

NEUROSURGERY

LECTURE - 1



DR HIMANSHU CHAMPANERI

CONSULTANT NEUROSURGEON

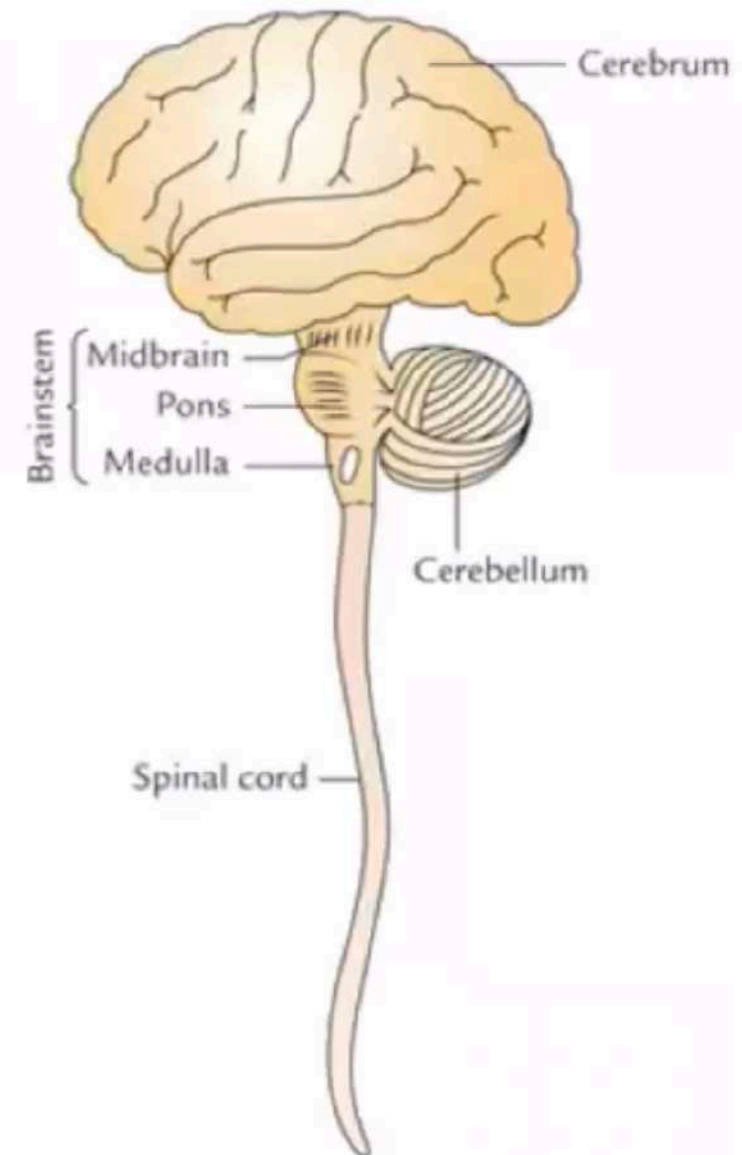
MEDANTA HOSPITAL, GURUGRAM

OVERVIEW

- **Anatomy of the brain**
- **Vascular anatomy of the brain**
- **Vascular diseases - aneurysms**

ORGANIZATION OF NERVOUS SYSTEM

- **Central nervous system & Peripheral n. s.**
 - Brain
 - Spinal cord
- **Brain**
 - 1/5th of the body weight, 1400g in M & 1200g in F
 - Six major parts
 1. Cerebrum
 2. Diencephalon
 3. Midbrain
 4. Pons
 5. Medulla oblongata
 6. cerebellum

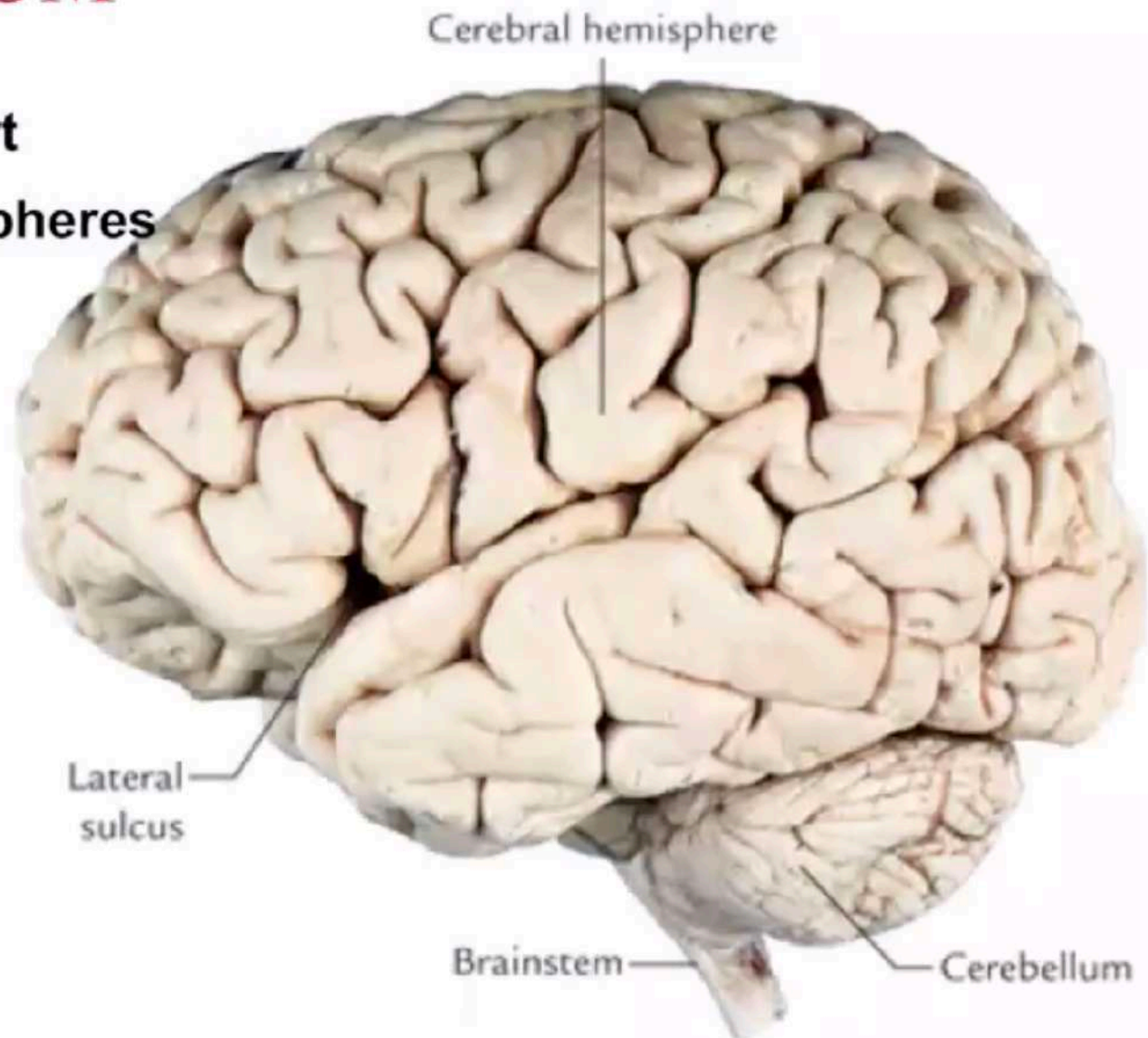


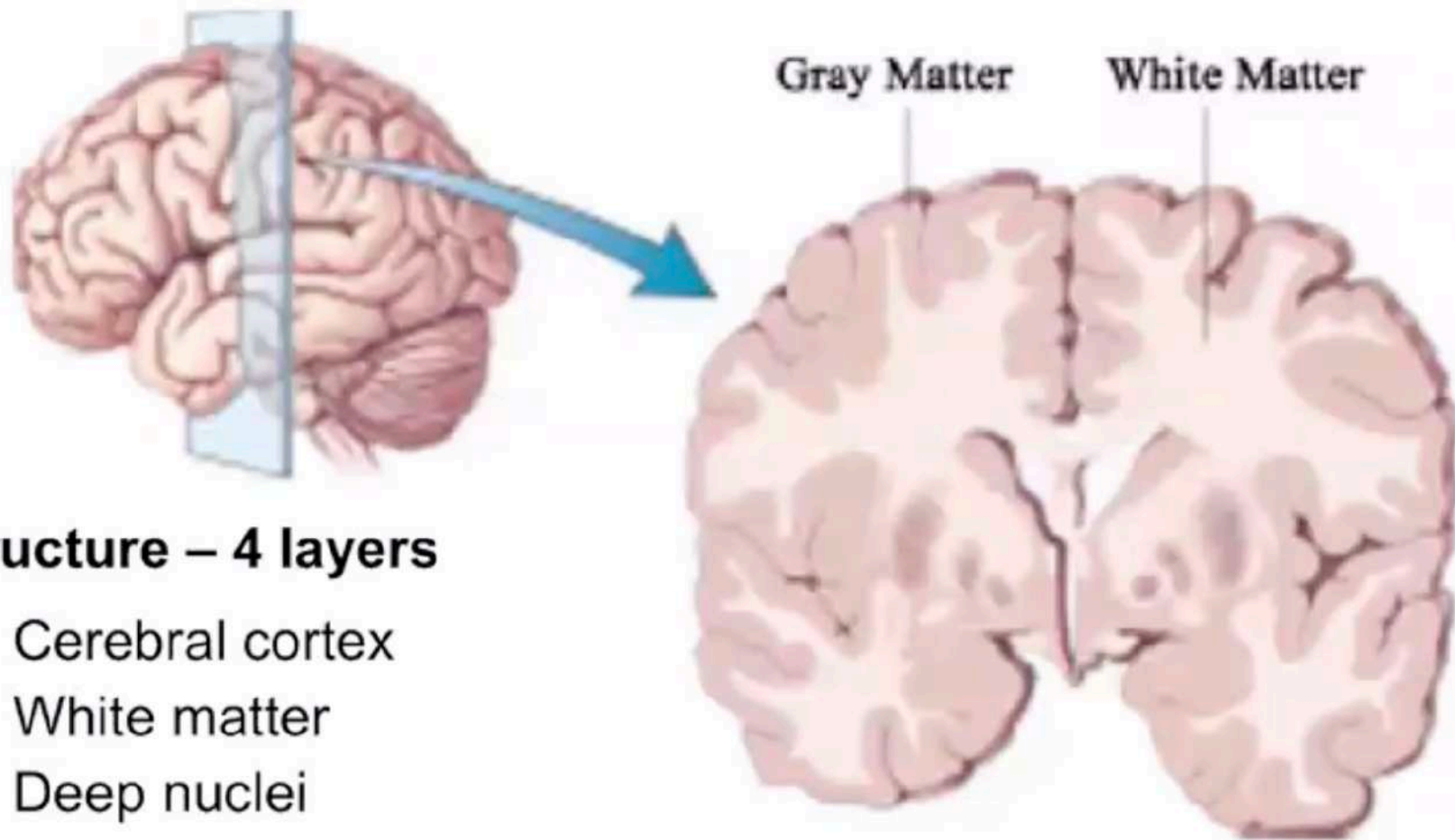
CEREBRUM



CEREBRUM

- Largest part
- Two hemispheres





- **Structure – 4 layers**
 - Cerebral cortex
 - White matter
 - Deep nuclei
 - Ventricular system

