Chapter 2: Studies of Human Learning and Memory

From *Mechanisms of Memory*, second edition

By J. David Sweatt, Ph.D.

Definitions

Learning: The acquisition of an altered behavioral response due to an environmental stimulus.

Memory: The processes through which learned information is stored.

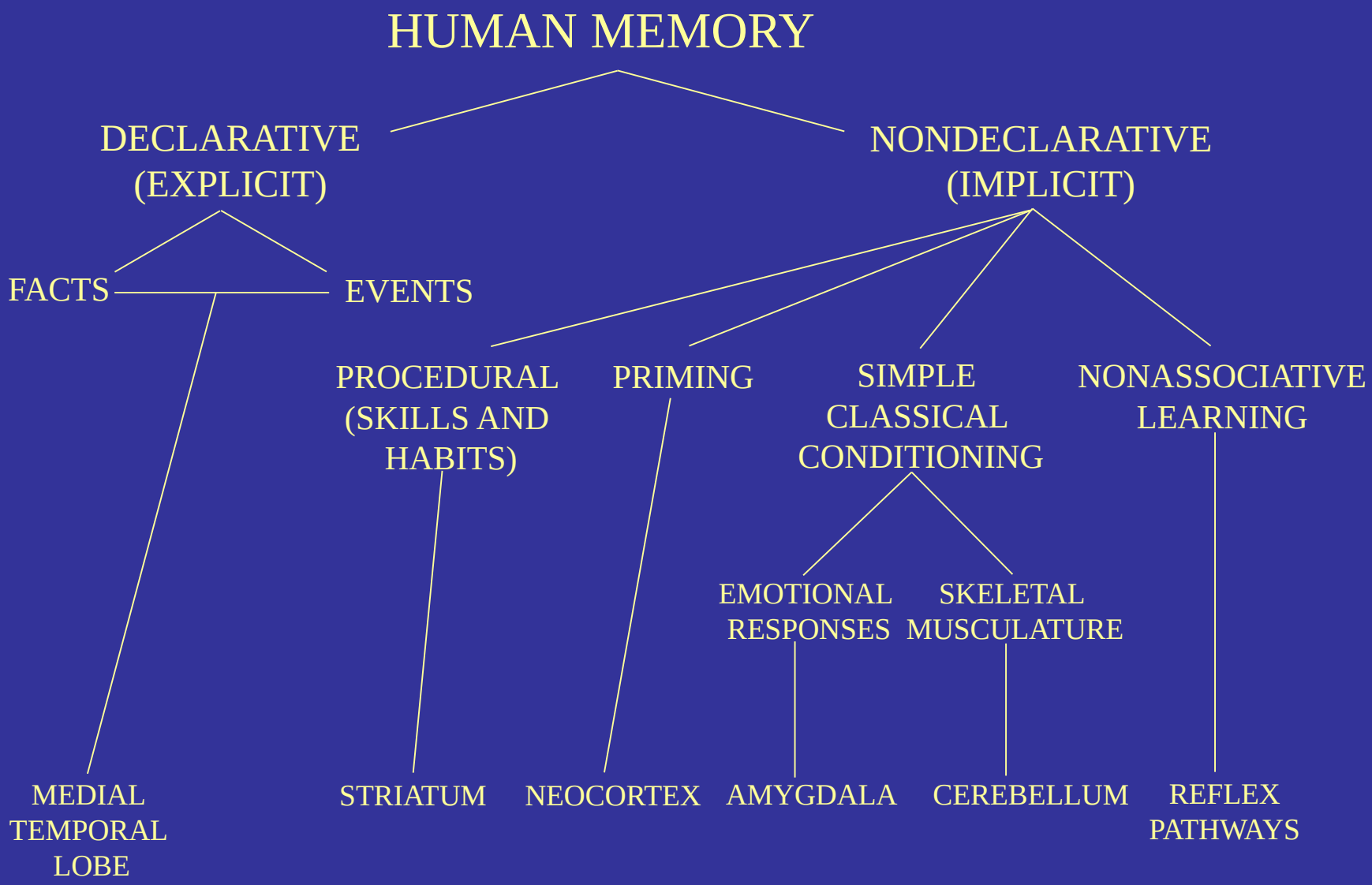
Recall: The conscious or unconscious retrieval process through which this altered behavior is manifest.

Movies Using Amnesia as a Plot Device

Movie	Director (plus Notable Actors)	Year
Anterograde Amnesia:		
Memento	Christopher Nolan (Guy Pearce)	2001
Finding Nemo	Andrew Stanton (Animated - Ellen DeGeneris as Dory)	2003
50 First Dates	Peter Segal (Adam Sandler)	2004
Retrograde Amnesia:		
The Bourne Identity	Doug Liman (Matt Damon)	2002
Total Recall	Paul Verhoeven (Arnold Schwarzenegger, Sharon Stone)	1990
Spellbound	Alfred Hitchcock (Ingrid Bergman, Gregory Peck)	1945
Eternal Sunshine of the Spotless Mind	Michel Gondry (Jim Carrey, Kate Winslet)	2004
The Forgotten	Joseph Ruben (Julianne Moore)	2004
Men in Black	Barry Sonnenfeld (Tommy Lee Jones, Will Smith)	1997
Not Sure:		
Mulholland Drive	David Lynch (Michael J. Anderson, Diane Baker)	2001

Table 1

Subdivisions of Human Memory



Milner B, Squire LR, Kandel ER: "Cognitive neuroscience and the study of memory". Neuron 1998, 20:445-468.

Multiple Memory Systems in the Human CNS

Memory Subtype	Corresponding CNS Subregion
Working Memory	Prefrontal Cortex, contributions from Caudate Nucleus
Declarative, Episodic, and Spatial Memory	Medial Temporal Lobe system including the Hippocampus, Dentate Gyrus, Ento-rhinal and Peri-rhinal cortices
Habits, Motor Skills, Procedural Memory	Striatum (Caudate Nucleus and Putamen), Globus Pallidus*, and Cerebellum
Priming	Occipital Cortex, Neocortex in general
Aversive Associative Conditioning	Amygdala
Motoric Associative Conditioning	Cerebellum
Olfactory and Taste Conditioning	Olfactory Bulb, Insular Cortex, Nucleus Tractus Solitarius (NTS), positive and negative reinforcement systems (Amygdala or Nucleus Accumbens)
Sensitization, Habituation	Spinal Cord, Brainstem Nuclei, Amygdala
Circadian Rhythm	Hypothalamus – Suprachiasmatic Nucleus (SCN)
Reward, Positive Reinforcement, Addiction	Nucleus Accumbens, Ventral Tegmental Area (VTA)

*Collectively the Caudate Nucleus, Putamen, and Globus Pallidus are referred to as the Basal Ganglia.

Table 2

Memory-associated Cognitive Dysfunction in Humans

Disease or Syndrome	Type of Memory Affected or Involved*	Likely Anatomical Locus
Schizophrenia	Working Memory	Prefrontal Cortex
Major Depression	Declarative Memory	?
Aging-related Dementias	Long-term Declarative and Episodic Memory	Temporal Lobe Hippocampal System
Korsakoff's Syndrome (Alcoholism, Malnutrition)	Long-term Declarative and Episodic Memory	Mamillary Bodies, Limbic System, Thalamus
Huntington's Disease and Parkinson's Disease	Motor Learning, Habit Learning	Nigro-striatal System
Attention Deficit	Generalized or Specific Learning	Frontal Lobes?
Hyperactivity Disorder (ADHD)	Disabilities, Dyslexia	Basal Ganglia?
Post-traumatic Stress Disorder* (PTSD)	Aversive Associative Conditioning, Lack of Extinction	Amygdala, Hippocampus

