

Lecture:



Physiology of Brain Circulation & CSF Formation

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الرجاء تحويل الجوال إلى وضع
الصامت مع الشكر



Cerebral Blood Flow

- **Cerebral blood flow (CBF)** :is the blood supply to the brain in a given time.
- In an adult, CBF is typically **750 ml/min**.
- **50-54 ml** of blood per 100 g of brain tissue per min.
- **Ischemia** results if blood flow to the brain below **18-25 ml** per 100 g per min, and **tissue death** occurs if flow decreased below **8-10 ml** per 100 g per minute.

Cerebral Blood Flow

- The adult brain weight is about 1300 – 1500 g (**2% of Total Body Weight**).
- **Consumes:**
 - ✓ “15-20% O_2 ” of the total cardiac output.
 - ✓ 25% glucose
- Able to respond to variations in demand.

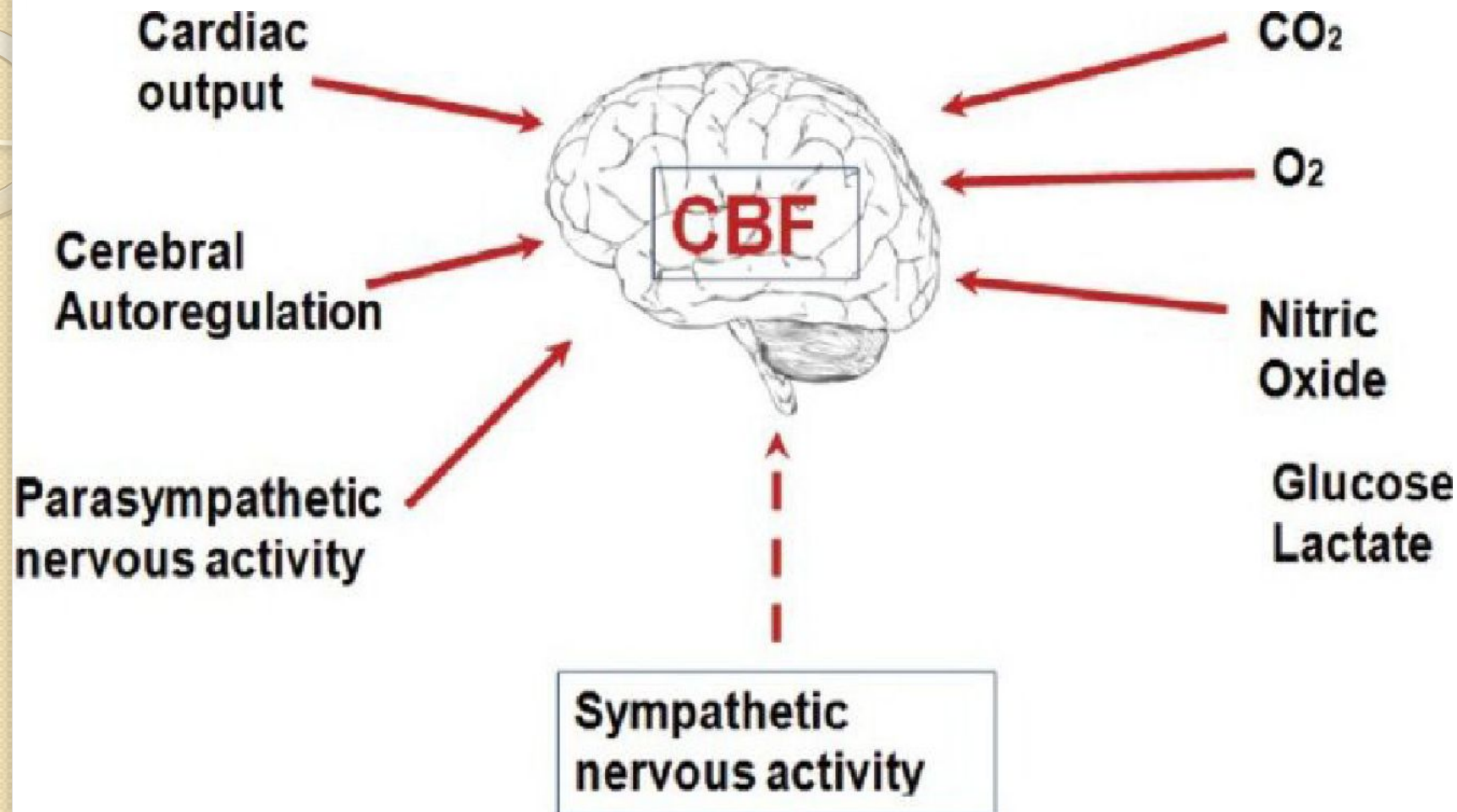
Brain Autoregulation

- The brain is very sensitive to **over and under perfusion**.
- **Cerebral autoregulation** refers to the physiological mechanisms that maintain blood flow at an appropriate level during changes in blood pressure.

□ Physiological Mechanisms of Autoregulation:

- **Myogenic/Arterial blood pressure.**
- **Chemical:**
 - ✓ Arterial partial pressure of carbon dioxide “**PaCO₂**”.
 - ✓ Arterial partial pressure of oxygen “**PaO₂**”.
- **Metabolic regulation.**
- **Neurogenic regulation.**

Factors Affecting Cerebral Blood Flow



Myogenic / Arterial Blood Pressure

- Arterioles **dilate or constrict** in response to changes in BP and ICP in order to maintain a constant CBF.
- The response to **lower pressure**, is arteriolar **dilation** in the brain.
- While when **blood pressure rises** they **constrict**.

Arterial Blood Pressure

- **Cerebral Perfusion Pressure (CPP)**

- **CPP** = MAP – ICP

MAP = Mean Arterial Pressure

ICP = Intra Cranial Pressure

- **ICP** – can be measured directly.

- **MAP:** pushes blood into the brain.

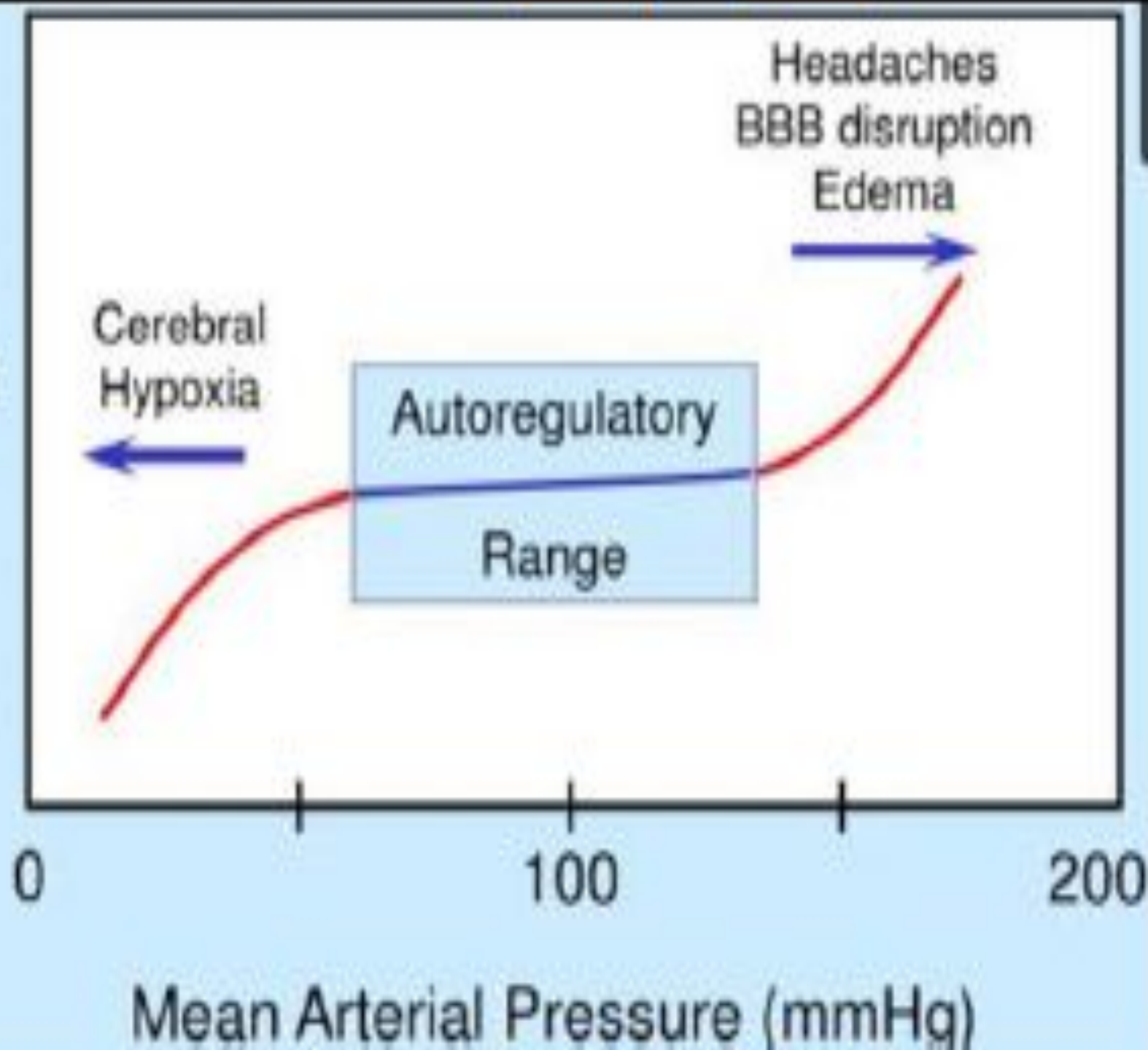
- Intracranial Pressure (**ICP**).

- **MAP** = Diastolic pressure + 1/3 Pulse pressure.

- **Pulse pressure** = Systolic BP – Diastolic BP.

- Eg. BP = 140/80, **MAP** = 80 + 20 = 100 mmHg

Cerebral
Blood
Flow

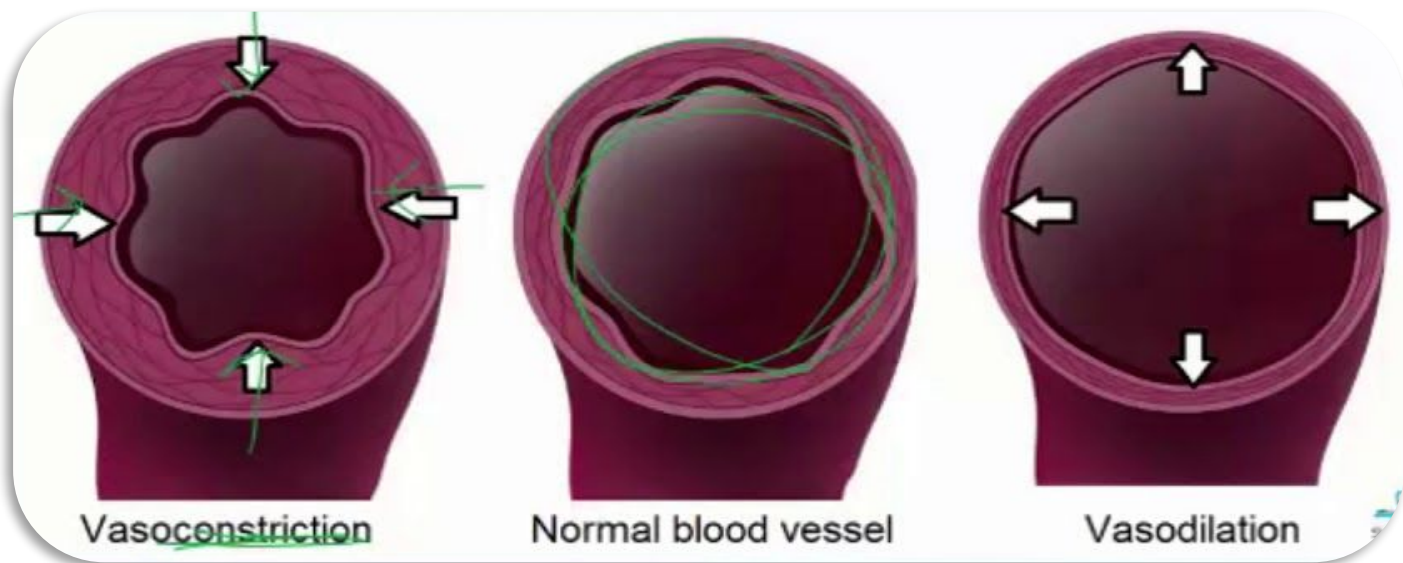


Cerebral Blood Flow

- **CBF**= Cerebral perfusion pressure (**CPP**) divided by the cerebrovascular resistance (**CVR**).
- **CBF** = **CPP / CVR**
- **CPP** = MAP – ICP
- **CPP** = is normally between 70 - 90 mmHg in an adult human.
- **Increase in ICP** → decreases CBF & cerebral perfusion.

Chemical Autoregulation

- **Elevation of PaCO_2** , leads to vasodilatation “High ICP”.
- **Depression of PaCO_2** , leads to vasoconstriction.
- **Elevation of PaO_2** , leads to vasoconstriction
“Hyperventilation used for management of brain oedema”.
- **Depression of PaO_2** , “**Hypoxia**”: leads to vasodilatation
“High ICP”.



Arterial Blood Pressure Autoregulation

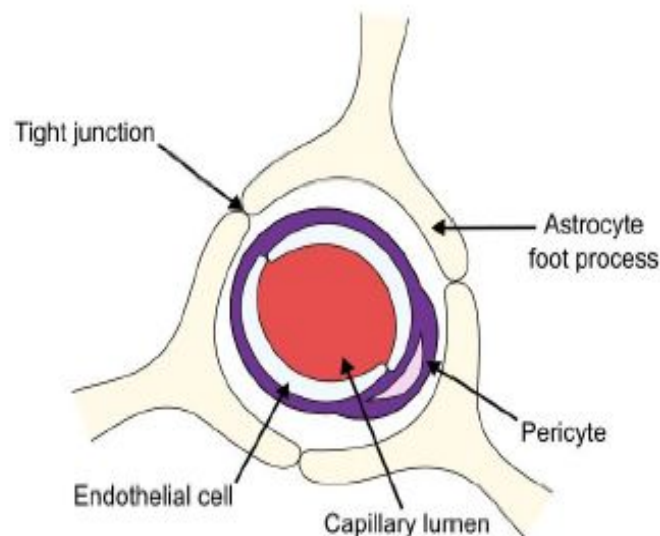
- **Baseline CBF:** 50 54 ml/100g/min
- **Critical ischemic threshold:** 20 –25 ml/100g/min
- **Severe Hypertension:**
 - Damage to blood brain barrier.
 - Risk of **cerebral oedema and acute hypertensive encephalomalacia** due to vasodilation.

Neurogenic Autoregulation

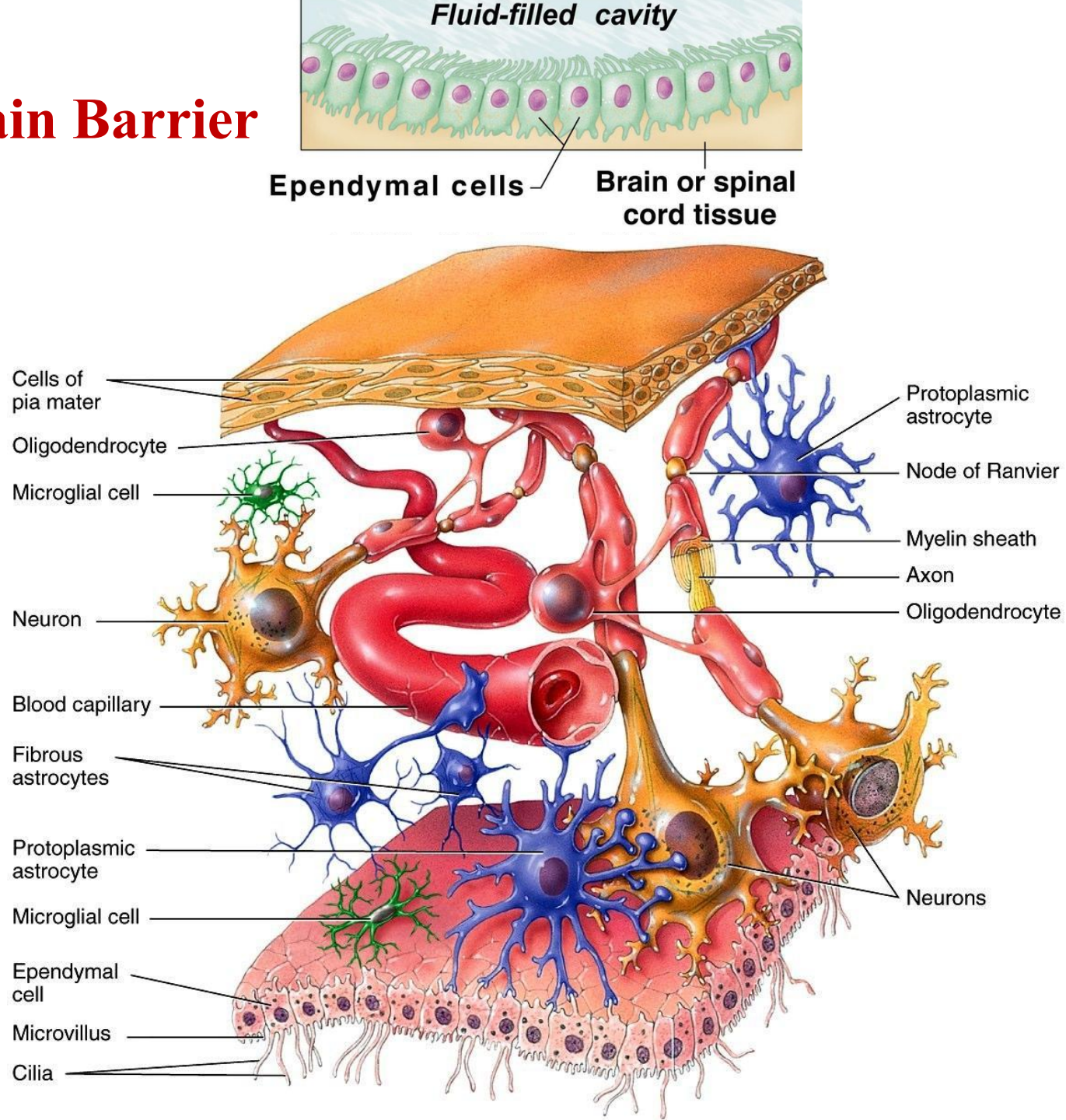
- **Neurogenic Autoregulation:**
 - **Sympathetic fibres:** vasoconstriction
 - **Parasympathetic fibres:** vasodilatation

The Blood–Brain Barrier

- It is the barrier between cerebral capillary blood, the CSF and brain tissue.
- CSF fills the ventricles and the subarachnoid space.
- It consists of the **endothelial cells of the cerebral capillaries** and the **choroid plexus epithelium**.

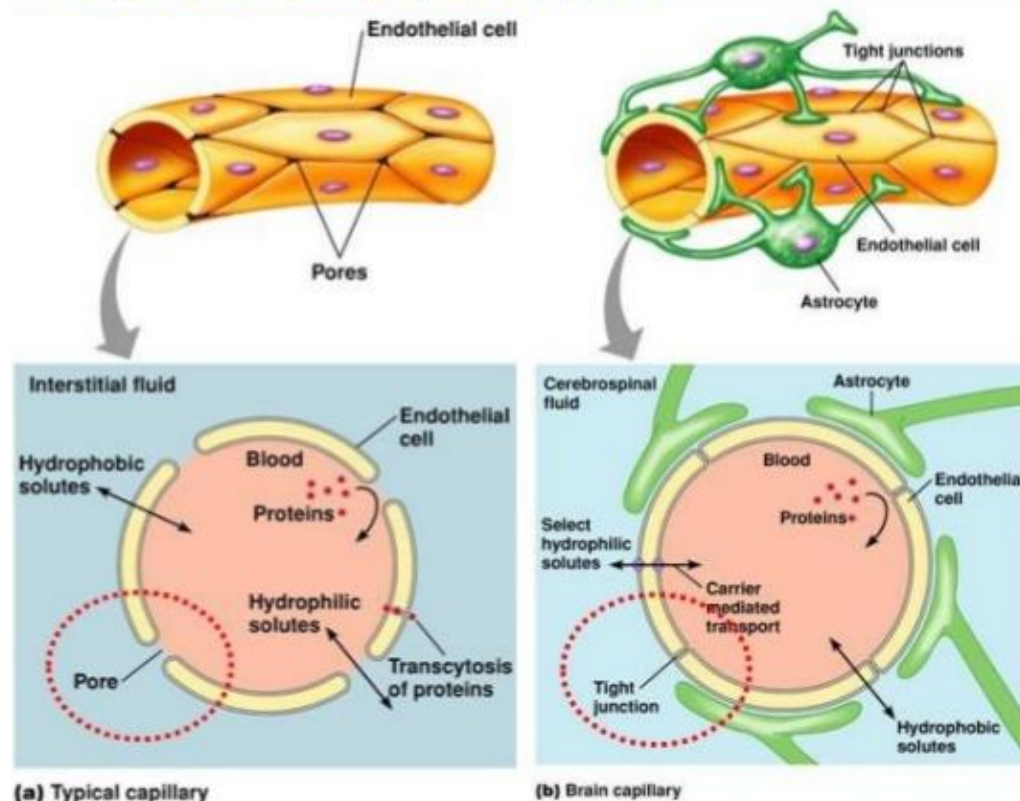


Blood-Brain Barrier



Blood-Brain Barrier

Can Pass	Cannot Pass
<ul style="list-style-type: none">• Glucose (via transport proteins).• Lipid-soluble substances.• O₂, CO₂, alcohol, anesthetics.	<ul style="list-style-type: none">• Large molecules ex. Proteins.• Most antibiotic drugs.
Trauma, inflammation and certain toxins can break down the BBB	



Functions of the Blood–Brain Barrier

- 1. It maintains a constant environment for neurons** in the CNS and protects the brain from endogenous or exogenous toxins.
- 2. It prevents the escape of neurotransmitters** from their functional sites in the CNS into the general circulation.
- 3. Drugs penetrate the blood.**

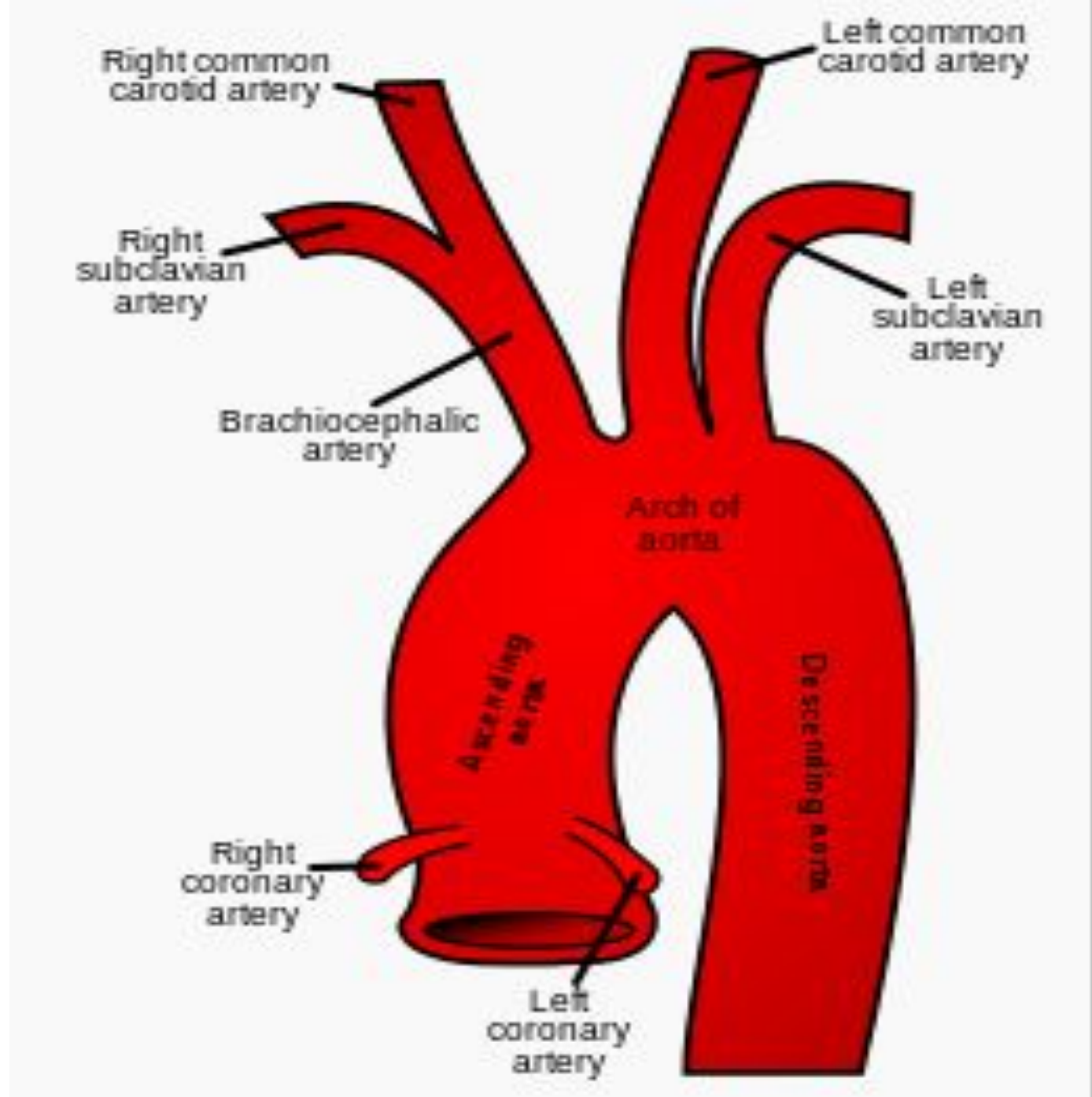
Development of BBB

- Premature infants with hyperbilirubinemia, free bilirubin pass BBB, and may stain basal nuclei causing damage (**Kernicterus**).

