ATAXIA

Dr/ Sara Kabbash

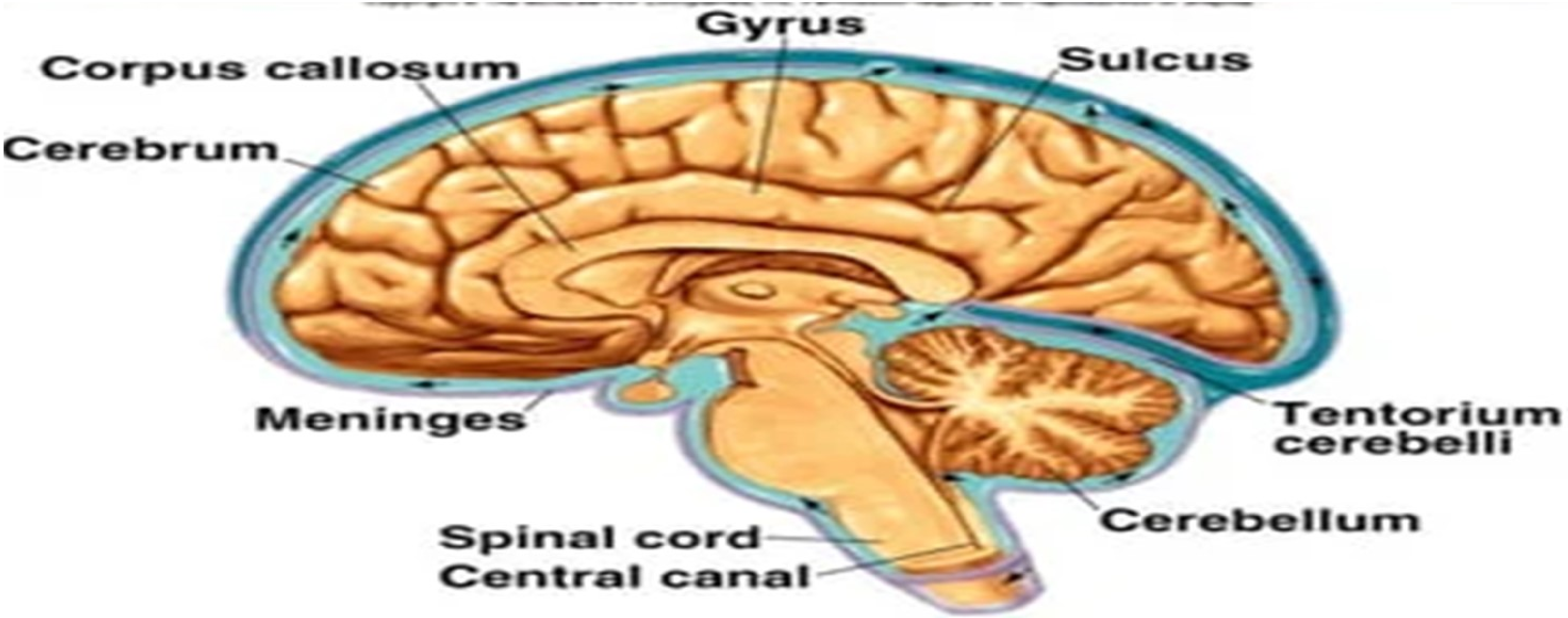
Bsc. PT, Msc. PT, PhD

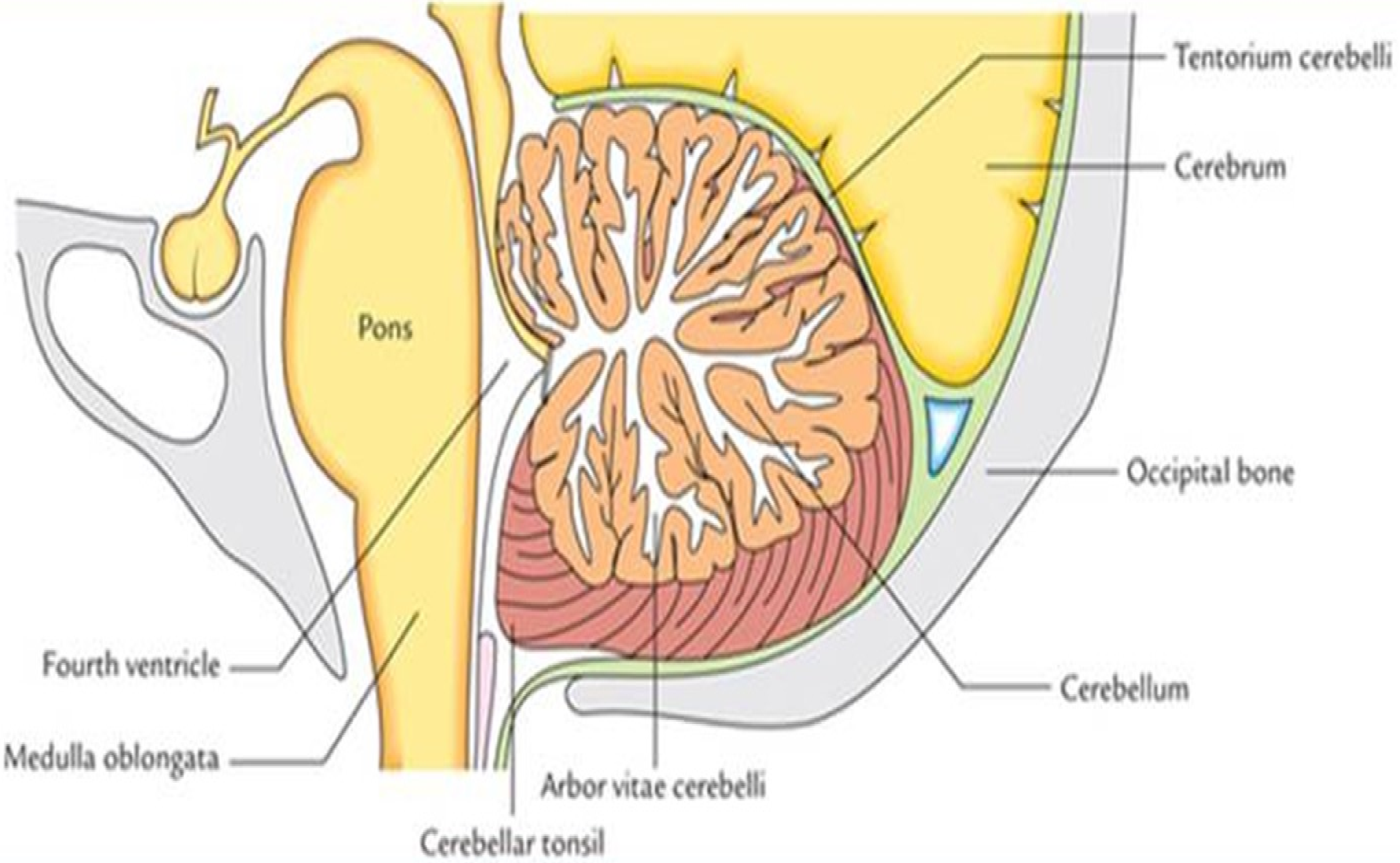
Lecturer of Physical Therapy for Neurology
Faculty of Physical Therapy
South Valley University

Cerebellum

- The term cerebellum is the diminutive form of cerebrum and means "**little brain.**"
- The cerebellum is indeed a little brain in that while it accounts **for only a fraction** of the total volume of the brain, it contains **more than half of all its neurons.**
- the human cerebellum has been considered to **function exclusively** in the **motor domain**. the cerebellum also performs significant **non motor functions** has been evolving. Recently, an anatomical substrate for involvement of the cerebellum in **higher cognitive function.**

- Located in the posterior cranial fossa, dorsal to the medulla and pons.
- Largest part of hind brain.

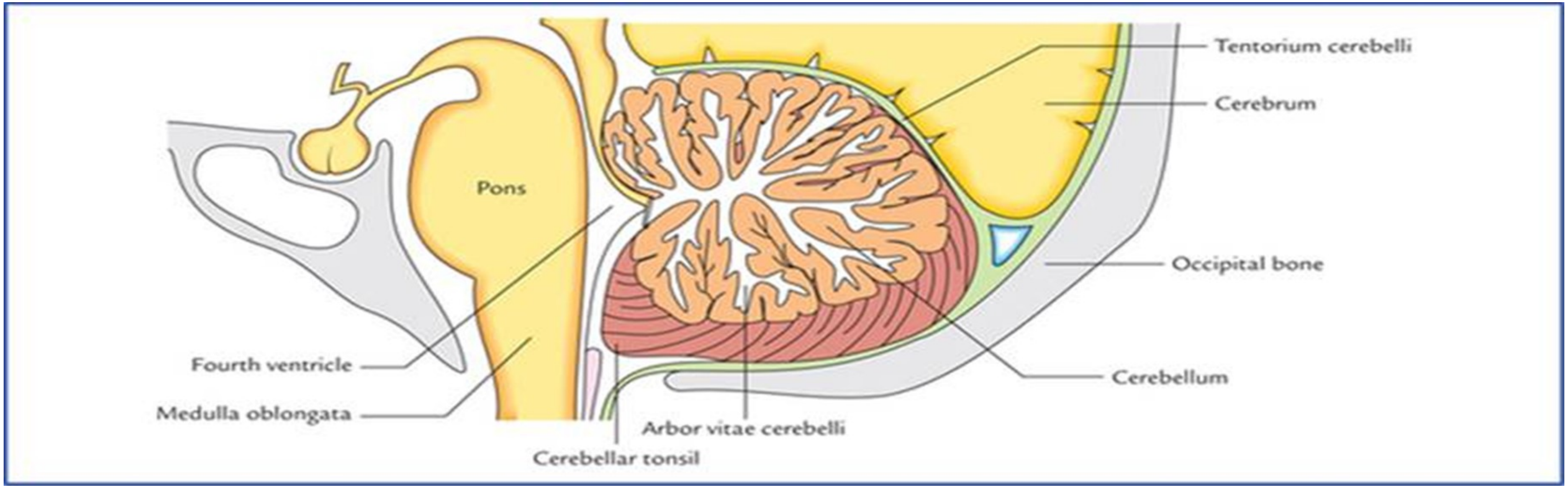



Tentorium cerebelli
Cerebrum
Pons
Occipital bone
Fourth ventricle
Cerebellum
Medulla oblongata
Arbor vitae cerebelli
Cerebellar tonsil

- The cerebellum consists of

- ➢Gray matter >>> an outer mantle of cortex whose cells are arranged into distinctive layers & deep cerebellar nuclei embedded in white matter .

- ➢ white matter >>> axons carry information to and from cells of the cortex.



Cerebellar Cortex

- **Molecular layer >>>** outermost layer, made up of the dendrites of Purkinje cells with certain types of interneurons stellate cells in its outer portion and basket cells in its inner portion.
- **Purkinje layer >>>** middle layer, Purkinje cells inhibition of the deep cerebellar nuclei, release the transmitter gamma-amino butyric acid (GABA).
- **Granular layer >>>** innermost layer, granule cells that are excitatory, releasing glutamate onto the Purkinje cells& inhibitory interneurons called Golgi neurons.

