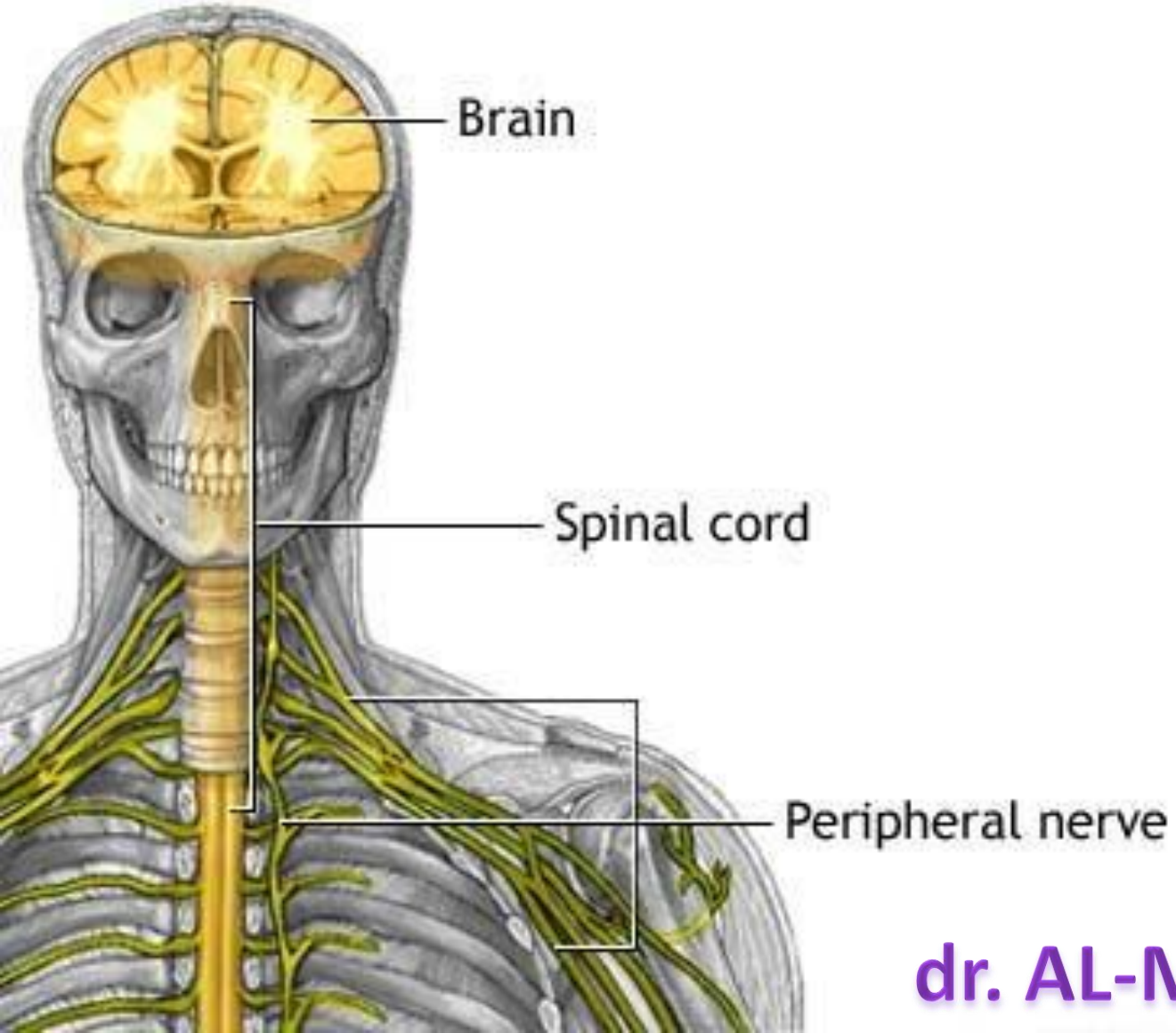
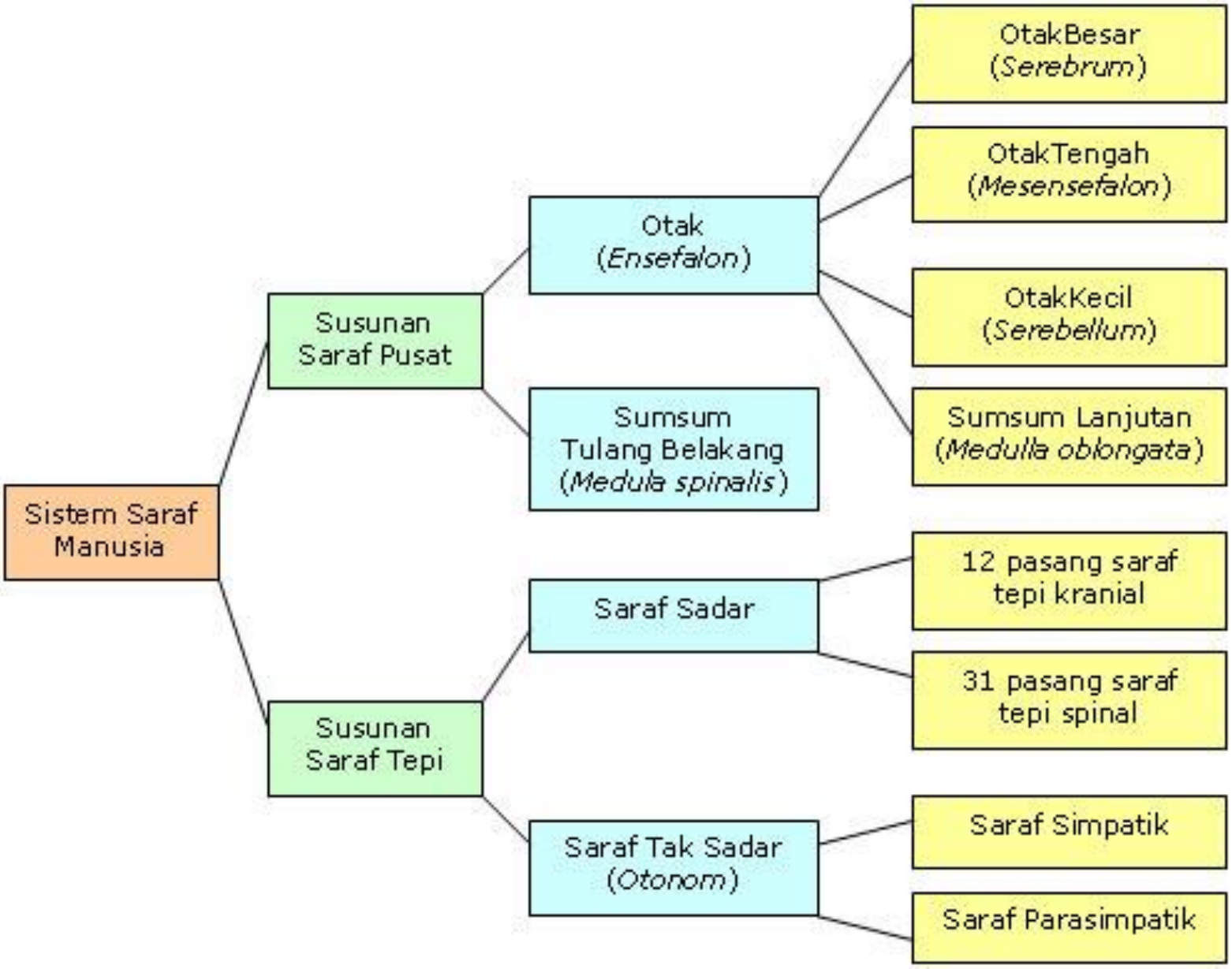
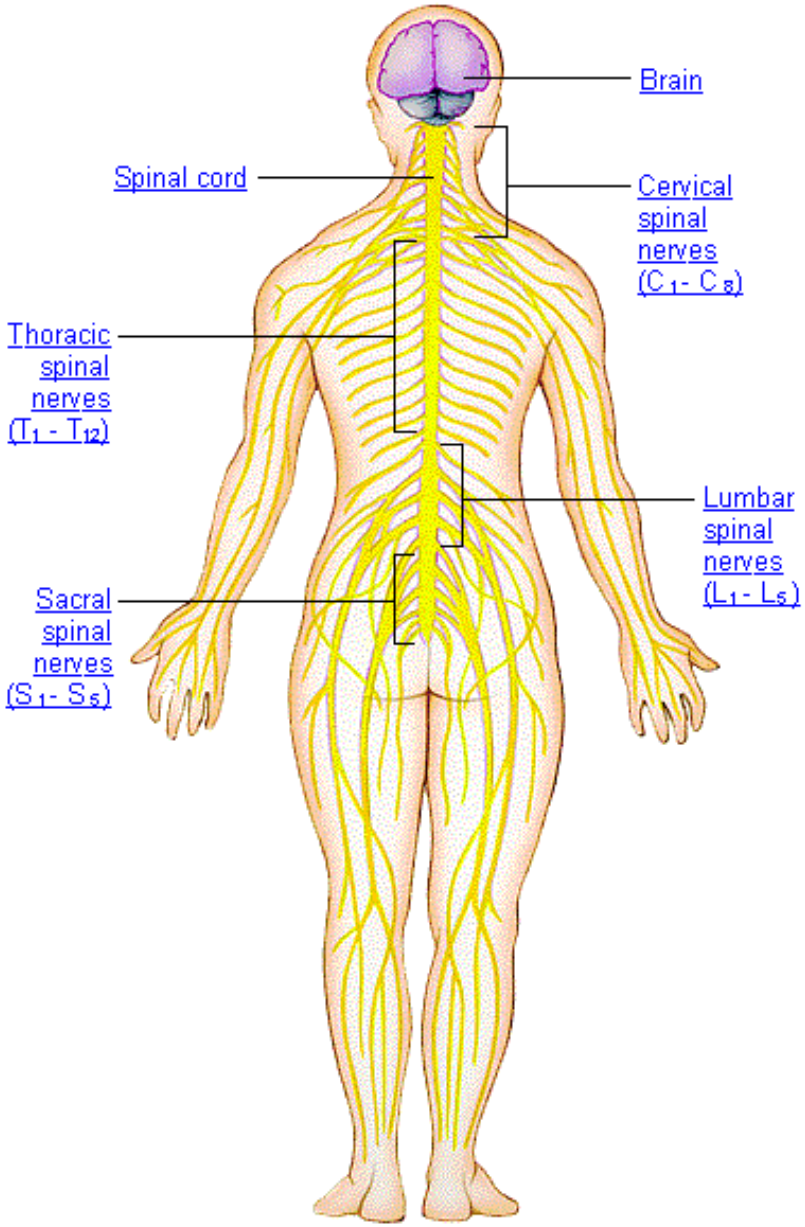
SISTEM SARAF

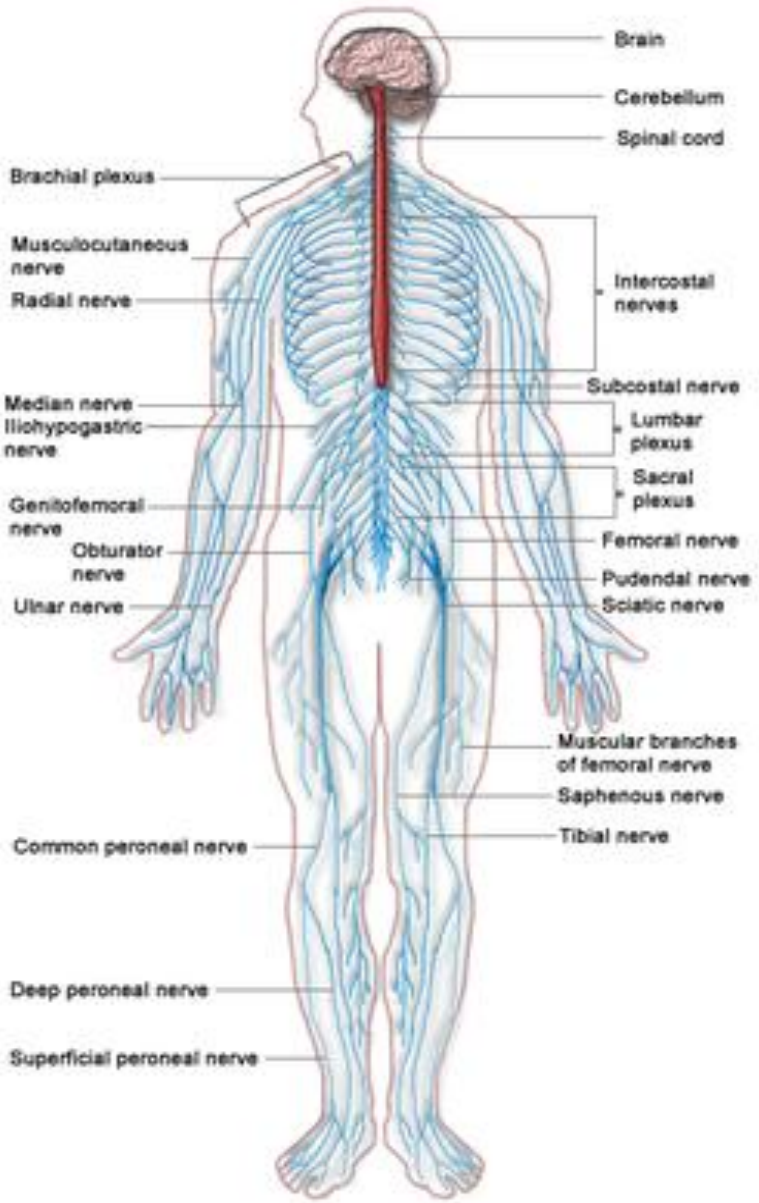


dr. AL-MUQSITH, M.Si

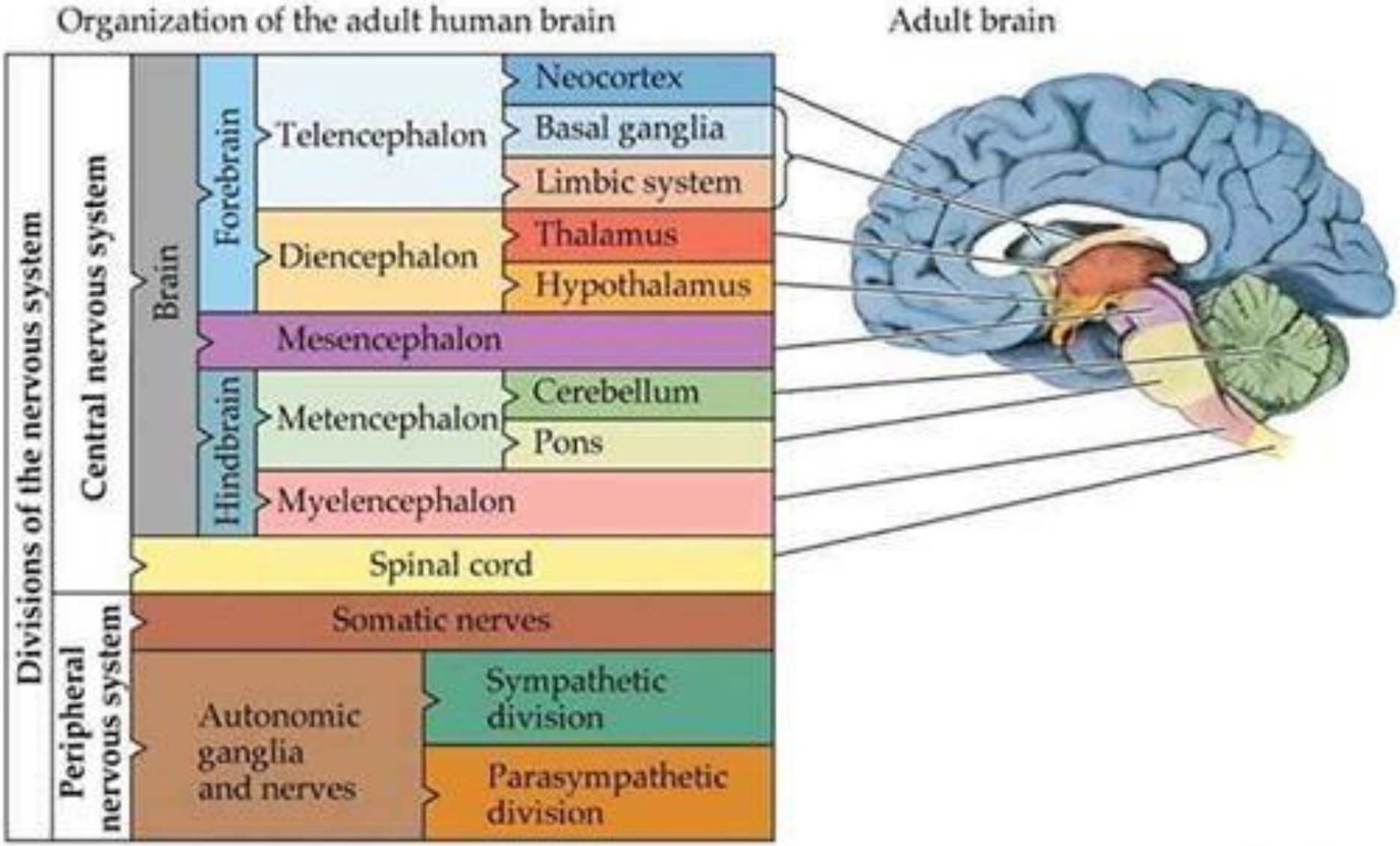

Sistem Saraf Manusia
Susunan Saraf Pusat
Susunan Saraf Tepi
Otak (*Ensefalon*)
Sumsum Tulang Belakang (*Medula spinalis*)
Saraf Sadar
Saraf Tak Sadar (*Otonom*)
OtakBesar (*Serebrum*)
OtakTengah (*Mesensefalon*)
OtakKecil (*Serebellum*)
Sumsum Lanjutan (*Medulla oblongata*)
12 pasang saraf tepi kranial
31 pasang saraf tepi spinal
Saraf Simpatik
Saraf Parasimpatik

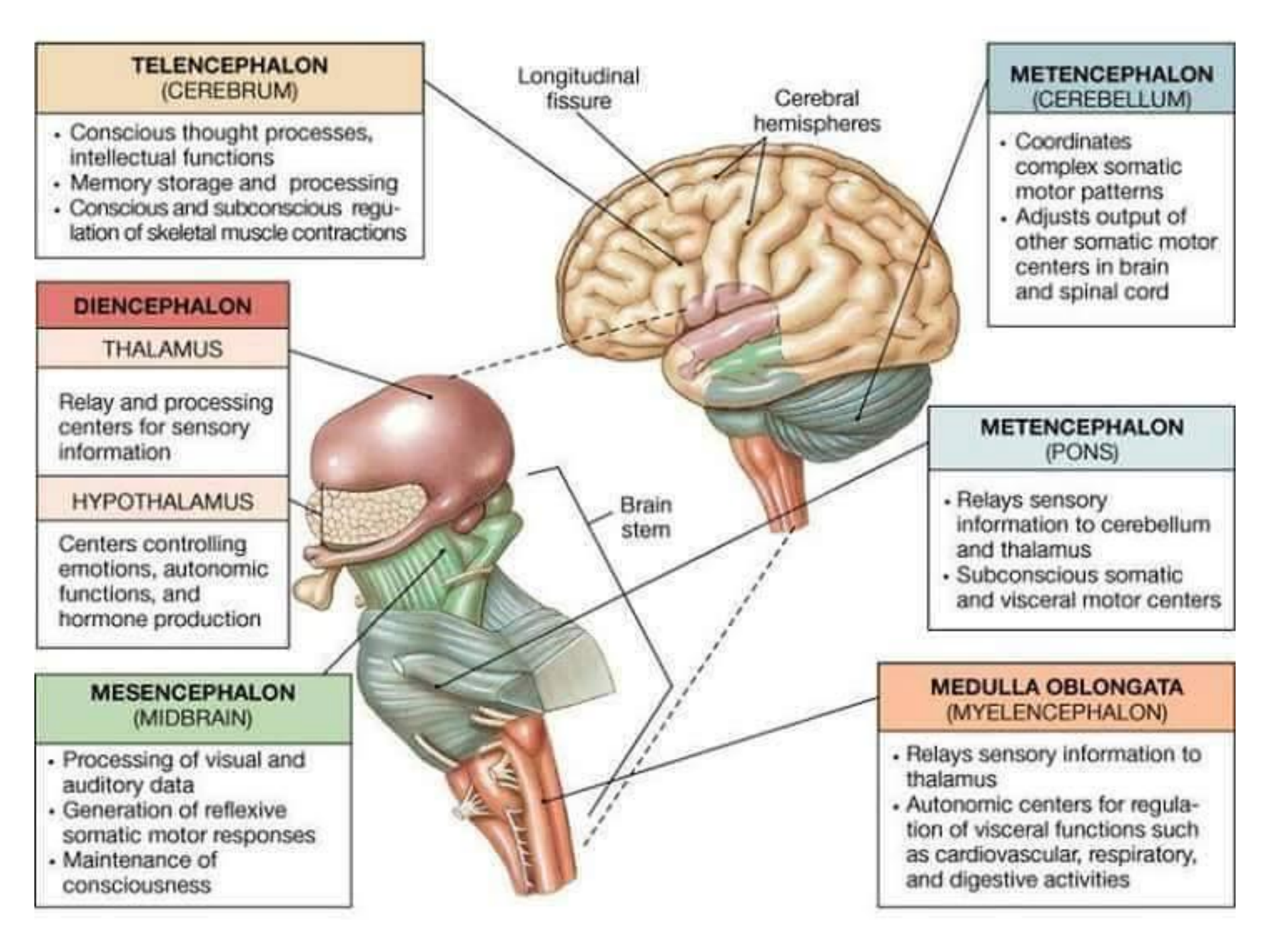
SSP dan SST

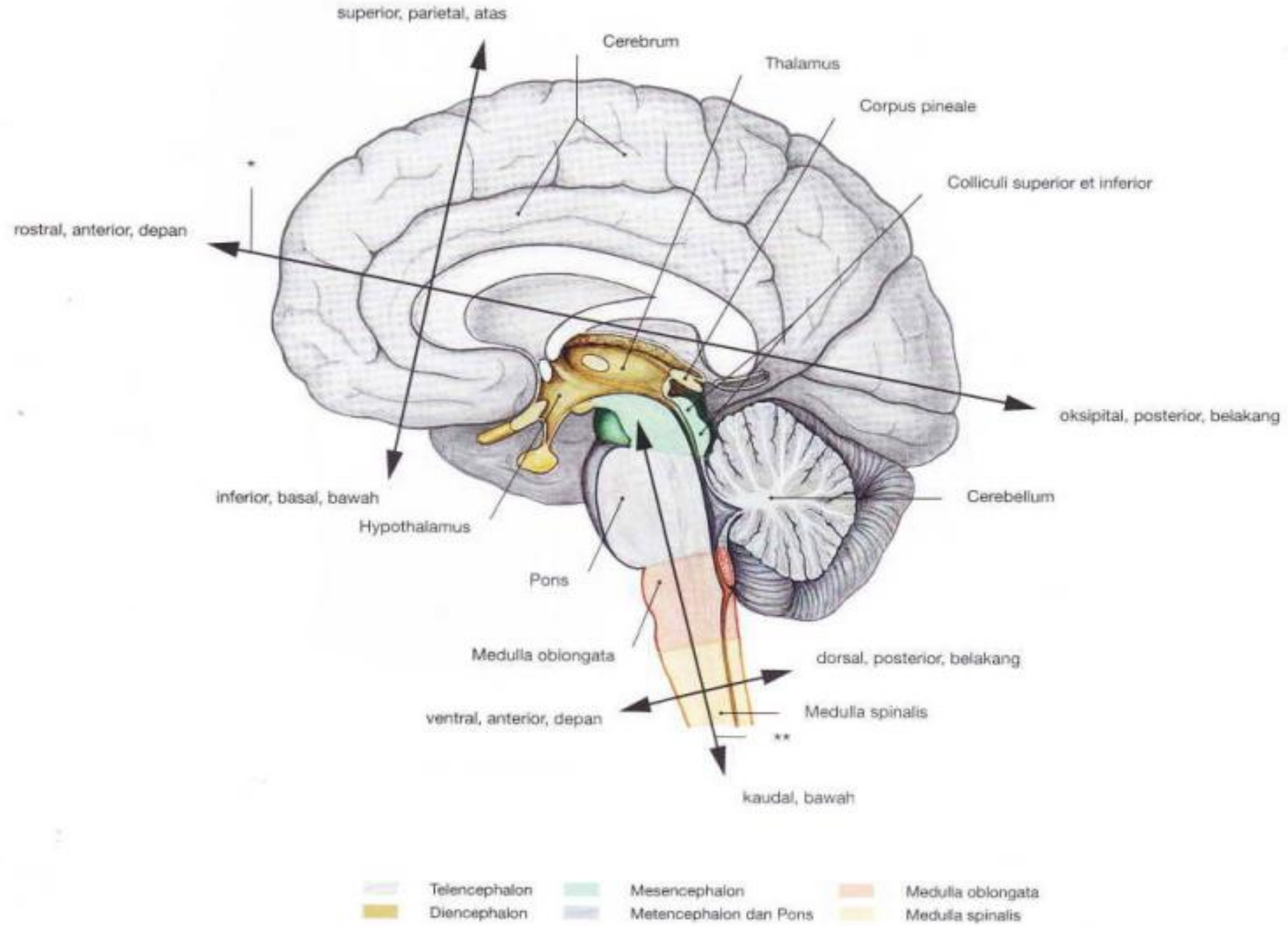

Brain
Spinal cord
Cervical spinal nerves (C_1 - C_8)
Thoracic spinal nerves (T_1 - T_{12})
Lumbar spinal nerves (L_1 - L_5)
Sacral spinal nerves (S_1 - S_5)


Brain
Cerebellum
Spinal cord
Brachial plexus
Musculocutaneous nerve
Radial nerve
Intercostal nerves
Subcostal nerve
Median nerve
Iliohypogastric nerve
Lumbar plexus
Sacral plexus
Genitofemoral nerve
Obturator nerve
Femoral nerve
Pudendal nerve
Ulnar nerve
Sciatic nerve
Muscular branches of femoral nerve
Saphenous nerve
Common peroneal nerve
Tibial nerve
Deep peroneal nerve
Superficial peroneal nerve

SISTEM SARAF PUSAT (SSP)


Organization of the adult human brain
Adult brain
Divisions of the nervous system
Central nervous system
Peripheral nervous system
Brain
Forebrain
Hindbrain
Telencephalon
Diencephalon
Mesencephalon
Metencephalon
Myelencephalon
Neocortex
Basal ganglia
Limbic system
Thalamus
Hypothalamus
Cerebellum
Pons
Spinal cord
Somatic nerves
Autonomic ganglia and nerves
Sympathetic division
Parasympathetic division

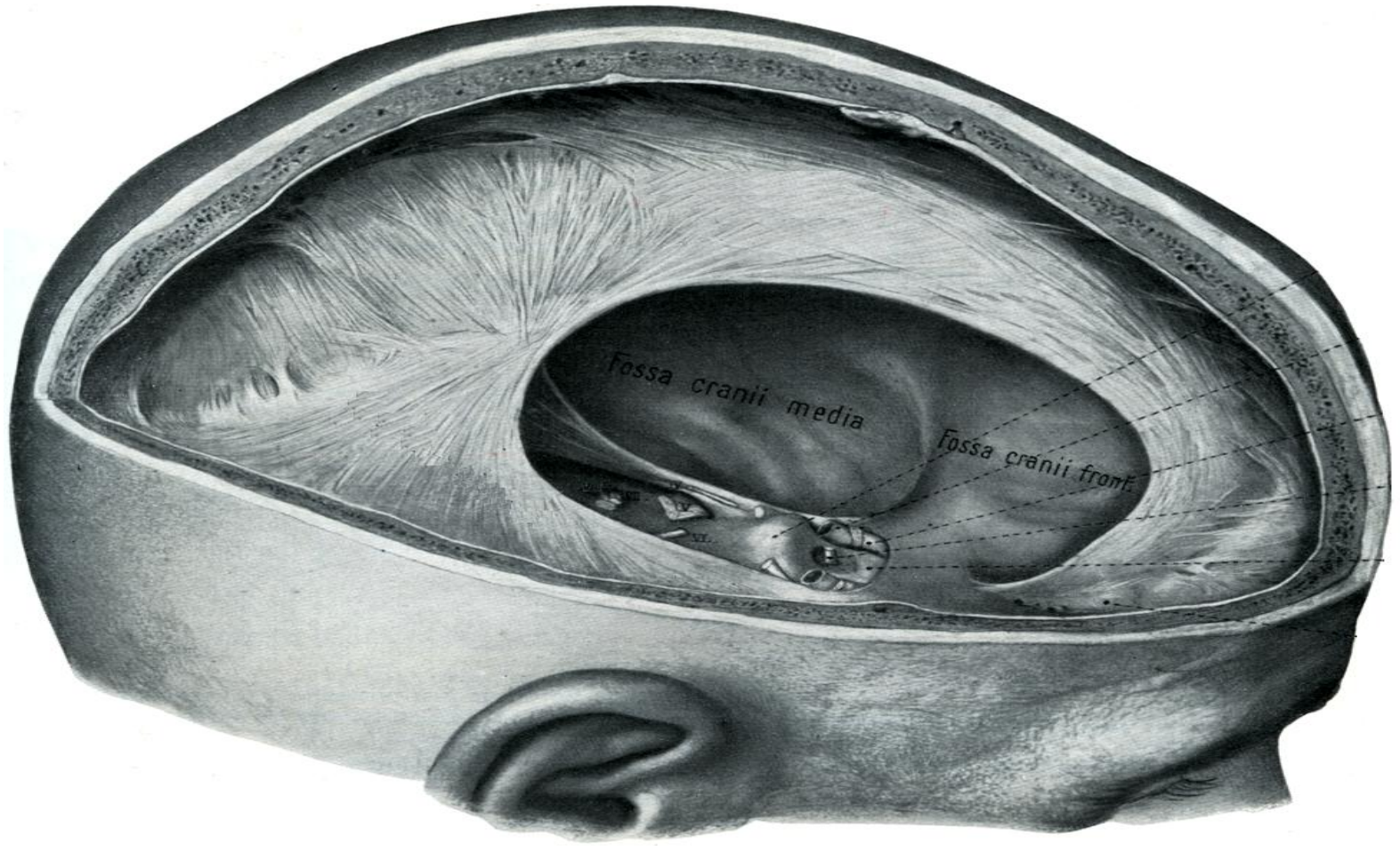

TELENCEPHALON
(CEREBRUM)
• Conscious thought processes, intellectual functions
• Memory storage and processing
• Conscious and subconscious regulation of skeletal muscle contractions
Longitudinal fissure
Cerebral hemispheres
METENCEPHALON
(CEREBELLUM)
• Coordinates complex somatic motor patterns
• Adjusts output of other somatic motor centers in brain and spinal cord
DIENCEPHALON
THALAMUS
Relay and processing centers for sensory information
HYPOTHALAMUS
Centers controlling emotions, autonomic functions, and hormone production
Brain stem
METENCEPHALON
(PONS)
• Relays sensory information to cerebellum and thalamus
• Subconscious somatic and visceral motor centers
MESENCEPHALON
(MIDBRAIN)
• Processing of visual and auditory data
• Generation of reflexive somatic motor responses
• Maintenance of consciousness
MEDULLA OBLONGATA
(MYELENCEPHALON)
• Relays sensory information to thalamus
• Autonomic centers for regulation of visceral functions such as cardiovascular, respiratory, and digestive activities


superior, parietal, atas
Cerebrum
Thalamus
Corpus pineale
Colliculi superior et inferior
rostral, anterior, depan
oksipital, posterior, belakang
inferior, basal, bawah
Hypothalamus
Cerebellum
Pons
Medulla oblongata
dorsal, posterior, belakang
ventral, anterior, depan
Medulla spinalis
**
kaudal, bawah
Telencephalon
Diencephalon
Mesencephalon
Metencephalon dan Pons
Medulla oblongata
Medulla spinalis

Berat Otak

- Neonatus : 400 gr
- Bayi 9 bln : 800 gr
- Anak 3 - 4 thn : 1200 - 1300 gr
- Dewasa
  - Pria : 1379 - 1434 gr
  - Wanita : 1230 - 1306 gr

PELINDUNG
SISTEM SARAF PUSAT

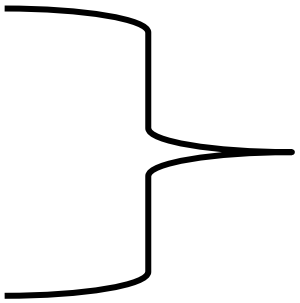


- SSP didukung dan dilindungi oleh tulang dan selaput pelindung
- Otak → pada rongga tulang kepala

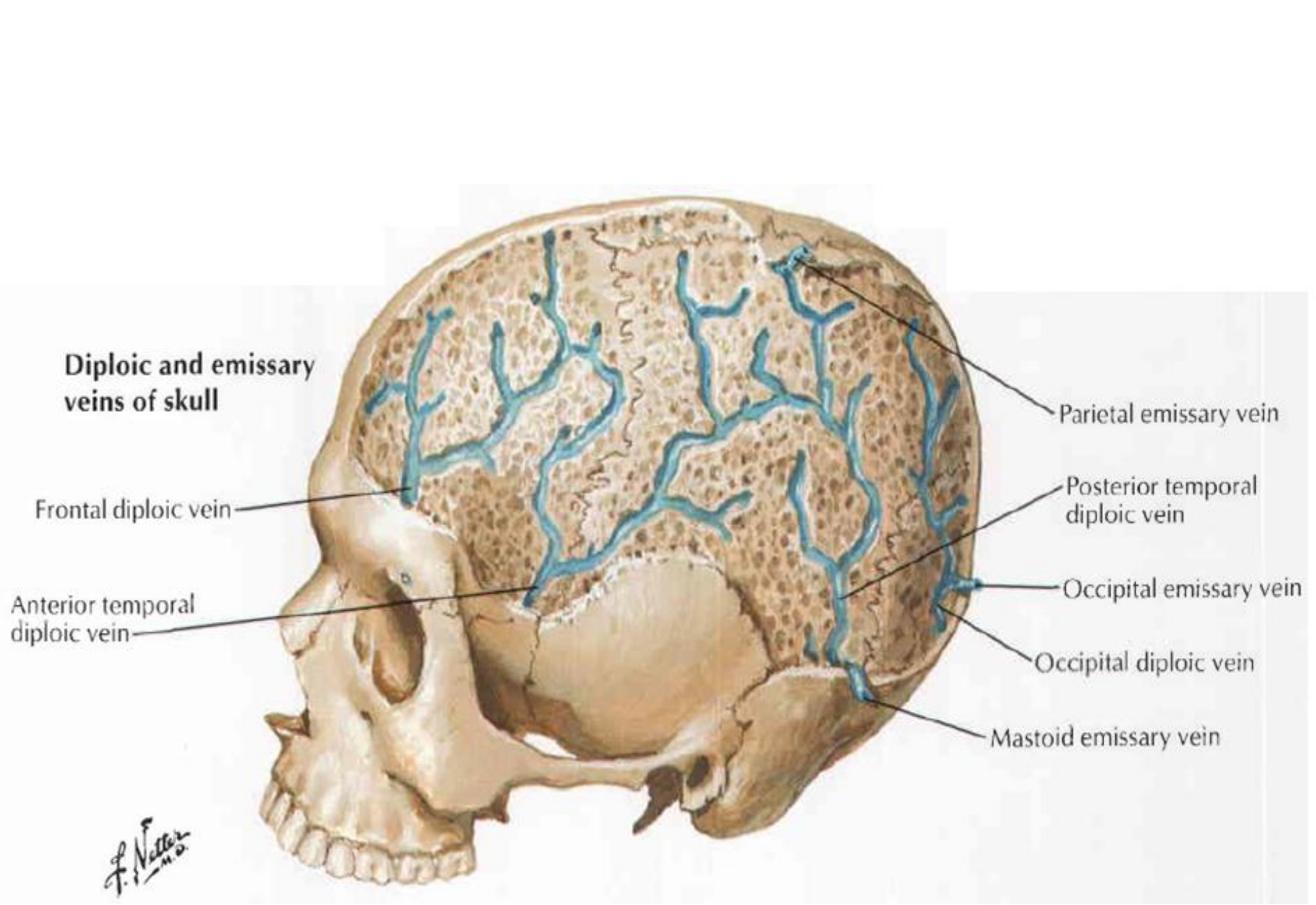
  Medulla spinalis → canalis vertebralis

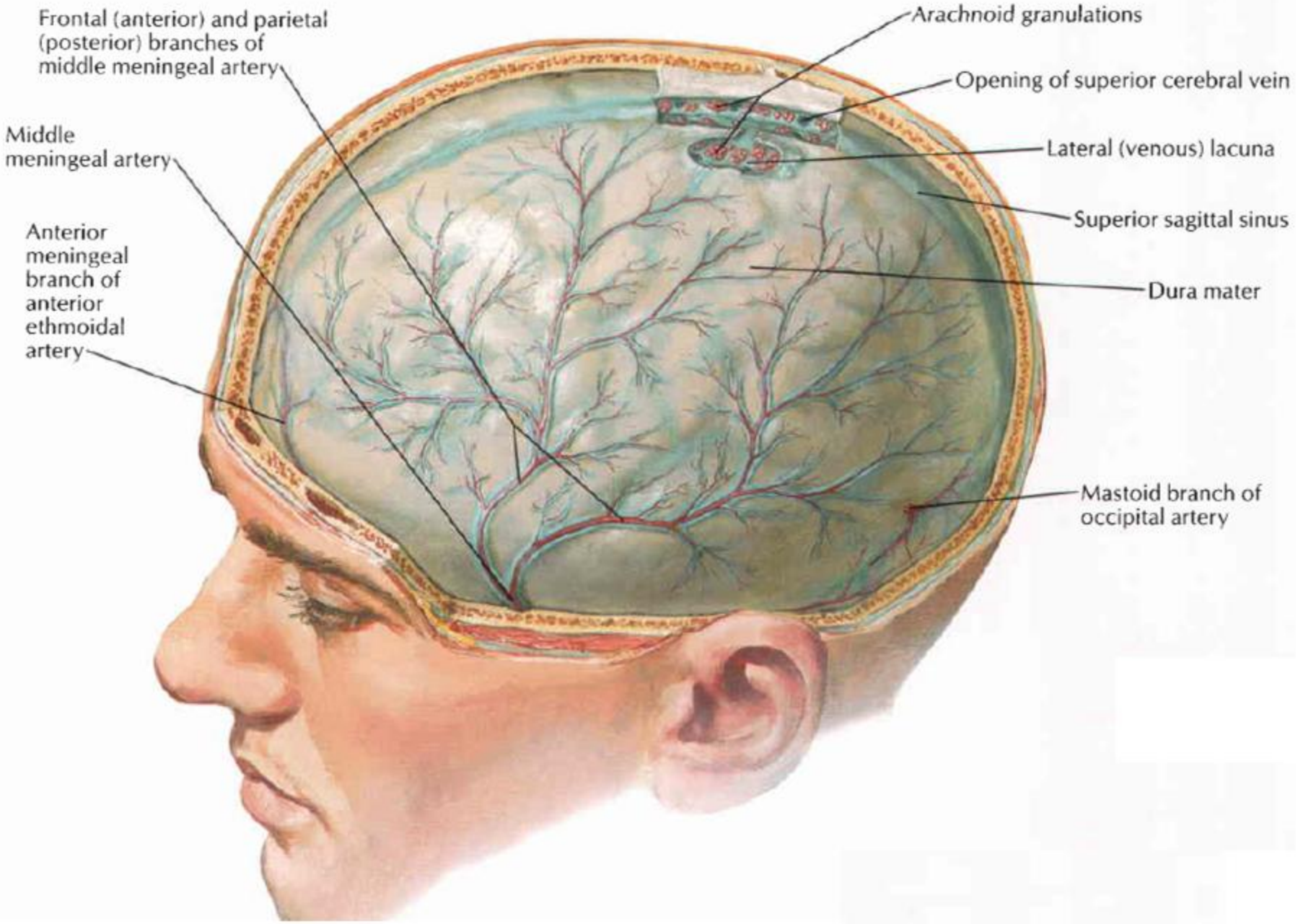
- Otak dan Medulla spinalis dilindungi oleh 3 membran

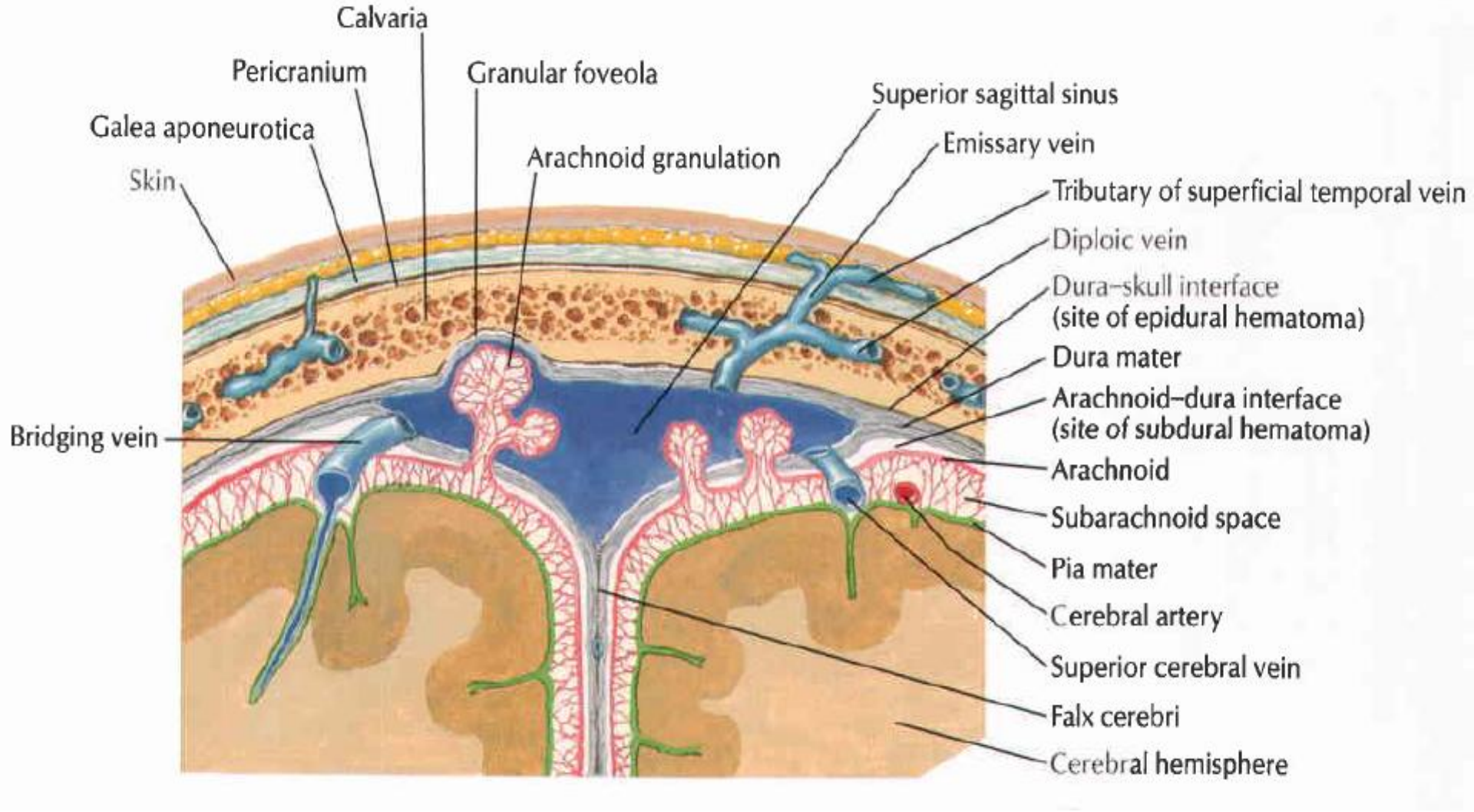
  - dura mater
  - arachnoid mater
  - pia mater

  Meningens

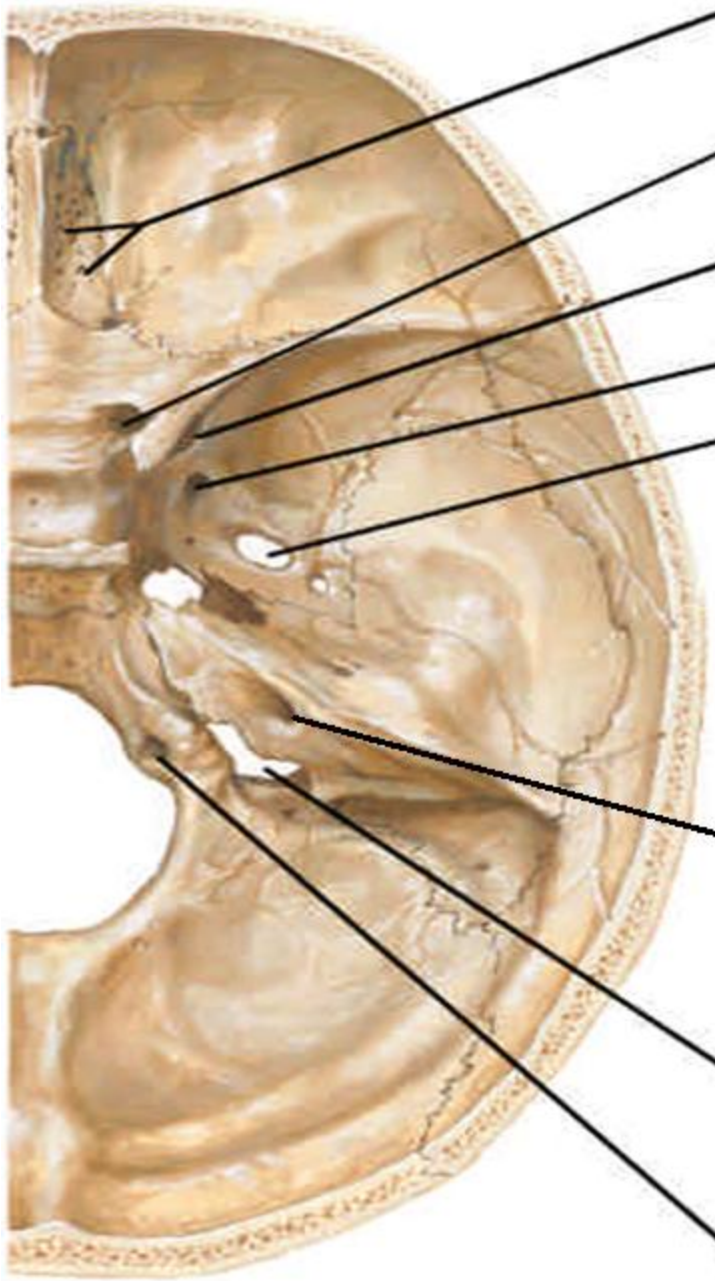

Diploic and emissary veins of skull
Parietal emissary vein
Posterior temporal diploic vein
Occipital emissary vein
Occipital diploic vein
Mastoid emissary vein
Frontal diploic vein
Anterior temporal diploic vein
F. Netter M.D.


Frontal (anterior) and parietal (posterior) branches of middle meningeal artery
Middle meningeal artery
Anterior meningeal branch of anterior ethmoidal artery
Arachnoid granulations
Opening of superior cerebral vein
Lateral (venous) lacuna
Superior sagittal sinus
Dura mater
Mastoid branch of occipital artery


Calvaria
Pericranium
Granular foveola
Superior sagittal sinus
Galea aponeurotica
Emissary vein
Arachnoid granulation
Skin
Tributary of superficial temporal vein
Diploic vein
Dura–skull interface
(site of epidural hematoma)
Dura mater
Bridging vein
Arachnoid–dura interface
(site of subdural hematoma)
Arachnoid
Subarachnoid space
Pia mater
Cerebral artery
Superior cerebral vein
Falx cerebri
Cerebral hemisphere

Cranium

- Cranium dan meningens sebagai pelindung otak
- Otak terletak pada cavitas basis cranii yang terdiri atas 3 fossa:
  - Fossa cranii anterior
  - Fossa cranii media
  - Fossa cranii posterior



Foramina of cribriform plate — Olfactory nerve bundles

Optic canal
- Optic nerve (II)
- Ophthalmic artery

Superior orbital fissure
- Oculomotor nerve (III)
- Trochlear nerve (IV)
- Ophthalmic nerve (V1)
- Abducens nerve (VI)
- Superior ophthalmic vein

Foramen rotundum — Maxillary nerve

Foramen ovale
- Mandibular nerve
- Accessory meningeal artery
- Lesser petrosal nerve (occasionally)

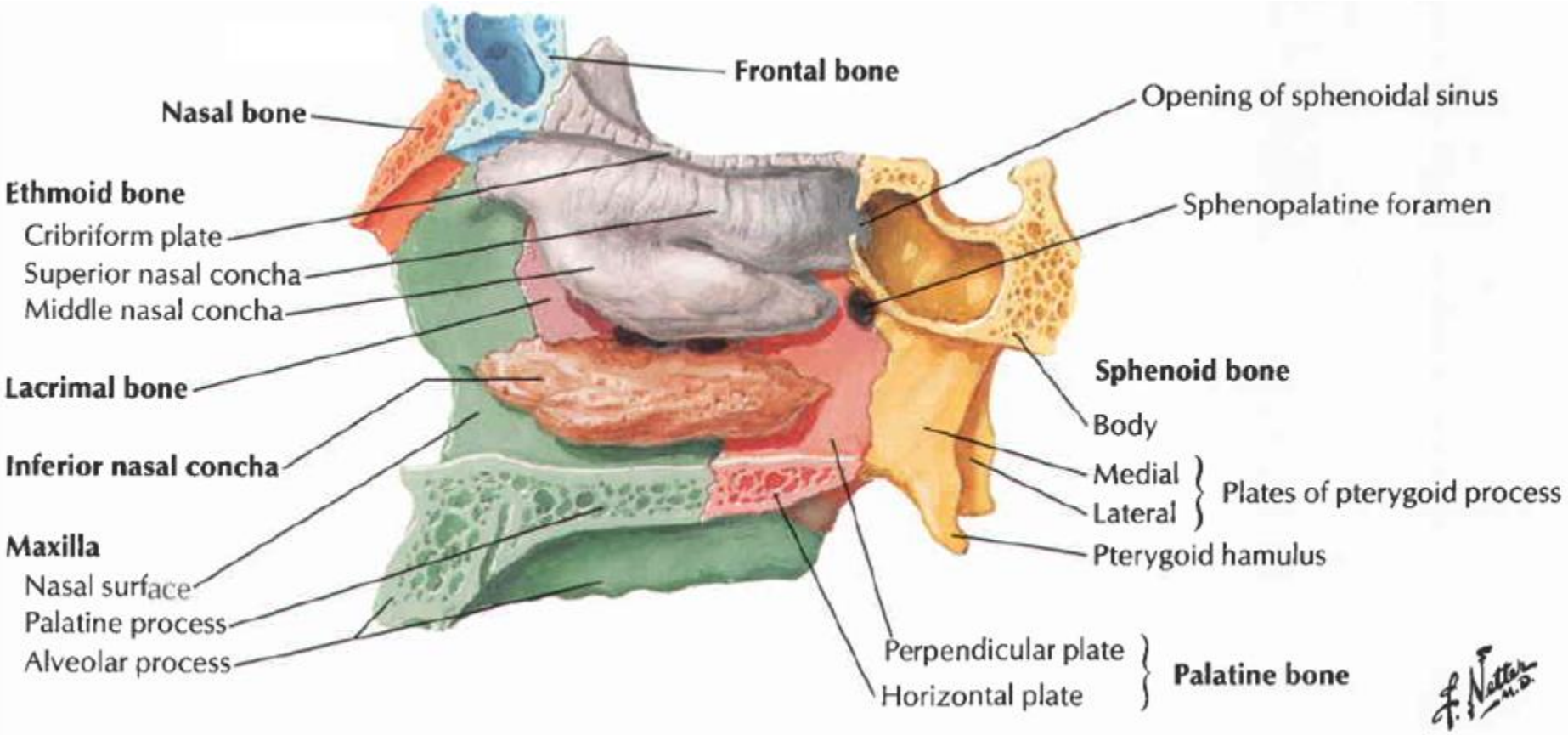
Internal acoustic meatus
- Facial nerve (VII)
- Vestibulocochlear nerve (VIII)
- Labyrinthine artery

Jugular foramen
- Inferior petrosal sinus
- Glossopharyngeal nerve (IX)
- Vagus nerve (X)
- Accessory nerve (XI)
- Sigmoid sinus
- Posterior meningeal artery

Hypoglossal canal — Hypoglossal nerve (XII)

Fossa cranii anterior

- Dibentuk oleh os. frontal, os. ethmoid, dan os. sphenoid
- Diisi oleh lobus frontalis hemisfer cerebri
- Membentuk atap dari bola mata dan berhubungan dengan sinus frontalis
- Terdapat lamina et foramina cribrosa yg merupakan penghubung N. I (olfactorius) ke cavitas cranialis dan melanjutkan diri menjadi bulbus olfactorius



View of lateral nasal wall with nasal septum removed

Middle Cranial Fossa

- Dibentuk oleh os. sphenoid dan os. temporal

- Diisi oleh lobus temporalis.

  pada bagian tengahnya terdapat gld. Pituitari pada fossa hipophisialis

- Ada beberapa foramina yang masuk dan keluar untuk pembuluh darah dan nervus cranialis:

- canalis opticus (N.II [opticus], A. Opthalmica)
- fissura orbitalis superior (N.III [occulomotorius], N.IV [trochlearis], N.VI [abducens] , N.V-1 [trigeminal divisi opthalmica]),
- Foramen rotundum (N.V-2 [trigeminal divisi maxillaris]),
- Foramen ovale (N.V-3 [trigeminal divisi mandibularis]),
- Foramen spinosum (A. Meningea media).