- **Surfaces – 3**

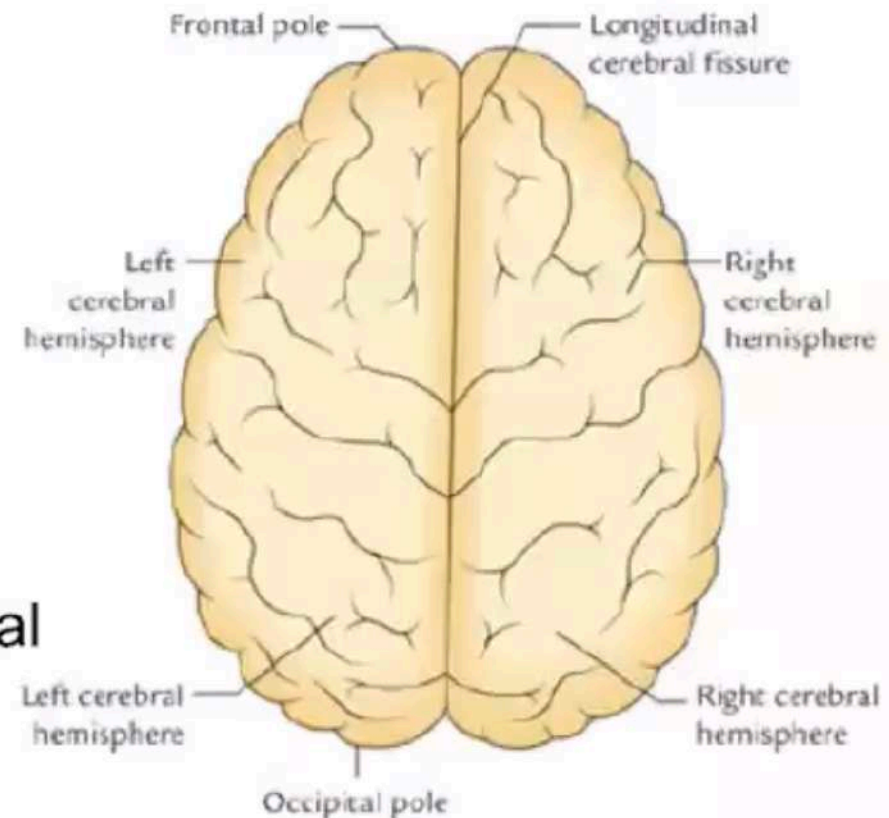
- Superolateral, medial & basal

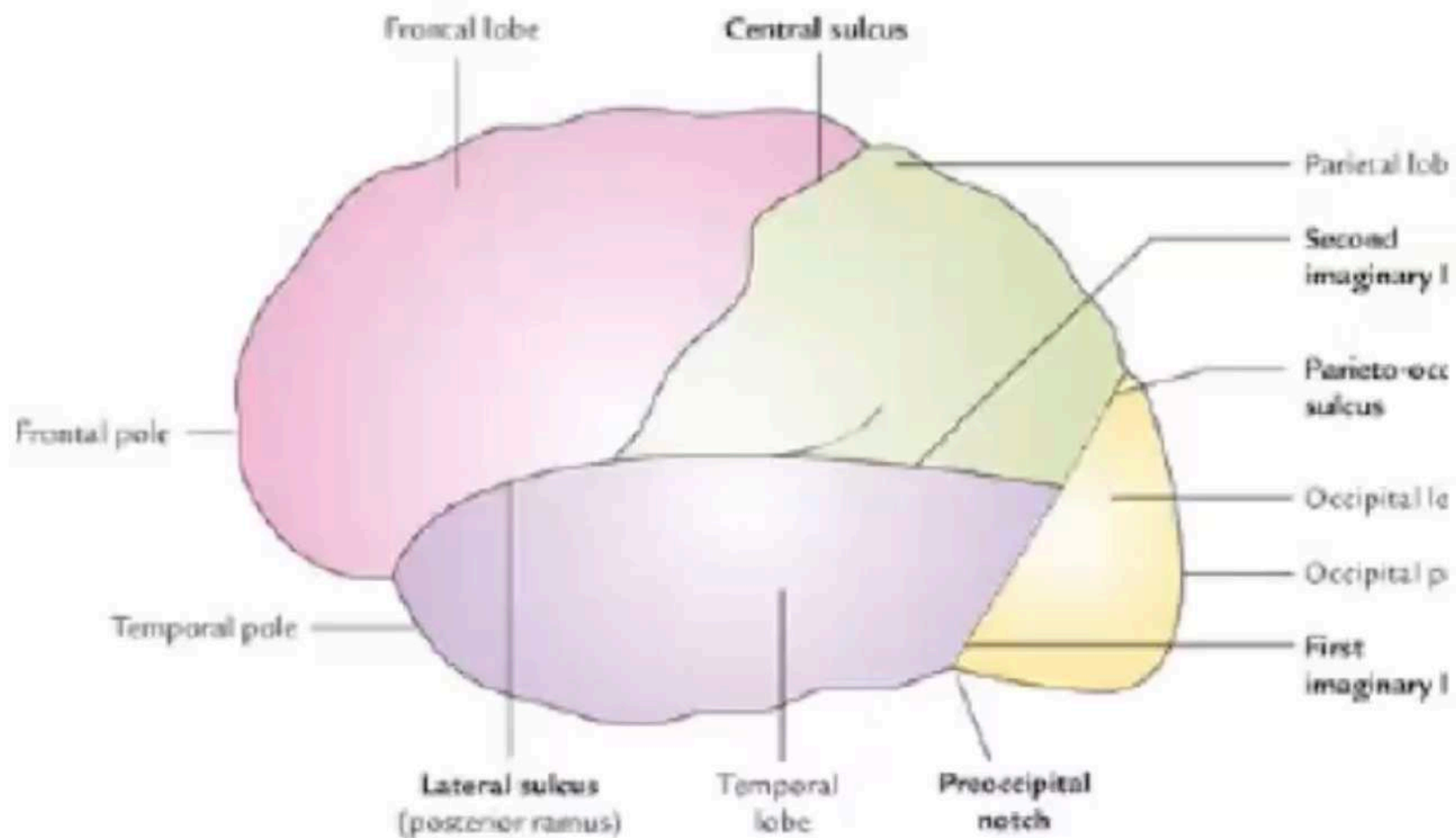
- **Poles - 3**

- Frontal, occipital & temporal

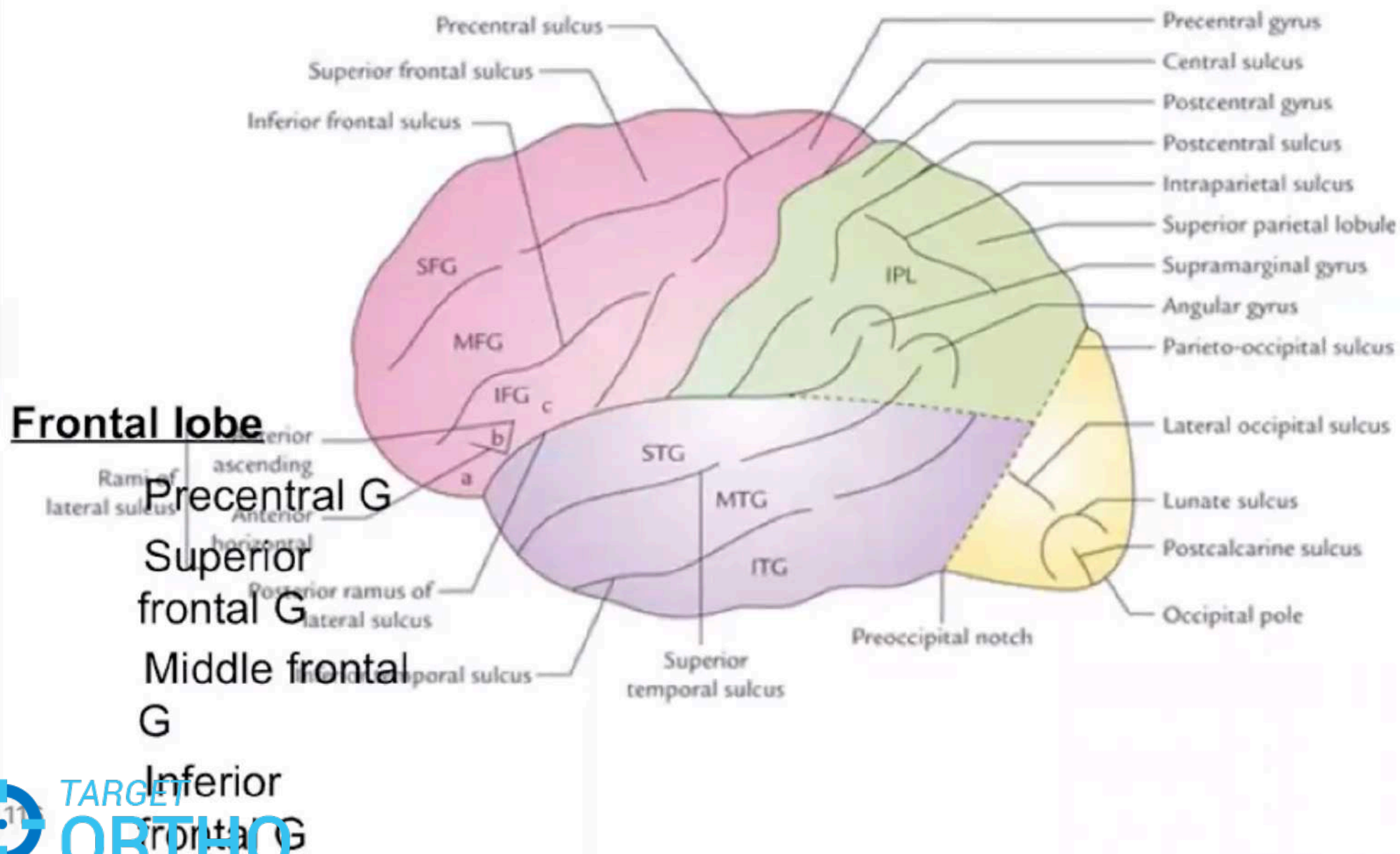
- **Main Sulci & gyri – 4**

- Sylvian, central, calcarine & parietooccipital

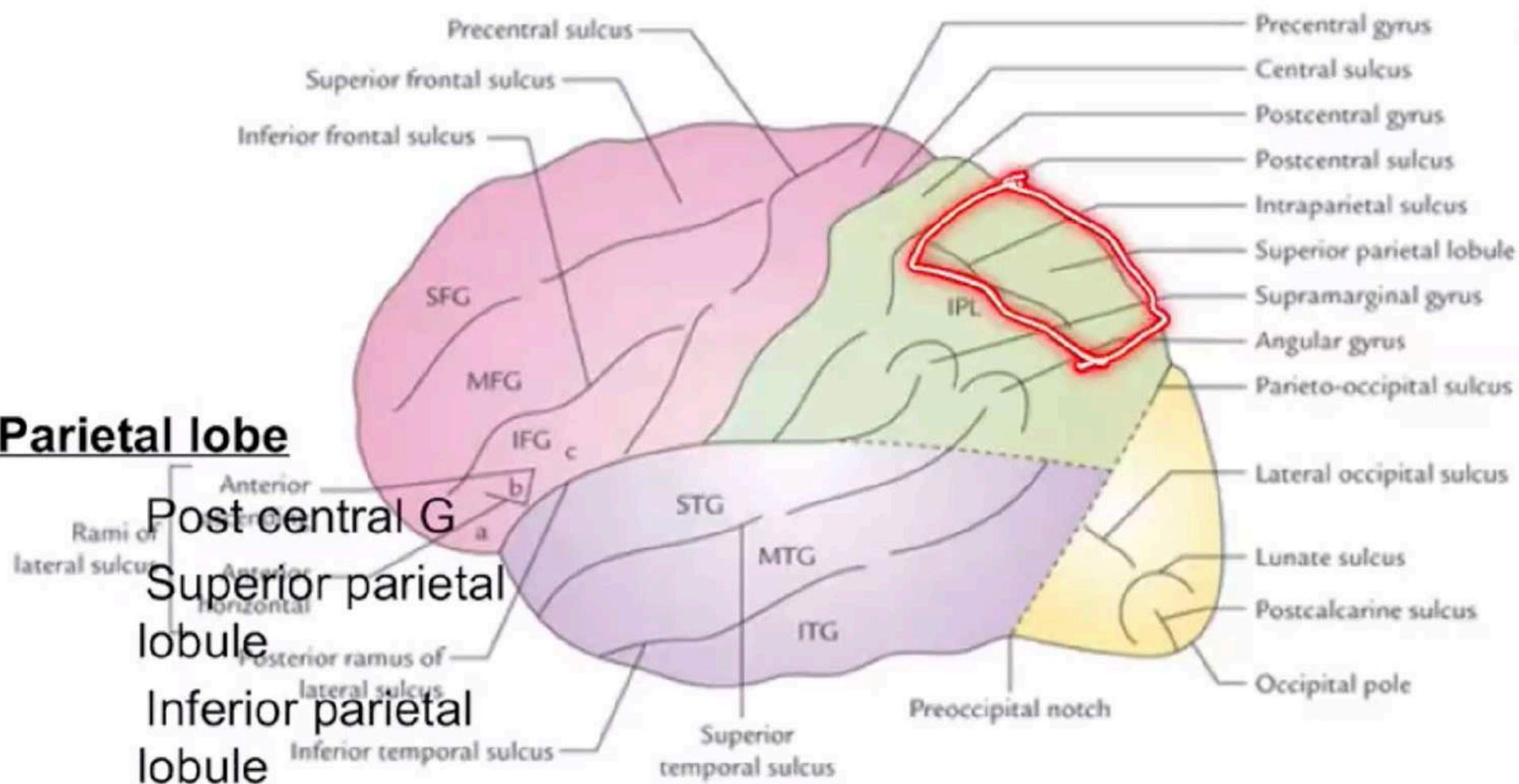




SUPEROLATERAL SURFACE

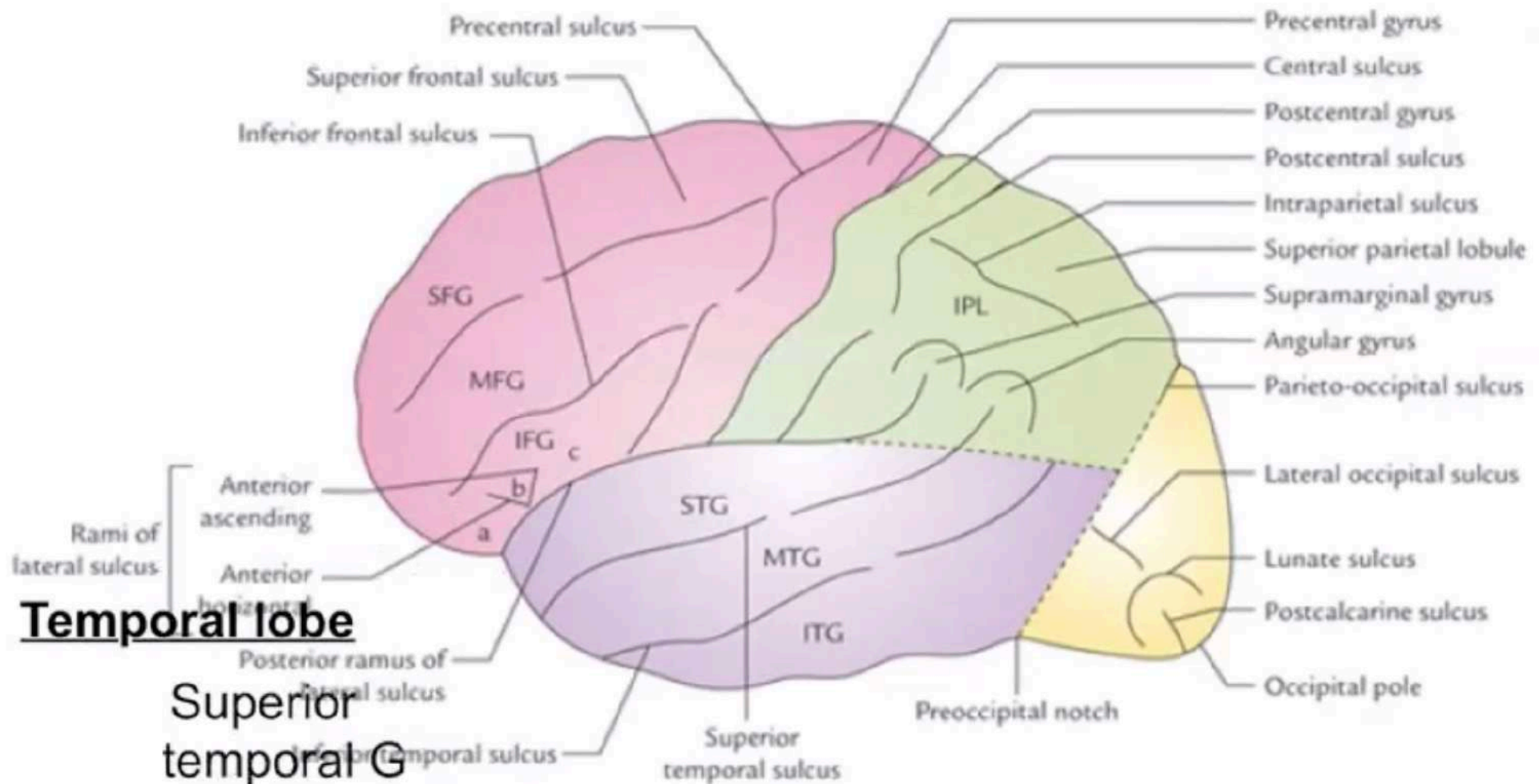


Parietal lobe



Post central G
Superior parietal lobule
Inferior parietal lobule

Target ORTHO
Inferior parietal lobule

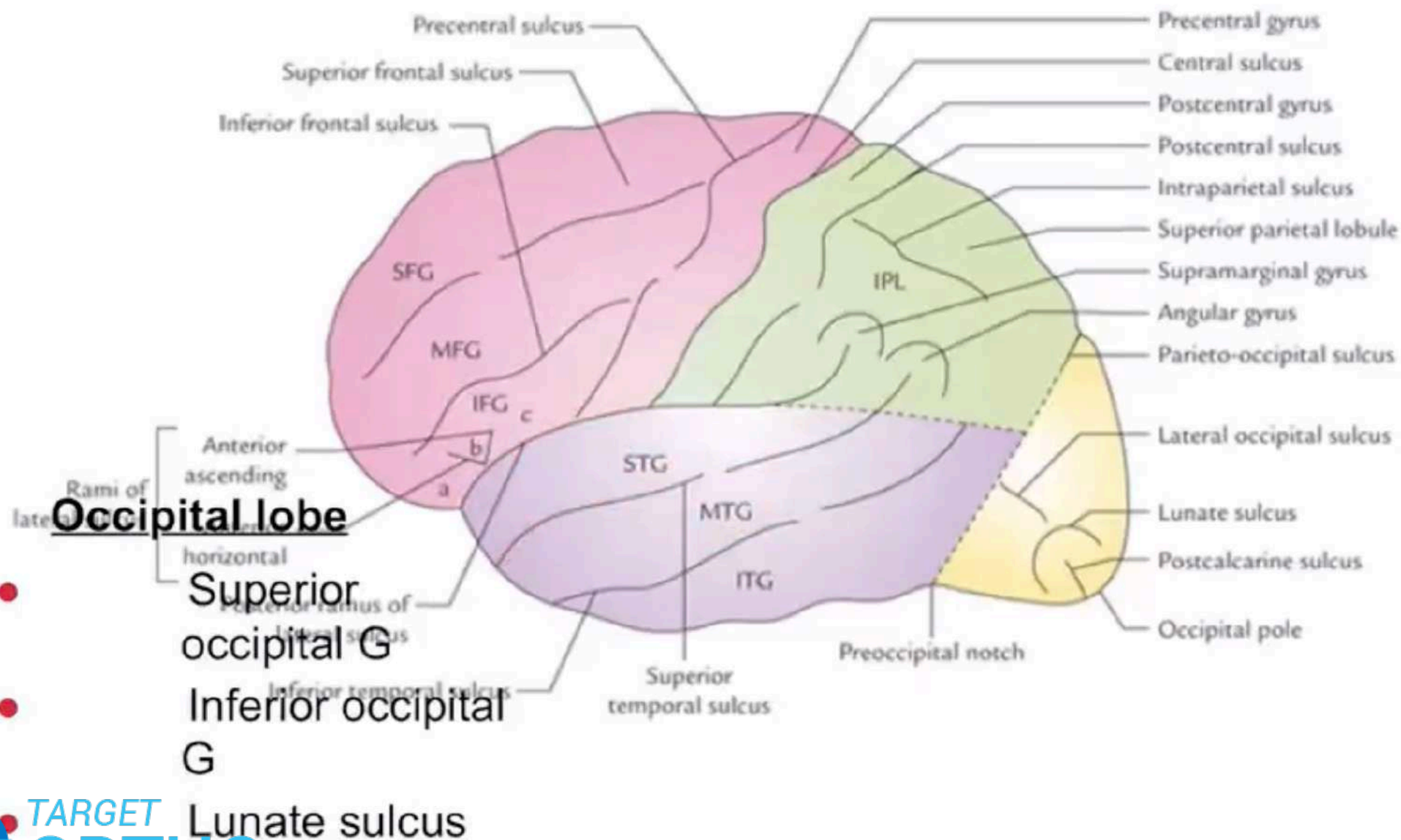


Temporal lobe

Superior temporal G

Middle temporal

Inferior temporal



Occipital lobe

Superior

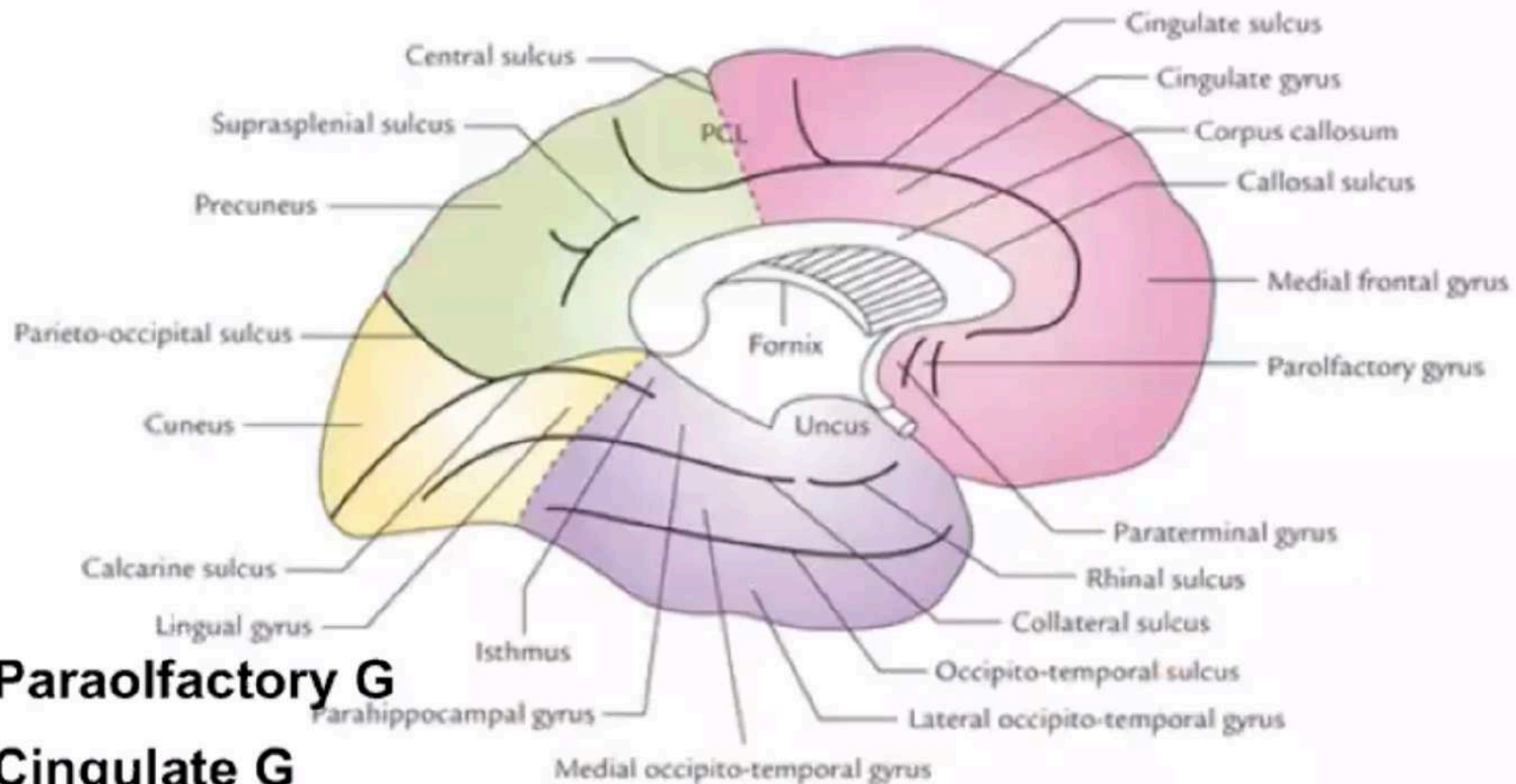
occipital G

Inferior occipital

G

Lunate sulcus

MEDIAL SURFACE



• **Paraolfactory G**

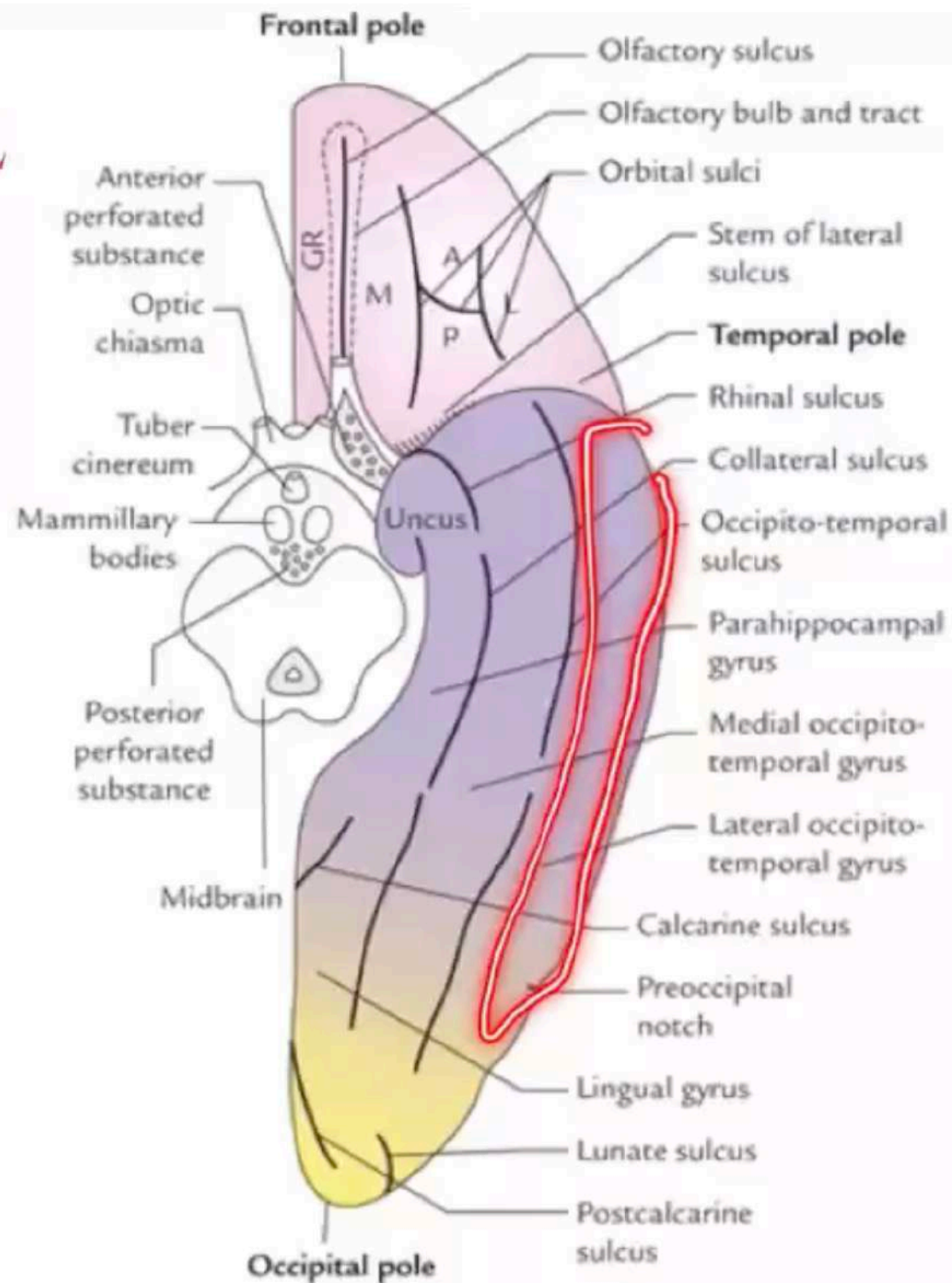
• **Cingulate G**

• **Medial frontal G**

• **Paracentral lobule**

• **Pre-cuneus**

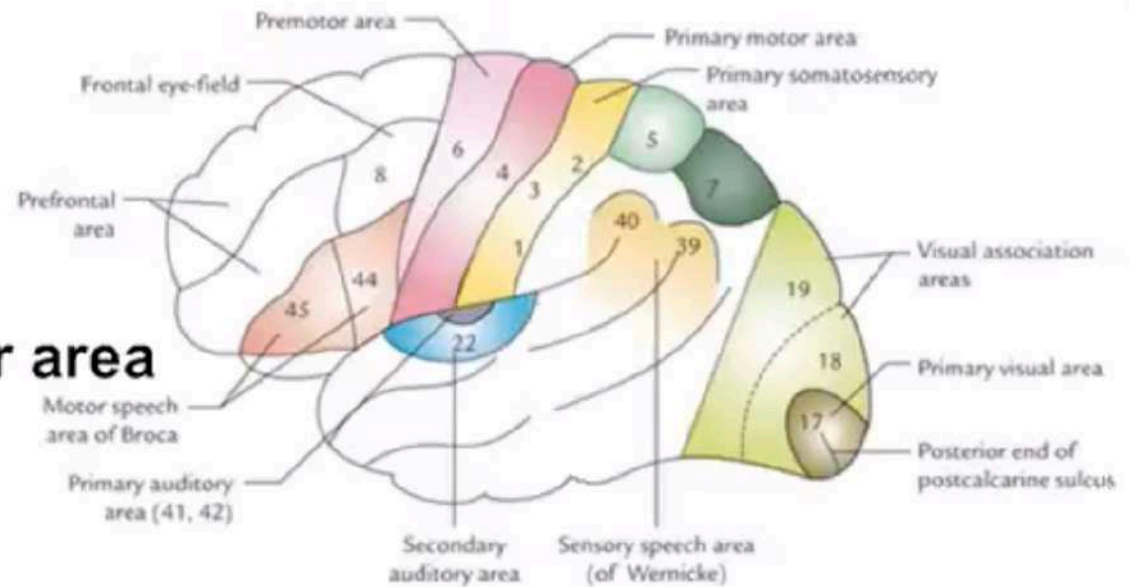
BASAL



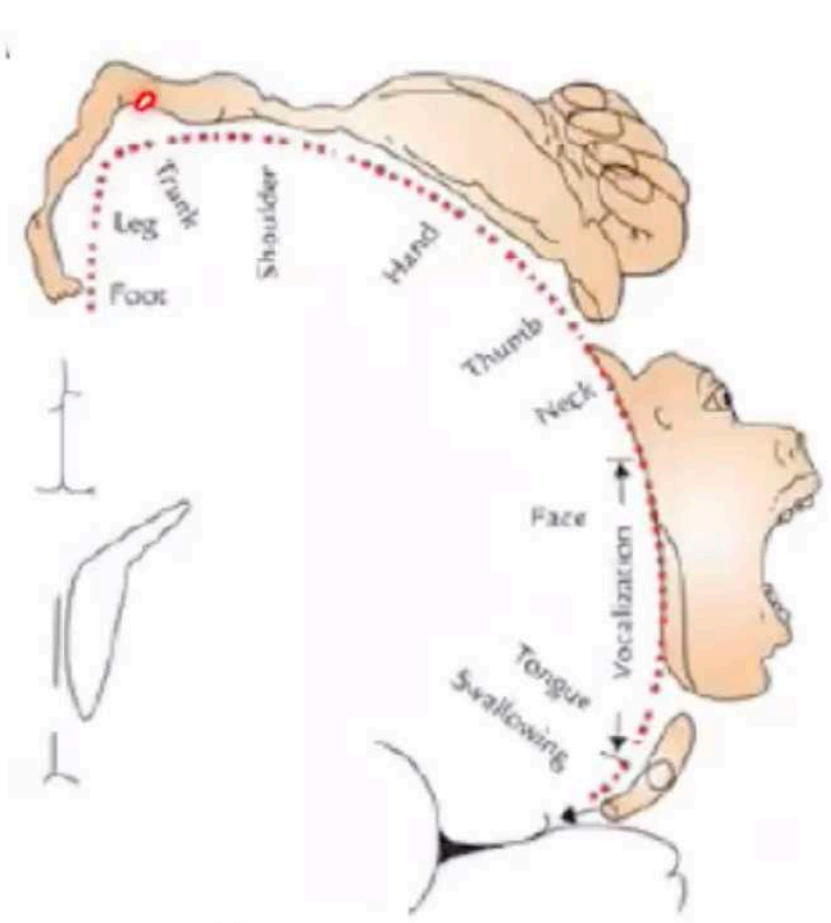
FUNCTIONAL AREAS

Frontal lobe

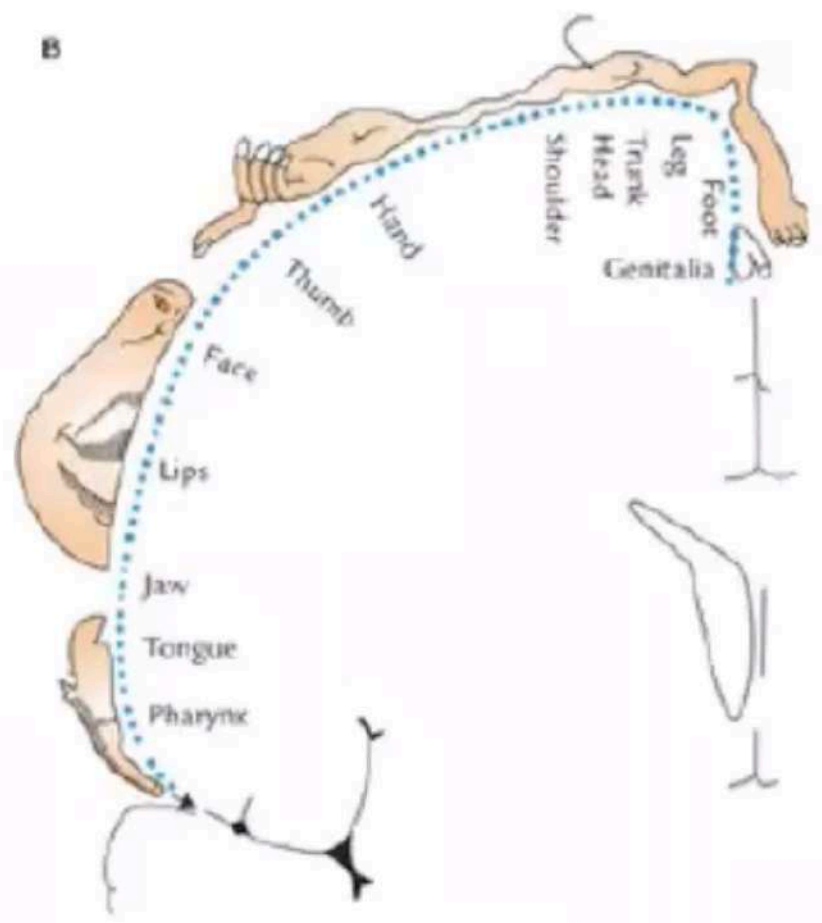
- Primary motor area
- Pre motor area
- Supplementary motor area
- Frontal eye field area
- Motor speech area
- Prefrontal area



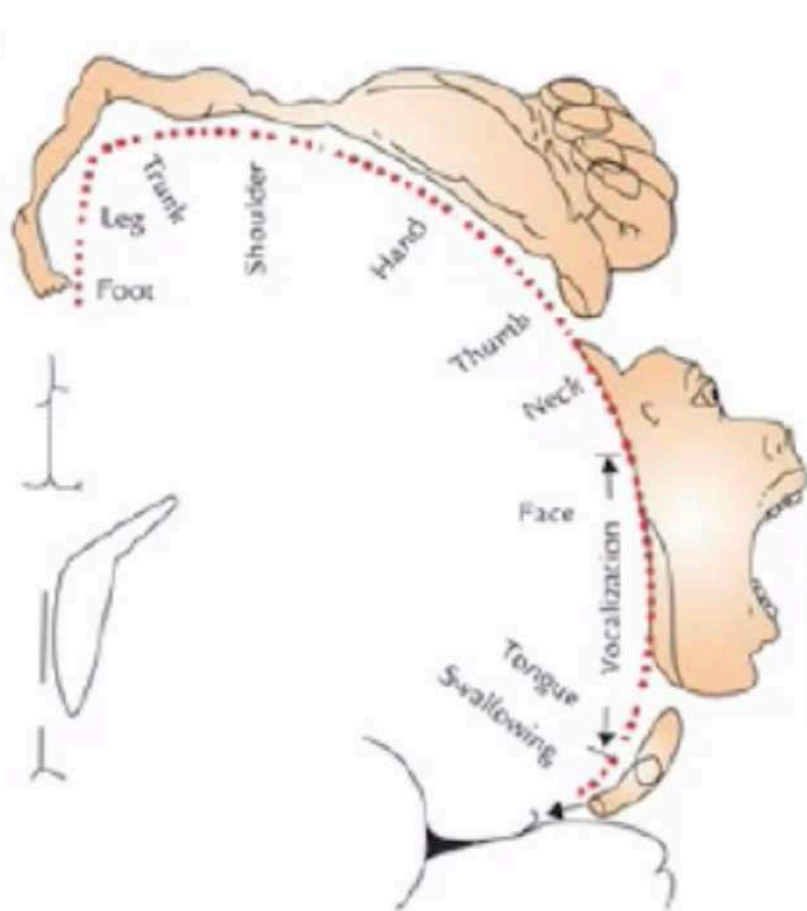
- Hemiplegia (primary motor area)
- Apraxia (premotor area)
- Gaze palsy (frontal eye field area)
- Broca's aphasia (motor speech area)



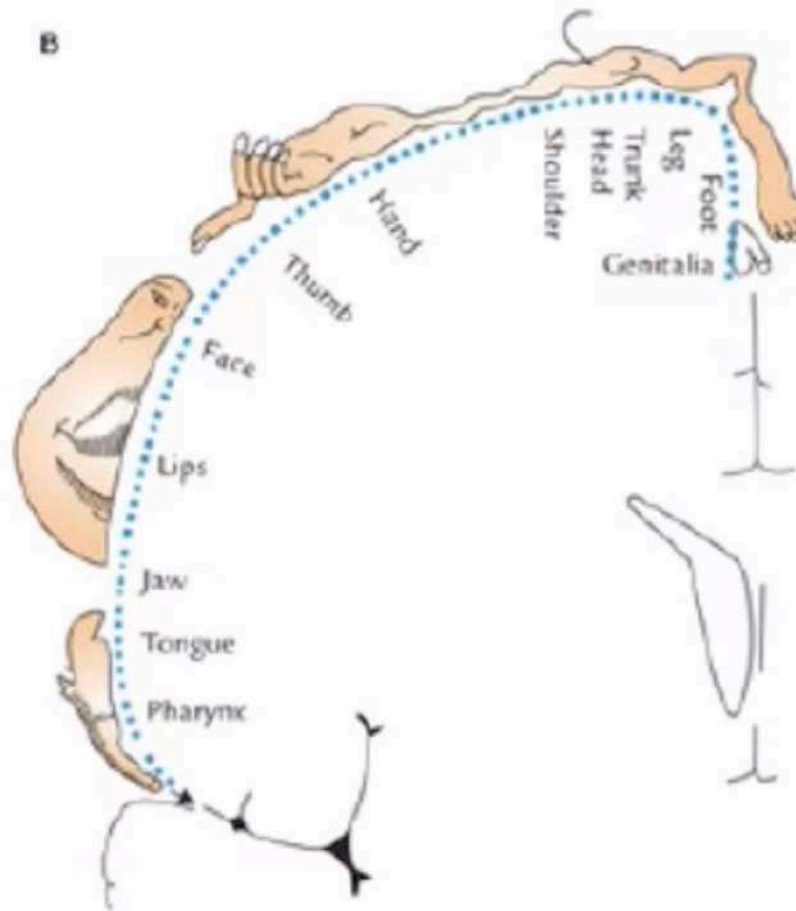
Motor areas



Sensory areas



Motor areas

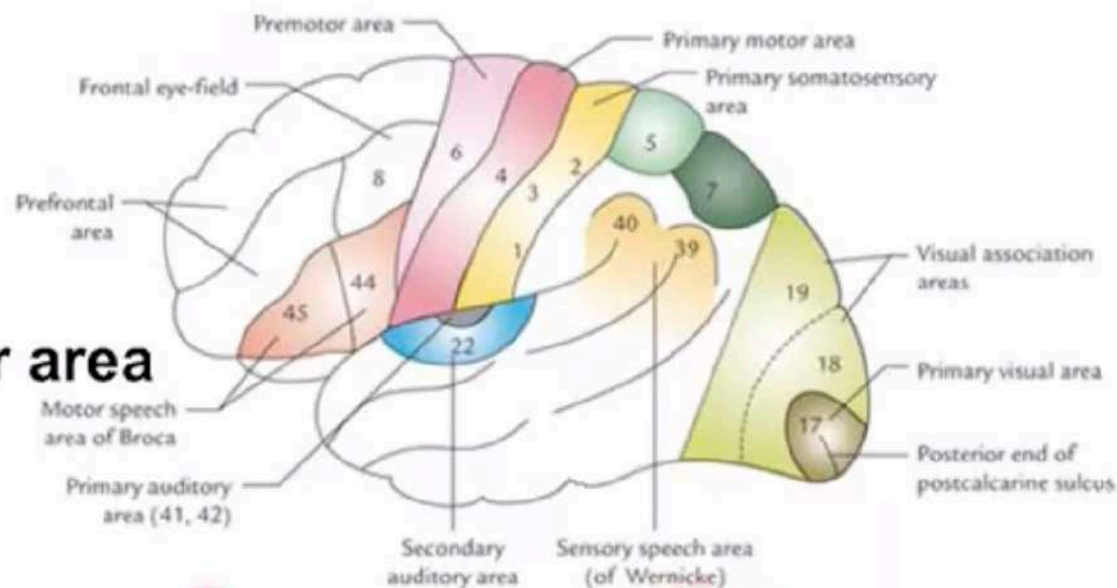


Sensory areas

FUNCTIONAL AREAS

Frontal lobe

- Primary motor area
- Pre motor area
- Supplementary motor area
- Frontal eye field area
- Motor speech area
- Prefrontal area

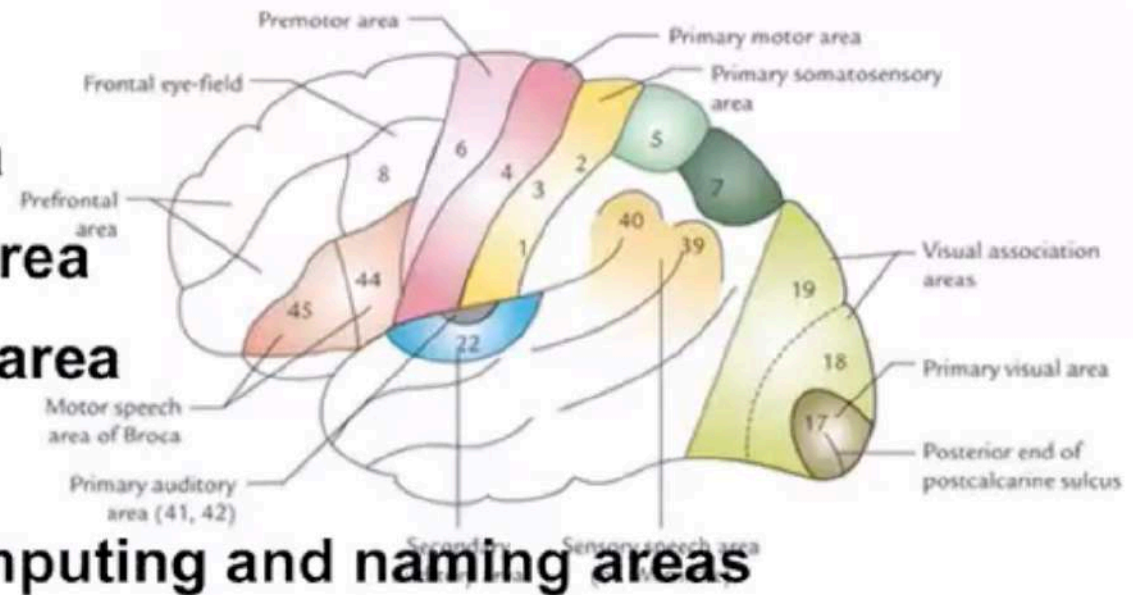


Broca's aphasia

- Hemiplegia (primary motor area)
- Apraxia (premotor area)
- Gaze palsy (frontal eye field area)
- Broca's aphasia (motor speech area)

Pareital lobe

- **Primary sensory area**
- **Secondary sensory area**
- **Sensory association area**
- **Sensory speech area**
- **Reading, writing, computing and naming areas**



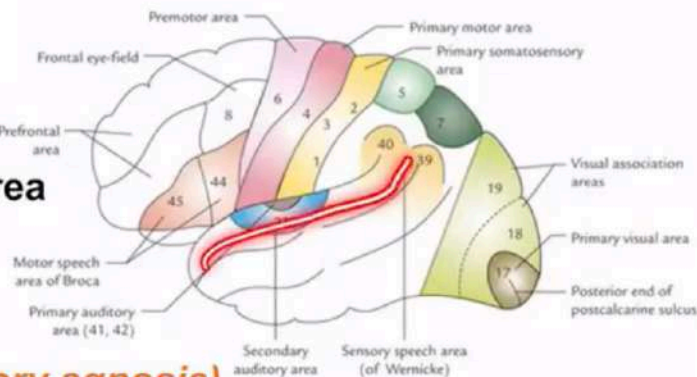
- **Astereognosis**
- **Sensory aphasia**
- **Selective aphasia**



Temporal lobe

- Primary auditory area
- Secondary auditory area

- Cortical deafness
- Word deafness (auditory agnosia)



Temporal lobe
Primary sensory area
Secondary sensory area
Sensory association area
Sensory speech area
Reading, writing, computing and naming areas

Astereognosis
Sensory aphasia
Selective aphasia

Screenshot 2023-01-05 at 3:39 PM

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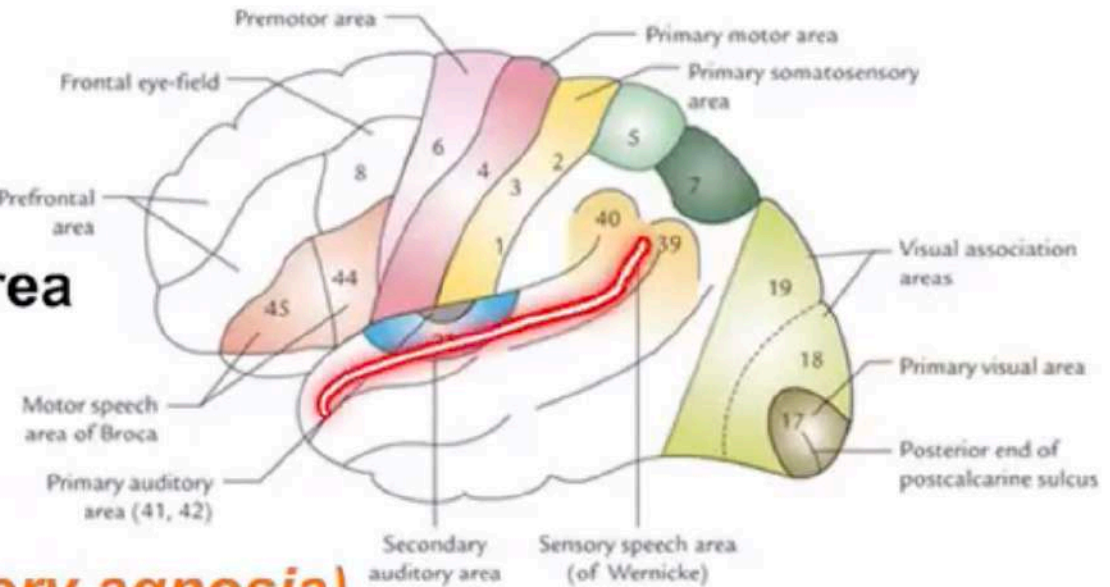
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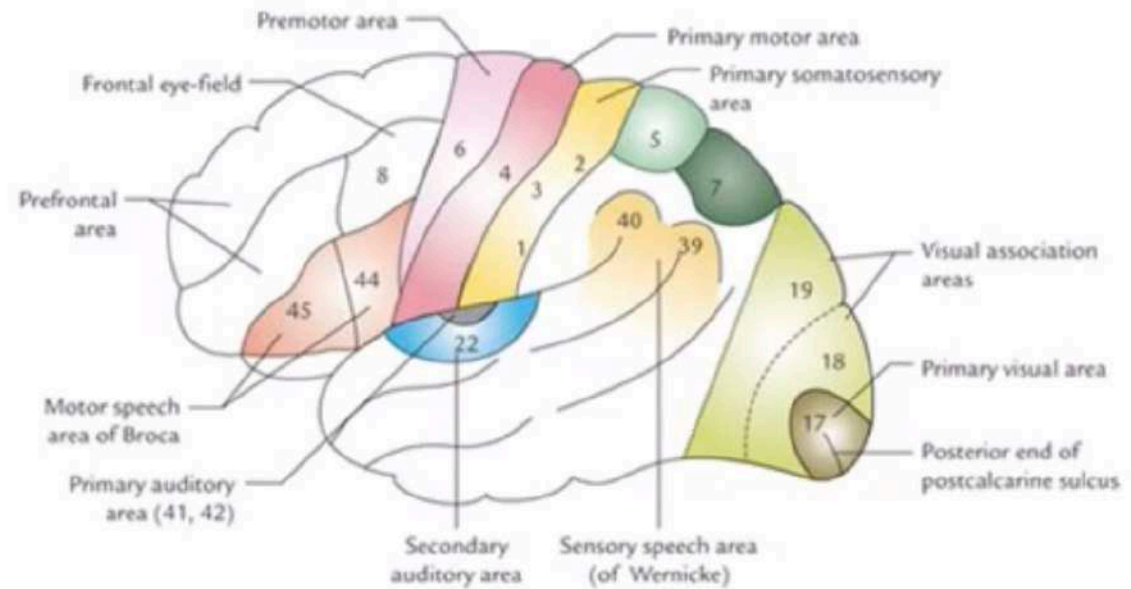
Temporal lobe

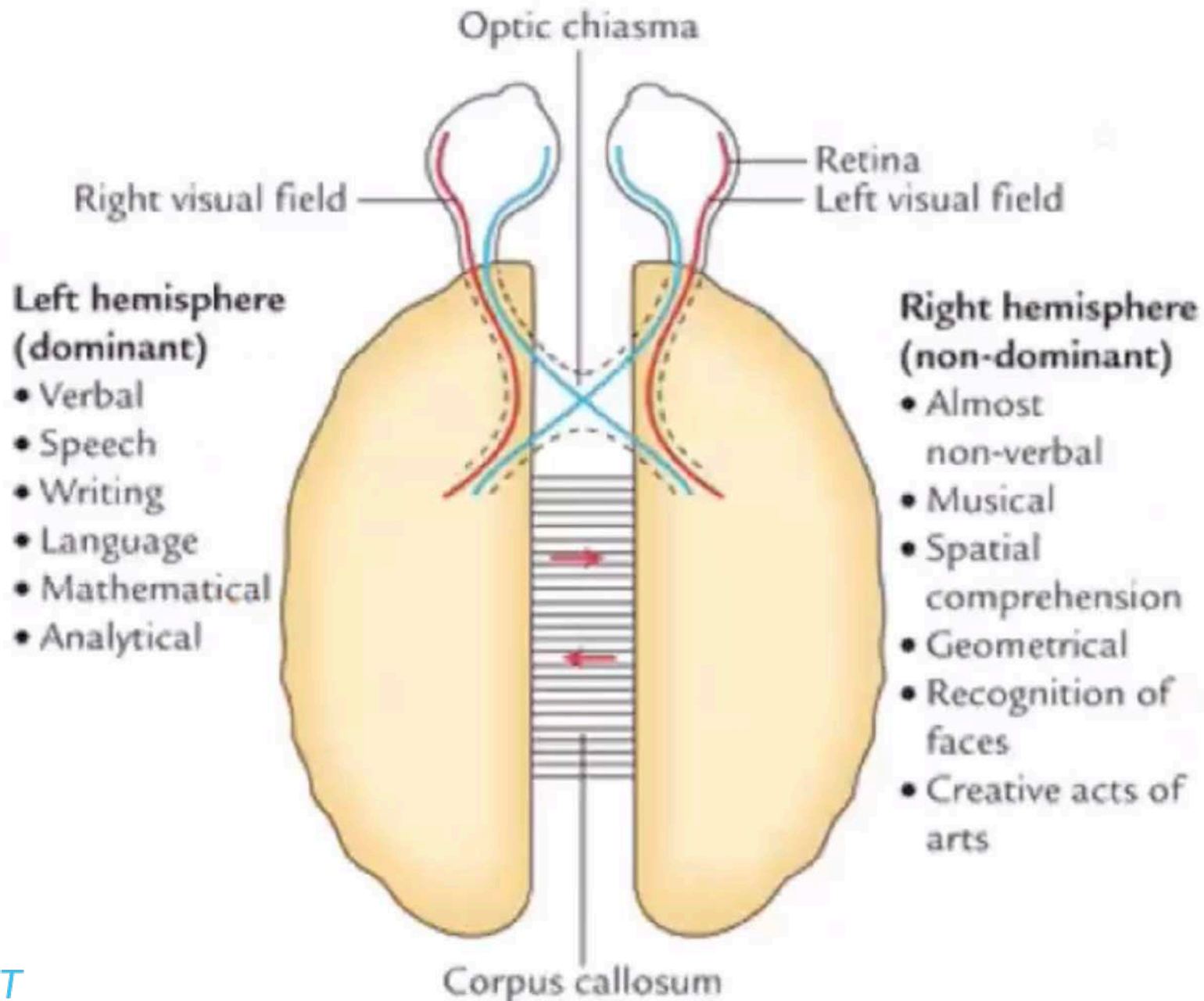
- Primary auditory area
- Secondary auditory area
- Cortical deafness
- Word deafness (auditory agnosia)