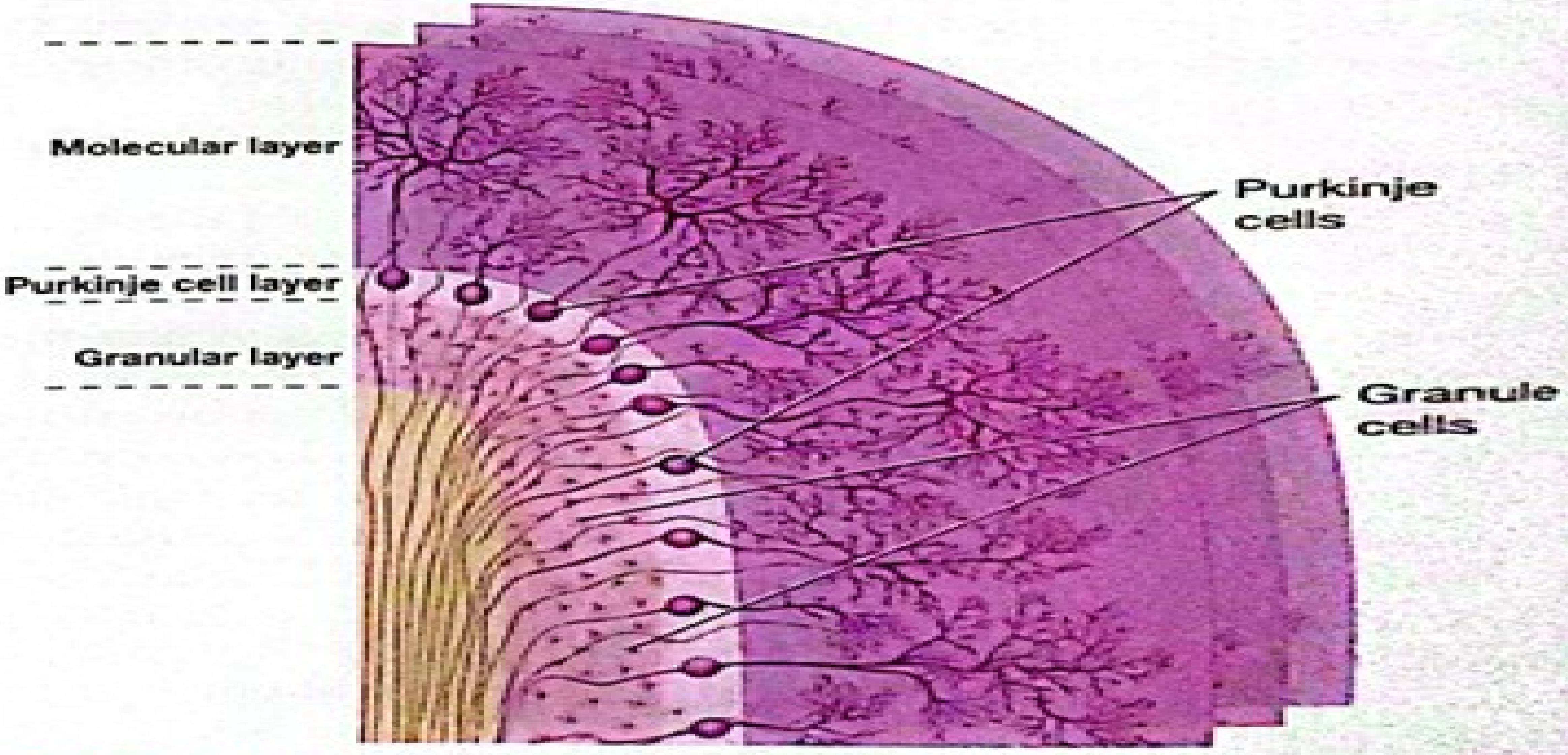
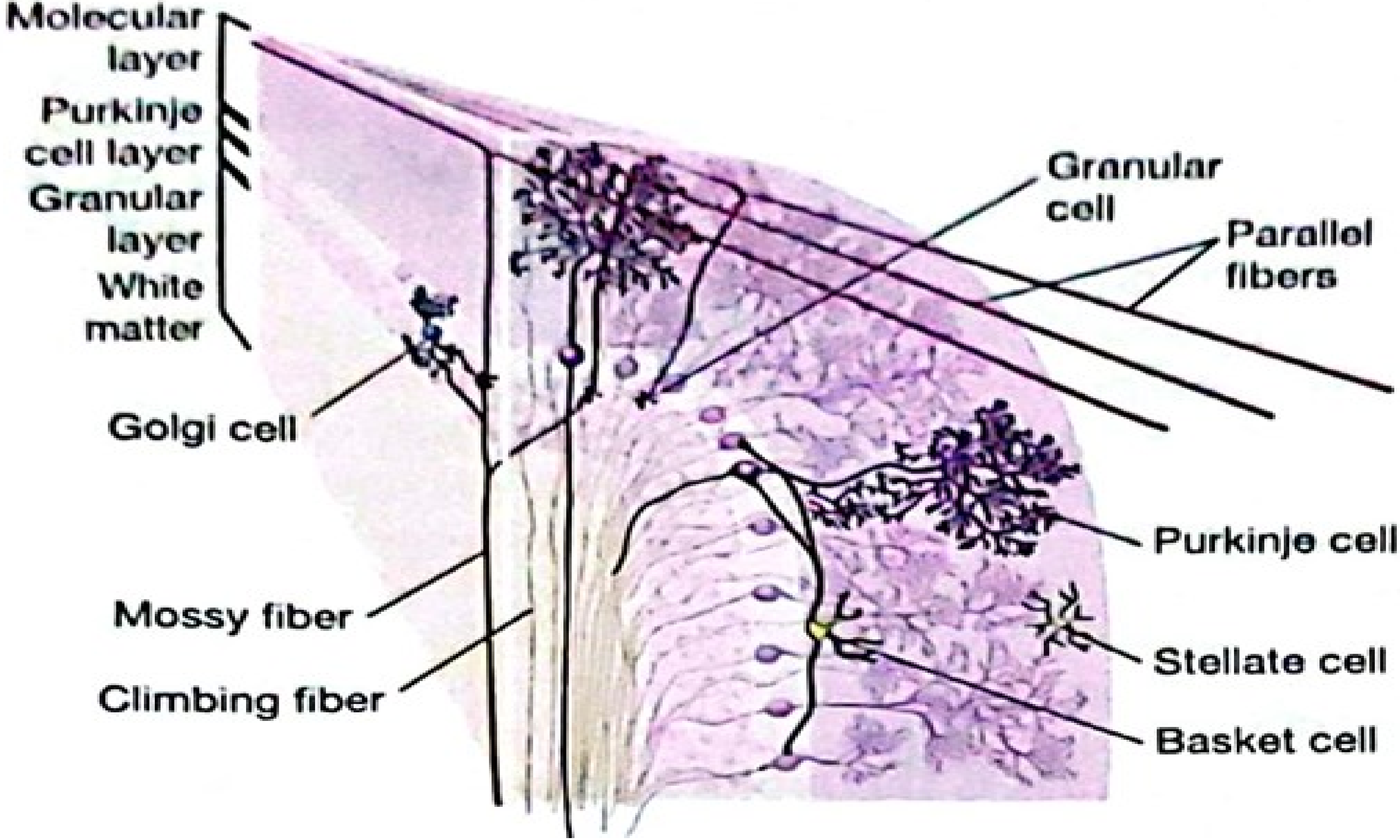


FIGURE 6-13 The three layers of the cerebellar cortex. The outermost molecular layer contains dendrites of Purkinje cells, the cell bodies of which reside in the Purkinje layer. The innermost granular layer is densely packed with small granular cells.



Molecular layer
Purkinje cell layer
Granular layer
White matter
Golgi cell
Mossy fiber
Climbing fiber
Granular cell
Parallel fibers
Purkinje cell
Stellate cell
Basket cell

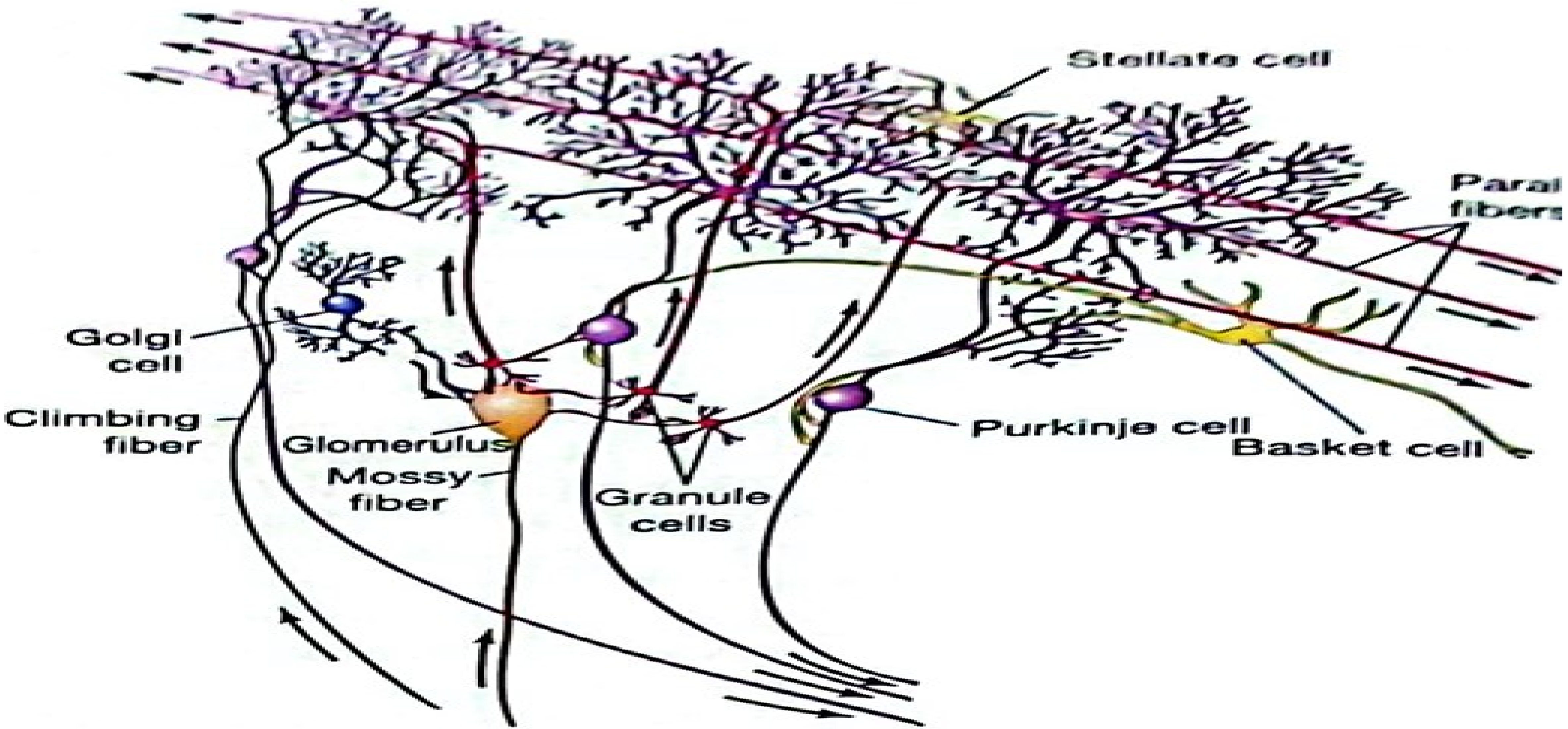
Cerebellar Input and Output Fibers

- Fibers afferent to cells of the cerebellar cortex are of two types, both of which are excitatory

✓**Climbing fibers >>>** originate from the contralateral inferior olivary nucleus and end directly on Purkinje cell.

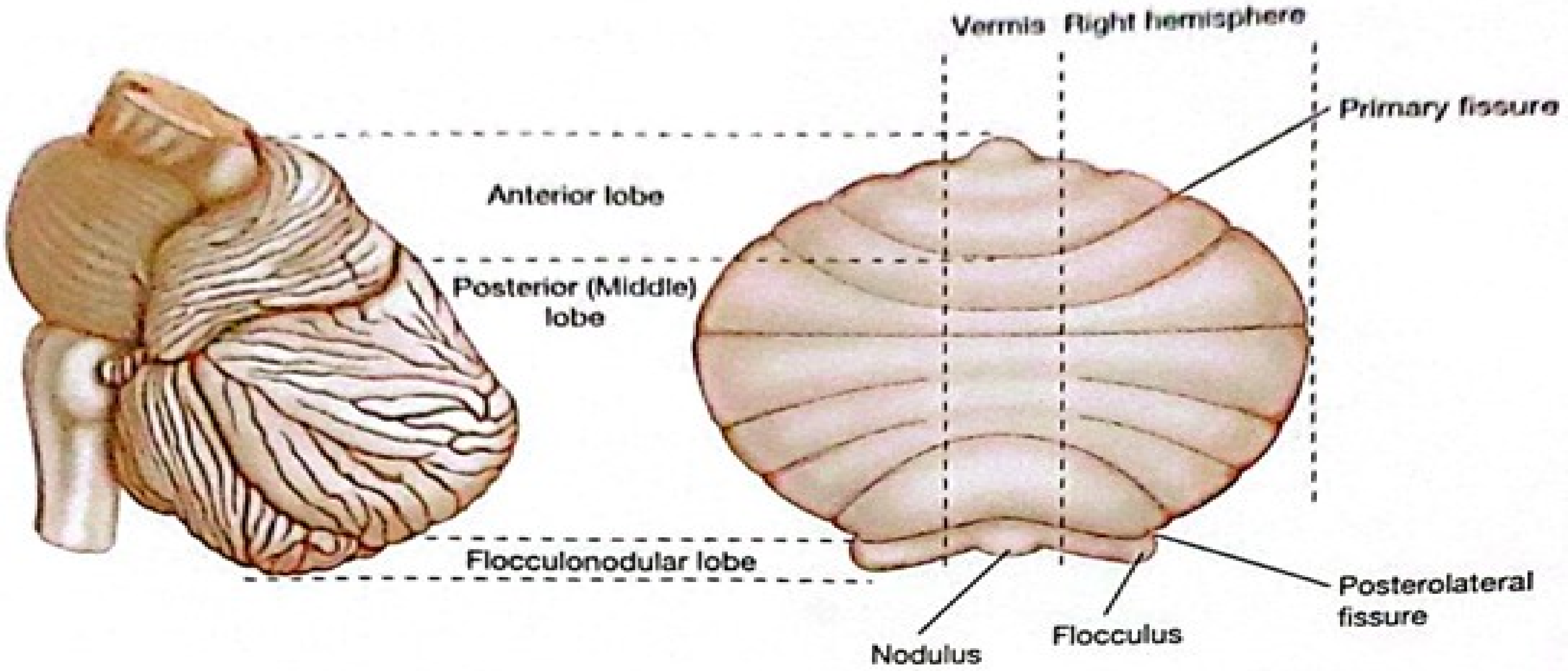
✓**Mossy fibers >>>** originate from cell bodies in the spinal cord, brain stem and cerebral cortex influence Purkinje cells indirectly via a granule cell relay.

- Output from the cerebellum is only via the Purkinje cells. These neurons either project directly to the vestibular or synapse in deep cerebellar nuclei, which in turn project to destinations outside the cerebellum. Because they are inhibitory, the net effect of Purkinje cell output is inhibitory



Mossy fibers have *indirect* connections with Purkinje cells, whereas climbing fibers have *direct* connections with the Purkinje cells. Mossy and climbing fibers are input fibers to the cerebellum, whereas axons of Purkinje cells are the output fibers.

