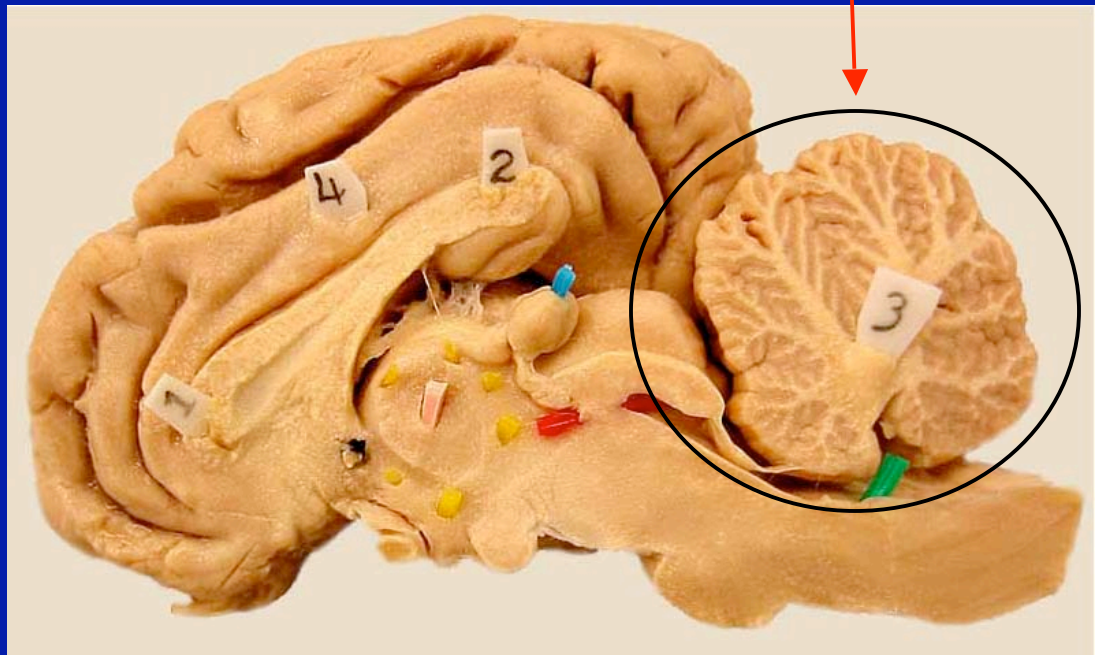
Cerebellum

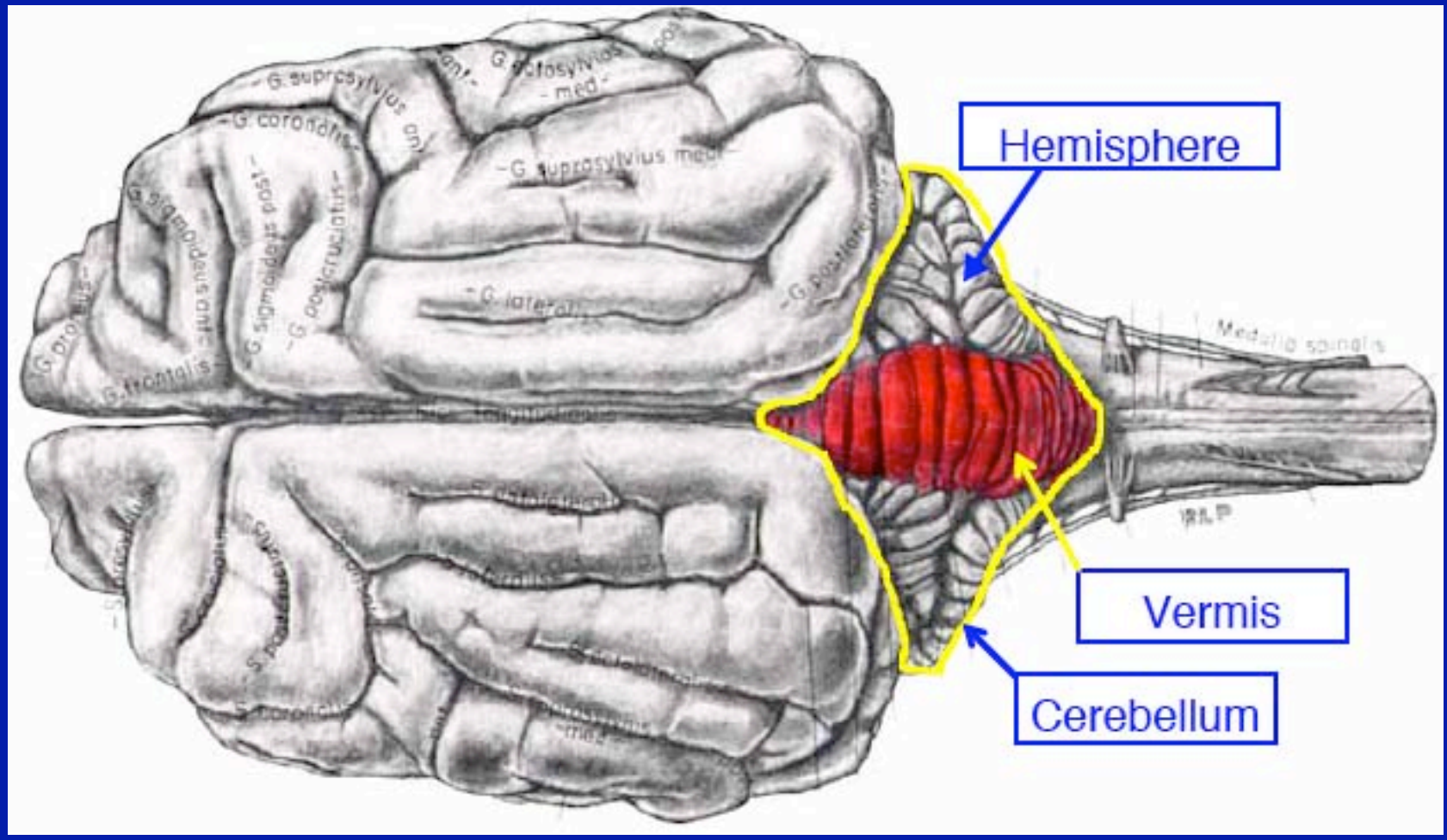
Objectives:

1. **To learn the basic anatomical organization and functional roles of the cerebellum**
2. **To understand the anatomical and chemical organization of the cerebellar cortex (cell layers, cell types, transmitters**
3. **To appreciate the clinical abnormalites that occur following cerebellar damage.**

Location: The term cerebellum literally means “little brain”. It is located dorsal to the brainstem and is connected to the brainstem by 3 pairs of cerebellar peduncles.



Dorsal View of the Cerebellum



Functions- 3 major functional roles

1. Coordination of Movement-the cerebellum controls the timing and pattern of muscle activation during movement.
2. Maintenance of Equilibrium (in conjunction with the vestibular system)
3. Regulation of Muscle Tone-modulates spinal cord and brain stem mechanisms involved in postural control.

Dysfunction: damage produces the following:

- **Ataxia-** a disturbance that alters the direction and extent of voluntary movements; abnormal gait and uncoordinated movements
- **Dysmetria-** altered range of motion (misjudge distance)
- **Intention Tremor**-oscillating motion, especially of head, during movement
- **Vestibular signs**-nystagmus, held tilt

Gross Anatomical Organization

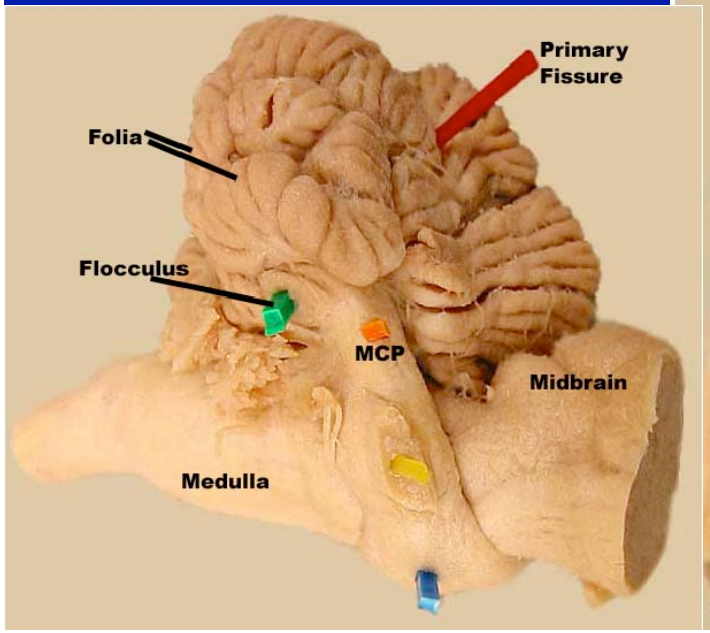
1. Internal Organization (similar to cerebral hemisphere)

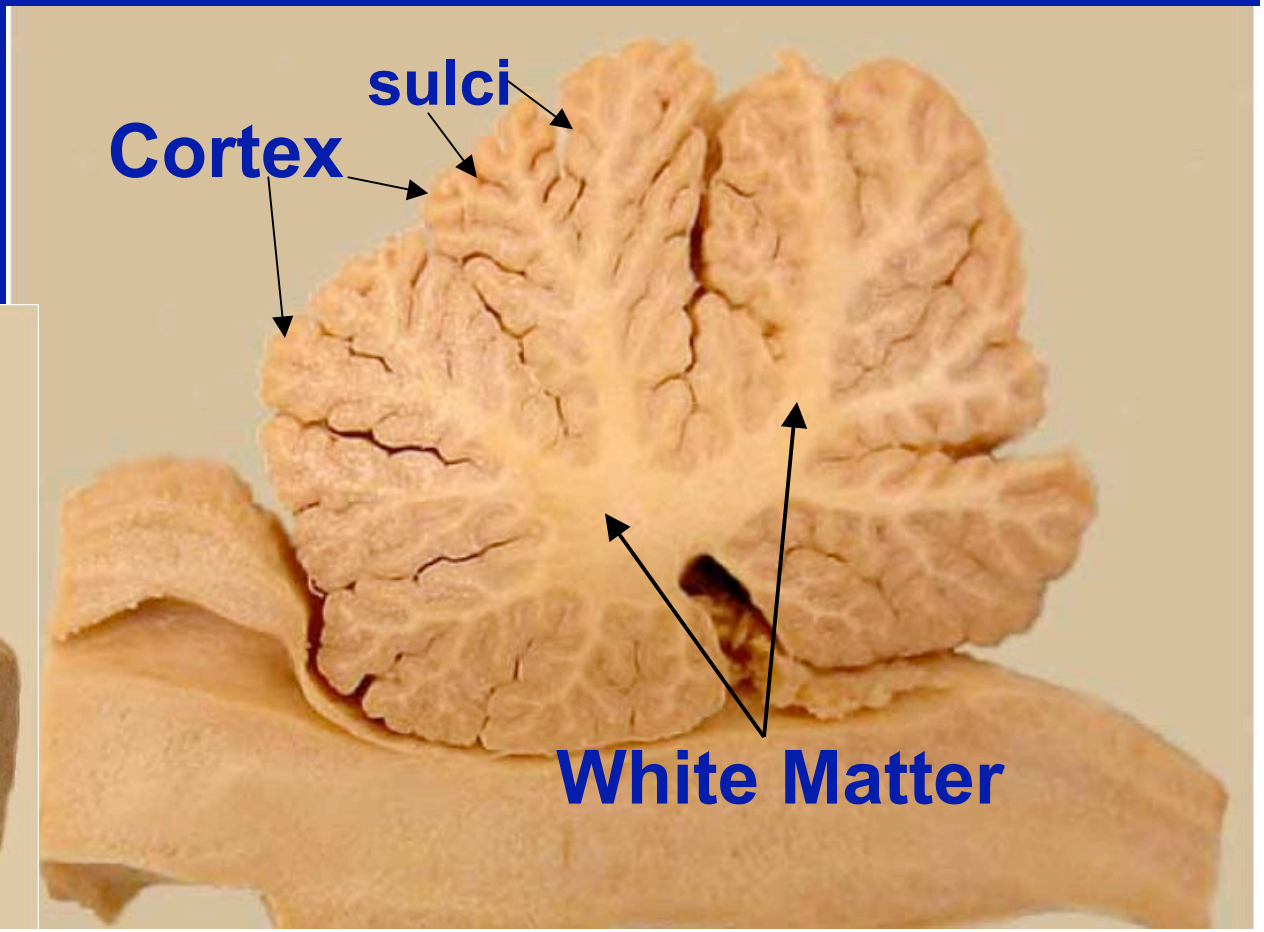
   a. Cerebellar Cortex-surface gray matter;sulci & folia

