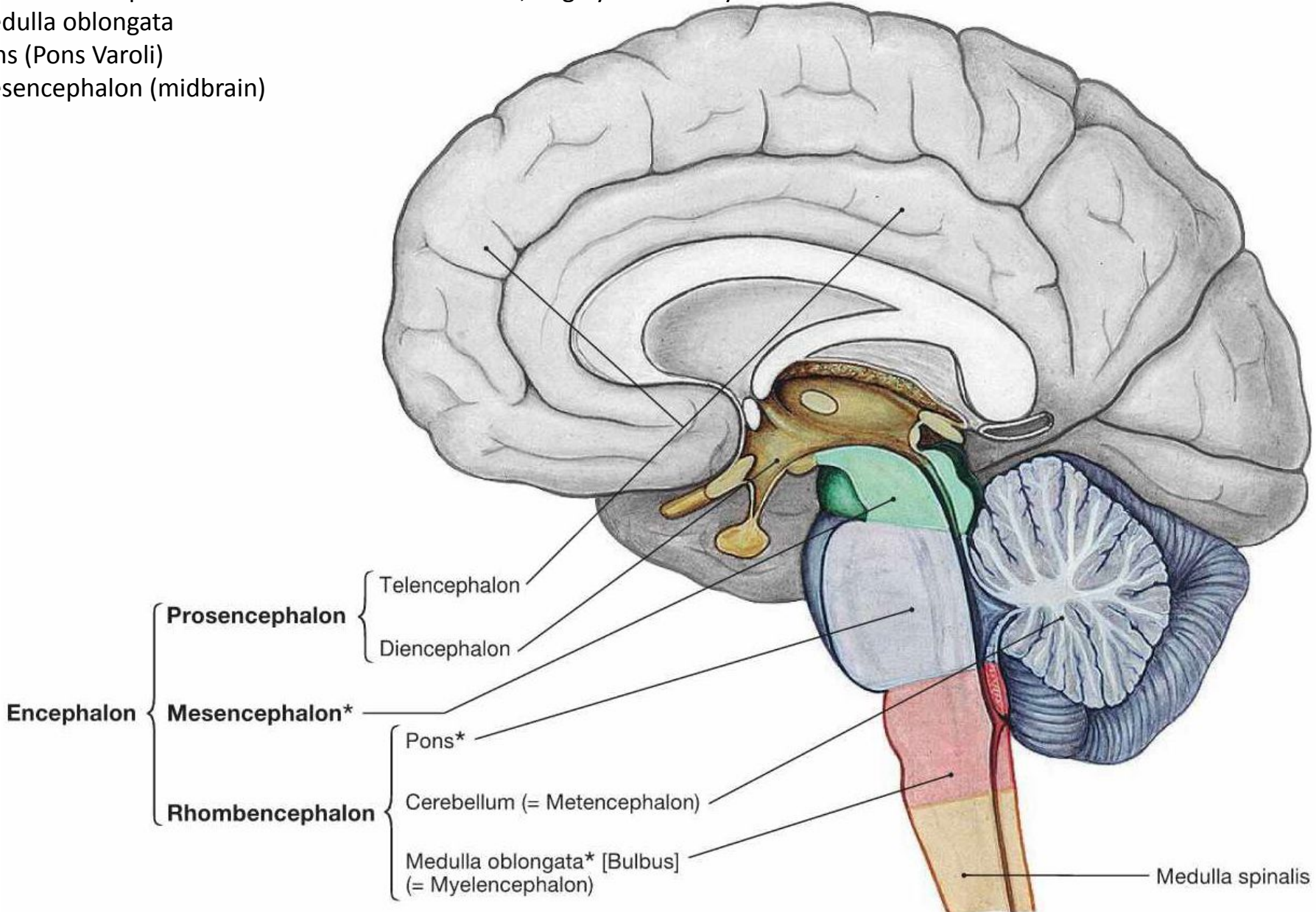


BRAINSTEM

- Continuation of the spinal cord beginning at the pyramidal decussation / exit of C1 rootlets
- Located in the posterior cranial fossa on the clivus, largely covered by the cerebellum
- Medulla oblongata
- Pons (Pons Varoli)
- Mesencephalon (midbrain)



BRAINSTEM

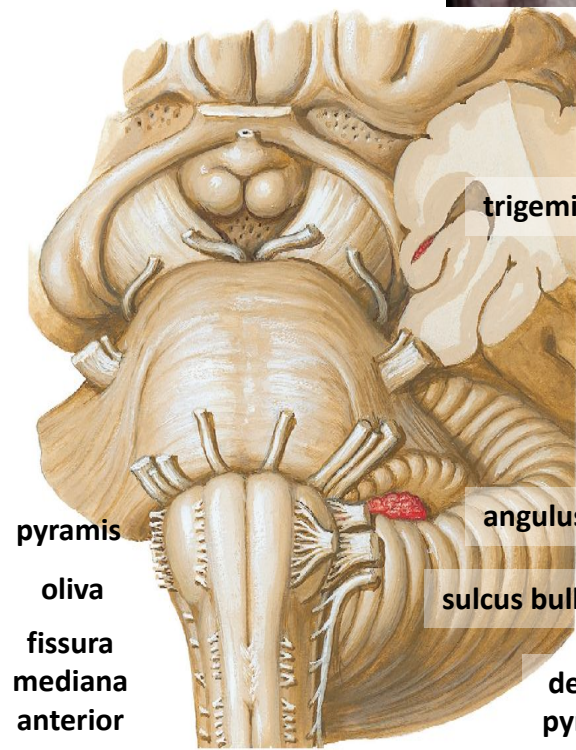
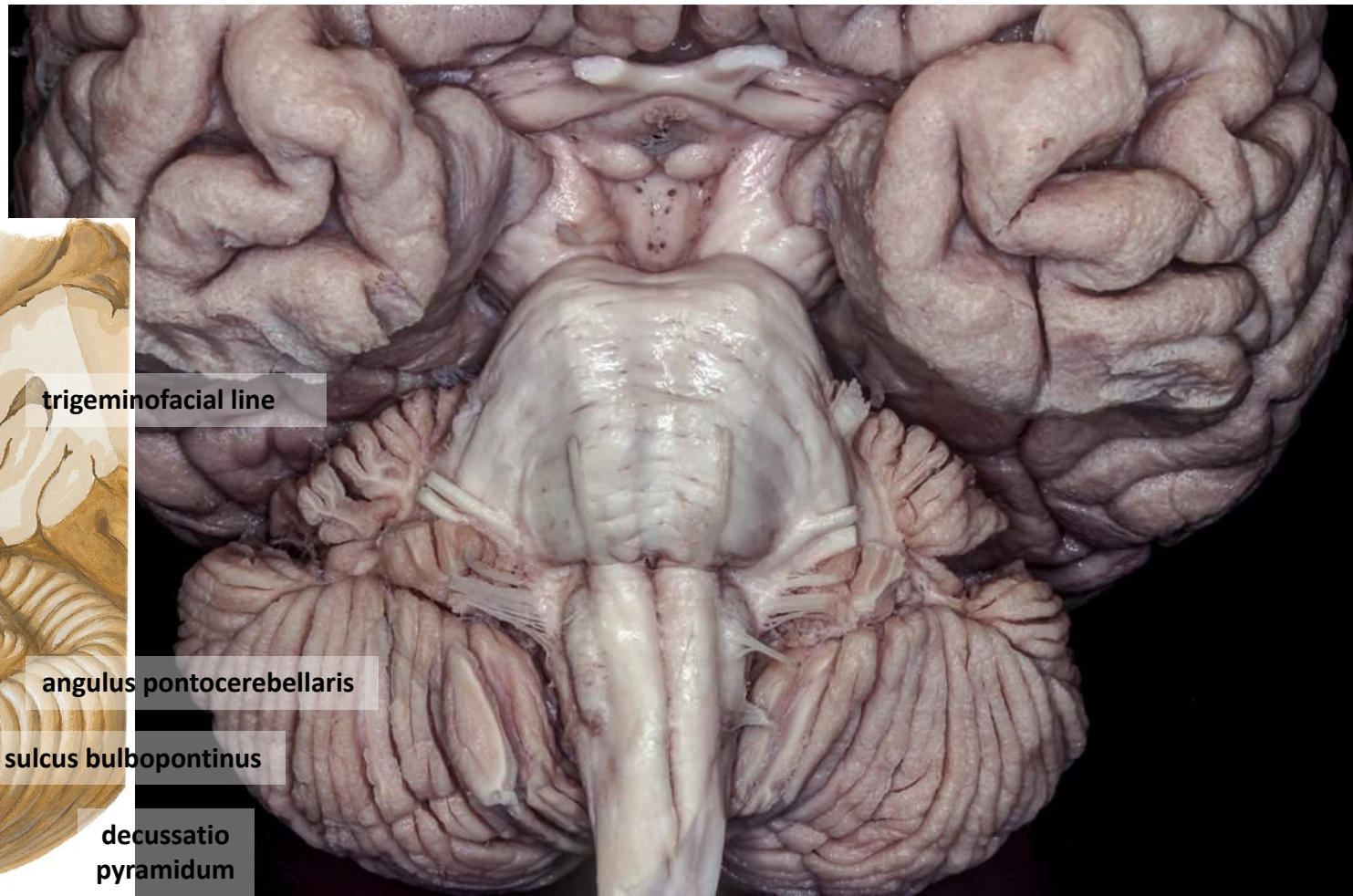
- Continuation of the spinal cord at the level of the pyramidal decussation / C1 rootlets
- In the posterior cranial fossa on the clivus, mostly covered by the cerebellum

Ventral view:

- Medulla oblongata — from the decussation to the sulcus bulbopontinus; contains the olive
- Pons (Varoli) — the trigemino-facial line separates the cerebellar peduncles
- Mesencephalon — ventrally: crura/pedunculi cerebrales with the interpeduncular fossa; dorsally: lamina quadrigemina

Dorsal view:

- Fossa rhomboidea (floor of the 4th ventricle)



trigemino-facial line

angulus pontocerebellaris

sulcus bulbopontinus

decussatio pyramidum

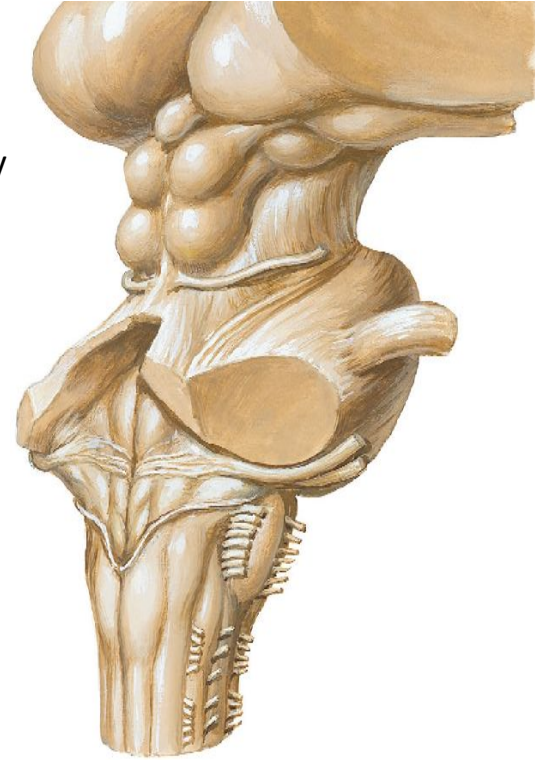
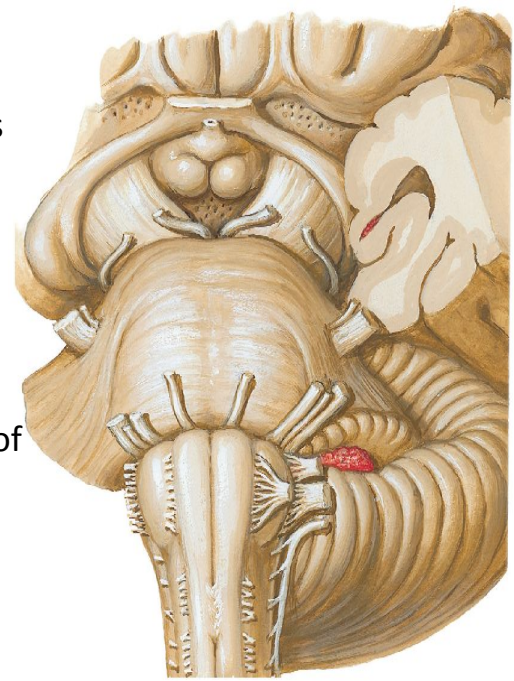
pyramis

oliva

fissura mediana anterior

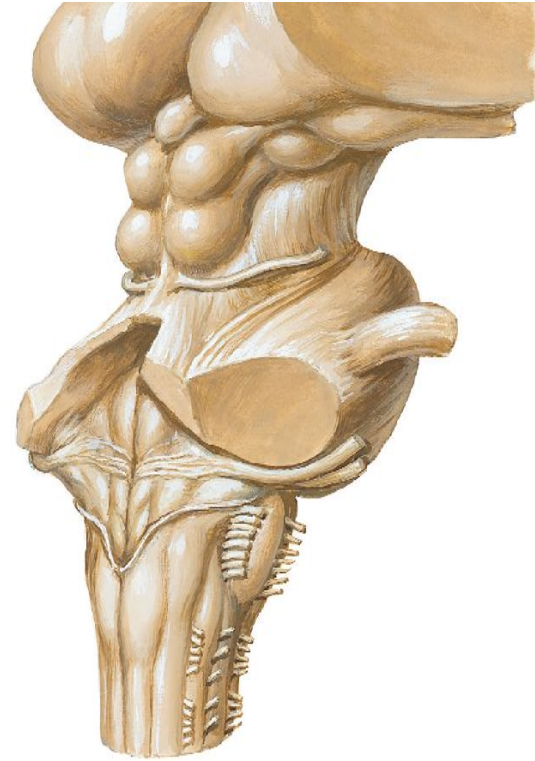
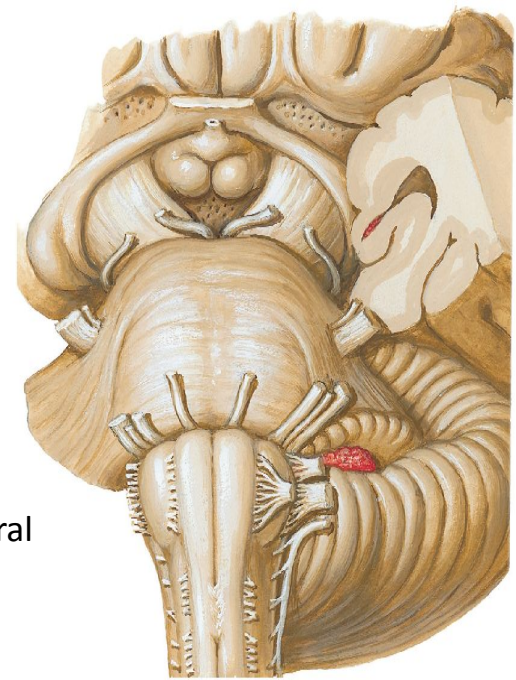
MEDULLA OBLONGATA

- Cranial continuation of the spinal cord; the boundary is defined by the exit of C1 rootlets (fila radicularia C1) and the pyramidal decussation
- Ventral surface rests on the clivus
- Ventral surface:
 - Pyramid of the medulla oblongata
 - Fissura mediana anterior
 - Sulcus bulbopontinus
 - Pyramidal decussation, laterally the sulcus ventrolateralis (anterolateralis) — exit of cranial nerve XII
 - Olive — located between the ventrolateral and dorsolateral (retro-olivary) sulci
 - Lateral to the olive emerge cranial nerves IX, X, and XI
- Dorsal surface:
 - Sulcus medianus dorsalis (posterior)
 - Fasciculus gracilis (Goll) medially → tuberculum gracile (clava)
 - Fasciculus cuneatus (Burdach) laterally → tuberculum cuneatum
 - Tuberculum trigeminale (lateral to the cuneate tubercle)
 - Inferior part of the rhomboid fossa with the attachment of the inferior medullary velum (taenia ventriculi quarti)
 - Inferior cerebellar peduncles



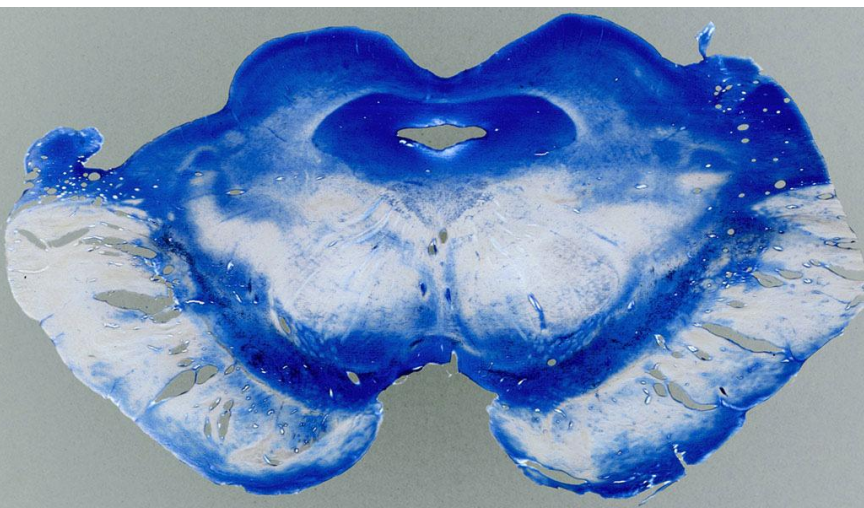
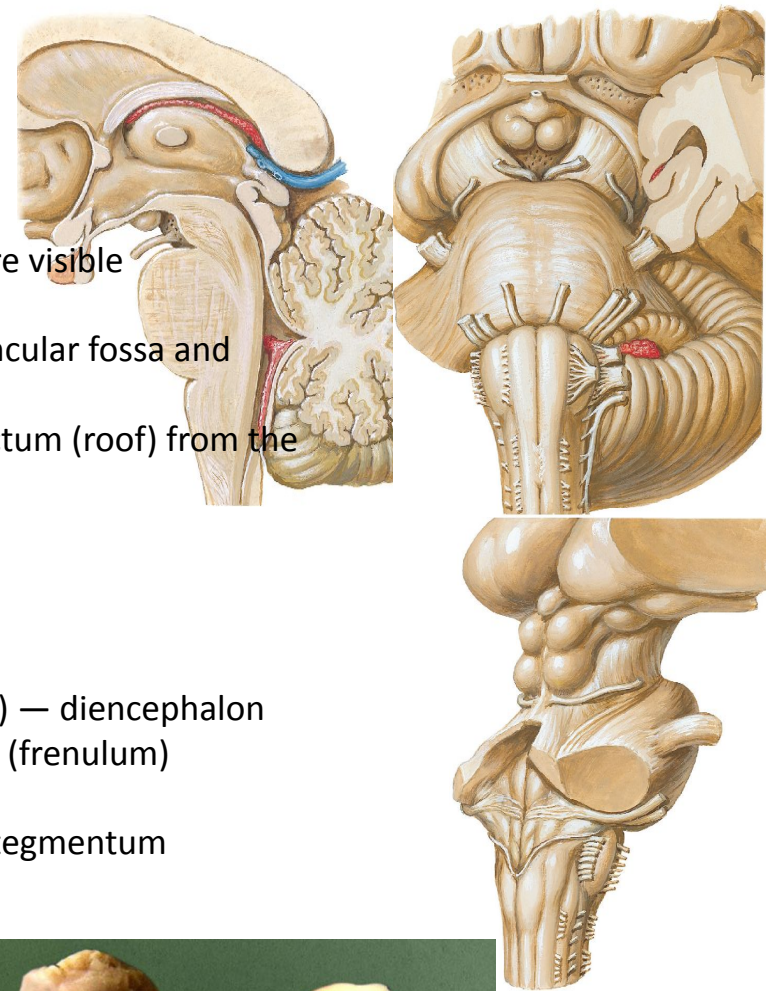
PONS VAROLI

- A transverse prominence on the ventral surface of the brainstem
- Ventrally faces the junction of the temporal bone with the sphenoid bone
- Structures:
 - Sulcus bulbopontinus — exit of cranial nerves VI and VII (two rootlets + nervus intermedius) and VIII
 - Sulcus basilaris
 - Trigeminal nerve (V)
 - Trigemino-facial line
 - Middle cerebellar peduncles (pedunculi cerebellares medii)
 - Dorsal side continues from the medulla oblongata; opening of the embryonic neural tube results in the formation of the rhomboid fossa



