Physiology Team

LECTURES 17-18

Physiology of the cerebellum & VIII

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OBJECTIVES

At the end of this lecture, student should be able to describe:

- Describe the **functional divisions** of the cerebellum (vestibulocerebellum, spinocerebellum and cerebrocerebellum)
- Define the **physiological roles** of the cerebellum in **regulation of movement** .
- Explain the **abnormalities** associated with cerebellar disease: Cerebellar nystagmus , changes in muscle tone , ataxia , drunken gait , scanning speech , dysmetria (past pointing) , intention tremor , rebound phenomenon and adiadochokinesia.
- Explain the **functional connections** of **8th** **cranial** nerve with motor cortex, temporal lobe, medial longitudinal bundle and spinal cord
- **Role of 8th** cranial nerve in **vertigo, nystagmus and balance.**

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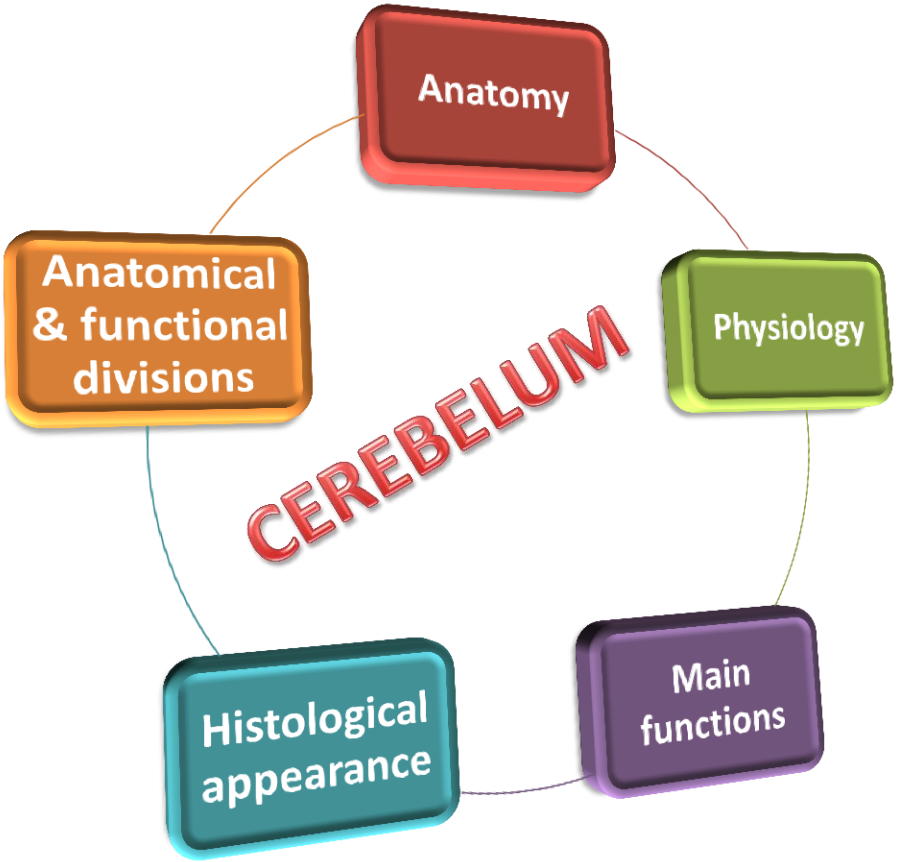
MIND MAP



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MIND MAP

important

Defects of

Cerebellar lesions

neocerebellar syndrome

due to **damage** of the **deep cerebellar nuclei** **(mostly)** as well as **the cerebellar cortex**

Its Manifestations: **(ipsilatteral !)**

- Hypotonia
- Athenia:(muscle weakness)
- **Motor** ataxia

Vesitbulocerebellum lesions

Due to a tumor **Medulloblastoma**

TRUNK ATAXIA

Is characterized by:

Equilibrium disturbances

Vesitubular lesion

Acoustic neuoma

Due to Benign tumour of 8th CN + near structures (V-VII)

unilaterally or bilaterally in an inherited disease called neurofibromatosis

Its Manifestations:

- Profound Deafness.
- Dizziness
- Ataxia
- Paralyzed limb

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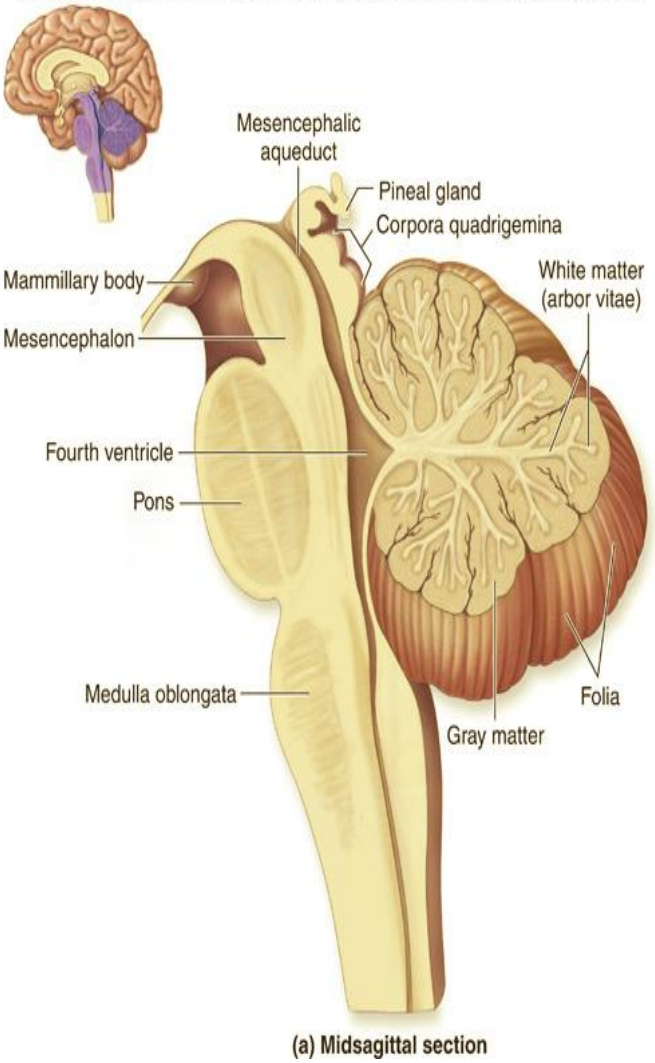
Anatomy of cerebellum

- Occupies a prominent position besides the main sensory & motor system in the brain stem.
- It connected to brain stem by three peduncles The anterior & posterior lobes on each side constitute 2 large cerebellar hemispheres, which are separated by a narrow band called the vermis.
- Various fibers inter & leave the cerebellum throgh these peduncles.



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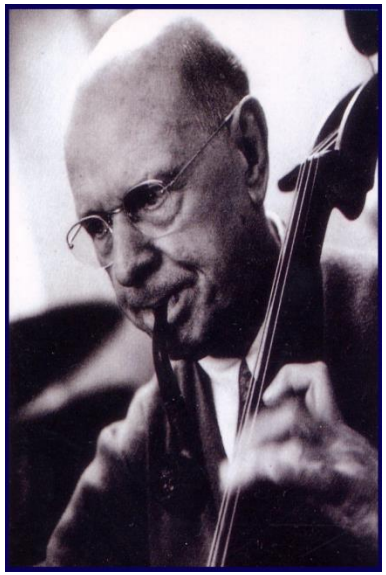
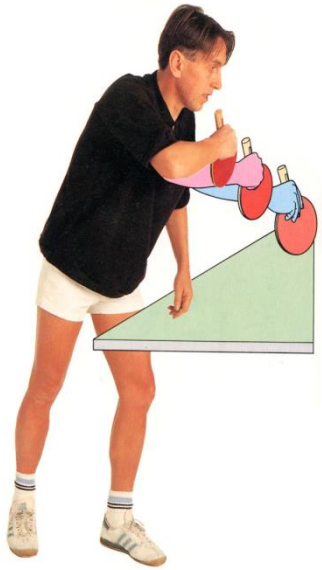
The main functions of cerebellum

- **Maintenance of equilibrium: (**balance, posture, eye movement)
- **Coordination of half automatic movement of walking and posture maintenance**
- **Adjustment of muscle tone** through the stretch reflex
- **Motor Learning – Motor Skills** like typing on keyboard, playing piano ... etc





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Anatomical & functional divisions of cerebellum

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

- **The cerebellum is anatomically and physiologically divided into three parts:**

Paleocerebellum: Anterior lobe [Spinocerebellum]

