Cerebellum

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Objectives

- The cerebellum plays a very important role in the control of posture and voluntary movements.
- It unconsciously influences the smooth contraction of voluntary muscles and carefully coordinates their actions, together with the relaxation of their antagonists.
- It is suggested that the reader commit the functions of the connections of the cerebellum to the remainder of the central nervous system to memory, as this will greatly assist in the retention of the material.
- Great emphasis is placed on the fact that each cerebellar hemisphere controls muscular movements on the same side of the body and that the cerebellum has no direct pathway to the lower motor neurons but exerts its control via the cerebral cortex and the brainstem.

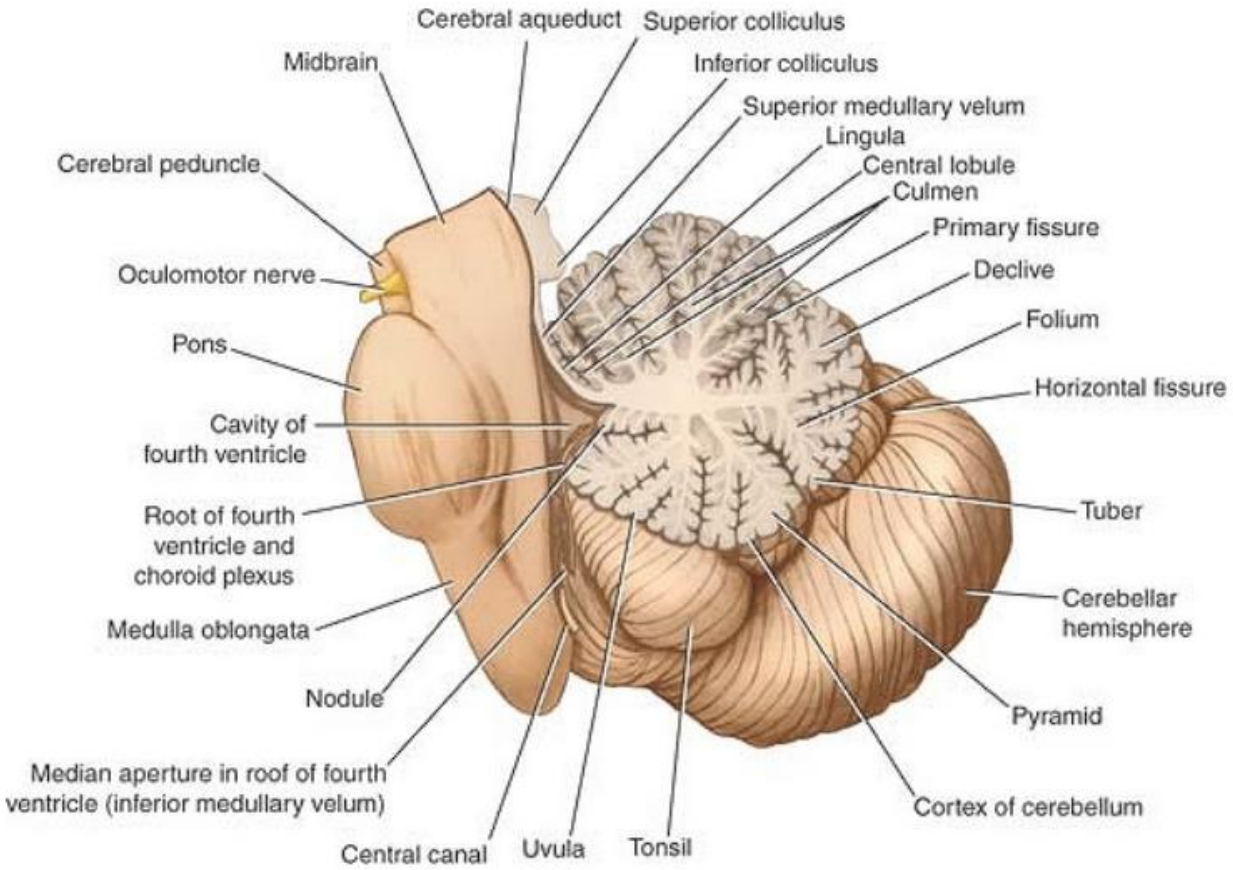
Gross Appearance of the Cerebellum

Cerebellum is situated in the posterior cranial fossa

And is covered superiorly by the tentorium cerebelli.

Largest part of the hindbrain

And lies posterior to the fourth ventricle, the pons, and the medulla oblongata .



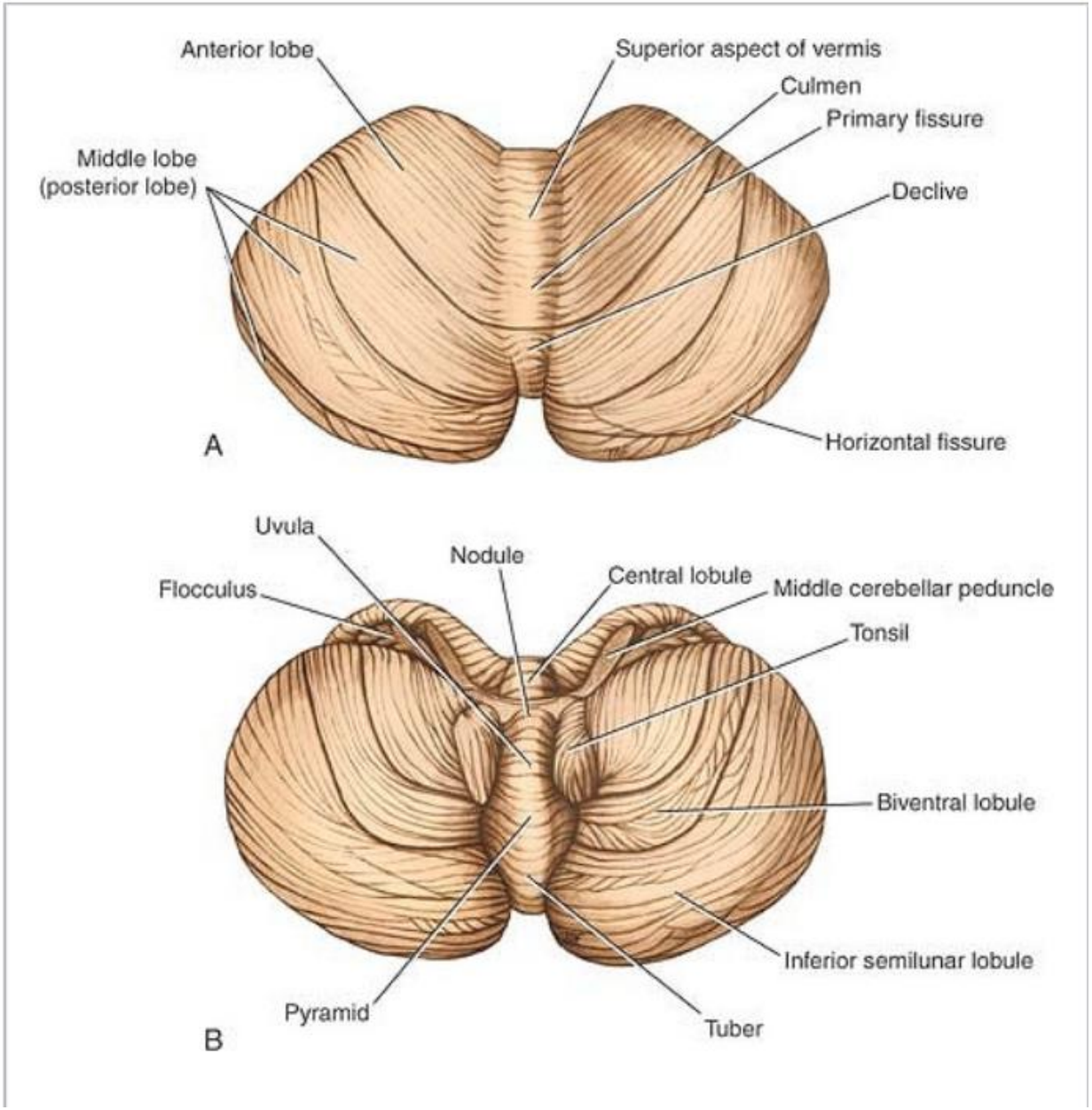
Gross Appearance of the Cerebellum

Cerebellum is somewhat ovoid in shape

And constricted in its median part.

It consists of two cerebellar hemispheres joined by a narrow median vermis.

Cerebellum is connected to the posterior aspect of the brainstem by three symmetrical bundles of nerve fibers called the superior, middle, and inferior cerebellar peduncles.



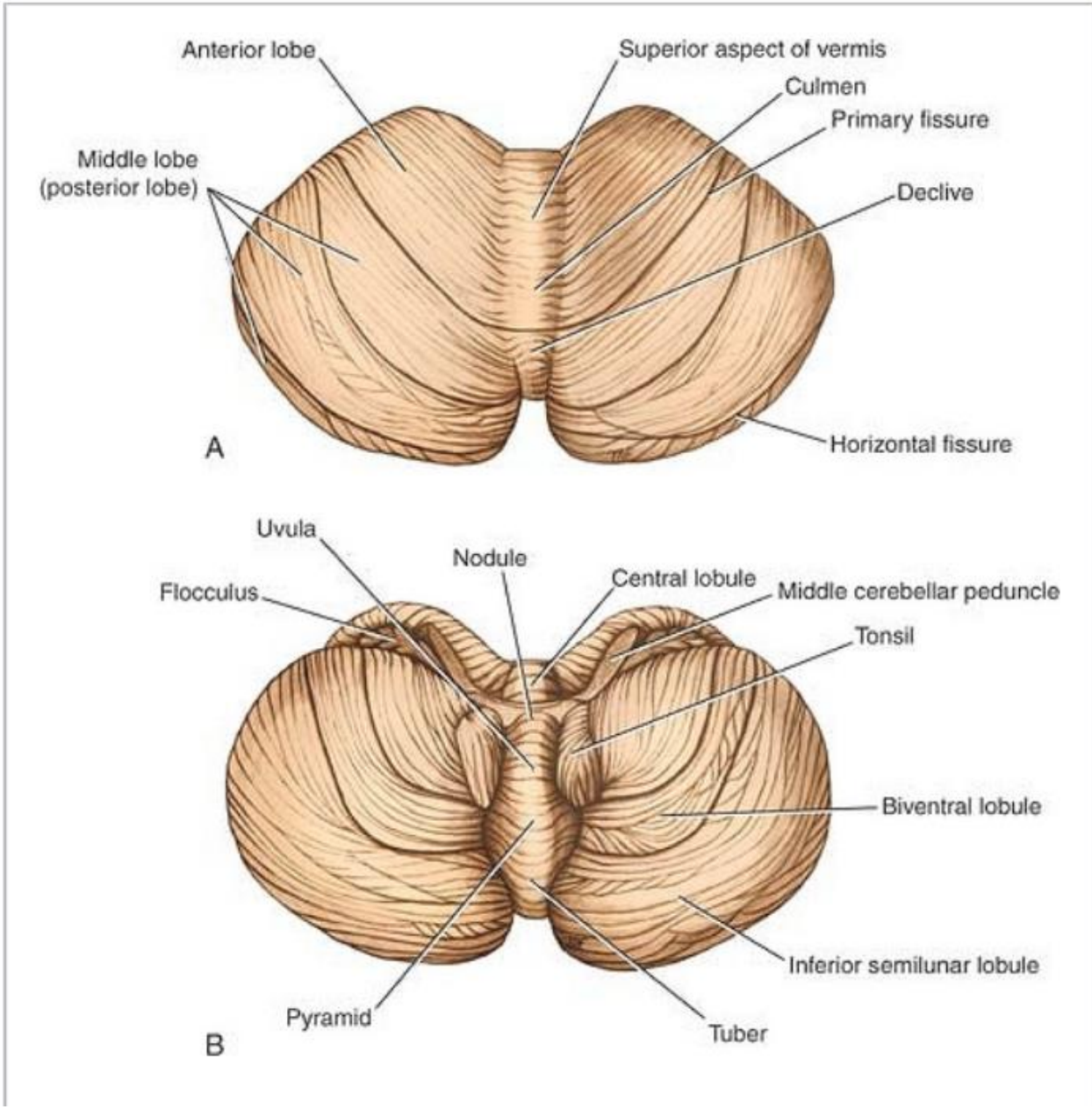
Gross Appearance of the Cerebellum

Cerebellum is divided into three main lobes:

Aanterior lobe, the middle lobe and the flocculonodular lobe.

