MEDICINE
KING SAUD UNIVERSITY

تمت المراجعة
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Physiology Team 436

CNS PHYSIOLOGY

- Text
- Important
- Formulas
- Numbers
- Doctor notes
- Notes and explanation

Lecture No.17

"Keep Moving Forward"

| We recommended you to read this lecture from neuroanatomy book. You can find the book on the team drive, page 117-123

Cerebellum (CB)

Objectives:

1. Describe the functional divisions of the cerebellum; vestibulocerebellum, spinocerebellum and cerebrocerebellum.
2. Understand cell types / nuclei of the cerebellum.
3. Understand the functions of cerebellum in regulation of movement, tone and balance.
4. Define the physiological roles of the cerebellum in regulation of movement.
5. Understand and Explain the abnormalities associated with cerebellar disease: Cerebellar nystagmus, changes in muscle tone, ataxia, drunken gait, scanning speech, dysmetria (past-pointing), intention tremors, rebound phenomenon and adiadochokinesia.

Cerebellum (CB)

1. Cerebellum is a highly folded part of the brain, lies underneath the occipital lobe of the cortex.
2. Occupies a prominent position beside the main sensory and motor systems in the brain stem.
3. It is connected or attached to the brain stem on each side by **three cerebellar peduncles**: (1)**superior**, (2)**middle** and (3) **inferior**.
4. It consists of two connected hemispheres (cerebellar hemispheres connected by vermis).
5. Each hemisphere controls the same side (ipsilateral) of the body (unlike the cerebral cortex).
6. Various fibers inter and leave the cerebellum through these peduncles.

ONLY IN MALES' SLIDES

1. Cerebellum is derived from a Latin word means "little brain." Cerebellum is the largest part of the hind brain, lies behind the pons and medulla Oblongata.
2. Shape: Oval shaped, with an approximate weight is 150 gm.
3. Location: Situated in the posterior cranial fossa.
4. Anteriorly: 4th ventricle, pons, and medulla oblongata.
5. Superiorily: Covered by tentorium cerebelli.
6. Posterio-inferiorly: Squamous occipital.

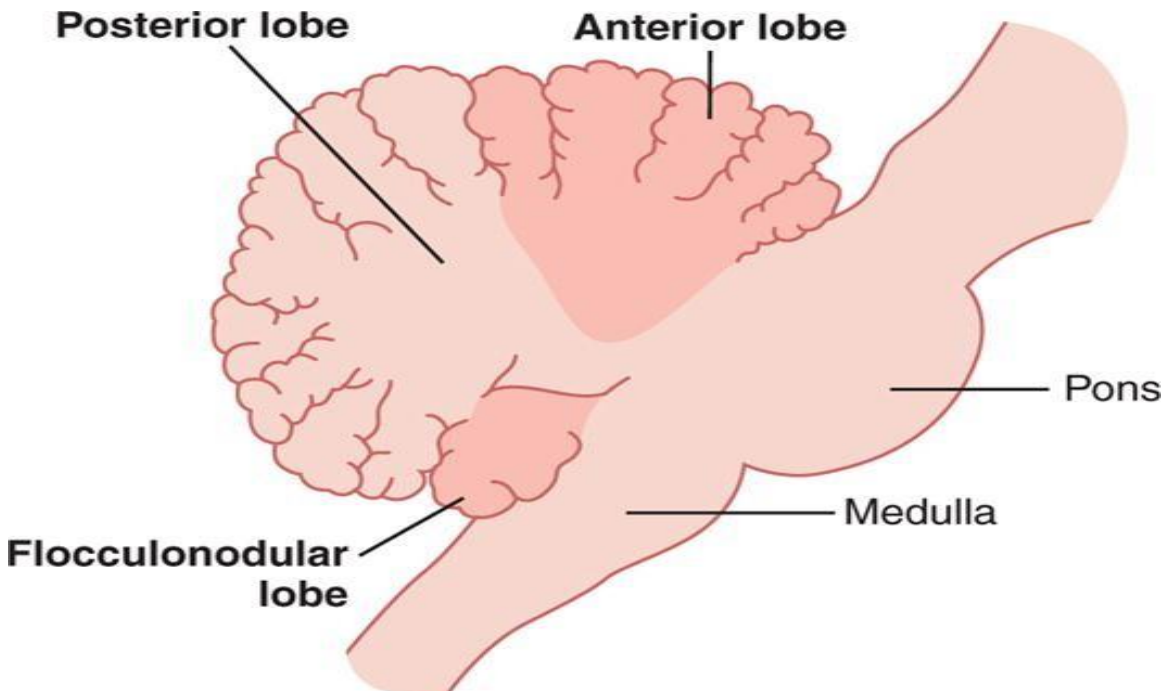
Cerebellum: the rule of 3

3 lobes	• Floculonodular lobe • Anterior lobe • Posterior lobe
3 cortical layers	• Molecular layer • Purkinje cell layer • Granular layer
3 purkinje's cells afferent paths	• Mossy fibers • Climbing fibers • Aminergic fibers
3 pairs of deep nuclei	• Fastigial • Interposed(globose & emboliform) • Dentate
3 pairs of peduncles	• Superior (pri.Output) • Middle (pri.Input) • Inferior (pri.Input)
3 functional division	• Vestibulocerebellum • Spinocerebellum • Cerebrocerebellum

Anatomical lobes of CB

- Anatomically, the CB is divided into 3 lobes:

1. The anterior lobe.
2. The posterior lobe.
3. The flocculo-nodular lobe.



- The anterior and posterior lobes are separated by the primary fissure.
- The posterior and flocculondular lobes are separated by the posterior fissure.

Anatomical & functional divisions of the CB

The anterior & posterior lobes on each side constitute 2 **large cerebellar hemispheres,** which are separated by a narrow band called the **vermis.**

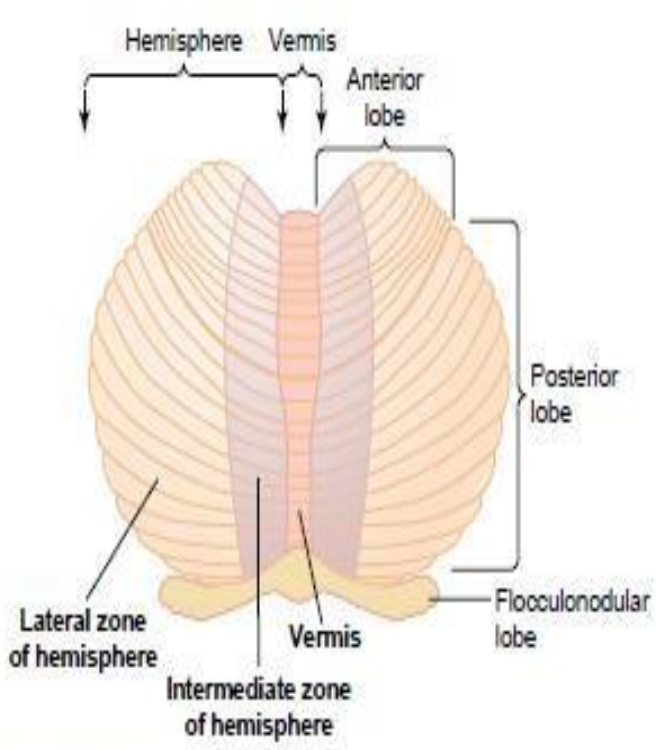


Figure 56–2

Functional parts of the cerebellum as seen from the posteroinferior view, with the inferiormost portion of the cerebellum rolled outward to flatten the surface.

