



Gaza Ophthalmic Centre

27.3.2 CEREBELLUM Part 2 Neurosciences I

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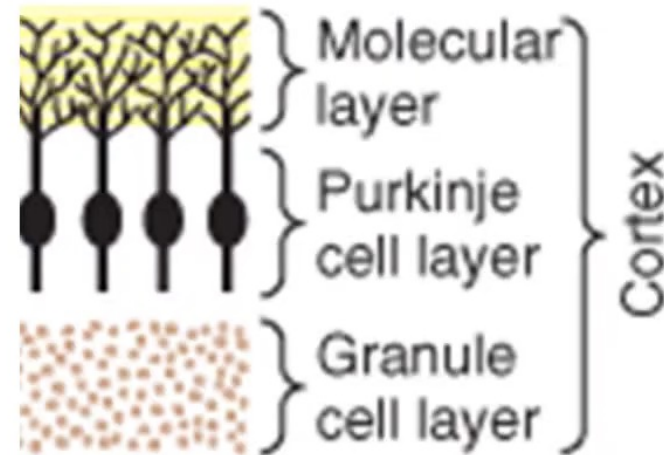
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Cerebellar Functional Structure

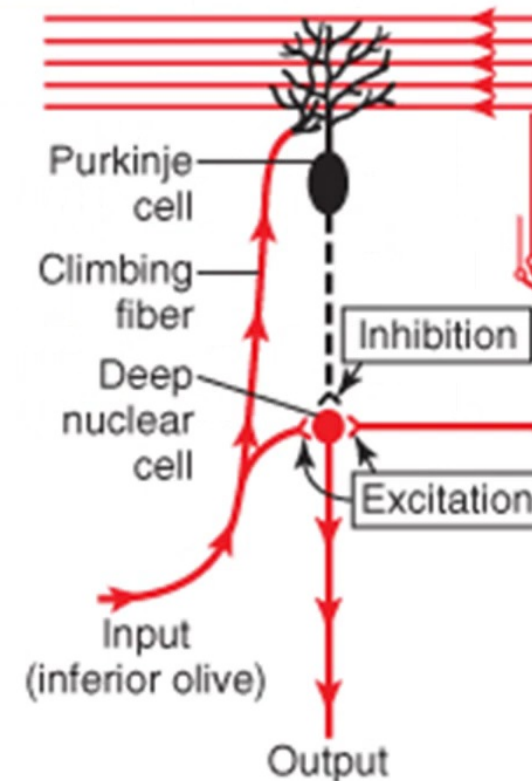
- Cerebellar cortex

1. External molecular layer
 - Interconnecting fibers
2. Intermediate Purkinji cell layer
 - Giant Purkinji cells
 - Axons → deep nuclei
 - → inhibitory signals
3. Internal granular layer
 - Granule cells



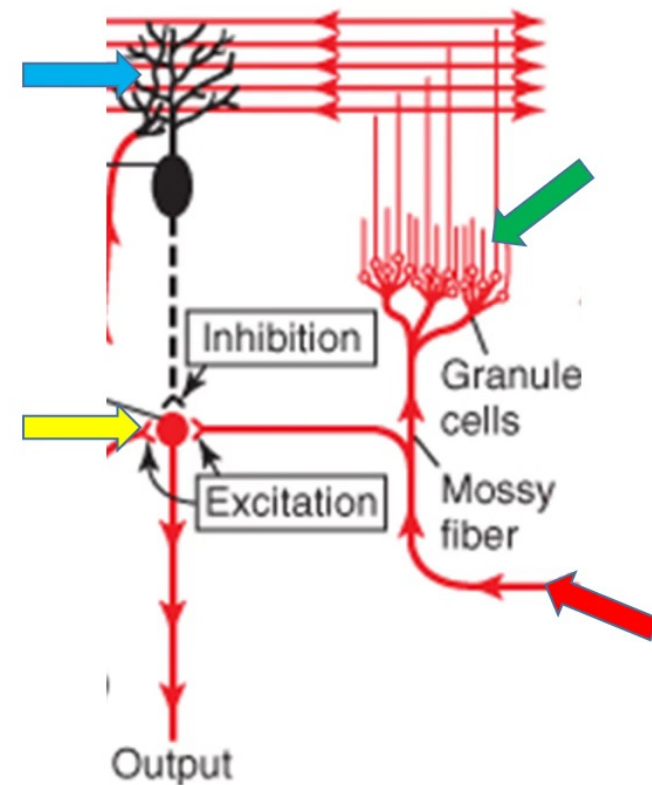
Cerebellar Functional Structure

- Climbing fibers
 - From inferior olive
 - → excitatory fibers
 - to deep nuclei
- Projects to dendrites of
 - Purkinji cells

