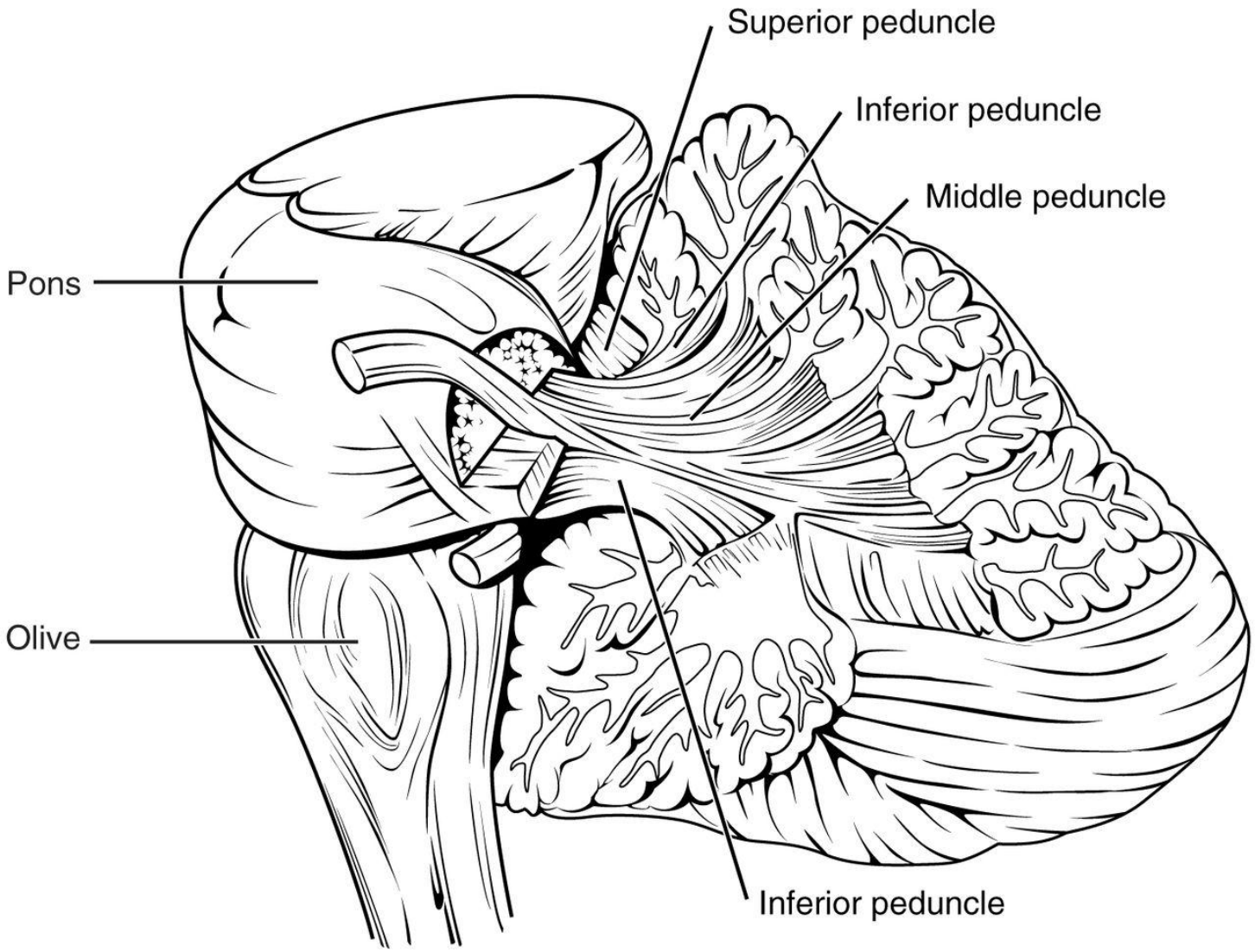
Cerebellum And Cerebellar Deficits



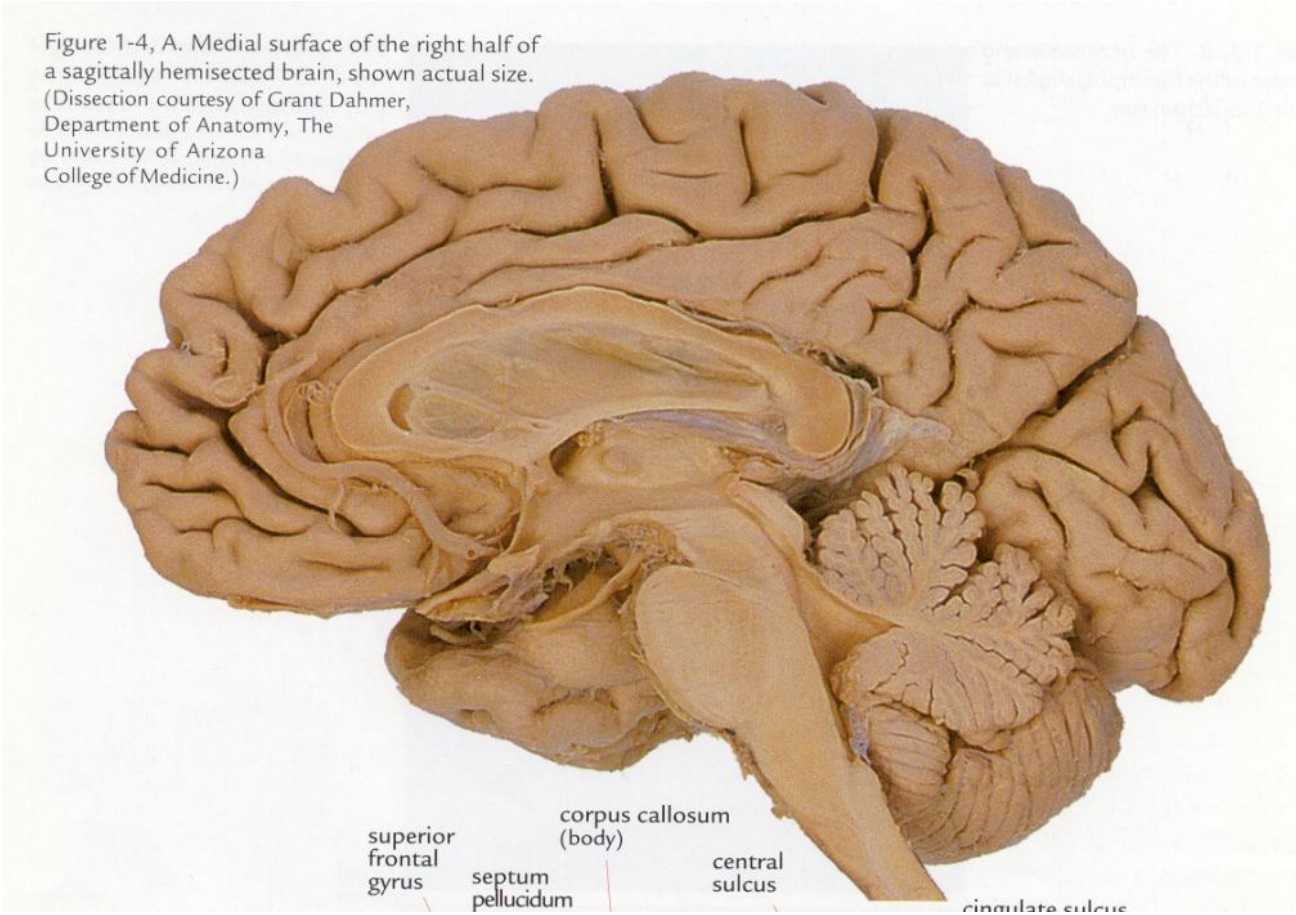
Learning Objectives

1. Explain the overall function of the cerebellum and the role it plays in motor control.
2. Describe the cerebellar anatomy: surfaces, fissures and lobes.
3. Explain the histological organization of the cerebellar cortex and name the cells found in each layer.
4. Describe the functional cerebellar regions.
5. Indicate the origin and name of the afferent pathways providing inputs to the cerebellum.
6. Explain the cerebellar processing.
7. Indicate the important efferent or output fibers passing through each of the cerebellar peduncles and their function.
8. Describe the deficits associated with damage to the cerebellum or the cerebellar peduncles.
9. Name the blood vessels that supply the cerebellum and explain the deficits that result from their occlusion.
10. Briefly explain other acute/chronic cerebellar disorders

OBJ. # 1

Cerebellar Functions

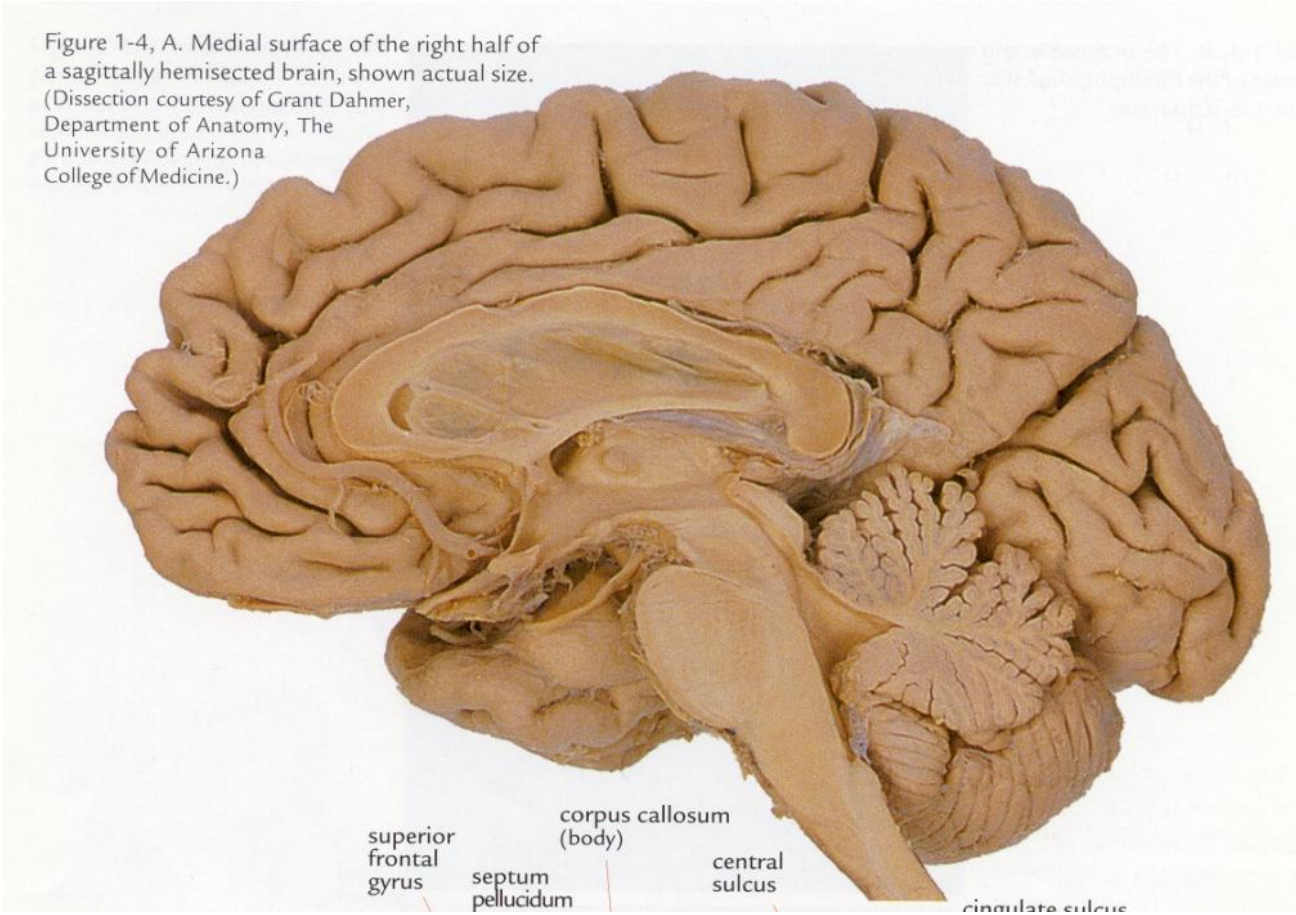
- Control of ongoing movement
  - Contribute to motor planning
  - Detecting motor error
  - Correct the error during movement
  - Stores the correction as memory
- Controls posture and gait
- Helps to regulate muscle tone



