

BASICS OF NEUROBIOLOGY

HIPPOCAMPAL FORMATION

ZSOLT LIPOSITS

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CHARACTERISTICS OF THE HIPPOCAMPAL FORMATION

THE HIPPOCAMPAL FORMATION IS PART OF THE LIMBIC SYSTEM OF THE BRAIN

IT IS COMPOSED OF THE DENTATE GYRUS AND THE HIPPOCAMPUS (CORNU AMMONIS). THE COMPLEX STRUCTURE BELONGS TO THE ALLOCORTEX

THE HIPPOCAMPUS IS DIVIDED INTO 3 SECTORS: CA1 (SOMMER'S SECTOR), CA2 AND CA3. THERE ARE 3 CYTOARCHITECTURAL LAYERS IN THE HIPPOCAMPUS: THE MOLECULAR, THE PYRAMIDAL AND THE POLYMORPHIC (ORIENS) LAYERS

THE DENTATE GYRUS COMPRISES THE MOLECULAR LAYER, THE GRANULE CELL LAYER AND THE HILUS. IN ITS SUBGRANULAR ZONE ADULT NEUROGENESIS OCCURS

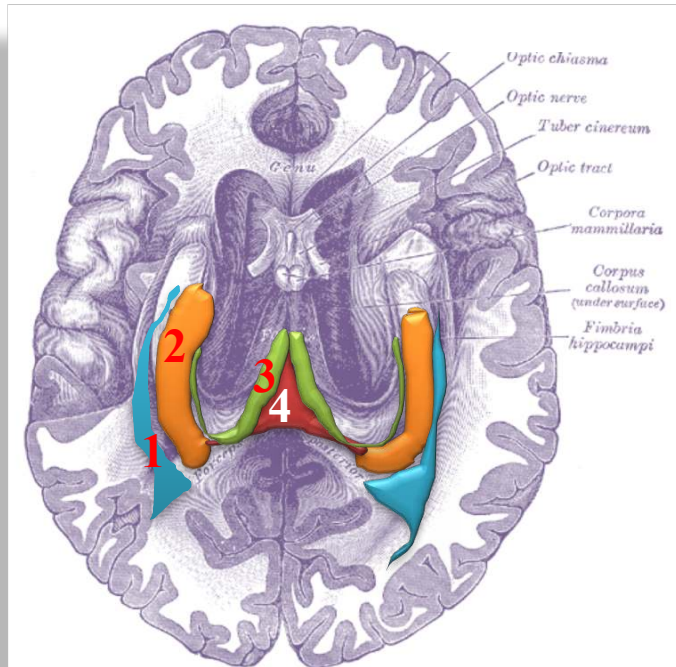
AFFERENTS ARRIVE VIA THE PERFORANT AND ALVEAR PATHS, EFFERENT FIBER PROJECTIONS LEAVE THE TEMPORAL LOBE VIA THE FORNIX SYSTEM. IT GIVES RISE TO BOTH ASSOCIATIVE AND COMMISSURAL EFFERENTS. THE HIPPOCAMPUS VIA THE LIMBIC CONNECTIONS IS LINKED WITH MULTIPLE BRAIN NETWORKS

INFORMATION CONVEYED BY THE PERFORANT PATH IS PROCESSED IN A TRISYNAPTIC INTRINSIC CIRCUIT WITHIN THE HIPPOCAMPAL FORMATION

THE HIPPOCAMPUS HAS A PIVOTAL ROLE IN LONG TERM MEMORY AND SPATIAL NAVIGATION. IT IS VULNERABLE TO HYPOXIA, EXCITOTOXINS AND AMYLOID

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MACROSCOPIC PROPERTIES OF THE HIPPOCAMPUS



1. LATERAL VENTRICLE
2. HIPPOCAMPUS
3. FORNIX
4. COMMISSURA FORNICIS

FOR A FIRST IMPRESSION, THE SUPERIOR VIEW OF A HORIZONTALLY SLICED BRAIN IS USEFUL. THE **HIPPOCAMPUS** IS A C-SHAPED, PAIRED STRUCTURE LOCATED IN THE TEMPORAL LOBE. ANTERIOR TO IT IS THE AMYGDALA, IN DORSAL DIRECTION THE LENTIFORM NUCLEUS IS A CLOSE NEIGHBOR. THE STRUCTURE PROTRUDES INTO THE INFERIOR HORN OF THE **LATERAL VENTRICLE**. ITS EFFERENT AND AFFERENT PATHS FORM THE **FORNIX**. IT BEGINS AS A THIN CRUS, CONTINUES AS CORPUS AND TERMINATES AS COLUMN SPLITTING INTO PRE- AND POST-COMMISSURAL COMPONENTS THAT TERMINATE IN THE SEPTUM AND HYPOTHALAMUS. FIBERS INTERCONNECTING THE TWO HIPPOCAMPAL STRUCTURES FORM **DAVE'S LYRE**

