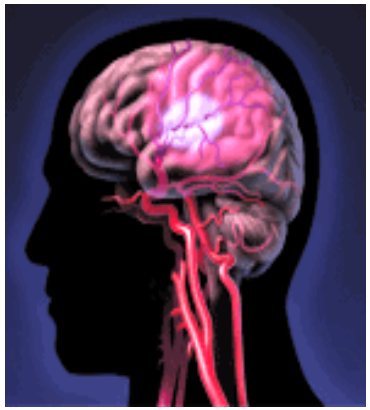
Khalleedd✅



Lecture:

Physiology of Brain Circulation & CSF Formation

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في بداية المحاضرة حاولو ازا عندكم معمة وبدكم تركزوا فيها عتمو الاضاءة حواليكم باختصار بدون م نفوت ب تفاصيل
لاني مش طايق حالي صراحة .بيقلك انو الاضاءة بتعمل constriction of the pupil وهاد بيعمل
parasympathatic effect
كل هادة كلام شحاتيت قوم اطفي الضواو وادرس كانك بتحضر فيلم ع نتفليكس

Cerebral Blood Flow

Brain consumption about 20-25% of CO → Fifth of the cardiac output.

- **Cerebral blood flow (CBF):** is the blood supply to the brain in a given time.
- In an adult, CBF is typically **750 ml/min.**

Regional blood supply

- **50-54 ml** of blood per 100 g of brain tissue per min.

Normally.

- **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).** And take 1/5 of CO → So its a very important organ.
- **Consumes:**
  - ✓ **"15-20% O_2"** of the total cardiac output.
  - ✓ **25% glucose**
- Able to respond to variations in demand.

الدم الواصل اله
يعني باختصار بيعرف يتأقلم على ظروف أقل من الطبيعي، بس لدرجة معينة طبعاً

By a way called autoregulation

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.

مجموعة الأشياء الي بتتحكم بال autoregulation

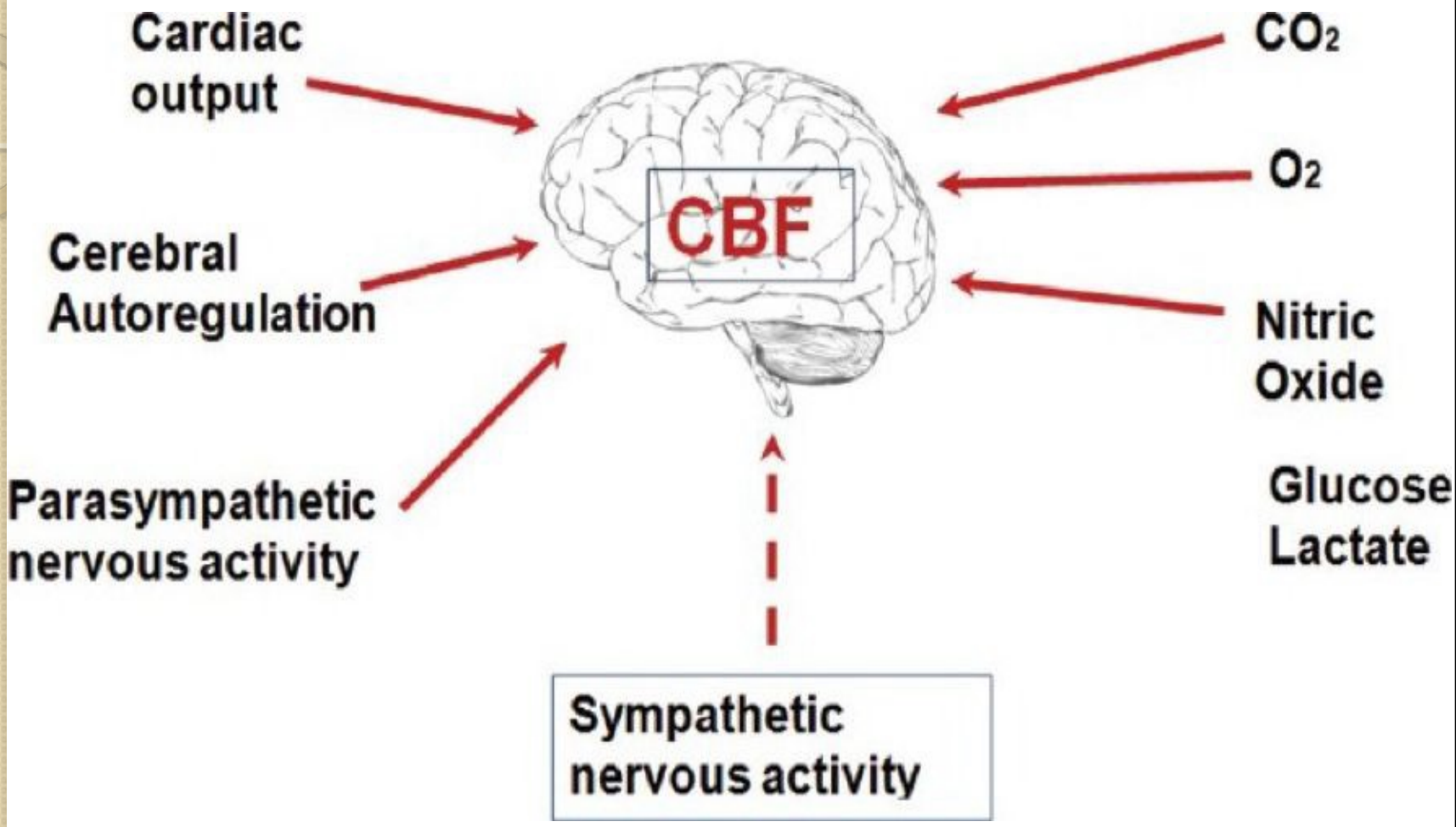
❑ Physiological Mechanisms of Autoregulation:

- Myogenic/Arterial blood pressure. By VC+VD
- Chemical:
  - ✓ Arterial partial pressure of carbon dioxide **"PaCO2"**.
  - ✓ Arterial partial pressure of oxygen **"PaO2"**. Decreased O2 cuz VD, Increased O2 cuz VC
- Metabolic regulation. Glucose — Hyperglycemia cuz VC, Hypoglycemia cuz VD
- Neurogenic regulation. Sympathetic + parasympathetic

معلومة حلوة تعرفها انهم بيستخدمو الفكرة هاي في انه لو اجت على ال icu حالة brain edema بنخطهم على mechanical ventilation with hyperventilation علشان اعمل VC وبهيك بمنع ال brain edema

الفكرة انو ال brain بدو يحافظ على ال Blood flow
ارتفاع ال BP بدو يعمل VC
انخفاض ال BP بدو يعمل VD
وكله في سبيل منع حصول ال brain edema

Factors Affecting Cerebral Blood Flow



Myogenic / Arterial Blood Pressure

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

بس بدي عشان يكون كلو تمام تفهمو الفرق بين ضغط الشريان وال blood flow وانو الي بيهمني انو احافظ على ال CBF وال perfusion for tissue
في مثال انو الضغط نازل يعني الدم الي بيوصل النسيج قليل ف انا بدي ازوده ف بدي اوسع الشرايين
والعكس في حالة الضغط العالي

Arterial Blood Pressure

- **Cerebral Perfusion Pressure (CPP)**
  - **CPP** = MAP – ICP

MAP = Mean Arterial Pressure

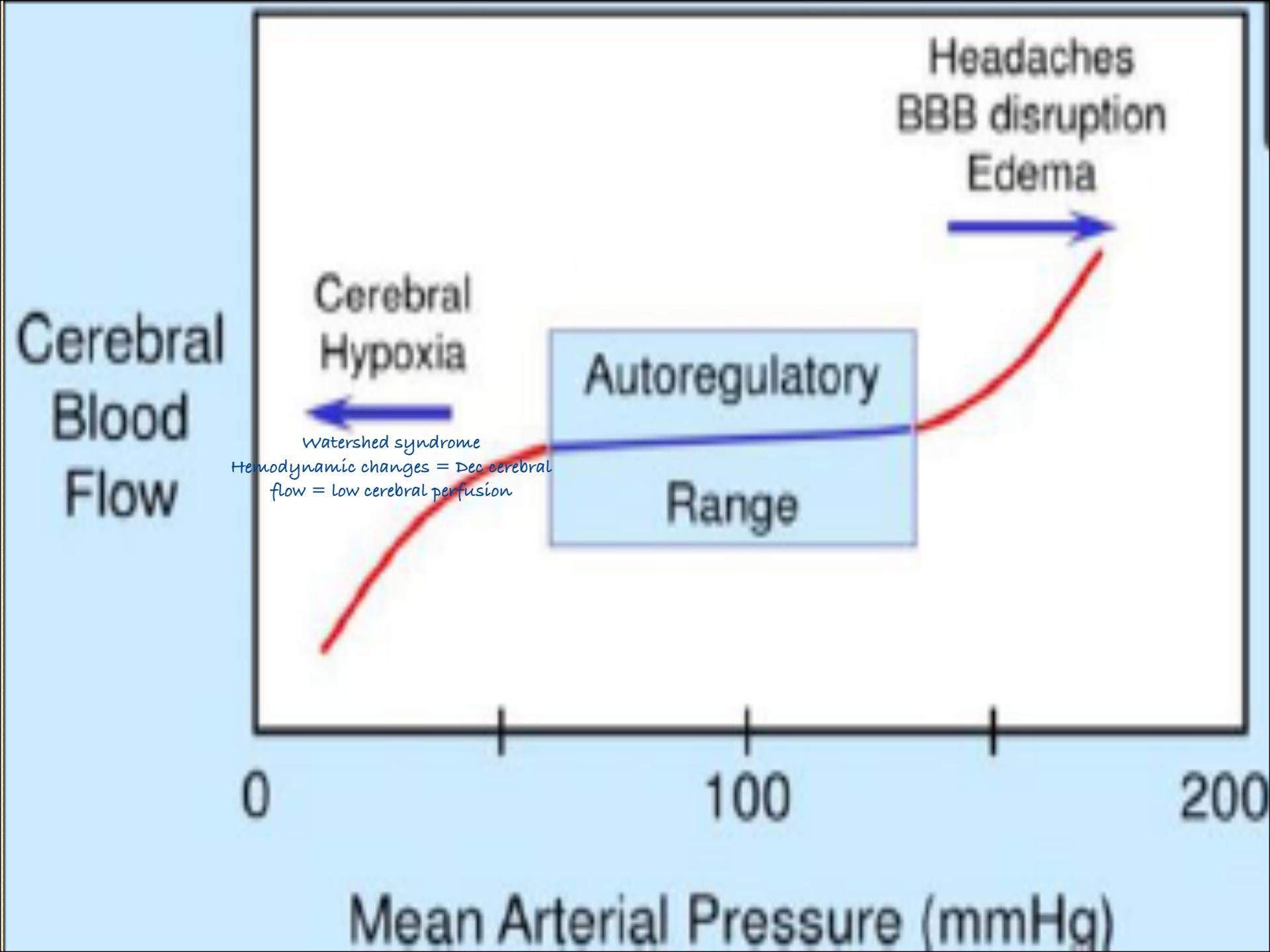
ICP = Intra Cranial Pressure

  - **ICP** – can be measured directly.
- **MAP:** pushes blood into the brain.
- Intracranial Pressure **(ICP)**.
  - **MAP** = Diastolic pressure + 1/3 Pulse pressure.

Sys-dias

  - **Pulse pressure =** Systolic BP – Diastolic BP.
    - Eg. BP =140/80, **MAP** = 80 + 20 = 100 mmHg

1/3 *60


Headaches
BBB disruption
Edema
Cerebral
Hypoxia
Cerebral
Blood
Flow
Autoregulatory
Range
Watershed syndrome
Hemodynamic changes = Dec cerebral
flow = low cerebral perfusion
0
100
200
Mean Arterial Pressure (mmHg)

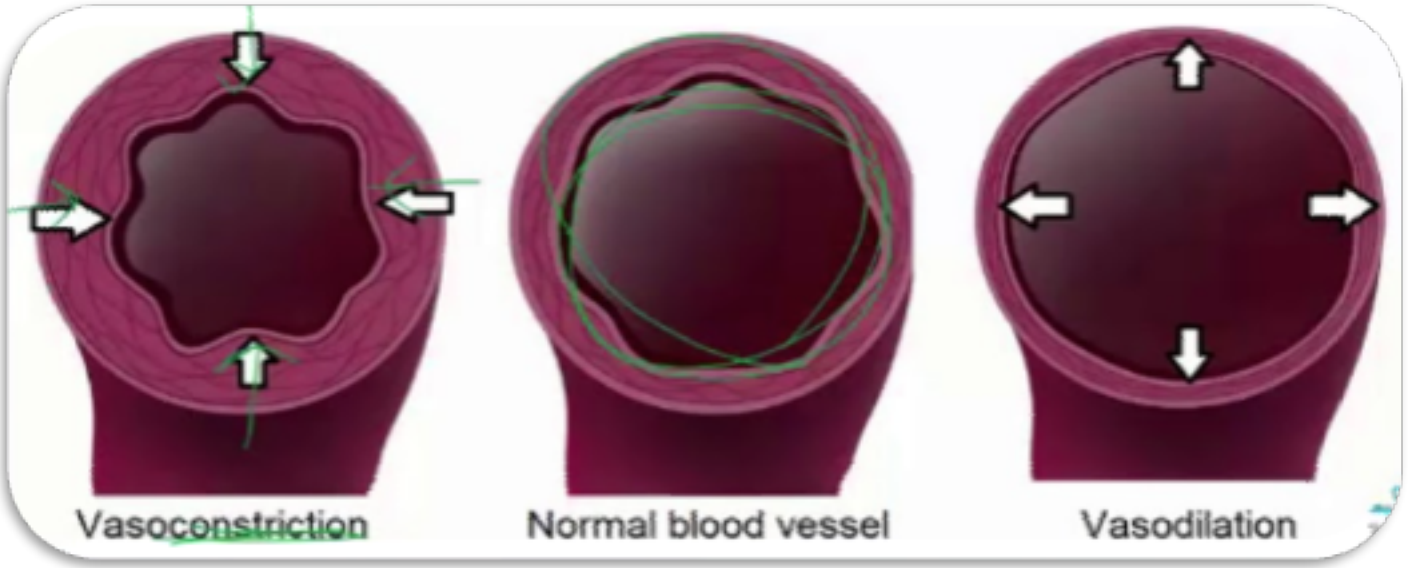
Cerebral Blood Flow

- **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 Treat the brain edema

  "Hyperventilation used for management of brain oedema".
- **Depression of PaO_2, "Hypoxia":** leads to vasodilatation "High ICP".



Arterial Blood Pressure Autoregulation

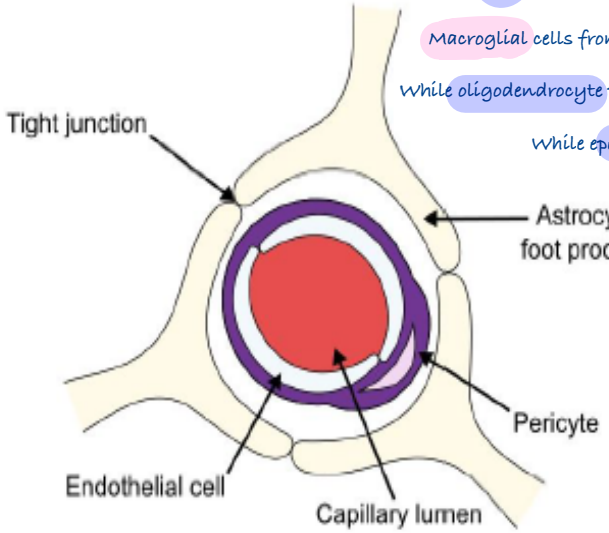
- **Baseline CBF:** 50 54 ml/100g/min
- **Critical ischemic threshold:** 20 –25 ml/100g/min
  Less than it is very dangerous
- **Severe Hypertension:** High BP
  - Damage to blood brain barrier.
  - Risk of cerebral oedema and acute hypertensive encephalomalacia due to vasodilation.
    المفروض مع زيادة الضغط يحصل VC

Neurogenic Autoregulation

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

The Blood–Brain Barrier

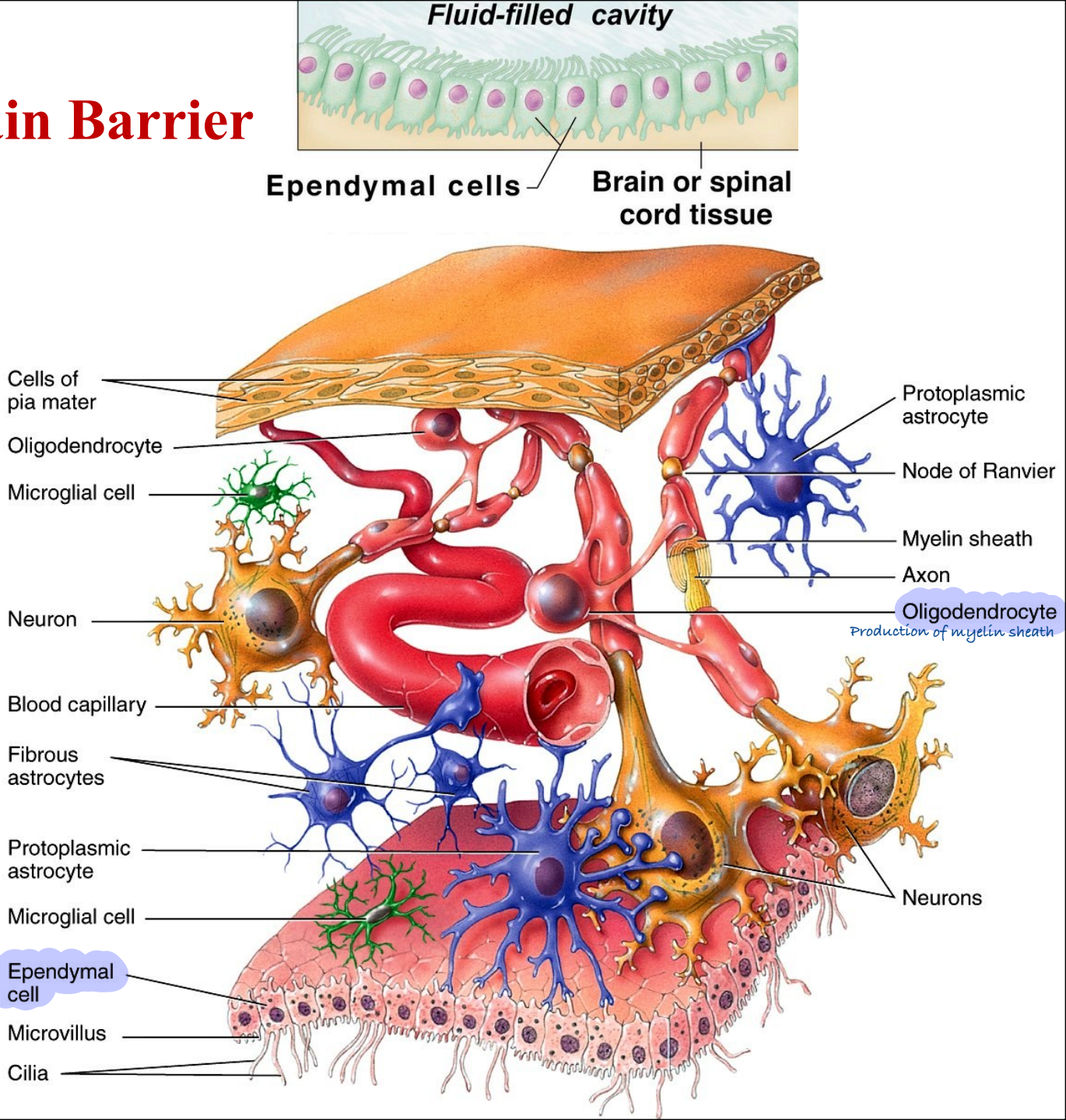
- It is the barrier between cerebral capillary blood, the CSF and brain tissue.
- CSF fills the ventricles and the subarachnoid space.
- It consists of the **endothelial cells of the cerebral capillaries** and the **choroid plexus epithelium.**



Macroglial cells from ectoderm 3 types astrocyte, ependymal, and oligodendrocyte
The astrocyte world as BBB
While oligodendrocyte produce myelin sheath and impaired in multiple sclerosis, it work as Shawn cells in PNS
While ependymal cells in choroidal plexus and produce CSF

Microglial cells from mesoderm and distributed through work as protection against infection and microorganisms and remove waste products inside the brain to the CSF

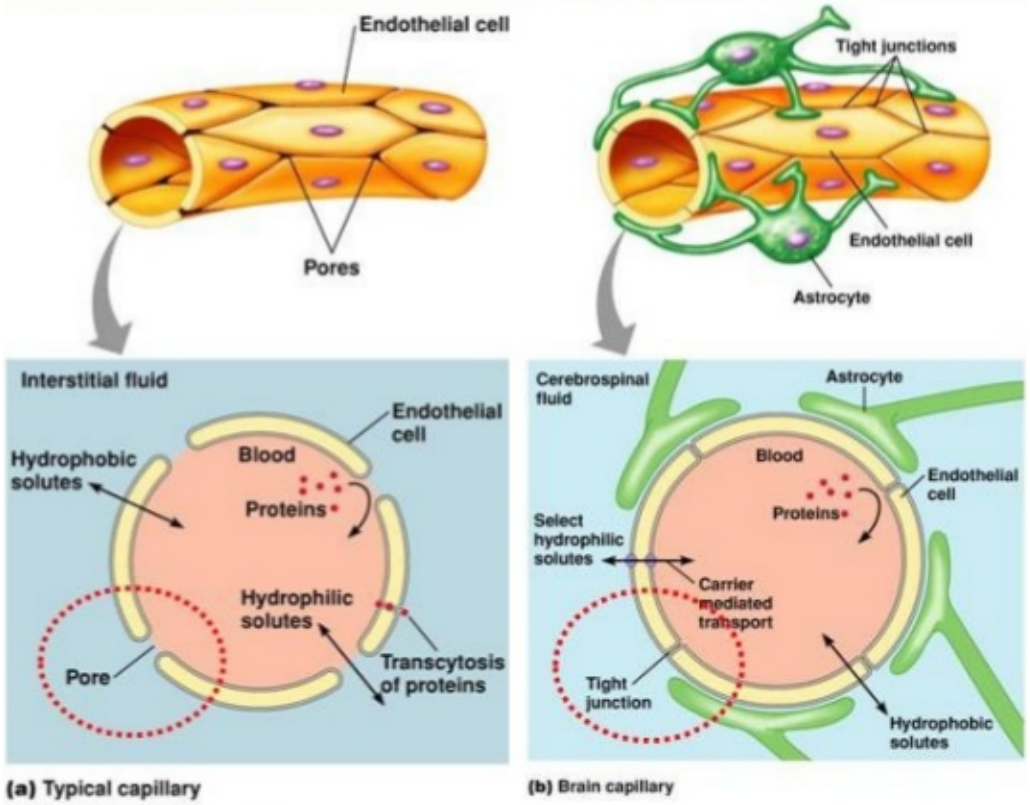
Blood-Brain Barrier



Blood-Brain Barrier

Can Pass	Cannot Pass
• Glucose (via transport proteins). • Lipid-soluble substances. • O_2, CO_2, alcohol, anesthetics.	• 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** (Cell bodies) in the CNS and protects the brain from endogenous (Metabolic and waste products.) or exogenous (That came from outside) toxins.
2. **It prevents the escape of neurotransmitters** (ما الهم اي وظيفة واهمية برة ال CNS في الطبيعي انهم ما يطلعو ويعدو ال BBB) from their functional sites in the CNS into the general circulation.
3. **Drugs penetrate the blood**.

(عشان تحدد مين ال drugs اللي مسموح انها تعمل penetration وتعدي ال BBB وتفوت ال CNS)

Development of BBB

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

الي بينولدوا على عُمر سبع او ثمن شهور

Bilirubin is a toxic material

هاي ليش حكينا عنها necli وما حكينا عنها ganglia
اقلكم الفرق .الاشي ما بسميه داخل الCNS بطلق عليه اسم nucli .اما الاشي بال PNS بطلق عليه اسك تاني عادي

And cause cerebral palsy with hyper kinetic type
بتكون رقبته مرتفعة لفوق الاكتور مثلها تمثيل

Ganglia is nerve cells located outside the CNS

هيك خلصت جزئية الفسيو وضايل الاناتومي الله يعينكم ،وأروى الله يسعدها بعتت انو بكرة ما عنا دوام ف انا بدي اسحب عليها من هان للمسا

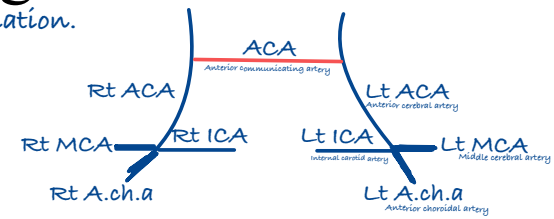
Blood Supply of the Brain

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

1. **Internal carotid system:** Right & Left internal carotid arteries (ICA).

