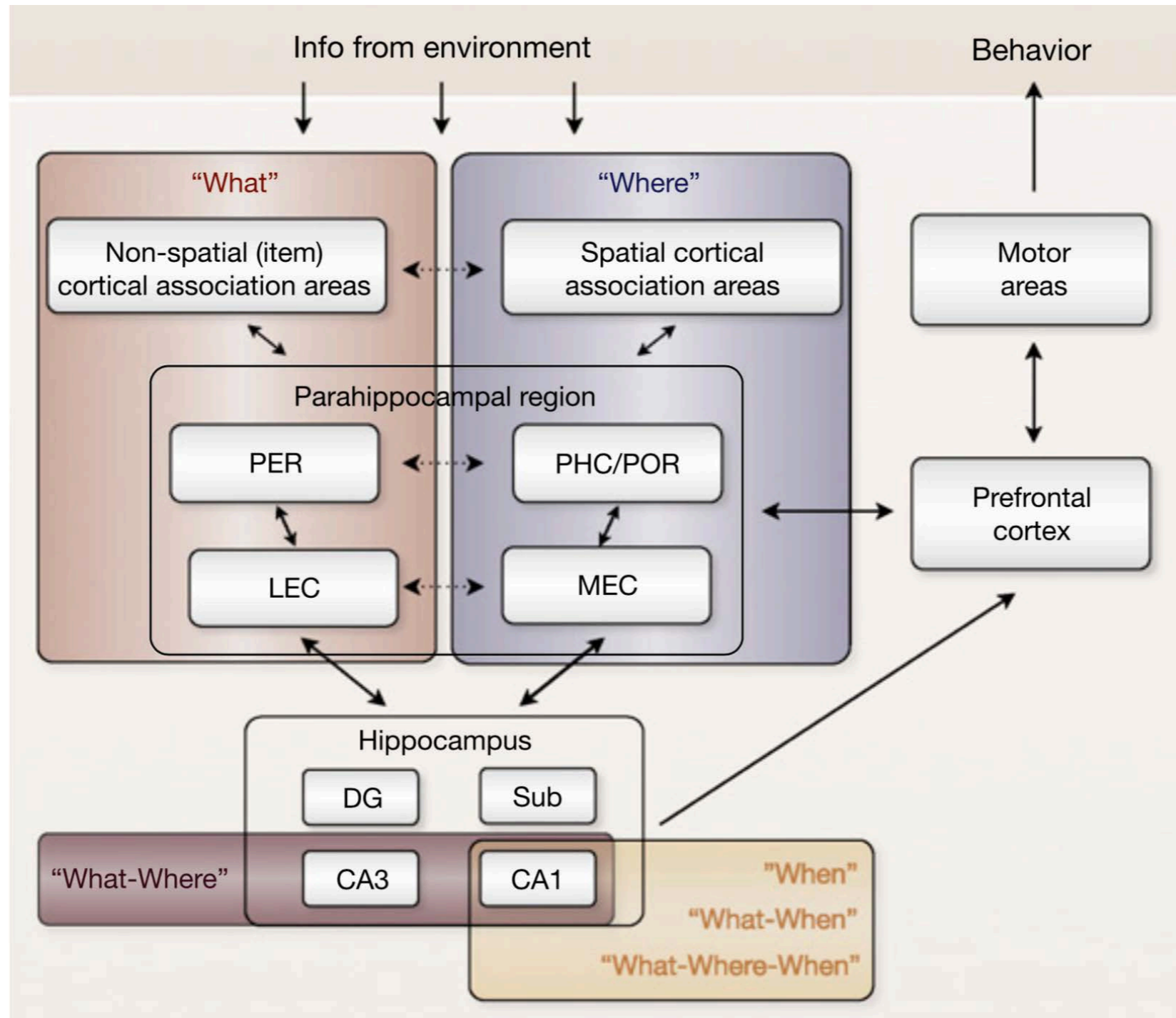
HIPPOCAMPAL-CORTICAL CONNECTIONS ACROSS SPECIES

Similar pattern of connections between brain structures



FUNCTIONAL ORGANIZATION OF MTL

HOW DOES IT SUPPORT MEMORY ENCODING & RETRIEVAL?



