CNS Module

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Cerebellum

Cerebellum

- **By the end of this session, you should be able to :**

1. Identify external features of cerebellum
2. Enumerate neurons, fibers, nuclei and layers of cerebellum
3. Identify connections of cerebellum
4. Identify clinical application

Cerebellum

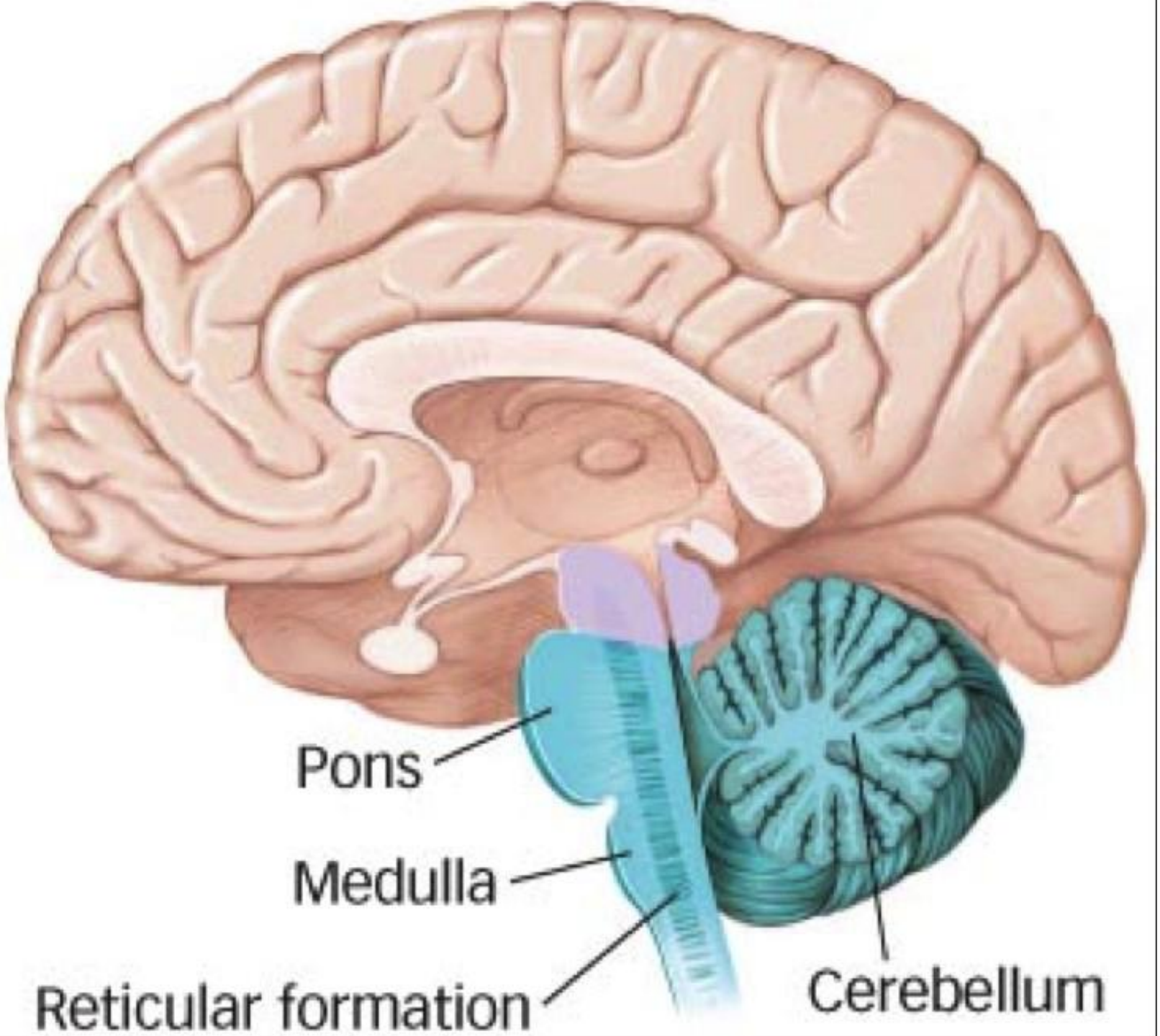
- The term cerebellum is from “Latin meaning” the little brain. It is a part of the hindbrain situated in the posterior cranial fossa.
- Only 10 % total volume of the brain but more than half of all its neurons.
- It is present behind the Pons and medulla oblongata , separated by fourth ventricle.

Cerebellum

- Position Located in the posterior cranial fossa, ***beneath*** the ***tentorium cerebelli*** and ***behind*** the ***pons*** and ***medulla***

- The cerebellum is ***extensively concerned with the processing of sensory information***.

- Although it has few ways to influence motor neurons directly, it is considered part of the motor system and ***concerned*** with ***equilibrium, muscle tone, postural control, and co-ordination of voluntary movements***

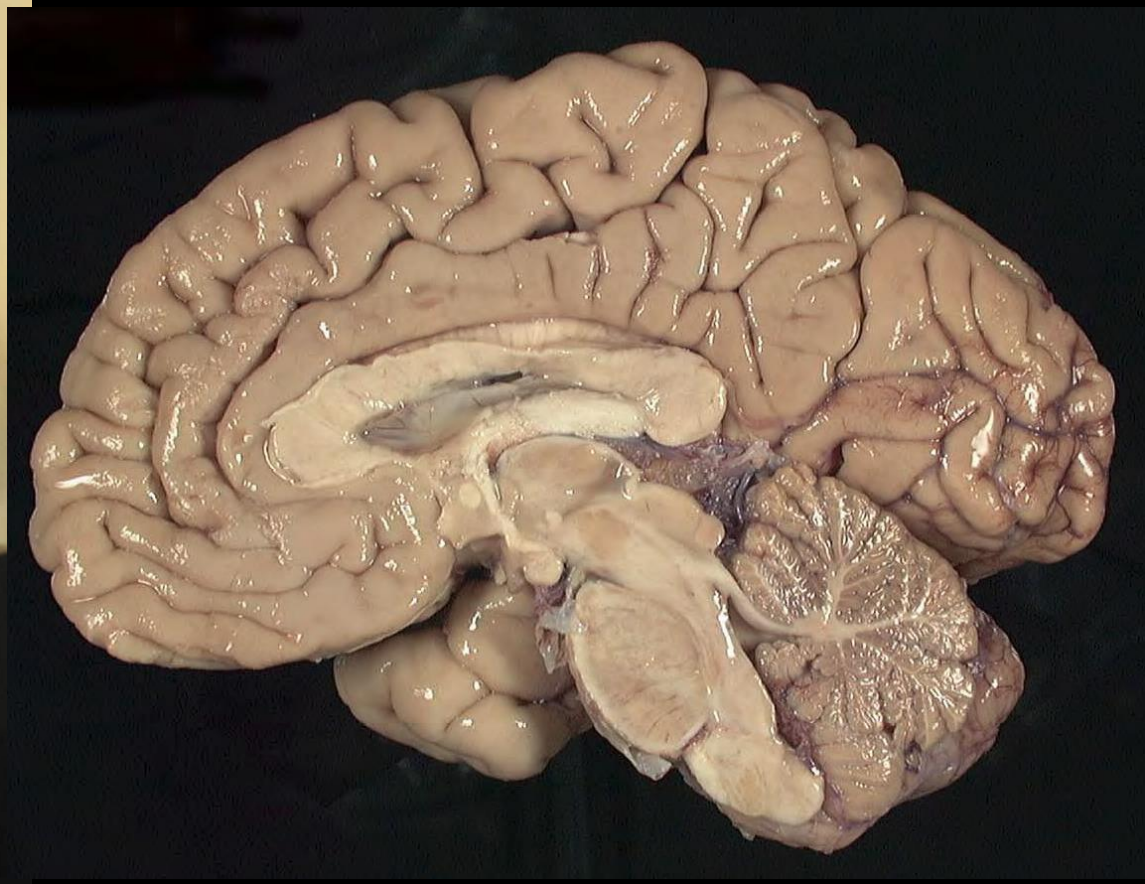

Pons
Medulla
Reticular formation
Cerebellum

Cerebellum

- It is the largest part of the hindbrain (10% of total weight) while in children the cerebellum forms 20% of the brain's weight

- It consists of two cerebellar hemispheres joined by a narrow median vermis.

- It's connected to brain stem by three **cerebellar peduncles**.



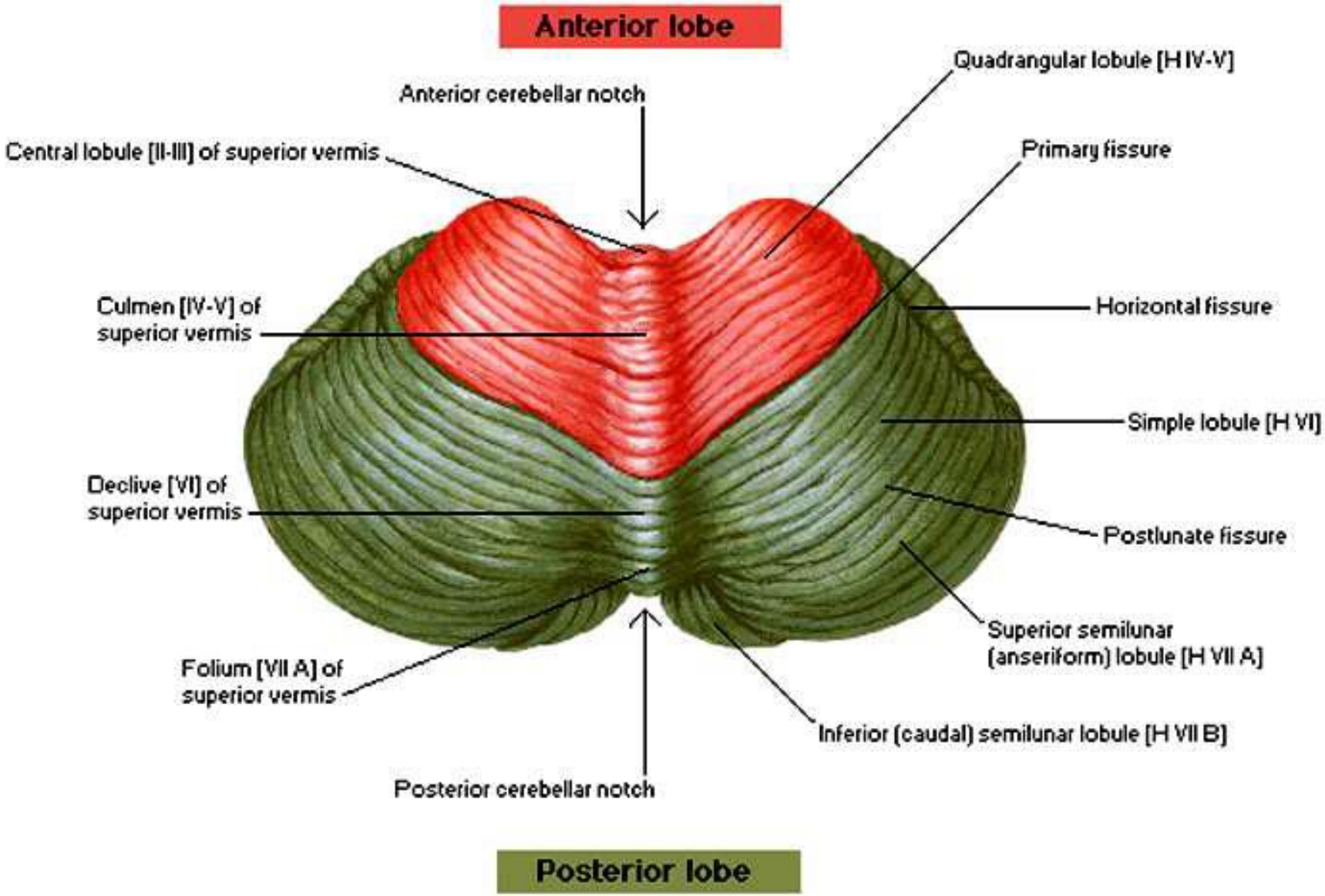
Surfaces

- The cerebellar surface is divided by numerous curve transverse fissures giving it a laminated appearance.