Arise from common carotid a.
Rt from brachocephalic a.
Lt from arch of aorta directly.

Supplies about 80% of cerebral blood flow and called ant. Circulation.



2. **Vertebro-basilar system:** Right & Left vertebral arteries (VA).

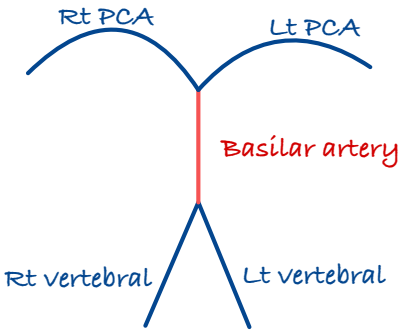
Also called cerebral a.

Arise from Rt and Lt vertebral a.

Supplies about 20-25 % of the cerebral blood flow and called post. Circulation.

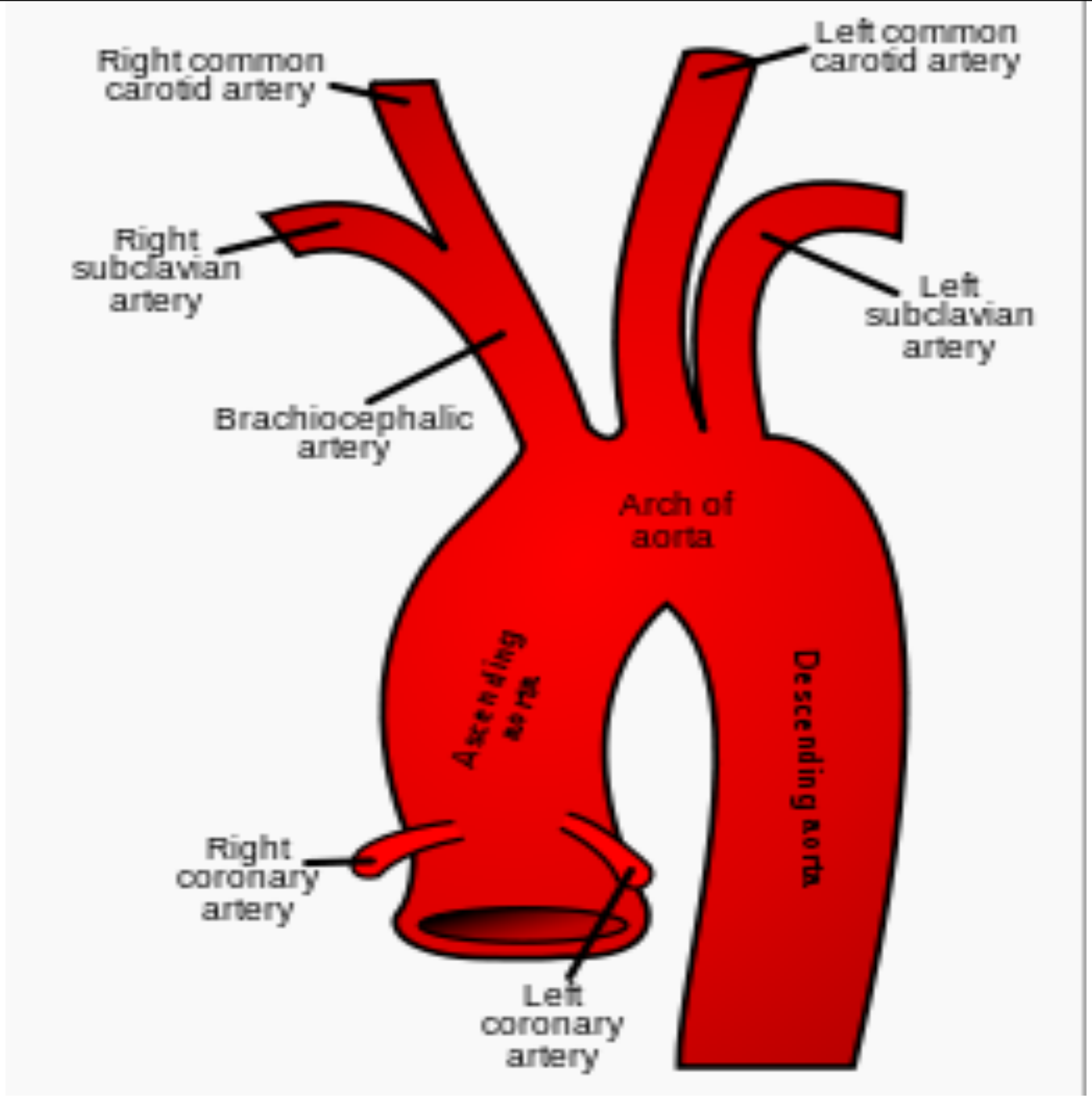
Cuz it supplies cerebellum occipital lobe brain stem

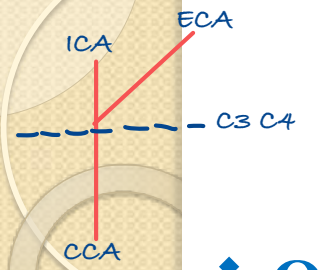
Rt PCA + Lt PCA بينقسم لتسمين Basilar aretery امتداد ال



PCA → posterior cerebral artery

وفائدة الها اهمية كبيرة انه عامل connection between the 2 systems
internal carotid and the vertebro-basilar systems


Right common carotid artery
Left common carotid artery
Right subclavian artery
Left subclavian artery
Brachiocephalic artery
Arch of aorta
Ascending aorta
Descending aorta
Right coronary artery
Left coronary artery

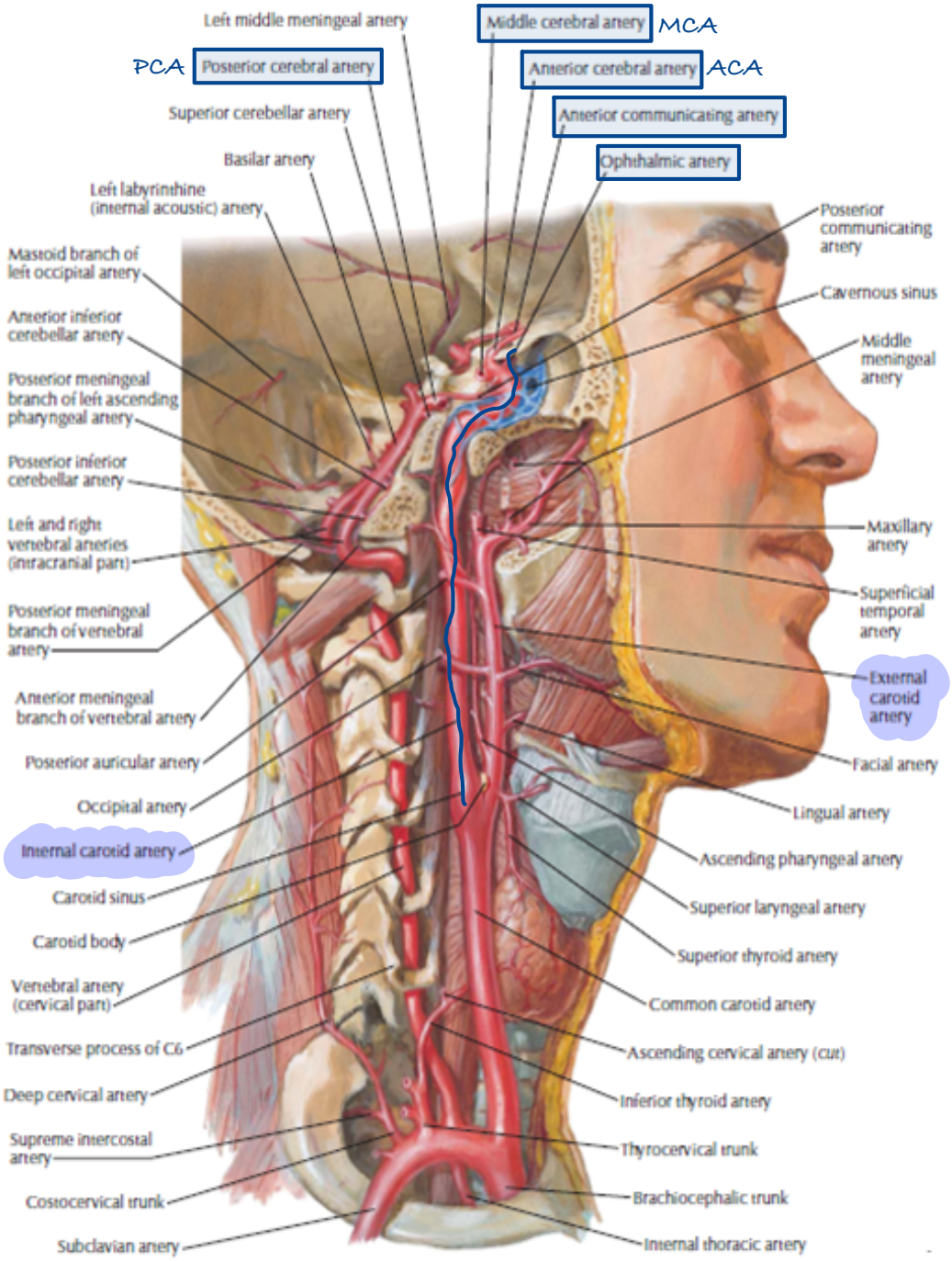


I. The Internal Carotid Artery (ICA)

❖ **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).**

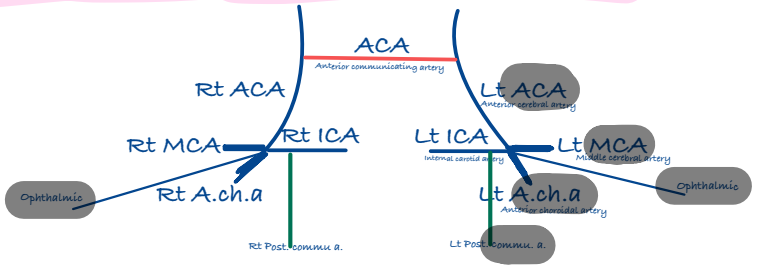
❖ **Function:** the ICA supplies structures in the orbit and a large part of the brain **(70- 80% of the brain blood supply).**

- Each ICA enters the skull through **the carotid foramen.**
- It gives **No branches** at the neck.



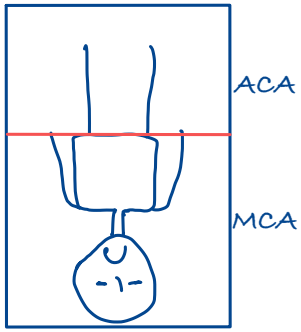
The blue matter is internal carotid artery sympathetic plexus.

Branches of the Internal Carotid Artery



1. **Ophthalmic artery.** 1st branch — Its terminal branch called central retinal artery
2. **Posterior communicating artery.** PCA
   Anastomosis between the vertebro-basilar system and internal carotid system.
3. **Anterior choroidal artery.**
4. **Anterior cerebral artery (ACA).**
   Medial branch
5. **Middle cerebral artery (MCA).** Largest branch
   Lateral branch

Two terminal branches



1. Ophthalmic Artery

- **Ophthalmic artery** which enters the orbit through the optic canal with the optic nerve.
- **Supplies** the eye, orbit contents & gives **central retinal artery.**

Its terminal branch

Supply the Retina (الشبكية) of the eye

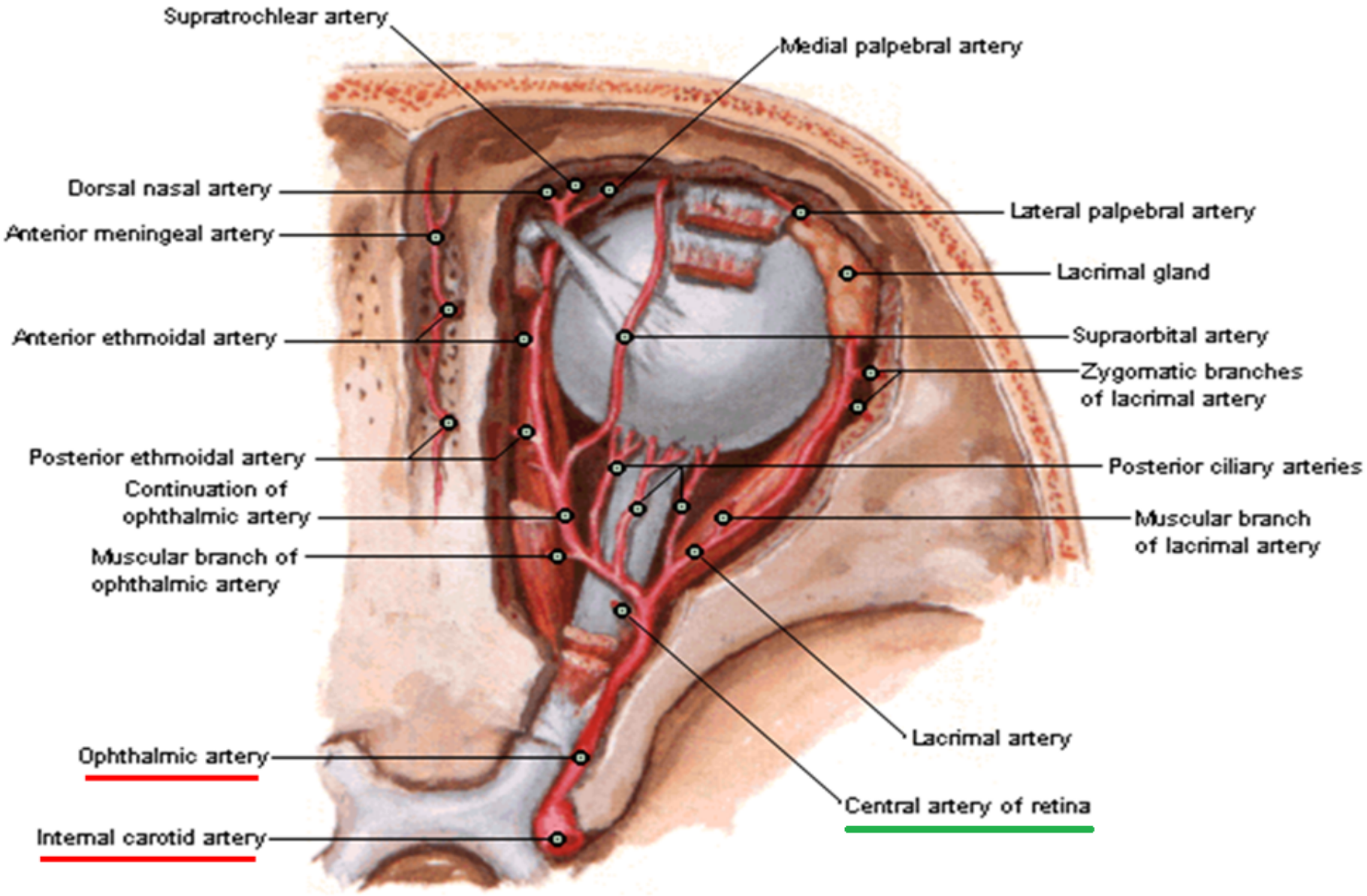
- **Also supplies** the frontal sinuses, part of frontal area of scalp and dorsal part of nose.
- Its occlusion results in **Ipsilateral Blindness.**

Occlusion of central retinal artery

If the occlusion happens to the patient and not treated by anti thrombotic drugs he will face lifelong blind, cuz it has no collateral supply

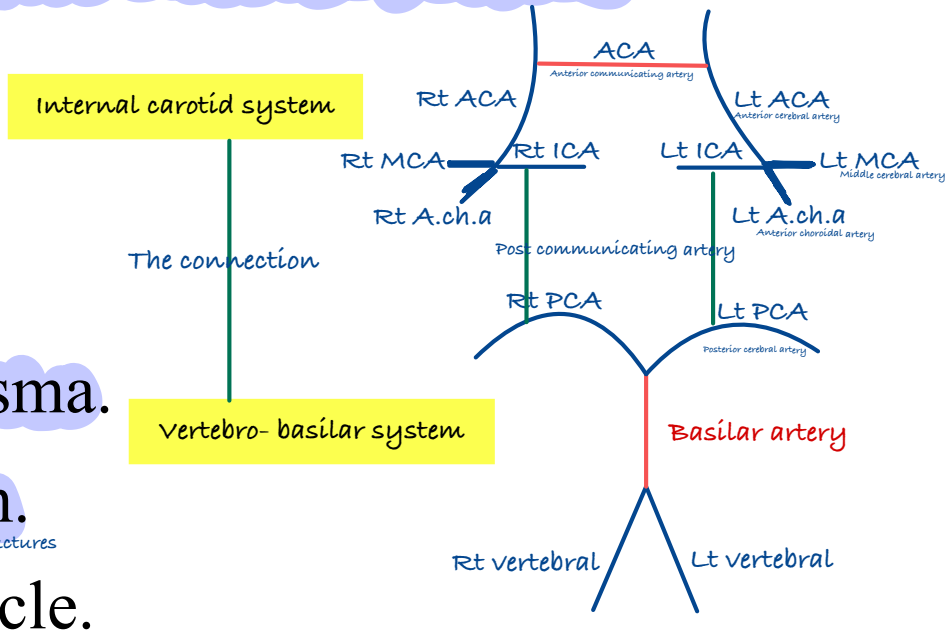
Arteries and Veins of Orbit and Eyelids

Superior View



2. Posterior Communicating Artery

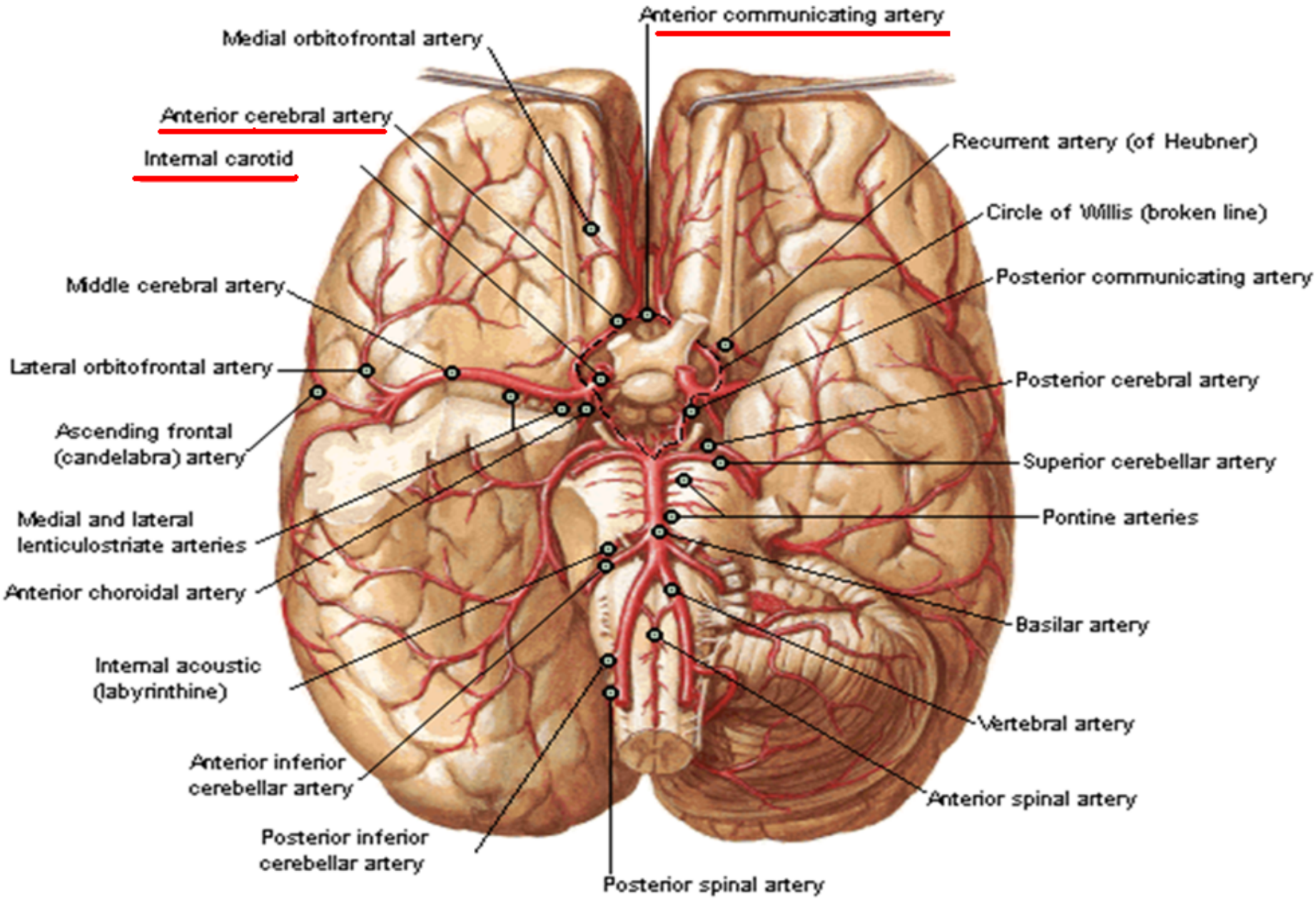
- The posterior communicating artery joints the **ICA** with the corresponding **posterior cerebral artery** to establish **the circle of Willis.**



- **It supplies:**
  - Optic tract and chiasma.
  - Part of diencephalon.
    medially the thalamus and related structures
  - Walls of third ventricle.
  - A common site of **Aneurysms.** 20%
    common sites for aneurysms
    بآخر المحاضرة حنعرف شو انواع وكم نسبة كل وحدة منهم

Arteries of Brain

Inferior View



3. Anterior Choroidal Artery

From its name it supplies the choroidal plexus

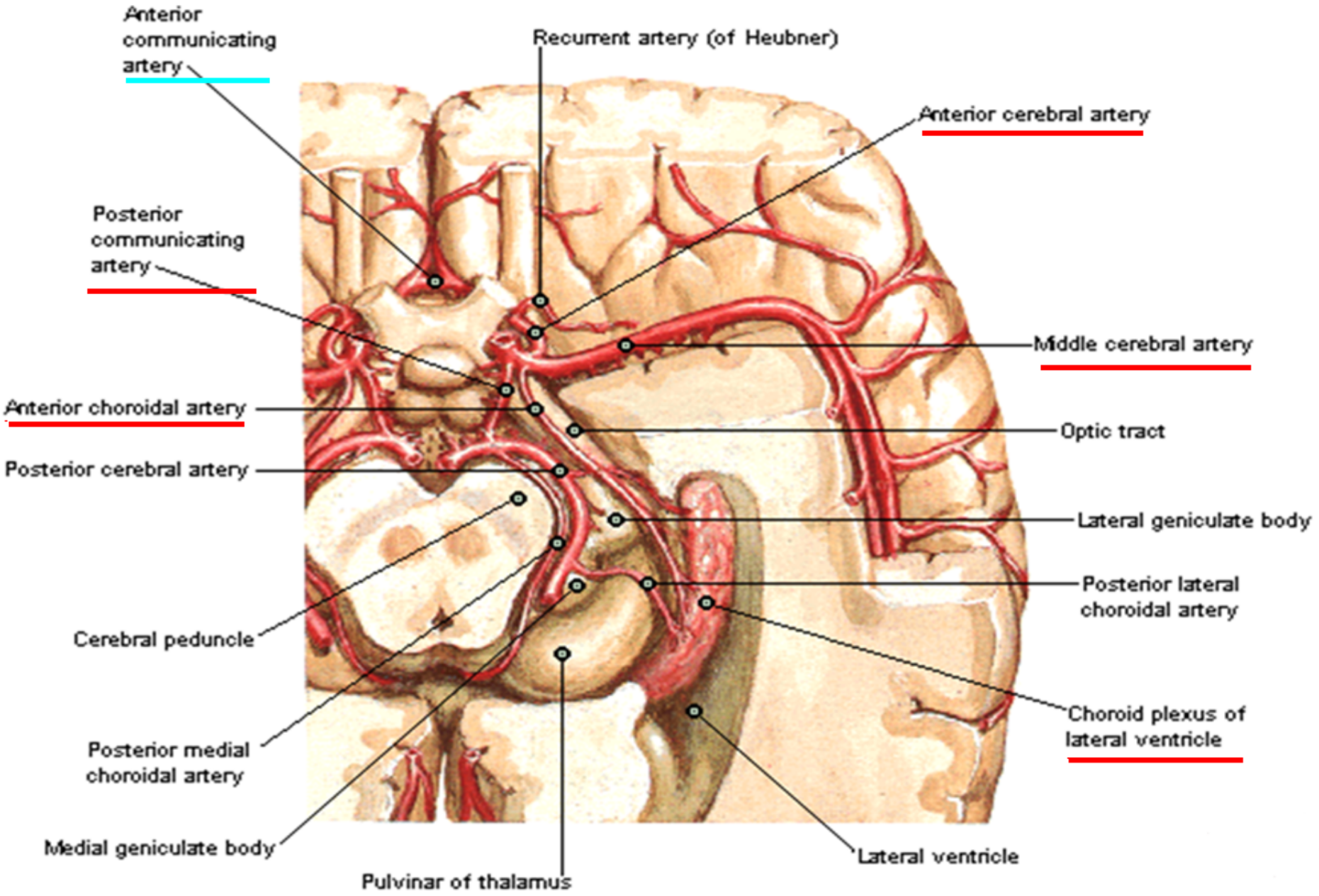
- **Origin:** from the ICA just before origin of the anterior & middle cerebral arteries.

