

Microscopy of the cerebellum, pathways. Functional considerations

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Parts of cerebellum

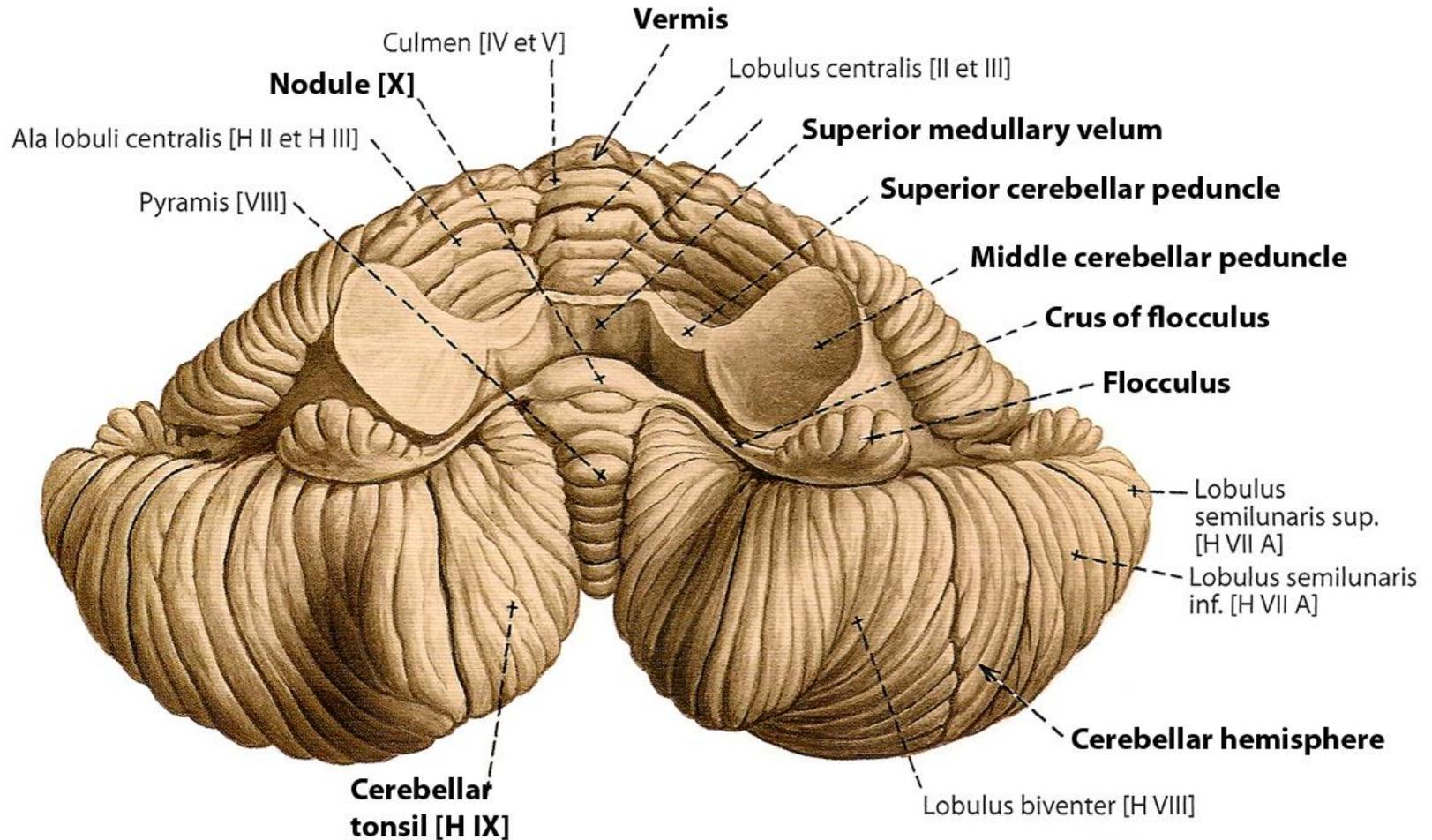
One possible division: **vermis** located in the middle + **cerebellar hemispheres** located on both sides of the vermis

Another possible division: **cerebellar cortex**, which can be divided into 10 cerebellar lobes separated by deep, parallel cerebellar fissures. The lobes are further folded by less deep, parallel grooves called cerebellar folias.

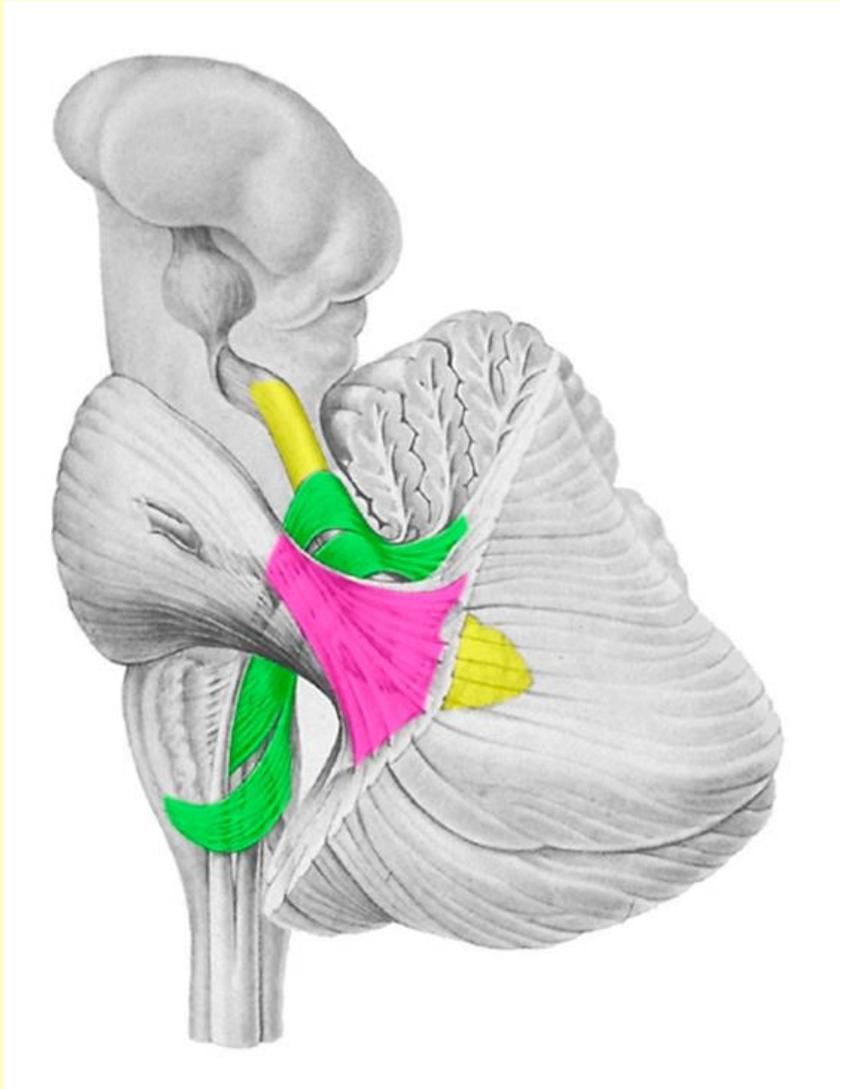
+ **cerebellar nuclei:** gray matter located deep into the cerebellum

+ **cerebellar peduncles:** white matter tracts with afferent (incoming) fibers reaching the cerebellar cortex and efferent (outgoing) fibers leaving the cerebellar nuclei

