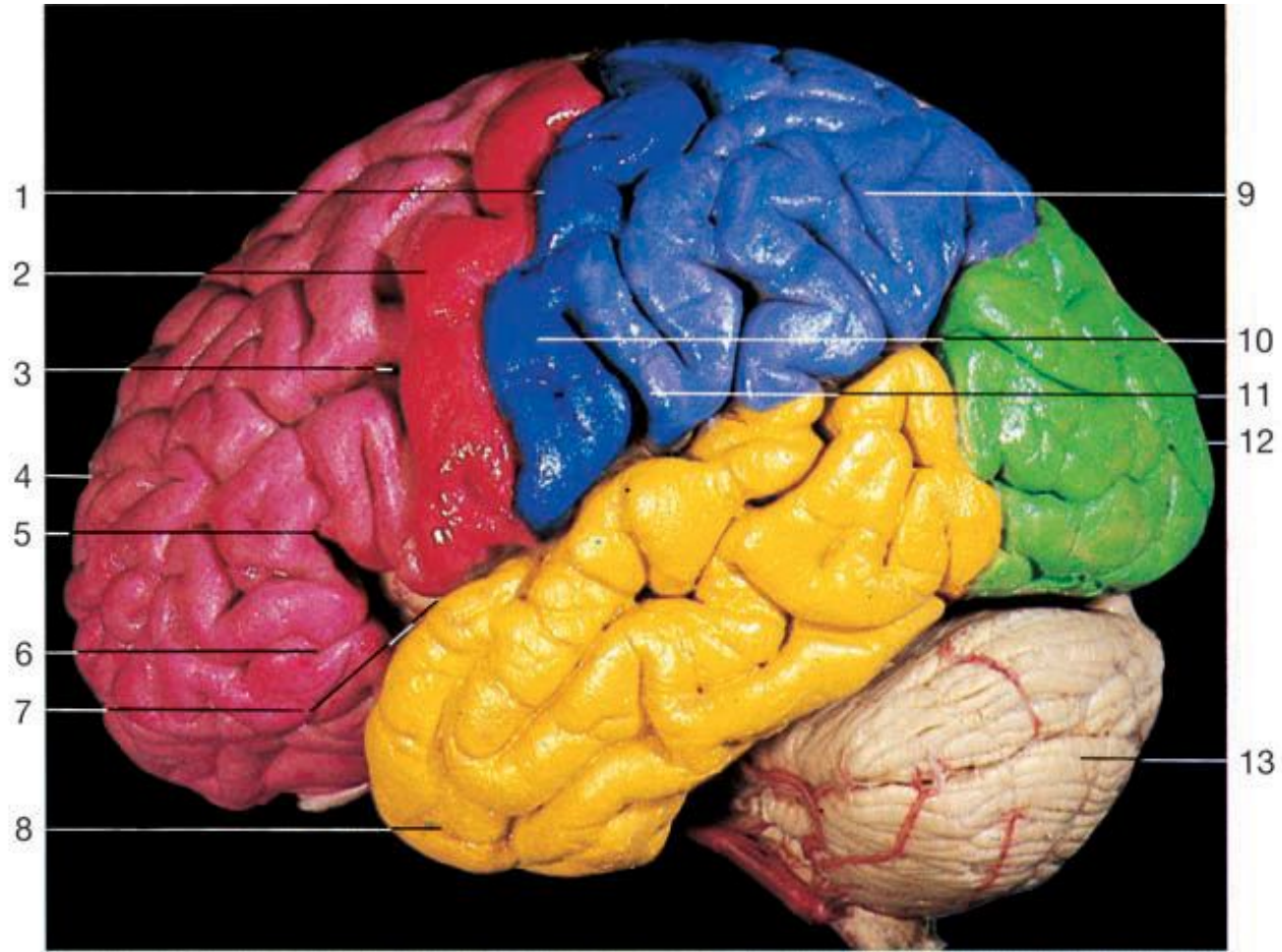
TELENCEPHALON

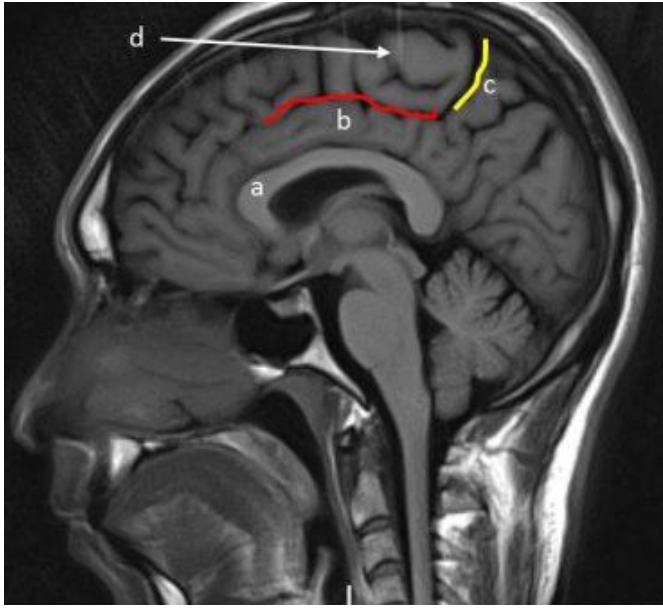
- The right and left hemispheres are separated by the longitudinal fissure of the brain and connected at the base of the fissure by a bundle of fibers—the corpus callosum
- The surface of the hemispheres is furrowed from the 3rd month in utero – gyri and sulci (great variability even between hemispheres of the same brain) → lobes (frontal, parietal, occipital, temporal, limbic, insular)
    - superolateral surface – central sulcus (of Rolando, extending onto the medial surface), lateral sulcus (of Sylvius), parieto-occipital sulcus (more pronounced and longer on the medial surface), pre-occipital notch
    - medial surface – cingulate sulcus, subparietal sulcus, collateral sulcus

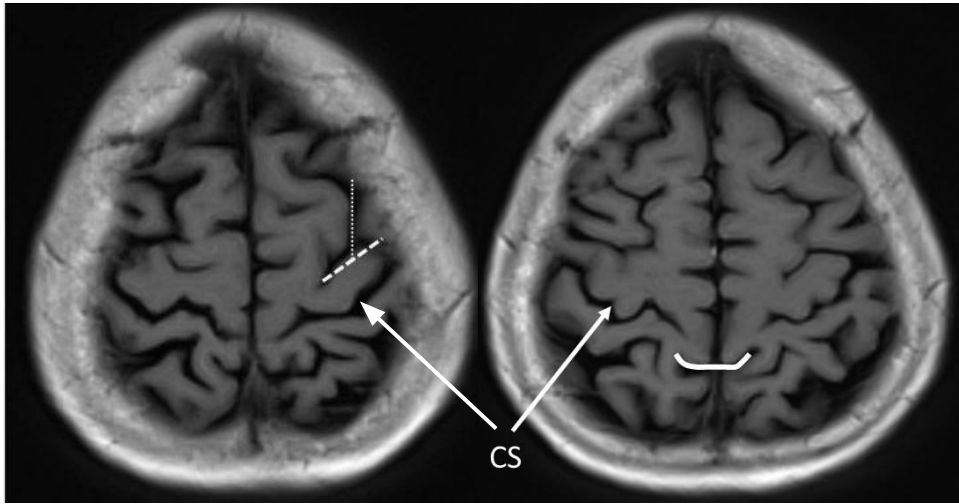


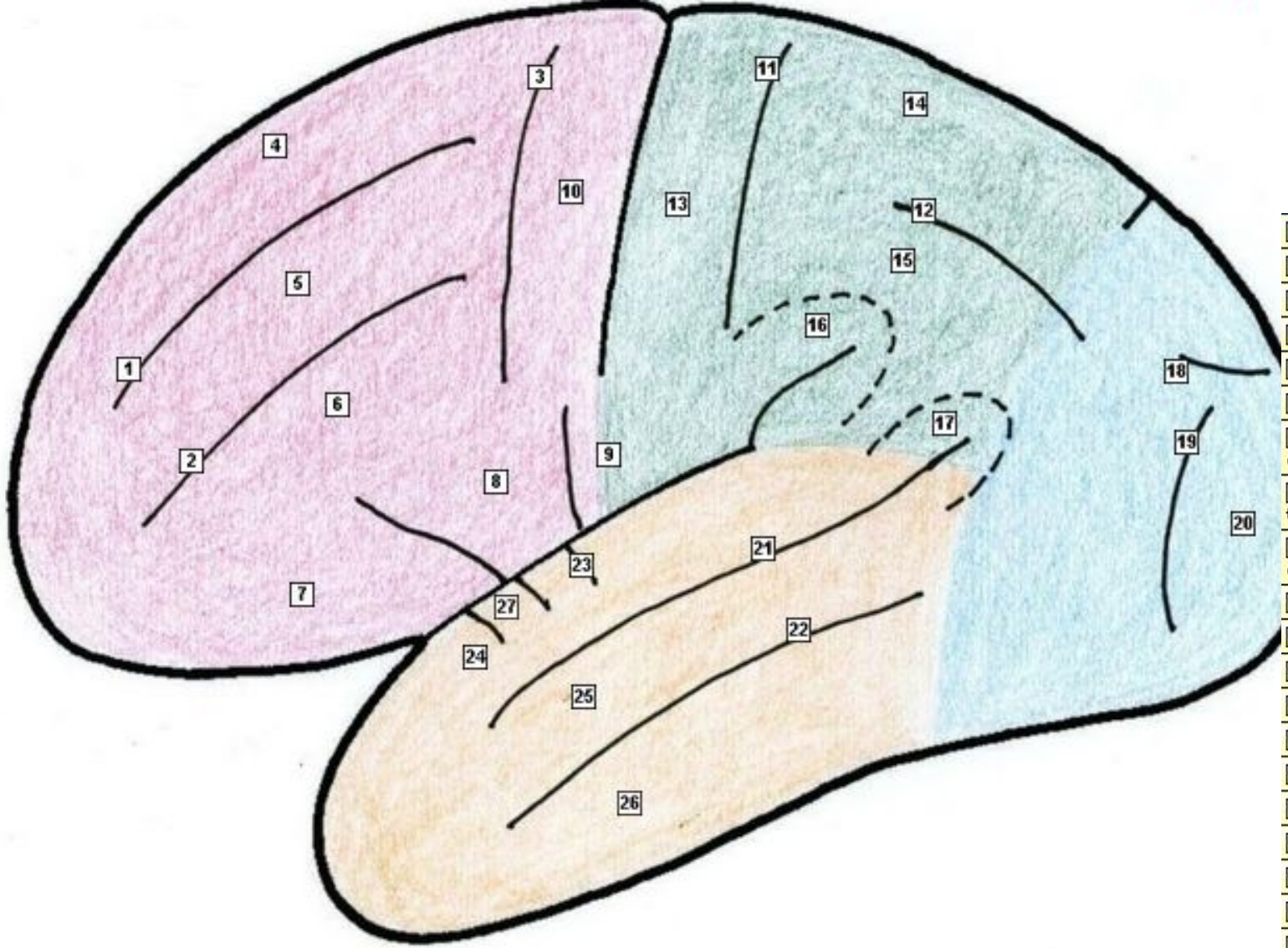
1 Central sulcus
2 Precentral gyrus
3 Precentral sulcus
4 Frontal lobe
5 Anterior ascending ramus of lateral sulcus
6 Anterior horizontal ramus of lateral sulcus
7 Lateral sulcus
8 Temporal lobe
9 Parietal lobe
10 Postcentral gyrus
11 Postcentral sulcus
12 Occipital lobe
13 Cerebellum

TELENCEPHALON

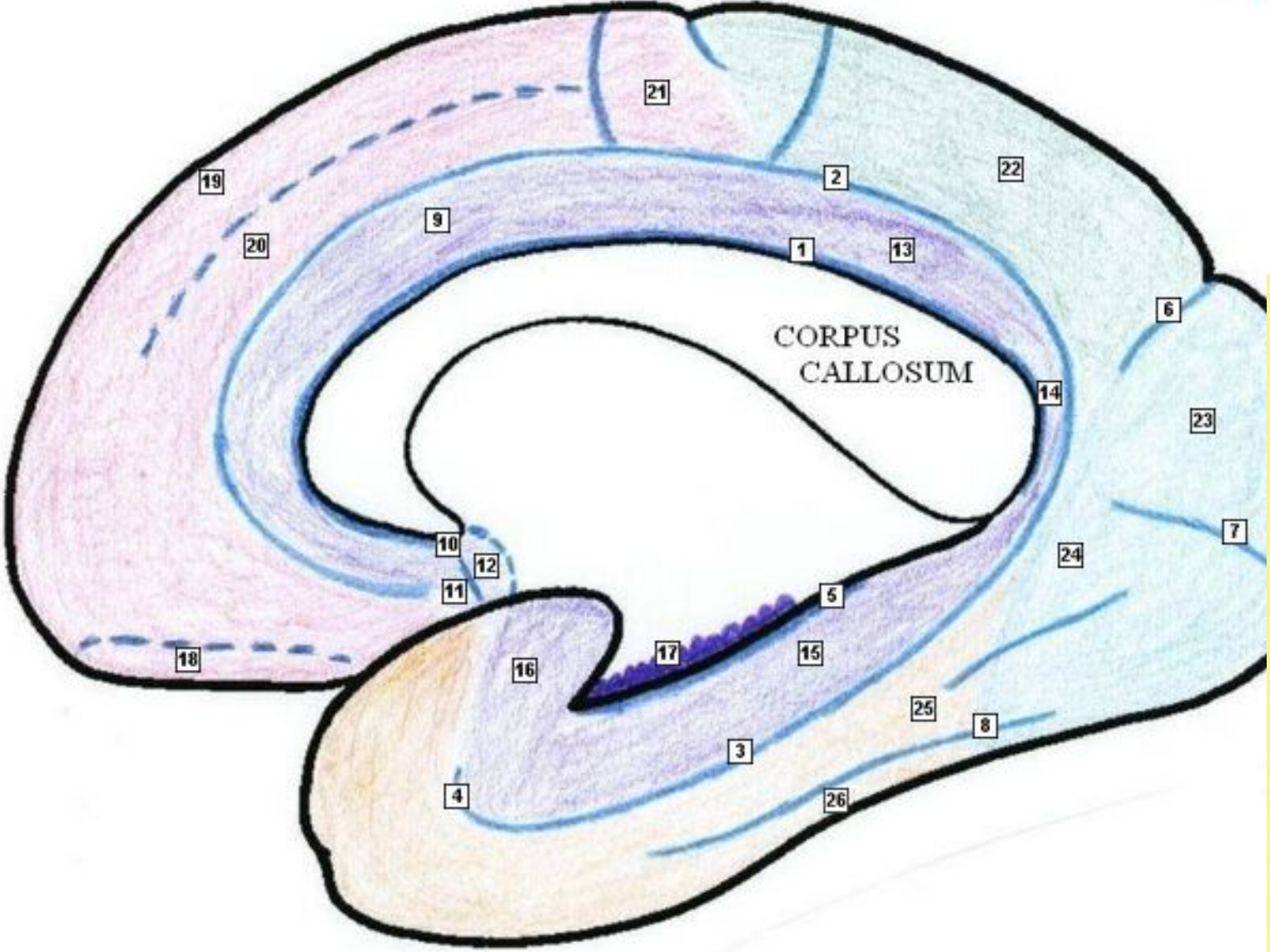
- Identification of the central sulcus on the medial surface
    - anterior to the marginal part of the cingulate sulcus
- on the superolateral surface
    - behind the superior frontal sulcus, which intersects the precentral sulcus
    - anterior to the marginal part of the cingulate sulcus (parenthesis)
- frontal lobe – anterior cerebral fossa
- temporal lobe – middle cerebral fossa
- occipital lobe – cerebral fossae



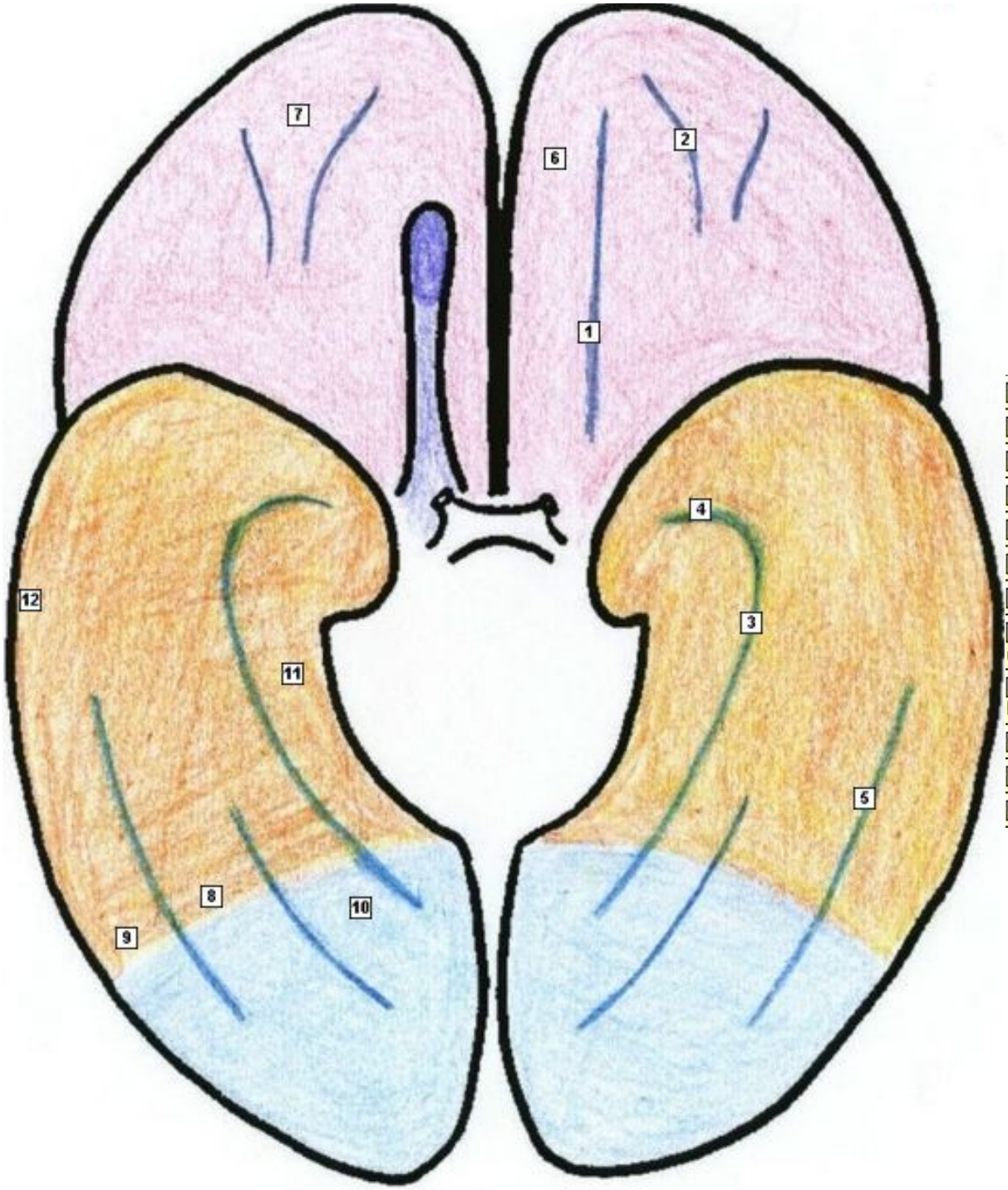




1 Sulcus frontalis superior
2 Sulcus frontalis inferior
3 Sulcus precentralis
4 Gyrus frontalis superior
5 Gyrus frontalis medius
6 Gyrus frontalis inferior
7 Gyrus frontalis inferior - pars orbitalis
8 Gyrus frontalis inferior - pars triangularis
9 Gyrus frontalis inferior - pars opercularis
10 Gyrus precentralis
11 Sulcus postcentralis
12 Sulcus intraparietalis
13 Gyrus postcentralis
14 Lobulus parietalis superior
15 Lobulus parietalis inferior
16 Gyrus supramarginalis
17 Gyrus angularis
18 Sulcus occipitalis transversus
19 Sulcus lunatus
20 Gyri occipitales
21 Sulcus temporalis superior
22 Sulcus temporalis inferior
23 Sulci temporales transversi
24 Gyrus temporalis superior
25 Gyrus temporalis medius
26 Gyrus temporalis inferior
27 Gyri temporales transversi



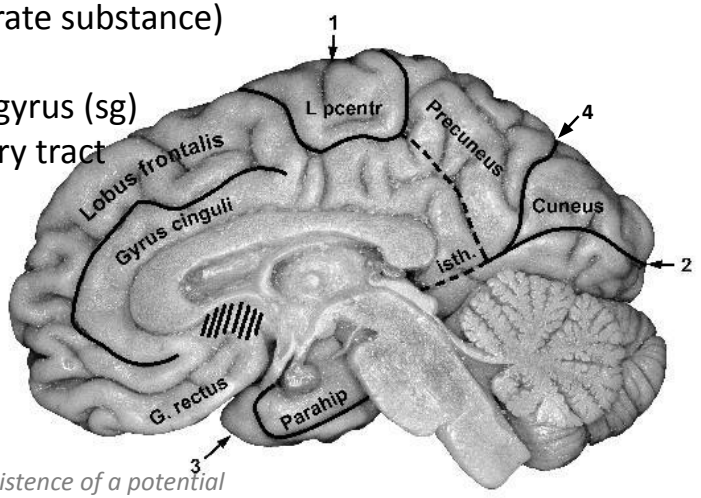
1 Sulcus corporis callosi
2 Sulcus cinguli
3 Sulcus collateralis
4 Sulcus rhinalis
5 Sulcus hippocampalis
6 Sulcus parietooccipitalis
7 Sulcus calcarinus
8 Sulcus occipitotemporalis
9 Lobus limbicus
10 Area subcallosa
11 Gyrus paraterminalis
12 *Area paraolfactoria*
13 Gyrus cinguli
14 Isthmus gyri cinguli
15 Gyrus parahippocampalis
16 Uncus gyri parahippocampalis
17 Gyrus dentatus (fasciola dentata)
18 Gyrus rectus
19 Gyrus frontalis superior
20 Gyrus frontalis medialis
21 Lobulus paracentralis
22 Precuneus
23 Cuneus
24 Gyrus lingualis
25 Gyrus occipitotemporalis medialis
26 Gyrus occipitotemporalis lateralis



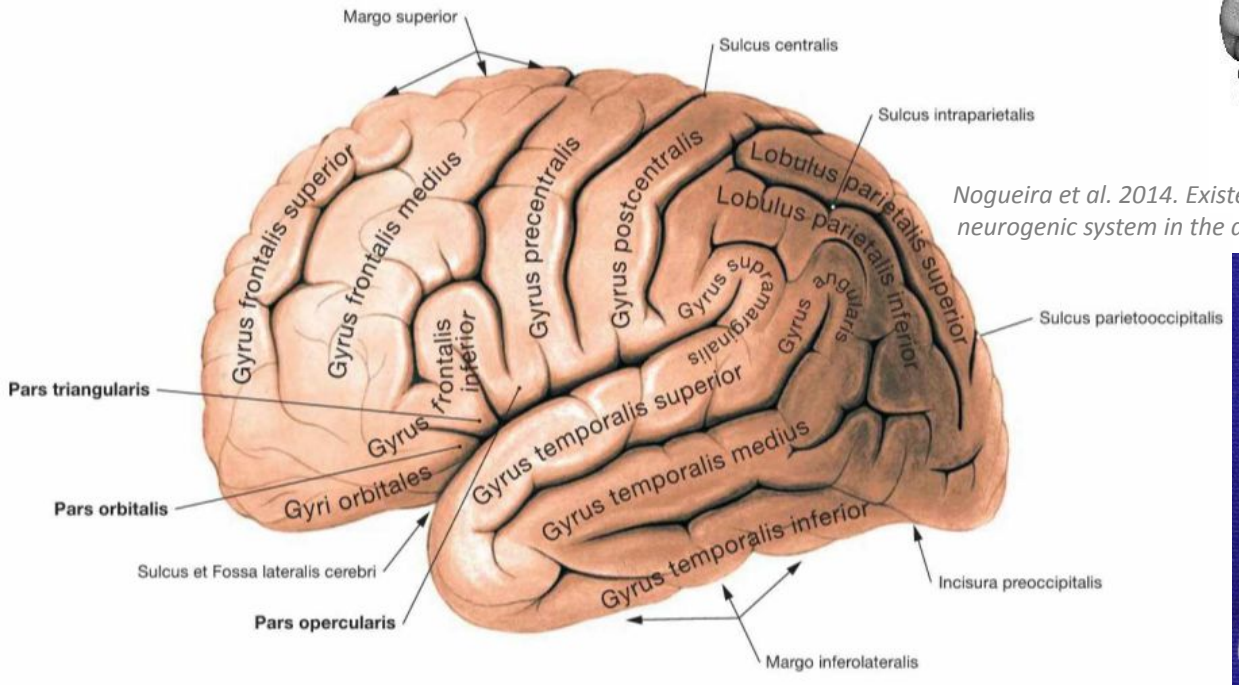
1 Sulcus olfactorius
2 Sulci orbitales
3 Sulcus collateralis
4 Sulcus rhinalis **variable continuation of 3**
5 Sulcus occipitotemporalis
6 Gyrus rectus
7 Gyri orbitales
8 Gyrus occipitotemporalis medialis **8 + 9 = gyrus fusiformis**
9 Gyrus occipitotemporalis lateralis
10 Gyrus lingualis
11 Gyrus parahippocampalis
12 Gyrus temporalis inferior

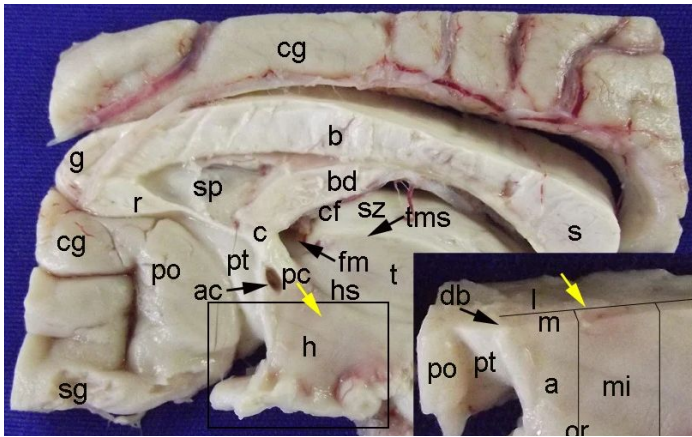
LOBUS FRONTALIS

- from the frontal pole to the central sulcus (Rolandi), caudally to the lateral fissure (Sylvii)
- superolateral surface
  - precentral sulcus (often discontinuous) – precentral gyrus
  - the horizontal superior and inferior frontal sulci separate the superior, middle, and inferior frontal gyri
- medial surface
  - cingulate gyrus (above the corpus callosum), separated by the corpus callosum sulcus and the cingulate sulcus
  - the remainder of the medial surface is formed by the superior frontal gyrus
  - anterior to the lamina terminalis – subcallosal gyrus; below the rostrum of the corpus callosum – paraterminal gyrus (pt), paraolfactory area (po) (continuation of the anterior perforate substance)
- orbital surface
  - the olfactory sulcus separates the orbital gyri from the medial rectus gyrus (sg)
  - adjacent to the olfactory sulcus are the olfactory bulb and the olfactory tract