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DEVELOPMENT OF THE HIPPOCAMPAL FORMATION

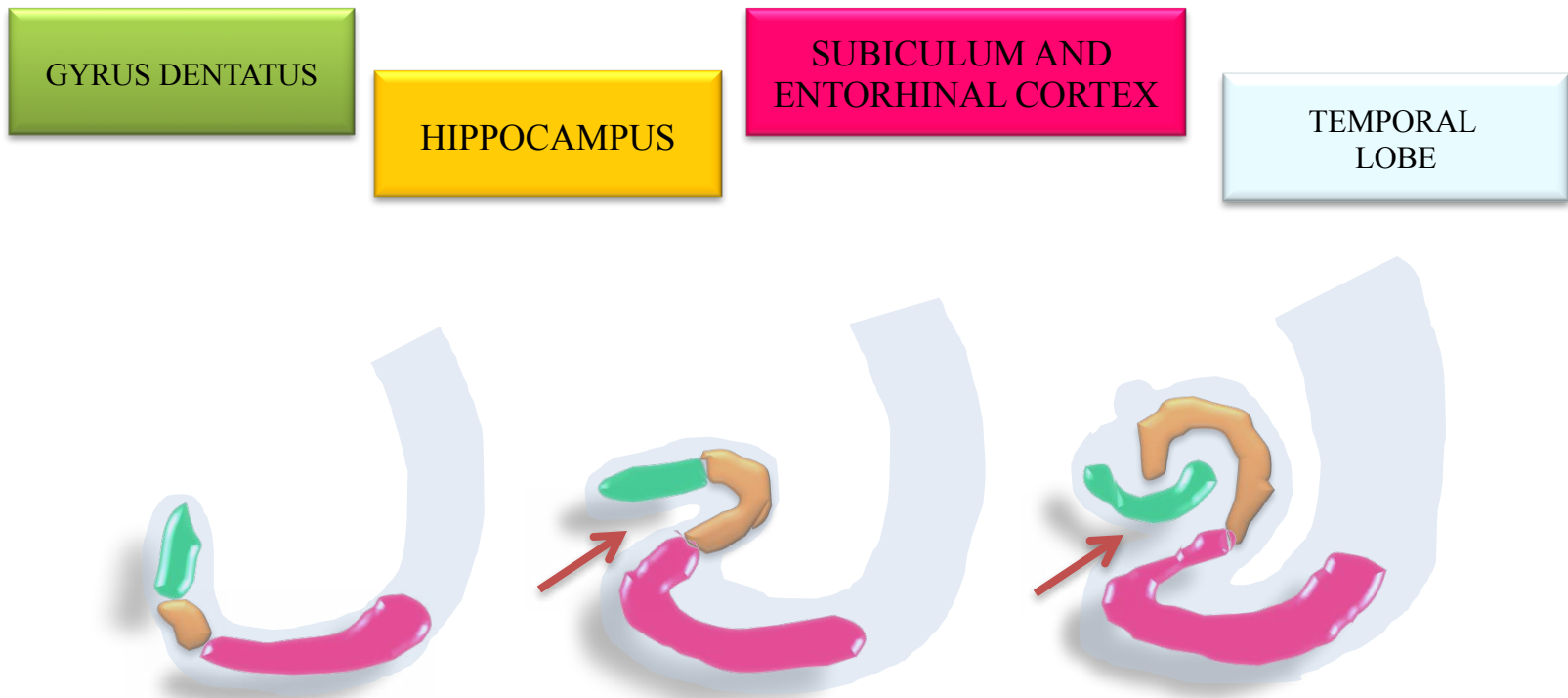
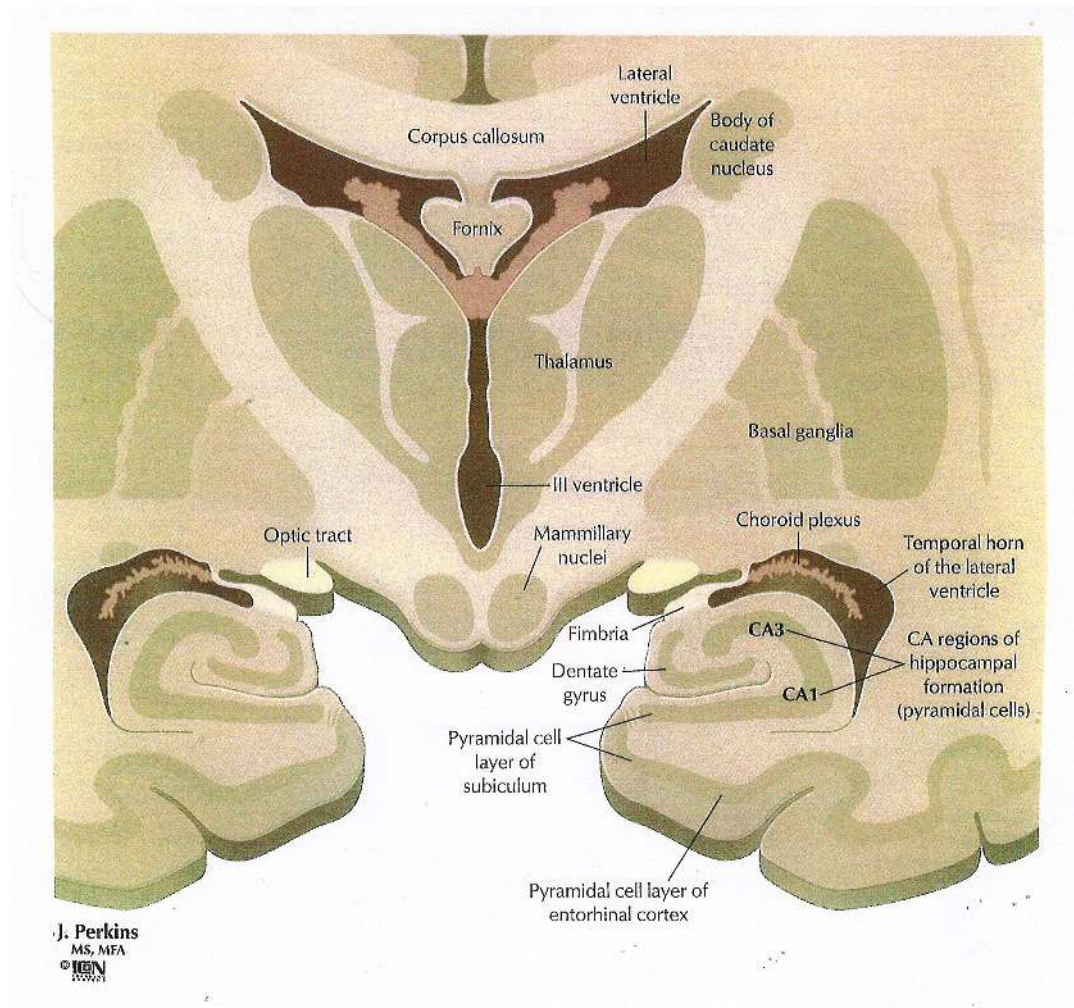