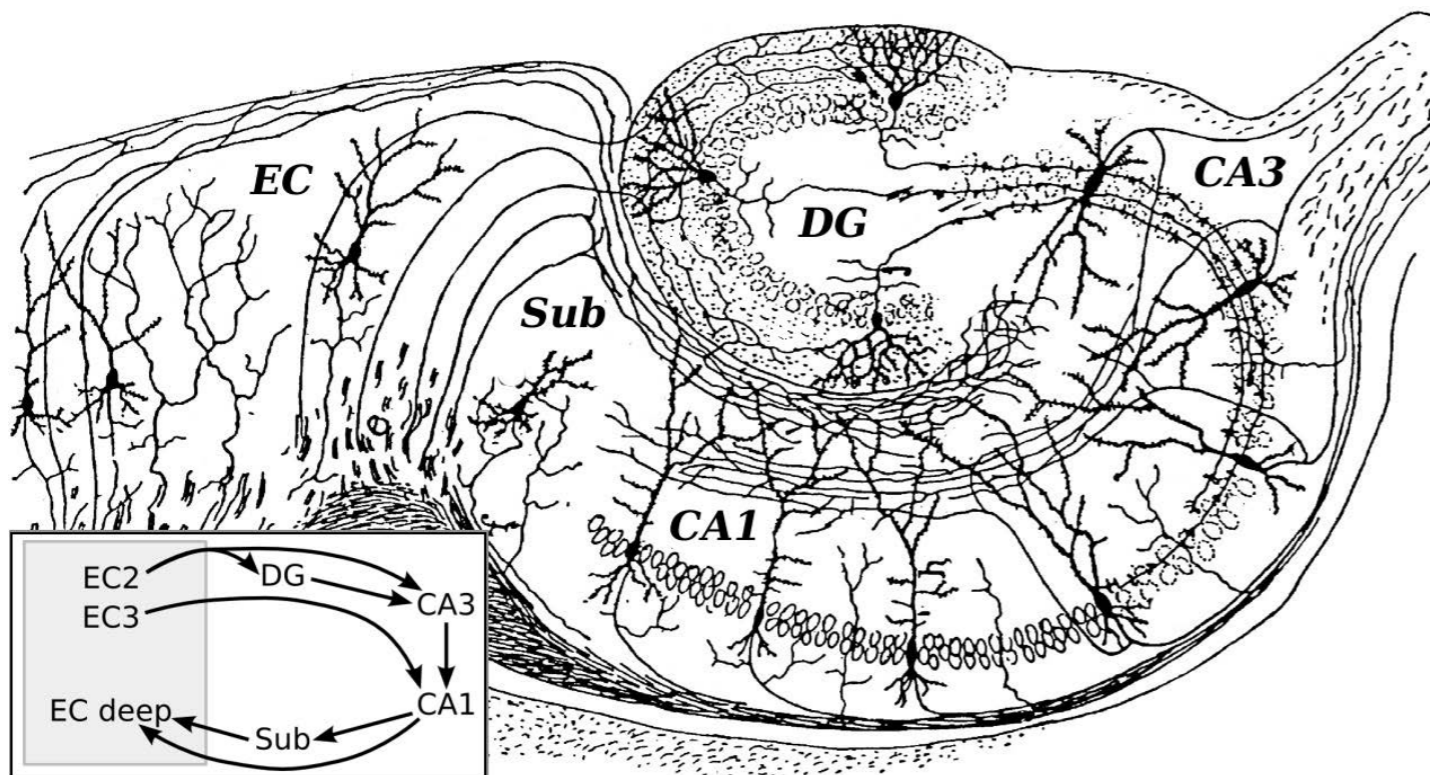
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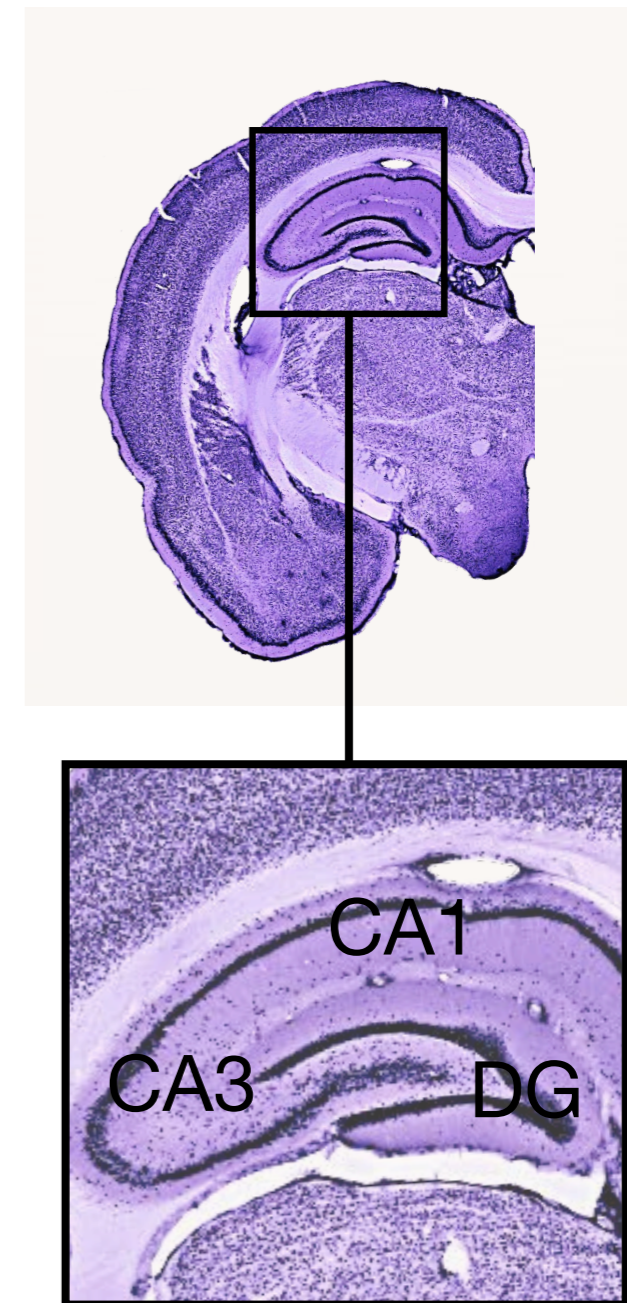
DETAILED ANATOMICAL ORGANIZATION OF MTL