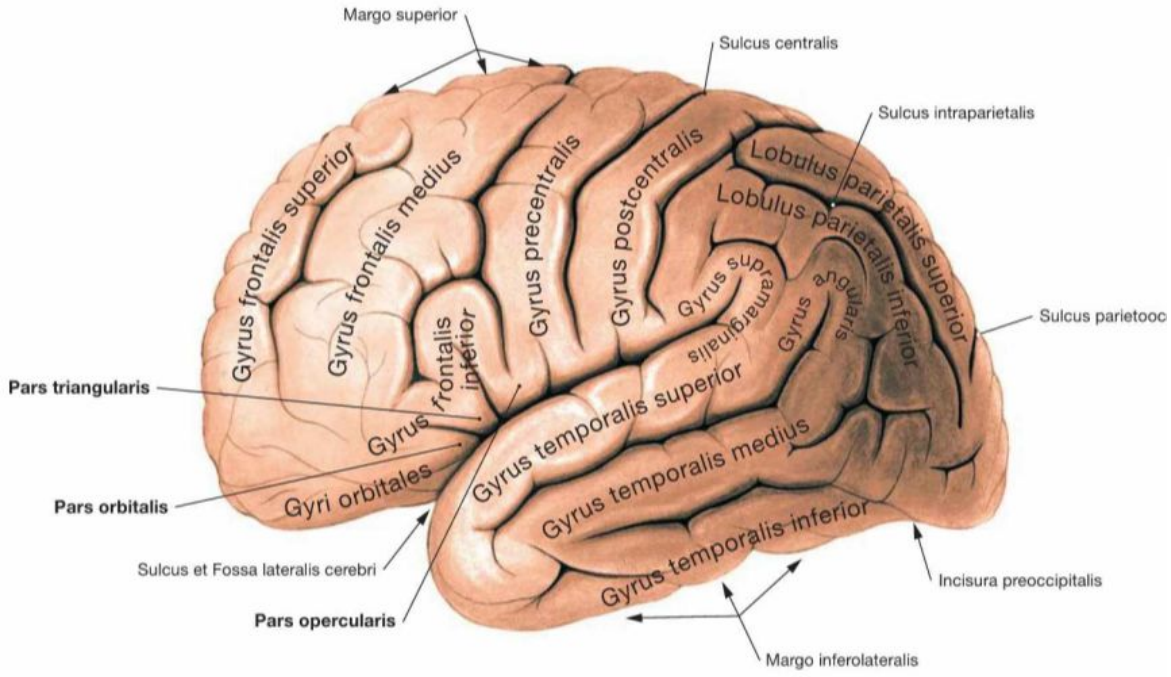
Nogueira et al. 2014. Existence of a potential neurogenic system in the adult human brain

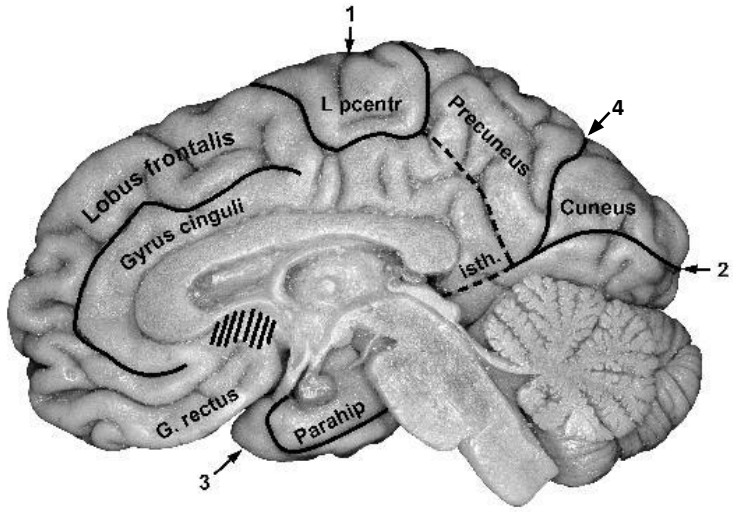




LOBUS PARIETALIS

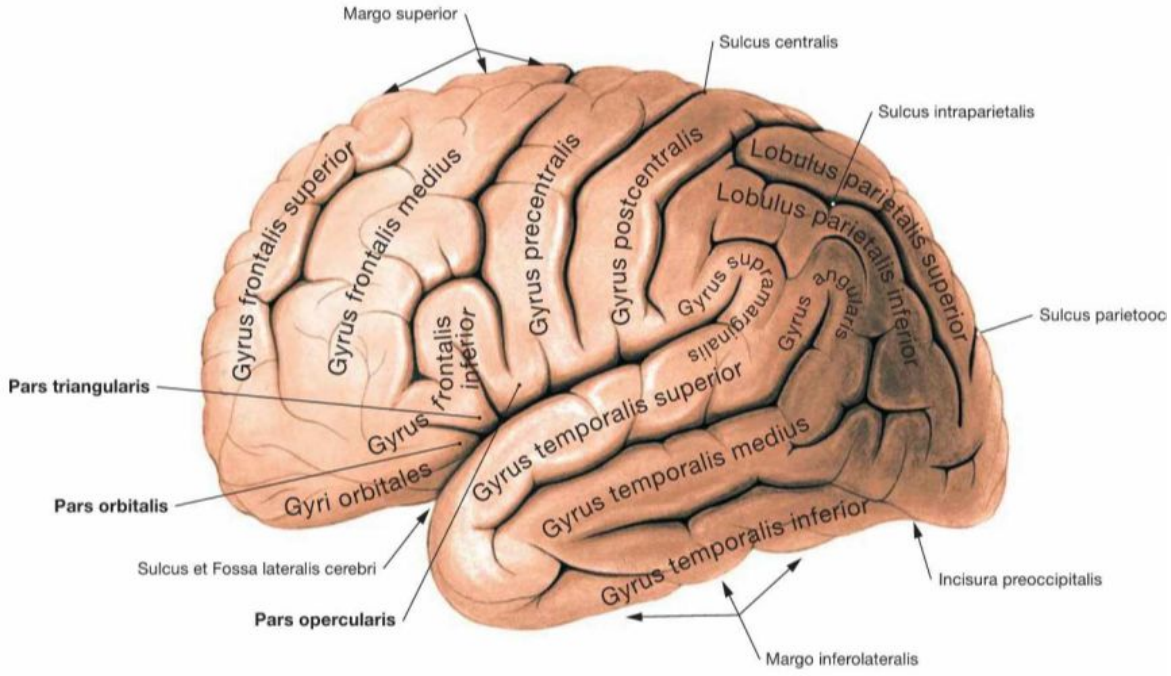
- from the central sulcus to the line connecting the parieto-occipital sulcus and the pre-occipital notch, caudally the lateral sulcus
- superolateral surface
  - postcentral gyrus
  - the horizontally running intraparietal sulcus, which separates two groups of gyri: superior and inferior parietal lobules
  - the inferior parietal lobule has two parts: the anterior—supramarginal gyrus (continuing into the superior temporal gyrus)—and the posterior—angular gyrus (continues into the middle temporal gyrus)
- medial surface
  - paracentral lobe – encircles the central sulcus (1)
  - precuneus – from the paracentral lobe to the parieto-occipital sulcus (4)

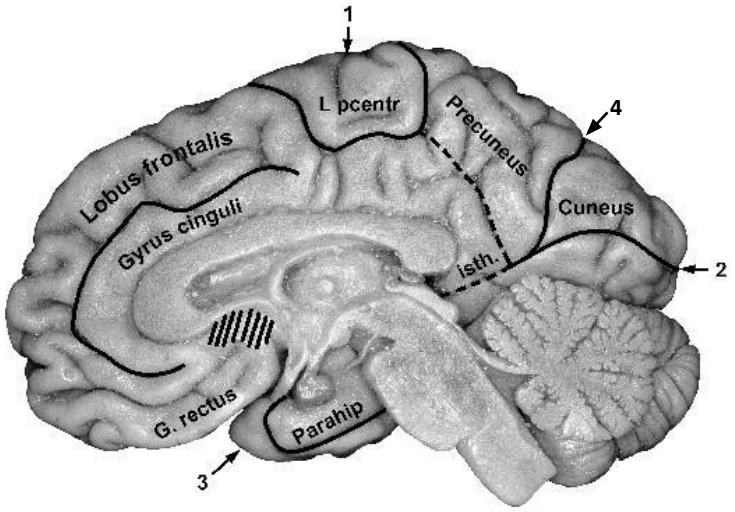




LOBUS OCCIPITALIS

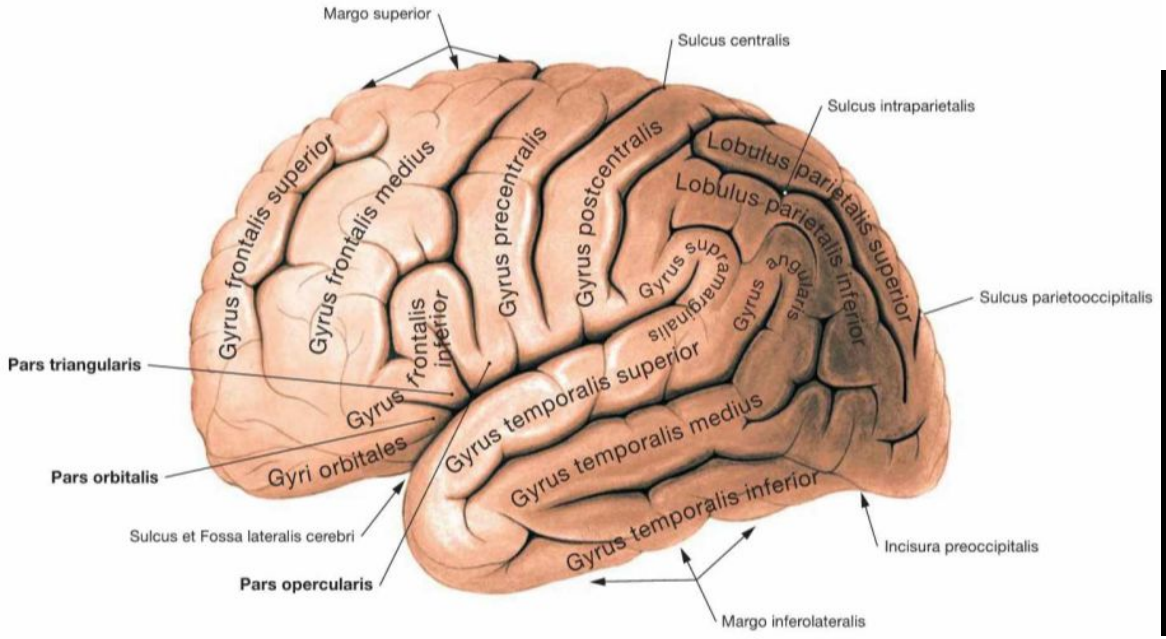
- between the parietooccipital sulcus and the preoccipital notch, ventrally the line connecting the former
- superolateral surface
    - of the occipital gyri (variable)
- medial surface
    - between the calcarine sulcus (defined by the calcar avis in the occipital corner of the lateral ventricle) and the parieto-occipital sulcus lies the cuneus
    - collateral sulcus – running parallel below the calcarine sulcus, separates the lingual gyrus (medial occipito-temporal gyrus)

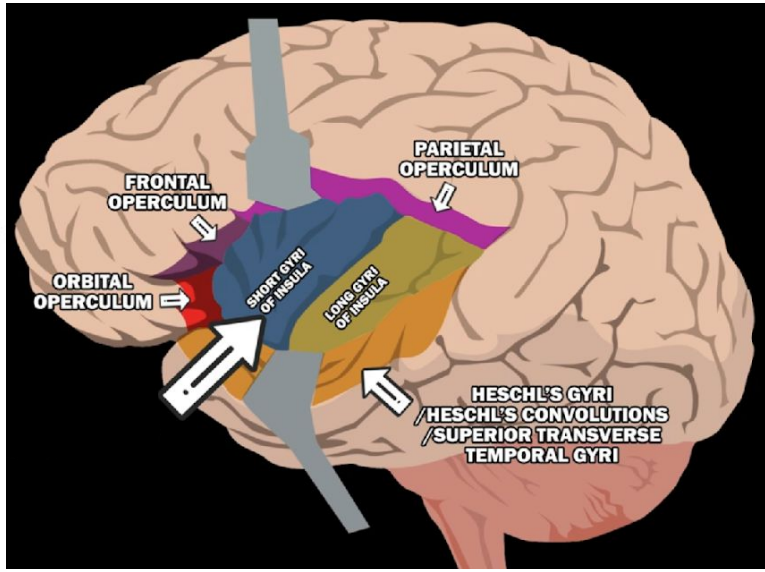




LOBUS TEMPORALIS

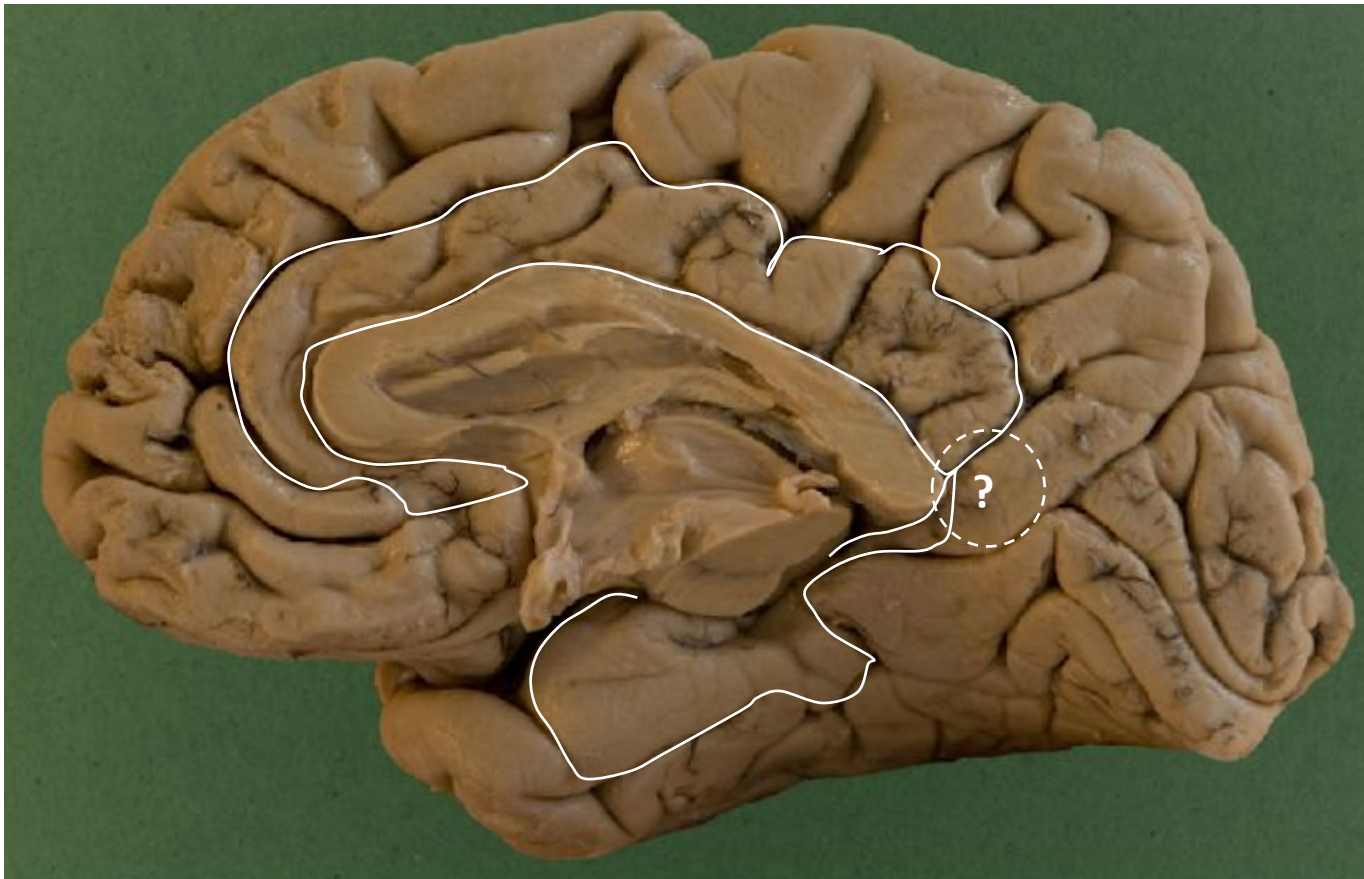
- from the parietal-temporal sulcus to the line connecting the parieto-occipital sulcus and the pre-occipital notch
- superolateral surface
    - the superior and inferior temporal sulci separate the superior, middle, and inferior temporal gyri
- lateral sulcus/fossa
    - on the upper surface of the posterior part of the superior temporal gyrus are one or two transverse temporal gyri—the anterior one is Heschl's gyrus (area 41, primary auditory area); the triangular area behind Heschl's gyrus is the planum temporale (part of Wernicke's speech area 22, larger on the left in right-handed individuals)
- medial face
    - collateral sulcus – separates the parahippocampal gyrus and the lingual gyrus (medial occipitotemporal region)

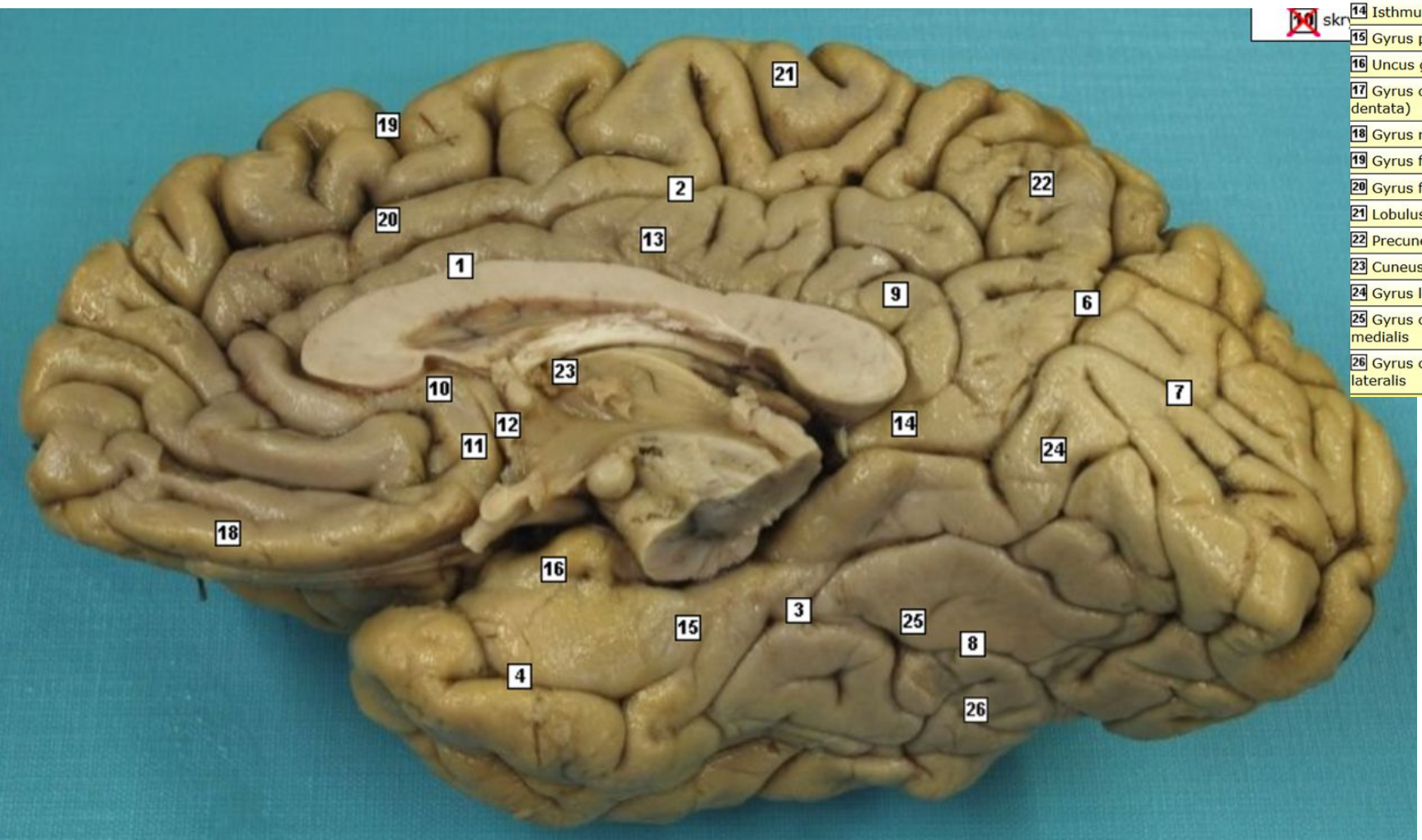




LOBUS LIMBICUS

- The cingulate sulcus, corpus callosum sulcus, calcarine sulcus, collateral sulcus, and hippocampal sulcus
- The cingulate gyrus and parahippocampal gyrus, including the uncus of the parahippocampal gyrus
    - The subiculum—the portion of the parahippocampal gyrus facing the hippocampal sulcus; the dentate gyrus lies above the subiculum





1 Sulcus corporis callosi
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8 Sulcus occipitotemporalis
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12 *Area paraolfactoria*
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22 Precuneus
23 Cuneus
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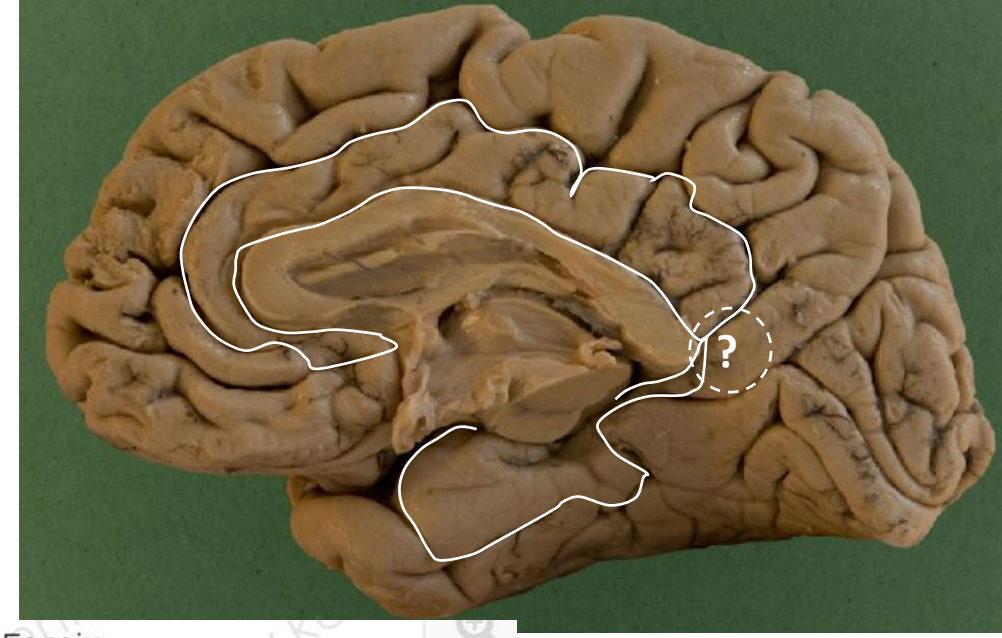
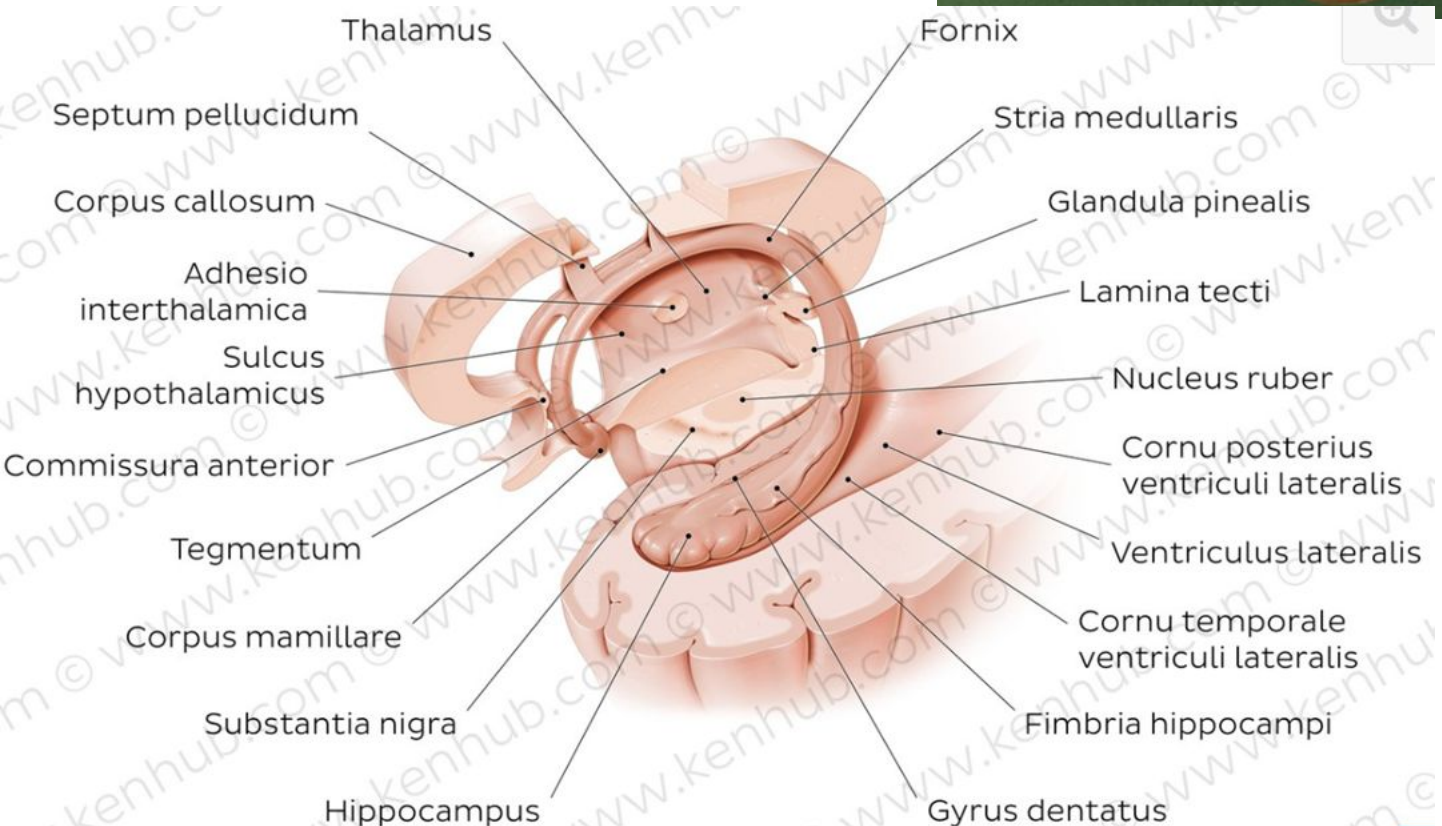
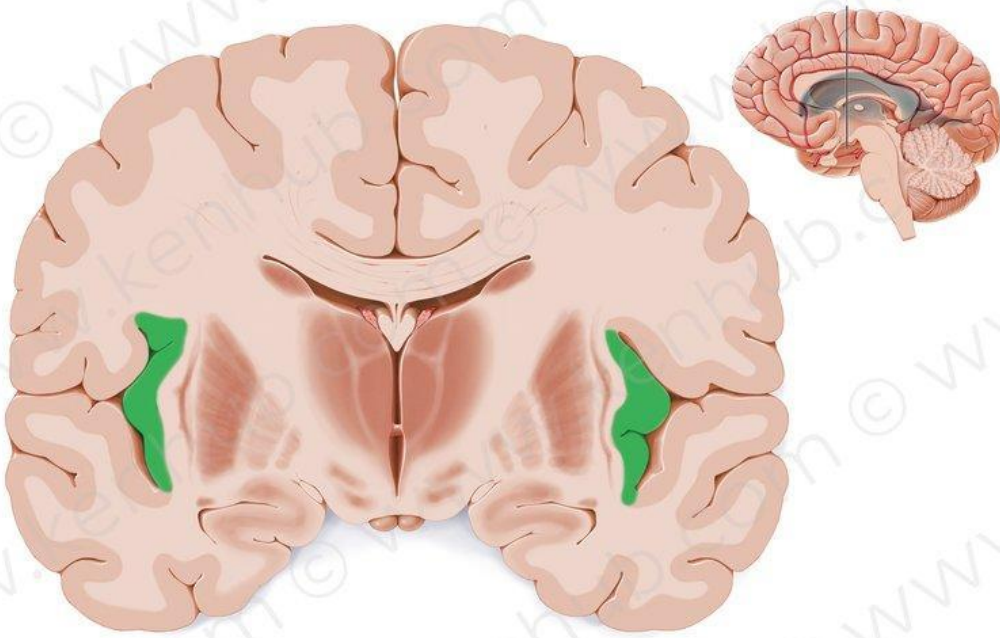
LOBUS LIMBICUS

