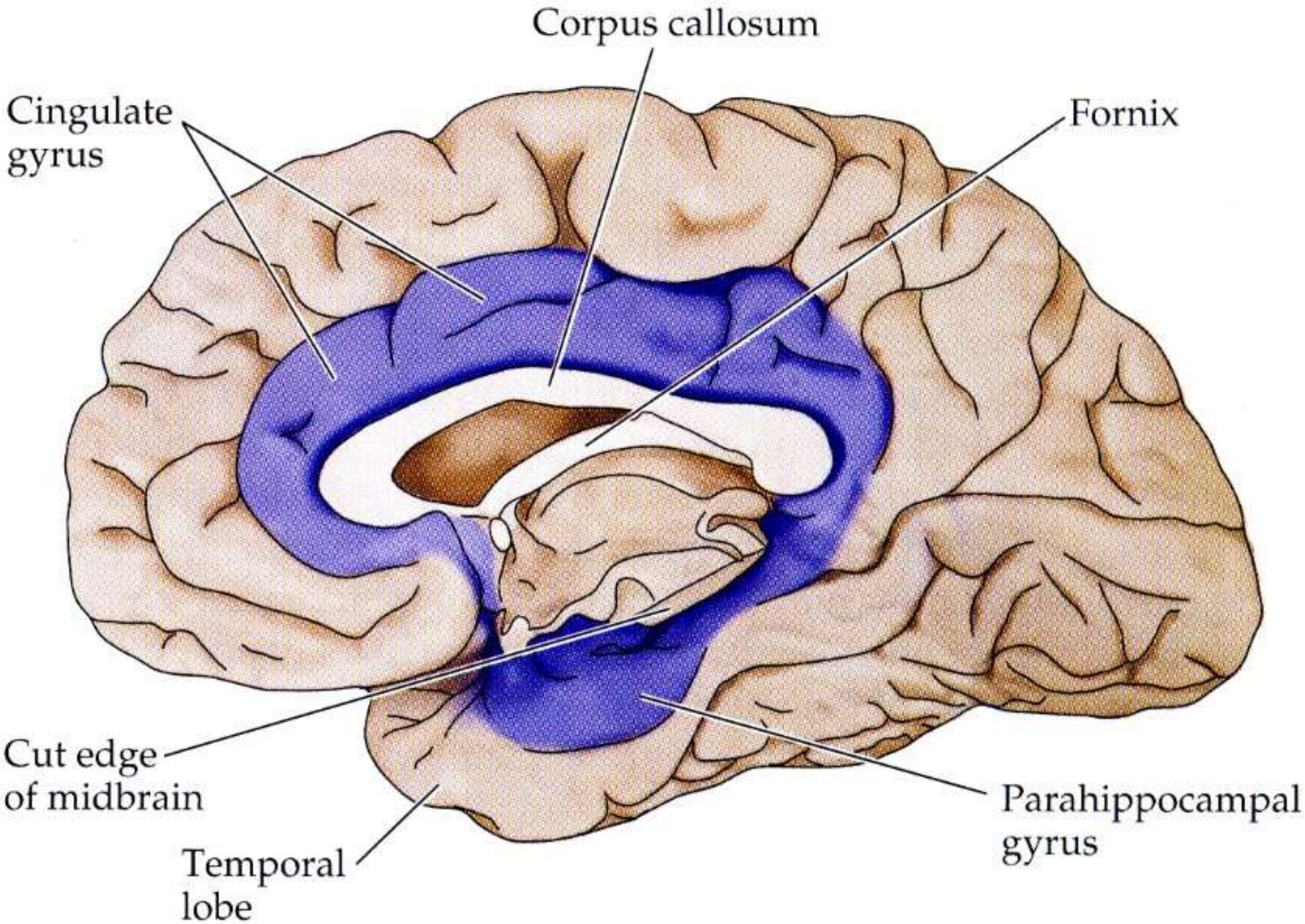
Limbic system
emotions + memory

Veronika Němcová

Classical limbic system

1) archicortex
2) periarchicortex
3) amygdala



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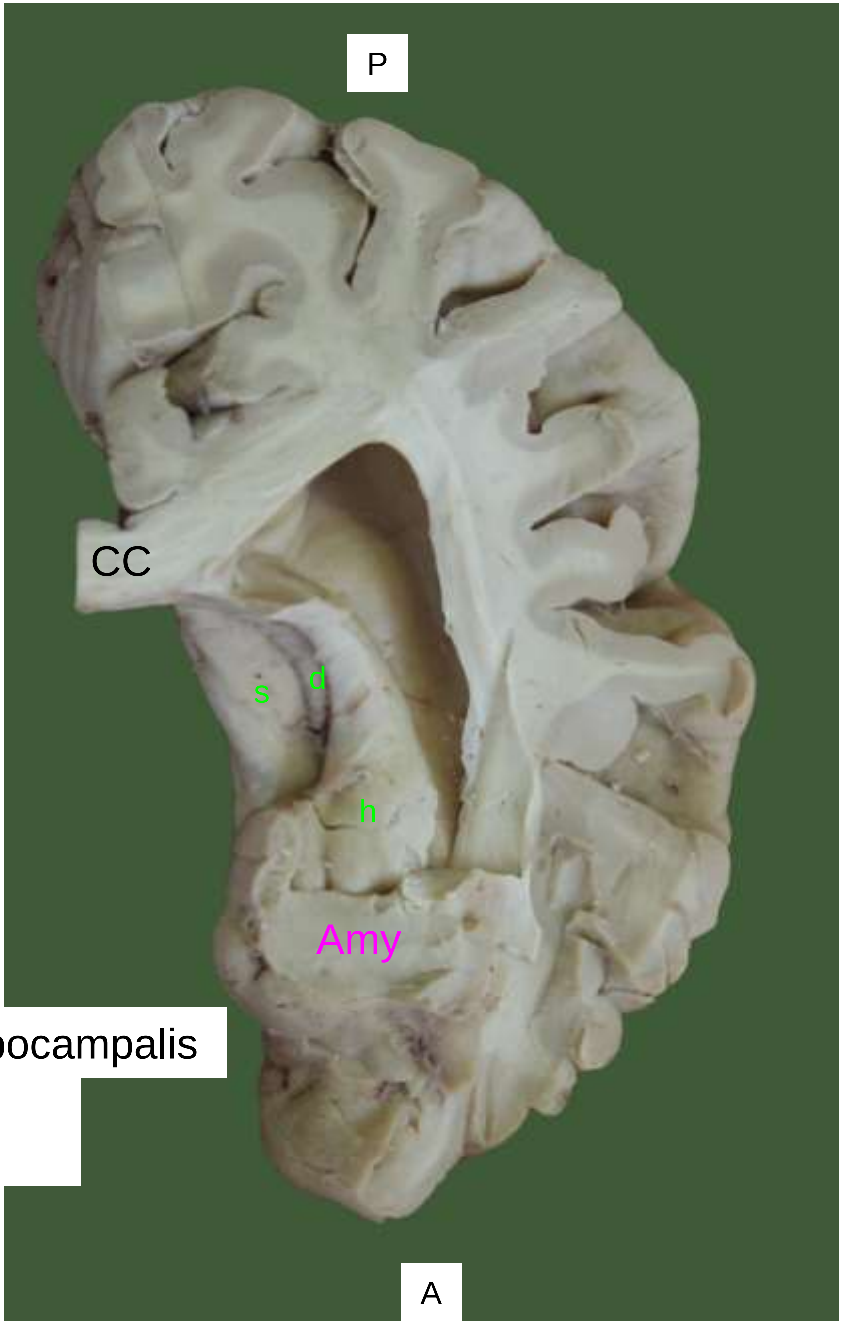
Limbic system - components

- **Archicortex**
- A) hippocampal formation (**g.dentatus, subiculum, cornu Ammonis)** = postcommissural hippocampus
- B) supracommissural hippocampus (indusium griseum, strie longitudinales)
- C) precommissural hippocampus (area subcallosa (BA 25)
- **Periarchicortex**
- A) **gyrus parahippocampalis BA 28 –entorhinal cortex**, presubiculum (BA 27), parasubiculum (BA 34) area perirhinalis (BA 35,36)
- B) **gyrus cinguli** (BA 23,24)
- **Amygdala** corticalis, medialis, centralis, basalis, lateralis

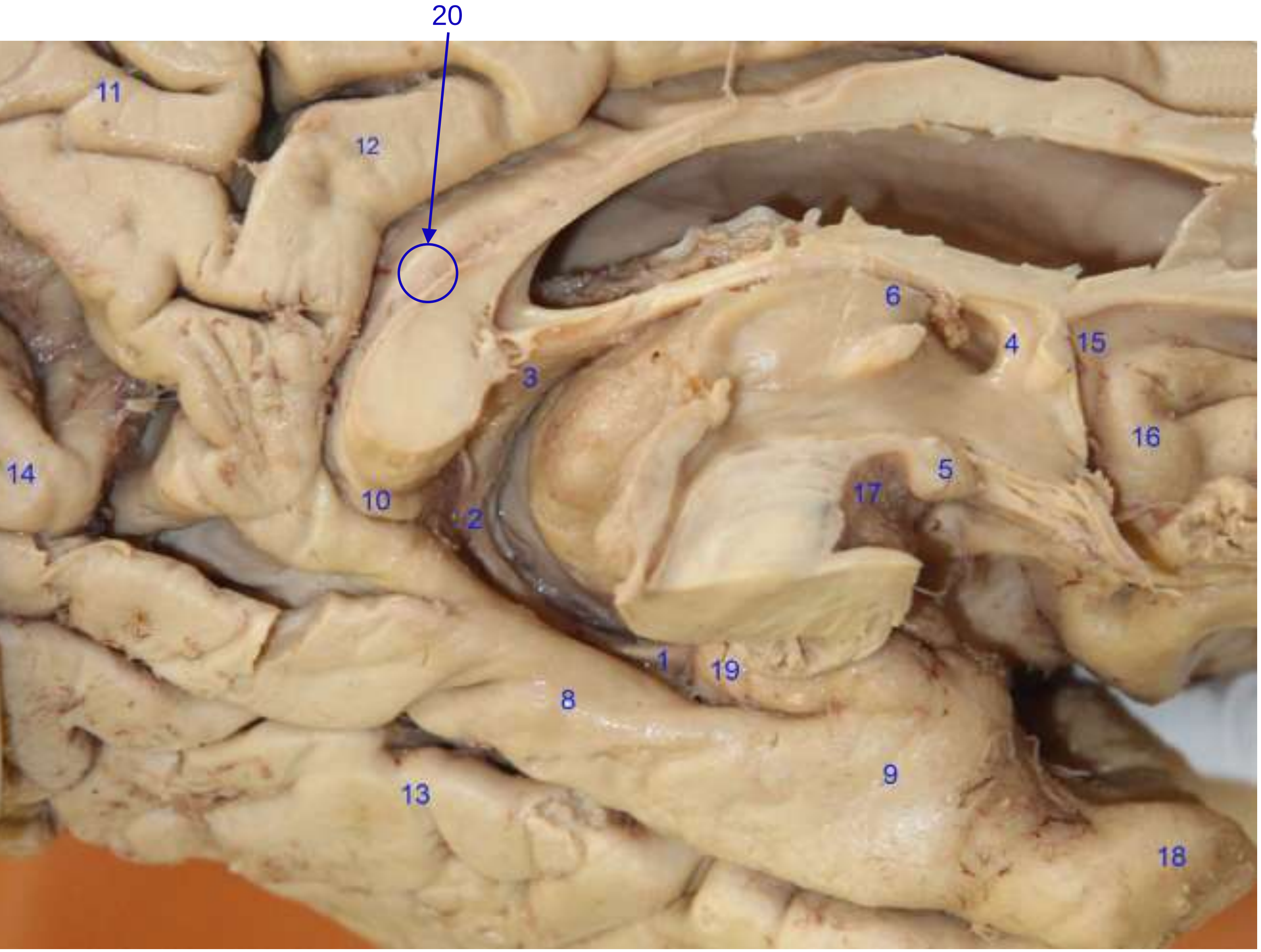
Hippokampal formation
= archicortex
= Cornu Ammonis +subiculum + g. dentatus

Inferior horn of lateral ventricle is open



s – subiculum – upper surface of g. parahippocampalis
h - hippocampus = Cornu Ammonis
d – gyrus dentatus

Amy – amygdala
CC- splenium corporis callosi

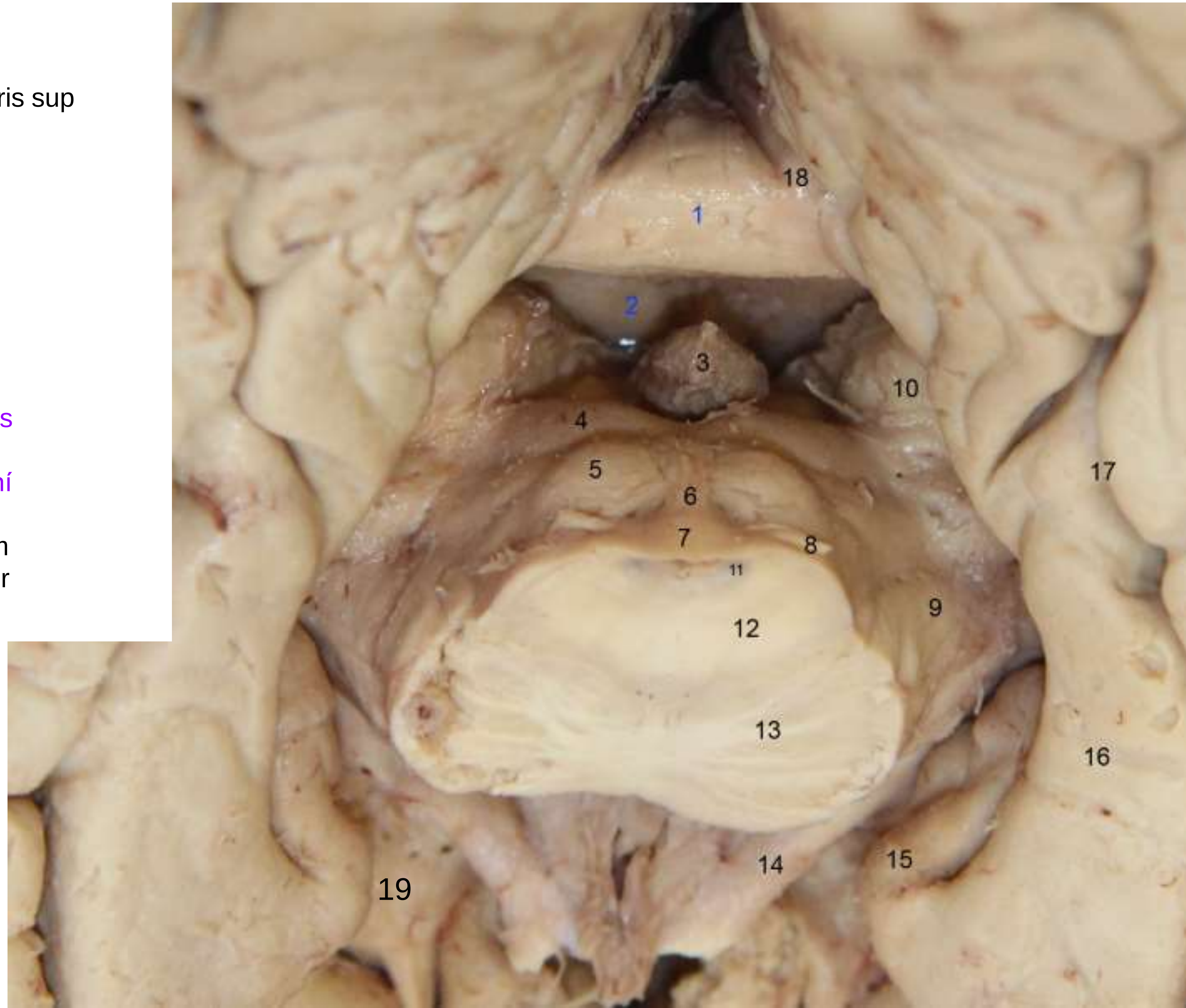


Limbic structures on the medial surface of hemisphere

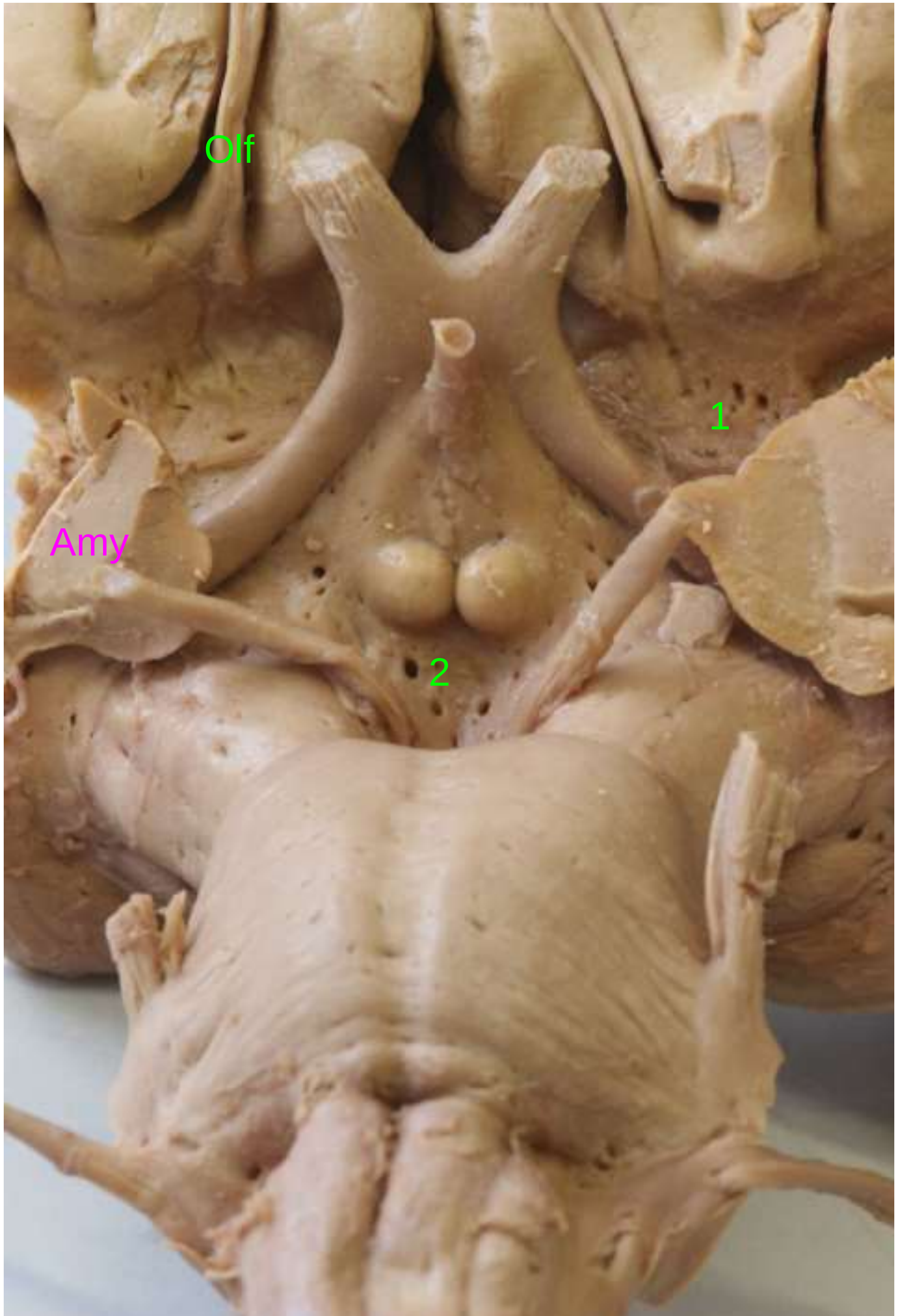
1-fimbria fornicis (hippocampi)
2-crus fornicis
3-commissura fornicis
4-columna fornicis
5-corpus mammillare
6-tuberculum anterius thalami
8-g. parahippocampalis
9-area 28
10- g. fasciolaris
11-precuneus
12-g.cinguli
13-g. occipitotemporalis lateralis
14-g. occipitotemporalis medialis
15-g. paraterminalis
16-g.subcallosus
18-polus temporalis
19-uncus (apex+ tenia Giacomini)
20-striae longitudinales + indusium griseum

Ventral aspect of limbic structures

1-corpus callosum
2- commissura fornicis
3-epiphysis
4-colliculus superior
5-colliculus inferior
6-frenulum veli medullaris sup
7-vellum medullare sup
8-IV.n
9-crura cerebri
10- pulvinar thalami
11- locus coeruleus
12- tegmentum pontis
13-pars basilaris pontis
14-tractus opticus
15-uncus
16-g. parahippocampalis
17-sulcus collateralis
18 –supracommissurální hippocampus
19- trigonum olfactorium = area perforata anterior

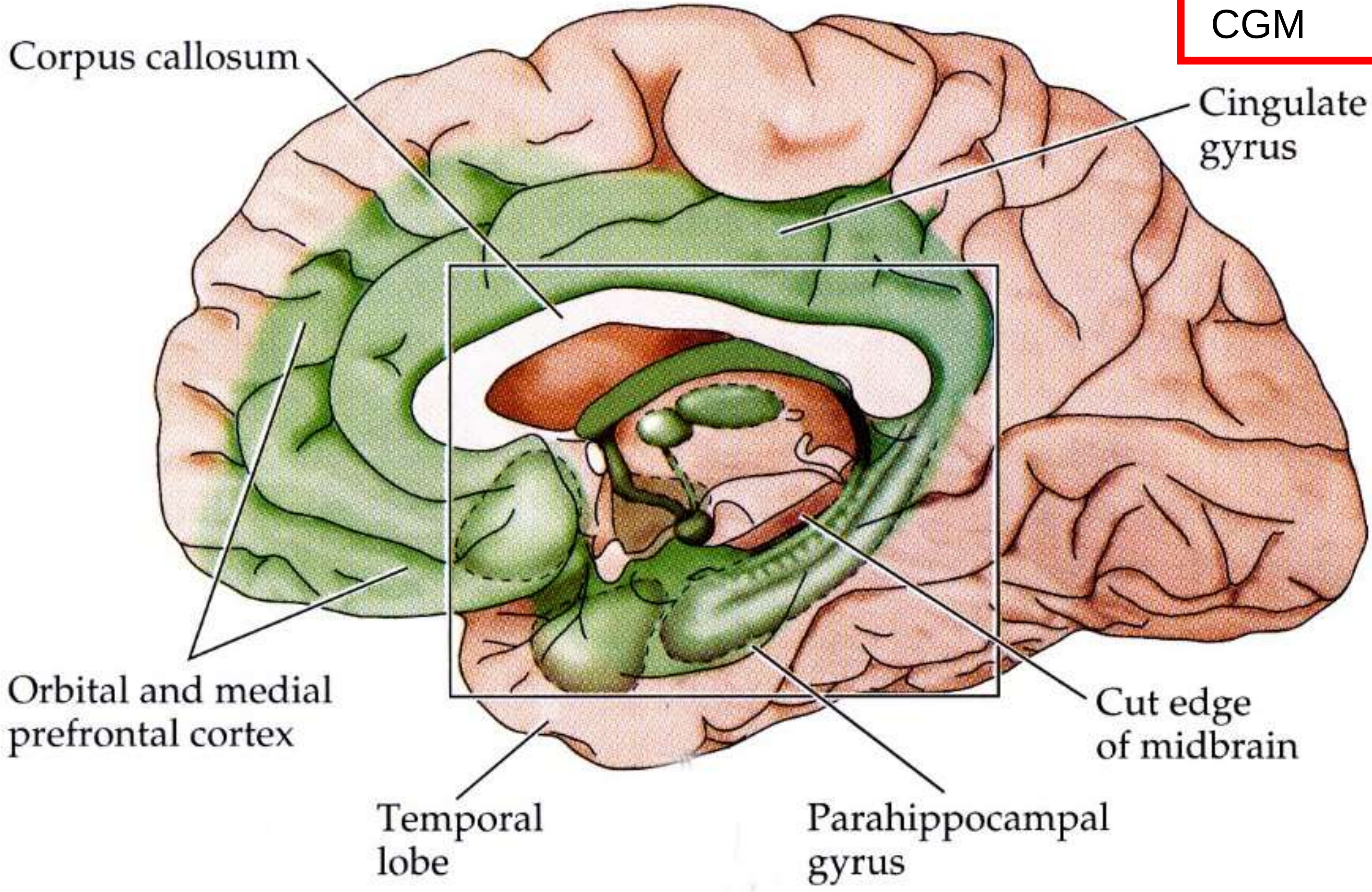


area perfotata anterior (1)
and area perforata posterior (2)



New aspect of limbic system

+ orbitofrontal cortex
mediofrontal cortex
insula
Striatum ventrale
Pallidum ventrale
Th (A.,MD)
Hypothalamus (CM)
CGM



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New aspect of limbic system

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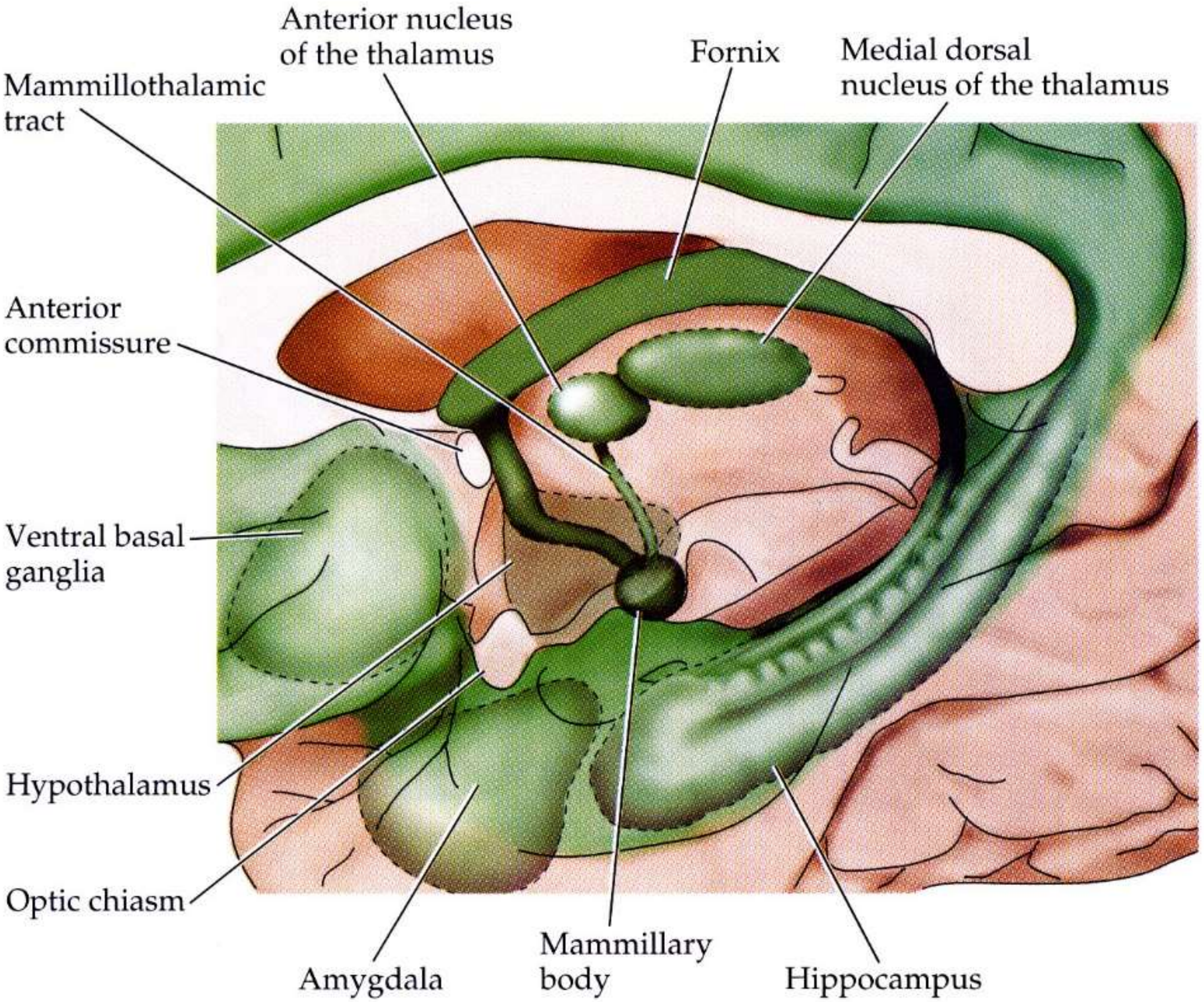

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Sensory inputs → Cortex

Limbic system

RF
Chem.
syst

Medial hypothalamus

Lateral hypothalamus

Reciprocal inhibition

CGM

VM and SM nerves nuclei

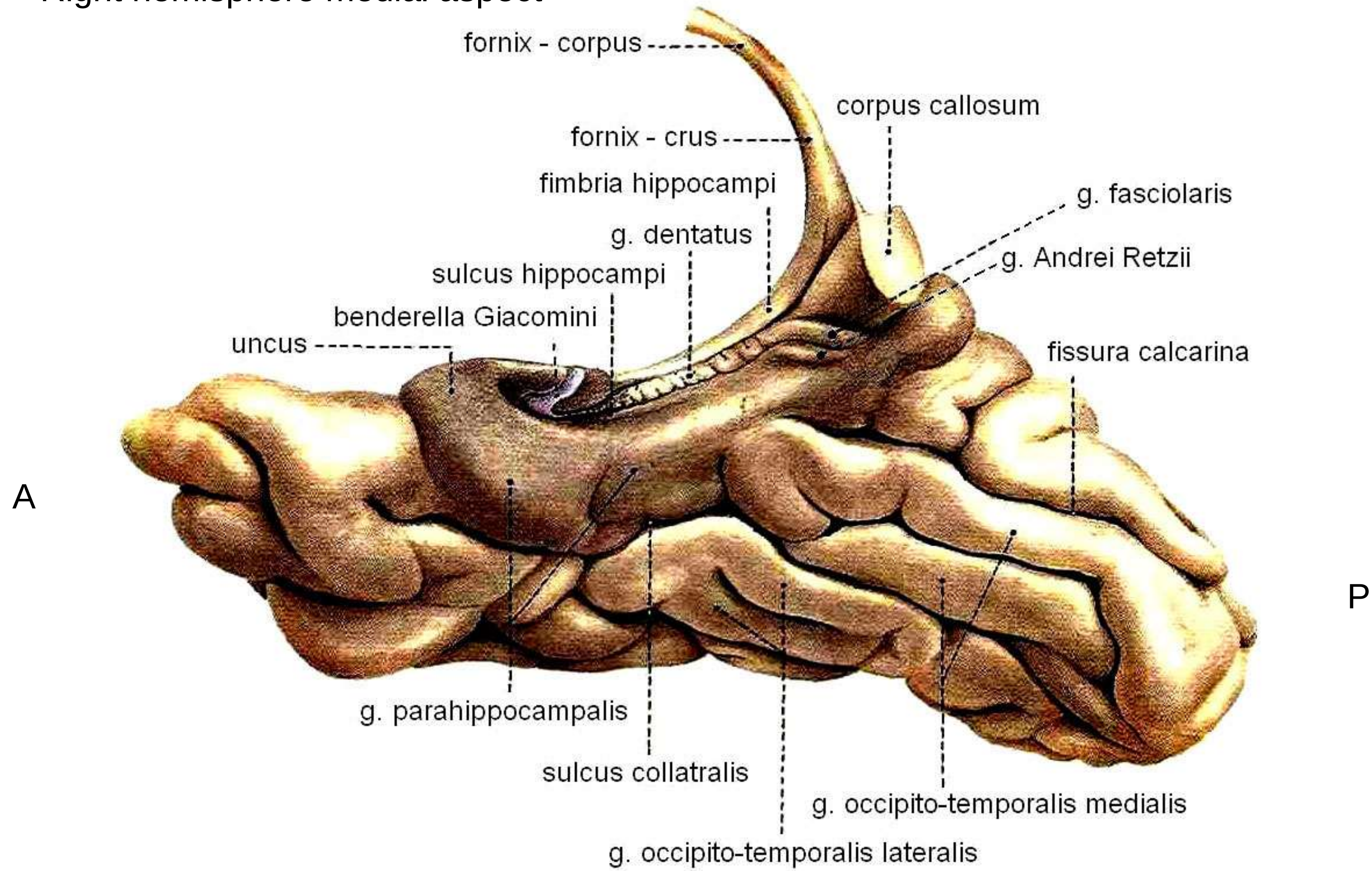
VM and SM nerves nuclei

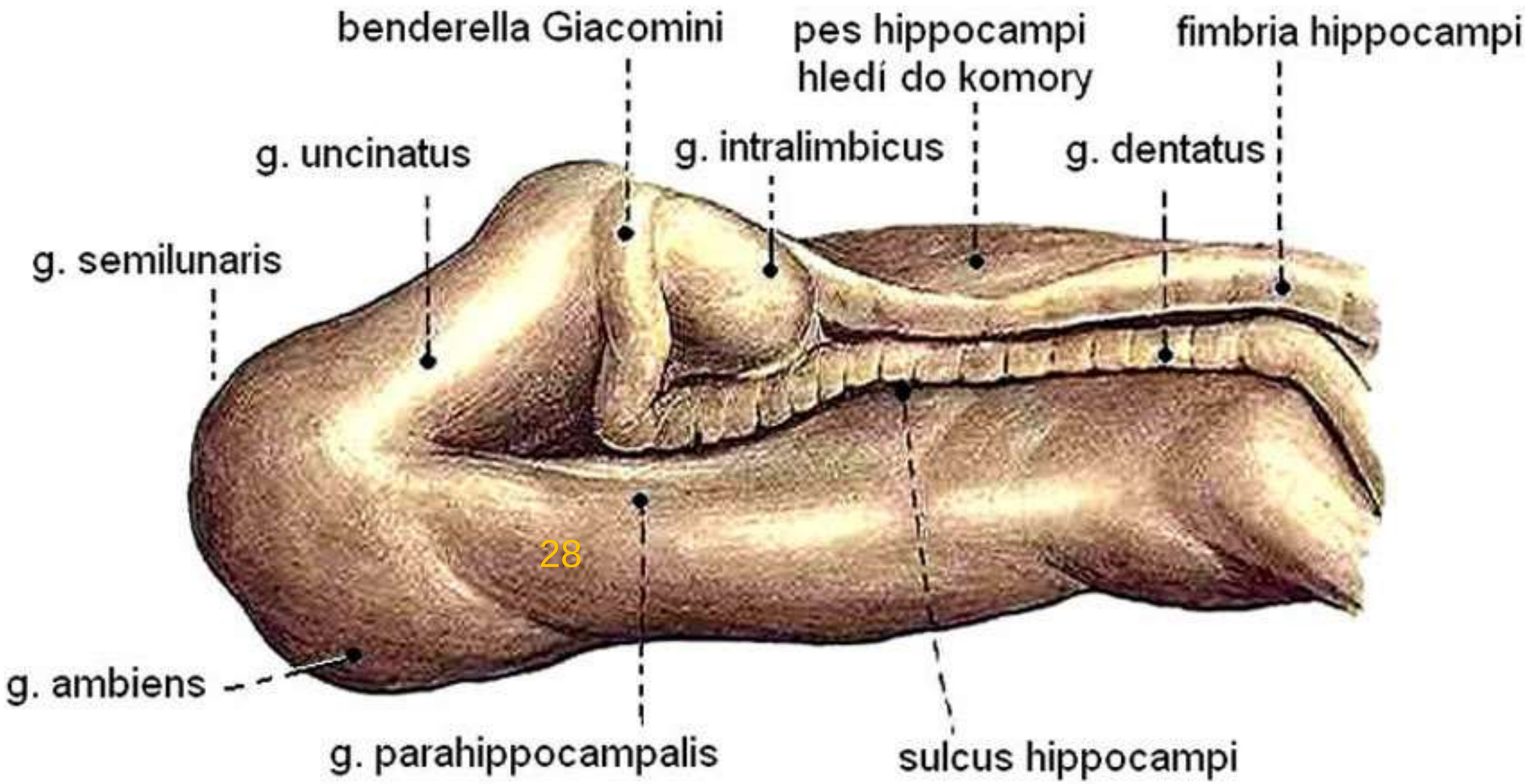
Affective aggression

Predatory aggression

LIMBIC LOBE

Right hemisphere medial aspect



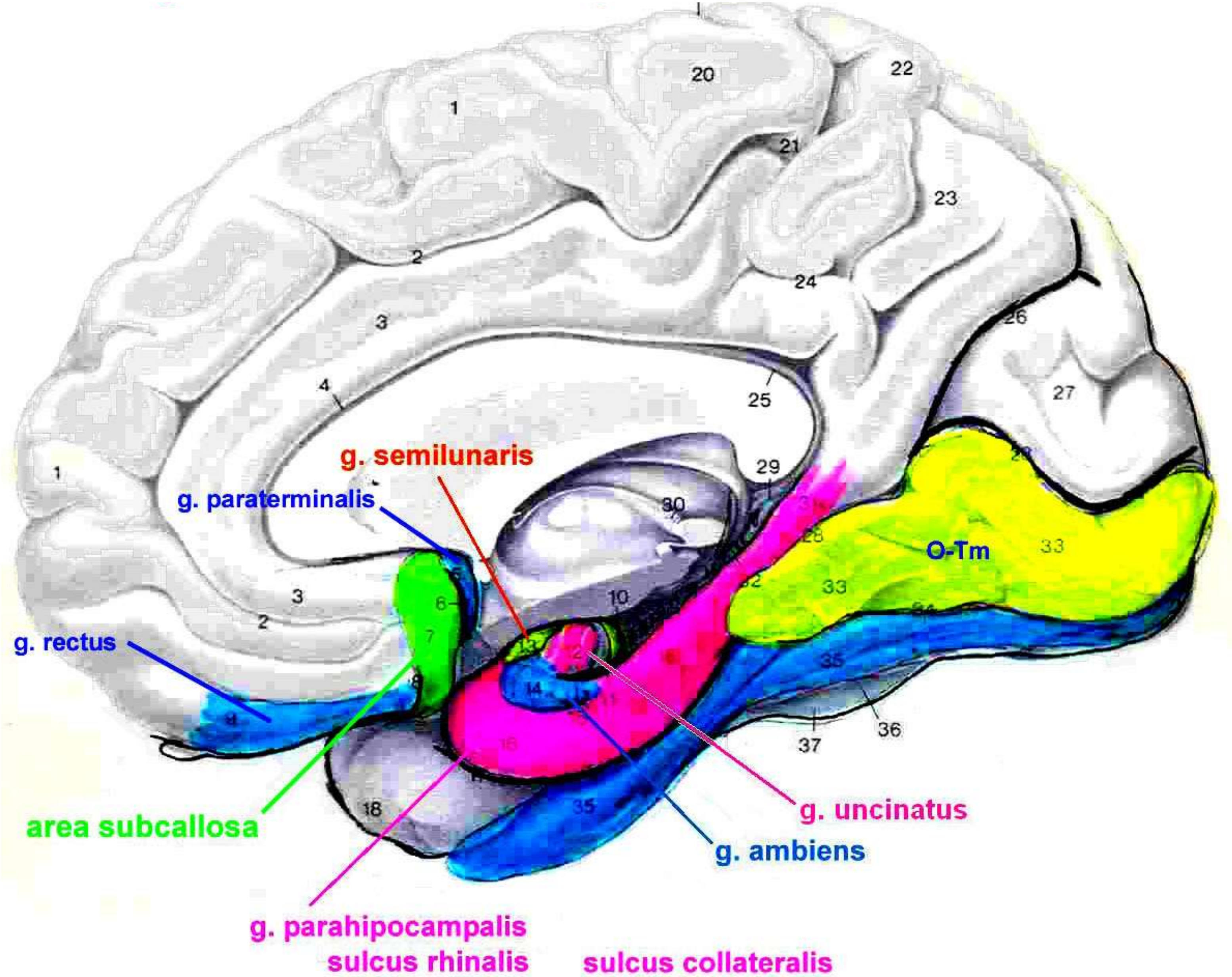


Right hemisphere medial aspect

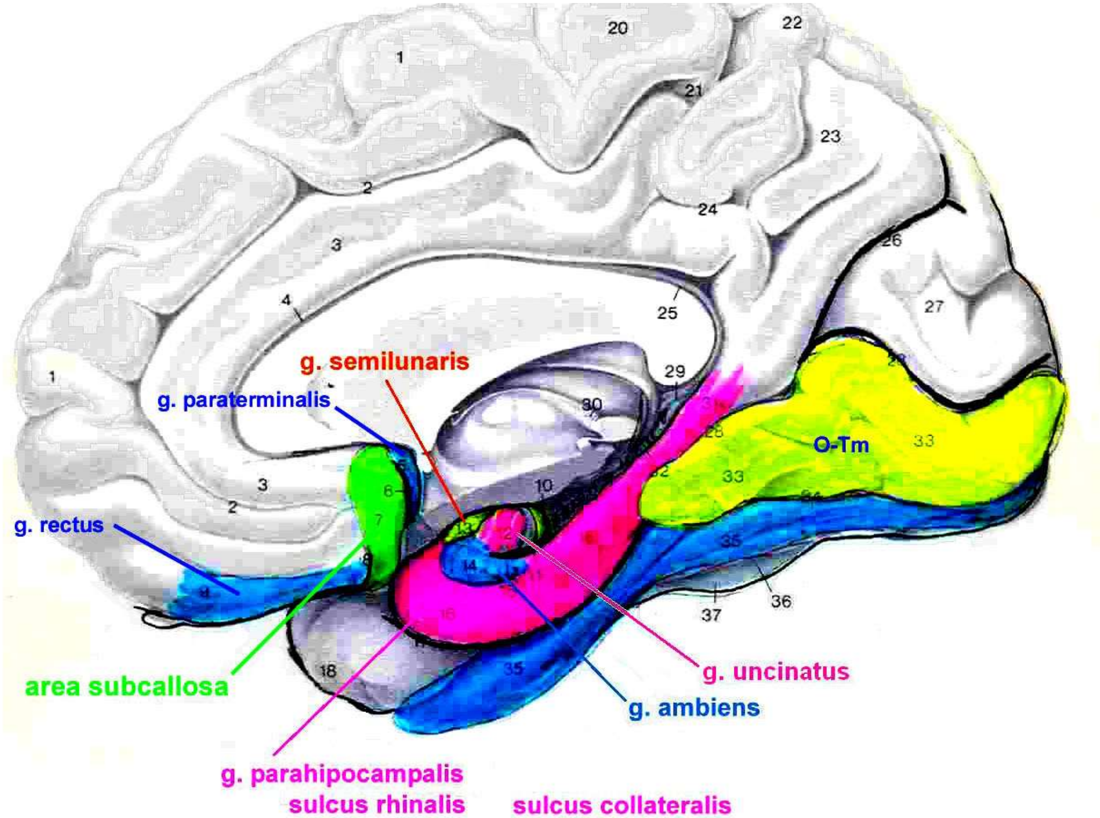
Anterior uncus:
g. Semilunaris = amygdala
g. Ambiens = paleokortex
Area 28= entorhinal cortex

Posterior uncus archikortex:
g. Uncinatus - hippocampus
Banderella Giacomini – g. dentatus
g. intralimbicus