THE TRISYNAPTIC CIRCUIT (AN OVERLY SIMPLISTIC VIEW)

Cajal's original drawings
(horizontal section)



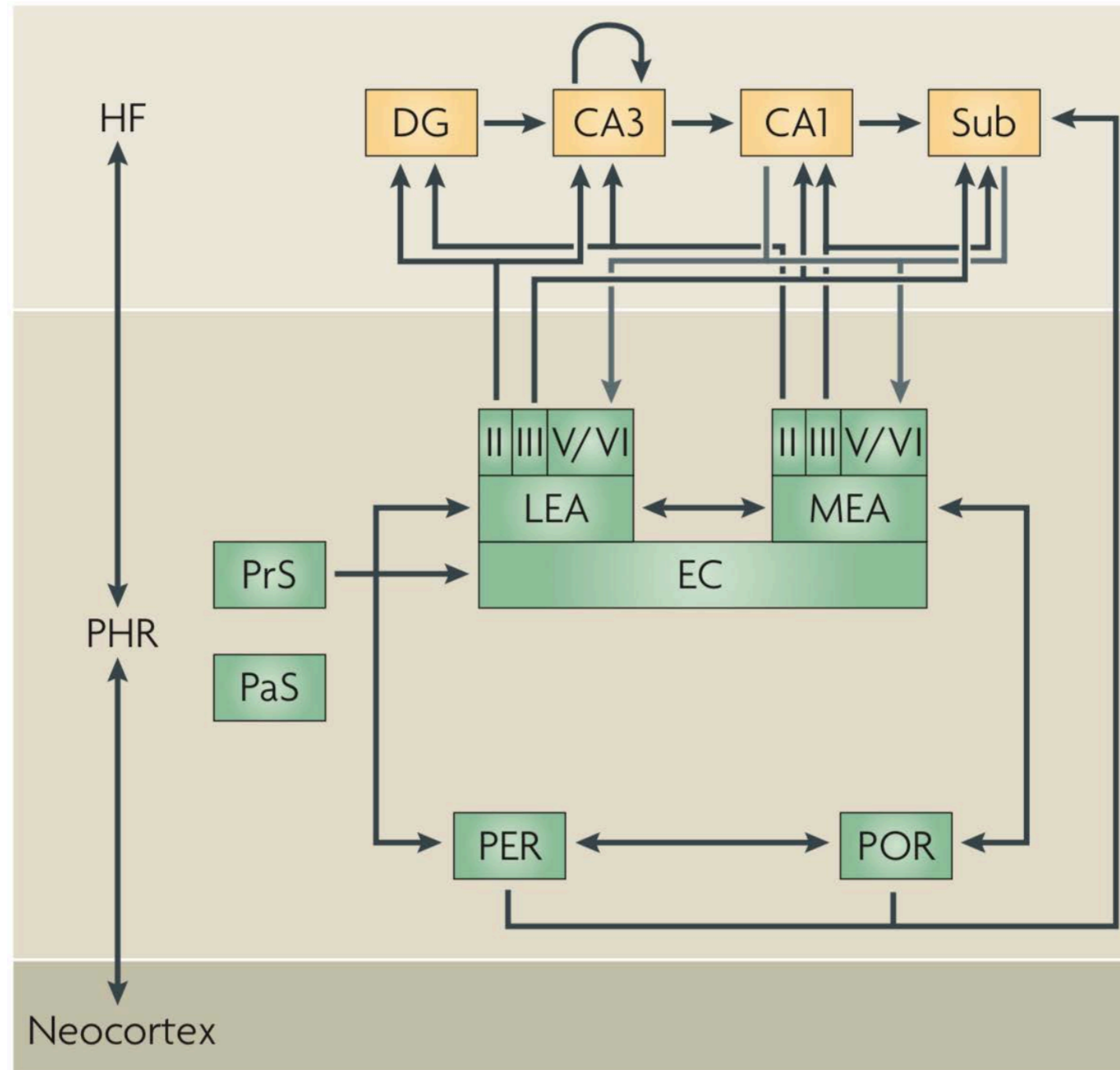
Standard (coronal) view



DETAILED ANATOMICAL ORGANIZATION OF MTL

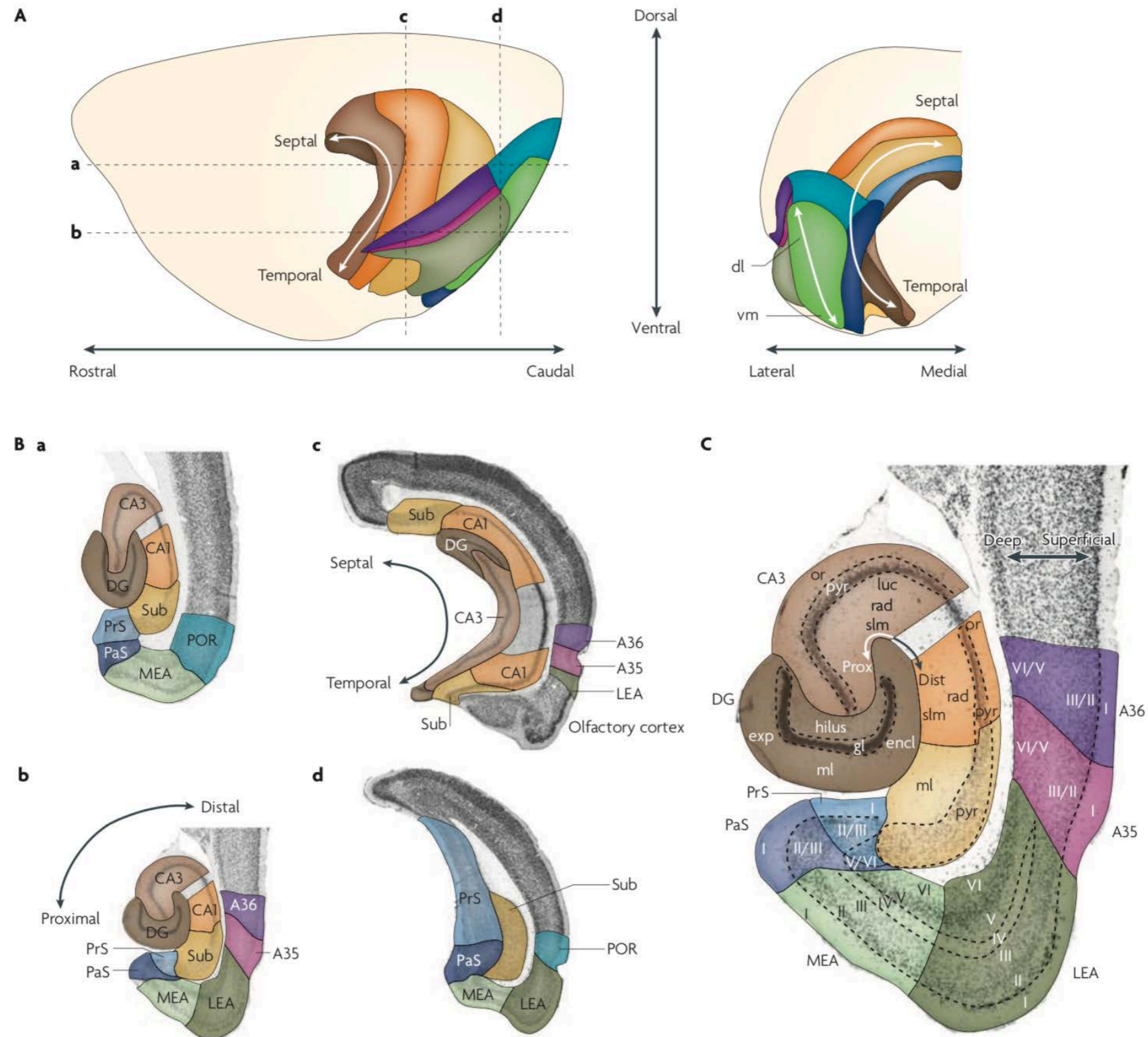
A MORE REALISTIC, BUT STILL SIMPLISTIC, VIEW

“Standard” model of hippocampal-parahippocampal circuitry