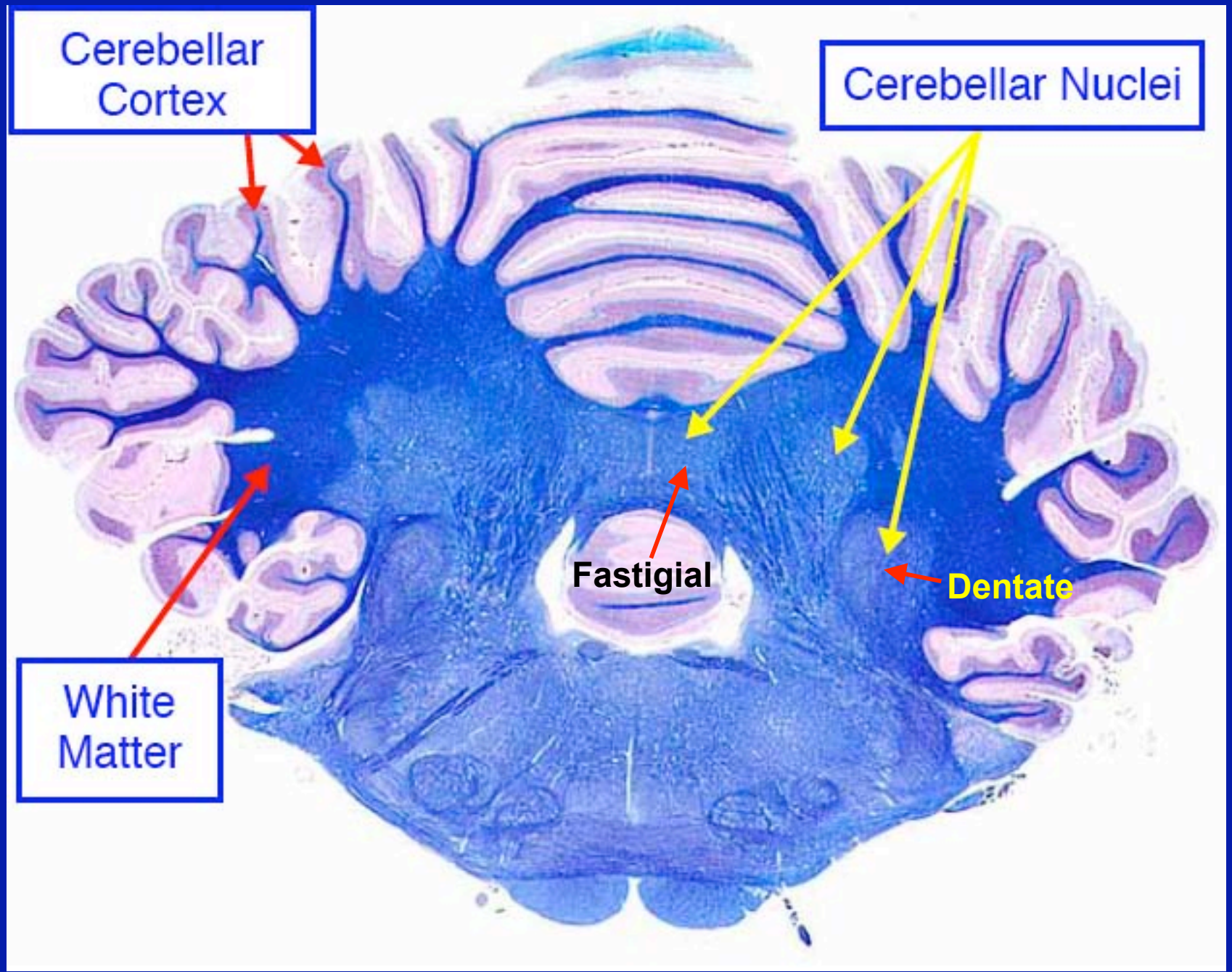
   b. White Matter-internal

   c. Cerebellar Nuclei- three pairs located in white matter:

      Fastigial
      Interpositus
      Dentate



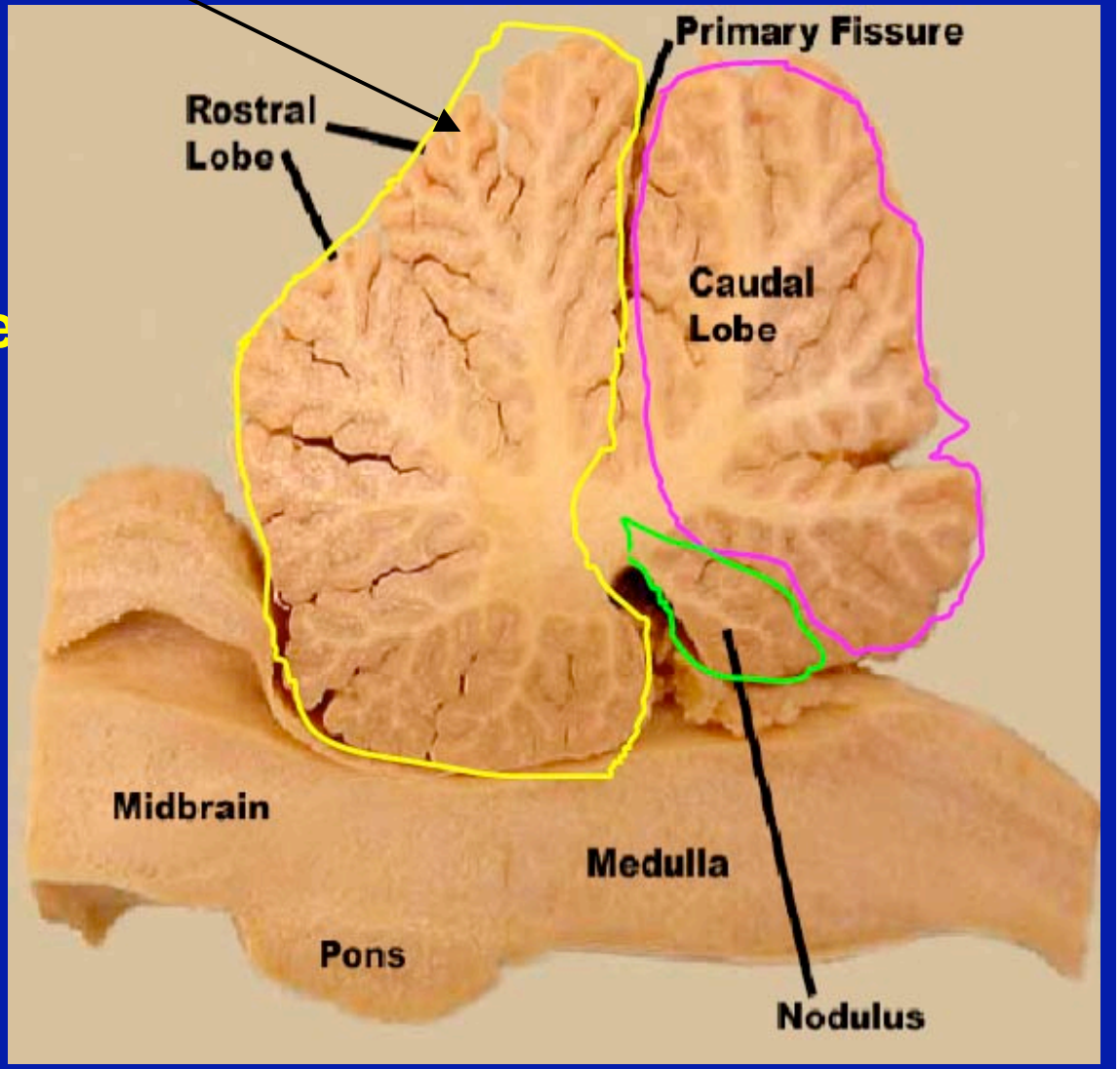



Cerebellar Cortex
Cerebellar Nuclei
Fastigial
Dentate
White Matter

2. Cerebellar Lobes:

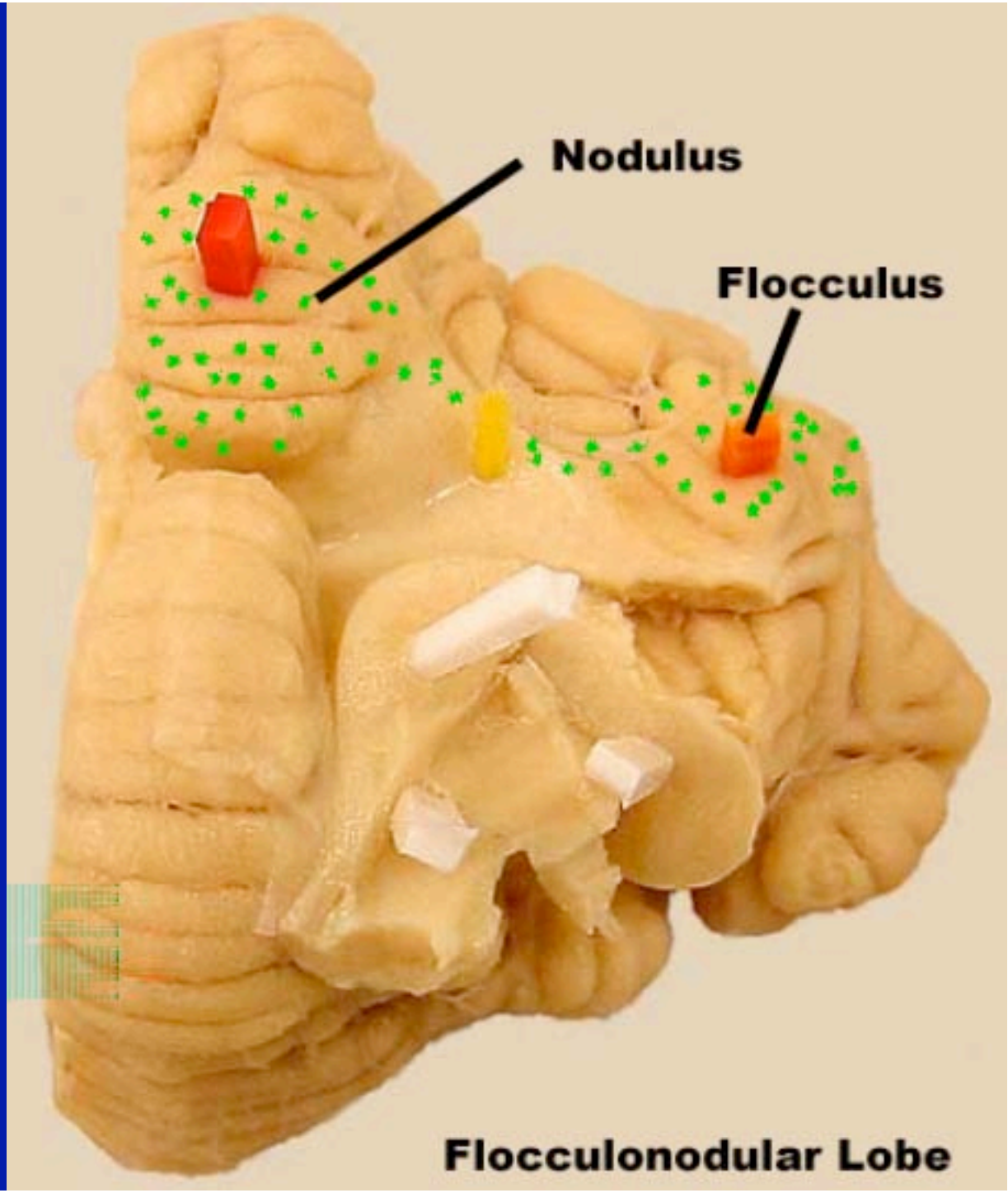
A. Rostral Lobe= Spinocerebellum (paleocerebellum)-related to spinal cord, postural tone. Damage results in forelimb hyperextension and hindlimb hip flexion

B. Caudal Lobe= cerebrocerebellum (neocerebellum)-damage results in hypotonia, hypermetria & intention tremor



C. Flocculonodular Lobe=

Vestibulocerebellum- associated with the vestibular system (eye movement, etc.); damage results in dysequilibrium, wide based gait and nystagmus

