CEREBELLUM

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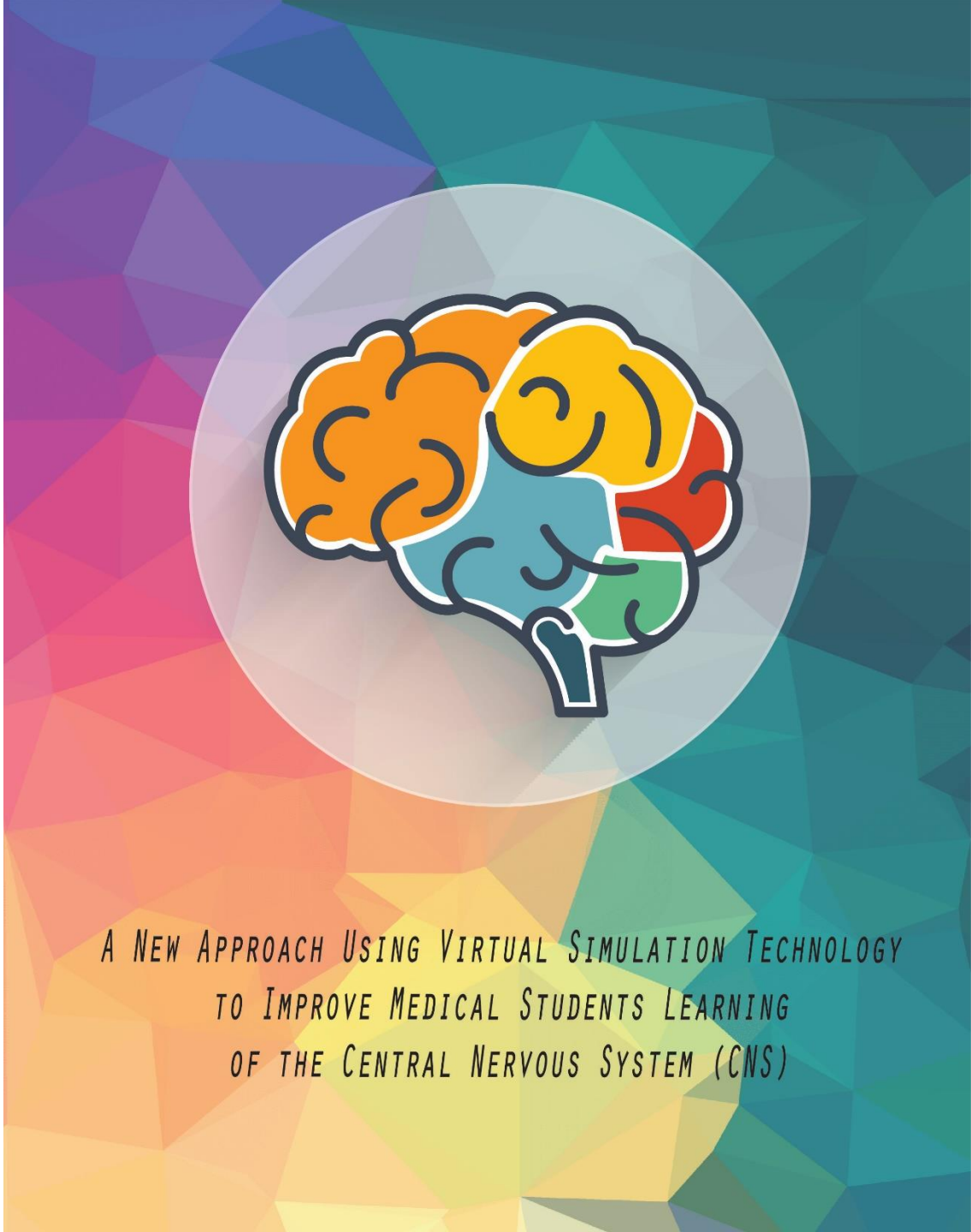


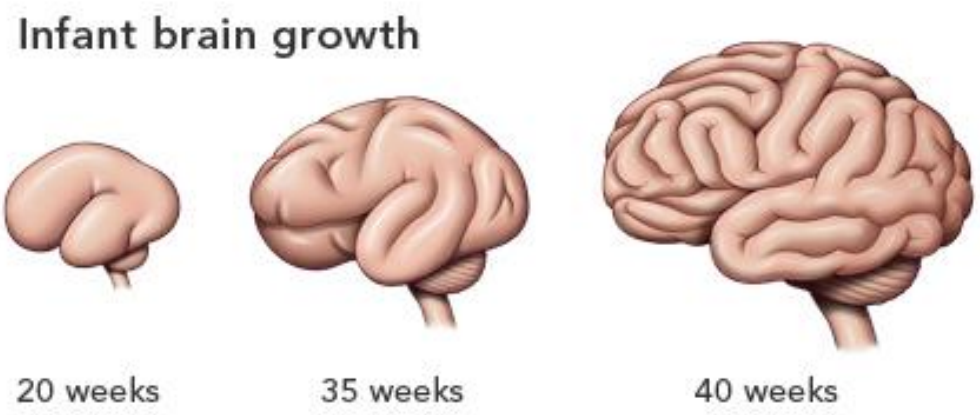
CEREBELLUM

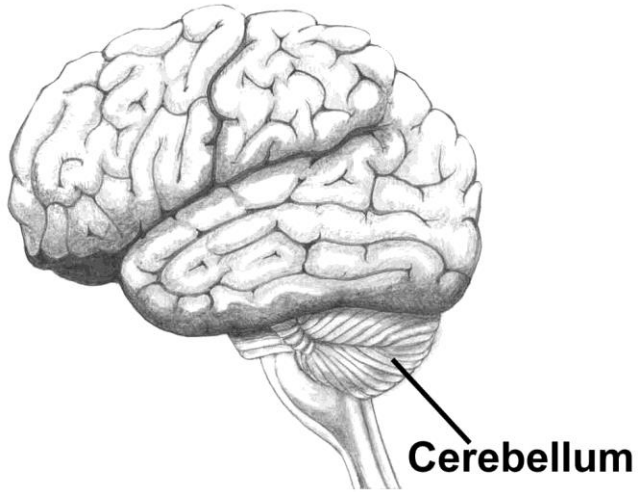
- **CEREBELLUM is one of the three major motor control centres of the brain.**

- **Motor control centres:**
  - **Cerebral cortex**
  - **Basal ganglia**
  - **Cerebellum**

Cerebellum

- **The term cerebellum is from Latin = little brain.**
- **In adults the weight ratio between cerebellum and cerebrum is 1:10, Infants 1:20**





Cerebellum

- **Is the largest part of the hindbrain**
- **Functions:**
  - **Entirely motor**
  - **Operates at an unconscious level**
  - **Controls maintenance of equilibrium (balance)**
  - **Influences posture and muscle tone**
  - **Coordinates movement**
- **It originates from the dorsal part of the brain stem**

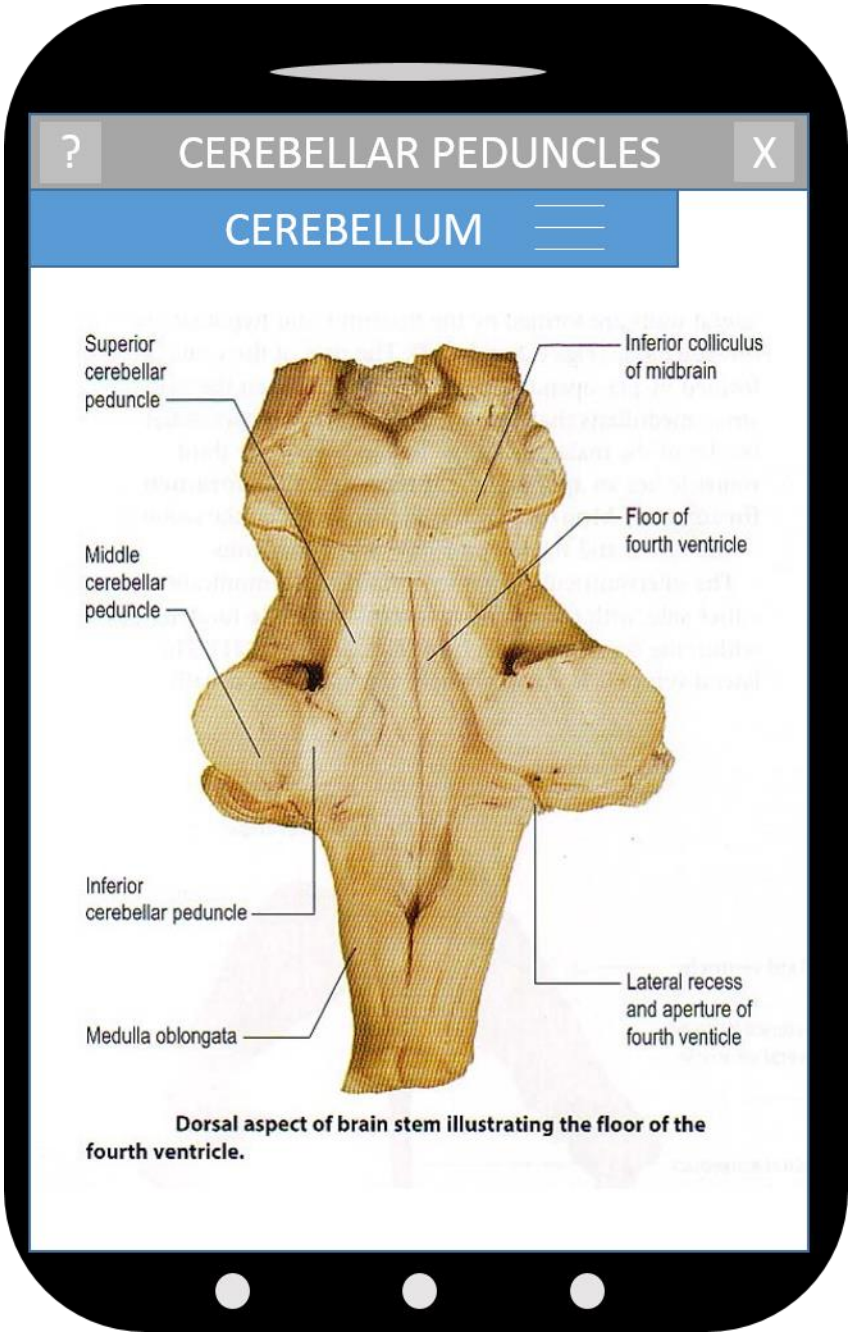
Cerebellum

Connected to the brain stem by 3 symmetrical bundles of nerve fibers:

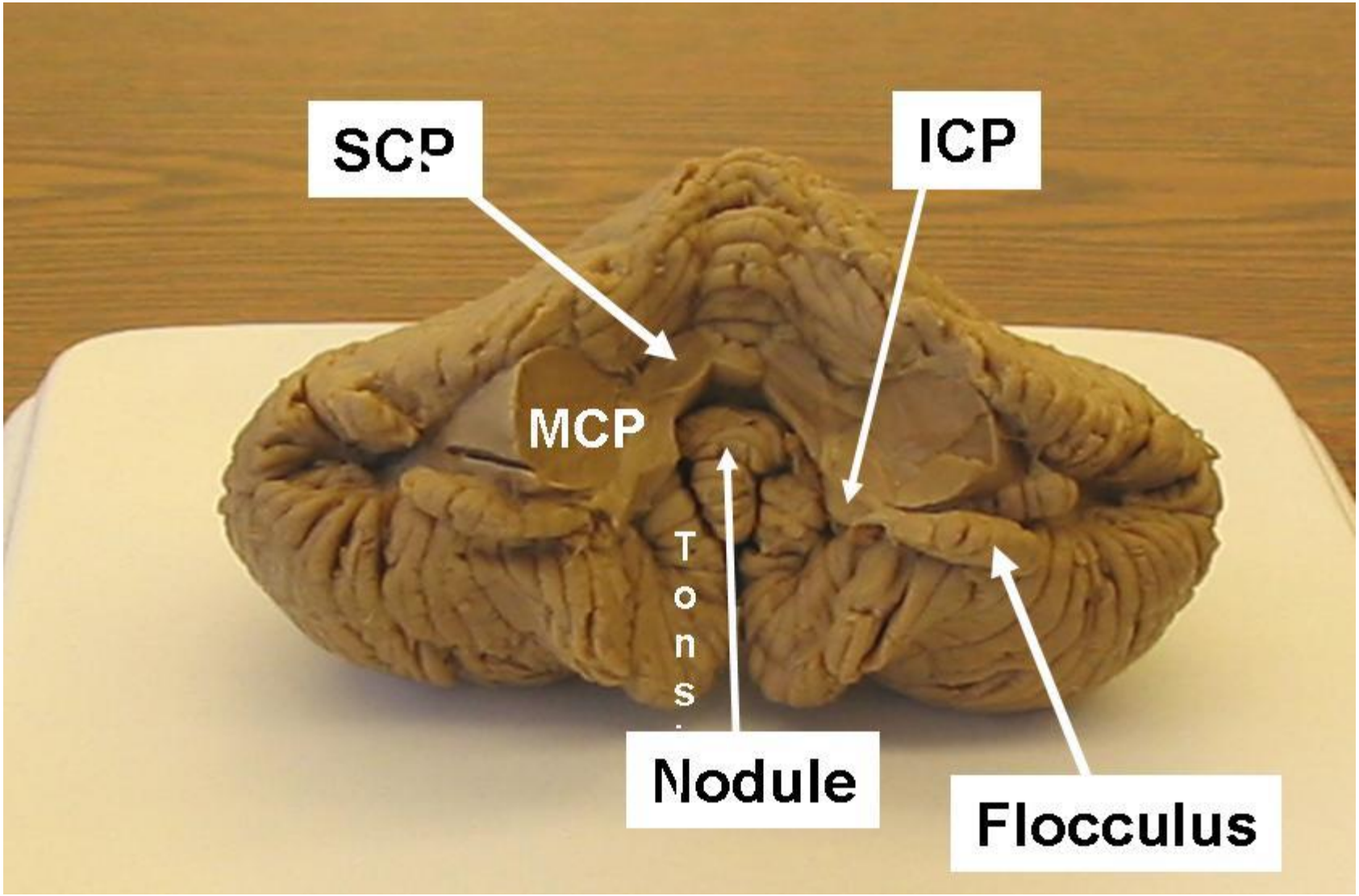
<u>Cerebellar peduncles</u>

fiber tracts that communicate with other parts of brain

- **Superior peduncle : to midbrain**
- **Middle peduncle : to pons**
- **Inferior peduncle : to medulla oblongata**

