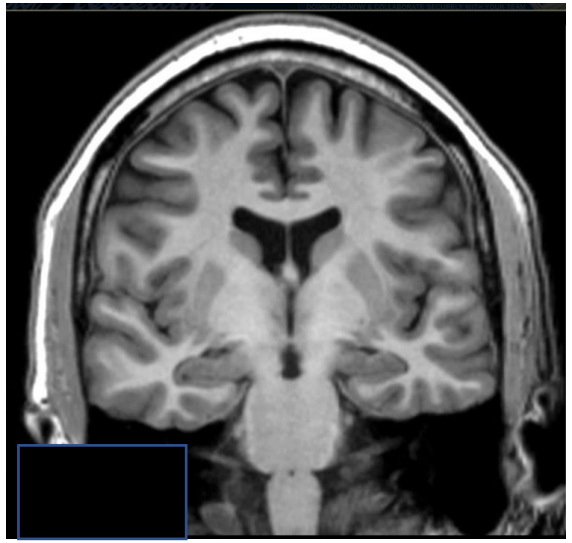


MRI Interpretation for Dementia - ANATOMY

Sharon Best, PA-C, MHS

APP2APP Virtual Lectures, Inc

https://app2app.org/

Objectives

1. Imaging Planes
2. T1 vs T2 vs FLAIR
3. MRI Anatomy Pertinent for Dementia
   - Medial Temporal Lobe structures and atrophy
   - Parietal atrophy - **Koedam scale**
   - Frontotemporal atrophy
   - Small Vessel Ischemic Disease - **Fazekas scale**
   - Microangiopathy: microhemorrhages and superficial siderosis

Imaging Planes

Imaging Planes

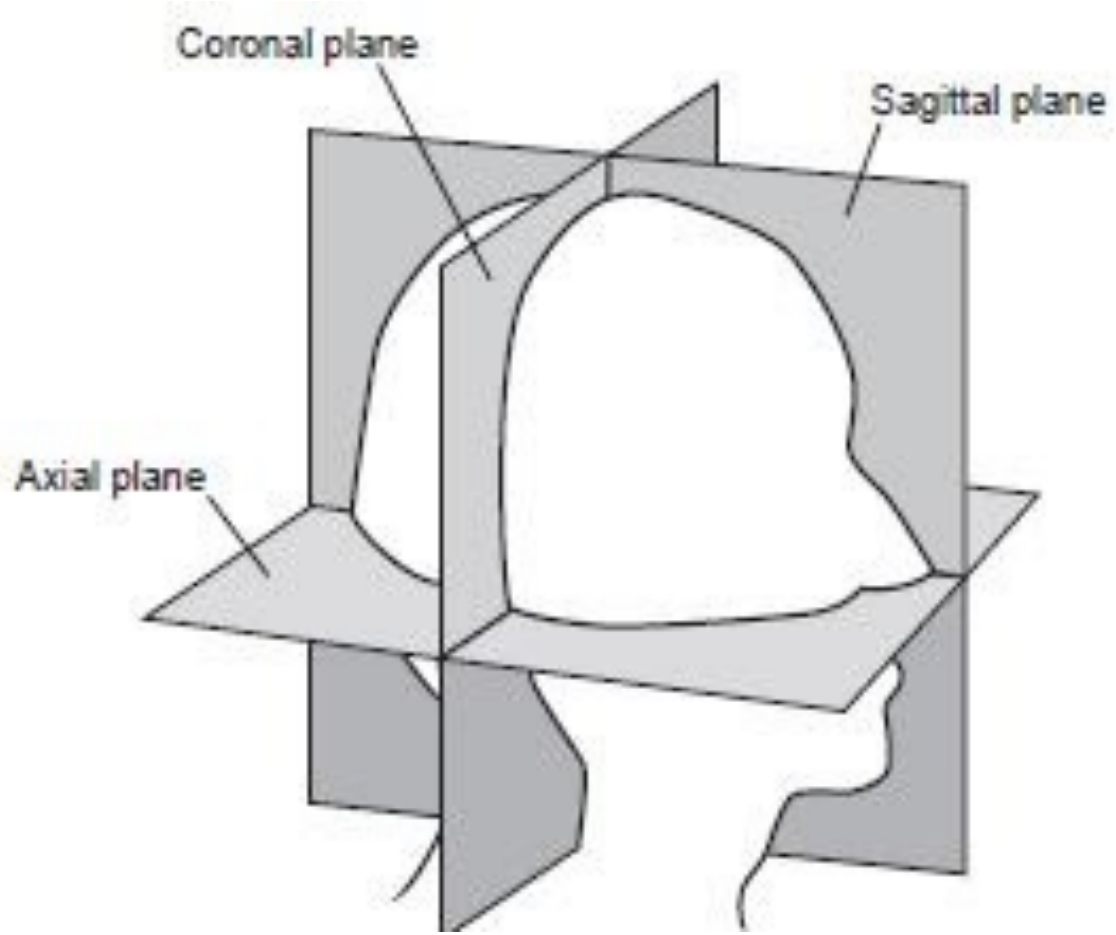
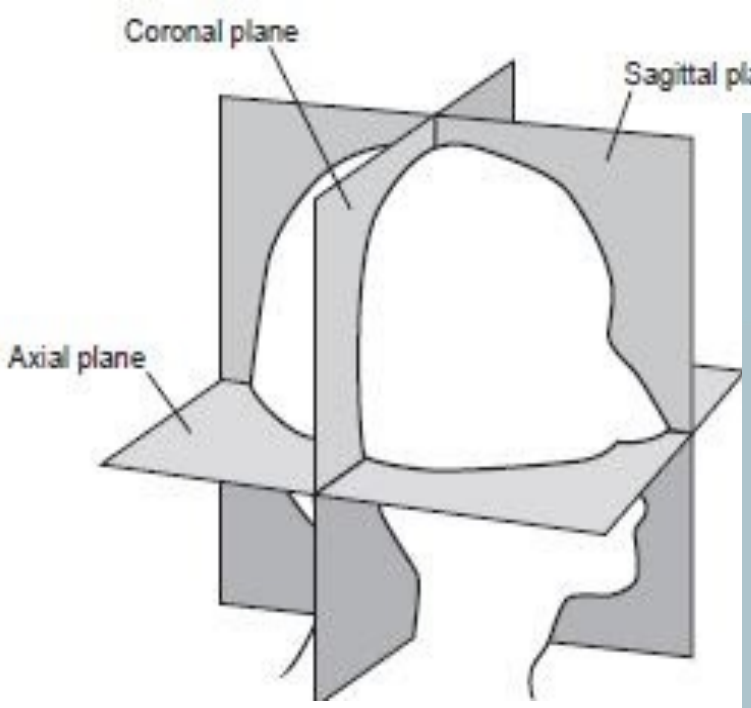
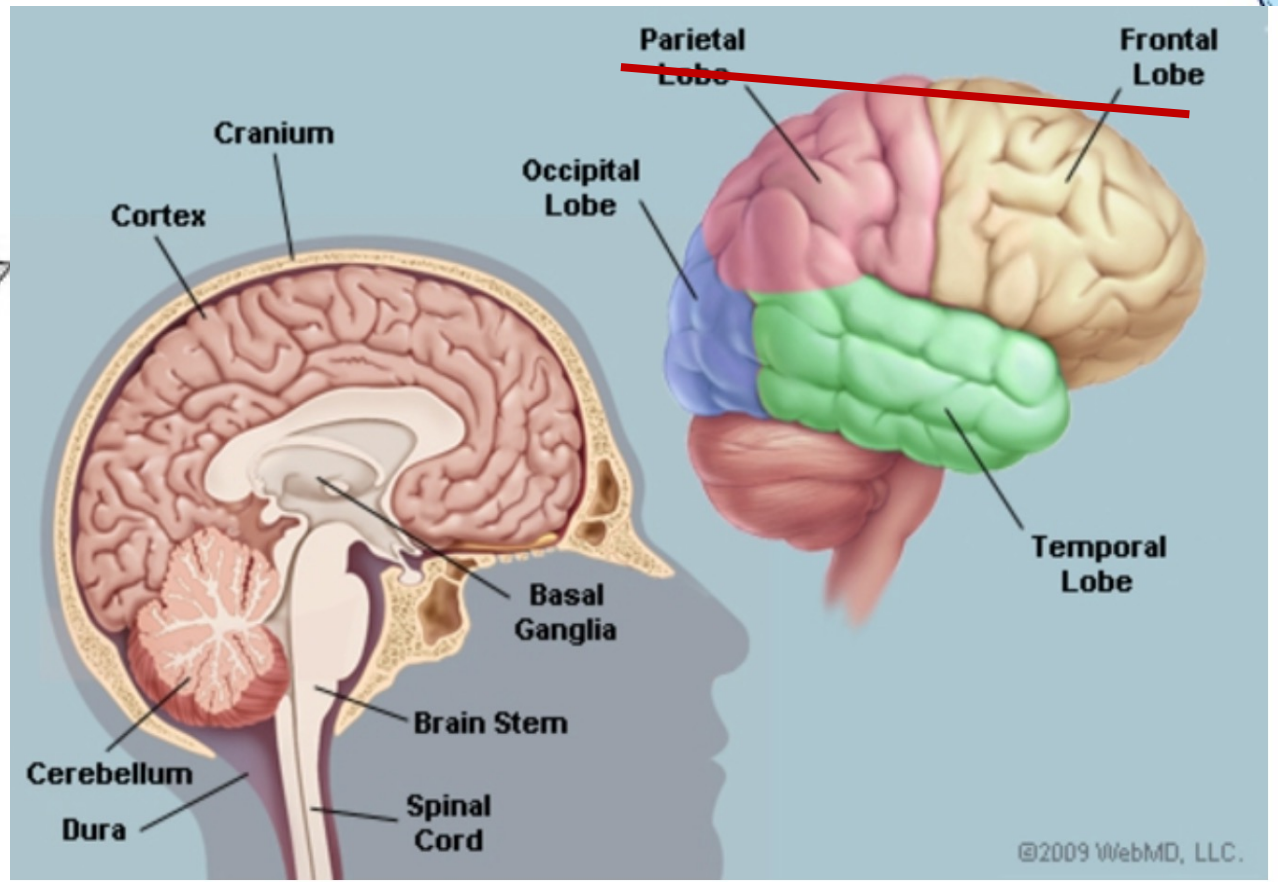


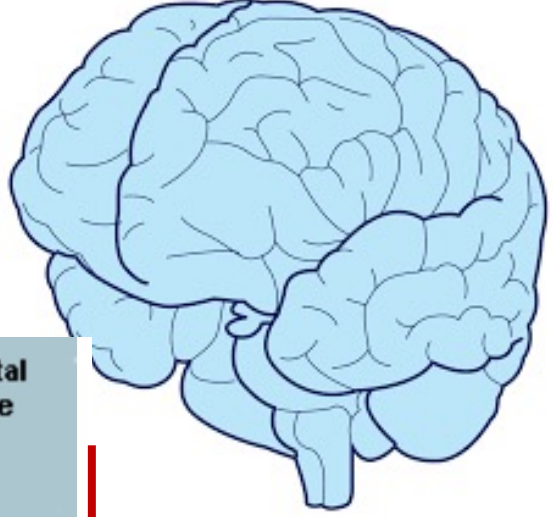
image ref: http://www.radtechonduty.com/2017/03/radiography-imaging-planes.html

Imaging Planes





https://www.webmd.com/brain/picture-of-the-brain#1

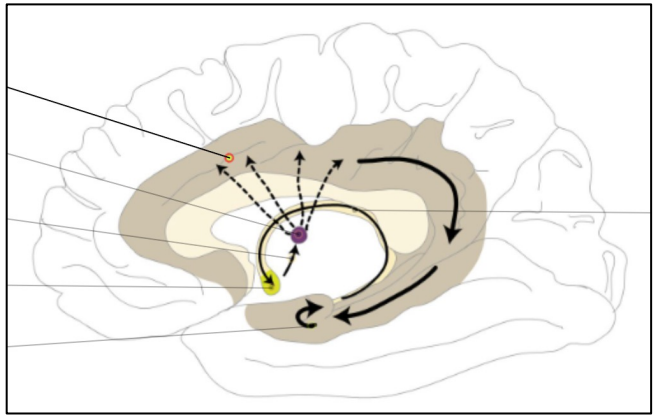


https://online.king.edu/infographics/parts-of-the-brain/

Note:
Sylvian fissure
Central sulcus
Pons and Poles

IAMOS practice

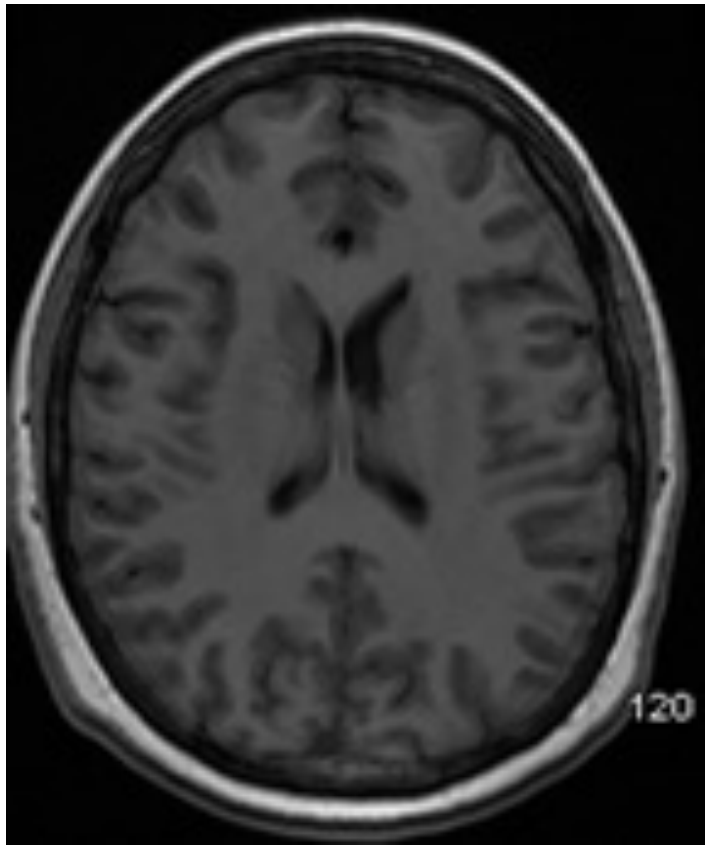
https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D



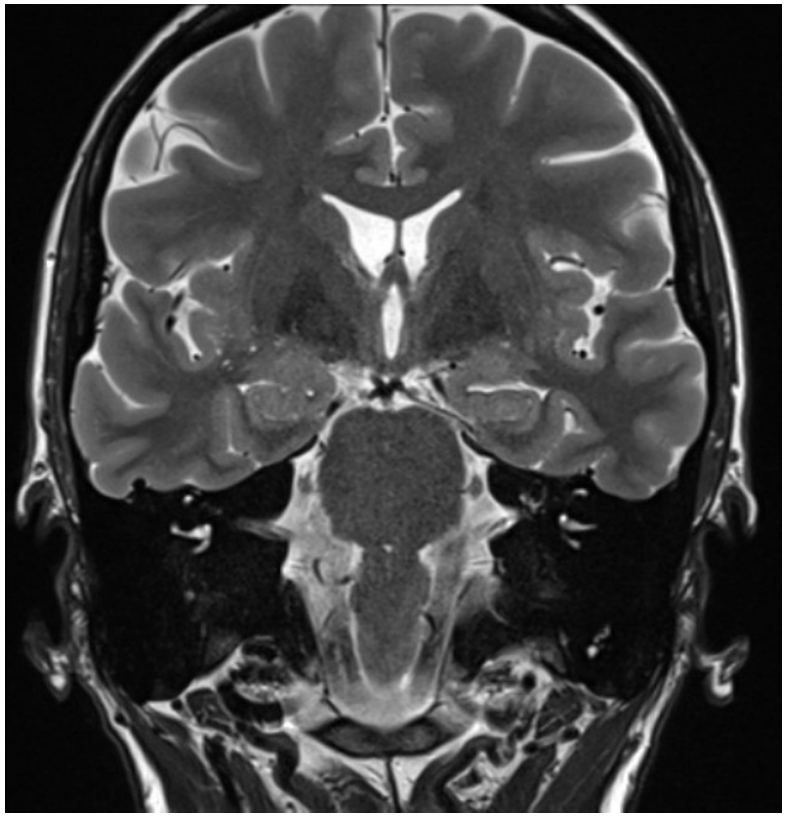
Cingulate gyrus

Imaging Planes

Sagittal



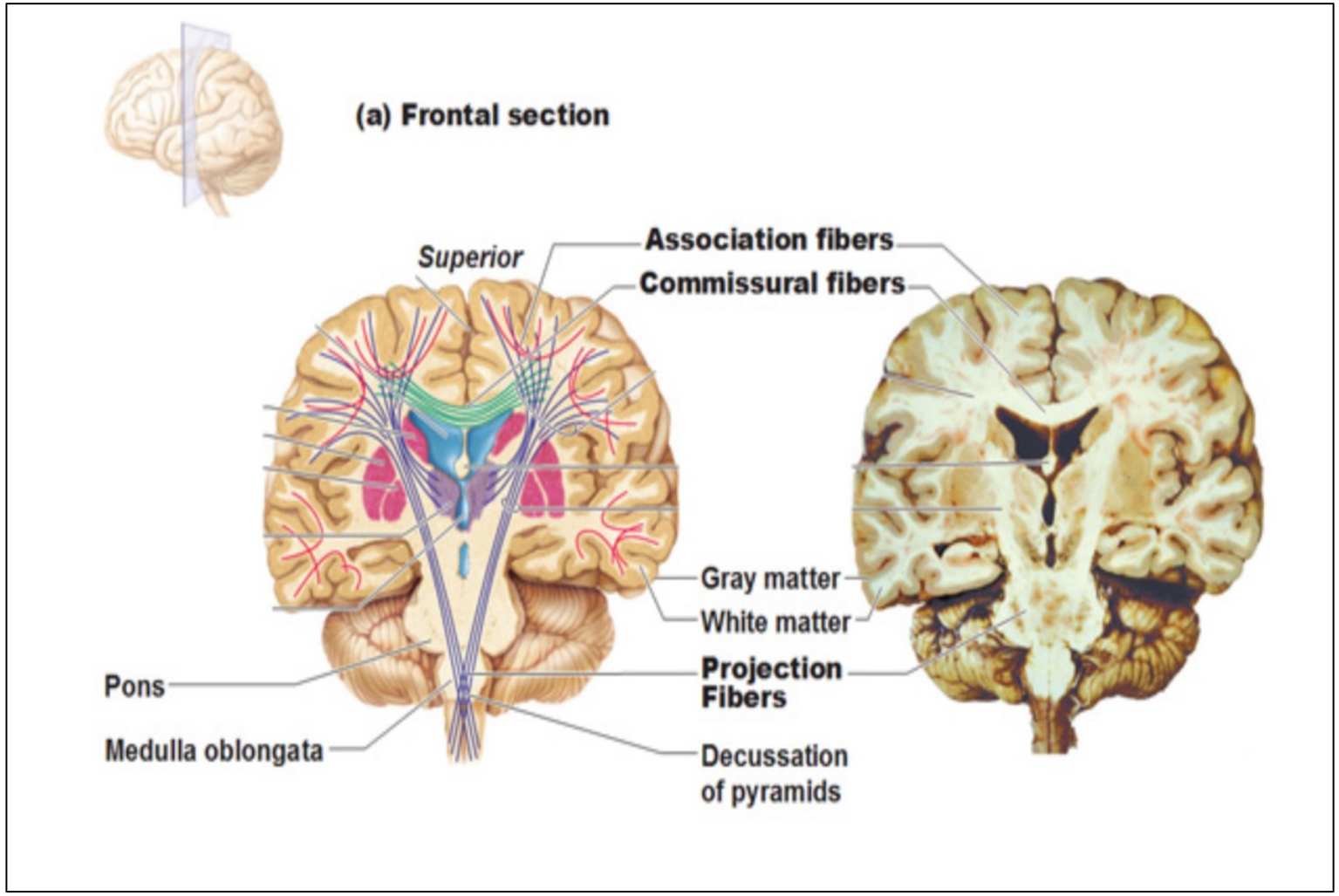
Axial

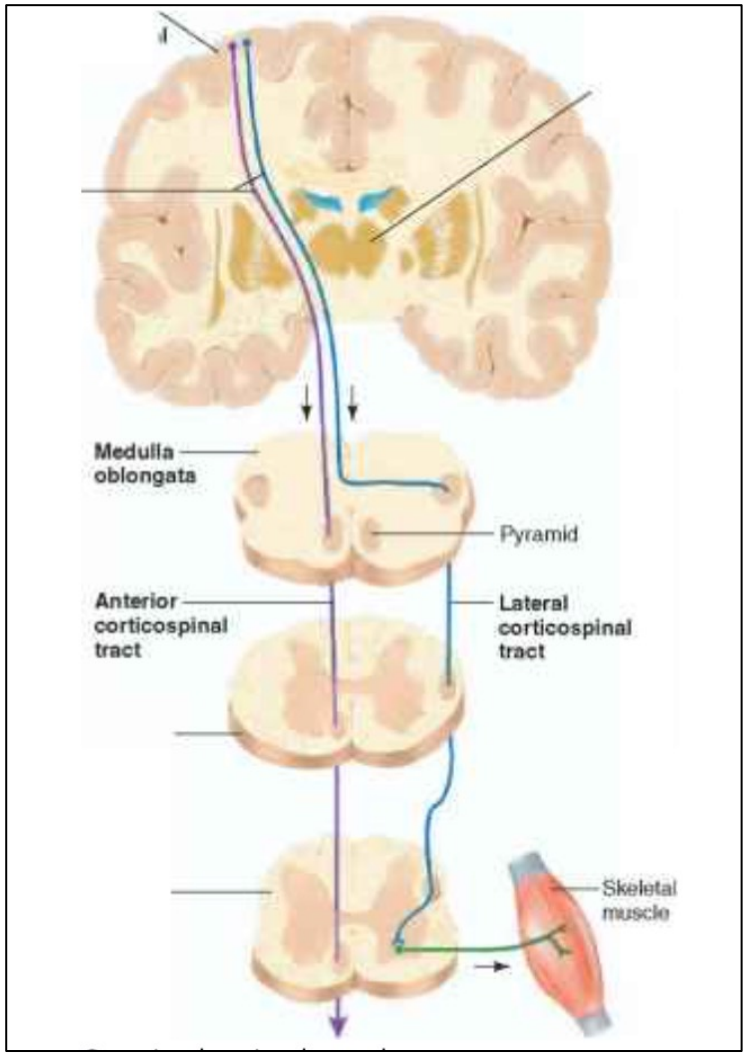


Coronal

T1 vs T2 vs FLAIR

Gray Matter (peripheral cortex and deep brain nuclei) vs White Matter (myelinated axons- subcortical regions)





https://antranik.org/cerebral-white-matter-and-gray-matter-and-basal-ganglia/

https://www.78stepshealth.us/human-physiology/descending-tracts.html

T1 vs T2

T1 Imaging:

- Gray matter is dark
- White matter is lighter
- CSF is darkest

T2 Imaging:

- Gray matter is light
- White matter is darker
- CSF is lightest

T1 MRI

T2 MRI

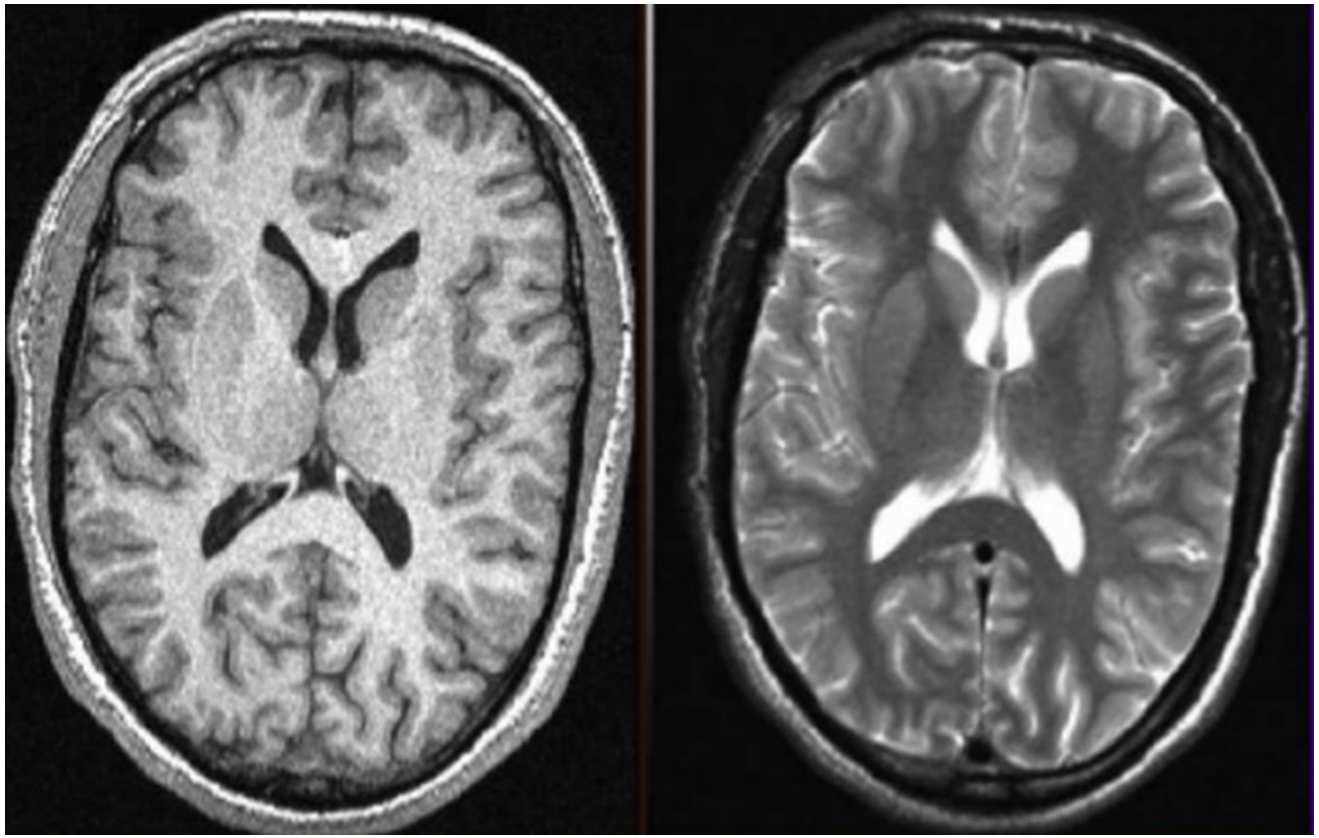
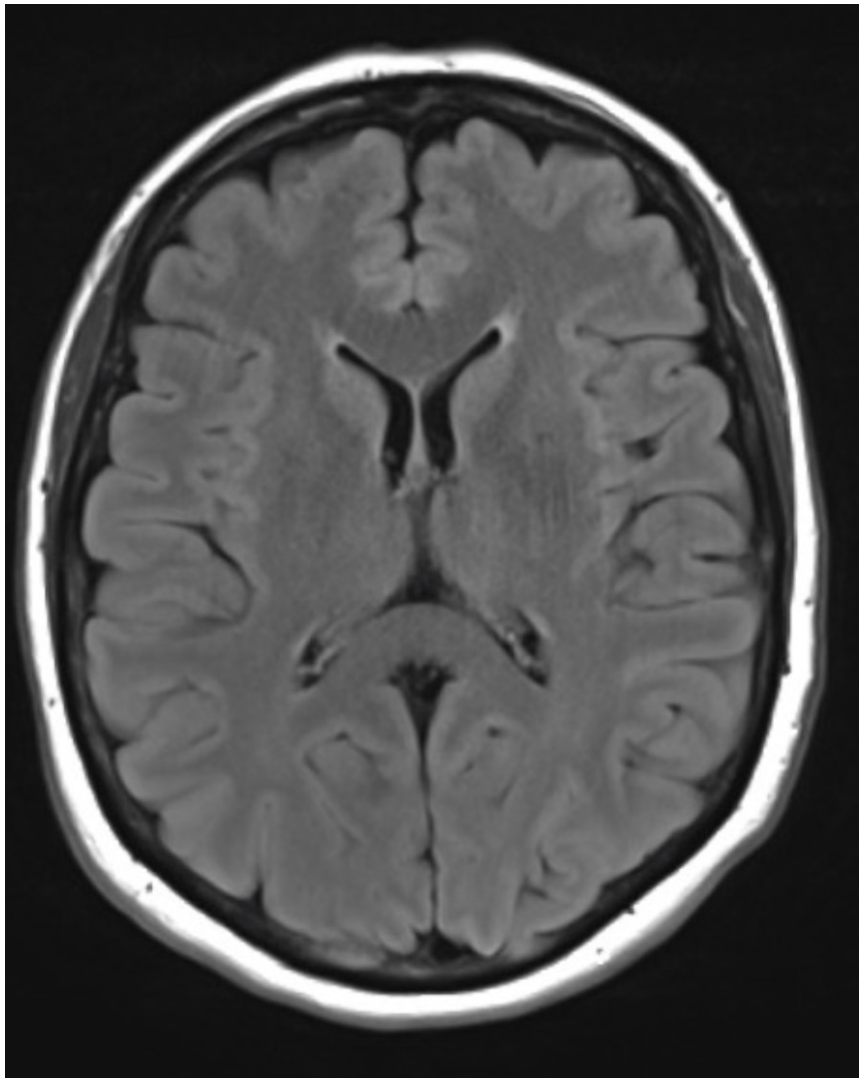


Image REF: http://casemed.case.edu/clerkships/neurology/web%20neurorad/mri%20basics.htm

FLAIR- Fluid Attenuated Inversion Recovery Sequences

- A T2 image with “fluid attenuated” (ie: the **fluid signal is suppressed**)
- Very sensitive to pathology
- Think! ***Patients’ permanent record***
- RECALL: T2 gray matter is light, white matter is darker, CSF is lightest.
- HOWEVER, in a FLAIR image:
  - The CSF is attenuated (suppressed)
  - Therefore, **gray matter is light, white matter is darker, CSF if black.**

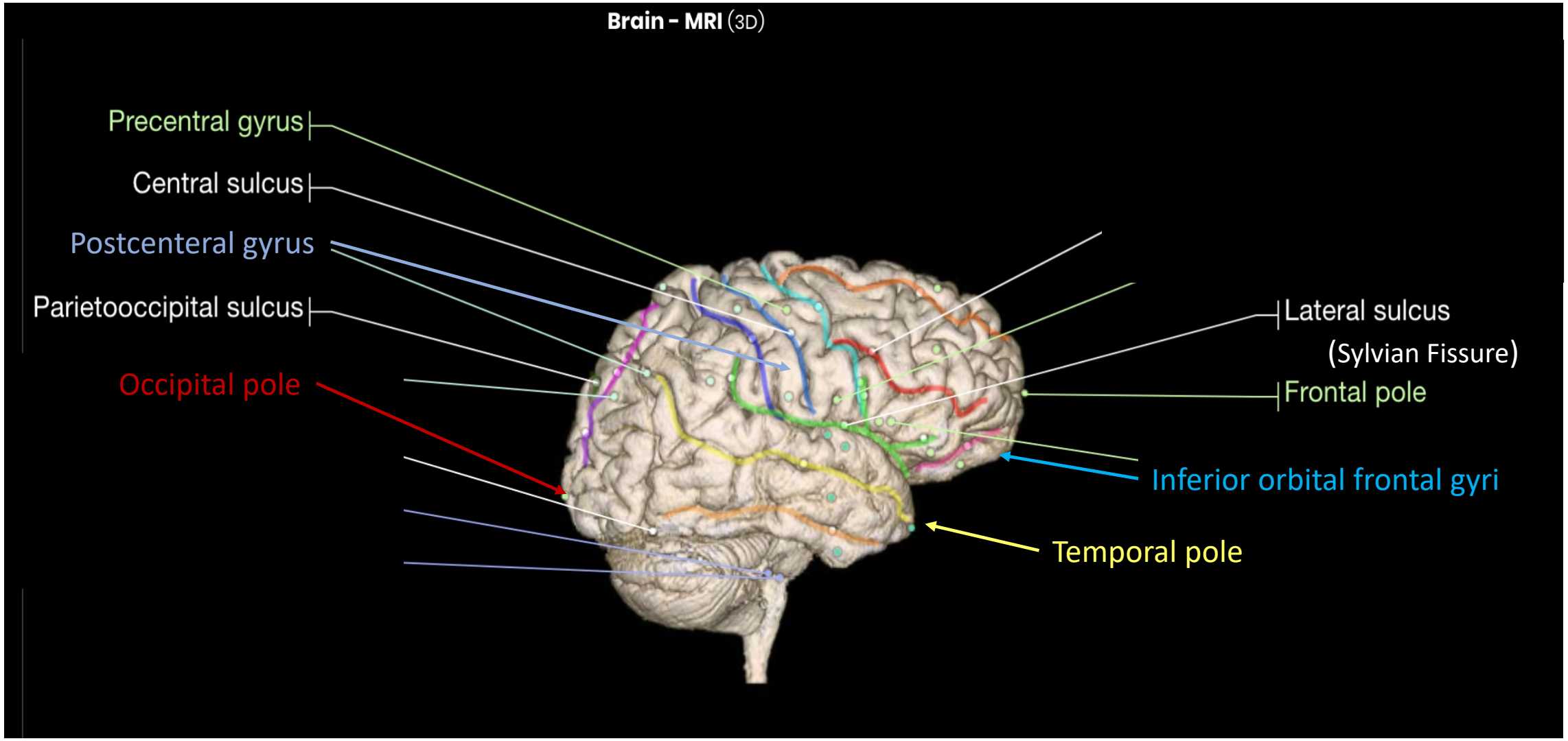
https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D



MRI Anatomy Pertinent for Dementia

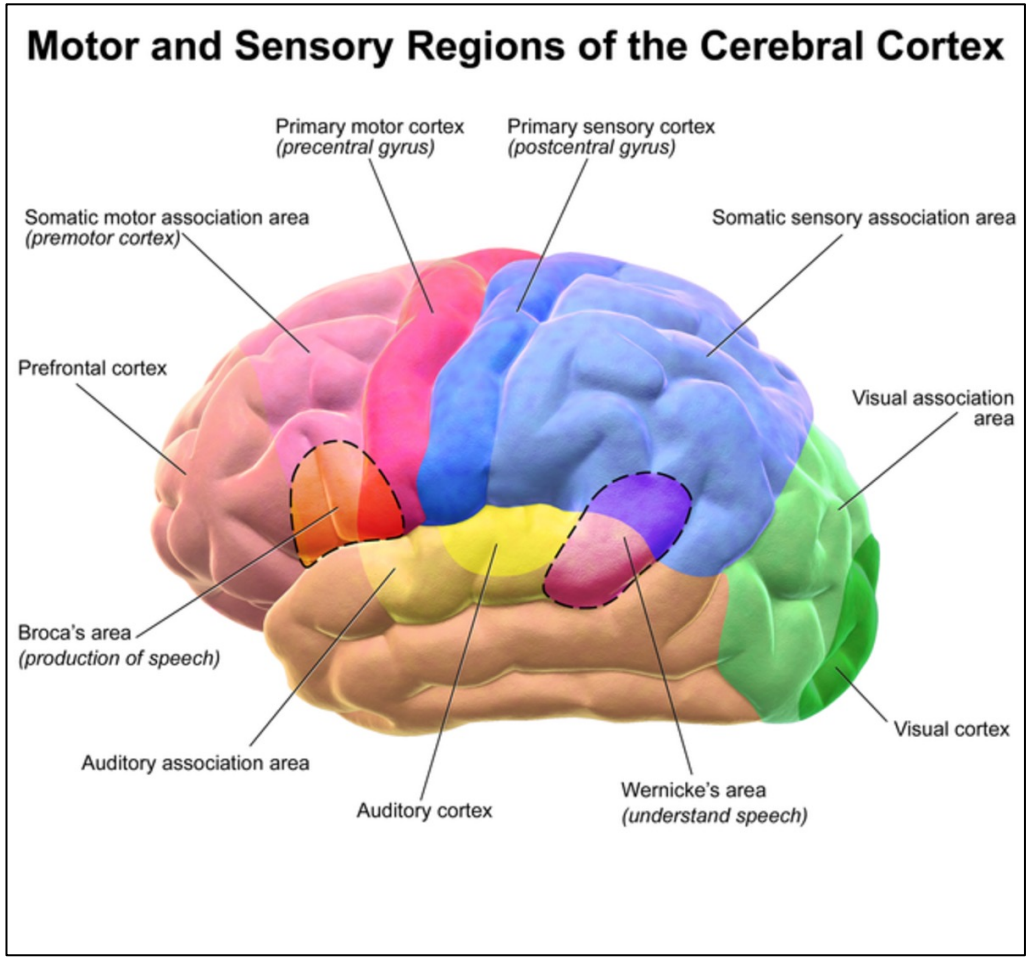
APP2APP Virtual Lectures, Inc

Important Gyri and Sulci and Poles of the Cortex



https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D

Important Motor and Sensory Regions of the Cortex



https://owlcation.com/stem/Exploring-the-Brain-Three-Regions-Named-after-Scientists

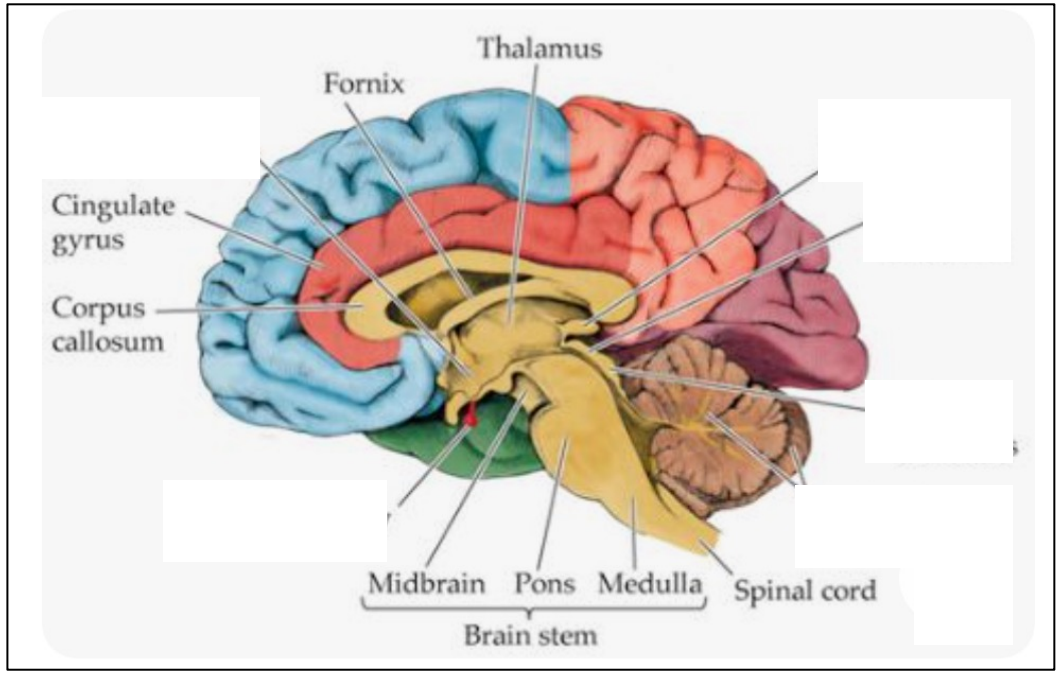
Brain Stem- Midline- Sagittal View

Brain Stem:

A. Medulla oblongata

B. Pons

C. midbrain (cerebral crus)



https://www.pinterest.com/pin/744149538403526897/

https://radiopaedia.org/cases/normal-brain-mri-5

Brain Stem Axial View

Brain Stem *(inferior → superior)*

A. Medulla oblongata
B. Pons
C. Midbrain (note: cerebral crus)

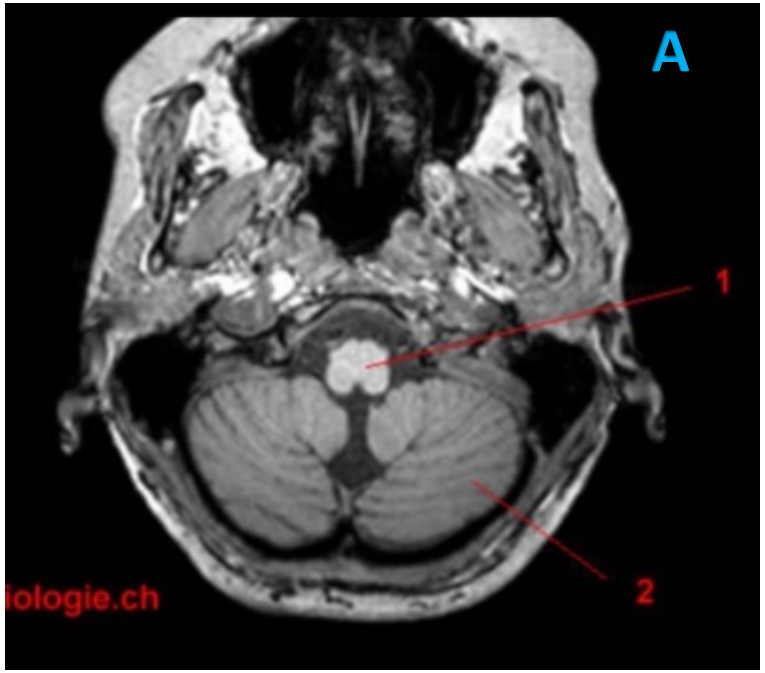
Cerebellum

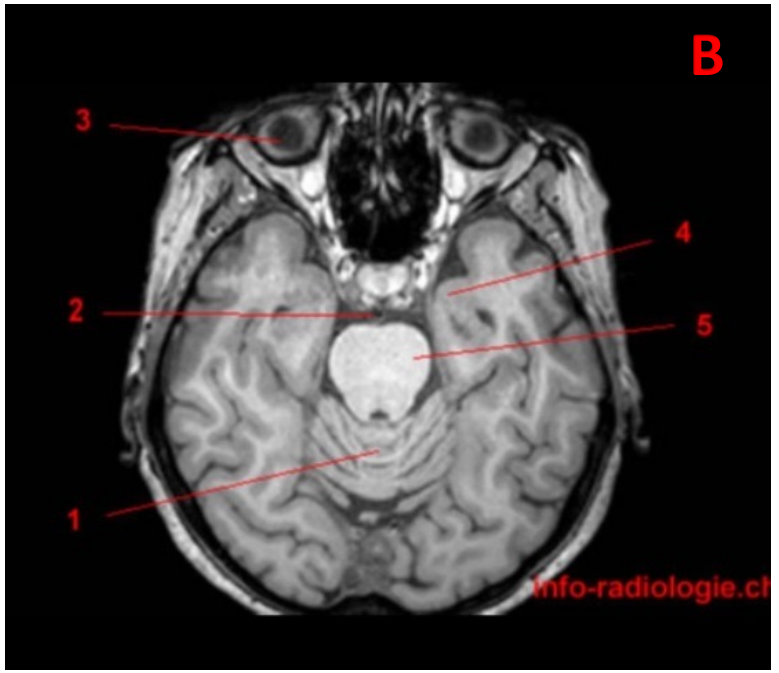
Temporal lobes

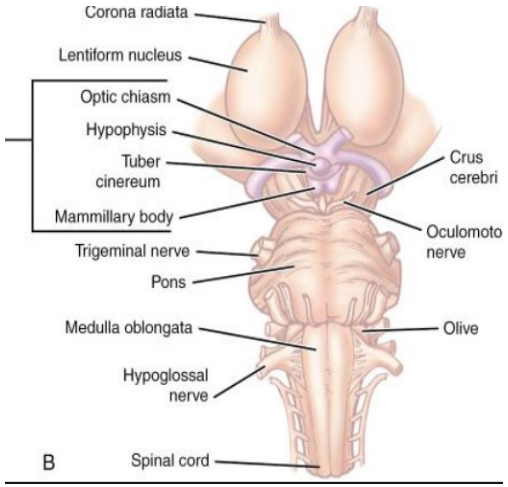
Parietal lobes:

**always scroll from base of the brain superiorly*

- At the level of the **medulla**, look at the **cerebellum**.
- At the level of the **Pons**, look at the **Poles (temporal** and **occipital).**
- At the level of the **midbrain**, look at **hippocampi** and the **temporal horns.**







BG and R/L Thalami

C midbrain

B pons

A medulla

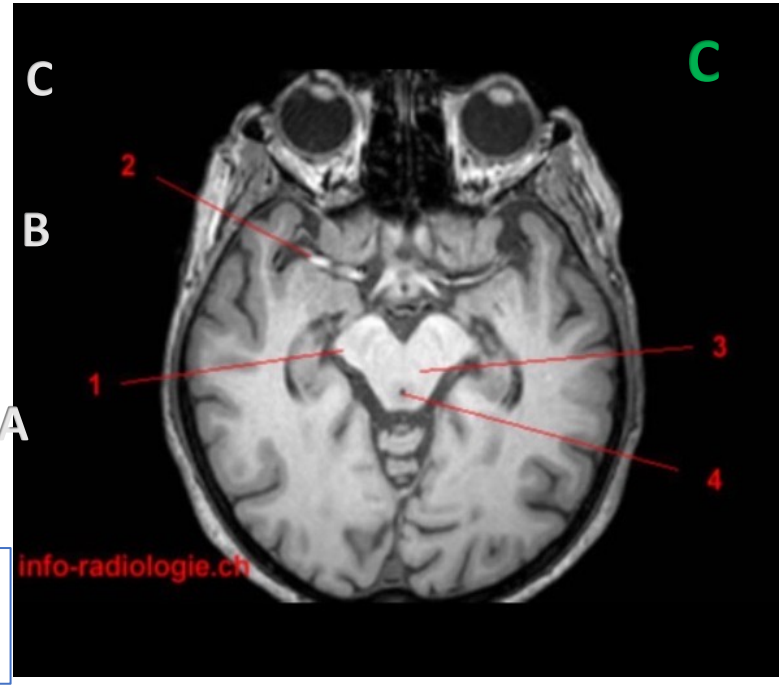


Image Ref:

1. https://testmyprep.com/subject/economy/new-and-emerging-theories-of-international-trade
2. 2. http://w-radiology.com/atlas_brain_mri.php

Brain Stem – Coronal View

Cerebral Peduncle: the most anterior portion of the midbrain; contains large ascending and descending **white matter tracts**.