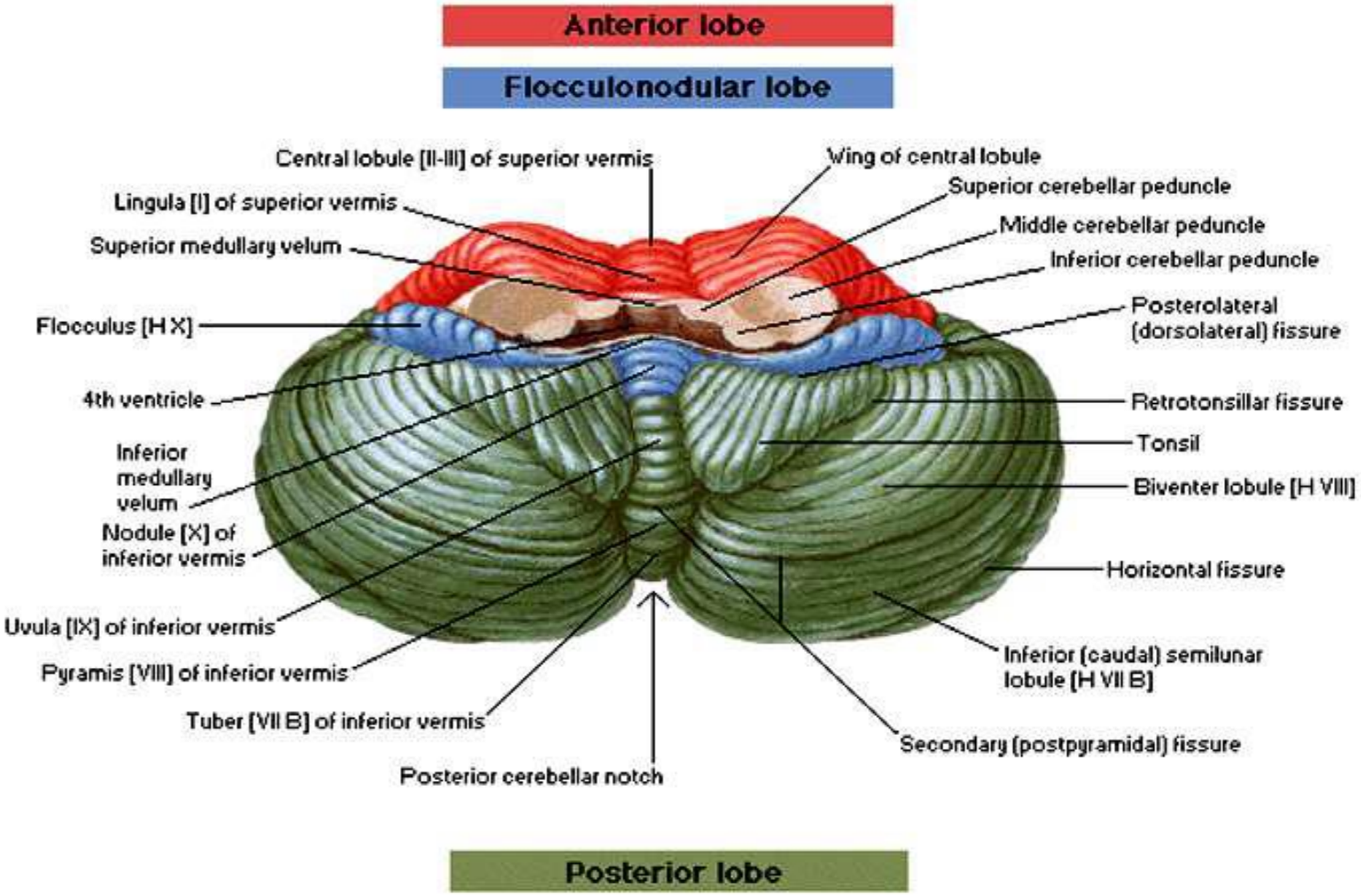
1. ***Superior surface (Tentorial)***
2. ***Inferior surface (Suboccipital)***
3. ***Anterior surface (Petrosal)***

Cerebellum

Superior Surface



Cerebellum
Inferior Surface



Cerebellum

- The cerebellum is divided into three main lobes: the ***anterior lobe***, the ***middle lobe***, (separated by a ***vermis***) and the ***flocculonodular*** lobe.

- The anterior lobe can be seen on the superior surface.

- It is separated from the ***POSTERIOR*** lobe by a wide V-shaped fissure called the ***primary fissure***.

Fissures

Primary fissure

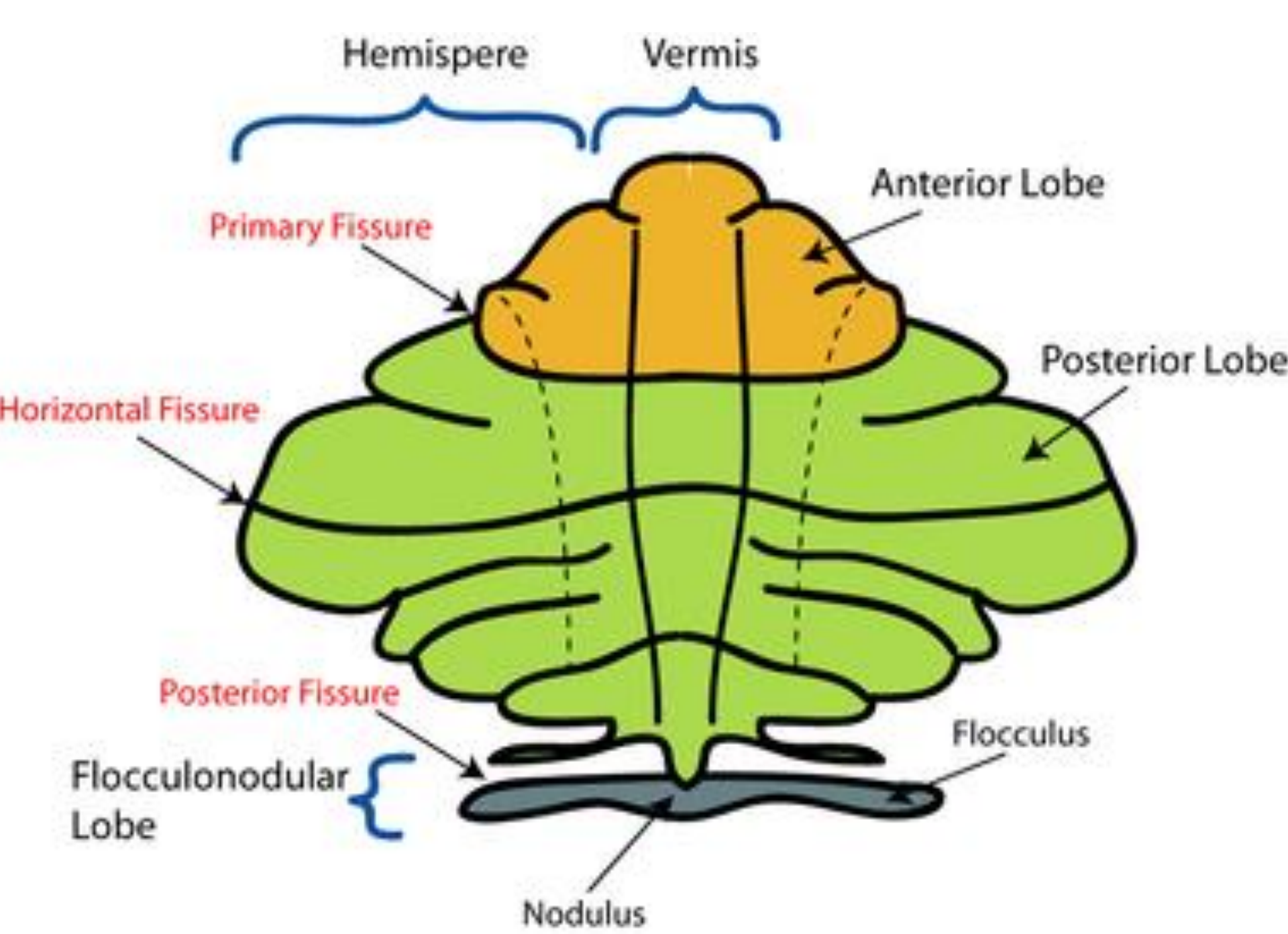
- V shaped.
- Separate the anterior lobe from the posterior lobe.

Horizontal fissure

- Deepest one.
- Separate the cerebellum to upper and lower portions.
- Of no morphologic or functional significance

Uvulonodular (Posterior) fissure

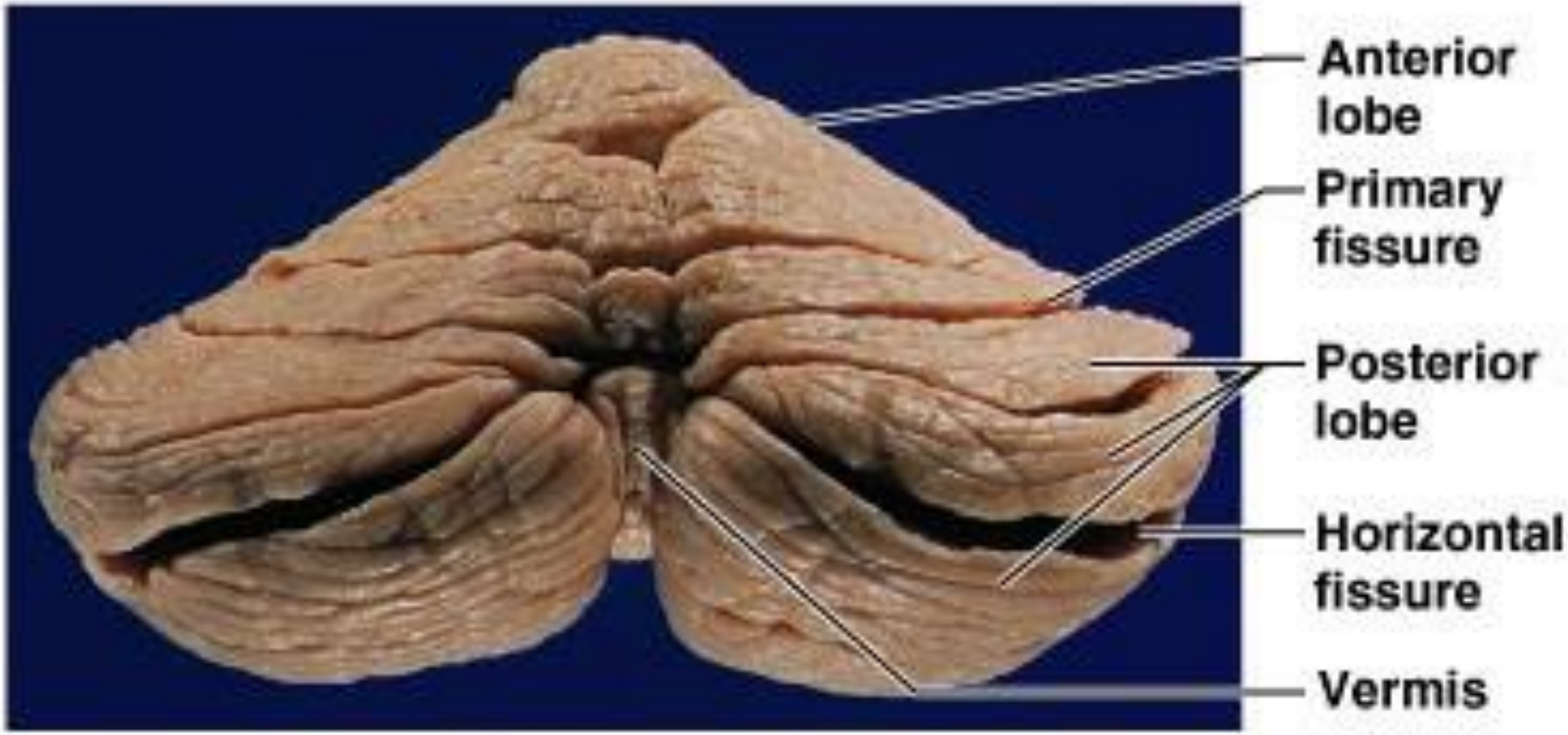
- Separate the ***POSTERIOR*** lobe from the flocculonodular lobe.