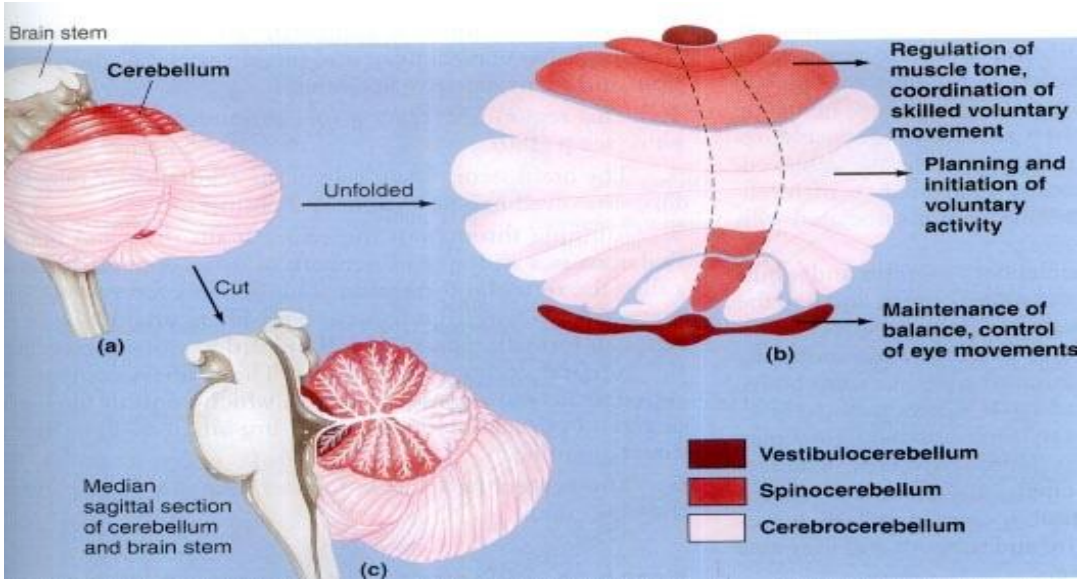
Neocerebellum: Posterior lobe [Cerebrocerebellum]

Archicerebellum: Flocculonodularlobe [Vestibulocerebellum]

Boy's slides

Functional divisions of cerebellum

Spinocerebellum	Cerebrocerebellum	Vestibulocerebellum
• **Paleocerebellum:** Anterior lobe • Regulation of muscle tone, coordination of skilled voluntary movements	• **Neocerebellum:** Posterior lobe • Planning & initiation of voluntary activities	• **Archicerebellum:** Flocculonodularlobe • Maintainance of balance, control of eye movements



Structures & connections of the cerebellum

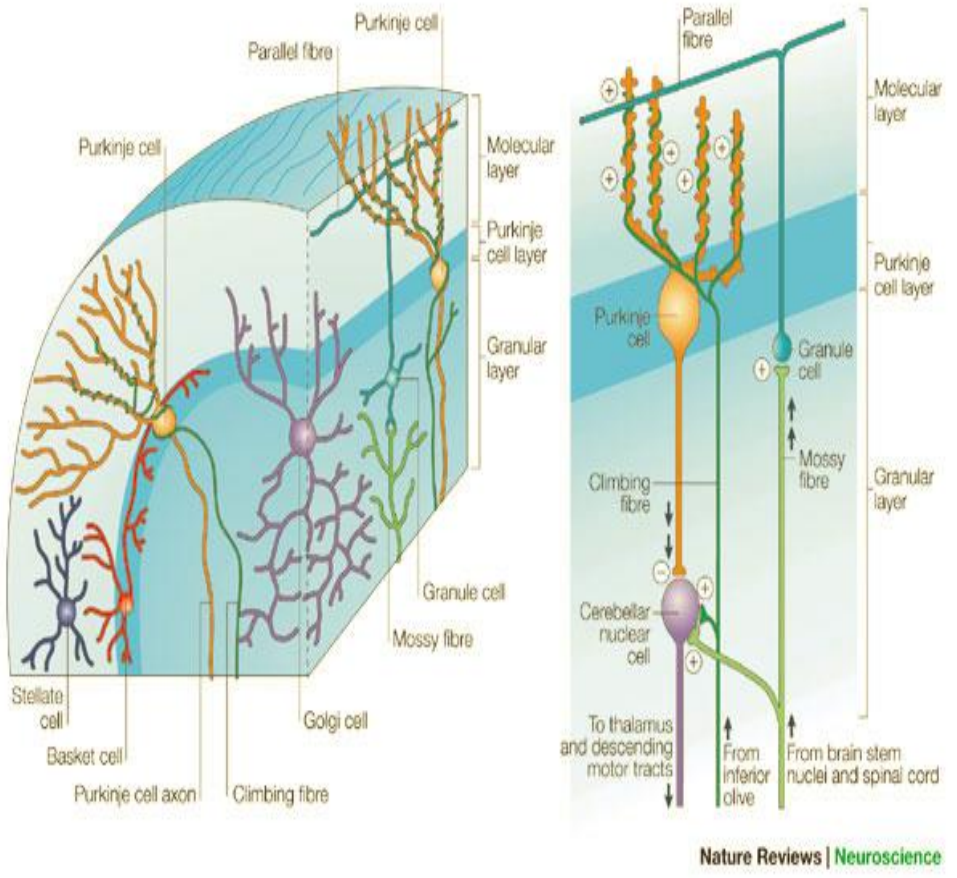
1. Purkinje cell
2. Granule cell
3. Basket cell
4. Golgi cell
5. Stellate cell

In cortex

6. Climbing fiber
7. Mossy fiber
8. Parallel fiber

Afferent

9. Inferior olivary nucleus
10. Deep cerebellar nuclei



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CEREBELLUM: THE RULE OF 3

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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