Blood Supply of the Brain

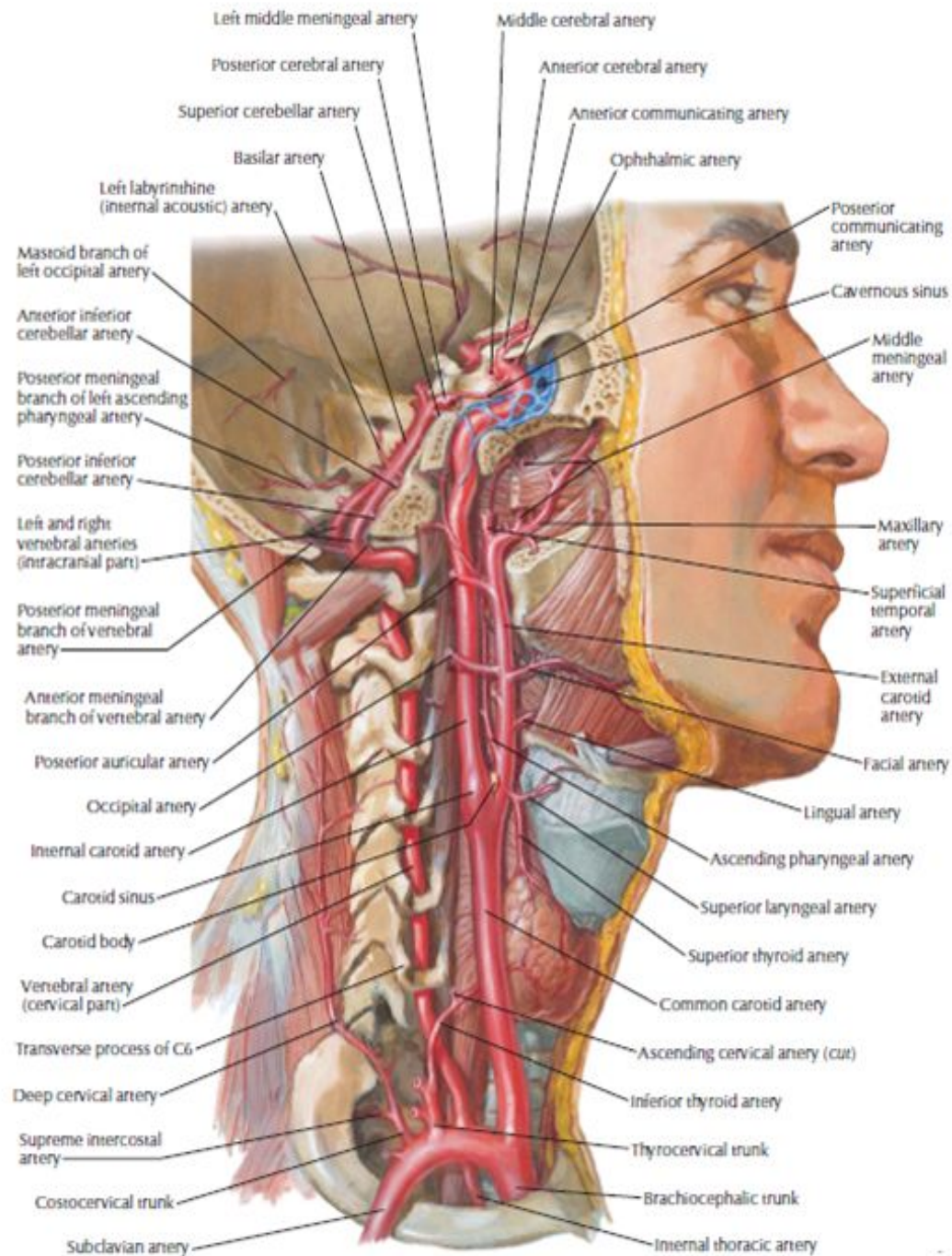
Brain blood supply formed of two main systems (arteries):

- 1. Internal carotid system:** Right & Left internal carotid arteries (ICA).
- 2. Vertebro-basilar system:** Right & Left vertebral arteries (VA).



I. The Internal Carotid Artery (ICA)

- ❖ **Origin:** arises in the neck of terminal branches of the CCA (**at Bifurcation**), at the level of the upper border of the thyroid cartilage (**opposite the disc between C₃ & C₄**).
- ❖ **Function:** the ICA supplies structures in the orbit and a large part of the brain (**70- 80% of the brain blood supply**).
 - Each ICA enters the skull through **the carotid foramen**.
 - It gives **No branches** at the neck.



Branches of the Internal Carotid Artery

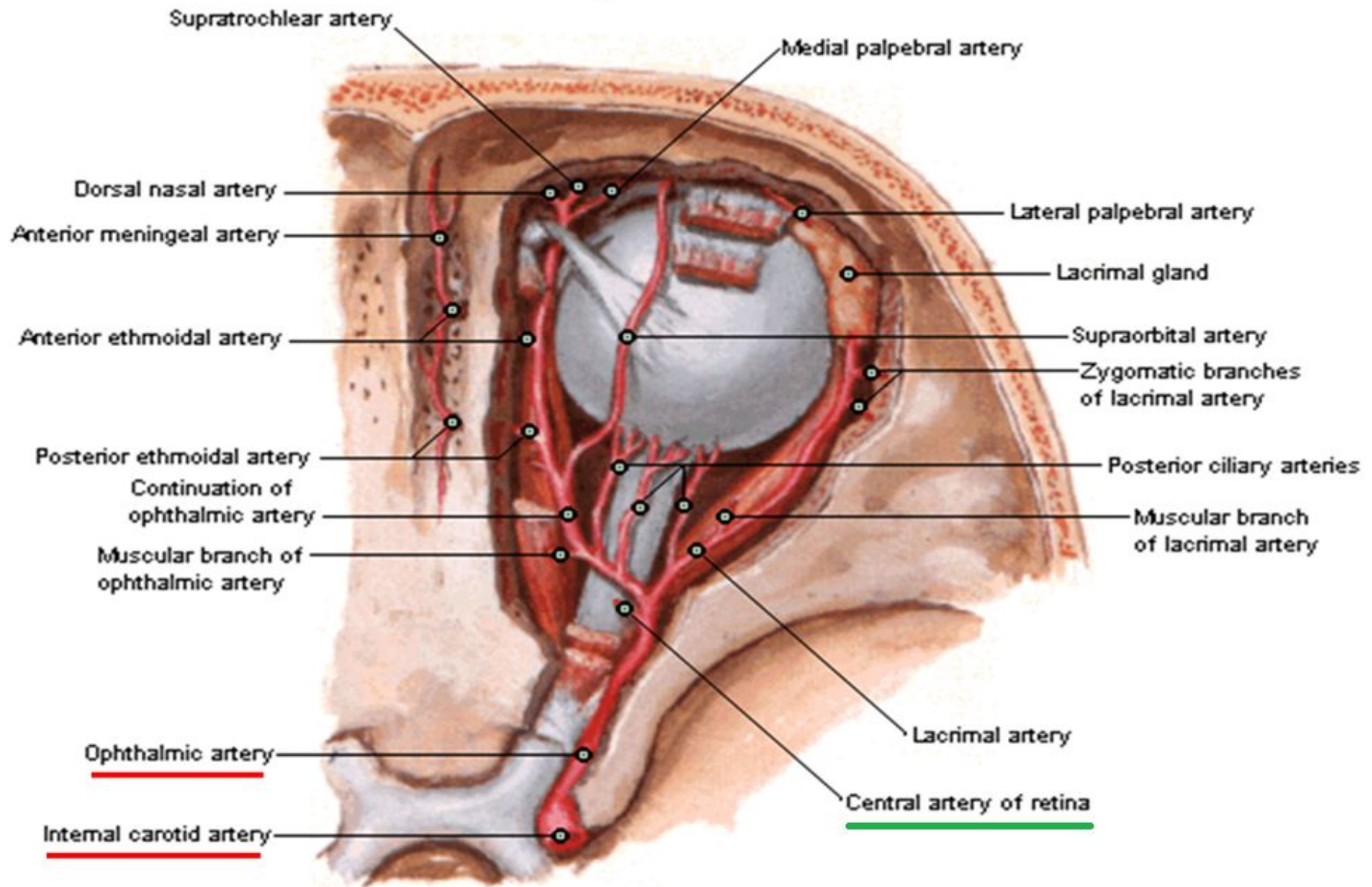
- 1. Ophthalmic artery.**
- 2. Posterior communicating artery.**
- 3. Anterior choroidal artery.**
- 4. Anterior cerebral artery (ACA).**
- 5. Middle cerebral artery (MCA).**

Ophthalmic Artery .1

- **Ophthalmic artery** which enters the orbit through the optic canal with the optic nerve.
- **Supplies** the eye, orbit contents & gives **central retinal artery**.
- **Also supplies** the frontal sinuses, part of frontal area of scalp and dorsal part of nose.
- Its occlusion results in **Ipsilateral Blindness**.

Arteries and Veins of Orbit and Eyelids

Superior View



Posterior Communicating Artery .2

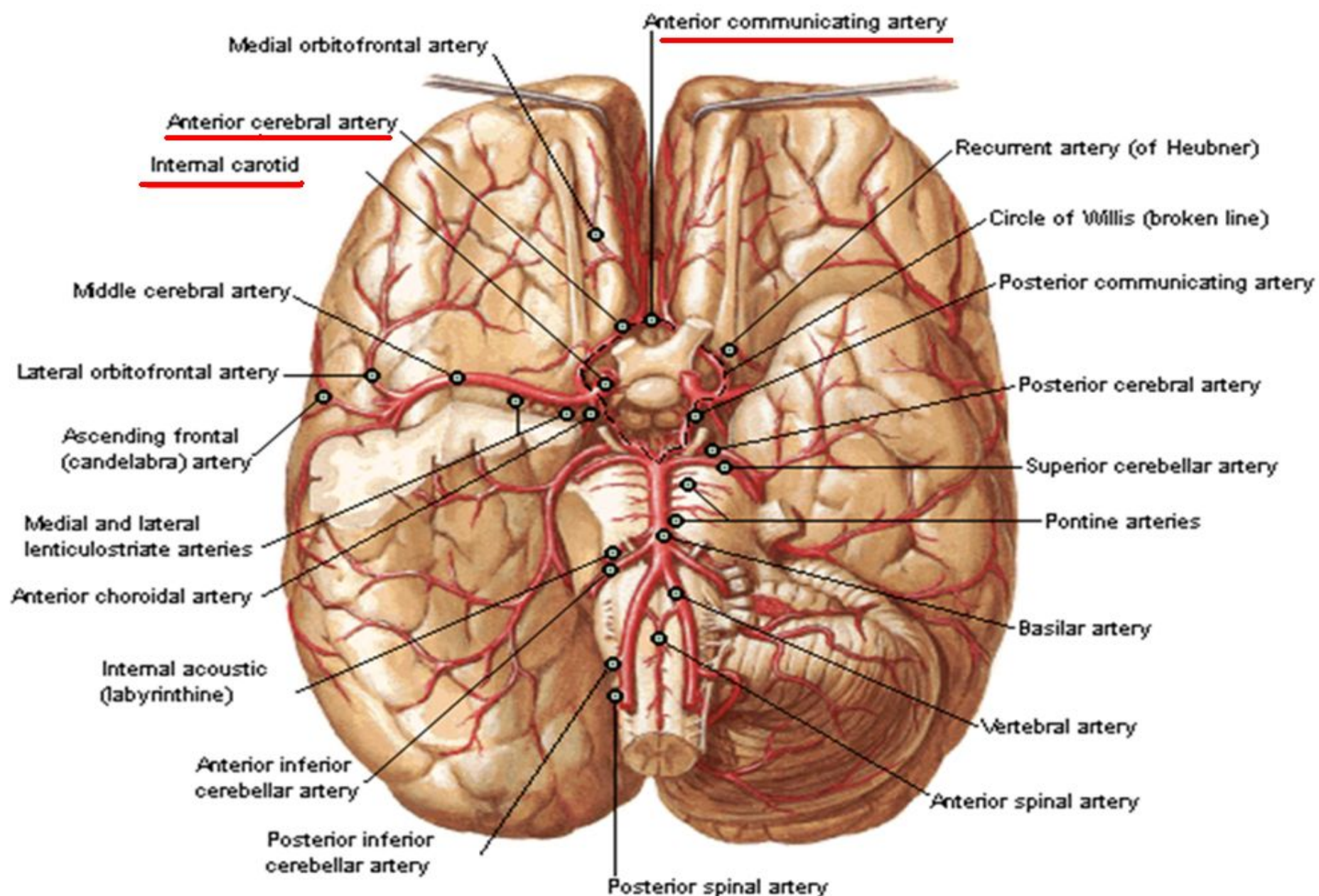
□ The posterior communicating artery joins the **ICA** with the corresponding **posterior cerebral artery** to establish the circle of Willis.

□ It supplies:

- Optic tract and chiasma.
- Part of diencephalon.
- Walls of third ventricle.
- A common site of **Aneurysms.**

Arteries of Brain

Inferior View



3. Anterior Choroidal Artery

□ **Origin:** from the ICA just before origin of the anterior & middle cerebral arteries.

□ **It supplies:**

- Choroid plexus of the lateral and third ventricles.
- Optic tract and optic chiasma.
- Hippocampus, tail of caudate nucleus, amygdaloid nucleus, globus pallidus and crus cerebri. .
- Lateral geniculate body.
- Posterior limb of internal capsule.

Arteries of Brain [Continued]

Inferior View

Anterior communicating artery

Recurrent artery (of Heubner)

Anterior cerebral artery

Posterior communicating artery

Middle cerebral artery

Anterior choroidal artery

Optic tract

Posterior cerebral artery

Lateral geniculate body

Posterior lateral choroidal artery

Cerebral peduncle

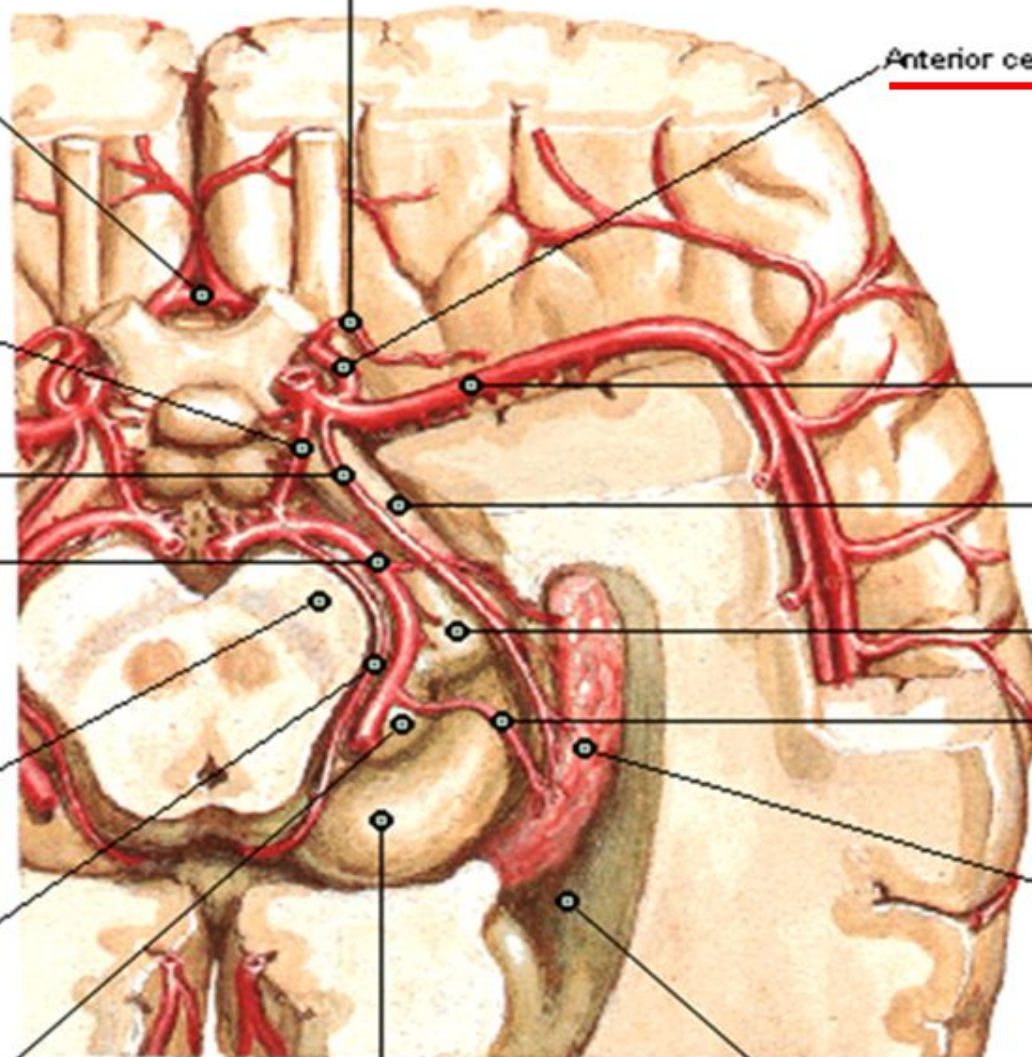
Choroid plexus of lateral ventricle

Posterior medial choroidal artery

Medial geniculate body

Lateral ventricle

Pulvinar of thalamus



4. Anterior Cerebral Artery (ACA)

- It is the smaller terminal branch of the ICA.
- It runs forward and joins the ACA of the opposite side by the **anterior communicating artery (the commonest site of Aneurysms)**.

□ Branches of the ACA:

1. Cortical branches.
2. Central branches (Striate arteries).

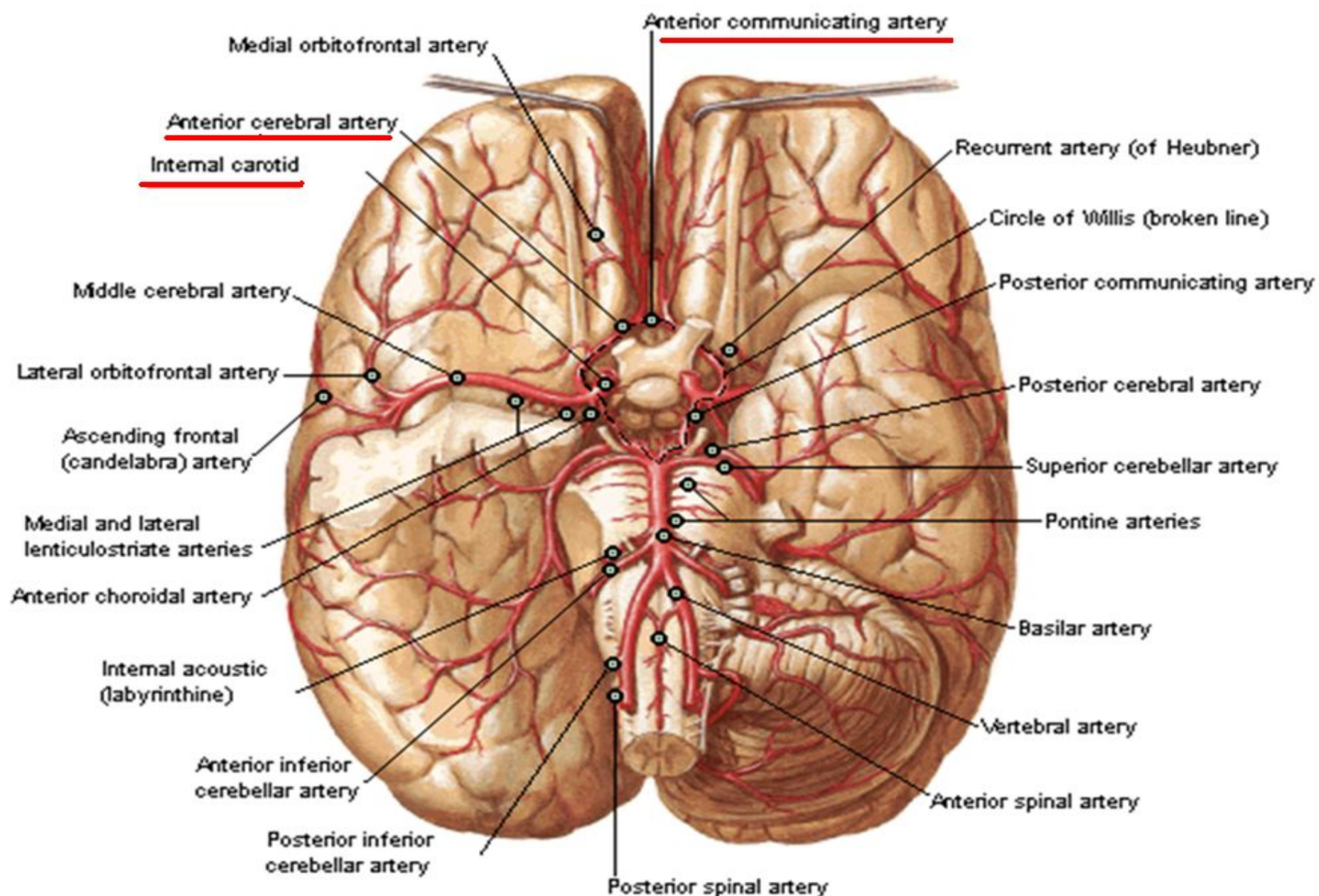
Territory of Anterior Cerebral Artery (ACA)

- Medial surface of the cerebral hemisphere from frontal pole to the parieto-occipital sulcus.
- Medial 1/3 of the orbital surface of the frontal lobe.
- Superior lateral surface of cerebral hemisphere (**except occipital lobe**).
- Anterior part of lentiform nucleus.
- Head of caudate nucleus.
- Supplies part of the corpus striatum and the anterior limb of the internal capsule via the **medial striate artery (of Heubner)**.

N.B.: The ACA supplies motor and sensory areas of the leg and foot “paracentral lobule”.