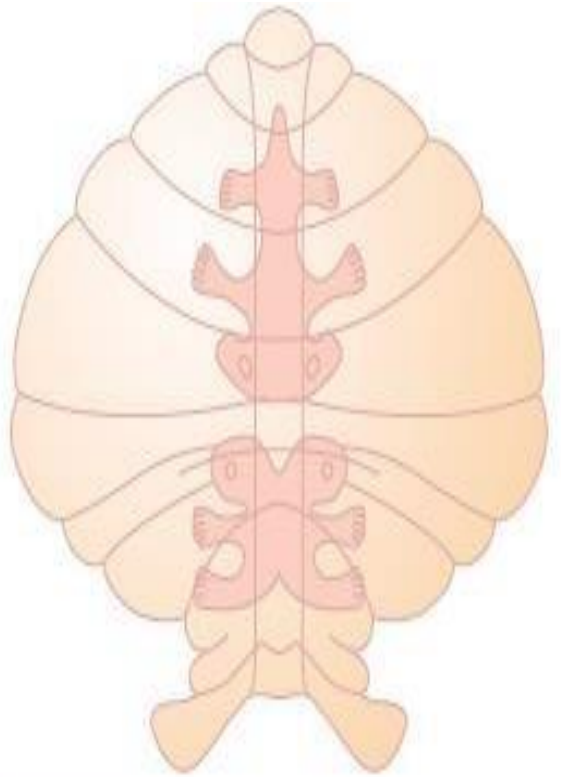
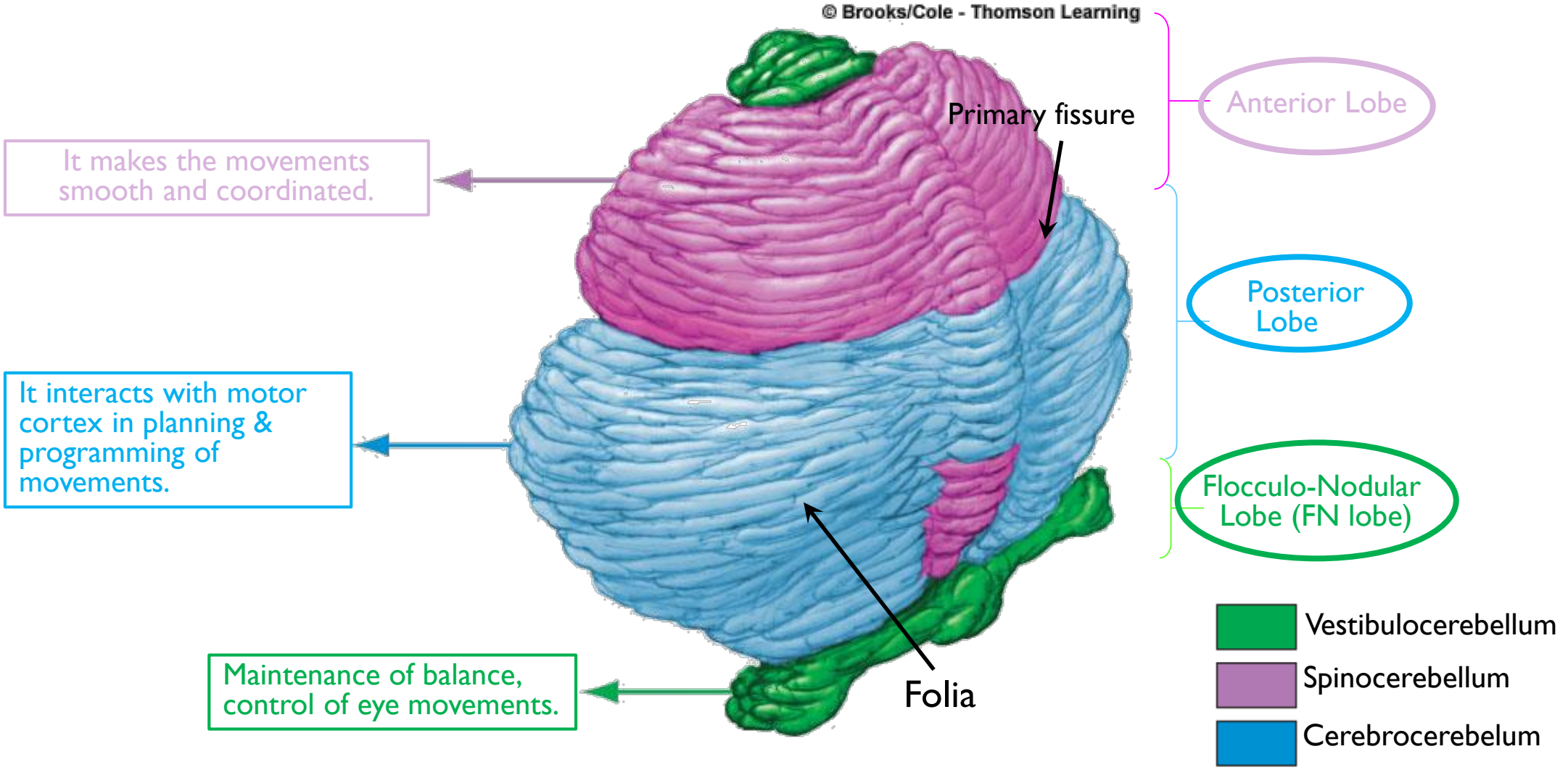


Figure 56–3

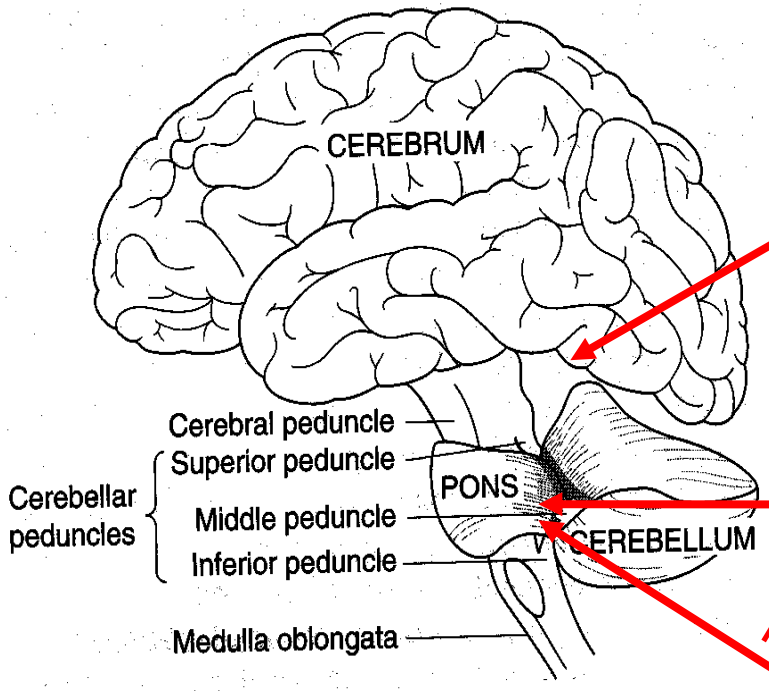
Somatosensory projection areas in the cerebellar cortex.

Cont.


© Brooks/Cole - Thomson Learning
Primary fissure
Folia
It makes the movements smooth and coordinated.
It interacts with motor cortex in planning & programming of movements.
Maintenance of balance, control of eye movements.
Anterior Lobe
Posterior Lobe
Flocculo-Nodular Lobe (FN lobe)
Vestibulocerebellum
Spinocerebellum
Cerebrocerebelum

Cerebellar peduncles

- Cerebellar peduncles: carry afferents from where?



Superior Cerebellar Peduncle

Inputs to the Cerebellum from the cerebrum

Middle Cerebellar Peduncle

Inputs to the Cerebellum from from the Pons

Inferior Cerebellar Peduncle

Inputs to the Cerebellum from the Medulla Oblongata

Principal afferent tracts to the cerebellum

Afferent tracts	Transmits
Vestibulocerebellar	Vestibular impulses from labyrinths, direct & via vestibular nuclei.
Dorsal Spinocerebellar	Prorioceptive & exteroceptive impulses from the body.
Ventral Spinocerebellar	Prorioceptive & exteroceptive impulses from the body.
Cuneocerebellar	Prorioceptive impulses, especially from the head and neck.
Tectocerebellar	Auditory & visual impulses via inferior and superior colliculi.
Pontocerebellar	Impulses from motor and other parts of cerebral cortex via pontine nuclei.
Olivocerebellar	Proprioceptive input from whole body via relay in inferior olive.

Cerebellum layers

- The cerebellum has an external cerebellar cortex separated by white matter from the deep cerebellar nuclei as follows:

Cerebellar Cortex	Cerebellar Nuclei
• Molecular Layer • Purkinje Cell Layer • Granular Layer • Purkinje cells • Basket cells • Golgi cells • Stellate cells GABA…Inhabit	• Dentate Nucleus • Globose Nucleus • Emboliform Nucleus • Fastigial Nuclei • Granular cells → Glutamate…Exci • Stellate • Globose and Emboliform also known as interpositus nucleus.

Functional divisions of the cerebellum

Functionally speaking , the Cerebellum is divided into 3 parts: Neocerebellum , Spinocerebellum & Vestibulocerebellum.