Middle Cerebellar Peduncles: connects the cerebellum to the **pons**; comprised of **white matter tracks** arising from the **pontine nuclei** and projecting to the contralateral cerebellar cortex.

Inferior Olives: the largest paired **nuclei** (**gray matter**) in the **olivary bodies** found in the medulla oblongata. The primary source of motor nuclei projecting to the cerebellum.

Pyramids: paired **white matter** structures in the medulla oblongata, contain groups of descending motor fibers collectively known as ***pyramidal tracts***. The fibers cross at the lower level of the medulla.

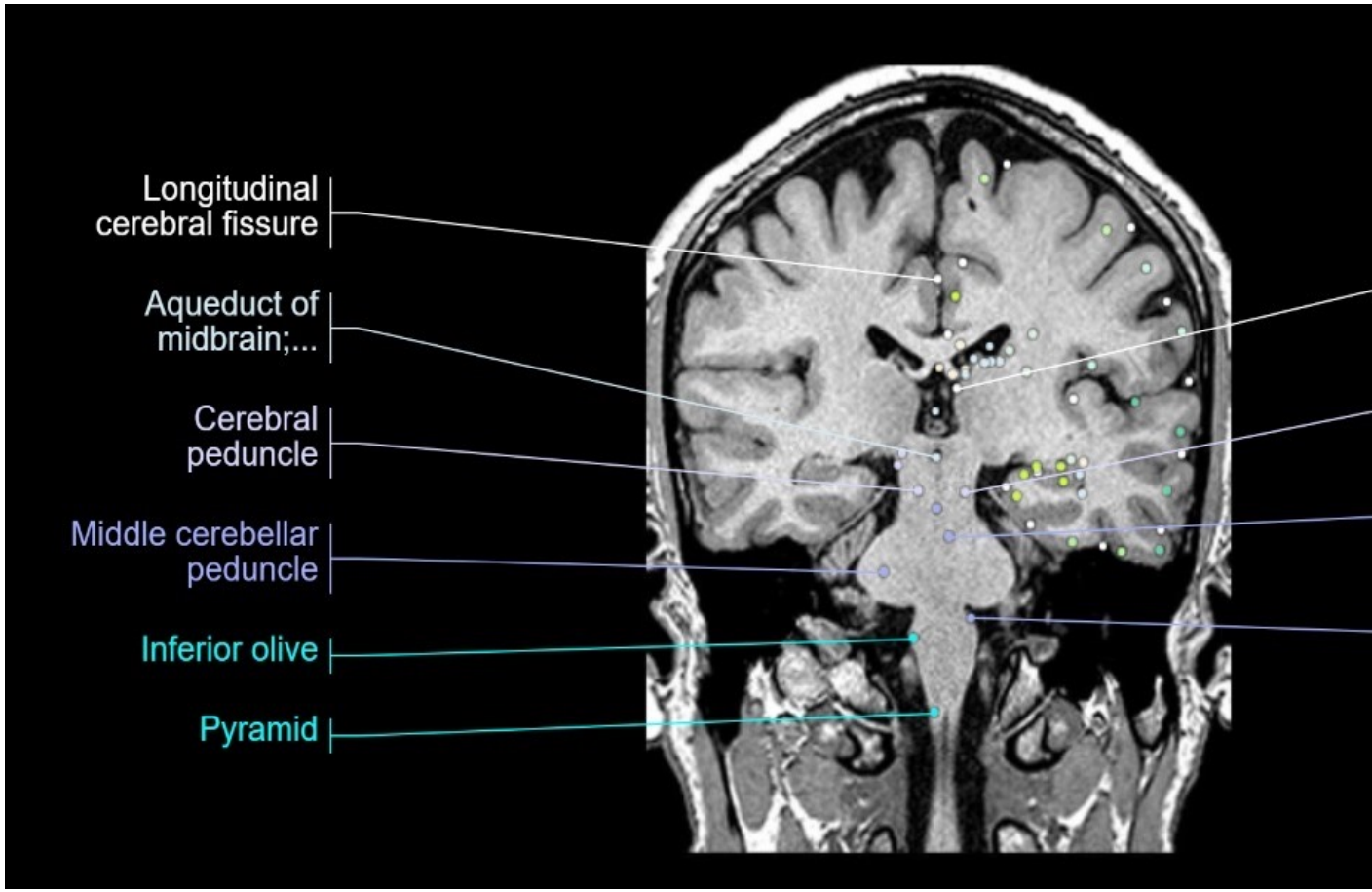
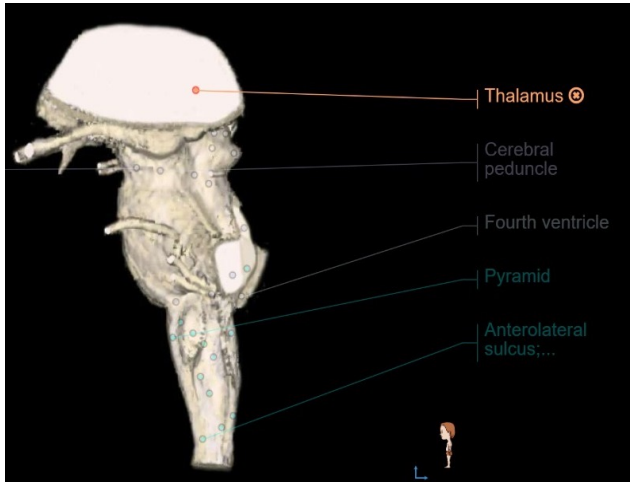


Image Ref: https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D

IAMOS practice

Thalami and Basal Ganglia

- **R/L Thalamus-** chiefly gray matter structures that will radiate to much of the cortex and basal ganglia.
- **Basal ganglia**: deep brain nuclei; intimately connected w/ brain stem, thalamus, and cerebral cortex. We will identify three BG on MRI:
  - **1) Globus pallidus**
  - **2) Putamen**
  - **3) Caudate nucleus**



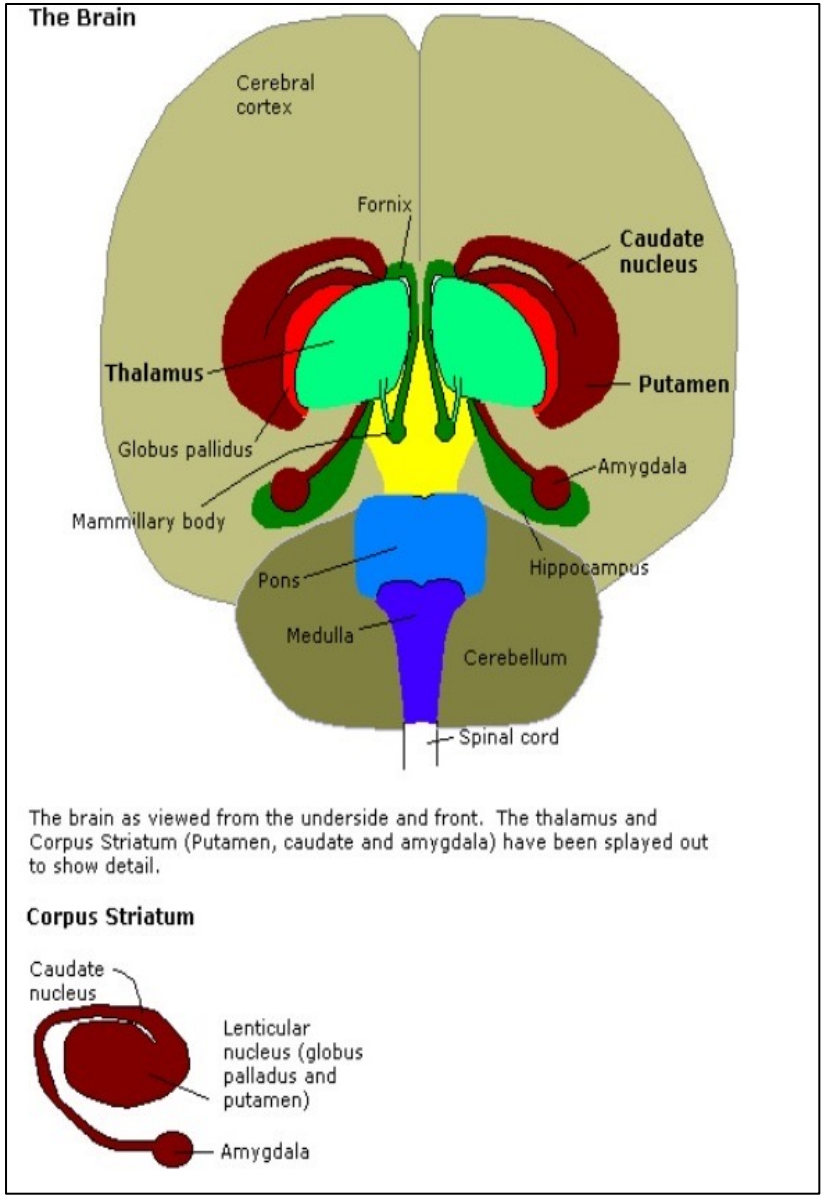
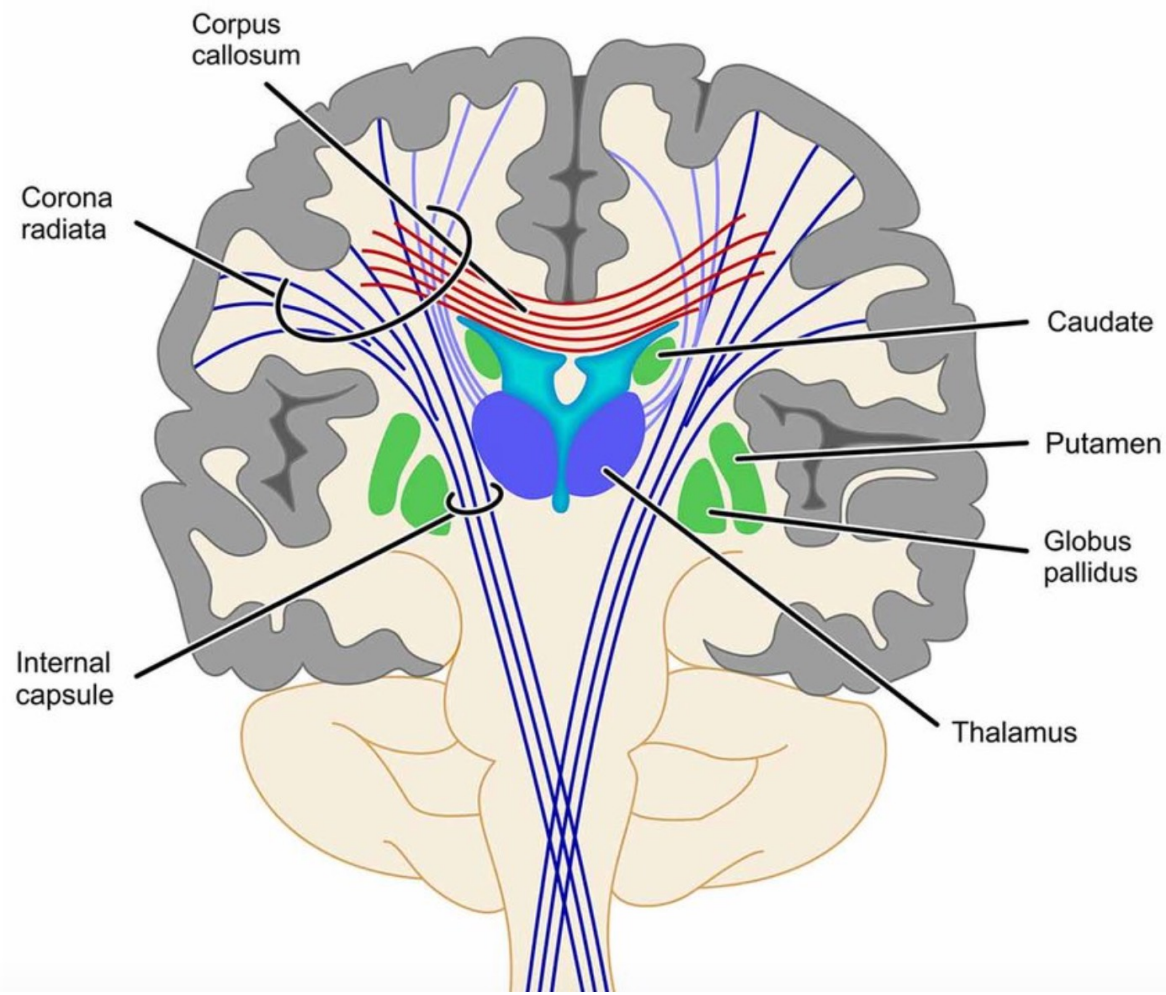


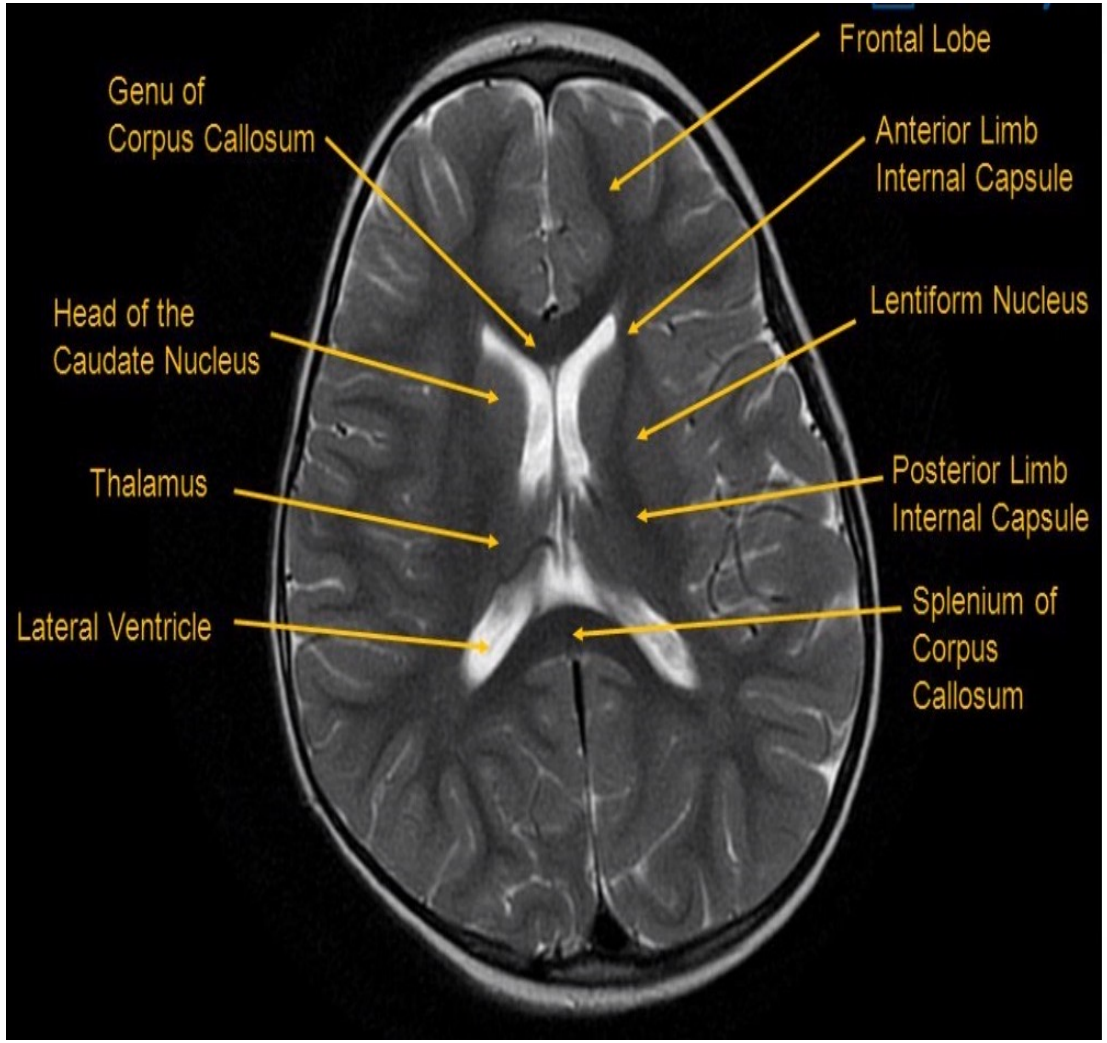
Image Ref:

1. https://en.wikipedia.org/wiki/Basal_ganglia
2. https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D

Corona Radiata, Internal Capsule, Basal Ganglia, and Thalami - Coronal View



Internal Capsule, Thalami and Basal Ganglia – Axial View

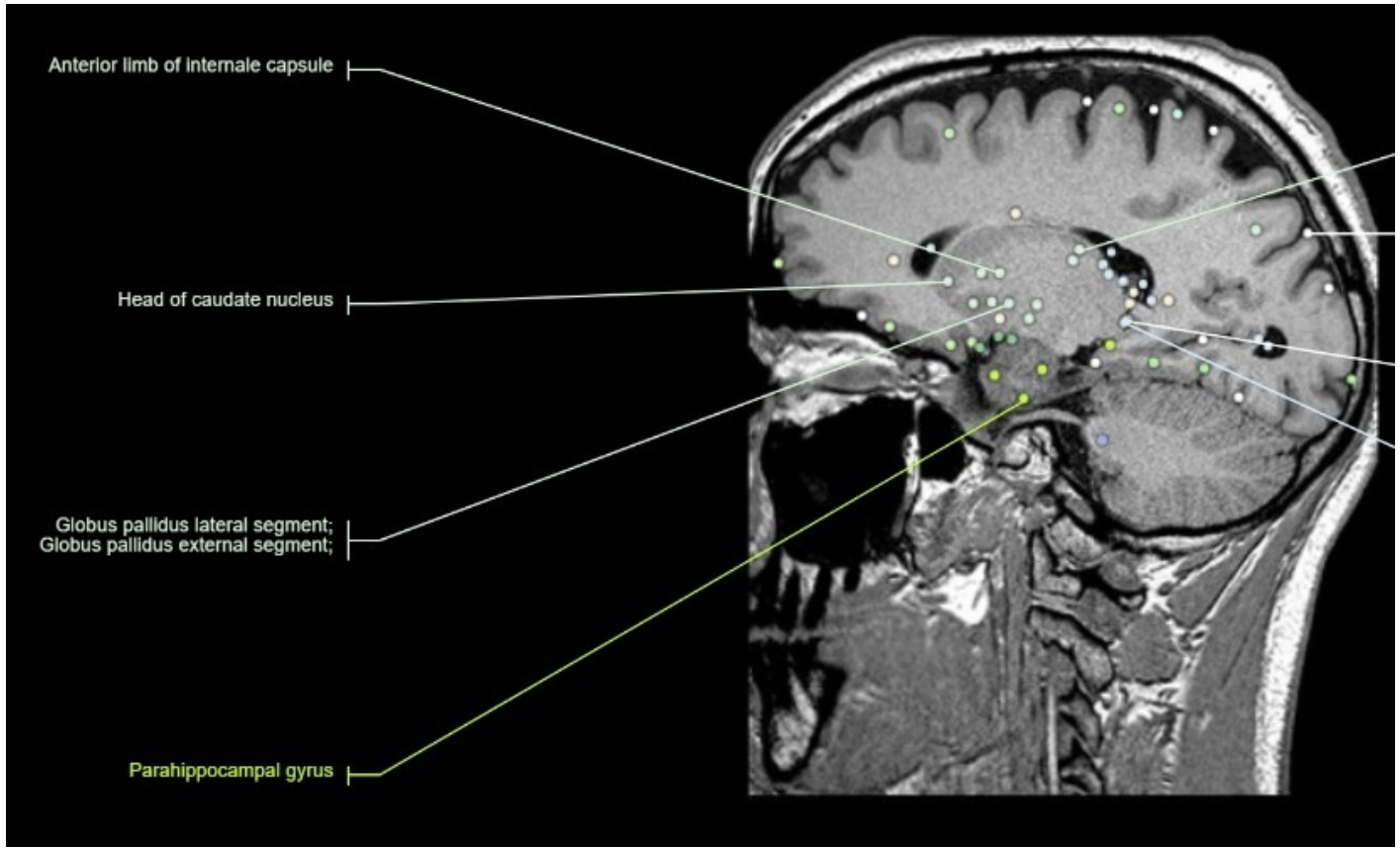


The Sweet Spot

- **Internal Capsule:** anterior limb, posterior limb, genu *(L. = knee)*
- *BASAL Ganglia: deep grey matter structures*
  - **Lentiform Nucleus** *(lens-shaped):* collectively the putamen and the globus pallidus.
  - **(Head of the) caudate nucleus:** learning & memory.
- **Thalamus:** relay for sensory/motor signals; involved in consciousness, sleep, alertness.
- **Corpus Callosum:** genu (bend) and splenium – transverse white matter tracks.

