Physiology Of Cerebellum

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- Important
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CNS

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Recommended Videos!

Please check out this link before viewing the file to know if there are any additions/changes or corrections. The same link will be used for all of our work Physiology Edit

Cerebellum *Latin word means little brain

✧ Below the cerebrum and behind the brainstem is the " Cerebellum", which Occupies a prominent position beside the main <u>sensory</u> and <u>motor</u> systems in the brain stem.

✧ Cerebellum is connected to each part of the brain stem by cerebellar peduncles (**superior**-midbrain , **middle**-Pons & **inferior**-medulla).

✧ Various fibers inter and leave the cerebellum through these peduncles.
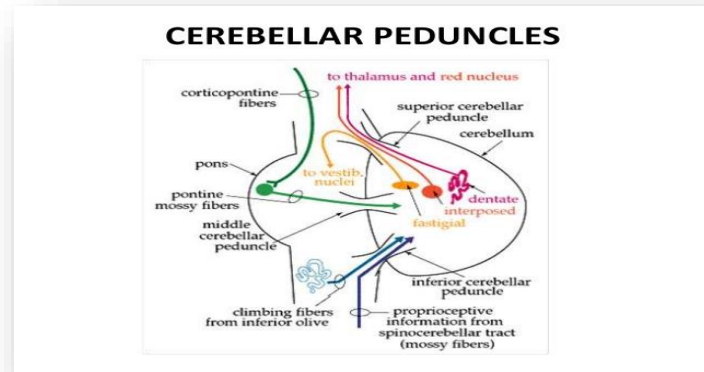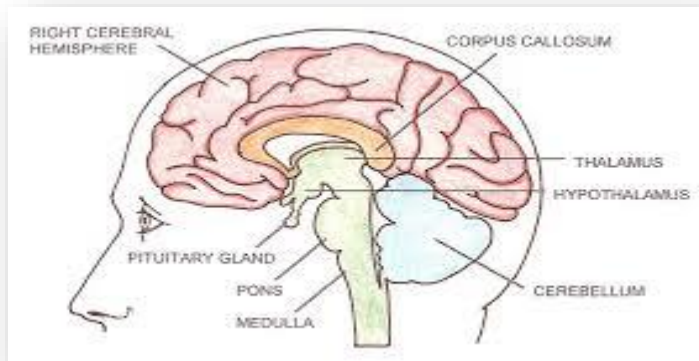
Functions of cerebellum

Maintenance of equilibrium : balance , posture , eye movement

Coordination of half-automatic movement of walking and posture maintenance

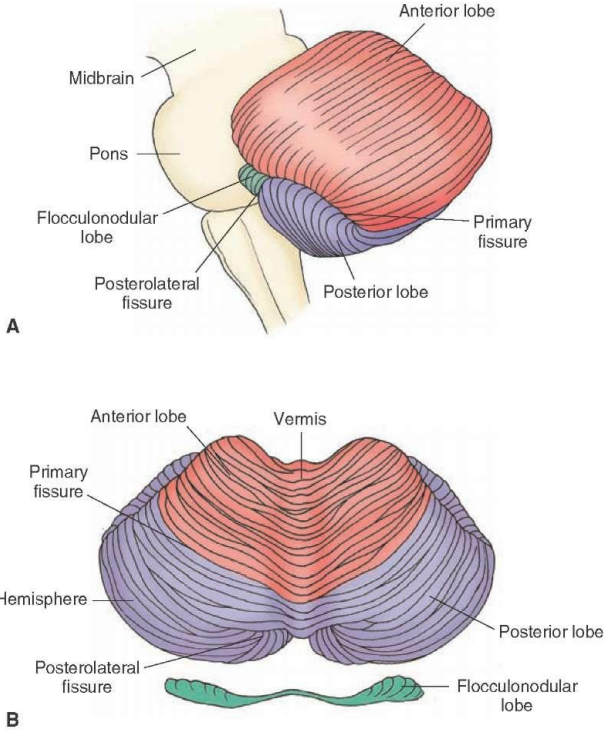Adjustment of muscle tone

Motor learning (Motor skills)