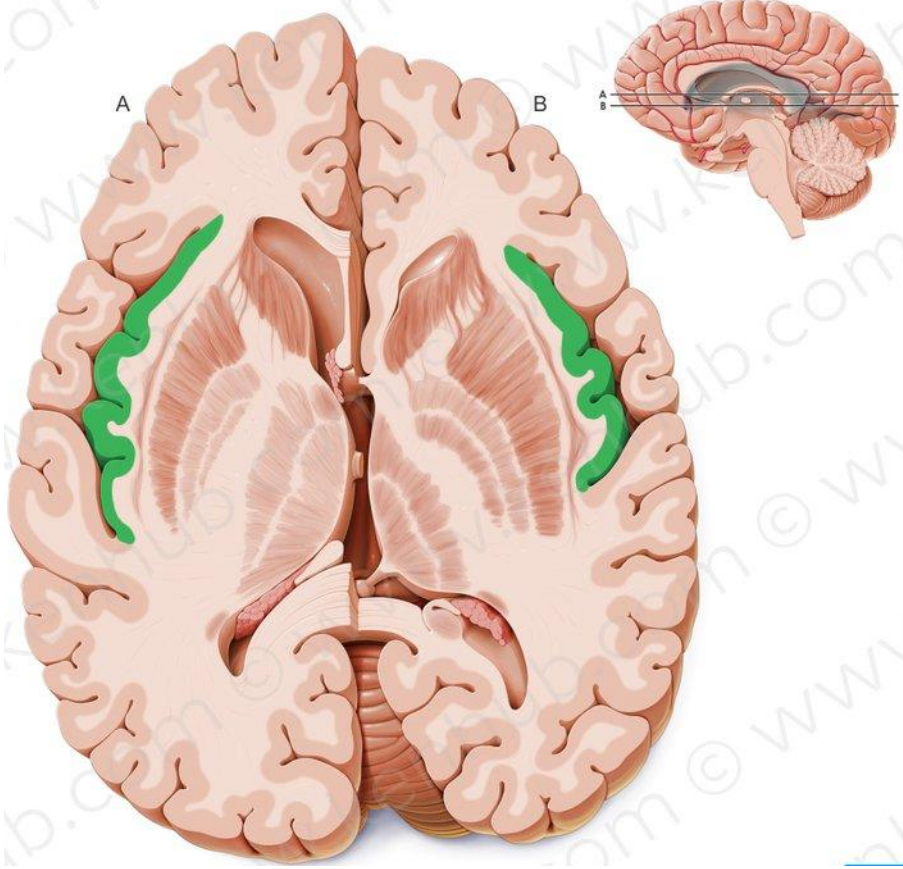


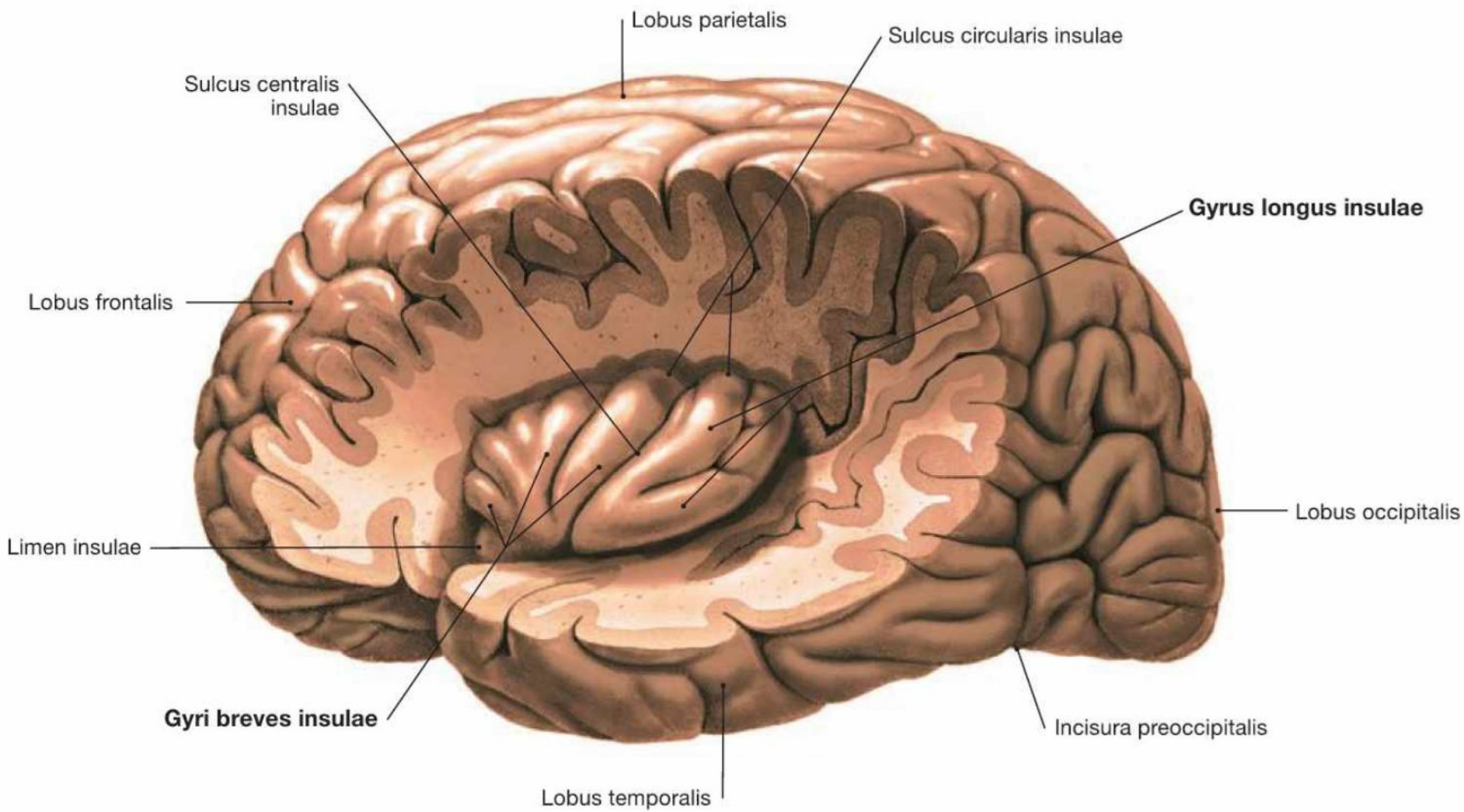


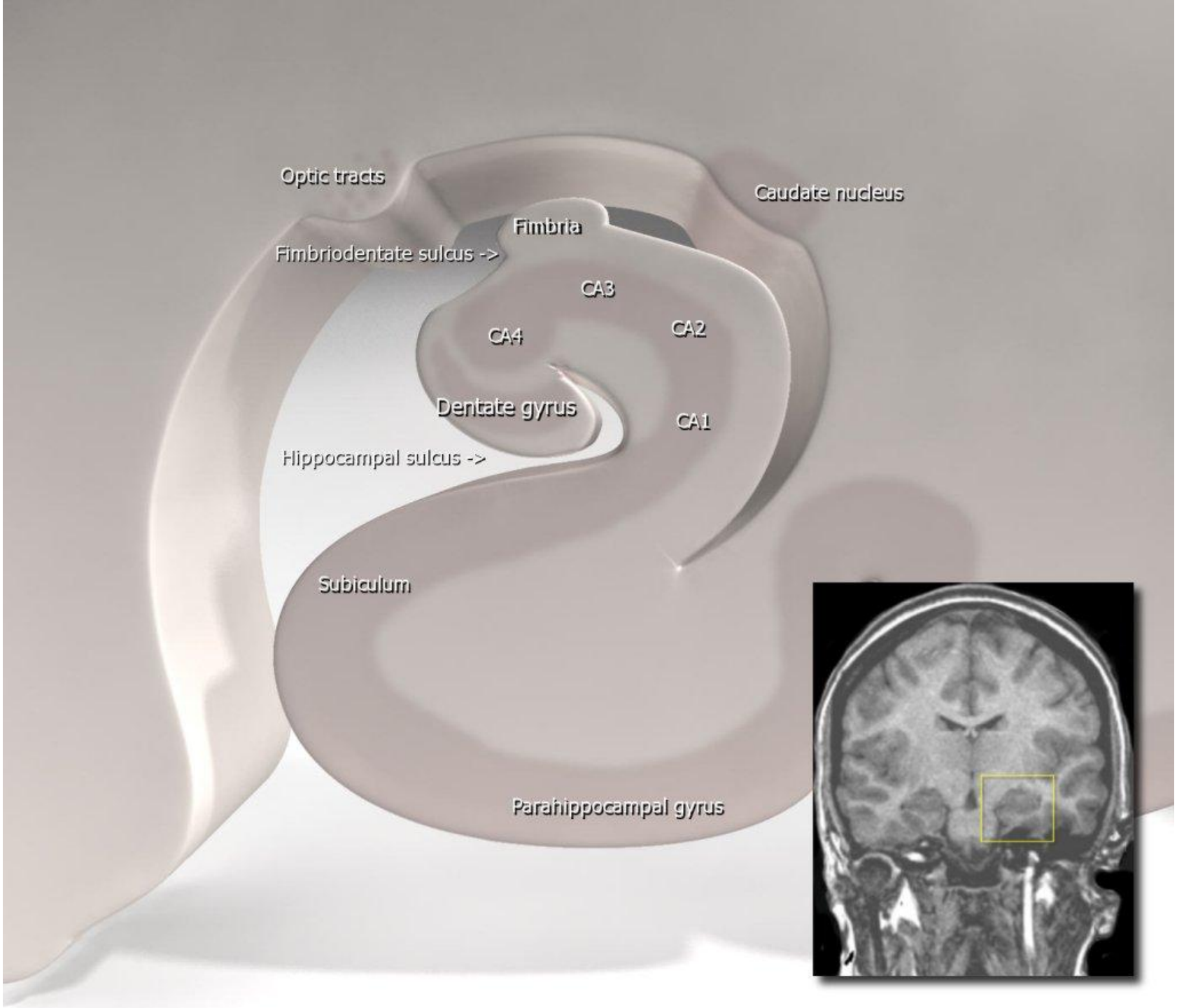
LOBUS INSULARIS

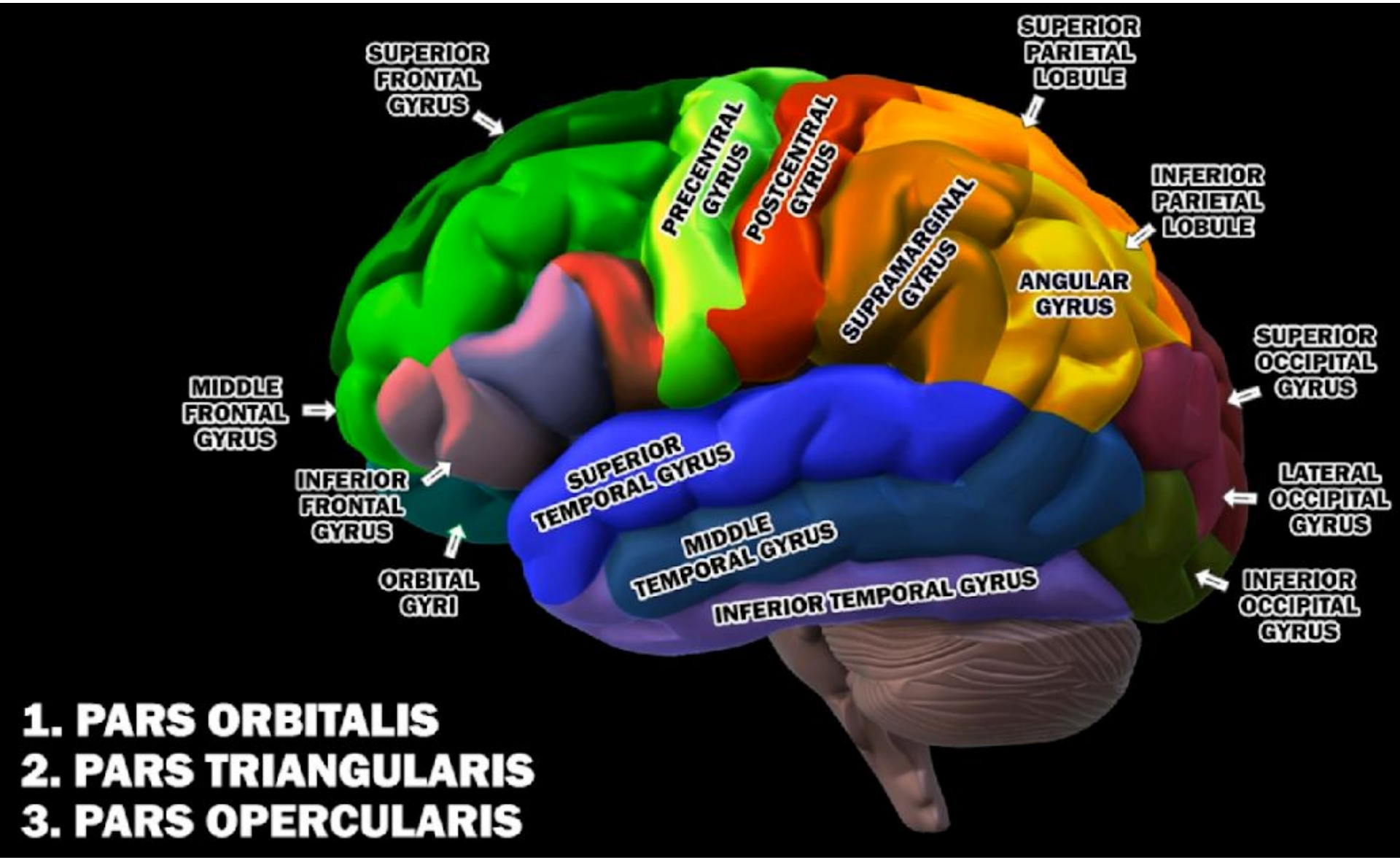
- embedded in the lateral cerebral fossa
- the short gyrus of the insula and the long gyrus of the insula

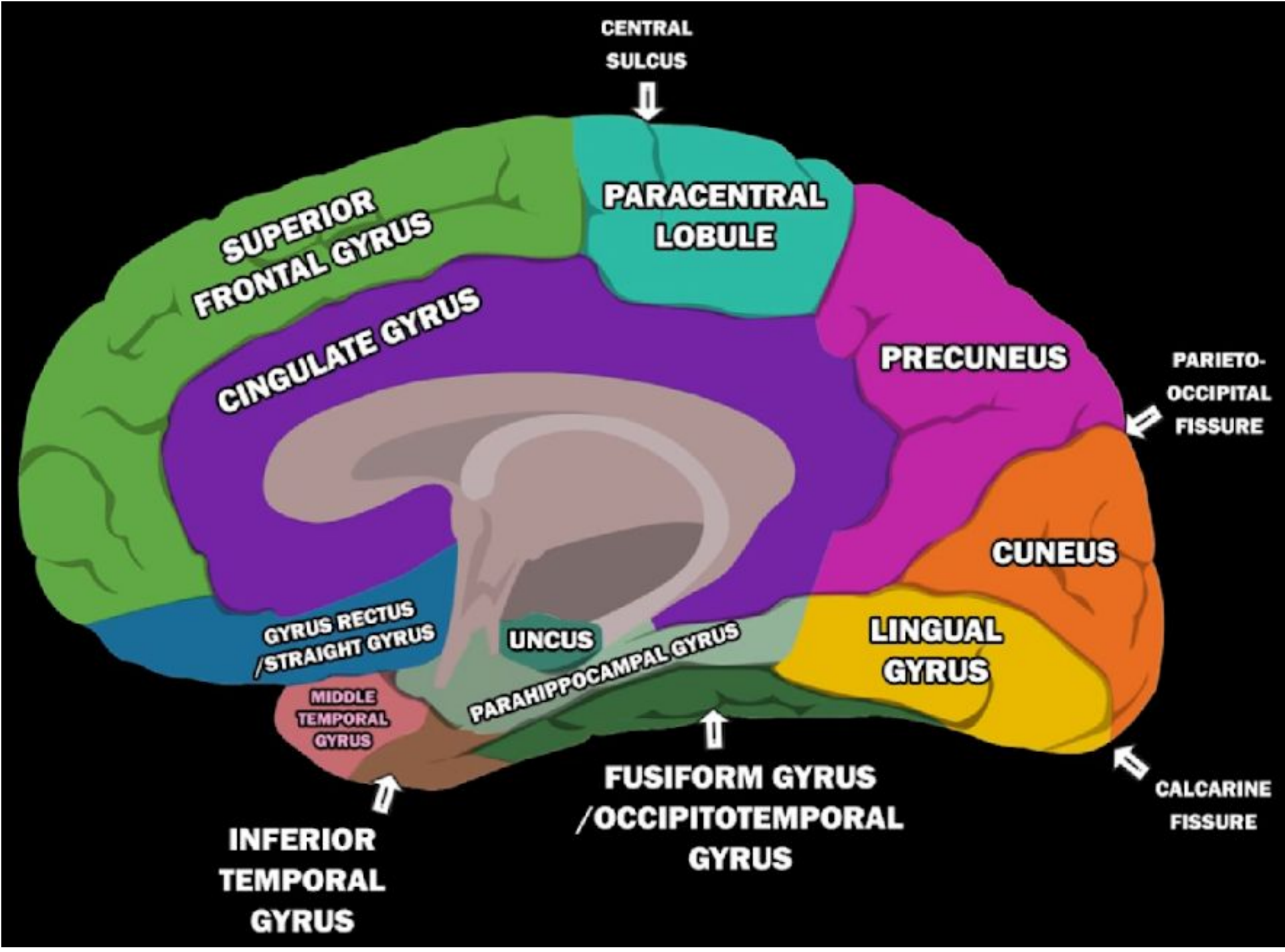


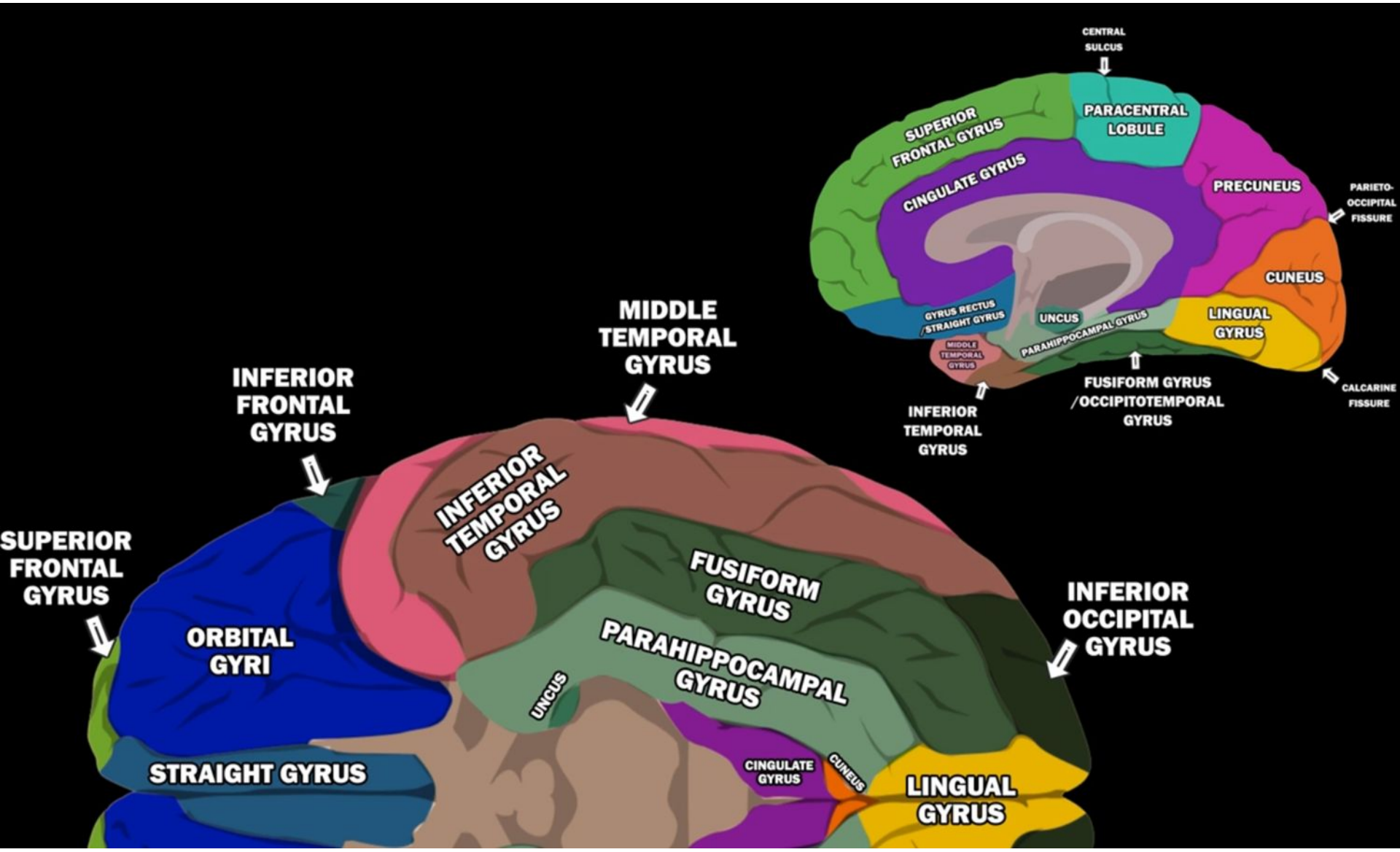


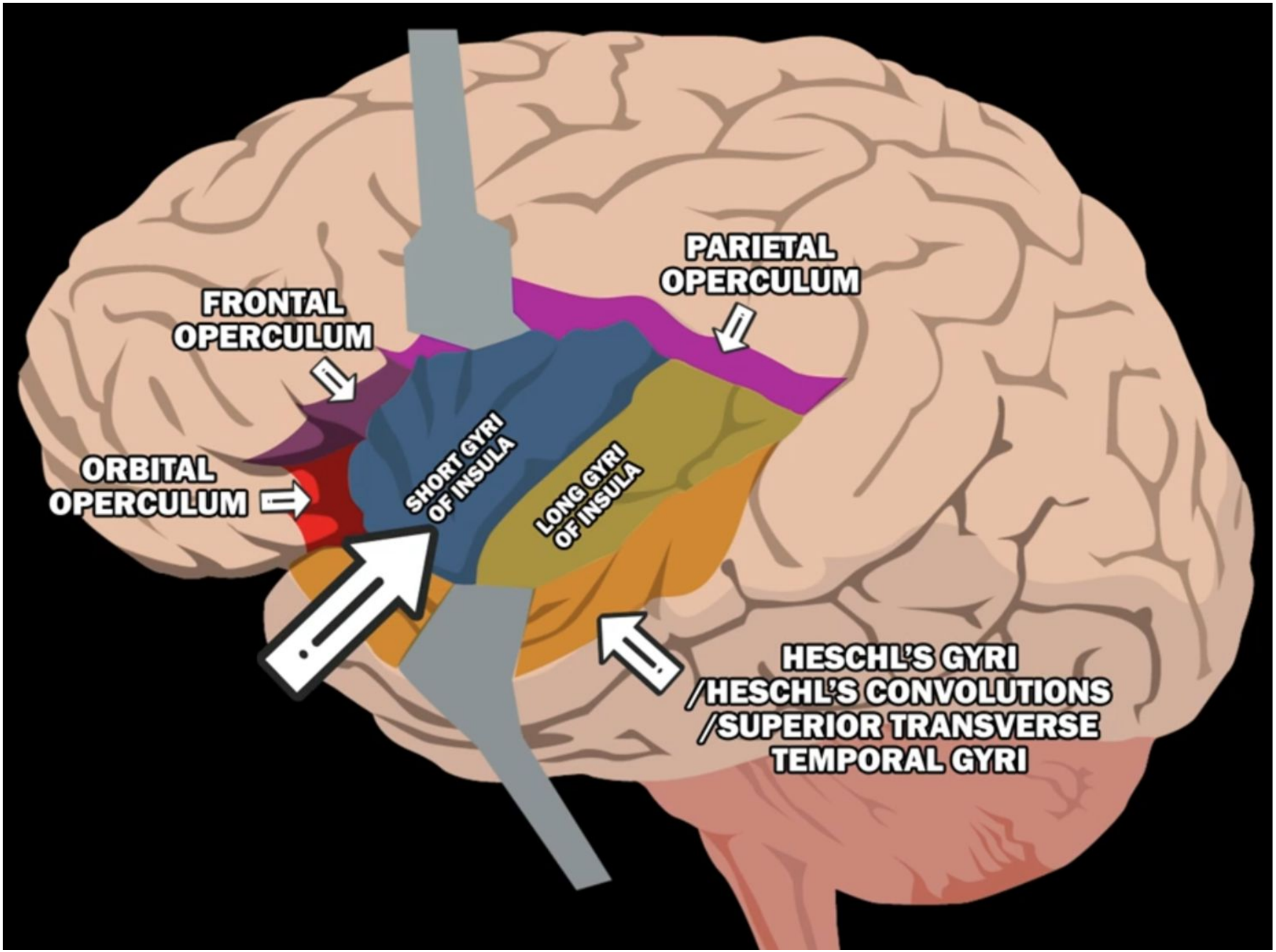

Lobus parietalis
Sulcus circularis insulae
Sulcus centralis insulae
Gyrus longus insulae
Lobus frontalis
Lobus occipitalis
Limen insulae
Gyri breves insulae
Incisura preoccipitalis
Lobus temporalis