ILLUSTRATION OF THE DEVELOPMENTAL EVENTS OF THE TEMPORAL LOBE WITH SPECIAL REFERENCE TO THE ESTABLISHMENT OF THE HIPPOCAMPAL FORMATION. ARROWS POINT TO THE HIPPOCAMPAL FISSURE

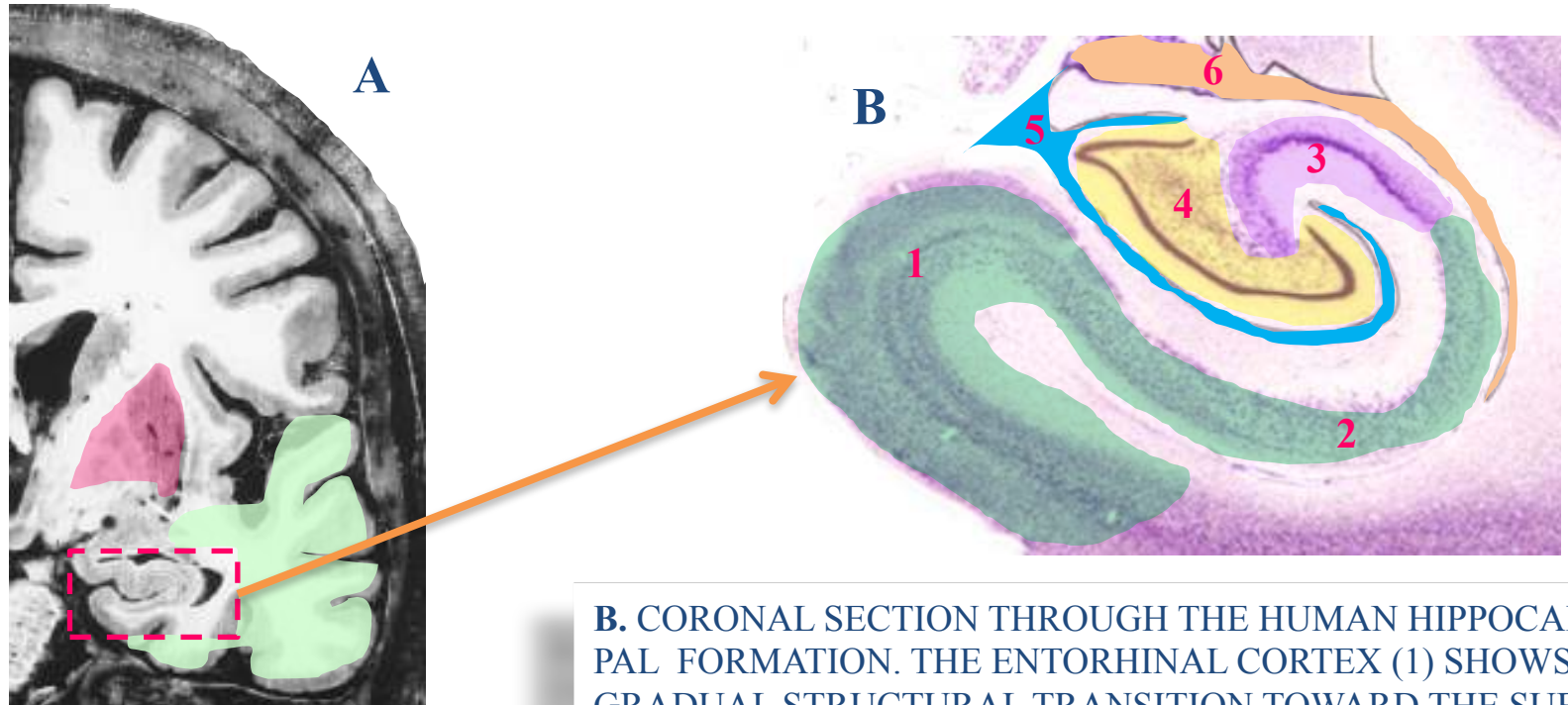
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LOCATION OF THE HIPPOCAMPAL FORMATION IN THE BRAIN



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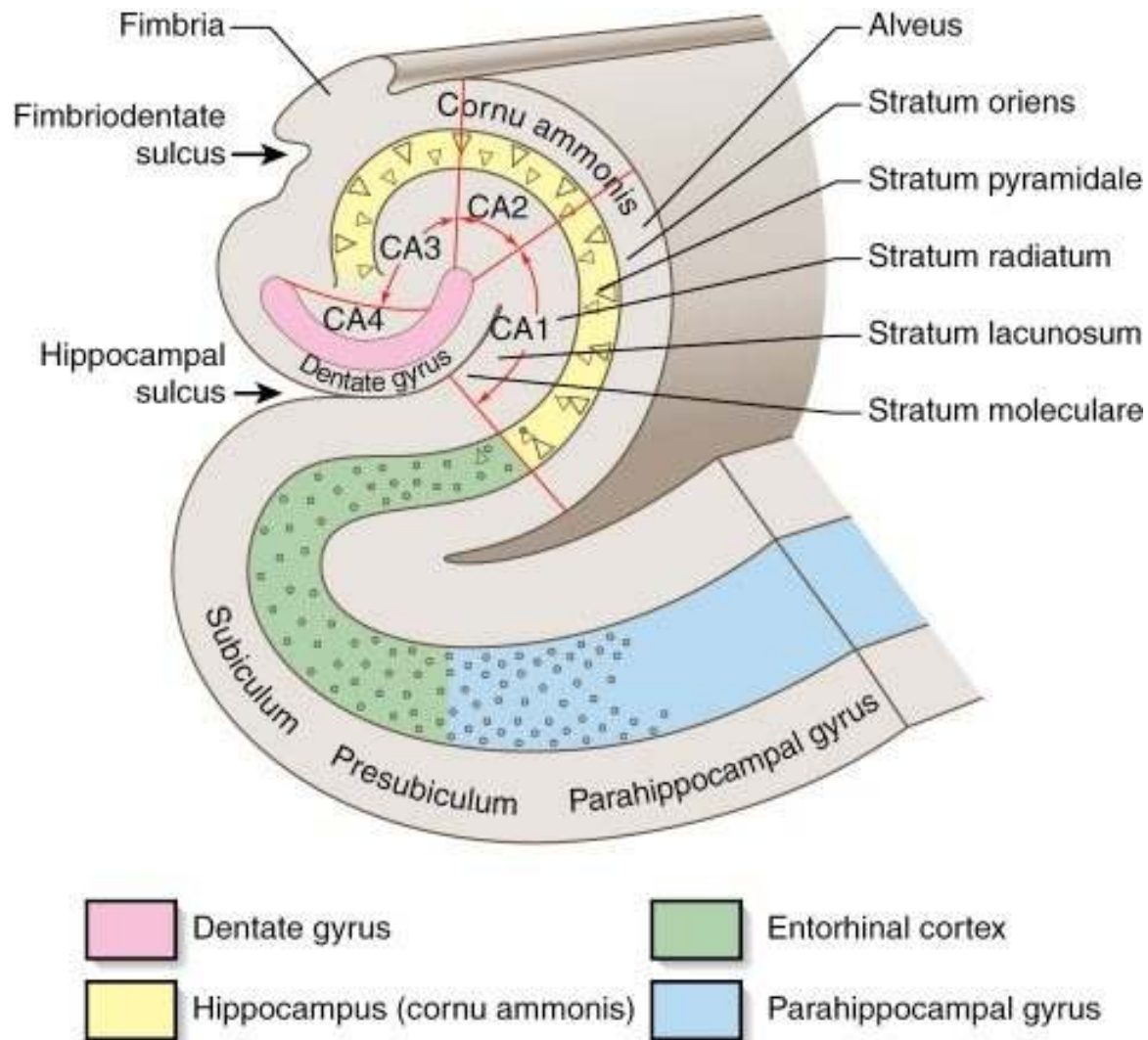
ORGANIZATION OF THE HIPPOCAMPAL FORMATION *IN SITU*



