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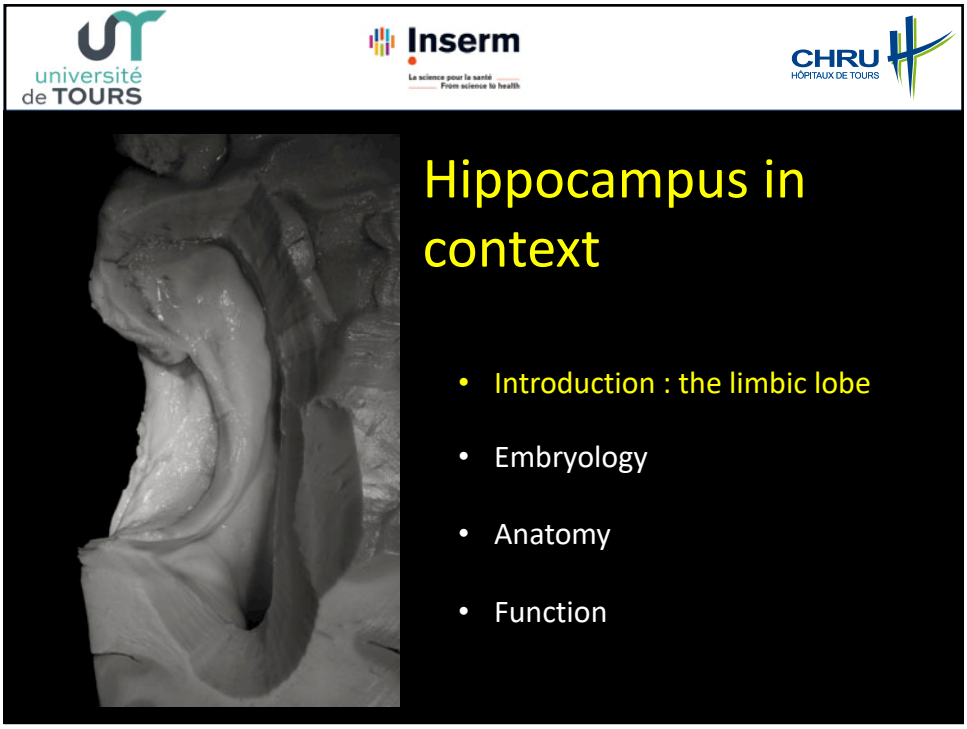
CHRU HÔPITAUX DE TOURS
Hippocampus in context
Christophe Destrieux
Laboratoire d'Anatomie,
Unité *IBrain*, INSERM U1253,
Service de Neurochirurgie
Tours - France
christophe.destrieux@univ-tours.fr

1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Hippocampus in context
• Introduction : the limbic lobe
• Embryology
• Anatomy
• Function

2

Sur la circonvolution limbique et la scissure limbique ;

PAR M. P. BROCA.

« Le lobe olfactif, réduit chez les primates à la bandelette olfactive (nerf olfactif) et au petit renflement qui la termine (ganglion olfactif), présente, chez tous les autres mammifères terrestres, un très grand développement.

Son extrémité antérieure, reçue dans la fosse ethmoïdale, est libre; mais en arrière sa base se continue sans interruption avec la partie du manteau qui entoure le limbe de l'hémisphère, et il constitue avec elle un grand lobe que l'auteur appelle le grand lobe limbique »

Bulletins de la Société d'anthropologie de Paris, II° Série, tome 12, 1877. pp. 646-657

3

Sur la circonvolution limbique et la scissure limbique ;

PAR M. P. BROCA.

1878, Revue d'anthropologie

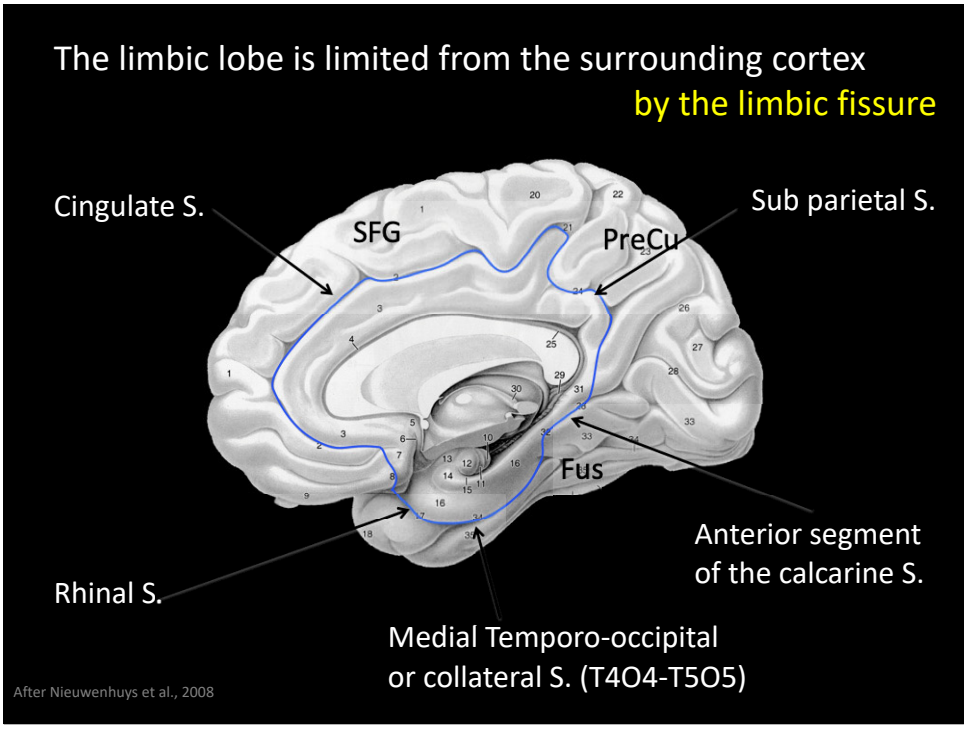
« Le seuil de l'hémisphère est circonscrit de toutes parts par le manteau, qui forme autour de lui un bord comparable à la bordure circulaire de l'entrée d'une bourse.

Je donne donc à ce bord le nom de limbe de l'hémisphère (limbus, bordure), et à la circonvolution qui le le forme, le nom de circonvolution limbique. »

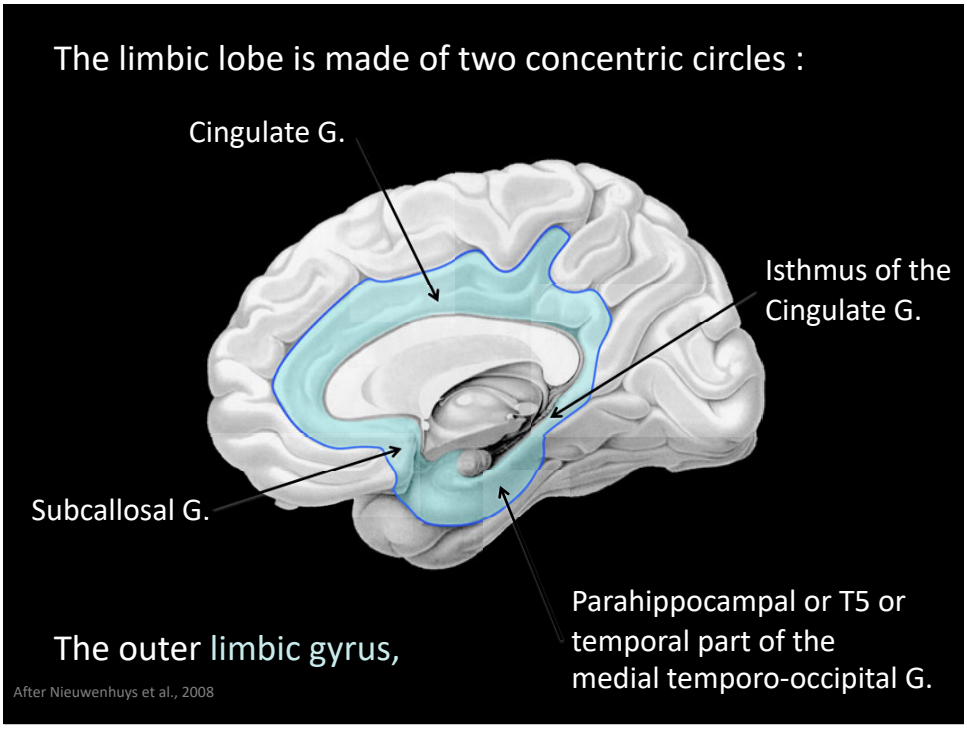
« The limit of the hemisphere is circumscribed on all sides by the mantle, which forms a rim around it comparable to the circular edge of the entrance to a purse.

Therefore, I call this rim the limbus of the hemisphere (limbus, rim), and the circumvolution that forms it is the limbic circumvolution. »

4


The limbic lobe is limited from the surrounding cortex
by the limbic fissure
Cingulate S.
SFG
PreCu
Sub parietal S.
Fus
Anterior segment
of the calcarine S.
Rhinal S.
Medial Temporo-occipital
or collateral S. (T4O4-T5O5)
After Nieuwenhuys et al., 2008

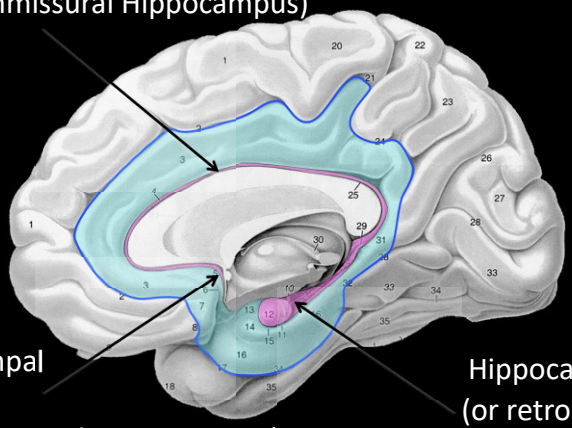
5


The limbic lobe is made of two concentric circles :
Cingulate G.
Isthmus of the
Cingulate G.
Subcallosal G.
Parahippocampal or T5 or
temporal part of the
medial temporo-occipital G.
The outer limbic gyrus,
After Nieuwenhuys et al., 2008

6

The limbic lobe is made of two concentric circles :

Indusium griseum
(or supracommissural Hippocampus)



Prehippocampal
rudiment
(or precommissural Hippocampus)

Hippocampus proper
(or retrocommissural
Hippocampus)

The outer limbic gyrus, and the inner intra limbic gyrus

After Nieuwenhuys et al., 2008

7

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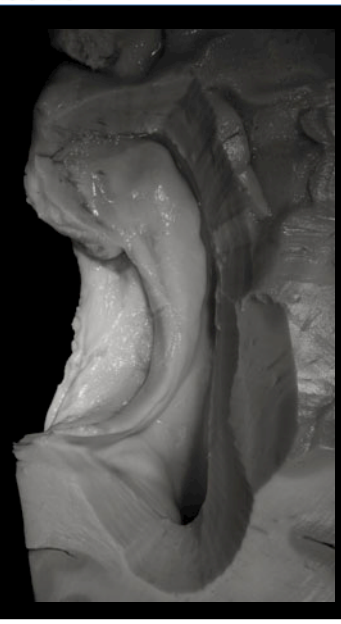
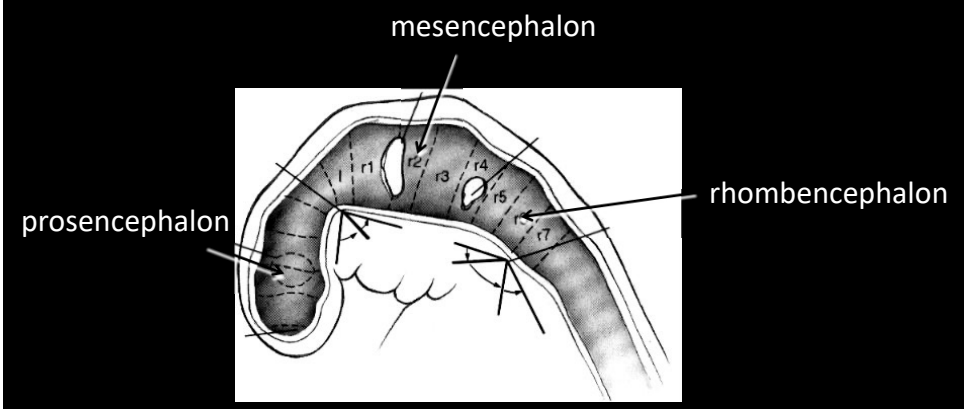


Hippocampus in context

- Introduction : the limbic lobe
- Embryology / compared anatomy
  - Vesicles – cortex development
- Anatomy
- Function

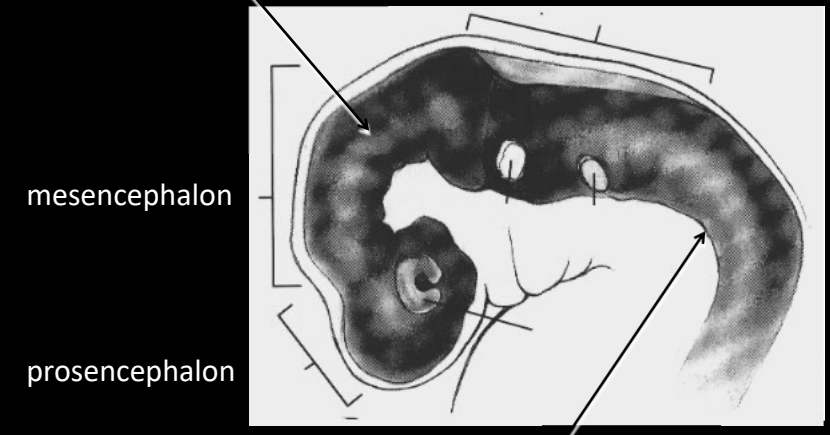
8

D19 : the neural tube gives 3 primary vesicles



9

D26 : 2 flexures appear



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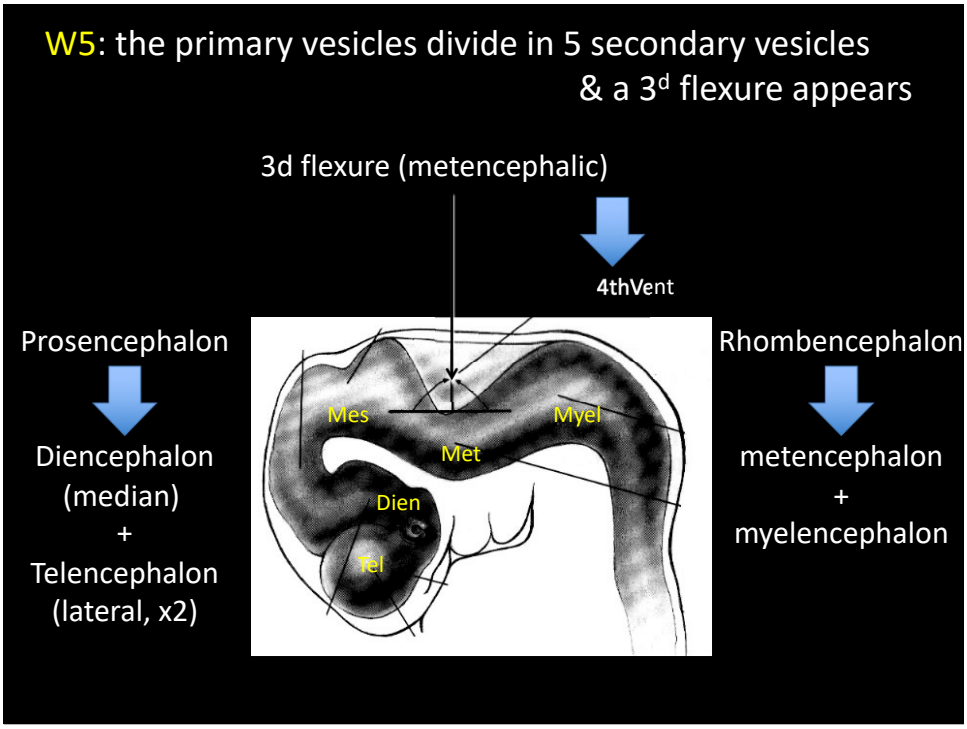
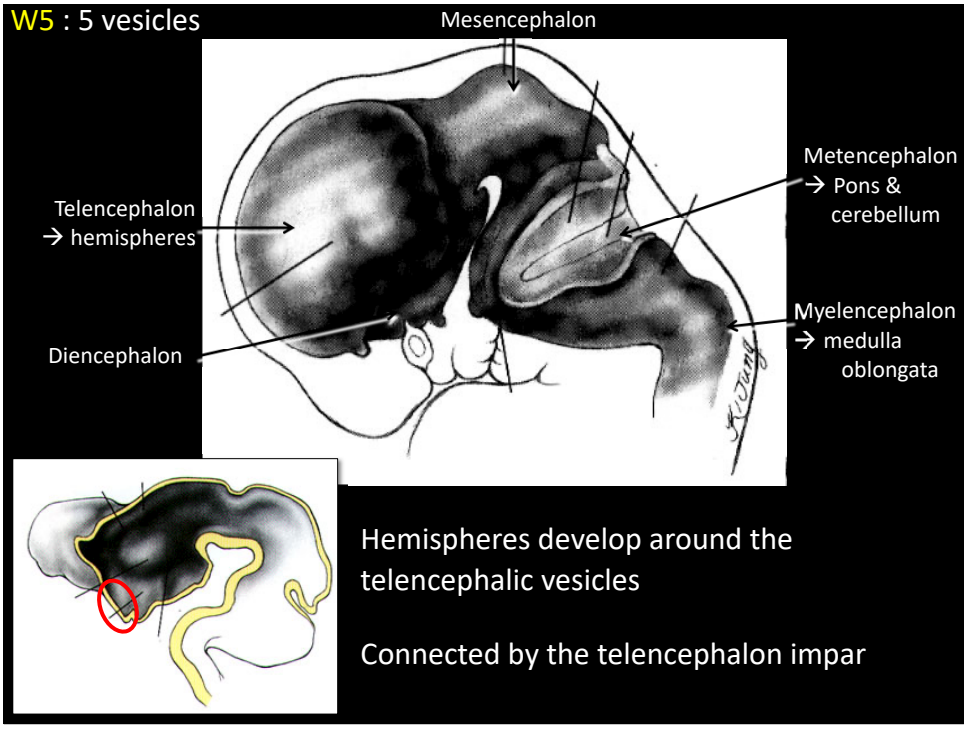

W5: the primary vesicles divide in 5 secondary vesicles
& a 3d flexure appears
3d flexure (metencephalic)
4thVent
Prosencephalon
Diencephalon
(median)
+
Telencephalon
(lateral, x2)
Mes
Myel
Met
Dien
Tel
Rhombencephalon
metencephalon
+
myelencephalon

11

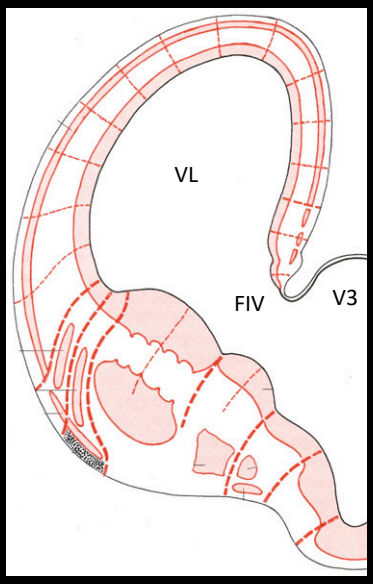

W5 : 5 vesicles
Mesencephalon
Telencephalon
→ hemispheres
Diencephalon
Metencephalon
→ Pons &
cerebellum
Myelencephalon
→ medulla
oblongata
Hemispheres develop around the
telencephalic vesicles
Connected by the telencephalon impar

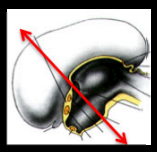
12

Telencephalon : vesicles are bordered by the pallium

variable number of layers

Dorsal
Pallium
neocortex
(new)
6 layers





Medial
Pallium
archicortex (old)
hippocampus (CA + DG)
3 layers

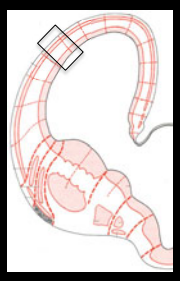
Ventro-lateral
Pallium
paleocortex
(very old)
piriform cortex
entorhinal cortex
4-6 layers