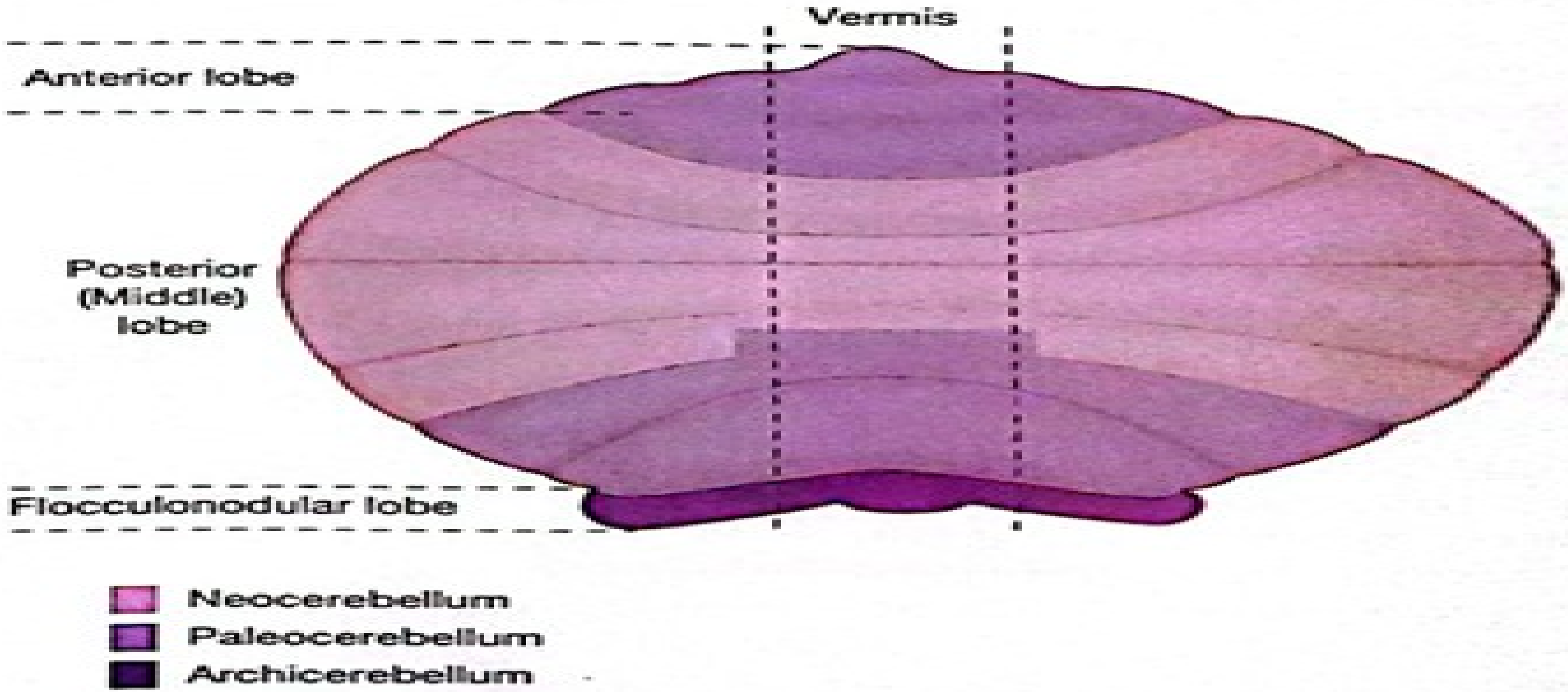
Fissures &lobes



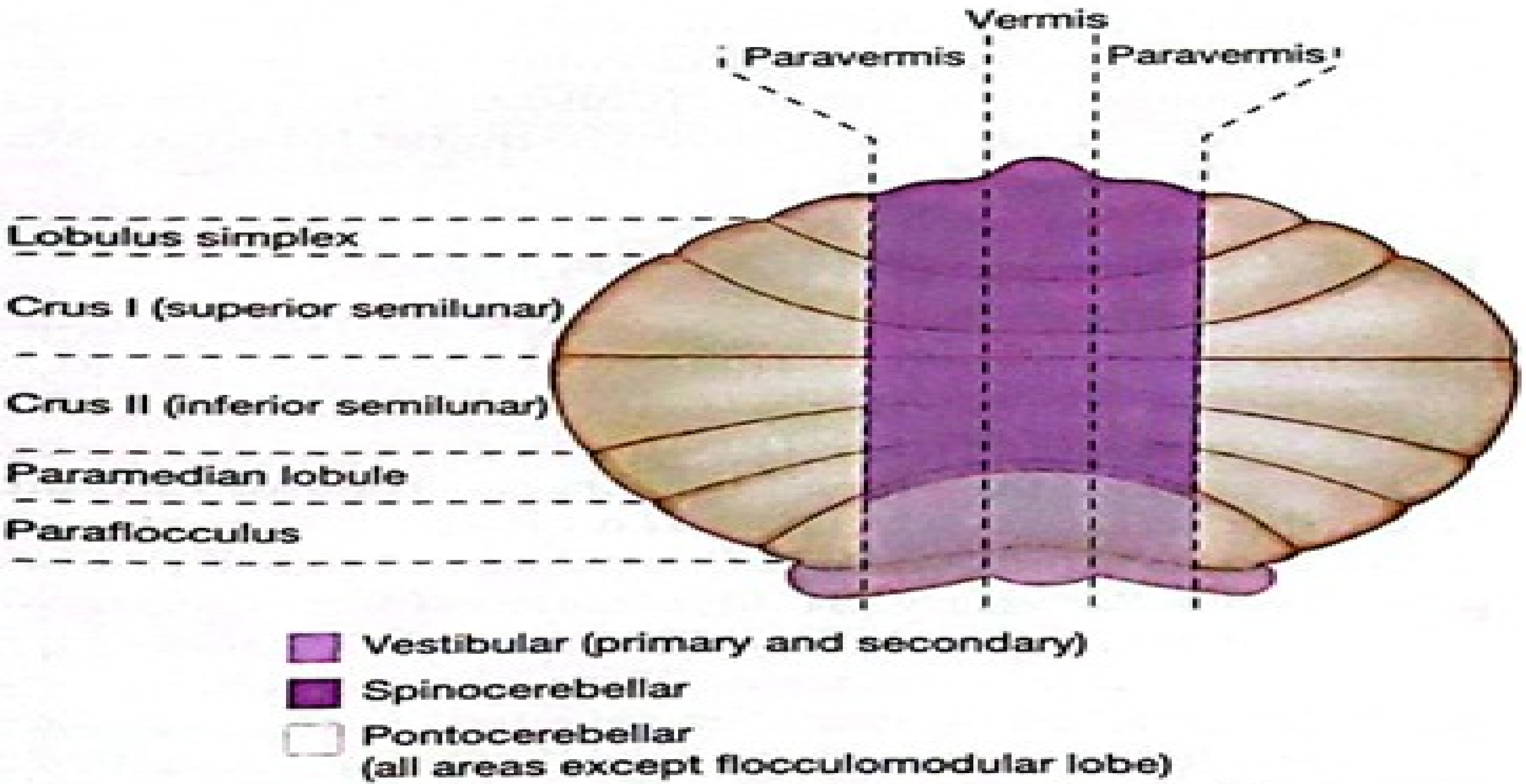
The cerebellum unfolded and flattened (right) to reveal the major landmarks and terminology.

Cerebellum is divided into three regions based on four different criteria:

1. Its gross anatomy as determined by its two major fissures (flocculonodular lobe, anterior lobe, and posterior lobe).
2. The phylogeny of its gross anatomy (archicerebellum, paleocerebellum, and neocerebellum).
3. The source of afferent fibers projecting to different regions of the cerebellar cortex (vestibulocerebellum, spinocerebellum, and pontocerebellum).
4. The pattern of projections from the cerebellar cortex to its underlying deep nuclei (medial zone, intermediate zone, and lateral zone).

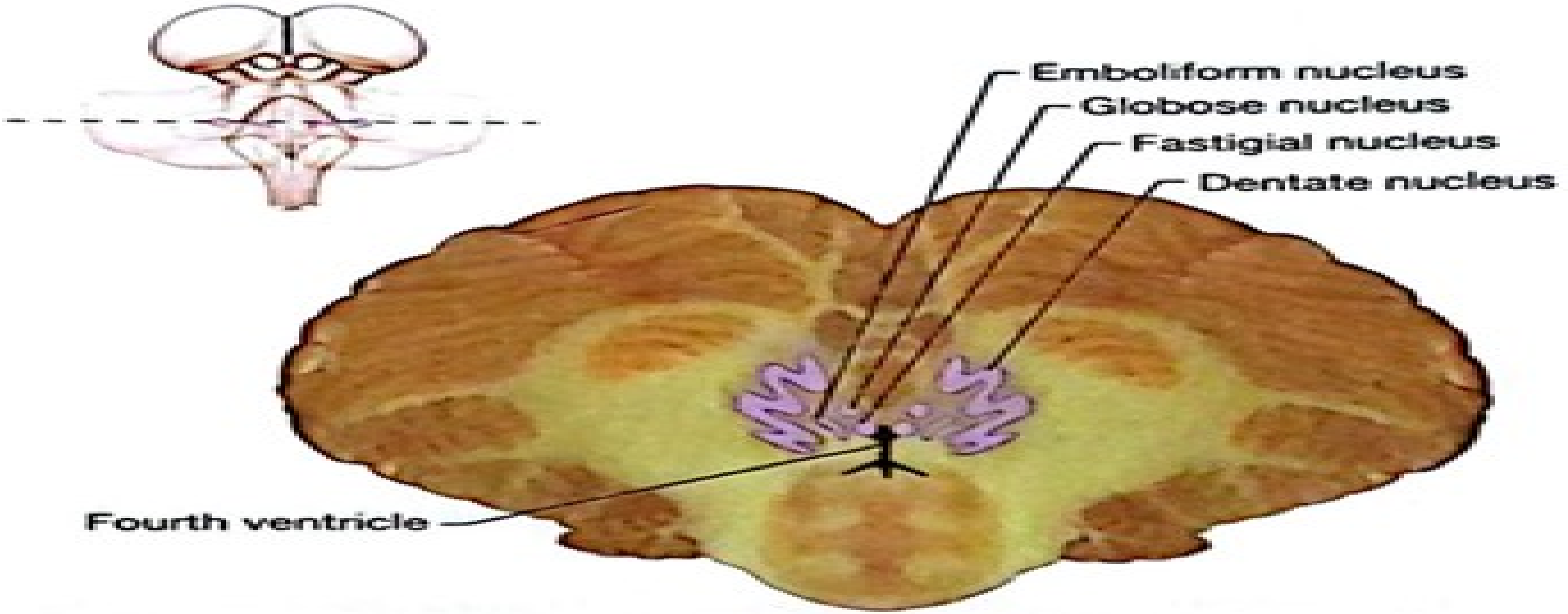


The cerebellum can be subdivided into three lobes noted earlier: the flocculonodular lobe, the anterior lobe, and the posterior lobe. The cerebellum can also be subdivided based on the phylogenetic order of appearance: the archicerebellum, paleocerebellum and neocerebellum.

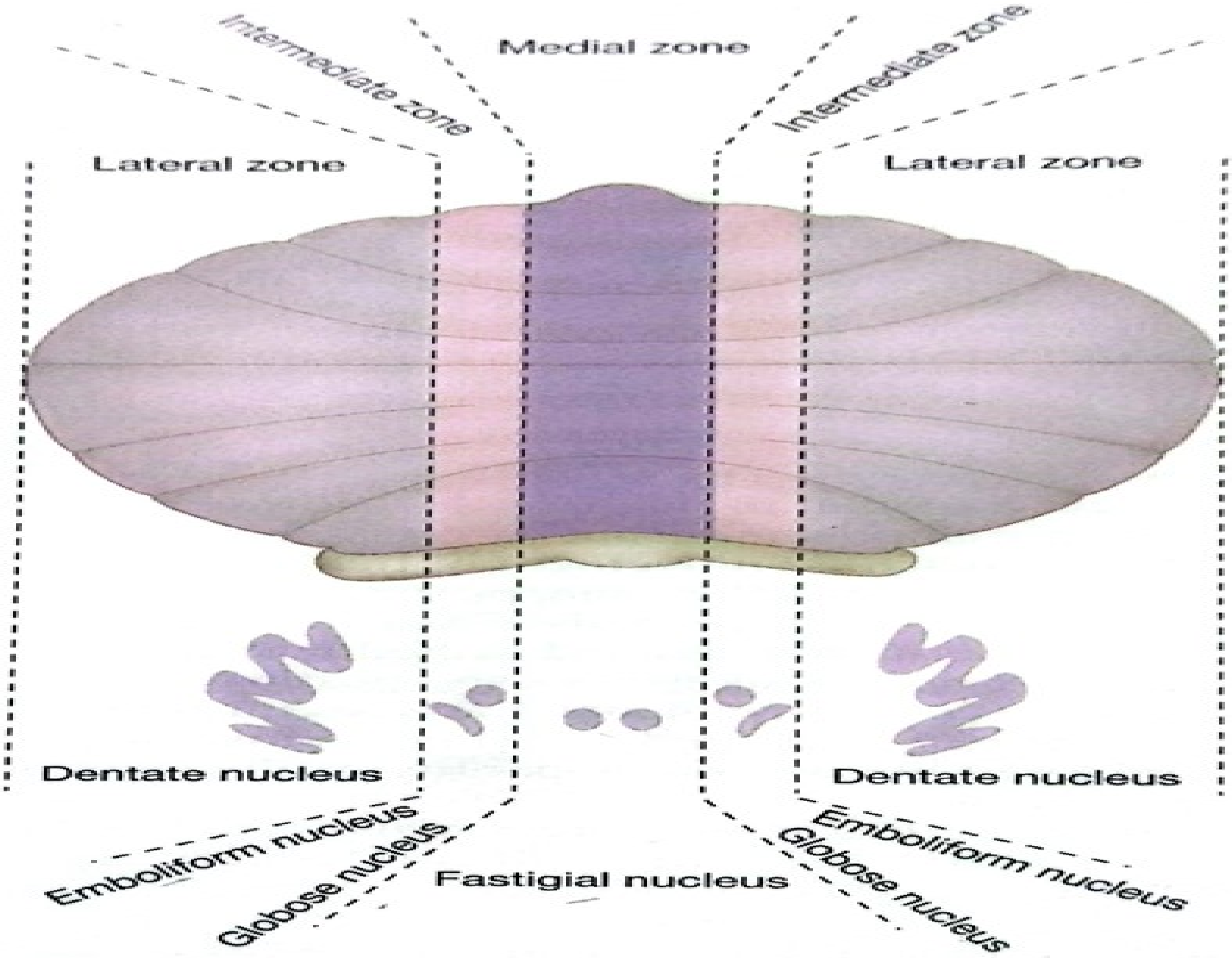


- There are three major categories of afferent projections: vestibulocerebellar, spinocerebellar, and pontocerebellar.