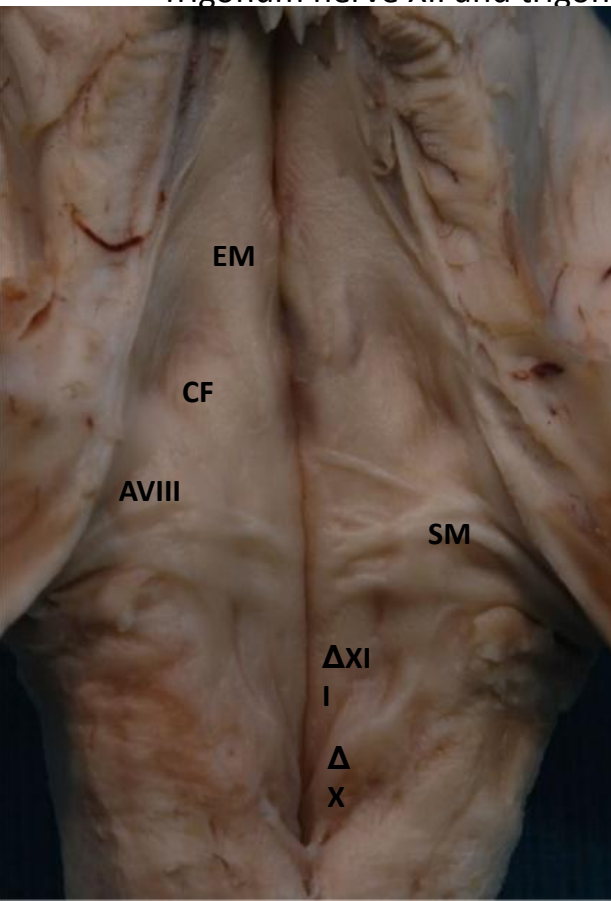
MESENCEPHALON

- Caudally connected to the pons, cranially to the diencephalon
- Dorsal and lateral surfaces are covered by the cerebral hemispheres
- Rostral end terminates at the corpora mamillaria (hypothalamus)
- On the ventral brain base, only the cerebral peduncles (crura cerebri) are visible
- Structures:
 - Cerebral peduncles (pedunculi/crura cerebri) with the interpeduncular fossa and substantia perforata interpeduncularis
 - Aqueductus mesencephali (cerebral aqueduct) separating the tectum (roof) from the tegmentum
 - Tectal plate (lamina tecti)
 - Superior colliculi — visual pathway
 - Inferior colliculi — auditory pathway
 - Rostral to the superior colliculi: area praetectalis
 - Between the superior colliculi: pineal body (corpus pineale) — diencephalon
 - Superior cerebellar peduncles with the superior medullary velum (frenulum)
 - Tegmentum mesencephali
 - Sylvian aqueduct visible in cross-section; separates tectum from tegmentum

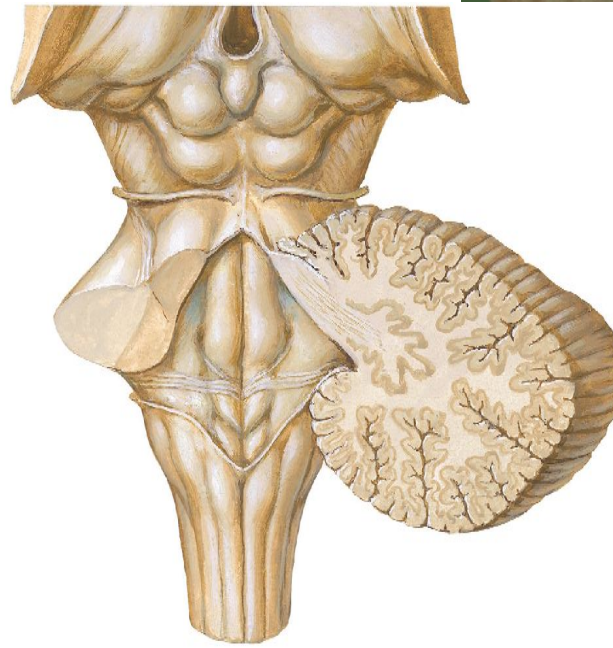


FOSA RHOMBOIDEA

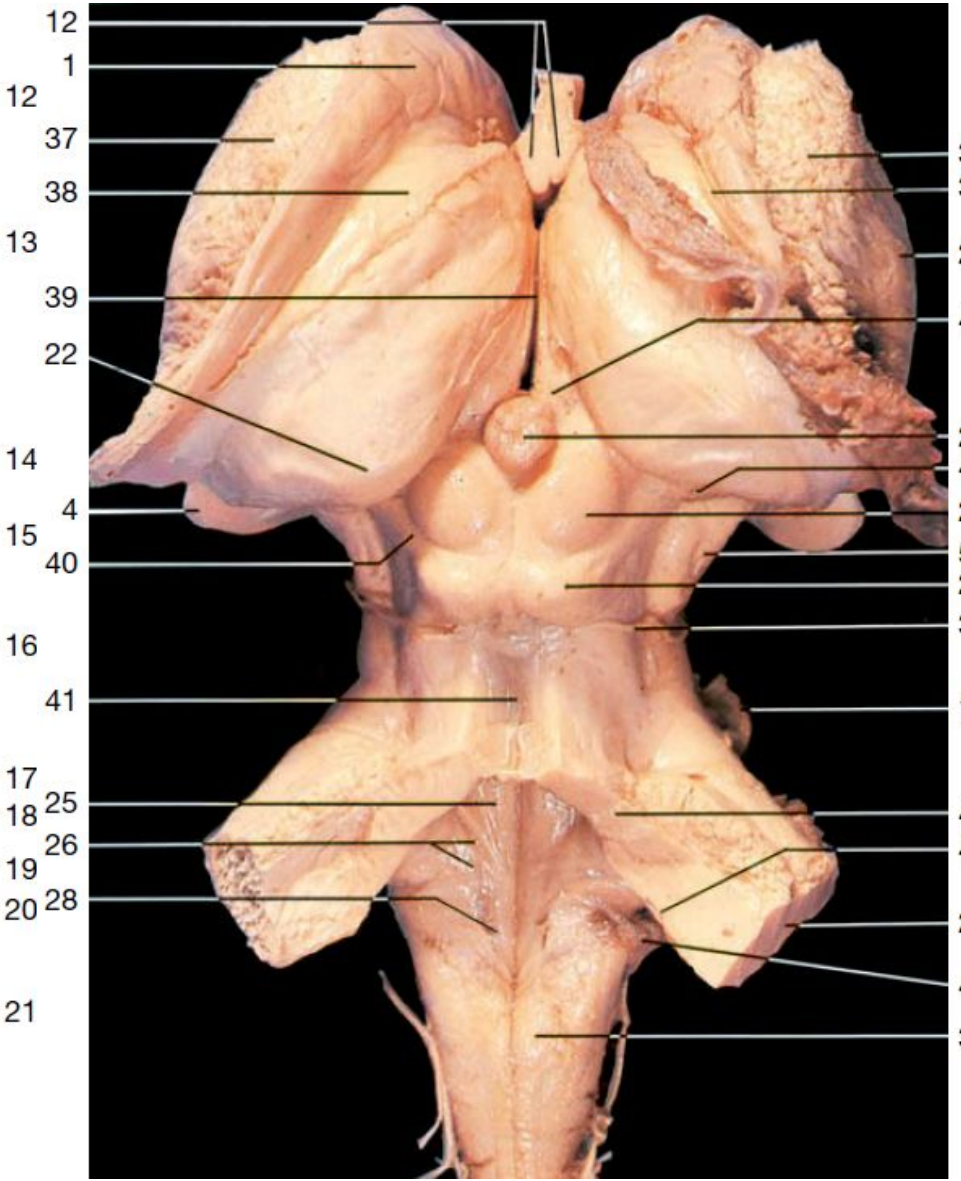
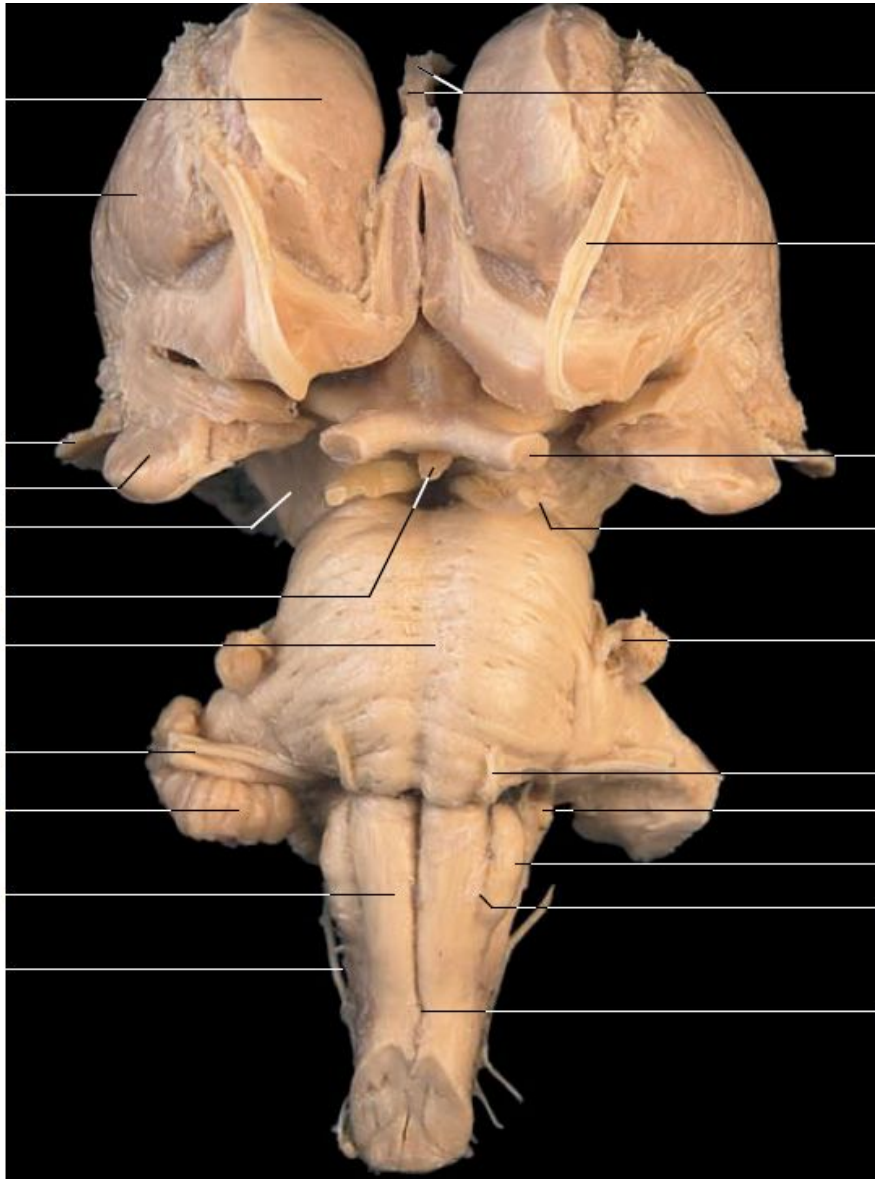
- The rhomboid fossa is the floor of the fourth ventricle
- Boundaries of the 4th ventricle: Dorsal surfaces of the medulla, pons, and part of the midbrain, cerebellar peduncles and the medullary vela (inferior velum with the choroid plexus); The cerebellum — the apex of the velum = fastigium
 - Recessus lateralis ventriculi quarti with the lateral aperture (foramen of Luschka); Caudal tip: obex and median aperture (foramen of Magendie)
 - Sulcus medianus and Sulci limitantes — define motor/sensory regions
 - Eminentia medialis and Colliculus facialis
 - Striae medullares
 - Area vestibularis laterally
 - Trigonum nerve XII and trigonum nerve X caudally

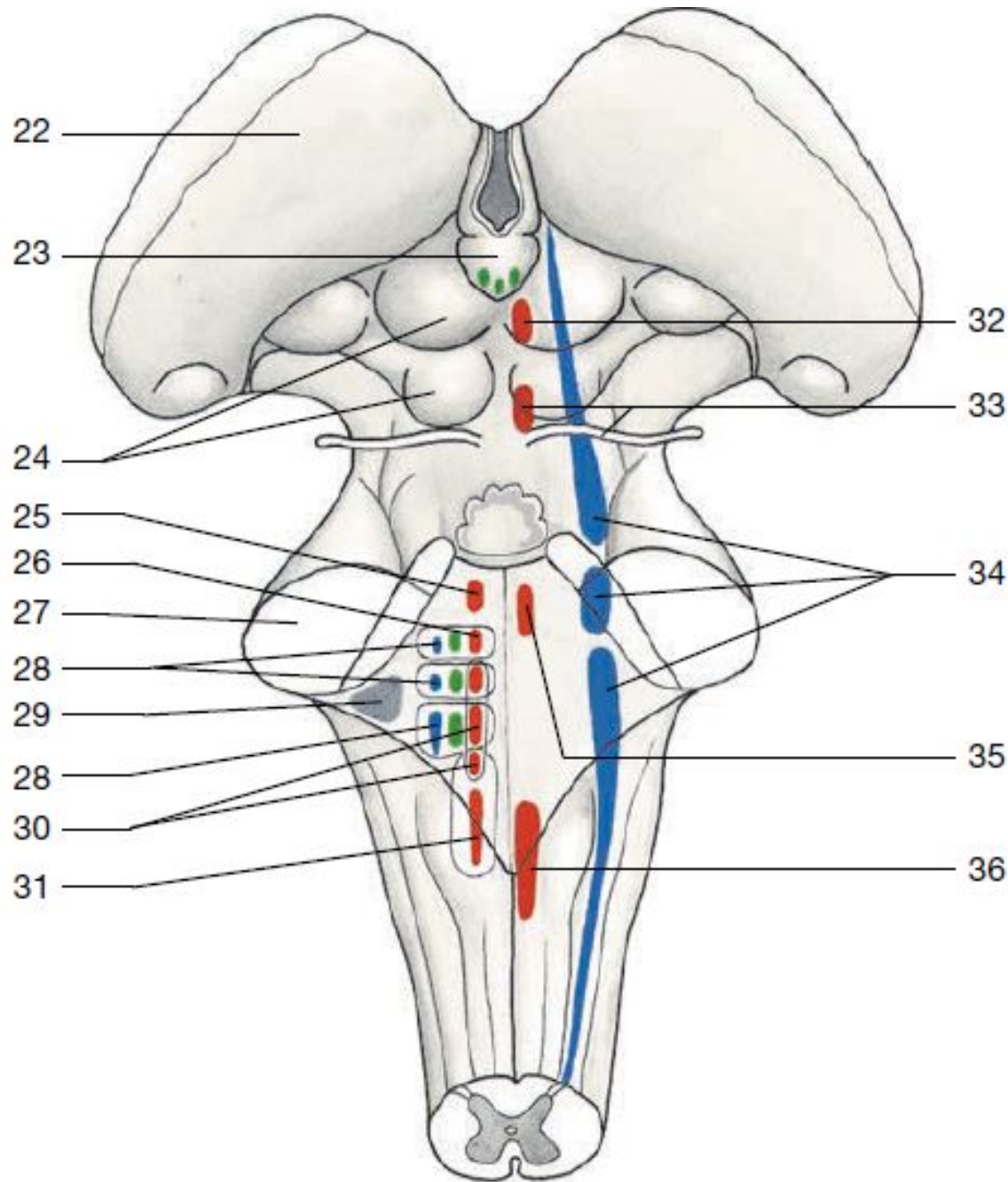


Cavalcanti et al. (2016).
Microsurgical anatomy of safe entry
zones to the brainstem. *Journal of
neurosurgery*, 124(5), 1359–1376.



BRAINSTEM

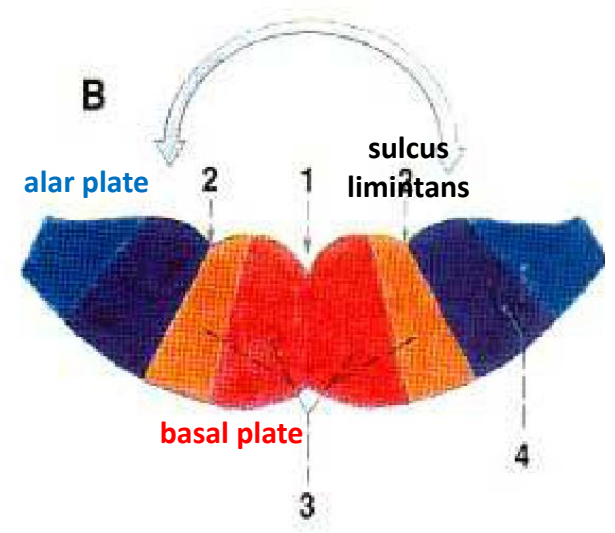
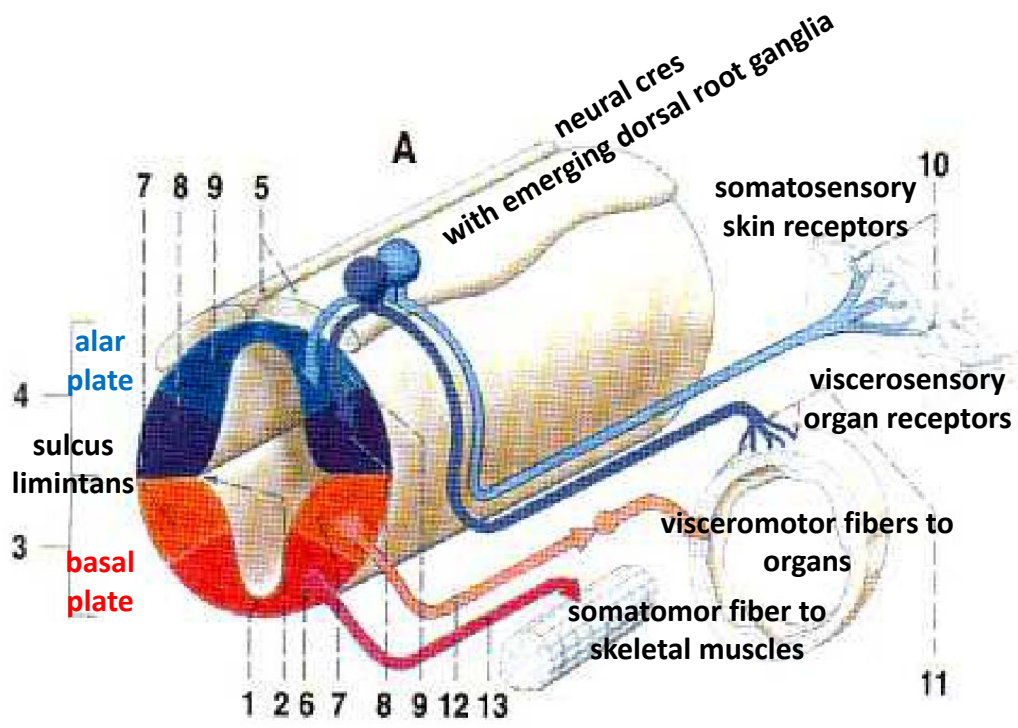




- 1 Caudate nucleus
- 2 Lentiform nucleus
- 3 Caudal extremity of caudate nucleus
- 4 Amygdaloid body
- 5 Cerebral peduncle
- 6 Infundibulum
- 7 Pons
- 8 Facial and vestibulocochlear nerves (n. VII, n. VIII)
- 9 Cerebellar flocculus
- 10 Medulla oblongata
- 11 Accessory nerve (n. XI)
- 12 Fornix and column of fornix
- 13 Olfactory tract
- 14 Optic nerve (n. II)
- 15 Oculomotor nerve (n. III)
- 16 Trigeminal nerve (n. V)
- 17 Abducent nerve (n. VI)
- 18 Glossopharyngeal and vagus nerves (n. IX, n. X)
- 19 Inferior olive
- 20 Hypoglossal nerve (n. XII)
- 21 Decussation of the pyramids
- 22 Thalamus
- 23 Epiphysis
- 24 Tectum of midbrain (superior and inferior colliculus)
- 25 Motor nucleus of trigeminal nerve (n. V)
- 26 Facial nucleus (n. VII)
- 27 Middle cerebellar peduncle
- 28 Visceral nucleus of glossopharyngeal and vagus nerves (n. IX and n. X), salivatory nucleus
- 29 Vestibular nucleus (n. VIII)
- 30 Ambiguous nucleus (n. IX, n. X, n. XI)
- 31 Spinal nucleus of accessory nerve (n. XI)
- 32 Motor nucleus of oculomotor nerve (n. III)
- 33 Trochlear nucleus and nerve (n. IV)
- 34 Sensory nucleus of trigeminal nerve (n. V)
- 35 Abducent nucleus (n. VI)
- 36 Hypoglossal nucleus (n. XII)
- 37 Internal capsule
- 38 Lamina affixa
- 39 Third ventricle
- 40 Brachium of inferior colliculus
- 41 Superior medullary velum
- 42 Habenular trigone
- 43 Medial geniculate body
- 44 Superior cerebellar peduncle
- 45 Inferior cerebellar peduncle
- 46 Choroid plexus of fourth ventricle