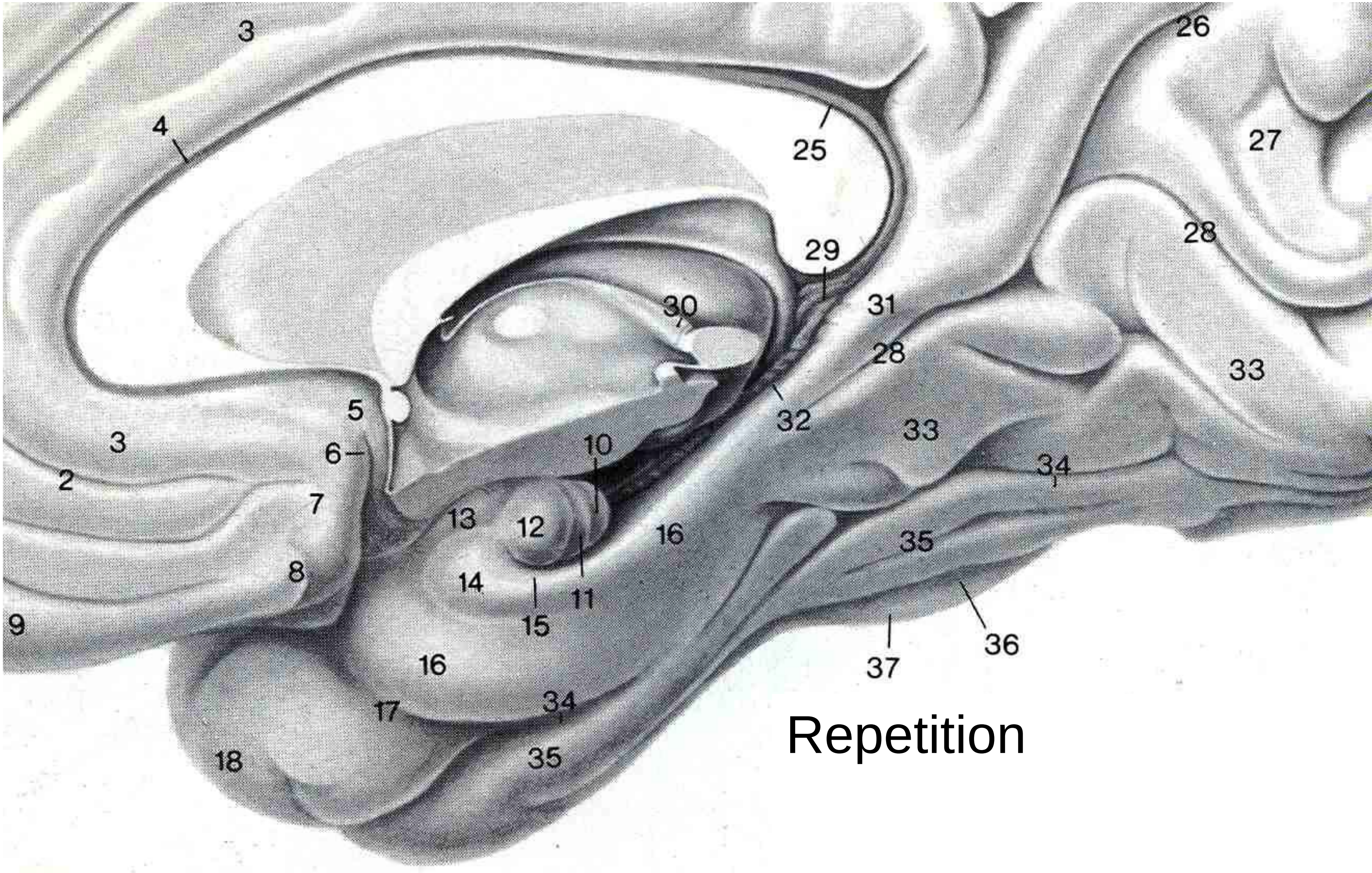
Gyrification on medial surface of the temporal lobe



Gyrification on medial surface of the temporal lobe



1 Gyrus frontalis superior
2 Sulcus cinguli
3 Gyrus cinguli
4 Sulcus corporis callosi
5 Gyrus paraterminalis
6 Sulcus parolfactorius posterior
7 Area subcallosa
8 Sulcus parolfactorius anterior
9 Gyrus rectus
10 Gyrus intralimbicus }
11 Limbus Giacomini } Uncus
12 Gyrus uncinatus }
13 Gyrus semilunaris
14 Gyrus ambiens
15 Incisura unci
16 Gyrus parahippocampalis
17 Sulcus rhinalis
18 Gyrus temporalis superior
19 Sulcus centralis
20 Lobulus paracentralis
21 Sulcus cinguli, pars marginalis
22 Lobulus parietalis superior
23 Precuneus
24 Sulcus subparietalis
25 Indusium griseum
26 Sulcus parieto-occipitalis
27 Cuneus
28 Sulcus calcarinus
29 Gyrus fasciolaris
30 Taenia thalami
31 Isthmus gyri cinguli
32 Gyrus dentatus
33 Gyrus occipitotemporalis medialis
34 Sulcus collateralis
35 Gyrus occipitotemporalis lateralis
36 Sulcus occipitotemporalis
37 Gyrus temporalis inferior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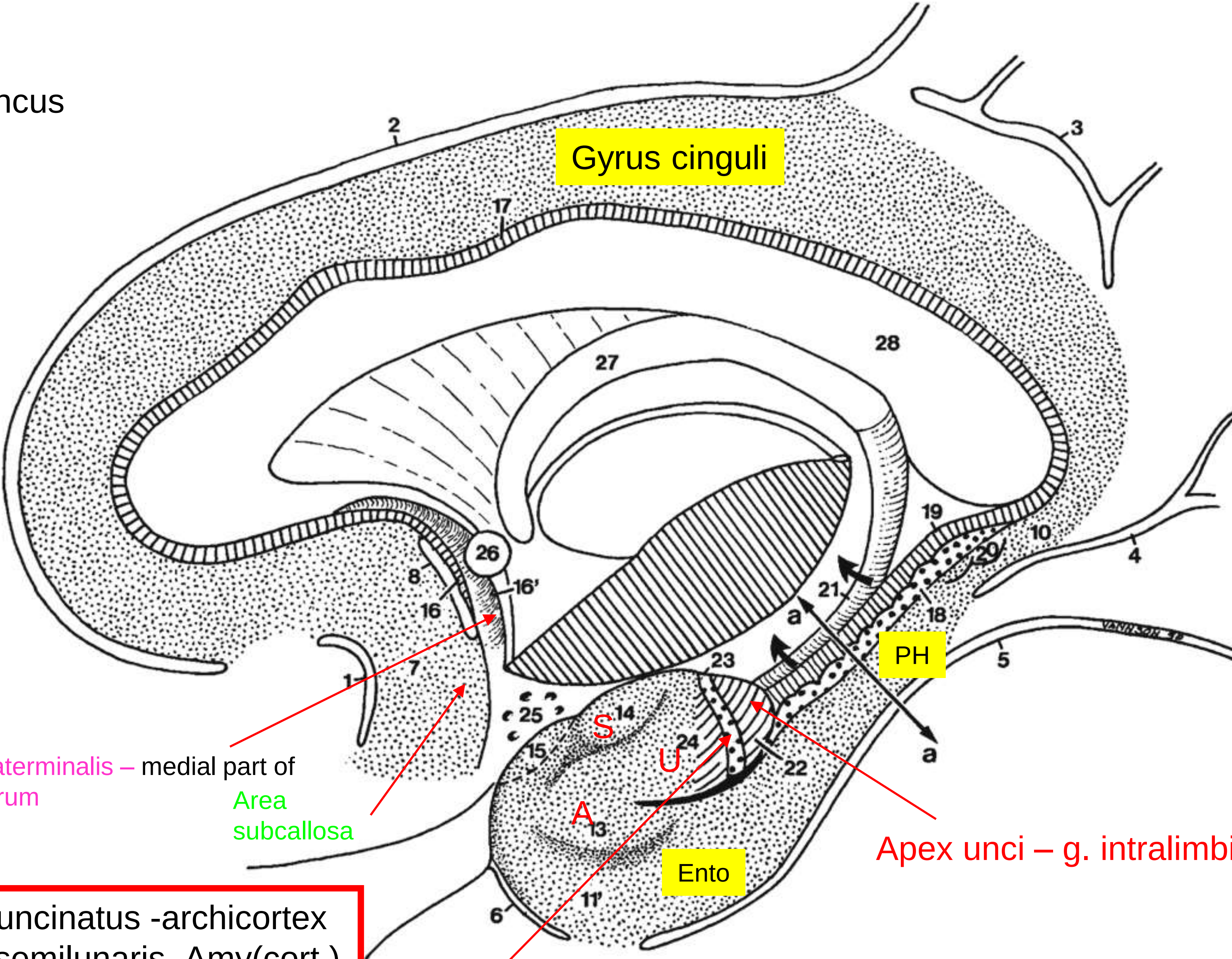
Repetition

Uncus



Gyrus paraterminalis – medial part of septum verum

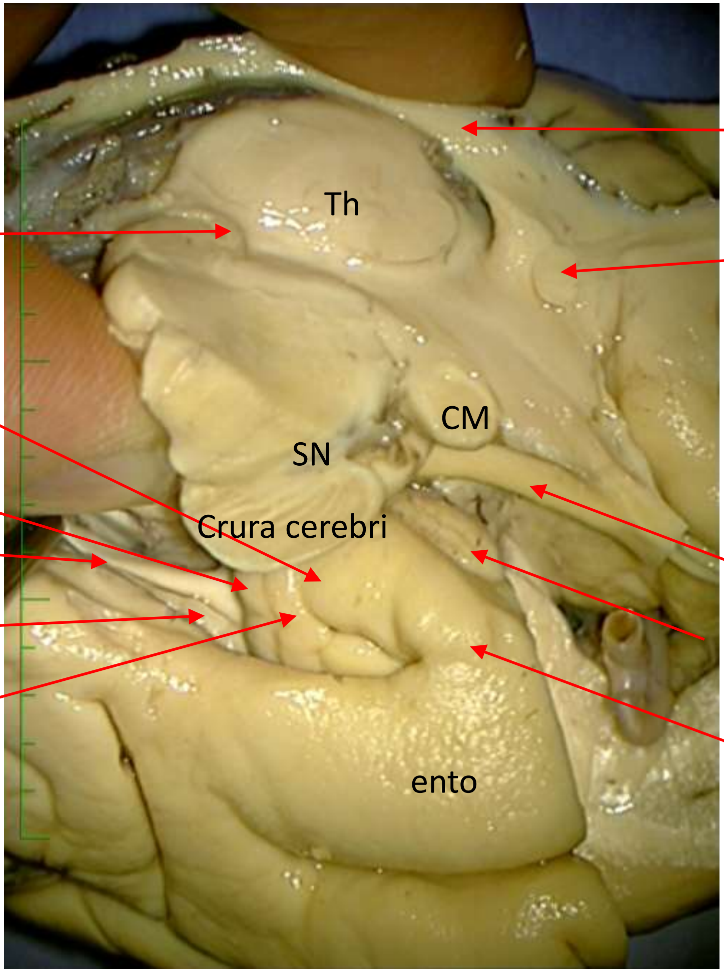
Area subcallosa

Apex unci – g. intralimbicus

Tenia Giacomini = g. dentatus

U- g. uncinatus -archicortex
S- g. semilunaris- Amy(cort.)
A- g. ambiens-paleocortex
Ento – area 28 -mesocortex

Uncus a crura mesencephali

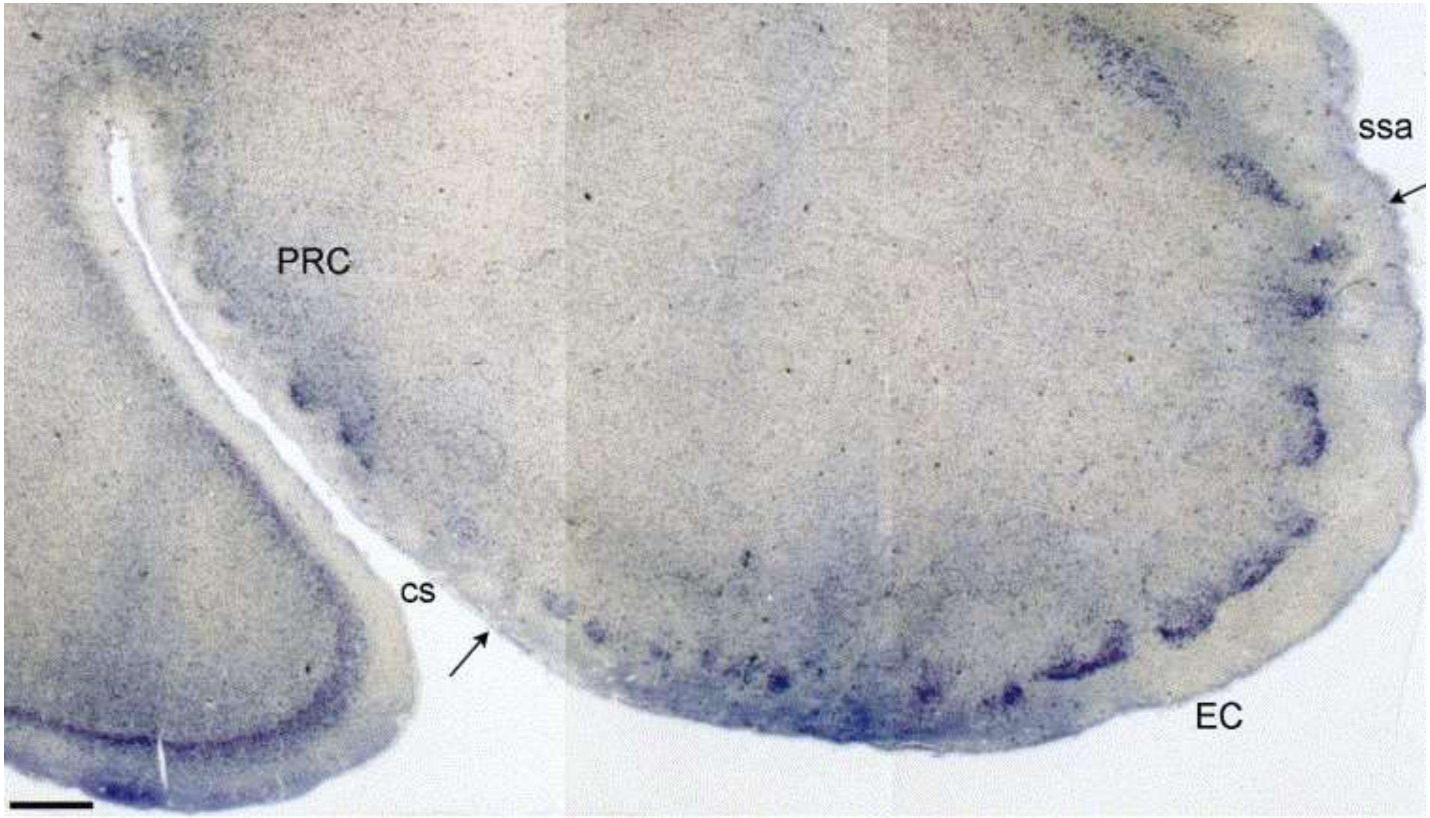


Preparace a foto Dr.Bartoš

Entorhinal cortex = area 28 verrucae areae entorhinalis

Islands of cells in area 28 make outside visible verrucae areae entorhinalis

Cell are one of firs degenerating cell in aging and Alzheimer dementia,
Negative correlation between age and size of area with verrucae

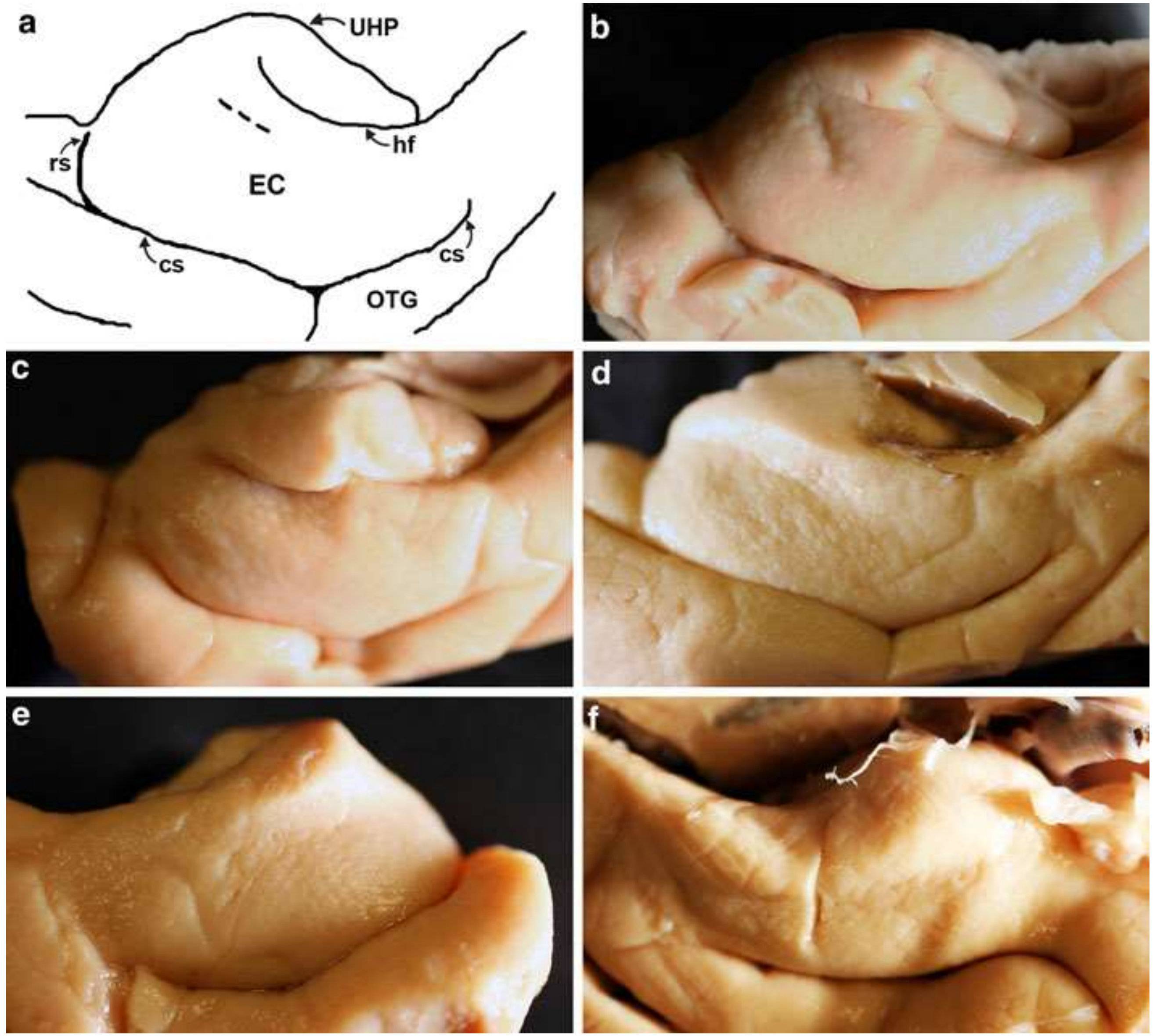


Hemispheric asymmetry, modular variability and age-related changes in the human entorhinal cortex, 2004

•G. Simic[a, ,] , S. Bexheti[a], Z. Kelovic[a], M. Kos[b], K. Grbic[a], P.R. Hof[c], I. Kostovic[a]

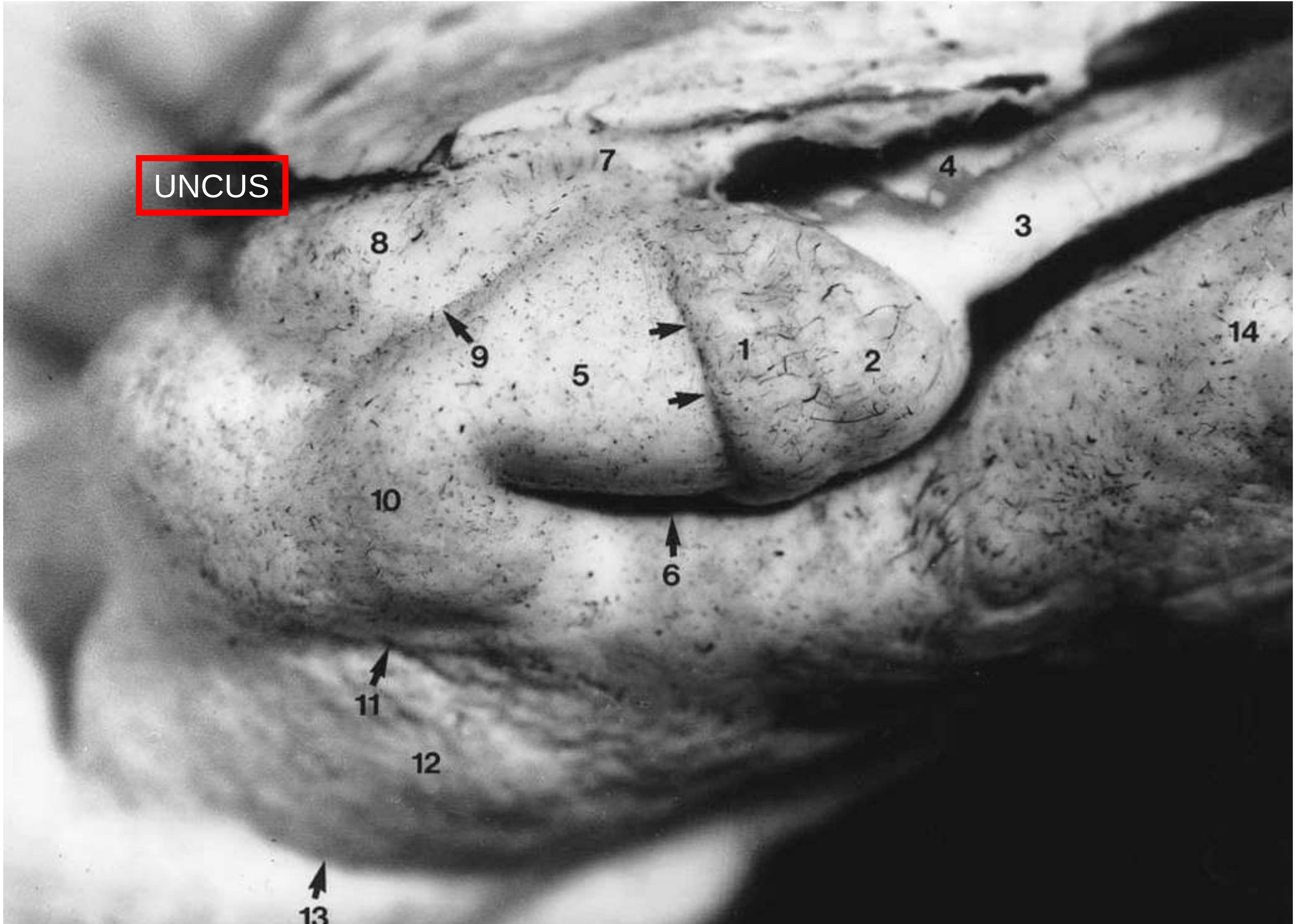
Verrucae areae entorhinalis

- Protruding islands of cells of 2. layer of enthorinal cortex



Entorhinal verrucae geometry is coincident and correlates with Alzheimer's lesions: a combined neuropathology and high-resolution ex vivo MRI analysis
Jean C. Augustinack • Kristen E. Huber • Gheorghe M. Postelnicu • Sita Kakunoori • Ruopeng Wang • Andre´ J. W. van der Kouwe • Lawrence L. Wald • Thor D. Stein • Matthew P. Frosch • Bruce Fischl

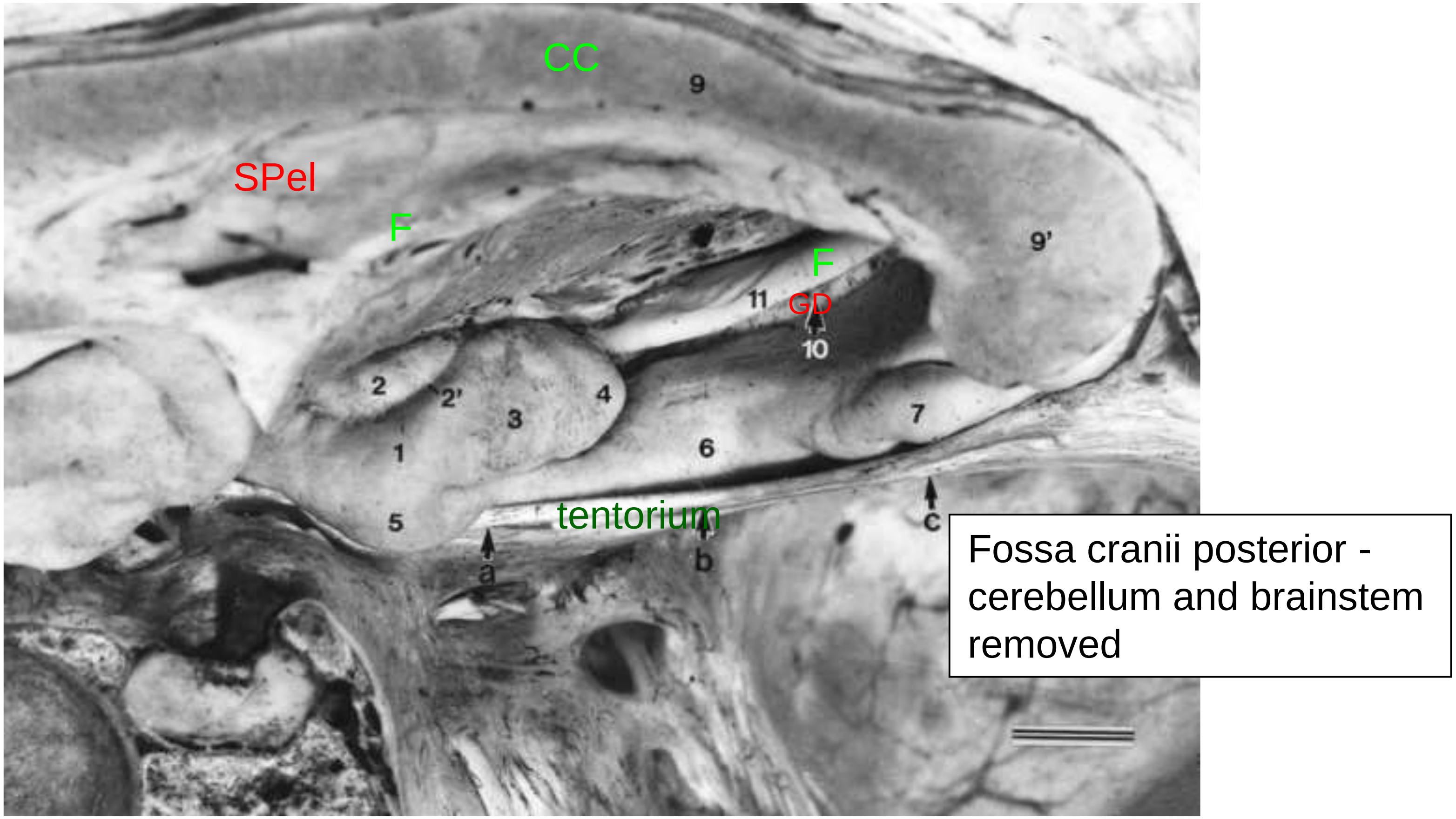
http://www.bu.edu/alzresearch/files/2014/10/Entorhinal-verrucae.pdf



Anterior segment piriform
8 semilunar gyrus, *9* semianular sulcus, *10* ambient gyrus, *11* uncal notch produced by the free edge of the tentorium cerebelli, *12* entorhinal area and verrucae gyri hippocampi, *13* rhinal sulcus, *14* parahippocampal gyrus

posterior segment - hippocampus:
1 band of Giacomini (*arrows* along the superficial hippocampal sulcus), *2* medial surface of uncal apex, *3* fimbria, *4* choroid fissure (the choroid plexuses have been removed), *5* uncinate gyrus, *6* uncal sulcus

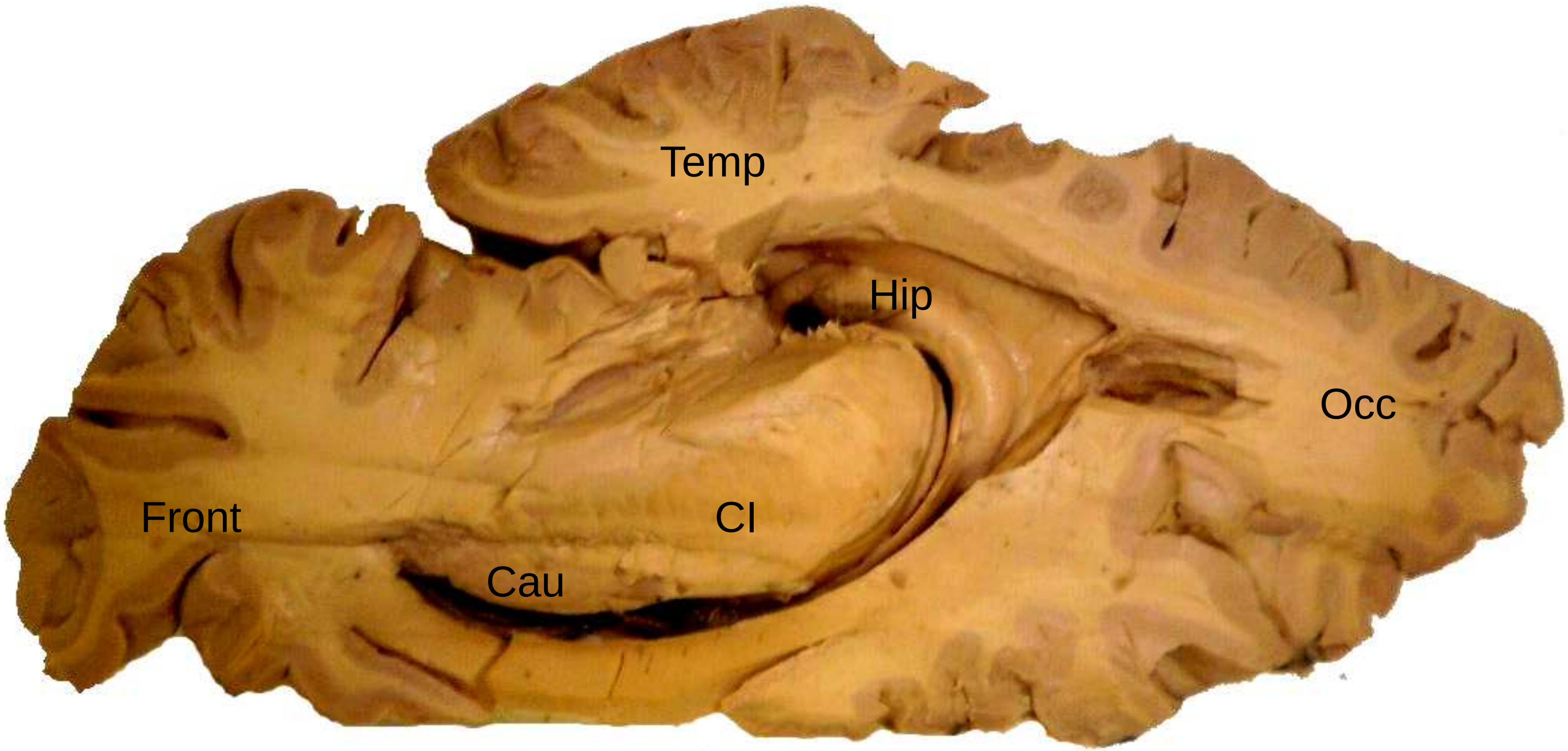
Uncus and tentorium cerebelli



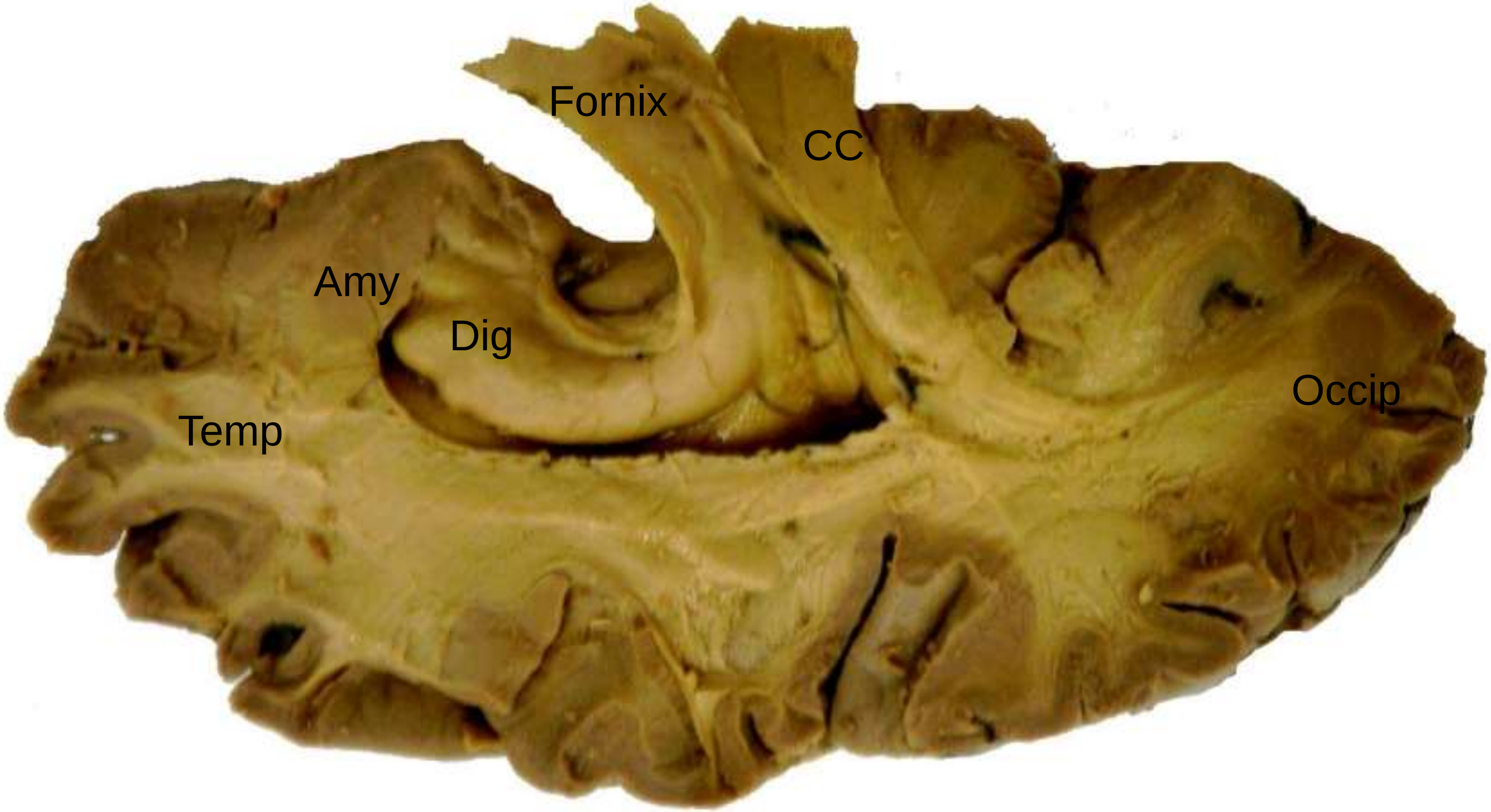
1 medial surface of uncus, *2* semilunar gyrus, *2* ˘ semianular sulcus, *3* uncinate gyrus, *4* uncal apex, *5* ambient gyrus overlying the free edge of the tentorium cerebelli (*arrow a*), *6* middle part of the parahippocampal gyrus far from the free edge (*arrow b*), *7* posterior part of the parahippocampal gyrus (isthmus) in close contact with the free edge (*arrow c*), *8* posterior cranial fossa, *9* corpus callosum, *9* ˘splenium, *10* margo denticulatus, *11* fi mbria

Duvernoy, The Human Hippocampus

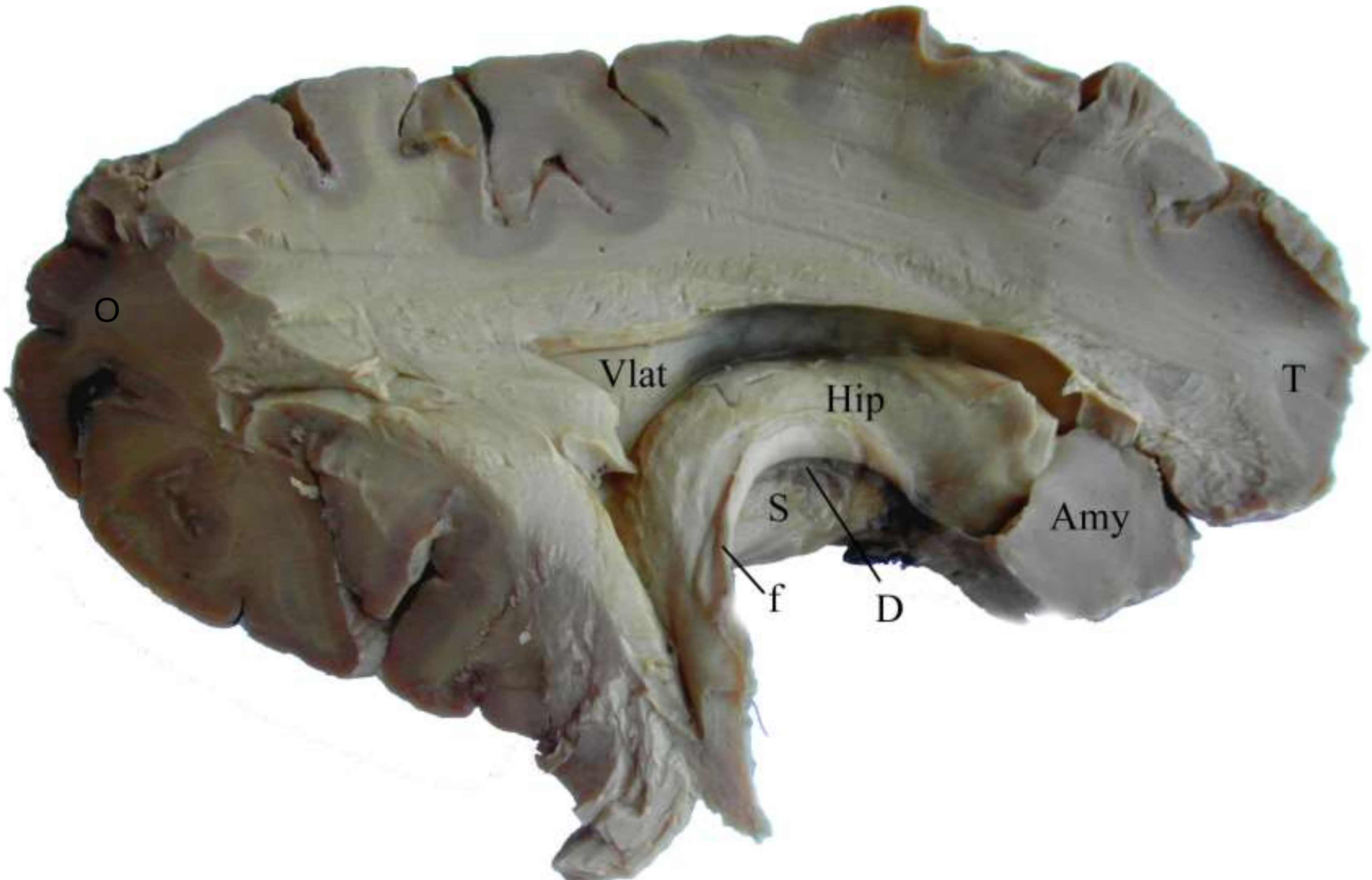
Hippocampus



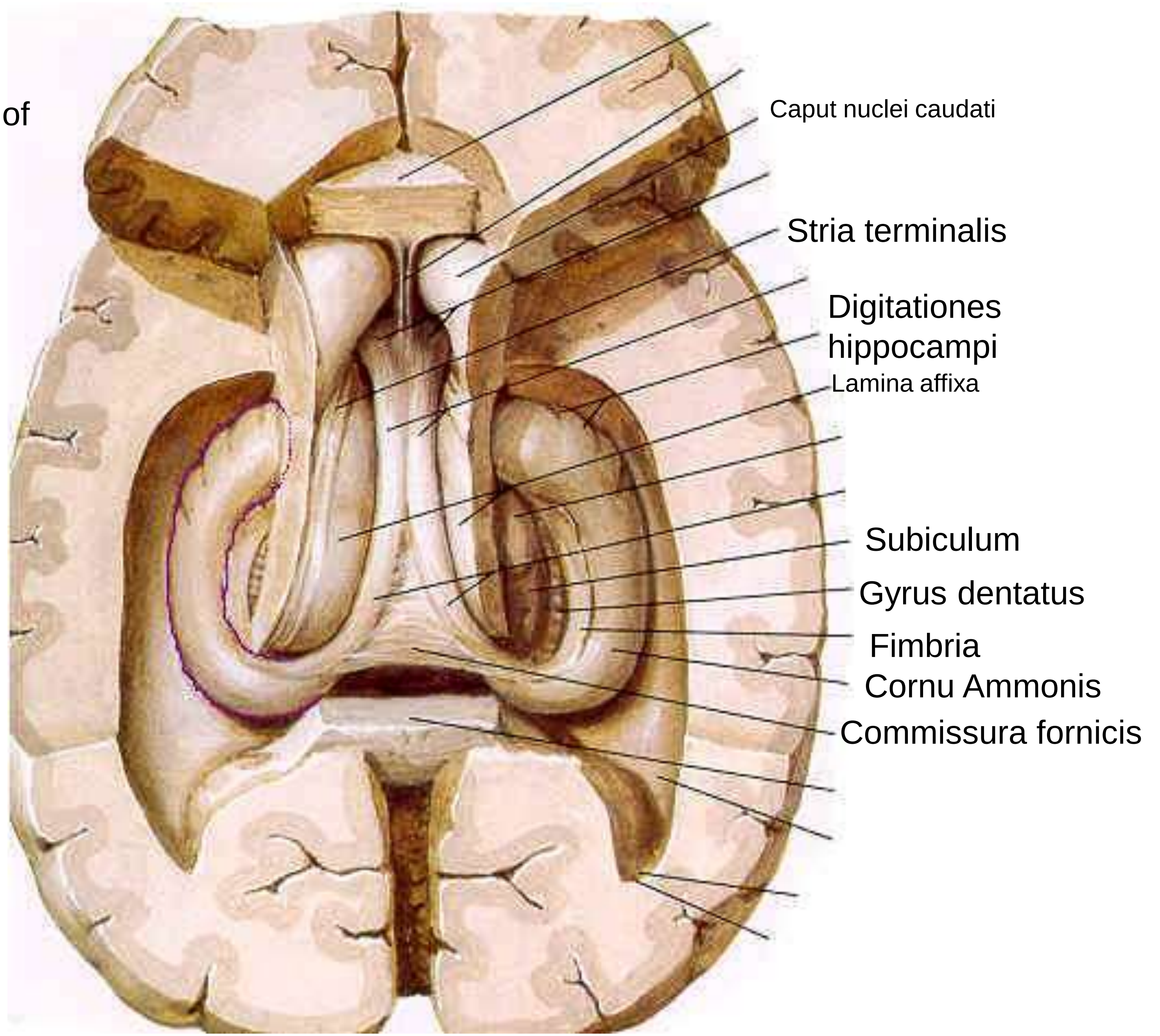
Hipocampus and amygdala

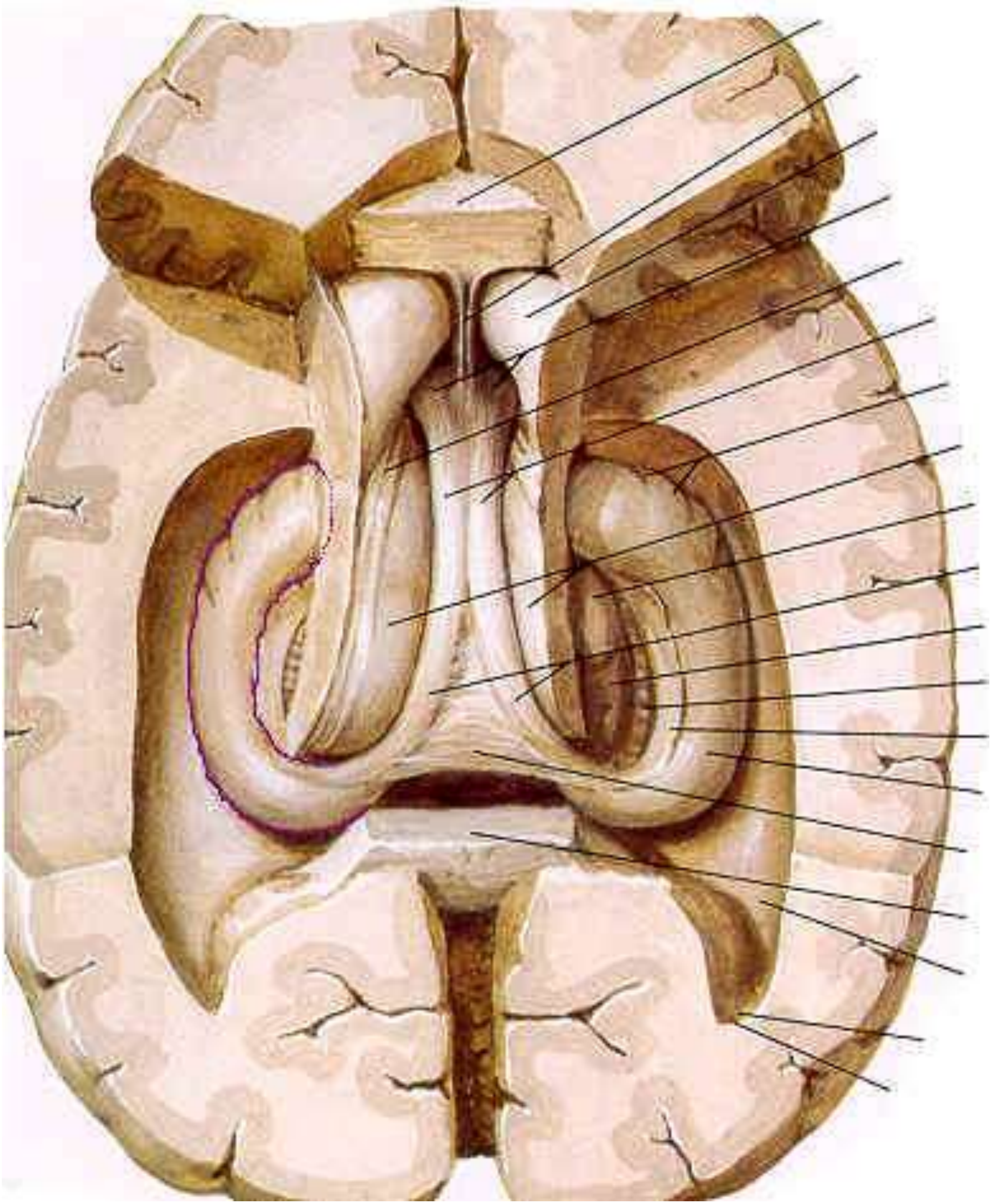


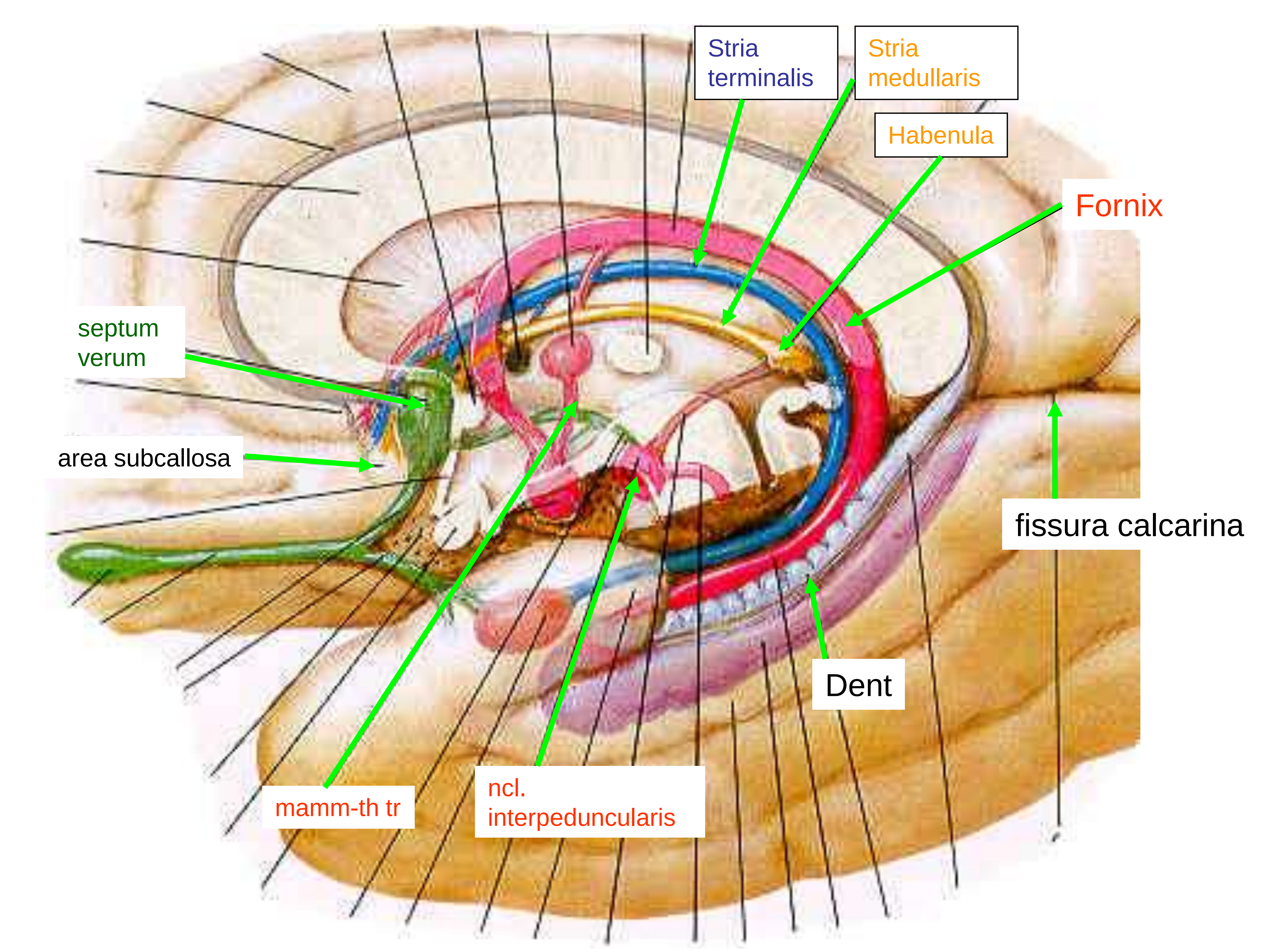
Hipocampus, dentate gyrus, subiculum and amygdala