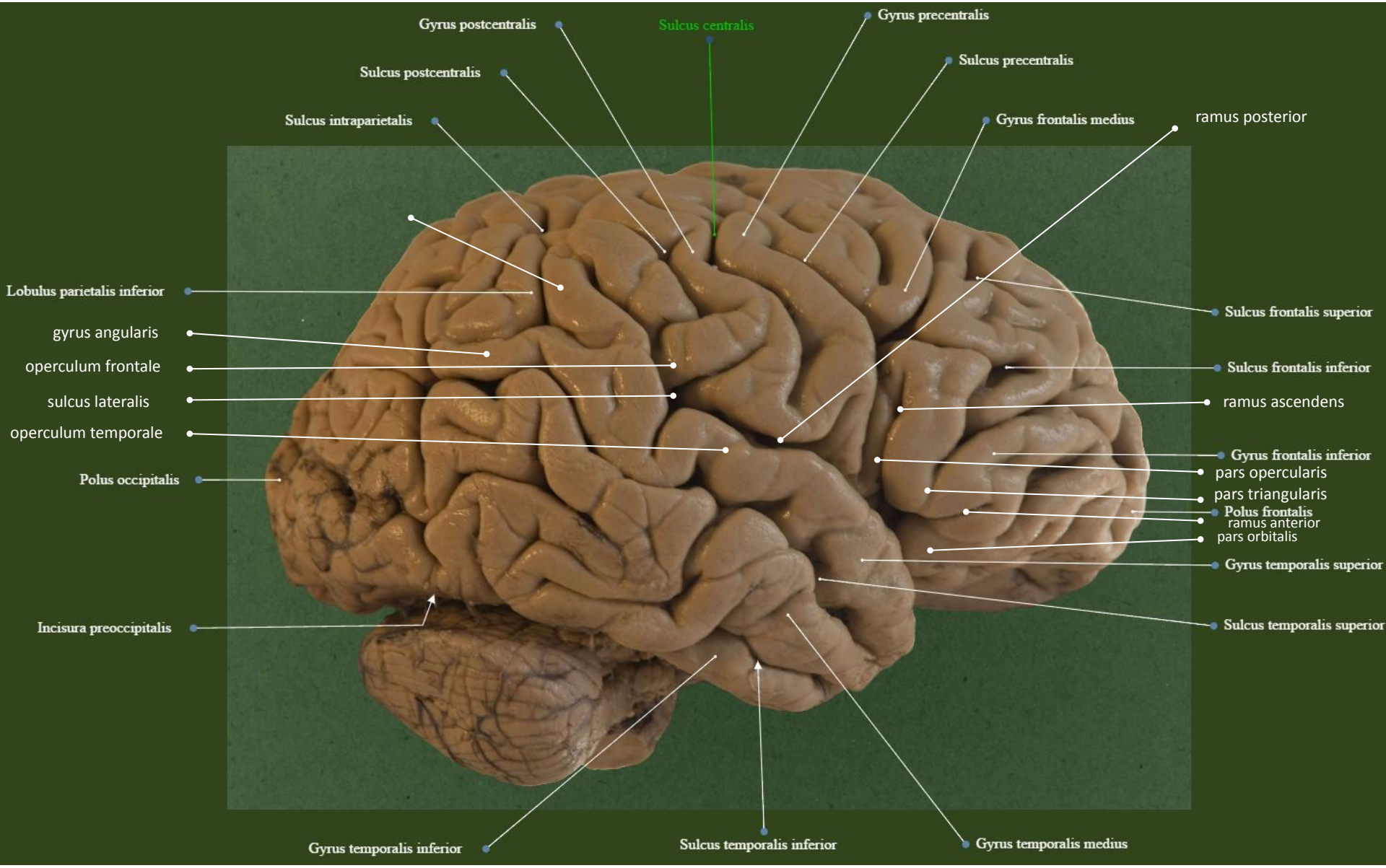

Optic tracts
Caudate nucleus
Fimbria
Fimbriodentate sulcus ->
CA3
CA4
CA2
Dentate gyrus
CA1
Hippocampal sulcus ->
Subiculum
Parahippocampal gyrus

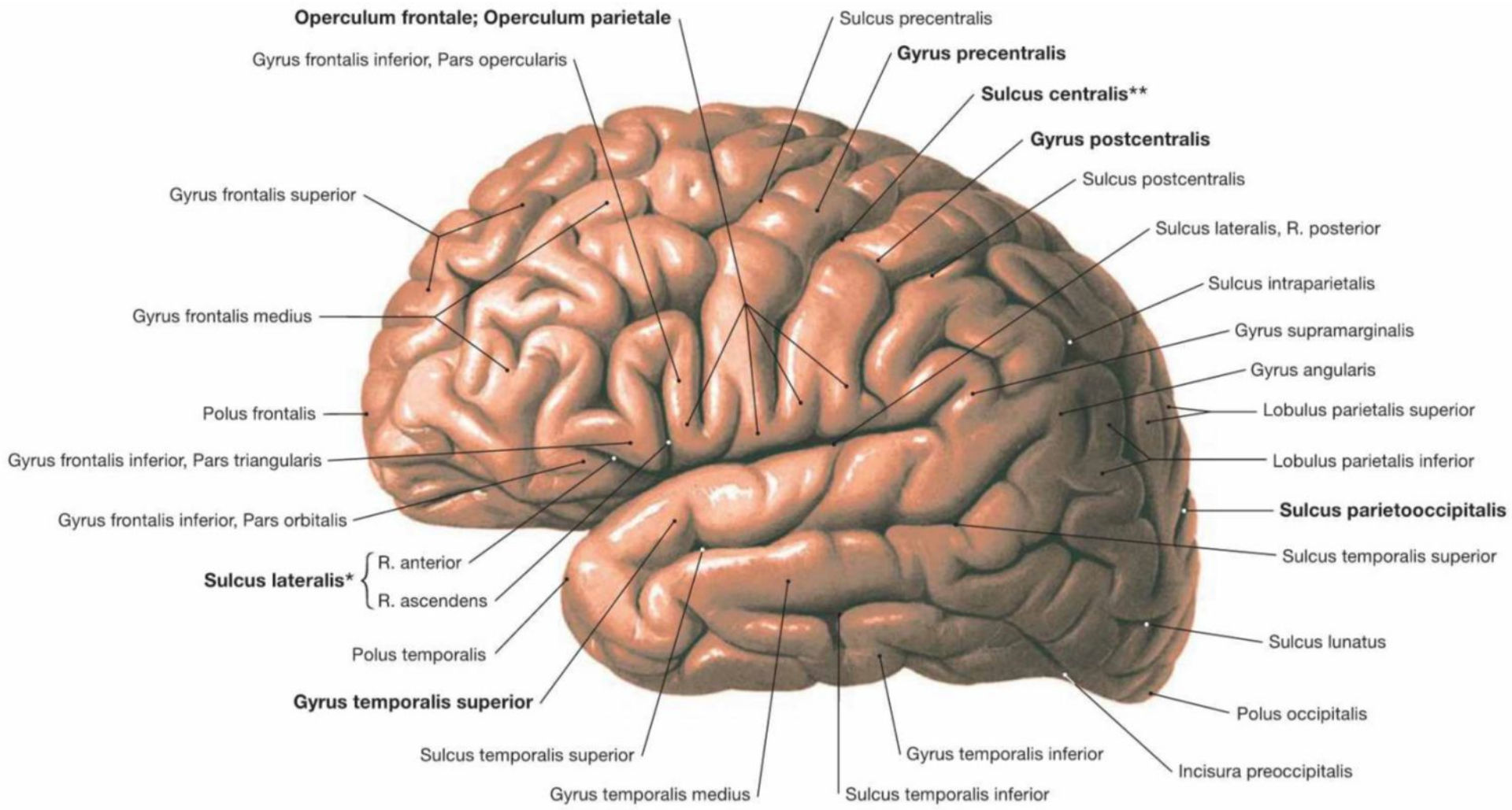

SUPERIOR FRONTAL GYRUS
SUPERIOR PARIETAL LOBULE
PRECENTRAL GYRUS
POSTCENTRAL GYRUS
INFERIOR PARIETAL LOBULE
SUPRAMARGINAL GYRUS
ANGULAR GYRUS
SUPERIOR OCCIPITAL GYRUS
MIDDLE FRONTAL GYRUS
SUPERIOR TEMPORAL GYRUS
INFERIOR FRONTAL GYRUS
LATERAL OCCIPITAL GYRUS
MIDDLE TEMPORAL GYRUS
ORBITAL GYRI
INFERIOR TEMPORAL GYRUS
INFERIOR OCCIPITAL GYRUS
1. PARS ORBITALIS
2. PARS TRIANGULARIS
3. PARS OPERCULARIS

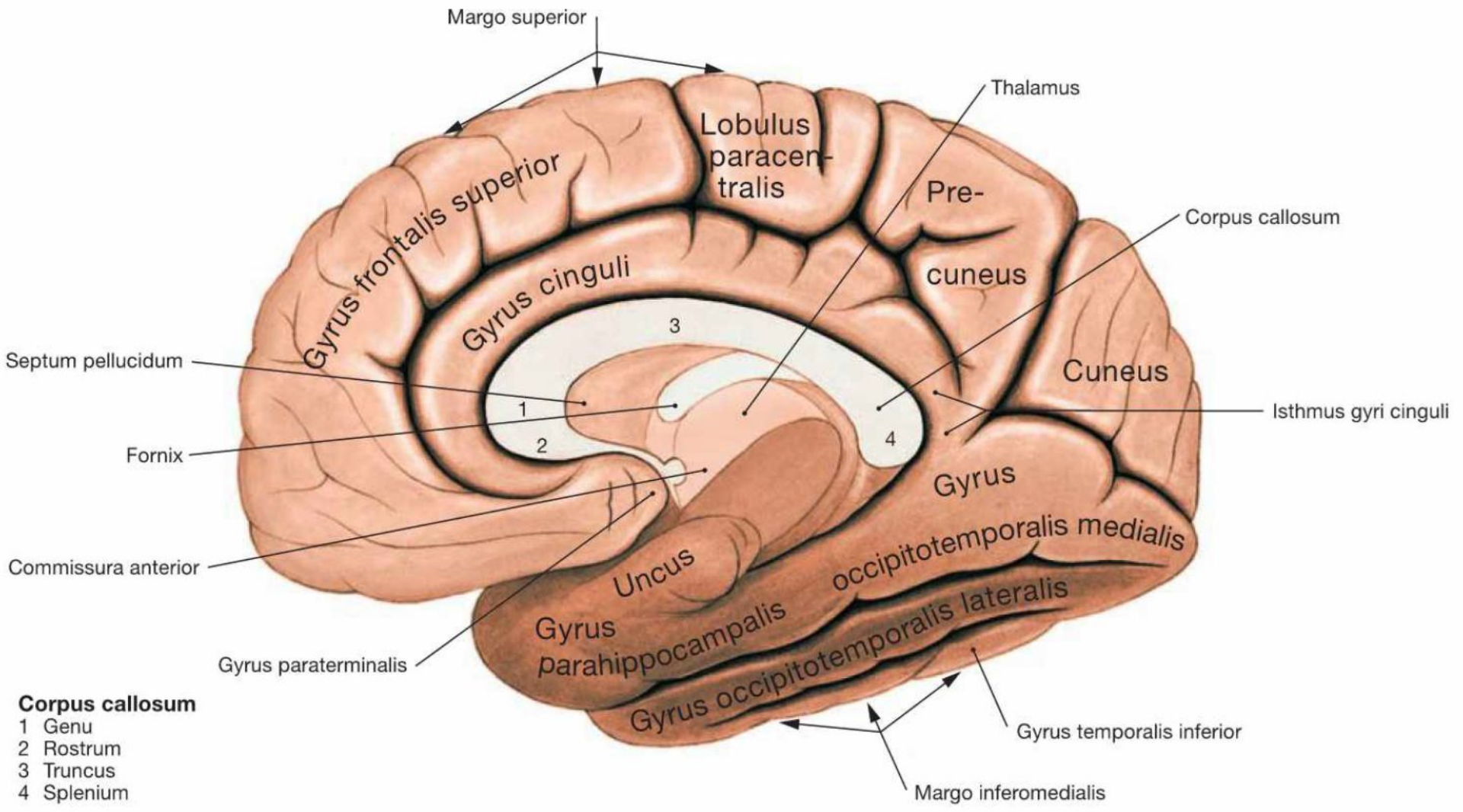

CENTRAL SULCUS
SUPERIOR FRONTAL GYRUS
PARACENTRAL LOBULE
CINGULATE GYRUS
PRECUNEUS
PARIETO-OCCIPITAL FISSURE
CUNEUS
GYRUS RECTUS /STRAIGHT GYRUS
UNCUS
PARAHIPPOCAMPAL GYRUS
LINGUAL GYRUS
MIDDLE TEMPORAL GYRUS
FUSIFORM GYRUS /OCCIPITOTEMPORAL GYRUS
CALCARINE FISSURE
INFERIOR TEMPORAL GYRUS


CENTRAL SULCUS
SUPERIOR FRONTAL GYRUS
PARACENTRAL LOBULE
CINGULATE GYRUS
PRECUNEUS
PARIETO-OCCIPITAL FISSURE
CUNEUS
GYRUS RECTUS /STRAIGHT GYRUS
UNCUS
PARAHIPPOCAMPAL GYRUS
LINGUAL GYRUS
MIDDLE TEMPORAL GYRUS
INFERIOR TEMPORAL GYRUS
FUSIFORM GYRUS /OCCIPITOTEMPORAL GYRUS
CALCARINE FISSURE
MIDDLE TEMPORAL GYRUS
INFERIOR FRONTAL GYRUS
INFERIOR TEMPORAL GYRUS
SUPERIOR FRONTAL GYRUS
FUSIFORM GYRUS
INFERIOR OCCIPITAL GYRUS
ORBITAL GYRI
PARAHIPPOCAMPAL GYRUS
UNCUS
STRAIGHT GYRUS
CINGULATE GYRUS
CUNEUS
LINGUAL GYRUS

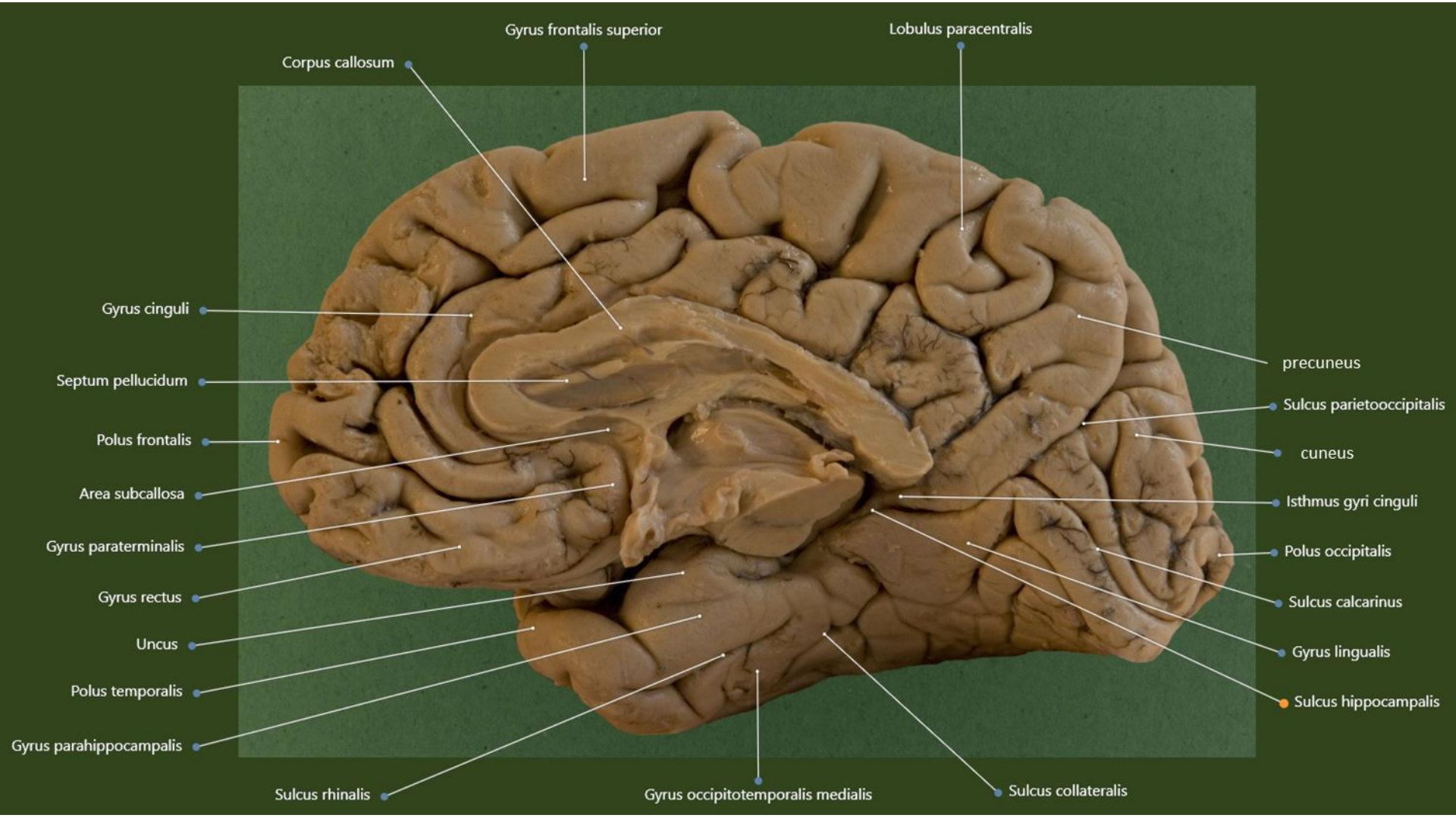

PARIETAL OPERCULUM
FRONTAL OPERCULUM
ORBITAL OPERCULUM
SHORT GYRI OF INSULA
LONG GYRI OF INSULA
HESCHL'S GYRI /HESCHL'S CONVOLUTIONS /SUPERIOR TRANSVERSE TEMPORAL GYRI

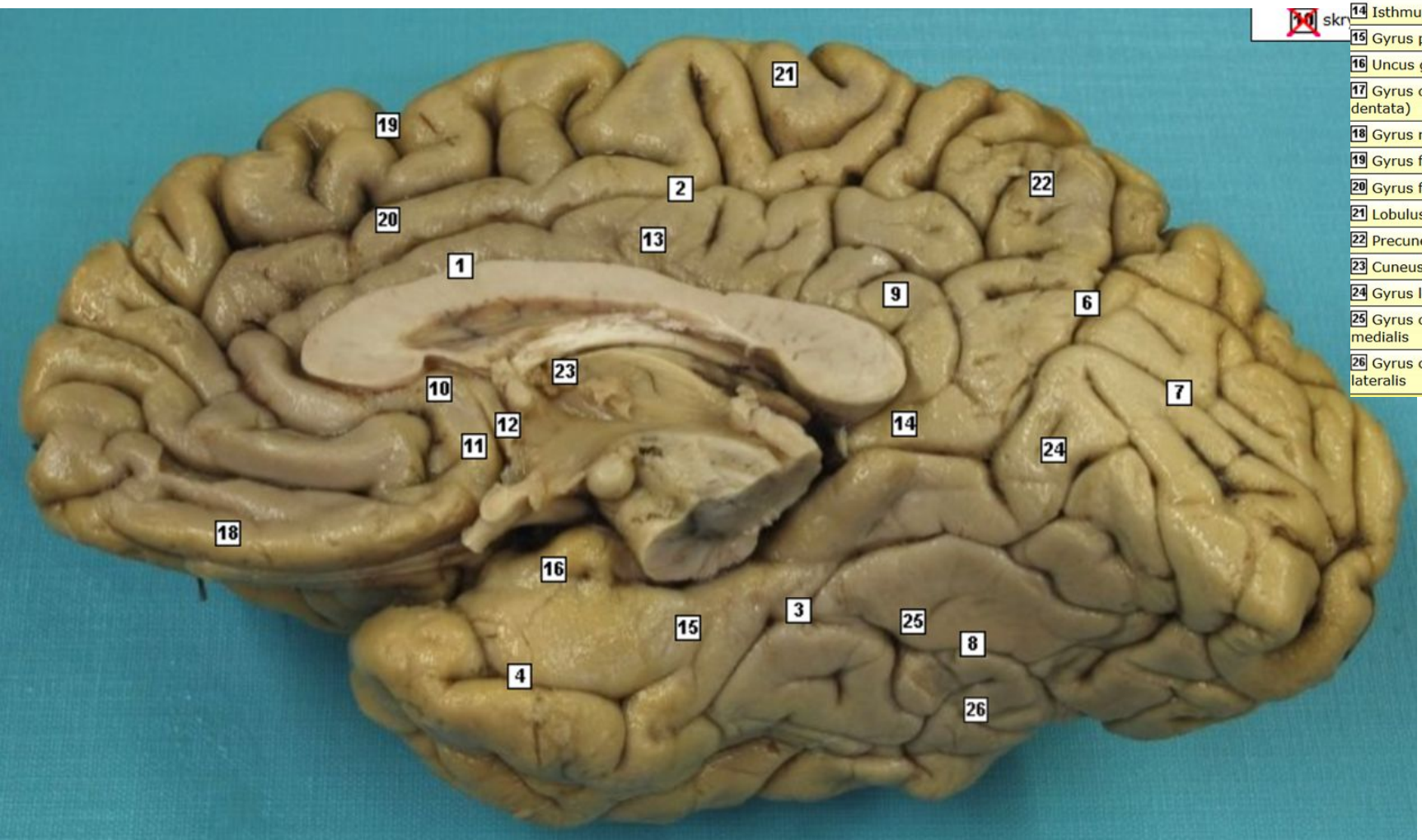

Gyrus postcentralis
Sulcus centralis
Gyrus precentralis
Sulcus postcentralis
Sulcus precentralis
Sulcus intraparietalis
Gyrus frontalis medius
ramus posterior
Lobulus parietalis inferior
Sulcus frontalis superior
gyrus angularis
operculum frontale
Sulcus frontalis inferior
sulcus lateralis
ramus ascendens
operculum temporale
Gyrus frontalis inferior
Polus occipitalis
pars opercularis
pars triangularis
Polus frontalis
ramus anterior
pars orbitalis
Gyrus temporalis superior
Incisura preoccipitalis
Sulcus temporalis superior
Gyrus temporalis inferior
Sulcus temporalis inferior
Gyrus temporalis medius


Operculum frontale; Operculum parietale
Gyrus frontalis inferior, Pars opercularis
Gyrus frontalis superior
Gyrus frontalis medius
Polus frontalis
Gyrus frontalis inferior, Pars triangularis
Gyrus frontalis inferior, Pars orbitalis
Sulcus lateralis*
R. anterior
R. ascendens
Polus temporalis
Gyrus temporalis superior
Sulcus temporalis superior
Gyrus temporalis medius
Sulcus precentralis
Gyrus precentralis
Sulcus centralis**
Gyrus postcentralis
Sulcus postcentralis
Sulcus lateralis, R. posterior
Sulcus intraparietalis
Gyrus supramarginalis
Gyrus angularis
Lobulus parietalis superior
Lobulus parietalis inferior
Sulcus parietooccipitalis
Sulcus temporalis superior
Sulcus lunatus
Polus occipitalis
Incisura preoccipitalis
Gyrus temporalis inferior
Sulcus temporalis inferior



Corpus callosum
1 Genu
2 Rostrum
3 Truncus
4 Splenium


Gyrus frontalis superior
Lobulus paracentralis
Corpus callosum
Gyrus cinguli
Septum pellucidum
Polus frontalis
Area subcallosa
Gyrus paraterminalis
Gyrus rectus
Uncus
Polus temporalis
Gyrus parahippocampalis
precuneus
Sulcus parietooccipitalis
cuneus
Isthmus gyri cinguli
Polus occipitalis
Sulcus calcarinus
Gyrus lingualis
Sulcus hippocampalis
Sulcus rhinalis
Gyrus occipitotemporalis medialis
Sulcus collateralis



