



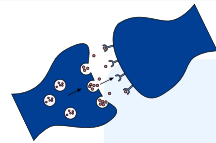
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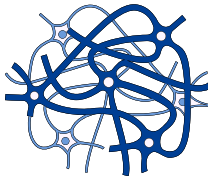
Brainstem Motor Function

Final | Lecture 1

إِنِّي تَوَكَّلْتُ عَلَى اللَّهِ رَبِّي وَرَبِّكُمْ مَا مِنْ دَابَّةٍ إِلَّا هُوَ آخِذٌ بِنَاصِيَتِهَا إِنَّ رَبِّي عَلَى صِرَاطٍ مُسْتَقِيمٍ



Done by: Mahmoud Aljunaidi



رحلة اليقين مع سورة يس

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

وَإِنْ نَشَأْ نُغْرِقْهُمْ فَلَا صَرِيخَ لَهُمْ وَلَا هُمْ يُنْقَذُونَ ﴿٤٣﴾ إِلَّا رَحْمَةً مِنَّا وَمَتَاعًا إِلَىٰ حِينٍ ﴿٤٤﴾

فلما خاطبهم الله تعالى بالقرآن، وذكر حالة الفلك، وعلم تعالى أنه سيكون أعظم آيات الفلك في غير وقتهم، وفي غير زمانهم، حين يعلمهم صنعة الفلك البحرية الشراعية منها والنارية، والجوية السابحة في الجو، كالطيور ونحوها، والمراكب البرية مما كانت الآية العظمى فيه لم توجد إلا في الذرية، **نَبَّهَ فِي الْكِتَابِ عَلَىٰ أَعْلَىٰ نَوْعٍ مِنْ أَنْوَاعِ آيَاتِهَا فَقَالَ: {وَأَيَّةٌ لَهُمْ أَنَّا حَمَلْنَا ذُرِّيَّتَهُمْ فِي الْفُلِّ الْمَشْحُونِ} أَي: المملوء ركباناً وأمتعة. فحملهم الله تعالى، ونجاهم بالأسباب التي علمهم الله بها، من الغرق، ولهذا نبههم على نعمته عليهم حيث أنجاهم مع قدرته على ذلك، فقال: {وَإِنْ نَشَأْ نُغْرِقْهُمْ فَلَا صَرِيخَ لَهُمْ} أَي: لا أحد يصرخ لهم فيعاونهم على الشدة، ولا يزيل عنهم المشقة، {وَلَا هُمْ يُنْقَذُونَ} مما هم فيه .**

{إِلَّا رَحْمَةً مِنَّا وَمَتَاعًا إِلَىٰ حِينٍ} حيث لم نغرقهم، لطفاً بهم، وتمتيعاً لهم إلى حين، لعلمهم يرجعون، أو يستدركون ما فرط منهم.

Side Note: Some information mentioned in the lecture's recording regarding sensory pathways has been discarded to lighten and shorten the lecture up.

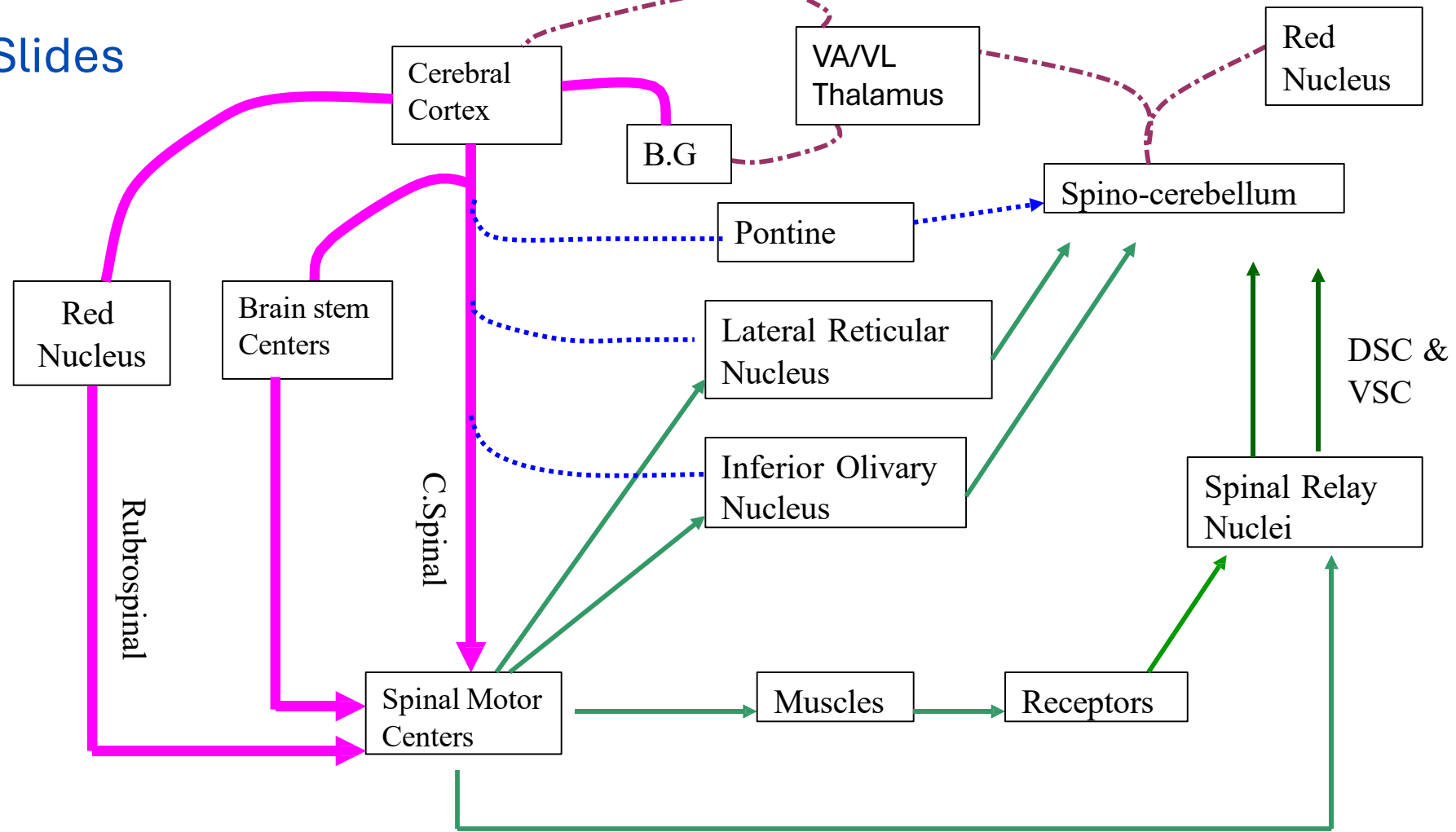
Brainstem Motor Function-





Faisal I. Mohammed, MD, PhD

Objectives

- Describe the general functions of the brainstem
- List the descending brainstem tracts
- Explain how these tracts work to control motor movements
- Outline some brainstem abnormalities

See Next Slides



-  Motor Command
-  Feed Back
-  Command Monitor
-  Corrective Command

Motor System

Motor System⁽¹⁾

- ✓ The **motor system** is responsible for producing and controlling voluntary movement.
- ❖ **Motor Pathway:**
 - Motor activity begins in the **Cerebral cortex**, where motor commands are generated.
 - These commands descend through **upper motor neurons** to the spinal cord.
 - In the spinal cord, the signal is transmitted to **lower motor neurons**, which exit the spinal cord and **directly** innervate skeletal muscles.
 - Activation of these lower motor neurons causes muscle contraction and produces movement.
- ✓ This basic pathway (from cortex to spinal cord to muscle) is the fundamental route through which voluntary motor actions occur.

Motor System⁽²⁾

- Within the muscles themselves, specialized sensory receptors monitor muscle activity and provide feedback to the central nervous system. Two important receptors are:
 1. **Muscle spindle.**
 - The muscle spindle is located within the muscle and detects **changes** in muscle length.
 - It responds not only to the **amount of stretch** (static change) but also to the **rate** at which the **muscle length changes** (dynamic change).
 2. **Golgi tendon organ.**
 - The Golgi tendon organ, located in the tendon, detects **changes in muscle tension**.
- These receptors are essential for **proprioception**, allowing the nervous system to monitor the position and activity of muscles.
- Information from these receptors is transmitted to the **Cerebellum** through the **Dorsal spinocerebellar tract** and the **Ventral spinocerebellar tract**.
 - These pathways provide the cerebellum with information about the **actual movement** taking place in the body.
 - This process forms part of a **feedback** mechanism that allows the nervous system to constantly monitor and adjust ongoing movements.

Motor System⁽³⁾

- At the same time, the cerebellum receives information about the **intended movement** from the cerebral cortex through the **Corticopontocerebellar tract**; this pathway conveys the motor plan generated by the cortex.
- The cerebellum then **compares** the intended movement with the actual movement occurring in the muscles. Because movements are rarely perfectly executed on the first attempt, the cerebellum detects differences between the intended and actual actions and **generates corrective signals**.
- These corrective signals are transmitted to the **Thalamus** (The Cortex Secretary). Specifically, the motor information passes through the **Ventral anterior nucleus (VA)** of the thalamus and the **Ventral lateral nucleus (VL)** of the thalamus before being sent back to the motor areas of the cerebral cortex.
 - In this way, the cortex receives updated information and **modifies** the original motor command to **improve the accuracy of the movement**.