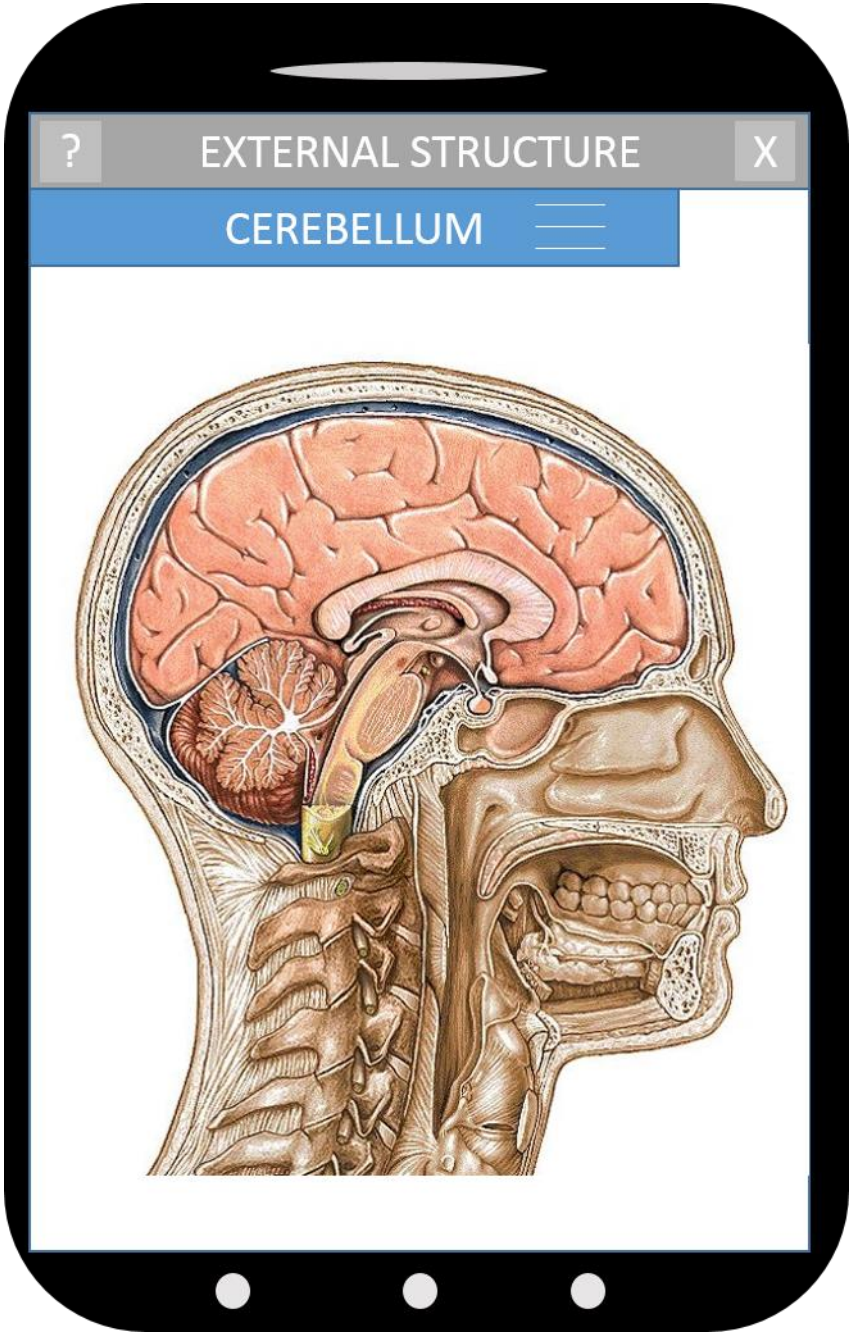


Peduncles of the cerebellum



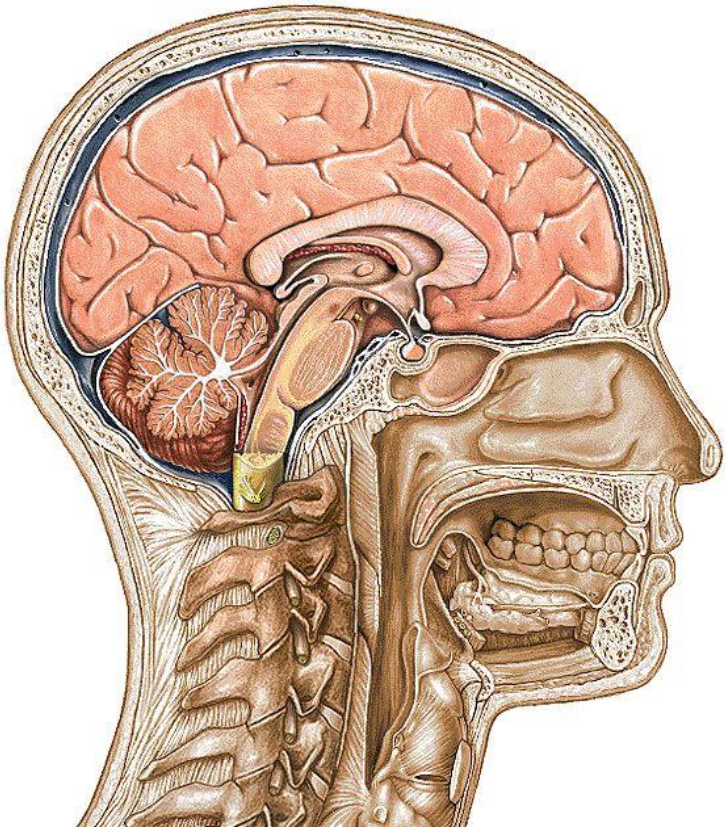
External structure of the cerebellum:

- Situated in the posterior cranial fossa
- Covered superiorly by the tentorium cerebelli = fold of dura mater



Cerebellum

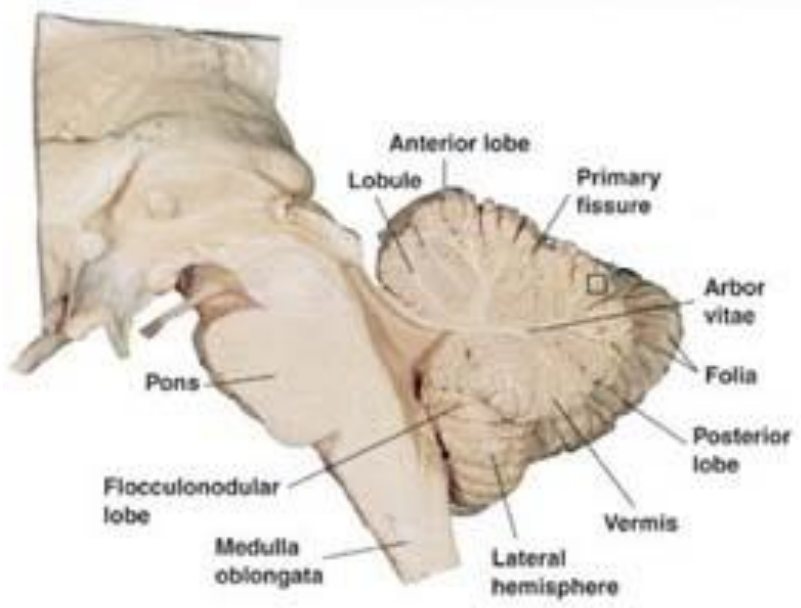
- Lies post. to the pons, medulla oblongata & 4th ventricle
- Consists of 2 cerebellar hemispheres joined by a narrow median vermis
- 2 surfaces, superior & inferior



(c) Superior view

- **Surface of the cerebellum is marked by a series of fissures**
- **Cortex folded in ridges called folia; white matter resembles a tree (arbor vitae)**

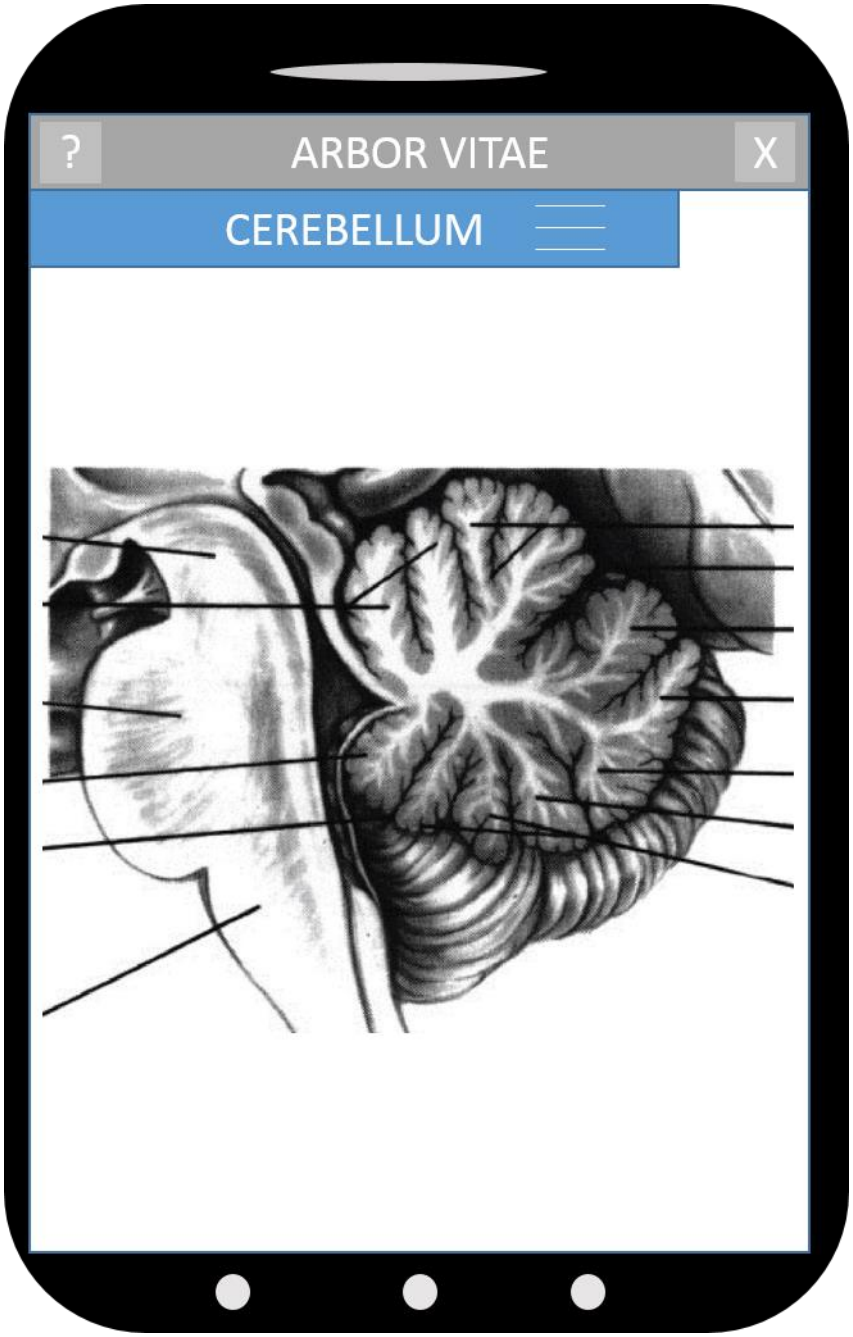
(c) Superior view



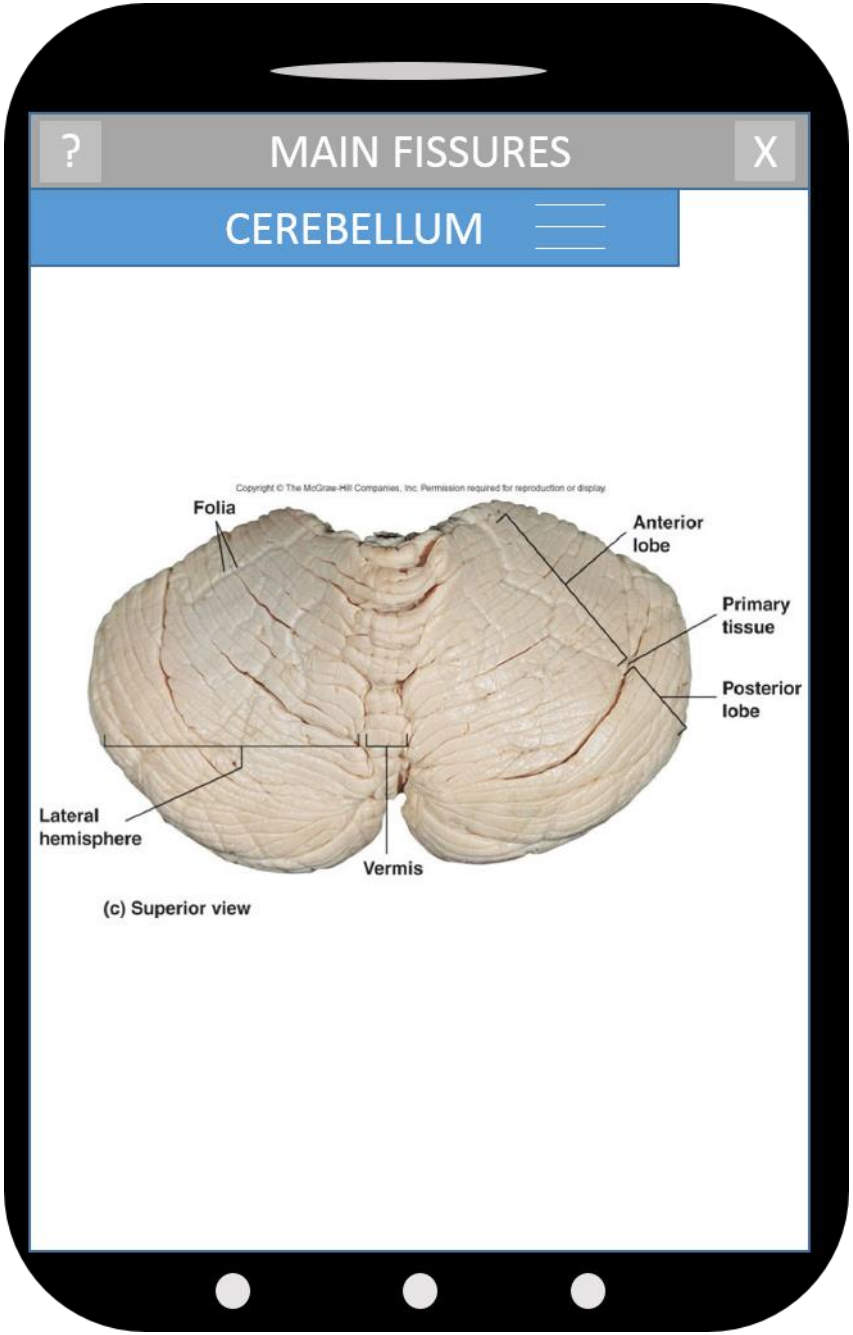
(a) Medial view

Arbor vitae

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

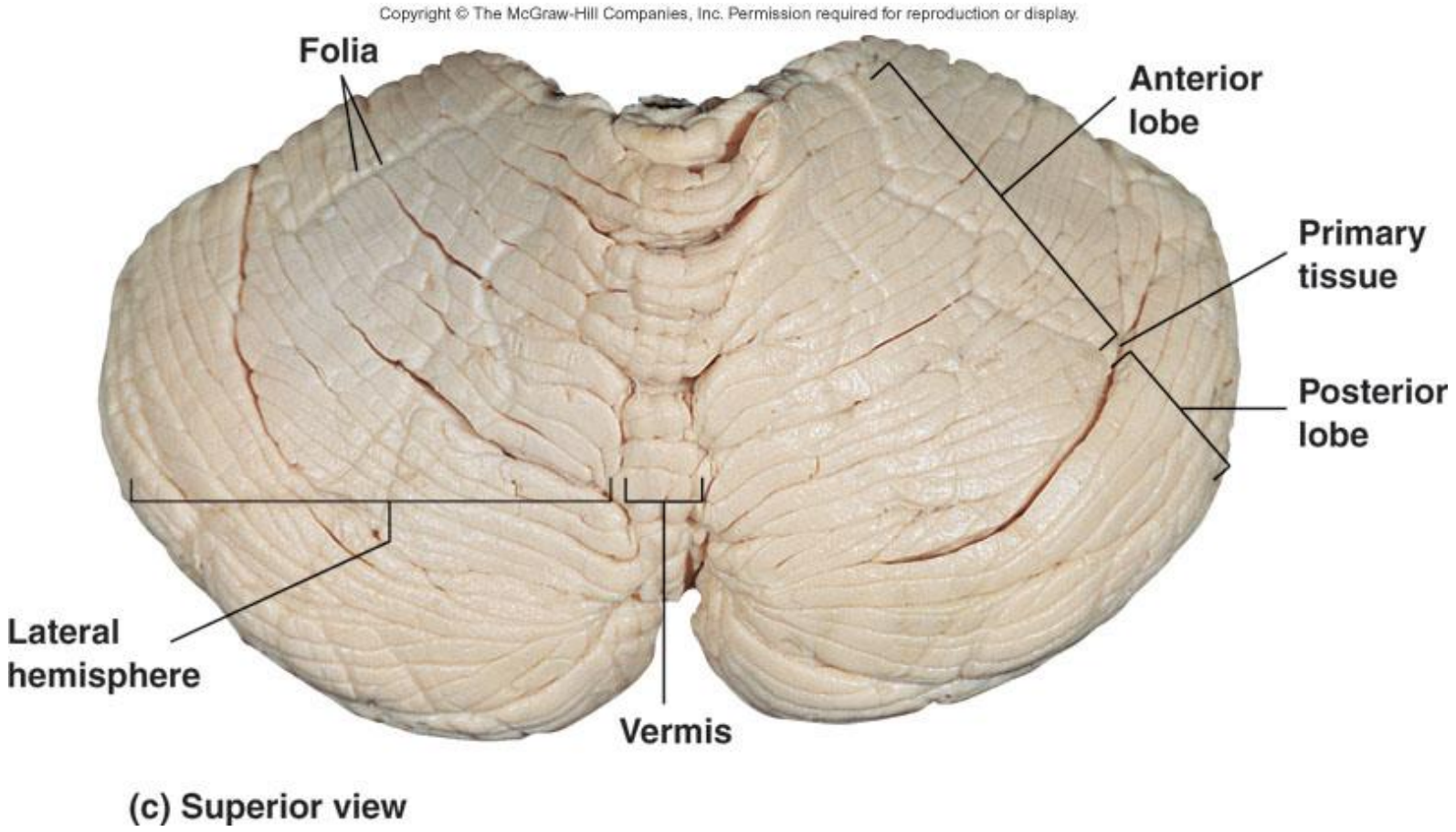


- **3 main fissures :**
  1) **Primary fissure**
     - **V-shaped fissure**
     - **Superior surface of cerebellum**