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13 Gyrus cinguli
14 Isthmus gyri cinguli
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16 Uncus gyri parahippocampalis
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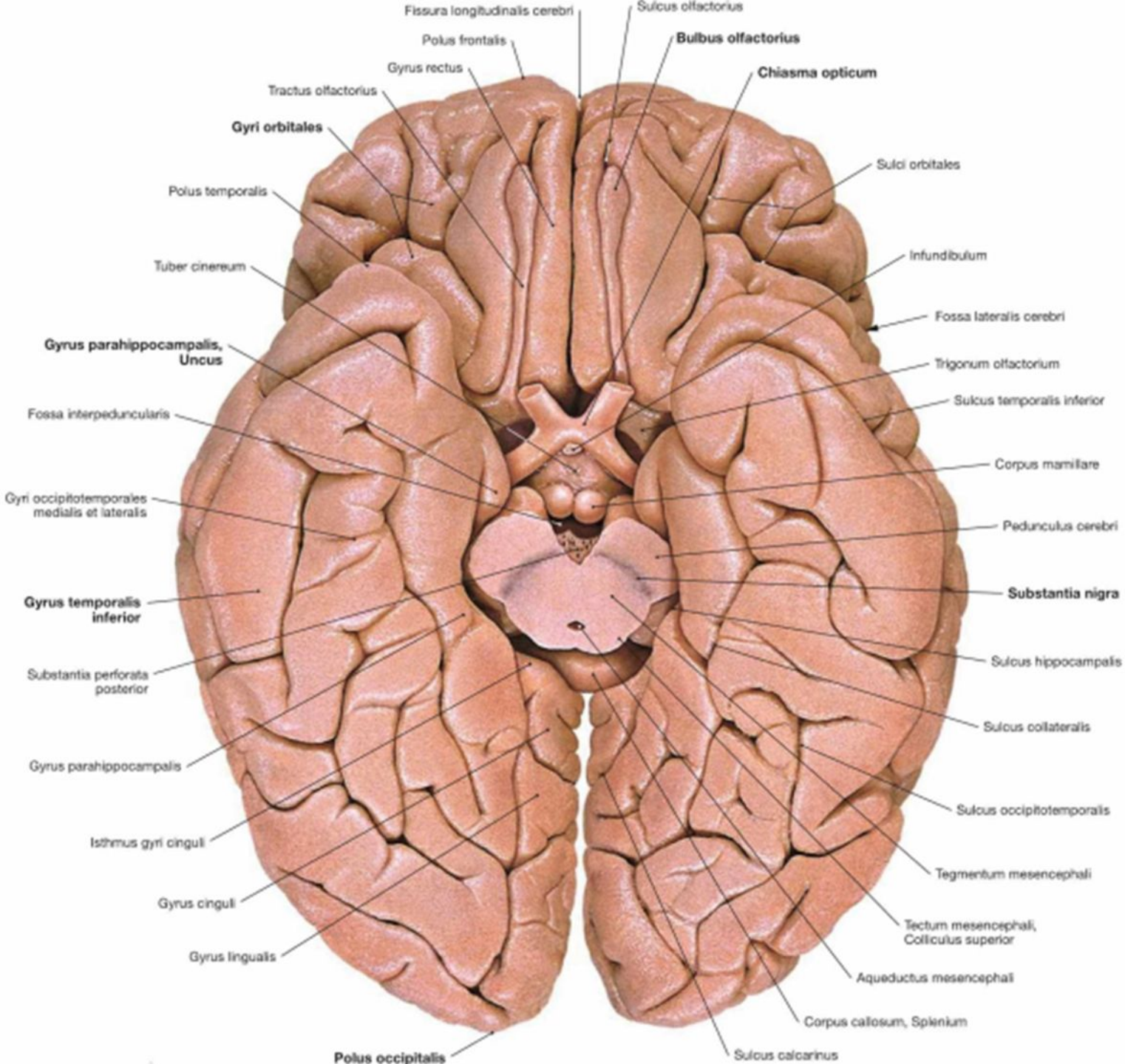
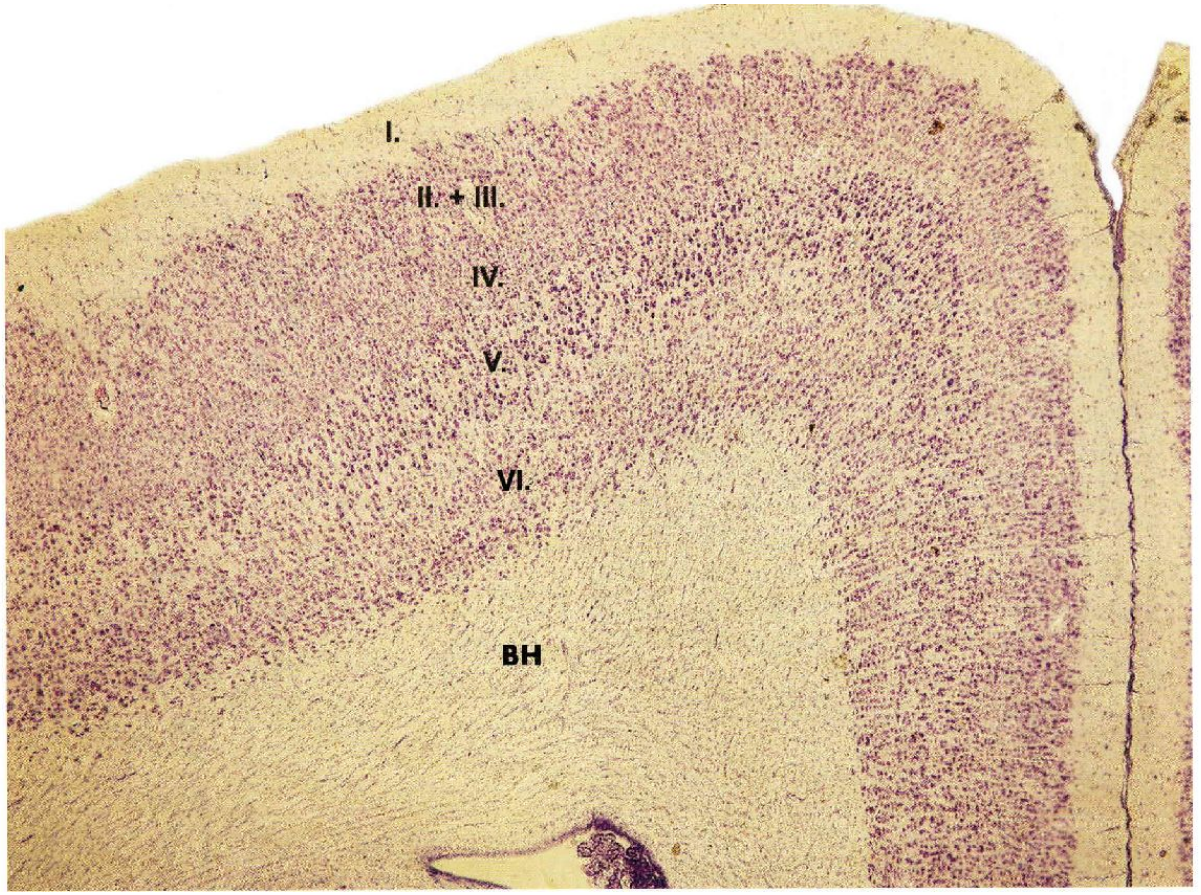
22 Precuneus
23 Cuneus
24 Gyrus lingualis
25 Gyrus occipitotemporalis medialis
26 Gyrus occipitotemporalis lateralis


Fissura longitudinalis cerebri
Sulcus olfactorius
Polus frontalis
Bulbus olfactorius
Gyrus rectus
Chiasma opticum
Tractus olfactorius
Gyri orbitales
Sulci orbitales
Polus temporalis
Infundibulum
Tuber cinereum
Fossa lateralis cerebri
Gyrus parahippocampalis, Uncus
Trigonum olfactorium
Sulcus temporalis inferior
Fossa interpeduncularis
Corpus mamillare
Gyri occipitotemporales medialis et lateralis
Pedunculus cerebri
Substantia nigra
Gyrus temporalis inferior
Sulcus hippocampalis
Substantia perforata posterior
Sulcus collateralis
Gyrus parahippocampalis
Sulcus occipitotemporalis
Isthmus gyri cinguli
Tegmentum mesencephali
Gyrus cinguli
Tectum mesencephali, Colliculus superior
Gyrus lingualis
Aqueductus mesencephali
Corpus callosum, Splenium
Polus occipitalis
Sulcus calcarinus

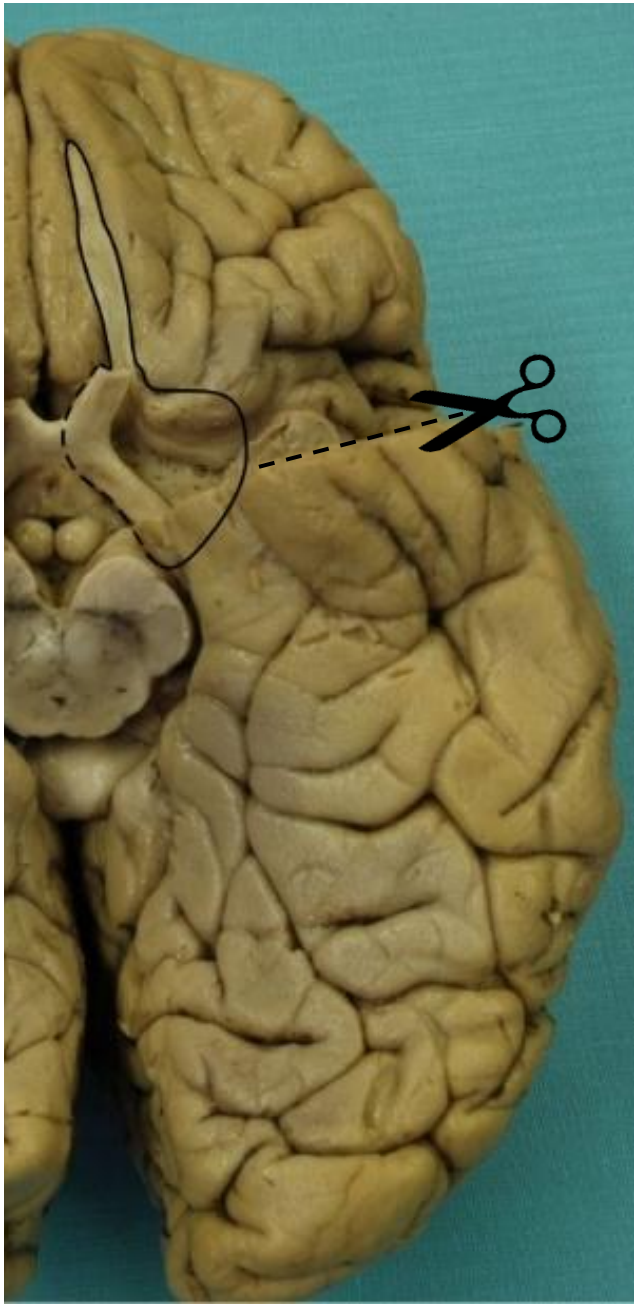
CEREBRAL CORTEX

- The surface of the cerebral hemispheres consists mainly of the cerebral cortex (2,500 cm^2, 2–4 mm)
  - Allocortex – three layers; divided into the paleocortex (1% of the surface) and the archicortex (3.5% of the surface)
  - neocortex (neopallium) – six layers (95.5% of the surface)
  - periallocortex (mesocortex) – transitional areas between the neocortex and the paleocortex/archicortex



PALEOCORTEX

- evolutionarily ancient, three-layered
  - 1st layer, lamina plexiformis – primarily fibers (dendrites of deeper neurons, efferent fibers of the olfactory bulb)
  - 2nd layer, lamina pyramidalis – pyramidal neurons with dendrites in the lamina plexiformis
  - 3rd layer, lamina multiformis – neurons of various shapes
- at the base of the hemisphere
  - olfactory bulb – connection of olfactory ganglion neurites to the mitral ganglion; their axons form the olfactory tract
  - olfactory tract – along the anterior perforate substance, it divides into the medial and lateral olfactory striae
  - piriform cortical area 52 – paleocortex, lateral to the lateral olfactory stria, extending to the uncus
- olfactory cortical area
  - piriform cortex + entorhinal cortex 28 + amygdala
  - afferents – mitral nuclei, then entorhinal cortex, claustrum, thalamus, substantia nigra, raphe nuclei, locus coeruleus
  - efferent projections – cortical (entorhinal cortex, amygdala, hippocampal formations) and subcortical (amygdala, hypothalamus, thalamus)
  - association connections
  - commissural connections – anterior commissure



ARCHICORTEX – HIPPOCAMPAL FORMATION

- evolutionarily ancient, three-layered

dentate gyrus

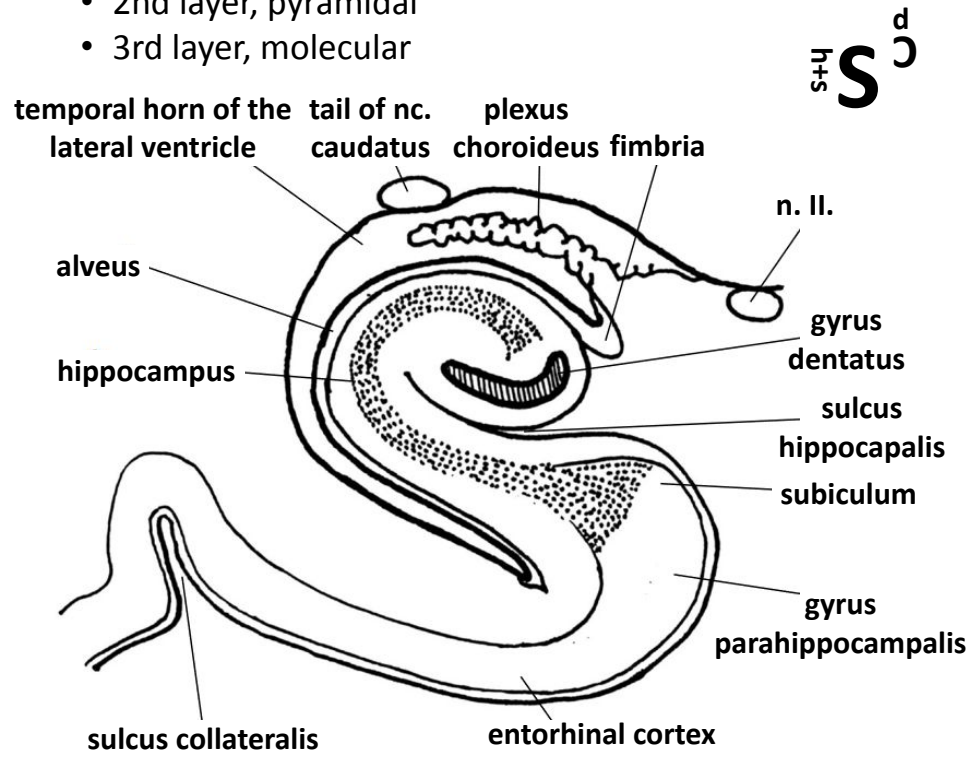
- 1st layer, molecular layer – interneurons and dendrites of granular cells
- 2nd layer, granular layer – granular cells (round neuronal cell bodies)
- 3rd layer, polymorphic – mossy nerve fibers and interneuron cell bodies

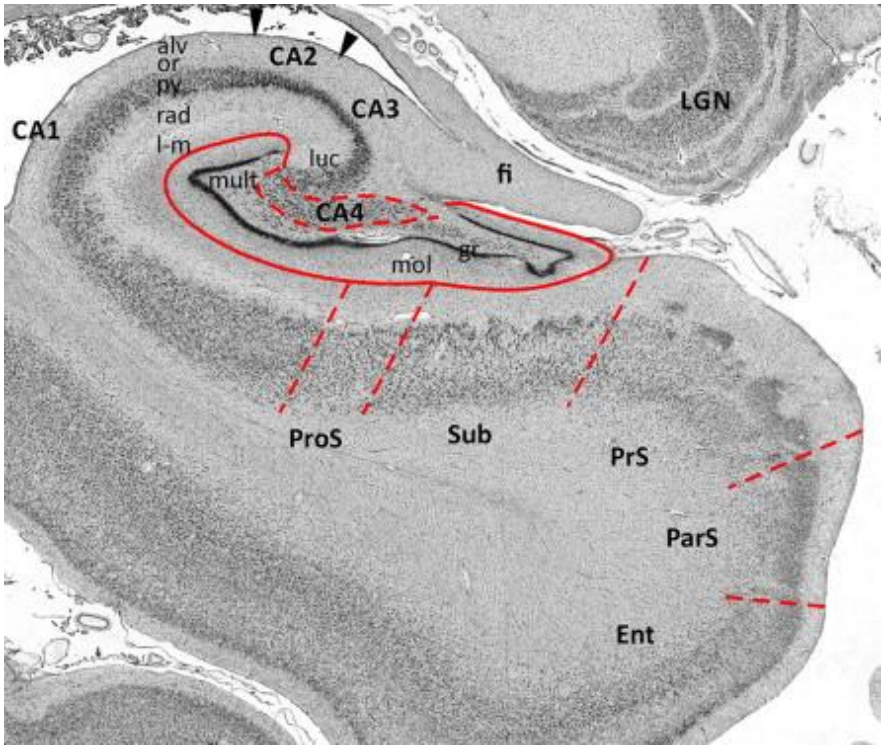
hippocampus (cornu Ammonis)

- 1st layer, stratum oriens – nerve fibers and interneuron cell bodies
- 2nd layer, pyramidal – pyramidal cells (pyramidal neuron cell bodies)
- 3rd layer, stratum radiatum – dendrites of pyramidal cells and interneuron cell bodi

subiculum (connects to CA1)

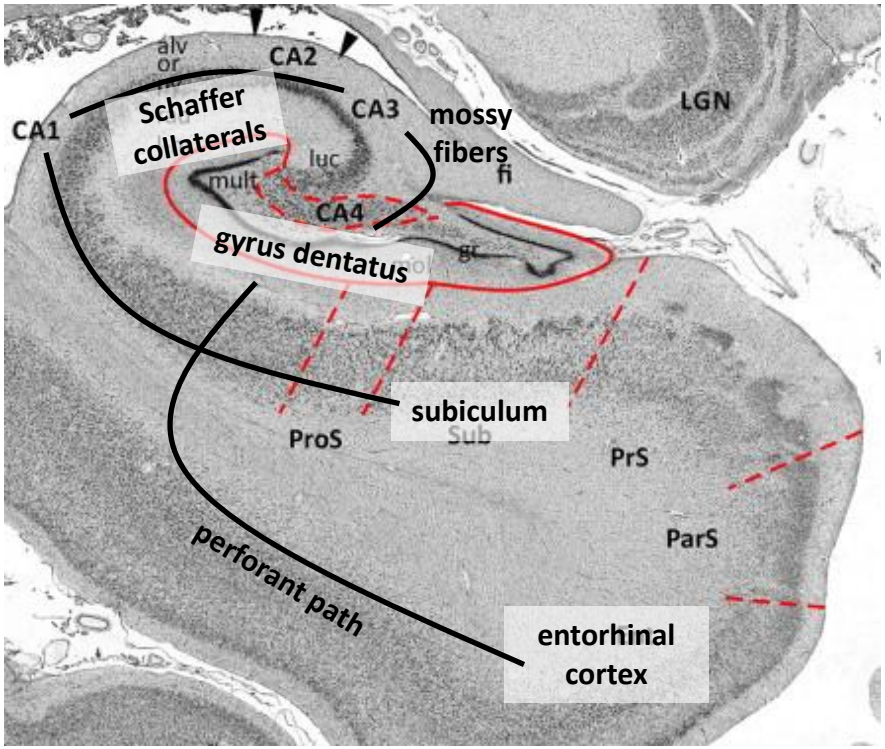
- 1st layer, polymorphic
- 2nd layer, pyramidal
- 3rd layer, molecular





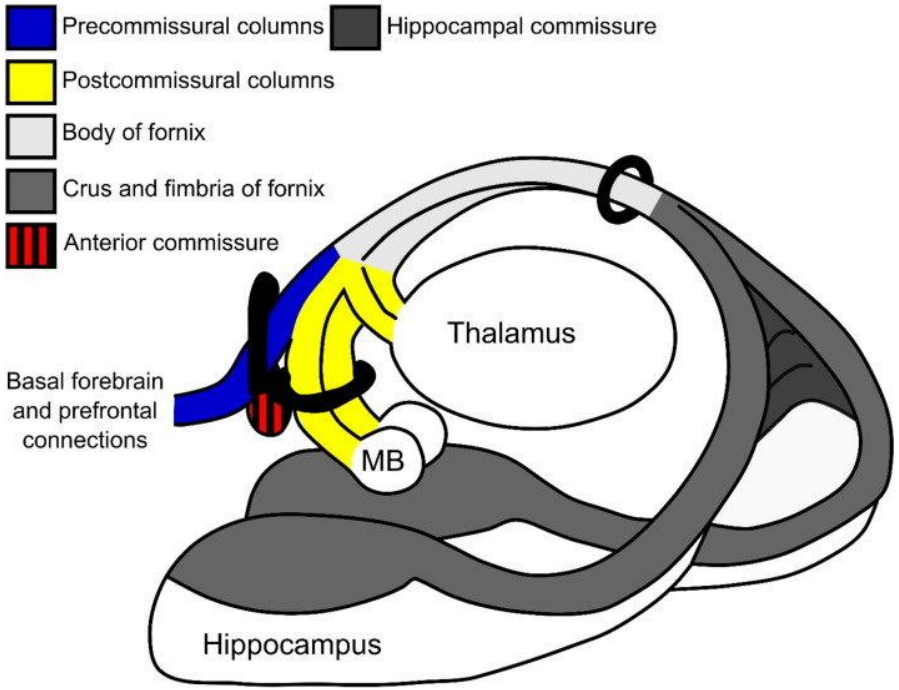
INTERNAL CONNECTIONS OF THE HIPPOCAMPAL FORMATION

- transmission of signals from the entorhinal cortex to the hippocampal formation for processing
  - memory functions and spatial orientation
  - entorh.
  - dentate gyrus – strongly inhibited → signal filter; afferent projections reduce the possibility of signal overlap in the dentate gyrus while simultaneously increasing the differences between similar signals (separating similar signals, amplifying differences)
  - CA3 – afferents via mossy fibers; axonal collaterals of CA3 pyramidal neurons form an autoassociative network (formation and storage of episodic memory)
  - CA1 – twice as many neurons as in CA3 → prevention of information loss, but reduced sensitivity to information noise; additionally, place cells (spatial orientation)
  - subiculum – main efferent of the hippocampal formation (to layers V and VI of the entorhinal cortex, perirhinal cortex, parahippocampal region, retrosplenial and prefrontal cortex); amplifies signals from CA1



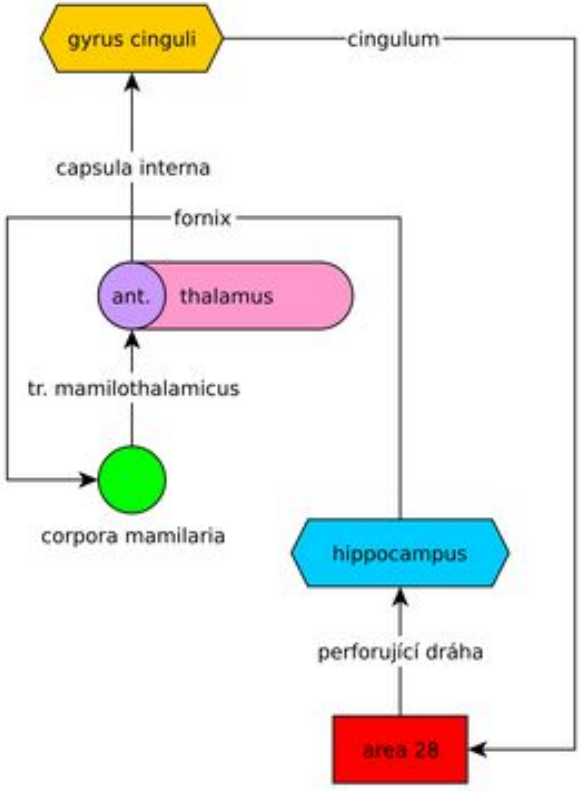
CONNECTIONS OF THE HIPPOCAMPAL FORMATION

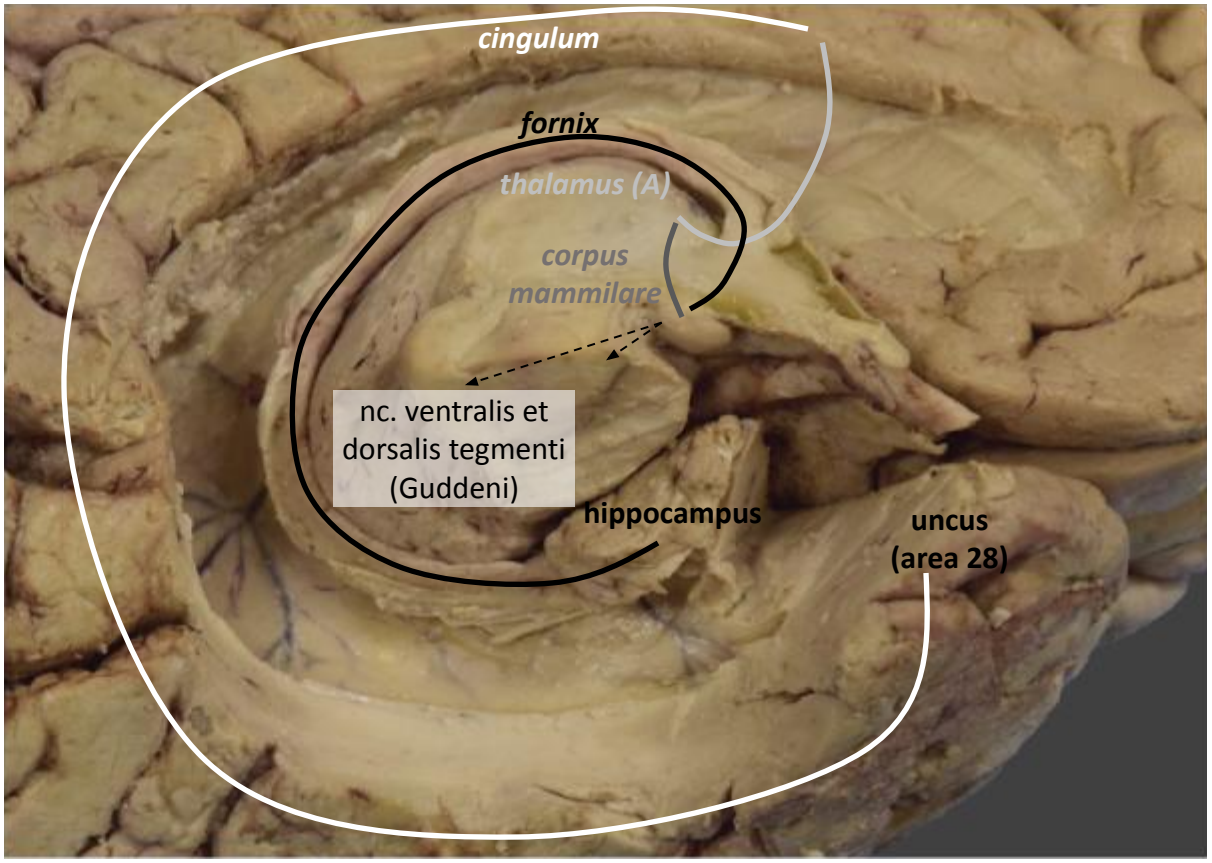
- afferent
  - cortical – entorhinal cortex (28), parahippocampal gyrus (35, 36)
  - subcortical – amygdala, thalamus (A, M), hypothalamus, septum verum, locus coeruleus, raphe nuclei
- efferent
  - cortical – from the subiculum to the entorhinal cortex, parahippocampal gyrus, and association areas of the temporal and frontal lobes
  - subcortical – via the fimbria and fornix; postcommissural – from the subiculum to the corpus mammillare and thalamus (A), precommissural – from CA1 to the septum verum, anterior hypothalamus, and nucleus accumbens