Motor System⁽⁴⁾

Smoothness of Movement

- Because of this continuous feedback and correction, movements become **smooth and well coordinated**.
- Without cerebellar correction, voluntary movements would be **inaccurate and oscillatory** (going up and down; متذبذبة).
 - For example, when reaching to grab an object, the hand might overshoot the target and then move back repeatedly before successfully grasping it. The cerebellum **continuously adjusts the motor command** during the movement so that these corrections occur **rapidly and smoothly**, often without the person being aware of them (**subconsciously**).
- ❖ **Movement is corrected multiple times before completion through 2 loops:**
 - A **short loop** within cerebellar circuits, cerebellum to spinal cord, allows extremely **rapid adjustments**, occurring within a few milliseconds (~5ms).
 - A **long loop** involves the pathway from the cerebral cortex to the spinal cord, then to the muscles, and back to the cerebellum through sensory feedback pathways, which takes longer (~100ms).
 - Because the short loop operates much faster than the long loop, the cerebellum can make **multiple corrections before a movement is completed**, which is why normal movements appear **smooth and precise**.

Cerebellar Injury: Effect on Smoothness

- When the cerebellum is damaged, several characteristic abnormalities appear:
 1. One of the most common is **action** (or **intention**) **tremor**, which occurs during voluntary movement. The tremor becomes more pronounced as the individual approaches a target; **a cerebellar tumor**.
 2. Patients may also develop **ataxia**, which refers to a **lack of coordination** and difficulty maintaining balance during walking or standing.
 3. Another sign of cerebellar dysfunction is **nystagmus**, a **rhythmic involuntary movement of the eyes** that occurs because the cerebellum also plays a role in coordinating eye movements.
- **Action tremor** differs from the tremor associated with Parkinson's disease, which primarily involves dysfunction of the basal ganglia; **resting tremor**.
 - ✓ In Parkinson's disease, the tremor typically **occurs at rest and decreases during voluntary** movement. In contrast, cerebellar tremor appears during movement and worsens as the person attempts to perform precise actions.

Motor System⁽⁵⁾: The Brain Stem

- ✓ **Motor control is also influenced by pathways originating in the Brainstem.**
- Several descending tracts from the brainstem help **regulate posture and muscle tone**:
 - The **Rubrospinal tract** mainly facilitates flexor muscles, whereas the **Vestibulospinal tract** and the **Reticulospinal tract** primarily influence extensor muscles.
 - ✓ These extensor muscles are often referred to as **anti-gravity muscles** because they help maintain posture and allow the body to stand and move against gravity, and they **have more receptors** when compared to flexor muscles.
- Motor pathways are often grouped into **lateral pathways** and **medial pathways**:
 - **Lateral pathways**, such as the corticospinal and rubrospinal tracts, control distal limb muscles and are responsible for **fine voluntary movements by controlling flexors**.
 - **Medial pathways**, including the vestibulospinal and reticulospinal tracts, control axial and proximal muscles and are important for **posture, balance, and coordination by controlling extensors**.
- Finally, the brainstem plays a critical role in the **organization of the nervous system** because nearly all ascending sensory tracts and descending motor tracts pass through it.
- Unlike wireless communication, neural signaling requires direct anatomical connections between neurons. As a result, **damage to the brainstem can disrupt multiple pathways simultaneously and may lead to severe neurological deficits such as paralysis or loss of sensation**.

Control of Motor Function by the Brainstem

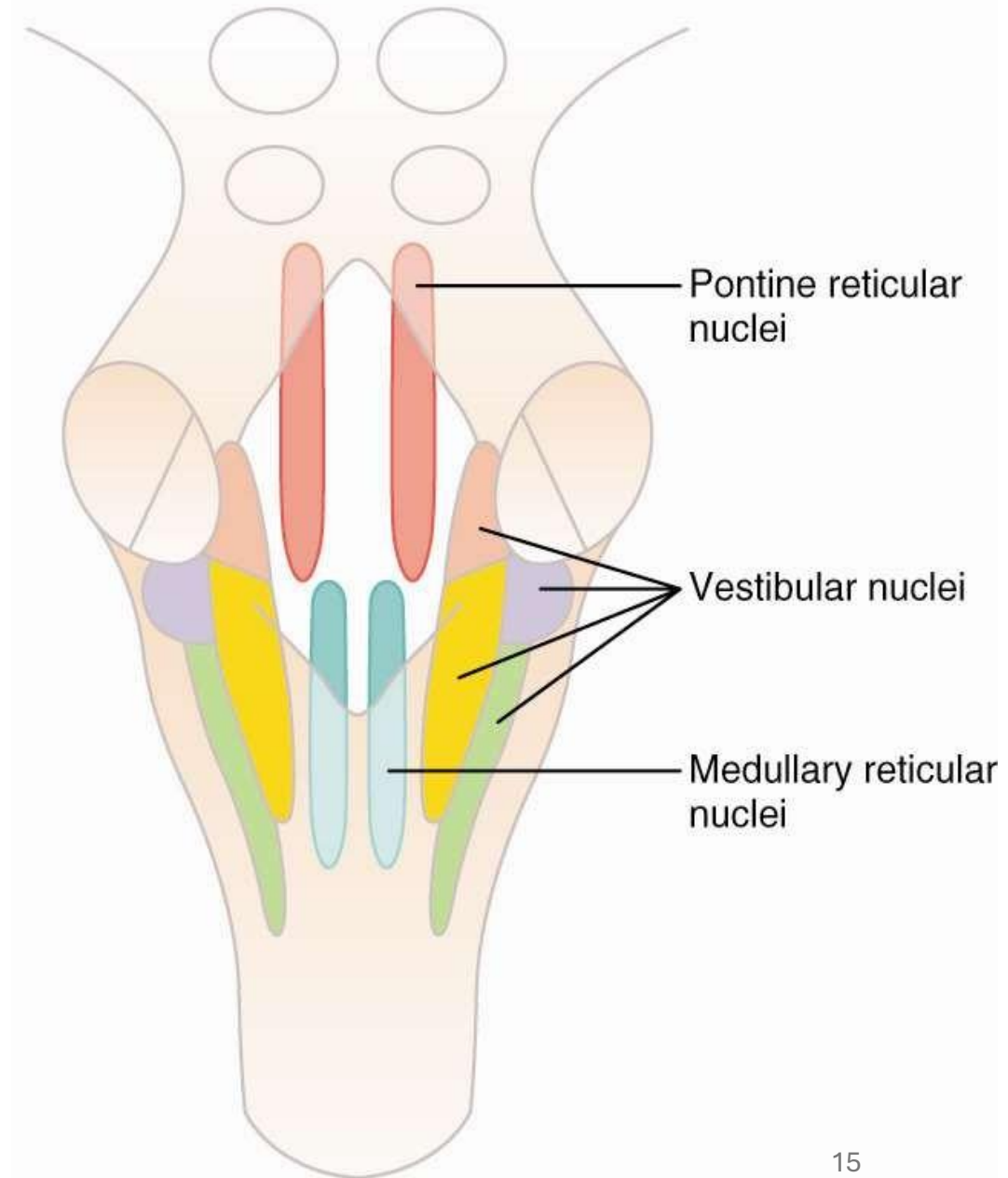
- Brainstem as an **extension of the spinal cord**.
 - Performs **motor and sensory functions** for the face and head (i.e., cranial nerves).
 - **Similar to spinal cord for functions from the head down.**
- Contains centers for stereotypic movement and equilibrium.

Support of the Body Against Gravity

- The **muscles of the spinal column** and the **extensor muscles** of the legs support the body against gravity (**Anti-gravity Muscles**).
- These muscles are under the **influence of brainstem nuclei**.
- The **reticulospinal tract is divided into 2 tracts** (medial and lateral) depending on the location of the nuclei, and each specializes in a particular “opposing” function:
 - The **pontine reticular nuclei**, **located in pons**, excite the antigravity muscles.
 - The **medullary reticular nuclei** inhibit the antigravity muscles.

Orientation of the Pontine and Medullary Reticular Nuclei

- This is the brainstem area.
- In **pinkish-red** is the **pontine reticular formation** (sometimes referred to as the medial reticulospinal system).
- While in **cyan blue** these represent the **medullary reticular formation** (lateral reticulospinal system).
- And the remaining are the **vestibular nuclei**, which are the most important for **balance**.
 - There are four vestibular nuclei: superior, inferior, lateral, and medial.
 - They receive input from the **vestibular apparatus**.
 - This input comes via the **vestibular part of the vestibulocochlear nerve (CN VIII)**.
- The vestibular and cochlear parts are continuous with each other and contain fluids:
 - **Endolymph** → similar to intracellular fluid, rich in potassium.
 - **Perilymph** → similar to extracellular fluid.