Table 3

Short-term Memory and the Multi-store Memory Model

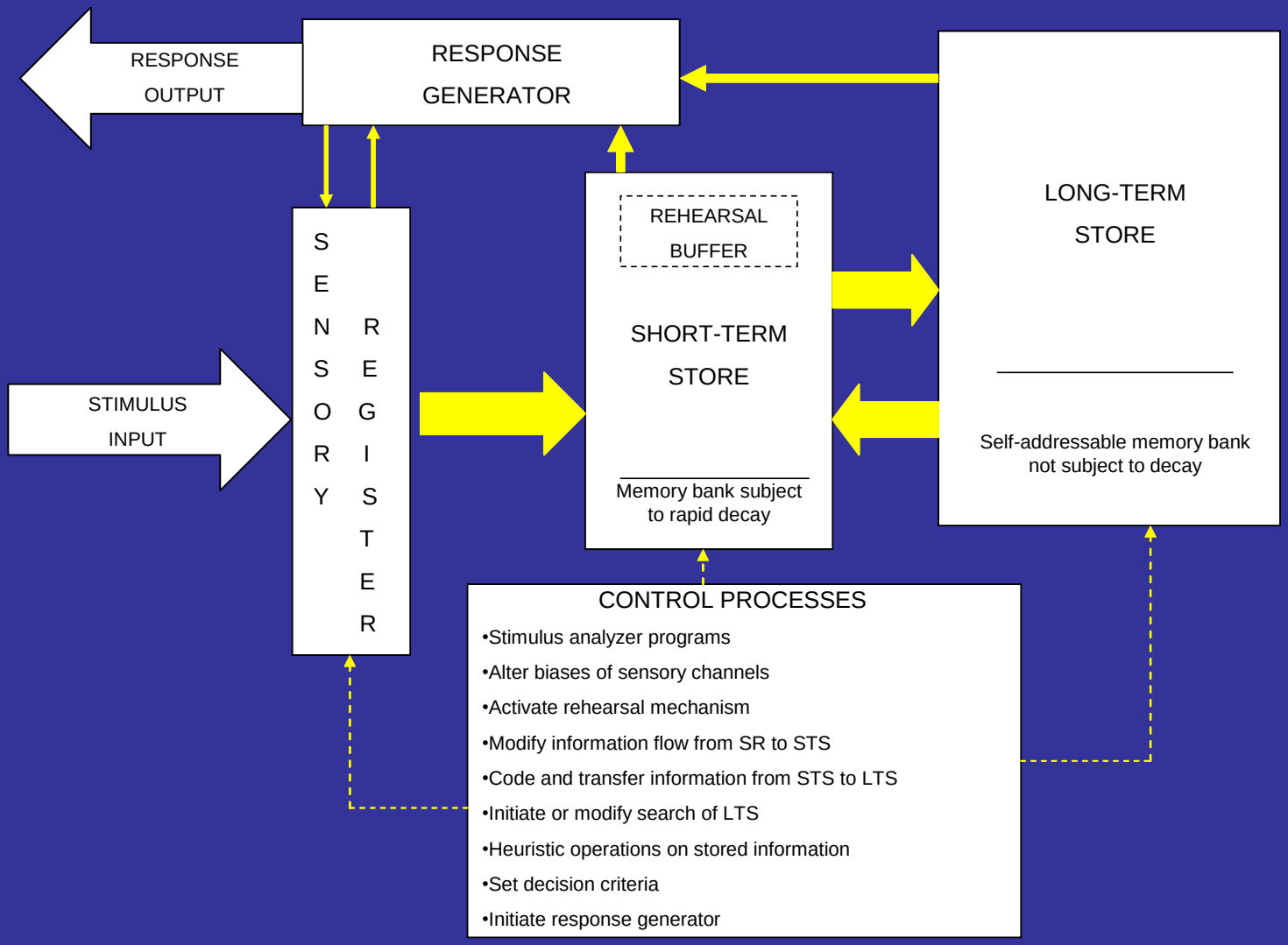


Figure 6A



624

52 x 12

Short-term Memory and the Multi-store Memory Model

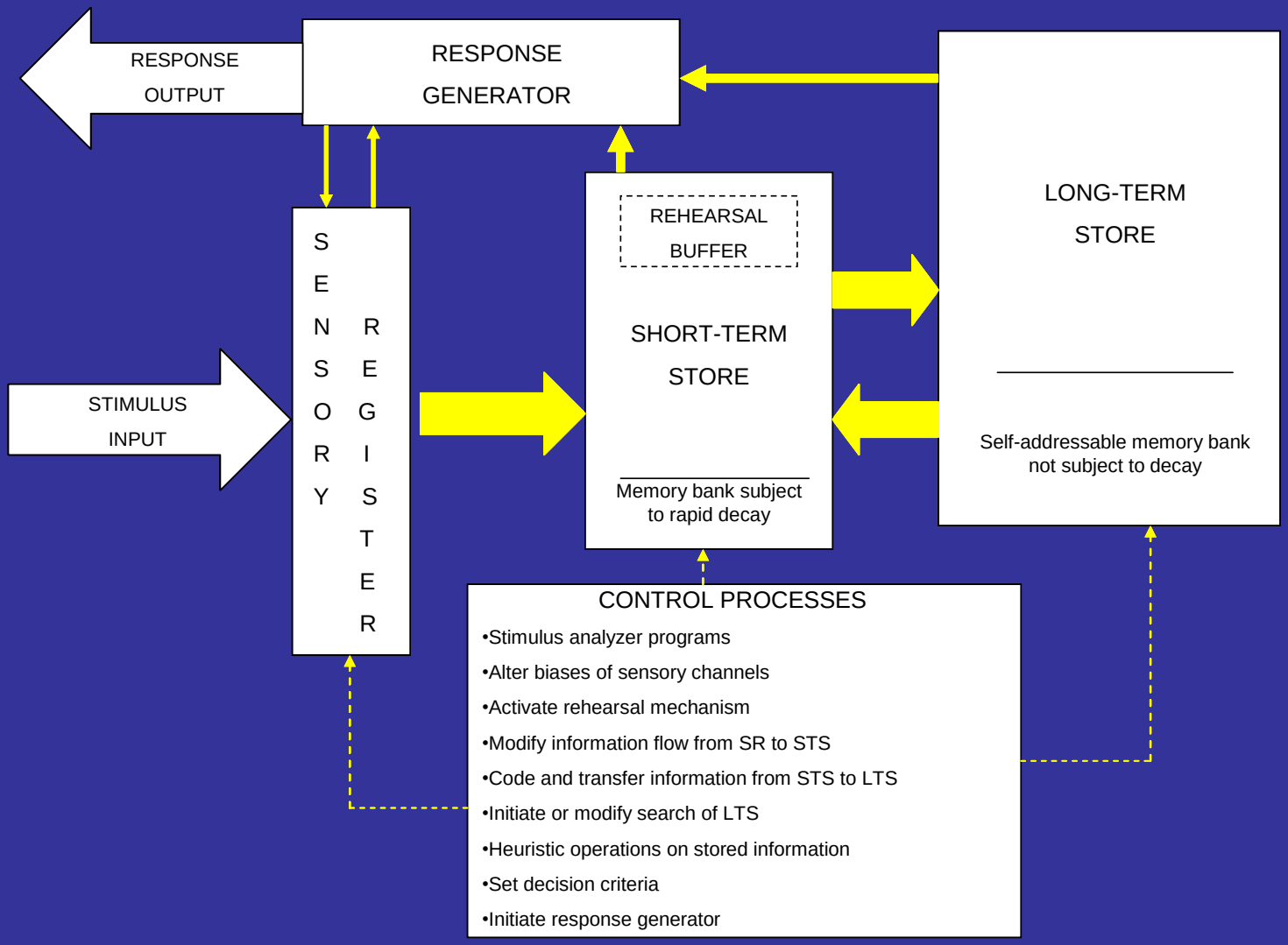


Figure 6A

Baddeley's Working Memory Module

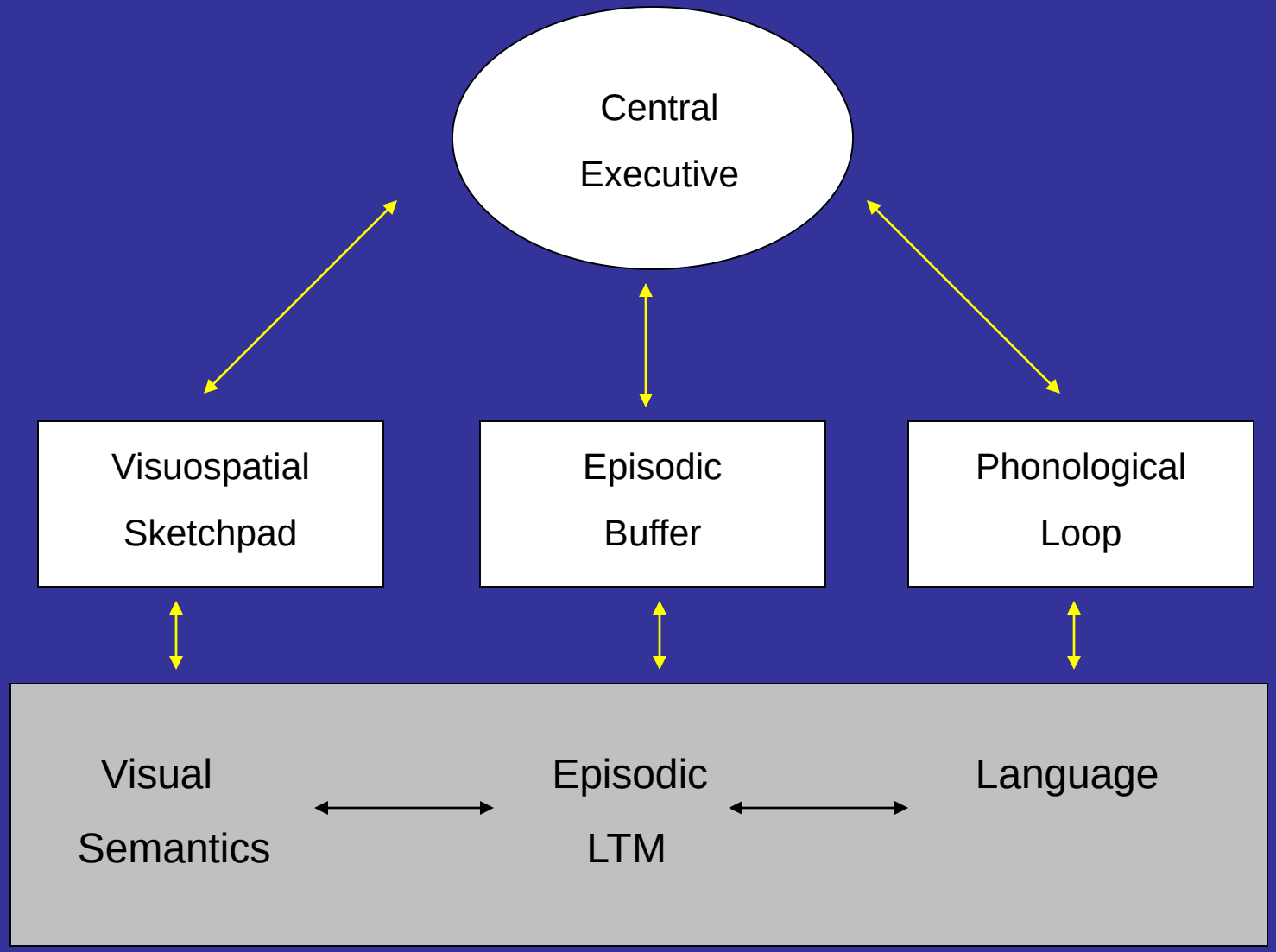


Figure 6B

Anatomical Subdomains of Working Memory

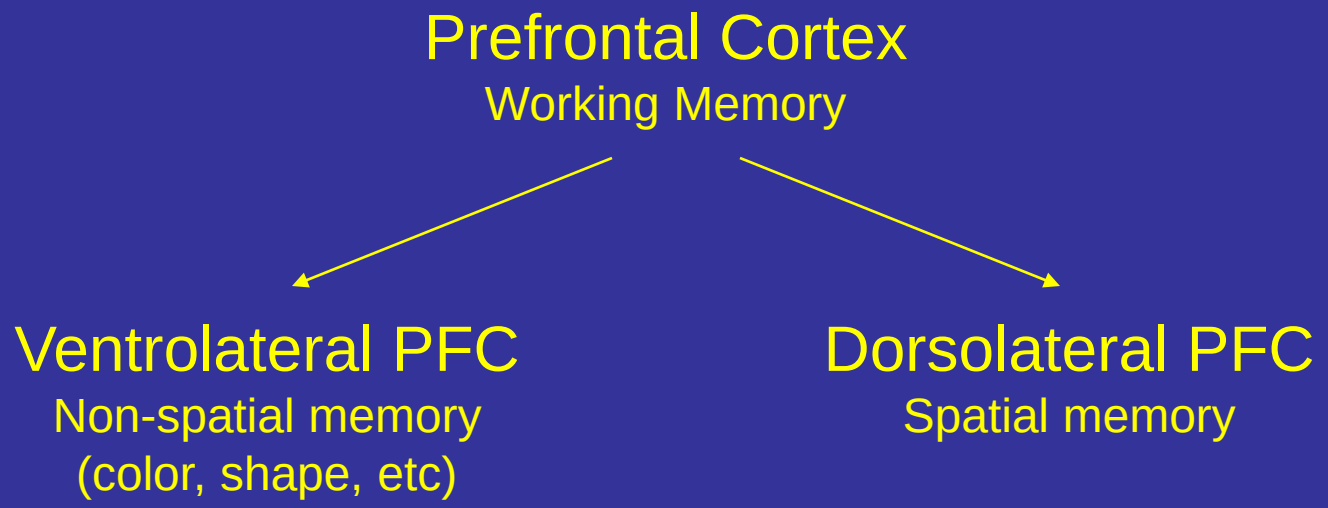


Figure 7

Short-term Memory

Working Memory

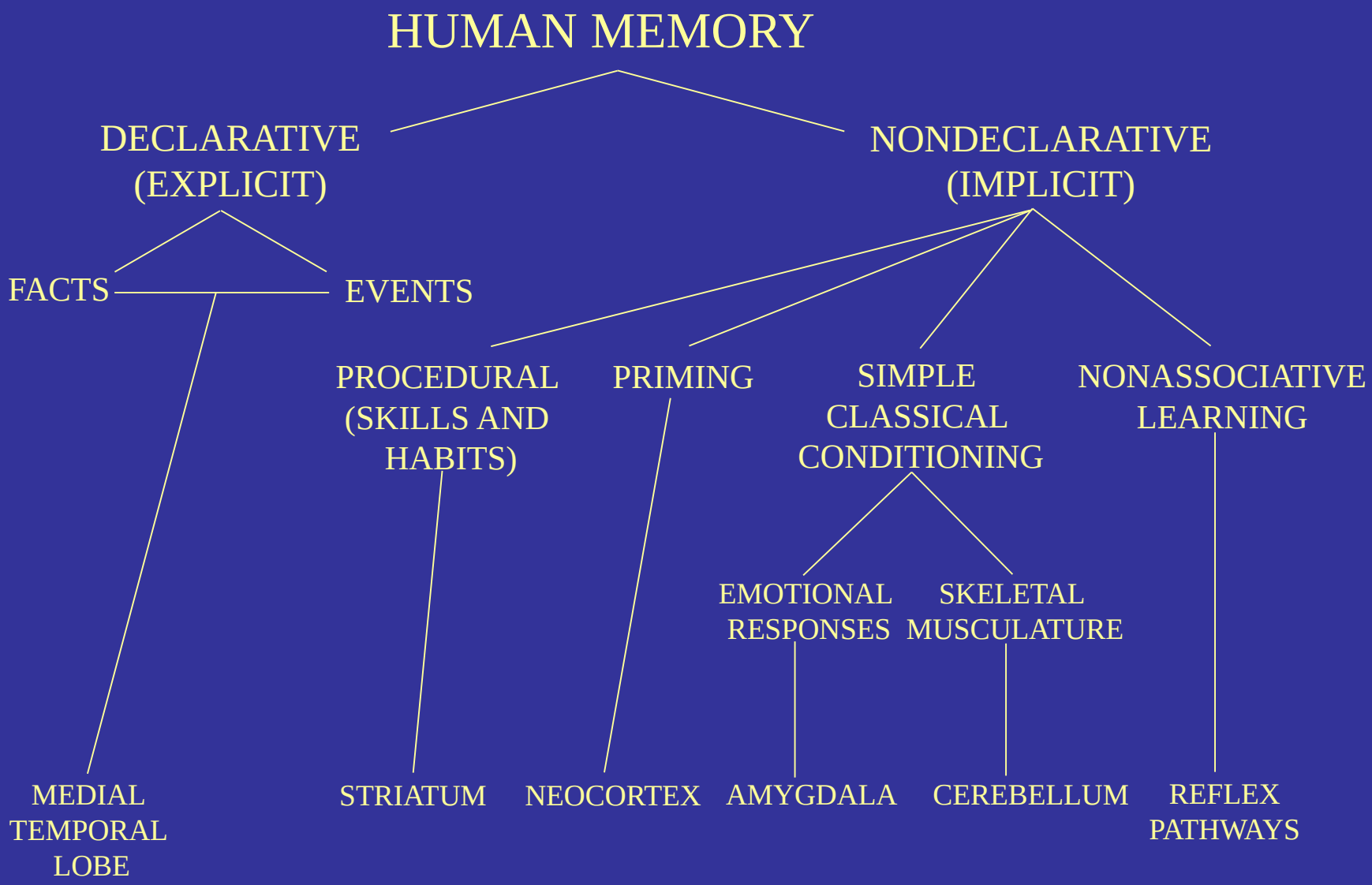
Action Potential Firing
Sustained Neural Circuit Activity

Long-term Memory

Persisting Molecular and Cellular Changes
Changes in Synaptic Structure
Anatomical Circuit Alterations

Figure 8

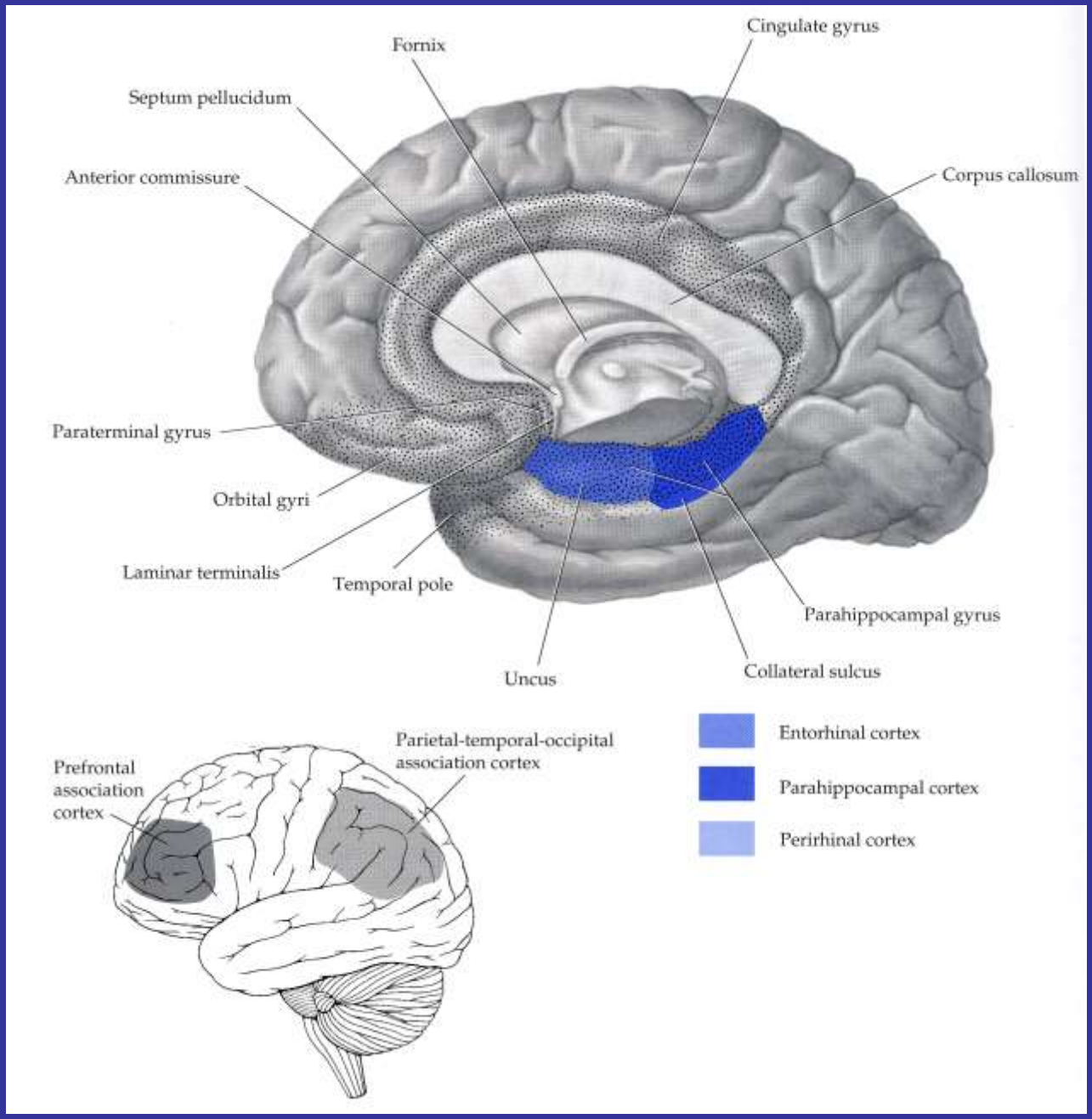
Subdivisions of Human Memory



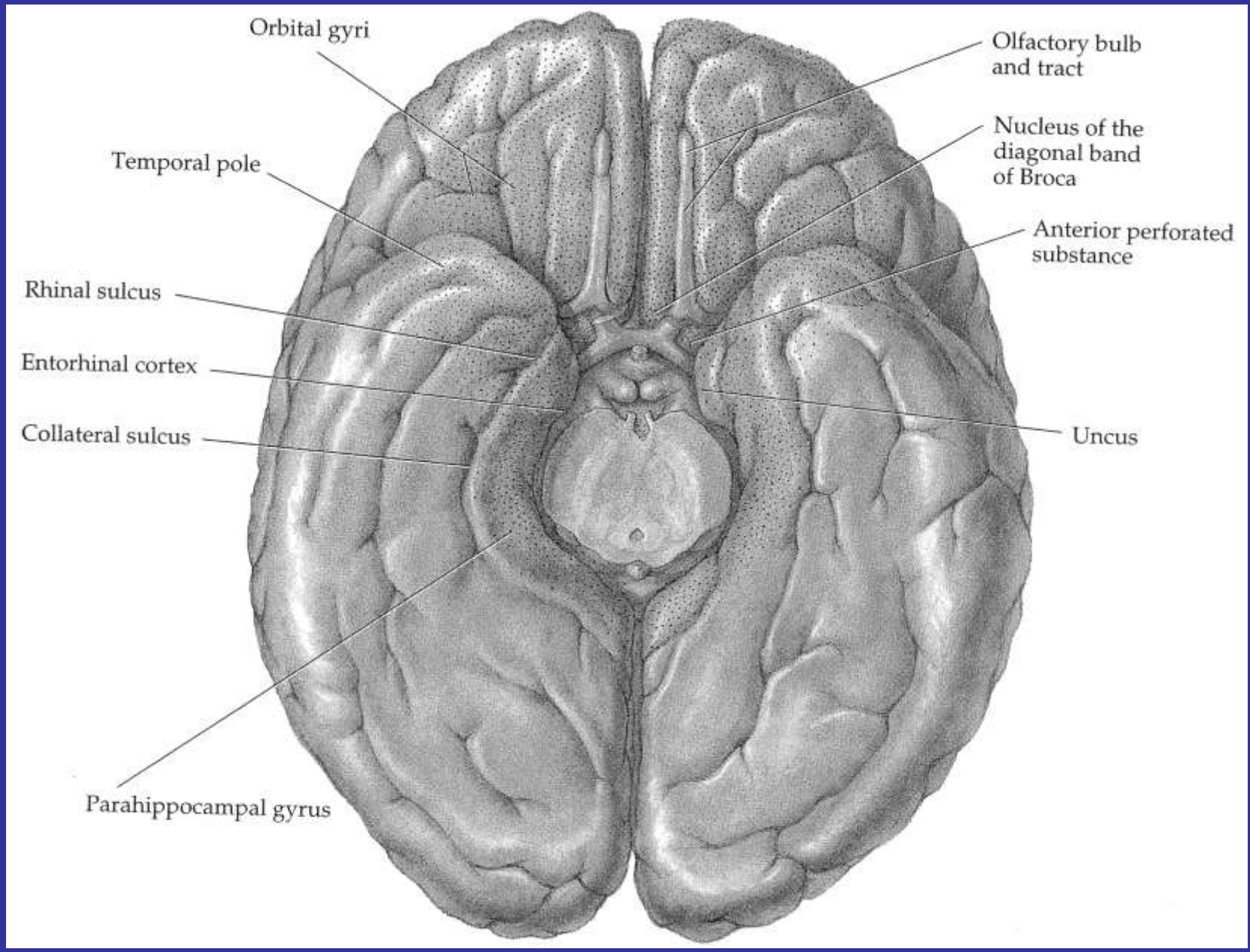
Milner B, Squire LR, Kandel ER: "Cognitive neuroscience and the study of memory". Neuron 1998, 20:445-468.