CICUIT OF PAPEZ

- Previous view – a regulatory mechanism for emotional behavior
- Current view – involvement in memory mechanisms (consolidation of memory traces)



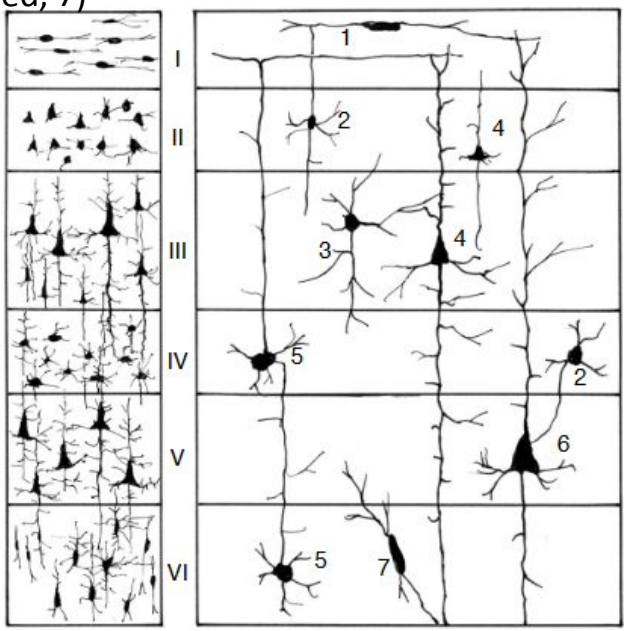


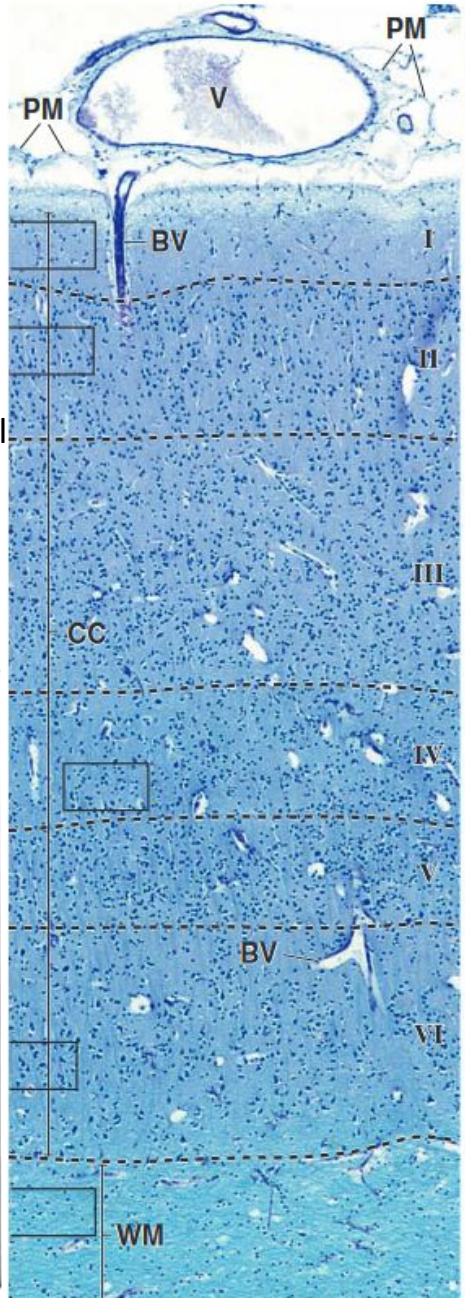
TRANSITIONAL CORTEX

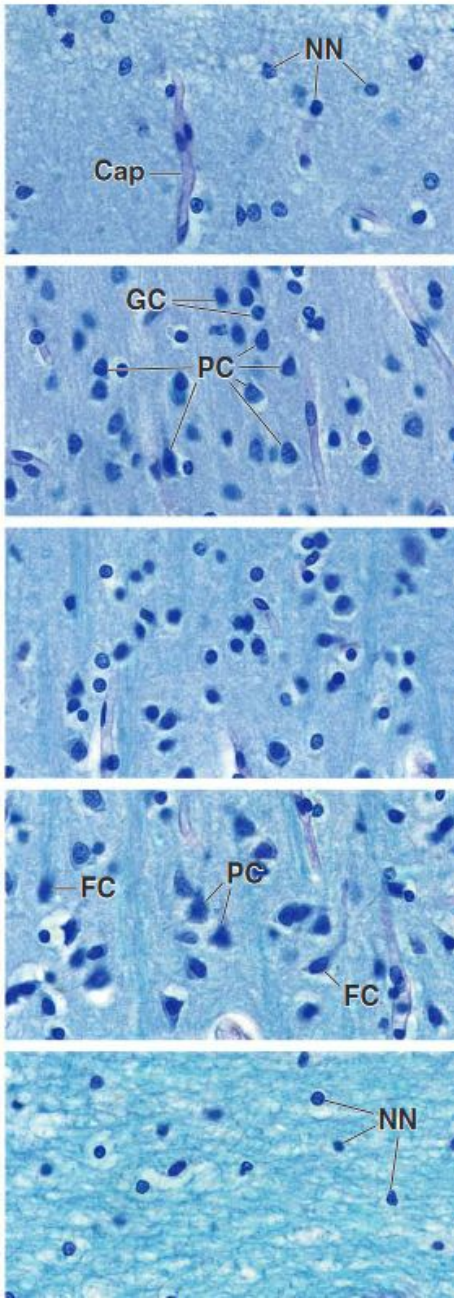
- peripaleocortex
  - at the base of the insular lobe and the periamygdalar cortical region
- periarchicortex
  - the medial surface of the parahippocampal gyrus and the uncus
  - compared to the neocortex, a reduction in layer IV
  - responsible for memory functions, part of the brain’s navigational system
  - entorhinal region 28
  - presubiculum 27
  - parasubiculum

NEOCORTEX

- six layers of neurons
- I. molecular layer (plexiform, zonal) – mainly axons and dendrites of neurons from other layers, horizontal Cajal-Retzius fibers (1)
- II. external granular layer – small pyramidal (4) and non-pyramidal neurons (2)
- III. lamina pyramidalis externa – medium-sized pyramidal neurons
- IV. lamina granularis interna – mainly stellate interneurons, afferent thalamocortical projections (from specific nuclei)
- V. lamina pyramidalis interna – large (up to 100 µm) pyramidal neurons (Betz, 6), from which projection fibers extend to the basal ganglia, thalamus, brainstem, and spinal cord; corticonuclear and corticospinal pathways originate here.
- VI. lamina multiformis – interneurons of various shapes (mainly spindle-shaped, 7)

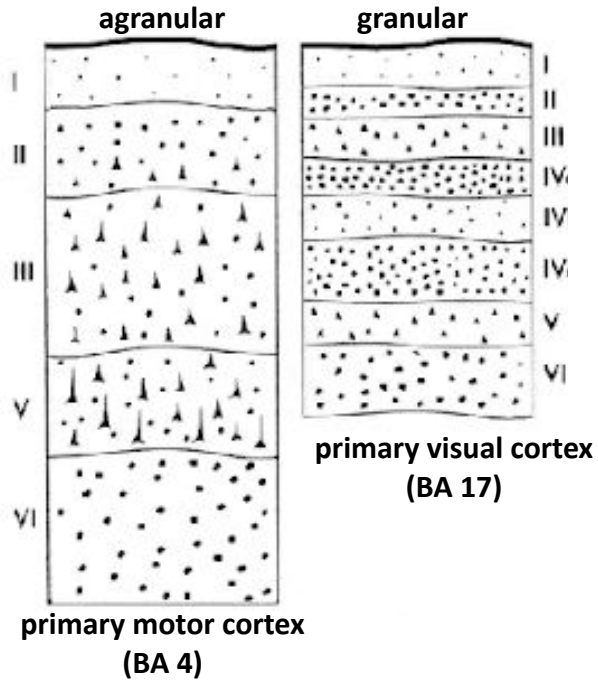






NEOCORTEX

- differences between individual regions:
  - thickness of the cortex and individual cortical layers
  - cellular composition
  - density and arrangement of myelinated fibers
  - neural transmitters, receptors, peptides, and enzymes
  - afferent and efferent connections
  - functional and metabolic properties of neurons
- two extreme types of neocortex
  - granular – afferent areas, dominant layer IV, reduction of layers III and V, predominance of non-pyramidal neurons
  - agranular – motor areas, layer IV reduced, predominance of pyramidal neurons
  - transitional types – e.g., frontal, parietal, polar
- cytoarchitectonic map (Brodmann)
  - local differences in cortical thickness, neuronal density, and layer structure



ZAPOJENÍ NEOKORTEXU

- afferents
  - thalamic nuclei
  - basal ganglia – external pallidum, amygdala, claustrum
  - modulatory afferents carrying neurotransmitters (locus coeruleus – norepinephrine, raphe nuclei – serotonin, substantia nigra – dopamine, Meynert's basal nucleus – acetylcholine)
  - cortical fibers – associative (ipsilateral hemisphere), commissural (contralateral hemisphere)
- efferent projections
  - cortical – mainly from layers II and III, associative and commissural
  - descending projection – mainly from layer V basal ganglia (striatum, amygdala, claustrum), thalamus (from layer VI), subthalamus, tectum and pretectal area, RF, ncll. pontis, cranial nerve nuclei, spinal cord

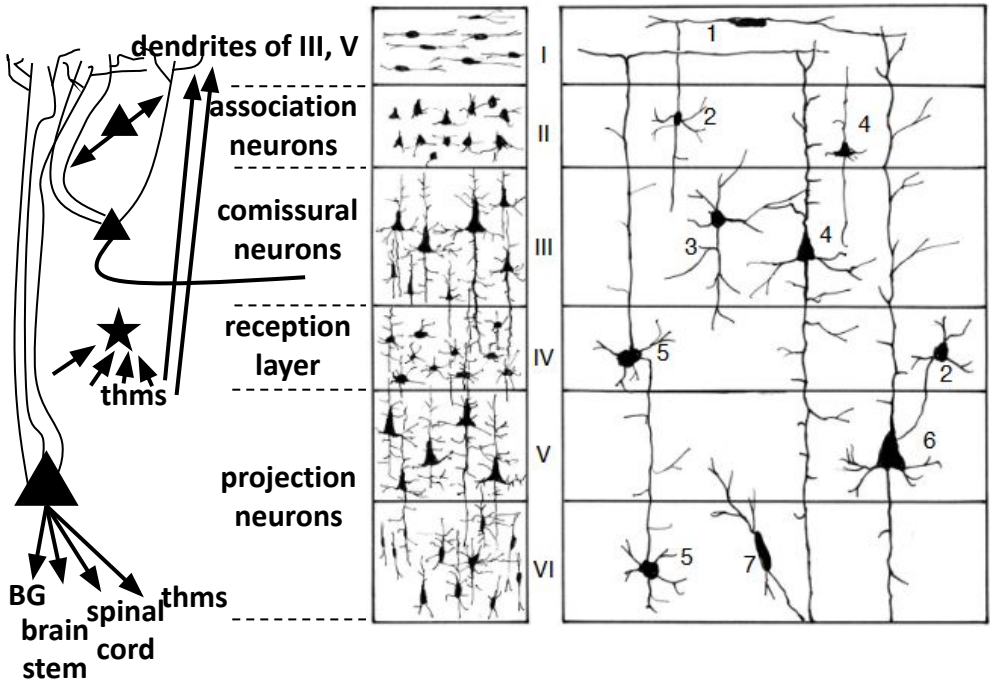
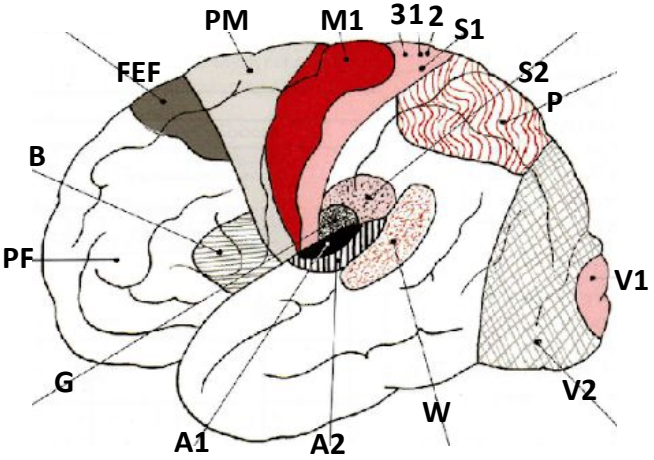
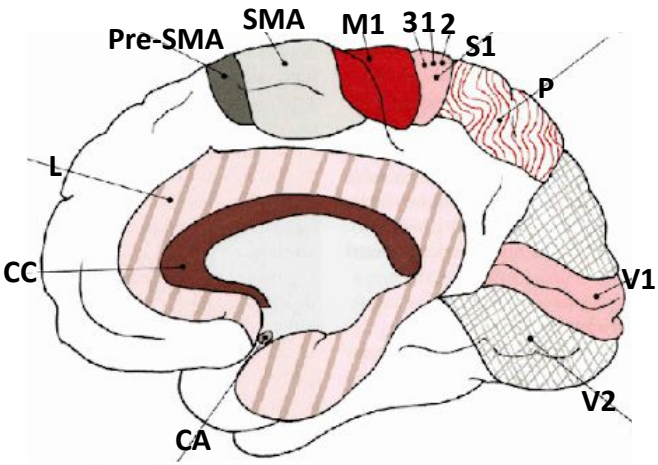
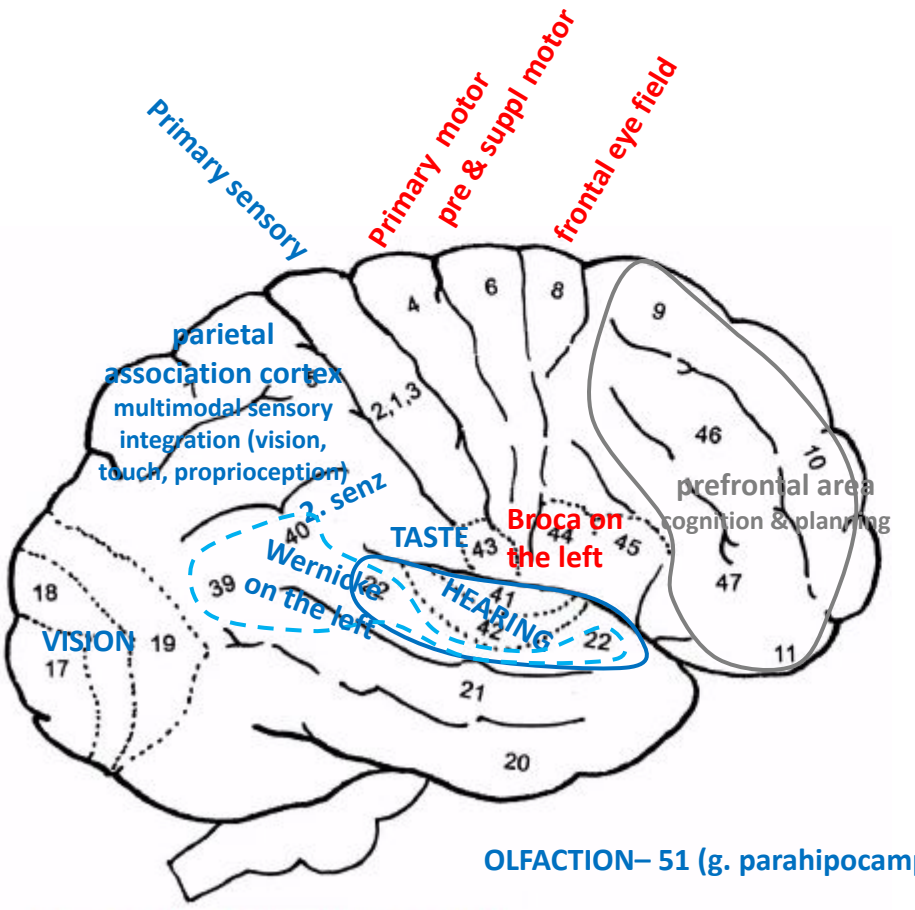


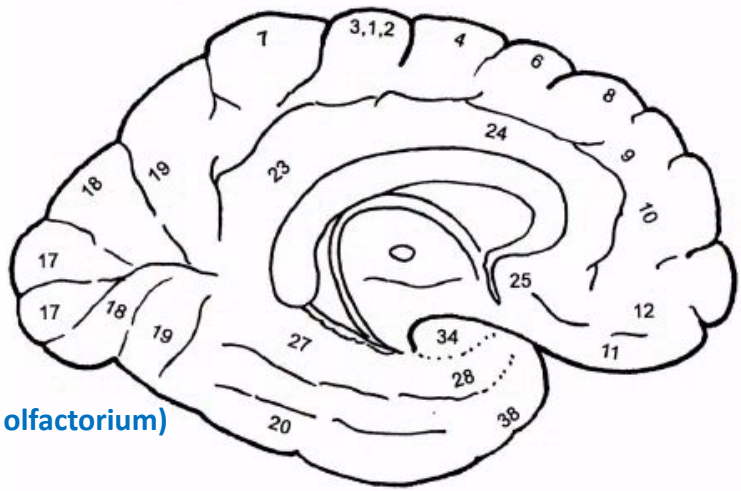
DIAGRAM OF CORTICAL REGIONS

- cytoarchitectonic map of the brain
  - Brodmann, 1907
  - division of the cortex based on the ratio of different types of neurons
  - corresponds to functionally defined areas





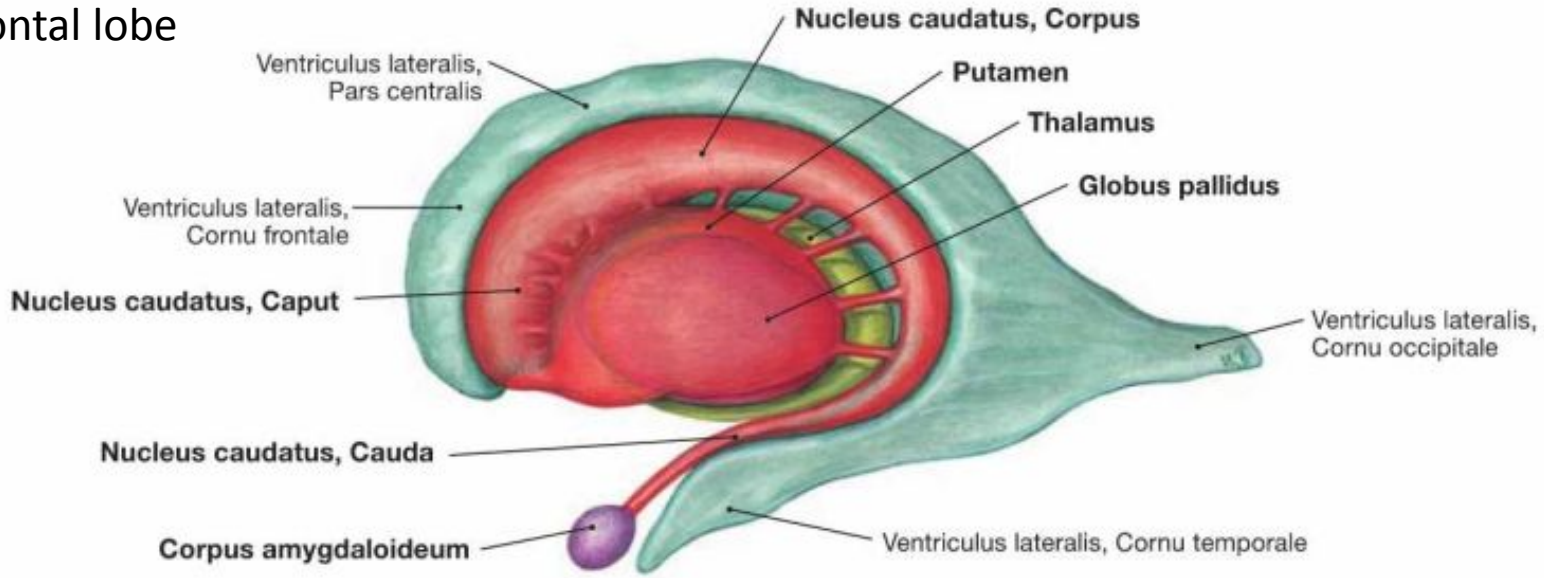


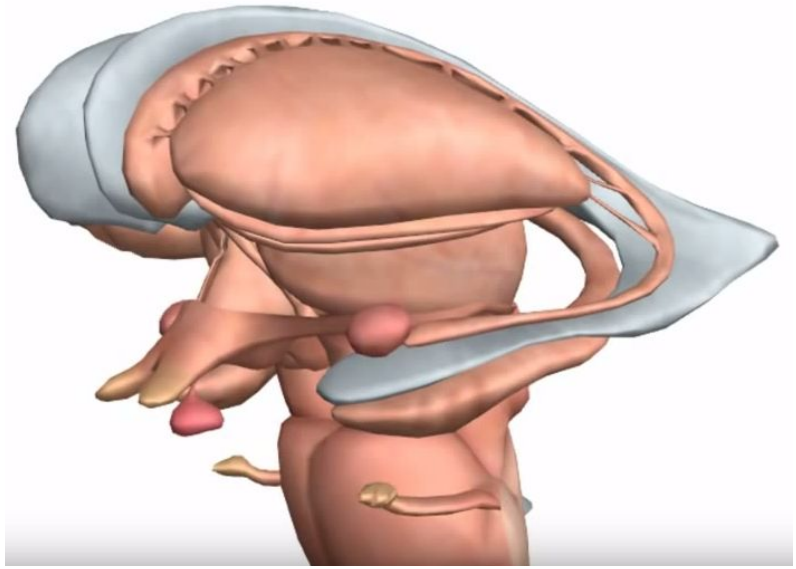


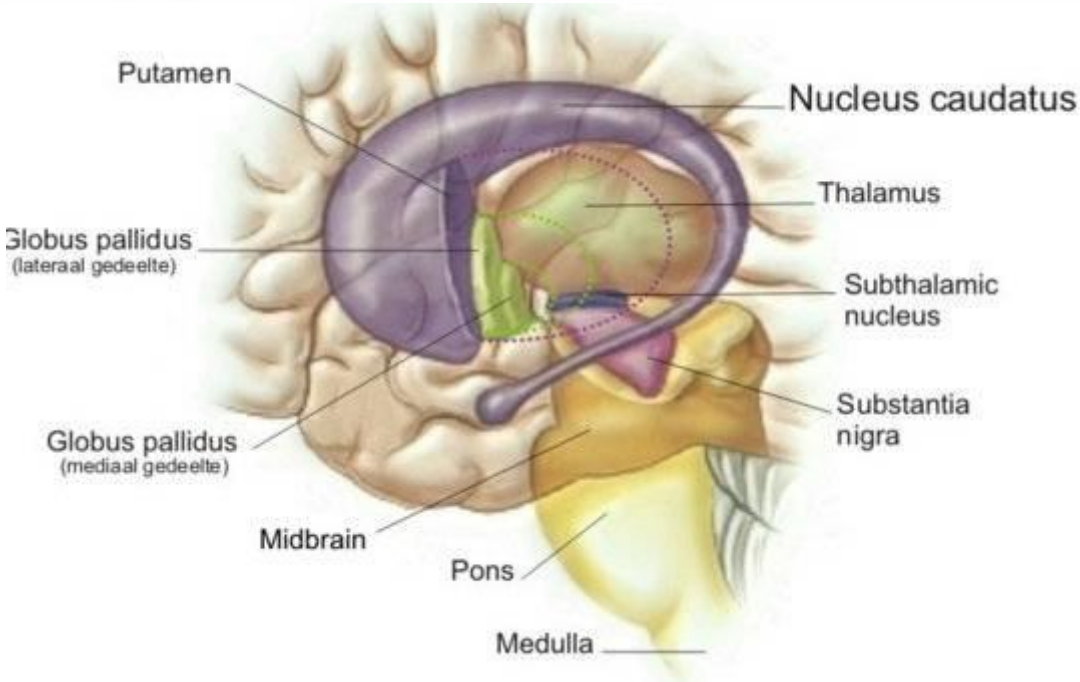
OLFACTION– 51 (g. parahipocampalis & trigonum olfactorium)

BASAL GANGLIA

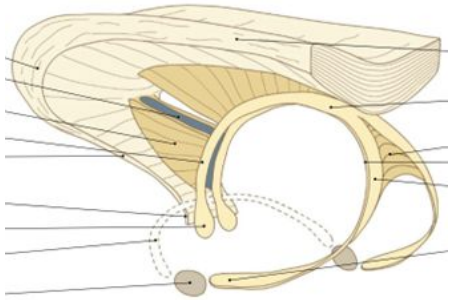
- clusters of gray matter surrounded by white matter, located primarily in the basal region of the frontal lobe
  - globus pallidus
  - putamen
  - caudate nucleus