DETAILED ANATOMICAL ORGANIZATION OF MTL

A NICE WAY TO VISUALIZE THIS CIRCUIT

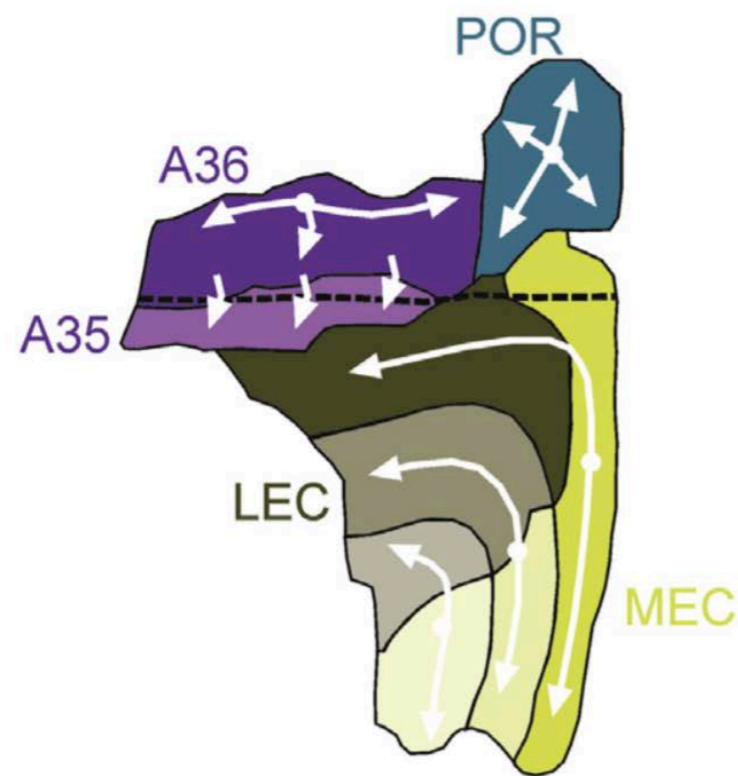


DETAILED ANATOMICAL ORGANIZATION OF MTL

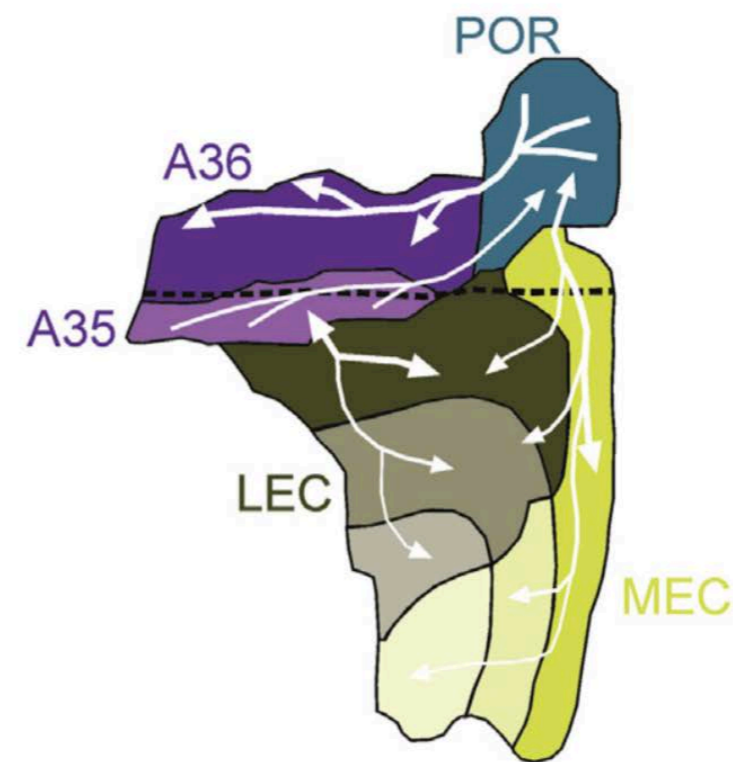
PARAHIPPOCAMPAL REGION CONNECTIONS

Unfolded maps of parahippocampal region:
entorhinal cortex (lateral and medial),
perirhinal cortex (A35, A36),
and postrhinal cortex (POR)