Functions of the Hippocampus

- Cognitive Processing:
  - Space
  - Time
  - Relationships
- Memory Consolidation



From JH Martin, *Neuroanatomy*



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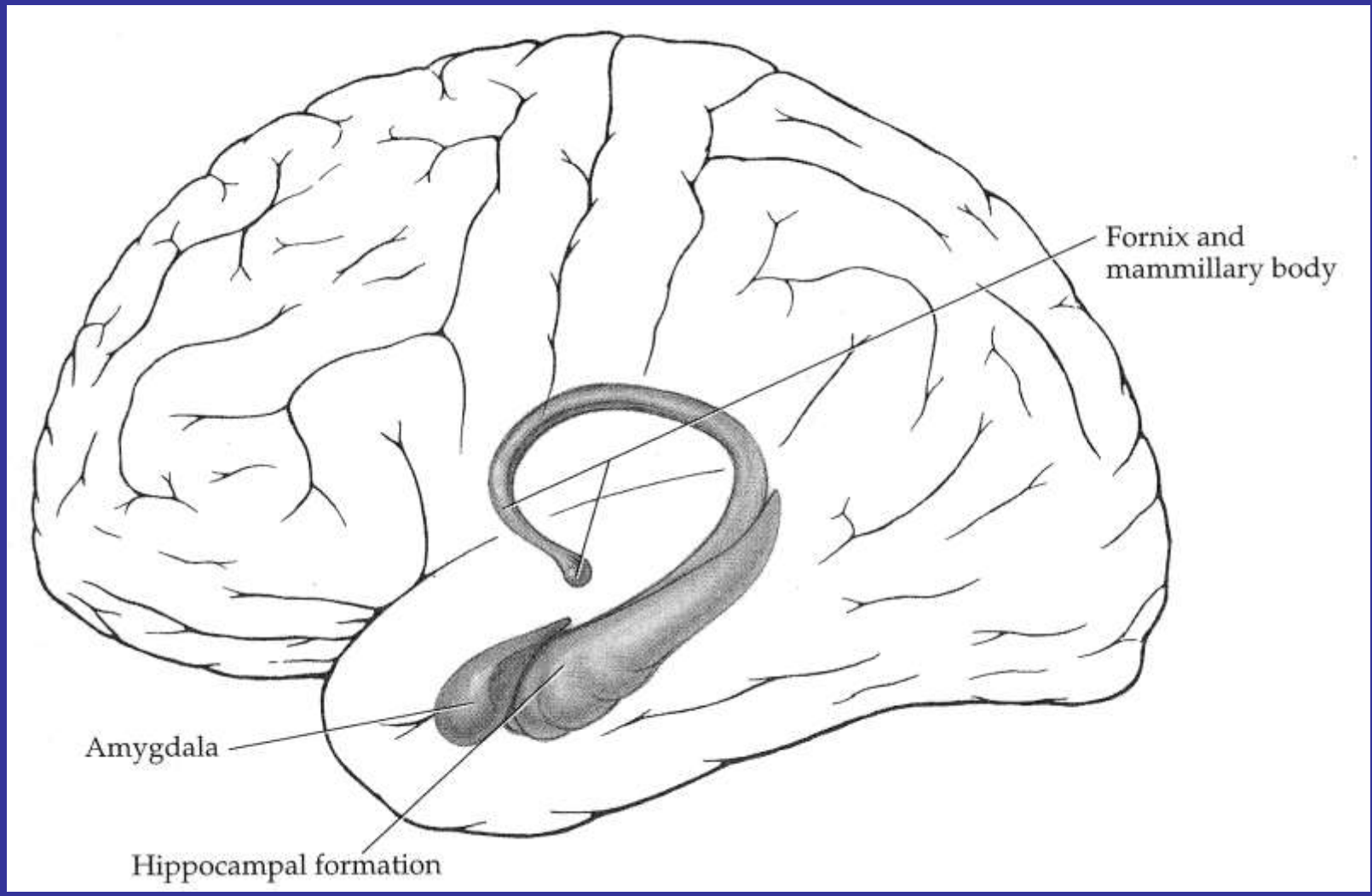
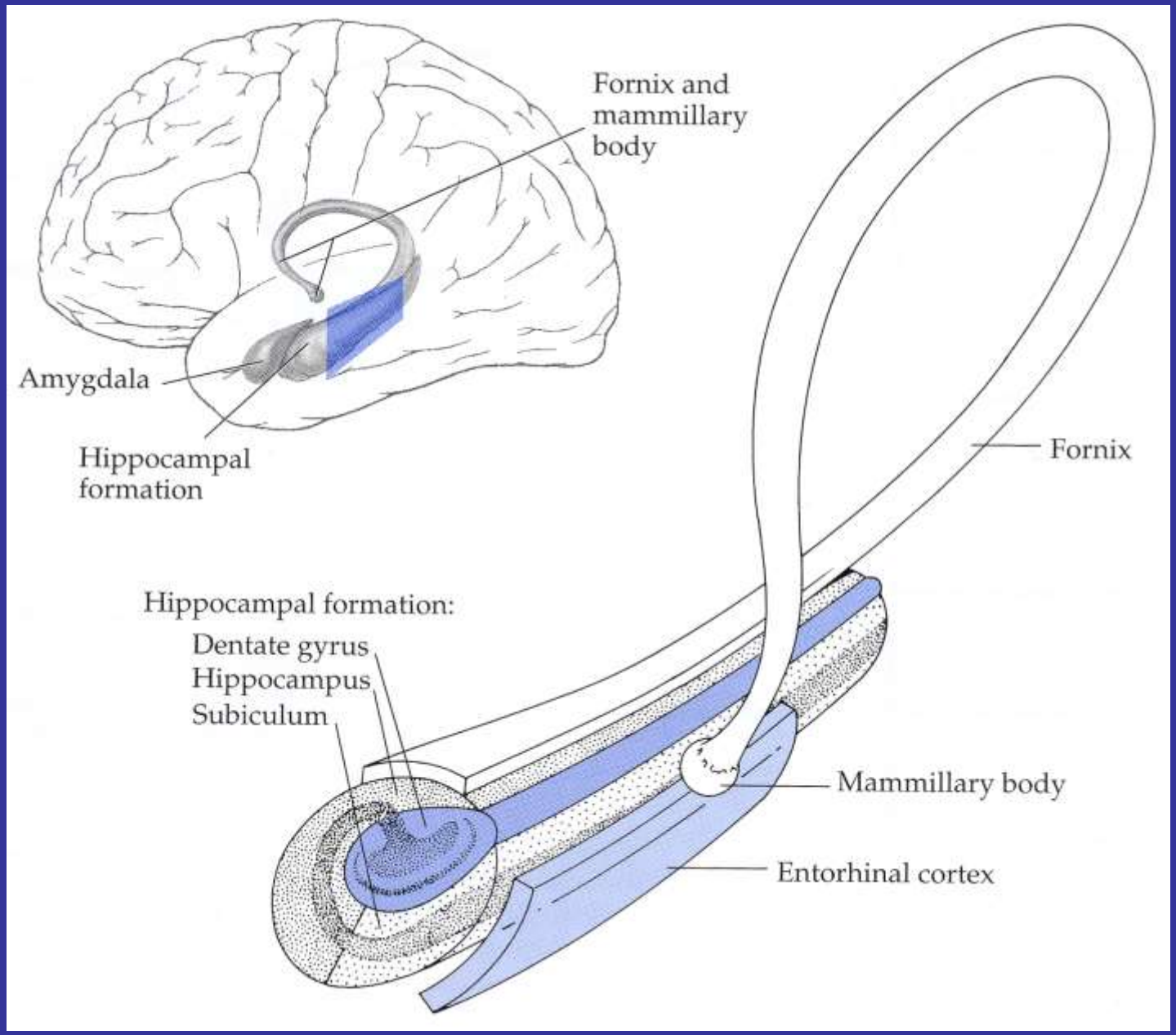


From JH Martin, *Neuroanatomy*

Lined Seahorse, *Hippocampus erectus*

Vertebrate Field Zoology Photo #148, Courtesy Samford University



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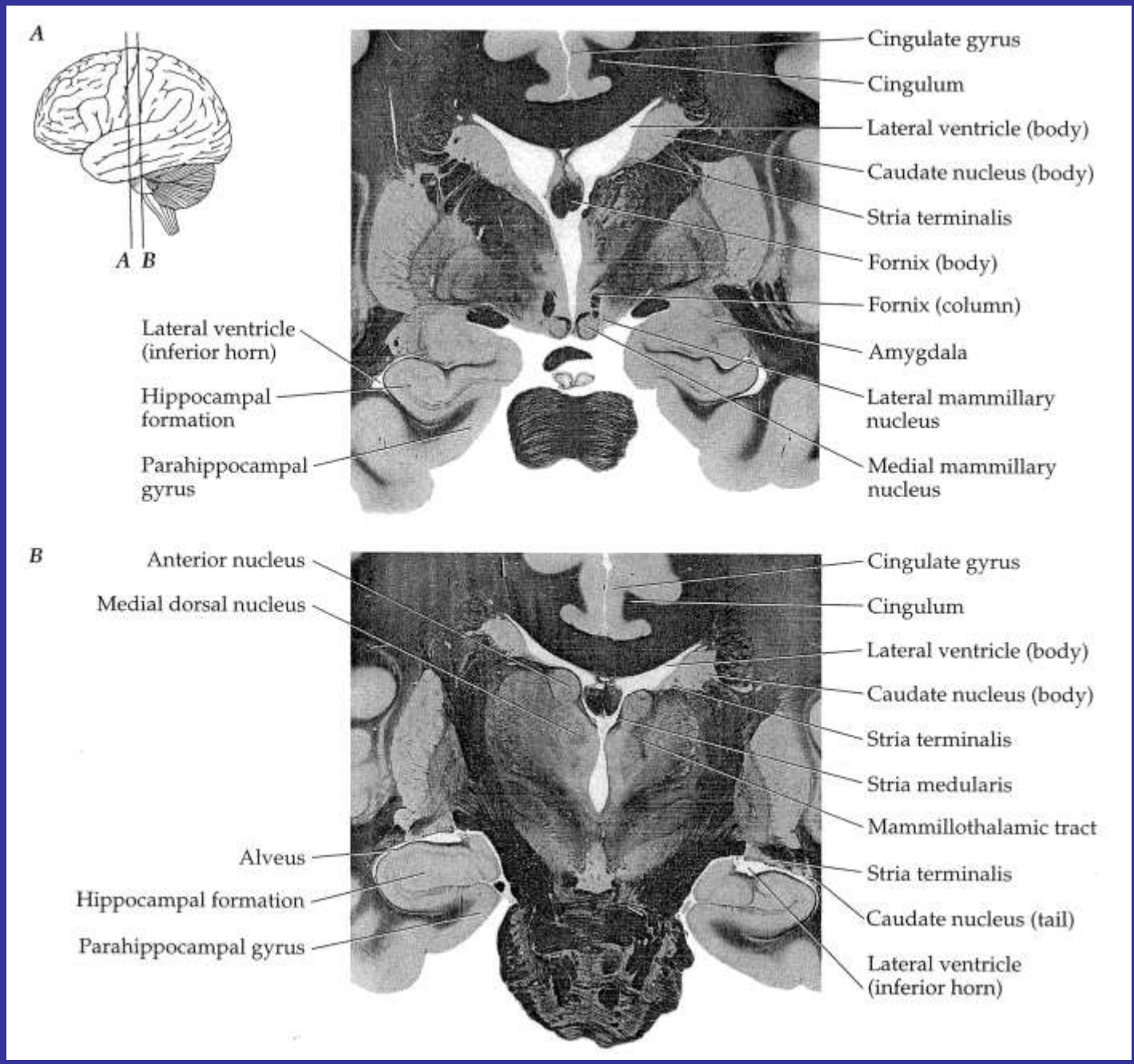

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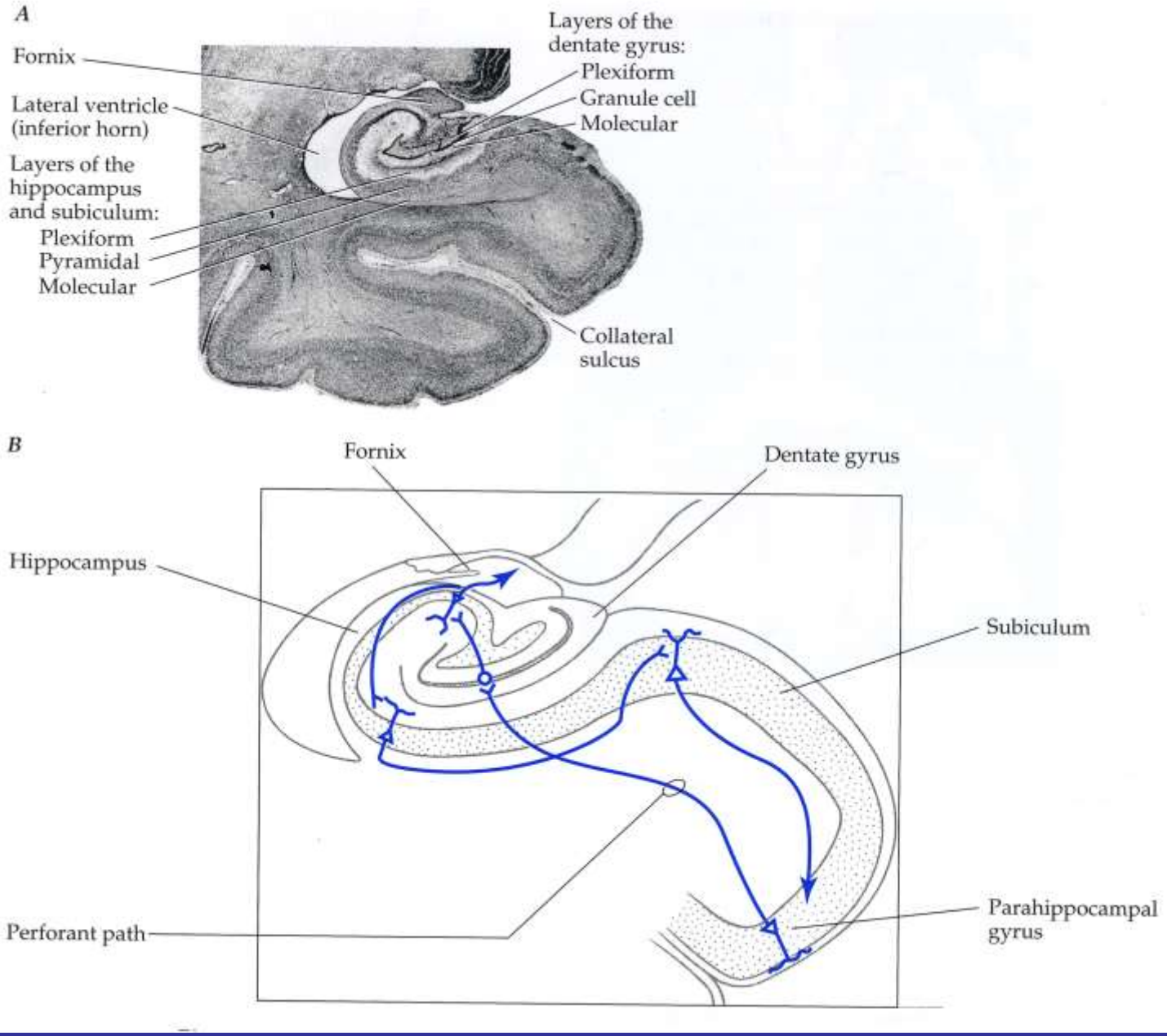