Posterior Cranial Fossa

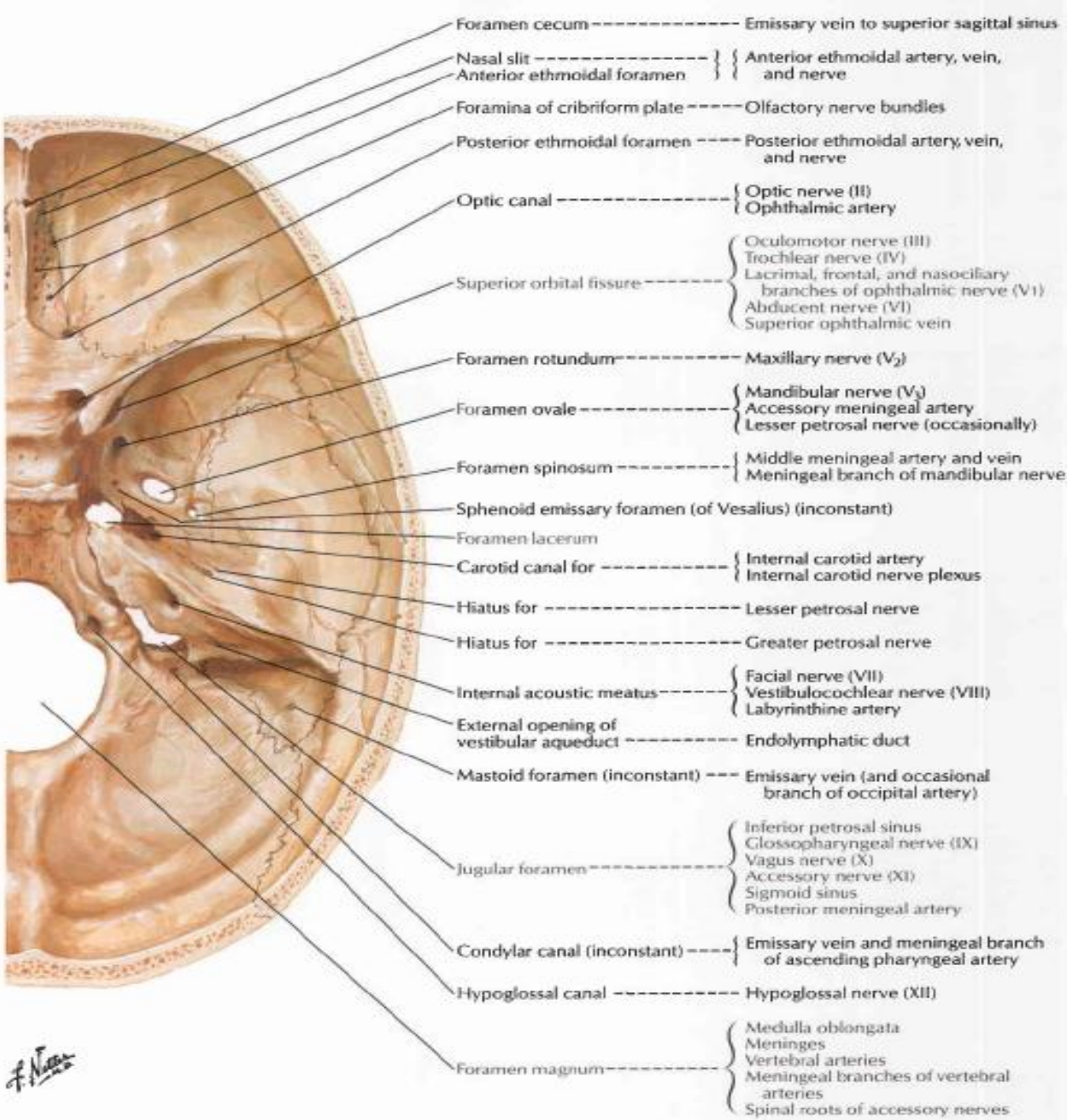
- Dibentuk oleh os. occipitalis dan os temporal pars petrosa

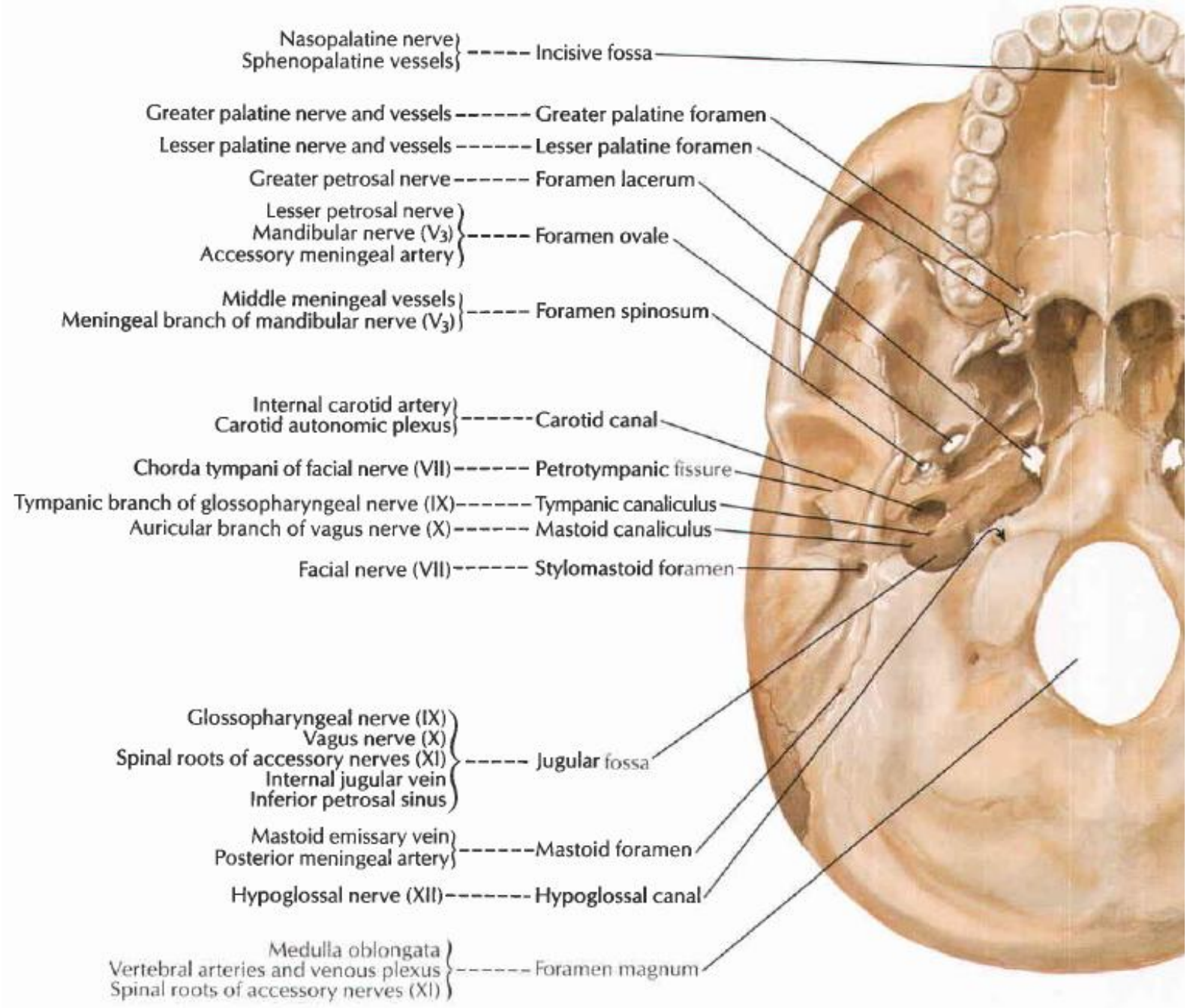
- Fossa cranii posterior berhubungan dengan brain stem (batang otak) dan cerebellum (otak kecil)

- Beberapa struktur penting yang melewati foramen di fossa cranii posterior:

- Foramen magnum (medulla oblongata, A. vertebralis, N. assesorius dari cornu spinalis),
- canalis hipoglossus (N.XII [hipoglossus]),
- foramen jugular (V. jugularis interna, N.IX [glossopharyngeus], N.X [vagus], dan N.XI [assesorius]),
- Meatus acusticus interna (N.VII [facialis] dan N.VIII [vestibulocochlear])

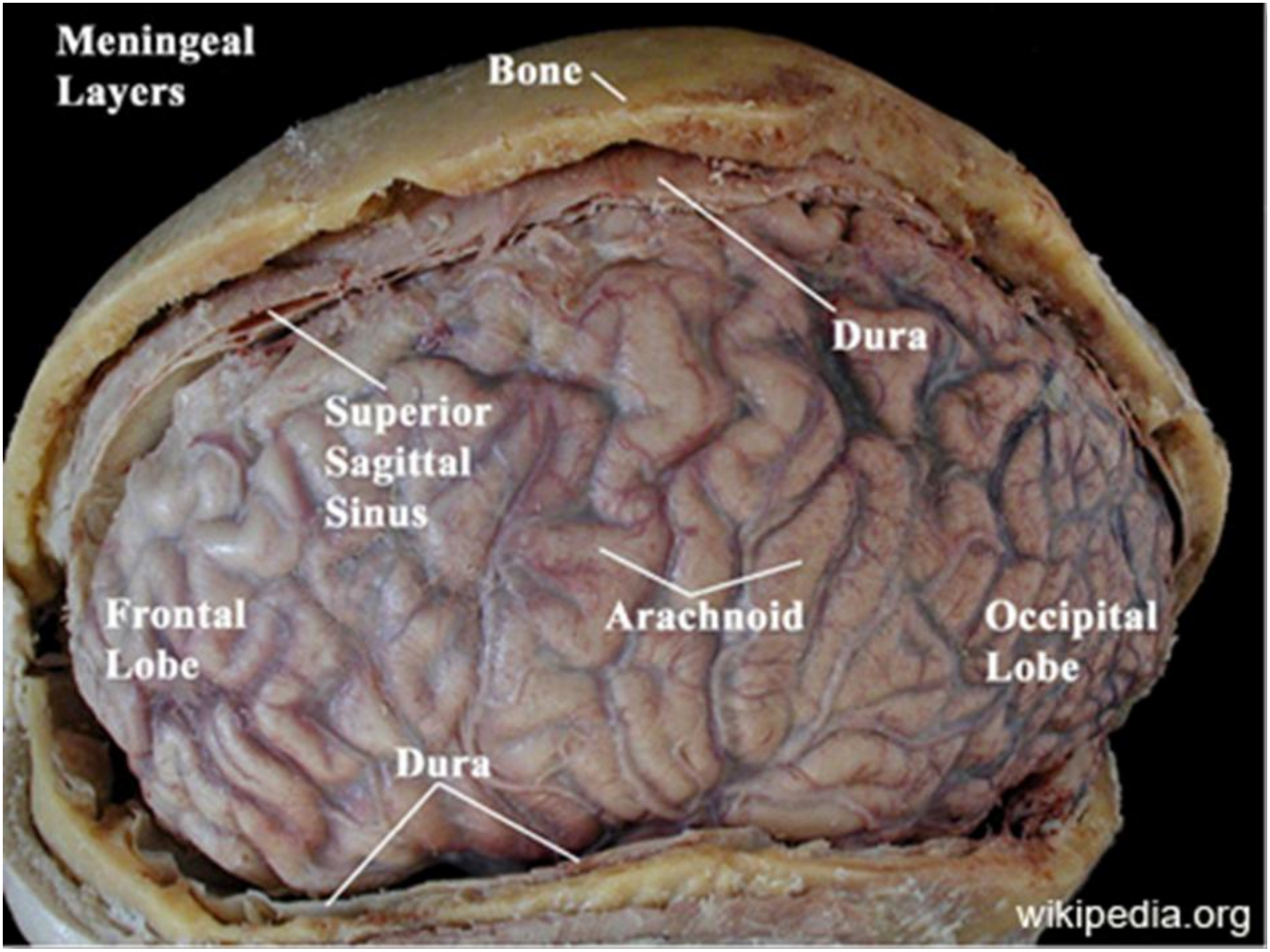
Cranial Nerve	Foramen of skull
I (olfactory)	Lamina cribrosa
II (optic)	Canalis opticus
III (oculomotor)	Fissura orbitalis superior
IV (trochlear)	Fissura orbitalis superior
V1 (opthalmic)	Fissura orbitalis superior
V2 (maxillary)	foramen rotundum
V3 (mandibular)	foramen ovale
VI (abducens)	Fissura orbitalis superior
VII (facial)	Meatus acusticus internus
VIII (vestibulocochlear)	Meatus acusticus internus
IX (glossopharyngeal)	Foramen jugularis
X (vagus)	Foramen jugularis
XI (spinal accessory)	Foramen jugularis
XII (hypoglossal)	Canalis hipoglossus


Foramen cecum
Emissary vein to superior sagittal sinus
Nasal slit
Anterior ethmoidal foramen
Anterior ethmoidal artery, vein, and nerve
Foramina of cribriform plate
Olfactory nerve bundles
Posterior ethmoidal foramen
Posterior ethmoidal artery, vein, and nerve
Optic canal
Optic nerve (II)
Ophthalmic artery
Superior orbital fissure
Oculomotor nerve (III)
Trochlear nerve (IV)
Lacrimal, frontal, and nasociliary branches of ophthalmic nerve (V1)
Abducent nerve (VI)
Superior ophthalmic vein
Foramen rotundum
Maxillary nerve (V2)
Foramen ovale
Mandibular nerve (V3)
Accessory meningeal artery
Lesser petrosal nerve (occasionally)
Foramen spinosum
Middle meningeal artery and vein
Meningeal branch of mandibular nerve
Sphenoid emissary foramen (of Vesalius) (inconstant)
Foramen lacerum
Carotid canal for
Internal carotid artery
Internal carotid nerve plexus
Hiatus for
Lesser petrosal nerve
Hiatus for
Greater petrosal nerve
Internal acoustic meatus
Facial nerve (VII)
Vestibulocochlear nerve (VIII)
Labyrinthine artery
External opening of vestibular aqueduct
Endolymphatic duct
Mastoid foramen (inconstant)
Emissary vein (and occasional branch of occipital artery)
Jugular foramen
Inferior petrosal sinus
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Accessory nerve (XI)
Sigmoid sinus
Posterior meningeal artery
Condylar canal (inconstant)
Emissary vein and meningeal branch of ascending pharyngeal artery
Hypoglossal canal
Hypoglossal nerve (XII)
Foramen magnum
Medulla oblongata
Meninges
Vertebral arteries
Meningeal branches of vertebral arteries
Spinal roots of accessory nerves


Nasopalatine nerve
Sphenopalatine vessels
Incisive fossa
Greater palatine nerve and vessels
Greater palatine foramen
Lesser palatine nerve and vessels
Lesser palatine foramen
Greater petrosal nerve
Foramen lacerum
Lesser petrosal nerve
Mandibular nerve (V3)
Accessory meningeal artery
Foramen ovale
Middle meningeal vessels
Meningeal branch of mandibular nerve (V3)
Foramen spinosum
Internal carotid artery
Carotid autonomic plexus
Carotid canal
Chorda tympani of facial nerve (VII)
Petrotympanic fissure
Tympanic branch of glossopharyngeal nerve (IX)
Tympanic canaliculus
Auricular branch of vagus nerve (X)
Mastoid canaliculus
Facial nerve (VII)
Stylomastoid foramen
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Spinal roots of accessory nerves (XI)
Internal jugular vein
Inferior petrosal sinus
Jugular fossa
Mastoid emissary vein
Posterior meningeal artery
Mastoid foramen
Hypoglossal nerve (XII)
Hypoglossal canal
Medulla oblongata
Vertebral arteries and venous plexus
Spinal roots of accessory nerves (XI)
Foramen magnum

MENINGENS

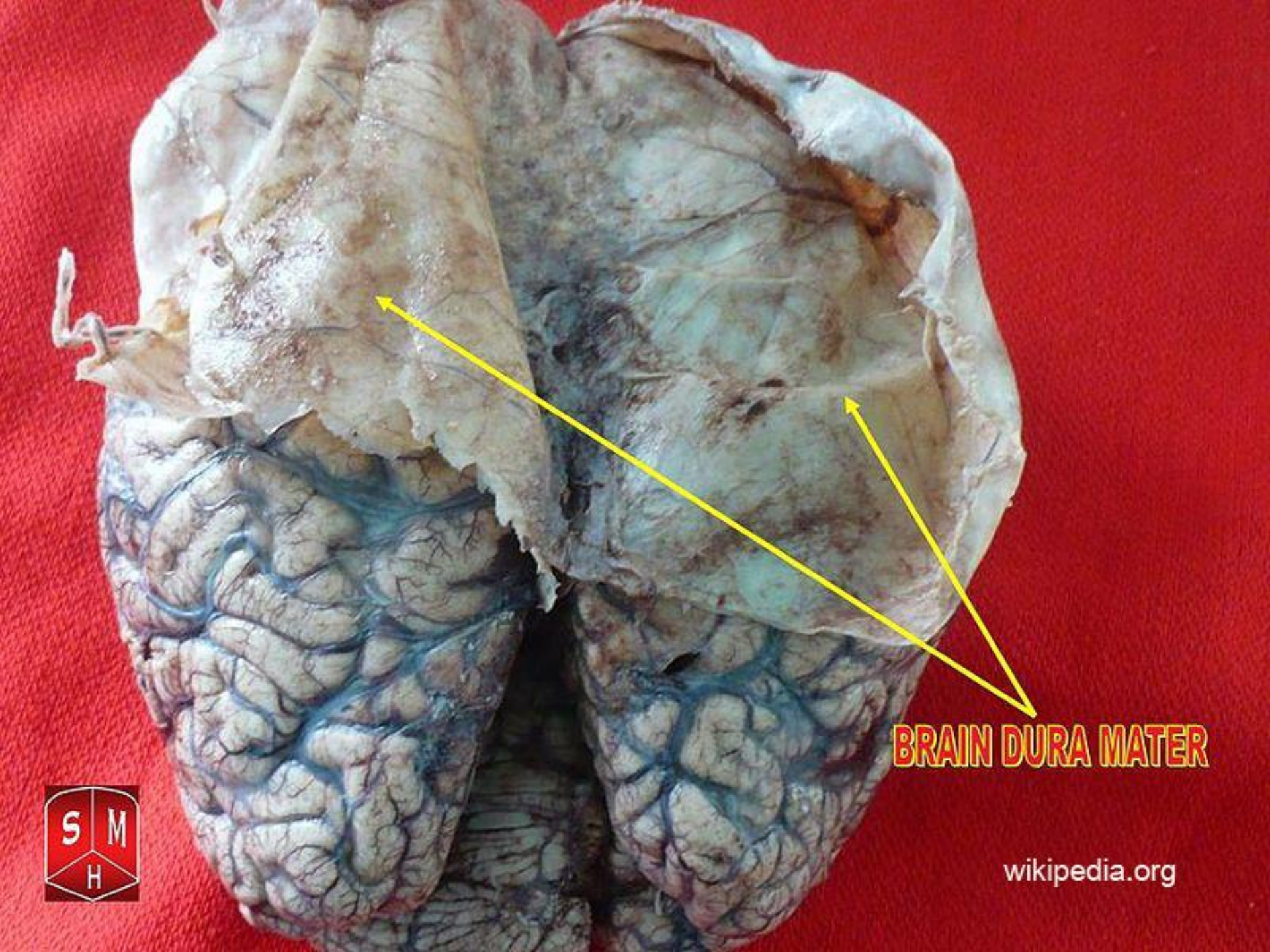
- Sistem membran yang melapisi SSP
- Membran terluar disebut duramater→ *meninx fibrosa* or *pachymeninx*
- Lapisan tengah disebut arachnoid mater, dan membran terdalam disebut piamater
- Arachnoid mater dan pia mater → *leptomeninges*

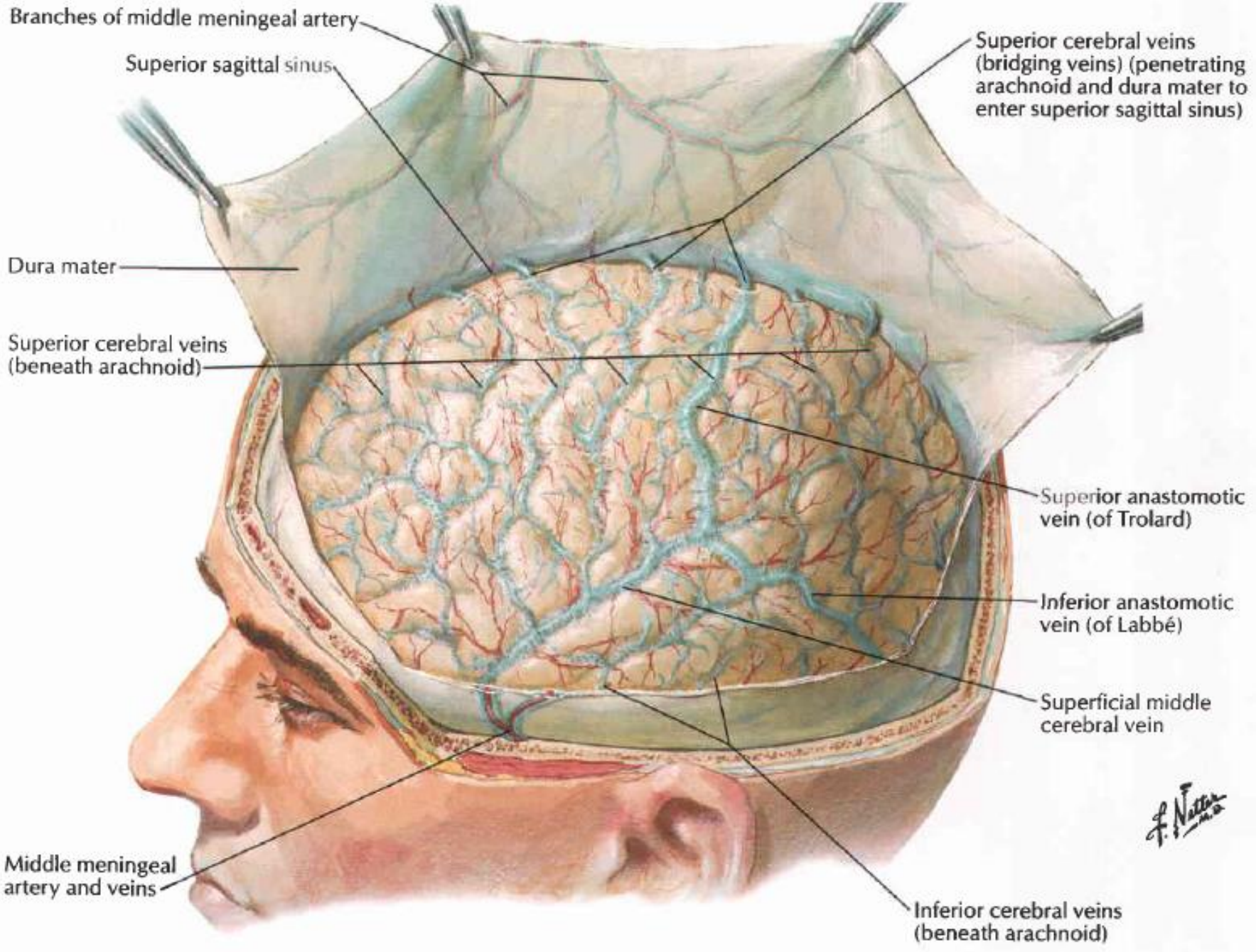

Meningeal Layers
Bone
Dura
Superior Sagittal Sinus
Frontal Lobe
Arachnoid
Occipital Lobe
Dura
wikipedia.org

Dura Mater Encephali

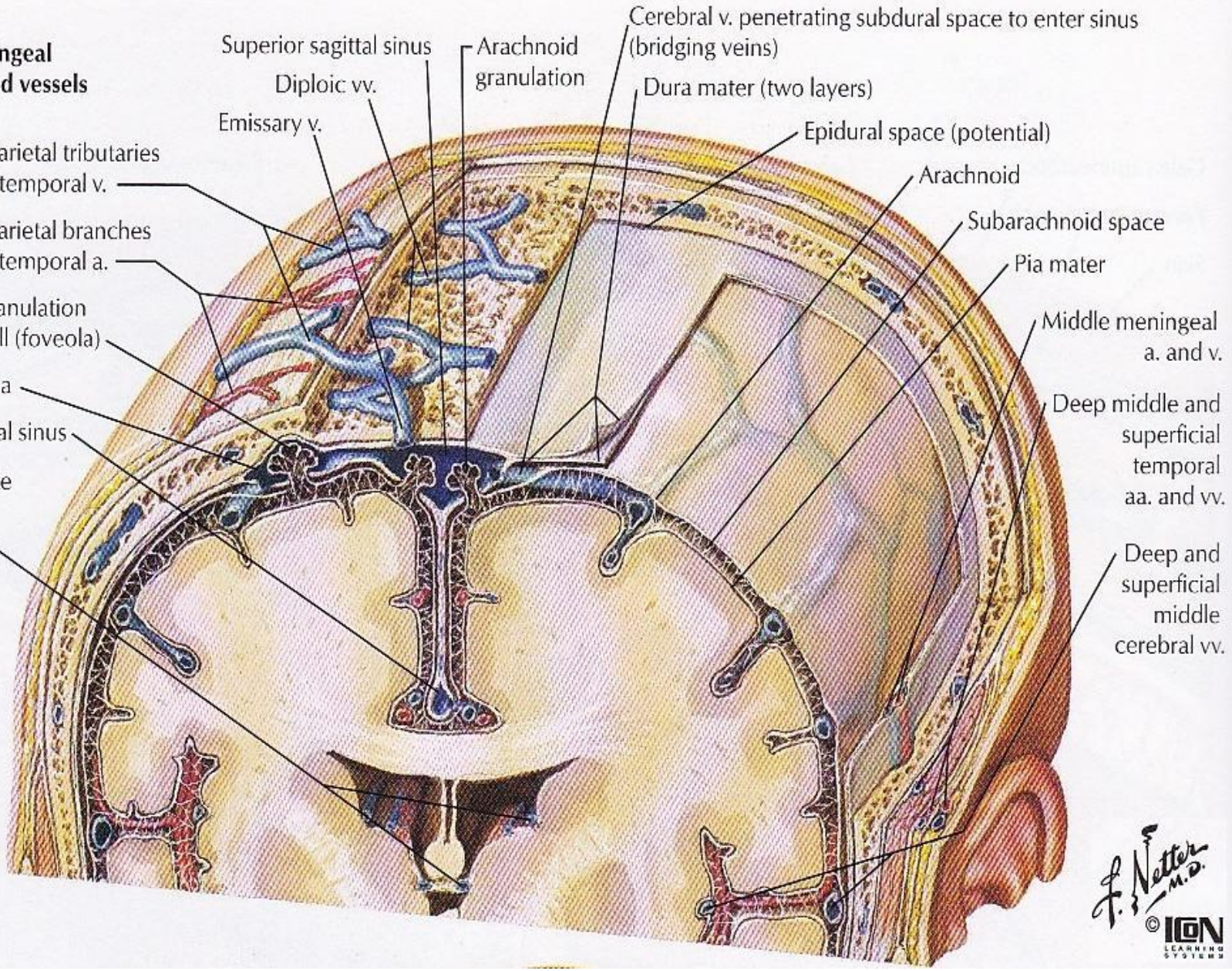
- Membran meningeal terluar
- Tebal dan keras, membran fibrosa yang membungkus otak
- Terdiri atas 2 lapisan:

1. periosteal layer, yang melekat pada calvaria (stratum endosteale/periosteale)
2. inner meningeal layer, yang melekat pada otak (stratum meningeale)


BRAIN DURA MATER
wikipedia.org


Branches of middle meningeal artery
Superior sagittal sinus
Superior cerebral veins (bridging veins) (penetrating arachnoid and dura mater to enter superior sagittal sinus)
Dura mater
Superior cerebral veins (beneath arachnoid)
Superior anastomotic vein (of Trolard)
Inferior anastomotic vein (of Labbé)
Superficial middle cerebral vein
Middle meningeal artery and veins
Inferior cerebral veins (beneath arachnoid)

Scalp, skull, meningeal and cerebral blood vessels



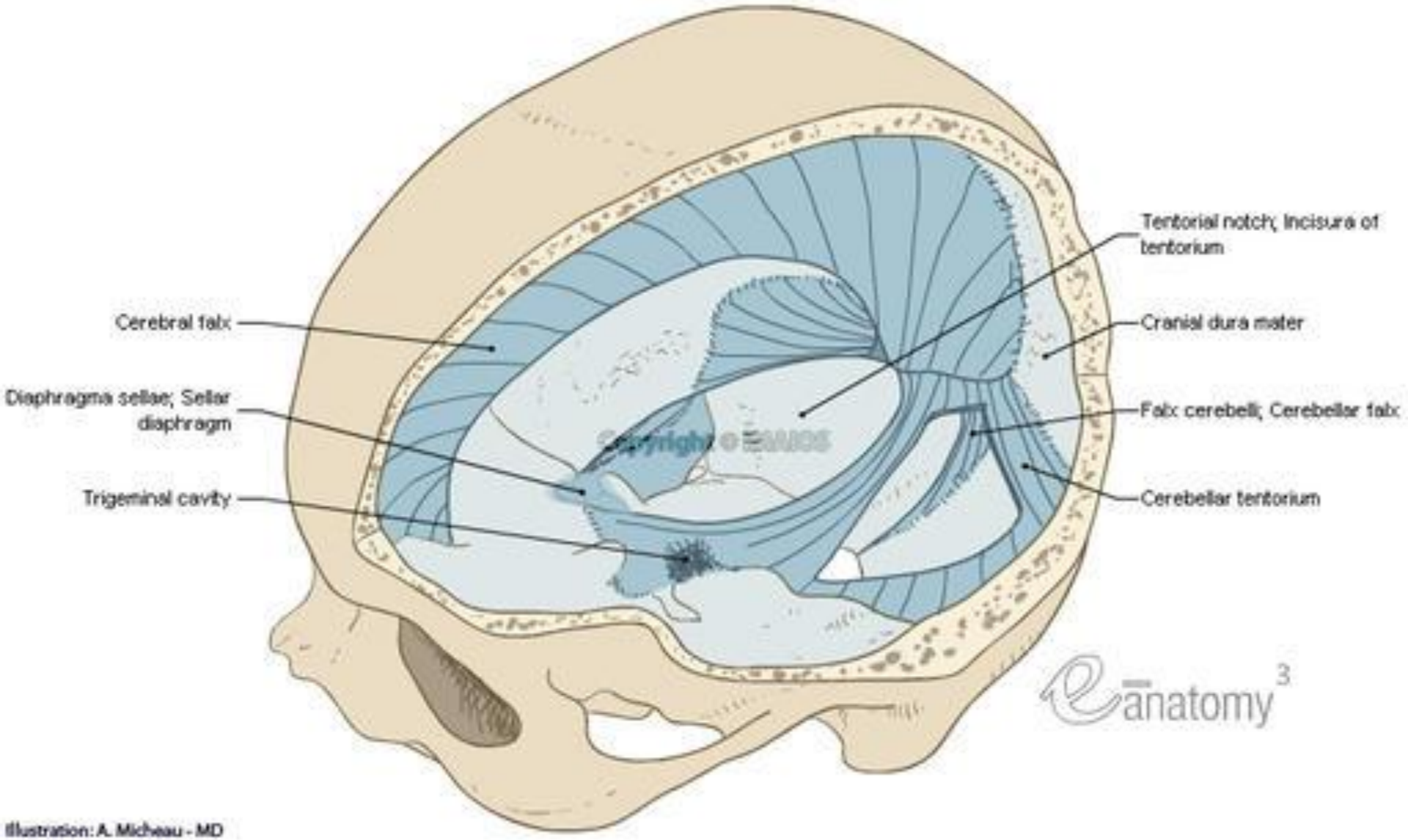
Dura Mater Encephali (Cont.…)

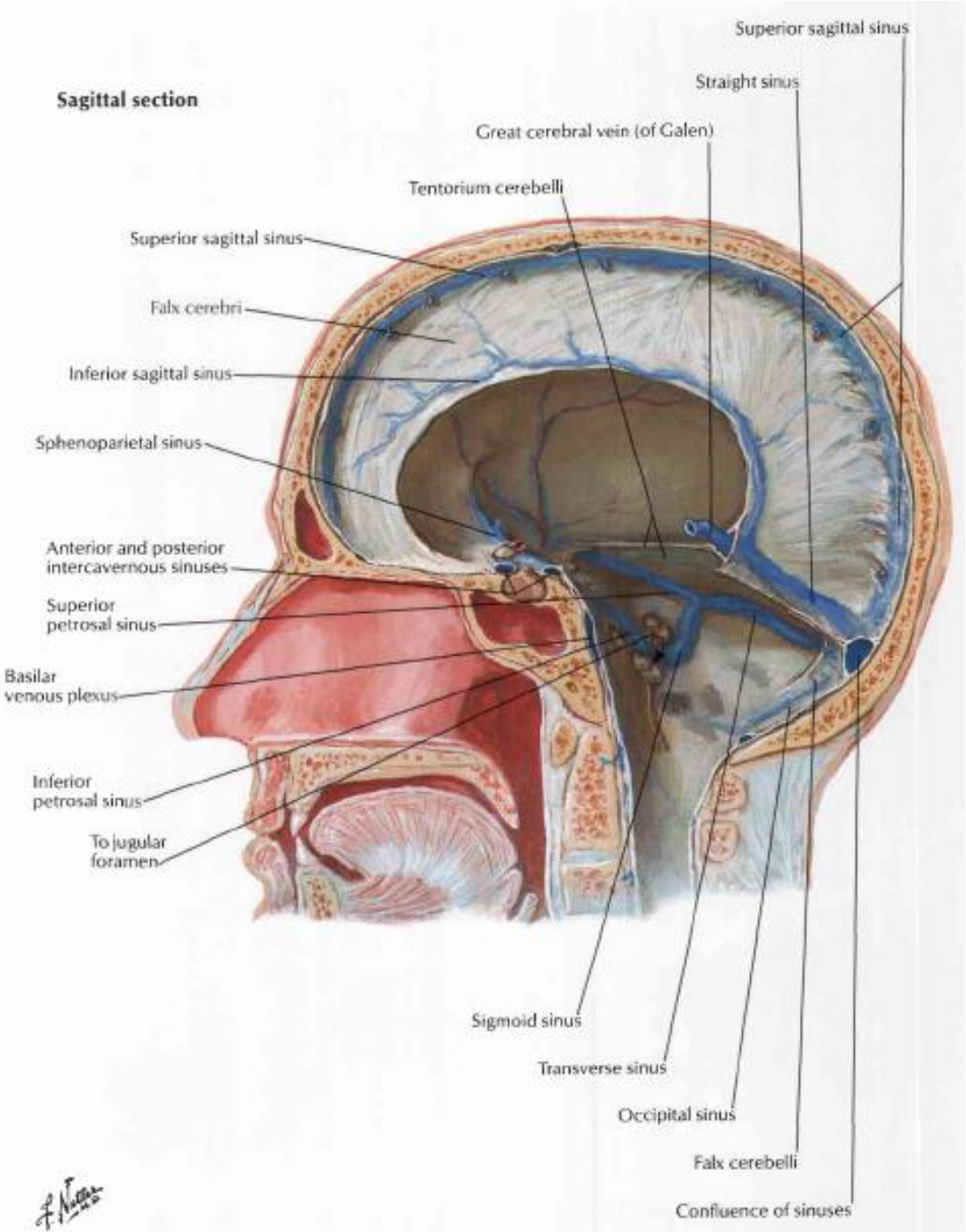
- Beberapa daerah yang membentuk lipatan duramater :

1. **Falx cerebri**, membentang di antara 2 hemisfer cerebri,
2. **Tentorium cerebelli**, membentang di antara cerebellum dan lobus occipital cerebellum dan mengelilingi otak tengah (midbrain)
3. **Falx cerebelli**, lipatan vertikal; di inferior tentorium cerebelli, memisakan hemisfer cerebelli
4. **Diaphragma sellae**, lipatan terkecil, menutupi gld. Pituitari dan sella turcica

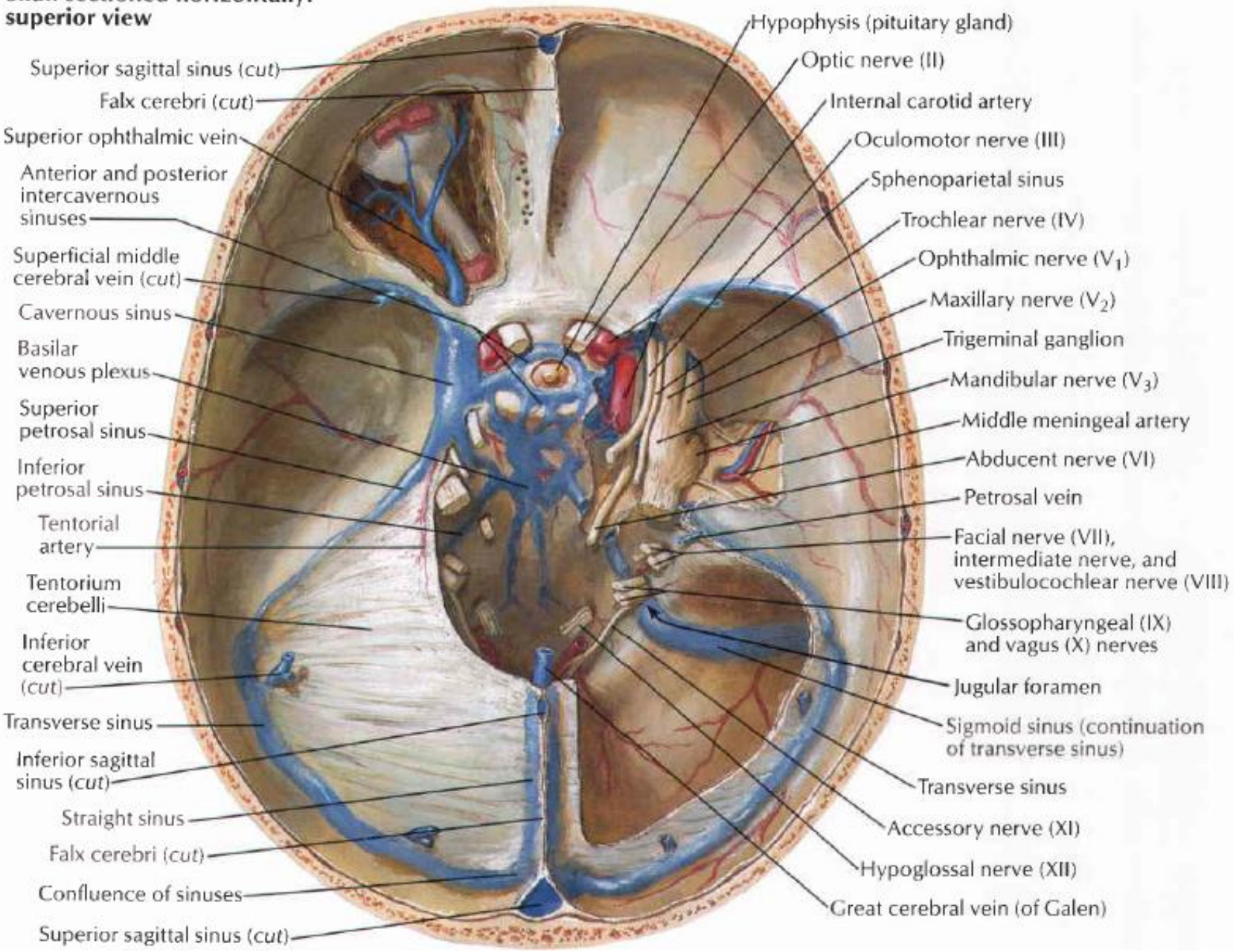
- Duramater mengandung beberapa sinus venosus, yang penting untuk drainase vena otak

- Sinus venosus terdapat pada falx cerebri, tentorium cerebelli dan dasar rongga kepala


Tentorial notch; Incisura of tentorium
Cerebral falx
Cranial dura mater
Diaphragma sellae; Sellar diaphragm
Falx cerebelli; Cerebellar falx
Trigeminal cavity
Cerebellar tentorium
anatomy 3
Illustration: A. Micheau - MD


Sagittal section
Superior sagittal sinus
Straight sinus
Great cerebral vein (of Galen)
Tentorium cerebelli
Superior sagittal sinus
Falx cerebri
Inferior sagittal sinus
Sphenoparietal sinus
Anterior and posterior intercavernous sinuses
Superior petrosal sinus
Basilar venous plexus
Inferior petrosal sinus
To jugular foramen
Sigmoid sinus
Transverse sinus
Occipital sinus
Falx cerebelli
Confluence of sinuses

Skull sectioned horizontally: superior view



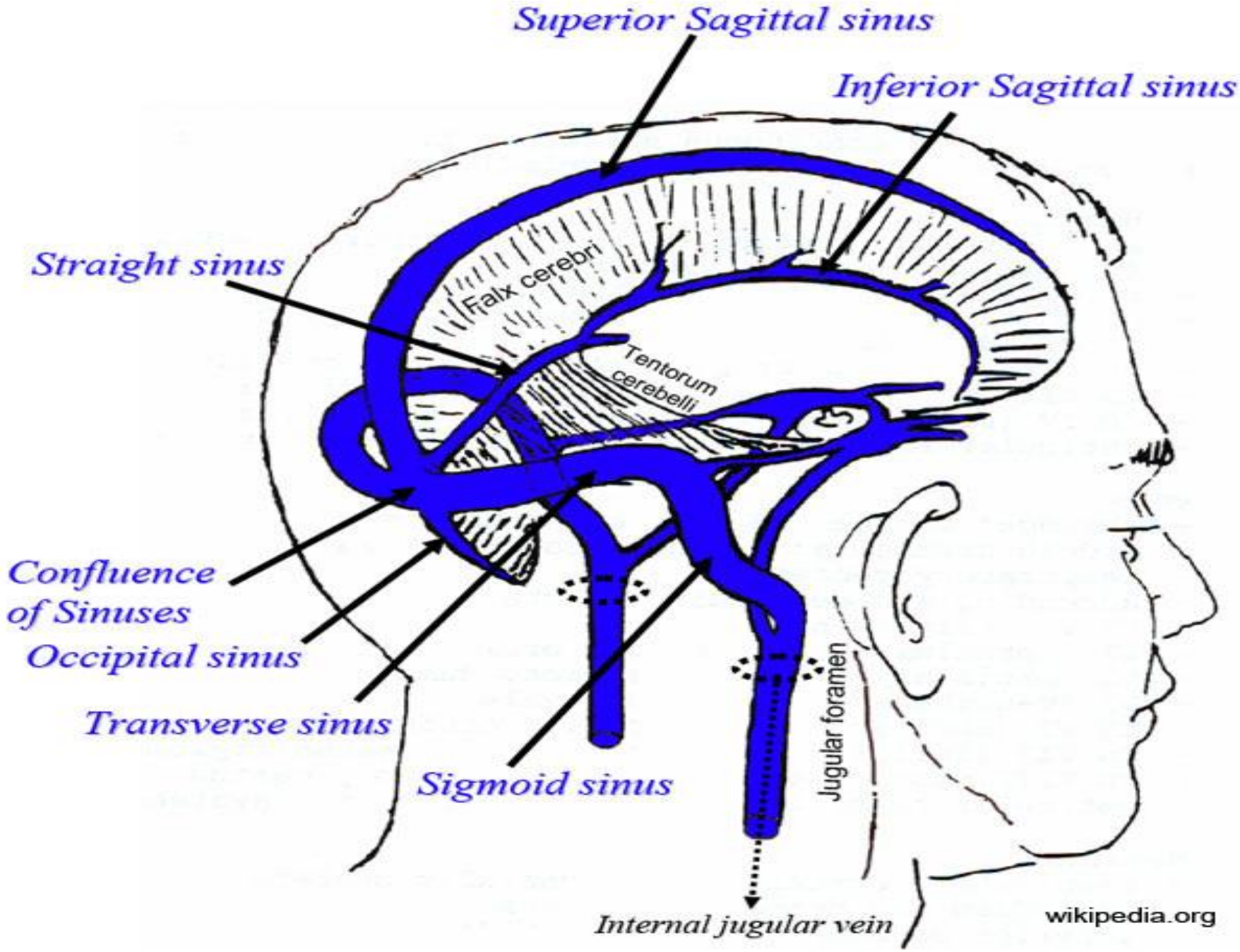
Sinus Venosus Duramater

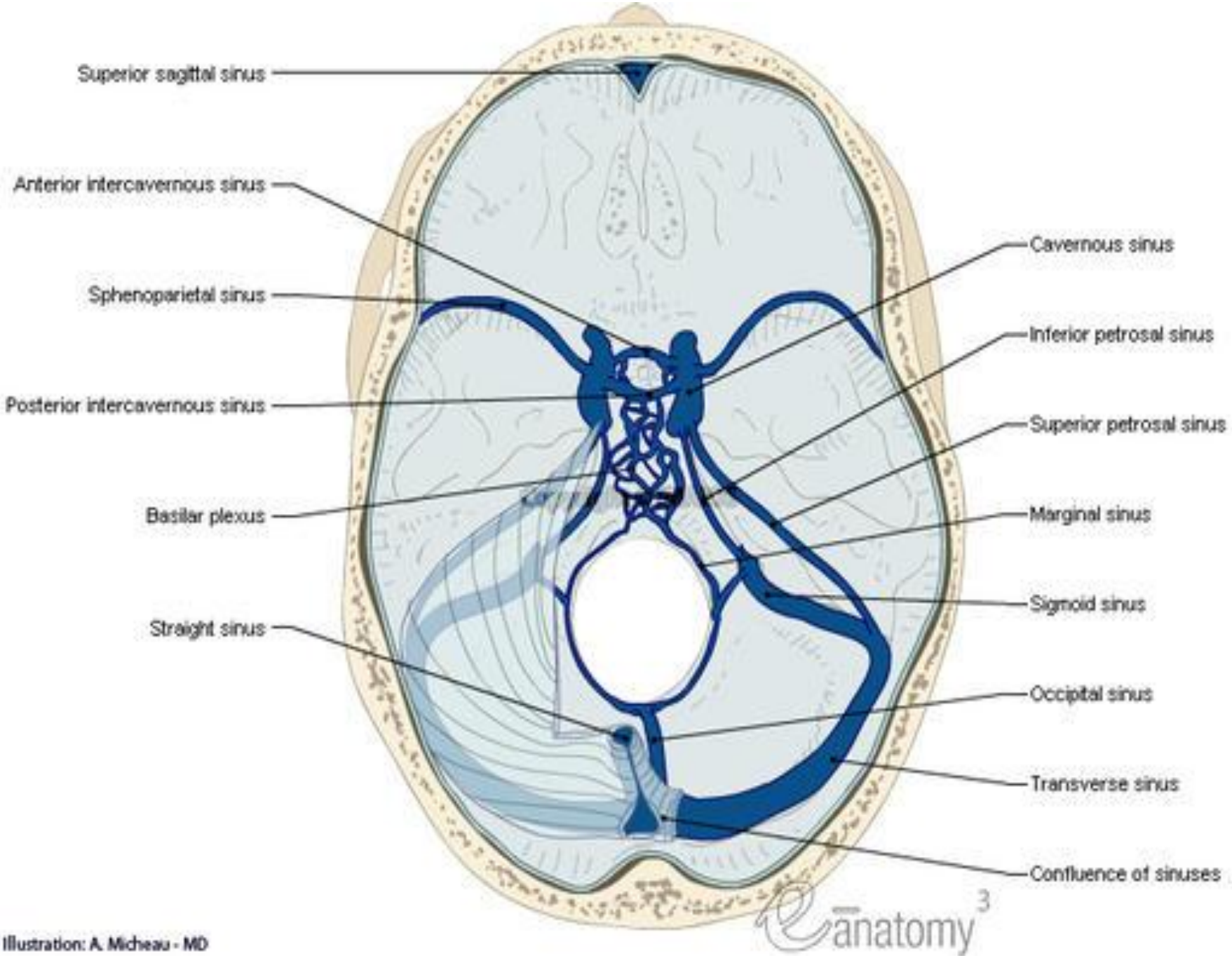
- Duramater terdiri atas 2 lapisan yang melekat satu sama lain, tetapi di beberapa tempat tertentu akan terpisah oleh pembuluh darah yang disebut sinus venosus duramater

