Blood supply to the brain

CSF circulation

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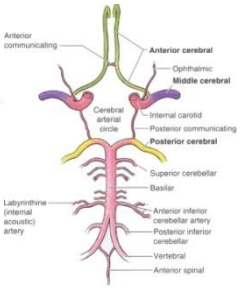
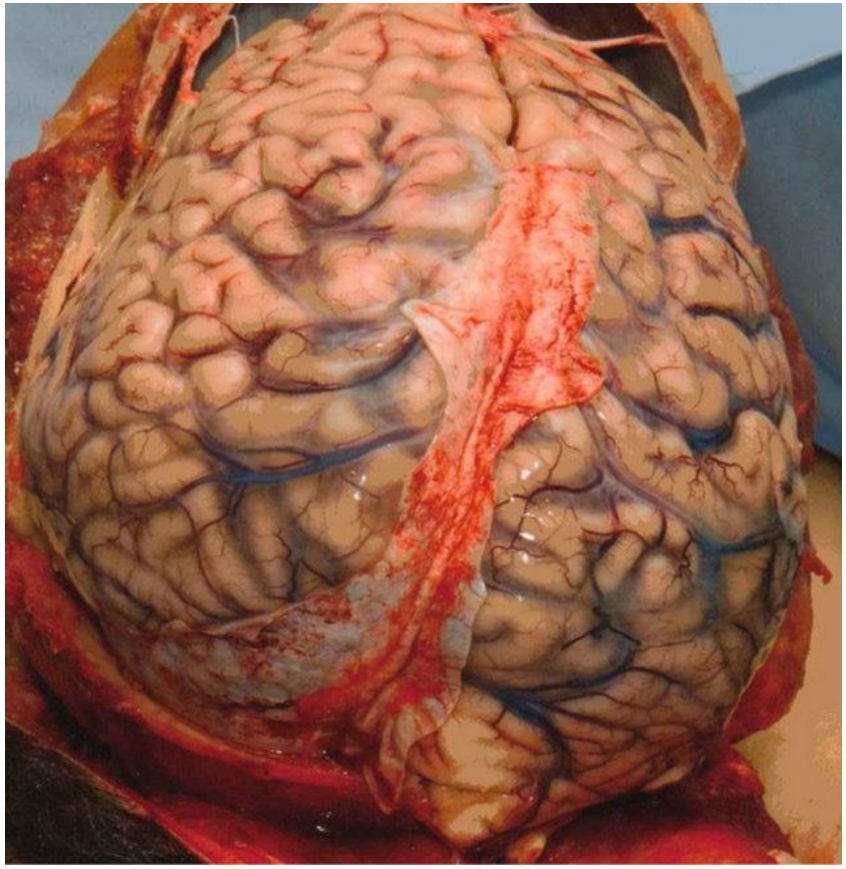
BLOOD SUPPLY TO THE BRAIN





Highly vascularized organ

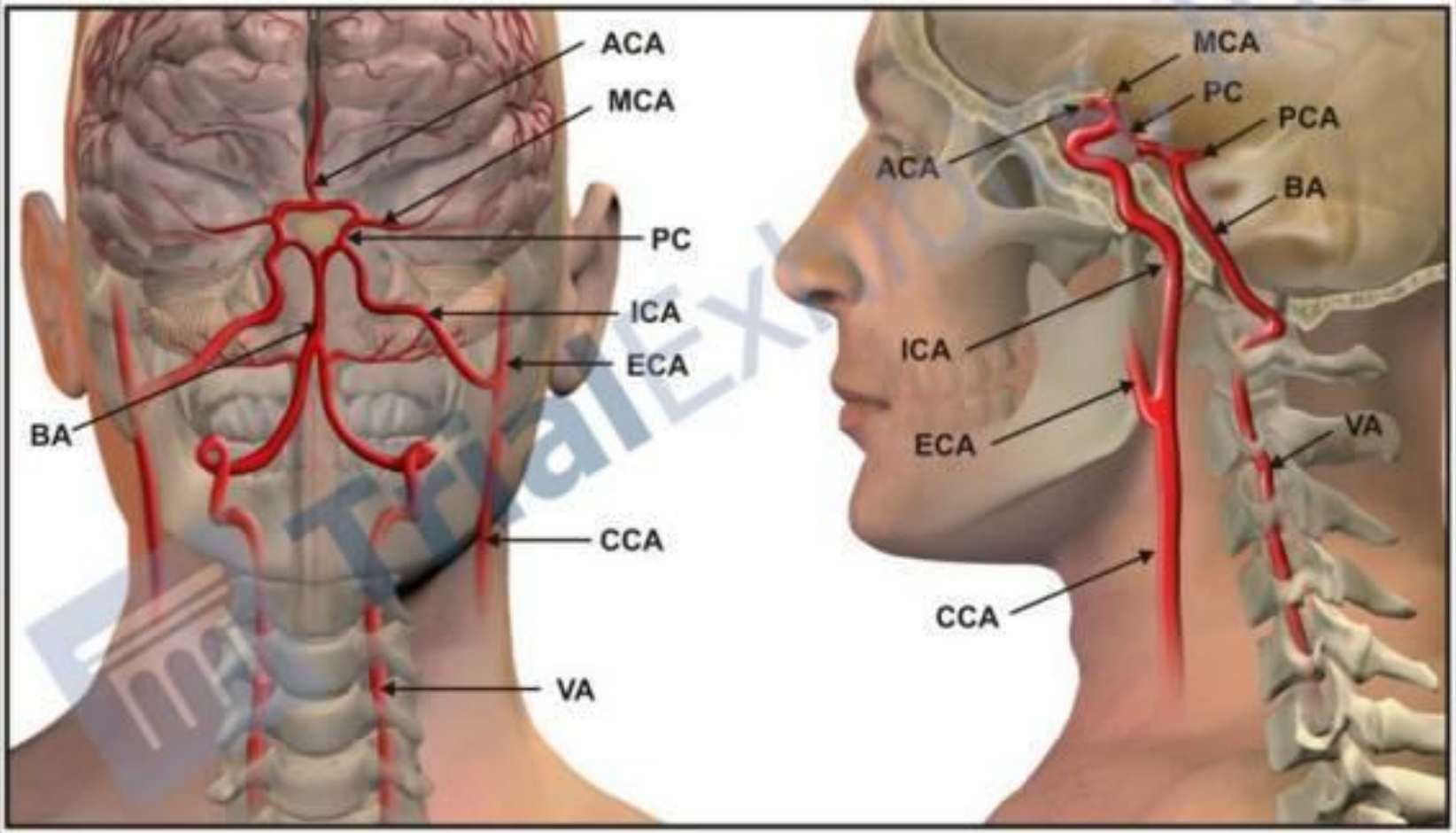
Extremly high demand for oxygen and nutrients: human brain represents 2% of the body weight, but receives 15% of the cardiac output, 20% of total body oxygen consumption and 25% of total body glucose utilization.

Cerebrovascular /neurovascular diseases and stroke are among the major causes of death

Blood Supply of the Brain

Arteries:

- Common Carotid (CCA)
- Anterior Cerebral (ACA)
- Vertebral (VA)
- Internal Carotid (ICA)
- Middle Cerebral (MCA)
- Posterior Communicating (PC)
- External Carotid (ECA)
- Posterior Cerebral (PCA)
- Basilar (BA)

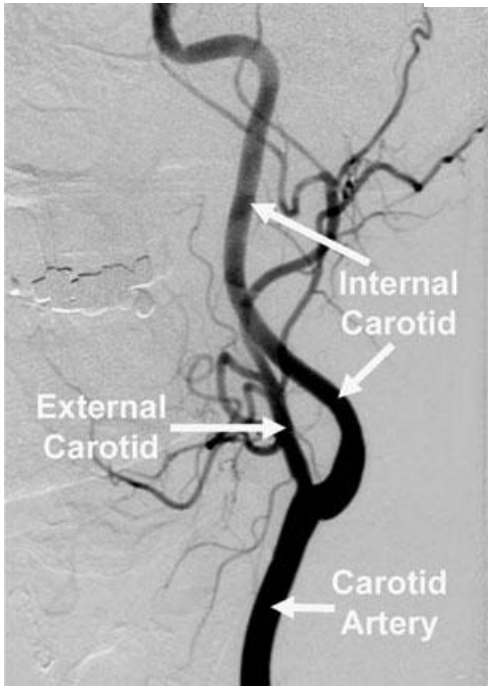


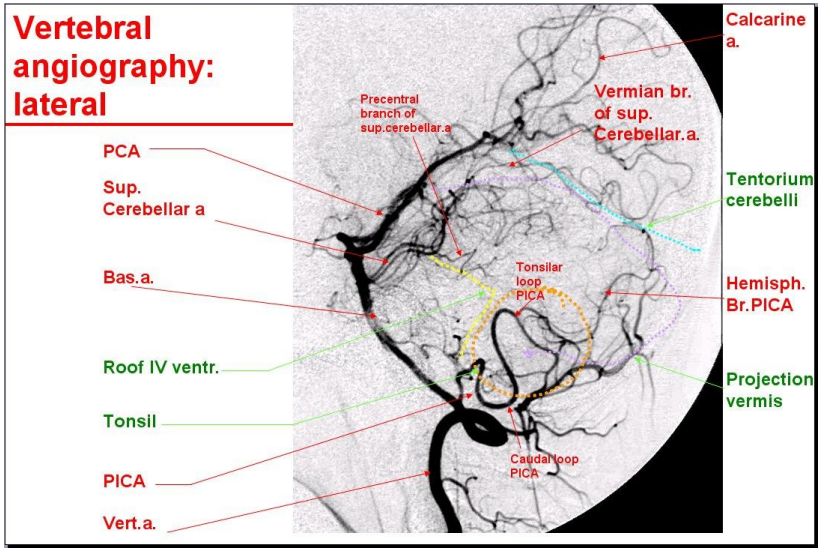
Front

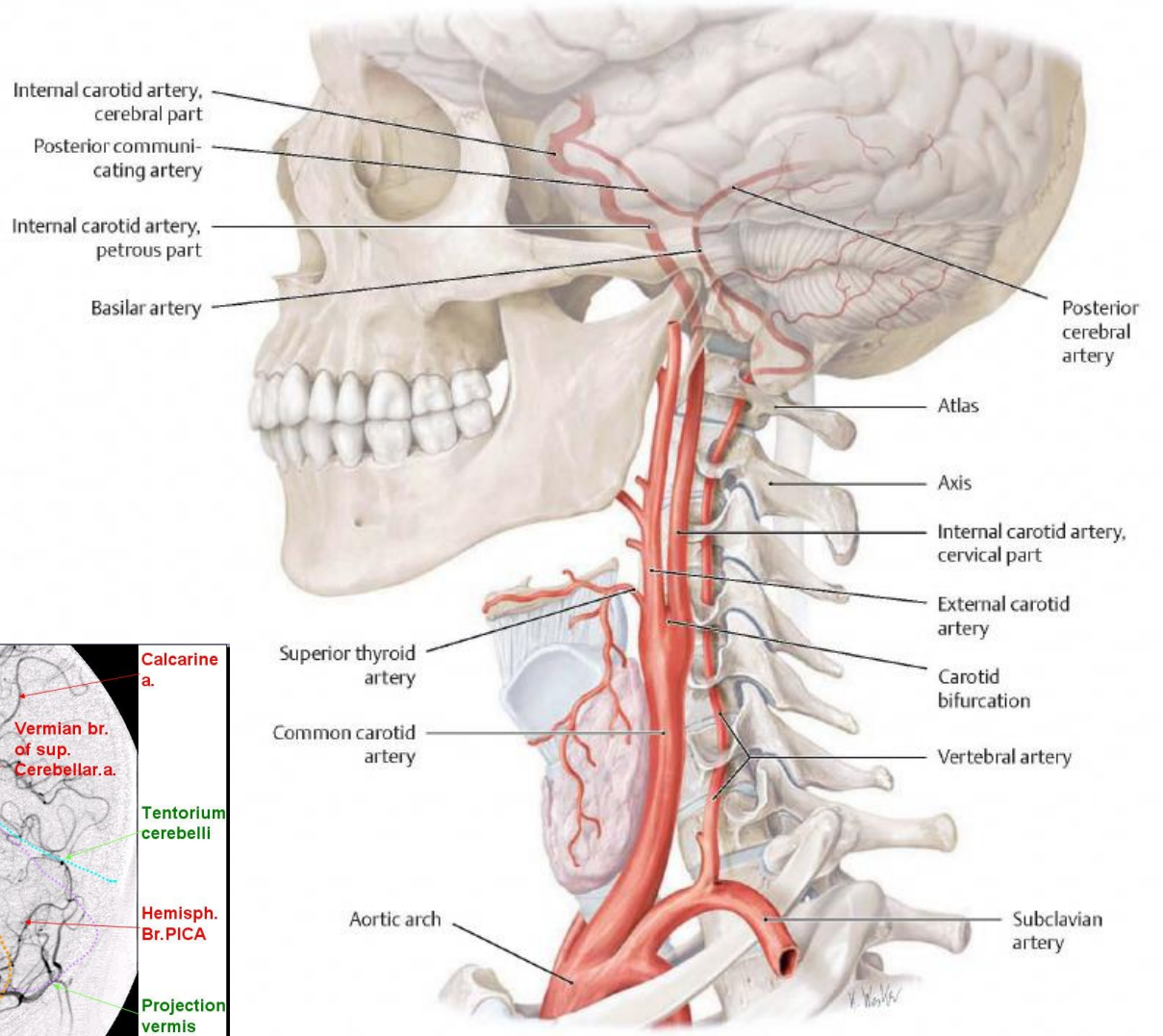
Side

ARTERIES OF THE BRAIN

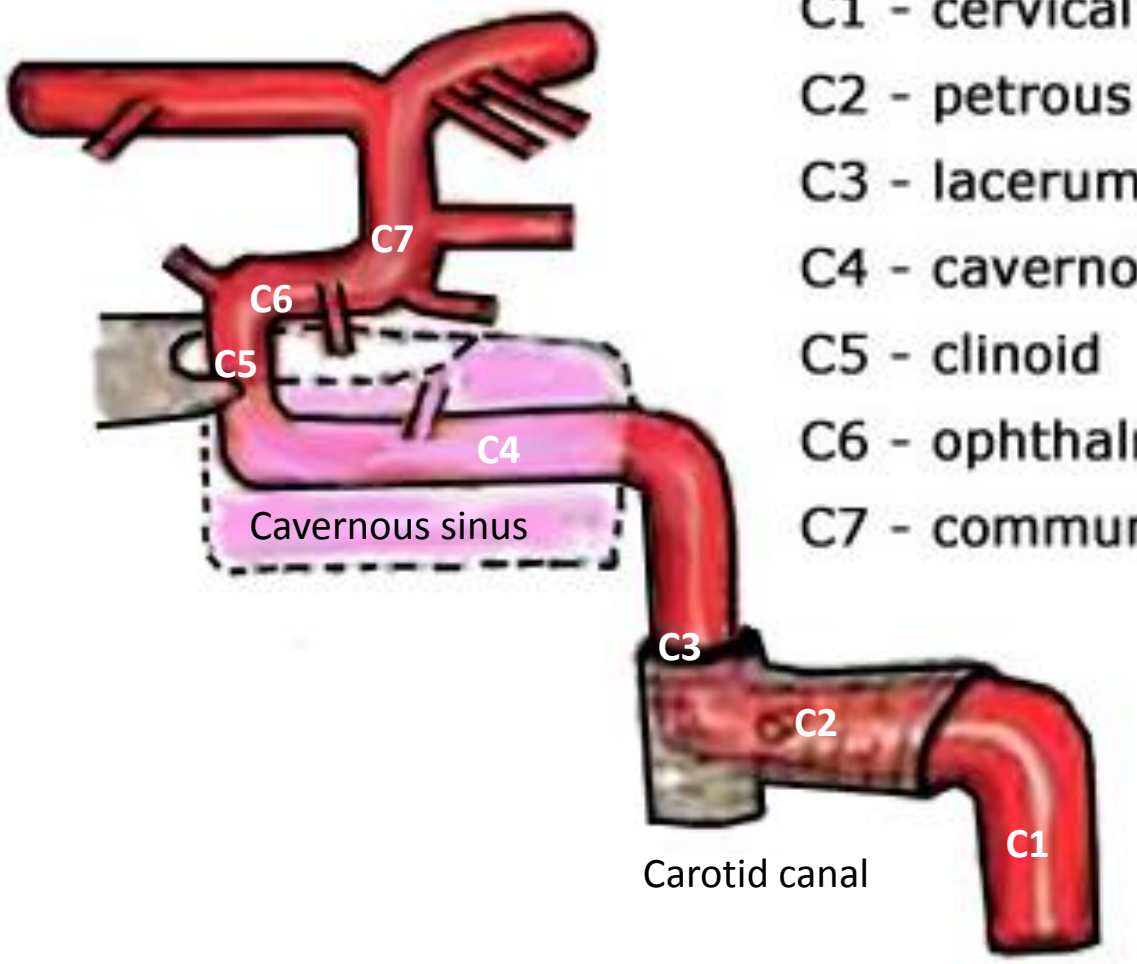
ARTERIES OF THE BRAIN



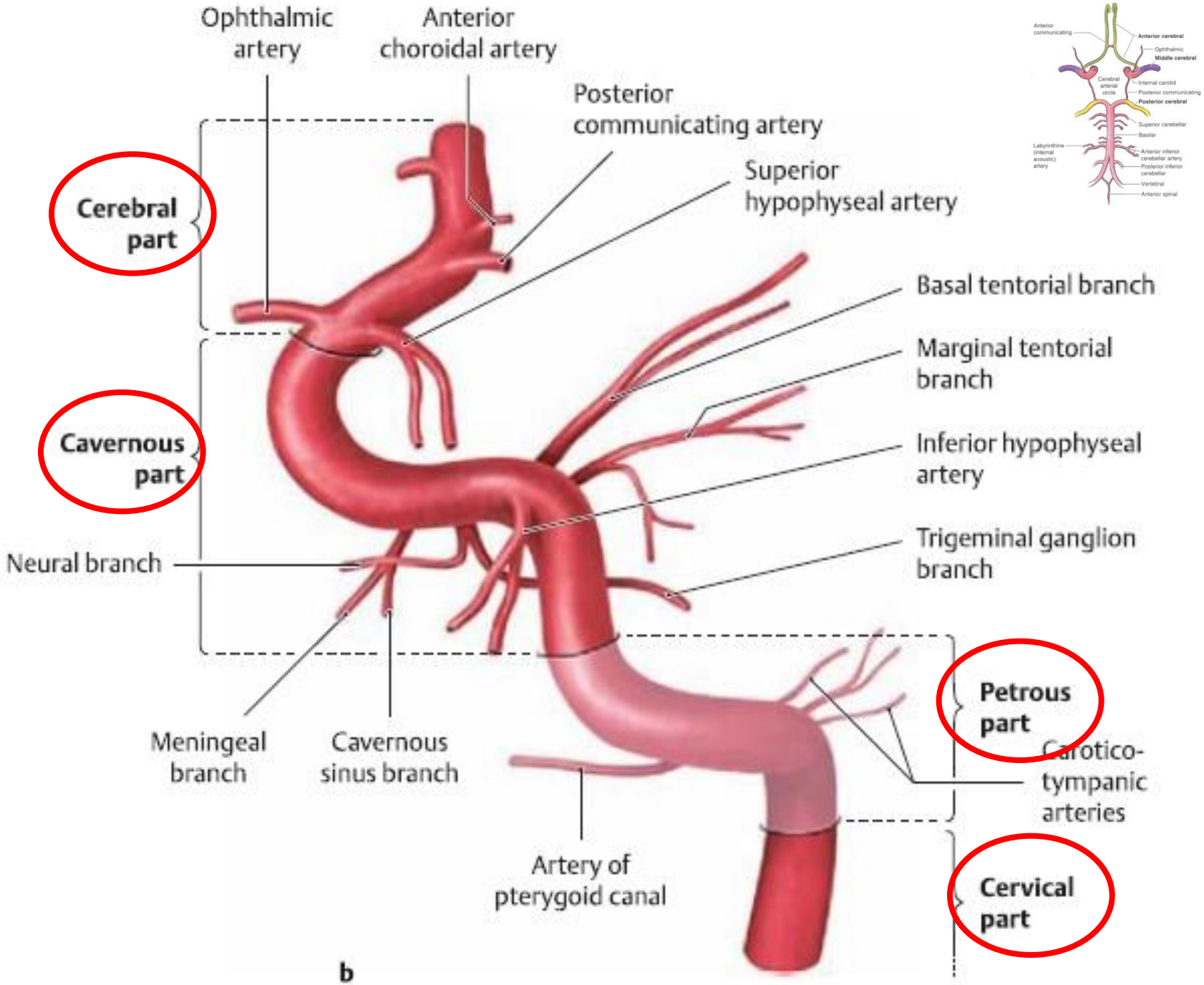




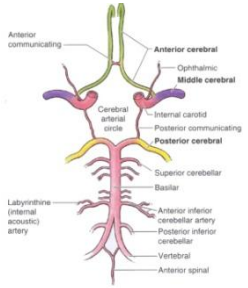
INTERNAL CAROTID ARTERY DIVISIONS



C1 - cervical
C2 - petrous
C3 - lacerum
C4 - cavernous
C5 - clinoid
C6 - ophthalmic
C7 - communicatin


Ophthalmic artery
Anterior choroidal artery
Posterior communicating artery
Superior hypophyseal artery
Cerebral part
Cavernous part
Basal tentorial branch
Marginal tentorial branch
Inferior hypophyseal artery
Trigeminal ganglion branch
Neural branch
Meningeal branch
Cavernous sinus branch
Petrous part
Caroticotympanic arteries
Artery of pterygoid canal
Cervical part
b

ARTERIES

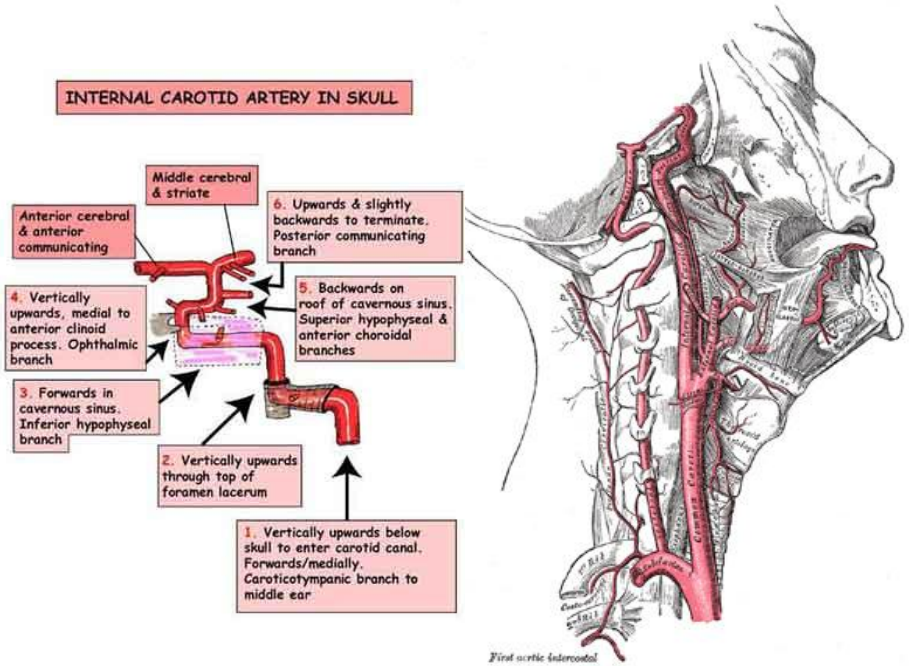


Internal carotid

- anterior cerebral
  (+ anterior communicating)
- middle cerebral
- posterior communicating