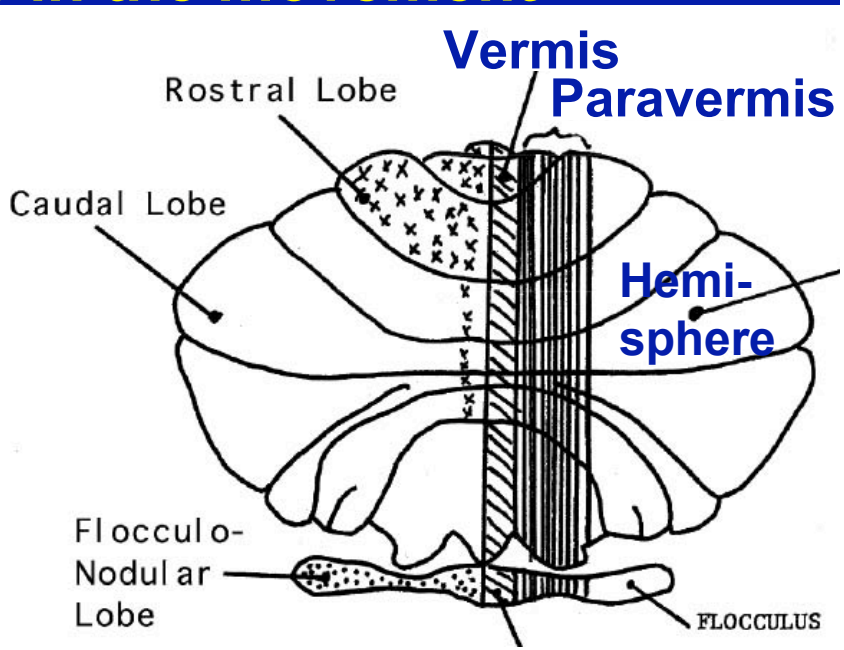


3. Longitudinal Zones

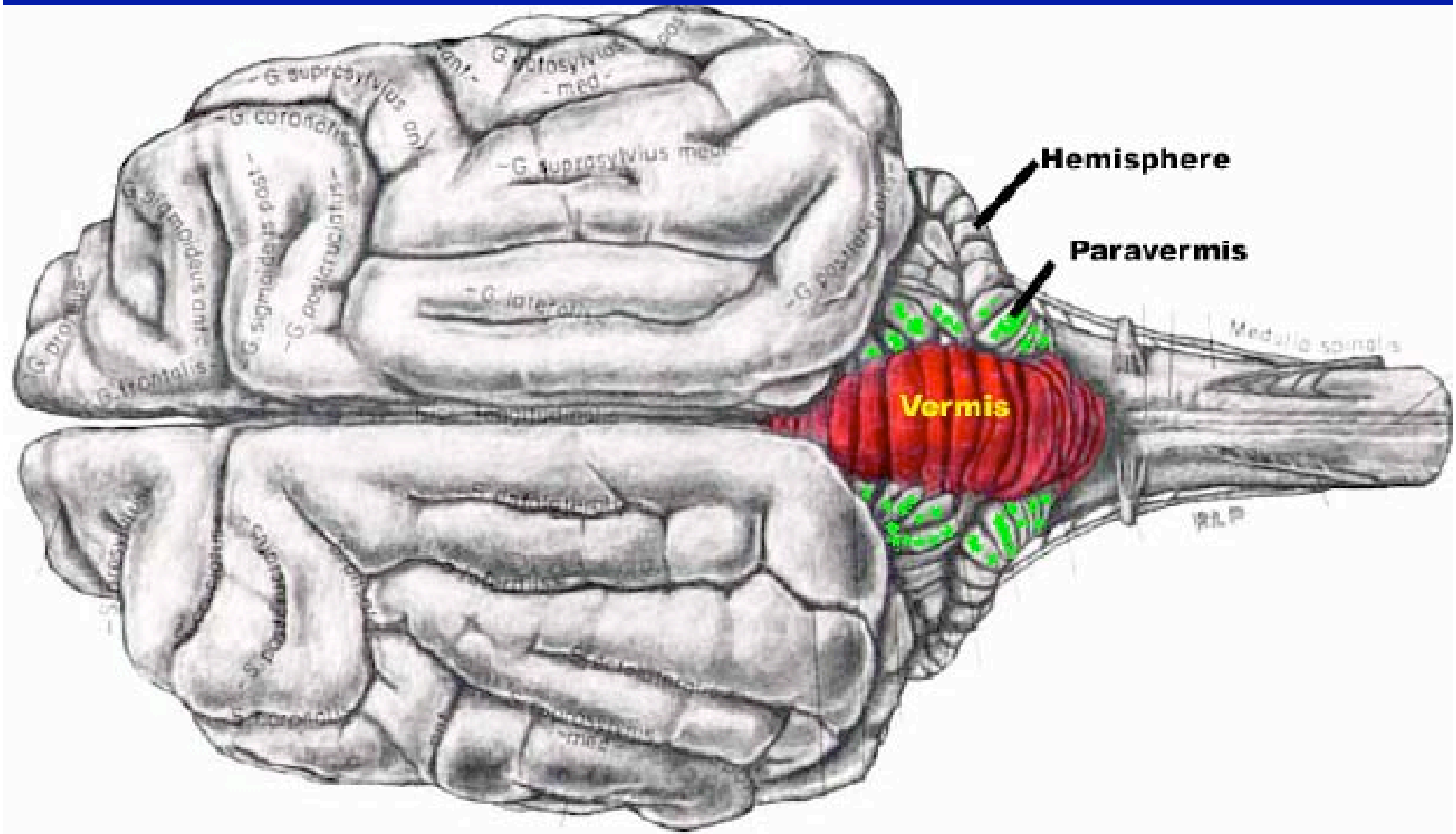
A. Vermis- most medal portion of cerebellum; associated with the fastigial nucleus, concerned with regulation of muscle tone for posture and locomotion.

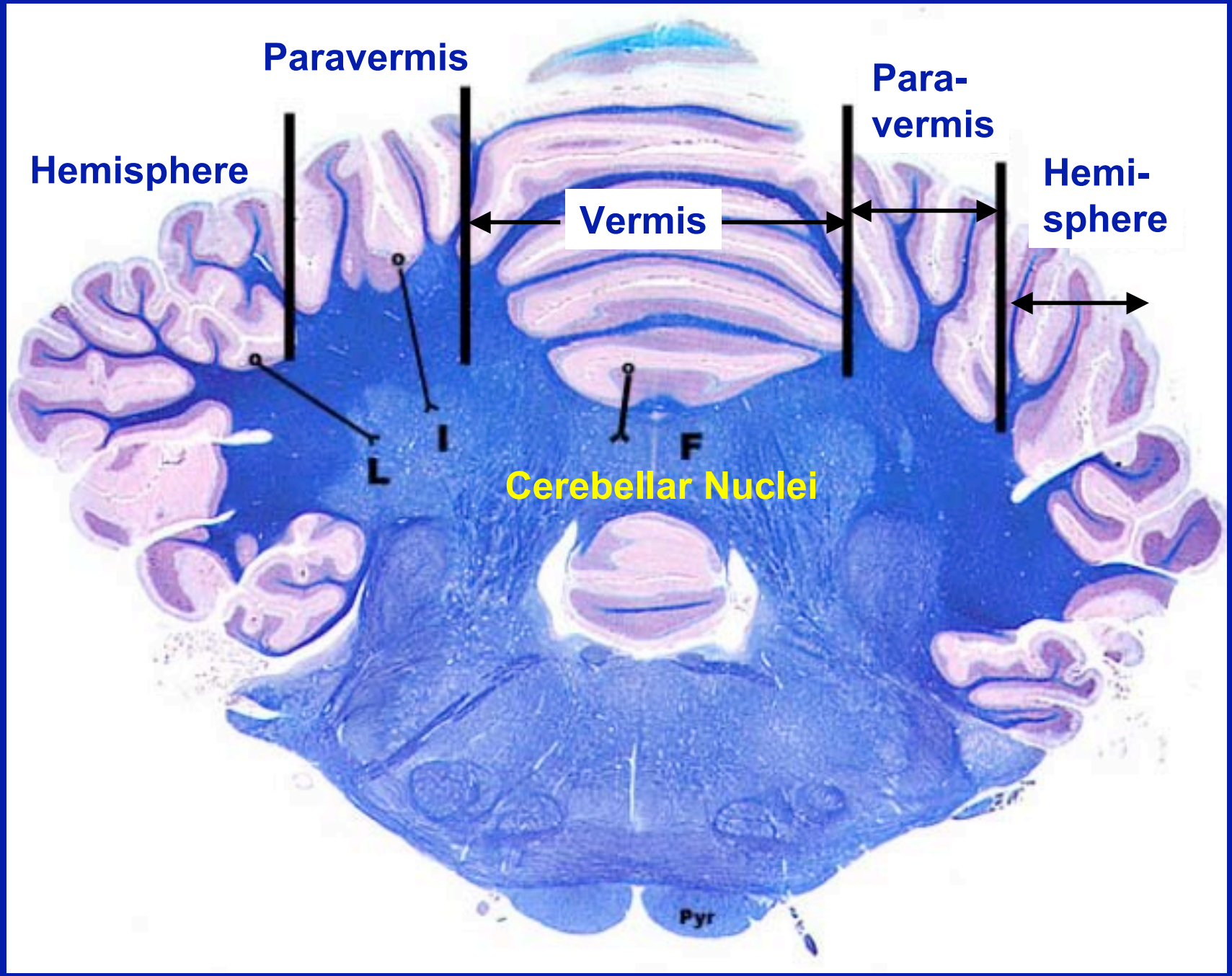
B. Paravermis- intermediate part of the cerebellum, associated with the interpositus nucleus; participates in the control of an evolving movement by utilizing proprioceptive sensory information generated by the movement itself to correct errors in the movement

C. Hemisphere-the largest and most lateral part of the cerebellum; associated with the dentate nucleus; influences the output to the motor cortex & permits fine delicate adjustments in muscle tone-> skilled movement



Longitudinal Zones





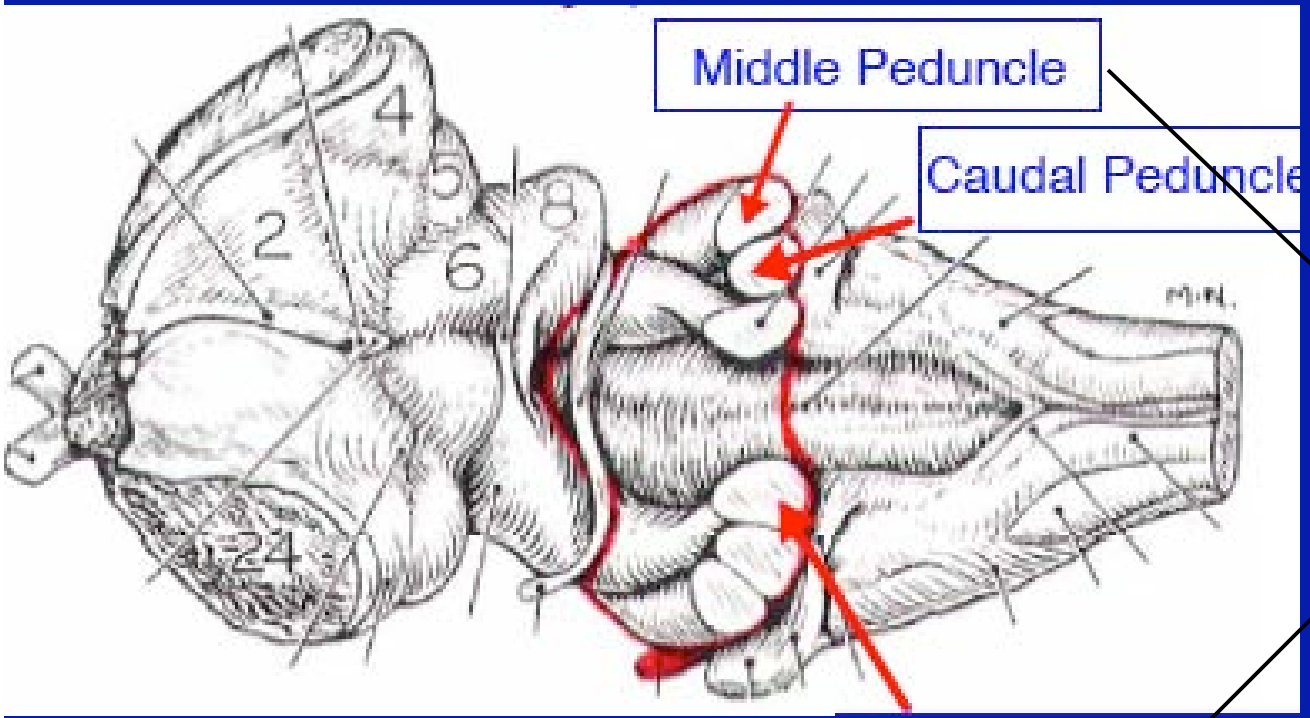
Longitudinal Zones in Transverse Section

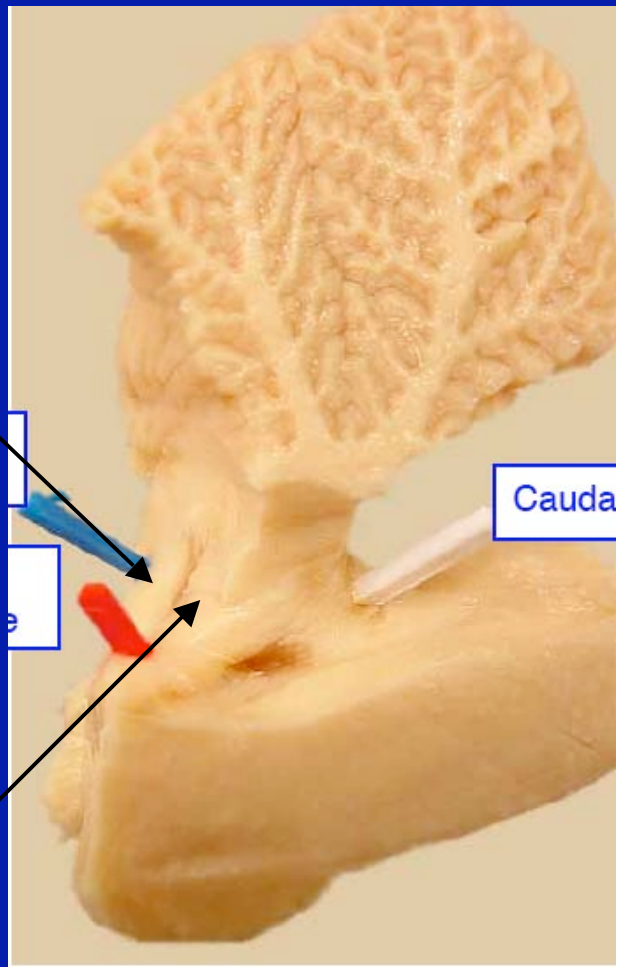
Cerebellar Peduncles (named by position)