Thalamus, Basal Ganglia - Sagittal View

Basal Ganglia



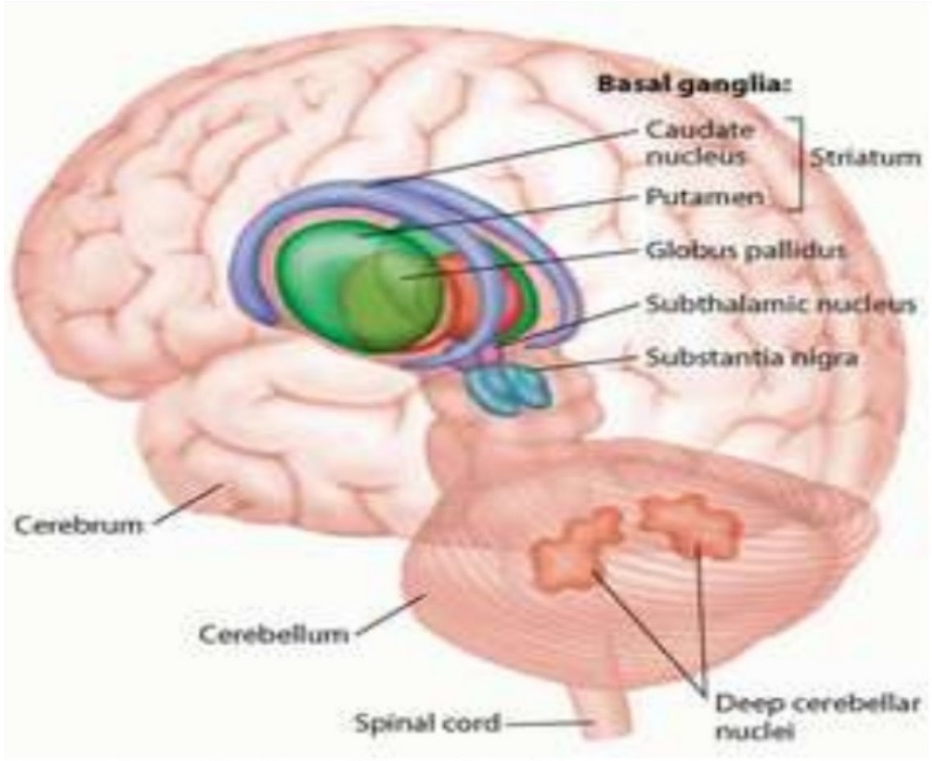
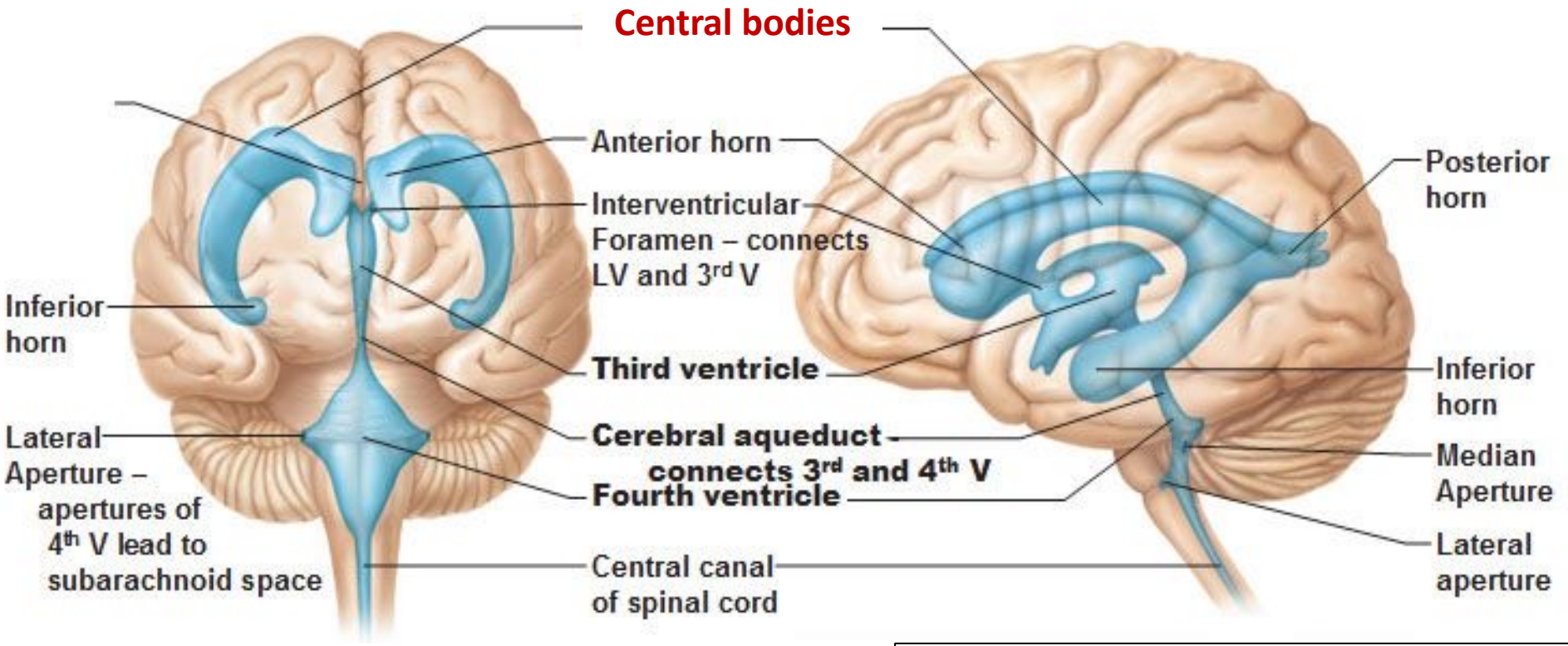


Image Ref: https://www.slideshare.net/DrNikhilGupta/neuroanatomy-of-basal-ganglia-and-its-clinical-implications

IAMOS practice

Image Ref: https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D

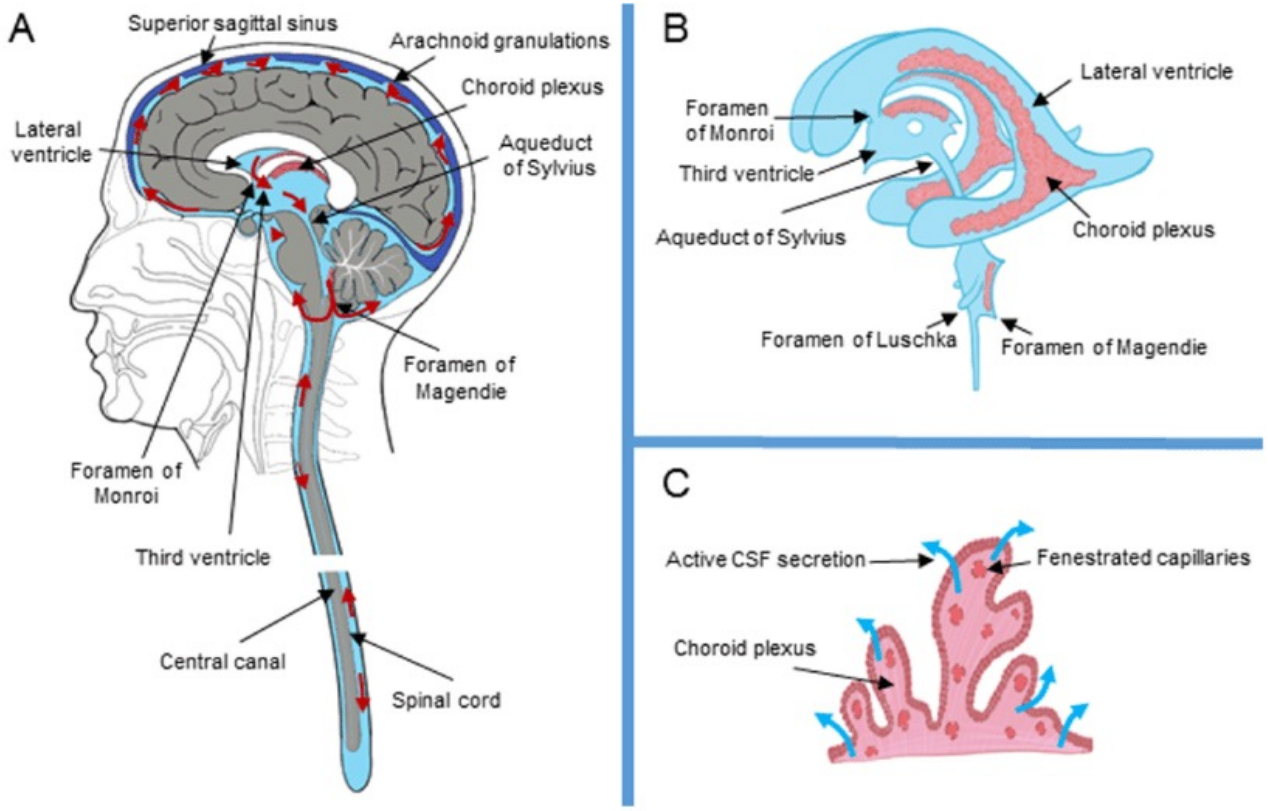
Ventricles of the Brain



- Lateral ventricles (paired)
- Third ventricle (single)
- Fourth ventricle (single)

- **Central bodies** of the **lateral ventricles**
- **Anterior** horn = **Frontal horn** (frontal lobe)
- **Posterior** horn = **Occipital horn** (occipital lobe)
- **Inferior** horn = **Temporal horn** (temporal lobe)
- **Atrium** = expansion at the **junction** of the **occipital** and **temporal horns**.

Choroid Plexus & the Choroid Fissure

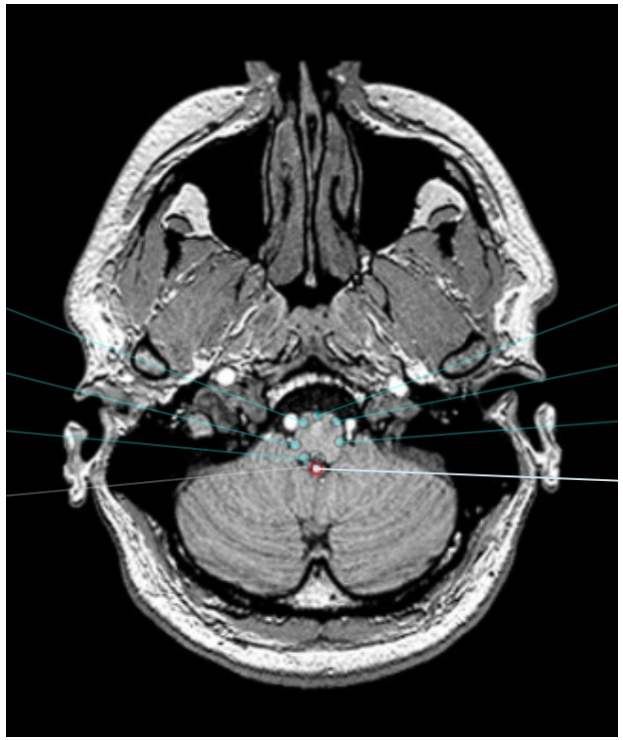


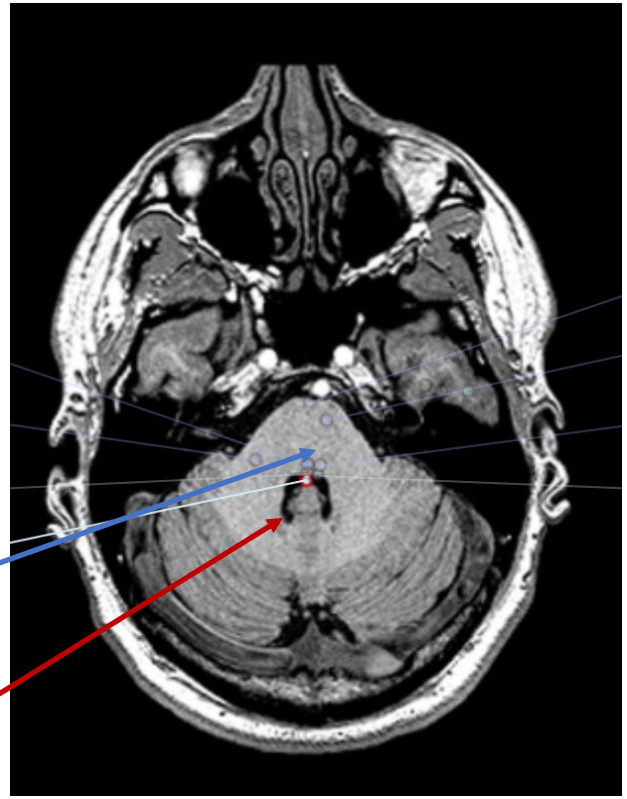
The **choroid plexus** is a network of specialized cells located in the cerebral ventricles that produces the CSF.

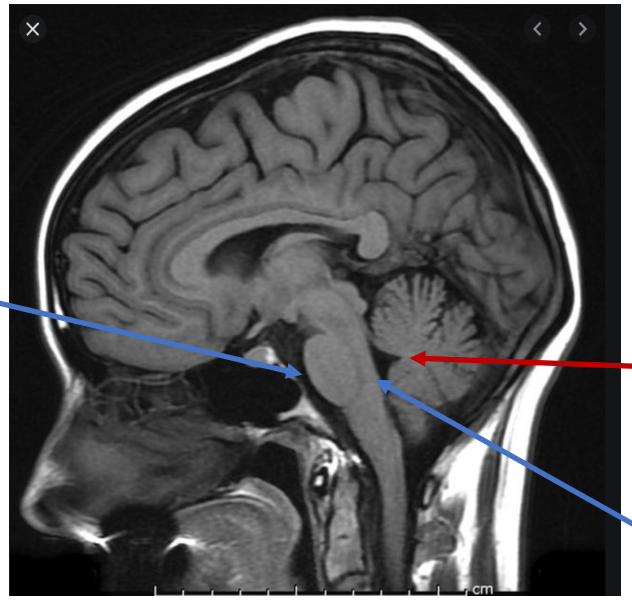
The choroid fissure: a cleft that forms in the medial wall of the lateral ventricle

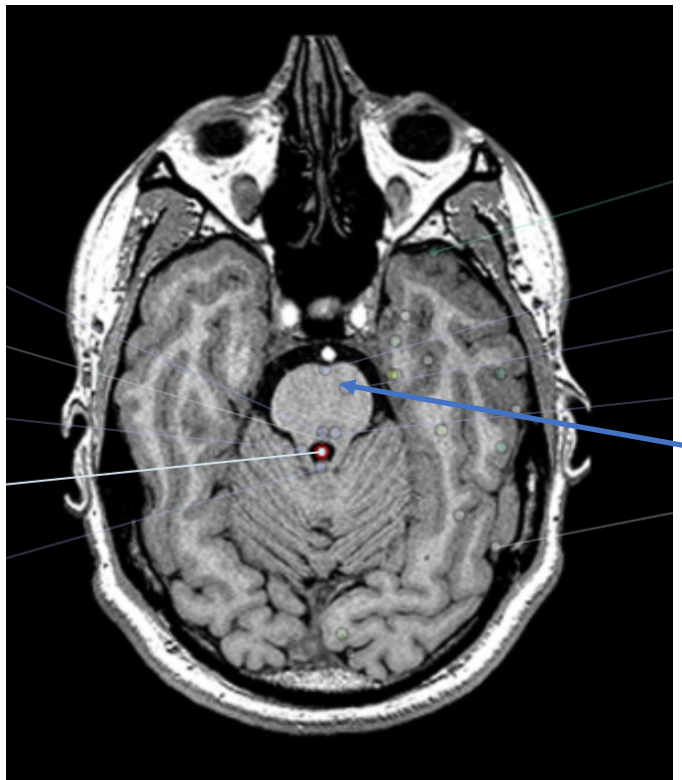
Image Ref: https://www.researchgate.net/figure/A-The-scheme-of-the-cerebrospinal-fluid-system-with-location-of-the-choroid-plexuses_fig8_316520924

Fourth Ventricle









Basilar pons – most anterior portion (ventral)

Fourth ventricle

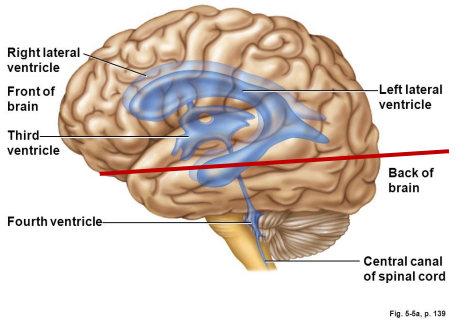
Tegmentum of pons (dorsal)

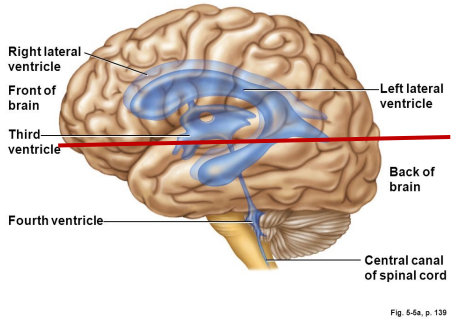
Tegmentum of pons (dorsal)

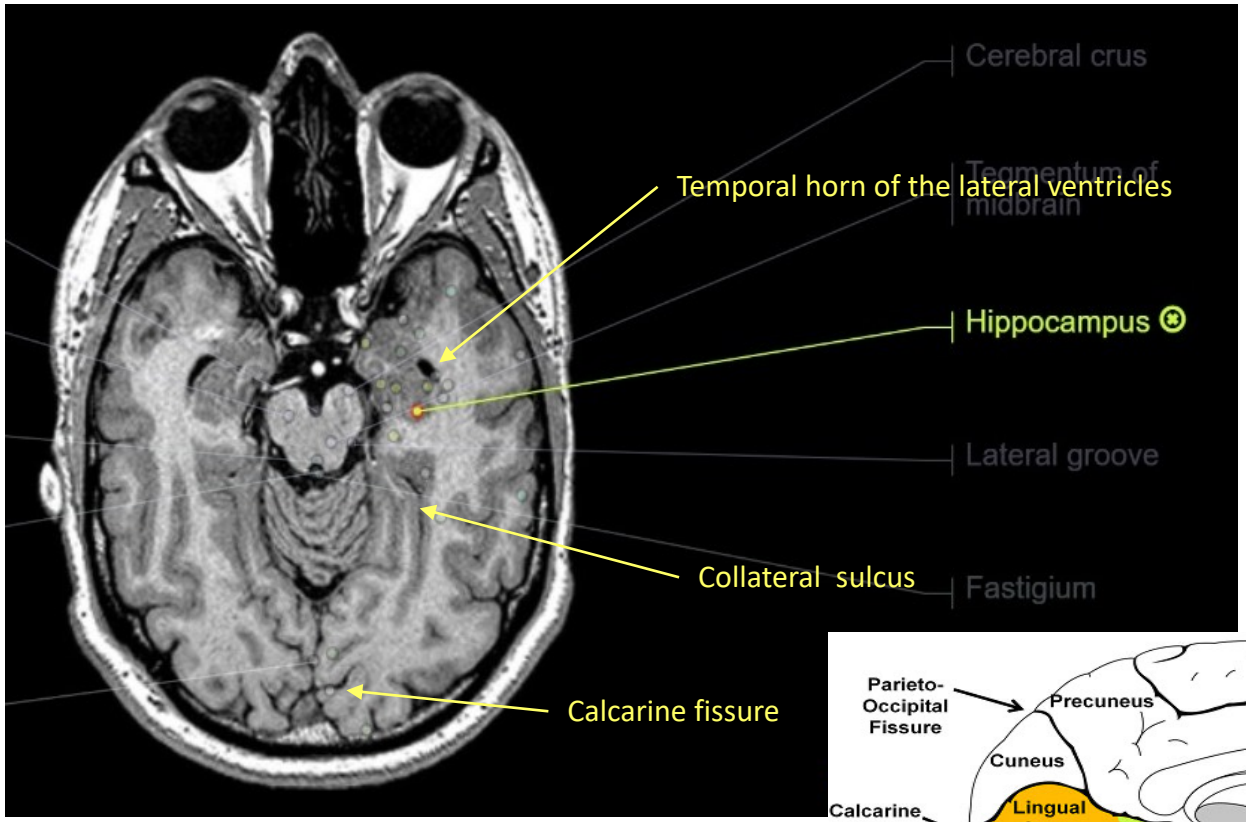
Fourth ventricle

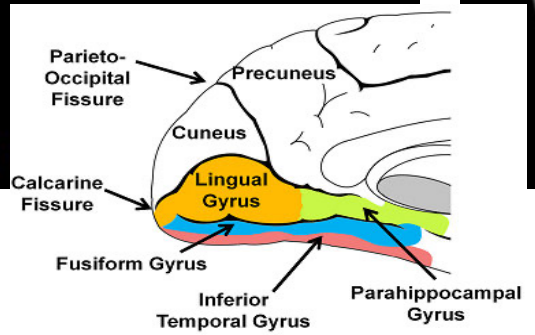
Basilar pons- most anterior portion (ventral)