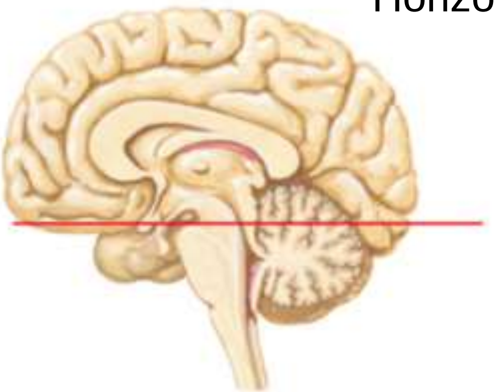
Superior aspect of hippokampal formation



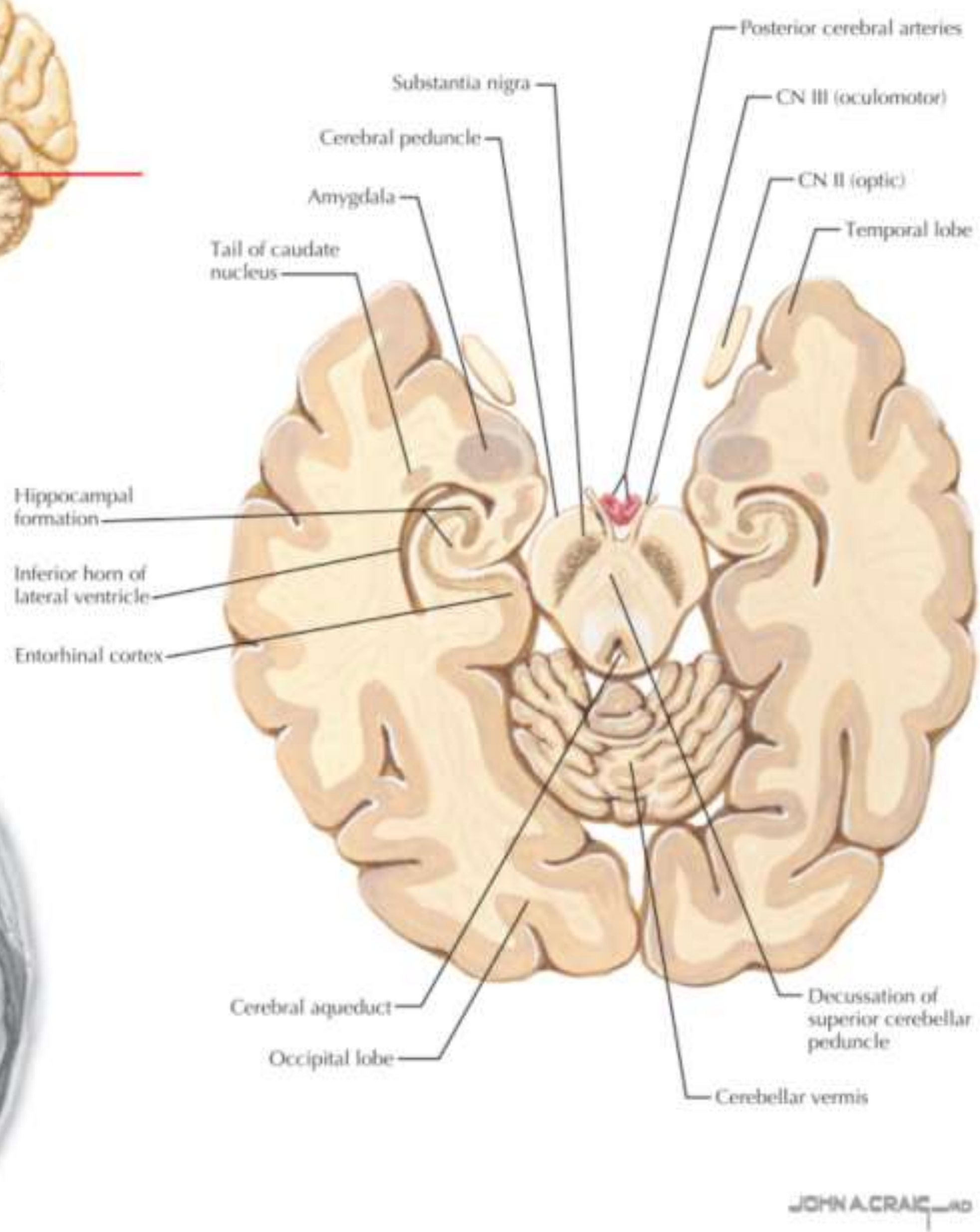


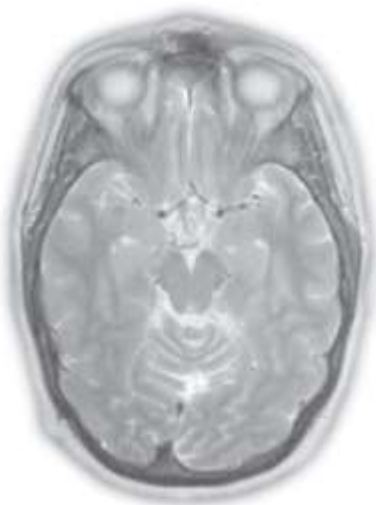

Stria terminalis
Stria medullaris
Habenula
Fornix
septum verum
area subcallosa
fissura calcarina
Dent
mamm-th tr
ncl. interpeduncularis

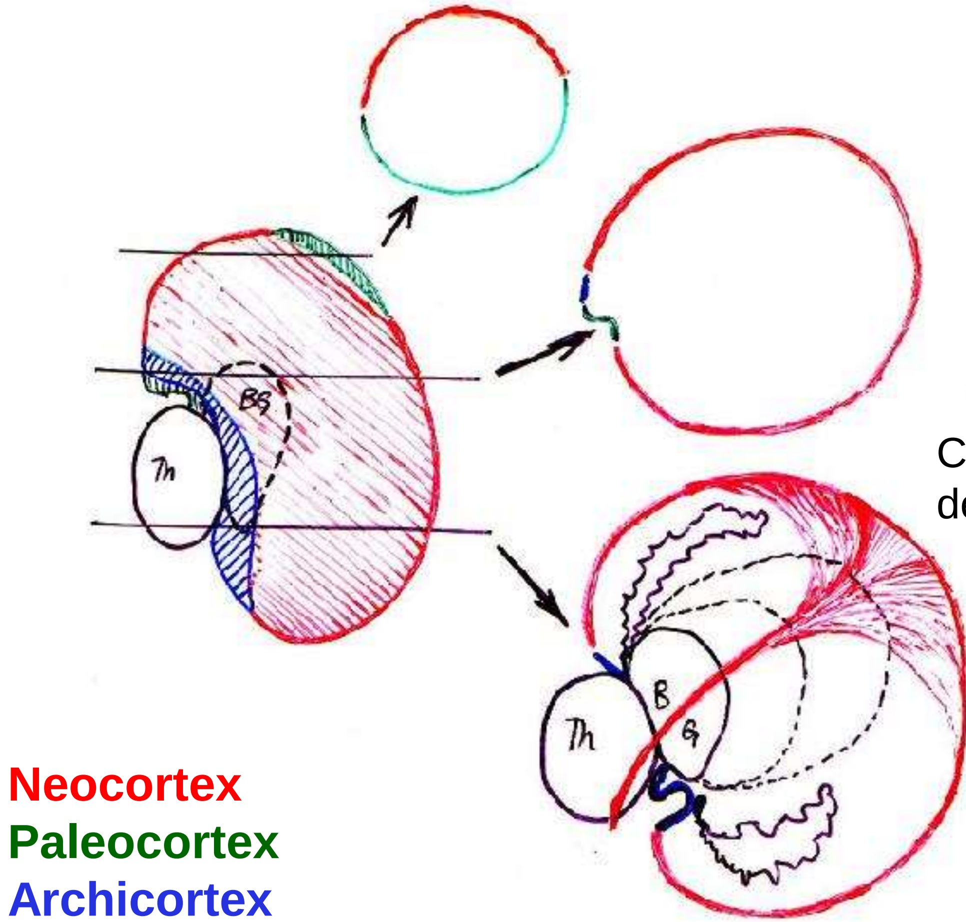
Horizontal section at the level of midbrain



Level of section (midbrain)



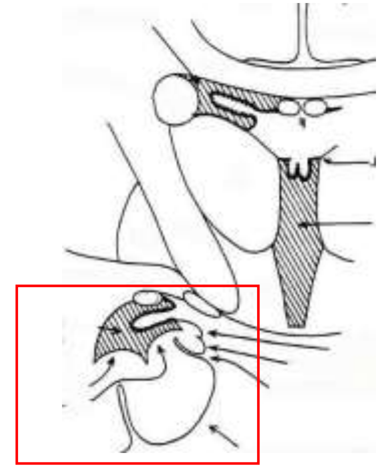




Crossection of the developing hemisphere

Development of the telencephalon

Development of the hippokampal formation



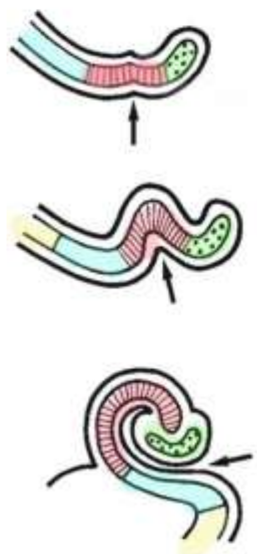
CA

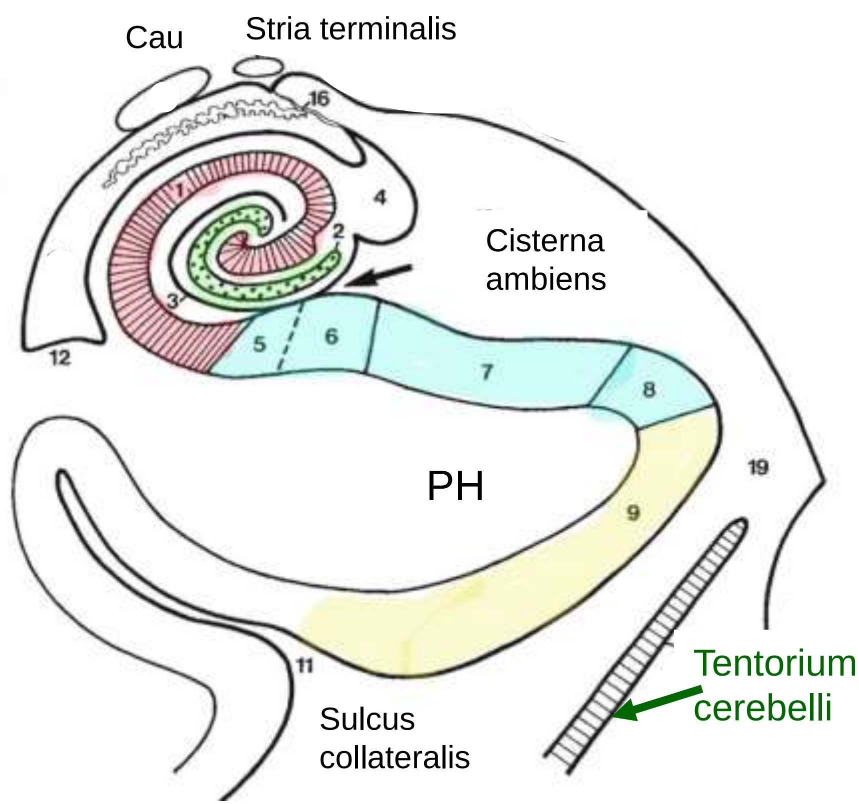
Gyrus dentatus

Subiculum

Area 28

Sulcus hippocampi ↑

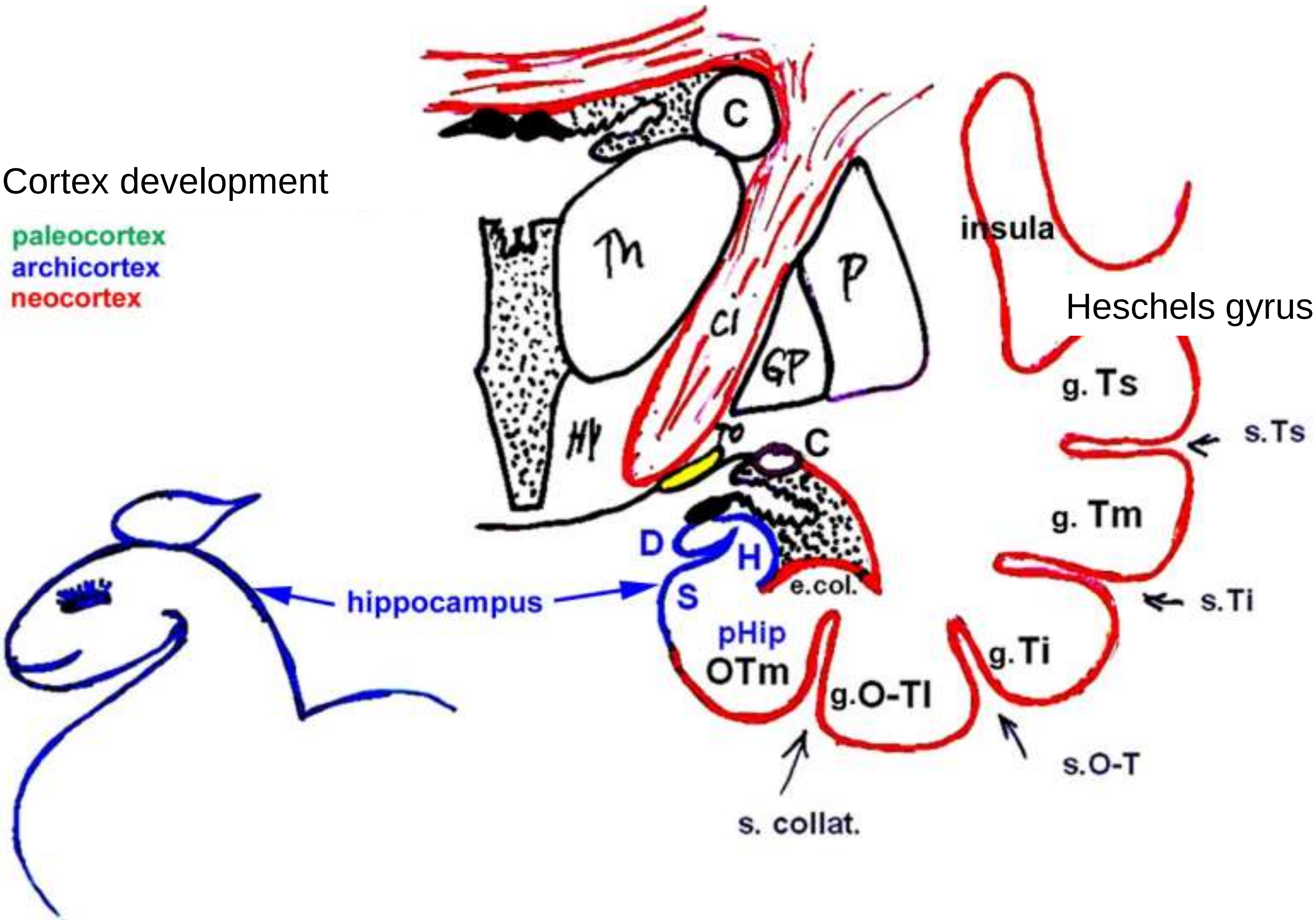




4 – fimbria hippocampi (fornicis)
16- fissura choroidea

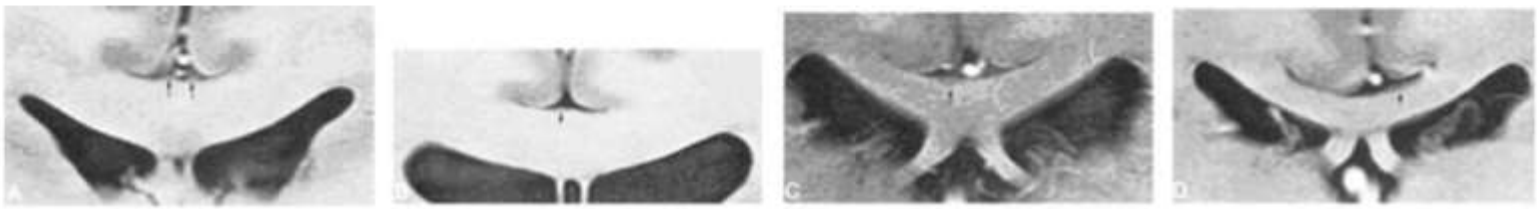
Cortex development

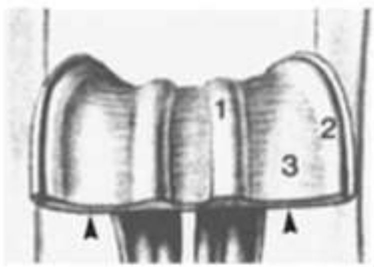
paleocortex
archicortex
neocortex



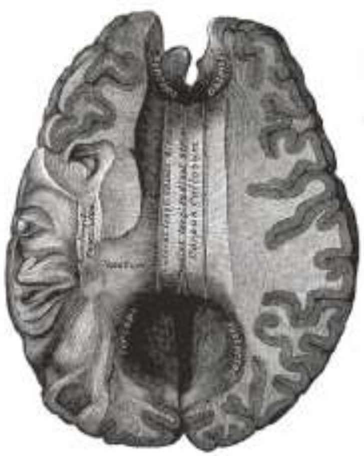
Schema of prof. Petrovický

Supracommissural hippocampus -human



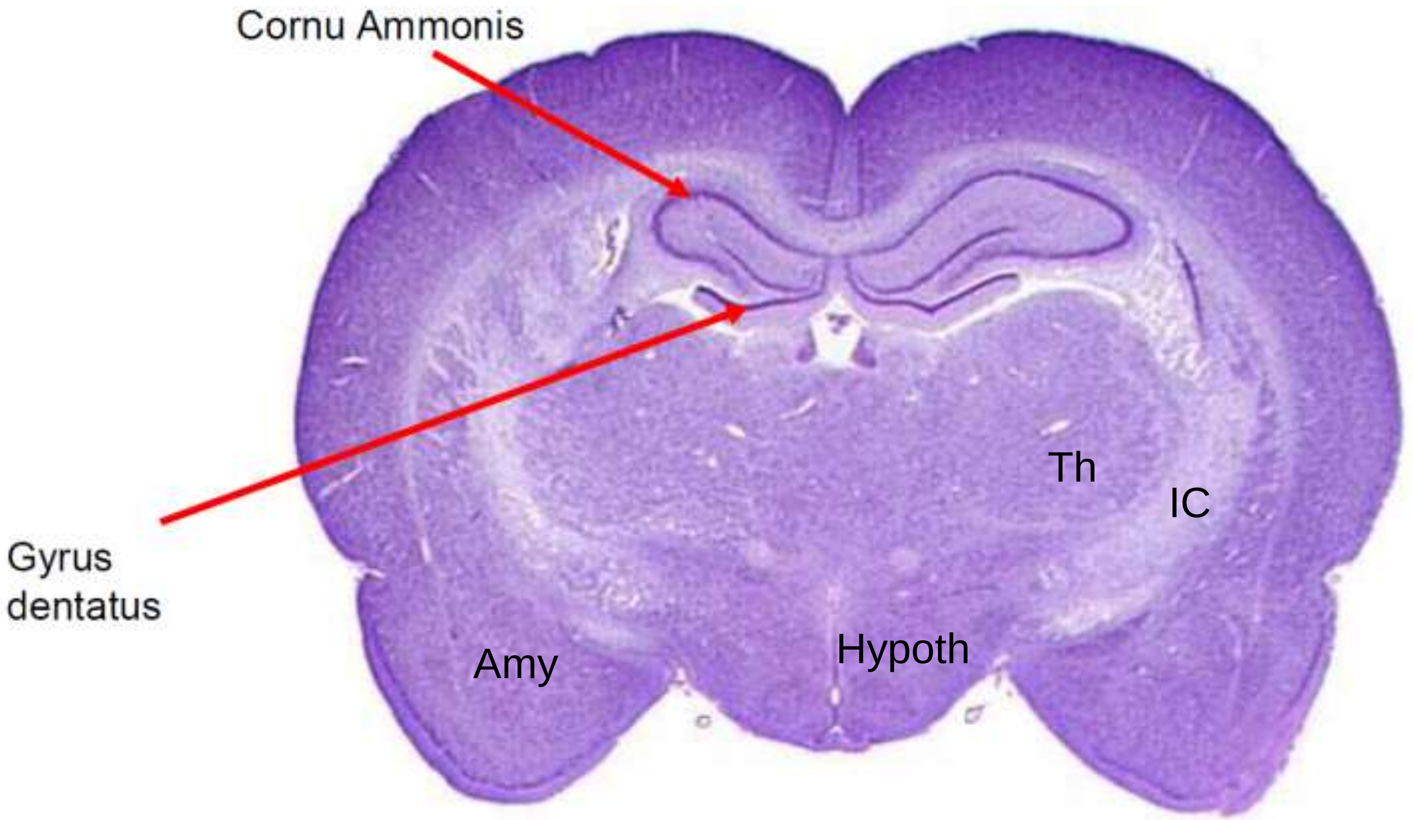


1) Stria longitudinalis medialis ; 2) Stria longitudinalis lateralis a 3) indusium griseum. (Reprinted from: Nieuwenhuys R, Voogd J, van Huijzen C. *The Human Central Nervous System*. Berlin: Springer-Verlag 1988:300, with permission.)

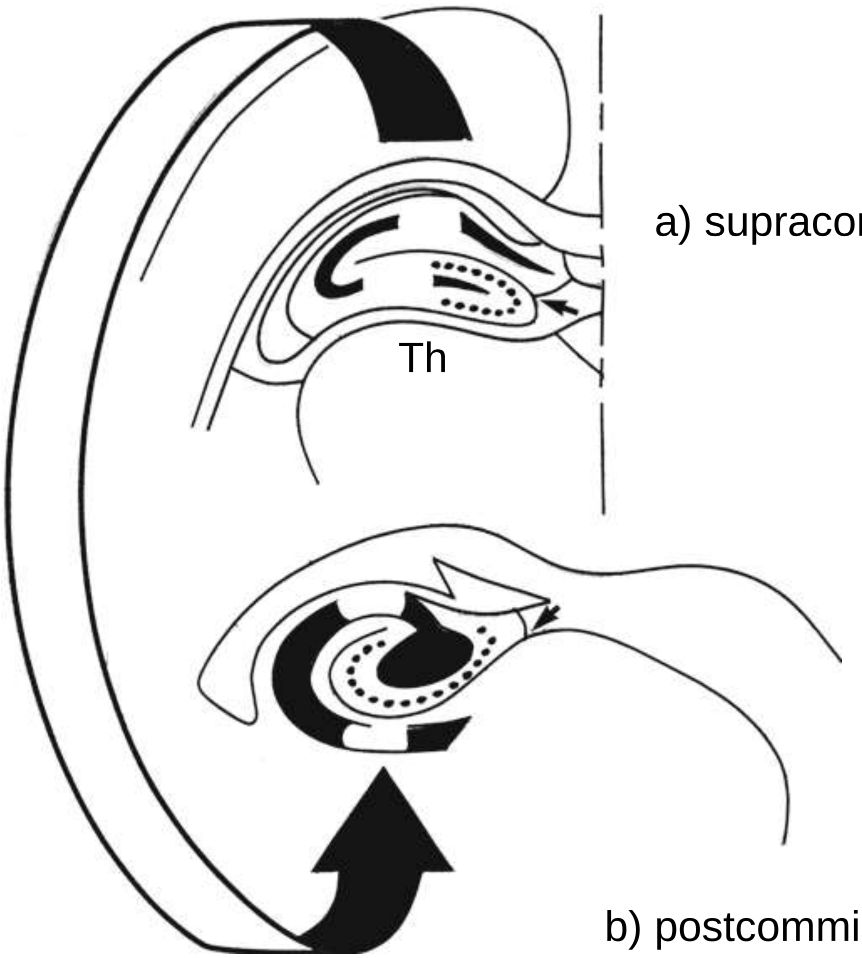


Representative MR images of the IG classical, symmetric two-strip (A), symmetric, but centrally fused (B), lateralized, single-strip (C), and thin-layer (D) patterns.fig 2. The medial and lateral longitudinal striae of Lancisii.

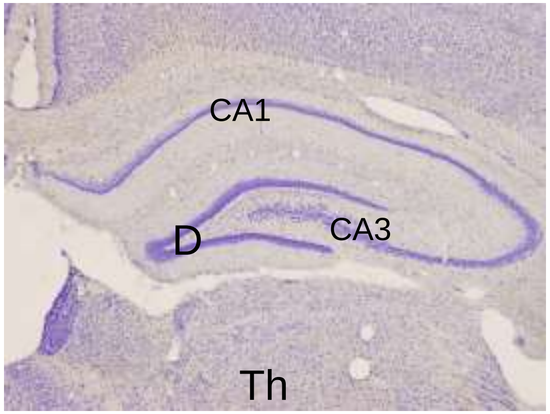
Supracommissural hippocampal formation – rat



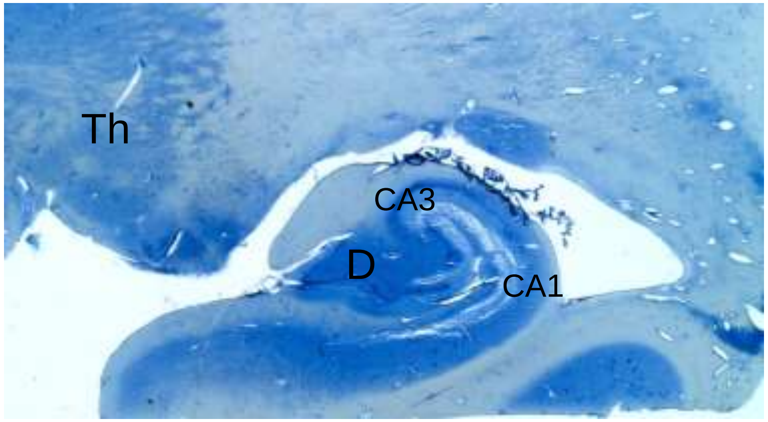
Hippocampation formation rat (a) and human (b)

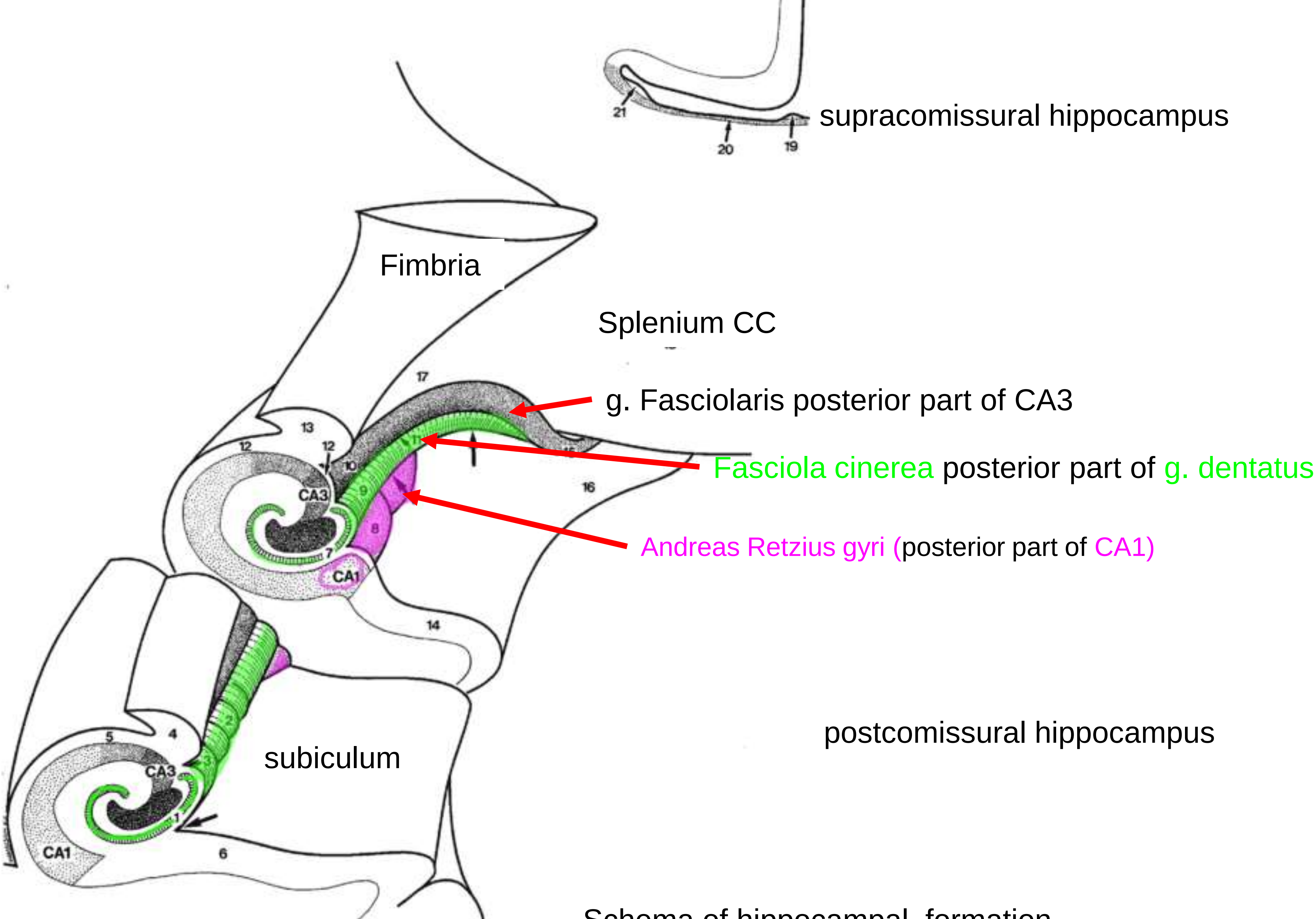


a) supracommissural



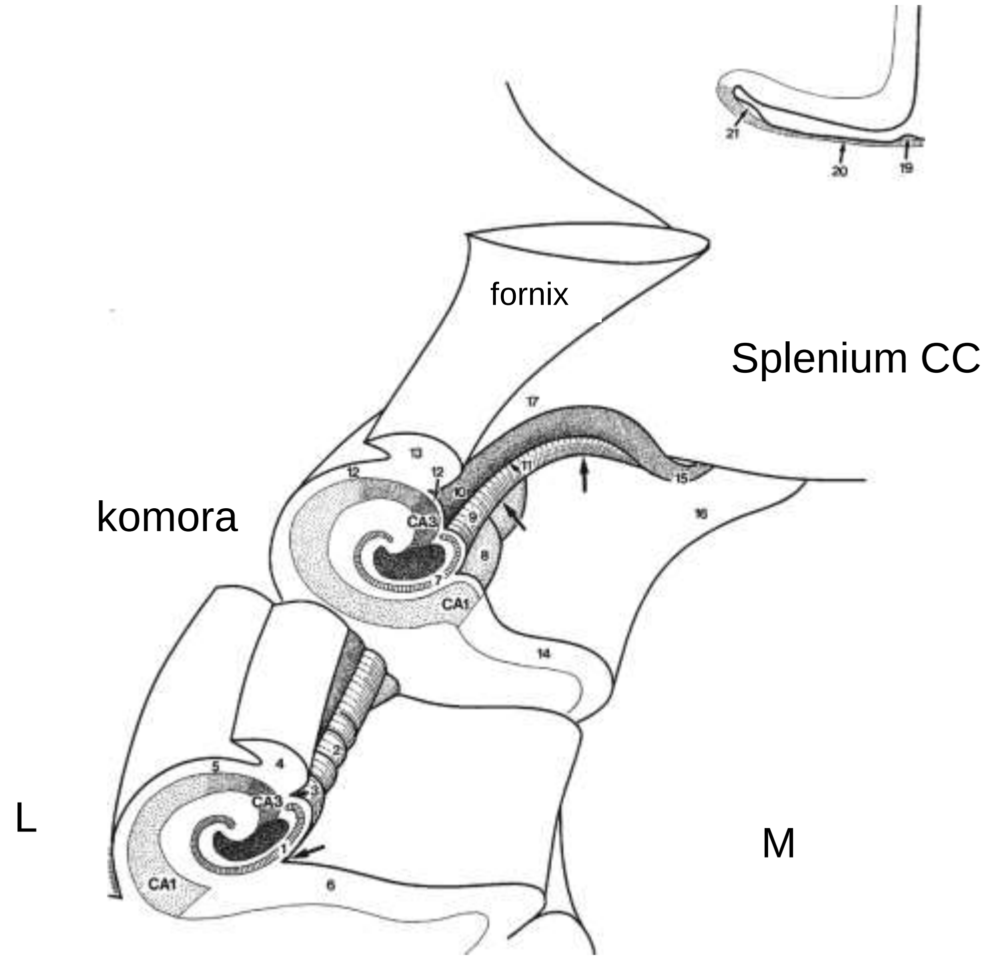
b) postcommissural





Schema of hippocampal formation
(POSTERIOR PART– cauda hippocampi)
anterior aspect

Schema of hippocampal formation (POSTERIOR PART– cauda hippocampi) anterior aspect



1,7 gyrus dentatus,
4, 13 fimbria,
5, 12 alveus,
6, 14 subiculum.
8 gyri of Andreas Retzius (CA1)
9 the fasciola cinerea = margo denticulatus,
10 gyrus fasciolaris (CA3) =hippocampus inversus,
11 sulcus dentatofasciolaris,
19 stria longitudinalis medialis
20 indusium griseum,
21 stria longitudinalis lateralis

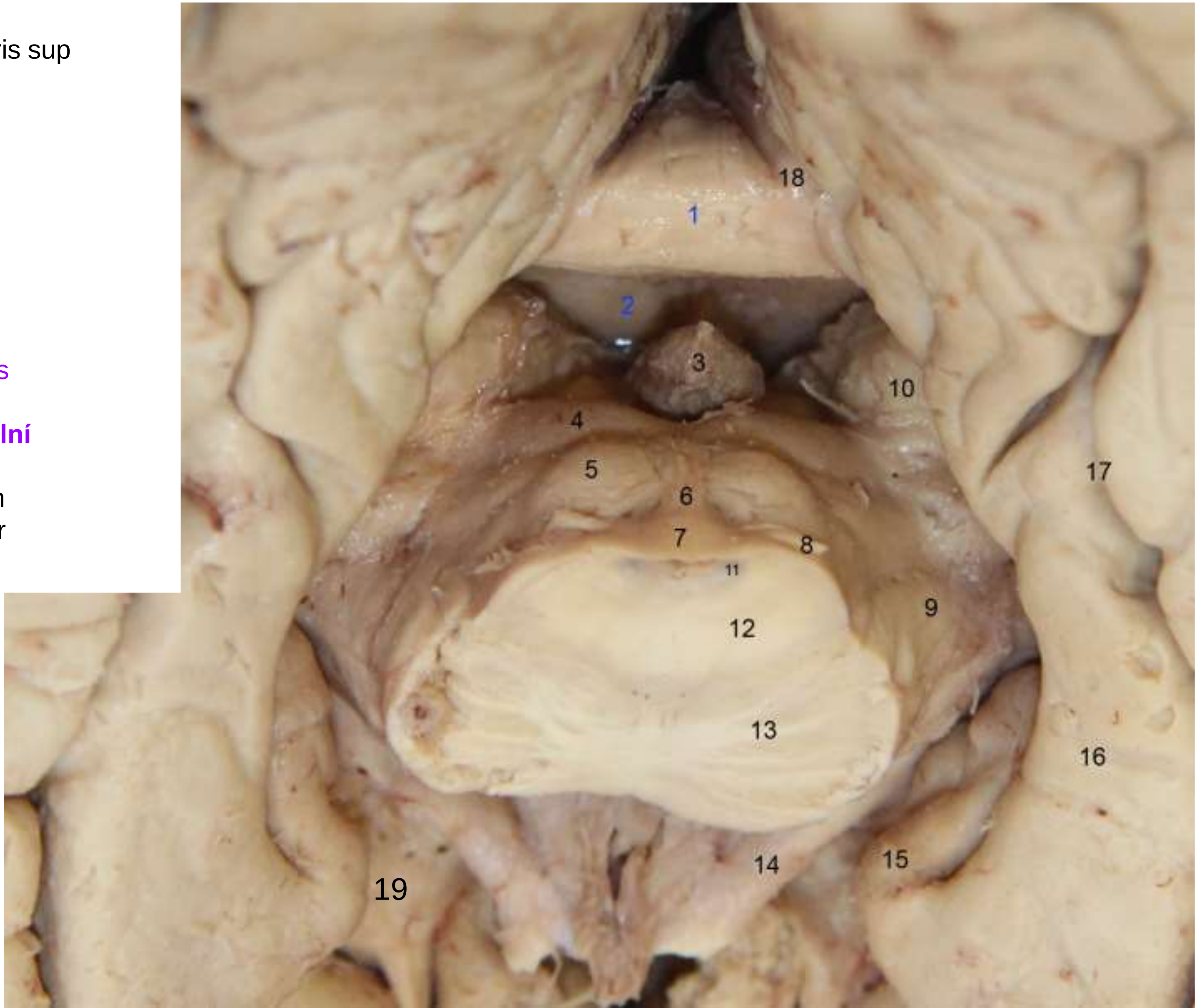
Duvernoy, The Human Hippocampus

Frontal section through the splenium corporis callosi

1corpus callosum, *2* splenium, *3* crus of fornix, *4* subcallosal trigone, *5* gyrus fasciolaris, *6* fasciola cinerea, *7* the subsplenial gyrus, an extension of the gyrus fasciolaris, *8* isthmus, *9* parahippocampal gyrus

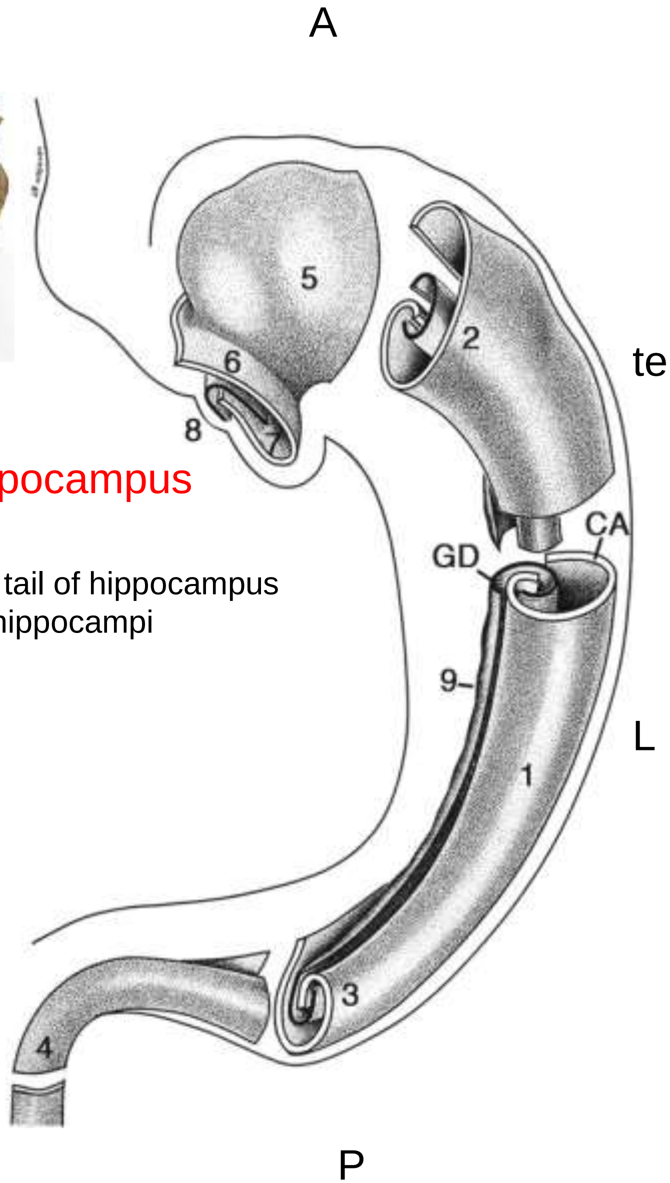
Limbic structures ventral aspect

1-corpus callosum
2- commissura fornicis
3-epiphysis
4-colliculus superior
5-colliculus inferior
6-frenulum veli medullaris sup
7-vellum medullare sup
8-IV.n
9-crura cerebri
10- pulvinar thalami
11- locus coeruleus
12- tegmentum pontis
13-pars basilaris pontis
14-tractus opticus
15-uncus
16-g. parahippocampalis
17-sulcus collateralis
18 –supracommissurální hippocampus
19- trigonum olfactorium
= area perforata anterior