Hemispere
Vermis
Anterior Lobe
Primary Fissure
Posterior Lobe
Horizontal Fissure
Posterior Fissure
Flocculus
Flocculonodular Lobe
Nodulus

Cerebellum

- The ***posterior lobe***, which is the largest part of the cerebellum, is situated between the ***primary*** and ***uvulonodular fissures (Posterolateral fissure).***

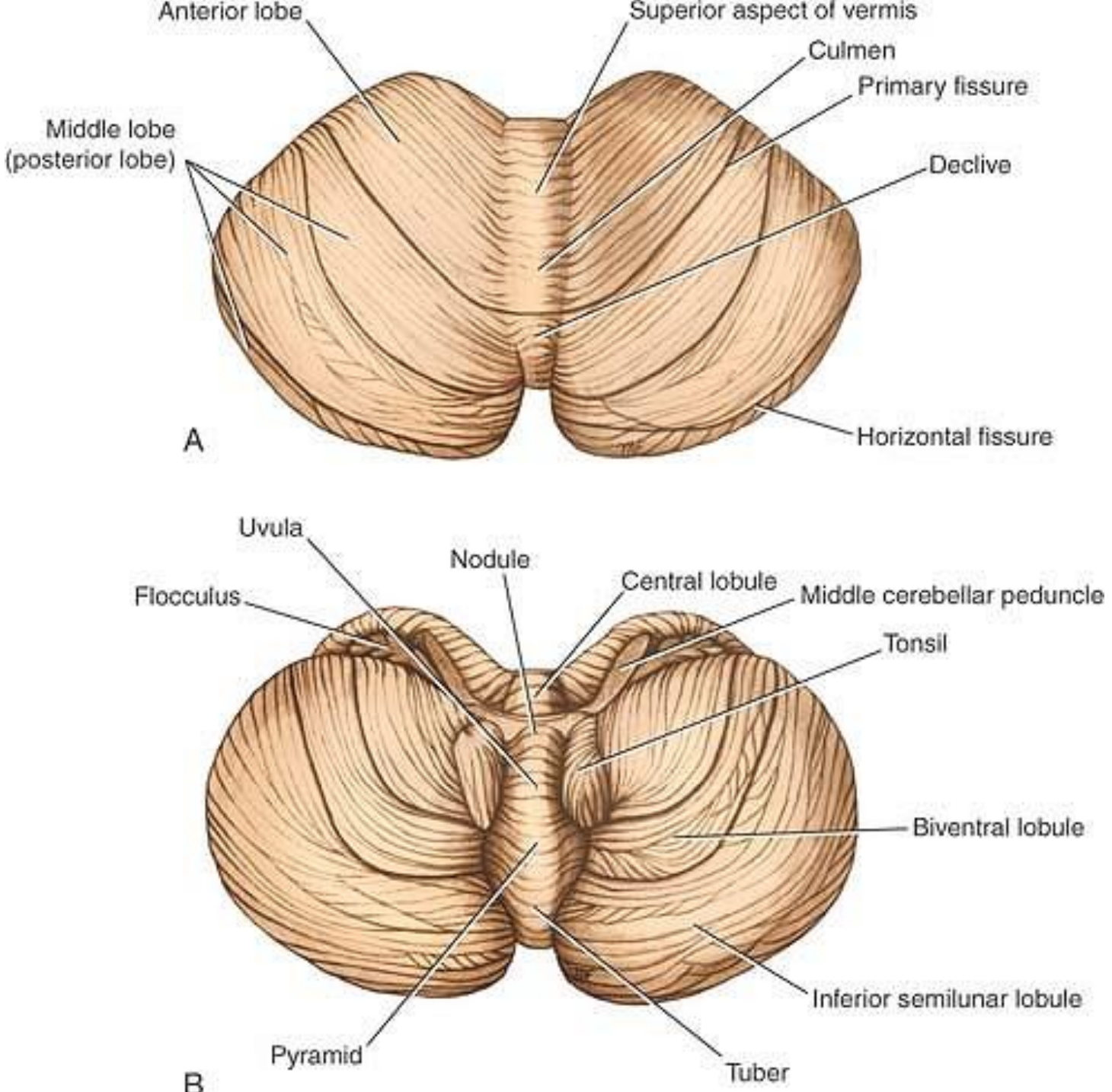
- The ***flocculonodular*** lobe is situated posterior to the uvulonodular fissure.

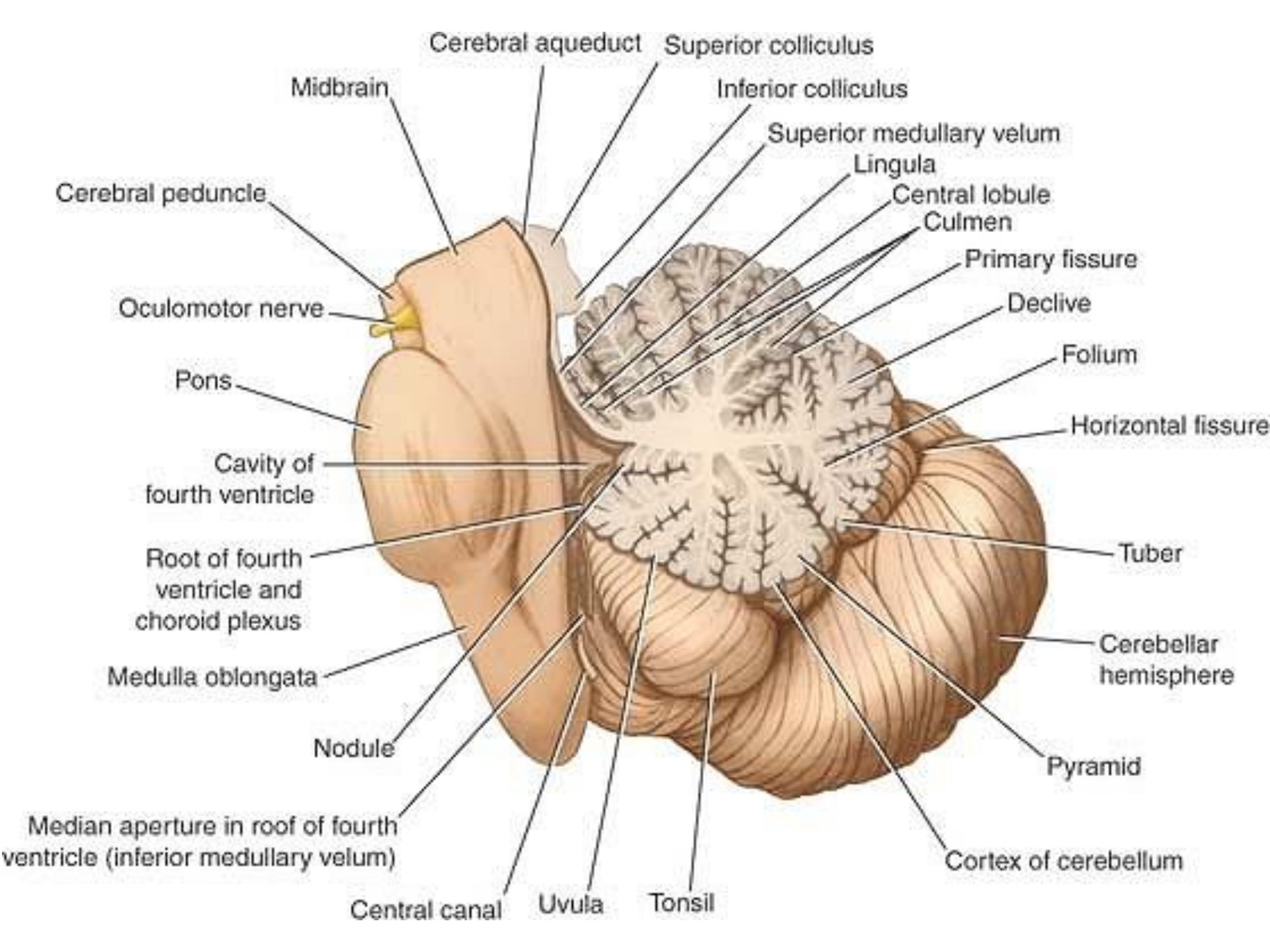


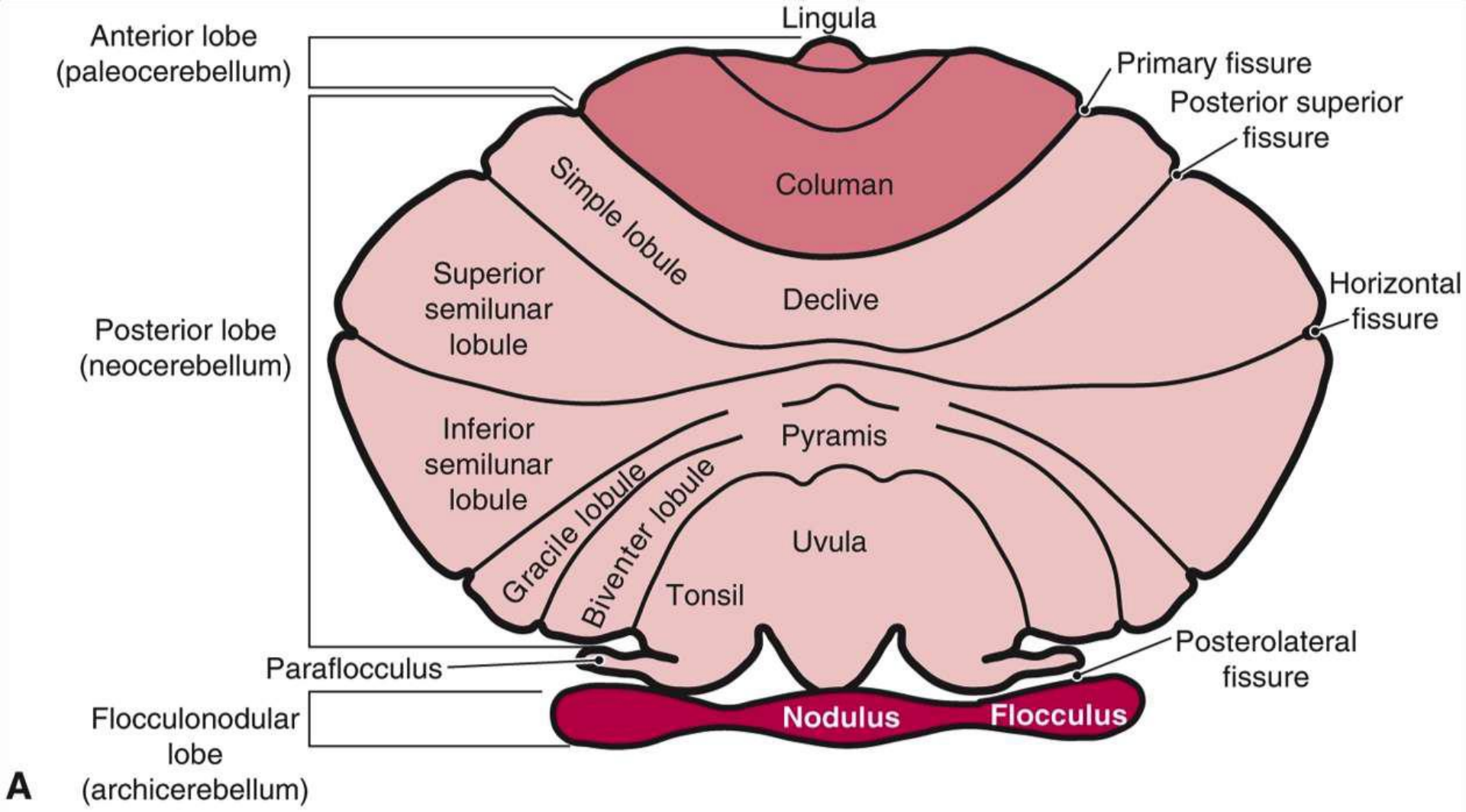
(b) Posterior view

Divisions of the Vermis

- ***Sup part of vermis***
  1. Lingula
  2. Culmen
  3. Declive
  4. Folium
- ***Inferior part of vermis***
  1. Tuber
  2. Pyramid
  3. Uvula
  4. Nodule


Anterior lobe
Superior aspect of vermis
Culmen
Primary fissure
Middle lobe
(posterior lobe)
Declive
Horizontal fissure
A
Uvula
Nodule
Central lobule
Middle cerebellar peduncle
Flocculus
Tonsil
Biventral lobule
Inferior semilunar lobule
Pyramid
Tuber
B


