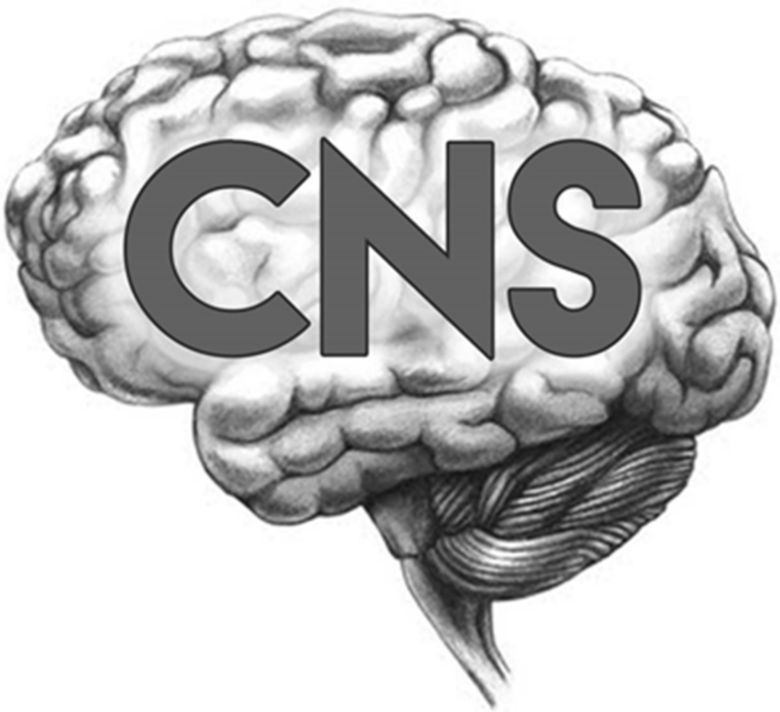


PHYSIOLOGY

☑ Sheet ○ Slide ○ Handout

Number

5

Subject

Cerebellum control functions

Done By

Tala Rawashdeh

Corrected by

Sundus al-khateeb

Doctor

Faisal mohammaed

Date: **00/00/2016**

Price:

This sheet was written according to the lecture of section 2.

Cerebellum and its Role in Motor Control

- **General concept:**

The cerebellum continuously receives information from the different motor control areas of the brain; from the cortex -through the cortico-ponto-cerebellar fibers-, from the reticular formation, and the vestibular nuclei etc…

The main function of the cerebellum is coordination of motor movement; the sequencing and timing of motor activities, especially in *rapid* movement assuring a *coordinated and smooth* movement. Other main function is comparison/monitoring (comparator); comparing actual movement with the intended movement, then making certain corrections and sending corrected signals back to the cerebral cortex via the thalamus. Without these functions, the motor movement will be broken down (absence of smooth progression from one muscle movement to the next) resulting in tremor, ataxia, dysmetria, and dyssynergia etc… (all referring to uncoordinated muscle movement)

Anatomically, the cerebellum is located in the posterior cranial fossa and lies behind the 4th ventricle. A superior view would show the anterior, posterior, and flocculonodular lobes. Inferior view shows peduncles and etc…

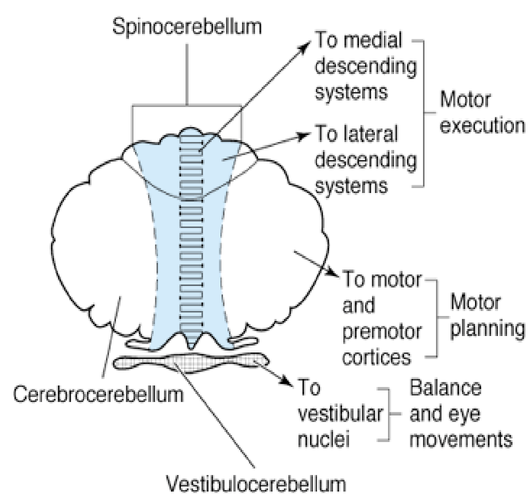
From a developmental point of view the oldest is the flocculonodular which explains why it belongs to the *archicerebellum* that -in terms of function- is called the vestibulocerebellum because it is connected to the vestibular system through efferent and afferent fibers.

- **Functional divisions of the cerebellum:**

1. Vestibulocerebellum: represented by the flocculonodular lobe, and part of the vermis.

2. Spinocerebellum: represented by most of the vermis, and paravermis (also called intermediate zone of the hemisphere)

3. Cerebrocerebellum: most lateral part of the hemispheres, associated with the cerebral cortex, and unlike the latter two, it does not receive fibers from the peripheral parts of the body.