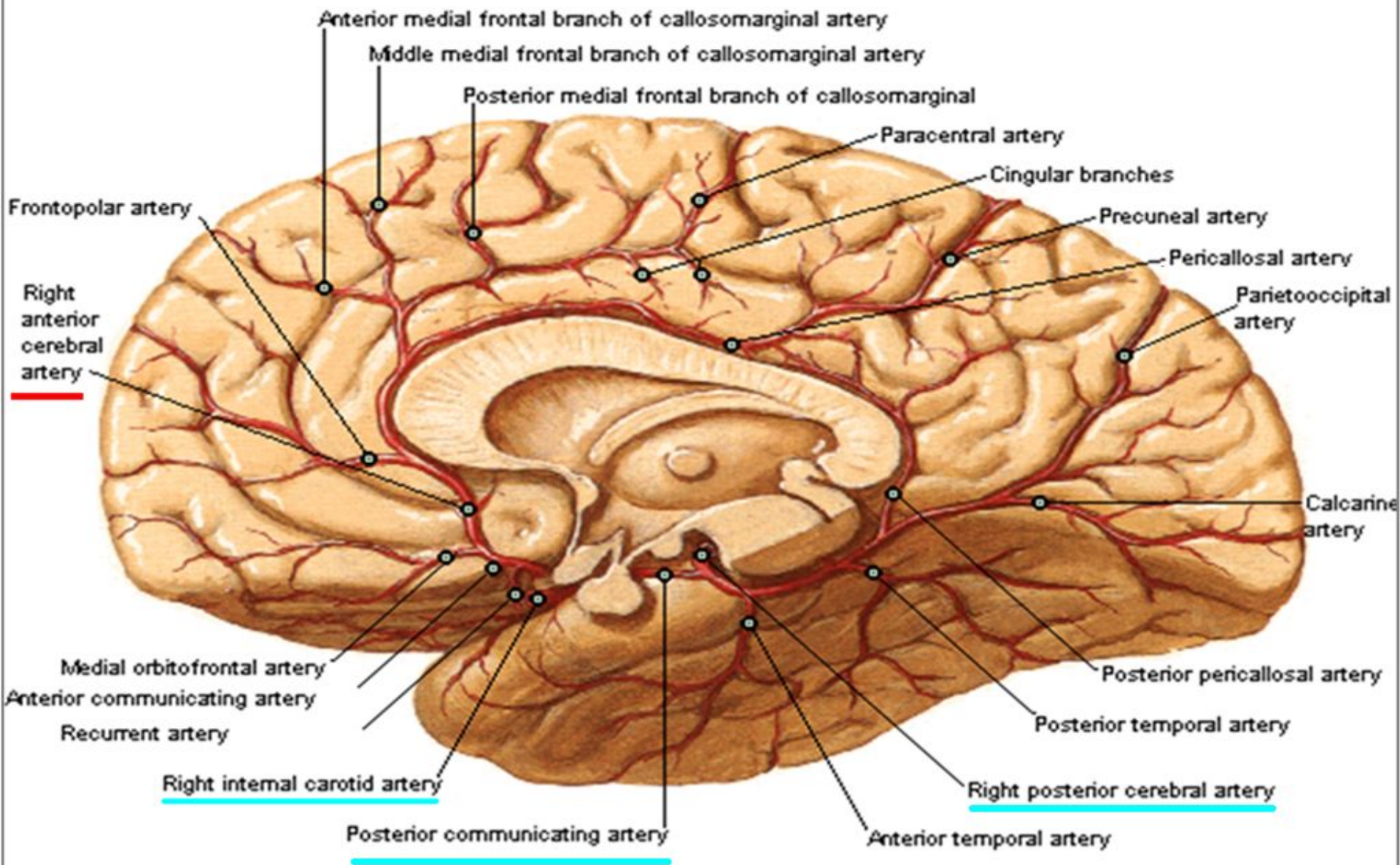
Arteries of Brain

Inferior View



Arteries of Brain

Medial View

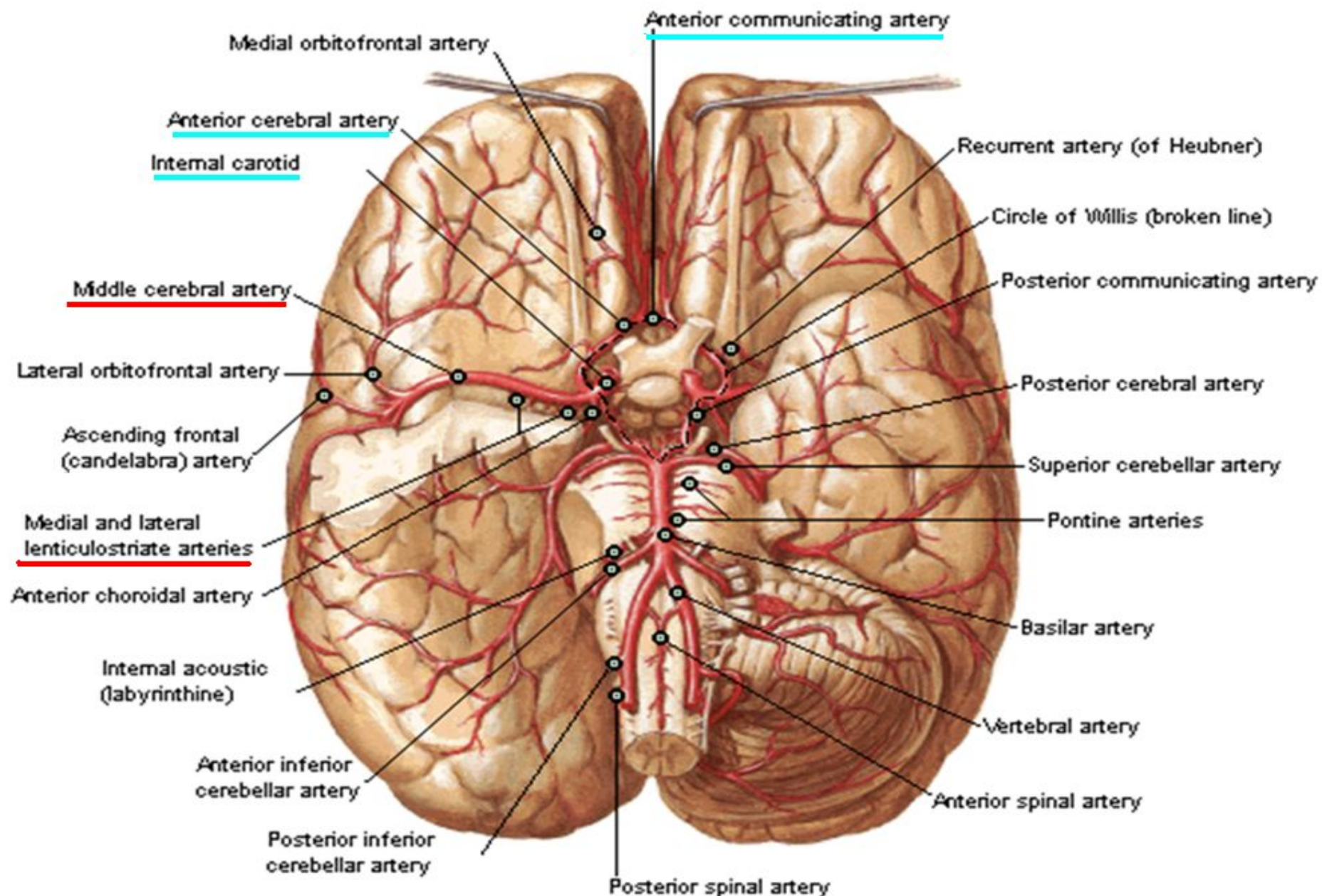


Middle Cerebral Artery (MCA) .5

- ❖ The lateral branch as the **largest of the 2 terminal branches** of ICA.
- ❖ It pass laterally in the stem of **the lateral sulcus**.
- ❖ It turns backwards and upwards in the posterior ramus of the lateral sulcus.
- ❖ Finally it divides into:
 - **Cortical branches.**
 - **Central branches.**

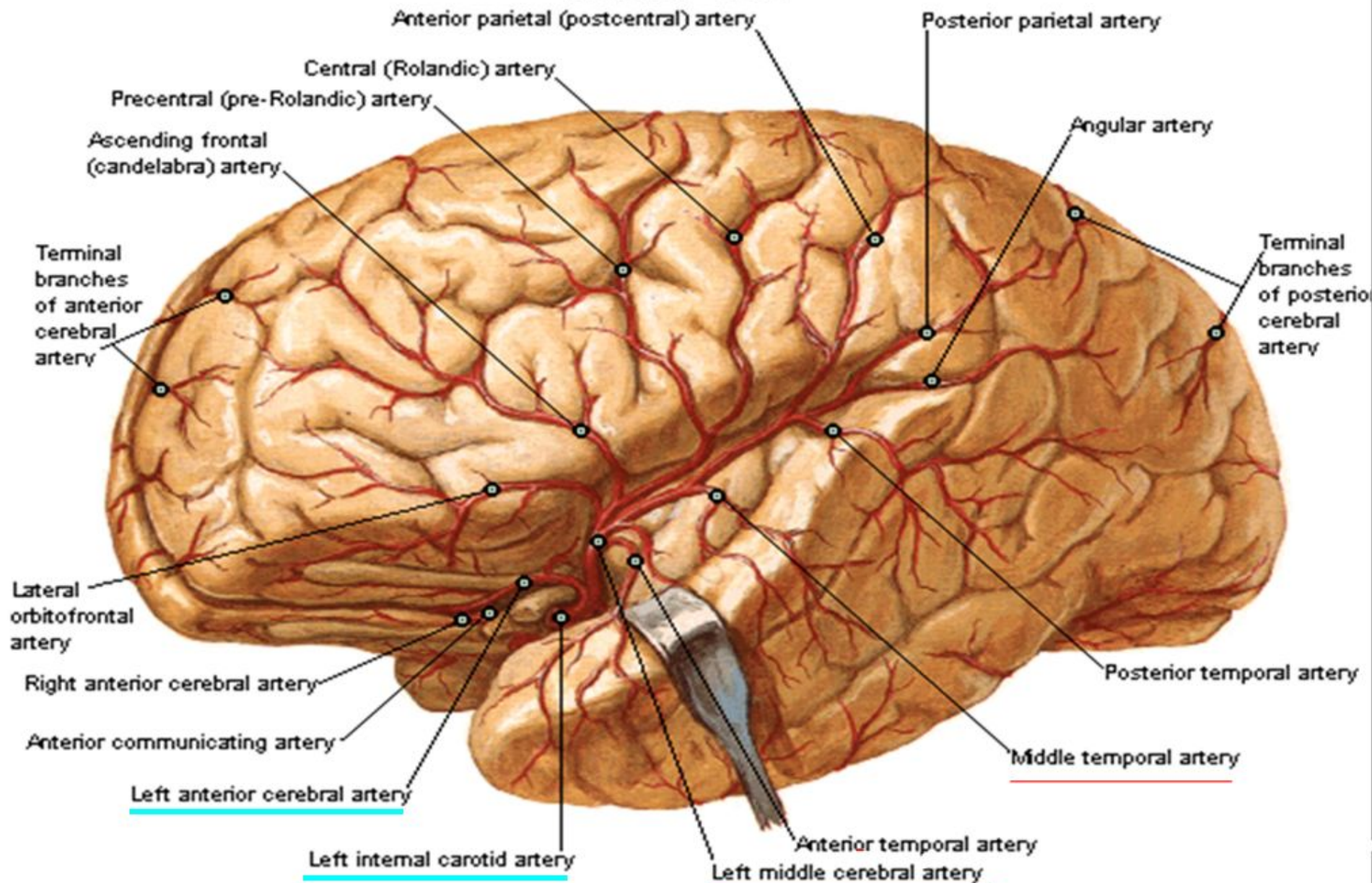
Arteries of Brain

Inferior View



Arteries of Brain

Lateral View



Territory of Middle Cerebral Artery (MCA)

1. Cortical branches: **supply:**

- Lateral 2/3 of the orbital part of frontal lobe.
- Temporal pole and insula.
- Most of the lateral surface of cerebral hemisphere

Except:

- **The upper part (superior inch):** supplied by the **ACA**.
- **Lower part of temporal lobe:** supplied by the **PCA**.
- **Occipital lobe:** supplied by the **PCA**.
- **Supplies the trunk, arm, and face areas of the cortical motor and sensory areas.**

2. Central Branches: are many branches called **striate arteries:**

a. Medial striate arteries: supply:

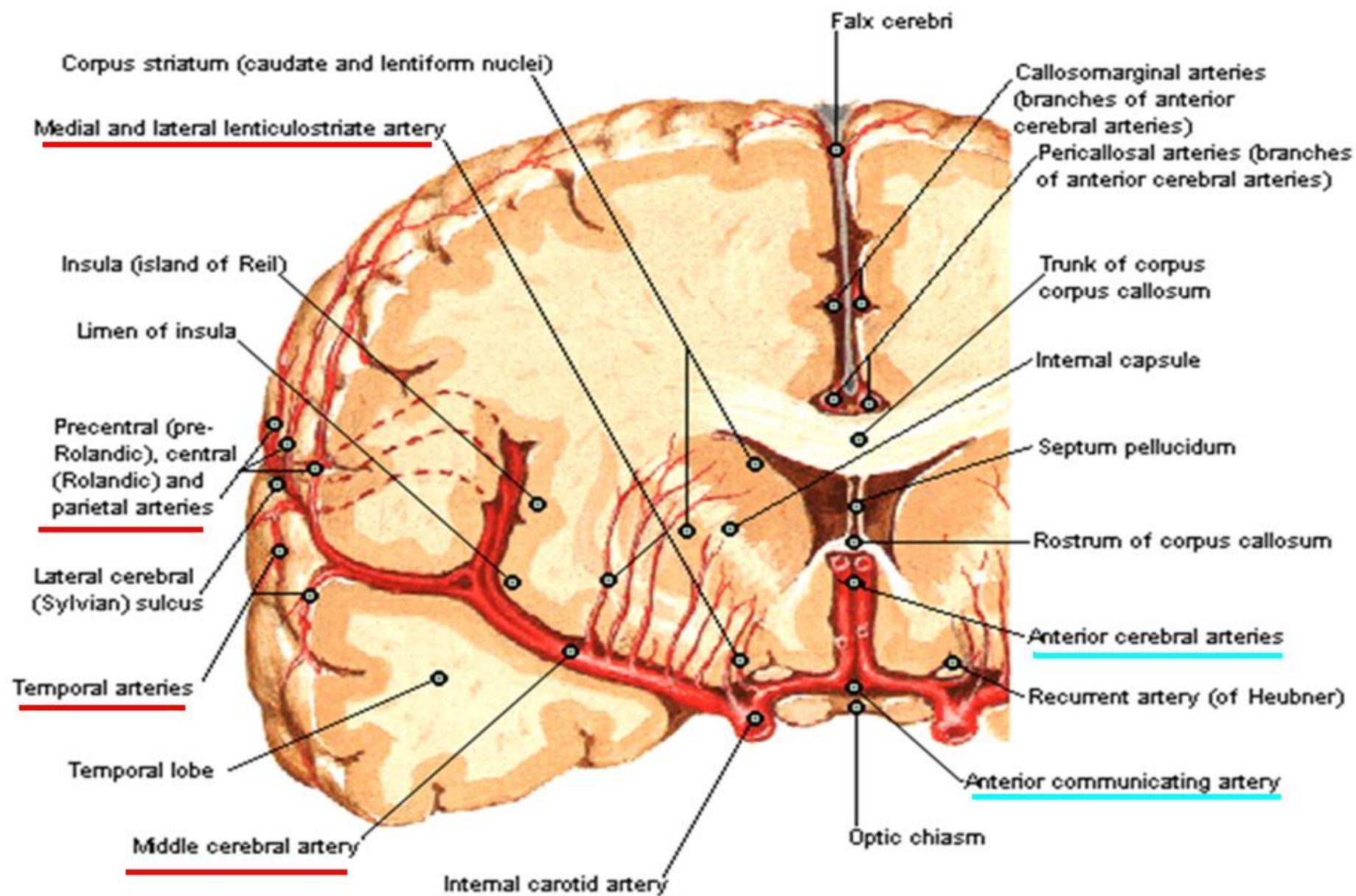
- Posterior part of lentiform nucleus.
- Body of caudate nucleus.
- The most of the internal capsule (posterior limb, genu, and posterior part of anterior limb).

b. Lateral striate arteries: supply:

- Corpus striatum (lentiform & caudate).
- Most of the internal capsule.
- One of these arteries is large and is liable to hemorrhage it is called **the artery of cerebral hemorrhage (Charcot's artery).**

Arteries of Brain

Frontal Section



II. The Vertebrobasilar System

A. Vertebral Artery

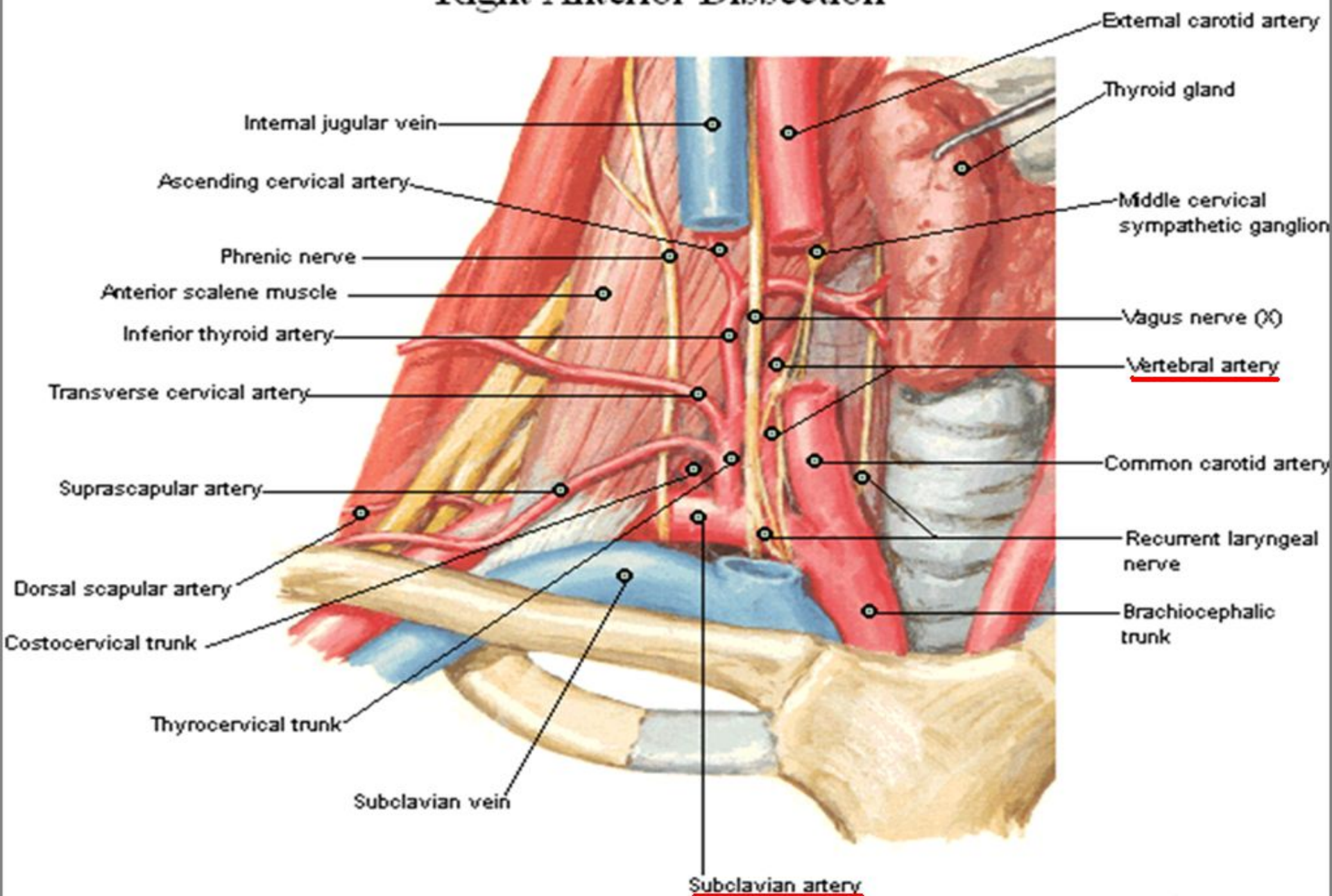
- **Origin:** each vertebral artery arises from the **first part of subclavian artery**.
- Supplies structures of the brain (**20- 30% of the brain blood supply**).

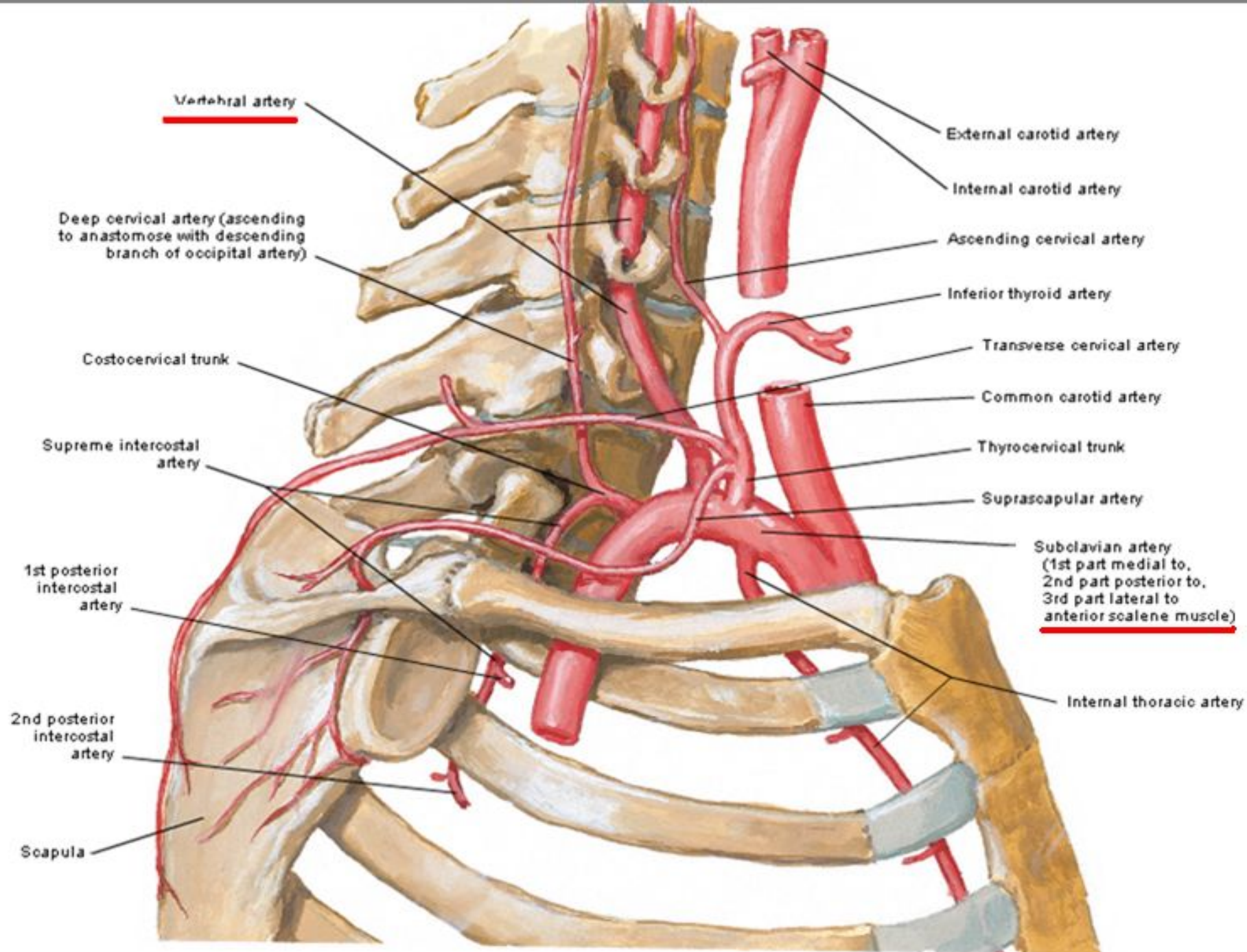
- **Course:**

From subclavian artery → then passes upwards through the transverse foramina of the upper 6 cervical vertebrae → foramen magnum → they pass upward and medially in front of the medulla oblongata → at the lower border of pons two vertebral arteries unite to form the single **Basilar Artery**.

Subclavian Artery

Right Anterior Dissection





Branches of the Vertebral Artery

1. **The meningeal branches:** are small and supply the bone and dura in the posterior cranial fossa.
2. **Posterior spinal arteries:** may arise from **the posterior inferior cerebellar artery.**
3. **Anterior spinal artery:** it unites with the other one to form the one anterior spinal artery.
4. **Medullary branches:** supply the ventral part of medulla oblongata.
5. **Posterior inferior cerebellar artery.**

Posterior Inferior Cerebellar Artery (PICA)

❑ The largest branch of vertebral artery.