View of the cerebellum from the brainstem



Cerebellar peduncles



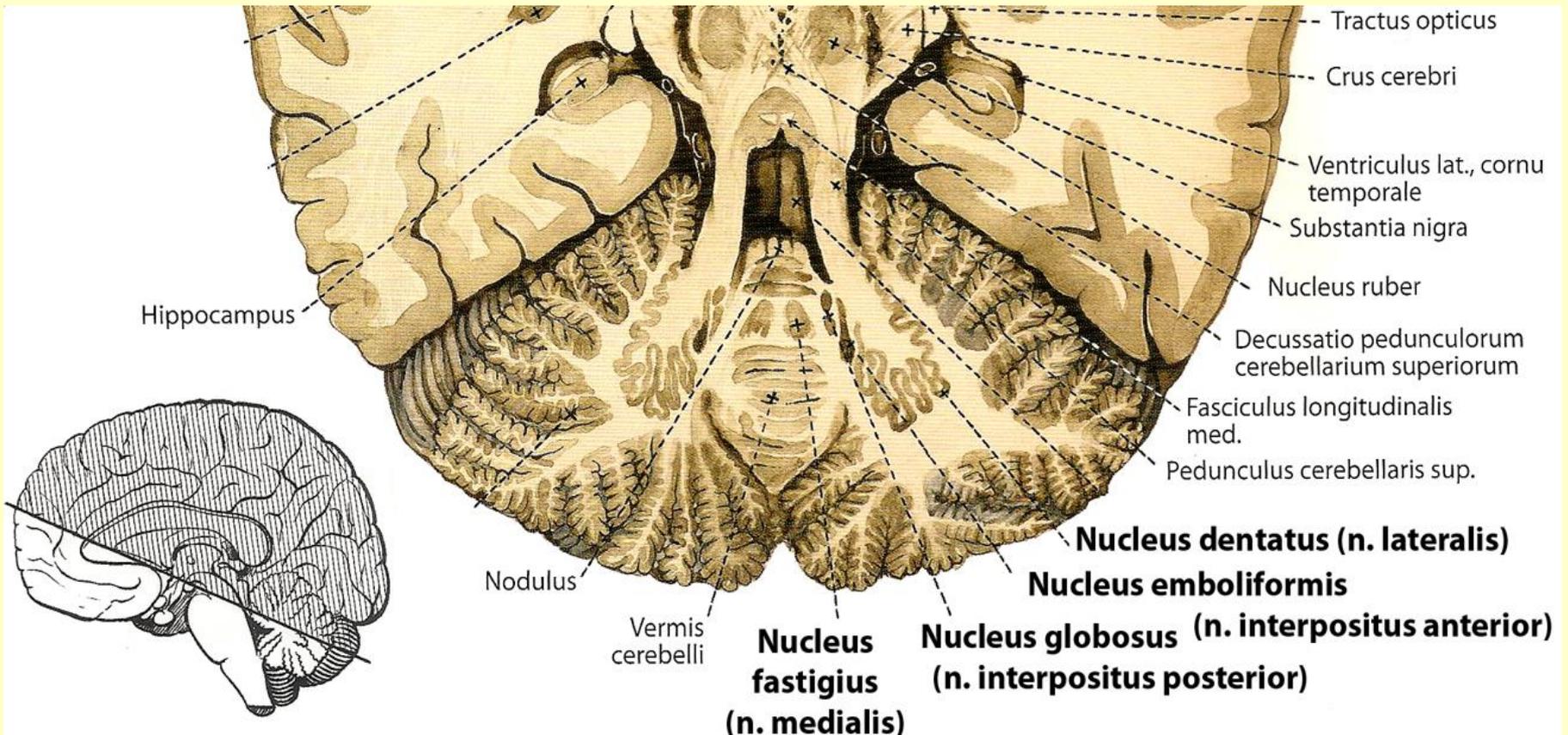
superior cerebellar peduncle

middle cerebellar peduncle

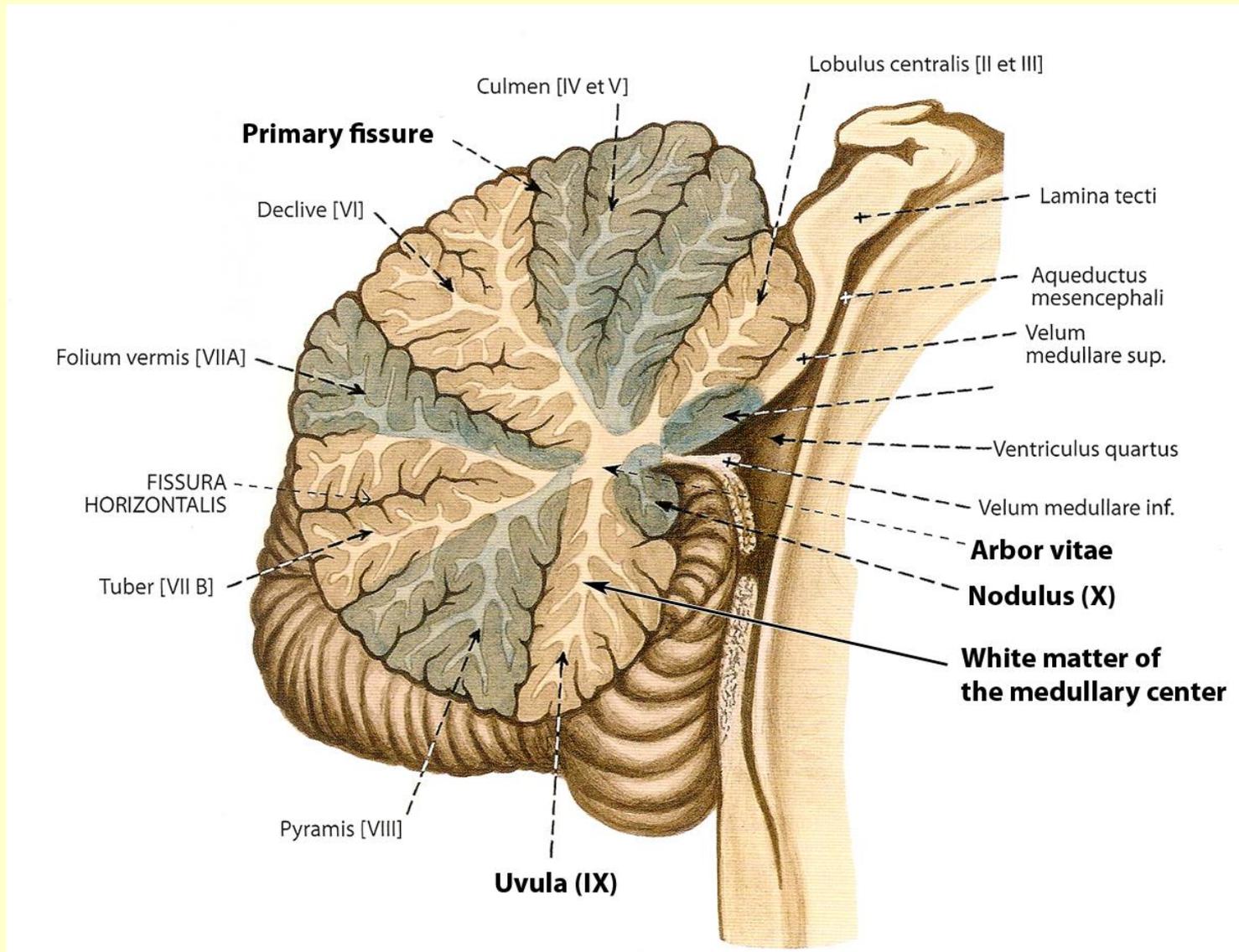
inferior cerebellar peduncle

Cerebellar nuclei

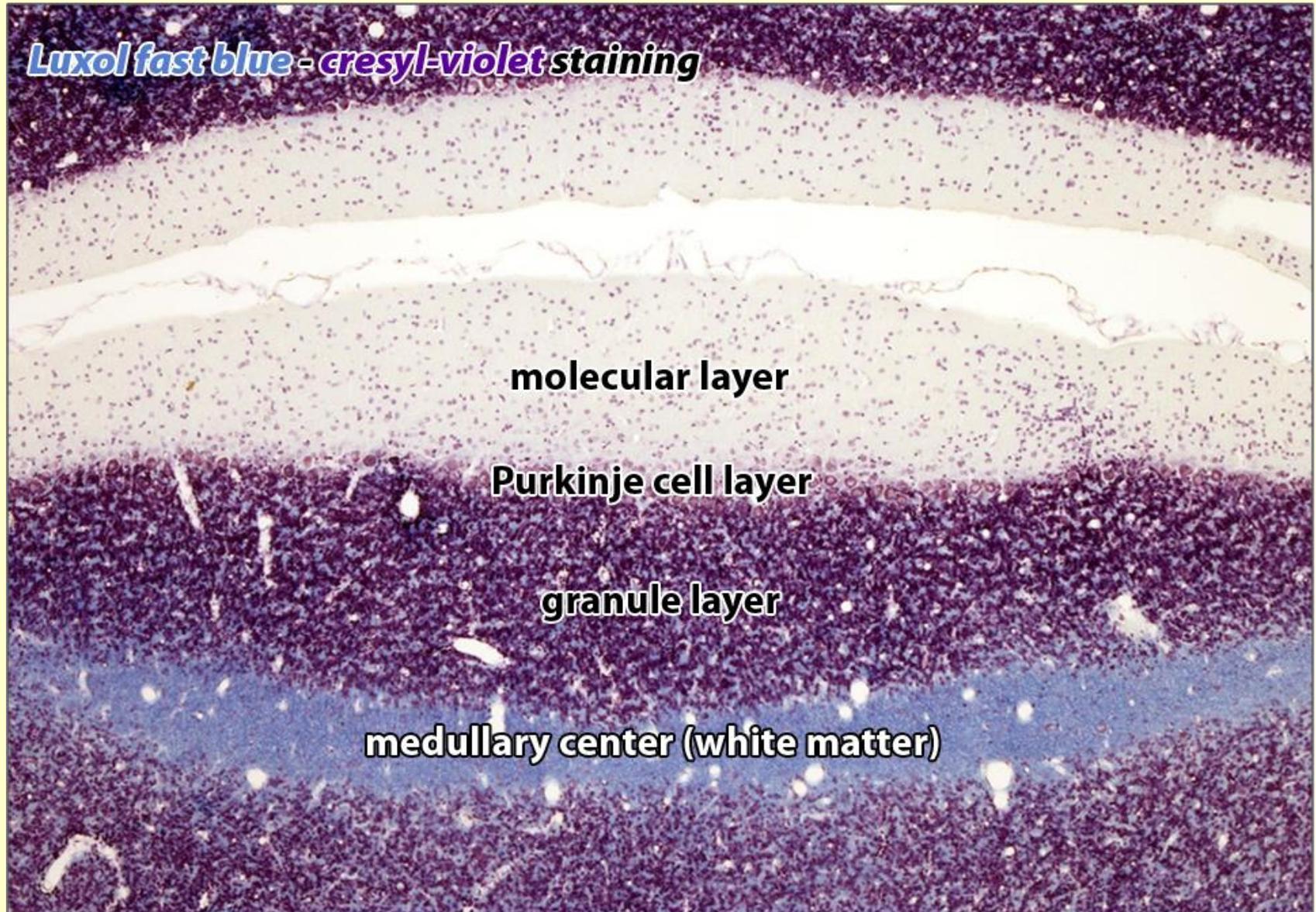
A near horizontal section of the cerebellum:



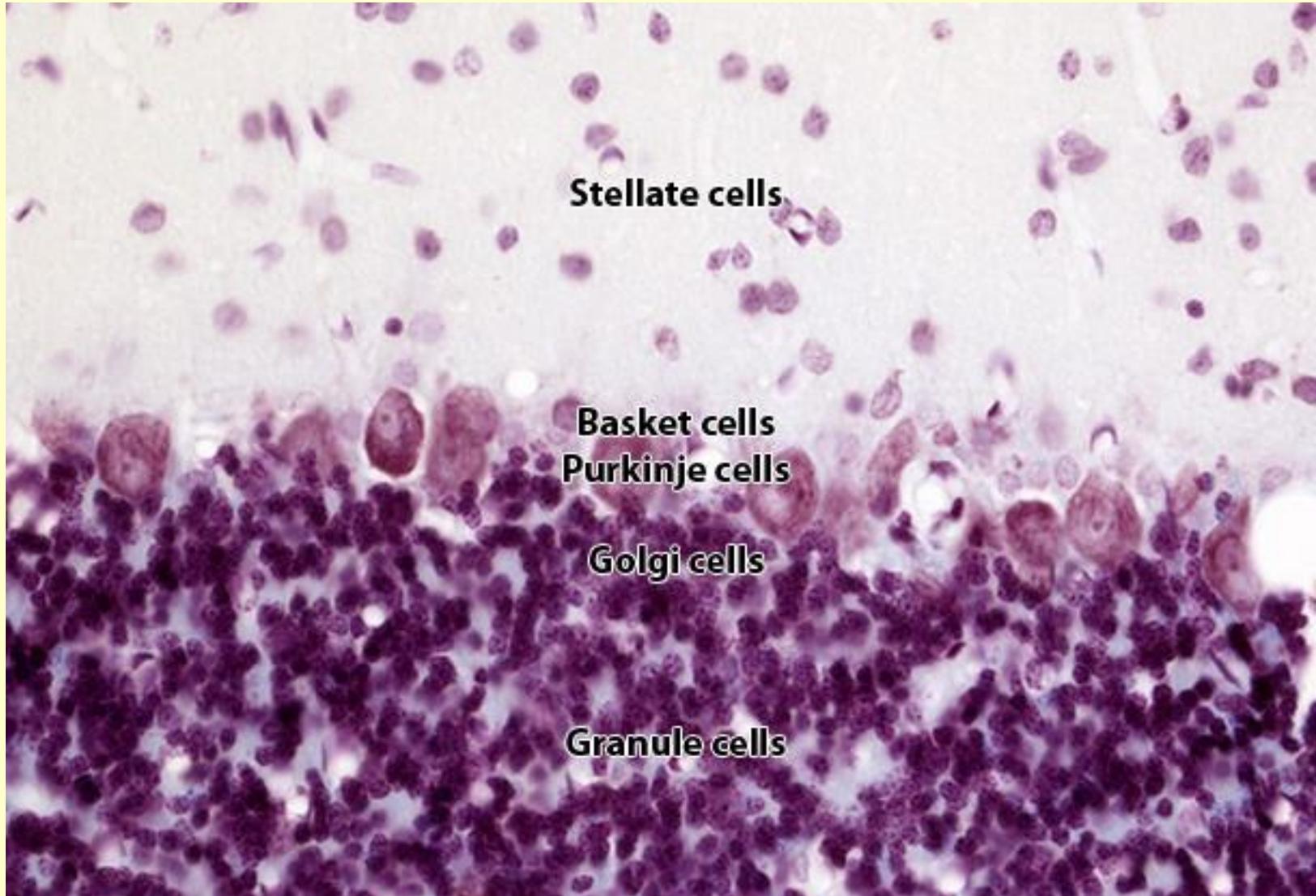
Mediosagittal section of the cerebellum



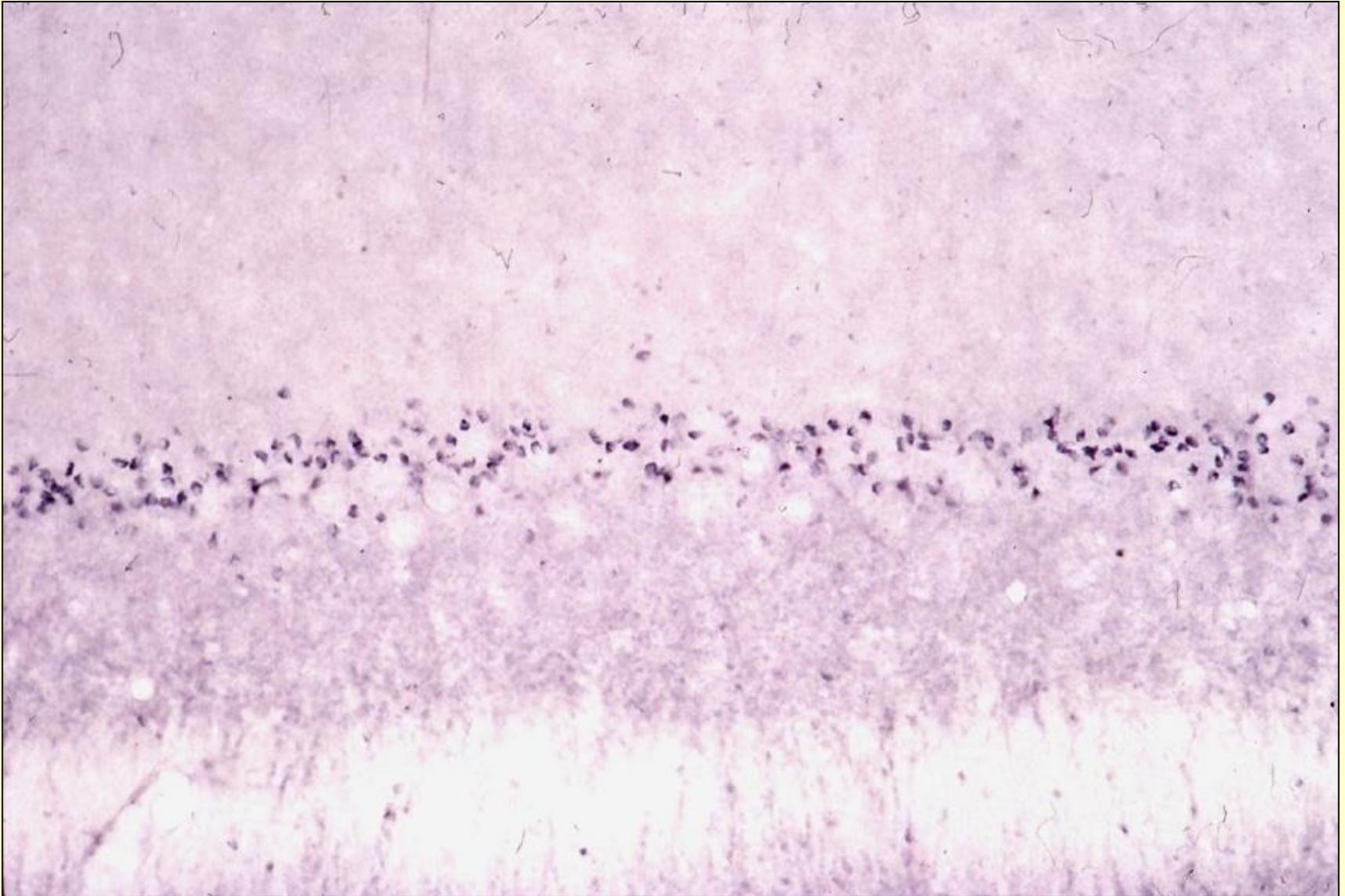
Microscopic layers of the cerebellar cortex



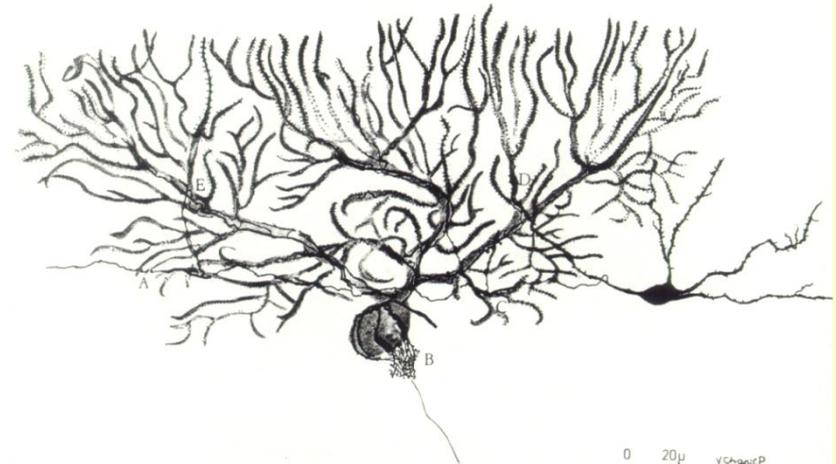
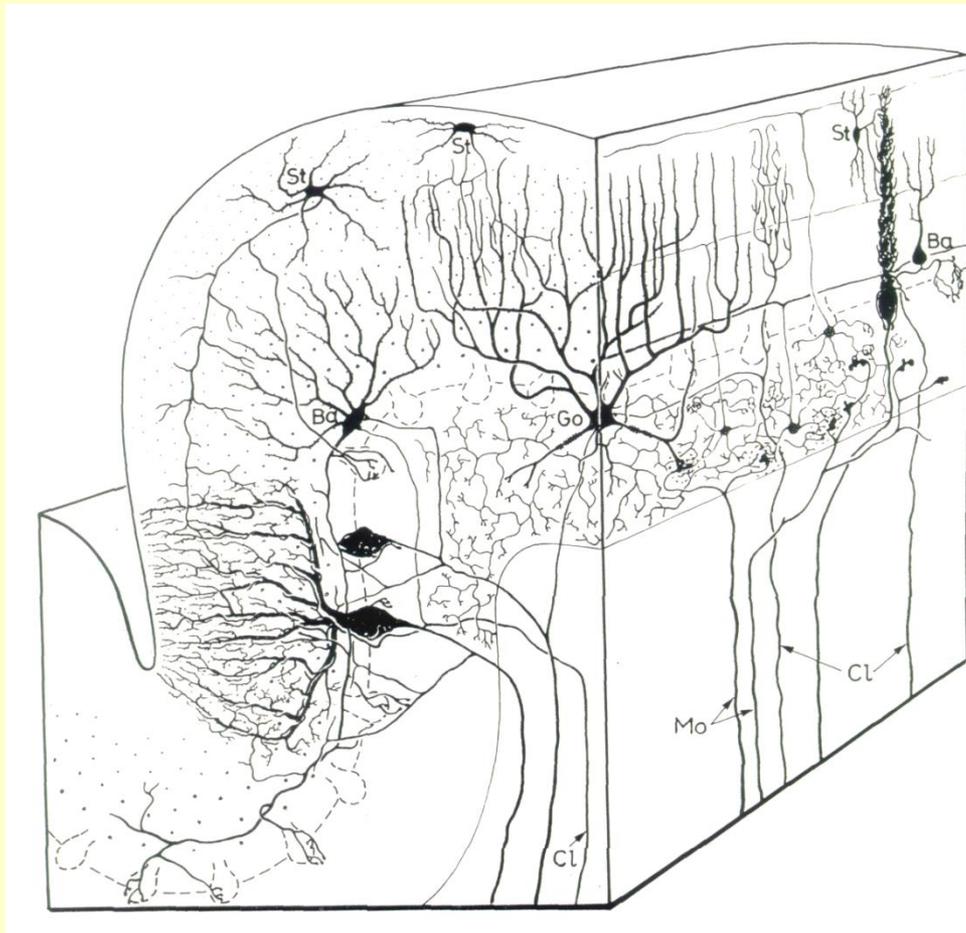
Cell types of the cerebellar cortex