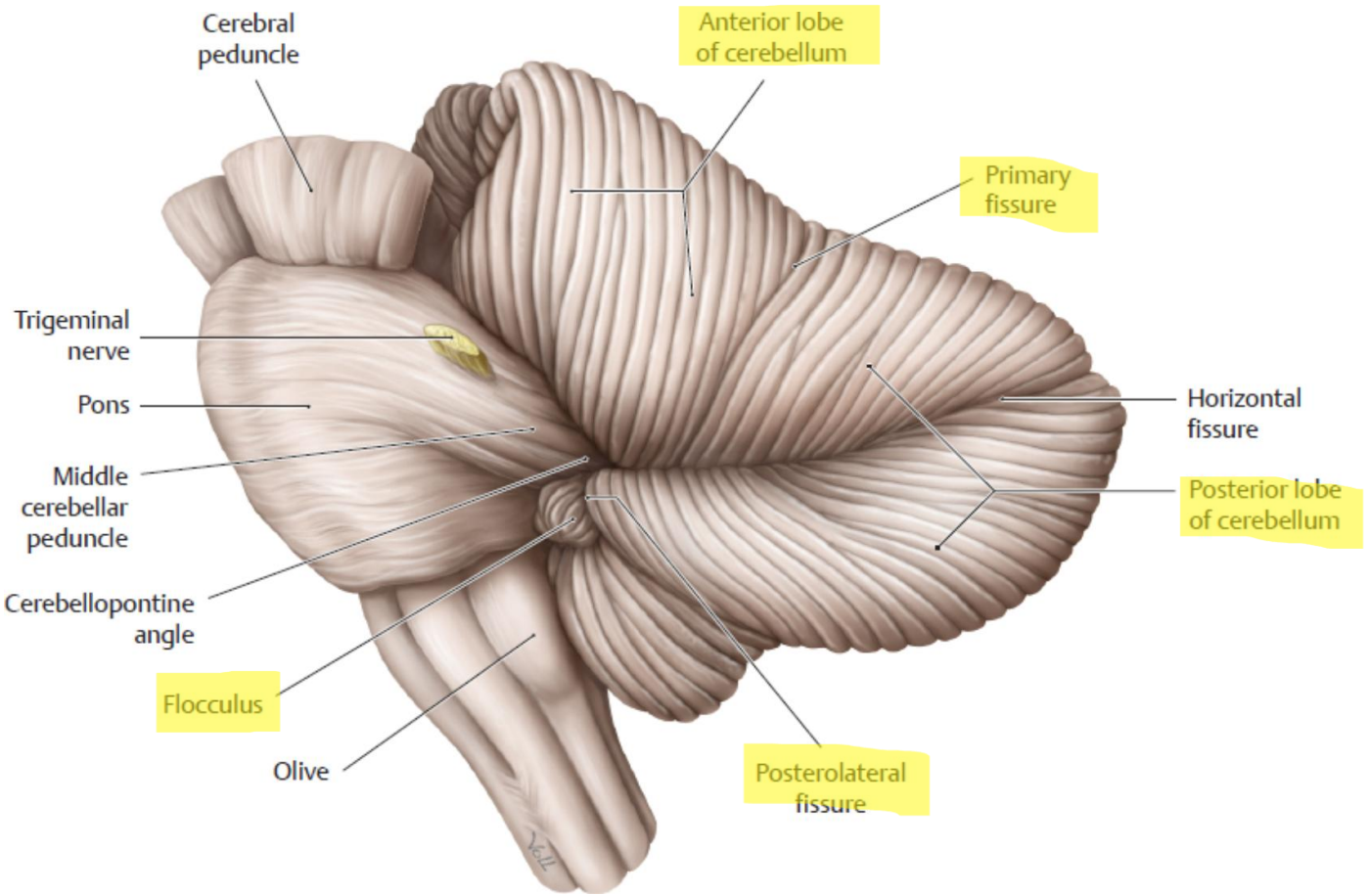
OBJ. # 1

Cerebellar Functions

- Monitor and modulate motor activity originating in other structures.
- Ex: At the end of a movement, automatic excitation of antagonist muscles and inhibition of agonist muscles – allows limbs to arrive at a precise location in space.



Cerebellar Anatomy

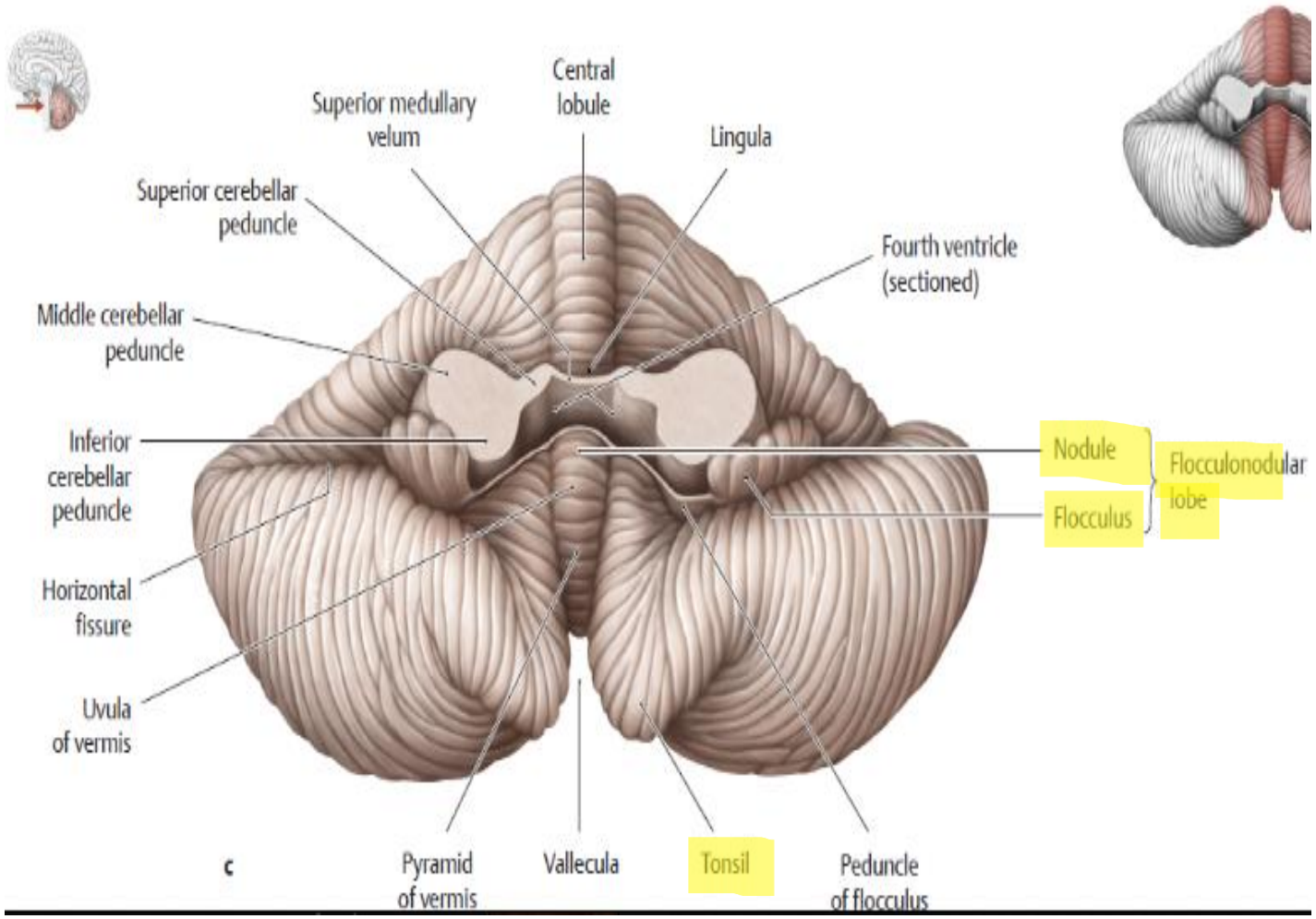


- **3 lobes**: **anterior**, **posterior** and **flocculonodular**
- **2 fissures**: **primary** and **posterolateral**
- **3 surfaces**: **superior**, **inferior**, and **ventral**

★ There is a horizontal fissure, however it has no clear functional or clinical significance

OBJ. # 2

Cerebellar Anatomy



- **3 lobes**: **anterior**, **posterior** and **flocculonodular**
- **2 fissures**: **primary** and **posterolateral**
- **3 surfaces**: **superior**, **inferior**, and **ventral**

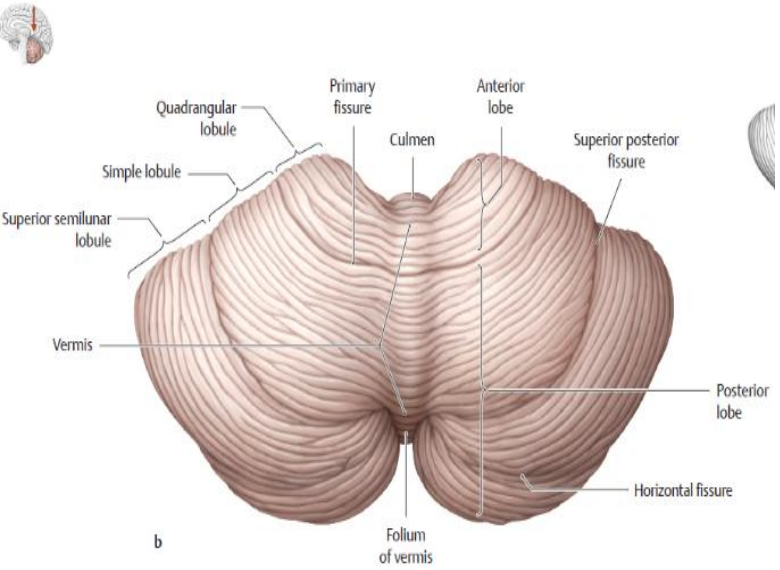
★ There is a horizontal fissure, however it has no clear functional or clinical significance