CerebellumLobe	Nuclei	Cortex	Inputs	Outputs	Function
Paleocerebellum	Interposed, Fastigial	Vermis & Medial portions of Cerebellar hemispheres	Spinal and brainstem paths	SCP to Red Nucleus, Fastigial to RF	Muscle tone, posture & coordination of movements
Neo- cerebellum	Dentate	Lateral portions of Cerebellar Hemisphere	Corticopontine, pontocerebellar	SCP	Planning and executive of voluntary & skilledhand movements
Archi cerebellum	Fastigial	Flocculonodular	Vestibular nuclei	Vestibular nuclei, RF	Balance, equilibrium

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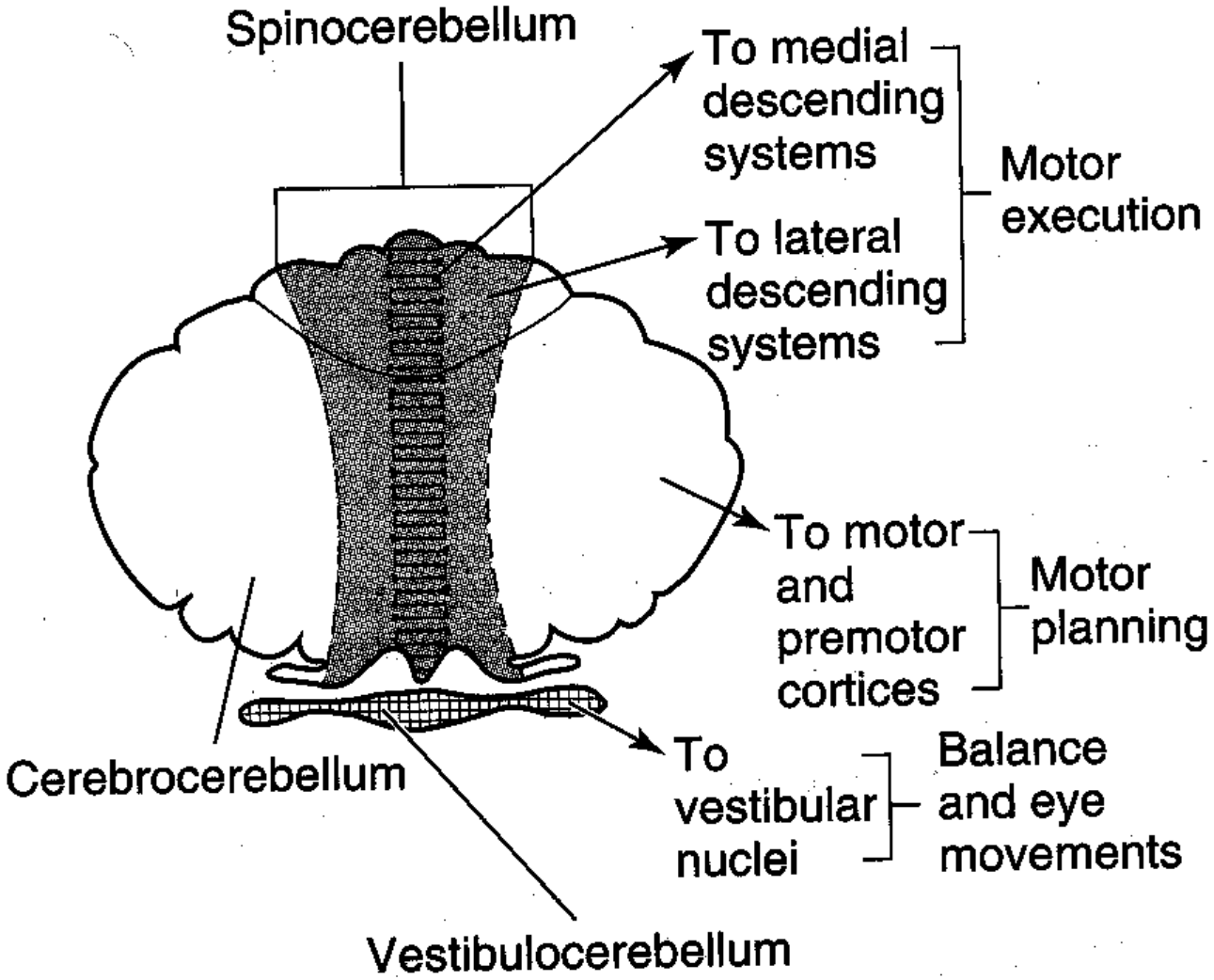

Spinocerebellum
To medial descending systems
To lateral descending systems
Motor execution
To motor and premotor cortices
Motor planning
To vestibular nuclei
Balance and eye movements
Cerebrocerebellum
Vestibulocerebellum

Cont.

Flocconudoular for equilibrium & vestibular connections

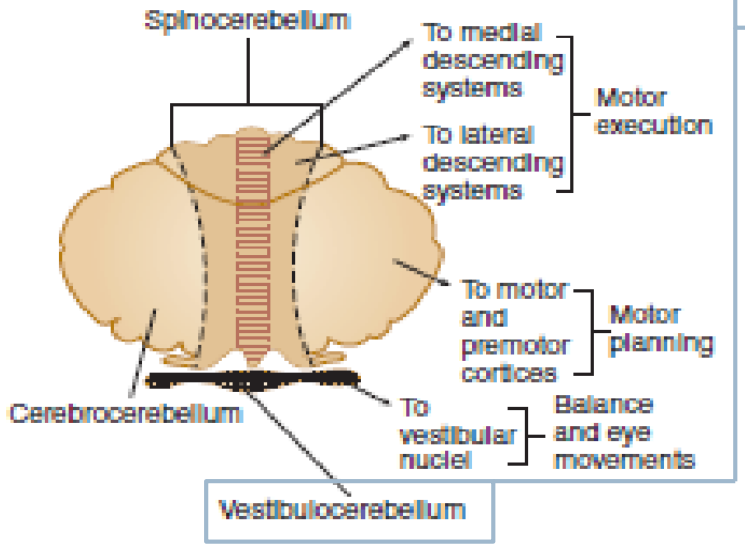
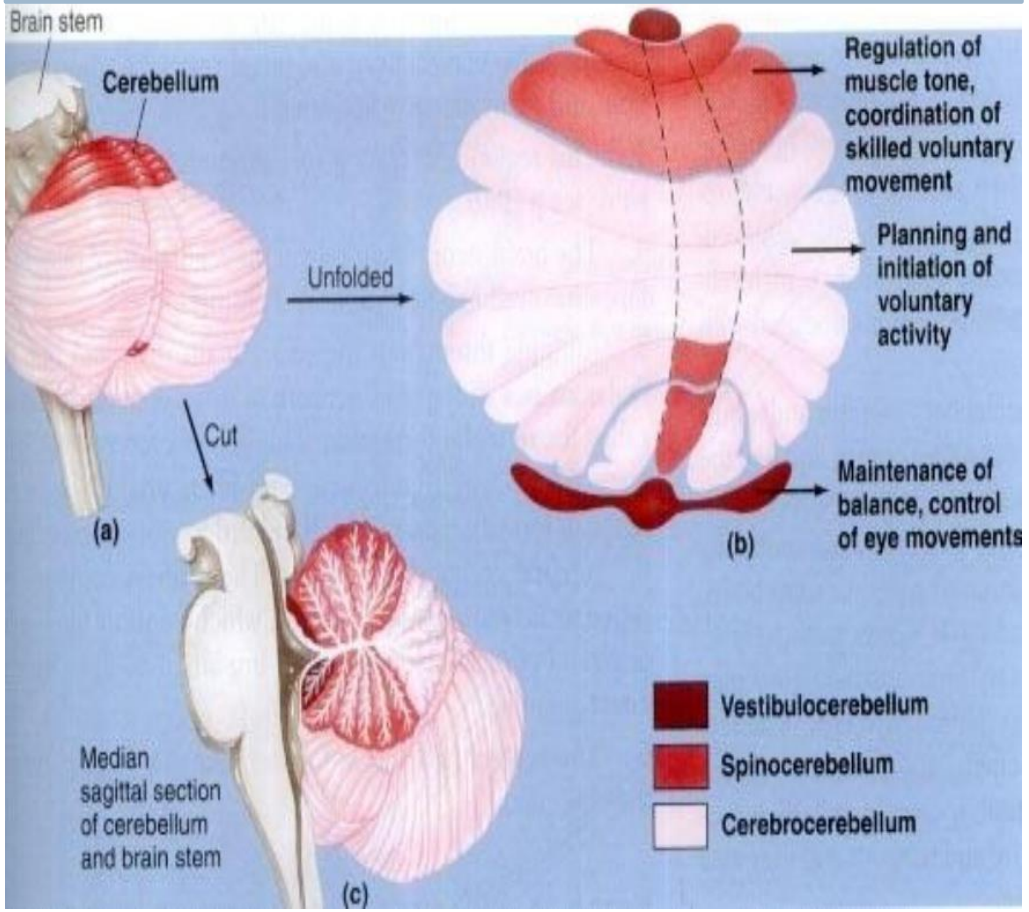