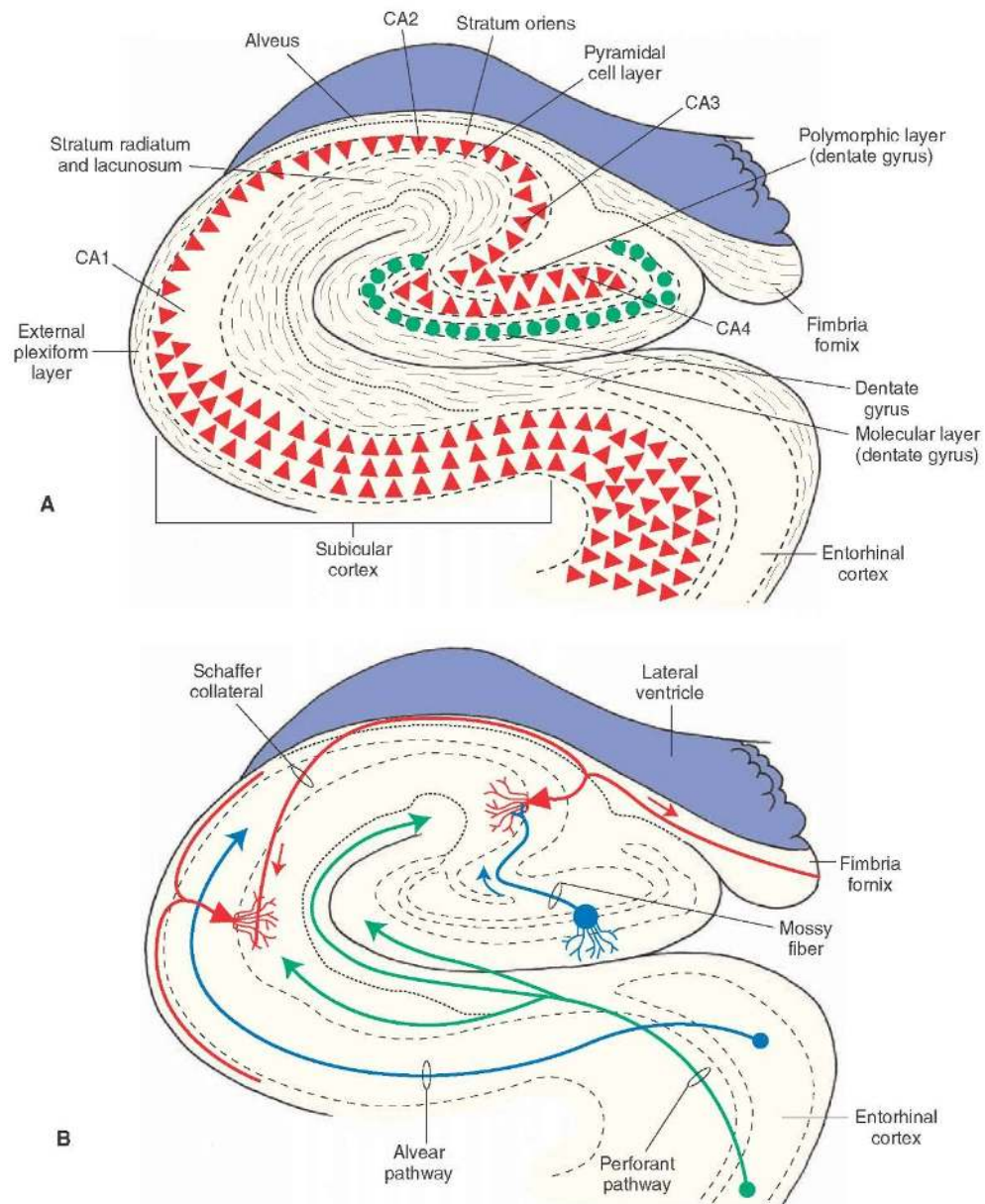
A. CORONAL RADIOLOGICAL PICTURE DEPICTS THE BRAIN *IN SITU*. IN THE TEMPORAL LOBE (GREEN HIGHLIGHT), THE HIPPOCAMPAL FORMATION APPEARS (ENFRAMED). LENTIFORM NUCLEUS IS IN PINK HIGHLIGHT