Allocortex (10%):
- paleocortex
- archicortex
- mesocortex (interm / neo)

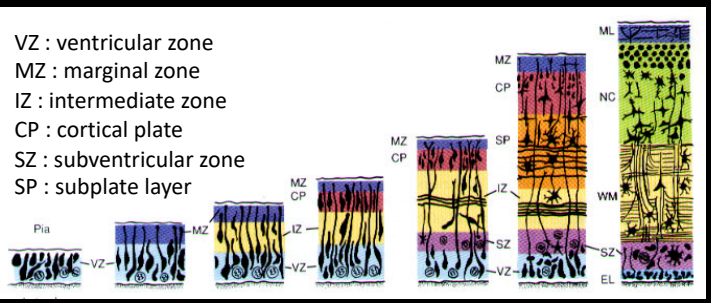
(close to Broca's limbic lobe)

13

Telencephalon : layered structure of the cortex



VZ : ventricular zone
MZ : marginal zone
IZ : intermediate zone
CP : cortical plate
SZ : subventricular zone
SP : subplate layer



- Cells of the ventricular zone give waves of neuroblasts which migrate towards the surface of the brain
- A new layer migrates through other layers to get its final location (heterotopias)
- Finally the ventricular zone gives the glioblasts and ependymal cells

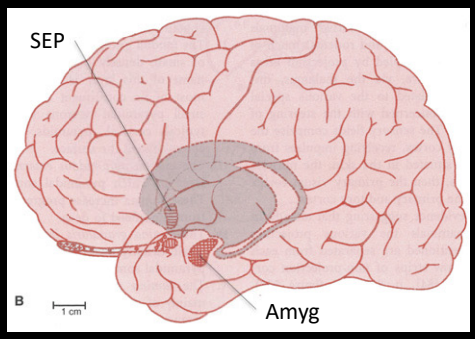
14

Telencephalon : schematically 2 parts

	Allocortex (=paleo + archi + meso)	Neocortex
Cytoarchitectonics	3(-6) layers	6 layers
Extent	Reptile: ++++ Human: +	Reptile: 0 Human: ++++
Subcortical input/output	Amygdala Septal nuclei	Thalamus

Allocortex + Amygdala + septal nuclei = limbic system

15



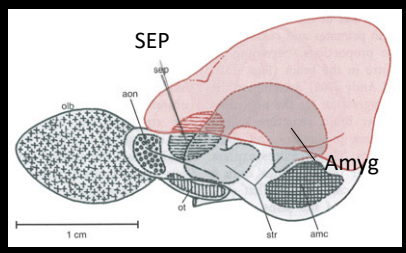
Schematically :
- Neocortex : conscient / voluntary actions
- Allocortex : emotions, motivation

« Le manteau de l'hémisphère se compose de deux parties: l'une brutale, représentée par le grand lobe limbique, l'autre, intellectuelle, représentée par le reste du manteau. »

Human : **neocortex** dominates

Allocortex limited to a « ring »
at the medial aspect of the hemisphere
connected to olfactory structures

Opossum : **allocortex** dominates



But too schematic :
- Insula and prefrontal Cx are involved in emotions
- Accumbens n. is involved in cognition

16

"… the bizarre distinction between cognition and emotion, as if somehow one could have thoughts without emotion, a mind without affect."

"The rift between emotion and cognition acquired a neuroanatomical counterpart in the duality between limbic system and neocortex."

A Damasio, 1995

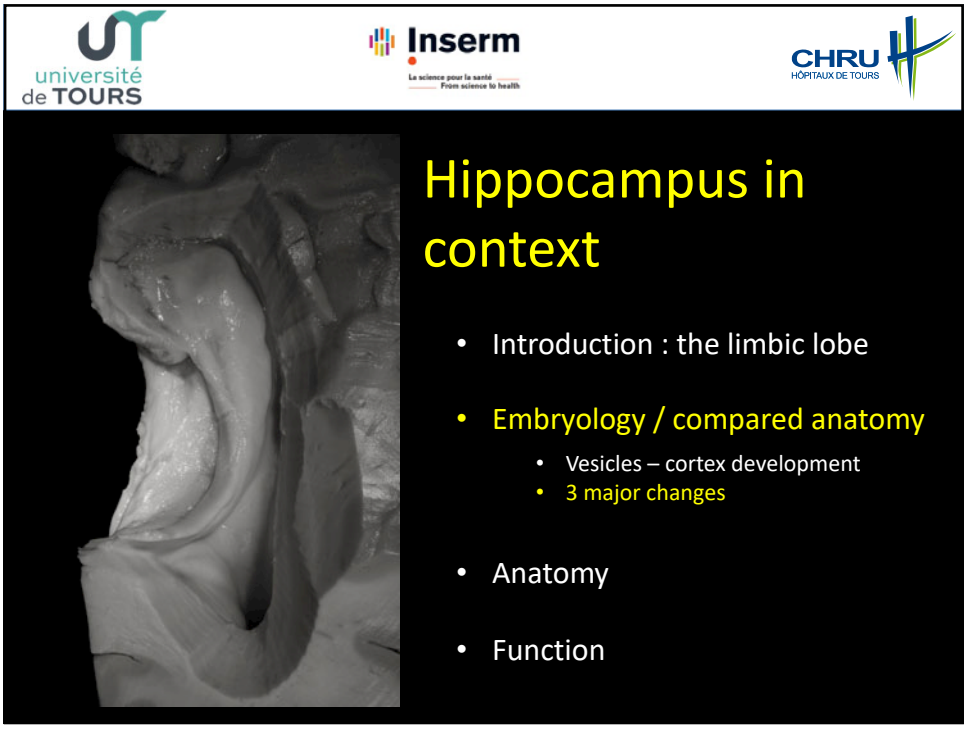
17

Every major behaviour involves

amygdala, septal nuclei, hippocampus, reticular substance, hypothalamus …

but also larges neocortical areas

18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Hippocampus in context
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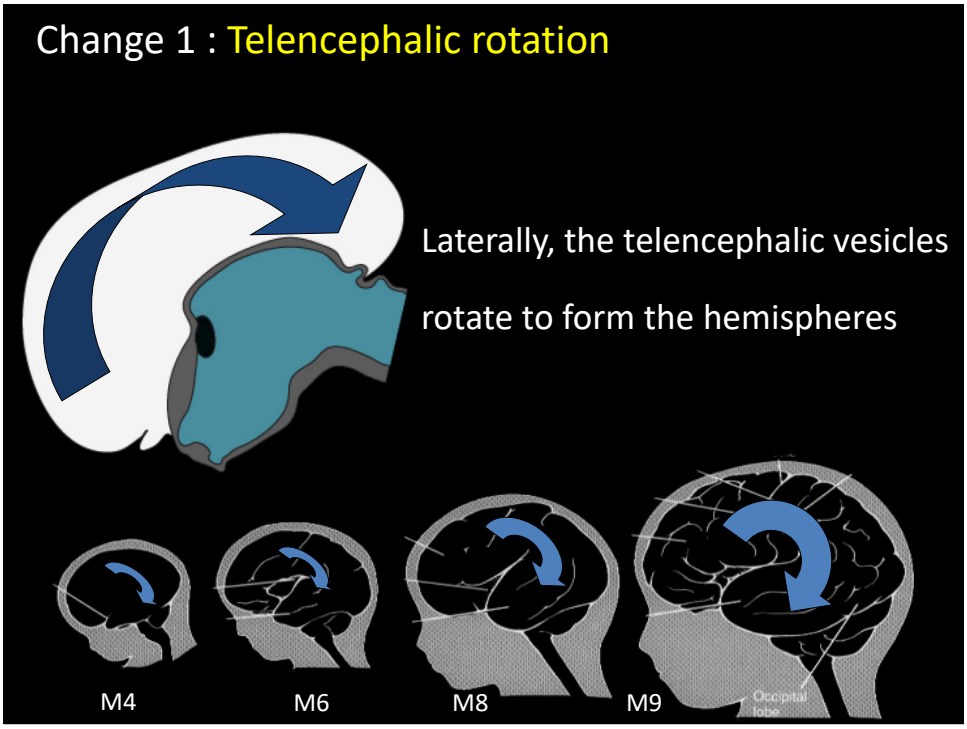
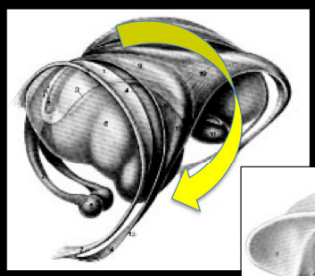
• Vesicles – cortex development
• 3 major changes
• Anatomy
• Function

19


Change 1 : Telencephalic rotation
Laterally, the telencephalic vesicles rotate to form the hemispheres
M4
M6
M8
M9
Occipital lobe

20

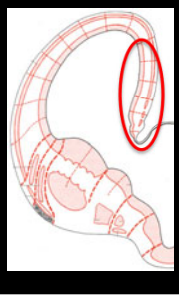
Change 1 : Telencephalic rotation

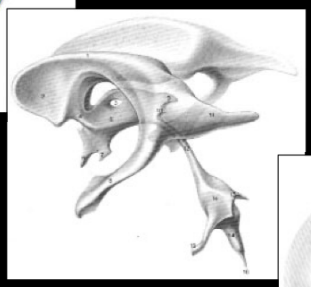


Several structures follow this rotation

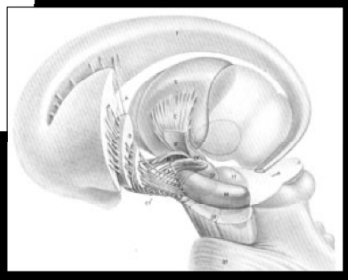
The - initially dorsomedial – hippocampus (medial pallium, archicortex) becomes ventral

fornix





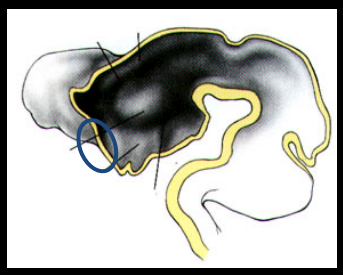
Ventricles
and choroid plexus



Caudate nucleus

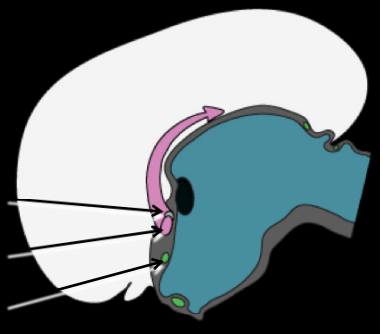
21

Change 1 : Telencephalic rotation



The telencephalic commissures develop from the *telencephalon impar*, located on the midline

The *telencephalon impar* thickens to form the commissural plate in which 3 commissures develop :



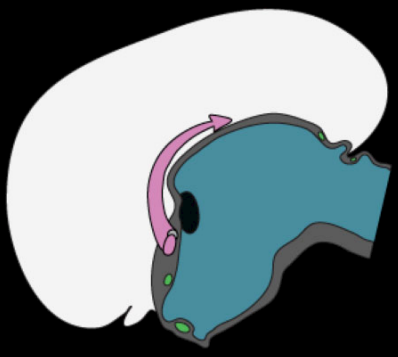
callosal

hippocampal

anterior

22

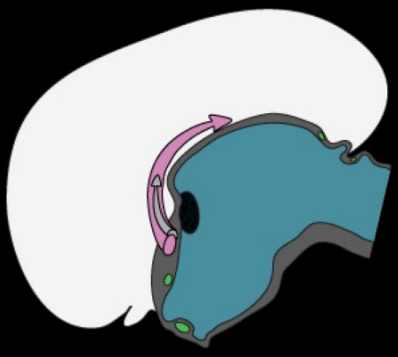
Change 1 : Telencephalic rotation



The hippocampal commissure is the first to follow the rotation from the supraoptic area to the temporal region

23

Change 1 : Telencephalic rotation

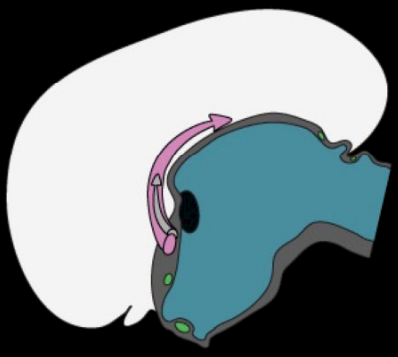


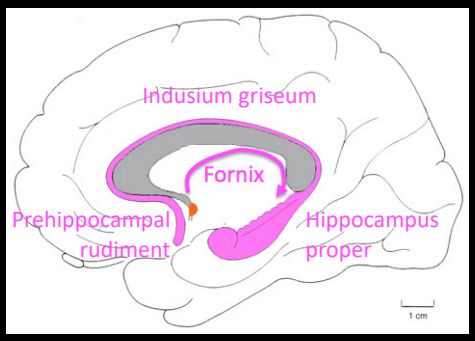
The callosal commissure then develops and splits the hippocampal commissure in 2 parts :

- ventral
- dorsal

24

Change 1 : Telencephalic rotation





After Nieuwenhuys et al., 2008

The callosal commissure then develops and splits the hippocampal commissure in 2 parts :

- ventral : fornix
- dorsal : prehippocampal rudiment and indusium griseum

They join around the splenium : hippocampus proper

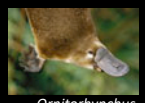
25

Variable extend of telencephalic commissures

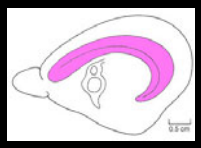
Development of the corpus callosum in mammals induces a partial involution of the dorsal hippocampus

Mammals

Monotremes and marsupials



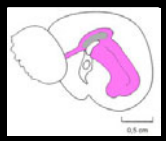
Ornitorhynchus anatinus



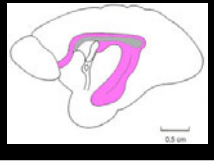
Acallosal

Eutherians (or placental)

Erinaceus europaeus hedgehog

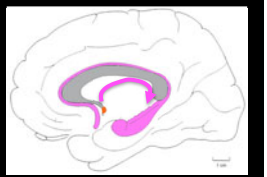


Galago demidovii



Callosal

Homo sapiens sapiens

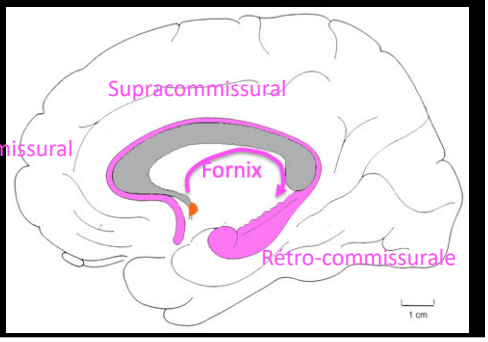


26

Variable extend of telencephalic commissures

In Human, the pre et supra-commissural parts involute:
indusium griseum & prehippocampal rudiment

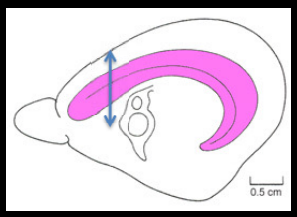
Its retrocommissural part develops:
hippocampus proper



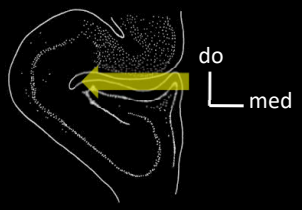
as does its ventral part:
fornix

27

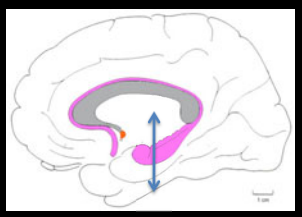
Change 2 : Invagination within the hippocampal S.



Ornitorhynchus anatinus



After Nieuwenhuys et al., 2008



Homo sapiens

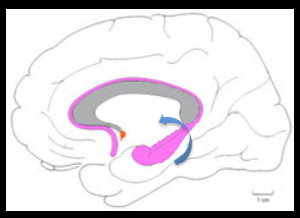
The hippocampal sulcus develops longitudinally at the medial aspect of the hemisphere

28

Change 3 : rotation along the longitudinal axis of the hippocampus proper

do
med

After Nieuwenhuys et al., 2008



The human hippocampus gets a complex rolled structure

29

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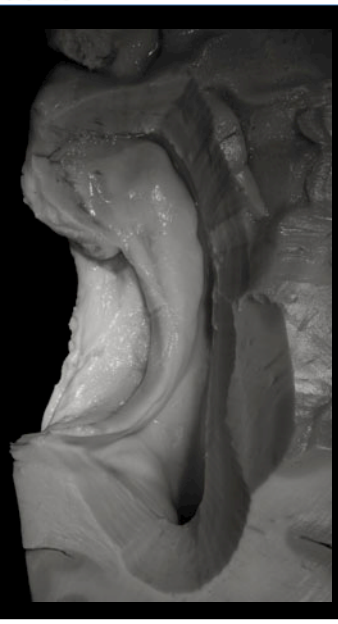


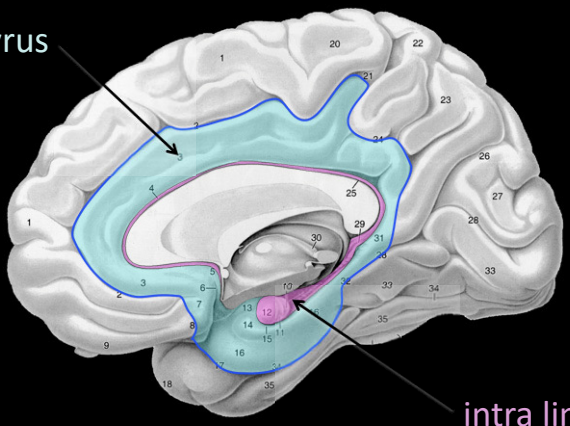
Hippocampus in context

- Introduction : the limbic lobe
- Embryology
- Anatomy
  - Intra limbic gyrus
  - Limbic gyrus
  - Septum
  - Amygdala
- Function

30

The limbic lobe is made of two concentric circles :

limbic gyrus



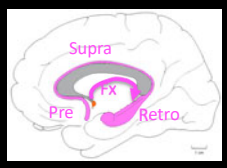
intra limbic gyrus

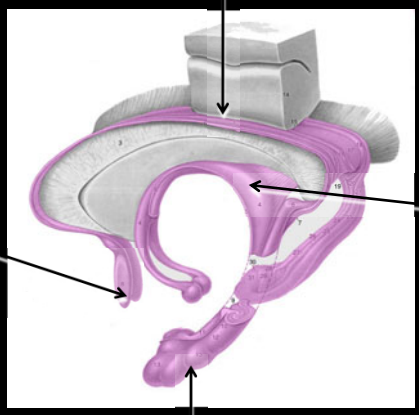
After Nieuwenhuys et al., 2008

31

The intralimbic gyrus is subdivided:

Supracommissural H: indusium griseum, around corpus callosum





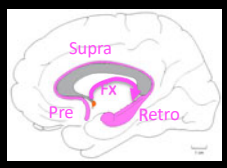
Subcommissural H: fornix

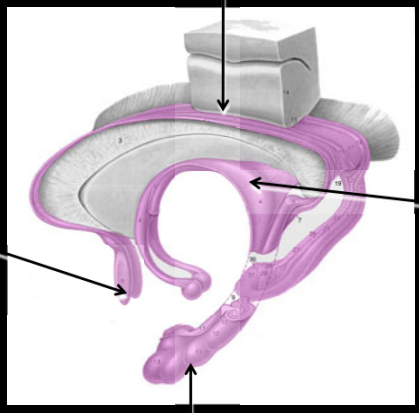
Precommissural H: within subcallosal area

