Cerebellum

John H. Martin, Ph.D.
Center for Neurobiology & Behavior
Columbia University

Cerebellar Signs

Hypometria & Response delays

Ataxia

Incoordination/ rapid alternating movements (disdiadocho-kinesia)

PNS Fig. 42-16

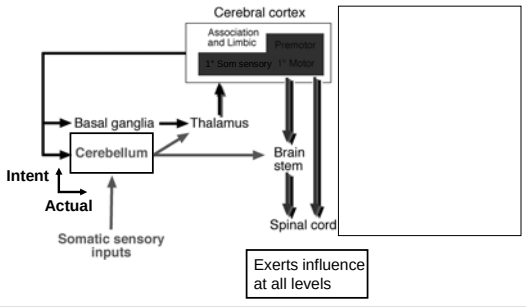
Research Points to Several Key Cerebellar Functions

- Comparison of intent and action (ie., errors) and generates corrective signals
- Motor learning and adaptation
- Plays a role in automating and optimizing behavior
- Motor cognition and general cognition & emotions (new evidence; controversial)

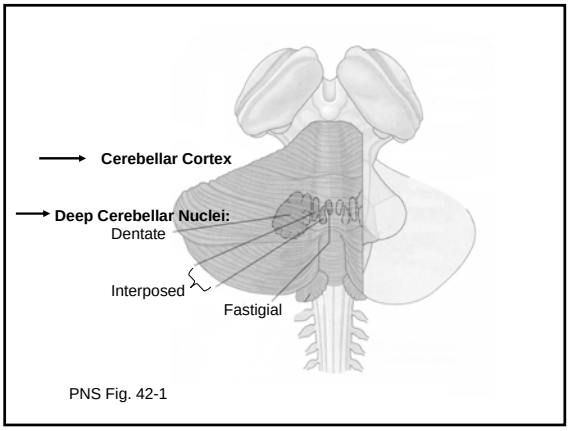
Goal: Cerebellar function

- Overview of motor system hierarchy
- Cerebellar anatomy
- Principal pathways out of the cerebellum-- *How the cerebellum impacts the motor pathways*
- Experimental approaches to reveal:
  - Motor learning
  - Mental processes underlying movement control
  - Role in cognition and emotions

Motor Hierarchy

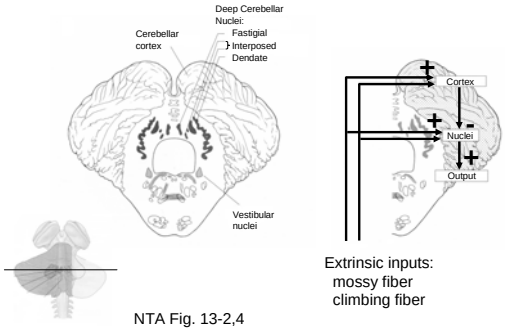


Cerebellar Functional Anatomy



PNS Fig. 42-1

Input-output Organization



Extrinsic inputs:
mossy fiber
climbing fiber

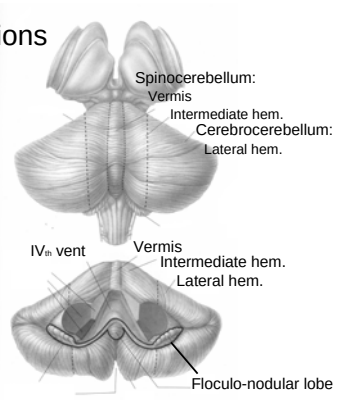
NTA Fig. 13-2,4

Cerebellar divisions

Spinocerebellum
(Vermis + Intermed. Hem)
Control of limbs
and trunk

Cerebrocerebellum
(Lateral hemisphere)
Planning of movement+

Vestibulo-cerebellum
(Floculo-nodular lobe)
Control of eye & head movements
Balance



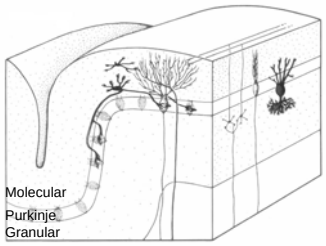
NTA Fig. 13-1

Cerebellar Cortex

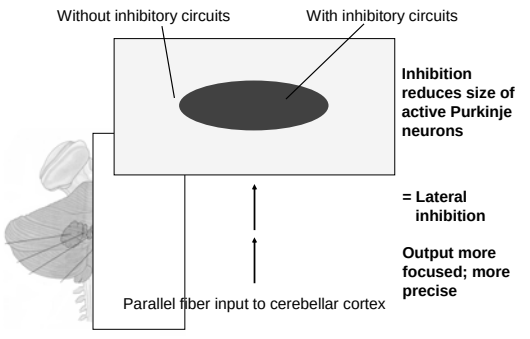
Inputs
Climbing fibers
•from Inferior olive
Mossy fibers

Output
Purkinje neurons

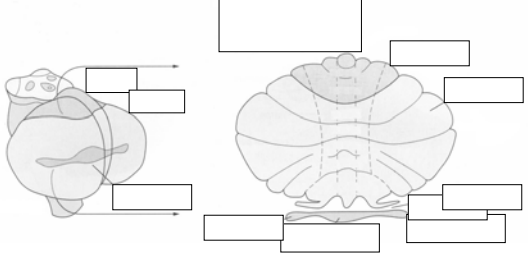
Interneurons
Granule neurons
Stellate neurons
Basket neurons
Golgi neurons