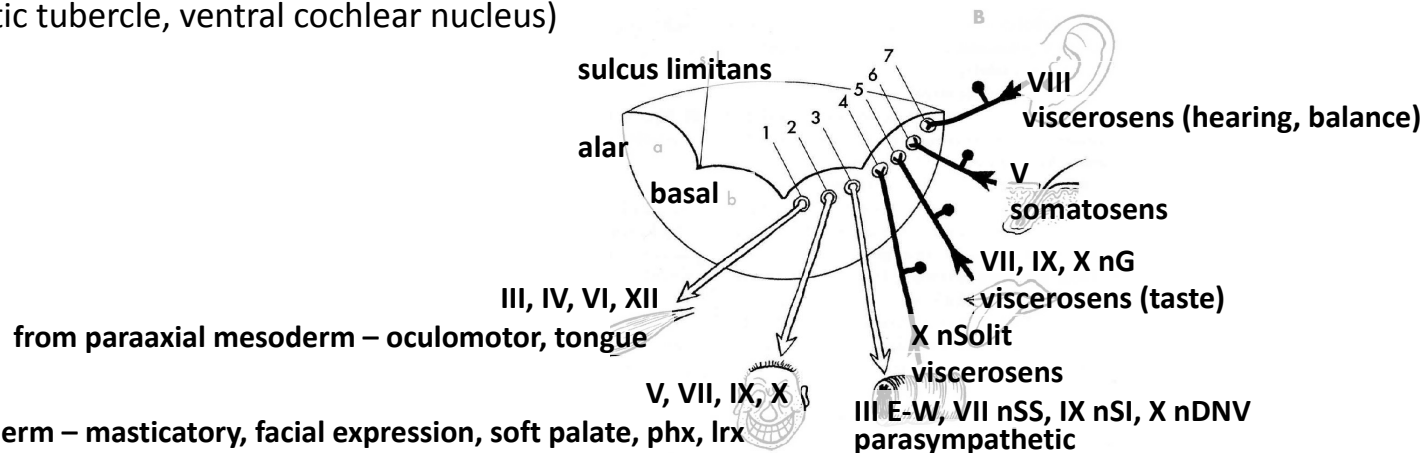
BRAINSTEM GRAY MATTER

- cranial nerve nuclei
 - medial to the sulcus limitans lie the somatomotor and visceromotor nuclei
 - lateral to the sulcus limitans lie the somatosensory and viscerosensory nuclei and special sensory nuclei
- nuclei of the reticular formation
- nuclei specific to individual divisions of the brainstem



CRANIAL NERVES NUCLEI

- Medial to the sulcus limitans lie the somato- and visceromotor nuclei
- Lateral to the sulcus limitans lie the somatosensory and viscerosensory nuclei and special sensory nuclei
- **somatomotor nuclei**
 - medial row, innervating muscles derived from the paraxial mesoderm (including the CN XII, VI, IV, and II)
 - lateral row, innervating muscles derived from the mesoderm of the gill arches (ambiguus, n. VII, motorius n. V)
- **visceromotor nuclei (parasympathetic)**
 - connected to the lateral column, but lying closer to the surface of the rhomboid fossa
 - ncl. dorsalis of n. X., ncl. salivatorius inferior – to n. IX., ncl. salivatorius superior – associated with n. VII., ncl. Edinger-Westphal
- **viscerosensory nucleus**
 - laterocaudal to the sulcus limitans (ncl. solitarius)
- **somatosensory nuclei**
 - below the floor of the fourth ventricle, lateral to the sulcus limitans and lateral to the ncl. solitarius
 - ncl. n. V. – spinalis, pontinus, mesencephalicus
- **special sensory nuclei**
 - fibers of the n. vestibularis (below the floor of the fourth ventricle, ncl. vestibularis medialis, lateralis, cranialis, and caudalis)
 - fibers of the cochlear nerve (lateral to the vestibular nuclei, at the junction of the medulla oblongata and pons, dorsal cochlear nucleus – acoustic tubercle, ventral cochlear nucleus)



RETICULAR FORMATION NUCLEI

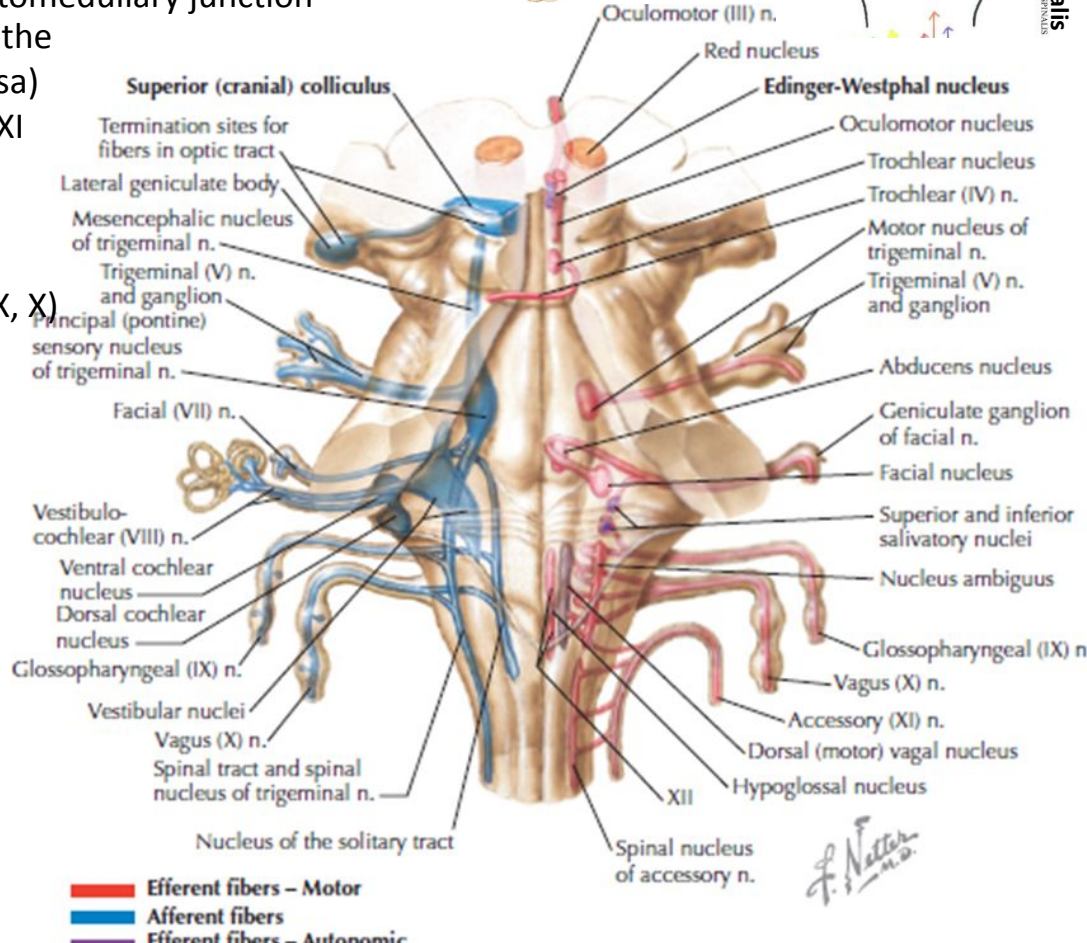
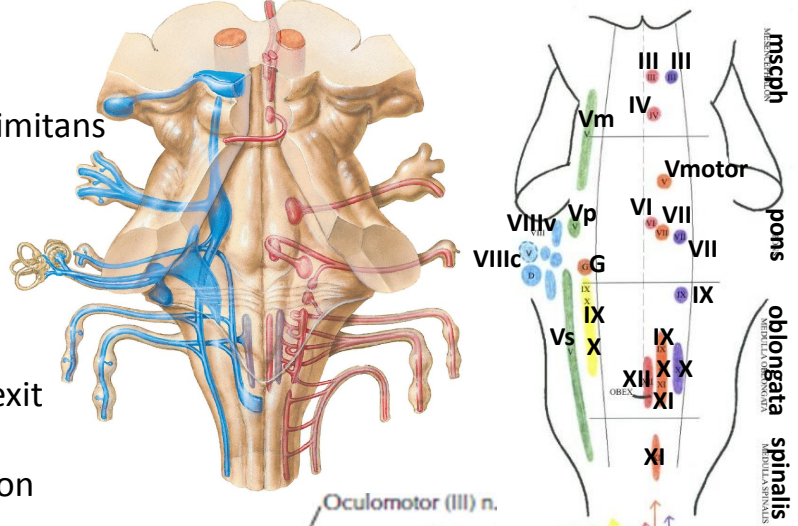
- an evolutionarily ancient group of nuclei in the central part of the brainstem, divided into three bands
- rafeal
 - unpaired, located along the midline throughout the entire length of the brainstem
- medial
 - extending throughout the entire length of the brainstem, more massive
 - pain relay
- lateral
 - in the medulla oblongata and pons
 - fibers mostly terminate in the medial system
- more recently, the following nuclei have been distinguished
 - precerebral – medulla oblongata and pons, projections to the cerebellum (mossy fibers to the anterior lobe and vermis)
 - monoaminergic – serotonergic neurons of the raphe system and noradrenergic neurons of the locus coeruleus
 - cholinergic – at the junction of the pons and midbrain
- functions
 - projections to the thalamocortical system = ascending activation system of the reticular formation – wakefulness
 - reflexes – blinking, coughing, sucking, swallowing, gag, salivary, oculocardiac
 - motor center – initiation of locomotion, decrease in postural muscle tone; junction of the pons and midbrain
 - pneumotactic center – respiratory rhythm, cranially from the respiratory
 - respiratory center – in the medulla oblongata beneath the rhomboid fossa
 - center regulating cardiac activity – near the dorsal root of the vagus nerve
 - vasomotor center – regulation of blood pressure, below the trigone of the vagus nerve
 - vomiting center – below the caudal end of the rhomboid fossa

NUCLEI SPECIFIC TO INDIVIDUAL REGIONS OF THE BRAIN STEM

- nuclei of the posterior columns
 - ncl. gracilis, ncl. cuneatus
 - zona glomerularis – termination of primary fibers of the lemniscus system (tr. spinobulbaris), continuing via decussation and into the lemniscus medialis to the thalamus (nVPL)
 - zona reticularis – termination of secondary fibers, continuing to the cerebellum, tectum, and ncl. ruber
 - lateral cuneate nucleus – the cuneocerebellar tract carries proprioception and cutaneous sensation from the upper limb to the cerebellum
- olivary nuclei
 - involved in motor control; after crossing in the inferior cerebellar peduncles (PCI), they enter the cerebellum as climbing fibers
- pontine nuclei
 - crossing of the somatotopically oriented corticopontocerebellar tract; after crossing in the PCM (brachia pontis), they enter the cerebellum (posterior lobe) as mossy fibers
- superior olivary nucleus and trapezoid body
 - level of the facial colliculus; relaying of the auditory pathway
- inferior colliculus
 - involved in the auditory pathway, tonotopic organization; efferent projection via the inferior collicular arm to the medial geniculate body
- superior colliculus
 - control of conjugate eye and head movements in response to visual and auditory stimuli, control of saccadic eye movements
- central gray matter
 - mesencephalon around the aqueduct; coping with stress and painful stimuli
- substantia nigra
 - interface between the tegmentum and the crura; dopamine production (control of movement and muscle tone; Parkinson's syndrome)
- ncl. ruber
 - tegmentum; coordination of movements
- ncl. interpeduncularis
 - beneath the interpeduncular fossa; part of the limbic system
- ncll. pretectales
 - beneath the superior colliculi; pupillary reflex
- ncl. ellipticus (Darkschewitz), ncl. interstitialis (Cajal), ncl. interstitialis rostralis
 - eye movements, NI and NIR center of vertical eye movements

CRANIAL NERVES NUCLEI

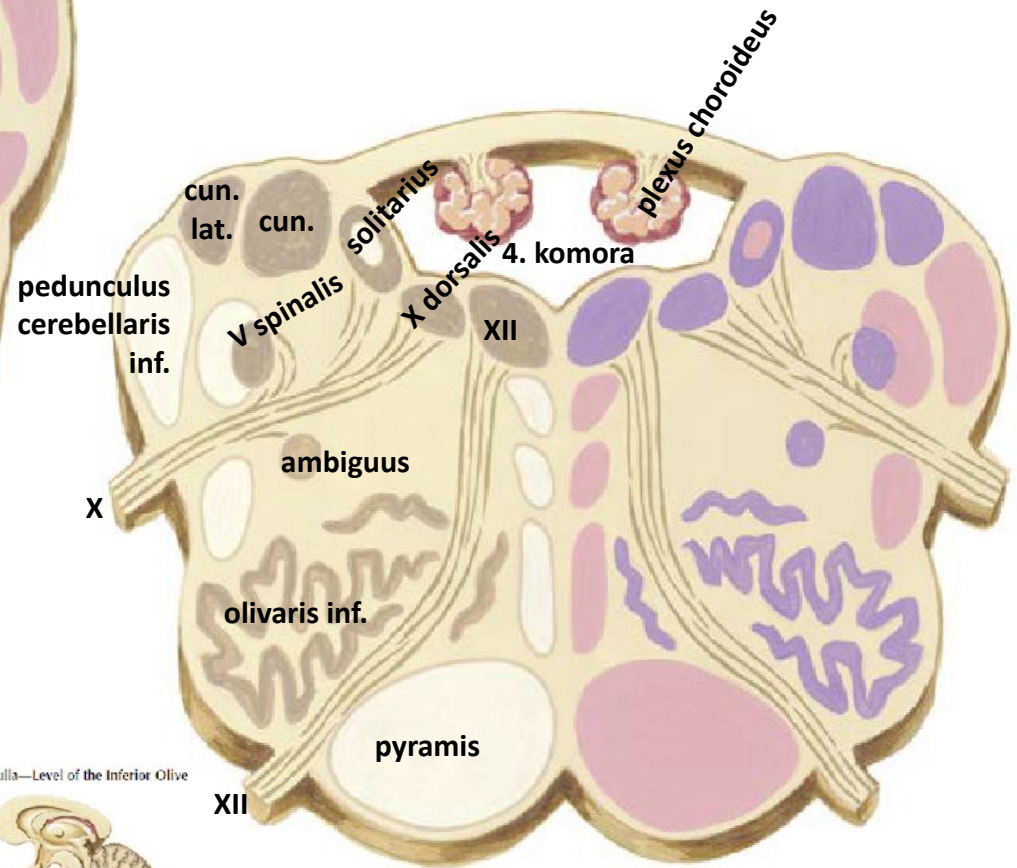
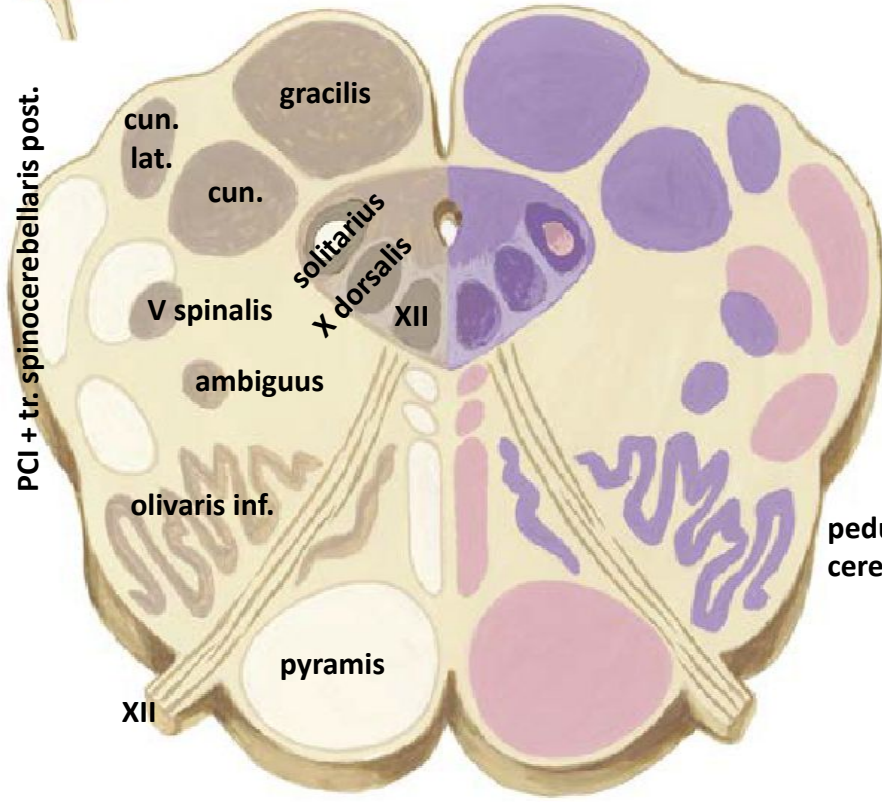
- the alar (sensory) and basal (motor) plates, separated by the sulcus limitans
- Nucleus of CN III (somatomotor) — level of the superior colliculi
- E-W nucleus (visceromotor → ciliary ganglion) — superior colliculi
- Nucleus of CN IV (somatomotor) — inferior colliculi
- nc. V.
 - M+P+S – span the lateral part of the entire brainstem
 - Motor nucleus — lateral in the pons, at level of trigeminal nerve exit
- CN VI nucleus — deep within the facial colliculus
- CN VII nucleus — dorsolateral to CN VI, at the pontomedullary junction
- CN VIII. nuclei (ncc. vestibulares a cochleares) – in the vestibular area (lateral recesses of the rhomboid fossa)
- Nucleus ambiguus (somatomotor) — for CN IX, X, XI (cranial root)
- nc. tractus solitarii (viscerosensory) — receives information from heart, GIT, RS, baroreceptors, chemoreceptors; gustatory nucleus → taste (VII, IX, X)
- Superior salivatory nucleus (visceromotor) → pterygopalatine & submandibular ganglia (CN VII)
- Inferior salivatory nucleus (visceromotor) → otic ganglion (CN IX)
- Dorsal nucleus of the vagus — preganglionic parasympathetic fibers (for the GIT until Cannon–Boehm point)
- Spinal accessory nucleus
- Hypoglossal nucleus



MEDULLA OBLONGATA

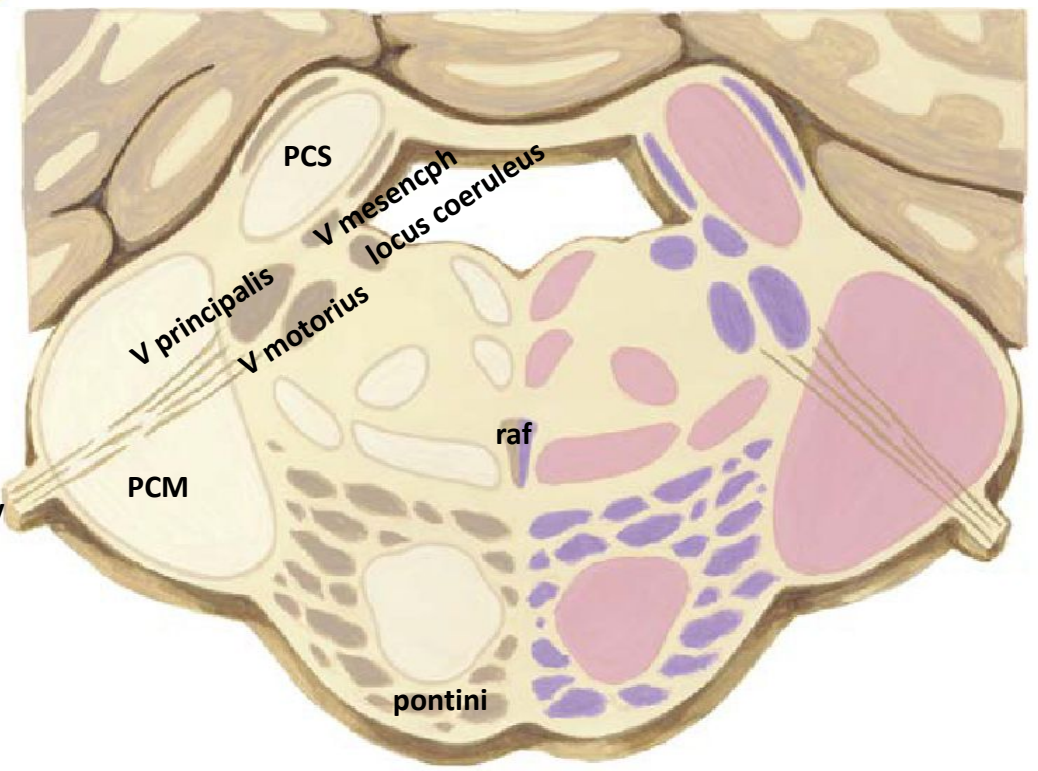
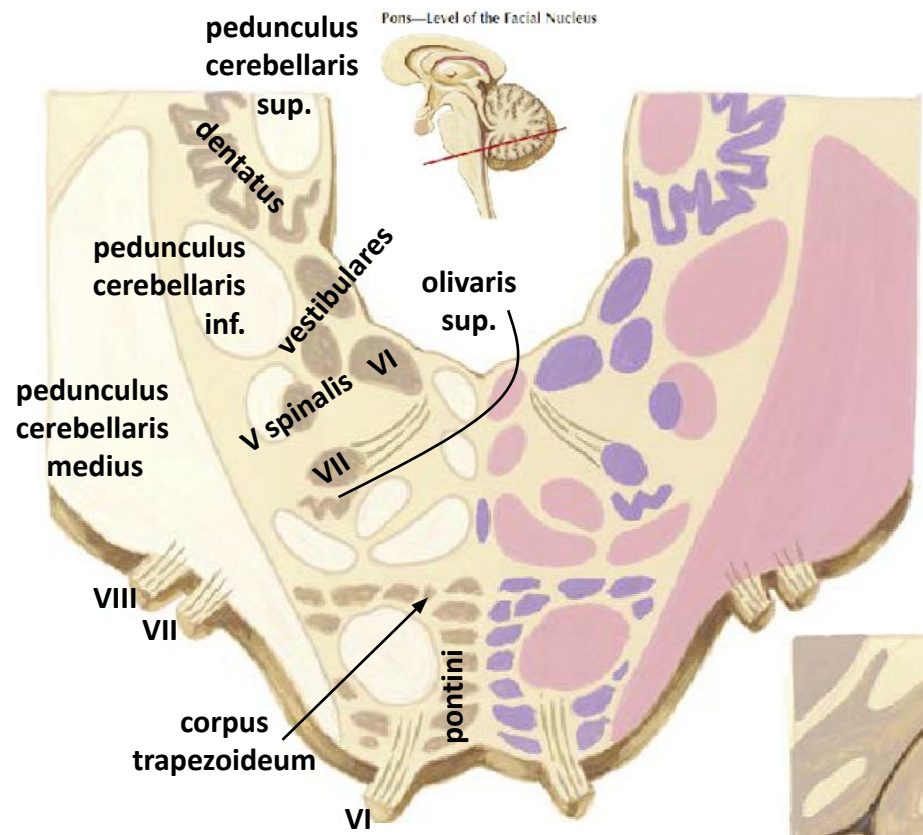


PCI + tr. spinocerebellaris post.