Retrocommissural H : at the medial aspect of the temporal lobe

32

Supracommissural H: indusium griseum, around corpus callosum





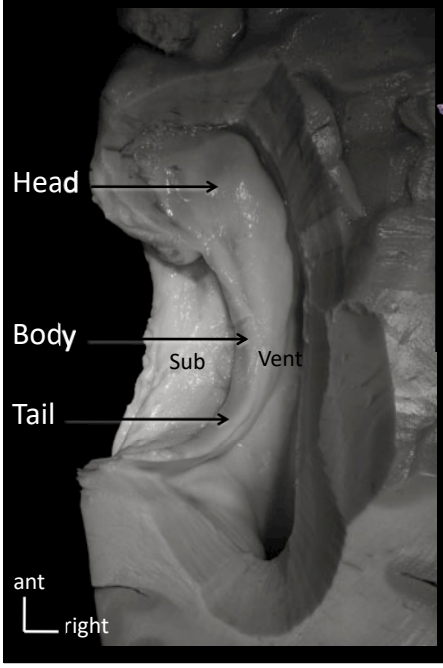
Subcommissural H: fornix

Precommissural H: within subcallosal area

Retrocommissural H : at the medial aspect of the temporal lobe

33

Retrocommissural Hippocampus: general aspect



Seen from above, the hippocampus is C-shaped :

- body, sagittal
- head & tail, coronal

http://www.debbymason.com

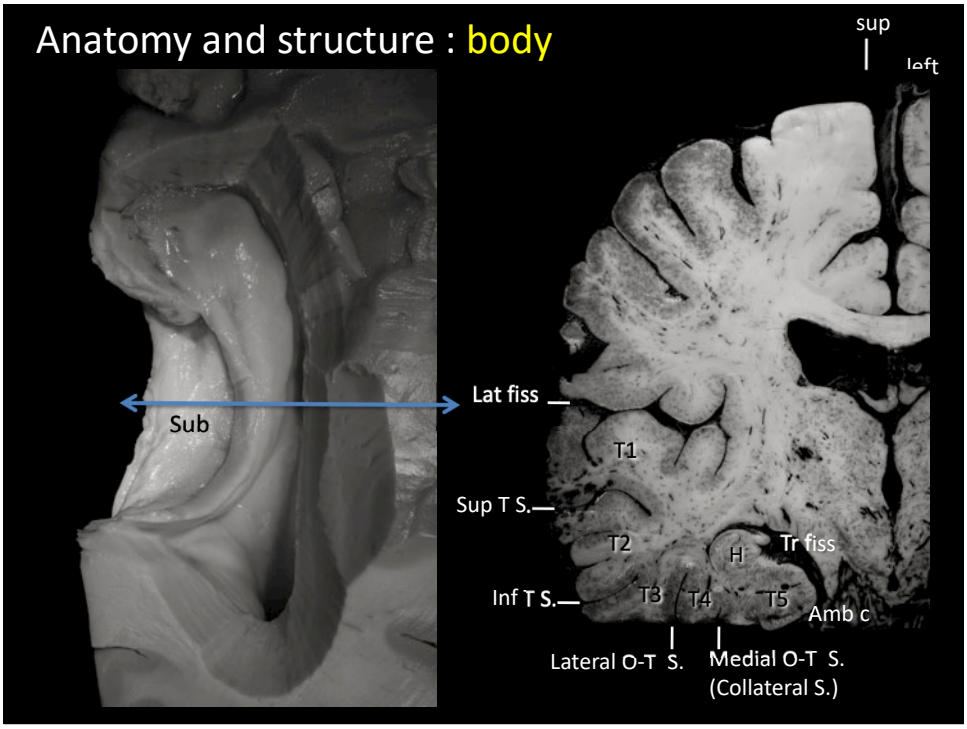
It lies on the superior, flat aspect of the parahippocampal G. (T5), or subiculum

It bulges from the floor of the inferior horn of the ventricle

34

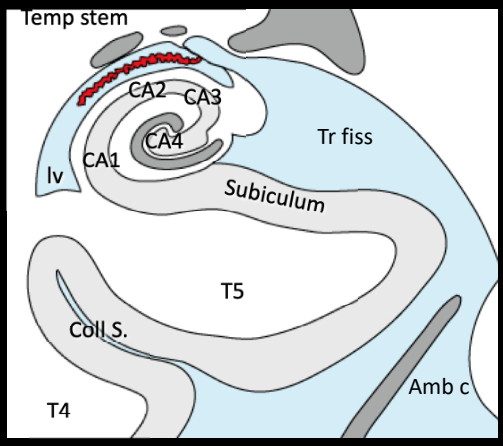

Body
ant
right
Seen from above, the hippocampus is C-shaped :
• body, sagittal
• head & tail, coronal
http://www.debbymason.com

35


Anatomy and structure : body
sup
left
Sub
Lat fiss
T1
Sup T S.
T2
H
Tr fiss
Inf T S.
T3
T4
T5
Amb c
Lateral O-T S.
Medial O-T S.
(Collateral S.)

36

Anatomy and structure : body



The hippocampus is made of 2 rolled up cortical laminae :
(1) the cornu Ammonis (CA1-4) that continues the subiculum

37

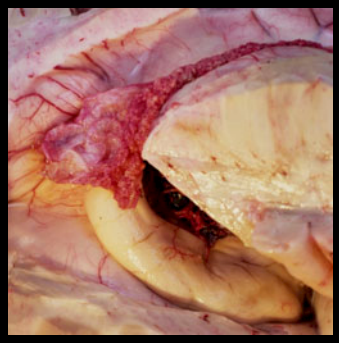
Anatomy and structure : body

Amon-Rê (Ammon-Zeus)
Ram Alley
Karnak temple in Luxor

http://fr.academic.ru/dic.nsf/frwiki/200498

Ammonite

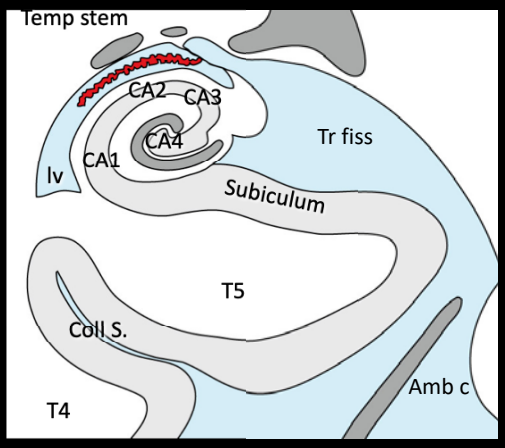
http://www.fossilmuseum.net/EdResources/AmmoImages.htm



Cornu Ammonis, Amon's horn

38

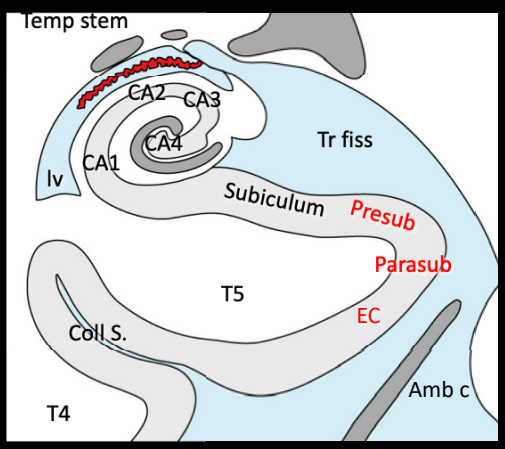
Anatomy and structure : body



The hippocampus is made of 2 rolled up cortical laminae :
(2) the gyrus dentatus, a medially concave groove around CA4

39

Anatomy and structure : body

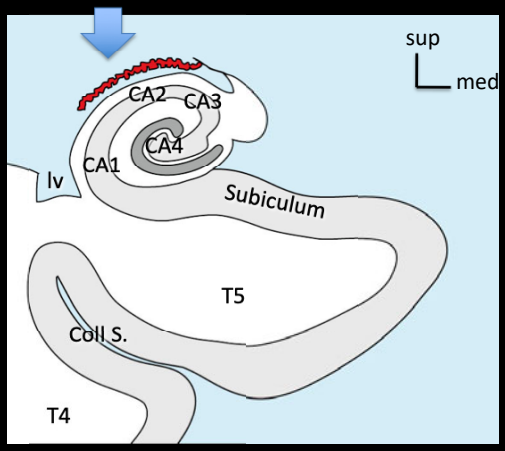


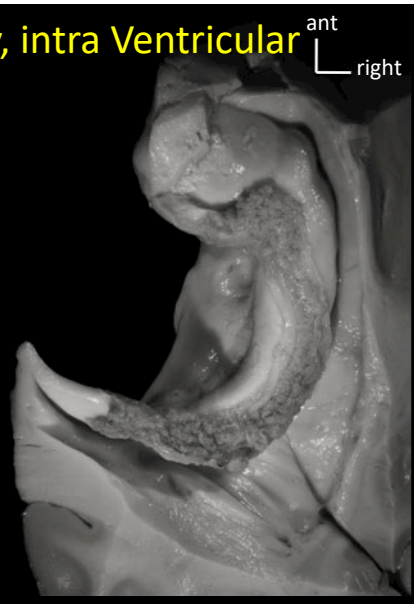
Depending of the authors, the subiculum is included in hippocampus or in T5

The pre-, parasubiculum and entorhinal cortex connect H to T5

40

Anatomy and structure : body, intra Ventricular

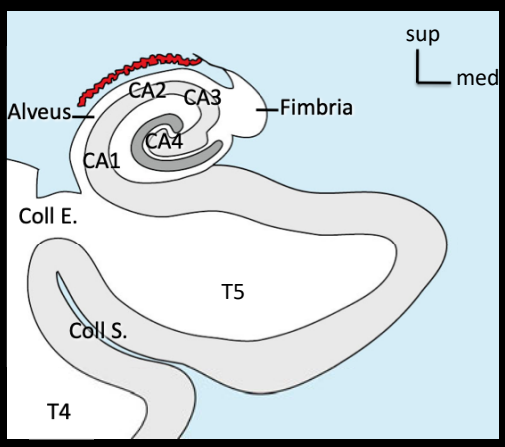


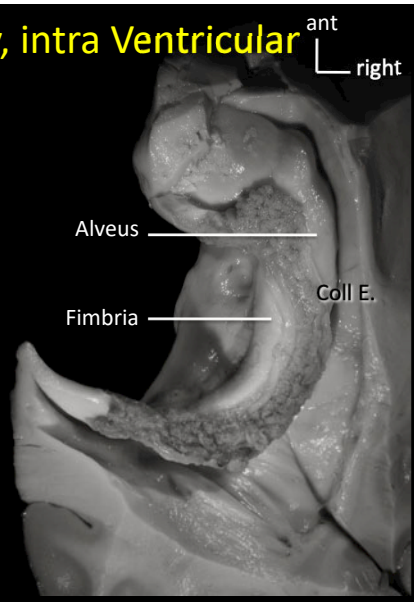


The hippocampus bulges in the
Inferior horn of the lateral ventricle
and has 2 aspects : intraventricular and extraventricular

41

Anatomy and structure : body, intra Ventricular



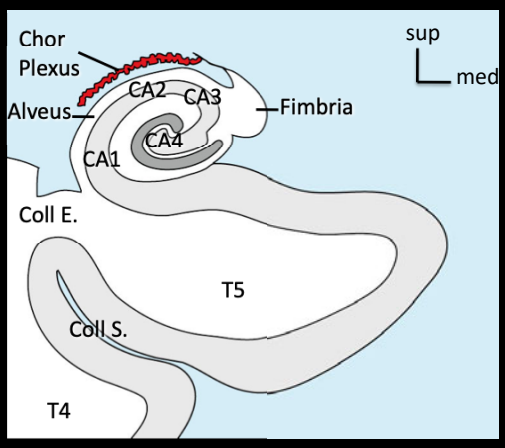


The body intraventricular aspect :
- forms the floor of the ventricle with the collateral eminence
- is covered by the alveus, continued by the fimbria

(alveus : hull of a boat; fimbria :"border of a piece of clothe")

42

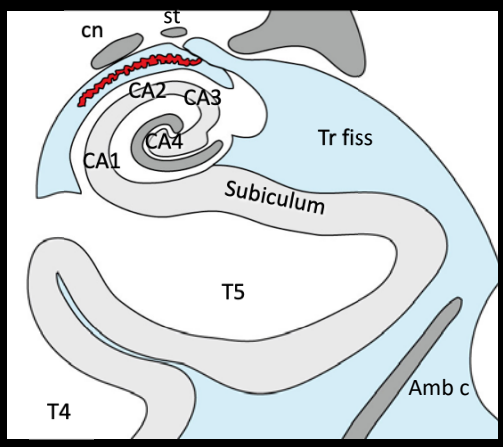
Anatomy and structure : body, intra Ventricular

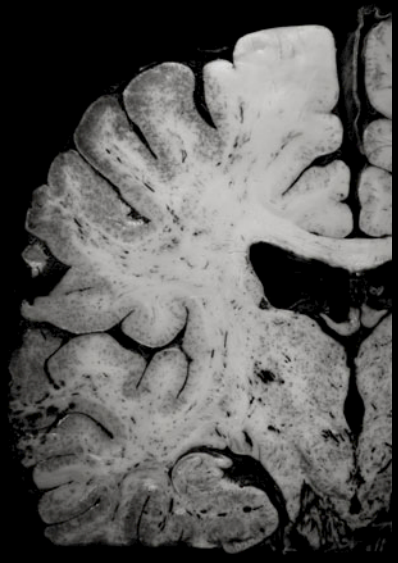


The body intraventricular aspect :
• is hidden by the choroid plexus

43

Anatomy and structure : body, intra Ventricular

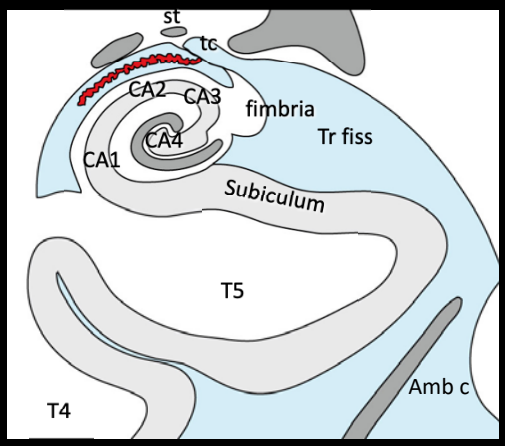




The intraventricular aspect faces
The roof of the inferior horn :
• tail of caudate nucleus, stria terminalis
• temporal stem (UF, IFOF, temporal loop of optic radiations)

44

Anatomy and structure : body, intra Ventricular

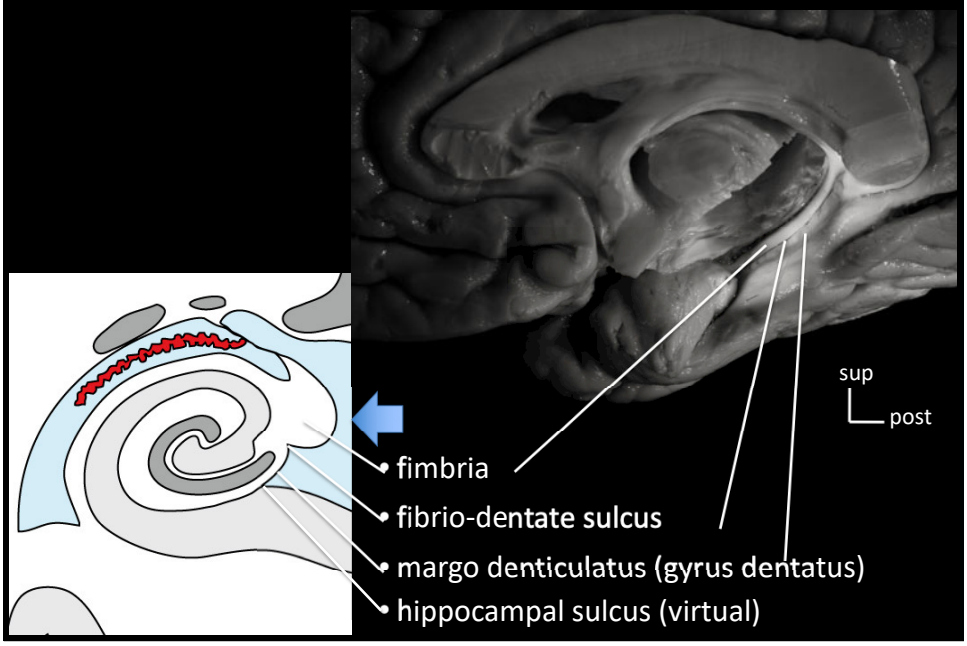


The Tela choroidea medially closes the inferior horn :

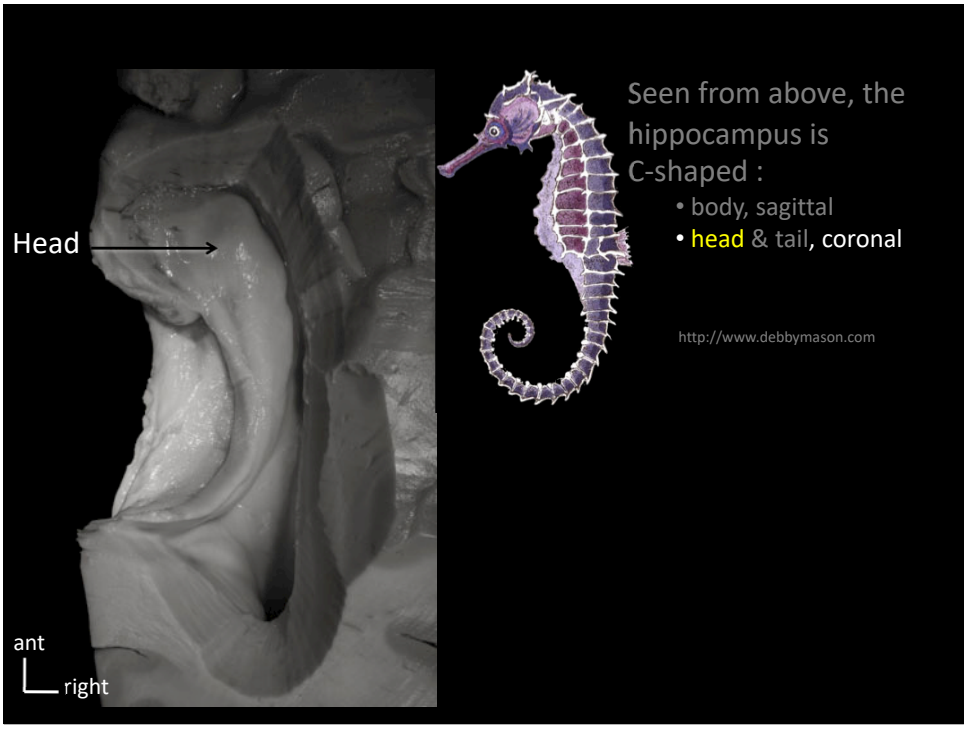
- juxtaposition of pia matter and ependyma
- between the tenias
- origin of the choroid plexuses