B. CORONAL SECTION THROUGH THE HUMAN HIPPOCAMPAL FORMATION. THE ENTORHINAL CORTEX (1) SHOWS A GRADUAL STRUCTURAL TRANSITION TOWARD THE SUBICULUM (2). THE HIPPOCAMPUS (3) WITH ITS 3 LAYERS IS APPARENT. NOTE AS THE HIPPOCAMPUS INVADES THE DENTATE GYRUS (4) THROUGH ITS HILUS. THE IMPORTANT HIPPOCAMPAL FISSURE (5) IS HIGHLIGHTED IN BLUE. A NEIGHBORING LANDMARK IS THE CHOROID FISSURE (6)

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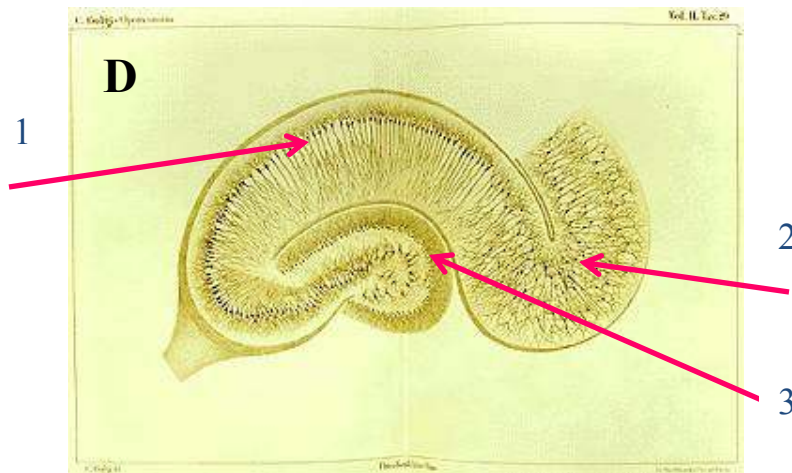
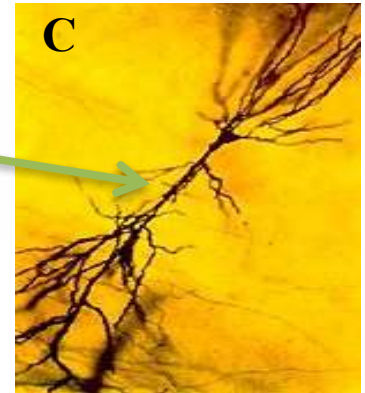
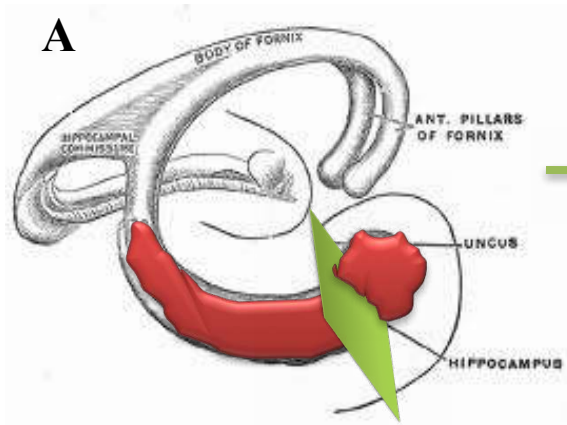


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HIPPOCAMPUS REVEALED BY GOLGI IMPREGNATION



A CORONAL SLICE (B) CUT FROM THE HIPPOCAMPUS (A) WAS IMPREGNATED BY THE GOLGI TECHNIQUE. IT VISUALIZES THE CELLULAR CONSTITUENTS INCLUDING THE PYRAMIDAL NEURONS (C). THE DRAWING (D) OF C. GOLGI MADE ABOUT HIS PREPARATION REVEALS THE PYRAMIDAL LAYER OF THE HIPPOCAMPUS (1), THE ENTORHINAL CORTEX (2) AND THE DENTATE GYRUS (3)

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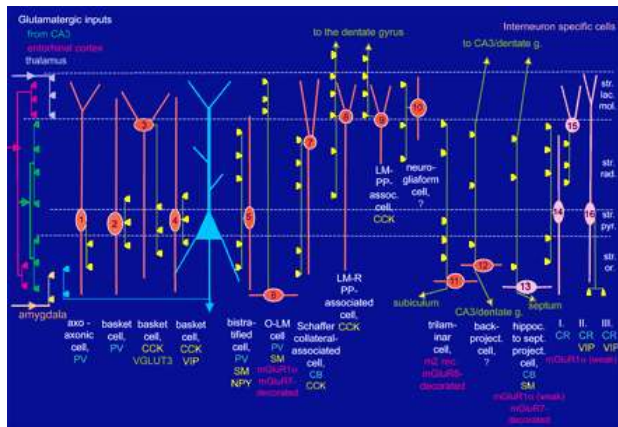
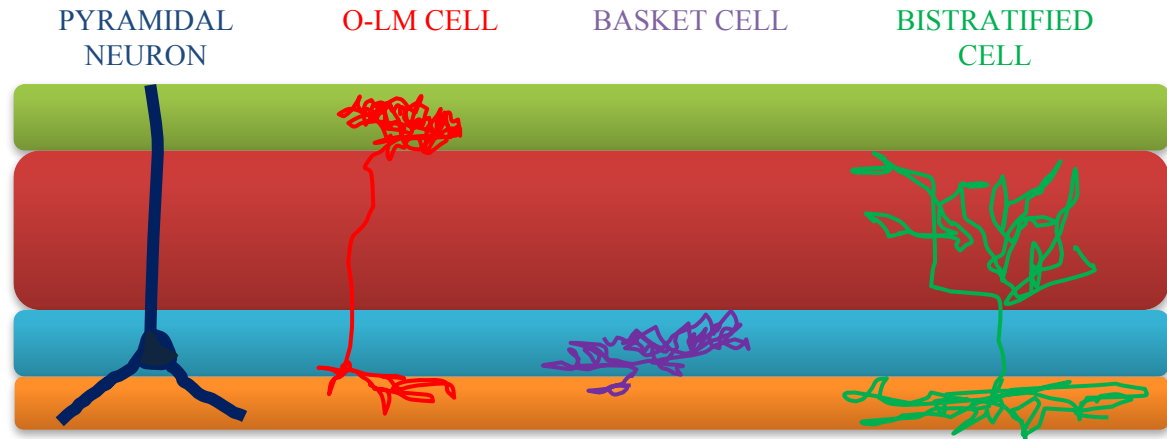
LAYERS AND CELL TYPES OF THE HIPPOCAMPUS