- **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.

Has 3 parts anterior limb, posterior limb, and Genu.

Arteries of Brain [Continued]

Inferior View



4. Anterior Cerebral Artery (ACA)

Medial branch

- 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)**. 40%

➢ **Branches of the ACA:**

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

Territory of Anterior Cerebral Artery (ACA)

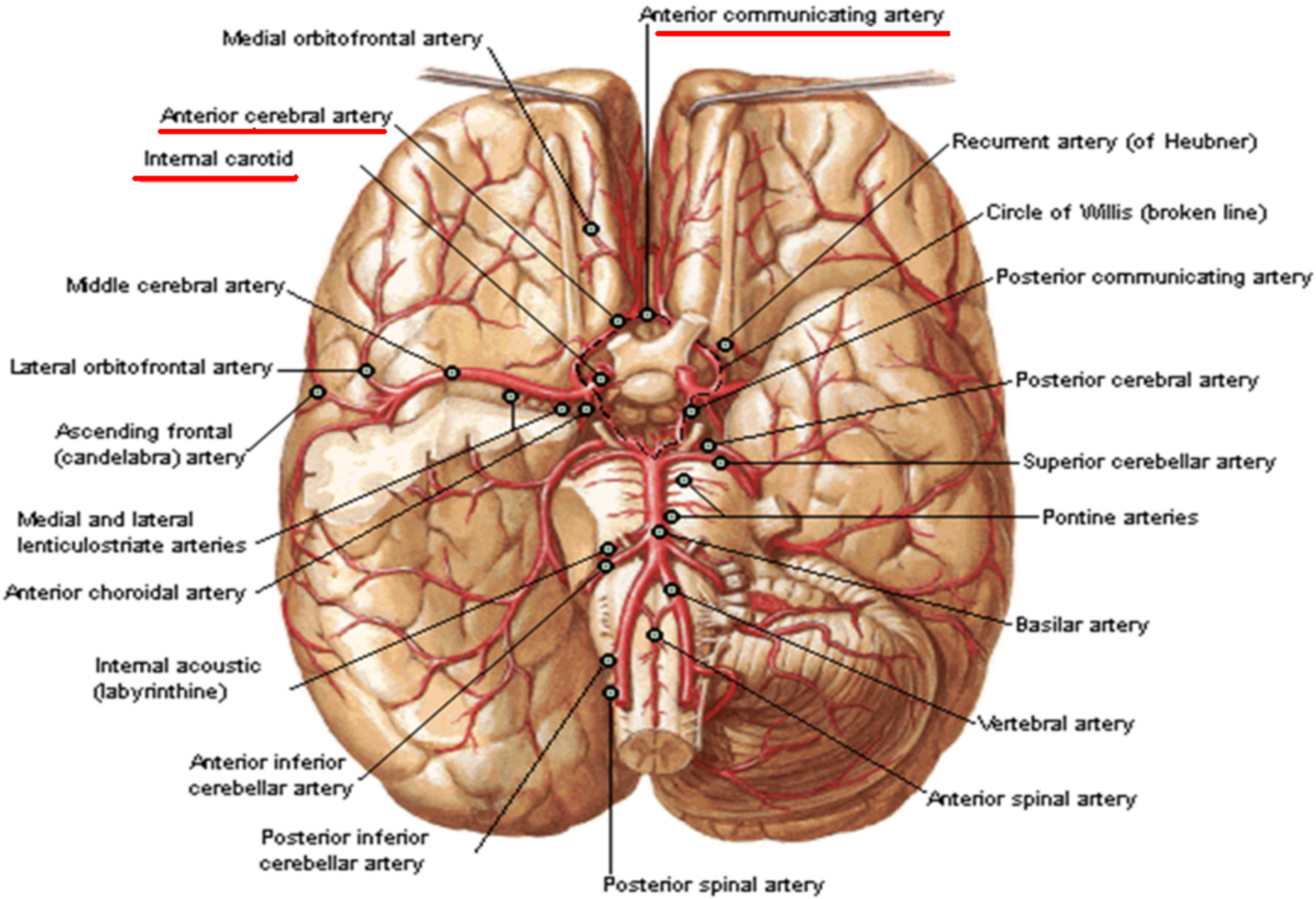
- Medial surface of the cerebral hemisphere from frontal pole to the parieto-occipital sulcus.
- Medial 1/3 of the orbital surface of the frontal lobe.
- Superior lateral surface of cerebral hemisphere **(except occipital lobe).** Supplied by PCA
- Anterior part of lentiform nucleus.
- Head of caudate 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". Lower limb

Supero lateral lobes of the cerebrum

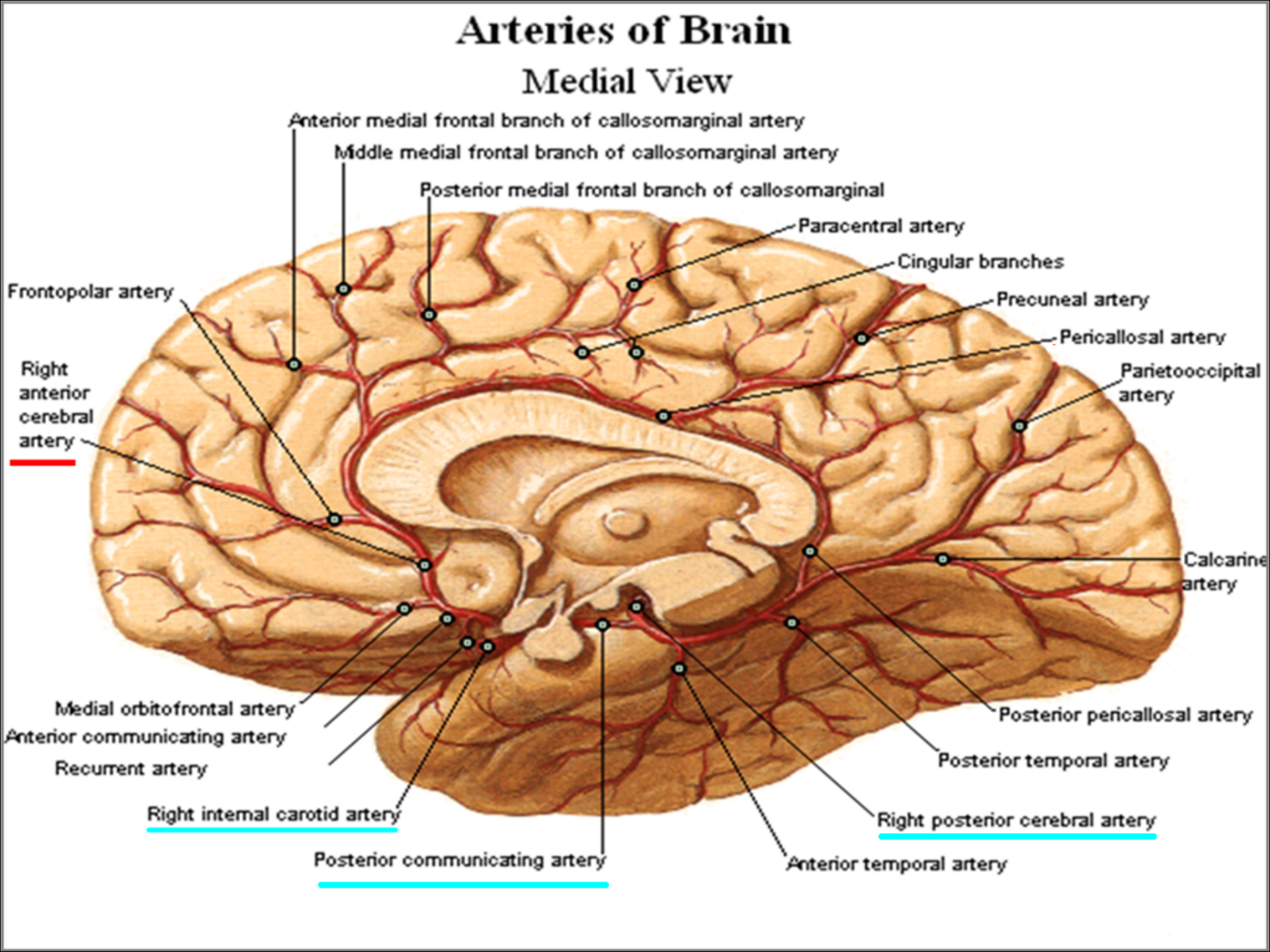
Arteries of Brain

Inferior View



Arteries of Brain

Medial View



5. Middle Cerebral Artery (MCA)

Lateral branch

- The lateral branch as the **largest** of the **2** **terminal branches** of ICA.

MCA and ACA

- It pass laterally in the stem of the **lateral sulcus.**

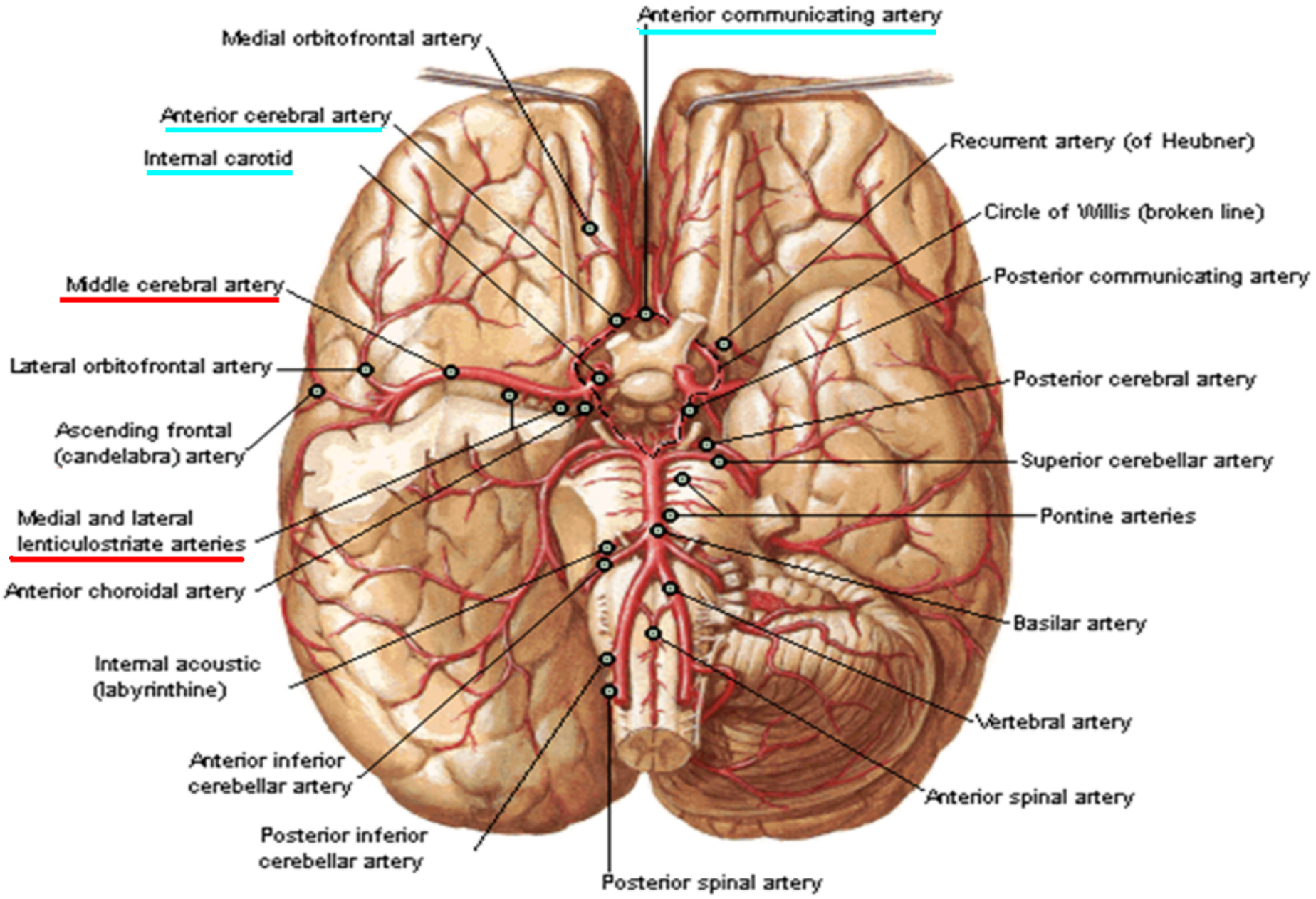
The fissure or sulci that separate the temporal lobe from frontal and parietal lobes

- It turns backwards and upwards in the posterior ramus of the lateral sulcus.
- **Finally it divides into:**
  - **Cortical branches.**
  - **Central branches.**

Striate

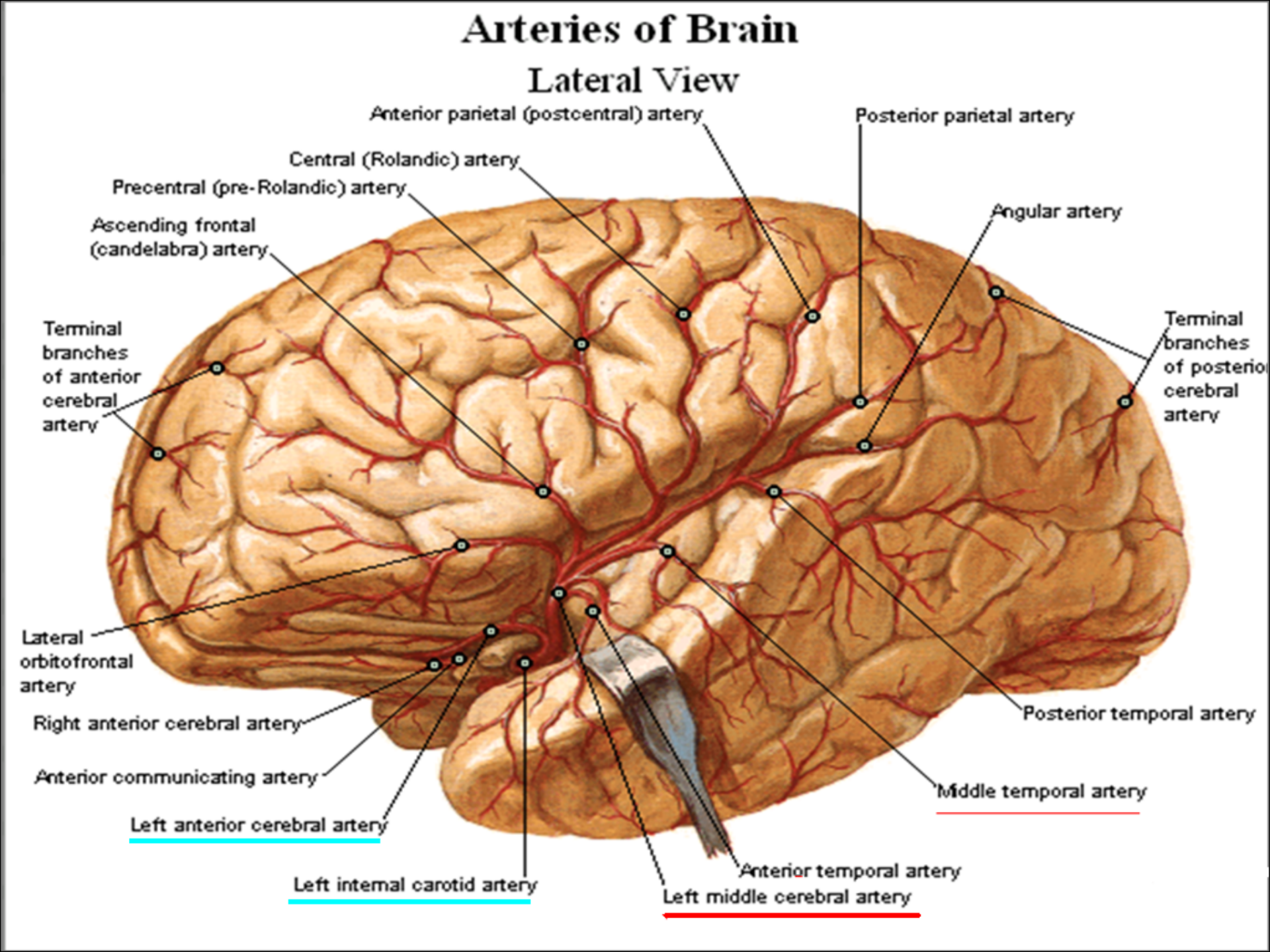
Arteries of Brain

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

Especially lower and middle while upper by ACA and occipital by PCA

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.** Face and upper limbs

Occlusion of MCA will cuz contralateral faciobrachial hemiplegia (hemihypooesthesia)

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

Divided to medial and lateral according to corpus striatum

Short

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).

Except ant. Part of ant. Limb by ACA

Long

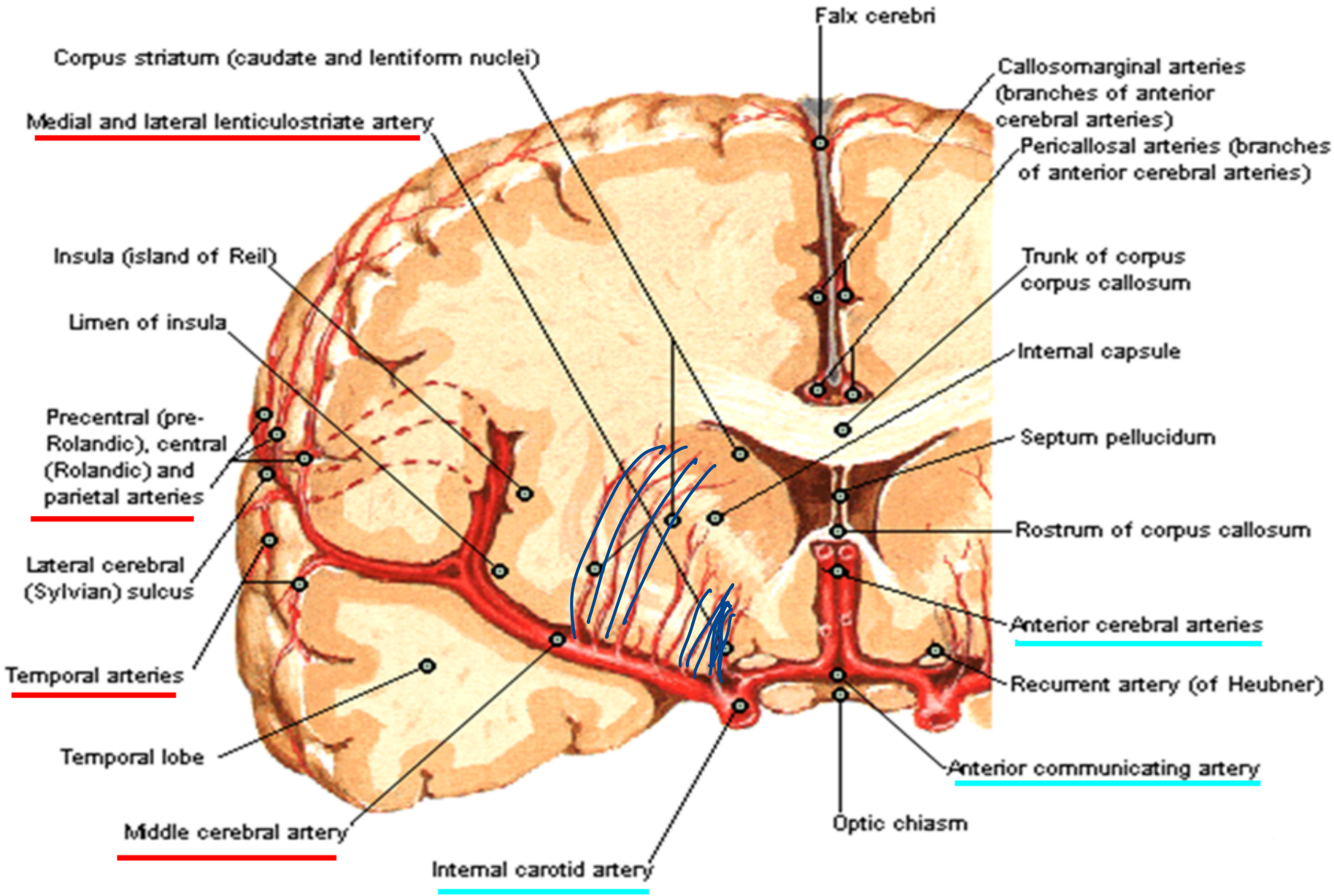
b. Lateral striate arteries: supply:

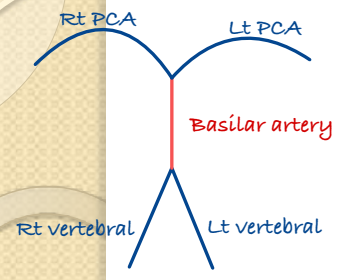
- Corpus striatum (lentiform & caudate).
- Most of the internal capsule.
- One of these arteries is large and is liable to hemorrhage it is called **the artery of cerebral hemorrhage (Charcot's artery).**

طاناخد نيورو كلينيكال حناخد عن ال hemorrhogic stroke وحناخد انو ال intracerebral hematoma سبعين
باطية منعهم بال basal nuclii وبناء ع هاد الكلام في artery اسمه charcots or gemorrhagic artery وهاد
من بنا بيكون ال thin very layer smooth

Arteries of Brain

Frontal Section





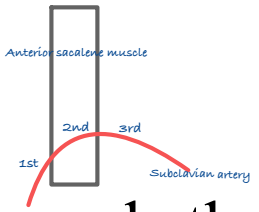
II. The Vertebrobasilar System

A. Vertebral Artery

- **Origin:** each vertebral artery arises from the first part of subclavian artery.

The anterior scalene muscle separates the subclavian to 3 parts.