45

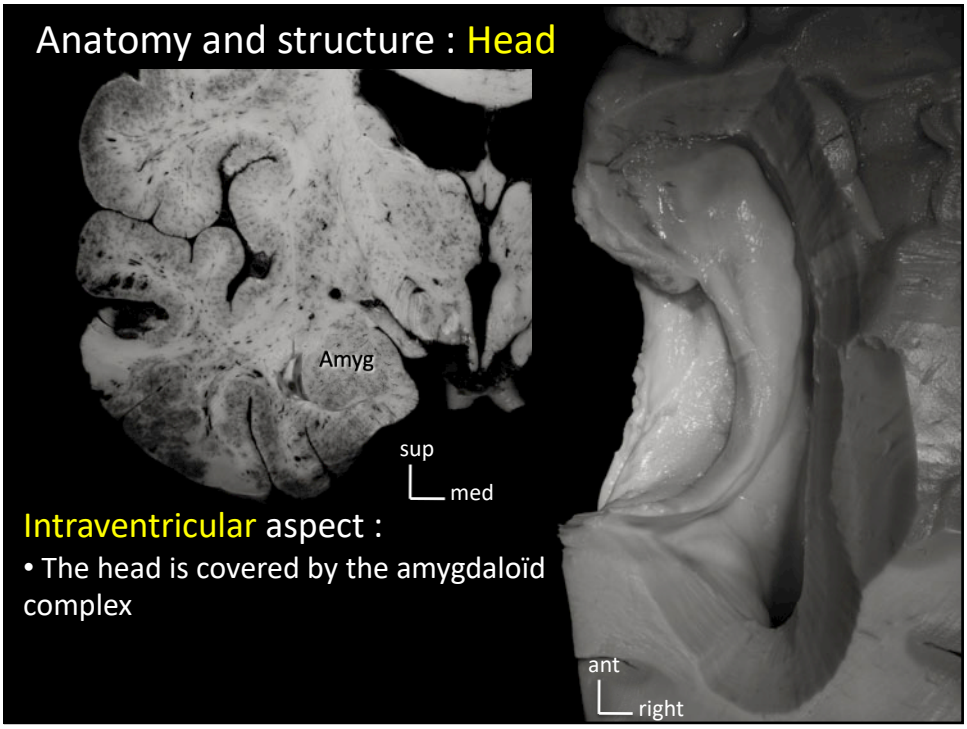
Anatomy and structure : body, cisternal



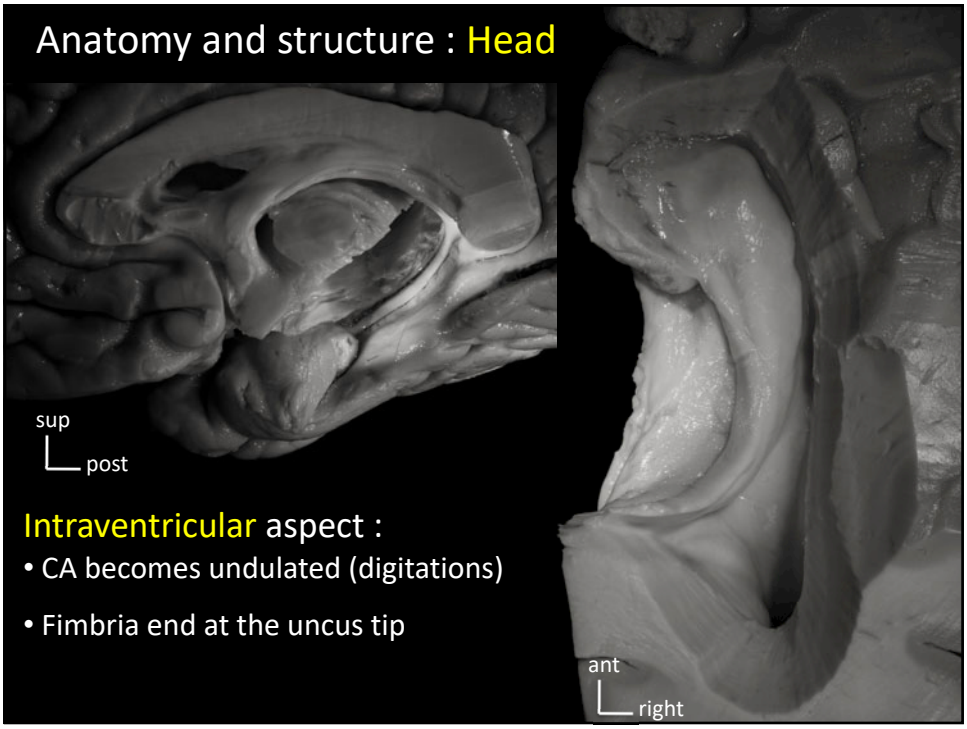
46


Head
ant
right
Seen from above, the hippocampus is C-shaped :
• body, sagittal
• head & tail, coronal
http://www.debbymason.com

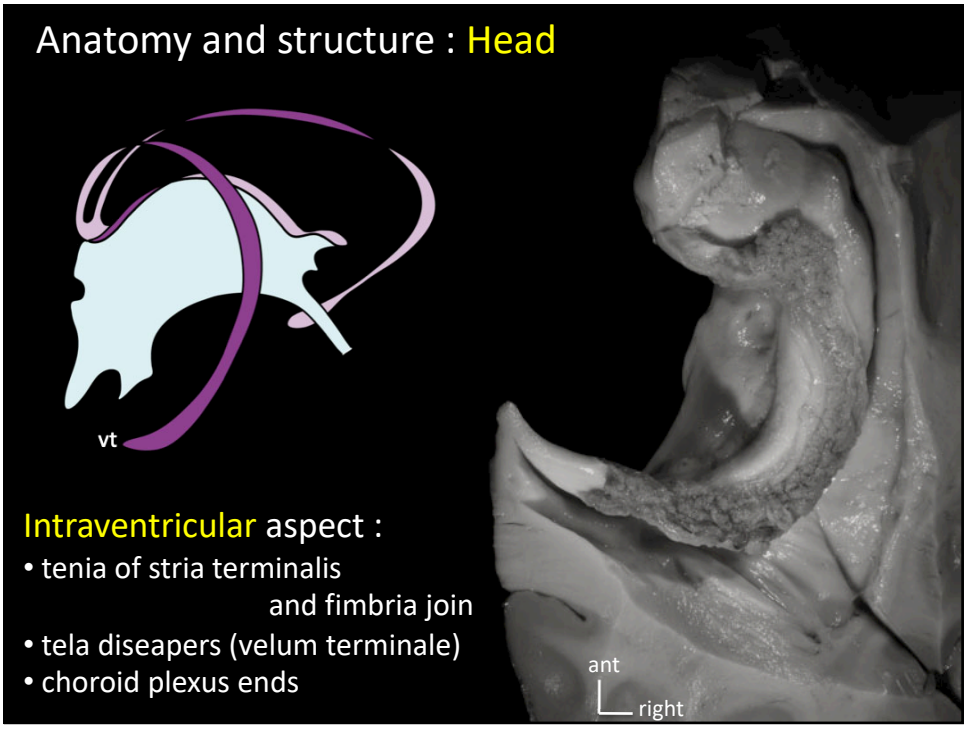
47


Anatomy and structure : Head
Amyg
sup
med
Intraventricular aspect :
• The head is covered by the amygdaloïd complex
ant
right

48

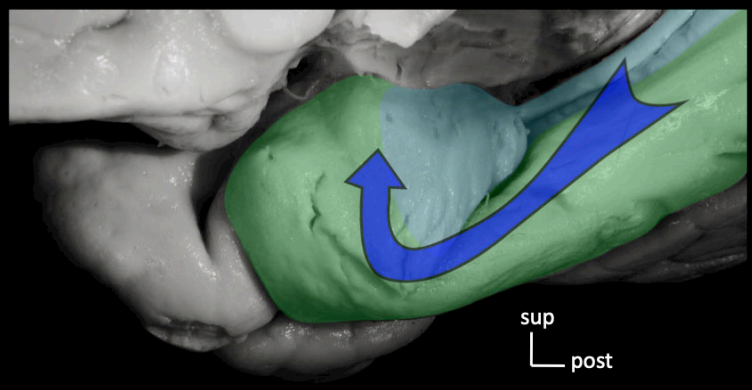

Anatomy and structure : Head
sup
post
Intraventricular aspect :
• CA becomes undulated (digitations)
• Fimbria end at the uncus tip
ant
right

49


Anatomy and structure : Head
vt
Intraventricular aspect :
• tenia of stria terminalis
and fimbria join
• tela diseapers (velum terminale)
• choroid plexus ends
ant
right

50

Anatomy and structure : Head

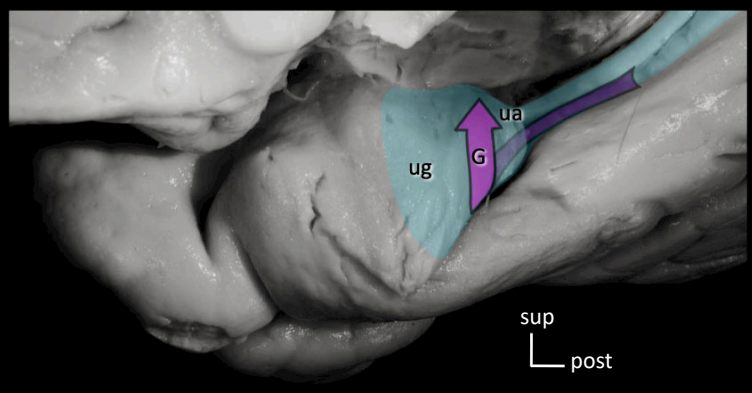


Cisternal aspect :

- hippocampus and parahippocampal gyrus curve posteriorly
- Uncus contains hippocampal (post) and parahippocampal (ant) parts
- The uncal sulcus limits the uncus from the parahippocampal G

51

Anatomy and structure : Head

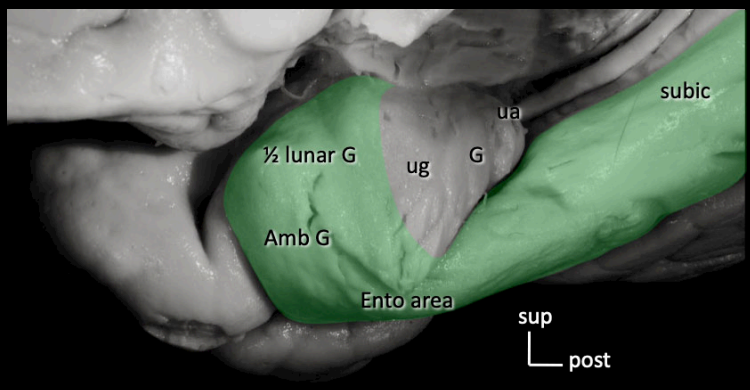


Cisternal aspect : hippocampal (post) part of the uncus

- uncal apex (end of fimbria)
- medial band of Giacomini (Gyrus Dentatus)
- uncinate gyrus (Cornu Ammonis)

52

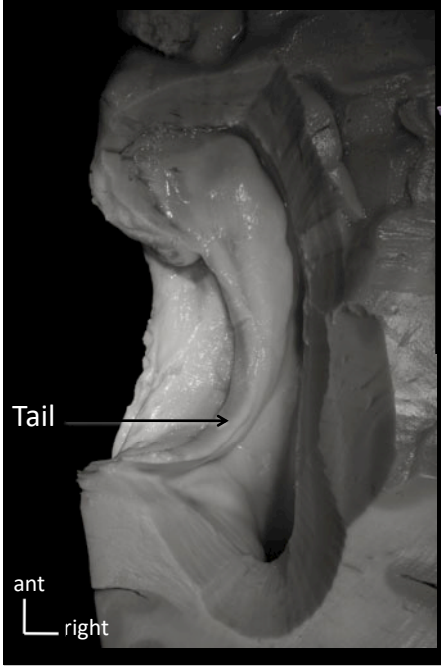
Anatomy and structure : Head



Cisternal aspect : parahippocampal (ant) part of the uncus

Anterior part of parahippocampal gyrus = Piriform lobe
- entorhinal area
- uncal part
  - ambient gyrus
  - semilunar gyrus

53



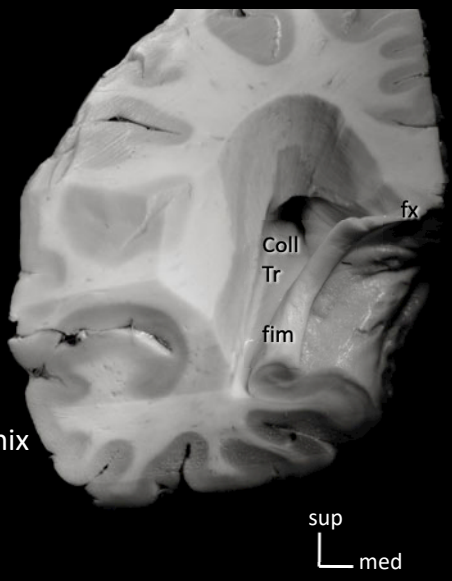
Seen from above, the hippocampus is C-shaped :
- body, sagittal
- head & tail, coronal

http://www.debbymason.com

54

Anatomy and structure : Tail

- ascends medially
- splits in dorsal or ventral elements relative to the splenium

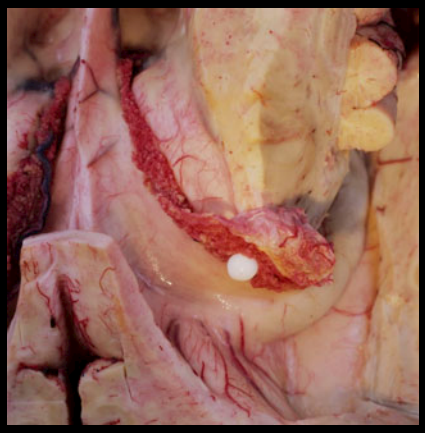


Intraventricular part :

- Collateral eminence enlarges (collateral trigone)
- Fimbria becomes crus of the fornix ("leg" of the fornix)

55

Anatomy and structure : Tail

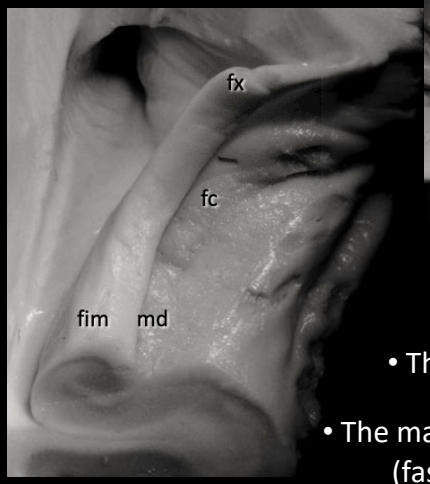


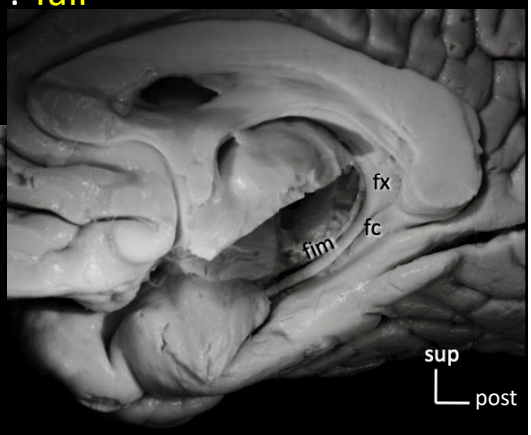
- Both crus of the fornix join on the midline (body) and split again (columns) at the anterior aspect of interventricular foramen
- Choroid plexus originates from the tela

56

Anatomy and structure : Tail

Extraventricular part :



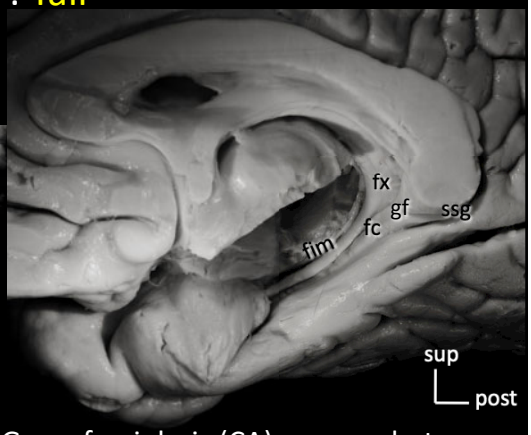


- The fimbria ascends ventral to CC
- The margo denticulatus becomes smooth (fasciola cinerea, “small band having the color of ashes”), and disappears

57

Anatomy and structure : Tail

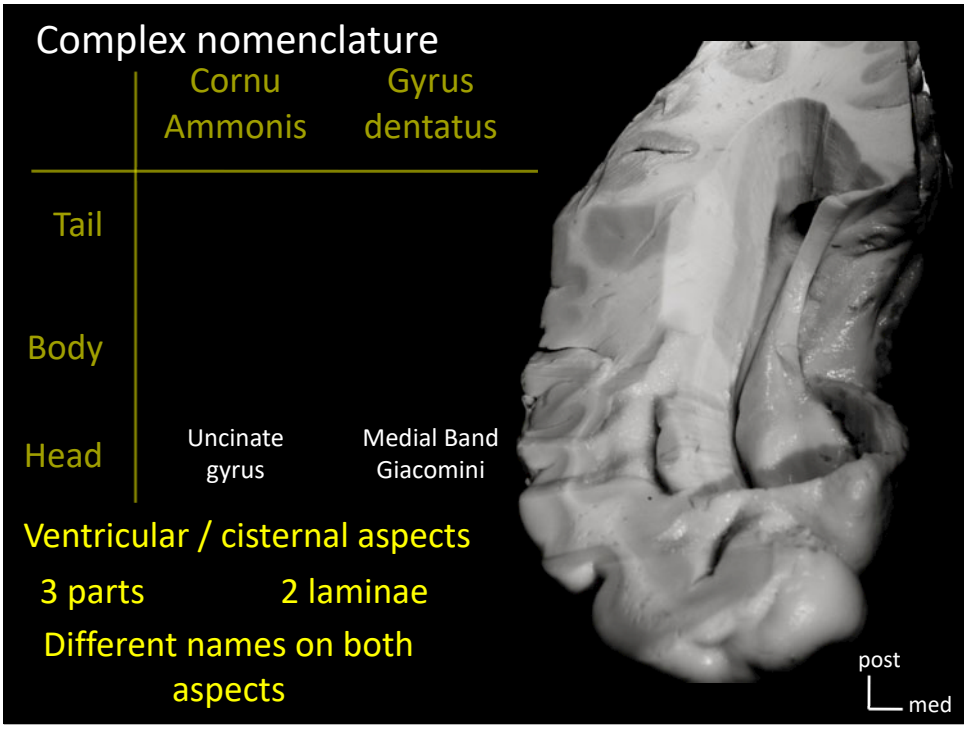
Extraventricular part :



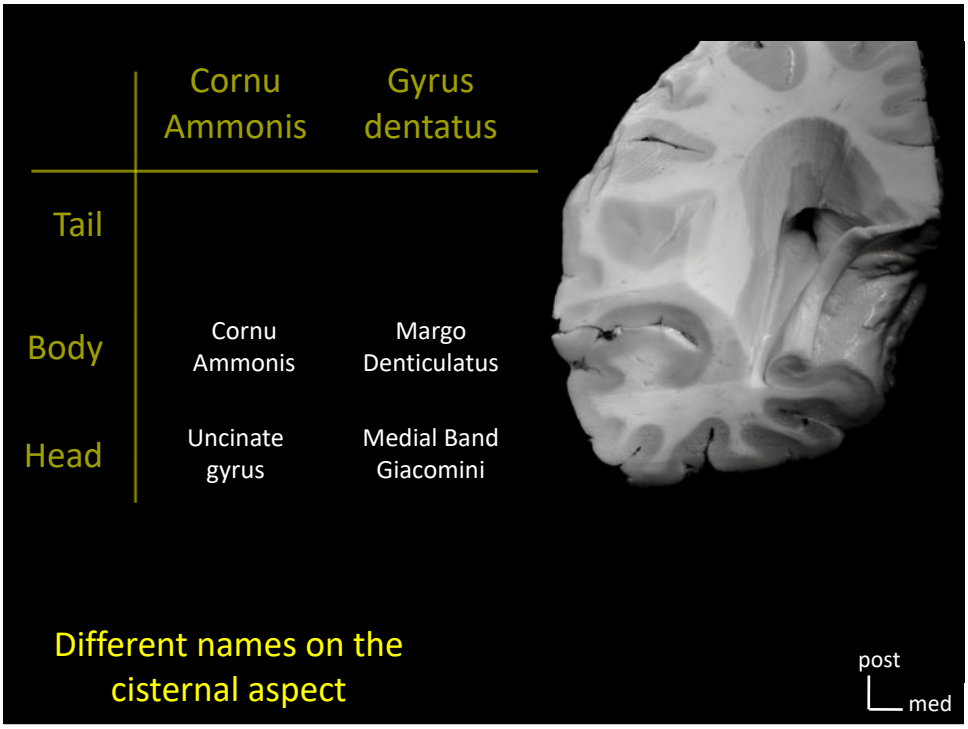
- The Gyrus fasciolaris (CA) appears between the fimbria and fasciola cinerea
- It is continued dorsal to the splenium : subsplenial gyrus that becomes the indusium