STR. LACUNOSUM-MOLECULARE

STR. RADIATUM

STR. PYRAMIDALE

STR. ORIENS

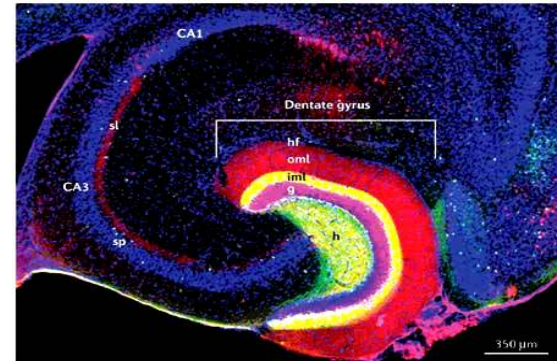
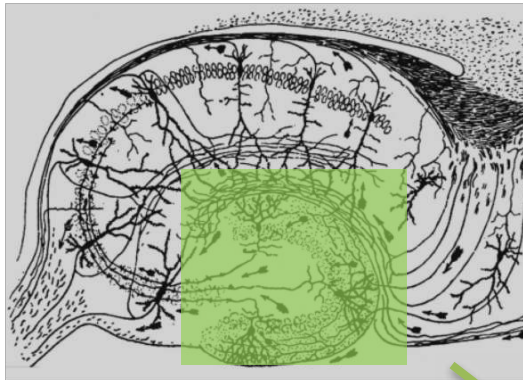


COURTESY OF P. SOMOGYI'S LABORATORY

PRINCIPAL, PYRAMIDAL NEURONS AND INHIBITORY INTERNEURONS SUCH AS O-LM CELLS, BASKET CELLS AND BISTRATIFIED CELLS OCCUPY THE MAIN LAYERS OF THE HIPPOCAMPUS. THE FIGURE ON LEFT SIDE SUMMARIZES THE PHENOTYPE, CHEMOTYPE AND CONNECTIONS OF INTERNEURONS THAT HAVE BEEN IDENTIFIED (*J PHYSIOL*, 2005 VOL. 562, 9-26)

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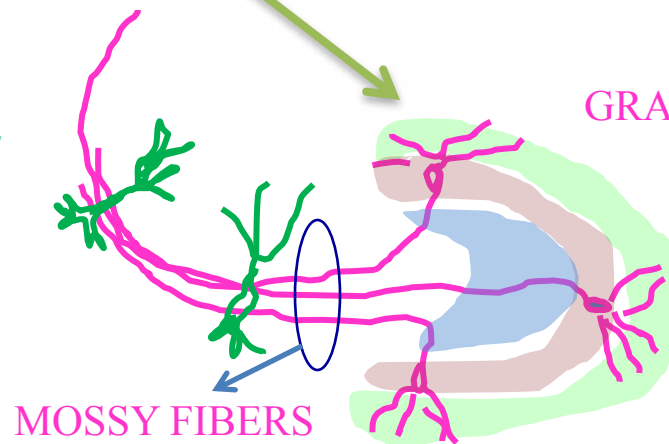
HISTOLOGICAL AND CHEMICAL DISSECTION OF THE DENTATE GYRUS