Pontine Reticular Nuclei

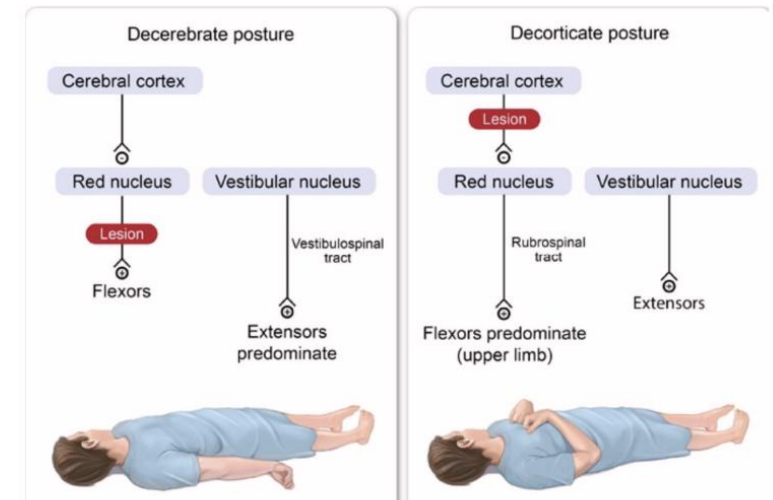
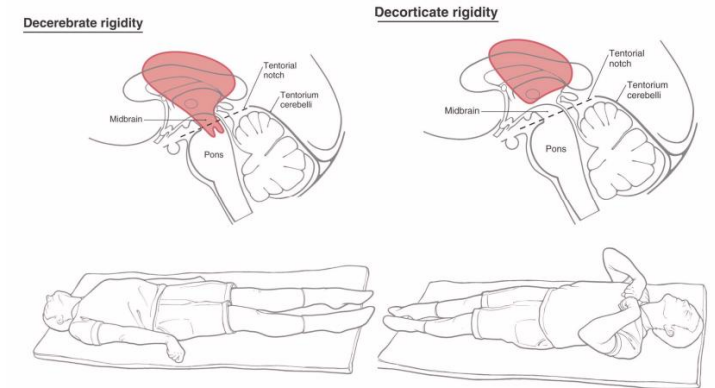
- Transmit excitatory signals through *pontine reticulospinal tract*.
- Pontine reticular nuclei have a high degree of natural excitability, *they are intrinsically active* (always firing).
- When unopposed **by the medullary reticulospinal tract**, they cause **powerful excitation** of the antigravity muscles.

Anti-gravity muscles and Their Regulation

- The body's **anti-gravity (extensor) muscles** must remain active to maintain posture, but they **should not be excessively rigid**. This balance is achieved through interaction between brainstem pathways.
- The **Pontine reticulospinal tract** facilitates extensor muscle tone, helping maintain upright posture. However, this activity is regulated by the **Medullary reticulospinal tract**, which inhibits the pontine tract.
- Importantly, the medullary reticulospinal tract itself is not intrinsically active; it requires stimulation from the **Cerebral cortex**. The cortex activates the medullary system, which in turn **suppresses excessive extensor tone**.
- ✓ This creates a continuous “checking” mechanism that **prevents rigidity**. So, what would happen if injury occurs?

Extensors Regulatory Pathways: Injury

- If cortical input to the medullary reticular formation is lost, this inhibitory control disappears. As a result, the **pontine reticulospinal tract becomes unopposed**, leading to excessive activation of extensor muscles.
 - ✓ This condition is known as **decerebrate rigidity**, where the limbs become extended and stiff.
- Recall from midterm's anatomy: This reflects severe brain injury, typically at or below the level of the red nucleus, and **demonstrates the importance of cortical control over brainstem motor pathways.**



Extrapyramidal Tract Pathways

➤ Everything here was mentioned but I've put them in gray to minimize repeats. Those in **Blue** are new.

Again: Motor pathways can be divided into **lateral** and **medial** systems.

- The lateral system, located in the lateral part of the spinal cord, includes the **Corticospinal tract**, **Rubrospinal tract**, and the **medullary reticulospinal tract**.
 - ✓ These pathways primarily **facilitate flexor muscles** and **inhibit extensors**, and they are responsible for voluntary, especially fine, movements.
- In contrast, the medial system, located in the medial part of the spinal cord, includes the **pontine reticulospinal** and the **Vestibulospinal tract (medial and lateral)**.
 - ✓ They promote extensor (anti-gravity) muscle activity and are essential for posture and balance.

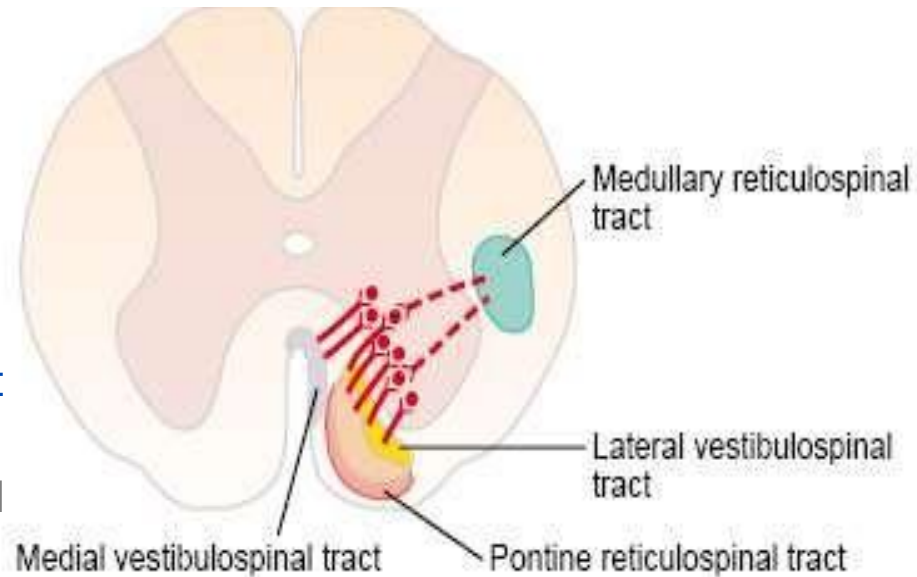


Figure 55-8

Vestibulospinal and reticulospinal tracts descending in the spinal cord to excite (solid lines) or inhibit (dashed lines) the anterior motor neurons that control the body's axial musculature.

Lateral system Pathways:
excites Flexors;
Lateral Corticospinal, Rubrospinal, medullary reticulospinal

Medial system pathways:
Excites extensors; Pontine reticulospinal, lateral and medial vestibulospinals

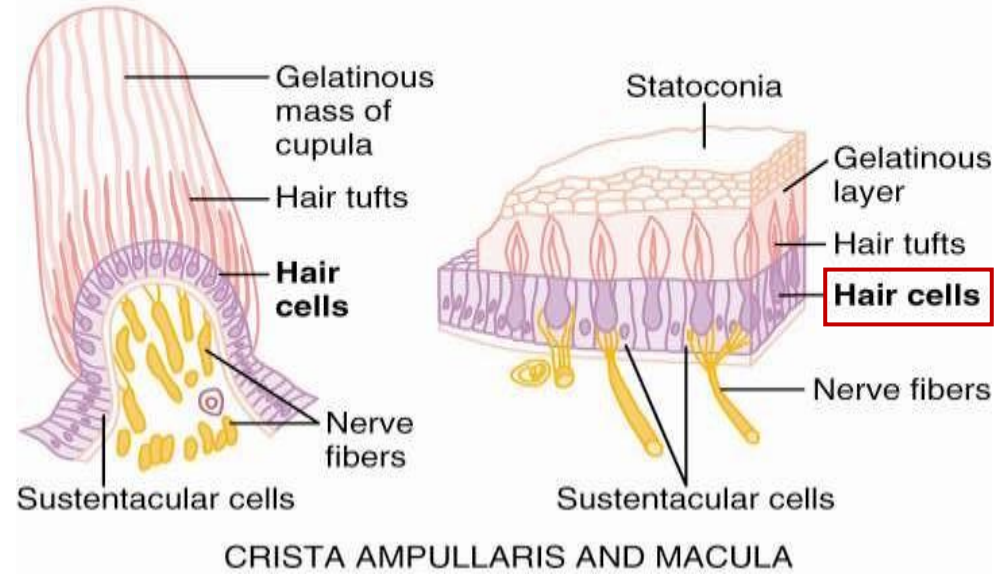
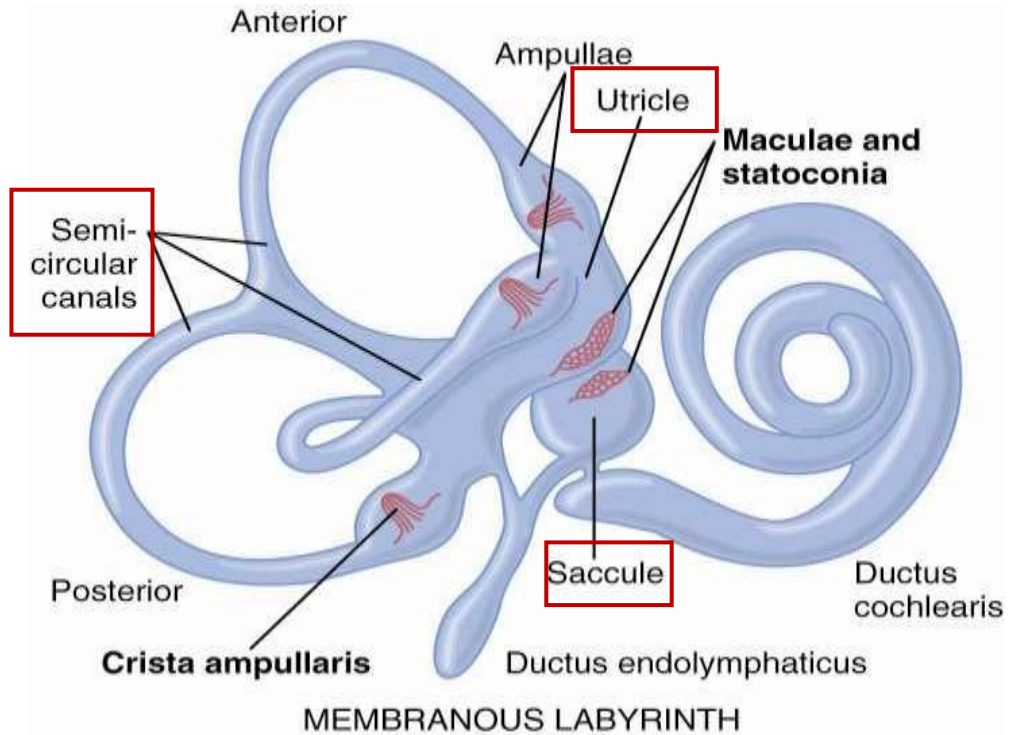
Medullary Reticular Nuclei

- Transmit inhibitory signals to the antigravity muscles through the *medullary reticulospinal tract*.
- These nuclei receive collateral input from the **corticospinal tract, rubrospinal tract, and other motor pathways**. Cortico- medullary input excites this tract.
- These systems can activate the **inhibitory action of the medullary reticular nuclei** and counterbalance the signals from the pontine reticulospinal.
- **Decerebrate rigidity** - removal of the cortical control over the medullary reticulospinal keeps pontine reticulospinal **un-checked** leads to **hyperactivity of anti-gravity muscles**.