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cerebellum

External layer of grey matter

Inner white matter

- Cerebellar cortex
- **Deeply in folded, giving a large surface area, and contains 5 different cell types:**

1. **Golgi**
2. **Basket**
3. **Stellate**

Inhibitory interneurons

4. **Granule** → excitatory
5. **purkinji** → Output cell – inhibit the deep nuclear cells

- **Contain 3 deep nuclei:**

1. **Dentate**
2. **Fastigial**
3. **Interpositous** (formed of globose & Emboliform nuclei)

- The inhibitory neurons in the cerebellum release **GABA** (e.g. stellate, basket, golgi, purkinji cells PC
- The excitatory neuron release **glutamate** (e.g. granular cells, that also has GABA receptors.

DON'T EAT GRASILS FOOD

From lateral to medial

D = dentate , **E**= embliform , **G** = globose , **F** = fasitgials

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Afferent –input- pathway

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.

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- Climbing fibers:

- Any fiber from inferior olivery neucleus And they also concern with perform of a new patern of movement,,and memorizing a new skill

2- Mossy fibers:

- 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 muscle

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CEREBELLAR PEDUNCLES CARRY AFFERENTS FROM:

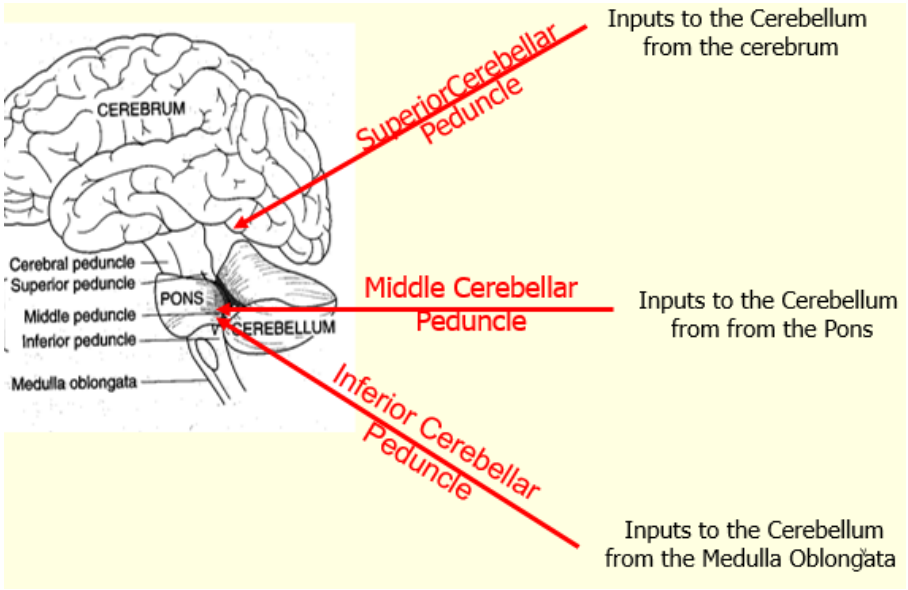
The cerebellum is anatomically and physiologically divided into three parts:

Paleocerebellum: Anterior lobe [Spinocerebellum]

Neocerebellum: Posterior lobe [Cerebrocerebellum]

Archicerebellum: Flocculonodularlobe [Vestibulocerebellum]

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.



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PRINCIPAL AFFERENT TRACTS TO THE CEREBELLUM

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AFFERENT TRACTS	TRANSMITS
Vestibulocerebellar	Vestibular impulses from labyrinths, direct & via vestibular nuclei.
Dorsal Spinocerebellar	Proprioceptive & exteroceptive impulses from the body.
Ventral Spinocerebellar	Proprioceptive & exteroceptive impulses from the body.
Cuneocerebellar	Proprioceptive 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.

Efferent-output- pathway

There are 3 main efferent pathways from the 3 parts of the CB,

- Are the axons of the 3 deep nuclei,
- Leave the CB through the **superior** and inferior peduncles