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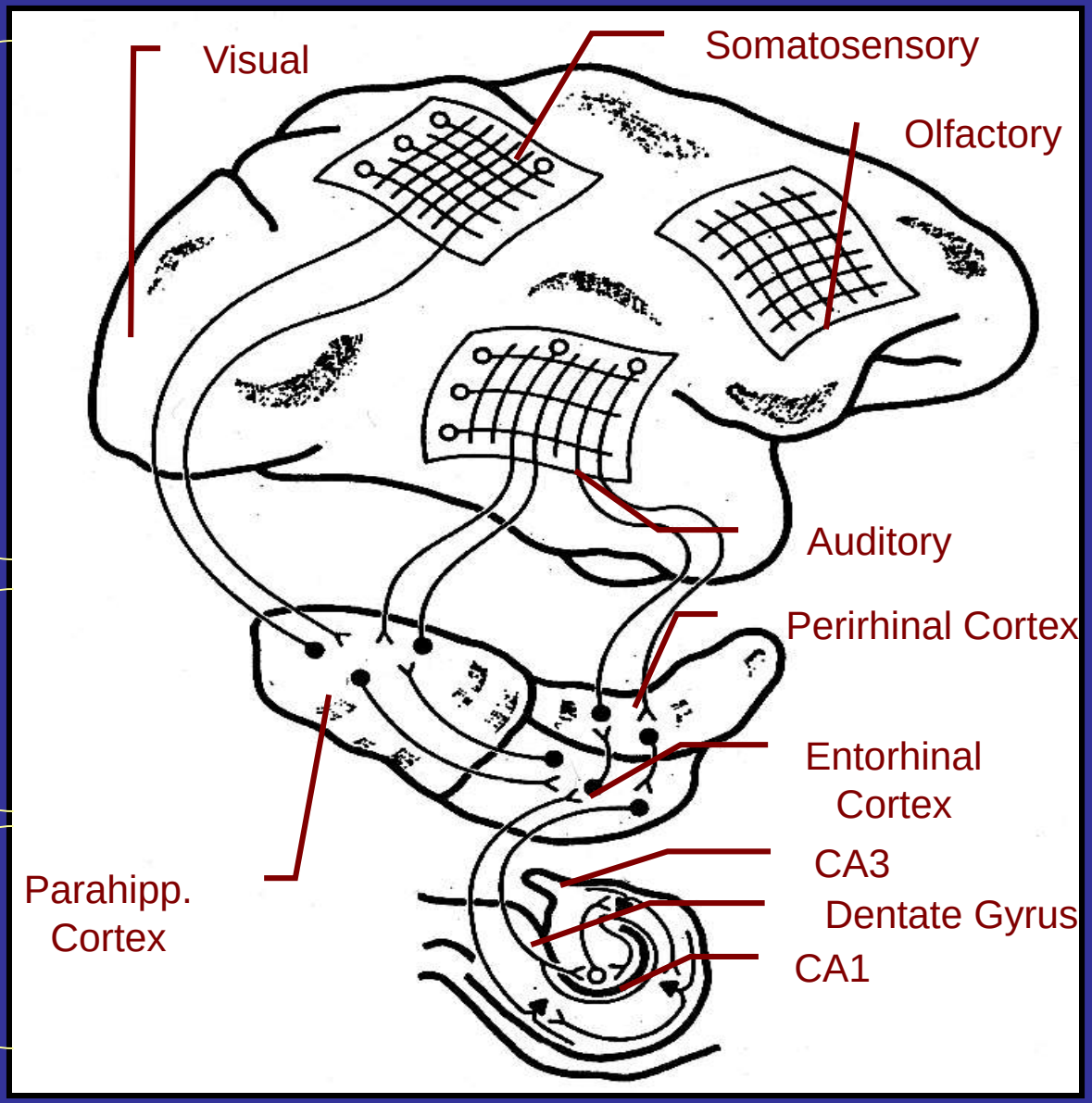
Hippocampal Connectivity in the CNS

Sensory Regions Of Cortex

Perirhinal/ Entorhinal Cortex

Hippocampal Formation



Hippocampal Output Pathway & Intrinsic Circuit

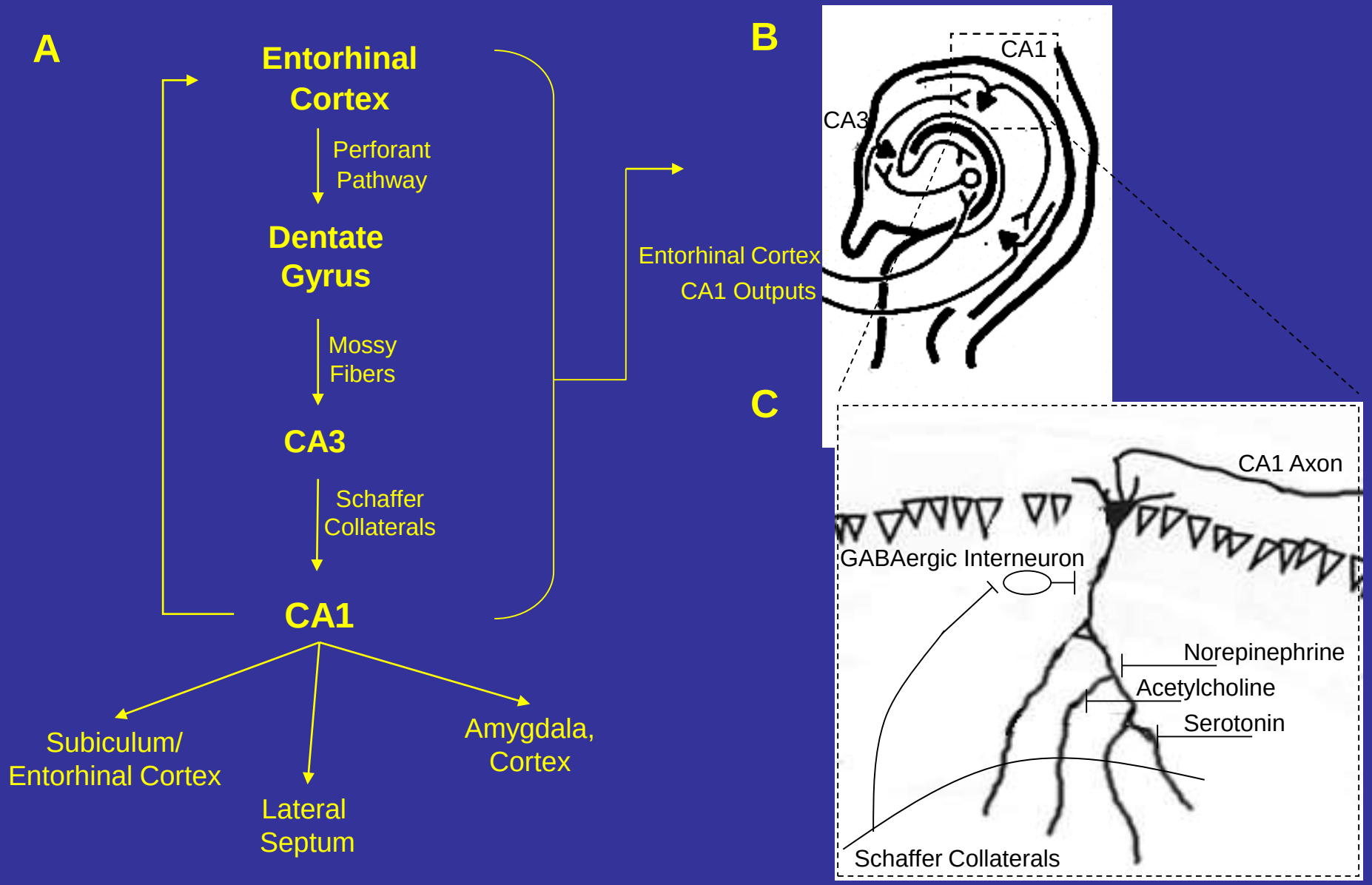


Figure 5

Hippocampal Pyramidal Neuron

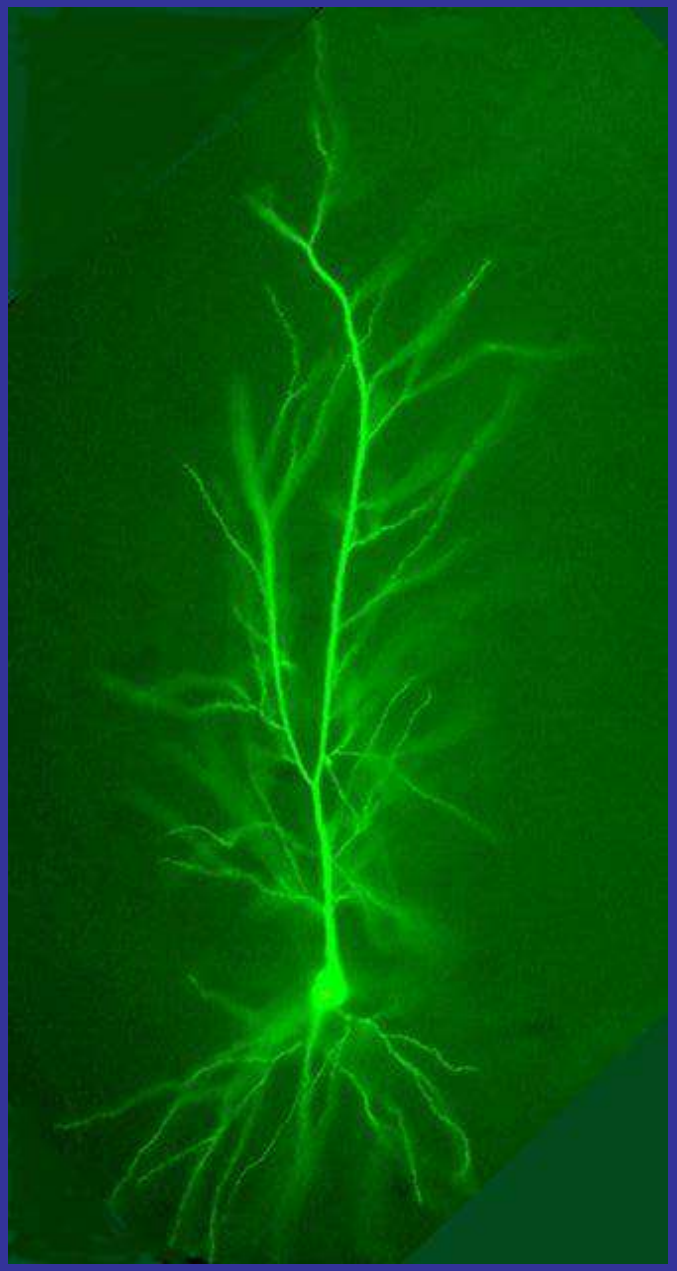


Figure 4

Major Neurotransmitters in the Hippocampus

Neurotransmitter	Abbreviation, Synonym	General role
Serotonin	5HT, 5-hydroxytryptamine	neuromodulation
Dopamine	DA	neuromodulation
Acetylcholine	ACh	neuromodulation
Norepinephrine	NE	neuromodulation
Gamma-amino Butyric Acid	GABA	inhibitory transmission
Glutamate	Glu	excitatory transmission

Table 4

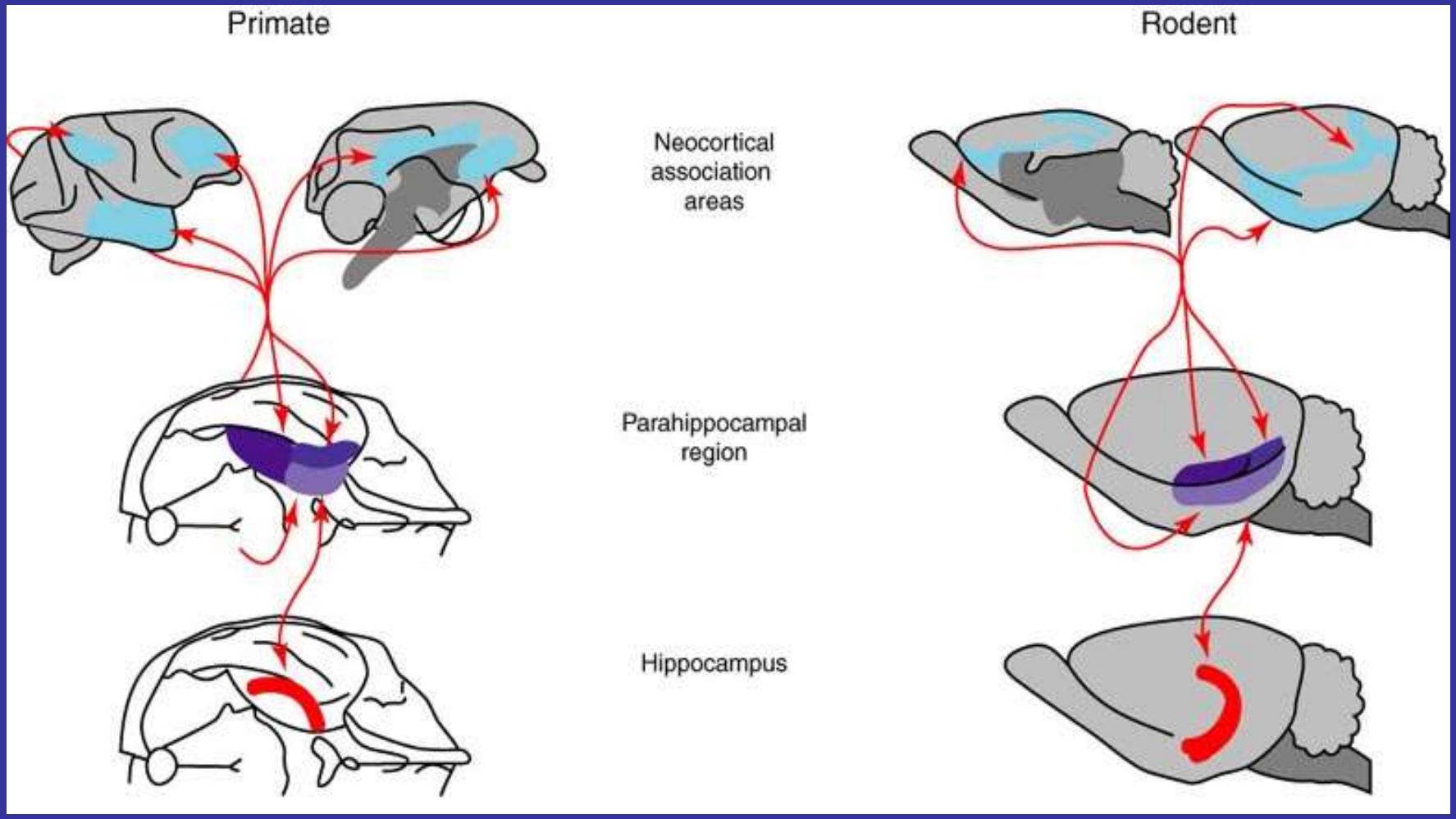


FIGURE 3 The anatomy of the hippocampal memory system in monkeys and rats. Multiple association areas in the cerebral cortex send outputs that converge on subdivisions of the cortex surrounding the hippocampus, which in turn sends its outputs to the hippocampus. The output path involves return projections from the hippocampus to the surrounding cortical region, which in turn projects back to the same cortical association areas. From Eichenbaum (2001).