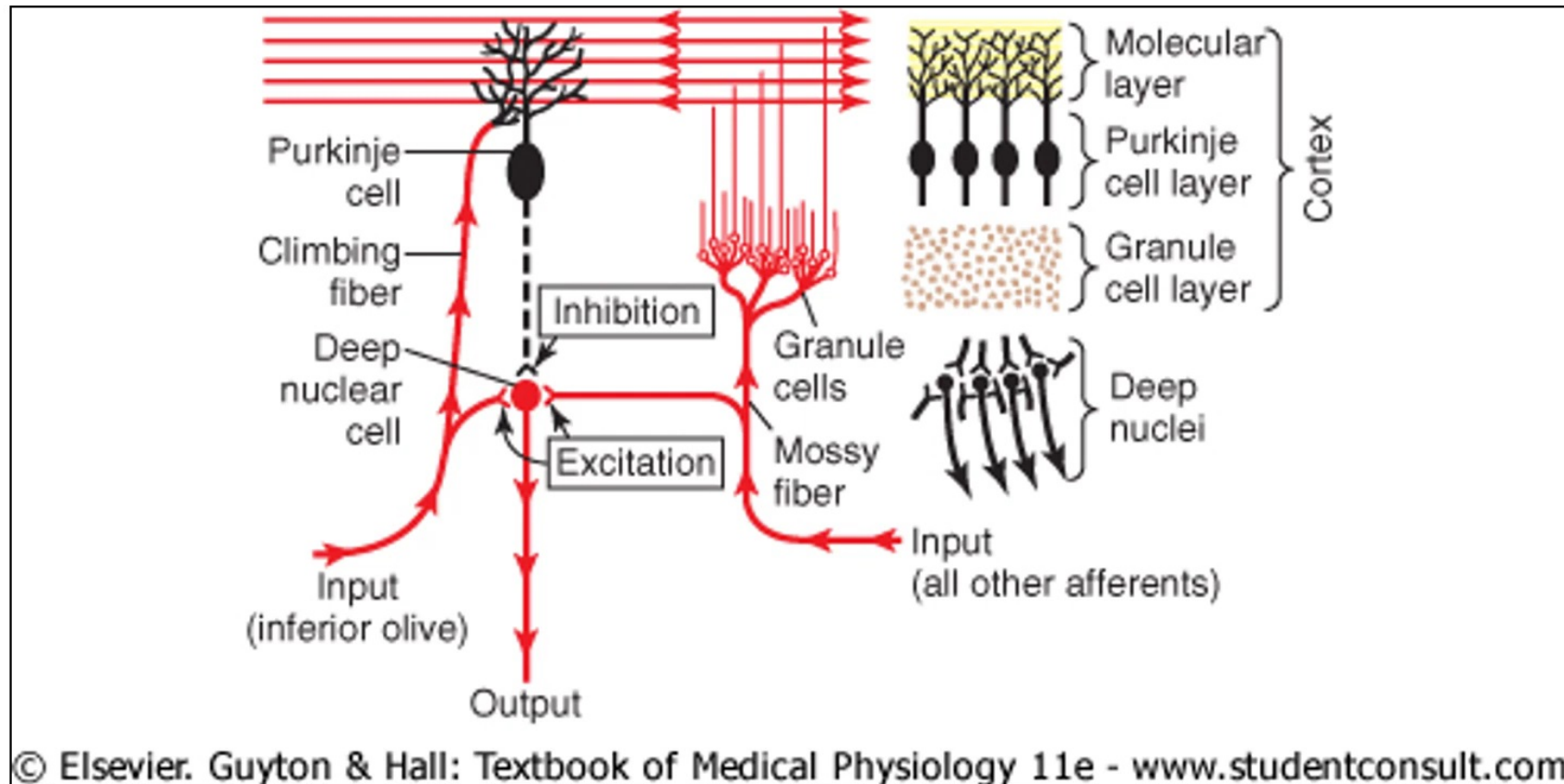


Cerebellar Functional Structure

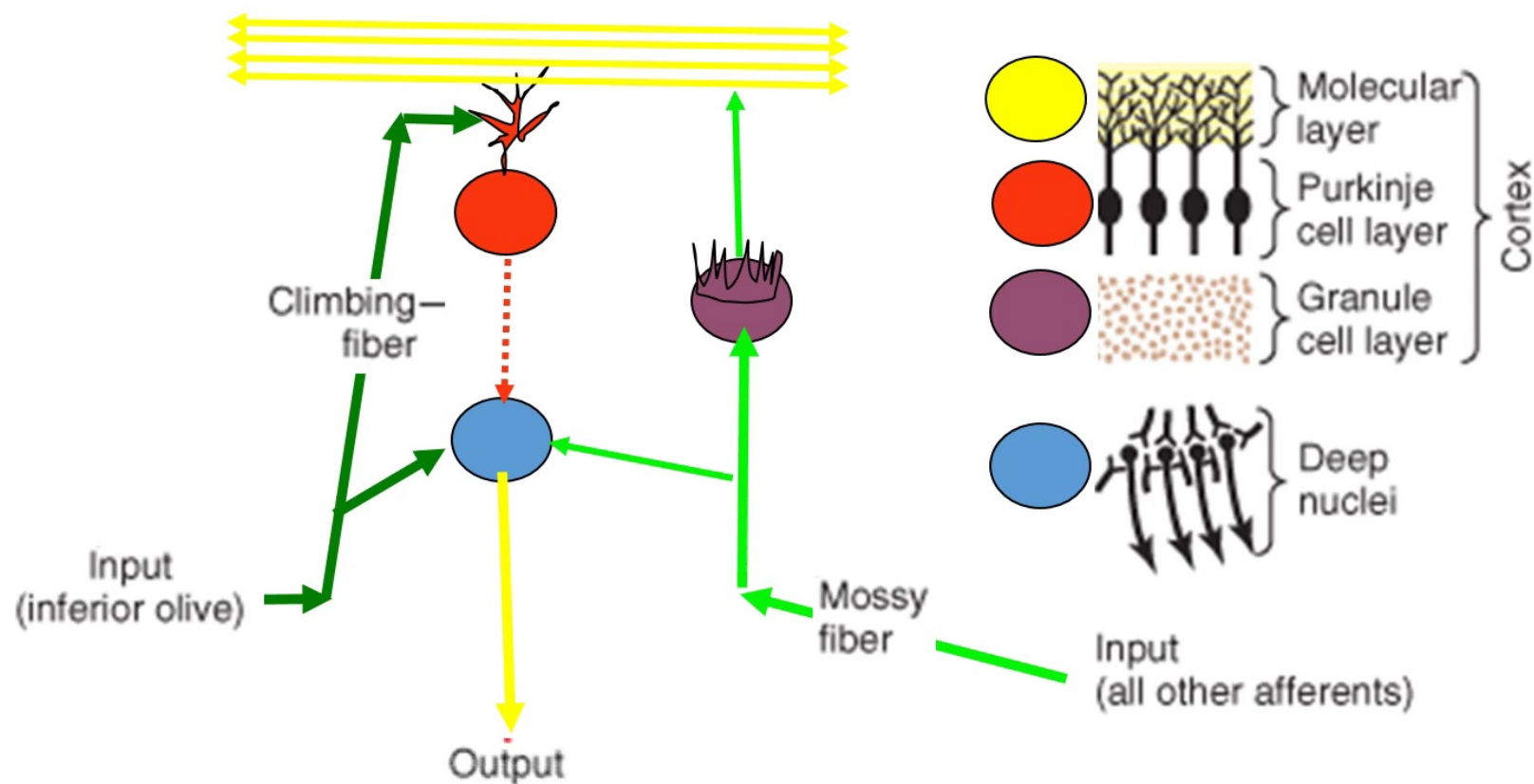
- Mossy fibers
 - From multiple sources
 - (including inferior olive partly)
 - Excitatory collaterals to
 - deep nuclei
 - Projects to granule cells →
 - Purkinji cells



Cerebellar Circuits

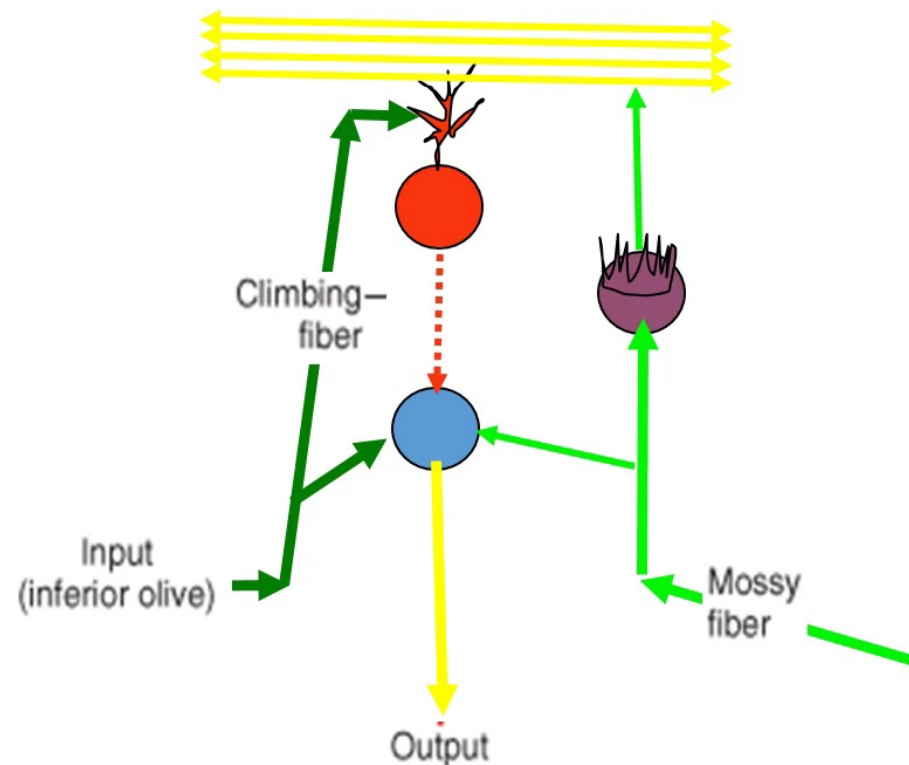


Cerebellar Circuits



Cerebellar Functional Structure

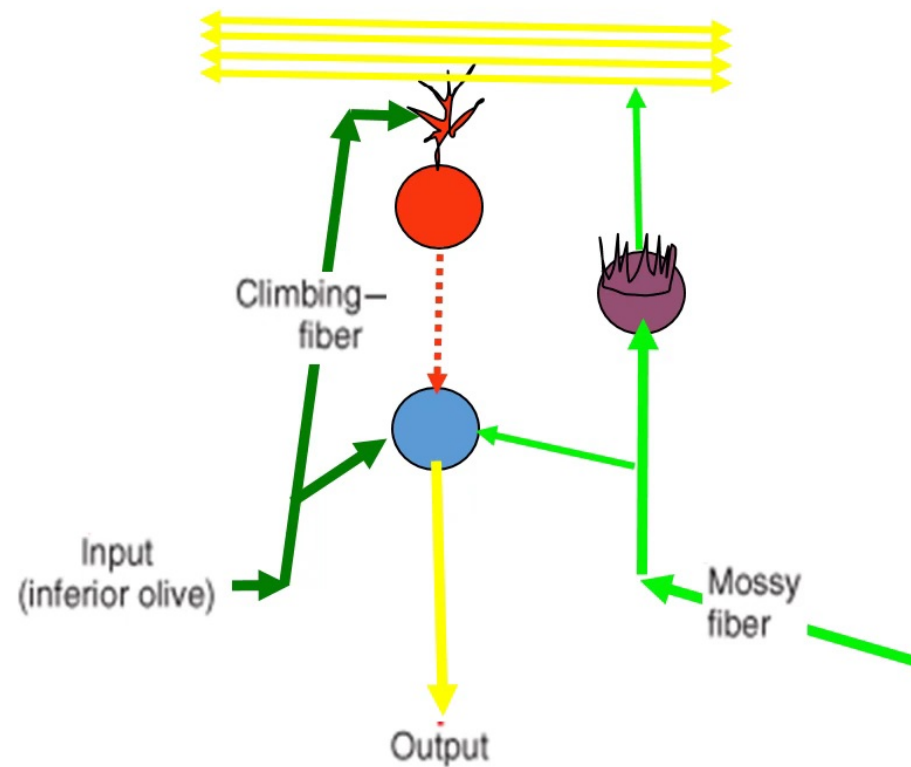
- All afferents terminate in the cerebellar cortex
- Cerebellar cortex
- (through Purkinji cells)
- → inhibitory signal to deep nuclei
- Deep nuclei receives
 1. Excitatory signals (mossy & climbing fibers)
 2. Followed by inhibitory signals from Purkinji cells
- Balance → +/- excitation



Cerebellar Functional Structure

- Cerebellar circuit →

- Modulation &
- Timing of
- Excitatory output of
- Deep nuclei
- During
- Muscle contraction