- Darah vena yang berasal dari otak akan masuk ke dalam beberapa sinus venosus dan kemudian akan dialirkan ke vena jugular interna dan dilanjutkan ke sirkulasi ekstracranial

Sinus Venosus Duramater

1. sinus sagitalis superior
2. sinus sagitalis inferior
3. sinus rectus
4. sinus sphenoparietal
5. sinus petrosus superior
6. sinus petrosus inferior
7. sinus cavernosus
8. sinus intercavernosus anterior et posterior
9. Sinus sigmoid
10. sinus transversus
11. sinus occipital
12. confluens sinuum


Superior Sagittal sinus
Inferior Sagittal sinus
Straight sinus
Falx cerebri
Tentorum cerebelli
Confluence of Sinuses
Occipital sinus
Transverse sinus
Sigmoid sinus
Jugular foramen
Internal jugular vein
wikipedia.org


Superior sagittal sinus
Anterior intercavernous sinus
Sphenoparietal sinus
Posterior intercavernous sinus
Basilar plexus
Straight sinus
Cavernous sinus
Inferior petrosal sinus
Superior petrosal sinus
Marginal sinus
Sigmoid sinus
Occipital sinus
Transverse sinus
Confluence of sinuses
anatomy 3
Illustration: A. Micheau - MD

Arachnoid Mater Encephali

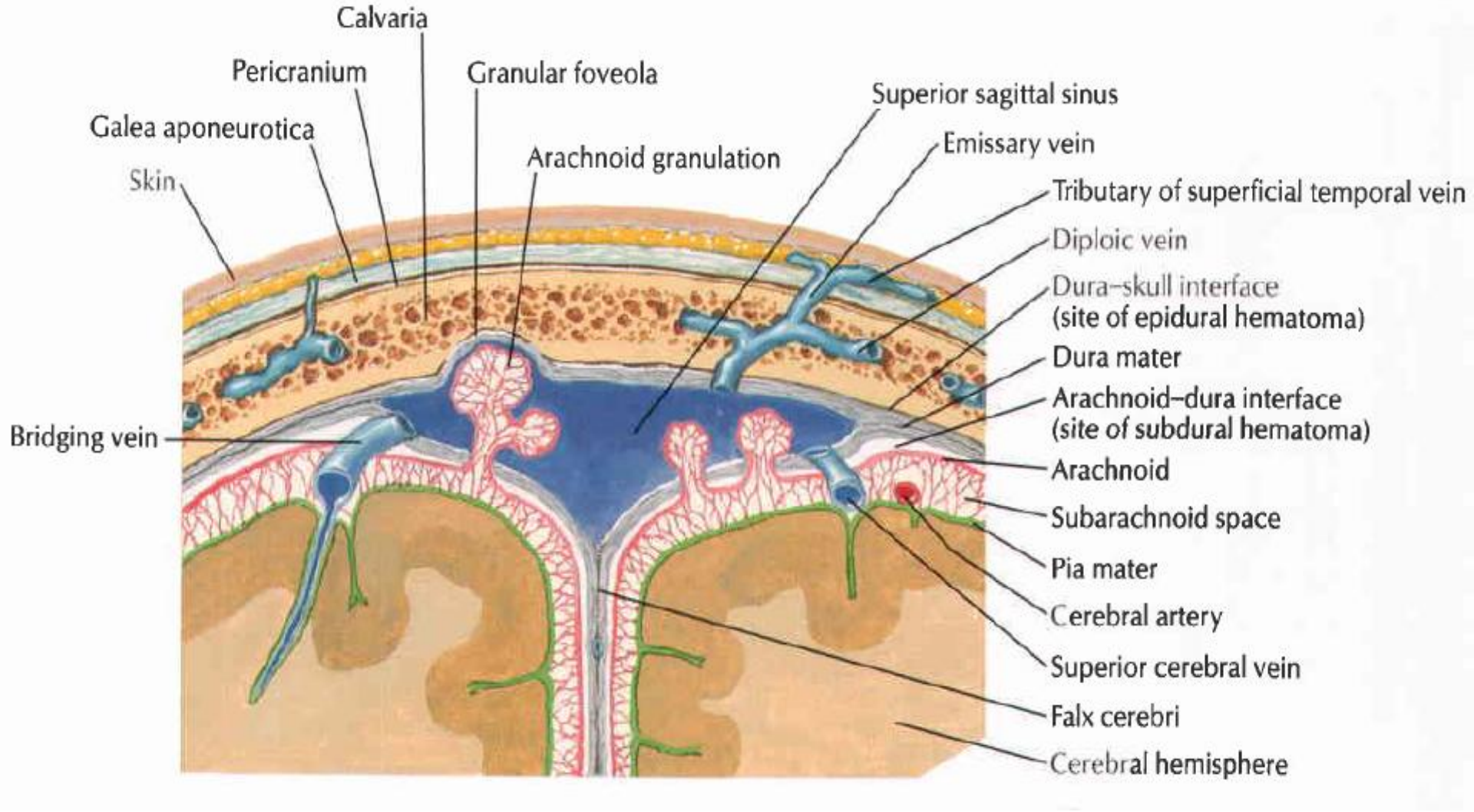
- Lapisan tengah meningen, disebut arachnoid mater karena memiliki penampilan seperti jaring laba-laba
- Lunak, transparan, seperti duramater (tidak melekat langsung pada otak)
- Dipisahkan dengan duramater oleh ruang subdural

Pia Mater Encephali

- Lapisan meningen terdalam
- tipis, membran yang mengandung pembuluh darah otak, membran yang mengikuti sampai ke bagian dalam otak (sulcus, fissura, dll)
- Ruang subarachnoid (di antara pia mater dan arachnoid mater)

- Ruang subarachnoid mengandung:

- jaringan penghubung berupa trabeculae dan dilalui oleh beberapa vena dan arteri
- Cerebrospinal fluid (CSF), yang disekresikan oleh plexus choroideus di dalam ventrikel otak

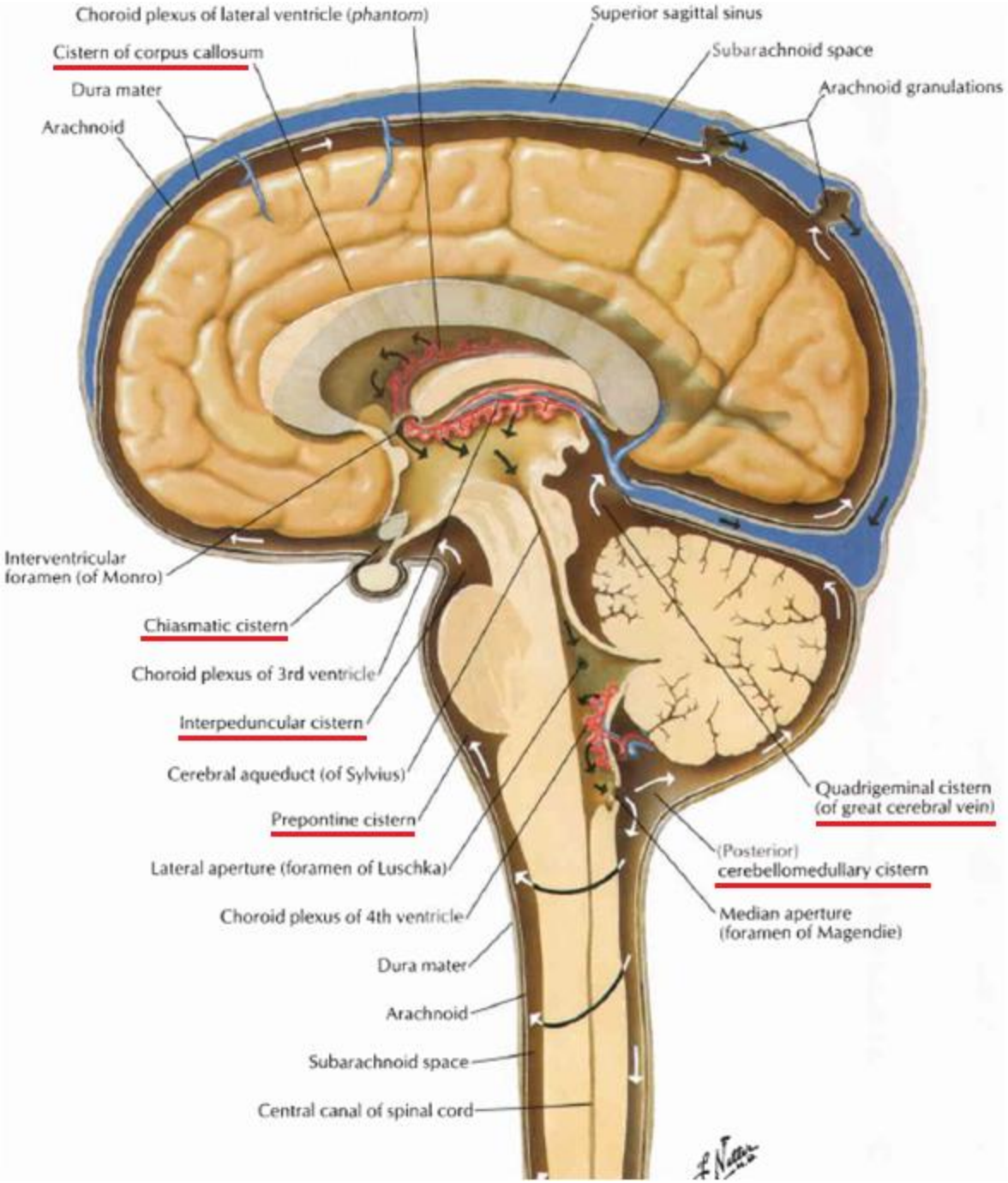

Calvaria
Pericranium
Granular foveola
Superior sagittal sinus
Galea aponeurotica
Emissary vein
Arachnoid granulation
Skin
Tributary of superficial temporal vein
Diploic vein
Dura–skull interface
(site of epidural hematoma)
Dura mater
Bridging vein
Arachnoid–dura interface
(site of subdural hematoma)
Arachnoid
Subarachnoid space
Pia mater
Cerebral artery
Superior cerebral vein
Falx cerebri
Cerebral hemisphere

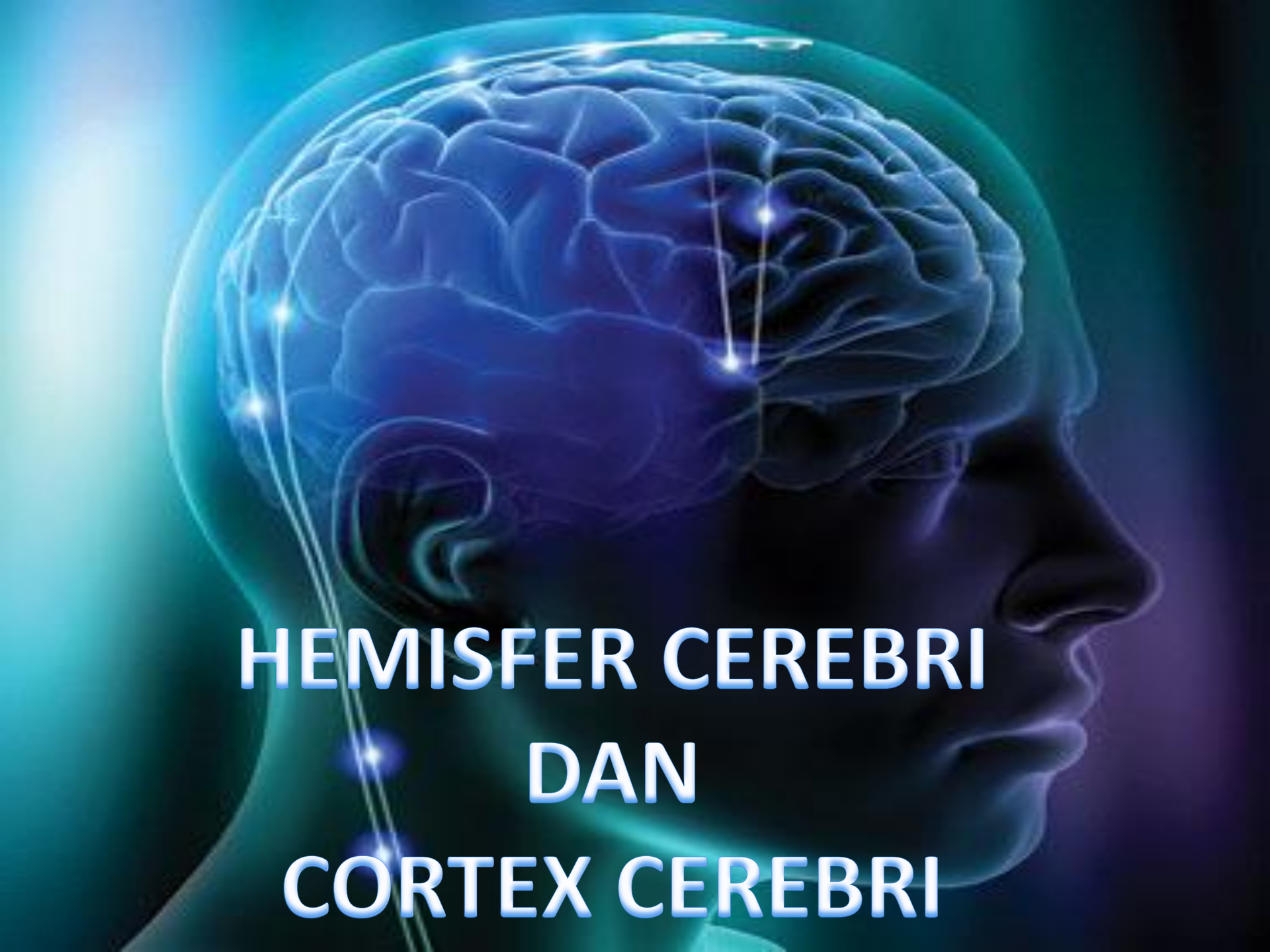
Cisterna Subarachnoid

- Ruang subarachnoid yang melebar dan agak dalam di beberapa daerah tertentu yang dibentuk oleh arachnoid mater

- Beberapa cisterna subarachnoid:

1. Cerebellomedullary cistern (Cisterna magna),
2. Interpeduncular cistern (Cisterna interpeduncularis),
3. Chiasmatic cistern,
4. Pontine cistern (Prepontine cistern or cisterna pontis),
5. Ambient cistern (Cisterna ambiens),
6. Quadrigeminal cistern (of great cerebral brain),
7. Cistern of corpus callosum.

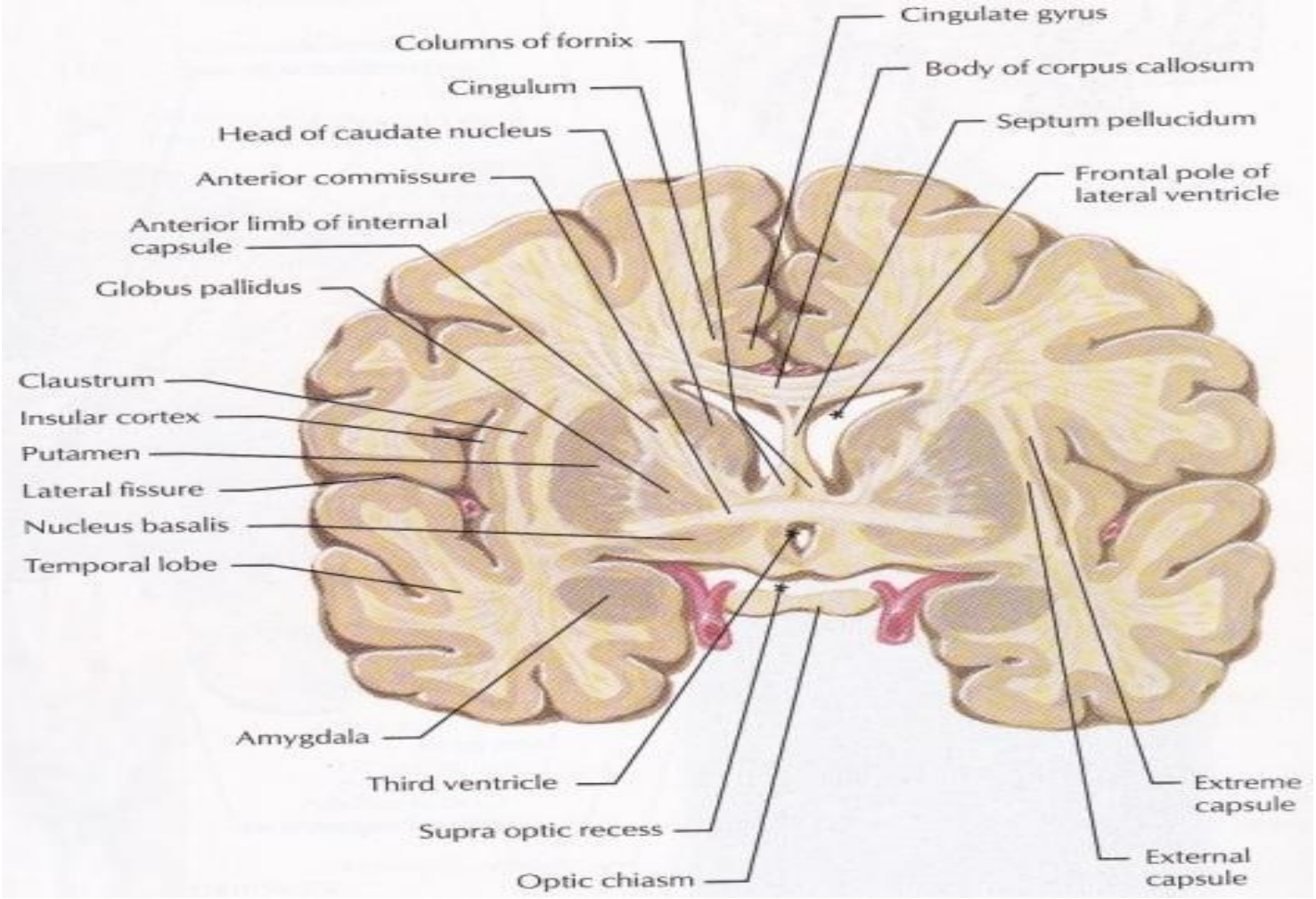

Choroid plexus of lateral ventricle (phantom)
Superior sagittal sinus
Cistern of corpus callosum
Subarachnoid space
Dura mater
Arachnoid granulations
Arachnoid
Interventricular foramen (of Monro)
Chiasmatic cistern
Choroid plexus of 3rd ventricle
Interpeduncular cistern
Cerebral aqueduct (of Sylvius)
Quadrigeminal cistern (of great cerebral vein)
Prepontine cistern
(Posterior) cerebellomedullary cistern
Lateral aperture (foramen of Luschka)
Median aperture (foramen of Magendie)
Choroid plexus of 4th ventricle
Dura mater
Arachnoid
Subarachnoid space
Central canal of spinal cord


HEMISFER CEREBRI
DAN
CORTEX CEREBRI

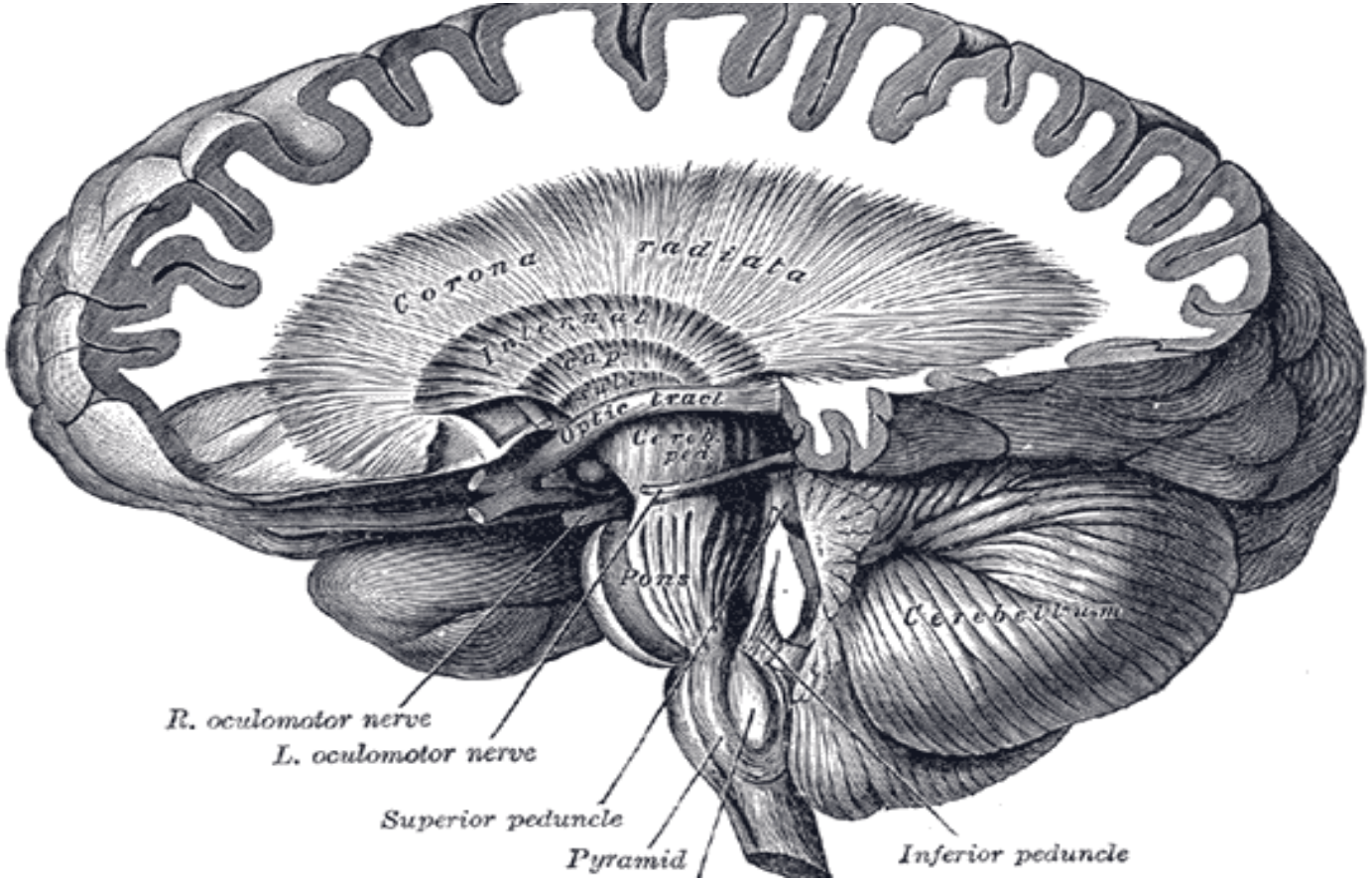
Hemisfer Cerebri

- Secara embriologi berasal dari telencephalon
- Terdiri atas:

- **Cortex cerebri** (substansia grisea/grey mater) meliputi gyrus dan sulcus
- **Centrum semi ovale** (substansia alba/white mater)
- **Ganglia basalis** (massa nukleus yang tertanam di dalam substansia alba)
- **Rhinencephalon**



- **capsula interna**
  - mengandung akson ascenden dan descenden
- **ventrikel lateral**
- **corpus striatum** or **ganglia basalis** → nucleus caudatus, putamen, and globus pallidus
- **corpus callosum**
- **fissura longitudinal major**

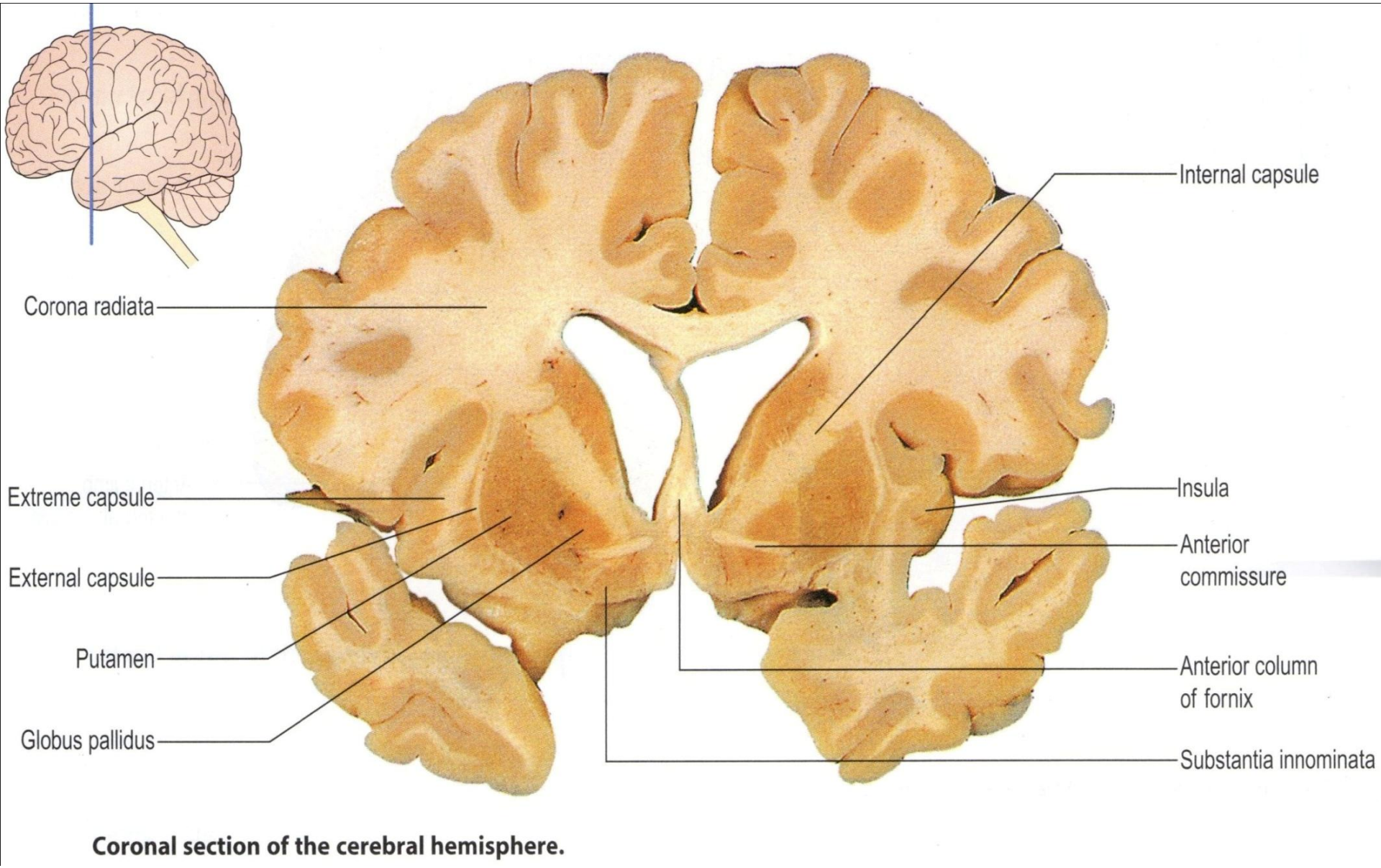


Corona radiata

• struktur seperti kipas angin yang terletak antara capsula interna dan cortex cerebri

• mengandung akson descenden dan ascenden yang membawa sinyal saraf dari dan ke cortex cerebri

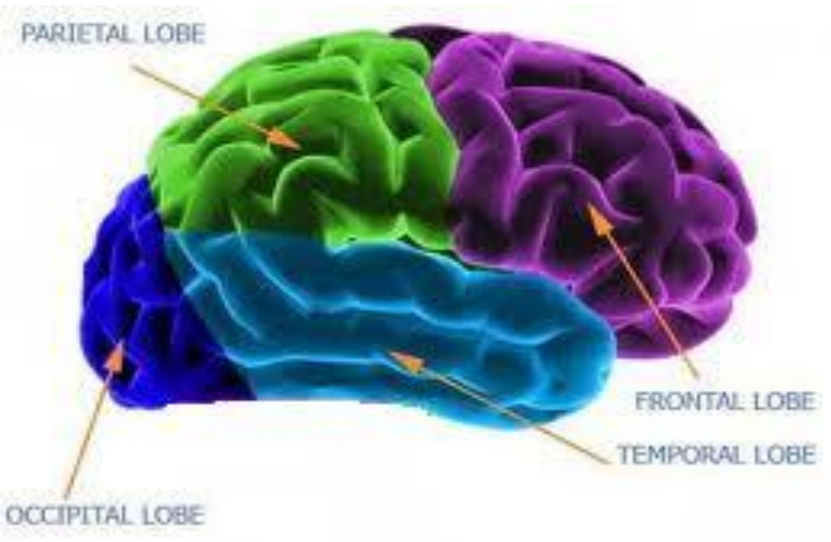
Corona Radiata

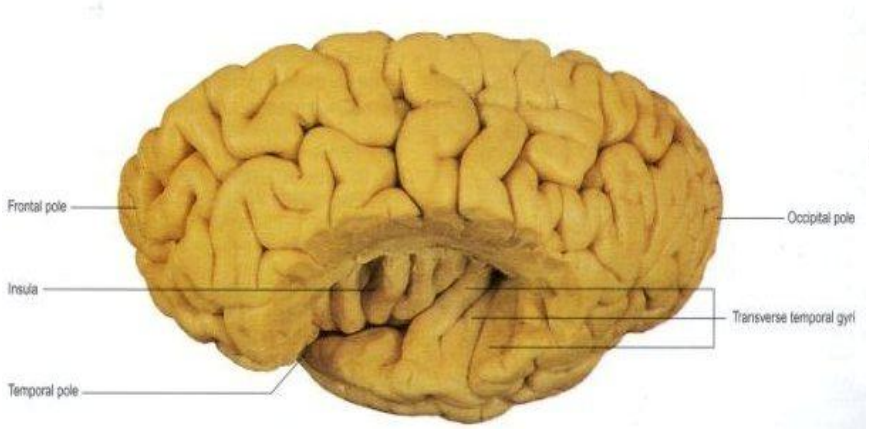


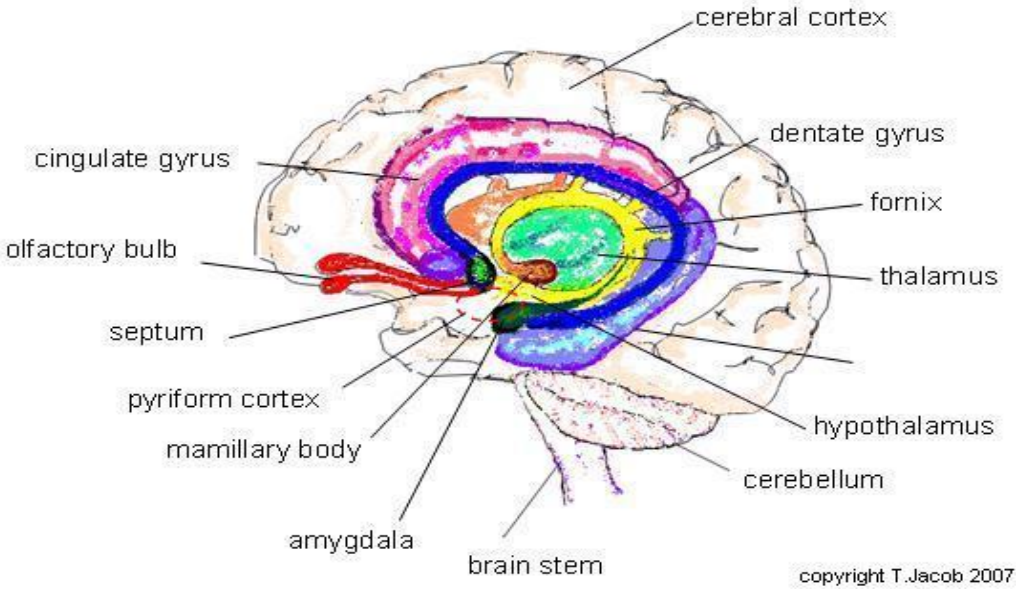
Coronal section of the cerebral hemisphere.

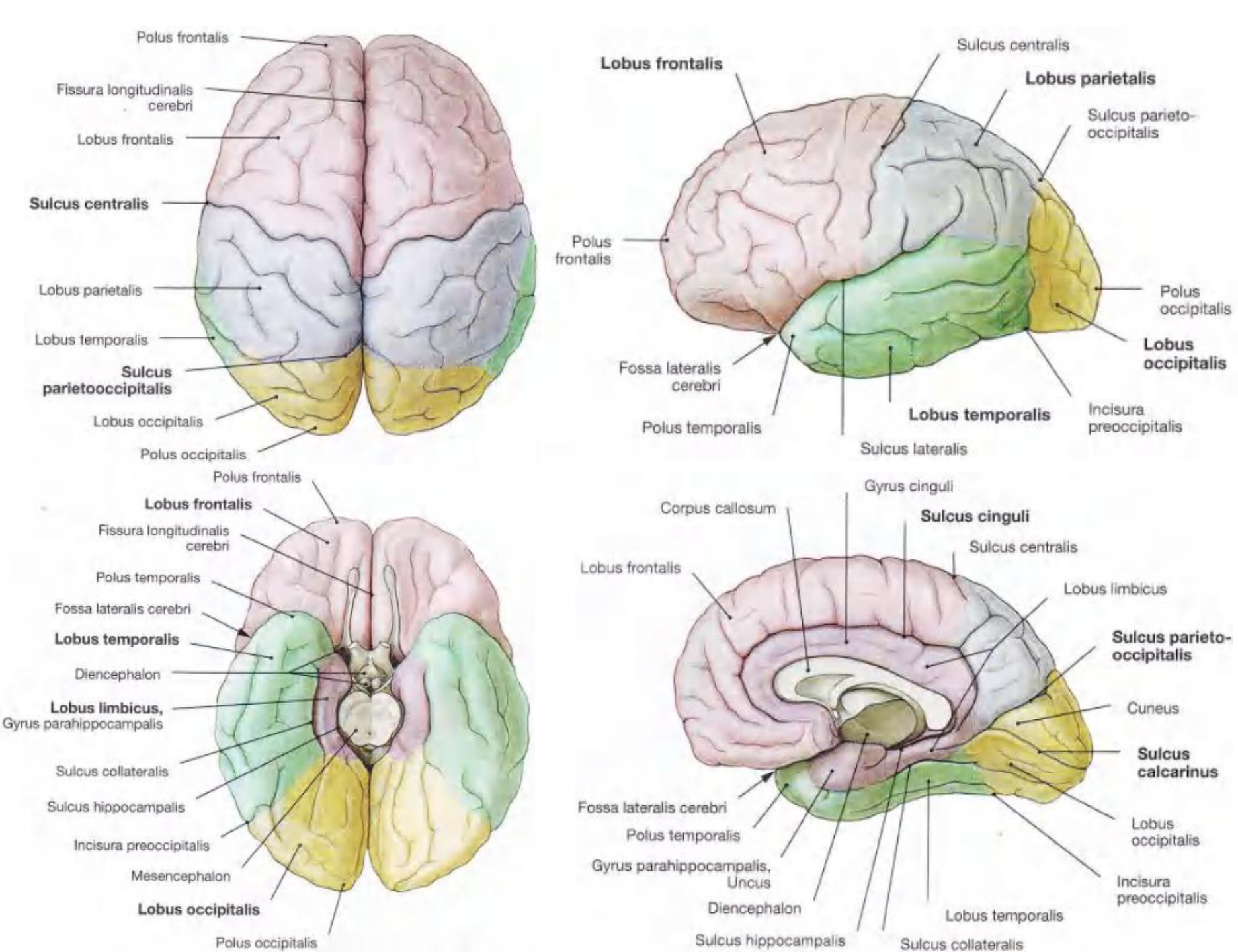
Lobus Hemisfer Cerebri

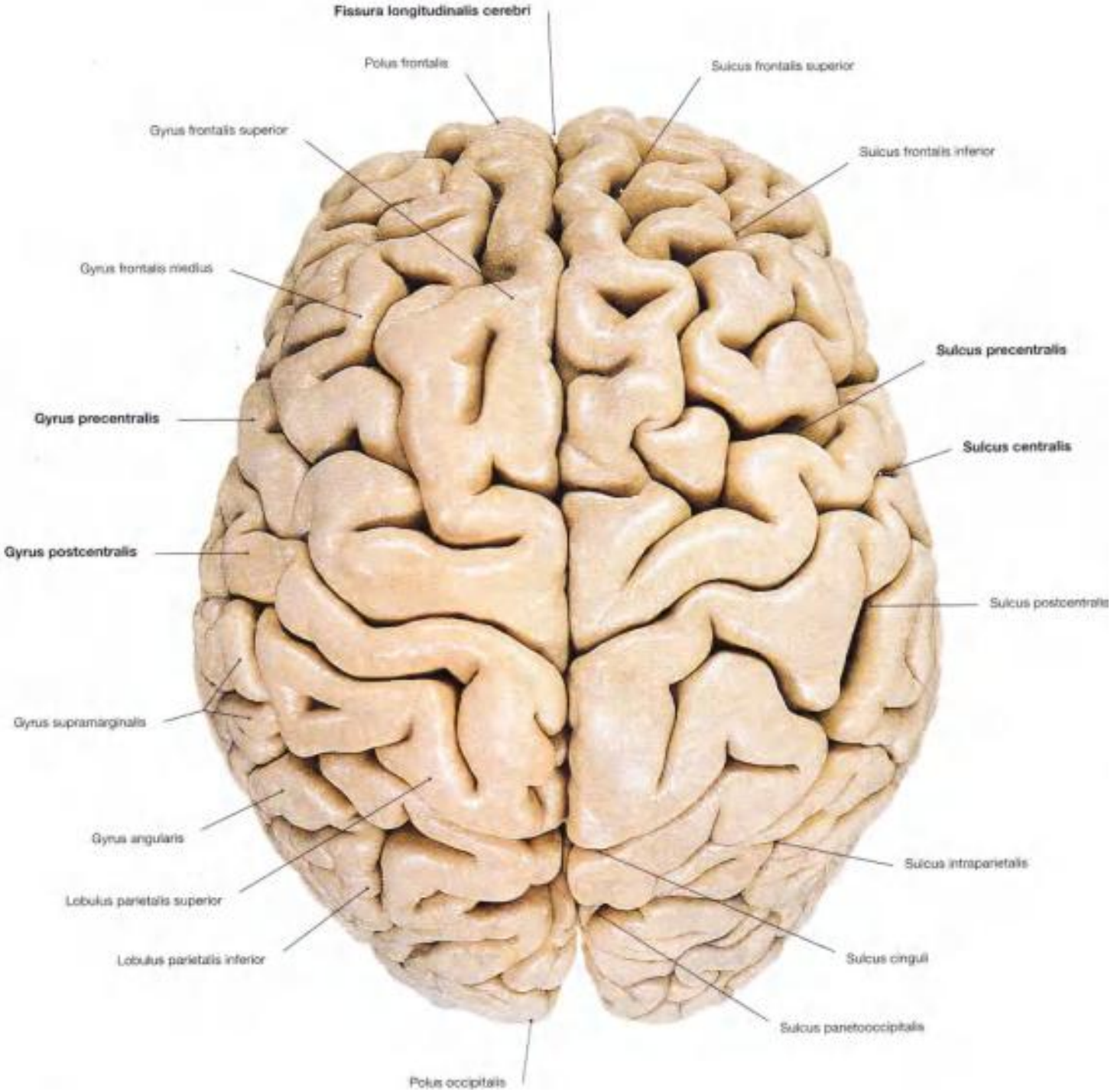
- Lobus frontal
- Lobus parietal
- Lobus temporal
- Lobus occipital
- Lobus insulae
- Limbic

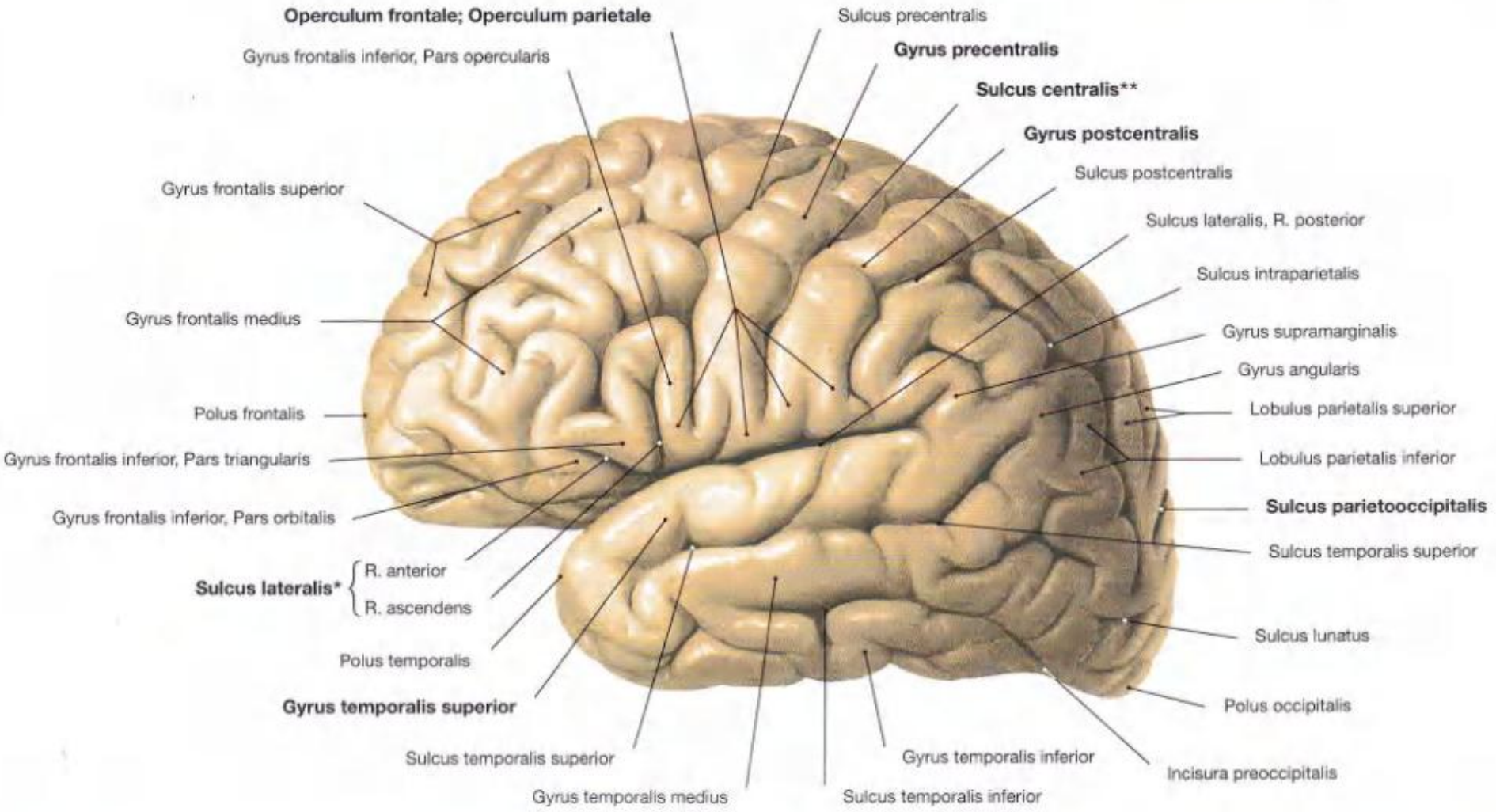


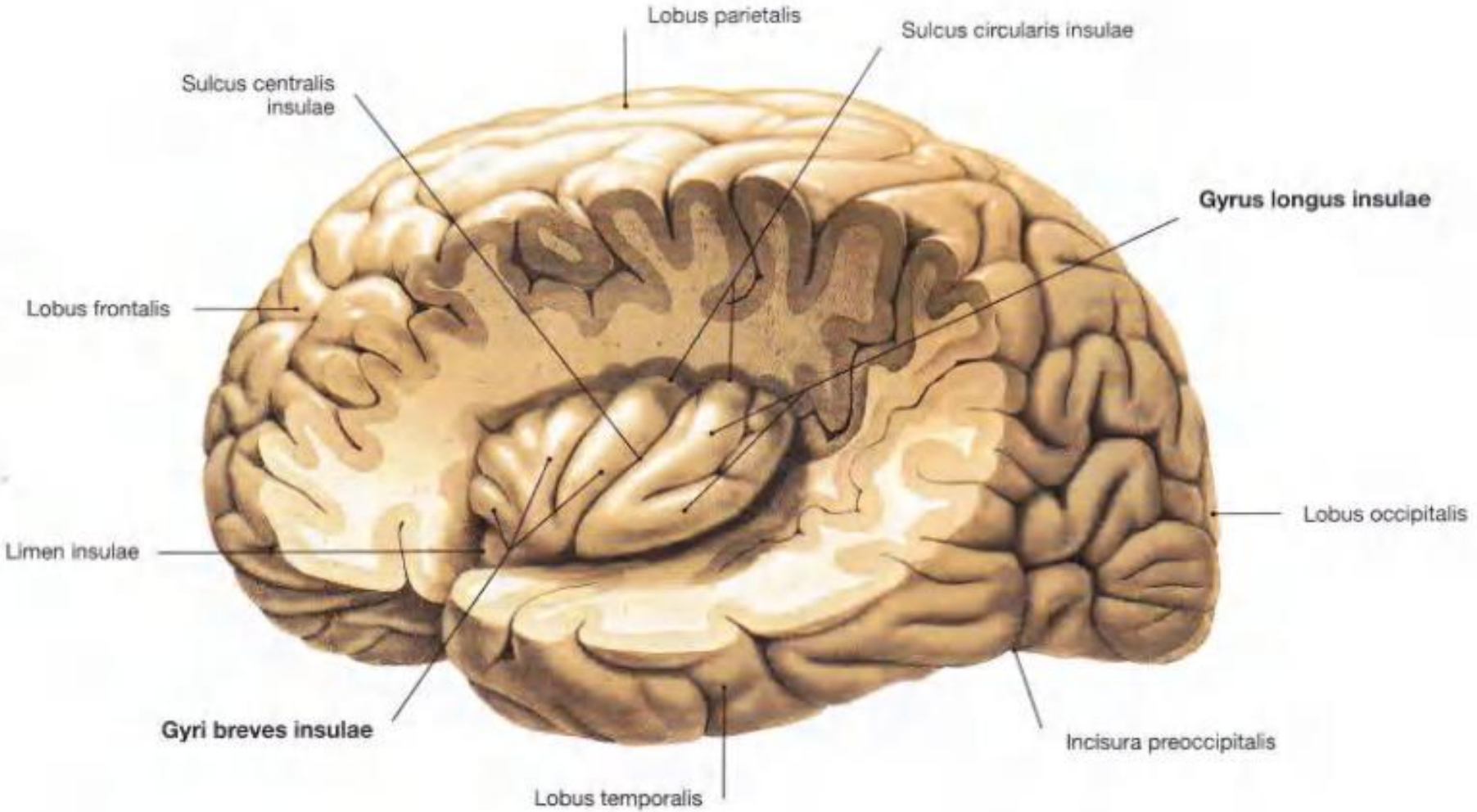


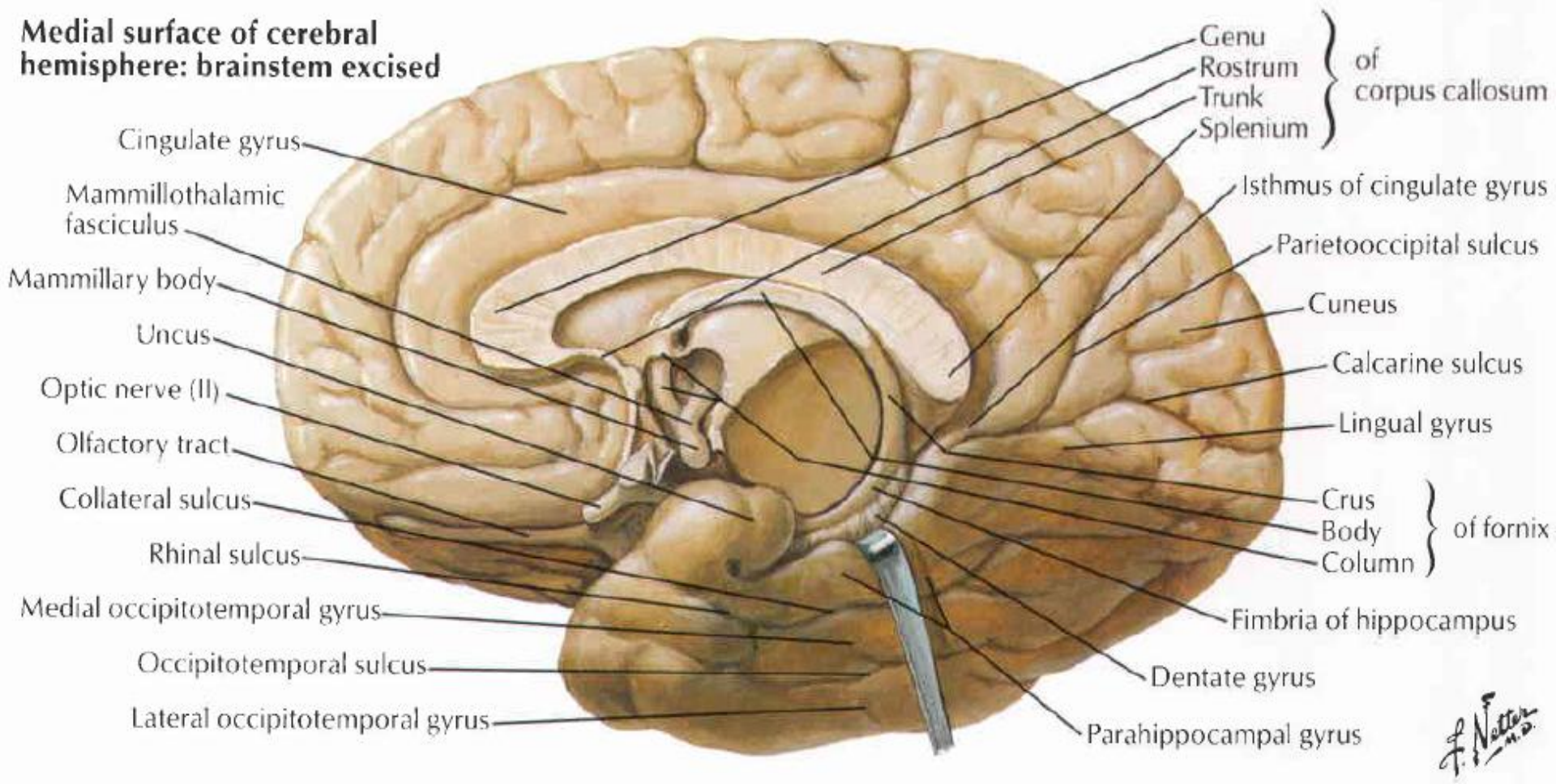


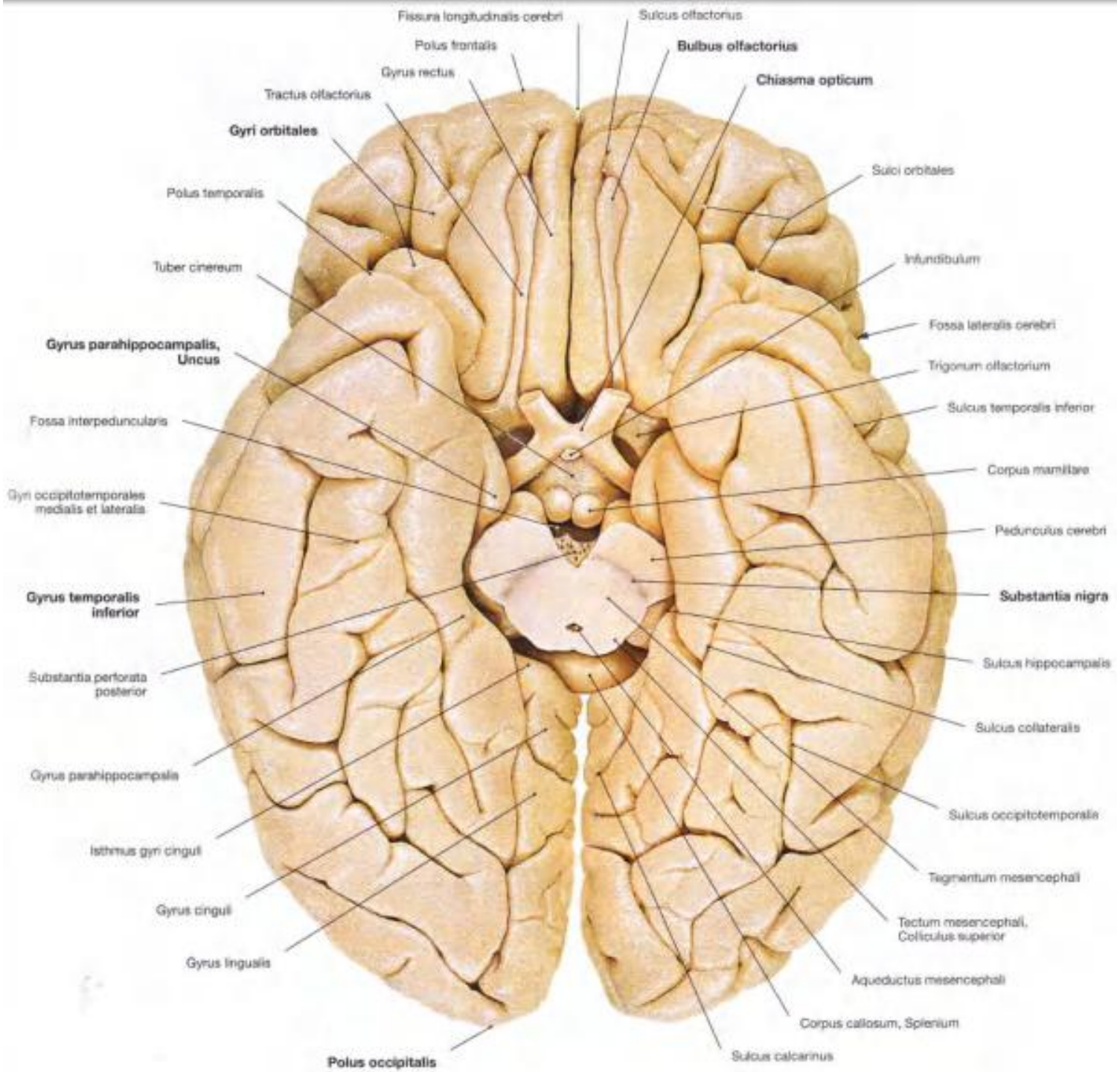

Polus frontalis
Fissura longitudinalis cerebri
Lobus frontalis
Sulcus centralis
Lobus parietalis
Lobus temporalis
Sulcus parietooccipitalis
Lobus occipitalis
Polus occipitalis
Lobus frontalis
Sulcus centralis
Lobus parietalis
Sulcus parieto-occipitalis
Polus frontalis
Polus occipitalis
Lobus occipitalis
Fossa lateralis cerebri
Lobus temporalis
Incisura preoccipitalis
Polus temporalis
Sulcus lateralis
Polus frontalis
Lobus frontalis
Fissura longitudinalis cerebri
Polus temporalis
Fossa lateralis cerebri
Lobus temporalis
Diencephalon
Lobus limbicus, Gyrus parahippocampalis
Sulcus collateralis
Sulcus hippocampalis
Incisura preoccipitalis
Mesencephalon
Lobus occipitalis
Polus occipitalis
Gyrus cinguli
Corpus callosum
Sulcus cinguli
Sulcus centralis
Lobus frontalis
Lobus limbicus
Sulcus parieto-occipitalis
Cuneus
Sulcus calcarinus
Fossa lateralis cerebri
Polus temporalis
Lobus occipitalis
Gyrus parahippocampalis, Uncus
Incisura preoccipitalis
Diencephalon
Lobus temporalis
Sulcus hippocampalis
Sulcus collateralis


Fissura longitudinalis cerebri
Polus frontalis
Sulcus frontalis superior
Gyrus frontalis superior
Sulcus frontalis inferior
Gyrus frontalis medius
Sulcus precentralis
Gyrus precentralis
Sulcus centralis
Gyrus postcentralis
Sulcus postcentralis
Gyrus supramarginalis
Gyrus angularis
Sulcus intraparietalis
Lobulus parietalis superior
Sulcus cinguli
Lobulus parietalis inferior
Sulcus parietooccipitalis
Polus occipitalis


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


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


Medial surface of cerebral hemisphere: brainstem excised
Cingulate gyrus
Mammillothalamic fasciculus
Mammillary body
Uncus
Optic nerve (II)
Olfactory tract
Collateral sulcus
Rhinal sulcus
Medial occipitotemporal gyrus
Occipitotemporal sulcus
Lateral occipitotemporal gyrus
Genu
Rostrum
Trunk
Splenium
of corpus callosum
Isthmus of cingulate gyrus
Parietooccipital sulcus
Cuneus
Calcarine sulcus
Lingual gyrus
Crus
Body
Column
of fornix
Fimbria of hippocampus
Dentate gyrus
Parahippocampal gyrus
F. Netter M.D.