Basilar

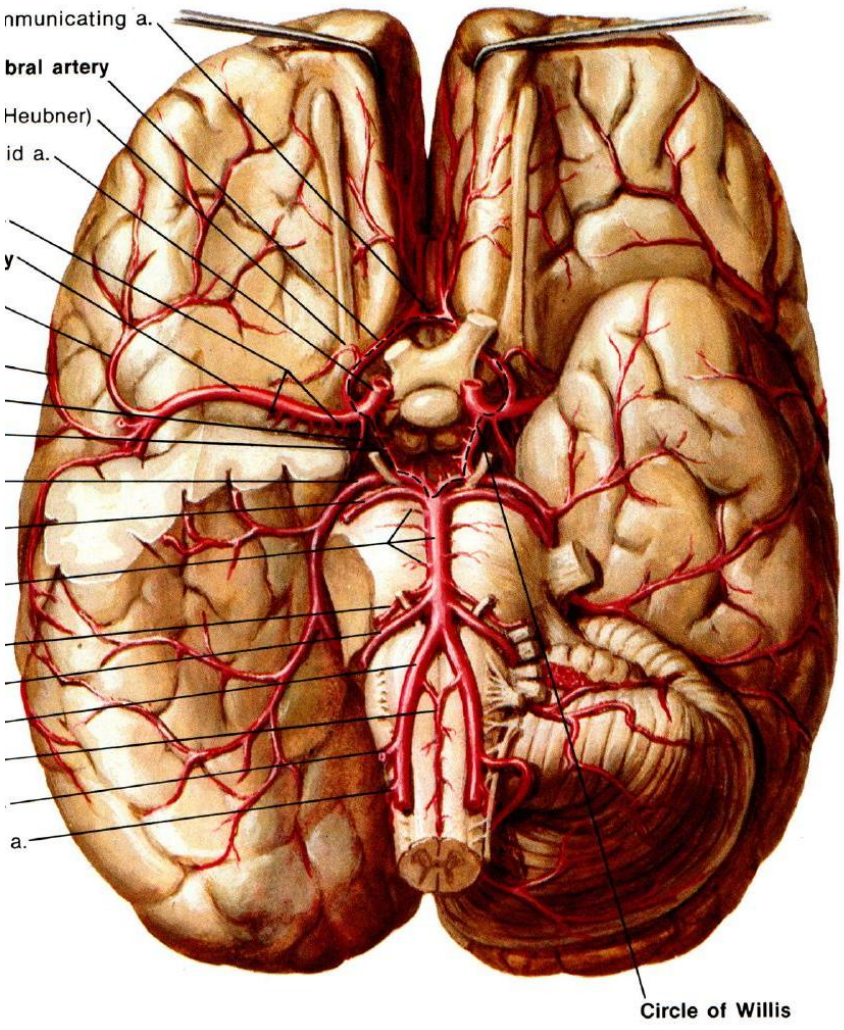
- anterior inferior cerebellar
- labyrinthic
- pontine
- superior cerebellar
- posterior cerebral

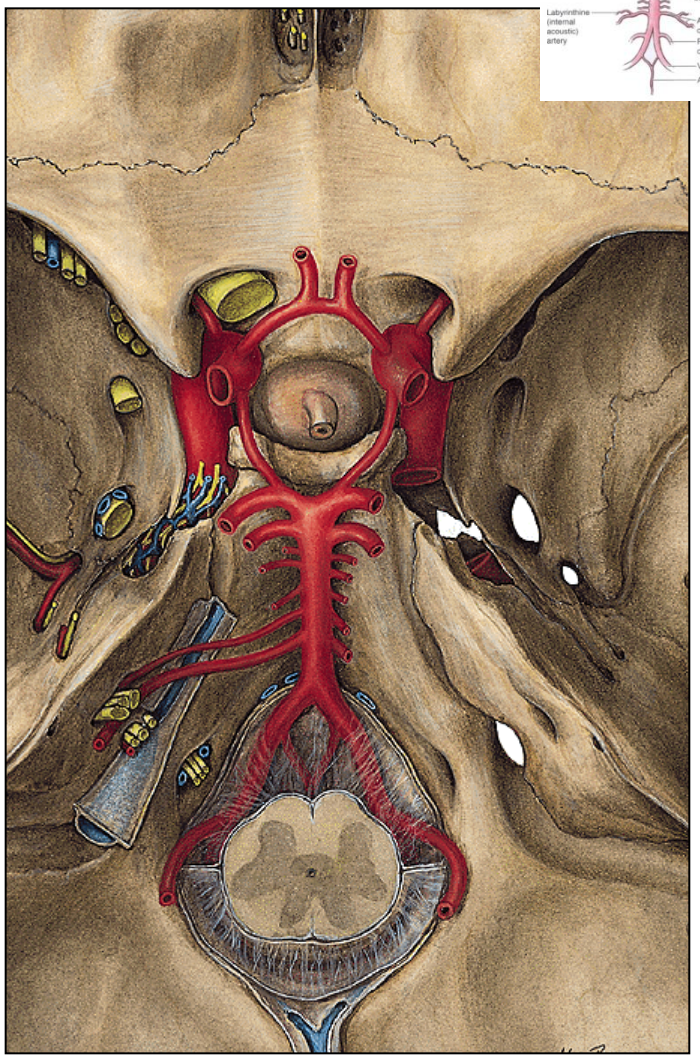


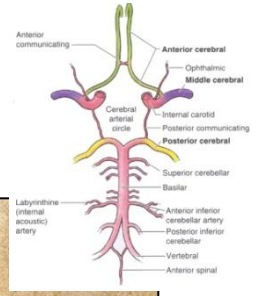
Vertebral

- posterior spinal
- anterior spinal
- posterior inferior cerebellar
- medial & lateral medullary

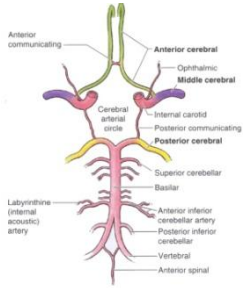
CIRCULUS ARTERIOSUS *WILLISI*

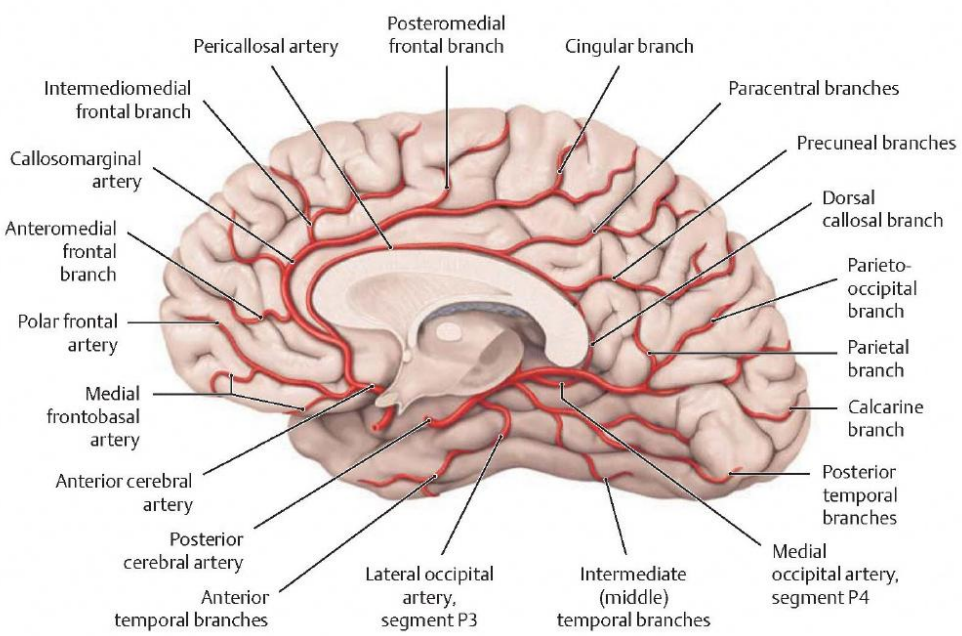


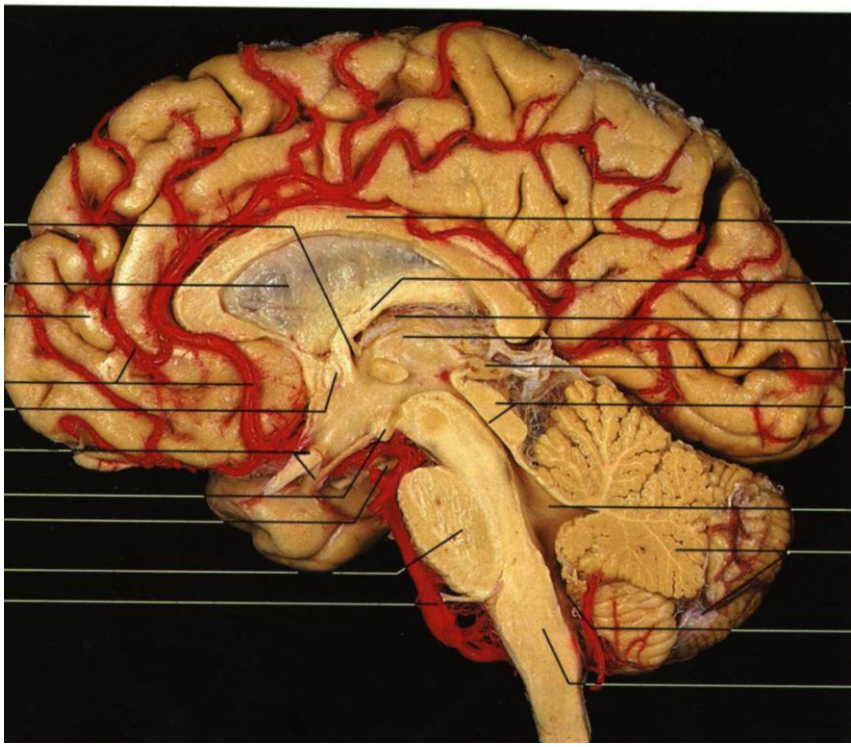




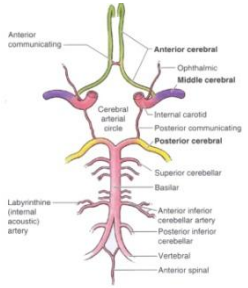
ANTERIOR CEREBRAL AND POSTERIOR CEREBRAL ARTERIES

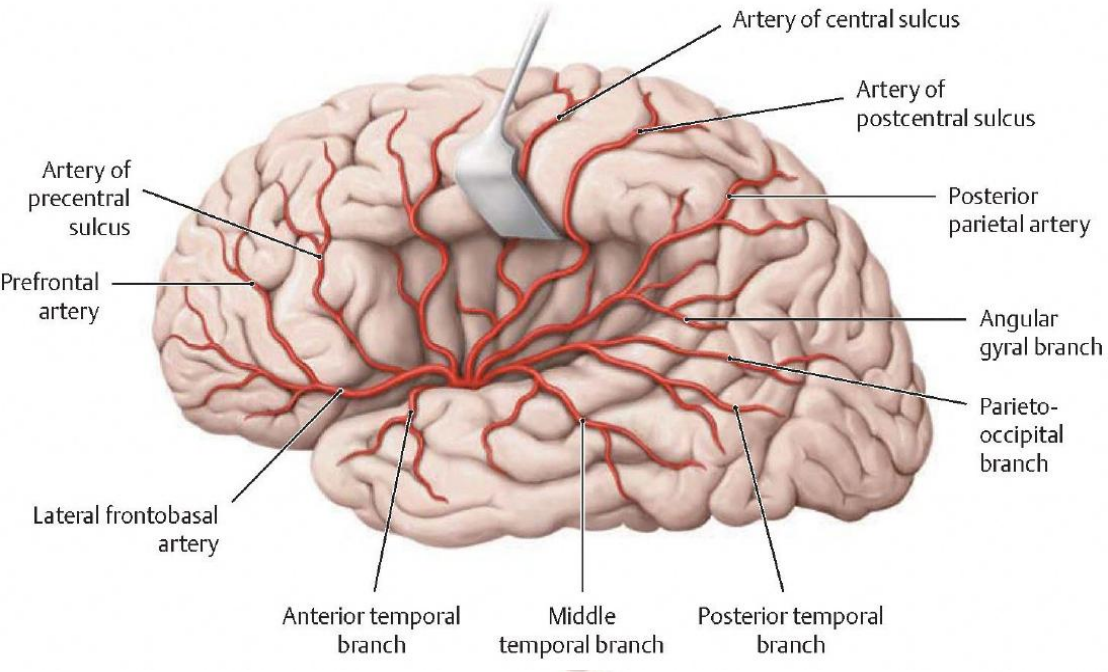


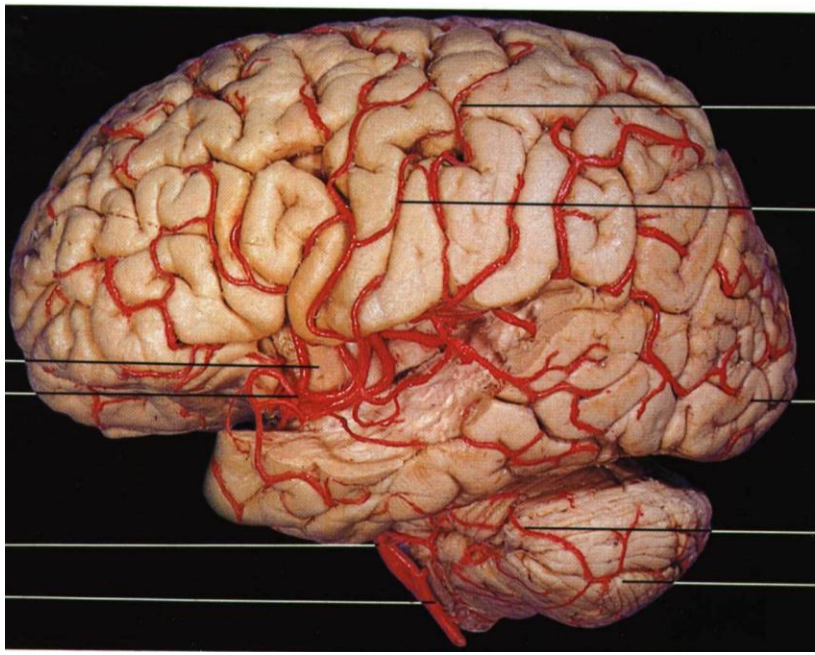




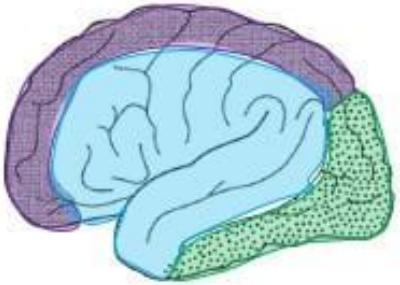
MIDDLE CEREBRAL ARTERY

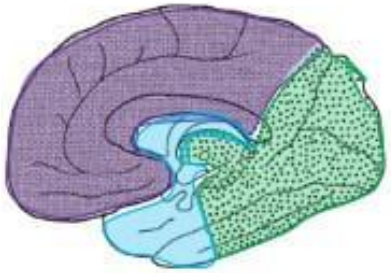


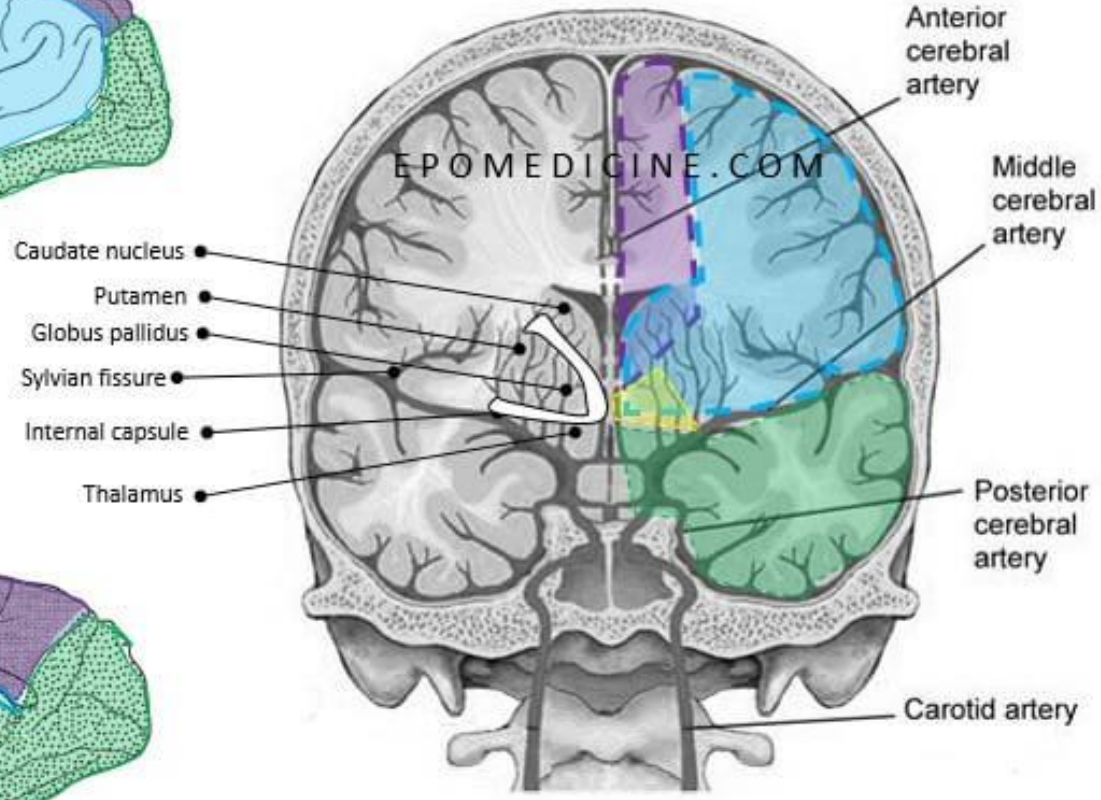




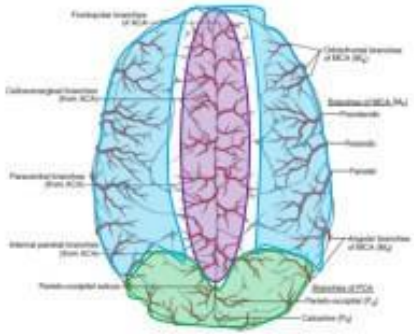
Blood Supply to the Brain



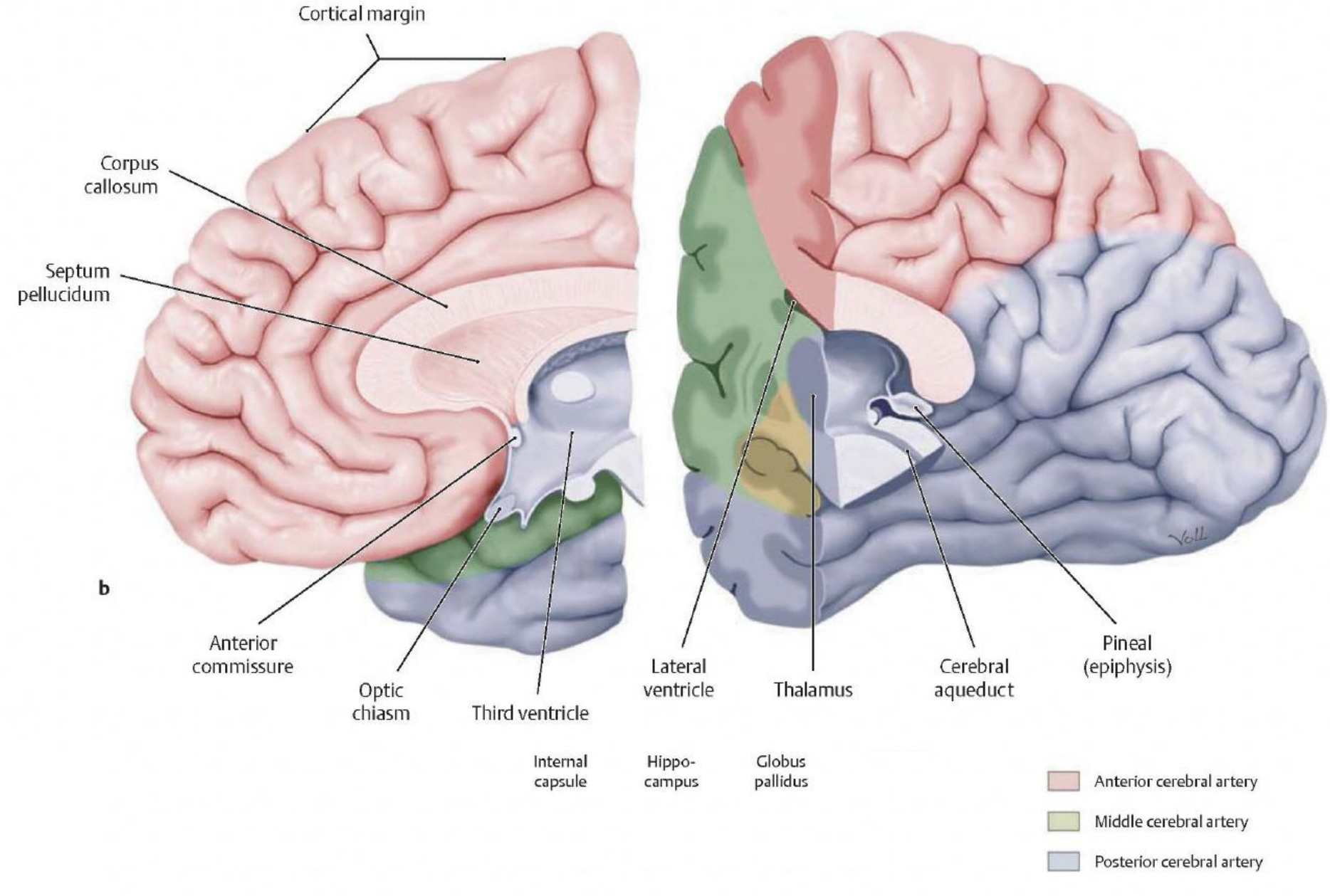




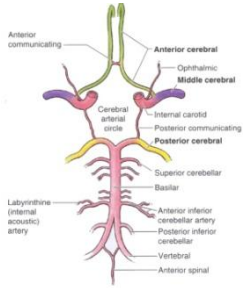
- ACA territory
- MCA territory
- Anterior choroidal territory
- PCA territory