OBJ. # 2

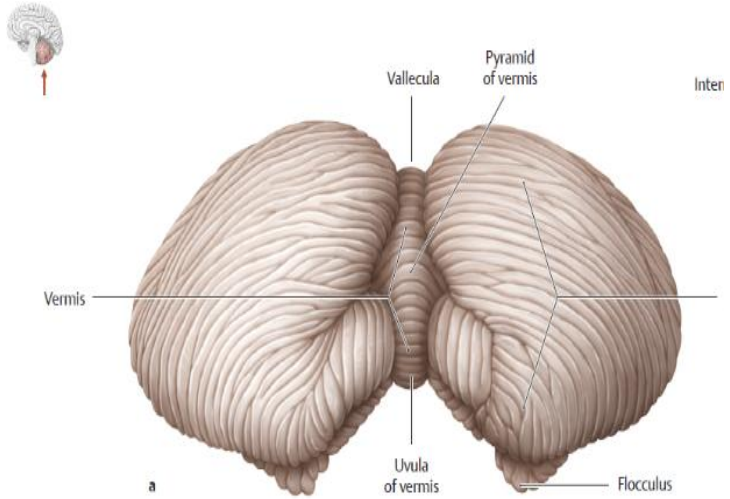
Cerebellar Anatomy

OBJ. # 2

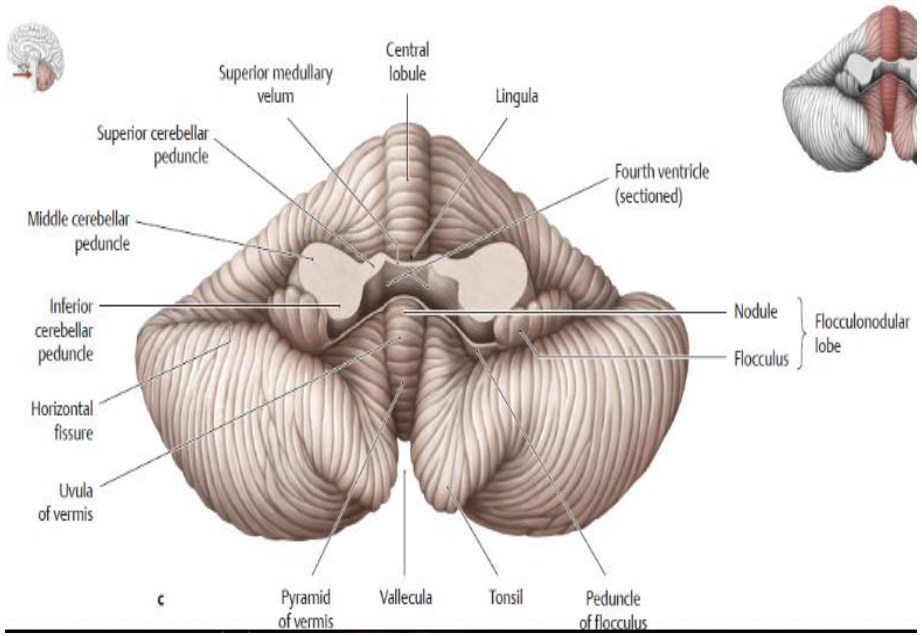
Superior surface



Inferior surface

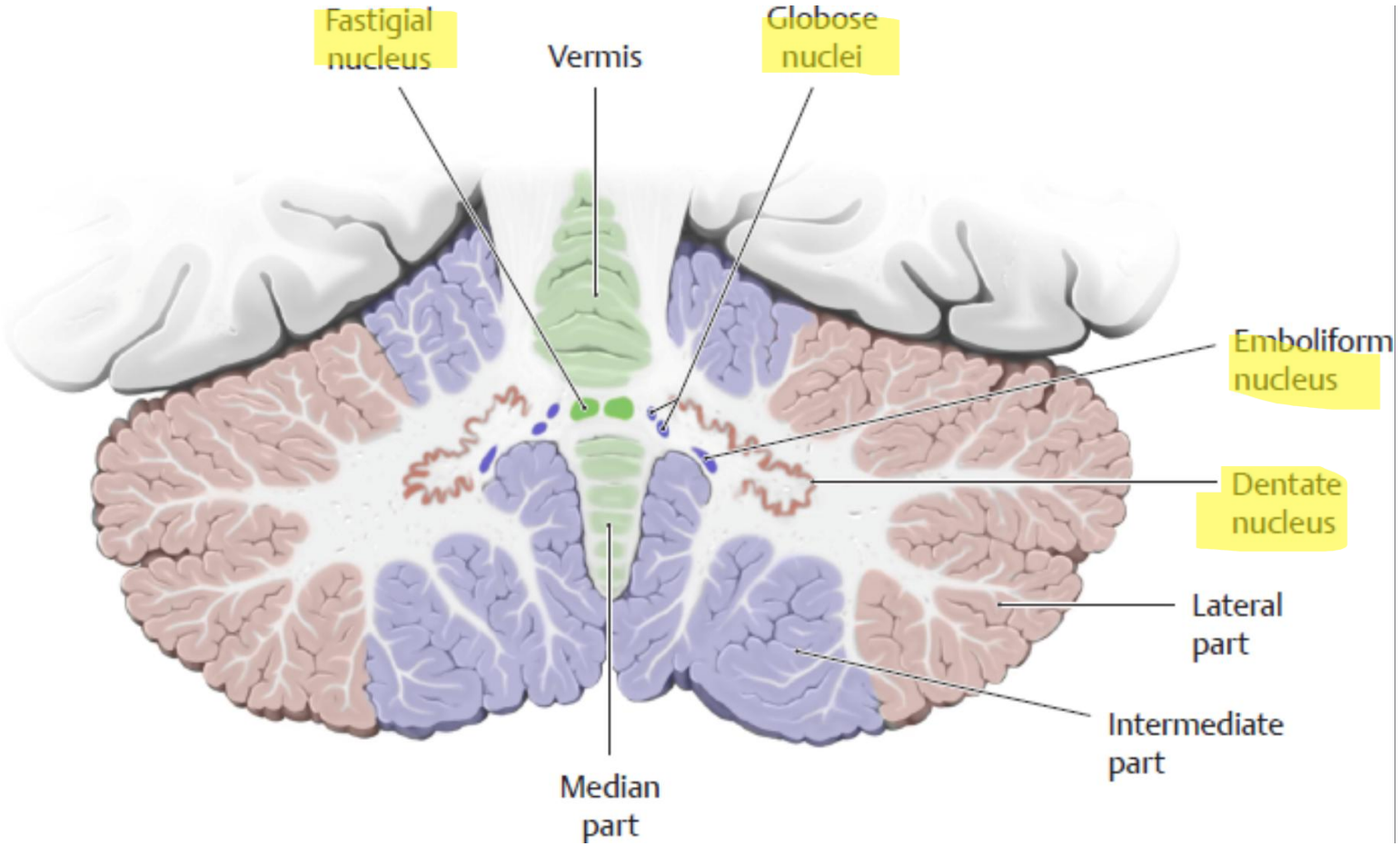


Ventral surface



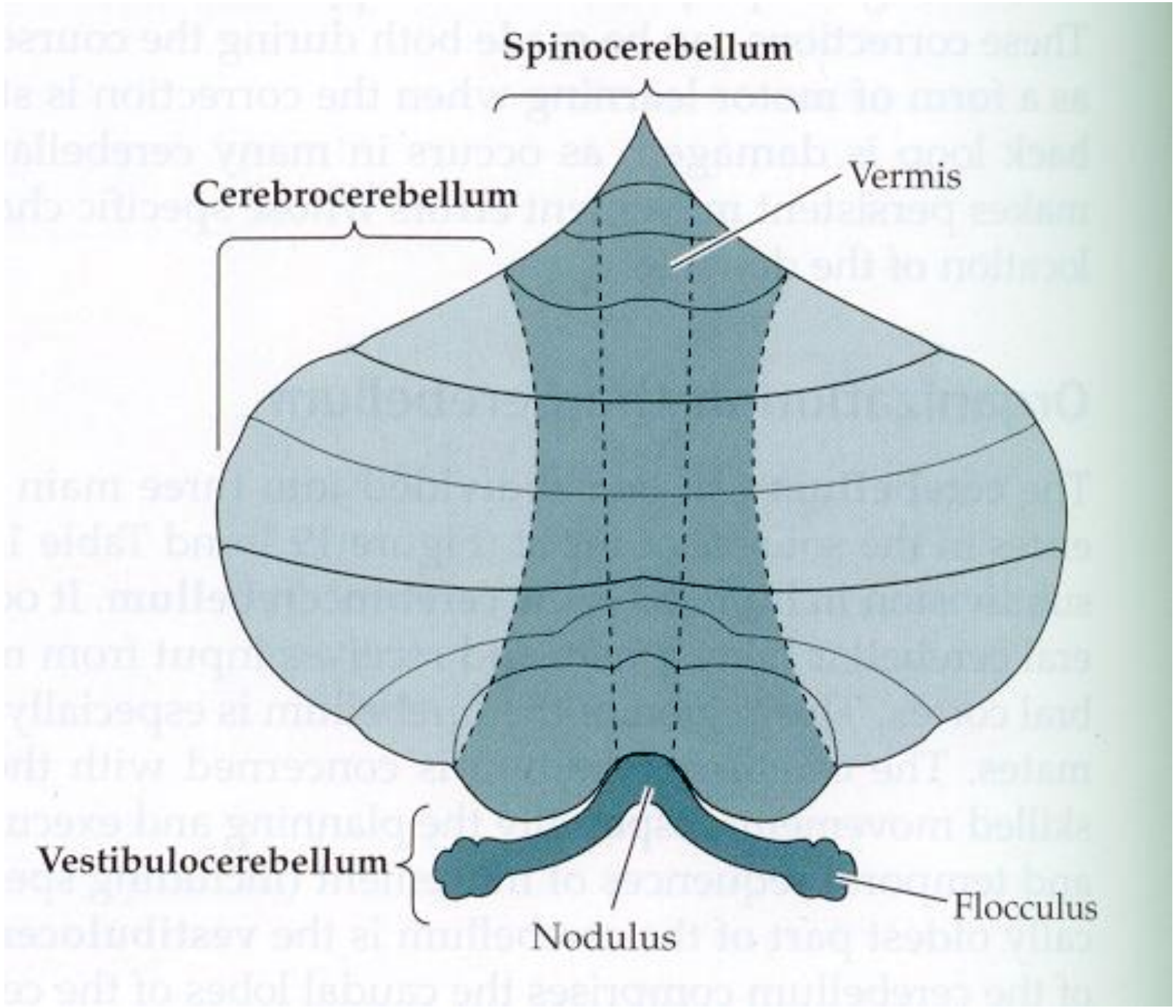
Cerebellar Anatomy

OBJ. # 2



- 4 deep cerebellar nuclei: **dentate, emboliform, globose,** and **fastigeal**.
- **The 4 vestibular nuclei are considered part of the deep cerebellar nuclei because they project directly to the cerebellum**

OBJ. # 4

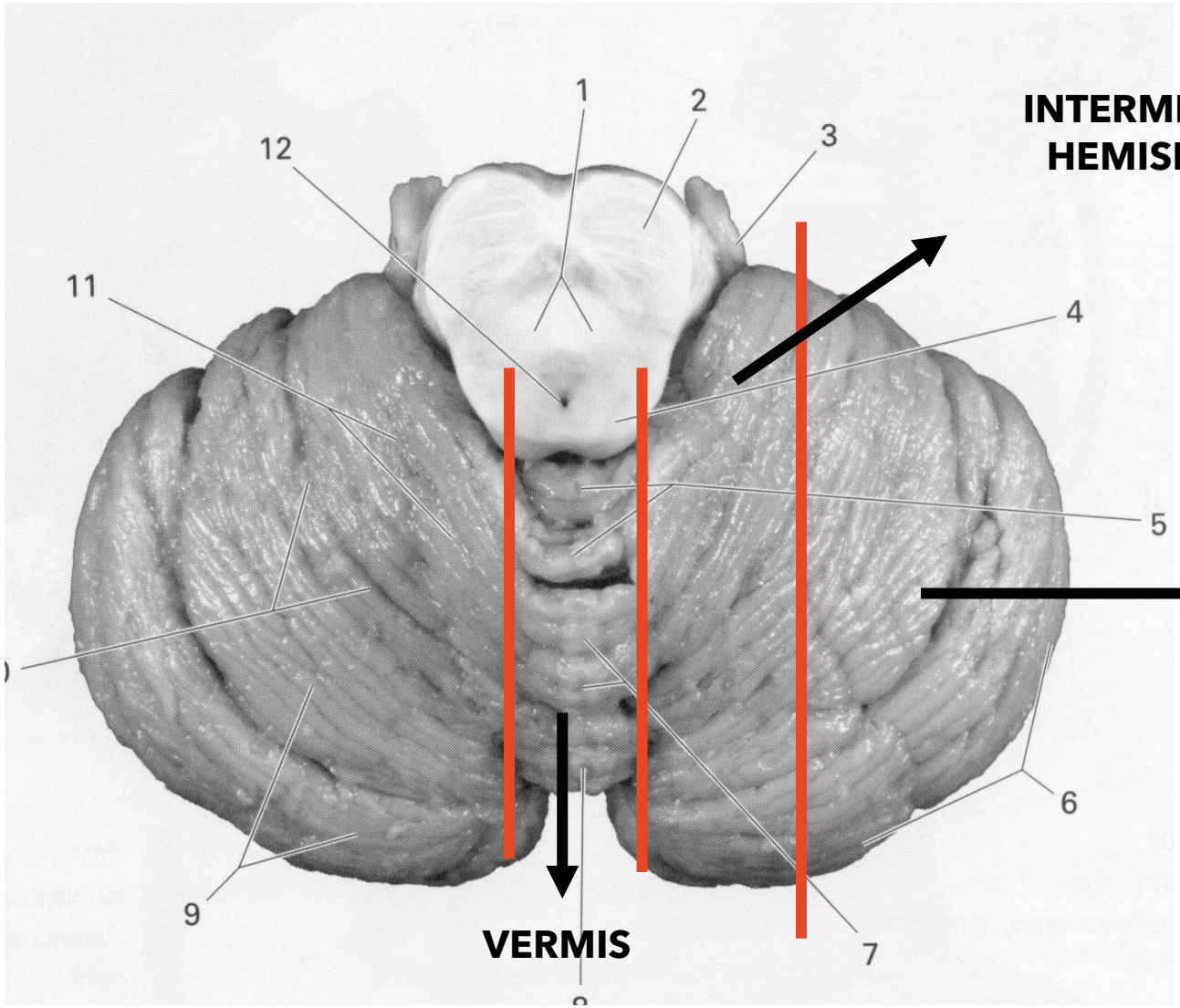


This is an ‘unrolled’ cerebellum

3 Functional Regions

3 Functional Regions

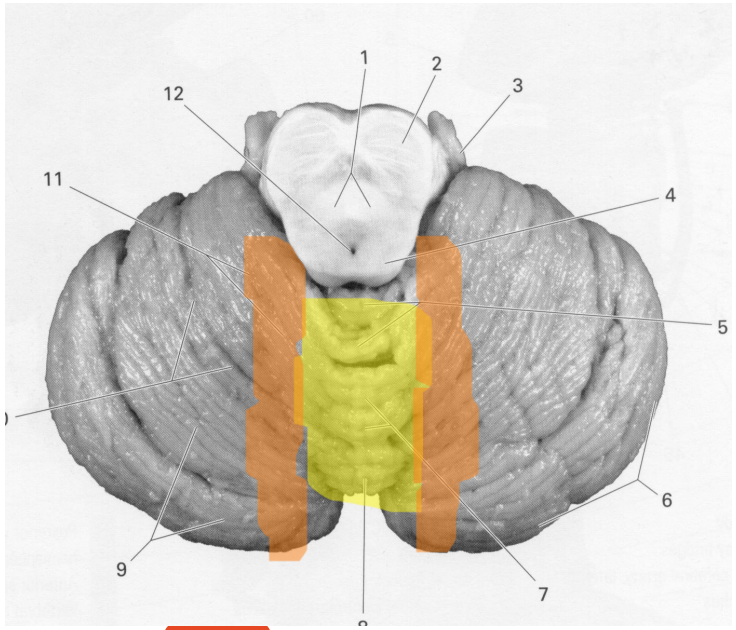
OBJ. # 4



OBJ. # 4

Cerebellar Functional Areas

Spinocerebellum – developmentally older structure:

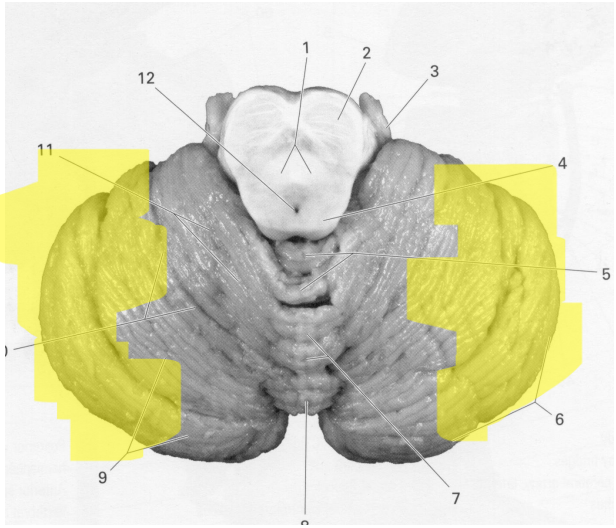


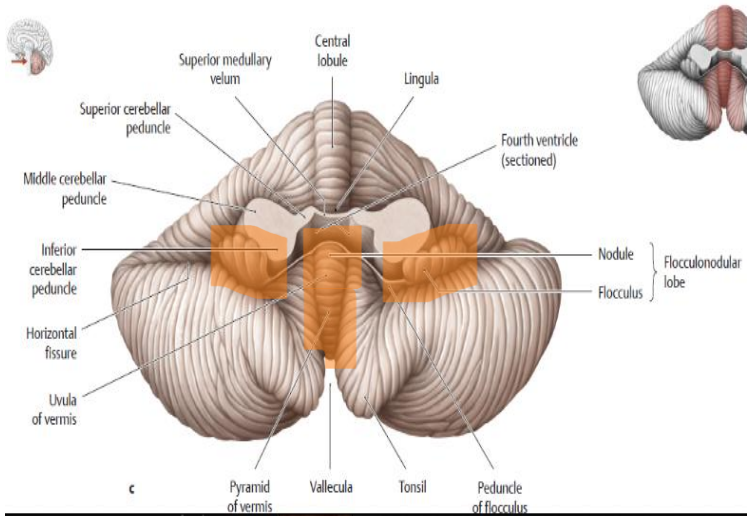
Superior Vermis → **Posture and axial muscle coordination/ Balance, gait and muscle tone**

Intermediate Hemispheres → **Motor coordination of limb movements**

OBJ. # 4

Cerebellar Functional Areas





Cerebrocerebellum

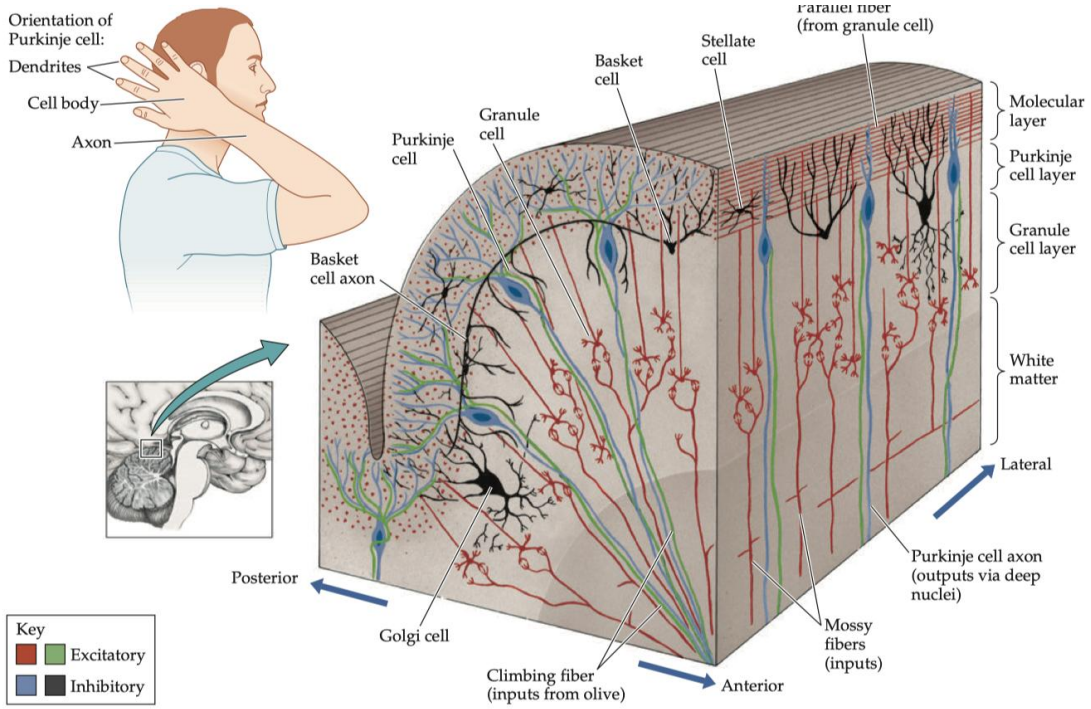
Lateral Cerebellar Hemispheres → **Motor planning + motor learning**

Vestibulocerebellum

Flocculonodular Lobe + Inferior Vermis → **Vestibulo-ocular Coordination and balance**

OBJ. # 6

Cerebellar Cortex Cellular Organization



3 Layers from outer to inner:

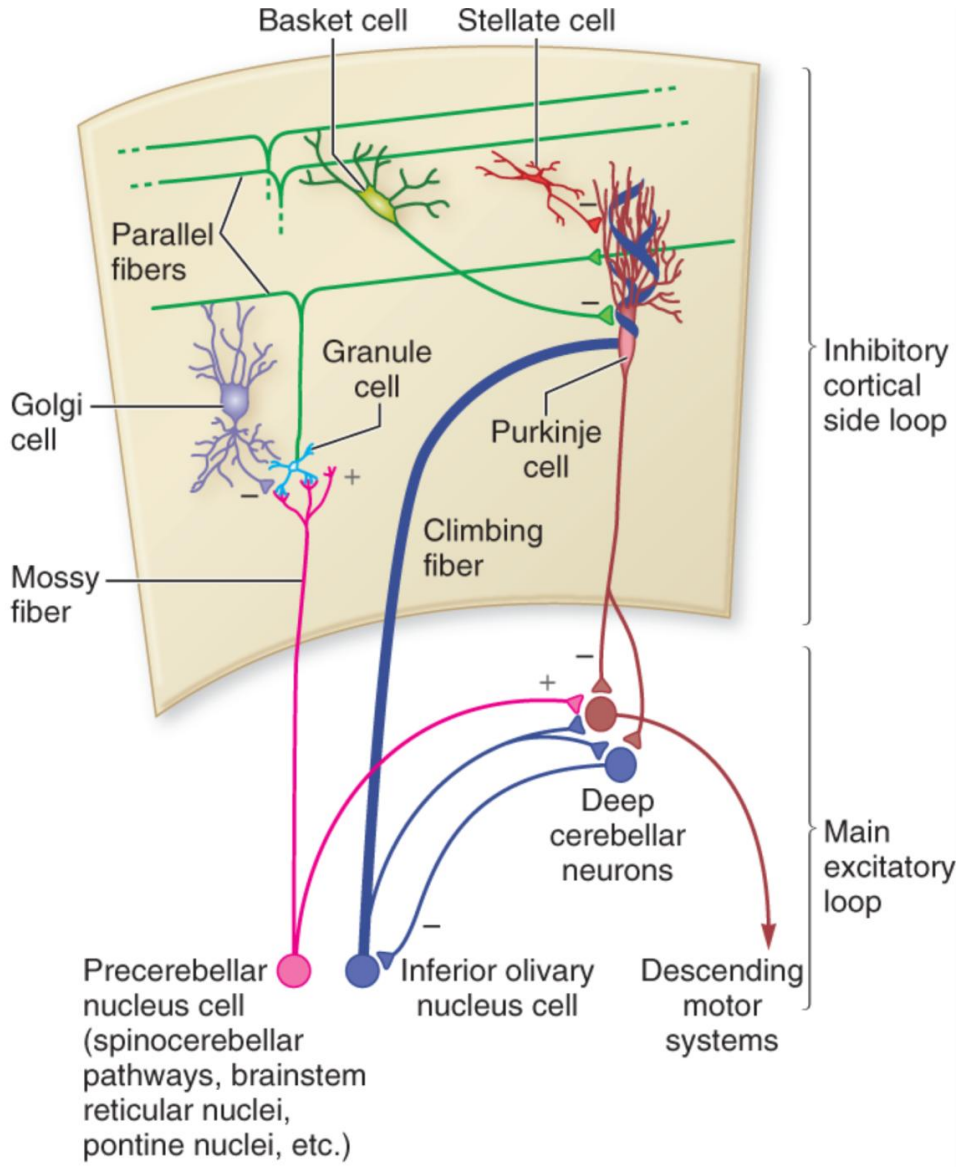
- Molecular
  - Mostly contains granule cell axons
  - Dendrites of purkinje cells
  - Some interneurons
- Purkinje cell
  - Contains the purkinje cells!
  - Second largest cells in the CNS
  - Only axons to leave the cerebellar cortex
  - Purkinje cells use GABA as neurotransmitter -> all output from cerebellar cortex is inhibitor
- Granule cell
  - Densely populated with granule cells and other interneurons, nearly as many cells as the rest of the nervous system
  - Only excitatory neuron in cerebellum (glutamate)

OBJ. # 6

Cerebellar Cortex

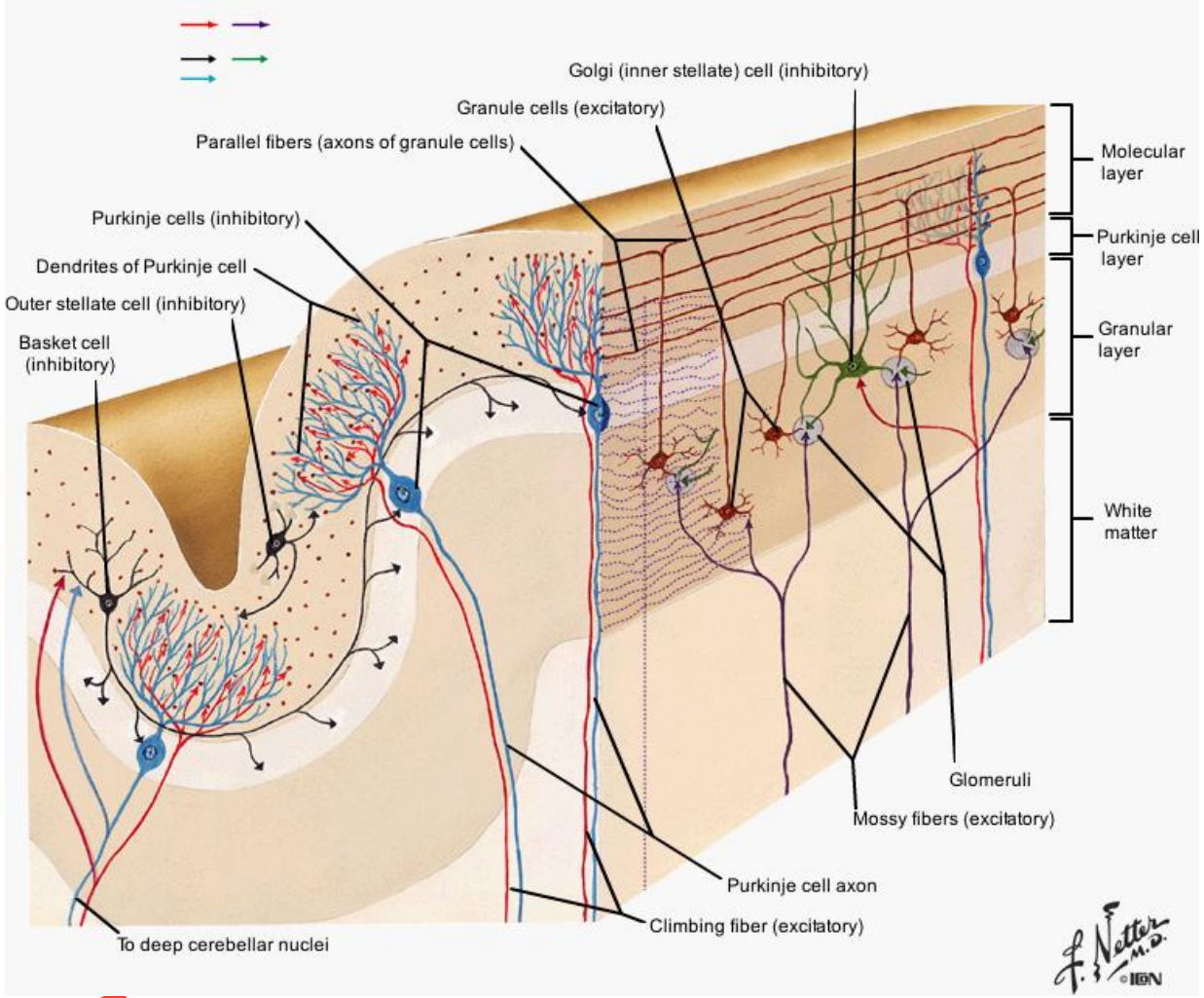
Inputs to the cerebellum:

- Climbing fibers
- Mossy fibers



Cerebellar Afferents:

OBJ. # 6



Mossy fibers:

- Enter via ICP and MCP
- Coming from pontocerebellar, spinocerebellar, and vestibulocerebellar tracts
- Form excitatory (glutamate) synapses on granule cells

Climbing fibers:

- Enter via ICP
- Projected from olivary nuclei (olivocerebellar tracts)
- Excitatory input directly on purkinje cells
- Important for motor learning

OBJ. # 6

Cerebellar Cortex Projections To Deep Cerebellar Nuclei

Lateral cerebellar hemispheres	→	Dentate Nucleus
Intermediate CerebellarHemispheres	→	Interposed Nuclei
Superior Vermis	→	Fastigeal Nuclei
Flocculonodular lobe and inferior vermis	→	Vestibular Nuclei

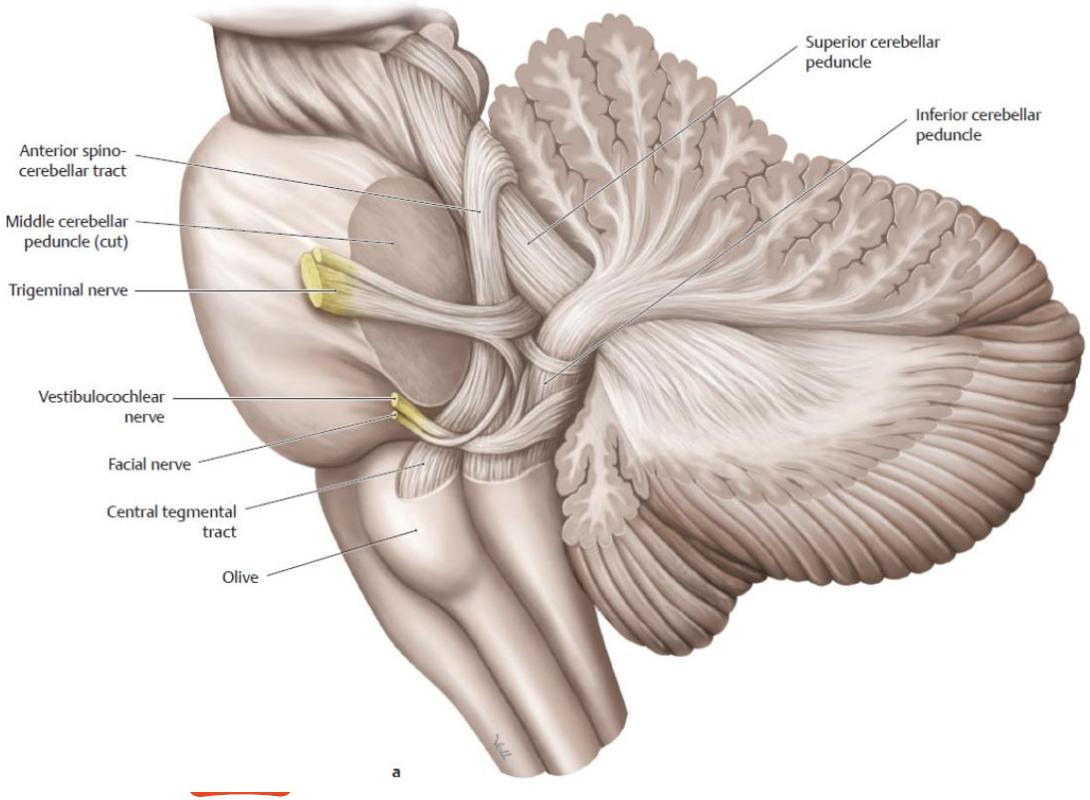
OBJ. # 6

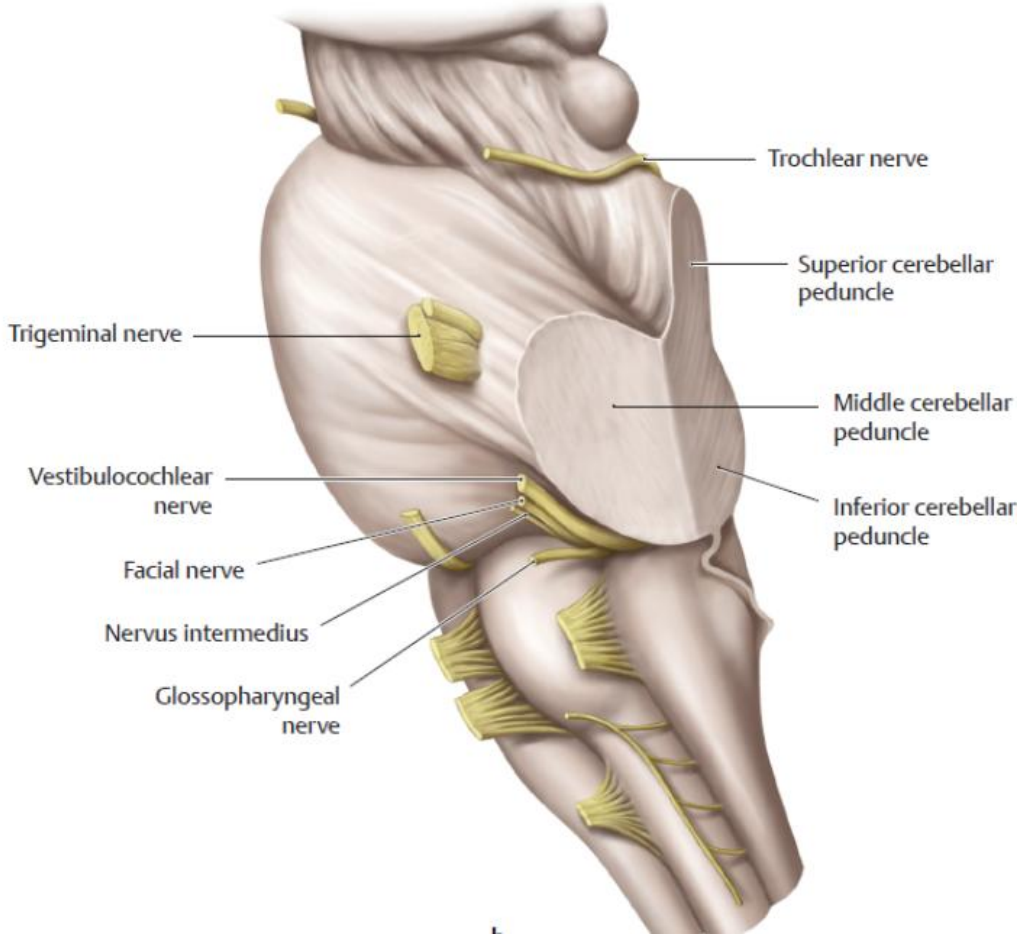
Cerebellar Cortex Projections To Deep Cerebellar Nuclei

TABLE 15.2 Main Cerebellar Output Pathways

REGION	DEEP NUCLEI	CEREBELLAR PEDUNCLE	MAIN OUTPUT TARGETS OR EQUIVALENT
Lateral hemispheres	Dentate nucleus	Superior cerebellar peduncle	Ventrolateral nucleus of thalamus (VL), parvocellular red nucleus
Intermediate hemispheres	Interposed nuclei	Superior cerebellar peduncle	VL, magnocellular red nucleus
Vermis	Fastigial nuclei	Superior cerebellar peduncle	VL, tectum
		Uncinate fasciculus[a], juxtarestiform body[b]	Reticular formation, vestibular nuclei
Inferior vermis and flocculonodular lobe	Vestibular nuclei	Juxtarestiform body[b]	Medial longitudinal fasciculus (eye movement pathways)

Cerebellar Peduncles





OBJ. # 5

Cerebellar Inputs And Outputs

Middle Cerebellar peduncle

Inferior Cerebellar peduncle

Processing of info In the cerebellar cortex → Info is transmitted to Cerebellar nuclei

CEREBELLUM

FLOCCULONODULAR LOBE

Inputs to the cerebellum reach the cerebellar cortex, they are processed and sent to the cerebellar nuclei. Cerebellar outputs leave the cerebellar nuclei to influence UMN in the cortex and brainstem

Superior Cerebellar peduncle

Inferior Cerebellar peduncle

OBJ. # 5

Cerebellar Inputs Middle Cerebellar Peduncle

Corticopontine fibers from all brain lobes terminate in pontine nuclei

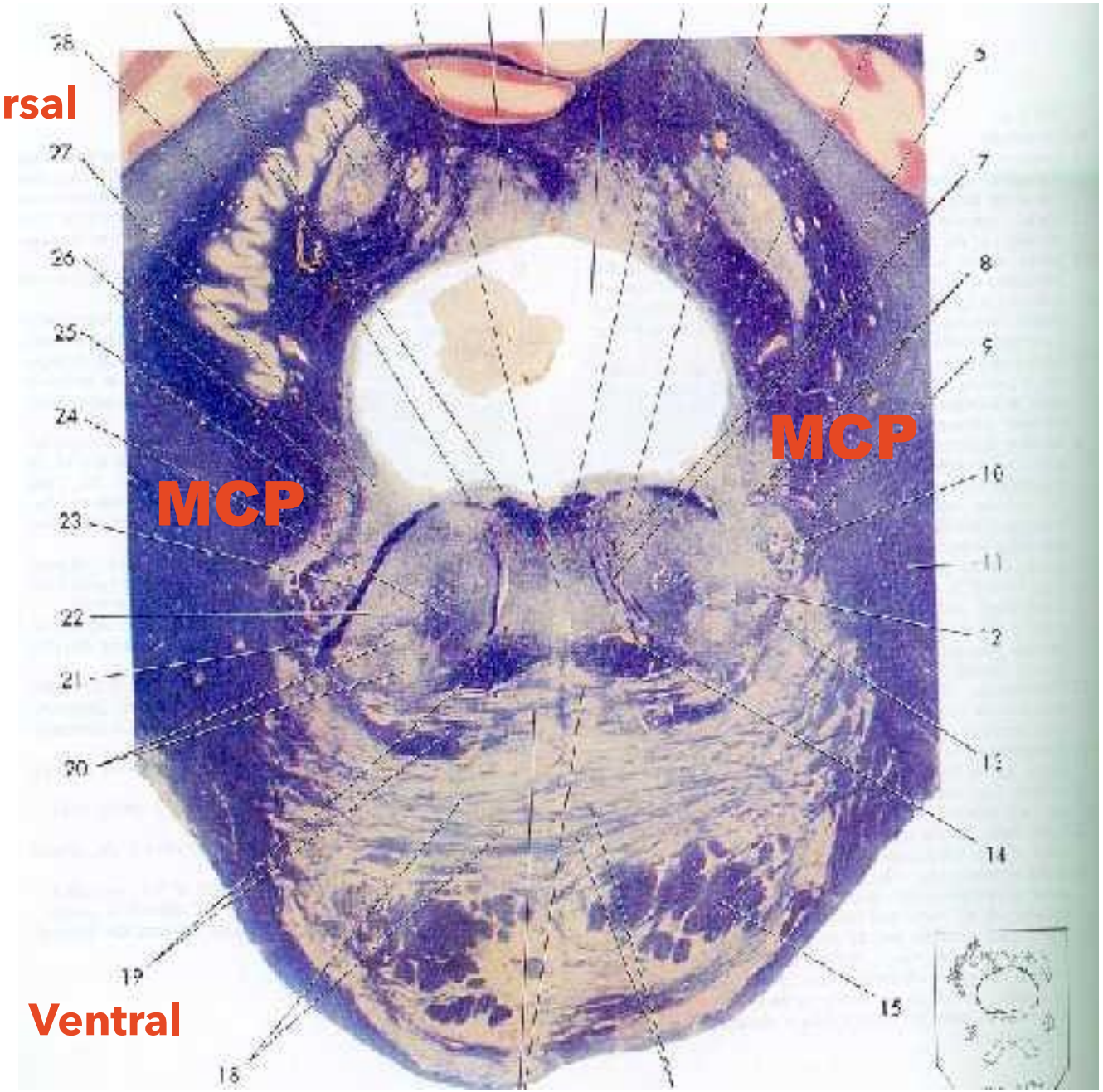
↓

Pontocerebellar fibers cross the midline and form the contralateral middle cerebellar peduncle

↓

They enter the cerebellum as **mossy fibers** to reach the entire cerebellar cortex, except the cortex of the nodulus