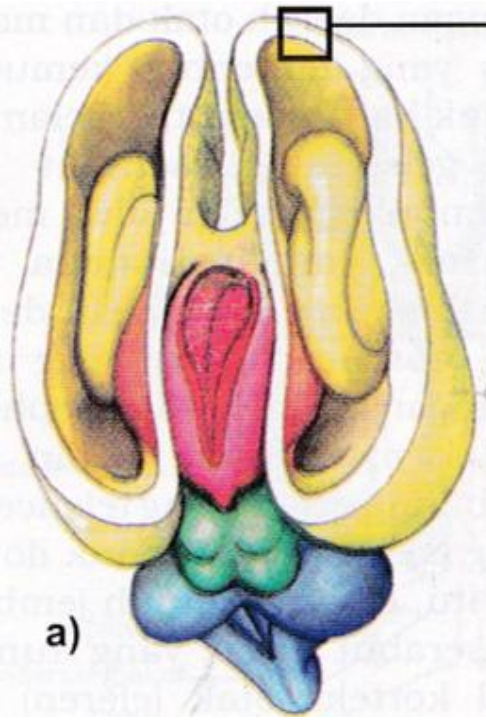

Fissura longitudinalis cerebri
Sulcus olfactorius
Polus frontalis
Bulbus olfactorius
Gyrus rectus
Chiasma opticum
Tractus olfactorius
Gyri orbitales
Sulci orbitales
Polus temporalis
Infundibulum
Tuber cinereum
Fossa lateralis cerebri
Gyrus parahippocampalis, Uncus
Trigonum olfactorium
Sulcus temporalis inferior
Fossa interpeduncularis
Corpus mamillare
Gyri occipitotemporales mediales et laterales
Pedunculus cerebri
Gyrus temporalis inferior
Substantia nigra
Substantia perforata posterior
Sulcus hippocampalis
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

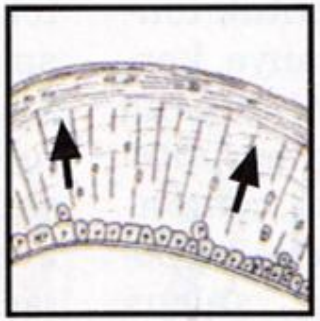
Cortex Cerebri

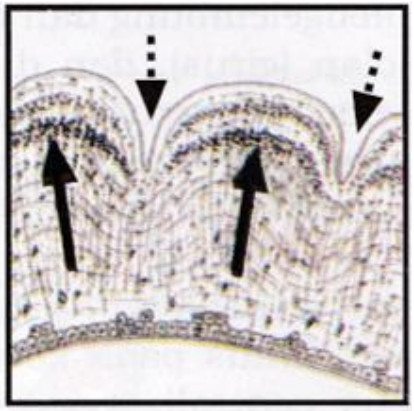
Struktur Histologi

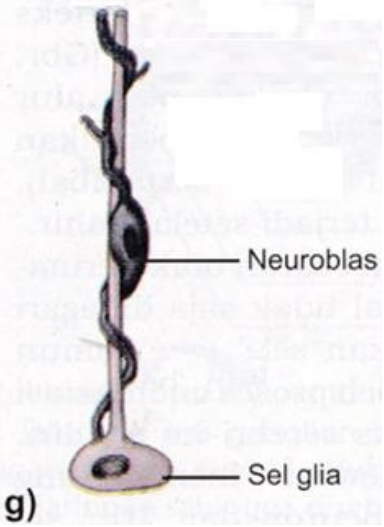
Terdiri atas :

- Archicortex dan Paleocortex → bagian filogenetikal tertua dari cortex cerebri
  - hippocampus dan bagian lain dari lobus temporal
  - Tiga lapis sel
- Neocortex
  - Enam lapis sel

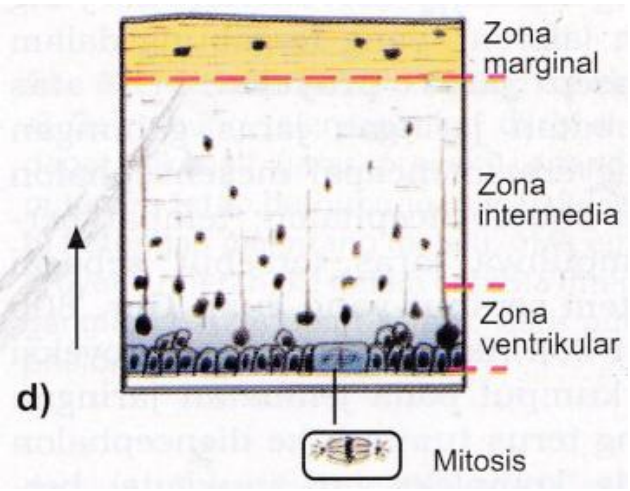


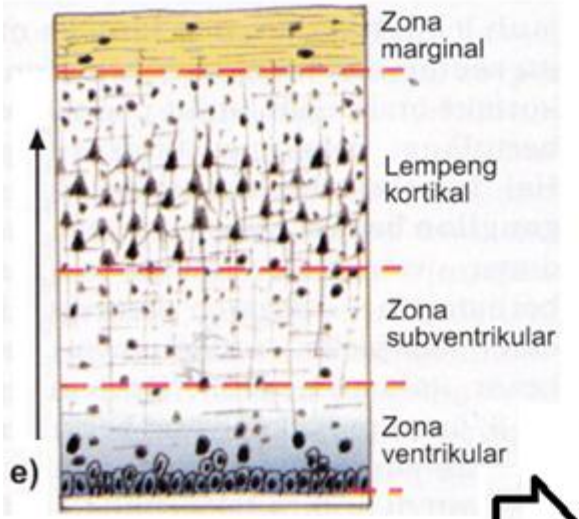


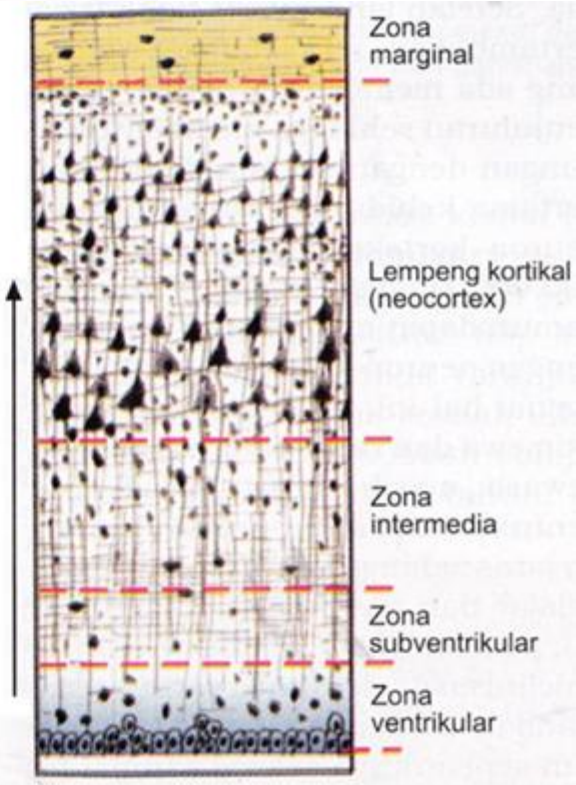




Otak embrional (Bulan ke-3)







Histological Structure of Cerebral Cortex

- **Molecular (plexiform) layer**

  Few nerve cell bodies but many dendritic and axonal processes in synaptic interaction
- **OUTER granular layer**

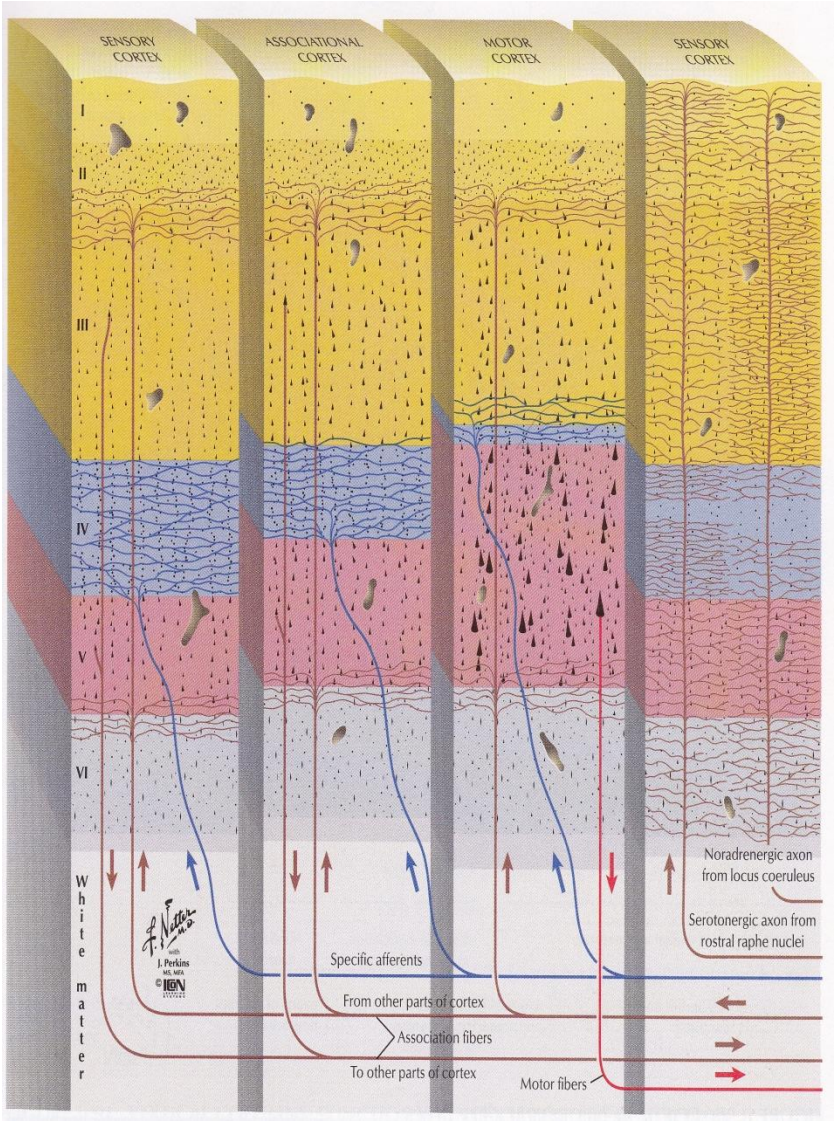
  Many small neurones, which establish intracortical connections
- **OUTER pyramidal cell layer**

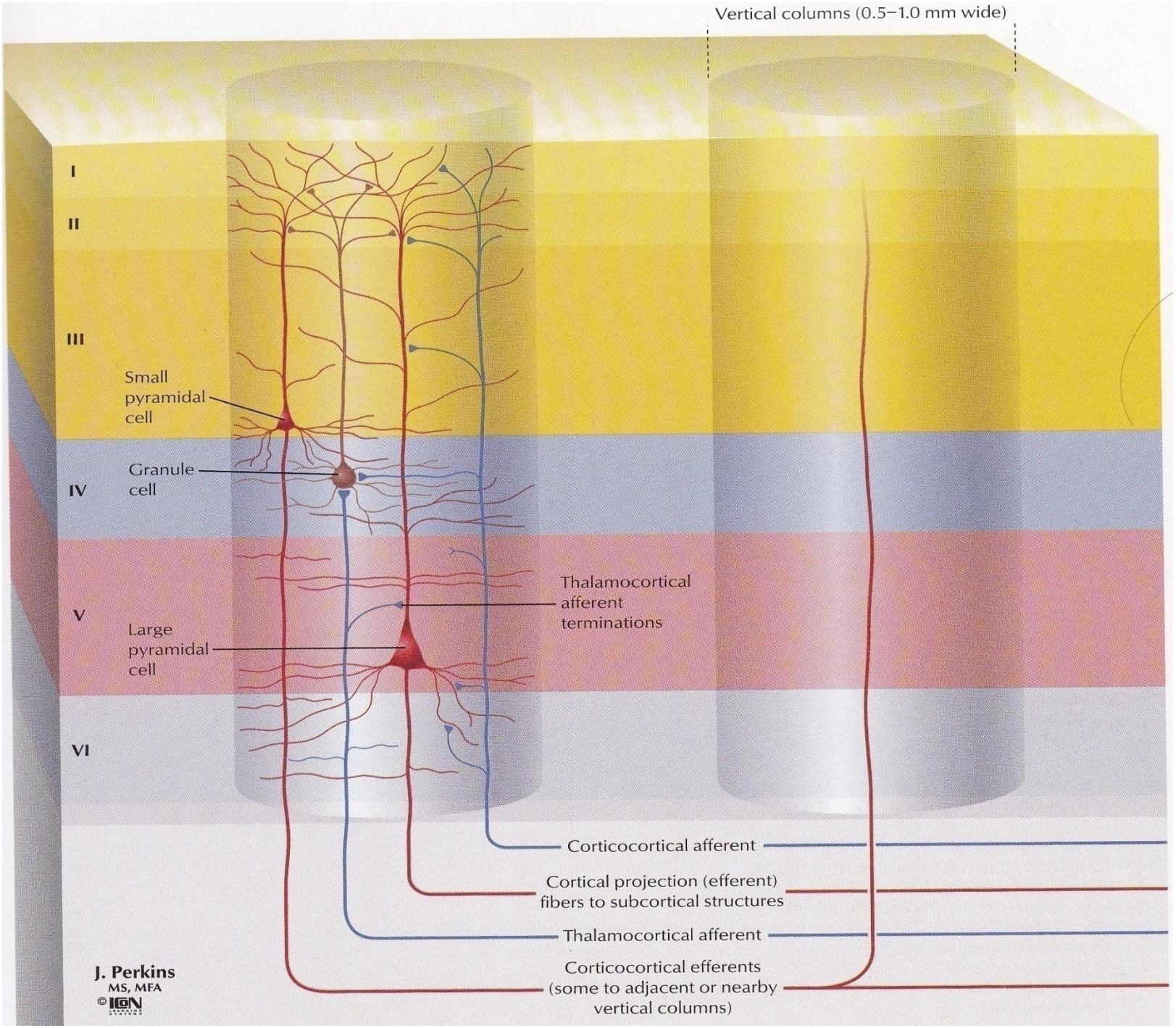
  Medium-sized neurones giving rise to association and commissural fibres
- **INNER granular layer**

  The side of termination of afferent fibres from the spesific thalamic nuclei
- **INNER pyramidal cell later (ganglionic layer)**

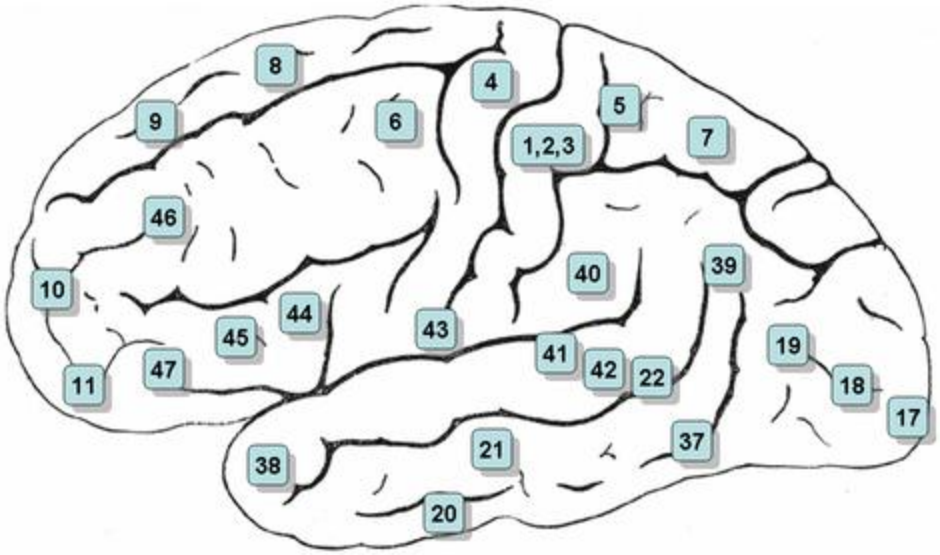
  Origin of projection fibres to extracortical targets. In primary motor cortex, this layer contains giant Betz's cells
- **Multiform cell layer**

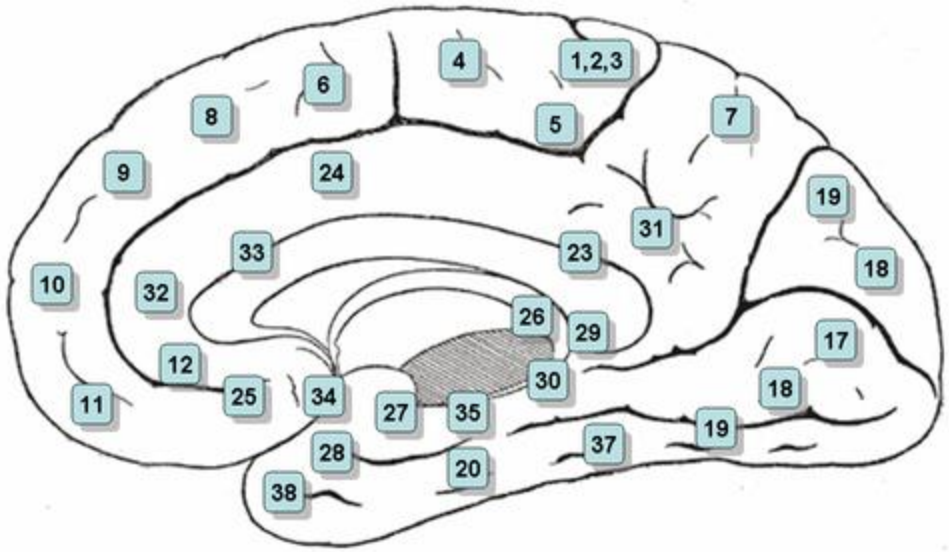
  Contains association and projection neurones

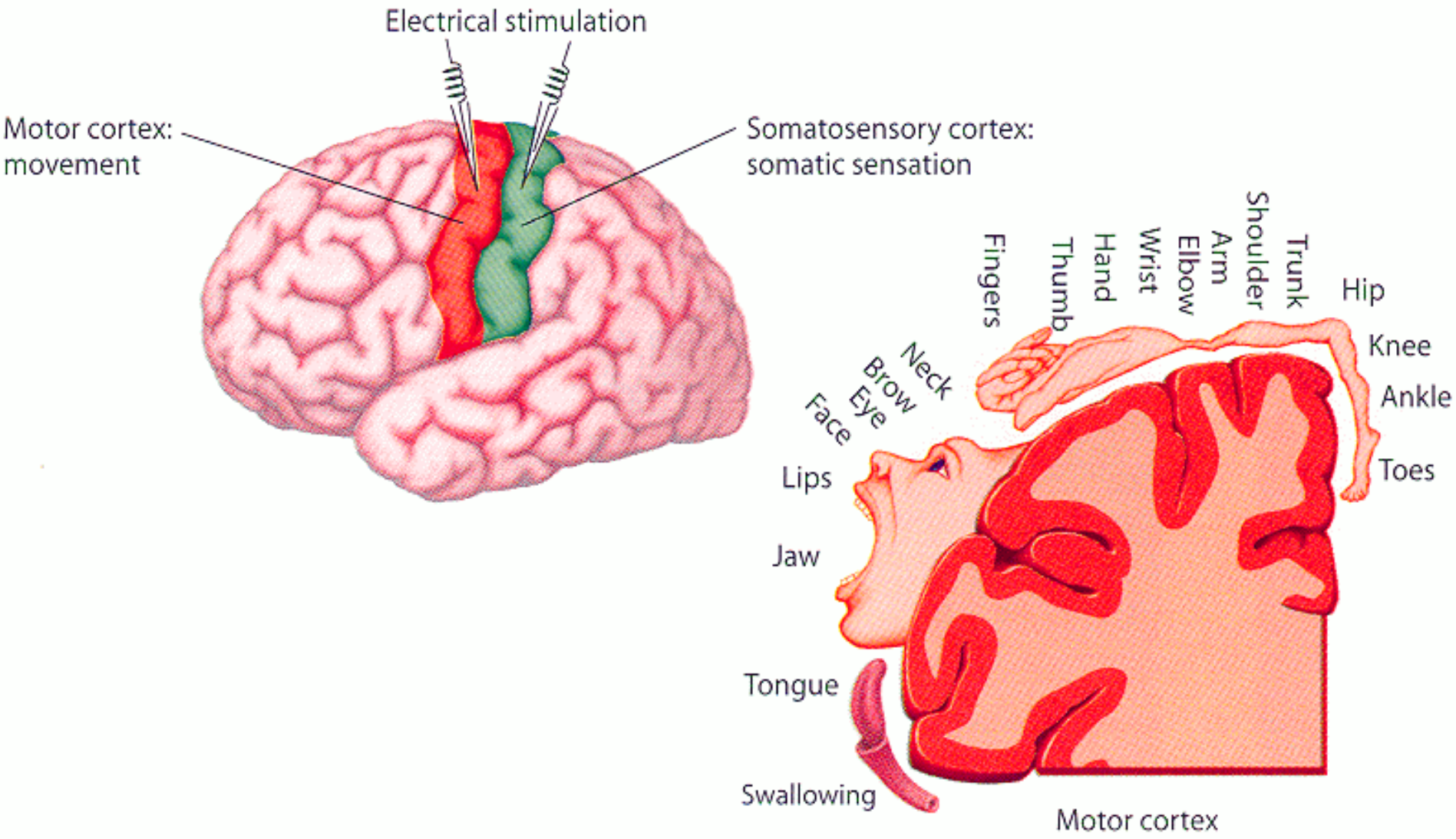


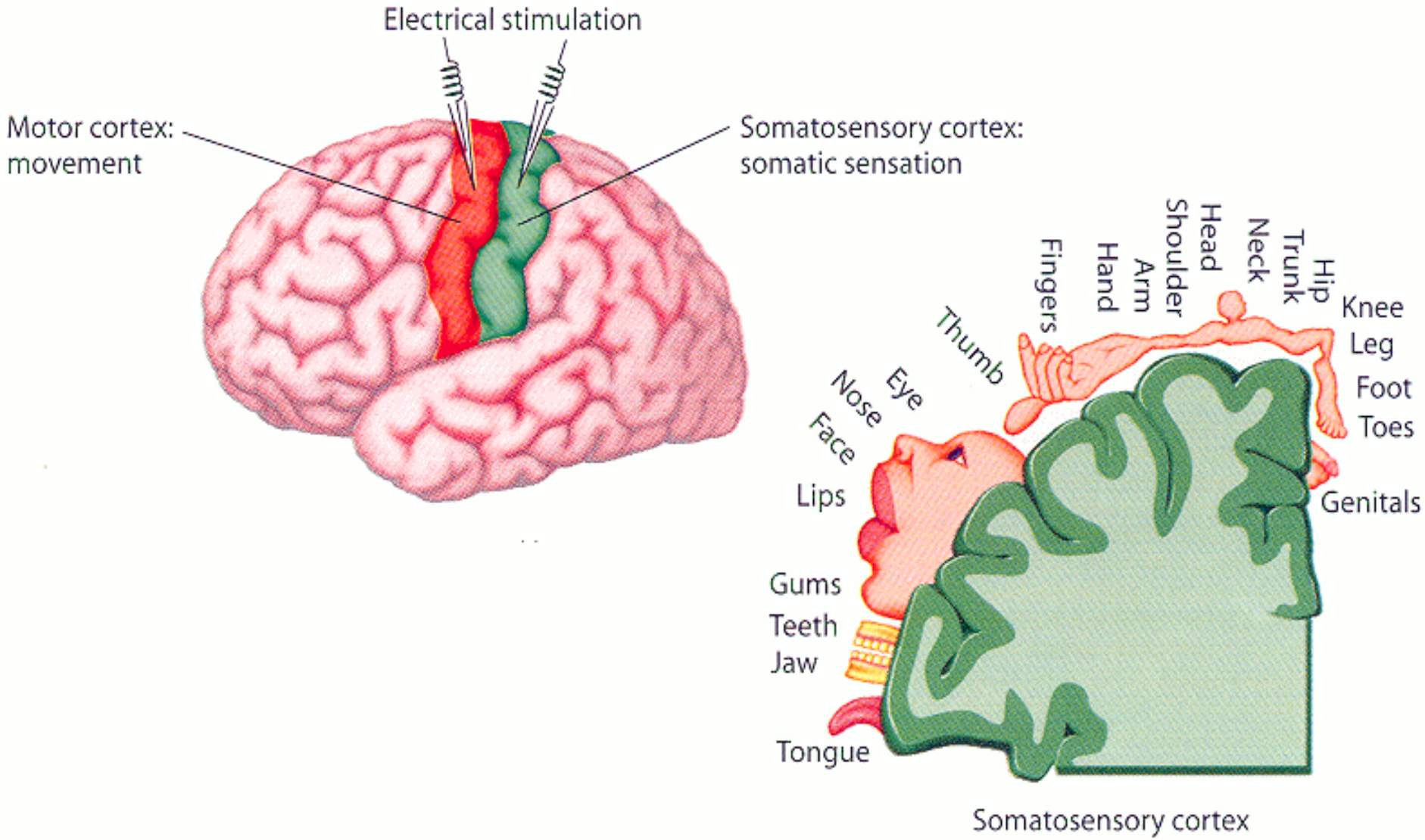

Vertical columns (0.5–1.0 mm wide)
I
II
III
IV
V
VI
Small pyramidal cell
Granule cell
Large pyramidal cell
Thalamocortical afferent terminations
Corticocortical afferent
Cortical projection (efferent) fibers to subcortical structures
Thalamocortical afferent
Corticocortical efferents (some to adjacent or nearby vertical columns)
J. Perkins
MS, MFA
©ION

Fungsi	Area Brodmann
Penglihatan	
primer	17
sekunder	18, 19, 20, 21, 37
Pendengaran	
primer	41, 42
sekunder	22
Sensasi tubuh (sensorik)	
primer	1, 2, 3
sekunder	5, 7
tersier	7, 22, 37, 39, 40
Motorik	
primer	4
sekunder	6
gerakan mata	8
bicara	44
tersier	9, 10, 11, 45, 46, 47

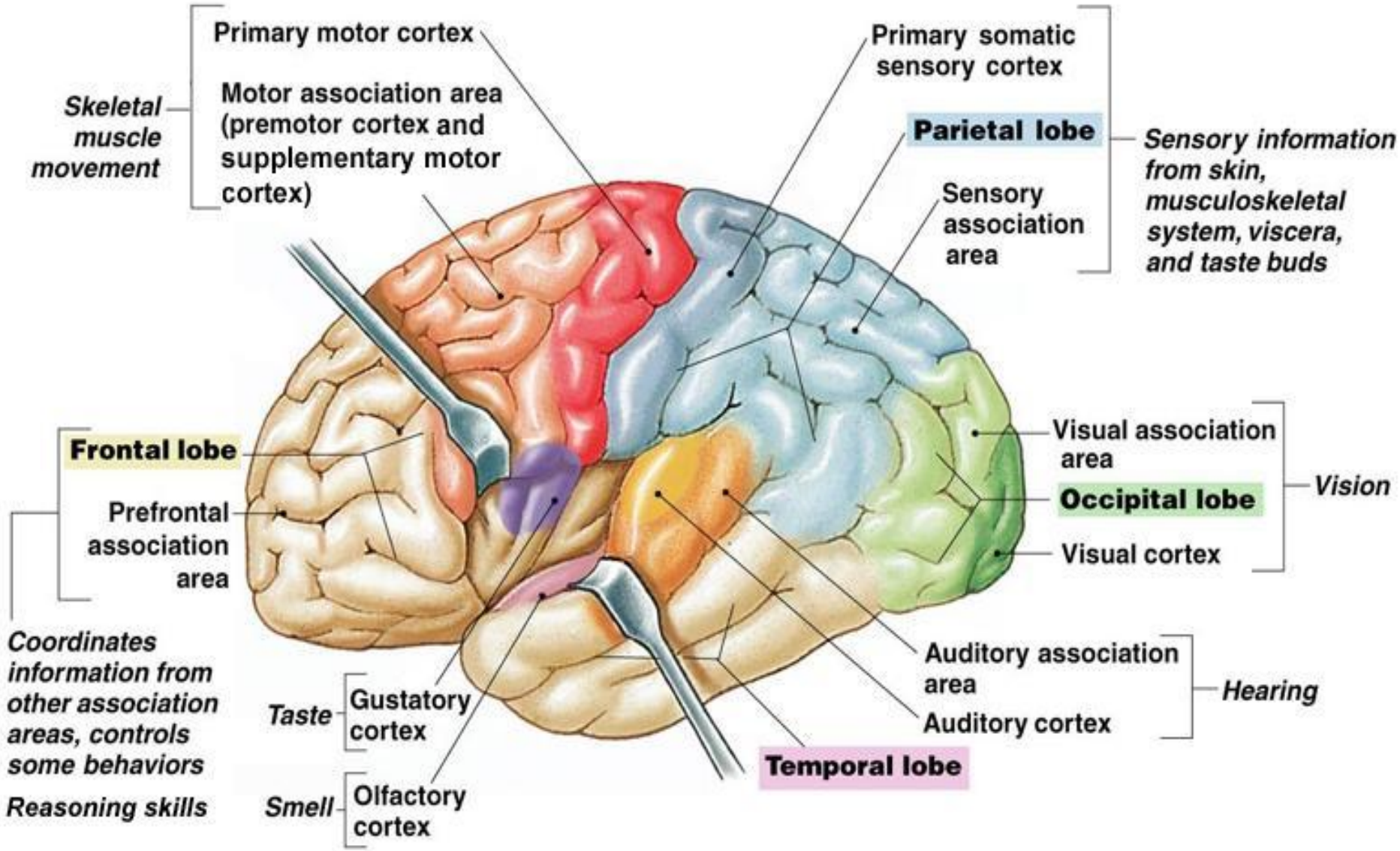




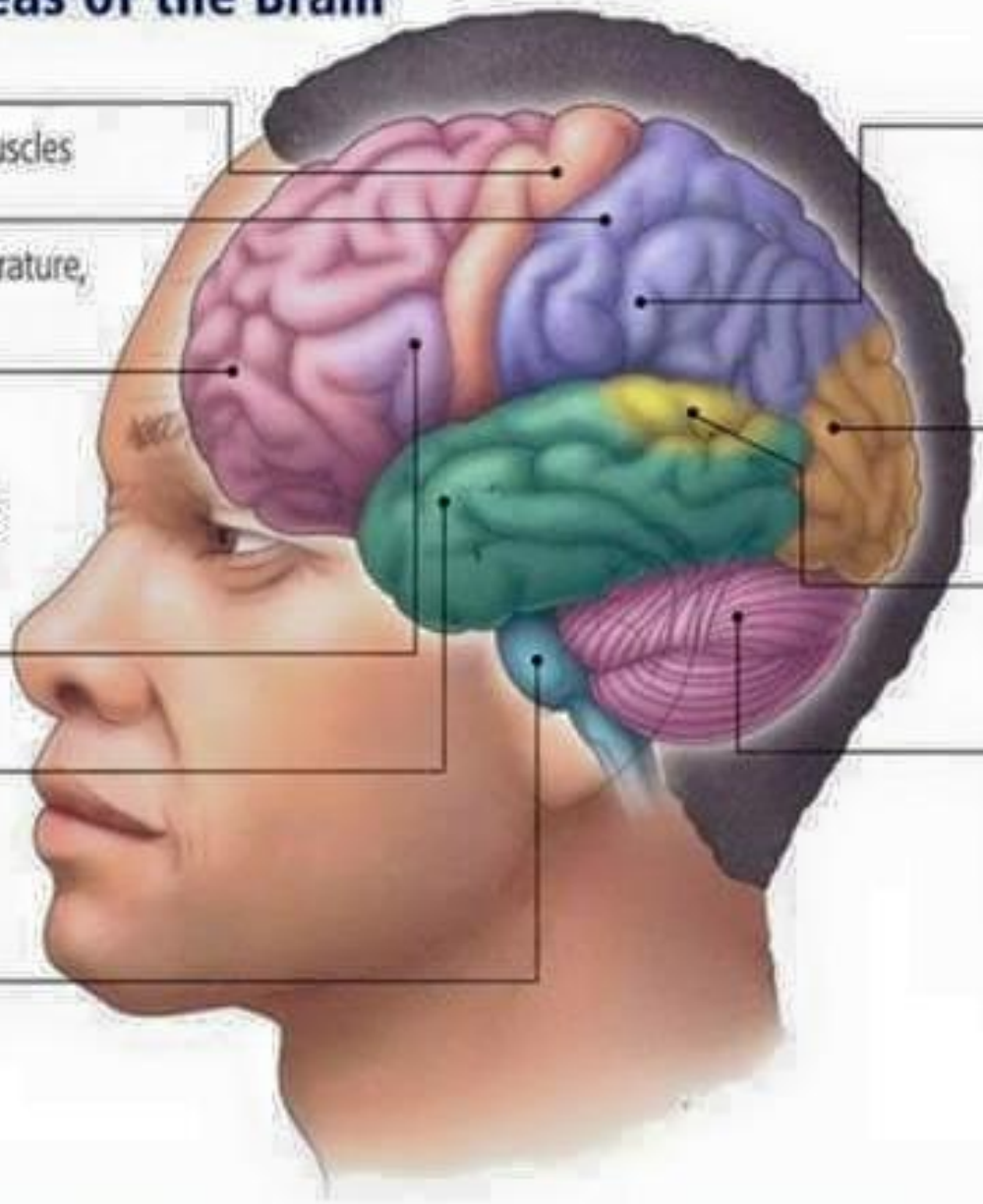

Electrical stimulation
Motor cortex:
movement
Somatosensory cortex:
somatic sensation
Fingers
Thumb
Hand
Wrist
Elbow
Arm
Shoulder
Trunk
Hip
Knee
Ankle
Toes
Neck
Brow
Eye
Face
Lips
Jaw
Tongue
Swallowing
Motor cortex


Electrical stimulation
Motor cortex: movement
Somatosensory cortex: somatic sensation
Fingers
Hand
Arm
Shoulder
Head
Neck
Trunk
Hip
Knee
Leg
Foot
Toes
Genitals
Thumb
Eye
Nose
Face
Lips
Gums
Teeth
Jaw
Tongue
Somatosensory cortex

Organisasi Fungsional



Functional Areas of the Brain[1]



Motor Area
- control of voluntary muscles

Sensory Area
- skin sensations (temperature, pressure, pain)

Frontal Lobe
- movement
- problem solving
- concentrating, thinking
- behaviour, personality, mood

Broca's Area
- speech control

Temporal Lobe
- hearing
- language
- memory

Brain Stem
- consciousness
- breathing
- heart rate

Parietal Lobe
- sensations
- language
- perception
- body awareness
- attention

Occipital Lobe
- vision
- perception

Wernicke's Area
- language comprehension

Cerebellum
- posture
- balance
- coordination of movement

Organisasi Fungsional Cerebrum

- Informasi sensorik → area sensorik primer (lobus parietal/somatosensori, lobus occipital/visual, lobus temporal/hearing → cortex asosiasi→ touch, sight, and hearing.

- **Lobus frontal**

 - area motorik primer, premotor, area motorik tambahan → pengaturan pergerakan

 - area prefrontal → pengaturan perilaku motorik

- Korteks asosiasi di lobus frontal, parietal, dan temporal hemisfer kiri → ekspresi bahasa

* Hemisfer kiri lebih dominan untuk bahasa

Organisasi Fungsional Cerebrum

- **Sistem Limbik**

- Tuberculum thalamica anterior
- Gyrus cinguli
- Gyrus parahipocampalis
- Gyri subcallosal
- Gyrus supracallosal (indusium griseum)
- Hipocampal formation (hippocampus & gyrus dentatus)
- Amigdala
- Fornix
- Area septal
- Corpus mamillaris

❖ menyimpan dan mengambil proses informasi pada regio posterior hemisfer

❖ Functions:

- respon “flight” & “fight”
- makan
- tingkah laku & endokrin dari respon seksual
- memori, motivasi, homeostasis
- otonom
- agresi, aspek emosi dari tingkah laku

Area Bahasa

- hemisphere kiri → dominan untuk bahasa dan kemampuan matematika
- hemisphere kanan → persepsi spatial dan potensi bermusik

- Area bahasa :

- Area Broca's

  artikulasi bahasa

- Area Wernicke's

  mengerti bahasa

- Gyrus angular & supramarginal

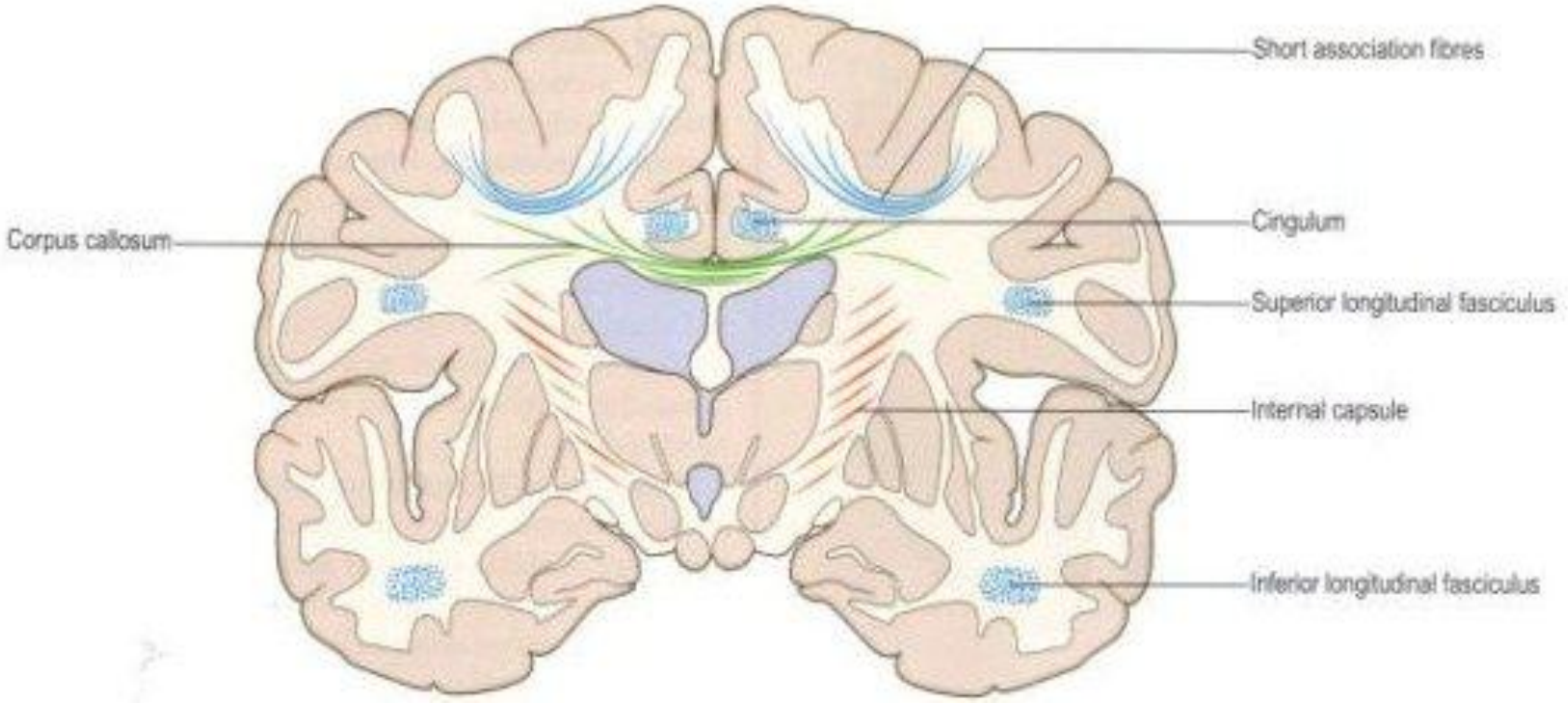
  asosiasi berbicara dan mendengar (berbicara, membaca, menulis, berhitung)

Bagian lain dalam otak

- **Thalamus**
  - menerima impuls dari reseptor sensorik menyampaikan informasinya ke bagian yang tepat di serebrum
- **Hypothalamus**
  - mengatur suhu tubuh rasa lapar, haus, marah, lelah,dll
  - Mengendalikan kelenjar pituitari untuk fungsi endokrin
- Keduanya berada di otak bagian depan

Substansia Alba Hemisphere Cerebri

1. Association fibres
   Penghubung jaras korteks di dalam satu hemisfer
2. Commisural fibres
   penghubung jaras antara hemisfer cerebral ke hemisfer cerebral yang lain
3. Projection fibres
   cortex cerebri – struktur subcortical



Association Fibres

- U fibres

  pendek dan dekat dengan area korteks
- fasciculus superior longitudinal

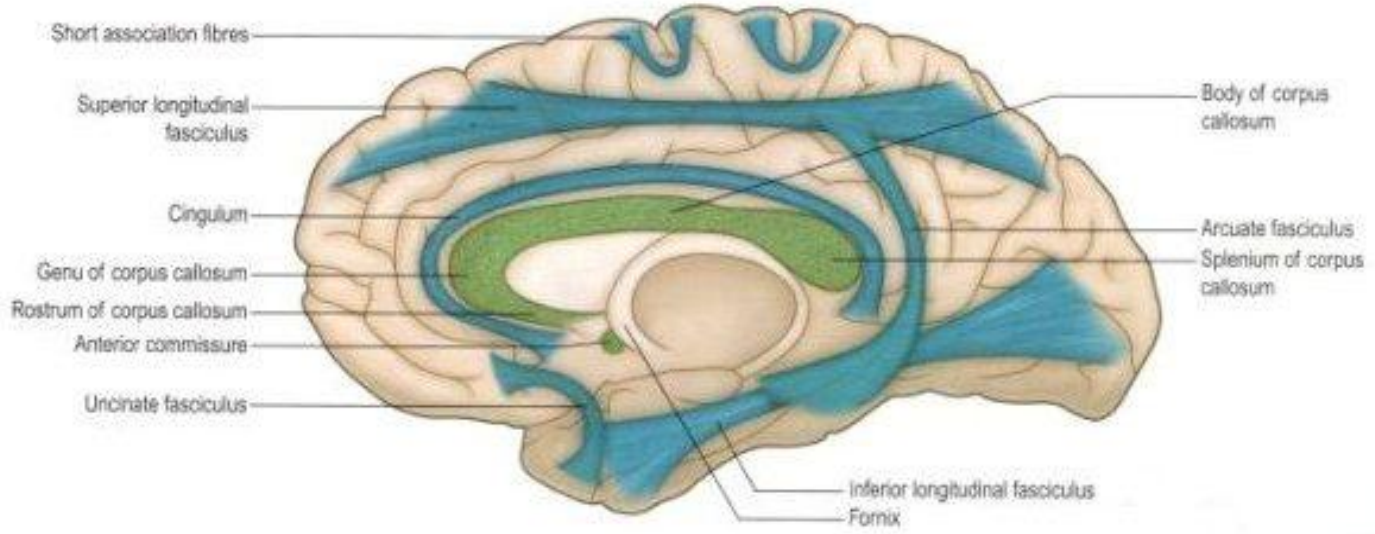
  lobus frontal – lobus occipital
- fasciculus arcuata

  gyrus di lobus frontal – lobus temporal (fungsi bahasa)
- fasciculus inferior longitudinal

  lobus occipital – lobus temporal (penglihatan)
- Fasciculus uncinatus

  lobus frontal anterior dan posterior – gyrus temporal (perilaku)
- Cingulum

  lobus frontal dan parietal – parahipokampus dan gabungan gyrus temporal lobus frontal



Commissural Fibres

- Corpus callosum

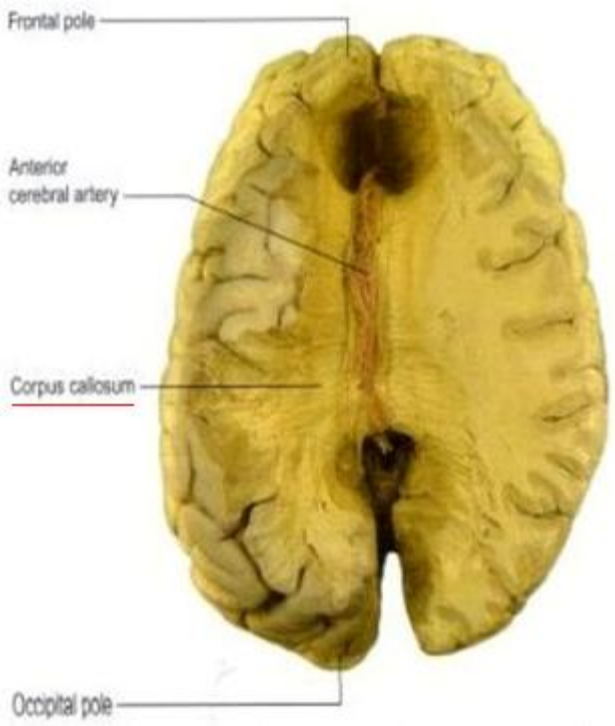
  - Spans two cerebral hemisphere and connects corresponding regions of neocortex
  - Anterior forceps : frontal pole – rostrum
  - Posterior forceps : occipital pole – splenium
  - Splenium interconnects occipital cortices (visual function)