Anatomical divisions of Cerebellum

Anterior Lobe

Posterior Lobe

Flocullonodular lobe

Vermis

"between each cerebellar hemisphere"

Functional divisions of Cerebellum

Spinocerebellum *"paleocerebullum"*
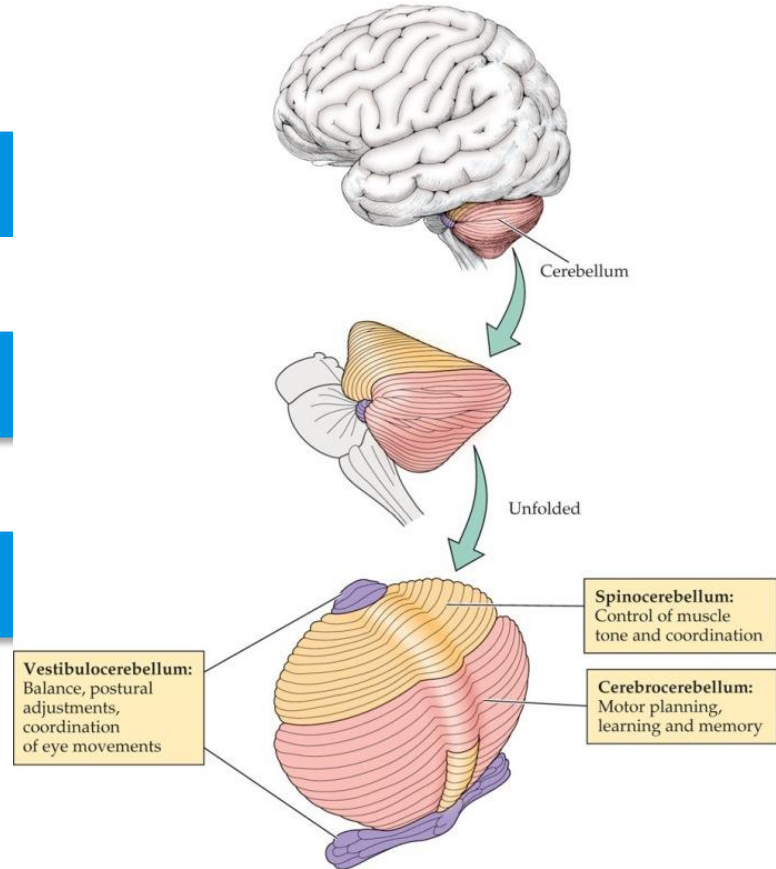
- Motor execution

Cerebrocerebellum *"neocerebullum"*

- Motor planning

Vestibulocerebellum *"Archicerebullum"*

- Balance and eye movement

Cerebellum

Unfolded

Spinocerebellum:
Control of muscle
tone and coordination

Cerebrocerebellum:
Motor planning,
learning and memory

Vestibulocerebellum:
Balance, postural
adjustments,
coordination
of eye movements

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Structures & Connections of the cerebellum

Cells found in the cerebellar cortex:

Purkinje cells
"the output cell"
They inhibit the deep cerebellar cells

Granule cells
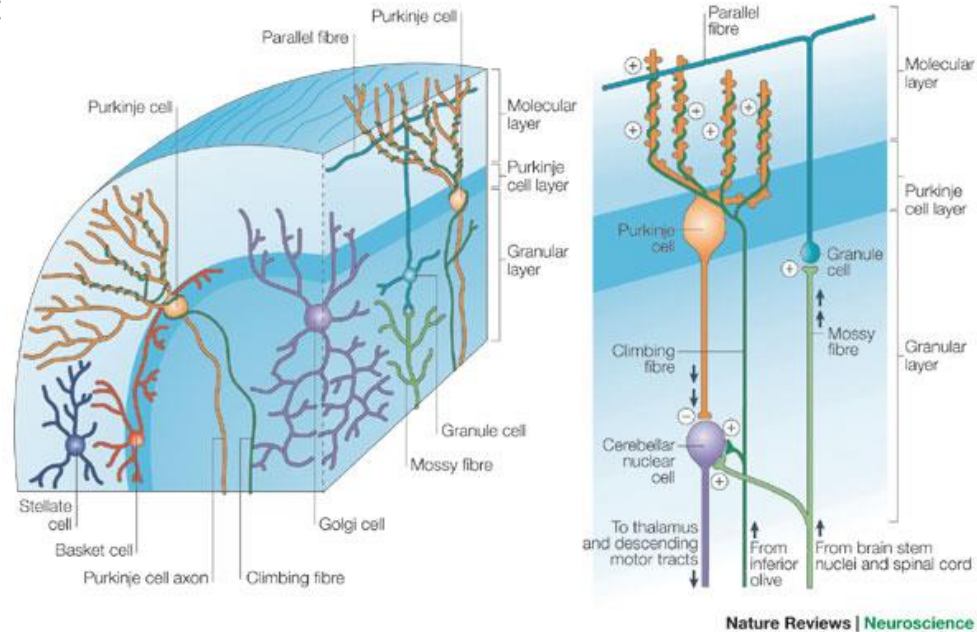"excitatory neuron"

Basket cells
"inhibitory interneuron"

Golgi cells
"inhibitory interneuron"

Stellate cells
"inhibitory interneuron"

Nature Reviews | Neuroscience

Excitatory neuron release Glutamate

Inhibitory neuron release GABA

Deep Cerebellar nuclei

The white matter contain <u>3 deep nuclei from lateral to medial</u> :

   1- Dentate
   2- Fastigial
   3- Interpositous (formed of globose and emboliform nuclei)

Some animals, including humans, do not have distinct emboliform and globose nuclei, instead having a single, fused interposed nucleus , so the term the term *interpositous nucleus* is often used to refer collectively to these two nuclei.

✧**All afferent fibers relay first at the deep nuclei and the cerebellar cortex, then the latter (cerebellar cortex) discharges to the deep nuclei, from which the efferent fibers originate and leave the Cerebellum.**

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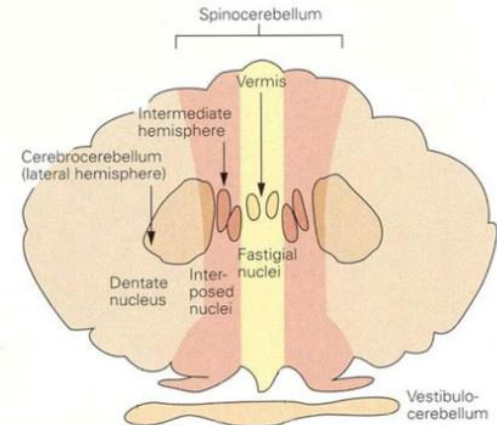
Afferent (input) pathways