Parts of hippocampus

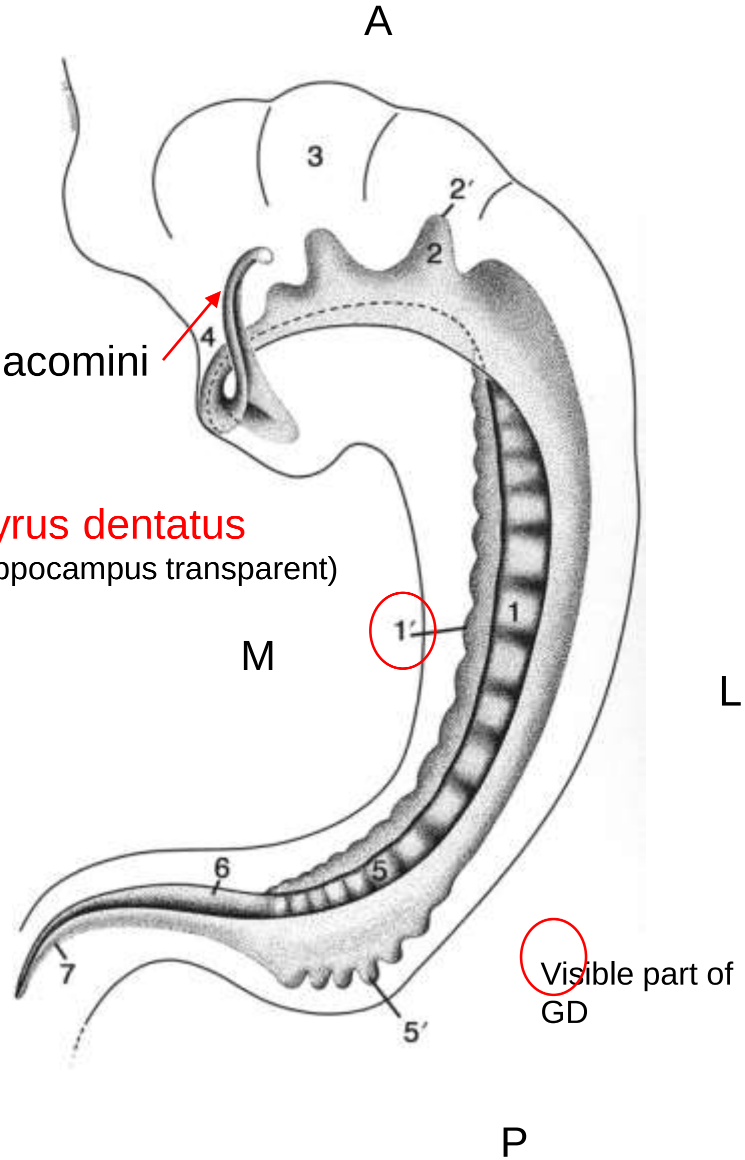
1-4- head, body, tail of hippocampus
5,6-digitationes hippocampi



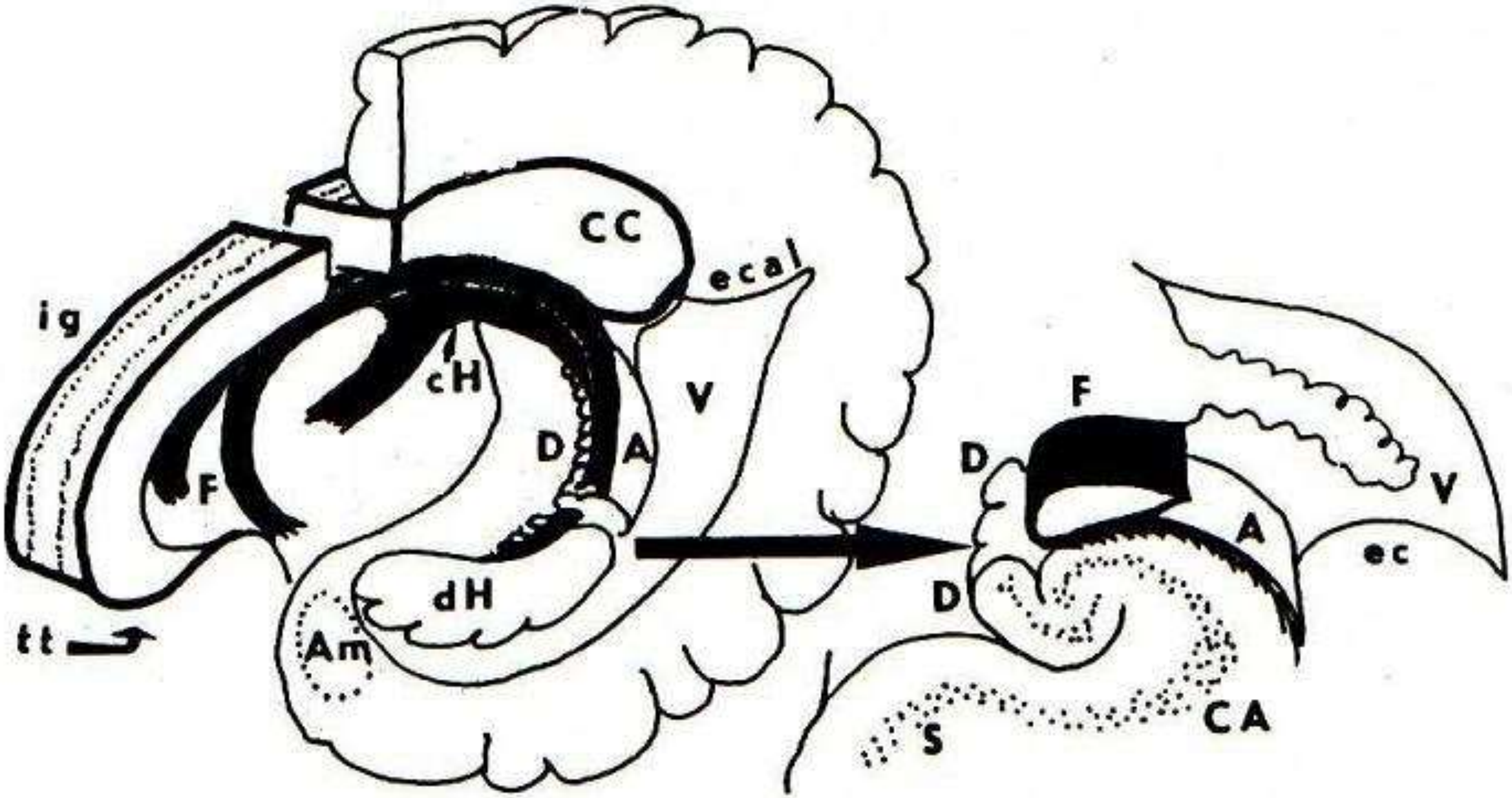
Duvernoy, The Human Hippocampus

Gyrus dentatus

(hippocampus transparent)

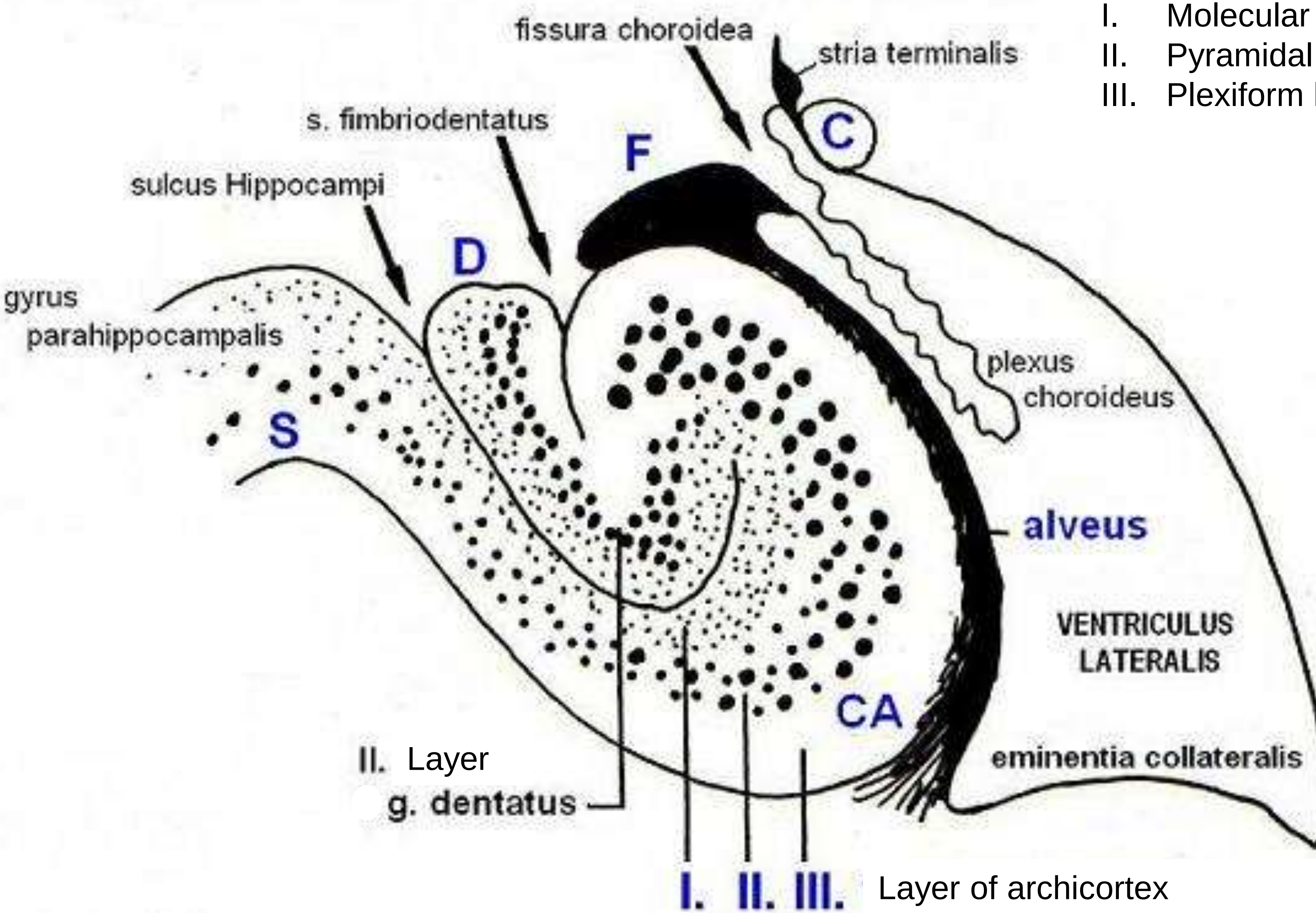


4- tenia Giacomini



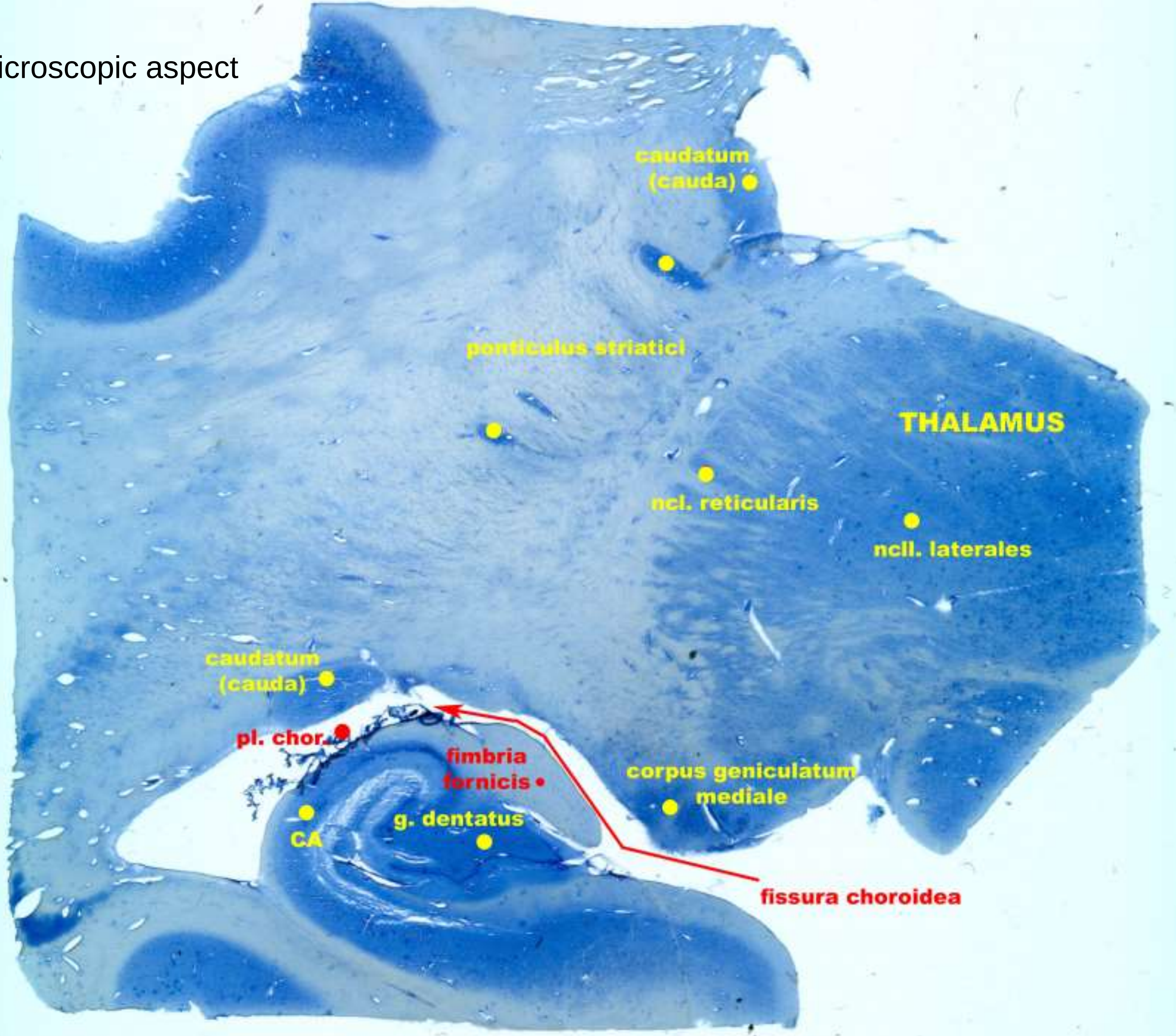
Hippocampal formation and crossection

I. Molecular layer
II. Pyramidal layer
III. Plexiform layer

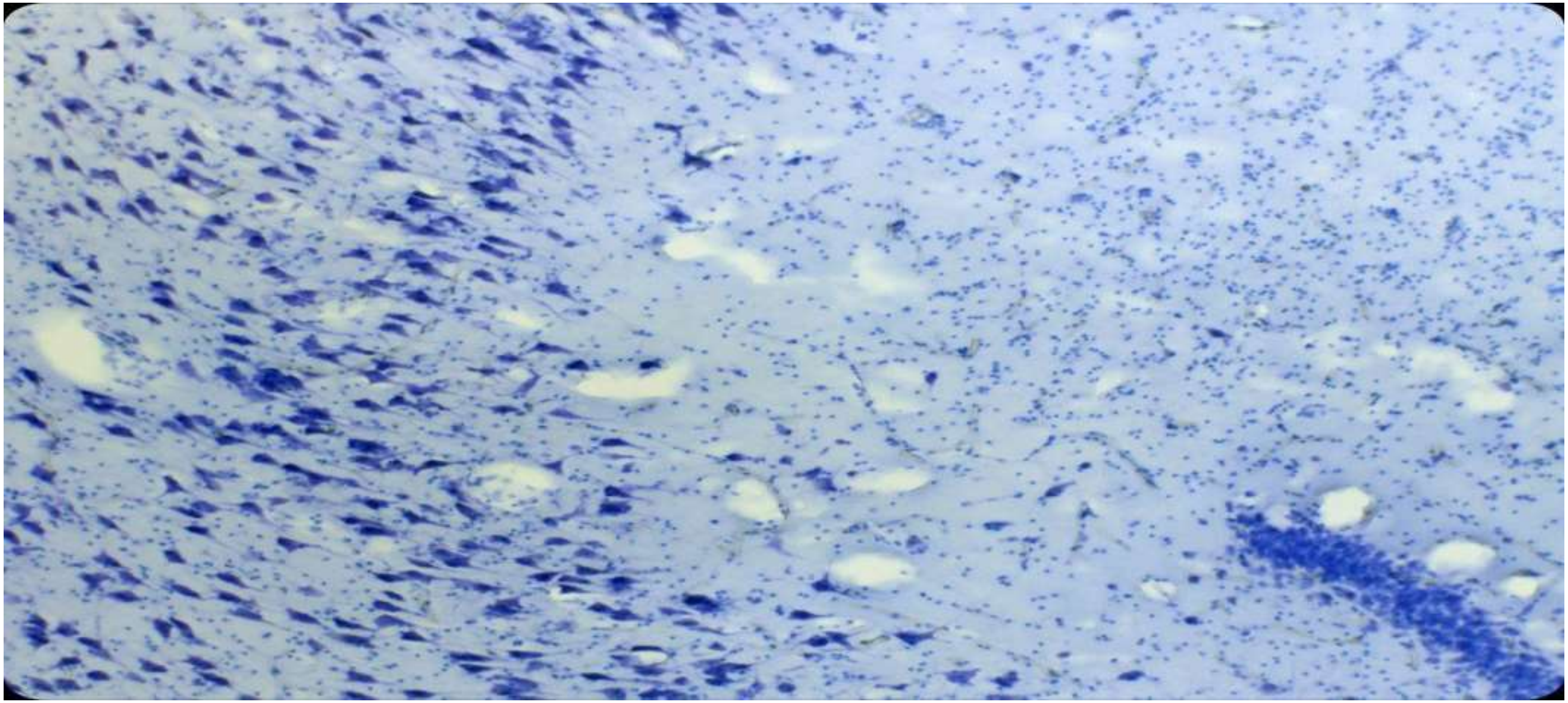


Layer of archicortex

Microscopic aspect

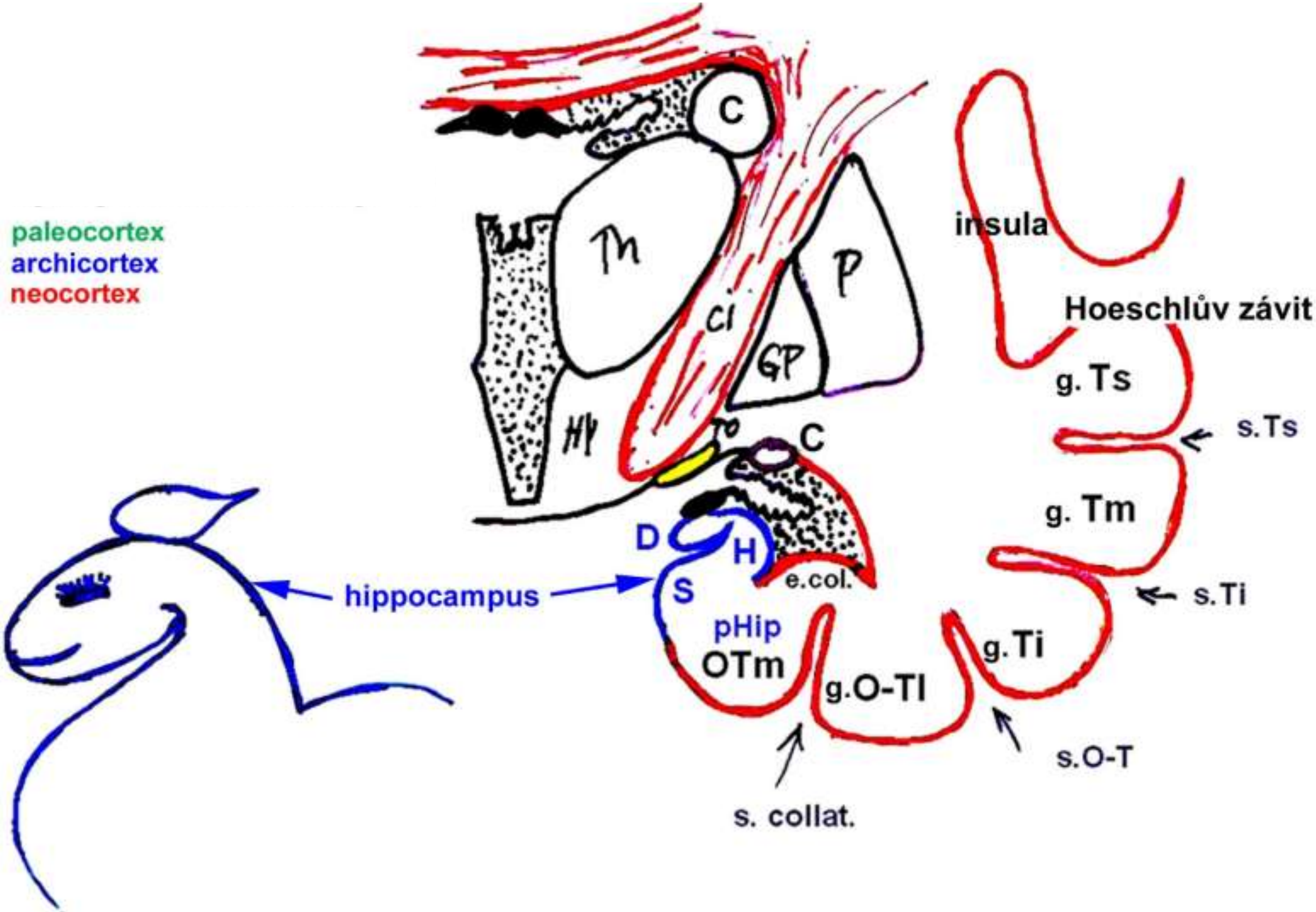


CA and subiculum – pyramidal neurons



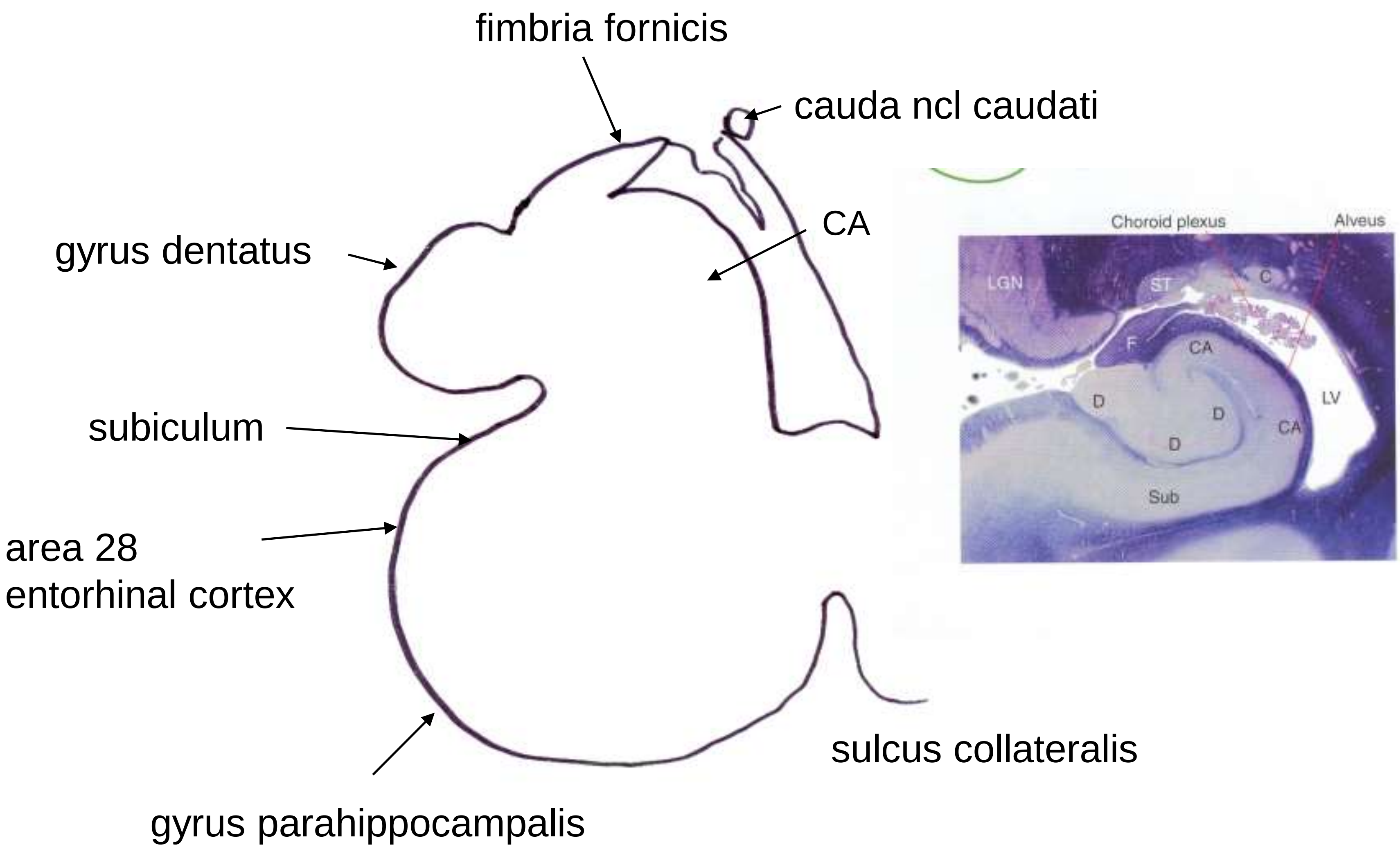
g. dentatus –
granular neurons

Frontal secion of the hippocampus



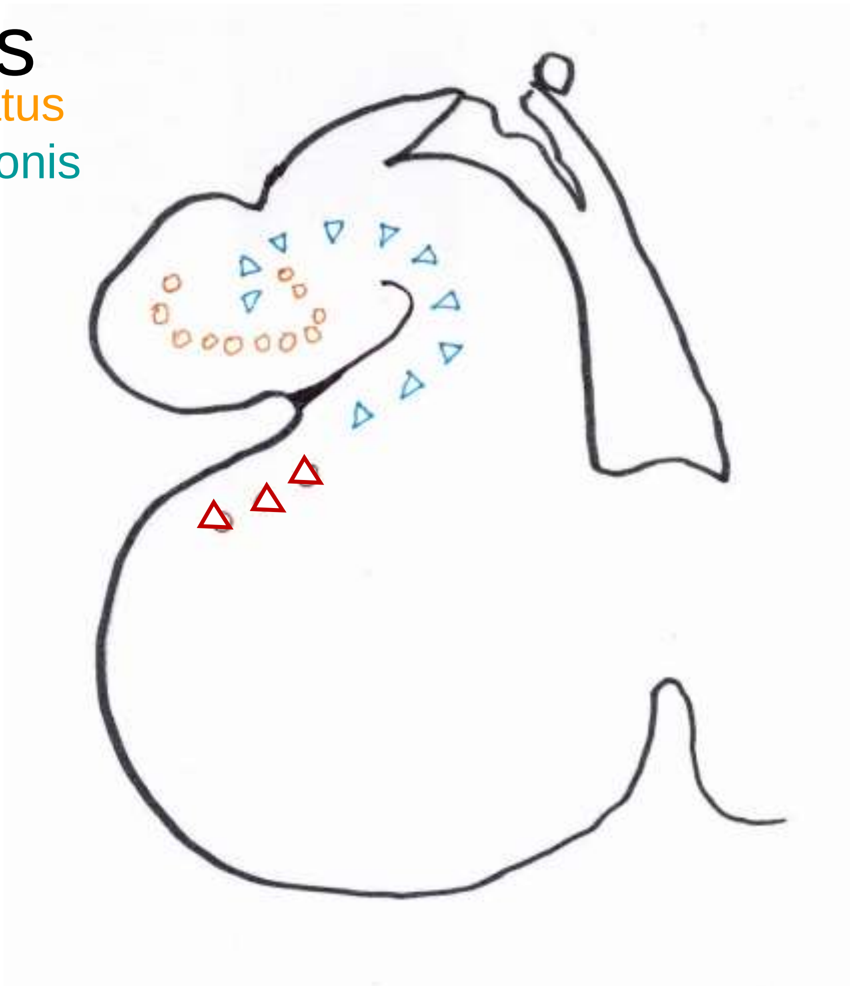
Schema prof. Petrovického

Frontal section of the hippocampus



Archicortex – hippokampal formation

- 3 parts
  gyrus dentatus
  cornu Ammonis
  subiculum

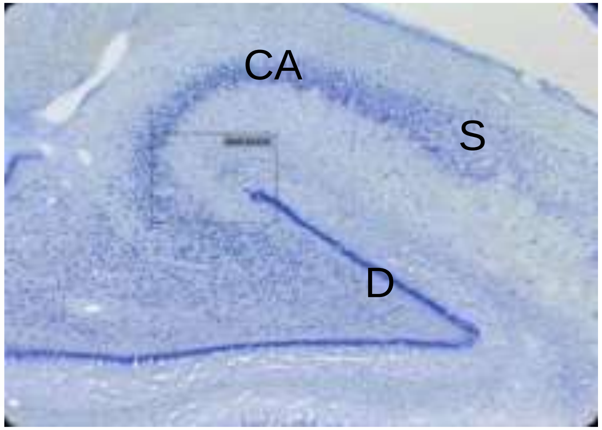


3 layers

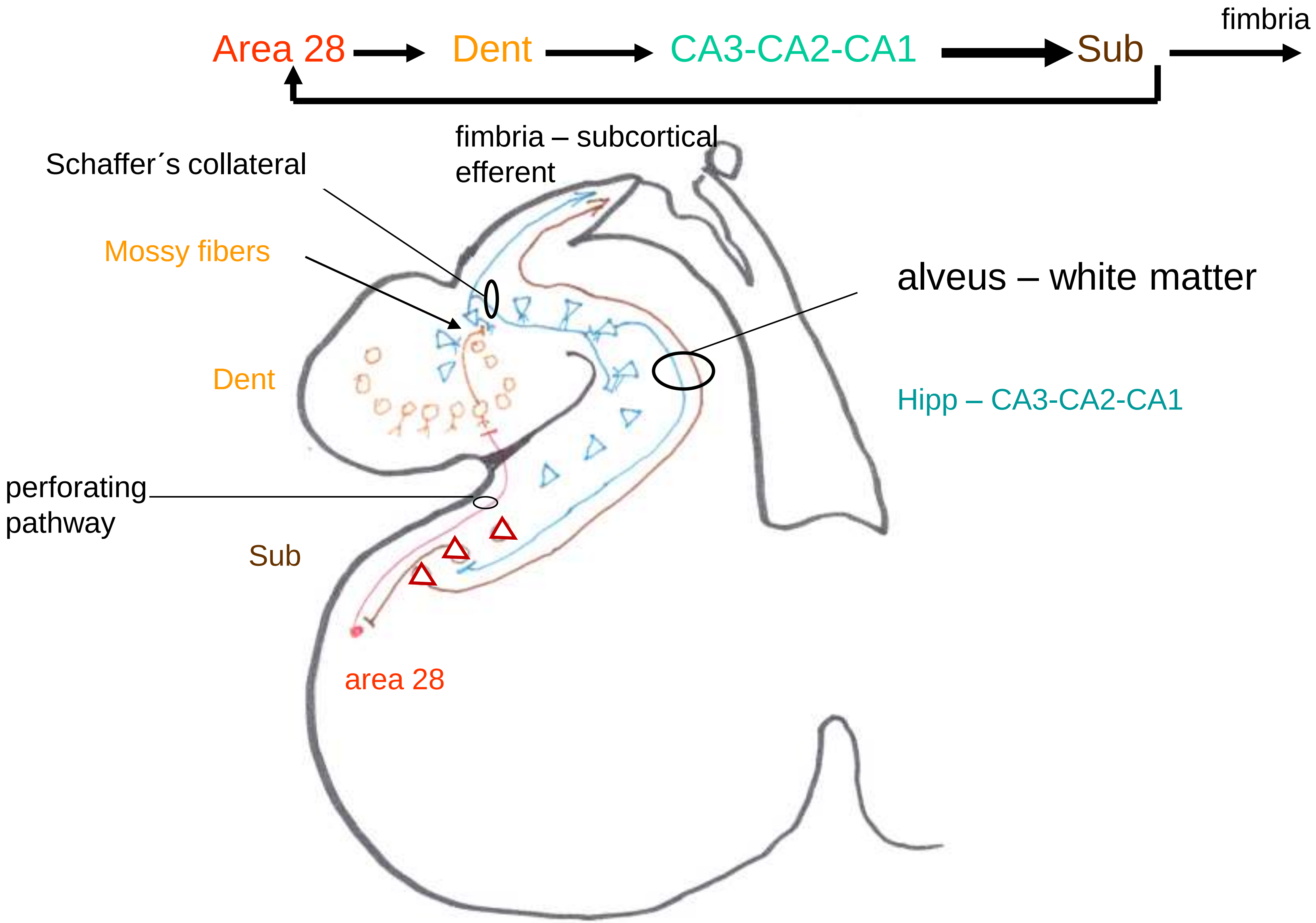
stratum moleculare

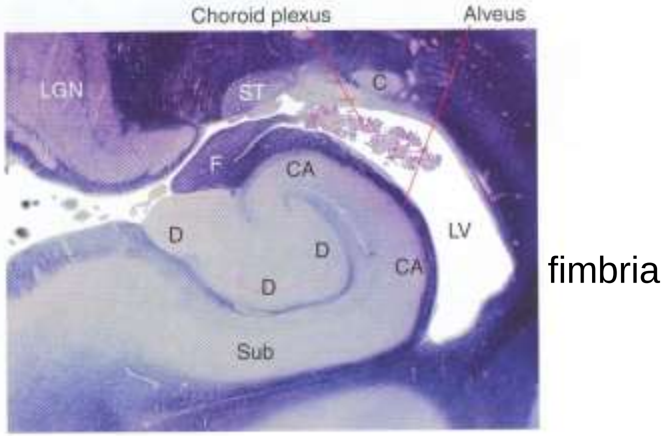
stratum pyramidale

stratum polymorfum

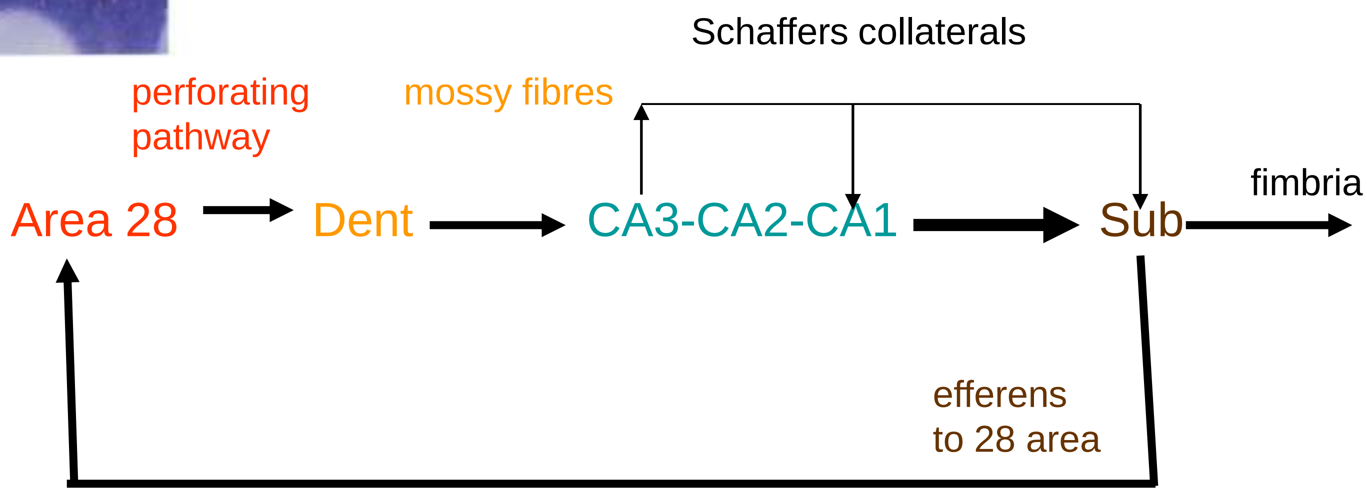


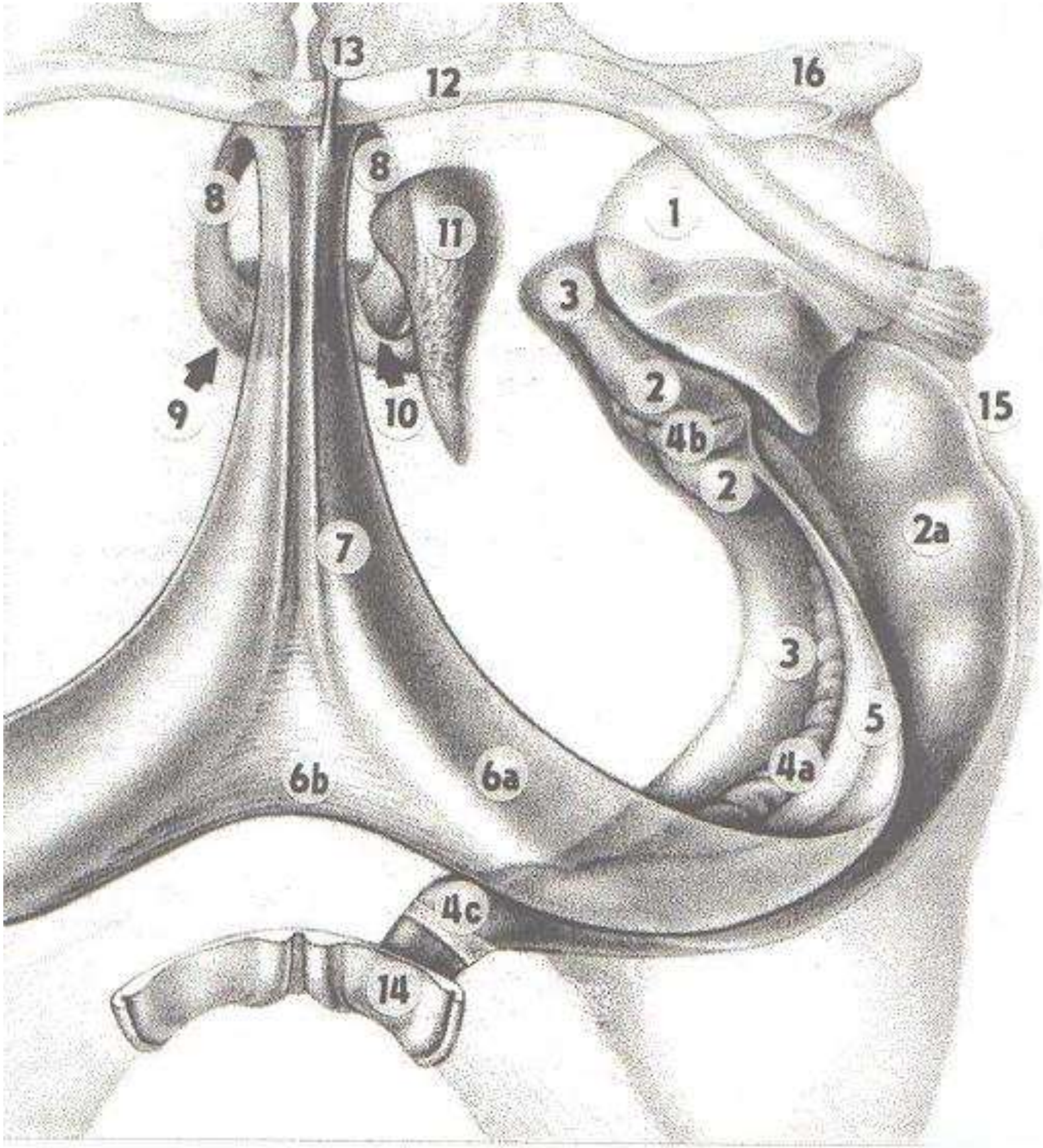
Andersen´s circuit – intrinsic hippocampal