Occipital lobe

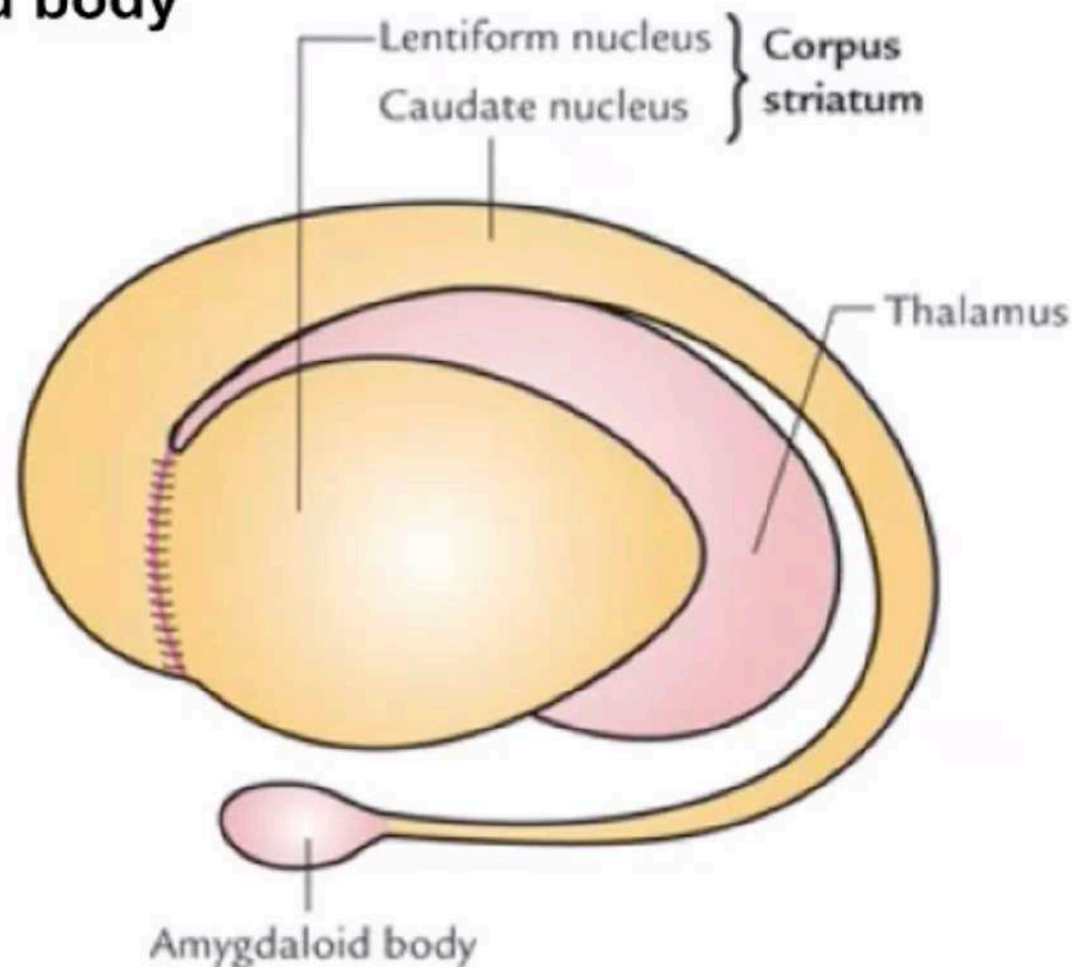
- Visual cortex/primary
- Secondary visual area
- Cortical blindness
- Visual agnosia

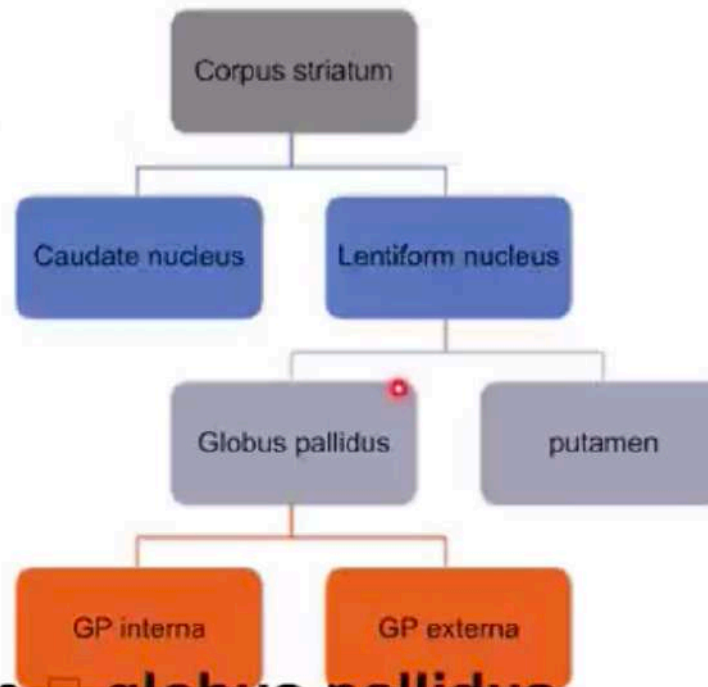




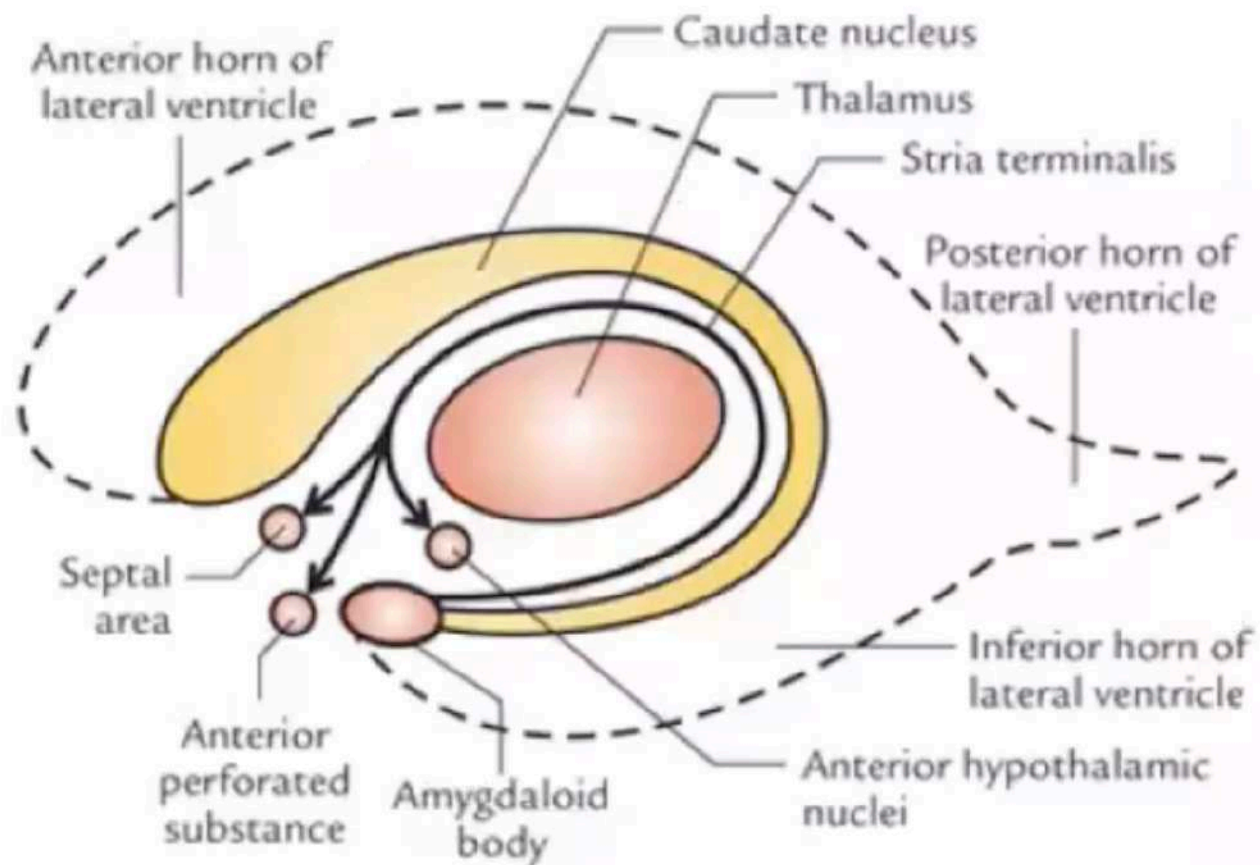
DEEP CEREBRAL NUCLEI

- Aka basal ganglia
- Anatomically – corpus striatum, claustrum, amygdaloid body



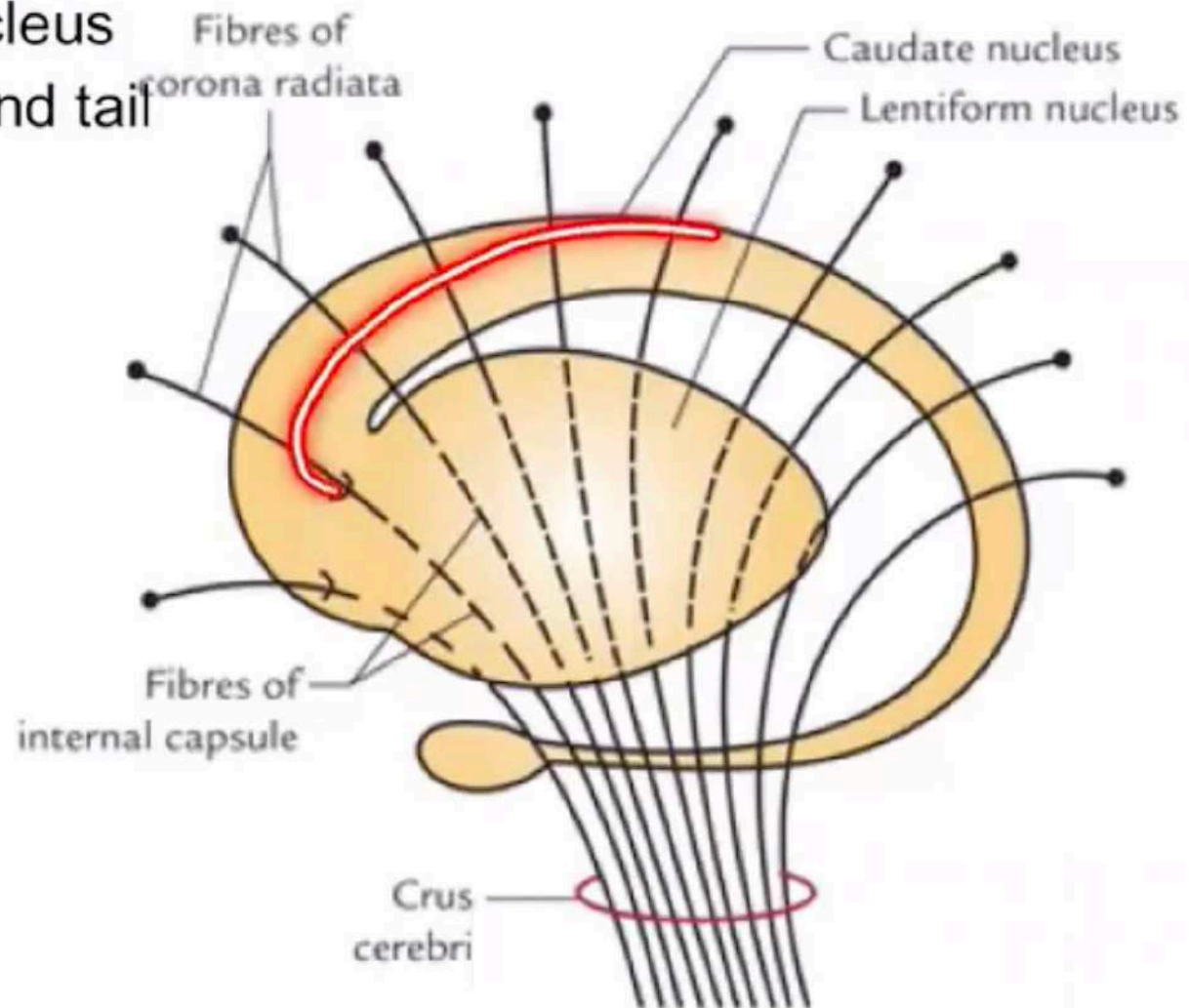


- **Paleostriatum** ☐ **globus pallidus**
- **Neostriatum** ☐ **caudate and putamen**



- **Caudate nucleus**

- C shaped nucleus
- Head, body and tail

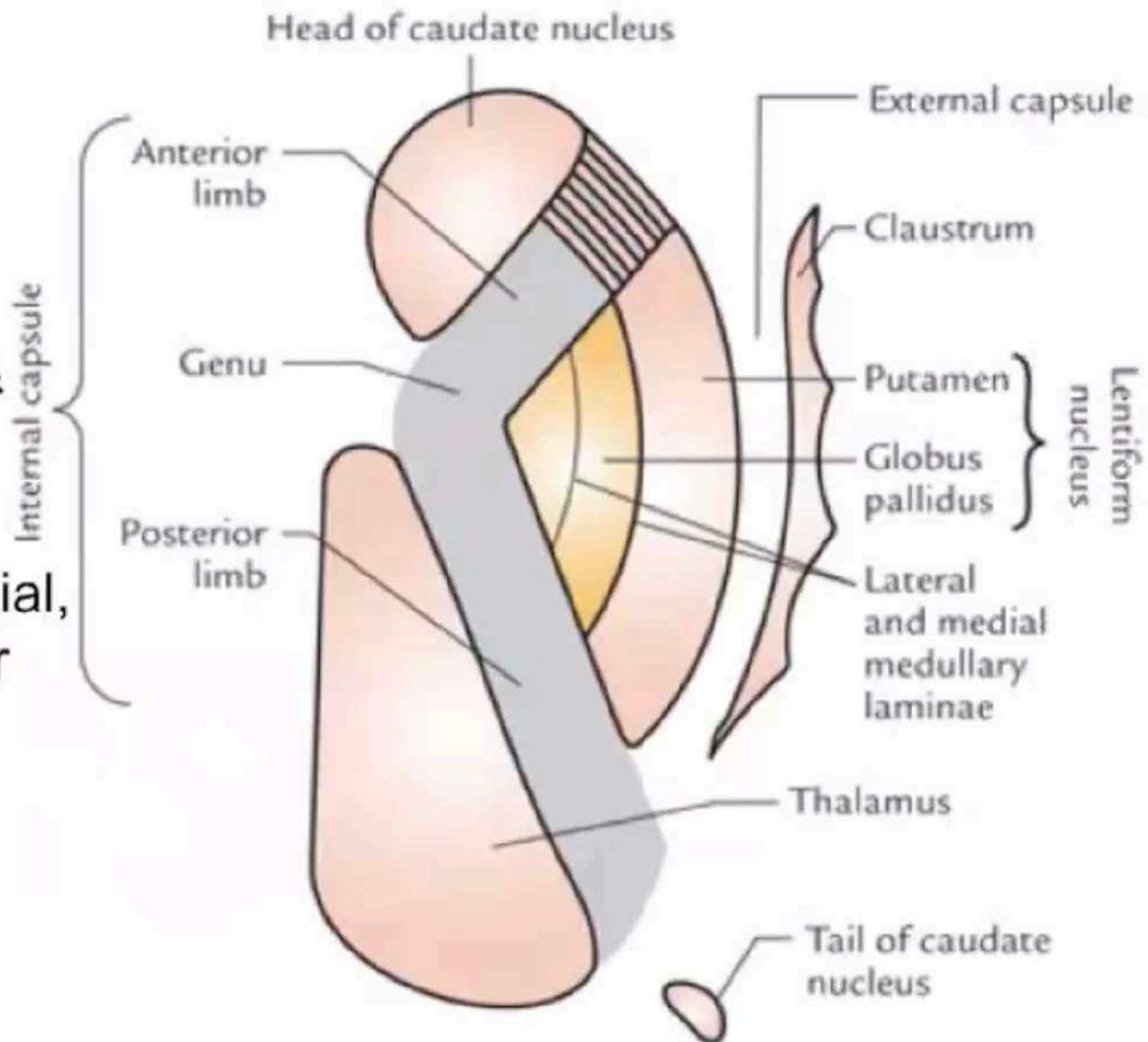


Lentiform nucleus

Globus pallidus & putamen

Biconvex shape

3 surfaces – medial, lateral and inferior



- **Functions of basal nuclei**

- Programming of voluntary movements
- Determine the rapidity and amplitude
- Inhibit unwanted muscular activity
- Regulate/reduces muscle tone
- Automatic associated movements

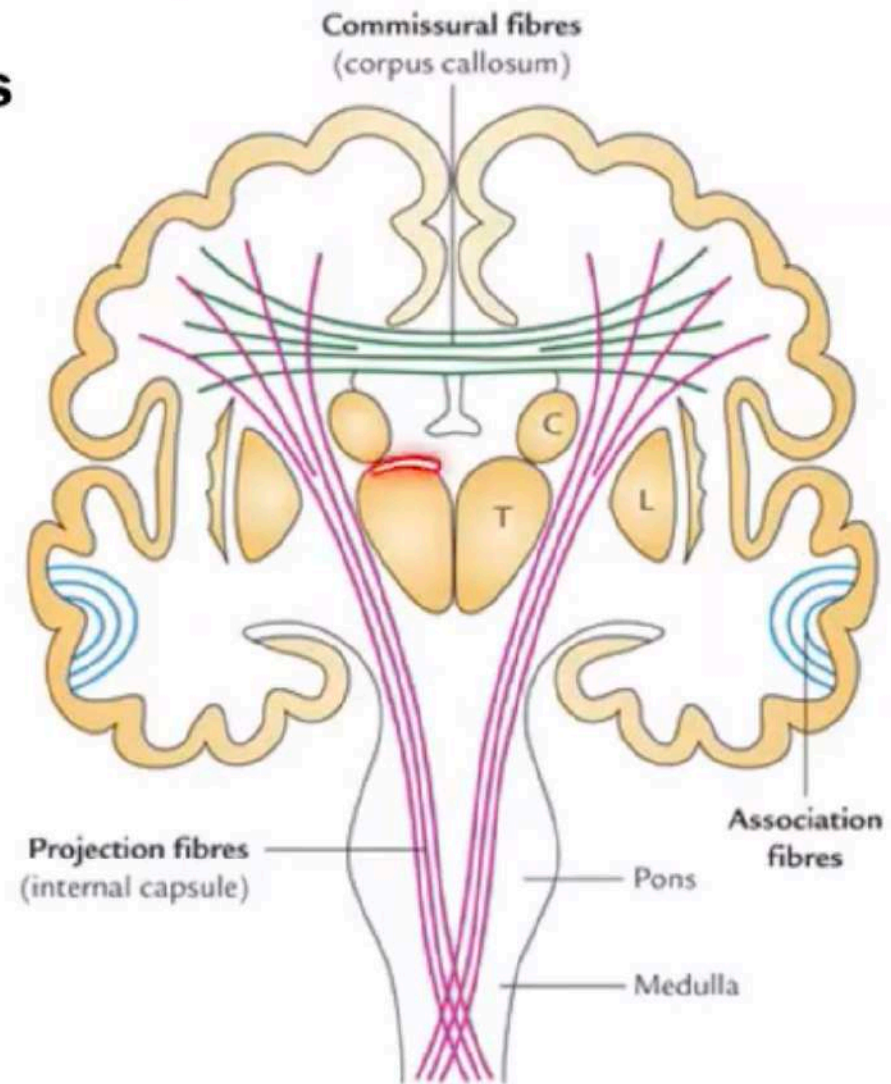
- ***Movement Disorders***

- *Parkinson's disease*
- *Chorea, athetosis, ballismus*

SUBCORTICAL WHITE MATTER

- **Types of white matter fibres**

1. Association fibres
2. Commissural fibres
3. Projection fibres



- **Association fibres**

- Short association fibres / arcuate fibres

- Long association fibres

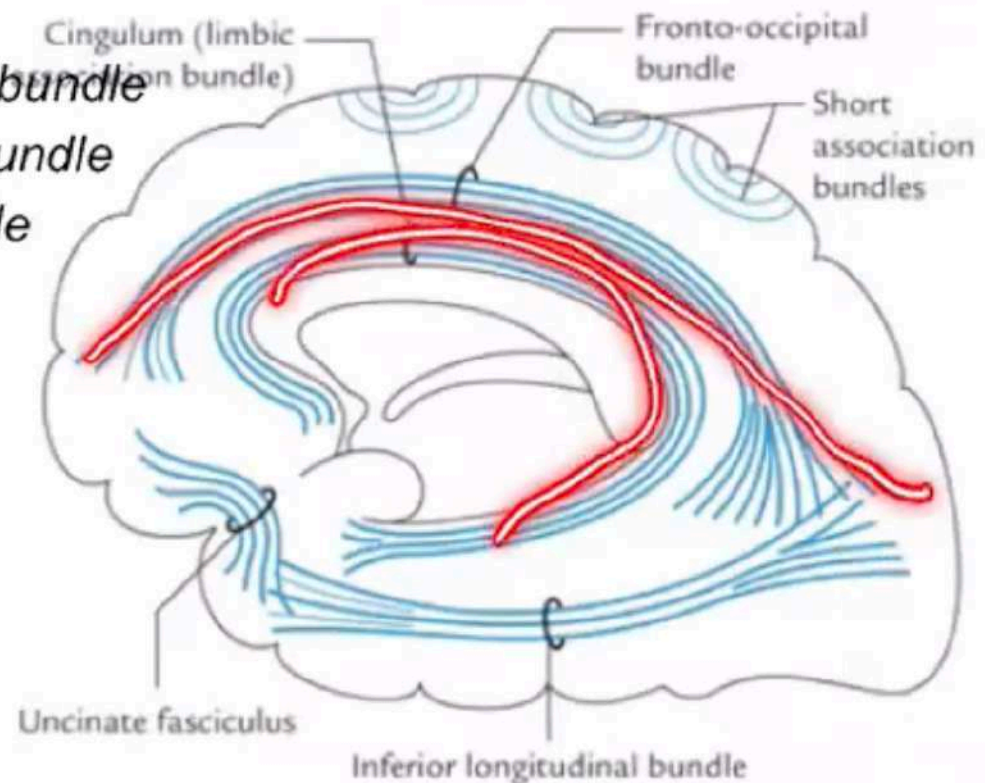
- *Uncinate fasciculus*

- *Cingulum*

- *Superior longitudinal bundle*

- *Inferior longitudinal bundle*

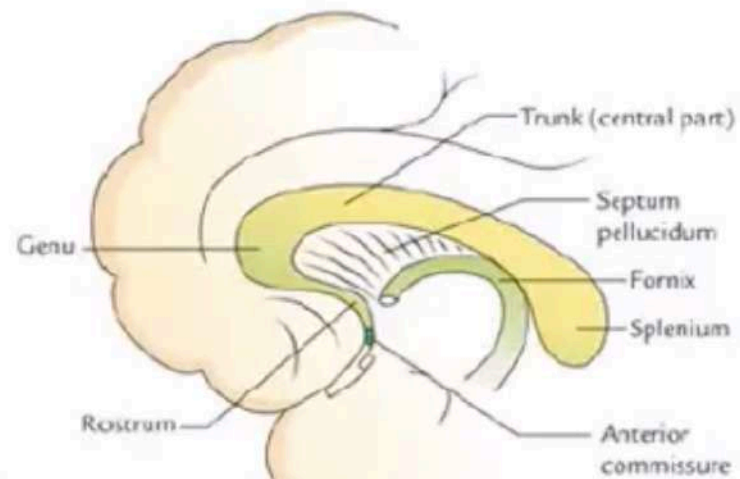
- *Fronto-occipital bundle*

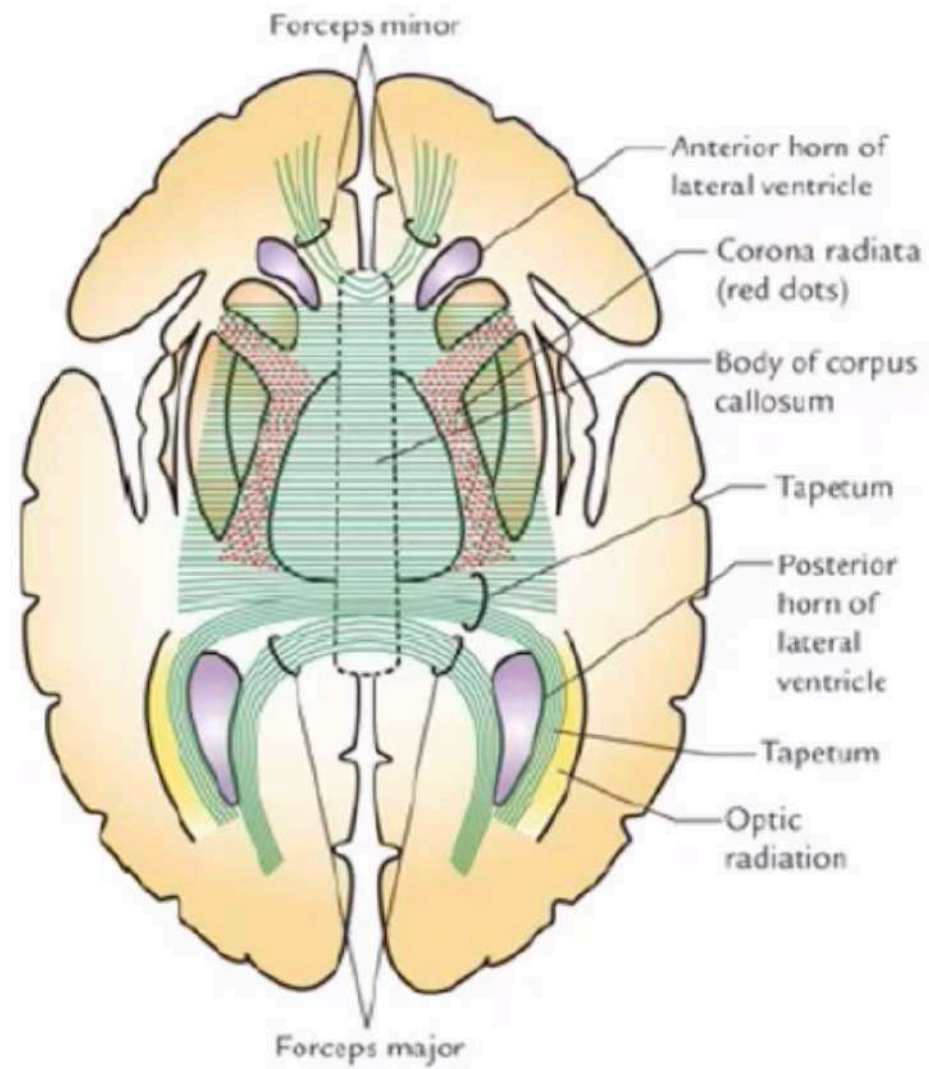


Commissural fibres

- **Corpus callosum**

- C shaped structure
- 4 parts – rostrum, genu, body & splenium
- Connected to septum pellucidum inferiorly
- Covered with indusium griseum superiorly
- Related to anterior cerebral vessels
- *Split – brain syndrome*
- *Akinetic mutism (anterior callosum)*
- *Alexia without agraphia (posterior callosum)*





- **Other commissural fibres**

- Anterior commissure
- Posterior commissure
- Habenular commissure
- Hippocampal/forniceal commissure