Vestibular Apparatus

- System of bony tubes and chambers in the temporal bone:
 - Semicircular ducts, **responsible for Angular/rotational acceleration.**
 - Utricle
 - Sacculle
- Within the **utricle** and the **sacculle** are sensory organs for detecting the **orientation of the head with respect to gravity** (linear acceleration) called the **macula**.
 - **Linear acceleration:** Moving forward, backwards and sideways.

The Vestibular Apparatus



Vestibular Apparatus

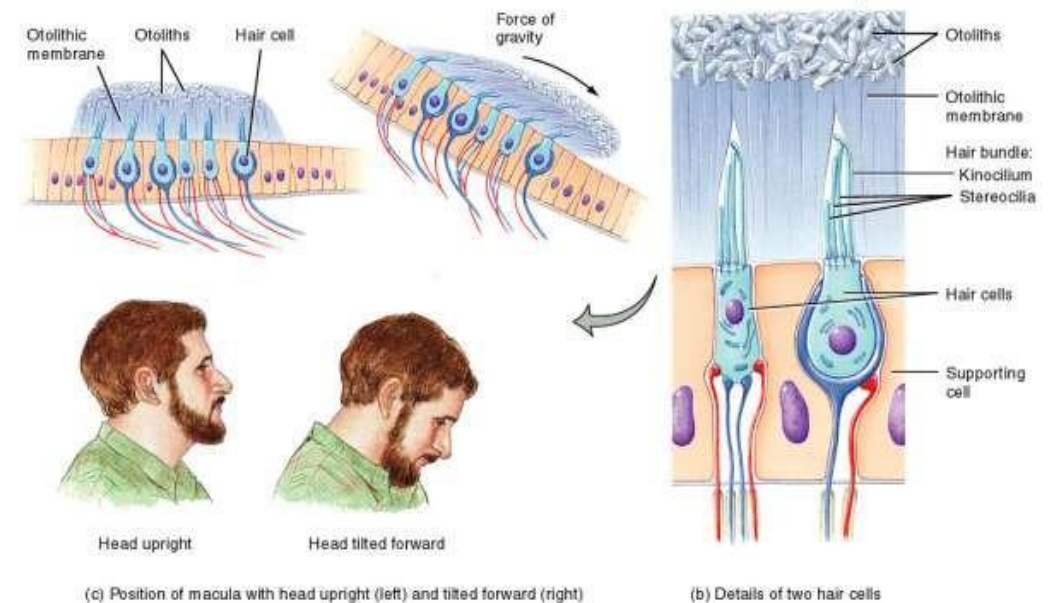
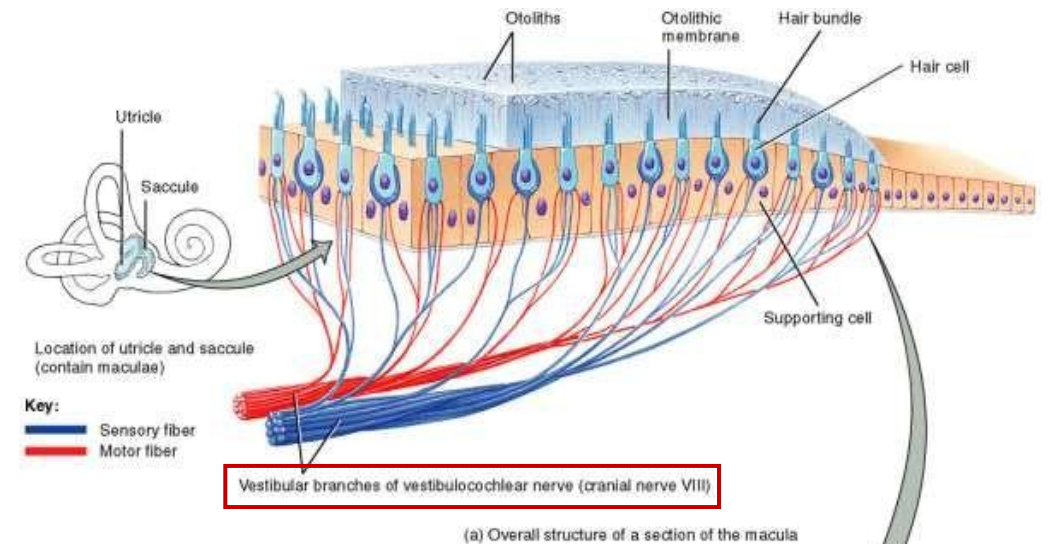
Explanation⁽¹⁾

- The inner ear contains **three semicircular canals**: the **anterior**, **posterior**, and **lateral** canals.
- These canals are arranged in three planes that are **perpendicular** (90 degrees) **to each other**.
 - This spatial arrangement allows the vestibular system to **detect movements of the head in all directions**, covering the full three-dimensional space.
- The **lateral semicircular canal** lies approximately in the transverse (horizontal) plane. However, in the normal anatomical position, it is slightly tilted, and it becomes truly horizontal when the head is flexed forward by about 30–45 degrees.
 - This canal is mainly responsible for detecting **horizontal rotational movements of the head**, such as turning the head side to side.
- The **anterior and posterior semicircular canals** are oriented in vertical planes and are positioned in a way that they function as pairs between the two ears. Specifically, the anterior canal on one side works together with the posterior canal on the opposite side (right anterior with left posterior, and left anterior with right posterior).
 - This pairing enhances the detection of **rotational movements in vertical and oblique planes**.

Vestibular Apparatus

Explanation⁽²⁾

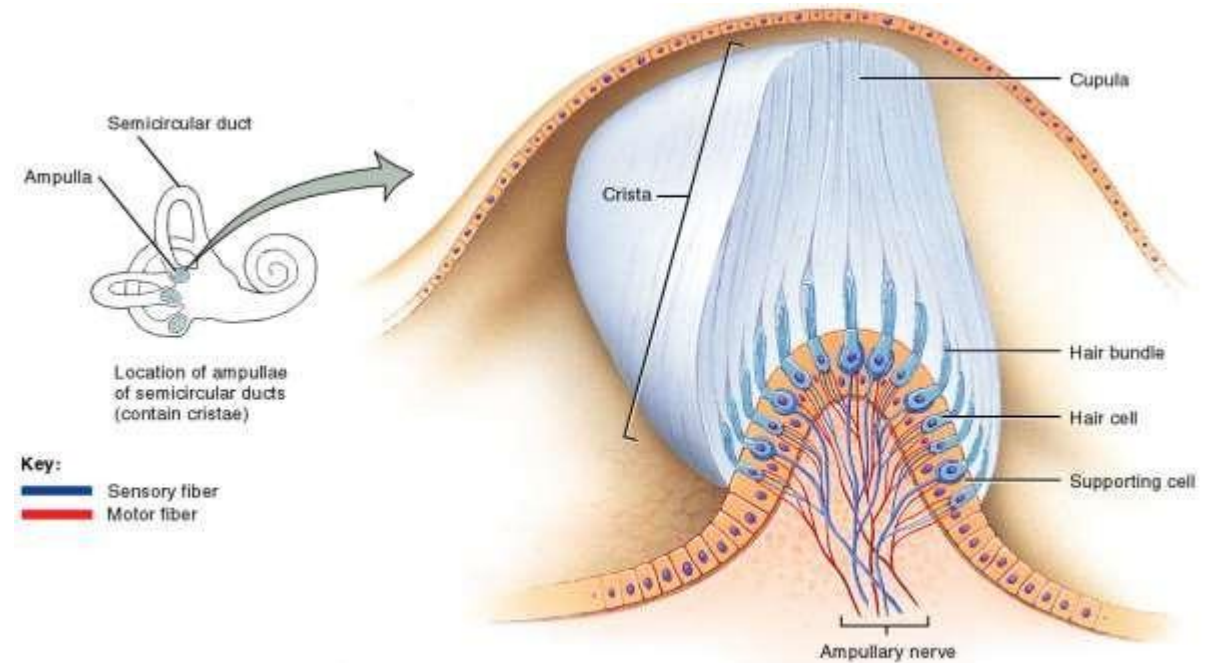
- In the utricle and saccule, the sensory receptors are called **maculae**. These maculae contain hair cells, similar to those found in the auditory system. The hair cells are covered by a specialized structure known as the **otolithic membrane**.
- The otolithic membrane contains crystals made of calcium carbonate (otoconia). These crystals make the **membrane relatively heavy**, allowing it to exert pressure on the underlying hair cells. **This added weight plays an important role in detecting linear acceleration and head position.**
- Both the utricle and saccule are filled with **endolymph**, which is the same fluid found throughout the membranous labyrinth of the inner ear.
- **Maculae** are supplied by both **sensory** and **motor** fibers.
 - The motor component acts as a **feedback mechanism** originating from the cortex, descending to regulate the sensitivity of the system. These motor fibers are known as **corticofugal fibers**.
 - They help control and adjust the sensitivity of the system, which may otherwise respond strongly to stimuli but lack proper sensitivity modulation.
 - **The same applies for the ampulla.**