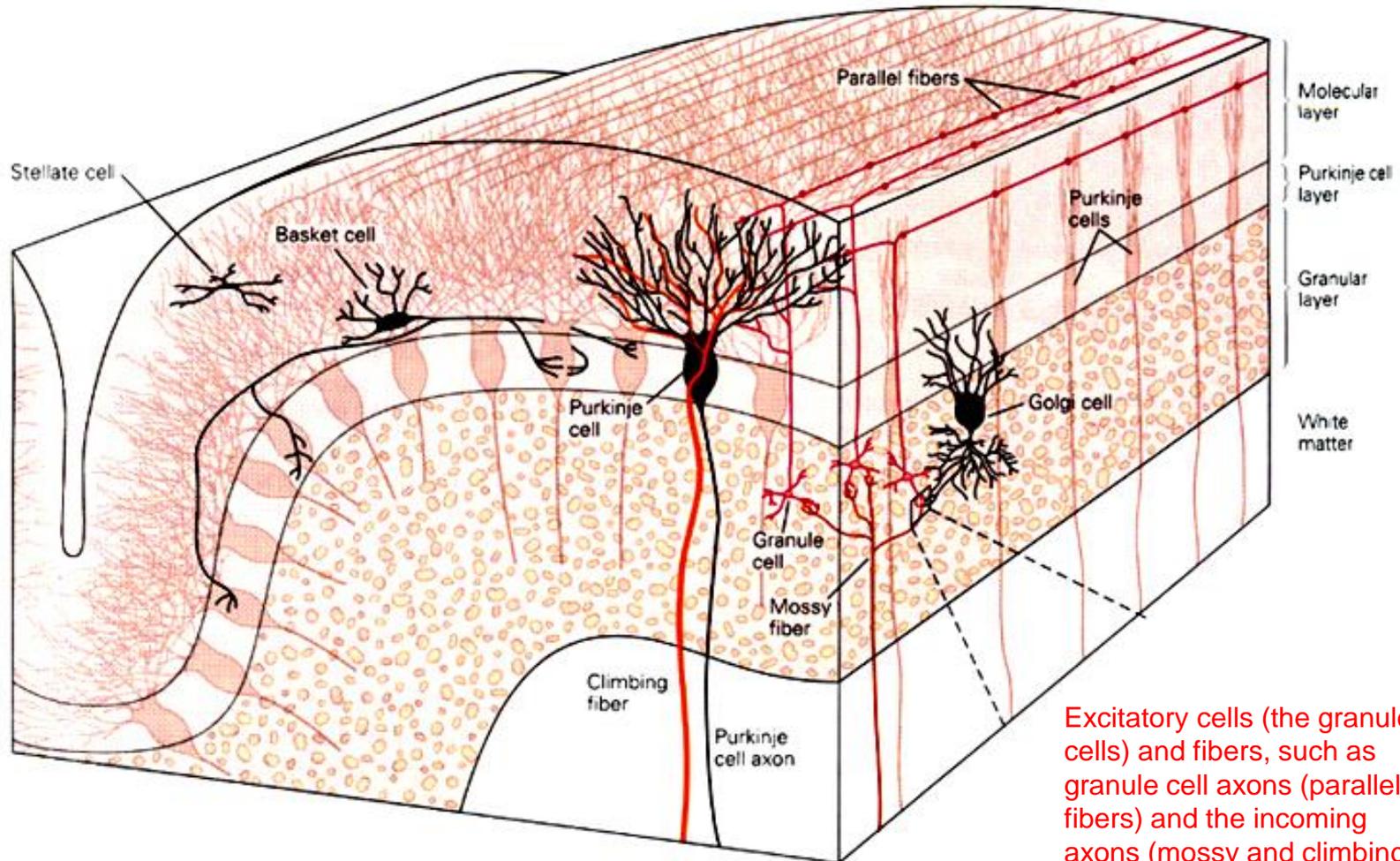
Cell bodies of cerebellar basket cells



Axons and dendritic trees of Purkinje cells

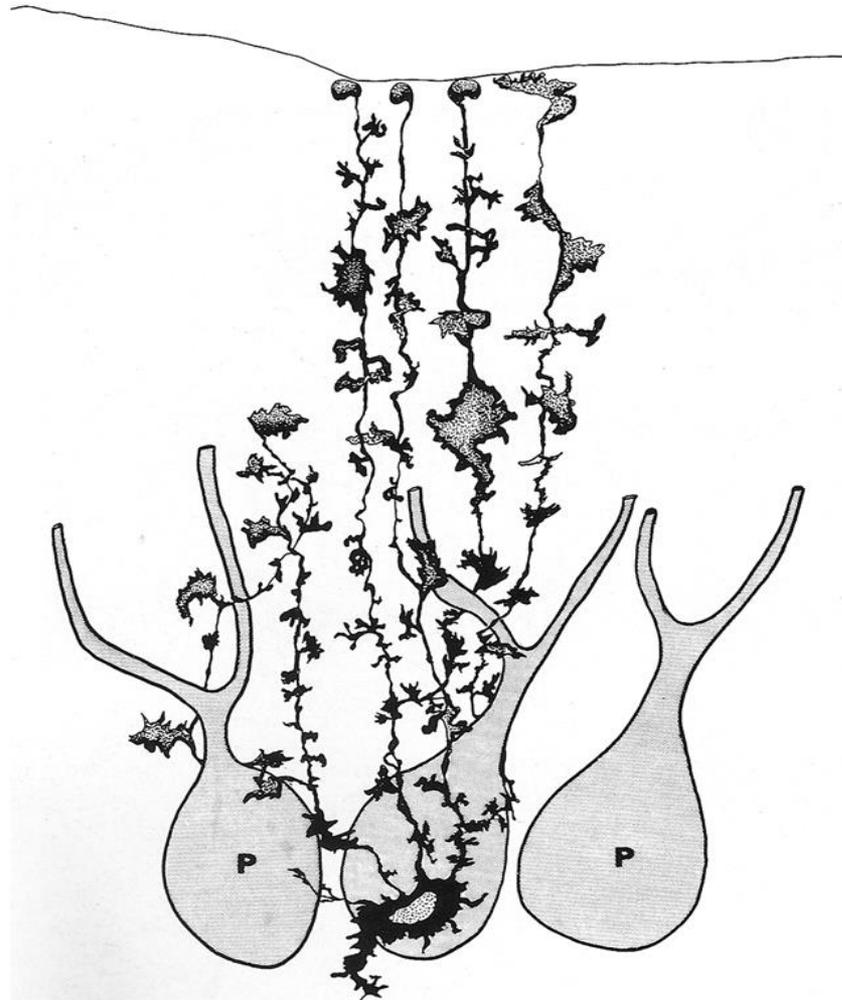
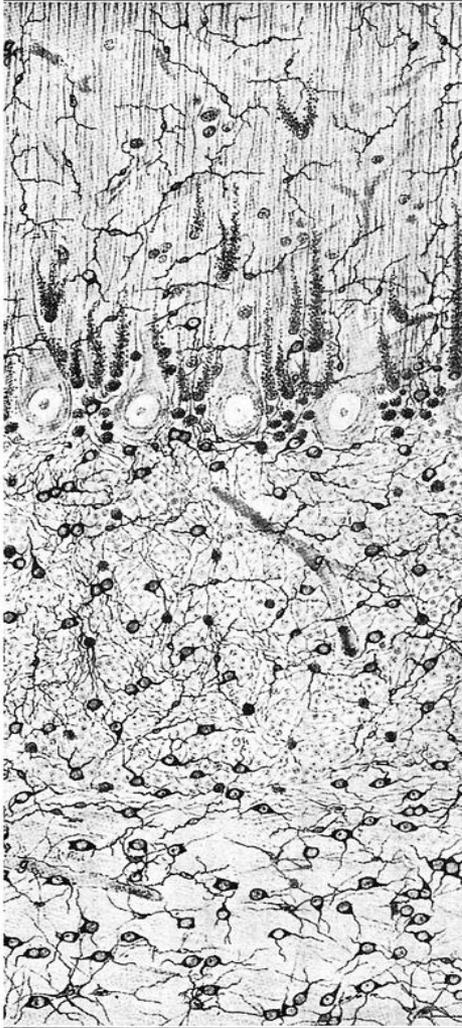


Morphology of the cells in the cerebellar cortex

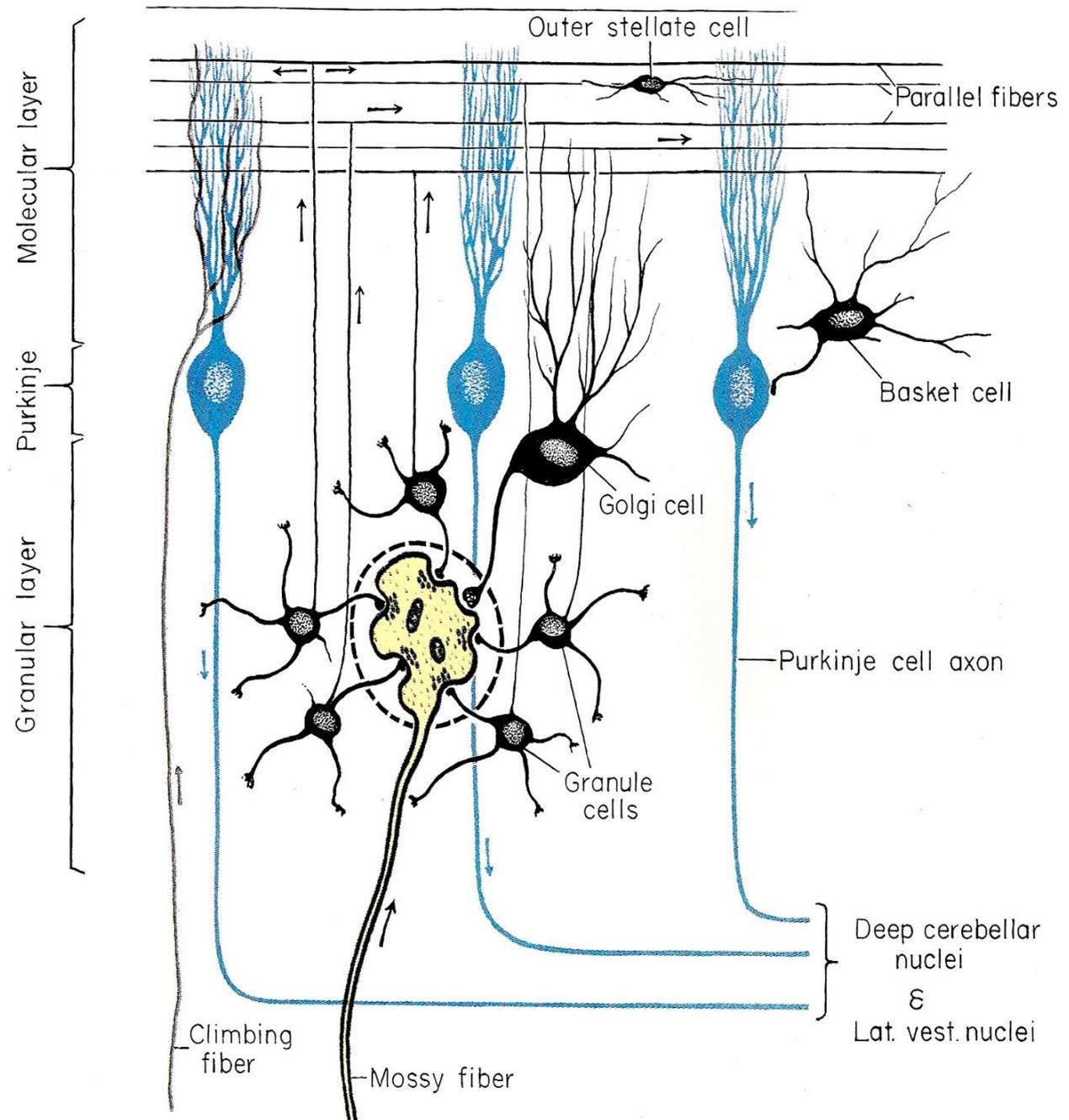


Excitatory cells (the granule cells) and fibers, such as granule cell axons (parallel fibers) and the incoming axons (mossy and climbing fibers) are red.