Hippocampus, Temporal horn, Thalamus, BG, Collateral sulcus, and Calcarine fissure









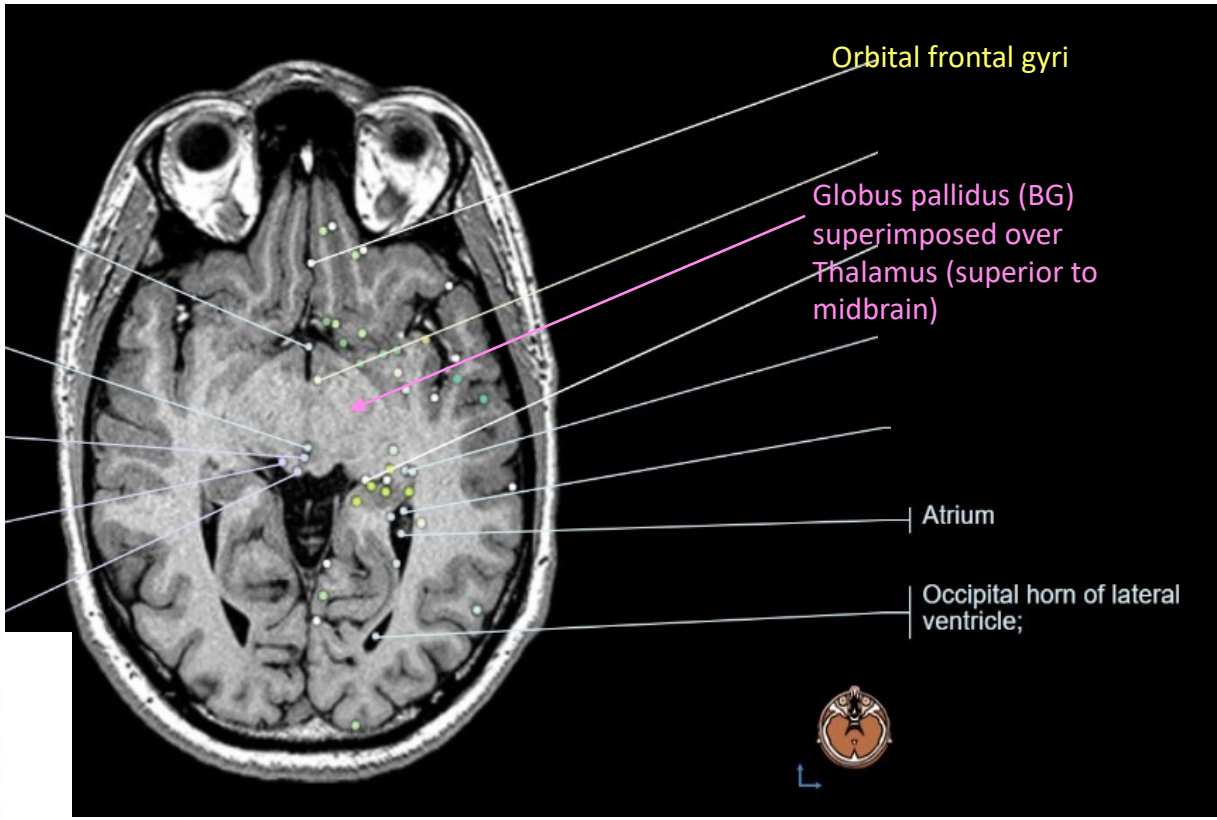
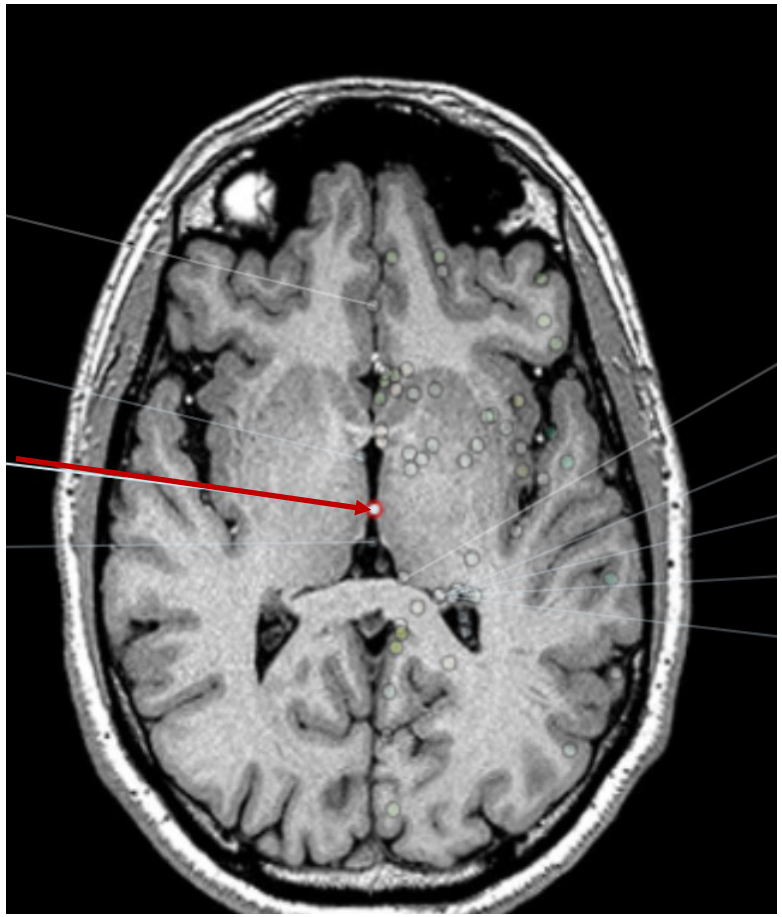
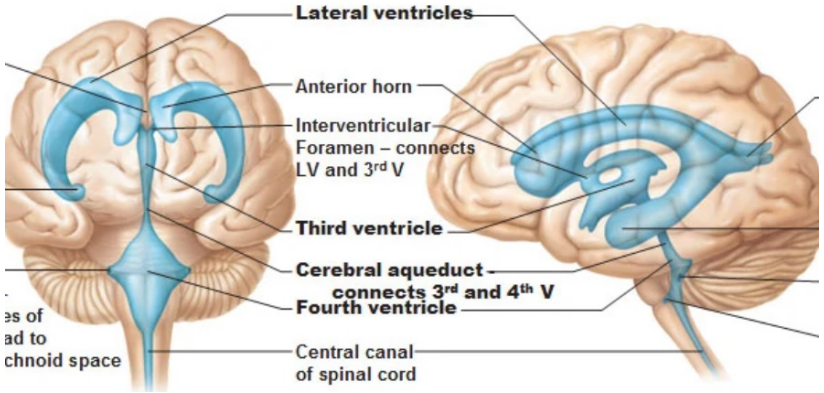


Image REF: https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D

Third Ventricle





Lateral Ventricles, Sulci, and Lobes

Lateral Ventricles
- frontal horn
- central body
- note: choroid plexus within

Frontal Pole
- Most anterior portion of frontal lobe

Insular sulci
- separates insular lobe from temporal lobe

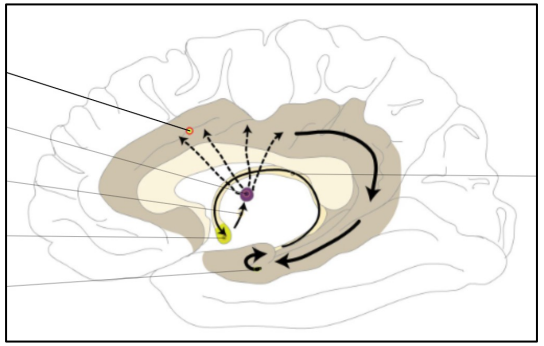
Central Sulcus
- separates frontal lobe from parietal lobe

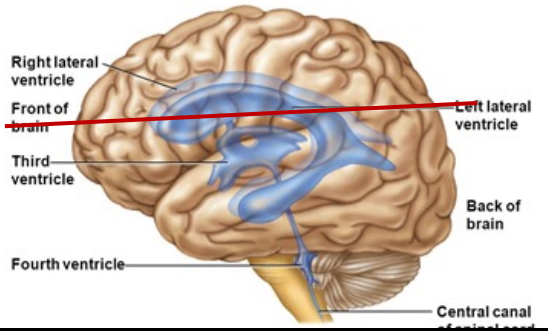
Lateral Sulcus (ie: Sylvian Fissure)
- separates frontal and parietal lobes from temporal lobe

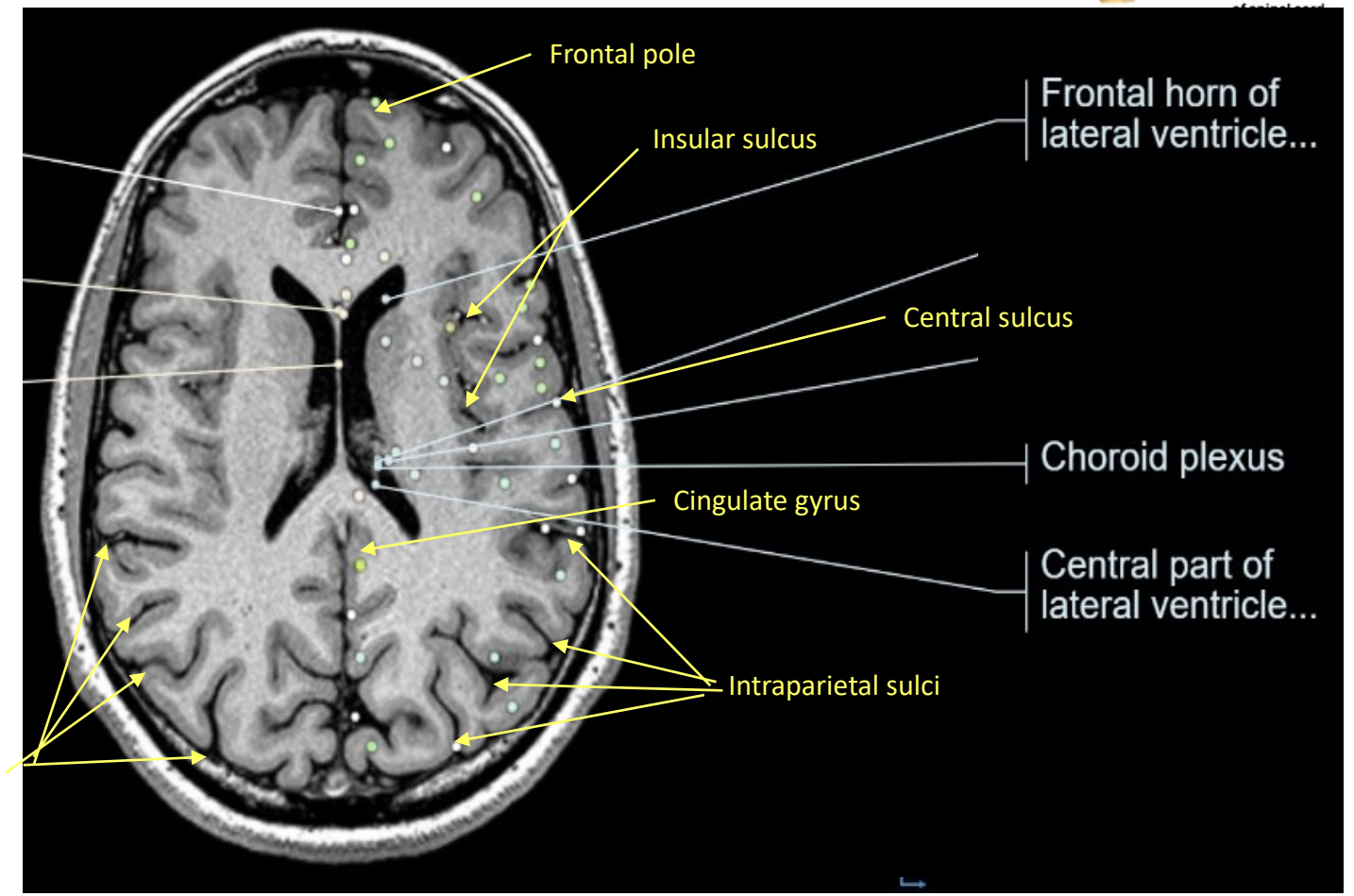
Cingulate gyrus:
- The posterior portion is labeled, which is typically atrophied in Alzheimer's Disease (A.D.) but preserved in DLB (ie: "Cingulate Island Sign").

Intraparietal sulcus
- sulci of parietal lobe- atrophied in A.D.

Parietooccipital sulcus
- separates parietal lobe and occipital lobe







IAMOS practice

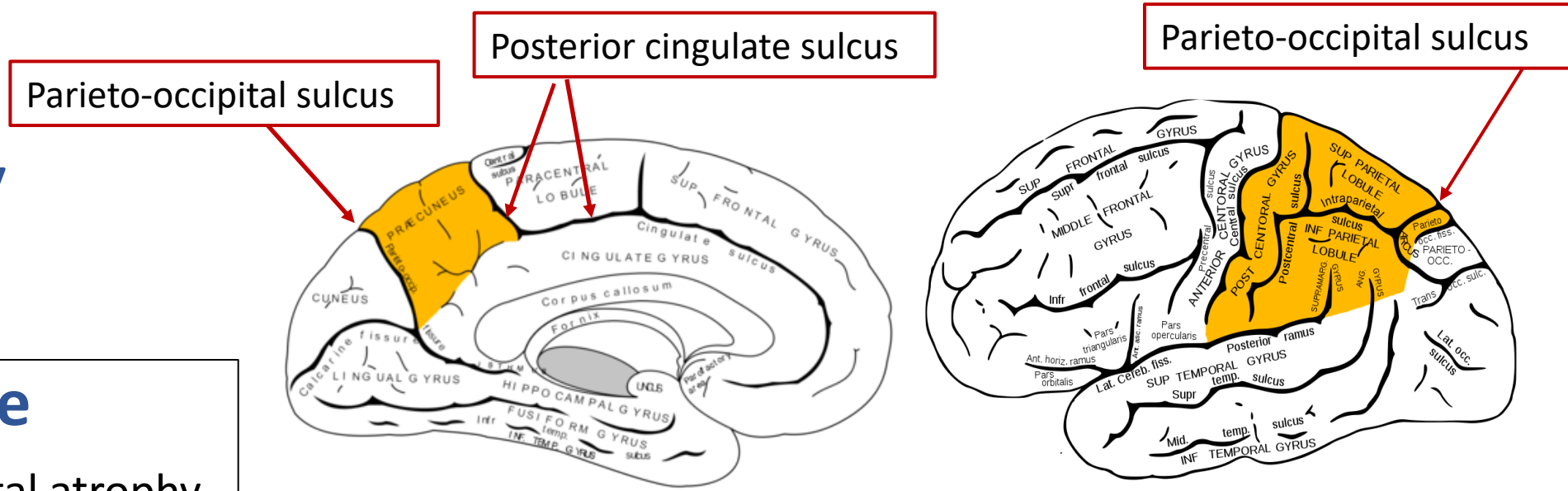
Image REF: https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D

Parietal Atrophy

Parietal Atrophy

The **Koedam scale**

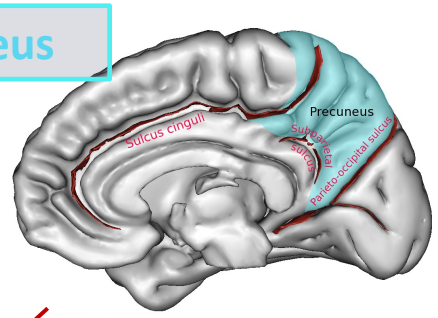
- Used to evaluate parietal atrophy.
- Widening of the **parieto-occipital** and **posterior cingulate sulci.**
- The **precuneus** is a portion of the **superior parietal lobule** on the **medial surface** of the brain.
- MCI pts may have **parietal atrophy prior to MTA (particularly in the precuneus).**

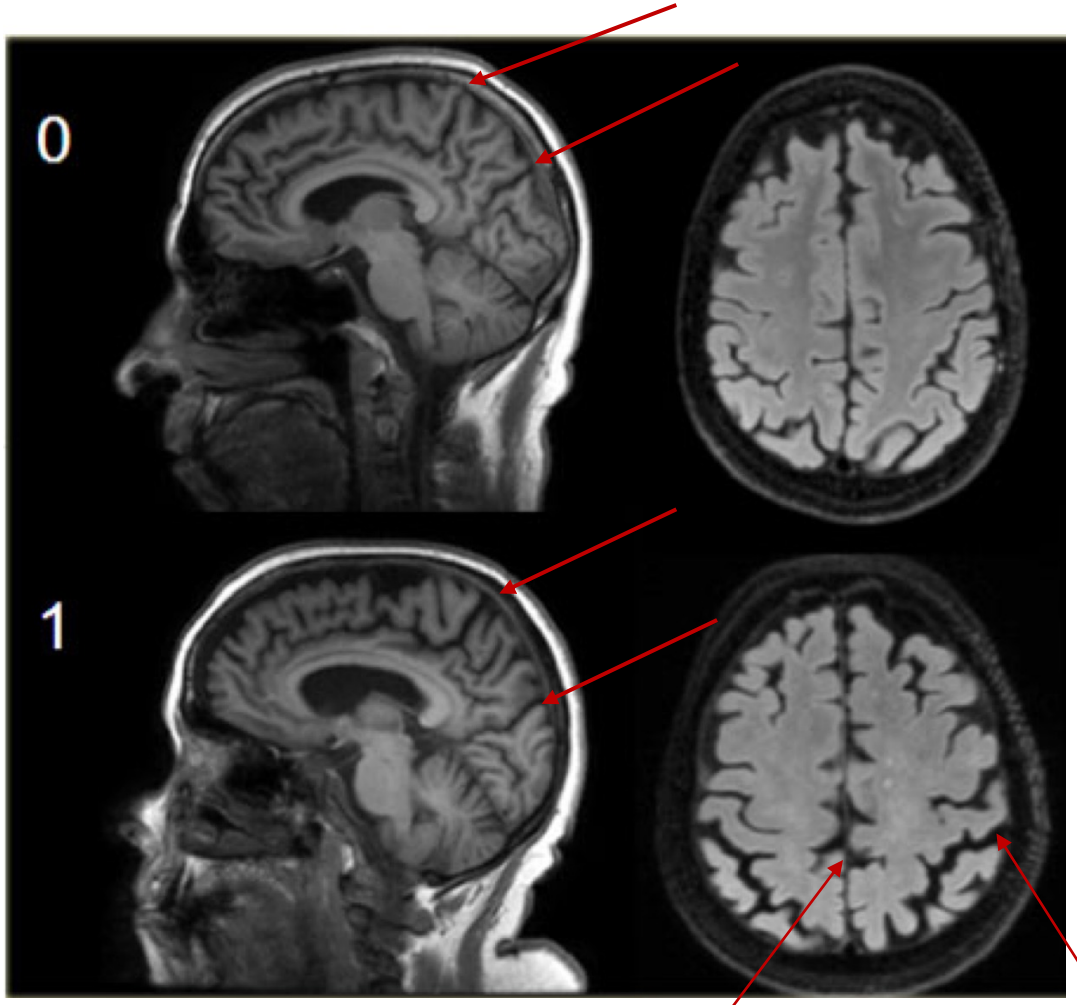


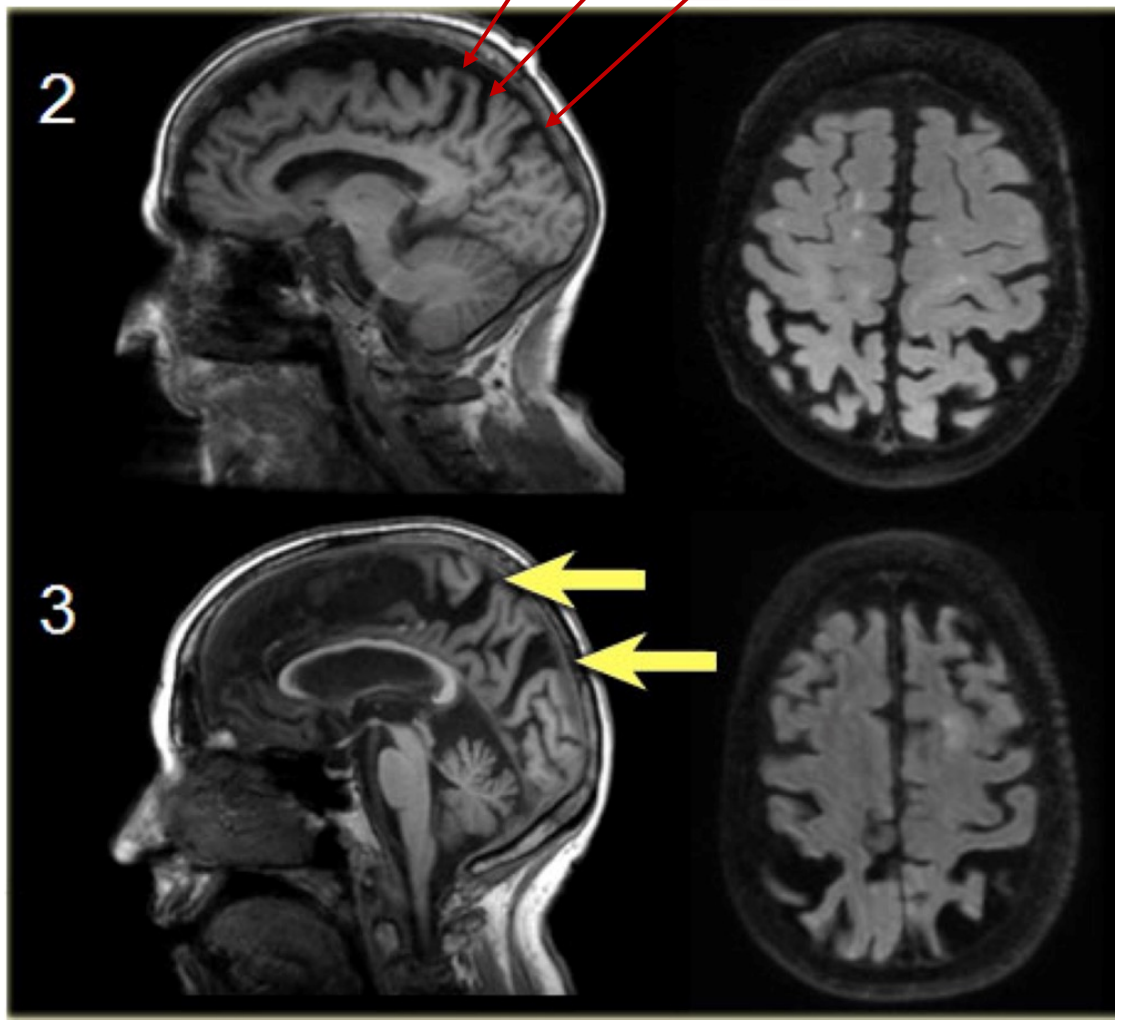
	Parenchyma	Sulci
Grade 0	No parietal atrophy	Closed sulci of parietal lobes and precuneus
Grade 1	Mild parietal atrophy	Mild widening of posterior cingulate and parieto-occipital sulci
Grade 2	Substantial parietal atrophy	Substantial widening of posterior cingulate and parieto-occipital sulci
Grade 3	End-stage “knife-blade” atrophy	Extreme widening of the posterior cingulate and parieto-occipital sulci