Projection fibres

- **Internal capsule**

- **Parts**

- Anterior limb

- Genu

- Posterior limb

- Retrolentiform part

- Sublentiform part

- **Motor fibres**

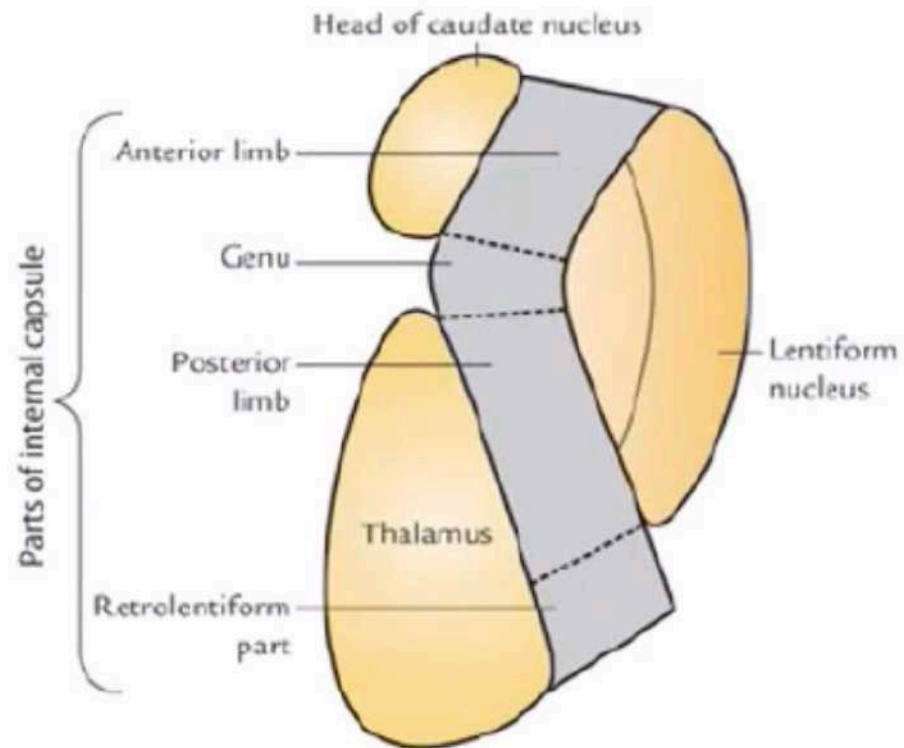
- Corticopontine

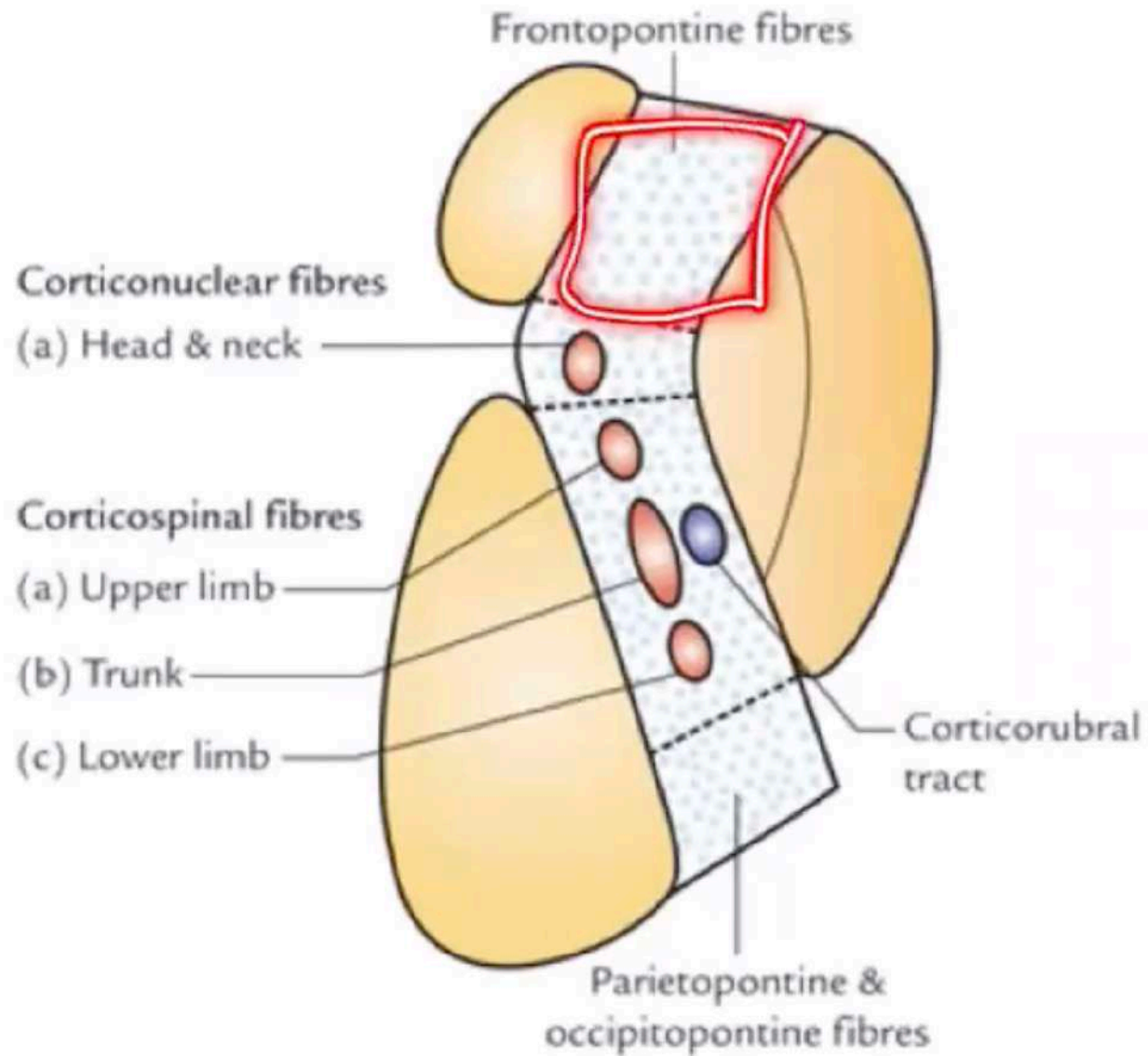
- Pyramidal fibres

- Extrapyrmidal fibres

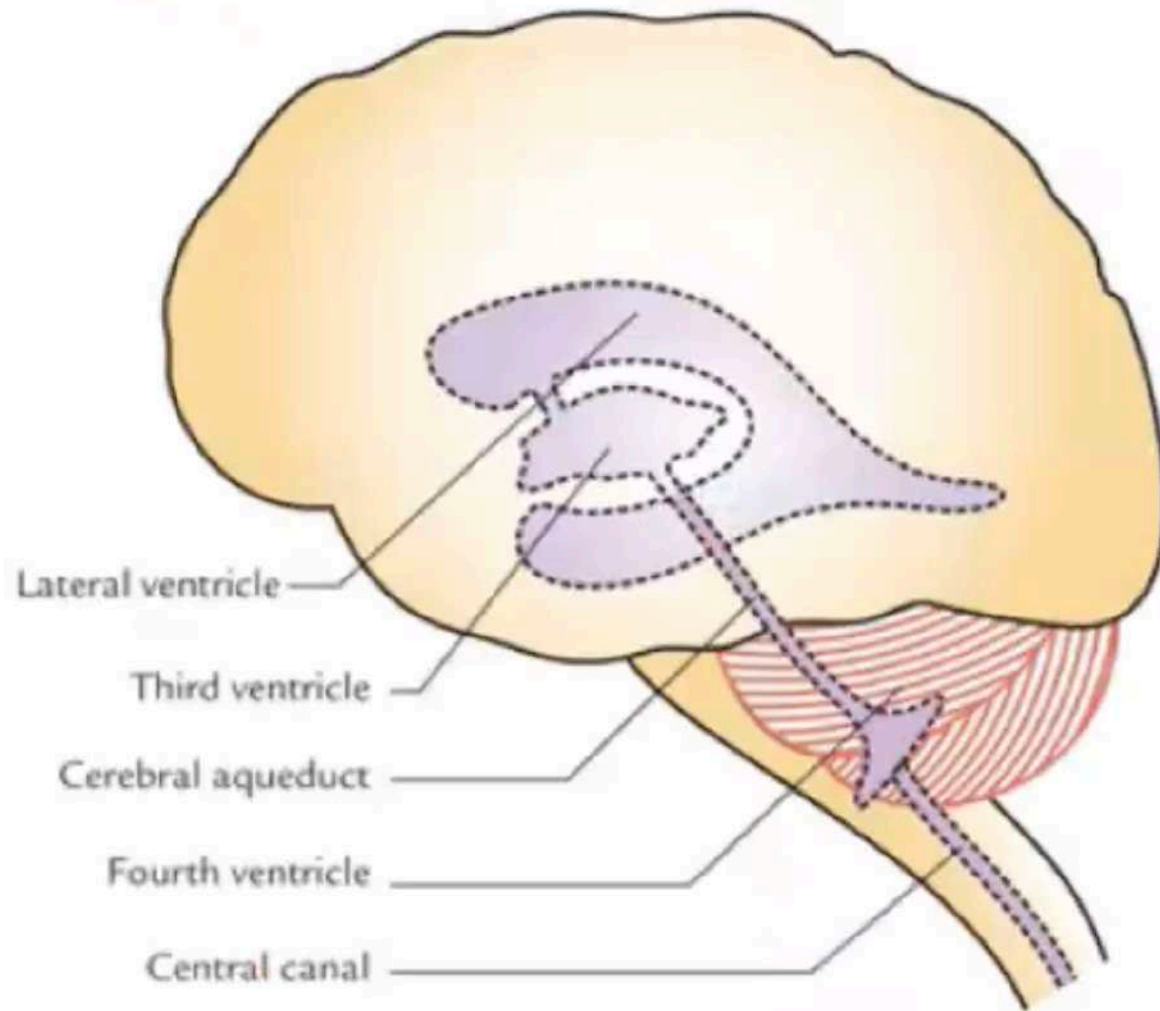
- **Sensory fibres**

- Thalamic radiations





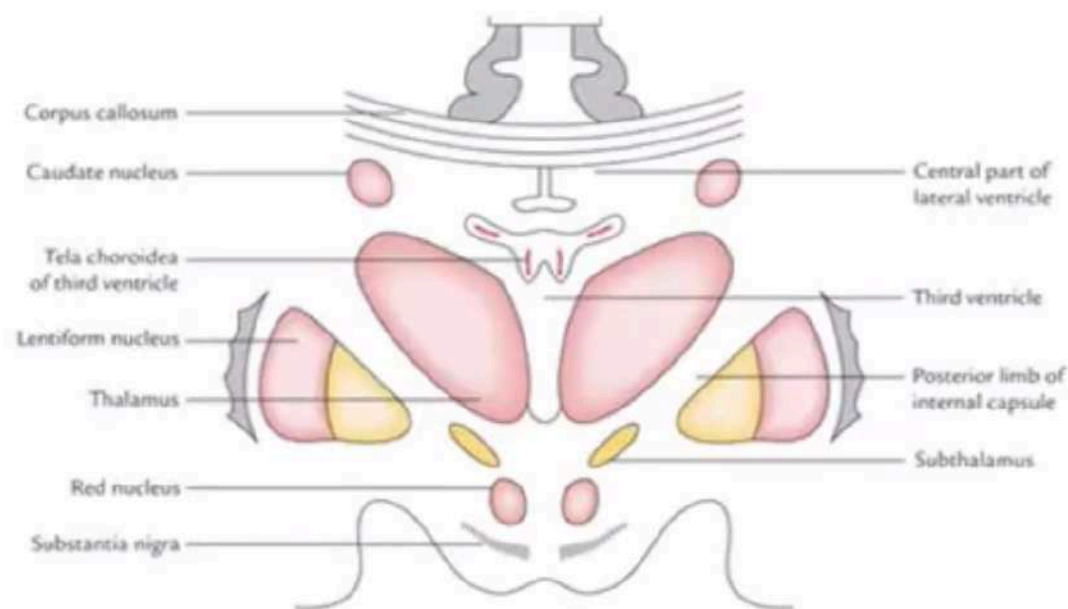
VENTRICULAR SYSTEM



DIENCEPHALON (THALAMUS)

THALAMUS

- **Great sensory gateways to cerebral cortex**
- **Ends – anterior & posterior**
- **Surfaces – superior, inferior, medial & lateral**
- **Consists of**
 - White matter – thin layer of external and internal medullary laminae
 - Gray matter – the thalamic nuclei



Thalamic nuclei

Anterior part

Anterior nucleus

Medial part

Medial dorsal N

Medial ventral N

Lateral part

Dorsal tier of nuclei

Lateral dorsal N

Lateral posterior N

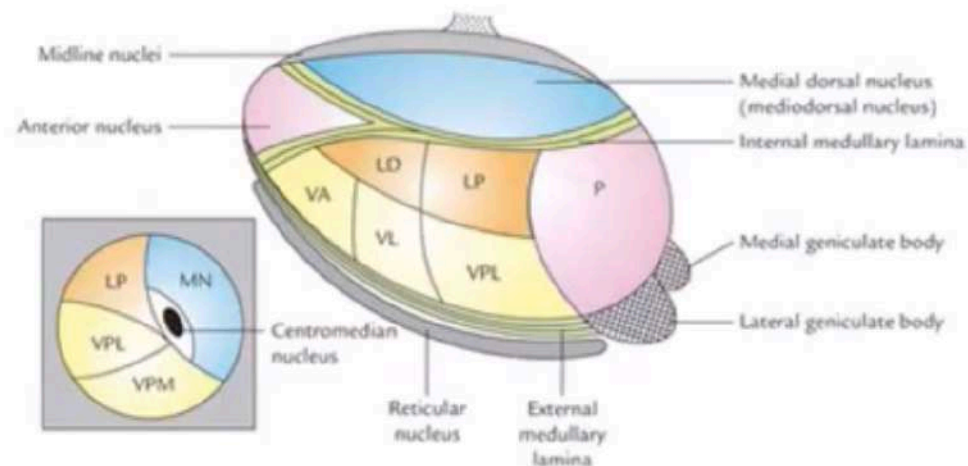
Pulvinar

Ventral tier of nuclei

Ventral anterior

Ventral lateral / ventral intermediate

Ventral posterior (medial & lateral)

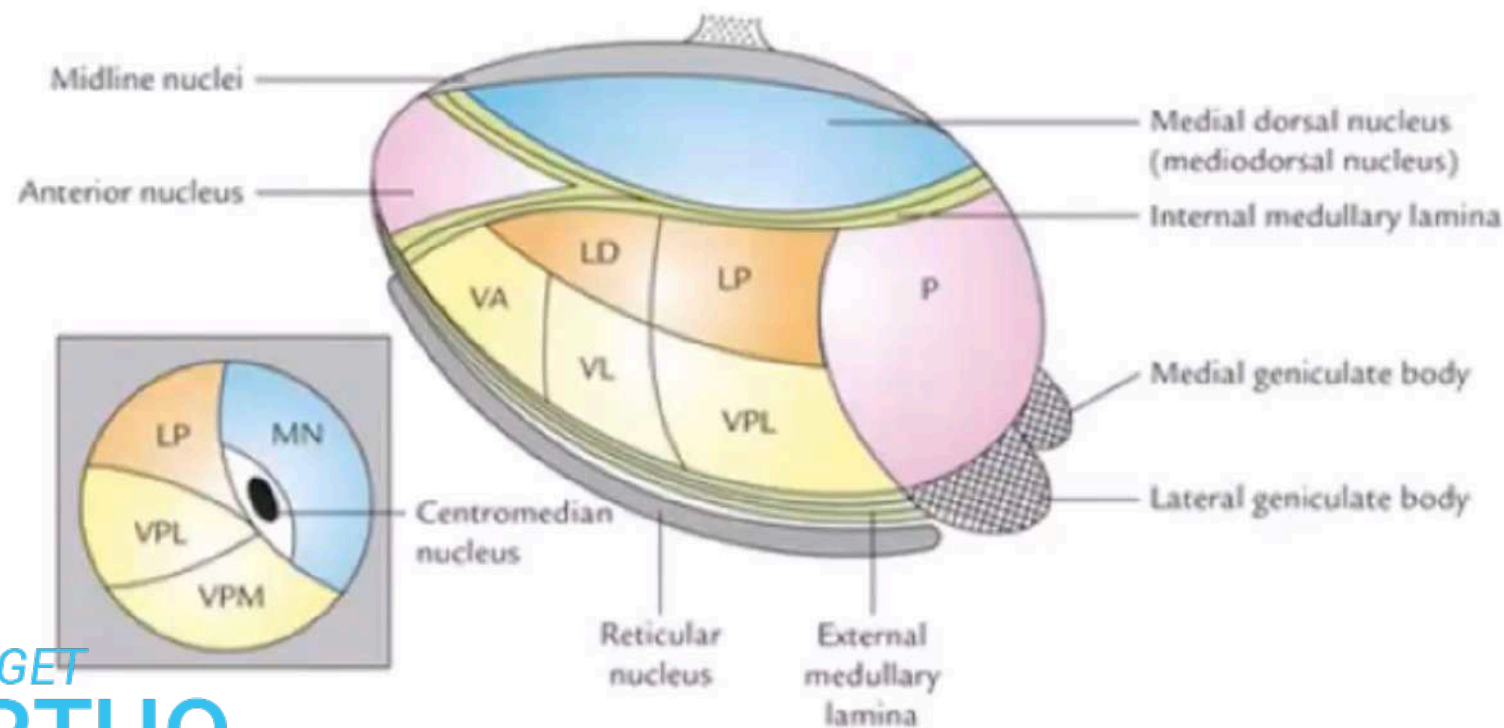


- **Functions**

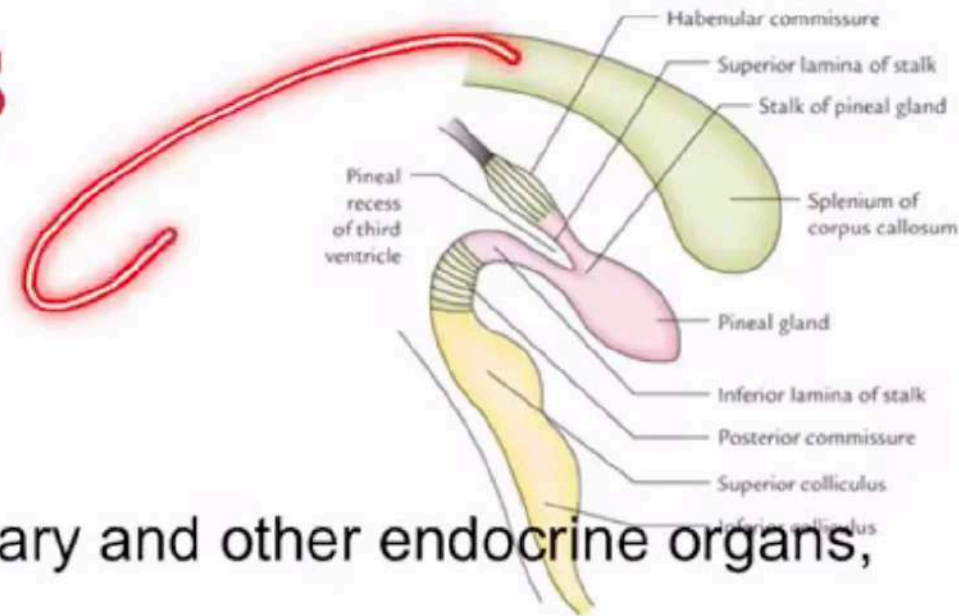
- Relay station of all sensory except olfactory
- Influences voluntary movements
- Ascending reticular activating system
- Determination of *affective reactions* i.e. moods
- Recent memory and attention (anterior nucleus)

METATHALAMUS

- **Medial geniculate body**
- **Lateral geniculate body**



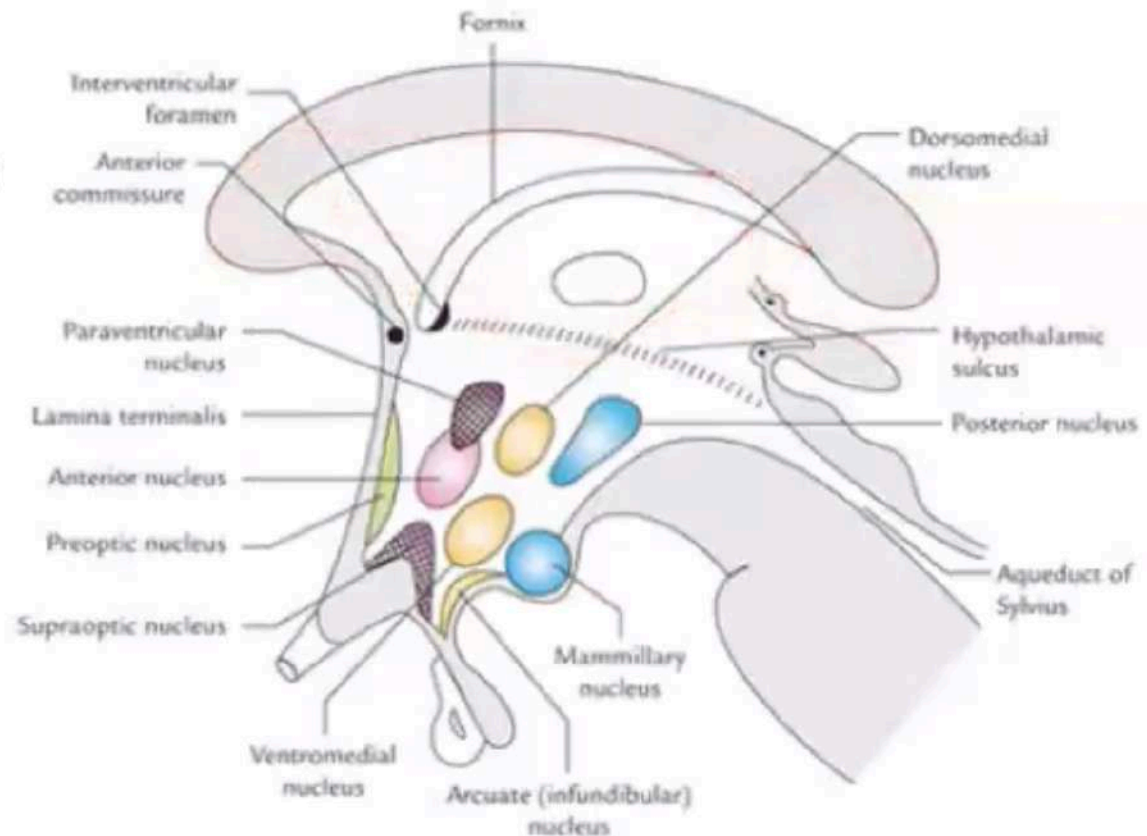
EPITHALAMUS



- **Pineal gland**
 - Pinealocytes
 - Secrete melatonin
 - Regulation of pituitary and other endocrine organs, mostly inhibitory
 - Supplied by nervus conarii, postganglionic sympathetic fibres from superior cervical symp. Ganglion
- **Habenular nucleus and commissure**
- **Posterior commissure**

HYPOTHALAMUS

- **Principal autonomic centre of the brain**
- **Subdivided into**
 - Preoptic region
 - Supraoptic region
 - Tuberal region
 - Mamillary region



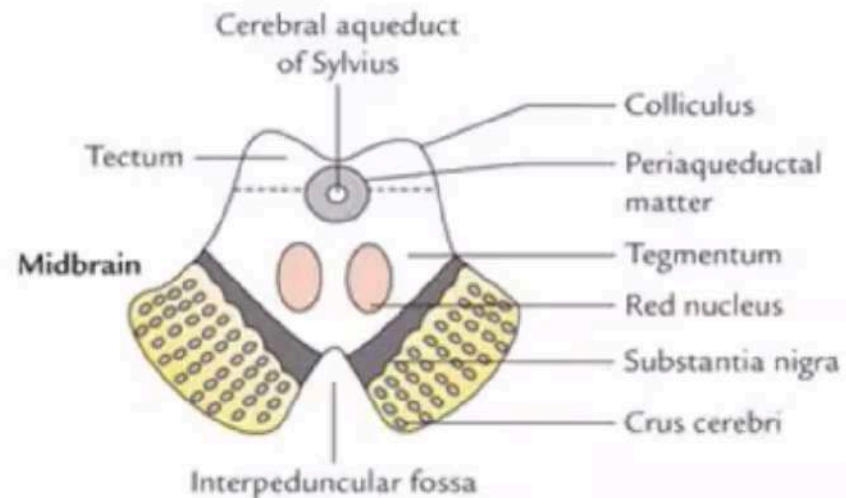
- **Functions**

- Autonomic control
 - Parasympathetic (anterior part) and sympathetic control (posterior part)
- Endocrine control
- Neurosecretion – oxytocin and vasopressin
- Food and water intake
- Emotional expression
- Thermoregulation
- Biological clock

BRAINSTEM

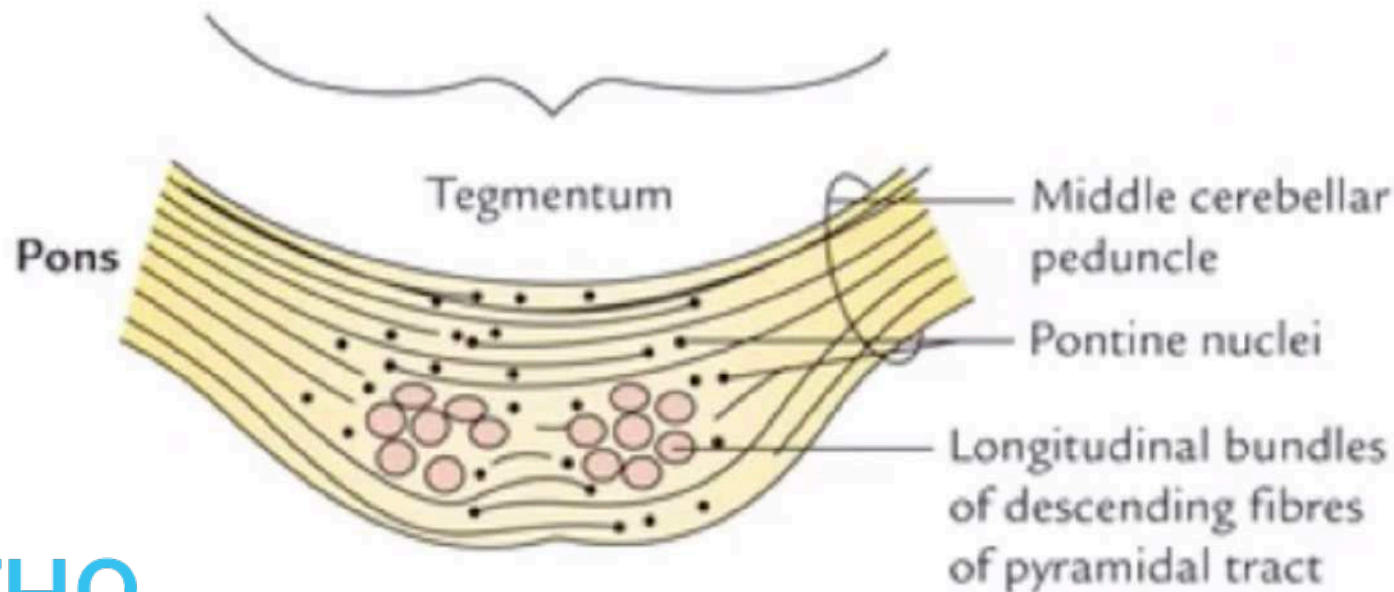
MIDBRAIN

- **Cerebral aqueduct**
- **Tectum**
 - Superior colliculi
 - Inferior colliculi
- **Tegmentum (red nuclei)**
- **Substantia nigra**
- **Crux cerebri**



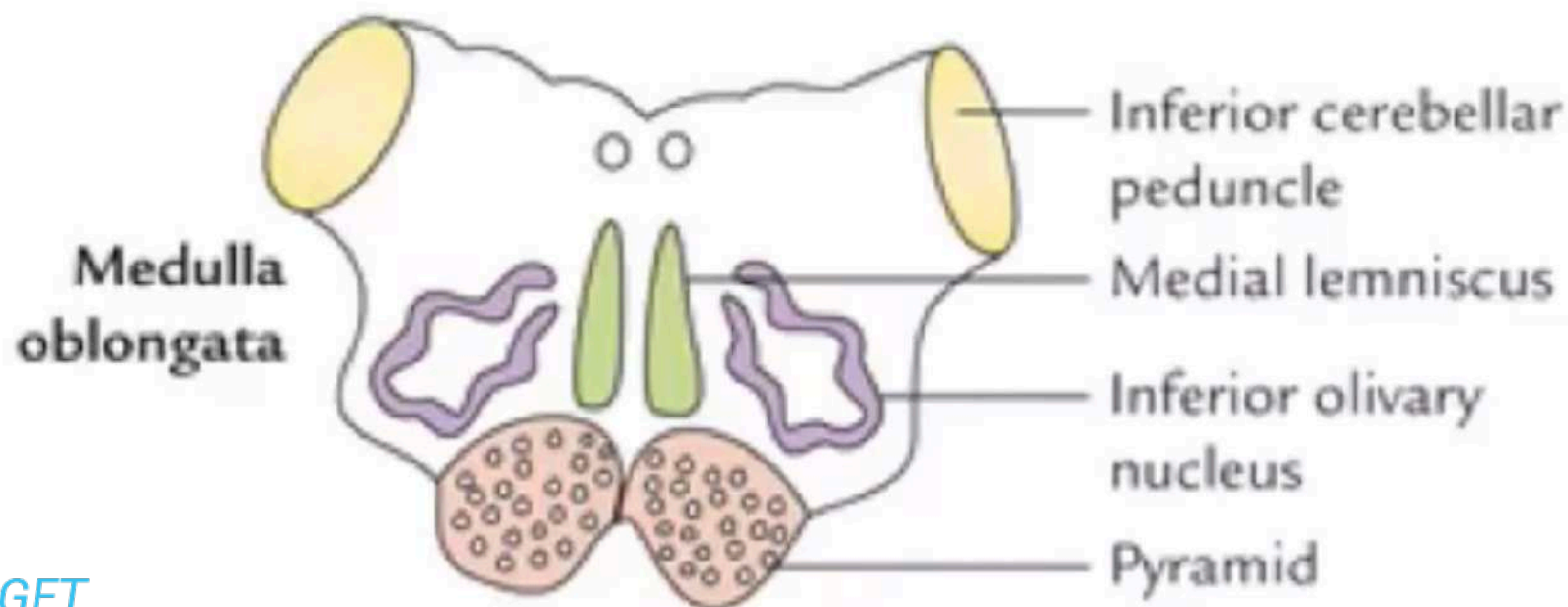
PONS

- **Ventral portion**
 - Pontine nuclei
 - Middle cerebellar peduncles
- **Dorsal portion or Tegmentum**
 - Sleep and respiratory centres