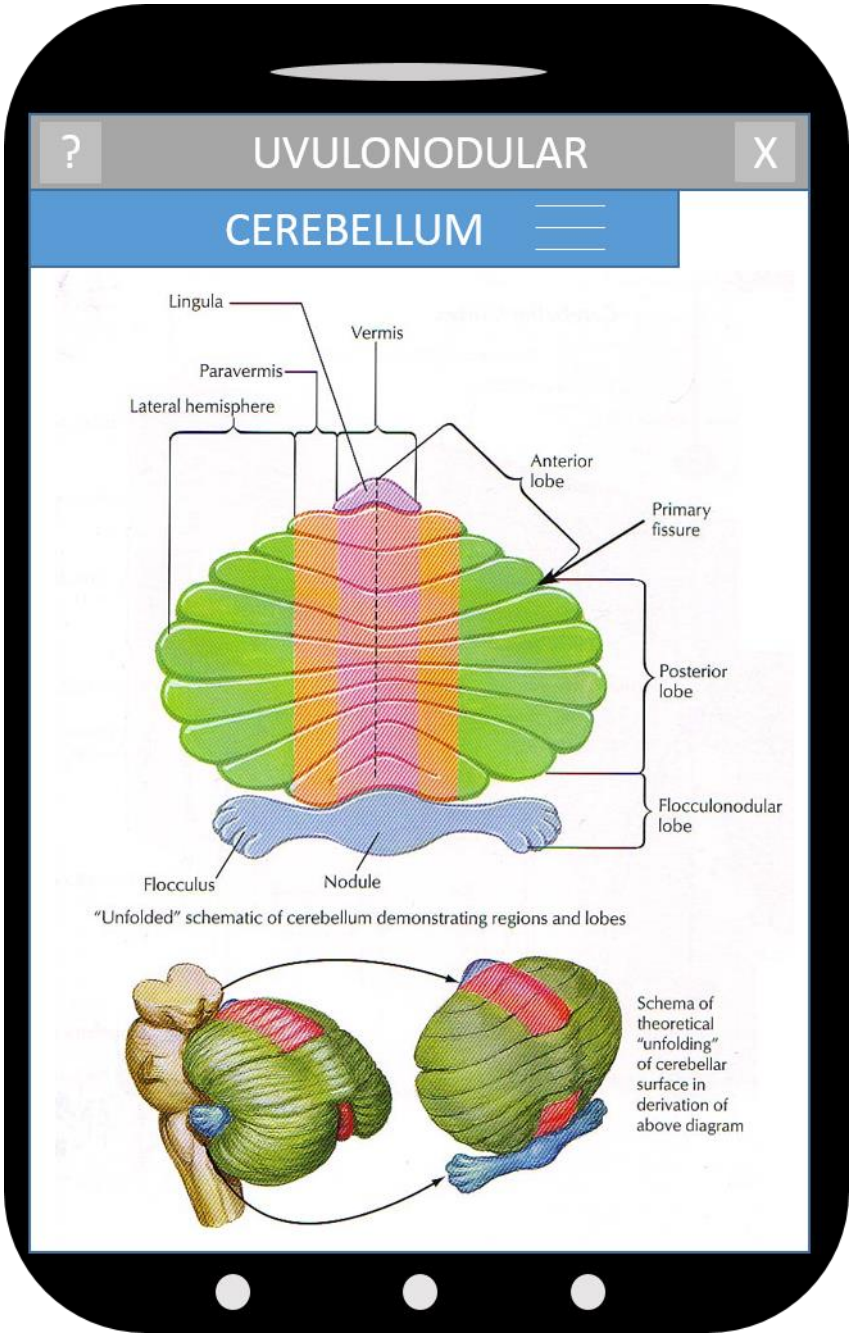


2) Horizontal fissure

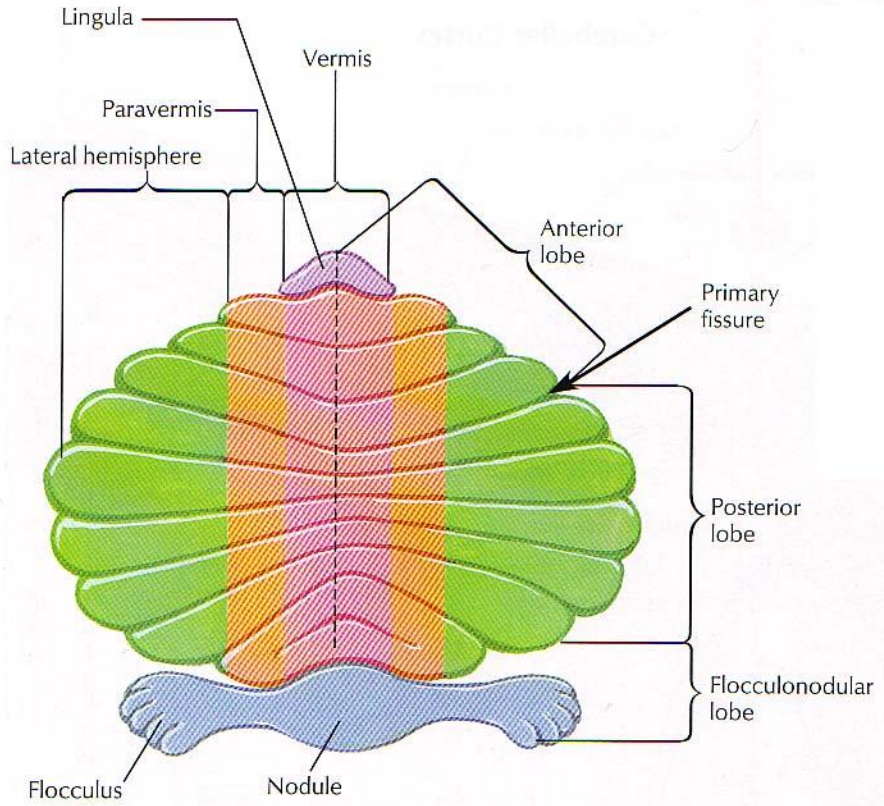
- **Located along the margin of the cerebellum**
- **separates the superior from the inferior surfaces**
- **Inferior surface of cerebellum**



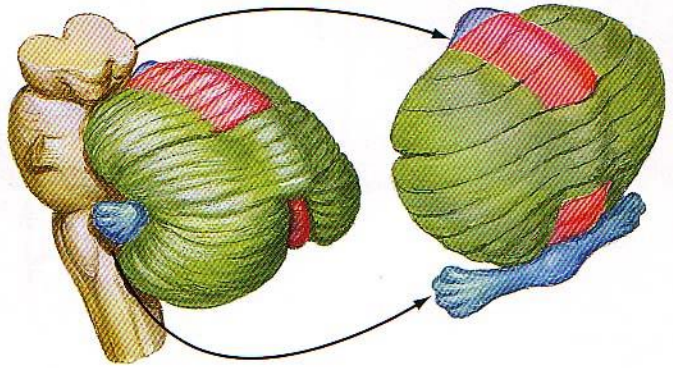
2) Uvulonodular / posterolateral fissure



- **The deepest fissures (primary & uvulonodular) divide cerebellum into 3 lobes:**
  - **Anterior lobe**
    - **ant to the primary fissure**
  - **Posterior/middle lobe**
    - **between ant & uvulonodular fissures**
    - **Largest**
  - **Flocculonodular lobe**
- **Ant & post/middle lobes = formed the <u>corpus cerebelli</u>**



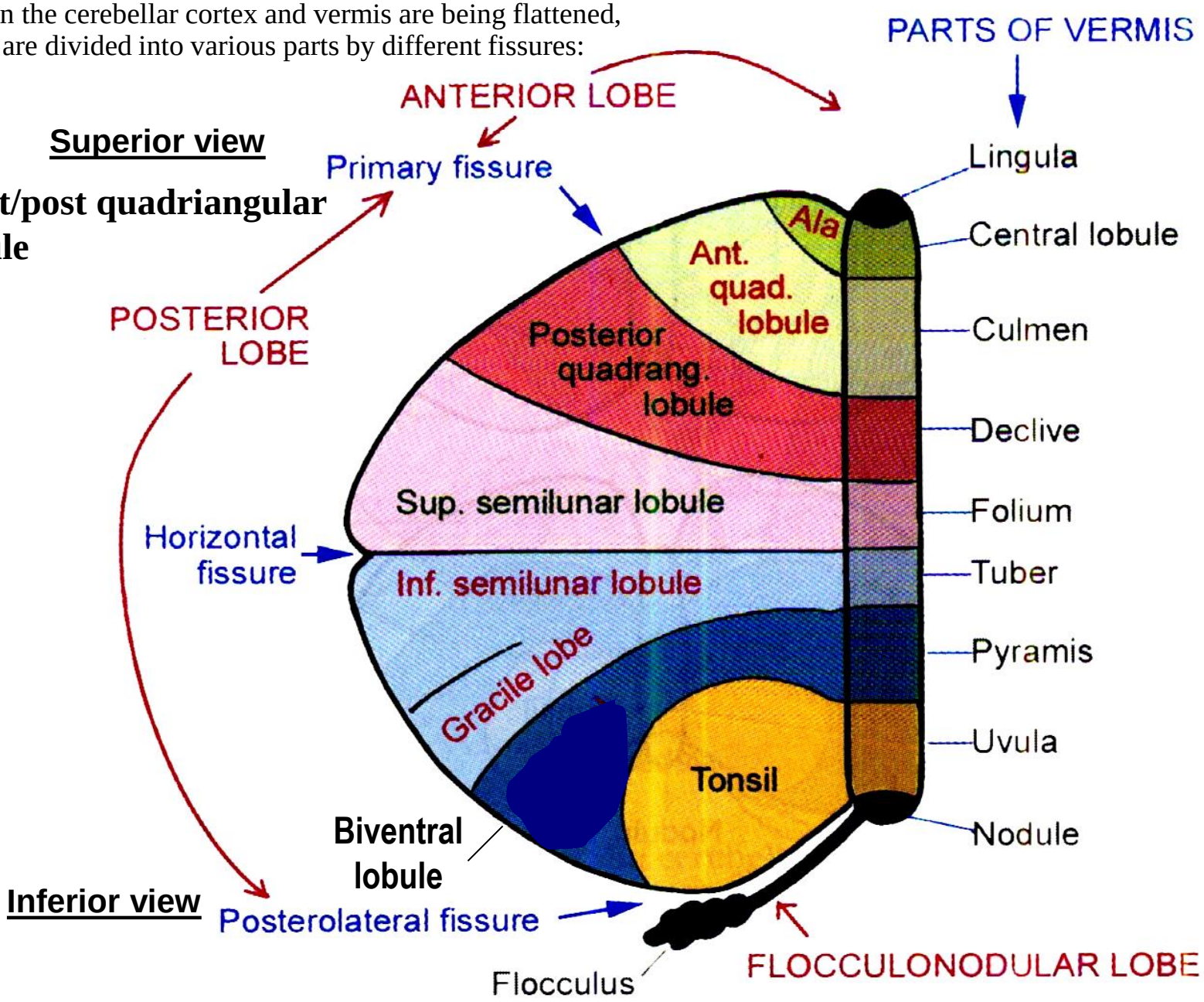
"Unfolded" schematic of cerebellum demonstrating regions and lobes



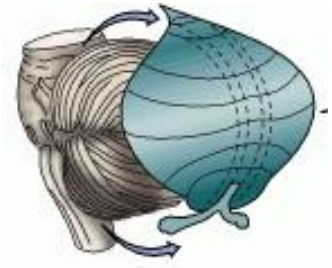
Schema of theoretical "unfolding" of cerebellar surface in derivation of above diagram

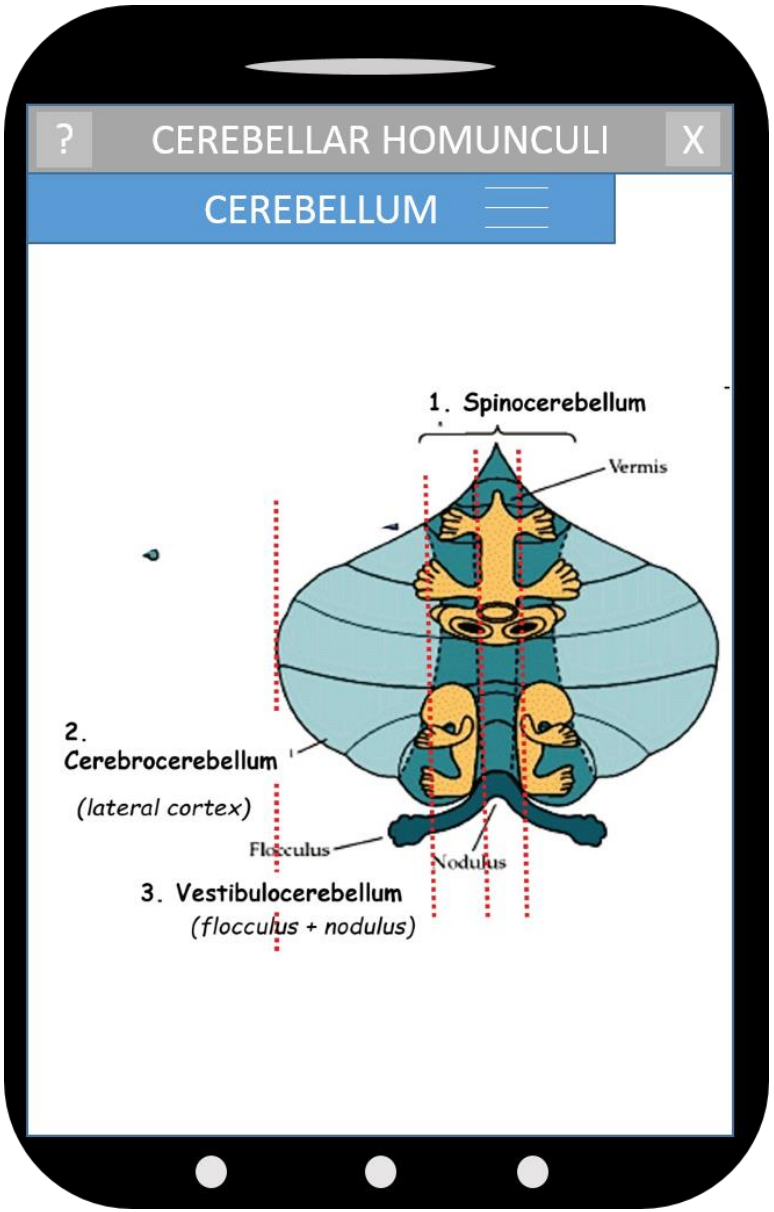
Parts of vermis and cerebellar lobation:

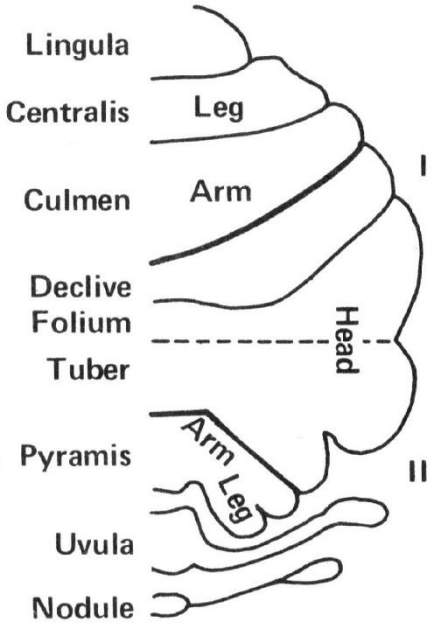
When the cerebellar cortex and vermis are being flattened, they are divided into various parts by different fissures:



Cerebellar homunculi (somatotopic maps of the body surface in cerebellum shows representing muscle and joint position)







Internal structure of the cerebellum:

- **Consists of:**
  - **outer layer of grey matter = cerebellar cortex**
  - **inner core of white matter**
    - **afferent & efferent fibers**
- **4 pairs of cerebellar nuclei**

Cerebellar cortex:

- **Cell bodies, dendrites, and synaptic connections of cerebellar neurons**
- **3 layers:**
  - **Outer = Molecular layer**
  - **Intermediate = Purkinje cell layer**
  - **Inner = Granular layer**