REF: http://www.radiologyassistant.nl/en/p43dbf6d16f98d/dementia-role-of-mri.html

Parietal Atrophy – Koedam Score





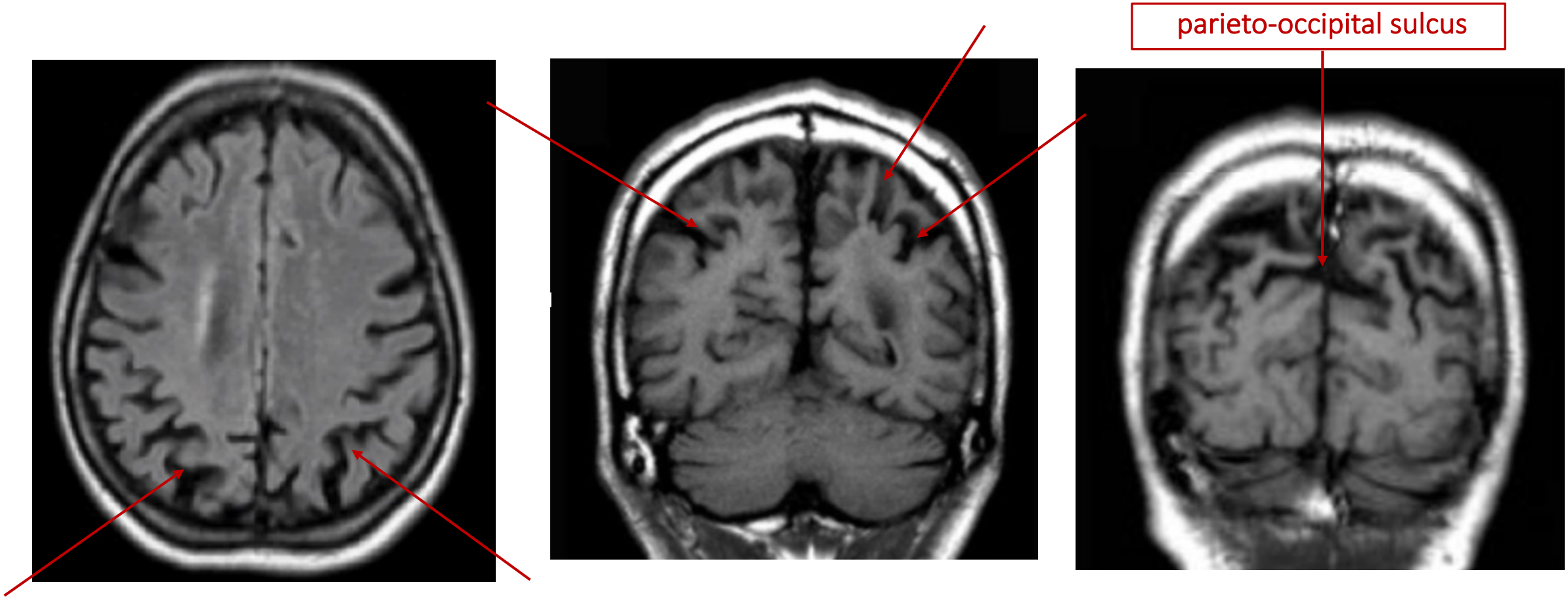


Parietoocipital sulcus

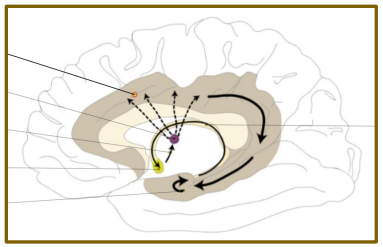
Intraparietal sulcus

REF: http://www.radiologyassistant.nl/en/p43dbf6d16f98d/dementia-role-of-mri.html

Posterior Parietal Atrophy

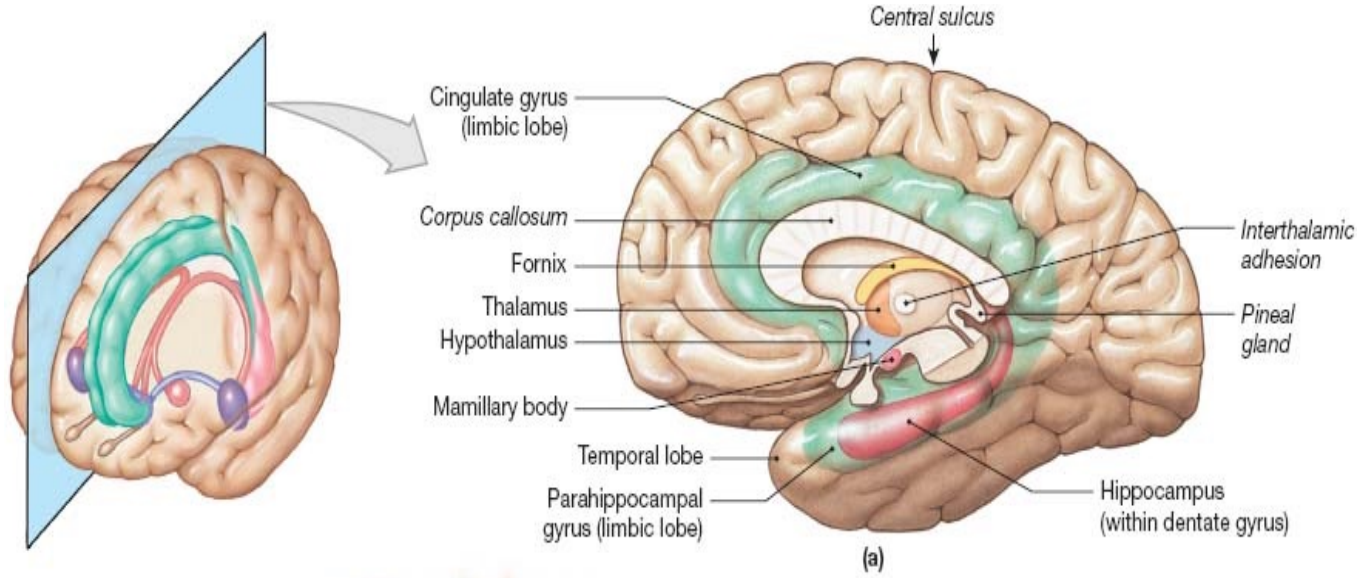


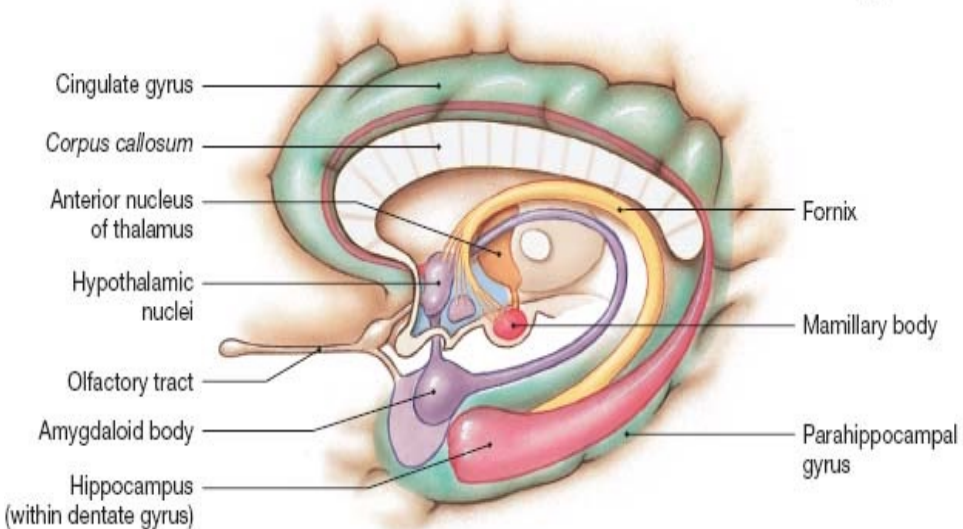
Medical Temporal Lobe



Cingulate gyrus

1. **Cingulate gyrus**
2. **Hippocampal formation**
   CA1-CA4, dentate gyrus, and subiculum
3. **Parahippocampal gyrus**





MRI Hippocampus - Axial View

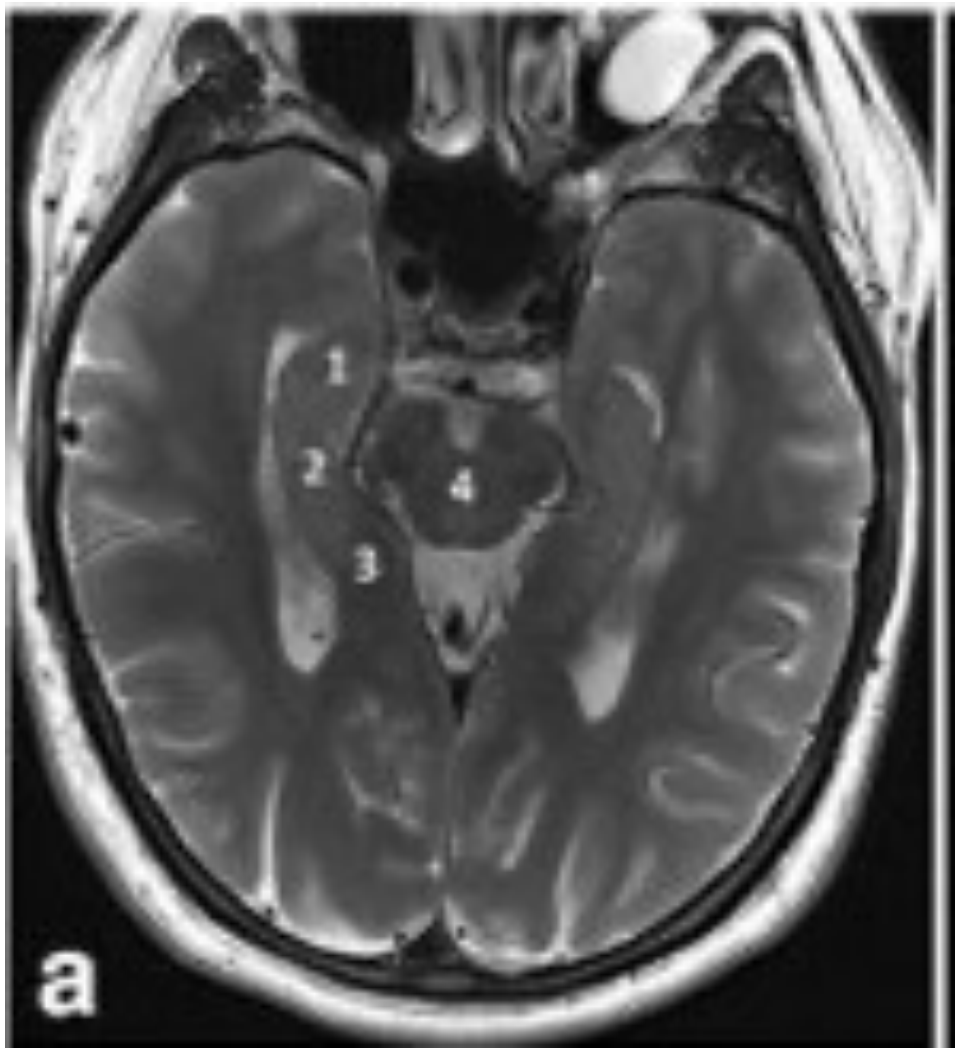


Image Ref: Dekeyzer, et al. 2017

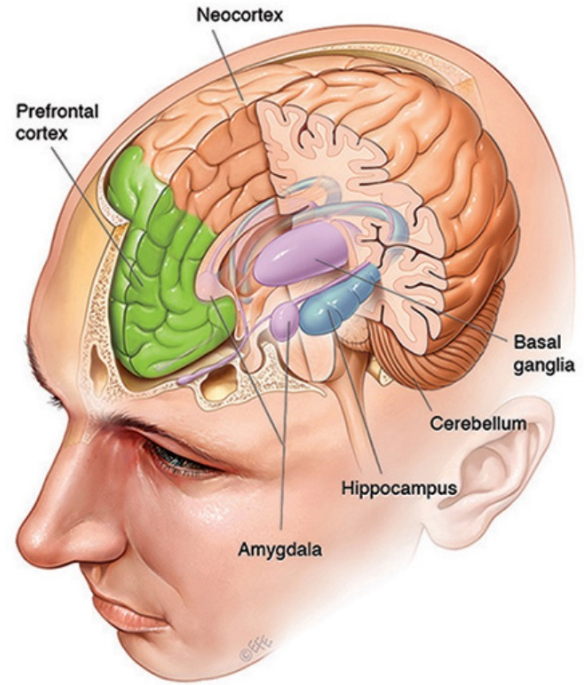


Image: :https://qbi.uq.edu.au/brain-basics/memory/where-are-memories-stored

Hippocampus:

1 = head is located anterior to the mesencephalon (mid-brain)

2 = body is at the level of the mesencephalon

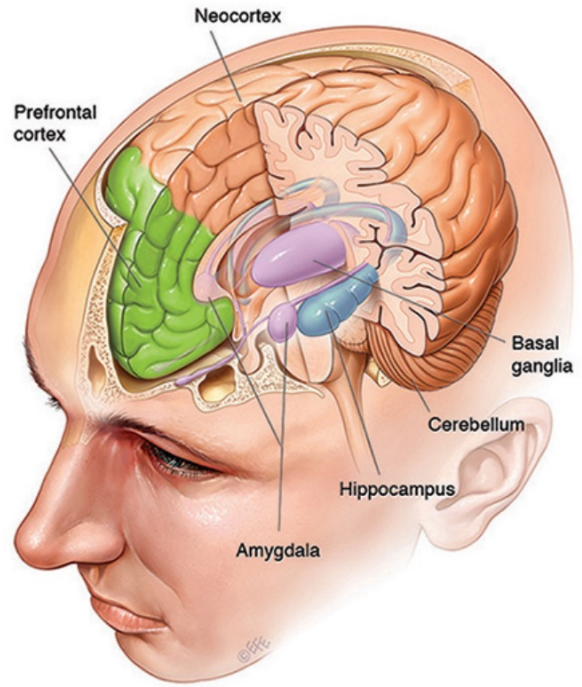
3 = tail is posterior to the mesencephalon

4 = **midbrain** (note the cerebral crus)

MRI Hippocampus Sagittal View

Temporal horn of the lateral ventricle

Atrium of the lateral ventricle



1 = hippo head is inferior to **temporal horn** of lateral ventricle.

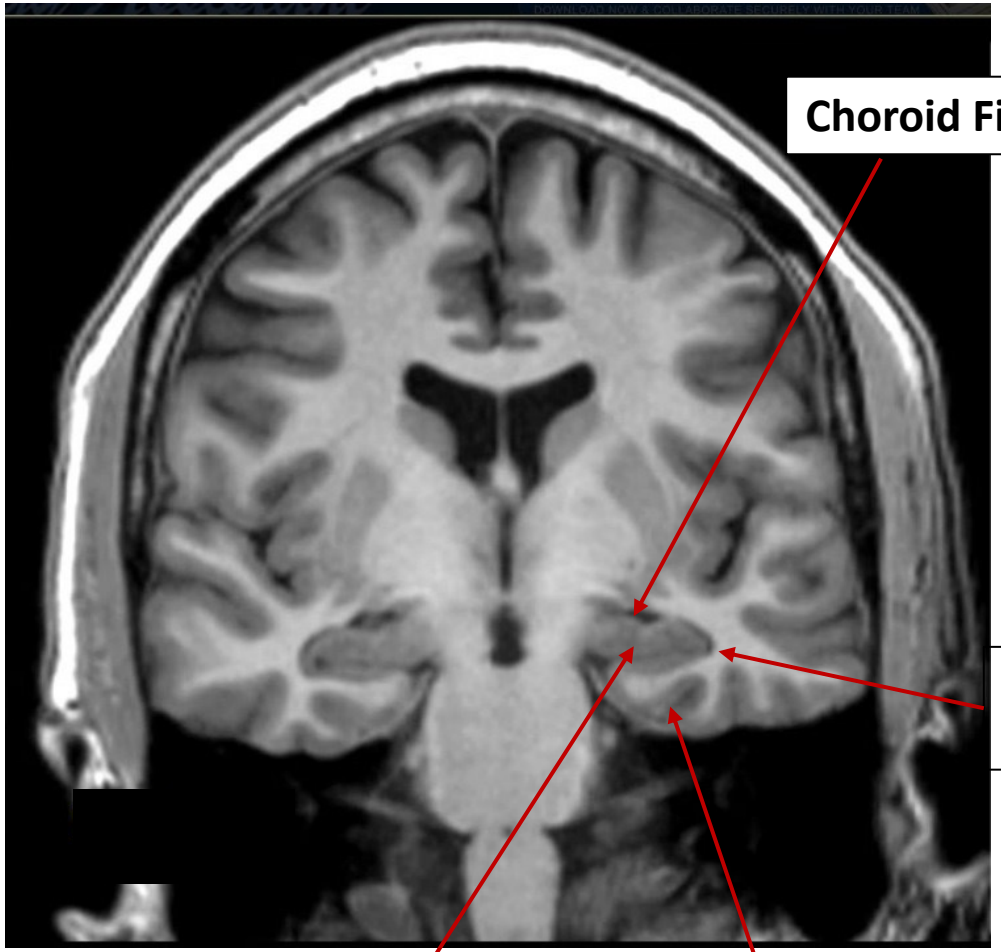
2 = **hippo body** is inferior to the **choroidal fissure** (site of attachment of the choroid plexus in the lateral ventricle)

3 = **hippo tail** Is anterior to the **atrium** of the lateral ventricle.

5= **amygdala** is anterior to the body of the hippocampus.

Image Ref: Dekeyzer, et al. 2017

MRI Hippocampus - Coronal View



Hippocampal Atrophy:

1. **Widening** of the **choroid fissure**
2. **Widening** of the **temporal horn**
3. **Widening** of the **collateral sulcus**
4. **Decreased height** of **hippocampal formation**

Choroid fissure: a cleft that forms as the height of the hippocampal formation decreases. Widening of this cleft is a very early sign of hippocampal atrophy.