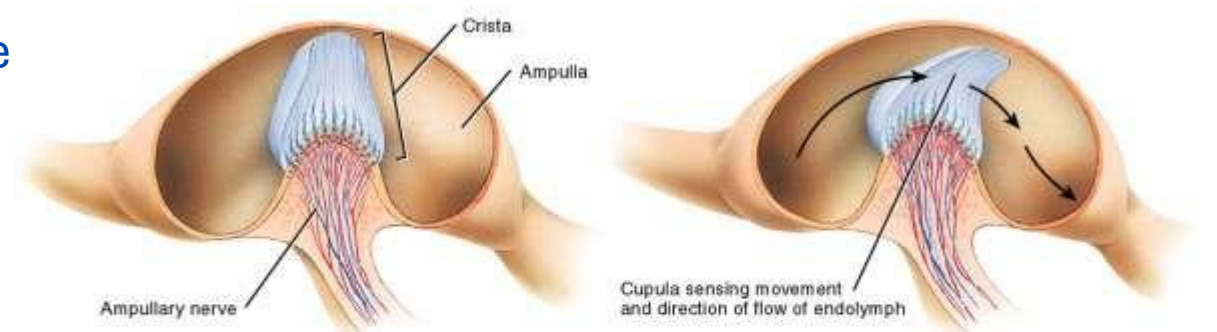
Vestibular Apparatus

Explanation⁽³⁾

- In contrast to utricle and saccule, within the semicircular canals, specifically at the ampulla (the base of each canal), there is a structure called the **crista ampullaris**.
- This structure also contains hair cells, but instead of being covered by an otolithic membrane, they are embedded in a **gelatinous structure** called the **cupula**.
- ✓ This differs from the auditory system in the cochlea, where hair cells are associated with the **tectorial membrane**.
 - In the cochlea, there are distinct types of hair cells: **inner hair cells** and **outer hair cells**. However, in the vestibular system (utricle, saccule, and semicircular canals), hair cells do not follow this same inner/outer classification.



(a) Details of a crista



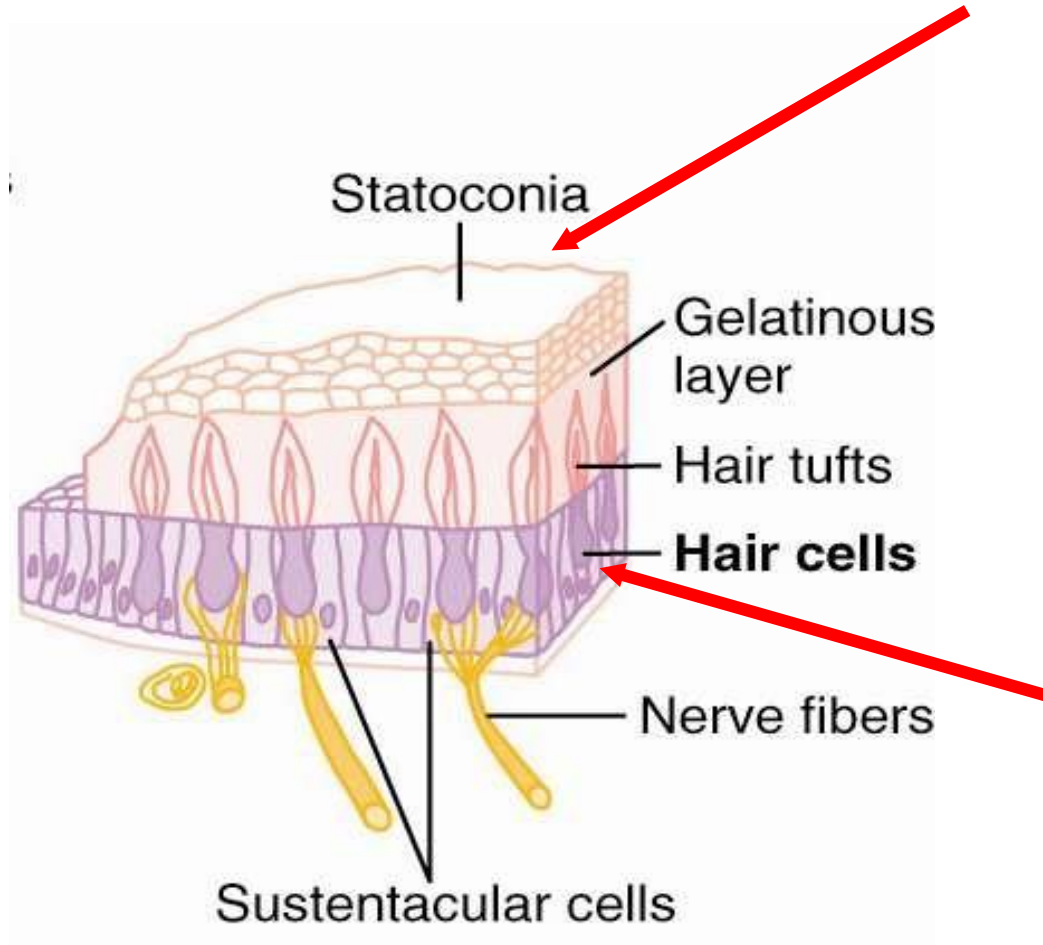
(b) Position of a crista with the head in the still position (left) and when the head rotates (right)

Vestibular Apparatus

Explanation⁽⁴⁾

- Movement of the head causes **displacement of endolymph** within these structures. Because the fluid lags behind motion due to inertia, it **bends the hair cells** in the opposite direction to the initial movement.
- Each hair cell has stereocilia and a single kinocilium (the longest stereocilium).
- When stereocilia bend **toward** the kinocilium, the cell depolarizes and increases its firing rate; bending **away** causes hyperpolarization and decreases firing.
- This bidirectional response is possible because the system has a **basal firing rate**, which allows both increases and decreases in signal intensity.

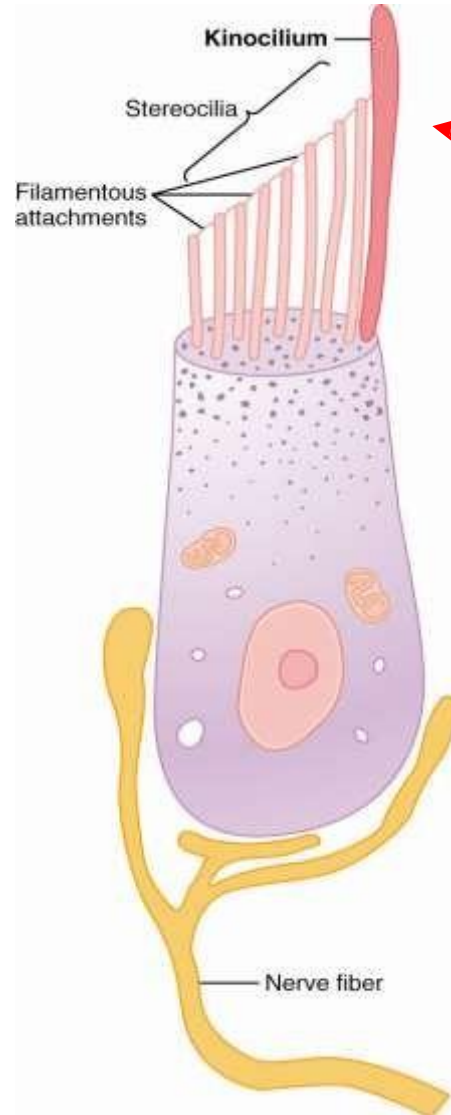
The Macula



The **stataconia** make the structure *top heavy* so that it is capable of responding to changes in head position.

Gravity sensitive receptor consists of gravity sensitive hair cells.