1. Caudal Cerebellar Peduncle- connects the cerebellum with the medulla, contains afferent and efferent axons.

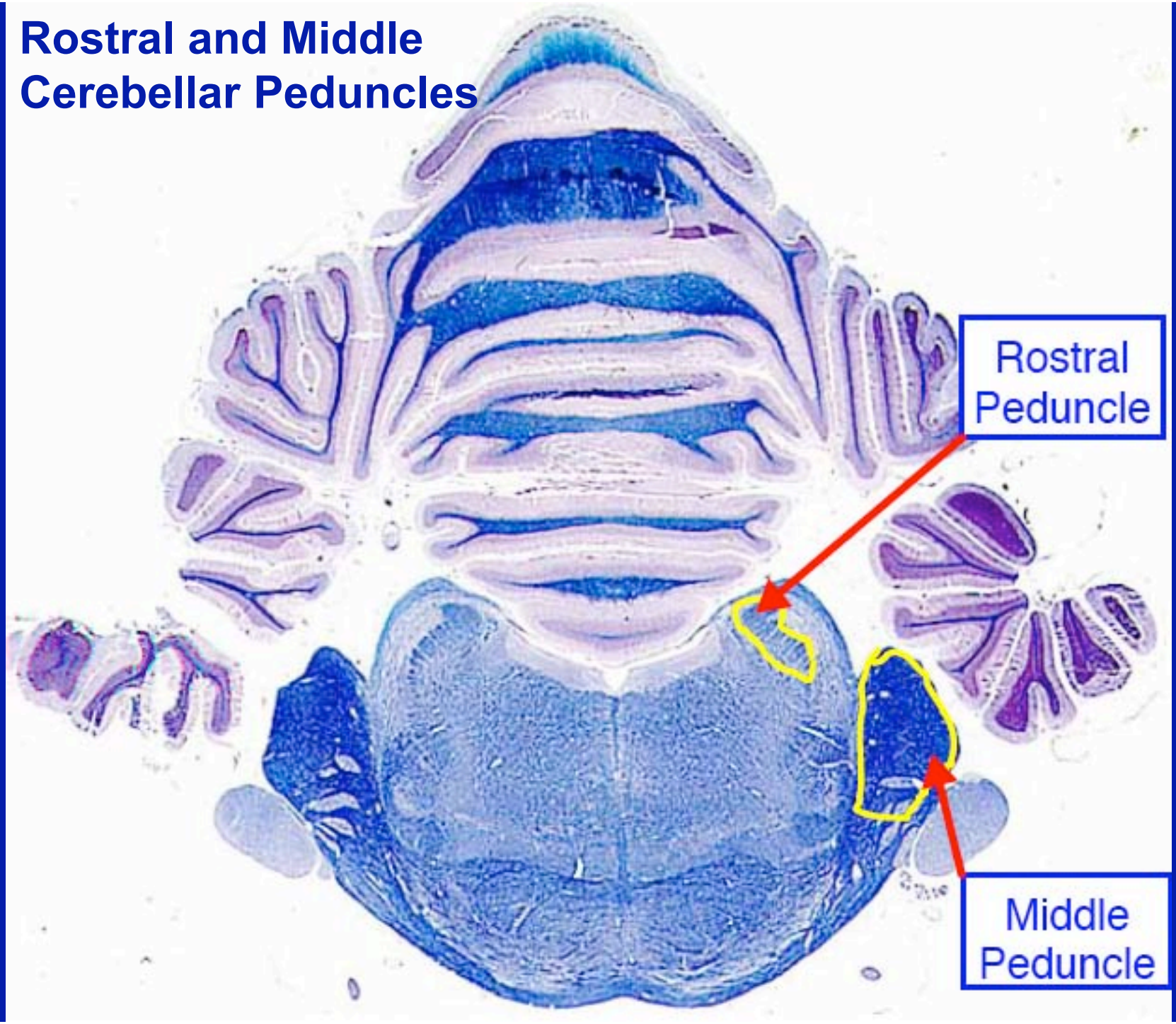
2. Middle Cerebellar Peduncle- connects cerebellum with the pons; contains only afferent axons from Pontine nuclei

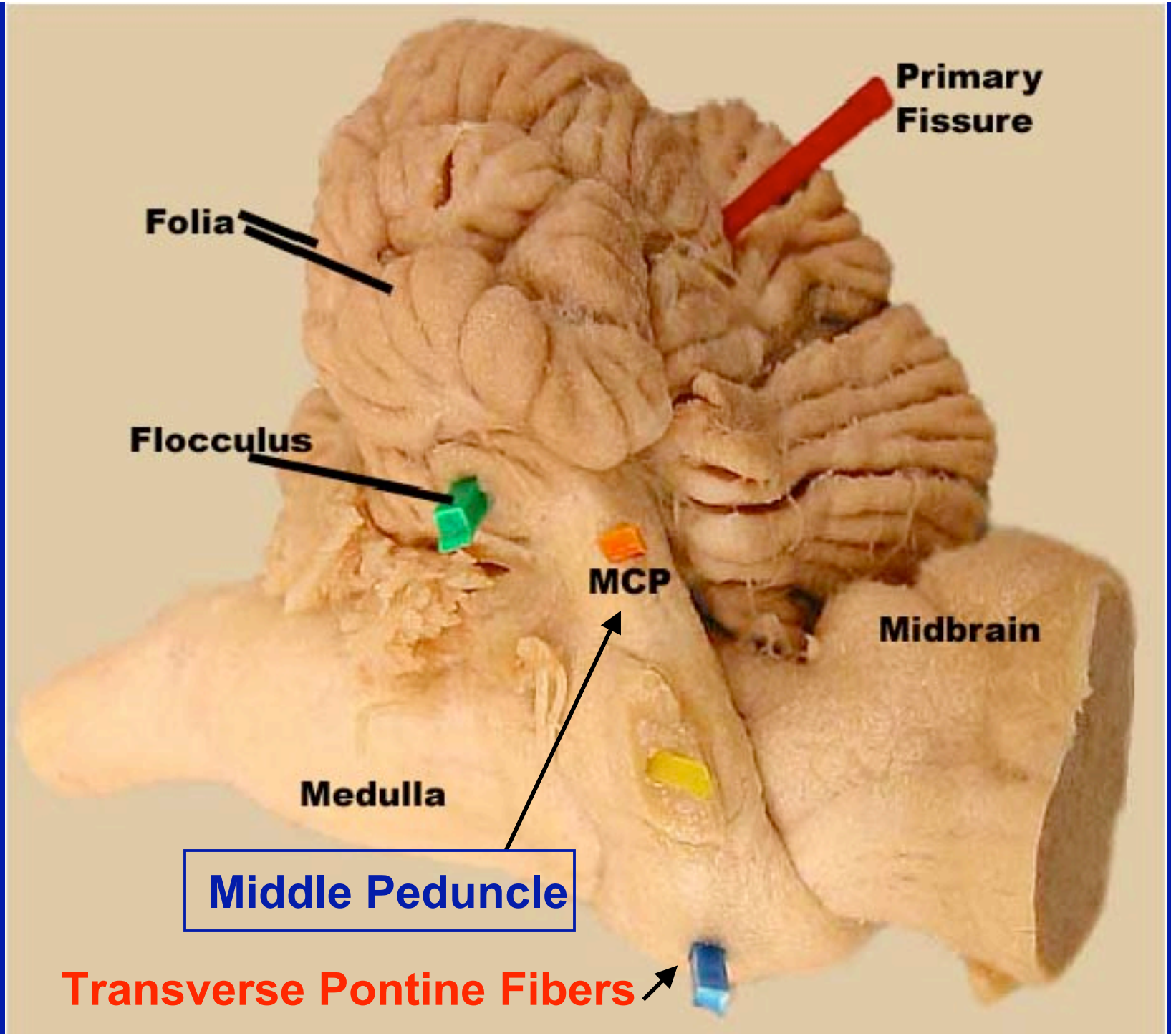
3. Rostral Cerebellar Peduncle-Connects cerebellum with the midbrain; it is predominantly efferent axons.



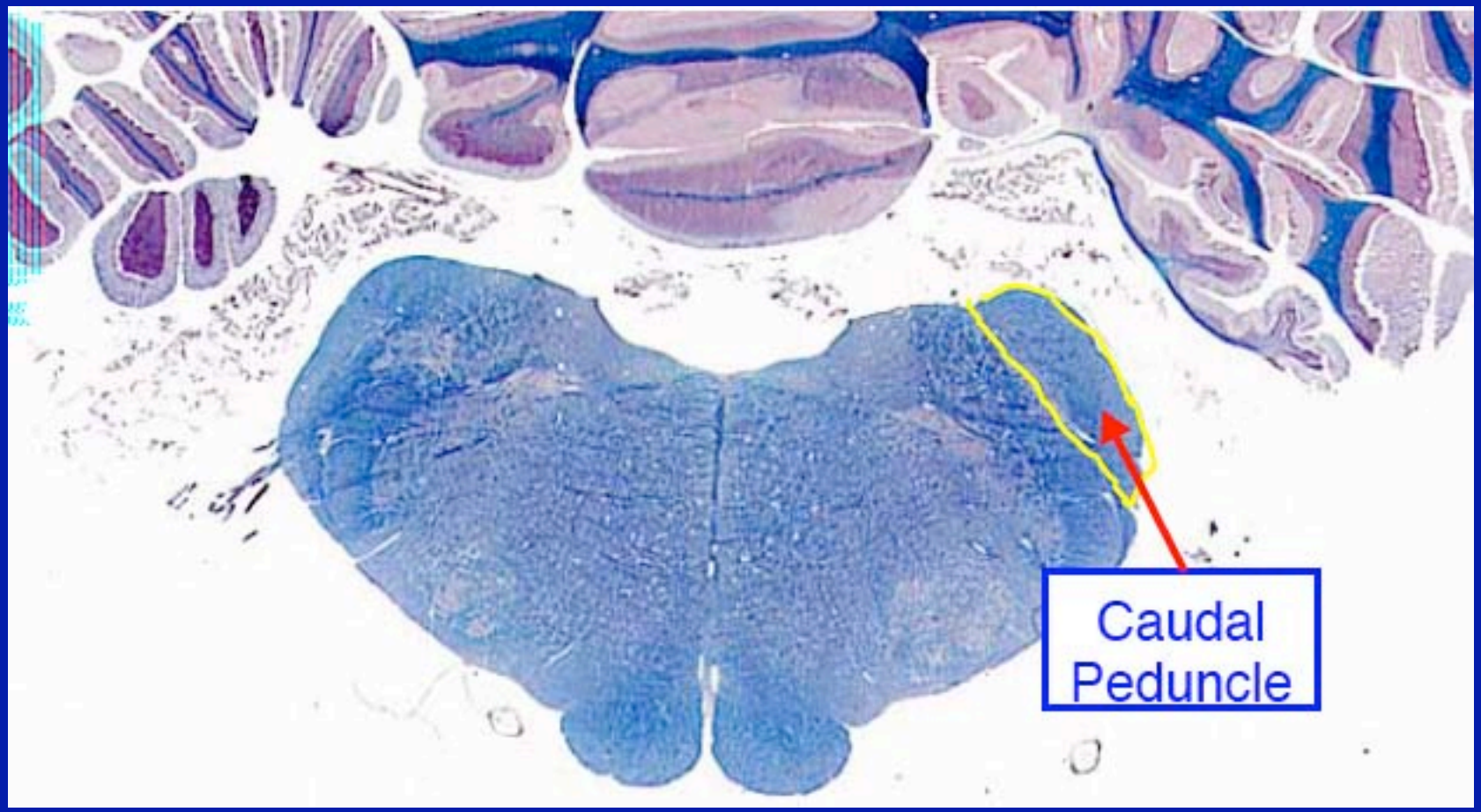


Rostral and Middle Cerebellar Peduncles




Primary Fissure
Folia
Flocculus
MCP
Midbrain
Medulla
Middle Peduncle
Transverse Pontine Fibers

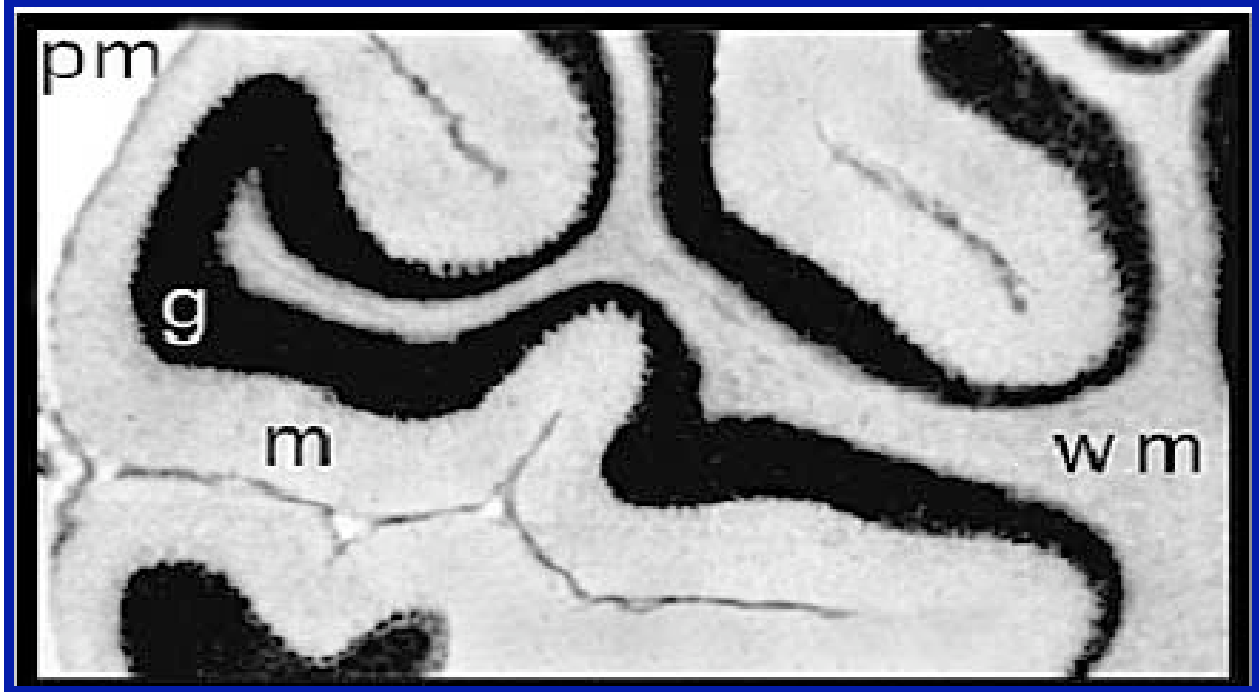
Caudal Cerebellar Peduncle



Cerebellar Cortex: the surface gray matter of the cerebellum.