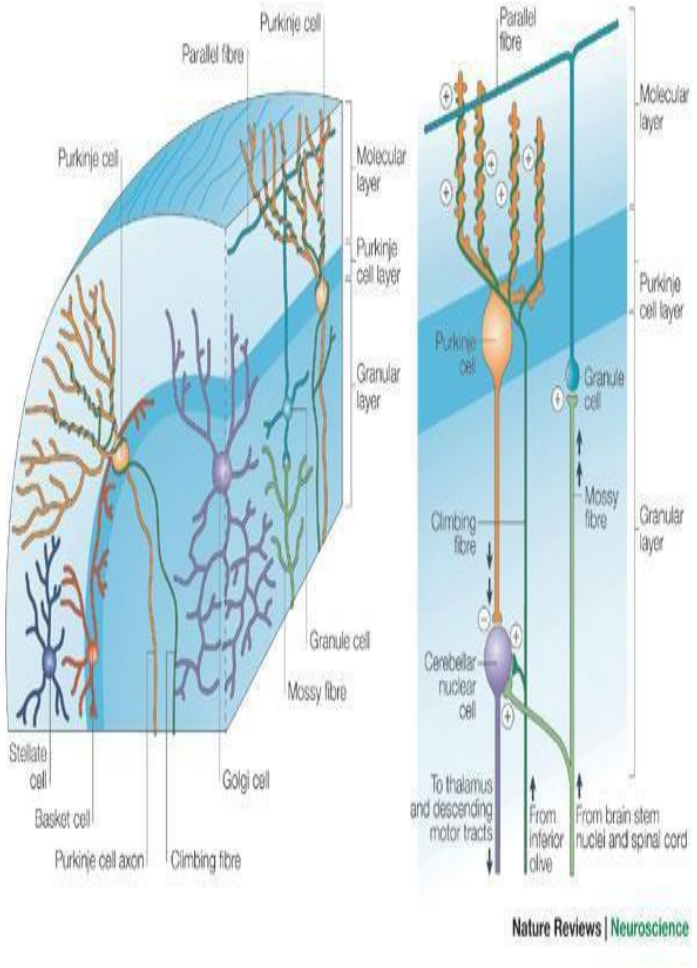
FIGURE 12–19 **Three functional divisions of the cerebellum.** The nodulus in the vermis and the flanking flocculus in the hemisphere on each side form the vestibulocerebellum which has vestibular connections and is concerned with equilibrium and eye movements. The rest of the vermis and the adjacent medial portions of the hemispheres form the spinocerebellum, the region that receives proprioceptive input from the body as well as a copy of the "motor plan" from the motor cortex. The lateral portions of the cerebellar hemispheres are called the cerebrocerebellum which interacts with the motor cortex in planning and programming movements. (Modified with permission from Kandel ER, Schwartz JH, Jessell TM (eds): Principles of Neural Science, 4th ed. New York, NY: McGraw-Hill; 2000.)

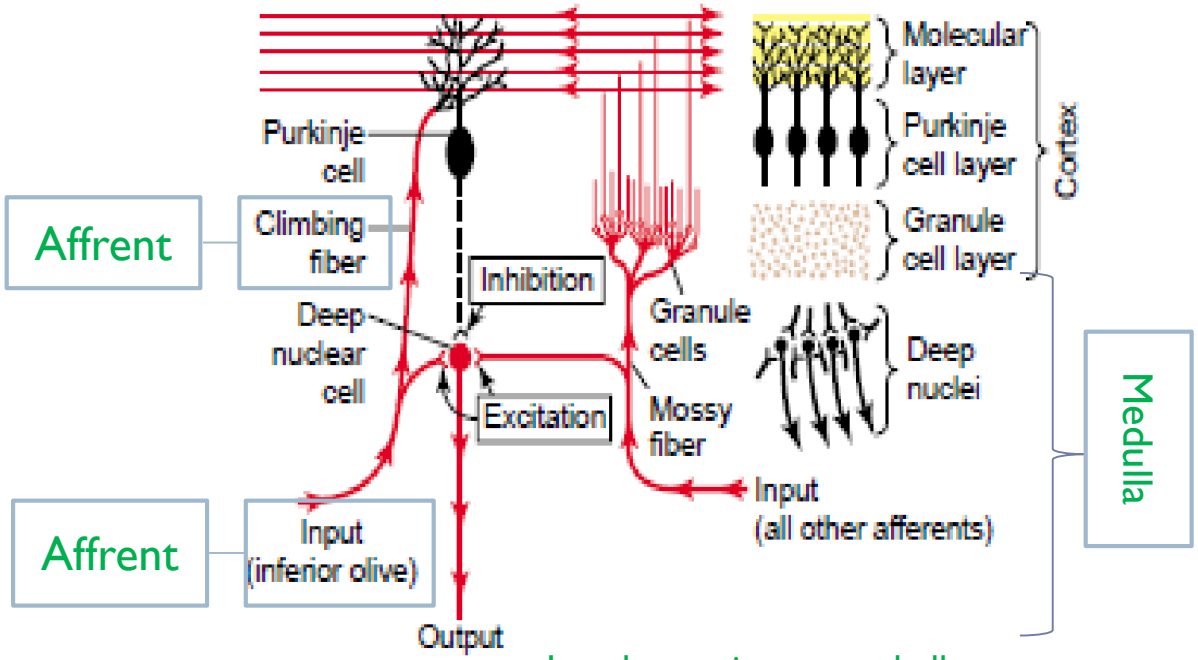
Cerebro-cerebellum (connections with cerebrum) they act together to establish movements and planning.



Structure & connections of cerebellum

1. Purkinje cell.
2. Granule cell.
3. Basket cell.
4. Golgi cell.
5. Stellate cell.
6. Climbing fiber.
7. Mossy fiber.
8. Parallel fiber.
9. Inferior olivary nucleus.
10. Deep cerebellar nuclei.





Impulses arrive to cerebellar cortex & leave it from deep nucli

Figure 56–7

The left side of this figure shows the basic neuronal circuit of the cerebellum, with excitatory neurons shown in red and the Purkinje cell (an inhibitory neuron) shown in black. To the right is shown the physical relationship of the deep cerebellar nuclei to the cerebellar cortex with its three layers.

Cont.

This slide is very important

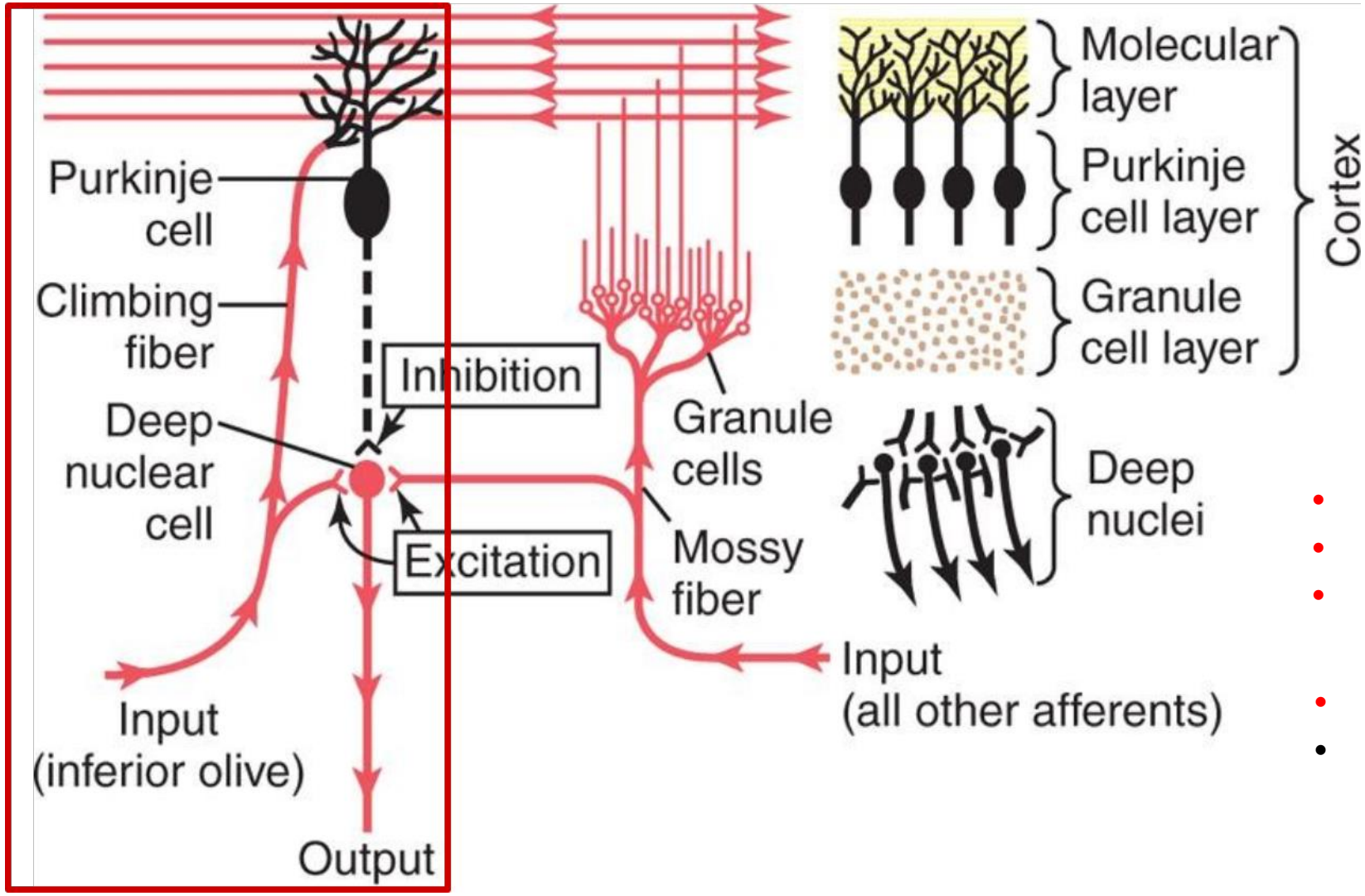
- The CB has an external layer of gray matter(cerebellar cortex), and an inner white matter.
- The cortex is deeply infolded, giving a large surface area, and it contains five different cell types:

1. Golgi, basket, stellate which are inhibitory interneurons (The over all output 3 inhibit + 1 excites).
2. The granule cells, which are excitatory.
3. The purkinje cells which are the output cells, inhibit the deep nuclear cells (DNCs).
4. The inhibitory neurons in the CB release GABA (ex: stellate, basket, Golgi, Purkinji cells).
5. The excitatory neurons release glutamate (ex: granule cells, that also has GABA A receptors) To be inhibited by GABA neurotransmitter.