PONS VAROLI

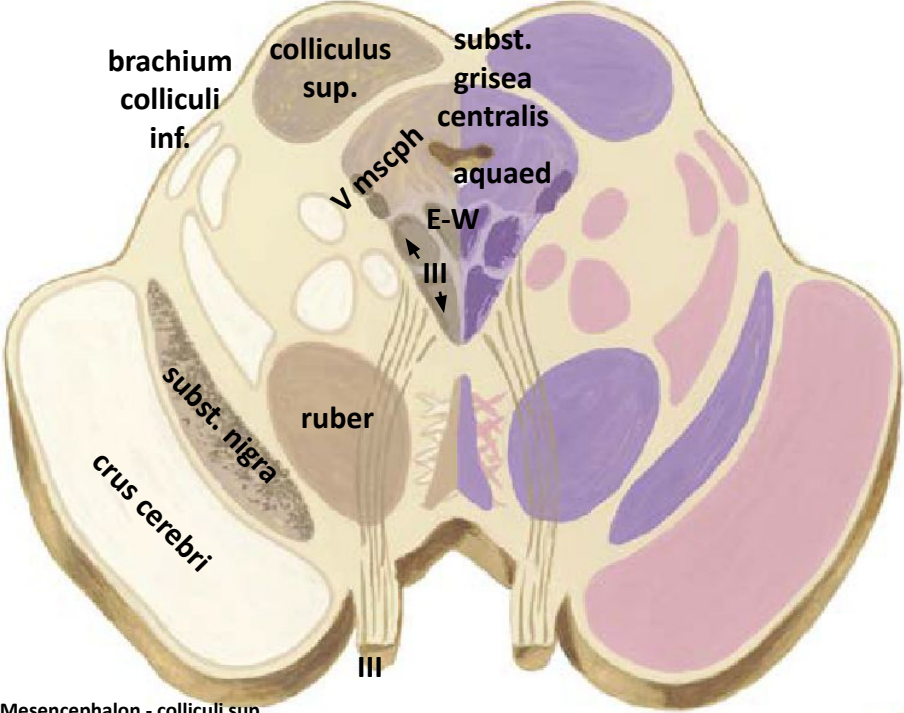
Pons—Level of the Facial Nucleus



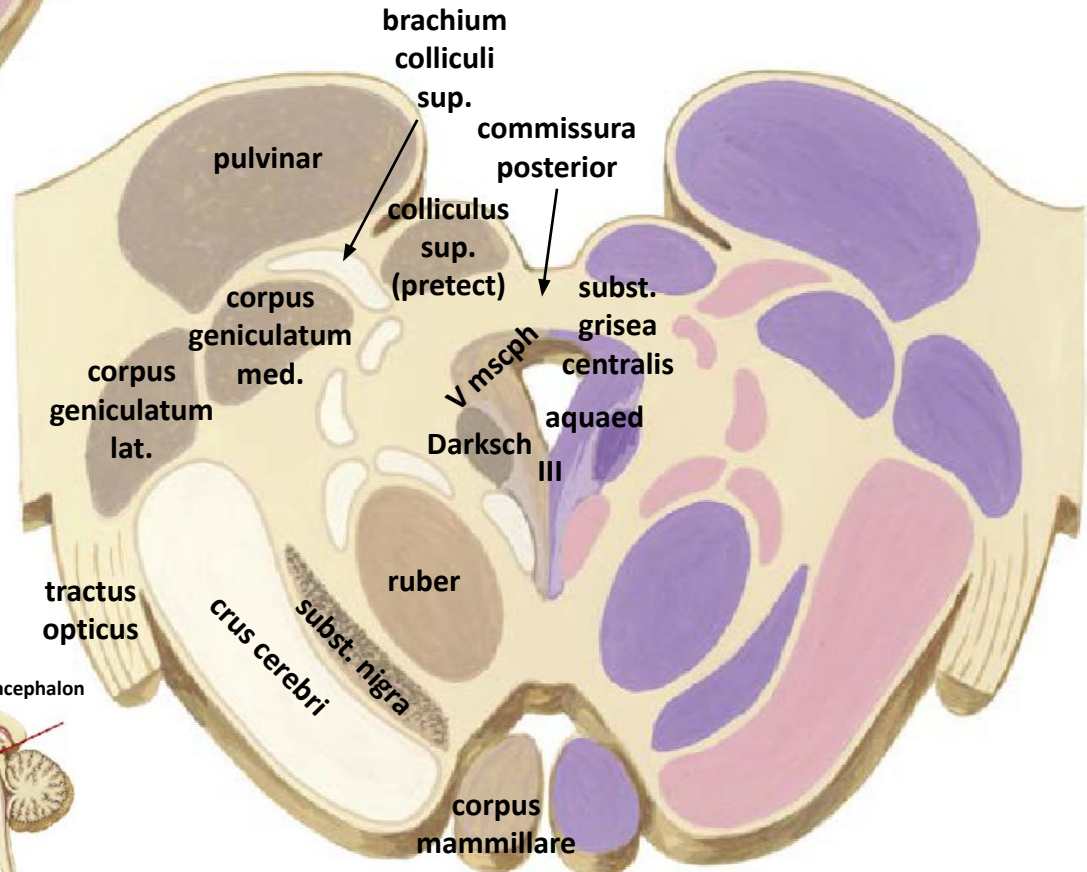
Pons—Level of Trigeminal



MESENCEPHALON



Mesencephalon - colliculi sup.



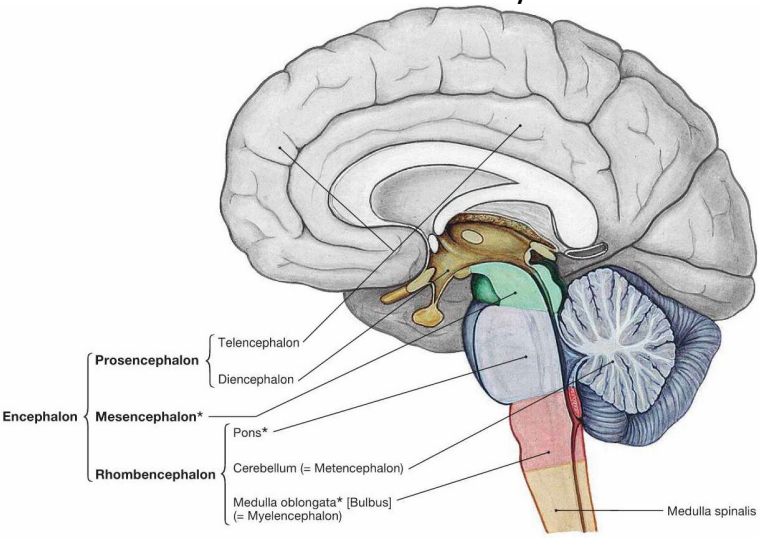
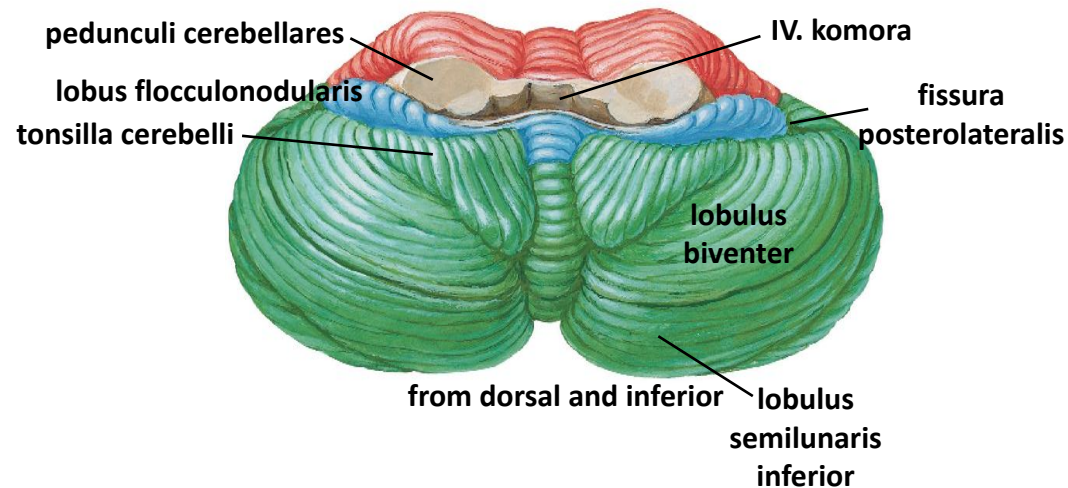
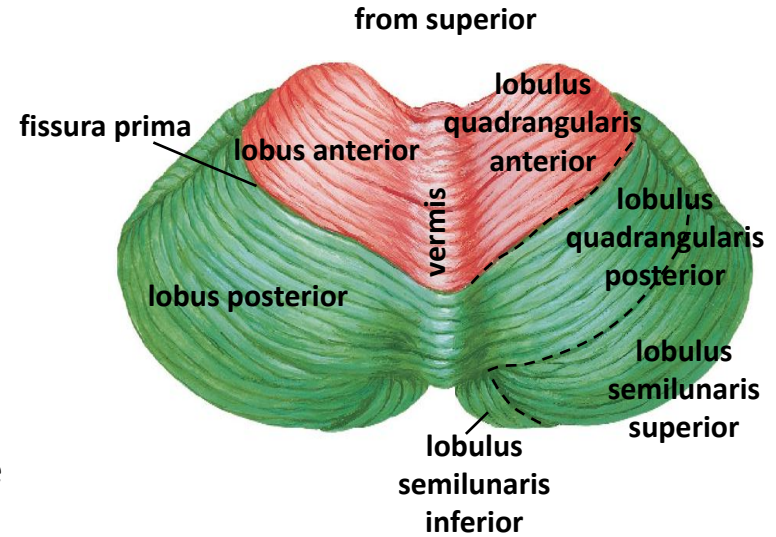
mesencephalon/diencephalon



CEREBELLUM

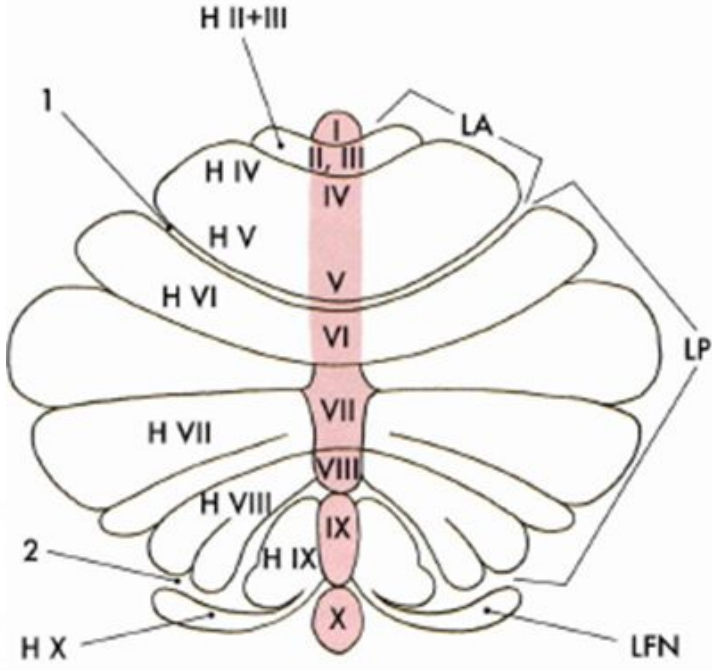
- in the posterior cranial fossa above the medulla oblongata and the pons
 - the posterior surface lies against the occipital bone (cerebellar fossae)
 - anterior margin opposite the posterior surface of the medulla oblongata
 - superimposed by the tentorium cerebelli in the transverse fissure of the brain
 - most of the roof of the fourth ventricle

- surface is fissured
 - cerebellar fissures separate the cerebellar folia
 - groups of folia form the cerebellar lobules
 - lobules are grouped into three main lobes
- vermis
- cerebellar hemispheres separated by the falx cerebelli
 - paravermian region
- anterior and posterior cerebellar incisures
- anterior lobe separated by the first fissure
- posterior lobe
- flocculonodular lobe separated by the posterolateral fissure
- connected to the brainstem by the cerebellar peduncles



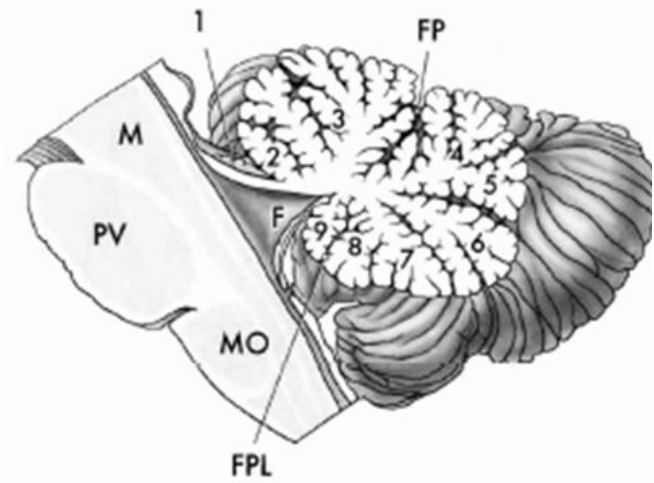
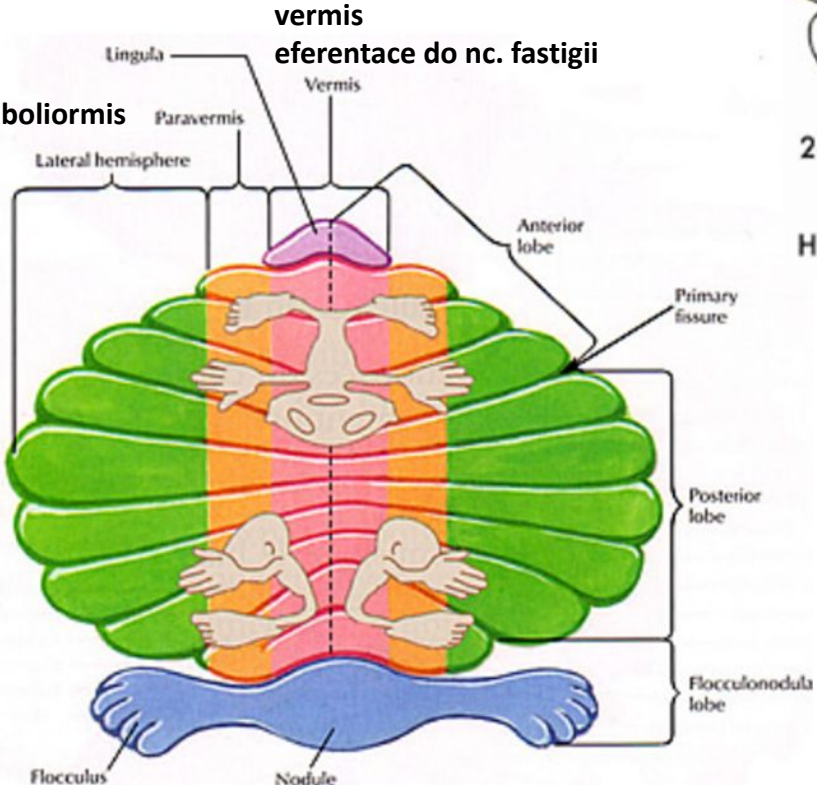
LOBES AND STRIPES

- in the vermis region – Roman numerals
- adjacent lobules in the hemispheres – H + numerals
- the division into three bands (zones) is based on the projections of Purkinje fibers from the cerebellar nuclei



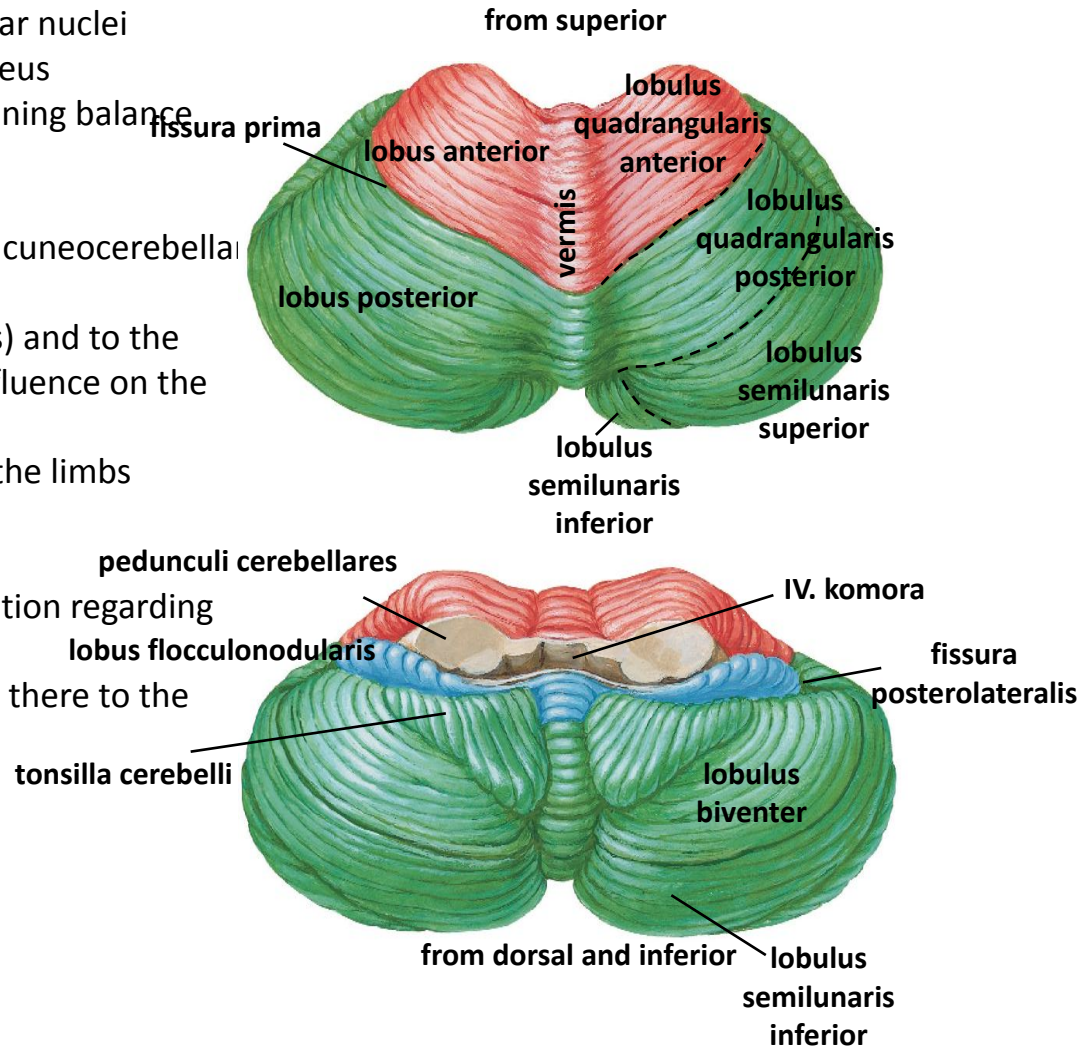
paravermis
eferentace do nc. globosi a emboliormis

laterální část hemisféry
eferentace do nc. dentatus



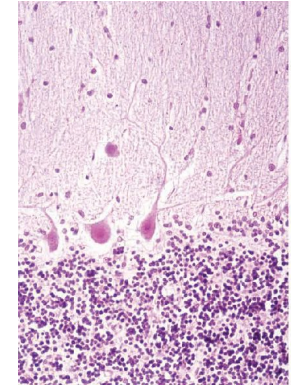
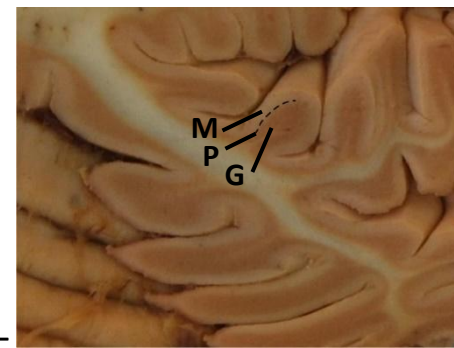
ANATOMICAL AND FUNCTIONAL DIVISIONS OF THE CEREBELLUM