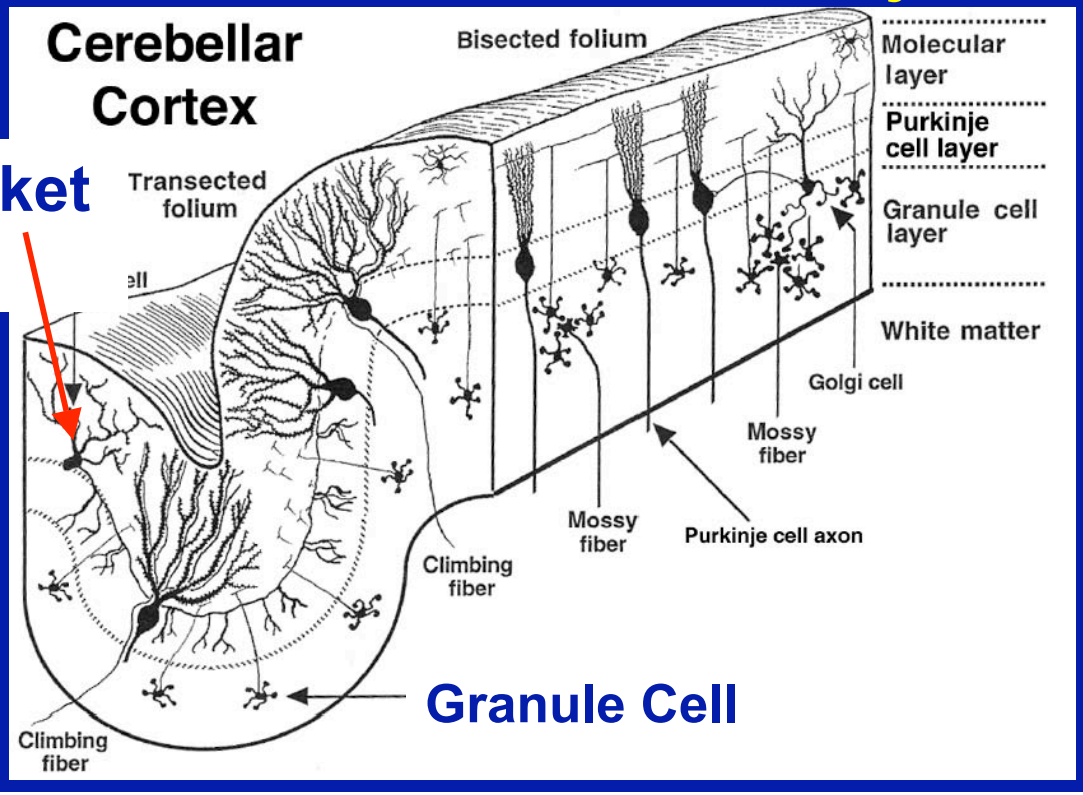
3 layers:

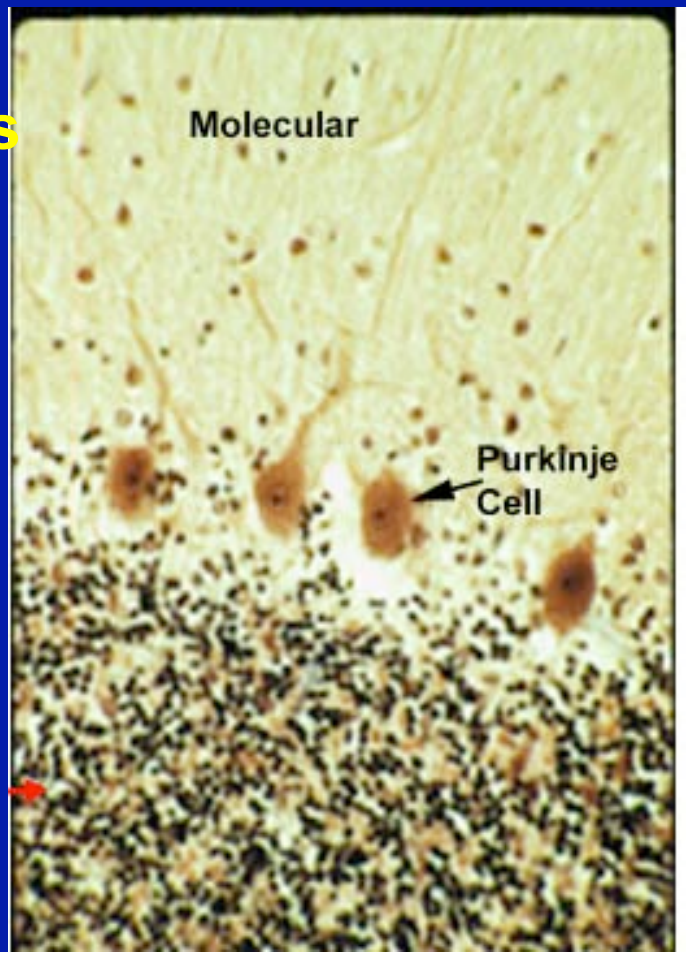
1. **Molecular Layer- most superficial, consisting of axons of granule cells (parallel fibers) and dendrites of PCs**
2. **Purkinje Cell Layer- middle layer consisting of a single layer of large neuronal cell bodies (Purkinje cells)**
3. **Granule Cell Layer- deepest layer (next to white matter) consising of small neurons called granule cells**

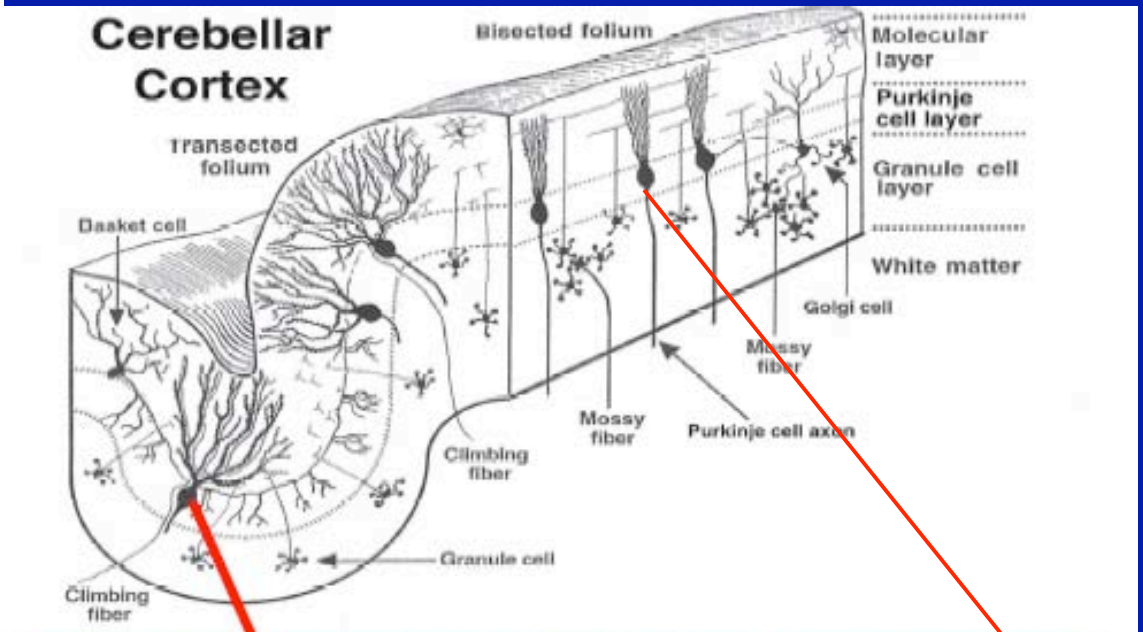


Cell Types and Afferent Fibers of the Cerebellar Cortex

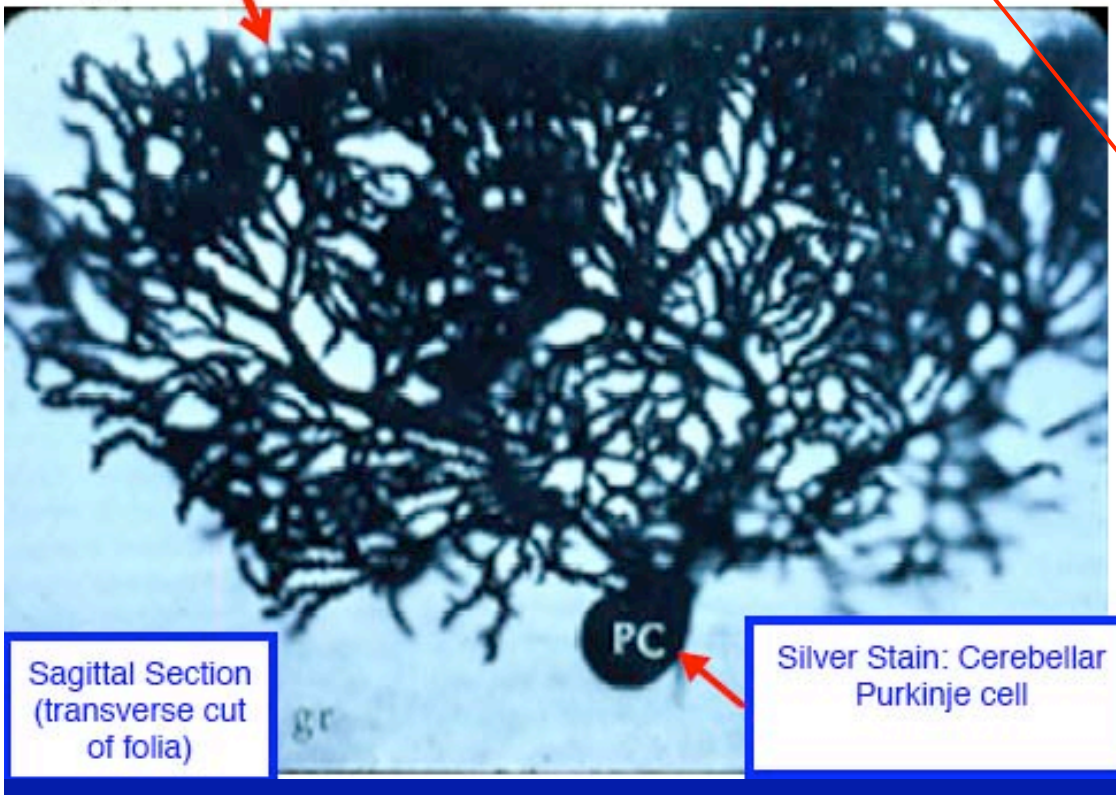
1. **Purkinje Cells** - the only output neuron from the cortex utilizes GABA to inhibit neurons in deep cerebellar nuclei
2. **Granule Cells**- intrinsic cells of cerebellar cortex; use glutamate as an excitatory transmitter; excites Purkinje cells via axonal branches called "parallel fibers"
3. **Basket Cells**- inhibitory interneuron; utilizes GABA to inhibit Purkinje cells





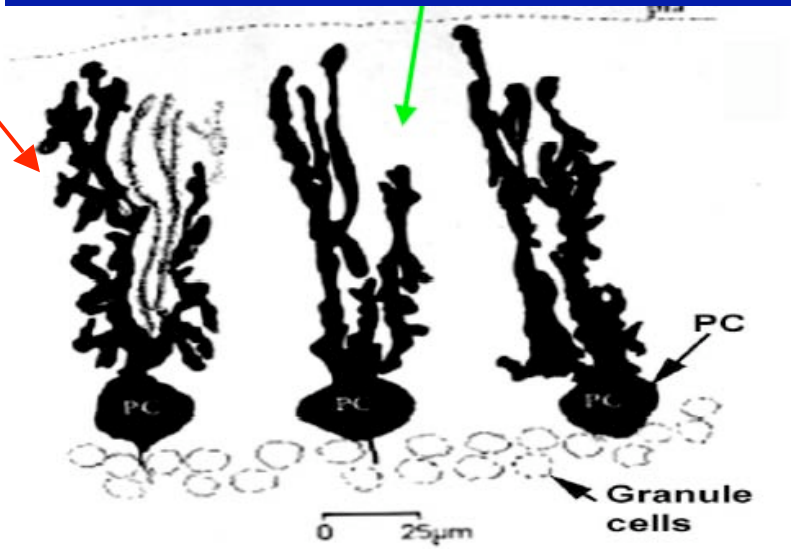


Cerebellar Purkinje cells in sagittal section and in transverse section



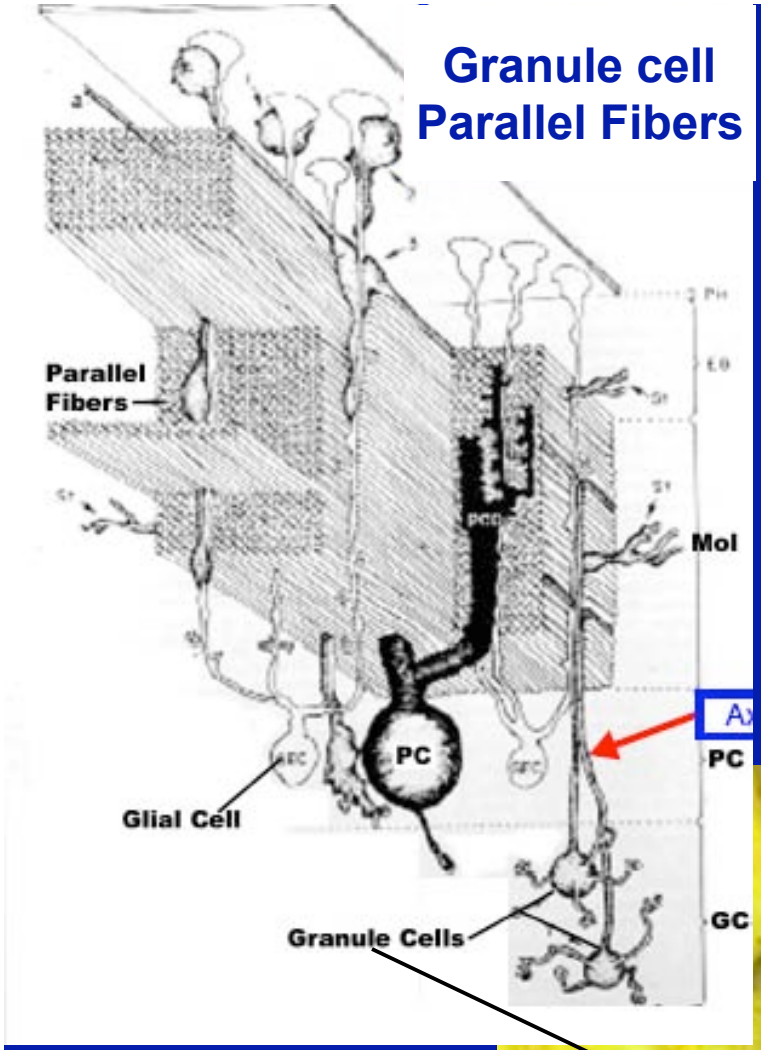
Sagittal Section (transverse cut of folia)