G fasciolaris, subsplenial g., indusium = dorsal hippocampus

58


Complex nomenclature
Cornu Ammonis
Gyrus dentatus
Tail
Body
Head
Uncinate gyrus
Medial Band Giacomini
Ventricular / cisternal aspects
3 parts
2 laminae
Different names on both aspects
post
med

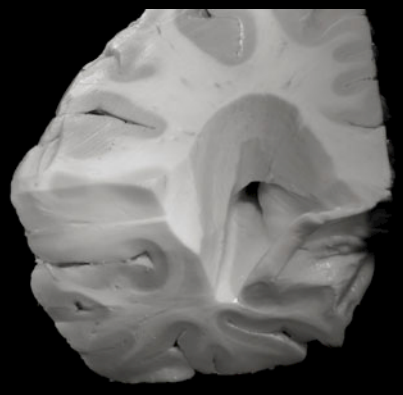
59


Cornu Ammonis
Gyrus dentatus
Tail
Body
Head
Cornu Ammonis
Margo Denticulatus
Uncinate gyrus
Medial Band Giacomini
Different names on the cisternal aspect
post
med

60

Complex nomenclature

	Cornu Ammonis	Gyrus dentatus
Tail	Gyrus fasciolaris / Subsplenial G	Fasciola cinerea
Body	Cornu Ammonis	Margo Denticulatus
Head	Uncinate gyrus	Medial Band Giacomini

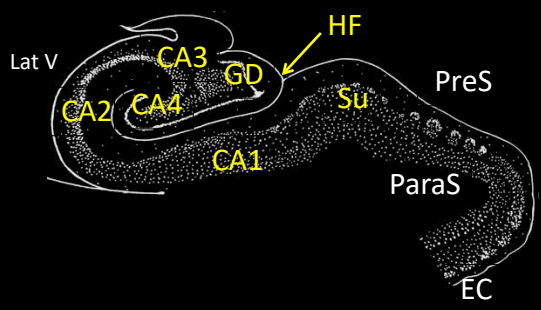


Different names on the cisternal aspect

post
med

61

Retrocommissural Hippocampus: cytoarchitectonics

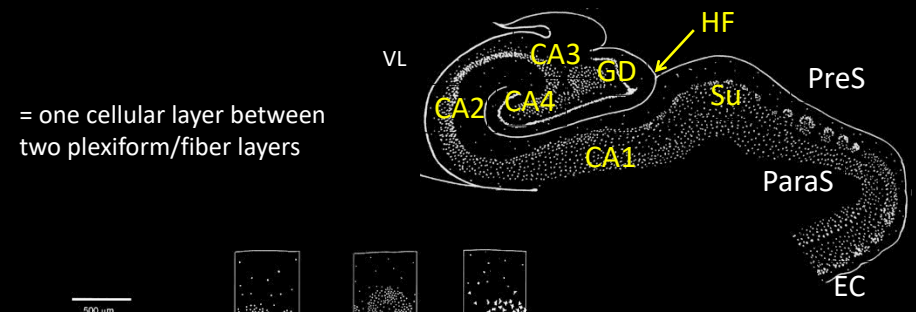


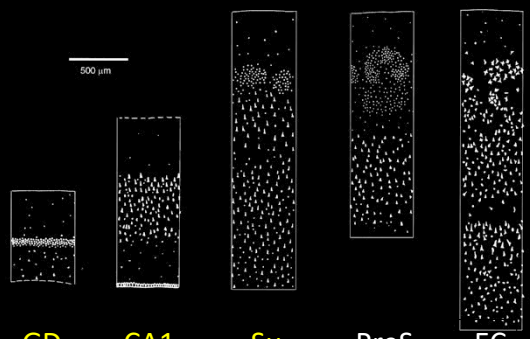
- Presubiculum, Parasubiculum and entorhinal cortex belong to parahippocal gyrus (T5)
- Subiculum is included into hippocampus or T5
- CA4 is sometimes included within CA3

62

Retrocommissural Hippocampus: archicortex
3-layers allocortex

= one cellular layer between two plexiform/fiber layers



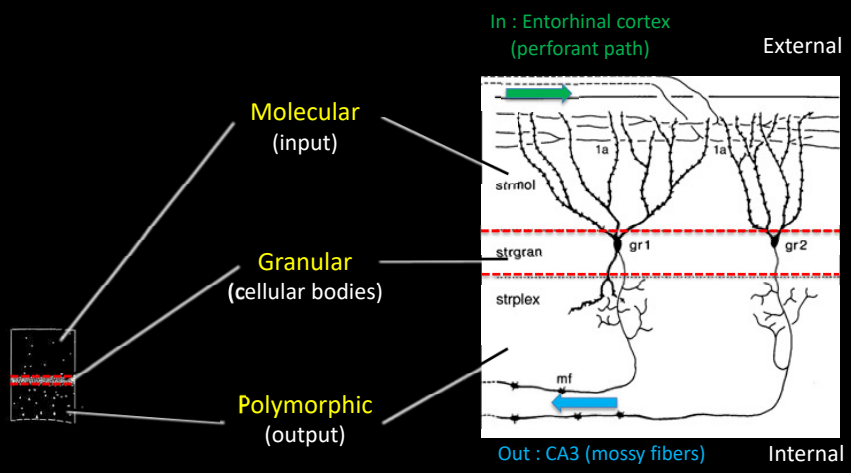


- Presubiculum, Parasubiculum and entorhinal cortex have 5 layers
- They are transitionnal with the neocortex (mesocortex)

63

Retrocommissural Hippocampus: archicortex
3-layers allocortex

Dentate Gyrus



64

Retrocommissural Hippocampus: archicortex
3-layers allocortex

Ammon Horn

In : various layer depending of origin

External

EC

CA3 (Schaffer)

st lacunosum/moleculare

apical dendrites

controlat Hippocampus

st radiatum

Pyramidal (cell bodies)

medial septal n.

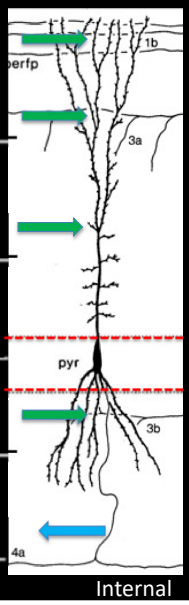
st oriens

basal dendrites + axons

Out : subiculum, fimbria

alveus

CA1



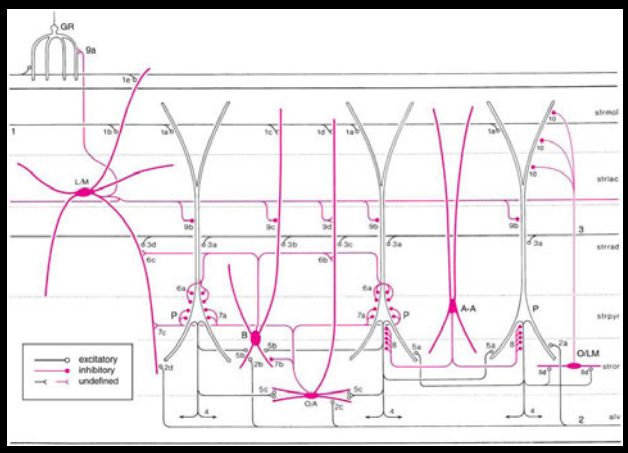
Internal

65

Retrocommissural Hippocampus: archicortex
3-layers allocortex

Ammon Horn

- >20 different types of interneurons
- mainly inhibitory (GABA)



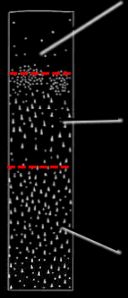
CA1

66

Retrocommissural Hippocampus: archicortex 3-layers allocortex

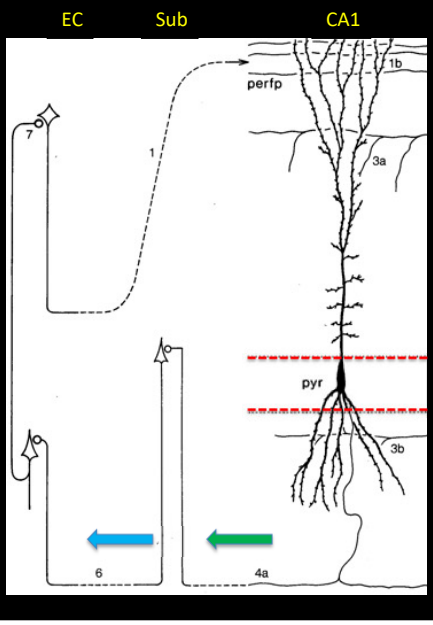
Subiculum

- Principal hippocampal output, towards cortex (EC) and subcortical structures
- High density of GABAergic neurons

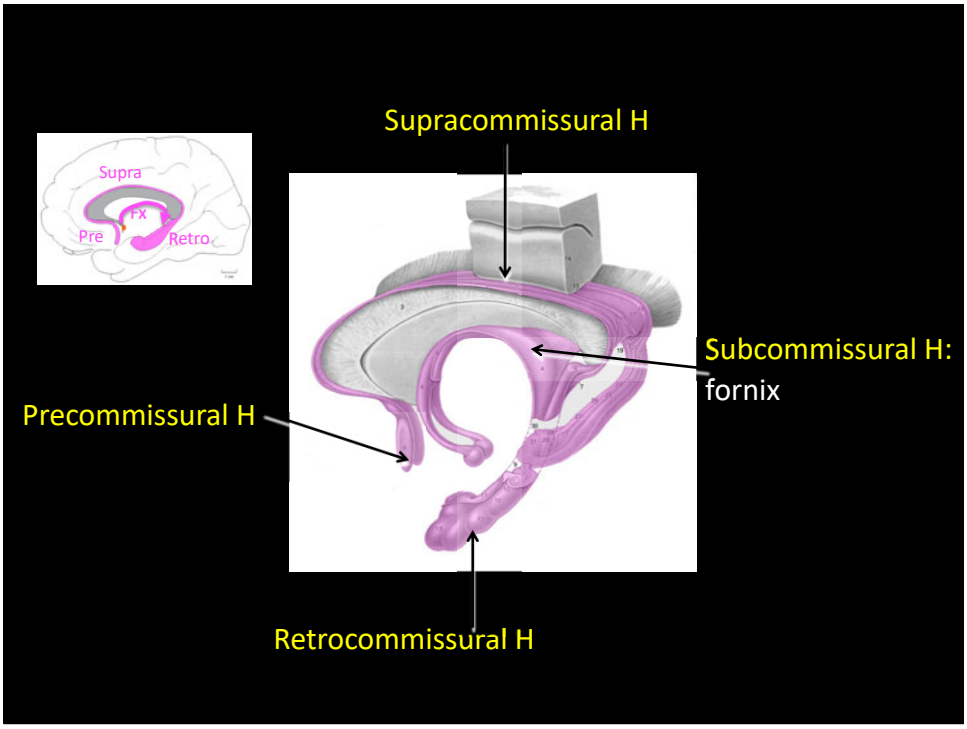


In : CA1

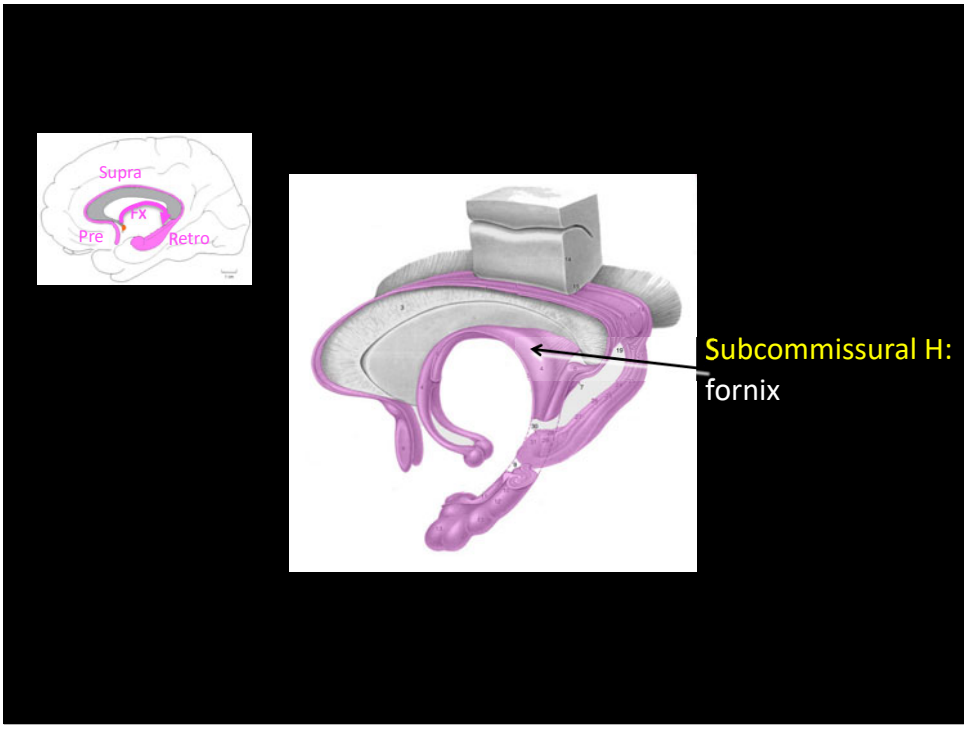
Out :
- EC
- septum n.
- accumbens n.
- ant thalamus
- hypothalamus
- mamillar body



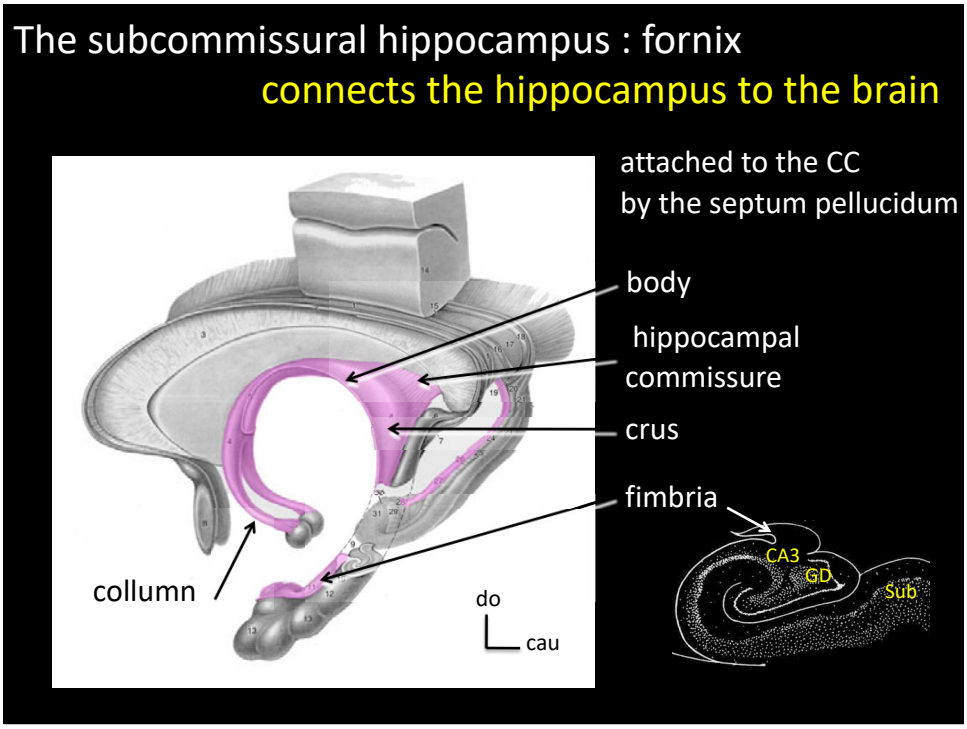
67



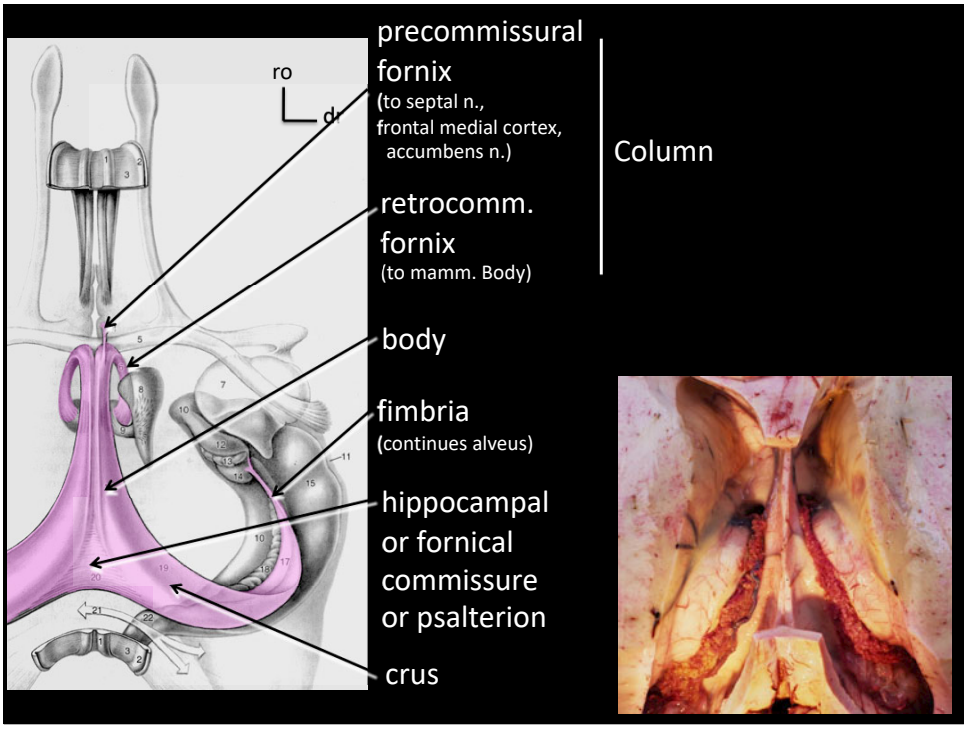
68


Supra
Fx
Pre
Retro
Subcommissural H:
fornix

69


The subcommissural hippocampus : fornix
connects the hippocampus to the brain
attached to the CC
by the septum pellucidum
body
hippocampal
commissure
crus
fimbria
collumn
do
cau
CA3
GD
Sub

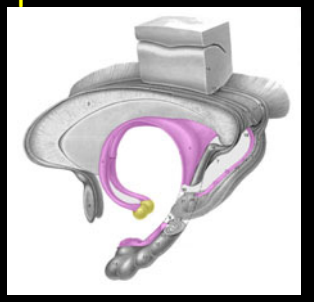
70

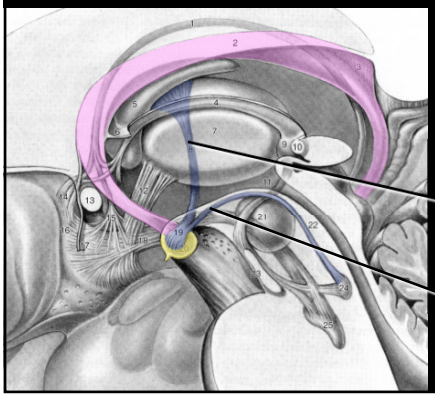


71

The subcommissural hippocampus : fornix connects the hippocampus to the brain

Ends rostrally mainly on the mamillar body (hypothalamus)…

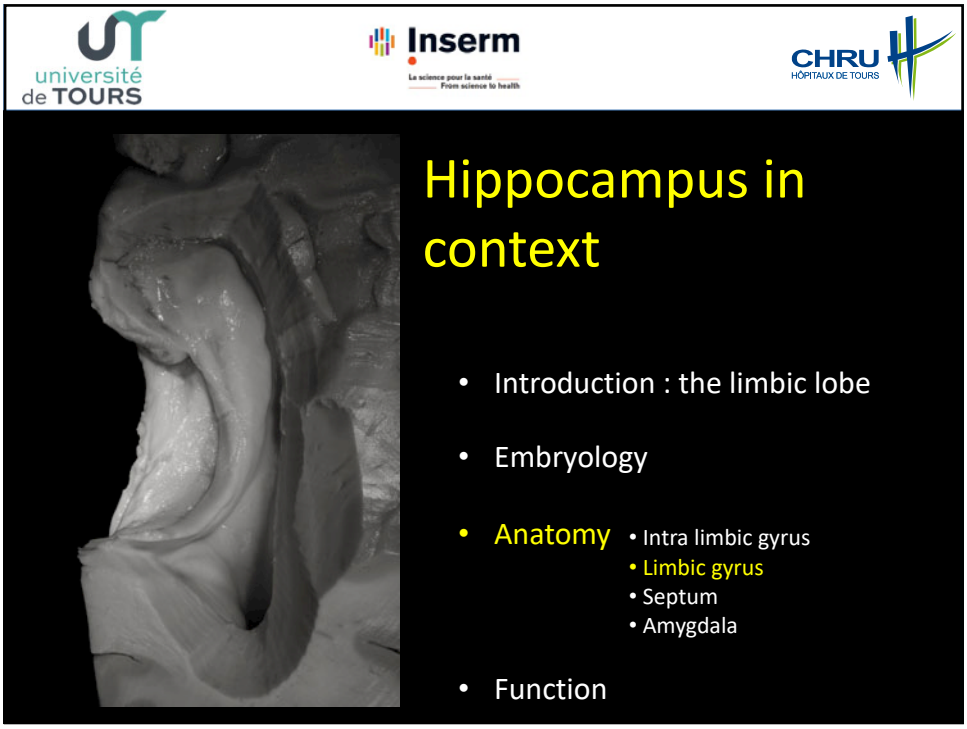




… which projects via the principal mammillary fasciculus onto :