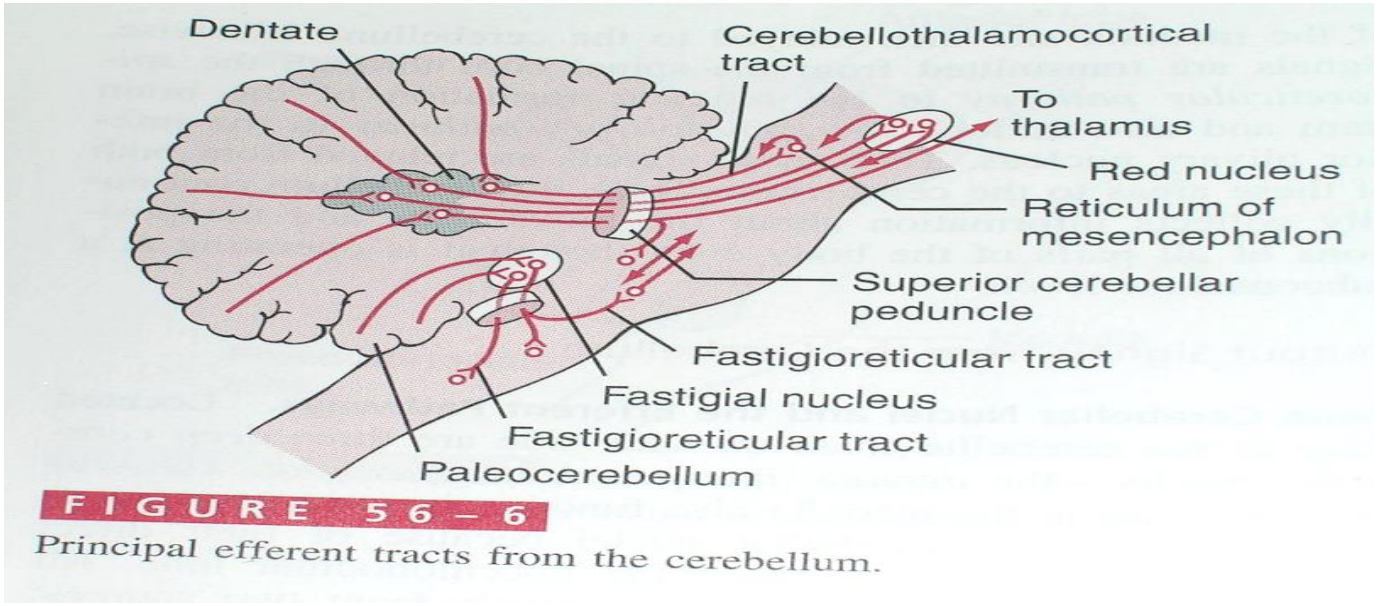

FIGURE 56–6
Principal efferent tracts from the cerebellum.

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OUTPUT FROM DEEP CEREBELLAR NUCLEI

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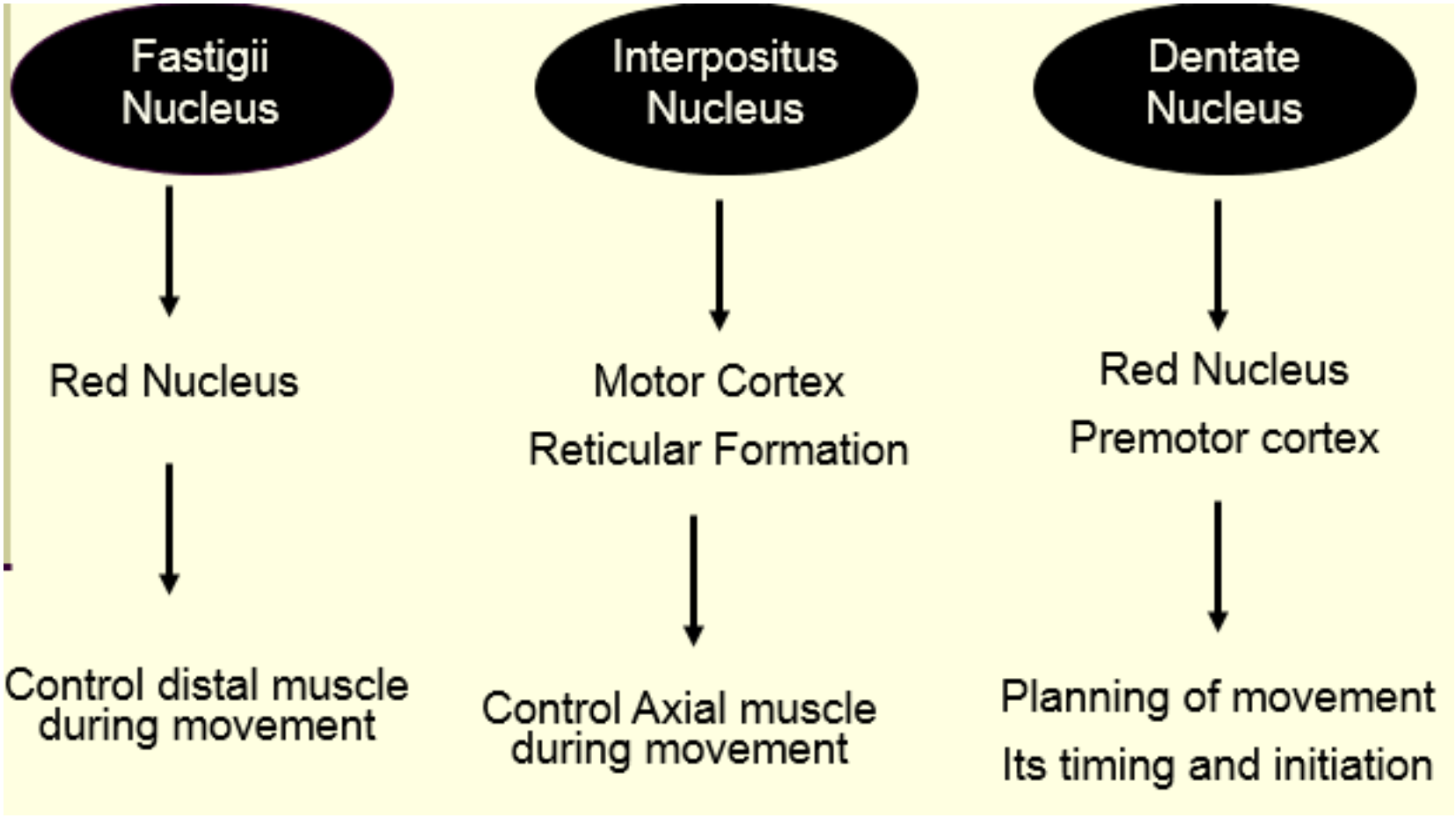