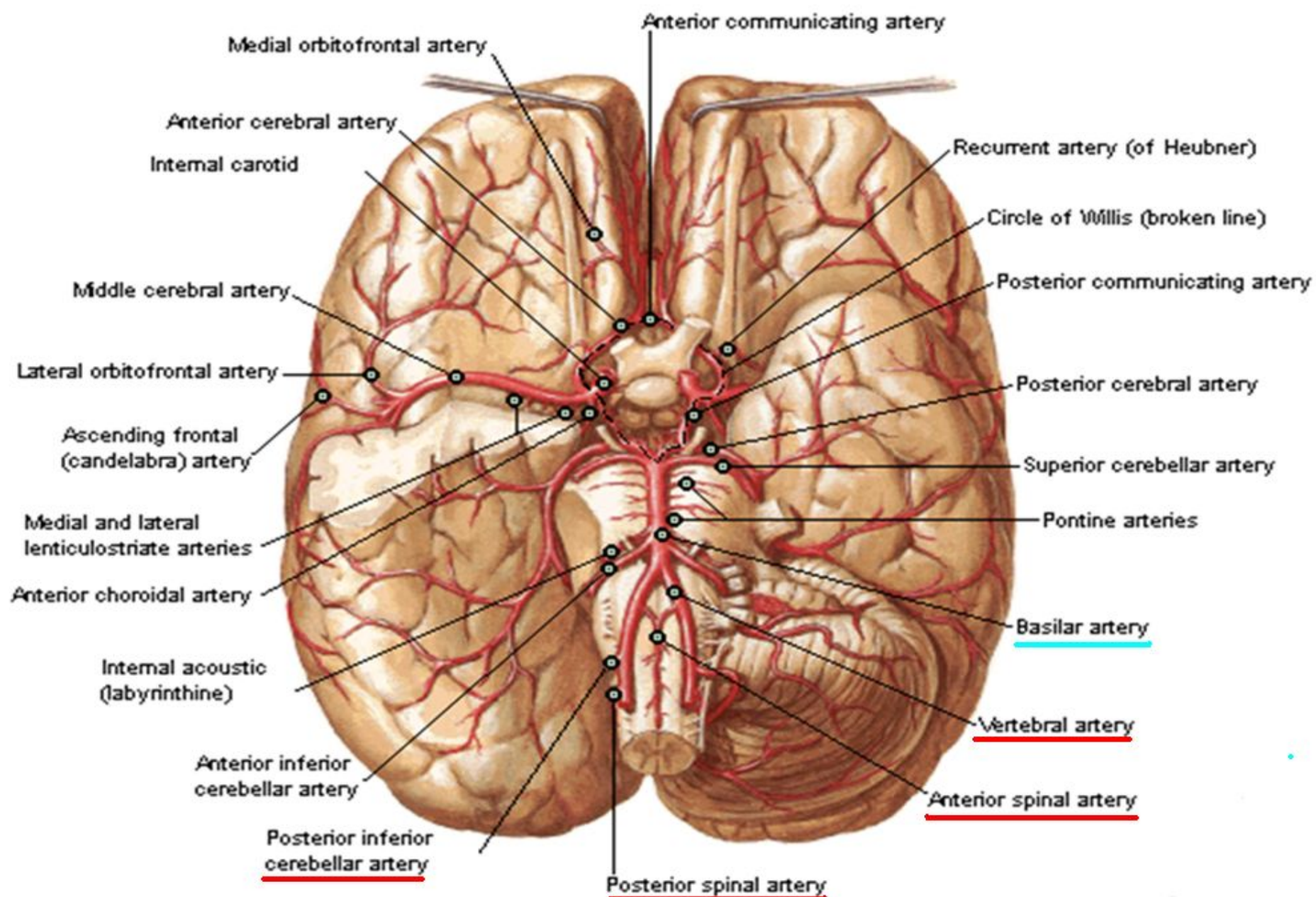
• It supplies the:

- Posterior part of inferior surface of cerebellum.
- Inferior cerebellar peduncle.
- Posteriolateral part of medulla oblongata.
- Choroid plexus of 4th ventricle.

❖ **Occlusion** of this artery leads to **lateral medullary syndrome (Wallenberg's syndrome)**.

Arteries of Brain

Inferior View



Basilar Artery

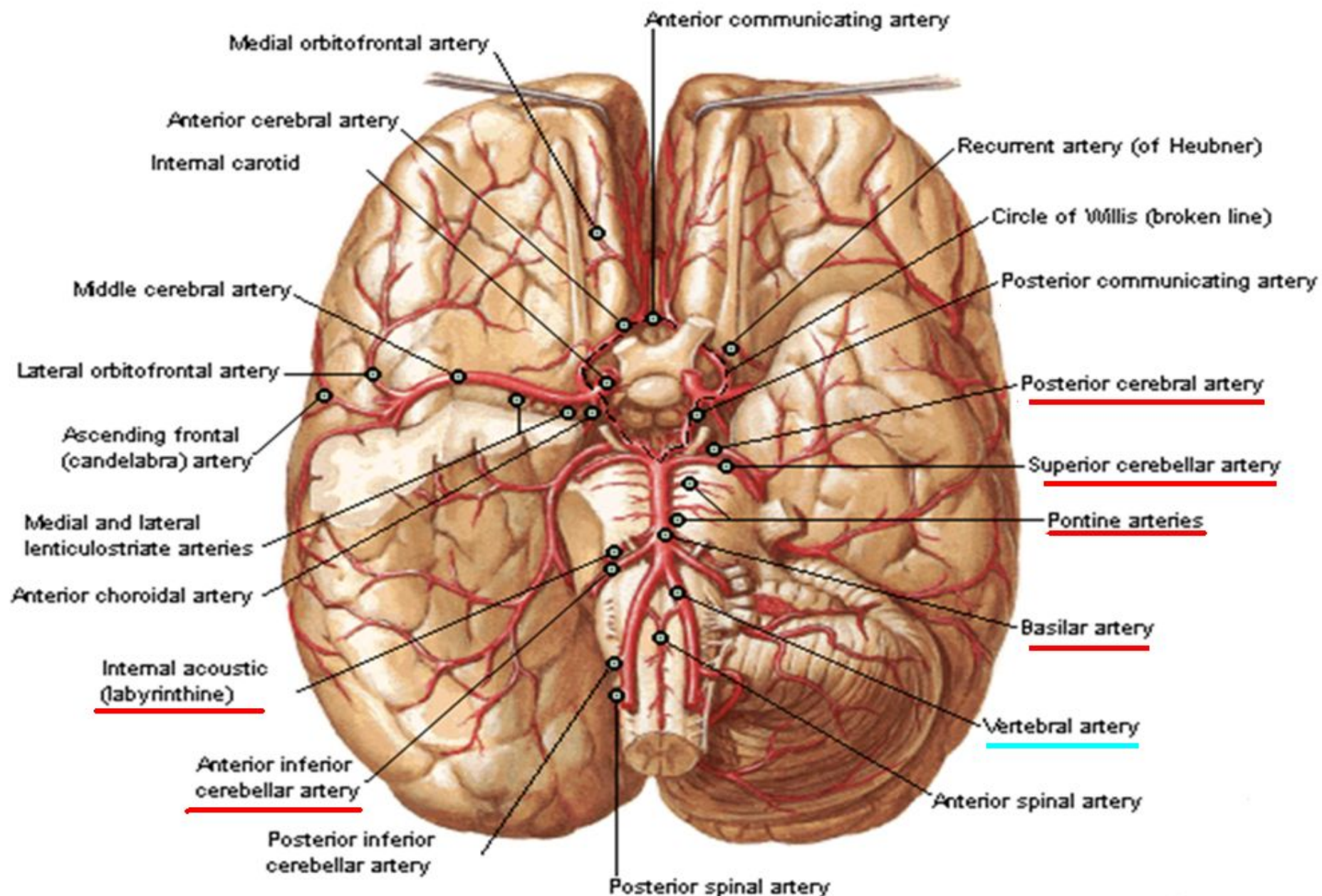
- **Origin:** at the lower border of pons by the union of the two vertebral arteries.
- It ascends along **the basilar groove** in front of the pons.
- **Termination:** at the upper border of the pons by dividing into two terminal branches (**posterior cerebral arteries**).
- It lies medial to the abducent and oculomotor nerves.

Branches of the Basilar artery

1. **Anterior inferior cerebellar artery:** supplies the anterior part of inferior surface of the cerebellum.
2. **Internal auditory (labyrinthine) artery:** it arises either from basilar or anterior inferior cerebellar arteries. Supplies the inner ear.
3. **Pontine (paramedian) branches:** are small branches to supply the pons.
4. **Superior cerebellar artery:** the oculomotor nerve separates it from the posterior cerebral artery. Supplies the superior surface of cerebellum, superior cerebellar peduncle, pons and midbrain.
5. **Posterior cerebral artery:** terminal branches.

Arteries of Brain

Inferior View

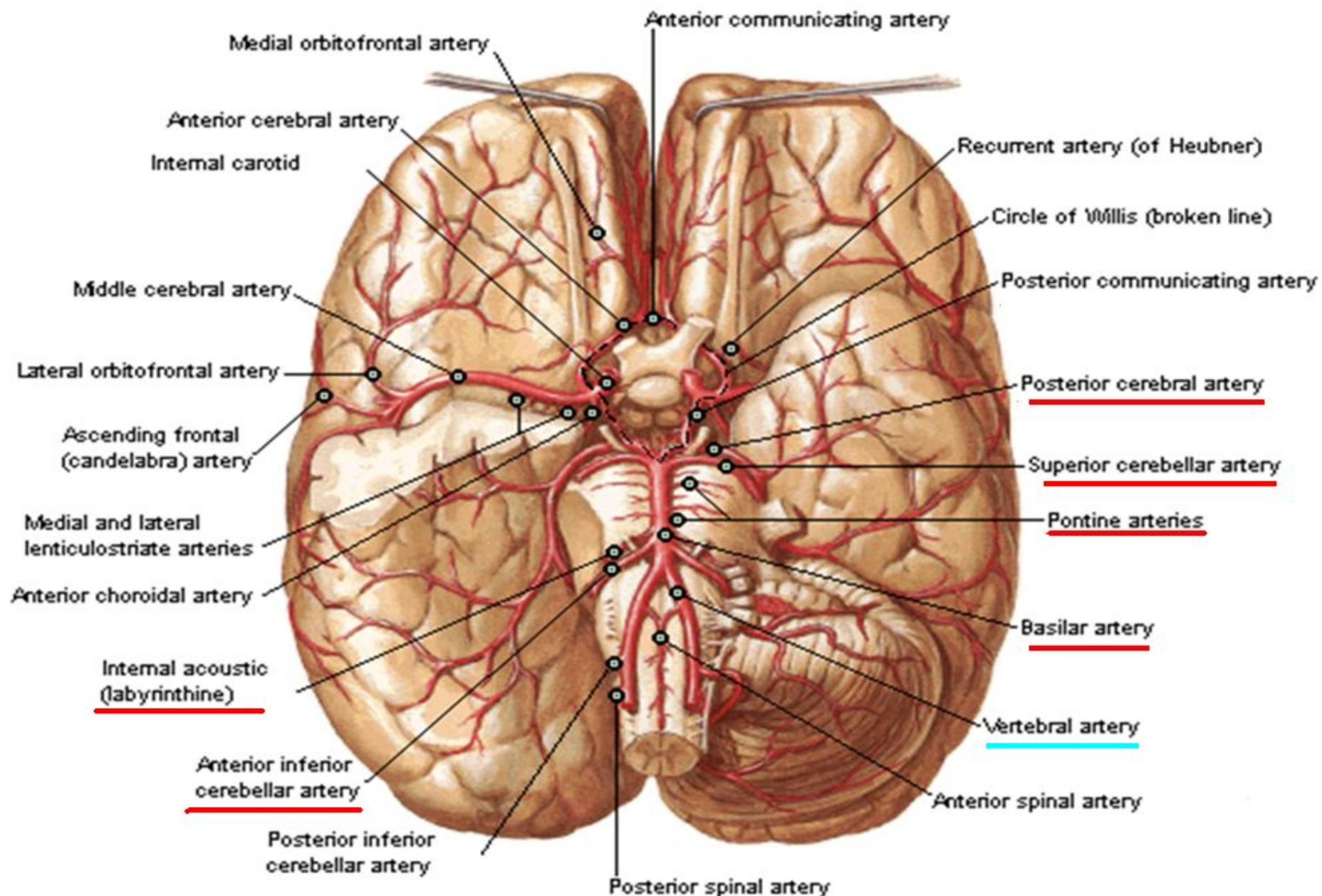


Posterior Cerebral Artery (PCA)

- It is the largest and terminal branches of the basilar artery at the upper border of the pons.
- It is separated from the superior cerebellar artery by **the oculomotor nerve.**
- Connects with the ipsilateral ICA by **the posterior communicating artery.**

Arteries of Brain

Inferior View



Branches of Posterior Cerebral Arteries

1. Cortical Branches:

- Inferiolateral part of temporal lobe.
- Occipital lobe “Visual cortex”.

2. Central Branches:

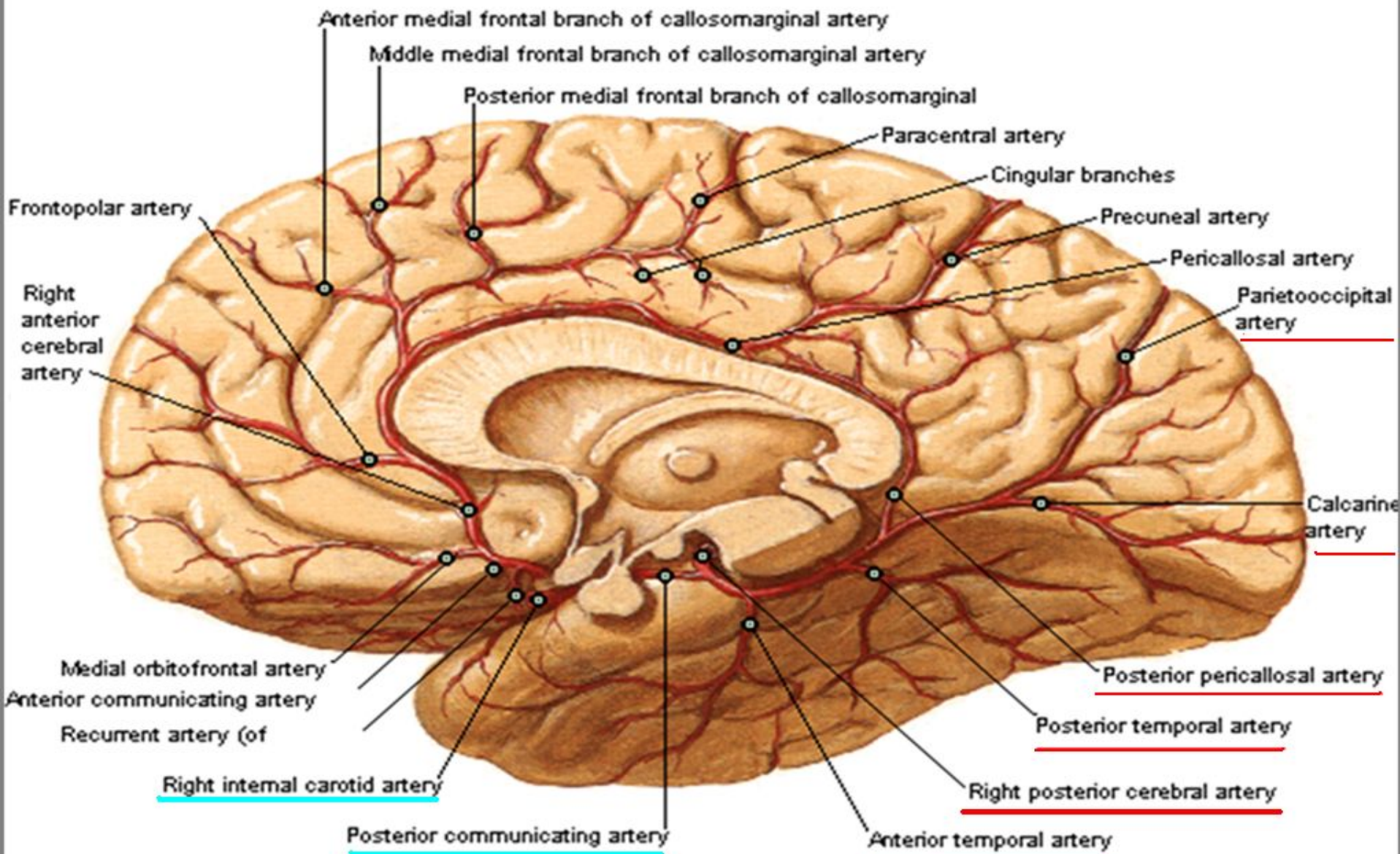
- Supply parts of the thalamus, medial geniculate body, splenium of the corpus callosum, lentiform nucleus, midbrain, and pineal body.

3. Posterior Choroidal Arteries:

- supply the choroid plexus of the lateral and third ventricles.

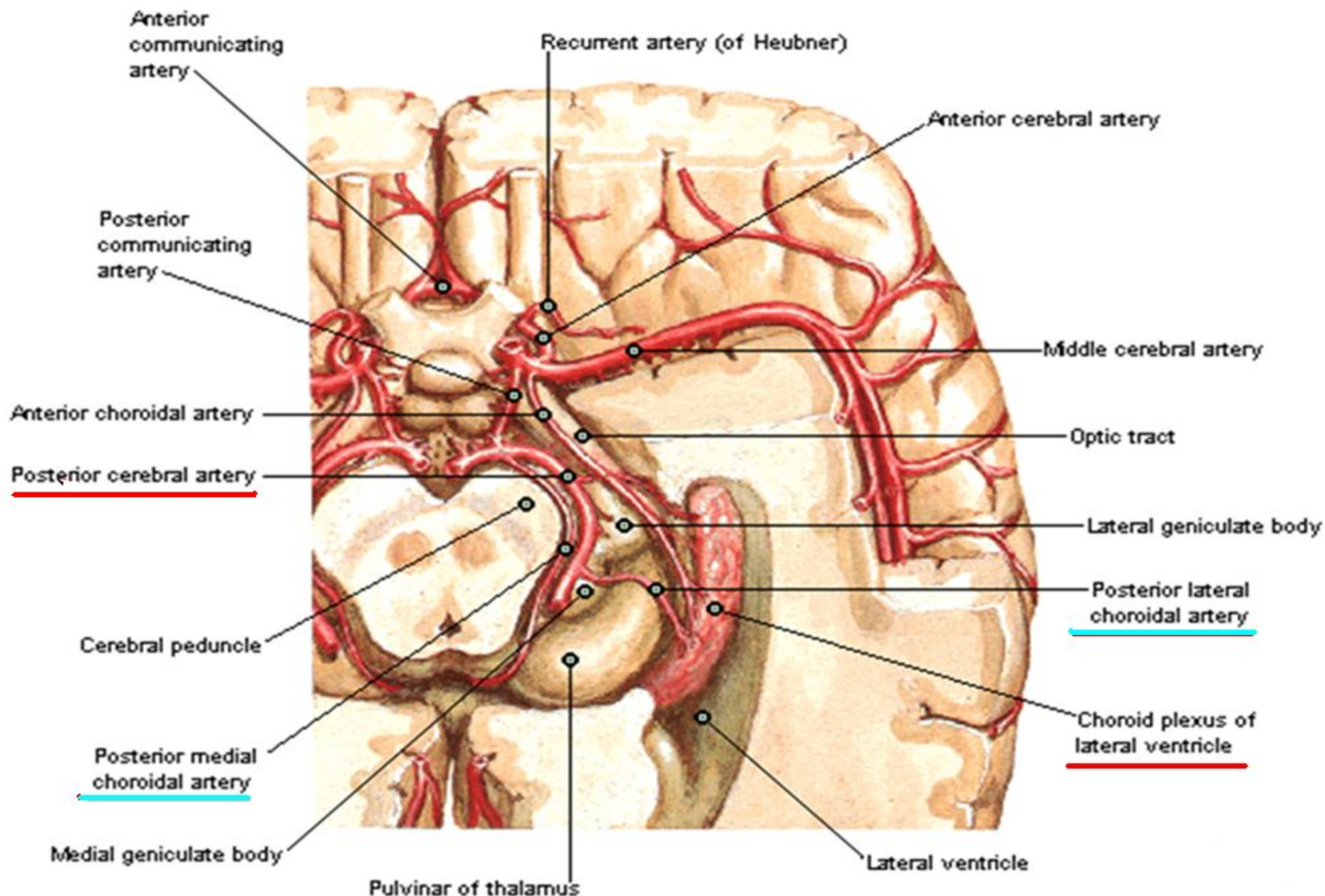
Arteries of Brain

Medial View



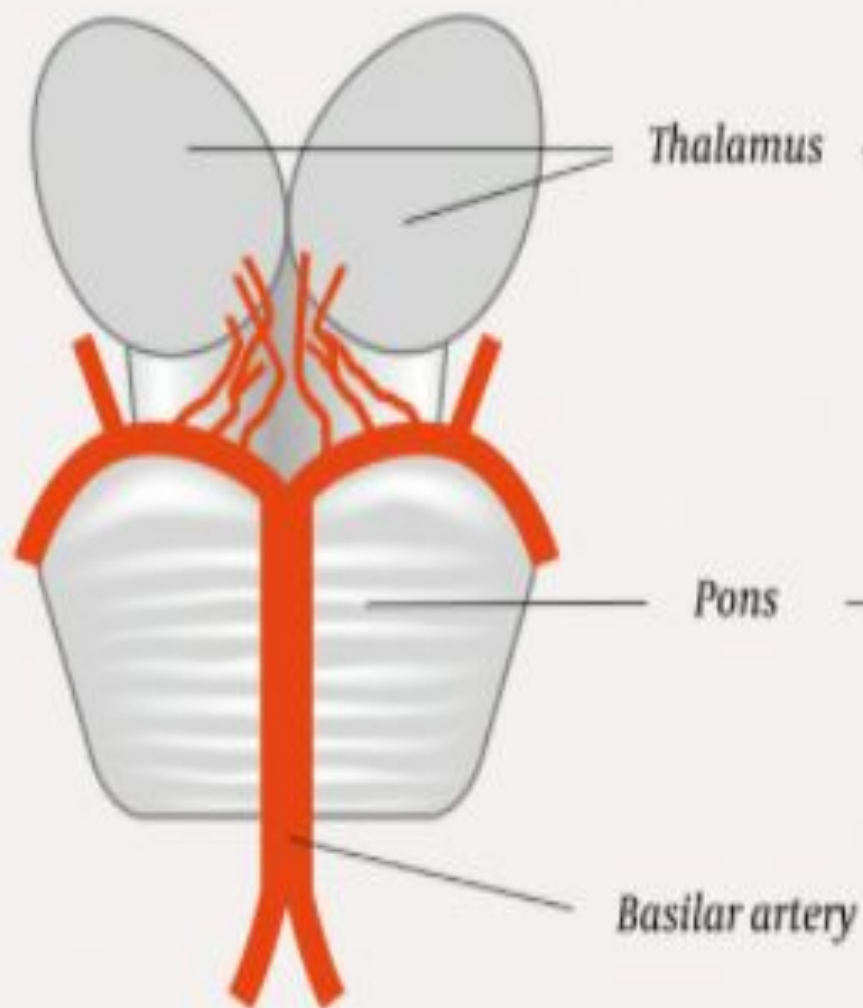
Arteries of Brain [Continued]

Inferior View

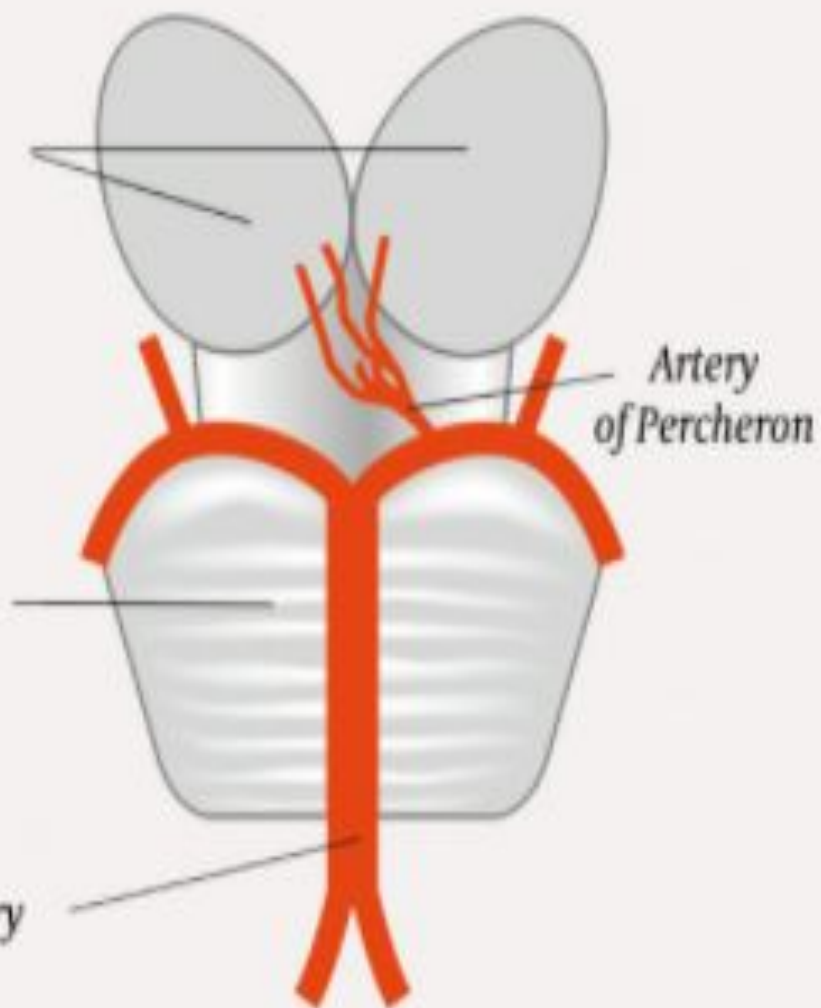


- 
- The **artery of Percheron** is a rare anatomical variation in the brain vascularization in which a single arterial trunk arises from the PCA to supply both sides of the thalamus and midbrain.