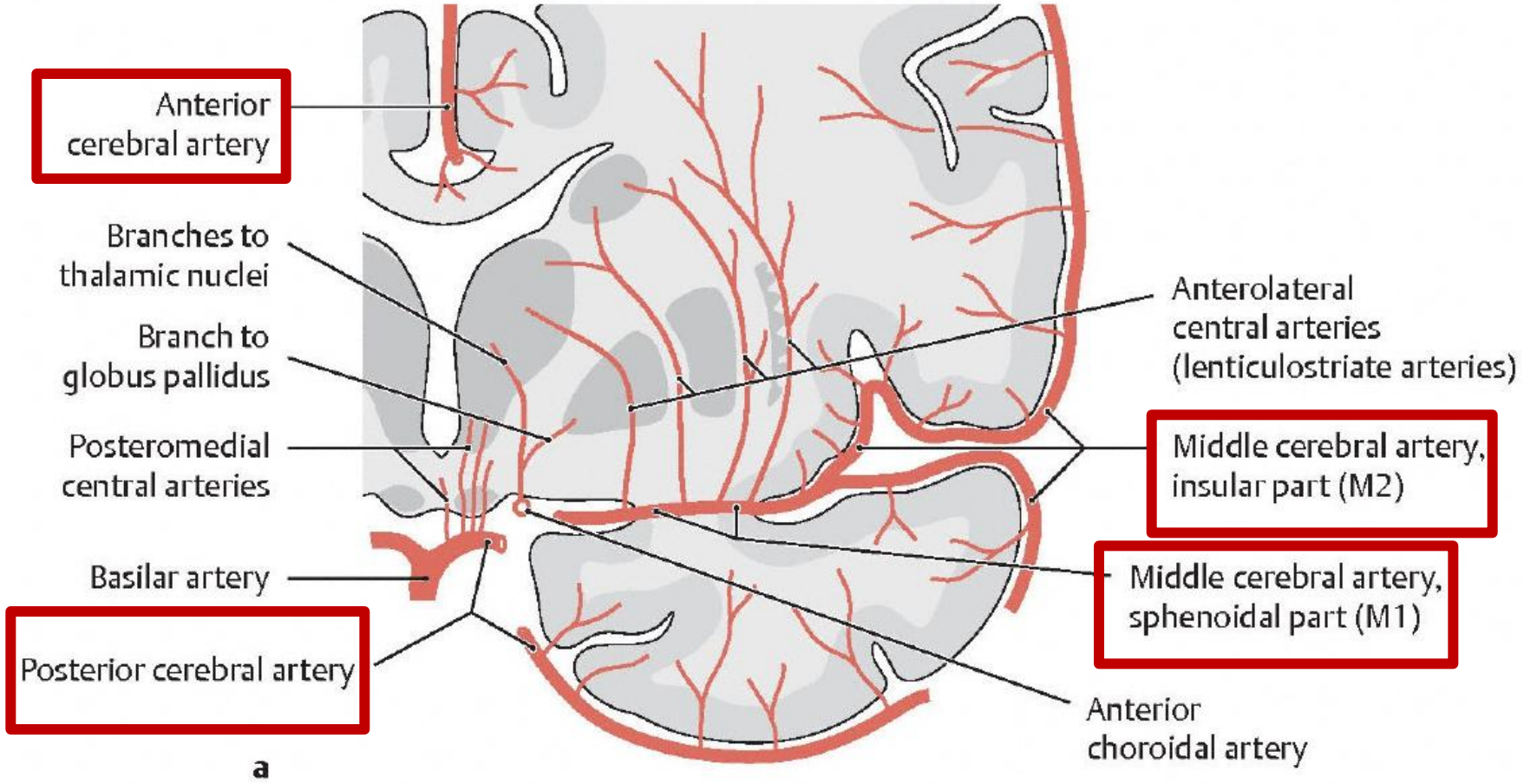


BLOOD SUPPLY AREAS (SURFACE AND DEEP)

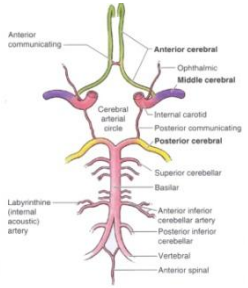


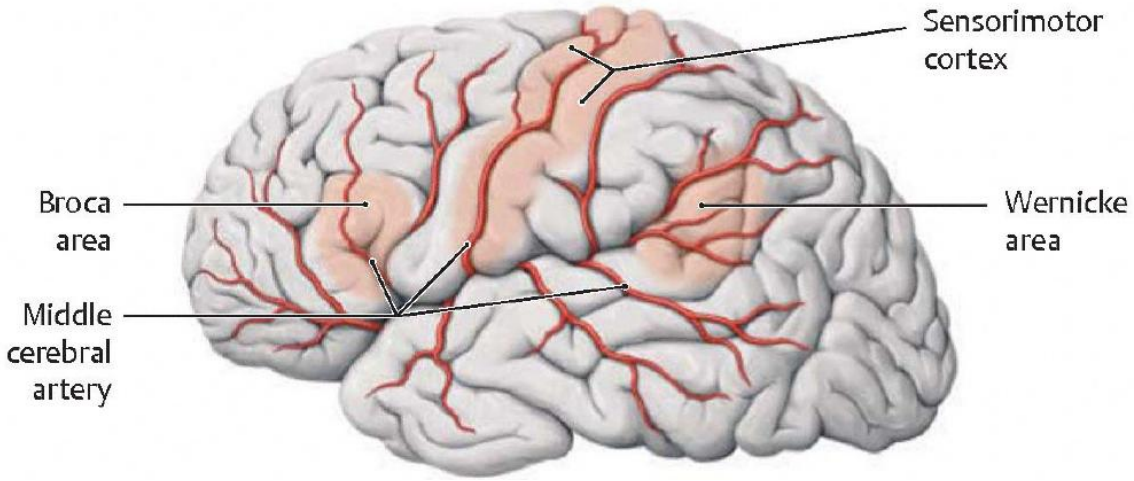
ARTERIAL SUPPLY AREAS (FRONTAL SECTION)

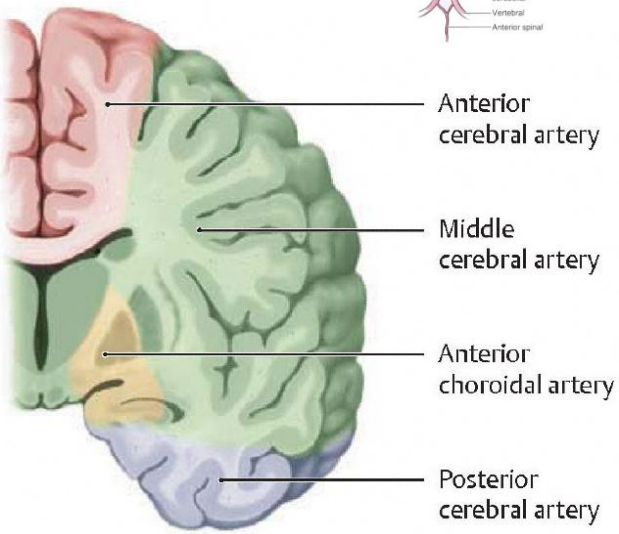


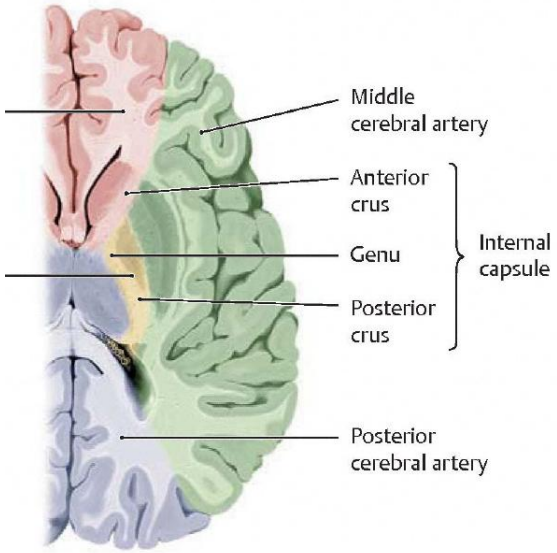


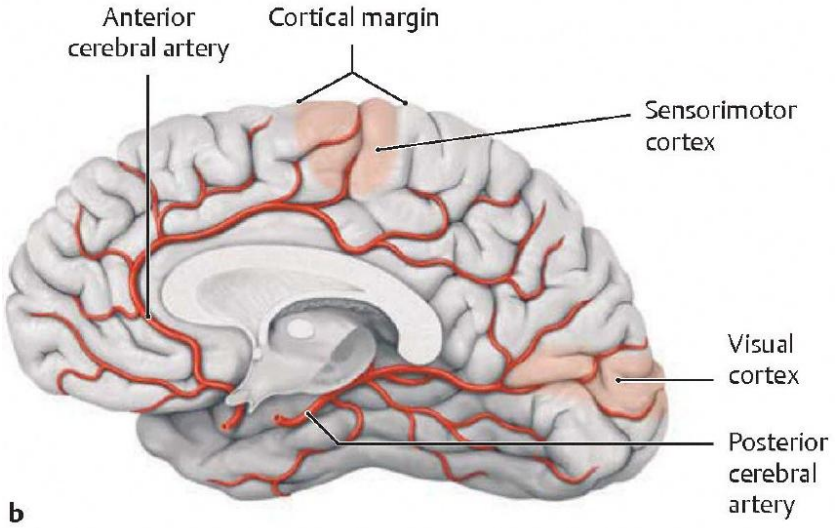
ARTERIAL SUPPLY AREAS (FUNCTIONAL CENTRES)



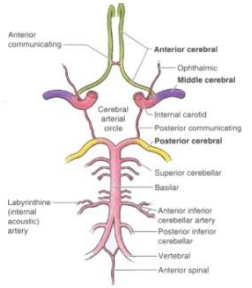


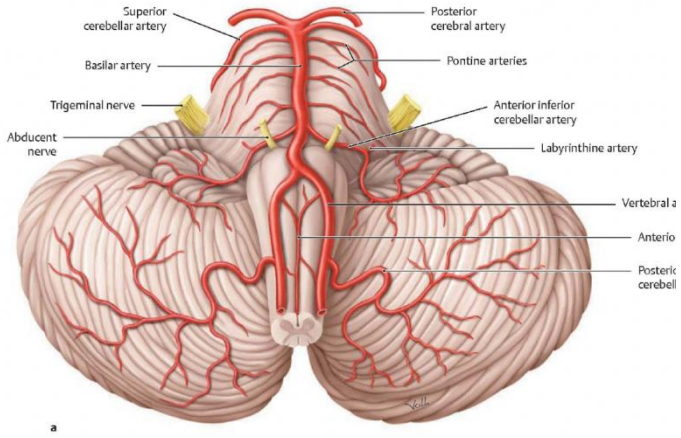


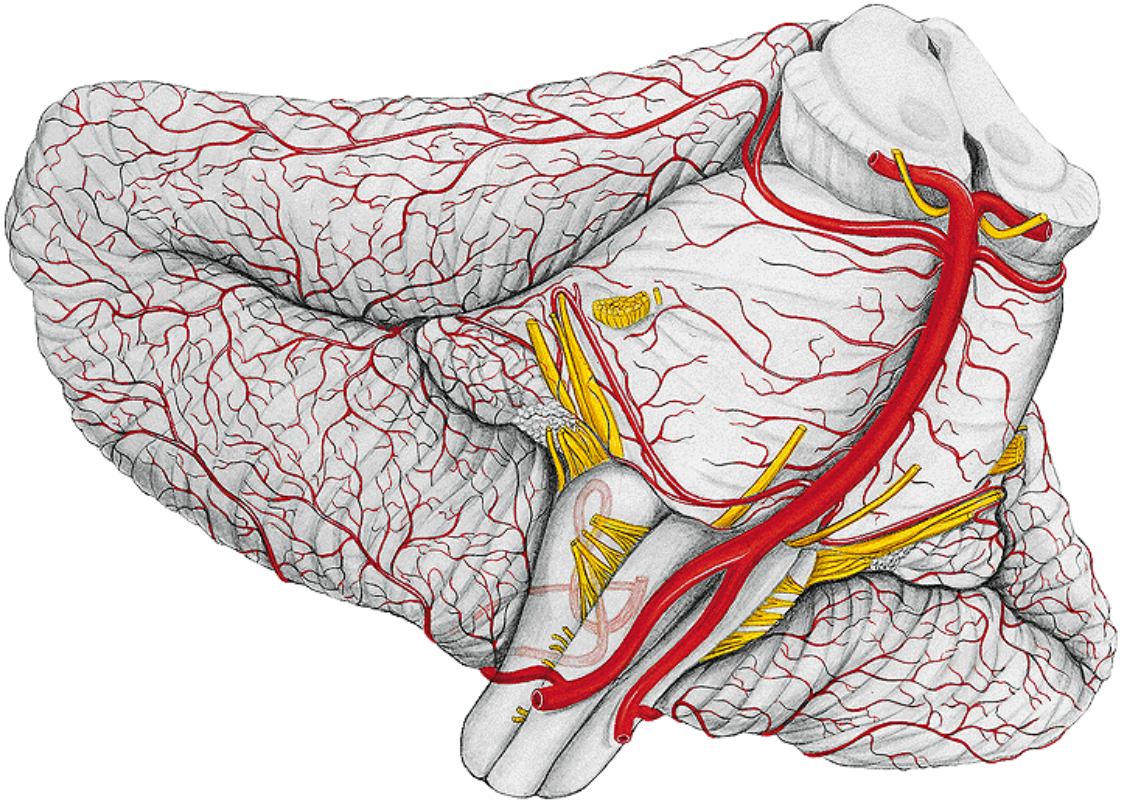


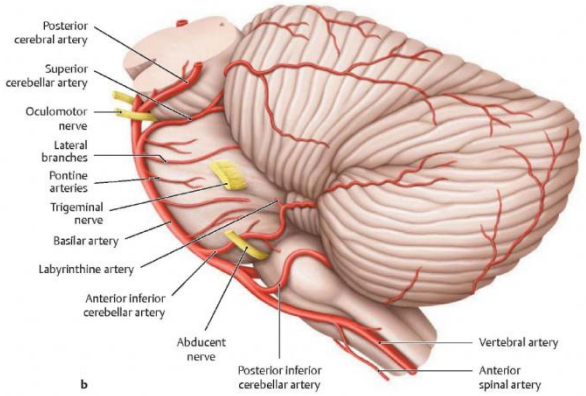


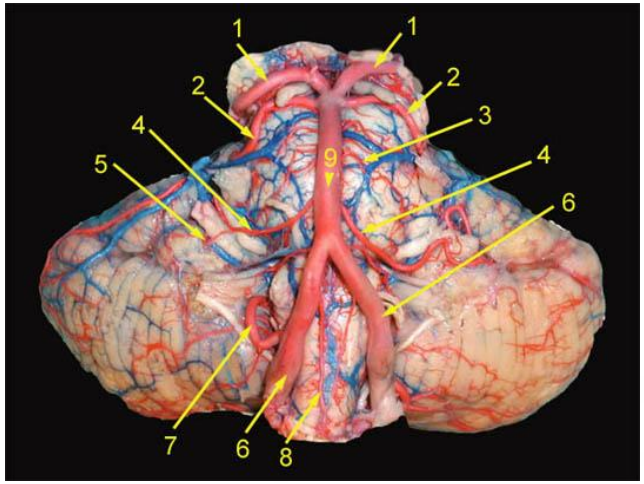
ARTERIAL SUPPLY AREAS (BRAINSTEM, CEREBELLUM)







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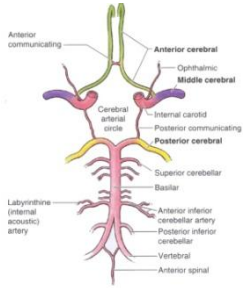
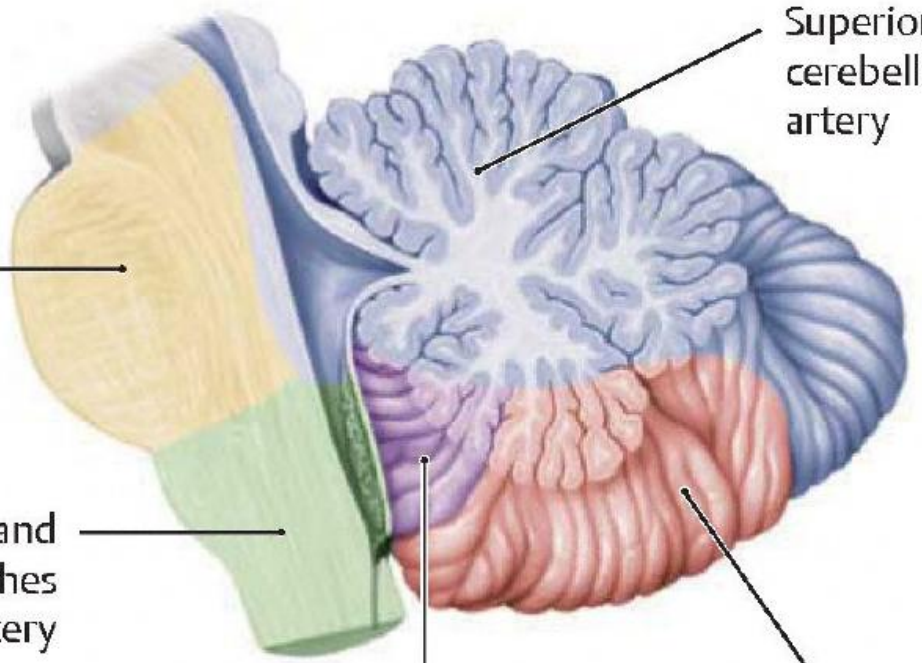
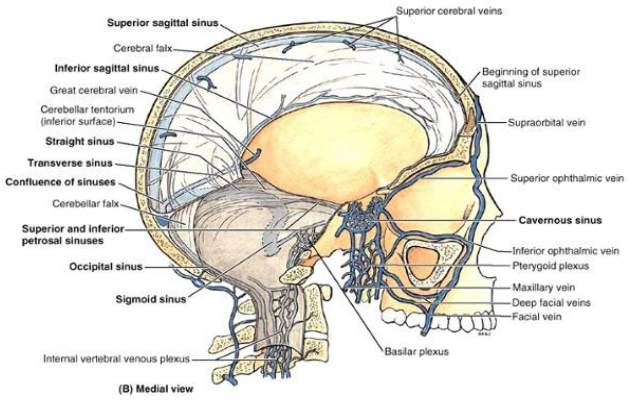

Anterior communicating
Anterior cerebral
Ophthalmic
Middle cerebral
Cerebral arterial circle
Internal carotid
Posterior communicating
Posterior cerebral
Superior cerebellar
Basilar
Labyrinthine (internal acoustic) artery
Anterior inferior cerebellar artery
Posterior inferior cerebellar
Vertebral
Anterior spinal

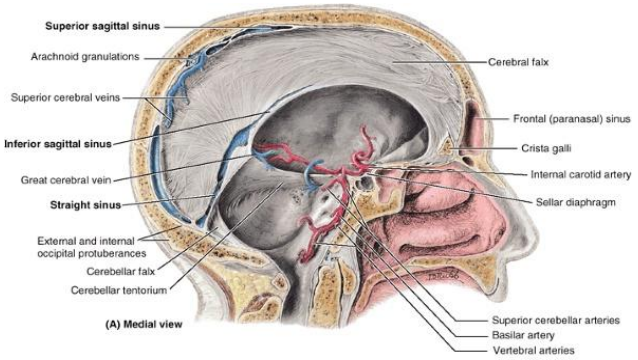

Superior cerebellar artery
Basilar artery
Anterior spinal artery and paramedian branches of the vertebral artery
Anterior inferior cerebellar artery
Posterior inferior cerebellar artery

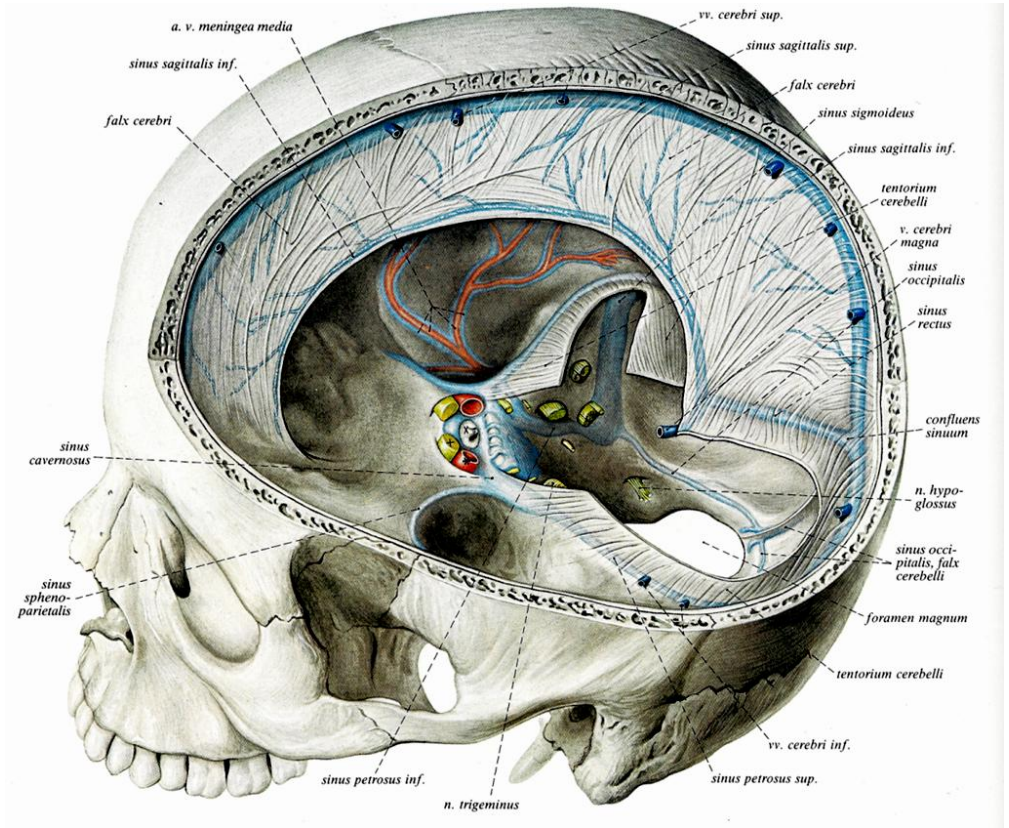
VENOUS DRAINAGE OF THE BRAIN

DURAL INFOLDINGS

- *falx cerebri*
- *tentorium cerebelli*
- *falx cerebelli*
- *diaphragma sellae*

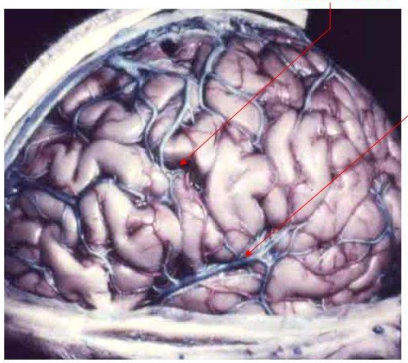


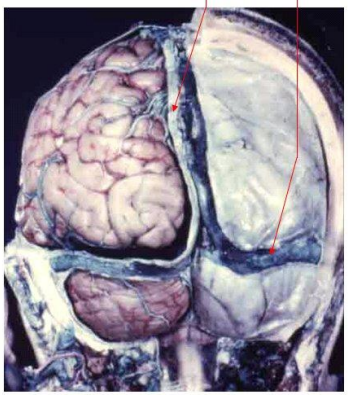




CEREBRAL VEINS

Superficial cerebral veins

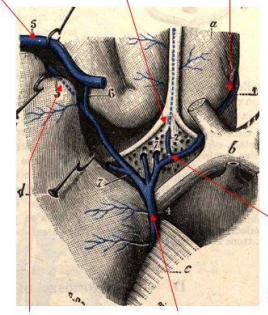




Superficial veins are more superficial than cortical arteries

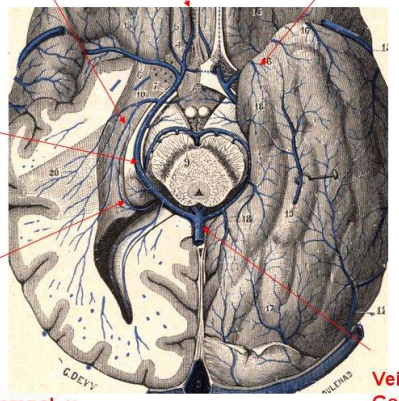
from D.L.Bassett. Stereoscopic Atlas of Human Anatomy .Sawyers inc 1952

Basal vein of Rosenthal



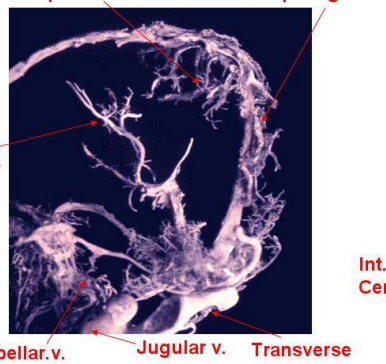
Origin of of basal vein Rosenthal

From L.Testut and A.Latarjet vol 2 of Traite d'Anatomie humaine 9th ed.Doin 1948



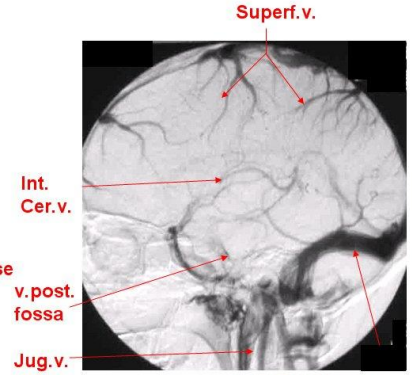
Afferents of basilar vein

Cerebral veins

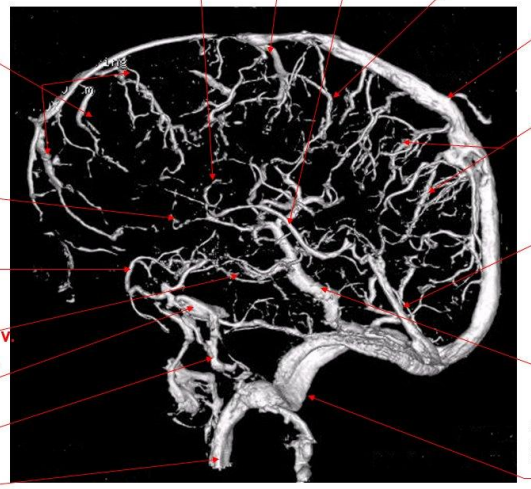


All these systems drain toward a large venous sinus and finally, to a jugular vein.