- ant. thalamic n. (mammillo-thalamic tract)
- mesencephalon (mammillo-tegmental tract)

72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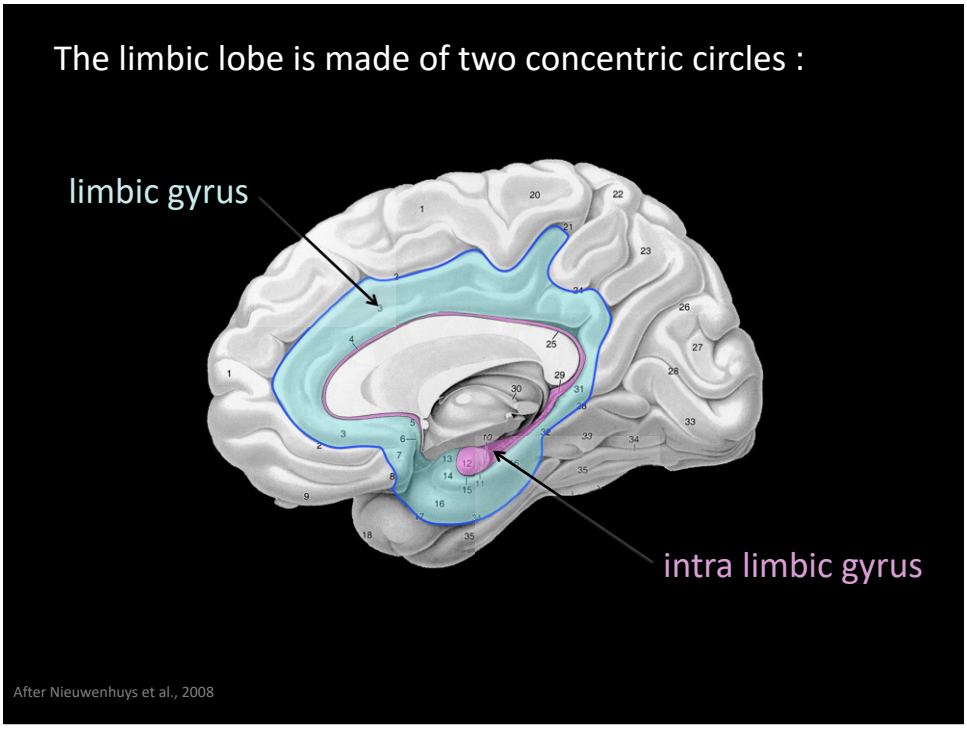
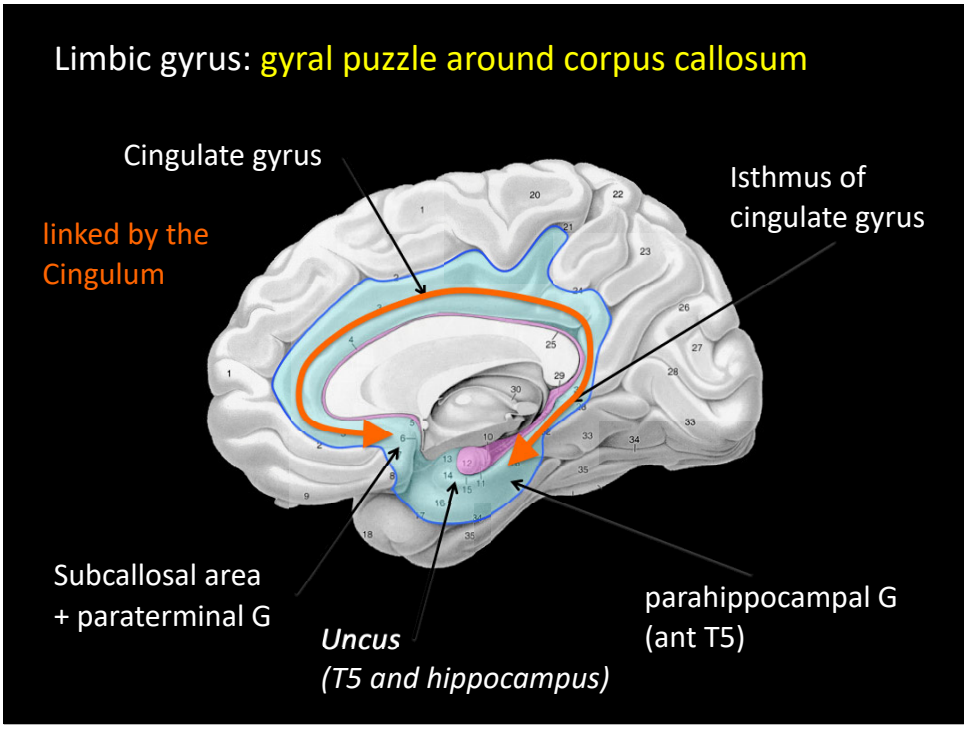
Hippocampus in context
• Introduction : the limbic lobe
• Embryology
• Anatomy
• Intra limbic gyrus
• Limbic gyrus
• Septum
• Amygdala
• Function

73


The limbic lobe is made of two concentric circles :
limbic gyrus
intra limbic gyrus
After Nieuwenhuys et al., 2008

74

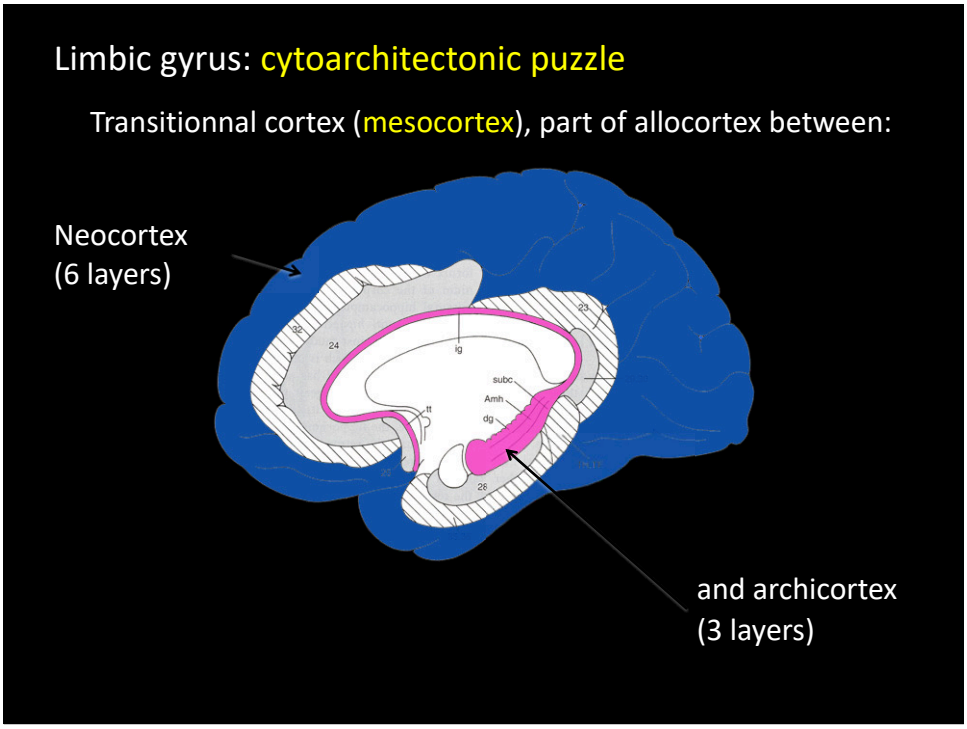
Limbic gyrus: gyral puzzle around corpus callosum



75

Limbic gyrus: cytoarchitectonic puzzle

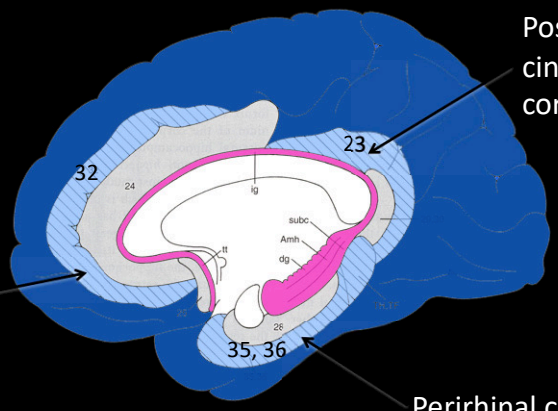
Transitionnal cortex (mesocortex), part of allocortex between:



76

Limbic gyrus: cytoarchitectonic puzzle

Transitionnal cortex (mesocortex), contains :

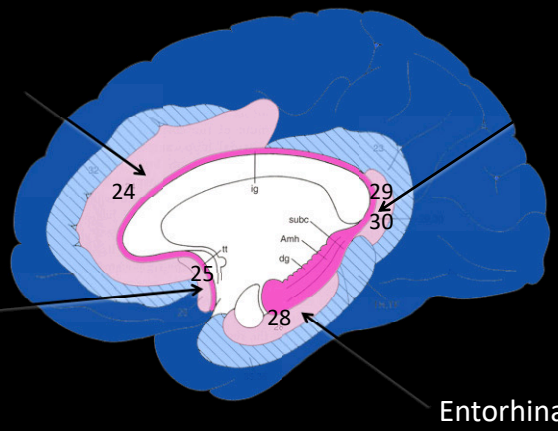


Proneocortex
(close to neocortex ; 6 layers)

77

Limbic gyrus: cytoarchitectonic puzzle

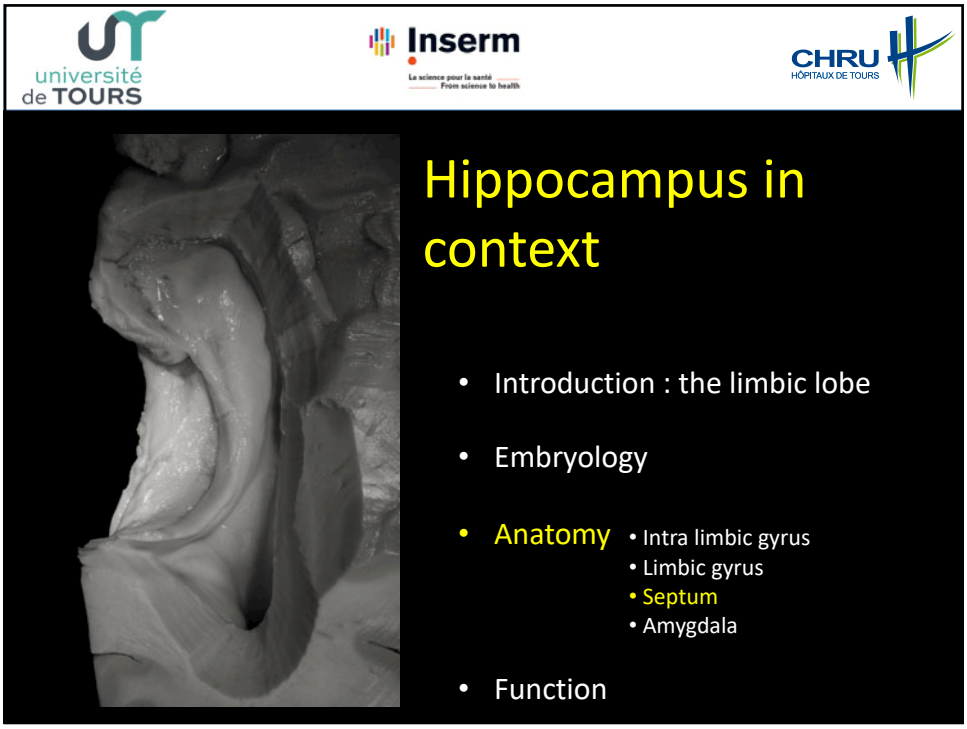
Transitionnal cortex (mesocortex), contains :



Periarchicortex
(5 layers)

+ Subicular complex
(Subiculum + presubiculum + parasubiculum)

78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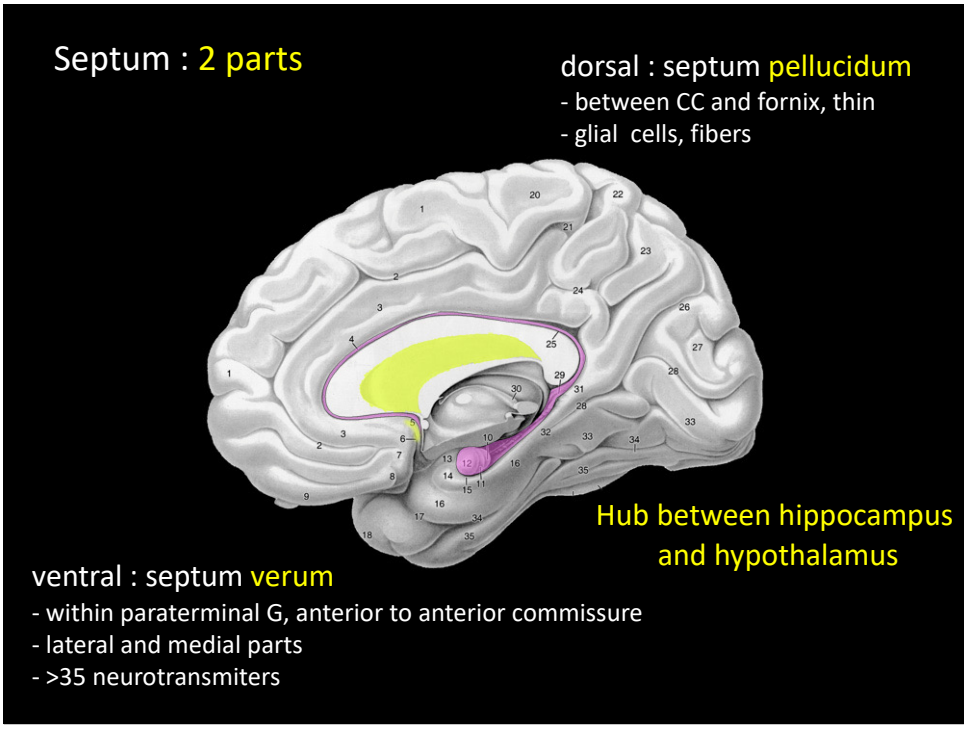
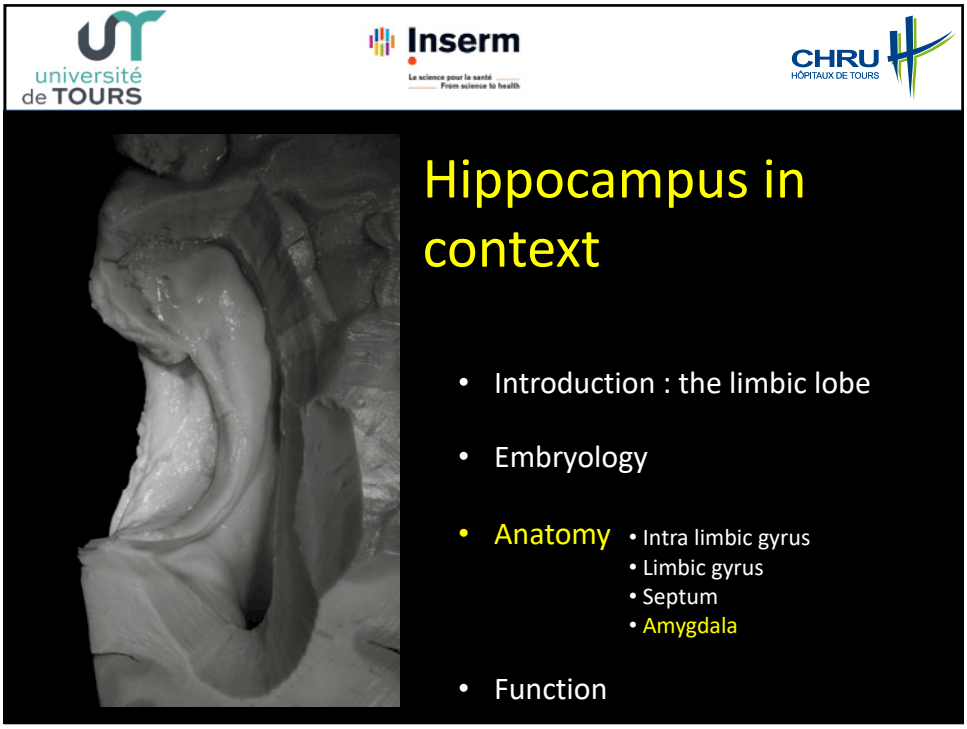
79


Septum : 2 parts
dorsal : septum pellucidum
- between CC and fornix, thin
- glial cells, fibers
Hub between hippocampus and hypothalamus
ventral : septum verum
- within paraterminal G, anterior to anterior commissure
- lateral and medial parts
- >35 neurotransmiters

80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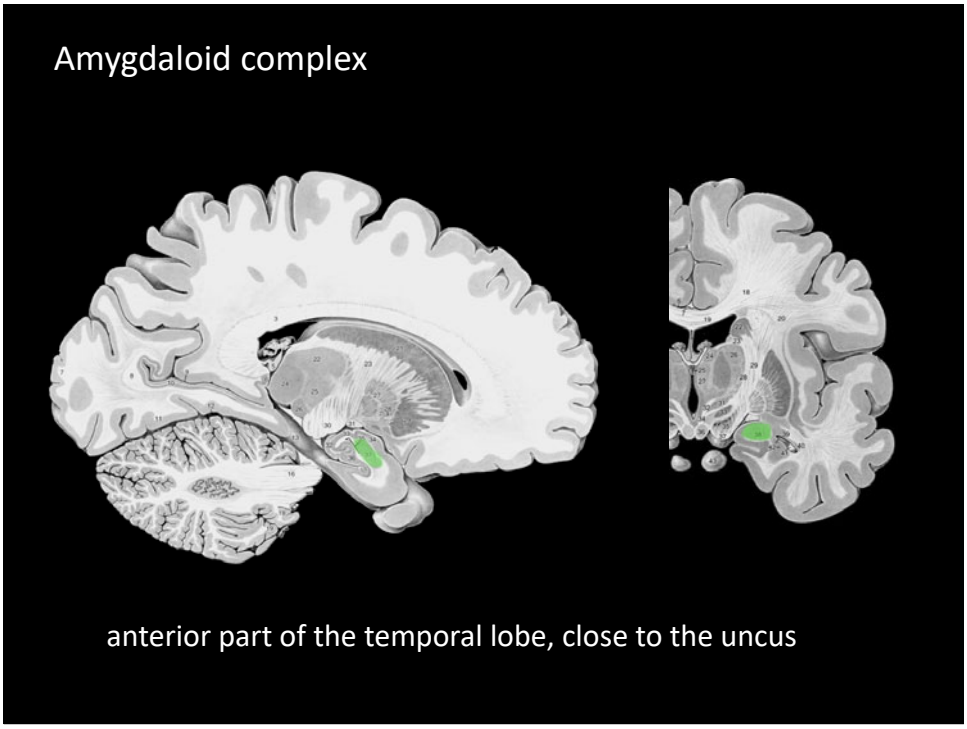
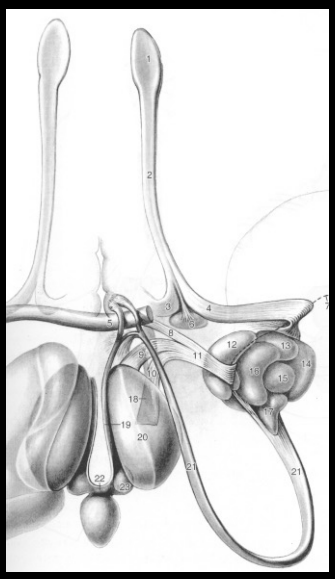
81