Cerebellar Functional Structure

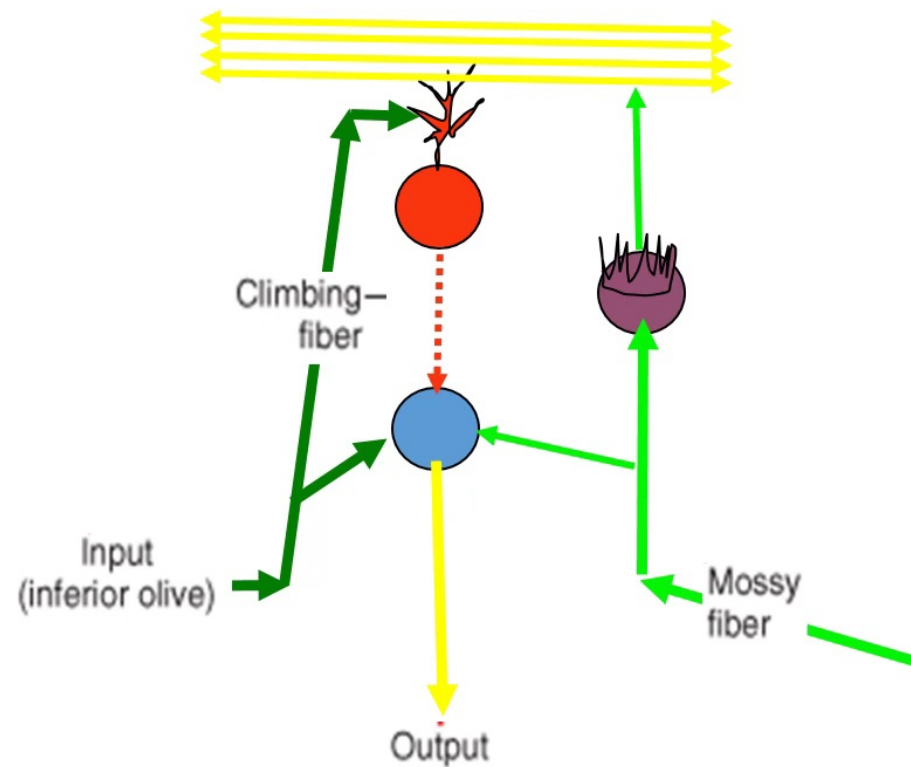
Deep nuclei →

- 1) Rapid excitatory signal

- →
- Feed back
- Motor cortex
- →
- Smoothing effect

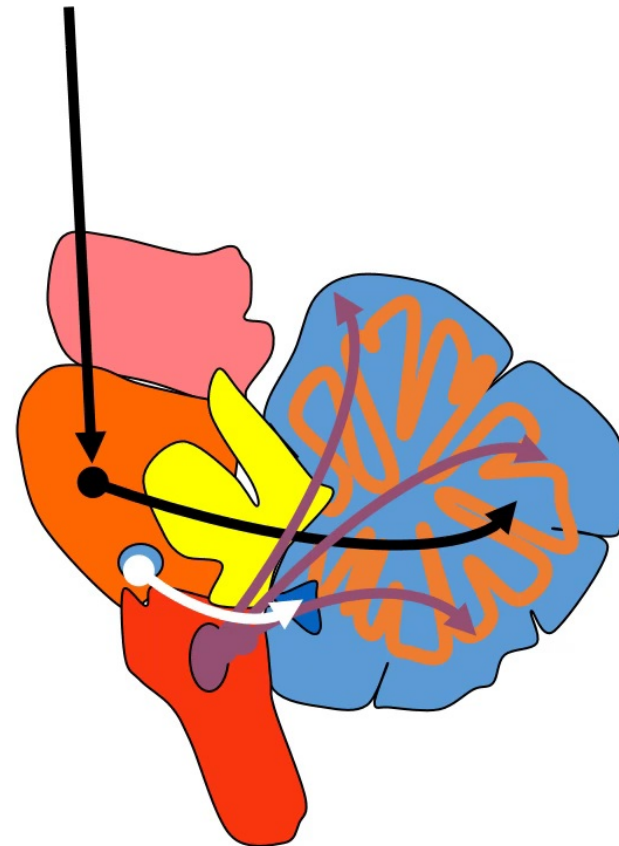
→

- 2) Inhibitory signals to
 - Motor cortex
 - →
 - Stops
 - Overshooting movements



Cerebellar Connections: Input

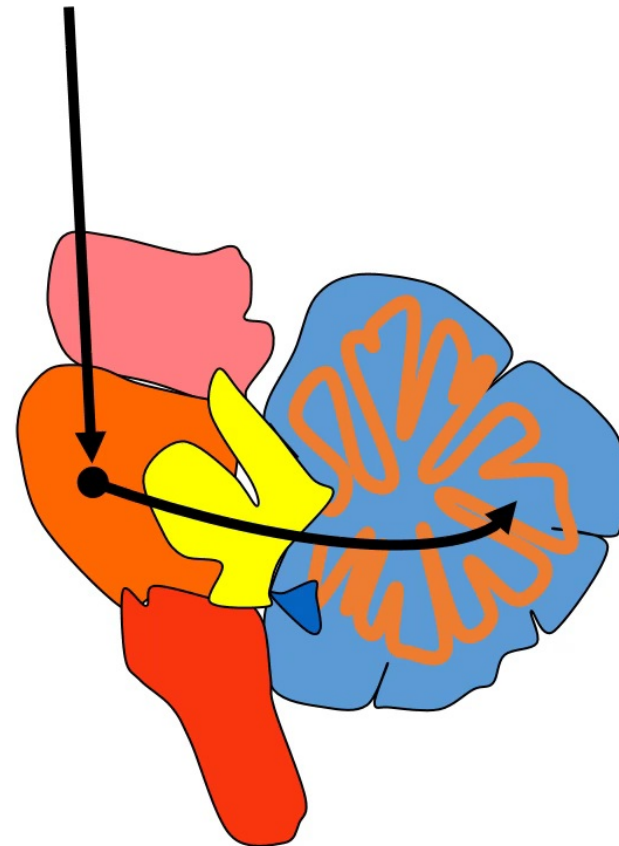
1. Cortico ponto cerebellar pathway
2. Olivo cerebellar tract
3. Vestibulo cerebellar tract
4. Reticulo cerebellar fibers



Cerebellar Connections: Input

1) Cortico ponto cerebellar pathway

- Motor & premotor cortex
- → pontile nuclei
- → pontocerebellar tract
- → middle cerebellar peduncle
- → CL cerebellar hemisphere