The anterior lobe may be seen on the superior surface of the cerebellum

And is separated from the middle lobe by a wide V-shaped fissure called the primary fissure.

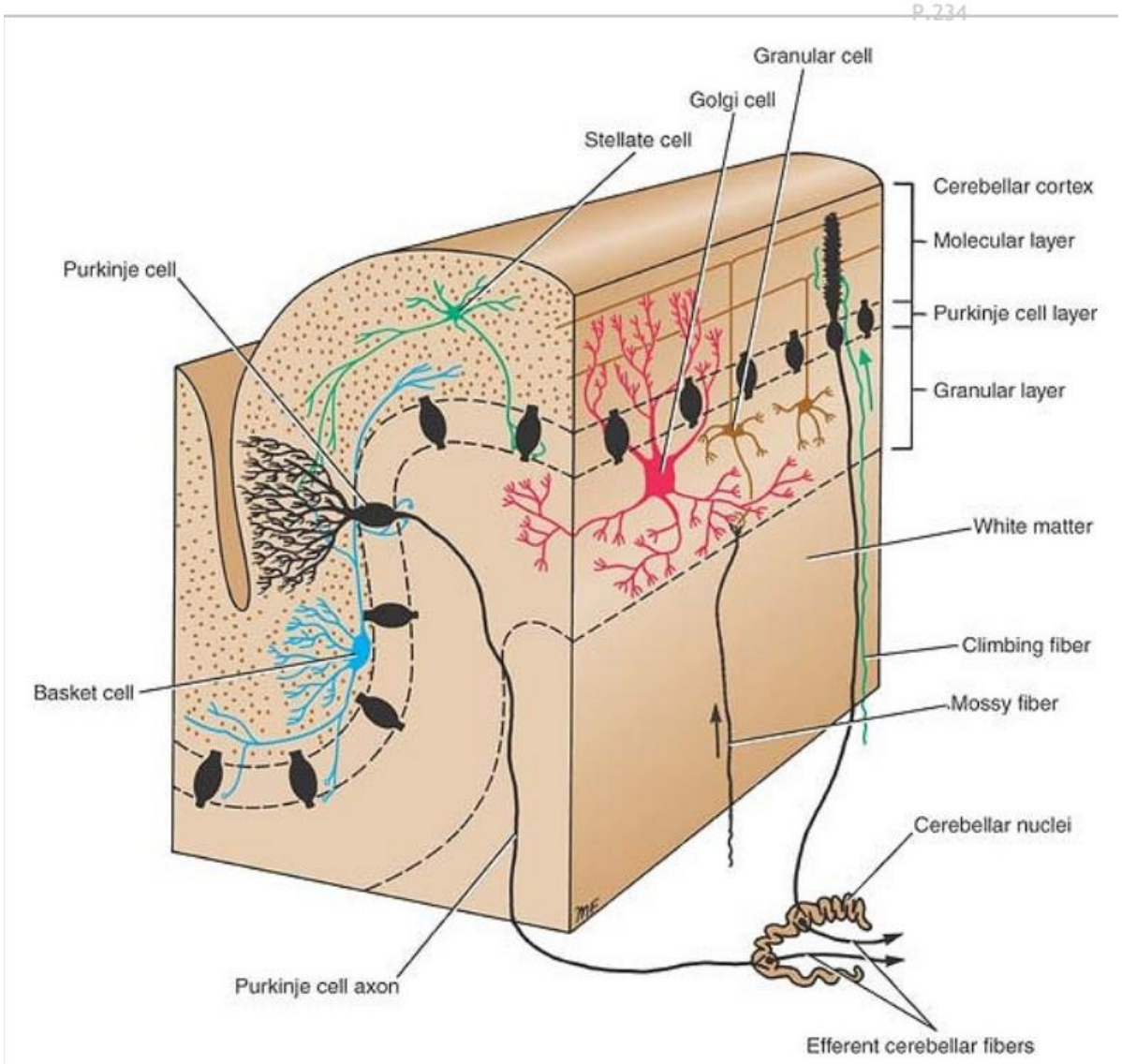


Structure of the Cerebellum

- The cerebellum is composed of an outer covering of gray matter called the cortex and inner white matter.
- Embedded in the white matter of each hemisphere are three masses of gray matter forming the intracerebellar nuclei.

Structure of the Cerebellar Cortex

- Gray matter of the cortex throughout its extent has a uniform structure.
- It may be divided into three layers:
- (1) An external layer, the molecular layer
- (2) A middle layer the Purkinje cell layer and
- (3) An internal layer, the granular layer



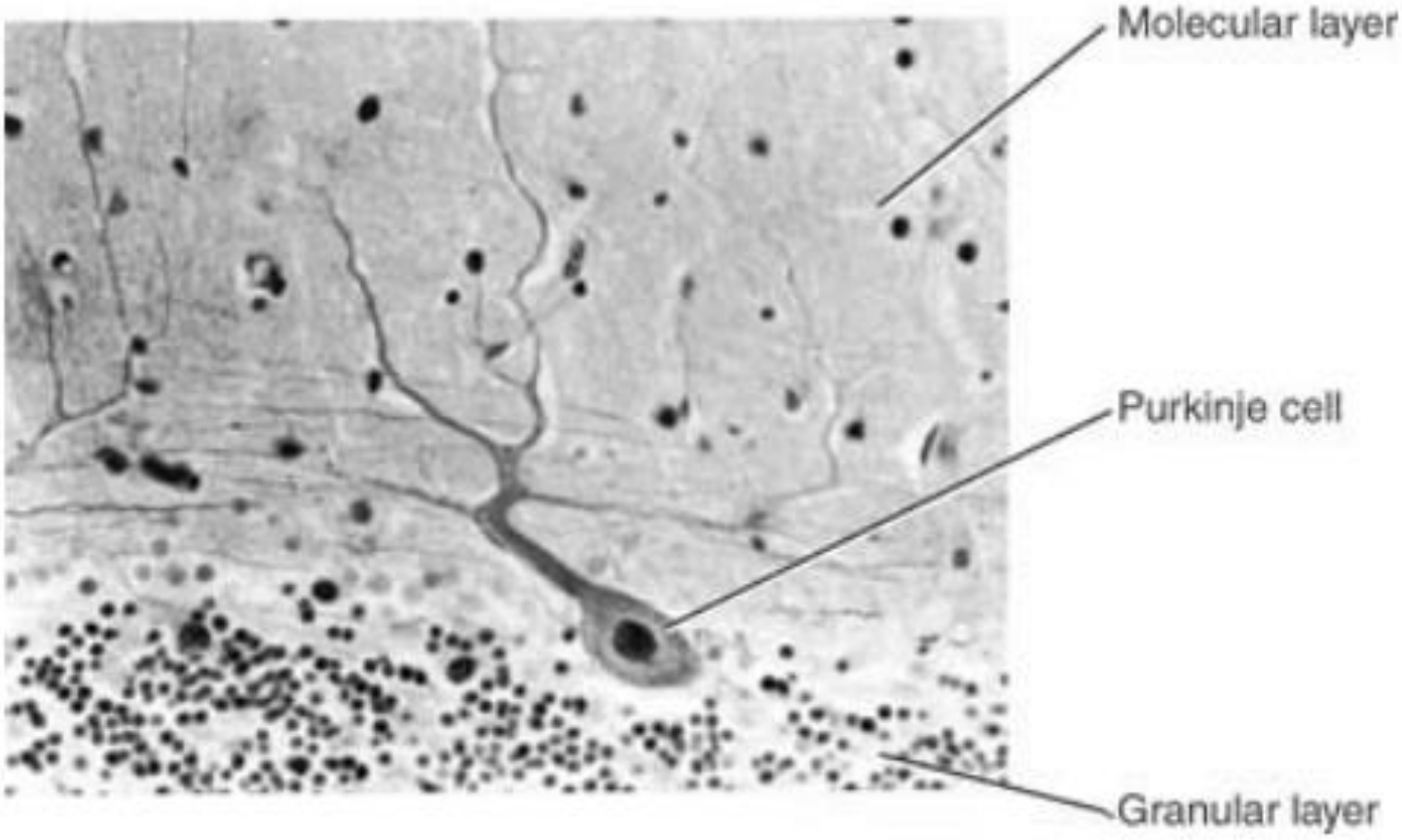
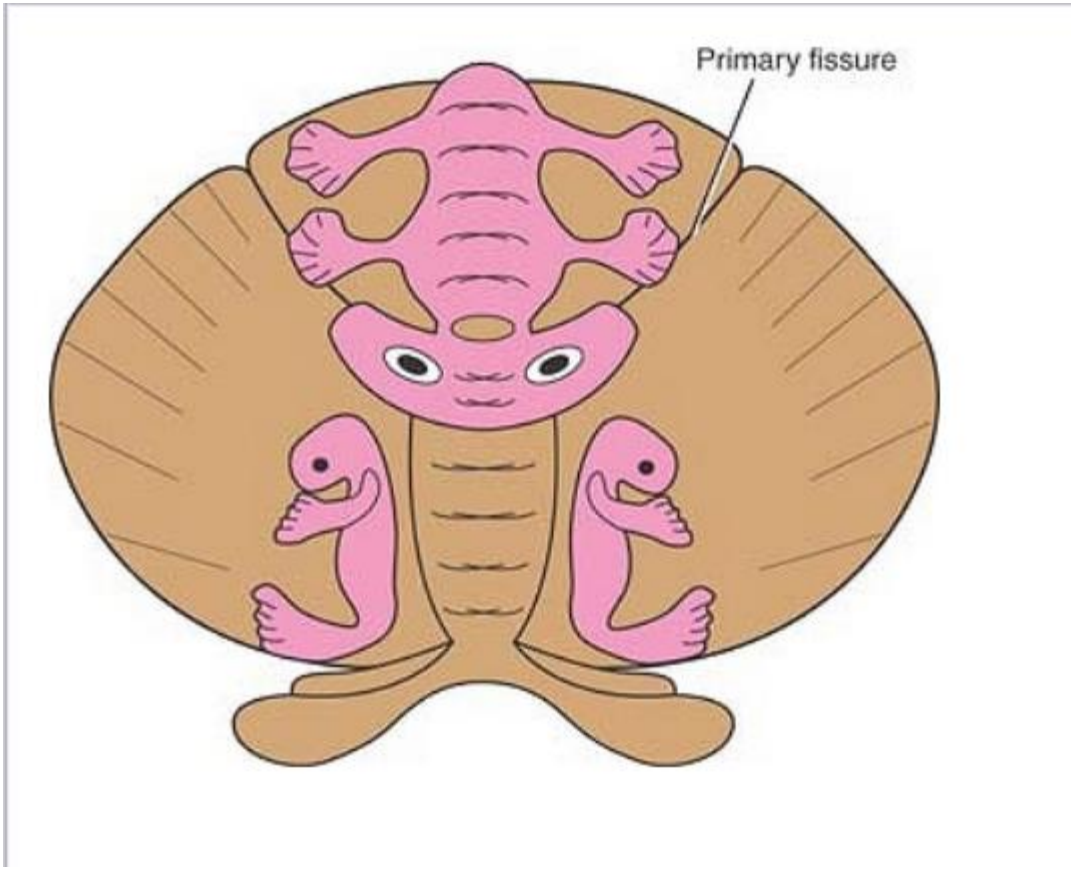


Figure 6-5 Photomicrograph of a cross section of a cerebellar folium, showing the three layers of the cerebellar cortex.

Functional Areas of the Cerebellar Cortex

Clinical observations by neurologists and neurosurgeons

- And the experimental use of the positron emission tomography scan have shown
- that it is possible to divide up the cerebellar cortex into three functional areas.