Functions of the Hippocampus

- Cognitive Processing:
  - Space
  - Time
  - Relationships
- Memory Consolidation

MRI scan of H.M. and control brain

H.M. **Control**

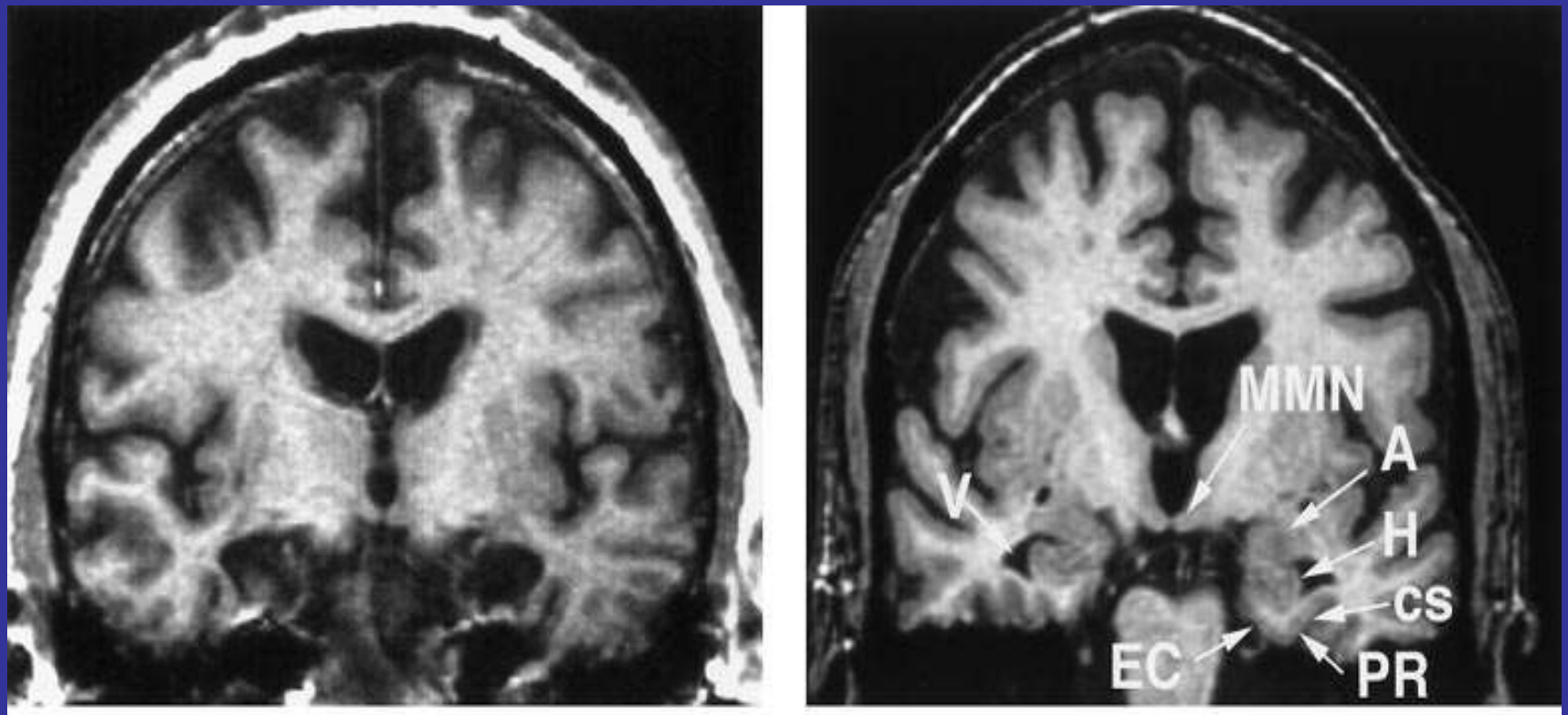
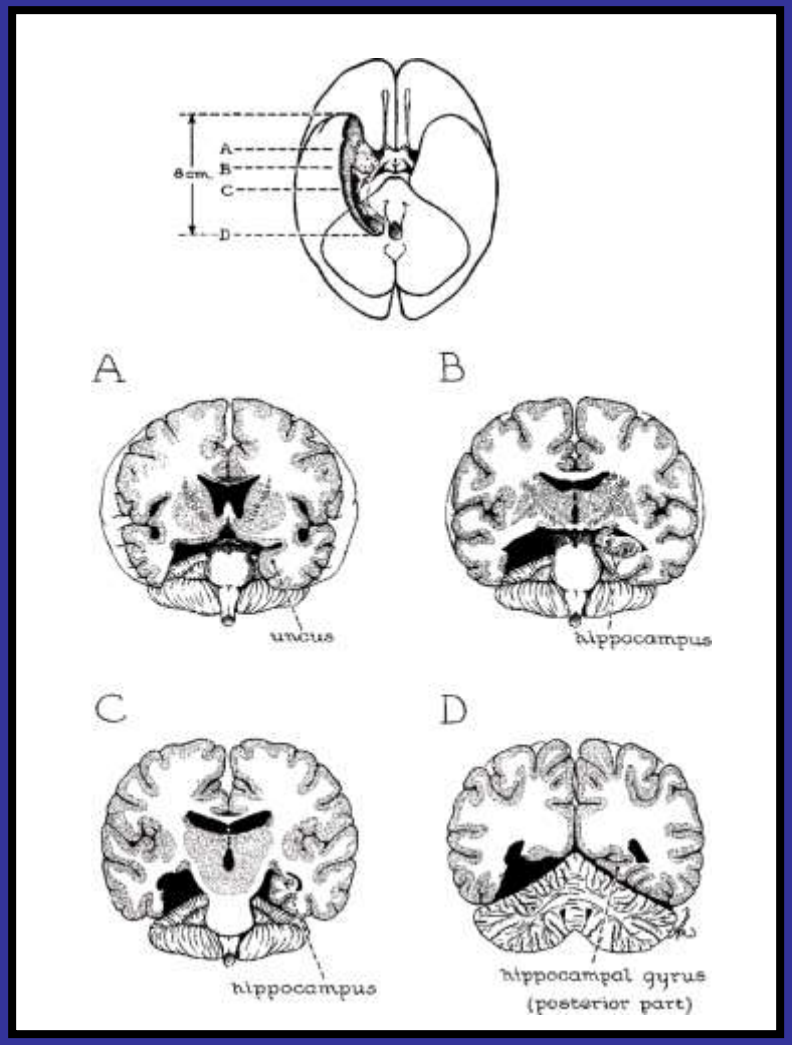