Cerebral aqueduct
Superior colliculus
Midbrain
Inferior colliculus
Superior medullary velum
Lingula
Cerebral peduncle
Central lobule
Culmen
Primary fissure
Oculomotor nerve
Declive
Folium
Pons
Horizontal fissure
Cavity of fourth ventricle
Root of fourth ventricle and choroid plexus
Tuber
Medulla oblongata
Cerebellar hemisphere
Nodule
Pyramid
Median aperture in roof of fourth ventricle (inferior medullary velum)
Cortex of cerebellum
Central canal
Uvula
Tonsil

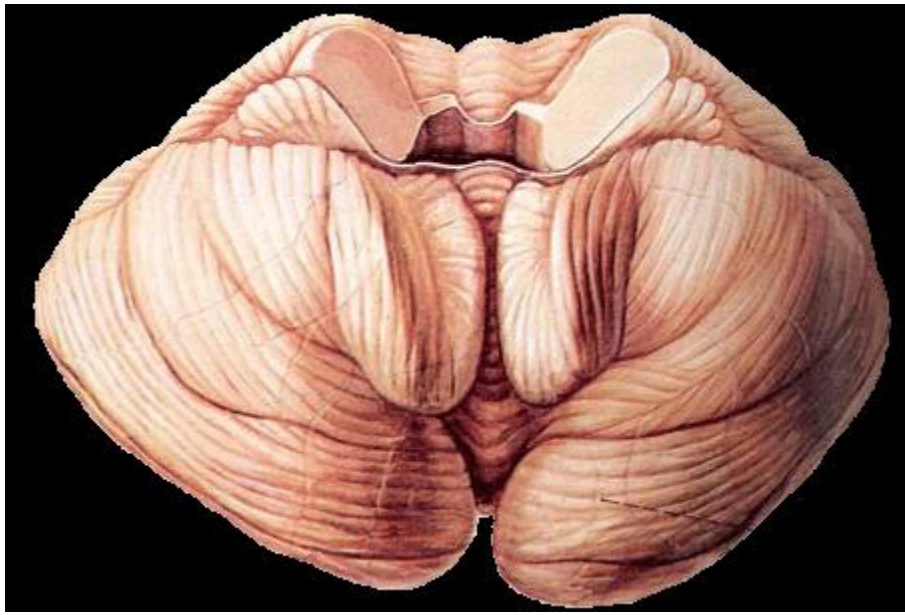


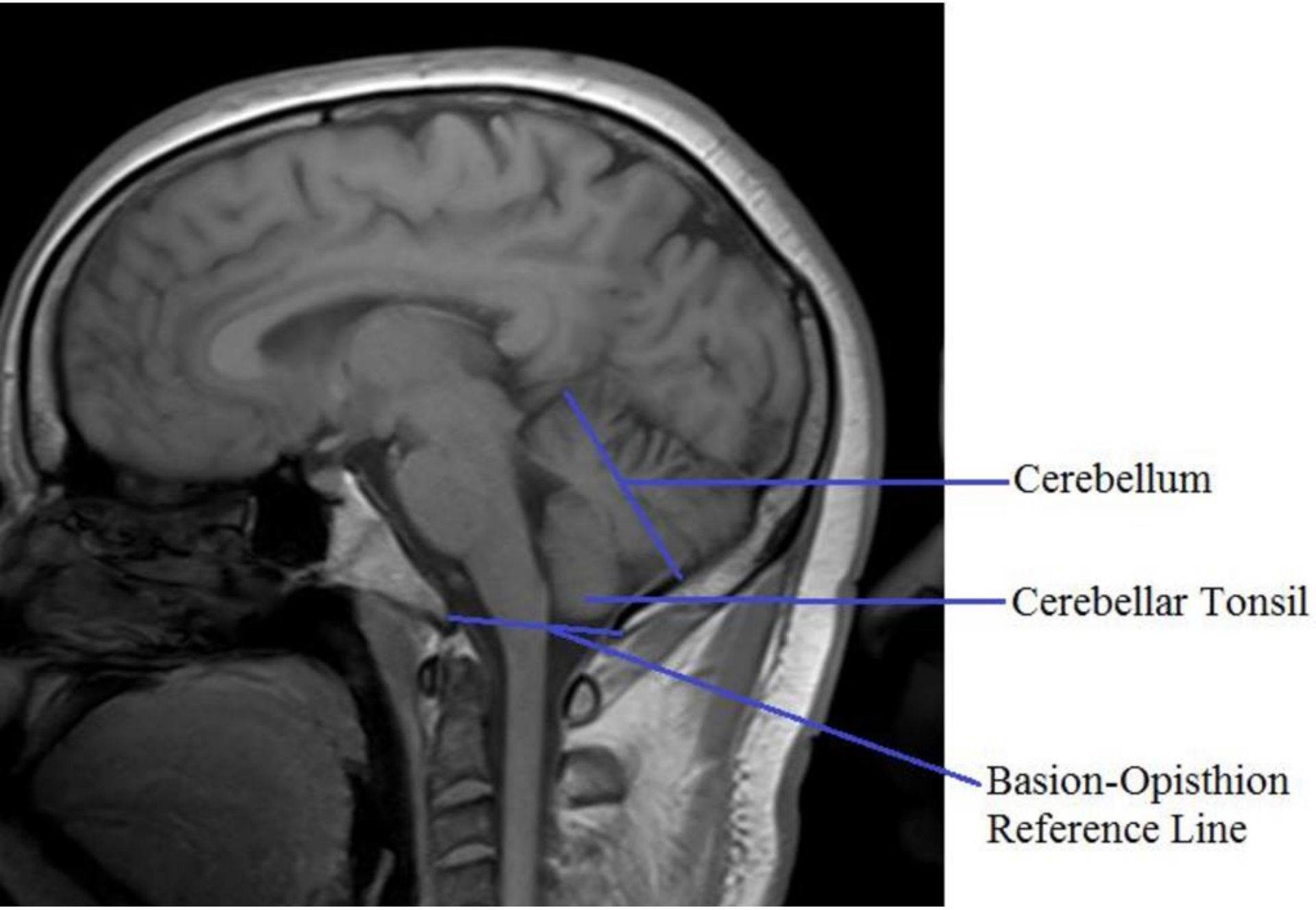
A

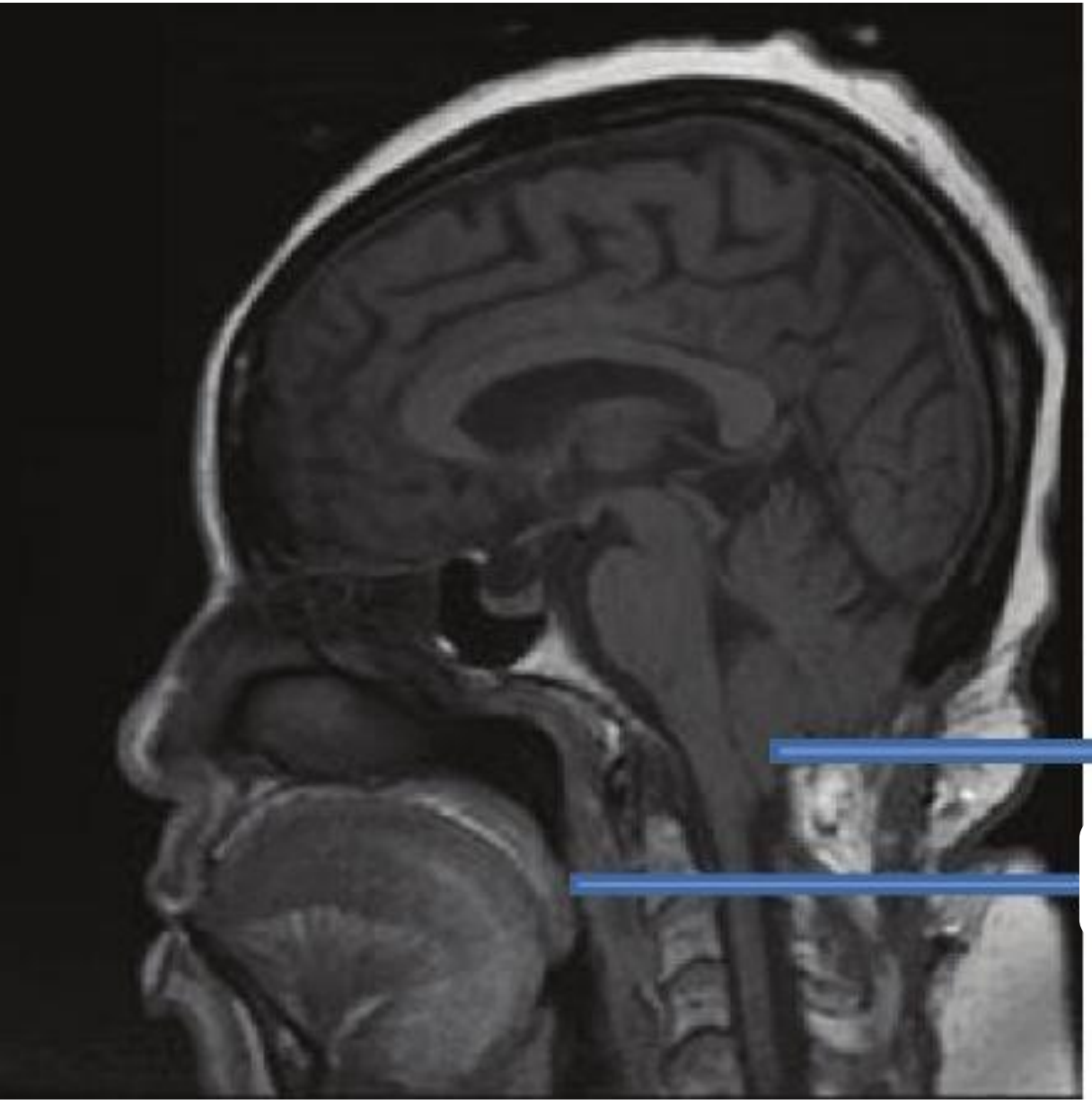
External Features

Tonsil of cerebellum

- Two elevated masses on inferior surface of hemispheric portion just nearby foramen magnum and may project through it




Cerebellum
Cerebellar Tonsil
Basion-Opisthion
Reference Line


Cerebellar tonsillar herniation


Hp
C.E cm
base

Internal Structure

- ***Outer gray matter*** called cerebral cortex, extensively folded forming folia, about 15% of the cortex is exposed to the outer surface, where as 85% faces the sulcal surfaces between the folia.

- ***Inner white matter***, showing distinctive treelike pattern called Arbor vitae

- 4 pairs of nuclei within white matter ,the deep cerebral nuclei

Arbor Vitae

- In Latin " ***tree of life***" it is so called because of the tree like appearance.
- It is the white matter of the cerebellum.
- It brings sensory and motor sensation to and from cerebellum.