You **have** to know which cell is excitatory or inhibitory and what neurotransmitters they release.

Functional unit of the cerebellar cortex-the purkinje cell and the deep nuclear cell

Functional unit



- Cerebral cortex
- Brainstem
- Spinal cord

- Red= excitatory
- Black =inhibitory

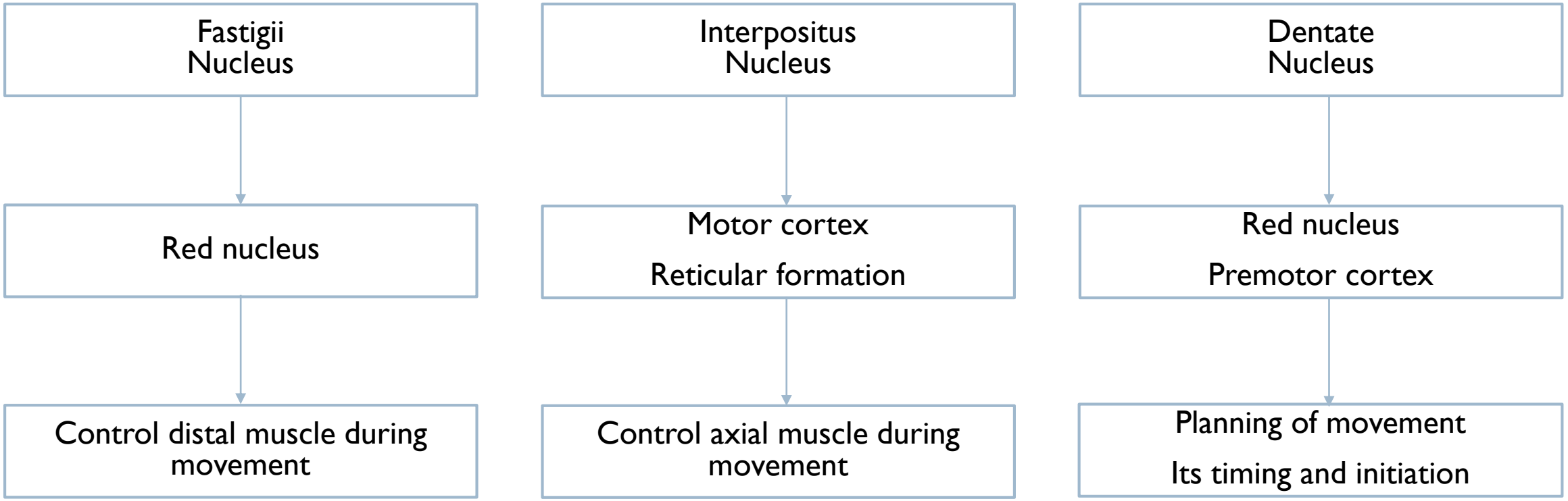
Cont.

- The white matter contains 3 deep nuclei:

1. Dentate.
2. Fastigial.
3. Interpositous (formed of globose & emboliform nuclei). emboliform nuclei = 2 united nucli

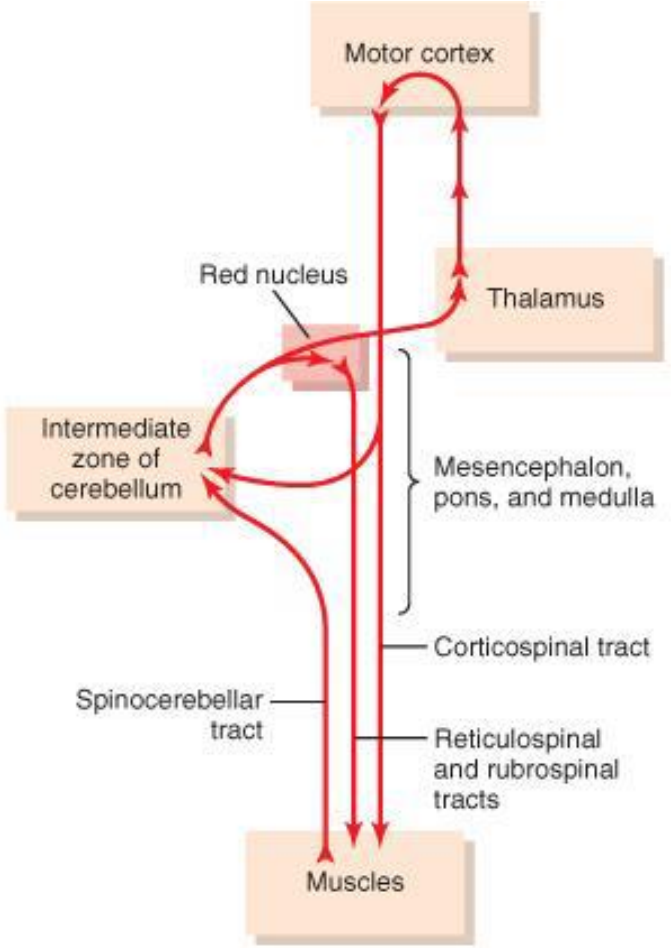
- All afferent fibers relay first at the deep nuclei and the cerebellar cortex, then the latter discharges to the deep nuclei, from which the efferent fibers originate and leave the CB.

Output from deep nuclei



Cerebellum and voluntary motor control

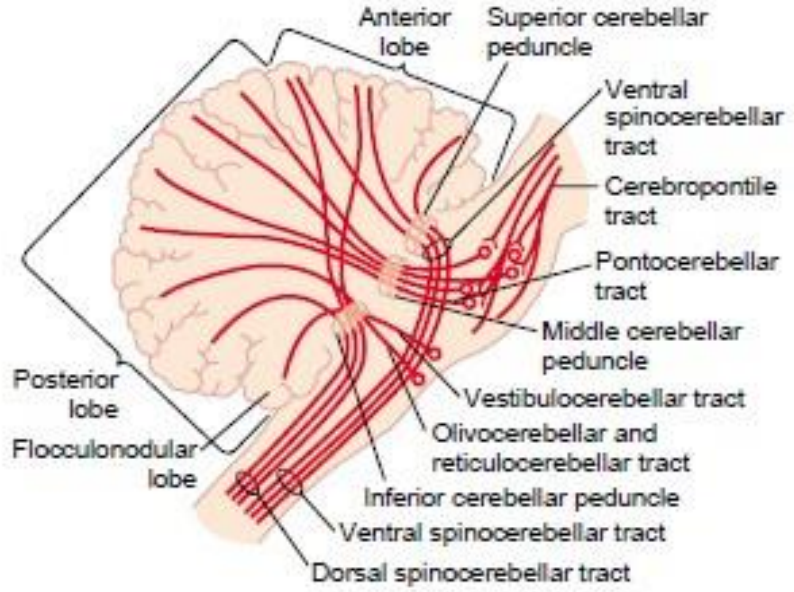
- Cerebral and cerebellar control of voluntary movements, involving especially the intermediate zone of the cerebellum.



Afferent (input) pathway

- The CB receives both sensory and motor information through a rich afferent nerve supply.

- This arises from:
- Other areas of the brain.
- Peripheral receptors.
- and enters the CB via the 3 cerebellar peduncles.



1. The climbing fibers:

- From the inferior olivary nucleus.
- It learns the cerebellum to perform new patterns of movements precisely.

2. The mossy fibers:

- From all other afferent fibers that enter the cerebellum + some fibers coming from the inferior olivary nucleus (so they are greater than the climbing fibers).
- Help the precise execution of the voluntary movements (concerning their initiation, duration and termination), which occurs by controlling the turn on and turn off output signals from the cerebellum to the muscles.

Efferent (out put) fibers

- There are 3 main efferent pathways from the 3 parts of the CB:

1. Are the axons of the 3 deep nuclei.
2. Leave the CB through the **cerebellar peduncles.**
3. Leave the CB through the **superior** and inferior peduncles.