Intrinsic connections



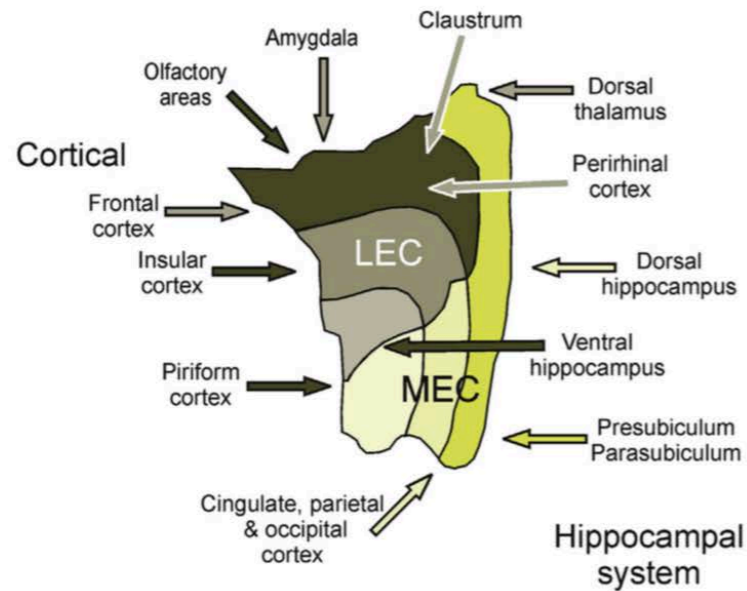
Extrinsic connections



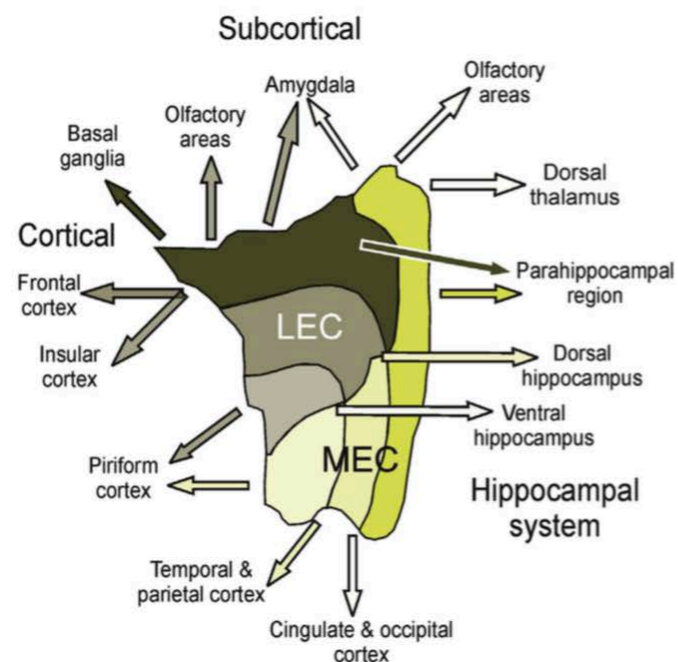
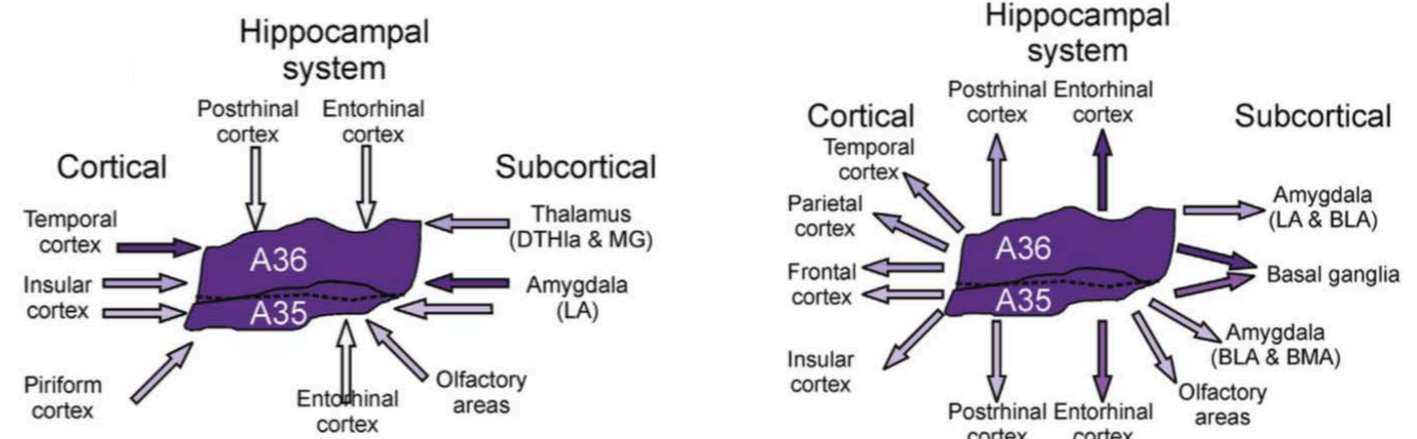
DETAILED ANATOMICAL ORGANIZATION OF MTL