Nature Reviews Neuroscience 7, 259-268, 2006

CA3 PYRAMIDAL
CELLS

GRANULE CELLS

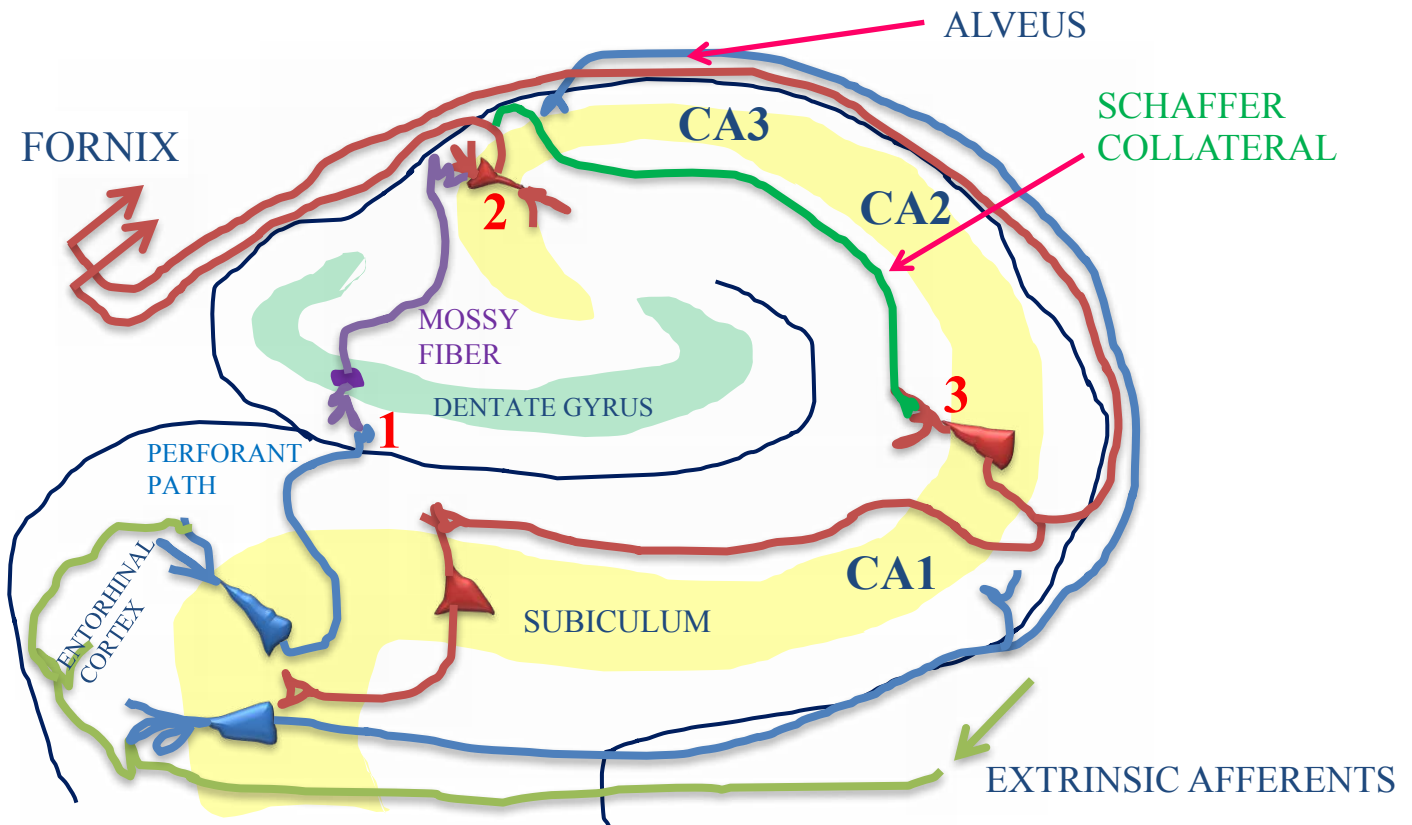


MOSSY FIBERS

MOLECULAR LAYER
GRANULE CELL LAYER
HILUS

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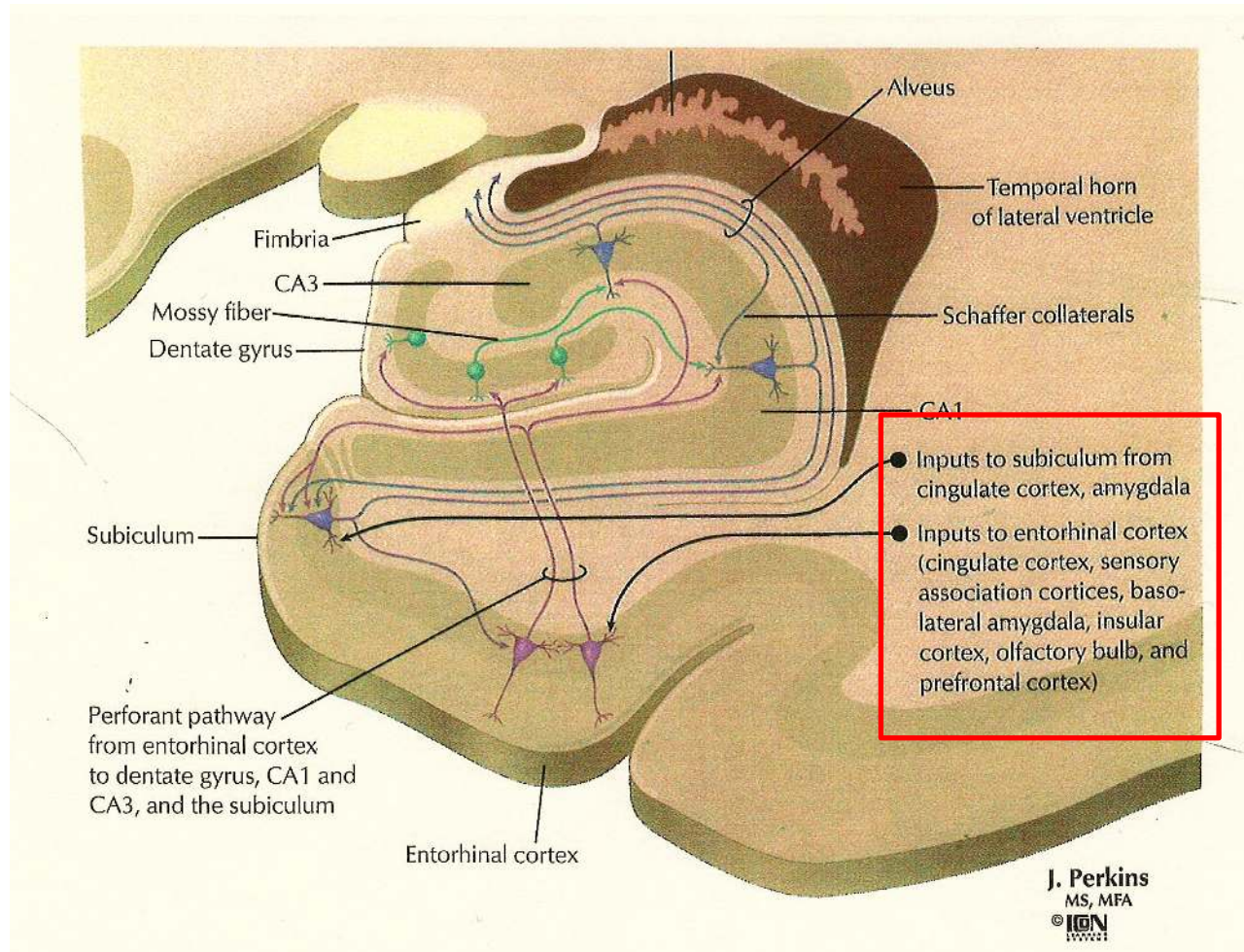
THE INTRINSIC CIRCUITS AND CONNECTIONS OF THE HIPPOCAMPAL FORMATION