Medial to the muscle



- Supplies structures of the brain (20- 30% of the brain blood supply).
- **Course:**

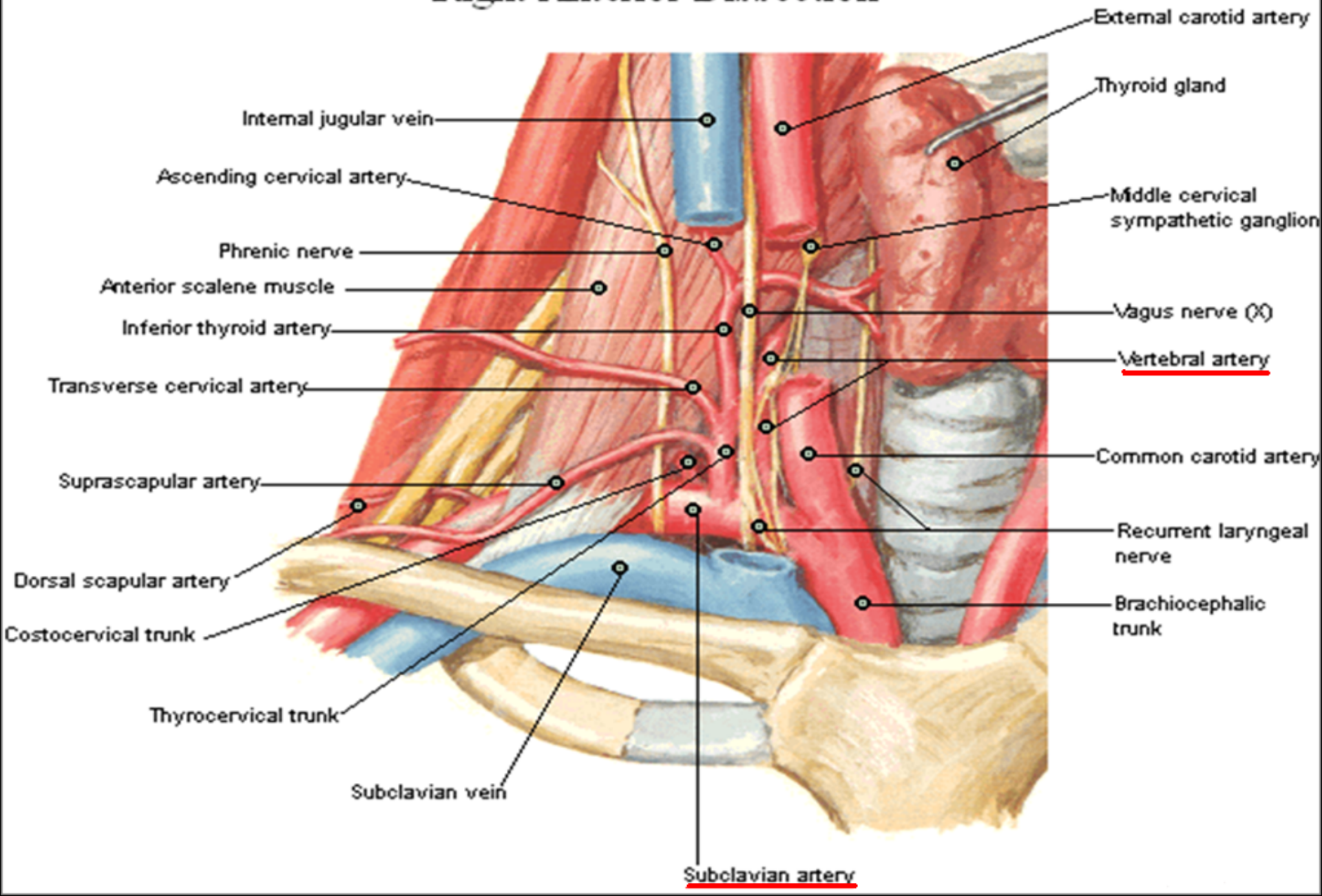
From subclavian artery → then passes upwards through the transverse foramina of the upper 6 cervical vertebrae → foramen magnum → they pass upward and medially in front of the medulla oblongata → at the lower border of pons two vertebral arteries unite to form the single **Basilar Artery.**

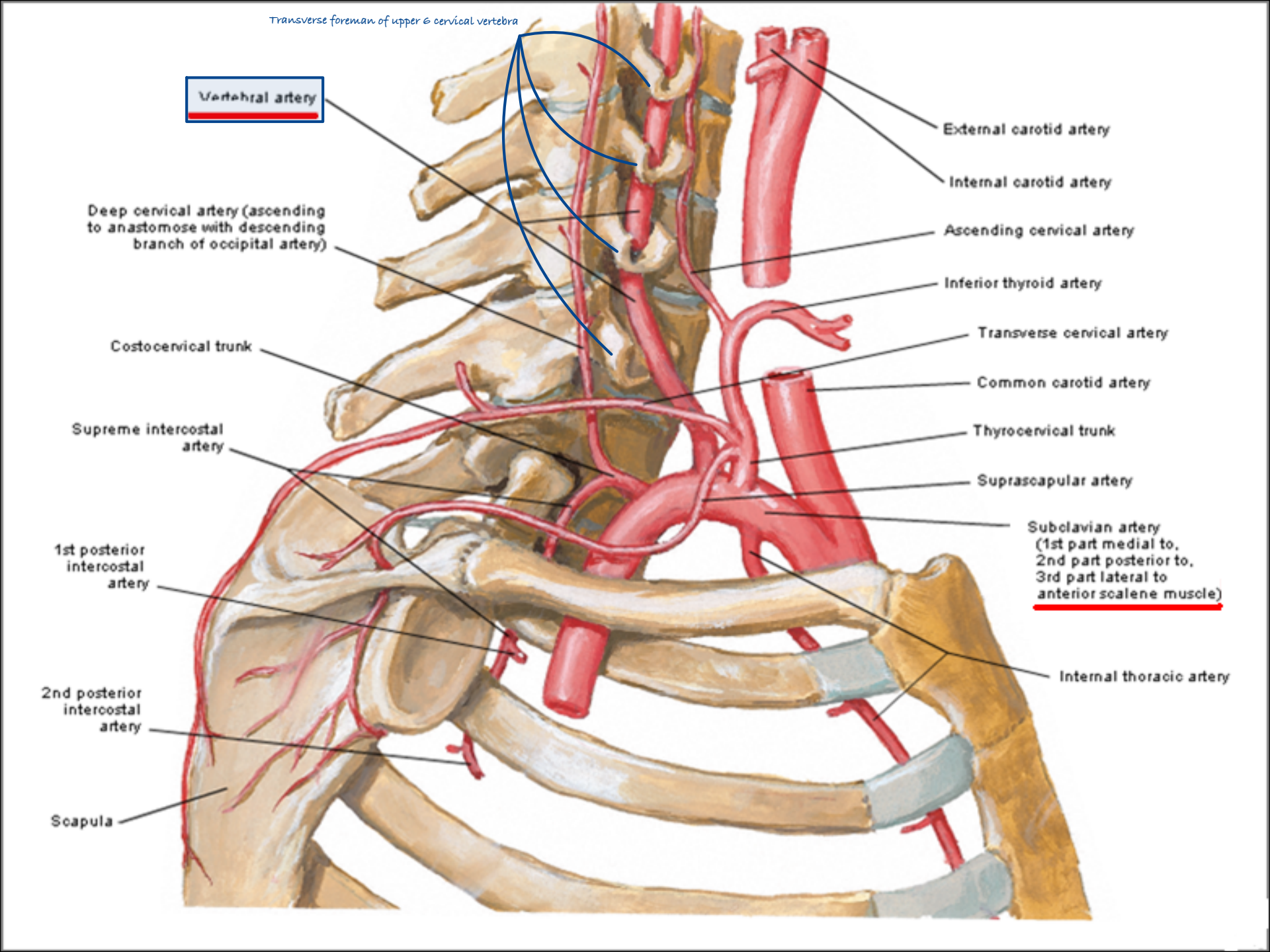
Basilar artery يوصلها هاي ويتحدوا مع بعض ويكونو هاي البال

Then bifurcate and give 2 post. Cerebral artery

Subclavian Artery

Right Anterior Dissection

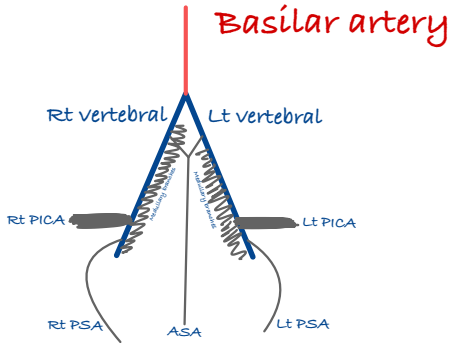



Transverse foreman of upper 6 cervical vertebra
Vertebral artery
External carotid artery
Internal carotid artery
Deep cervical artery (ascending to anastomose with descending branch of occipital artery)
Ascending cervical artery
Inferior thyroid artery
Costocervical trunk
Transverse cervical artery
Common carotid artery
Supreme intercostal artery
Thyrocervical trunk
Suprascapular artery
Subclavian artery (1st part medial to, 2nd part posterior to, 3rd part lateral to anterior scalene muscle)
1st posterior intercostal artery
Internal thoracic artery
2nd posterior intercostal artery
Scapula

Branches of the Vertebral Artery

1. **The meningeal branches:** are small and supply the bone and dura in the posterior cranial fossa.
2. PSA **Posterior spinal arteries:** may arise from the posterior inferior cerebellar artery. Anatomical variant
3. ASA **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. PICA **Posterior inferior cerebellar artery.** Largest branch

سؤال منطقي حنسأله لحالنا وجوابه انو ال vertebral artery أقرب من ال basilar artery على ال spinal cord



Posterior Inferior Cerebellar Artery (PICA)

- **The largest branch of vertebral artery.**
  - **It supplies the:**
    - Posterior part of inferior surface of cerebellum.
      From its name
    - Inferior cerebellar peduncle. connect the cerebellum with medulla oblongata
    - Posteriolateral part of medulla oblongata.
    - Choroid plexus of 4th ventricle.

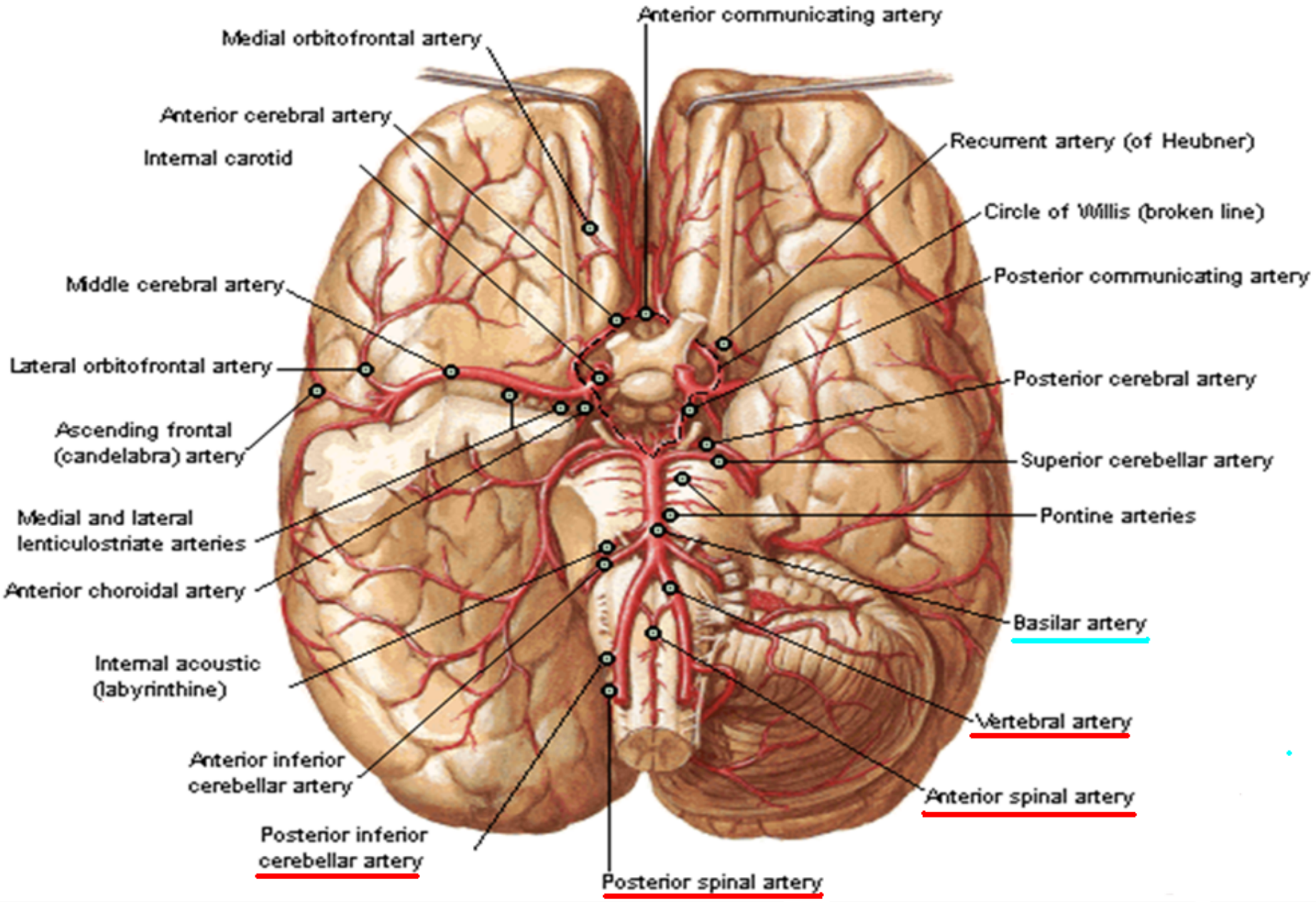
- **Occlusion** of this artery leads to **lateral medullary syndrome (Wallenber's syndrome).**

Case: 52 y/o female with HTN and DM came to the clinic complain from sudden onset of ataxia with MRI scan we find multiple lesions and patches in cerebellum and medulla oblongata and they diagnose it mistakenly with multiple sclerosis because it was multiple lesions

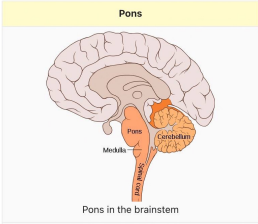
النتيجة انو حدث damage in cerebellum بمقابله ترتخ على نفس الساید الي صارت فيه المشكلة، لانه Horner syndrome وبايخ على ال spinal cord الي بيكون حاامل ال sympathatic fibres، بعديه اتضرب التراكت الي هه ال hypothalamus بينضرب ال sensation of face بسبب حصول damage of desc. spinal nucleus اما التاثير على الجسم بيحصل على الساید الثاني

Arteries of Brain

Inferior View



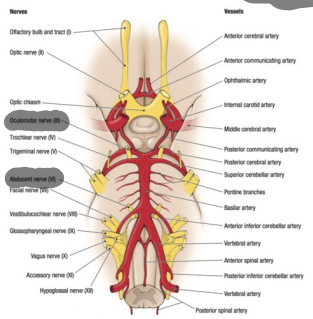
The **pons** (from Latin *pons*, "bridge") is part of the brainstem that in humans and other bipeds lies inferior to the midbrain, superior to the medulla oblongata and anterior to the cerebellum.

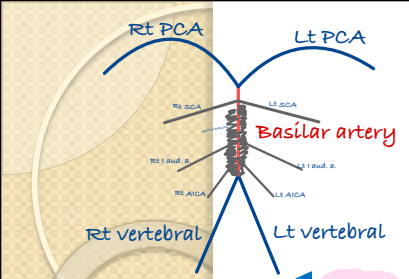


Pons in the brainstem

B. Basilar Artery

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



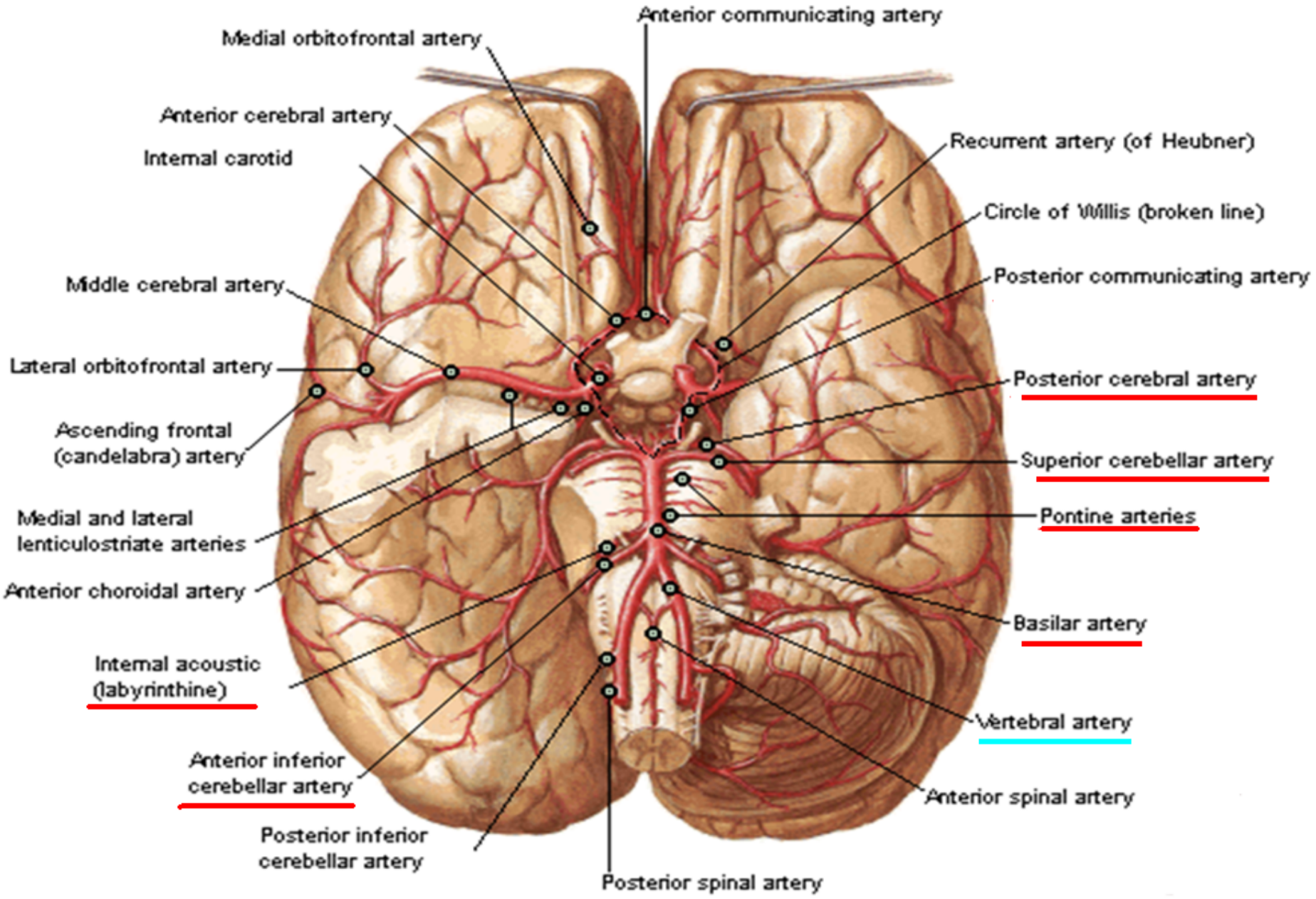


Branches of the Basilar artery

1. AICA **Anterior inferior cerebellar artery:** supplies the anterior part of inferior surface of the cerebellum. (From its name)
2. **Internal auditory (labyrinthine) artery**: it arises either from basilar or anterior inferior cerebellar arteries. Supplies the inner ear. (Internal carotid give abranch for the eye; Basilar give for the ear)
3. **Pontine (paramedian) branches:** are small branches to supply the pons. (ضريبة مرور)
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. PCA **Posterior cerebral artery:** terminal branches.

Arteries of Brain

Inferior View

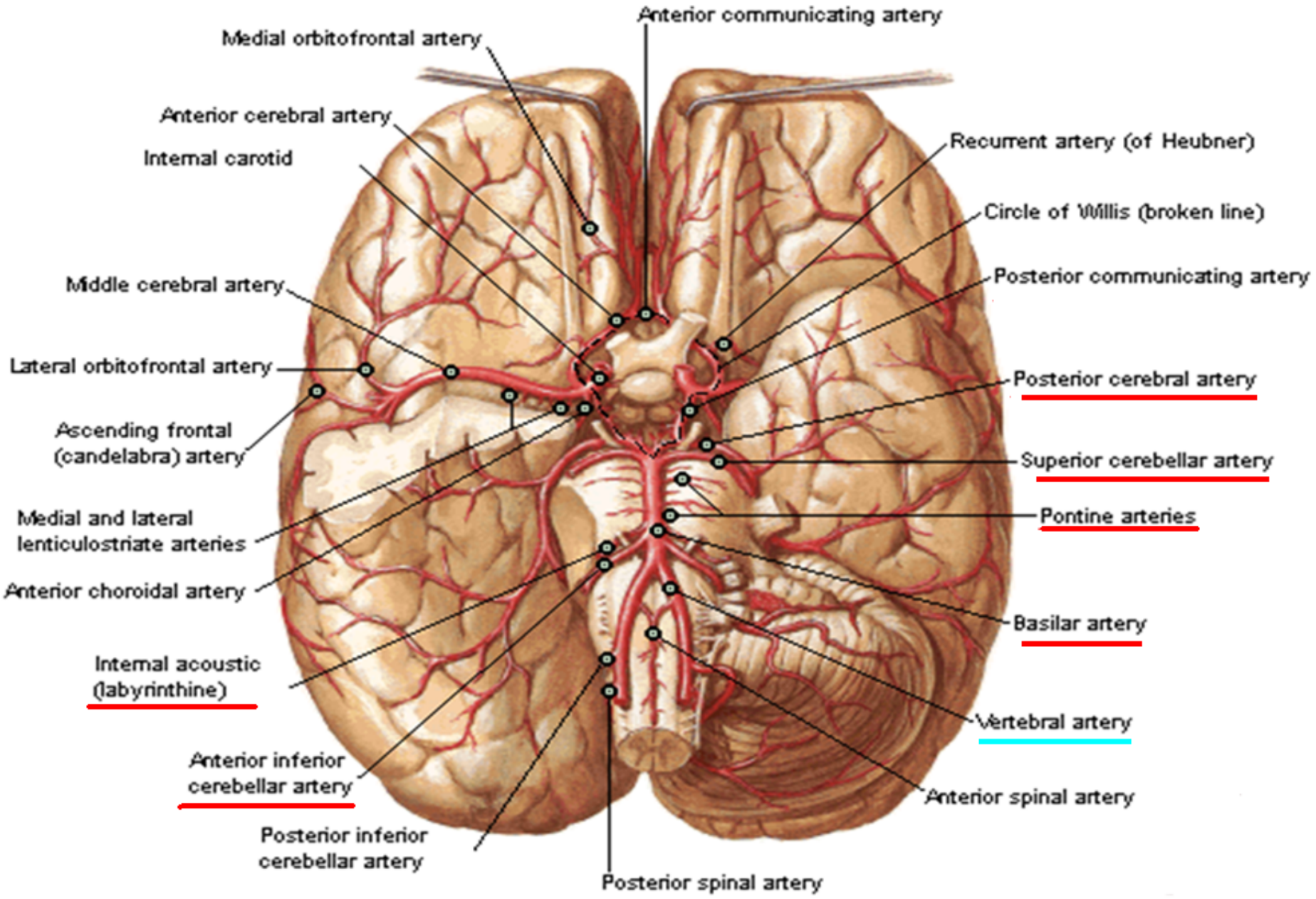


Posterior Cerebral Artery (PCA)

- 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.** The nerves lies laterally
- 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".
  Primary and secondary

2. Central Branches:

Diencephalon and subcortical structure

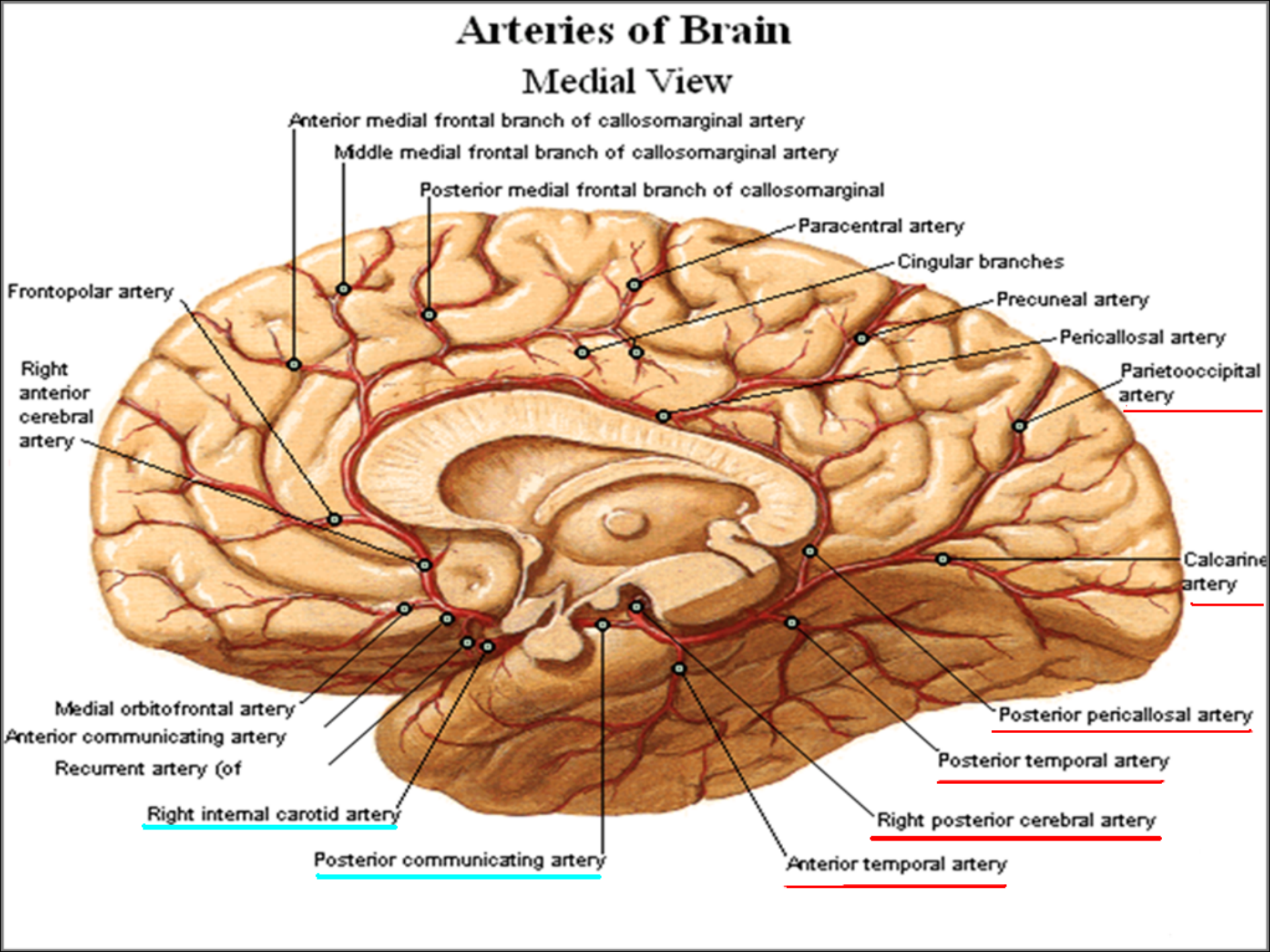
- Supply parts of the thalamus, medial geniculate body, splenium of the corpus callosum, lentiform nucleus, midbrain, and pineal body.