Cerebellar nuclei



There are four paired deep cerebellar nuclei buried in each cerebellar hemisphere. The fastigial nucleus is most medial, the dentate nucleus most lateral. Between these two nuclei are two additional nuclei, a more medial globose nucleus, and a more lateral emboliform nucleus.

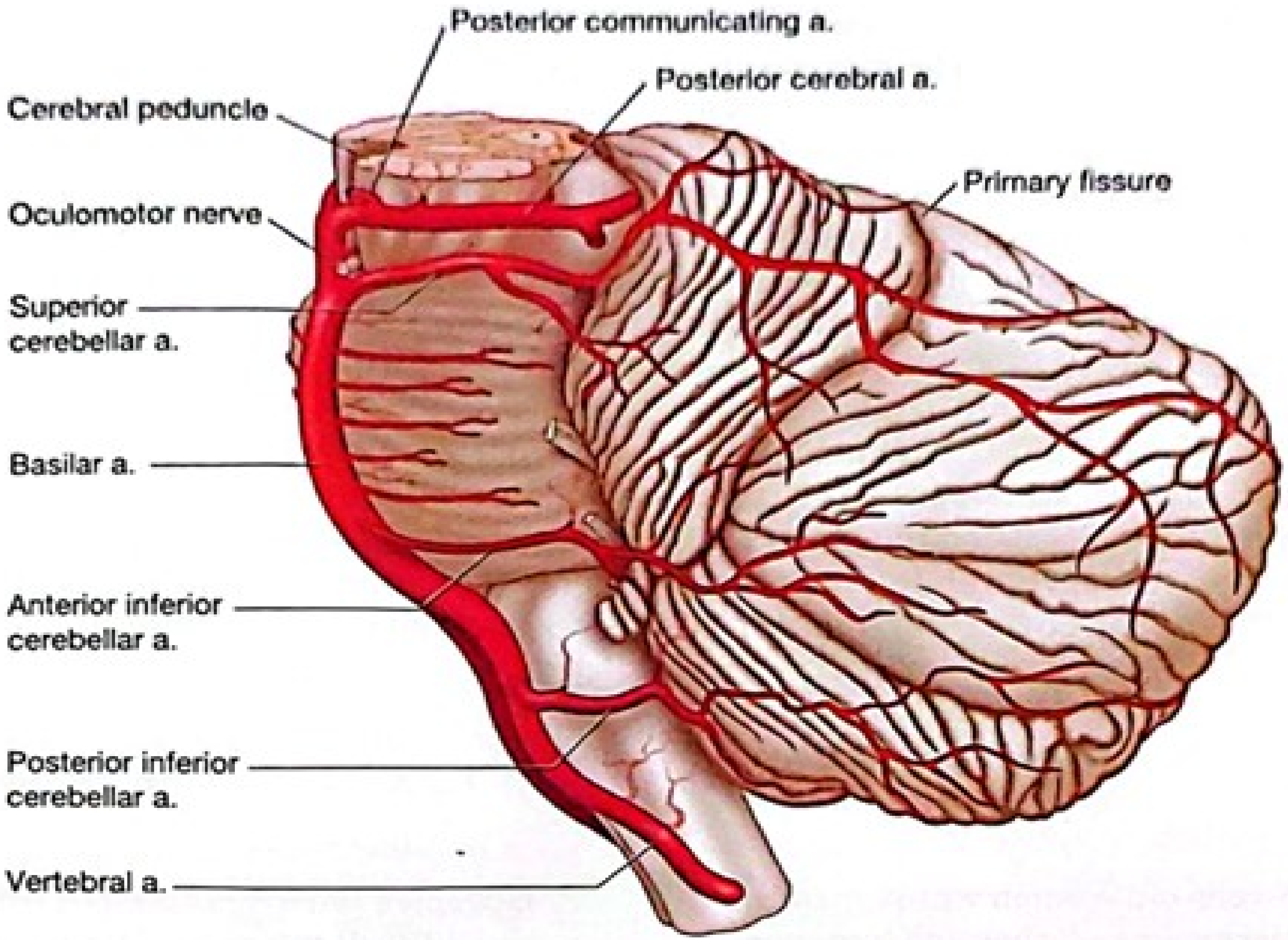


The longitudinal zones and their corticonuclear projections to related deep cerebellar nuclei.

Table 19-1 Terminology Used to Discuss the Cerebellum

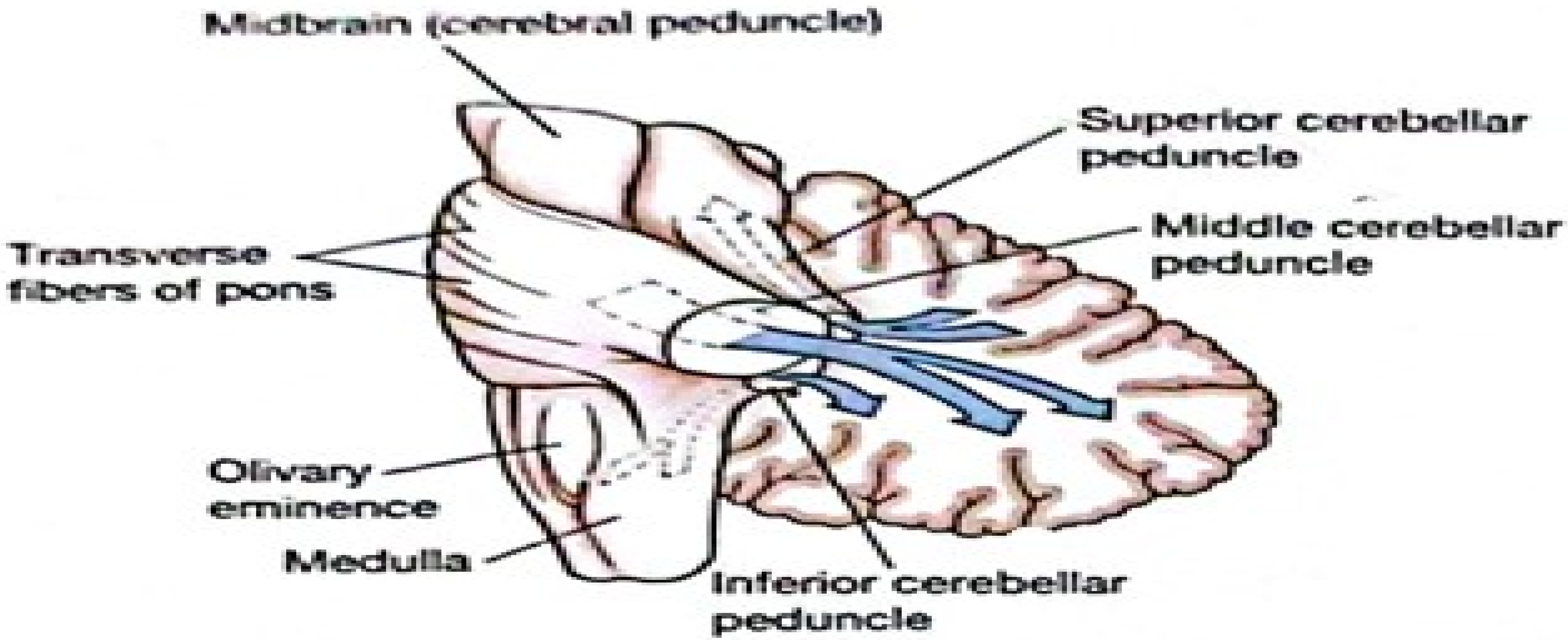
PHYLOGENY	LOBES	LONGITUDINAL ZONES	FUNCTIONAL REGIONS
Archicerebellum	Flocculonodular	Vermis	Vestibulocerebellum
Paleocerebellum	Anterior	Intermediate	Spinocerebellum
Neocerebellum	Posterior	Lateral	Pontocerebellum

Blood supply



Blood supply of the cerebellum. Three arteries nourish the cerebellum: a posterior inferior cerebellar artery, a branch of the vertebral artery; an anterior inferior cerebellar artery, a branch of the inferior portion of the basilar artery; and a superior cerebellar artery, a branch of the rostral portion of the basilar artery.

Cerebellar peduncles



Three pairs of cerebellar peduncles connect the cerebellum to the brainstem.

Summary of the Input Pathways to the Cerebellum

PATHWAY	ORIGIN	PEDUNCLE	FUNCTION
Spinocerebellar	Clarke nucleus	Inferior cerebellar peduncle	Proprioceptive and cutaneous sensation from the trunk and legs
Cuneocerebellar	Accessory cuneate nucleus	Inferior cerebellar peduncle	Proprioceptive and cutaneous sensation from the arms and neck
Trigeminocerebellar	Trigeminal nucleus	Inferior cerebellar peduncle	Proprioceptive and cutaneous sensation from the face and jaw
Olivocerebellar Vestibulocerebellar Pontocerebellar	Inferior olivary nucleus Vestibular nucleus Pontine nucleus	Middle cerebellar peduncle	Motor skills learning Balance Cognitive, visual, and motor input from the cortex

- The **cerebellum** is involved in a number of aspects of motor behavior, in a modulatory and regulatory capacity. In contrast to other components of the motor system, cerebellar damage **does not result in paralysis or paresis** (muscle strength is not impaired), although **hypotonia is common**. Movement still can be performed by persons with cerebellar damage, but they may lose their smoothness, accuracy, and coordination.
- People with cerebellar damage may exhibit **postural instability** because the normal cerebellum helps **maintain muscle tone** and the **body's position and balance in space during the execution of movement**. **Motor incoordination** may be apparent in **limb, orofacial, and eye movements** following cerebellar damage

- the cerebellum is positioned to **monitor descending motor signals from the cerebral cortex**, and **ascending sensory information from the spinal cord and vestibular system**. This is commonly referred to as the "**comparator" function of the cerebellum.**
- the cerebellum **compares** the **intended movement** with the **actual movement**, which permits **detection of motor errors** when these two signals do not match. When motor errors are detected, the cerebellum plays a role **in correcting them in ongoing and subsequent movements**.
- the cerebellum also has an important role in **motor learning.**
- Despite receiving a massive input derived from peripheral somatosensory receptors, patients with cerebellar damage do not complain of alterations in somatosensation. They may stagger, reel, fall & Their movements may deviate to one side of the desired target. but their sense of position in space is not defective. For this reason, the sensory function of the cerebellum is referred to as **unconscious proprioception**

TABLE 16.3 Functional Longitudinal Cerebellar Zones

Functional Zone	Alternate Name	Major Afferents	Major Efferents	Role in Movement	Clinical Signs If Damaged
Flocculonodular lobe Flocculonodular lobe; med and lat vestib nuclei	Vestibulocerebellum	• Vestib primary afferents (semicircular canals and otoliths) • Vestib nuclei • Visual areas	• Med and lat vestib nuclei	• VOR • Gaze and eye movements • Posture and balance	• Nystagmus • Impaired VOR • Imbalance
Medial zone Vermis; fastigial nuclei		• Vestib and retic nuclei • DSCT and VSCT	• Vestib and retic nuclei • Cerebrum	• Gaze and eye movements • Postural tone • Balance • Locomotion	• Oculomotor deficits • Hypotonia • Imbalance • Falls • Gait ataxia
	Spinocerebellum				
Intermediate zone Intermediate hemispheres; globose and emboliform nuclei		• DSCT and VSCT • Retic nuclei • Cerebrum	• Cerebrum • Red nucleus	• Limb movements • Coordinate agonist-antagonist muscle pairs	• Imbalance • Gait ataxia • Tremor • Lack of check • Dysdiadochokinesia • Dysmetria
Lateral zone Lateral hemispheres; dentate nuclei	Cerebrocerebellum or Neocerebellum	• Cerebrum (wide range of areas: motor, premotor, prefrontal, somatosensory, sensory association, visual, auditory cortices)	• Cerebrum (same areas as afferent projections) • Red nucleus	• Complex, multijoint voluntary limb movements • Visually guided movements • Motor planning • Sensorimotor error assessment	• Dysdiadochokinesia • Dysmetria • Dyssynergia • Decomposition

Functions of cerebellum

1. important for movement control
2. Coordination.
3. Role in timing and programming of voluntary movement.
4. damping function.
5. Adjust of muscle tone.
6. Motor learning and motor skill.
7. cognitive function.

8. Act as a comparator (closed Loop model) >>> Compare the voluntary command for movement with the sensory signals produced by the involving movement.
9. act as a compensator >>> It performs predictive compensatory modification of reflexes in preparation of movement
10. Act as adaptive feed control system (open loop model) >>> It programs or model voluntary movement skill based on memory of previous sensory input and motor output.

What is Ataxia?

- In-coordination of voluntary movement activity with or without disequilibrium in absence of motor weakness

Coordination

- Integration between motor and sensory system in a harmonically manner to produce purposeful movement or the ability to use right muscles at right time with proper intensity to reach certain goal.
- Coordination is the ability to execute smooth, accurate, controlled movement.

- Coordinated movements are characterized by appropriate speed, distance, direction, timing, and muscular tension. In addition, they involve easy reversal between opposing muscle groups (appropriate sequencing of contraction and relaxation), and proximal fixation to allow distal motion or maintenance of a posture.
- Behavior of two or more degrees of freedom in relation to each other to produce skilled activity

Structures Responsible For Coordination

1. Intact cerebellum.
2. Intact motor system.
3. Intact sensory cortex.
4. Intact proprioceptors.
5. Intact vestibular system.
6. Intact vision.

TYPES OF ATAXIA

1. Cerebellar ataxia
2. Sensory ataxia
3. Vestibular ataxia
4. Mixed ataxia

Cerebellar ataxia

Cerebellar ataxia develops as a result of lesions to the cerebellum, and/or the afferent and efferent connections of the cerebellum.