- **Longitudinal functional parts of the cerebellum:**

1. Vermis (central area): works in conjugation with the flocculonodular lobe to control vestibular function.

Any disturbance in the areas of the vestibulocerebellum will result in disequilibrium, and abnormal eye movement which we call *nystagmus.*

In this area (vermis), cerebellar control of the axial muscles, shoulder and hip girdle takes place.

2. Intermediate zone/paravermis: immediately lateral to the vermis. Being part of the spinocerebellum, it is concerned with controlling motor activity of the distal parts of the upper and lower limbs.

Note: the spinocerebellum executes its motor control through a medial descending pathway in the vermis, and a lateral descending pathway in the paravermis.

3. Lateral zone: works along with cerebral cortex in the **planning** of coordinated motor movement.

- **Deep nuclei of the cerebellum:**

- Each functional part of the cerebellum has deep nuclei through which the efferent fibers pass, after having originated in the cortex of the corresponding functional part.

- Vermis (and flocculonodular lobe): an efferent pathway that originates in the vermis passes through the ***fastigial nuclei***

- Intermediate zone: an efferent originating in this area then passes to the ***interposed nucleus*** (to both of its parts the globose and the emboliform)

- Lateral zone: fibers pass to the ***dentate nucleus***

- Also, there's a nucleus in the medulla called the lateral vestibular nucleus, and has direct connections with the flocculonodular lobe, this is why functionally and not structurally it can be considered part of the deep cerebellar nuclei .

Now, the cortex of the cerebellum – similarly to the cerebral cortex- has topographical representation of body parts; axial, hip and shoulder girdle lie in the vermis, whereas the distal parts of the limbs and facial region lie in the intermediate zone.

As mentioned previously, the lateral zones do not have topographical representations, and receive input almost exclusively from the cerebral cortex.

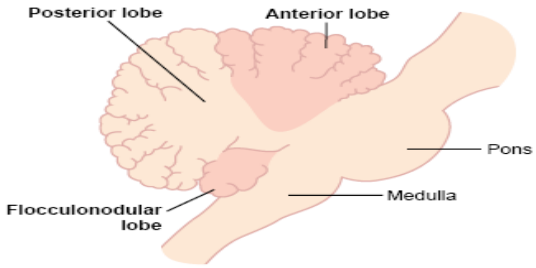
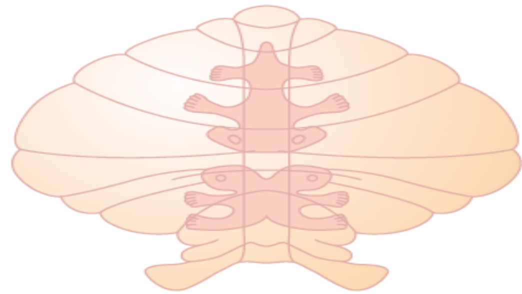


Figure 56–1



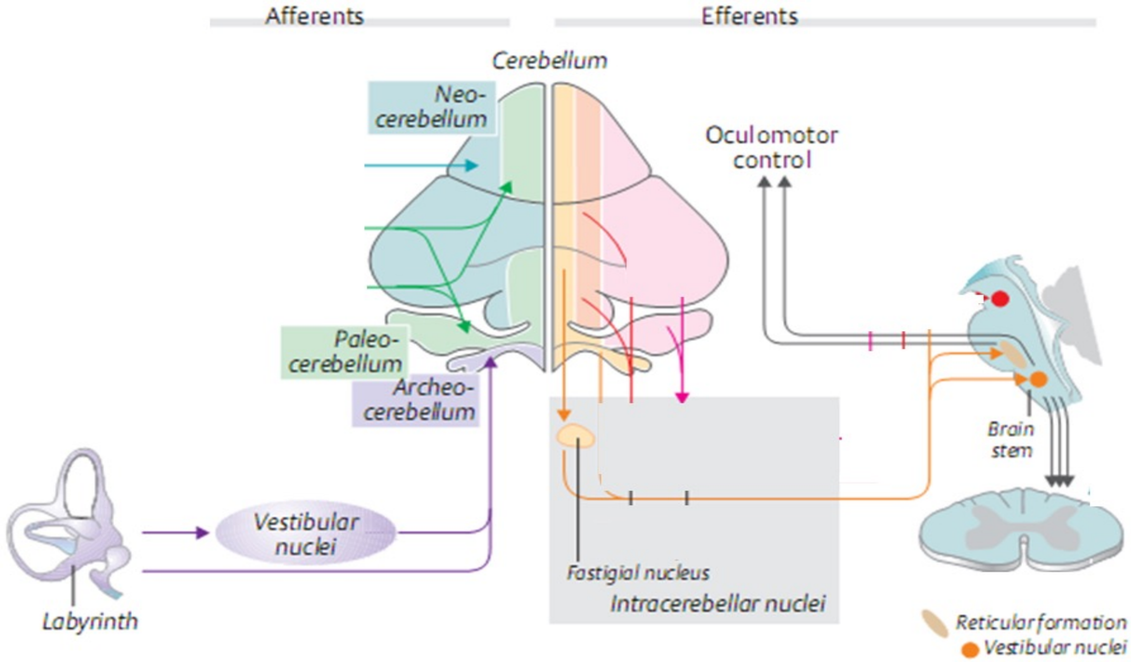
- **Vestibulocerebellum and control of equilibrium:**