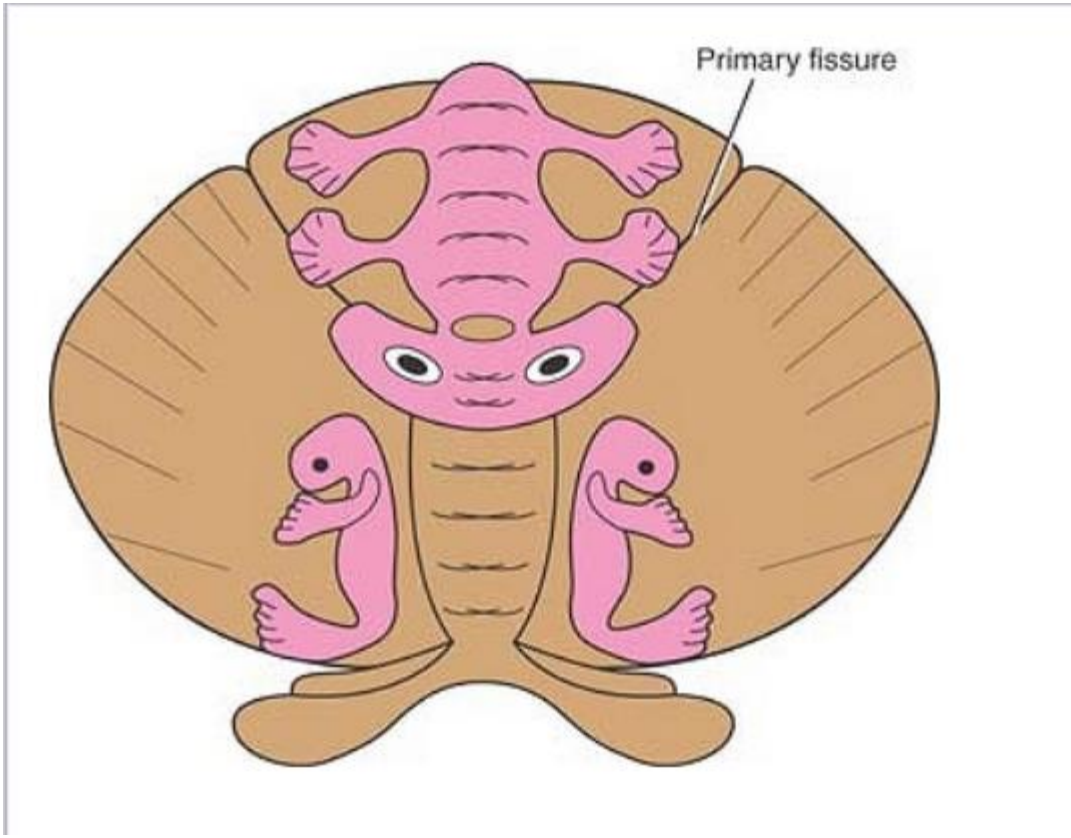


Cortex of the vermis

- Influences the movements of the long axis of the Body i.e
- the neck,the shoulders, the thorax, the abdomen, and the hips .

Functional Areas of the Cerebellar Cortex

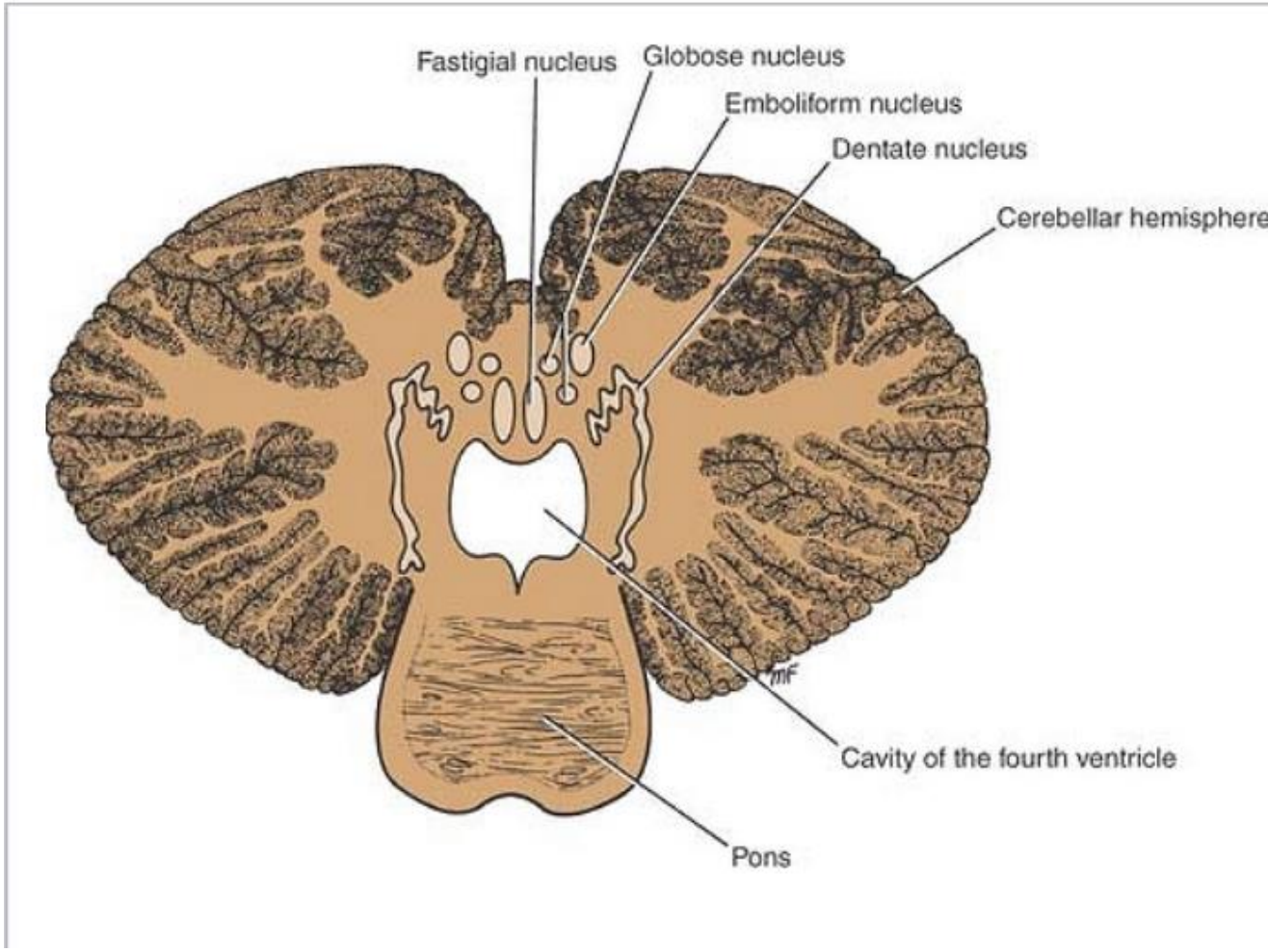
- Immediately lateral to the vermis is a so-called intermediate zone of the cerebellar hemisphere.
- This area has been shown to control the muscles of the distal parts of the limbs, especially the hands and feet .
- lateral zone of each cerebellar hemisphere appears to be concerned with
- The planning of sequential movements of the entire body
- And is involved with the conscious assessment of movement errors



Intracerebellar Nuclei

- Four masses of gray matter
- Are embedded in the white matter of the cerebellum on each side of the midline.
- From lateral to medial, these nuclei are

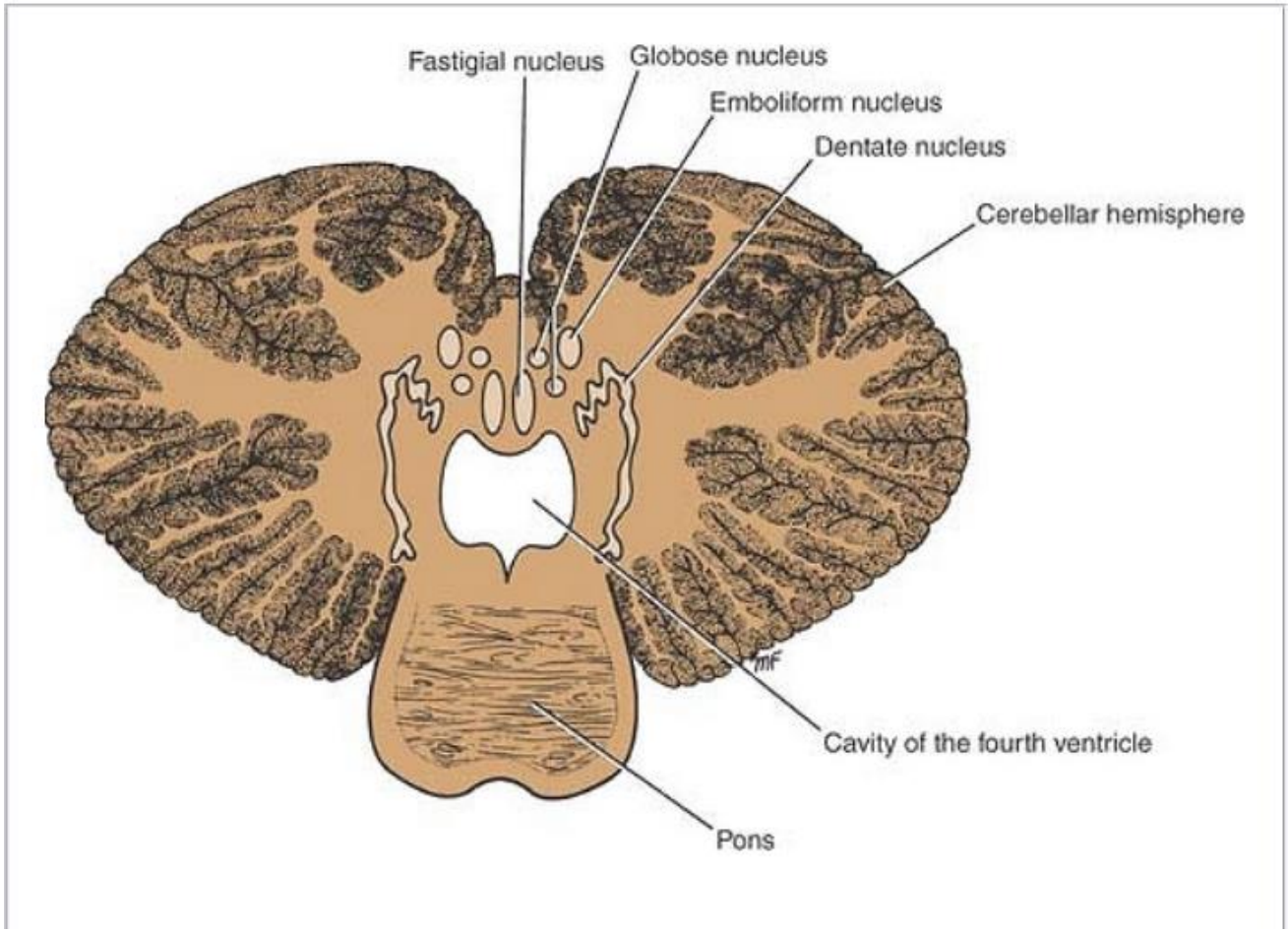
1- Dentate
2- Emboliform
3- Globose and the
4- Fastigial.



Intracerebellar Nuclei

Dentate nucleus

- Is the largest of the cerebellar nuclei.
- It has the shape of a crumpled bag with the opening facing medially.
- Interior of the bag is filled with white matter made up of efferent fibers
- That leave the nucleus through the opening to form a large part of the superior cerebellar peduncle.