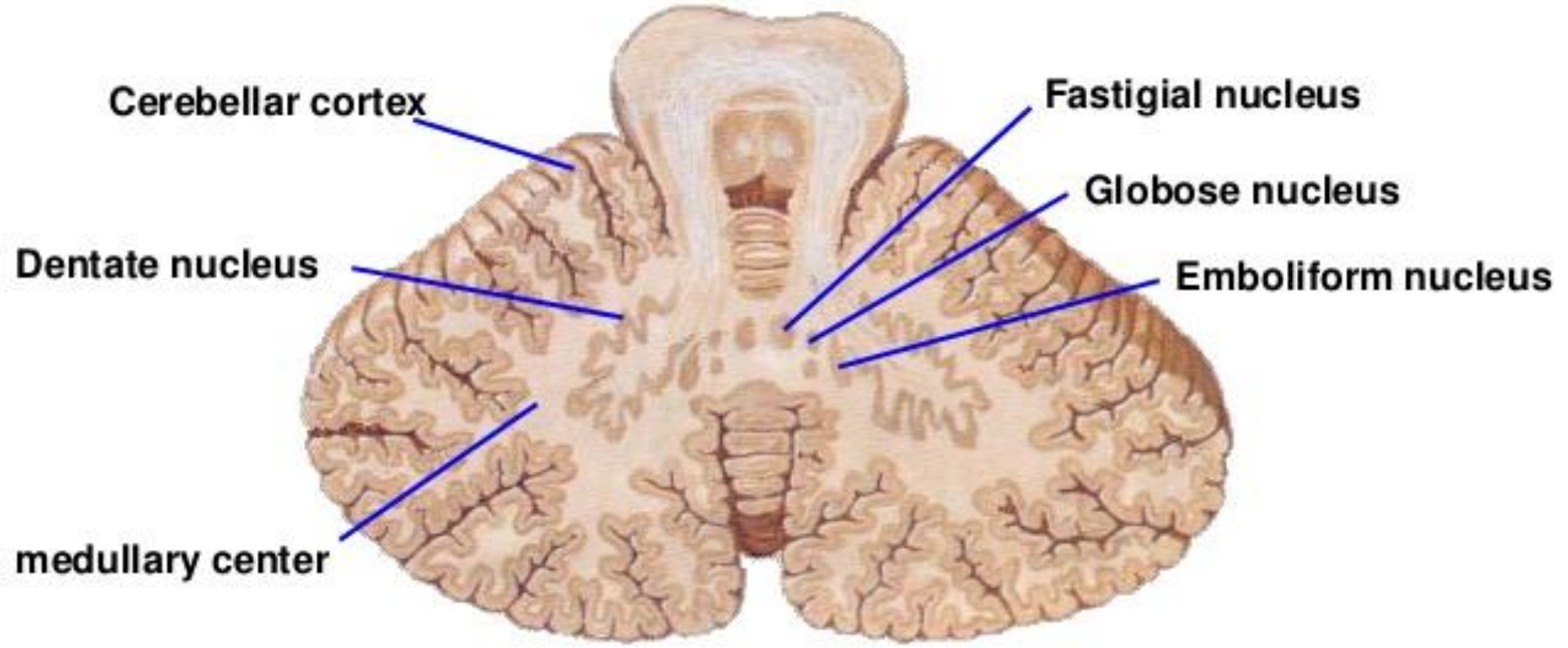
Deep Cerebellar nuclei

- ***4 Nuclei on each side***

From medial to lateral, they are known as:

1. Fastigial Nuclei
2. Globose Nucleus
3. Emboliform Nucleus
4. Dentate Nucleus

- **Constitute the primary source of efferent fibers from the cerebellum to the other part of the brain.**

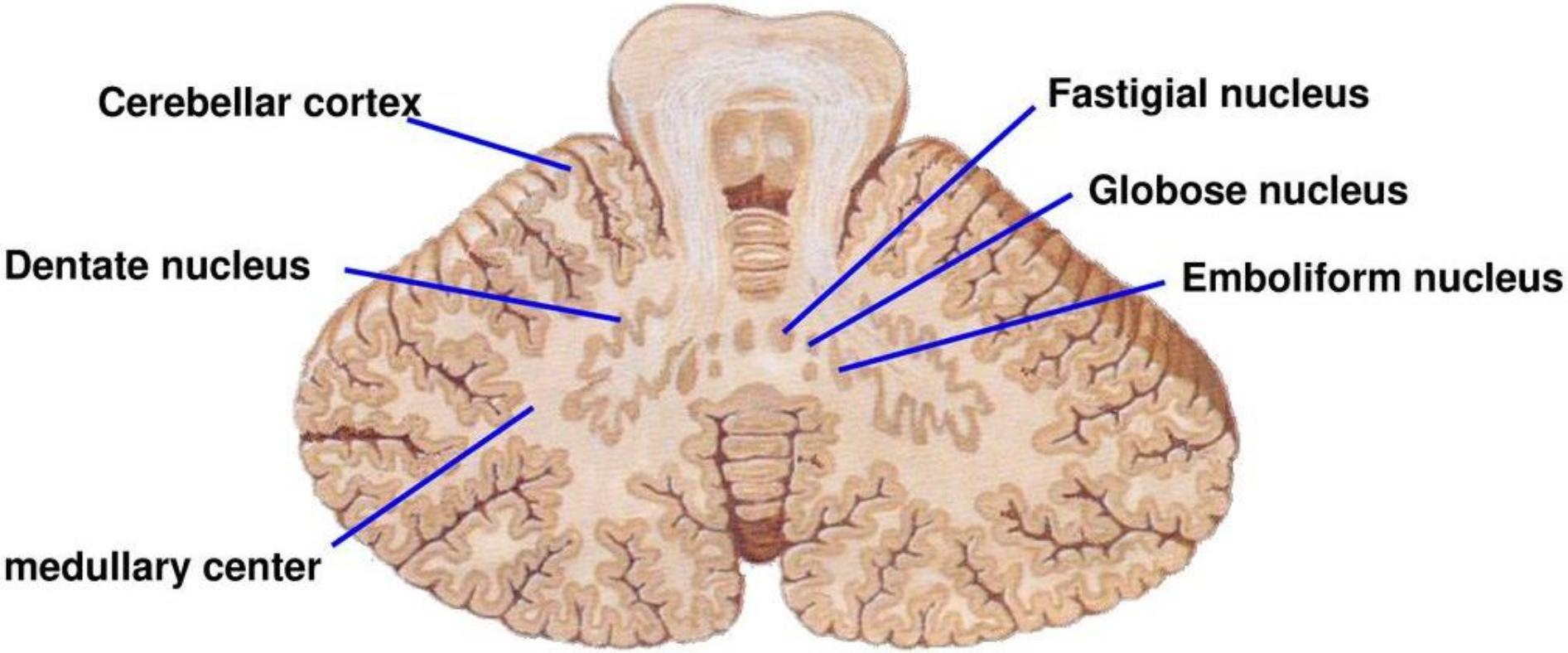

Cerebellar cortex
Fastigial nucleus
Globose nucleus
Dentate nucleus
Emboliform nucleus
medullary center

Deep Nuclei

- ***Dentate***
  - Fine movement
  - Most efferent fibers go through superior cerebellar peduncle ***towards the thalamus***

- ***Globose + Emboliform (interposed nucleus)***
  - Segmental reflexes, speeds the initiation of movements triggered by somatosensory cues that guide the response, stops unwanted and promotes wanted oscillations, stabilizes holds

- ***Fastigial***
  - Stance and gait, controls muscles only in the modes of sitting, standing, and walking
  - Situated near the midline at the anterior end of superior vermis


Cerebellar cortex
Fastigial nucleus
Globose nucleus
Dentate nucleus
Emboliform nucleus
medullary center

Peduncles

Three symmetrical bundles of nerve fibers called the ***superior***, ***middle***, and ***inferior cerebellar peduncles***

1. ***Superior cerebellar peduncle :***

a) Connects to midbrain.

b) Contains efferent fiber systems extending to red nucleus and thalamus.

Peduncles

2. ***Middle cerebellar peduncle :***

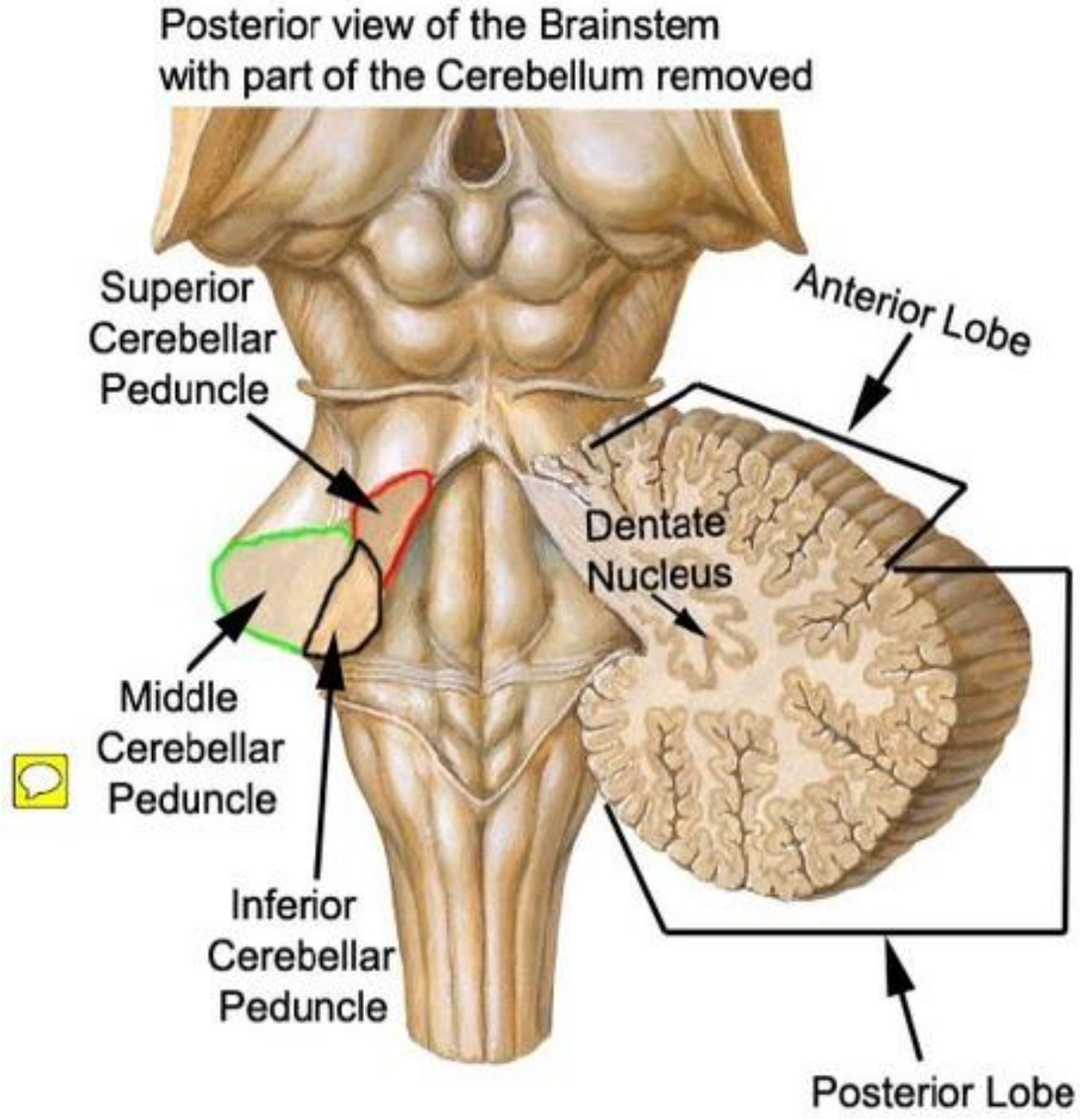
a) Connects to pons

b) Contains fiber mass originating from pontine nuclei and represent continuation of corticopontine tracts.

3. ***Inferior cerebellar peduncle :***

a) Connects to medulla.

b) Contains spinocerebellar tracts and connections to vestibular nuclei.


Posterior view of the Brainstem
with part of the Cerebellum removed
Superior
Cerebellar
Peduncle
Anterior Lobe
Dentate
Nucleus
Middle
Cerebellar
Peduncle
Inferior
Cerebellar
Peduncle
Posterior Lobe

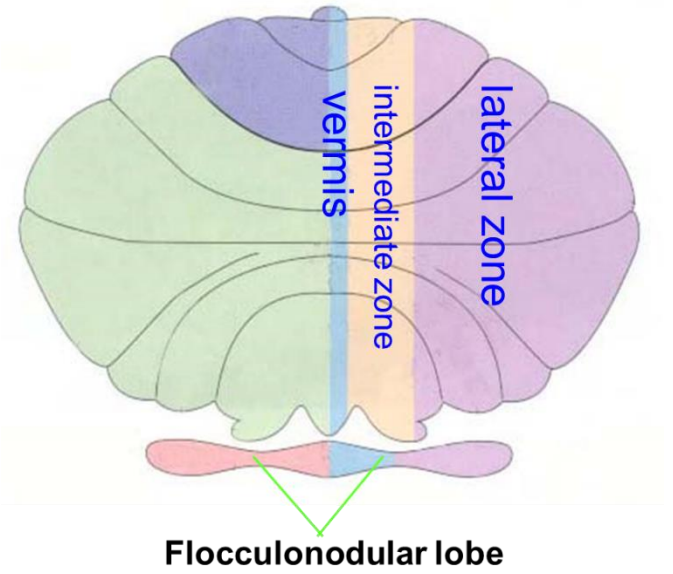
Functional Subdivisions of Cerebellum

- Functionally, the Cerebellum is also divided into 3 longitudinal zones:

- Archicerebellum (***Flocculonodular lobe***)