Cerebellar Afferents

- Cerebral cortex
 - Cerebro ponto cerebellar pathway

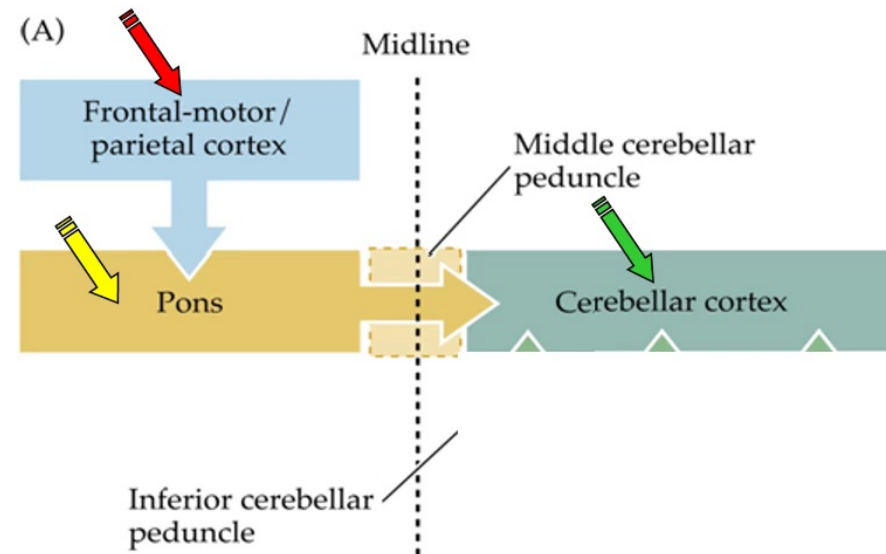
1. Fronto pontine tract

2. TPO pontine tract

- → pontine nuclei

- → **MCP**

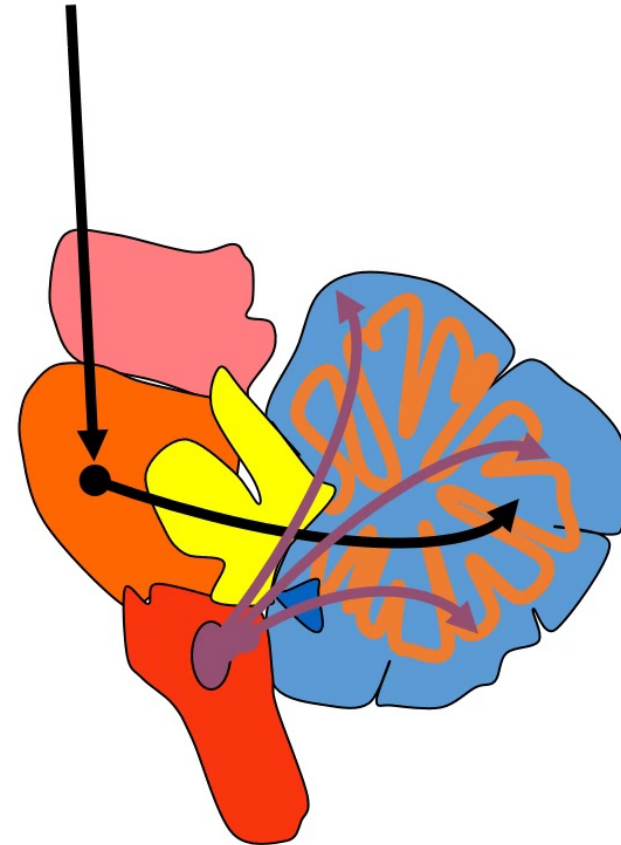
- → Neocerebellum



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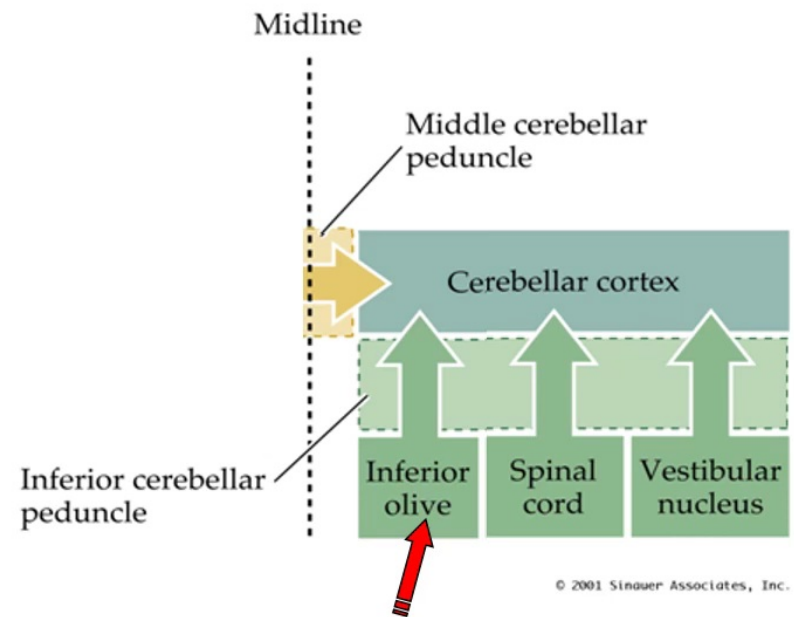
- **Inferior olive →**
- **Inferior cerebellar peduncle**
- **→all cerebellar parts**
- **Inf olive receives from**
 1. **Motor cortex**
 2. **BG**
 3. **RF**
 4. **Spinal cord**



Cerebellar Afferents

- Cerebral cortex
 - Cerebro pallido olivo cerebellar pathway
 - Cerebral cortex
 - → globus pallidus
 - → inf olive
 - → olivo cerebellar fibres
 - → **ICP**
 - → all parts of the cerebellum

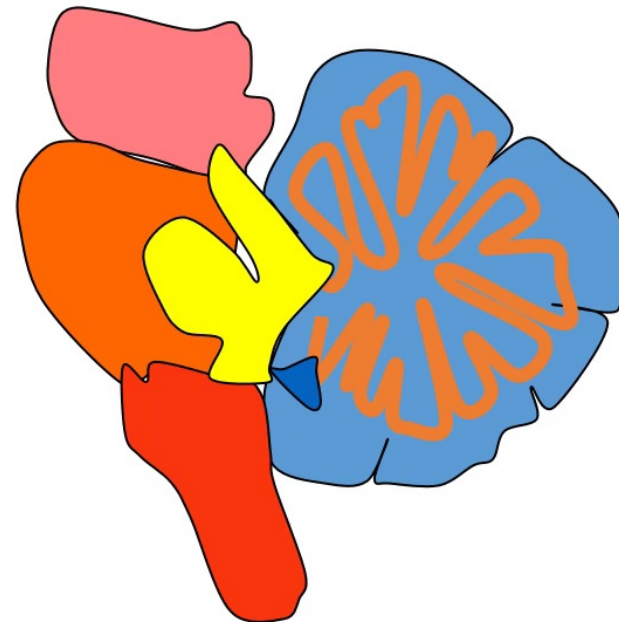
(A)



Cerebellar Connections: Input

3) Vestibulo cerebellar tract

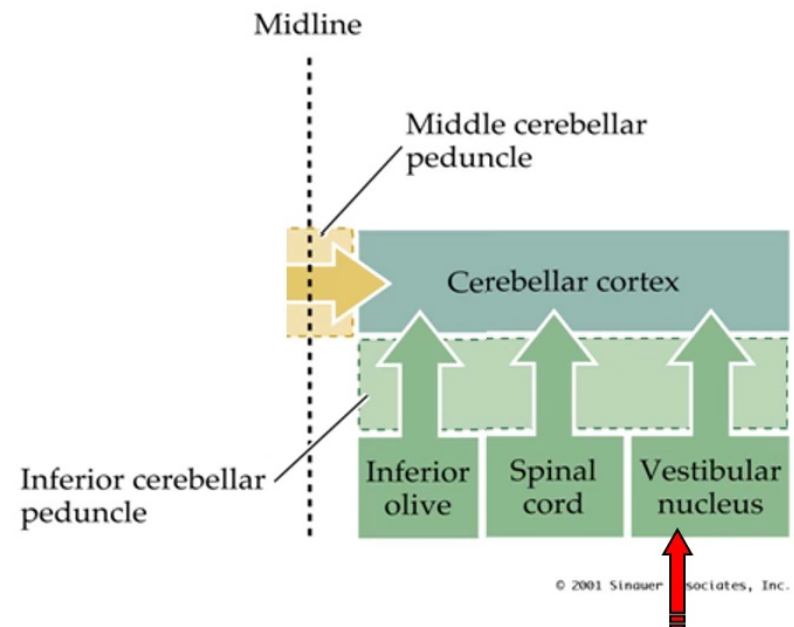
- Vestibular apparatus →
- Vestibular nuclei →
- Inf cerebellar peduncle
• →
- Flocculonodular lobe &
• Fastigial Nc
- * Body posture & equilibrium



Cerebellar Afferents

- Peripheral organs
 - Internal ear →
 - Direct vestibulo cerebellar T
 - → **ICP**
 - → flocculonodular lobe
 - VN
 - → indirect vestibulo cerebellar T
 - → **ICP**
 - → flocculonodular lobe

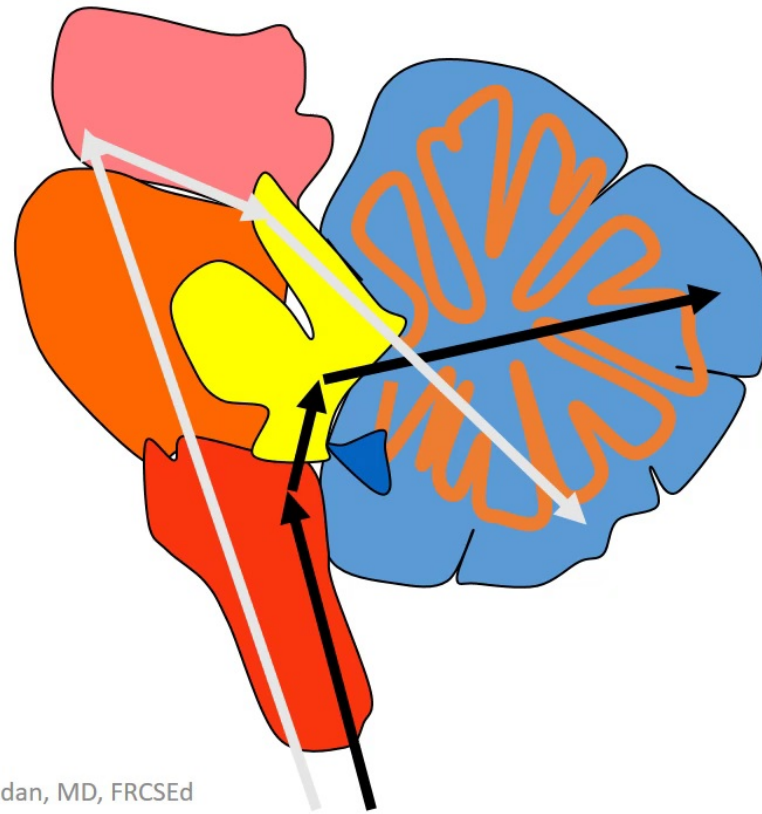
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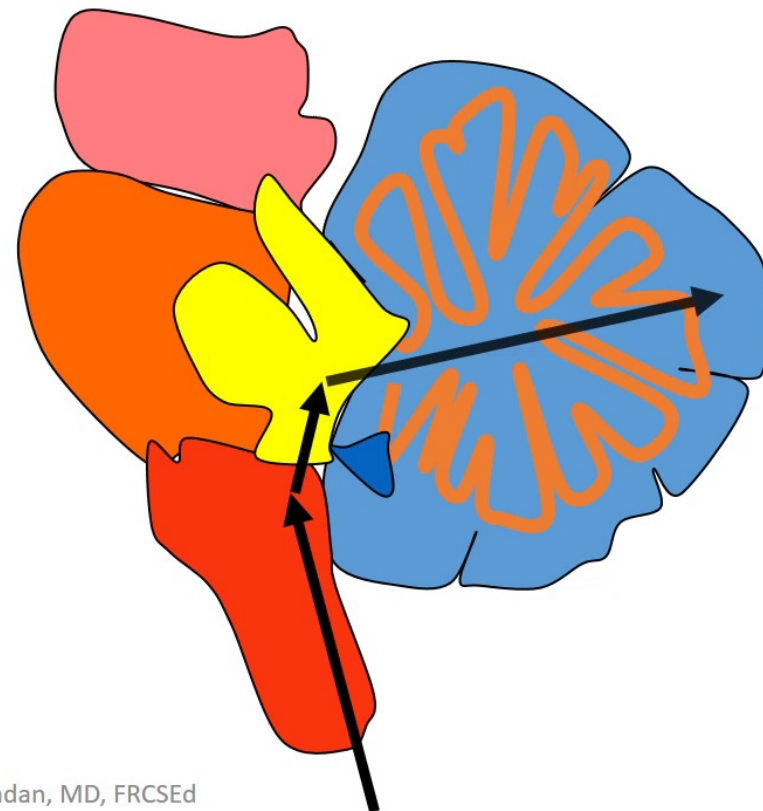
Cerebellar Afferent from the spine