There are three main divisions in the venous drainage of the brain:
1-Superficial supratentorial veins.
2-Deep cerebral veins.
3-Infratentorial veins.



Cerebral veins



Angiography 3D

SUPERFICIAL VEINS

anterior, posterior & inferior cerebral vv.

superficial middle cerebral v.

superior anastomotic v. (Trolard)

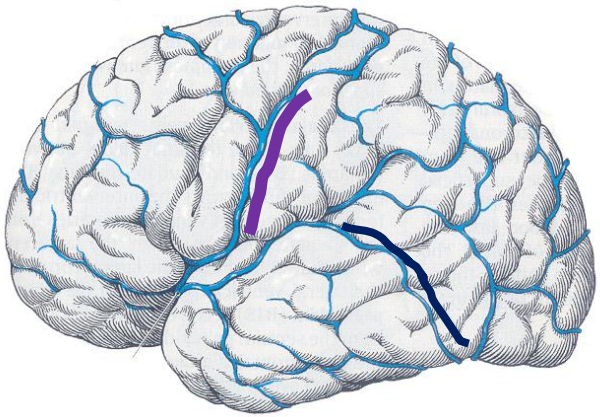
inferior anastomotic v. (Labbé)

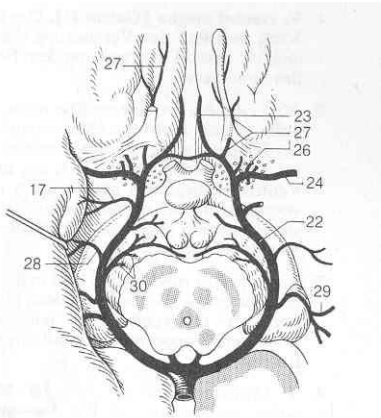
superior & inferior cerebellar vv.

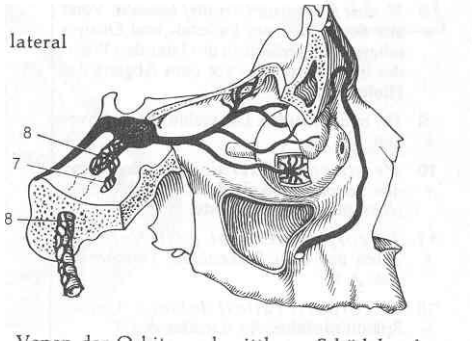
DEEP VEINS

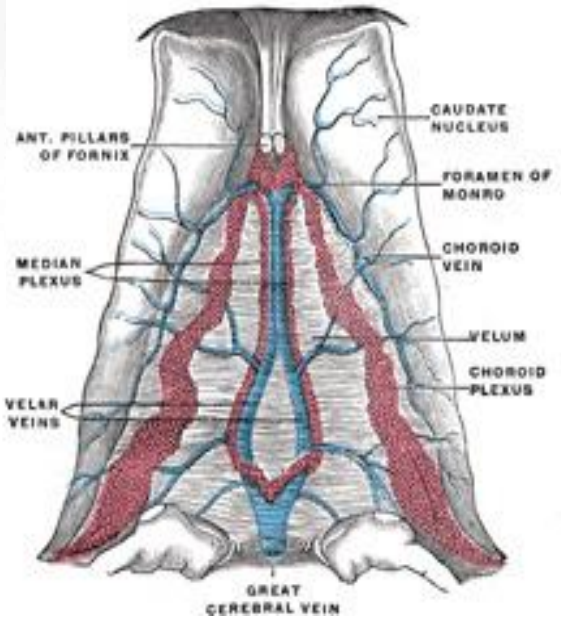
great cerebral v. of Galen

- *Internal cerebral vv.*
  - -- thalamostriate v.
  - -- septal v.
  - -- superior choroidal v.
- *basal v. of Rosenthal*
  - -- anterior cerebral v.
  - -- deep middle cerebral v.





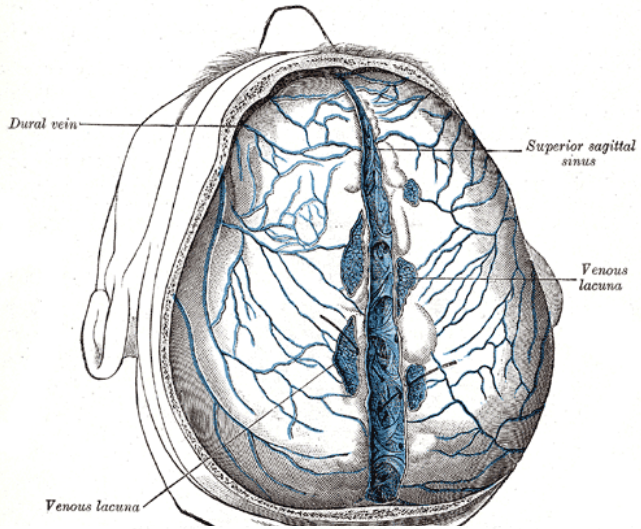


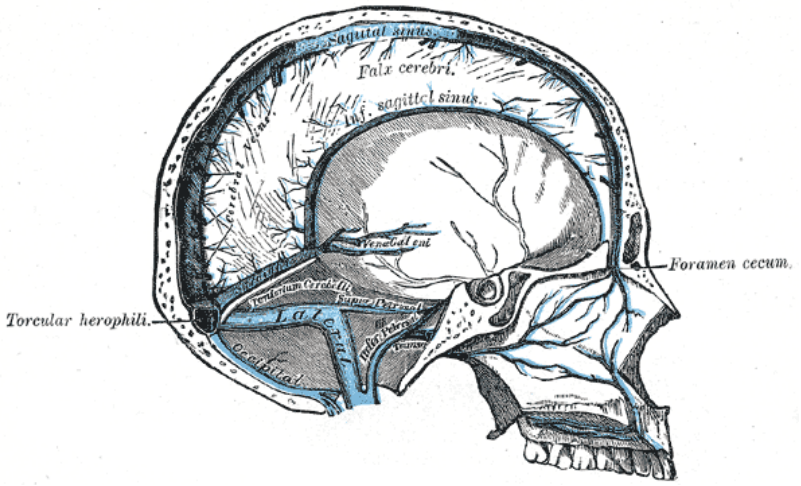


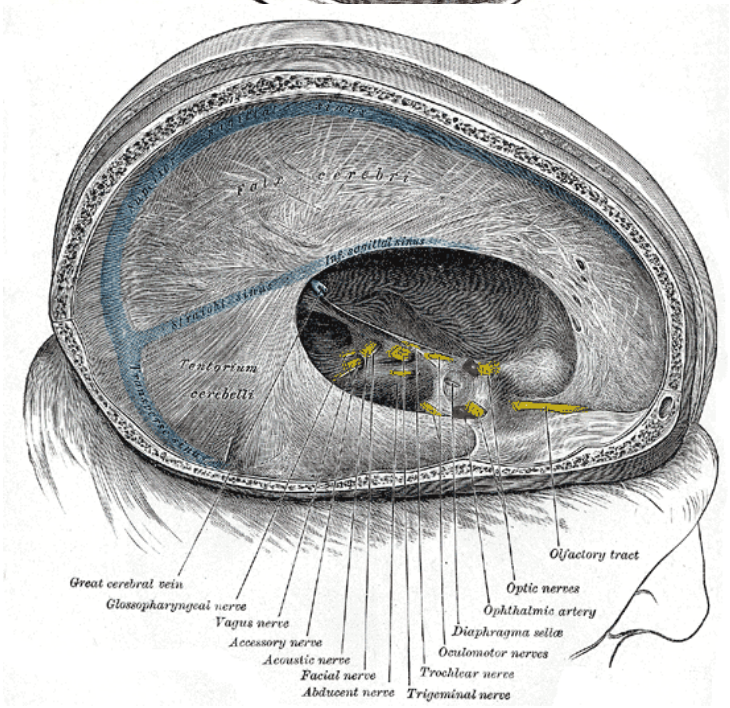
DURAL SINUSES & TRIBUTARIES

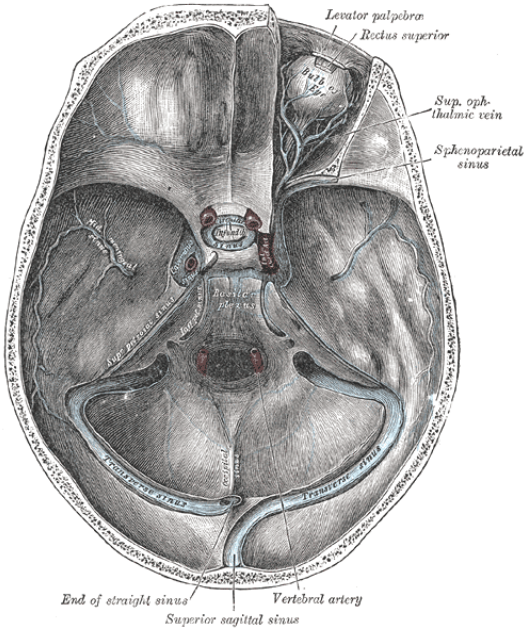
Superior sagittal sinus	- superior cerebral vv.
Inferior sagittal sinus	
Straight sinus	- great cerebral vein of Galen
Occipital sinus	
confluens sinuum	
Transverse sinus	- inferior cerebral vv.
Sigmoidal sinus	
Superior petrosal sinus	- inferior cerebral vv.
Inferior petrosal sinus	- labyrinthic v.
Sphenoparietal sinus	
	+ vv. of the dura mater
Cavernous sinus	**- inferior cerebral vv.**
	superficial middle cerebral v.
	superior ophtalmic v.