- Three basic functional areas based on different afferent pathways and sensory modalities
- Functional cortical area + associated nucleus = cerebellar modulus
- Vestibular cerebellum
 - Lobulus flocculonodularis (Lobus X, HX)
 - developmentally oldest
 - afferents from the vestibular ganglia and vestibular nuclei
 - efferents to the fastigial nucleus and the red nucleus
 - muscle tone and coordination of muscles maintaining balance
- Spinal cerebellum
 - vermis and paravermian region
 - afferents from the spinocerebellar tracts and the cuneocerebellar tract (position and movement of the limbs)
 - efferents to the fastigial nucleus (from the vermis) and to the emboliform and globose nuclei (paravermis) – influence on the rubrospinal and reticulospinal tracts
 - control of the axial and proximal musculature of the limbs
- Pontine cerebellum
 - posterior lobe
 - afferents from the pontocerebellar tract (information regarding movement preparation)
 - efferent projections to the dentate nucleus (from there to the thalamus)
 - control of the distal muscles of the limbs

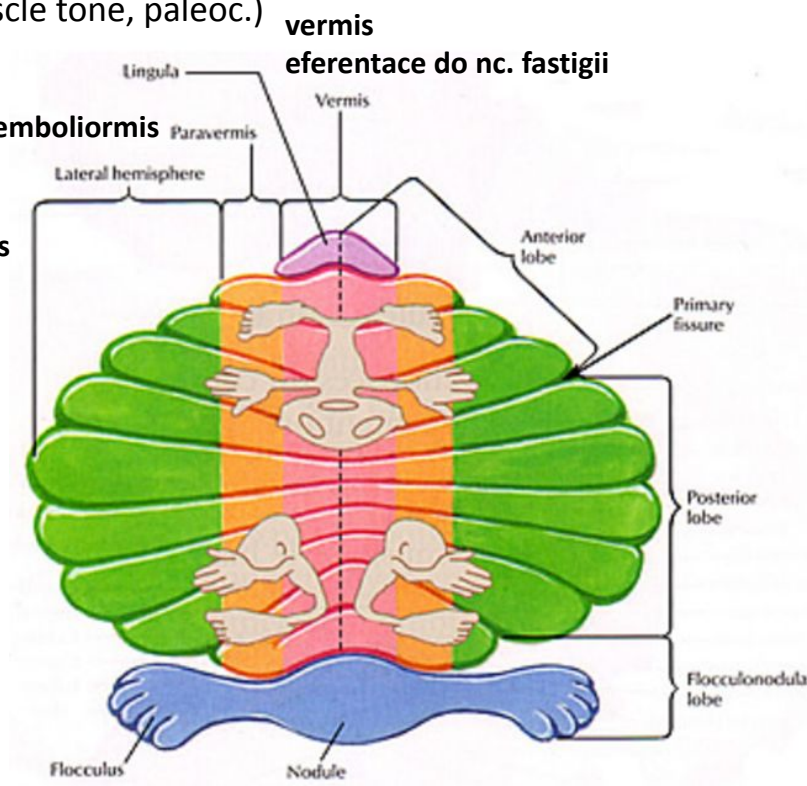
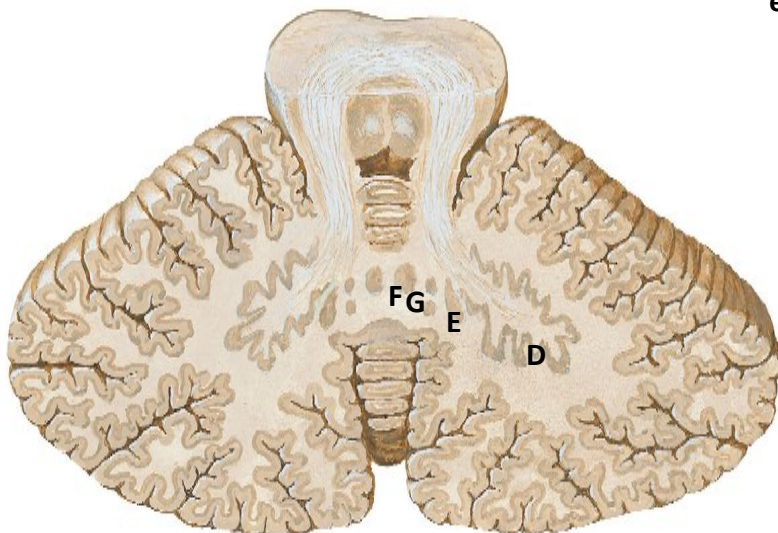


CEREBELLUM – INTERNAL STRUCTURE

- cortex cerebellaris
 - stratum moleculare (M)
 - stratum Purkynjense (P)
 - stratum granulare (G)
- A white substance extends into the meninges as the laminae albae
 - mostly myelinated fibers of the peduncles, terminating as CF & MF
 - climbing fibers
 - mossy fibers
 - axons of Purkinje cells
 - efferent fibers from the cerebellar nuclei
- nuclei cerebellares
 - nucleus dentatus (cerebrocerebellum/pontocerebellum, movement coordination, neoc.)
 - nucleus emboliformis, nucleus globosus (spinocerebellum, muscle tone, paleoc.)
 - nucleus fastigii (vestibulocerebellum, balance, archic.)

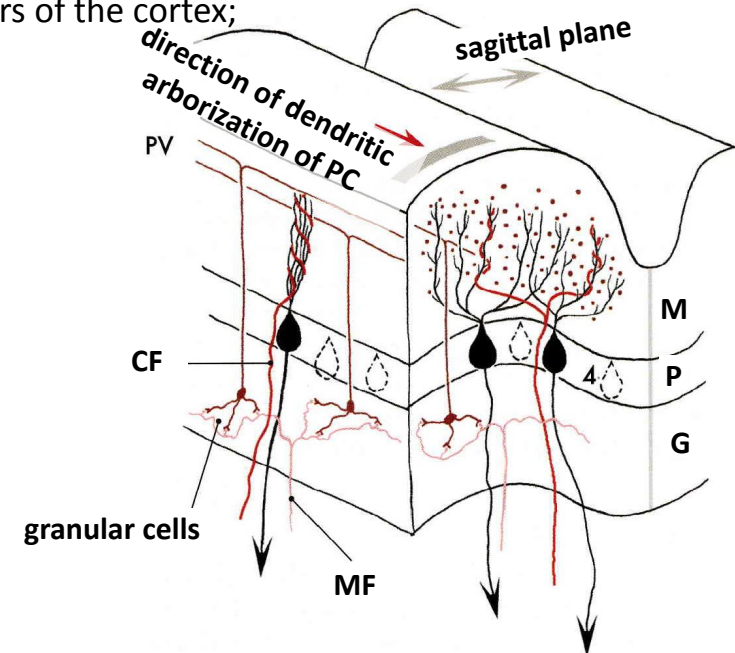
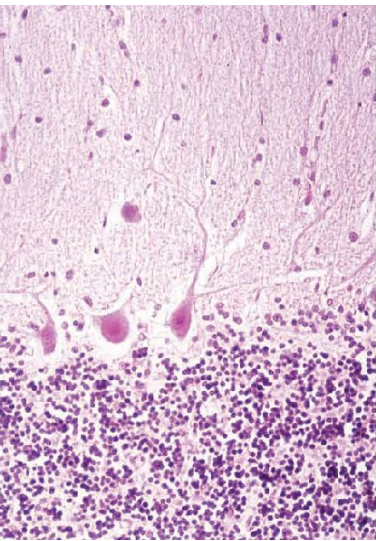
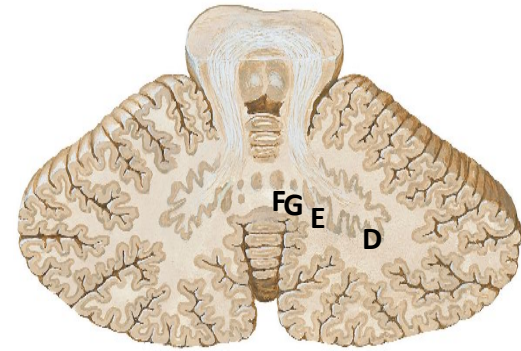


vermis
 eferentace do nc. fastigii
paravermis
 eferentace do nc. globosi a emboliormis
laterální část hemisféry
 eferentace do nc. dentatus

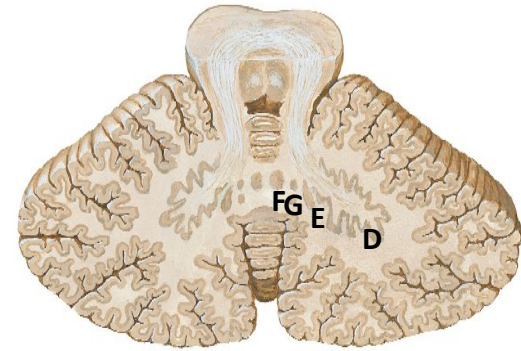


CEREBELLAR CORTEX

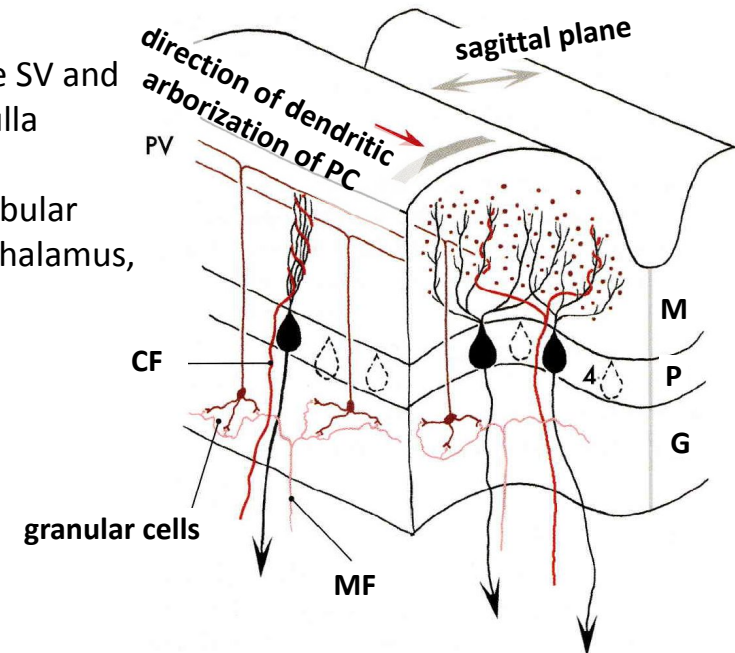
- stratum moleculare (M)
 - inhibitory interneurons of Purkinje cells – stellate cells, basket cells
 - climbing fibers – from the contralateral inferior olive
 - parallel fibers (axons of granular cells)
 - dendrites of Purkinje and Golgi cells
- Purkinje layer (P)
 - pear-shaped cell body with 2 to 3 main dendrites, dendritic arborization oriented sagittally
 - axons are the sole efferent of the cortex – to the cerebellar nuclei (excluding direct cerebellovestibular pathways)
- granular layer (G)
 - granular cells (the only excitatory cells of the cortex) activate Purkinje cells
 - axons divide in the molecular layer via T-shaped bifurcation into parallel fibers → among the arborizations of Purkinje cells (200,000 to 300,000 fibers per arborization, but a small number of synapses)
 - Golgi cells – inhibit the activity of granular cells; dendrites in all layers of the cortex; their activity is synchronized with Lugar cells



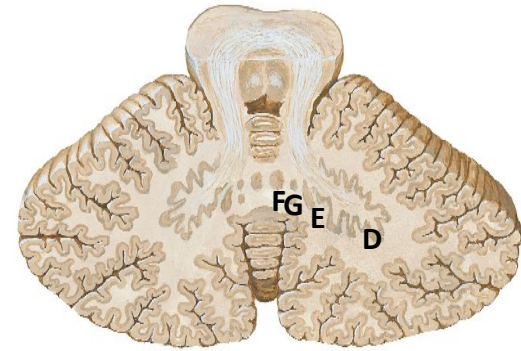
CEREBELLAR NUCLEI



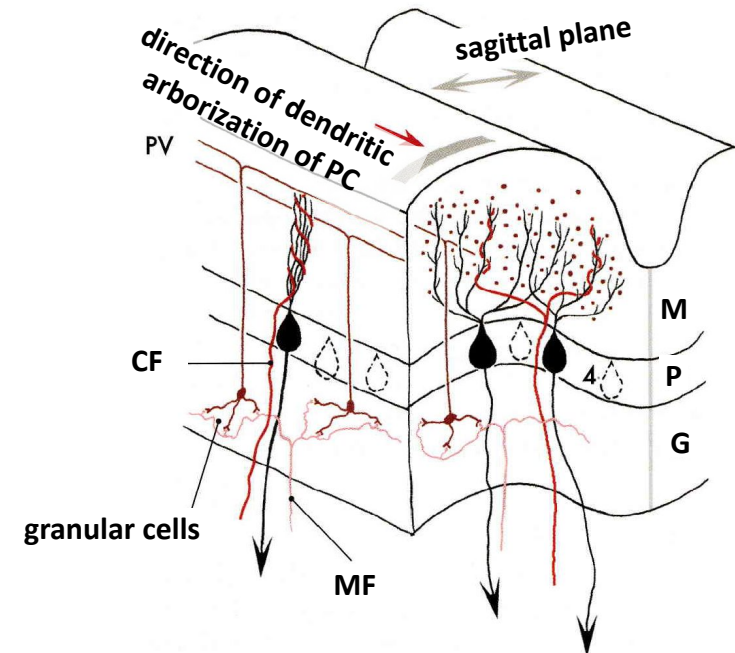
- nc. dentatus
 - axons from the neocortex and parts of the paleocortex (from the motor cortex)
 - efferent projections to the contralateral thalamus (ventrolateral nucleus) and to the red nucleus – muscle coordination, trajectory, force, and speed of movement
- nc. emboliformis a nc. globosus
 - axons from the paleocortex (muscles, joints, skin receptors)
 - efferents to the contralateral nc. ruber
- nucleus fastigii
 - axons from the archic. (head position and movements)
 - efferents to the vestibular nuclei
- relay station
 - cerebellar cortex → brainstem, thalamus
 - afferents from the cerebellar cortex (PB axons) and collaterals of the SV and MV, and fibers of monoaminergic systems (axons from the RF, medulla oblongata)
 - efferents (collectively cerebellofugal projections) influence the vestibular nuclei, olivary nuclei, RF, oculomotor nuclei, nc. ruber, and, via the thalamus, extensive cortical areas



CORTEX AFERENT FIBERS



- climbing fibers
 - axons of the contralateral inferior olive (olivocerebellar tract)
 - collaterals to the cerebellar nuclei
 - to Purkinje cells – 1 ascending fiber to 1 Purkinje cell (glutamate mediator → excitation of Purkinje cells)
 - ascending fiber activity suppresses the influence of mossy fibers
- mossy fibers
 - axons of spinal cord neurons, reticular formation, cranial nerve nuclei, ncll. pontis
 - in the cerebellum, they lose their myelin sheath, send collaterals to the cerebellar nuclei, and branch out in the granular layer
 - excitatory influence on granular cells
- (multilaminar fibers)
 - noradrenergic from the locus coeruleus
 - serotonergic from the raphe nuclei (RF)
- (other weaker systems)
 - dopaminergic (ventral tegmental area)
 - cholinergic (RF)
 - histaminergic (hypothalamus)



AFFERENT CONNECTIONS OF THE CEREBELLUM

- mossy fibers – signals from the vestibular system, proprioceptors, skin, and visual and auditory receptors; to the cerebellar cortex and nuclei
- cortico-ponto-cerebellar connections – information about cortical activities (movement preparation and execution), topographically organized
- ascending fibers – olivocerebellar connection – likely related to motor learning

- **tr. pontocerebellaris**
 - the most massive afferent system
 - through the brachia pontis to the cortex as mossy fibers
 - connects to the corticopontine tract
 - a) motor and premotor system to the anterior lobe
 - b) association and limbic systems to the posterior lobe
- **tr. vestibulocerebellaris**
 - position and movements of the head and body
- **tr. spinocerebellaris (anterior, posterior, rostralis), tr. cuneocerebellaris**
 - proprioception, cutaneous sensation from the lower limbs and lower half of the trunk, and from the upper limbs and upper half of the trunk
- **tr. nucleocerebellaris**
 - from the motor nuclei of the cranial nerves and from certain sensory nuclei (V., nucleus solitarius)

EFFERENT CONNECTIONS OF THE CEREBELLUM

Vermis	nc. fastigii
Paravermální oblast Paravermis	nc. emboliformis a nc. globosus
Laterální část hemisféry Lateral hemisphere	nc. dentatus

- axons of Purkinje cells from the cortex
 - corticonuclear projections
 - inhibitory and topographically organized
- from the nuclei
 - a) inhibitory to the inferior olive
 - b) excitatory to many brainstem and thalamic nuclei
- ncl. fastigii
 - to: vestibular nuclei, contralateral RF (pons, medulla oblongata), contralateral thalamus
 - vestibulospinal tract influences motor neurons of the extensors (neck and deep back muscles)
- ncl. emboliformis and ncl. globosus
 - to: ncl. ruber, contralateral thalamus, contralateral ncl. olivaris, and RF (pons)
 - through the superior cerebellar peduncle
 - rubrospinal tract, reticulospinal tract influence on motor neurons of proximal limb muscles
- dentate nucleus
 - through the superior cerebellar peduncle, crosses in the midbrain
 - to: mainly contralateral thalamus (cerebellothalamic tract); red nucleus, interstitial nucleus (Cajal), Dakschewitz, ncl. III., nc. olivaris, and RF (pons)
 - influences the primary motor area, memory, spatial vision, language mechanisms, attention, and emotional responses

CEREBELLAR PEDUNCLES AND THEIR FIBERS

Pedunculus cerebellaris inferior (corpus restiforme + corpus juxtarestiforme)

tr. spinocerebellaris dorsalis

tr. cuneocerebellaris

tr. reticulocerebellaris (z oblongátové retikulární formace)

tr. trigeminocerebellaris

Corpus juxtarestiforme

tr. vestibulocerebellaris

vlákna z nc. fastigii do vestibulárních jader a do retikulární formace

Pedunculus cerebellaris medius (brachia pontis)

tr. pontocerebellaris

tr. reticulocerebellaris (z pontinní retikulární formace)

Pedunculus cerebellaris superior (brachia conjunctiva)

tr. spinocerebellaris anterior

vlákna z locus coeruleus (noradrenergí)

hypothalamocerebellární vlákna

eferentní vlákna z mozečkových jader do retikulární formace, do nc. ruber a do thalamu

(Vlákna z rafeálních jader retikulární formace mířící do mozečku jsou obsažena ve všech pedunculi cerebellares.)