- Very fast 120 m/sec
- Direct pathway
 1. Dorsal spinocerebellar tract
 2. Ventral spinocerebellar tract
- Indirect pathway
 1. Spino reticular pathway
 2. Spino olivary pathway



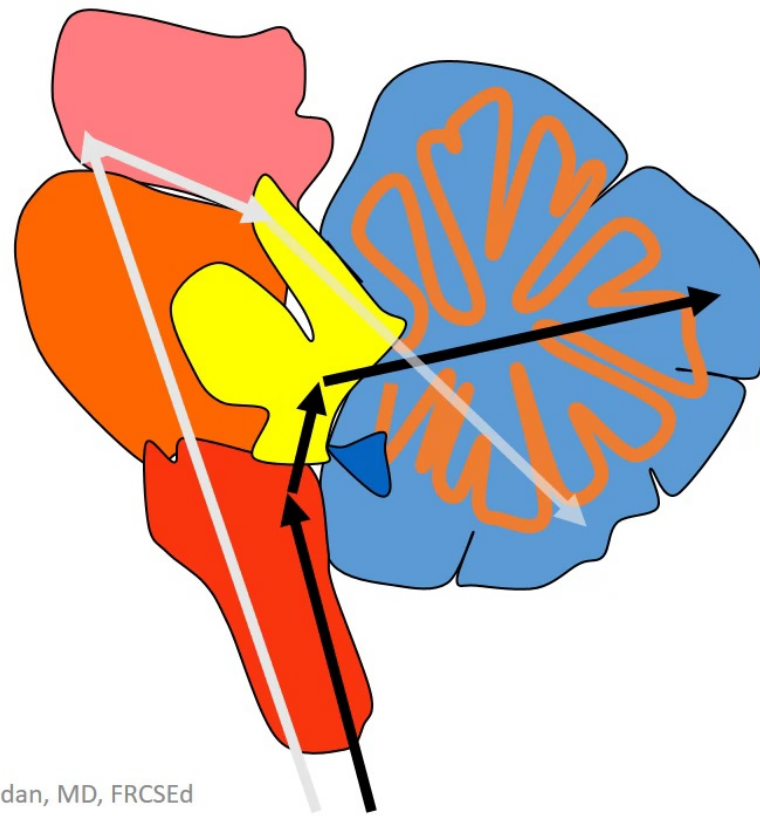
Cerebellar Afferent from the spine

- Direct pathway
 - Dorsal spinocerebellar tract
 - →
 - ICP →
 - IL spinocerebellar cortex
 - Signals from
 1. Muscle spindles
 2. Golgi tendon organs
 3. Joint receptors
 4. Tactile receptors
 - Inform cerebellum about
 1. Momentary state of position of limbs
 2. Muscle tension
 3. Rate of movement
 4. Forces on body surface



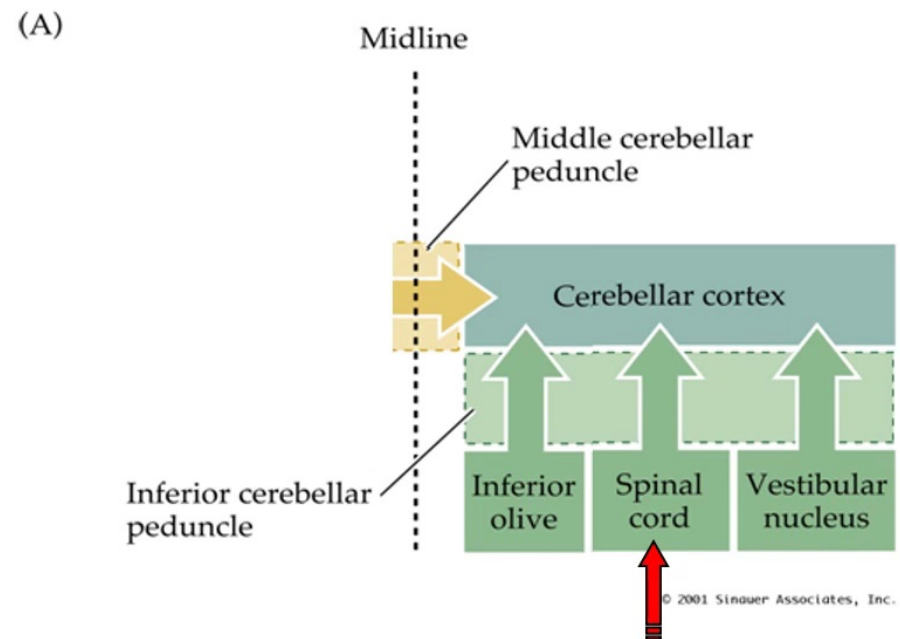
Cerebellar Afferent from the spine

- Direct pathway
 - Ventral spinocerebellar tract
 - →
 - SCP →
 - Spinocerebellar cortex of
 - Both sides
 - Transmits
 - Copy of motor signals
 - Arriving to
 - AHMC



Cerebellar Afferents

- Peripheral organs
 - Muscles →
 - Dorsal spino cerebellar T
 - → **ICP**
 - → spinal cerebellum
 - Ventral spino cerebellar T
 - → **SCP**
 - → spinal cerebellum
 - D&V external arcuate fibers
 - → **ICP**
 - → spinal cerebellum



Cerebellar Output Pathways

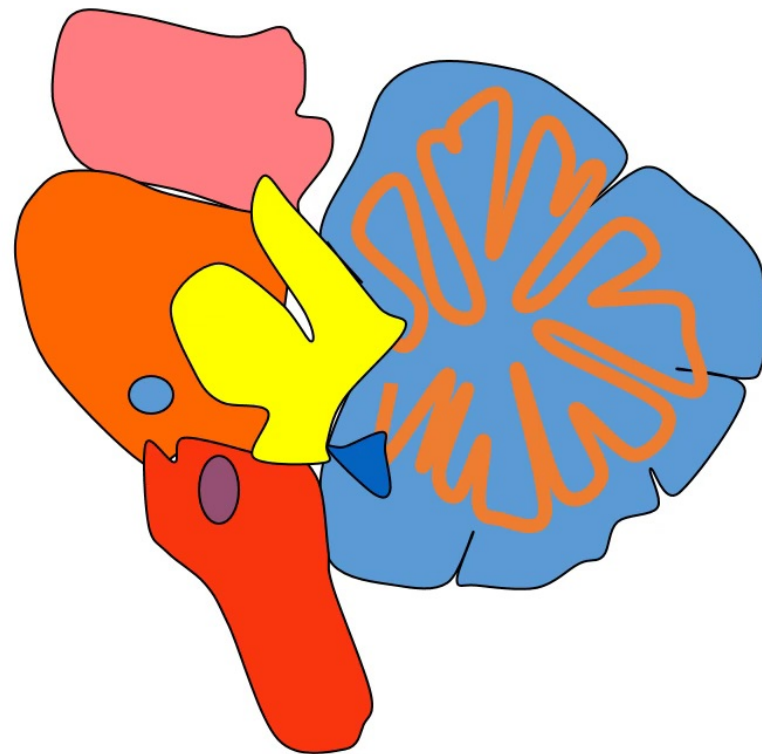
- Vestibulocerebellum

- 1) Vermis →

- Fastigial Nc →
- ICP →
- MRF & PRF →
- Reticulospinal tract

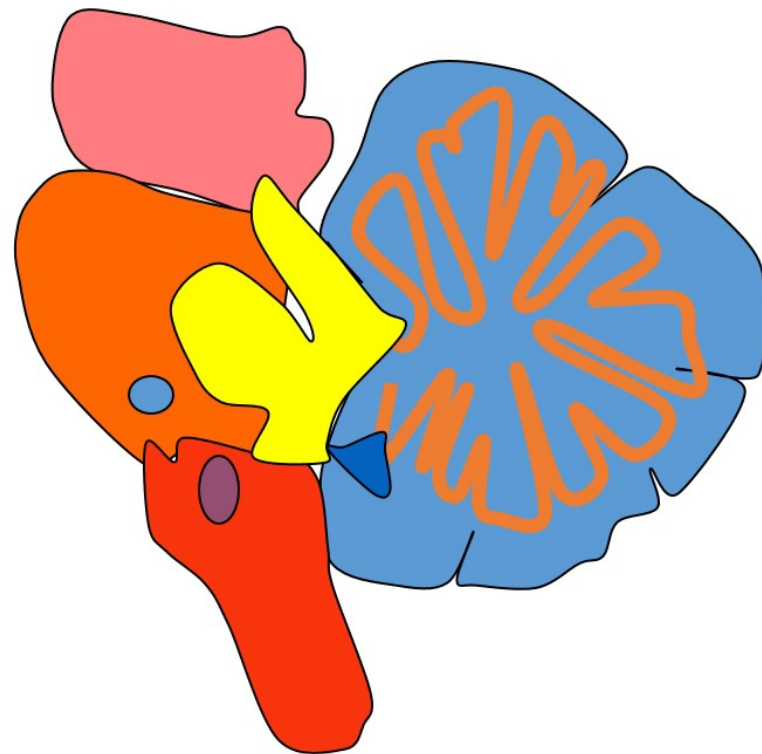
- 2) Vestibular Nc →

- Vestibulospinal tract
- Control of equilibrium
- Axial muscles
 - Shoulder & hip muscles