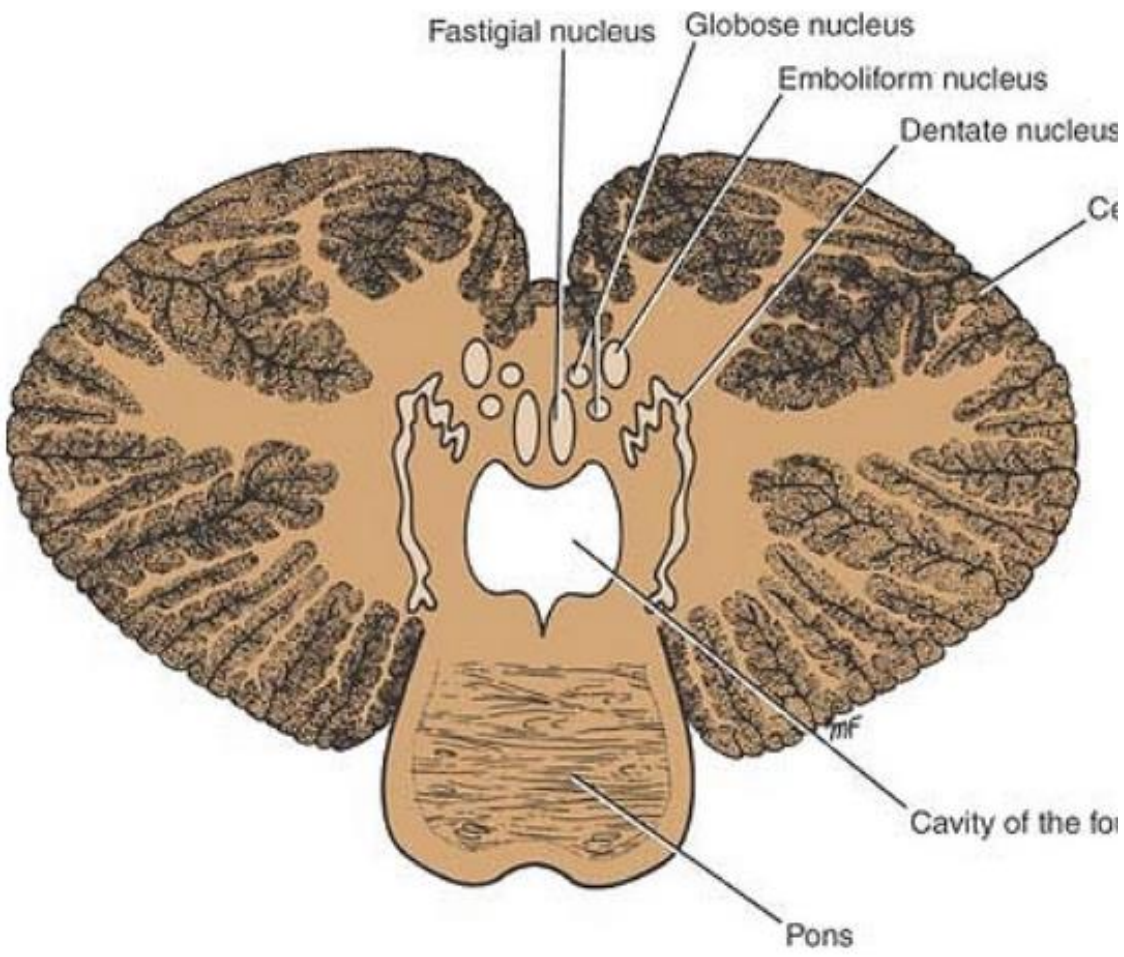
Intracerebellar Nuclei

Emboliform nucleus

- Is ovoid shape
- And is situated medial to the dentate nucleus
- Partially covering its hilus .

Globose nucleus

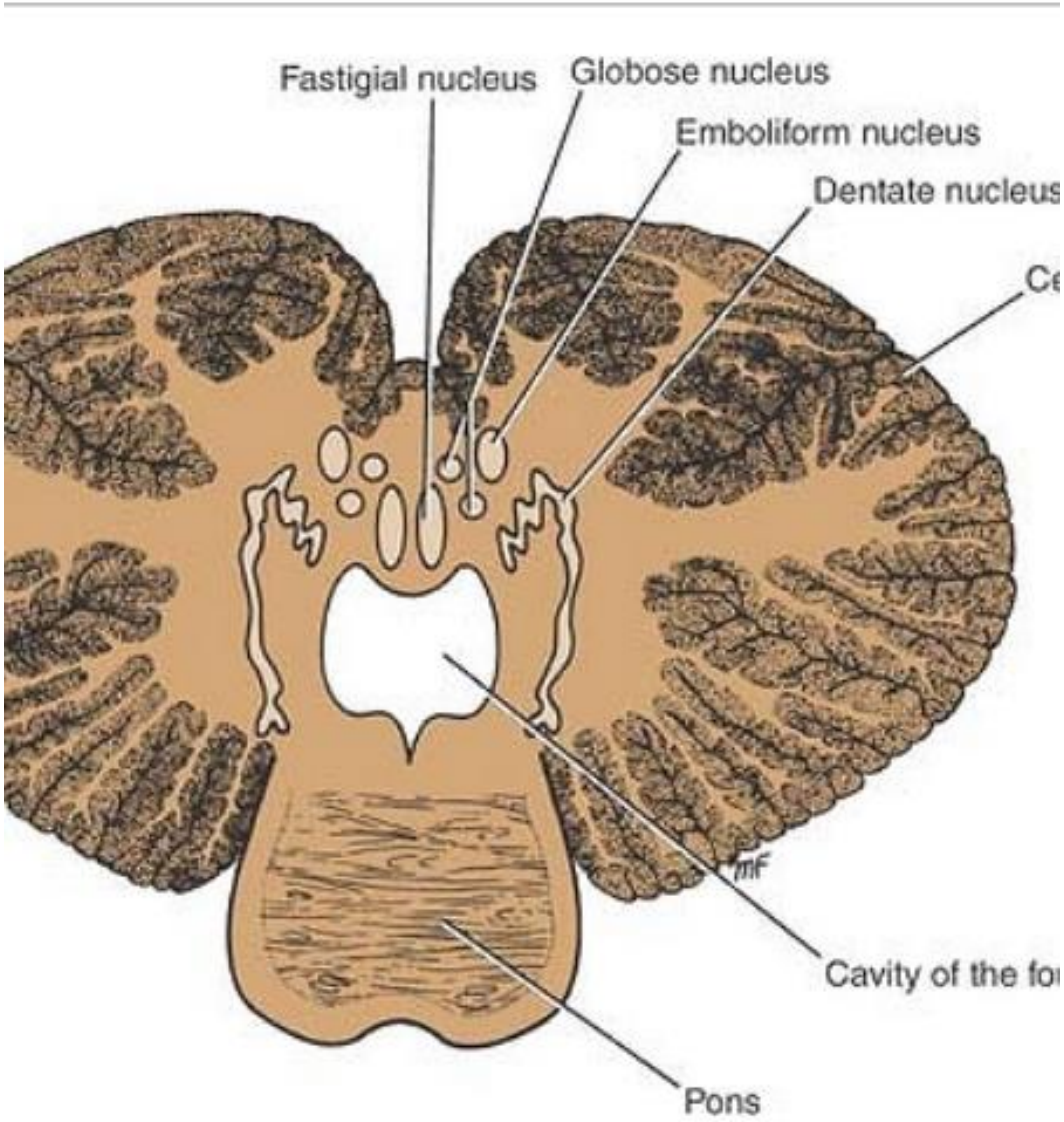
- consists of one or more rounded cell groups
- That lie medial to the emboliform nucleus .



Intracerebellar Nuclei

Fastigial nucleus

- lies near the midline in the vermis
- And close to the roof of the fourth ventricle
- It is larger than the globose nucleus .
- Intracerebellar nuclei are composed of large, multipolar neurons with simple branching dendrites.
- The axons form the cerebellar outflow in the superior and inferior cerebellar peduncles.



Cerebellar Afferent Fibers From the Cerebral Cortex

The cerebral cortex sends information to the cerebellum by three pathways:

(1) the corticopontocerebellar pathway,
(2) the cerebro-olivocerebellar pathway,
(3) the cerebroreticulocerebellar pathway.

Corticopontocerebellar Pathway

Corticopontine fibers

- Arise from nerve cells in the frontal,parietal, temporal, and occipital lobes of the cerebral cortex
- And descend through the corona radiata and internal capsule
- And terminate on the pontine nuclei

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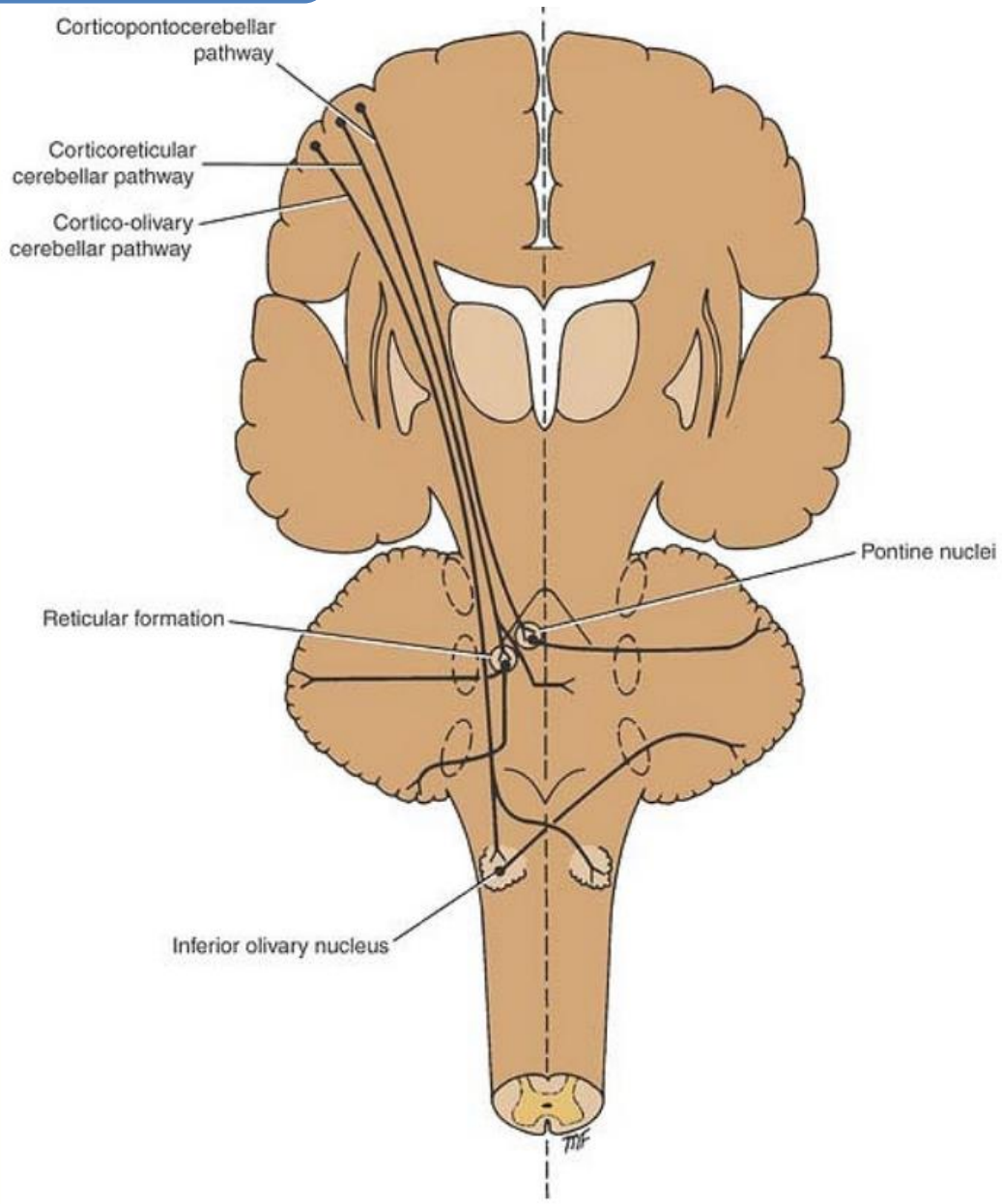
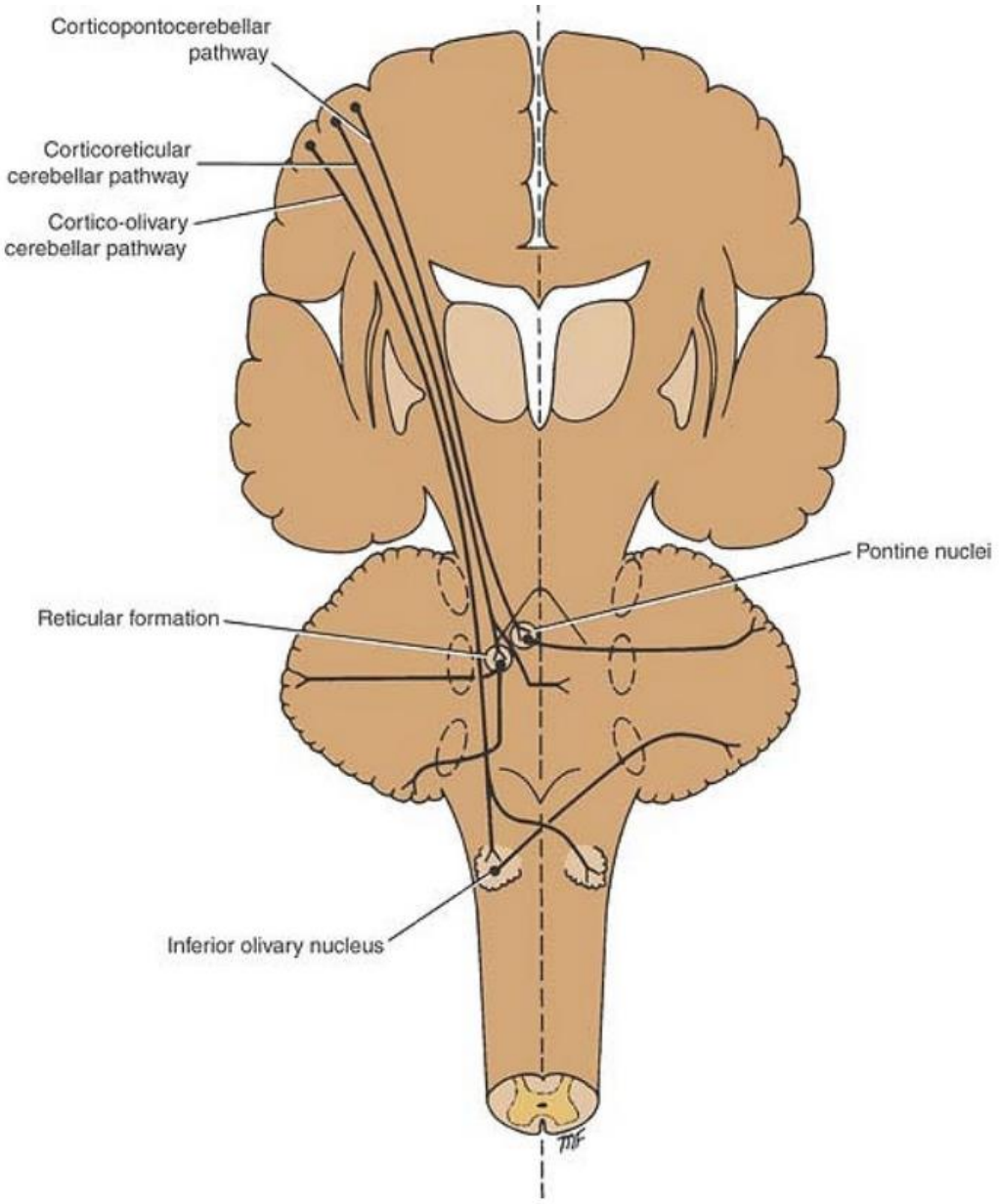