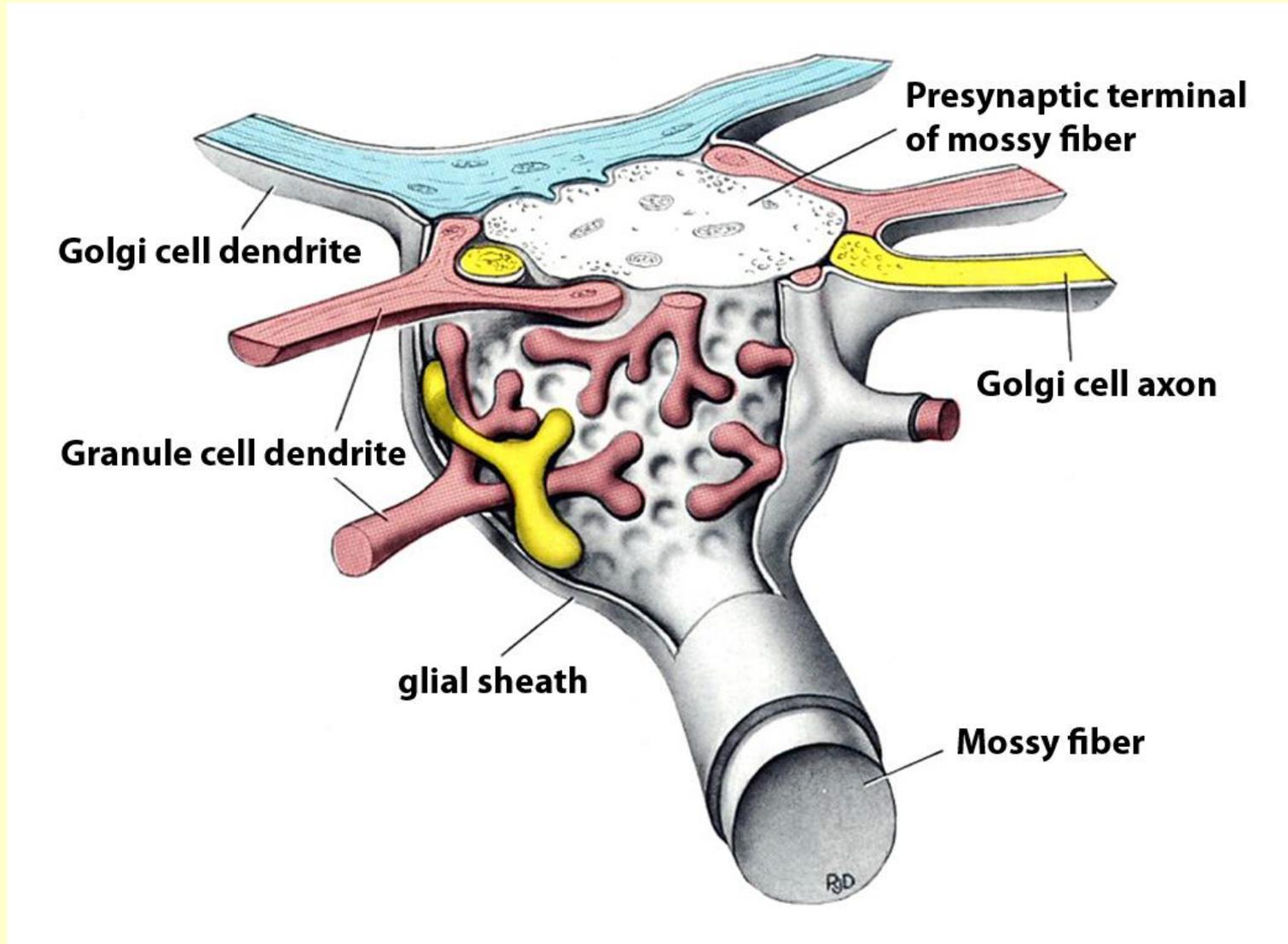
Bergmann glia – the special astrocytic glial cell of the cerebellum



Inputs
(climbing and mossy fibers)
and
outputs of cerebellar cortex



Structural model of cerebellar glomerulus



Components of the layers of cerebellar cortex

Molecular layer

cell bodies: basket and stellate cells

dendrites: Purkinje, basket, stellate, and Golgi cells

axons: granule, basket and stellate neurons, climbing fibers

Purkinje cell layer

cell body: Purkinje cell

dendrites: Passing dendrites of Golgi cells

axons: basket cells, passing axons of granule cells and climbing fibers

Granule cell layer

cell bodies: granule and Golgi cells

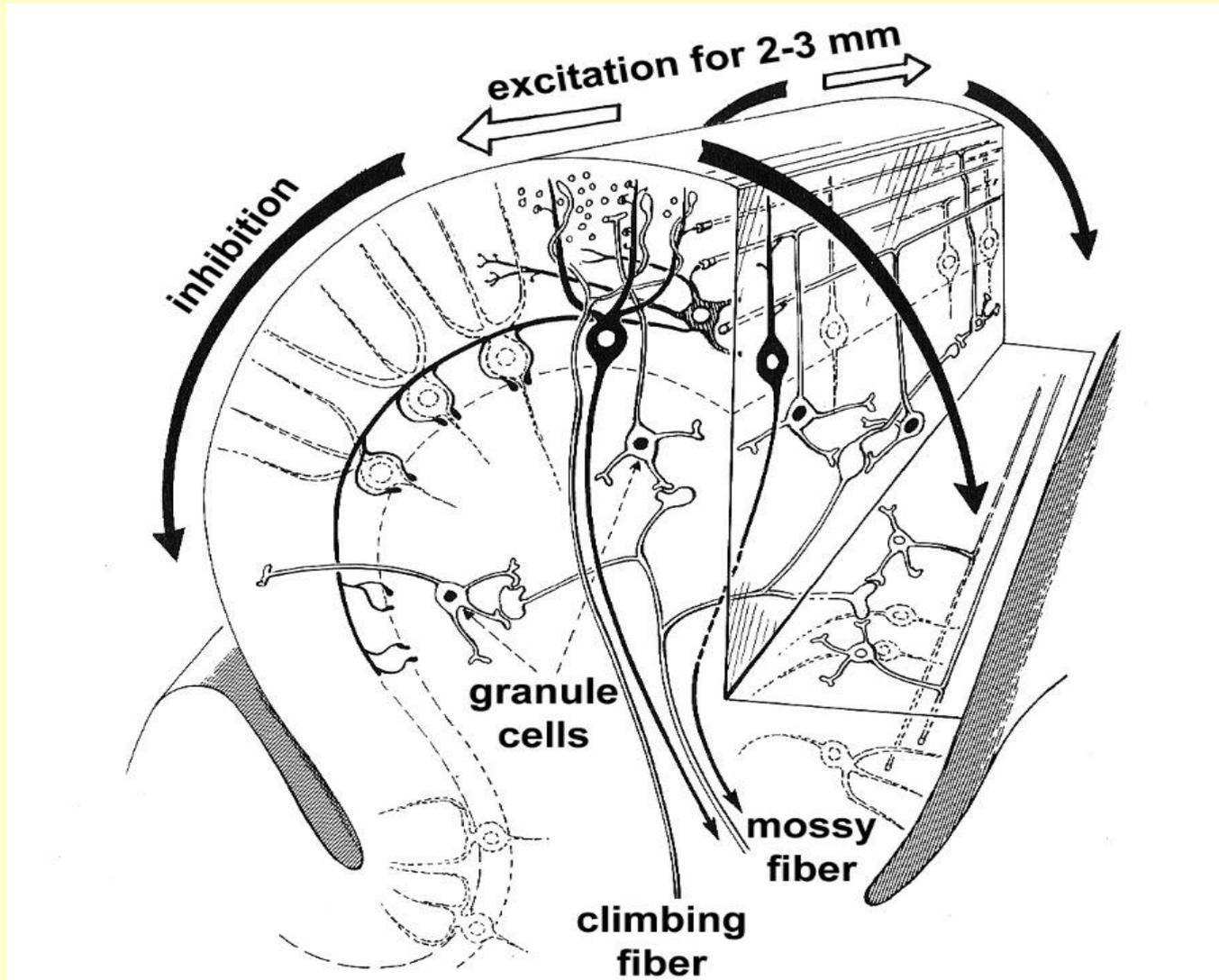
dendrites: granule and Golgi cells

axons: Golgi cell axons, mossy fibers, ascending granule cell axons, passing climbing fibers, and Purkinje cell axons

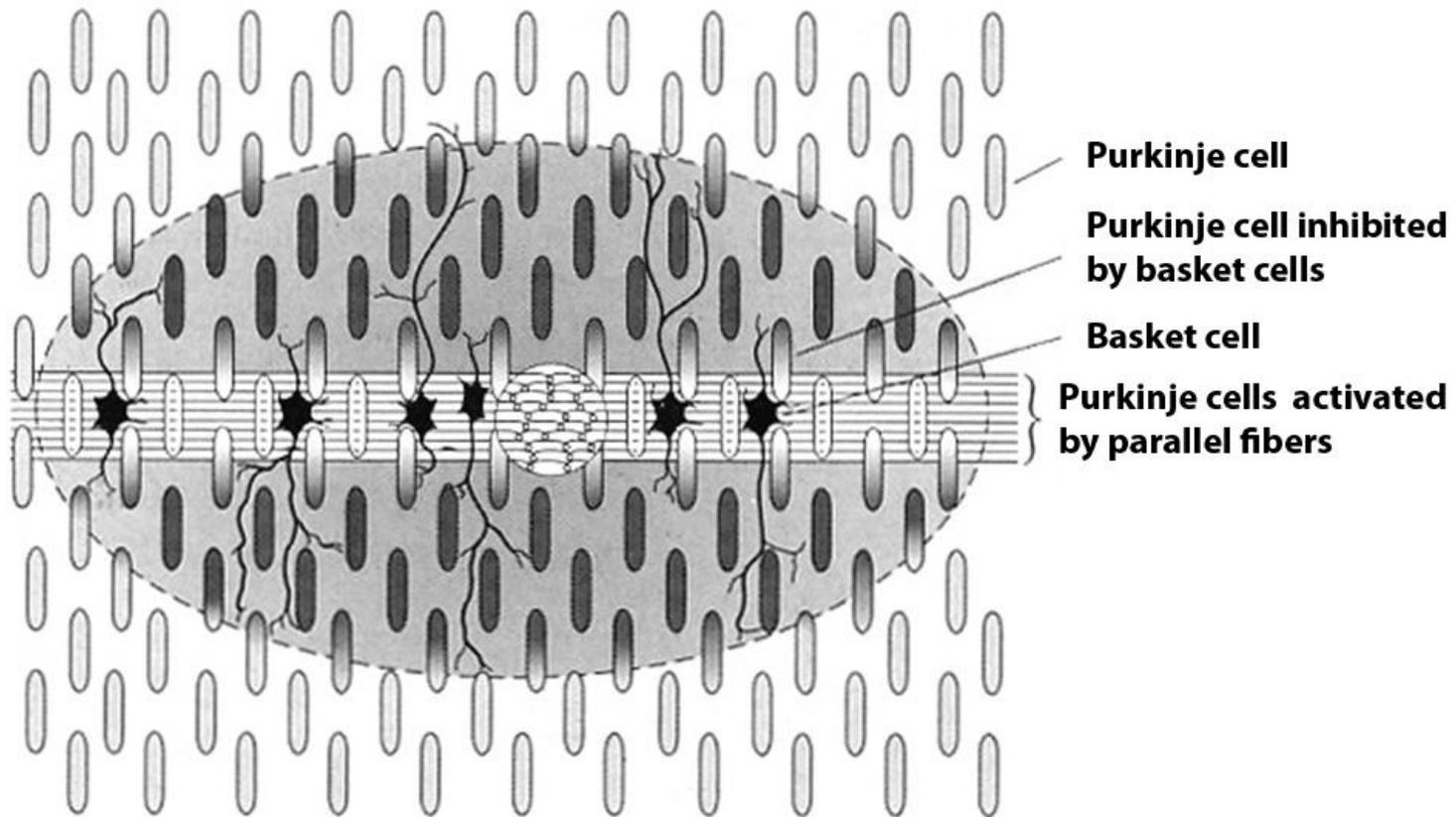
Connections of the cells of the cerebellar cortex