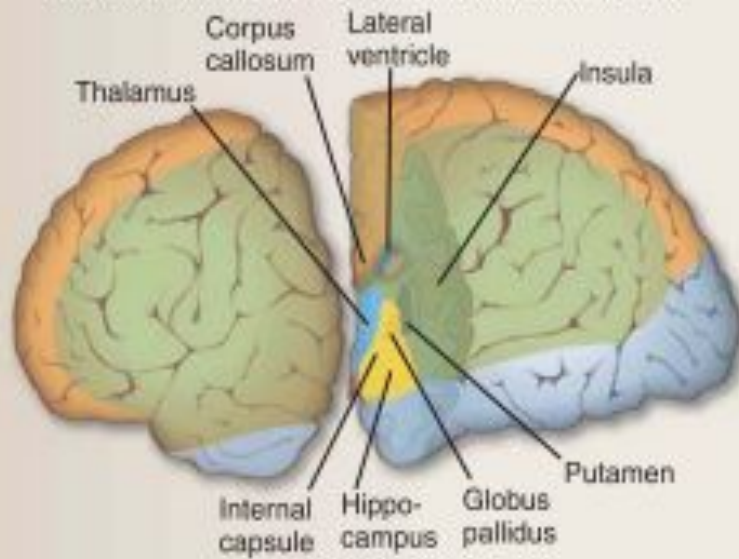
Normal anatomy



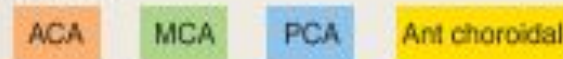
Anatomy with artery of Percheron



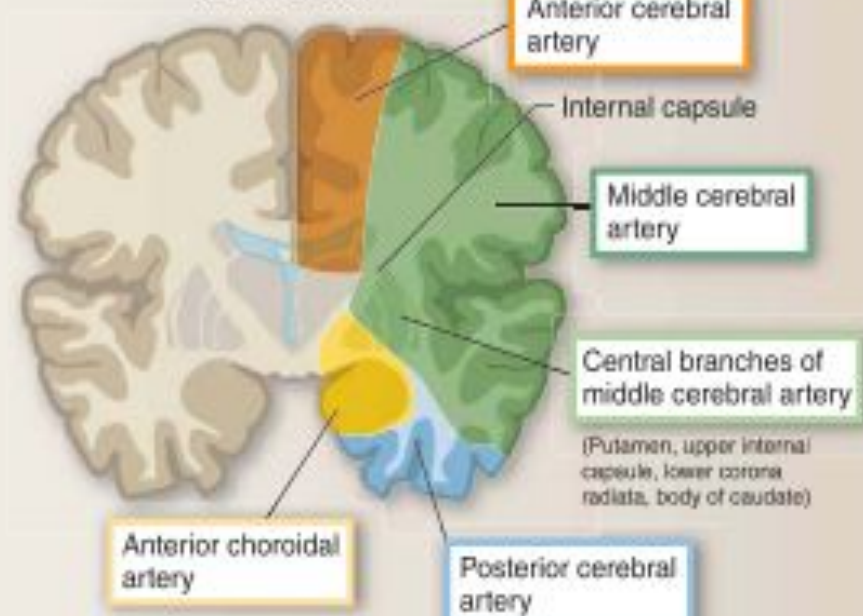
Lateral view **Coronal section through left cerebral hemisphere**



Arteries

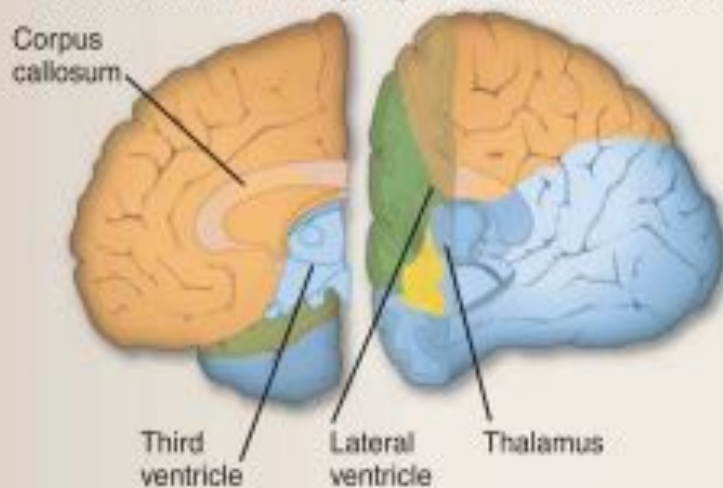


Coronal view

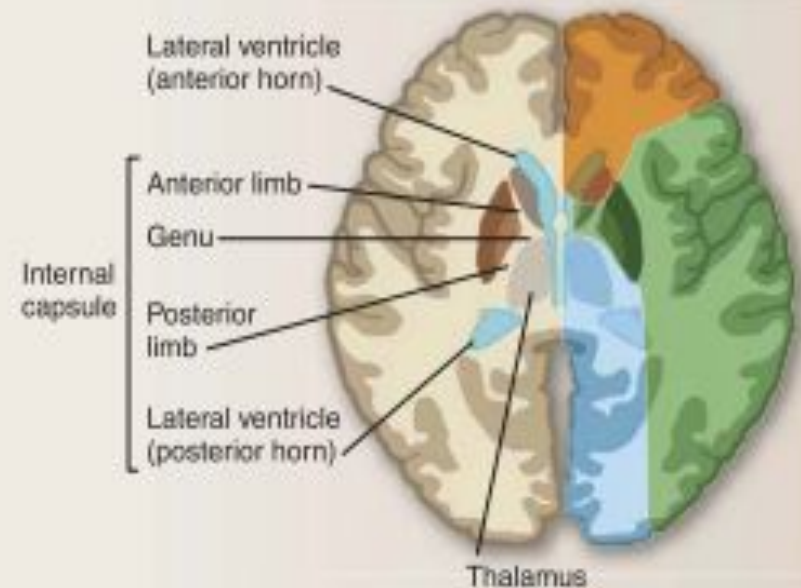


Medial view

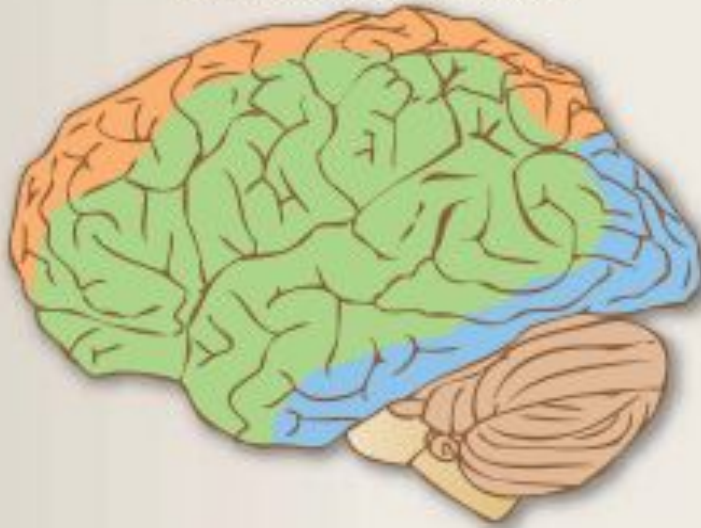
Coronal section through right cerebral hemisphere



Horizontal view



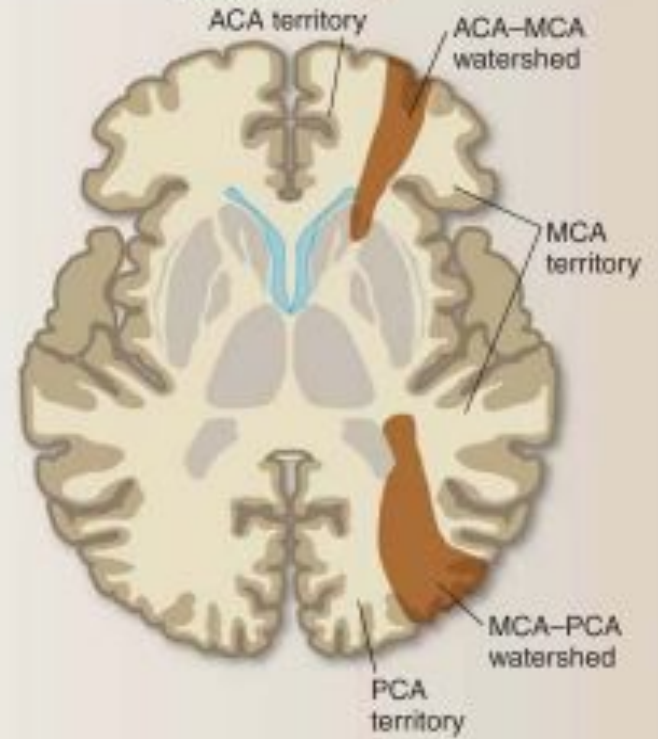
Lateral view of left hemisphere



Medial view of left hemisphere



Horizontal view



MCA

ACA

PCA

Inferior view



Circle Of Willis

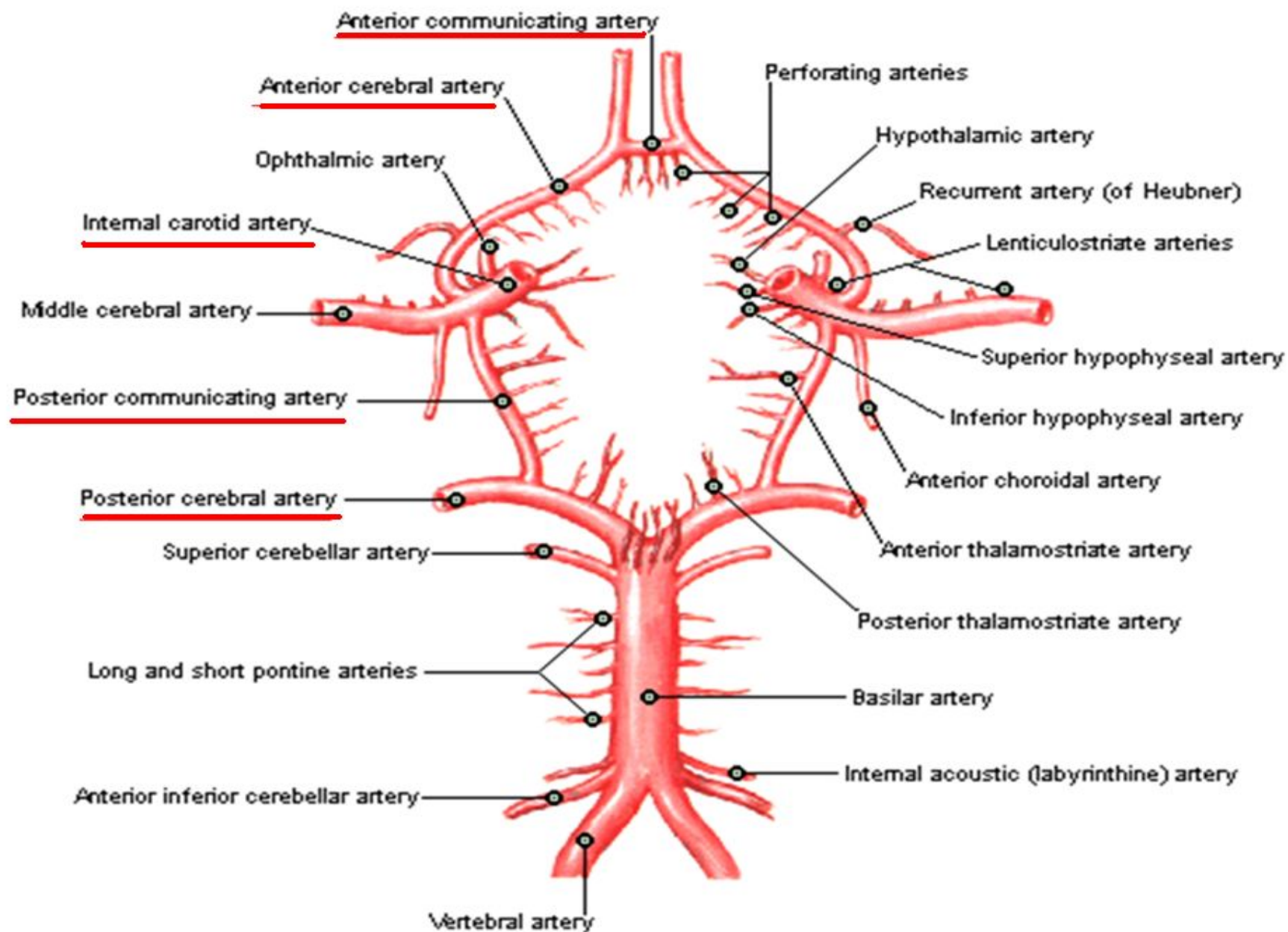
- ❖ **Definition:** it is an arterial anastomoses between **the vertebral and internal carotid arteries of both sides**).
- ❖ It lies in the interpeduncular fossa at the base of the brain
- ❖ **Function:**
 - Direct blood to other branches in cases of occlusion.
 - Connect carotid system with vertebrobasilar system.

Circle Of Willis

- 1. Anterior communicating artery.**
- 2. Right & left of ACA.**
- 3. Right & left ICA.**
- 4. Right & left posterior communicating arteries.**
- 5. Right & left PCA.**
- 6. Basilar artery.**

Circle of Willis - Vessels Dissected Out

Inferior View



The Important Anastomoses Between the Cerebral Arteries

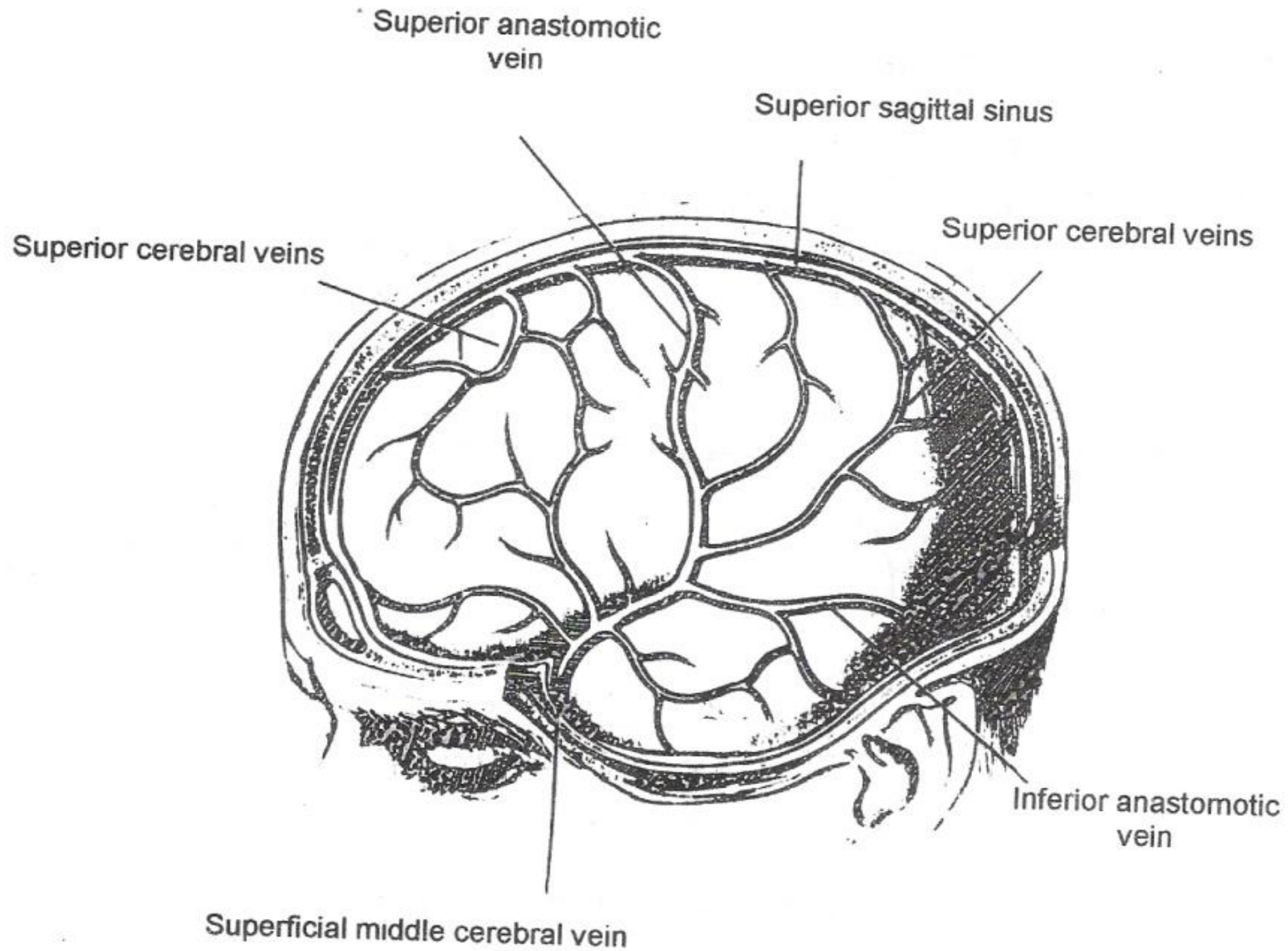
- 1. Anastomoses between the branches of the cerebral arteries** on the surface of the cerebral hemisphere.
- 2. The circle of Willis:** between ICA and vertebro-basilar system.
- 3. Anastomoses between the branches of the internal and external carotid arteries:**
 - a. Anastomoses between the branches of the ophthalmic artery with the facial and maxillary arteries.
 - b. Anastomoses between the meningeal branches of the internal carotid artery with middle meningeal branch of maxillary artery.

Venous Drainage

- A. Superficial cerebral veins:** laceration of these vessels results in subdural hemorrhage (hematoma).
- B. Deep cerebral veins.**
- C. Dural Cerebral Sinuses.**
 - The veins of the brain have no muscular tissue in their thin layer.
 - No valves.
 - Drain into the cranial or dural venous sinuses.

Cerebral Veins

1. **Superior cerebral veins:** drain into **the superior sagittal sinus.**
2. **Inferior cerebral veins:** drain into **the petrosal and transverse sinuses.**
3. **Middle cerebral veins:**
 - a. **Superficial middle cerebral veins:** drain into **the cavernous sinus.**
 - b. **Deep middle cerebral veins:** drain into **basal vein** → Great cerebral vein → **the straight sinus.**



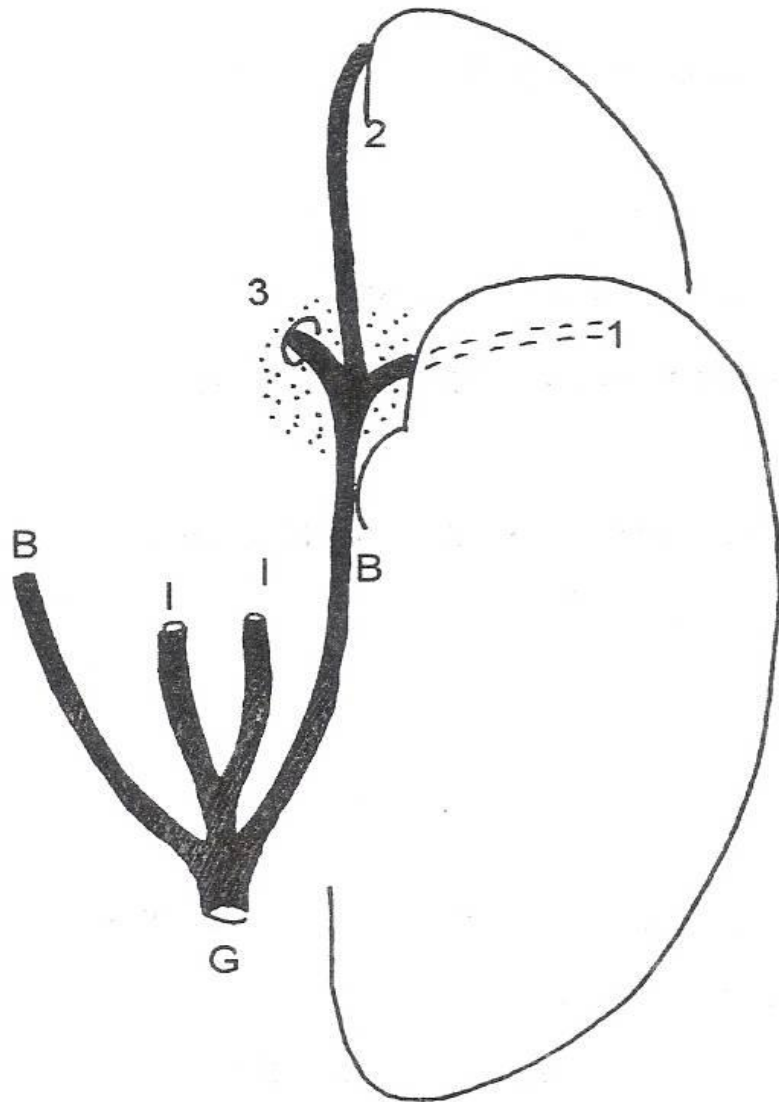
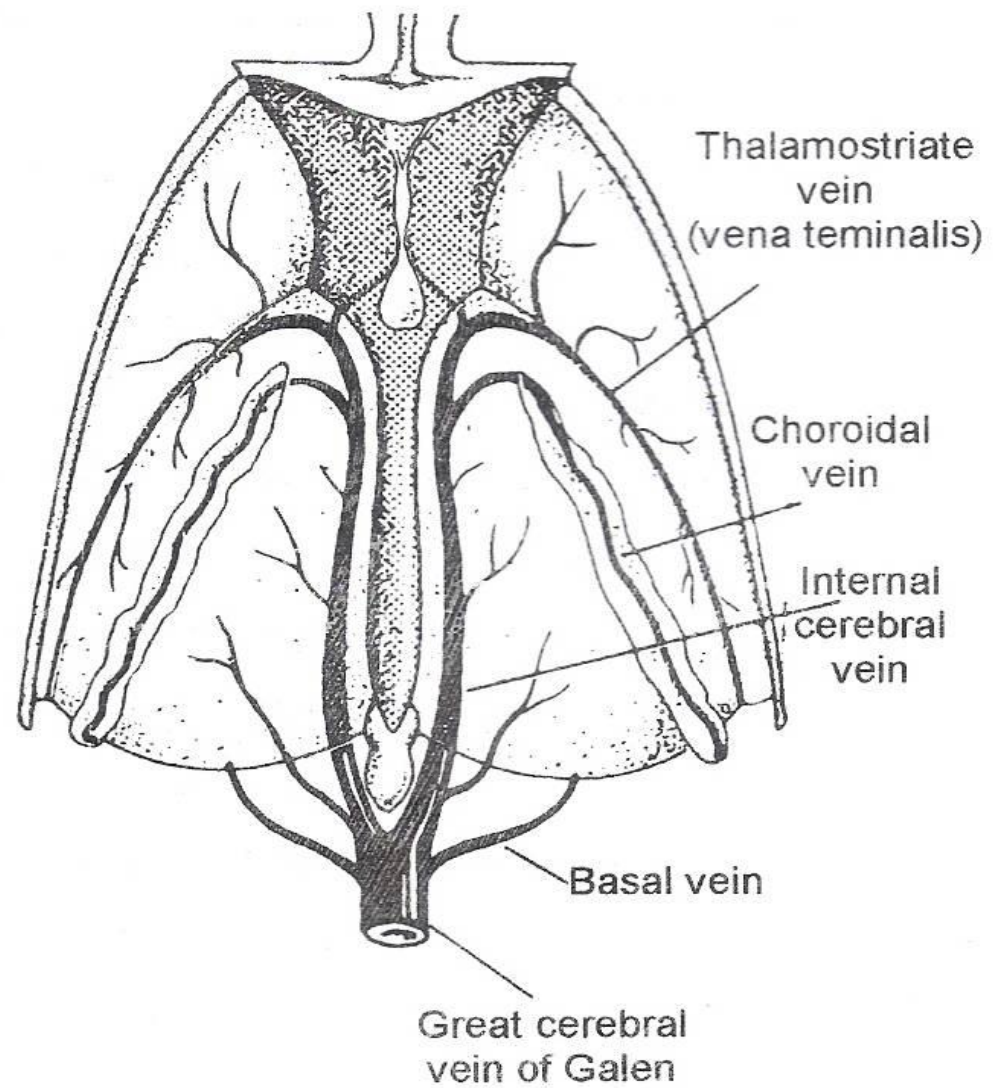
4. Basal vein (vein of Rosenthal): by union of three veins:

- **Deep middle cerebral vein.**
- **Anterior cerebral vein.**
- **Striate veins.**

- The two basal veins drain into **the great cerebral vein.**

5. The Internal Cerebral Vein: there are two internal cerebral veins and they are formed by the union of

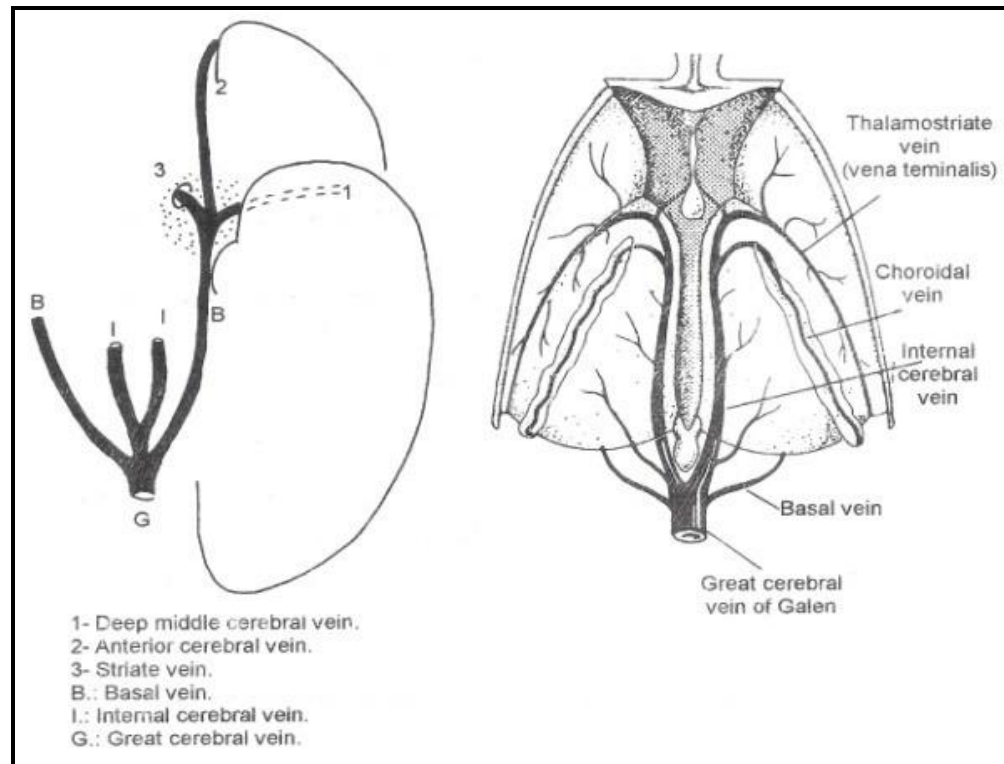
- **Thalamostriate vein**
- **Choroid vein.**
- The two internal cerebral veins run in the roof of the 3rd ventricle backwards to form **the great cerebral vein**, which drains into **the straight sinus.**

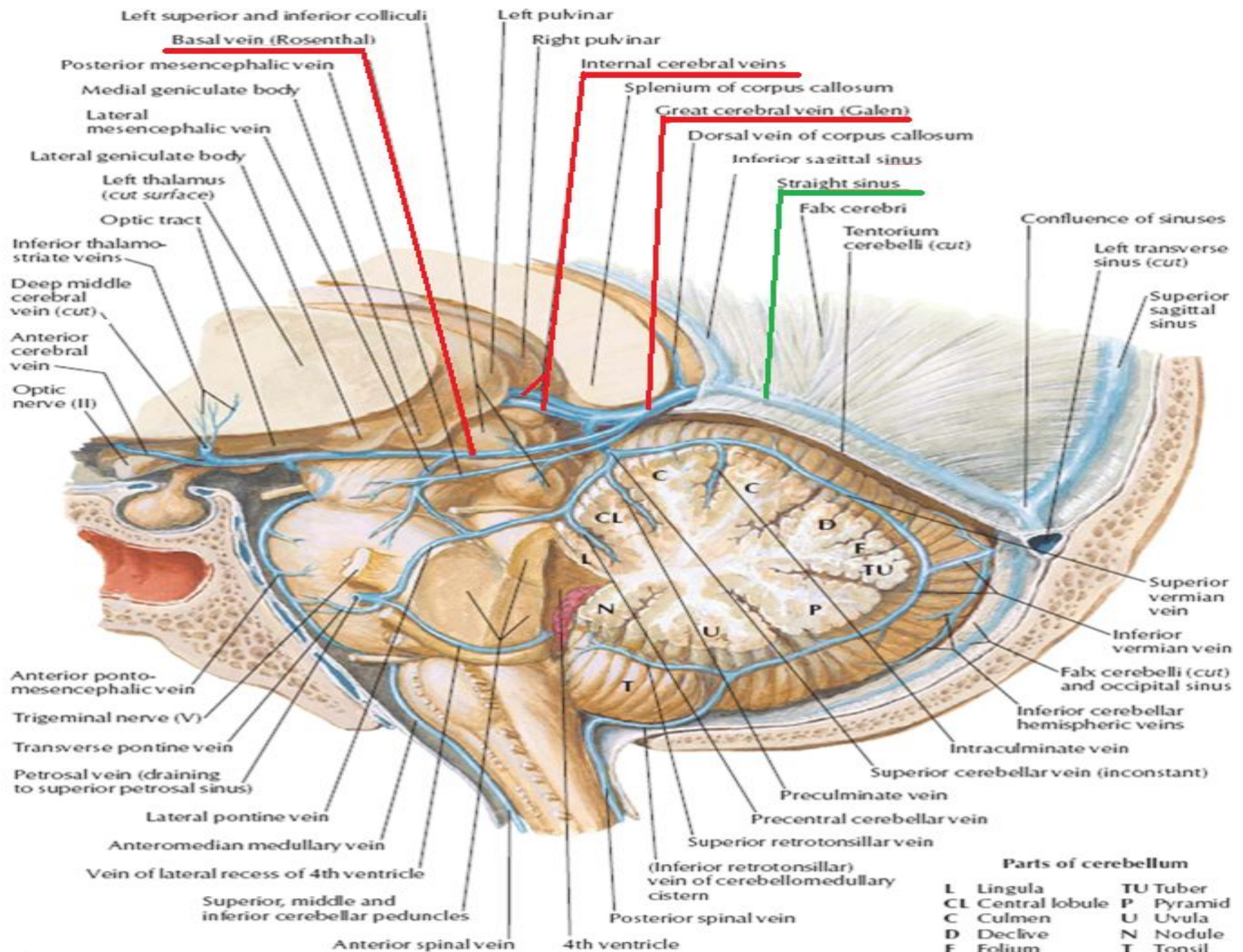


- 1- Deep middle cerebral vein.
- 2- Anterior cerebral vein.
- 3- Striate vein.
- B.: Basal vein.
- I.: Internal cerebral vein.
- G.: Great cerebral vein.

6. Great cerebral vein (vein of Galen):

- Is the main vein of the medial surface of C.H.
- Formed by union of **the two internal cerebral veins**.
- **The great cerebral vein** unites with **the inferior sagittal sinus** to form **the straight sinus**.
- It receives also **the two basal veins**.





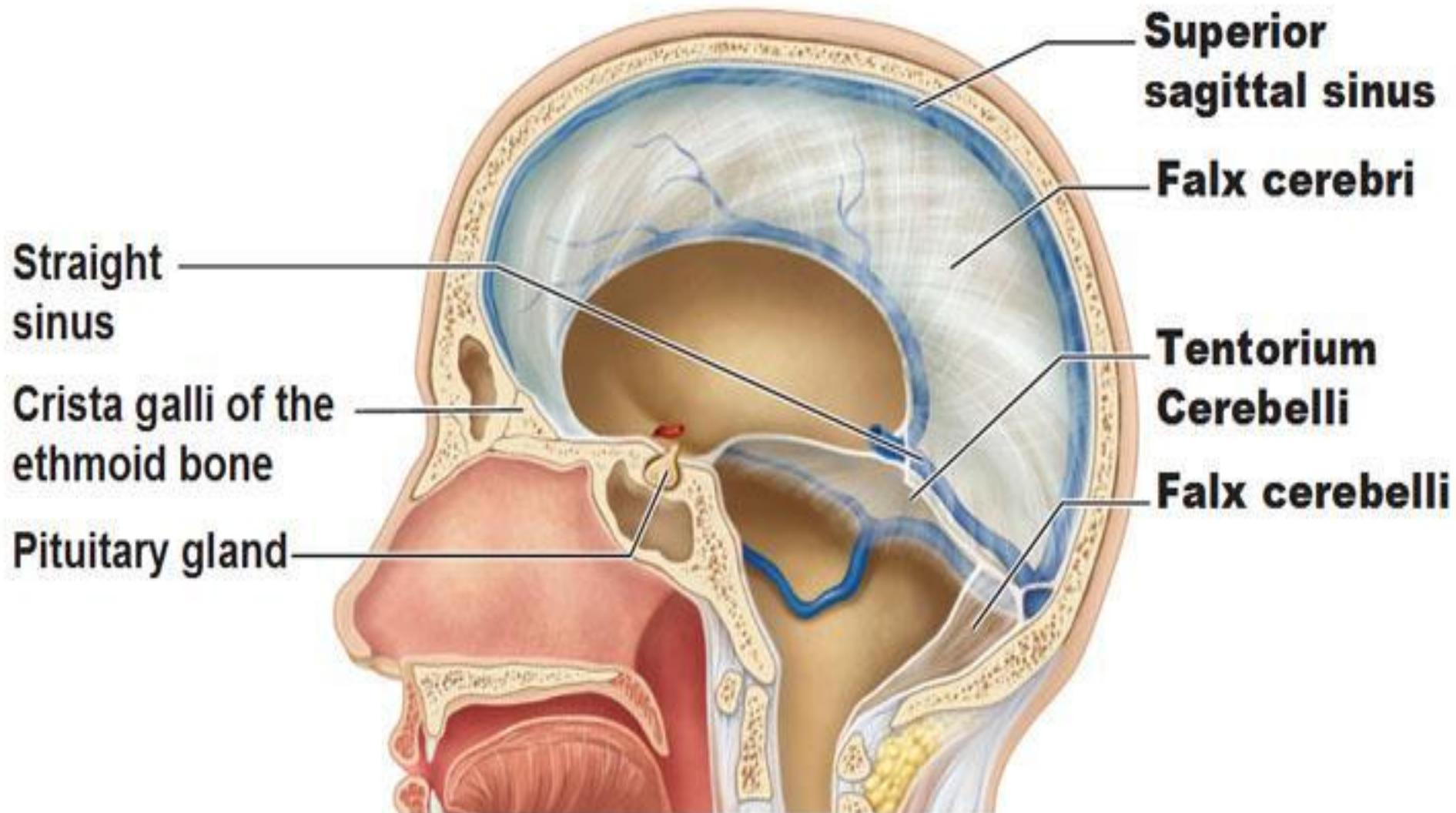
The Cerebral Dural Sinuses

- ❑ **The dural venous sinuses (also called dural sinuses, cerebral sinuses, or cranial sinuses)** are venous channels found between **two layers of dura mater in the brain.**
- ❑ They receive blood from superficial and deep veins of the brain.
- ❑ They receive CSF from the subarachnoid space (by the arachnoid granulation and villi).
- ❑ The dural sinuses finally connected with the internal jugular vein.
- ❑ There are at least **three single and six paired** dural sinuses.

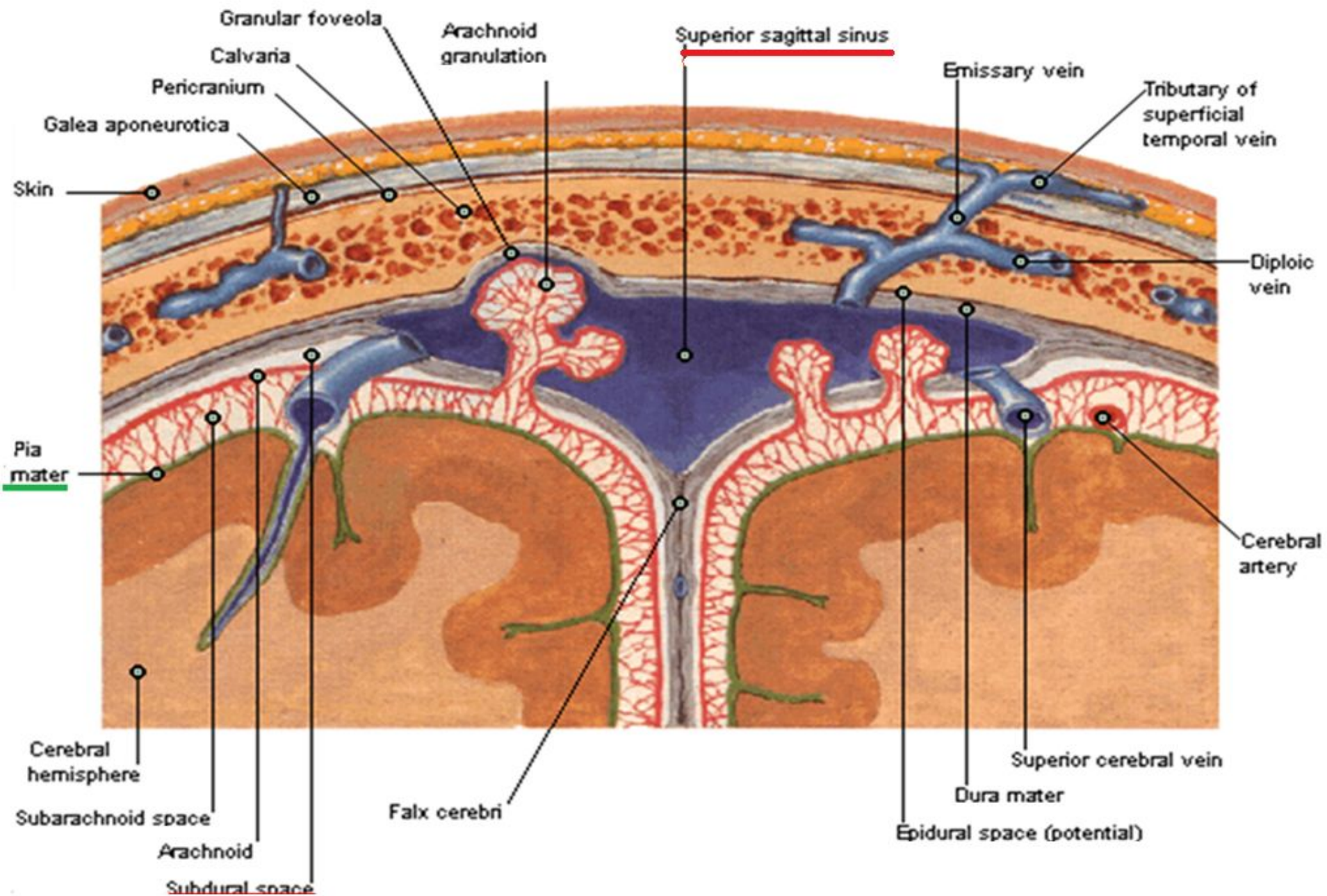
The Single Venous Sinuses

1. **The superior sagittal sinus:** usually terminates in **the right transverse sinus.**
2. **The inferior sagittal sinus:** joins the great cerebral vein to form **the straight sinus.**
3. **The straight sinus “tentorial or rectus sinus”:** formed by the union of **the great cerebral vein and the inferior sagittal sinus,** and usually drains into **the left transverse sinus.**