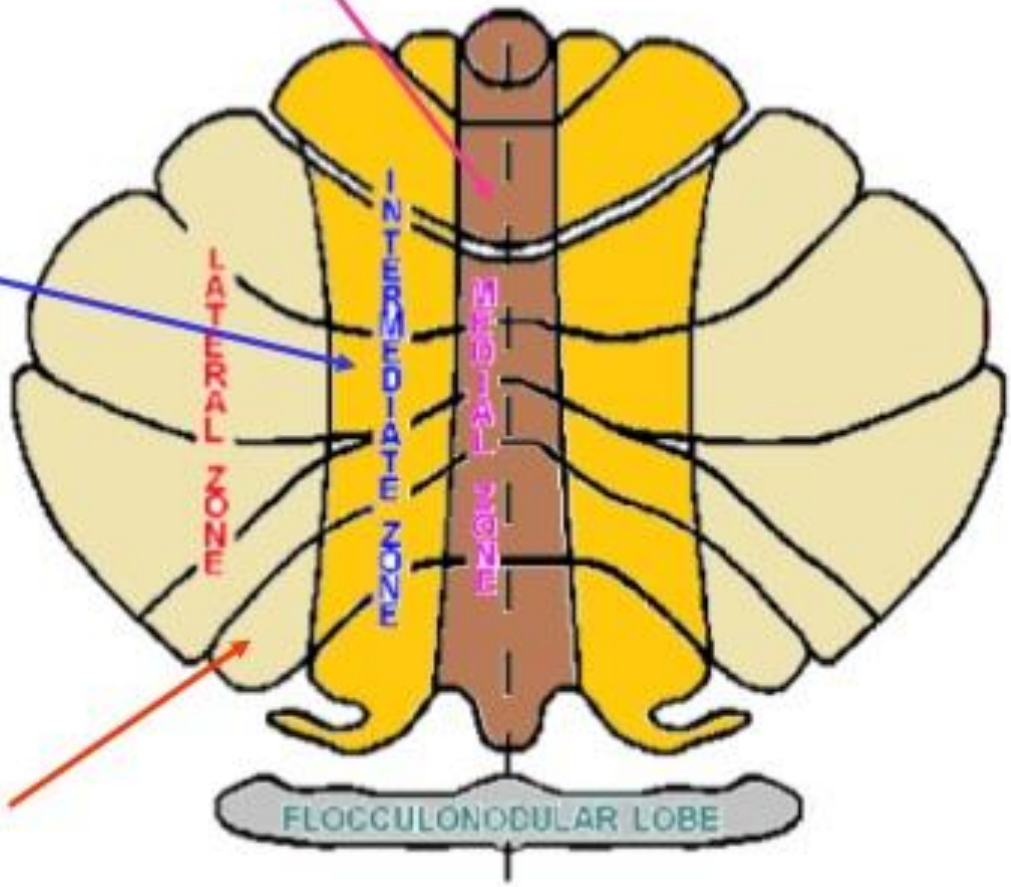
- Paleocerebellum (***Vermis and intermediate zone***)

- Neocerebellum (***Lateral zone***)



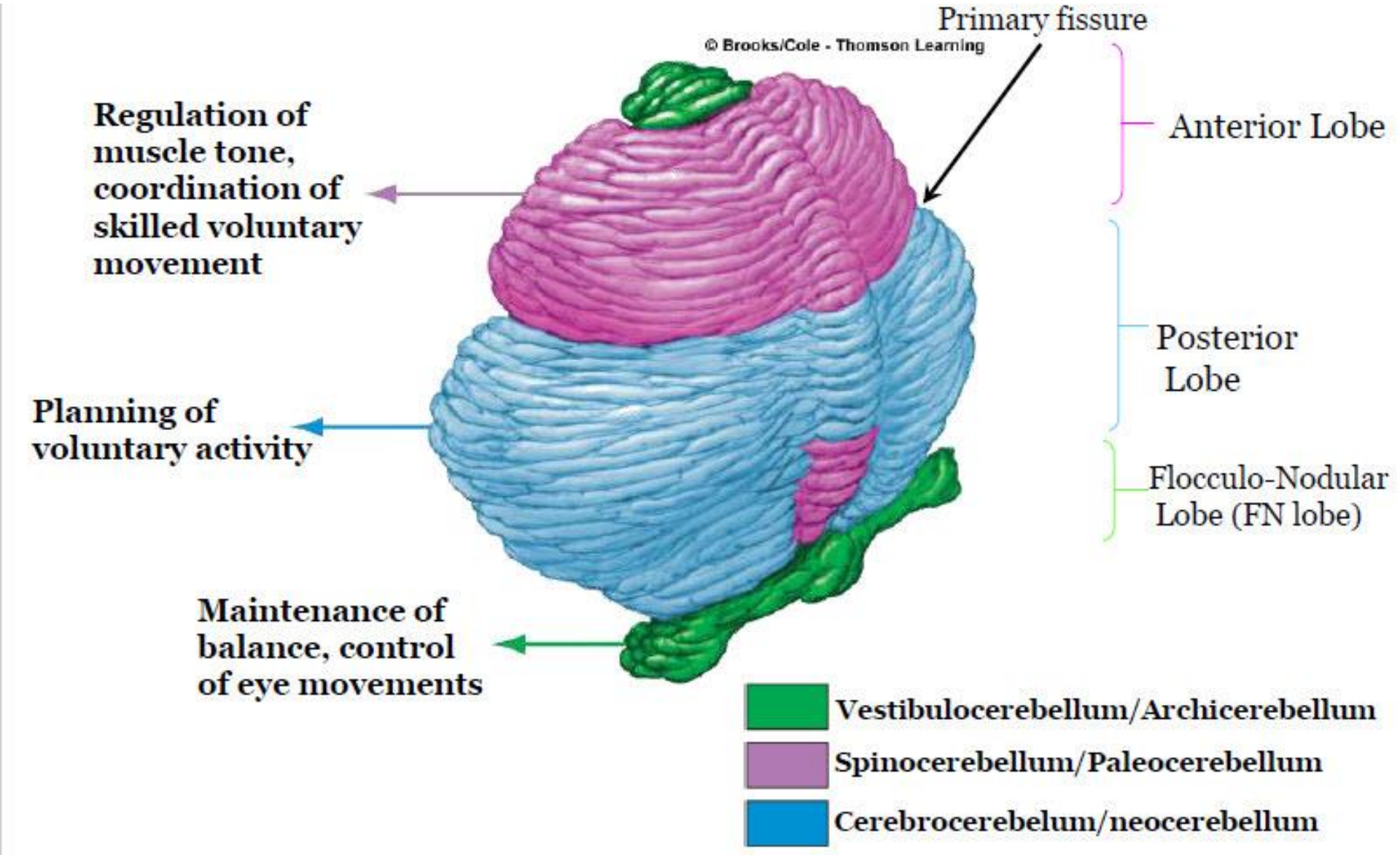
longitudinal division:

1. Vermis (medial zone)
2. Paravermal Region
   (Intermediate zone)
3. Cerebellar Hemisphere:
   (Lateral zone)



Functional Divisions of the Cerebellum

Each zone consists of underlying white matter and a deep cerebellar nucleus to which it topographically projects, *vermis* to *fastigial nucleus*, *paravermal* cortex to *interposed nuclei*, and *hemisphere* to *dentate nucleus*


© Brooks/Cole - Thomson Learning
Primary fissure
Anterior Lobe
Posterior Lobe
Flocculo-Nodular Lobe (FN lobe)
Regulation of muscle tone, coordination of skilled voluntary movement
Planning of voluntary activity
Maintenance of balance, control of eye movements
Vestibulocerebellum/Archicerebellum
Spinocerebellum/Paleocerebellum
Cerebrocerebelum/neocerebellum

Functional Lobes of the Cerebellum

The ***flocculonodular lobe***, behind the posterolateral fissure, consists of paired appendages called ***flocculi*** located posteriorly and inferiorly and ***joined*** medially ***by*** the ***nodulus*** (part of the vermis) lobe and the associated ***fastigial nuclei***.

It is also called the ***archicerebellum*** because it is the oldest part of the cerebellum and the ***vestibulo-cerebellum*** because this lobe is integrated with the vestibular system.

It plays a significant role in regulation of ***muscle tone*** and maintenance of ***equilibrium*** and ***posture*** through influences on the ***trunk (axial) musculature including balance of the body and eye movement*** (via vestibulo-ocular reflex).

Archicerebellum

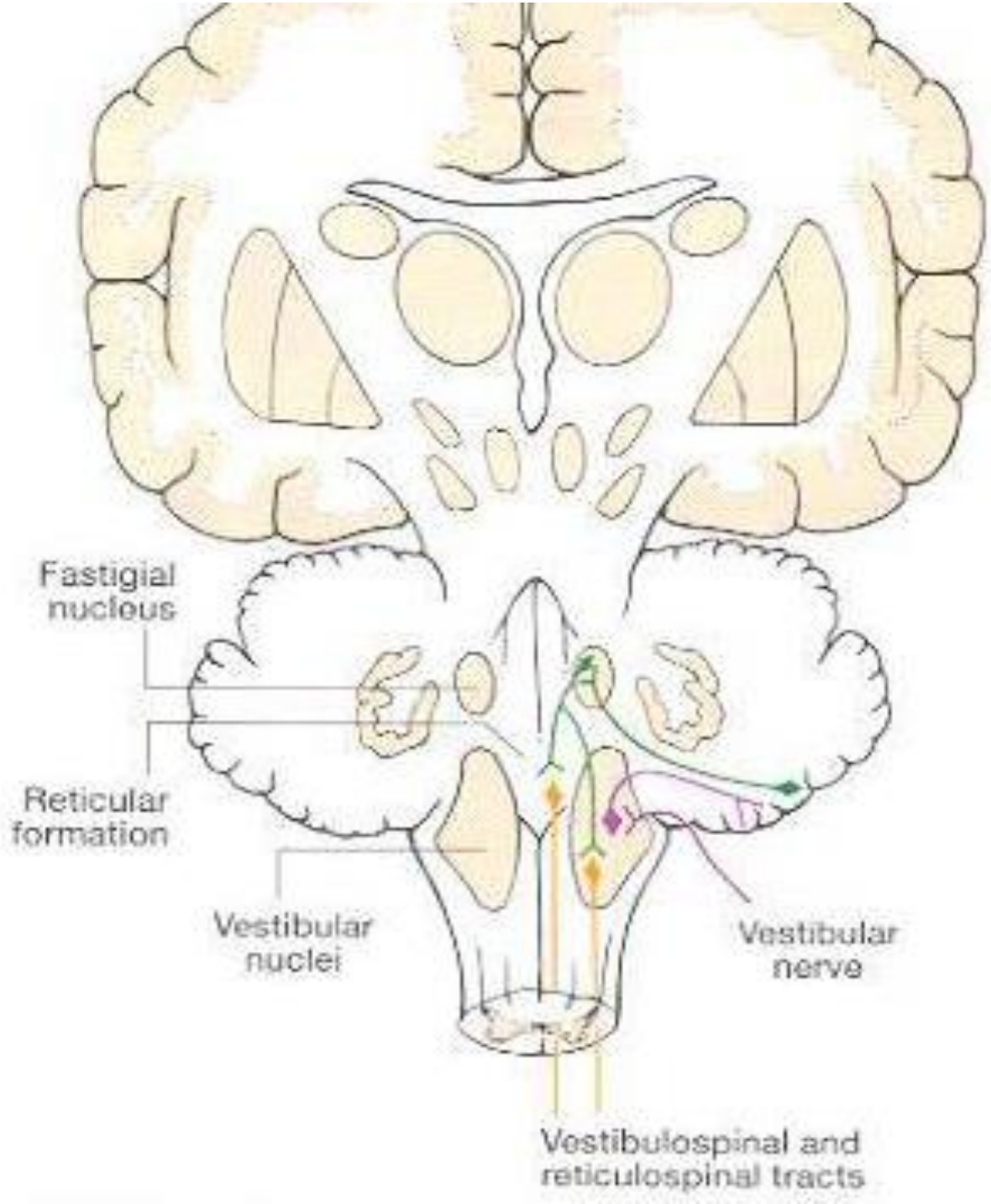
It has connections with vestibular & reticular nuclei of brain stem through the inferior cerebellar peduncle (ICP).

Afferent vestibular fibers: Pass from vestibular nuclei in pons and medulla to the cortex of ipsilateral flocculonodular lobe.

Efferent cortical fibers: Project to fastigial nucleus (most medial), which projects to vestibular nuclei & reticular formation.