- Vestibulo-cerebellar dysfunction
- Spino-cerebellar dysfunction
- Cerebro-cerebellar dysfunction

CAUSES

Acquired	Degenerative Nonhereditary
1. Stroke (infarct, hemorrhage)	1. Multiple system atrophy (MSA)
2. Tumor (primary brain tumor, metastatic disease)	2. Idiopathic late-onset cerebellar ataxia (ILOCA)
3. Structural (Chiari malformation, agenesis, hypoplasia, etc.)	
4. Toxicity (alcohol, heavy metals, drugs, solvents, etc.)	**Hereditary**
5. Immune mediated (multiple sclerosis, gluten ataxia, etc.)	1. Autosomal dominant disorders (episodic ataxias, spinocerebellar ataxias)
6. Trauma	2. Autosomal recessive disorders (Friedreich ataxia, early onset cerebellar ataxia, etc.)
7. Infection (cerebellitis, etc.)	3. X-linked disorders (mitochondrial disease, fragile X-associated tremor, etc.)
8. Endocrine (hypothyroidism)	

Items	Friedreich's ataxia	Marie's ataxia
Age of onset	1st decade	2nd and 3rd decades
Site of lesion	Pyramidal tract, Archi-cerebelum, peripheral nerves and posterior column	Pyramidal tract ,and neo-cerebellum
Cerebellar manifestation	Mainly Archi-cerebellar	Mainly Neo-cerebellar
Deep reflexes	Diminished or lost	Exaggerated
Sensations	Impaired superficial and deep sensations	Preserved Sensation
Associated findings	• Skeletal deformities • Congenital heart disease • And ECG changes	• Mental impairment • Ocular nerve palsies • Extrapyramidal syndromes

Sensory ataxia

It is ataxia due to loss of the proprioceptive (deep) sensations, at any point in their pathway.

Causes:

- Peripheral nerve: peripheral neuropathy specially diabetic, alcoholic and nutritional.
- Posterior root: tabes dorsalis.
- Posterior column: subacute combined degeneration of the cord.
- Medial lemniscus: brain stem lesions.
- Thalamus: thalamic syndrome.
- Cortical sensory area: parietal lobe lesions.

Vestibular ataxia

can develop due to central factors such as medullar stroke and multiple sclerosis, and peripheral vestibular diseases such as Menier's, benign paroxysmal vertigo, or vestibular neuronitis

General manifestations in ataxic patients

Dysmetria

- This refers to inaccuracy in achieving a final end position (hypermetria equals overshoot; hypometria equals undershoot).
- It is impaired ability to properly scale movement distance.
- Slow movements tend to produce hypometria, whereas fast movements almost always bring about hypermetria
- Many patients with cerebellar lesions will show **both forms** even during successive movements.
- Dysmetria can be seen in: both proximal & distal joints. single-joint & multijoint movements.

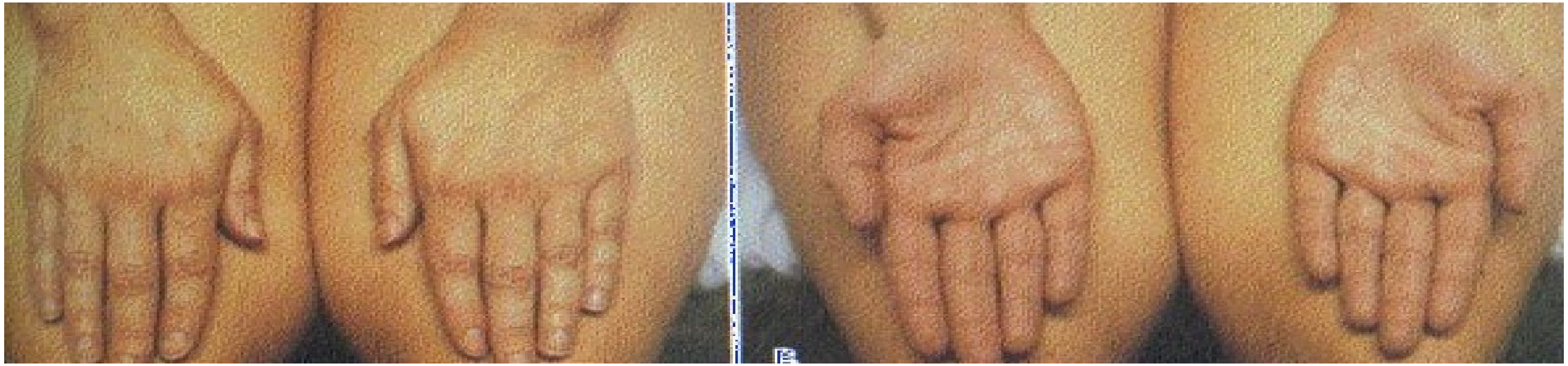
Dysynergia

- It is distinct particularly during multi-joint movements. This may have several reasons: agonist-antagonist and synergistic muscles may not be able to contract in correct order during voluntary movement; or antagonist muscle may be failing to control eccentric contraction during the concentric contraction of agonist muscle. With the combination of these two factors, the extremity undergoes a sudden velocity resulting in inappropriate and uncontrolled motor movement.

Dysdiadochokinesia

This is the inability to perform rapidly alternating movements such as alternately tapping with palm up and palm down. The rhythm is poor and force of each tap is variable.

- Diadochokinesia= ability to perform RAM.
- Dysdiadochokinesis = slow, irregular, clumsy movements



Tremor

- Kinetic tremor >>> oscillation that occurs during the course of the movement.
- Intention tremor >>> a specific form of kinetic tremor the increase in tremor towards the end of the movement.
- Postural tremor >>> occurs when holding a limb in a given position.
- Titubation >>> tremor affecting the head and upper trunk typically after lesion of the vermis.
- Postural truncal tremor >>> affects the legs and lower trunk, is seen in anterior cerebellar lobe lesions

Decomposition

- Breaking down of a movement sequence or a multijoint movement into a series of separate movements, each simpler than the combined movement.
- Patients with cerebellar damage, when asked to reach to a target in front of and above the resting arm, will often flex the shoulder first and then, while holding the shoulder fixed, extend the elbow

Lack of Check (Rebound)

- It is inability to rapidly and sufficiently halt movement of a body part after a strong isometric force, previously resisting movement of the body part, is suddenly released.
- This phenomenon is presumed to be caused by delayed cessation of agonist and/or delayed activation of the antagonist muscles

Hypotonia

- It appears to arise from decreased excitatory drive to vestibulospinal and reticulospinal pathways. two major output pathways from the cerebellar vermis & flocculonodular lobe.
- hypotonia usually presents as a decrease in the extensor tone necessary for holding the body upright against gravity.
- This occurs in acute cerebellar lesions, but it is rarely seen in chronic lesions. Hypotonia is distinct particularly in proximal and antigravity muscles

postural instability in both static and dynamic conditions

- There is increased **postural sway**, either excessive or diminished postural responses to perturbations, poor control of equilibrium during voluntary movements of the head, arms, or legs, and sometimes of the trunk, called **titubation.**
- Human cerebellar damage is also associated with hypermetric postural responses to surface displacements or during step initiation (i.e., **dynamic instability**).
- Specifically, patients tend to produce larger than normal surface-reactive torque responses and exaggerated and prolonged muscle activity, thereby overshooting the initial posture during the return phase of the recovery from a perturbation

Gait

- The manner of walking may be markedly affected by ataxia and hypotonia. It is **irregular** and **staggering**. In the acute stage when hypotonia is marked the patient tends to **fall backward & towards the affected side**. The patient deviates toward the affected side and then corrects him/herself back to the intended rout.
- Hypermetria may manifest itself by raising the feet to an unnecessary high level above the ground and by bringing them back often in a stamping maneuver.
- **Decomposition** of movement may result in the lag of the trunk to move forward with the movement of the legs with a tendency to fall backward.

Type of gait

according to site of lesion

- Archi-cereballar lesion >>> wide base or drunken.
- Neo cerebellar lesion >>> deviation to one side or zigzag.

according to distribution of lesion

- If unilateral lesion >>> **Staggering towards affected side** in **mild lesion** and **Zigzag** in **severe lesion.**
- If bilateral lesion >>> **walks with wide base** in **mild lesion** and **drunken gait** in **severe lesion**

Oro-facial dysfunction/ Oculomotor performance (nystagmus)

- abnormal eye movements that develop in horizontal and vertical directions mostly as nystagmus at the end point.
- Oculomotor impaired following cerebellar damage.
- impaired eye movements may have a significant negative impact on physical function. For example, impaired saccades can prevent a patient from reading saccadic pursuit can exacerbate already & poor visually guided limb movements

Oro-facial dysfunction (ataxic dysarthria)

- Staccato /scanning speech.
- the primary impairment of speech may be related to the **planning & prediction of movements rather than in the execution of speech components directly**.
- most speech impairments appear to be attributable to alterations in timing & coordination >>> inability of the muscles of the larynx, to initiate or stop action quickly.
- The most consistent characteristics of ataxic dysarthria:

✓impaired articulation (the correct pronouncement of speech sounds).

✓ impaired prosody(the pattern of stress and intonation of certain syllables or words).

✓slowed speech and either a lack of or excessive loudness variability

Impaired Motor Learning

- cerebellum has been linked to learning of a wide variety of motor behaviors,:

✓ recovering balance after a perturbation.

✓ learning new walking patterns.

✓ adjusting voluntary limb movements.

✓ eye movements.

- The type of learning that appears most reliant on the cerebellum is **associative** and **procedural.**

- Specifically, the cerebellum appears to be essential for learning to adjust a motor behavior through **repeated practice** of, or exposure to, the **behavior and using error information** from one trial to **improve performance** on subsequent trials.
- cerebellum-dependent motor learning is driven by **errors directly occurring during the movement** , rather than other types of feedback such as knowledge of results after the fact (e.g., hit or miss).
- In the laboratory setting, **cerebellar learning** is most easily tested via **motor adaptation,** a form of motor learning that requires a modification of an already well learned motor behavior for new environmental or physical demands (in contrast to learning of a completely novel skill).

- Adaptation is a highly automatic process to rapidly adjust movements for new, predictable demands (e.g. adjusting the walking pattern for snow or sand; adjusting eye movements for glasses).
- Adaptation when it is repeated many times, it can result in more **permanent storage** of a movement pattern e.g. new bifocal glasses Individuals with impaired cerebellar adaptive learning

Non-motor cognitive behavior Impairments

- increased activation within the cerebellum during performance of certain tasks with a predominant cognitive component, such as:

✓ language processing.

✓ working memory.

✓ certain neurodevelopmental behaviors and & neuropsychiatric disorders

Weakness and fatigue(Asthenia)

- Generalized non-specific weakness as a feature of cerebellar dysfunction. This occurs more often with extensive and deep lesions and is most apparent in the proximal musculature. Fatigue has also been noted as a common feature of cerebellar dysfunction

PHYSICAL THERAPY MANAGEMENT

- As is the case with all brain lesions, there is nearly always some level of natural, or **spontaneous, recovery** following damage to the cerebellum.
- The extent of recovery depends on complex interactions among numerous factors including the **source of damage**, **the severity**, **location and volume of damage**, **the presence or absence of damage to other brain regions**, the **presence or absence of other coexisting medical conditions**, **age**, and other factors.
- motor recovery from a first ever **ischemic cerebellar stroke** is generally excellent, with **minimal to no residual deficits in up to 83 % of individuals**.
- people with damage to the **deep nuclei** do not recover as well as those with damage to only the **cerebellar cortex and white matter**.
- individuals with a degenerative cerebellar disorders tend to have progressively worsening clinical signs and symptoms .

Precautions should be taken in consideration during assessment of ataxic patients

- Determine of basic functional capabilities.
- Assessment must be done bilaterally even in unilateral lesion.
- Examination of functional activities must include: Assistance needed Time to complete to the activity &Potential hazards to the client.
- Assessment must be done in quiet place to avoid distraction.
- Age and psychological state must be considered.
- Postural stability should be assisted sequentially.
- Evaluation of gait: walk slowly, change direction and different speeds.

- The patient progression in ambulation can be determined by the number of times they lose their balance in a treatment session, frequency of a specific error, the distance ambulated, or the level of assistance needed.
- It is also generally useful to compare the **same movements** with **and without vision**, to determine whether or not **visual feedback improves movement quality.**
- Posture and balance should always be observed in both static and dynamic conditions and in both sitting and standing, as the patient's capabilities allow.
- Important considerations specific for patients with cerebellar dysfunction include careful monitoring for symptoms of nausea or vertigo (common in acute cerebellar stroke , may resolve quickly),

- the tests of voluntary movement coordination is that the examiner must carefully **dissociate limb incoordination** from **deficits of balance** and/or **vision.**
- For example, if the patient has difficulty maintaining quiet unsupported sitting, he or she will most likely demonstrate several abnormal movement patterns that resemble classic limb ataxia when asked to move the limbs (e.g., dyssynergia, dysmetria) if tested in this unsupported position.
- In this situation the examiner cannot distinguish whether the deficits observed are caused by a true incoordination of voluntary limb movements or because of an inability to maintain the trunk in a stable and upright position that provides the limb a stable base from which to generate movement.
- Thus to test coordination, the examiner must give the patient the necessary head and trunk support required for the limb movement task (e.g., test **sitting in a high back chair with manual support at shoulders** or perform in **supine**)

- Similar confusion may arise if the patient has significant visual or other oculomotor impairments such as diplopia.
- patient would be likely to show apparent dysmetria during visually targeted movements, but it could not be determined whether it is caused by real limb ataxia or a visual impairment preventing the patient from accurately identifying the target location in space.
- This is not to say that it would not be beneficial to test limb coordination in positions or situations that also challenge balance and/or vision; only that during the initial examination of the patient, one should be careful to ensure an accurate determination of the source of the movement impairment

- It is also important to examine the patient's initial level of endurance (fatigability) both in the cardiovascular and muscular systems.
- For the cardiovascular system, this can be approximated by recording the response to sustained aerobic exercise on one or more measurement scales (e.g., perceived exertion, HR , BP, RR).
- For the muscular system, this can be approximated by recording the maximal number of repetitions of a specific set of ms. Contr. or limb movements that can be tolerated before force output or ROM is reduced.