Cell type	Layer	Character	Target neuron
<u>Projection neuron</u>			
Purkinje cell	Purkinje cell layer	inhibitory	neurons in deep cerebellar and vestibular nuclei
<u>Interneurons</u>			
Granule cells	granule layer	excitatory	Purkinje, stellate-, basket- and Golgi cells
Basket cells	molecular layer	inhibitory (feed-forward)	Purkinje cells
Stellate cells	molecular layer	inhibitory (feed-forward)	Purkinje cells
Golgi cells	granule layer	inhibitory (feed-back)	granule cells

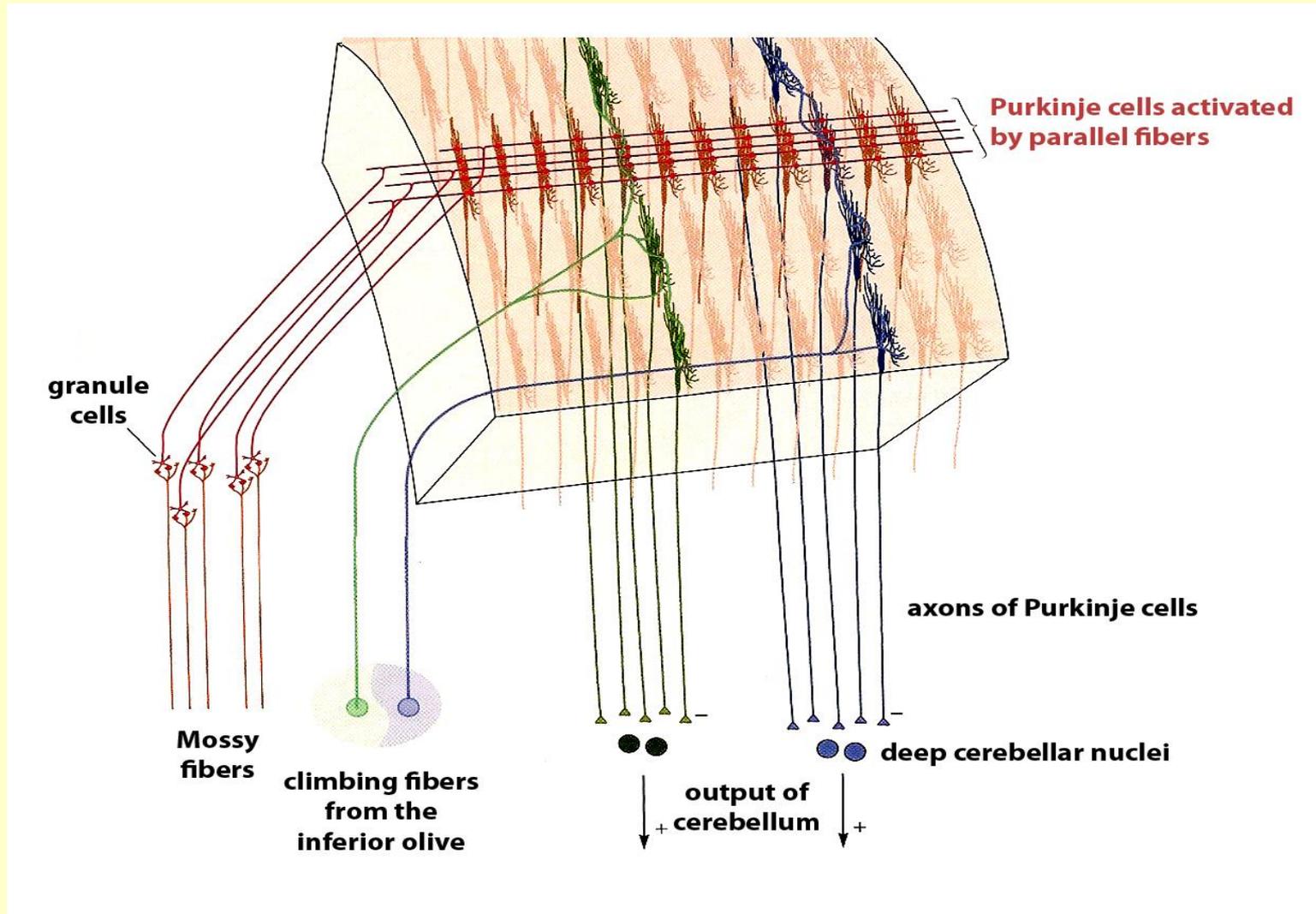
Excitatory and inhibitory actions of the parallel fibers of the granule cells



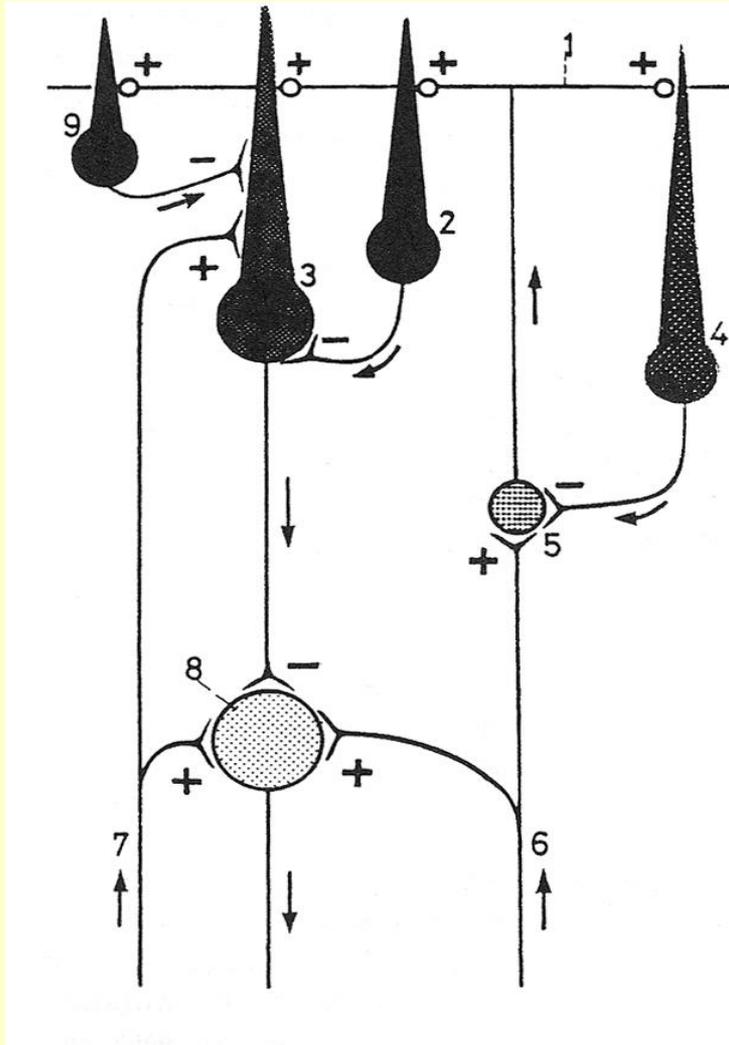
Functional unit of the cerebellar cortex: a line of Purkinje cells activated by parallel fibers with surrounding inhibited Purkinje cells



Climbing fibers activate individual Purkinje cells. If it coincides with activation by parallel fibers, the cells undergo prolonged inhibition by long-term depression: a proposed mechanism of motor learning



Output of the cerebellum is a negative mirror of the activity of Purkinje cells of the cerebellar cortex



1. Parallel fibers
2. Basket cell
3. Purkinje cell
4. Golgi cell
5. Granule cell
6. Mossy fiber
7. Climbing fiber
8. Neuron in the cerebellar nu.
9. Stellate cell

Cerebellar pathways and their connections with different parts of the cerebellum

Afferent pathways of the cerebellum

Pathways terminating in mossy fibers:

Pontocerebellar tract – crossed pathway in the middle cerebellar peduncle conveying information to the cerebellum from frontal, occipital and temporal lobes of the cerebral cortex

Vestibulocerebellar tract – uncrossed pathway in the inferior cerebellar peduncle carrying primary vestibular fibers as well as fibers from the medial and inferior vestibular nuclei

Spinocerebellar afferents (detailed in the next slide)

Pathways terminating in climbing fibers:

Olivocerebellar tract – crossed pathway in the superior cerebellar peduncle conveying input to the cerebellum via the inferior olive from the cerebral cortex, thalamus, red nucleus, vestibular nuclei and the spinal cord

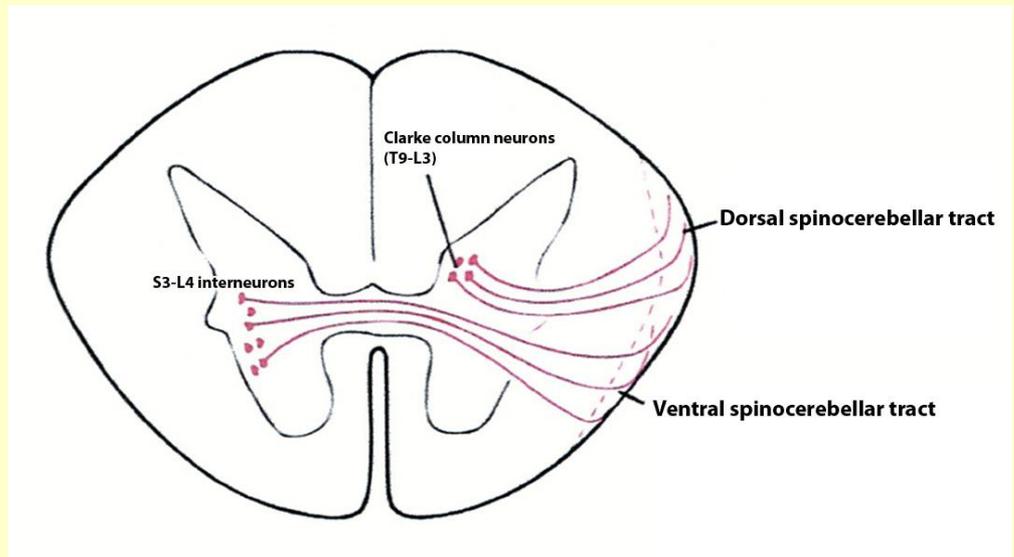
Monoaminergic afferents:

Uncrossed noradrenergic fibers from the locus coeruleus and serotonergic fibers from the raphe nuclei in the superior and inferior cerebellar peduncles

Spinocerebellar afferent pathways

Dorsal/posterior spinocerebellar tract (Flechsig)

Uncrossed pathway in the inferior cerebellar peduncle originating in the nucleus dorsalis (Clarke nucleus) of the spinal cord to convey proprioceptive and epicritic sensibility from the lower body part to the cerebellum



Ventral/anterior spinocerebellar tract (Gowers)

Crossed pathway in the superior cerebellar peduncle conveying information on motor orders to the lower body part to the cerebellum from premotor interneurons of the spinal cord

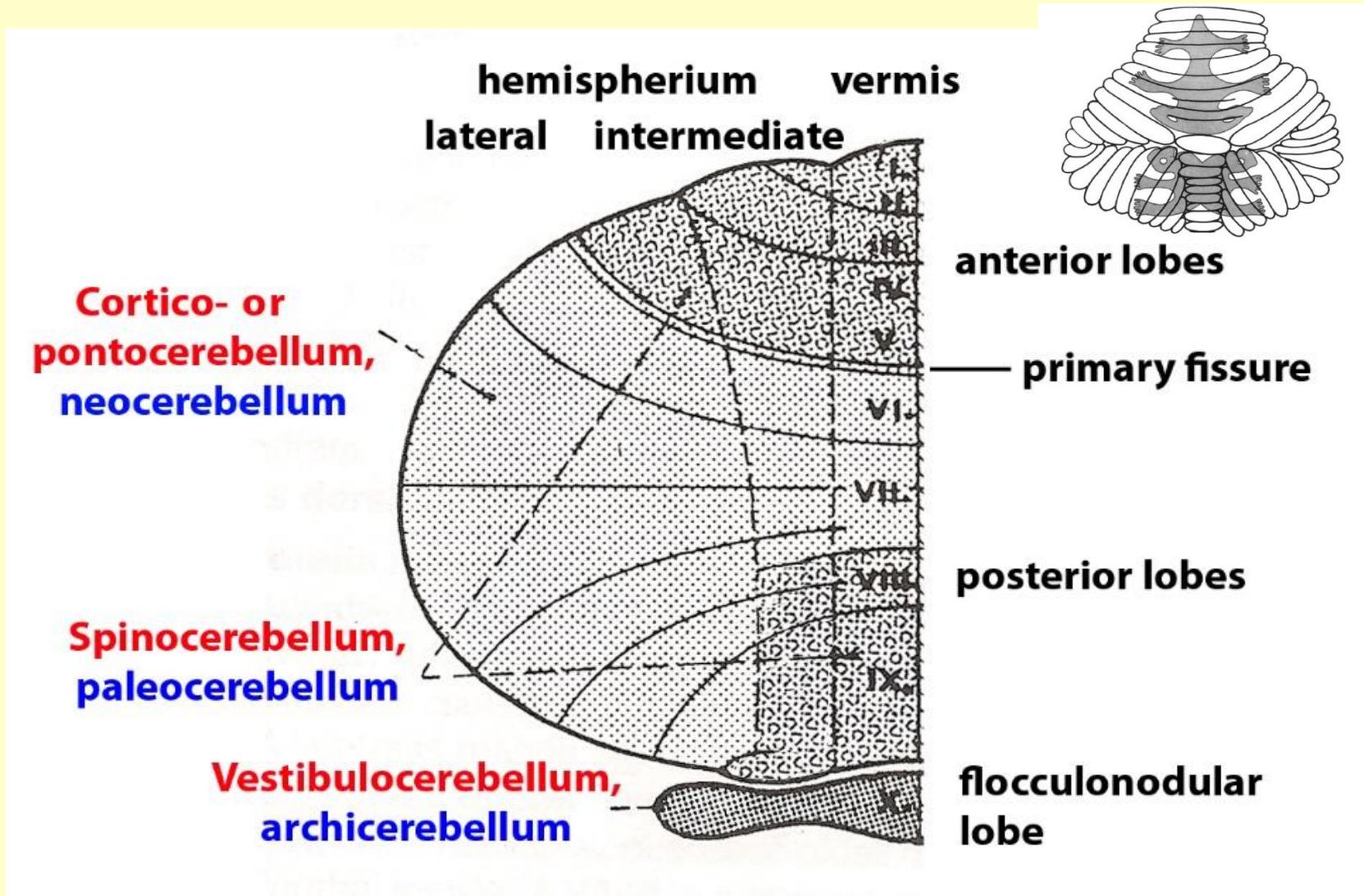
Cuneocerebellar tract

Uncrossed pathway in the inferior cerebellar peduncle originating in the external (or accessory) cuneate nucleus to convey proprioceptive and epicritic sensibility from the upper body part to the cerebellum.

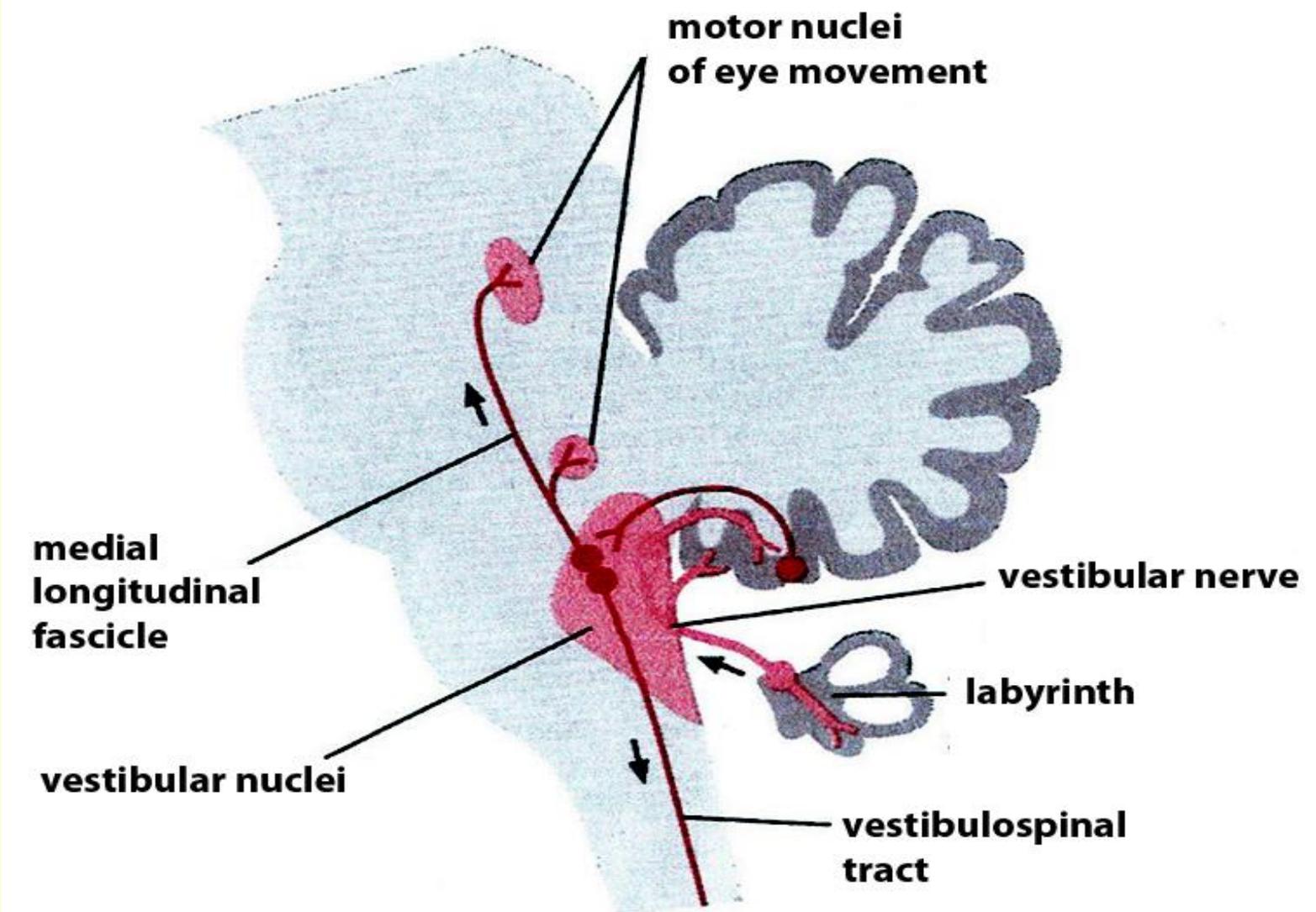
Rostral spinocerebellar tract

Crossed pathway in the superior cerebellar peduncle conveying information on motor orders to the upper body part to the cerebellum from premotor interneurons of the brainstem

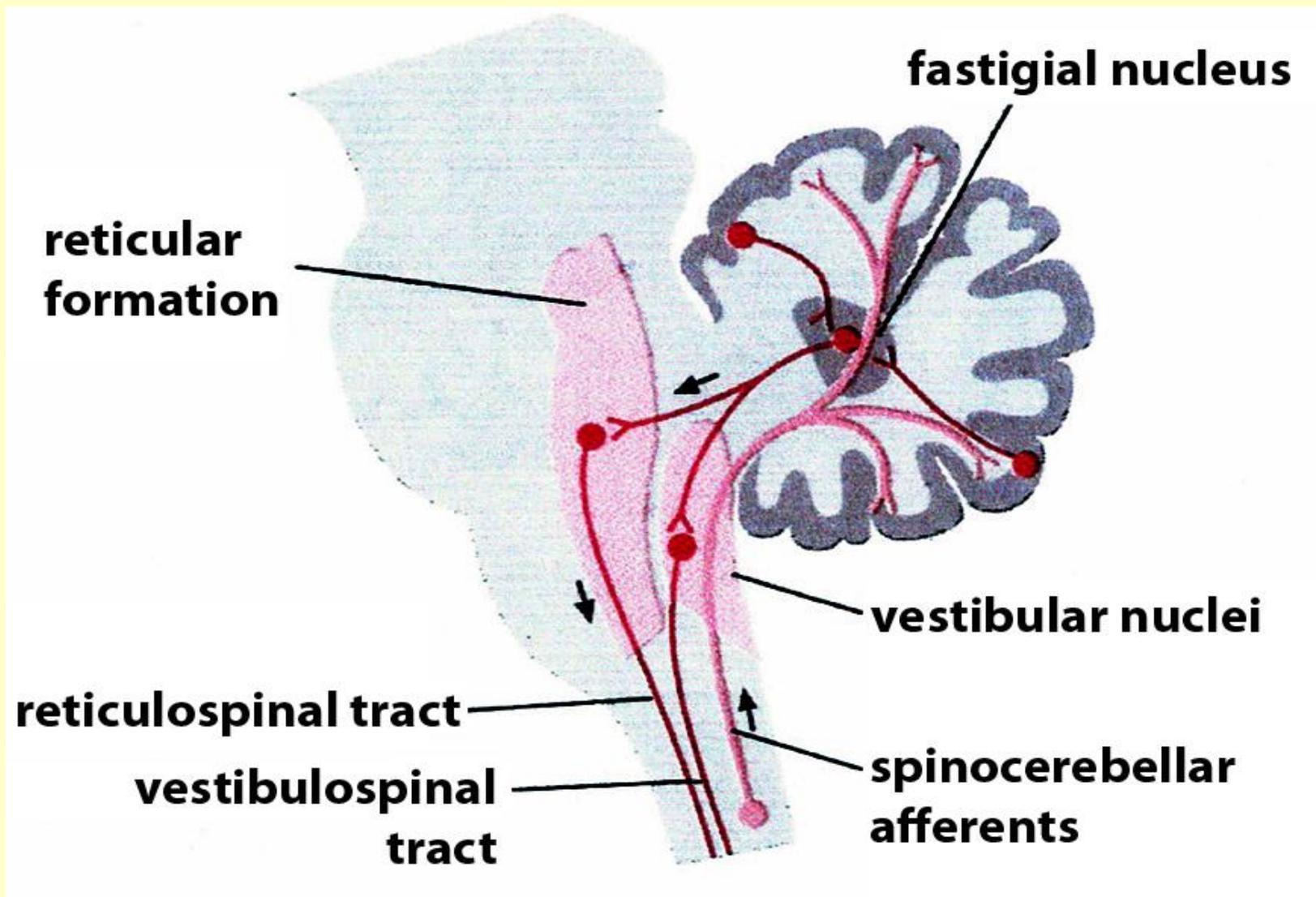
Division of the cerebellum based on the origin of inputs and filogenetic development