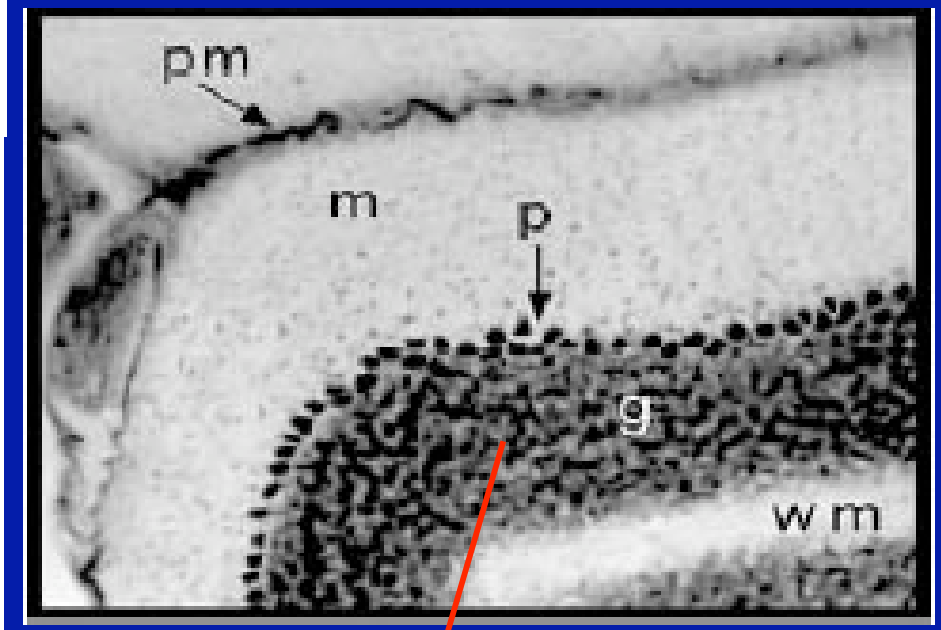
Silver Stain: Cerebellar Purkinje cell



Transverse

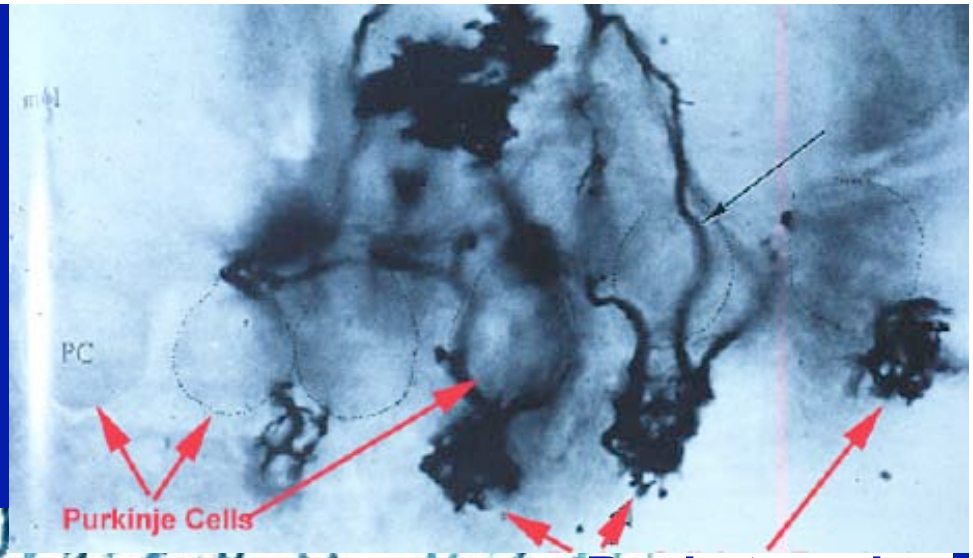
Granule cell Parallel Fibers



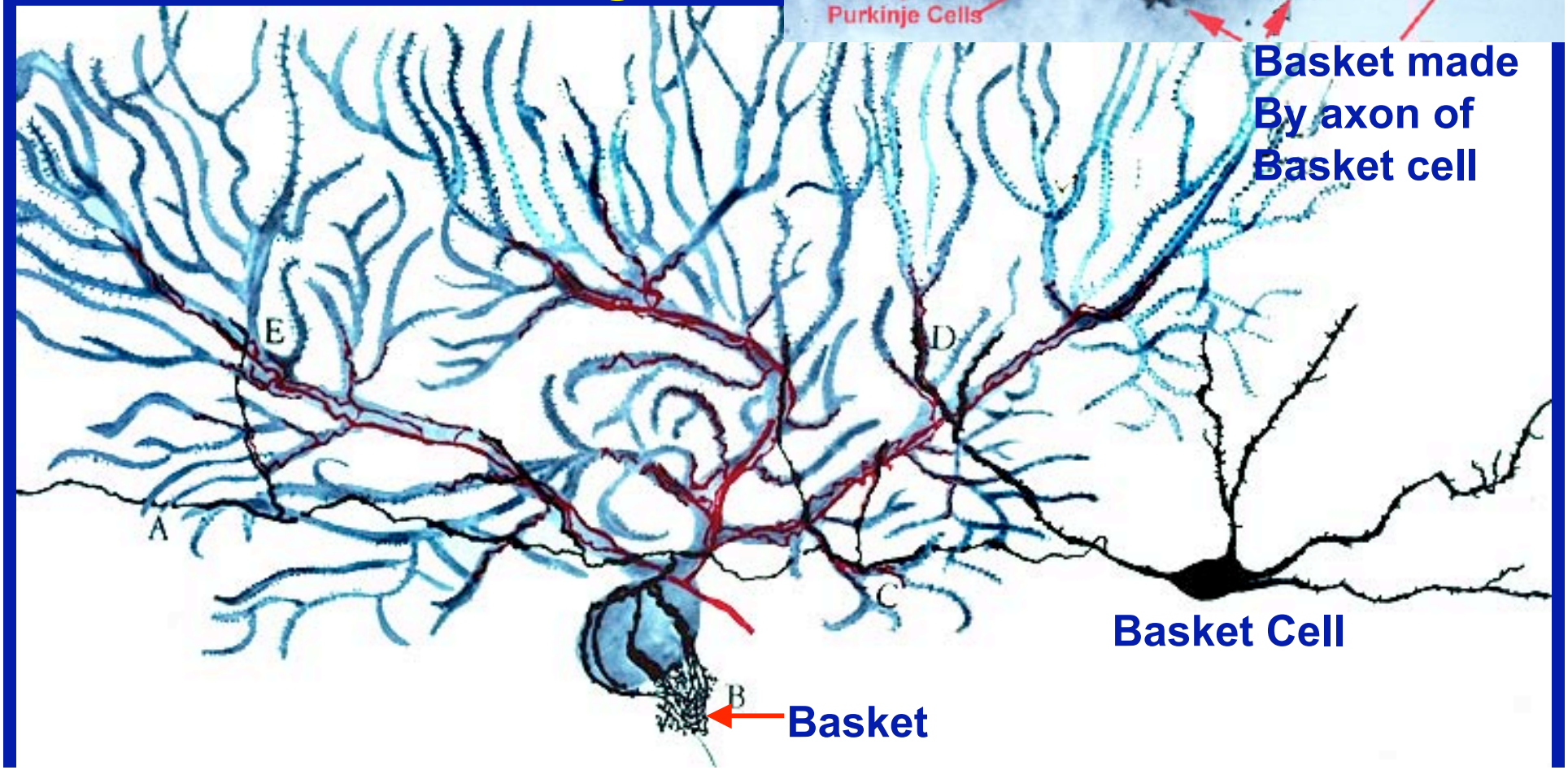


Granule cells

Basket cell axon forms a basket on Purkinje cell initial segment →
Inhibits axonal firing