Amygdaloid complex
anterior part of the temporal lobe, close to the uncus

82

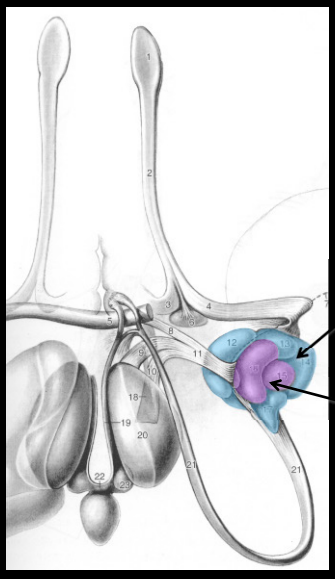
Amygdaloid complex : multiple nuclei



Basal
Accessory Basal
Lateral
Cortical
Medial
Central

83

Amygdaloid complex : multiple nuclei forming 2 groups



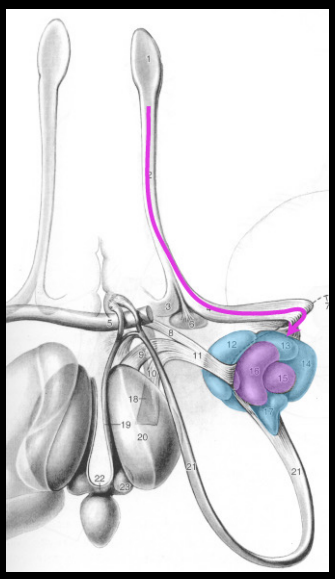
Baso-lateral
- Basal
- Accessory basal
- Lateral
- Cortical

Cortico-Medial
- Medial
- Central

N. of stria terminalis
Part of the substantia innominata
are associated to the cortico-medial group
(Extended amygdala)

84

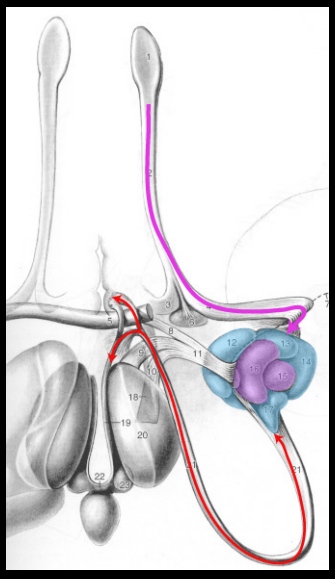
Amygdaloid complex : connected by 3 white matter tracts



Lateral olfactory stria
from olfactory system

85

Amygdaloid complex : connected by 3 white matter tracts



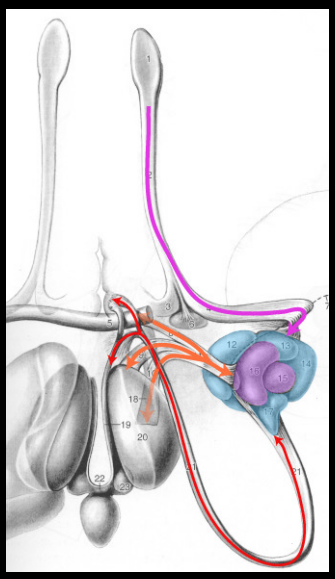
Lateral olfactory stria

Stria terminalis
(= dorsal amygdalofugal pathway)

- septal nuclei
- hypothalamus

86

Amygdaloid complex : connected by 3 white matter tracts



Lateral olfactory stria

Ventral amygdalofugal pathway
from and towards :
- fronto-medial cortex,
- hypothalamus,
- mediodorsal thalamic n.

Stria terminalis

87

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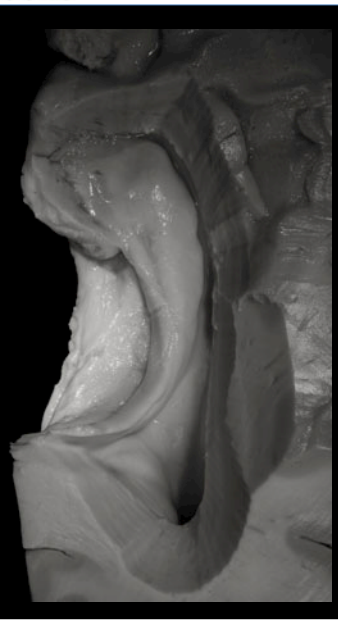
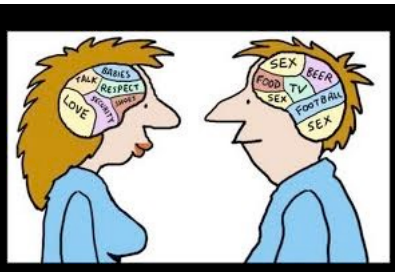


Hippocampus in context

- Introduction : the limbic lobe
- Embryology
- Anatomy
- Function
  - Intrinsic connections
  - Input / output

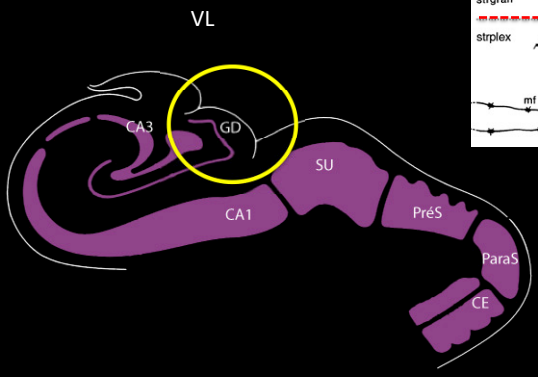
88

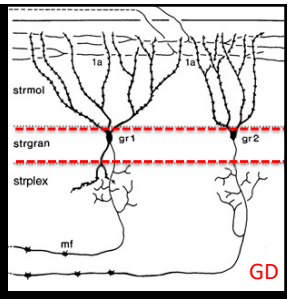


- Limbic structures participate to various behaviours
- No « center » for memory, emotions, agressiveness, sexual behaviour…
- Involve multiple structures
- Behaviour influenced by a large network including these structures, via their visceral and somatic projections

89

Hippocampus : intrinsic connections

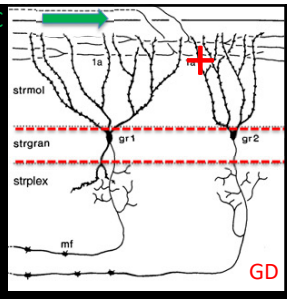


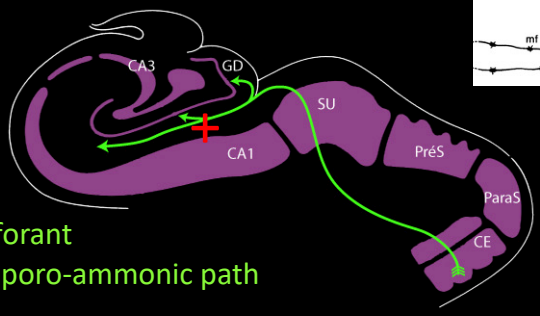


The dentate gyrus is the main entry point of hippocampal circuitry

90

Hippocampus : intrinsic connections



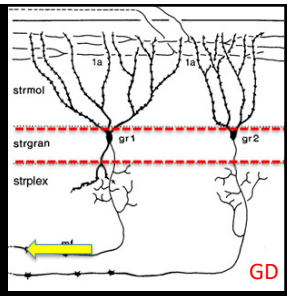


perforant
temporo-ammonic path

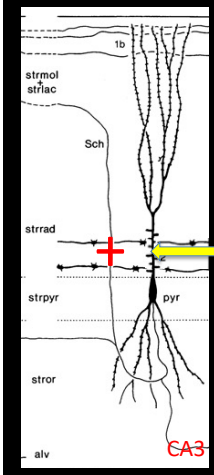
The dentate gyrus is the main entry point of hippocampal circuitry
Gets excitatory input from entorhinal cortex (perforant path)

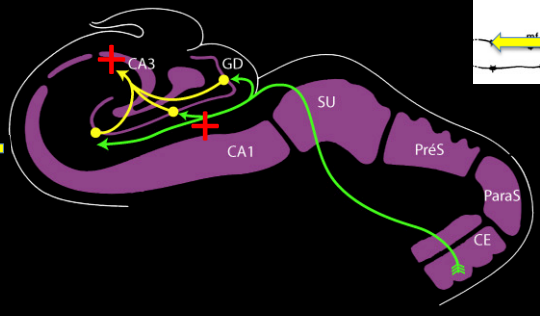
91

Hippocampus : intrinsic connections



mossy fibers

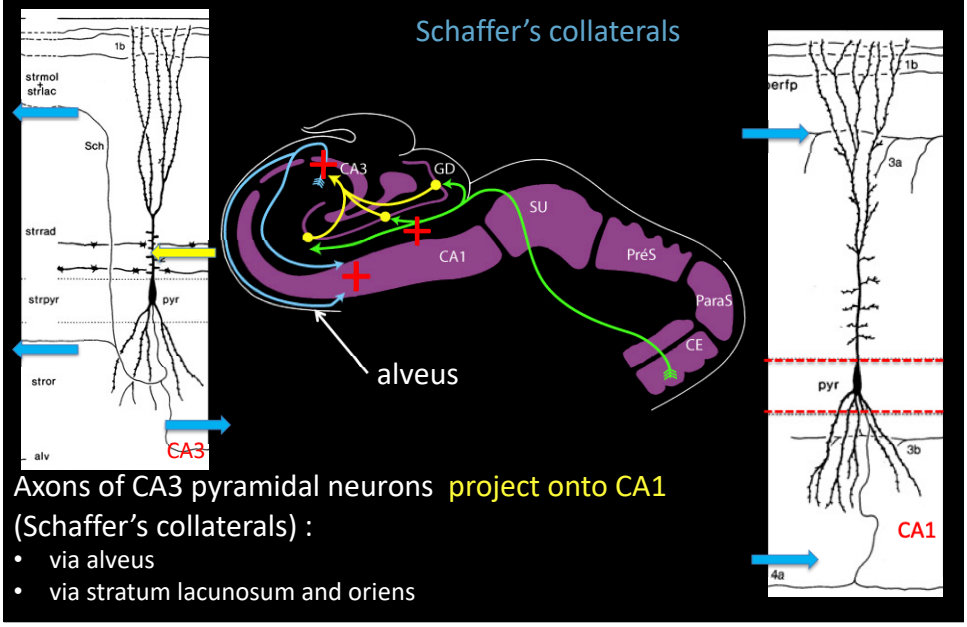




The dentate gyrus is the main entry point of hippocampal circuitry
It projects onto the stratum lucidum of CA3 (mossy fibers)

92

Hippocampus : intrinsic connections

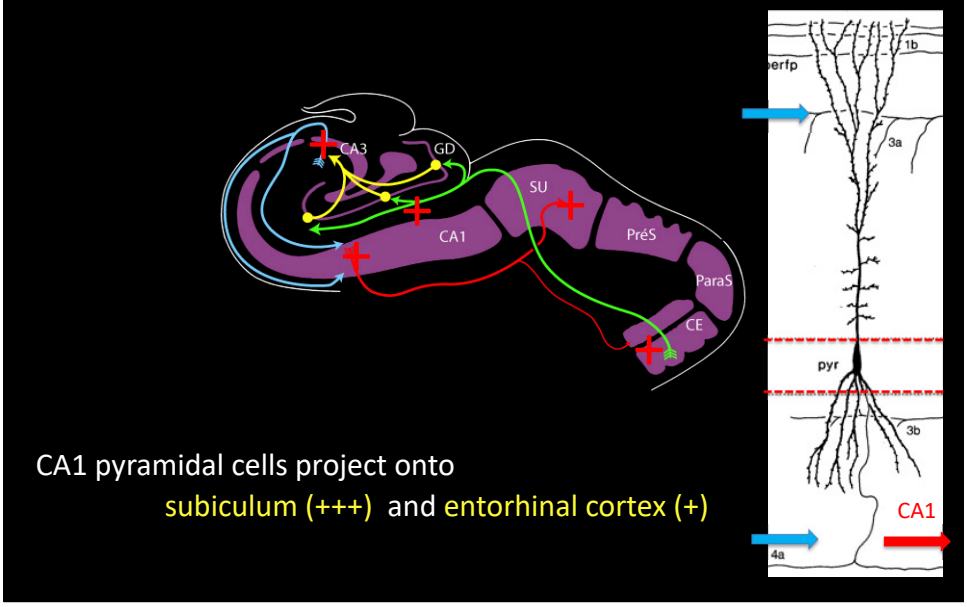


Axons of CA3 pyramidal neurons project onto CA1 (Schaffer's collaterals) :

- via alveus
- via stratum lacunosum and oriens

93

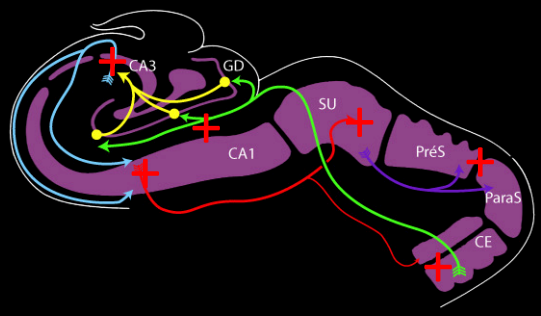
Hippocampus : intrinsic connections



CA1 pyramidal cells project onto subiculum (+++) and entorhinal cortex (+)

94

Hippocampus : intrinsic connections

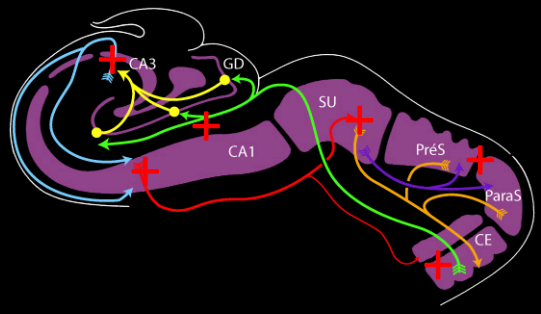


Subiculum pyramidal cells project onto
presubiculum and parasubiculum

95

Hippocampus : intrinsic connections

Excitatory entorhino-hippocampo-entorhinal circuit



Subiculum, presubiculum and parasubiculum
finally project onto entorhinal cortex

96

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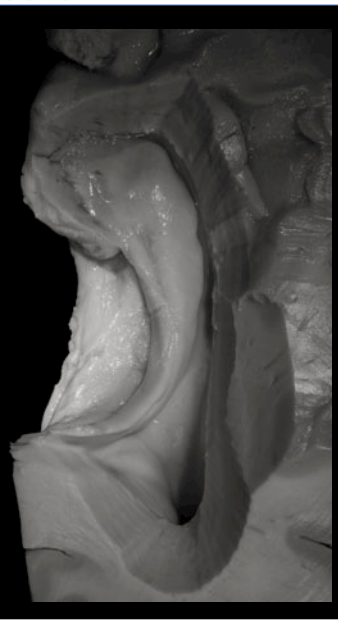

Hippocampus in context

- Introduction : the limbic lobe
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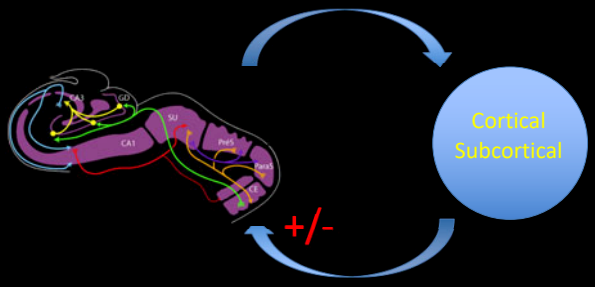
- Function
  - Intrinsic connections
  - Input / output

97

Hippocampus : input/output

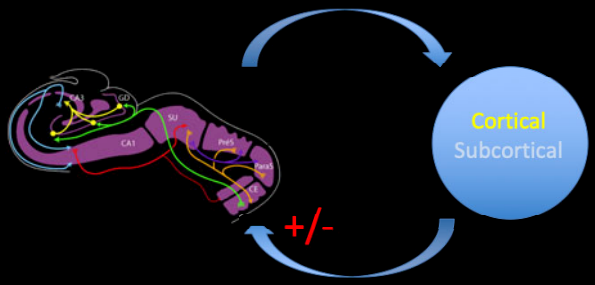
- Modulate the activity of the intrinsic circuits



- Mainly reciprocal connections
- Via :
  - fornix
  - cingulum
  - direct projections towards temporal lobe
- Input/Output : cortical and subcortical

98

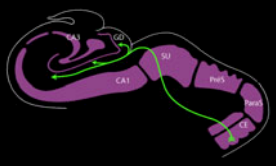
Hippocampus : Cortical input/output

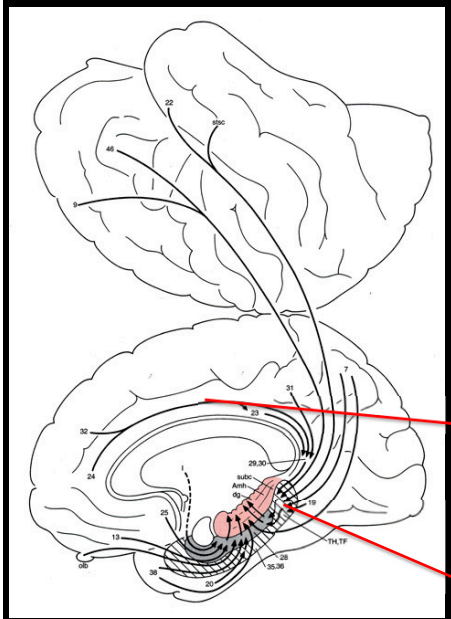


99

Hippocampus : cortical input

- Neocortex projects to :
  - entorhinal cortex (entry of hippocampal circuit)
  - or subiculum

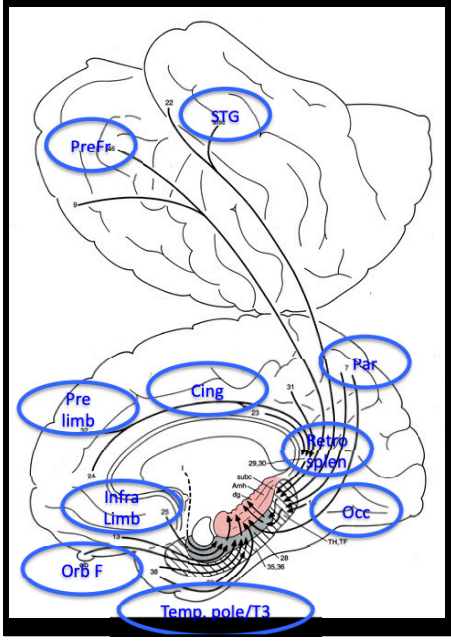




- Direct or via other parts of the medial temporal lobe (preprocessing)
- Major role of the cingulum (from medial aspect of the hemisphere to T5)
- Mainly to posterior hippocampus