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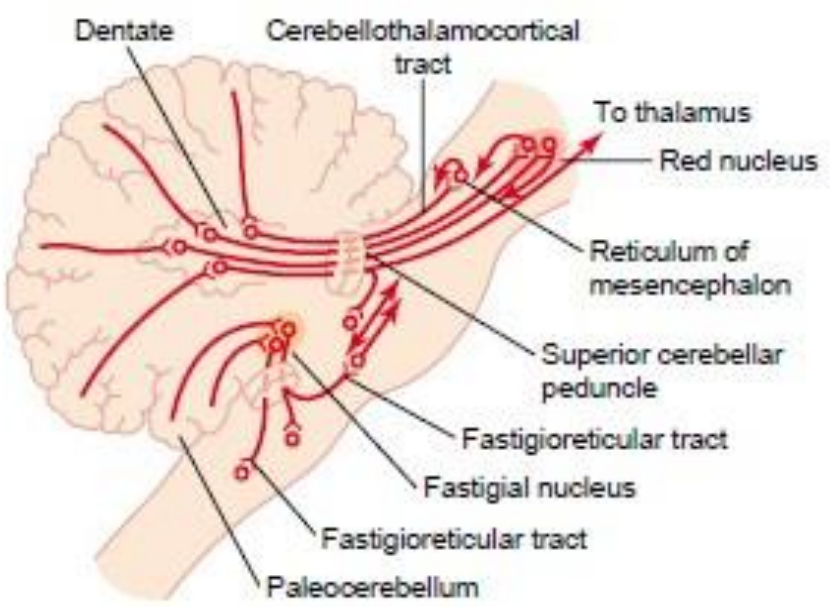


Figure 56–6

Principal *efferent* tracts from the cerebellum.

Functions of the cerebellum

- The CB is called the silent area, because its stimulation does not give rise to any sensation and cause almost no motor movements.
- It is important in the precise execution of rapid muscular movements (Coordinate what is already present).
- Damage to the CB cause almost total incoordination of muscular movements, although the muscles are not paralyzed.
- The cerebellum is concerned only with subconscious control of motor activity, and its functions as well as the involved part include the following:

A. Control of equilibrium & postural movements	B. Control of the Stretch Reflex	C. Control of voluntary movement by the cerebellum
• The function of the vestibulocerebellum. • It receives information from the vestibular apparatus (It will till that the person is moving), then through the fastigial nucleus, it discharges to the brain stem, and through the vestibulospinal and reticulospinal tracts. • It controls equilibrium & postural movements by affecting the activity of the axial muscles (trunk & girdle muscles[1]).	• The cerebrocerebellum exerts a facilitatory (a little bit hypertonic) effect on the stretch reflex & increases the muscle tone, while the spinocerebellum probably exerts an inhibitory effect. • However, normally the facilitatory effect predominates (so cerebellar diseases often result in hypotonia).	Next slide.

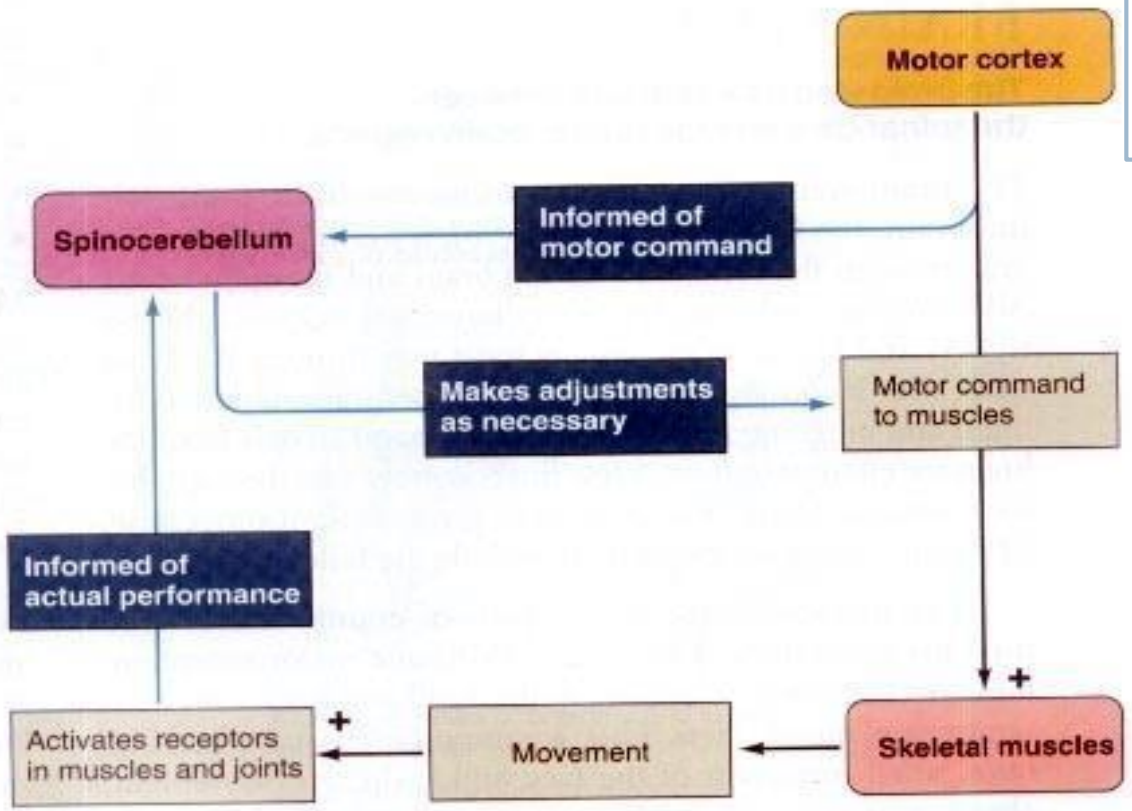
[1] Shoulder gridle, Pelvic gridle

Cont.

A. Control of equilibrium & postural movements

B. Control of the Stretch Reflex

C. Control of voluntary movement by the cerebellum



Observe motor cortex & muscle function & compare it so it adjusts (increase or decrease) the impulses from the motor cortex

A comparetive function

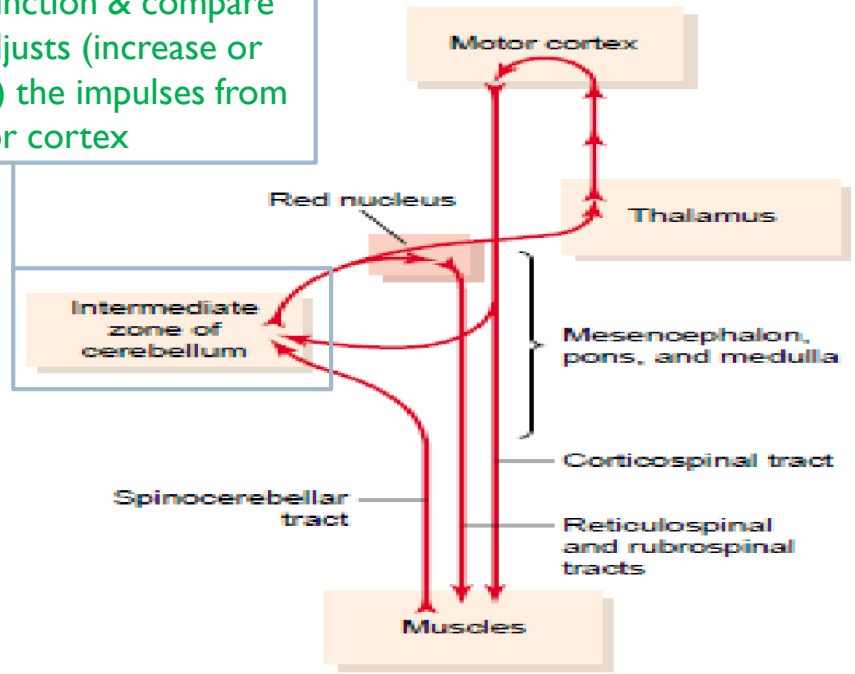


Figure 56–8

Cerebral and cerebellar control of voluntary movements, involving especially the intermediate zone of the cerebellum.

Cont.

- Each cerebellar hemisphere is connected by efferent and afferent pathways to the contra lateral cerebral cortex (the cortico – ponto-crebello-dentato- thalamo- cortical circuit).

- The cerebellum exerts its effects on the same side of the body:
  - The vermis controls muscle movements of the axial body, neck, shoulders and hips.
  - The intermediate zones controls muscle contractions in the distal portions of both the upper and lower limbs (especially the hands, fingers, feet and toes).
  - The lateral zones help in the planning of sequential movements.

- Other functions of cerebellum:

  The CB co-ordinates involuntary postural movements initiated by extra-pyramidal system by acting as a comparator (in the same way as in voluntary movement) and correcting errors so movements do not over shoot.

Cont.

Maintenance of equilibrium (balance, posture, eye movement). To avoid nystagmus.

2. Coordination of the half Automatic movement of walking and posture maintenance. (The movement we don't think about, like walking).