The afferent vestibulocerebellar fibers originate from either: (1) the vestibular system (vestibular nuclei in the brain stem) or (2) the vestibular apparatus itself. Almost all of these terminate in the flocculonodular lobe and fastigial nucleus, delivering information concerning balance and position.

Efferent fibers then leave from the fastigial nucleus to: (1) the reticular formation (fastigioreticular tract), (2) vestibular nuclei, and (3) motor nuclei of certain cranial nerve,,

Now these three parts send their efferent as vestibulospinal and reticulospinal fibers that arise next adjust the axial, hip and shoulder muscle contractions(antigravity muscles) , and this is how equilibrium is regulated. Efferent fibers synapsing in the motor nuclei of cranial nerves that supply the extra-ocular muscles regulate the eye movement.

This figure shows afferent and efferent fibers of the vestibulocerebellum:



- **Spinocerebellum and control of distal limb movements:**

The spinocerebellum receives afferents from: (1) peripheral body through the spinocerebellar tract, and (2) the cerebral cortex and brain stem telling the cerebellum about the intended movement through olivocerebellar, reticulocerebellar, vestibulocerebellar tracts and etc…

The corticospinal tract sends divergent signals to the intermediate zone

From the periphery it receives two main pathways: dorsal spinocerebellar and ventral spinocerebellar.

- Dorsal spinocerebellar:

Receives its information from muscle spindles, Golgi tendon organs, and from large tactile receptors. These tell the cerebellum about the actual movement, in terms of length and tension, as well as the rate of change in length and tension (velocity), which is eventually an important function for the prediction of the position of the body after a certain time interval.

This tract is uncrossed, it goes ipsilateral only.

- Ventral spinocerebellar:

Does not reach these receptors, instead, it receives information from the alpha motor neurons. When the alpha motor neurons receive a collection of signals (both inhibitory and excitatory) from different descending pathways, it generates what is known as the ***grand potential***, which is the impulse that is being transmitted to the muscles.

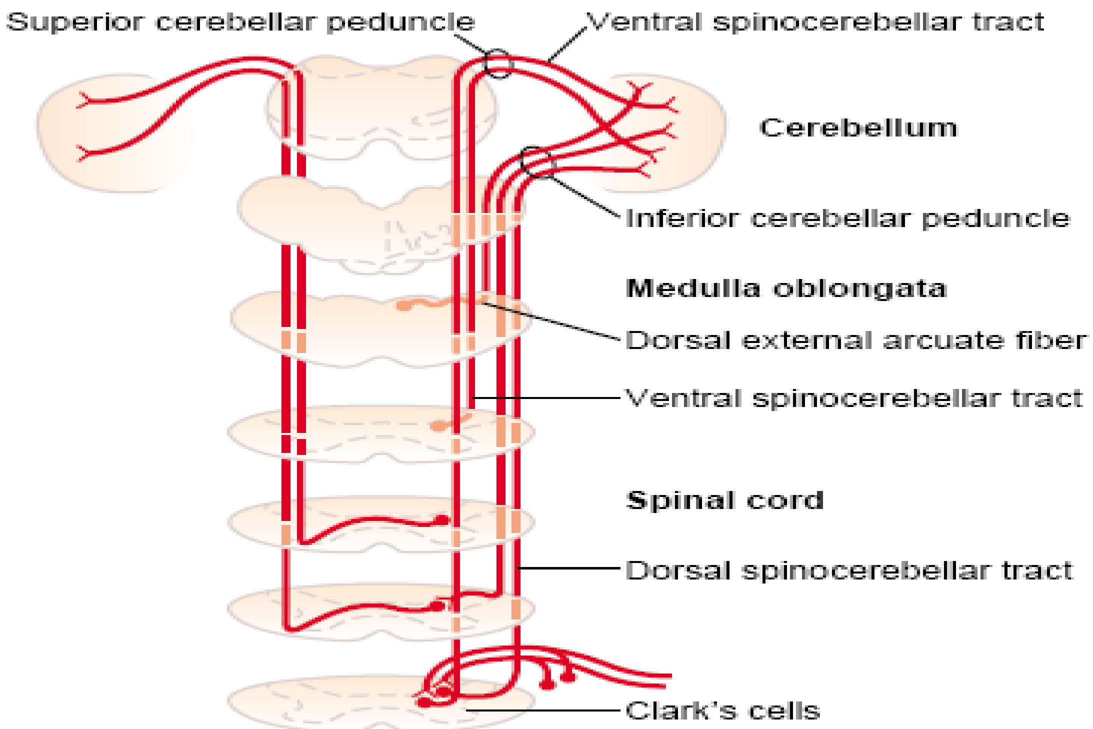
The job of the ventral spinocerebellar tract is to send a copy of this grand potential to the cerebellum. This tract is bilateral (affects ipsilateral and contralateral areas.)