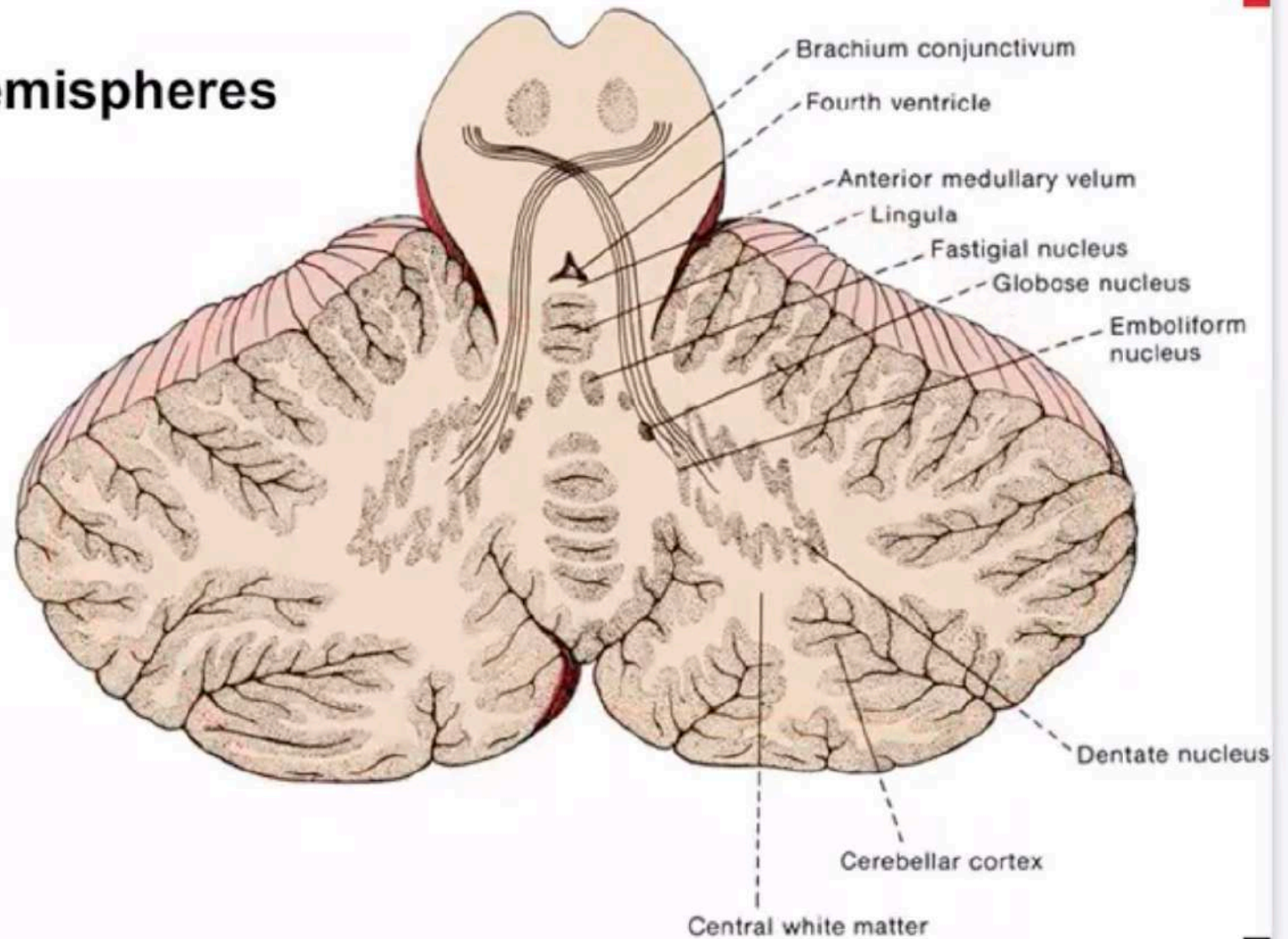
MEDULLA OBLONGATA

- **Pyramids**
- **Olive**
- **Cerebellar peduncles**
- **nuclei**



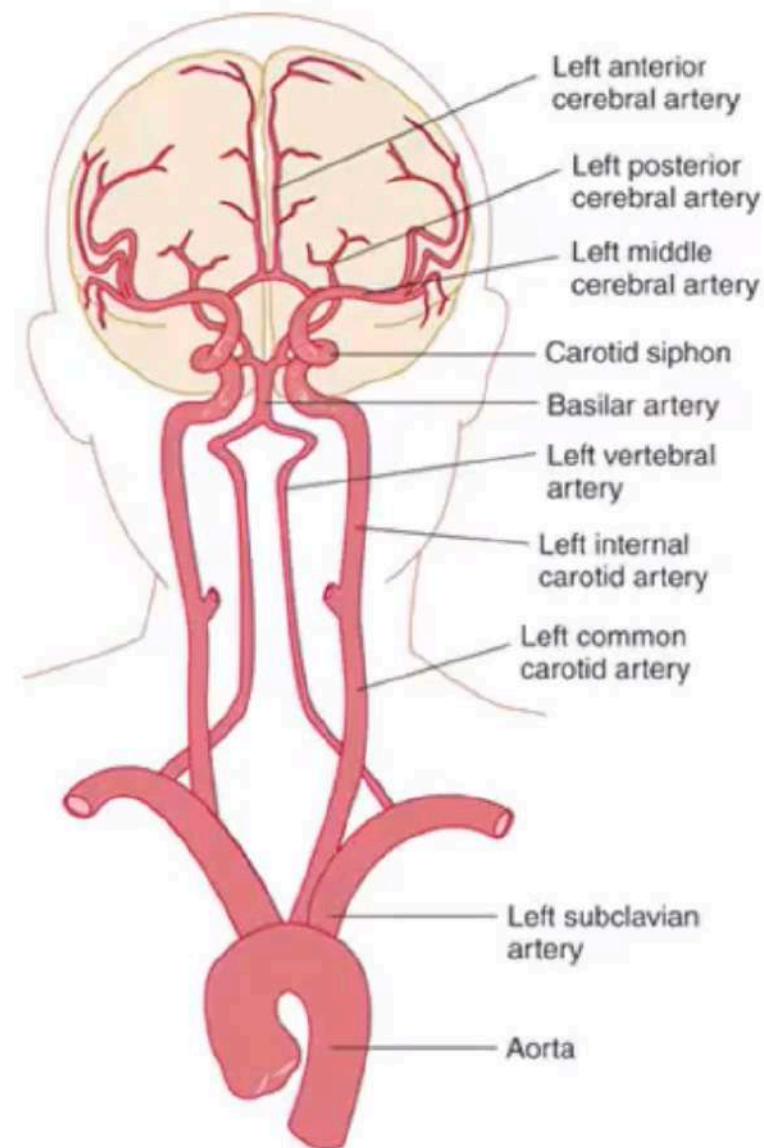
CEREBELLUM

- Cerebellar hemispheres
- Vermis
- Tonsils
- Deep nuclei



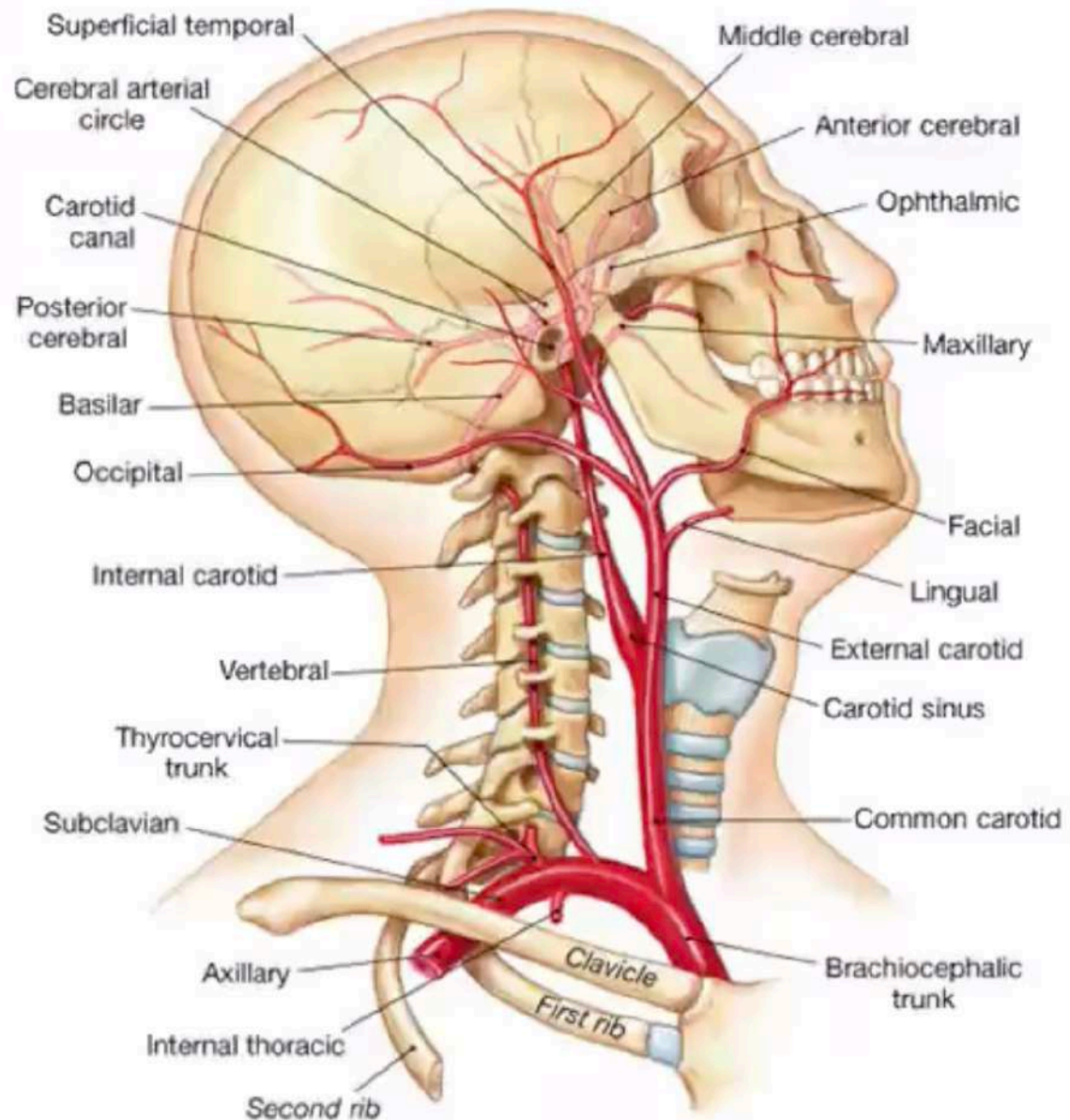
ARTERIAL SUPPLY OF THE BRAIN

- **The brain is supplied by two pairs of**
- Internal carotid arteries
- Vertebral arteries



CAROTID SYSTEM / ANTERIOR CIRCULATION

- **Two common carotid arteries**
- **External & internal carotid arteries**



EXTERNAL CAROTID ARTERY

- **8 branches**

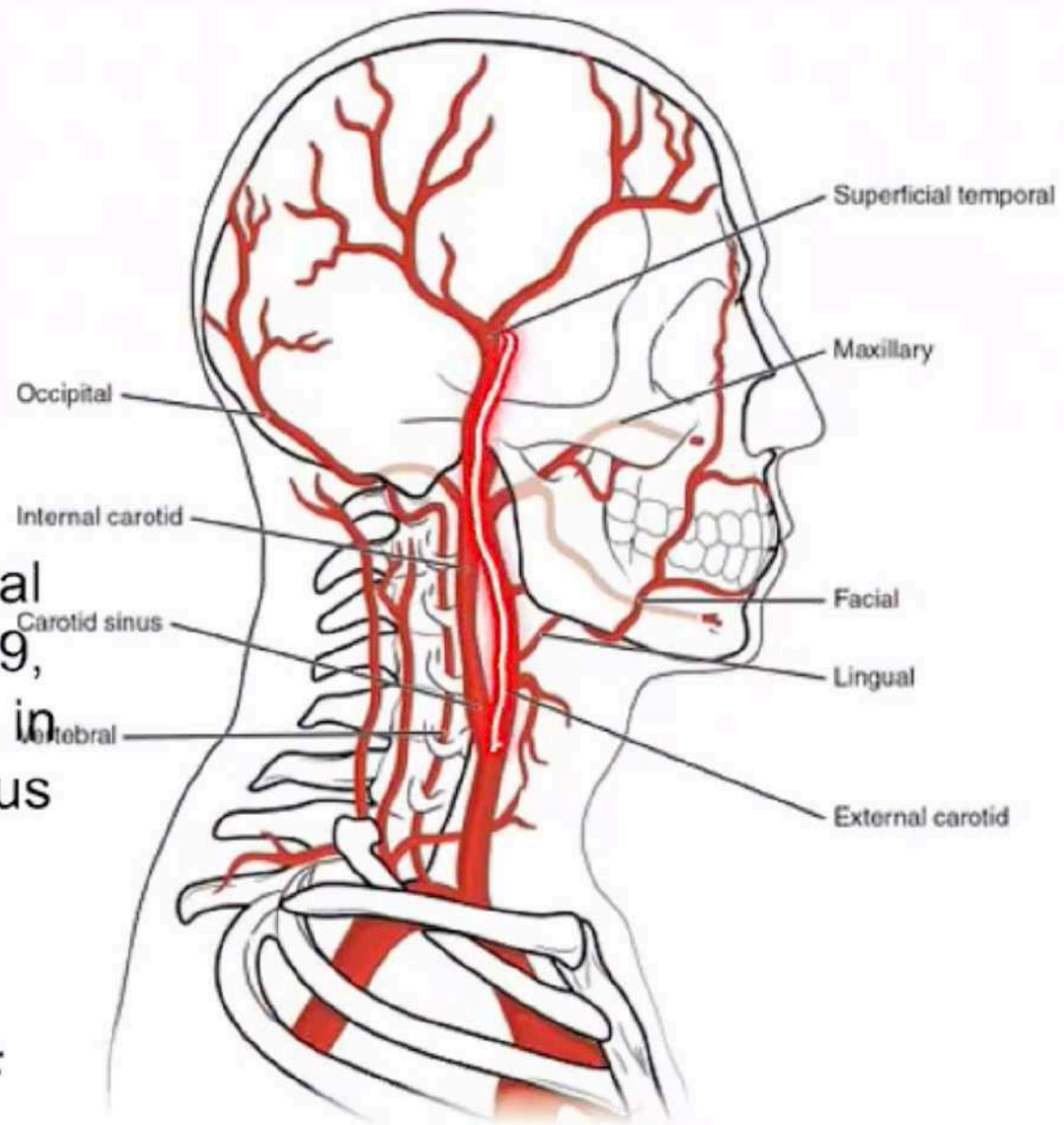
1. **Superior thyroid artery**

2. **Ascending pharyngeal artery**

1. Neuromeningeal trunk – supplied 9, 10 & 11 CN (imp in embolizing glomus tumors, caused LCN palsy)

2. Pharyngeal branch (feeds JF tumors)

3. **Lingual artery**



1. **Occipital artery**

2. **Posterior
auricular artery**

3. **Maxillary artery**

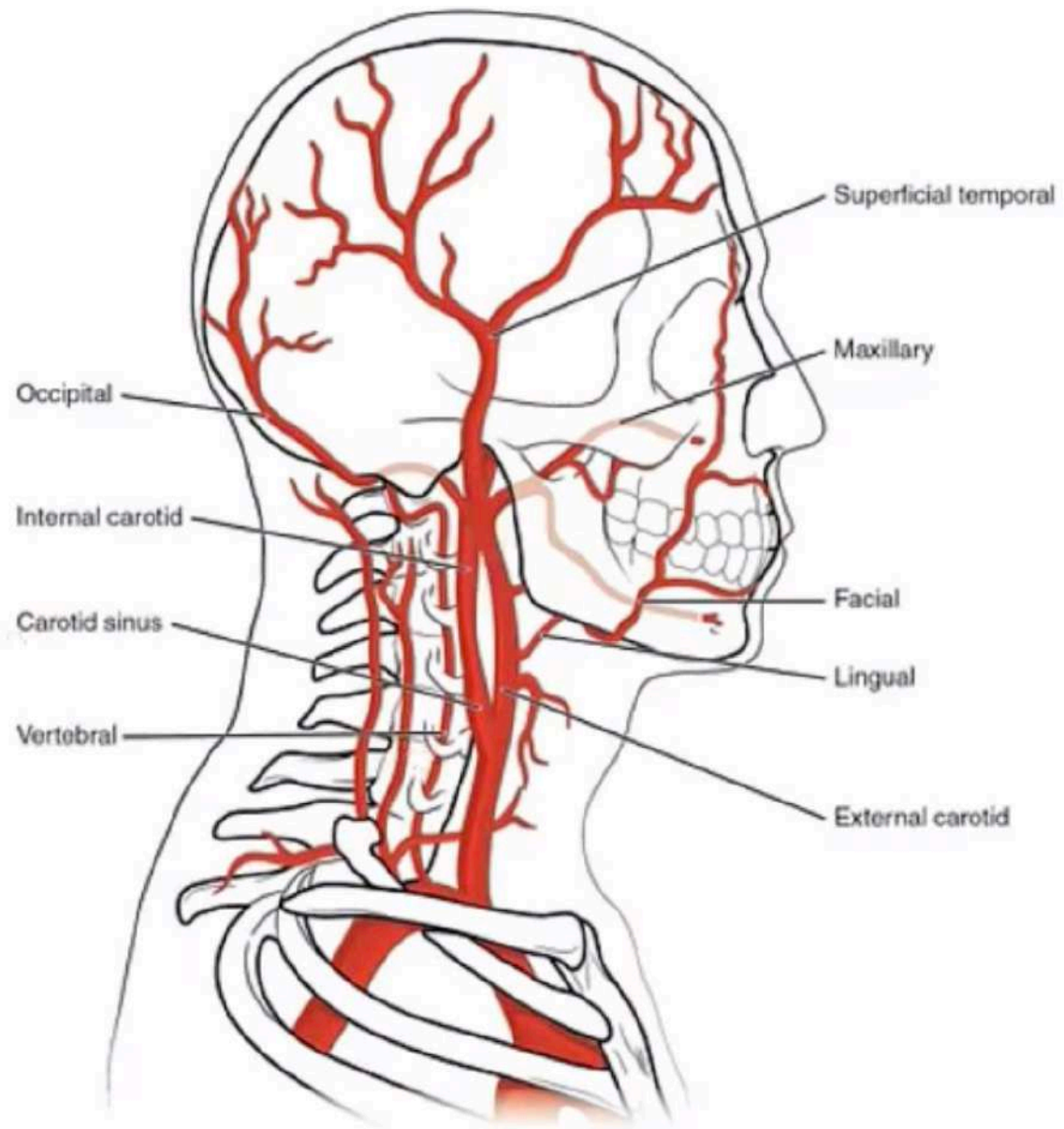
1. Middle
meningeal A

2. Accessory
meningeal A

3. Inferior
alveolar A

4. Infraorbital A

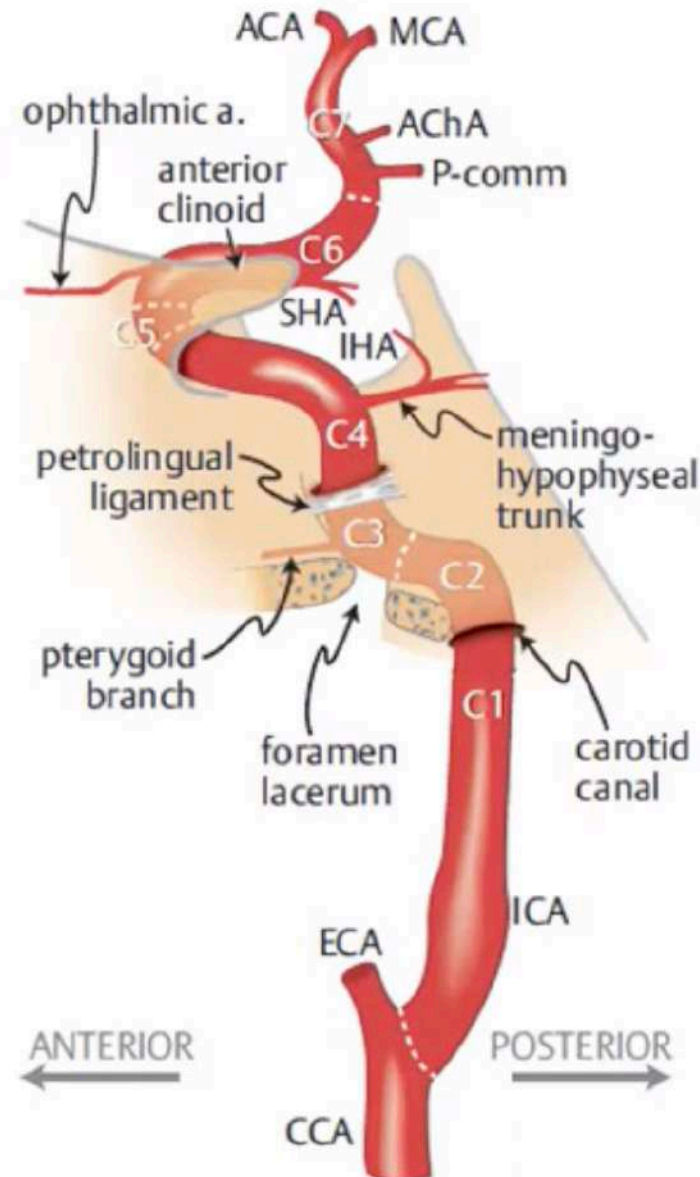
5. Distal
branches –
anastomose
with ophthalmic
A



INTERNAL CAROTID ARTERY

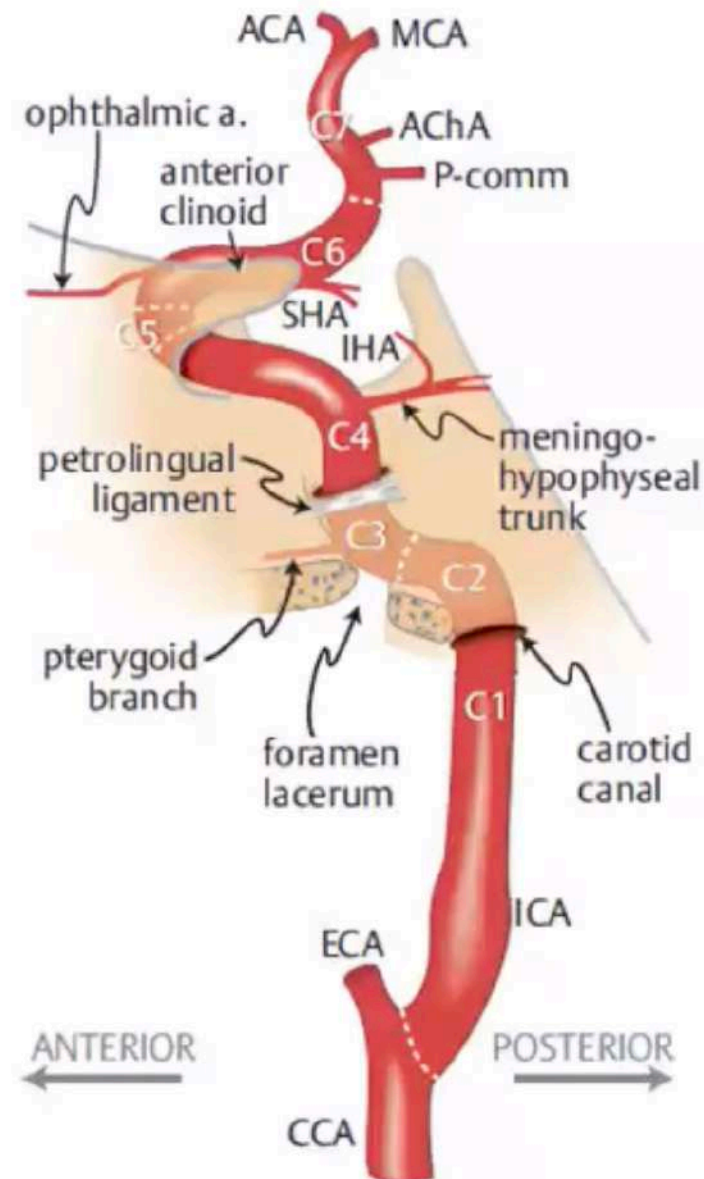
Course & branches

- **C1 – cervical segment**

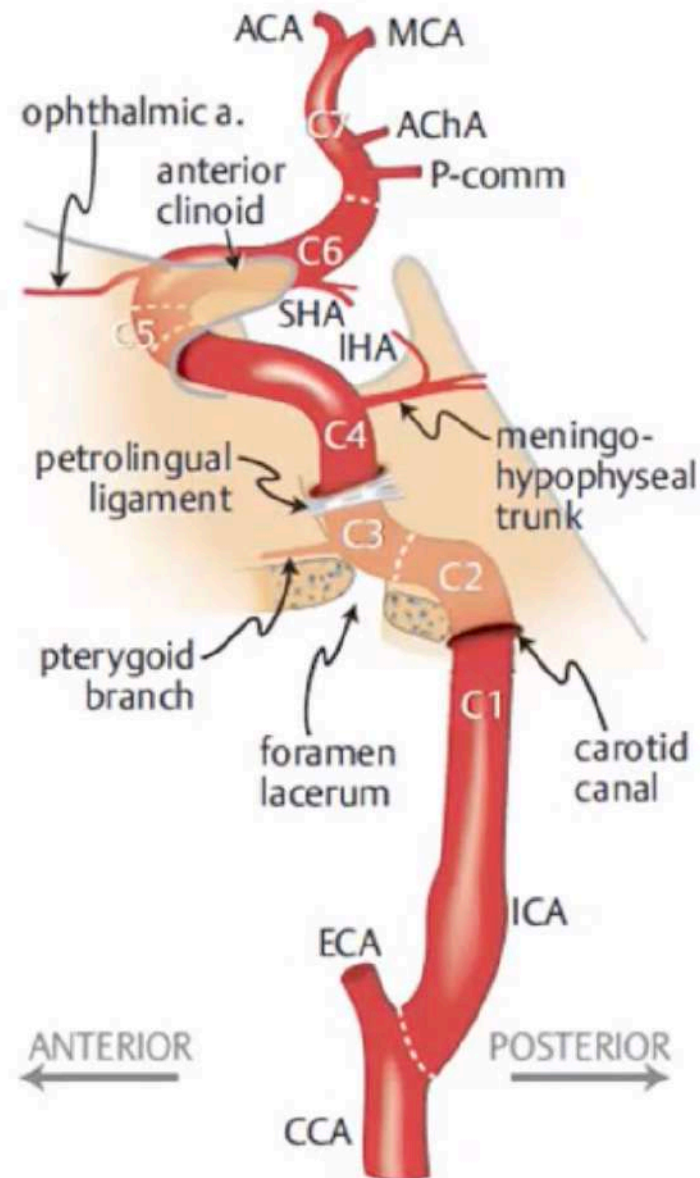


- **C2 – petrous segment**

- Vertical segment
- Posterior loop
- Horizontal segment



- **C3 – lacerum segment**
- Caroticotympanic br. (inconsistent)
- Pterygoid (vidian) br. (in 30%)



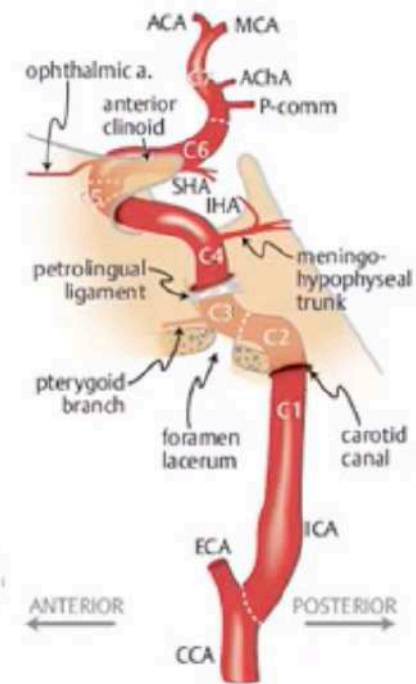
● C4 – cavernous segment

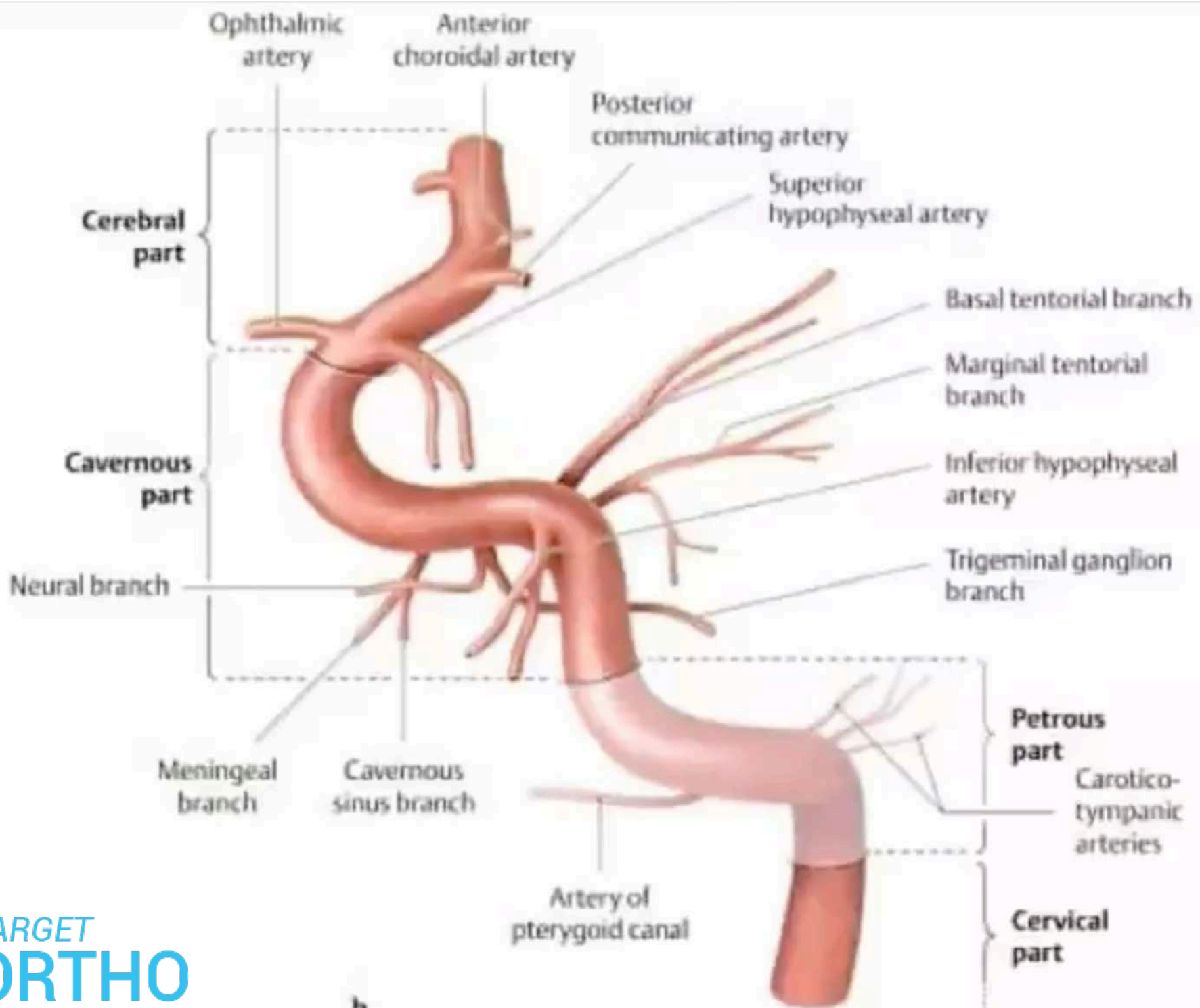
● Medial loop and posterior loop

● Ends at proximal dural ring

● Branches

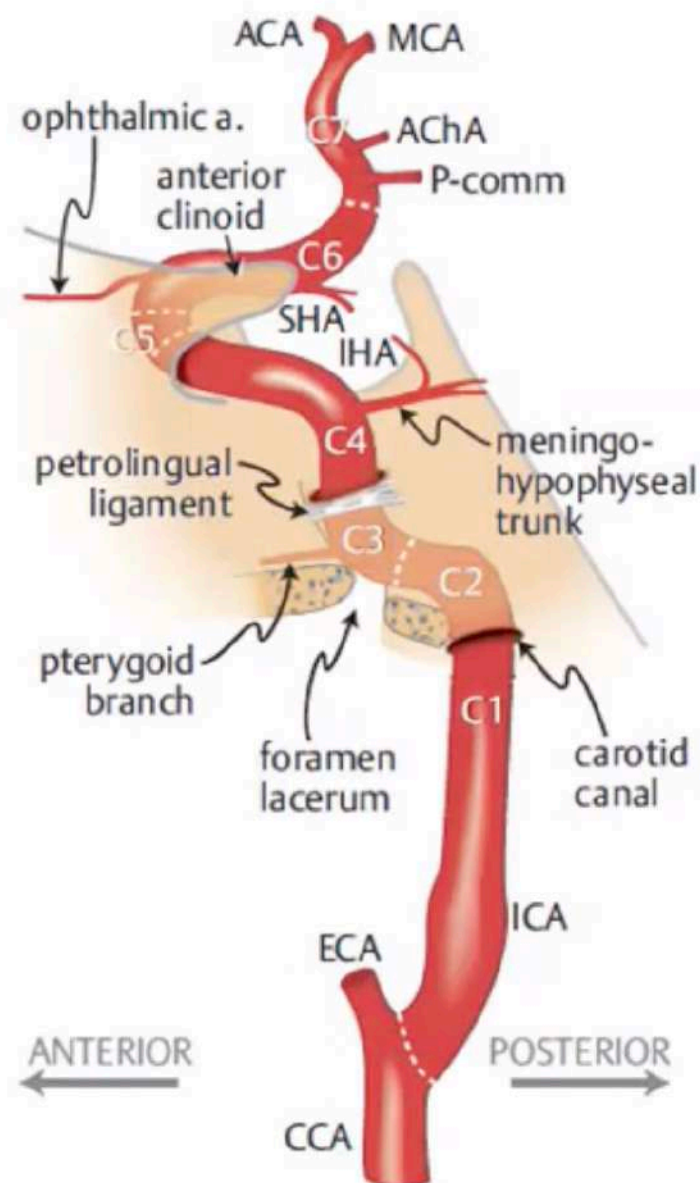
1. Meningohypophyseal trunk (MHT) – supplies petroclival meningiomas and dural AVMs
 1. Tentorial artery (artery of Bernasconi & Cassinari) supplies petroclival meningiomas
 2. Dorsal meningeal artery (aka dorsal clival a.)
 3. Inferior hypophyseal a. - to posterior pituitary – post-partum occlusion causes infarcts (Sheehan's necrosis)
2. Anterior meningeal a.
3. A. to inferior cavernous sinus
4. Capsular aa. Of McConnell (30%) – pituitary capsule