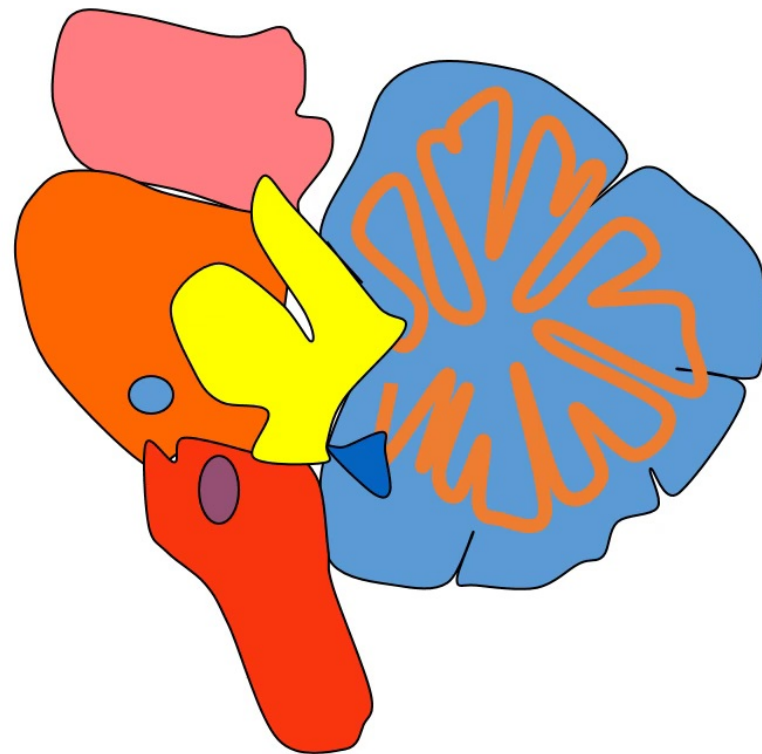
Cerebellar Output Pathways

- **Spinocerebellum**
 - **Nucleus interpositus** →
 - VLN & VAN of thalamus →
 - Motor cerebral cortex
 - **Medial thalamic nucleus** →
 - BN
 - Red nucleus &
 - RF
 - **Coordinate movements of**
 - **Limb peripheral muscles**



Cerebellar Output Pathways

- Cerebrocerebellum
 - Lateral zone of
 - Cerebellar hemisphere →
 - Dentate nucleus →
- VAN & VLN →
- Cerebral cortex
- Coordination & planning of
- Sequential movements



