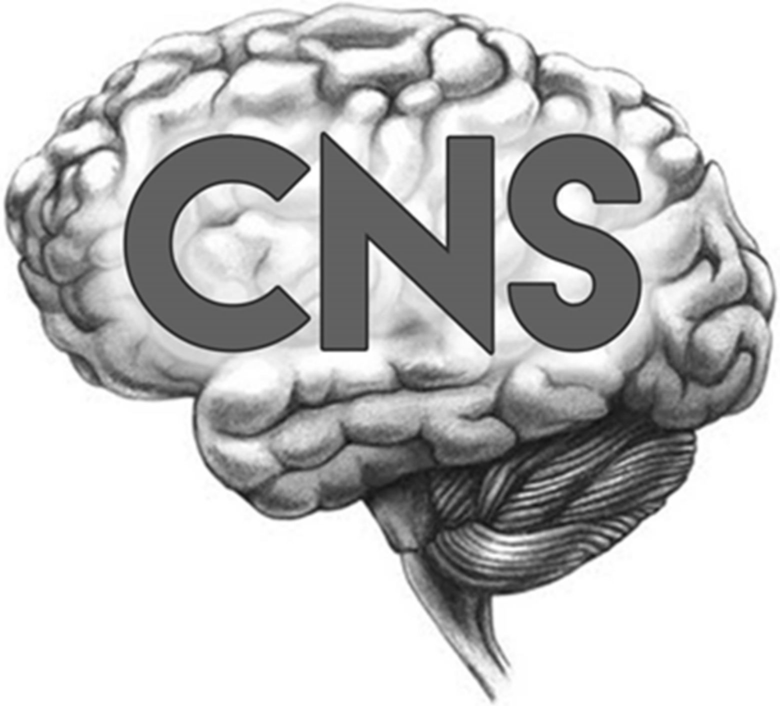


# PHYSIOLOGY

☑ Sheet ○ Slide ○ Handout

Number

3

Subject

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Price:

بسم الله الرحمن الرحيم

- This sheet was written according to the recording of section 1.
- Anything written in *Italic* was not mentioned during the lecture. READ THEM to understand.

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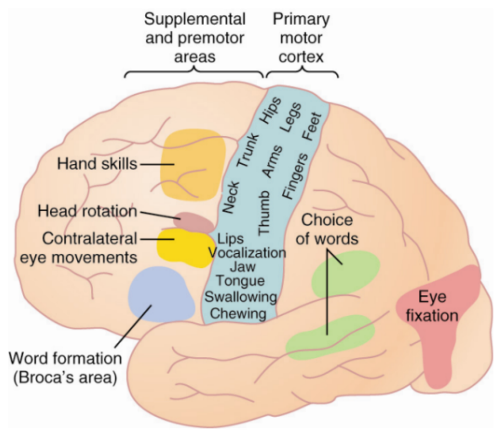
❖ Concepts discussed during the last lecture :
  - Lobes of the cerebral hemispheres.
  - Motor areas of cerebral cortex.
  - Histological layers of the cortex.
  - Afferent and efferent cerebral pathways.

## ❖ Brief Revision:




- Motor cortex is divided into:
  - ➢ **Premotor cortex**
    **-** This area represents body actions that require *programming* and *coordination*.
    - Stimulation of this area results in the movement of muscle groups to perform a certain task.
    - **Examples**: eye movement, movement of the tongue, larynx, head rotation and hand skills.

  - ➢ **Primary motor area**
    **-** representation is precise, disproportionate to the size of muscle but the number of motor units and upside down.

  - ➢ **Supplemental motor area**
    -Mainly for bilateral movement of programmed actions.

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- Motor tracts ( pathways):
  - ➢ **Pyramidal tract:**

→ **Corticospinal tract :**

- This tract begins within the **cerebral cortex**, then passes through the **internal capsule** ( along with the extrapyramidal tract), all the way to the **brain stem**. It doesn't synapse at the brain stem (**Direct motor pathway**) but continues until about **90% of fibers decussate** to the contralateral side at the base of the **medulla**, forming the **lateral corticospinal tract** that descends through the lateral column of white matter. The remaining 10% do not decussate, but continue as the **ventral( anterior) corticospinal tract** descending through the ventral column of the white matter. Thereafter, the majority of fibers synapse with interneurons, and a minority of fibers synapse with alpha motor neurons directly ( mainly those coming out of the giant pyramidal cells of Betz) and these mainly control the movement of distal muscles.

  - **Note**: The Rubrospinal tract( an extrapyramidal tract) descends along with the lateral corticospinal tract forming the **Lateral motor system.** Thy both control the movement of flexors with the following difference :
    - **Lateral corticospinal tract** controls the movement of distal flexor muscles of the hand( needed for skilled movements and manipulation).
    - **Rubrospinal tract** controls the major flexor muscles like those of the wrists and elbows.