3. Posterior Choroidal Arteries:

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

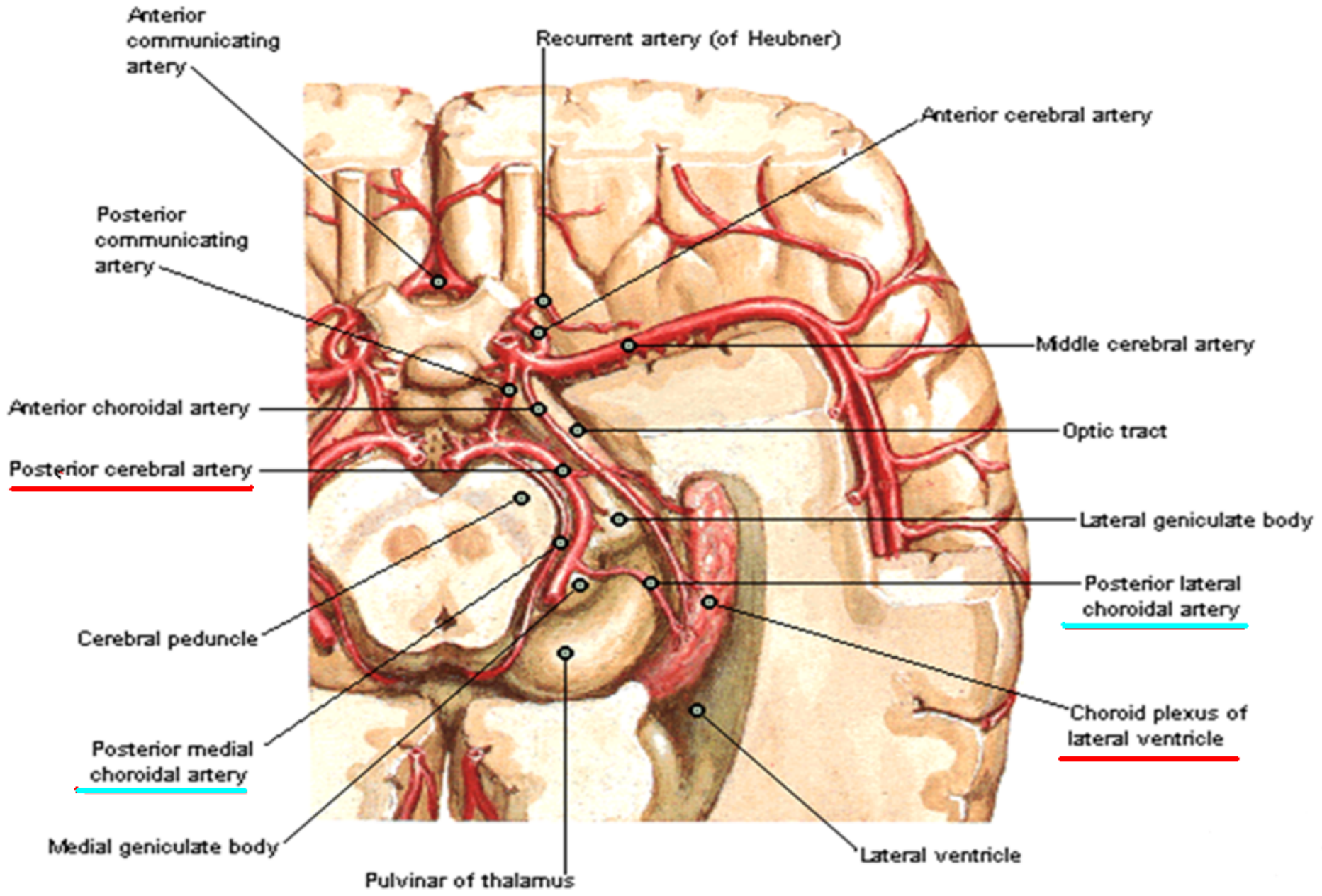
Arteries of Brain

Medial View



Arteries of Brain [Continued]

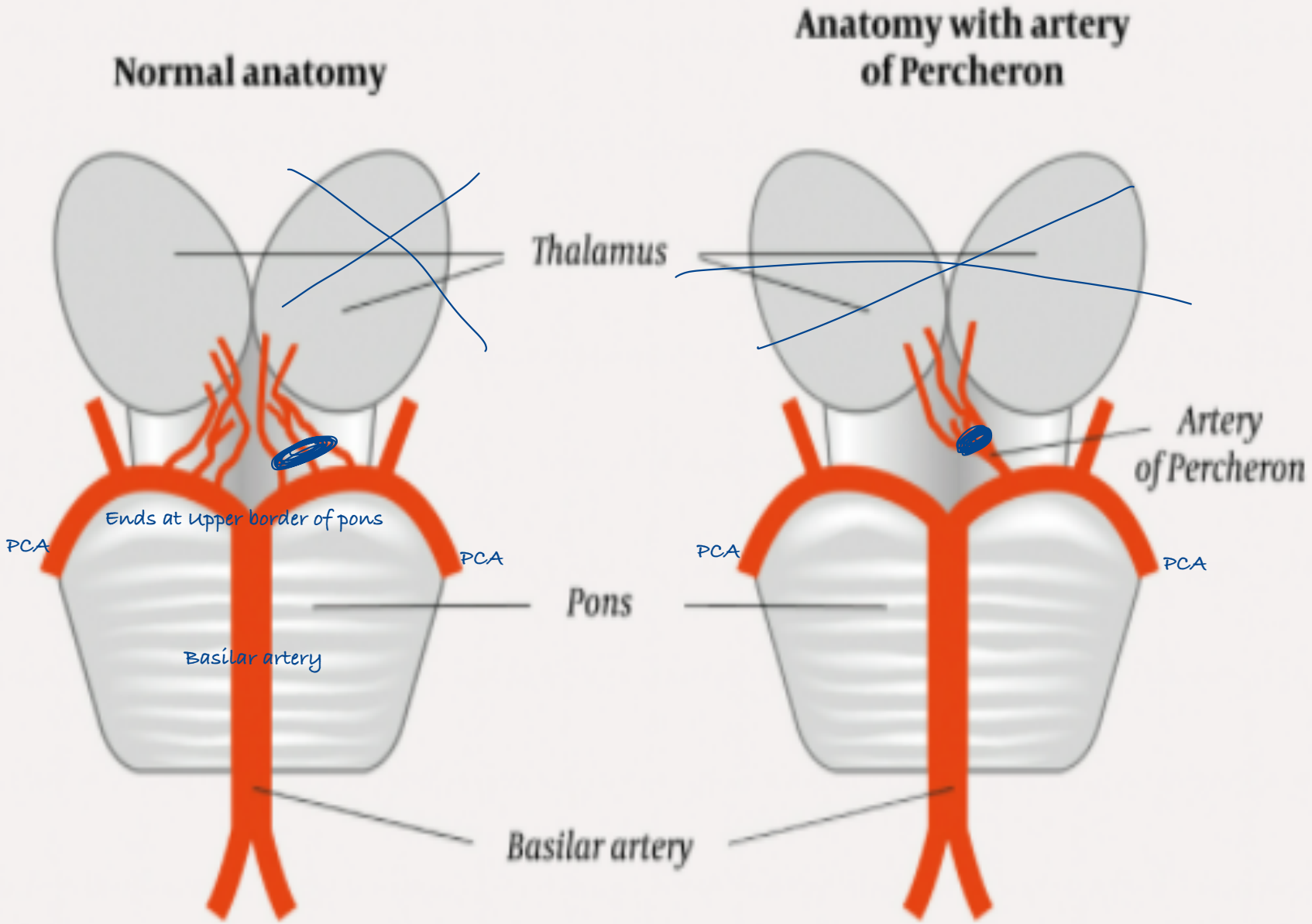
Inferior View

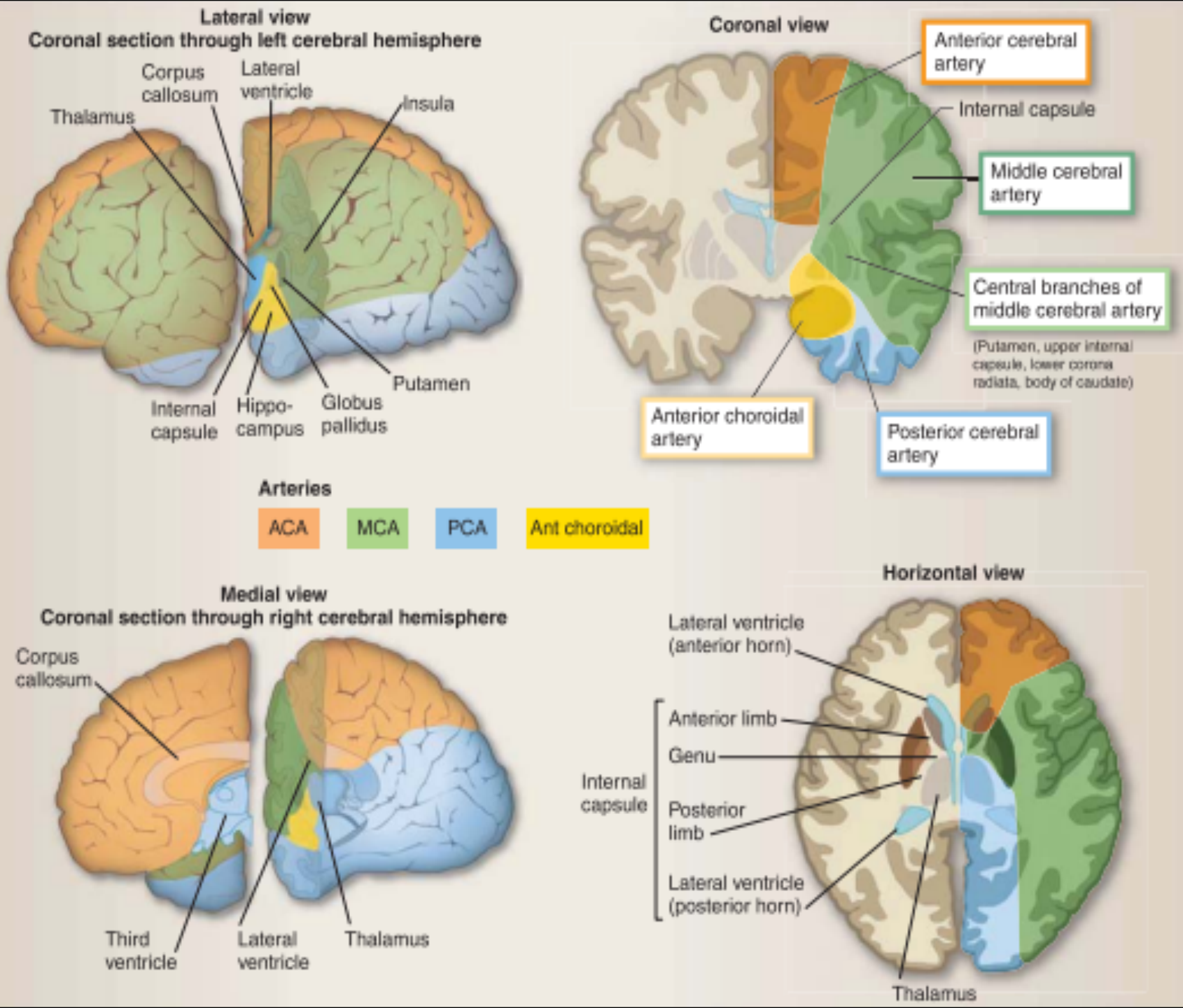


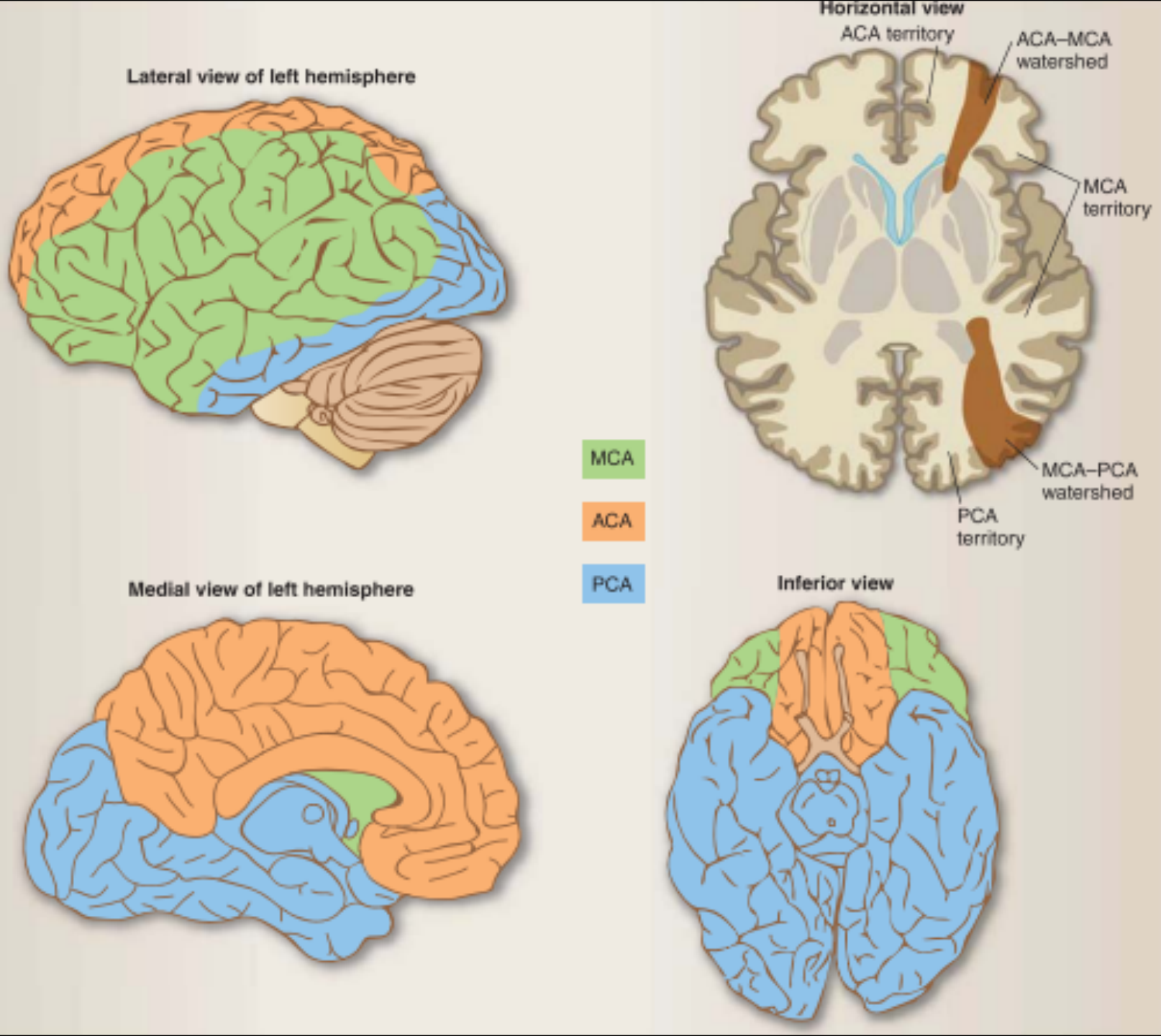
Clinical anatomy:

- 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.

يعني بالحالة العادية لو صار جلطة بالجزء الأيمن بيتأثر الجزء الأيمن من ال thalamus حيتأثر الجزء الأيمن، والعكس صحيح، بس في حالة انو انا عندي شريان واحد بيغذي هاي الستركشرز، وصار فيه مشكلة ف حيتأثر الجانبين تعوض ال thalamus


Normal anatomy
Anatomy with artery of Percheron
Thalamus
Ends at upper border of pons
PCA
PCA
Pons
Basilar artery
Artery of Percheron
PCA
PCA
Basilar artery


Lateral view
Coronal section through left cerebral hemisphere
Corpus callosum
Lateral ventricle
Thalamus
Insula
Internal capsule
Hippo-campus
Globus pallidus
Putamen
Coronal view
Anterior cerebral artery
Internal capsule
Middle cerebral artery
Central branches of middle cerebral artery
(Putamen, upper internal capsule, lower corona radiata, body of caudate)
Anterior choroidal artery
Posterior cerebral artery
Arteries
ACA
MCA
PCA
Ant choroidal
Medial view
Coronal section through right cerebral hemisphere
Corpus callosum
Third ventricle
Lateral ventricle
Thalamus
Horizontal view
Lateral ventricle (anterior horn)
Internal capsule
Anterior limb
Genu
Posterior limb
Lateral ventricle (posterior horn)
Thalamus


Lateral view of left hemisphere
Horizontal view
ACA territory
ACA–MCA watershed
MCA territory
MCA–PCA watershed
PCA territory
MCA
ACA
PCA
Medial view of left hemisphere
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 80% system with vertebrobasilar 20% system.

Circle Of Willis

1. **Anterior communicating artery.** Between ACA
2. **Right & left of ACA.**
3. **Right & left ICA.**
4. **Right & left posterior communicating arteries.**
5. **Right & left PCA.** Post. Cerebral artery

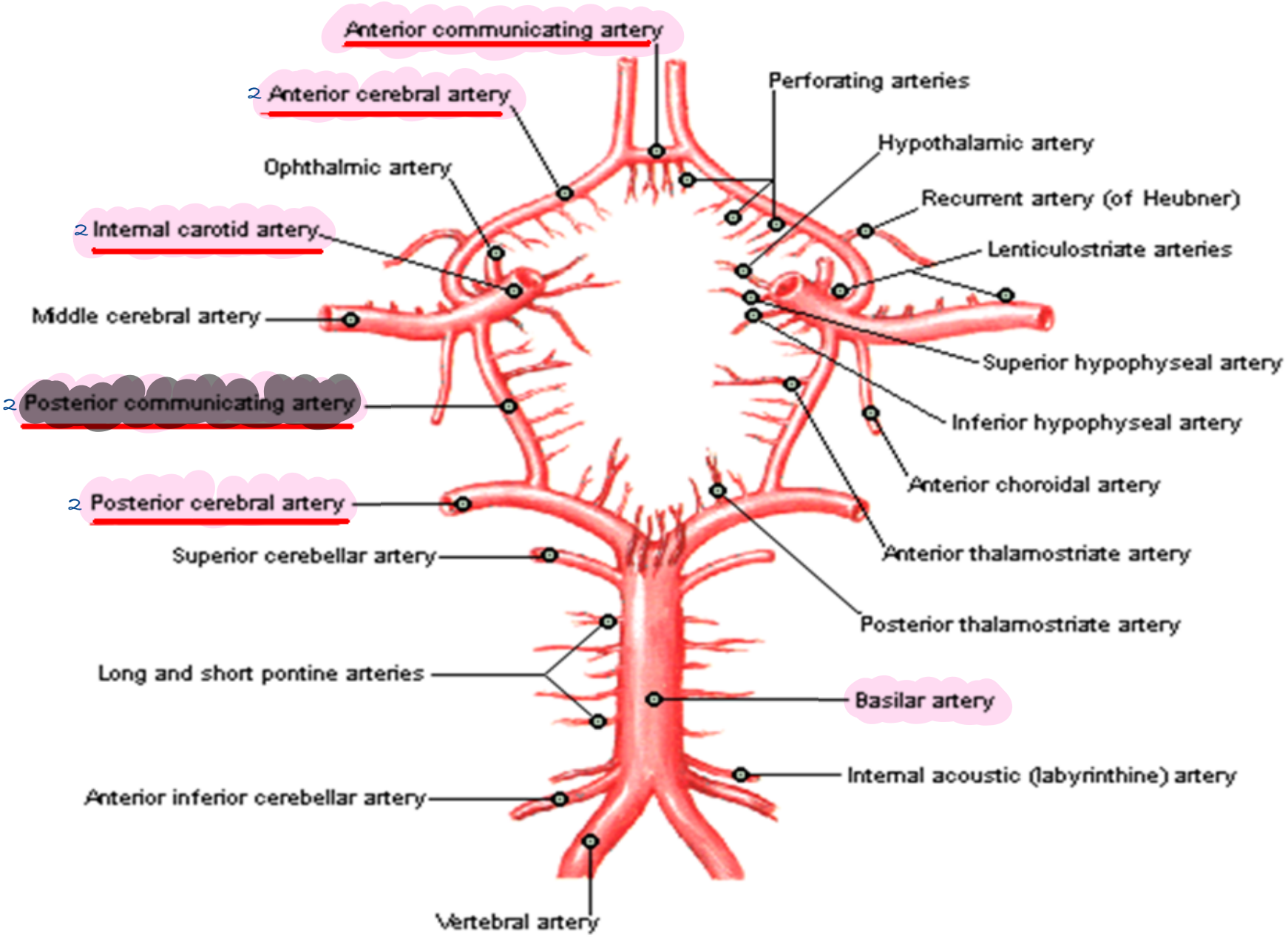
9 arteries

---

6. **Basilar artery.** Upper part of it

Circle of Willis - Vessels Dissected Out

Inferior View



The Important Anastomoses Between the Cerebral Arteries

Between anterior middle and posterior branches

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

Venous Drainage

A. **Superficial cerebral veins:** laceration of these vessels results in subdural hemorrhage (hematoma).

B. **Deep cerebral veins.**

C. **Dural Cerebral Sinuses.**

Dura matter in the brain its a part of connective tissue composed 2 layers outer endostial layer and inner menengial lager
طبعاً وعشان الكلام يكون مربط بدنا نعرف انو خارج البرايين زي السباينل كورد بيكون وه لاير

ال sinus هاي بتنشأ من انو في بعض المناطق بيصير في فراغ بين الطبقتين تعون ال dura matter

- The veins of the brain have no muscular tissue in their thin layer.
- No valves.
- Drain into the cranial or dural venous sinuses.