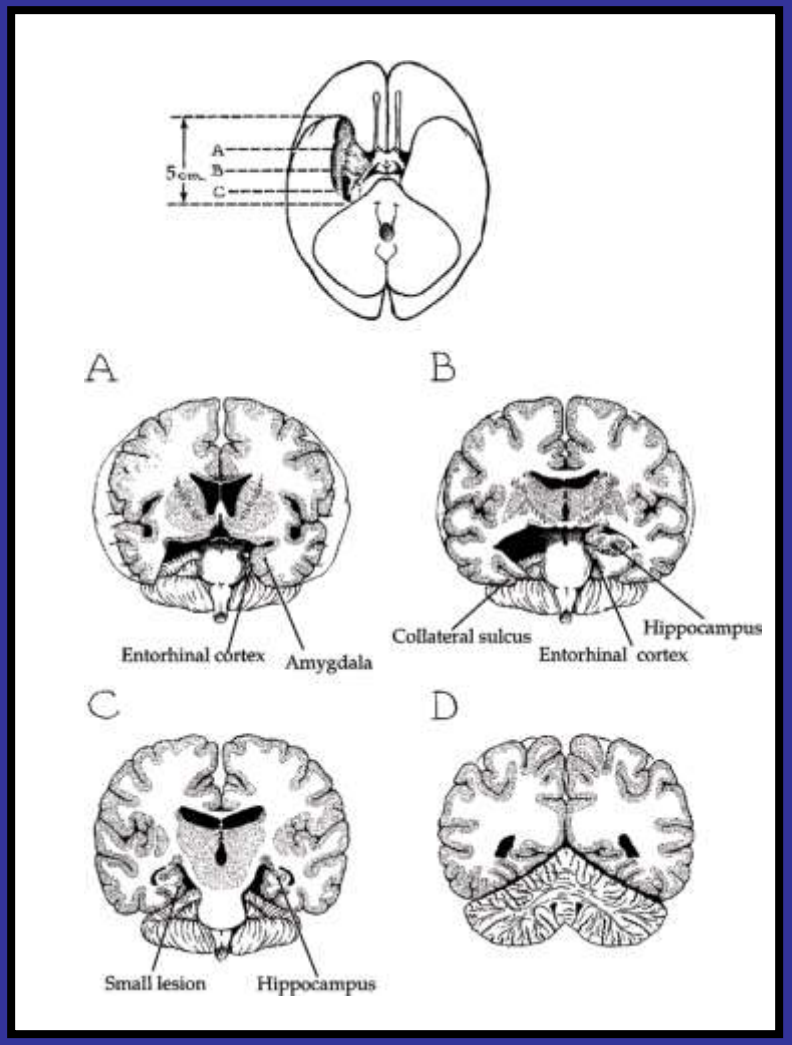
Figure 6

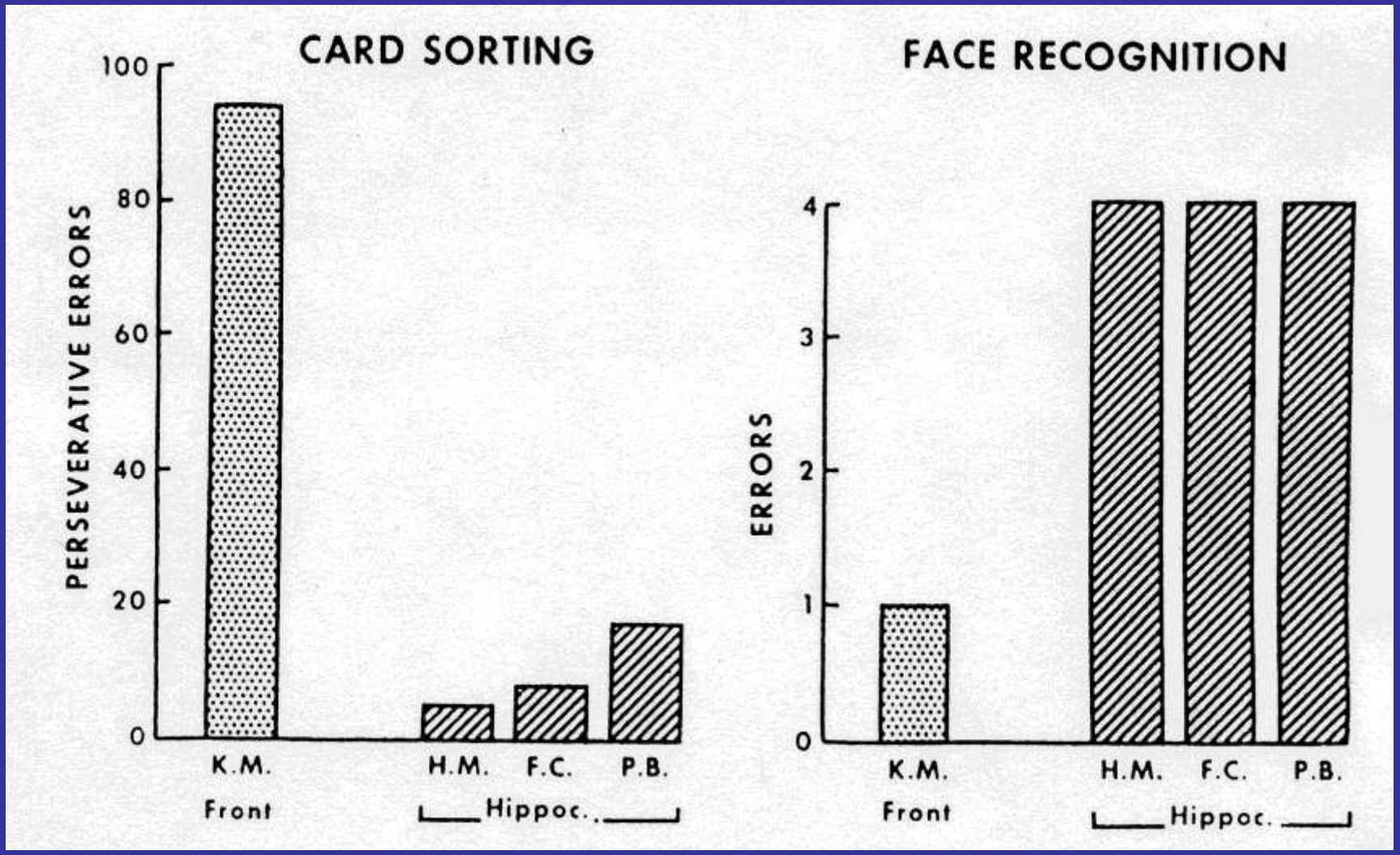
MRI of HM's Brain lesions

Surgeon's Estimate of H.M.'s lesions



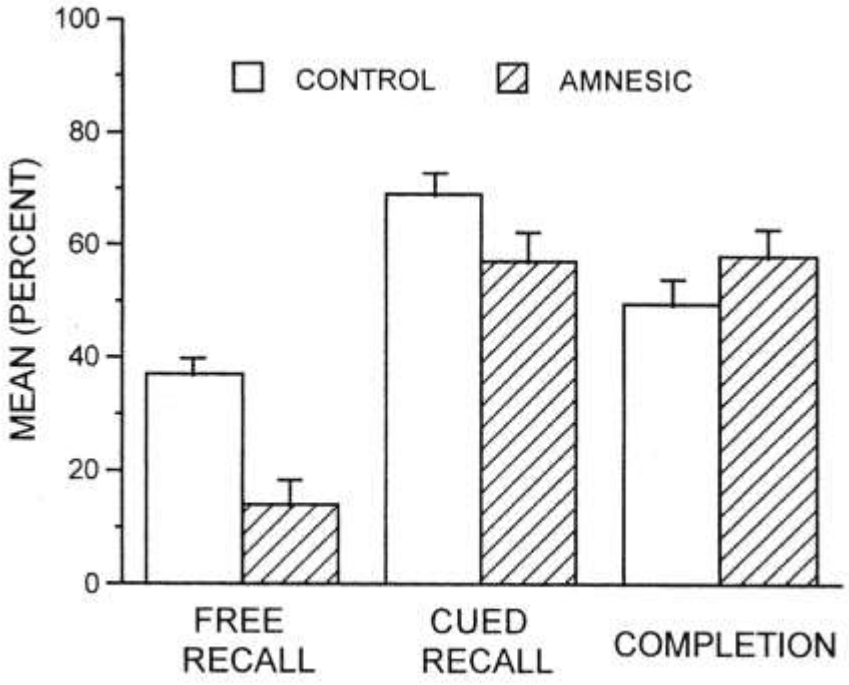
Revised Estimate based on MRI





From Eichenbaum and Cohen

ABSENT	ABS_____
INCOME	INC_____
FILLY	FIL_____
DISCUSS	DIS_____
CHEESE	CHE_____
ELEMENT	ELE_____



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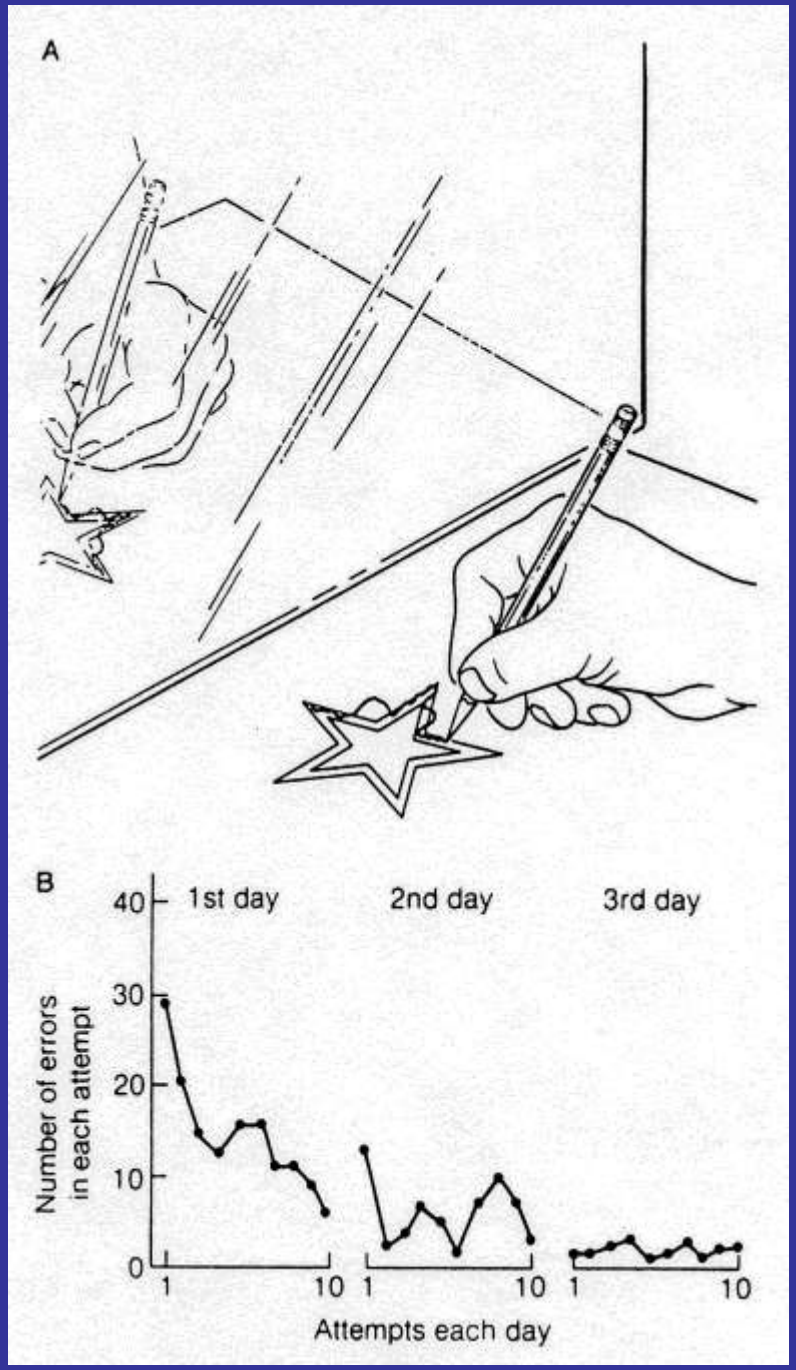


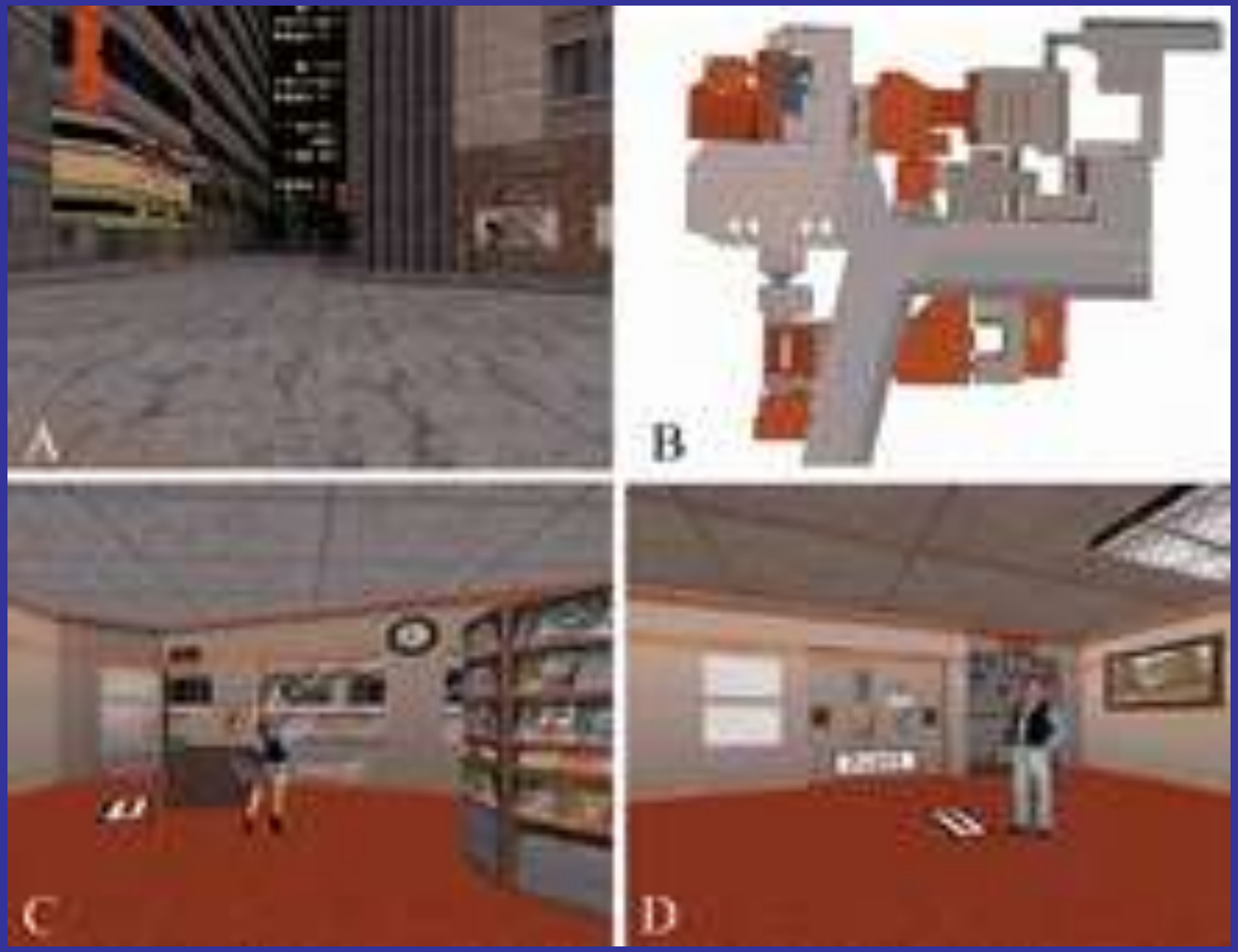
From Eichenbaum and Cohen

Four Types of Experiments

Hypothesis: **A**→**B**→**C**

Experiment	Prediction
• Determine	• None (**A** makes **C** happen)
• Block	• Blocking **B** should block **A** causing **C**
• Mimic	• Activating **B** should cause **C**
• Measure	• **A** makes **B** happen

Virtual Maze



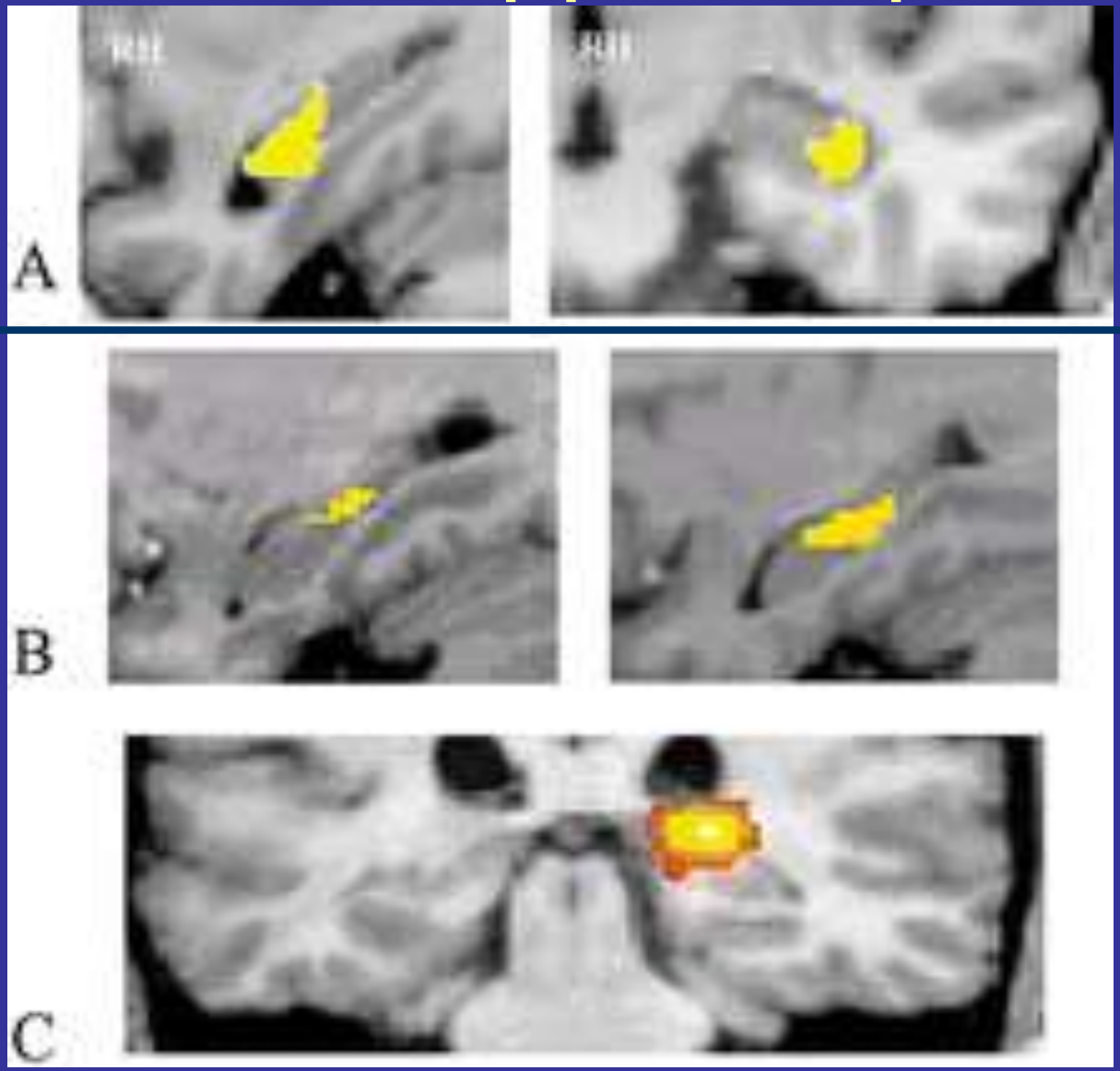
Burgess N, Maguire EA, O'Keefe J.
The human hippocampus and spatial and episodic memory.
Neuron. 2002 35:625-41.

MRI of Hippocampus

fMRI in Virtual Maze Navigation

Morphometry of London Taxi Drivers

Right Posterior Hippocampal Volume Correlates with Time Spent Driving



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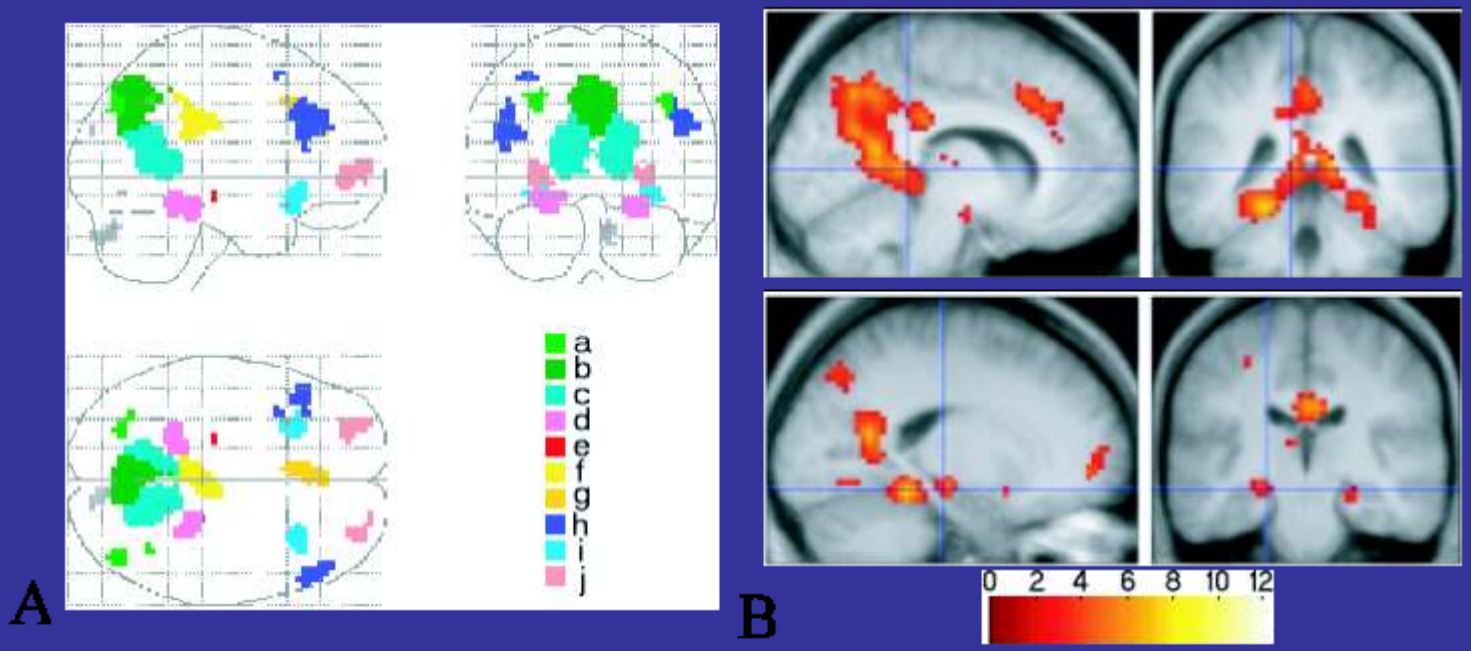
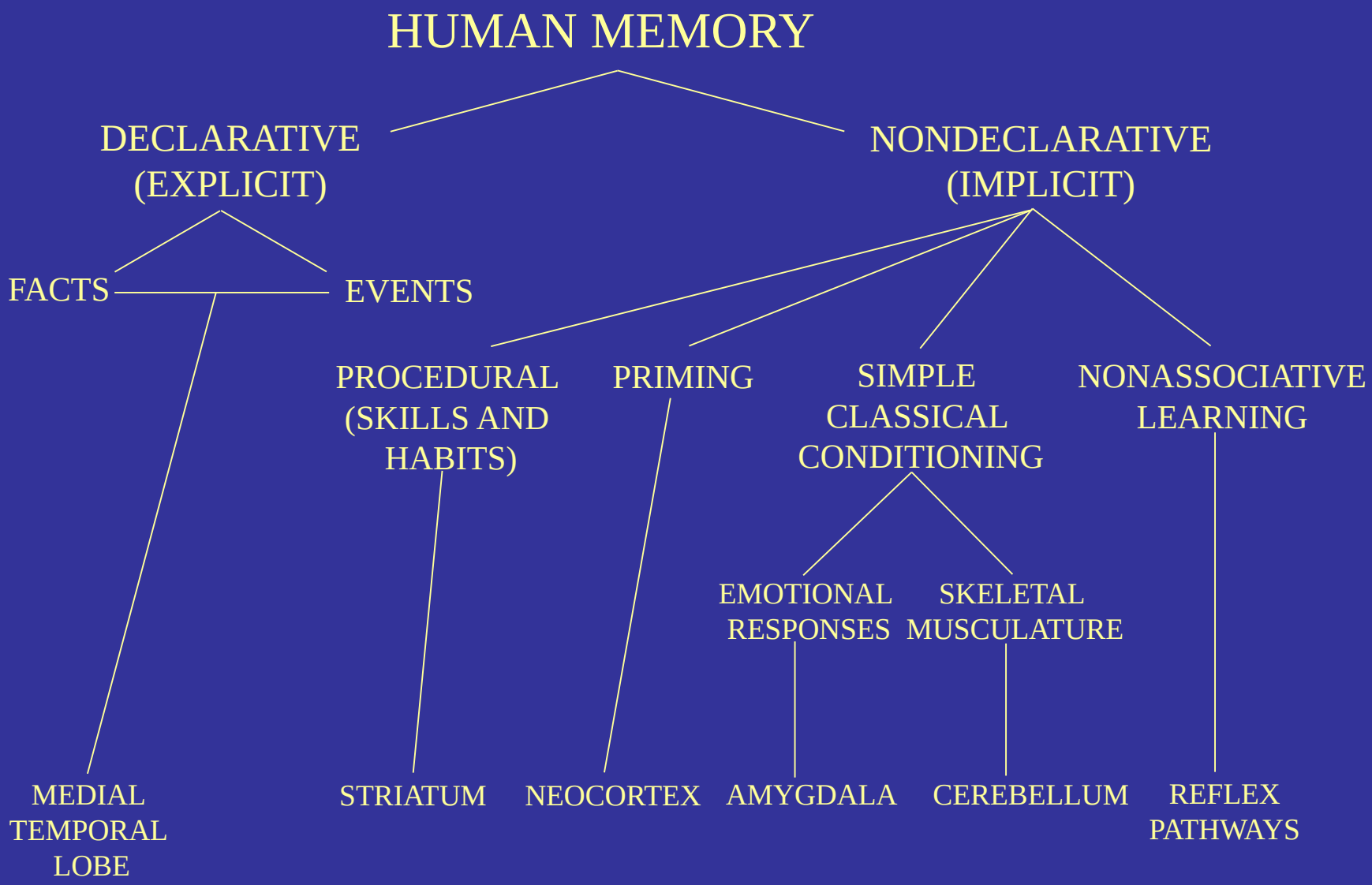
Neuroimaging of the retrieval of the Spatial Context of an Event