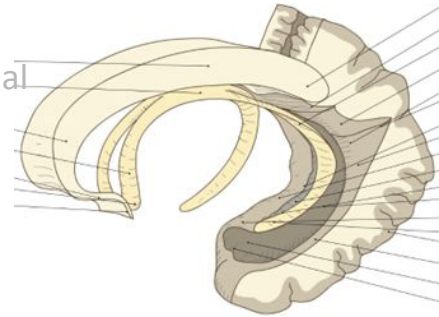


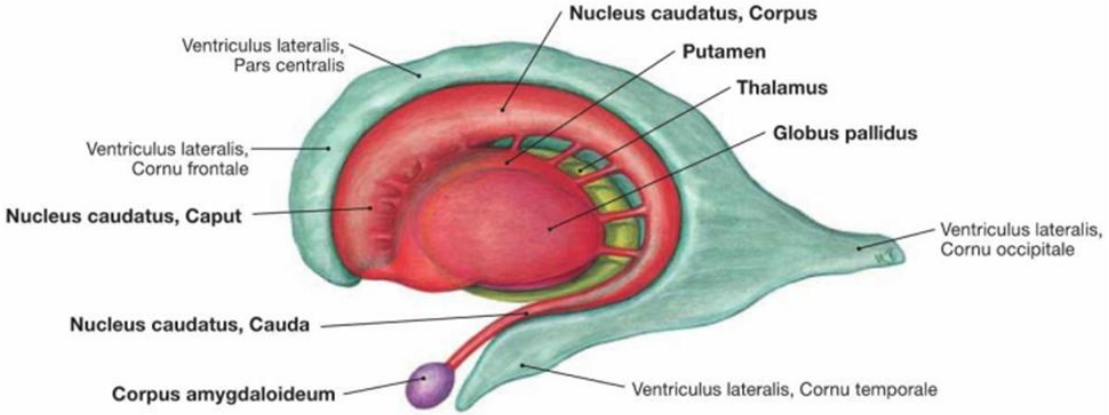


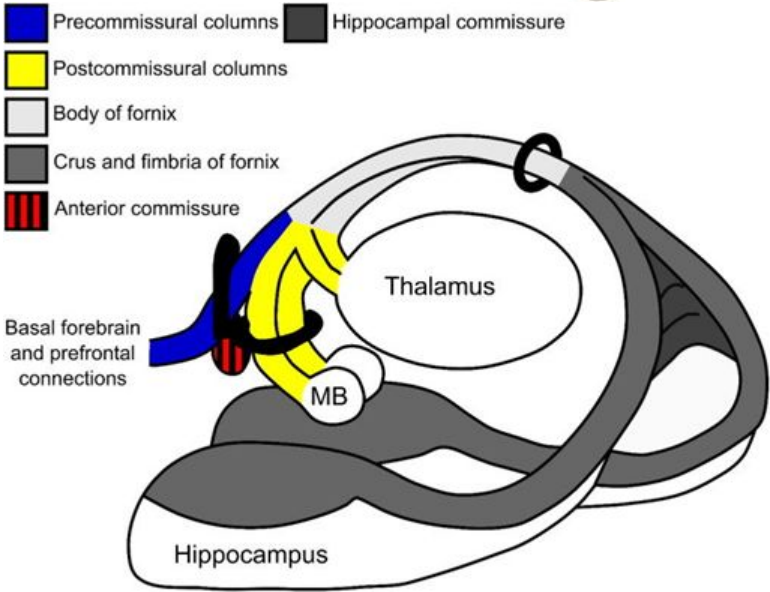
BASAL GANGLIA

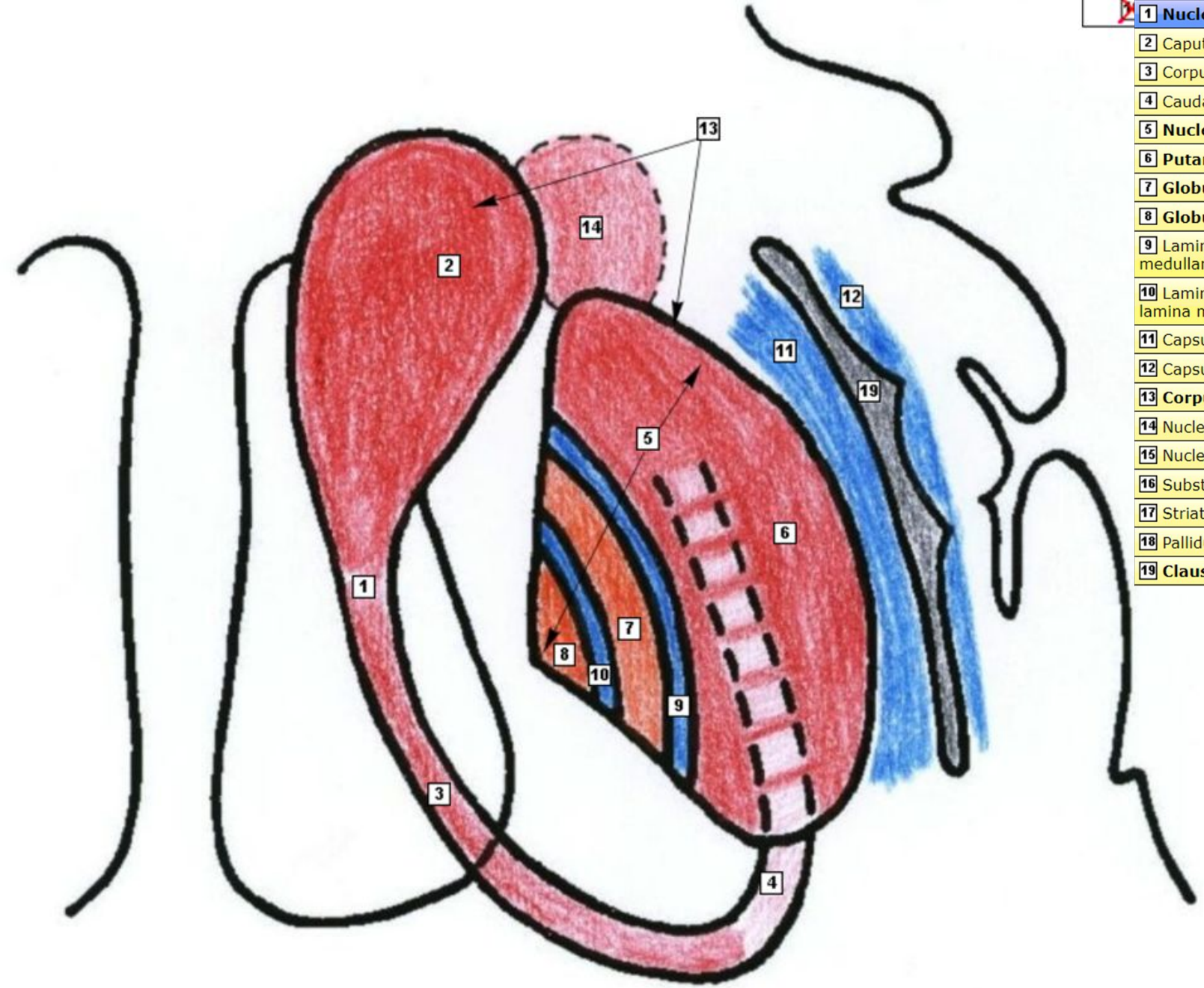


- lateral ventricle
  - The corpus callosum runs along the midline (roof)
    commissural fibers
  - The medial wall formed by the septum pellucidum
    glial plate
  - Medial and iferior is the fornix
    nerve bundle hippocampus – rest of the limbic system
  - The caudate nucleus extends laterally, beneath the corpus callosum
    integrates sensory and motor information from the association areas of the cortex
- third ventricle
  - thalamus
    integration and transmission of signals from the lower parts of the nervous system (spinal cord, brainstem, cerebellum) and the basal ganglia to the cerebral cortex and striatum
  - globus pallidus
    voluntary movement control
  - putamen
    regulace volního pohybu, ovlivňuje různé typy učení, artikulace, odměňování



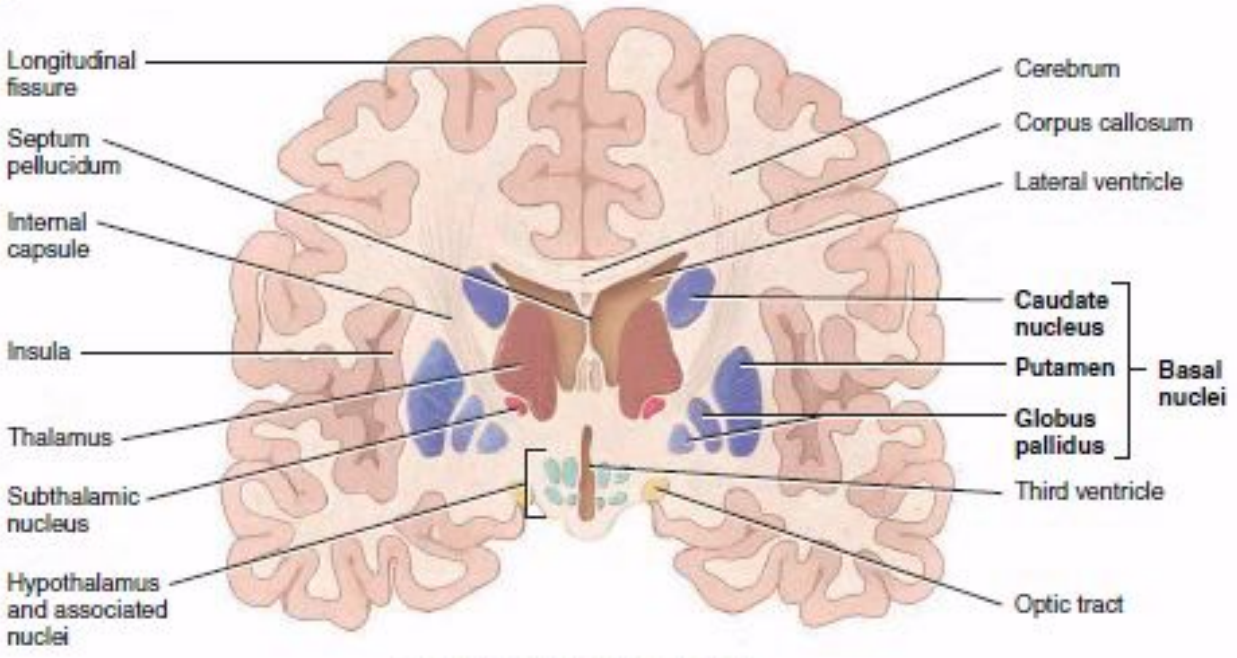


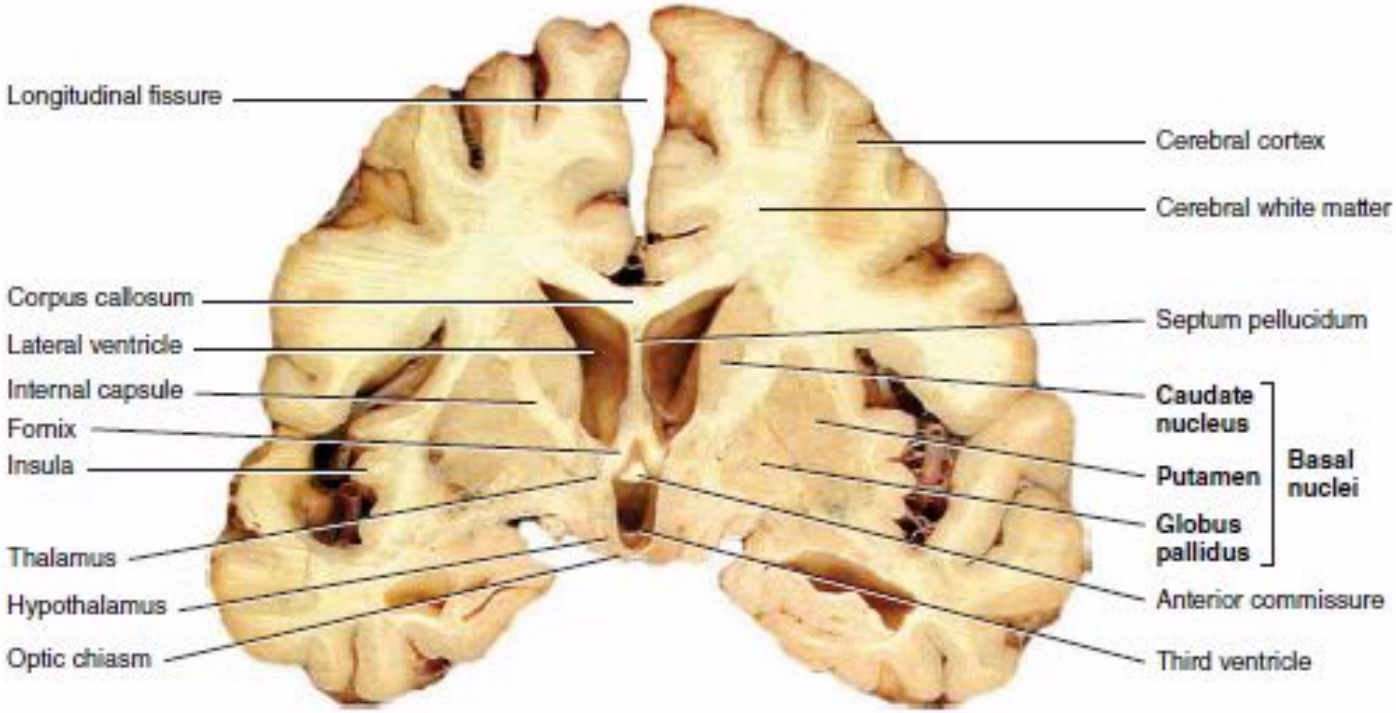


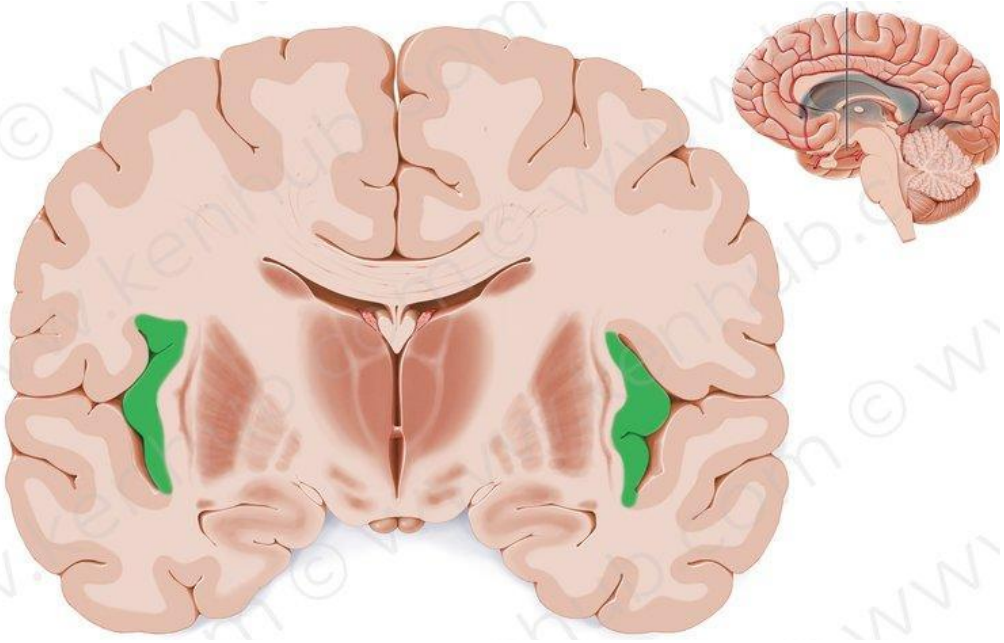


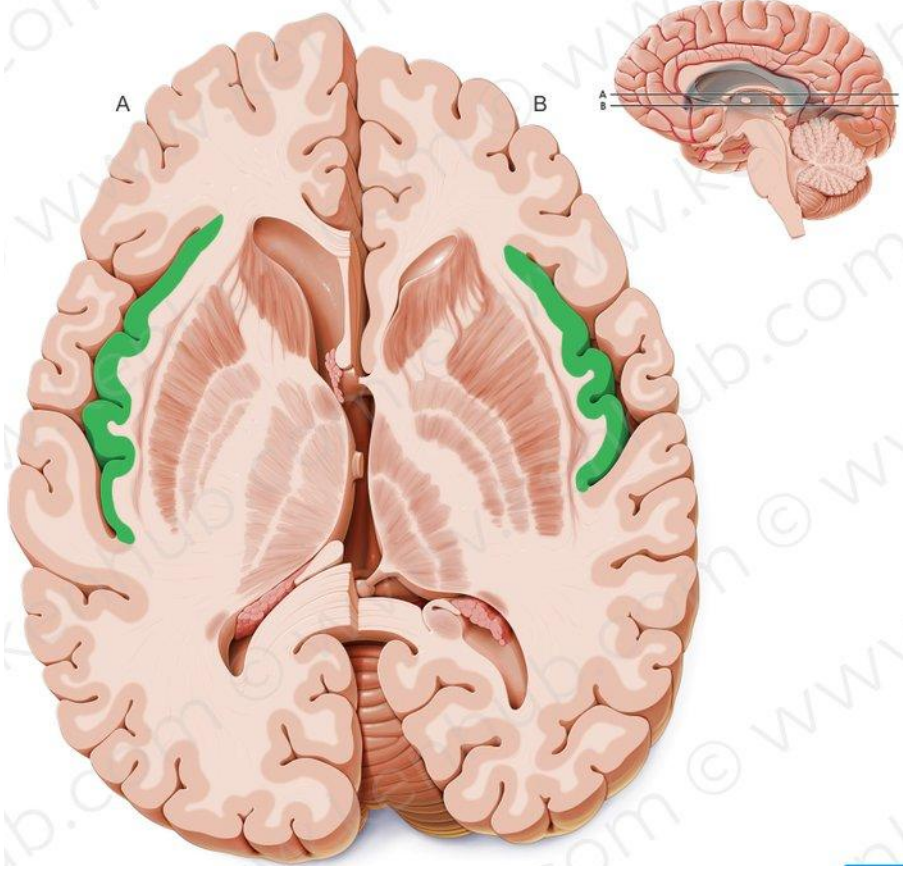
1 **Nucleus caudatus**
2 Caput nuclei caudati
3 Corpus nuclei caudati
4 Cauda nuclei caudati
5 **Nucleus lentiformis**
6 **Putamen**
7 **Globus pallidus** lateralis
8 **Globus pallidus** medialis
9 Lamina medullaris lateralis; lamina medullaris externa
10 Lamina medullaris medialis; lamina medullaris interna
11 Capsula externa
12 Capsula extrema
13 **Corpus striatum**
14 Nucleus accumbens
15 Nucleus basalis (Meynerti)
16 Substantia innominata (Reicherti)
17 Striatum
18 Pallidum
19 **Claustrum**

BASAL GANGLIA

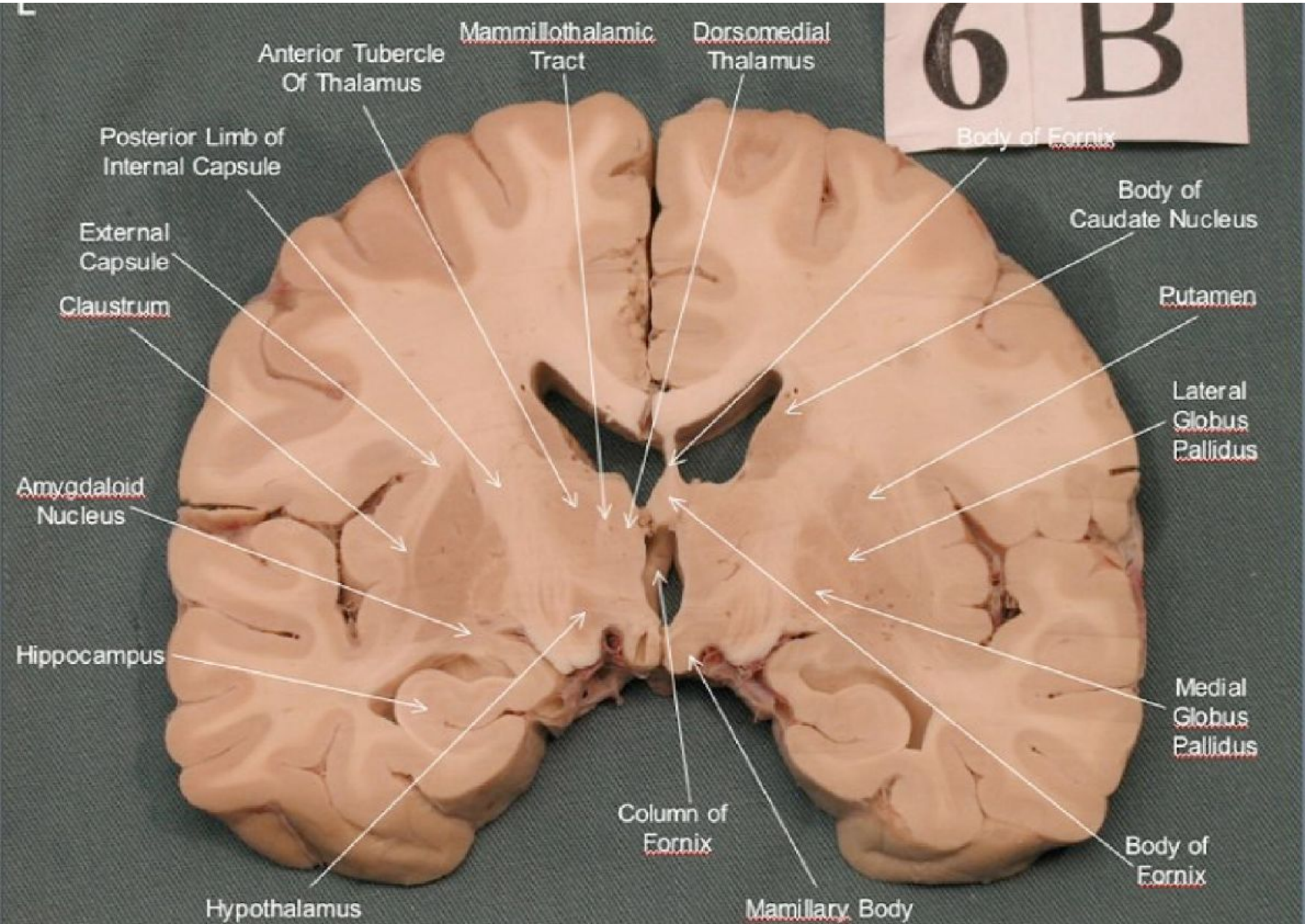




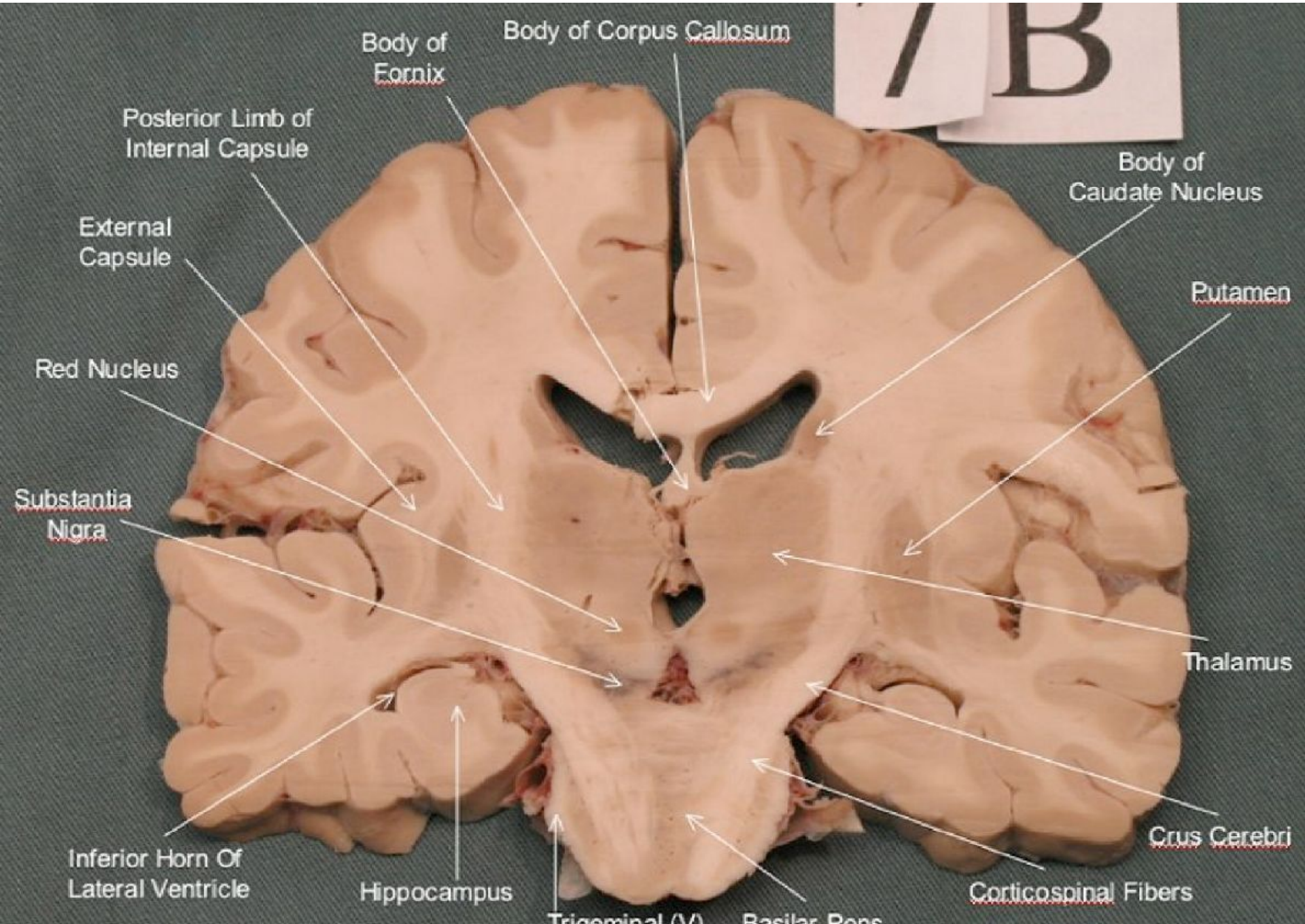



A
B

A BRAIN SECTION AT THE LEVEL OF THE CORPUS MAMMILLARIS

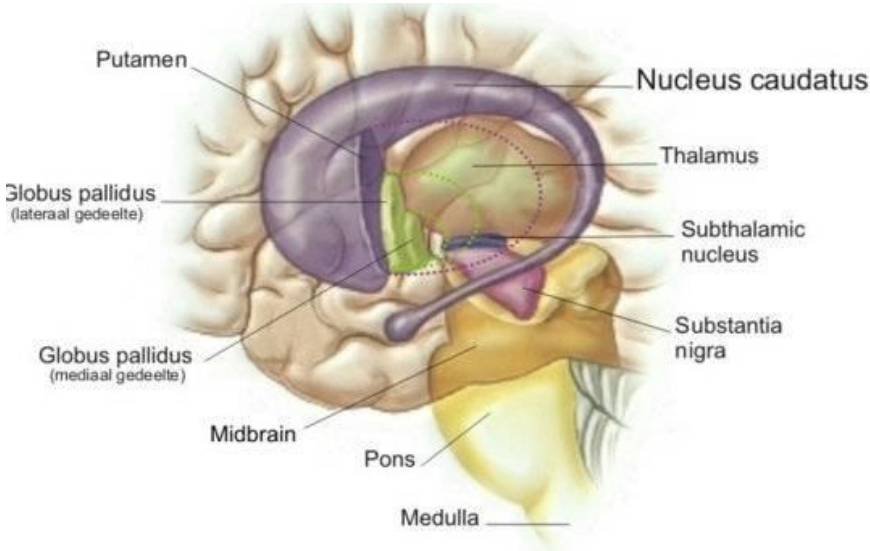


A BRAIN SECTION AT THE LEVEL OF THE TEGMENTAL TRANSITION IN THE CRURA CEREBRI



BASAL GANGLIA

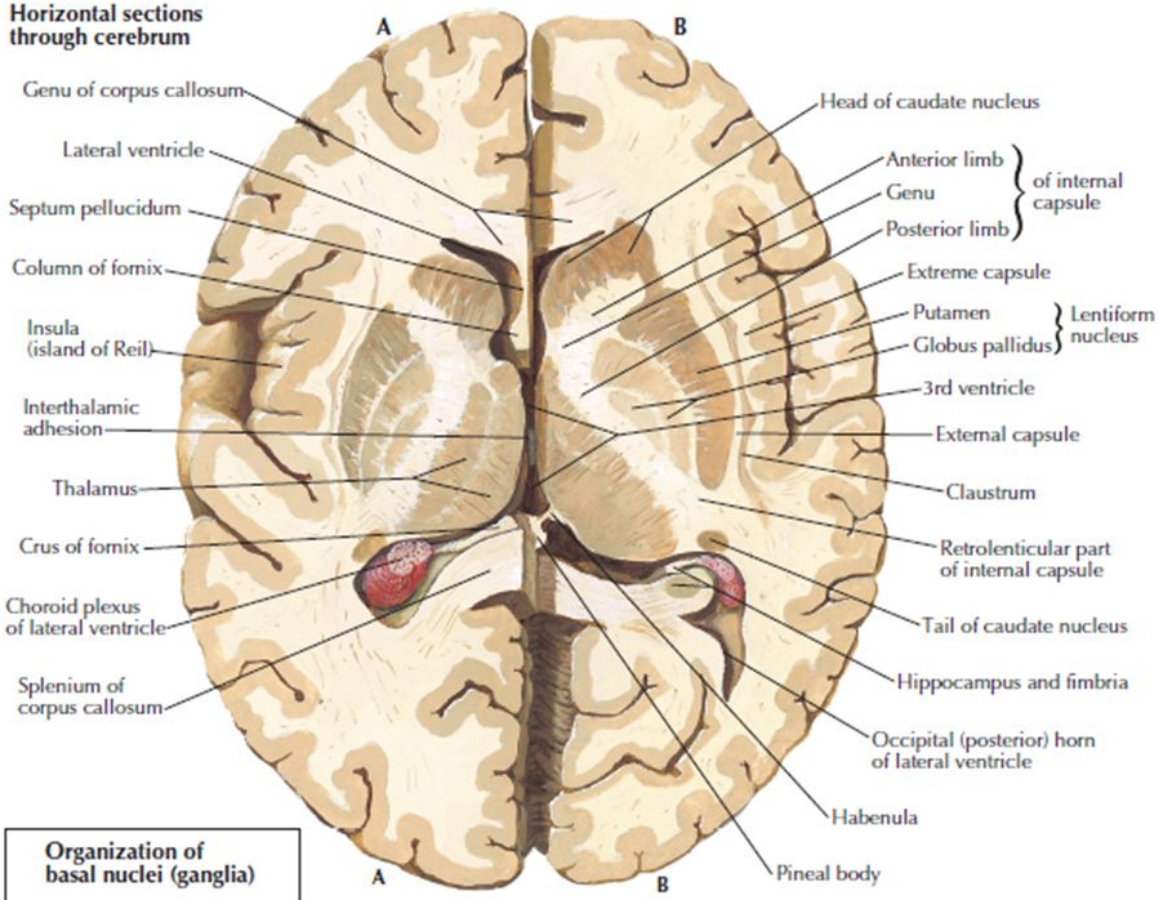
- The basal ganglia receive signals from the cortex and relay information to the motor areas of the cortex via the medial and ventral nuclei of the thalamus
- They regulate the initiation and termination of movement
  - Activity in the putamen precedes the movement itself
  - Activity in the caudate nucleus precedes eye movements
  - The globus pallidus regulates muscle tone for specific movements
- control of subconscious skeletal muscle contractions
  - e.g., limb swing during walking
  - hearty laughter in response to a joke
- assistance in initiating and terminating cognitive processes
  - attention focus
  - memory
  - planning
  - cooperation with the limbic system in regulating emotional expressions