Corticopontocerebellar Pathway

Pontine nuclei

Give rise to the transverse fibers of the pons

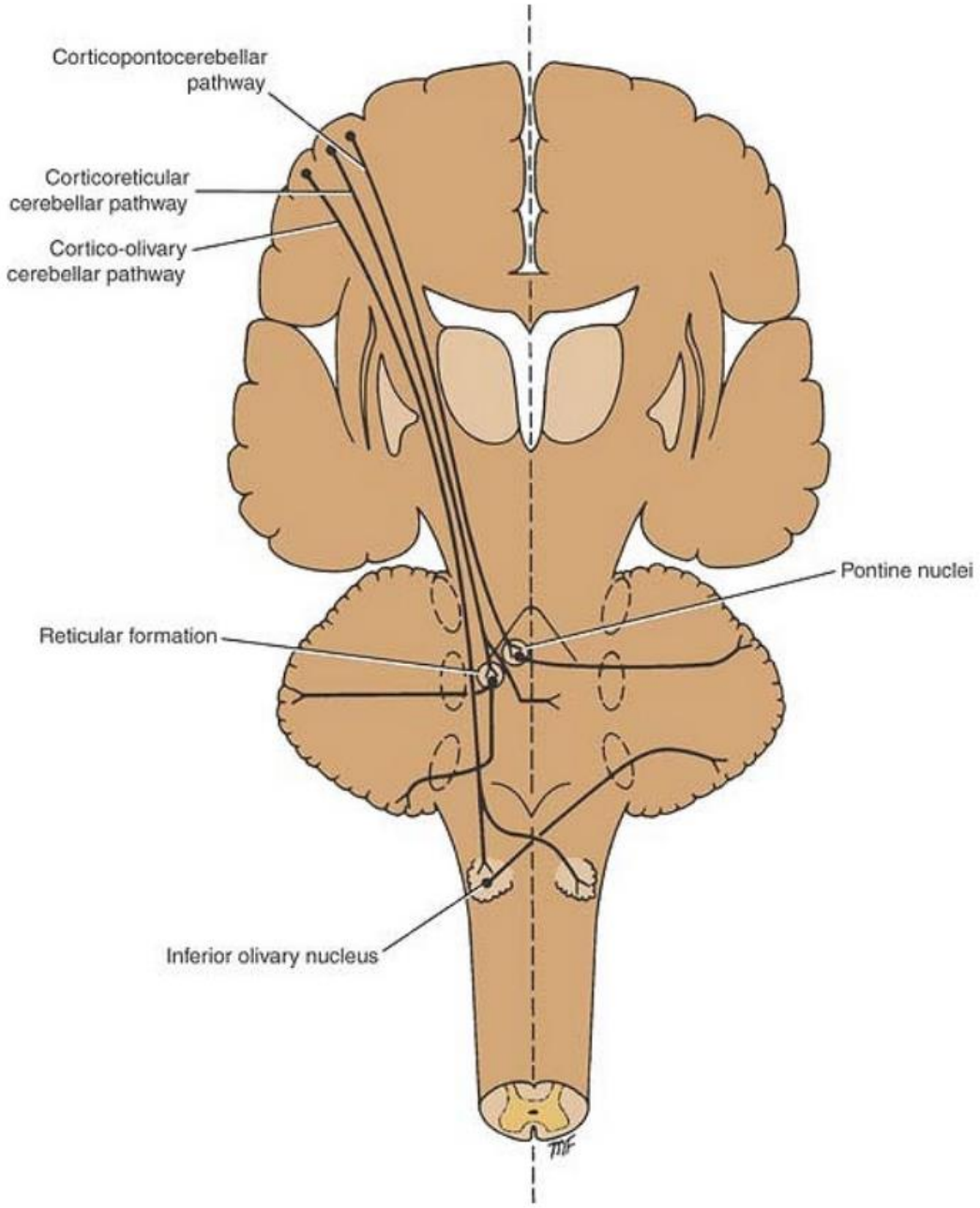
- which cross the midline and enter the opposite cerebellar hemisphere as the middle cerebellar peduncle .



Cerebro-olivocerebellar Pathway

Cortico-olivary fibers

- Arise from nerve cells in the frontal, parietal, temporal, and occipital lobes of the cerebral cortex
- And descend through the corona radiata and internal capsule to
- Terminate bilaterally on the inferior olivary nuclei .
- The inferior olivary nuclei give rise to fibers that cross the midline and enter the opposite cerebellar hemisphere through the inferior cerebellar peduncle.
- These fibers terminate as the climbing fibers in the cerebellar cortex.



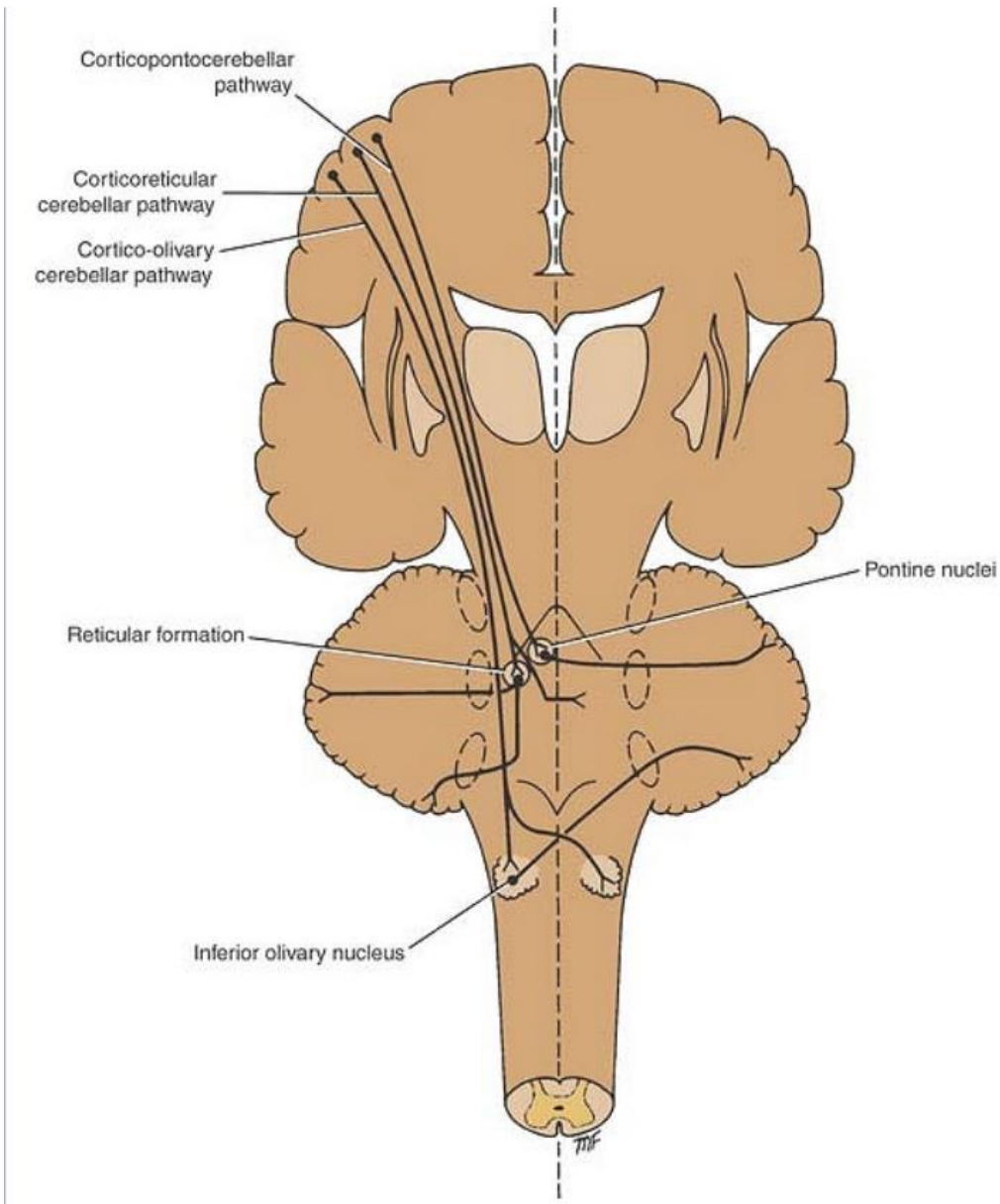
Cerebroreticulocerebellar Pathway

Corticoreticular fibers

- Arise from nerve cells from many areas of the cerebral cortex, particularly the sensorimotor areas.
- They descend to terminate in the reticular formation on the same side
- And on the opposite side in the pons and medulla .
- The cells in the reticular formation give rise to the

Reticulocerebellar fibers

- That enter the cerebellar hemisphere on the same side through the inferior and middle cerebellar peduncles.



Cerebroreticulocerebellar Pathway

- This connection between the cerebrum and the cerebellum is important in the control of voluntary movement.
- Information regarding the initiation of movement in the cerebral cortex is probably transmitted to the cerebellum
- So that the movement can be monitored and appropriate adjustments in the muscle activity can be made.