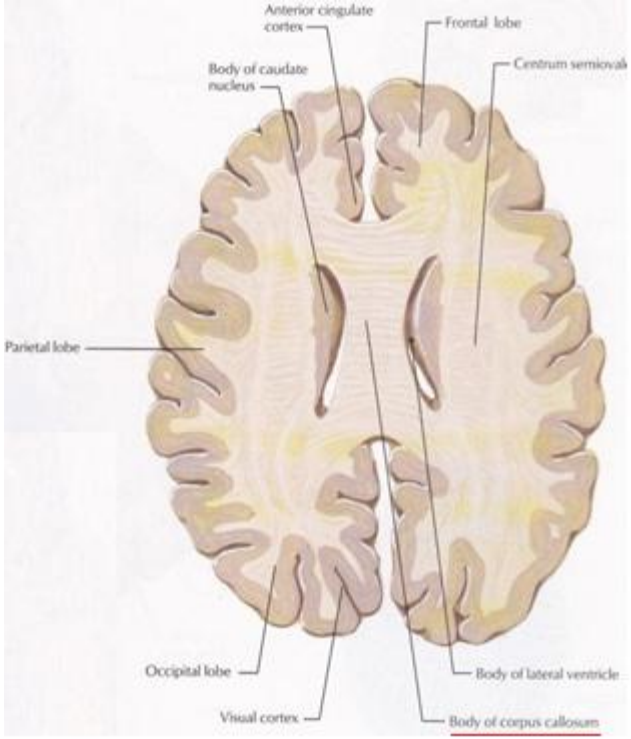
- Anterior commissure

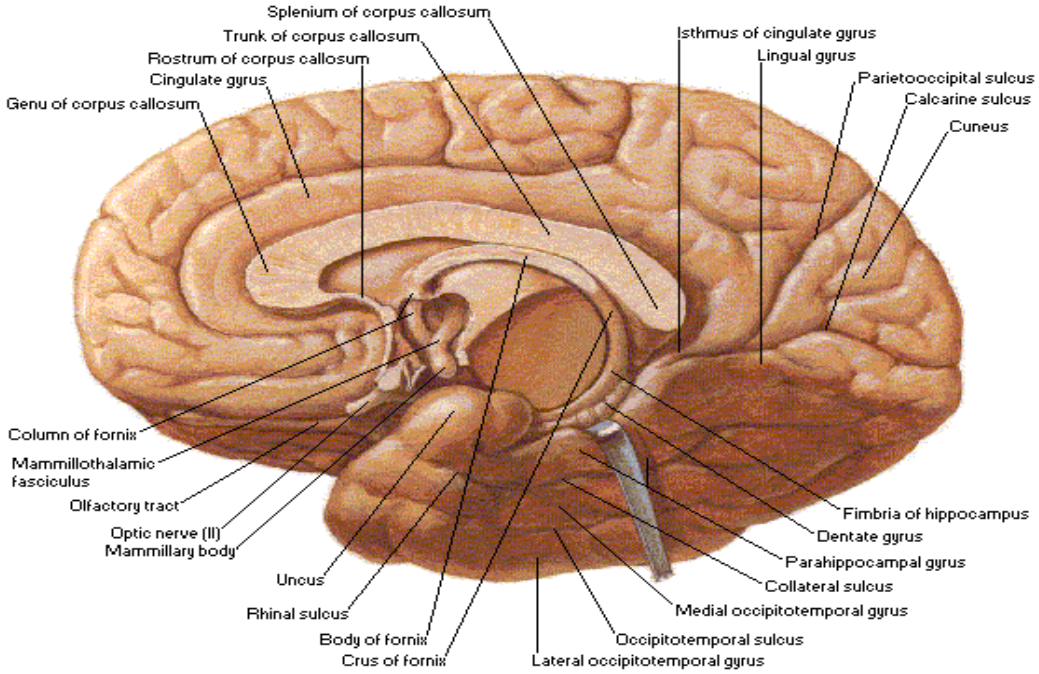
  - Transversely in front of anterior column of fornix
  - Interconnects inferior – middle temporal gyri – olfactory regions on the two sides

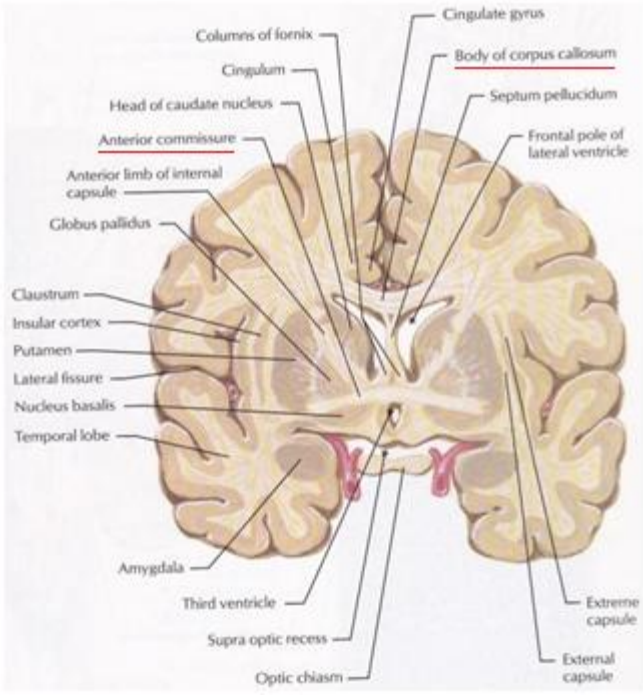
- Hippocampal commissure

  Posterior columns of fornix on each side


Frontal pole
Anterior cerebral artery
Corpus callosum
Occipital pole


Anterior cingulate cortex
Frontal lobe
Body of caudate nucleus
Centrum semiovale
Parietal lobe
Occipital lobe
Visual cortex
Body of lateral ventricle
Body of corpus callosum


Splenium of corpus callosum
Trunk of corpus callosum
Rostrum of corpus callosum
Cingulate gyrus
Genu of corpus callosum
Isthmus of cingulate gyrus
Lingual gyrus
Parietooccipital sulcus
Calcarine sulcus
Cuneus
Column of fornix
Mammillothalamic fasciculus
Olfactory tract
Optic nerve (II)
Mammillary body
Uncus
Rhinal sulcus
Body of fornix
Crus of fornix
Lateral occipitotemporal gyrus
Occipitotemporal sulcus
Medial occipitotemporal gyrus
Collateral sulcus
Parahippocampal gyrus
Dentate gyrus
Fimbria of hippocampus


Columns of fornix
Cingulate gyrus
Cingulum
Body of corpus callosum
Head of caudate nucleus
Septum pellucidum
Anterior commissure
Frontal pole of lateral ventricle
Anterior limb of internal capsule
Globus pallidus
Claustrum
Insular cortex
Putamen
Lateral fissure
Nucleus basalis
Temporal lobe
Amygdala
Third ventricle
Supra optic recess
Optic chiasm
Extreme capsule
External capsule

Projection Fibres

- Consist of afferent fibres to cortex & efferent fibres away from cortex

- **Corona radiata**

- **Internal Capsule**

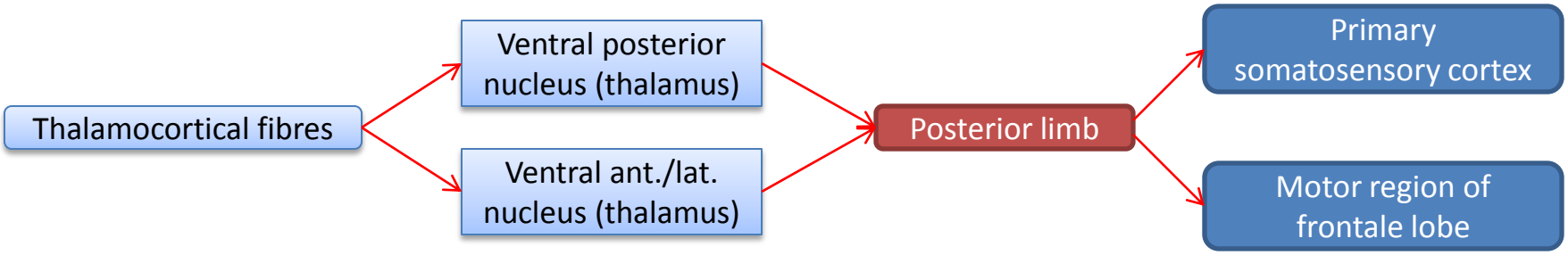
❖ Anterior limb

- Mediodorsal nucleus (thalamus) – prefrontal cortex
- Frontopontine fibres – pontine nuclei (basal pons)

Projection Fibres

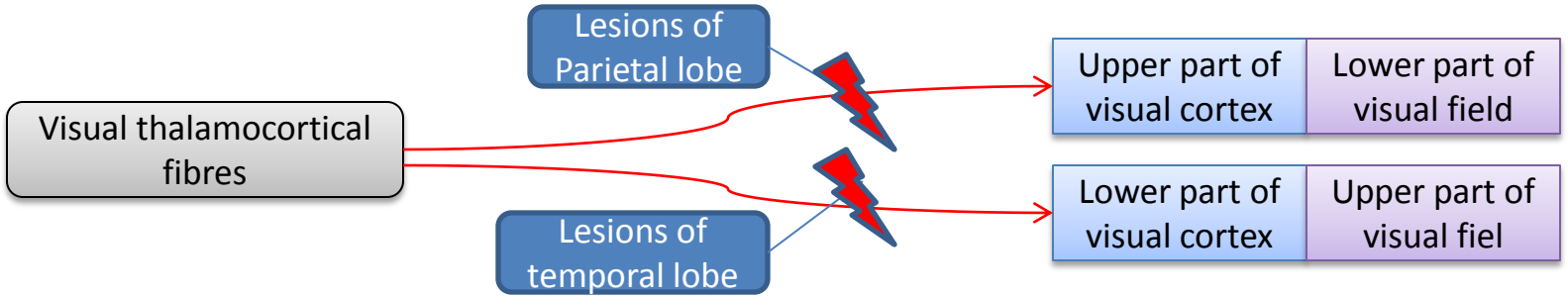
❖ Posterior limb

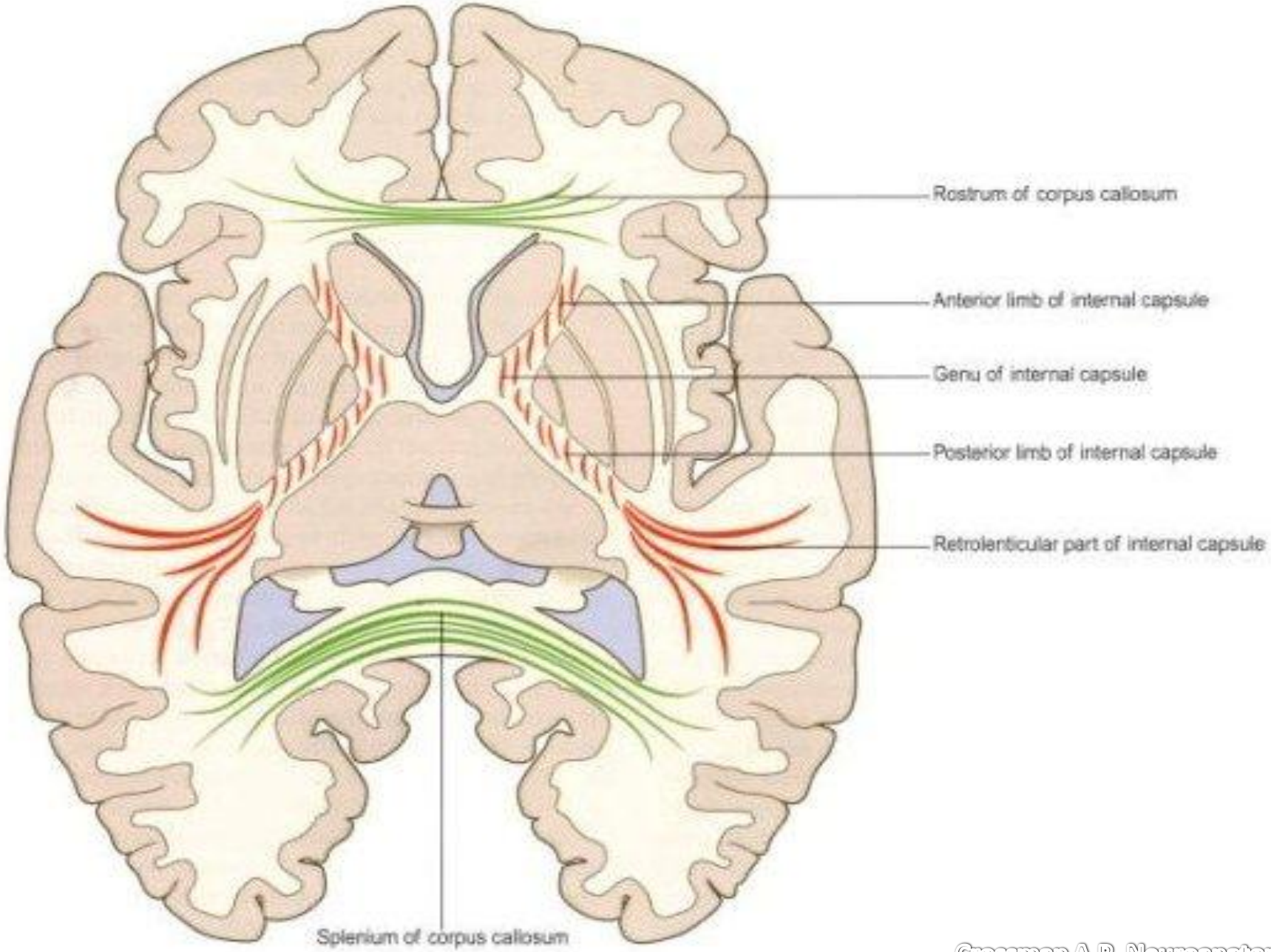
- contains corticobulbar & corticospinal motor fibres



❖ Retrolenticular

- Consists of fibres arising from med./lat. geniculate nuclei as auditory/visual radiations → auditory/visual cortices

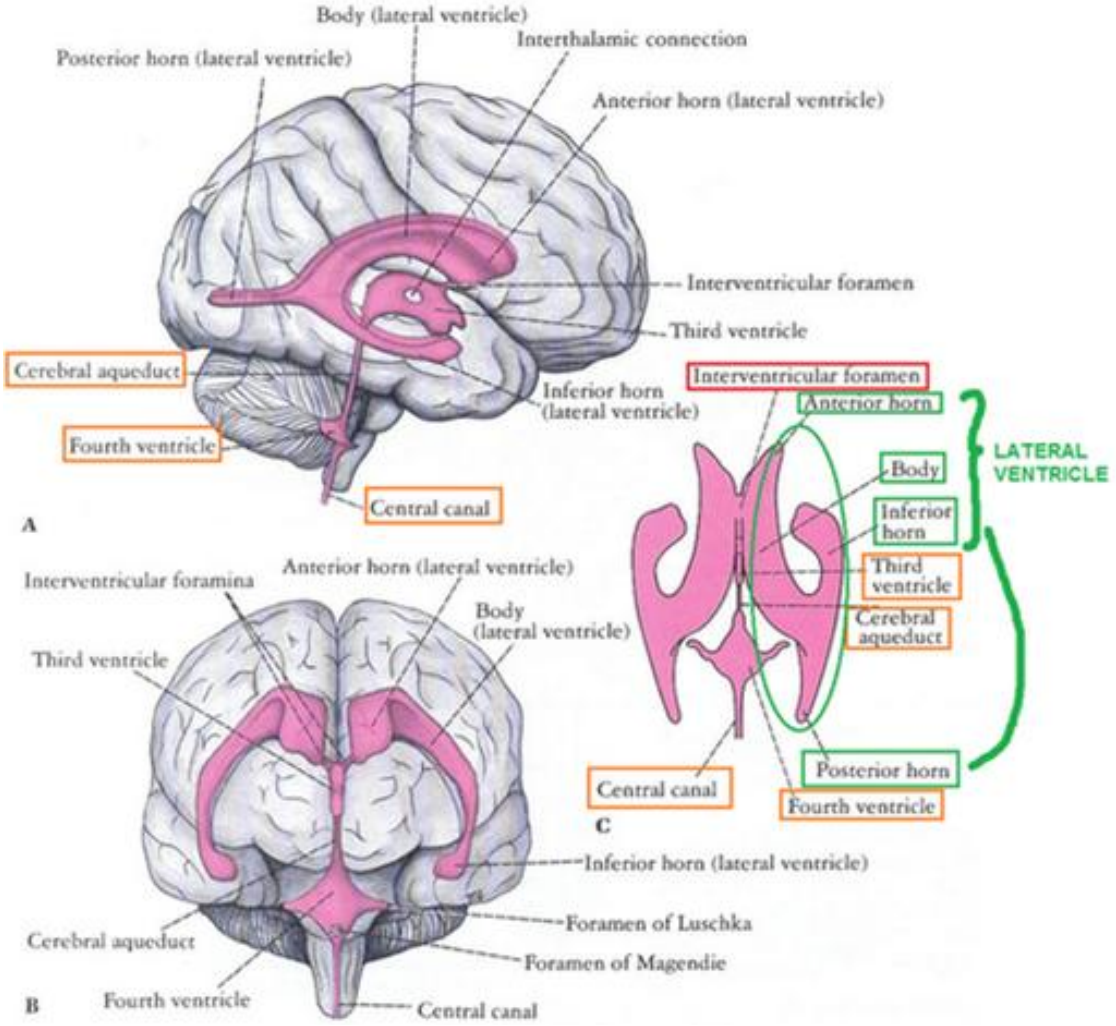


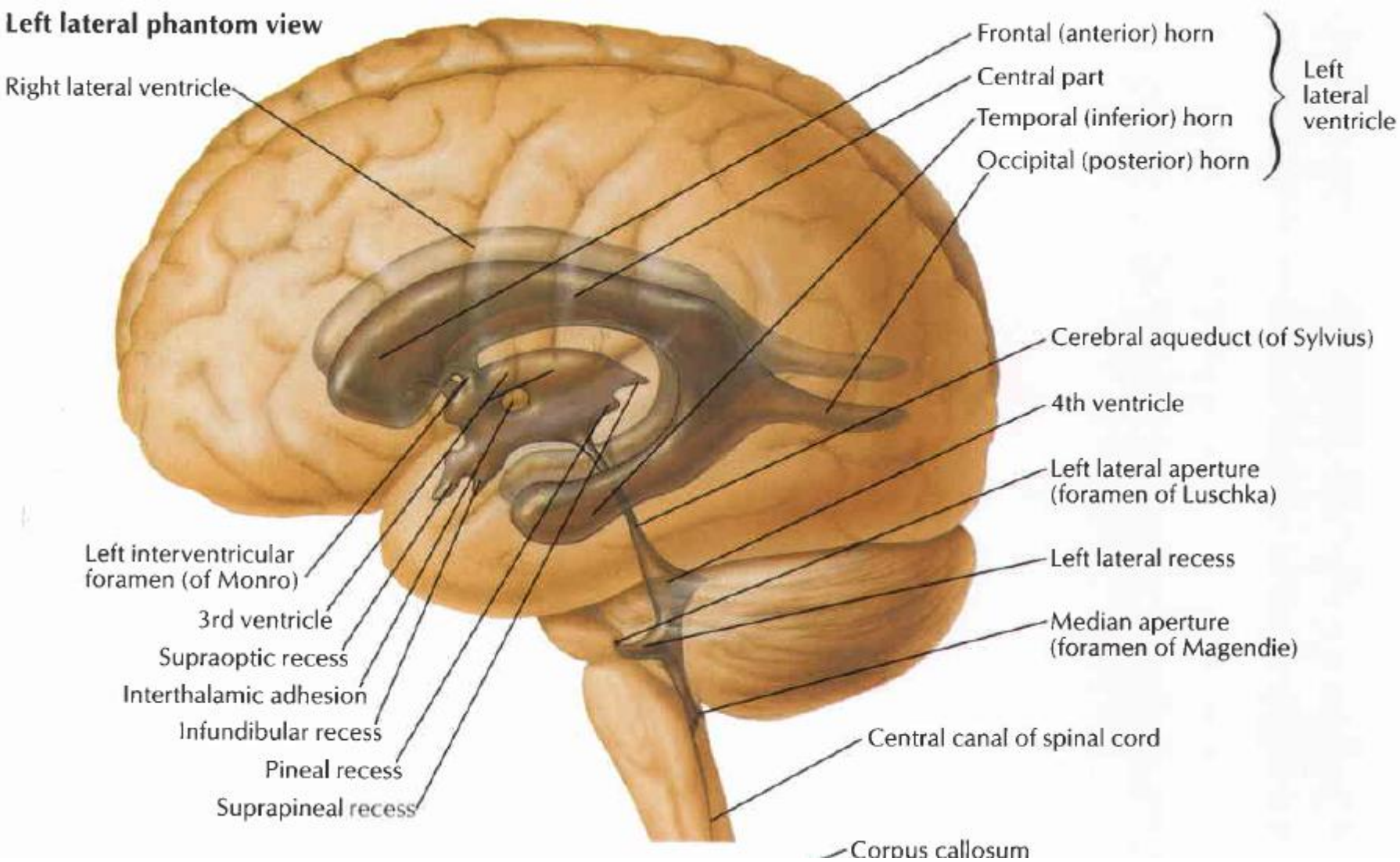


SISTEM VENTRIKEL OTAK
dan
CAIRAN SEREBROSPINAL (CSS)

VENTRICULAR SYSTEM

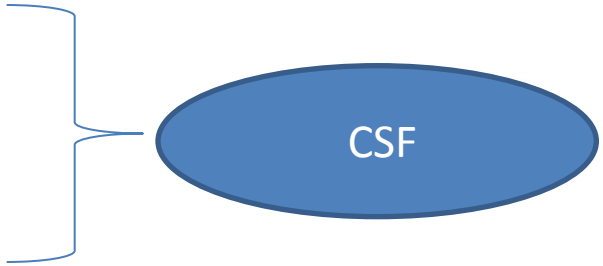
- Terdiri atas:
  - ventrikel lateral
  - ventrikel ketiga (tertius)
  - ventrikel keempat (Quartus)




Left lateral phantom view
Right lateral ventricle
Frontal (anterior) horn
Central part
Temporal (inferior) horn
Occipital (posterior) horn
Left lateral ventricle
Cerebral aqueduct (of Sylvius)
4th ventricle
Left lateral aperture (foramen of Luschka)
Left lateral recess
Median aperture (foramen of Magendie)
Central canal of spinal cord
Corpus callosum
Left interventricular foramen (of Monro)
3rd ventricle
Supraoptic recess
Interthalamic adhesion
Infundibular recess
Pineal recess
Suprapineal recess

Cairan Serebospinal

- Sistem ventrikel
- Ruang subarachnoid cranial



- Tiap ventrikel mengandung plexus choroideus, dengan sel ependim sebagai penghasil CSS

Plexus Choroideus

- Lokasi:
  - **Cornu anterior dan corpus ventrikel lateral (Paling banyak produksi CSS)**
  - Ventrikel ketiga
  - Ventrikel keempat
- Dibentuk oleh:
  - Invaginasi pembuluh darah piamater ➔ lumen ventricular
- Bentuk seperti spons
- <u>Plexus choroideus menerima arterialisasi:</u>

  - A. choroidal anterior (corpus ventrikel lateral),
  - A. choroidal posterior (cornu inferior ventrikel lateral, ventrikel ketiga),
  - cabang A. cerebellaris posterior inferior

CHOROID PLEXUS

www.neuromedia.neurobio.ucla.edu

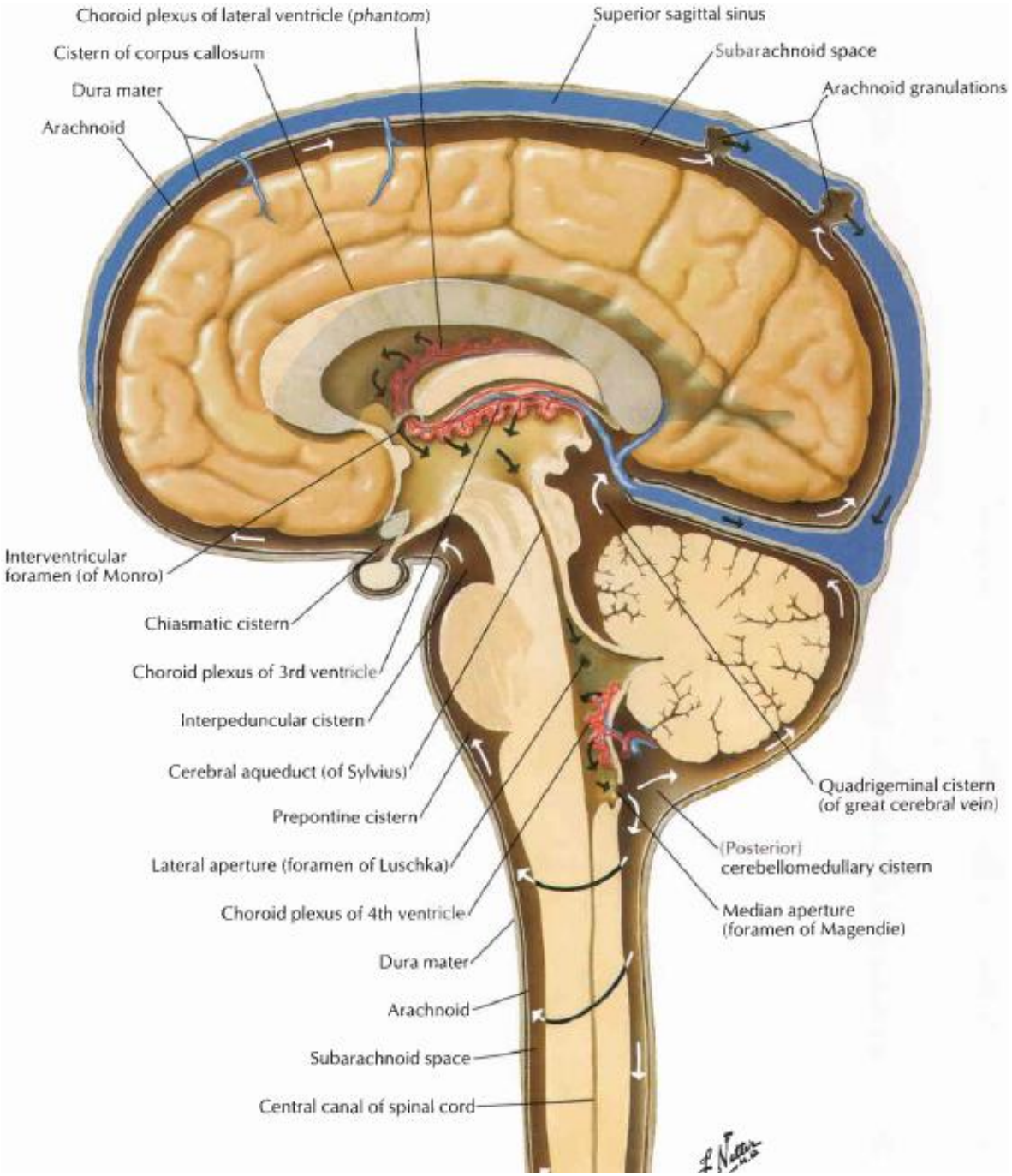
Fisiologi CSS

- Volume : 150 ml
- Tekanan : 5-15 mmHg
- Waktu CSS diproduksi (20 ml/jam):
  - Sekretori aktif (80% oleh choroid plexus)
  - Difusi pasif (reabsorpsi oleh villi arachnoid)
- CSS mengandung:
  - Beberapa protein
  - Beberapa sel

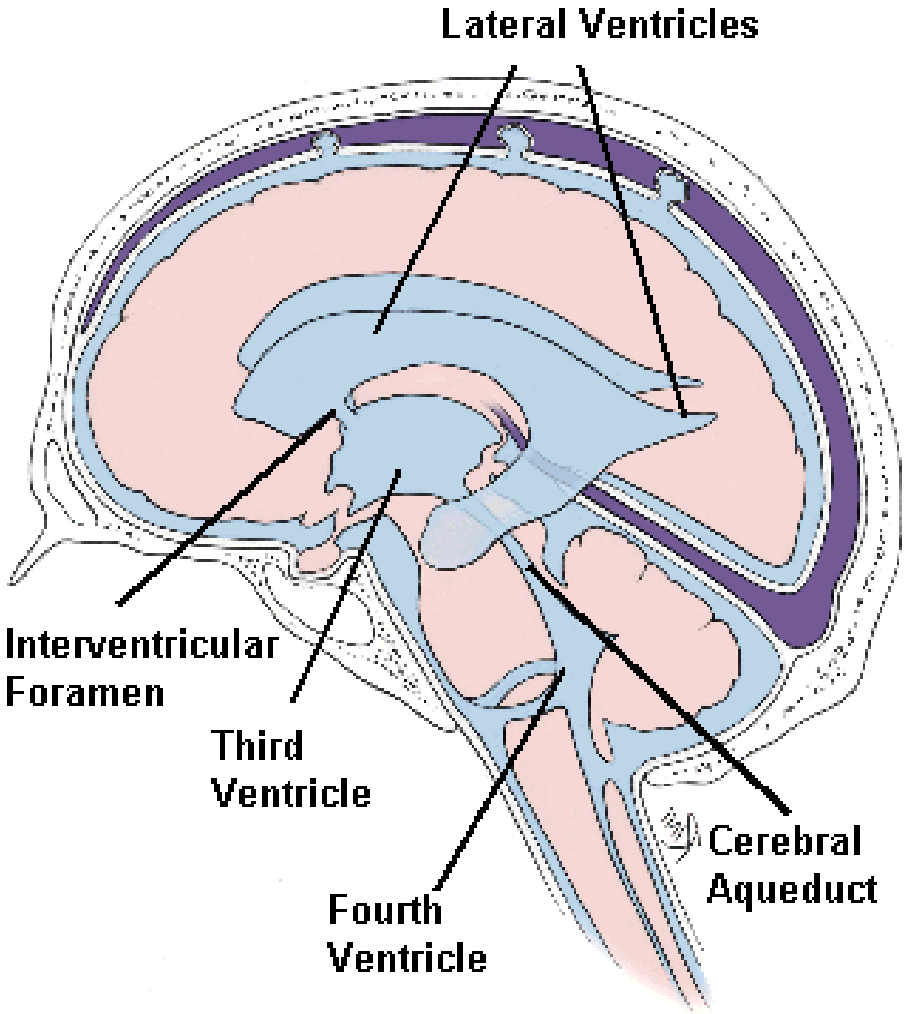
- CSS direabsorpsi oleh sistem vena melalu villi arachnoid, terutama ke dalam sinus sagitalis superior

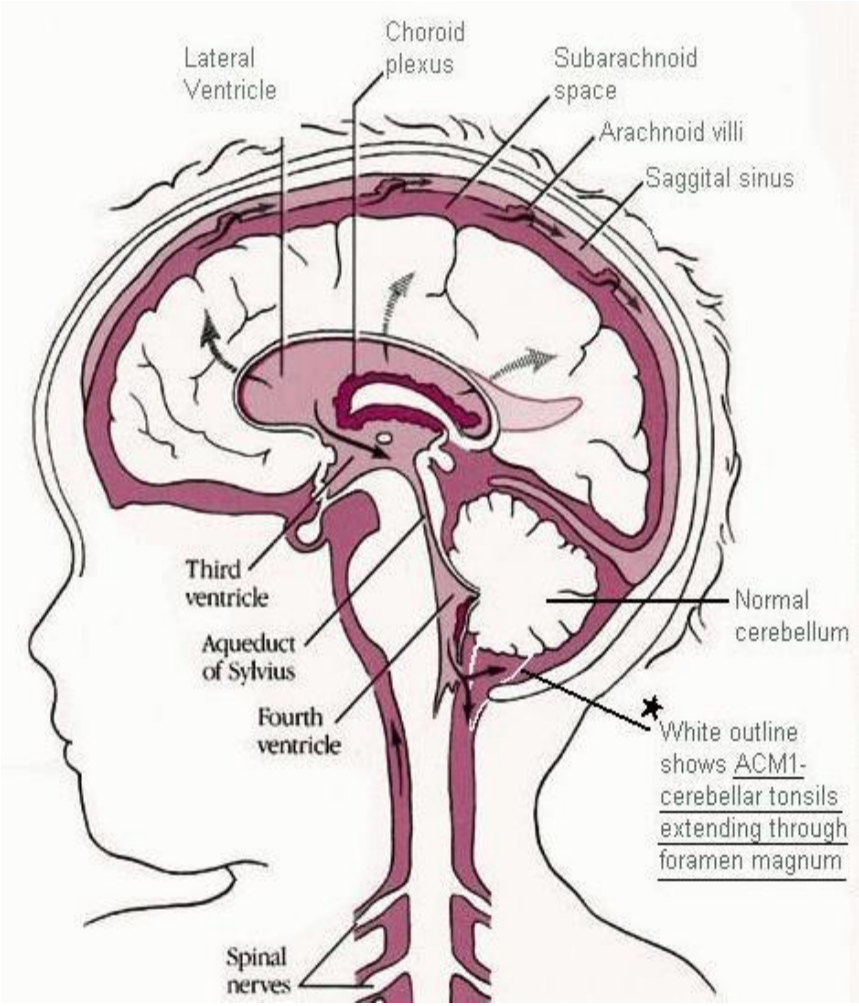
- Reabsorpsi dapat terjadi karena:
  - Tekanan hidrostatik ruang subarachnoid lebih tinggi daripada tekanan di lumen sinus
  - Tekanan osmotik koloid darah vena ke CSS

- Fungsi CSS:
  - Mengatur keseimbangan elektrolit dan metabolik
  - Homeostasis
  - Melindungi otak dari gerakan kepala yang mendadak (*shock absorber*)
  - Menyalurkan nutrisi dan mengeluarkan sisa metabolisme


Choroid plexus of lateral ventricle (*phantom*)
Superior sagittal sinus
Cistern of corpus callosum
Subarachnoid space
Dura mater
Arachnoid granulations
Arachnoid
Interventricular foramen (of Monro)
Chiasmatic cistern
Choroid plexus of 3rd ventricle
Interpeduncular cistern
Cerebral aqueduct (of Sylvius)
Quadrigeminal cistern (of great cerebral vein)
Prepontine cistern
(Posterior) cerebellomedullary cistern
Lateral aperture (foramen of Luschka)
Median aperture (foramen of Magendie)
Choroid plexus of 4th ventricle
Dura mater
Arachnoid
Subarachnoid space
Central canal of spinal cord

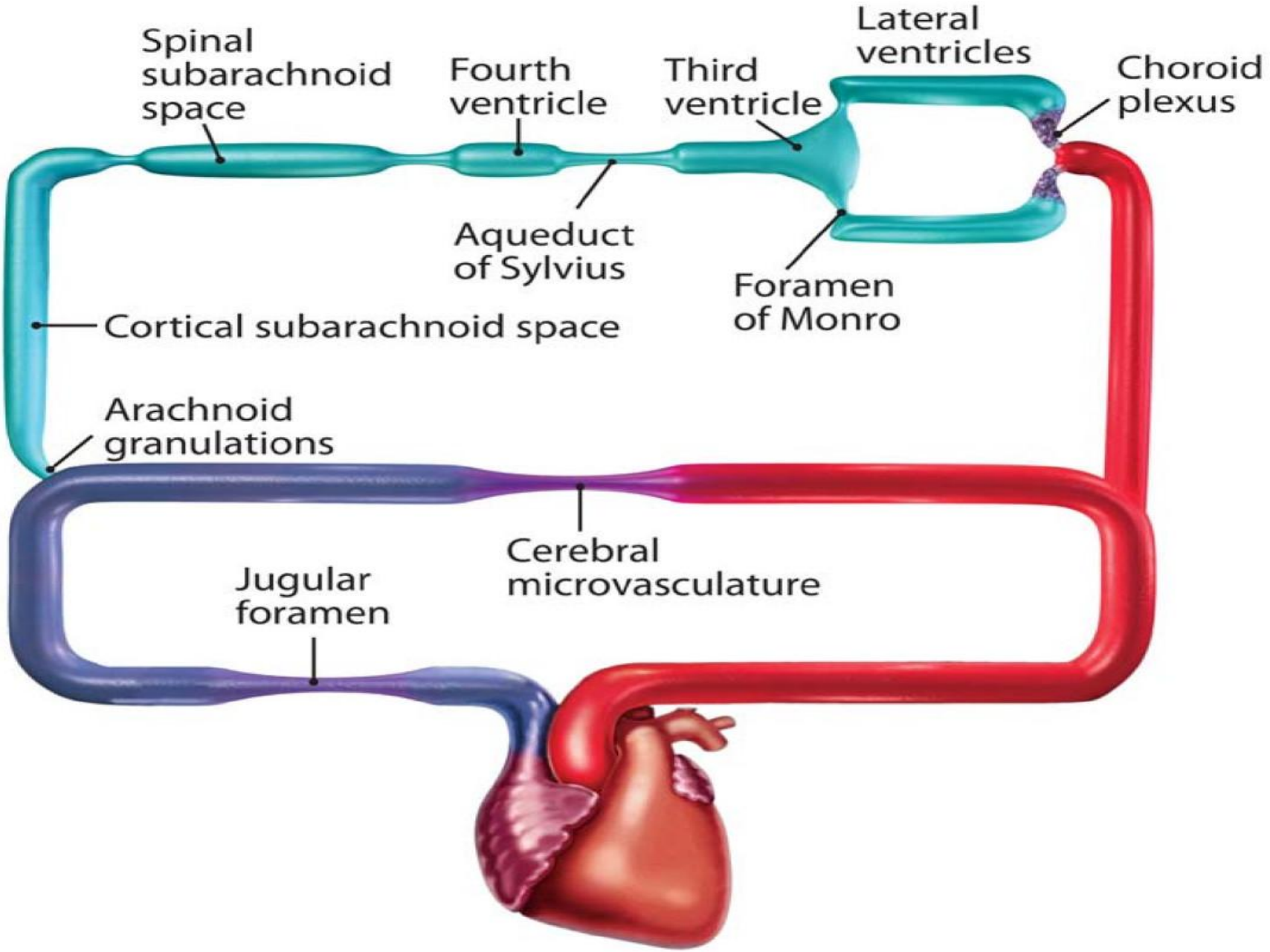
Sistem Ventrikel dan CSS



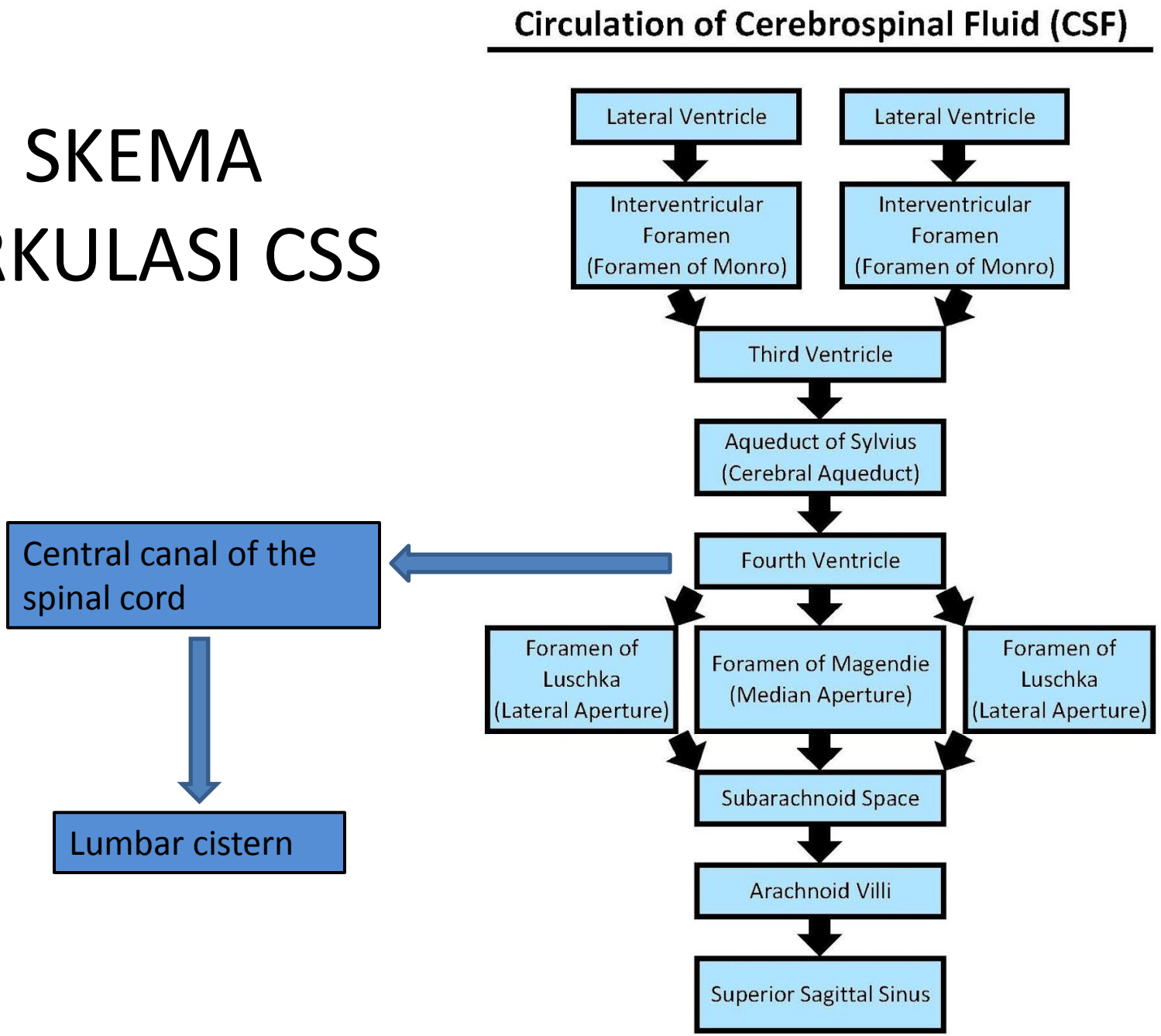


Perjalanan CSS

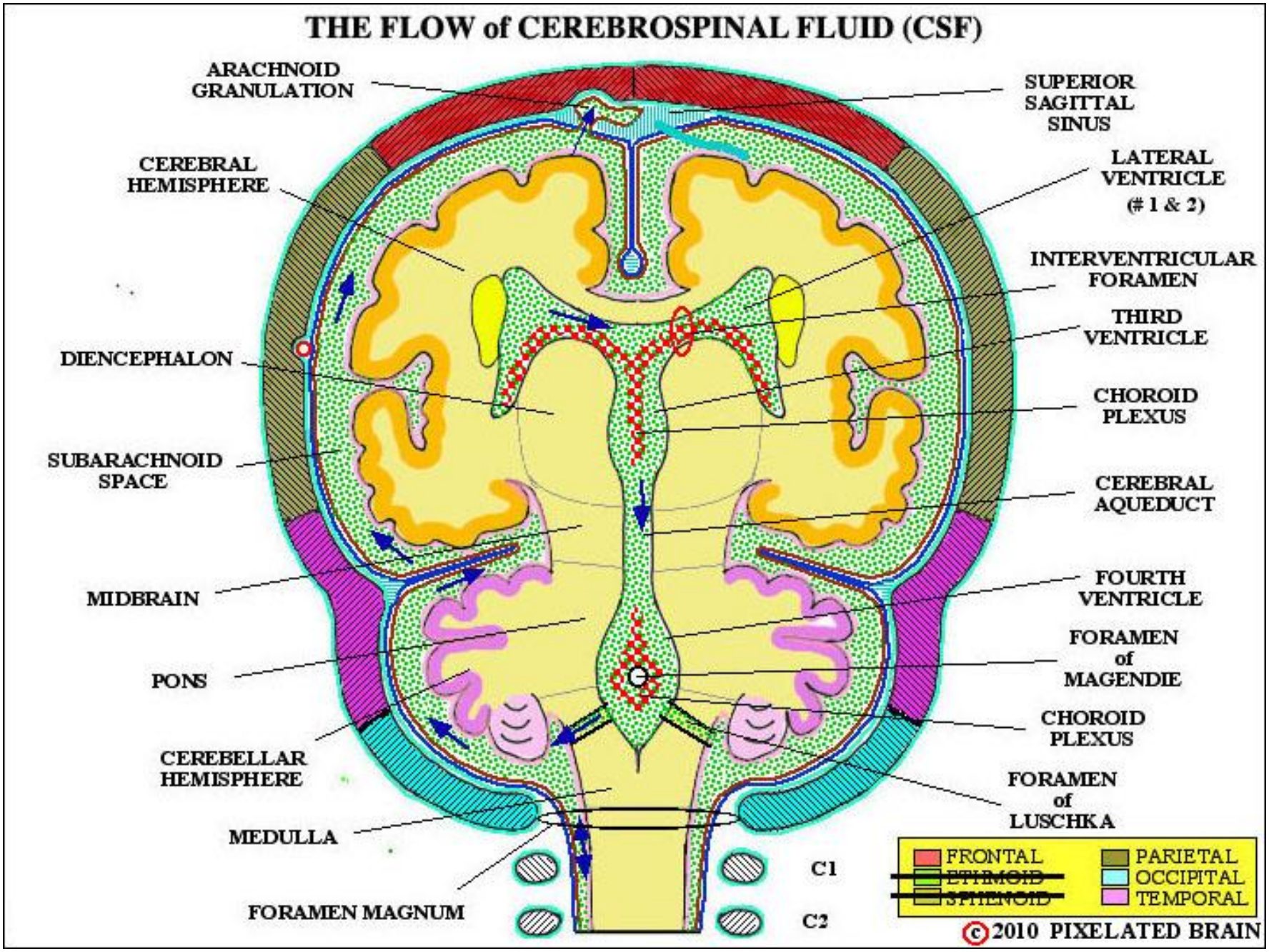
- Ventrikel Lateral → (foramen monroe/for. interventricular) → Ventrikel tertius → (Aquaductus sylvii /Aquaductus cerebri/ Aquaductus mesencephali) → Ventrikel Quartus → Apertura medial/for. Magendie dan Apertura lateral/for. Luschka → Cisterna (pelebaran ruang subarachnoid) → Spatium subarachnoid → (granulationes arachnoidea/pachioni) → Sinus Duralis → Vena jugularis → V.C Superior → Cor.