3. Adjustment of muscle tone.

4. Motor learning – motor skills (Fine movements, like piano).

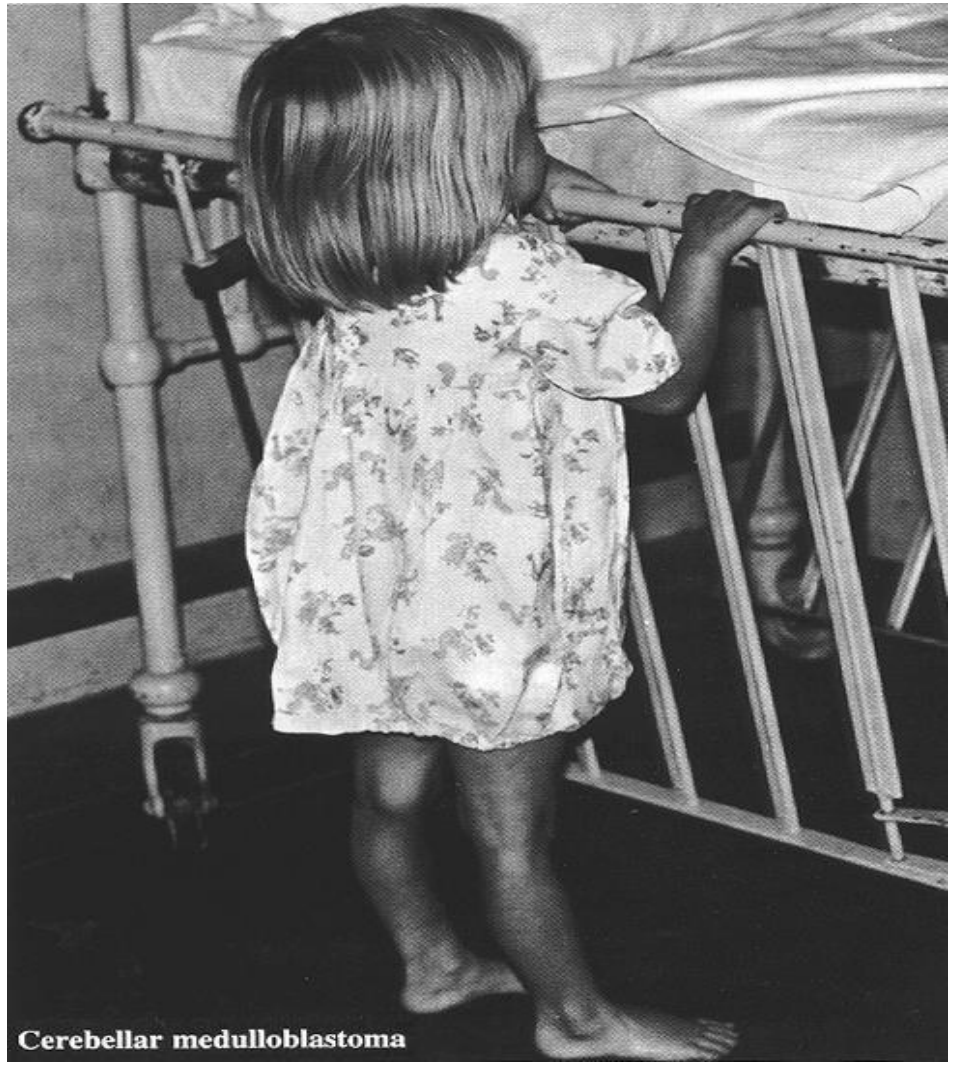
Clinical features / tests related to cerebellum

Ataxia	Reeling, wide-based gait.
Decomposition of movement	Inability to correctly sequence fine, coordinated acts.
Dysarthria	• Inability to articulate words correctly, with slurring. • Inappropriate phrasing.
Dysdiadochokinesia	Inability to perform rapid alternating movements.
Dysmetria	Inability to control range of movement.
Hypotonia	Decreased muscle tone.
Nystagmus	Involuntary, rapid oscillation of the eyeballs in a horizontal, vertical, or rotary direction, with the fast component maximal toward the side of the cerebellar lesion.
Scanning speech	Slow enunciation with a tendency to hesitate at the beginning of a word or syllable.
Tremor	Rhythmic, alternating, oscillatory movement of a limb as it approaches a target (intention tremor) or of proximal musculature when fixed posture or weight bearing is attempted (postural tremor).

Lesions of the vestibulocerebellum

- Ex: Due to a tumor called medulloblastoma.
- Leads to trunk ataxia (Incoordination of movement of the trunk) which is characterized by:

- Equilibrium disturbances: the patient sways on standing, cannot maintain the erect posture, needs support, and walks by a staggering or drunken gait and have nystagmus (Remarkable).
- Can't stand erectly (defected vestibulo cerebellar pathway).


Cerebellar medulloblastoma

Ataxia

- This is incoordination of voluntary movements.
- It is either sensory or motor (or mixed).
- Motor ataxia: Is due to defect in the coordination of the voluntary movements.
- It commonly occur in lesions of either:
  - the cerebellum or spinocerebellar tracts.
  - the labyrinth (vestibular apparatus).
  - the cortical motor areas.

Posture
Gait – Ataxia Tremor

Manifestation of the neocerebellar syndrome

Hypotonia	Asthenia	Motor ataxia
Due to loss of the facillitatory effect of the CB on the stretch reflex, and it is associated with pendular knee jerk.	Muscle weakness: this is due to difficulty in initiation and maintenance of muscle contraction secondary to loss of the potentiating signals by the mossy fiber circuit.	Incoordination of the voluntary movements, specially the rapid movements (becoming abnormal in rate, range, force and direction).

Cerebellar Ataxia

Cerebellar Ataxia: Ataxia is incoordination of muscle movement leading to imbalance.

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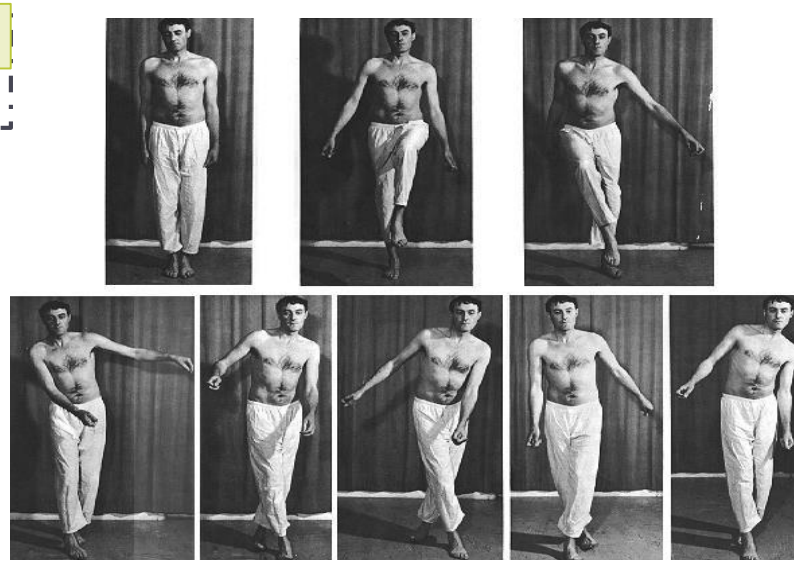


Left cerebellar tumor ataxic gait and position:

a. Sways to the right in standing position.

b. Steady on the Right leg.

c. Unsteady on the left leg.

d. ataxic gait.

Manifestation of Motor Ataxia

Dysmetria

Inability to control the distance of the motor act, which may either overshoot the intended point (=hypermetria or past pointing) or stop before it.

Kinetic (intension, action or terminal) tremors

- This an oscillatory movement that appears on performing a voluntary movement (especially at its end) but is absent at rest.
- It can be demonstrated by the finger nose test.
- It occurs secondary to dysmetria and is due to a series of subconscious correction of the overshoot followed by overshoot of the correcting movements demonstrated by the finger nose test. Its secondry to dysmetria.

 He can keep steady on the left side and he may fall on the diseased side.

Cont.

Cerebellar Syndrome

2:33

Manifestation of Motor Ataxia

Rebound phenomenon

This is over shooting of a limb when a resistance to its movement is suddenly removed. (Loss of the braking function of the CB), (the arm pulling or flexion) test.

Asynergia

This is loss of the harmony between the three groups of muscles involved in performance of voluntary movement the agonists, protagonists (Puts the muscle in a position that facilitates its function). and antagonists.

Failure of progression of movements: manifested by

A- adidokokinesia (dysdiadokokinesia)

Inability to perform alternate (opposite) movements successively at a rapid rate e.G pronation and supination of the forearm or upward and downward movement the hand.

B- decomposition (fragmentation of movements): inability to perform actions involving simultaneous movements at more than one joint.

Dysartheria

Dysartheria: this is difficulty in producing clear speech. It is due to incoordination of the speech muscles secondary to loss of the predictive functions of the CB. The syllables may be too long or too short, loud or weak and speech may be also staccato or scanning i.E. Cut off into separate syllables.

Nystagmus

This is tremor of the eyeballs that occurs on looking to an object placed at one side of the head. (Mainly in vestibulocerebellar damage).