It affects the lower motor neurons (of anterior horn cells) bilaterally via descending **vestibulospinal** and **reticulospinal tracts**.

Also, vestibular nuclei → medial longitudinal fasciculus → ***motor nuclei in brain stem associated with movement of eyeball***.


Fastigial nucleus
Reticular formation
Vestibular nuclei
Vestibular nerve
Vestibulospinal and reticulospinal tracts

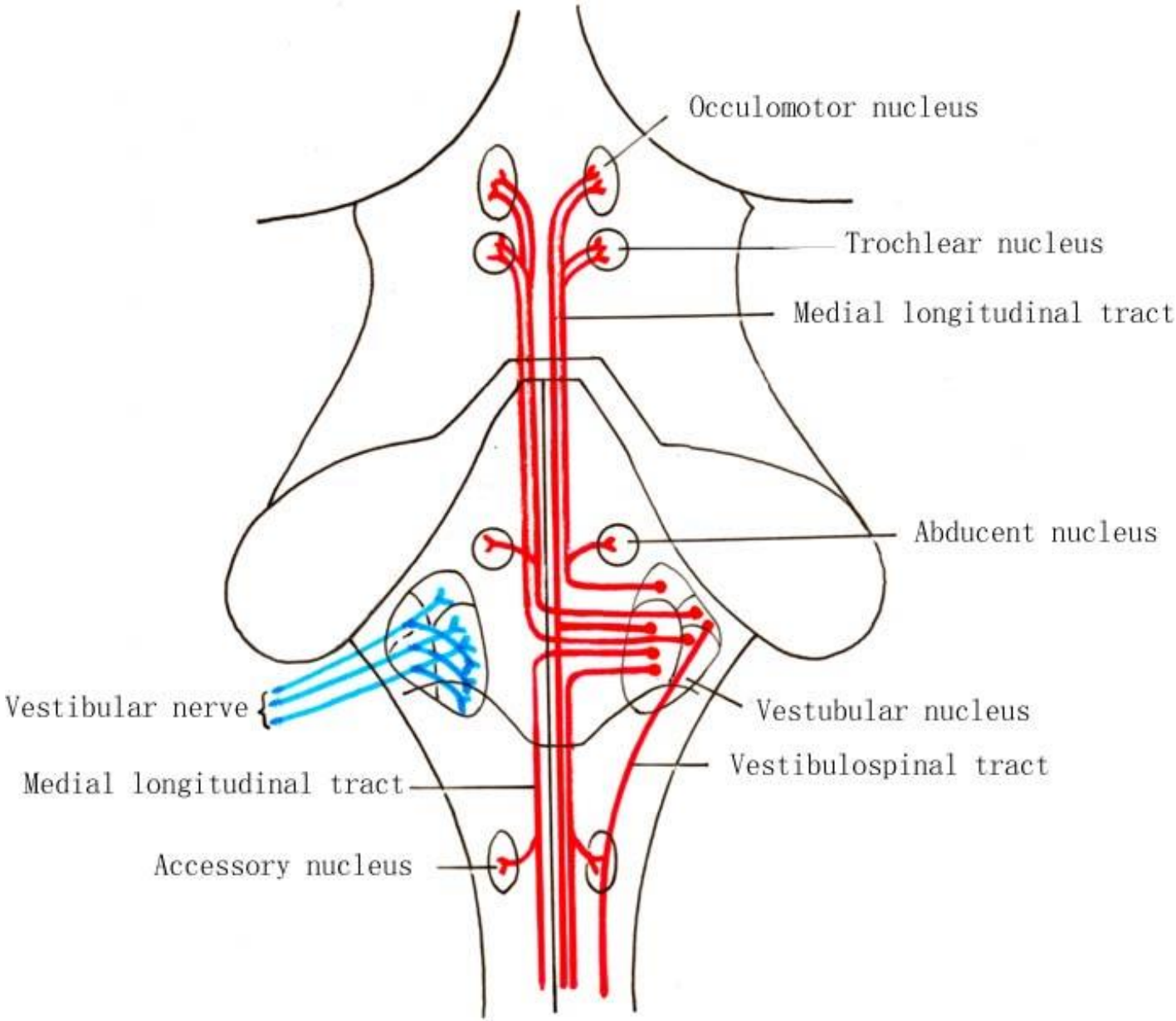


Fig. 15-23 The equilibratory pathway

Functional Lobes of the Cerebellum

- The anterior lobe, located anterior to the primary fissure, is also called the ***paleocerebellum***, 2nd oldest part. This lobe ***together with the vermal*** and ***paravermal portions*** of the posterior lobe constitute the ***spinocerebellum***

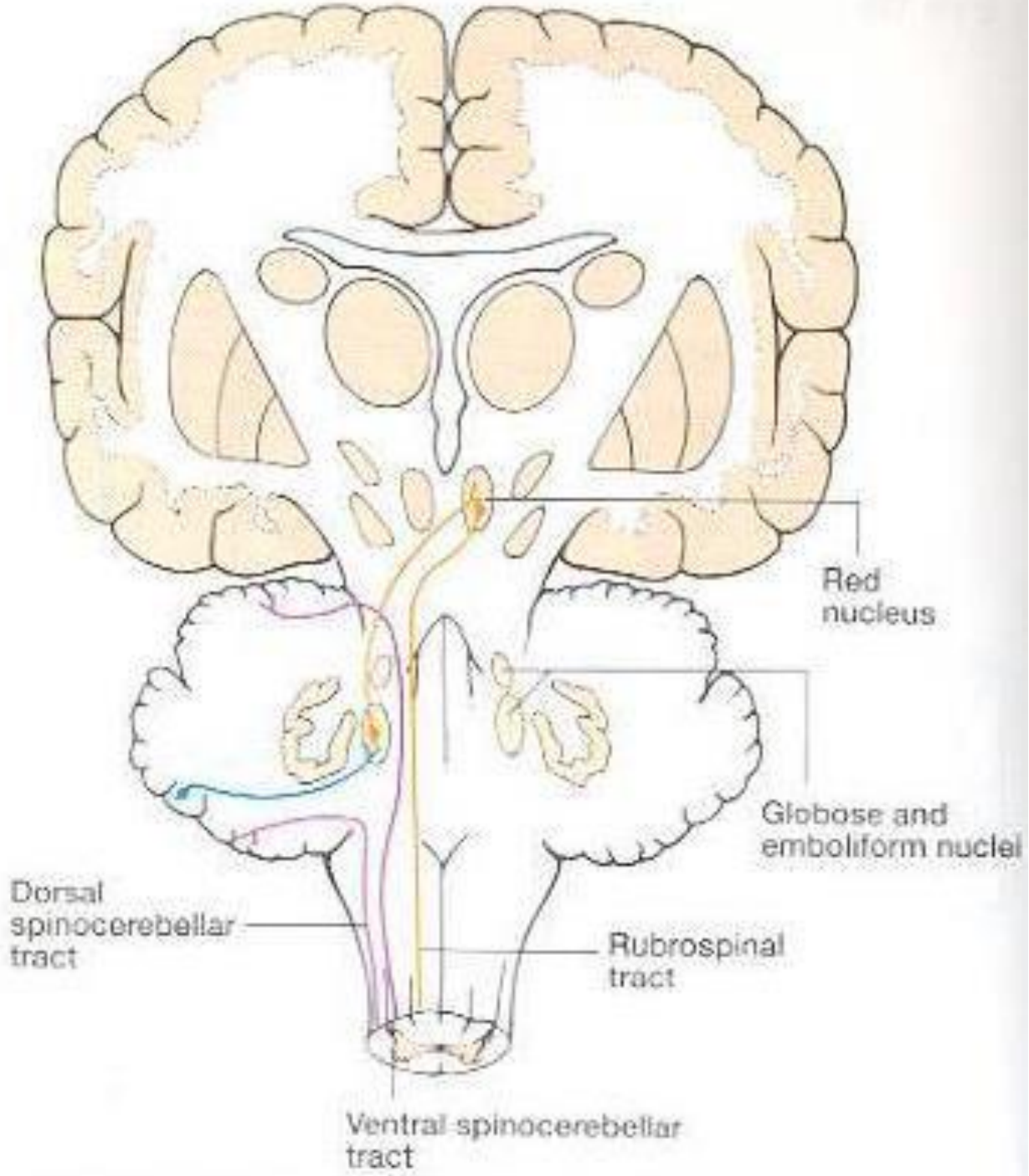
- The spinocerebellum plays a role in the regulation of ***muscle tone***, receives ***proprioceptive*** and ***exteroceptive*** ***(****external stimuli, typically light touch, pain, and temperature, detected by various receptors****)*** inputs from the body and limbs via the spinocerebellar pathways, and from the head via fibers from the brainstem

Paleocerebellum

Afferents spinal Fibers consist of dorsal & ventral spinocerebellar tract from muscle, joint & cutaneous receptors to enter the cortex of **ipsilateral vermis** & **paravermis** Via inferior & superior cerebellar peduncles

Efferent fibers pass to globose & emboliform nuclei, then Via sup. C. peduncle to contra-lateral red nucleus of midbrain to give rise descending rubro-spinal tract.

It affects the lower motor neurons (of anterior horn cells) via **rubro-spinal tract**.


Red nucleus
Globose and emboliform nuclei
Dorsal spinocerebellar tract
Rubrospinal tract
Ventral spinocerebellar tract

Functional Lobes of the Cerebellum

- The large posterior lobe is located between the primary fissure and the posterolateral fissure. This is the newest lobe (***neocerebellum***) receives input from the ***cerebral cortex*** via a relay in the basilar pons.

- It performs a significant role in ***planning*** and ***programming*** of ***movements*** important for muscular ***coordination*** during phasic activities.

Neocerebellum

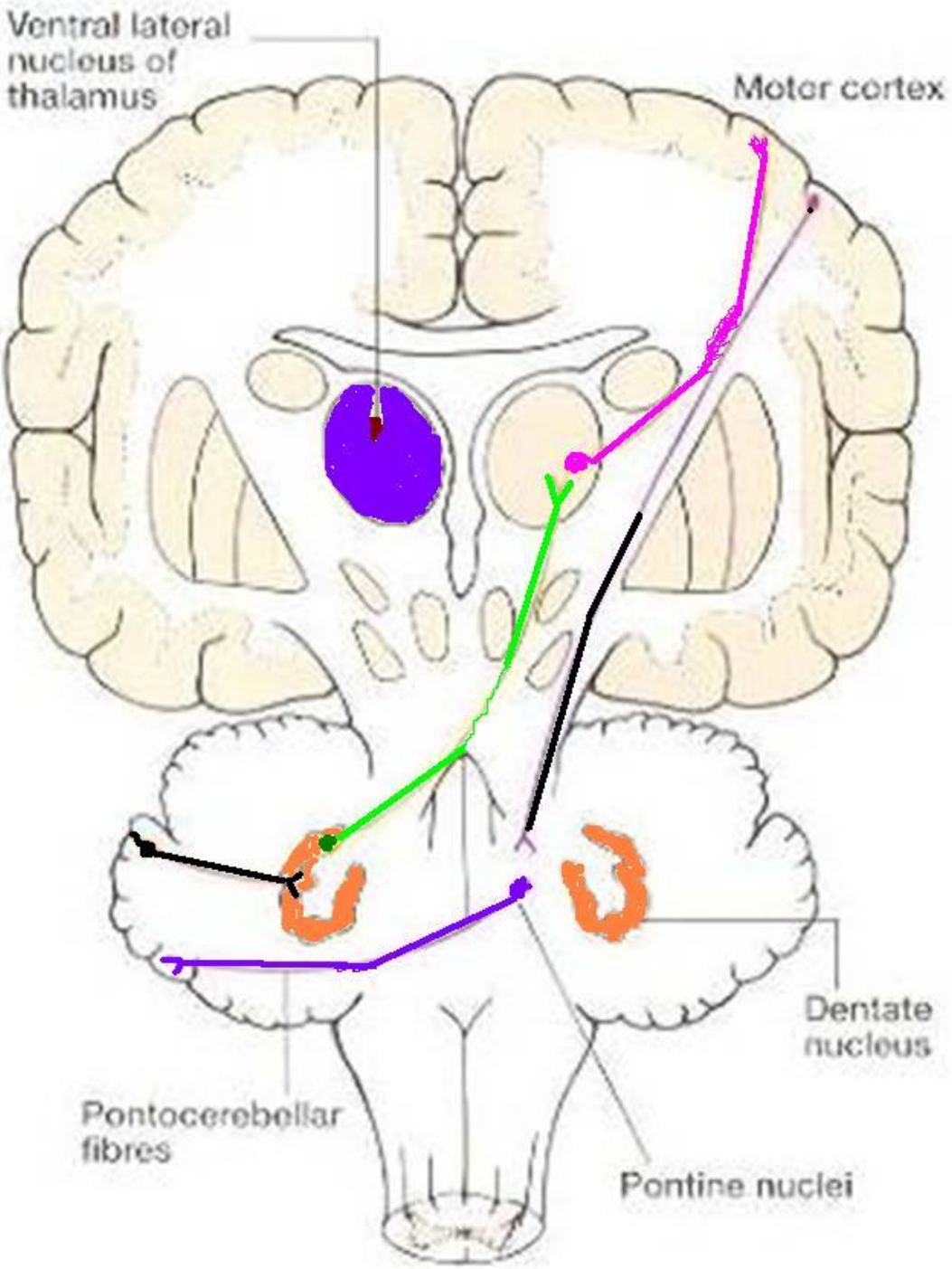
- It is the remaining largest part of cerebellum.
- It includes the most of the two cerebellar hemispheres + dentate nuclei (most lateral).
- It receives impulses from the cerebral cortex via cerebro-ponto-cerebellar pathway.
- Function: **Coordination of voluntary movements** (planning & programming movement)

Neocerebellum

It receives afferents from ***cerebral cortex*** involved in planning of movement - to pontine nuclei, cross to opposite side via **MCP** to end in lateral parts of cerebellum (cortico-ponto-cerebellar tract).