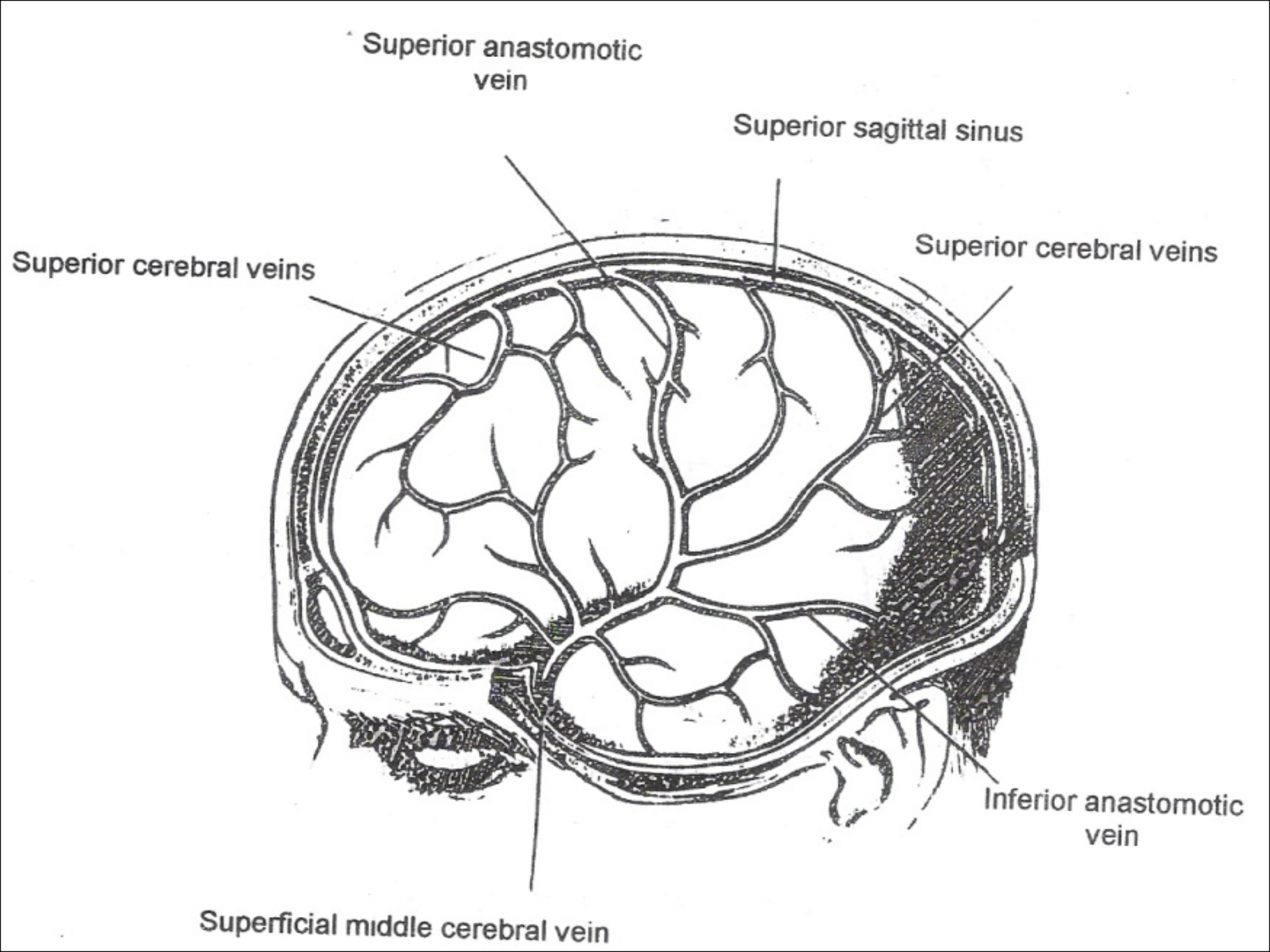
Take the blood from cerebral veins and CSF

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.**


Superior anastomotic vein
Superior sagittal sinus
Superior cerebral veins
Superior cerebral veins
Inferior anastomotic vein
Superficial middle cerebral vein

3 veins

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

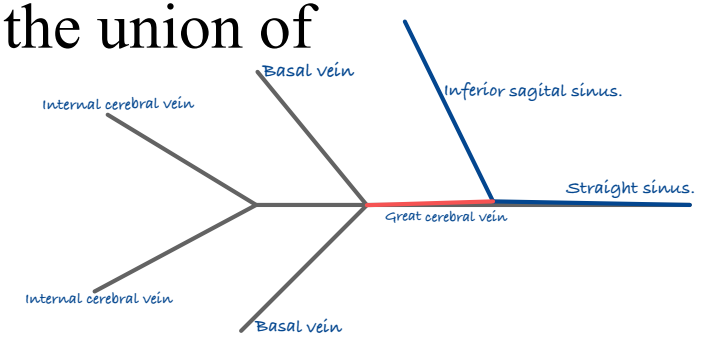
- **Deep middle cerebral vein.**
- **Anterior cerebral vein.**
- **Striate veins.**

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

2 veins

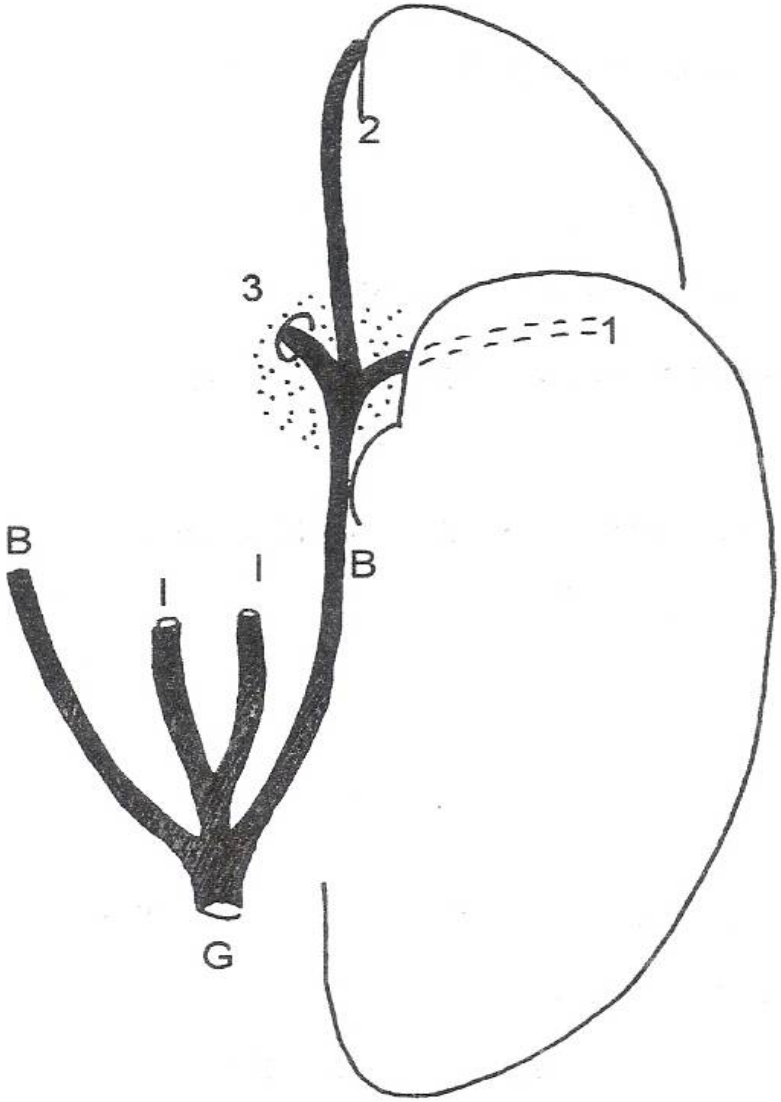
5. The Internal Cerebral Vein: there are two internal cerebral veins and they are formed by the union of

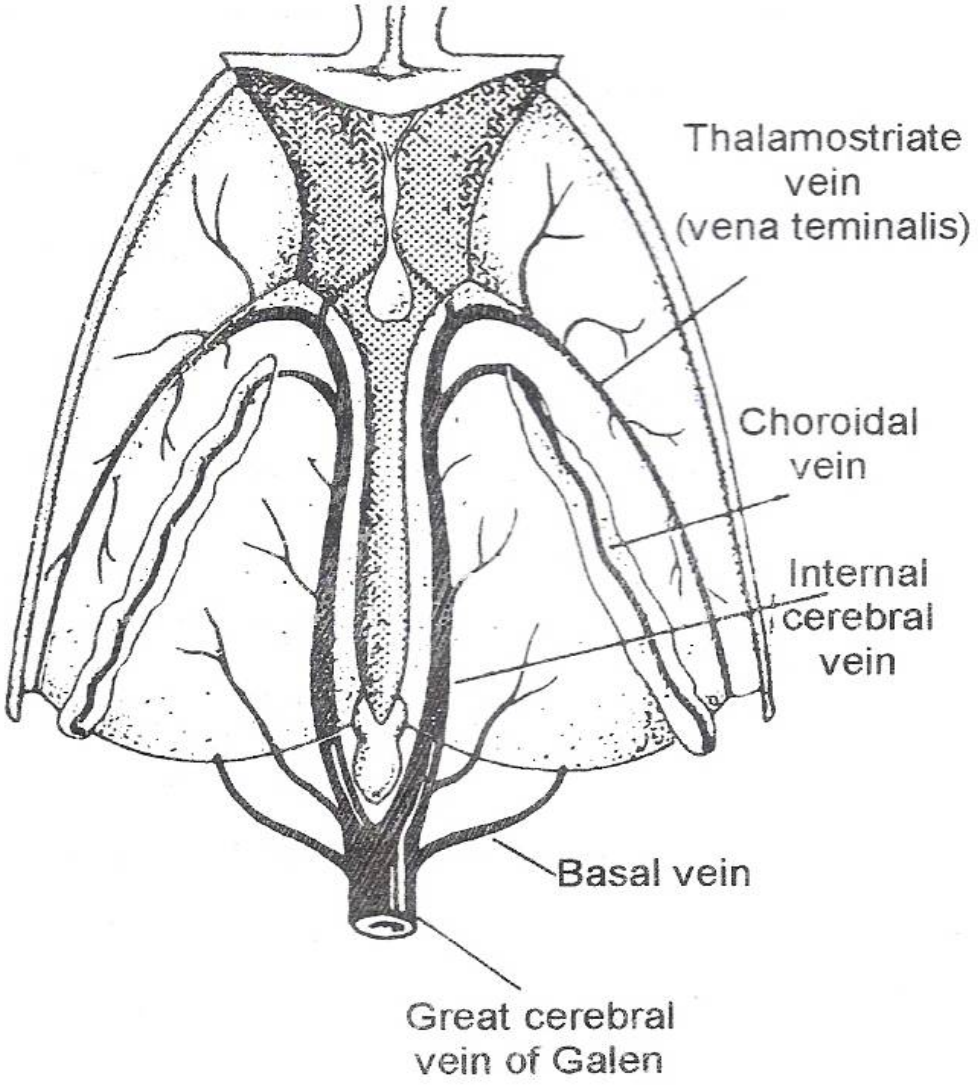
- **Thalamostriate vein**
- **Choroid vein.**



- 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.**

With addition the inferior sagital sinus

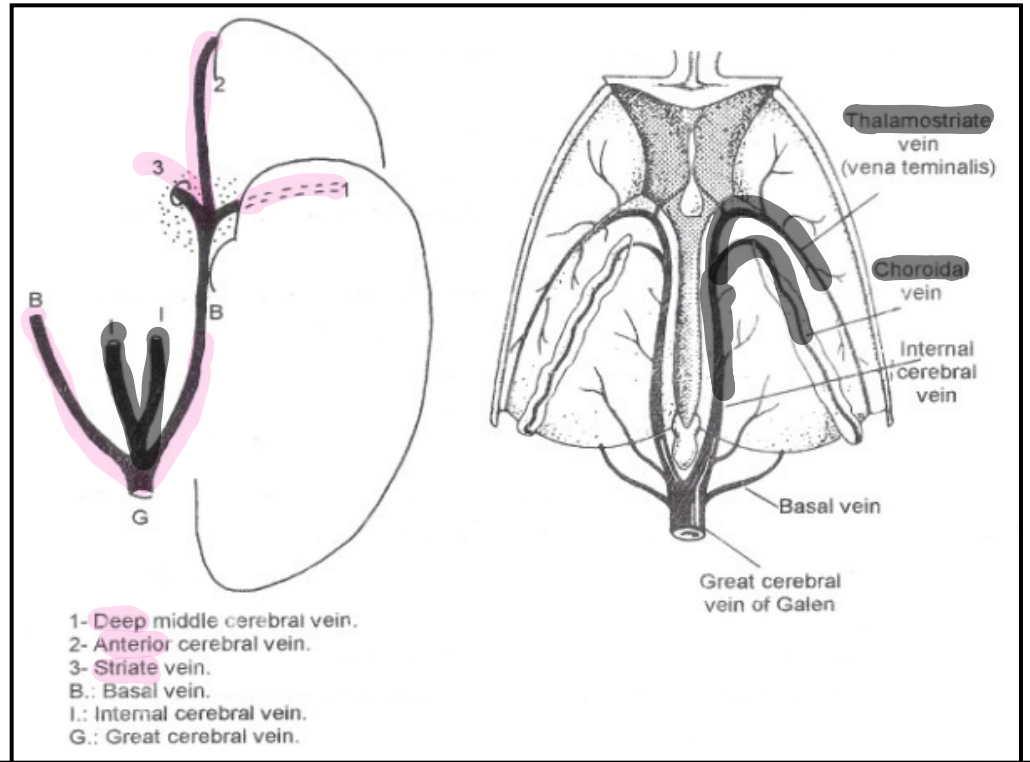


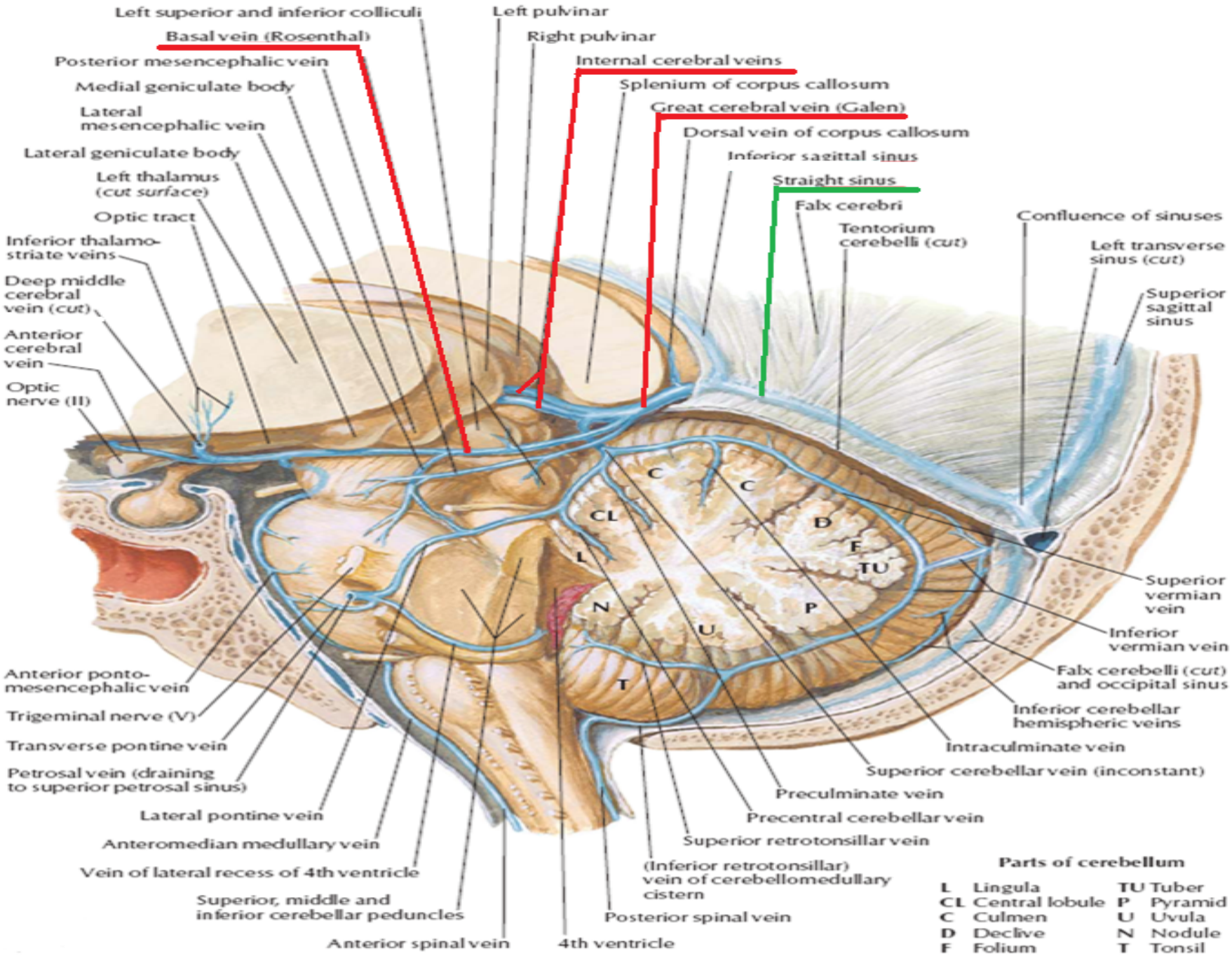


1- Deep middle cerebral vein.
2- Anterior cerebral vein.
3- Striate vein.
B.: Basal vein.
I.: Internal cerebral vein.
G.: Great cerebral vein.

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.




Left superior and inferior colliculi
Basal vein (Rosenthal)
Posterior mesencephalic vein
Medial geniculate body
Lateral mesencephalic vein
Lateral geniculate body
Left thalamus (cut surface)
Optic tract
Inferior thalamostriate veins
Deep middle cerebral vein (cut)
Anterior cerebral vein
Optic nerve (II)
Left pulvinar
Right pulvinar
Internal cerebral veins
Splenium of corpus callosum
Great cerebral vein (Galen)
Dorsal vein of corpus callosum
Inferior sagittal sinus
Straight sinus
Falx cerebri
Tentorium cerebelli (cut)
Confluence of sinuses
Left transverse sinus (cut)
Superior sagittal sinus
Superior vermian vein
Inferior vermian vein
Falx cerebelli (cut) and occipital sinus
Inferior cerebellar hemispheric veins
Intraculminate vein
Superior cerebellar vein (inconstant)
Preculminate vein
Precentral cerebellar vein
Superior retrotonsillar vein
(Inferior retrotonsillar) vein of cerebellomedullary cistern
Posterior spinal vein
4th ventricle
Anterior spinal vein
Superior, middle and inferior cerebellar peduncles
Vein of lateral recess of 4th ventricle
Anteromedian medullary vein
Lateral pontine vein
Petrosal vein (draining to superior petrosal sinus)
Transverse pontine vein
Trigeminal nerve (V)
Anterior pontomesencephalic vein
L
CL
C
C
D
F
TU
P
U
N
T
Parts of cerebellum
L Lingula
CL Central lobule
C Culmen
D Declive
F Folium
TU Tuber
P Pyramid
U Uvula
N Nodule
T Tonsil

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. Then to brachiocephalic vein then right atrium.
- There are at least **three single and six paired** dural sinuses.

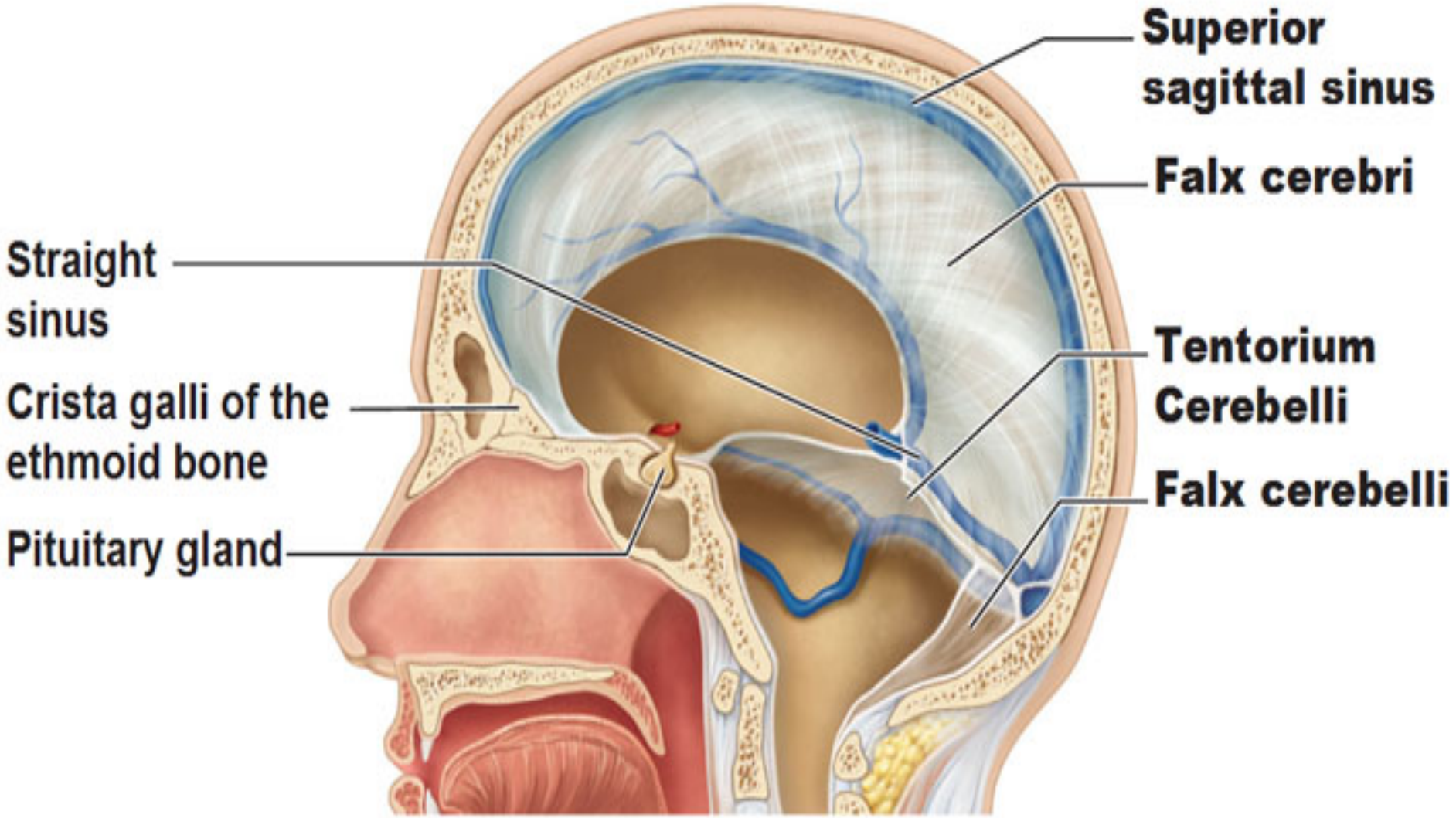
So it occlusion happens it may cuz bilateral symptoms and they came with hemorrhage and bleeding. Cuz there is no drains to the cerebral veins so it will increase the venous pressure and rupture all the veins. The treatment is full dose coagulant to open the sinus

As they are single so they would be in the middle.

The Single Venous Sinuses

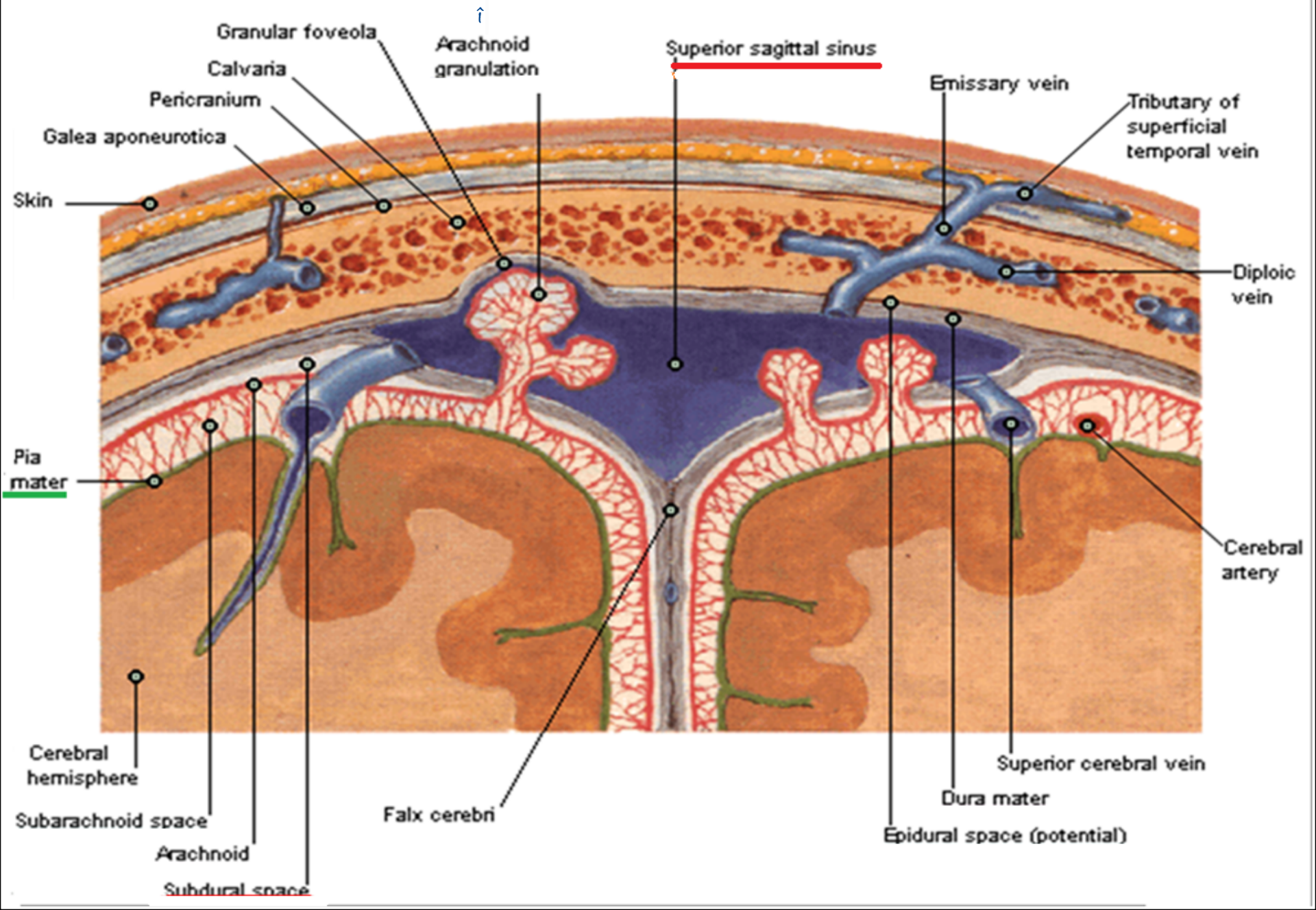
1. **The superior sagittal sinus:** usually terminates in **the right transverse sinus.**
2. **The inferior sagittal sinus:** joins the great cerebral vein to form **the straight sinus.** With great cerebral vein.
3. **The straight sinus "tentorial or rectus sinus":** formed by the union of **the great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