100

Hippocampus : cortical input



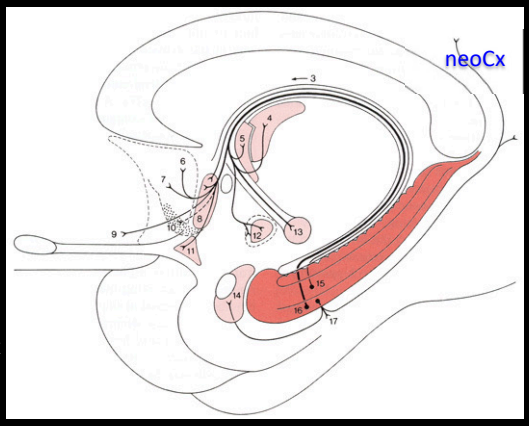
- unimodal areas
  (visual, auditory, olfactory)
- mainly multimodal association areas
  (get input from unimodal areas)
- Preprocessed Information
  - by association areas
  - by entorhinal cortex / T5

Hippocampal convergence of mainly preprocessed sensitive and sensorial information :
- from various modalities
- from various complexity

101

Hippocampus : cortical output

- extrafornical (+++)
  - via subiculum, EC, T5 post
  - to unimodal areas
  - and multimodal association areas
- fornical (+)
  - from subiculum
  - to gyrus rectus / frontal medial cx (precommissural fibers)



Permanent neocortico-hippocampo-neocortical dialog involved in souvenirs formation

102

Hippocampus : elaboration of new souvenirs « stored » elsewhere

Henry Gustav Molaison, HM
(1926 – 2008)

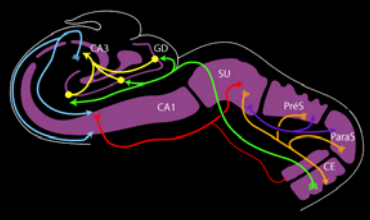
- Bilateral temporal medial epilepsy
- 1953 : bilateral hippocampal resection (W. Scoville)
- Unable to form new souvenirs whereas long term memory and working memory were preserved

Medial temporal lobe is involved in elaboration of new souvenirs, the storage being performed elsewhere

103

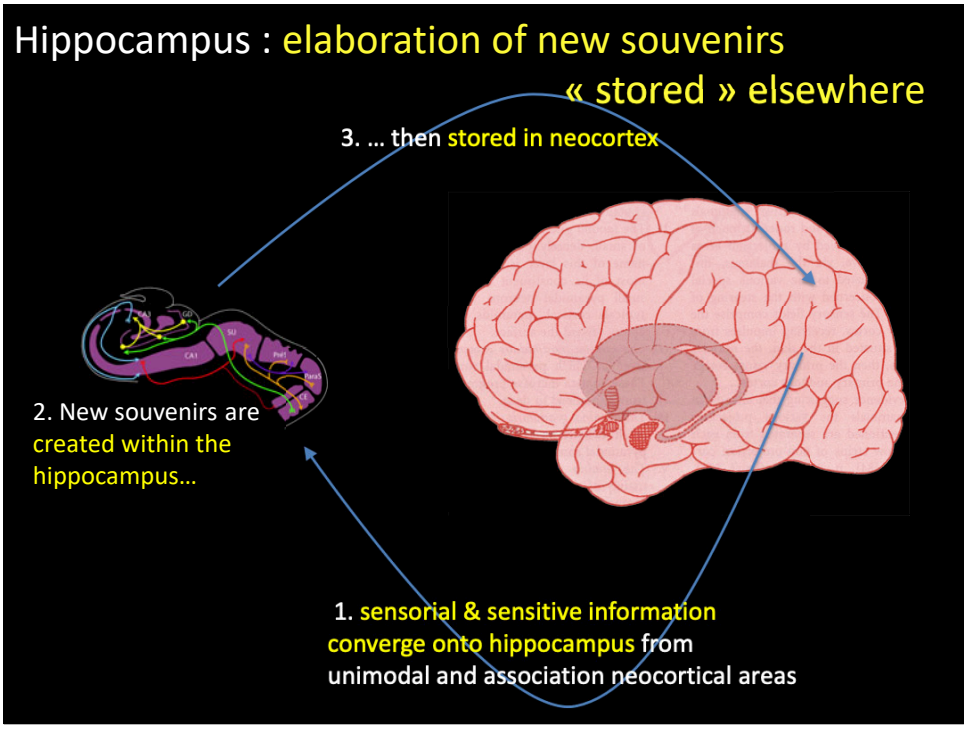
Hippocampus : elaboration of new souvenirs « stored » elsewhere

Alzheimer's desease

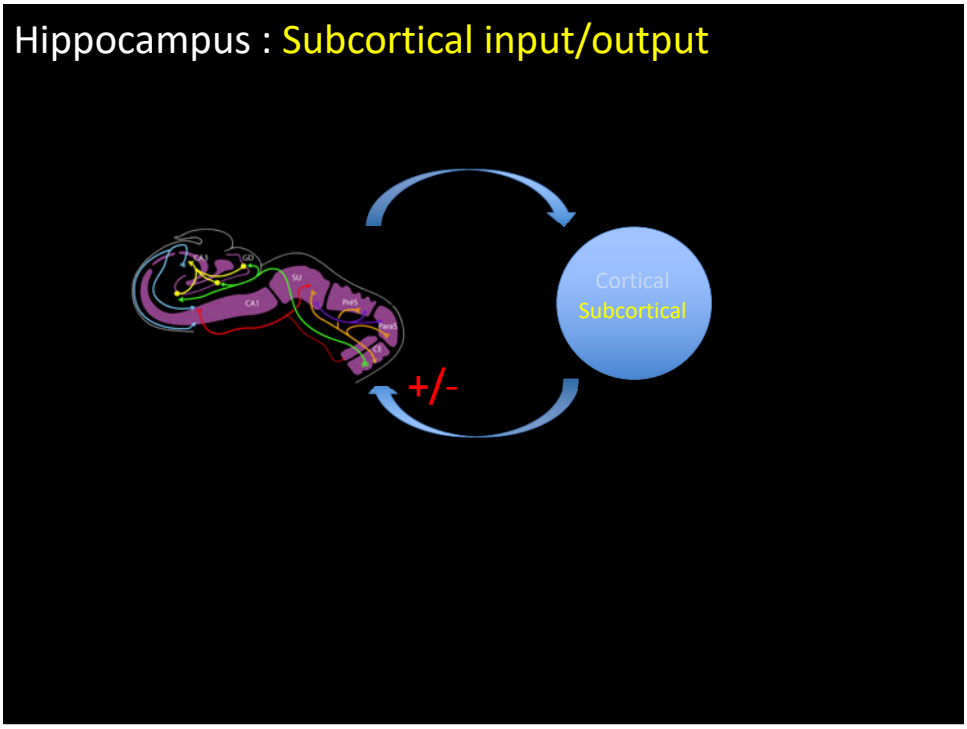


- major rarefaction of cholinergic pyramidal cells in CA1 & subiculum ; induces a disorganisation :
  - of intrinsic circuit
  - of fornical projections to subcortical targets
- alteration of entorhinal cortex and dentate gyrus (perforant path)

104


Hippocampus : elaboration of new souvenirs « stored » elsewhere
3. … then stored in neocortex
2. New souvenirs are created within the hippocampus…
1. sensorial & sensitive information converge onto hippocampus from unimodal and association neocortical areas

105

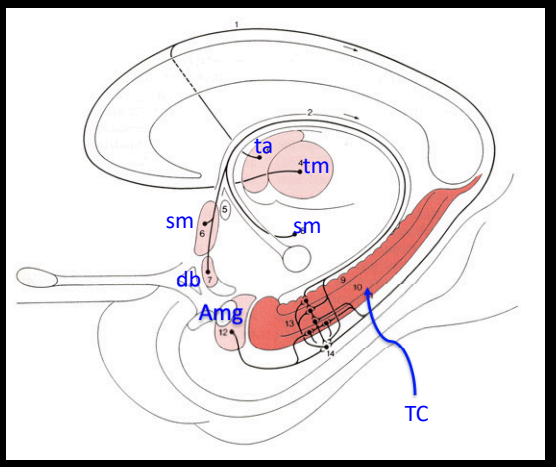

Hippocampus : Subcortical input/output
Cortical
Subcortical
+/-

106

Hippocampe : subcortical input

Mainly towards anterior hippocampus

- Brainstem monoaminergic system : 5HT, NA, DA
- supramammilar area
- thalamus
  - anterior (Papez),
  - median (n reuniens, visceral input)
  - via cingulum
- septal nuclei
  - mainly cholinergic, GABA, SP
  - via fornix (+++) or cingulum (+)
  - via EC or direct
- amygdala, baso-lateral group (conscient process), via EC

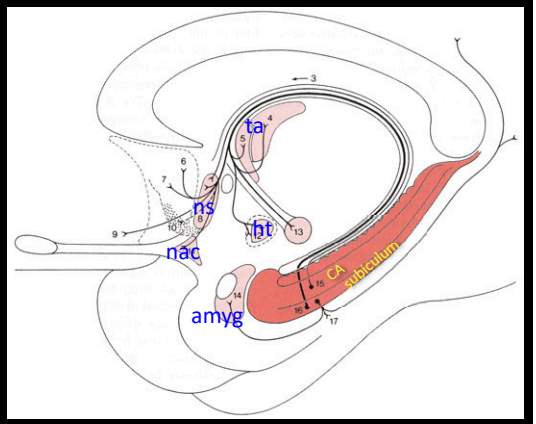


107

Hippocampe : subcortical output

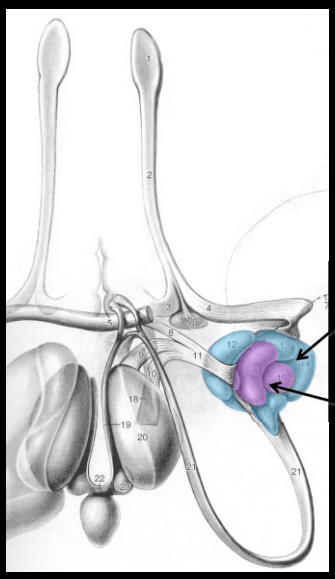
Mainly from subiculum (+CA1-2-3)

- Fornical
  - precommissural
    - septal n.
    - accumbens n.
    - caudate-putamen
  - retrocommissural
    - hypothalamus (mammillary body +++)
    - thalamus (anterior n.)
    - n of bed of stria terminalis
- Extra Fornical : towards amygdala, basal N. (conscient process)



108

Hippocampe : interaction with amygdala



Thalamus, Association Cortex → Conscient processes

Baso-lateral
- Basal
- Basal accessoire
- Lateral
- Cortical

Cortico-Medial
- Medial
- Central

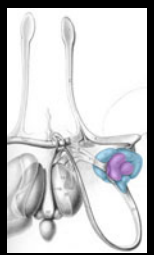
olfactory bulb, hypothalamus, septum brainstem n. → Vegetative processes

109

Electrical stimulation of the amygdaloid complex: induces comportemental changes

cortico-medial group →

Vegetative reaction
- salivation, chewing
- urination, defecation



baso-lateral group →

Somatic reactions
- excitation, arousal, environnement screening
- fear,
- déjà vu, dreamy state

110

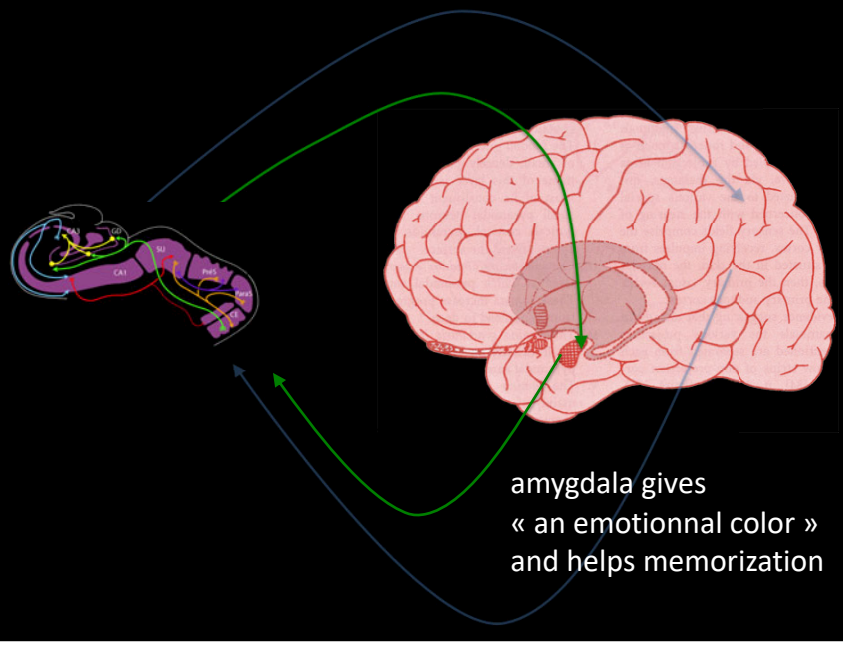
Hippocampe : interaction with amygdala

Amygdala:

- behaviour related to emotion :
  - somatic responses : fight, flight or freeze
  - visceral responses : blood pressure, cardiac rate, cortisol…
- association of such a response to depleasant / pleasant valence of stimuli
  - loss of conditionned fear reaction in case of bilateral lesion of amygdala
  - facilitates encoding of stimuli with a high emotional meaning
- social interactions

111

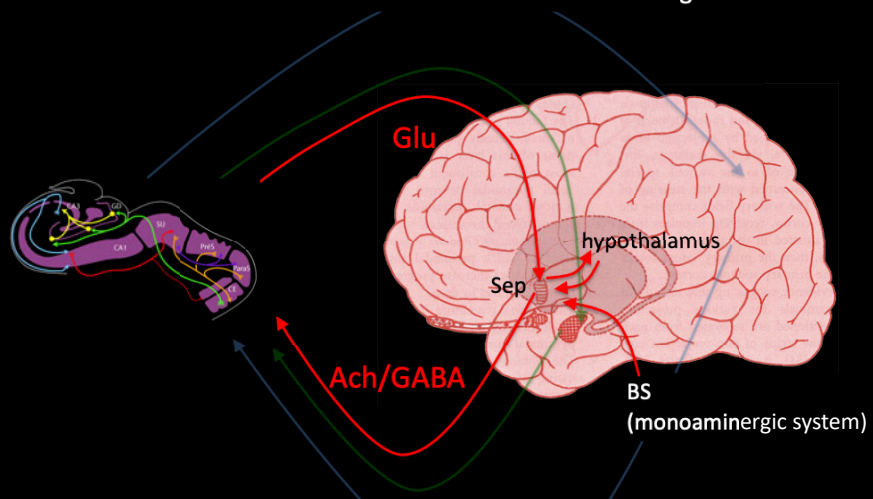
Hippocampe : interaction with amygdala



116

Hippocampe : interaction with septal nuclei

interconnected to structures involved in survival behaviour and vegetative control

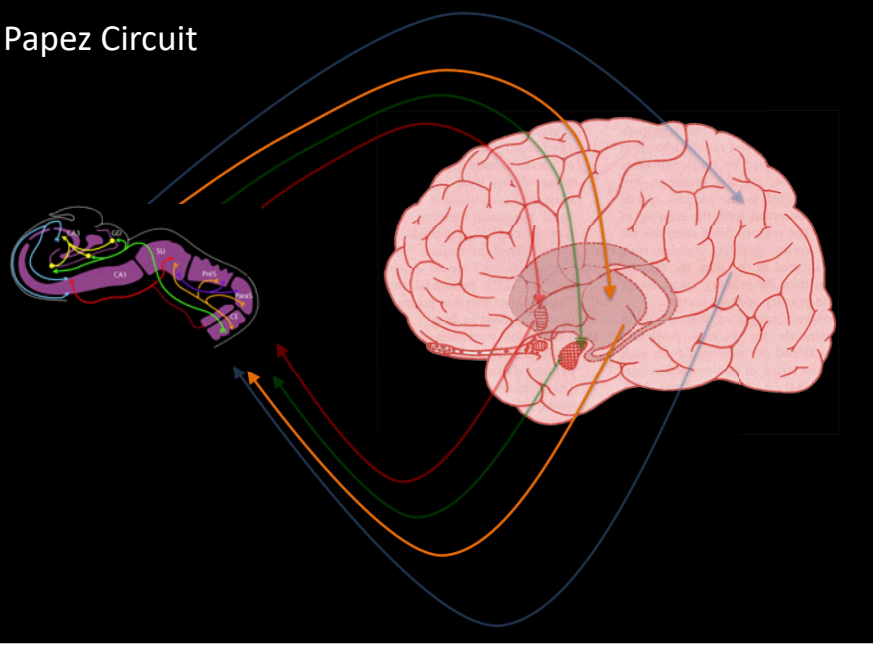


Creation of souvenirs is influenced by current behaviour
Hippocampus influences main behaviour (survival, ingestion, reproduction, reaction to stress)

117

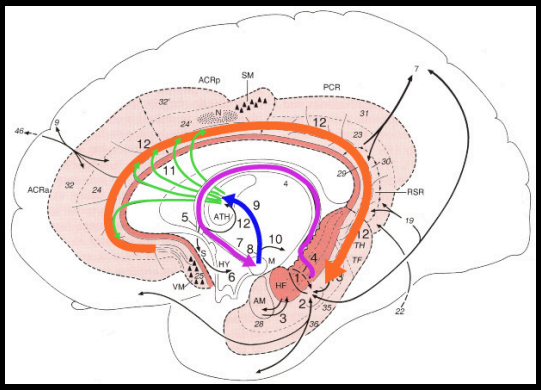
Hippocampe : interaction with thalamus

Papez Circuit



118

Hippocampe : Papez circuit



1 : hippocampo-mammillairy (fornix)

2 : mammillo-thalamic (mammillo-thalamic tract)

3 : thalamo-cingulate

4 : cingulo-hippocampal (cingulum)

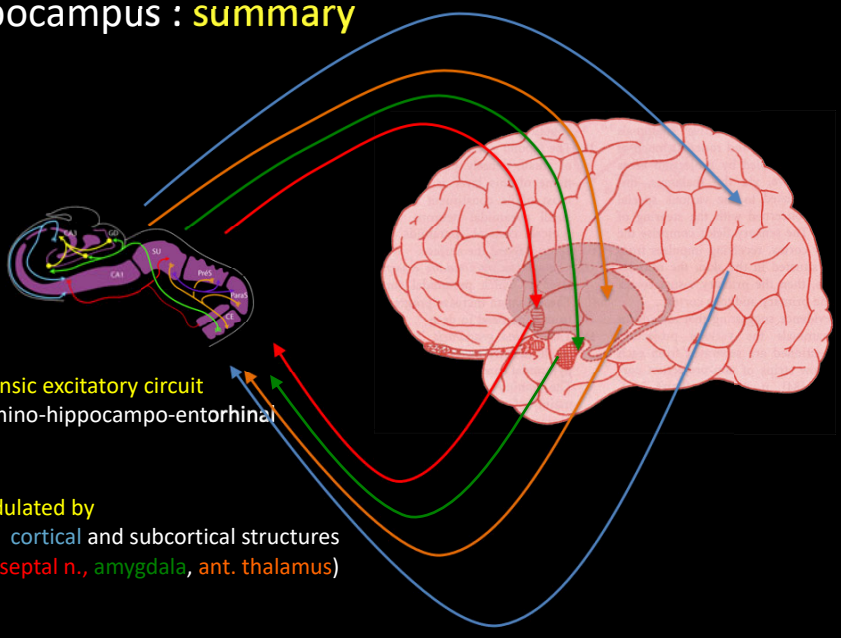
Papez : *« a proposed mecanism of emotions »*. Arch Neurol Psy, 1937

Rather involved in memory :

- Bilateral fornix lesion and amnesia… but inconstant
- Constant lesion of mammillary bodies during Korsakoff syndrome … but wider lesions (medio-dorsal thalamus)

119

Hippocampus : summary



1 – intrinsic excitatory circuit
entorhino-hippocampo-entorhinal

2 – modulated by
cortical and subcortical structures
(septal n., amygdala, ant. thalamus)

3 – reciprocal connections

120

Hippocampus : summary

- Hippocampus : not the only structure involved in memory

- Part of a wider circuit
  (hippocampus, medial thalamus, cingulate G, prefrontal cortex perirhinal cortex, septal n.)

- Lesion of a part of the network can induce memory impairment

121

References - morphology

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122