Hair Cells



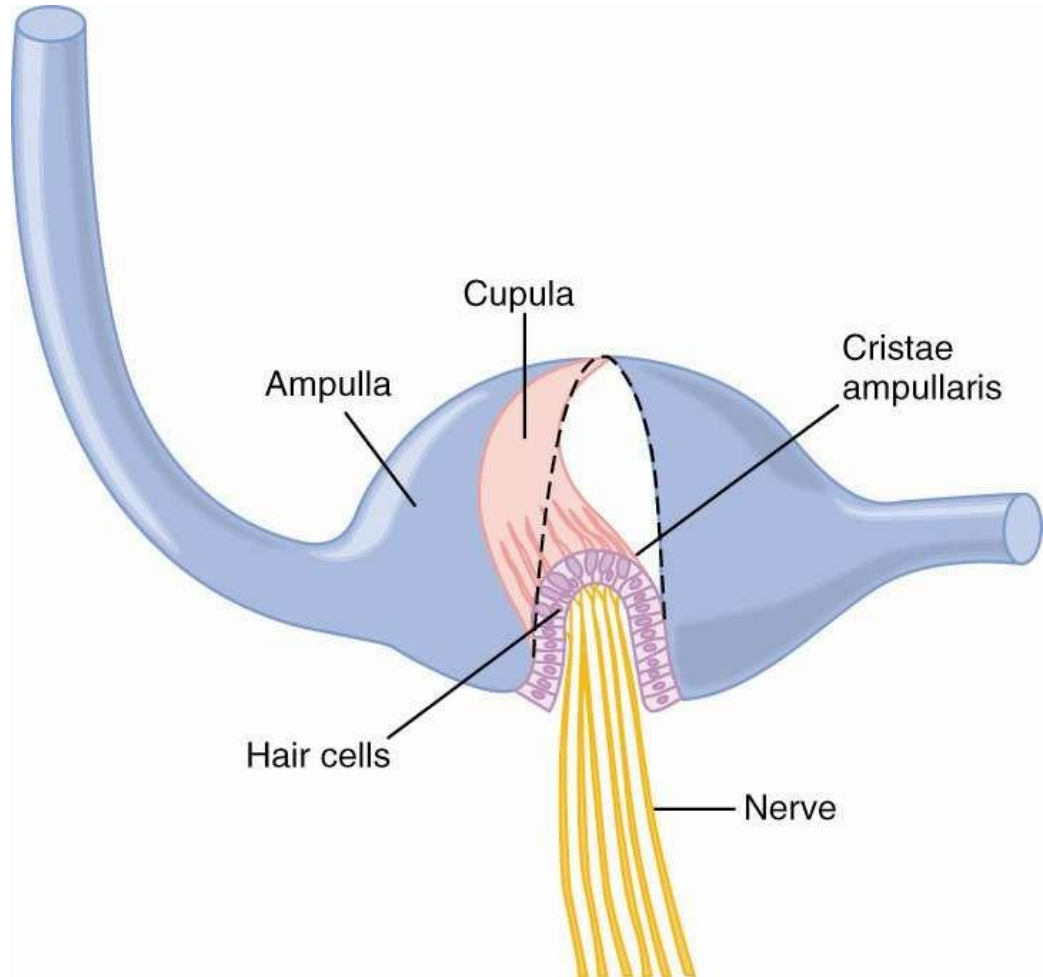
Have a series of protrusions called *stereocilia* and one large protrusion called the *kinocilium*. These structures are directionally sensitive.

Bending in one direction causes depolarization, bending in the opposite direction cause hyperpolarization.

Detection of Head Orientation

- In each macula different hair cells are oriented in different directions. **As a result, movement in any direction will be detected and hair cells are activated.**
- Some are stimulated when the head bends forward, some when the head bends backward, some when the head bends to the side.
- The pattern of excitation of the hair cells apprises the brain of the **orientation of the head with respect to gravity** (linear acceleration)

Semicircular Canals



- **All located at 90⁰** to each other representing all 3 planes (X, Y, Z) in space. (lateral or horizontal, anterior and posterior)
- Each duct has an enlargement at the end called an ***ampulla***.
- Within the ampulla is a sensory structure called the ***crista ampullaris***.
- **Bending the crista ampullaris in a particular direction excites the hair cells.**

Mechanisms of Vestibular Function and Equilibrium

- Hair cells in different orientations ensure that movement in any direction is detected. In the semicircular canals, which are arranged **at right angles** to each other, rotational movement in any plane will activate specific sets of hair cells; **not all hair cells are excited, some are inhibited**. When rotation begins, **endolymph movement initially lags behind, stimulating the receptors**. However, if rotation **continues at a constant speed**, the fluid eventually **catches up**, and the firing rate returns to baseline.
 - ✓ This explains why the sensation of dizziness decreases during constant motion but reappears when motion stops.
- The information from these receptors is transmitted via the **Vestibulocochlear nerve (CN VIII)** to the **Vestibular nuclei**. From there, signals descend through vestibulospinal tracts to adjust muscle tone and maintain balance. These nuclei also send projections to the nuclei controlling eye movements, particularly via connections with the **Oculomotor nerve (CN III)**, allowing coordination between head and eye movements. This coordination is essential for **stabilizing vision during motion** and preventing abnormal eye oscillations such as **nystagmus**.
- **Equilibrium** is maintained not only by the **vestibular system** but also through integration with visual input and proprioception from the neck and body.
 - For example, when getting off a moving bus, the body compensates by **gradually reducing speed** rather than stopping abruptly. This prevents a mismatch between body movement and endolymph motion, which would otherwise lead to **imbalance or falling**.

Maintaining Equilibrium

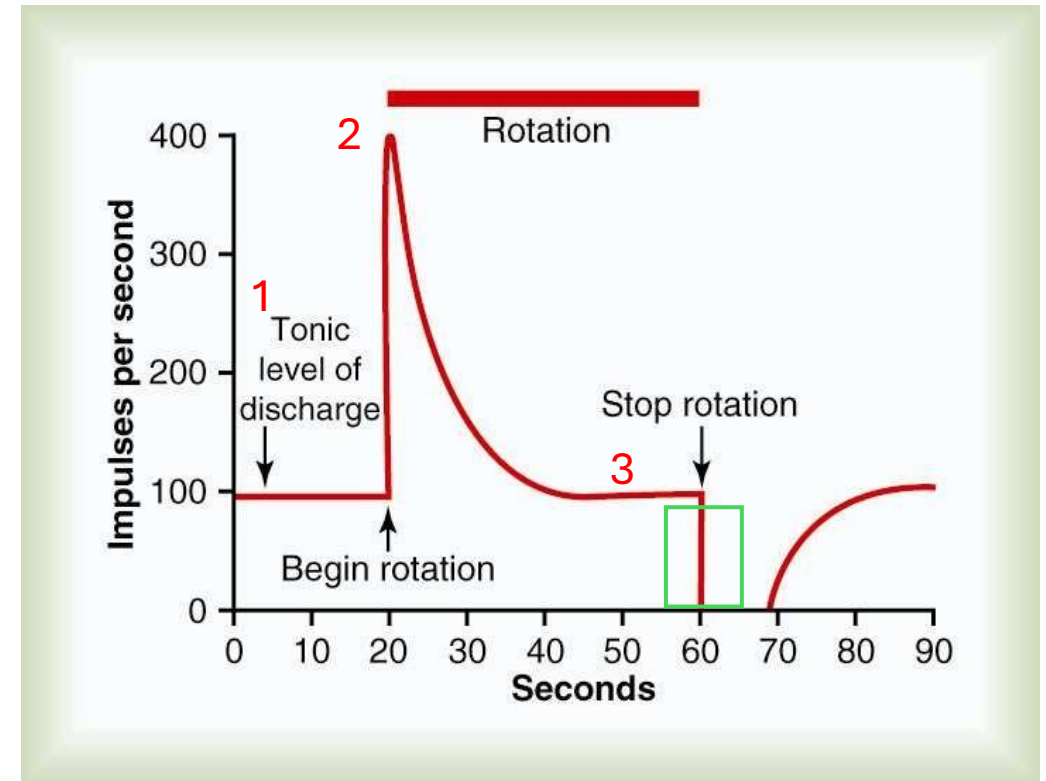
- Information from the hair cells in the maculae of the utricles and saccules is transmitted **to the brain** via the **vestibular nerve**.
- When the body is accelerated forward the hair cells of the maculae bend in the opposite direction, this causes one to feel as if they are falling backward.
- **Reflexes cause the body to lean forward.**

Semicircular Ducts Detect Angular Acceleration

- Rotation of the duct detects **rotational movements of the head** (rotational acceleration)
- Endolymph tends to **remain stationary** in the duct because of inertia.
- Rotation of the duct in one direction causes relative movement of endolymph in the opposite direction activating the receptors in the crista ampullaris.
- Stop the rotation, the opposite happens.

Response of a Hair Cell When a Semicircular Canal is Stimulated

- ❖ The sensory system maintains a basal⁽¹⁾ (resting) impulse rate even when static. This baseline is crucial because it allows the brain to detect change in two directions:
 - **Acceleration**⁽²⁾: When rotation or movement begins, the impulse rate increases above the basal level.
 - **Deceleration/Direction Change**: Even during active rotation, if the rate of change shifts, the impulse rate may decrease below the basal level.
 - **Steady State**⁽³⁾: Once you reach a constant speed (steady velocity), the impulse rate returns to its normal level. This is why, in a moving car or plane at a constant speed, you no longer "feel" the motion.