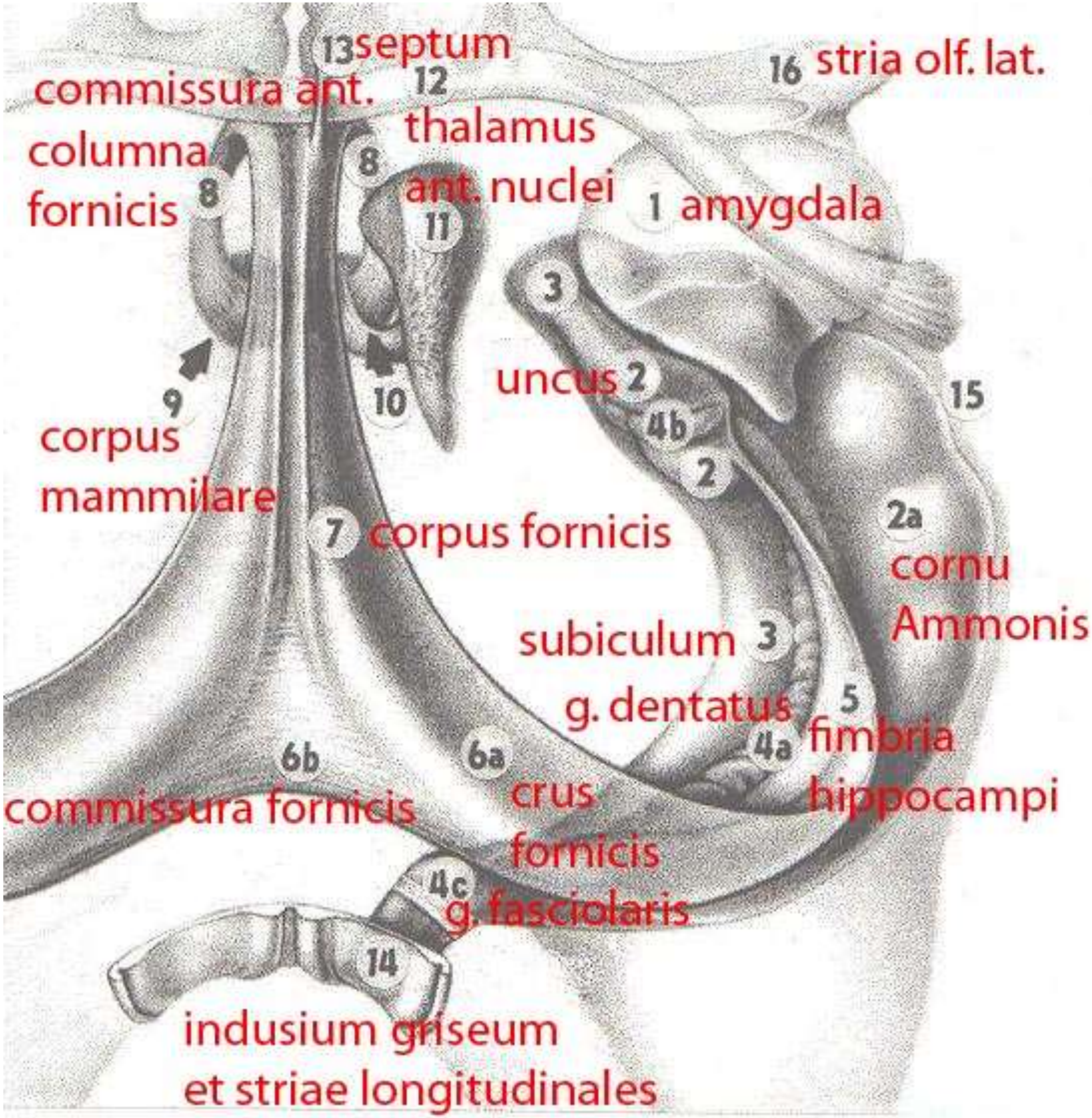




Andersens circuit –inner hippocampal

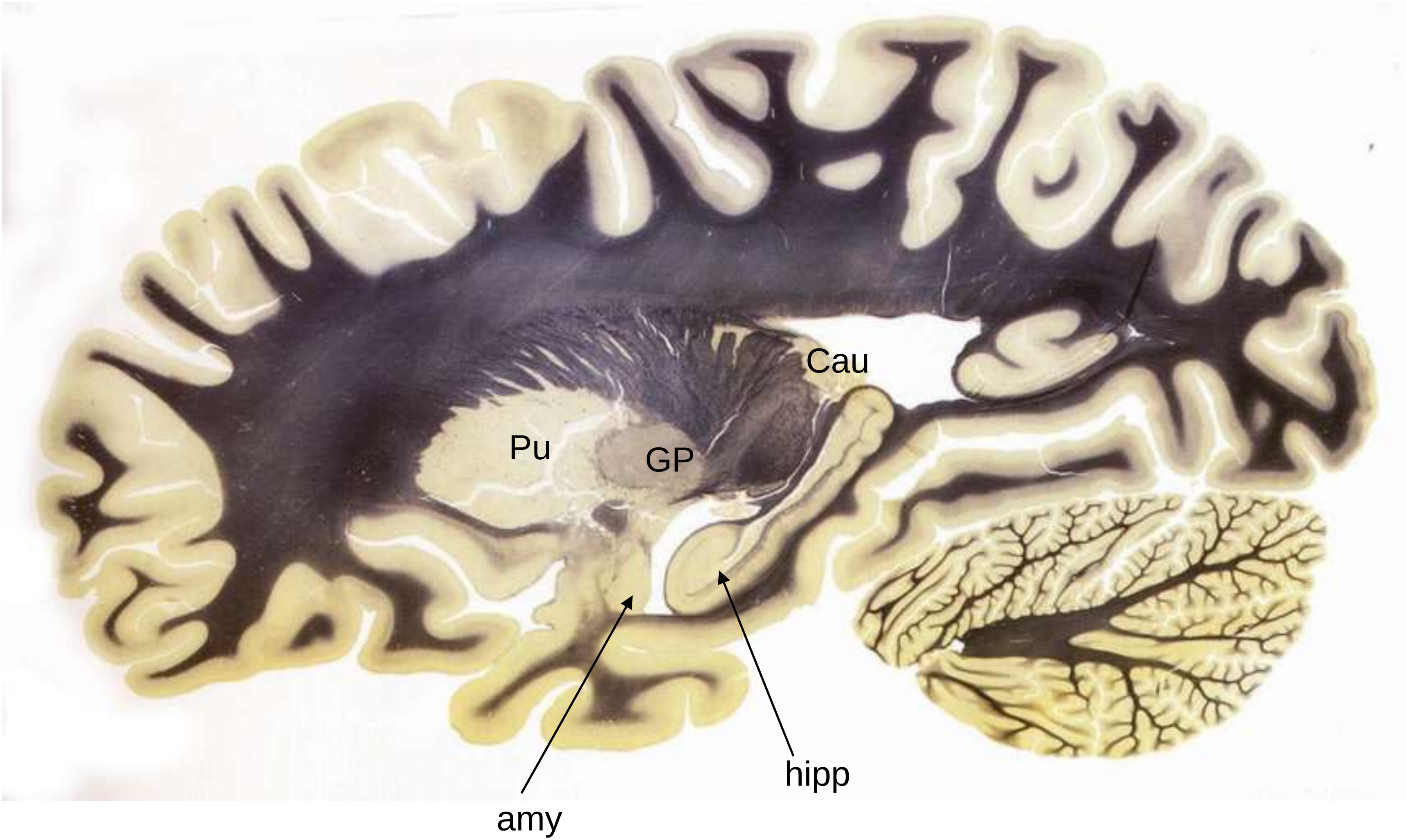


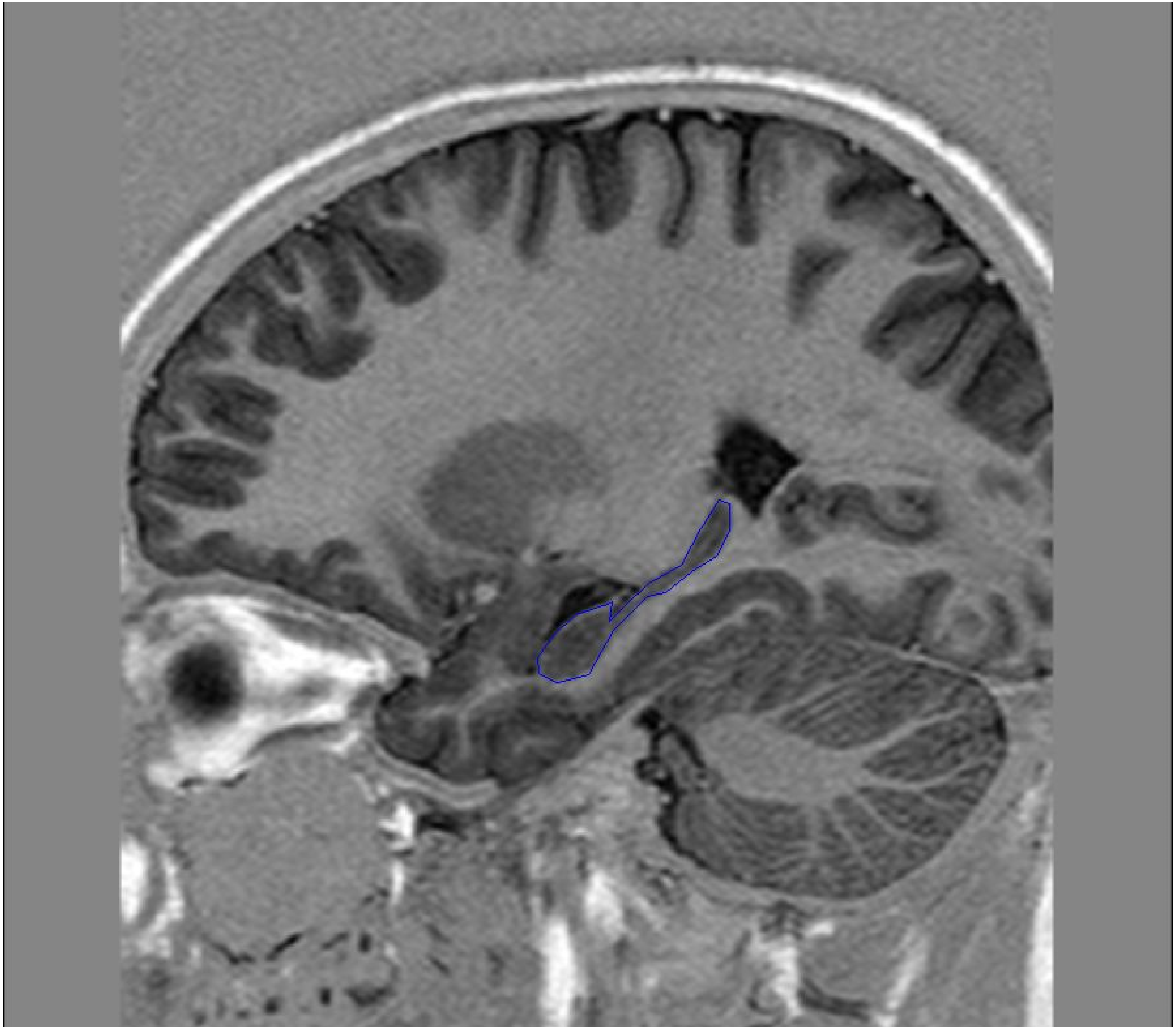

13
12
16
8
8
11
1
3
9
10
2
4b
15
2
2a
7
3
5
4a
6b
6a
4c
14



13 septum
commissura ant. 12
thalamus
columna
fornicis 8
8
ant. nuclei
11
1 amygdala
16 stria olf. lat.
3
uncus 2
4b
2
15
9
corpus
mammilare
10
7 corpus fornicis
2a
cornu
Ammonis
subiculum 3
g. dentatus 5
4a fimbria
hippocampi
6b
6a
commissura fornicis
crus
fornicis
4c
g. fasciolaris
14
indusium griseum
et striae longitudinales

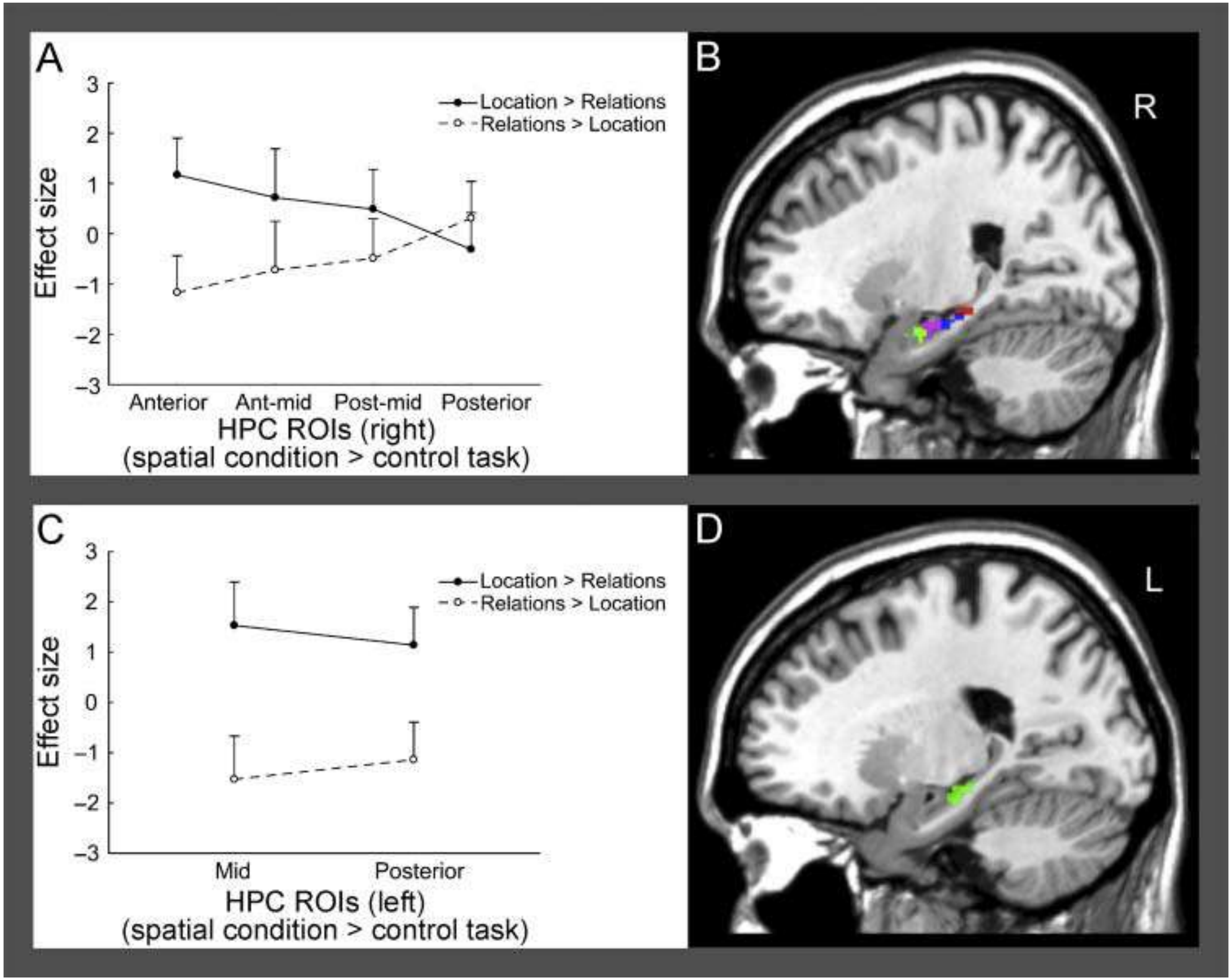
???


Cau
Pu
GP
hipp
amy



Hipp

fMRI study participants thought about episodes from their lives



Spatial Cognition and the Hippocampus: The Anterior–Posterior Axis

Lynn Nadel[1], Siobhan Hoscheidt[2], and Lee R. Ryan[1]

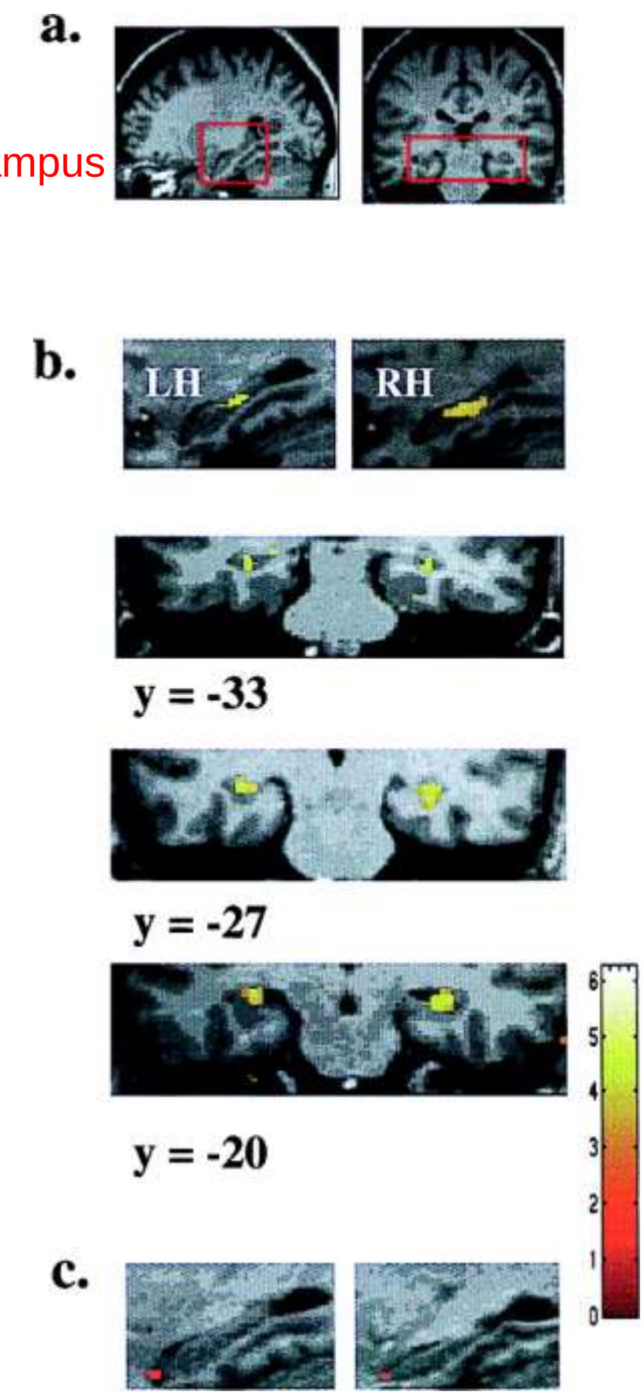
spatial relational information preferentially activated the posterior hippocampus

information about locales (or contexts) preferentially activated the anterior hippocampus

location-specific =green,
relations-specific = red, overlapping = violet and blue

VBM findings.

London taxi drivers have greater volume of posterior hippocampus



. (a Left) Sagittal section of an MRI scan with the hippocampus indicated by the red box. (a Right) Coronal section through the MRI scan, again with the hippocampi indicated.

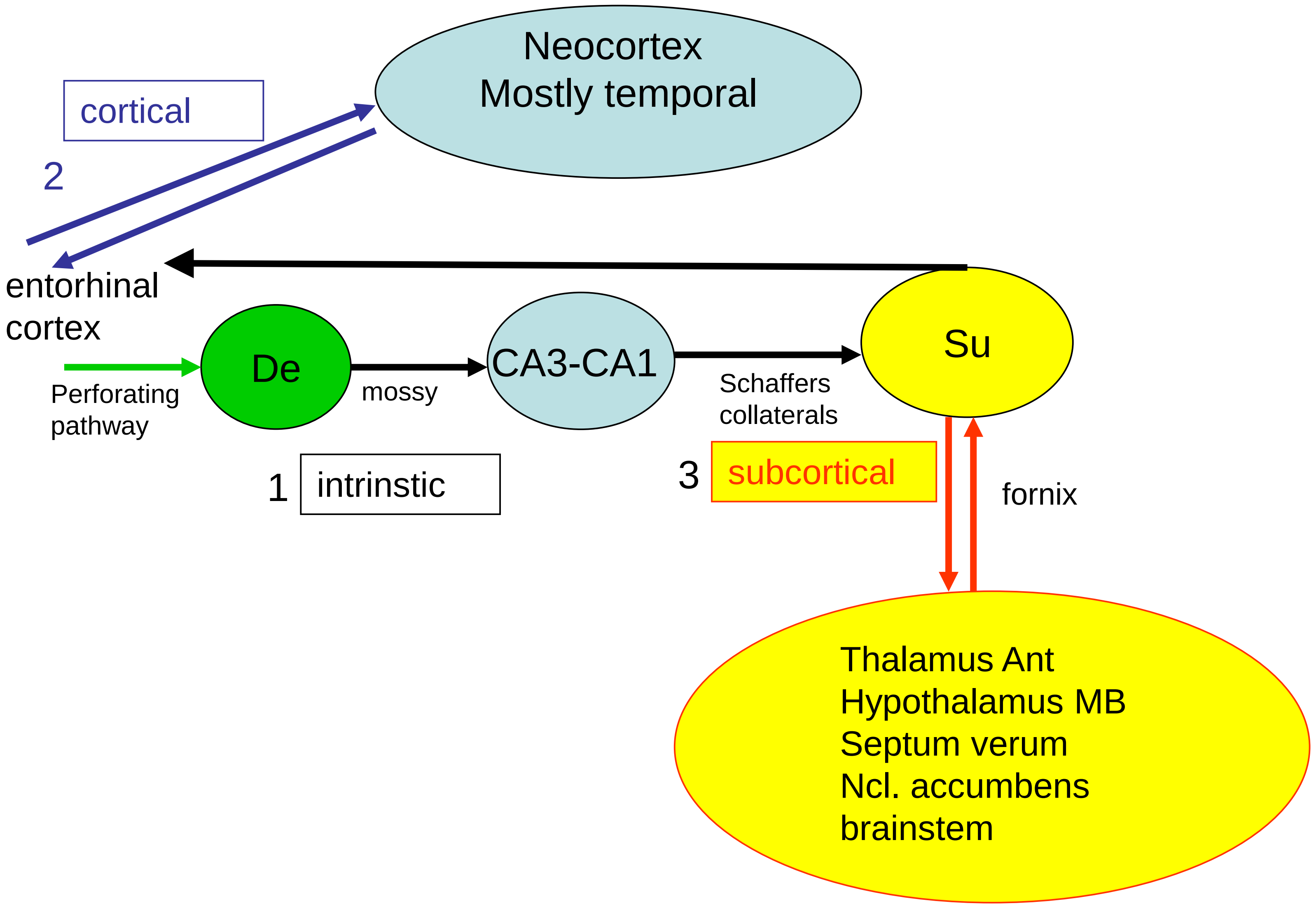
(b). Increased gray matter volume in the posterior of the left and right hippocampi (LH and RH, respectively) of taxi drivers relative to those of controls, shown in the top of the figure in sagittal section. Underneath, the areas of gray matter difference are shown in coronal sections at three different coordinates in the y axis to illustrate the extent of the difference down the long axis of the hippocampus.

(c) Increased gray matter volume in the anterior of the left and right hippocampi of controls relative to those of taxi drivers, shown in sagittal section.

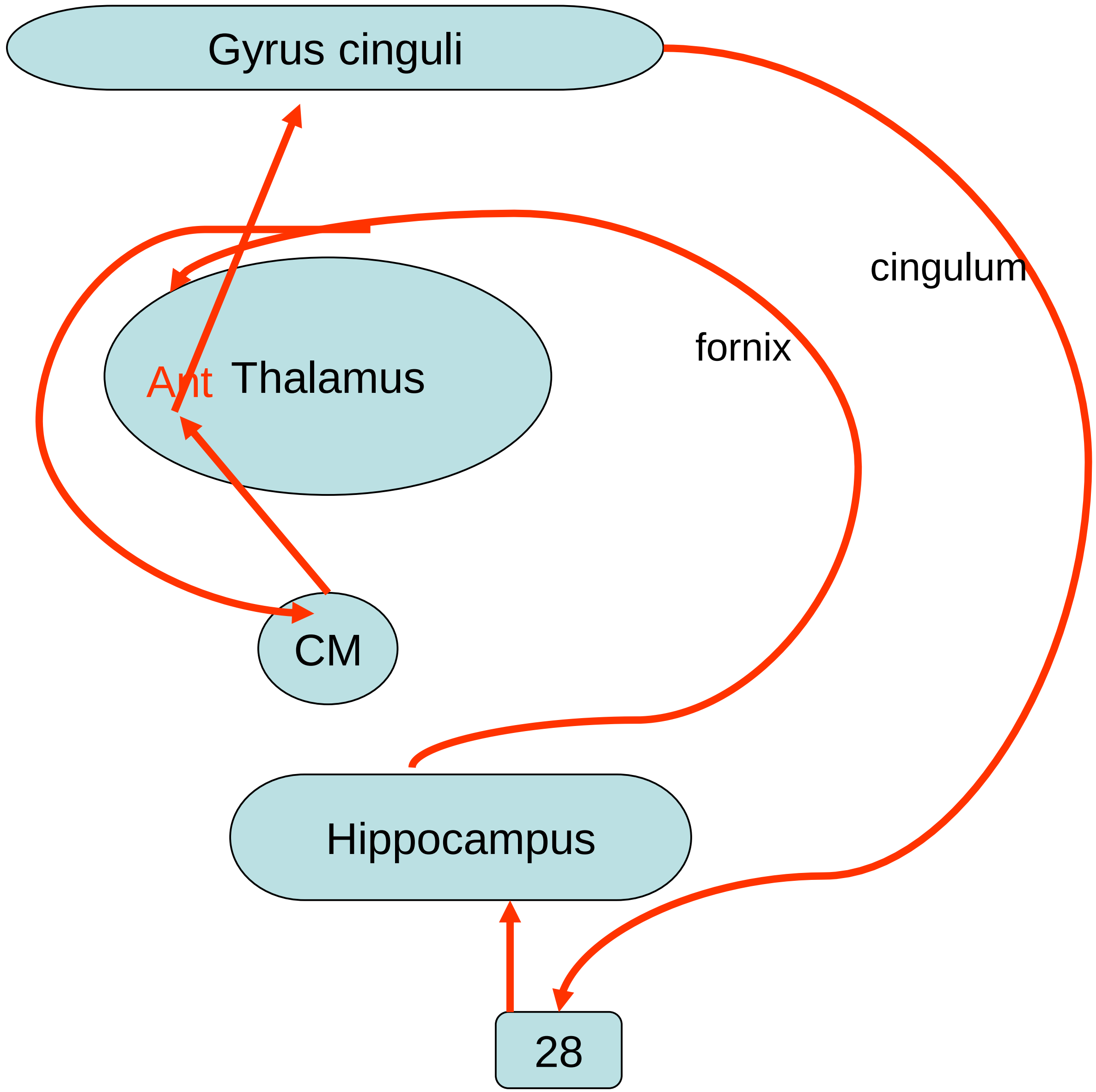
Maguire E A et al. PNAS 2000;97:4398-4403

PNAS

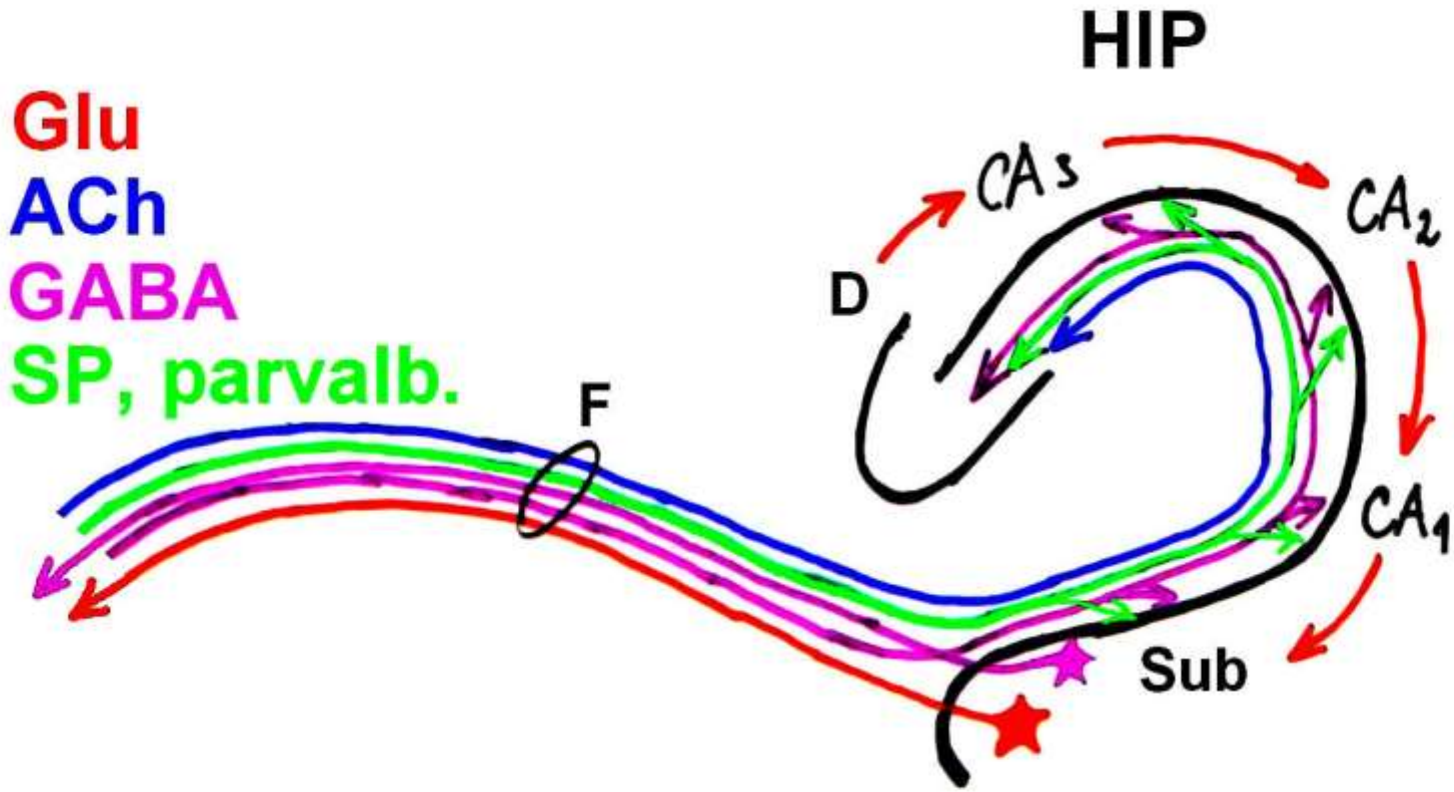
Hippocampal circuits



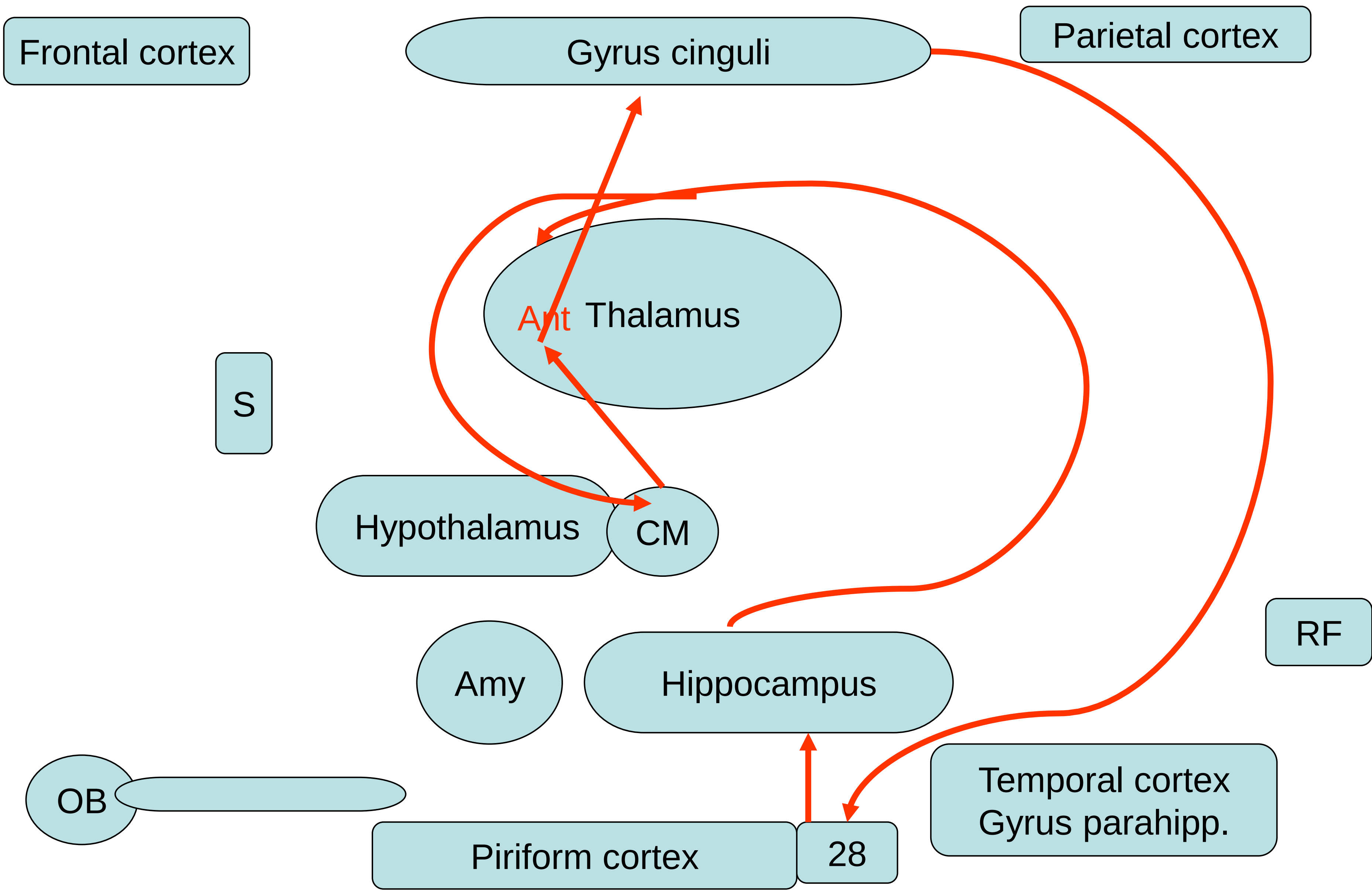
Papez circuit



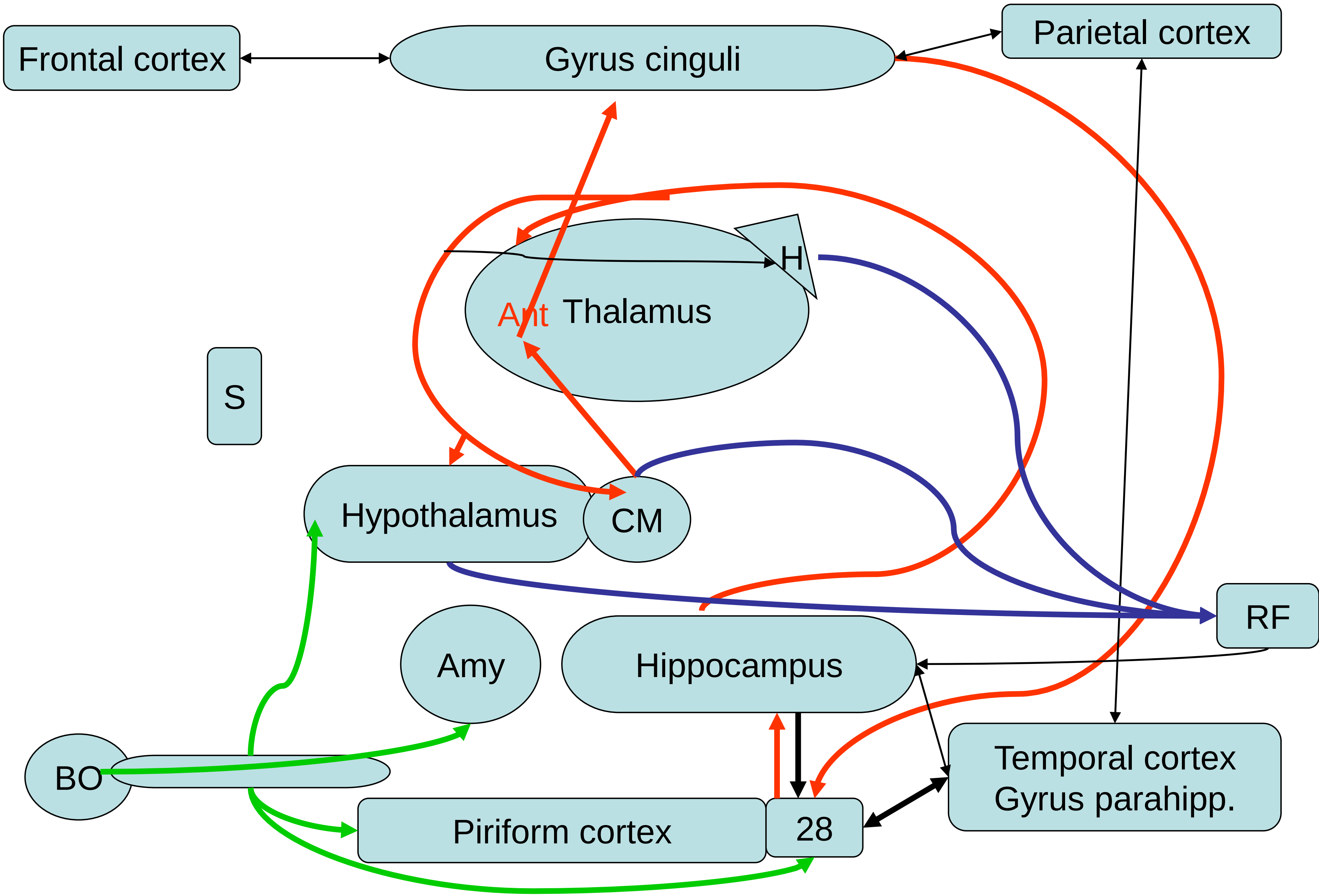
Neurotransmitters in fibers of fornix



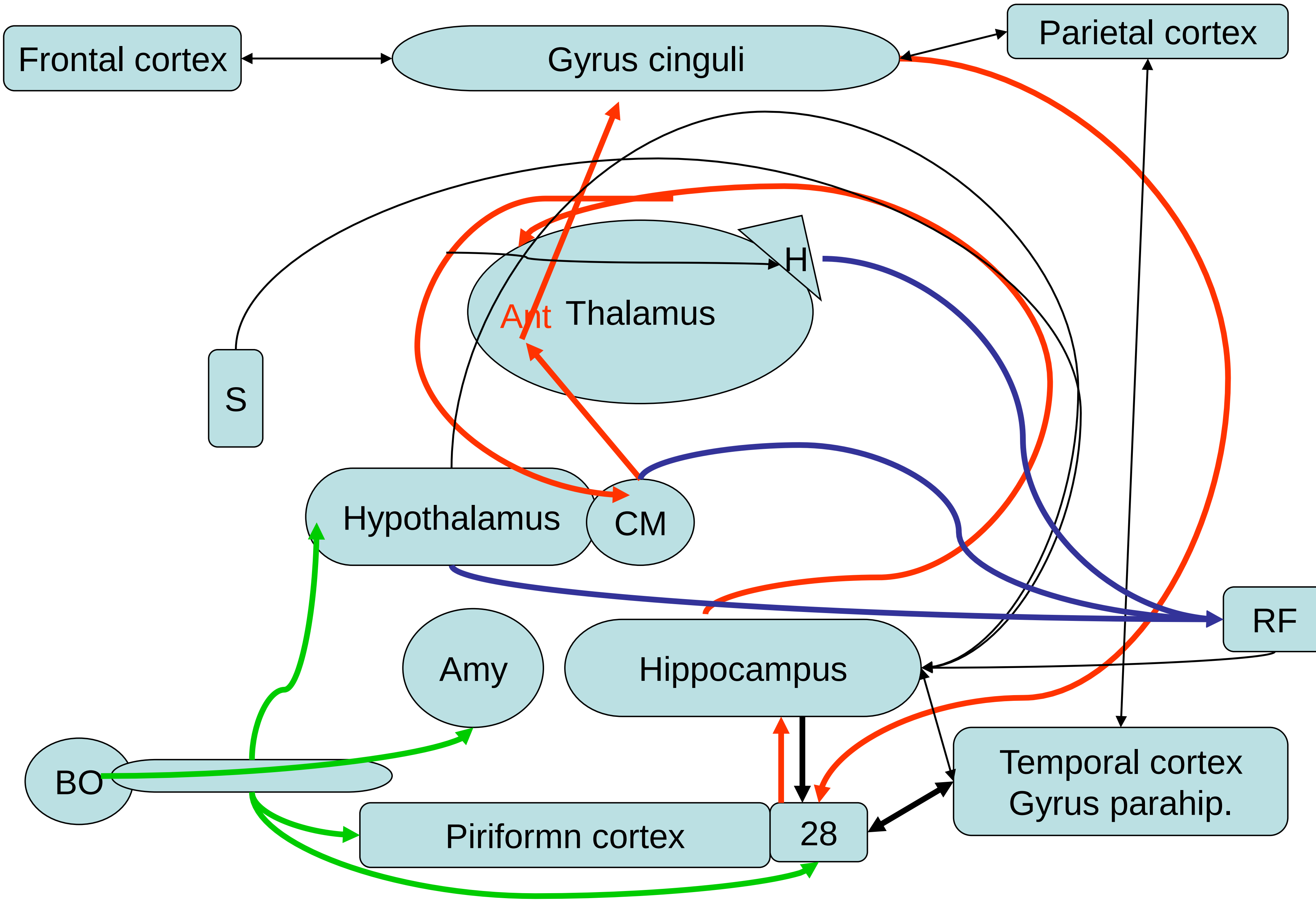
Fornix = 1) subcortical efferent of hippocampal formation
2) contains afferent fibers from septum (ACh)



Frontal cortex
Gyrus cinguli
Parietal cortex
Ant
Thalamus
S
Hypothalamus
CM
RF
Amy
Hippocampus
OB
Temporal cortex
Gyrus parahipp.
Piriform cortex
28



Frontal cortex
Gyrus cinguli
Parietal cortex
H
Ant
Thalamus
S
Hypothalamus
CM
RF
Amy
Hippocampus
BO
Temporal cortex
Gyrus parahipp.
Piriform cortex
28


Frontal cortex
Gyrus cinguli
Parietal cortex
H
Ant
Thalamus
S
Hypothalamus
CM
RF
Amy
Hippocampus
BO
Temporal cortex
Gyrus parahip.
Piriformn cortex
28

Fornix projets to:

- Ncl. anteriores thalami
- Habenula
- Septum
- Hypothalamus
- Nucleus accumbens

Hippocampus and a entorhinal cortex spatial cognition

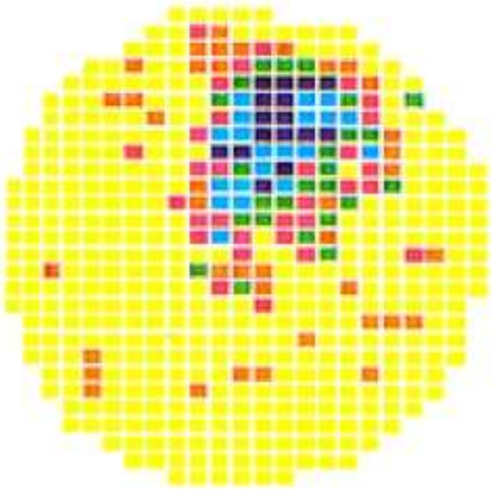
Cells with characteristic firing pattern that encodes spatial parameters relating to the animal's current position and orientation.