The Dura Mater and Dural Sinuses



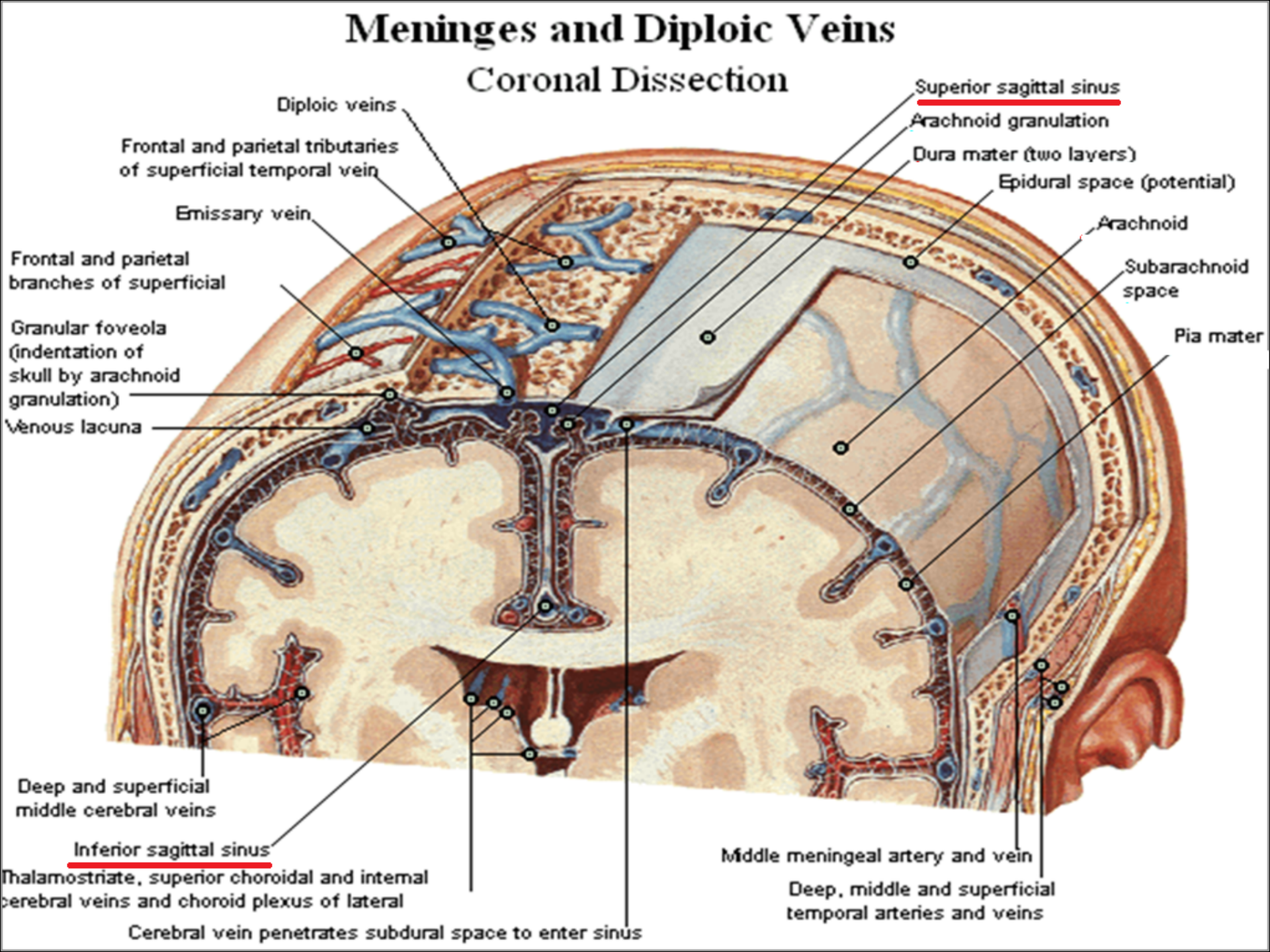
(a) Midsagittal view

Absorption the CSF from
subarachonoid space to dural sinuses



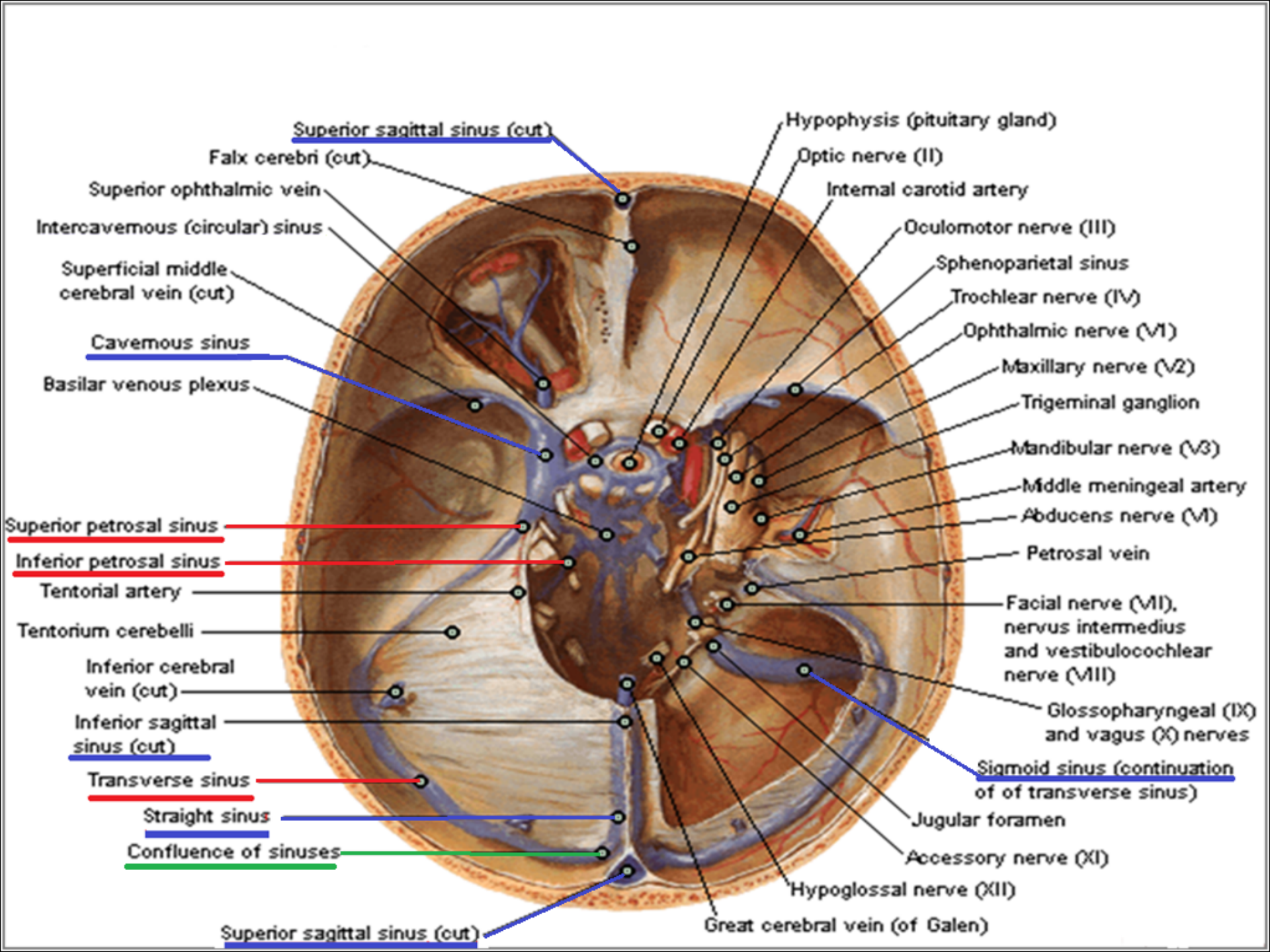
Meninges and Diploic Veins

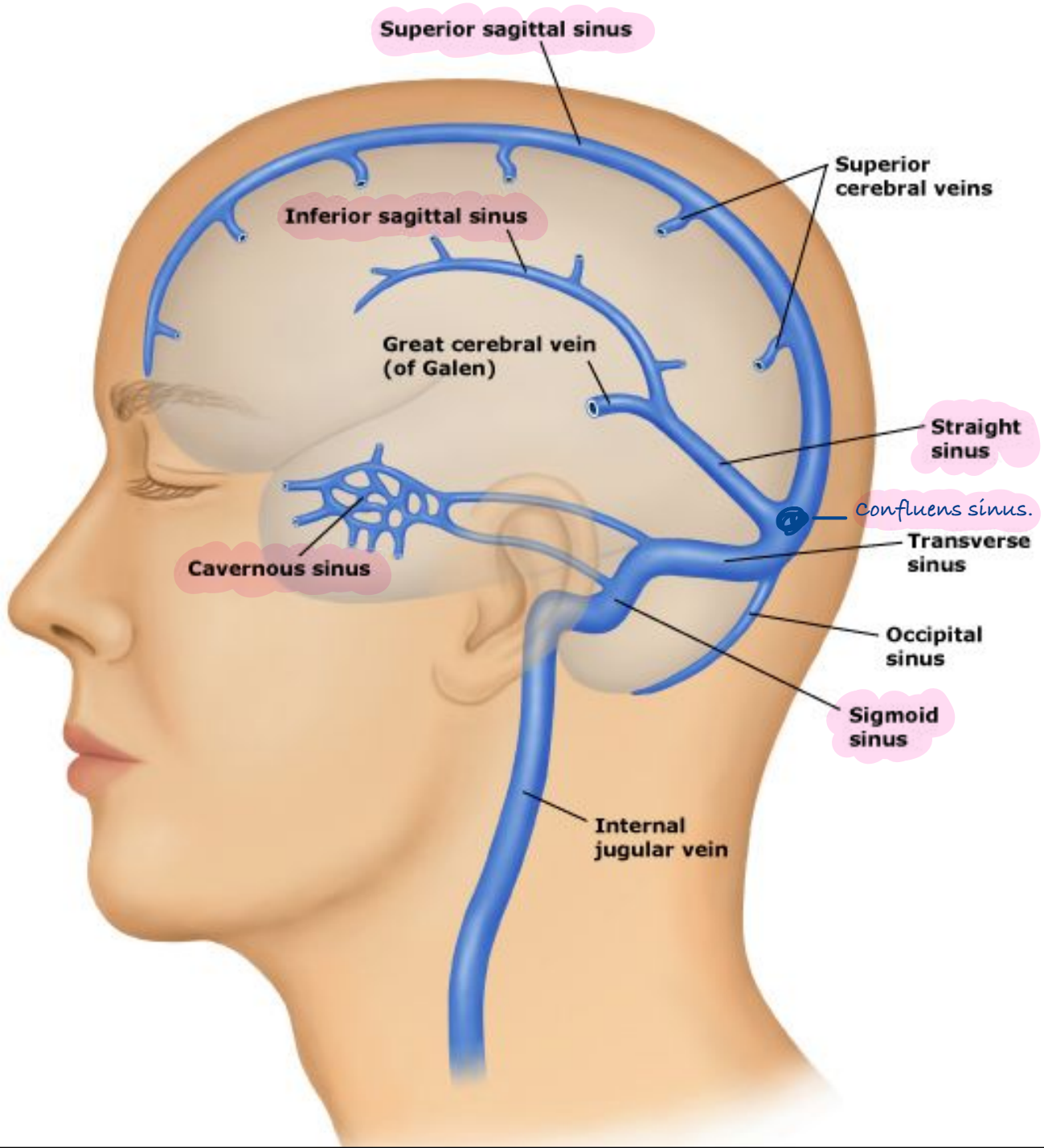
Coronal Dissection



The Paired Sinuses Rt and Lt

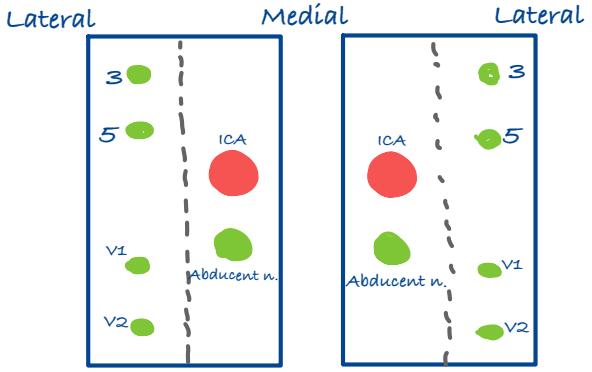
1. **The spheno-parietal sinus:** drains into **the cavernous sinus.**
2. **The cavernous sinuses:** drains into **the superior and inferior sinuses.**
3. **The superior petrosal sinuses:** extends from the cavernous sinus to the junction of **the transverse and sigmoid sinus.**
4. **The inferior petrosal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


Superior sagittal sinus (cut)
Falx cerebri (cut)
Superior ophthalmic vein
Intercavernous (circular) sinus
Superficial middle cerebral vein (cut)
Cavernous sinus
Basilar venous plexus
Superior petrosal sinus
Inferior petrosal sinus
Tentorial artery
Tentorium cerebelli
Inferior cerebral vein (cut)
Inferior sagittal sinus (cut)
Transverse sinus
Straight sinus
Confluence of sinuses
Superior sagittal sinus (cut)
Hypophysis (pituitary gland)
Optic nerve (II)
Internal carotid artery
Oculomotor nerve (III)
Sphenoparietal sinus
Trochlear nerve (IV)
Ophthalmic nerve (V1)
Maxillary nerve (V2)
Trigeminal ganglion
Mandibular nerve (V3)
Middle meningeal artery
Abducens nerve (VI)
Petrosal vein
Facial nerve (VII), nervus intermedius and vestibulocochlear nerve (VIII)
Glossopharyngeal (IX) and vagus (X) nerves
Sigmoid sinus (continuation of of transverse sinus)
Jugular foramen
Accessory nerve (XI)
Hypoglossal nerve (XII)
Great cerebral vein (of Galen)


Superior sagittal sinus
Superior cerebral veins
Inferior sagittal sinus
Great cerebral vein (of Galen)
Straight sinus
Confluens sinus.
Transverse sinus
Cavernous sinus
Occipital sinus
Sigmoid sinus
Internal jugular vein

The Cavernous Sinuses

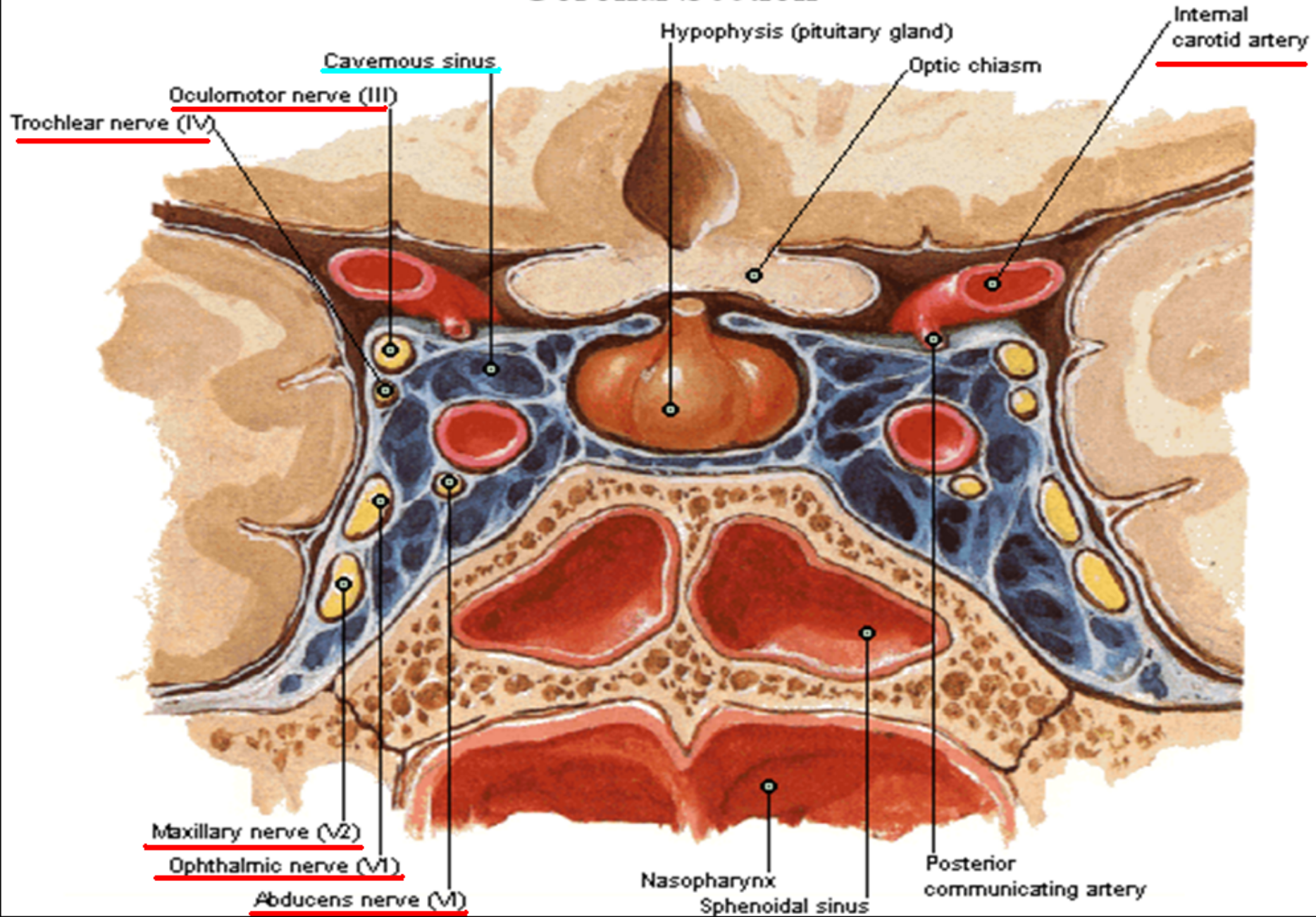
- **Contains within the lateral wall of the cavernous sinus:**
  1. The oculomotor nerve.
  2. The trochlear nerve.
  3. The ophthalmic (V1) division of the trigeminal nerve.
  4. The maxillary (V2) division of the trigeminal nerve.
- **Contains within the medial wall of the cavernous sinus:**
  1. The abducent nerve.
  2. The internal carotid artery.



Cavernous sinus thrombosis → painful ophthalmoplegia.

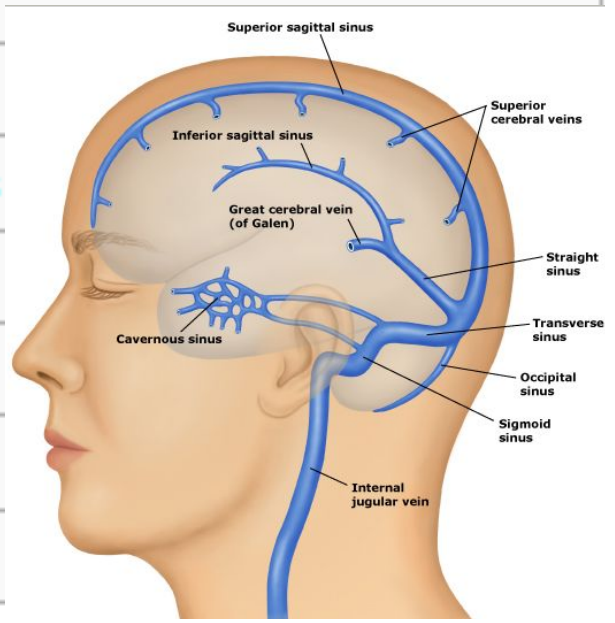
Cavernous Sinus

Coronal Section



The Cerebral Dural Sinuses

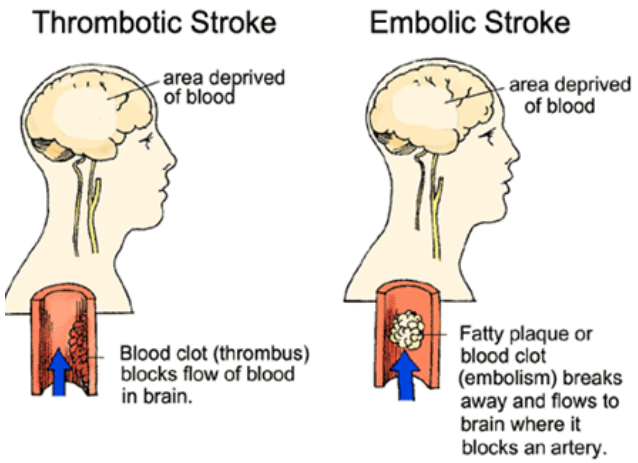
Name	Drains to
Inferior sagittal sinus	Straight sinus
Superior sagittal sinus	Typically becomes right transverse sinus or confluence of sinuses
Straight sinus	Typically becomes left transverse sinus or confluence of sinuses
Occipital sinus	Confluence of sinuses
Confluence of sinuses	Right and Left transverse 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



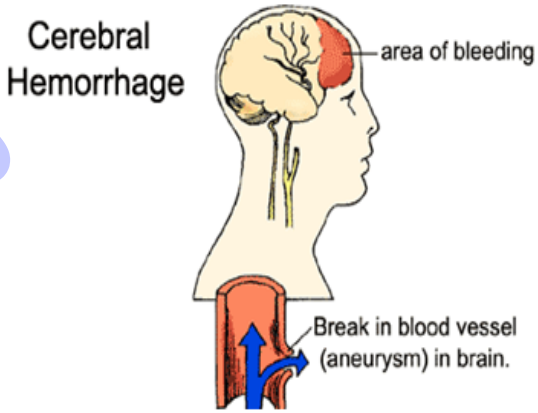
The **confluence of sinuses** is the connecting point of the superior sagittal, and straight sinuses.