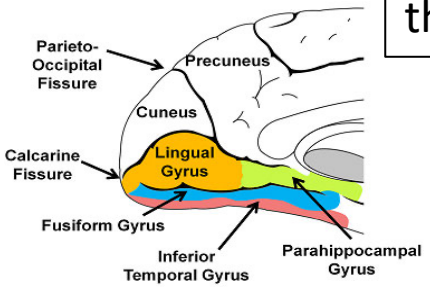


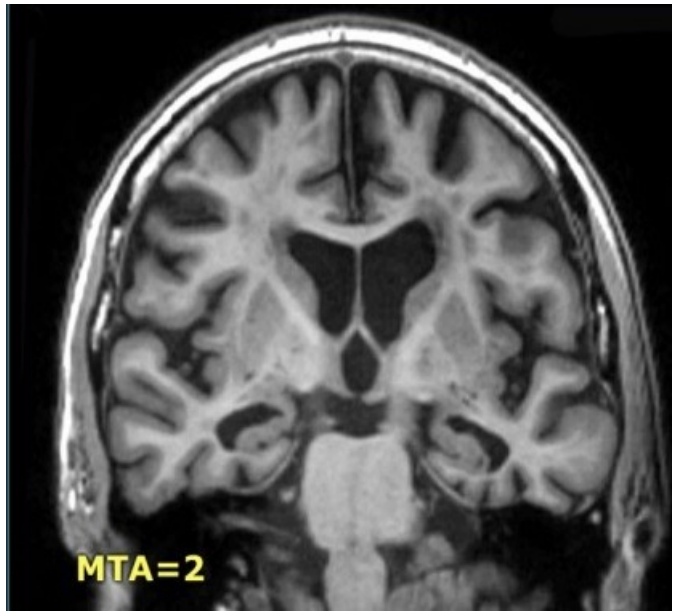
Image REF: https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D

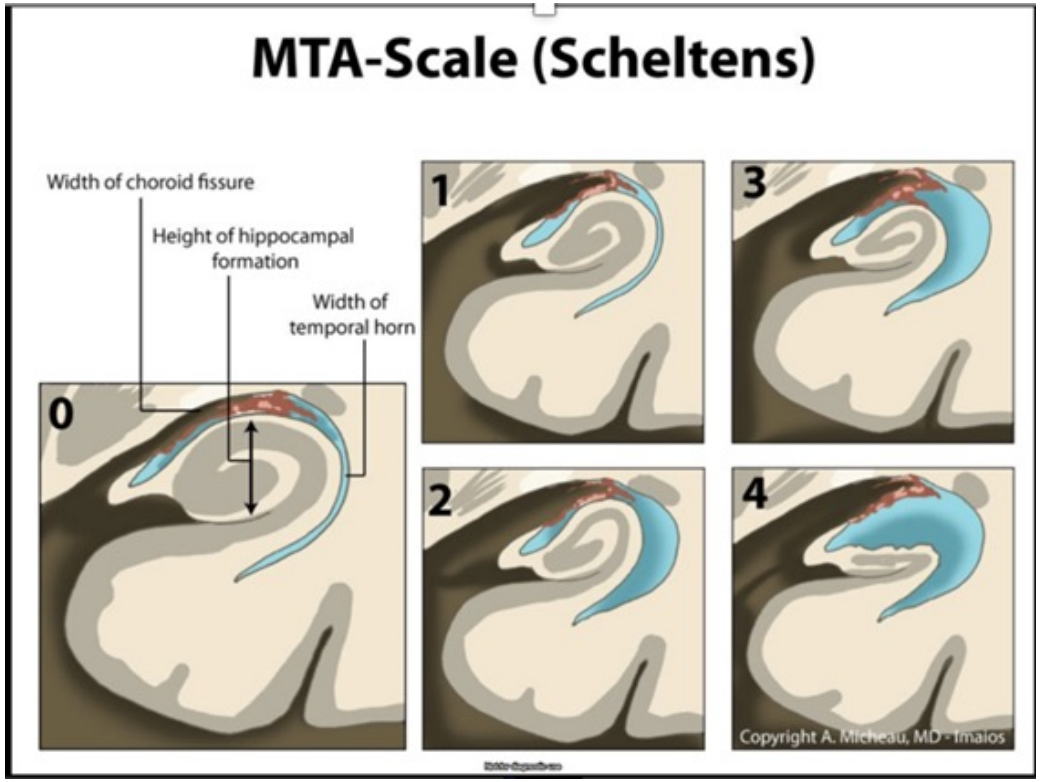
Medial Temporal Lobe Atrophy

Hippocampal Atrophy and MTA-Score (Scheltens)

MTA-score will be best assessed via **Coronal view**

1. Width of **choroid fissure**
2. Width of **temporal horn**
3. Height of **hippocampal formation**

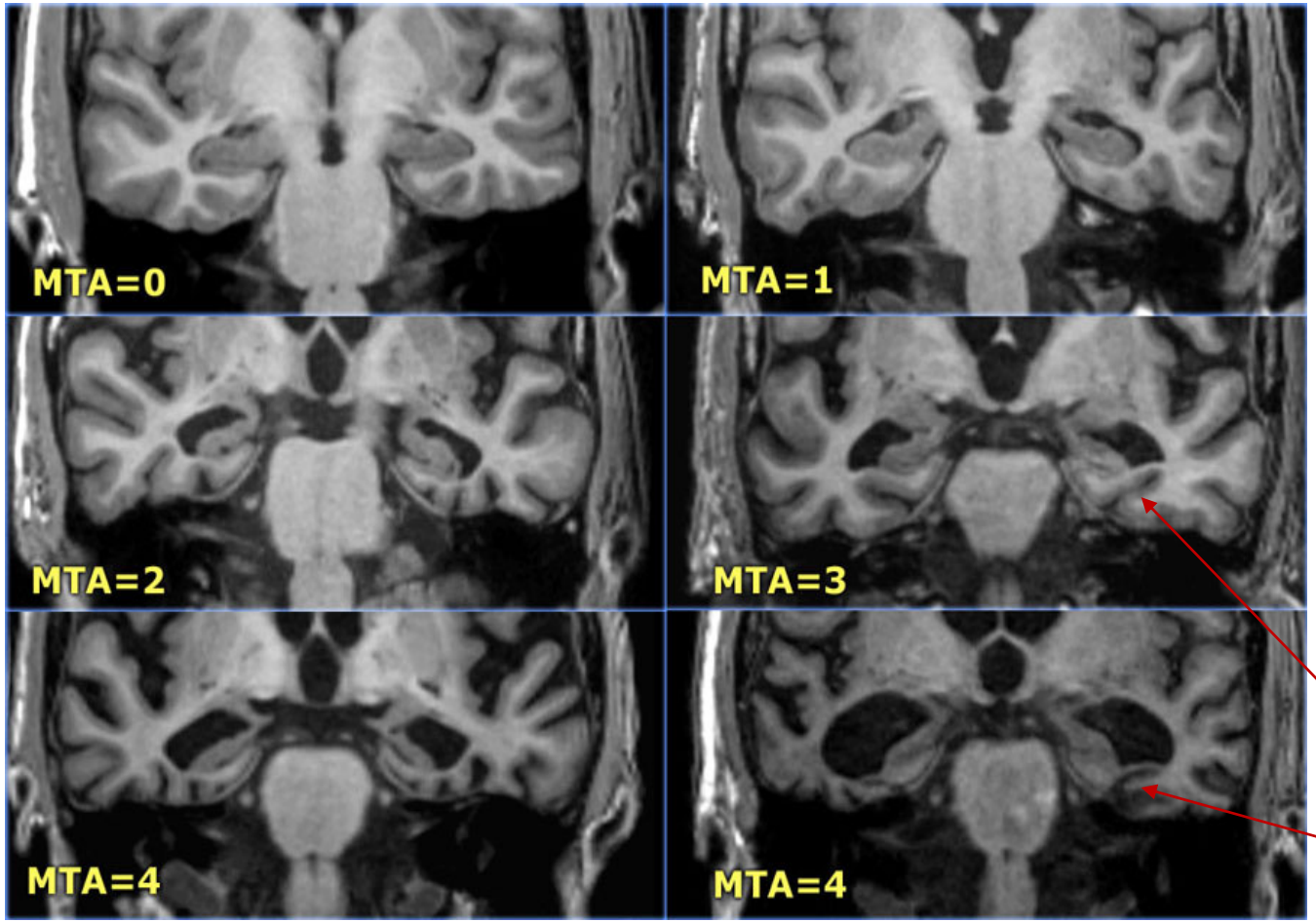




MTA Score	Width of choroid fissure	Width of temporal horn	Height of hippocampal formation
0	N	N	N
1	↑	N	N
2	↑↑	↑	↓
3	↑↑↑	↑↑	↓↓
4	↑↑↑	↑↑↑	↓↓↓

Image REF: https://www.imaios.com/en/e-Cases/Channels/Radiology/Radiological-classifications-commonly-used-in-medical-imaging/MTA-scale-for-Medial-Temporal-lobe-Atrophy-Scheltens

MRI: Hippocampal Atrophy and MTA Score (Scheltens)



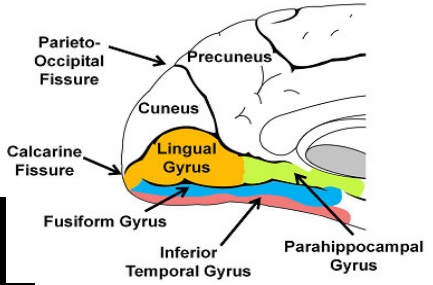
MTA Score	Width of choroid fissure	Width of temporal horn	Height of hippocampal formation
0	N	N	N
1	↑	N	N
2	↑↑	↑	↓
3	↑↑↑	↑↑	↓↓
4	↑↑↑	↑↑↑	↓↓↓

<75 years: ≥2 is abnormal
≥75 years: ≥3 is abnormal

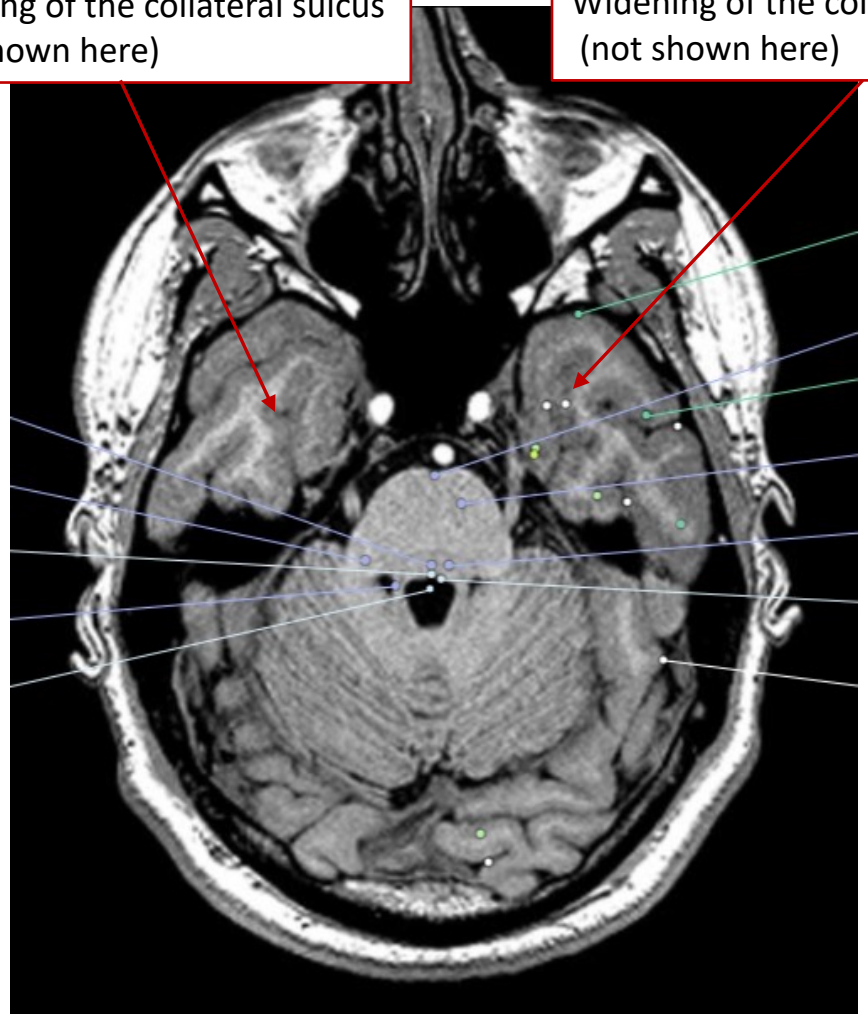
Collateral sulcus

REF: http://www.radiologyassistant.nl/en/p43dbf6d16f98d/dementia-role-of-mri.html:

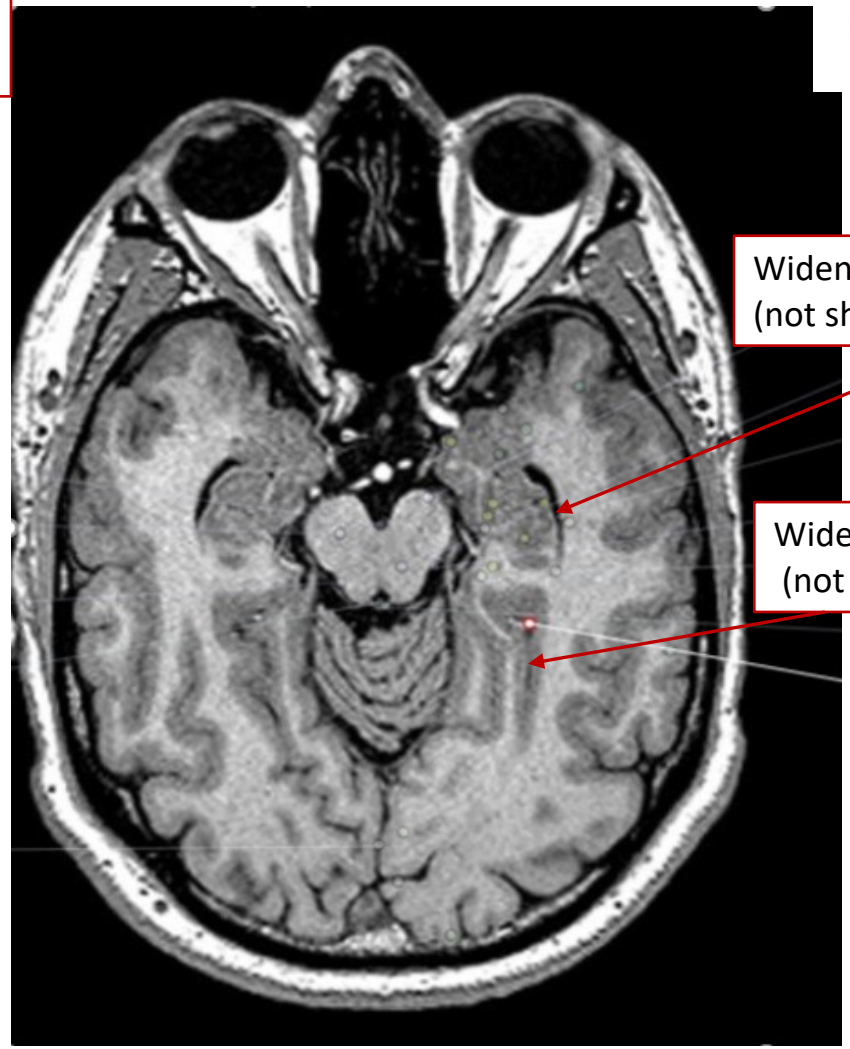
Collateral Sulcus on Axial View



Widening of the collateral sulcus (not shown here)



Widening of the collateral sulcus (not shown here)



Widening of the temporal horn (not shown here)

Widening of the collateral sulcus (not shown here)

Image REF: https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D

IAMOS practice

Frontotemporal Atrophy

Frontotemporal Atrophy

Image A/B:

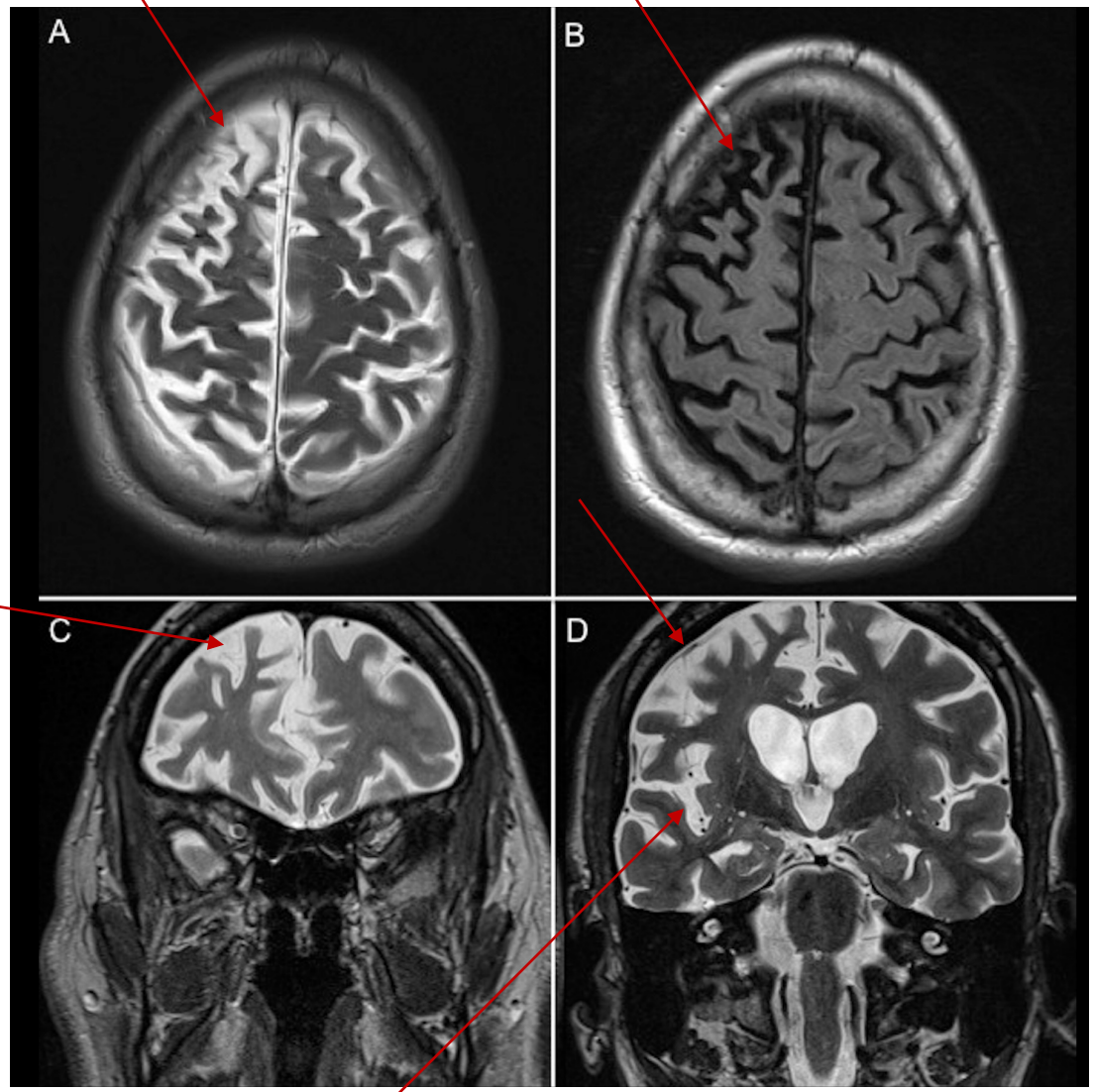
- Axial T2/Axial FLAIR with **R frontal lobe atrophy.**

Image C:

- Coronal T2 also showing the **R frontal lobe atrophy.**

Image D:

- Coronal T2 showing the **R frontotemporal atrophy**.
- Note the **widening** of the **R Sylvian fissure.**
- Note the **widening of the sulci** b/t the **superior/middle and inferior temporal gyri**.
- Note **hippocampal atrophy R>L.**



Ref: https://radiopaedia.org/cases/behavioral-variant-frontotemporal-dementia-1?lang=us

Frontotemporal Atrophy

Image A:

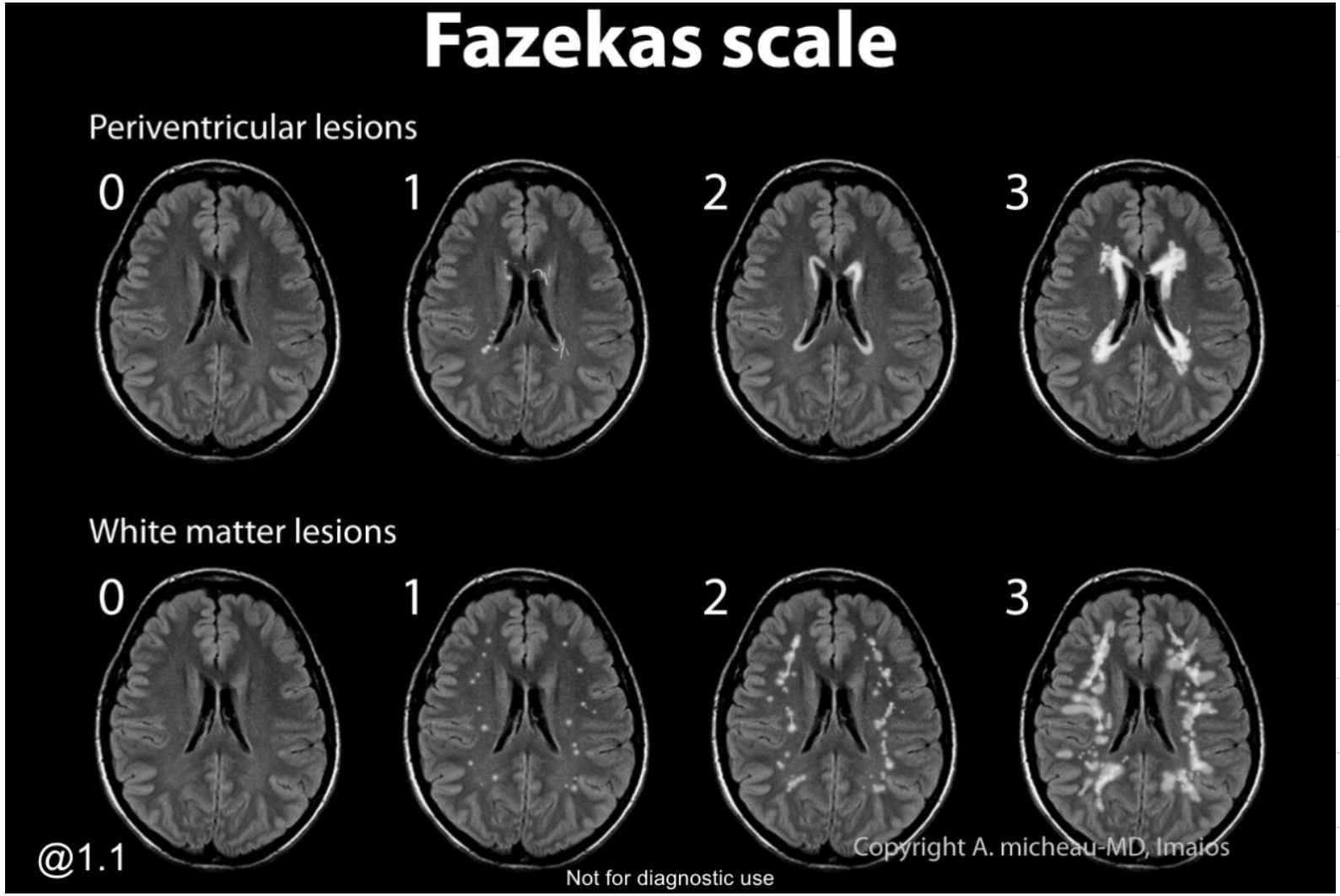
Axial FLAIR showing ventriculomegaly greatest in frontal horns and bilateral frontal cortical atrophy (bvFTD).

Image Ref:
https://reader.elsevier.com/reader/sd/pii/S2211568413002350?token=6D43912E8B8000A3B92667E8996AD1265D416582041D346969B3A99DCC0EA7D97FDB73279392D93E41BA06FEE3874FD8.