Cerebellar Afferent Fibers From the Spinal Cord

- The spinal cord sends information to the cerebellum from somatosensory receptors by three pathways:

(1) The anterior spinocerebellar tract,

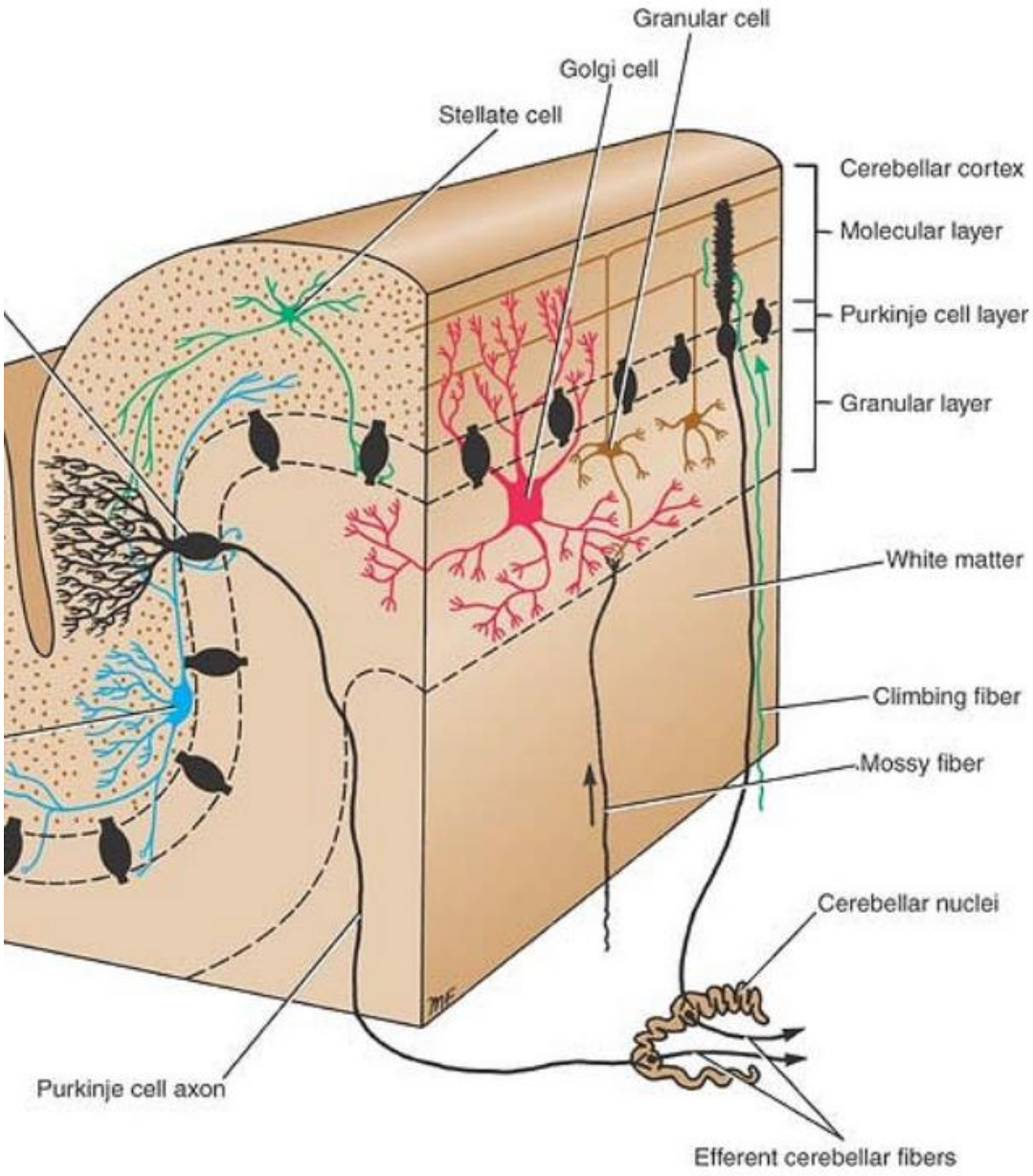
(2) The posterior spinocerebellar tract, and

(3) The cuneocerebellar tract.

(THESE PATHWAYS ALREADY DISCUSS IN CHAPTER OF SPINAL CORD)

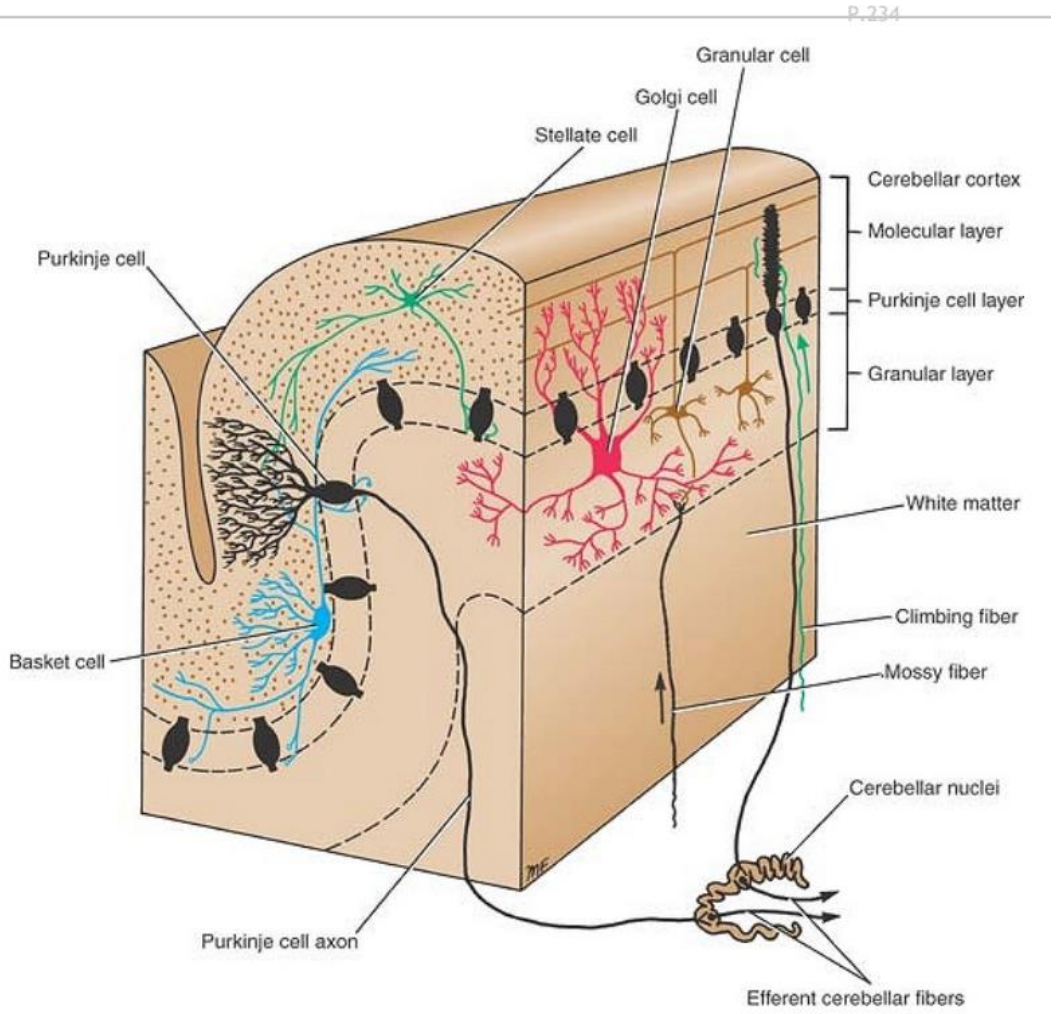
Cerebellar Efferent Fibers

- Entire output of the cerebellar cortex is through the axons of the Purkinje cells.
- Most of the axons of the Purkinje cells end by synapsing on the neurons of the deep cerebellar nuclei .
- The axons of those neurons that from the cerebellar nuclei constitute the efferent outflow from the cerebellum.



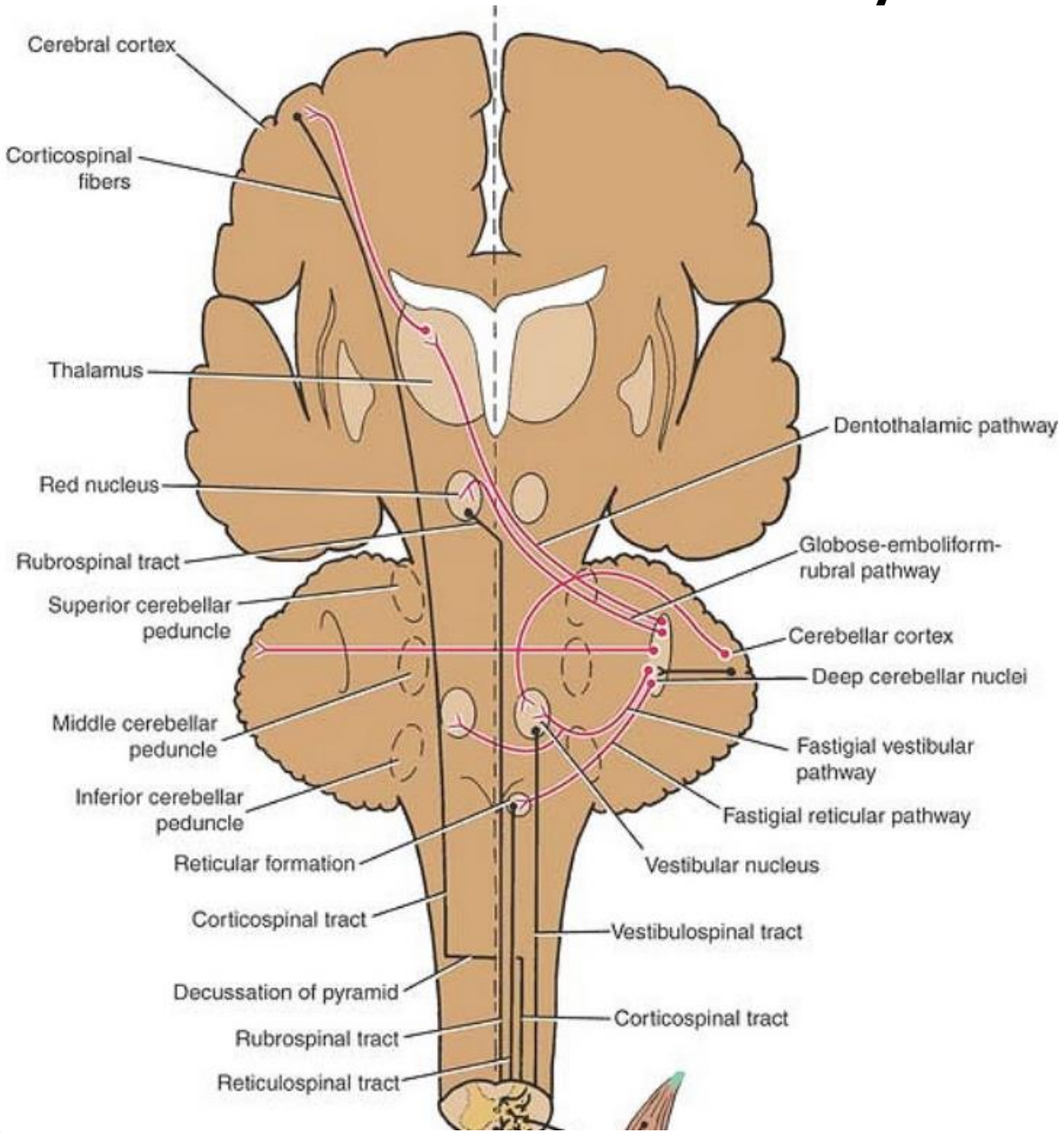
Cerebellar Efferent Fibers

- A few Purkinje cell axons pass directly out of the cerebellum to the lateral vestibular nucleus.
- The efferent fibers from the cerebellum connect with the red nucleus, thalamus, vestibular complex, and reticular formation.



Globose-Emboliform-Rubral Pathway

- Axons of neurons in the globose and emboliform nuclei travel through the superior cerebellar peduncle
- And cross the midline to the opposite side in the decussation of the superior cerebellar peduncles .
- The fibers end by synapsing with cells of the contralateral red nucleus
- which give rise to axons of the rubrospinal tract .