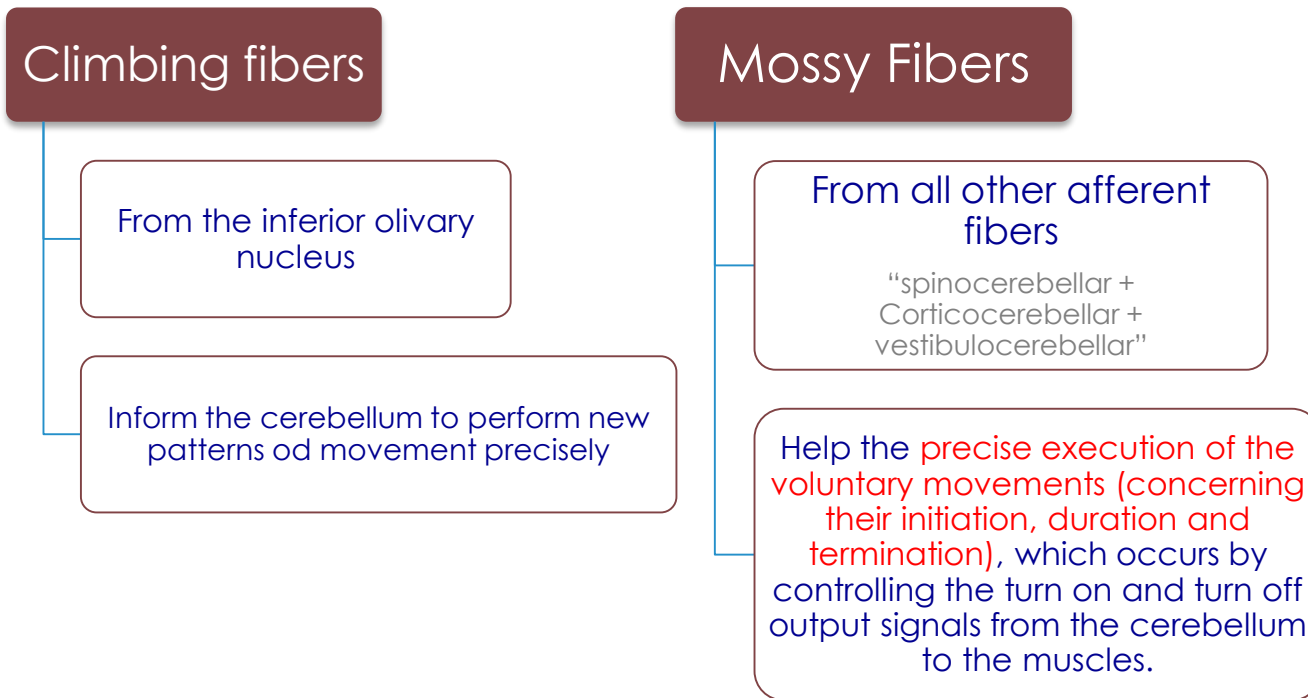✧ **The Cerebellum receives both sensory and motor information through a rich afferent nerve supply.**

Climbing fibers

From the inferior olivary nucleus

Inform the cerebellum to perform new patterns od movement precisely

Mossy Fibers

From all other afferent fibers

"spinocerebellar + Corticocerebellar + vestibulocerebellar"

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 (Output) pathways

Extra Information (found in anatomy)

Vestibulocerebellum

- ✧ **There are 3 main efferent pathways from the 3 parts of the Cerebullem**
- ✧ **They Are the axons of the 3 deep nuclei.**
- ✧ **Leave the Cerebellum through the superior and inferior peduncles**
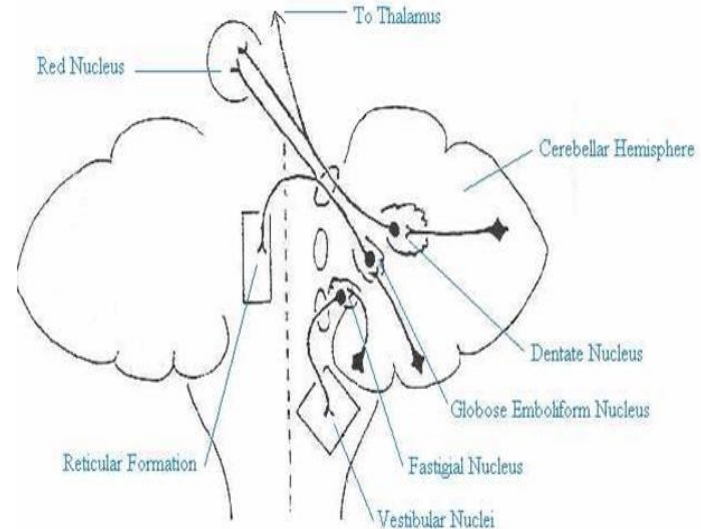
Spinocerebellum

| Spinocerebellar tract | Vermis and paravermis | Interpositous nuclei | Red nucleus |

Neocerebellum

| Cerebral cortex | Lateral area cortex | Dentate nuclei | Red nucleus+ VL nucleus |

Red Nucleus — To Thalamus — Cerebellar Hemisphere — Dentate Nucleus — Globose Emboliform Nucleus — Fastigial Nucleus — Vestibular Nuclei — Reticular Formation

VL = Ventral lateral nucleus of the thalamus

Functions of the cerebellum

◆ Stimulation of the cerebellum does not give rise to any sensation and cause almost no motor movements, that's why it is called the "silent area".