OBJ. # 5



Cerebellar Inputs
Inferior Cerebellar Peduncle

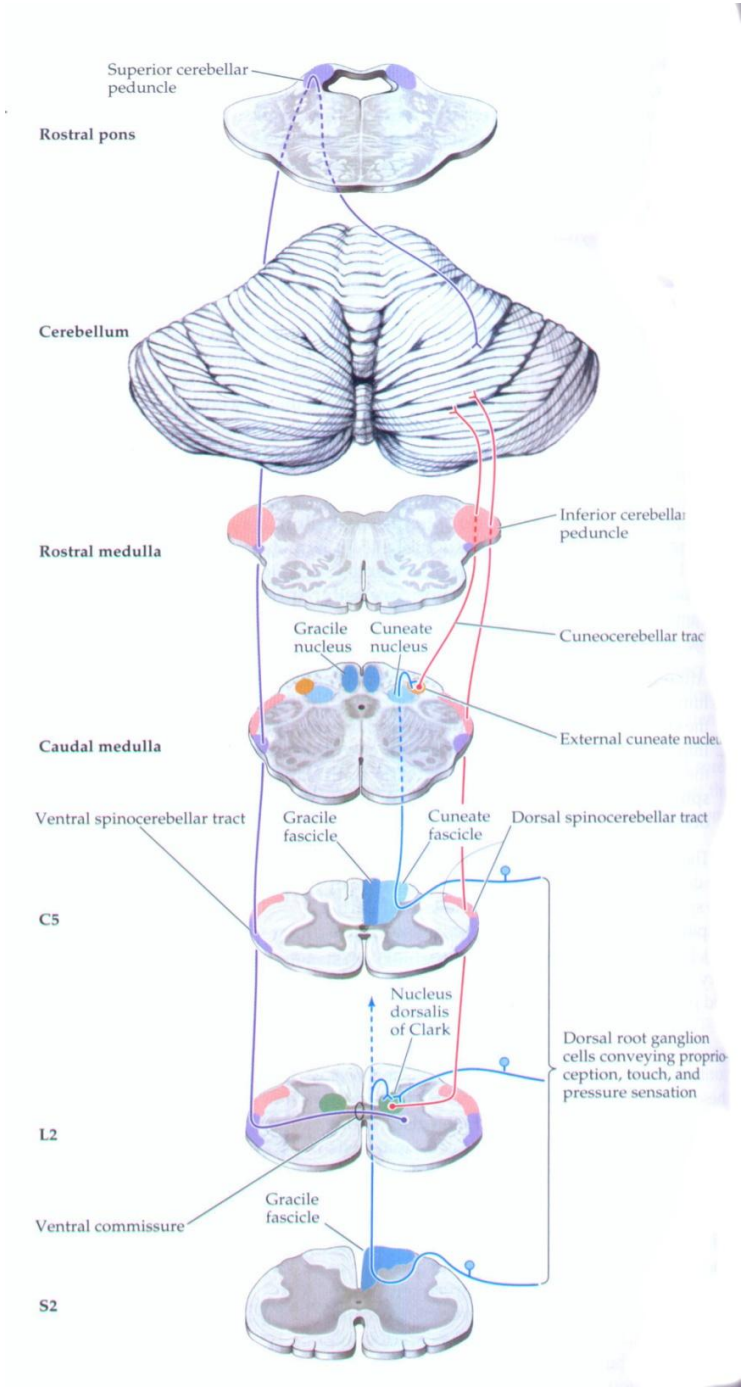
OBJ. # 5

- **Spinocerebellar fibers** travel in several tracts.
  - Dorsal spinocerebellar tract
  - Ventral spinocerebellar tract
  - Cuneocerebellar tract
  - Rostral spinocerebellar (we don't know much about this pathway)

- They convey sensory information about limb proprioception from all levels of the spinal cord. The fibers terminate mostly in the paravermal area and superior vermis as mossy fibers

OBJ. # 5

Spinocerebellar Fibers



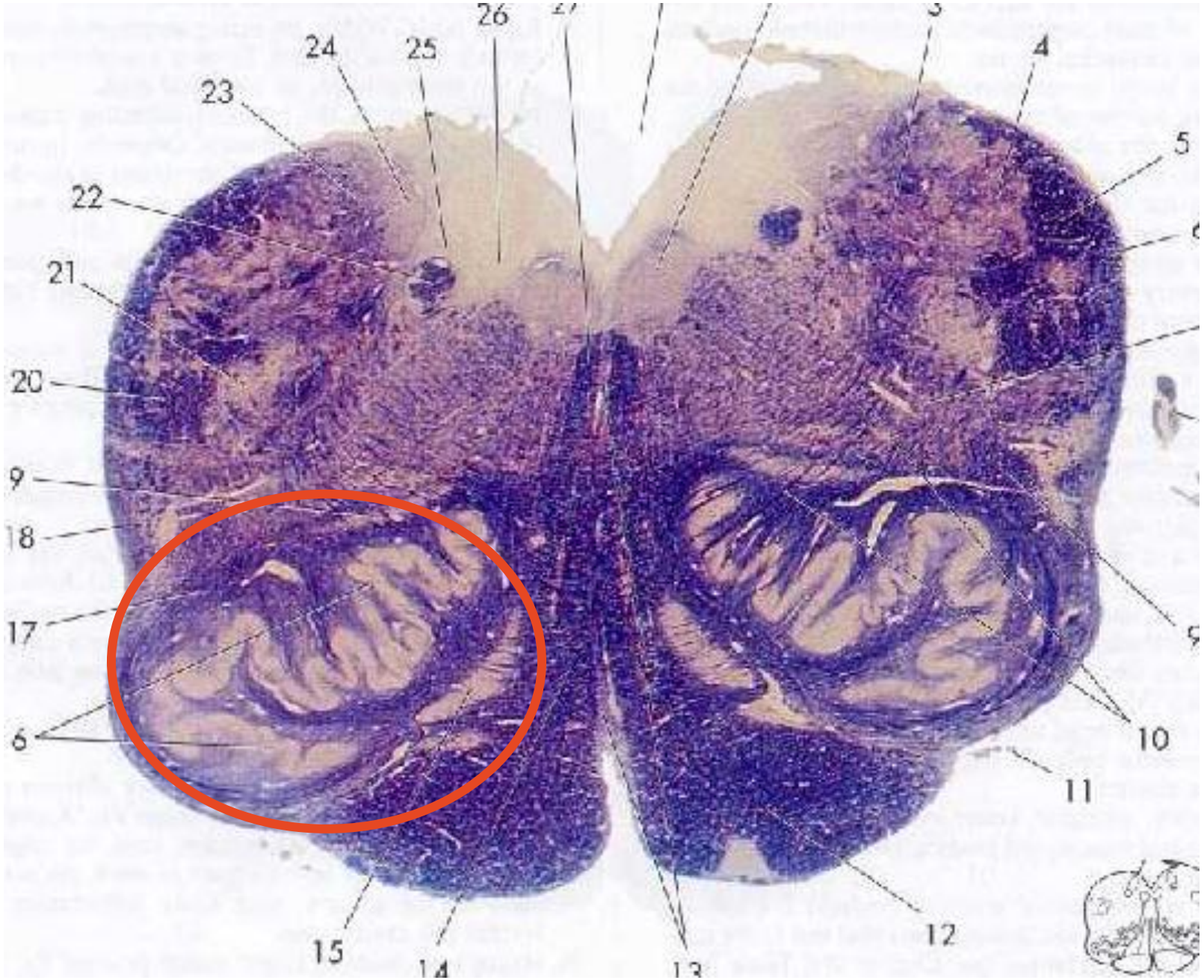
Cerebellar Inputs
Inferior Cerebellar Peduncle

OBJ. # 5

Spinocerebellar fibers travel in several tracts. They convey sensory information about limb movement from all levels of the spinal cord. The fibers terminate mostly in the intermediate zone and superior vermis as mossy fibers

Olivocerebellar fibers cross the midline to enter the contralateral cerebellum as **climbing fibers** to terminate in the entire cerebellar cortex

OBJ. # 5



Inferior Olivary Nucleus

Cerebellar Inputs
Inferior Cerebellar Peduncle

OBJ. # 5

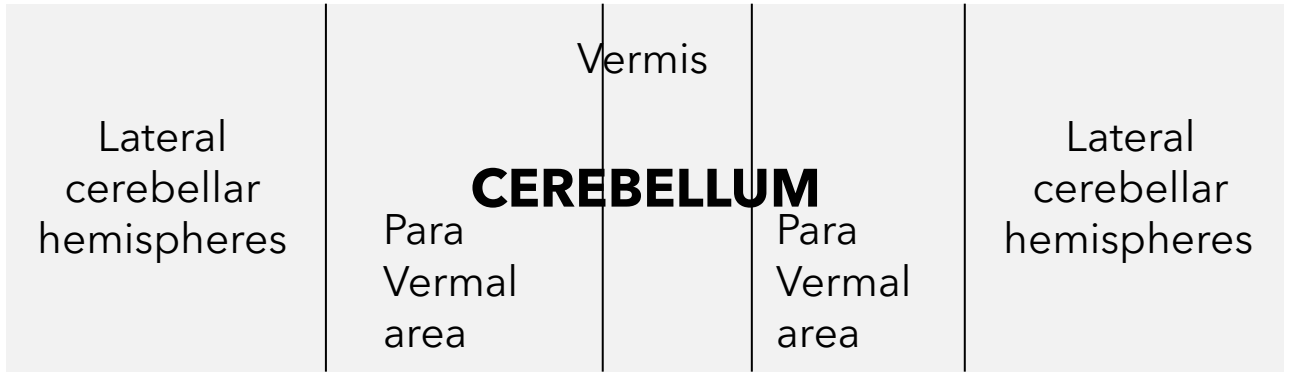
Spinocerebellar fibers travel in several tracts. They convey sensory information about limb movement from all levels of the spinal cord. The fibers terminate mostly in the intermediate zone and superior vermis as mossy fibers

Olivocerebellar fibers cross the midline to enter the contralateral cerebellum as climbing fibers to terminate in the entire cerebellar cortex

Primary and secondary vestibular fibers project via the juxtarestiform body, a subtract of the inferior cerebellar peduncle, as **mossy fibers** to terminate in the flocculonodular lobe and inferior vermis

Cerebellar Inputs

OBJ. # 5



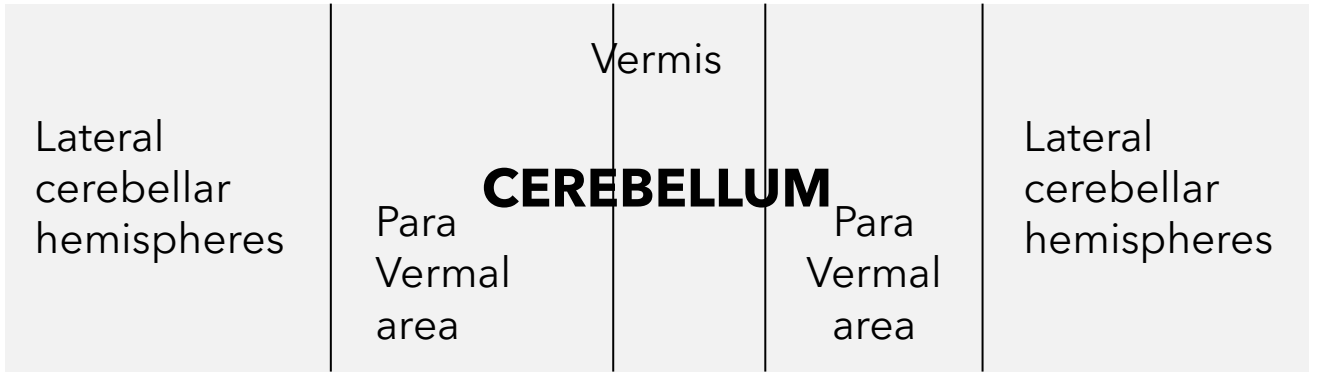
- Middle Cerebellar peduncle
- Pontocerebellar fibers

FLOCCULONODULAR LOBE

Inferior Cerebellar peduncle

- Spinocerebellar
- Olivocerebellar
- Reticulocerebellar
- Vestibulocerebellar
- Trigeminal fibers