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Functions of the cerebellum

- 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.***
- 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 (movement).***

يهتم المخيخ بشكل أساسي بوظائف التوازن وتنظيم الوظائف الحركية و بتظيم الحركات وذلك بالمعنى العام(الحركة+الوقوف+التوازن)،يتلقى إشارات(معلومات)من جميع المراكز العصبية ويعالجها ليقدم لبرنامج الحركة تنظيم زمني ومكاني دقيق

1-CONTROL OF EQUILIBRIUM & POSTURAL MOVEMENTS

- The function of the **vestibulocerebellum.**
- It receives information from the vestibular apparatus

-then through the **fastigal 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).

Eg: lesion of vestibolocerebellum:

Due to a tumor called **medulloblastoma**

- .**Lead to trunk ataxia which is characterized by:**

1. . **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.

2-CORRECTING ERRORS SO MOVEMENTS DO NOT OVER SHOOT

The CB co-ordinates involuntary postural movements initiated by extrapyramidal system by acting as a comparator (in the same way as in voluntary movement) and correcting errors so movements do not over shoot. That way in case of CB injury they suffer from ataxia =which is over shooting=incoordination)

3-CONTROL OF THE STRETCH REFLEX

-The ***cerebrocerebellum exerts a facilitatory 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 disease** often results in ***hypotonia)*** ***because the facilitatory effects (cerebrocerebellum) on the muscle tone takes the upper hand, so if there is a damage to the cerebellum, the net result will be hypotonia***

4-CONTROL OF VOLUNTARY MOVEMENT

- The doctor said, it's like 2 stages: planning & performance stages.

✓ **Planning stage:** starts as an idea e.g. open the door, this idea will go to the cortical association area, basal ganglia & cerebrocerebellum. These 3 area will make the plan (e.g. you need 10 steps to reach the door & these steps will involved these specific muscles & joints…etc

Then this idea will go to the motor & premotor area to give orders to the muscles & joints which perform the required action.

✓ **Performance stage**: The afferent fibers come from the muscle & then goes to the spinocerebellar. to know if the action performed by the muscles correspond with the orders that coming from the motor & premotor area or not. If it is not, the spinocerebellum tries to change the tone of the muscles. Thus the final output will be correspond the plan.

So the spinocerebellum recieves: 1- afferent fibers from the muscles & 2- orders from motor & premotor area.