Small Vessel Ischemic Disease

APP2APP Virtual Lectures, Inc

Small Vessel Ischemic Disease

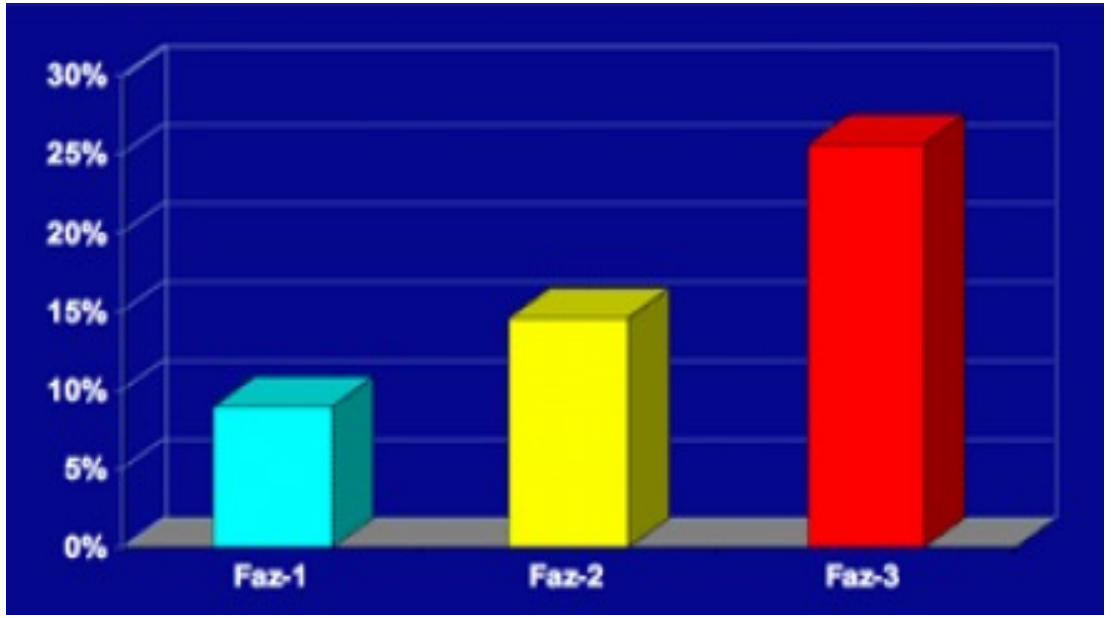


	Periventricular lesions
0	No lesions
1	Caps or thin lines
2	Smooth halos
3	Extends into white matter
	White matter lesions
0	No lesions
1	Punctate foci
2	Confluence beginning
3	Large confluent areas

Fazekas 1 = normal in elderly pts. **Fazekas 2/3** = is considered pathological. May be seen in **cognitively normal** individuals, but they are considered high **risk for cognitive decline.**

Ref: https://www.imaios.com/en/e-Cases/Channels/Radiology/Radiological-classifications-commonly-used-in-medical-imaging/Fazekas-scale-in-ARWMC-scale-on-MRI

”The LADIS Study (Leukoaraiosis and Disability Study)



- Longitudinal study **2001-2009**
- Conducted in **11 European countries**
- **639 enrolled, 633 completed** (> 99%)
- **Age 65-84**, functionally autonomous individuals
- **MRIs mild, mod, severe SVID** (via mod FAZ score)
- **No disability or mild disability** assessed via an **IADL scale** (Instrumental Activity of Daily Living).
- Some enrolled for **medical eval** for **mild cognitive complaints, motor dist,** or **minor CV events**.
- Some enrolled due to **incidental findings of SVID on MRI.**

RESULTS:

- **1 yr FU**: transition from **autonomy** to **disability** was **9, 15** and **26%** for mild, mod, and severe SVID.
- **3 yr FU:** Transition to **disability to death** was **10.5, 15.1,** and **29.5%,** respectively, for patients with mild, moderate, and severe SVID ($p < 0.001$).

REF: LADIS study: https://www.ncbi.nlm.nih.gov/pubmed/15459510

Image REF: http://www.radiologyassistant.nl/en/p43dbf6d16f98d/dementia-role-of-mri.html

Microangiopathy

Microhemorrhages

Two types of MR Imaging:

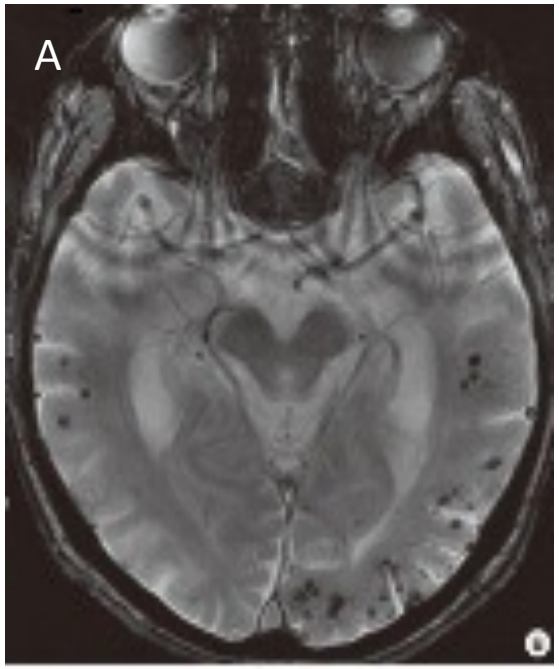
1. **SWI:** Susceptibility Weighted Imaging
2. **GRE:** Gradient (Recalled) Echo Imaging

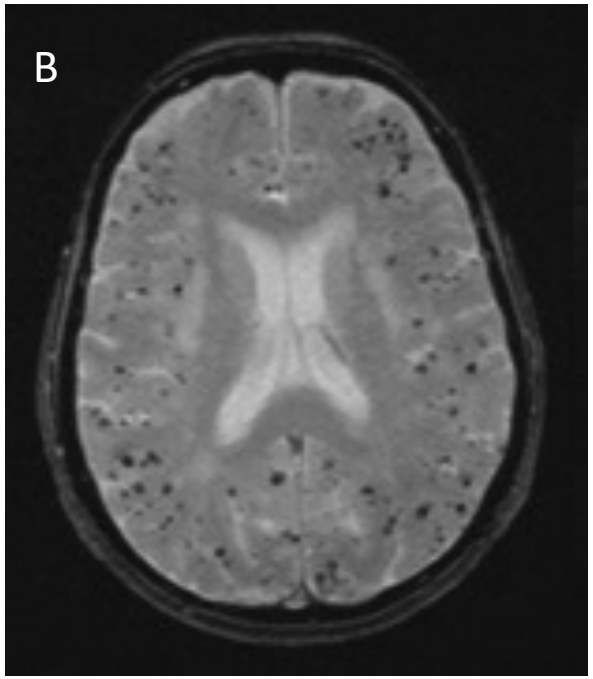
Images A, B, C:

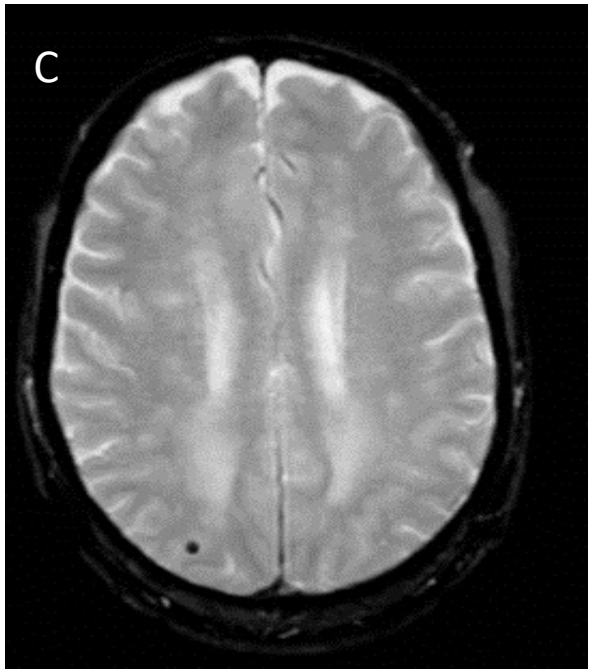
- **Cerebral amyloid angiopathy (CAA):** microhemorrhages in the **peripheral cortical distribution**, associated with **Alzheimer's disease**.

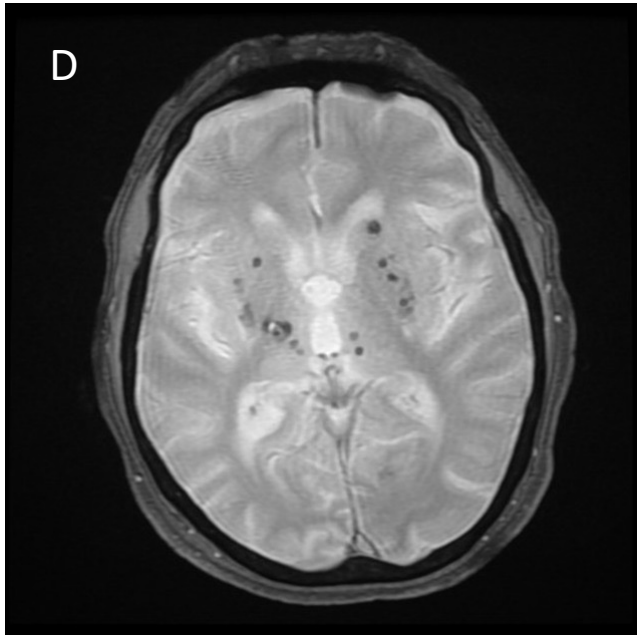
Image D:

- **Hypertensive microangiopathy:** microhemorrhages in the **basal ganglia, pons** and **cerebellar hemispheres**, associated with chronic **HTN**.



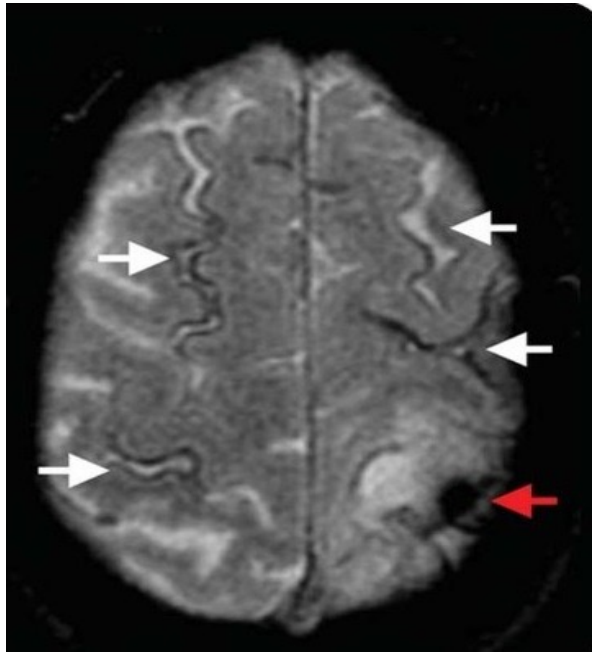


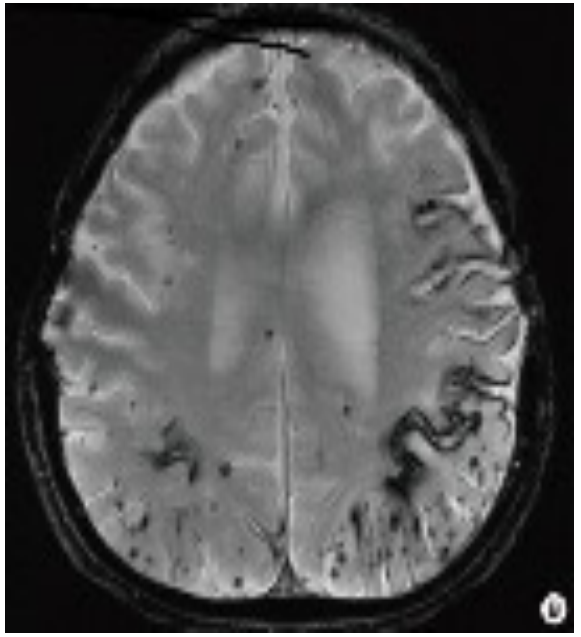


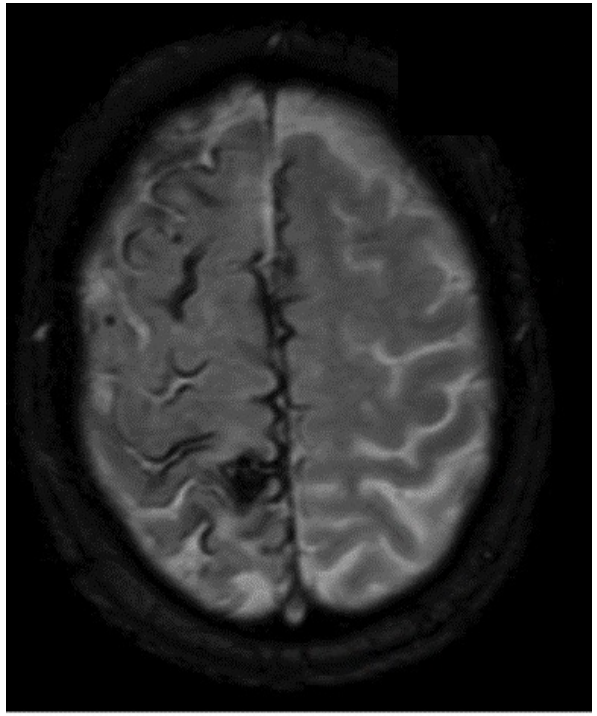


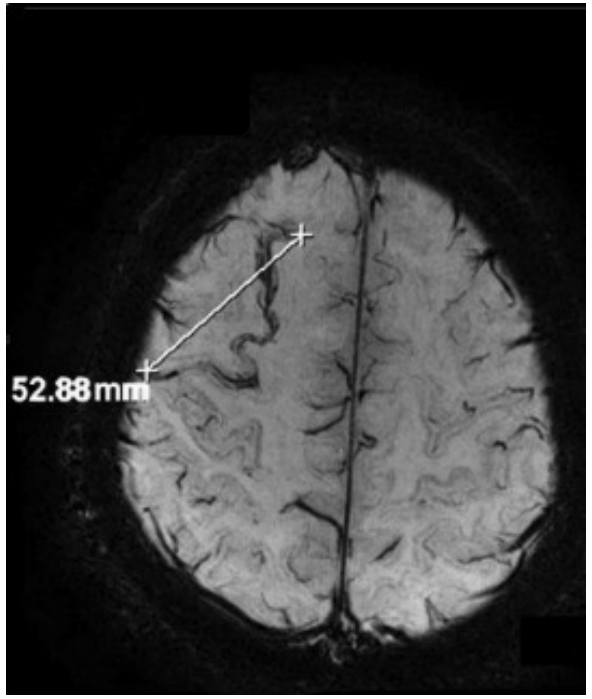
Superficial Siderosis

- **GRE** or **SWI** sequences will show a **serpentine pattern** of **blood deposits** within **sulci.**
- **Superficial hemorrhage** within the **subarachnoid** and/or **subpial space.**
- Ask about falls, possibility of **SAH** not completely resolved.
- May often be associated with **cerebral amyloid angiopathy.**









Summary

1. **Imaging Planes:** sagittal, axial, coronal.
2. **T1 vs T2 vs FLAIR**: shades of gray matter, white matter, and CSF.
3. **Basic MRI Anatomy**
4. **MRI Anatomy Pertinent in Dementia**:
   a) **Hippocampal atrophy:** Schelten's MTA Scoring- widening of the choroid fissure and temp horn, and loss of height in the hippocampal formation.
   b) **Parietal atrophy**: Koedam's Scale – widening of the parietal-occipital sulci and the post cingulate sulci, widening of the parietal parenchyma (noting the precuneus may be first affected).
   c) **Frontotemporal atrophy:** associated with FTD.
   d) **Small Vessel Ischemic Disease**: Fazekas scale rating periventricular lesions and/or WMHs.
   e) **Microangiopathy:** (SWI/GRE)
      - **Peripheral cortical lesions** represent CAA (AD) vs **deep brain lesions** in the brainstem, BG, and cerebellum representing chronic hypertension.
      - **Superficial Siderosis:** blood products in subarachnoid/subpial spaces – CAA (AD) or SAH.

References

1. Dekeyzer, DeKock, et al. "Unforgettable" – a pictorial essay on anatomy and pathology of the hippocampus. Insights Imaging (2017) 8:122-212.
2. Imaios: Online Radilogy Reference https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Brain-MRI-3D
3. Inzitari, D., et al. LADIS Study Group. "Risk of rapid global functional decline in elderly patients with severe cerebral age-related white matter changes: the LADIS study." Arch Intern Medicine (2007) Jan 8;167(1):81-8.
4. Korhonen, V. E., Soje, E., et al. "Frontotemporal dementia as a comorbidity to idiopathic normal pressure hydrocephalus (iNPH): a short review of literature and an unusual case." Fluids and Barriers of the CNS 2017, volume 14, Article number: 10.
5. LADIS Study Group: 2001–2011: "A Decade of the LADIS (Leukoaraiosis And DISability) Study: What Have We Learned about White Matter Changes and Small-Vessel Disease?" Cerebrovasc Dis 2011;32:577–588
6. Quach, C. Hommet, C., et al. "Early-onset dementias: Specific etiologies and contribution of MRI. Diagnostic and Interventional Imaging (2014) 95, 377-398.
7. Radiology Assistant: free radiology reference: http://www.radiologyassistant.nl/en/p43dbf6d16f98d/dementia-role-of-mri.html
8. Radiopaedia: Online Radiology Reference: https://radiopaedia.org/?lang=us

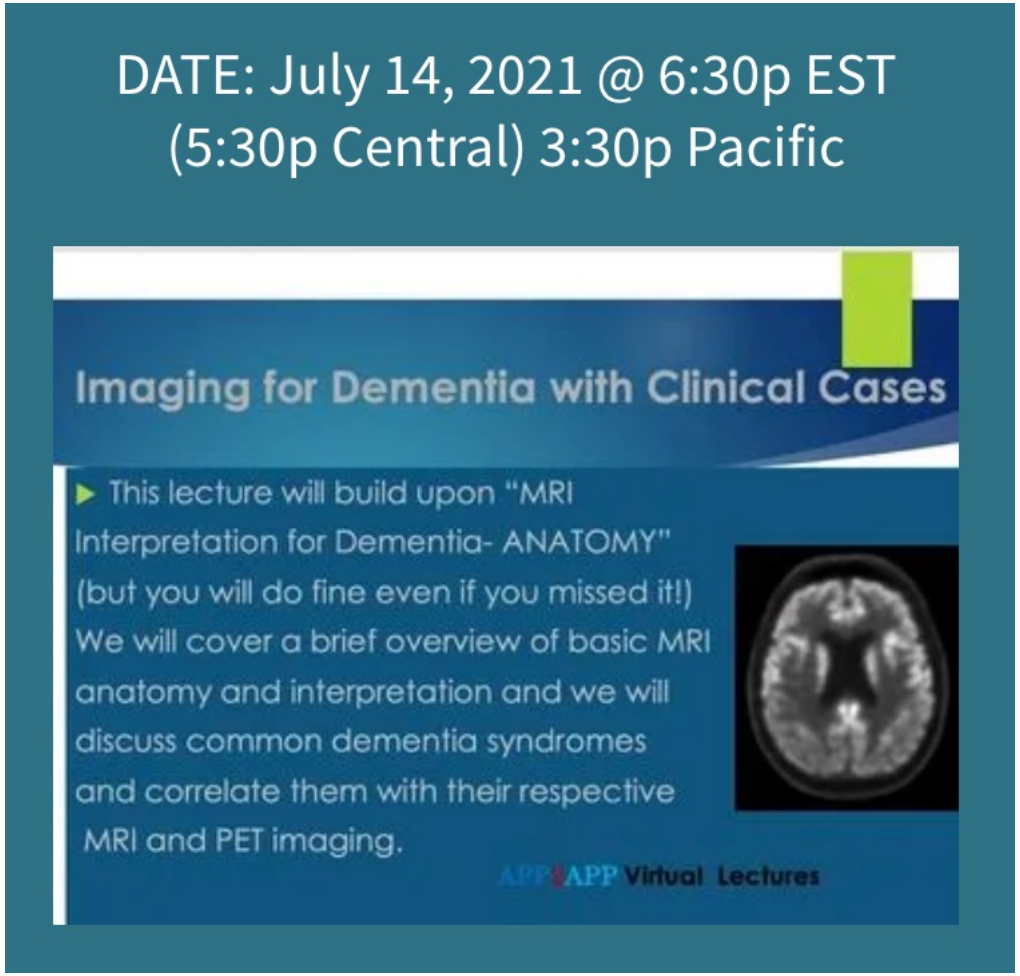
Imaging for Dementia with Clinical Cases

APP2APP Virtual Lectures, Inc

Four Functional Cognitive Systems and their correlation with MRI and FDG PET Imaging

Four Functional Cognitive Systems & MRI Cortical Atrophy Patterns

1. **Medial Temporo-Limbic Network:** memory and learning
   - ✓ Alzheimer's Disease and MCI with AD etiology
     - **MRI:** predominant MTL, posterior parietal atrophy. SWI-cortical microbleeds/superficial siderosis. **PET** same.
2. **Occipito-Temporal /Occipito-Parietal Network:** vision or object recognition
   - ✓ Posterior Cortical Atrophy (PCA)
     - ✓ **MRI:** Predominant occipito-parietal or occipito-temporal atrophy (**posterior cingulate gyrus involved** on PET.
   - ✓ Dementia of Lewy Bodies (DLB)
     - ✓ **MRI**: often normal. May have occipito-parietal atrophy (**posterior cingulate gyrus spared** on PET.
3. **Perisylvian Language Network:** PPAs- language
   - ✓ Primary Progressive Aphasia- **Logopenic (lvPPA)**
     - **MRI:** atrophy in the temporo-parietal junction L>R and posterior parietal cortex. **PET** same.
   - ✓ Primary Progressive Aphasias- **Semantic (svPPA)**
     - **MRI:** atrophy in the anterior temporal pole, L>R . **PET** same.
   - ✓ Primary Progressive Aphasia- **Agrammatic/Non-fluent (nfvPPA)**
     - **MRI:** atrophy in ventro-lateral portion of inferior frontal gyrus (*Broca's area*) and premotor cortex. **PET** same
4. **Fronto-Temporal Network:** executive, attention, behavior
   - ✓ Behavioral Variant of Frontotemporal Dementia (bvFTD). **MRI**: frontal and anterior temporal atrophy. **PET** same.



https://app2app.org/

APP2APP Virtual Lectures, Inc

Sharon Best, PA-C, MHS Sharon.best@pennmedicine.upenn.edu