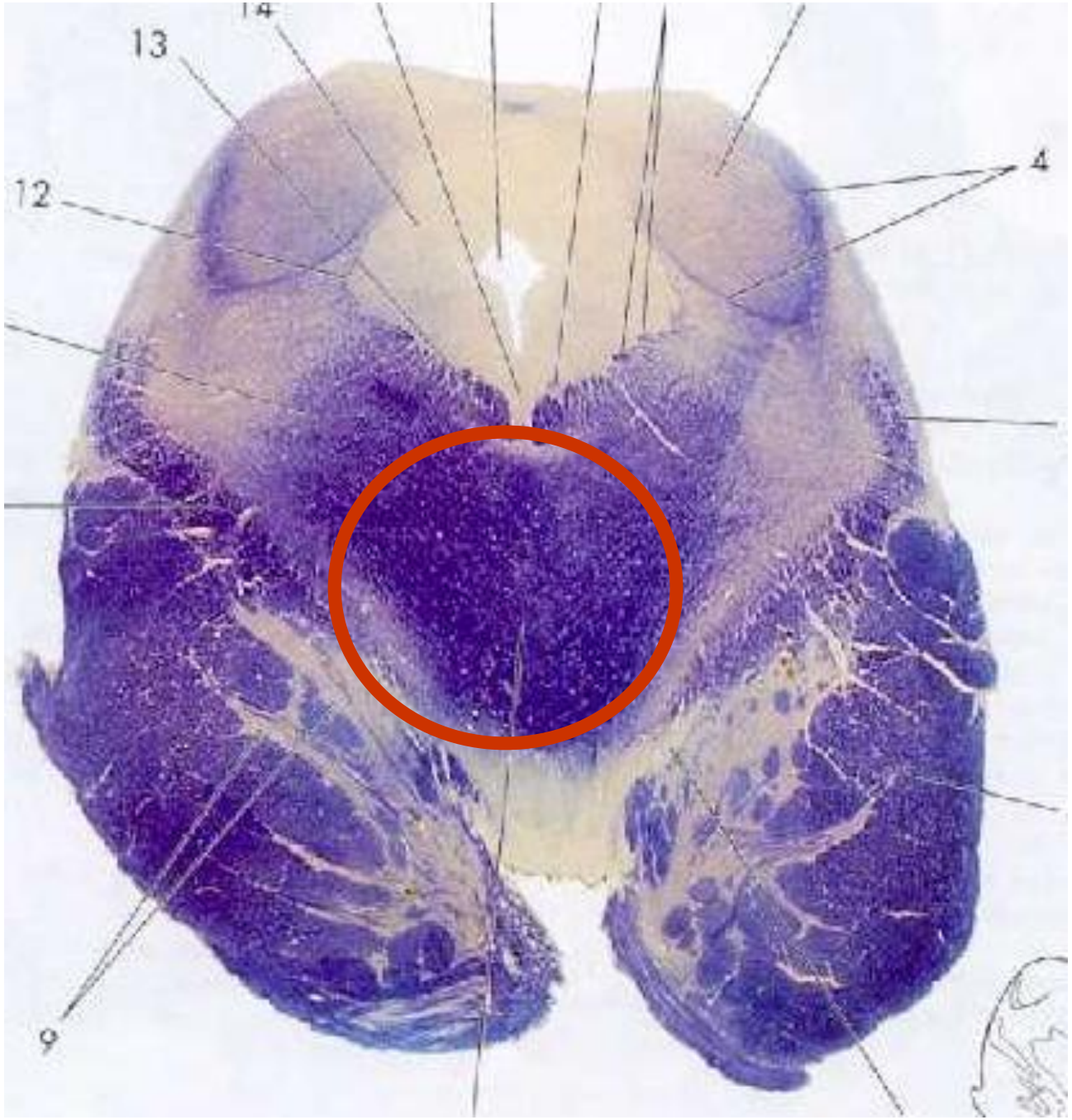
CEREBELLAR OUTPUTS



OBJ. # 7

- **Superior Cerebellar peduncle – decussates in the caudal midbrain**
  - Thalamus VA/VL ----- Motor cortex (contralateral)
    - To influence the corticospinal tracts
  - Red Nucleus (contralateral)

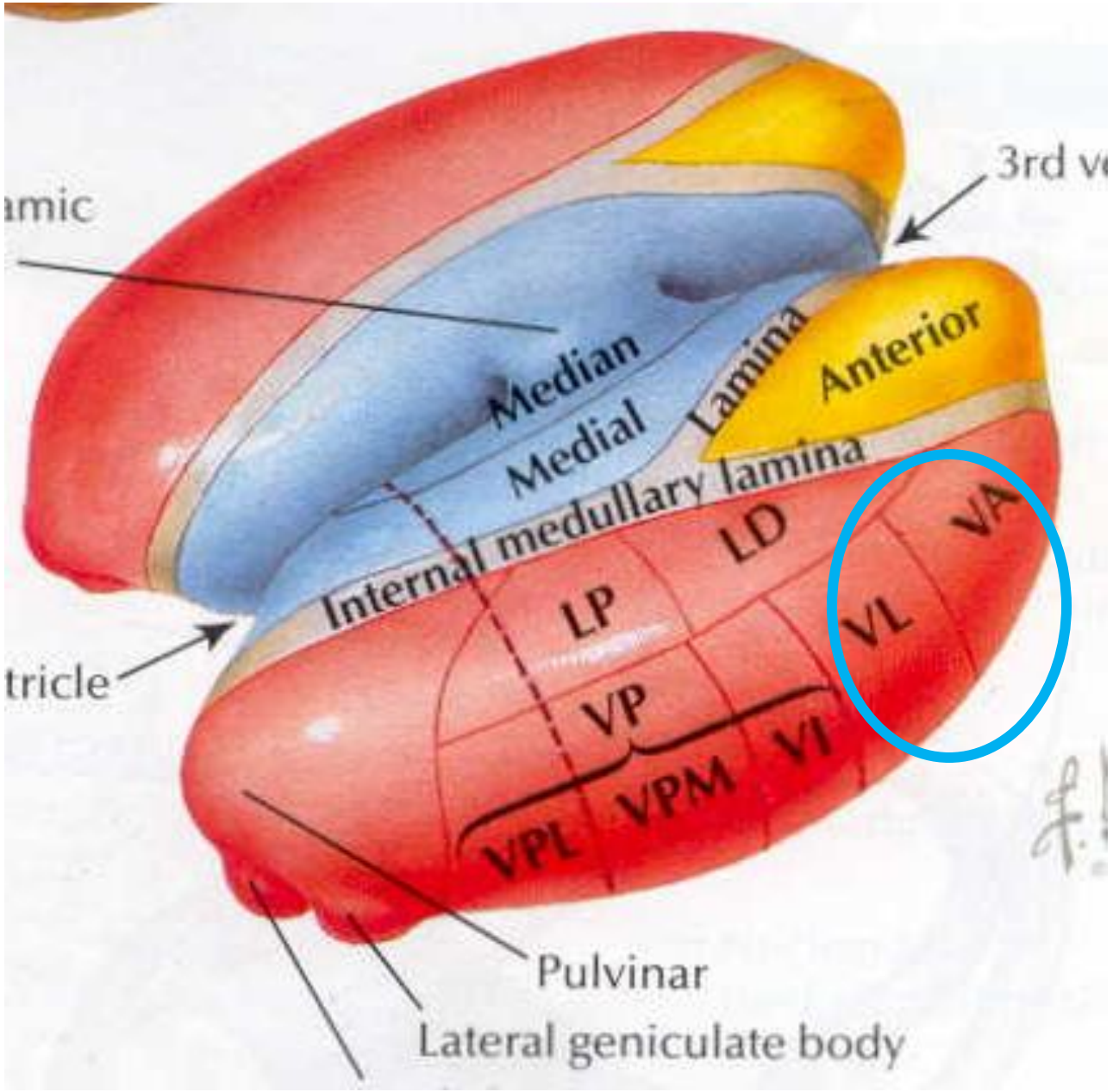
- **Inferior Cerebellar peduncle** (ipsilateral)
  - To reticular formation
    - To influence reticulo-spinal tracts
  - **To vestibular nuclei**
    - To influence vestibulo-spinal tracts and gaze centers



Superior Cerebellar Peduncles decussation

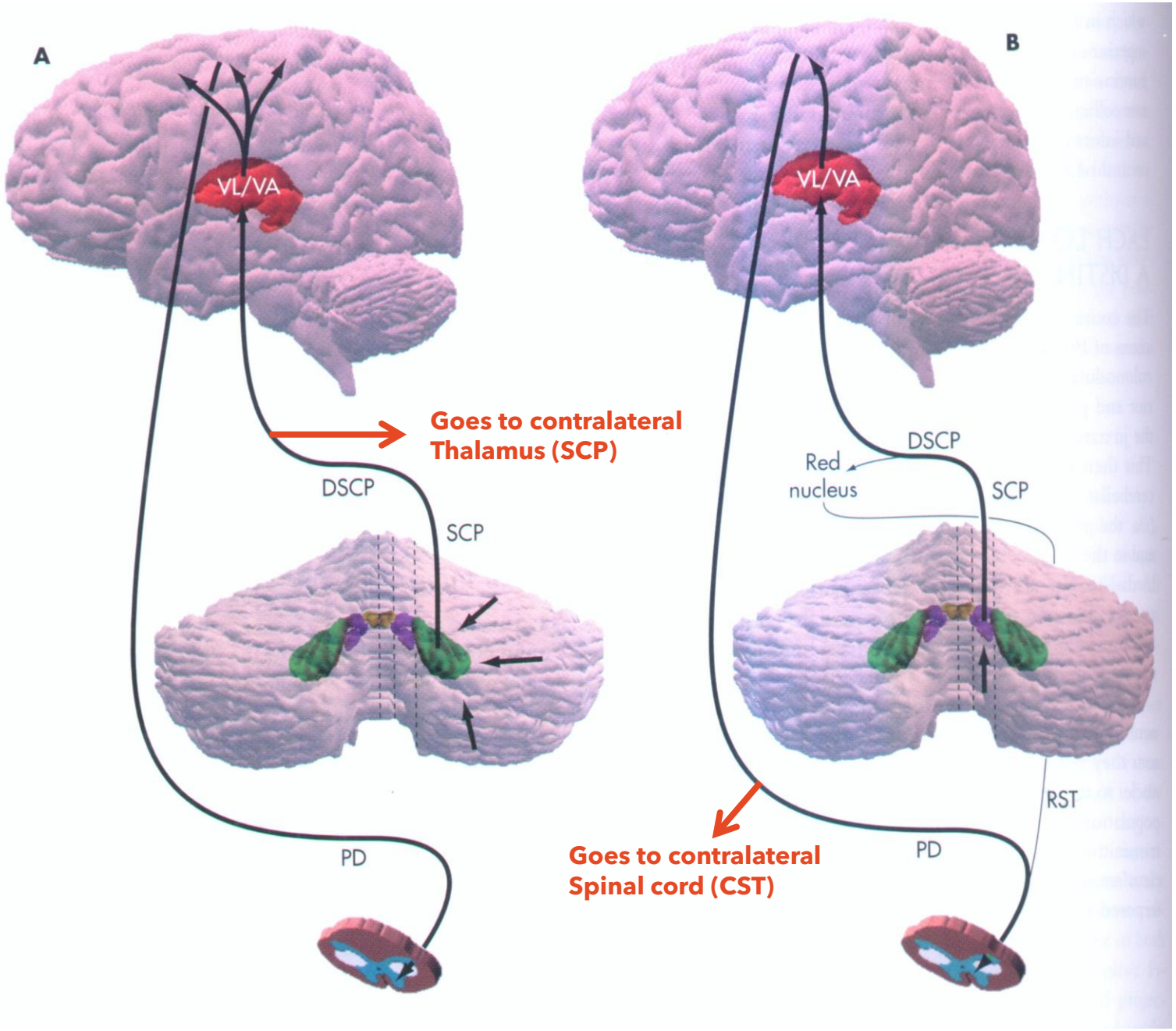
OBJ. # 7

OBJ. # 7



Thalamus

Clinical Correlates



Why do cerebellar lesions produce ipsilateral deficits?

OBJ. # 10

Cerebellar Lesions

Lack of motor coordination due to cerebellar damage is called ATAXIA

OBJ. # 8

ATAXIA = Inability to perform smooth, coordinated movements that result in irregularity and fragmentation of the normal motor sequence

Lesions to the cerebellum or cerebellar pathways produce different type of abnormalities:

- Incoordination or ataxia
- Intention tremor
- Disorders of equilibrium and gait
- Decreased muscle tone
- Scanning dysarthria
- Stability of eye movements is affected – nystagmus
- Frequently nausea and vomiting are present

Ataxic Movements

Appendicular ataxia

OBJ. # 8

Dysmetria / past pointing
- Finger-nose-finger test
- Heel-shin test

→ Wavering movement with over- or undershooting

Dysrhythmia
- Precision finger tapping
- Tapping on the floor

→ Abnormal timing of movement

Dysdiadochokinesia / Adiadochokinesia

→ Abnormal coordination of Rapid alternating movements

Ataxic Movements

Gait is Wide-based, unsteady with tendency to fall towards lesioned side

- Make the patient walk → Observe the gait
- Tandem gait impaired → Patient will fall or deviate towards one side

OBJ. # 8

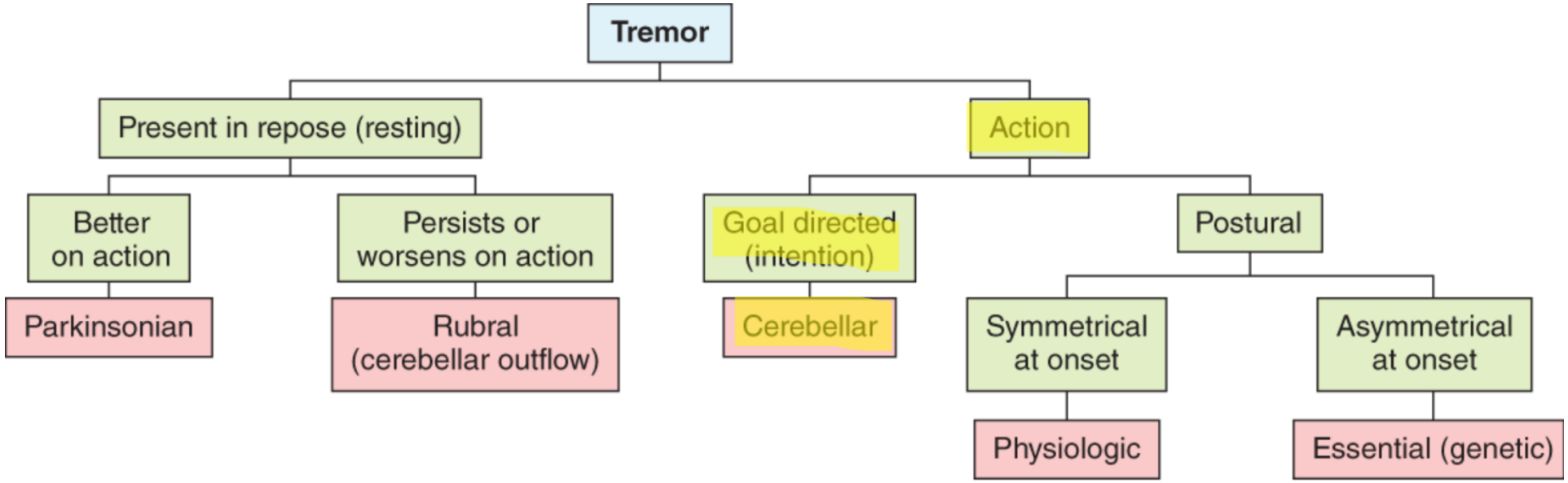
- Romberg → Patient is unable to maintain position with eyes open *or* closed. This is technically a negative Romberg test.