After the spinocerebellum receives these input from different sources, it will compare these together and integrate the information after the comparison, then it might send corrective commands to the thalamus (VA, VL nuclei) and back to the cerebral cortex, so it could send another corrected command.

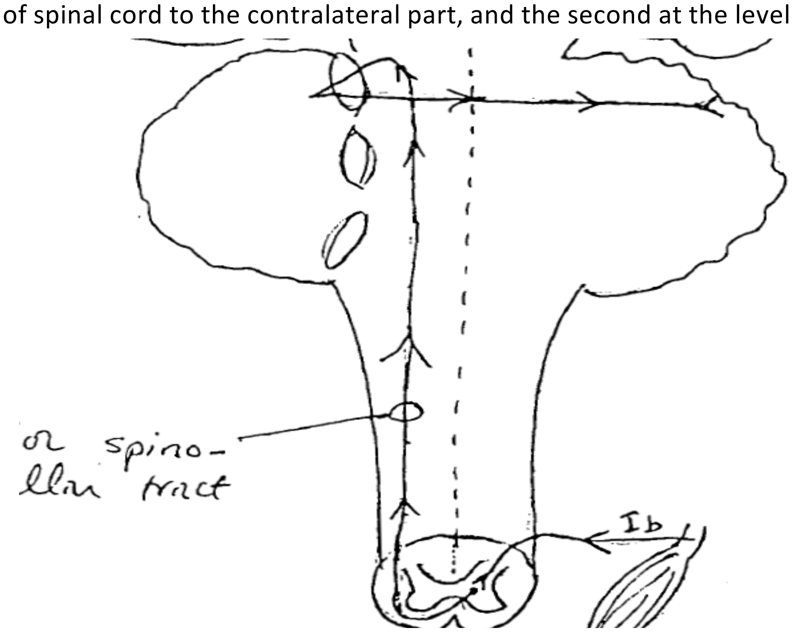
** The cerebral cortex never sends the exact required signal, usually sends either more or less.

- The efferent fibers of spinocerebellum then pass through the interposed nucleus to the VL and VA nuclei of the thalamus, then to: (1) cerebral cortex, (2) basal ganglia and (3) red nucleus, reticular formation (fastigioreticular tract) of brain stem and (4) vestibular nuclei (fastigiovestibular tract) where correction could take place. The corrected commands are then carried through the corticospinal and rubrospinal tracts down the spinal cord to the distal muscles of the limbs.

The below figure shows the **bilateral** ventral spinocerebelluar tract and **unilateral** dorsal spinocerebellar.



- As it is seen in this figure, afferent fibers to the cerebellum are double crossed (crossed two times), first one at the level of spinal cord to the contralateral part, and the second at the level of the brain stem back to the same side that it was on, that's why the effect of cerebellum on muscles is ipsilateral (right half of cerebellum controls the right body muscles and the left half of it controls the left body muscles) unlike cerebral hemispheres which affect the contralateral side of the body.



- **Cerebrocerebellum function in planning sequenced and timed movements:**

The cerebrocerebellum receives input from: (1) all the different parts of the cerebral cortex; motor areas, and primary and association somatosensory areas, which provides motor information as well as information concerning the posture of the body (from the somatosensory). The afferent fibers carrying this input are the cortico-ponto-cerebellar fibers. (2) the inferior olive, and even the vestibular nuclei -but are not exactly the same as the ones reaching the flocculonodular lobe-.

The efferents fibers then leave from the cortex of the cerebellum to the dentate nucleus, and from there it leaves to the VA, VL nuclei of the thalamus and synapses contralaterally**. Finally, it reaches the cerebral cortex to aid in the programming of the movement.