Spinal subarachnoid space
Fourth ventricle
Third ventricle
Lateral ventricles
Choroid plexus
Aqueduct of Sylvius
Foramen of Monro
Cortical subarachnoid space
Arachnoid granulations
Cerebral microvasculature
Jugular foramen

SKEMA SIRKULASI CSS



THE FLOW of CEREBROSPINAL FLUID (CSF)



CEREBELLUM

CEREBELLUM

- Bagian otak terbesar kedua setelah cerebrum
- Fungsi:

  koordinasi otot & menjaga keseimbangan → sikap tubuh
- Susunan substansia grisea dan alba = cerebrum
- Hemisfer cerebelli mengendalikan tonus otot dan sikap, bersifat ipsilateral (>< cerebrum)

Cerebellum

- Letak:

  dasar fossa cranii posterior (antara brainstem dan lobus occipital hemisfer cerebri)
- Dipisahkan dari lobus occipitalis oleh tentorium cerebelli
- Dipisahkan dari brain stem oleh ventrikel quartus

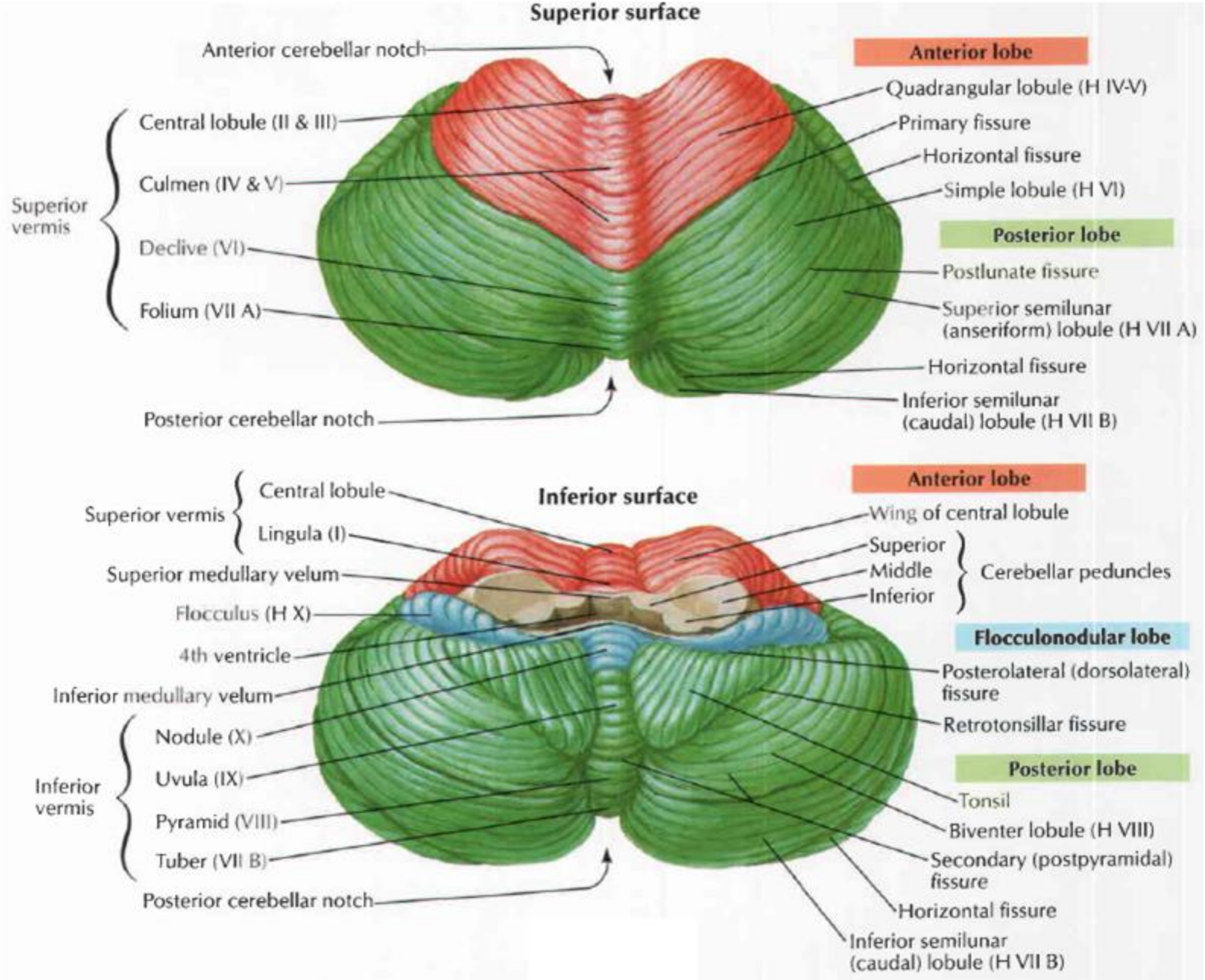
Berat (dewasa): 140-150 gram

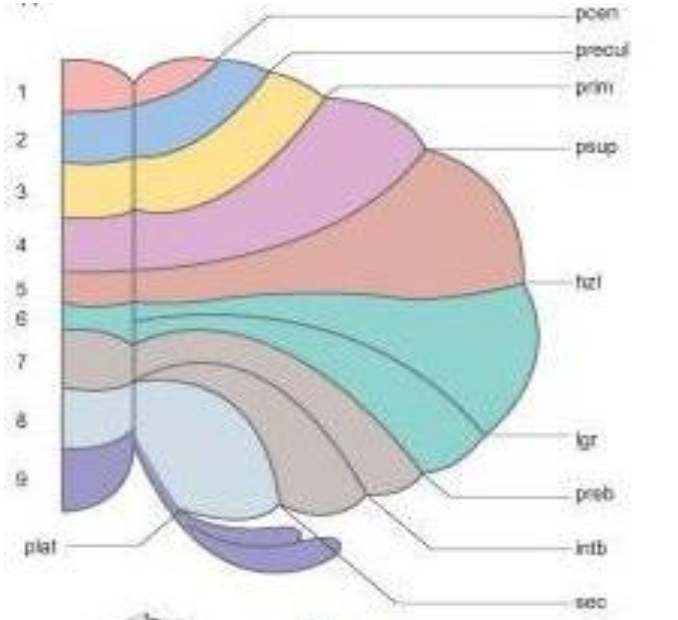
Bayi = 1:20

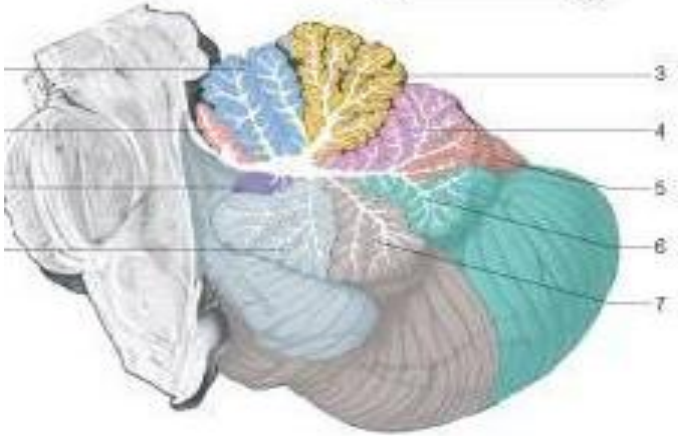
Pembagian cerebellum

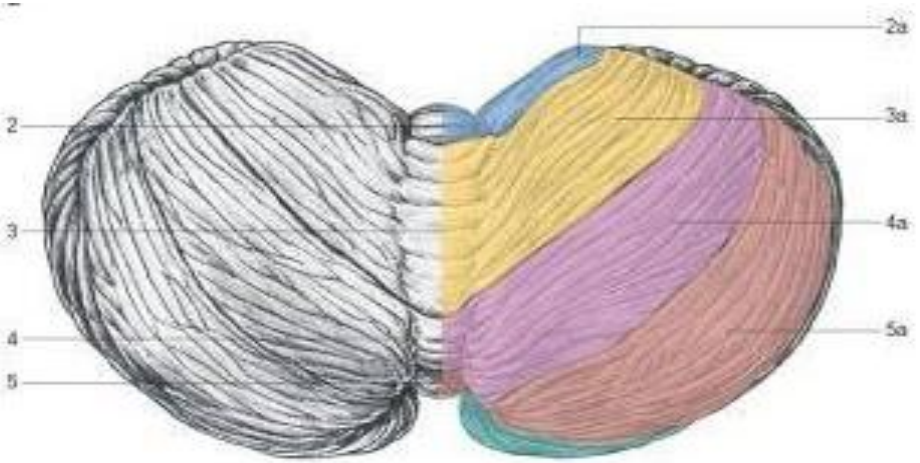
1. Vermis cerebelli (medial)
2. Hemisphere cerebelli (lateral vermis)

Hemisphere	Vermis	Hemisphere
	Lingula	
Ala lobuli centralis	Lobulus centralis	Ala lobuli centralis
Lobulus quadrangularis ant.	Culmen	Lobulus quadrangularis ant.
Fissura prima (sup. ant.)		Fissura prima (sup. ant.)
Lobulus quadrangularis post.	Declive	Lobulus quadrangularis post.
Fissura postlunata		Fissura postlunata
Lobulus semilunaris sup. (anseriform)	Folium	Lobulus semilunaris sup. (anseriform)
Fissura horizontalis		Fissura horizontalis
Lobulus semilunaris inf.	Tuber	Lobulus semilunaris inf.
Lobulus biventer	Pyramis	Lobulus biventer
Fissura retrotonsillar	Fissura secunda (postpyramidal)	Fissura retrotonsillar
Tonsil	Uvula	Tonsil
Fissura posterolateral (dorsolateral)		Fissura posterolateral (dorsolateral)
Flocculus	Nodulus	Flocculus

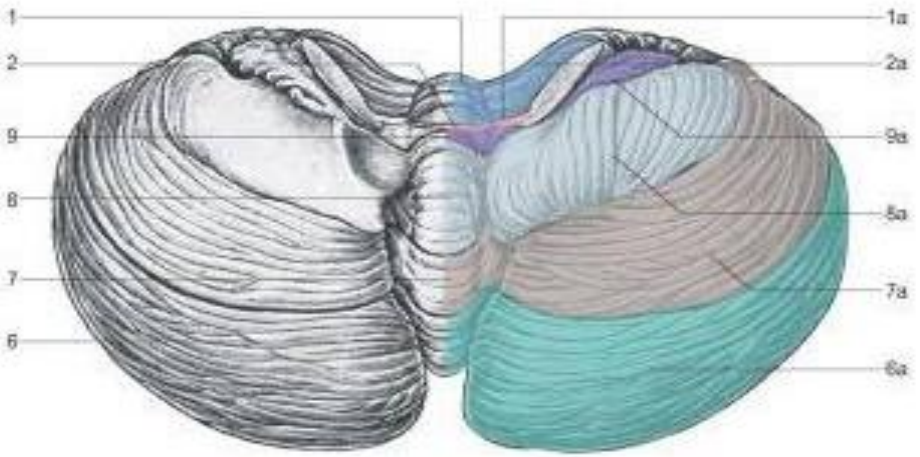

Superior surface
Anterior cerebellar notch
Anterior lobe
Quadrangular lobule (H IV-V)
Primary fissure
Horizontal fissure
Simple lobule (H VI)
Central lobule (II & III)
Culmen (IV & V)
Superior vermis
Declive (VI)
Folium (VII A)
Posterior lobe
Postlunate fissure
Superior semilunar (anseriform) lobule (H VII A)
Horizontal fissure
Inferior semilunar (caudal) lobule (H VII B)
Posterior cerebellar notch
Inferior surface
Anterior lobe
Superior vermis
Central lobule
Lingula (I)
Wing of central lobule
Superior
Middle
Inferior
Cerebellar peduncles
Superior medullary velum
Flocculus (H X)
4th ventricle
Flocculonodular lobe
Posterolateral (dorsolateral) fissure
Inferior medullary velum
Retrotonsillar fissure
Posterior lobe
Nodule (X)
Uvula (IX)
Pyramid (VIII)
Tuber (VII B)
Inferior vermis
Tonsil
Biventer lobule (H VIII)
Secondary (postpyramidal) fissure
Horizontal fissure
Posterior cerebellar notch
Inferior semilunar (caudal) lobule (H VII B)







D



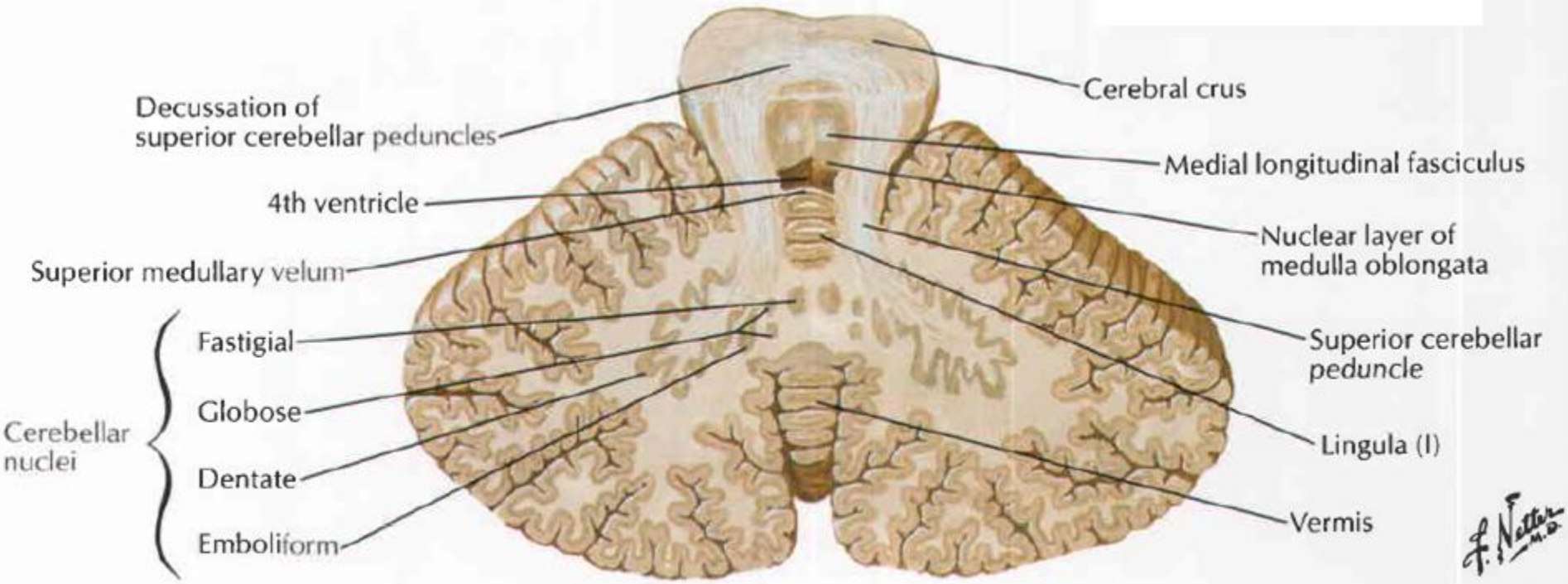
Anterior lobe
1 Lingula
2 Central
3 Culmen

Posterior lobe
4 Simple
5 Folium
6 Tuber
7 Pyramis
8 Uvula

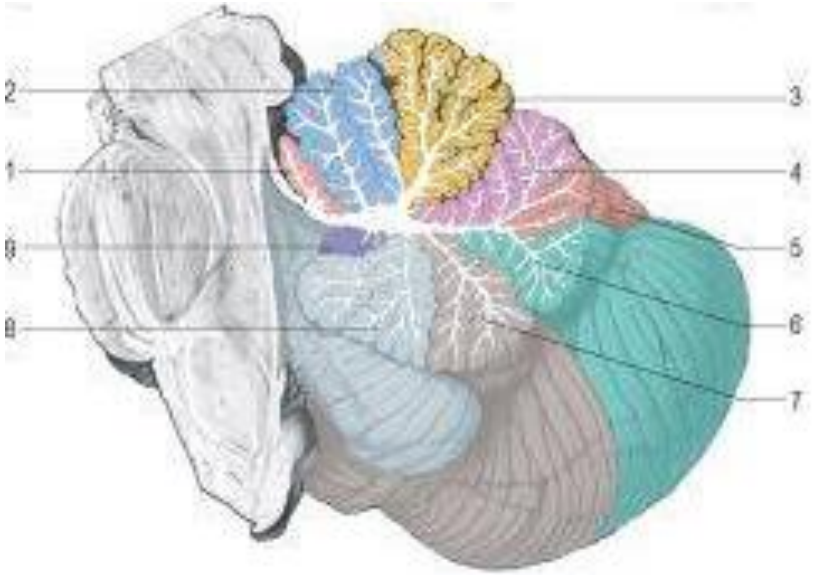
Flocculonodular lobe
9 Nodule

Fissures
poen precentral
precul preculminate
prim primary
psup posterior superior
hzl horizontal
lgr lunogracile
preb prebiventral
intb intrabiventral
sec secondary
plat posterolateral

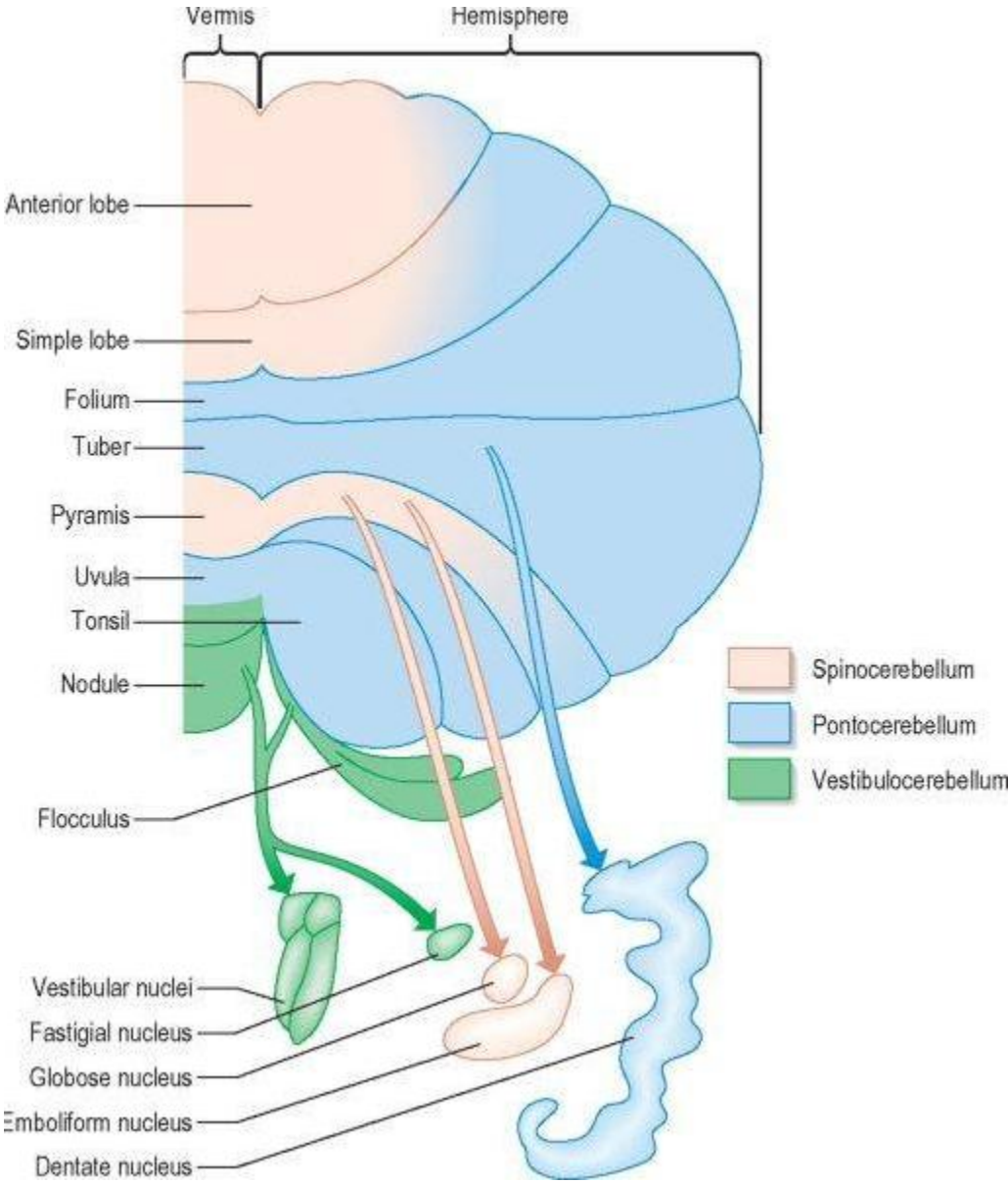
Wings
1a Wing of lingula
2a Wing of central lobule
3a Anterior quadrangular lobule
4a Posterior quadrangular lobule
5a Superior semilunar lobule
6a Inferior semilunar lobule
7a Biventral lobule
8a Tonsil of cerebellum
9a Flocculus

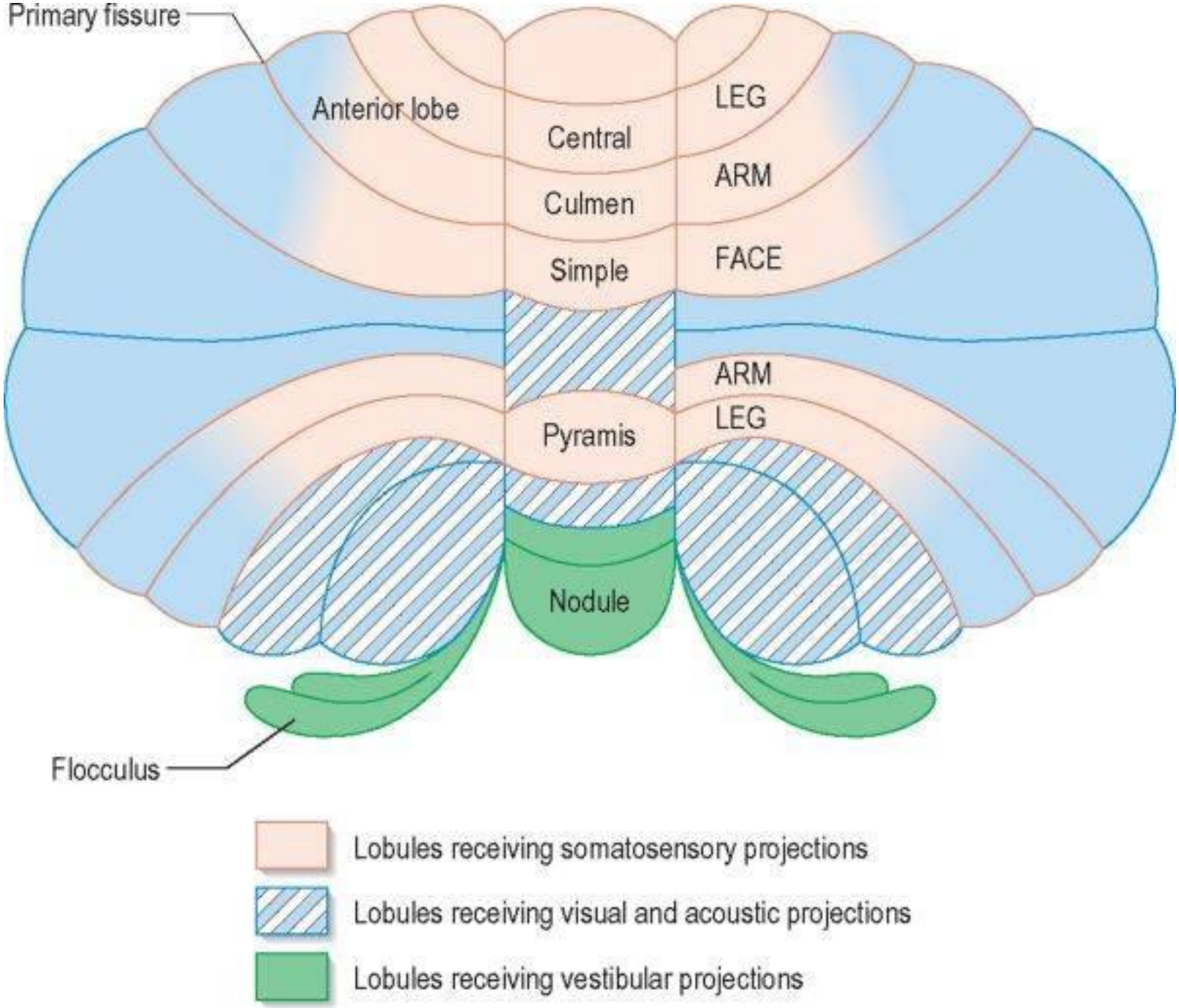


Section in plane of superior cerebellar peduncle



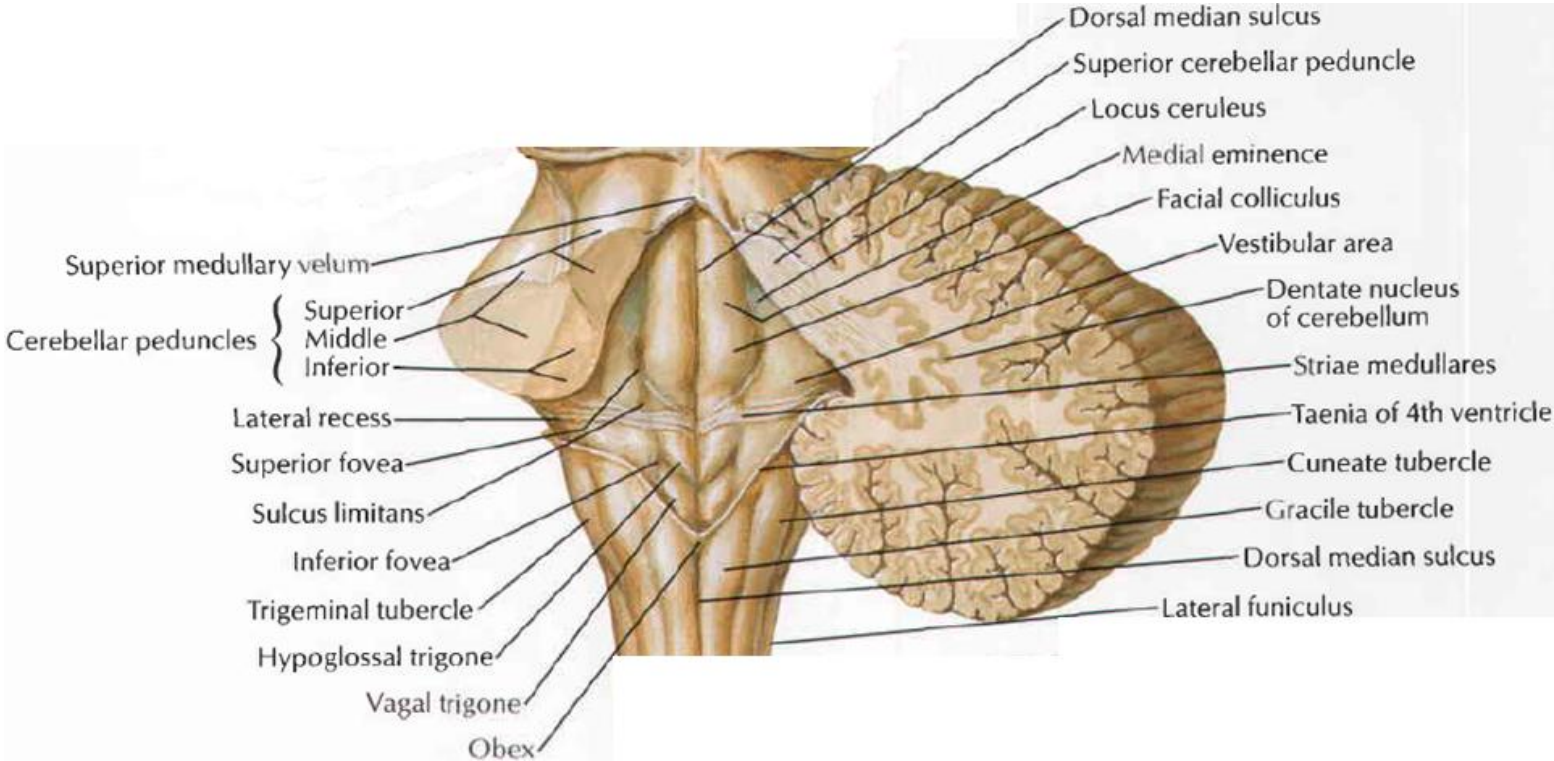
Anterior lobe	Posterior lobe	Flocculonodular lobe
1 Lingula	4 Simple	9 Nodule
2 Central	5 Folium	
3 Culmen	6 Tuber	
	7 Pyramis	
	8 Uvula	



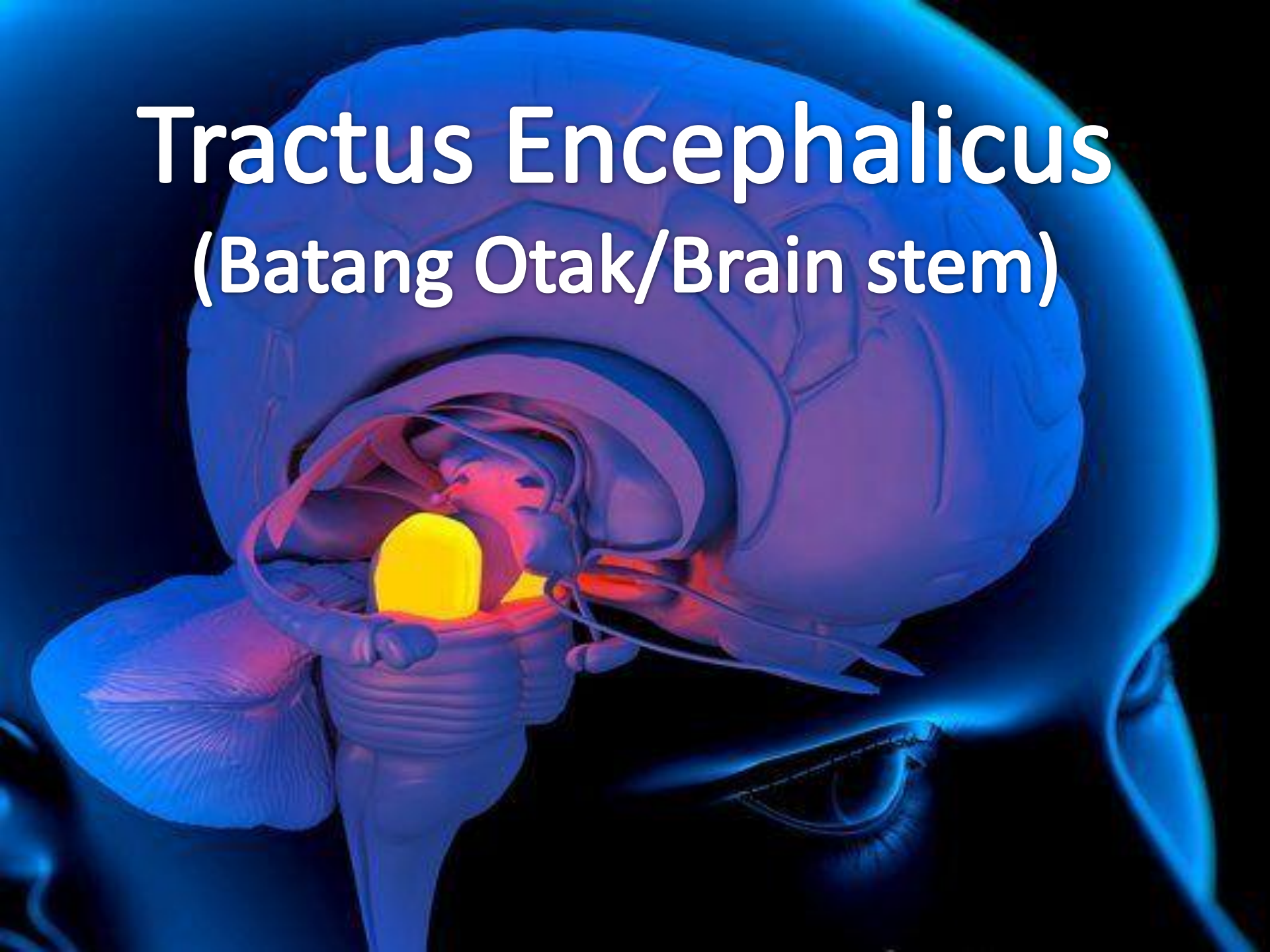

Primary fissure
Anterior lobe
Central
Culmen
Simple
LEG
ARM
FACE
ARM
LEG
Pyramis
Nodule
Flocculus
Lobules receiving somatosensory projections
Lobules receiving visual and acoustic projections
Lobules receiving vestibular projections

Perlekatan cerebellum dgn organ sekitarnya:

1. **Pedunculus cerebellaris superior** → cerebellum + mesencephalon
2. **Pedunculus cerebellaris media (brachium pontis)** → cerebellum + pons
3. **Pedunculus cerebellaris inferior (corpus restiforme)** → cerebellum + medulla oblongata



Tractus Encephalicus
(Batang Otak/Brain stem)



Brain Stem (batang otak)

- Terdiri atas:
  - Medulla oblongata
  - Pons
  - Mesencephalon (midbrain/otak tengah)

- Dimulai dari bagian bawah os occipital (clivus) dan berhubungan dengan cerebellum

  batas: rostral → diencephalon

  caudal → medulla spinalis (decussatio piramidum)

- Terdiri atas traktus serat ascenden and descenden

- Nukleus batang otak menerima serat saraf dari dan ke dalam nervus cranial (III-XII) dan mengirimnya ke nucleus nervus cranialis di batang otak

FUNGSI BATANG OTAK

- Terdiri atas matrik neuron yang kompleks dan heterogen→ formatio reticularis

  fungsi :

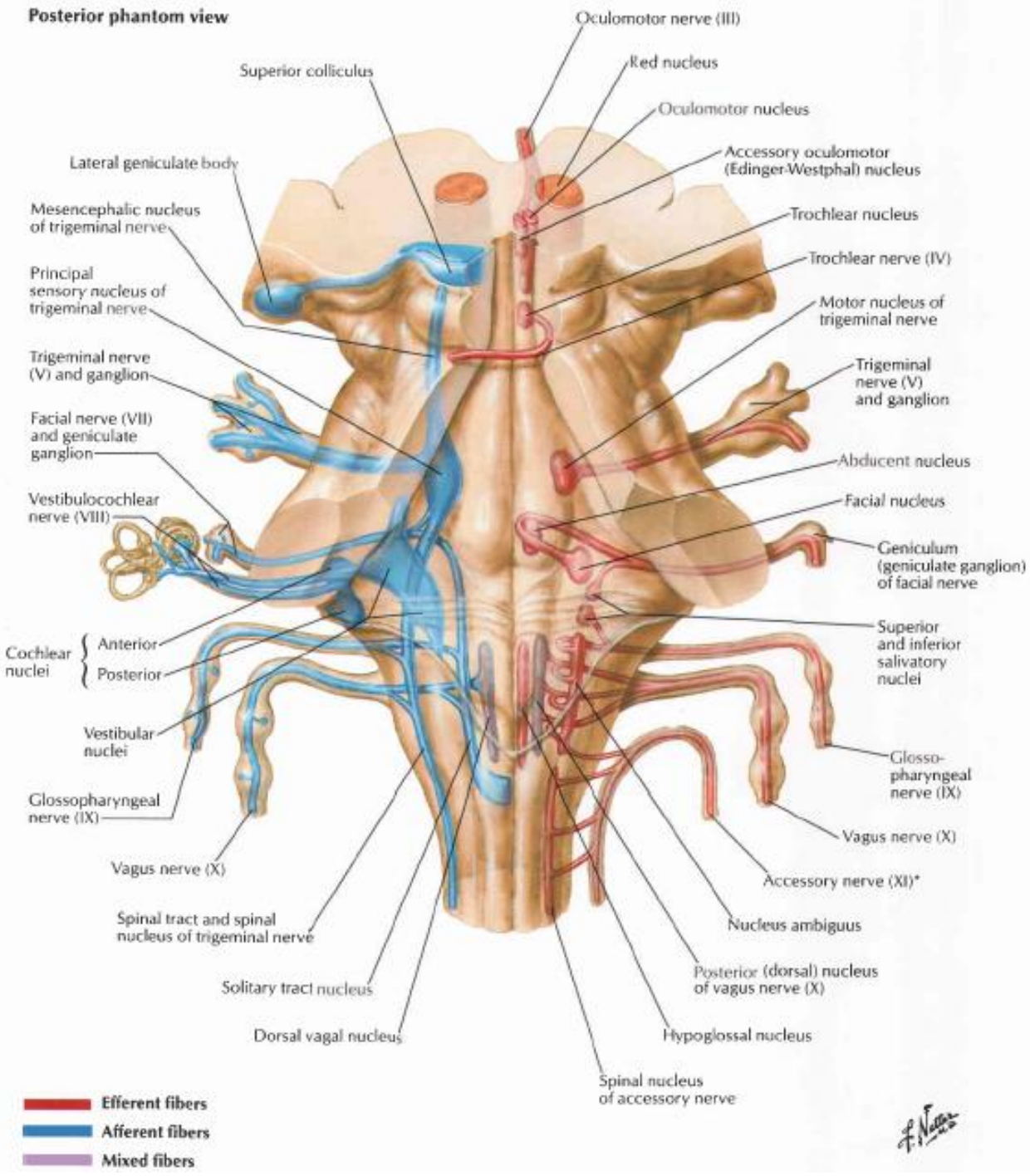
 - mengontrol kesadaran
 - persepsi nyeri
 - pengaturan sistem kardiovaskular dan respirasi

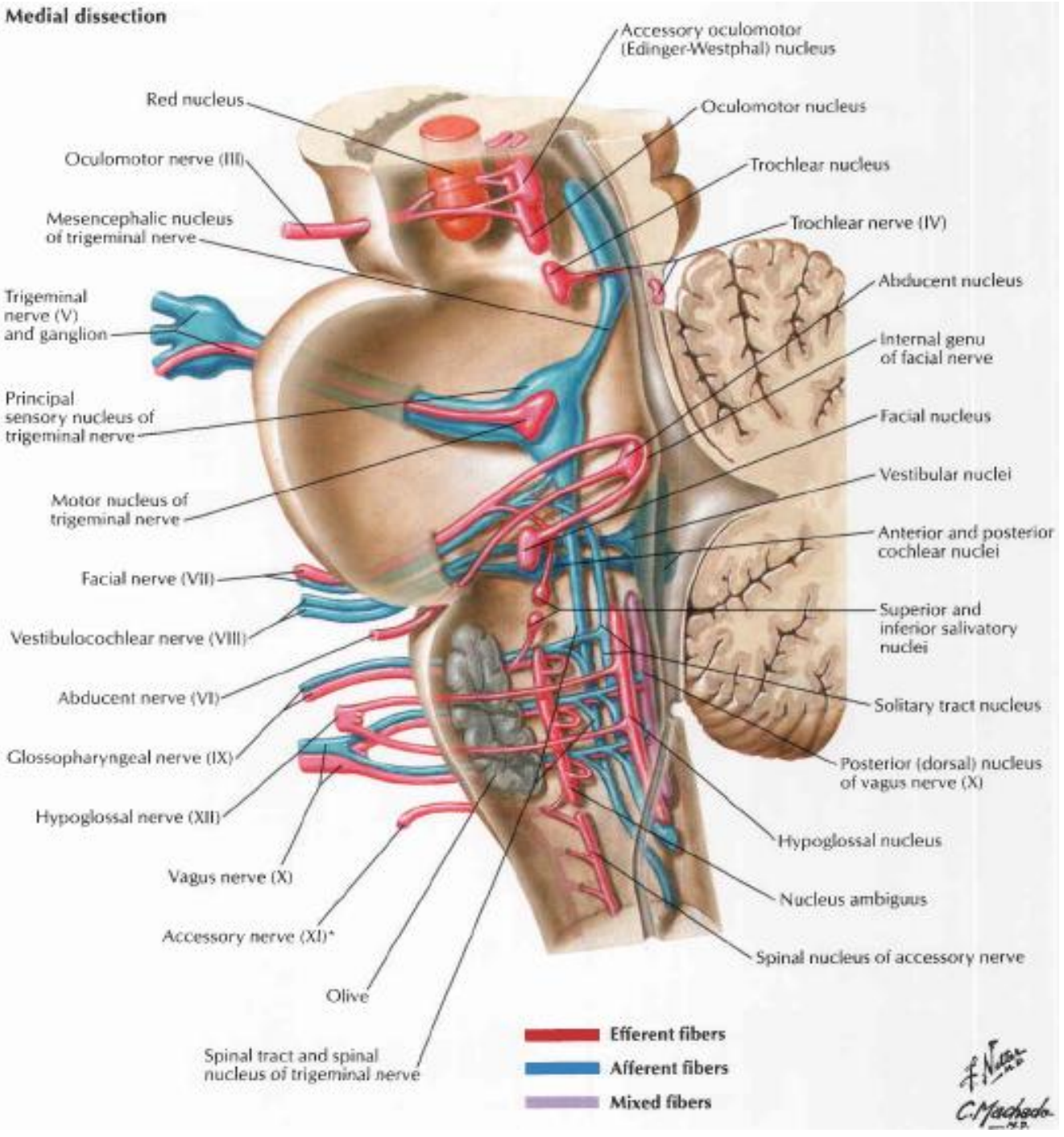
- Juga berhubungan dengan mekanisme nukleus nervus cranialis, cerebellum, batang otak, dan medulla spinalis→ gerakan, postur, dan tonus otot

- **Medulla Oblongata** – bag bawah batang otak, menghubungkan pons dg sumsum tlg blkg, mengendalikan denyut jantung , kecepatan bernafas dan aliran darah dalam pembuluh
- **Pons** – menyampaikan sinyal dari serebrum ke serebelum

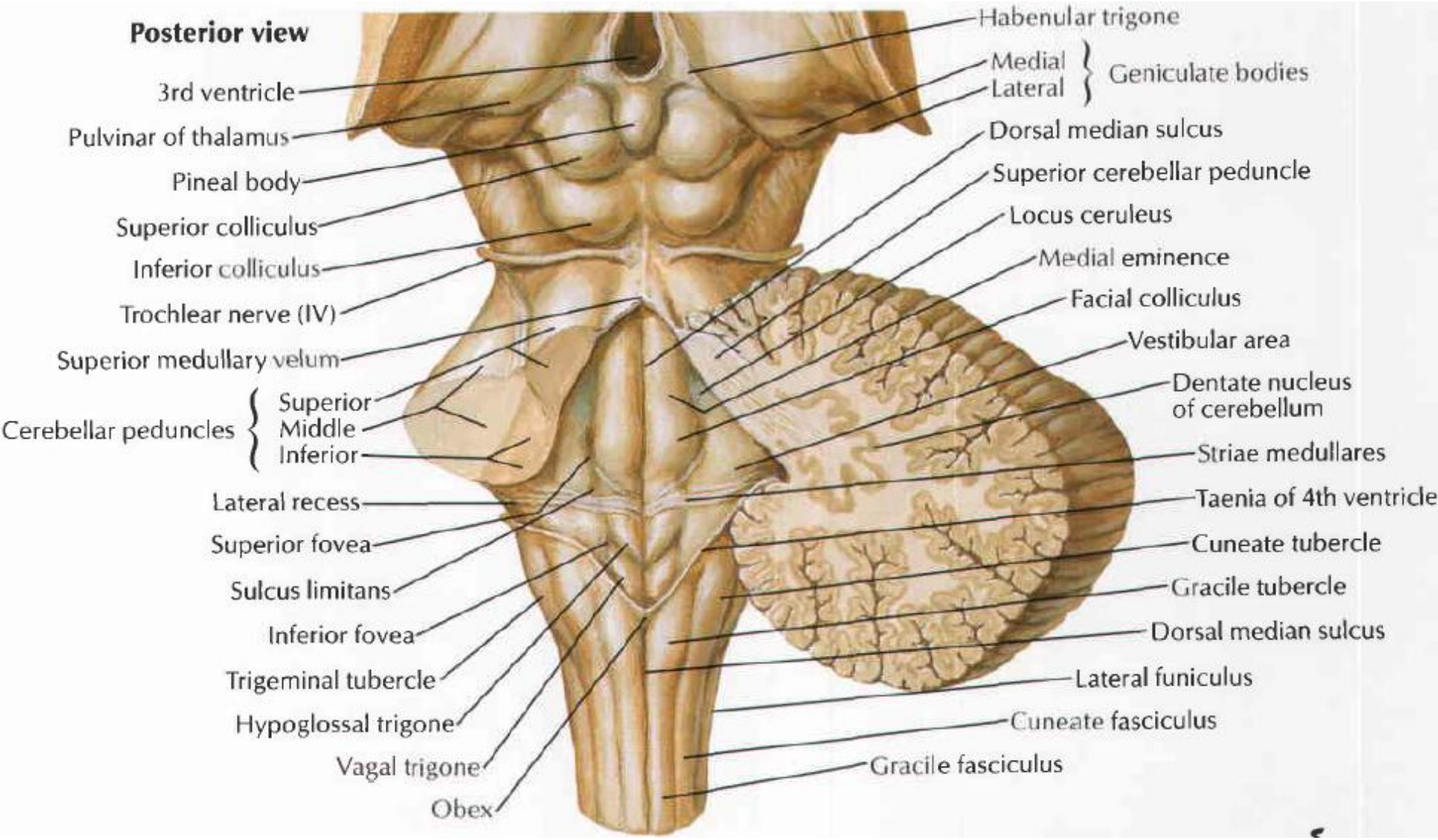
Jaras Ascenden dan Descenden Batang Otak

Ascenden	Descenden
Lemniscus medialis	Traktus corticospinalis
Tractus spinothalamicus	Tractus corticonuclearis
Lemniscus trigeminalis	Corticopontine fibres
Lemniscus lateralis	Tractus rubrospinalis
Reticularis fibres system	Tractus tectospinalis
Fasciculus longitudinalis medialis	Fasciculuc longitudinal medialis
Pedunculus cerebellaris superior	Tractus vestibulospinalis
Pedunculus cerebellaris inferior	Tractus reticulospinalis
Secondary vestibularis fibres	Tractus tegmentalis centralis
Secondary gustatorius fibres	Tractus descenden N.V

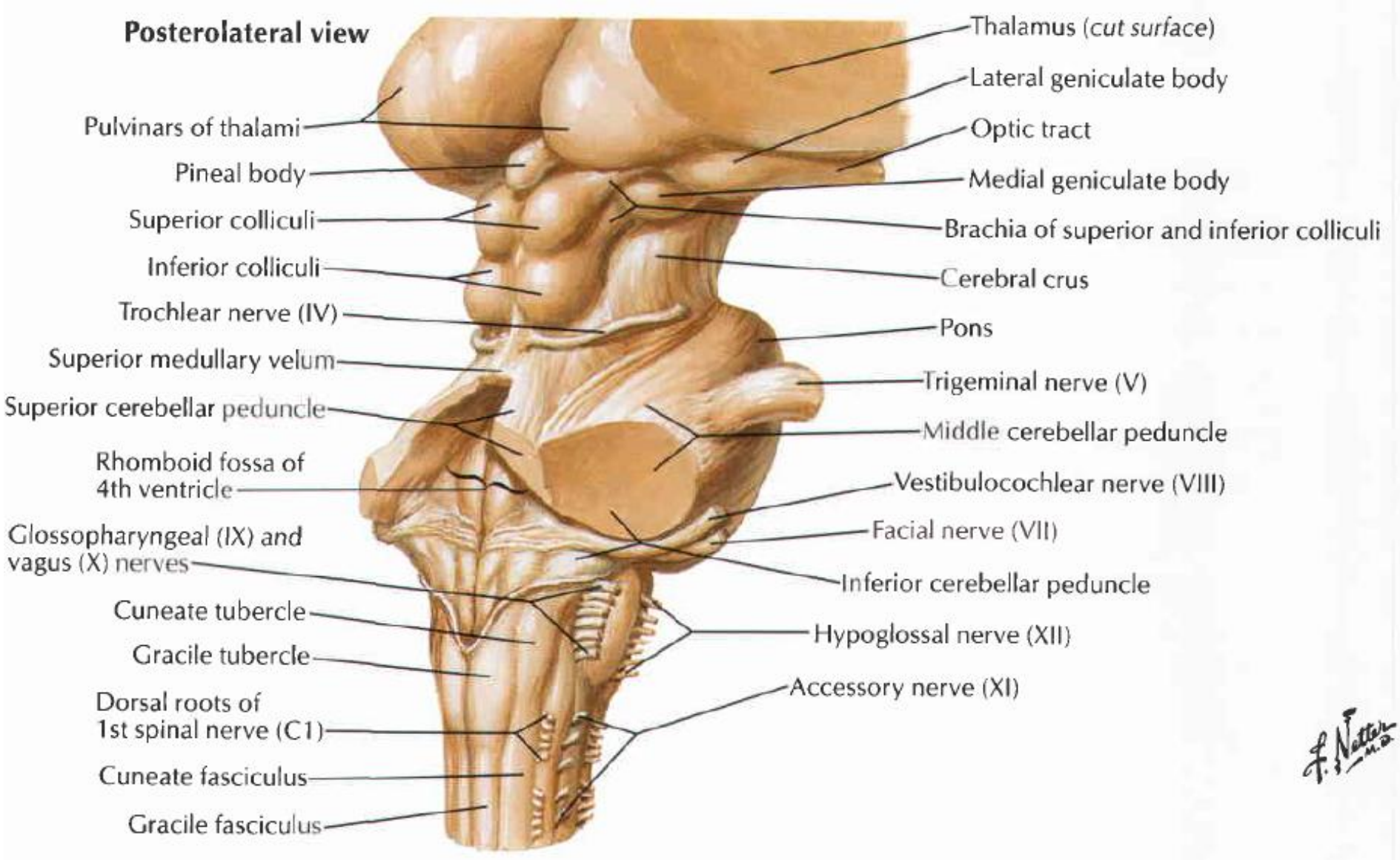

Posterior phantom view
Oculomotor nerve (III)
Red nucleus
Superior colliculus
Oculomotor nucleus
Lateral geniculate body
Accessory oculomotor (Edinger-Westphal) nucleus
Mesencephalic nucleus of trigeminal nerve
Trochlear nucleus
Trochlear nerve (IV)
Principal sensory nucleus of trigeminal nerve
Motor nucleus of trigeminal nerve
Trigeminal nerve (V) and ganglion
Trigeminal nerve (V) and ganglion
Facial nerve (VII) and geniculate ganglion
Abducent nucleus
Facial nucleus
Vestibulocochlear nerve (VIII)
Geniculum (geniculate ganglion) of facial nerve
Cochlear nuclei
Anterior
Posterior
Superior and inferior salivatory nuclei
Vestibular nuclei
Glossopharyngeal nerve (IX)
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Vagus nerve (X)
Accessory nerve (XI)*
Spinal tract and spinal nucleus of trigeminal nerve
Nucleus ambiguus
Posterior (dorsal) nucleus of vagus nerve (X)
Solitary tract nucleus
Dorsal vagal nucleus
Hypoglossal nucleus
Spinal nucleus of accessory nerve
Efferent fibers
Afferent fibers
Mixed fibers


Medial dissection
Accessory oculomotor (Edinger-Westphal) nucleus
Red nucleus
Oculomotor nucleus
Oculomotor nerve (III)
Trochlear nucleus
Mesencephalic nucleus of trigeminal nerve
Trochlear nerve (IV)
Abducent nucleus
Trigeminal nerve (V) and ganglion
Internal genu of facial nerve
Principal sensory nucleus of trigeminal nerve
Facial nucleus
Vestibular nuclei
Motor nucleus of trigeminal nerve
Anterior and posterior cochlear nuclei
Facial nerve (VII)
Superior and inferior salivatory nuclei
Vestibulocochlear nerve (VIII)
Abducent nerve (VI)
Solitary tract nucleus
Glossopharyngeal nerve (IX)
Posterior (dorsal) nucleus of vagus nerve (X)
Hypoglossal nerve (XII)
Hypoglossal nucleus
Vagus nerve (X)
Nucleus ambiguus
Accessory nerve (XI)*
Spinal nucleus of accessory nerve
Olive
Spinal tract and spinal nucleus of trigeminal nerve
Efferent fibers
Afferent fibers
Mixed fibers

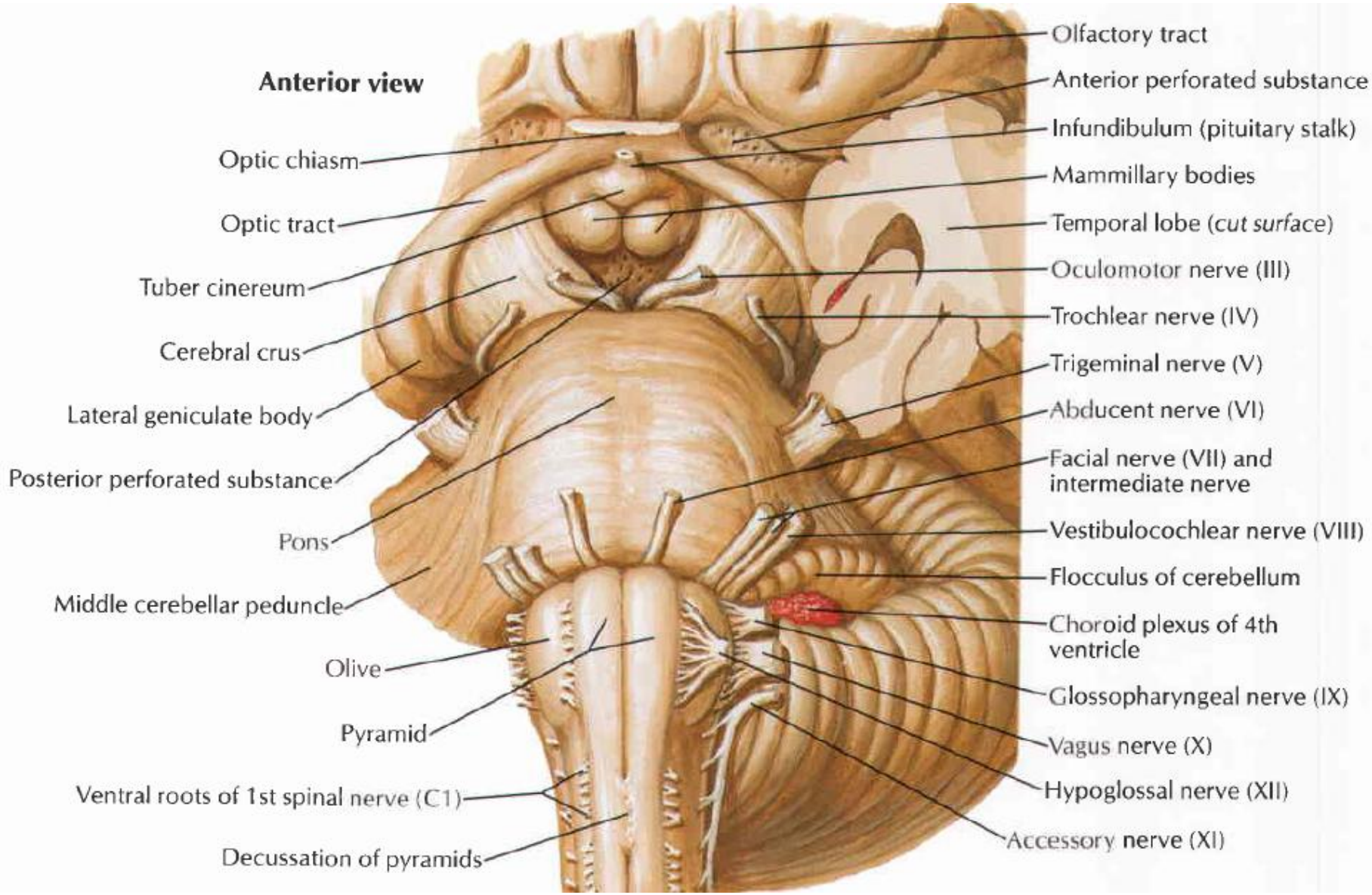
Dorsal Surface (External Feature)