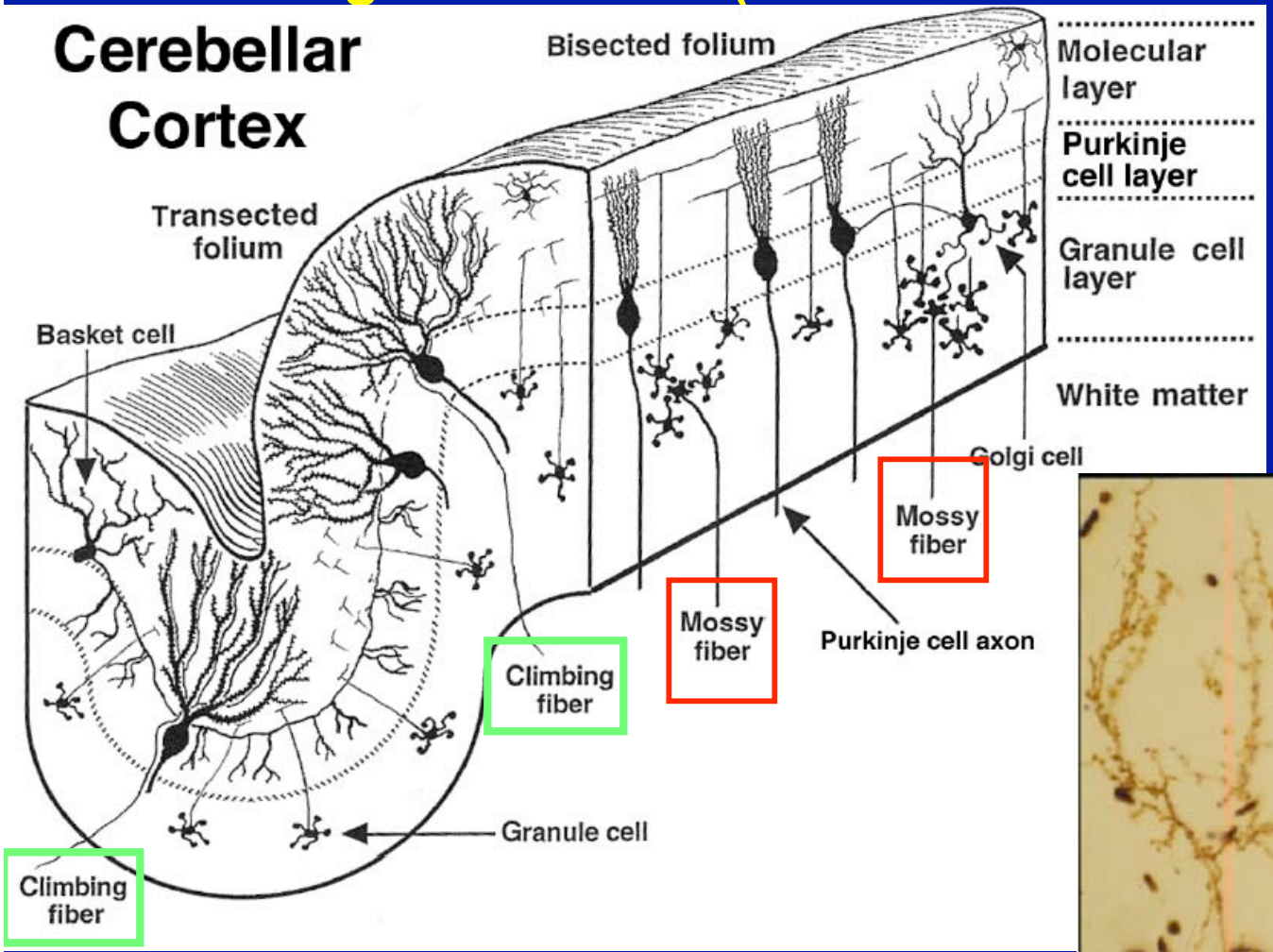
Basket made By axon of Basket cell

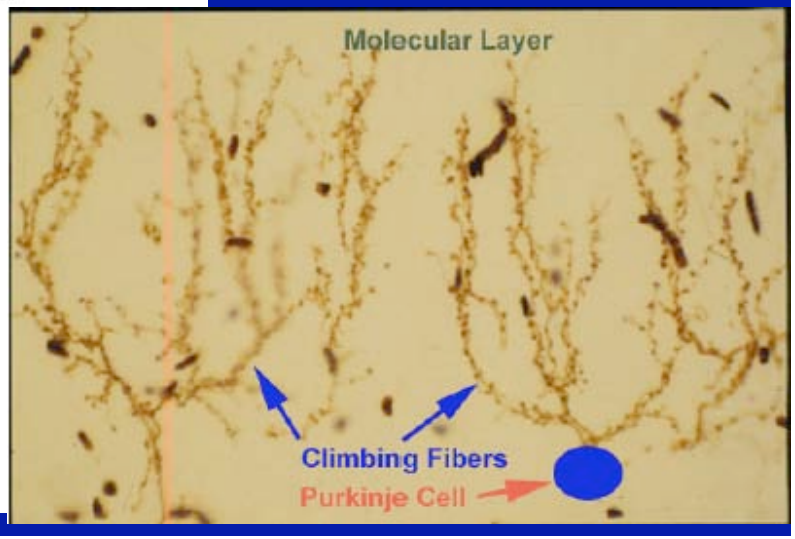


Basket Cell

Basket

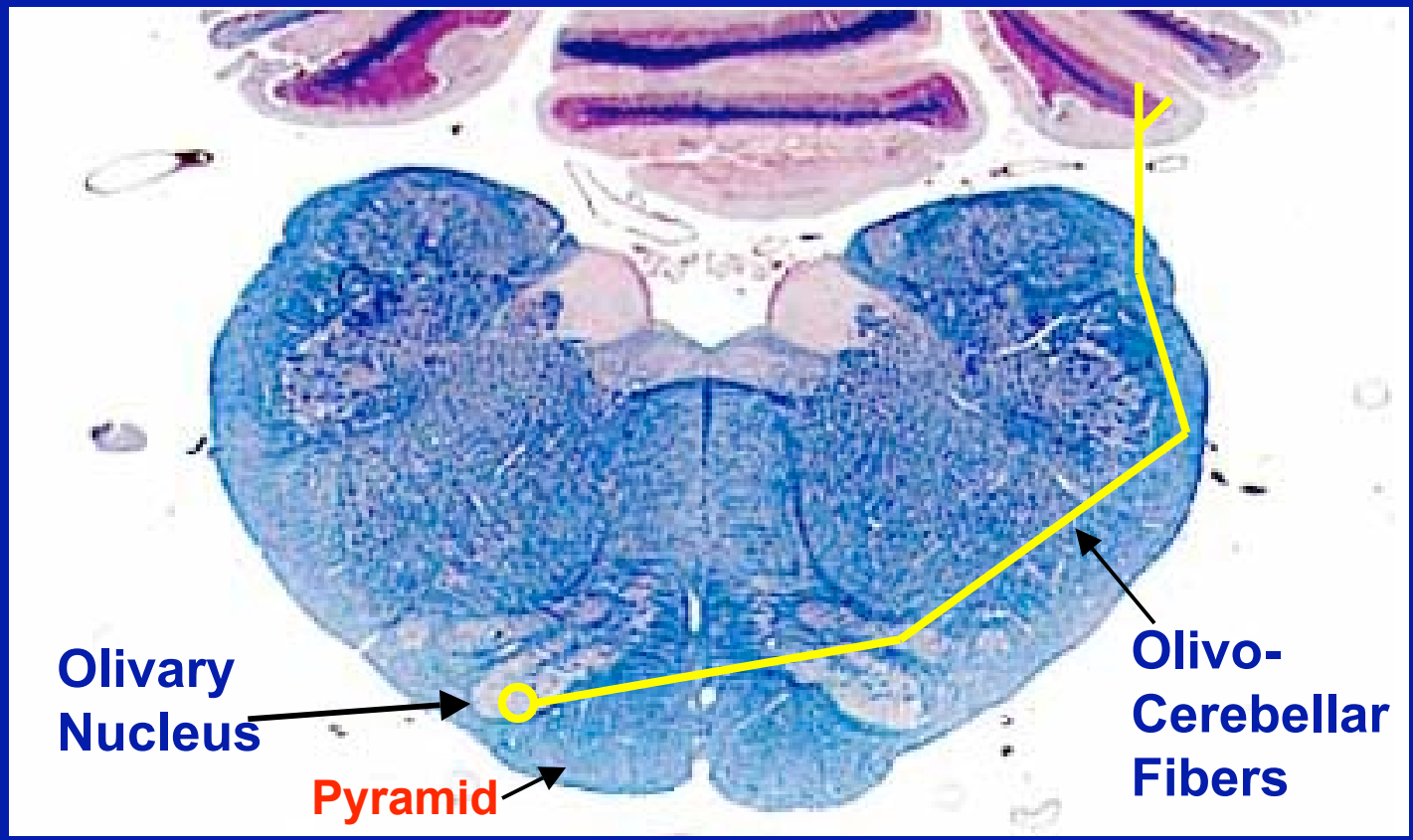
3. **Climbing Fibers**- axons arising from the olivary nucleus; use glutamate and aspartate to excite Purkinje cell and cerebellar nuclei neurons
4. **Mossy Fibers**- all other axons that enter the cerebellum; excite granule cells (and neurons in cerebellar nuclei)





Major Cerebellar Inputs (axons entering the cerebellum):

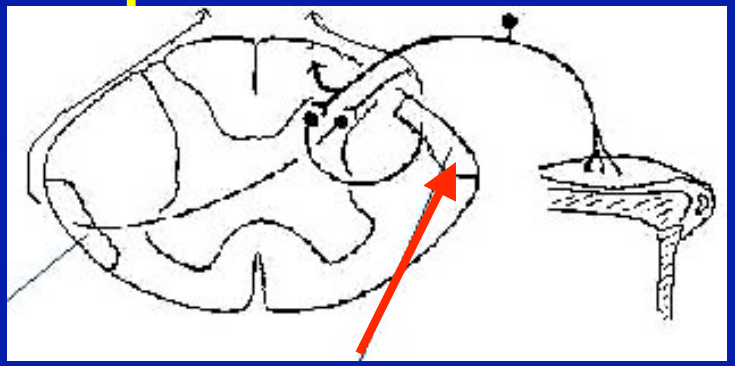
1. **Climbing Fiber Inputs = Olivocerebellar fibers-- arise exclusively from the olivary nucleus of the caudal medulla; have a powerful excitatory effect on Purkinje cells upon which they synapse.**



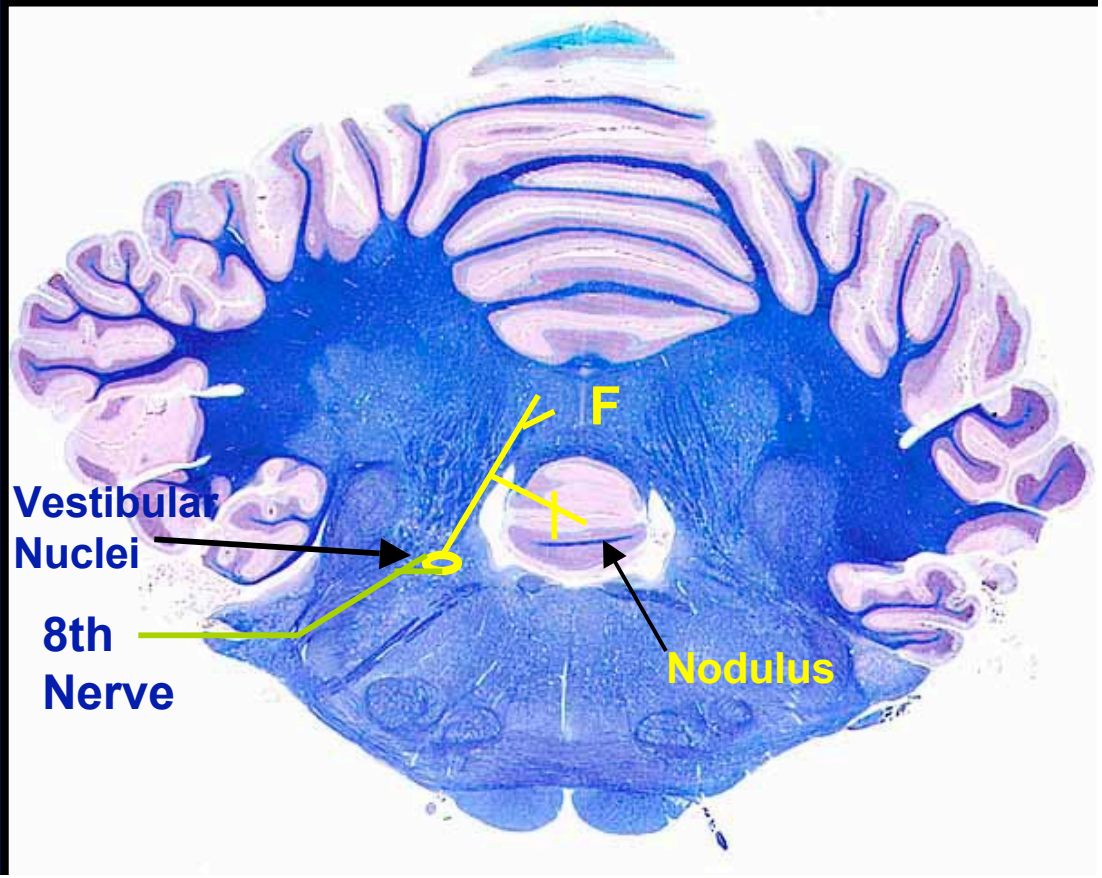
2. Mossy fiber Inputs:

A. Vestibulocerebellar fibers--arise mainly from the vestibular nerve and vestibular nuclei; project to flocculo-nodular lobe and fastigial nucleus (coordinate head and eye movement.

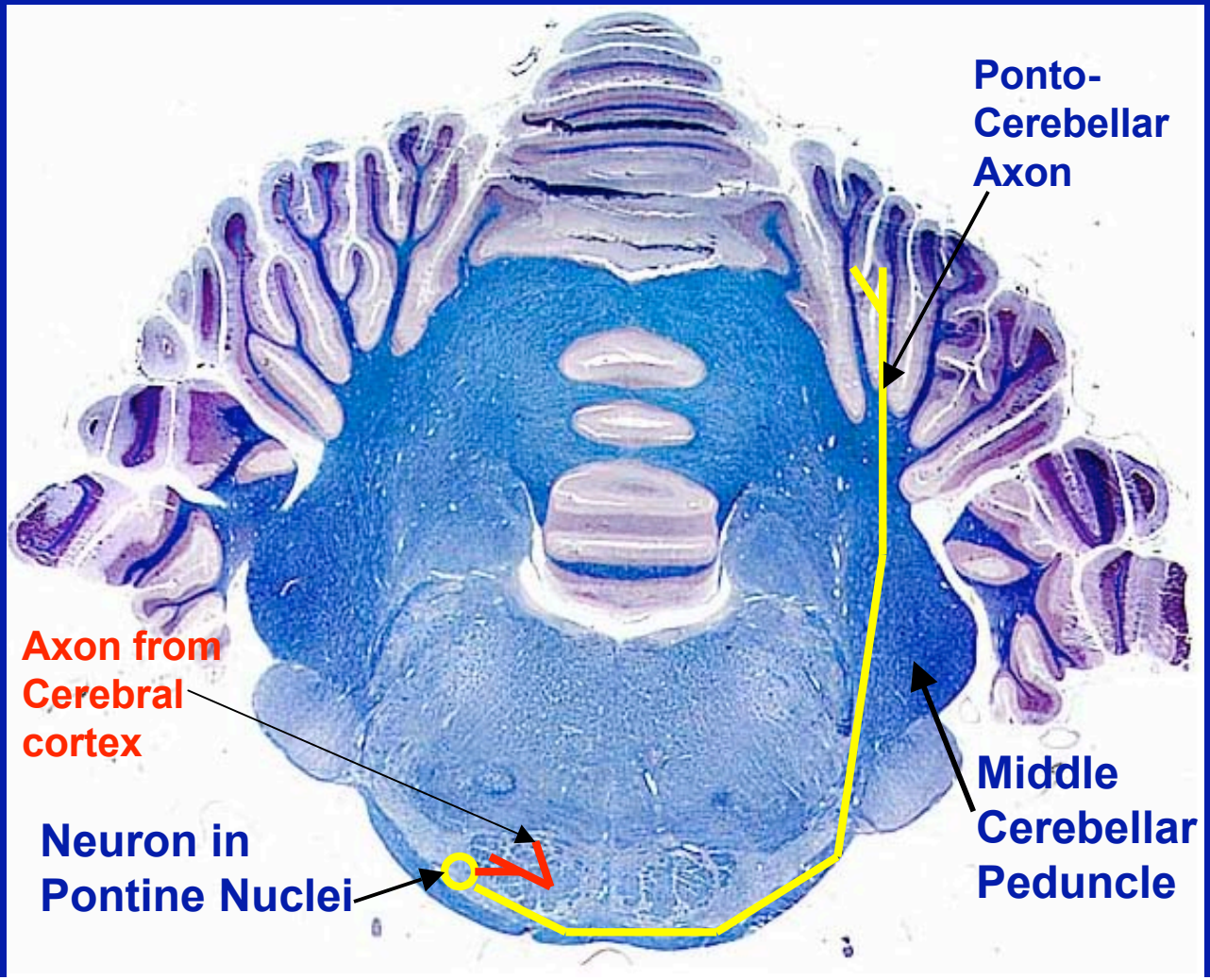
B. Spinocerebellar Fibers- arise from spinal cord -->via spinocerebellar tracts-->go to rostral lobe; makes cerebellum aware of ongoing movements via proprioceptive input from muscle spindles and joint receptors.