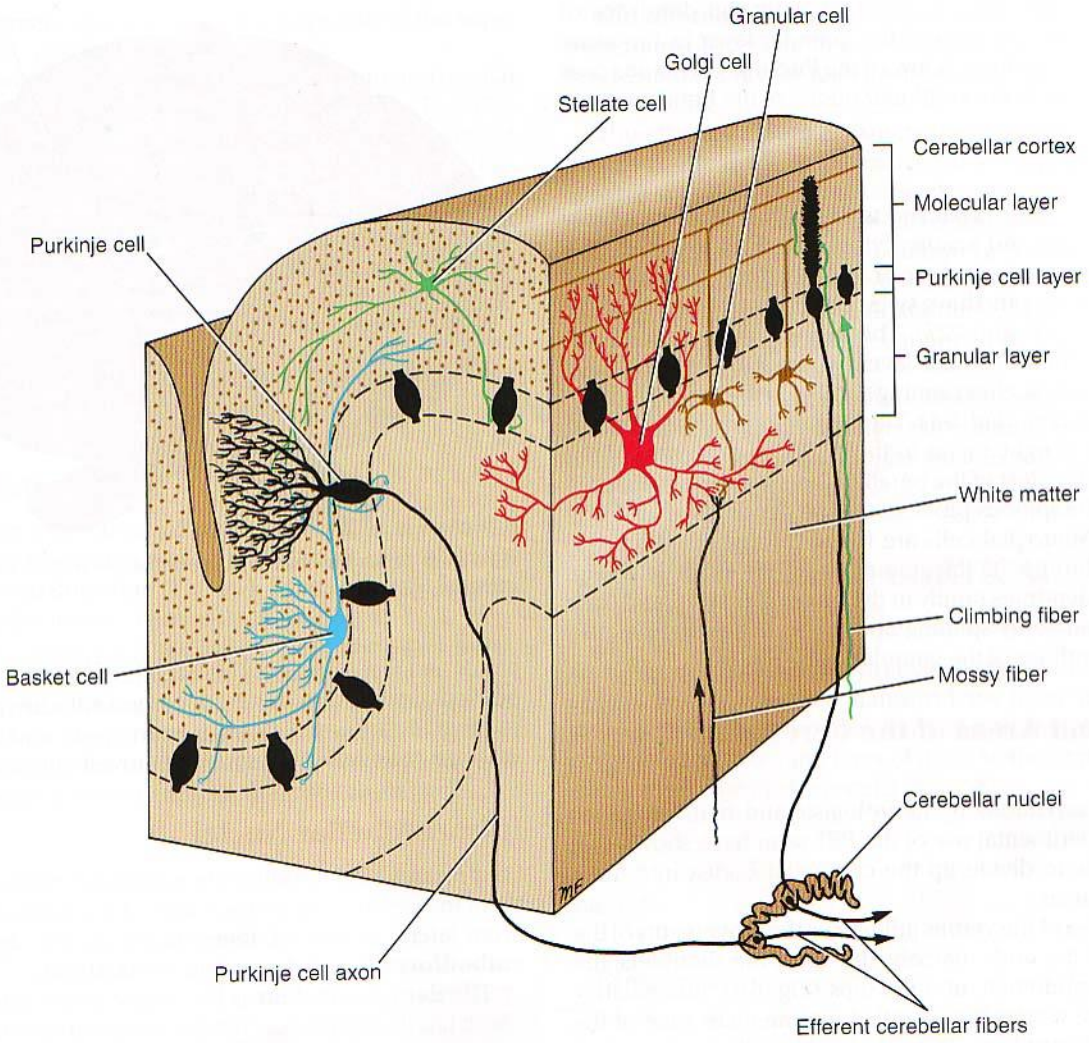
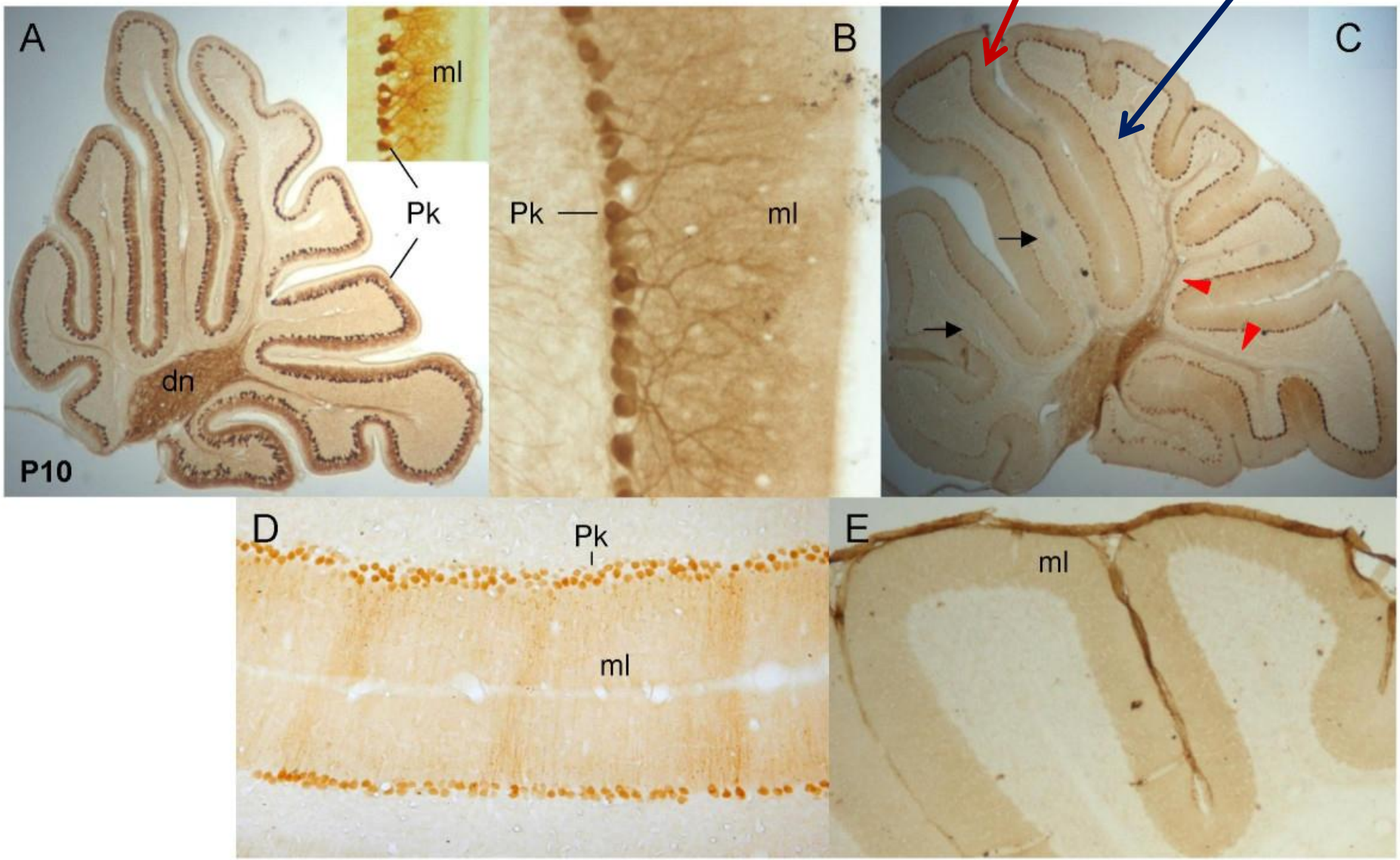


Figure 6-4 Cellular organization of the cerebellar cortex. Note the afferent and efferent fibers.

Structure of the cerebellum



- **Purkinje cells:**
  - **largest in CNS**
  - **Receive 200,000 synapses**
  - **Inhibitory**
  - **only cerebellar cortex neurons sending axons to cerebellar nuclei**
- **Cortex has 10^{12} neurons; more than cerebral cortex**

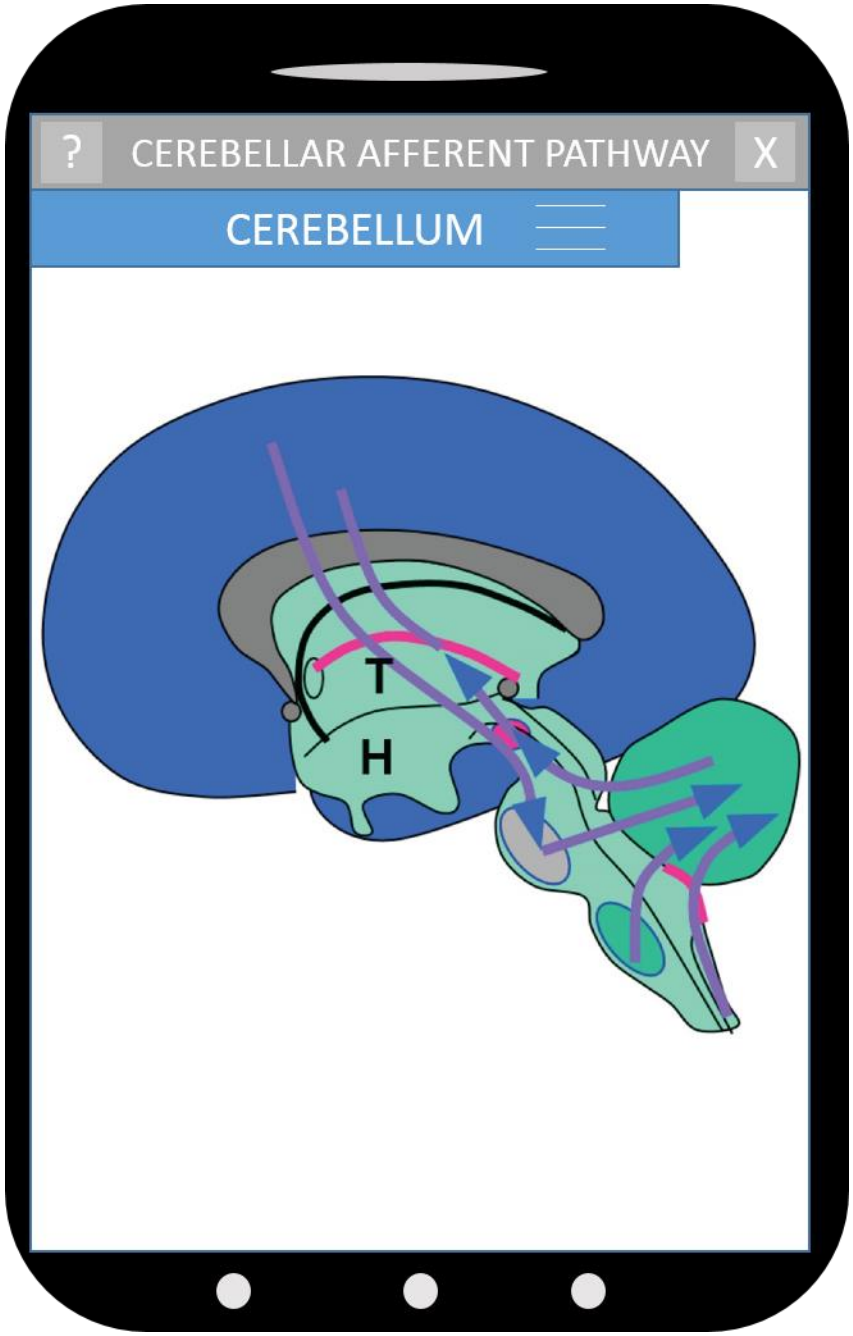
Afferent fibers to cerebellum:

- **Arise from:**
  1) **Spinal cord (Spinocerebellar fibers)**
  2) **Inferior Olivary nucleus (Olivocerebellar fibers)**
  3) **Vestibular nuclei (Vestibulocerebellar fibers)**
  4) **Pons (Pontocerebellar fibers)**
- **Enter through one of the peduncles, and go to cortex**
- **Terminate in the cerebellar cortex where they are excitatory to cortical neurons**

*** Fibers from inferior olivary nucleus end as climbing fibers, others end as mossy fibers**

Cerebellar AFFERENT pathway

- **From cerebral cortex**
  - cortico-ponto-cerebellar fibres
  - cerebro-olivo-cerebellar fibres
  - cerebro- reticulo- cerebellar fibres
- **From spinal cord**
  - anterior spinocerebellar tract
  - posterior spinocerebellar tract
  - cuneocerebellar tract
- **From vestibular nucleus**
  - vestibulocerebellar tract [flocculonodular lobe]
- **From other areas**
  - red nuclelus, tectum



Climbing fibres & Mossy fibres:

- climbing fibres go directly to the Purkinje cell.

- mossy fibres **DO NOT** go directly to the Purkinje cell.
Each mossy fibre branches profusely in the white matter. Each of these branches has multiple (up to 50) swellings (that resembled moss to the old time neuroanatomists)

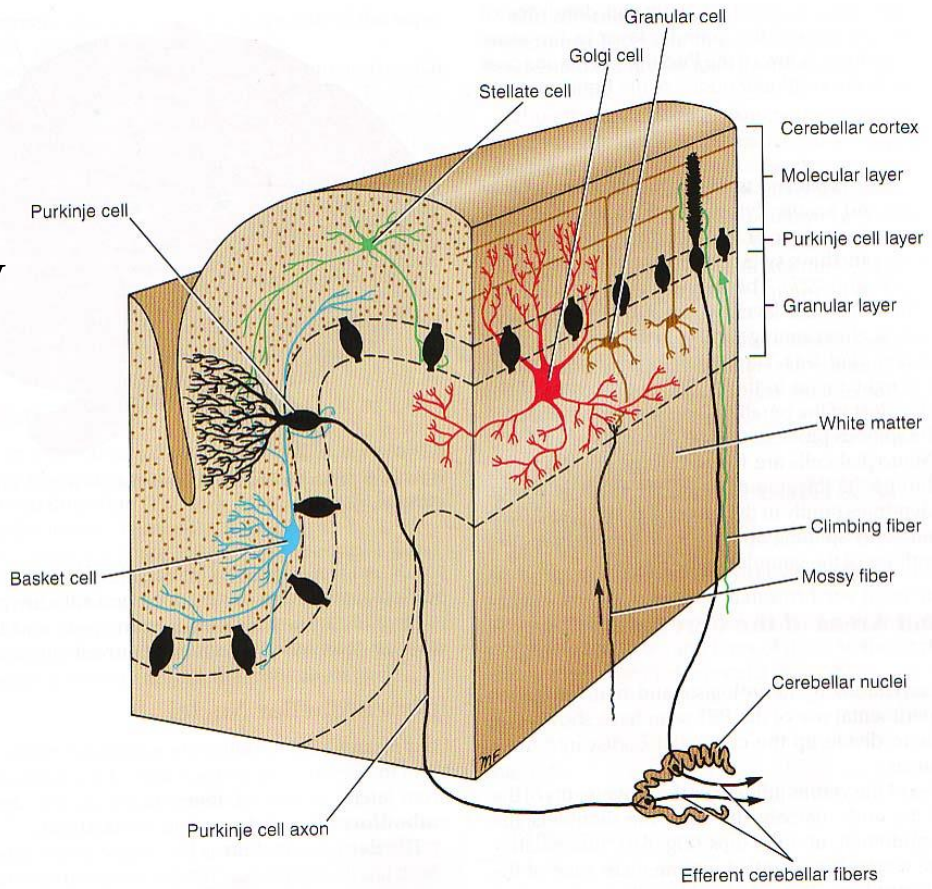


Figure 6-4 Cellular organization of the cerebellar cortex. Note the afferent and efferent fibers.

Efferent fibres:

- **The axons of the Purkinje cells are the ONLY axons to leave the cerebellar cortex**
- **Most of the fibres end in the cerebellar nuclei**
- **4 cerebellar nuclei:**
  1) **Fastigial nucleus**
  2) **Globose nucleus**
  3) **Emboliform nucleus**
  4) **Dentate nucleus**
     - largest

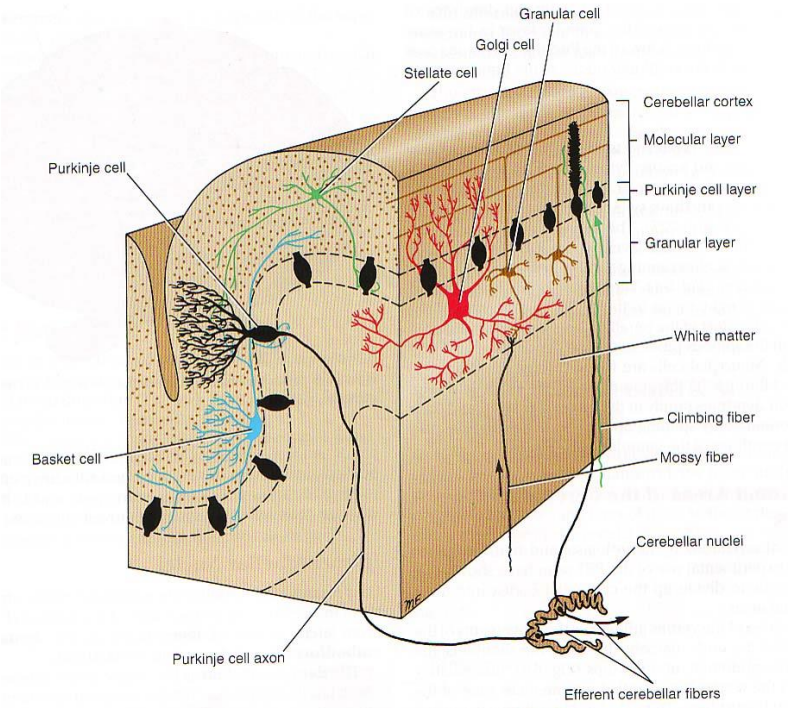
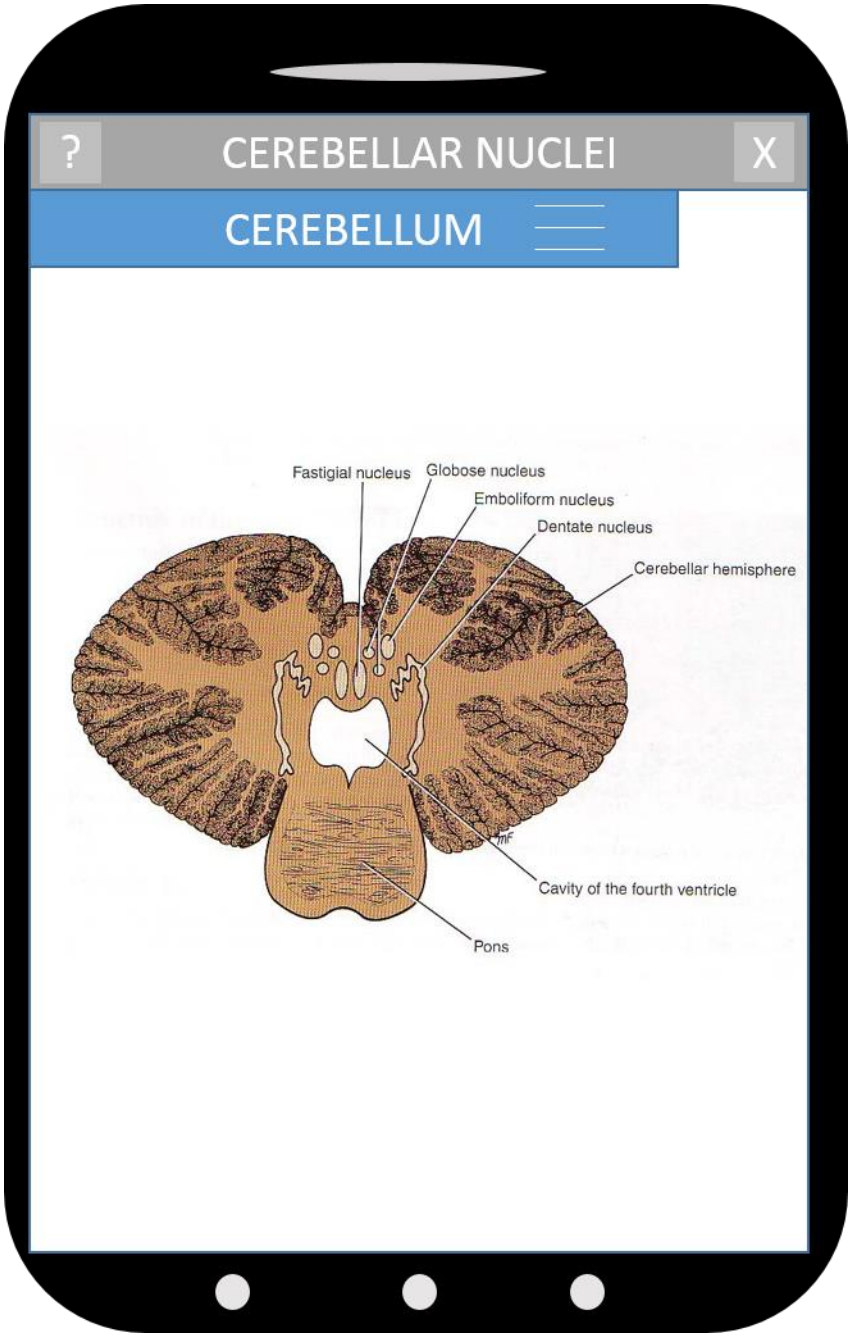


Figure 6-4 Cellular organization of the cerebellar cortex. Note the afferent and efferent fibers.