The Dura Mater and Dural Sinuses

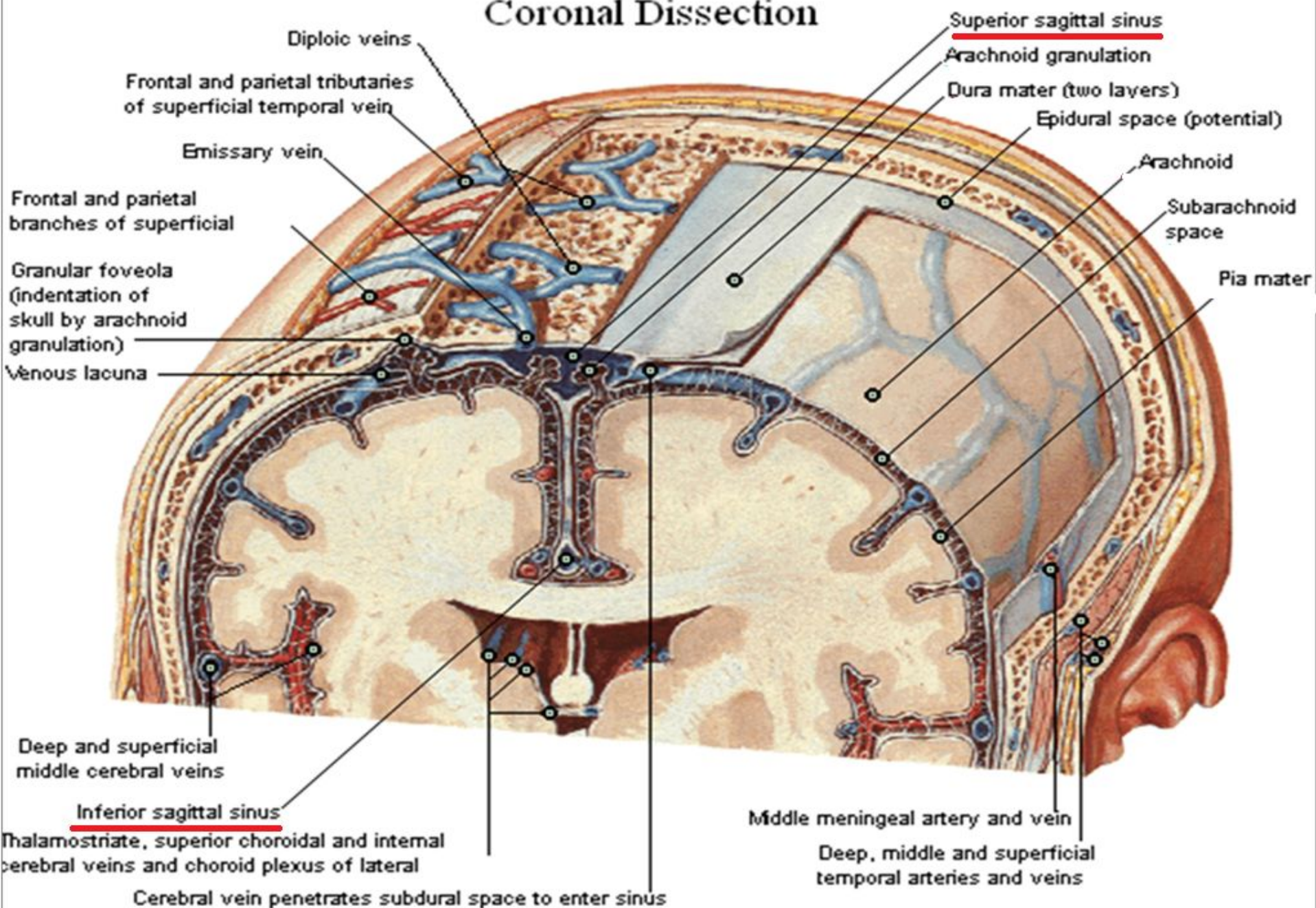


(a) Midsagittal view



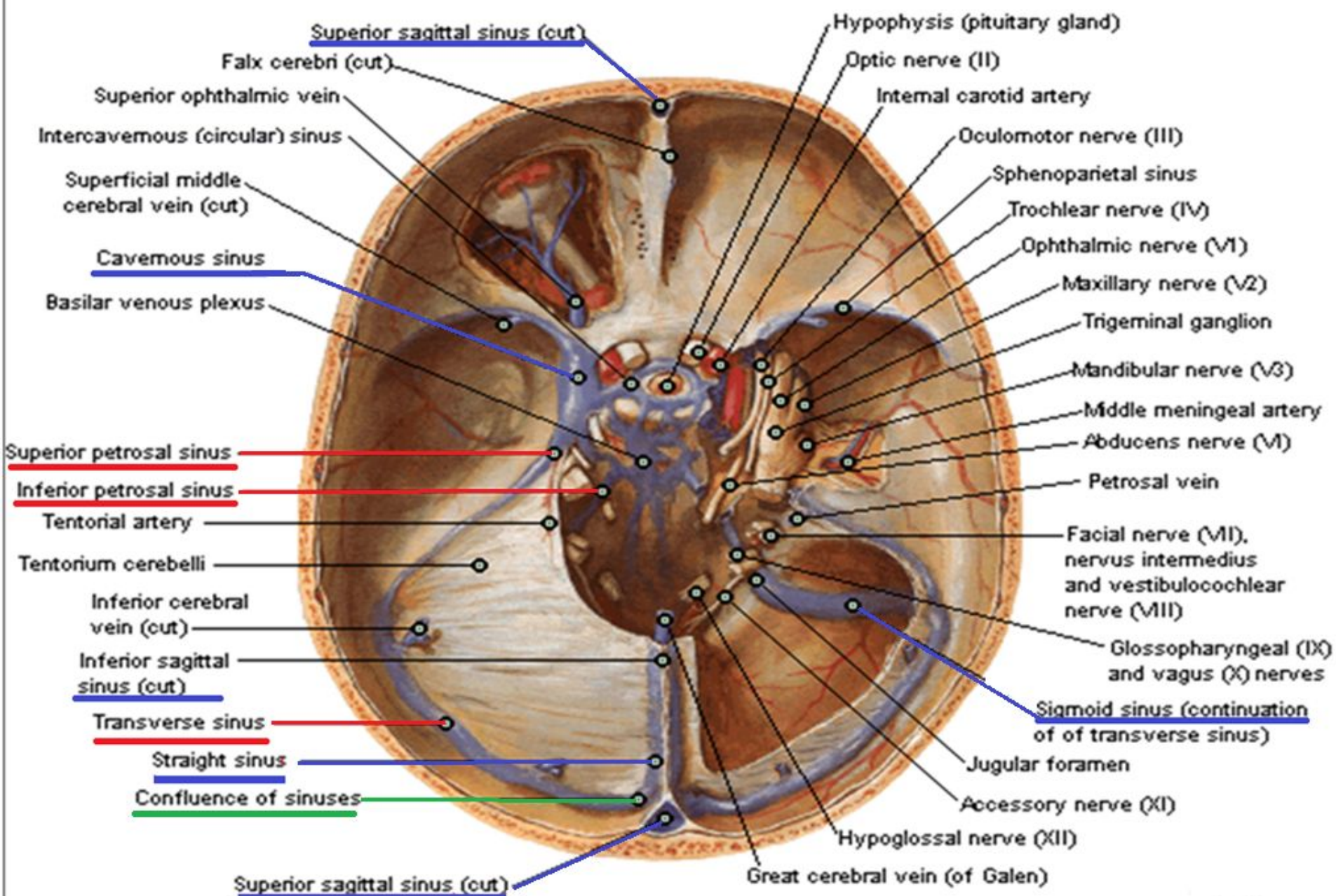
Meninges and Diploic Veins

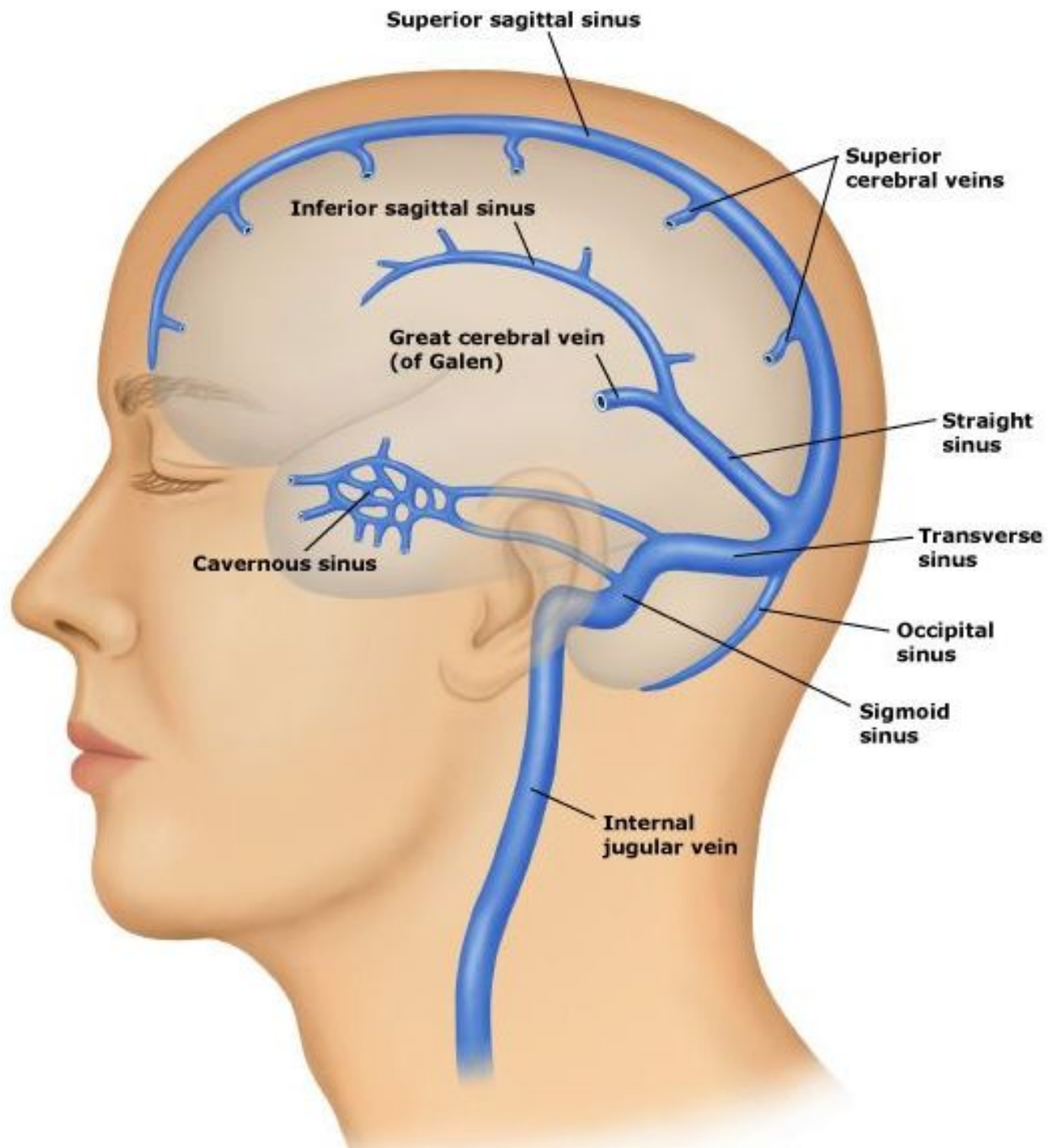
Coronal Dissection



The Paired Sinuses

1. **The sphenoparietal sinus:** drains into **the cavernous sinus.**
2. **The cavernous sinuses:** drains into **the superior and inferior sinuses.**
3. **The superior petrosal sinuses:** extends from the cavernous sinus to the junction of **the transverse and sigmoid sinus.**
4. **The inferior petrosal sinuses:** drains the cavernous sinus **into the sigmoid sinus.**
5. **The transverse (lateral) sinuses:** drains into **the sigmoid sinus.**
2. **The sigmoid sinuses:** a continuation of the transverse sinus at the superior petrosal sinuses and drains into **the internal jugular vein.**





The Cavernous Sinuses

❑ Contains within the **lateral wall** of the cavernous sinus:

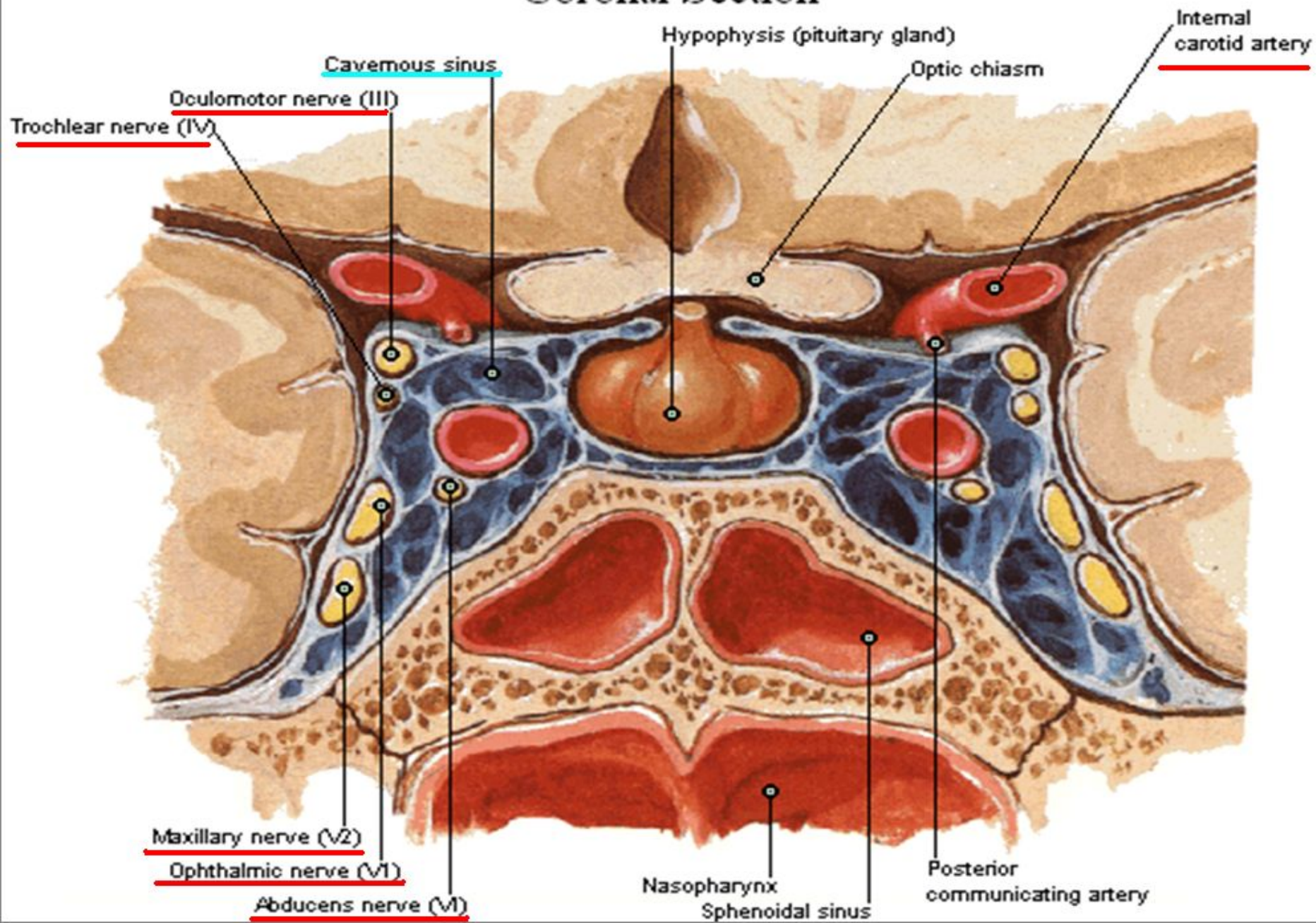
1. The oculomotor nerve.
2. The trochlear nerve.
3. The ophthalmic division of the trigeminal nerve.
4. The maxillary division of the trigeminal nerve.

❑ Contains within the **medial wall** of the cavernous sinus:

1. The abducent nerve.
2. The internal carotid artery.

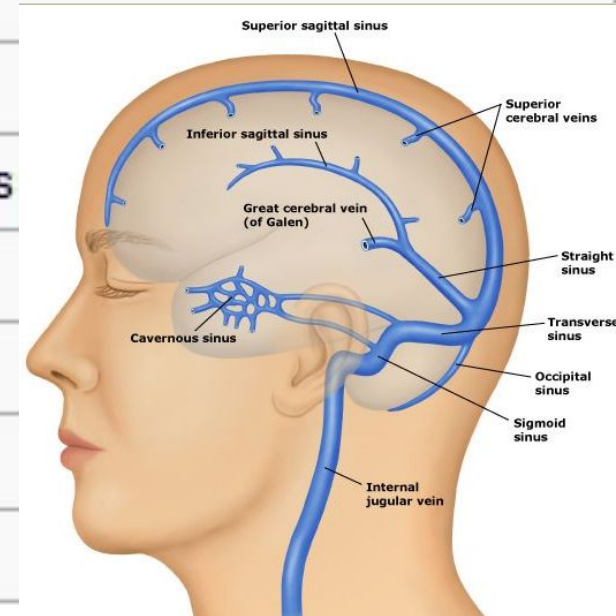
Cavernous Sinus

Coronal Section



The Cerebral Dural Sinuses

Name	Drains to
Inferior sagittal sinus	Straight sinus
Superior sagittal sinus	Typically becomes right transverse sinus or confluence of sinuses
Straight sinus	Typically becomes left transverse sinus or confluence of sinuses
Occipital sinus	Confluence of sinuses
Confluence of sinuses	Right and Left transverse sinuses
Sphenoparietal sinuses	Cavernous sinuses
Cavernous sinuses	Superior and inferior petrosal sinuses
Superior petrosal sinus	Transverse sinuses
Transverse sinuses	Sigmoid sinus
Inferior petrosal sinus	Sigmoid sinus
Sigmoid sinuses	Internal jugular vein

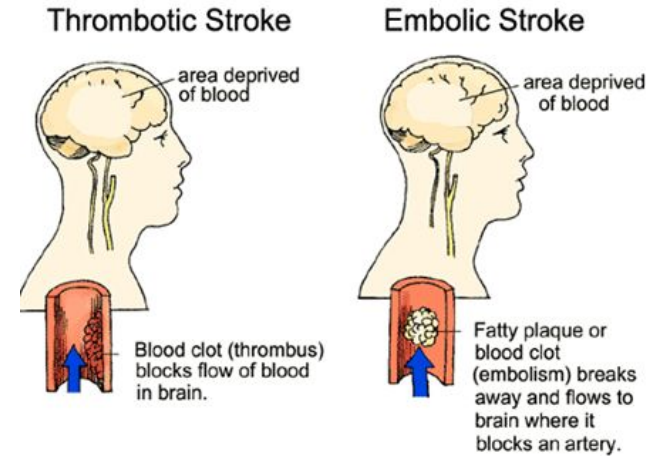


The **confluence of sinuses** is the connecting point of the superior sagittal, and straight sinuses.

Classification of Stroke

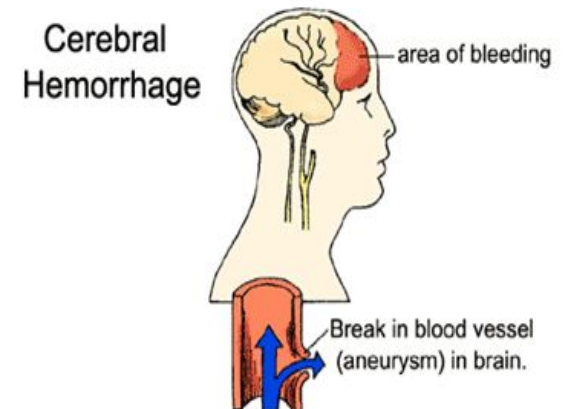
Ischemic Stroke: 85%.

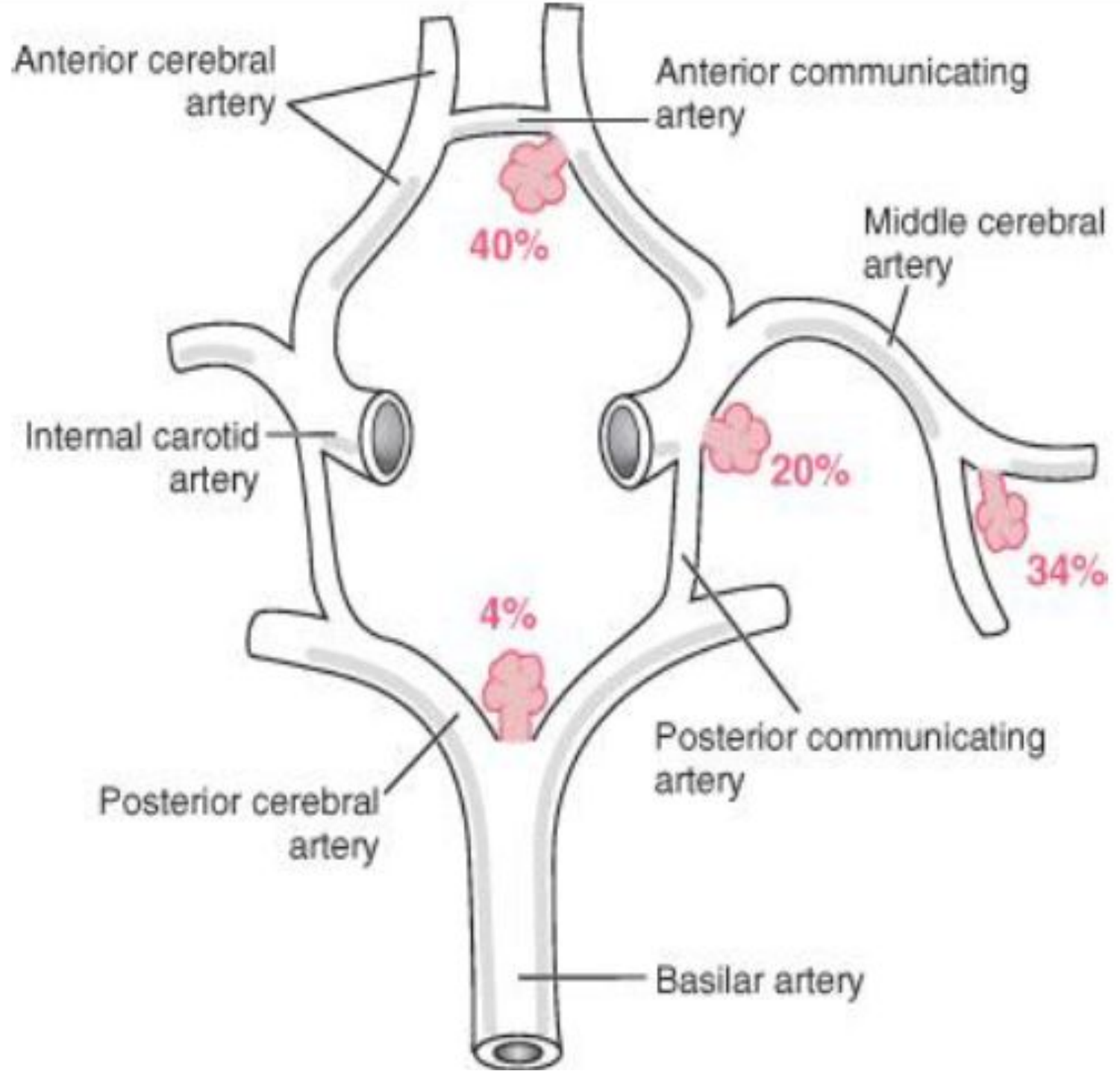
- Thrombotic.
- Embolic.
- Lacunar.
- Hemodynamic.

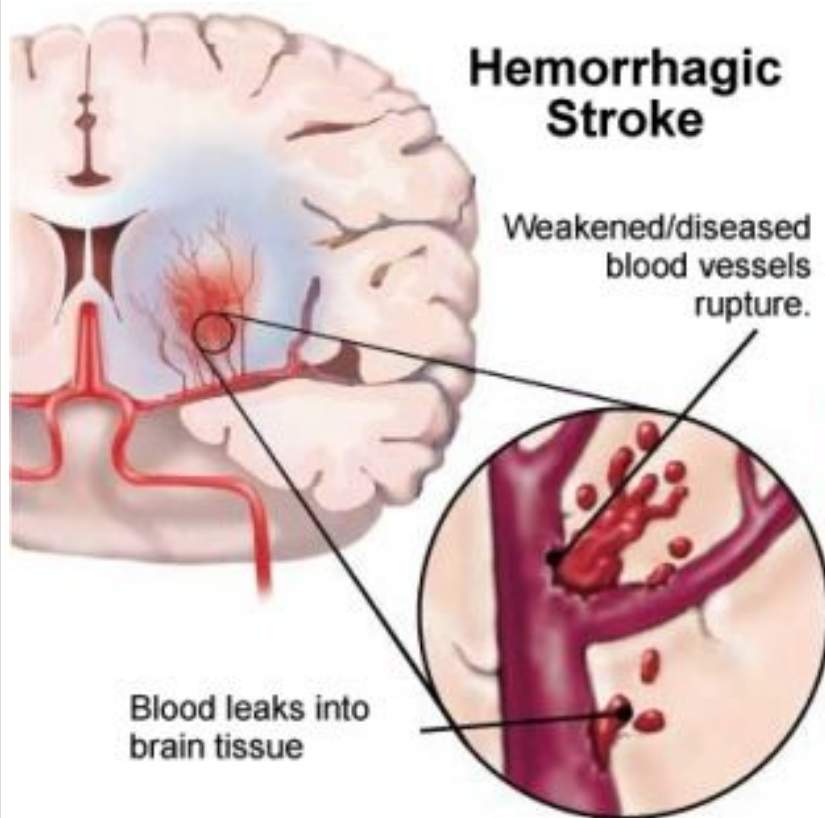
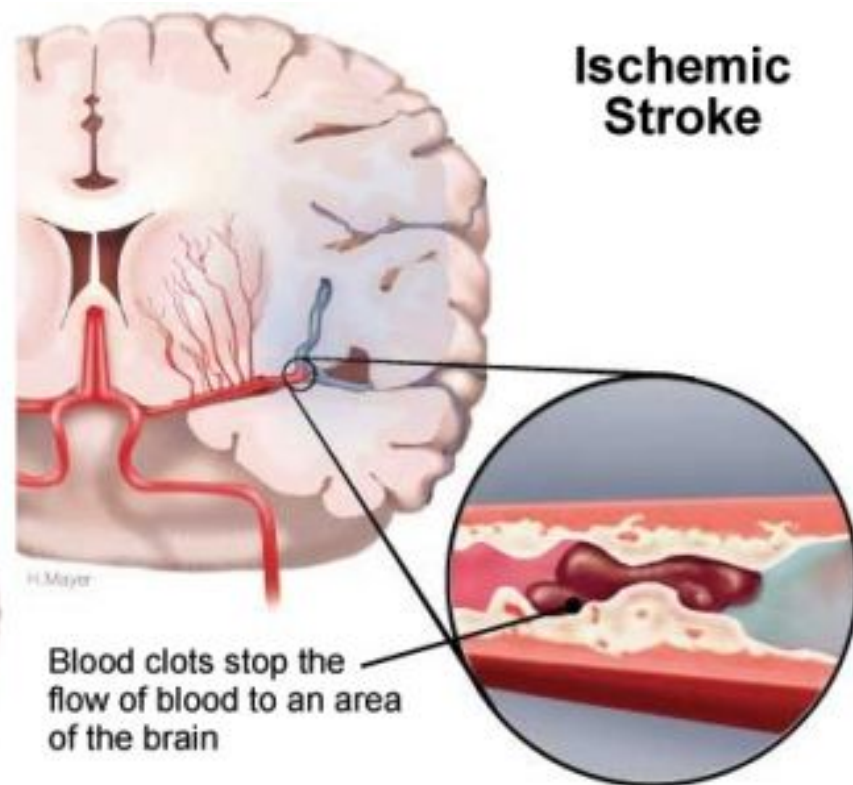


Hemorrhagic Stroke: 15 %.

- Intracerebral and intracerebellar hemorrhage 10%.
- Subarachnoid hemorrhage 5%.







Internal Carotid Artery Occlusion

1. The symptoms and signs are those of **MCA** including contralateral hemiparesis and hemianesthesia.
2. There is **partial** or **complete loss of vision** on the same side, but permanent loss is rare (emboli dislodged from the internal carotid artery reach the retina through the ophthalmic artery).

Occlusion of the main Anterior Cerebral Artery

- Contralateral weakness and hyperreflexia in the lower extremity.
- Contralateral somatosensory loss in the lower extremity with paresthesia, numbness, and loss of vibration sensation.
- Urinary incontinence with bilateral infarction.
- Apraxia.
- Mentality and personality changes.

Occlusion of the main Middle Cerebral Artery

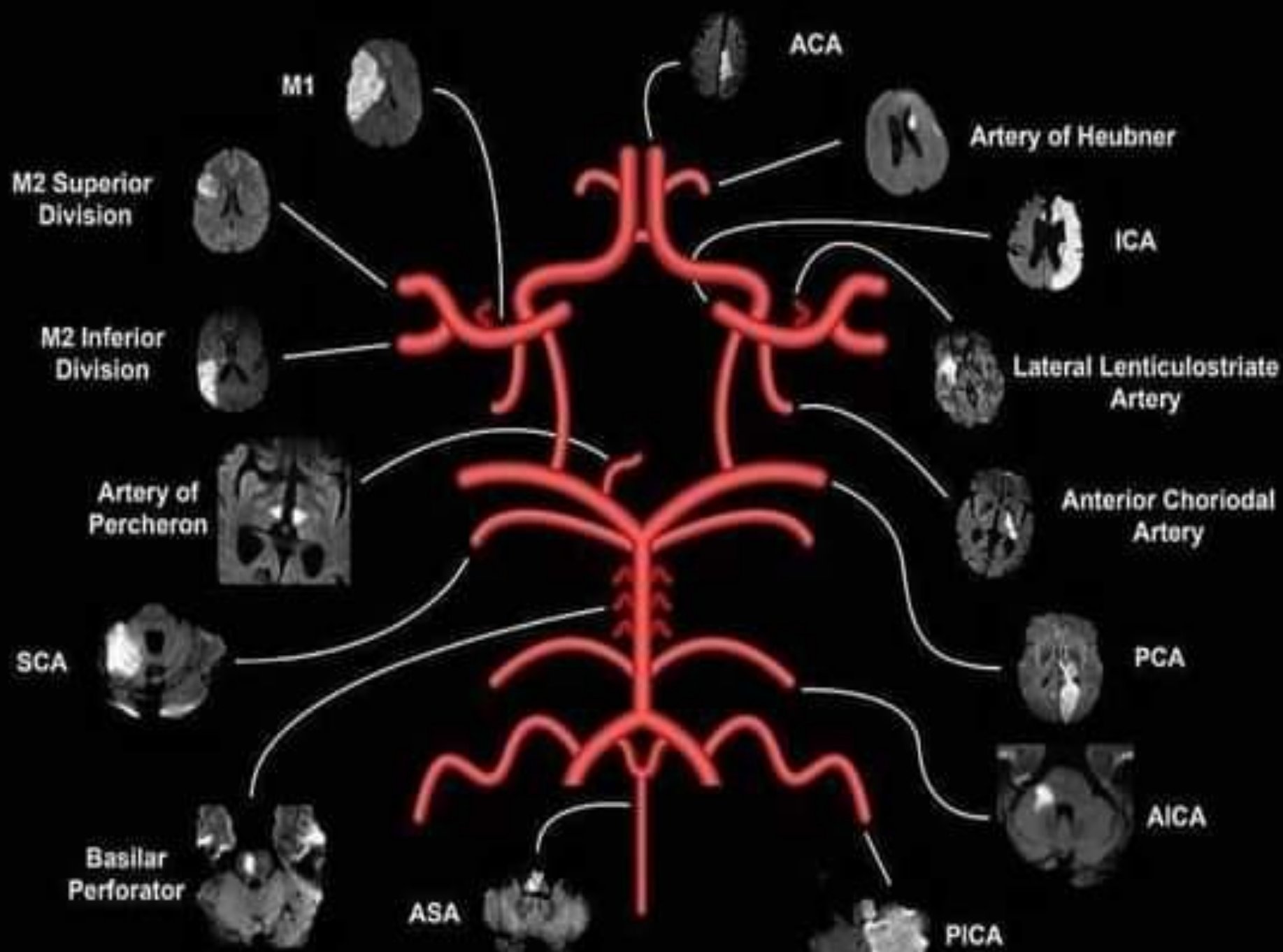
- Contralateral facial weakness and weakness and loss of sensation in the upper extremity and face “**Contralateral faciobrachial type hemiplegia and hemihypoesthesia**”.
- Loss of sensory discrimination and stereognosis.
- **Hemineglect** (may occur with either left or right parietal lesions).
- Conjugate deviation of the eyes to the affected side
- Frontal lobe syndrome.
- **Brocca’s** expressive aphasia, agraphia.
- **Wernicke** “sensory” aphasia.
- Contralateral homonymous hemianopia (damage to the optic radiation).
- Anosognosia.