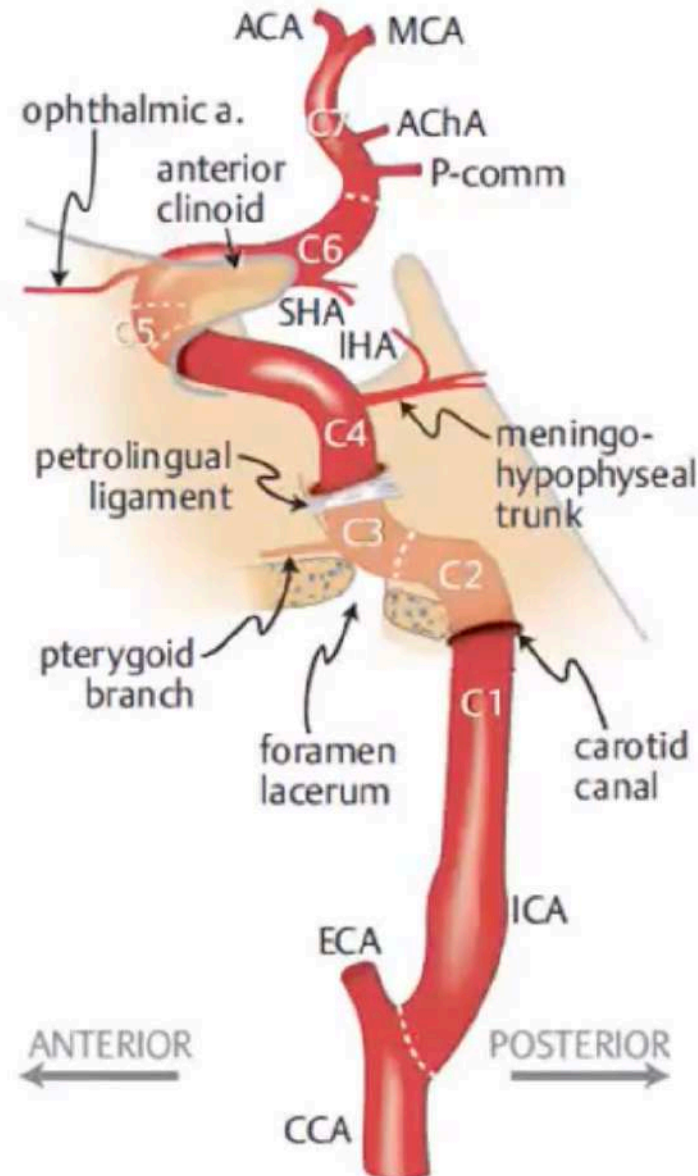


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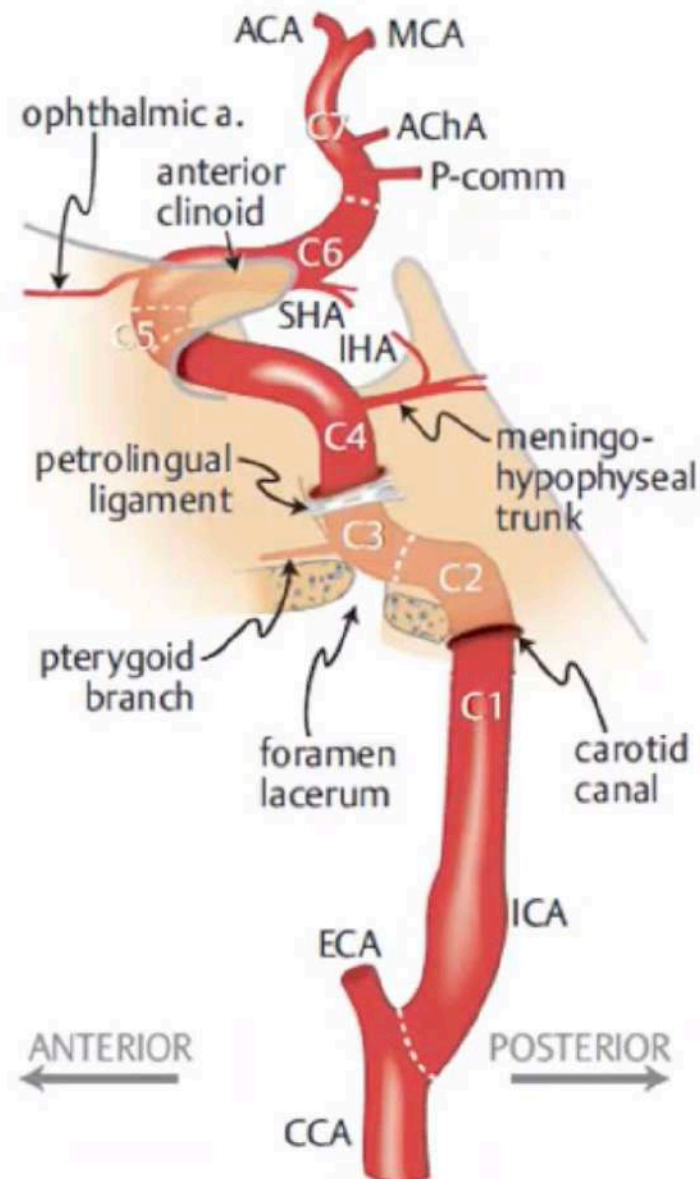
- **C5 – clinoid segment – between dural rings**



- **C6 – ophthalmic segment**
- Superior hypophyseal a. – medial branch to anterior pituitary
- Ophthalmic a. – enters orbit through optic canal

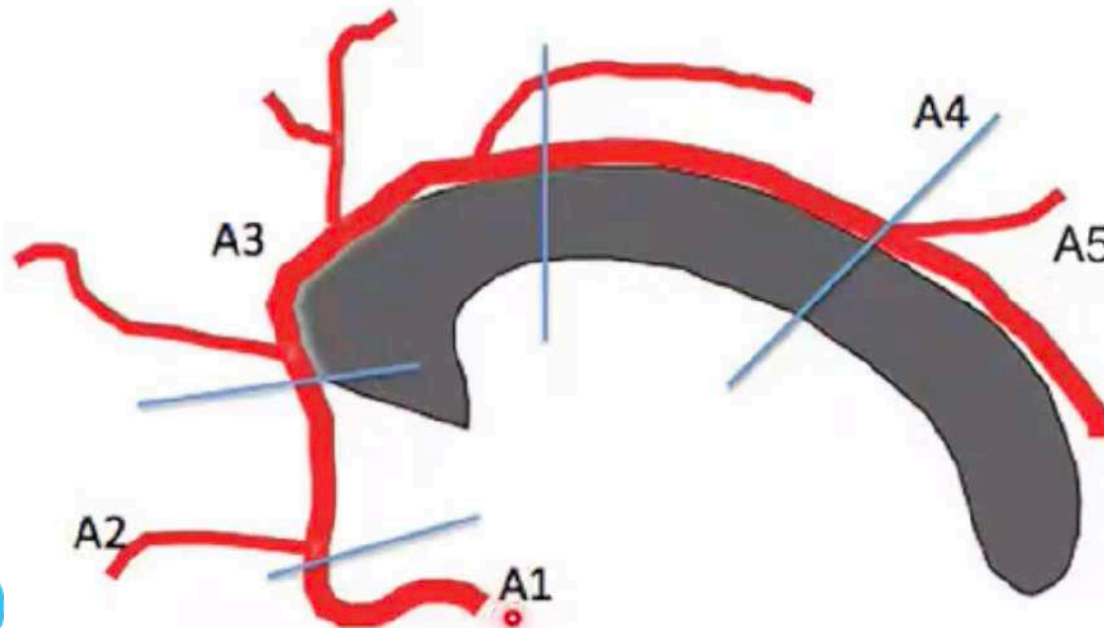


- **C7 – communicating segment**
- Posterior communicating a.
- Thalamoperforators to optic tract, chiasm & posterior hypothalamus
- Anterior choroidal artery



ANTERIOR CEREBRAL ARTERY

- **A1 (precommunicating):** origin to ACOM
- **A2 (postcommunicating):** ACOM to callosomarginal
- **A3 (precallosal):** CM to genu of corpus callosum
- **A4 (supracallosal)**
- **A5 (terminal branch, post callosal)**



Branches

Recurrent artery of
Heubner – caudate
head, putamen and
anterior internal
capsule

Medial orbitofrontal a.

Frontopolar a.

Callosomarginal a.

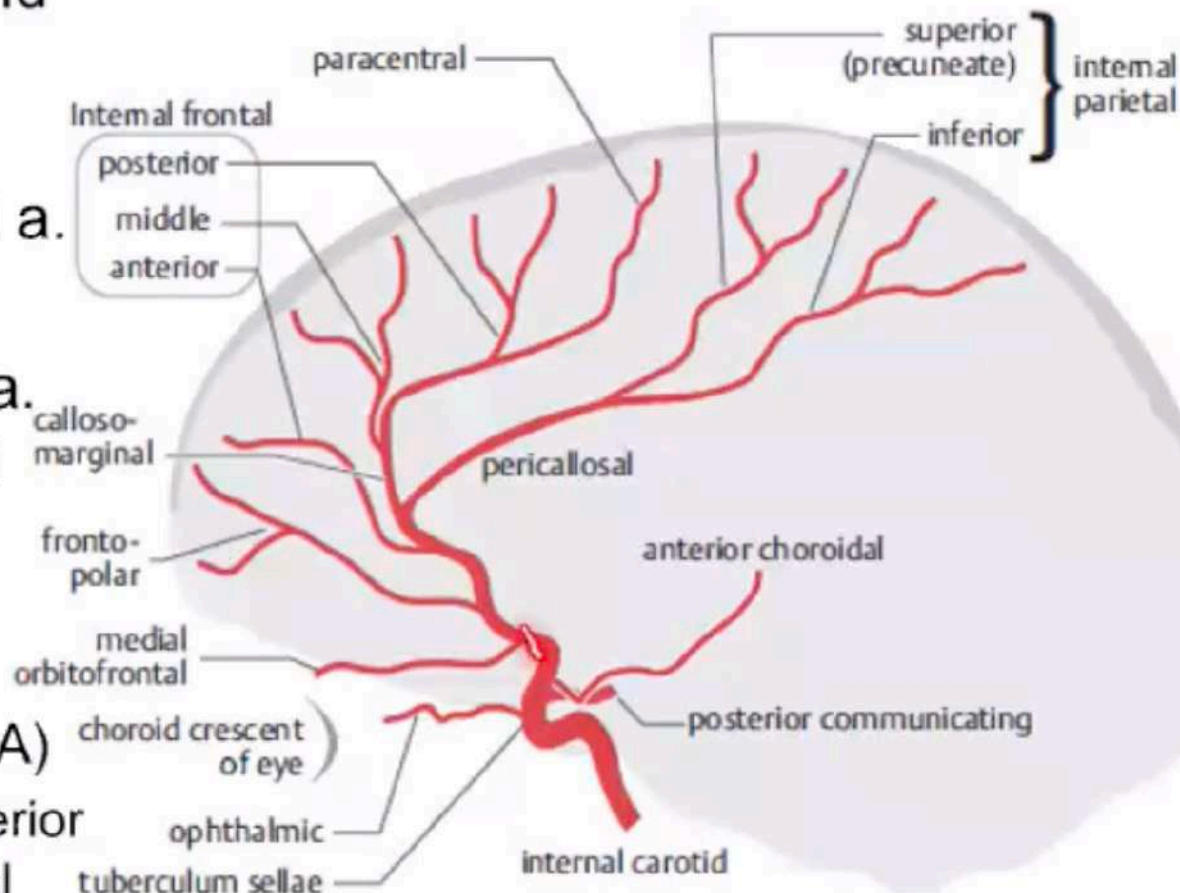
Internal frontal
branches

Paracentral a.

Pericallosal a.

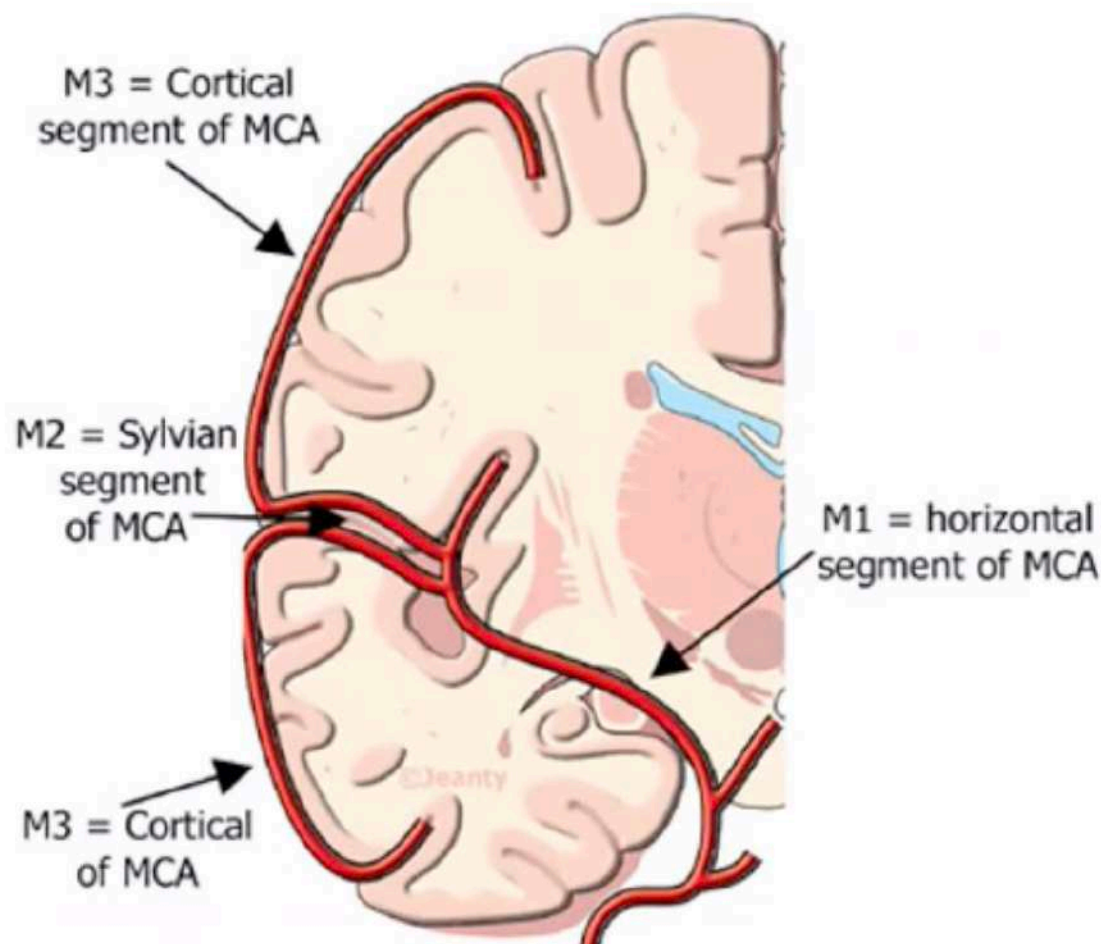
(continuation of ACA)

Superior & inferior
internal parietal
arteries



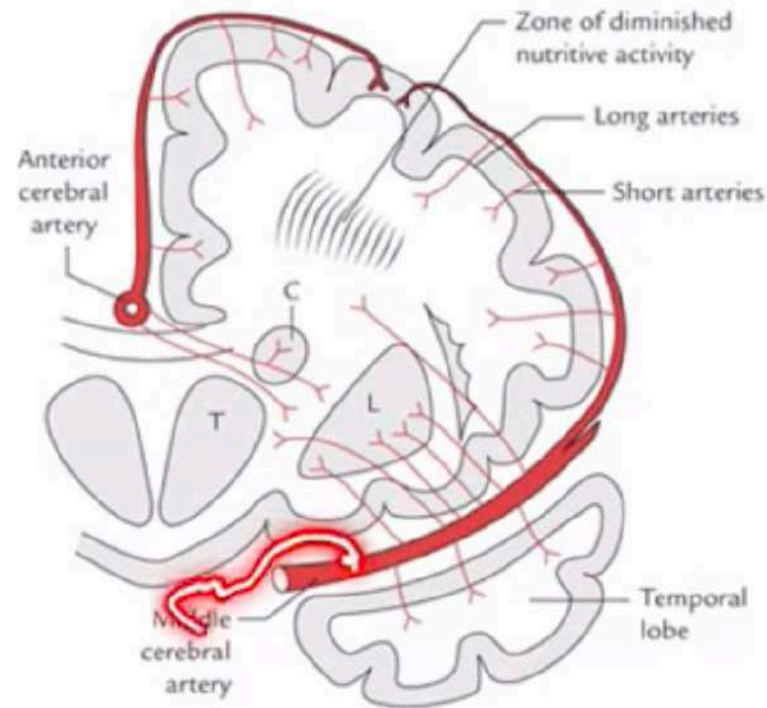
MIDDLE CEREBRAL ARTERY

- **M1 : origin to bifurcation**
 - Bifurcates in 50%
 - Pseudo-trifurcation in 25%
 - Lateral frontoorbital a.
 - Prefrontal br.
 - Precentral, central, ant & post parietal a.
- **M2 : bifurcation to emergence from Sylvian fissure**
- **M3-4 : distal branches**
- **M5 : terminal branches**



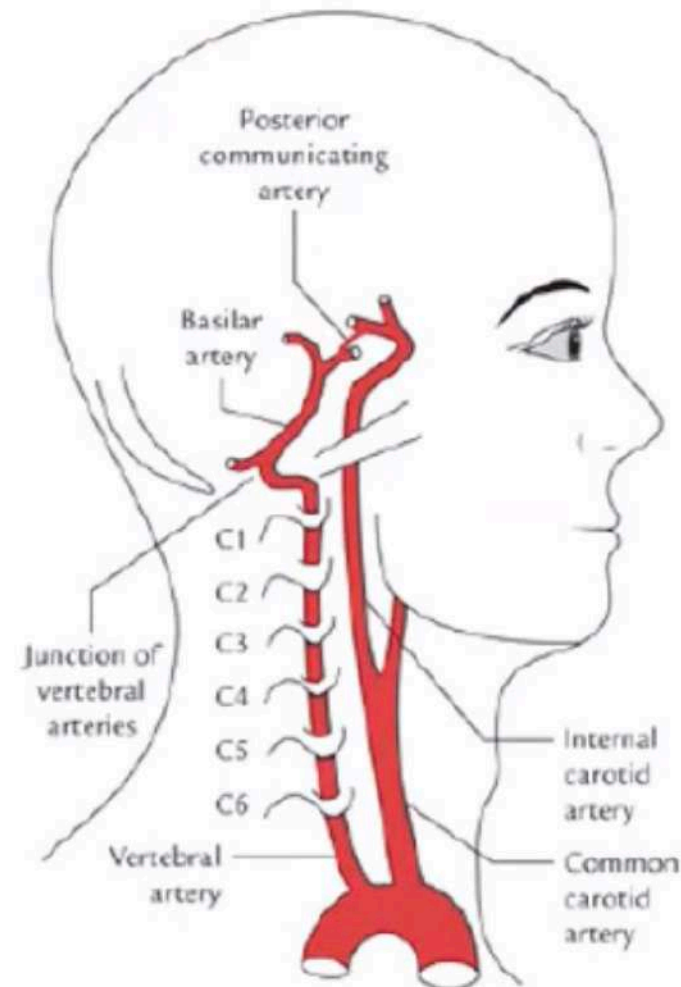
BRANCHING PATTERN

- **Cortical branches**
- **Central branches**
- **Choroidal branches**

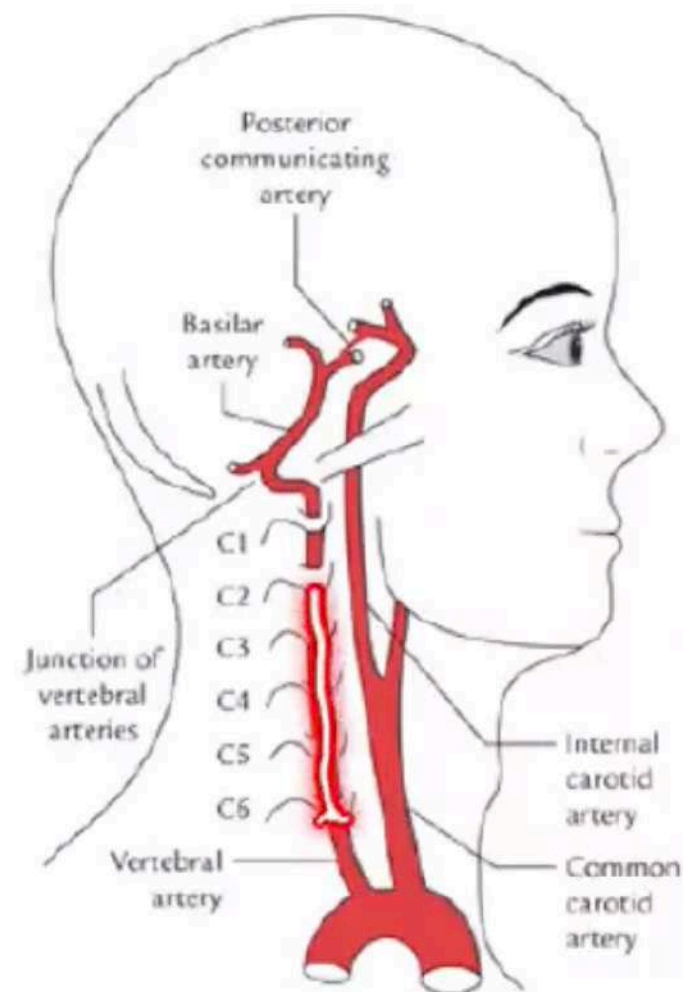


VERTEBRAL ARTERY

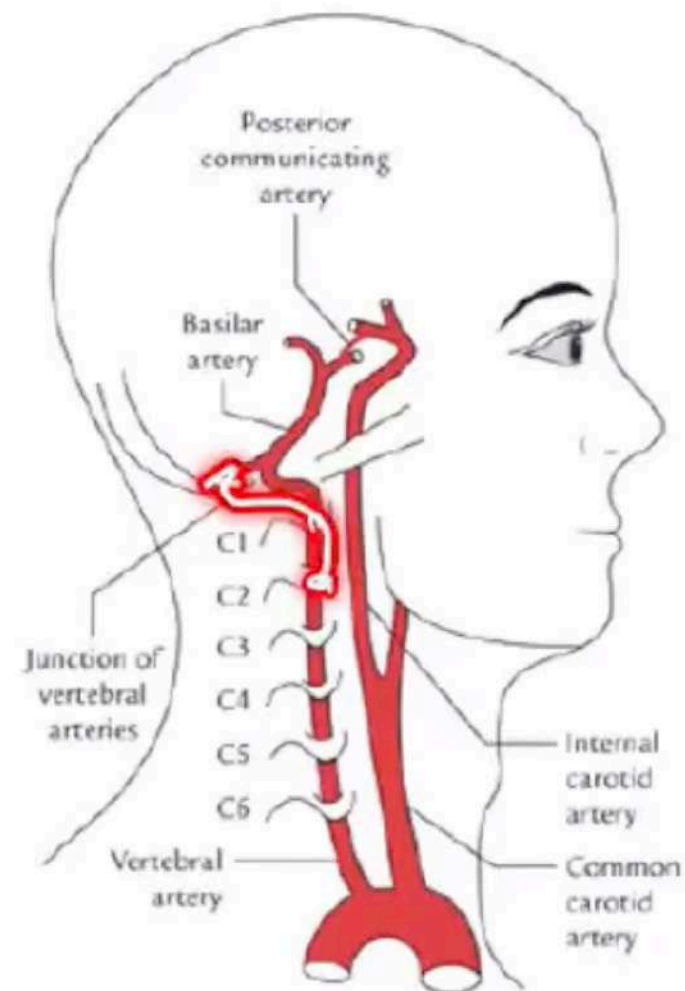
- **V1 (prevertebral): origin to foramen transversarium**



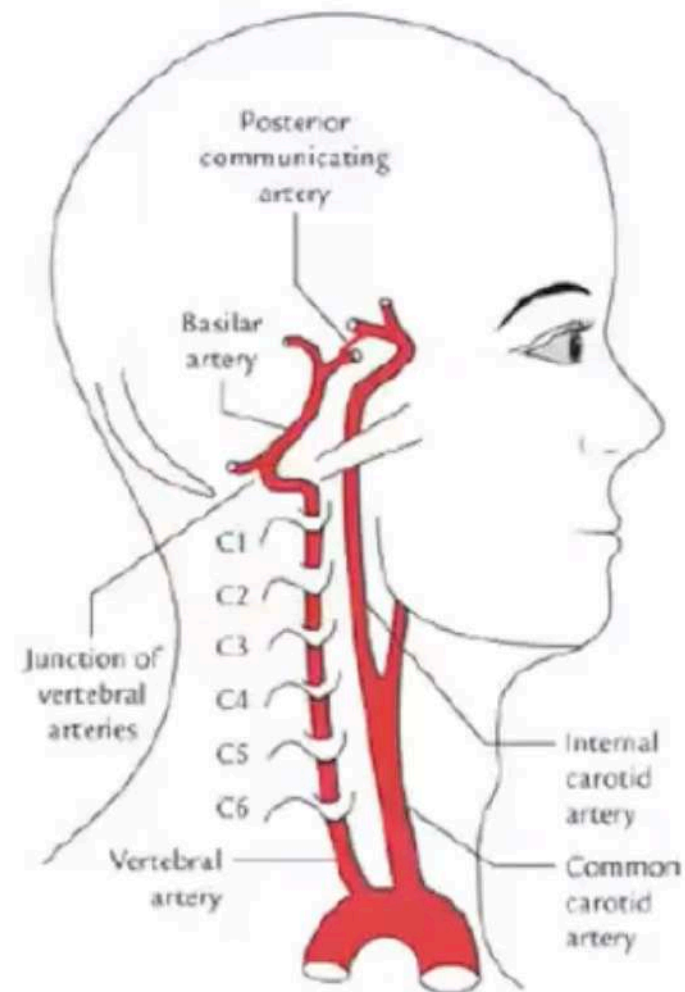
- **V2 (vertebral): within the transverse foramina**



- **V3 : axis foramen to foramen magnum**

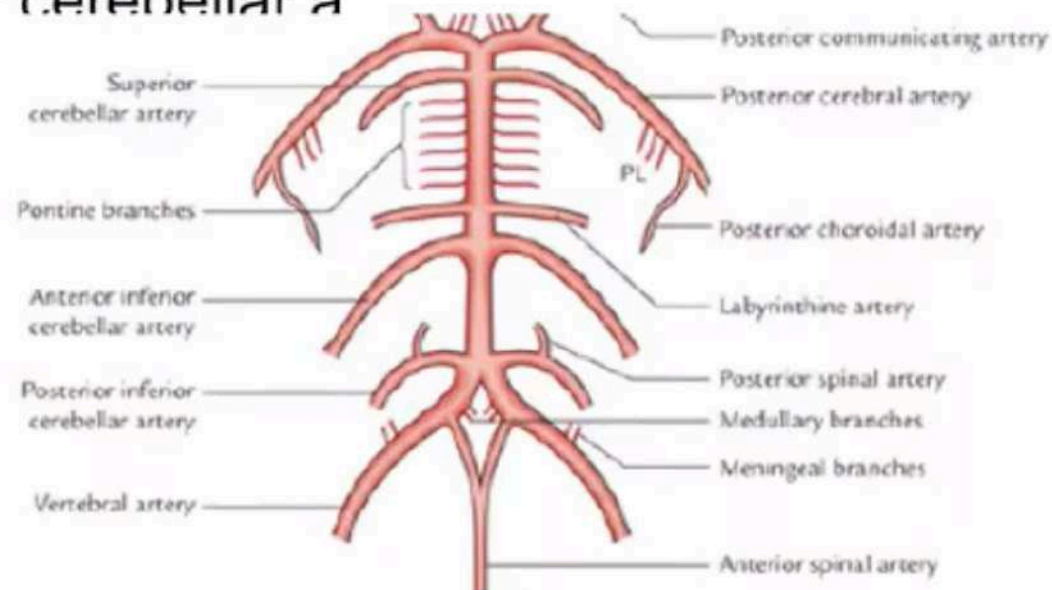


- **V4 : pierces the dura**



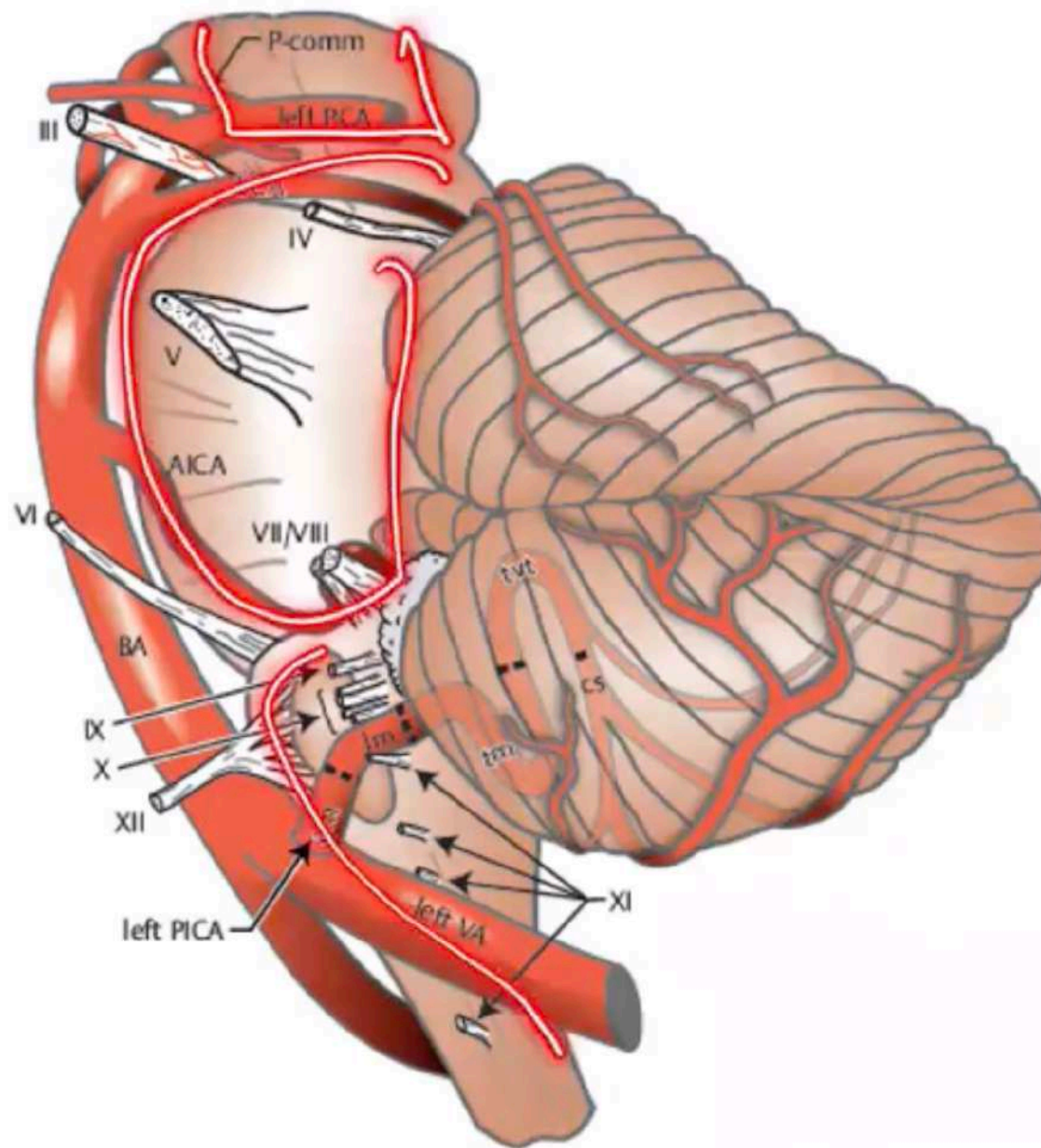
- **Branches**

- Anterior meningeal a. (at the body of C2, feeds chordomas, FM meningiomas)
- Posterior meningeal – some dural AVM
- Medullary (bulbar) aa.
- Posterior spinal a.
- Posterior inferior cerebellar a
- Anterior spinal



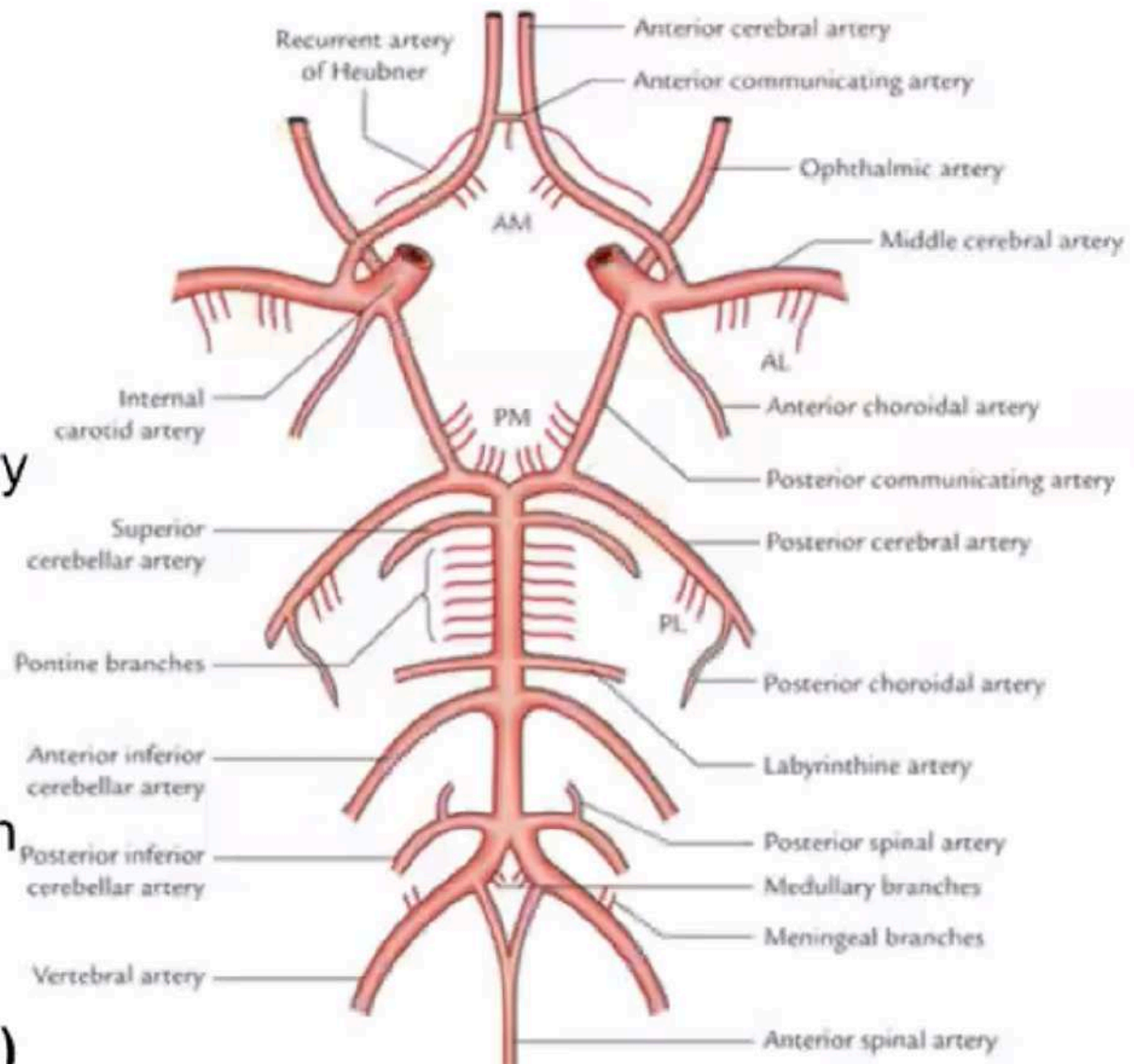
POSTERIOR INFERIOR CEREBELLAR ARTERY

- **5 segments**
 - Anterior medullary – origin to olive, supplies ventral medulla
 - Lateral medullary – to origin of LCN, supplies brainstem
 - Tonsillomedullary – to tonsillar midportion
 - Telovelotonsillar – to tonsillomedullary fissure
 - Cortical segments