4 cerebellar nuclei



Efferent fibres of the cerebellar nuclei:

- **Efferent fibres end in :**
  1) **Vestibular nuclei of the medulla & pons**
  2) **Reticular nuclei of the medulla & pons**
  3) **Red nucleus of the midbrain**
  4) **Ventral lateral nucleus of the thalamus**

Functional anatomy of the cerebellum:

- **Consist of 3 functional subdivisions**

1) Archicerebellum

- Flocculonodular lobe + Fastigial nuclei

2) Paleocerebellum

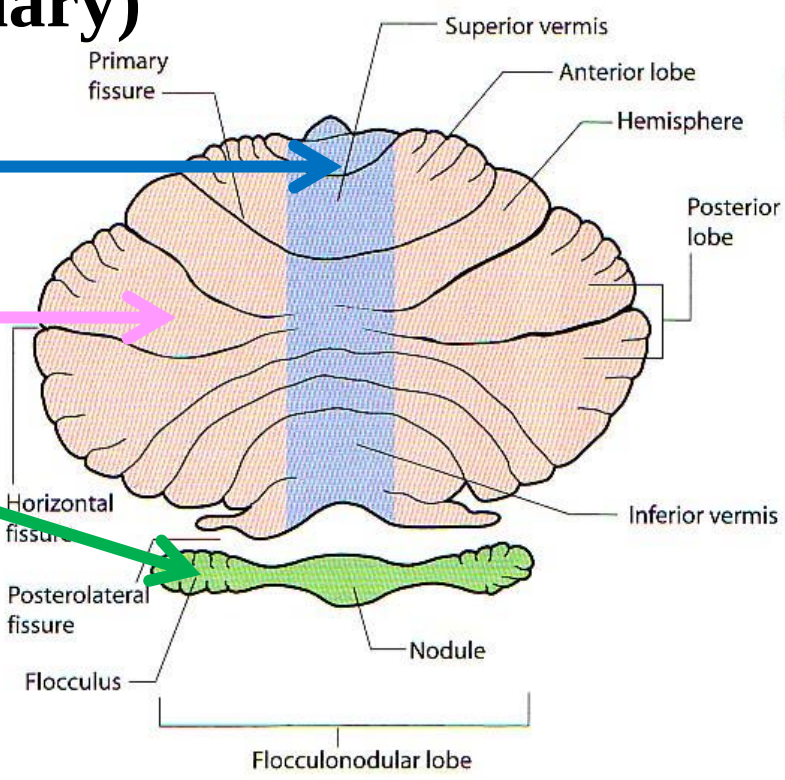
- Vermis + paravermis + Globose and Emboliform nuclei

3) Neocerebellum

- Cerebellar hemisphere + Dentate nuclei

Functional (Evolutionary)

- **Paleocerebellum**
- **Neocerebellum**
- **Archicerebellum**



Schematic drawing of cerebellum showing relationship between anatomical and functional divisions.

Green : Archicerebellum

Blue : Paleocerebellum

Pink : Neocerebellum

1) Archicerebellum:

posterior lobe (Vestibular part)

- it is formed by

- flocculonodular lobe + fastigial nuclei

- *Embryologically***,** it is the oldest part of cerebellum.
- it receives afferent fibres from vestibular apparatus of internal ear via vestibulo-cerebellar tracts.
- it is concerned with **equilibrium**.

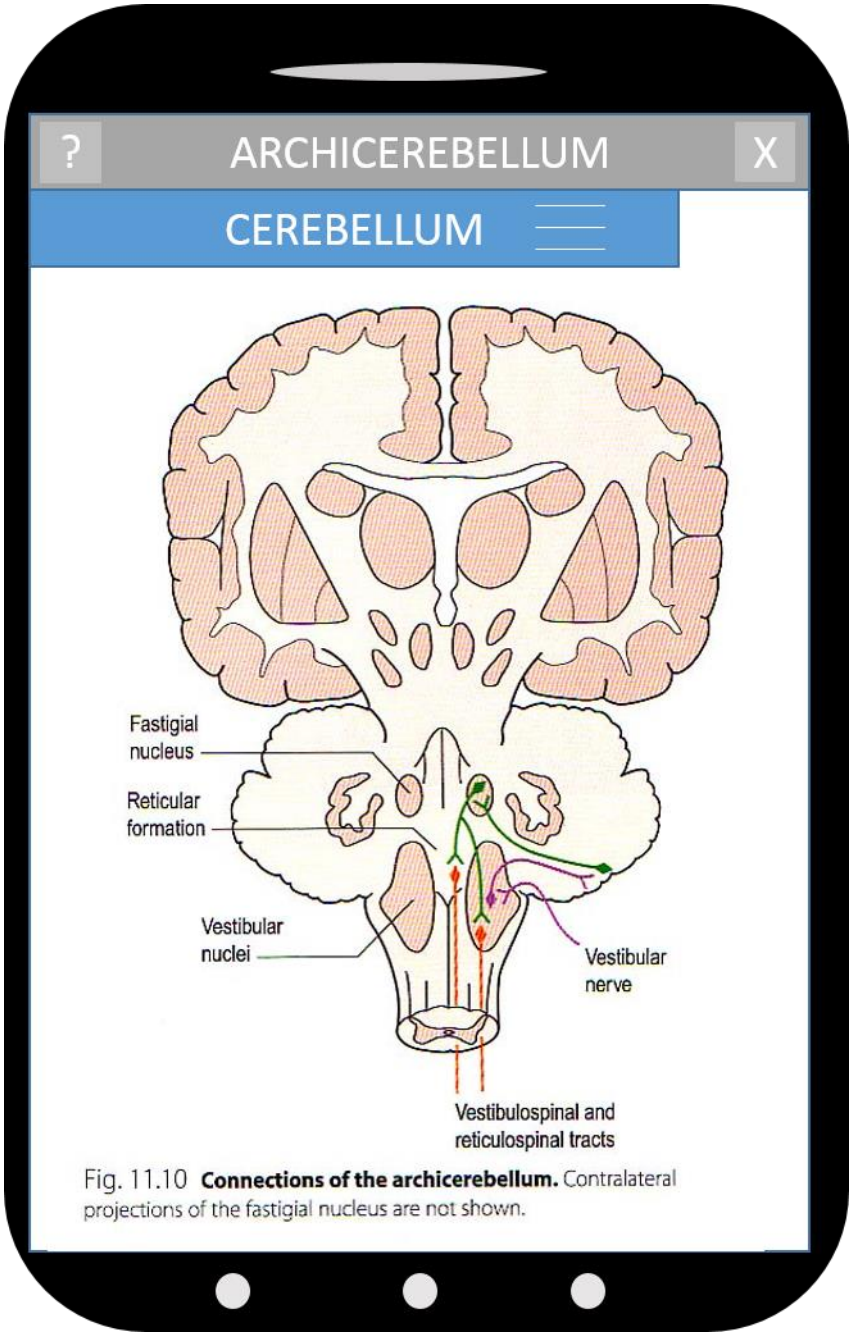


Fig. 11.10 **Connections of the archicerebellum.** Contralateral projections of the fastigial nucleus are not shown.

1) Archicerebellum:

- connections with ***vestibular & reticular nuclei** **of brain stem** through the inferior cerebellar peduncle.
- ***Afferent vestibular fibres** pass from vestibular nuclei (in pons & medulla) to the cortex of ipsilateral flocculonodular lobe.

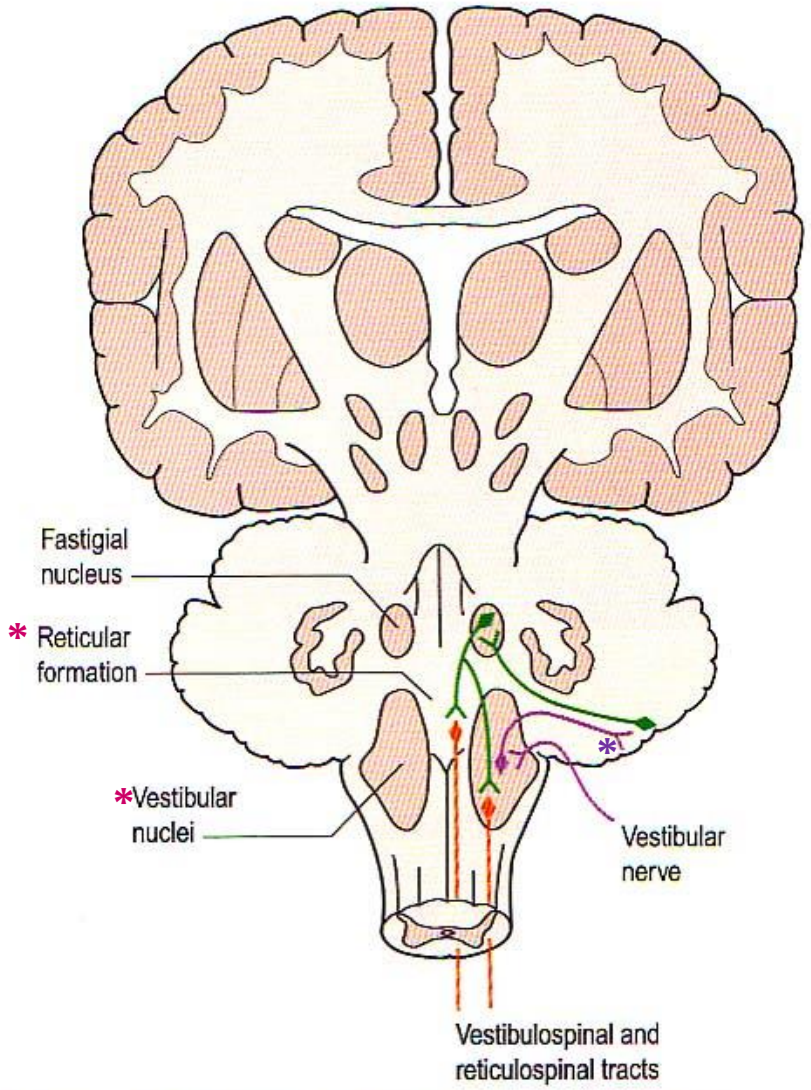


Fig. 11.10 **Connections of the archicerebellum.** Contralateral projections of the fastigial nucleus are not shown.

1) Archicerebellum:

- ***Efferent cortical (Purkinje cell) fibres** project to fastigial nucleus, which projects to vestibular nuclei & reticular formation.
- It affects the lower motor system bilaterally via descending **vestibulospinal** & **reticulospinal tracts**.

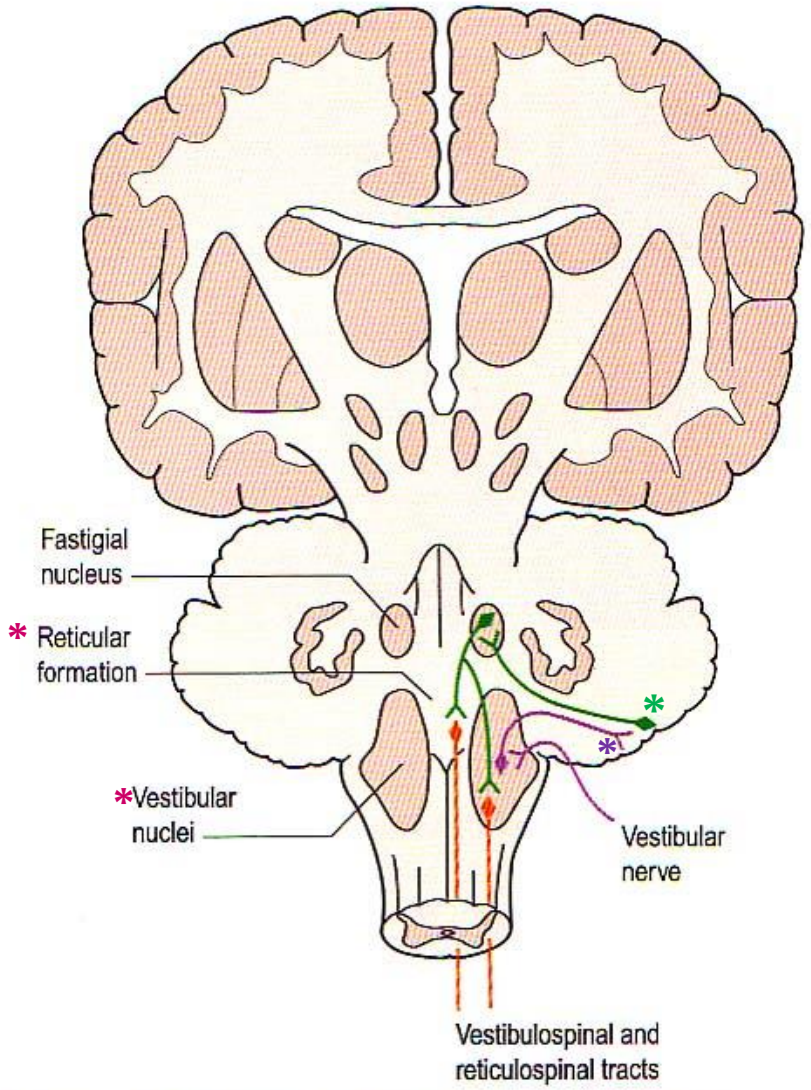
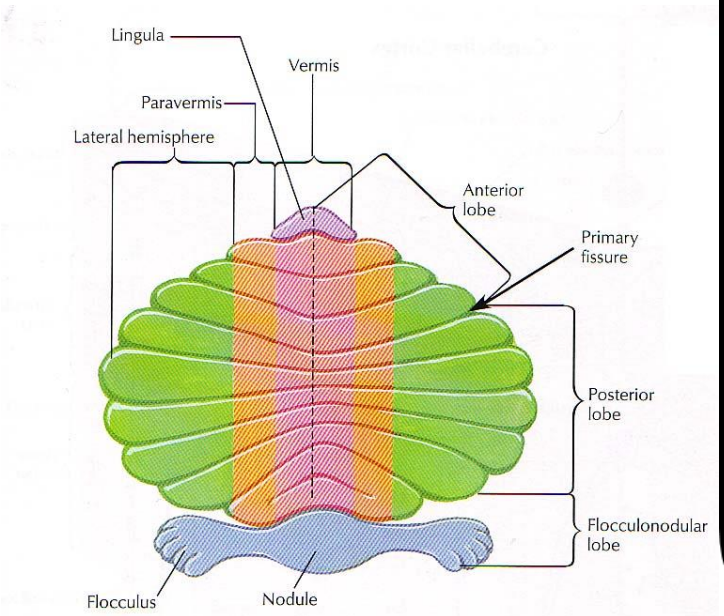


Fig. 11.10 **Connections of the archicerebellum.** Contralateral projections of the fastigial nucleus are not shown.