** contralateral synapse: due to this, double crossing of the fibers occurs, which means any lesion will result in an ipsilateral manifestation.

- **Important note:**

Since the afferent fibers of the cortico-ponto-cerebellar tract transmit signals faster than the spinocerebellar fibers, a type of correction can take place even before receiving information about the actual movement.

Meaning, correction of the commands can occur in two ways: through a long loop that is after receiving information about the actual movement through spinocerebellar tracts , OR through the upward cortico-ponto-cerebellar pathway (that is before receiving input from the periphery.)

- **So what are the functions of the cerebellum?**

1. Regulation of equilibrium:

When the equilibrium is disturbed -either acceleration or deceleration-, this information is brought up by the vestibular system to the vestibulocerebellum, which initiates immediate corrected signals to the vestibular nuclei and reticular formation, those being part of the medial system pathways, adjust the antigravity muscles (posture) which helps to maintain equilibrium.

- Diseases of the inner ear (affecting the apparatus) disturb this equilibrium -that could manifest as a sense of dizziness-, as well as any damage to any part of the process mentioned above.

Within the context of equilibrium, it is important to mention that a coordination between the exposure to acceleration and the movement of the head must be maintained. This is accomplished through the association between the vestibular nuclei, the superior colliculus and the medial longitudinal bundle. Effects are executed through the tecto-spinal tract which arises from the superior colliculus.

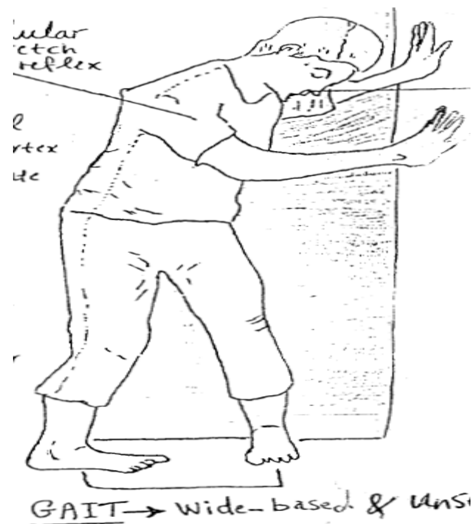
If this coordination is lost, it ends with nystagmus*.

* Nystagmus : inability to fix the eyes on a specific object (dancing eyes.)

2. Regulation of posture (axial and antigravity muscles):

If there is any abnormality in this regulation, the body is going to sway (being unable to correct your posture), and to prevent the body from falling down the person would have a wide based gait also known as the drunken sailor gait.

The test performed by policemen to assess the balance of a drunk person is called the heel-to-toe test or tandem test.



3. Coordination of voluntary movement:

It means the ability of the person to progress smoothly and precisely from one movement to the next. This is accomplished through the mechanisms mentioned earlier in the sheet (spinocerebellum and [1] comparator function between the actual movement and intended command .)

All body movements (which are basically flexion and extension) resulting from the commands of the cerebral cortex are pendular (resembling the movement of a pendulum); oscillating back and forth, unable to stop at the intended point for several cycles before it eventually settles (this is due to the development of momentum by the stimulated body part). To prevent this, the cerebellum coordinates the movement by sending stop signals at the right time, thus working as a ***damping system***.

The cerebellum is able to do this through the information it receives about the *rate of change* in muscle activity. ([2] prediction of body position)

The correction is active and occurs very fast that it goes unnoticed.

[3] Planning of sequential movement, especially rapid movements (ballistic movements).

[1],[2] and [3] are mechanisms by which the cerebellum coordinates movement.

4. The role of cerebellum in learning of motor skills:

for example when a child first learns how to write they usually apply too much pressure holding the pencil and struggle to do this, this is because the movement is principally cortical and cerebellum is not yet fully functional, as the cerebellum develops and begins aiding in the programming of this movement, corrections are applied to enhance the skill.

*Same concept applies to car driving during first period after taking license.

"The cerebellum learns by its mistakes –that is, if a movement does not occur exactly as intended, the cerebellar circuit learns to make a stronger or weaker movement the next time."

5. The role of the cerebellum in ballistic movements:
   - Ballistic movements usually are movements of agonist then antagonist muscles in a very fast manner .

"Ballistic movements, such as the movements of the fingers in typing, occur so rapidly that it is not possible to receive feedback information about it. These are called ballistic, meaning that the entire movement is preplanned and set into motion to go a specific distance and then stop." Guyton, page 688

"The human brain is a wonderful organ. It starts to work as soon as you are born and doesn't stop until you stand up to speak in public."