PARAHIPPOCAMPAL REGION CONNECTIONS

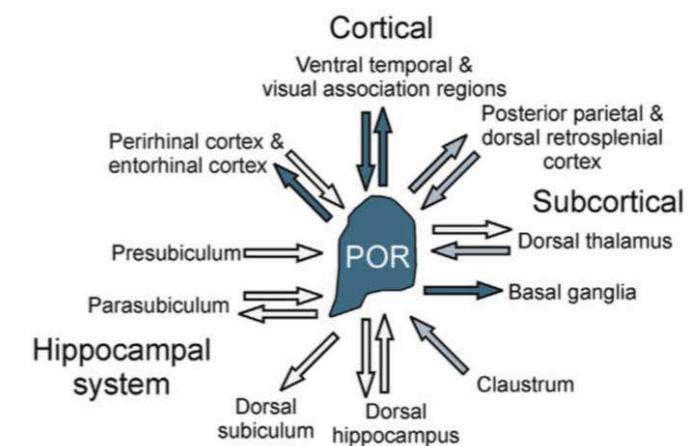
LEC and MEC major connections



Perirhinal cortex (A36, A35) major connections

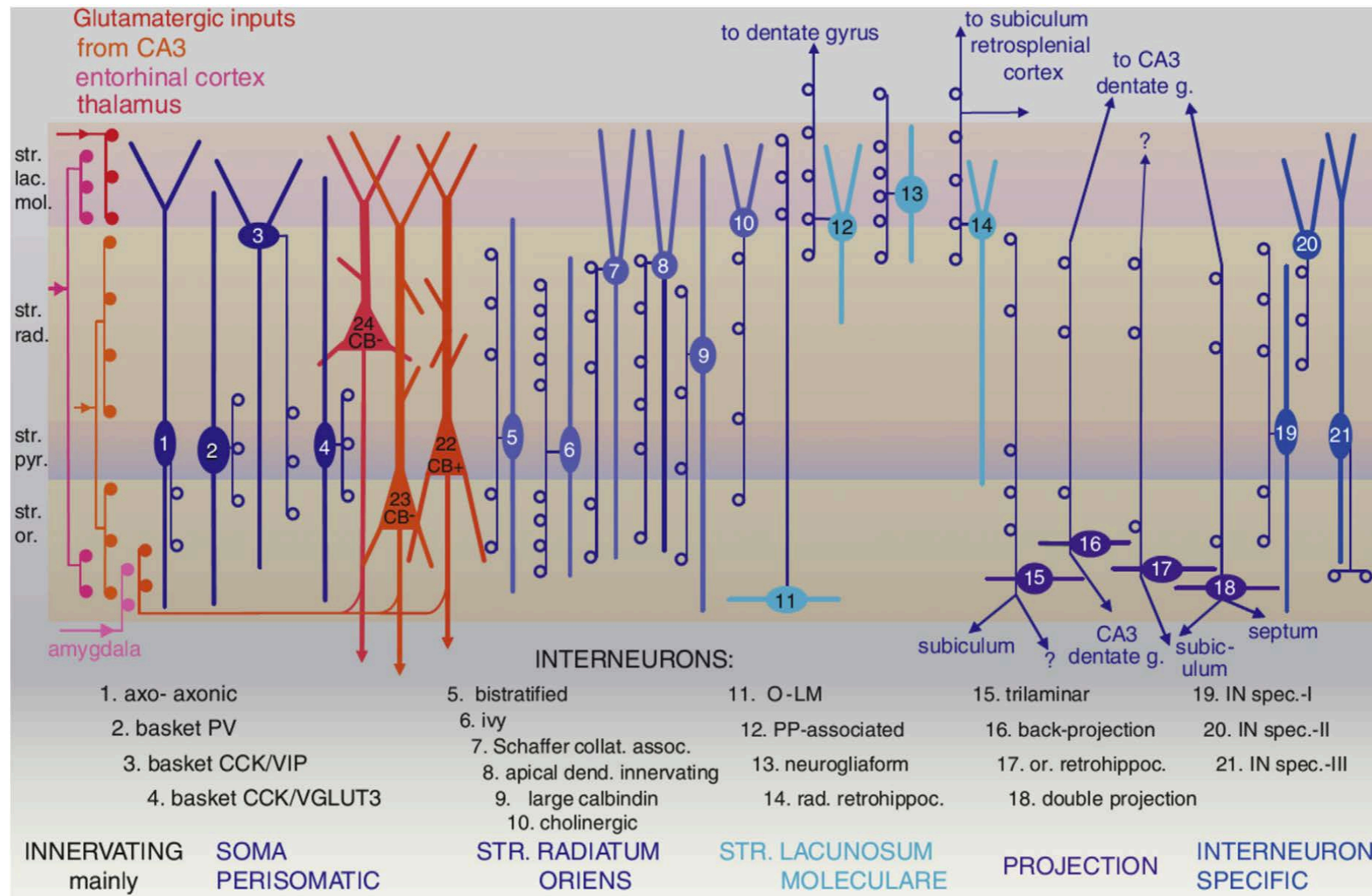