Assessment of ataxic patients

- Motor assessment including muscle tone and muscle test.
- Sensory assessment including superficial and deep sensation.
- ROM.
- Coordination assessment (Non-Equilibrium &Equilibrium co-ordination).
- Orofacial function/oculomotor function assessment.
- Functional Activity assessment. (bed mobility, transfer ,ADL).
- Romberg's Test.
- Gait assessment.

Non-Equilibrium co-ordination tests

Pronation/supination	With elbows flexed to 90° and held close to body, the patient alternately turns the palms up and down. This test also may be performed with shoulders flexed to 90° and elbows extended. Speed may be gradually increased. The ability to reverse movements between opposing muscle groups can be examined at many joints. Examples include active alternation between flexion and extension of the knee, ankle, elbow, or fingers.
Rebound test	The patient is positioned with the elbow flexed. The therapist applies sufficient manual resistance to produce an isometric contraction of biceps. Resistance is suddenly released. Normally, the opposing muscle group (triceps) will contract and "check" movement of the limb. Many other muscle groups can be tested for this phenomenon, such as the shoulder abductors or flexors and the elbow extensors.

Finger to nose	The shoulder is abducted to 90° with the elbow extended. The patient is asked to bring the tip of the index finger to the tip of his or her nose.
Finger to therapist's finger	The patient and therapist sit opposite each other. The therapist's index finger is held in front of the patient. The patient is asked to touch the tip of his or her index finger to the therapist's index finger. The position of the therapist's finger may be altered during testing to observe ability to change distance, direction, and force of movement.
Finger to finger	Both shoulders are abducted to 90° with the elbows extended. The patient is asked to bring both hands toward the midline and approximate the index fingers from opposing hands.

Alternate heel to knee, Heel to toe	**From a supine position, the patient is asked to touch the knee and big toe alternately with the heel of the opposite extremity.**
Toe to examiner's finger	**From a supine position, the patient is instructed to touch the great toe to the examiner's finger. The position of finger may be altered during testing to observe ability to change distance, direction, and force of movement.**
Heel on shin	**From a supine position, the heel of one foot is slid up and down the shin of the opposite LE.**
Drawing a circle	**The patient draws an imaginary circle in the air with either UE or LE (a table or the floor also may be used). This also may be done using a figure eight pattern. This test may be performed in the supine position for the LE.**

The none quilibrium coordination examination focuses on movement capabilities in several main areas:

- **Alternate or reciprocal motion** >>> which is the ability to reverse movement between opposing muscle groups.
- **Movement composition, or synergy** >>> which involves movement control achieved by muscle groups acting together.
- **Movement accuracy** >>> which is the ability to gauge or judge distance and speed of voluntary movement.
- **Fixation or limb holding** >>> which addresses the ability to hold the position of an individual limb or limb segment.

Key to Grading

- 4 Normal Performance
- 3 Minimal Impairment:
  - Able to accomplish activity; slightly less than normal control, speed, and steadiness
- 2 Moderate Impairment:
  - Able to accomplish activity
  - movements are slow, awkward, and unsteady
- 1 Severe Impairment:
  - Able only to initiate activity without completion.
  - movements are slow with significant unsteadiness, oscillations, and/or extraneous movements
- 0 Activity Impossible

Equilibrium co-ordination tests

- Sitting in a normal comfortable position
- Sitting, weight shifting in all directions
- Sitting, multidirectional functional reach
- Sitting, picking an object up off floor
- Standing in a normal comfortable posture
- Standing, feet together (narrow base of support)
- Standing on one foot
- Standing, with one foot directly in front of the other (tandem position)
- Standing: eyes open (EO) to eyes closed (EC) (Romberg Test)
- Standing in tandem position: EO to EC (Sharpened Romberg Test)
- Standing, multidirectional functional reach
- Walking, placing feet on floor markers
- Walk: sideways
- Walk: backwards
- Walk: cross stepping
- Walk: in a circle, alternate directions
- Walk: on heels
- Walk: on toes
- March in place
- Walk with horizontal and vertical head turns
- Step over or around obstacles
- Stair climbing with handrail
- Stair climbing without handrail
- Stair climbing: one step at a time
- Stair climbing: step over step

Key to Grading

4 Normal:

- Able to maintain steady balance without handhold support (static)
- Accepts maximal challenge, can shift weight easily within full range in all directions (dynamic)

3 Good:

- Able to maintain balance without handhold support, limited postural sway (static)
- Accepts moderate challenge, able to maintain balance while picking object off floor (dynamic)

2 Fair:

- Able to maintain balance with handhold support; may require occasional minimal assistance (static)
- Accepts minimal challenge, able to maintain balance while turning head/trunk (dynamic)

1 Poor:

- Requires handhold support and moderate to maximal assistance to maintain position (static)
- Unable to accept challenge , Unable to move without loss of balance (dynamic)

0 Absent:

- Unable to maintain balance

- **Smooth pursuit**: In sitting, keeping the head still, patient follows pen tip or similar small object with eyes. Test in all movement planes and directions and through full range of motion. Vary speed. Observe for saccadic (choppy) pursuit.
- **Saccades**. In sitting, keeping the head still and when verbally prompted, patient alternately fixes gaze on one of two pen tips, or a pen tip and the examiner's nose, or other small objects. Vary the target (pen tip) locations, testing a variety of end point locations, directions of movement, and distances traveled, including full range of motion. Observe for dysmetria, particularly on initial trials.
- **Gaze-evoked nystagmus**: In sitting, keeping the head still, patient maintains gaze in a variety of locations, including near end-ranges of lateral gaze. "Observe for nystagmus, particularly toward the direction of gaze.

Romberg's Test

Romberg's test

Ask patient to stand with the heels together, first with the eyes open, then with the eyes closed.

Note any excessive postural swaying or loss of balance:

- Present when eyes open or closed = cerebellar deficit (cerebellar ataxia)
- Present only when eyes are closed ('positive' Romberg's) = proprioceptive deficit (sensory ataxia)

Goals of Physical Treatment

- Improving balance and postural reactions against external stimuli and gravitational changes.
- Improving and increasing postural stabilization following the development of joint stabilization.
- Developing upper extremity functions (i.e. eye hand coordination).
- Through developing independent and functional gait, improving the life quality of the patient by increasing the patient's independence while performing ADL.

Certain Principles should to be considered during Treating Ataxic Patient.

- Prolonged activity cause fatigue of muscle. Frequent **rest period** needs to be given to prevent fatigue.
- Therapist need to recognize that no therapeutic procedures will totally eliminate dysynergia but therapist need to decrease it before performing specific function activities.
- posture stability is improved by using anti gravity in developmental sequence.
- The training room should be quiet to avoid any distraction.
- home exercise program and sports activities.
- Active participation of the patient/avoid passive.
- Careful supervision to prevent falling & Intense concentration of the patient.

- Cold application, vibration, and strong resistance have adverse effects on the ataxic patients.
- Repetition of task or sequence of task is very important.
- practiced consciously at first >>> automatic exercise activities
- simple >>> complex
- eyes open >>> closed
- proximal tonus and stabilization >>> distal segments
- compensation methods and supportive aids and equipment should be employed when necessary.
- Difficulty is also increased by progressively adding increased challenges to balance (movements performed in sitting >>> standing).

- Consider more intensive, longer duration intervention >>> Notably, reported gains in the literature were made under conditions of very frequent (**10 hours/week**) or very long (**6 months**) training schedules. This could be a necessity for patients with health conditions in which motor learning is impaired.

incoordination

- **Frenkel's exercises**.
- **Specific techniques of PNF**:

a- Slow reversal: - It is isotonic contraction of antagonist followed by isotonic contraction of agonist.

b- Slow reversal hold: - It is isotonic contraction of antagonist followed by isometric contraction of antagonist, followed by the same sequence of agonist

- **Repetition of non equilibrium tests** with specific modification (Interruption of the range, with eye open then closed, and change speed).
- **Combined pattern of PNF**:

a- Bilateral symmetrical

b-Bilateral asymmetrical

c- Reciprocal same diagonal

d-Reciprocal opposite diagonal

Frenkel's exercises

- It is a series of coordinated exercise designed to improve coordination of lower limb with specific graduation to compensate proprioceptive loss by other intact neural sense.
- **Principles**

✓ It should be done slowly.

✓The patient must watch movement carefully so put pillow under the head if the patient is supine lying.

✓When he control one activity then proceed the next one.

✓Command should be sharp

- Frenkel exercises teach the patient to use vision as the principal source of feedback in guiding the adaptation to sensory perturbations, such as loss or diminished proprioception. These authors proposed vision as the main source of information to the CNS regarding the target and hand positions, resulting in sensorimotor adaptation. Proprioception possibly plays a secondary role in sensorimotor adaptation.

Examples of Frenkel Exercises

Half-lying	▪ Hip and knee flexion and extension of each limb, foot flat on the mat/plinth ▪ Hip abduction and adduction of each limb with the foot flat; knee flexed; then with knee extended ▪ Hip and knee flexion/extension of each limb, heel lifted off mat ▪ Heel of one limb to opposite leg (toes, ankle, shin, patella) ▪ Heel of one limb to opposite knee, sliding down crest of tibia to ankle ▪ Hip and knee flexion and extension of both limbs, legs together ▪ Reciprocal movements of both limbs – flexion of one leg during extension of the other
Sitting	▪ Knee extension and flexion of each limb; progress to marking time ▪ Hip abduction and adduction ▪ Alternate foot placing to a specific target (using floor markings or a grid in which the patient has to put his foot)
Standing	▪ Standing up and sitting down to a specific count (metronome) ▪ Standing foot placing to a specific target (floor markings or grid) ▪ Standing weight shifting
Walking	▪ Sideways or forward to a specific count (parallel lines or floor markings may be used as targets to control foot placement, stride length, and step width) ▪ Turning around to a specific count (floor markings can be helpful in maintaining a stable base of support)

Graduations of Frenkel's exercises

1. Fast then slow
2. Big joint then small joint
3. One joint then more than one joint
4. One direction then more than one direction
5. Unilateral then bilateral
6. Symmetrical then asymmetrical
7. Continuous then interrupted
8. on the bed then off the bed
9. Wide BOS then narrow BOS.
10. Supine then sitting then standing

Training of coordination should include (5Ps)

- **Perception** : To tell whether or not performance is occurring as desired through proprioceptive pathways and reinforced by visual and tactile perception.
- **Precision** : Breaking down activity to units which are simple so that they can be practiced more precisely.
- **Perceptual practice** : Repetition of activity at frequently intervals.
- **Peak performance** : The patient practice the movement below peak performance which is determined according to complexity , muscular effort and repetition in order to avoid occurrence of fatigue.
- **Progression:** Revision of peak performance as improvement occur and transition of exercises into functional goal.

Balance

- Approximation: - Joint approximation of hips and shoulders.
- Slow reversal hold for trunk rotation. This precedes rhythmic stabilization.
- Rhythmic stabilization.
- Resisted exercises (PNF upper trunk)
- Weight shifting: In all directions from sitting.
- ADL trunk rotatory exercises: By putting arms overhead and apply trunk rotation

Static stance

- Feet together, arms across chest, eyes open and closed, with and without slow head movements. Progression: increase time with eyes closed, increase and vary speed of head movements.
- Stand on foam, feet apart, arms across chest, eyes closed briefly and intermittently. Progression: narrow base of support, increase time with eyes closed.
- Semi tandem stance, arms across chest, eyes closed briefly and intermittently. Progression: narrow base to full tandem stance, increase time with eyes closed, perform semi tandem stance on foam.
- Unilateral stance, arms across chest, eyes open. Progression: perform with intermittent, then longer periods with eyes closed, perform on

Dynamic stance

a. March in place, arms across chest, eyes open and closed. Progression: increase time with eyes closed, add and incrementally increase pause time in unilateral stance, add head movements.

b . Standing toe taps, forward/backward/side, alternating legs, arms across chest, eyes open and closed Progression: increase step distance, increase time with eyes closed, add head movements.

c. March in place on foam, arms across chest, eyes closed briefly and intermittently. Progression: increase time with eyes closed, add and incrementally increase pause time in unilateral stance.

d. Standing 360-degree turn, rightward/leftward, arms across chest, eyes open and closed. Progression: tighten turns, increase speed.

e. Standing reaches, feet apart and together, eyes open and closed. Progression: increase time with eyes closed, increase reach distance, vary directions, narrow base of support to feet together position.

f. Standing bends and squats, feet tapart and together, eyes open and closed. Progression: increase time with eyes closed, narrow base of support to feet together, reach to touch the floor.

g. Transitions: standing to supine on floor and back up. Progression: transition in and out of all possible positions, with and without upper extremity support, eyes open and closed, including kneel, half-kneel, quadruped, side sit, squat, etc.

TABLE 21-7 **Mat Activities and Balance Training in Functional Positions**

OPTIMIZING POSTURAL CONTROL IN FUNCTIONAL POSITIONS

Aim	*Principle*	*Example of Activity in Logical Sequence*	*Functional Activity to Be Practiced Functionally*	*Precautions/Contraindications*
1. To prepare and teach the patient to bridge (do hip extension) in supine crook-lying position	Practice the different components of the activity (i.e., stabilization of the trunk, hip and knee flexion, hip extension concentrically and eccentrically)			
	1.1 To enhance isometric trunk stability in a symmetrical position (trunk muscles work as stabilizers) Place the patient in symmetrical position (i.e., crook lying in supine). If incoordination in the legs or the trunk increases, stabilize the legs over a (few) pillows.	Ask the patient to breathe slowly through pursed lips to get isometric contraction of the trunk muscles. Contraction of the trunk muscles can be facilitated by placing the hand lightly over the abdomen. 		Avoid an effort that will cause an increase in titubation, facial movements, or any other compensatory strategies. Limit the number of consecutive expirations to approximately six to avoid dizziness.
	1.2 Stabilization of the trunk during activities with the limbs	Place the patient in a supine crook-lying position. Ask the patient to lift both arms alternatively/simultaneously into 90-degree flexion, performing the activity with pursed lips expiration. Stabilize the shoulder girdle while performing the activity. 		The therapist guides the movemen to limit incoordination and rebour reactions in the trunk and legs. Prevent fixation at neck and/or wi facial movements (i.e., frowning and clenching teeth, pressing lips together/grinning).