Dorsal spinocerebellar Tr



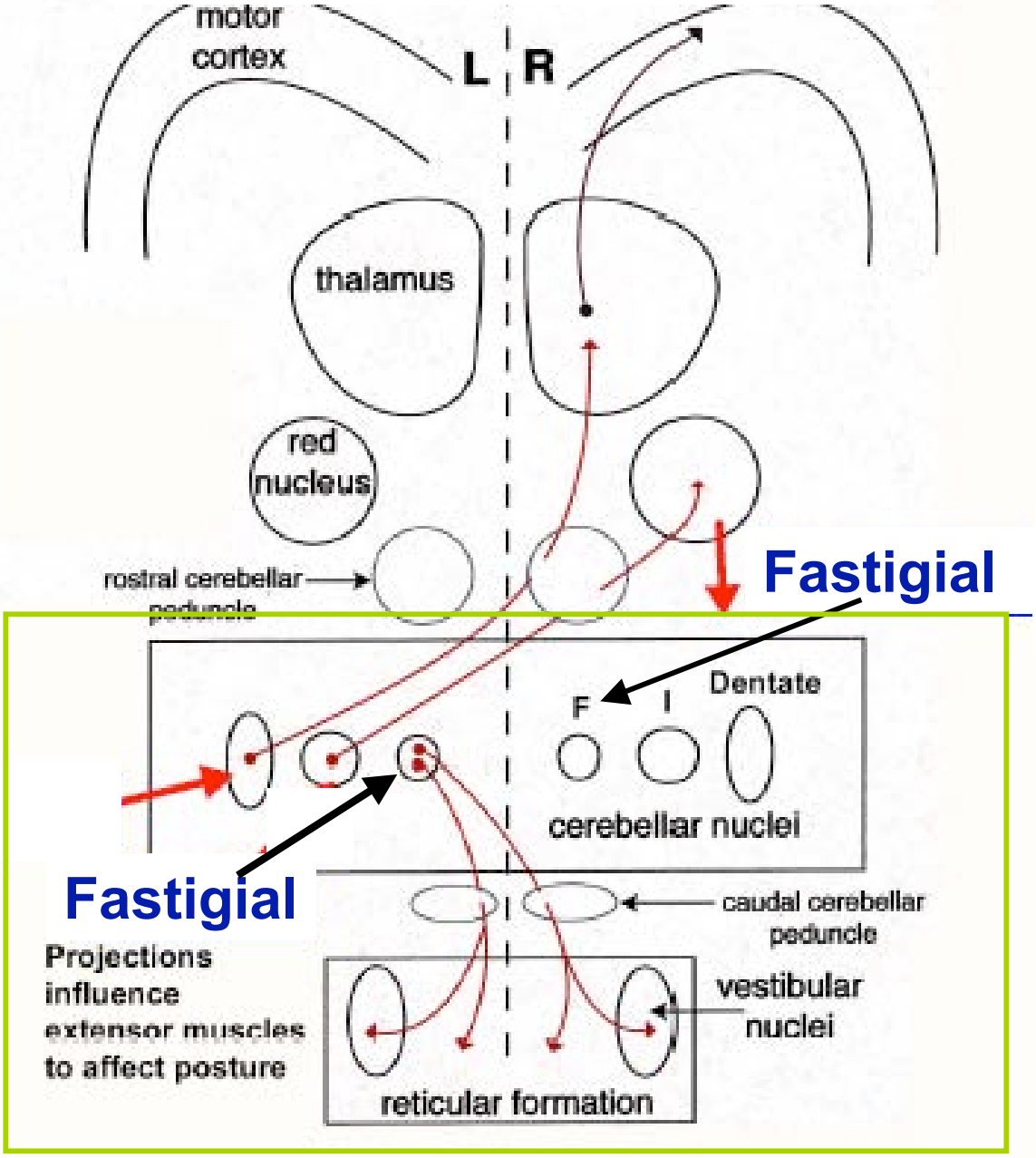
C. Cerebropontocerebellar fibers--arise from pyramidal cells in the cerebral cortex, synapse on pontine nuclei which send their axons to the contralateral cerebellar cortex via pontocerebellar fibers (form middle peduncle)- Alerts cerebellum regarding anticipated movements.



Major Cerebellar Outputs (arise from neurons in deep cerebellar nuclei):

1. Fastigial Nucleus Projections: (via caudal peduncle)--> vestibular nuclei and reticular formation--> vestibulospinal & reticulospinal tracts influence spinal motor neurons--> effect extensor muscles related to maintaining posture and balance.

Cerebellar Output (efferents)



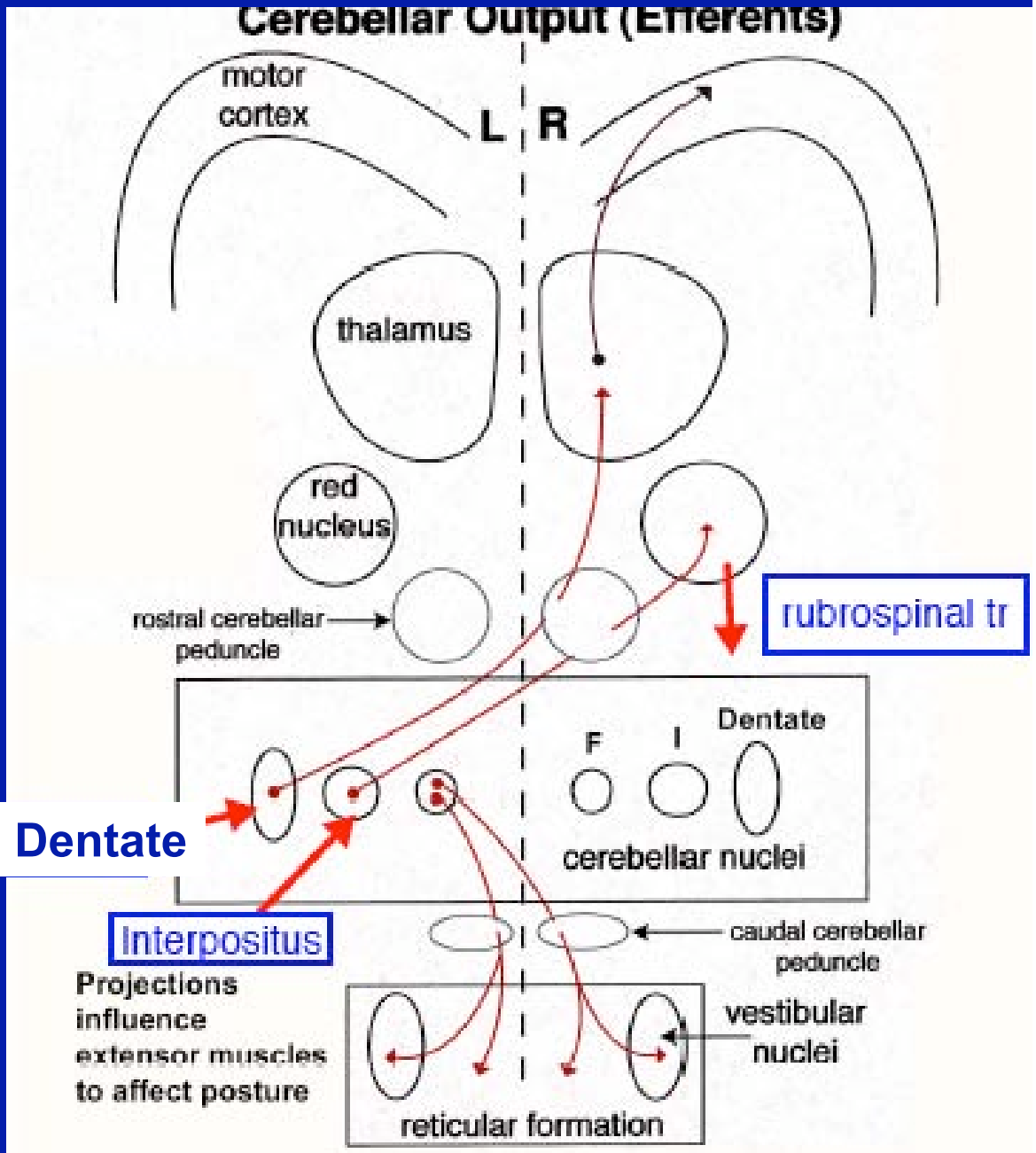
From Lab Guide, page 57

2. Interpositus Nucleus

Projections: (via rostral peduncle)-->go to red nucleus to influence rubrospinal tract--> correct errors related to the gross movements of the animal

3. Dentate Nucleus

Projections: (via rostral peduncle)--> projects to thalamus to influence the output from the motor cortex-->makes delicate adjustments related to fine, skilled movements

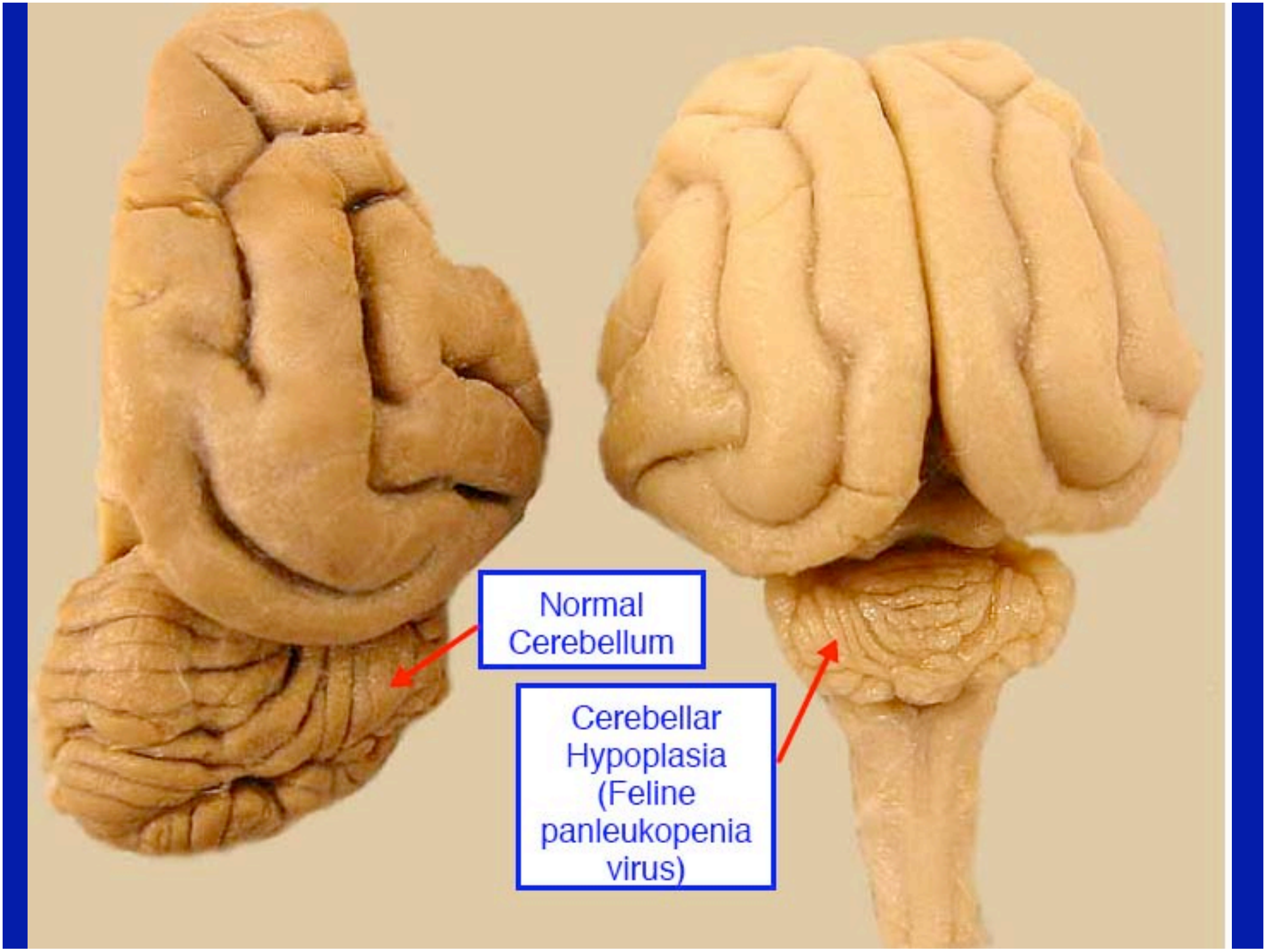


Clinical Abnormalities:

Lesions of the cerebellum (damage to input, output or cortex) result in symptoms that occur because the cerebellum's normal function is interrupted-->ataxia, dysmetria, intention tremor occur.

Cerebellar disorders usually result from:

1. Tumors (i.e., cerebellar cystic meningioma)
2. Viral Infections (encephalitis; distemper)- this may occur *in utero* (feline panleukopenia virus)
3. Heavy metal poisoning
4. Genetic Disorders: cerebellar degeneration, i.e., English sheepdogs, Gordon setters, Kerry Blue Terriers, Arabian Horses, Yorkshire Pigs; autosomal recessive.


Normal
Cerebellum
Cerebellar
Hypoplasia
(Feline
panleukopenia
virus)

1. Small lesions produce no signs or only transient symptoms; small deficits are compensated for by other parts of the brain

2. Lesions of the cerebellar hemispheres result in loss of muscular coordination and jerky puppet-like movements of the limbs on the ipsilateral side (same side as lesion)

3. Lesions of the vermis result in truncal tremor and gait ataxia (splayed stance and swaying of the body while walking)

[signs]

Memories from my trip down south this past summer

Sign Seen at MacDonalds in Georgia

Sign Seen in Alabama

Sign seen
in
Tennessee

Outhouse in West Virginia