  **-** The **medial motor system** contains the ventral corticospinal tract, this tract mainly controls the extensor muscles( anti-gravity muscles) including the hip and shoulder girdle.

- **NOTE1:** the medial motor system is composed of :
  - ✓ Ventral (anterior) corticospinal tract.
  - ✓ Vestibulospinal tract
  - ✓ Reticulospinal tract
  - ✓ Tectospinal tract
- **NOTE2:** The medial motor system mainly controls the gross movements of the trunk and proximal muscles, where the lateral motor system mainly controls the precise movements of the distal muscles.

- Extrapyramidal tract:

Mainly arises from area 6 in the cerebral cortex and controls the axial and proximal muscles mainly.

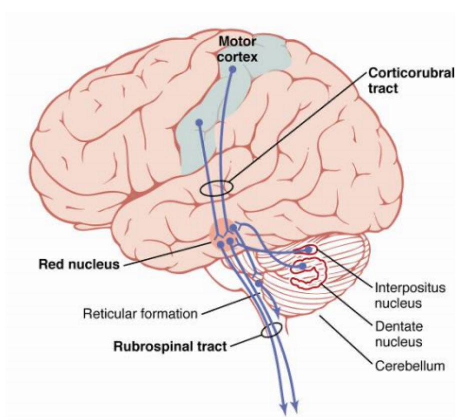
*Clinical correlate:*
*Some patients may have a lesion in the internal capsule. On physical examination, they fail to move the distal muscles of the hand; they can't write or tie their shoes. Surprisingly, these patients are still able to move their proximal muscles. What gave them this ability is NOT the extrapyramidal tract as it's affected along with the pyramidal tract within the internal capsule. It's the ventral corticospinal tract that gave them this ability.*

- **Transmission of cortical motor signals :**
  - Direct pathway:
    - corticospinal tract.
    - for discrete dilated movements.
  - Indirect pathway:
    - signals to the basal ganglia, cerebellum or brain stem.

- **NOTE:** pyramidal and extrapyramidal tracts are examples on **corticofugal fibers**, that sharpen the signal by lateral inhibition.

- **Slides 28, and 29 in slide 2 mention the other motor pathways of the motor cortex that were and will be discussed profusely. They are represented in the figure below.**

  - You should know that each motor and sensory signal coming from any part of the body is precisely represented on the thalamus.
  - **Example:** a certain motor signal for a certain motor action is represented on a specific site on the ventrolateral(VL) and



ventroanterior(VA) nuclei( not haphazardly).

- **Incoming sensory pathways to the motor cortex:**

***- Generally, afferent fibers to the cortex could be****:*

*1. **corticocortical fibers** :information and orders come to the cortex from the cortex itself. These include:*

*a) Association fibers*

*b)commissural fibers*

*2.**thalamo-cortical fibers(specific and non-specific)**: from thalamus to the cortex.*

*3.**extrathalamic subcortical fibers**.*

**1.** subcortical fibers from adjacent areas of the cortex (the same cerebral hemisphere) especially the **somatic sensory areas** from the **parietal cortex**, **visual (occipital**) and **auditory (temporal**) cortex. (point1)

**2**.subcortical fibers from the **opposite hemisphere** which pass through **corpus callosum**.( point1)

**3**.**somatic sensory fibers** from the **ventrobasal complex** of the thalamus (i.e cutaneous and proprioception).(point2)

- The motor areas in the thalamus are VL and VA nuclei
- The sensory areas in the thalamus are the **ventrobasal complex**, these are subdivided into **VPL (ventropsterolateral**) and **VPM( ventroposteromedial)**

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## Red nucleus and rubrospinal tract

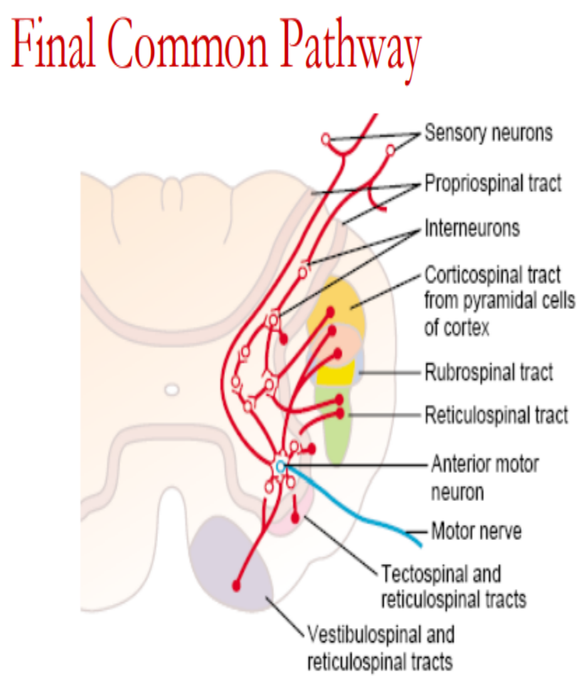
- Receives substantial input from the **primary motor cortex**.
- Primary motor cortex neurons synapse at the lower portion of the red nucleus called the **magnocellular portion** wich contains large neurons similar to Betz cells.