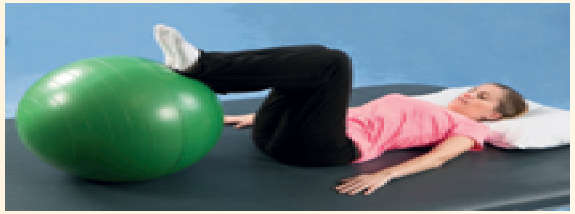
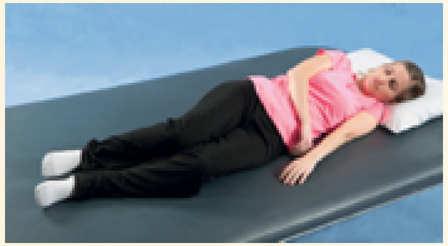
	Patient is in supine crook-lying position with arms in slight abduction for stabilization. Ask the patient to lift one leg at a time/both legs simultaneously (with assistance) into 90-degree hip and knee flexion. The activity can be performed with pursed lip breathing to facilitate trunk stabilization. 		The therapist assists/guides the movement to limit incoordination and rebound reactions in the arms or trunk. Avoid fixation by performing a Valsalva maneuver.
	Patient puts legs over a ball with the hips in 90-degree flexion and the lower legs resting on the ball. Patient can maintain stability/move the ball in small-range movements with or without expiration/assistance. 		Avoid rebound phenomenon, titubation, increase in ataxia/incoordination, and all previously mentioned fixation/compensatory strategies.
	Ask the patient to lift one leg into 90-degree hip and knee flexion. The activity can be performed with pursed lips breathing to enhance trunk stability. This activity requires rotational stability control of the	Practice the sequence of movements during the bridging activity (hip and knee flexion and hip extension). The patient may or may not assist with stabilizing her trunk by pressing on her arms.	If the patient is not ready to manage rotational trunk control, titubation of the trunk, increased intentional tremor, or rebound phenomenon may occur. Perform the activity within the patient's ability to do

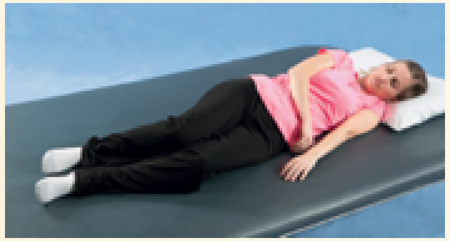
TABLE 21-7 Mat Activities and Balance Training in Functional Positions—cont'd

OPTIMIZING POSTURAL CONTROL IN FUNCTIONAL POSITIONS				
Aim	***Principle***	***Example of Activity in Logical Sequence***	***Functional Activity to Be Practiced Functionally***	***Precautions/Contraindications***
		trunk, which may be one of the limitations during bridging. 	The therapist should give just enough assistance to the patient to let her experience good quality movement.	the activity without titubation, intentional limb tremor, or rebound phenomenon occurring.
	1.3 Use compensation with the eyes and cognitive concentration on performing a "smooth" movement as compensatory movement strategies to decrease ataxia).	With the patient in a half-lying/semi-Fowler position, perform hip and knee flexion by keeping the foot on the supporting surface (bed) for additional exteroceptive input through the plantar surface of the foot. The activity can also be performed in half-lying (semi-Fowler) position so that the patient can see her legs and concentrate on performing the hip and knee flexion "smoothly" and in the correct sequence.  Sitting with the back supported against the bed/wall may be the best position for starting this activity.		The friction between the foot and the supporting surface should not be so much that it causes increased incoordination/rebound phenomenon. Ensure the correct sequence of movements. Prevent unwanted compensatory strategies.

	1.4 To practice bridging	Supine lying: Flex the hips and knees and extend the hips to bridge. Patients should concentrate on doing a posterior tilt of the pelvis and pelvic floor contraction during the hip extension (bridging). The activity can be performed with/without pursed lips breathing. 	Practice bridging in a controlled way at a speed that limits titubation, intentional tremor, or rebound phenomenon of the limbs.	Prevent/limit increase in titubation/incoordination/rebound phenomenon as well as compensatory strategies.

When the patient is in the final stages of rehabilitation, progression can include bridging by using only one leg OR bridging with the legs/one leg on a small therapy ball. Precautions include prevention or at least limiting of titubation/incoordination/rebound phenomenon and compensatory strategies.

2. Rolling to one side	To obtain and implement central control in a functional activity, such as rolling to one side	Roll to one-quarter turn from supine lying by moving the shoulder girdle and pelvis forward simultaneously. Guidance by the therapist can be given against the direction of the rolling action. Repeat the activity reciprocally from sidelying toward supine and back to perform the activity bilaterally. 	Progression: Initiate rolling with either the pelvis or the shoulder girdle to obtain (some) rotational trunk control. Perform rolling toward prone and back to supine through a bigger range.	Limit inconsistent muscle contraction that leads to jerky movements. Prevent/limit rebound phenomenon, titubation, and/or compensatory strategies.

	1.4 To practice bridging	Supine lying: Flex the hips and knees and extend the hips to bridge. Patients should concentrate on doing a posterior tilt of the pelvis and pelvic floor contraction during the hip extension (bridging). The activity can be performed with/without pursed lips breathing. 	Practice bridging in a controlled way at a speed that limits titubation, intentional tremor, or rebound phenomenon of the limbs.	Prevent/limit increase in titubation/incoordination/rebound phenomenon as well as compensatory strategies.
When the patient is in the final stages of rehabilitation, progression can include bridging by using only one leg OR bridging with the legs/one leg on a small therapy ball. Precautions include prevention or at least limiting of titubation/incoordination/rebound phenomenon and compensatory strategies.				
2. Rolling to one side	To obtain and implement central control in a functional activity, such as rolling to one side	Roll to one-quarter turn from supine lying by moving the shoulder girdle and pelvis forward simultaneously. Guidance by the therapist can be given against the direction of the rolling action. Repeat the activity reciprocally from sidelying toward supine and back to perform the activity bilaterally. 	Progression: Initiate rolling with either the pelvis or the shoulder girdle to obtain (some) rotational trunk control. Perform rolling toward prone and back to supine through a bigger range.	Limit inconsistent muscle contraction that leads to jerky movements. Prevent/limit rebound phenomenon, titubation, and/or compensatory strategies.

OPTIMIZING POSTURAL CONTROL IN FUNCTIONAL POSITIONS				
Aim	***Principle***	***Example of Activity in Logical Sequence***	***Functional Activity to Be Practiced Functionally***	***Precautions/Contraindications***
			Practice actions that may include supine lying, throwing off blankets, flexing legs, bridging movement to shift sideways in bed, and rolling to the side in preparation to sit up.	
Proprioceptive neuromuscular facilitation (PNF) with the legs and the arms can be performed at this stage. (PNF dynamic reversals of antagonists, stabilizing reversals, rhythmic stabilization, rhythmic initiation, and a combination of isotonics can be implemented.) Frenkel exercises for the arms and/or legs in half-lying (semi-Fowler) position can also be performed at this stage. (The principles of both PNF and Frenkel exercises are discussed in the following paragraphs.)				
3. To improve sitting stability by optimizing postural reactions in sitting	Trunk stability during lateral weight shift in preparation for balance reactions and functional shifting forward and backward in sitting	Sitting symmetrically (with or without arm and feet support): Arm support can be either at the patient's side or on a table in front of her. Arm support may be necessary when the patient experiences major instability in sitting. Less arm/feet support can be used as part of the progression. 		If deep pressure increases titubation or rebound phenomenon, decrease the pressure but maintain the touch to facilitate stability of the patient's trunk during the weight shift.

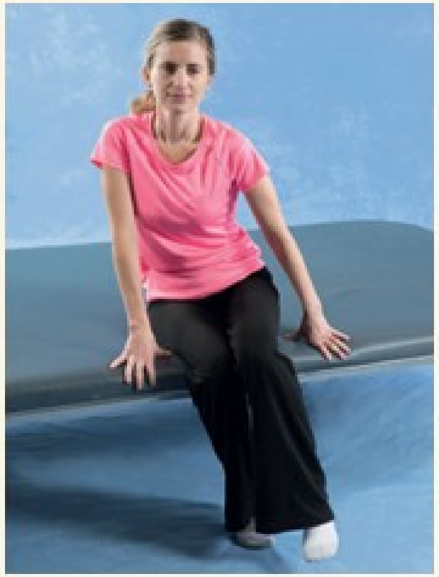
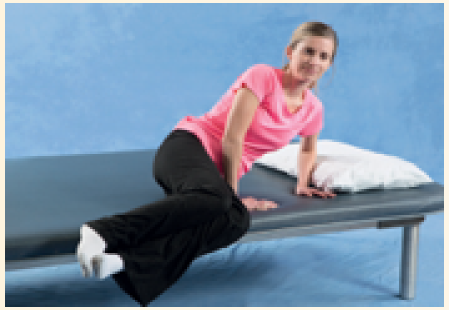
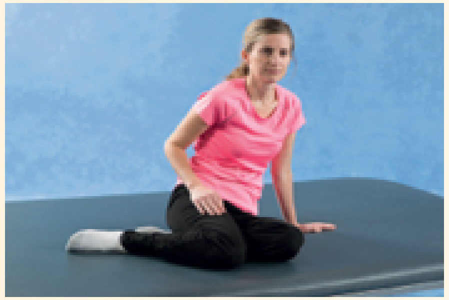
	Careful, deep, sustained pressure on the patient's trunk can be performed to assist her in stabilizing the trunk. When the patient has achieved optimal trunk stability, perform lateral weight shift followed by anterior-posterior weight shift. 		
4. To practice the functional task of shifting forward and backward in sitting in a plinth/bed by doing hip hitching	Progression: Repeat the deep, sustained pressure on the trunk with the arms in various positions/asymmetrical positions. Add weight shift in asymmetrical positions as appropriate as part of the progression.	Sit independently and shift forward with unilateral pelvis elevation and anterior rotation for forward shifting and posterior rotation for backward shifting. The action can be performed on a hard surface (i.e., a plinth) or a soft surface (i.e., on the patient's bed). A soft surface is more difficult than a hard surface.	If deep pressure or the adoption of an asymmetrical position with the arms increases titubation or rebound phenomenon, decrease the pressure but maintain the touch or more symmetrical position with the arms to facilitate stability of the patient's trunk.

TABLE 21-7 Mat Activities and Balance Training in Functional Positions—cont'd

OPTIMIZING POSTURAL CONTROL IN FUNCTIONAL POSITIONS

Aim	*Principle*	*Example of Activity in Logical Sequence*	*Functional Activity to Be Practiced Functionally*	*Precautions/Contraindications*
5. To optimize changing position from sitting to lying	Obtain changing position by using the arms as support and to enhance eccentric control and rotational trunk control.	Assist the patient in performing eccentric arm support from sitting to sidelying, followed by lifting the legs onto the bed. Repeat the activity bilaterally. 	The patient is encouraged to perform the activity independently on a hard surface as well as on her bed.	Changing position from sitting to sidelying is mechanically easier for the patient than changing position from lying to sitting. Limit titubation, rebound phenomenon, and increases in incoordination and compensatory strategies.
6. To optimize changing position from lying to sitting	To optimize rotational trunk control together with eccentric and concentric control of the limbs	Assist the patient in changing position from sidelying to sitting by taking the legs off the bed and using asymmetrical arm support.  Perform the activity with progressively less assistance as the patient is able to do it independently. Repeat the activity bilaterally.	Practice lying to sitting and lying down again on a hard surface as well as on the bed.	Limit titubation, rebound phenomenon, and increased incoordination due to exertion. Ensure that the patient uses appropriate righting reactions during the performance of the activity (to prevent compensatory strategies).

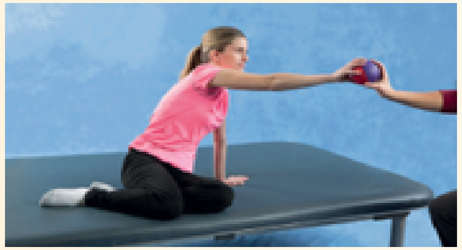
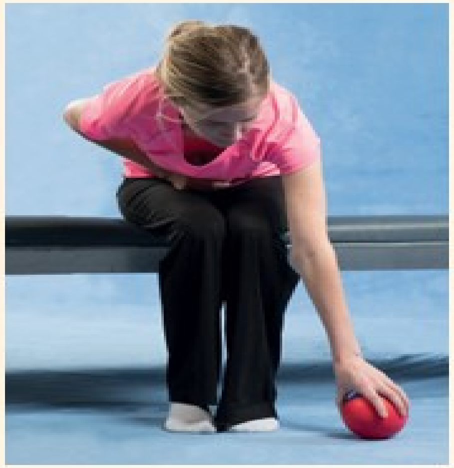
7. To optimize stability in asymmetrical positions	Optimize rotational trunk control with and without arm support as well as dynamic changing of position in sitting.	Side sitting with bilateral arm support: Careful deep sustained pressure on the patient's trunk can be performed to assist her in stabilizing the trunk and limbs. When the patient has achieved optimal trunk and limb stability, lift the less supporting arm and when possible perform weight shift by reaching toward an object. 		Limit titubation, rebound phenomenon, and increased incoordination due to exertion. Ensure that the patient uses appropriate righting reactions during the performance c the activity.
8. Practice changing position in sitting		With guidance to the limbs, assist the patient in changing position into side sitting to the **opposite** side. Careful, deep, sustained pressure on the patient's trunk can be performed to assist her in stabilizing the trunk and limbs. When the patient has achieved optimal trunk and limb stability, lift the less supporting arm and when possible perform weight shift by reaching diagonally toward an object with the nonsupportive hand.	Change position by moving from side sitting on one side to side sitting on the other side. Perform the changing of positions with guidance at the limbs/trunk to independence on hard and soft surfaces.	Limit titubation, rebound phenomenon, and increased incoordination due to exertion. Ensure that the patient uses appropriate postural reactions during the performance of the activity.
	Taking systematically more weight on the legs, perform forward weight shift in preparation for standing up.	Reaching forward with or without supporting the arms on a table or a therapy ball.	Pick up an object from the floor. Prepare for putting on socks and shoes.	Limit titubation, rebound phenomenon, and increased incoordination due to exertion. Ensure that the patient uses appropriate postural