Differential Diagnosis of Tremor

OBJ. # 9

There are basically 2 types of tremors:

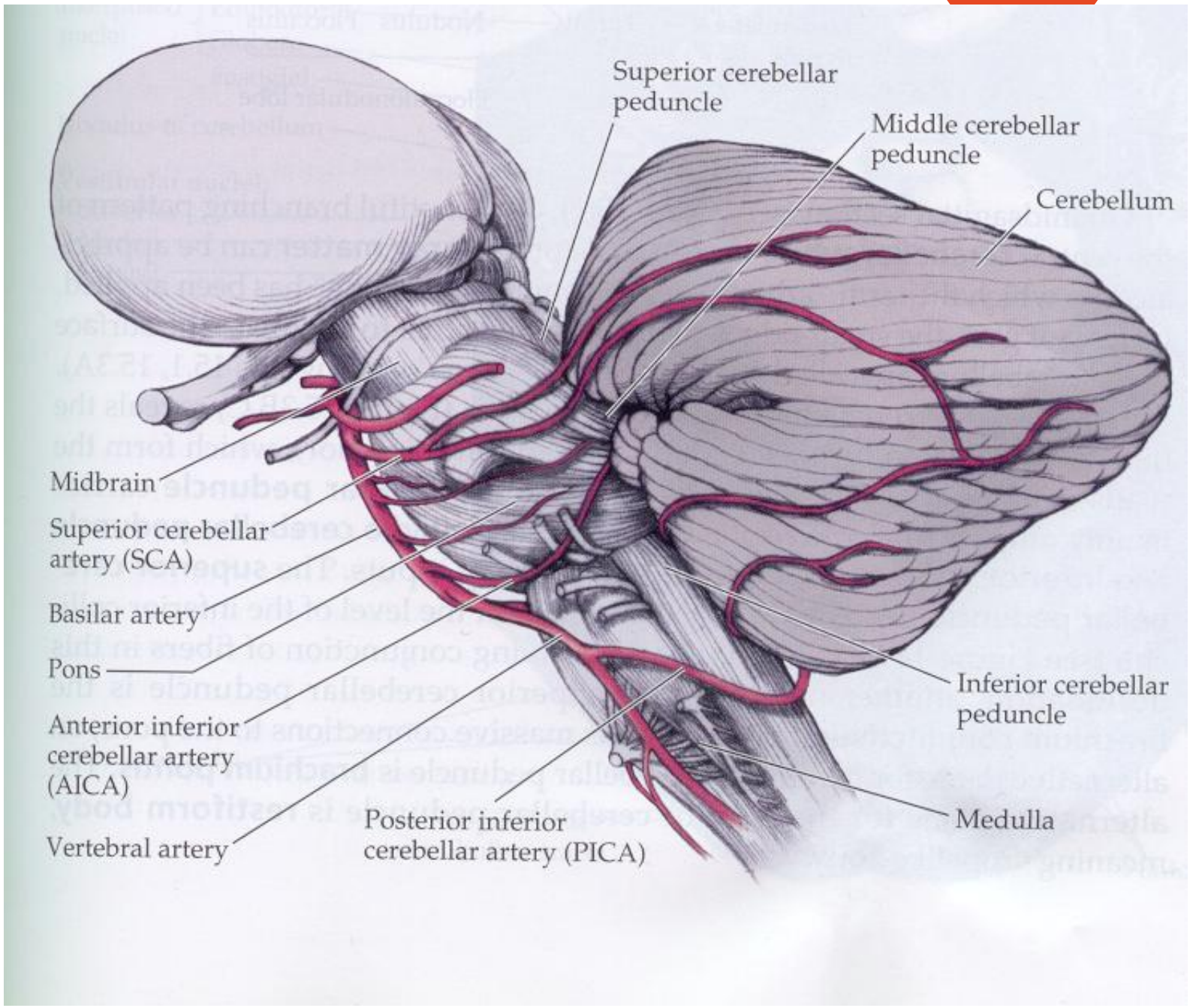
- Action tremor
- Repose (resting) tremor



From: Part 2. Cardinal Manifestations of Neurologic Disease
Adams and Victor's Principles of Neurology, 10e, 2014

Vascular Supply

OBJ. # 10



Cerebellar Infarcts

OBJ. # 10

3 main arteries that supply the cerebellum:

- Superior cerebellar artery
- Anterior inferior cerebellar artery (AICA)
- Posterior inferior cerebellar artery (PICA)

* Brainstem supply is variable for each of these arteries as some brainstem structures receive more supply from basilar perforating branches

Primary symptoms include:

- Vertigo
- Dizziness
- Nausea and Vomiting
- Gait unsteadiness
- Limb clumbsiness
- Headache
- Dysarthria
- Diplopia

Vascular Supply

OBJ. # 10

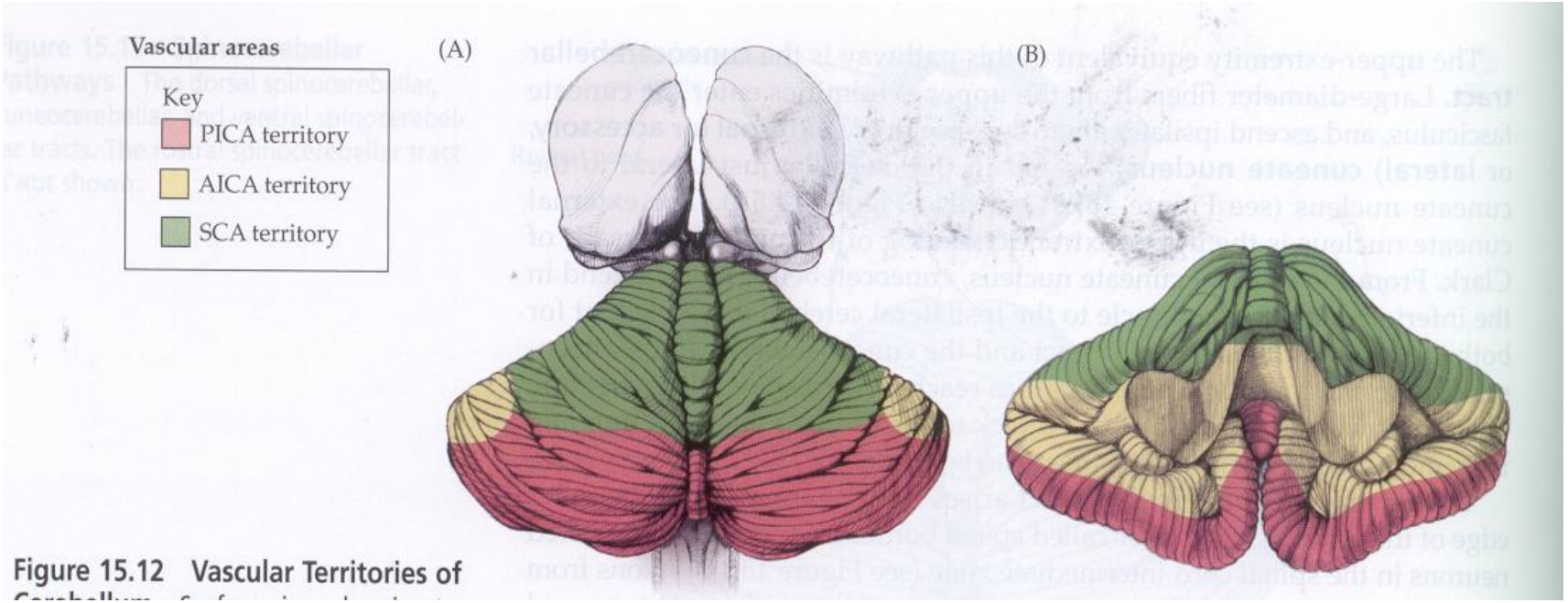


Figure 15.12 Vascular Territories of

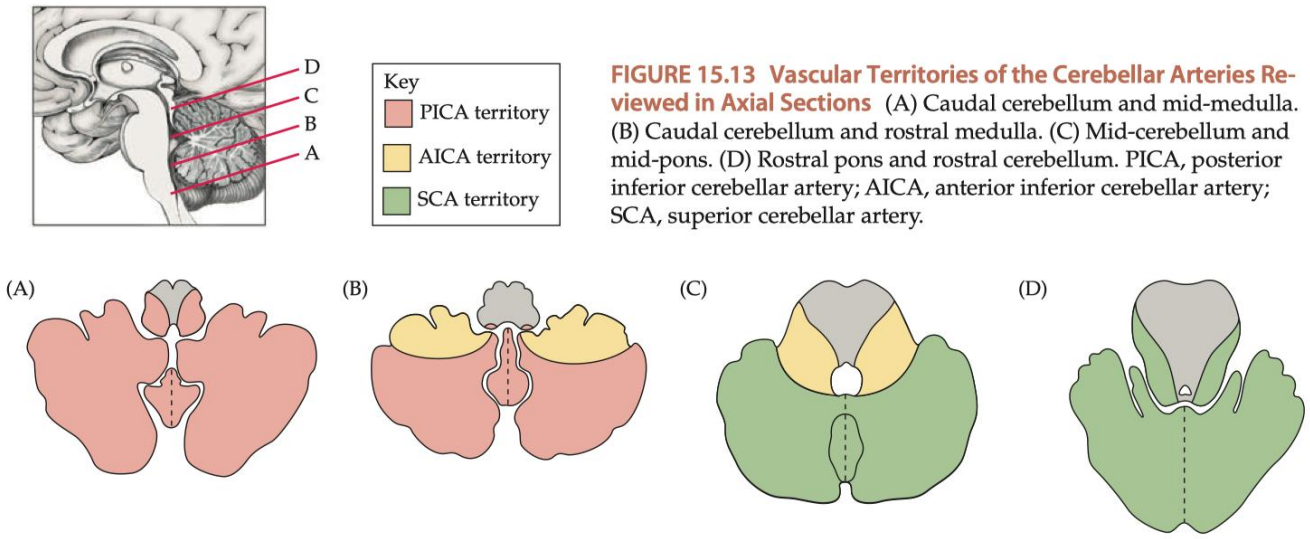


FIGURE 15.13 Vascular Territories of the Cerebellar Arteries Reviewed in Axial Sections (A) Caudal cerebellum and mid-medulla. (B) Caudal cerebellum and rostral medulla. (C) Mid-cerebellum and mid-pons. (D) Rostral pons and rostral cerebellum. PICA, posterior inferior cerebellar artery; AICA, anterior inferior cerebellar artery; SCA, superior cerebellar artery.

Cerebellar Infarcts

OBJ. # 10

It is difficult to localize cerebellar strokes between the three cerebellar arteries:

- They provide variable blood supply to the cerebellum
- Brainstem involvement is variable due to basilar artery perforating branches

Symptoms that can be common to SCA, AICA, PICA syndromes:

- Ipsilateral ataxia
- Dysarthria
- Ipsilateral Horner's syndrome
- Ipsilateral facial pain/temp loss
- Contralateral body pain/temp loss

Symptoms suggestive of AICA:

- Ipsilateral hearing loss (CN VIII)
- Ipsilateral facial paralysis

Symptoms suggestive of SCA:

- Contralateral hearing loss (crossing fibers of lateral lemniscus)
- Contralateral 4th nerve palsy
- Relative lack of vertigo/nausea

Cerebellar Disorders Etiology

OBJ. # 11

Acute Ataxia

- Toxic
- Ischemic stroke
- Hemorrhagic stroke
- Traumatic hematoma
- Multiple Sclerosis
- Infections / brain abscess
- Para-neoplastic syndrome

Chronic Ataxia

- Cerebellar metastasis: lung and breast carcinomas, melanomas
- Multiple sclerosis
- Chronic ingestion of toxics
- Degenerative disorders
- Genetic ataxias