2) Paleocerebellum:

- it is formed by **midline vermis** + surrounding **paravermis** + **globose & emboliform nuclei**.
- It receives afferent proprio-ceptive impulses from muscles & tendons (*Spinocerebellar tract).



"Unfolded" schematic of cerebellum demonstrating regions and lobes

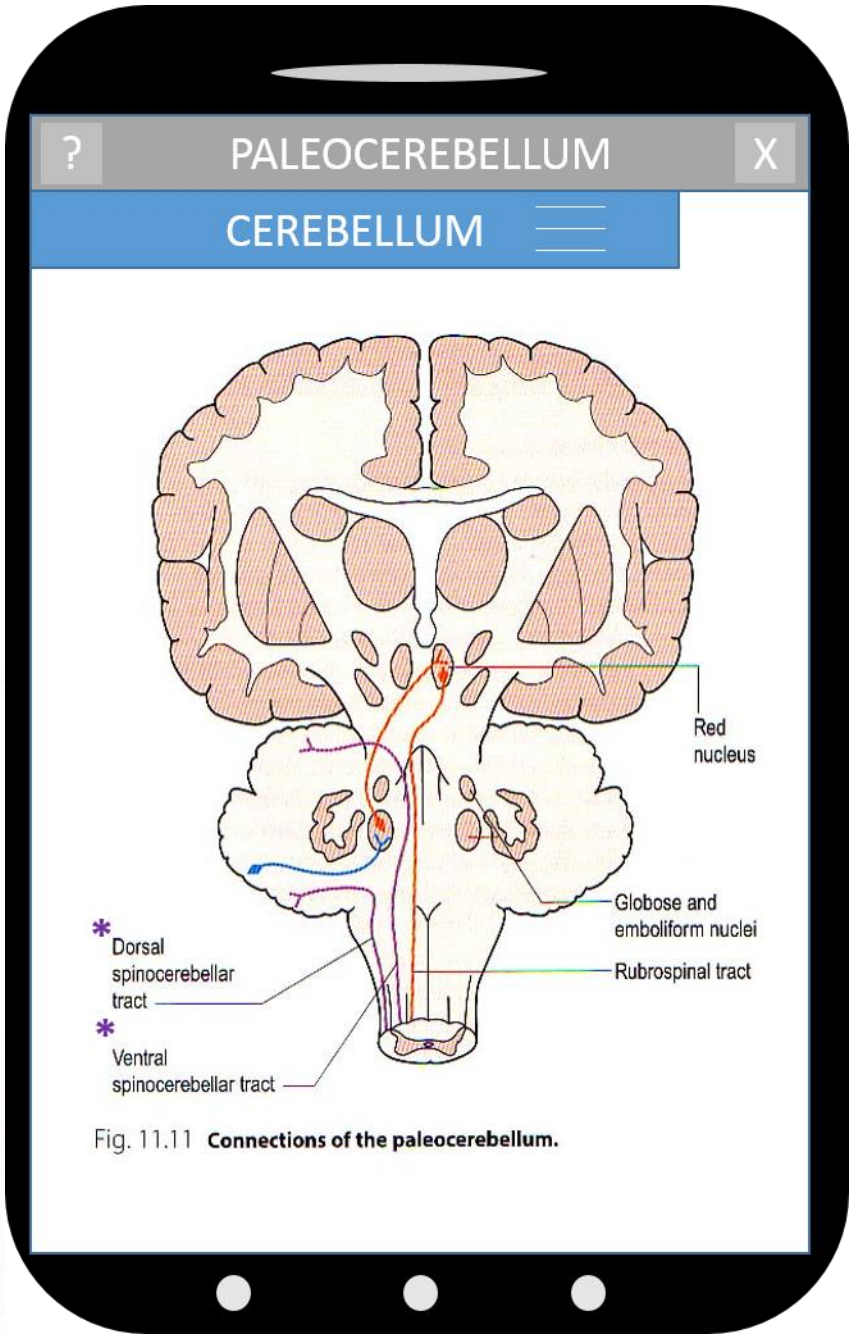


Fig. 11.11 **Connections of the paleocerebellum.**

2) Paleocerebellum:

- It is concerned with ***muscle tone & posture.***
- **Afferents spinal fibres** consist of dorsal & ventral ***spinocerebellar tract*** from muscle, joint & cutaneous receptors to enter the cortex of ***ipsilateral vermis & para vermis*** via inferior & superior cerebellar peduncles.

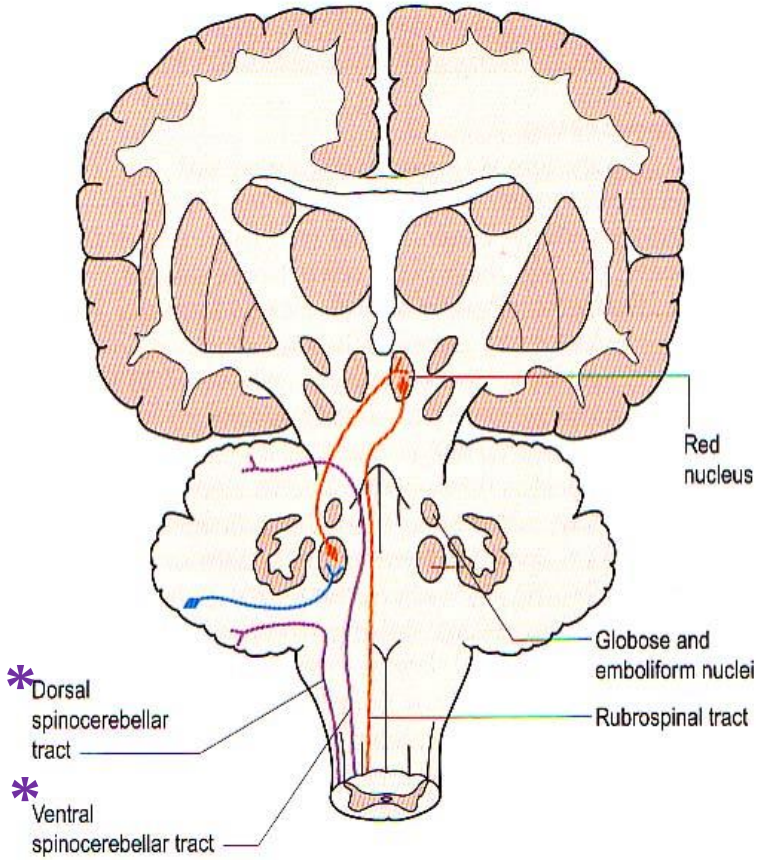


Fig. 11.11 **Connections of the paleocerebellum.**

2) Paleocerebellum:

- Efferents cortical fibres pass to ***globose & emboliform nuclei,*** then via superior cerebellar peduncle to *contra-lateral *red nucleus of midbrain* to give rise *descending rubro-spinal tract*.

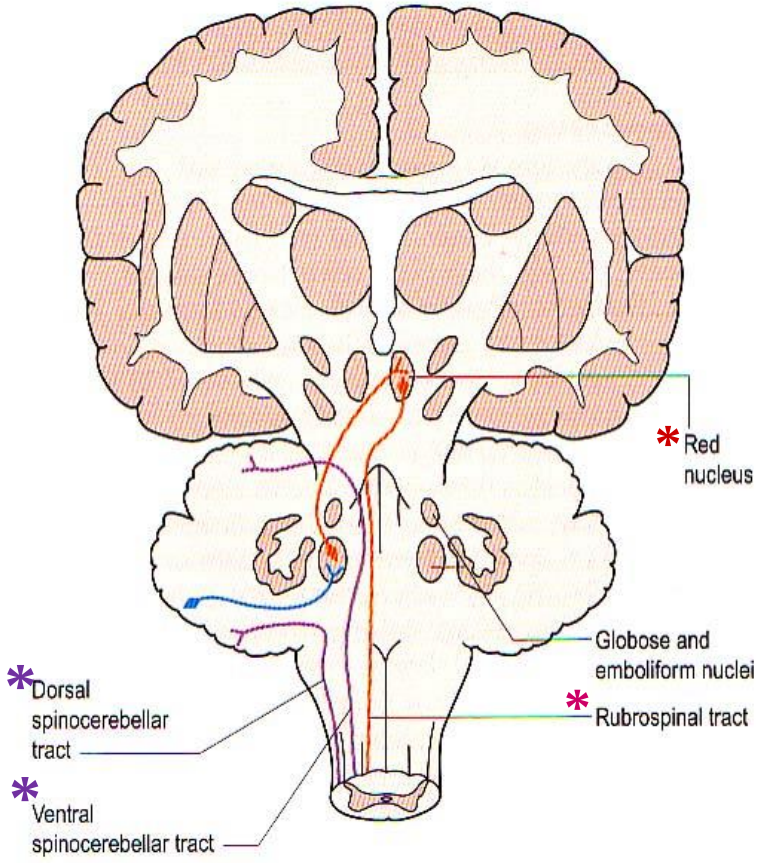
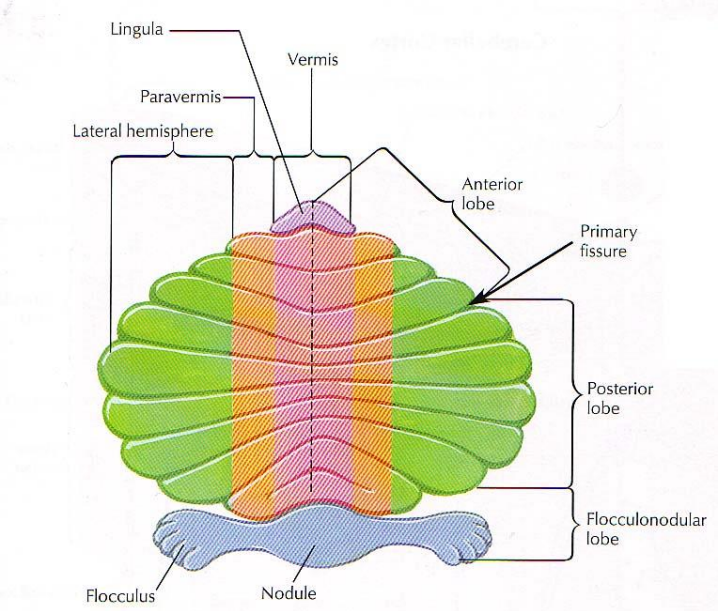


Fig. 11.11 **Connections of the paleocerebellum.**

3) Neocerebellum:

- it is the remaining largest part of cerebellum.
- it includes the *most 2-cerebellar hemispheres + dentate nuclei*.



"Unfolded" schematic of cerebellum demonstrating regions and lobes

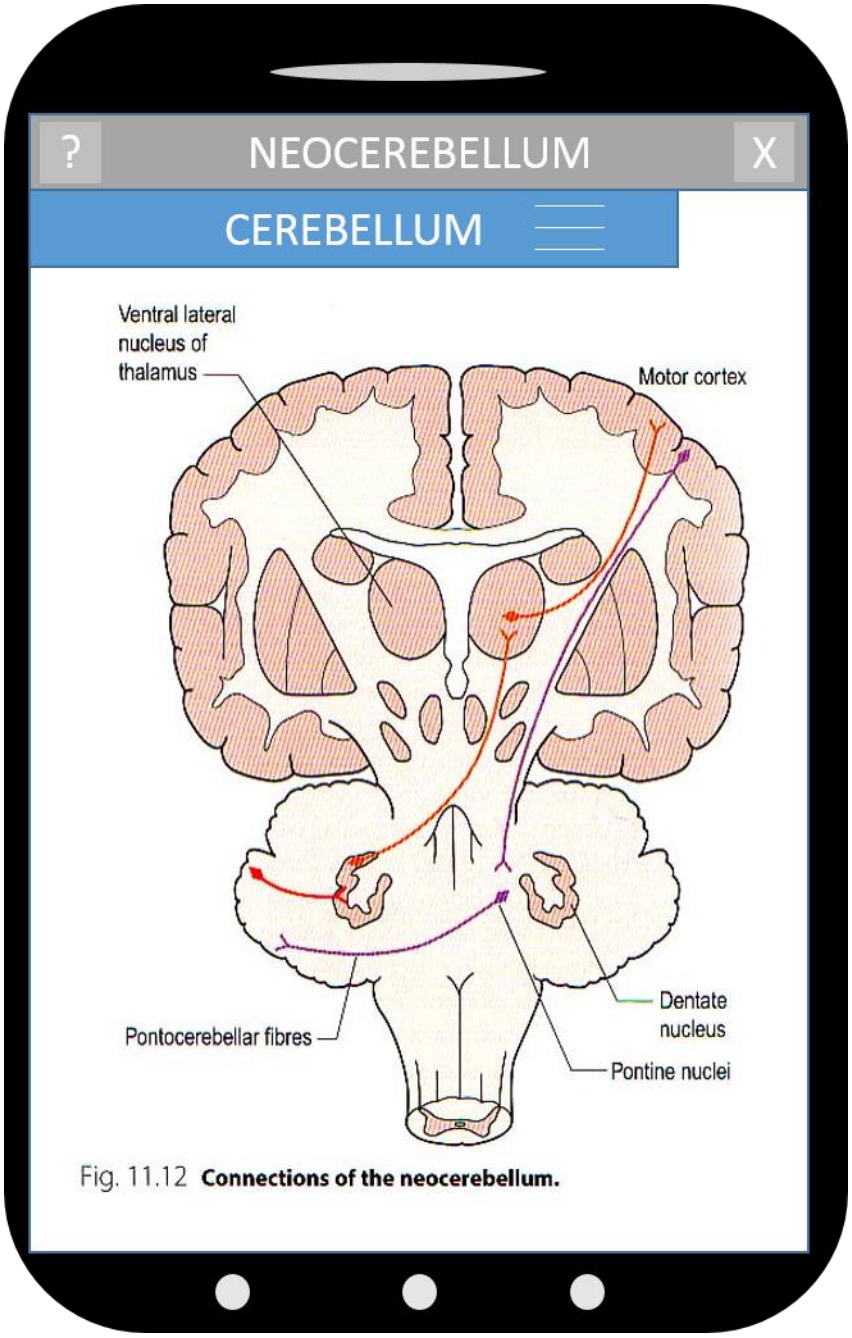


Fig. 11.12 **Connections of the neocerebellum.**

3) Neocerebellum:

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

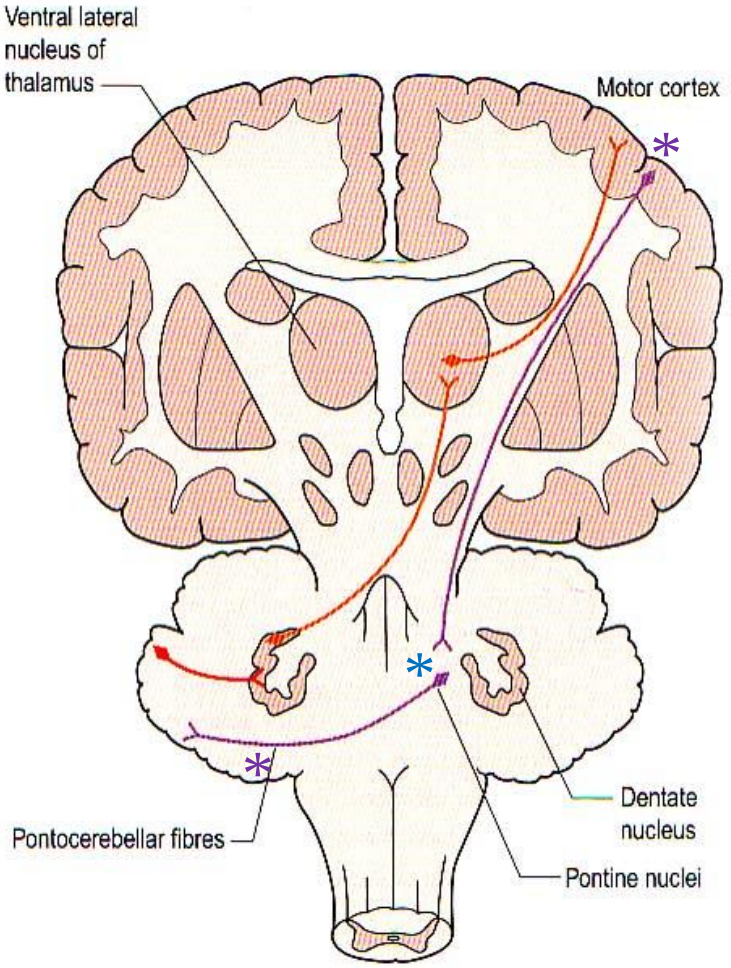


Fig. 11.12 **Connections of the neocerebellum.**

3) Neocerebellum:

- it sends ***efferents*** to ventro-lateral nucleus of *thalamus*.
- it controls ***voluntary movements (muscle coordination).***

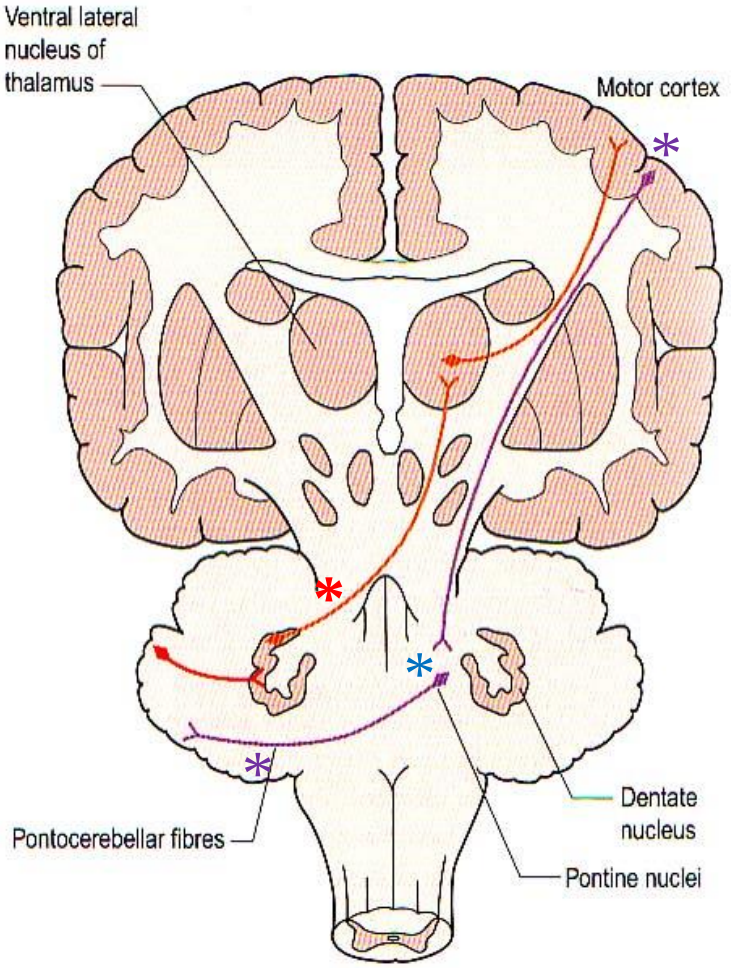


Fig. 11.12 **Connections of the neocerebellum.**

3) Neocerebellum:

- Neocerebellar efferents project to dentate nucleus, which in turn projects to contra-lateral red nucleus & ventral lateral nucleus of thalamus, then to motor cortex of frontal lobe, giving rise descending cortico-spinal & cortico-bulbar pathways.
  Efferents of dentate nucleus form a major part of superior cerebellar peduncle.