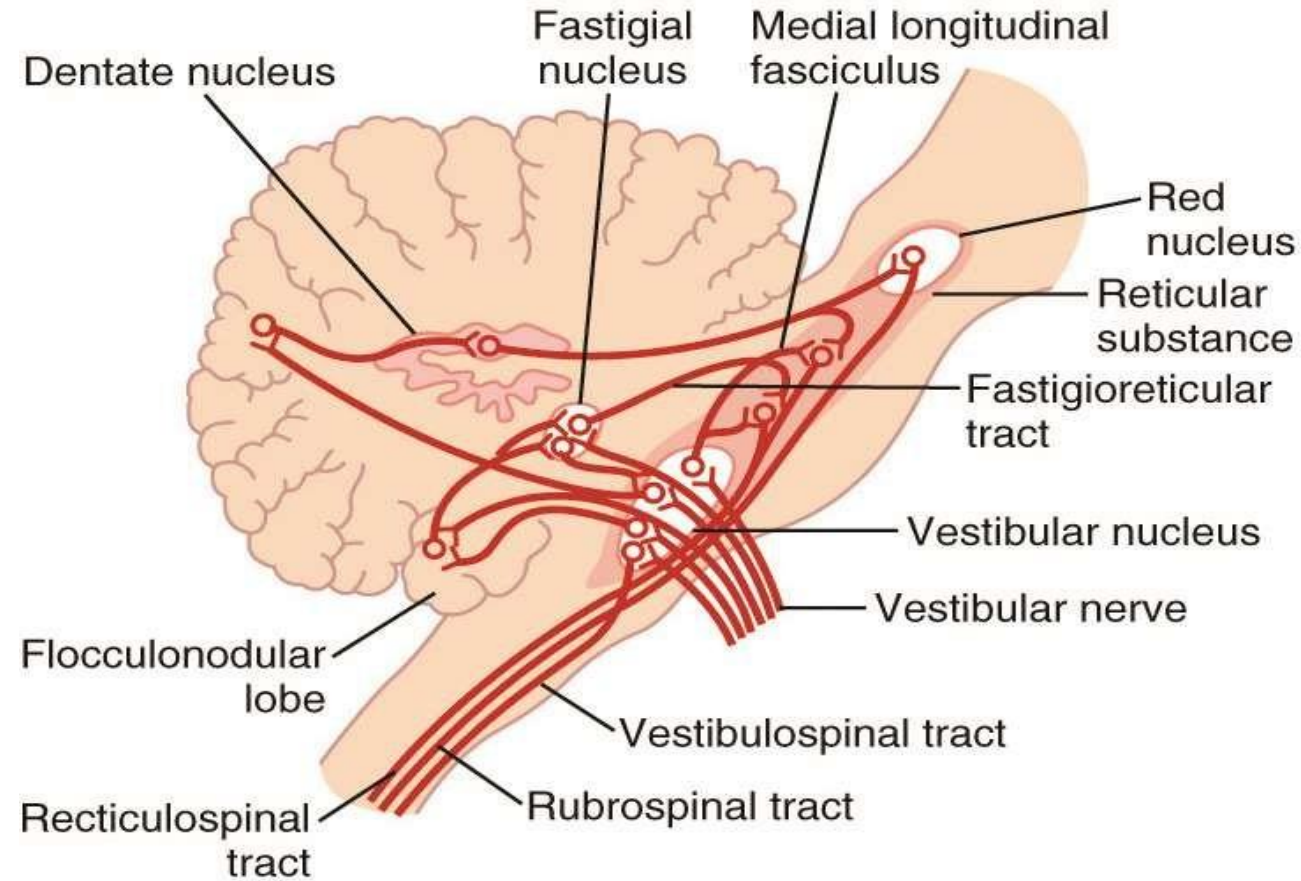
Electrical Potential and Adaptation

- At the level of hair cells, stimulation produces a **graded receptor potential**.
- This electrical response has a **maximum limit** (+30). As stimulus intensity increases, the receptor potential rises only up to a certain point, after which it **cannot increase further** because the ion channels become saturated; **ceiling effect**.
- With stronger or prolonged stimulation, the receptor does not simply maintain a high voltage. Instead, it **adjusts its sensitivity over time**, often reducing the response despite the continued stimulus. This allows the receptor to stay responsive to changes in the environment and prevents it from becoming saturated during intense or ongoing stimulation; **adaptation**.

Predictive Function of the Semicircular Ducts

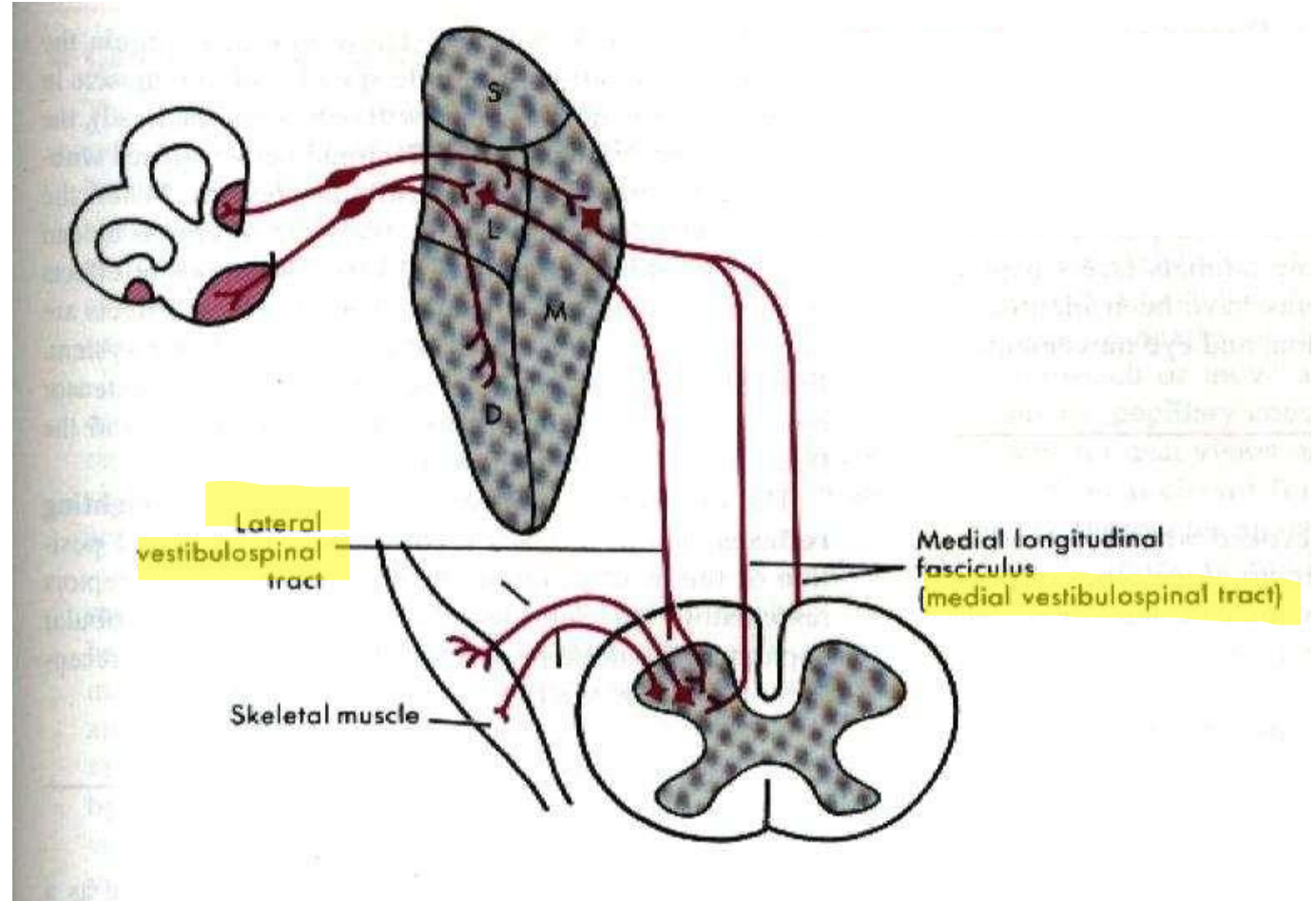
- The body doesn't just react to where you are; it predicts where you will be. This is a **subconscious** calculation based on **velocity** (speed) and **distance**. For example:
 - If you are walking toward a wall 6 meters away, your brain uses the current speed to calculate exactly when you need to start slowing down to stop.
- Semicircular ducts predict situations in which **equilibrium will be affected** and this information is sent to the brain.
- **Corrective measures** are initiated before the equilibrium is affected.
- **Neck proprioceptors** and **visual input** also contribute to the maintenance of equilibrium.
- Research showed that when **receptors**, like muscle spindles or vestibular hair cells, are **destroyed**, this **predictive ability vanishes**. Without that sensory feedback, a subject, like the monkeys in the study the doctor mentioned, would walk right into a wall because the "stop command" wasn't calculated in time.