Postrhinal cortex major connections (called parahippocampal cortex in primates)



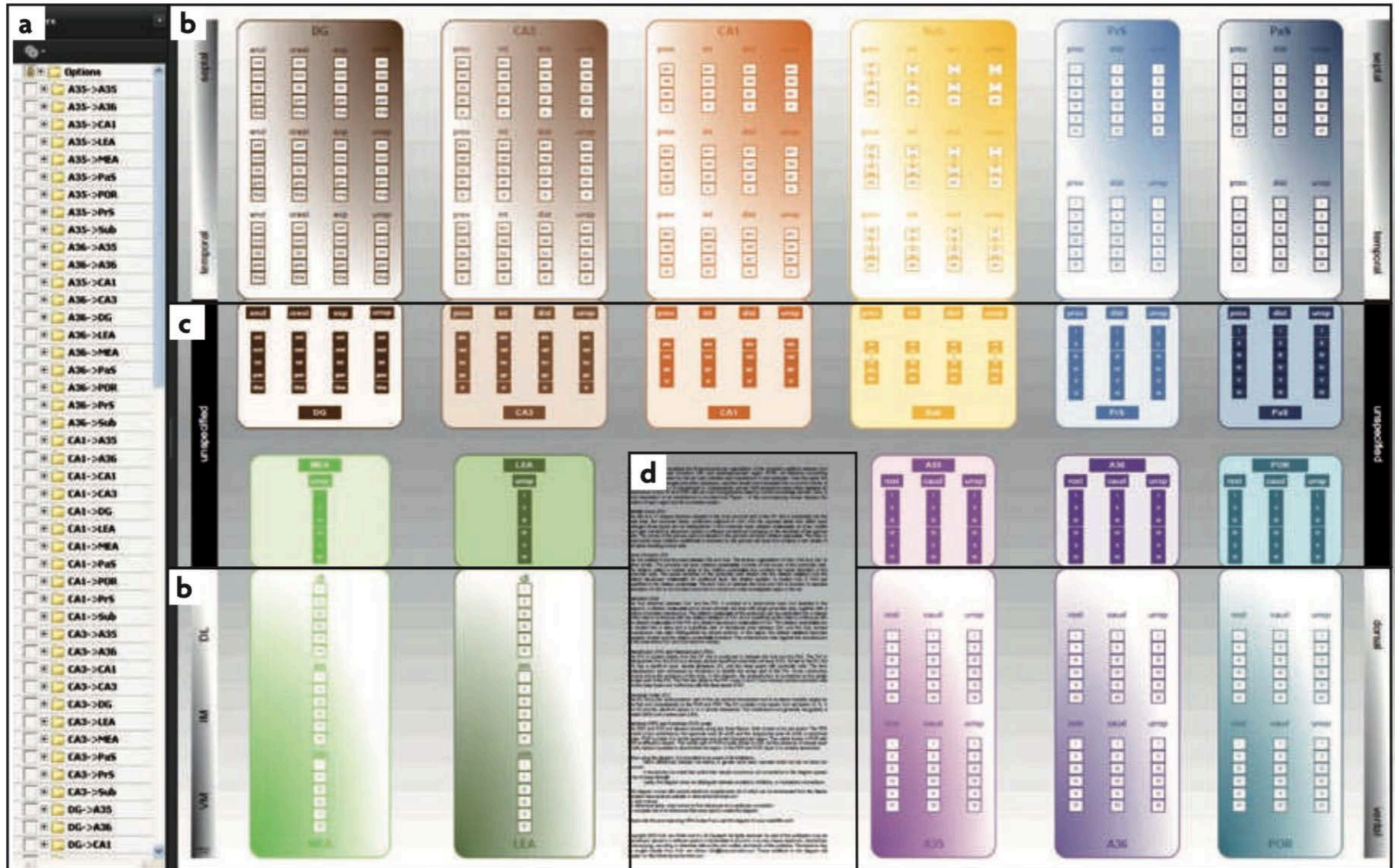
DETAILED ANATOMICAL ORGANIZATION OF MTL BUT WAIT... IT GETS MORE COMPLICATED!