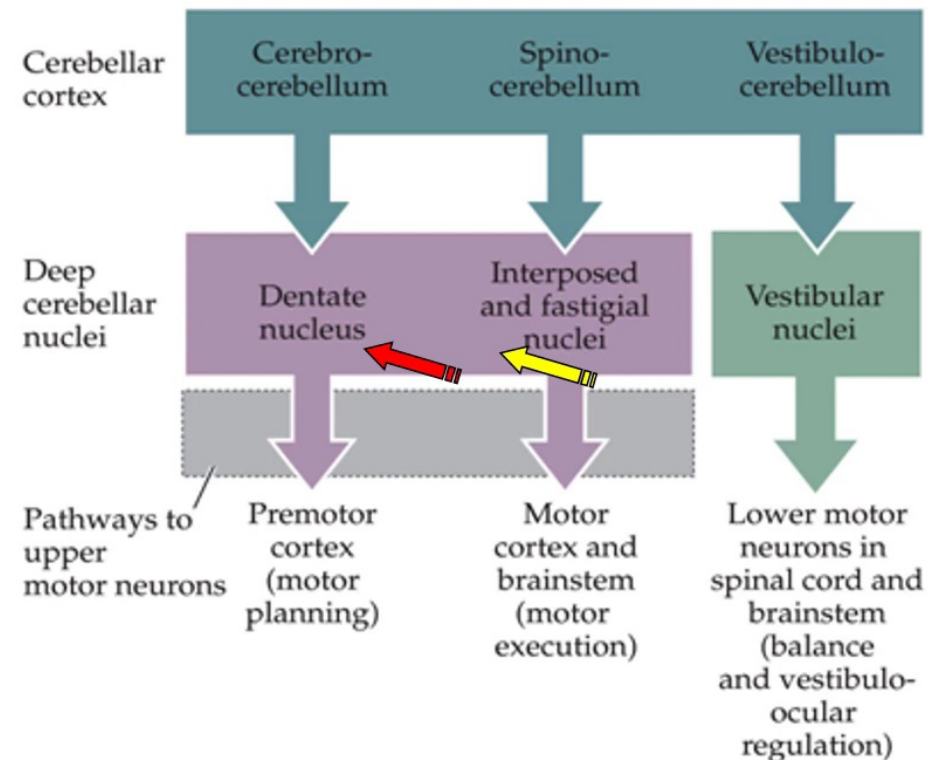
Cerebellar Efferents

Nearly all Efferents

- Leave from the
- Cerebellar nuclei

- Nuclei

1. Dentate most laterally
2. Interpositus inbetween
 1. Globose
 2. Emboliform
3. Fastigial most medially in the vermis

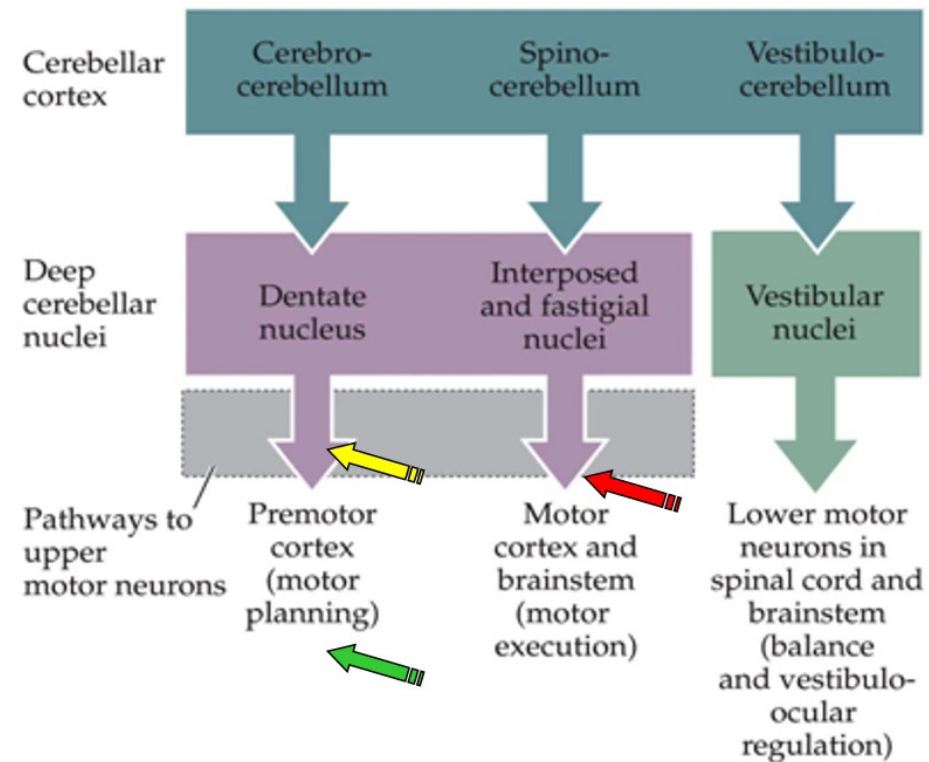


Cerebellar Efferents

- Efferents reach nuclei in

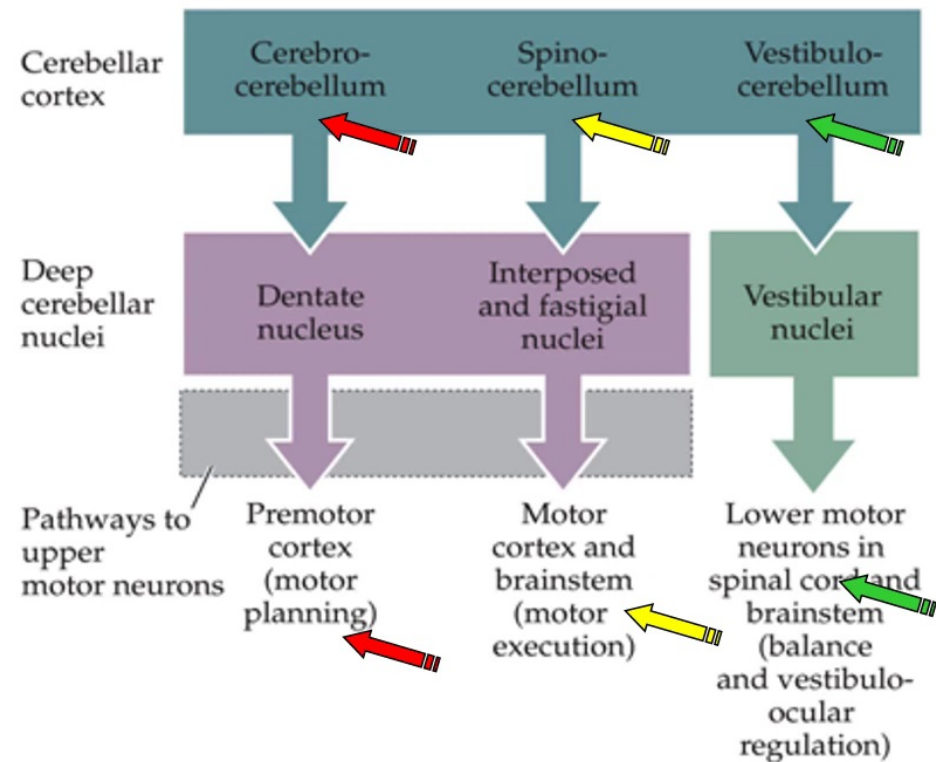
- Brain stem →
- Spinal cord →
- AHC

- Thalamus →
- Area 4, 6 & 8

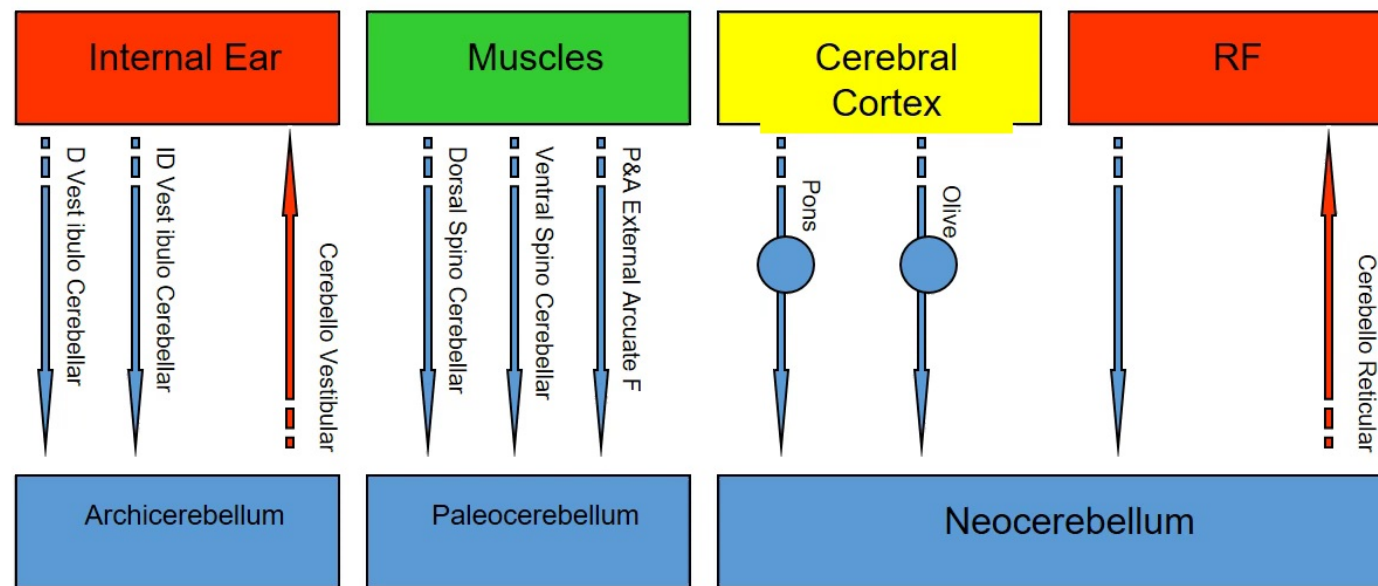


Cerebellar Efferents

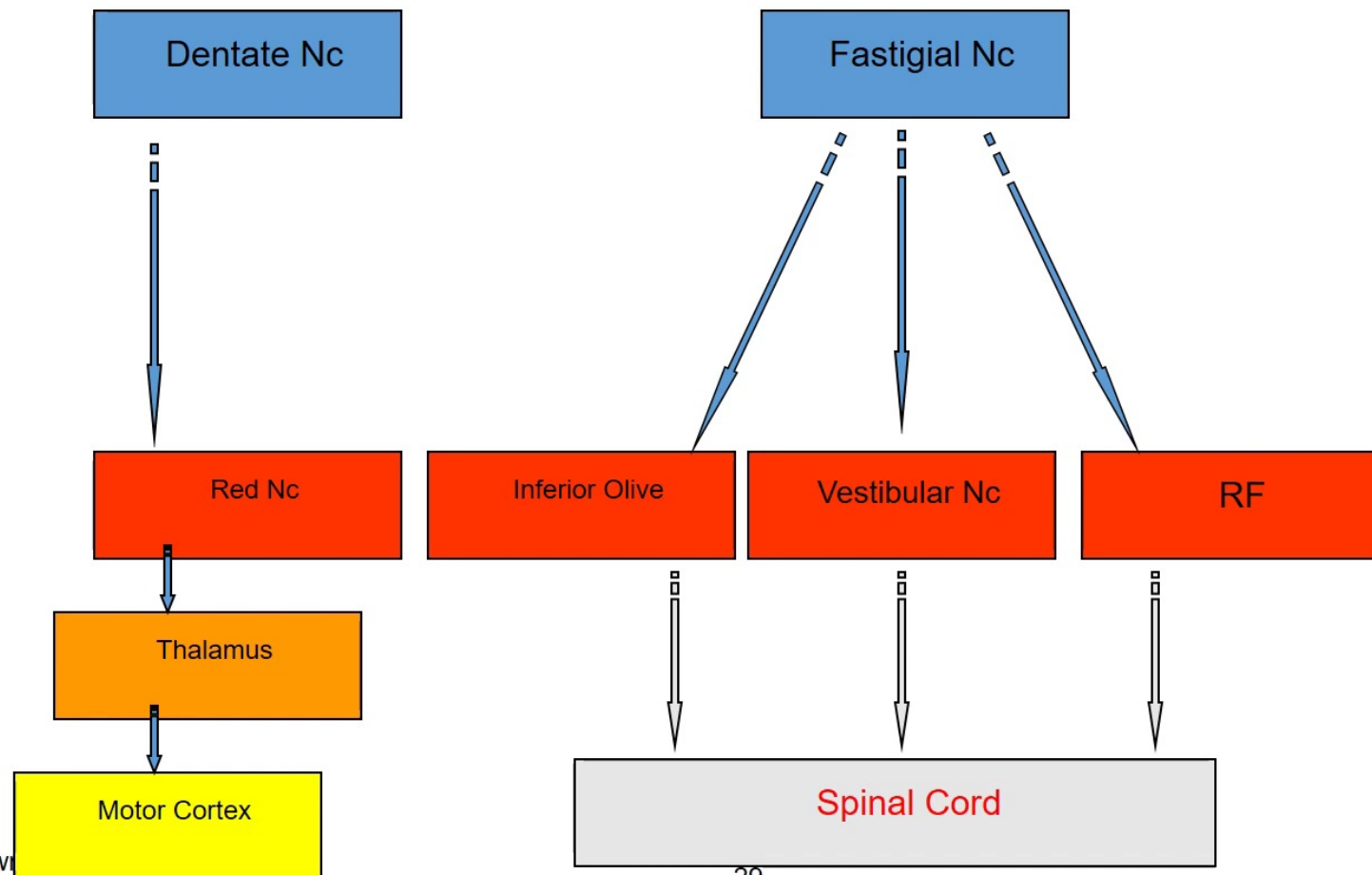
- Higherarchy
- System of
- Co-ordination



Cerebellum: Connections



Cerebellum: Efferents



Cerebellar Functions

- Cerebellum is not a sensory organ
- Cerebellum is not a motor organ
- Cerebellum is responsible for the
- Synergy of
- **MUSCLE ACTION**
 1. Coordinates the action of
Different 'muscle groups'
 2. Times the contraction properly



Cerebellar Functions

- Cerebellum is not a sensory organ
- Cerebellum is not a motor organ
- Cerebellum is responsible for the
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- **MUSCLE ACTION**
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Different 'muscle groups'
 2. Times the contraction properly



Cerebellar Control of Movement

1. Posture & equilibrium
2. Stretch reflex
3. Voluntary movement



Cerebellar Control of Movement

- Posture & equilibrium
 - Rapid motion → vestibular system
 - → Flocculonodular lobe + vermis
 - → BS
 - → reticulospinal & vestibulospinal T
 - → change of Tone of axial & girdle muscles
 - Damage → widebase staggering gate