Neuronal Connections of the Vestibular Apparatus



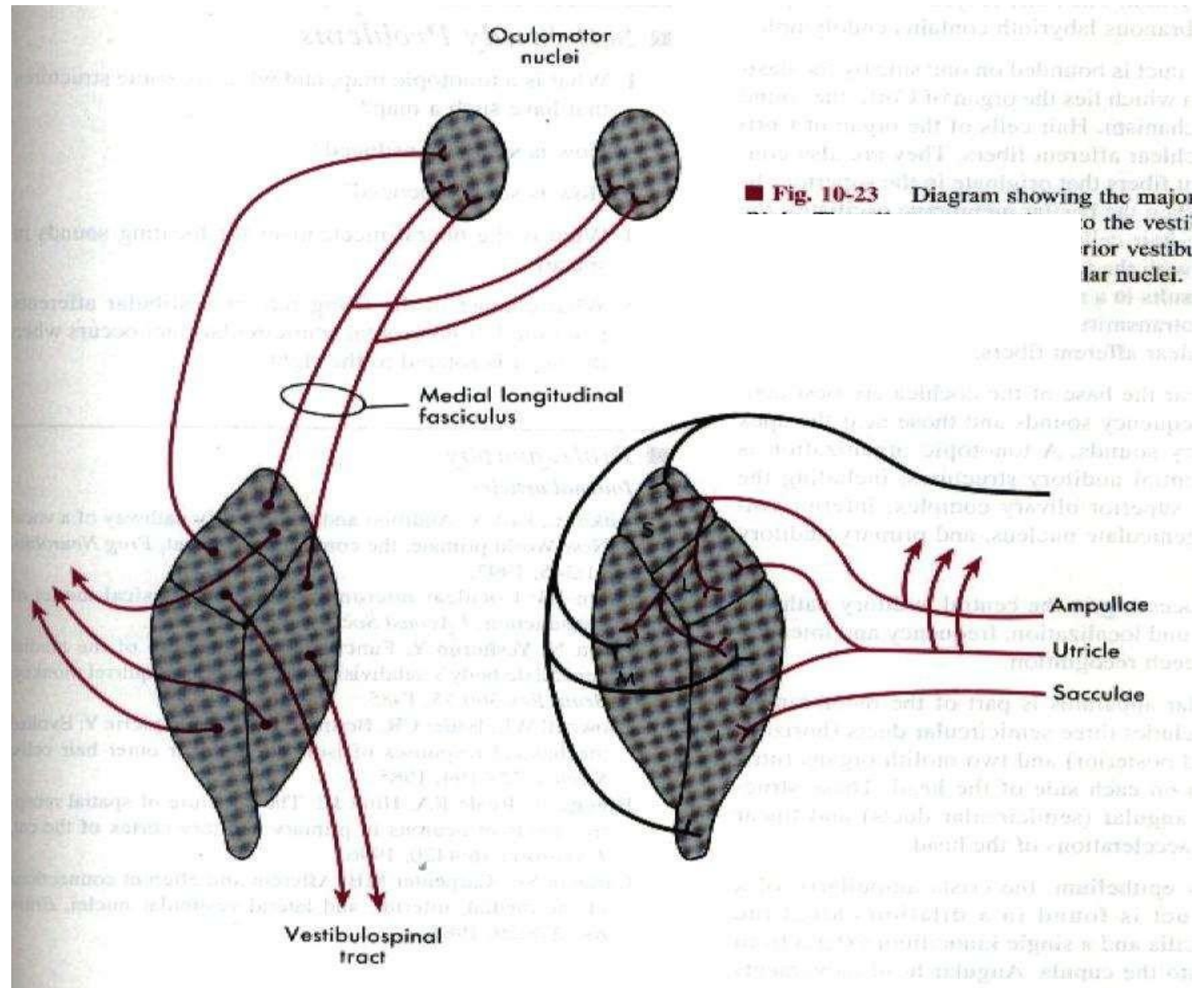
Vestibular Nuclear system

Showing that there are 4 vestibular nuclei: superior, medial, lateral and inferior.



Vestibular Nuclei

Showing the connection between the vestibular system and the oculomotor nuclei. (as shown in slide 31, paragraph 2)



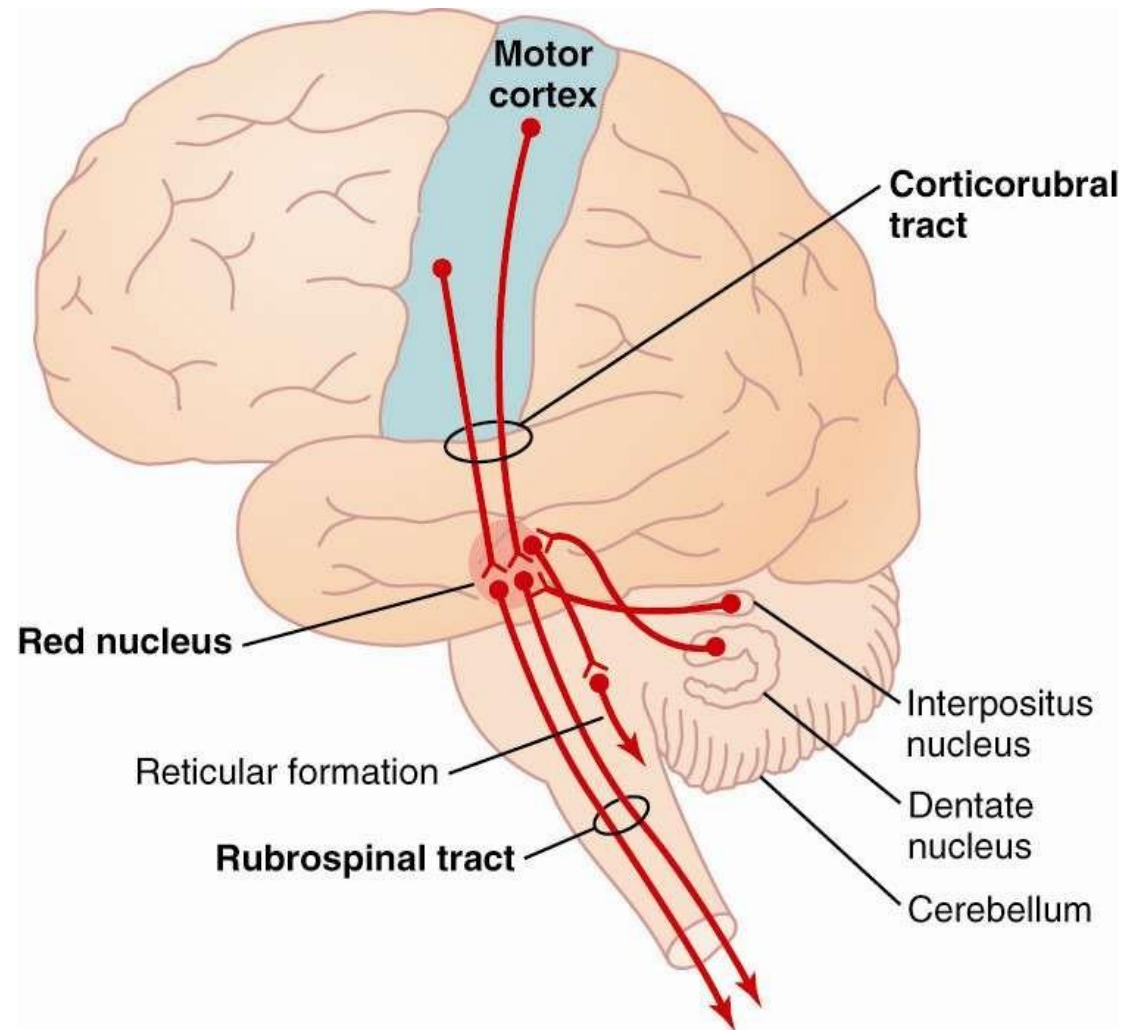
Red Nucleus and the Rubrospinal Tract

- Substantial input from **primary motor cortex** (Cortico-rubral fibers)
- Primary motor cortex fibers synapse in the lower portion of the nucleus called the **magnocellular portion** which contains large neurons similar to Betz cells.
- Magnocellular portion gives rise to rubrospinal tract.
- Magnocellular portion has **somatotopic organization** similar to primary motor cortex.
- **Note:** Every part of the CNS is somatotopically organized, meaning specific body regions are represented in corresponding areas.

Red Nucleus and the Rubrospinal Tract

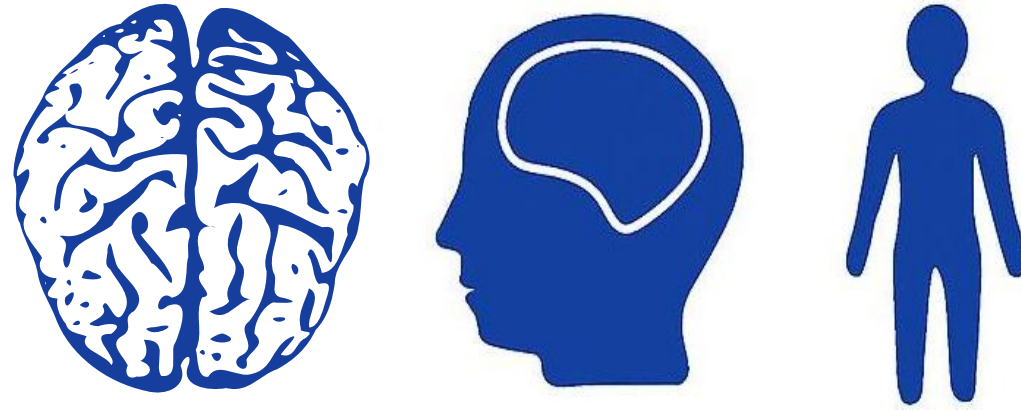
- Stimulation of red nucleus causes relatively fine motor movement, but **not as discrete as primary motor cortex**.
- Control the movement of **large flexors** unlike corticospinal that controls the distal flexors concerned with fine precise movements *like writing*.
- **Accessory route for transmission** of discrete signals from the motor cortex.

Red Nucleus and Rubrospinal Tract





Thank You



**PHYSIOLOGY
QUIZ
LECTURE 1**

اللهم إن عمر عطية في ذمتك وحبل جوارك، فقه من فتنة القبر وعذاب النار،
أنت أهل الوفاء والحق، فاغفر له وارحمه إنك أنت الغفور الرحيم.

سُورَةُ الْحَدِيدِ

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

يَوْمَ تَرَى الْمُؤْمِنِينَ وَالْمُؤْمِنَاتِ يَسْعَى نُورُهُمْ بَيْنَ أَيْدِيهِمْ
وَبِأَيْمَانِهِمْ بِشْرِكُمْ الْيَوْمَ جَنَّاتٌ تَجْرِي مِنْ تَحْتِهَا الْأَنْهَارُ خَالِدِينَ
فِيهَا ذَلِكَ هُوَ الْفَوْزُ الْعَظِيمُ

Scan the QR code or click it for FEEDBACK



Corrections from previous versions:

| Versions | Slide # and Place of Error | Before Correction | After Correction |
|----------|----------------------------|---|---|
| V0 → V1 | 15 | Pontine → lateral Medullary → medial | Pontine → medial Medullary → lateral |
| V1 → V2 | | | |