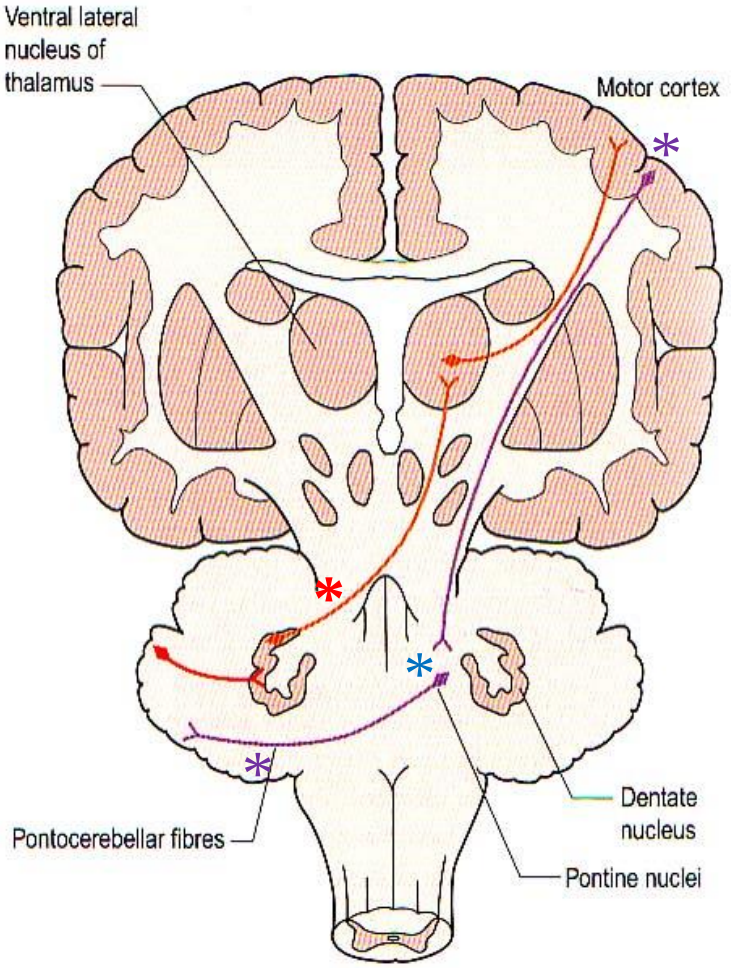
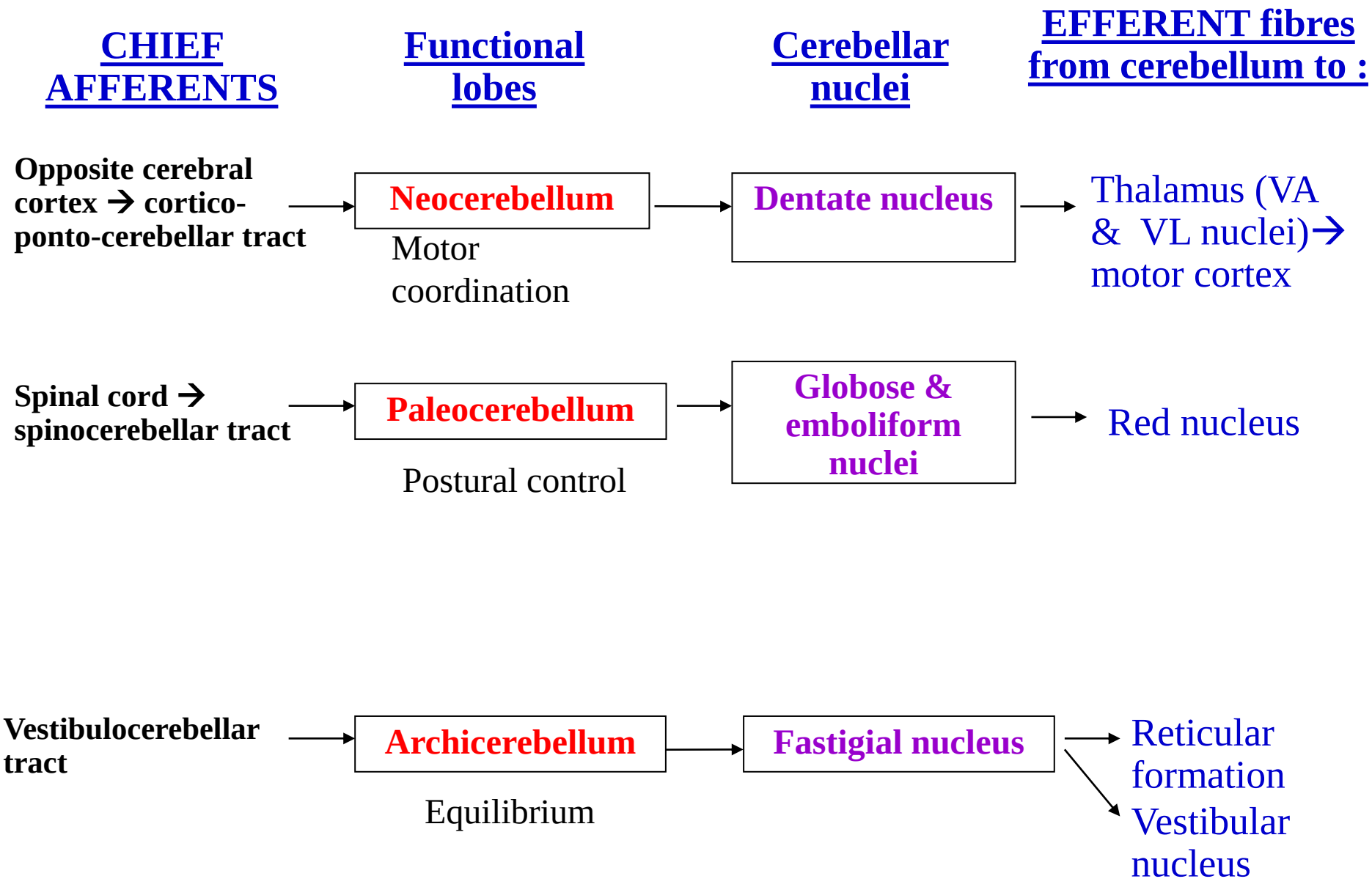


Fig. 11.12 **Connections of the neocerebellum.**

Main cerebellar connections:



Blood supply:

- **The cerebellum is supplied by the:**

1) Basilar artery

i - Superior cerebellar a.

= supplies the superior surface of the cerebellum

ii - Anterior inferior cerebellar a.

= supplies the anterior & inferior parts of the cerebellum

2) Vertebral artery

iii - Posterior inferior cerebellar a. (tortuous arteries)

= supplies: - inferior surface of the vermis

- central nuclei of the cerebellum

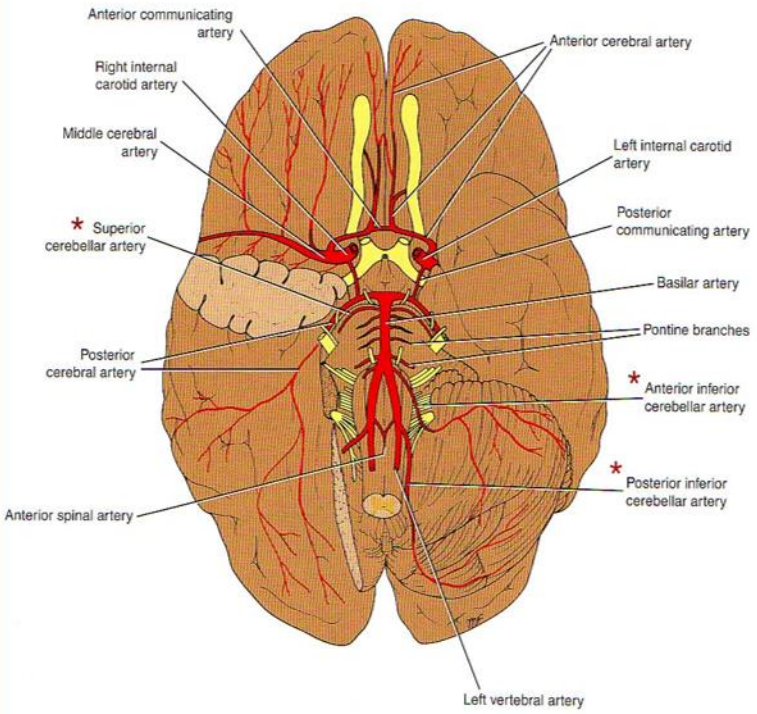
- undersurface of the cerebellar hemisphere

?

BLOOD SUPPLY

X

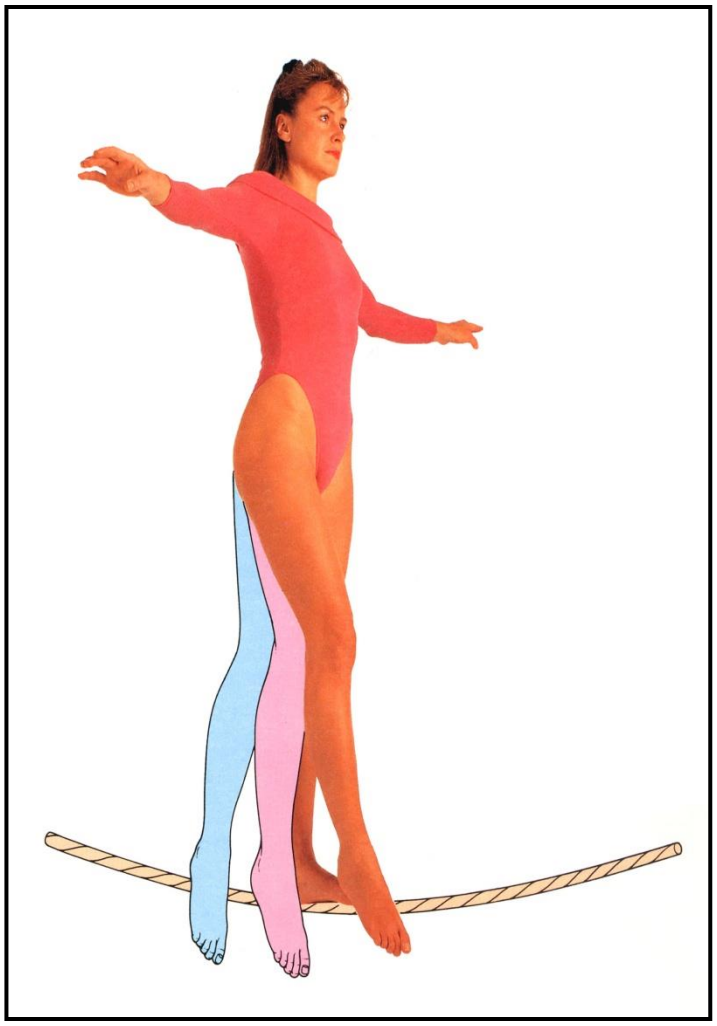
CEREBELLUM

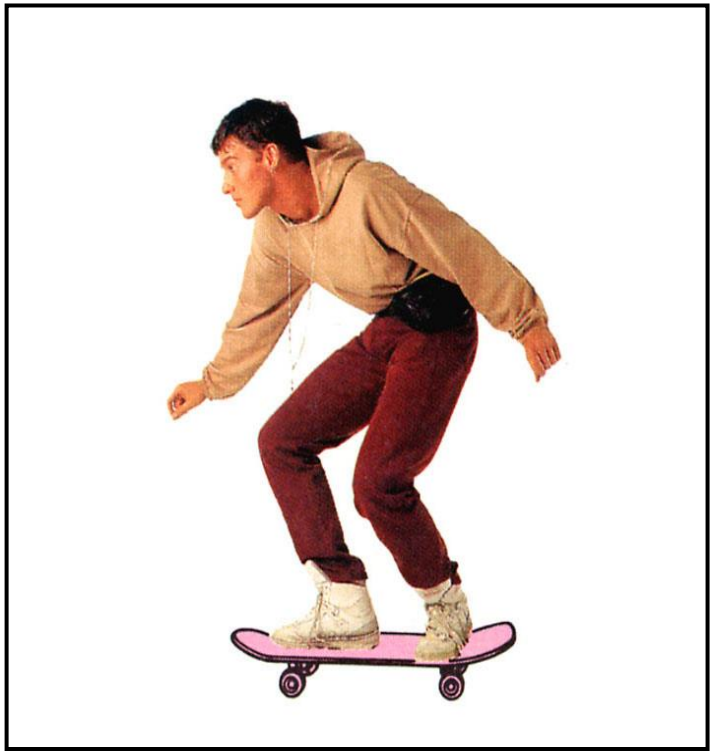


Functions of cerebellum:

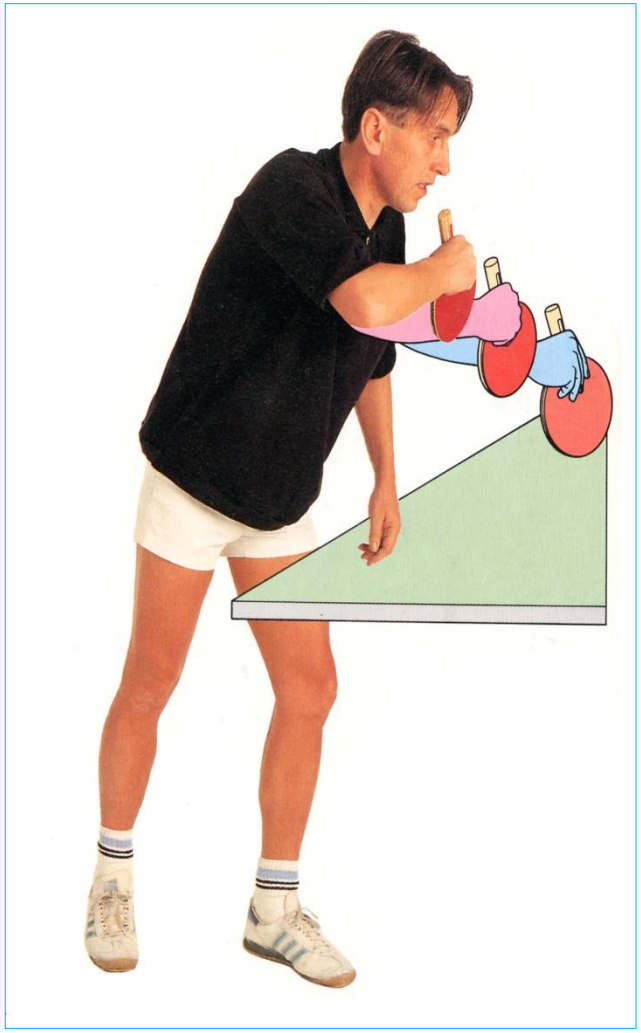
- ***Maintenance of Equilibrium***
  - balance, posture, eye movement
- ***Coordination of half-automatic movement of walking and posture maintenance***
  - posture, gait
- ***Adjustment of Muscle Tone***
- ***Motor Leaning – Motor Skills***
- ***Cognitive Function***