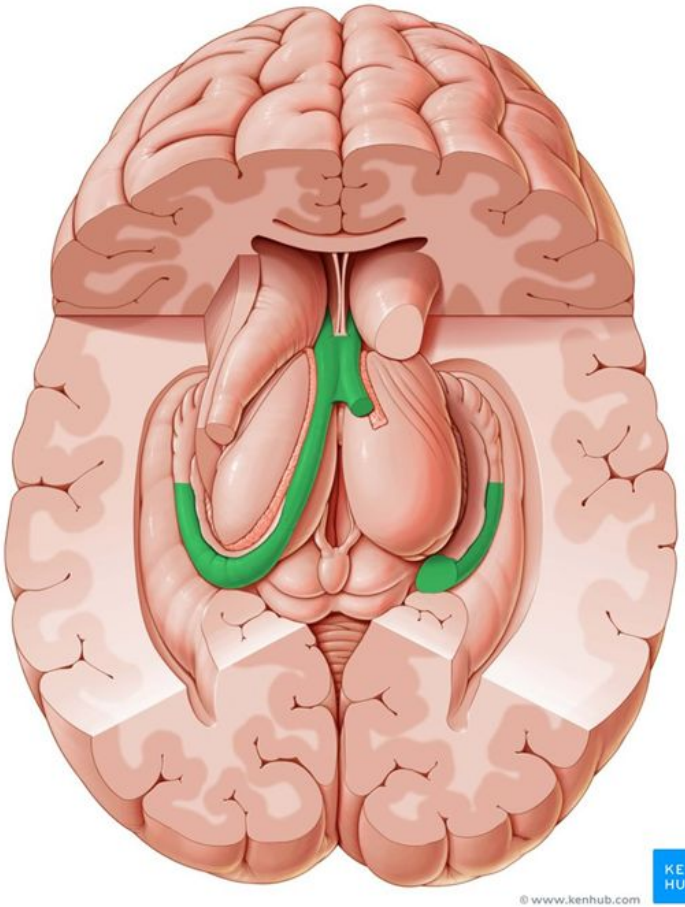


CLAUSTRUM

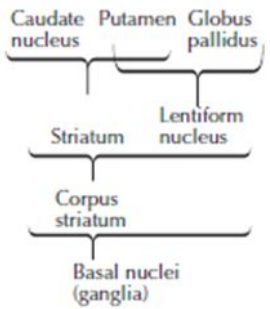
- the gray matter between the putamen (white external capsule) and the insular cortex (white capsula extrema)
- structurally and neurochemically similar to the neocortex
- afferents from the entire neocortex, excitatory
- reciprocal efferents, continuing to the thalamus and the pretectal area
- active during tasks requiring multimodal integration of sensory signals (e.g., visual and auditory)

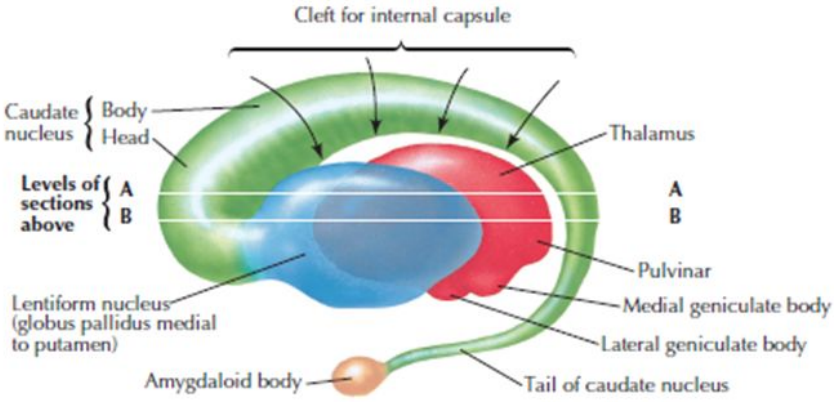
Horizontal sections through cerebrum



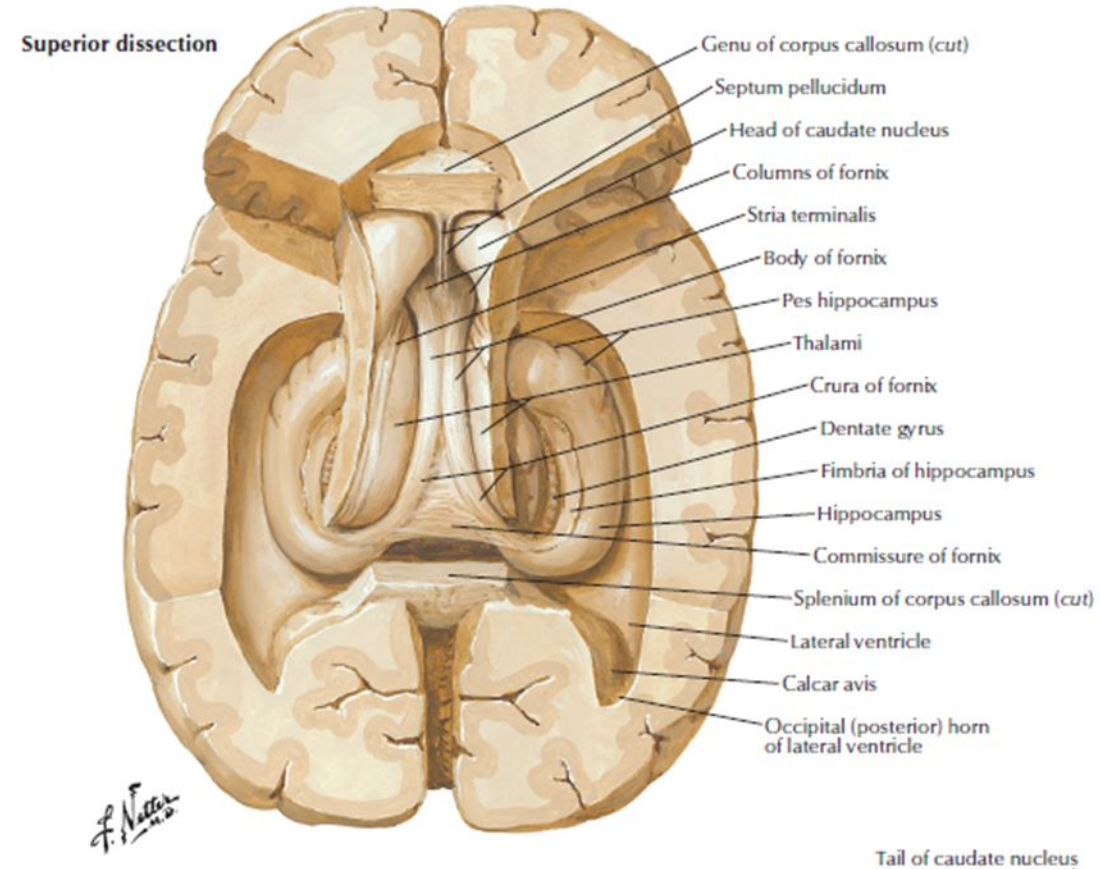


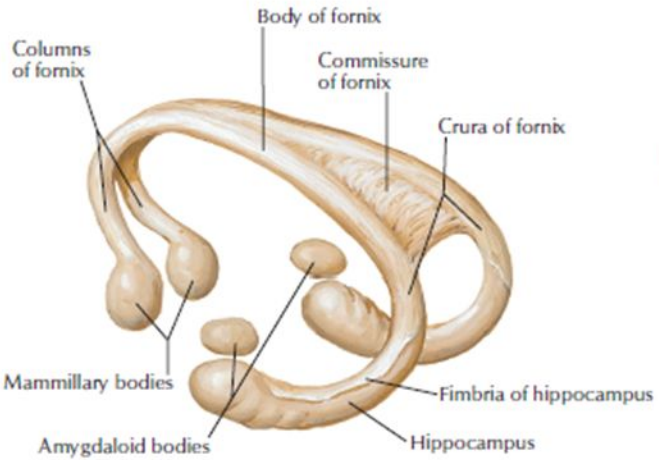
Organization of basal nuclei (ganglia)



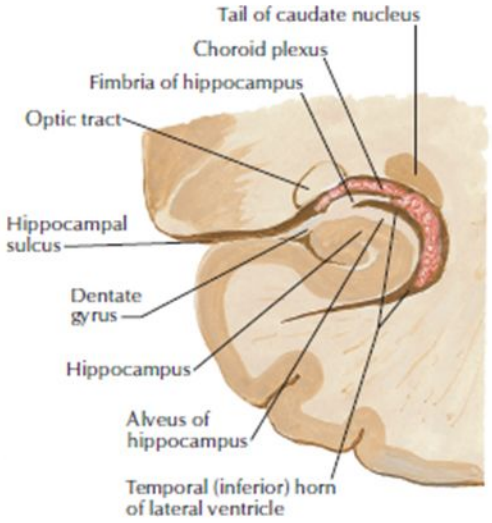


Interrelationship of thalamus, lentiform nucleus, caudate nucleus, and amygdaloid body (schema): left lateral view

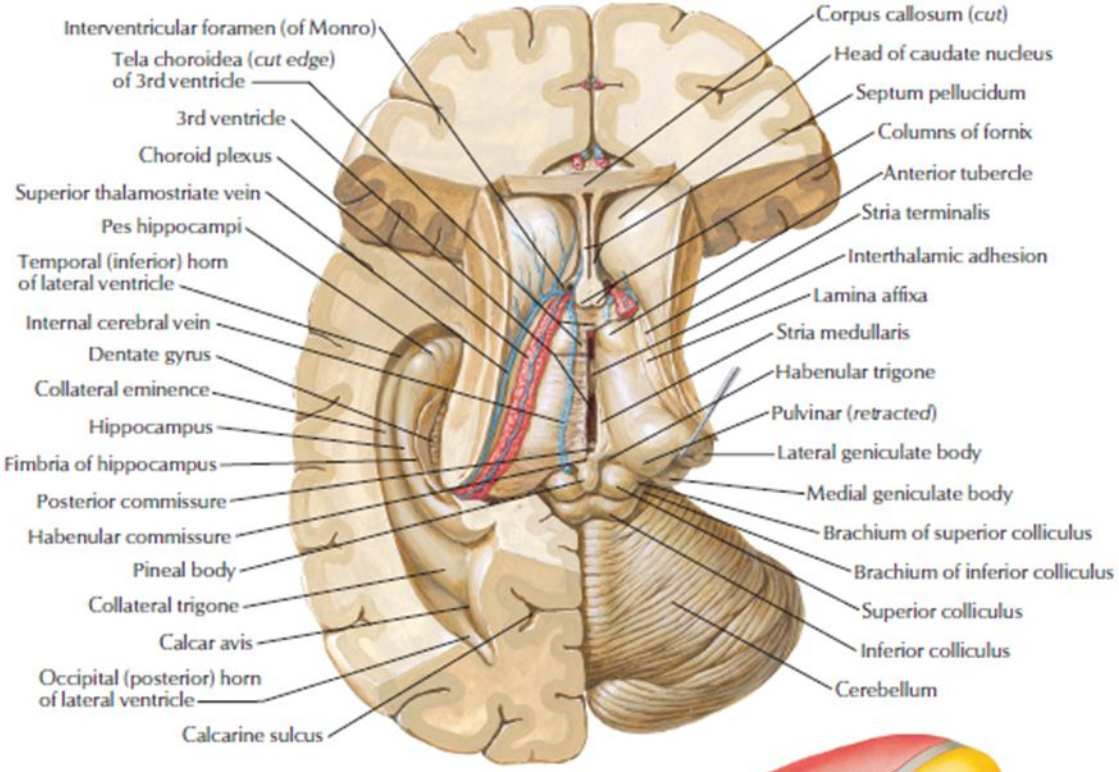


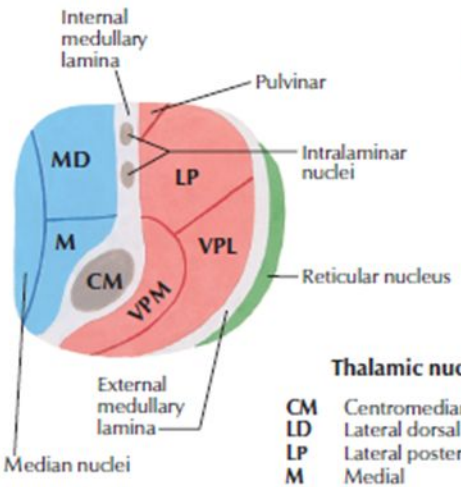


Fornix: schema



Coronal section: posterior view

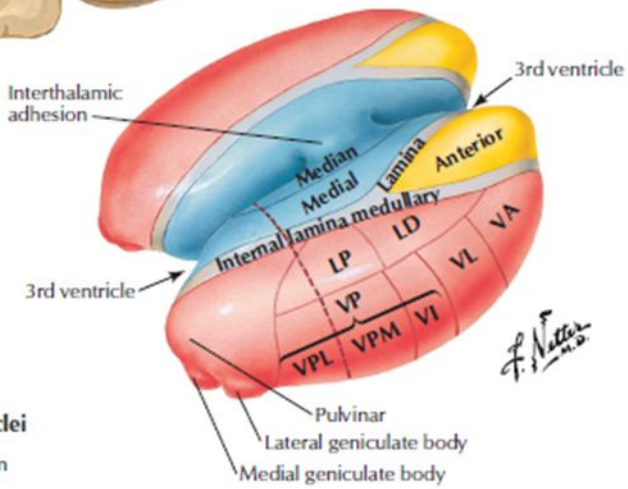




Schematic section through thalamus
(at level of broken line shown in figure at right)

Thalamic nuclei

CM	Centromedian
LD	Lateral dorsal
LP	Lateral posterior
M	Medial
MD	Medial dorsal
VA	Ventral anterior
VI	Ventral intermedial
VL	Ventral lateral
VP	Ventral posterior
VPL	Ventral posterolateral
VPM	Ventral posteromedial

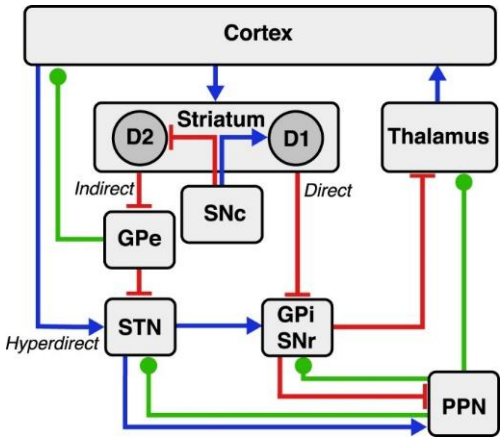


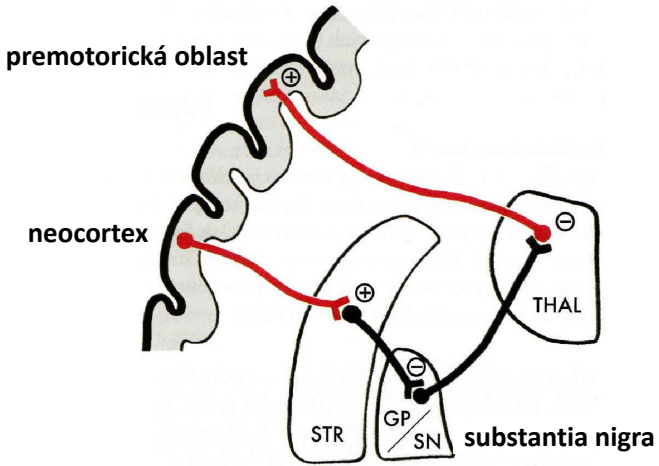
Schematic representation of thalamus
(external medullary lamina and reticular nuclei removed)

Lateral nuclei
Medial nuclei
Anterior nuclei

BG FUNCTIONS

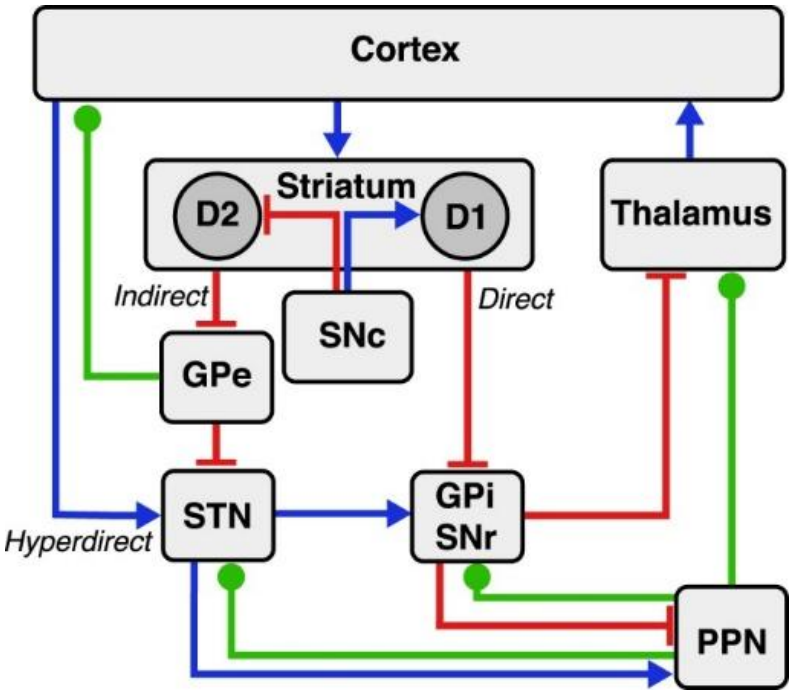
- striatum – the gateway to the system
  - receives excitatory glutamatergic inputs from nearly the entire cerebral cortex
  - contains 90–95% medium spiny neurons, which are inhibitory (GABAergic) (Frost-Nylén et al., 2024)
  - functionally divided into:
  - dorsal striatum – control of conscious motor functions and executive functions
  - ventral striatum (ncl. accumbens) – part of the limbic system, associated with reward and motivation (Burbaud et al., 2022)
- output structures
  - globus pallidus internus, substantia nigra pars reticulata
  - their neurons are tonically active and constantly send inhibitory signals to the thalamus and brainstem (Deniau et al., 2007; Frost-Nylén et al., 2024).
  - They function as a brake—for movement to occur, these output nuclei must be inhibited, thereby releasing the brake (disinhibition) of the target structures
- dopamine
    - Produced in the substantia nigra pars compacta and released into the striatum
    - Acts via two types of receptors:
    - D1 receptors—excitatory, stimulate the direct pathway (promotion of movement)
    - D2 receptors – inhibitory, attenuate the indirect pathway (suppression of movement inhibition) (Neve et al., 2004; Zhou et al., 2023)
  - a deficiency of dopamine leads to difficulties with movement initiation (Parkinson's disease), an excess leads to involuntary movements

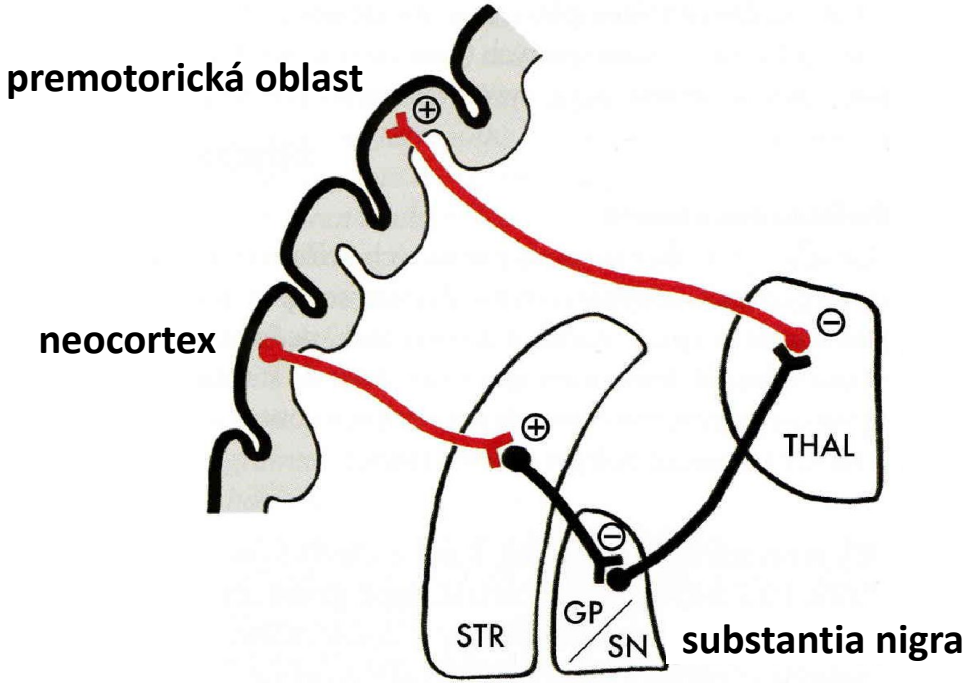




THREE BASIC PATHWAYS

- Direct (Go!)
  - cortex → striatum → GPi/SNr (inhibition) → thalamus (disinhibition) → cortex
  - this pathway facilitates and initiates voluntary movement (Eisinger et al., 2019; Frost-Nylén et al., 2024)
  - Dopamine enhances this pathway via D1 receptors
- Indirect (No-Go!)
  - cortex → striatum → GPe → STN → GPi/SNr (excitation) → thalamus (inhibition) → cortex
  - serves to suppress unwanted or competing motor programs (Frost-Nylén et al., 2024)
  - Dopamine inhibits this pathway via D2 receptors, thereby reducing its inhibitory effect
- Hyperdirect (emergency brake)
  - Direct connection from the cortex to the subthalamic nucleus, bypassing the striatum
  - The STN subsequently strongly excites the output nuclei (GPi/SNr), leading to the immediate cessation of all motor activity (Frost-Nylén et al., 2024; Nambu et al., 2002)
  - Crucial for behavioral switching and the cessation of impulsive responses in crisis situations





CIRCUITS OF THE BG

- The basal ganglia do not function as a single unit, but rather in parallel loops
  - These loops process different types of information but follow the same anatomical principle (cortex → BG → thalamus → cortex) (Alexander et al., 1986)
  - The main circuits include the motor, oculomotor, associative, and limbic circuits (Simonyan, 2019)
- Motor cicuit
  - connects the motor and premotor areas of the cortex with the putamen
  - ensures precise fine-tuning of voluntary movements
  - helps with the automation of learned movement patterns (switching between conscious and automatic control) (Frost-Nylén et al., 2024; Seger, 2006)
- Associative (cognitive) circuit
  - connected to the prefrontal cortex and the head of the caudate nucleus
  - plays a role in executive functions—planning, problem-solving, working memory, and attention (Alexander & Crutcher, 1990; Seger, 2006)
  - allows us to select behavioral strategies based on context
- Limbic (emotional) circuit
  - includes the nucleus accumbens and ventral striatum
  - key for reward processing, motivation, and emotional behavior (Seger, 2006; Simonyan, 2019)
  - dysfunction in this circuit is associated with depression, apathy, and addictions
- Oculomotor circuit
  - specifically controls saccadic eye movements (rapid eye movements)
  - The SNr sends inhibitory projections to the superior colliculus (mesencephalon) (Hikosaka et al., 2000; Seger, 2006)
  - allows us to quickly focus our gaze on visually or motivationally significant objects

BG & CRBL INTERACTIONS

- Traditionally viewed as separate systems, but they are directly interconnected at the subcortical level
- The cerebellum learns through error correction (sensory feedback), while the basal ganglia learn through rewards (dopamine) (Bostan & Strick, 2018)
- Their cooperation is essential for smooth, coordinated, and purposeful movement (Hoshi et al., 2005)