Blue Box 1

Subdivisions of Human Memory



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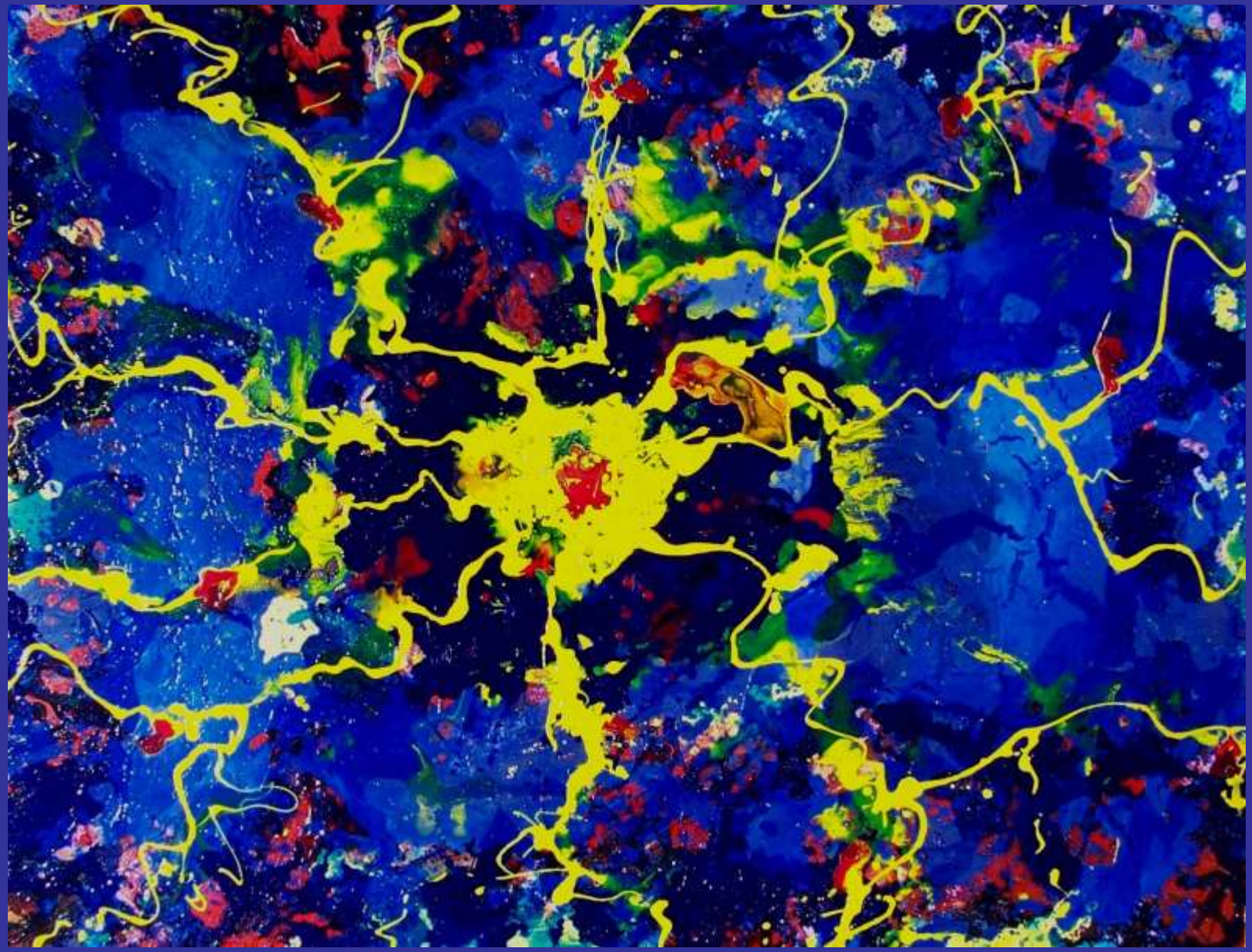
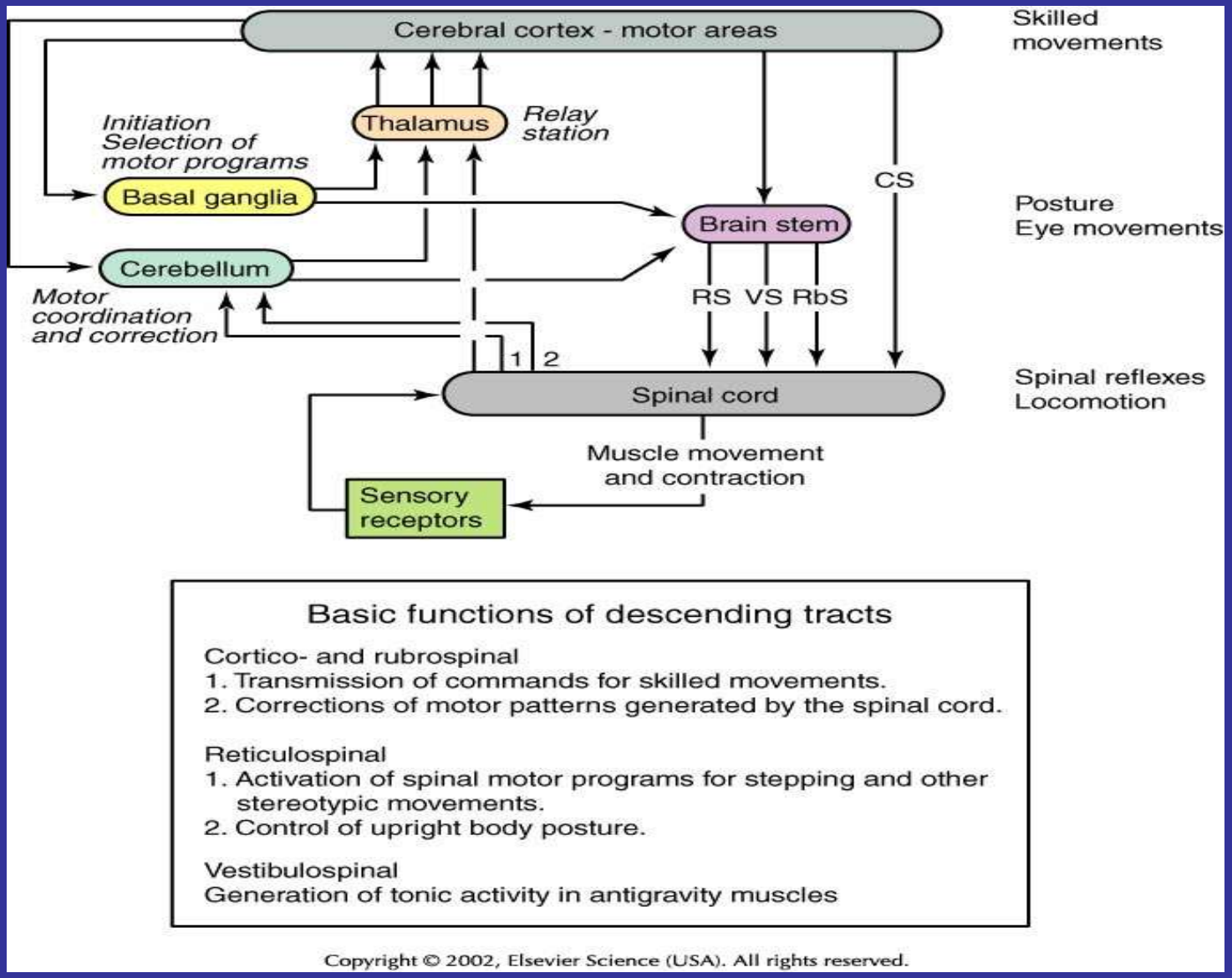
Human Excellence in Motor Learning and Memory

Figure 10



Medium Spiny Neuron

Summary Scheme of Interaction Between Motor Centers



Basic functions of descending tracts

Cortico- and rubrospinal
1. Transmission of commands for skilled movements.
2. Corrections of motor patterns generated by the spinal cord.

Reticulospinal
1. Activation of spinal motor programs for stepping and other stereotypic movements.
2. Control of upright body posture.