SUMMARY OF THE FUNCTIONS OF THE CEREBELLUM

- Two main afferents to the cortex
 - Climbing fibers – glutamate (excitatory), from the inferior olivary nucleus to the dendrites of Purkinje cells
 - Mossy fibers – GABA (inhibitory), axons of neurons in the spinal cord and brainstem to granular cells
 - information from the vestibular apparatus, proprioceptors, skin receptors, the visual pathway, the auditory pathway, the RF, and the cerebral cortex
- in the cerebellum
 - collaterals of the CF and MF to the nuclei
 - granular cells – glutamate (excitatory), the axon branches into parallel fibers that activate Purkinje cells, basket cells, stellate cells, and Golgi cells
- in the cerebellar cortex
 - Purkinje cells – GABA (inhibitory), single efferent → in the cortex, all excitatory influences are converted into inhibition

Vermis	nc. fastigii
Paravermální oblast Paravermis	nc. emboliformis a nc. globosus
Laterální část hemisféry Lateral hemisphere	nc. dentatus

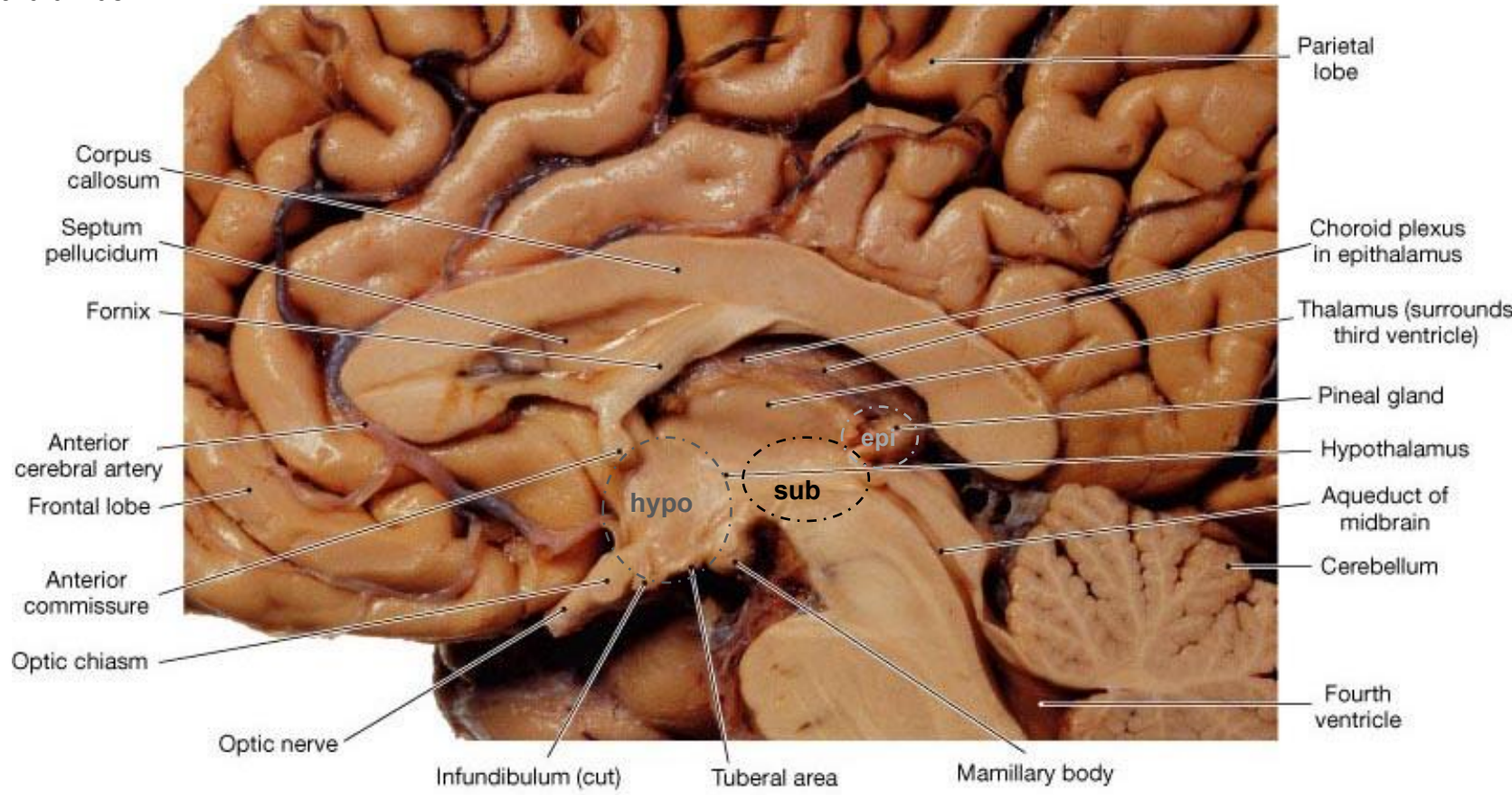
- efferents from the cortex and from the nuclei
 - a) from Purkinje cells – vestibular nuclei, cerebellar nuclei

ncl. fastigii	vestibular ncc. RF (pons a medulla obl.) (ipsi- i contralat.)
ncl. emboliformis ncl. globosus	ncl. ruber RF (pons) thalamus – contralat.
ncl. dentatus	excitatory– ncl. ruber, thalamus (contralat.) inhibitory – oliva inferior

- b) from the nuclei

DIENCEPHALON

- overlaid by the hemispheres of the telencephalon
- The third ventricle and the structures laterally adjacent to it
- The medial wall of the diencephalon is divided by a shallow groove—the hypothalamic sulcus (roughly a continuation of the sulcus limitans)—into a dorsal portion (thalamus) and a ventral portion (hypothalamus)
- dorsoventral division:
 - epithalamus
 - thalamus (dorsalis) – the largest in primates – and metathalamus
 - subthalamus (thalamus ventralis)
 - hypothalamus



(a) Midsagittal section

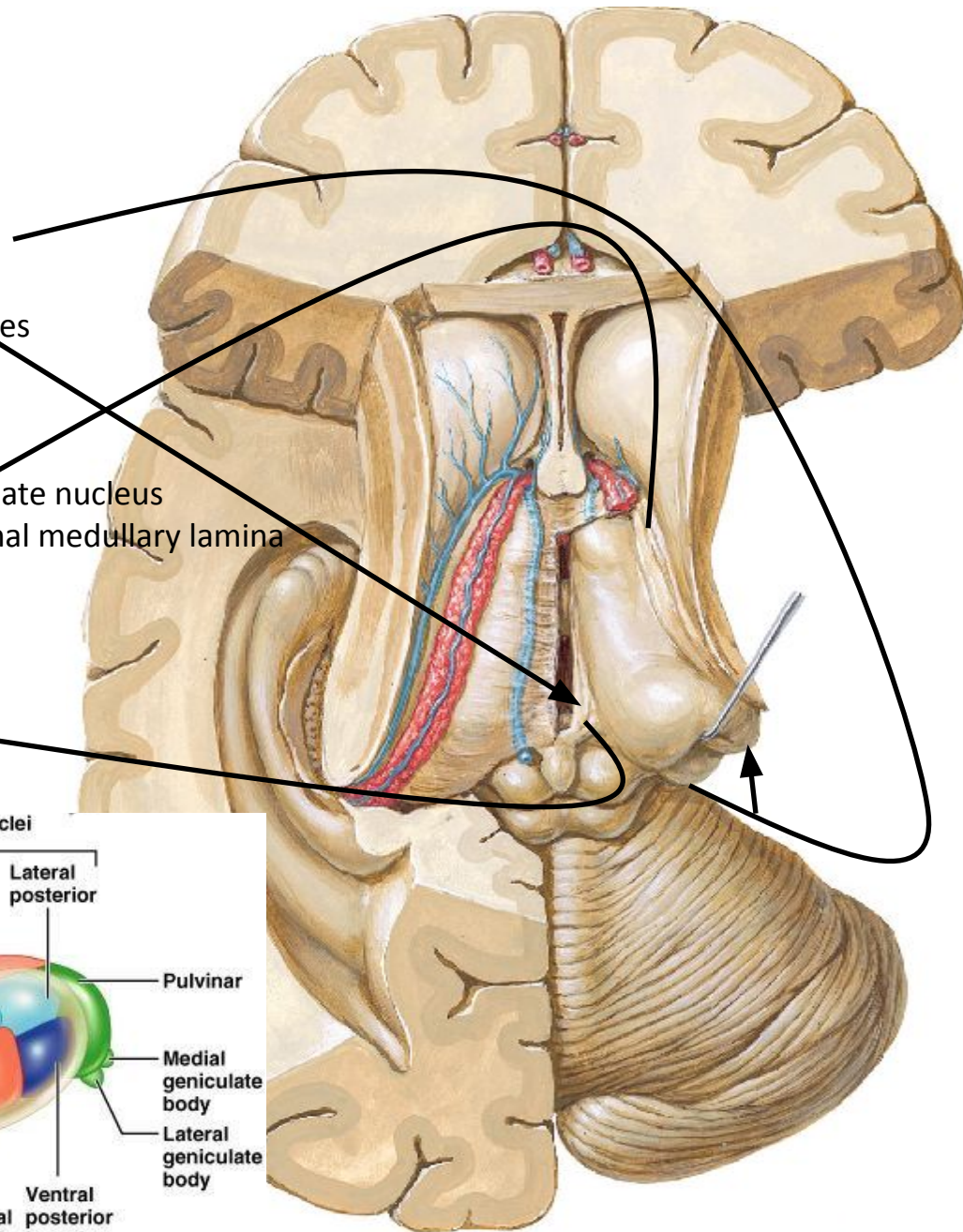
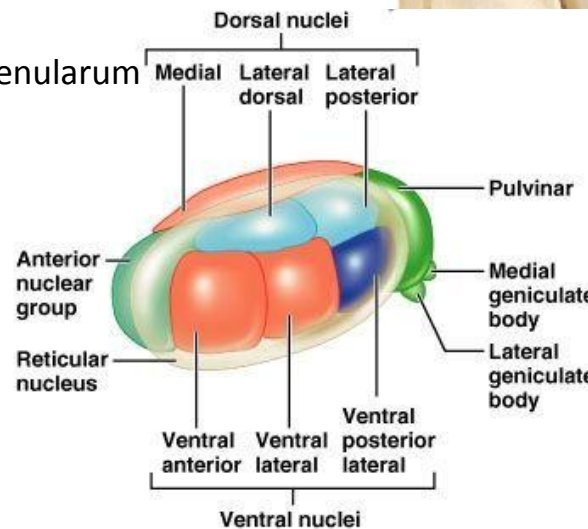
DIENCEPHALON

thalamus

- egg-shaped
- anterior tubercle
- thalamic pulvinar
- below are the medial and lateral geniculate bodies
- medullary stria
- fibers at the junction of the medial and dorsal surfaces
- interthalamic adhesion
- gray matter connecting the medial surfaces
- terminal stria
- bundle of fibers between the thalamus and the caudate nucleus
- divided by the course of the white matter of the internal medullary lamina

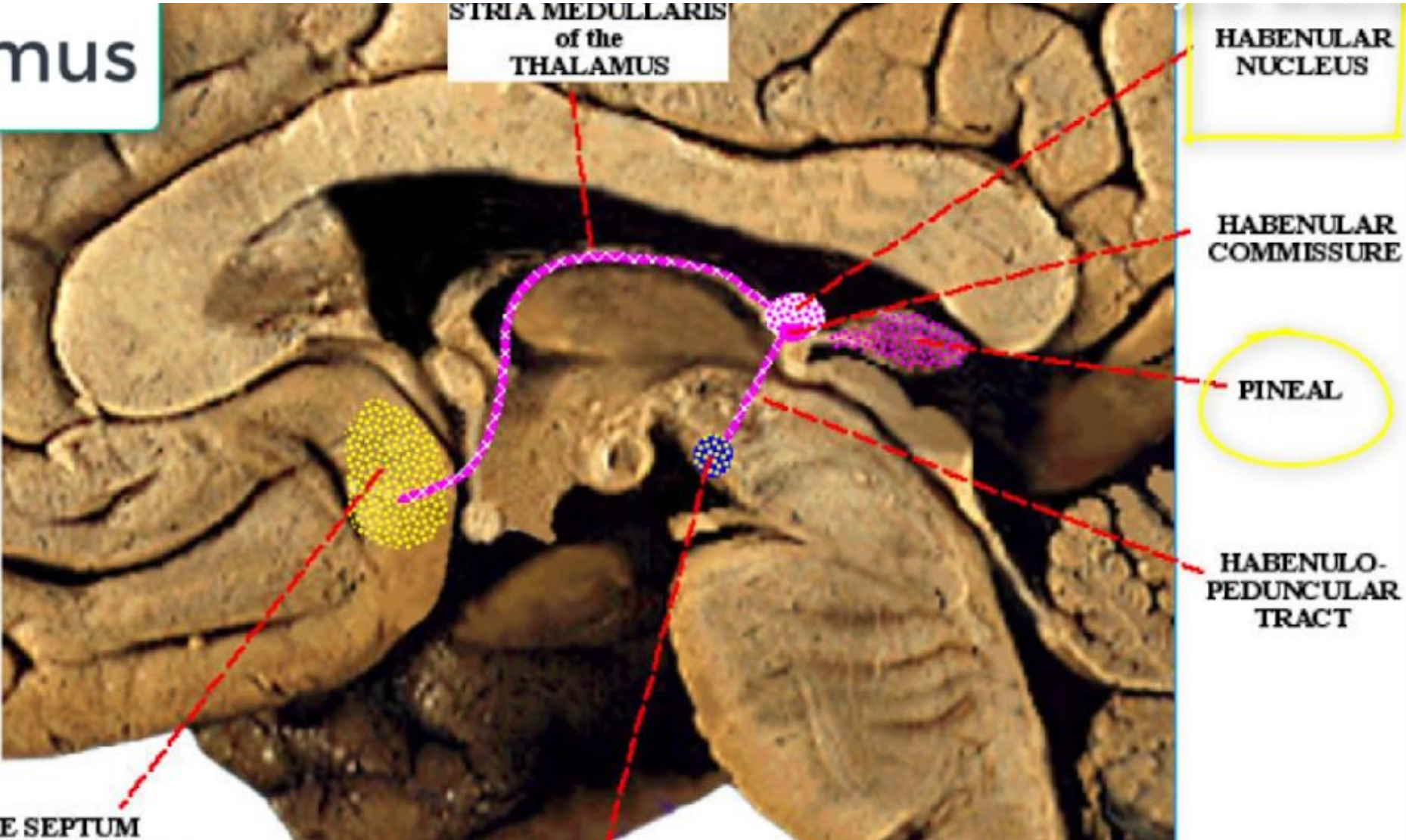
epithalamus

- on the dorsal surface of the thalamus
- below the trigonum habenulare, the habenular nuclei
- commissura habenularum with the pineal body
- commissura posterior
- just below the commissura habenularum



EPITHALAMUS

Thalamus



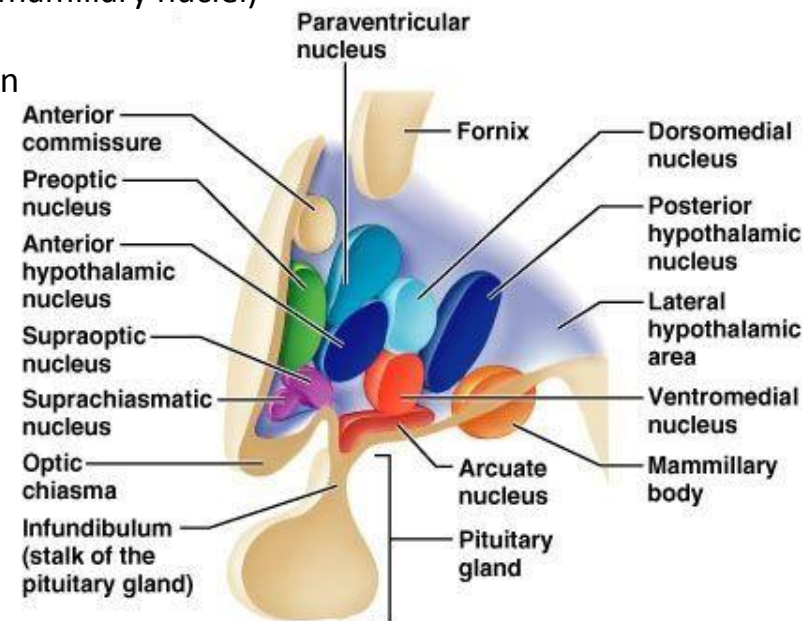
DIENCEPHALON

subthalamus

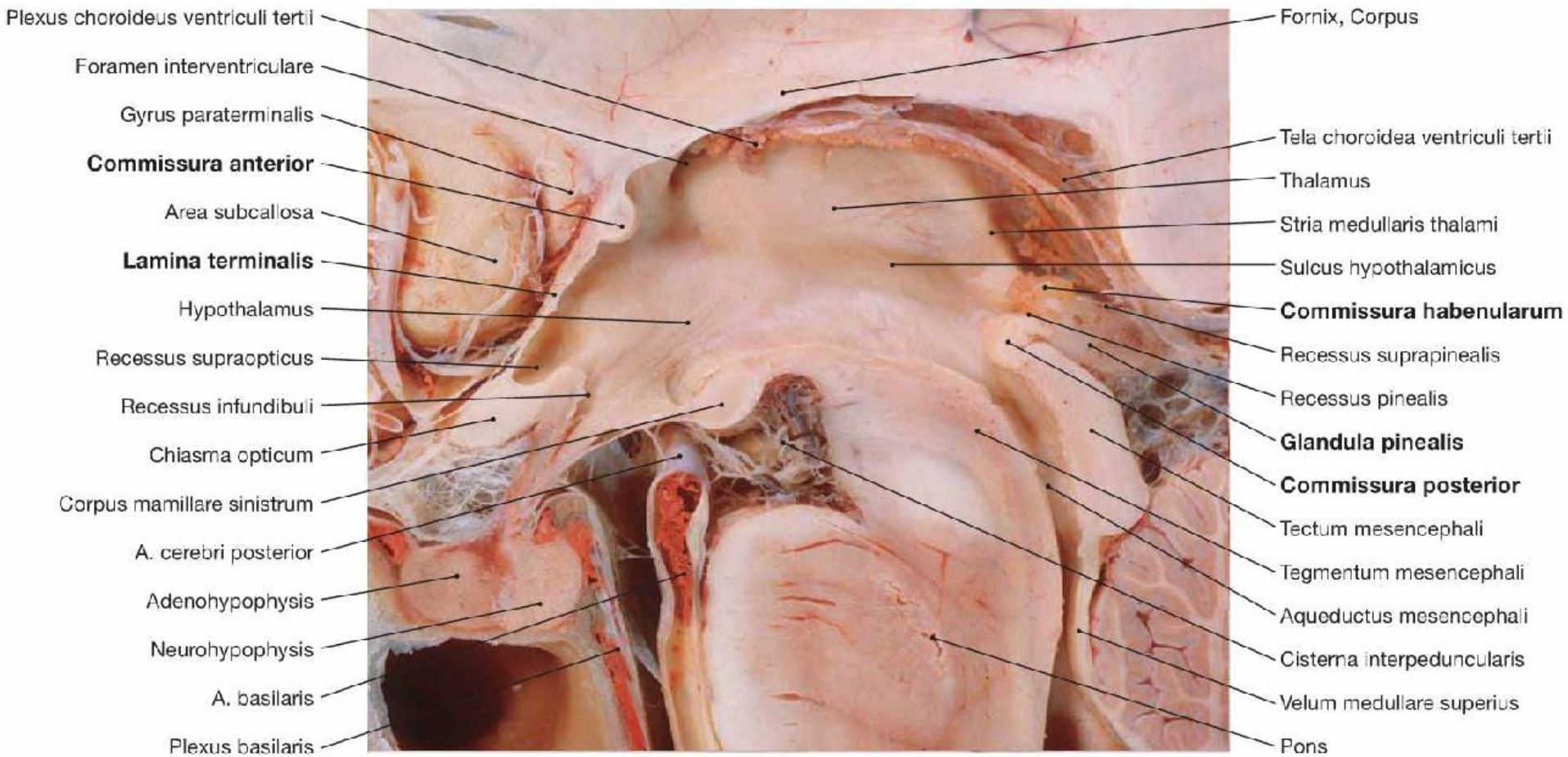
- subthalamic nucleus and zona incerta
- ventrally to the thalamus and laterally to the hypothalamus
- the thalamic nucleus of the reticular nucleus is in contact with the internal capsule; basally, this nucleus transitions into the zona incerta

hypothalamus

- rostral to the lamina terminalis, caudal to the corpora mammillaria, medial to the third ventricle, opposite the thalamus is the sulcus hypothalamicus, at the base is the infundibulum
- divided by the fornix
- medial
 - anterior – level of the optic chiasm (medial preoptic area, paraventricular nucleus, supraoptic nucleus, suprachiasmatic nucleus)
 - middle – level of the tuber cinereum (ventromedial and dorsomedial hypothalamic nuclei, tuberal nuclei, infundibular nucleus)
 - posterior – level of the corpora mamillaria (medial and lateral mamillary nuclei)
- lateral
 - diffusely distributed neurons, with bundles of fibers in between
 - lateral preoptic area, lateral hypothalamic area