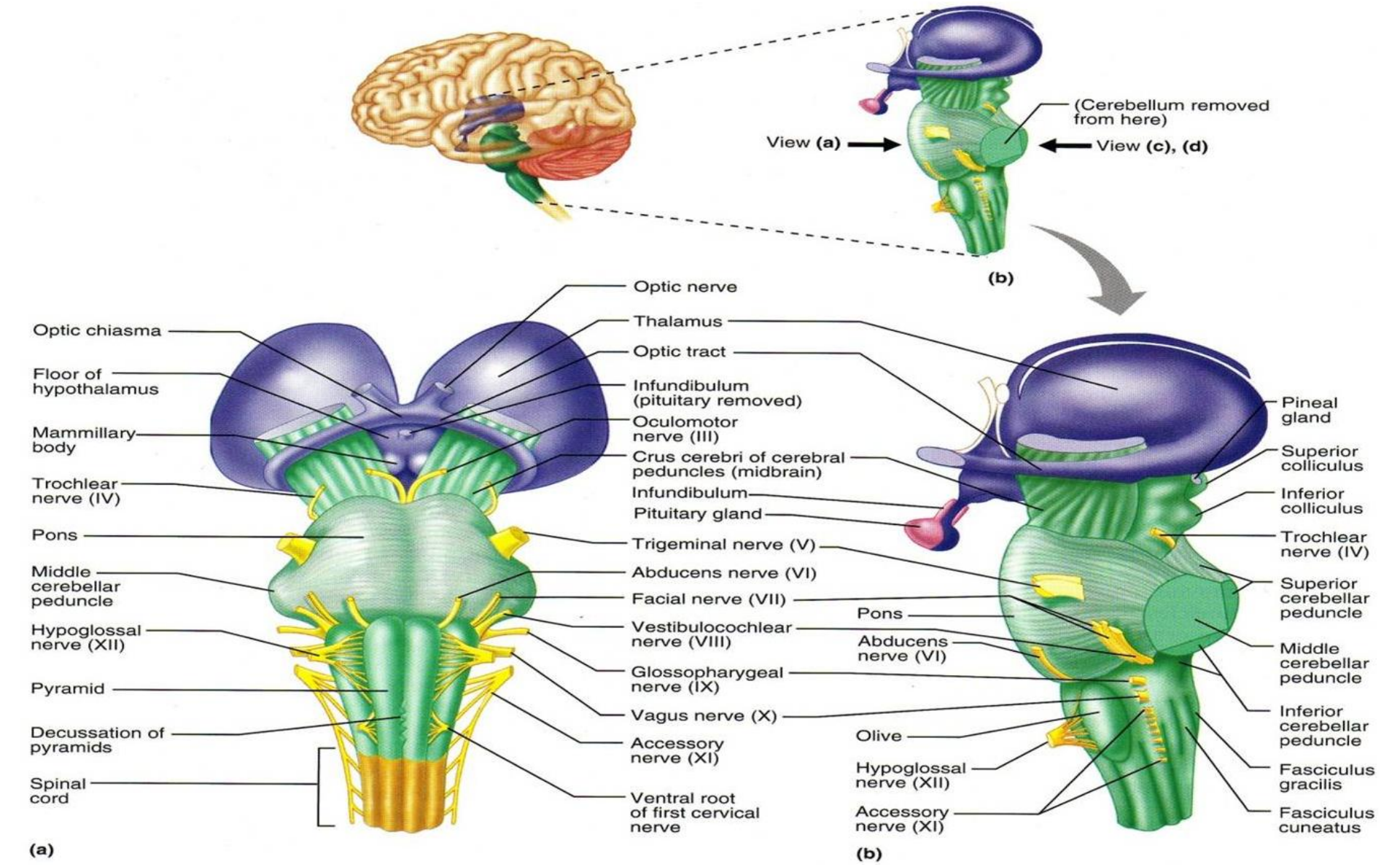


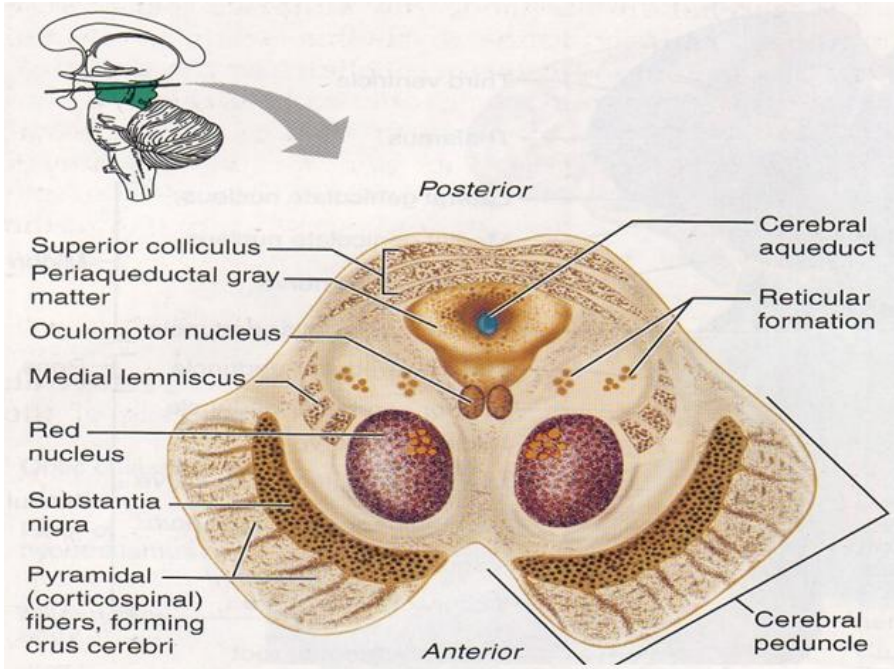
Dorsal Surface (External Feature)

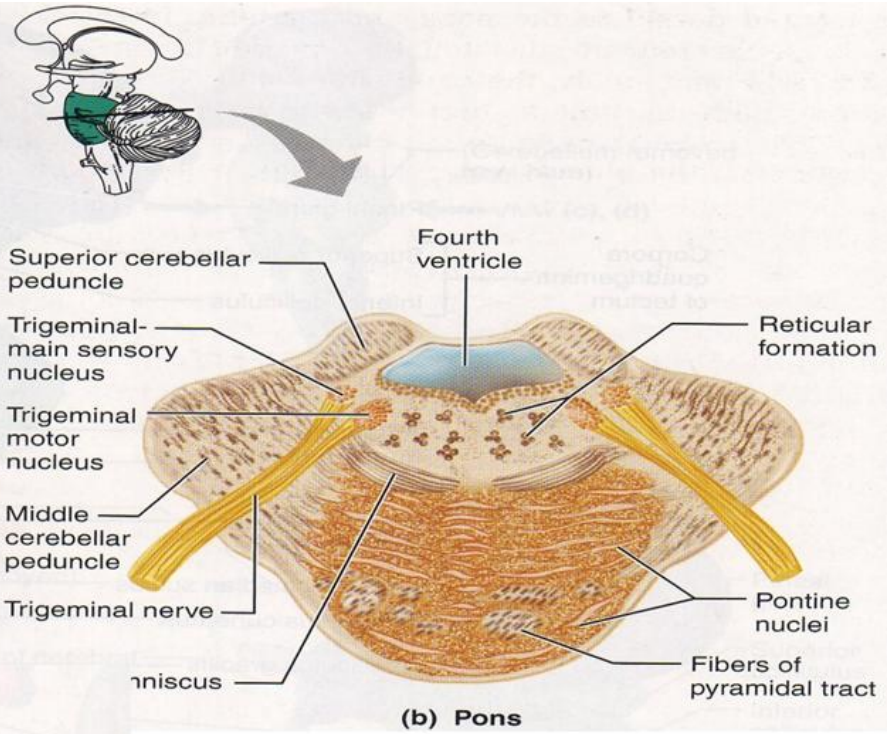


Vental Surface (External future)

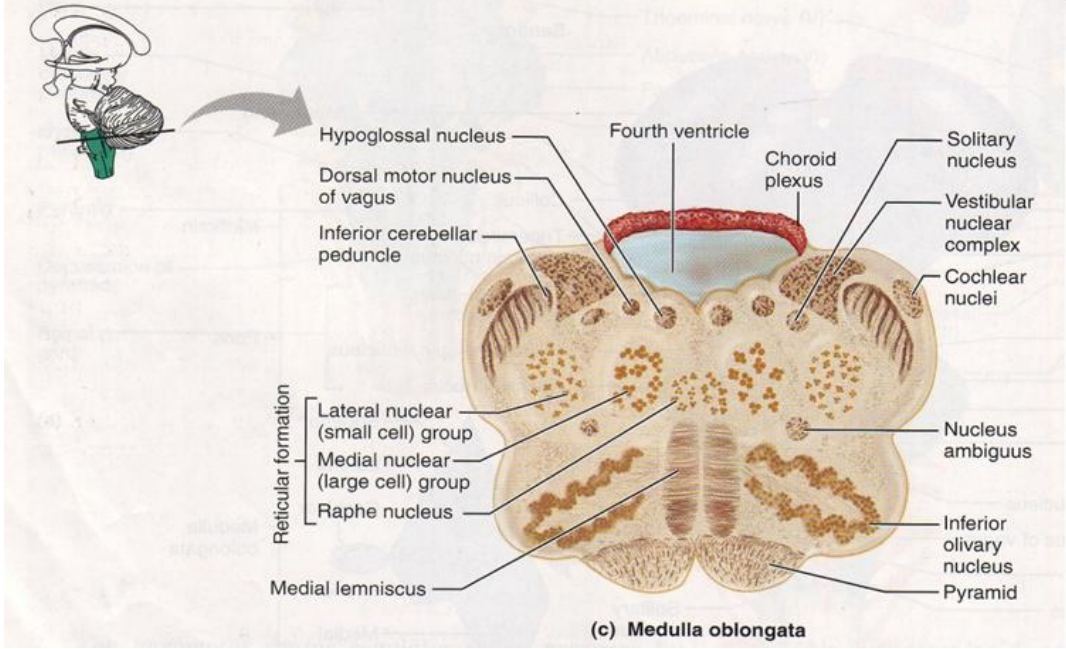



(Cerebellum removed from here)
View (a)
View (c), (d)
(b)
Optic nerve
Optic chiasma
Thalamus
Floor of hypothalamus
Optic tract
Infundibulum (pituitary removed)
Mammillary body
Oculomotor nerve (III)
Crus cerebri of cerebral peduncles (midbrain)
Trochlear nerve (IV)
Infundibulum
Pituitary gland
Pons
Trigeminal nerve (V)
Middle cerebellar peduncle
Abducens nerve (VI)
Facial nerve (VII)
Hypoglossal nerve (XII)
Vestibulocochlear nerve (VIII)
Pyramid
Glossopharygeal nerve (IX)
Vagus nerve (X)
Decussation of pyramids
Accessory nerve (XI)
Spinal cord
Ventral root of first cervical nerve
(a)
Pineal gland
Superior colliculus
Inferior colliculus
Trochlear nerve (IV)
Superior cerebellar peduncle
Pons
Abducens nerve (VI)
Middle cerebellar peduncle
Inferior cerebellar peduncle
Olive
Fasciculus gracilis
Hypoglossal nerve (XII)
Accessory nerve (XI)
Fasciculus cuneatus
(b)





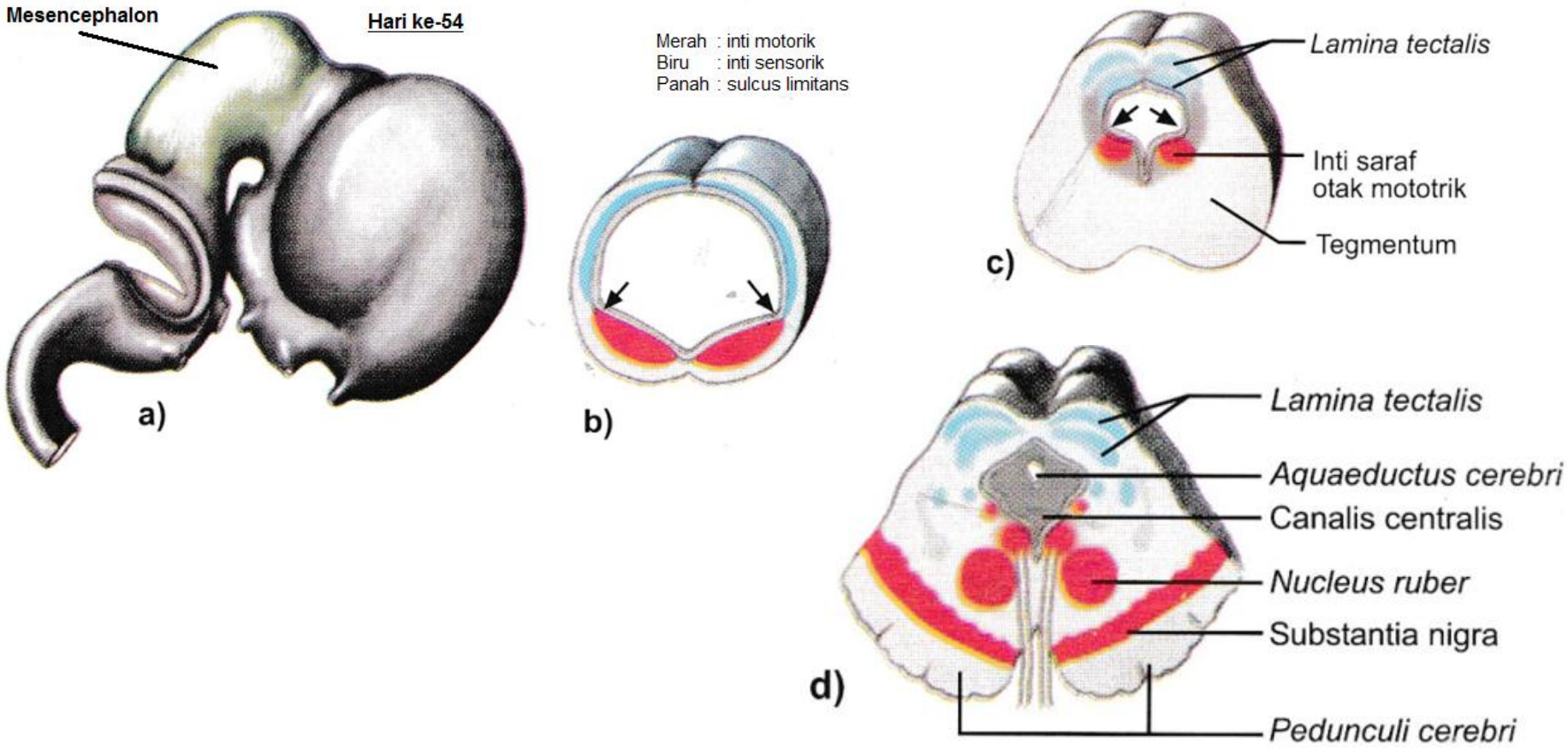
(b) Pons



(c) Medulla oblongata

Mesencephalon (midbrain)

- Dibagi atas bagian dorsal dan ventral pada tingkat aquaductus cerebri



1. Bagian ventral (Tegmentum)
2. Bagian dorsal (**tectum**)
   - colliculus inferior and superior (**corpora quadrigemina**)

- **Colliculus inferior** (bagian dari proyeksi auditori/acustik ascenden)

  Jaras auditori ascenden (lateral lemniscus) → colliculus inferior → serat eferen → nucleus geniculatum medial (thalamus) → corteks auditori (lobus temporal)

- **Colliculus Superior** (bagian dari sistem visual)

- Eferen Utama :

  serat corticotectal fibres (dari korteks visual lobus occipital & area mata depan dari lobus frontal)

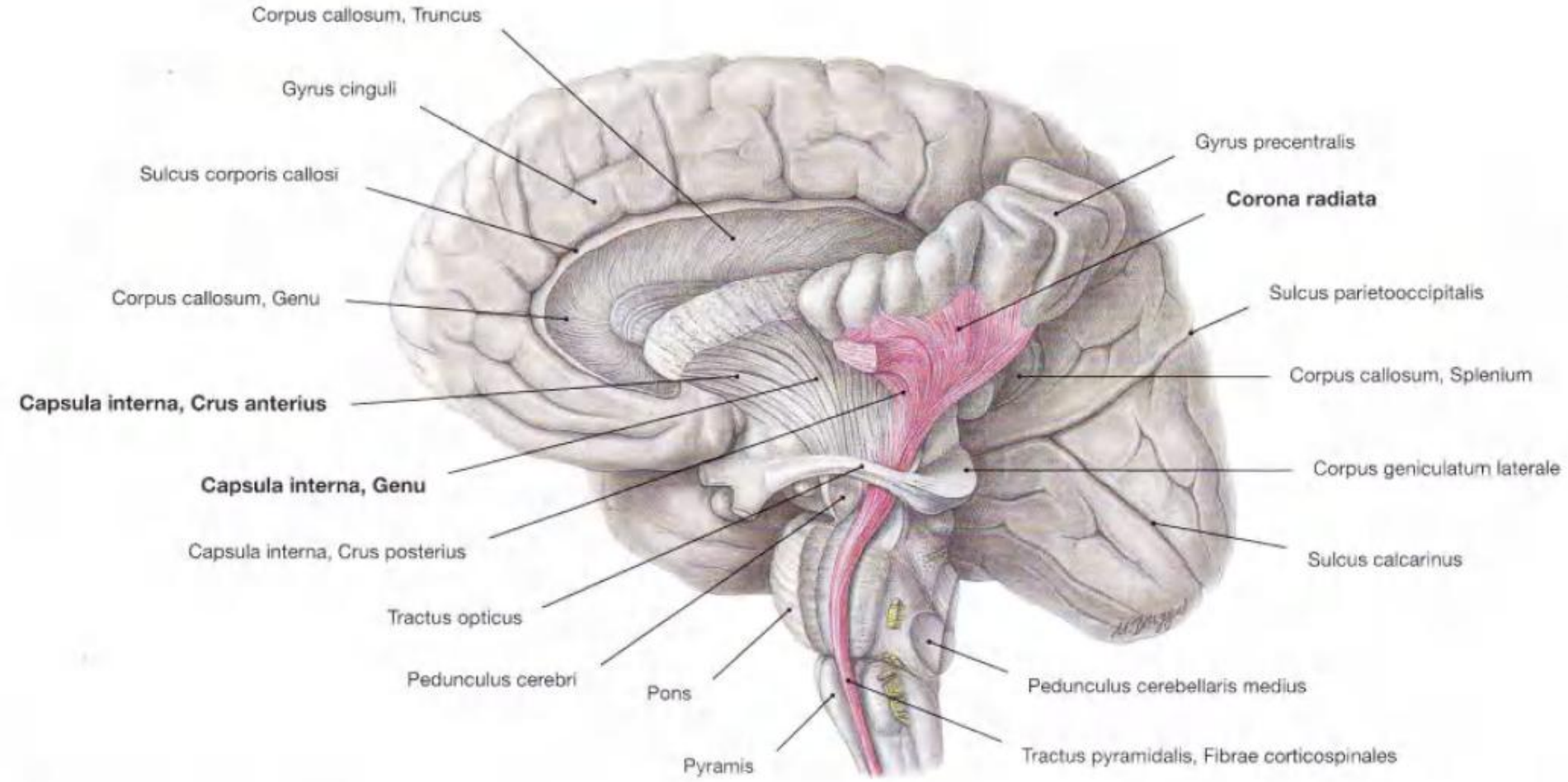
  Fungsi :

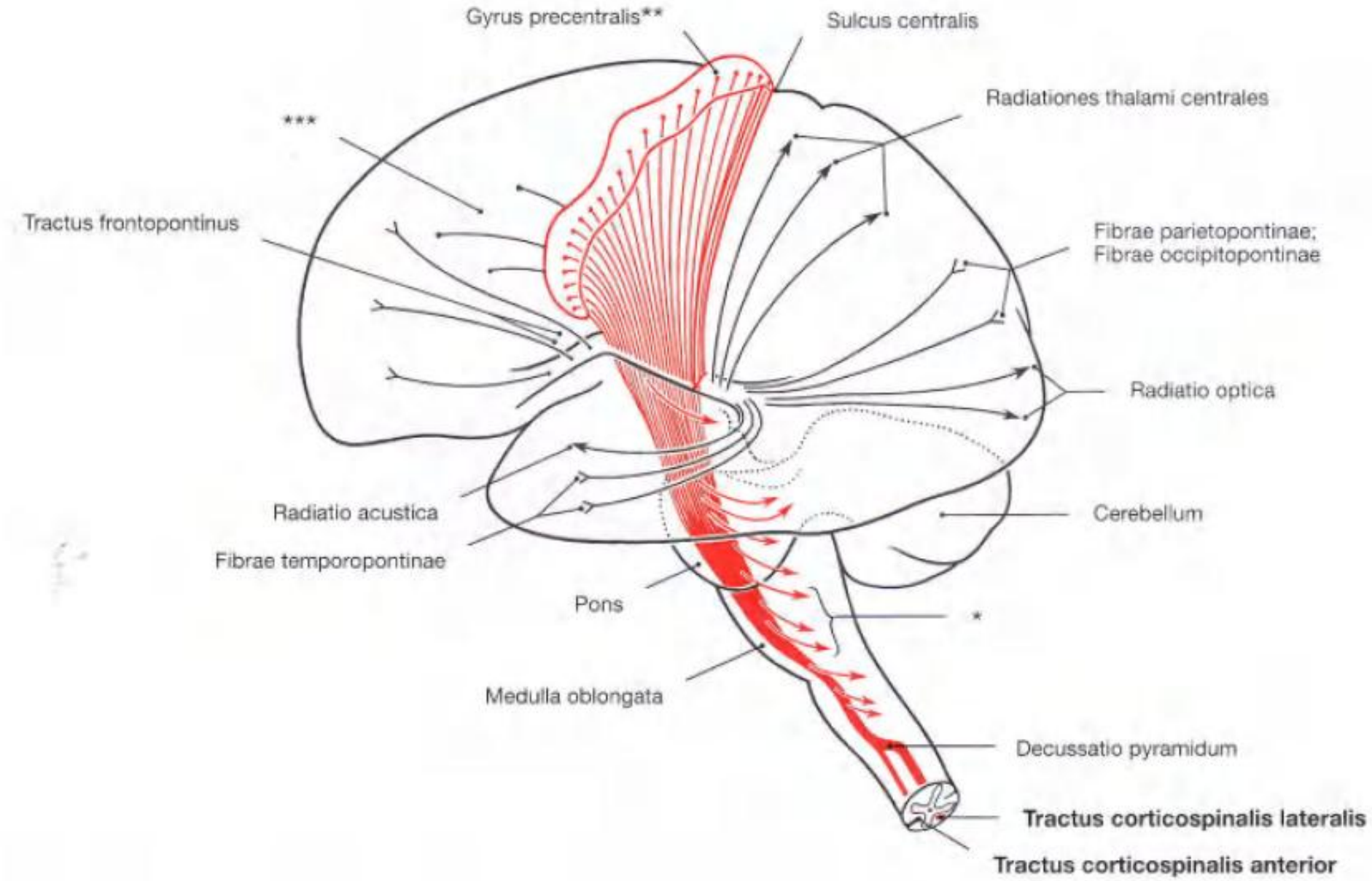
  * Gerakan bola mata → gerakan mengikuti objek (smooth pursuit) atau mengubah arah tatapan (saccadic eye movements)
  * daya akomodasi mata (fungsi tambahan)

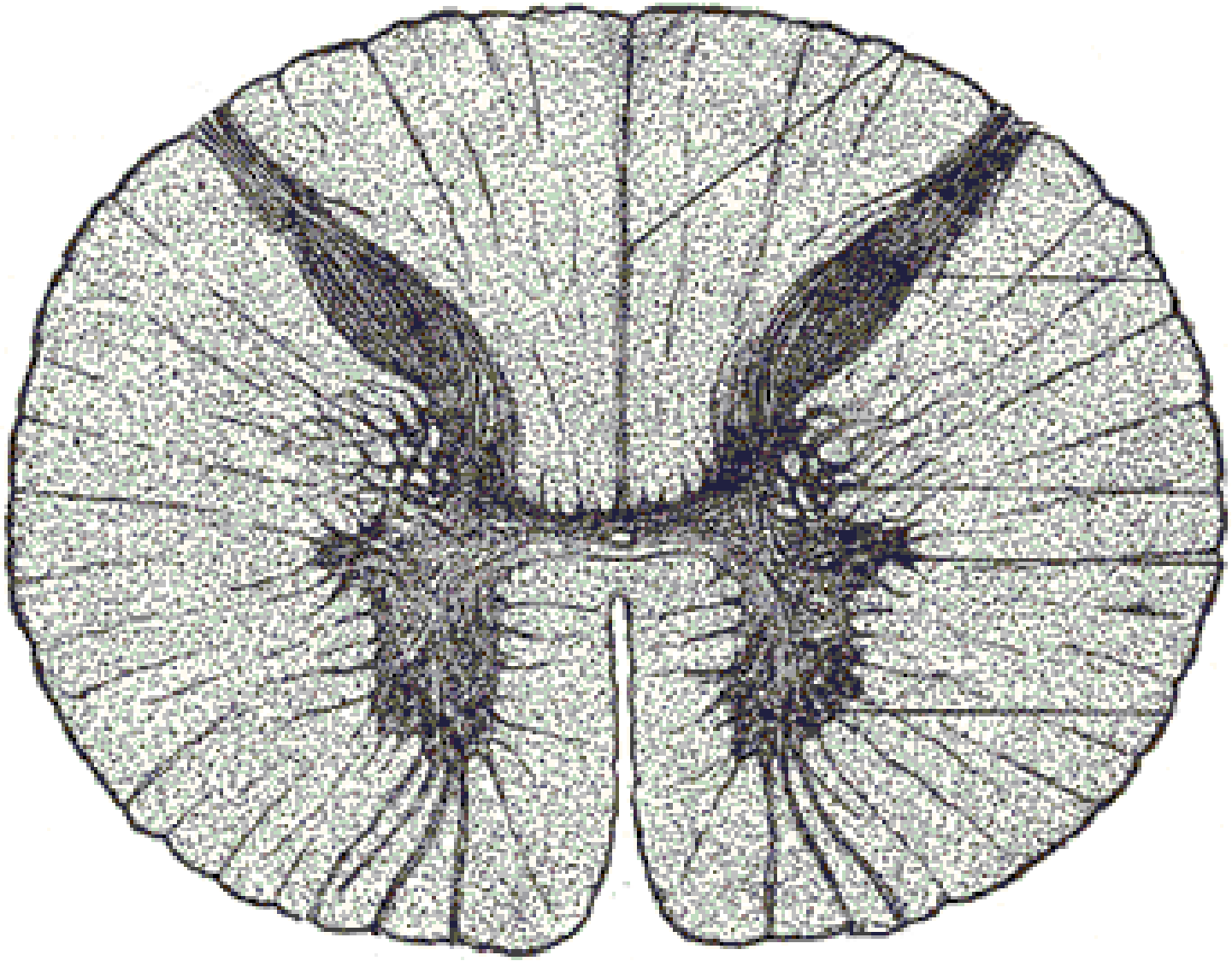
- Sebagian kecil serat visual (tractus opticus) → colliculus superior, pada **pretectal nucleus**.

  Hal ini berhubungan dgn neuron parasimpatik:

  - mengontrol otot polos mata
  - bagian dari jalur refleks cahaya pupil


Corpus callosum, Truncus
Gyrus cinguli
Sulcus corporis callosi
Corpus callosum, Genu
Capsula interna, Crus anterius
Capsula interna, Genu
Capsula interna, Crus posterius
Tractus opticus
Pedunculus cerebri
Pons
Pyramis
Gyrus precentralis
Corona radiata
Sulcus parietooccipitalis
Corpus callosum, Splenium
Corpus geniculatum laterale
Sulcus calcarinus
Pedunculus cerebellaris medius
Tractus pyramidalis, Fibrae corticospinales

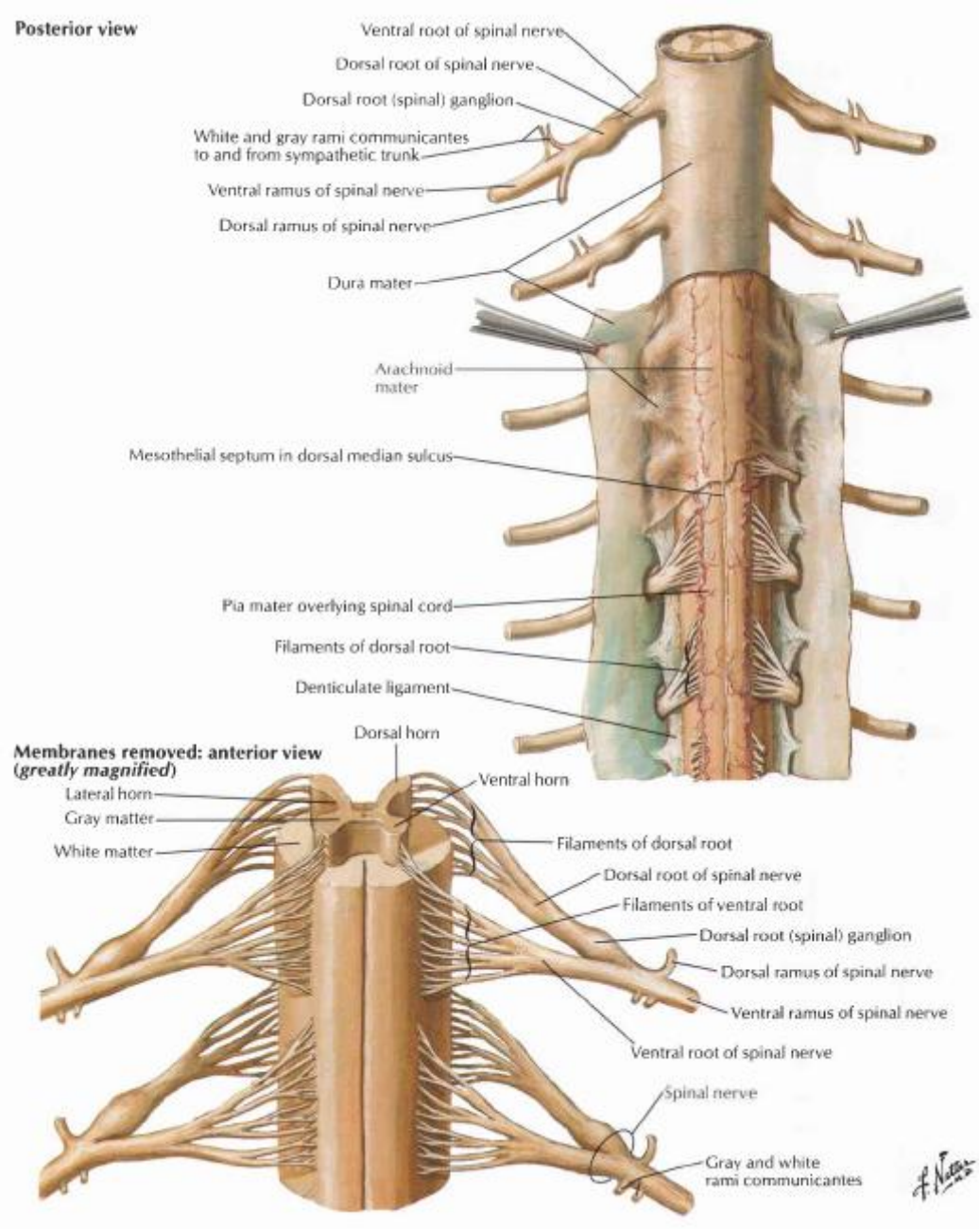

Gyrus precentralis**
Sulcus centralis
Radiationes thalami centrales
***
Tractus frontopontinus
Fibrae parietopontinae;
Fibrae occipitopontinae
Radiatio optica
Radiatio acustica
Cerebellum
Fibrae temporopontinae
Pons
*
Medulla oblongata
Decussatio pyramidum
Tractus corticospinalis lateralis
Tractus corticospinalis anterior

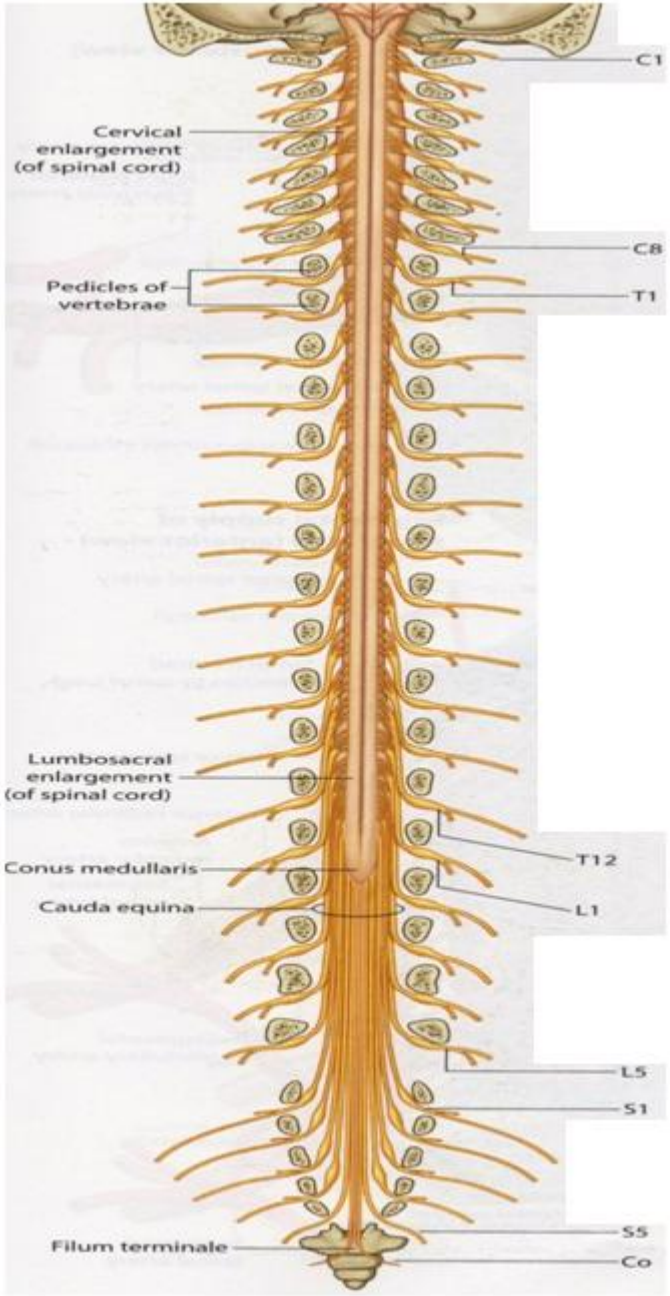


MEDULLA SPINALIS

Medulla spinalis

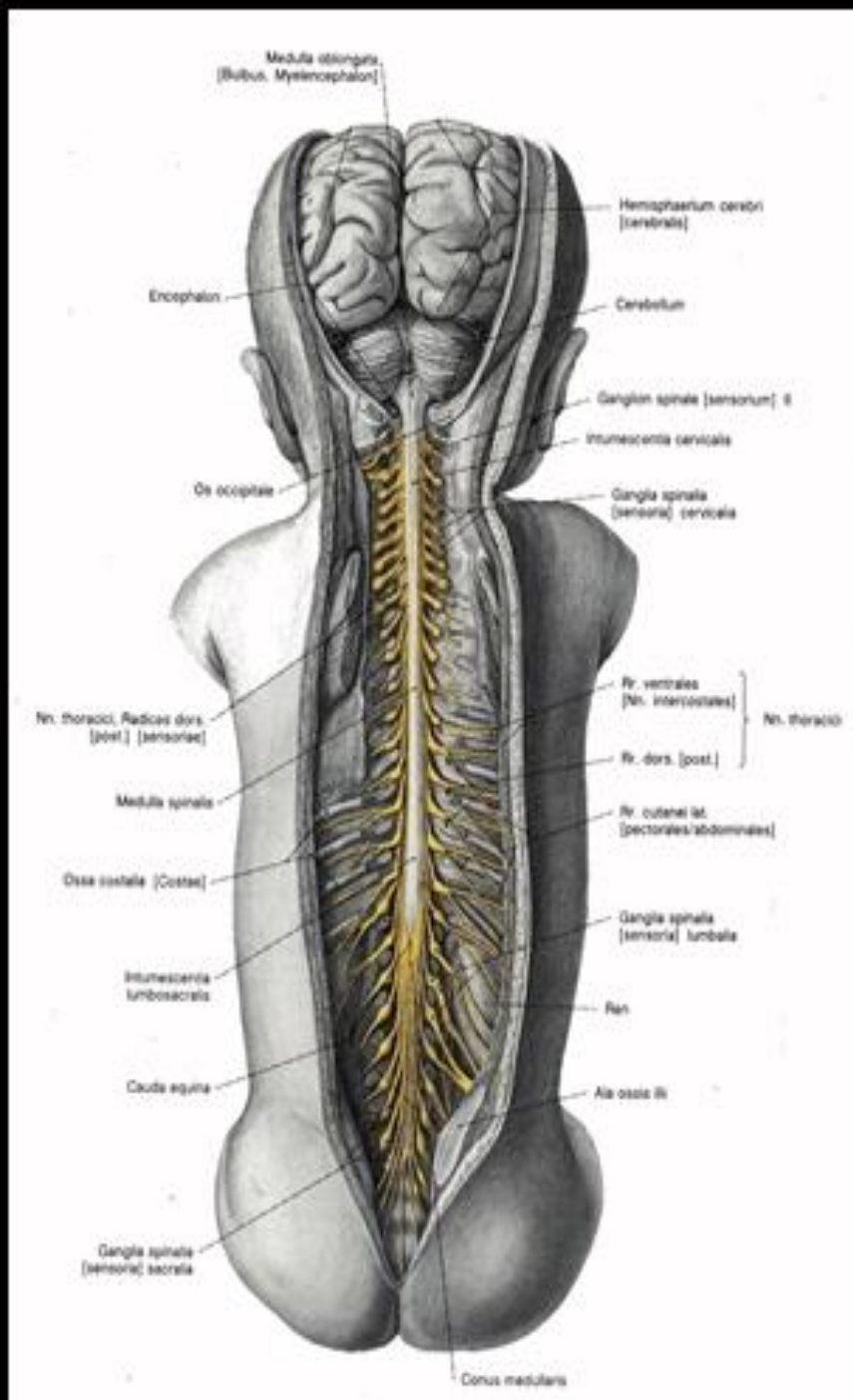
- Bagian SSP → decussatio pyramidum – antara VL1-VL2
- Setelah VL1 → Conus medullaris/conus terminalis
- Di bawah conus terminalis → Filum terminale
- Akar saraf lumbal dan sakral terkumpul → Cauda Equina
- Setiap pasangan syaraf keluar melalui → foramina intervertebralis
- Syaraf Spinal dilindungi oleh tulang vertebra, ligamen, meningen spinal, dan CSS

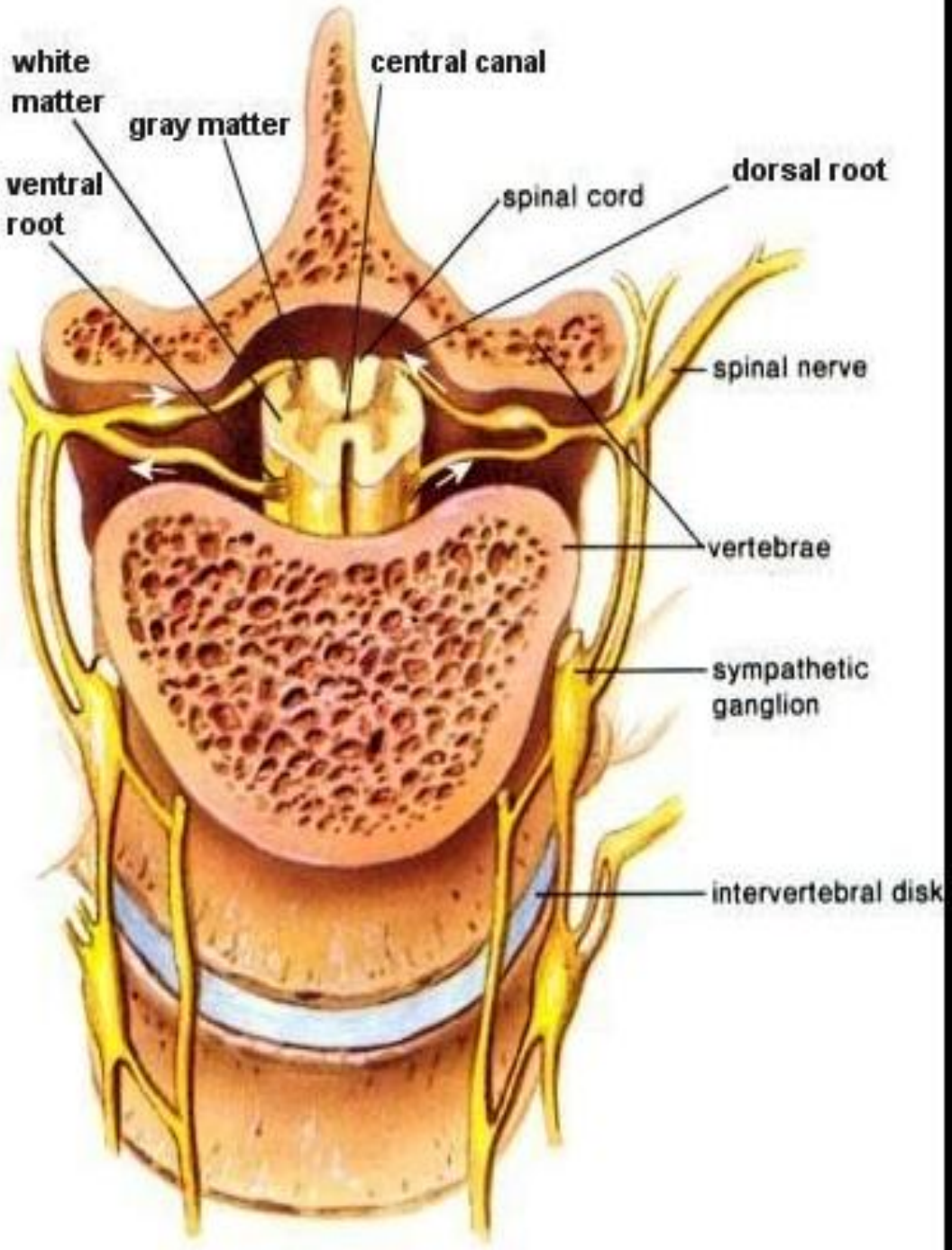

Posterior view
Ventral root of spinal nerve
Dorsal root of spinal nerve
Dorsal root (spinal) ganglion
White and gray rami communicantes to and from sympathetic trunk
Ventral ramus of spinal nerve
Dorsal ramus of spinal nerve
Dura mater
Arachnoid mater
Mesothelial septum in dorsal median sulcus
Pia mater overlying spinal cord
Filaments of dorsal root
Denticulate ligament
Membranes removed: anterior view
(greatly magnified)
Dorsal horn
Ventral horn
Lateral horn
Gray matter
White matter
Filaments of dorsal root
Dorsal root of spinal nerve
Filaments of ventral root
Dorsal root (spinal) ganglion
Dorsal ramus of spinal nerve
Ventral ramus of spinal nerve
Ventral root of spinal nerve
Spinal nerve
Gray and white rami communicantes


C1
Cervical enlargement (of spinal cord)
C8
Pedicles of vertebrae
T1
Lumbosacral enlargement (of spinal cord)
T12
Conus medullaris
L1
Cauda equina
L5
S1
S5
Filum terminale
Co

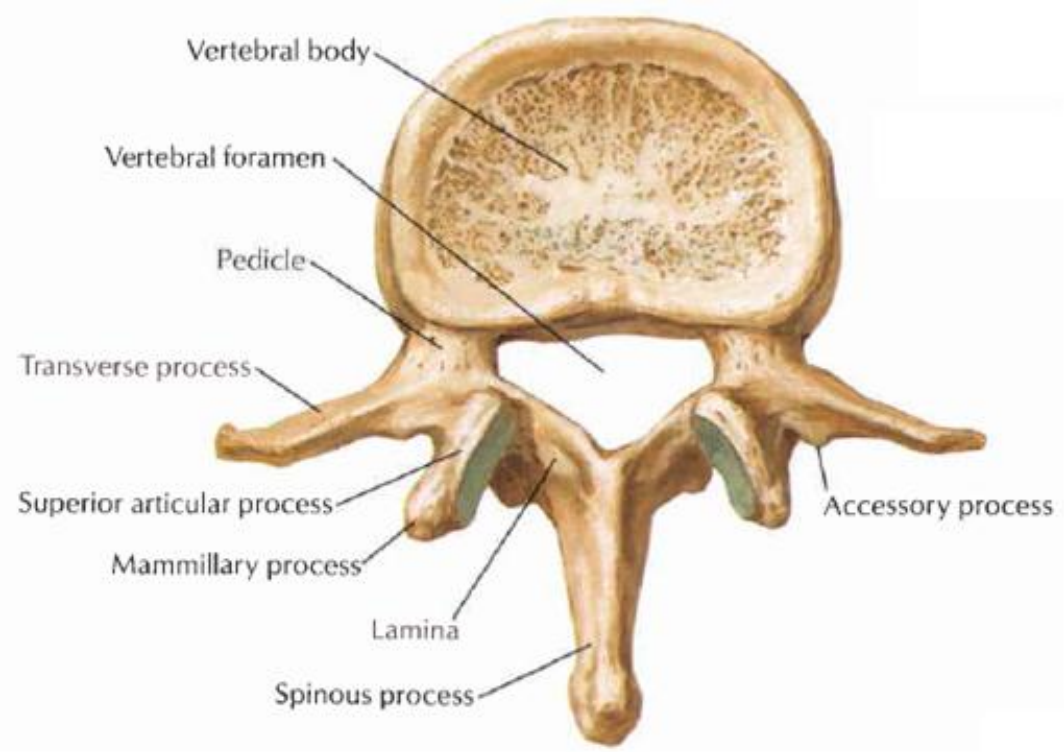
- Medulla spinalis →
  panjang: 40-45 cm, berat: 34-38 gram, D: ± 12 mm
  canalis vertebralis → panjang: 61-71 cm

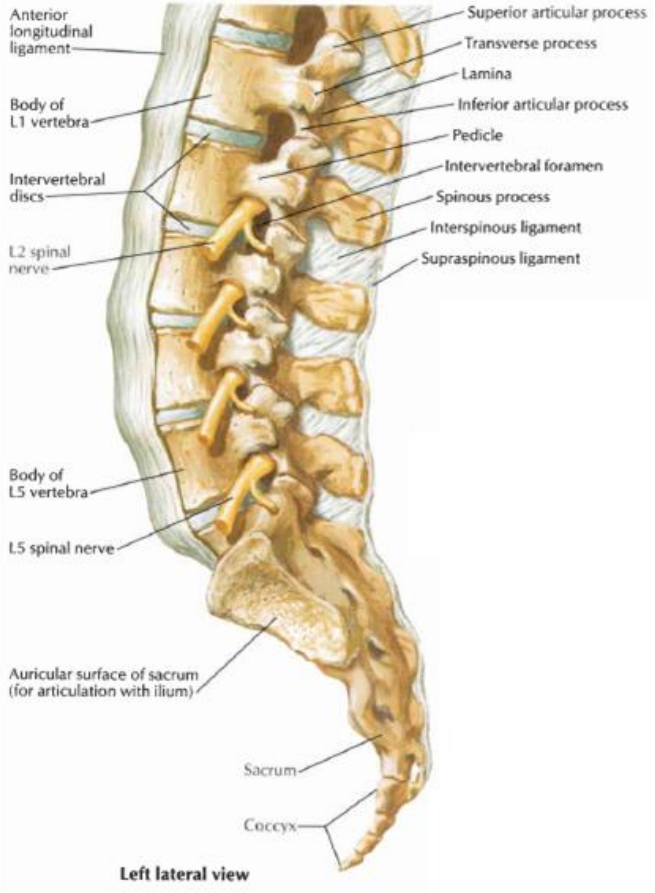
- Medulla Spinalis dpt dibagi menjadi:
  1. pars cervicalis
     mengeluarkan 8 psg N.spinalis ervicales
  2. Pars thoracica
     mengeluarkan 12 psg N.spinalis thoracales
  3. Pars lumbalis
     mengeluarkan:
     - 5 psg N.spinalis lumbales
     - 5 psg N.spinalis sacrales
     - 1 psg N.spinalis coccygeus

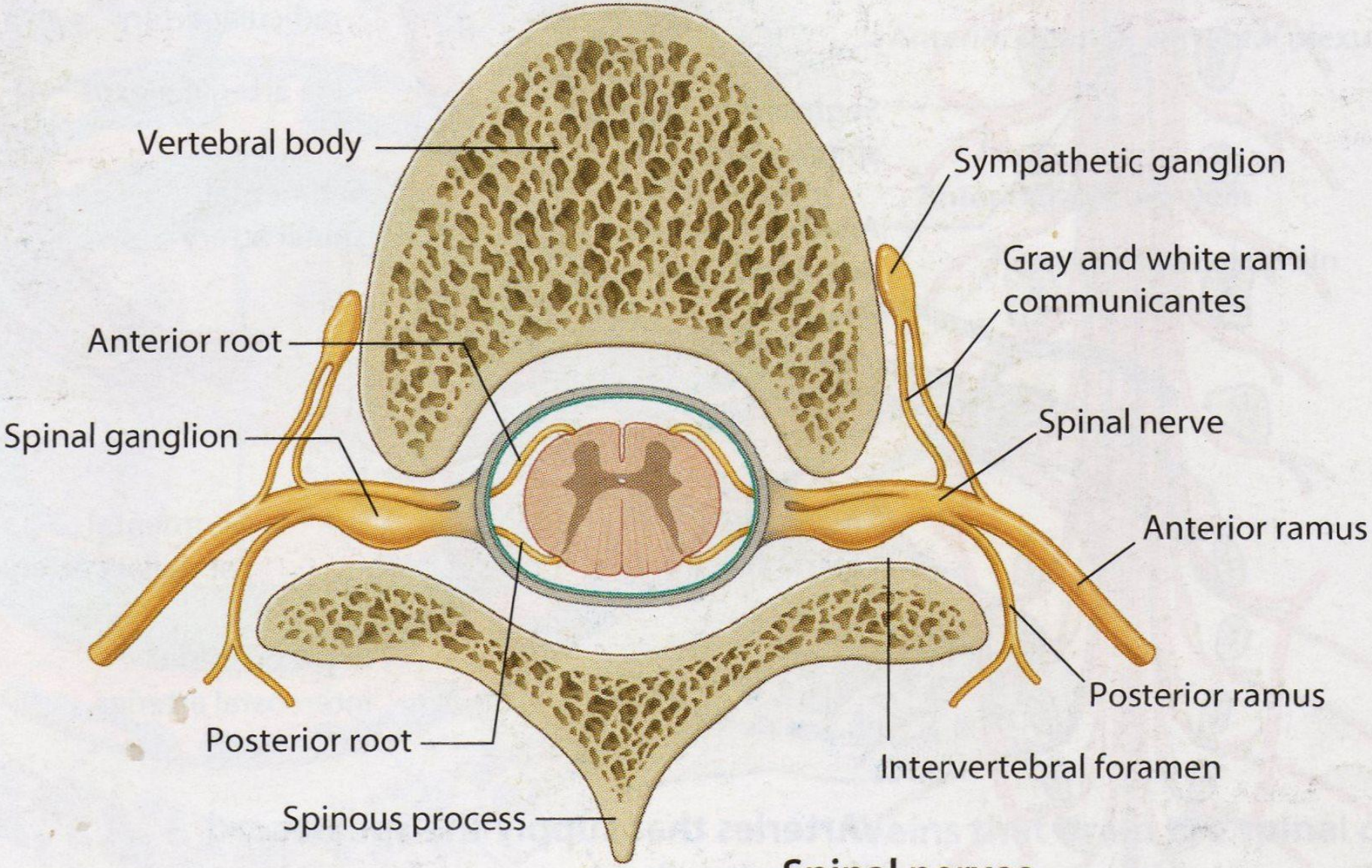

Medulla oblongata [Bulbus, Myelencephalon]
Hemisphaerium cerebri [cerebrale]
Encephalon
Cerebellum
Ganglion spinale [sensorium]
Intumescentia cervicalis
Os occipitale
Ganglia spinalia [sensoria] cervicalia
Nn. thoracici, Radices dors. [post.] [sensoriae]
Rr. ventrales [Nn. intercostales]
Nn. thoracici
Rr. dors. [post.]
Medulla spinalis
Rr. cutanei lat. [pectorales/abdominales]
Ossa costalia [Costae]
Ganglia spinalia [sensoria] lumbalia
Intumescentia lumbosacralis
Ren
Cauda equina
Ala ossis ilii
Ganglia spinalia [sensoria] sacralia
Conus medullaris


white matter
central canal
gray matter
ventral root
spinal cord
dorsal root
spinal nerve
vertebrae
sympathetic ganglion
intervertebral disk