Outputs of vestibulocerebellum

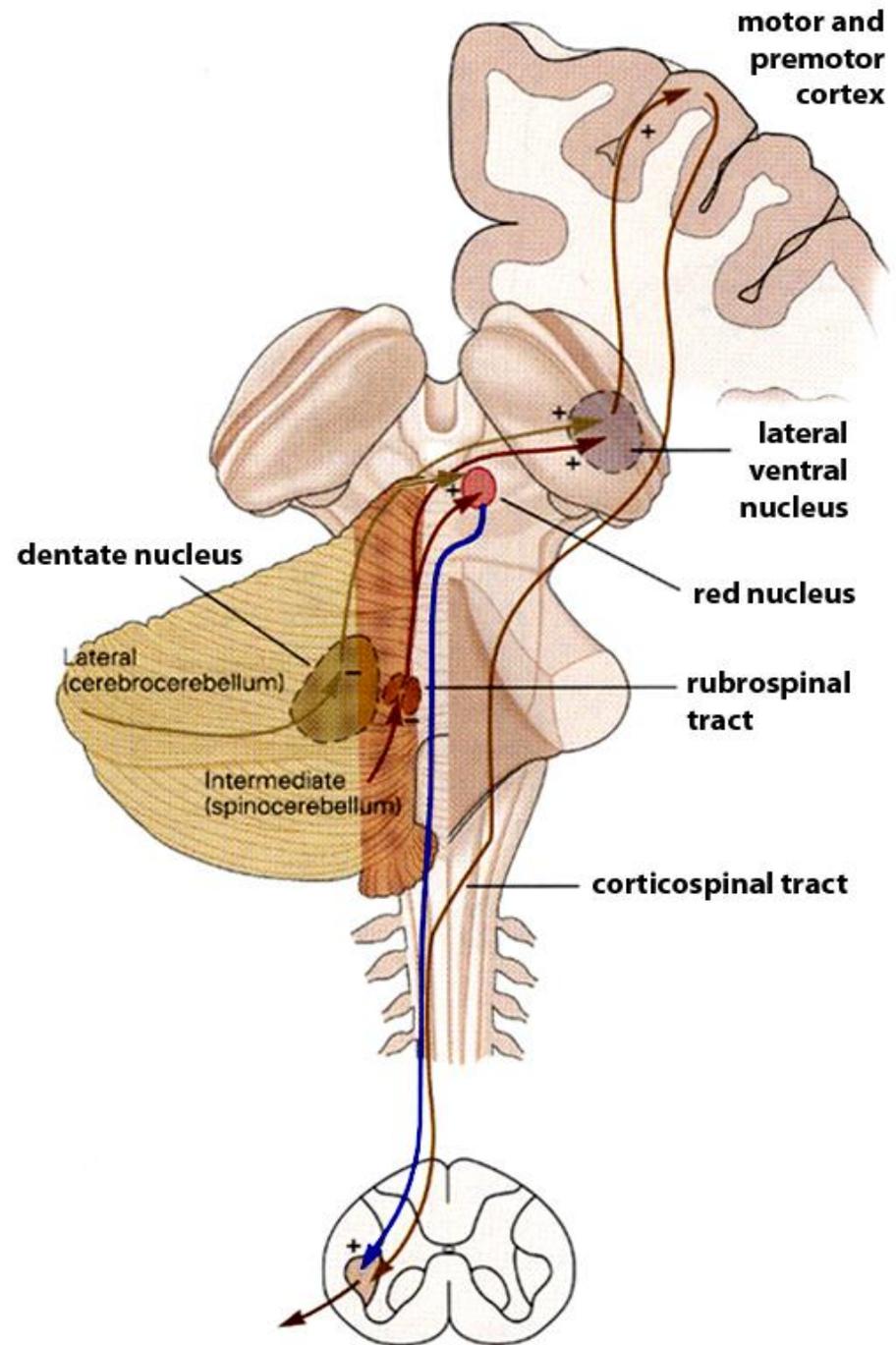


Outputs of spinocerebellum from the vermis (cerebelloreticular and cerebellovestibular tracts)

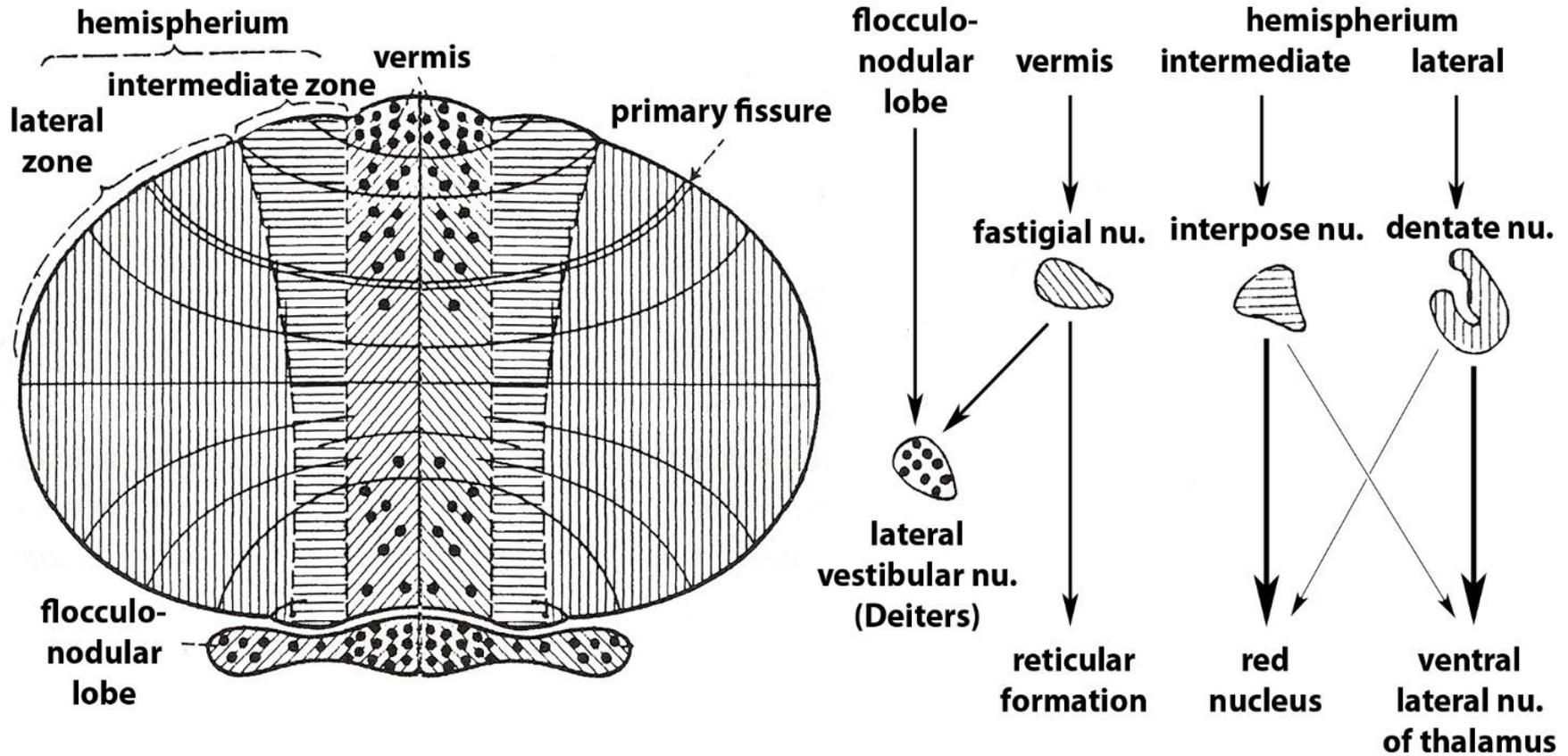


Outputs of the cerebellum originating in the hemispheres

(cerebellorubral and cerebellothalamic tracts)



Summary of targets of Purkinje cells



Afferent and efferent pathways in the cerebellar peduncles

Superior cerebellar peduncle:

ventral spinocerebellar tract (Gowers)
rostral spinocerebellar tract
cerebellothalamic tract
cerebellorubral tract

Middle cerebellar peduncle:

pontocerebellar tract

Inferior cerebellar peduncle:

olivocerebellar tract (the only pathway with climbing fibers)
dorsal spinocerebellar tract (Flechsig)
cuneocerebellar tract
vestibulocerebellar tract
cerebellovestibular tract
cerebelloreticular tract

Functional divisions of the cerebellum

	Anatomical regions	Incoming information	Relay nucleus	Termination	Function
Vestibulocerebellum	flocculonodular lobe	vestibular labyrinth	lateral vestibular	spinal and eye movement motoneurons	eye movement, neck muscles, body balance
Spinocerebellum	vermis	vestibular nuclei, spinal cord	fastigial	vestibular nuclei, reticular formation	muscle tone, posture, coordination of trunk muscles
	intermediar cortex	spinal cord	interpose	red nucleus (magnocellular), thalamus (VL) - motor cortex	execution of movements, coordination of limbs
Cerebrocerebellum	lateral cortex	cerebral cortex	dentate	thalamus (VL) - motor cortex, red nucleus (parvocellular)	initiation of movements, temporal planning of movements, cognitive functions

**Thank you for
your attention!**