Nystagmus is a very common feature of multiple sclerosis).

Staggering (drunken) gait

The patient walks unsteady – on a wide base (zigzag-like gait) in a drunken (swaying) manner, and tends to fall on the diseased side. Such gait is more apparent with archicerebellar damage.

ONLY IN FEMALES' SLIDES

Bilateral dysfunction of the cerebellum is caused by alcoholic intoxication, hypothyroidism, inherited cerebellar degeneration (ataxia), multiple sclerosis or non metastatic disease.

Dysdiadochokinesis

- Dysdiadochokinesis: rapidly alternating movements.
- Dysdiadochokinesis: Inability to perform rapidly alternating movements. Is called dysdiadochokinesia.
- It is usually caused by multiple sclerosis in adults and cerebellar tumors in children.
- Patients with other movement disorders (e.g. Parkinson's disease) may have abnormal rapid alternating movement testing secondary to akinesia or rigidity, thus creating a false impression of dysdiadochokinesia.

Finger to finger & finger nose test

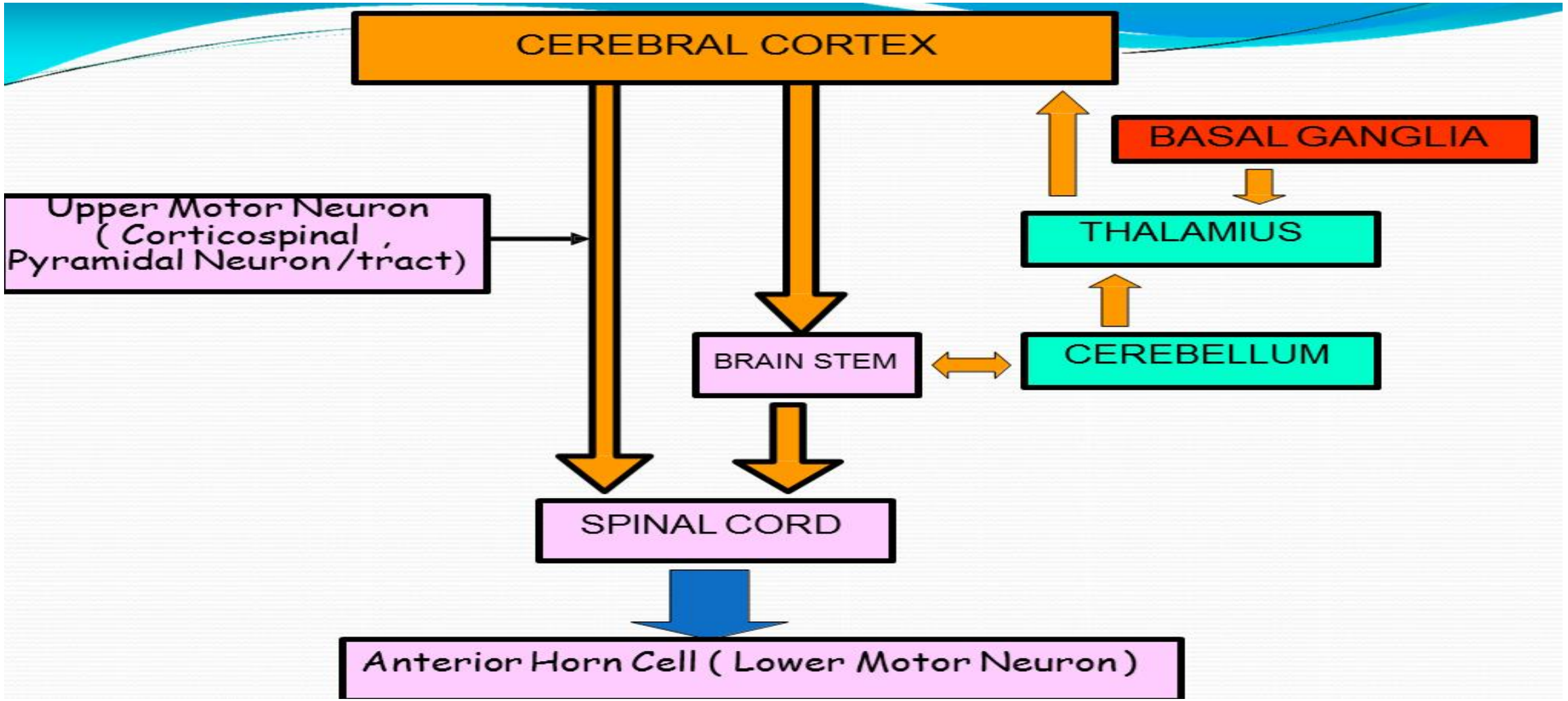
- While the examiner holds his finger at arm's length from the patient. Patient touches her nose and then touches the examiner's finger. After several sequences, the patient is asked to repeat the exercise with her closed eyes.
- A patient with a cerebellar disorder tends to miss the target.
- To see if there is dysmetria.
- Other signs:

- Patient is unstable.
- Has dysmetria.
- Bundler knee jerk.
- Can’t do quick supination and pronation.

Heel to shin test

- The heel to shin test is a measure of coordination and may be abnormal if there is loss of motor strength, proprioception or a cerebellar lesion.
- If motor and sensory systems are intact, an abnormal, asymmetric heel to shin test is highly suggestive of an ipsilateral cerebellar lesion.

Summary


CEREBRAL CORTEX
BASAL GANGLIA
Upper Motor Neuron
(Corticospinal ,
Pyramidal Neuron/tract)
THALAMIUS
BRAIN STEM
CEREBELLUM
SPINAL CORD
Anterior Horn Cell (Lower Motor Neuron)

Neuroanatomy corner

- Cerebellar lesions cause incoordination of the upper limbs(intention tremor), lower limbs (cerebellar ataxia), speech(dysarthria) and eyes (nystagmus).

- Because of the pattern of ipsilateral and decussated path ways that enter and leave the cerebellum, unilateral lesions of the cerebellar hemisphere cause symptoms on the same side of the body. This is in contrast to cerebral lesions (e.g. in the cerebral cortex, internal capsule or basal ganglia),which give rise to contralateral symptoms. A unilateral cerebellar hemispheric lesion causes ipsilateral incoordination o the arm (intention tremor) and of the leg, causing an unsteady gait, in the absence of weakness or sensory loss.

Functional anatomy of the cerebellum		
Archicerebellum	Paleocerebellum	Neocerebellum
Corresponds to the flocculonodular lobe and fastigial nucleus. Its principal connections are with the vestibular and reticular nuclei of the brainstem and it is concerned with the maintenance of equilibrium.	Corresponds to the vermis and paravermal area, together with the globose and emboliform nuclei. It receives fibers from the spinocerebellar tracts and projects to the red nucleus of the midbrain.	Corresponds to most of the cerebellar hemisphere and the dentate nucleus. It receives afferents from the pons and projects to the ventral lateral nucleus of the thalamus.

 We recommended you to read this lecture from neuroanatomy book. You can find the book on the team drive, page 117-123

Neuroanatomy corner

Lesions of the cerebellum:

- A midline lesion o the cerebellum (such as a tumor) leads to loss o postural control; as a result, it is impossible to stand or sit without toppling over, despite preserved coordination o the limbs them selves.
- Because of the pattern of ipsilateral and decussated pathways that enter and leave the cerebellum, unilateral lesions of the cerebellar hemisphere cause symptoms on the same side of the body. This is in contrast to cerebral lesions (e.g. in the cerebral cortex, internal capsule or basal ganglia), which give rise to contralateral symptoms.
- A unilateral cerebellar hemispheric lesions causes ipsilateral incoordination o the arm (intention tremor) and of the leg, causing an unsteady gait, in the absence of weakness or sensory loss.
- Bilateral dysfunction of the cerebellum, caused by alcoholic intoxication, hypothyroidism , inherited cerebellar degeneration/ataxia, multiple sclerosis or paraneoplastic disease, causes slowness and slurring of speech (dysarthria), incoordination of both arms and a staggering, wide-based, unsteady gait (cerebellar ataxia).
- Cerebellar lesions also impair coordination of eye movements. The eyes exhibit a characteristic, in voluntary and rhythmic to-and- fromotion (nystagmus), greatest in amplitude when gaze is directed to the same side as the lesion . Nystagmus is a very common feature of multiple sclerosis. The combination of nystagmus with dysarthria and intention tremor constitutes 'Charcot'striad ', which is highly diagnostic o the disease.

 We recommended you to read this lecture from neuroanatomy book. You can find the book on the team drive, page 117-123

Thank you!

اعمل لترسم بسمة، اعمل لتمسح دمعة، اعمل و أنت تعلم أن الله لا يضيع أجر من أحسن عملا.

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QUIZ

اقتراحات وشكاوي

References:

- Females' and Males' slides.
- Guyton and Hall Textbook of Medical Physiology (Thirteenth Edition.)
- Neuroanatomy An Illustrated Colors Text 5th.