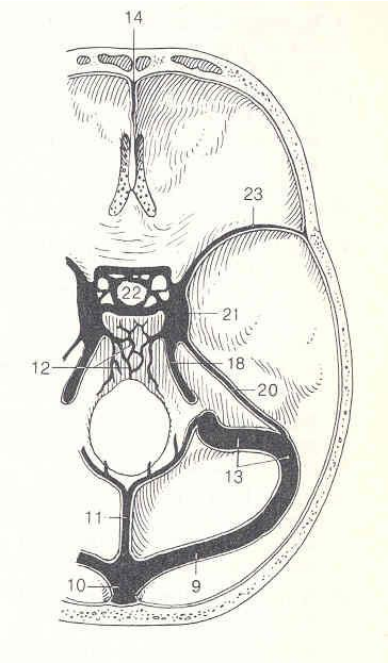
SINUSES AND VEINS



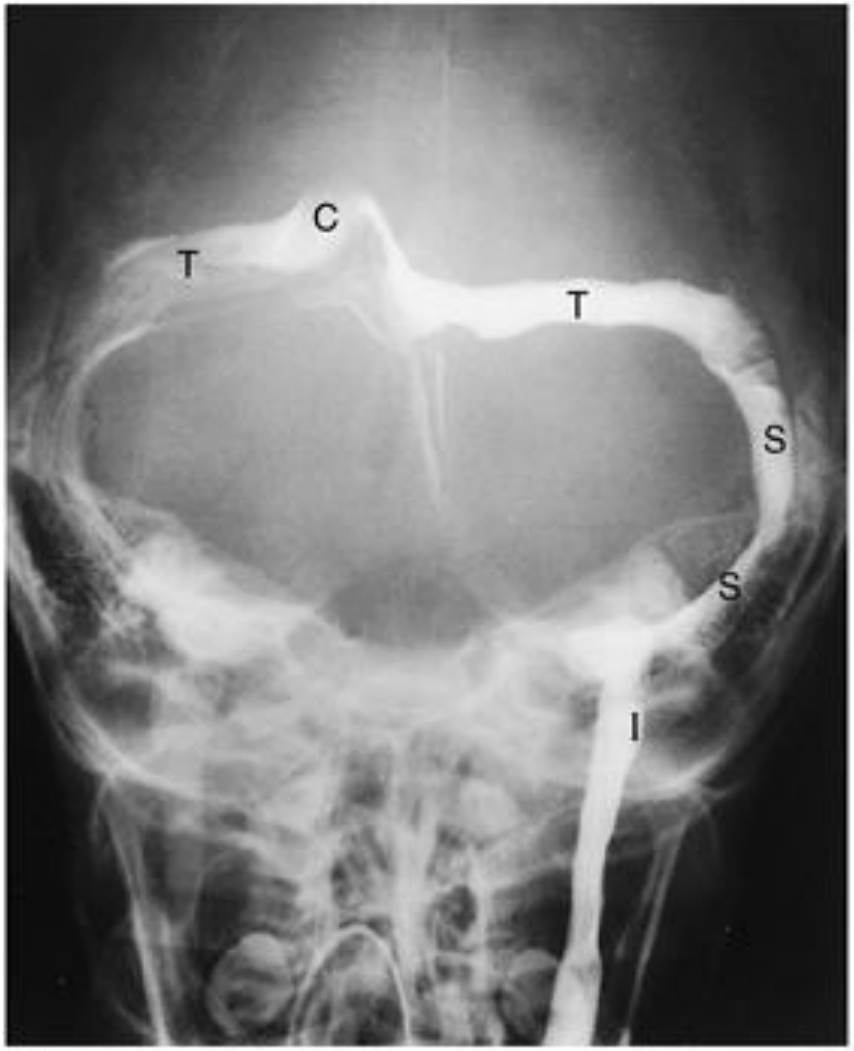




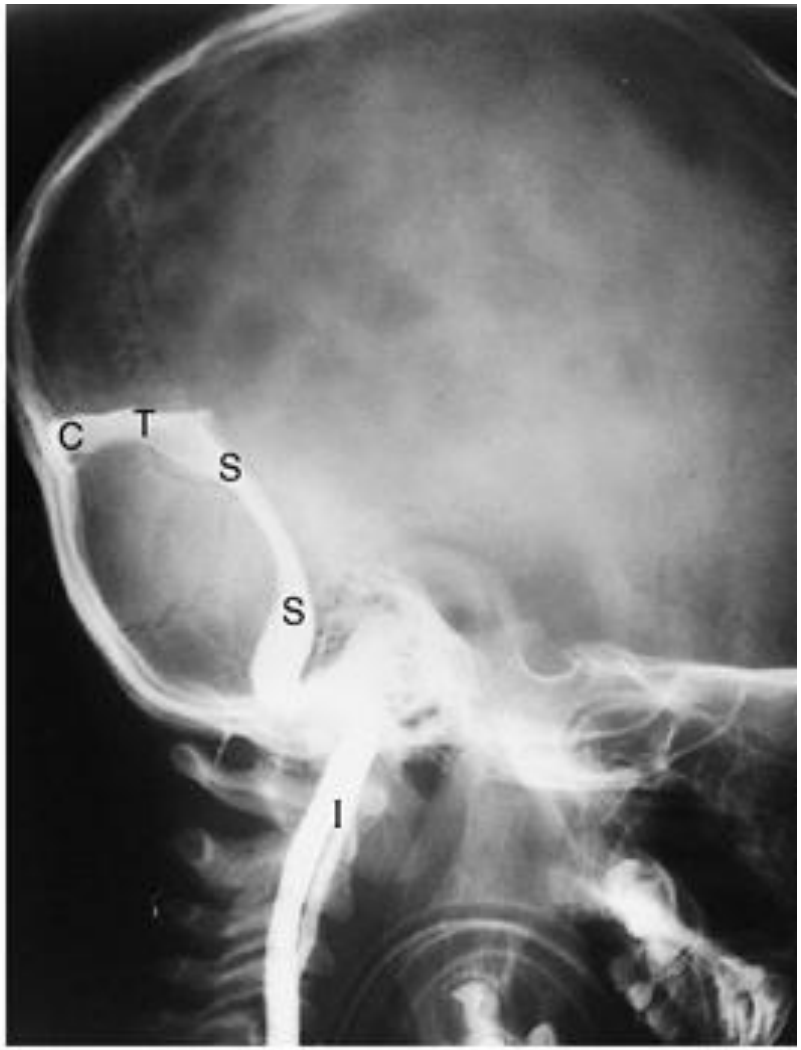




DURAL SINUSES & VEINS



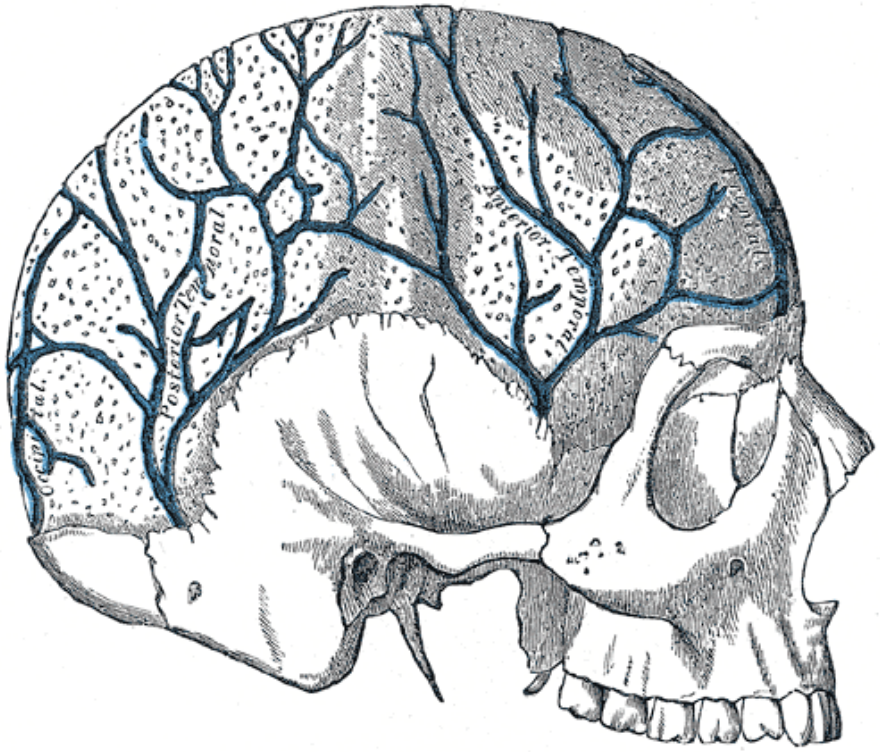
(A) Anteroposterior view

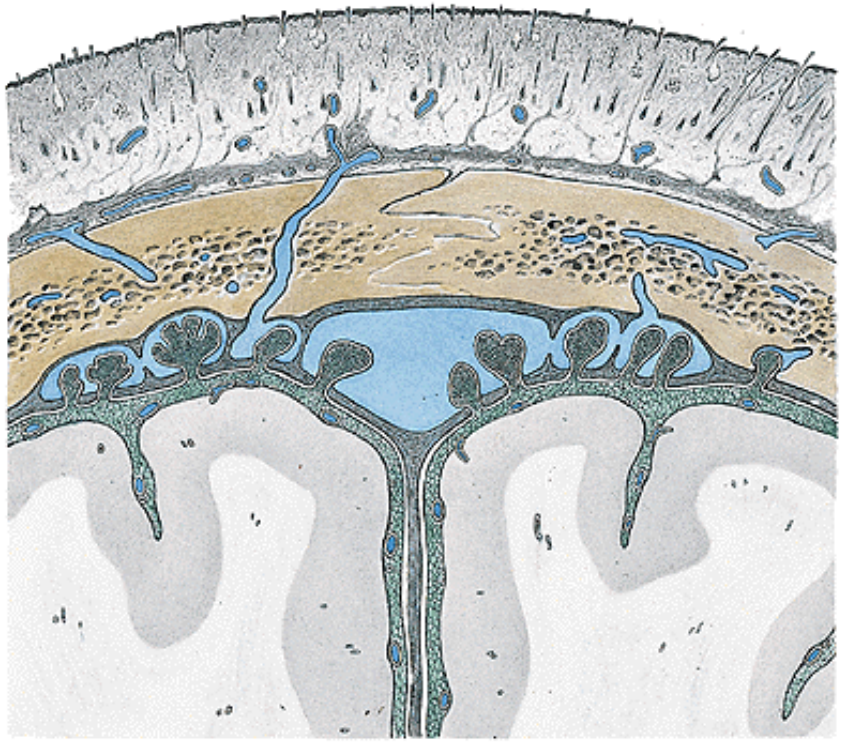


(B) Lateral view

DIPLOIC VEINS

BASIC FEATURES OF THE DURAL SINUSES

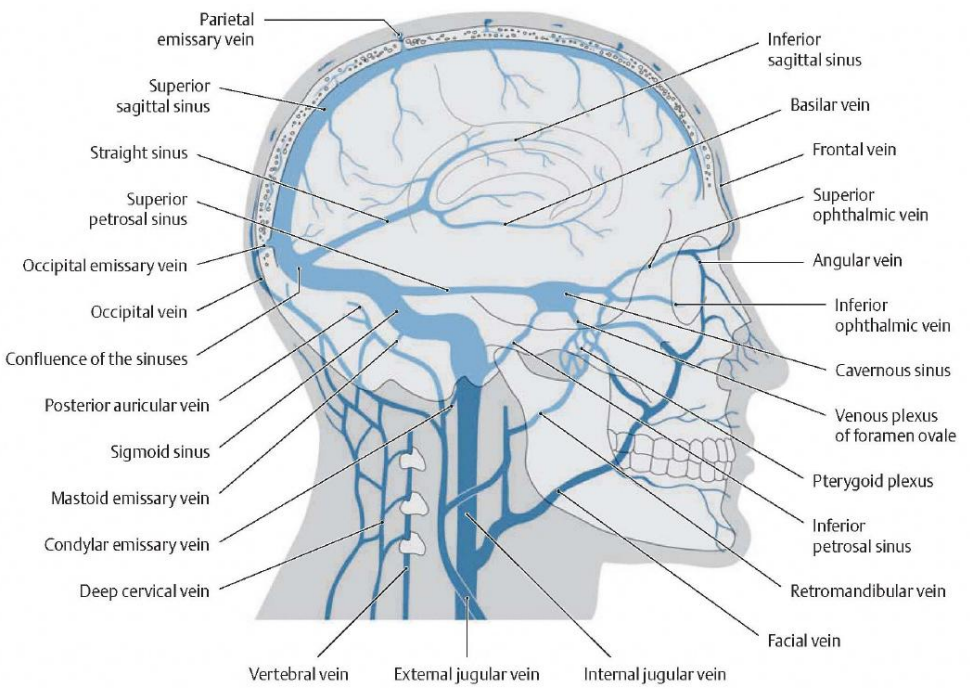


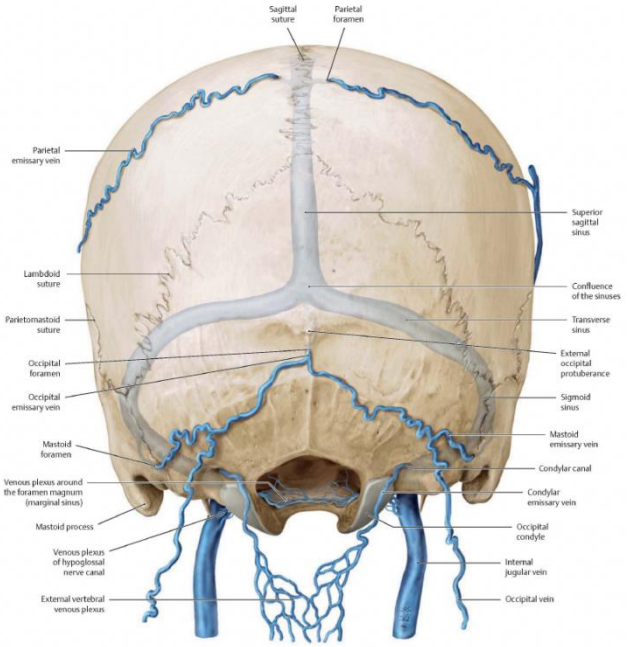


ALTERNATIVE ROUTES OF DRAINAGE

CONNECTIONS OF THE DURAL SINUSES

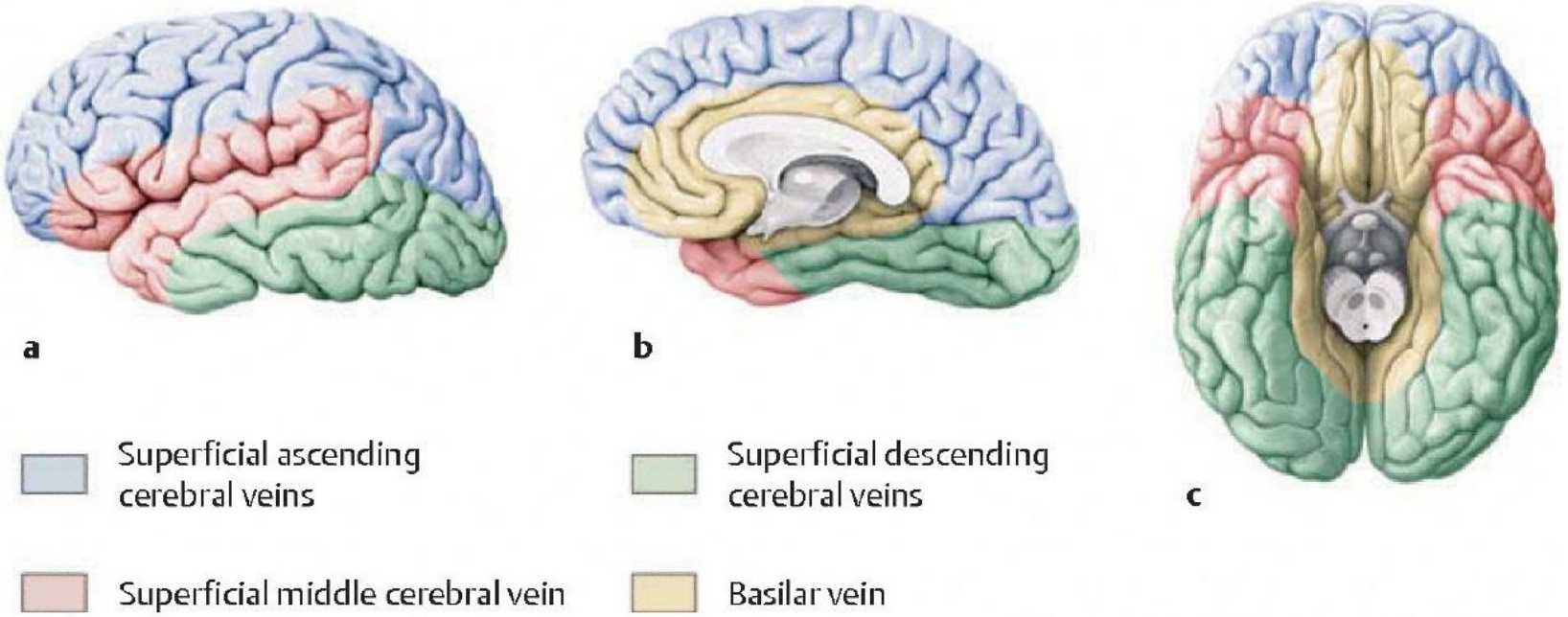
VENOUS EMISSARIES

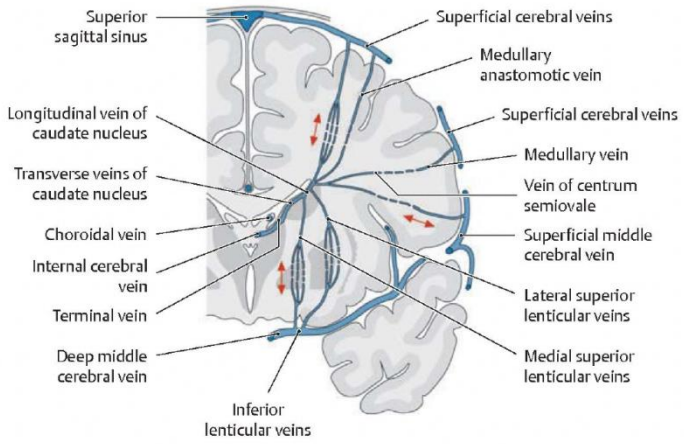


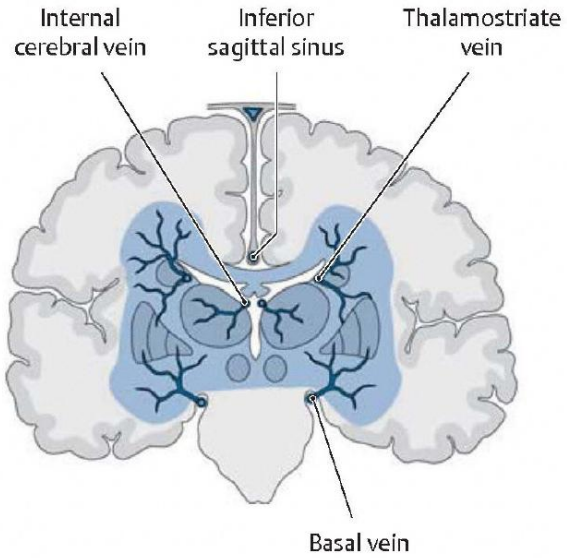


If the jugular foramen and/or the internal jugular vein is obliterated, blood may find alternative routes and escapes through the diploic and emissary veins connecting the dural sinuses with the veins of the scalp skin