Cerebellar Control of Movement

- Stretch reflex
 - Neocerebellum facilitates SR
 - Paleocerebellum inhibits SR



Cerebellar Control of Movement

- Voluntary movement
 - Servocomparator function
 - Prevent overshoot &
 - Damping function
 - Sequence &
 - Timing of movement



Cerebellar Servocomparator Function

1. Motor corex

1. Cortico ponto cerebellar tract &

2. Red nucleus



- sequential intended plan of movement

2. Periphery

- Spinocerebellar tracts



- Performance of movement

3. Spinocerebellum

- compares movement with plan



Cerebellar Servocomparator Function

4. Nucleus interpositus →

- corrective signals →

1. Thalamus →

1. Motor cortex →
2. Corticospinal tract

2. Red nucleus magnocellular portion →

1. Rubrospinal tract

- →

5. lateral AHMN →

- Distal muscles



Cerebellar Servocomparator Function

6. Cerebellum

1. Onset →

1. Turn on agonists
2. Inhibits antagonists

2. End →

1. Turn off agonists
2. Turn on antagonists



Clinical Cerebellar Abnormality

- Mainly due to damage of the deep nuclei
- Affects IL side
- 1. Hypotonia
 - 1. Flacid muscles
 - 2. Pendular tendon jerks
- 2. Asthenia
 - Difficulty in maintaining muscle contraction
- 3. Ataxia



Clinical Cerebellar Abnormality

- Ataxia
 - Incoordination of movement
 1. Rate
 2. Range
 3. Force
 4. Direction
 - Manifestation
 1. Dysmetria
 2. Intention kinetic tremors
 3. Rebound phenomenon
 4. Adiadokokinesia
 5. Decomposed movement
 6. Dysarthria
 7. Nystagmus
 8. Staggering gate



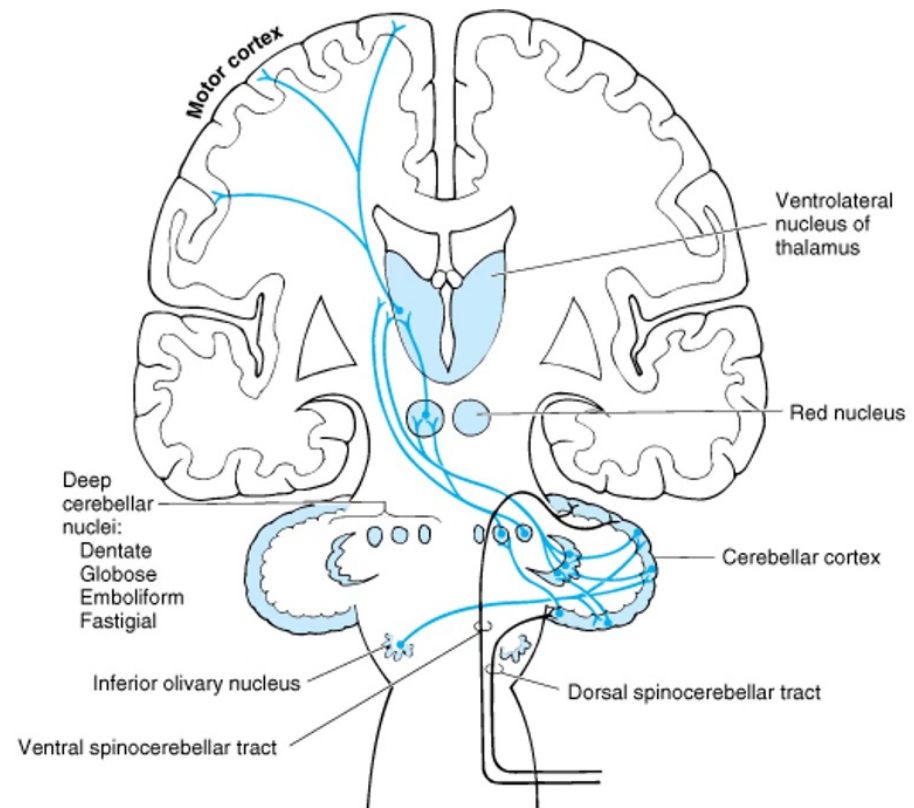
Cerebellar functions

1) Coordinating

- skilled
- voluntary movements by
 - influencing muscle activity

2) Controlling

- Equilibrium and
- Muscle tone through
 - Connections with the
 1. vestibular system and
 2. the spinal cord and
 3. its gamma motor neurons

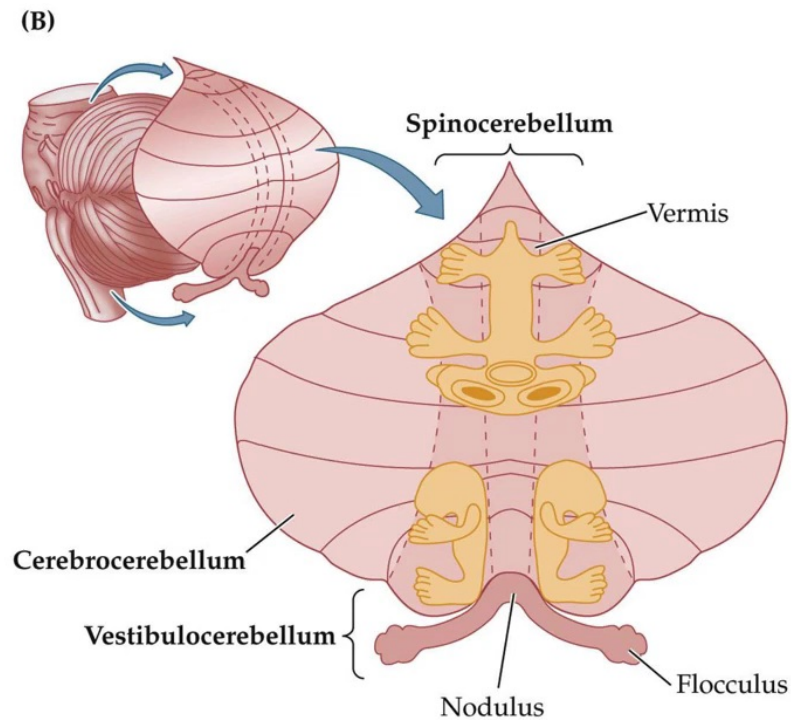


Cerebellar functions

There is a

- Somatotopic organization of
- Body parts within the
- Cerebellar cortex

- The cerebellum receives
- collateral input from the
 - Sensory and
 - Special sensory systems



Principles of Cognitive Neuroscience, Figure 9.13 (Part 2)

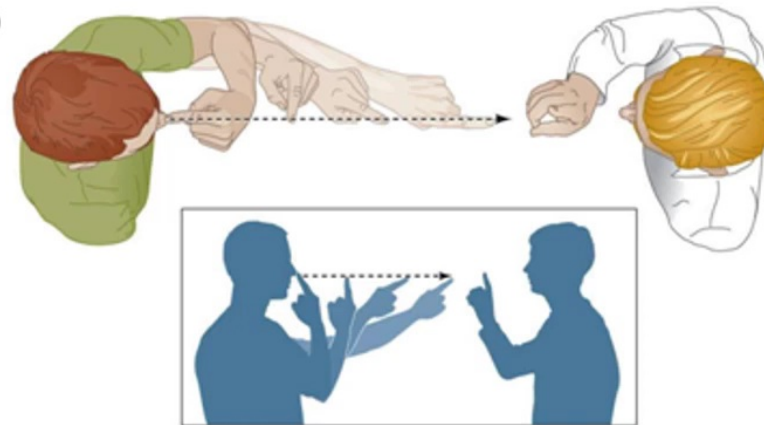
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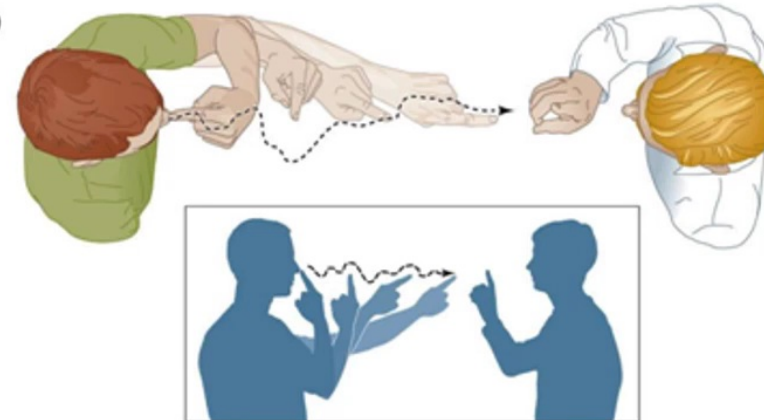
Cerebellar Disease

- Ipsilateral
- Ataxia
 - Disturbance of posture & gait
 - Vermis
 - Not corrected by vision
 - Drunken gait
 - Hemisphere
 - Tends to fall to same side
 - Decomposition of movement
 - Dysmetria
 - Dysdiadocokinesia
 - Scanning speech
- Hypotonia
- Pendular knee jerk
- Asthenia
- Intension tremors
- Nystagmus

(A)



(B)



Thanks