Neocerebellar efferents project to dentate nucleus, which in turn projects to contra-lateral (via SCP) red nucleus but mostly to **ventral lateral (VL) nucleus of thalamus**, then to motor cortex of frontal lobe.

The motor cortex giving rise descending cortico-spinal & corticobulbar tracts to affects the lower motor neurons.


Ventral lateral nucleus of thalamus
Motor cortex
Dentate nucleus
Pontocerebellar fibres
Pontine nuclei

Summary of
Cerebellum
Functional Subdivisions

SCP = superior cerebellar peduncle
MCP = middle cerebellar peduncle
ICP = inferior cerebellar peduncle

	Archicerebellum	Paleocerebellum	Neocerebellum
Nuclei Related	Fastigial	Globose & Emboliform	Dentate
Afferents	from **Vestibular** nuclei (Vestibulocerebellar fibres), (through ICP)	from **spinal cord** (dorsal spinocerebellar tracts through ICP & ventral spinocerebellar tract through SCP)	from **Pons** (Pontocerebellar fibres) (through MCP)
Efferents	cortical (purkinje cell) Fibres project : to **Fastigial nucleus**, which projects to **vestibular nuclei** (through ICP) + to **Reticular** formation	to globose & embliform nuclei which project to **red nucleus** (through SCP)	to **Red nucleus** but mostly to **Ventral Lateral Nucleus of Thalamus** (through SCP) then to **motor cortex**
Function	1. controls body **Balance** (via vestibulospinal & reticulospinal tracts). 2. Control of eye movement (via VO vestibulo-ocular reflex)	controls **posture & muscle tone** (via Rubrospinal tract).	**coordination of voluntary movements** (via descending corticospinal & corticobulbar tracts or rubrospinal tract).

Superior Cerebellar Peduncle

- It joins the back of the midbrain below the tectum

- ***Afferent passes though the superior cerebellar peduncle***

1. Ventral spinocerebellar tract
2. Tecto-cerebellar fibers from the superior and inferior colliculi
3. Hypothalamocerebellar fibers

- ***Efferent passes though the superior cerebellar peduncle***

1. Cerebellorubral tract
2. Dentato-thalamic fibers, Dentato-rubal fibers
3. Fastigio-reticular fibers

Middle Cerebellar Peduncles

It is the thickest of the cerebellar peduncles connects to the pons.

Afferent passes though the middle cerebellar peduncle

1. Pontocerebellar fibers which form the main bulk of the peduncle
2. Reticulo-cerebellar fibers from the reticular formation of the pons

Efferent passes though the middle cerebellar peduncle

1. Cerebello-reticular fibers
2. Cerebellopontine fibers

Inferior Cerebellar Peduncle

Afferent passes though the inferior cerebellar peduncle

1. Dorsal spinocerebellar fibers
2. Olivo-cerebellar fibers
3. Paraolivo-cerebellar fiber

Inferior Cerebellar Peduncle

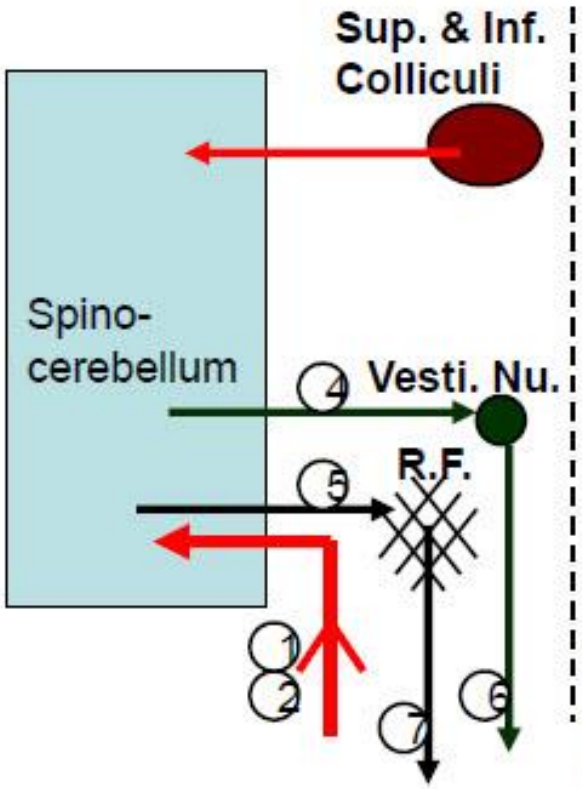
4. Vestibulo-cerebellar fibers
5. Dorsal external arcuate fibers
6. Ventral external arcuate fibers
7. Reticulo-cerebellar fibers
8. Trigeminocerebellar fibers from the main sensory nucleus and nucleus of spinal tract of the trigeminal nerve from the main and the same side

Inferior Cerebellar Peduncle

Efferent passes though the inferior cerebellar peduncle

1. Cerebello-olivary fibers
2. Cerebello-vestibular fibers
3. Cerebello-reticular fibers

(1) CONTROL OF TONE & POSTURE:



- Mainly function of Spinocerebellum.

CHANGE IN BODY POSTURE

Proprioceptive from Body

↓

1.Spino-cerebellar (dor. & Vent.)
2.Cuneo-cerebellar
3.Tecto-cerebellar (Visual & Auditory)

↓

REFLEX CORRECTION OF MUSCLE TONE

4.Cereb.-vestibular
5.Cereb.-reticular

↓

6.Vestibulo-spinal
7.Reticulo-spinal

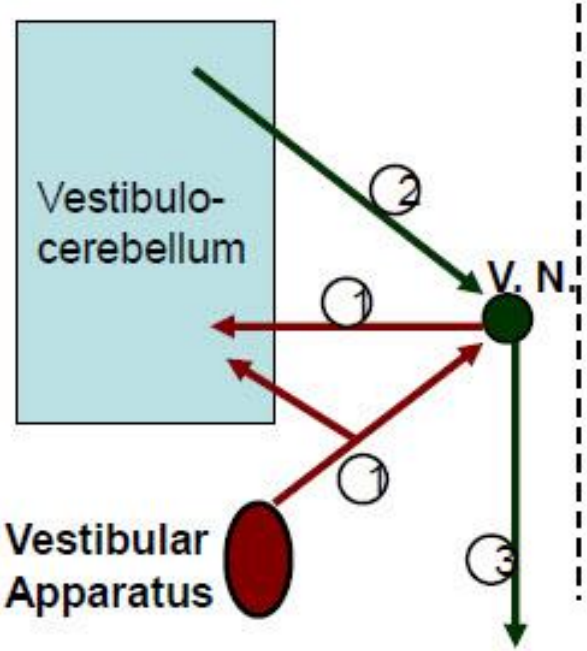
↓

A.H.C.

EASY MAINTANENCE OF NEW POSTURE

(2) CONTROL OF EQUILIBRIUM:

- Mainly function of Vestibulocerebellum.



CHANGE IN HEAD POSITION / ACCELARATION

Labyrinthine Afferents

↓

1.Vestibulo-cerebellar

↓

REFLEX CORRECTION OF MUSCLE TONE

2.Cereb.-vestibular **3.Vestibulo-spinal**

↓

A.H.C.

MAINTANENCE OF BODY EQUILIBRIUM

Function of Cerebellum

CONTROL OF VOLUNTARY MOVEMENT:

- Act as a "comparator of a served mechanism"
- ***Cerebellum receives two types of information***
- Intended plan of movement (direct information from the motor cortex)

Function of Cerebellum

What actual movements result (***feedback from periphery***)

These two are compared: ***an error is calculated,*** controlling the timing and sequence of firing

Corrective output signals goes to:

1. Motor cortex via thalamus
2. Brain stem nuclei and then down to the anterior horn cell through extrapyramidal tracts

A Comparator of a Served Mechanism - Explanation

- Once a movement pattern has been selected the efferent commands are transmitted to the spinal motor centers to initiate muscle activity. At the same time a copy of this information (efferent or efference copy) is transmitted internally to be processed by the comparator system

- Here, the information from the efference copy and the information from the sensory inputs are matched against the expected outcome of the action. Any mismatch will result in motor reorganization and correction of the movement.

- The comparator system reduces the processing demands placed on the CNS by selectively drawing attention to movement, but only when there is a change from the norm. As long as the information is similar it will remain at a low priority within the overall motor processes.

- Hence, many of our familiar daily activities (e.g. walking) remain below consciousness until we make a mistake (e.g. tripping).

Function of Cerebellum

1. The essential ***function*** of the cerebellum is to ***coordinate***, by ***synergistic*** action, all reflex and voluntary muscular activity.

2. Thus, it ***graduates*** and ***harmonizes muscle tone*** and maintains normal body posture.

3. It permits voluntary movements, such as walking, to take place ***smoothly*** with ***precision*** and ***economy*** of effort.

4. It must be understood that although the cerebellum plays an important role in skeletal muscle activity, it is ***not able to initiate muscle movement***.

Cerebellar Dysfunction

Characteristics feature

1. ***Disturbance of posture***

A. **Hypotonia**

There is diminished resistance to passive movements of joints.

Shaking the limb produces excessive movements at the terminal joints.

Cerebellar Dysfunction

B. **Body weight thrown on healthy leg**, Patient assumes a wide base when he or she stands and is often stiff legged to compensate for loss of muscle tone.

C. When the individual walks, he or she lurches and staggers toward the affected side.

D. **Nystagmus (eyes make repetitive, uncontrolled movements)**

Cerebellar Dysfunction

2. ***Ataxia***

A. Incoordination of movements, unsteady gait with a wide base, The muscles contract irregularly and weakly. Tremor occurs when fine movements, such as buttoning clothes, writing, and shaving, are attempted (***intension tremors***).

B. Decomposition of movements (movement occurring in stages)

C. Dysmetria: movement is poorly carried out in direction, range, and force like past pointing (hypermetria) or movement of bodily parts (as the arm and hand) short of the intended goal (hypometria)

Cerebellar Dysfunction

3. ***Intention tremors:***

A. Jerky movements with to and fro motion on reaching an object

B. Coarse tremor occurring at 4-6/sec.

C. Staccato speech, interrupted explosive speech.

D. Drunken gait

Clinical Test to Assess Cerebellar Dysfunction

- ***Finger nose test***
- ***Rebound Phenomenon of Holmes,*** reflex that occurs when one attempts to move a limb against resistance that is suddenly removed.
- ***Adiadochokinesia- unable to carry out rapidly alternate and opposite movements***
- ***Heel-Knee test***

- For further inquiries ***PLZ*** feel free to contact at any time through email

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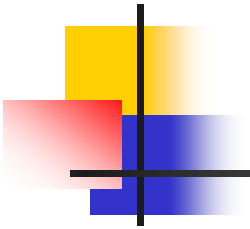

Thank You