Three types of pyramidal cells (cells 22–24) are accompanied by at least 21 classes of interneurons in CA1 alone



DETAILED ANATOMICAL ORGANIZATION OF MTL

EVERYTHING YOU EVER WANTED TO KNOW AND MORE



OVERVIEW

- Basic functional organization of the medial temporal lobes across species
- Detailed hippocampal-parahippocampal anatomical organization
- More anatomical resources

MORE ANATOMICAL RESOURCES

OPTIONAL READINGS

Optional chapter on class website

CHAPTER

20

Hippocampal Formation

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OUTLINE

Anatomy of the Hippocampal Formation (HF)	512	(Sub)Cortical Connectivity	528
Dentate Gyrus (DG)	512	Connectivity of CA3	530
Laminar Organization	512	Intrinsic Connectivity	530
Cytoarchitectonics	513	Connections with the Hippocampal Formation and Parahippocampal Region	530
Hippocampus Proper	517	Subcortical Connectivity	531
Laminar Organization	517	Connectivity of CA2	532
Cytoarchitectonics	517	Connections with the Hippocampal Formation	532
Subiculum (Sub)	520	Subcortical Connectivity	532
Laminar Organization	520	Connectivity of CA1	532
Cytoarchitectonics	520	Intrinsic Connectivity	532
Anatomy of the Parahippocampal Region (PHR)	521	Connections with the Hippocampal Formation and Parahippocampal Region	533
Presubiculum (PrS)	521	Connectivity with the (Neo)cortex	534
Position	521	Subcortical Connectivity	535
Laminar Organization	521	Connectivity of the Subiculum (Sub)	537
Cytoarchitectonics	521	Intrinsic Connectivity	537
Parasubiculum (PaS)	522	Connections with the Hippocampal Formation and Parahippocampal Region	537
Position	522	Connectivity with the (Neo)cortex	538
Laminar Organization	522	Subicular Subcortical Connectivity	539
Cytoarchitectonics	522	Connectivity of the Presubiculum (PrS)	541
Entorhinal Cortex (EC)	522	Intrinsic Connectivity	541
Position	522	Connections with the Hippocampal Formation and Parahippocampal Region	541
Laminar Organization	522	Connectivity with the (Neo)cortex	542
Subareas of the Entorhinal Cortex	522	Subcortical Connectivity	542
Borders between LEC and MEC	523	Connectivity of the Parasubiculum (PaS)	543
Cytoarchitectonics	523	Intrinsic Connectivity	543
Perirhinal and Postrhinal Cortex	525	Connections with the Hippocampal Formation and Parahippocampal Region	543
Perirhinal Cortex (PER)	525	Connectivity with the (Neo)cortex	544
Postrhinal Cortex (POR)	526	Subcortical Connectivity	544
Connectivity of the Hippocampal Formation and Parahippocampal Region	526		
Connectivity of the Dentate Gyrus (DG)	526		
Connections with the Hippocampal Formation and the Parahippocampal Region	528		

MORE ANATOMICAL RESOURCES

ONLINE RESOURCES

<http://hippocampome.org> Curated knowledge base of the circuitry of the hippocampus of normal adult, or adolescent, rodents at the mesoscopic level of neuronal types. Knowledge concerning dentate gyrus, CA3, CA2, CA1, subiculum, and entorhinal cortex is distilled from published evidence and is continuously updated as new information becomes available. Each reported neuronal property is documented with a pointer to, and excerpt from, relevant published evidence, such as citation quotes or illustrations.

<http://neuromorpho.org> Centrally curated inventory of digitally reconstructed neurons associated with peer-reviewed publications. It contains contributions from over 100 laboratories world-wide and is continuously updated as new morphological reconstructions are collected, published, and shared. To date, the largest collection of publicly accessible 3D neuronal reconstructions and associated metadata.

<http://temporal-lobe.com> Curated knowledge base of the hippocampal–parahippocampal–retrosplenial connectivity, based on tract-tracing literature of the rat. The repository provides an interactive connectome, an easy way to lookup who published “A projects to B” and images and 3D models to visualize complex anatomical concepts.

<http://www.rbwb.org> Collection of brain mapping and atlas oriented database applications and tools. The main category of available data is high resolution mosaic images covering complete histological sections through the rat and mouse brain. A highly structured relational database system for archiving, retrieving, viewing, and analyzing microscopy and imaging data, aiming at presentation in standardized brain atlas space, is used to present a series of web applications for individual research projects.