◆ It is important in the precise execution of rapid muscular movements.

◆ Damage to the Cerebellum cause almost total incoordination of muscular movements, although the muscles are not paralyzed. "which means that They continue to be able to generate motor activity, but it loses precision, producing erratic, uncoordinated, or incorrectly timed movements".

◆ The cerebellum is concerned only with subconscious control of motor activity, and its own functions as well as the involved part of the cerebellum.

A. Control of equilibrium and postural movement

Vestibulocerebellum

Vestibular nuclei → Floculonodular cortex → Fastigeal nuclei → Back to vestibular nuclei → Vesibulospinal and Reticulospinal tract

And finally, the Vestibulospinal tract affect the activity of axial muscles --> equilibrium

Lesion of the vestibulocerebellum

1. Due to medulloblastoma
2. Lead to Trunk ataxia
3. Equilibrium disturbances
   a. Sways in standing
   b. Cannot maintain the erect postion
   c. Drunken gait(staggering)

B. 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 diseases often result in hypotonia).

✧ Cerebrocerebellum > spinocerebellum

* Muscle tone:
is the amount of tension or resistance to stretch in a muscle

* Hypotonia :
is a state of low Muscle tone.

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C. Control of voluntary movement by cerebellum:

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

✧ **The cerebellum exerts its effects on the same side of the body**:.

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 vermis controls muscle movements of the axial body neck, shoulders and hips.

The **lateral zones** help in the planning of sequential movements.

Another function of cerebellum : The Cerebellum co-ordinates involuntary postural movements initiated by extra-pyramidal system by acting as comparator (in the same way as intvoluntary movement) and correcting errors so movements do not over shoot.

Defects produced by cerebellar lesions in human

❖ The neocerebellar syndrome:

1. The cause :

Damage of the deep cerebellar nuclei as well as the cerebellar cortex

Due to

Bilateral dysfunction caused by alcoholic intoxication, Hypothyroidism , inherited cerebellar degeneration , MS , non metastatic disease

One side of the cerebellum --> ipselateral manifestation

Bilateral dysfunction   --> bilateral manifestation

2. Manifestation :

a.   Hypotonia --> loss of the facilitatory effect of the CB on the stretch reflex, and it is associated with **pendular knee jerk**.

b.   Asthenia (Muscle Weakness)

c.   Motor ataxia (incoordination of the muscle movement)

SEE the SYMPTOMS of motor ataxia

Defects produced by cerebellar lesions in human

❖ Ataxia :

This is incoordination of voluntary movements. It is either sensory or motor (or mixed).
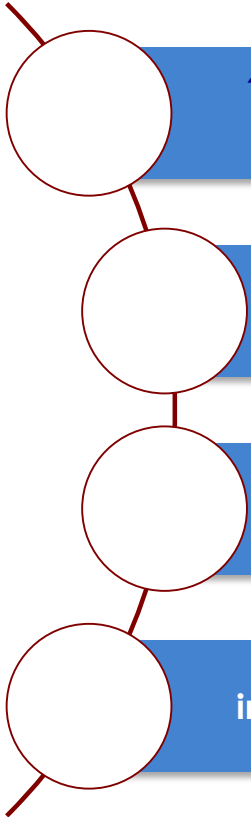
Motor ataxia :

✧ 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.

Cerebellar Ataxia "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:

1-Dysmetria: Inability to control the distance of the motor act, which may either overshoot the intended point.

2-Kinetic (intension) 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".

3. 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).

4-Asynergia: This is loss of the harmony between the three groups of muscles involved in performance of voluntary movement the agonists, protagonists, and antagonists).