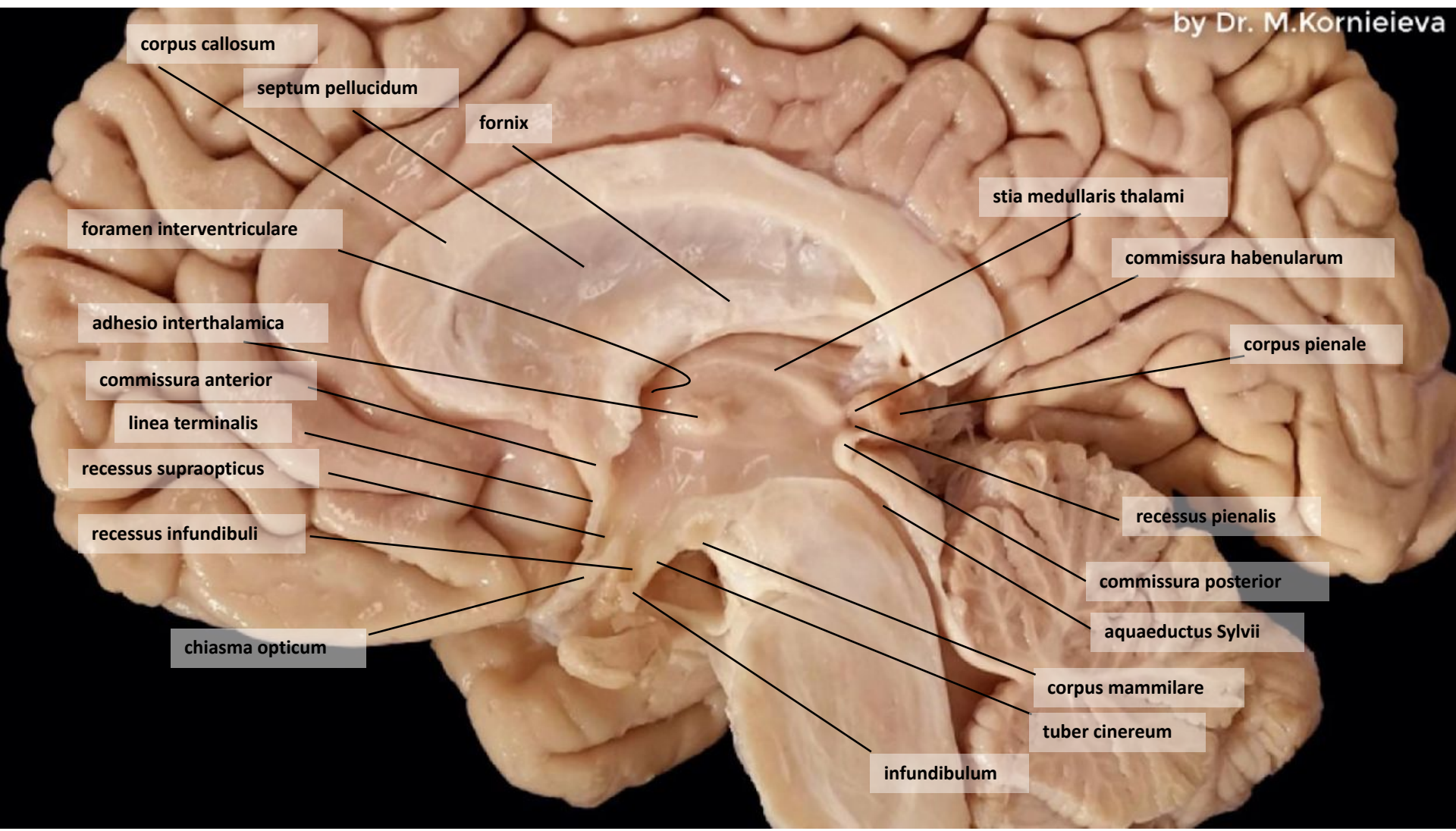


DIENCEPHALON



DIENCEPHALON

by Dr. M.Kornieieva



corpus callosum

septum pellucidum

fornix

foramen interventriculare

stia medullaris thalami

commissura habenularum

adhesio interthalamica

corpus pienale

commissura anterior

linea terminalis

recessus supraopticus

recessus pienalis

recessus infundibuli

commissura posterior

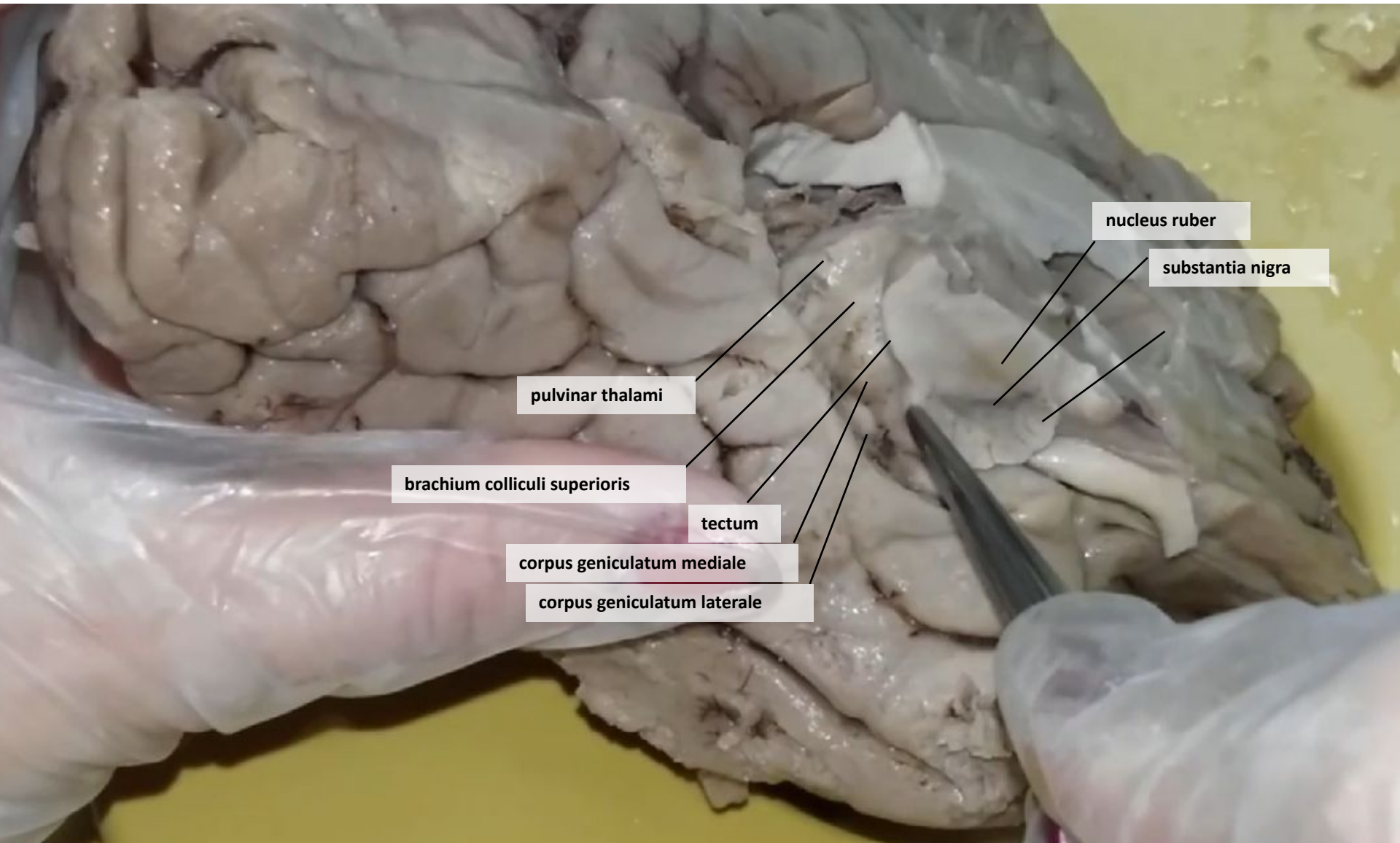
chiasma opticum

aquaeductus Sylvii

corpus mammilare

tuber cinereum

infundibulum



nucleus ruber

substantia nigra

pulvinar thalami

brachium colliculi superioris

tectum

corpus geniculatum mediale

corpus geniculatum laterale

THALAMUS

- neurons
 - projection neurons – axons pass through the reticular nucleus (collaterals) and terminate in the cerebral cortex/striatum; neurotransmitter – glutamate (excitatory)
 - inhibitory interneurons – unmyelinated axons, neurotransmitter – GABA (inhibit excitatory and projection neurons)
 - neurons of the reticular nucleus of the thalamus – axons project back to the thalamus, neurotransmitter – GABA (inhibitory)
- nuclei
 - a group of neurons under the influence of the same afferents, projecting to a single area of the cortex (reciprocally—to the area from which they received a projection) or the telencephalon
 - afferents from the spinal cord, brainstem, cerebellum, basal ganglia, and cerebral cortex
 - Textbooks describe a simpler classification of nuclei (Michigan classification, generally for primates)
 - The lamina medullaris interna divides the thalamus into anterior, medial, and lateral groups of nuclei; it contains the intralaminar nuclei
 - The reticular nuclei envelop the lateral surface of the nuclei like a shell; they are separated from the thalamus by nerve fibers of the lamina medullaris externa
- function
 - anterior nuclei – part of the limbic system, memory functions
 - ncl. medialis dorsalis – together with the prefrontal cortex, generates emotional responses and regulates cognitive functions and memory components
 - ncll. intralaminares – ascending reticular activating system
 - ncll. mediani – limbic system, connection between the prefrontal cortex and the hippocampus
 - anterior and lateral ventral nuclei – part of the basal ganglia circuit, motor nuclei of the thalamus
 - intermediate ventral nucleus – responds to proprioceptive stimulation (joint movement, muscle contraction)
 - ncl. ventralis medialis – transmits signals of pain, heat, and cold, as well as homeostatic information (pH changes, hypoxia, local metabolism, immune and hormonal activities) to the insula
 - ncl. ventralis posterolateralis – proprioception and cutaneous sensation to primary (3, 1, 2) and secondary sensory areas
 - ncl. ventralis posteromedialis – from the innervation area of the V. nerve to the postcentral gyrus in the parietal lobe
 - lateral nuclei – most connections (both afferent and efferent) are cortical
 - posterior nuclei – extensive reciprocal connections with association cortical areas, integration of somatosensory, visual, and auditory signals
 - ncl. reticularis – inhibitory projections back to the thalamus, under the excitatory influence of thalamocortical and corticothalamic projections

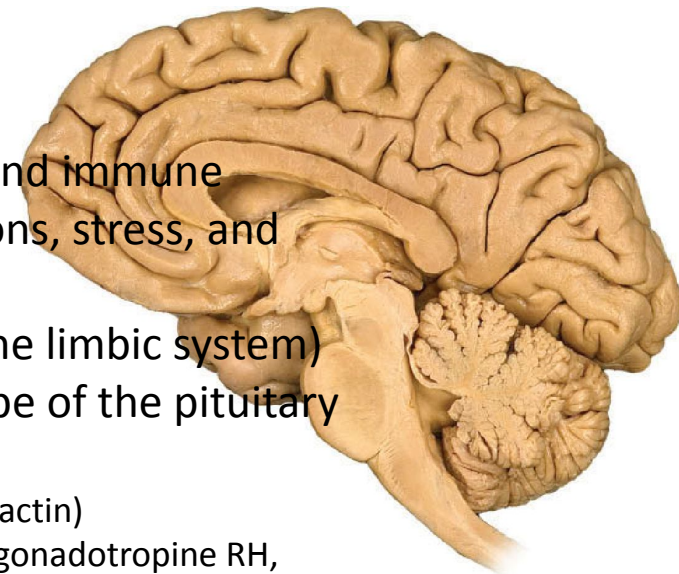
FUNCTIONAL ORGANIZATION OF THE THALAMUS

- integration and transmission of signals from the spinal cord, brainstem, cerebellum, and basal ganglia to the cerebral cortex and striatum
 - this transmission is significantly influenced by feedback from the cerebral cortex (corticothalamic projection)
- nonspecific nuclei (IL, M)
 - modulate the excitability of extensive cortical areas → prepare the cortex to receive and analyze signals from specific thalamic nuclei
 - part of the ascending reticular activating system
- specific special sensory nuclei (CGM, CGL)
 - transmission of auditory (CGM) and visual information to the cortex (CGL)
- specific sensory nuclei (VPL, VPM)
 - somatosensory input from the trunk (VPL), from the head, and taste perception (VPM)
- specific motor nuclei (VA, VL)
 - involvement in motor circuits of the cerebellum (VL), cerebral cortex (VA), and basal ncc.
 - movement planning (VA)
- association nuclei
 - integration of visual, auditory, tactile, and proprioceptive stimuli (P)
 - involvement in the limbic system – amplification of emotions through repeated looping (A)
 - integration of thought, judgment, mood, and state of mind with sensory stimuli (M, MD)

IL, M activation system ARAS
CGM hear them auditory sensory afferents
CGL visuel visual sensory afferents
VPM trigem sensory afferents form the head
VPL body tell sensory input from the body
VA basal ganglia motor circuit of the basal ganglia
VL cerebell cerebellar motor circuit
P sensory with postury integration of sensory and postural stimuli
A hysteria amplification of emotions
A, M limbic system circuits of the limbic system and regulation of cognitive functions

HYPOTHALAMUS

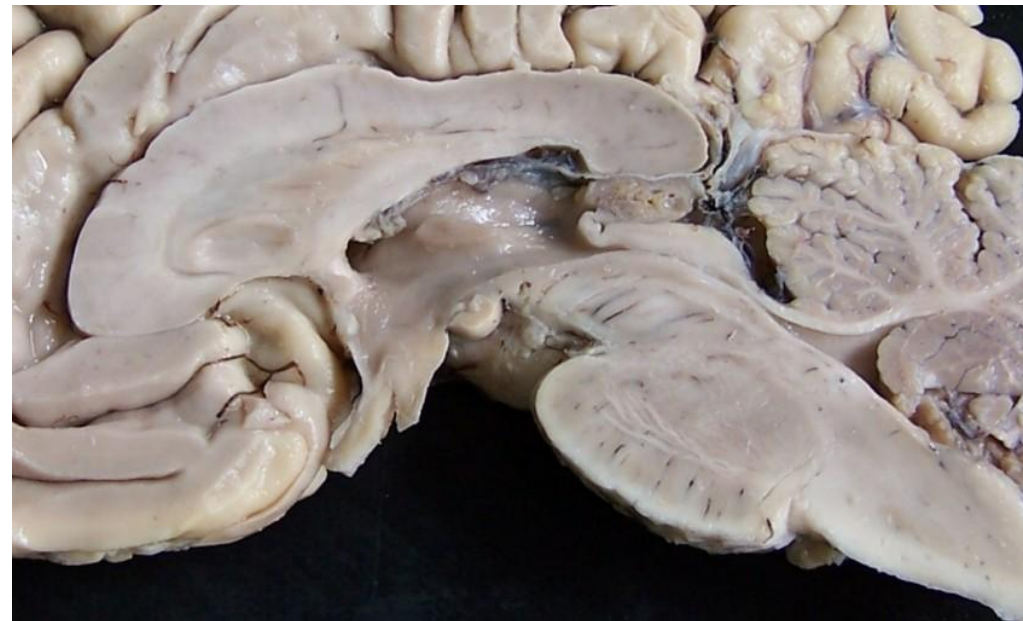
- part of the diencephalon
- a central hub for information from the nervous, humoral, and immune systems regarding the body's internal environment, emotions, stress, and olfactory and pain sensations
- the highest center of the ANS (significantly influenced by the limbic system)
- regulates secretion from the adenohypophysis (anterior lobe of the pituitary gland)
 - inhibitory factors (**statins**) – somatostatin (-GH, -TSH), dopamin (-prolactin)
 - releasing factors (**liberins**) – growth hormone RH, corticotropine RH, gonadotropine RH, thyrotropin RH (+TSH, +prolactin)
- produces neurohypophyseal hormones (neurosecretion)
 - oxytocin
 - vasopresin (antidiuretic hormon)



Tortora et Nielsen 2017 Principles of human anatomy



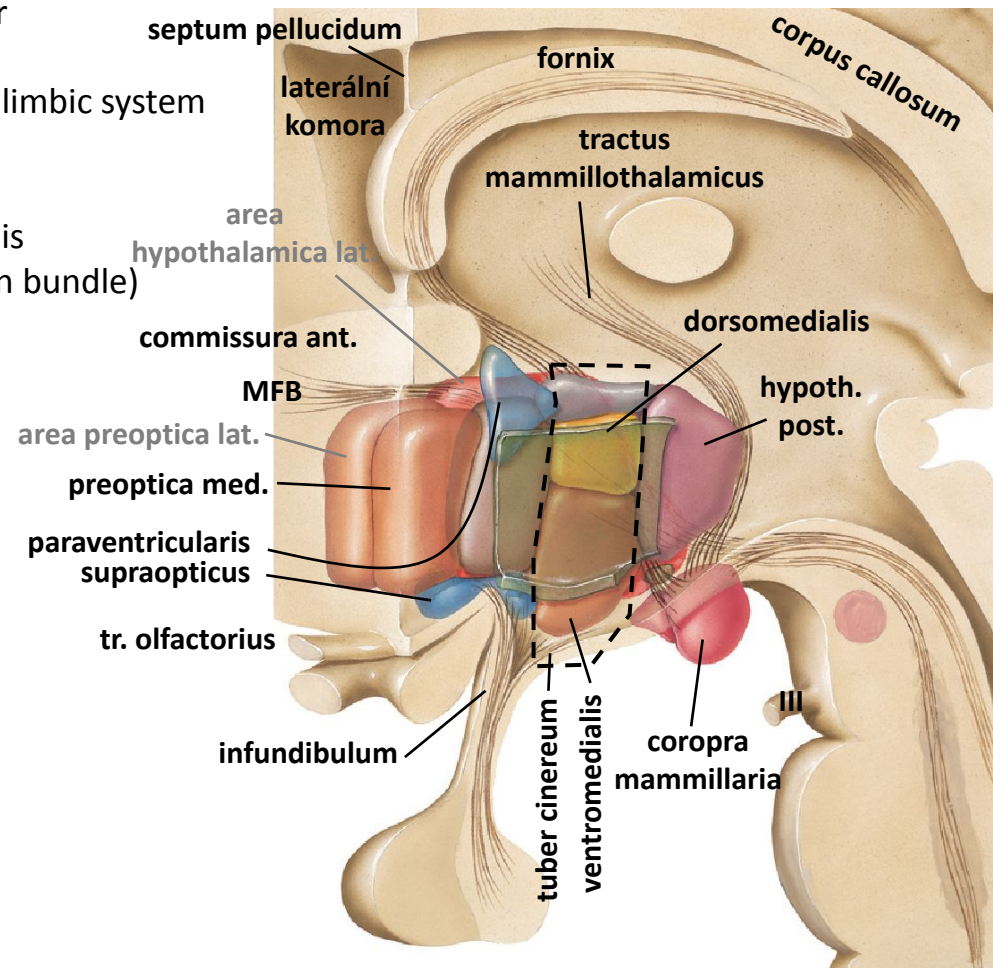
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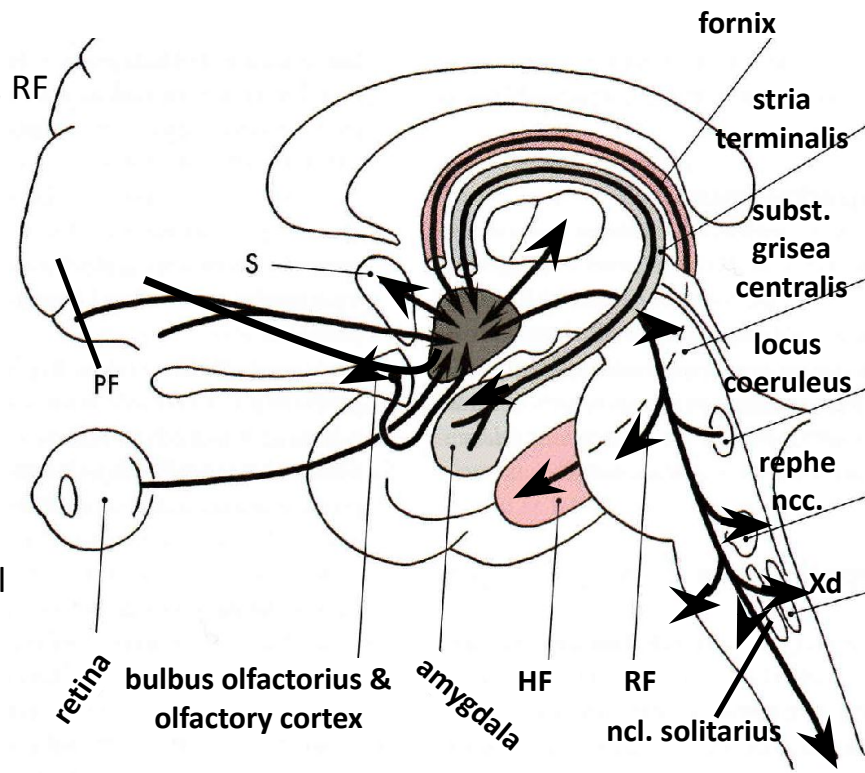
HYPOTHALAMUS

- a neuronal continuum whose cellular clusters are referred to as hypothalamic nuclei; medial and lateral hypothalamus
- anterior hypothalamus
 - medial preoptic area – regulation of temperature, sleep, sexual behavior, control of sex hormone production
 - paraventricular nucleus and supraoptic nucleus – neurosecretory hormones producing oxytocin and vasopressin (antidiuretic hormone); to the neurohypophysis via the hypothalamohypophyseal tract (neurosecretion)
 - suprachiasmatic nucleus – afferent branch from the optic tract; pacemaker of circadian rhythms
- middle hypothalamus
 - ventromedial and dorsomedial hypothalamic nuclei, tuberal nuclei, infundibular nucleus
 - influences metabolic functions and sexual behavior
- posterior hypothalamus
 - ncc. mammillares – memory functions; part of the limbic system
 - nc. hypothalamicus posterior
- lateral hypothalamus
 - area preoptica lateralis, area hypothalamica lateralis
 - fasciulus telencephalicus medialis (medial forebrain bundle)
- most nuclei have homeostatic functions
- ncl. mammillares part of the Papez circuit
 - memory functions