NUMBERS IN RED (1-3) INDICATE COMMUNICATION SITES OF THE TRI-SYNAPTIC CIRCUIT

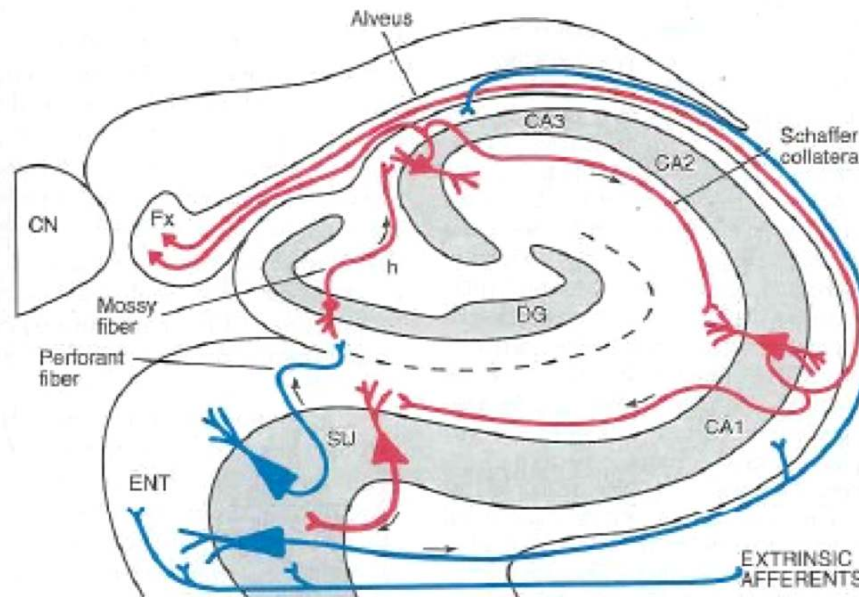
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NEURONAL INPUTS TO THE HIPPOCAMPUS



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AFFERENT AND EFFERENT CONNECTIONS OF THE HIPPOCAMPUS



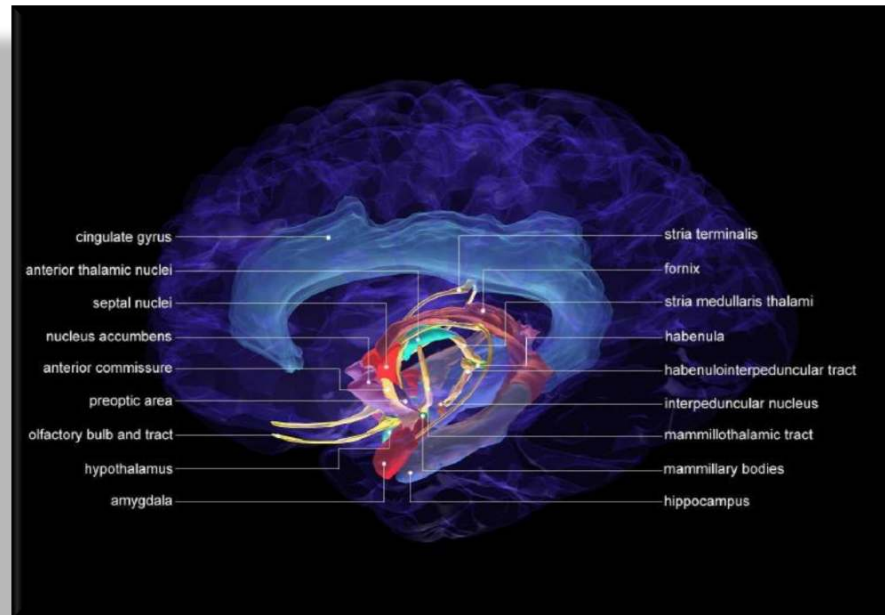
MAIN **AFFERENT** INPUTS ARRIVE FROM ENTORHINAL CORTEX VIA THE PERFORANT AND ALVEAR PATHS. **EFFERENTS** ARE SENT TO THE SOURCES OF AFFERENT INPUTS. THE FORNIX IS THE MAIN PROJECTING EFFERENT SYSTEM TO THE SEPTUM, SUBSTANTIA INNOMINATA, ANTERIOR HYPOTHALAMUS AND THE MAMMILLARY BODY

INTEGRATION OF THE HIPPOCAMPUS WITHIN THE LIMBIC SYSTEM



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INTEGRATION OF THE HIPPOCAMPUS WITHIN THE LIMBIC SYSTEM



THE MAIN LIMBIC STRUCTURES ARE HIGHLY INTEGRATED WITH EACH OTHER. A PROMINENT FORMATION IS THE CIRCUIT (RING) OF PAPEZ. IT INVOLVES THE CONNECTIONS AND PROJECTIONS OF THE HIPPOCAMPAL FORMATION WITH EMPHASIS ON THE LINK WITH THE MAMMILLARY BODY. THIS NUCLEUS PROJECTS VIA THE THALAMUS TO THE CINGULATE CORTEX THAT IS KNOWN TO FEED BACK TO ENTORHINAL CORTEX. A DESCENDING UNIT IS CALLED THE MAMILLOTEGMENTAL FASCICULUS ORIENTED MAINLY TO THE RAPHE NUCLEI AND THE RETICULAR FORMATION

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FUNCTIONAL CORRELATES OF THE LIMBIC SYSTEM

PHYSIOLOGICAL CORRELATES

1. PLACE CELLS
2. THETA RHYTHM
3. SHARP WAVES
4. LONG TERM POTENTIATION (LTP)
5. SHORT TERM POTENTIATION
6. LEARNING
7. SPATIAL MEMORY
8. MORRIS WATER MAZE
9. EMOTIONS
10. BEHAVIOR

PATHOLOGICAL CORRELATES

1. ANXIETY
2. DEPRESSION
3. EPILEPSY
4. SCHIZOPHRENIA
5. AMNESIA
6. KORSAKOFF'S PSYCHOSIS
7. ABNORMAL SEXUAL ACTIVITY
8. ABNORMAL APPETITE
9. AGING
10. ALZHEIMER DISEASE