REGIONAL DISTRIBUSTION OF VENOUS DRAINAGE

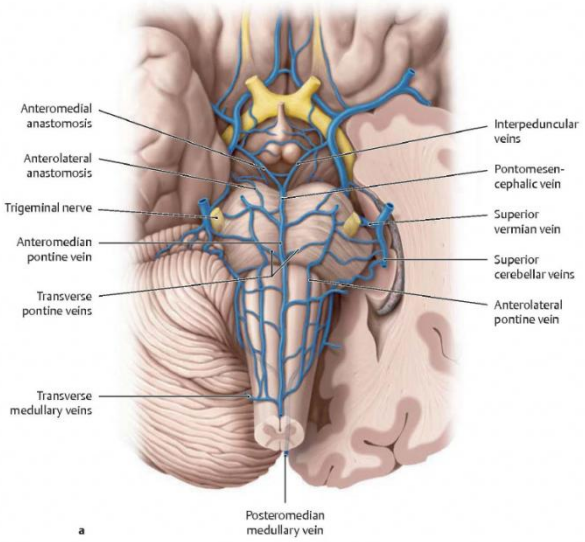


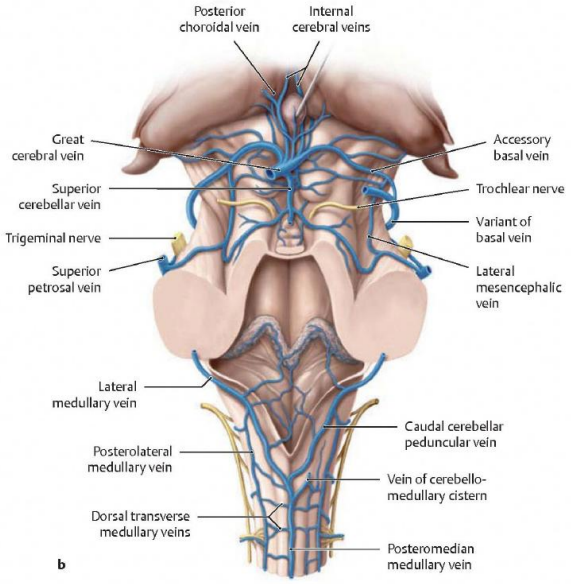


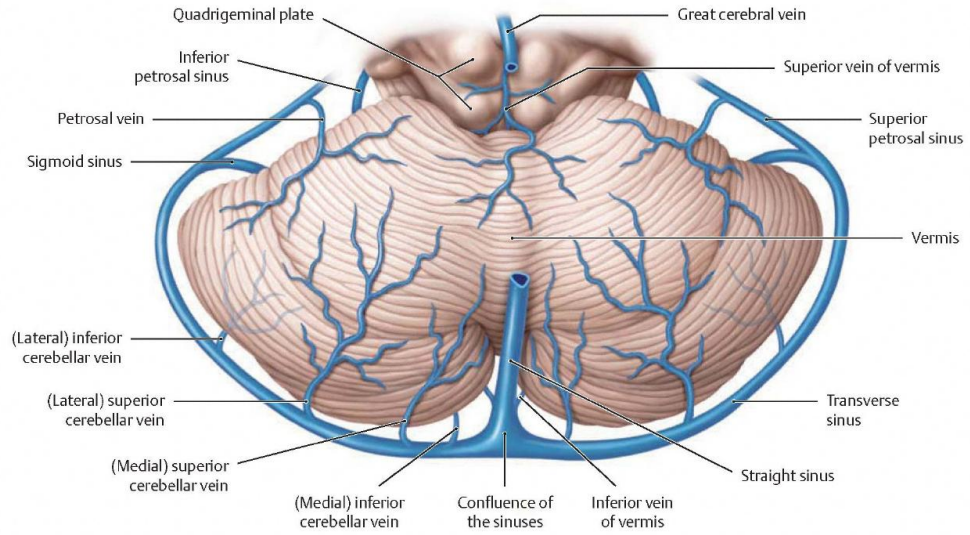


D Anastomoses between the superficial and deep cerebral veins

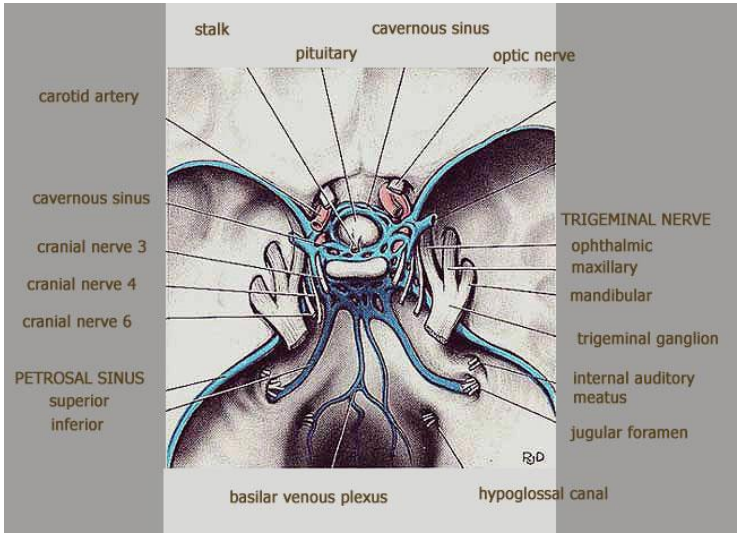
BRAINSTEM AND CEREBELLUM

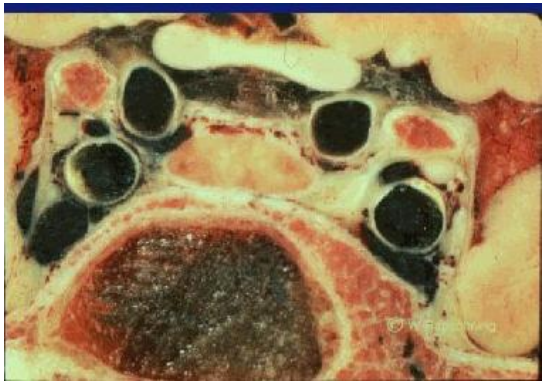


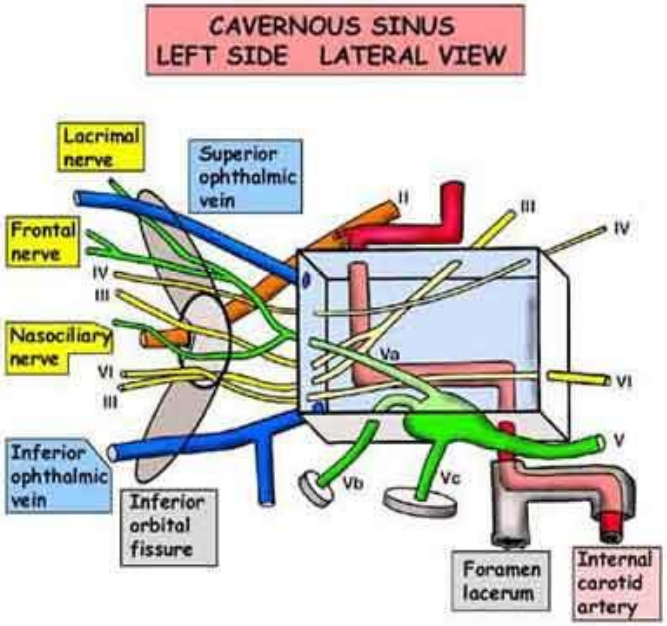


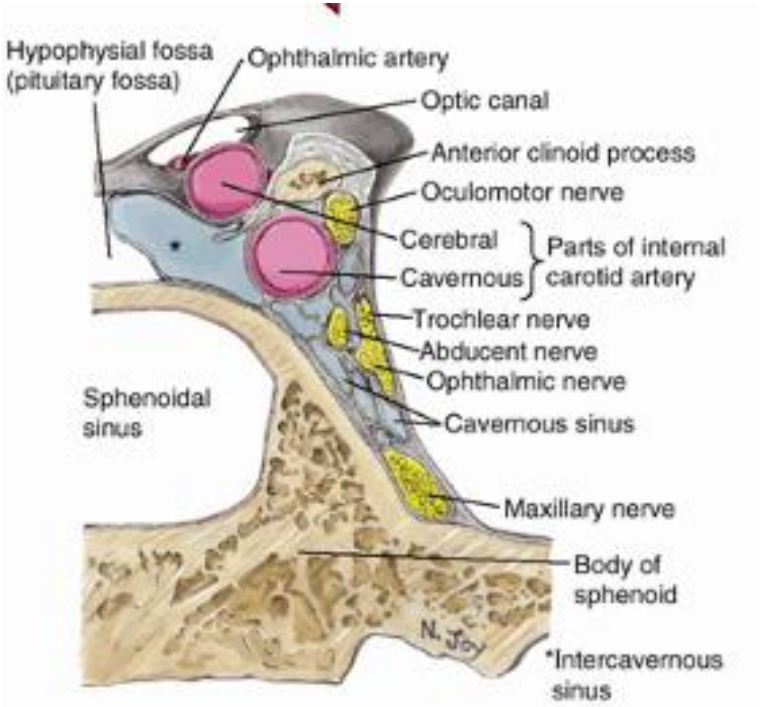


THE CAVERNOUS SINUS









(C) Posterior view of coronal section of right cavernous sinus

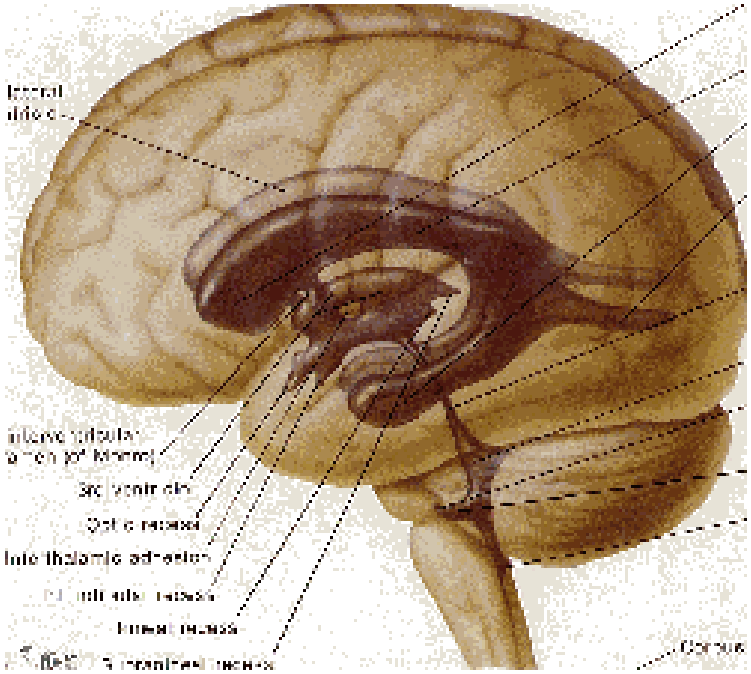
FORMATION OF CEREBROSPINAL FLUID

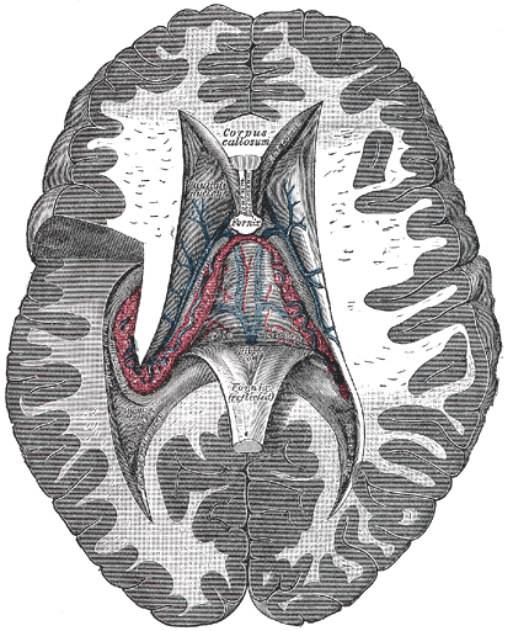
CEREBROSPINAL FLUID SPACES

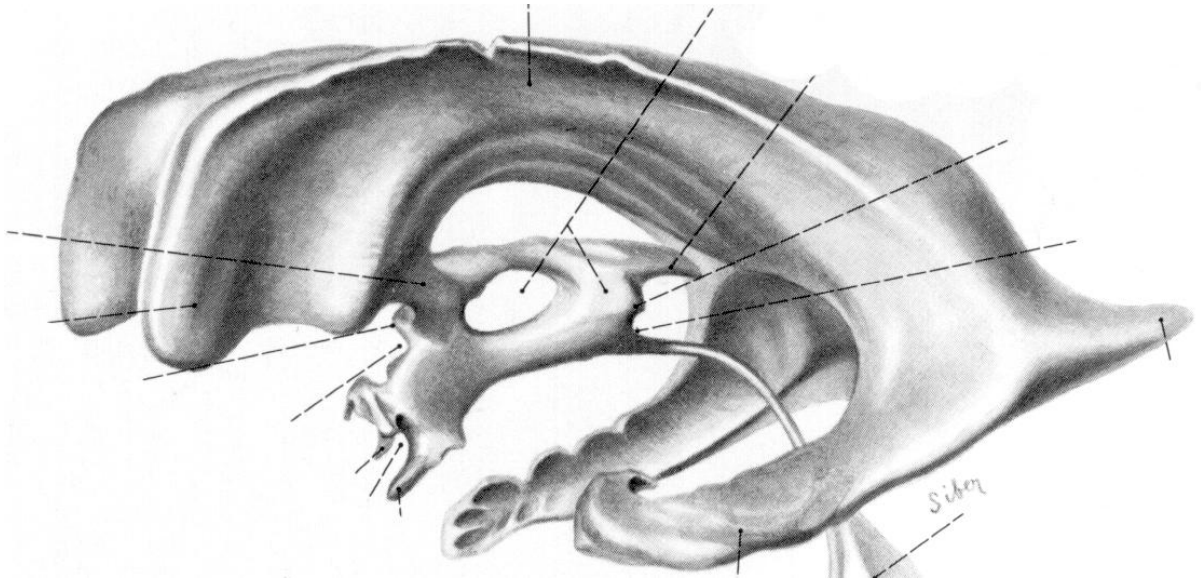
INTRACEREBRAL
ventricles

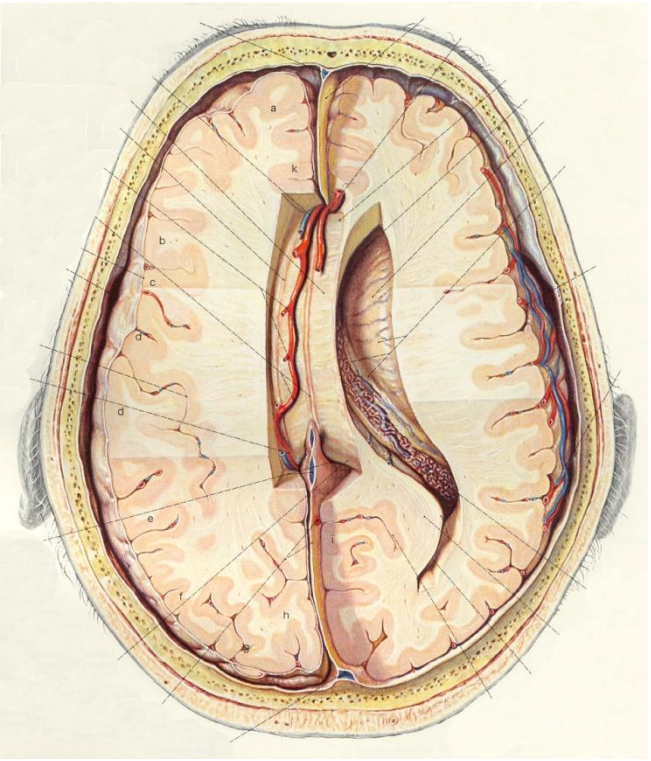
EXTRACEREBRAL
subarachnoidal space

The *CHOROIDAL PLEXUS* produces CSF





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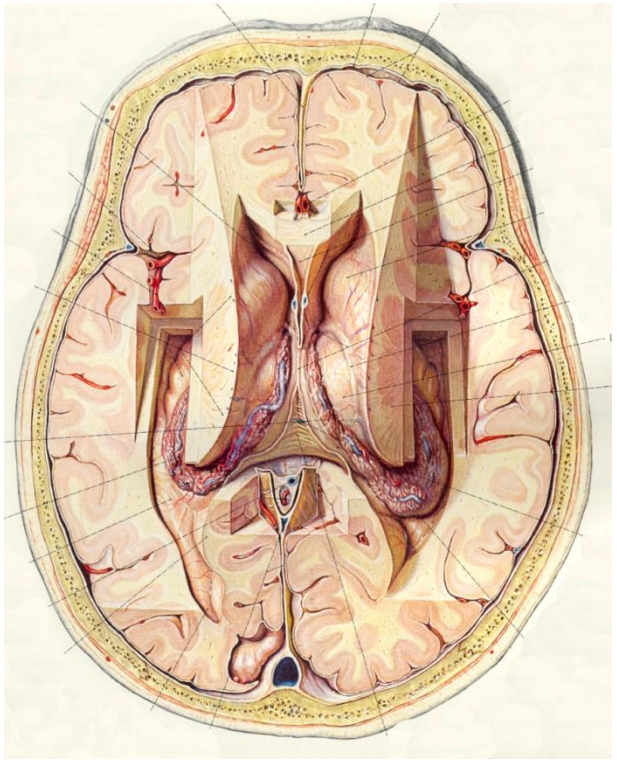
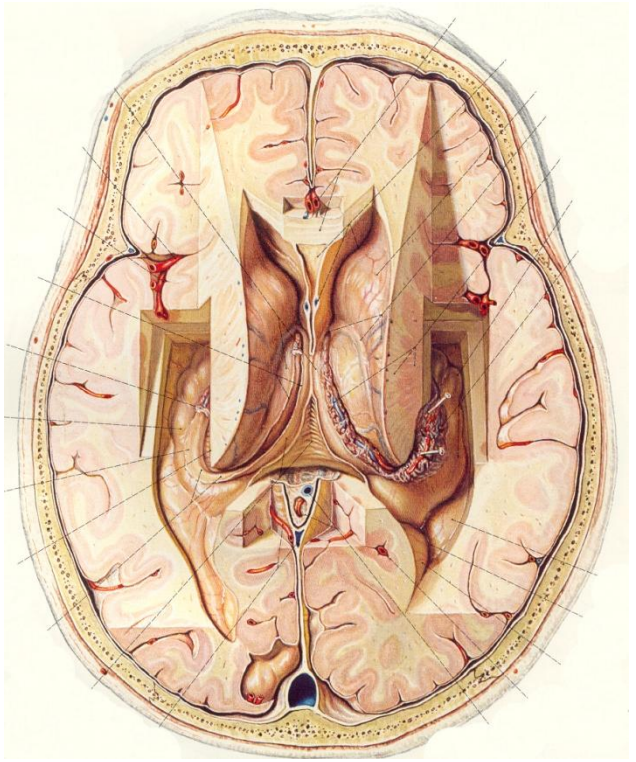
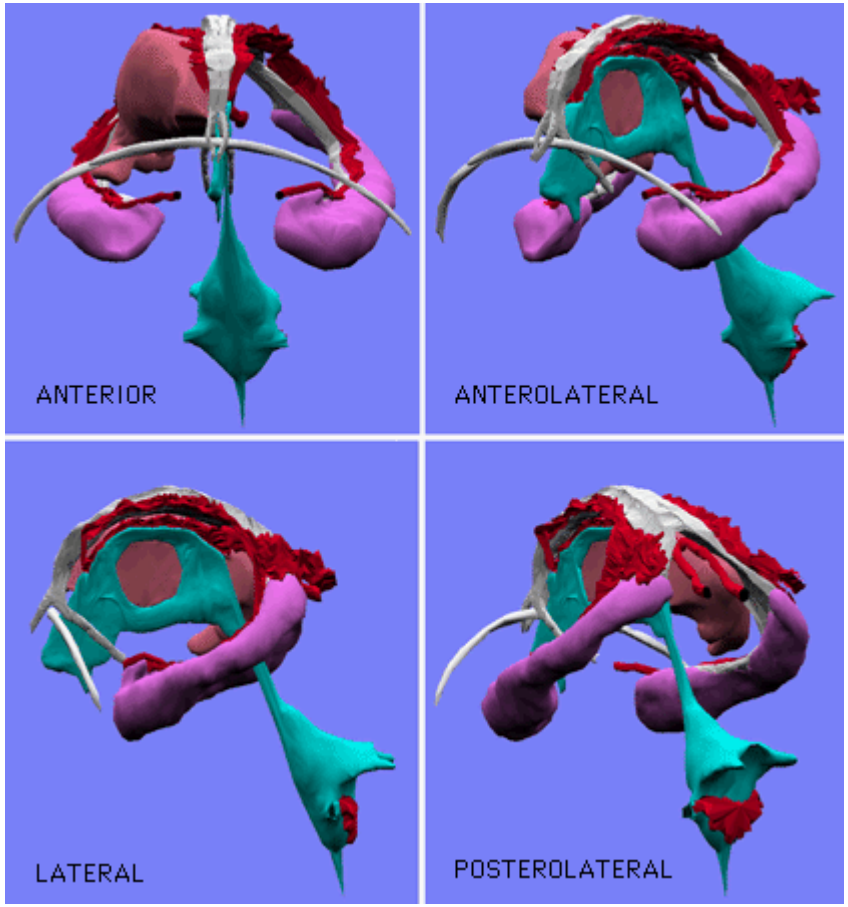
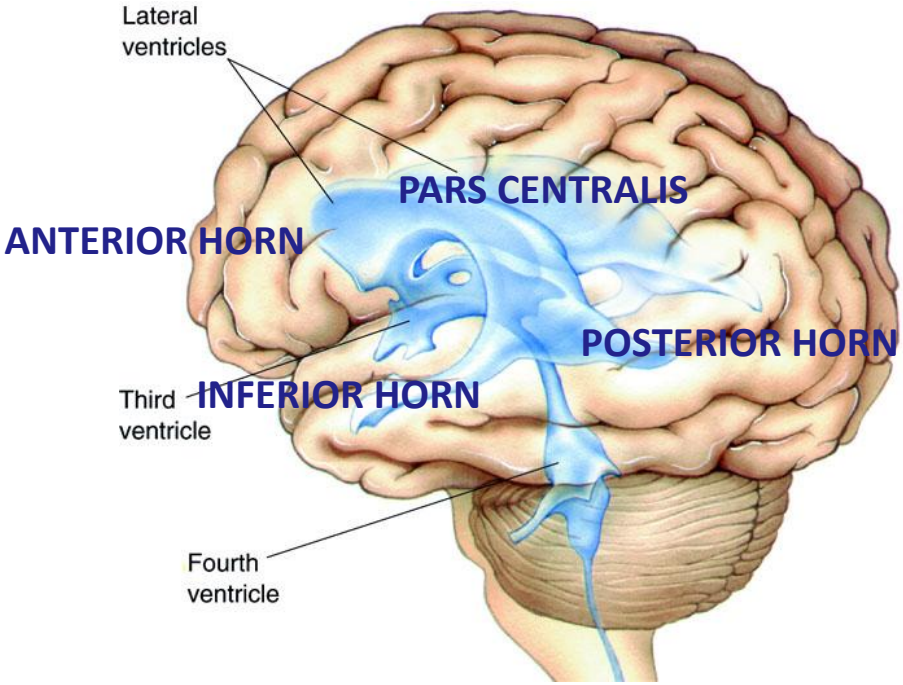
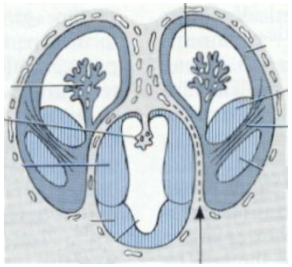




CASTING OF THE VENTRICLES AND THE CHOROIDAL PLEXUS

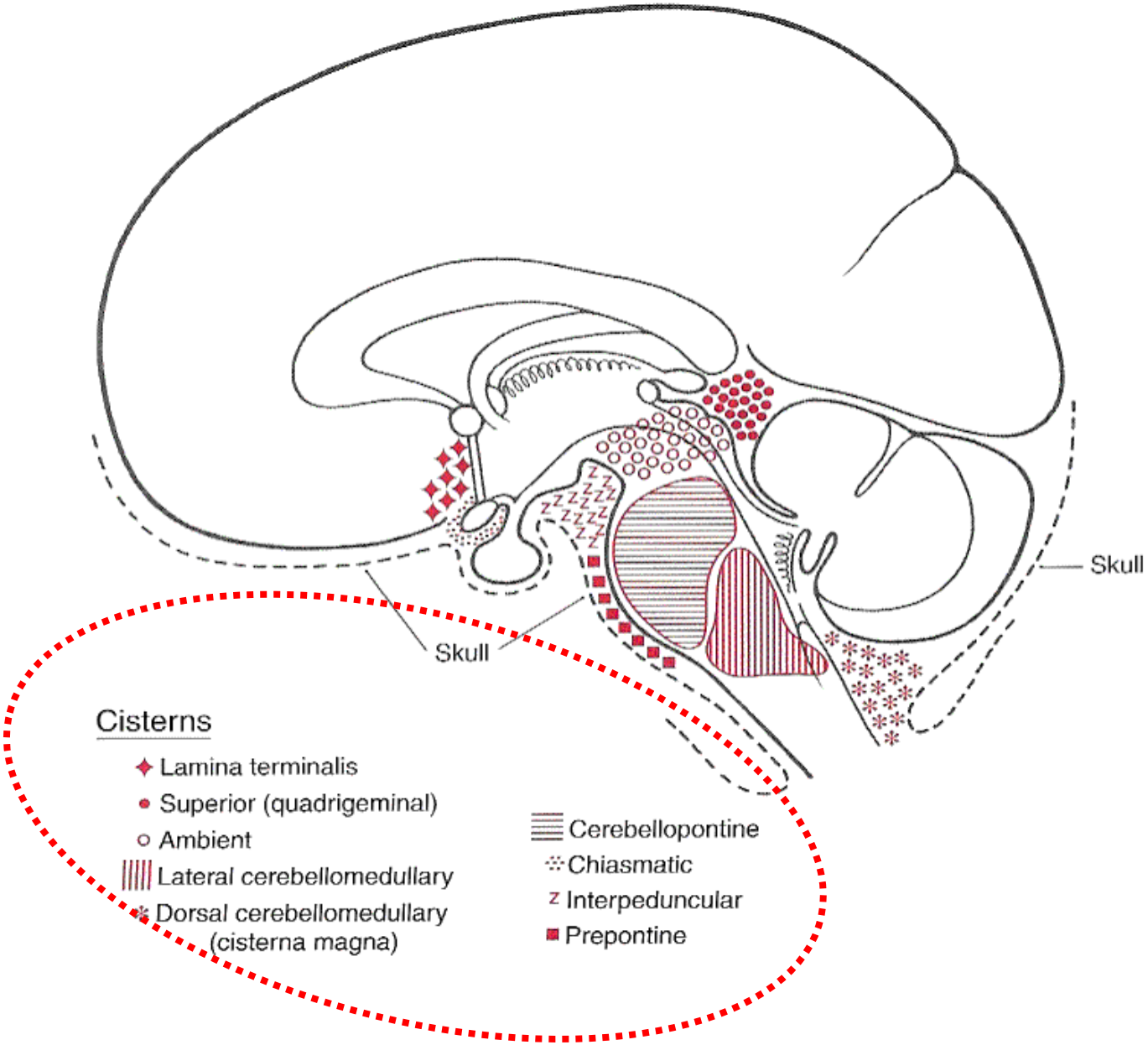






Development of the choroidal plexus

THE SUBARACHNOIDAL SPACE



CEREBROSPINAL FLUID PRODUCTION AND CIRCULATION

-CSF is formed in the lateral ventricles, circulates through the interventricular foramina into the 3rd ventricle, and then via the cerebral aqueduct into the 4th ventricle. Here the fluid escapes via the lateral apertures of the fourth ventricle and the medial foramen of the fourth ventricle into the subaracnoid spaces, where it difuses over the brain and spinal cord.

DAILY PRODUCTION: 430 to 450 ml of CSF , so the fluid must be changes every 6 to 7 hours

Respiratory and circulatory changes are believed to change the pressure within the closed system and promote the mixing and diffusion of fluid.

- PRESSURE – lying 70–220 mmH2O (= cca 690-2160 Pa)

-PROTEIN CONTENT: cca 0,15 - 0,45 g/l (lower than in the serum)

VERY IMPORTANT FOR DIAGNOSTIC PURPOSES- BBB rupture ?

– SUGAR CONTENT 50 - 70 % of the blood sugar level.

CSF (LIQUOR) CIRCULATION

EXTRACEREBRAL vs INTRACEREBRAL CSF SPACES

Plexus choroideus

↓

1+2. Ventricle

↓

Foramina monroi

↓

3. Ventricle

↓

Cerebral aqueduct

↓

4. Ventricle

↓

Foramen Magendi /Luschka

↓

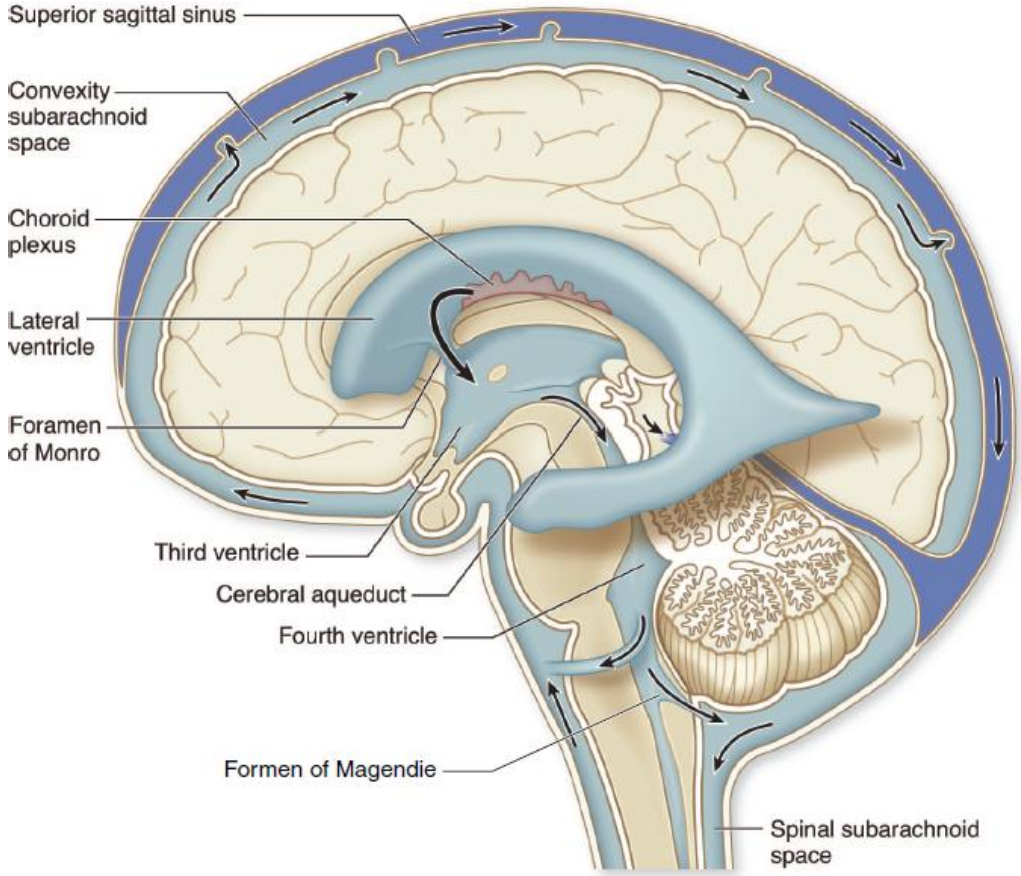
Cysterna magna

↓

Subarachnoidal space

↓

Arachnoidal villi

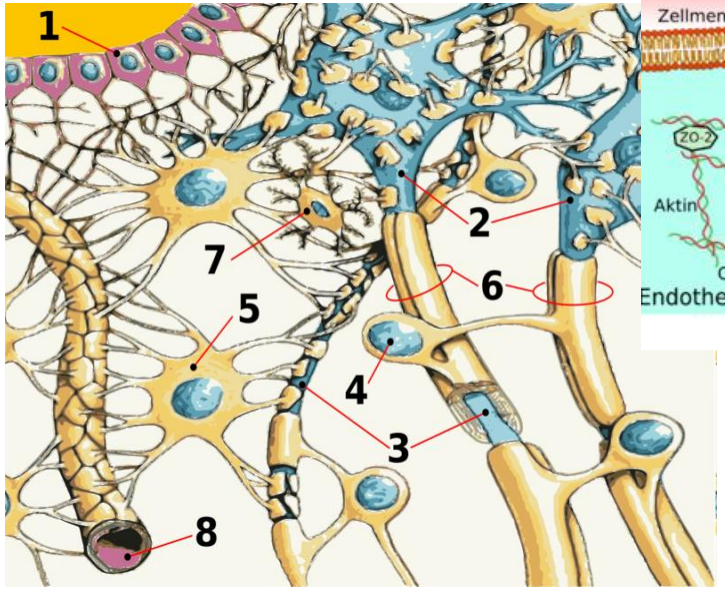


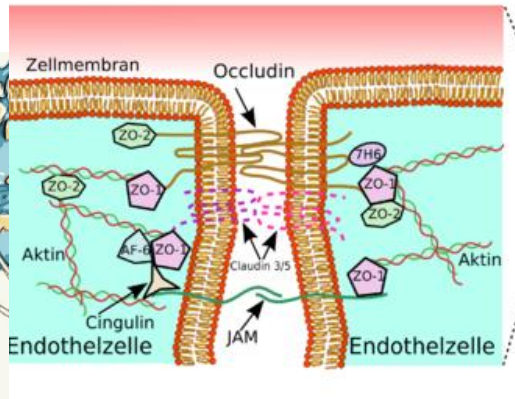
Source: A. H. Ropper, M. A. Samuels, J. P. Klein, S. Prasad: Adams and Victor's Principles of Neurology, 11th Edition
www.neurology.mhmedical.com

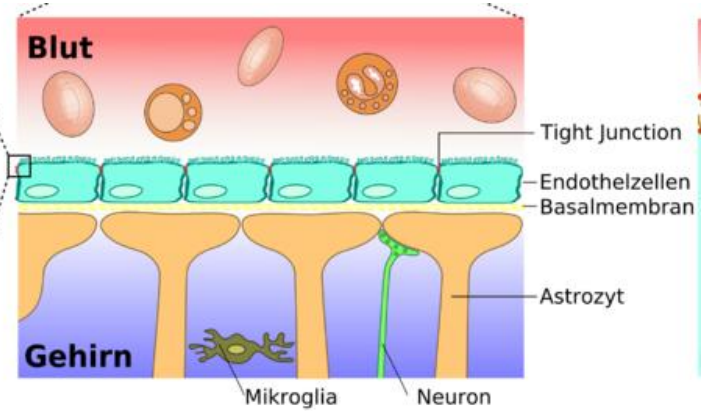
https://www.youtube.com/watch?v=asQo6cmOjd0

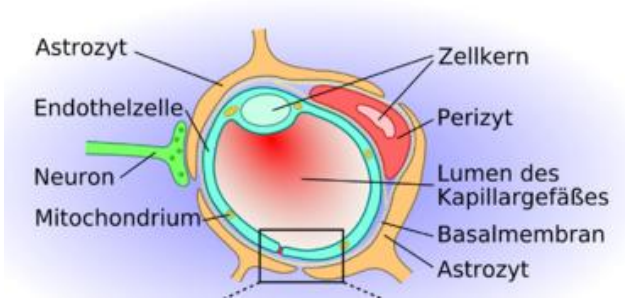
BLOOD – BRAIN BARRIER

The blood–brain barrier is a separation of circulating blood from the brain extracellular fluid in the central nervous system. It occurs along all capillaries and consists of tight junctions around the capillaries that do not exist in normal circulation. Endothelial cells restrict the diffusion of microscopic objects (e.g. bacteria) and large or hydrophilic molecules into the cerebrospinal fluid (CSF), while allowing the diffusion of small hydrophobic molecules (O2, CO2, hormones). Cells of the barrier actively transport metabolic products such as glucose across the barrier with specific proteins. This barrier also includes a thick basement membrane and astrocytic endfeet.

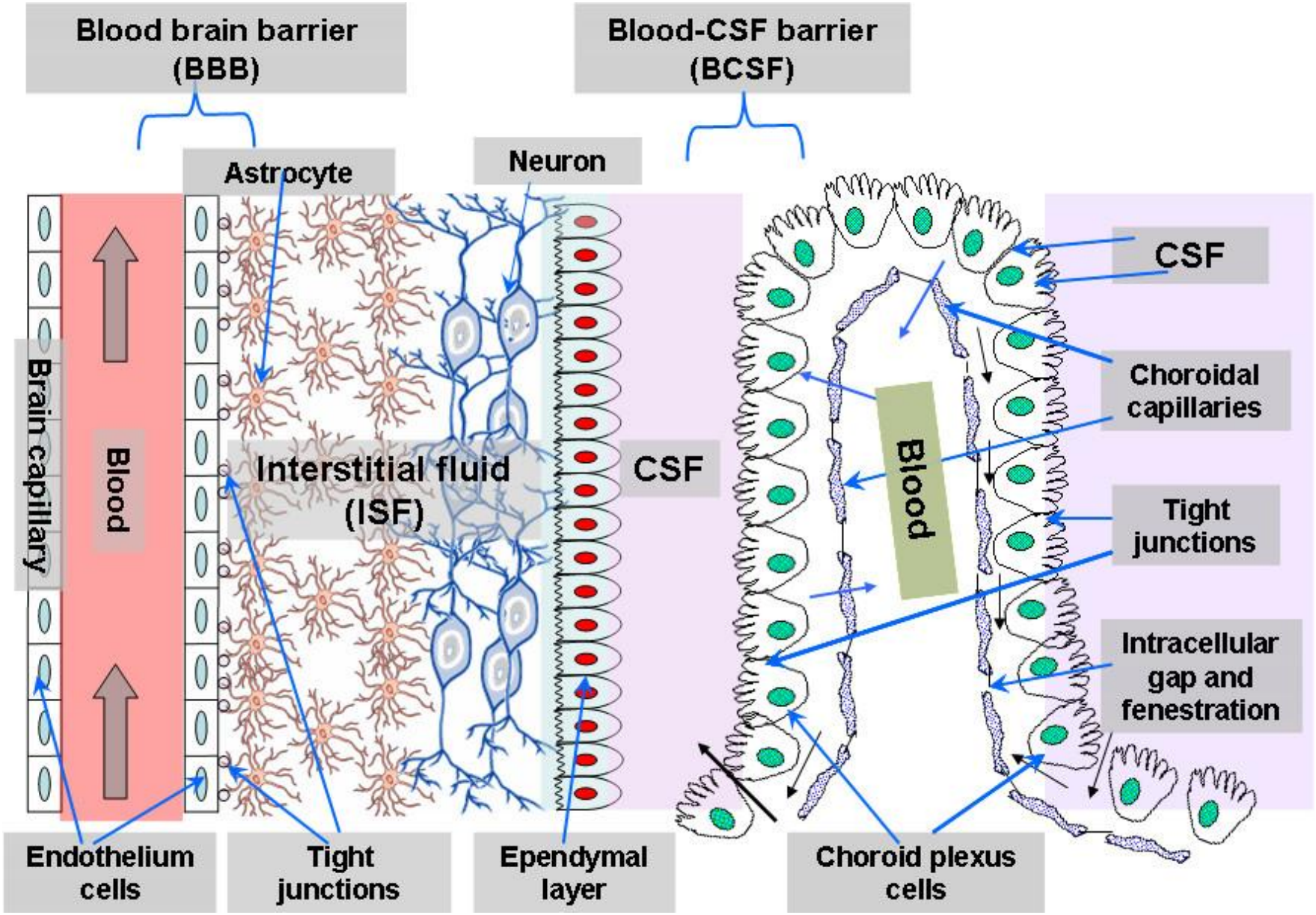








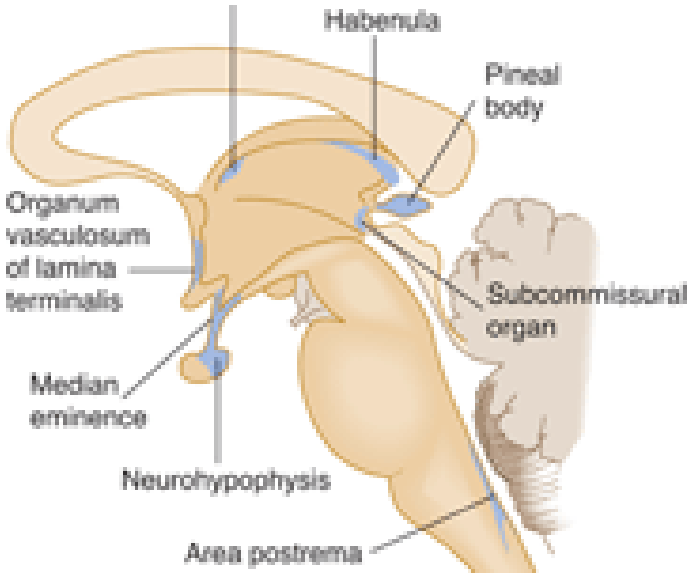
1885 Paul Ehrlich


Blood brain barrier
(BBB)
Blood-CSF barrier
(BCSF)
Astrocyte
Neuron
Brain capillary
Blood
Interstitial fluid
(ISF)
CSF
Endothelium
cells
Tight
junctions
Ependymal
layer
CSF
Choroidal
capillaries
Blood
Tight
junctions
Intracellular
gap and
fenestration
Choroid plexus
cells

CIRCUMVENTRICULAR ORGANS

The circumventricular organs (CVOs) are highly vascularized structures located around the third and fourth ventricles and characterized by the lack of a blood–brain barrier (BBB).
These specialized areas are points of communication between the blood, the brain parenchyma, and the CSF.