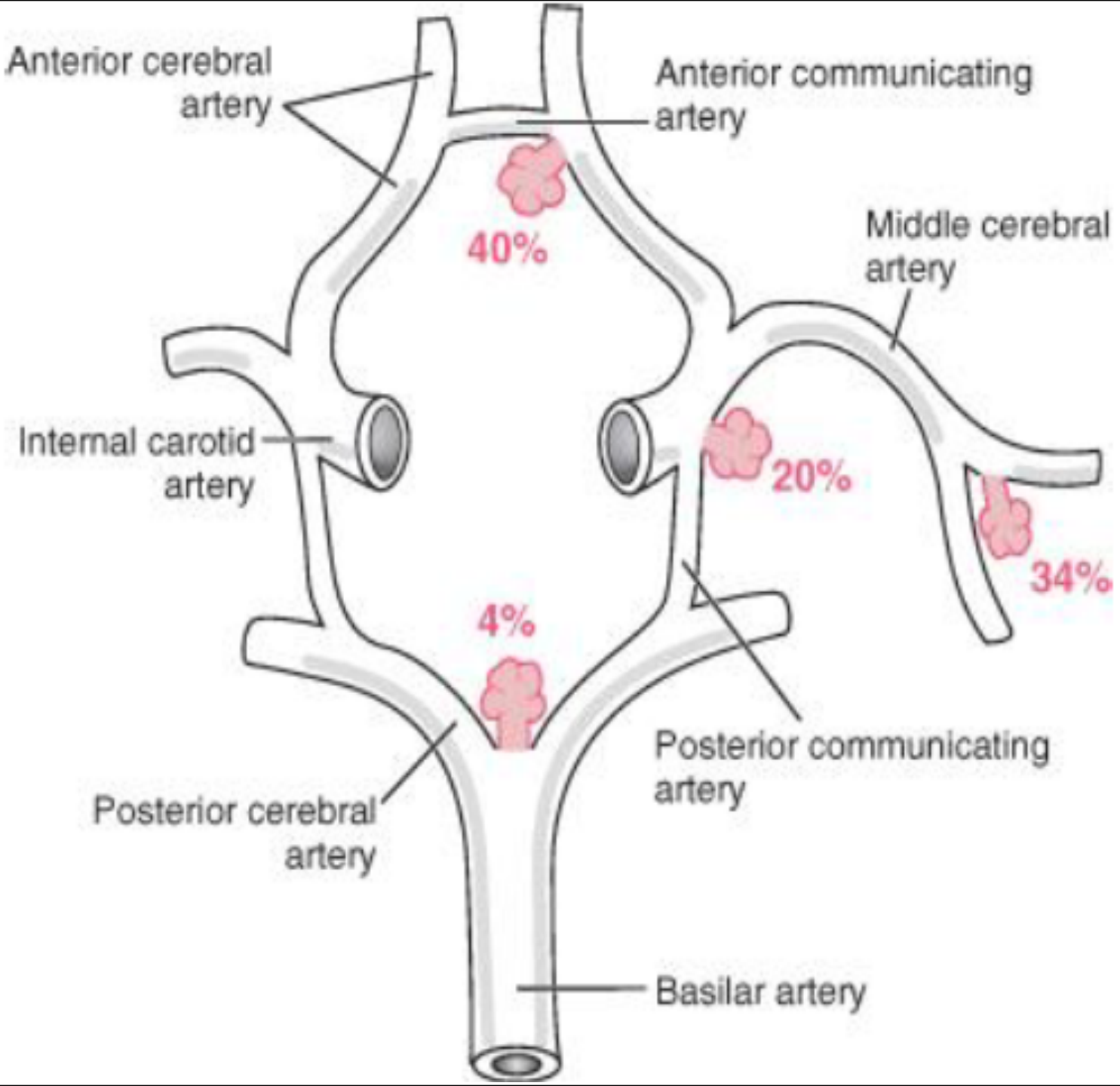
Classification of Stroke

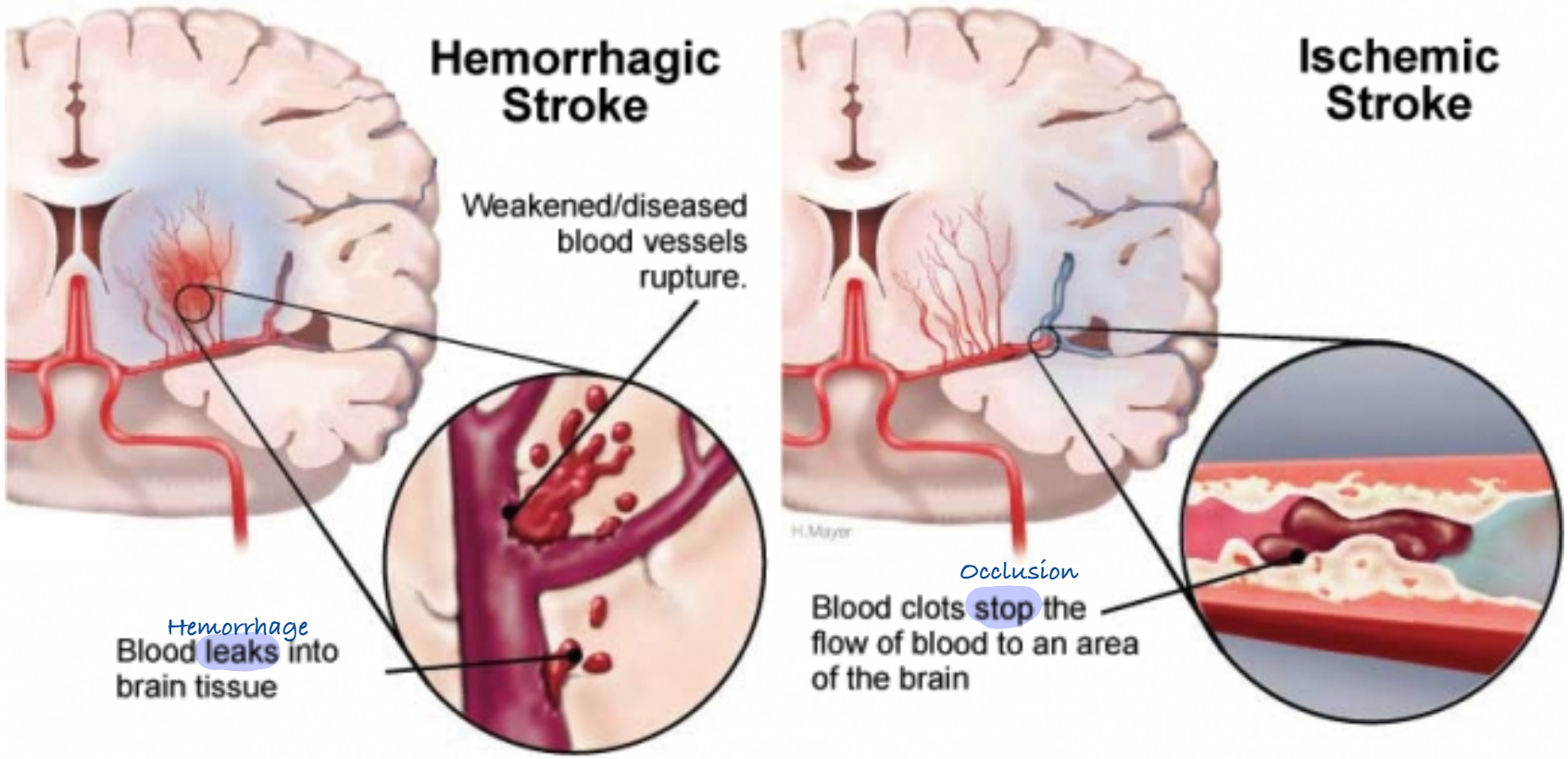
- Occlusion of arteries
  Ischemic Stroke: 85%.
  - Thrombotic.
  - Embolic. Migratory thrombus
  - Lacunar.
  - Hemodynamic. Watershid syndrome



- Rupture of blood vessels.
  Hemorrhagic Stroke: 15 %.
  - Intracerebral and intracerebellar hemorrhage 10%.
  - Subarachnoid hemorrhage 5%.
    In subarachnoid space.




Anterior cerebral artery
Anterior communicating artery
40%
Middle cerebral artery
Internal carotid artery
20%
34%
4%
Posterior communicating artery
Posterior cerebral artery
Basilar artery



Rupture of large artery cause subarachnoid hemorrhage
If penetrating artery like charcots artery it will cause intracerebral hematoma

Occlusion Internal Carotid Artery ICA

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 الشبكية through the ophthalmic artery Gives retinal 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. Loss of motor skills
- Mentality and personality changes.

Occlusion of the main Middle Cerebral Artery MCA

- 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. Nonfluent
  - **Wernicke** "sensory" aphasia. Fluent
  - Contralateral homonymous hemianopia) damage to the optic radiation.(فقدان نصف مجال الابصار
  - Anosognosia. المريض متجاهل المرض وغير واعي انه مريض

Occlusion of the main Posterior Cerebral Artery PCA

- **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.

  Macular area take dual blood supply

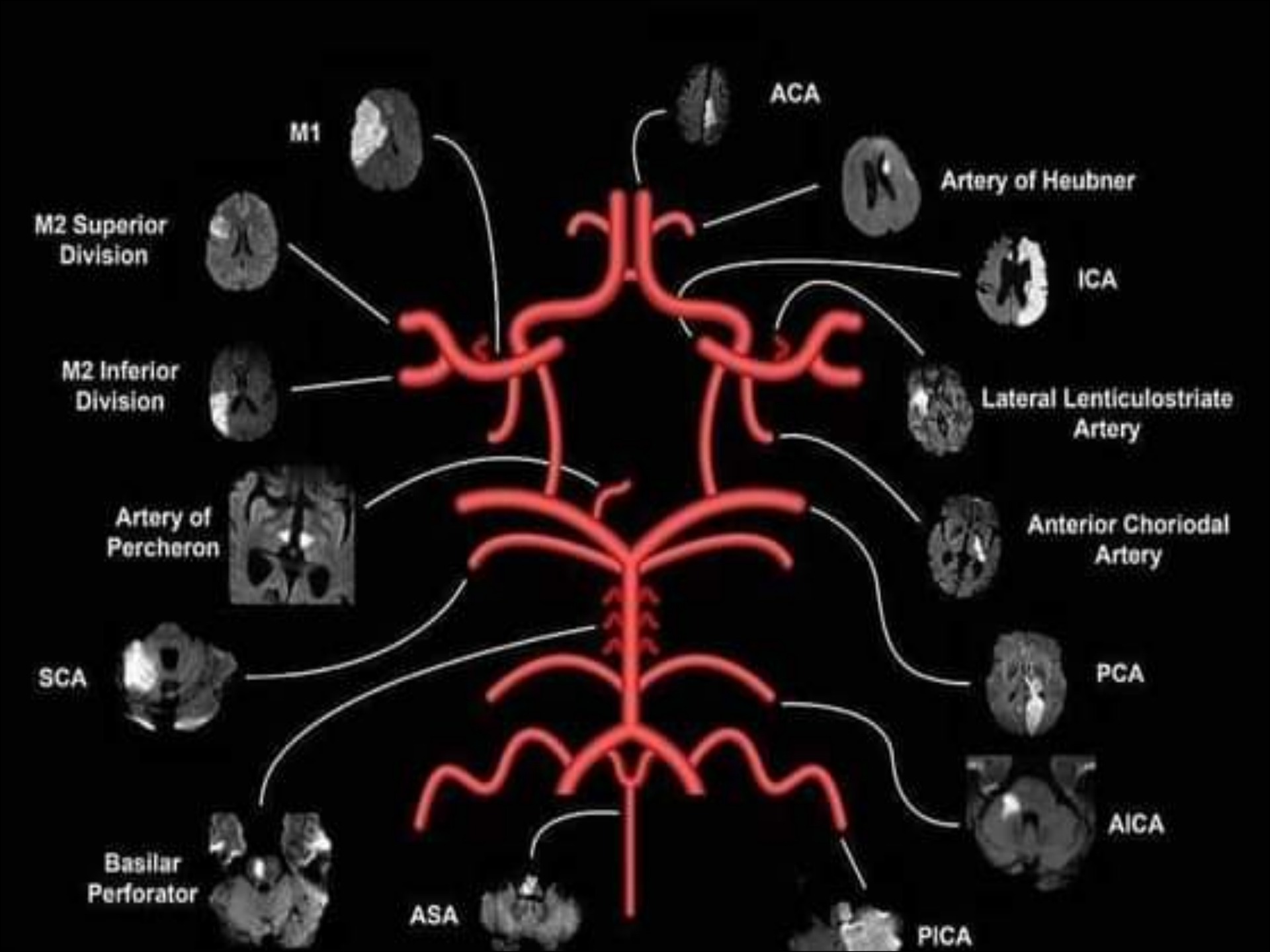
- **Bilateral Lesion of occipital lobe: cortical blindness** (pupils are reactive to light).
- **Irritation of occipital lobe:** Visual hallucination.
- Memory deficit **(amnesia).**
- Visual agnosia.
- **Thalamic syndrome.**

  Contralateral pain hemi type
  Contralateral anesthesia
  Emotional liability
  Decrease consciousness

Vertebrobasilar Artery Occlusion

Damage of trigeminal sensory nucleus

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. صعوبة في البلع والكلام
4. Vertigo, nystagmus, nausea, and vomiting
5. Ipsilateral Horner syndrome
6. Ipsilateral ataxia and other cerebellar signs
7. Unilateral or bilateral hemiparesis
8. Coma


ACA
M1
Artery of Heubner
M2 Superior Division
ICA
M2 Inferior Division
Lateral Lenticulostriate Artery
Artery of Percheron
Anterior Choriodal Artery
SCA
PCA
AICA
Basilar Perforator
ASA
PICA

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.:

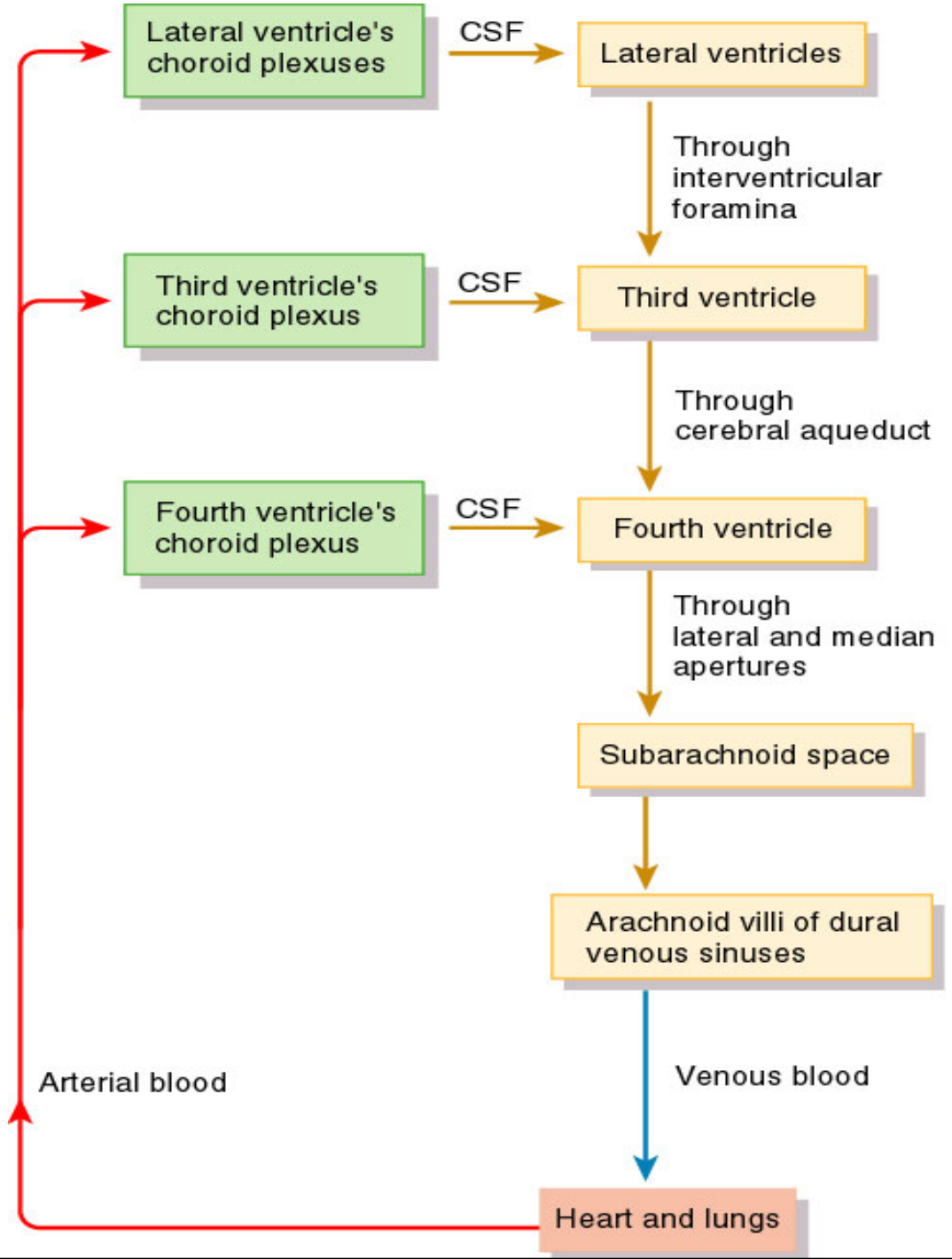
- The C.S.F. is secreted by the ependymal cells covering the choroid plexuses of the ventricles, mainly the lateral ventricles.
- The ependymal cells extract the CSF from the capillaries and secrete it into the cavity of the ventricles.

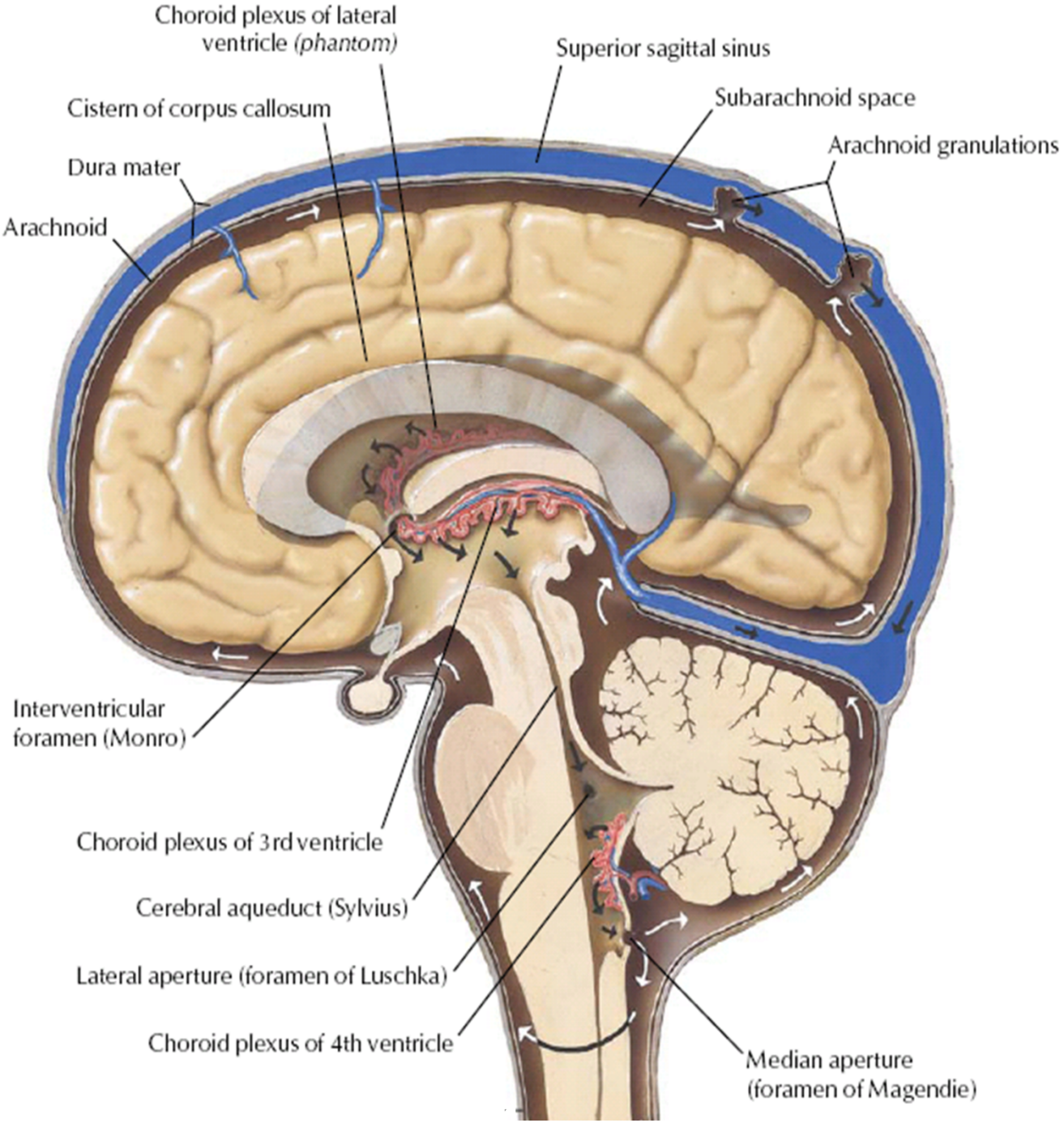
Formation of Cerebrospinal Fluid

- **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

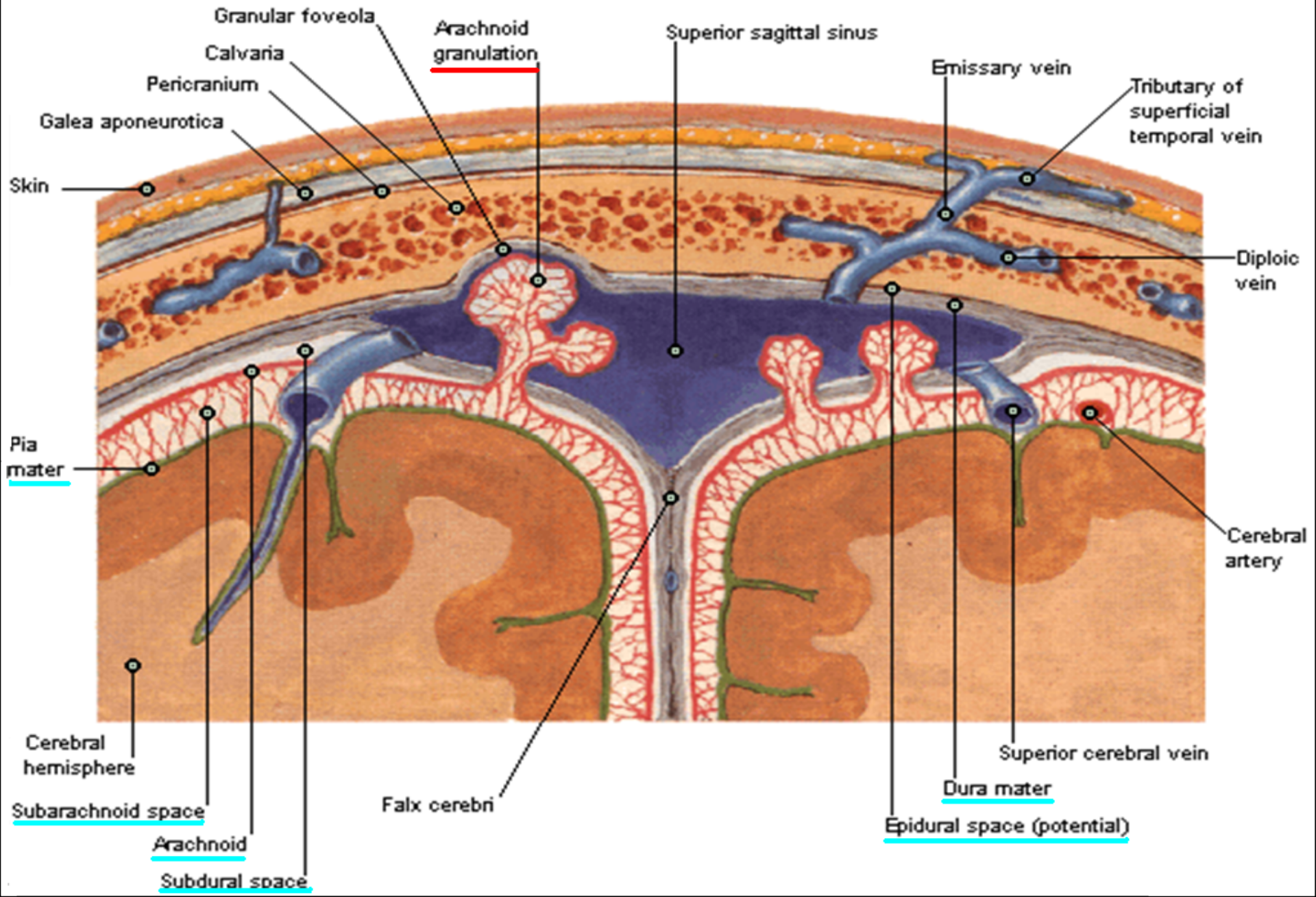
The CSF in each lateral ventricle → interventricular foramen of Monro → third ventricle → aqueduct of Sylvius → fourth ventricle → some fluid enter the central canal of spinal cord but the majority passes through the 3 foramina (one median of foramen Magendie to cerebellomedullary cistern of subarachnoid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


Lateral ventricle's choroid plexuses
CSF
Lateral ventricles
Through interventricular foramina
Third ventricle's choroid plexus
CSF
Third ventricle
Through cerebral aqueduct
Fourth ventricle's choroid plexus
CSF
Fourth ventricle
Through lateral and median apertures
Subarachnoid space
Arachnoid villi of dural venous sinuses
Venous blood
Heart and lungs
Arterial blood


Choroid plexus of lateral ventricle (phantom)
Superior sagittal sinus
Cistern of corpus callosum
Subarachnoid space
Arachnoid granulations
Dura mater
Arachnoid
Interventricular foramen (Monro)
Choroid plexus of 3rd ventricle
Cerebral aqueduct (Sylvius)
Lateral aperture (foramen of Luschka)
Choroid plexus of 4th ventricle
Median aperture (foramen of Magendie)

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.


Granular foveola
Arachnoid granulation
Superior sagittal sinus
Calvaria
Emissary vein
Pericranium
Tributary of superficial temporal vein
Galea aponeurotica
Skin
Diploic vein
Pia mater
Cerebral artery
Cerebral hemisphere
Superior cerebral vein
Falx cerebri
Dura mater
Subarachnoid space
Epidural space (potential)
Arachnoid
Subdural space

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

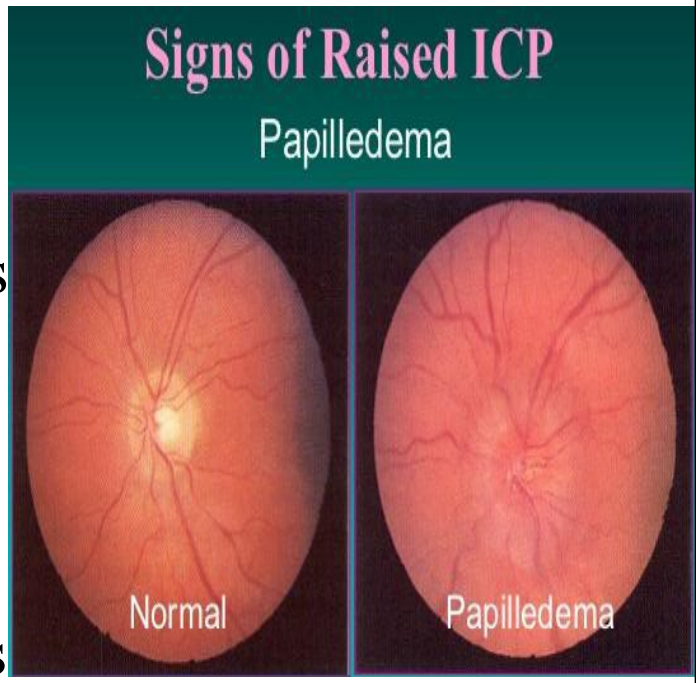
Hydrocephalus

- **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 dis **)papilledema).**
- Persistent **papilledema leads to optic atrophy and blindness**.



Thank You