Place cells of hippocampus – maps of enviroment -John O'Keef

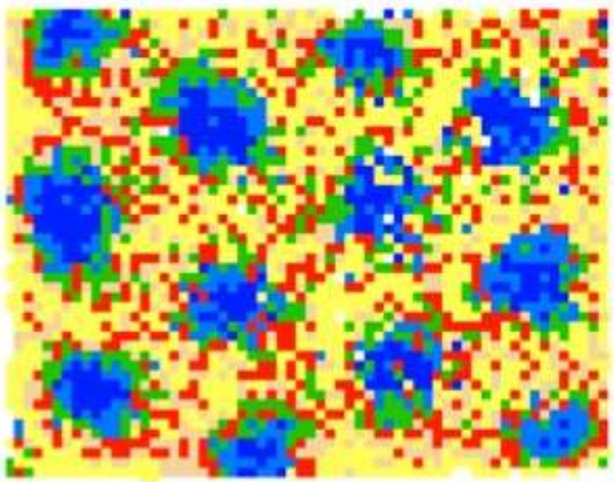
Grid cells area 28 –– Moser and Moser

Head position cells area 28

Boundary cells area 28 + subiculum, pre- and parasubiculum specialized to code environmental boundaries



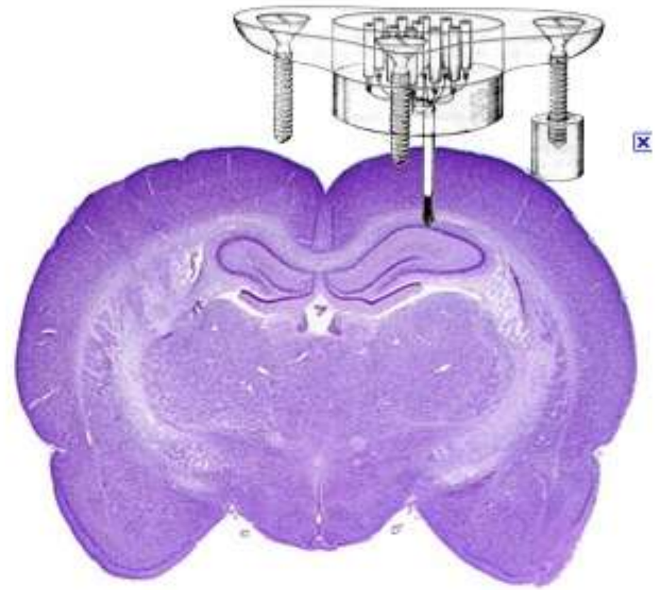
place cell

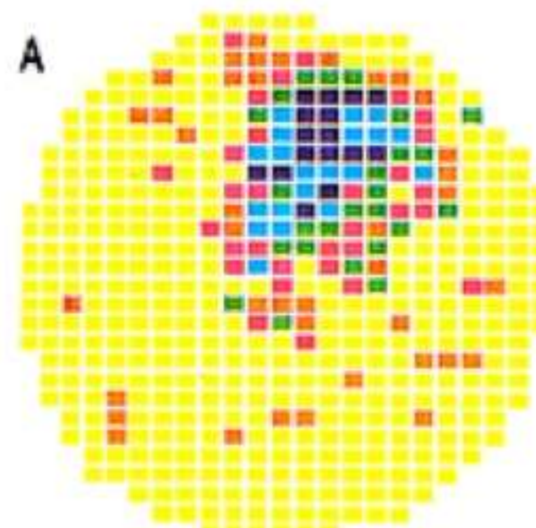


grid cell

Place Cell Recording

electrode

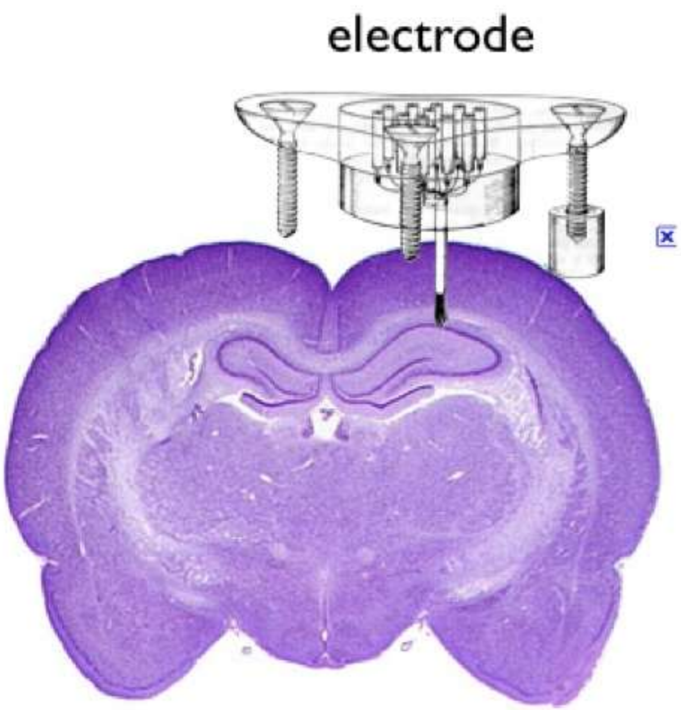


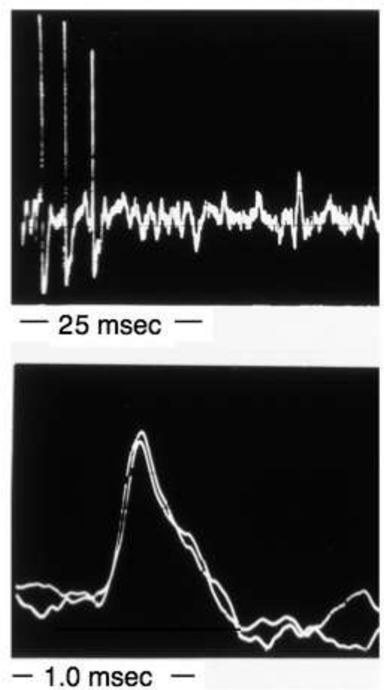


Hippocampus and a entorhinal cortex
spatial cognition

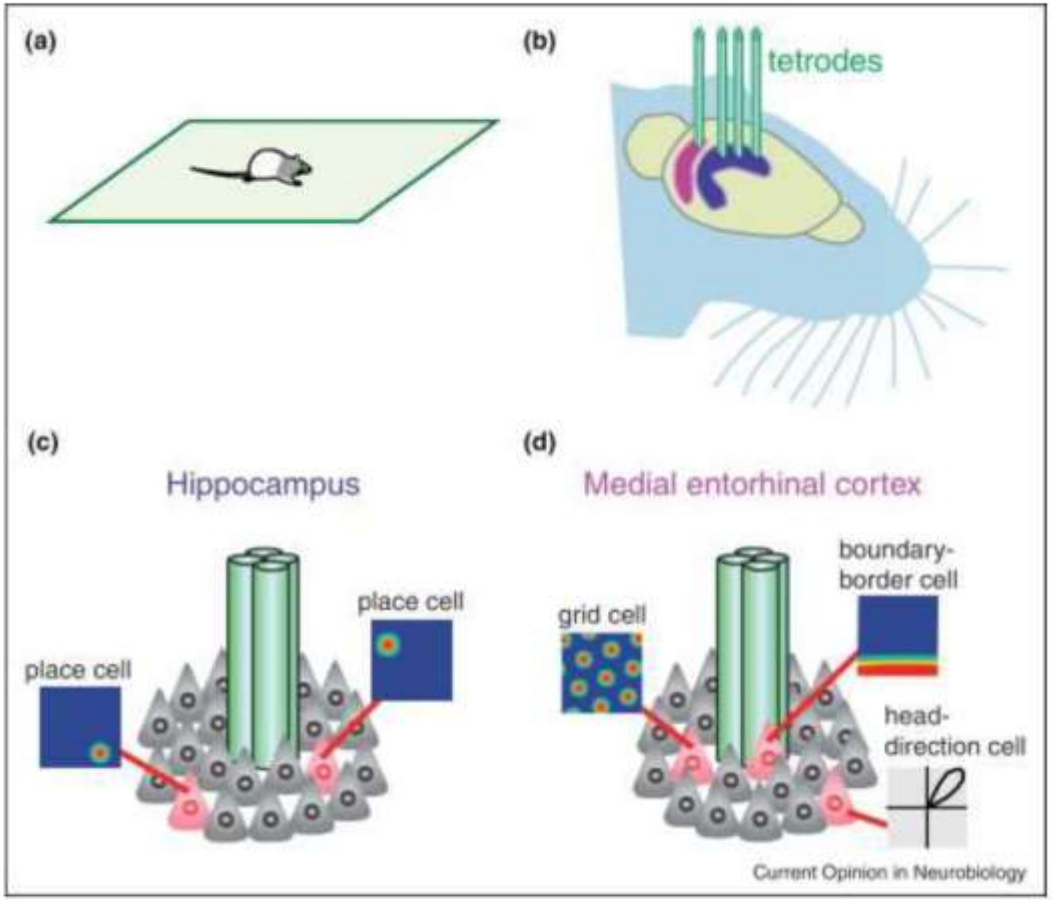
O'Keefe + Nadel

1) "Place-cells" John O'Keefe, 1971
in hippocampus
2) „grid cells“ Edward and May-Britt Moser, 2005
In medial entorhinal cortex





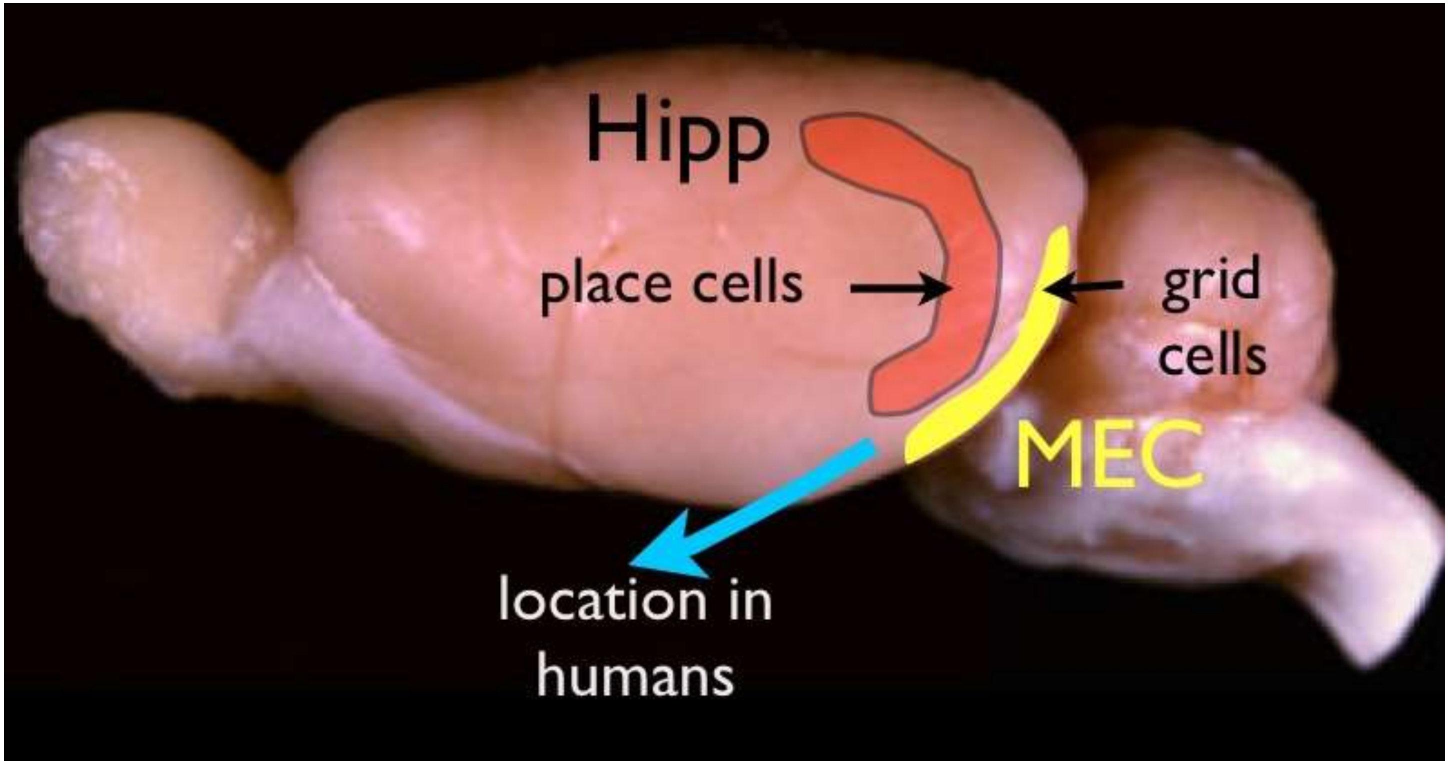
Edward and May-Britt Moser



Spatial and memory circuits in the medial entorhinal cortex

- Takuya Sasaki[1],
- Stefan Leutgeb[1, 2],
- Jill K Leutgeb

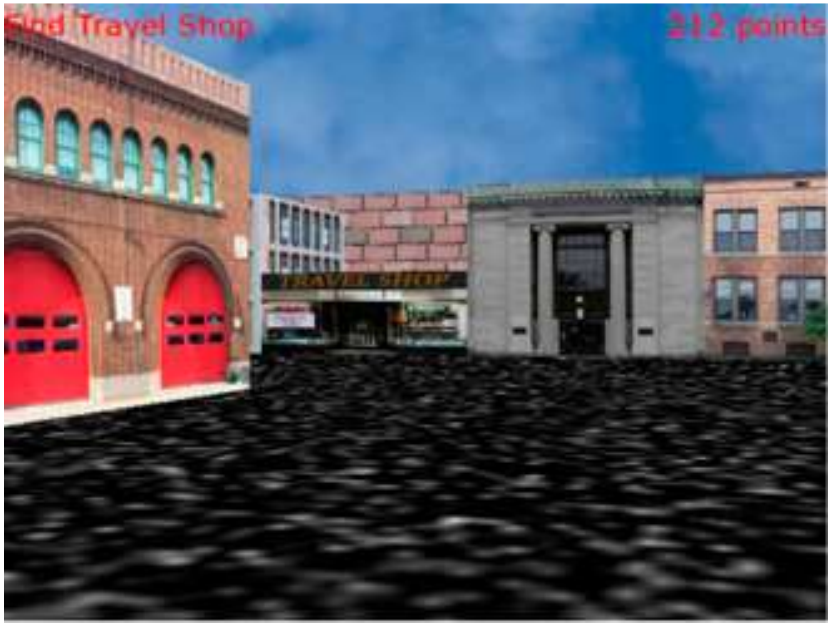
(a) While rats explore an environment the activity patterns of populations of neurons can be monitored using large-scale recording techniques. **(b)** Recording arrays with multiple independently moveable electrode bundles that each consist of four electrodes (*i.e.*, tetrodes) allow for the sampling of large brain regions within the rodent brain. Here, the medial entorhinal cortex (MEC) is shown in purple and the hippocampus in blue. **(c)** and **(d)** The four electrodes that comprise a tetrode can record the action potentials of dozens of neurons located in close proximity to the electrode tip. This method, used in awake-behaving rats, has revealed distinct functional cell types in MEC and in hippocampus and has been critical for determining network computations by simultaneously monitoring the activity patterns of a large number of neurons. (c) Hippocampal principal neurons are spatially tuned and fire action potentials at distinct locations in an environment that an animal actively explores (see (a)). Firing rate maps are shown for two active place cells (highlighted in pink). For rate maps, peak rates are indicated in red, zero firing in blue. (d) Grid cells, border cells, and head-direction cells comprise a large fraction of the cells in MEC.



Thelma

Grid neurons in the brain activate during navigation to help humans keep track of where they are

Michael Kahana of Penn, and Itzhak Fried of UCLA



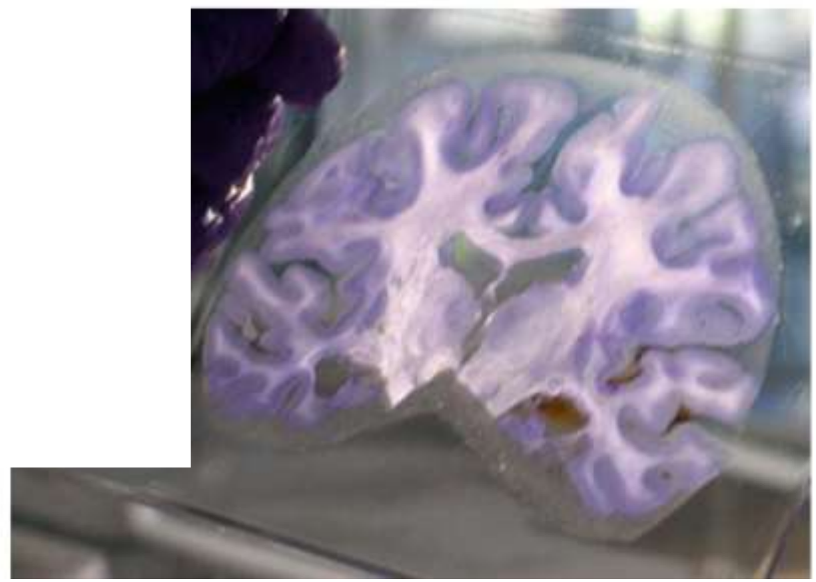
Humans have
in enthorhinal cortex „path cells and grid cells
In hippocampus – place cells

http://www.foxnews.com/science/2013/08/05/grid-cells-help-humans-navigate/#

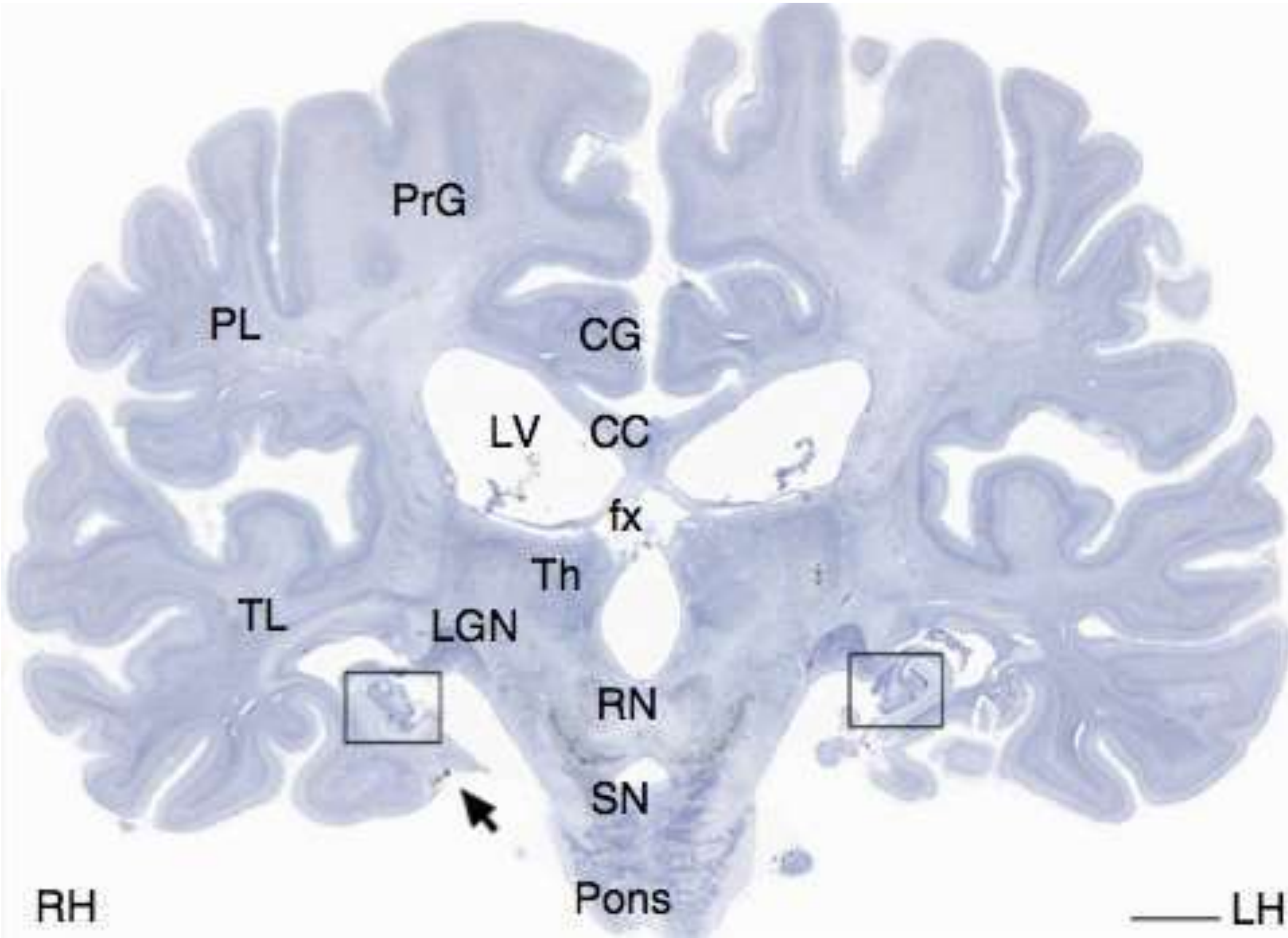
Pacient H.M.

Henry Molaison

At 7 years – injury – epileptic seizures
At 27 years there were bilateraly removed temporal lobes
Anterograde amnesia
He was good in crosswords
He lived untill 83 years



Pacient H.M.



Suzanne Corkin et al. J. Neurosci. 1997;17:3964-3979

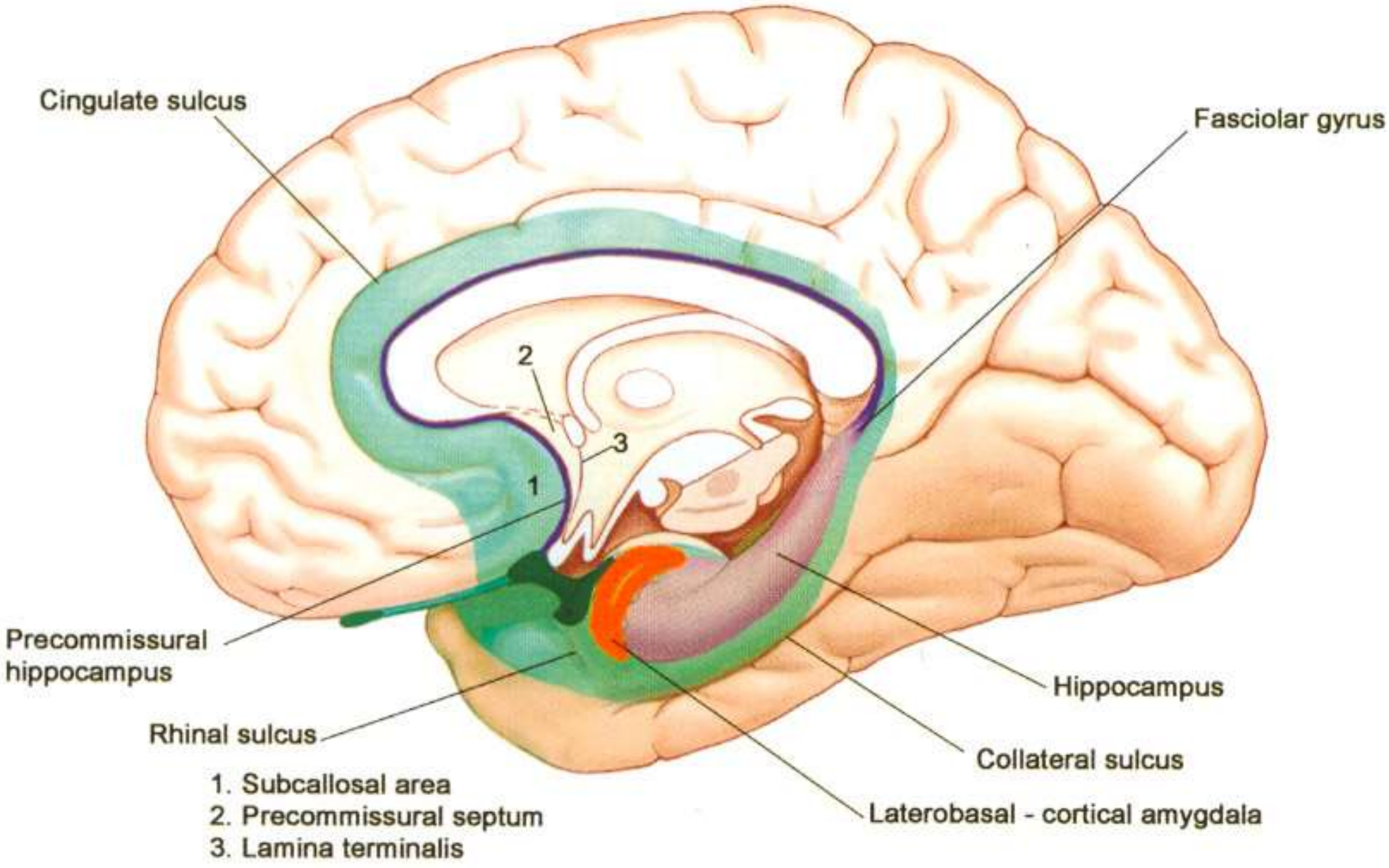
A fast, subcortical pathway to the amygdala is thought to have evolved to enable rapid detection of threat.

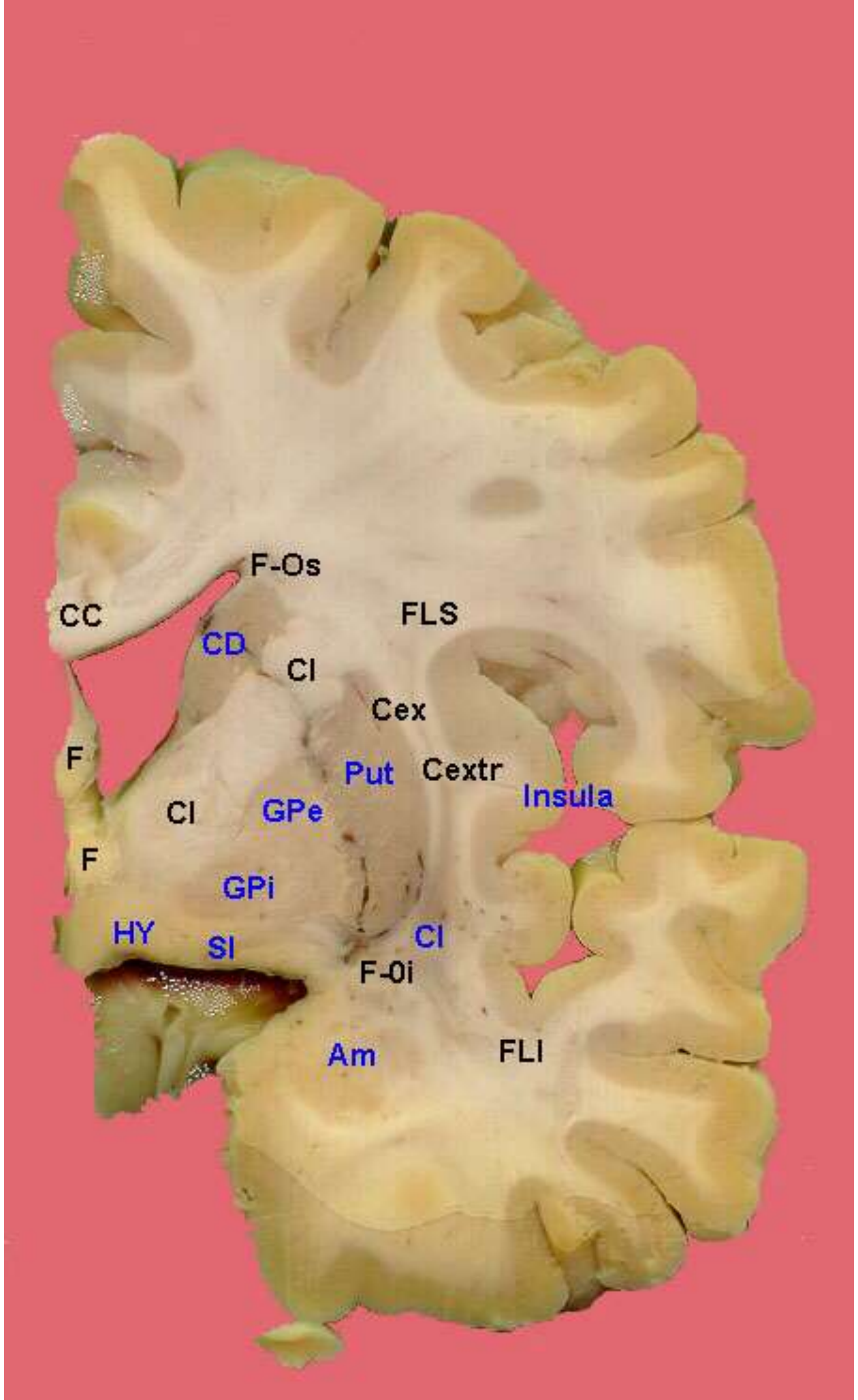
Activation of amygydala by fearful face

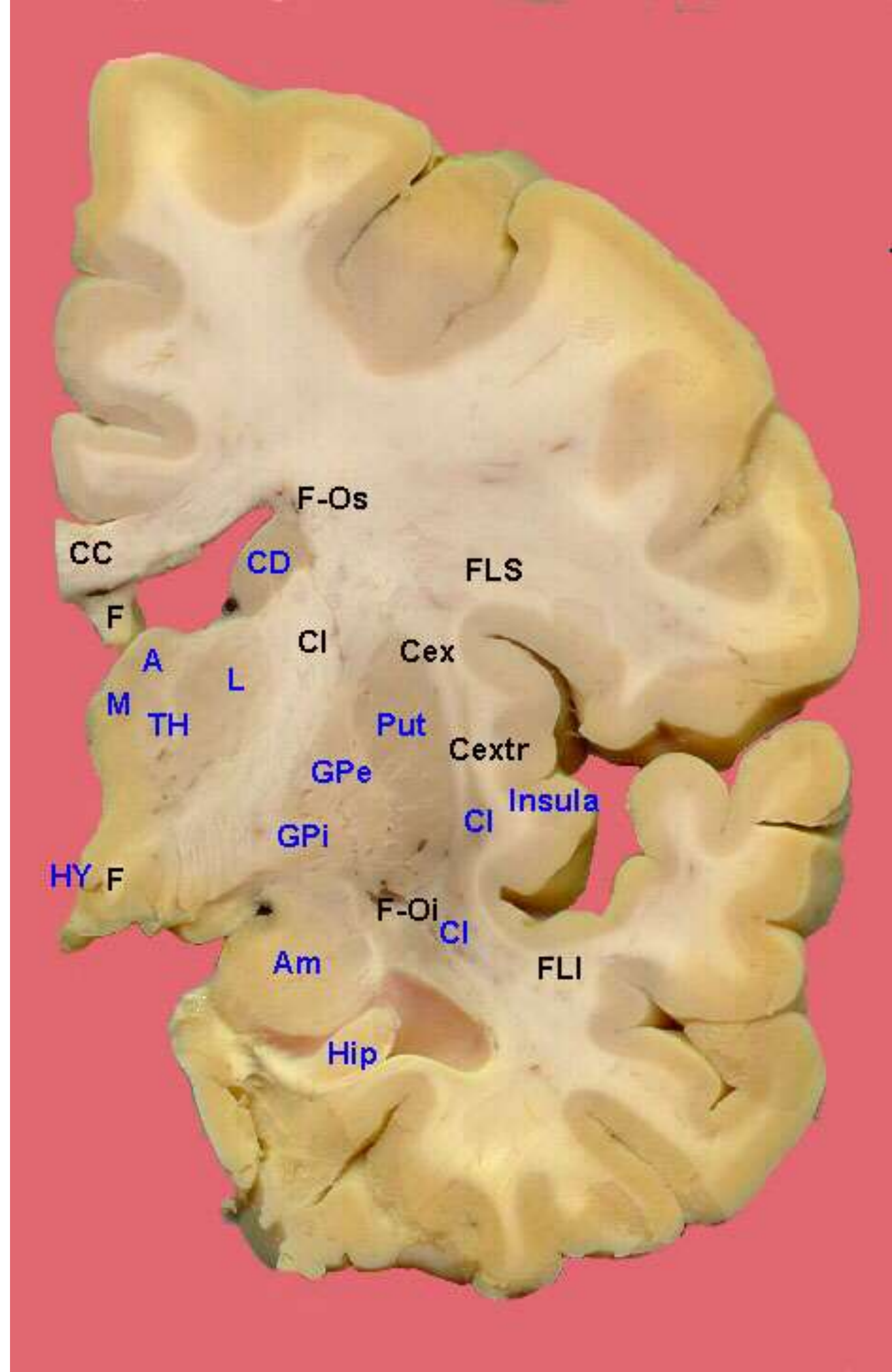
74-ms post-stimulus onset, to fearful, but not neutral or happy, facial expressions

Nature Neuroscience **A fast pathway for fear in human amygdala**
Constantino Méndez-Bértolo,[1, 2, n1] Stephan Moratti,[1, 3, 4, n1] Rafael Toledano,[5] Fernando Lopez-Sosa,[1] Roberto Martínez-Alvarez,[6] Yee H Mah,[7] Patrik Vuilleumier,[8] Antonio Gil-Nagel[5] & Bryan A Strange[1, 9]
Nature Neuroscience **Volume:** 19, **Pages:** 1041–1049 (2016)

Amygdala in limbic system




F-Os
CC
FLS
CD
Cl
Cex
F
Put
Cextr
Insula
Cl
GPe
F
GPi
HY
Cl
SI
F-0i
Am
FLI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F-Oi
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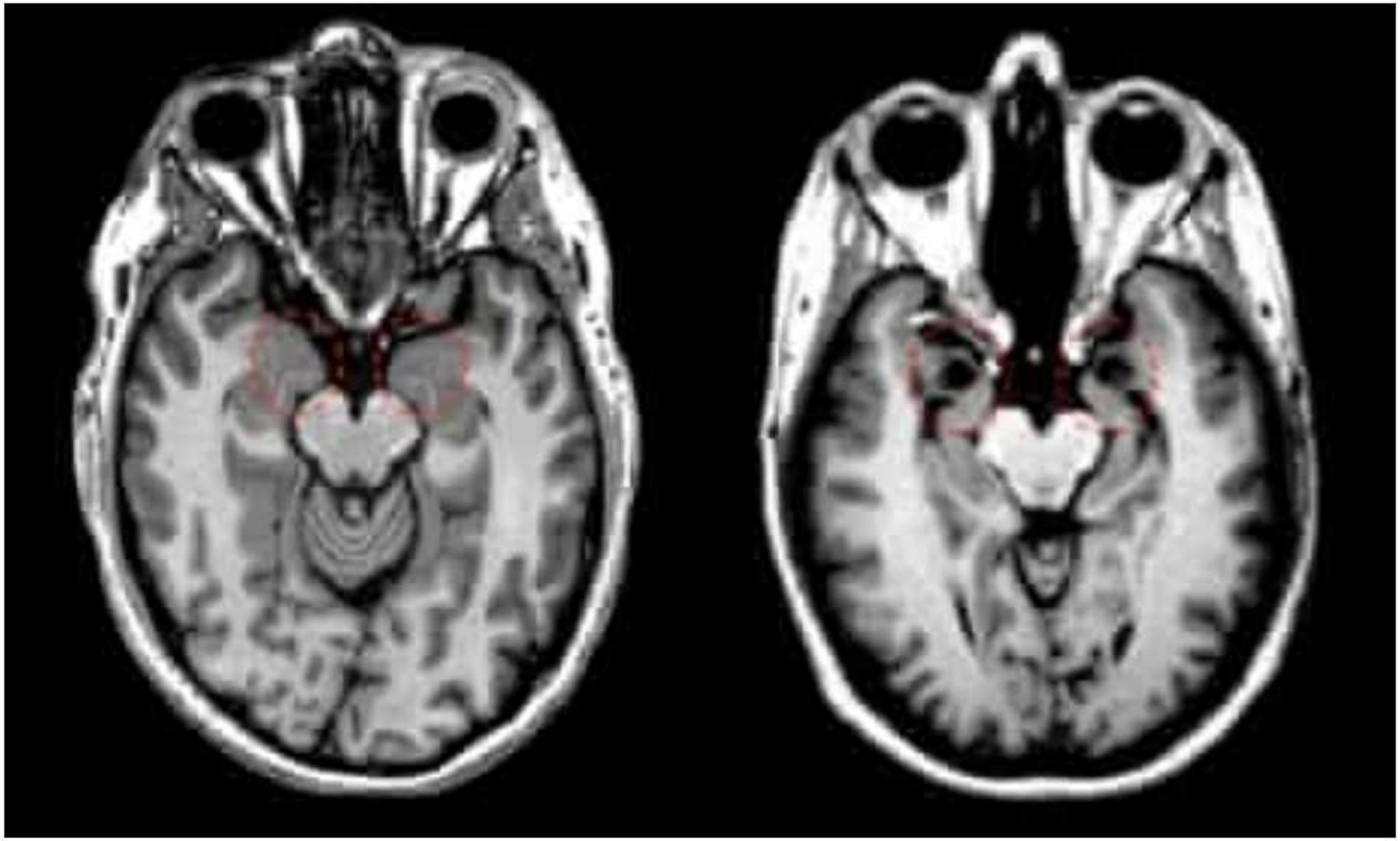
FLI
Hip

Pacient S.M. bilateral amygdalar degeneration (Urbach-Wiethe disease)



▲ MRI scans show the brain of a healthy, neurologically intact individual (left) and focal bilateral amygdala damage in patient S.M. (right, circled in red). Photograph: Iowa Neurological Patient Registry/University of Iowa

The human amygdala and the induction and experience of fear, Feinstien JS et al, 2011

Klüver-Bucy syndrom

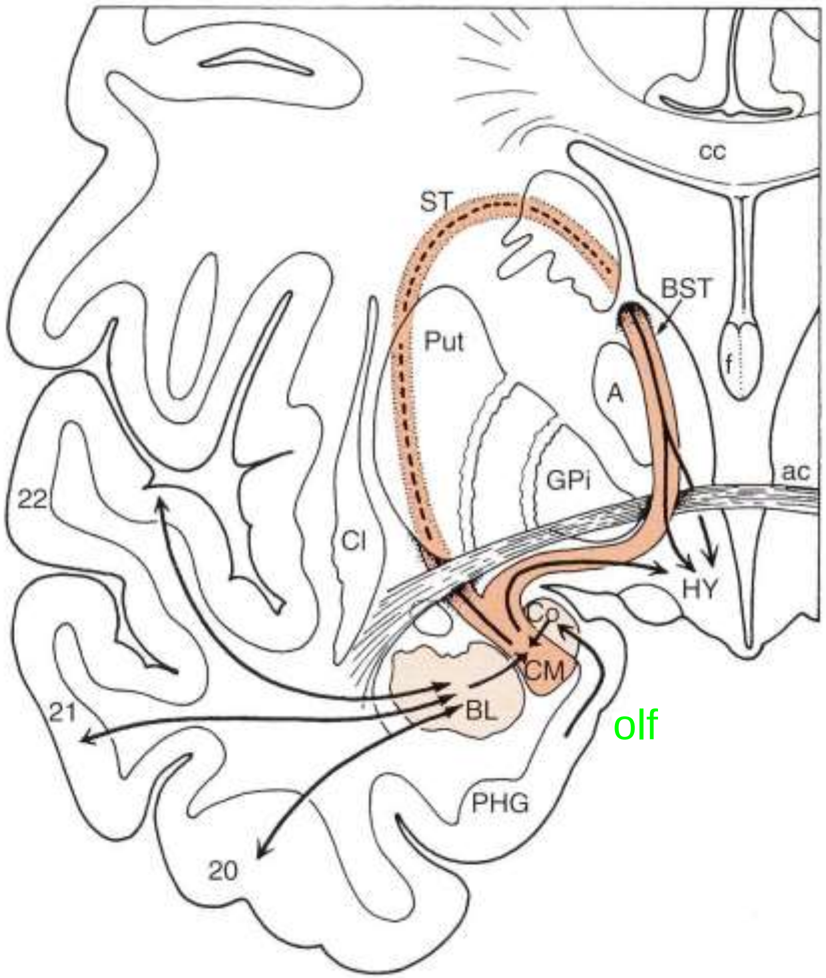
In macaques was removed anterior part of temporal lobe (1939)

- Placidity (diminished fear responses or reacting with unusually low aggression)
- Oral tendencies
- Visual agnosia
- Hypersexuality
- Dietary changes and hyperphagia,
- In humans with herpes simplex encefalitis, injuries, **Pick disease, Rey syndrome, adrenoleukodystrophy and developmental bilateral changes in temporal lobes**

Humans with Kluver Bucy sy have also dementia, amnesia, aphasia, no hypersexuality

Paul Bucy

Amygdala – scheme of the nuclei and connections



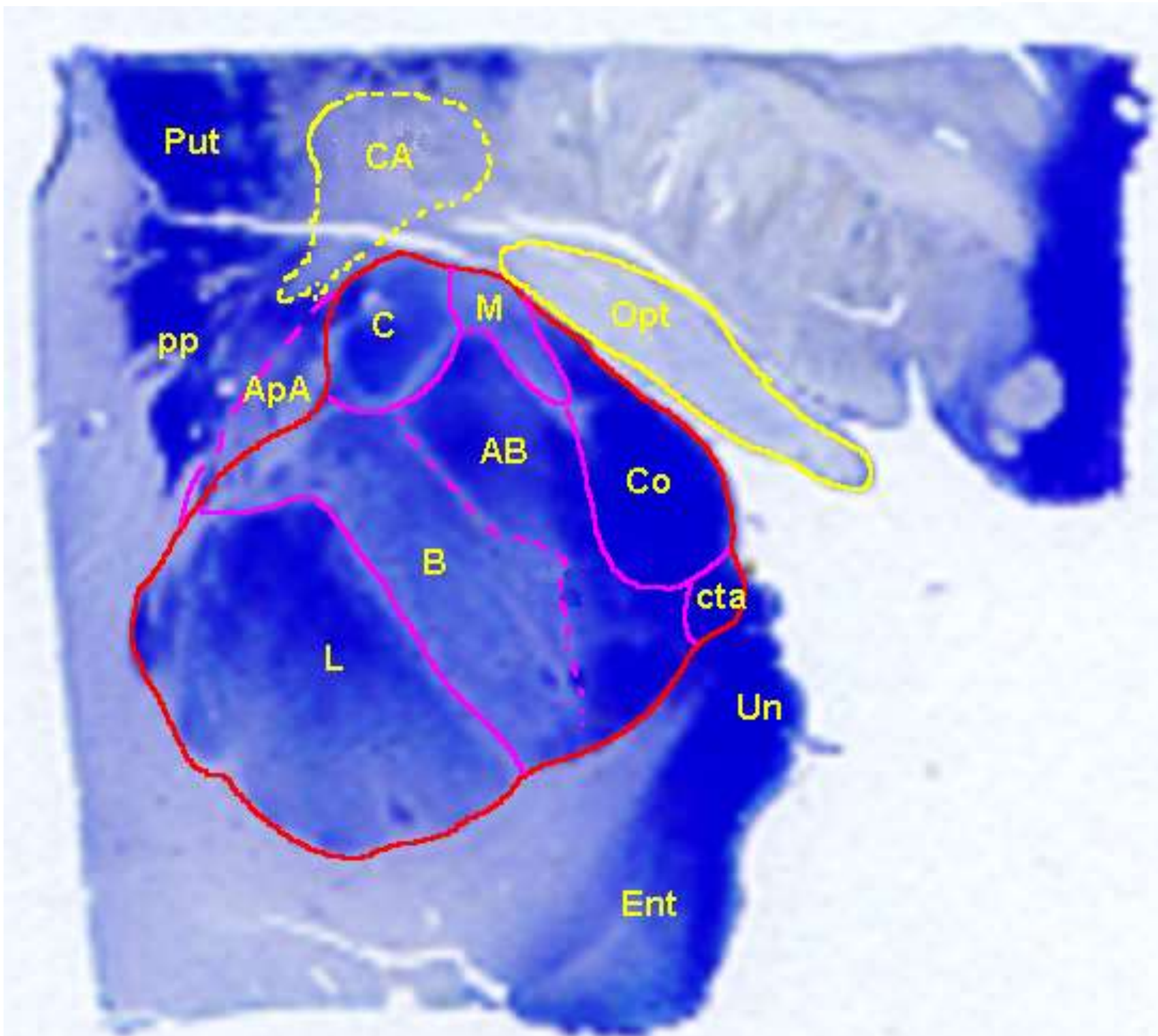
Classical amygdala

Subnuclei:

Cortical

Medial
Central

Basal
Lateral



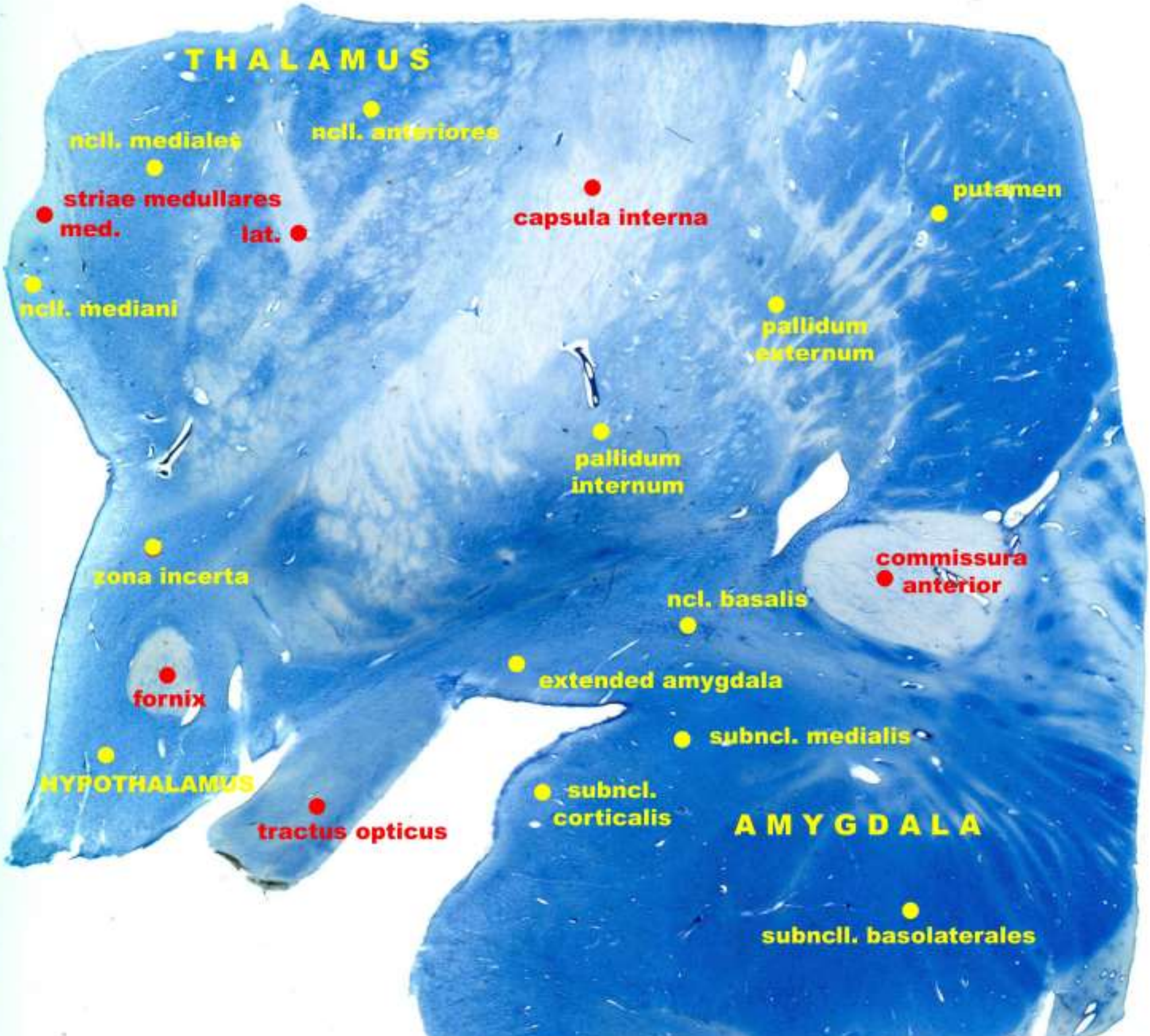
Amygdala - subnuclei

Cortical – connected with olfactory cortex

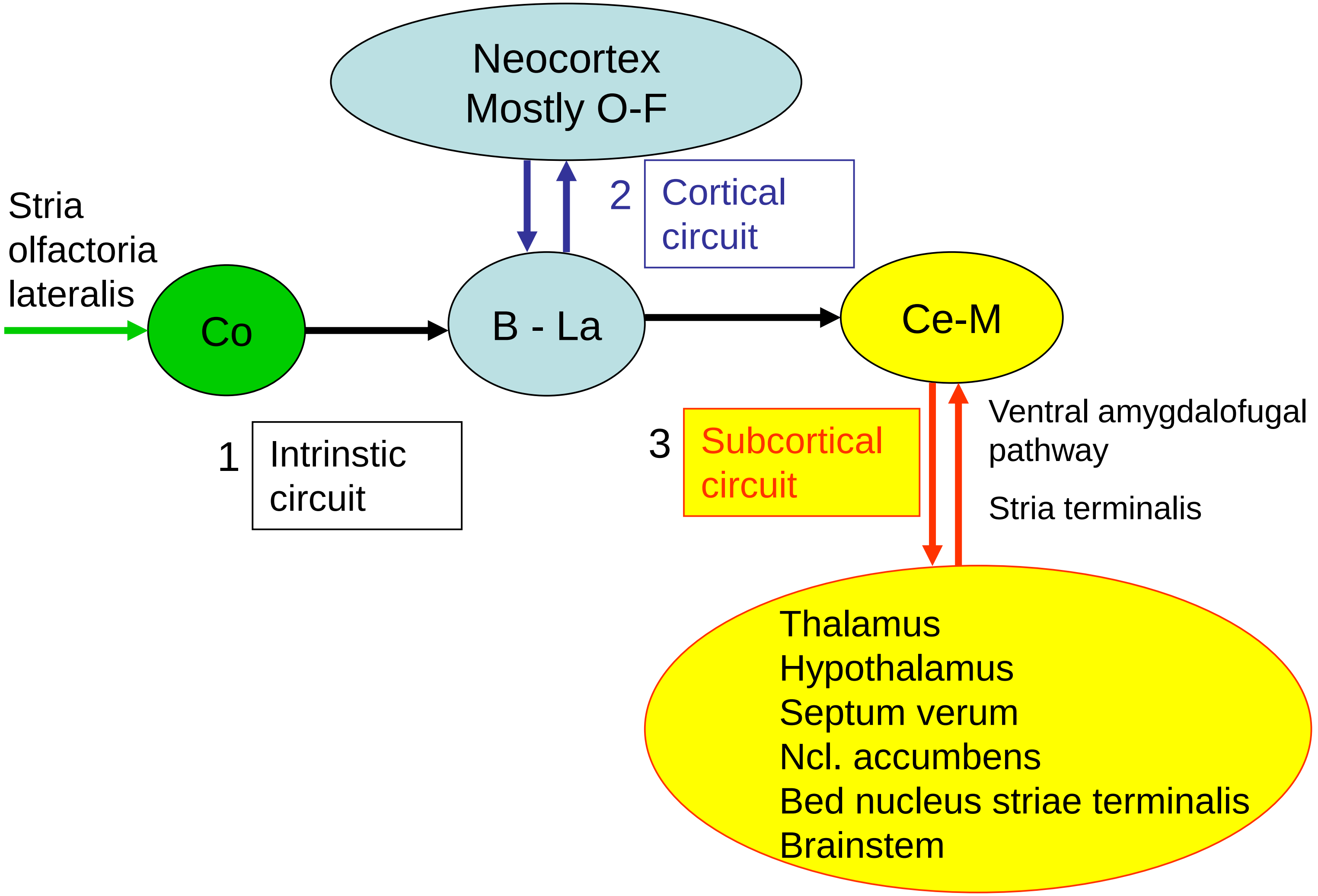
Medialis
Centralis
— Connected with hypothalamus and brainstem

Lateralis
Basalis
— Connected with association cortex, hypothalamus, thalamus

Extended amygdala – pars in the substantia innominata and in the bed nucleus striae terminalis


THALAMUS
ncll. anteriores
ncll. mediales
striae medullares
med.
lat.
capsula interna
putamen
ncll. mediani
pallidum externum
pallidum internum
commissura anterior
zona incerta
ncl. basalis
extended amygdala
fornix
subncl. medialis
HYPOTHALAMUS
subncl. corticalis
tractus opticus
AMYGDALA
subncll. basolaterales

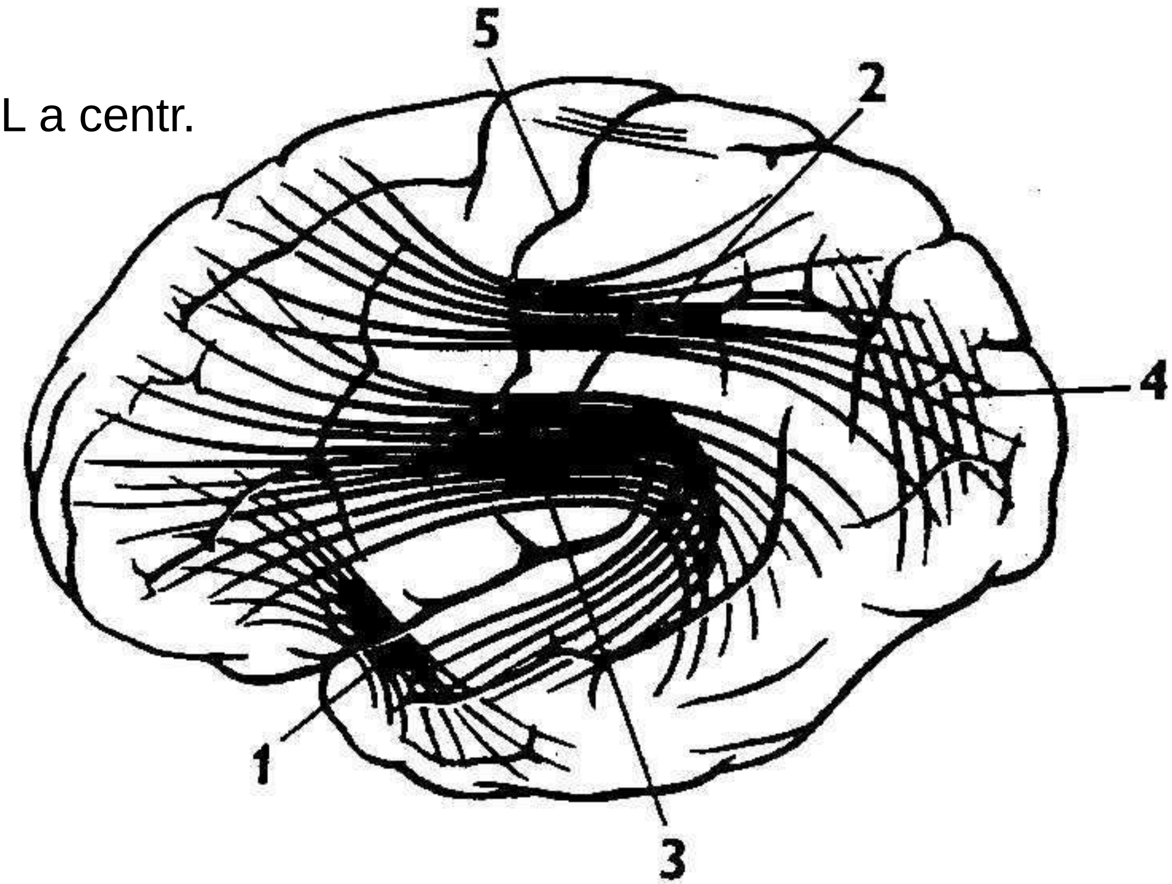
Amygdalar circuits



Amygdalar circuits

- cortical in the uncinate fascicle

BL – OF,insula, temp. – BL a centr.