NTA Fig. 13-11

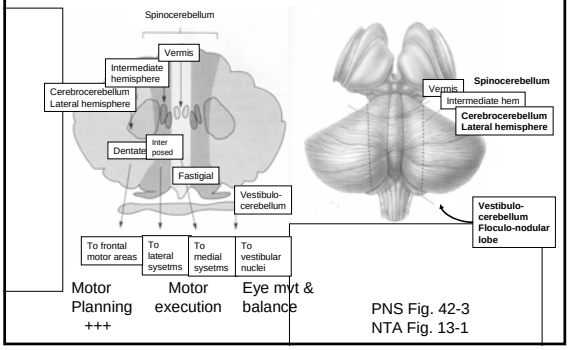


Functional divisions of ~~cerebellar cortex~~ --> Deep nuclei



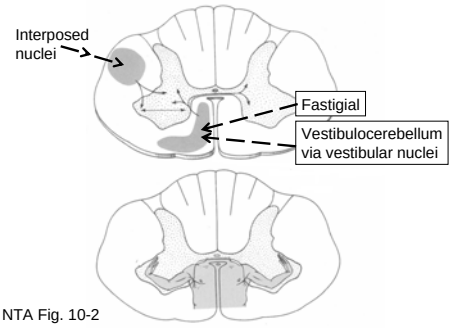
PNS Fig. 42-2

Functional divisions of cerebellar cortex --> Deep nuclei

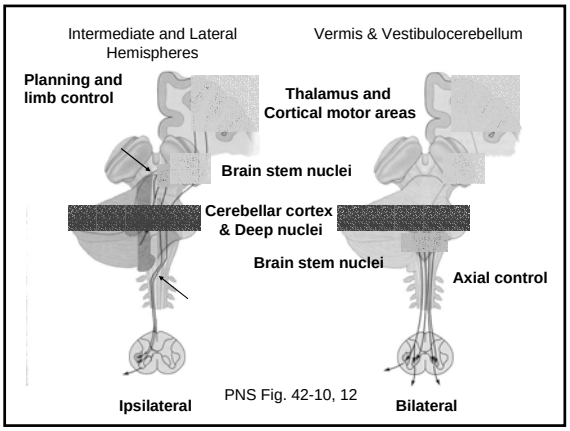


PNS Fig. 42-3
NTA Fig. 13-1

Medial & lateral systems



NTA Fig. 10-2

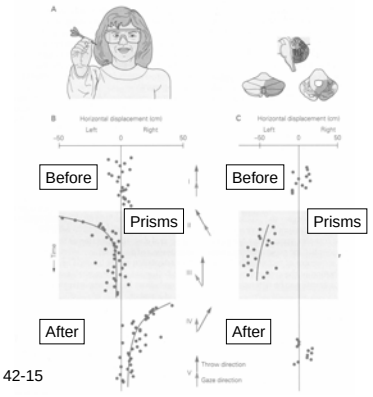


PNS Fig. 42-10, 12

Functions of the Cerebellum

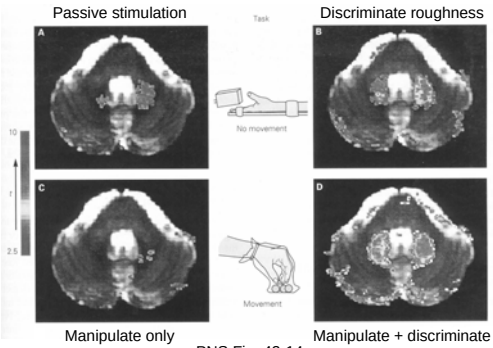
- Motor learning/adaptation
- Non-motor functions:
  - Active tactile exploration
  - Higher brain functions (cerebellar cognitive-affective syndrome)

Motor Learning



PNS Fig. 42-15

Non-motor Function



PNS Fig. 42-14

Cerebellar Motor Functions

- Implemented via lateral and medial pathways, especially the corticospinal tract
- Incorporated into motor programs via frontal motor areas (SMA, premotor cortex…)
- Becomes part of motor strategy via prefrontal cortex

Cerebellar Cognitive Affective Disorder

- Lesions of the posterior cortex and vermis
- Impairment of executive functions
  - Planning, verbal fluency, abstract reasoning
- Difficulties with spatial cognition
  - Visuo-spatial organization, visual memory
- Personality changes
  - Blunting of affect, inappropriate behaviors
- Language disorders
  - Agrammatism

Conclusions

- Cerebellar lesions produce
  - Incoordination & errors not weakness
  - Lose ability to anticipate errors
  - Lose ability to correct
- Motor learning
  - Requires sensory awareness
  - Implemented via the descending cortical and brain stem pathways
- Cognitive and emotional disturbances
  - Anatomical connections to prefrontal and cingulate cortex (via thalamus)
- No single function
  - Clearly mostly motor; learning, optimizes
  - Functions may apply to cognitive and emotional behaviors