Vestibulospinal
Generation of tonic activity in antigravity muscles

Figure 11

Basal Ganglia in the Human Brain

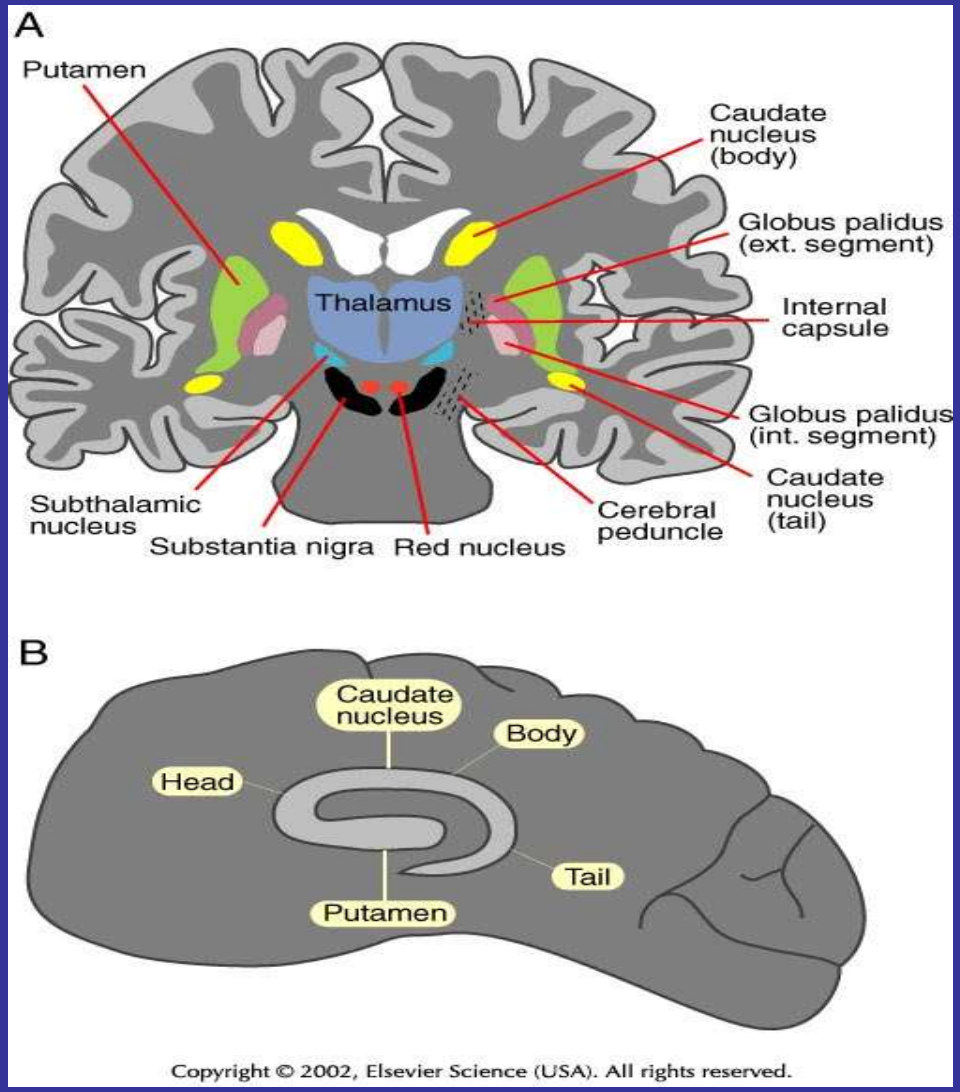


Figure 12

The Striatal Motor Learning System

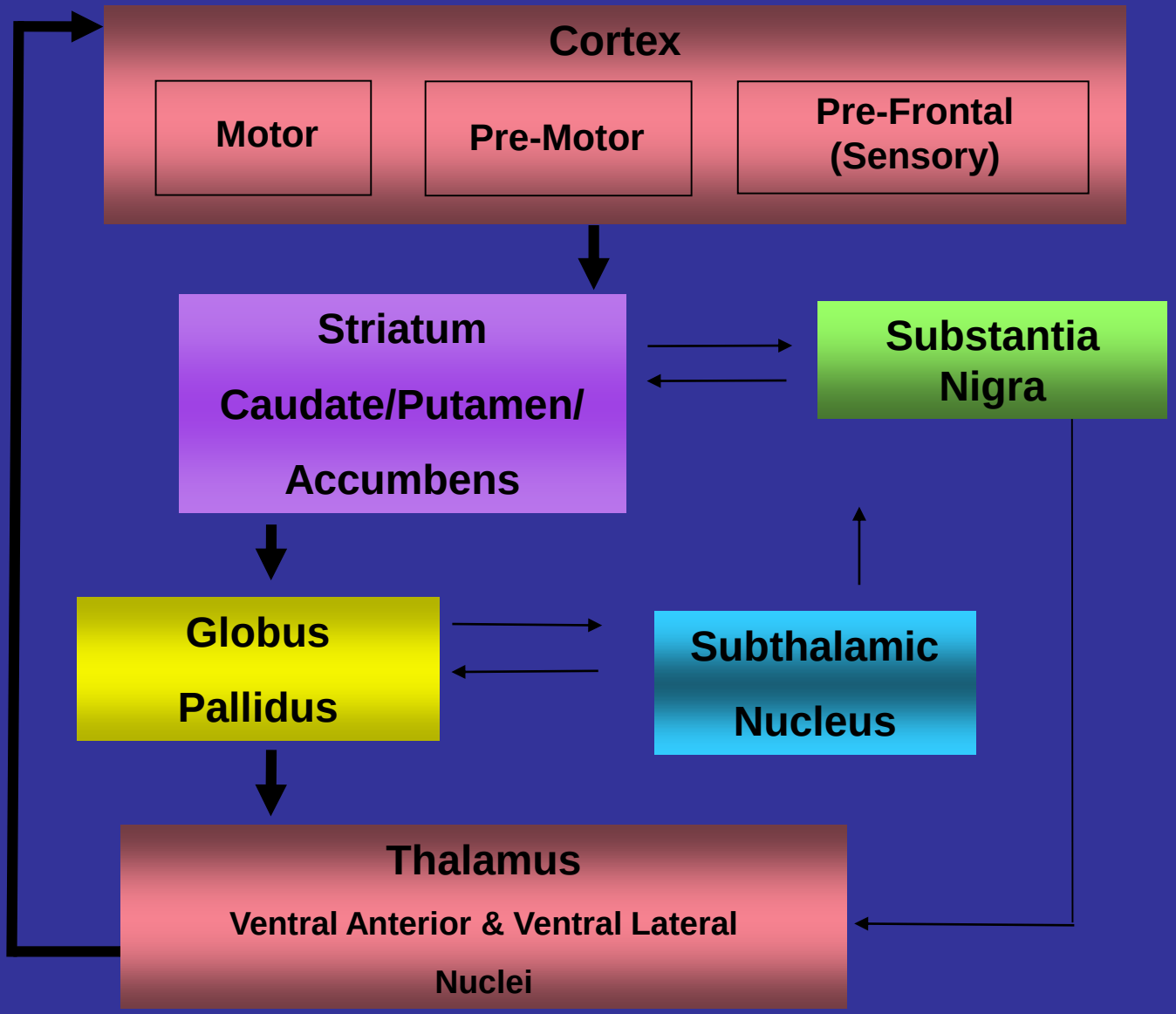


Figure 13

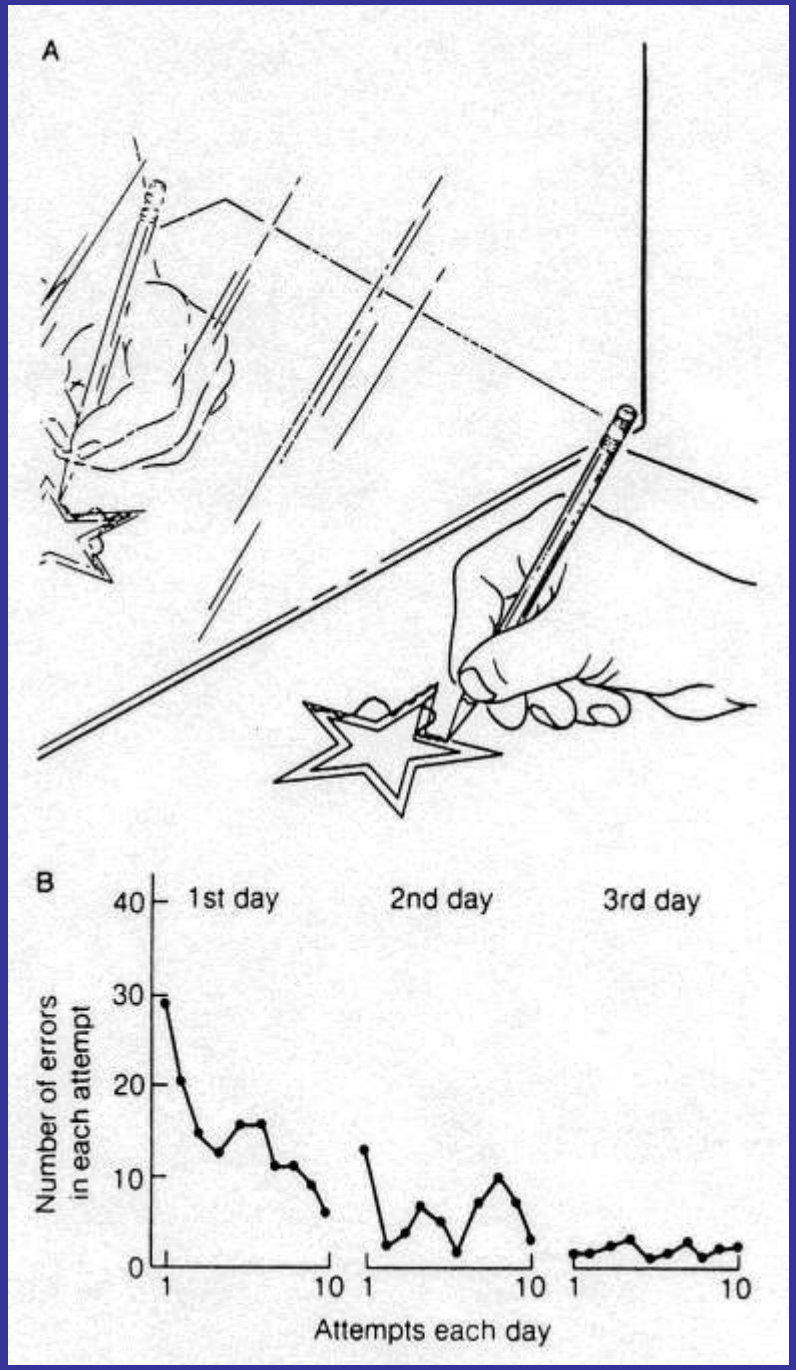


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Table 3

Human Excellence in Declarative Learning and Memory

Rajan Srinavasen Mahadevan

Figure 14

1000 Decimal places of pi

3.14159265358979323846264338327950288419716939937510582097494459
23078164062862089986280348253421170679821480865132823066470938446
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Figure 15

Kim Peek

Figure 16

The Penfield Stimulation Experiments

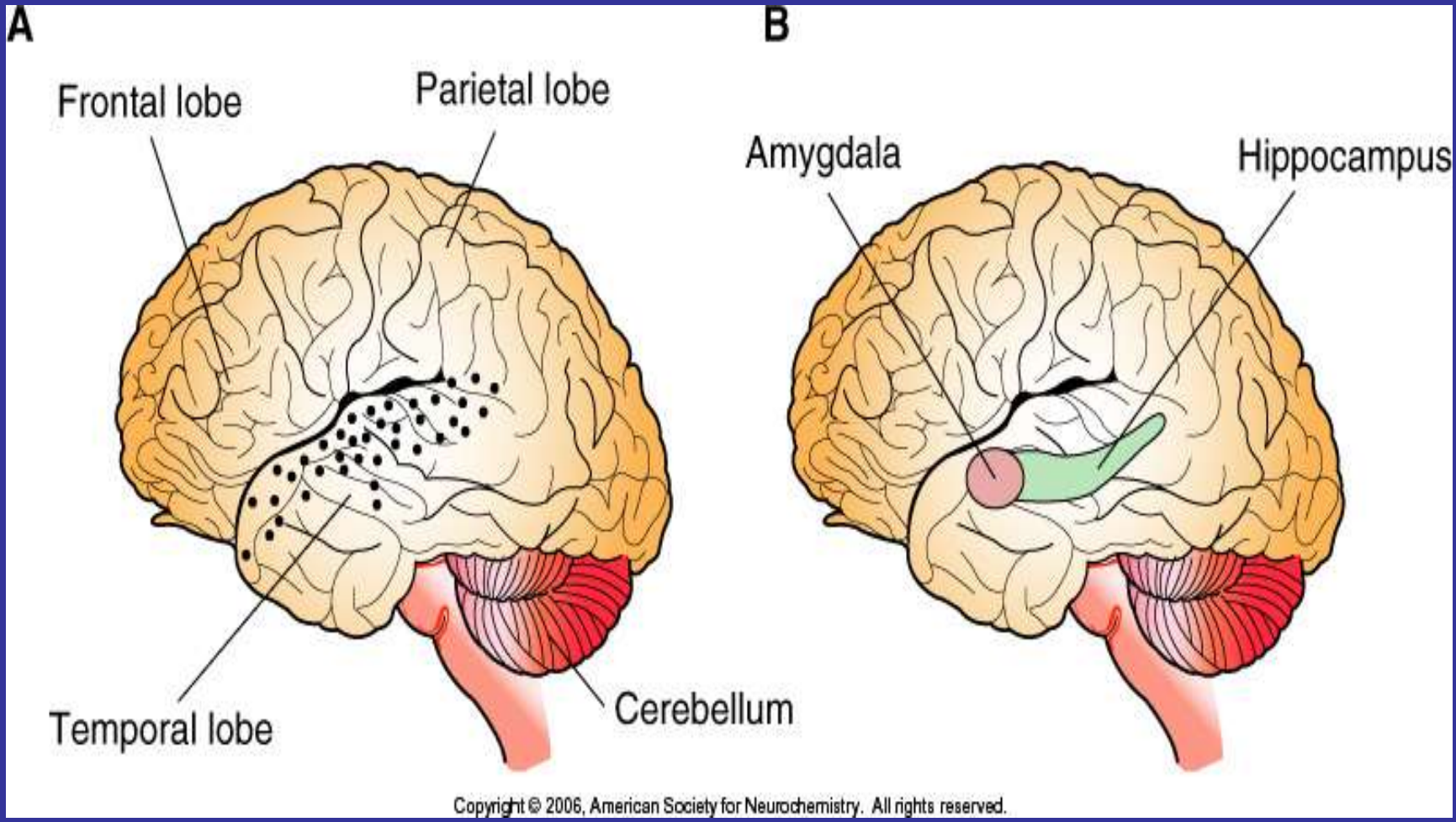
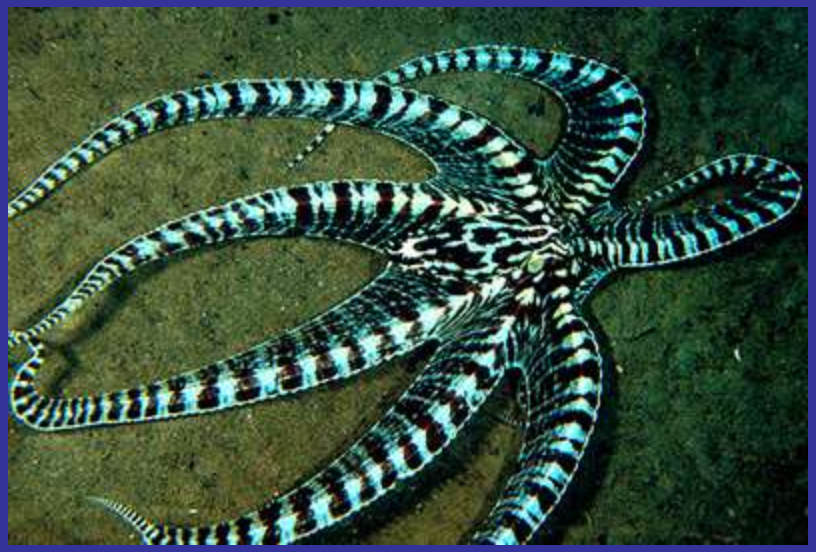
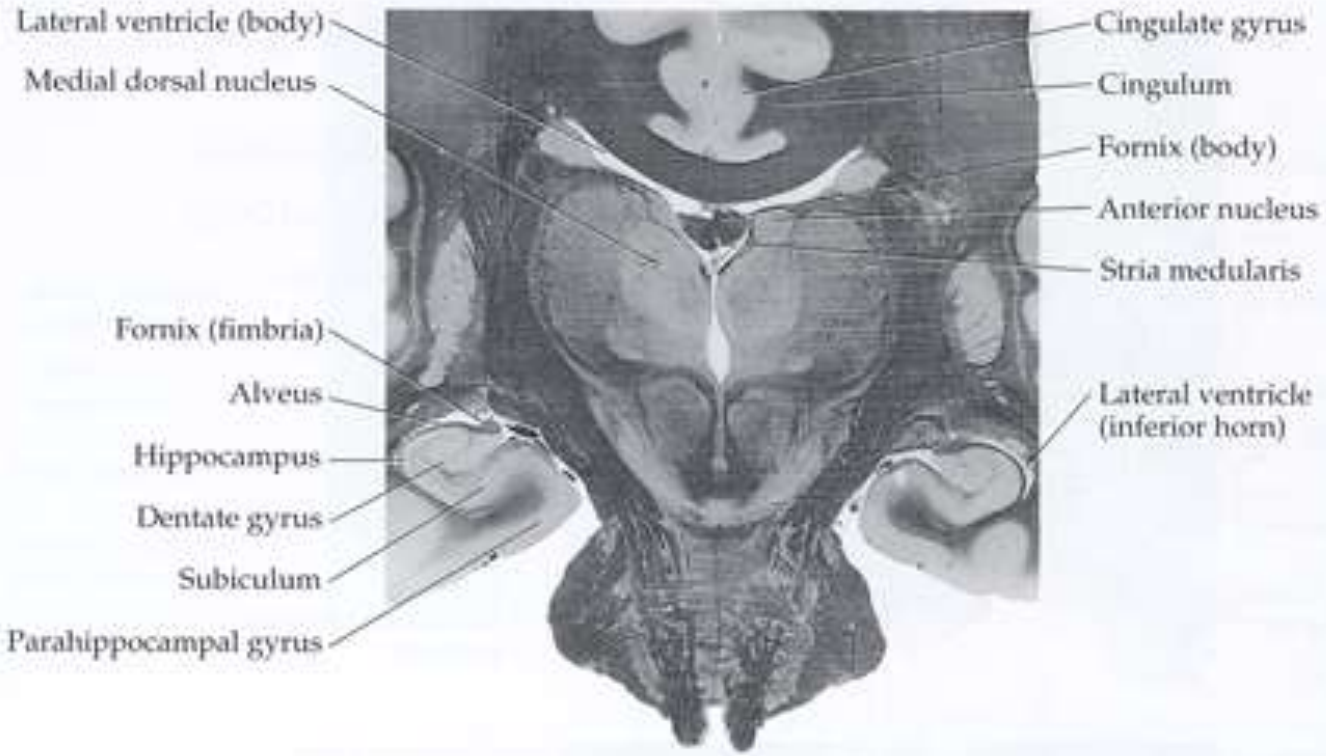


Figure 2

The Mimic Octopus



The Mimic Octopus

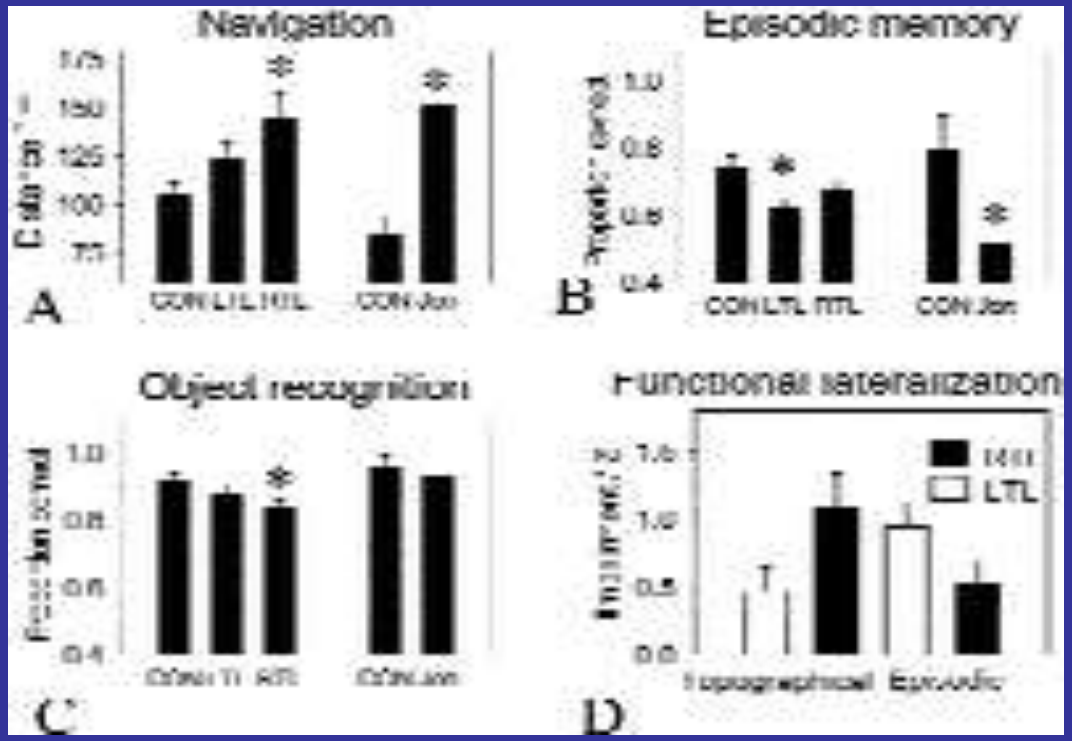


From JH Martin, *Neuroanatomy*

Lateralization of Hippocampal Function

Distance Traveled To Correct Location

Percent Correct



Percent Correct

Impairment Ratio

Studies of hippocampectomy patients

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