- Medulla spinalis terdapat di dalam canalis vertebralis
- Medulla spinalis memberi cabang 31 pasang nervus spinalis yang menerima dari dan mengirim sinyal ke perifer







Spinal nerves (transverse section)

Perbandingan panjang vertebra dan medulla spinalis

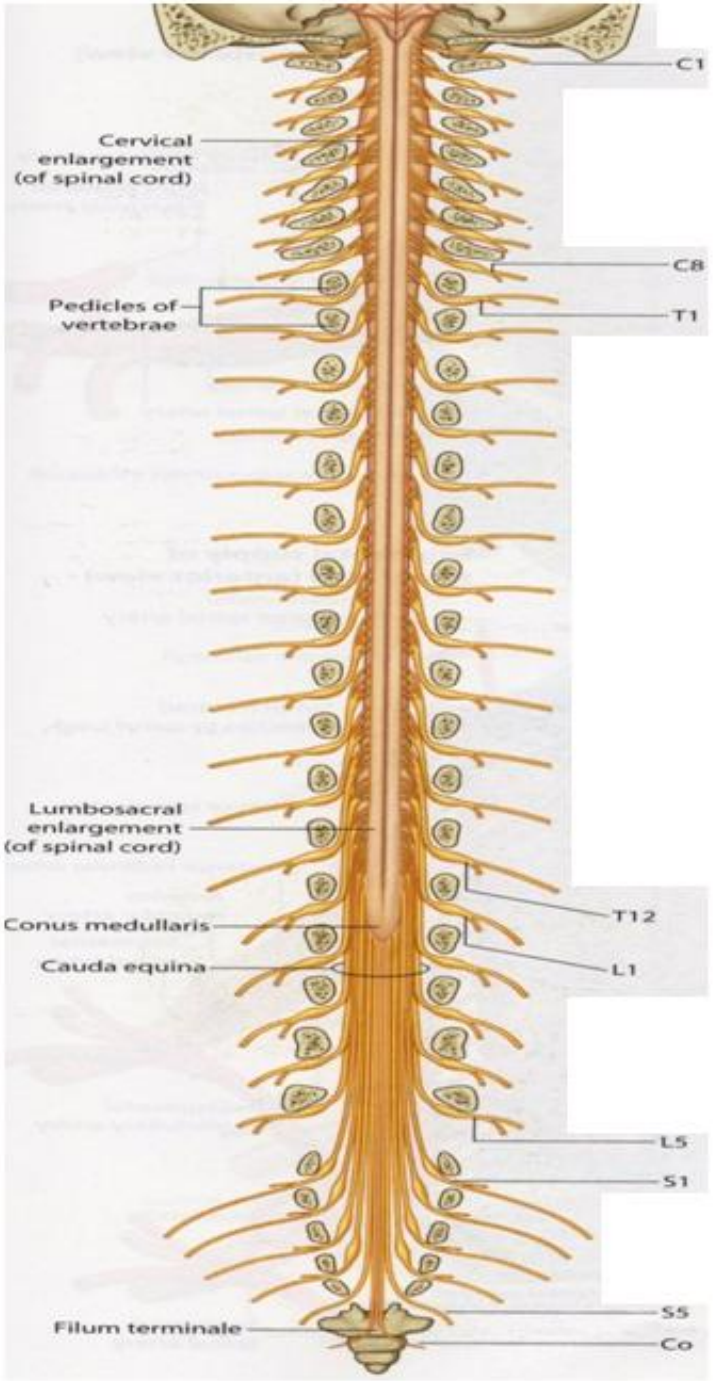
Janin umur 3 bulan →panjang medulla spinalis sama dengan vertebra

Terjadi perubahan perbandingan panjang vertebra dan medulla spinalis

Lahir→corda terminalis medulla spinalis sejajar vertebra L3

Dewasa → corda terminalis medulla spinalis sejajar vertebra L1 and L2

- Lokasi segmen medulla spinalis berdasarkan segmen tulang (dewasa)
  - segmen cervical→ 1 segmen lebih tinggi dari vertebranya
  - Segmen thoracis → 2 segmen lebih tinggi dari vertebranya
  - Segmen lumbaris→ 4 segmen lebih tinggi dari vertebranya



Struktur Internal

- Terdiri atas substansi abu-abu (substansia grisea) dan substansi putih (substansia alba)
- Substansia grisea dikelilingi di bagian luarnya oleh substansia alba

- Substansi grisea mengandung badan sel dan dendrit dan neuron efferen, akson tak bermyelin, syaraf sensoris dan motoris dan akson terminal dari neuron
- Substansi grisea membentuk seperti huruf H (kupu-kupu) dan terdiri dari tiga bagian yaitu: anterior, posterior dan lateral

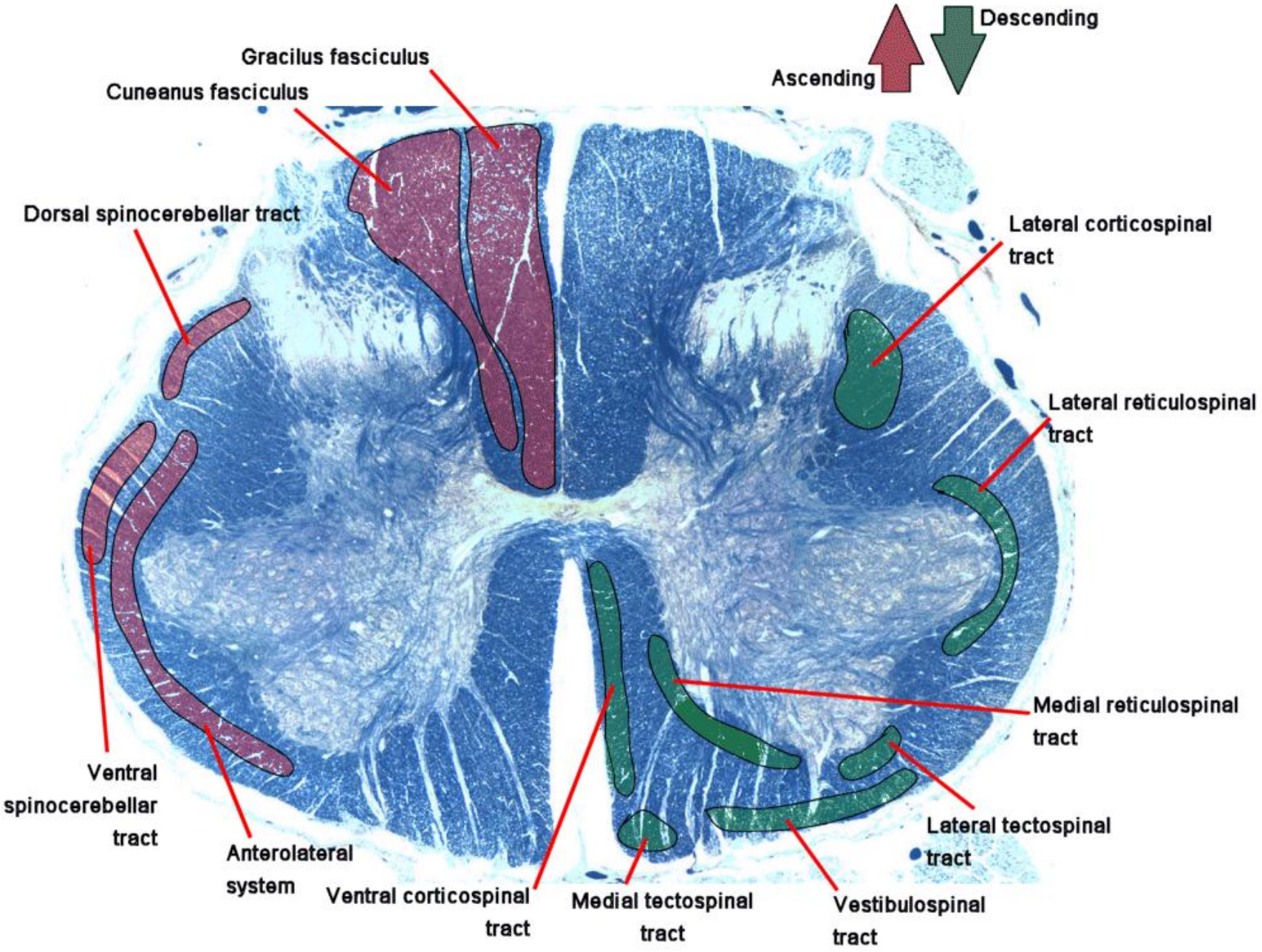
- Substansia grisea :
  - cornu dorsalis → neuron sensorik
  - cornu ventralis → neuron motorik
  - cornu lateralis → preganglion neuron simpatis

- Substansia alba (tractus ascenden & desenden)

<u>Tractus ascenden:</u>
- columna dorsalis (fasciculus gracilis & cuneatus)
- tractus spinothalamica lateralis dan ventralis (anterior)
- tractus spinocerebellar ventral & dorsal
- tractus spinocorticalis
- tractus spinovestibularis
- tractus spinoreticularis
- tractus spinotectalis
- tractus spinopontinus
- tractus spinoolivaris

Tractus descenden:

1. tractus piramidalis
    - tractus corticospinal lateral & ventral
2. tractus extrapiramidalis
    - tractus reticulospinalis
    - tractus vestibulospinalis medial & lateral
    - tractus rubrospinalis
    - tractus tectospinalis lateral & medial
    - tractus olivospinalis


Descending
Ascending
Gracilus fasciculus
Cuneanus fasciculus
Dorsal spinocerebellar tract
Lateral corticospinal tract
Lateral reticulospinal tract
Medial reticulospinal tract
Lateral tectospinal tract
Vestibulospinal tract
Medial tectospinal tract
Ventral corticospinal tract
Anterolateral system
Ventral spinocerebellar tract

Tractus Spinalis Ascenden (Jaras Sensoris)

- Membawa impuls (nyeri, suhu, taktil, proprioseptif) ke otak

- 3 neuron di antara reseptor perifer dan korteks cerebri:
  - First order neurone/ primary afferent fibre
  - Second order neurone
  - Third order neurone

- Tractus ascenden:
  - columna dorsalis (fasciculus gracilis and cuneatus),
  - tractus spinothalamicus
  - tractus spinocerebellaris ventral & dorsal

Neurone	Location of Cell body	Axon	Function
1st order neurone/ primary afferent fibres	Dorsal root ganglia	-Enter spinal cord through dorsal root of a spinal nerve -Remains on the ipsilateral side -Synapse with 2nd order neurone (in medulla spinalis or medulla oblongata)	Mediate spinal reflexes and intersegmental coordination
2nd order neurone	Spinal cord or medulla oblongata	-Crosses over to the opposite side (decussates) -Ascends to the thalamus to synapse with 3rd order neurone	Connect 1st order neurone with 3rd order neurone
3rd order neurone	Thalamus	- Passes to the somatosensory cortex in parietal lobe ipsilateral	

Jaras Motorik

- Jaras saraf mulai dari cortex motorik cerebri sampai ke efektor (otot, kelenjar)
- Jaras menyilang di medulla oblongata

- Dibagi menjadi 2, yaitu:

1. Upper Motor Neuron (UMN)

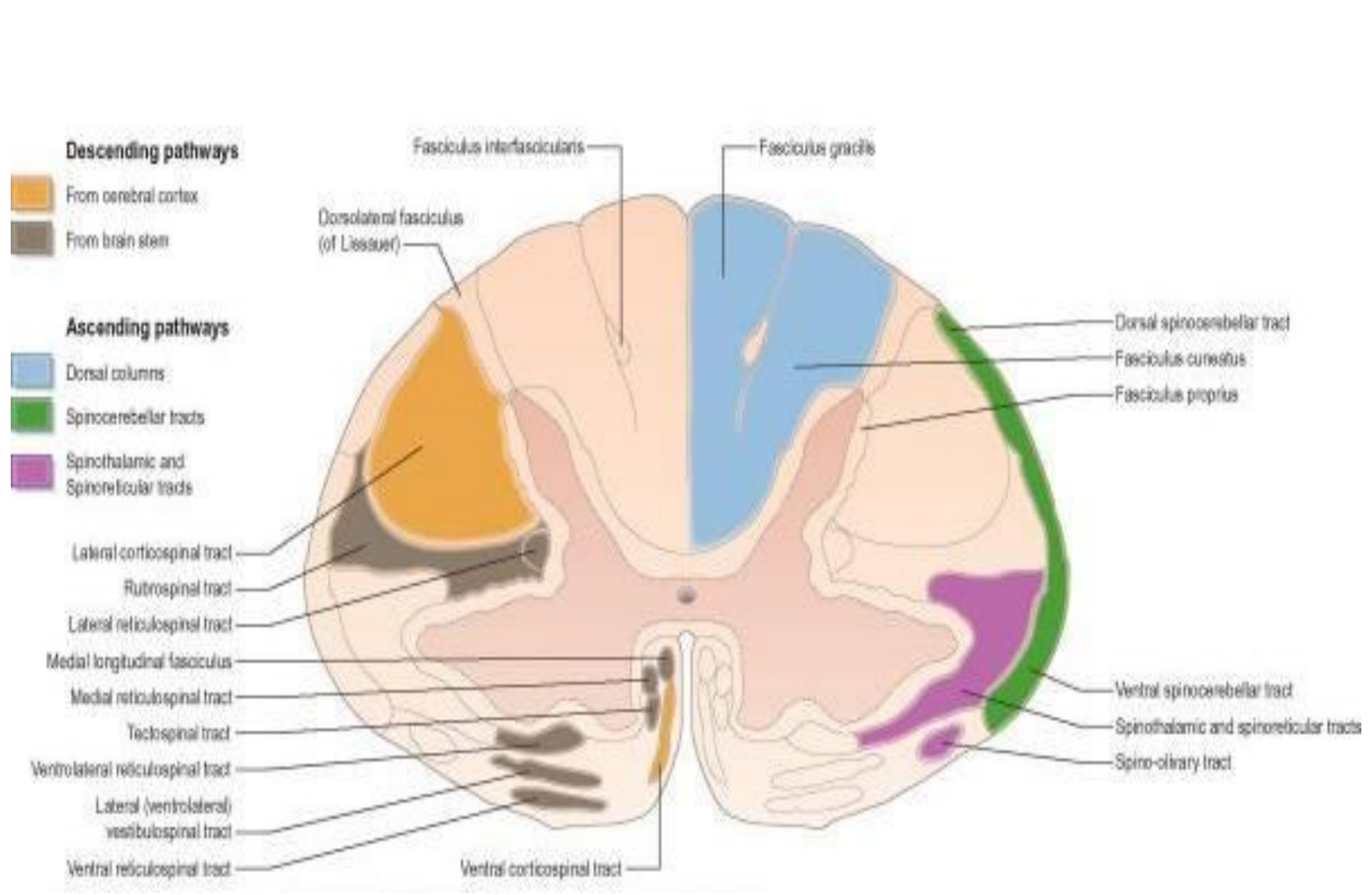
Jaras saraf mulai dari cortex motorik cerebrum sampai cornu anterior medulla spinalis

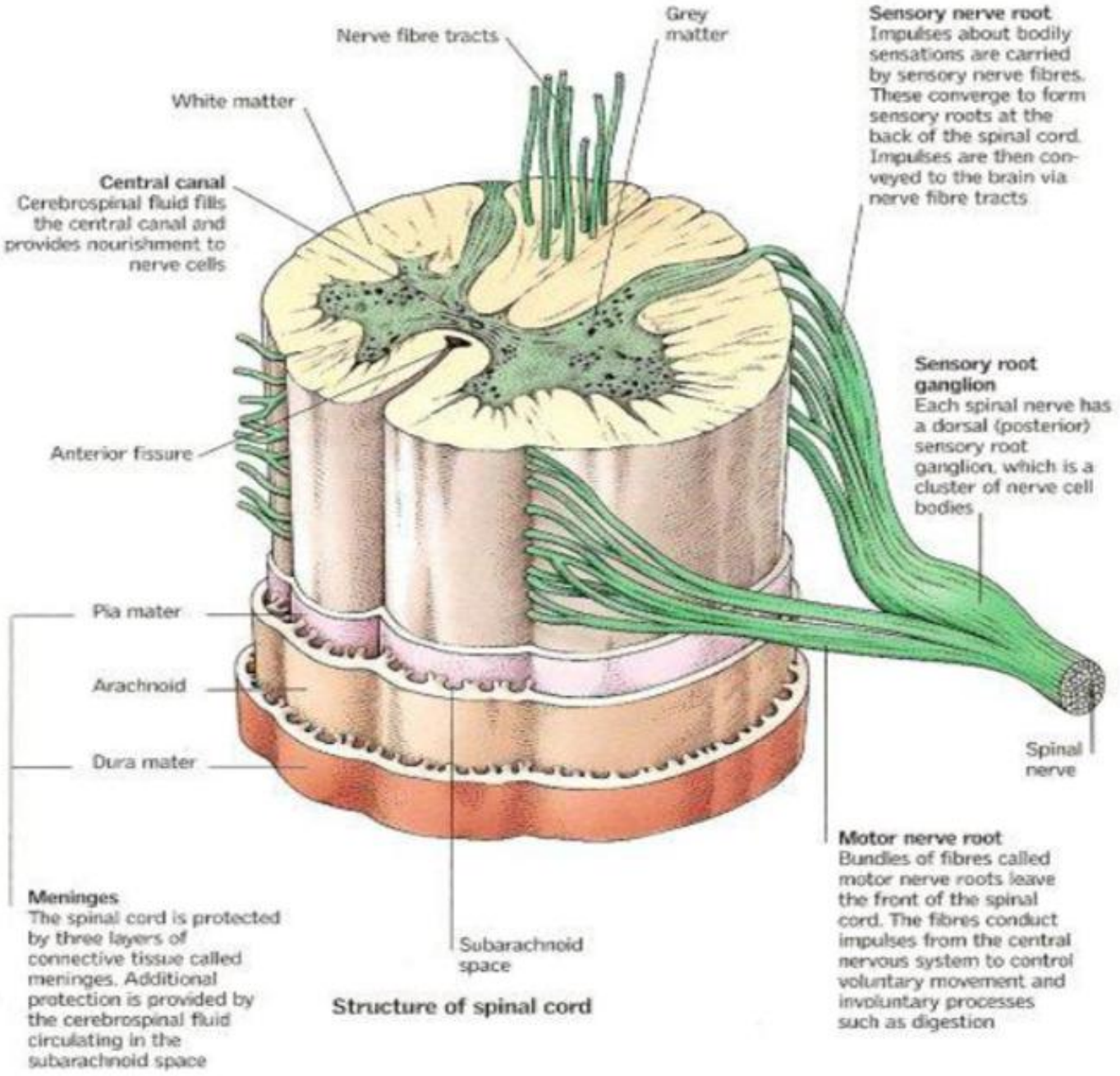
Kerusakan: paralisa spastik

2. *Lower Motor Neuron (LMN)*

Jaras saraf mulai dari cornu anterior medulla spinalis sampai ke efektor

Kerusakan: paralisa flacid (layuh)


Descending pathways
From cerebral cortex
From brain stem
Ascending pathways
Dorsal columns
Spinocerebellar tracts
Spinothalamic and Spinoreticular tracts
Fasciculus interfascicularis
Fasciculus gracilis
Dorsolateral fasciculus (of Lissauer)
Dorsal spinocerebellar tract
Fasciculus cuneatus
Fasciculus proprius
Lateral corticospinal tract
Rubrospinal tract
Lateral reticulospinal tract
Medial longitudinal fasciculus
Medial reticulospinal tract
Tectospinal tract
Ventrolateral reticulospinal tract
Lateral (ventrolateral) vestibulospinal tract
Ventral reticulospinal tract
Ventral corticospinal tract
Ventral spinocerebellar tract
Spinothalamic and spinoreticular tracts
Spino-olivary tract

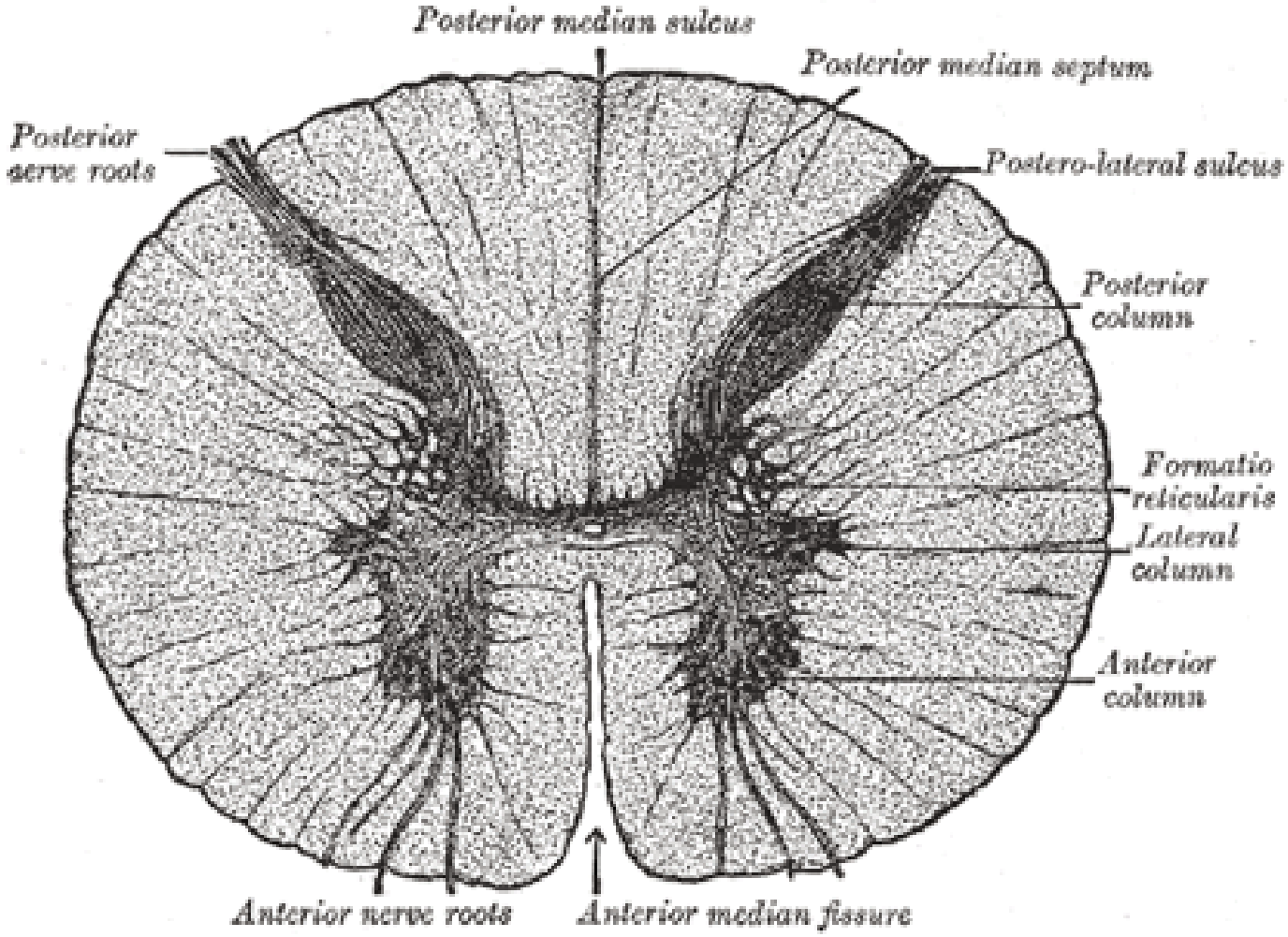


Structure of spinal cord

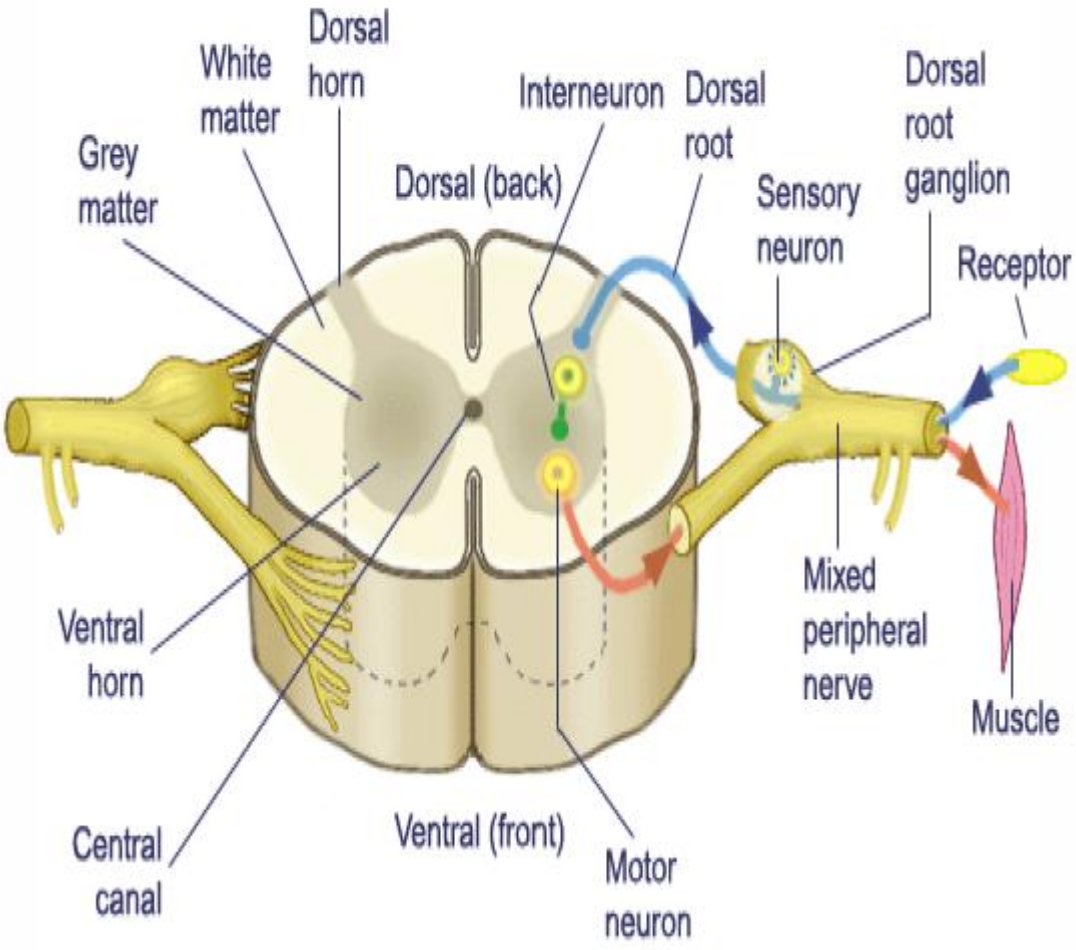
Materi Essensial

- badan sel yang membentuk bagian materi kelabu/abu-abu (*substansi grissea*)
- serabut saraf yang membentuk bagian materi putih (*substansi alba*)
- sel-sel neuroglia, yaitu jaringan ikat yang terletak di antara sel-sel saraf di dalam sistem saraf pusat

Substansia Grisea dan Alba



Substansia Grisea



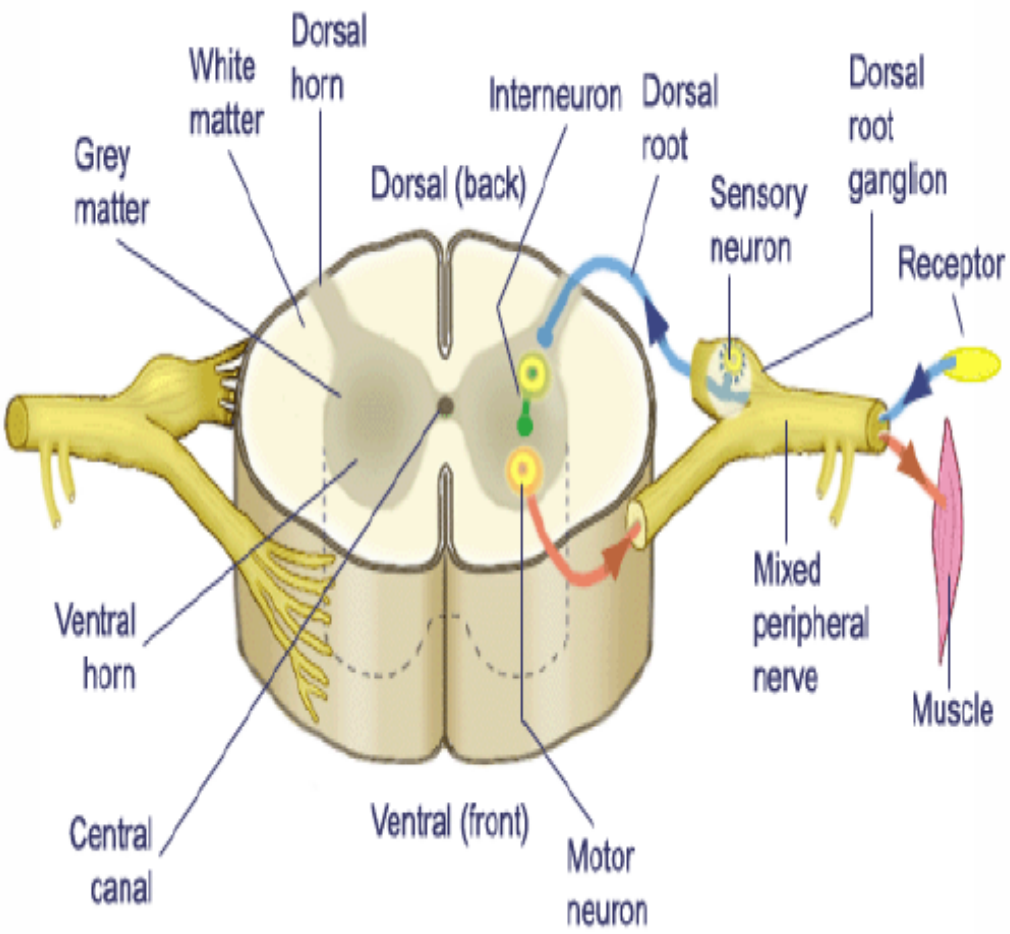
- Gray Matter
  - Bentuk huruf "H" di lapisan dalam
  - Kanal tengah = pada *gray commissure*
  - Tanduk posterior/dorsal
  - Tanduk anterior/ventral
- Terdiri atas
  - Badan sel
  - Akson tak bermyelin
  - Dendrit
  - Saraf glia

Substansia Grisea

- Tanduk posterior = mengandung interneuron, menghantarkan informasi dari badan sel di luar sumsum tulang ke sumsum tulang
  - Akar dorsal mengandung serabut sensorik
    - Sensorik somatik
    - Sensorik viseral
  - Ganglia akar dorsal - mengembang di akar dorsal, tempat interneuron melewatinya
- Tanduk anterior = mengandung badan sel saraf motorik yang mengirimkan impuls dari akson sumsum tulang ke otot dan kelenjar
  - Akar ventral mengandung
    - Motorik viseral
    - Motorik somatik

- **Sensorik somatik – *"body senses"***
  - sentuhan, tekanan, suhu, keseimbangan
- **Sensorik viseral – *"organ senses"***
  - Rasa sakit, suhu di dalam organ
  - C/ mual, lapar, kram
- **Motorik somatik – *"body movement"***
  - Kontraksi tidak sadar otot rangka
- **Motorik viseral – *"organ movement"***
  - Kontraksi otot2 polos, kelenjar
  - = sistem saraf otonom

Substansia Alba



- Mengelilingi substansi kelabu/gray matter
- Membentuk kolom putih
  - » Funiculus posterior
  - » Funiculus anterior
  - » Funiculus lateral
- Terdiri atas
  - » Akson bermyelin
  - » Akson tanpa myelin

Substansia Alba

- Fungsi : memungkinkan komunikasi diantara sumsum tulang dan antara otak + sumsum tulang
- 2 tipe utama serabut saraf :
  - Serabut saraf menaik/ascending : membawa informasi sensorik dari tubuh ke otak
    - c/ sentuhan, tekanan, rasa sakit dan suhu
  - Serabut saraf menurun/descending: membawa informasi motorik dari otak ke sumsum tulang
    - c/ mengendalikan ketelitian, gerakan terlatih = menulis, menjaga keseimbangan, melakukan gerakan

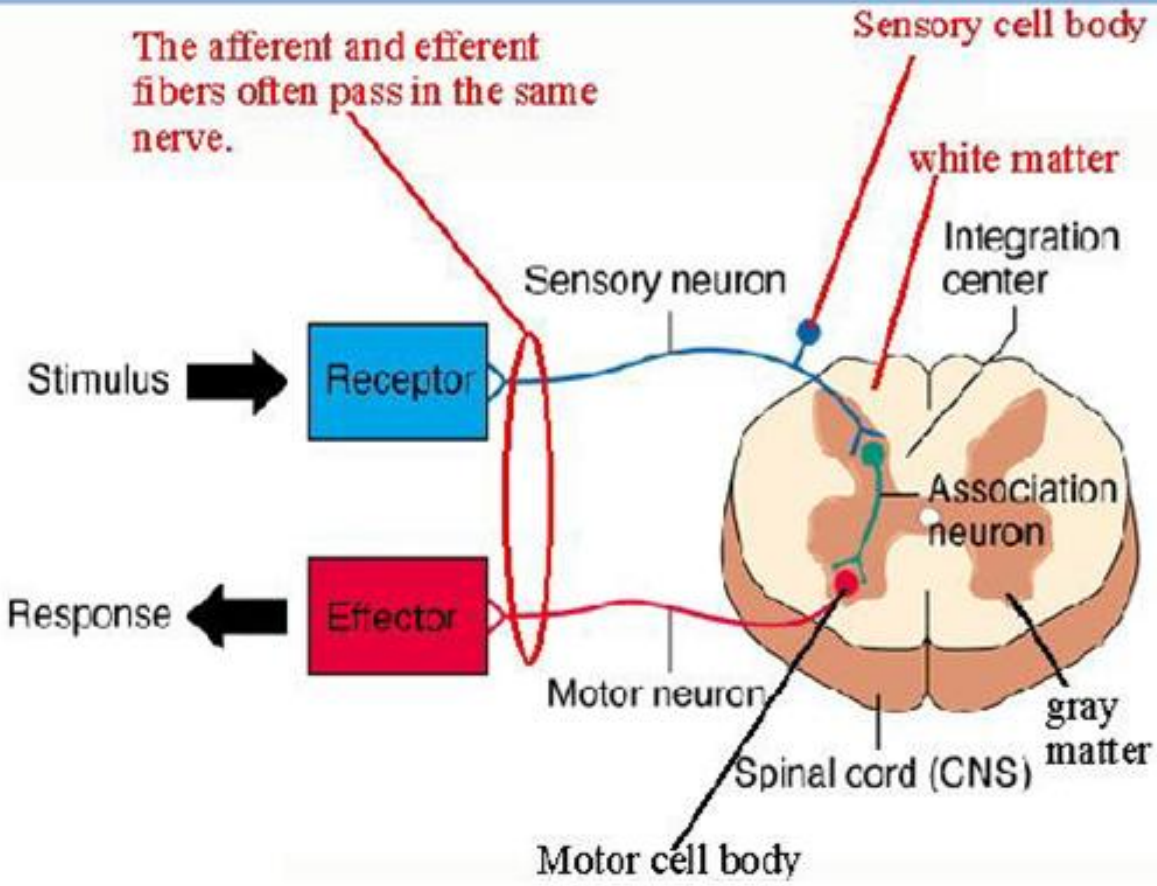
PERAN MEDULA SPINALIS

- Menerima serat afferen dari reseptor sensorik badan dan anggota gerak
- Mengontrol pergerakan badan dan anggota gerak
- Jalur innervasi autonom untuk organ viscera

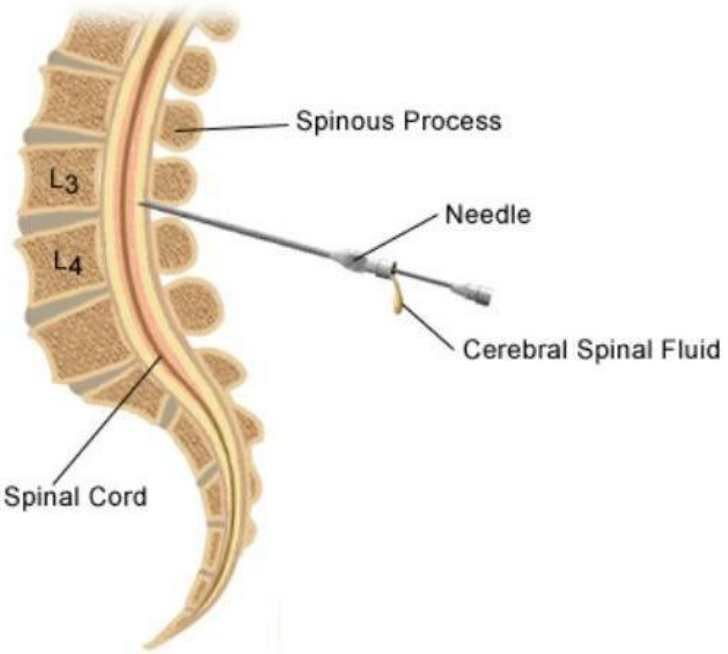
Lengkung refleks

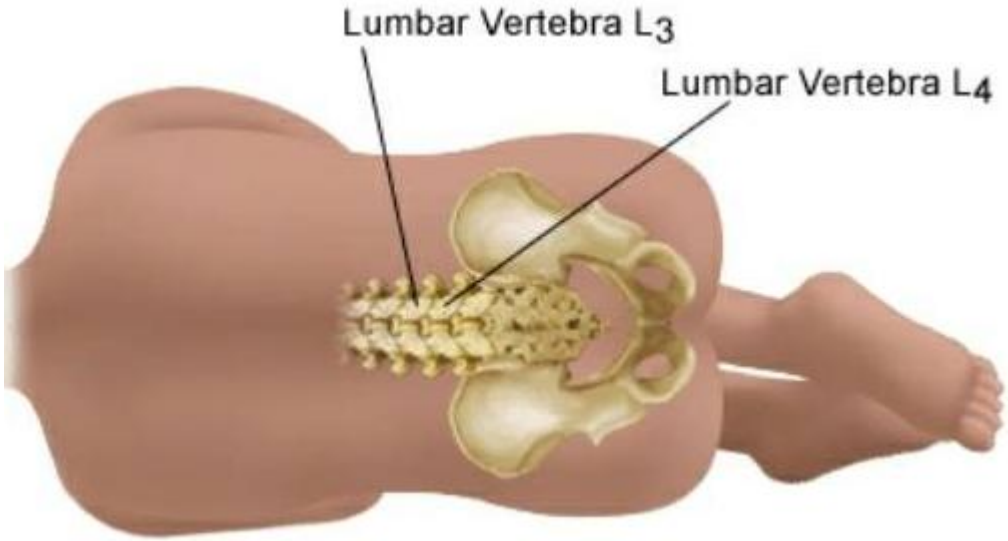
Refleks

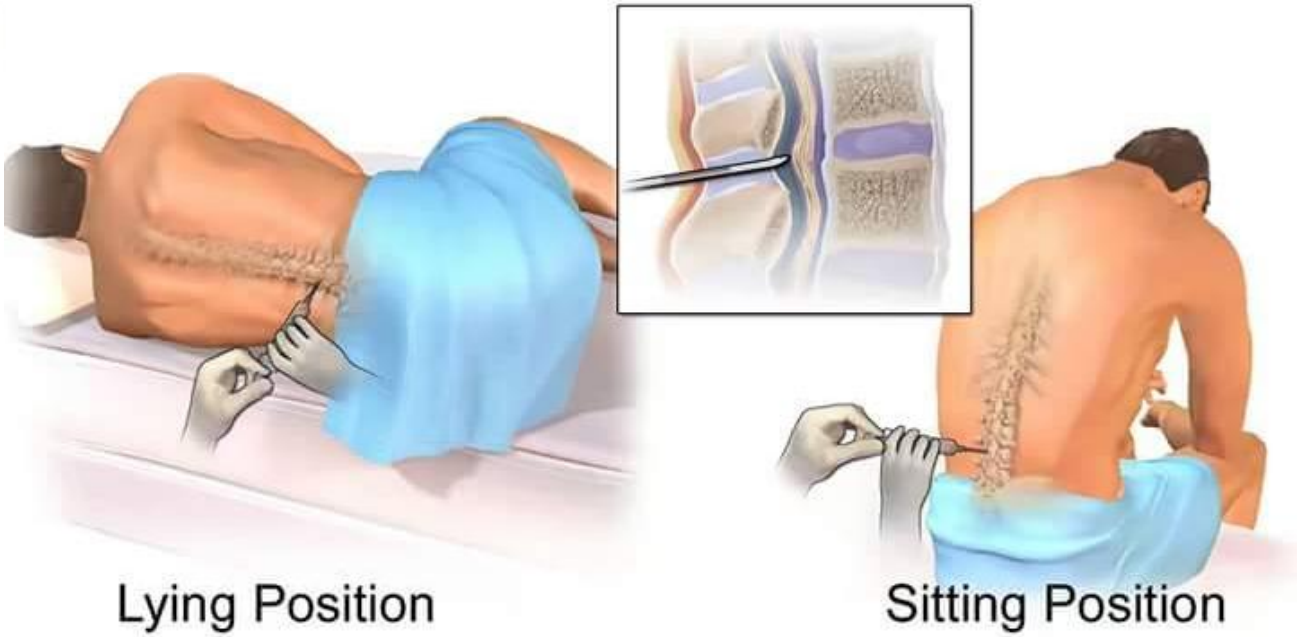
- Cepat, otonom, respon yang tidak disadari
- Hasil dari **reflex arcs/lengkung refleks** – jalur saraf terpendek



Lumbar Puncture (Spinal Tap)

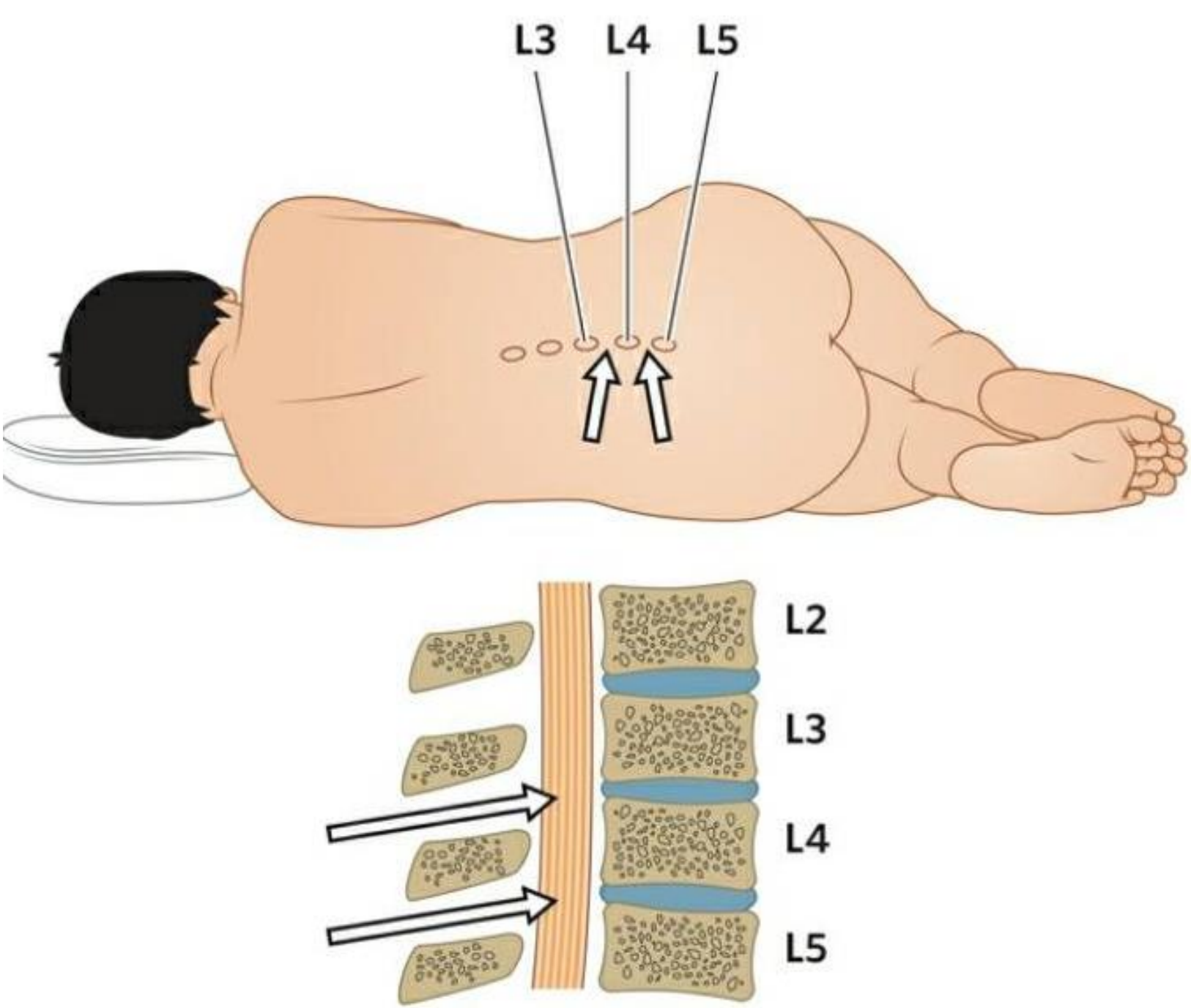




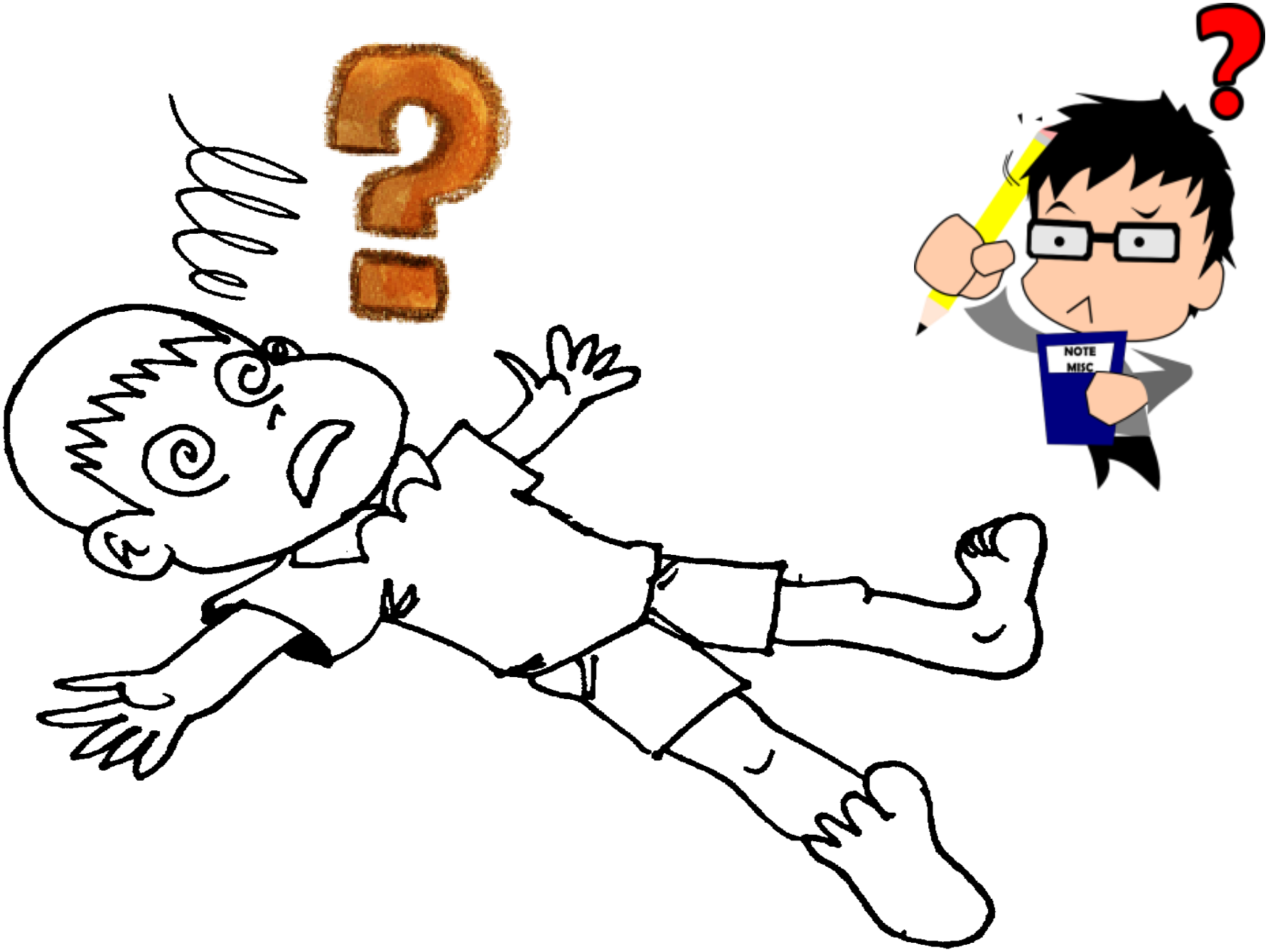


Lying Position

Sitting Position


L3
L4
L5
L2
L3
L4
L5


SELAMAT BELAJAR


NOTE
MISC