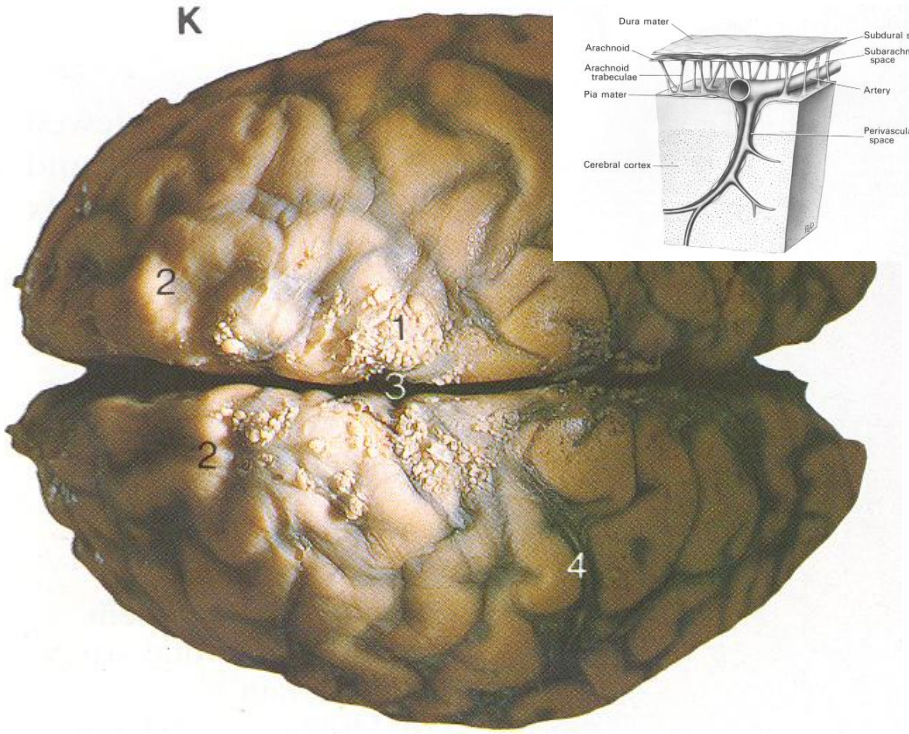
Neurons and glial cells of the CVOs express a unique repertoire of receptors and ion channels and receive a wide range of chemical signals from the bloodstream.

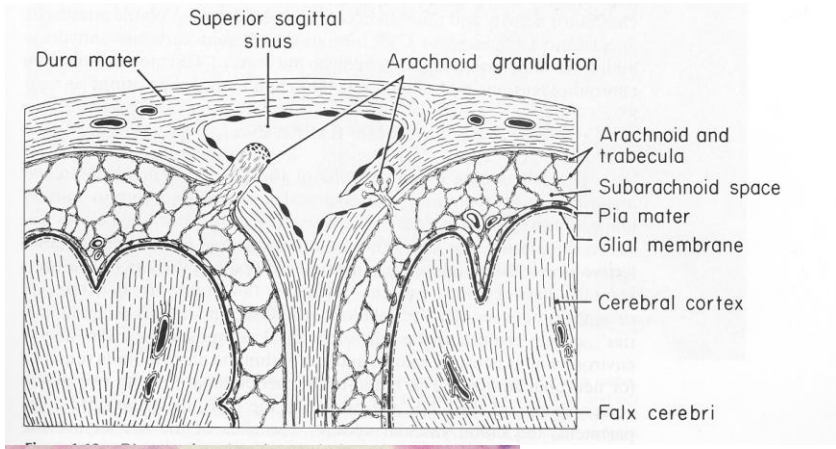


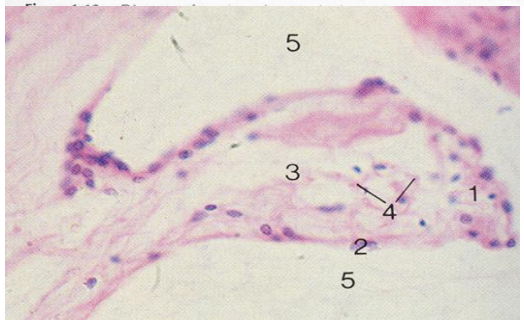
Via their interconnections with the hypothalamus and brainstem, these sensory CVOs have a critical role in sodium and water balance, cardiovascular regulation, energy metabolism, and immunomodulation. They are also involved in mechanisms of fever, vomiting, and other responses to potentially noxious stimuli; they are sites of access to the CNS for circulating microorganisms, prion proteins, and autoantibodies.

Subfornical organ	sensory	*fluid regulation*
Organum vasculosum	sensory, secretory	*detects peptides, fluid regulation*
Median eminence	secretory	*regulates the anterior pituitary through the release of neurohormones*
Neurohypophysis	secretory	*store and secretes the hormones oxytocin and ADH into the blood, but does not synthesize either hormone*
Subcommissural organ	secretory	*secretes certain proteins into the cerebrospinal fluid, its specific function is as yet unknown.*
Pineal gland	secretory	*stimulated by darkness to secrete melatonin and is associated with circadian rhythms*
Area postrema	sensory	*the vomiting centre of the brain (can detect noxious substances in the blood and stimulate vomiting in order to rid the body of these toxic chemicals)*

ARACHNOID GRANULATIONS







1 Arachnoid villus
2 Mesothelial cells
3 Subarachnoid space
4 Trabeculae
5 Venous lacunae

Zakharov et al. suggested that CSF, flowing along the cranial nerves and spinal nerve roots, **will reach into the lymphatic channels**; this flow may play a substantial role in **CSF reabsorbtion**, **in particular in the neonate**, in which arachnoid granulations are sparsely distributed. The flow of CSF to the **nasal submucosal lymphatic channels** through the cribiform plate seems to be specially important.

Zakharov A, Papaiconomou C, Djenic J, Midha R, Johnston M (2003). "Lymphatic CSF absorption pathways in neonatal sheep revealed by sub arachnoidal injection of Microfil". Neuropathol. Appl. Neurobiol. ***29*** *(6): 563–73*

CLINICAL CONSIDERATIONS

CLINICAL CONSIDERATIONS

Atherosclerosis – brain infarction
Epidural, subdural, subarachnoideal and intracerebral haemorrhage

Symptomes according to failing blood supply in certain regions

Anterior cerebral artery

Weakness/paralysis of muscles and loss of sensory functions in the contralateral lower limbs.

Middle cerebral artery

Paralysis & sensory disfunction in the contralateral head&neck , the upper limbs. If the dominant hemisphere is damaged, speech disorders are apparent

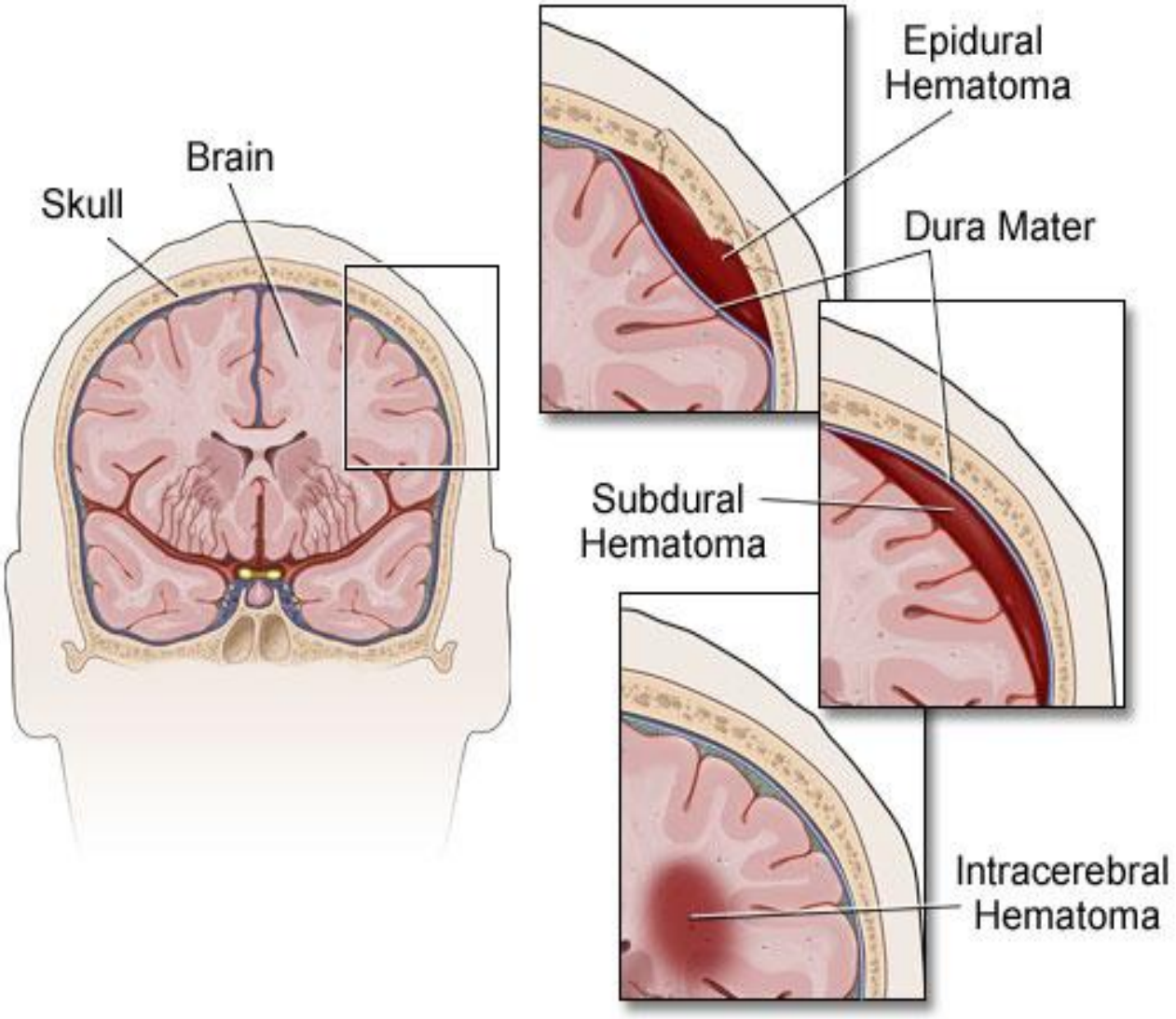
Posterior cerebral artery

Loss of visual field and/or blindness.

Vertebro-basilar system

Eye movement (gaze) malfunction, double vision
Anisocoria (different sized pupils)
Vertigo, loss of balance
Dysphagia / dysphonia (troubled deglutition and phonation)
Drowsiness or unconsciousness

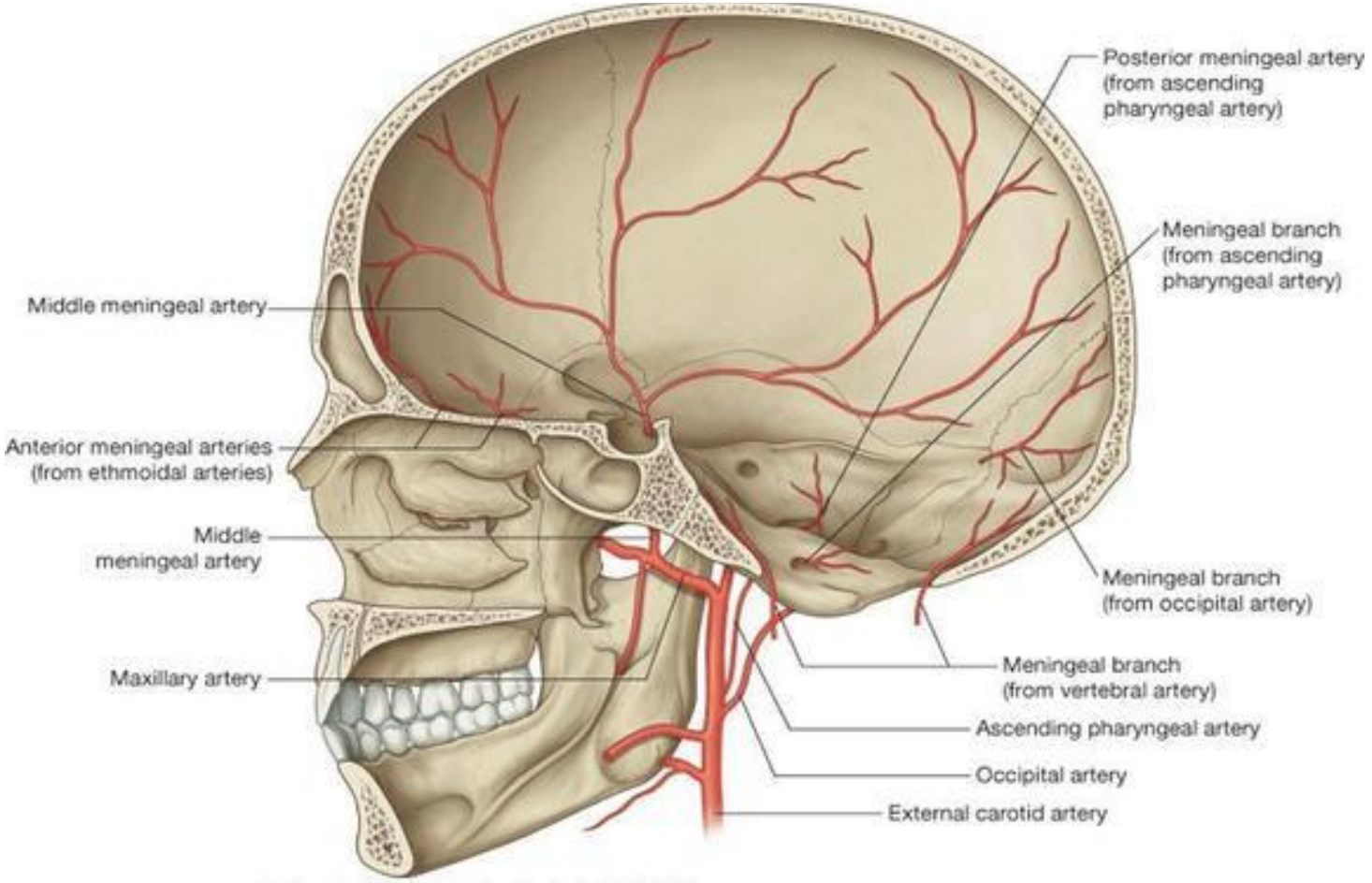
Intracranial Hematoma (ICH)



EPIDURAL HAEMORRHAGE - DUE TO HEAD TRAUMA

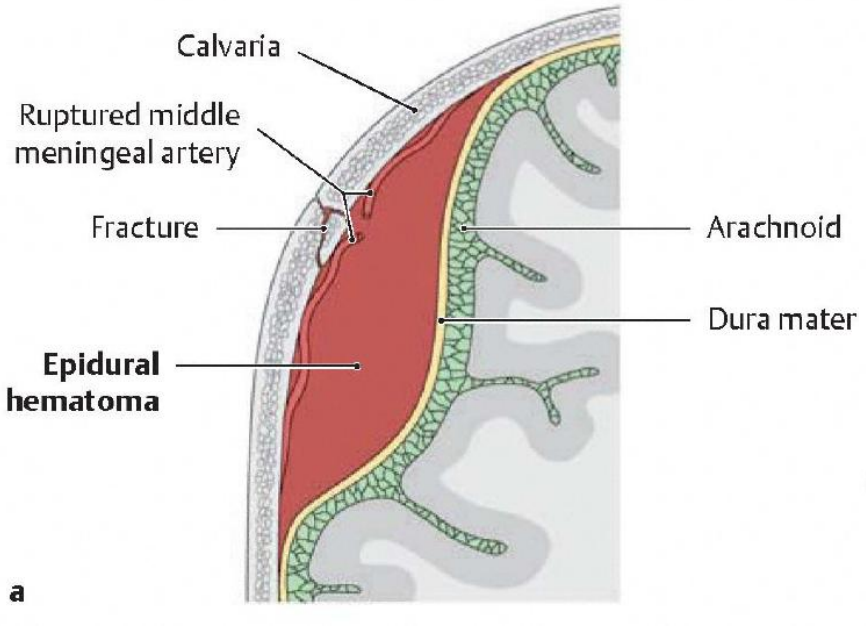
FRACTURE

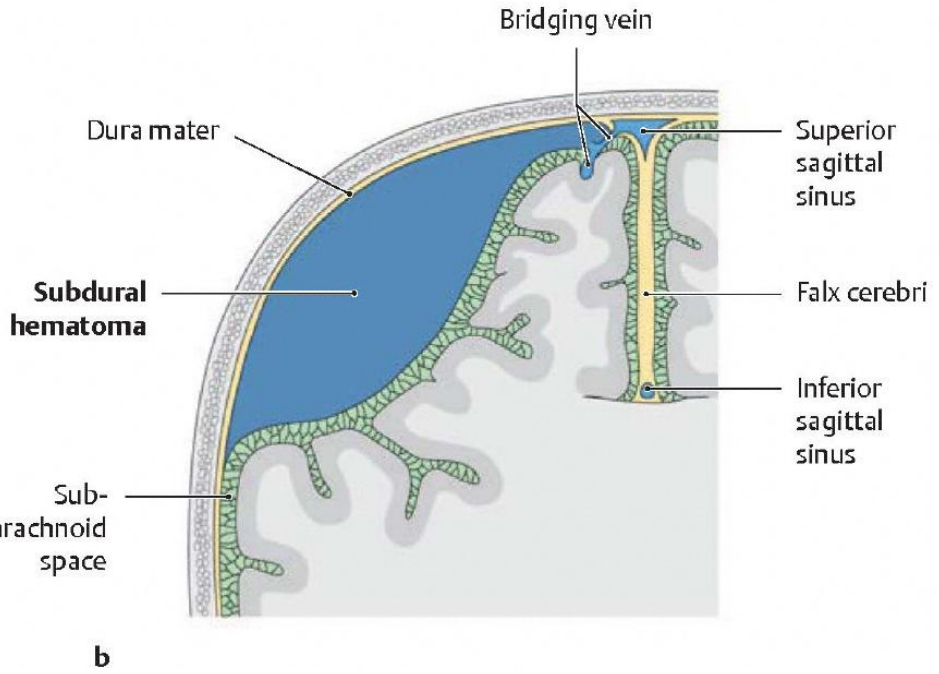
Meningeal arteries run in the epidural space

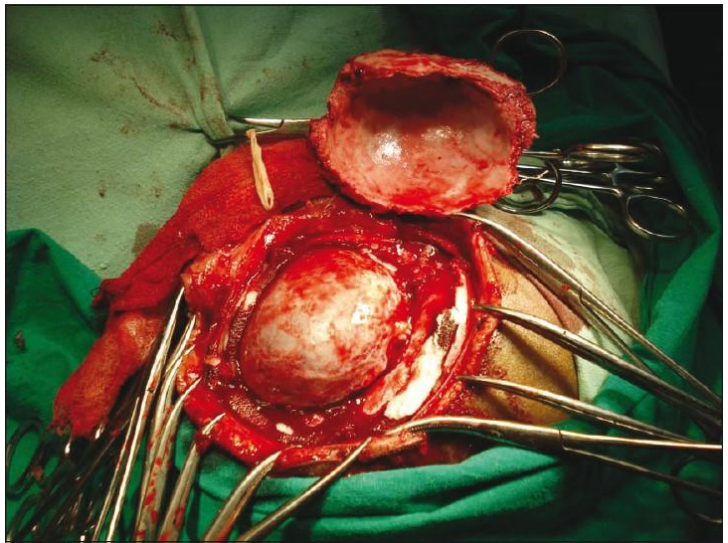


Drake: Gray's Anatomy for Students, 2nd Edition.