TABLE 21-7	Mat Activities and Balance Training in Functional Positions—cont'd			
		OPTIMIZING POSTURAL CONTROL IN FUNCTIONAL POSITIONS		
Aim	***Principle***	***Example of Activity in Logical Sequence***	***Functional Activity to Be Practiced Functionally***	***Precautions/Contraindications***
		Progression would be to reach downward to the feet to pick up an object. 		reactions during the performance of the activity.
PNF techniques can be performed in sitting to optimize postural stability. Special caution should be given to prevention of aggravating titubation, ataxia/incoordination, and rebound phenomenon. Bilateral or unilateral PNF with the arms and trunk can be performed in sitting with the feet fully supported. Frenkel exercises for the arms and/or legs in sitting with the feet fully supported can also be performed at this stage. This can be progressed to functional reaching activities during activities appropriate for the patients' self-care, household chores, socioeconomic role, etc. Practice skilled functional activities of the upper limb in front of a table/in another appropriate environment. Balance reactions can be practiced with the appropriate postural reactions and protective arm and leg reactions. (The principles of PNF and Frenkel exercises are discussed in the text.)				
9. To achieve postural stability in standing	Change position from sitting to standing by using arm support, pressing down on a high surface to facilitate postural control. PRECAUTION: Standing up by pulling onto the parallel bars teaches the patient the wrong way of activating postural control during standing to sitting.	Change from sitting to standing from a high surface with a table in front of the patient for hand support in standing. Careful, deep, sustained pressure/approximation on the patient's trunk muscles and the pelvis/hip joints/upper legs to control knee extension can be performed to assist him/her in stabilizing the trunk and the hip		If deep pressure/joint approximation increases titubation or rebound phenomenon, decrease the pressure but maintain the touch to facilitate stability of the patient's trunk/hip joints/legs to limit rebound phenomenon, and/or titubation as the trunk muscles contract/during standing. The patient should not have a surface on which she can pull herself up.

joints/legs. When the patient has achieved optimal trunk stability, perform lateral weight shift followed by anterior-posterior weight shift in walk-standing.

OPTIMIZING POSTURAL CONTROL IN FUNCTIONAL POSITIONS

Aim	*Principle*	*Example of Activity in Logical Sequence*	*Functional Activity to Be Practiced Functionally*	*Precautions/Contraindications*
10. Practice sitting to standing and standing to sitting.	Assist/facilitate postural control during changing position from standing to sitting in a symmetrical position.	Make the seating surface higher so the patient does not have to perform hip and knee flexion up to 90 degrees but only for about 30°. Sitting to standing and standing to sitting through a smaller range onto and from a higher surface decreases the effort of the activity but allows the patient to perform the activity in a more appropriate movement pattern.	Practice sitting to standing and standing to sitting. Practice sitting to standing and standing to sitting in relevant environments for the patient. Use rhythm/counting to assist the patient in performing coordinated movements.	Precautions as described in the previous section
11. Prepare the patient for walking	Prepare the patient for walking by doing a lateral weight shift. Facilitate rotational trunk control further by performing weight shift in walk-standing.	Practice standing position with the arms symmetrically supported on a high surface/in parallel bars without grasping and pulling on the bars.  Standing in parallel bars is the position of choice for starting the weight shift. Perform lateral weight shift by keeping the feet on the ground by	Practice marching in one spot by supporting the hands on a surface with an appropriate height. Use rhythm/counting to assist the patient in performing coordinated movements.	Precautions as described in the previous section

		lifting only the heels, progressed by lifting the feet alternately. 		
PNF to optimize the patient's postural stability in standing can be performed with the appropriate precautions as mentioned previously in sitting. Unexpected perturbation of the patient's balance in sitting or standing while reaching limits of stability. Carefully guard the patient to prevent falling. Reaching movements/activities in standing include trunk and arm movements. Frenkel exercises in standing can also be performed at this stage. (Principles of Frenkel exercises are discussed in previous paragraphs.)				
12. Progressing in preparing the patient for walking	Optimize postural control in standing and walking in a position that limits rotational trunk control.	Standing in a parallel bar with both hands holding onto the same bar (standing sideways in parallel bar) Initiate walking sideways while holding onto the parallel bar. Use rhythm/counting to assist the patient in performing coordinated movements. Vision can initially be used as a compensatory strategy to optimize coordination of the legs during the activity. A mirror can be used to optimize vision as a compensatory strategy if appropriate.	Practice walking sideways by pressing with the hands on a wall/holding onto furniture without grasping objects.	Precautions as described in the previous section
13. Practice walking	Optimize postural control in preparation for walking.	Assist the patient in adopting a walk-standing/step-standing position (pelvic rotation), arms symmetrically supported on a high surface/in parallel bar. Perform an anterior-posterior	Practice taking a step forward and backward.	Prevent compensatory strategies. All other precautions as described in the previous section Do not let the patient pull onto the parallel bars to prevent falling.

TABLE 21-7 Mat Activities and Balance Training in Functional Positions—cont'd

OPTIMIZING POSTURAL CONTROL IN FUNCTIONAL POSITIONS				
Aim	***Principle***	***Example of Activity in Logical Sequence***	***Functional Activity to Be Practiced Functionally***	***Precautions/Contraindications***
		weight shift by lifting only the heels/ toes. Progress to lifting the feet alternately during anterior-posterior weight shift.		Encourage the use of the trunk anc protective stepping to maintain postural stability during gait. Once patients have learned to pull onto the parallel bars for stability, it is very difficult to unlearn the action, and it will limit their progress to more unstable walking aids.
		Progress by walking forward and backward in the parallel bars by using rhythm/counting/vision as compensatory strategies to optimize coordination. (The principles of Frenkel exercises in standing can be performed at this stage.)		Facilitate stability of the patient's trunk/hip joints/legs. Prevent compensatory strategies. All other precautions as described in the previous section
The decision on how and where to start reeducation of gait and which walking aid to select depends on the patient's trunk and lower limb stability and coordination during optimizing postural stability in functional starting positions. The most stable gait pattern that can be implemented is the four-point gait. Progress to two-point gait with a reciprocal gait pattern with a walker that provides stability (of the arms and, as such, also the trunk) or an elbow crutch in each hand. Further progression includes walking with a walking stick in one or both hands when the patient is relatively stable in standing. Heavy walkers and/or weighted waist belts may decrease the presentation of ataxic gait but at the same time may increase patient fatigue (Armutlu, 2001). Visual cues in the form of symmetrical marks on the floor that indicate an appropriate step length as well as rhythm (counting or verbal cueing to take steps) can optimize the patient's coordination and step length during gait. Verbal feedback by the physiotherapist or caregiver, rhythm, and visual cues are still relevant even when the patient's gait has progressed to more unstable/less supportive walking aid Falling is very common in patients with degenerative cerebellar ataxia and often results in injuries and/or a fear of falling. Fear of falling can contribute to a decrease in the patient's mobility, leading to secondary physical impairment due to immobility, a decrease in community participation, and social isolation (van de Warrenburg, 2005).				
14. Visuomotor education during functional activities enhances the equilibrium responses of patients with balance deficiencies secondary to cerebellar and vestibular ataxia, tabes dorsalis, and other somatosensory ataxias (Schulmann, 1987).				
15. Balance and gait training progressed Performing activities (step taking/walking) with eyes open and eyes closed Walking on a line/tandem walking on a line with support and progressed to no support Walking forward, sideways, backward and suddenly changing direction, stopping and starting movement/stepping, stepping over objects or walking around them, changing speed of walking from as fast as possible to as slow as possible Walking on heels and toes, stair climbing, walking with turning the head (looking upward or sideways) Unstable surfaces in sitting and standing can be used to progress balance exercises and, as such, optimize the patient's functional ability.				

The main overall purpose of the mat activities and balance training in functional positions is to optimizing postural control in functional positions.

Tremor

- Tonic holding and approximation.
- Alternative isometric exercise.
- Slow reversal hold with hold at the end and in between
- It can be reduced by ankle and wrist weights (Velcro cuffs)

Nodding of the head and Titubation of the Trunk

- Rhythmic Stabilization.
- Alternative isometric exercise.

Asthenia

- Graduated Resistive exercises to antigravity muscles.
- Endurance Ex

Vertigo

- Vestibular habituation training.
- The cawhorno-cooksey exercises.

TABLE 21-6 Cawthorne-Cooksey Exercises

FOCUS OF THE EXERCISE	ACTIVITY	EXERCISE #	START DATE	ONE MONTH	TWO MONTHS	THREE MONTHS
Eye movement	Movement of your eye while keeping your head still (1) Up and down, then side to side following your finger	1				
	(2) Focusing on your finger moving from 3 feet to 1 foot from your face	2				
Head movement: eyes open	(3) Bending forward and backward	3				
	(4) Turning from side to side	4				
Head movement: eyes closed	(5) Bending forward and backward	5				
	(6) Turning from side to side	6				
Trunk movement: eyes open	Eyes and head must follow the object					
	(7) From standing, bend forward to pick up an object from the floor and back up to standing.	7				
	(8) From standing, bend forward to pick up an object from the floor, turn to left to place the object behind, leave the object, turn to the right to pick up the object, now place the object back in front	8				
	(9) From standing, drop shoulders and head sideways to left and then right	9				
	(10) From standing, reach with object up into the air to left then right	10				
	(11) From standing, pick up an object from the floor and reach high into the air	11				
	(12) Change from sitting to standing, turn one way, sit down, stand up, turn the opposite way, sit down	12				
	(13) Turning on one spot to left and right	13				
Trunk movement: eyes closed	(14) From standing, bend forward to touch the floor and back to standing	14				
	(15) From standing, bend forward to touch the floor, turn left to touch the chair behind, turn to right to touch the chair, back to front	15				

TABLE 21-6 Cawthorne-Cooksey Exercises—cont'd

FOCUS OF THE EXERCISE	ACTIVITY	EXERCISE #	START DATE	ONE MONTH	TWO MONTHS	THREE MONTHS
	(16) From standing, drop shoulders and head, sideways to left and then right	16				
	(17) From standing, touch the floor, reach high into the air	17				
	(18) Change from sitting to standing, turning one way, sit down, stand up, turn opposite way, sit down	18				
	(19) Turning on spot to left and right	19				
Lying down	If possible, do not use a pillow					
Lying down: eyes open	(20) Rolling head from side to side	20				
	(21) Rolling whole body from side to side	21				
	(22) Sitting up straight forward	22				
	(23) From lying, roll onto your side, sit up over the edge of the bed, lie down on the opposite side, and roll onto your back	23				
Lying down: eyes closed	(24) Rolling head from side to side	24				
	(25) Rolling whole body from side to side	25				
	(26) Sitting up straight forward	26				
	(27) From lying, roll onto your side, sit up over the edge of the bed, lie down on the opposite side, and roll onto your back.	27				

During the first assessment, the patient is asked to perform each exercise five times. The patient's performance is rated on a four-point scale in which 0 = no symptoms, 1 = mild symptoms, 2 = moderate symptoms, and 3 = severe symptoms. The patient's home exercises entail the practicing of only those exercises that cause mild to moderate symptoms. Progression is based on the way the patient tolerates the effect of the exercises over time. (Adapted with permission from Meldrum D, Walsh RM. Vestibular and balance rehabilitation. In: Stokes, M, ed. *Physical Management in Neurological Rehabilitation*. Philadelphia, PA: Elsevier-Mosby; 2004:413–430.)

Gait

Preparation for ambulation

- This starts from sitting or prone to reach a quadruped position, then advances to kneeling and then applies crawling.
- When standing from sitting, patient slides forward in the chair and bends his trunk to put COG over his feet .The trunk and legs should be extended only after gaining balance on the feet.
- Standing activities should be started in the parallel bars.
- Standing balance exercises.
- Approximation through shoulders and hips.
- Tremor can be reduced by ankle weight or weighted belt.
- Rhythmic Stabilization for trunk rotation.
- Maintain Standing without pulling on bars.
- Once standing is stable, alternate lifting of feet is practiced.

a. Narrow base of support, arms at sides. Progression: increase gait speed.
b. Normal base of support, arms at sides with periodic head movements. Progression: narrow base of support, increase and vary speed and frequency of head movements.
c. Gait with wide turns, arms at sides. Progression: sharpen angle of the turn, increase gait speed, add head movements.
d. Gait with eyes closed, arms at sides. Progression: add turns, add head movements, increase gait speed.
e. Gait with perturbations: (i) self-imposed, e.g., large arm movements; (ii) external, e.g., pushes by therapist. Progression: increase speed and amplitude of perturbations, make external perturbations unexpected.

a. Sideways and backward gait, eyes open, arms at sides. Progression: narrow base of support, add head movements, perform with eyes closed, increase gait speed.
b. Incline and decline gait, eyes open, arms at sides. Progression: narrow base of support, add head movements.
c. Gait on foam, padded or other compliant surface, eyes open, arms at sides. Progression: narrow base of support, add turns, add head movements, perform with eyes closed.
d. Semitandem gait, eyes open, arms at sides. Progression: narrow base to tandem gait, add head movements, perform with eyes closed.
e. Gait while negotiating obstacles, eyes open, arms at sides, avoid/step onto/step over. Progression: increase obstacle number and size, vary obstacle placement.
f. Gait while distracted, eyes open, arms at sides. Add cognitive task as a distracter; start with responding to simple yes/no questions, progress to difficult tasks (e.g., counting, performing two- or three-digit addition/ subtraction).

- Use of supportive aids In cases which restorative physical treatment applications are insufficient, use of supportive devices enables the patient to function more easily within his present functional level.- In cases of severe ataxia, suspending--weights from the extremities and the use of weighted walkers can be preferred