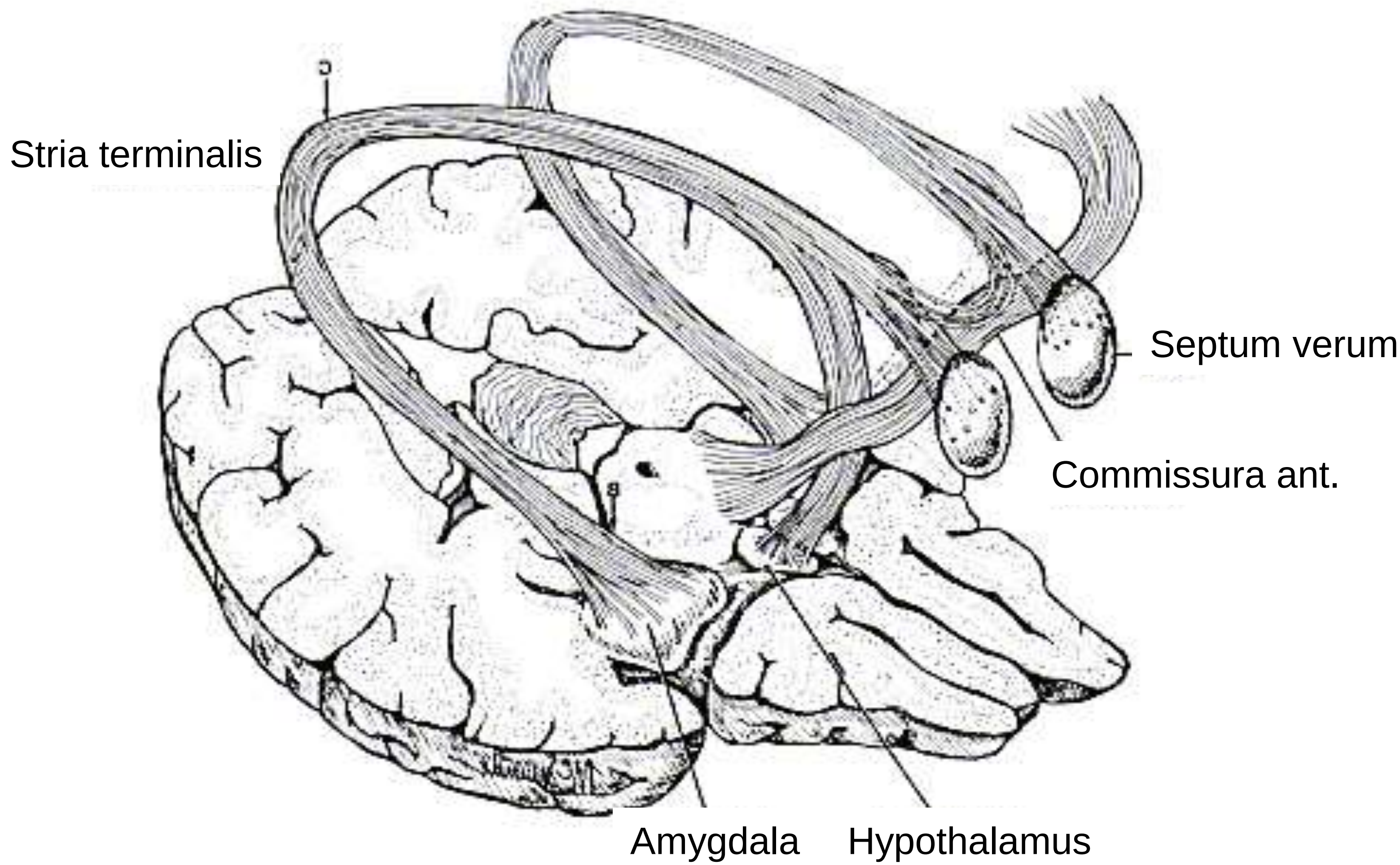


Subcortical connections of amygdala

- Stria terminalis (from all nuclei)
- to O-F cortex, thalamus (MD), hypothalamus (VM), area adolfactoria
- Ventral amygdalofugal system (Cent,M, Ext)
- - Hypothalamus (Ant), ncl.basalis, Acc
- Brainstem circuit (from central nuclei)

monoaminergic system, RF, dX, ncl solitarius

Stria terminalis



Fornix

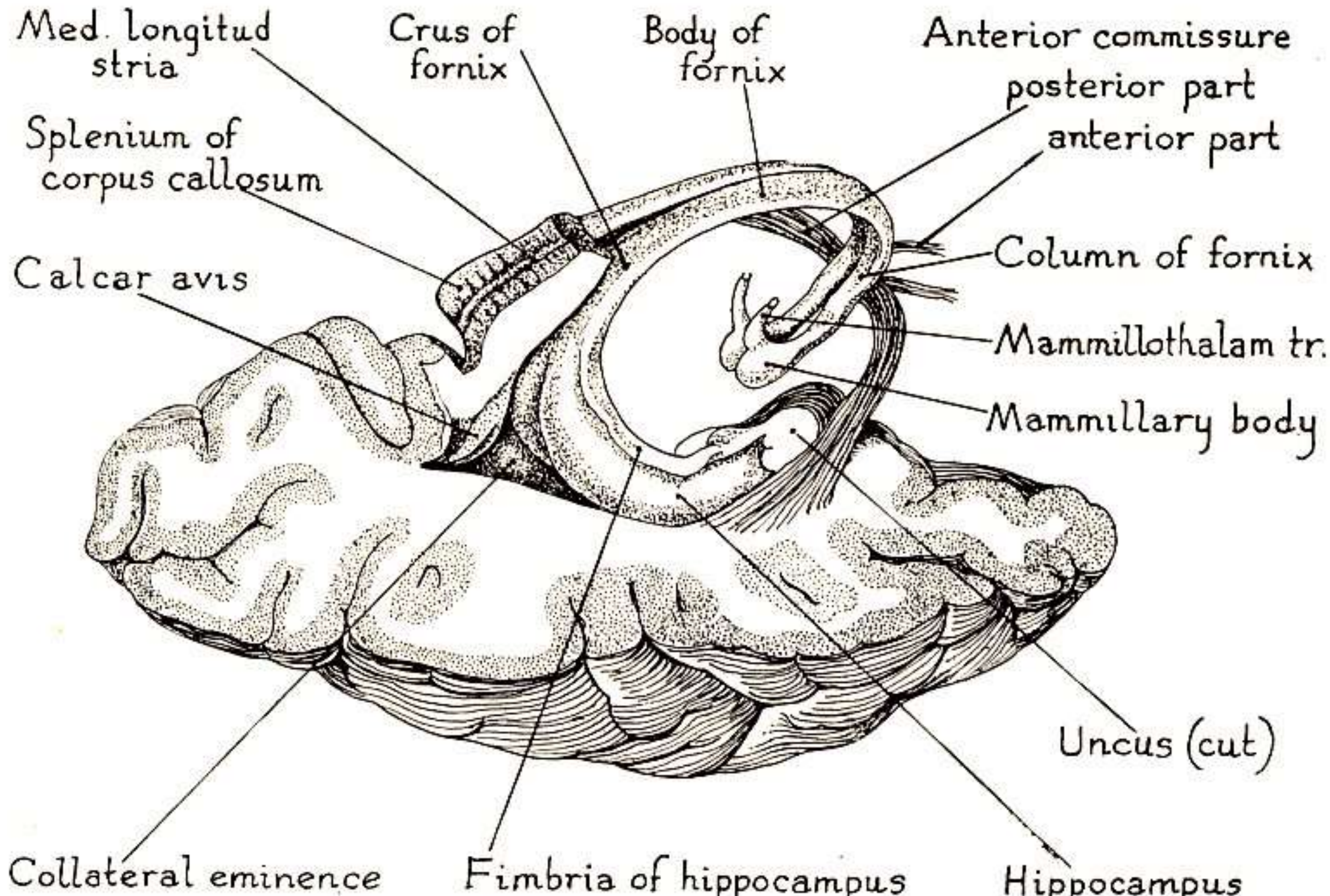


FIG. 310. Dissection of right hemisphere showing inferior and posterior horns of the lateral ventricle, hippocampus, fornix and anterior commissure. (After Rauber-Kopsch.)

Common characteristics in organization of connections of the hippocampus and amygdala

1) Direct projection to the neocortex: Temp O-F

2) An curved efferent running to subcortical areas (Th, Hypoth, Spt)

Fornix Stria terminalis

3) Similar circuits of connections

Hip-Hyp(CM)-Th(Ant)-g.cinguli-Hip

Amy-Hyp(Ant)-Th(MD)-Frontal cortex-Amy

4) Connections with the brainstem

with a relay in corpus mamillare and habenula

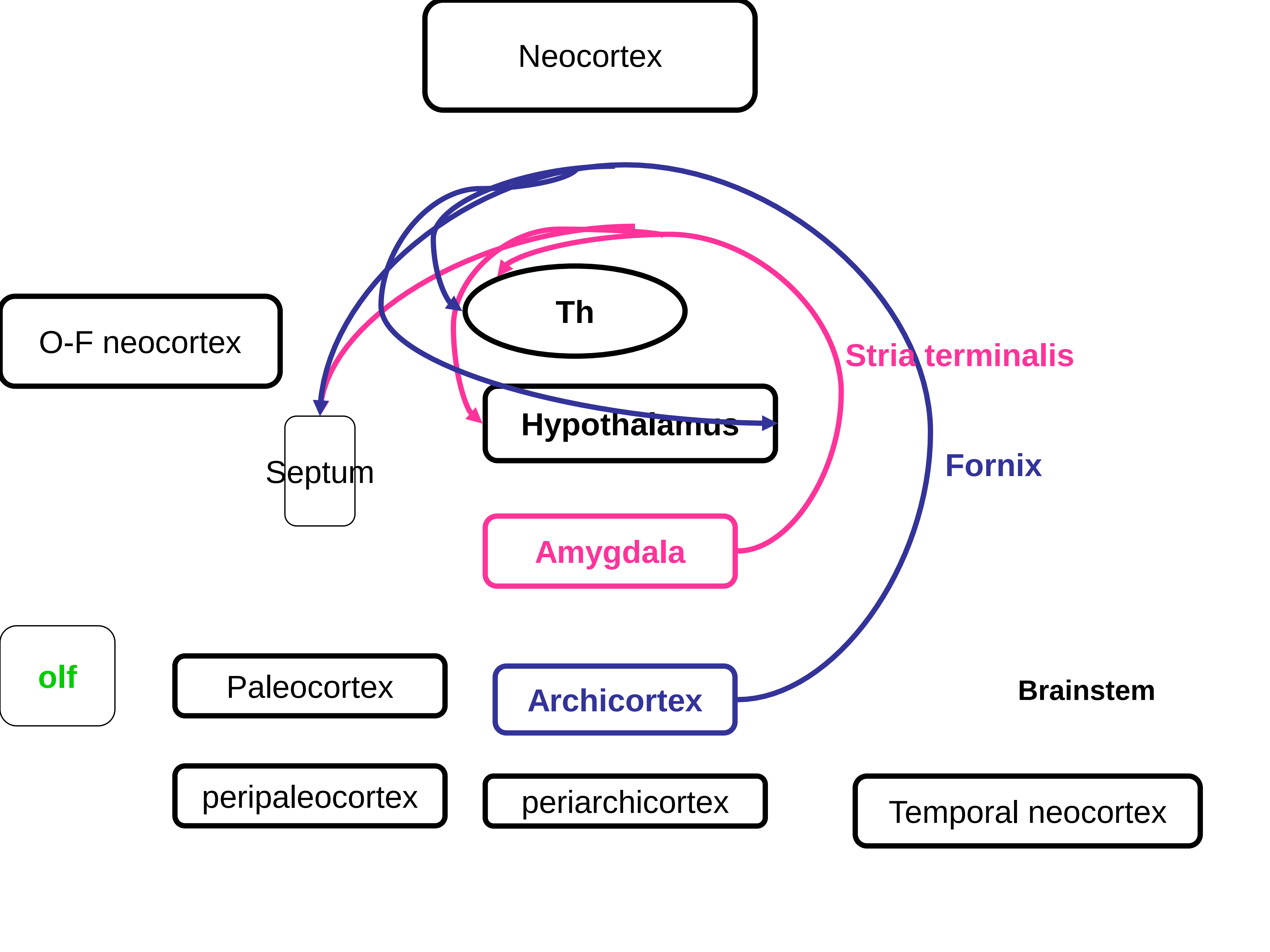
directly

5) Nearly all connections are two-way ones – they form circuits

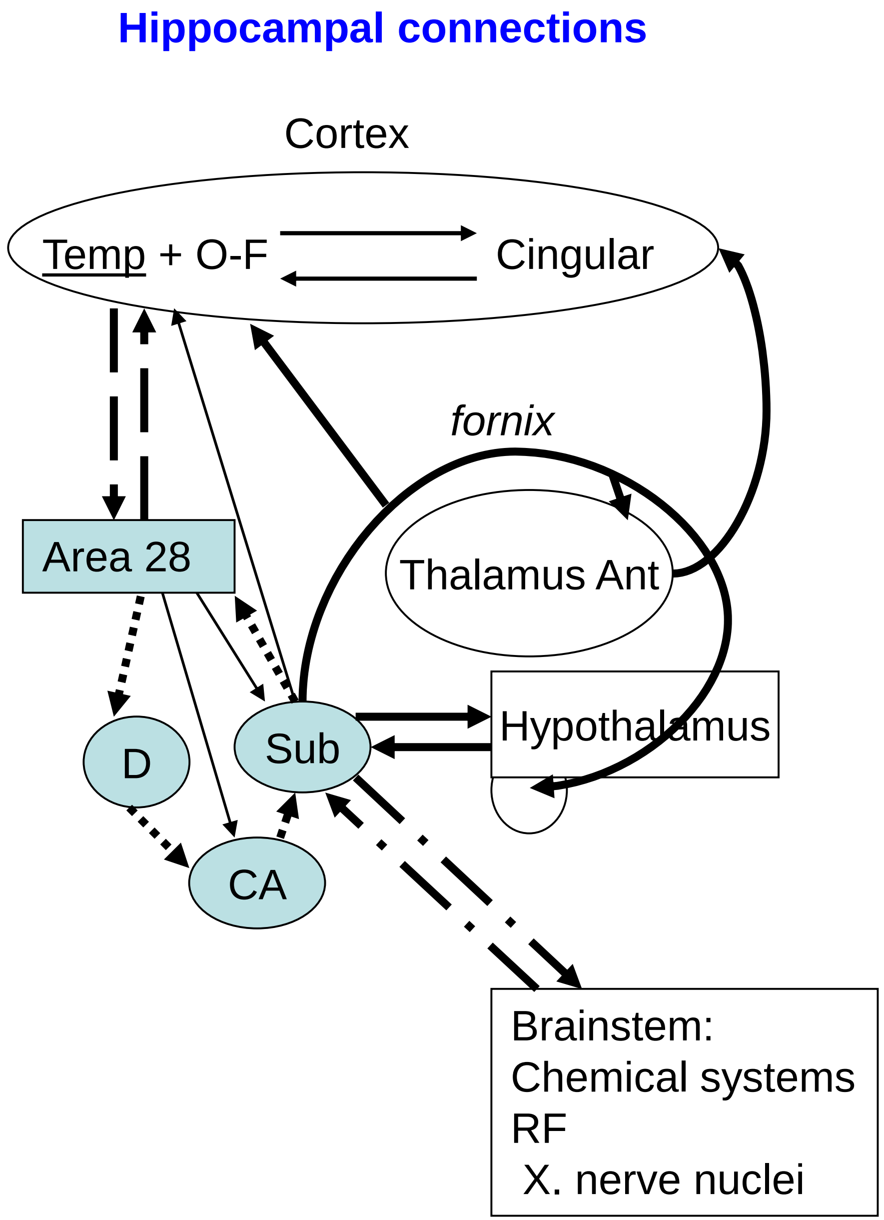
6) Afferent input from the olfactory pathway, without feedback

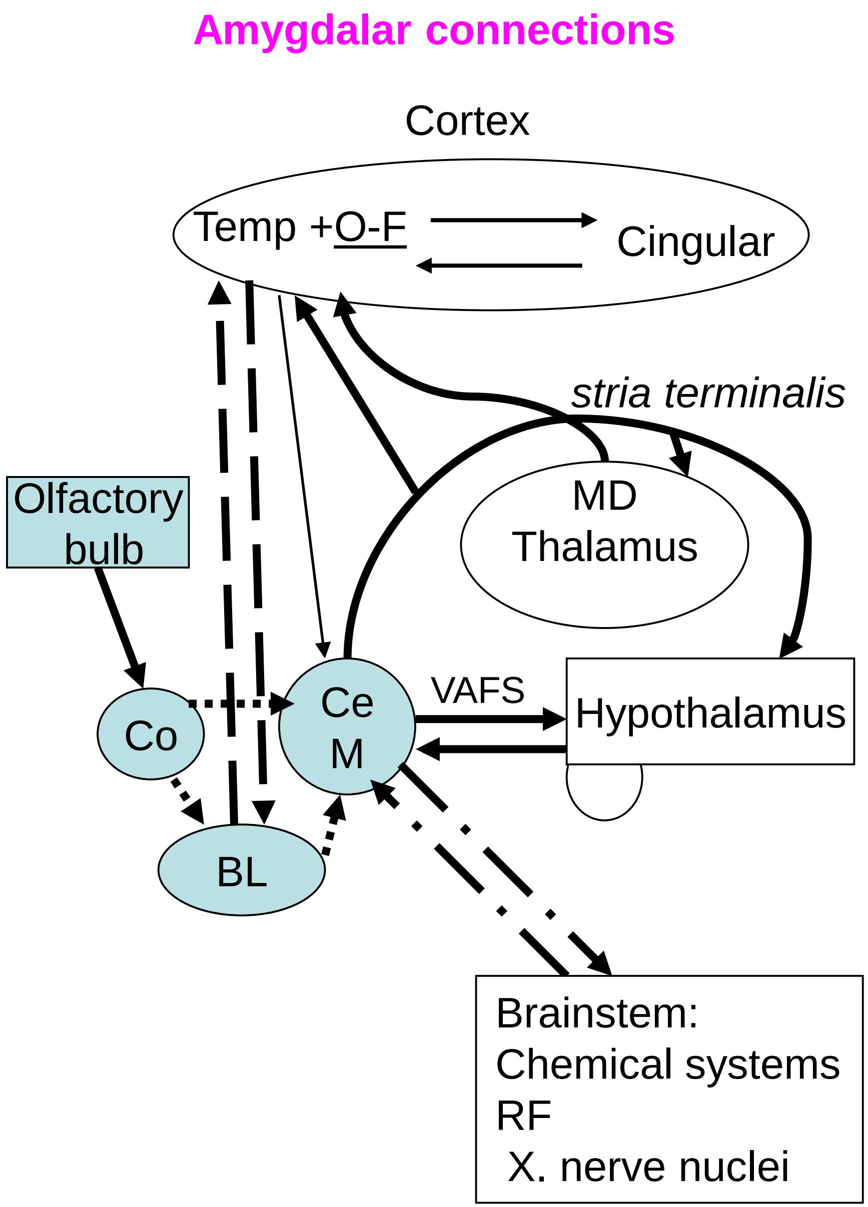
via the periarchikortex

directly to cortical subnucleus



Neocortex
O-F neocortex
Th
Stria terminalis
Hypothalamus
Septum
Fornix
Amygdala
olf
Paleocortex
Archicortex
Brainstem
peripaleocortex
periarchicortex
Temporal neocortex


Hippocampal connections
Cortex
Temp + O-F
Cingular
fornix
Area 28
Thalamus Ant
D
Sub
Hypothalamus
CA
Brainstem:
Chemical systems
RF
X. nerve nuclei


Amygdalar connections
Cortex
Temp +O-F
Cingular
stria terminalis
Olfactory bulb
MD Thalamus
Co
Ce M
VAFS
Hypothalamus
BL
Brainstem:
Chemical systems
RF
X. nerve nuclei

Chemical systems

- Neurotransmitters:
- Inhibitory : GABA, glycin
- Excitatory: acetylcholine Ach (groups Ch1-CH6)
- catecholamines groups A1-A14
- serotonine groups B1-B9 (rapheal nuclei)
- **glutamate**
- Modulation- substance P, encephaline, calbindine, VIP, nitric oxide, etc.

In each neuron is a cocktail of neurotransmitters and modulators

Neurotransmiters

Biogennic amines

Adrenaline, noradrenaline, dopamine - A groups

Serotonine – B groups

Acetylcholine – Ch groups, SM a VM motoneurons, striatic interneurons

Histamine – tuberomammillary nucleus of hypothalamus

Aminoacids

Glutamate, aspartate– excitatory (e.g. in spinal ganglion, cortical and thalamic projecting neurons, cerebellar nuclei neurons

GABA, glycin – inhibitory (e.g Renshaw´s cells – spinal cord interneurons RFneurons, thalamic and cortical interneurons, basal ganglia projecting neurons, Purkynje cells)

Nucleotides

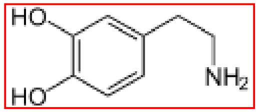
Adenosine

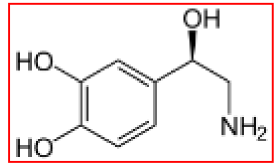
Neuropeptides - modulators

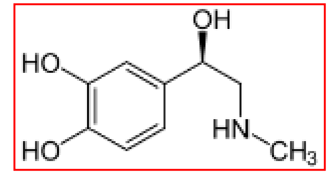
Substance P, VIP, somatostatin, cholecystokinin

Gas - NO

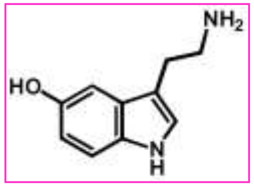
Dopamine
Noradrenaline
Adrenaline





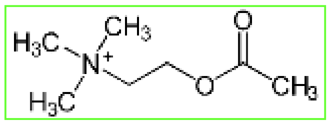


Serotonine

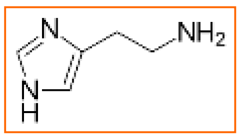


NEUROTRANSMITTERS

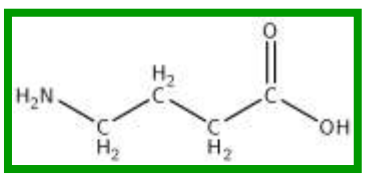
Acetylcholine

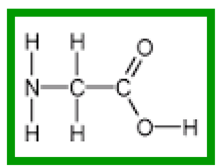


Histamine

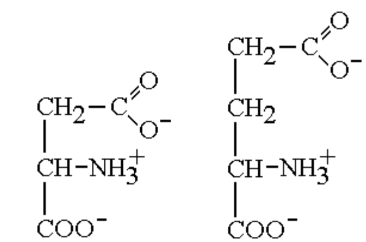


GABA



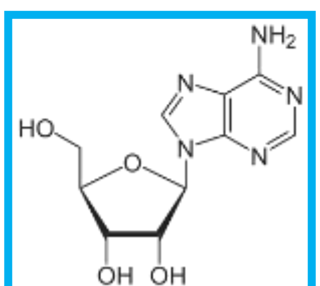


Glycine



Aspartate Glutamate

Adenosine

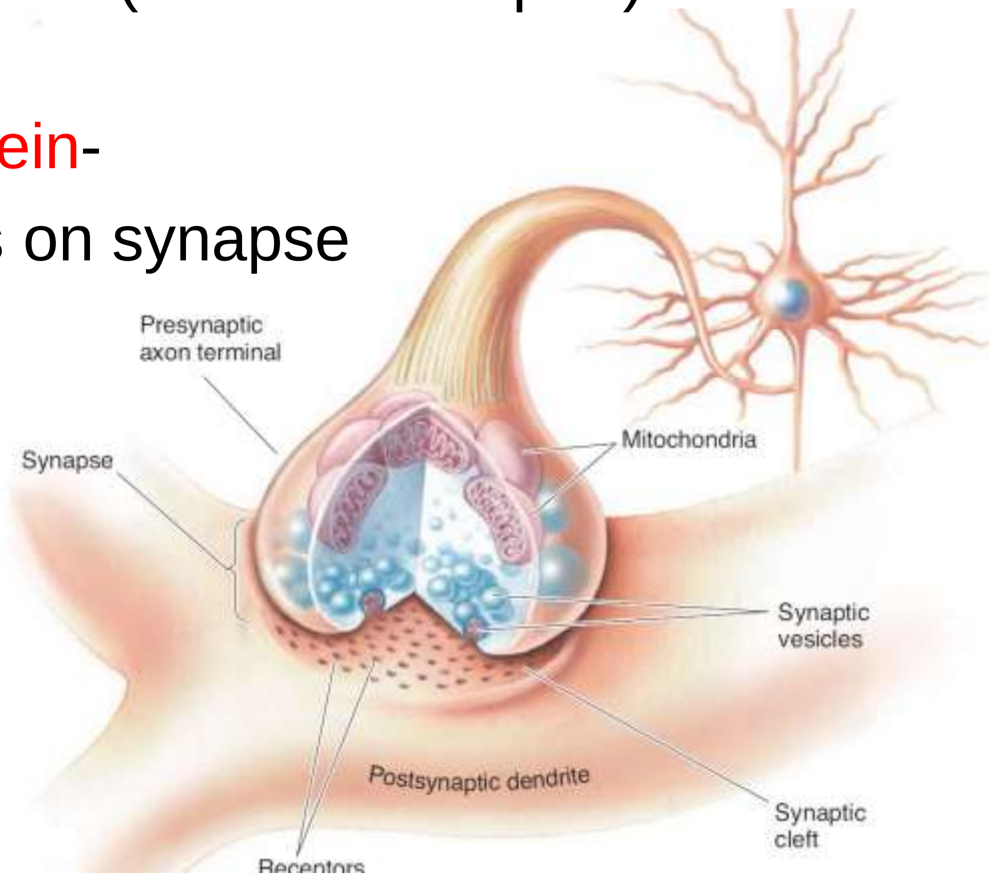


coffein- block of receptors for adenosine

Neurotransmiters act after binding on receptors of target cells and can

- 1) directly open ion channal (nicotinic receptor) – miliseconds on synapse
- 2) act through the G protein-

  hunderts of miliseconds on synapse



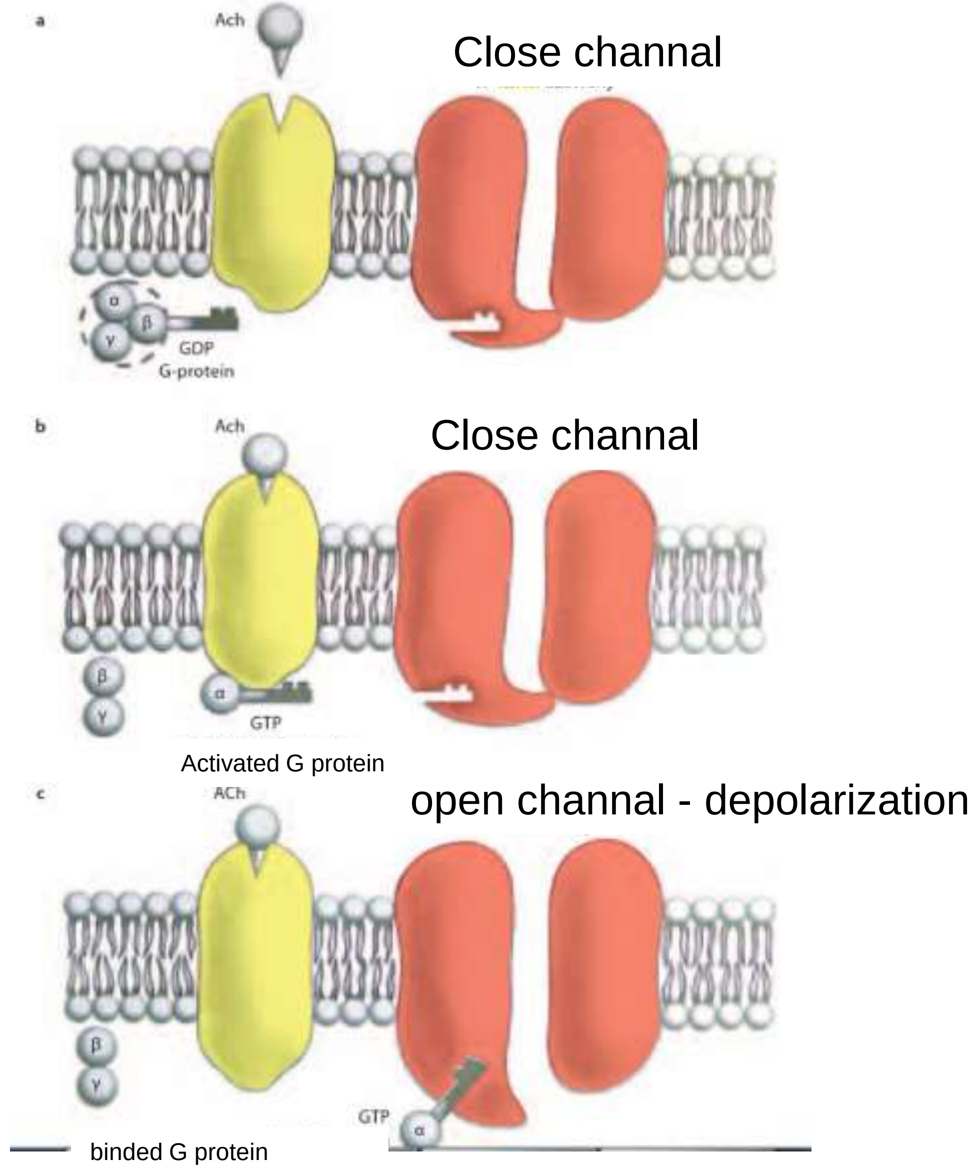
G-protein coupled receptors activation can

1) Postsynapticly depolarizate – excitate
2) Postsynapticly hyperpolarizate – inhibit

It depends on kind of receptor

e.g noradrenaline on beta receptors excitates and on alfa receptors inhibits

G protein coupeled receptor for ACh
 - opening of potassium channal



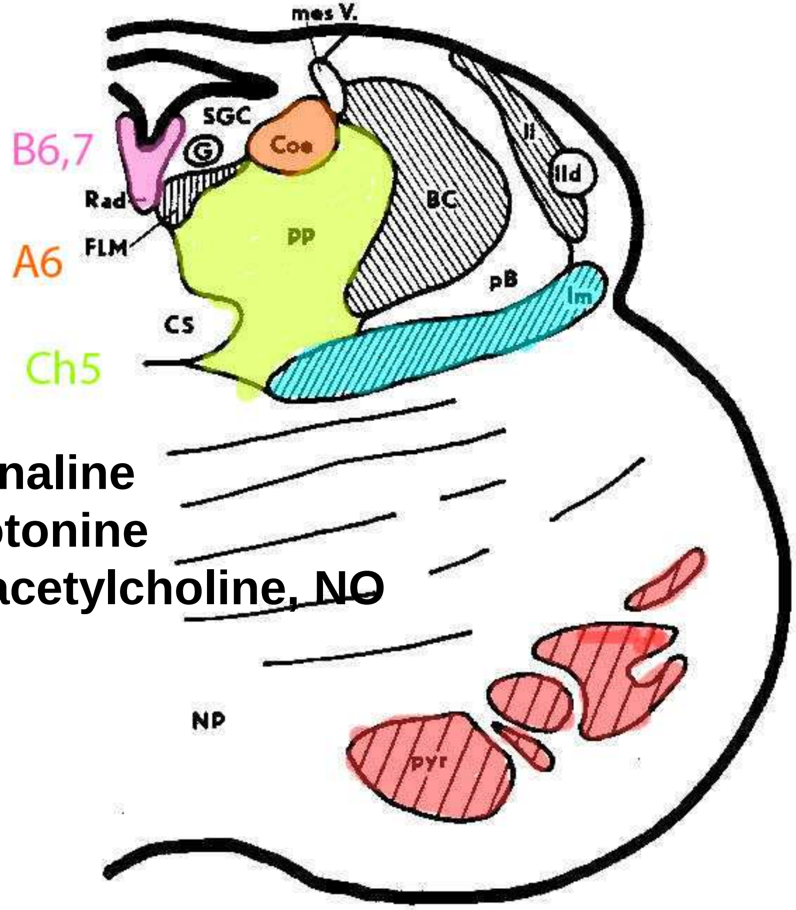
Fyziologie a patologická fyziologie pro klinickou praxi, Rokyta et al

Neurotransmitterem leaves the synaptic cleft by

- 1) reabsorbtion (serotonine, histamine,catecholamines), GABA, glycine, glutamate, aspartate
- 2) enzymatic brakedown (AChE)
- 3) reabsorbtion into glia

Pharmacotherapy !

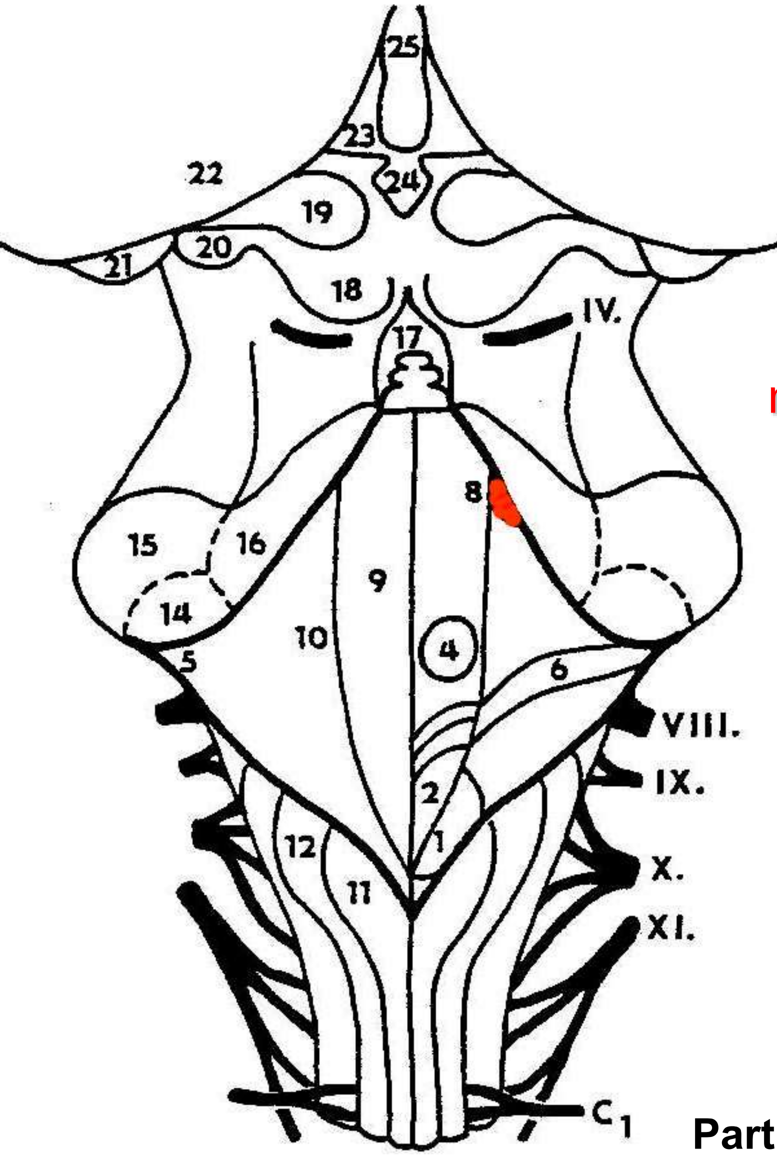
Pontomesencephalic junction

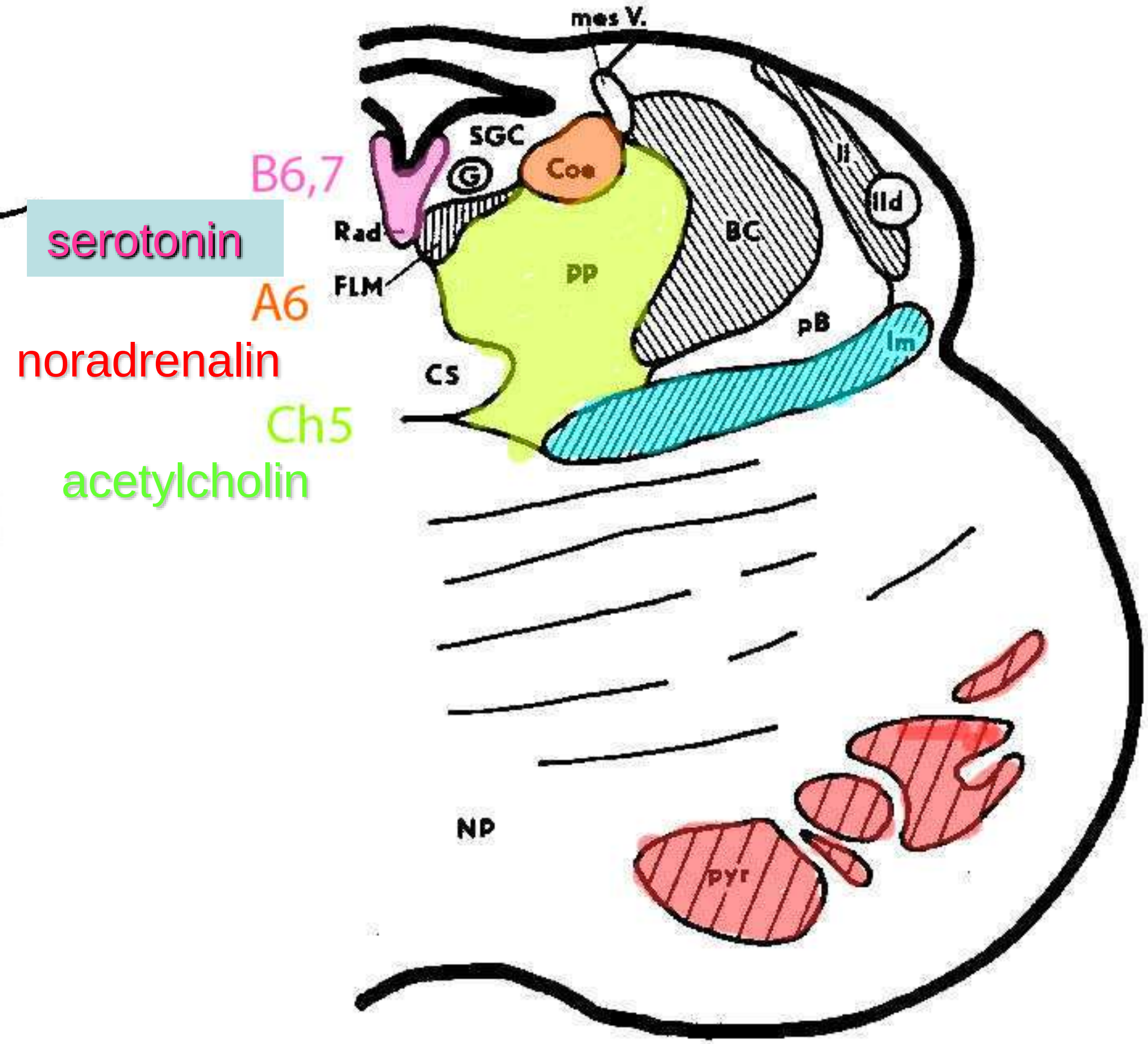


Neurotransmitters

A6 – locus coeruleus – noradranaline
B6,7 –ncl. raphe dorsalis – serotonine
Ch5 – ncl pedunculo pontinus acetylcholine, NO