EXTRACEREBRAL HAEMORRHAGE

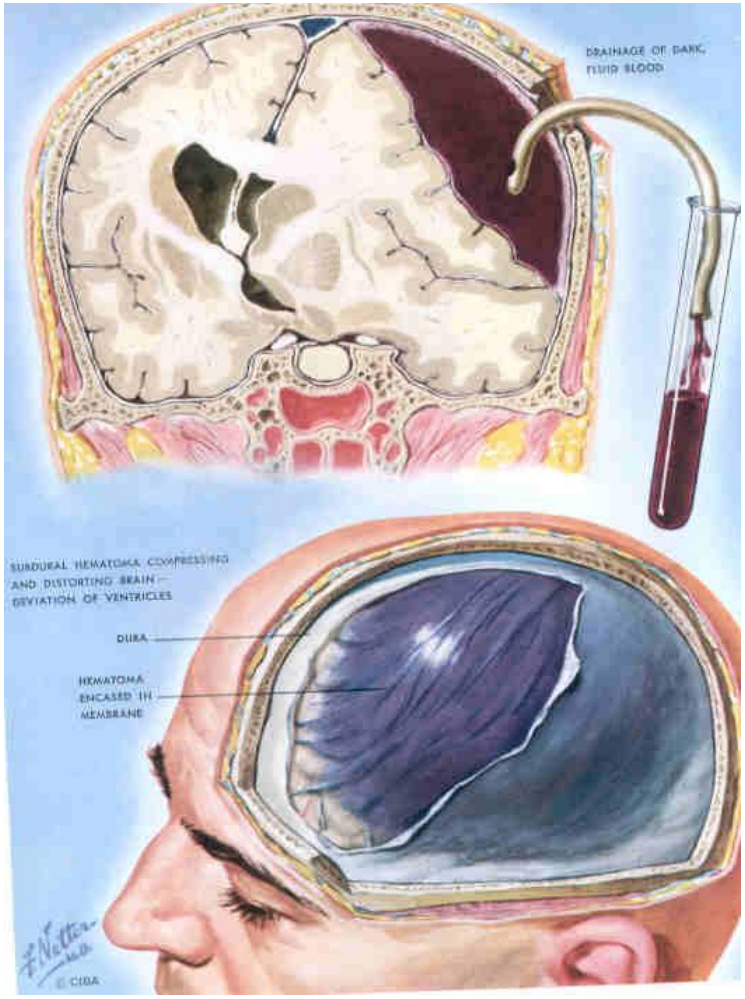






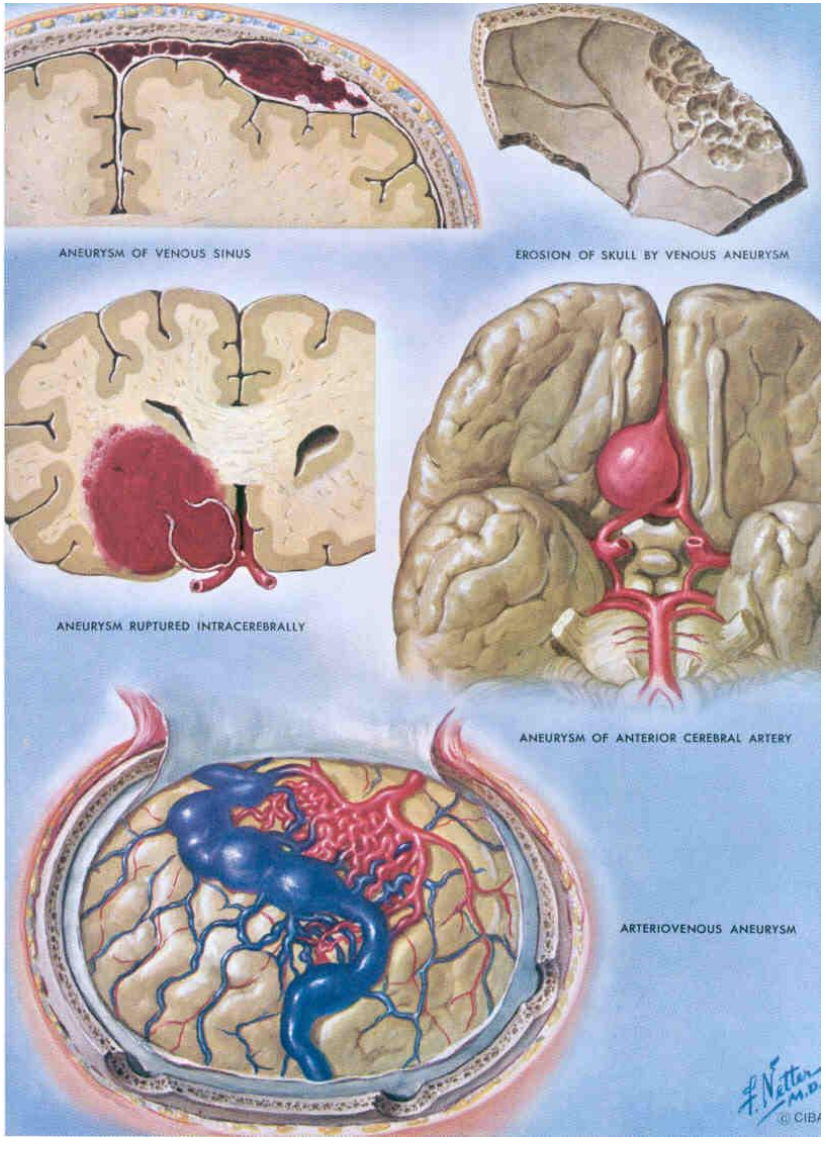
SUBDURAL HAEMORRHAGE

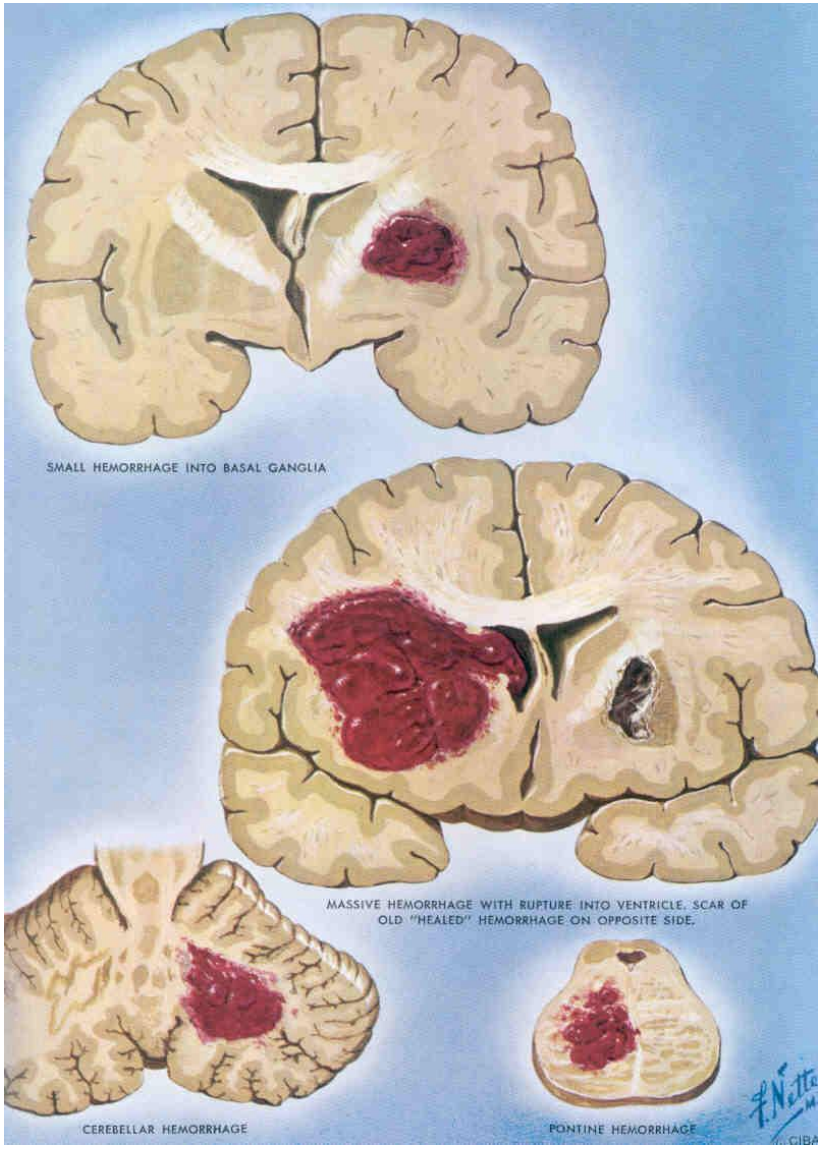
Compression of brain tissue



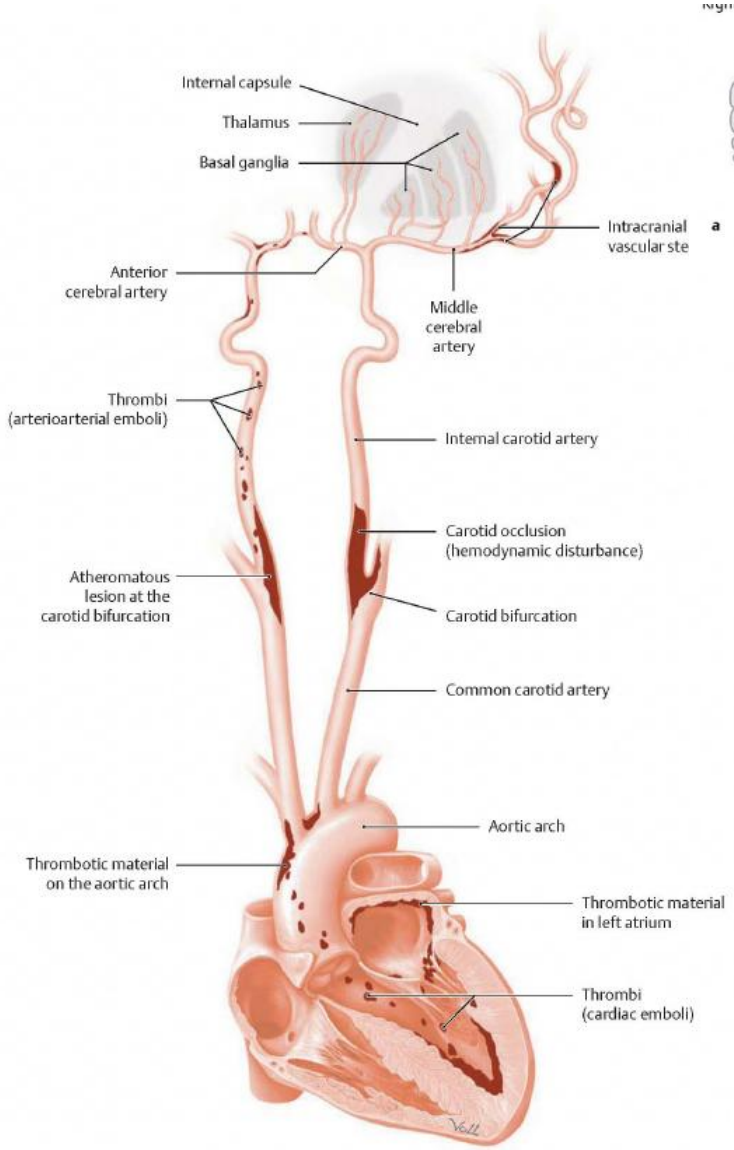
INTRACEREBRAL HAEMORRHAGE

Aneurysm or other vascular rupture





CEREBROVASCULAR /NEUROVASCULAR DISEASE



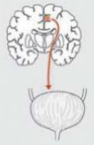
B Cerebral venous thrombosis
Coronal section, anterior view.

a Medial (right) and posterior (left) superior cerebral wein thrombosis.
b Right inferior cerebral vein thrombosis.
c Bilateral thrombosis of internal cerebral veins.

Illustrator: Markus Voll pp. 264-265

Schuenke et al. THIEME Atlas of Anatomy • Head and Neuroanatomy

Thieme

Vascular territory	Neurological symptoms	
Anterior cerebral artery	Hemiparesis (with or without hemisensory deficit) 	Bladder dysfunction 
Middle cerebral artery	Hemiparesis (with or without hemisensory deficit) mainly affecting the arm and face (Wernicke-Mann type) 	Aphasia 
Posterior cerebral artery	Hemisensory losses 	Hemianopia 

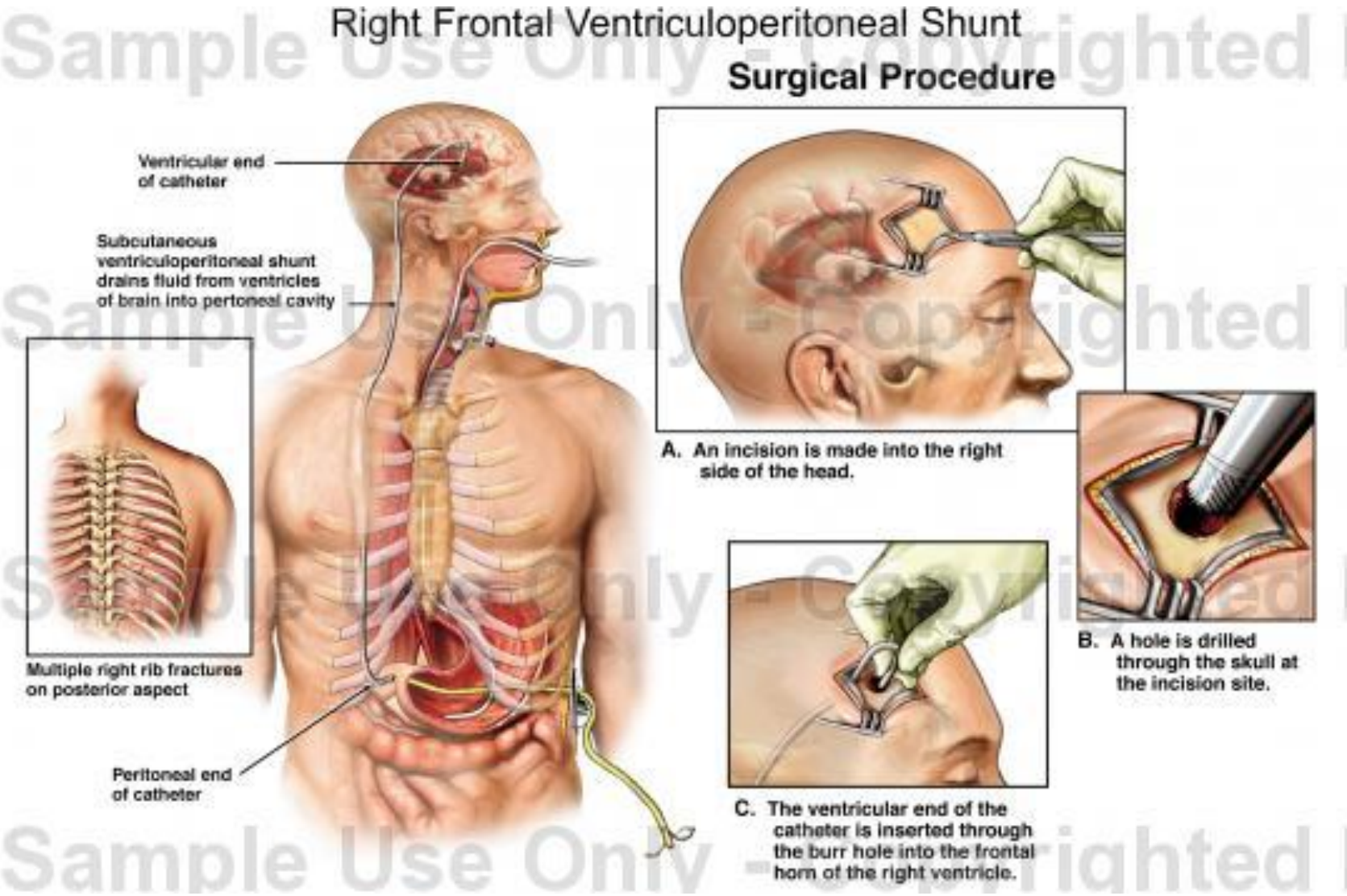
HYDROCEPHALUS

„STARCHILD”

The most common cause of hydrocephalus is CSF flow obstruction, hindering the free passage of cerebrospinal fluid through the ventricular system and subarachnoid space (e.g., stenosis of the cerebral aqueduct or obstruction of the interventricular foramina - foramina of Monro secondary to tumors, hemorrhages, infections or congenital malformations).
Hydrocephalus can also be caused by overproduction of cerebrospinal fluid (relative obstruction) (e.g., papilloma of choroid plexus).

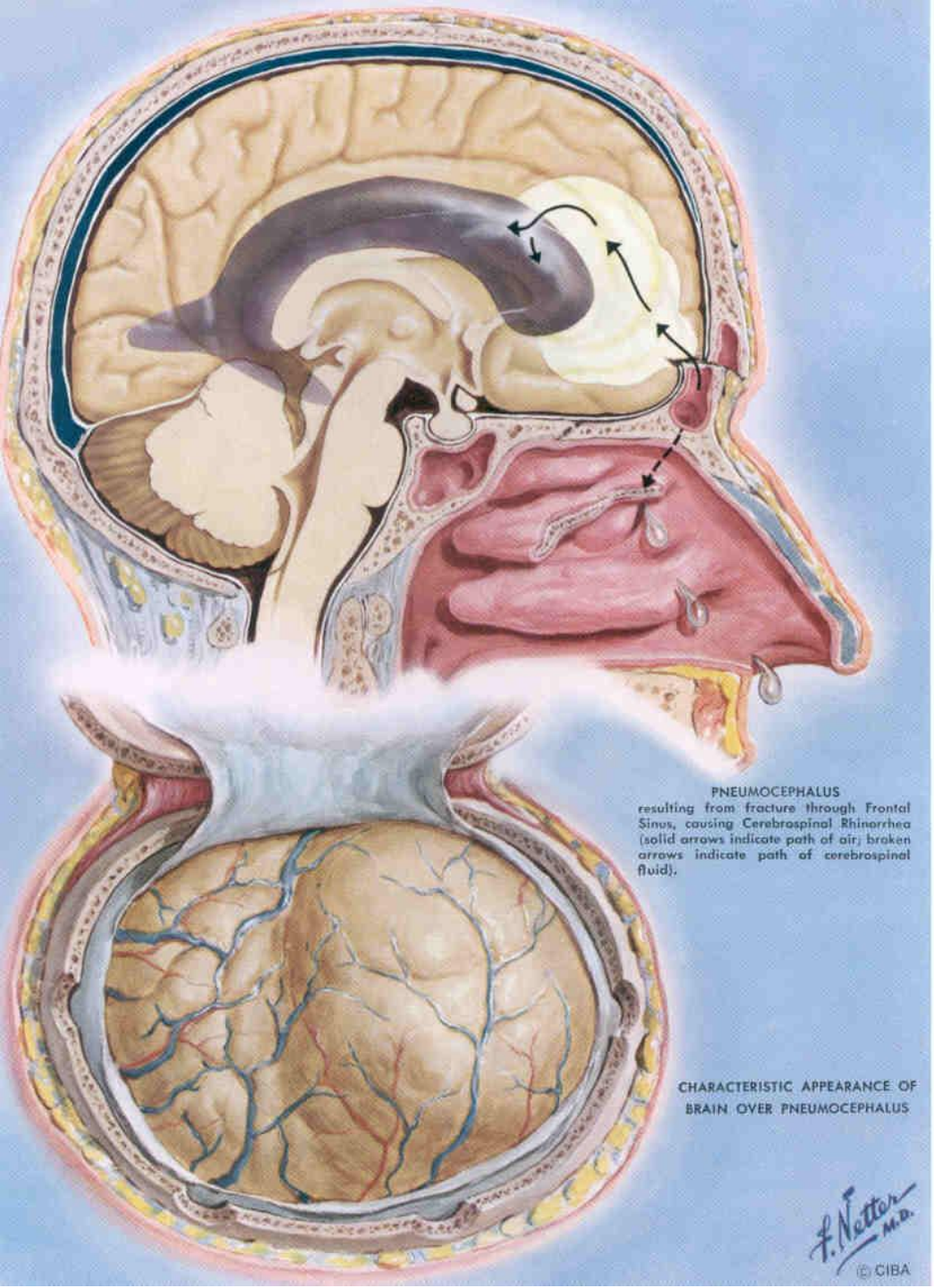
Symptoms of increased intracranial pressure may include headaches, vomiting, nausea, papilledema, sleepiness or coma. Elevated intracranial pressure may result in uncal and/or cerebellar tonsill herniation, with resulting life threatening brain stem compression.

HYDROCEPHALUS THERAPY



HEAD TRAUMA

CSF leakage



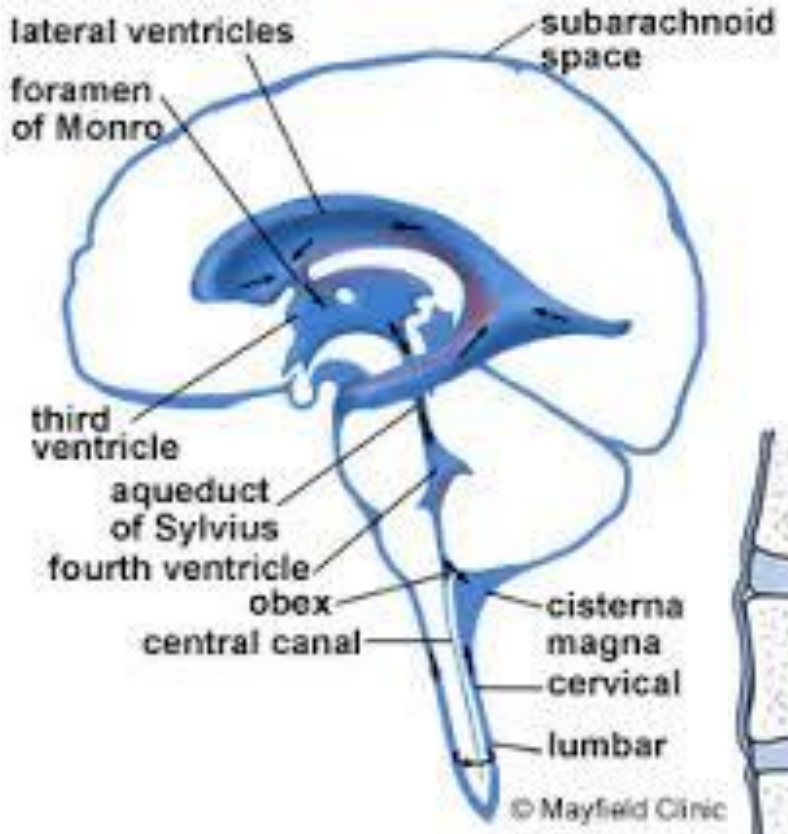
This one must to go around the world. I'll make sure of this ha ha. Loco PC 2002

THANK YOU FOR YOUR ATTENTION!

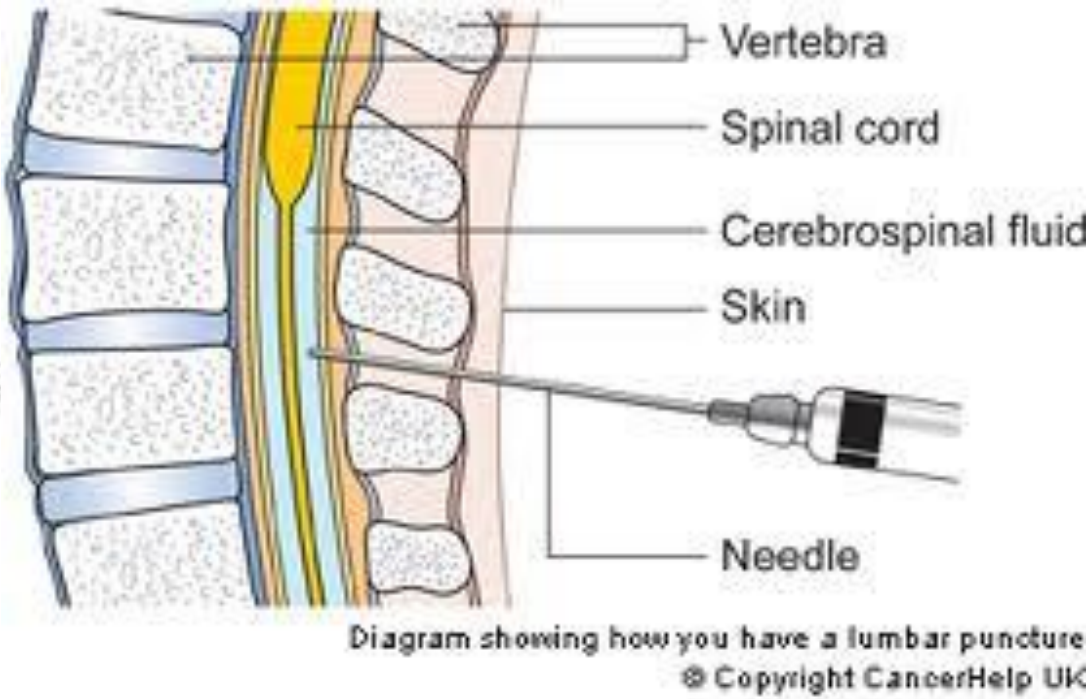
Acknowledgement, references

Dr M Kozsurek
Dr D Lendvai
Dr O Kántor

Liquor-terek és mintavétel



Lumbálpunkció helye: L3-L4 (-L5)



Fertőzések

virus
baktérium
egyéb, pl BSE