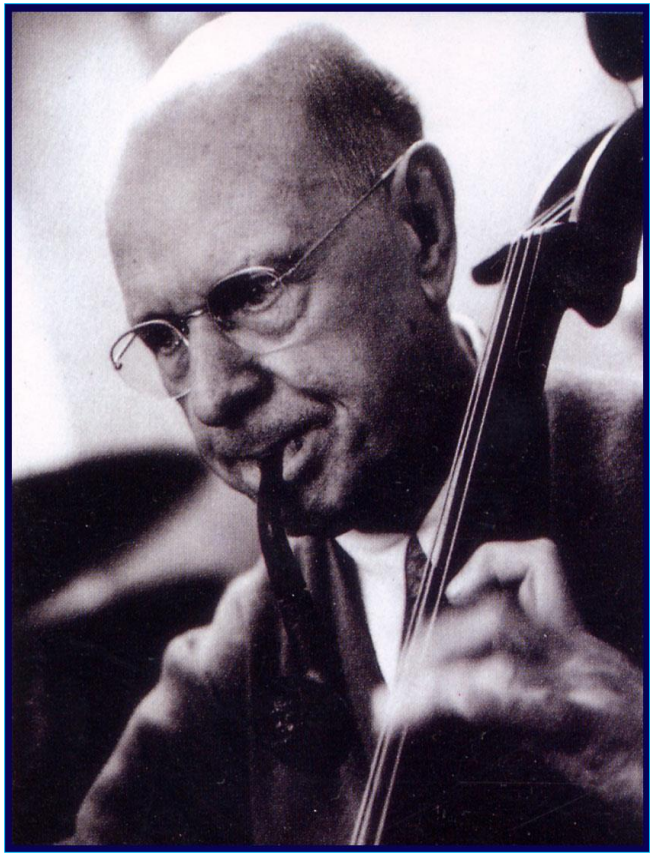
Balance





Motor skills





- **Two neuro anatomical features of clinical important are:**

1) **Cortex of cerebellum has a uniform microscopic structure identical in all regions**
2) **Cerebellar hemisphere connected to same side of the body, lesion give rise to signs and symptoms in the same side of the body**

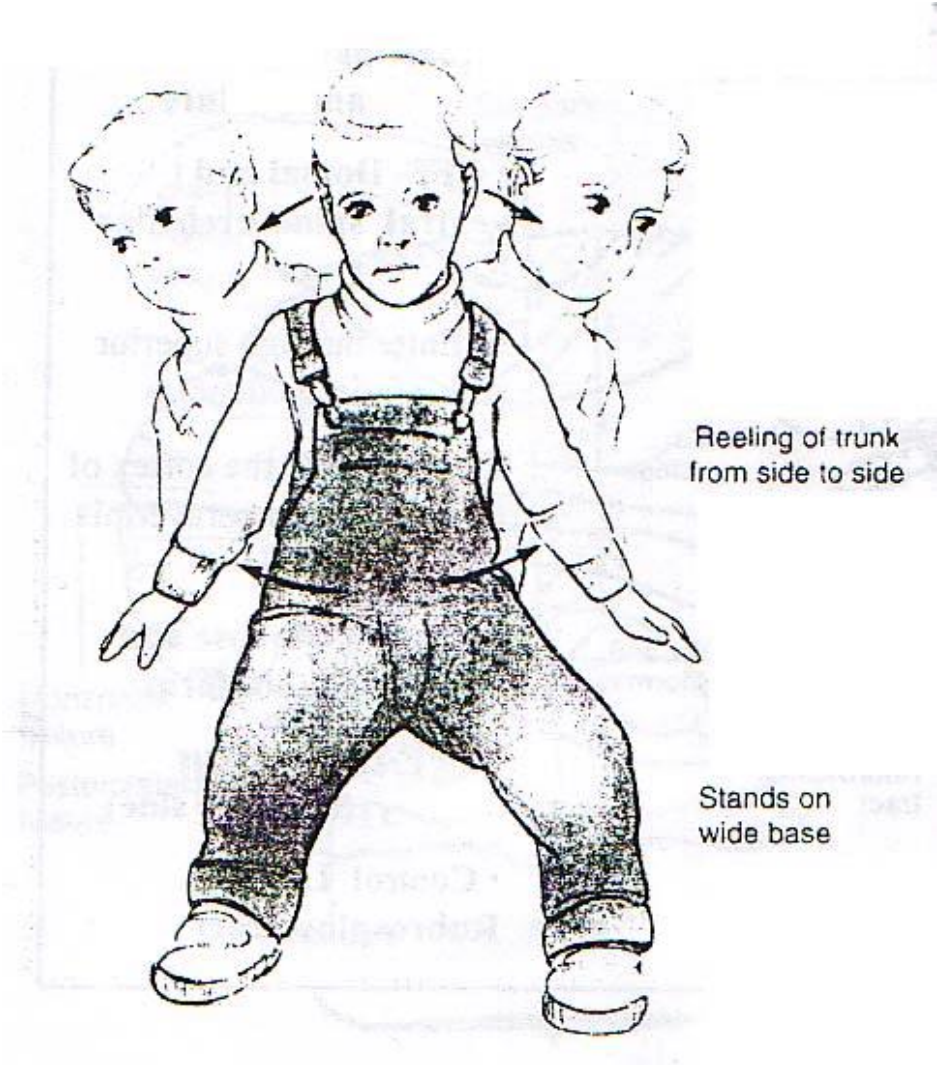
Applied anatomy: Various cerebellar dysfunction

The cerebellar lesions → deficits in coordinating movements; clinical (motor) signs of cerebellar lesions are always **IPSILATERAL** to the lesion → **cerebellar syndrome**

- Dysdiadochokinesia – *jerky action; unable to make rapid alternating movement*
- Ataxic gait
- Slurred speech - *slow, slurred, too (loud, soft, long, short), scanning speech*
- Hypotonia
- Intentional tremor – *tremor during movement*
- Nystagmus – *horizontal tremor/ ossilatory movement of the eyes while looking to other side*
- Gait - *staggering gait*

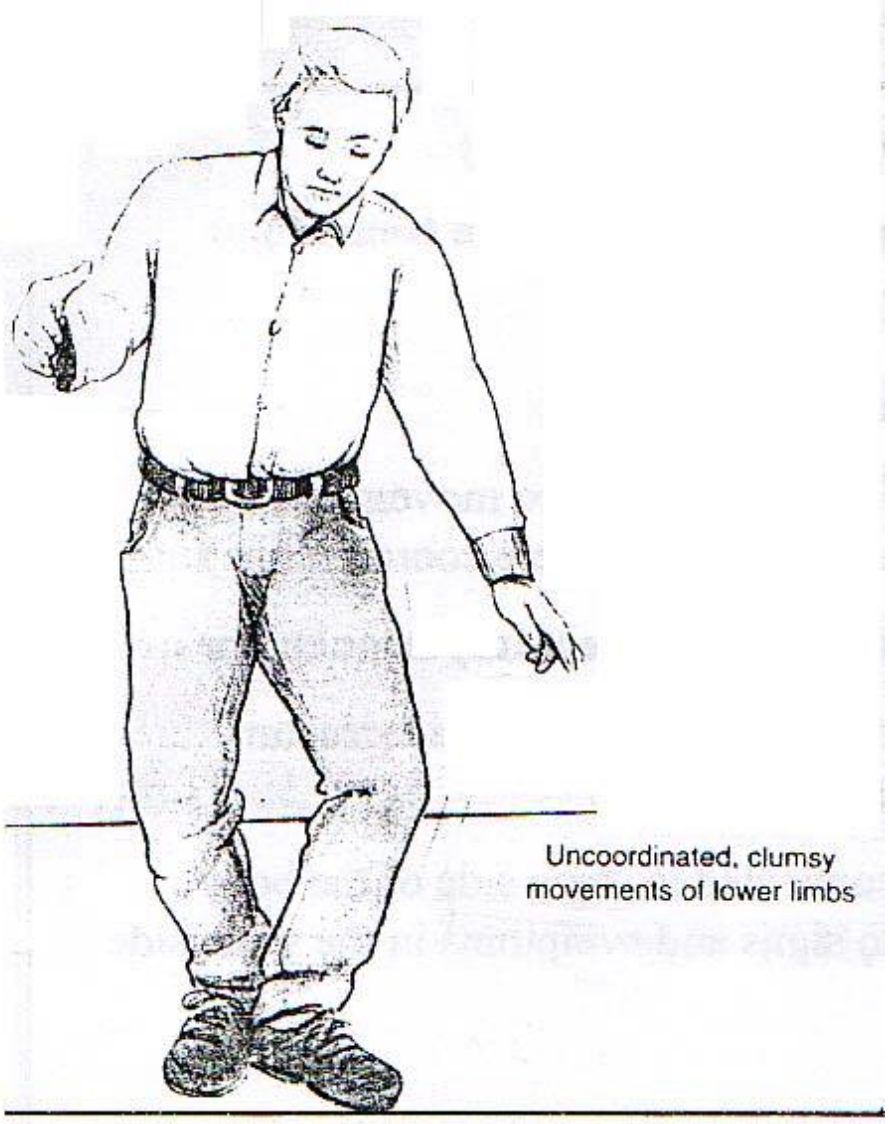
Flocculonodular lobe syndrome

- **Disturbance of balance**
- **Trunkal ataxia**
- **Lack of coordination of paraxial muscles**
- **Attempts to walk on a wide base**
- **In severe cases: impossible for patient to sit or stand without falling**



Anterior lobe syndrome

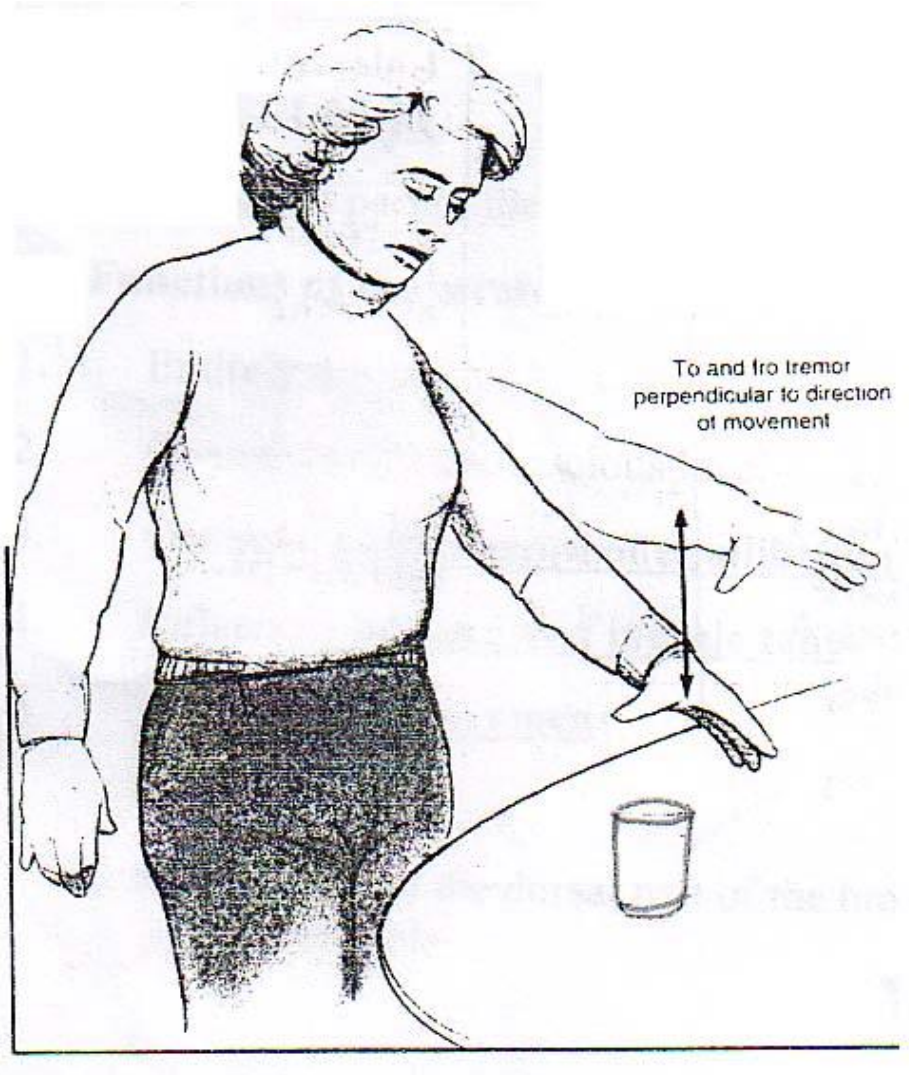
- **Gait ataxia**
- **Uncordinated, clumsy movements of the lower limb**



Posterior lobe syndrome

- **Loss of coordination of voluntary movements**
- **Intention tremor**

***Intention tremors are slower types of tremors, so the movements look broader and coarse**



- **Cerebellar lesions causes:**
  1) **Incoordination of the upper limbs (intention tremor)**
  2) **Lower limbs (Cerebellar ataxia)**
  3) **Speech (Dysarthria)**
  4) **Eyes (Nystagmus)**

     - involuntary to and fro movements of the eyes, due to lack of muscle coordination

ATAXIA & INTENTION TREMOR

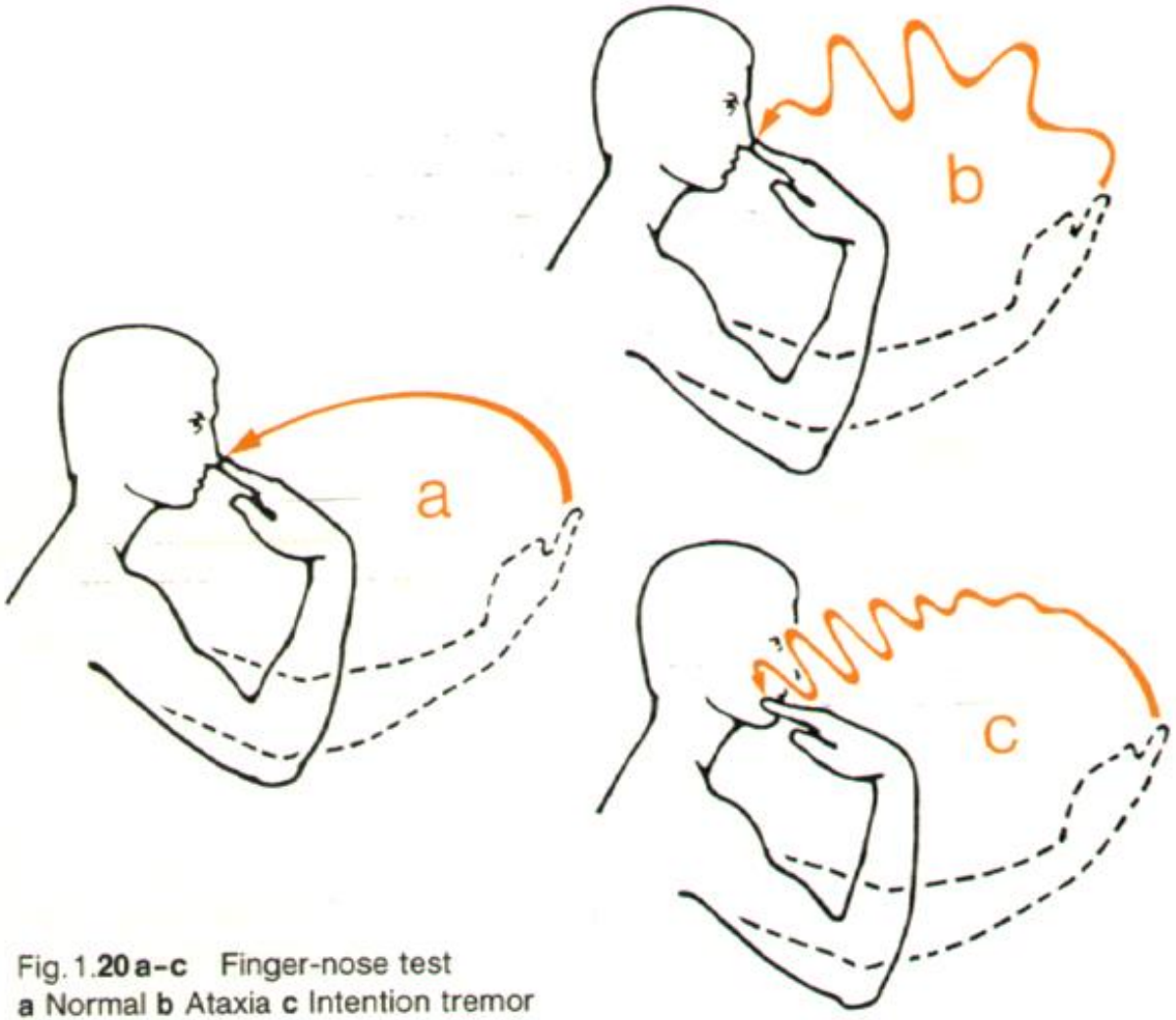


Fig. 1.**20 a–c** Finger-nose test
a Normal **b** Ataxia **c** Intention tremor