Pontomesencephalic junction

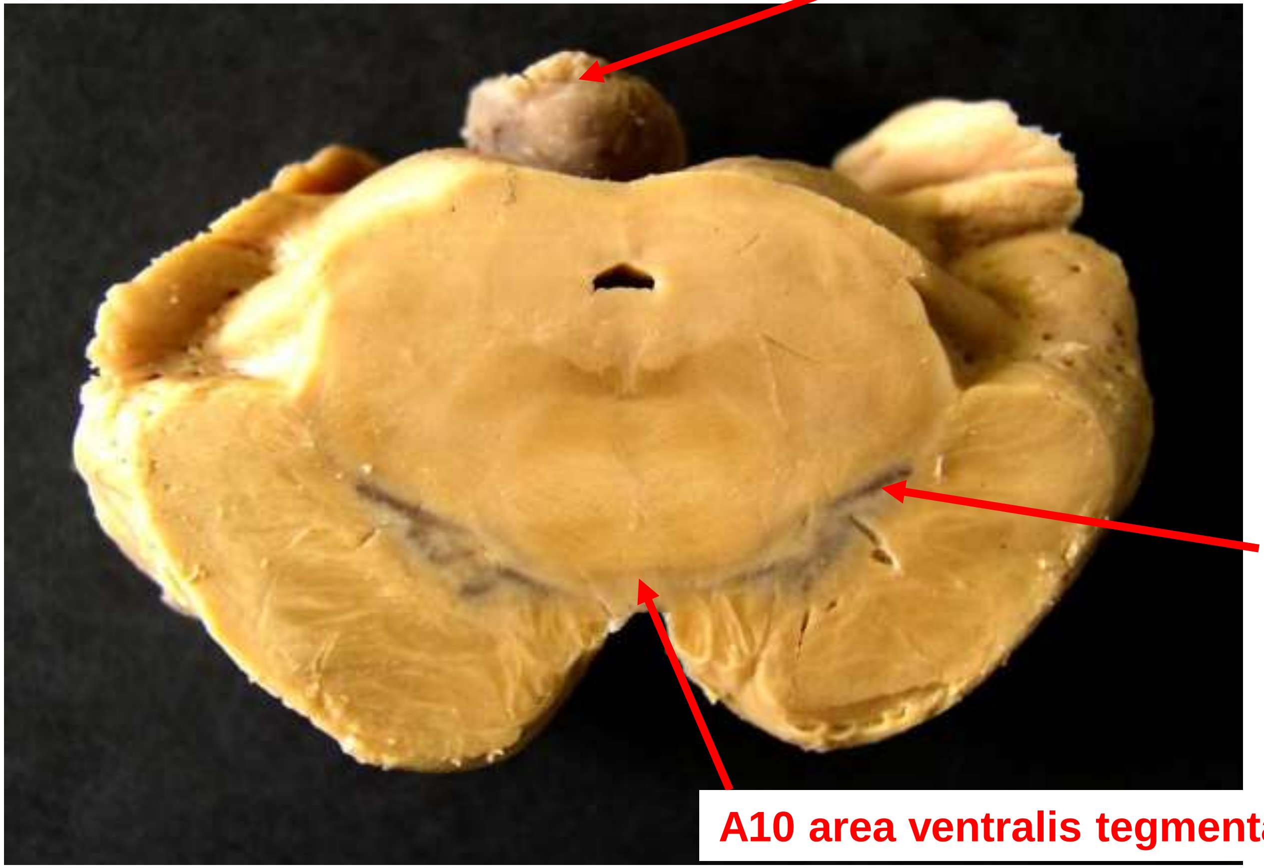




Part of reticular formation activating systém - wakefulness

Mesencephalon upper

corpus pineale

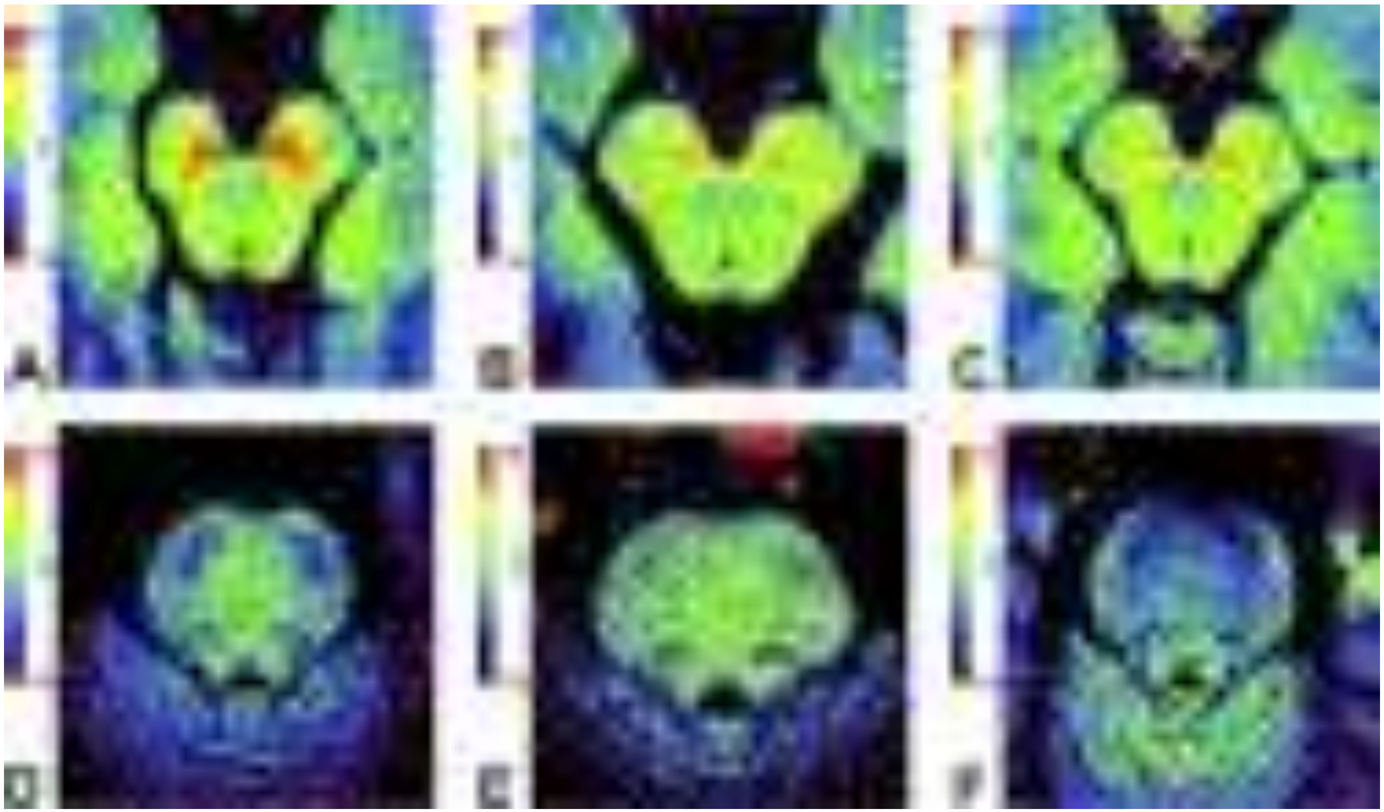


A9
substantia
nigra
comp

A10 area ventralis tegmentalia Tsai (VTA)

Use of **Neuromelanin-Sensitive MRI** to Distinguish **Schizophrenic and Depressive Patients and Healthy Individuals** Based on Signal Alterations in the **Substantia Nigra and Locus Ceruleus**

Eri Shibata, , , Makoto Sasaki, Koujiro Tohyamac, Kotaro Otsuka, Jin Endoh, Yasuo Terayama and Akio Sakaia



SUBSTANTIA NIGRA A9+A10 (VTA)

LOCUS COERULEUS A6

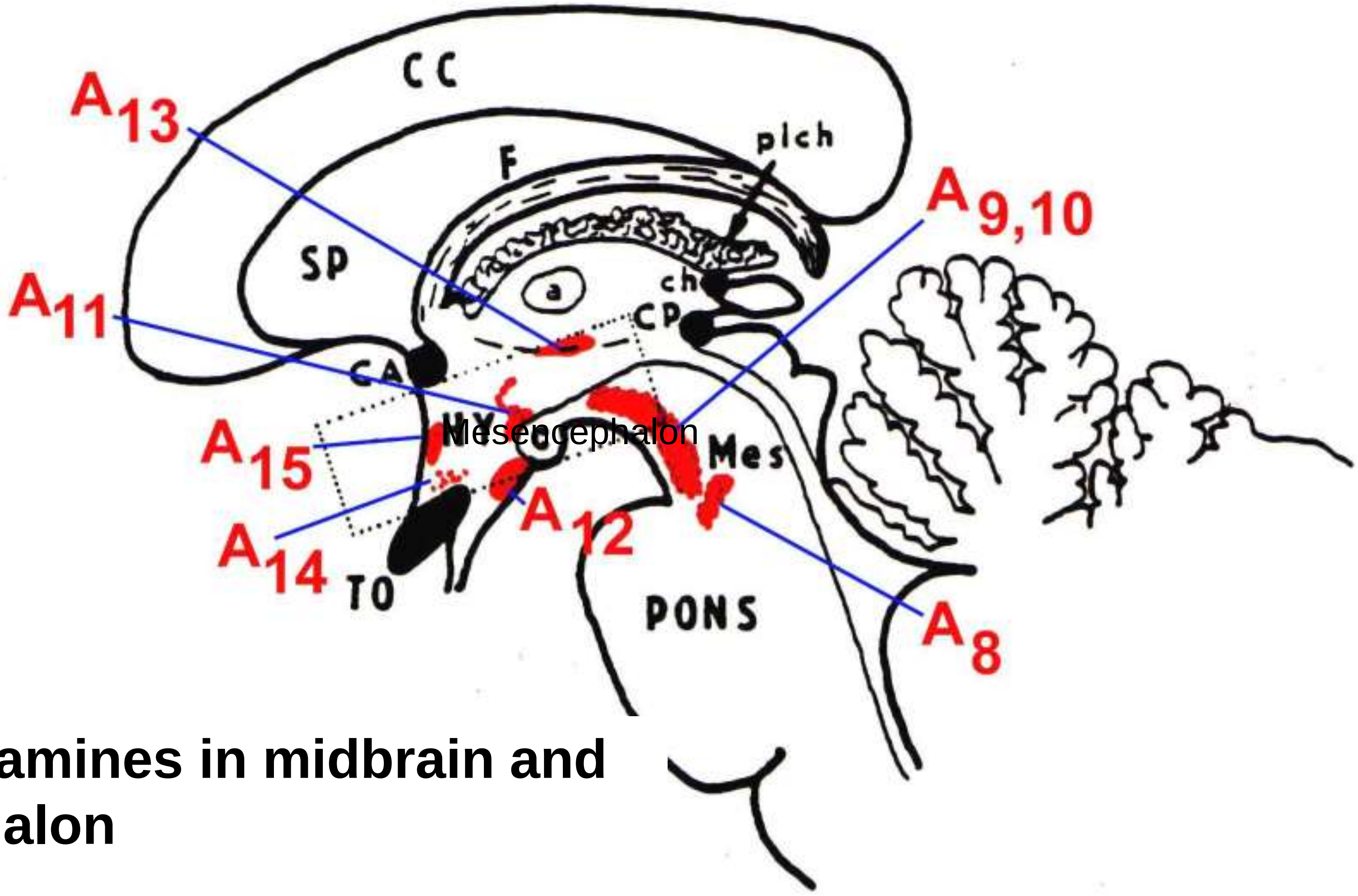
schizophrenia

depression

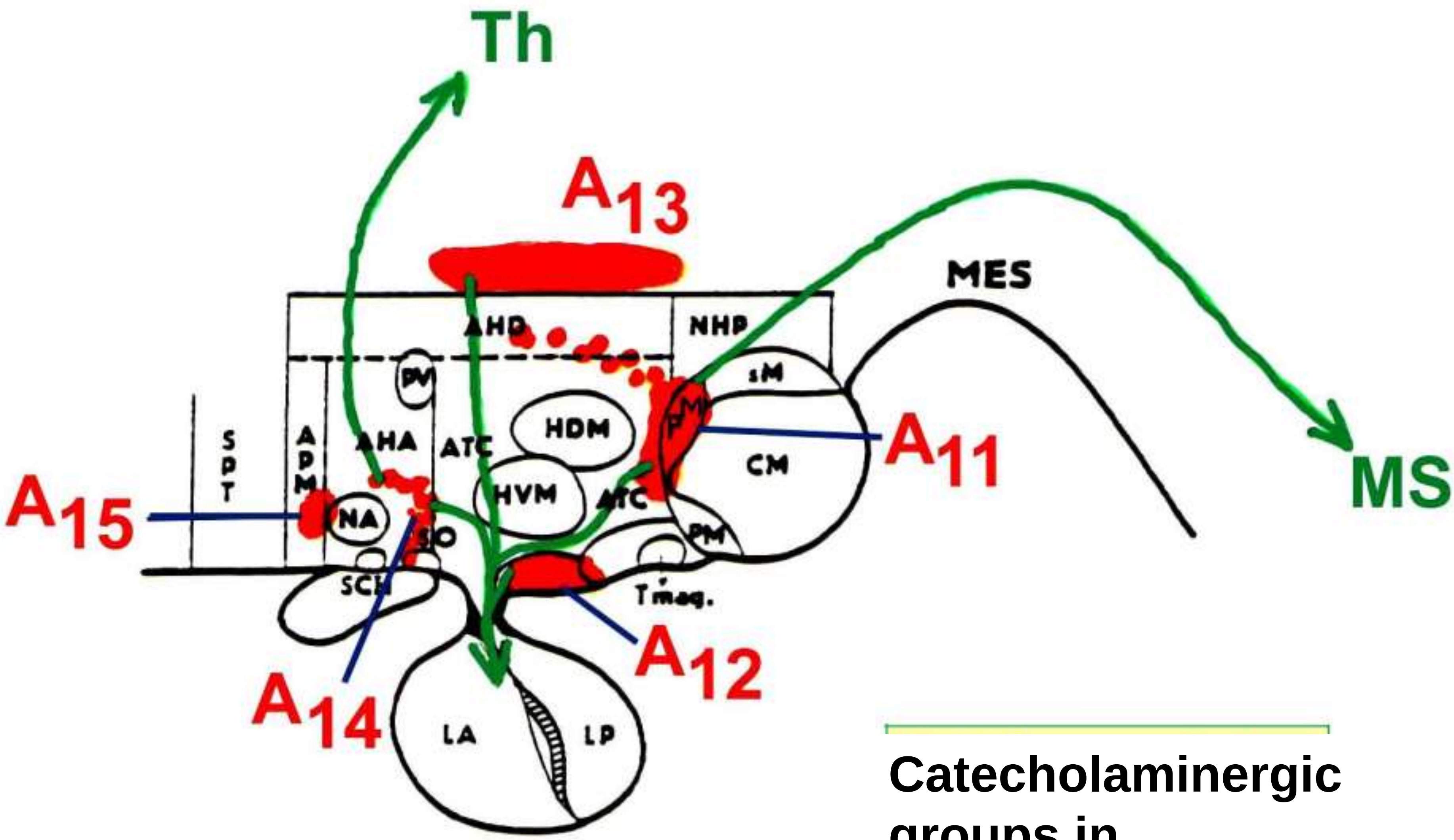
healthy

Intensity in SNig

Intensity in LCoe



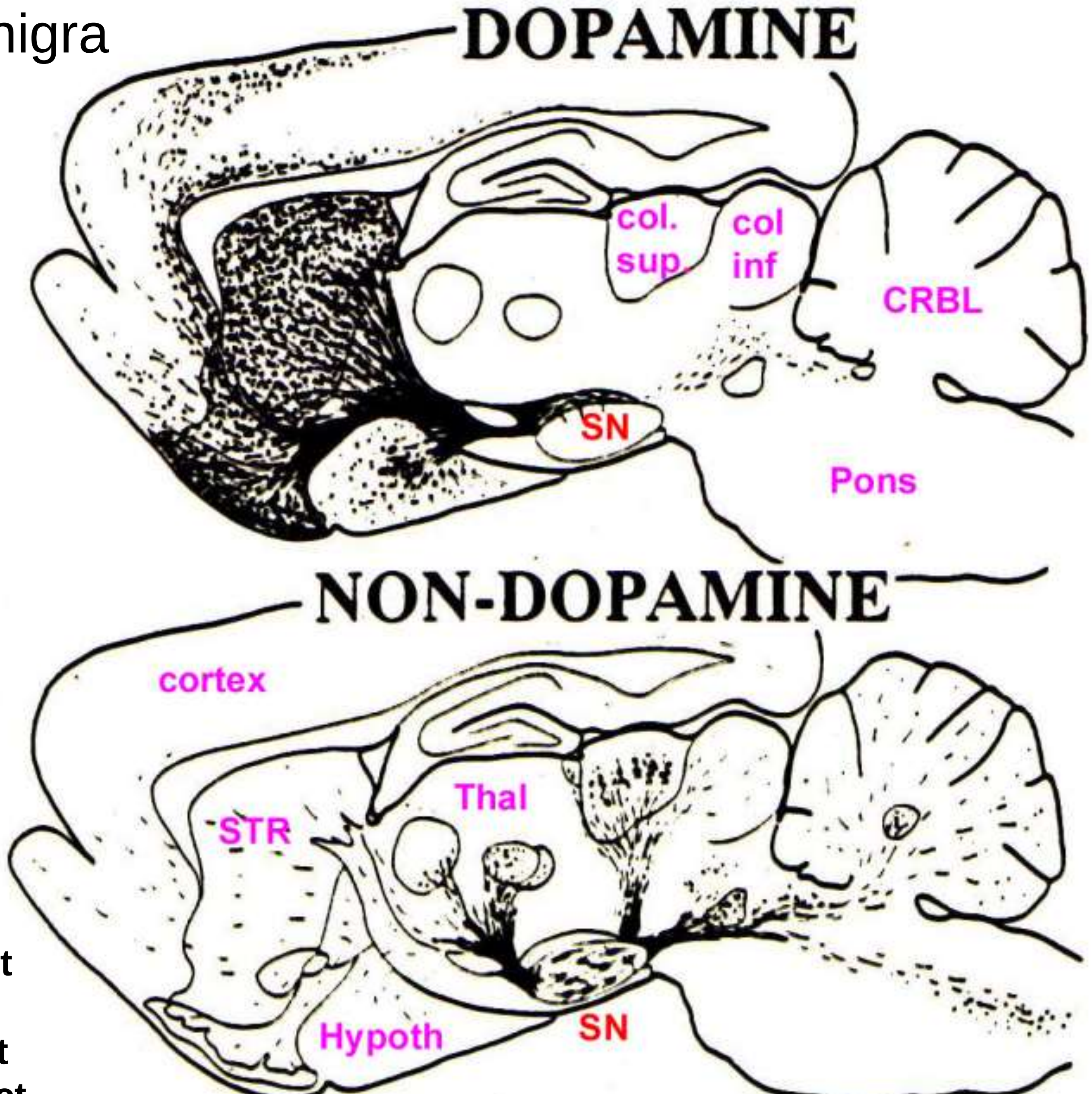
Catecholamines in midbrain and diencephalon



Catecholaminergic groups in hypothalamus and their projections

Substantia nigra

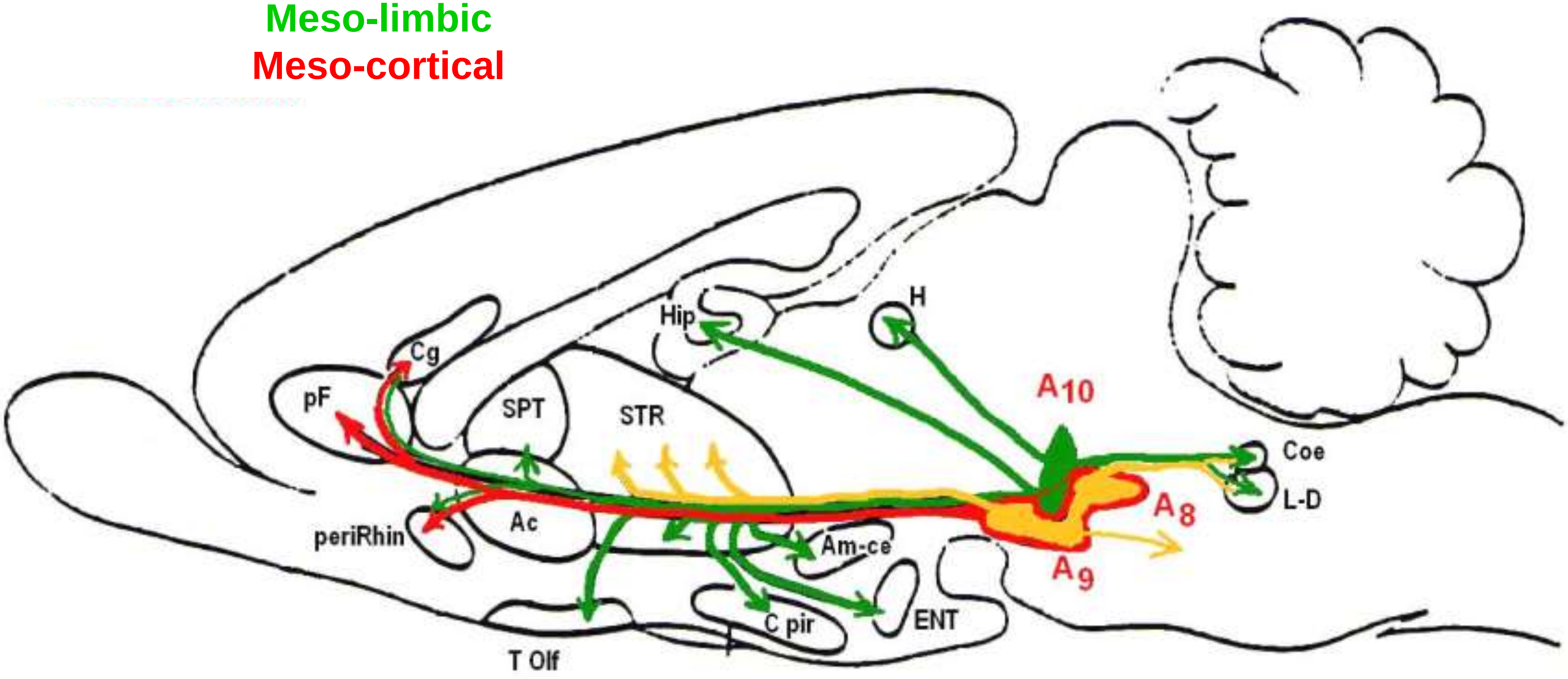
cortex,
ncl accumbens
and BG



Nigro-thalamic tract
Nigro-tectal tract
Nigro-reticular tract
Nigro-cerebelar tract

Dopaminergic projection from the midbrain

Meso- striatic
Meso-limbic
Meso-cortical

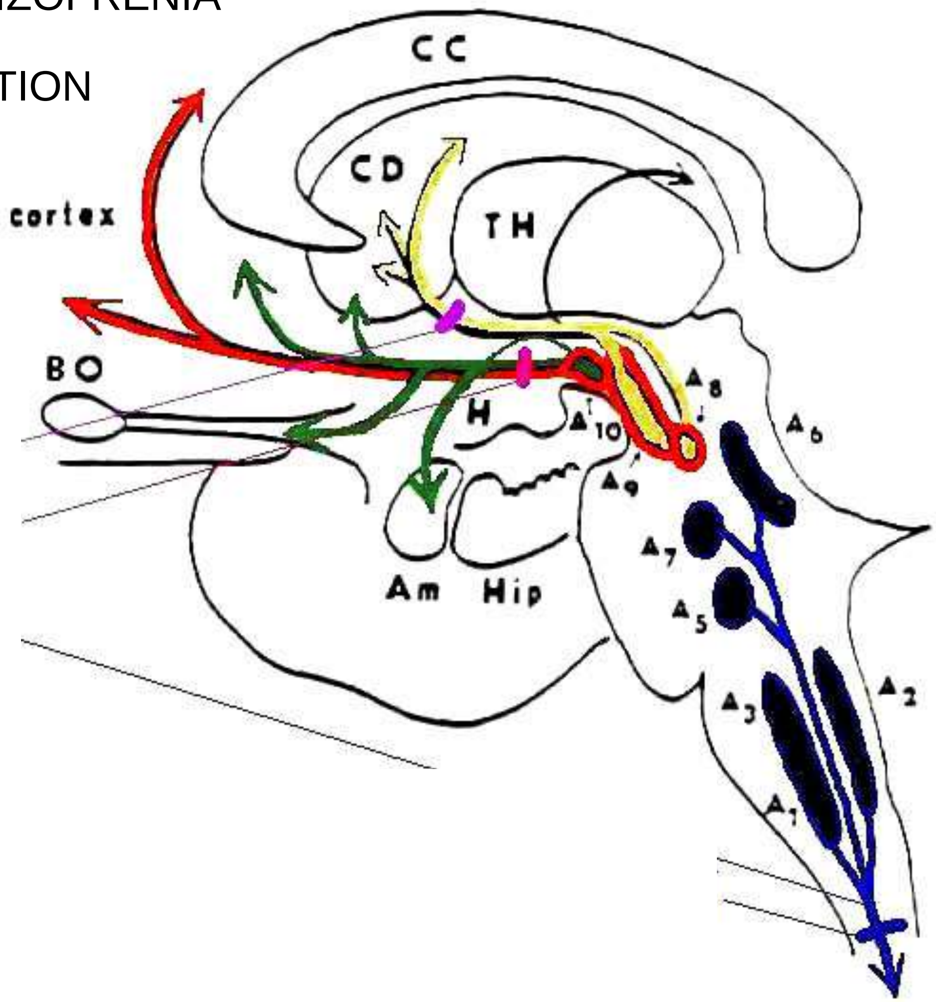


Dopaminergic projection from brainstem

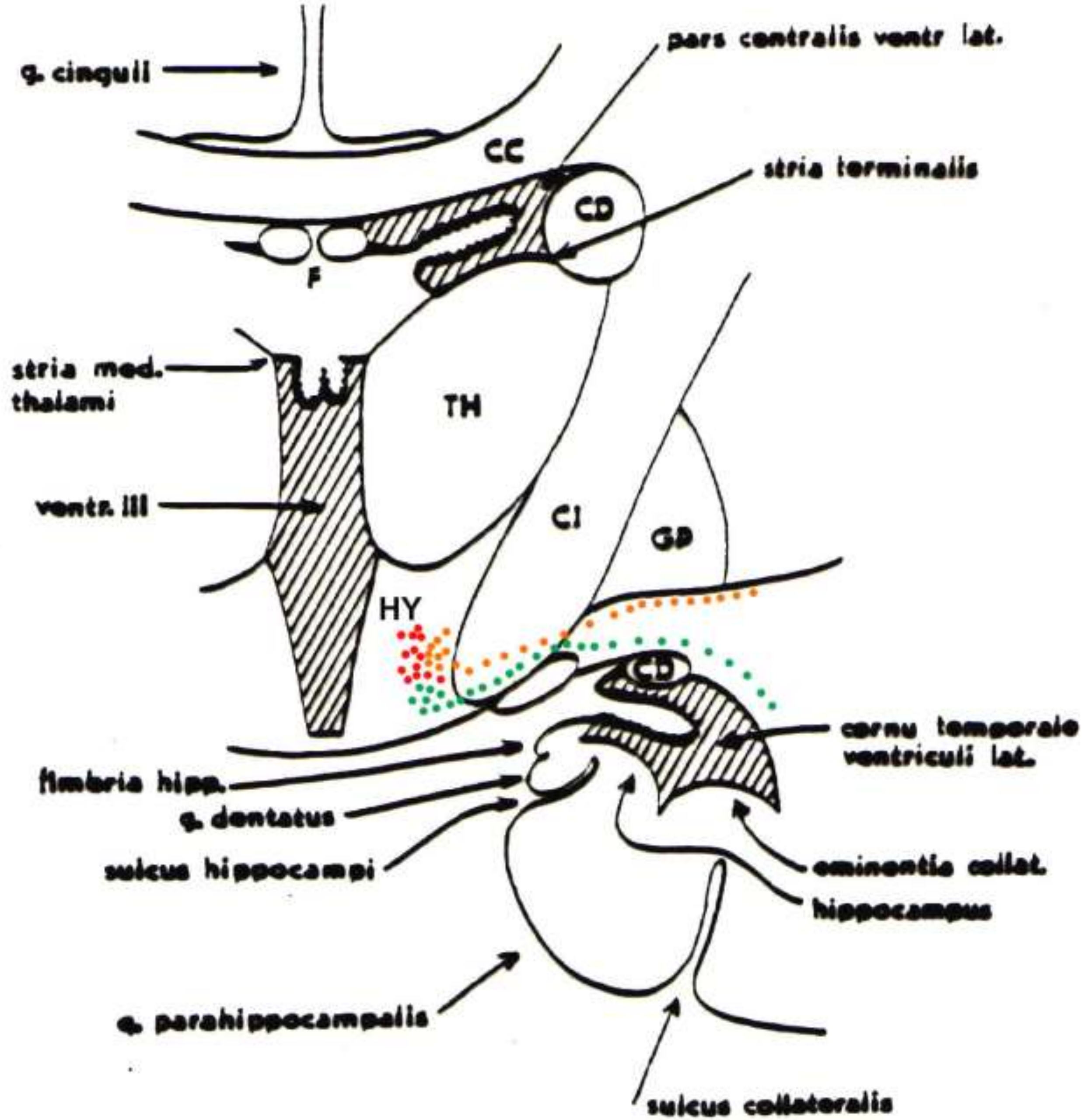
meso-striatic PARKINSON

meso-cortikál SCHIZOFRENIA

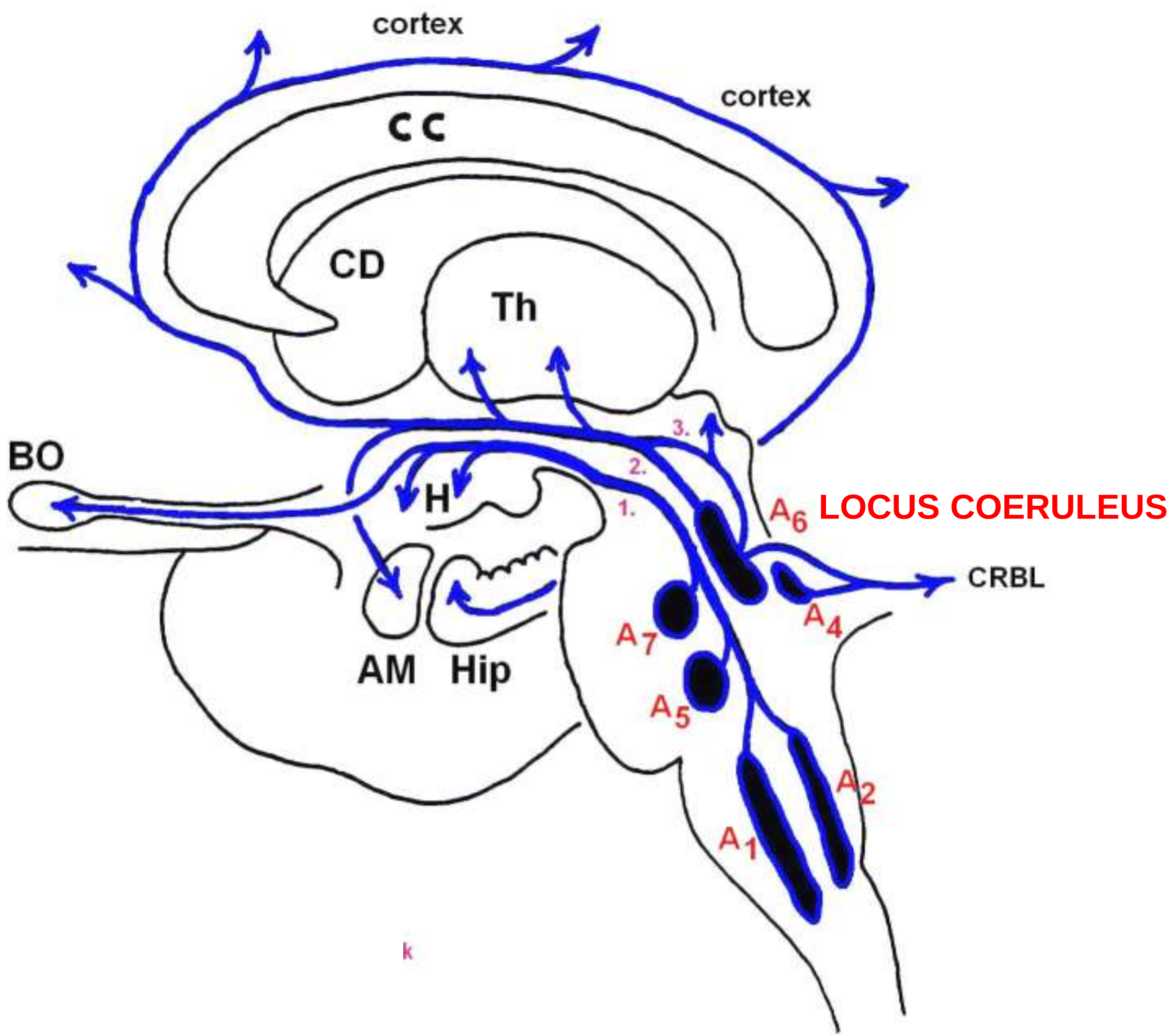
meso-limbic ADDICTION



Localization of „chemical tracts“ in hypothalamus – medial forebrain bundle

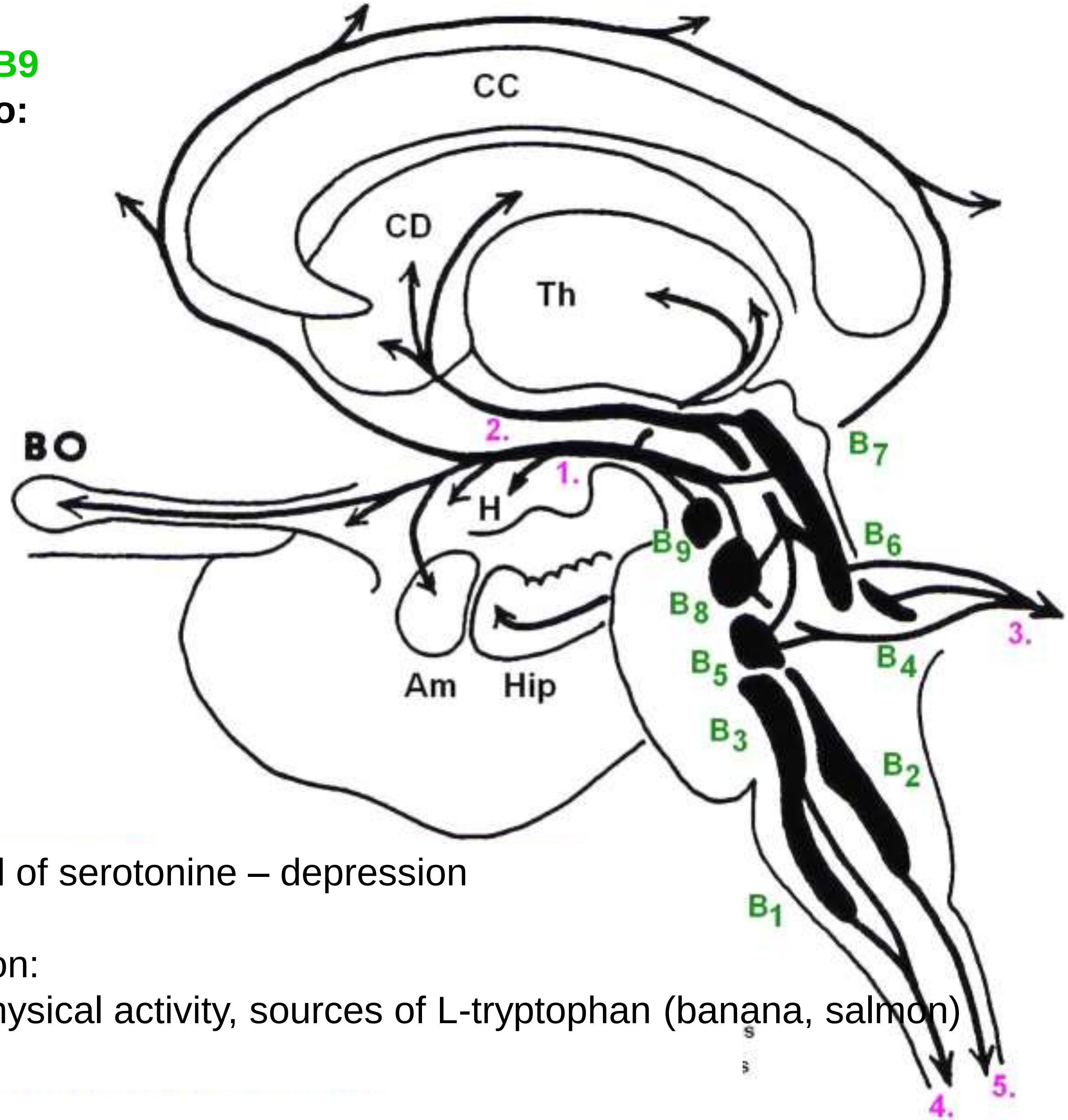


LOCUS COERULEUS (A6) supplies the cortex and other structures by noradrenaline



SEROTONINERGIC GROUPS

Groups B1-B9
Projection to:
Cortex
Striatum
Paleocortex
Am+Hip
Thalamus
Crbl
Spinal cord



Low level of serotonine – depression

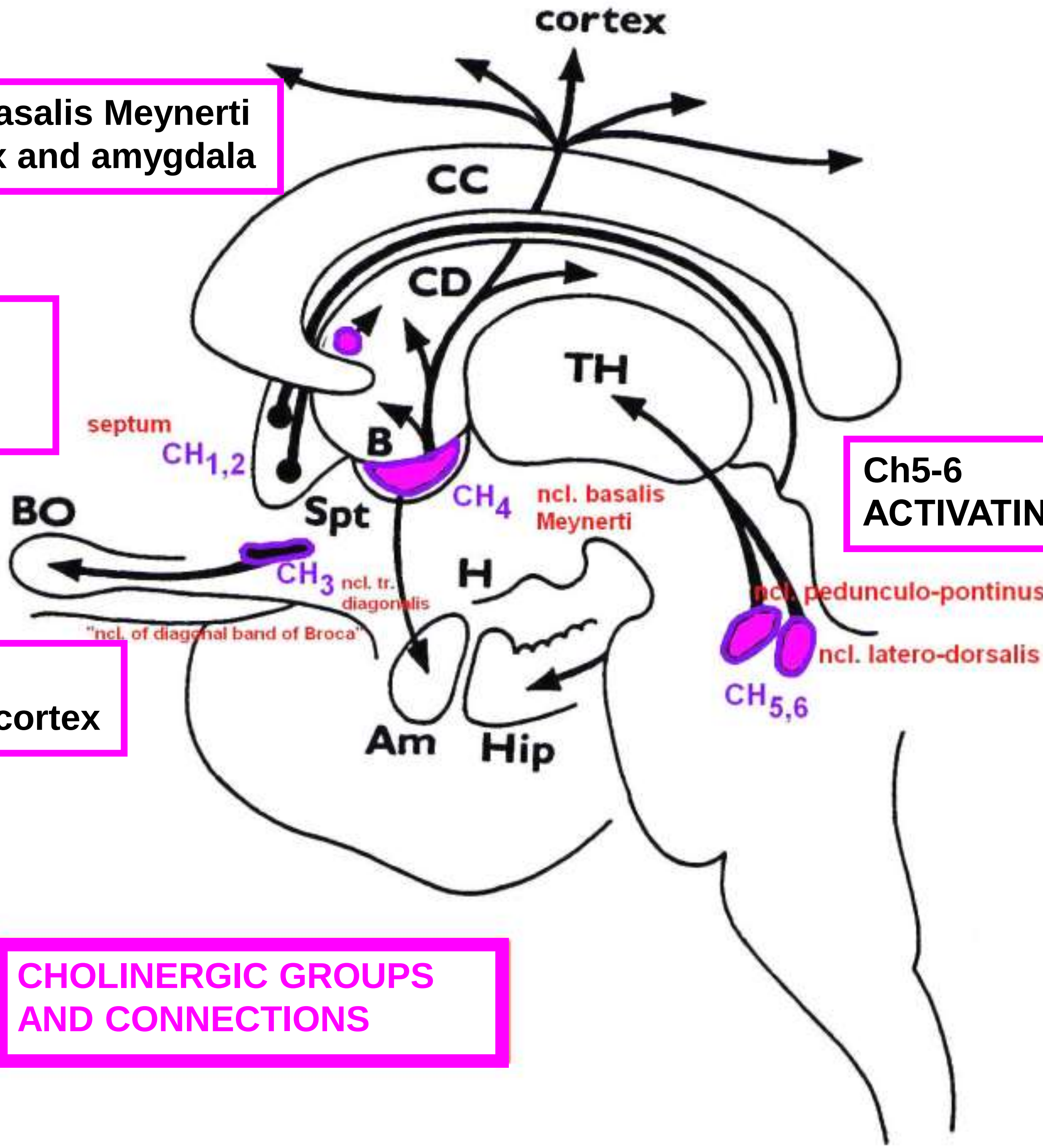
Prevention:
Sleep, physical activity, sources of L-tryptophan (banana, salmon)

Ch4 – ncl. basalis Meynerti to neocortex and amygdala

Ch1-2 –by fornix to archicortex

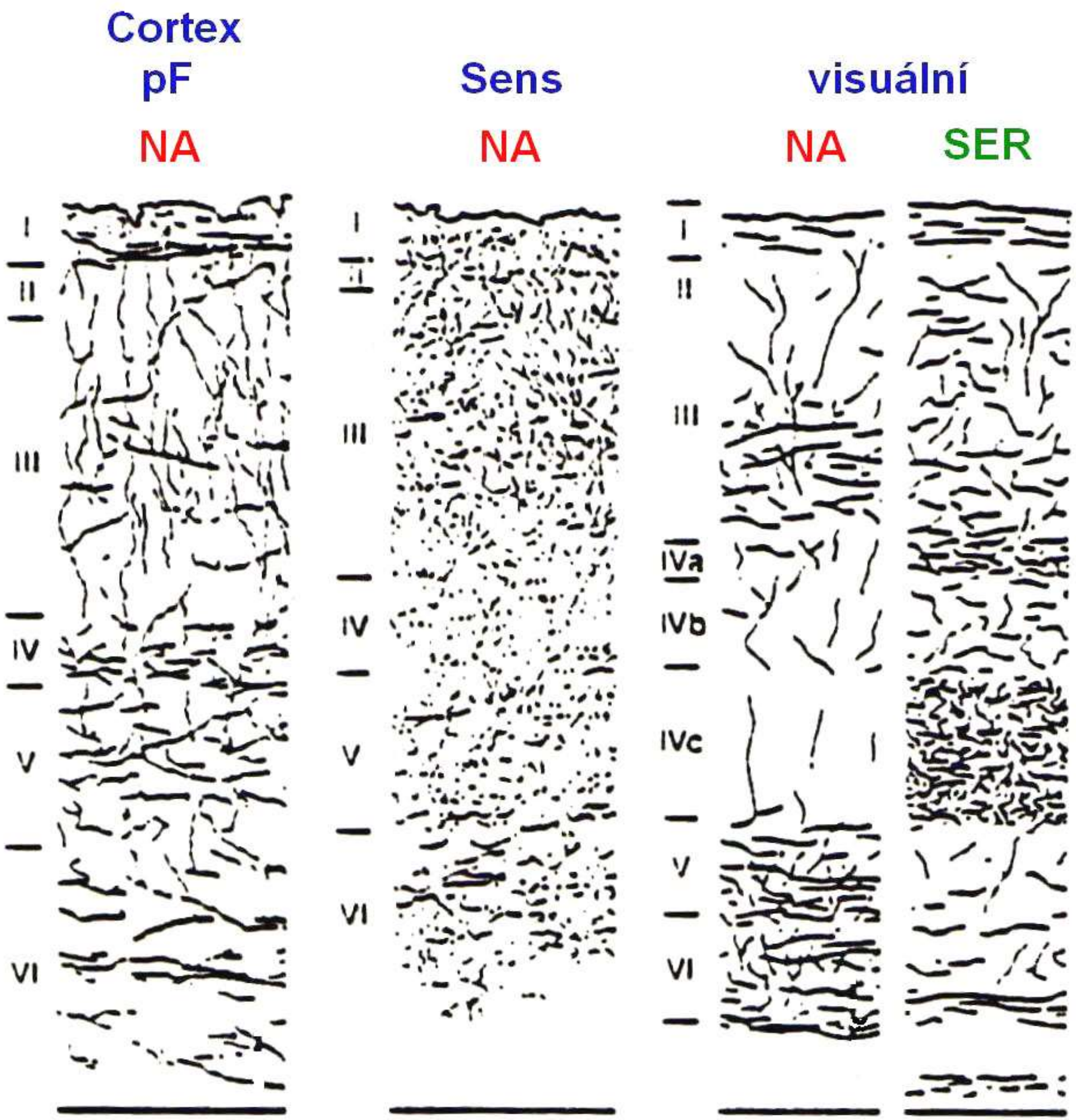
Ch3 to paleocortex

Ch5-6 ACTIVATING SYSTÉM



CHOLINERGIC GROUPS AND CONNECTIONS

Catecholaminergic fibers in cortex



Sources

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- H-J ten Donkelaar Clinical Neuroanatomy
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