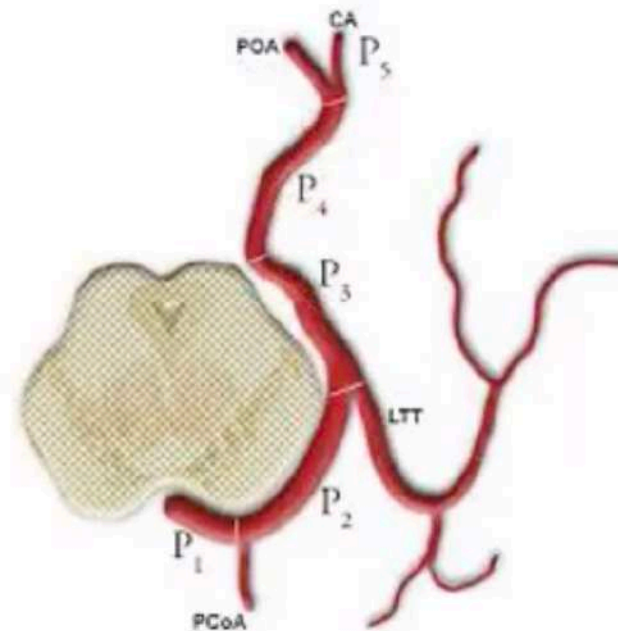


BASILAR ARTERY

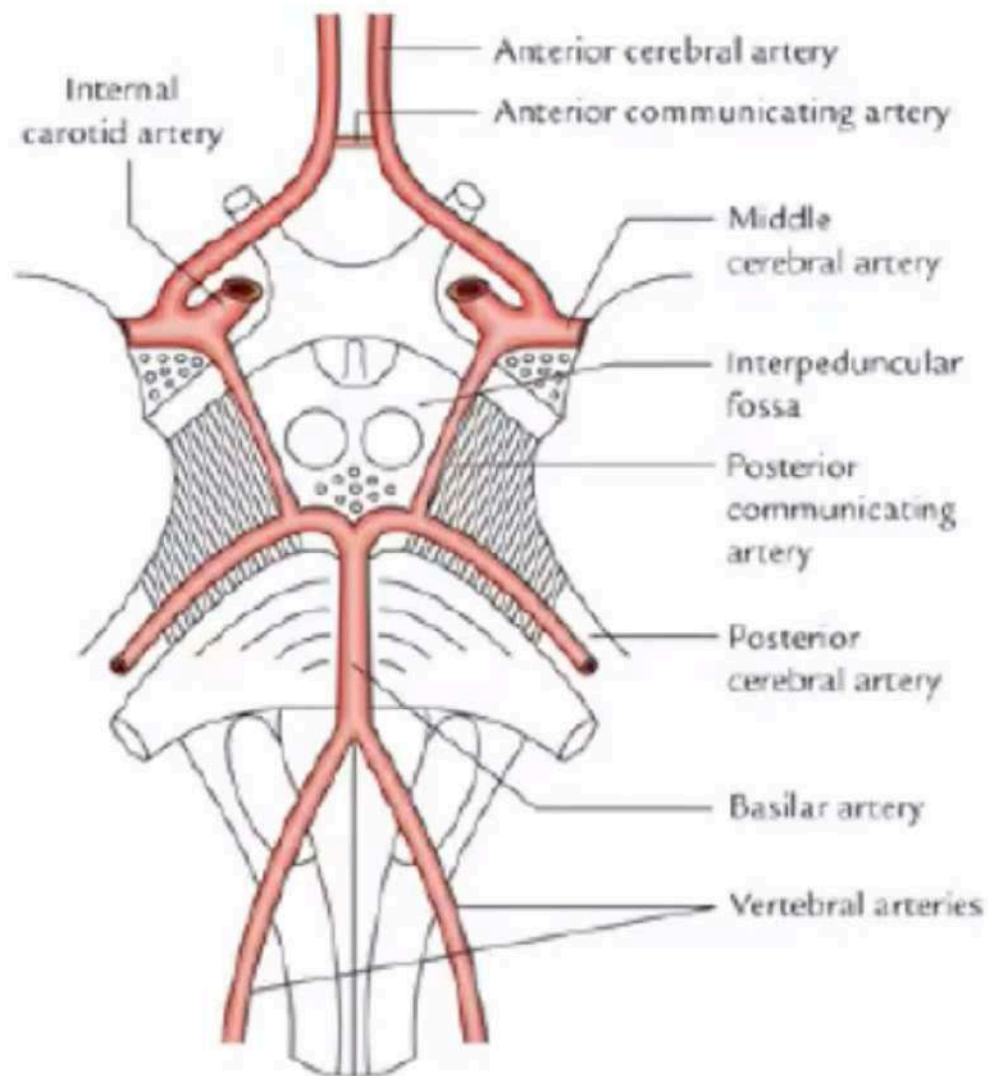
- **Anterior inferior cerebellar artery**
- Anterior to 6,7,8 CN
- Gives off the labyrinthine artery
- Supply anteriolateral inferior cerebellum
- Anastomose with PICA
- **Internal auditory (labyrinthine artery)**
- Pontine branches

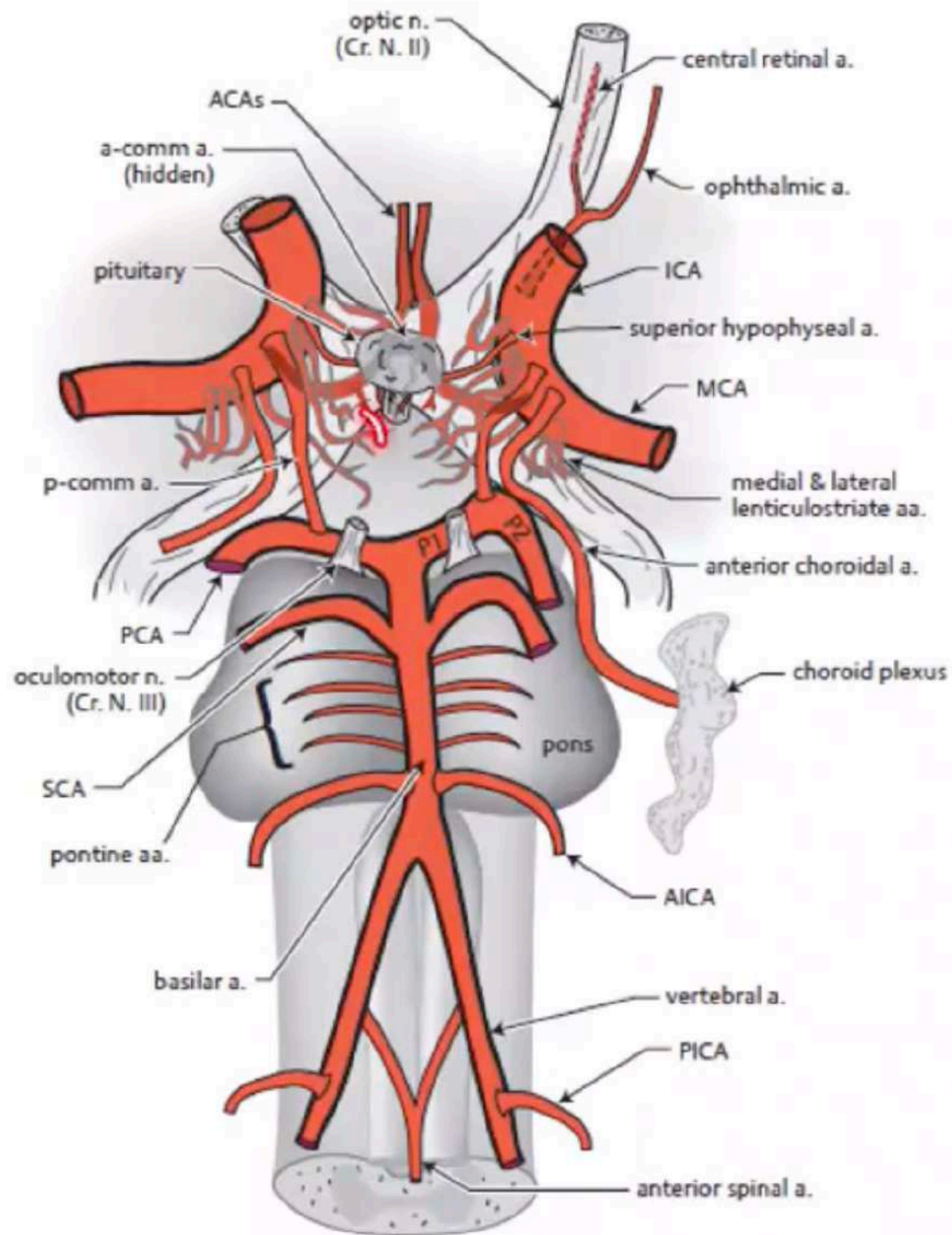


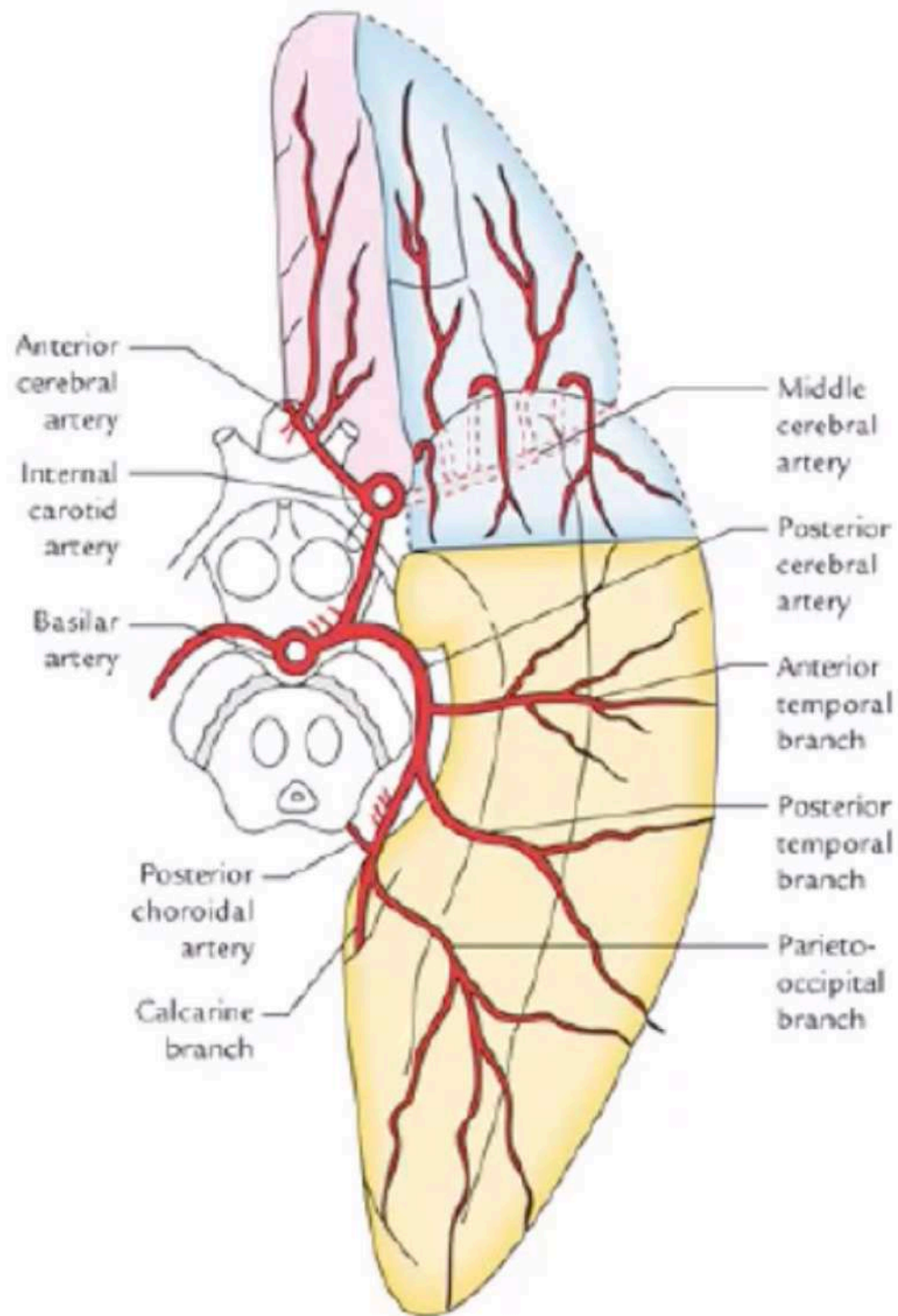
- **P3 : to the origin of terminal branches**
 - Aka quadrigeminal segment
 - Quadrigeminal & geniculate br.
 - Post. Pericallosal br.
- **P4 : after the origin of parietooccipital and calcarine arteries**

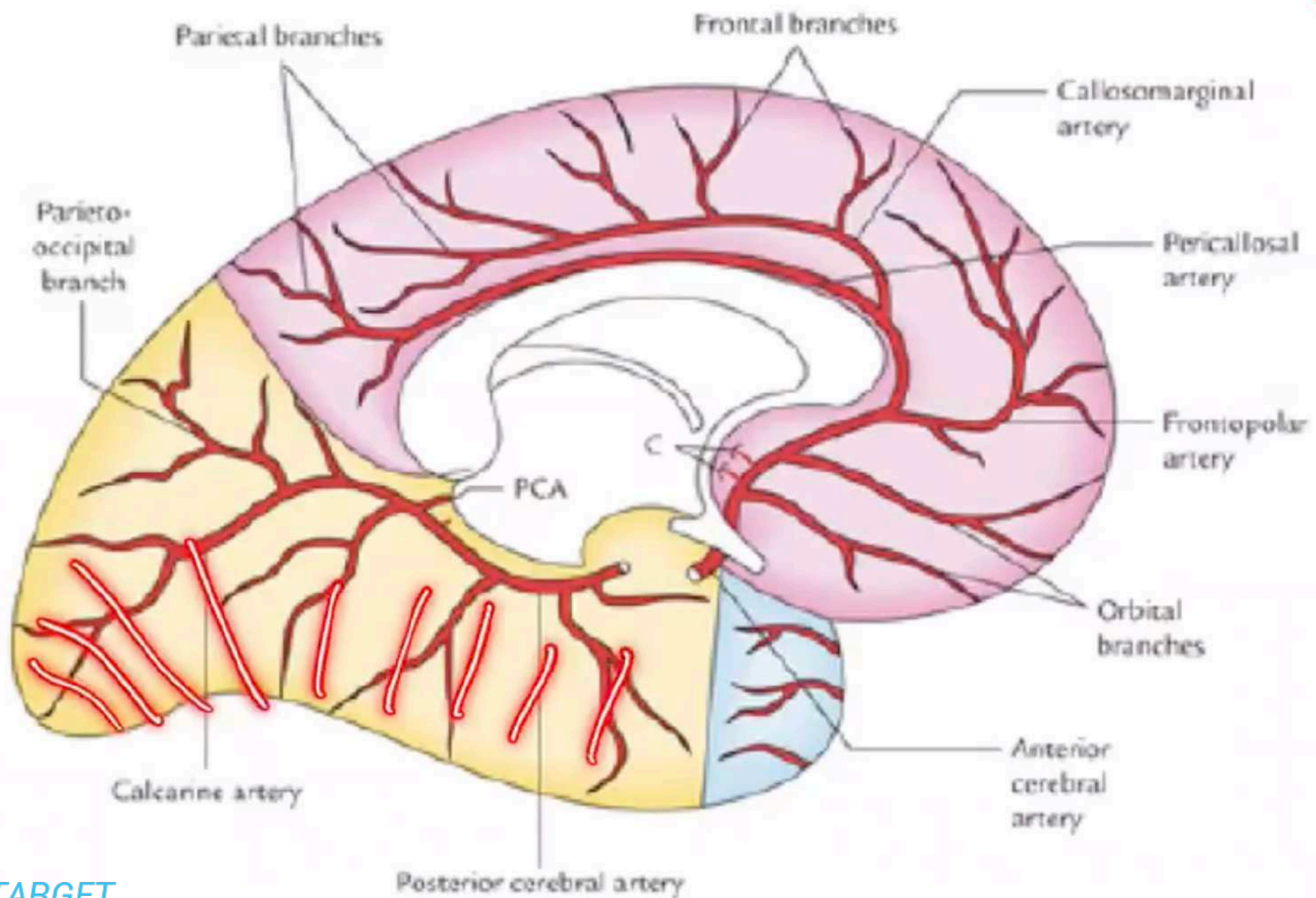


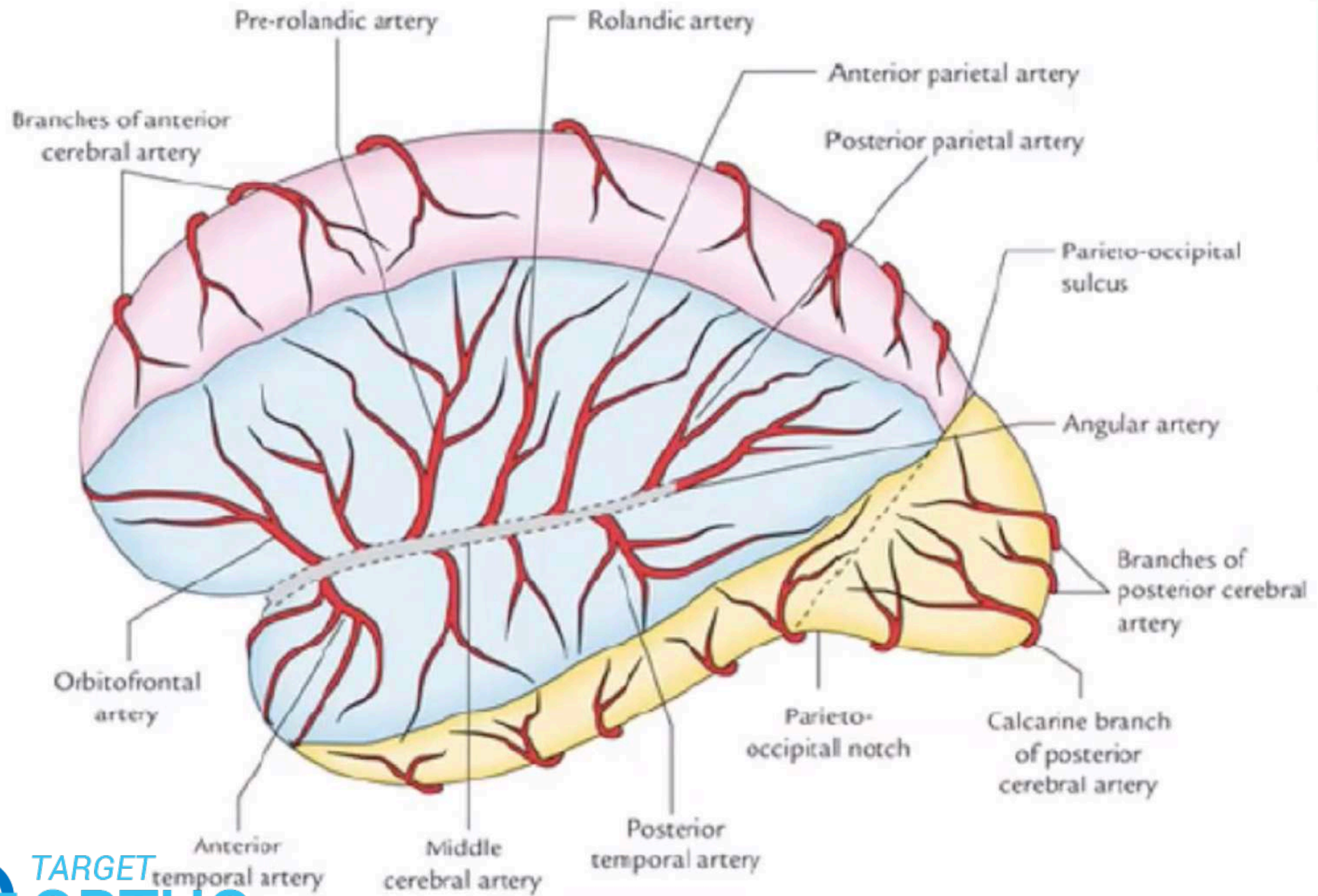
DISTRIBUTION OF BLOOD SUPPLY

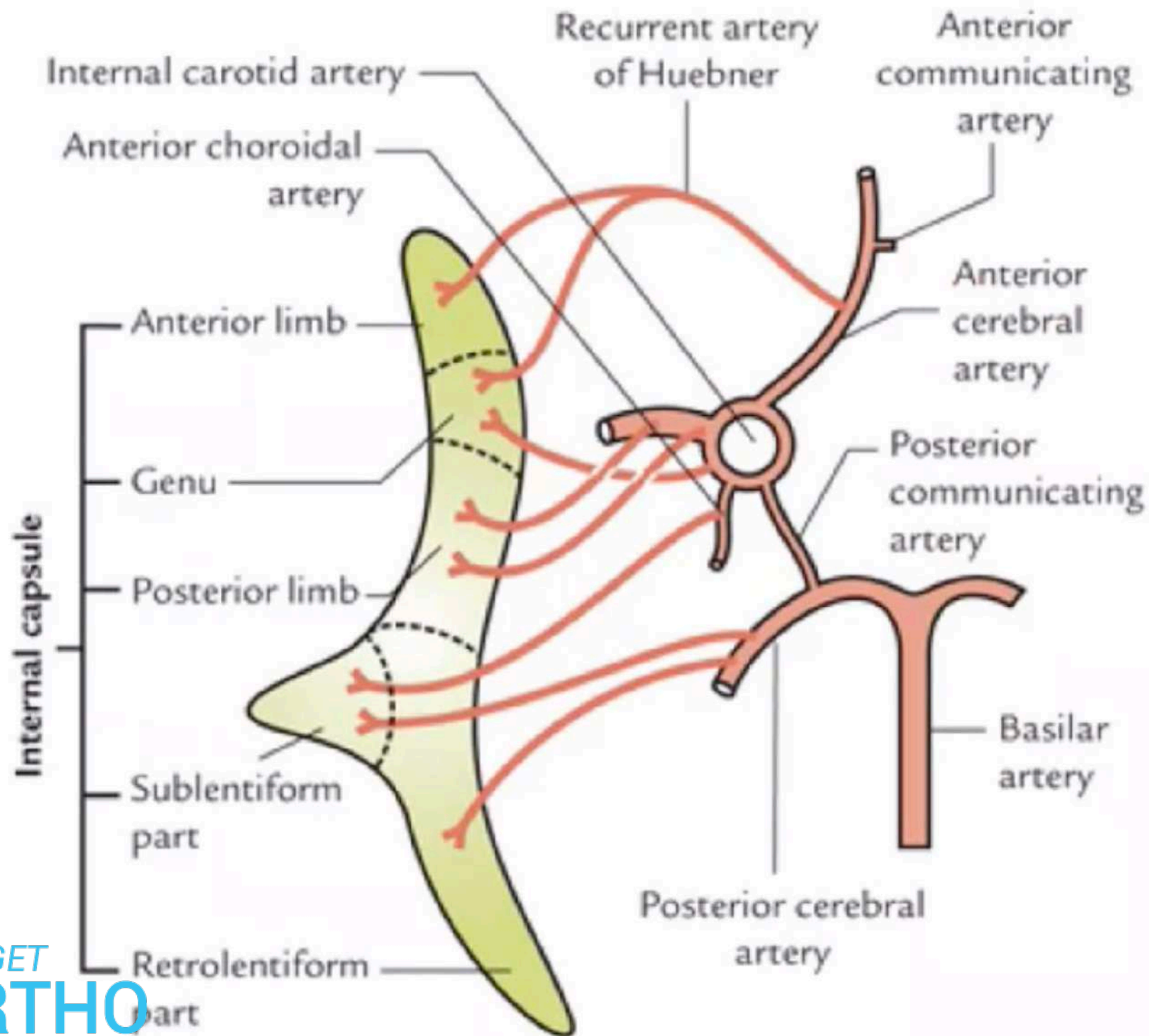






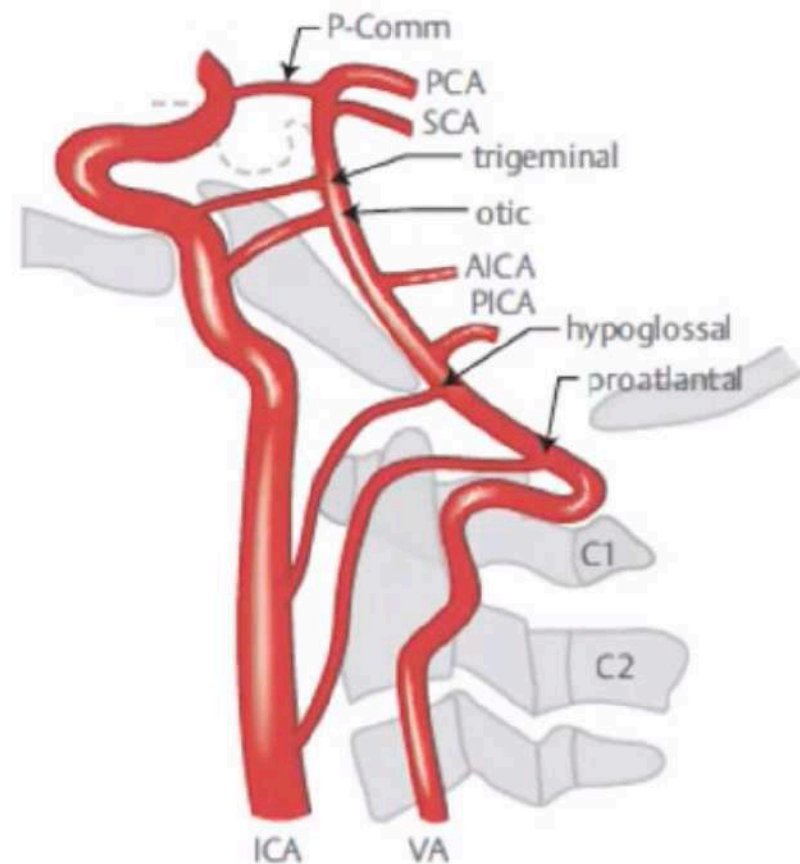


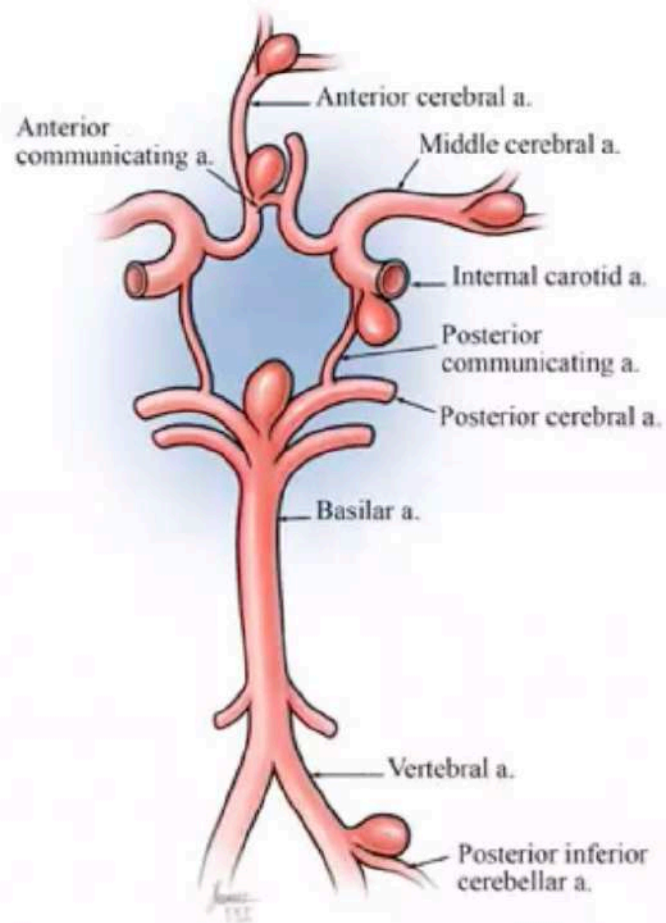




CAROTID-VERTEBROBASILAR ANASTOMOSES

- **PCOM artery**
- **Persistent primitive trigeminal a. (PPTA)**
 - 0.6% incidence
 - MC of persistent fetal anastomoses (83%)
 - Asso. With trigeminal neuralgia
 - Connects upper basilar a. to ICA
 - Saltzman classification
- **Otic**
- **Hypoglossal**
- **Proatlantal intersegmental**





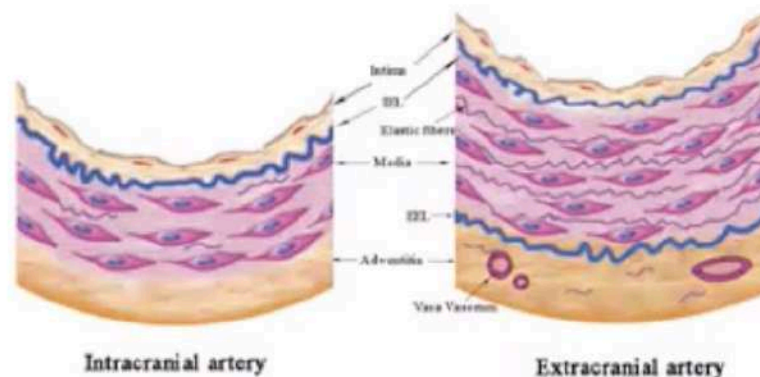
VASCULAR DISEASES – ANEURYSMS

EPIDEMIOLOGY

- Autopsy prevalence of aneurysms – 0.2-7.9%
- Incidental aneurysmal detection – 1-5% population
- Ratio of ruptured:unruptured (incidental) ranges from 5:3 to 5:6
- Almost 50% aneurysms rupture
- Unruptured aneurysms – common in F (3:1 ration) and in elderly
- Only 2% aneurysms present during childhood, when thre are more frequent in males (2:1) and more in posterior circulation (40-45%)

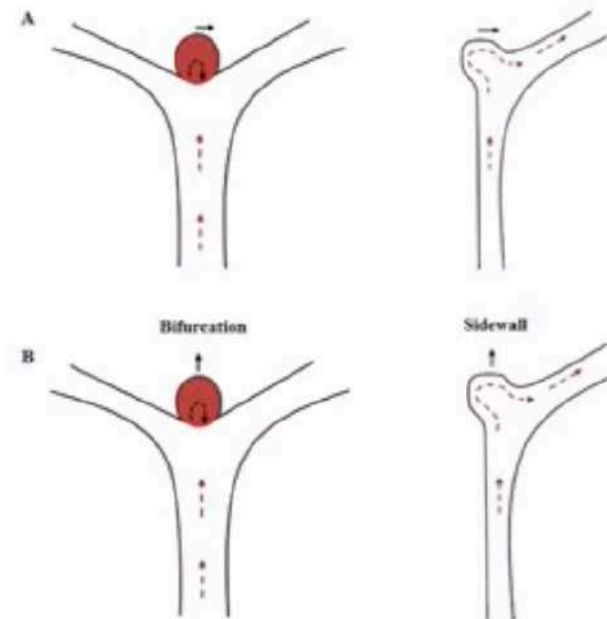
ETIOLOGY

- **Different characteristic of intracranial arteries**
 - Lesser elasticity in tunica media
 - Thinner adventitia of the blood vessels
 - Internal elastic lamina is more prominent
 - Lie within subarachnoid space with little supporting connective tissue
- **Predisposition for saccular aneurysms**