ROLE OF THE HYPOTHALAMUS

- fornix – hippocampal formation → mammillary body
- stria terminalis – amygdala → medial hypothalamic region
- medial telencephalic fasciculus (MFB) – olfactory cortex and septum → mesencephalon
- stria medullaris – hypothalamus, olfactory cortex, and septum → habenular nuclei
- fasciculus mammillaris princeps – corpus mammillare → a) anterior thalamic nuclei, b) RF (pons – ventral tegmental nucleus [Guddeni])
- fasciculus longitudinalis dorsalis – medial hypothalamus → spinal cord
- afferent connections
 - cortico-, septo- (MFB), amygdalo- (stria terminalis), retino-, and reticulohypothalamic (MFB) tracts
 - signals from nearly all receptors, solitary nucleus → taste and GIT, prefrontal cortex, hippocampal formations
- efferent pathways
 - hypothalamocortical, septal, amygdalar, thalamic, reticular, and spinal tracts
 - hypothalamohypophyseal tract
 - mostly reciprocal; hypothalamic, prefrontal, cingulate gyrus, RF → nuclei of the cranial parasympathetic system and spinal sympathetic and parasympathetic systems
- přední jádra – parasympatikus, střední jádra – sympatikus, zadní jádra – limbický systém
 - anterior nuclei – parasympathetic system, middle nuclei – sympathetic system, posterior nuclei – limbic system
- functional centers – later research has shown that individual functions are localized within neural networks (neurons in several nuclei)
 - pacemaker of circadian rhythms
 - lesions – sleep disorders, obesity, sexual dysfunction, genital hypoplasia, thermoregulatory disorders

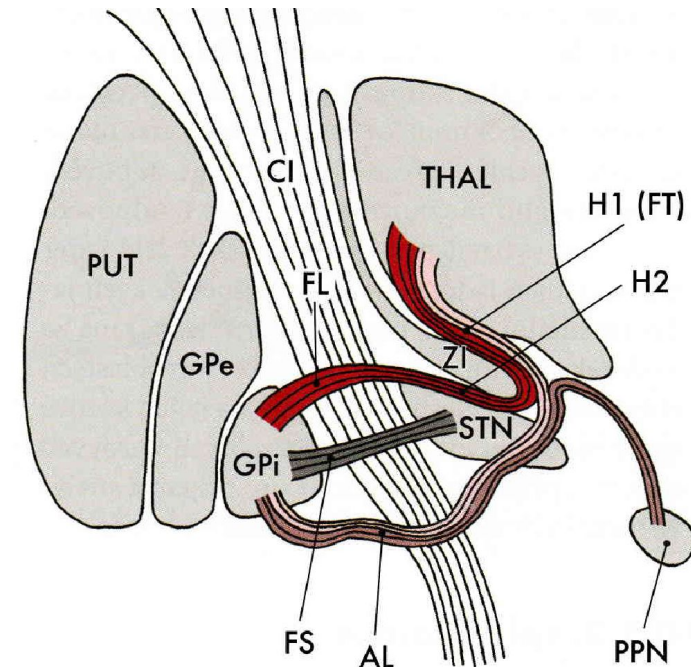


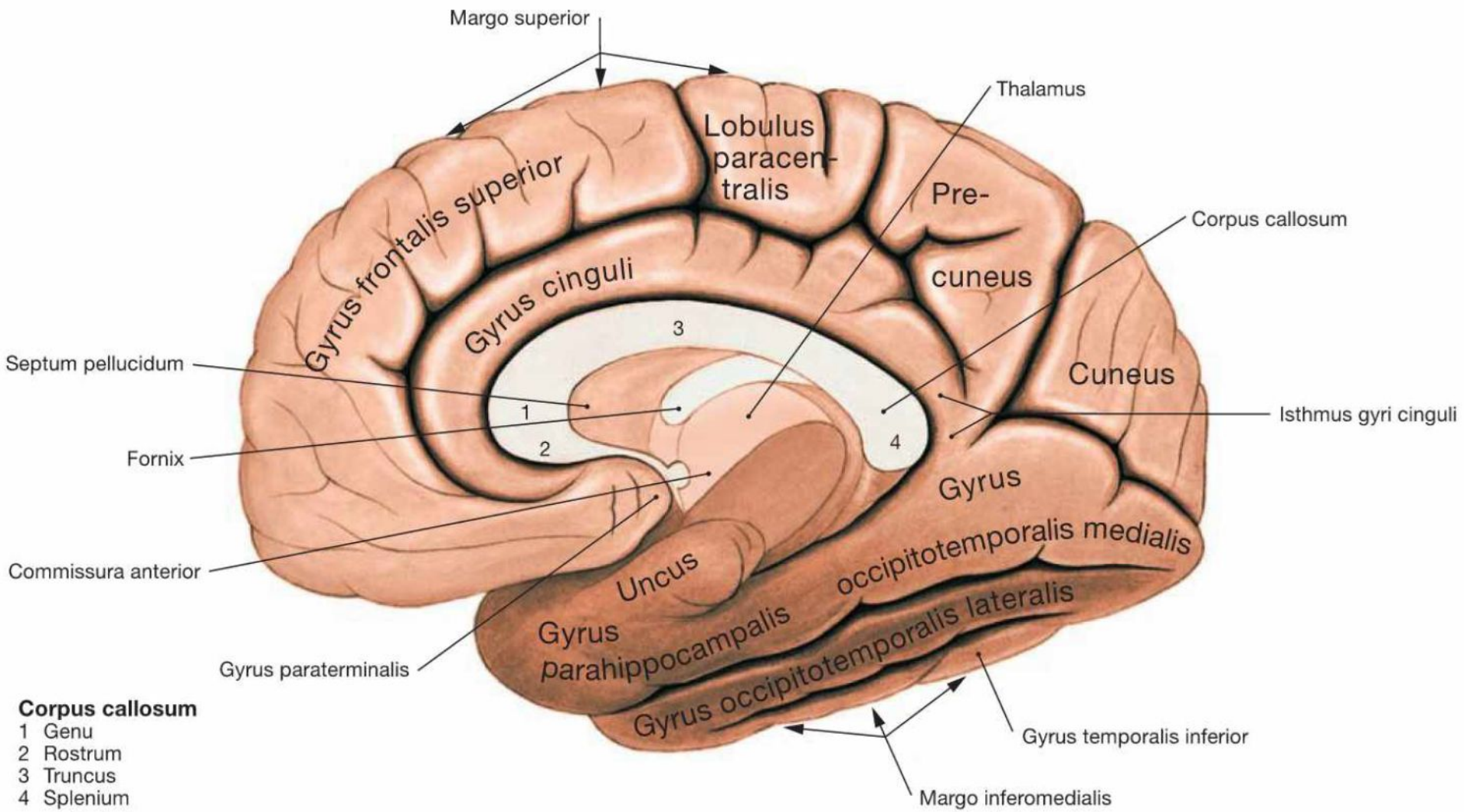
EPITHALAMUS

- habenular nuclei
 - located beneath the surface of the trigonum habenulare, connected by the commissura habenularum
 - stria medullaris thalami – afferent projections from the septum verum, olfactory cortical areas, hippocampal formations, hypothalamus, and basal ganglia (internal pallidum); efferent projections – tr. habenulointerpeduncularis
 - part of the limbic system
- corpus pineale
 - pinealocytes produce serotonin, which is metabolized into melatonin (affects sleep and sexual behavior)
 - affects the activity of the pituitary gland and other endocrine glands (primarily inhibitory) – suppresses gonadal development and sexual activity
- posterior commissure
 - Cajal, Darkschewitz, pretectal nuclei, habenulotectal fibers

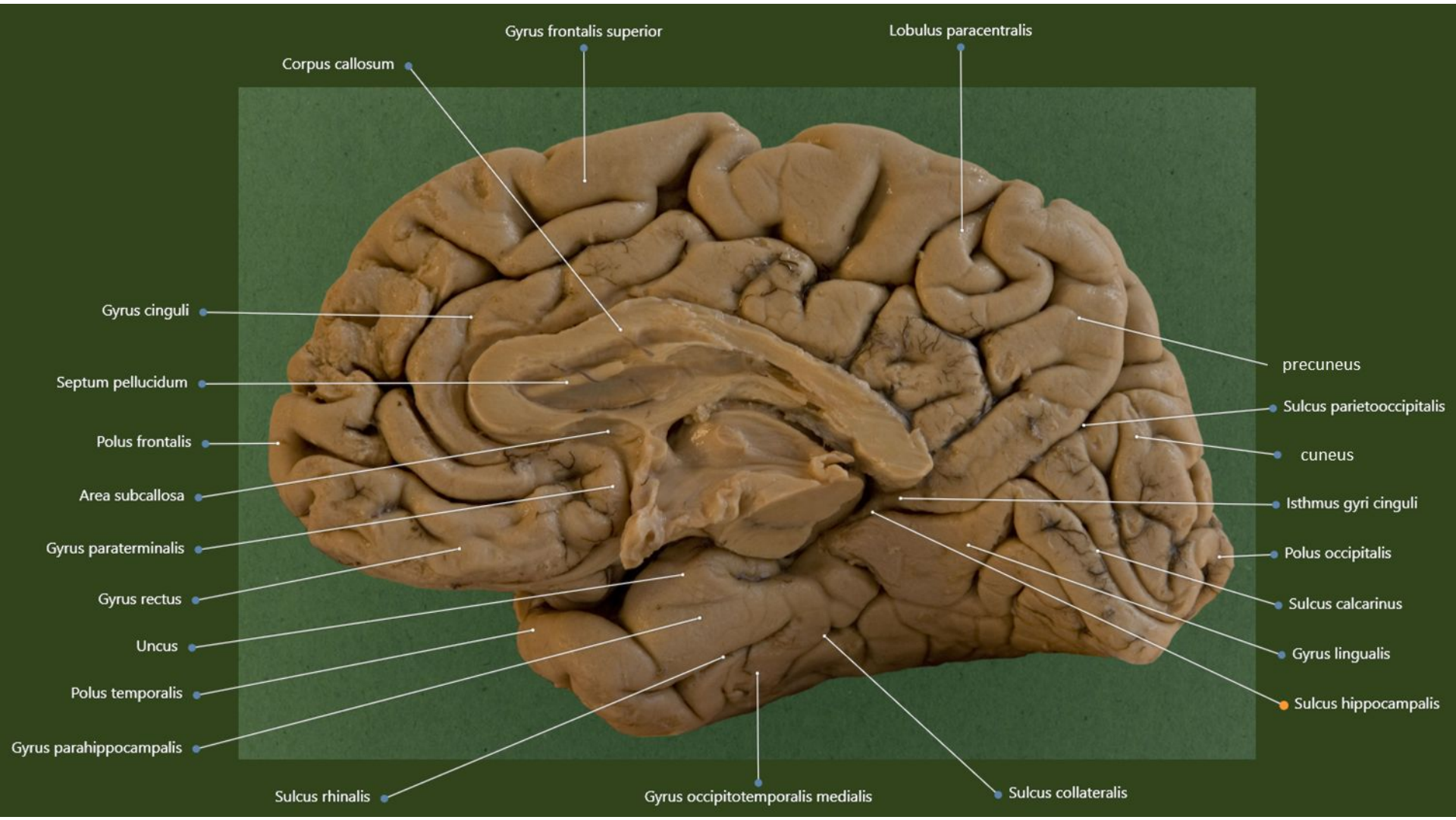
SUBTHALAMUS

- subthalamic nucleus (STN)
 - functionally part of the basal ganglia
 - primarily projection neurons (excitatory)
 - Afferents – cerebral cortex, external pallidum (GPe) (subthalamic fasciculus, FS), thalamus, brainstem
 - Efferents – to the external and internal pallidum, then to the substantia nigra, striatum, and pedunculopontine nucleus (PPN)
 - part of the hyperdirect and indirect pathways of the basal ganglia circuit
 - lesion – hemiballism (sudden and uncontrollable movements of contralateral limbs)
- zona incerta (ZI)
 - transitions into the reticular nucleus of the thalamus; separated from the thalamus by the thalamic fasciculus (FT), and from the subthalamic nucleus by the lenticular fasciculus (FL)
 - afferents – brainstem, thalamus, cerebral cortex (frontal lobe)
 - efferent projections – extensive; descending reciprocally to the brainstem, ascending to the hypothalamus, thalamus, and cortex



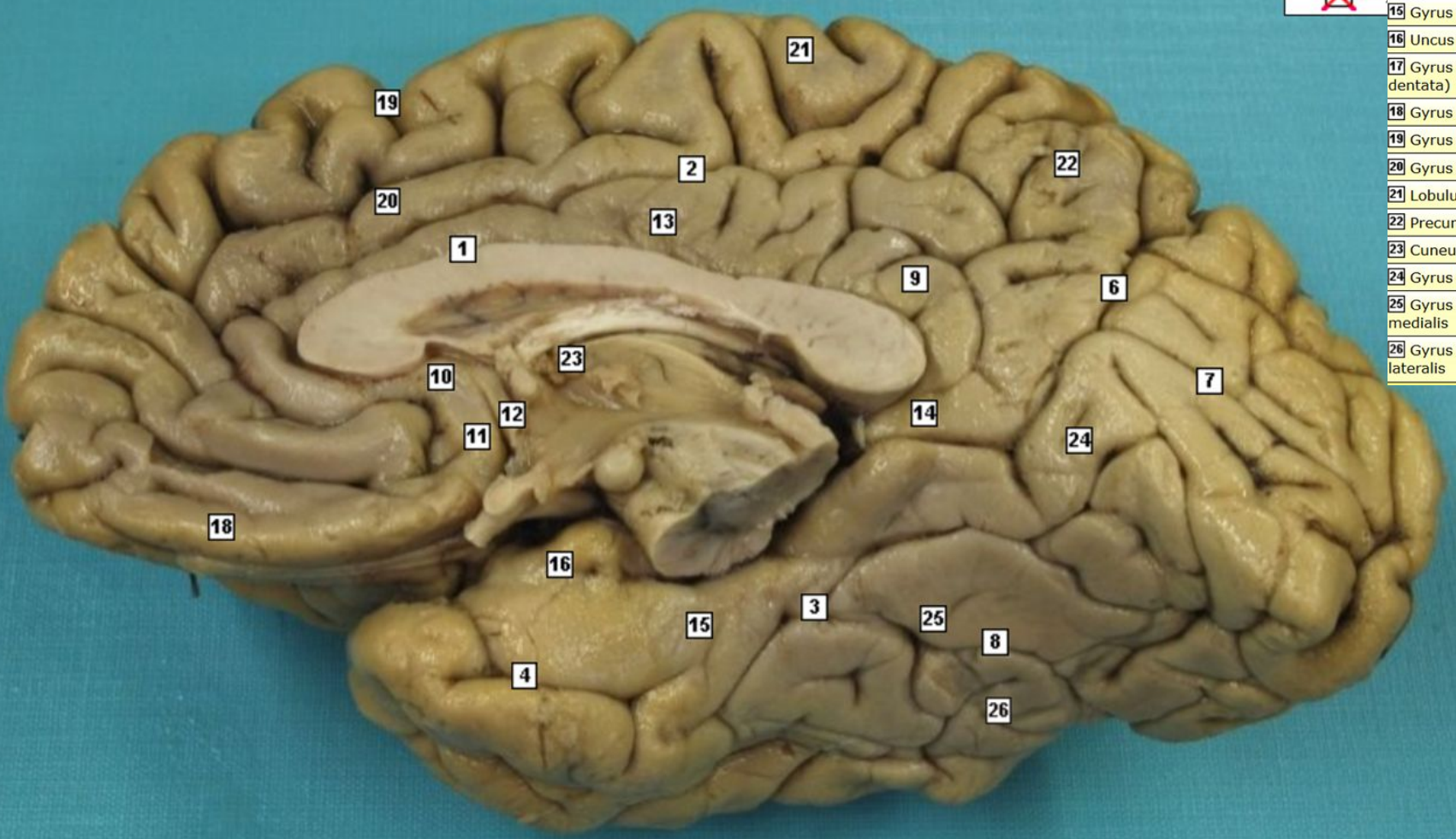


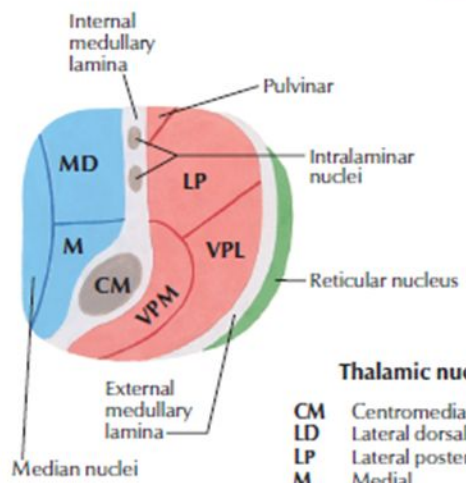
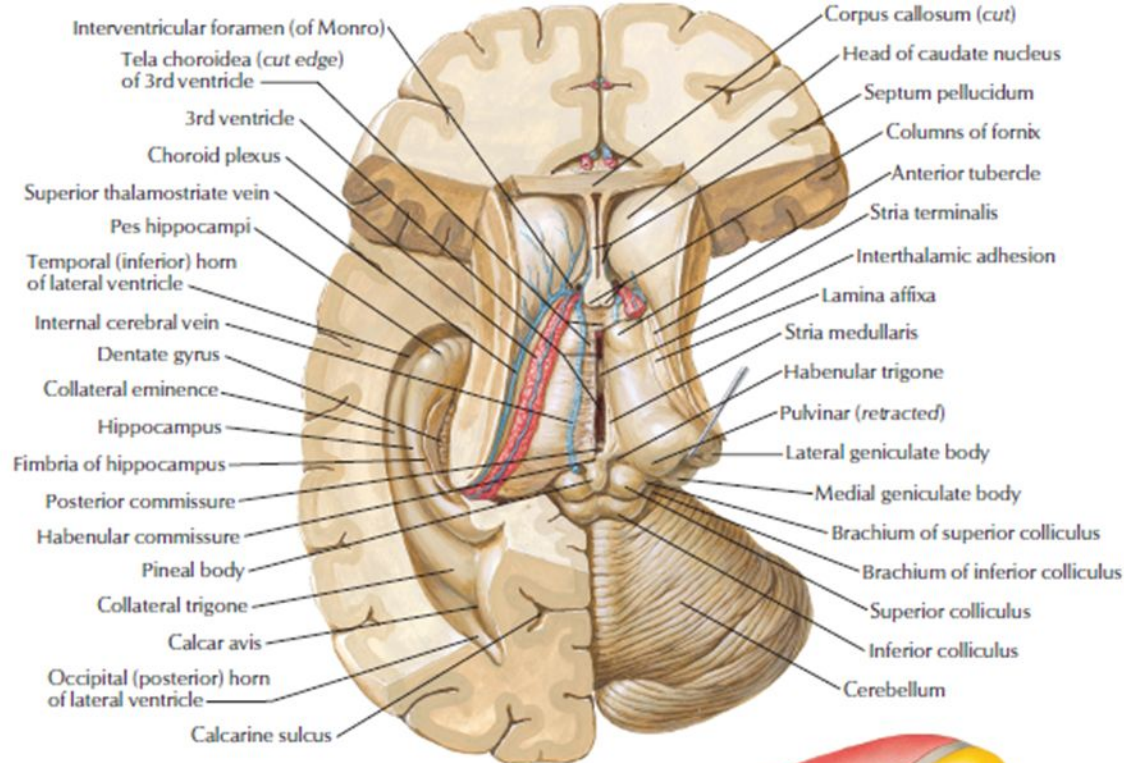
- Corpus callosum**
 1 Genu
 2 Rostrum
 3 Truncus
 4 Splenium



- 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

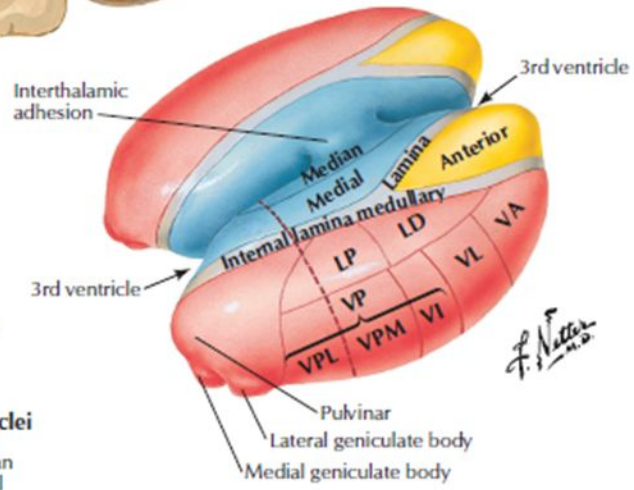
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Schematic section through thalamus
(at level of broken line shown in figure at right)

- 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