Occlusion of the main Posterior Cerebral Artery

- **Unilateral Lesion of occipital lobe:** **contralateral homonymous hemianopia** with **macular sparing** due to the occipital pole receiving collateral blood supply from the middle cerebral artery.
- **Bilateral Lesion of occipital lobe:** **cortical blindness** (pupils are reactive to light).
- **Irritation of occipital lobe:** Visual hallucination.
- Memory deficit (**amnesia**).
- Visual agnosia.
- **Thalamic syndrome.**

Vertebrobasilar Artery Occlusion

1. Ipsilateral pain and temperature sensory loss of the face and contralateral pain and temperature sensory loss of the body
2. Attacks of hemianopia or complete cortical blindness.
3. Bulbar syndrome.
4. Vertigo, nystagmus, nausea, and vomiting
5. Ipsilateral Horner syndrome
6. Ipsilateral ataxia and other cerebellar signs
7. Unilateral or bilateral hemiparesis
8. Coma



The Cerebro-Spinal Fluid

Definition: it is the fluid which circulates in the ventricles and central canal of the CNS and also fills the subarachnoid space.

Production of the C.S.F.:

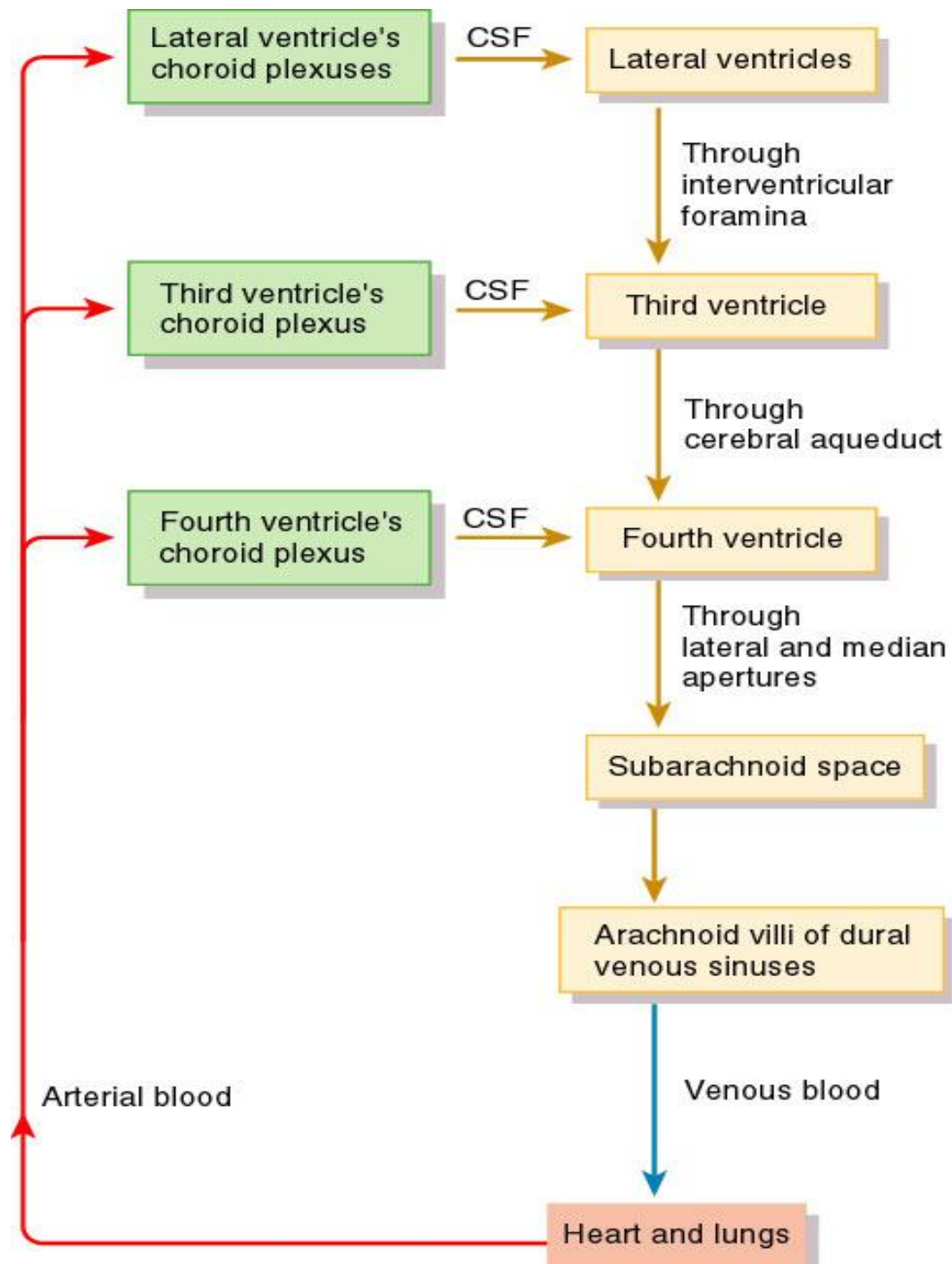
- The C.S.F. is secreted by the ependymal cells covering the choroid plexuses of the ventricles, mainly the lateral ventricles.
- The ependymal cells extract the CSF from the capillaries and secrete it into the cavity of the ventricles.

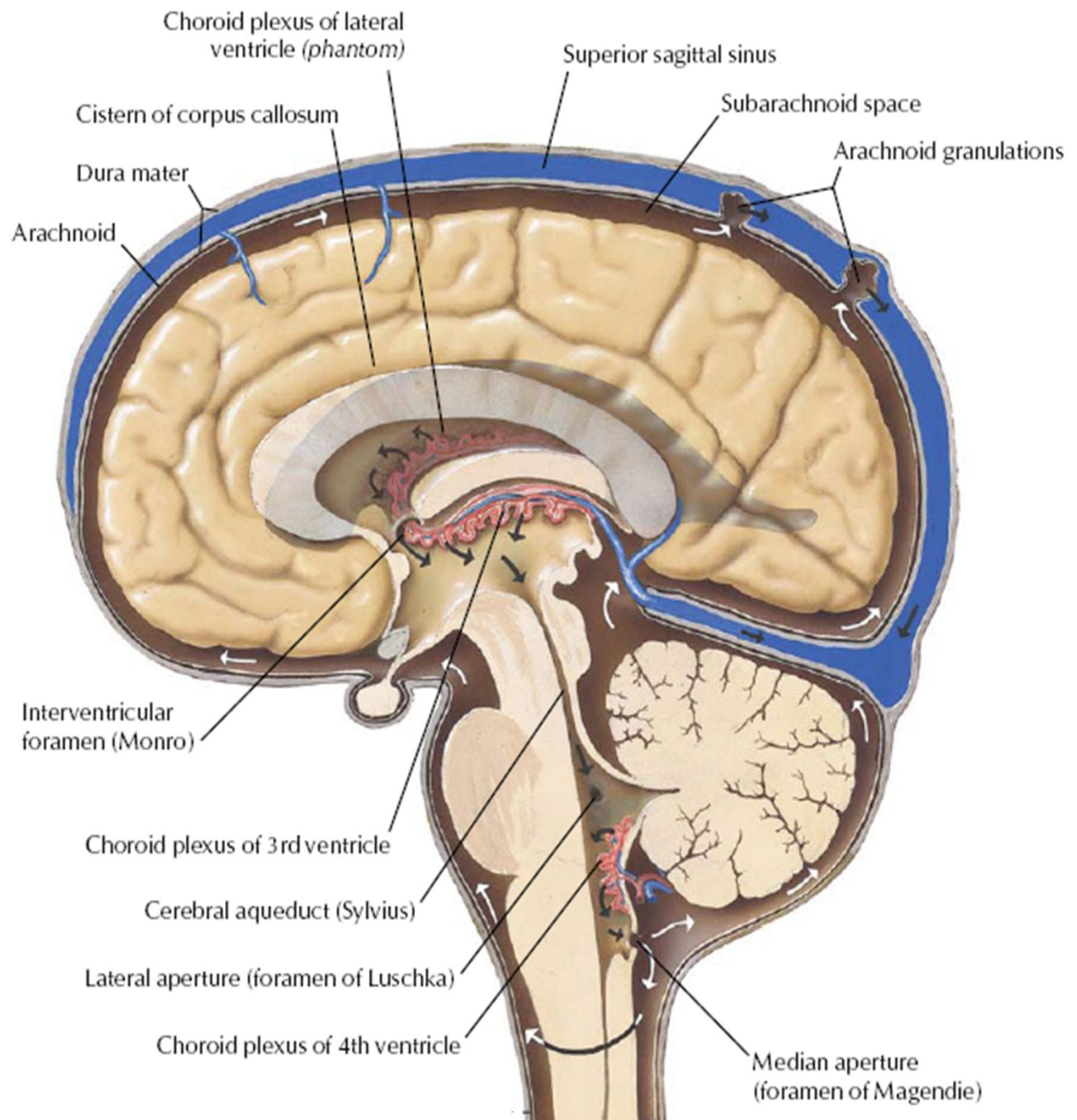
Formation of Cerebrospinal Fluid

- **CSF is formed mainly** in the choroid plexuses of the lateral, 3rd & 4th ventricles.
- Some originates from **the ependymal cells** lining the ventricles & from the brain substance through the perivascular spaces.
- The choroid plexuses actively secrete CSF.

Circulation of the Cerebro-Spinal Fluid

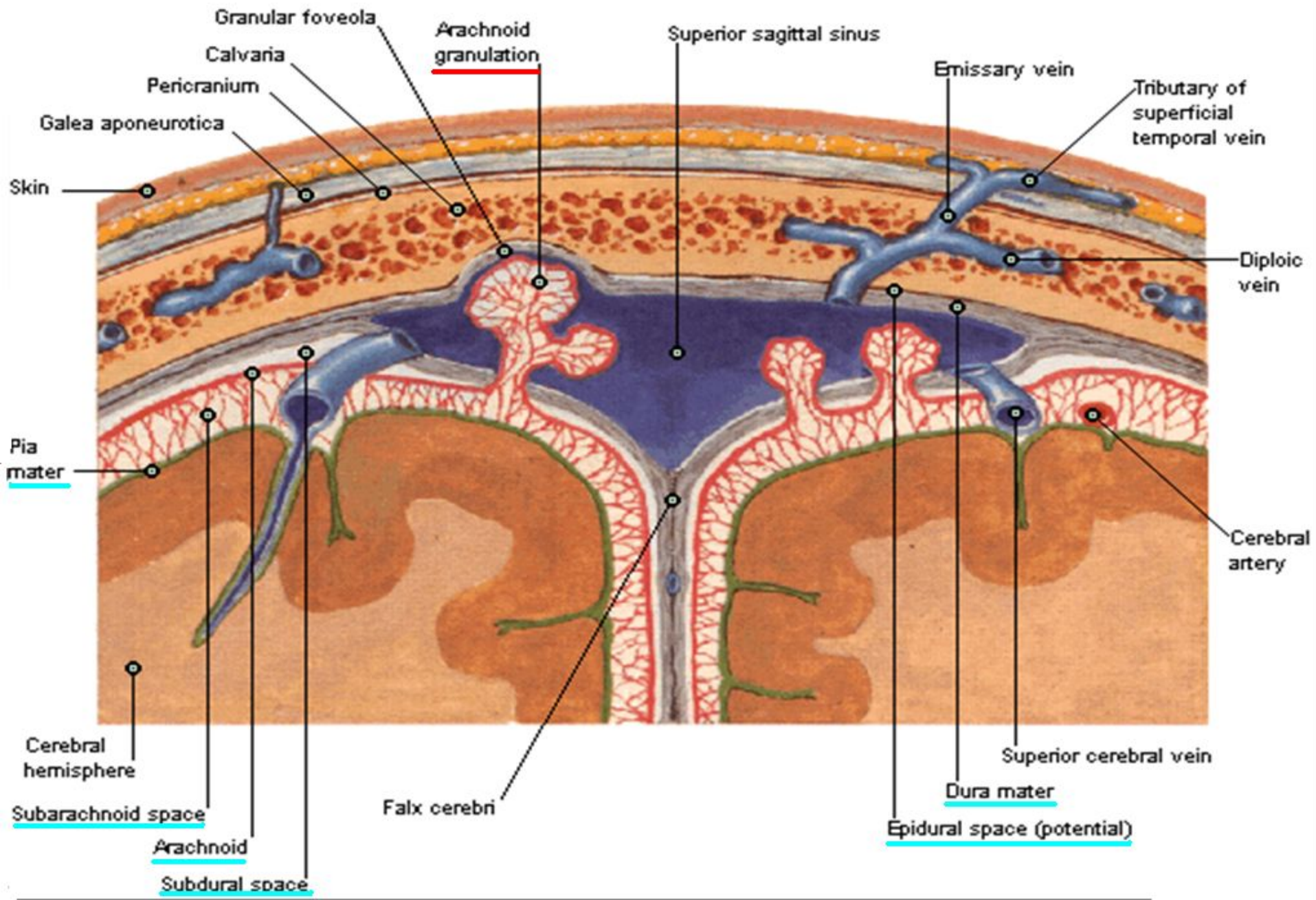
The CSF in each lateral ventricle → interventricular foramen of
Monro → third ventricle → aqueduct of Sylvius → fourth
ventricle → some fluid enter the central canal of spinal cord but
the majority passes through the 3 foramina (one median of
foramen Magendie to cerebellomedullary cistern of
subarachnoid space & two lateral foramina of Luschka to
pontine cistern of subarachnoid space) → subarachnoid space
where it flows over the surface of the brain and spinal cord.





Absorption of the Cerebro-Spinal Fluid

- The CSF circulates in the subarachnoid space.
 - Absorbed by **arachnoid villi and granulations** which absorbs the C.S.F. from the subarachnoid space into the dural venous sinuses, **especially the superior sagittal sinus** to reach the blood stream.



Functions of the Cerebro-Spinal Fluid

1. Support and protects the CNS against trauma.
2. It takes the place of the lymph in the CNS which is devoid of lymphatic vessels.
3. Regulation of the intracranial pressure.
4. Removes metabolites and toxics from the central nervous system.
5. Nourishes the central nervous system.

Characters of the Normal Cerebro-Spinal Fluid

- **Appearance:** clear watery fluid, isotonic.
- **Amount:** 100- 150 ml.
- **Replacement:** it continuously produced and absorbed at a rate of 400-500 ml daily (it is replaced 3 times per day).
- **Pressure:** 100-180 mm of water.
- **Rate of production:** 0,3-0,4 ml/min.
- **Cells:** 0-5 WBCs per cubic millimeter.
- **Glucose:** 60 mg/dl (70% of serum glucose).
- **Total protein:** 15-45 mg/dl.

Formation of CSF by the Choroid Plexus Epithelium

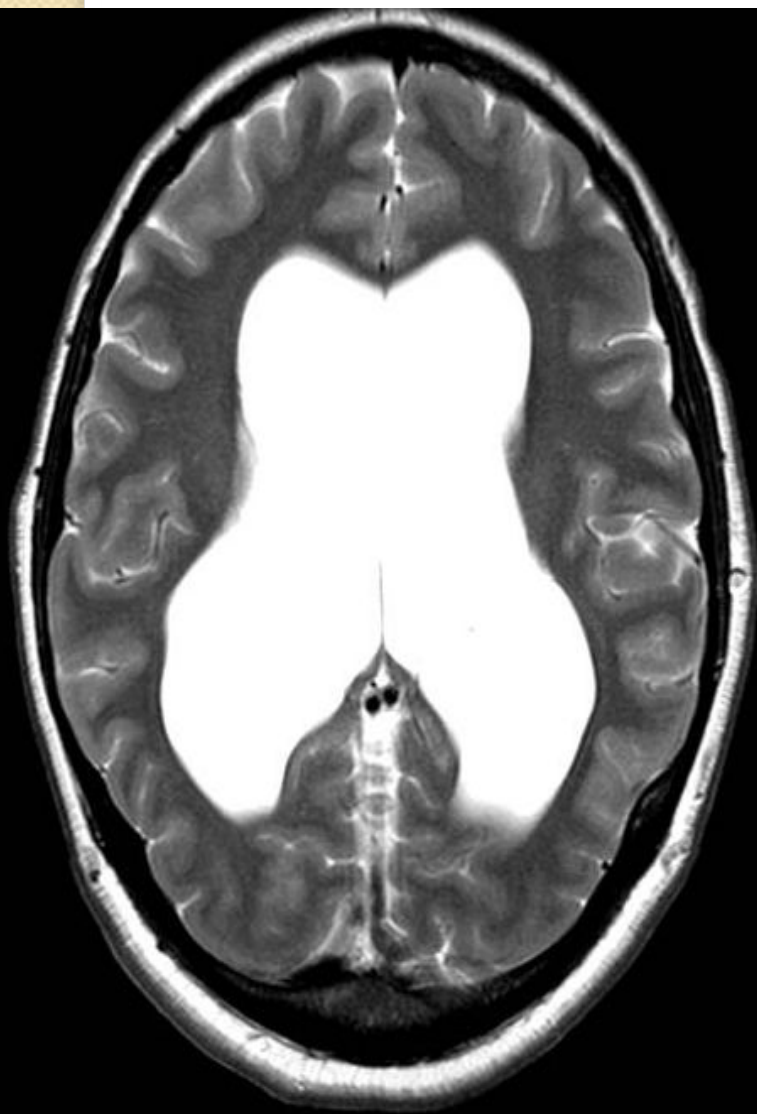
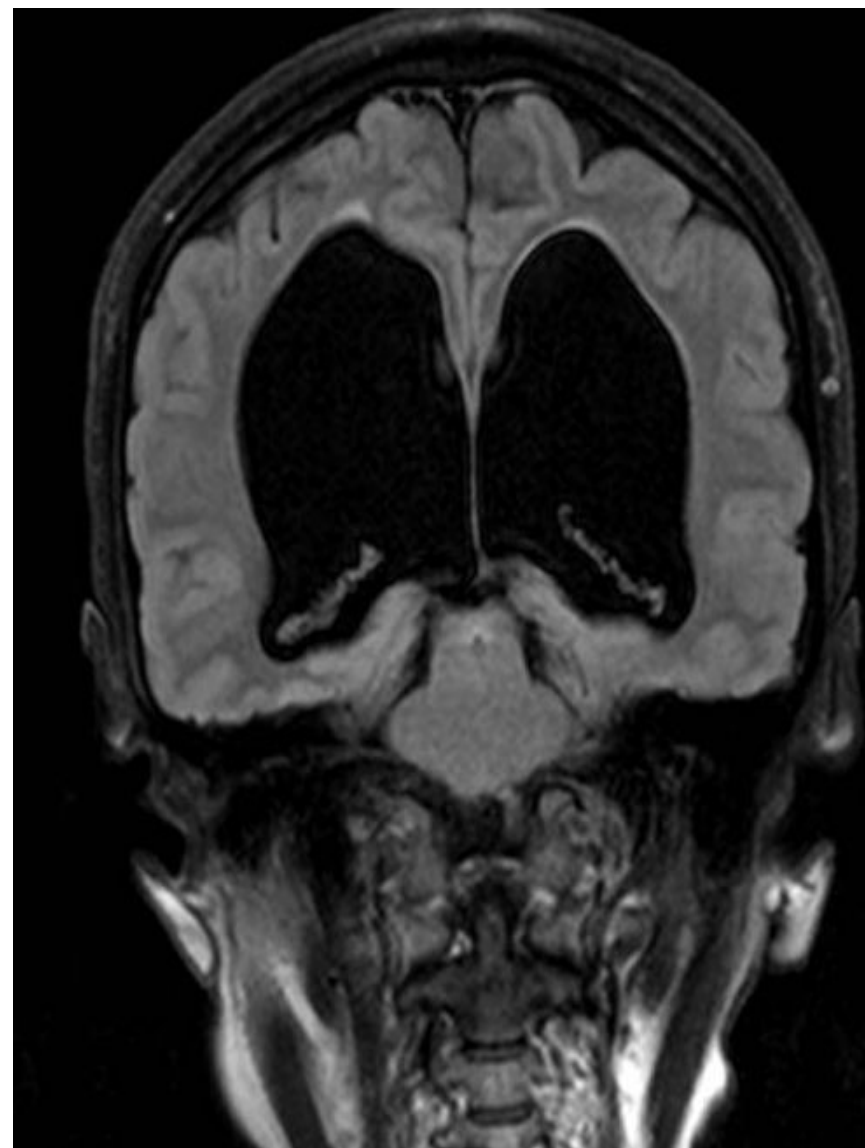
- Lipid-soluble substances (CO_2 and O_2) and H_2O freely cross the blood–brain barrier and equilibrate between blood and CSF.
- **Protein** and **cholesterol** are **excluded** from the CSF because of their **large molecular size**.
- Other substances are transported by carriers in the choroid plexus epithelium.
- They may be secreted from blood into the CSF or absorbed from the CSF into blood.

CSF Sampling

- **To analyse the constituents of the CSF:**
 - Meningitis
 - Malignant disease
 - Multiple sclerosis and other neurological diseases
- **To remove CSF to reduce intracranial pressure:**
 - For Surgical access
 - Pseudotumor cerebri

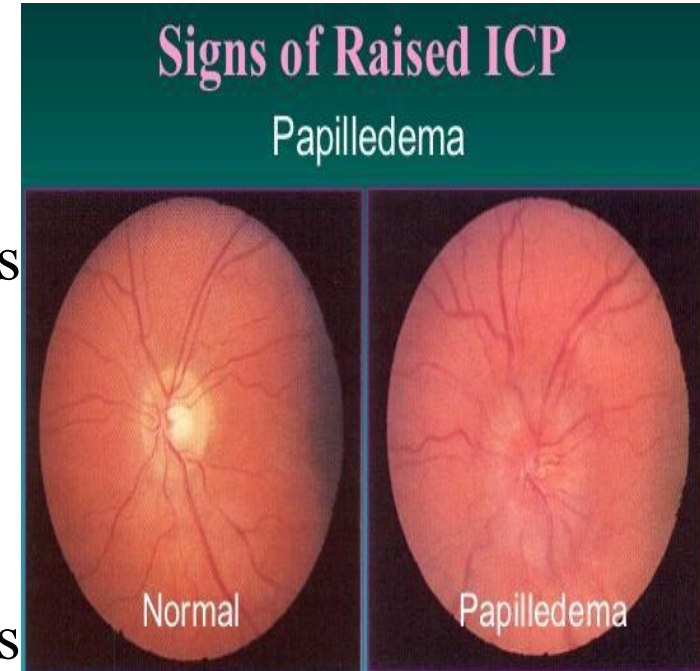
Hydrocephalus

- **Definition:** Distension of the ventricular system (Ventriculomegaly) due to inadequate passage of CSF from its point of production to the point of absorption”.
- **3 causes:**
 1. Choroid plexus papilloma: Rarely over-secretion of CSF.
 2. Can be from Obstruction to flow of CSF from the ventricles into the subarachnoid Space (**Obstructive**)
 - Masses in ventricles or adjacent brain.
 - Developmental membranes or stenosis of aqueduct.
 3. Can be from failure of absorption (**Communicating**)
 - Failure of the absorbing mechanism usually after a change in CSF contents e.g. acutely after Meningitis or SAH, Chronically also. Cryptogenic, congenital



Raised CSF Pressure & Papilledema

- The optic nerves are surrounded by sheaths derived from the pia mater, arachnoid mater, and dura mater.
- A rise of CSF pressure will compress the thin walls of the retinal vein.
- This will result in congestion of the retinal vein, bulging forward of the optic disc, and edema of the optic disc (papilledema).
- Persistent **papilledema** leads to **optic atrophy and blindness**.



Thank You