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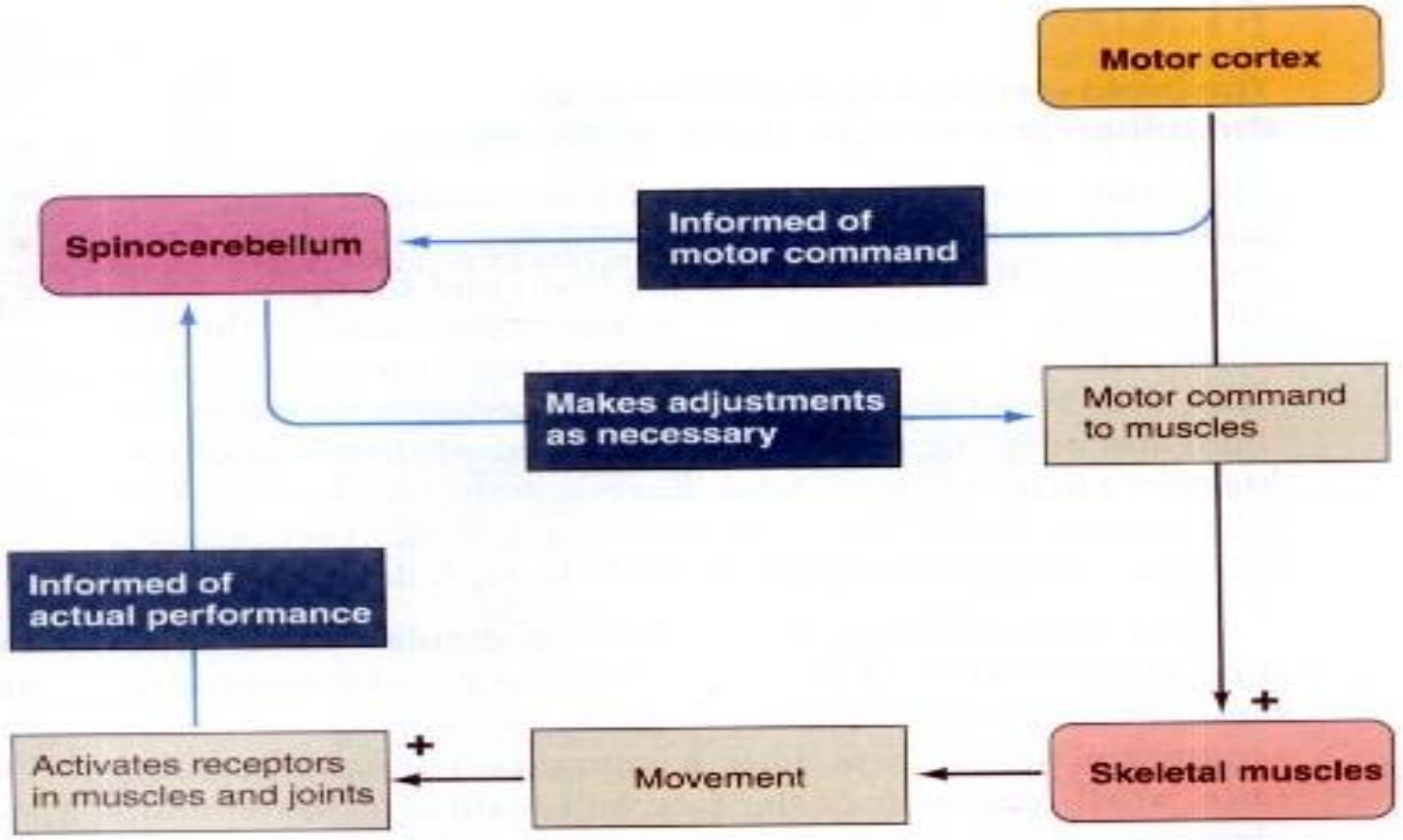

Note that

- Each cerebellar hemisphere is connected by efferent and afferent pathways to *the contra lateral cerebral cortex (the cortico – ponto-crebello-dentato- thalamo-cortical circuit).*
- ***Right cerebellum communicates with the left cerebral cortex (which control the right side of the body). So, the cerebellum is ipsilateral & vise versa.***

- ***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*** ***(paravermal – spinocerebellum)*** *controls muscle contractions in the* **distal portions** of both the upper and lower limbs (especially the hands, fingers, feet and toes).

✓ ***The lateral zones*** ***(cerebrocerebellum)*** *help in the planning of sequential* movements.

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Defects produced by cerebellar lesions in humans

THE NEOCEREBELLAR SYNDROM

due to damage of the deep cerebellar nuclei as well as the cerebellar cortex

- **manifestations** occur **(ipsilatteral)**

=> abnormal **HEEL TO SHIN TEST**

- BILATERAL DYSFUNCTION of the cerebellum is caused by:
- Alcoholic intoxication
- hypothyroidism
- inherited cerebellar degeneration (ataxia)
- multiple sclerosis
- non metastatic disease.

MANIFESTATION:

A) Hypotonia: Due to loss of the facillitatory effect of the CB on the stretch reflex, and it is associated with ***pendular knee jerk*.**

b) Athenia*:* (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.

c) Motor ataxia: Incoordination of the voluntary movements, specially the rapid movements (becoming abnormal in rate, range, force and direction). *Detailed in next 2 slides*

Video http://www.dailymotion.com/video/x1j0an_cerebellar-disease_family

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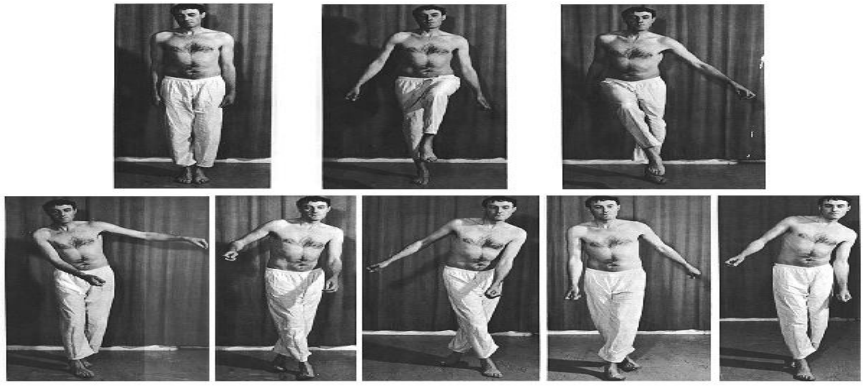
ATAXIA



Ataxia 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:

A- the cerebellum or spinocerebellar tracts.
B- the labyrinth (vestibular apparatus).
C- the cortical motor areas.