- **Risk zones**

- Curve in the parent artery
- Angle between parent and a significant branching artery
- Point to the direction that parent would have taken



- **Etiology**

- Congenital predisposition (defect in the muscular layer)
- “atherosclerotic” or hypertensive – most common etiology of saccular aneurysms
- Embolic: as in atrial myxoma
- Infections – “mycotic aneurysms”
- Traumatic
- Other conditions

CONDITIONS ASSOCIATED

- **Autosomal dominant polycystic kidney disease**
 - Prevalence of aneurysms 10-30%
 - MC in MCA
 - Multiple aneurysms in 31%
 - 64% rupture occur before age 50
 - 10-20 fold increased risk of SAH
 - Recommendations
 - MRA screening every 2-3 years for a young patient with ADPKD with either 1) history of aneurysms or 2) kindred of ADPKD with aneurysms
 - Every 5-20 years of patient with ADPKD in a kindred of ADPKD with no history of aneurysms

- **Fibromuscular dysplasia**
 - Prevalence in renal FMD is 7%, in aortocranial FMD is 21%
- **Arteriovenous malformations**
 - Including moyamoya disease
- **Connective tissue disorders**
 - Ehlers-Danlos, esp type IV (deficient collagen type III), also has high rate of arterial dissection
 - Marfan syndrome
 - Pseudoxanthoma elasticum

- **Familial intracranial aneurysm syndrome**
 - 2 or more relatives, third degree or closer, harbor radiologically proven IC aneurysms
- **Coarctation of the aorta**
- **Hereditary hemorrhagic telangiectasia (Osler-Weber-Rendu syndrome)**
- **Atherosclerosis**
- **Bacterial endocarditis**
- **MEN type I**
- **NF type I**

LOCATION OF CEREBRAL ANEURYSMS

- **Saccular aneurysms aka berry aneurysms**

- Major named cerebral arteries
- Apex of branch points

- **Mycotic aneurysms**

- Occur more peripherally

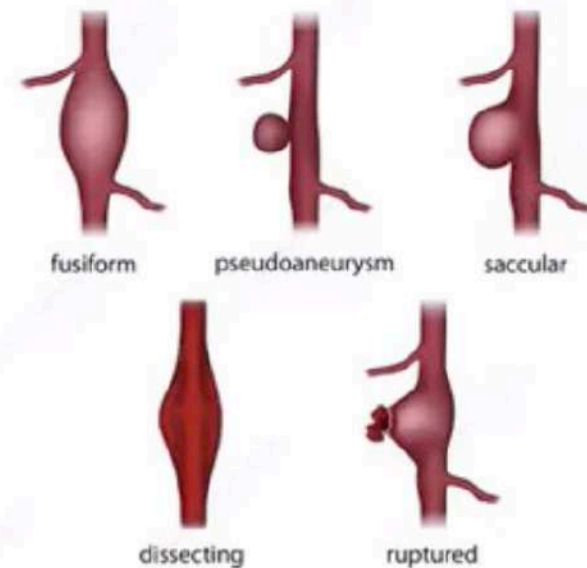
- **Fusiform aneurysms**

- More in VB system

- **Dissecting aneurysms**

- Categorized with arterial dissection

Types of aneurysm



- **Saccular aneurysms location:**

1. **85-95% in carotid system, 3 MC locations**

1. ACOM (single MC): 30% (ACOM & ACA more common in males)

2. PCOM: 25%

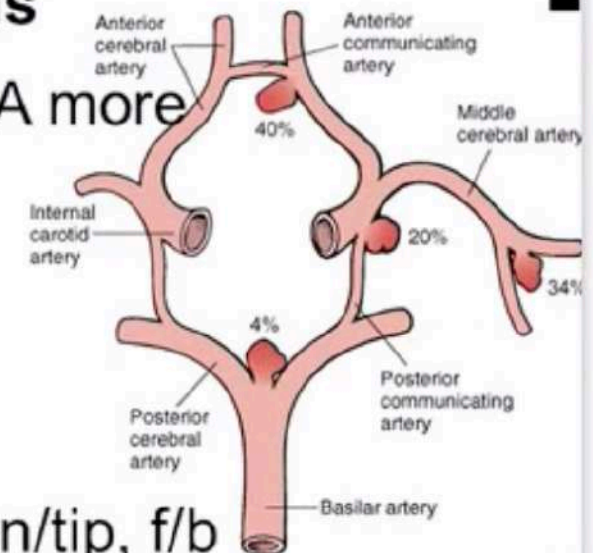
3. MCA: 20%

2. **5-15% in posterior circulation**

1. 10% on basilar artery: basilar bifurcation/tip, f/b BA-SCA, BA-VA junction, AICA

2. 5% on vertebral a.: VA-PICA jn MC

3. **20-30% have multiple aneurysms**



PRESENTATION

- **Major rupture**
 - MC produces SAH, accompanied by
 - Intracerebral hemorrhage (ICH): in 20-40%, common with aneurysms distal to circle of Willis, eg. MCA
 - Intraventricular hemorrhage (IVH): in 13-28%
 - Subdural hemorrhage (SDH): 2-5%

SAH

- 10-15% patients die before reaching hospital
- Mortality 10% in first few days
- 30-day mortality around 46%
- Risk of rebleed – 15-20% within 2 weeks
- Goal of early intervention – reduce risk of rebleed
- 7% mortality and 7% morbidity due to vasospasm
- Moderate to severe disability in 30%



- **Grading SAH**
- Hunt and Hess Grade

Grade	Description
1	asymptomatic, or mild H/A and slight nuchal rigidity
2	Cr. N. palsy (e.g. III, VI), moderate to severe H/A, nuchal rigidity
3	mild focal deficit, lethargy, or confusion
4	stupor, moderate to severe hemiparesis, early decerebrate rigidity
5	deep coma, decerebrate rigidity, moribund appearance
Add one grade for serious systemic disease (e.g. HTN, DM, severe atherosclerosis, COPD) or severe vasospasm on arteriography.	
*original paper did not consider patient's age, site of aneurysm, or time since bleed; patients were graded on admission and pre-op	

WFNS SAH grade

WFNS grade	GCS score ^a	Major focal deficit ^b
0 ^c		
1	15	–
2	13–14	–
3	13–14	+
4	7–12	+ or –
5	3–6	+ or –

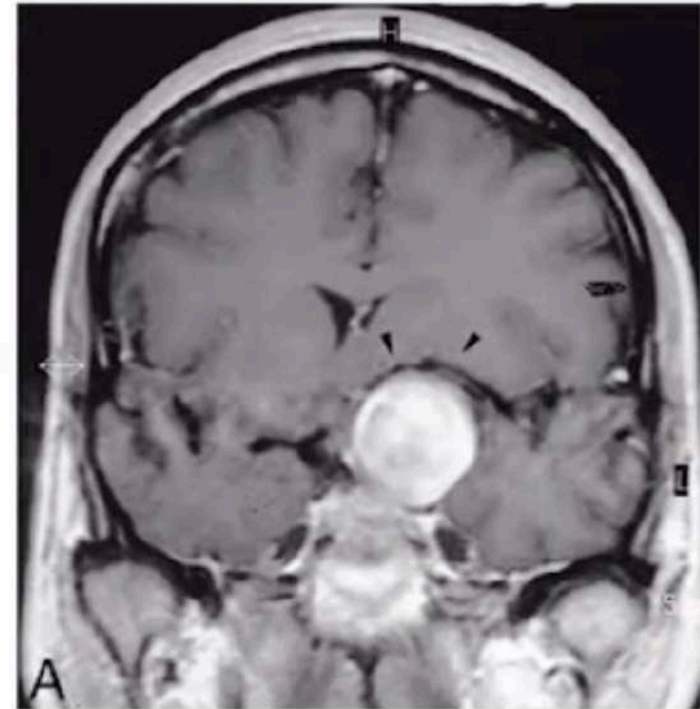
IVH

- Occurs in 13-28% of ruptured aneurysms
- Size of ventricles on admission – most important prognostic indicator
- Distal PICA aneurysms
 - May rupture directly into 4th ventricle
- ACOM aneurysm
 - Ruptures into 3rd ventricle
- Distal basilar/carotid terminal aneurysms



PRESENTATION OTHER THAN MAJOR RUPTURE

- **Mass effect**
 - Giant aneurysms: incl brainstem compression and cranial neuropathies
 - Parasellar aneurysms: endocrine disturbance
- **Minor hemorrhage – warning or sentinel hemorrhage**
 - Present with thunderclap headache
 - “worst headache of life”
 - Shortest latency from symptom to SAH (10 days)

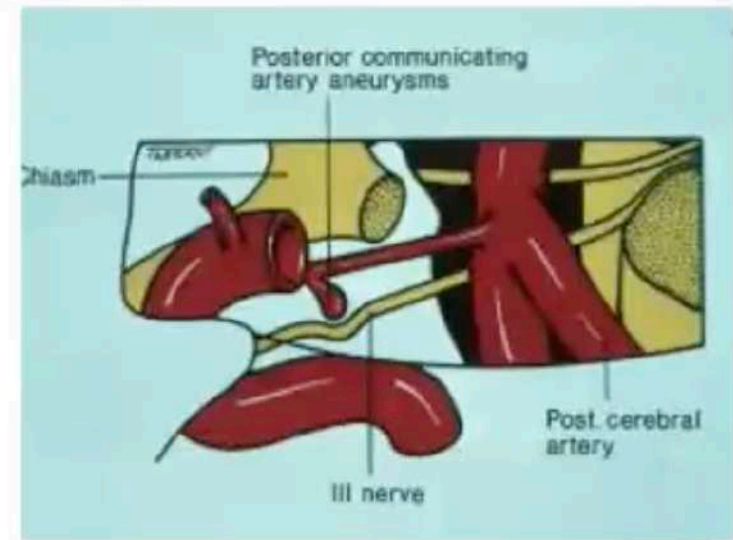


- **Small infarcts or TIA**
 - Due to distal embolisation
- **Seizures**
- **Headache**
 - Acute: thunderclap nature
 - Chronic: >2 weeks
- **incidental**



CRANIAL NEUROPATHIES

- **Oculomotor palsy (3rd)**
 - 9% of PCOM aneurysms
 - EOM palsy, ptosis, dilated pupil
- **Visual loss**
 - Ophthalmic a. aneurysms
 - Chiasmal syndromes – ACOM/basilar top aneurysms
- **Facial pain syndrome**
 - Intracavernous/supraclinoid aneurysms



TREATMENT OPTIONS

- **Determining factors**
 - Age and condition of the patient
 - Anatomy of aneurysm
 - Associated vasculature
 - Available treatment options
- **Natural history**
 - SAH
 - Enlargement to giant aneurysm
 - Spontaneous thrombosis - rare

ADDITIONAL THERAPIES

- **Donot address the aneurysm directly**

- Continue medical management

- Control of HTN

- Calcium channel blockers

- Stool softeners

- Activity restrictions

- Options NOT used

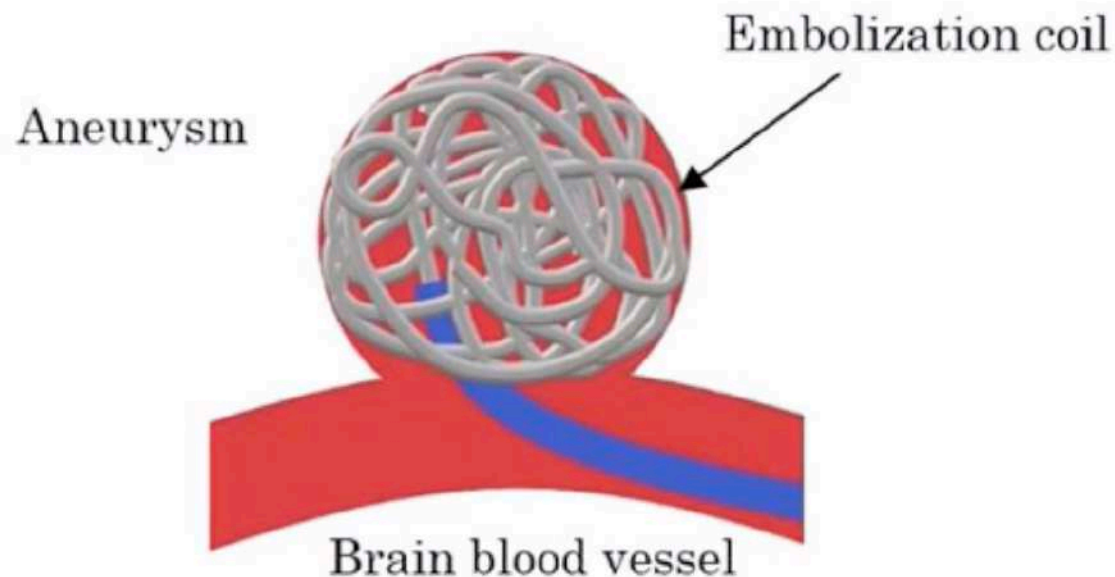
- Antifibrinolytic therapy

- Serial lumbar puncture

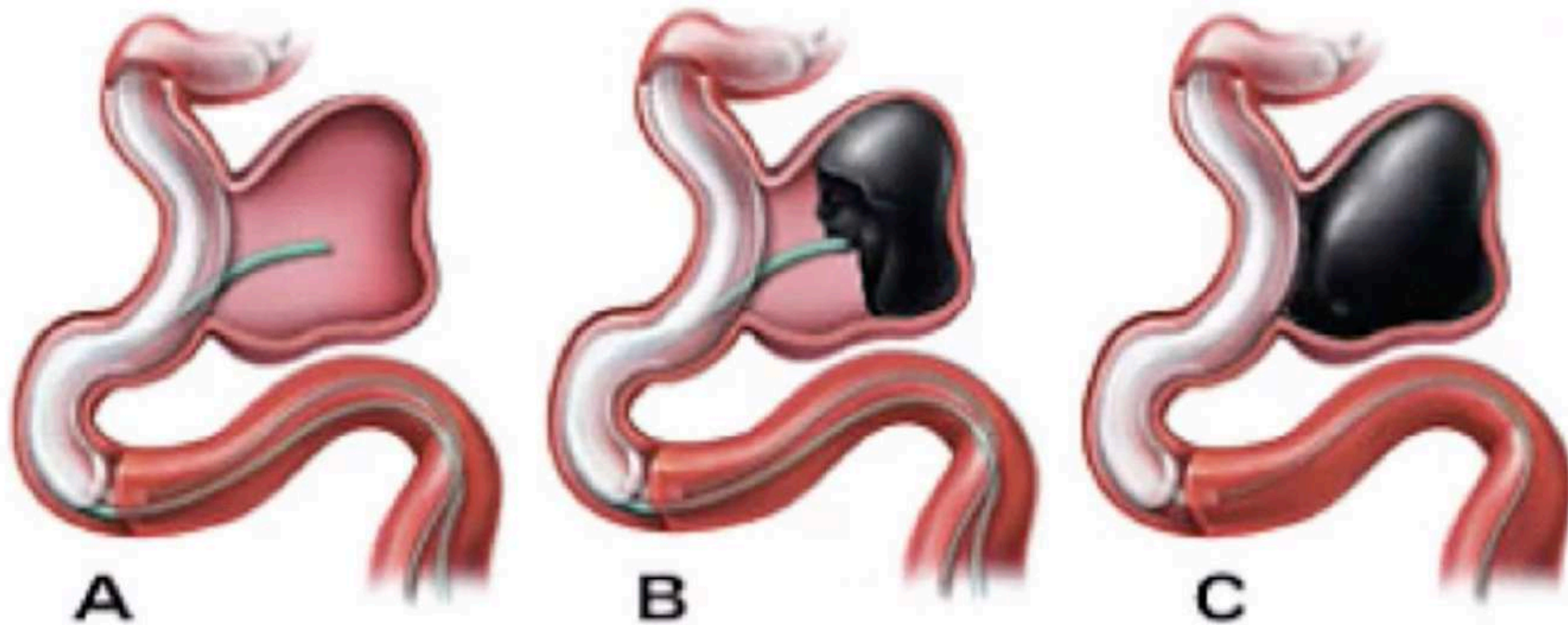
ENDOVASCULAR TECHNIQUES

Thrombosing the aneurysm

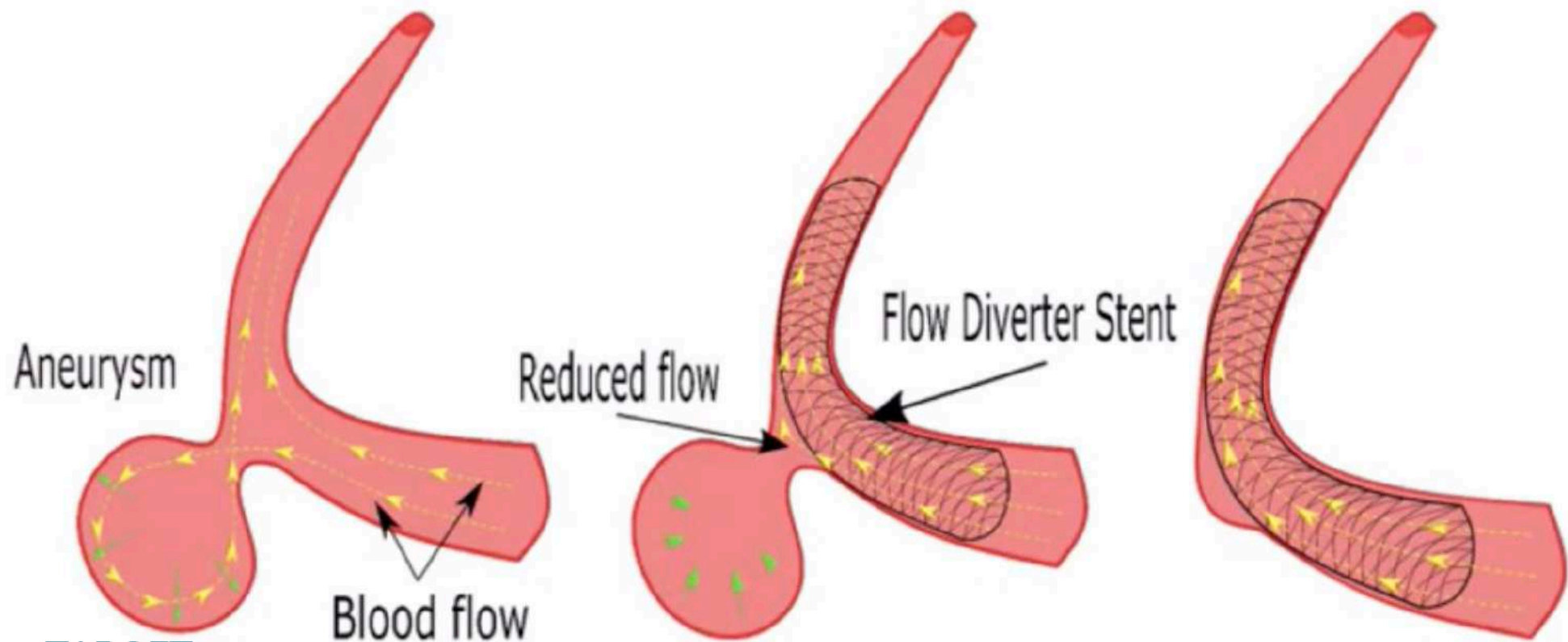
- “coiling” with Guglielmi electrolytically detachable coils



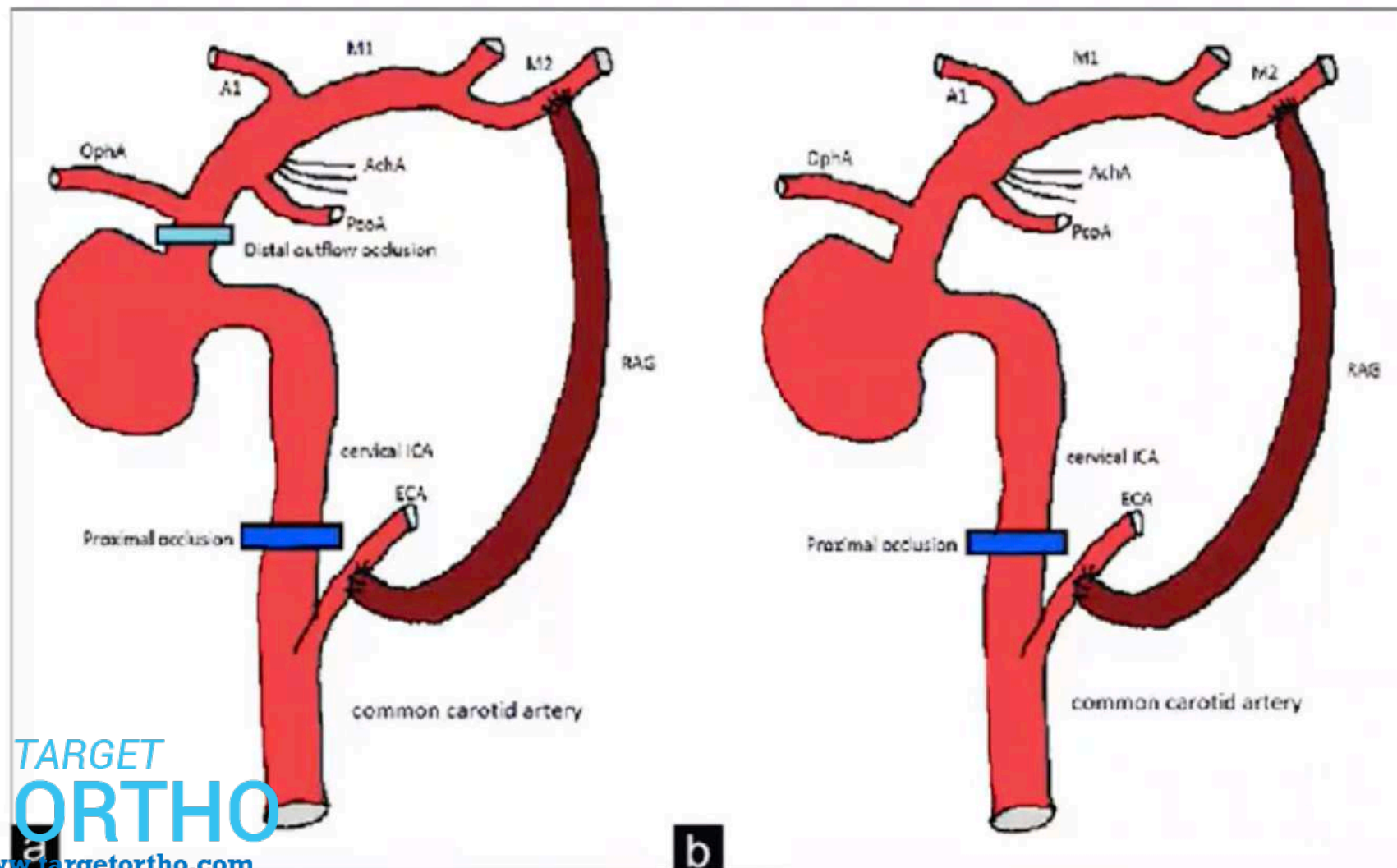
- Onyx HD 500 use for wide-necked or giant aneurysms



- “flow diversion” with “covered stents”



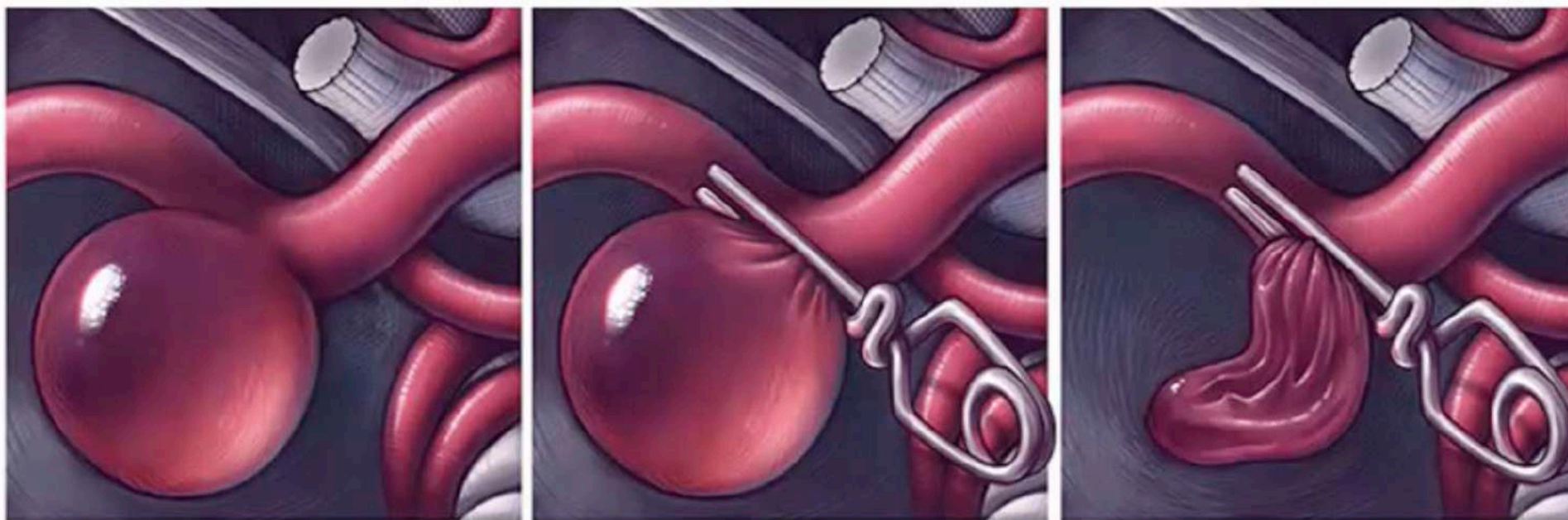
Trapping the aneurysm



SURGICAL TREATMENT OPTIONS

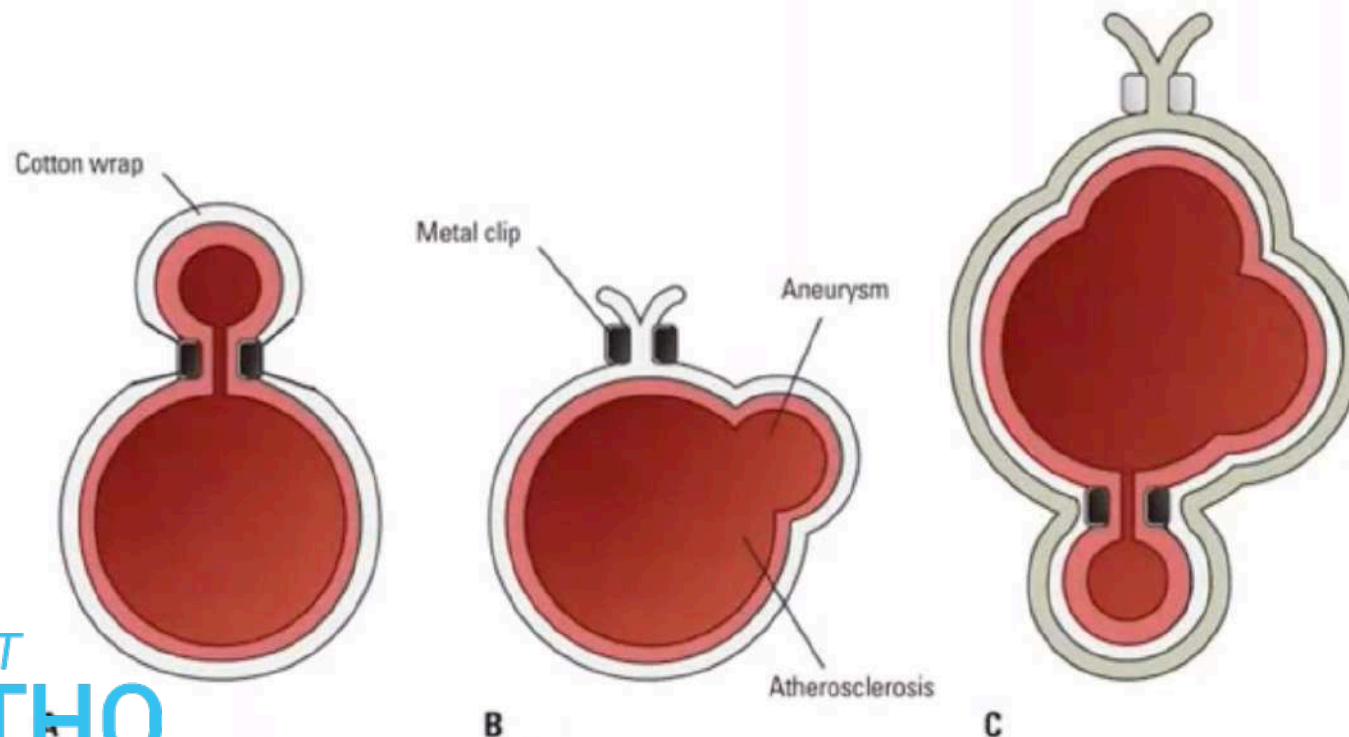
Clipping

- The surgical gold standard



Wrapping or coating the aneurysm

- When little else can be done
- Eg fusiform basilar aneurysms, neck in the cavernous sinus



COILING VS CLIPPING

ISAT (international subarachnoid hemorrhage aneurysm trial)

- 1997 to 2002, was stopped prematurely because of a significant outcome difference between the 2 groups favouring endovascular coil embolisation

- **Factors to consider**

- Availability of equipment and expertise
- Anatomy & location of aneurysm
- Mass effect
- Associated hemorrhage
 - >50ml of ICH present, prefer clipping
- Patient's age
 - > 70 yo, favor coiling
- Clinical state
- anticoagulation

SURGICAL TACTICS

- Intraoperative aneurysmal rupture
- Cerebral protection
- Intraoperative angiography

OUTCOMES

- **Recurrence**
 - 1.5% at 4.4 years
- **Follow up**

Perform indicated study at the following times after treatment	
<i>Coiled aneurysms</i>	<i>Clipped aneurysms</i>
Study: gad-MRA ^a or CTA ^b	Study: CTA
6 mos	1 year
1.5 years	5 years
3.5 years	every 10 years thereafter
7 every 5–10 years (as with clipped aneurysms)	
^a gad-MRA indicates gadolinium MRA, which is more sensitive here than TOF-MRA (p. 247). Use the same modality for each follow-up to facilitate accurate comparison	
^b gad-MRA is usually preferred after coiling because of dense artifact from coils on CTA	

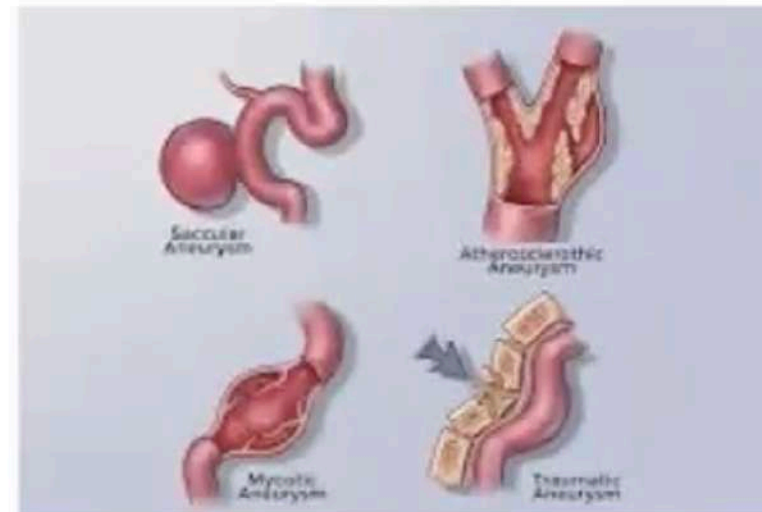
SPECIAL CONDITIONS

Traumatic aneurysms

- <1% aneurysms
- Most are pseudoaneurysms
- Present with delayed ICH
- Treatment similar to as described before

Mycotic aneurysms

- 4% of IC aneurysms
- 3-15% of patients with SBE, streptococcus MC
- Distal MCA branches (75-80%)
- Mostly fusiform morphology and very friable
- Treated with
 - Antibiotics for 4-6 weeks
 - Serial angiography
 - Delayed clipping



Giant aneurysms

- >2.5 cm
- Present with mass effect
- Surgical clipping – possible in only 50% cases
- Vascular bypass
- Trapping
- Proximal arterial ligation
- wrapping