Manifestations of Motor ataxia:

5-Dysartheria:

a. This is difficulty in producing clear speech.

b. It is due to incoordination of the speech muscles secondary to loss of the predictive functions of the CB.

c. 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.

6-Nystagmus:

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

b. Nystagmus is a very common feature of multiple sclerosis).

7-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

# Manifestations of Motor ataxia:

8-Failure of progression of movements:

Adidokokinesia (= dysdiadokokinesia) :
Inability to perform alternate movements successively at a rapid rate. **e.g pronation and supination or upward and downward movement the hand.**

b- Decomposition (fragmentation of movements): Inability to perform actions involving simultaneous movements at more than one joint.

Finger to finger & finger to nose tests

- **A patient with a cerebellar disorder tends to miss the target.**

1.A
2.D
3.B
4.A
5.A
6.B
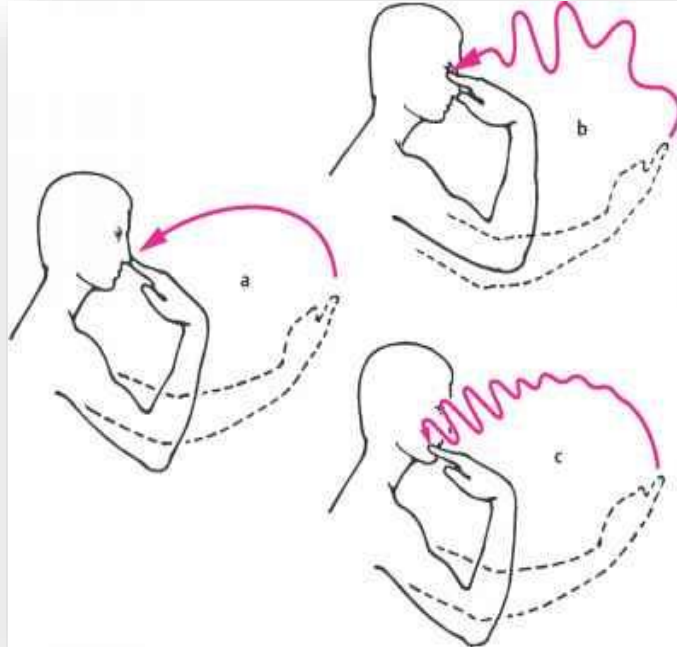
1- "Motor planning" is the function of :
A. cerebrocerebellum
B. Spinocerebellum
C. Vestibulo cerebellum
D. non of the above

2- which of the following is an excitatory internenuron:
A. Stellate cells
B. Basket cells
C.Golgi cells
D.Granule cells

3- efferent fibers originate and leave the cerebellum from the cerebellum cortex
A. true
B. False

4-cerebellar diseases often result in :
A. Hypotonia
B. Hypertonia
C. A&b
D. Non of the above

5- Loss of the breaking functions of the cerebellum describes :
A. Rebound phenomenon.
B. Asynergia.
C. Adidokokinesia.
D. Dysartheria.

6-The manifestations of Neocerebellar syndrome occur on the opposite side of the lesiom.
A. True
B. False

MCQs

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1- what are the most common affected sructures by Motor ataxia ?
a- the cerebellum or spinocerebellar tracts
b- the labyrinth (vestibular apparatus)
c- the cortical motor areas.

2- define the " Asynergia " ?
This is loss of the harmony between the three groups of muscles involved in performance of voluntary movement the agonists, protagonists, and antagonists.

3- give a brief description about the cerebellar ataxia ?
Usually is part of motor ataxia, and it is associated with ataxic gait

4- what are the corresponding functions of the Vermis , intermediate zones, later zones ?
Vermis :controls muscle movements of the axial body, neck, shoulders and hips
Intermediate zones: controls muscle contractions in the distal portions of both the upper and lower limbs.
Lateral Zones : help in the planning of sequential movements.

THANK YOU FOR CHECKING OUR WORK!

BEST OF LUCK

Done By:

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