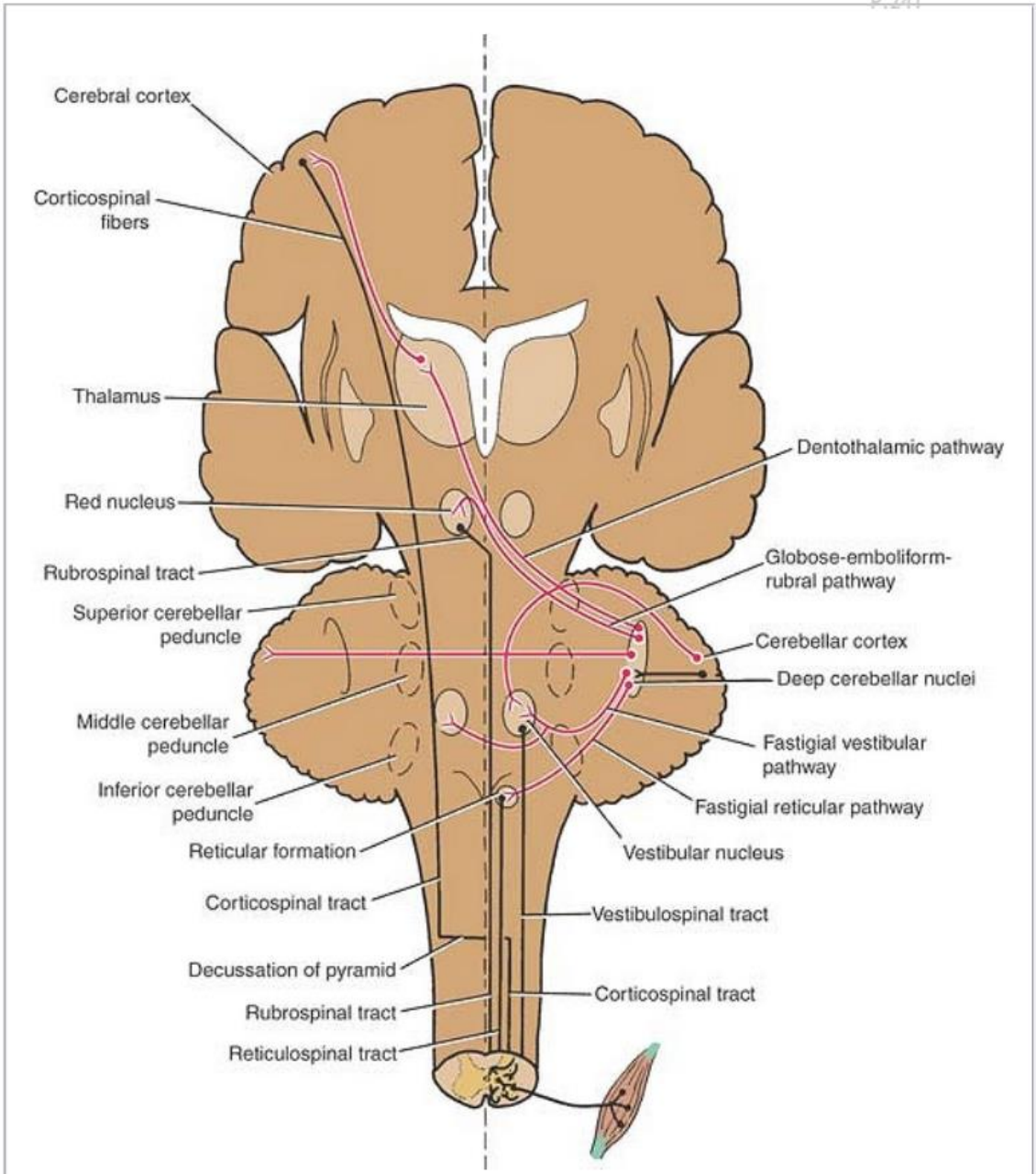


Globose-Emboliform-Rubral Pathway

- Thus, it is seen that this pathway crosses twice
- Once in the decussation of the superior cerebellar peduncle
- And again in the rubrospinal tract close to its origin.

By this means

- the globose and emboliform nuclei influence motor activity on the same side of the body



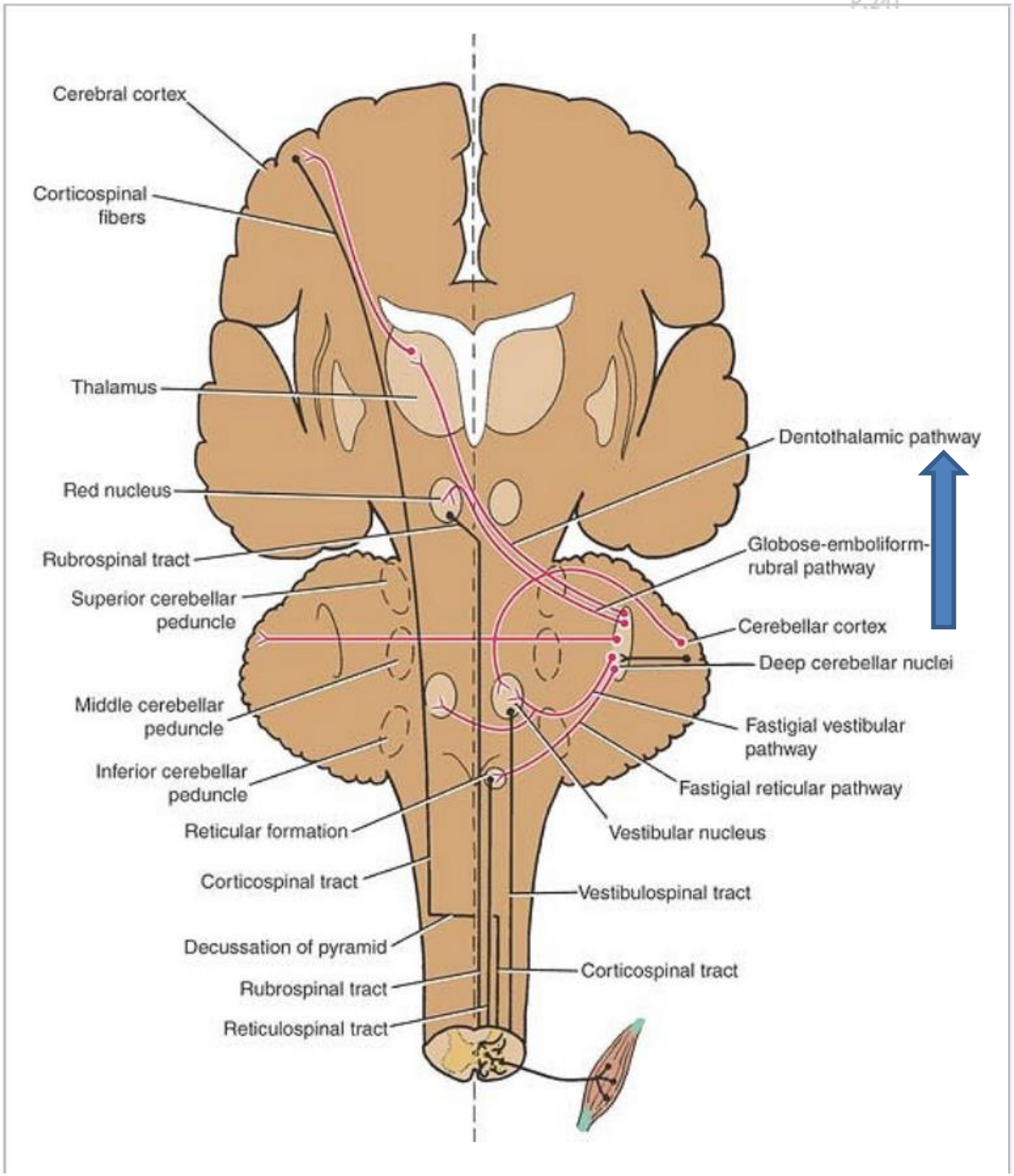
Dentothalamic Pathway

Axons of neurons in the dentate nucleus travel through the superior cerebellar peduncle

And cross the midline to the opposite side in the decussation of the superior cerebellar peduncle .

The fibers end by synapsing with cells in the contralateral ventrolateral nucleus of the thalamus.

The axons of the thalamic neurons ascend through the internal capsule and corona radiata and terminate in the primary motor area of the cerebral cortex.



Dentothalamic Pathway

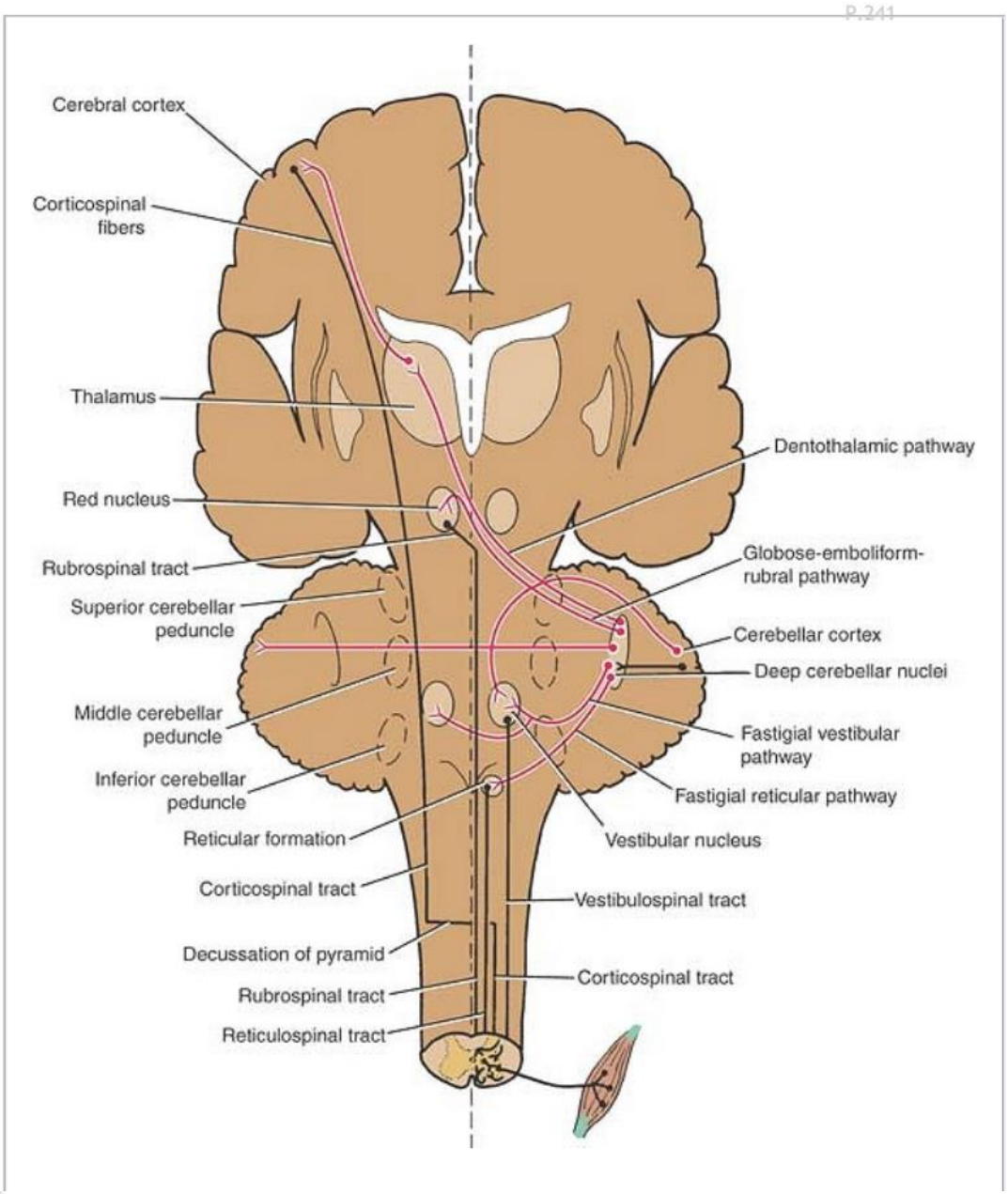
By this pathway

Dentate nucleus

- Can influence motor activity by acting on the motor neurons of the opposite cerebral cortex
- Impulses from the motor cortex are transmitted to spinal segmental levels through the corticospinal tract.