Cerebellar Ataxia:

Due to 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.

Manifestations of Motor Ataxia

	Definition	Result
1- Dysmetria	Inability to control the distance of the motor act	Either: 1- overshoot the intended point (hypermetria or pastpointing) or 2- stop before it.
2- Kinetic (intension, action or terminal) tremors	Occurs secondary to dysmetria due to a series of subconscious correction of the overshoot followed by overshoot of the correcting movements	Appears on performing a voluntary movement (absent at rest) Shows in finger nose test
3- Rebound phenomenon	Over shooting of a limb when a resistance to its movement is suddenly removed.	Loss of the braking function of the Cerebellum. Shows in the arm pulling or flexion test
4- Asynergia	Loss of harmony between the three groups of muscles of voluntary movement the : agonists, protagonists, and antagonists	--
5-Failure of progression of movements	**A-** Adidokokinesia **=(**dysdiadokokinesia**)** **B-** Decomposition **=(**fragmentation of movements**)**	A- e.g CANNOT DO pronation and supination B- CANNOT DO simultaneous movements at more than one joint.
6-Dysartheria	Due to incoordination of the speech muscles secondary to loss of the predictive functions of the CB	Difficulty in producing clear speech (syllables too long/short or too loud/weak) staccato or scanning
7- Nystagmus	Tremor of the eyeballs	N.B= Common feature of multiple sclerosis + vestibulocerebellar damage
8- Staggering (drunken) gait	The patient walks unsteady – on a wide base (zigzag-like gait)	Tends to fall on the diseased side. Such gait is more apparent with archicerebellar damage.

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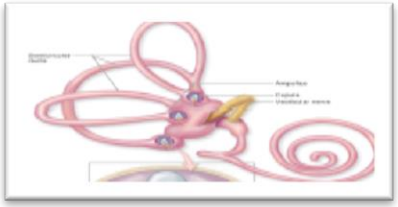
The Vestibular apparatus
(Head position)



- Is the organ that senses head n position changes relative to gravity.
- Movement causes fluid vibration resulting in hair cell displacement that activates the vestibular part of the 8th nerve **(balance).**

Which ends in the vestibular nuclear complex located in the floor of the fourth ventricle

VIII C.N CONDUCTS TWO SPECIAL SENSES:

Hearing (audition) = cochlear part and
Balance (vestibular) = vestibular part

VESTIBULOSPINAL FIBRES

Influence the activity of the spinal motor neurons concerned with the:

- *Control of body posture and balance.*
- *Control of head and eye movements*.

Other fibres project to thalamus then to the cortical regions responsible for *Conscious awareness of vestibular sensations*.

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Cont.

THE VESTIBULAR NERVE (VN):

- The receptor cells located in the membranous labyrinth embedded in the petrous part of the temporal bone.
- The central processes of the VN end in the vestibular nuclei in medulla.

VESTIBULAR NUCLEI (via vestibulospinal tracts) connects to:

1- Spinal motor neurons:

-Control of posture
-Maintenance of equilibrium
-Coordination of the head &eye movements.

2- Thalamus: (cortical regions)

The awareness of the vestibular stimulation.

Fibres from the vestibular nuclei contribute to the
((Medial & lateral vestibulospinal tracts))

VESTIBULAR LESION = (Acoustic neuroma)

Benign tumour of 8th + near nerves V-VII

Manifestations: *Dizziness*, profound *Deafness*, *Ataxia* and paralysis of the cranial nerves V-VII and limbs.

((occurs either unilaterally or bilaterally in an inherited disease called **neurofibromatosis))**

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SUMMARY

Boys' slides

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

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QUESTIONS

Q1: D
Q2: A
Q3: C
Q4: A

Q1) Ataxia can happen by lesion of all of these places except :

A) spinocerebellar tracts.
B) B) the labyrinth.
C) C) cortical motor areas. D) cochlea

Q2) Inability to control the distance of the motor act is :

A) Dysmetria B) Asynergia C) Dysartheria D) Nystagmus

Q3) Finger nose test demonstrate which of motor ataxia feature :

A) Dysartheria
B) Rebound phenomenon
C) Kinetic tremors
D) Asynergia

Q4-which one consider as the output cell to send the impluse out of CB?

A. perkingi cell
B. basket cell
C. granular cell

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THE END

If there are any Problems or Suggestions,
Feel free to contact:

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THANK YOU