Remember

- that most of the fibers of the corticospinal tract cross to the opposite side in the decussation of the pyramids or later at the spinal segmental levels.
- Thus, the dentate nucleus is able to coordinate muscle activity on the same side of the body

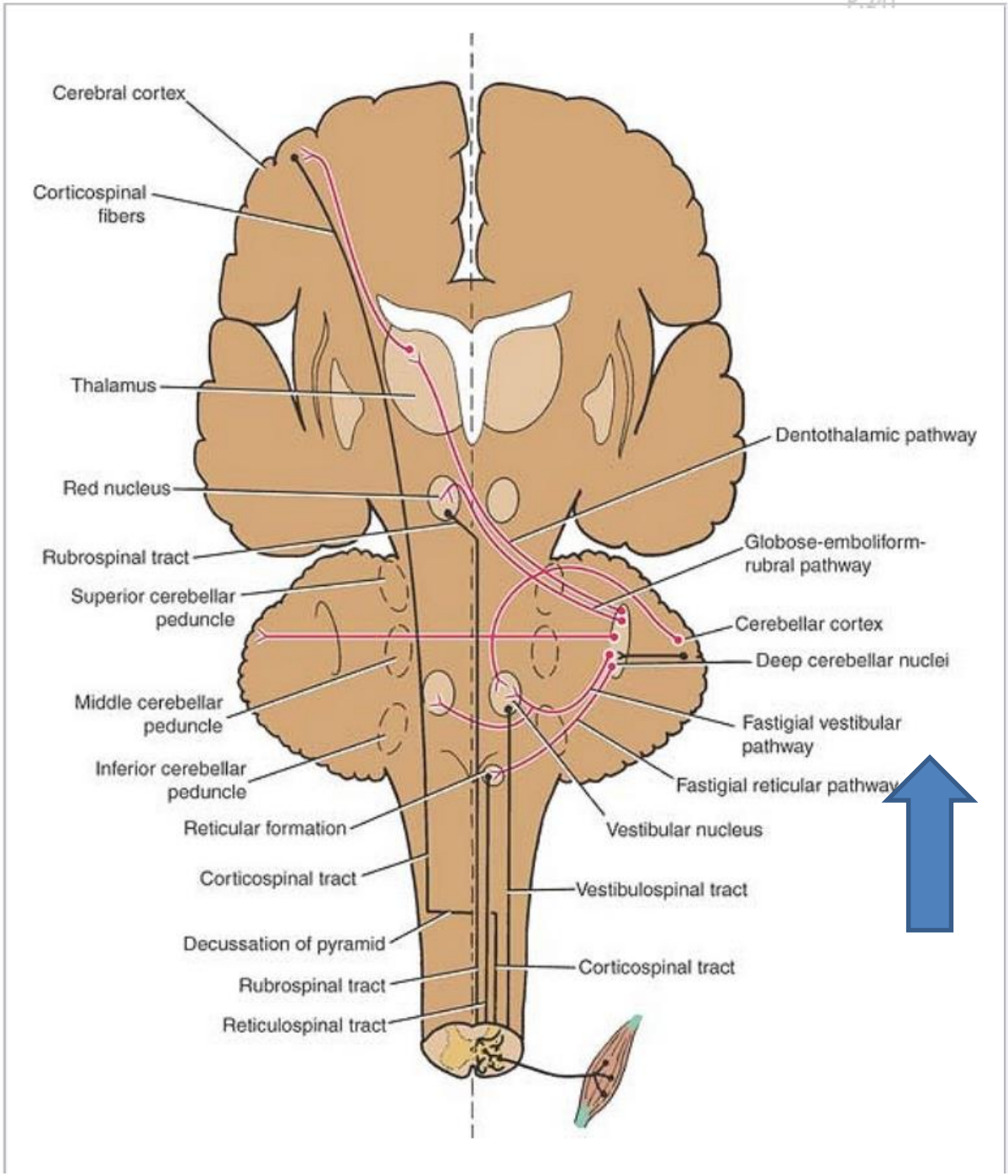


Fastigial Vestibular Pathway

- The axons of neurons in the fastigial nucleus
- Travel through the inferior cerebellar peduncle
- And end by projecting on the neurons of the lateral vestibular nucleus on both sides .

Remember

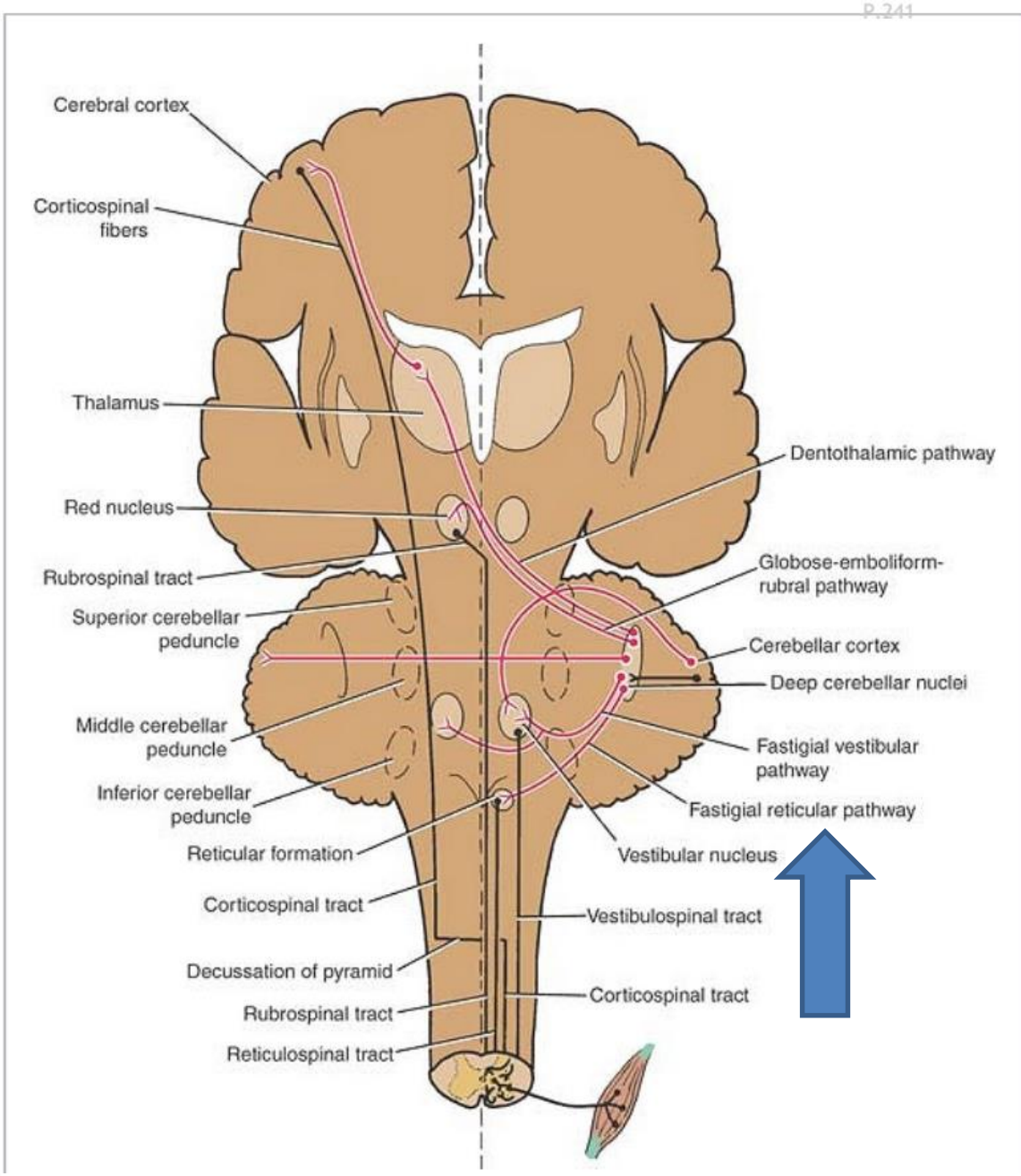
- That some Purkinje cell axons project directly to the lateral vestibular nucleus.
- The neurons of the lateral vestibular nucleus form the vestibulospinal tract.



Fastigial Reticular Pathway

Fastigial nucleus

- Exerts a facilitatory influence mainly on the ipsilateral extensor muscle tone.
- **Fastigial Reticular Pathway** The axons of neurons in the fastigial nucleus travel through the inferior cerebellar peduncle
- And end by synapsing with neurons of the reticular formation .
- Axons of these neurons influence spinal segmental motor activity through the reticulospinal tract.



Signs and Symptoms of Cerebellar Disease

Hypotonia

- The muscles lose resilience to palpation.
- There is diminished resistance to passive movements of joints.
- Shaking the limb produces excessive movements at the terminal joints.
- The condition is attributable to loss of cerebellar influence on the simple stretch reflex.

Signs and Symptoms of Cerebellar Disease

Postural Changes and Alteration of Gait

- The head is often rotated and flexed, and the shoulder on the side of the lesion is lower than on the normal side.
- The patient assumes a wide base when he or she stands and is often stiff legged to compensate for loss of muscle tone.
- When the individual walks, he or she lurches and staggers toward the affected side.

Signs and Symptoms of Cerebellar Disease

Disturbances of Voluntary Movement (Ataxia)

- The muscles contract irregularly and weakly.
- Tremor occurs when fine movements, such as buttoning clothes, writing, and shaving, are attempted.
- When the patient is asked to touch the tip of the nose with the index finger, the movements are not properly coordinated, and the finger either passes the nose (past-pointing) or hits the nose.
- A similar test can be performed on the lower limbs by asking the patient to place the heel of one foot on the shin of the opposite leg.

Signs and Symptoms of Cerebellar Disease

Dysdiadochokinesia

Is the inability to perform alternating movements regularly and rapidly.

Ask the patient to pronate and supinate the forearms rapidly.

On the side of the cerebellar lesion, the movement are slow, jerky, and incomplete.

Signs and Symptoms of Cerebellar Disease

Disturbances of Reflexes

- Movement produced by tendon reflexes tends to continue for a longer period of time than normal.
- The pendular knee jerk, for example, occurs following tapping of the patellar tendon.
- Normally, the movement occurs and is self-limited by the stretch reflexes of the agonists and antagonists.
- In cerebellar disease, because of loss of influence on the stretch reflexes, the movement continues as a series of flexion and extension movements at the knee joint; that is, the leg moves like a pendulum.

Signs and Symptoms of Cerebellar Disease

Disturbances of Ocular Movement

- Nystagmus, which is essentially an ataxia of the ocular muscles, is a rhythmical oscillation of the eyes.
- It is more easily demonstrated when the eyes are deviated in a horizontal direction.

Signs and Symptoms of Cerebellar Disease

Disorders of Speech

- Dysarthria occurs in cerebellar disease because of ataxia of the muscles of the larynx.
- Articulation is jerky, and the syllables often are separated from one another.

- A 56-year-old woman was examined by a neurologist for a variety of complaints,
- including an irregular swanging gait and a tendency to drift to the right when walking.

- Her family recently noticed that she had difficulty in keeping her balance when standing still, and she found that standing with her feet apart helped her keep her balance.

- On examination, it was apparent that she had diminished tone of the muscles of her right upper limb, as seen when the elbow and wrist joints were passively flexed and extended.

- Similar evidence was found in the right lower limb.
- When asked to stretch out her arms in front of her and hold them in position, she demonstrated obvious signs of right-sided tremor.

- When asked to touch the tip of her nose with the left index finger, she performed the movement without any difficulty, but when she repeated the movement with her right index finger, she either missed her nose or hit it due to the irregularly contracting muscles.

- When she was asked to quickly pronate and supinate the forearms, the movements were normal on the left side but jerky and slow on the right side.

- A mild papilledema of both eyes was found.

- No other abnormal signs were demonstrated.

- The right-sided hypotonia, static tremor, and intention tremor associated with voluntary movements, right-sided dysdiadochokinesia, and the history were characteristic of right-sided cerebellar disease.

- A computed tomography scan revealed a tumor in the right cerebellar hemisphere.

- Understanding the structure and the nervous connections of the cerebellum and, in particular, knowing that the right cerebellar hemisphere influences voluntary muscle tone on the same side of the body enable the neurologist to make an accurate diagnosis and institute treatment.

thank you!