- **Magnocellular portion** gives rise to the rubrospinal tract.
- Stimulation of the red nucleus causes relatively fine motor movement but not as discrete as primary motor cortex.
    - ✓ ***Explanation:***
      *Rubrospinal tract arising from the magnocellular portion of the red nucleus forms part of the lateral system pathway. The lateral system pathway aslo contains the lateral corticospinal tract (descending from primary motor cortex). Both rubrospinal and lateral corticospinal tracts control the flexor muscles, the lat. Corticospinal, however, mainly controls precise and skilled movements of the distal muscles, whereas the rubrospinal tract controls the major flexor muscles of the wrist and elbow, their movement is not as discrete and precise as distal muscles of the hand, for example.*

- Ultimately, all motor pathways of all different origins are going to synapse with the alpha motor neorons, whether directly or indirectly (through interneurons).

**- interneurons are either excitatory or inhibitory, leading to a balanced movement achieved by the excitation of certain muscles and inhibition of antagonizing muscles.**

- The alpha motor neurons receive a group of signals from different sources**.** They receive directly from the corticospinal tract and indirectly through interneurons and rubrospinal tract. Some are excitatory signals (EPSP), others are inhibitory signals (IPSP). All these potentials summate and we end up having the so-called **grand potential.**



## ❖ Lesions of the primary motor cortex :

**1- Primary motor cortex lesions** : Loss of voluntary control of discrete movements of the distal segments of the limbs (corticospinal tract lesion)

- In contrary, if you lose the rubrospinal tract, you will still be able to move your distal muscles; you can write and type ..etc. however, you won't be able to flex your elbow and wrist joints ( which are also involved in these actions).

**2- Broca's area lesion :** expressive aphasia

**3- hand skill area lesion**: motor apraxia

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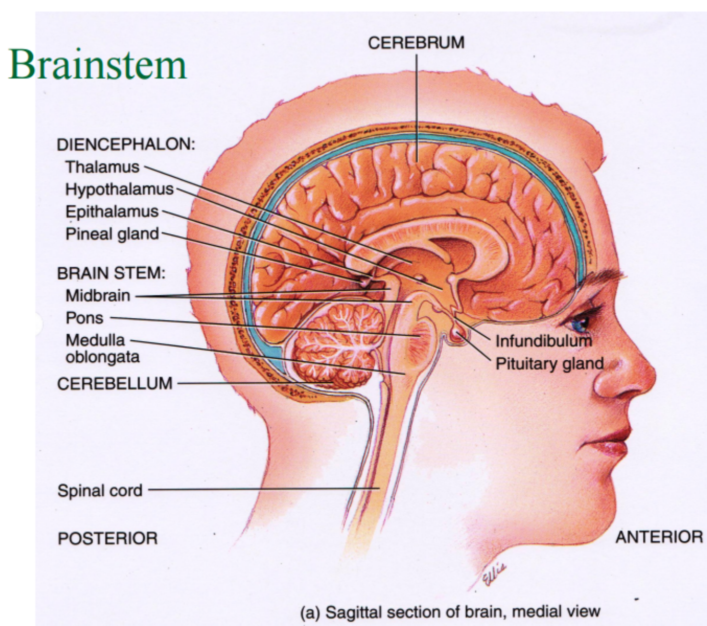
# ❖ Brainstem :

- ➢ Just like the cortical pathways, the brain stem has descending pathways that originate within the brain stem, they receive their orders from the cortex.
- ➢ the specific area that is represented in the cortex has a an identical area represented somewhere in the brain stem.

❖ The figure to the right shows a medial view of a sagittal section of brain showing the **three main parts of the brain stem :**
- Midbrain
- pons
- Medulla



(a) Sagittal section of brain, medial view

❖ Brainstem as an extension of the spinal cord. It performs motor and sensory functions for the face and head (i.e., cranial nerves). Similar to spinal cord for functions from the head down. In addition, the medulla contains vital centers like cardiovascular( cadiac and vasomotor) and respiratory centers.

## ❖ Support of the body against gravity

- The muscles of **spinal column** (axial muscles) and **extensor muscles of the leg** support the body against gravity.
- These muscles are under the influence of brainstem nuclei.
- The **pontine reticular nuclei excite** the anti-gravity muscles.
- The **medullary reticular nuclei inhibit** the anti-gravity muscle.

- There is reticular formation in pons as well as the medullary area of the brainstem, coming out of this reticular formation are pathways( tracts**)** called **pontine reticulospinal tract** and **medullary reticulospinal tract**.
    - The **medullary reticulospinal pathway** is part of the **lateral system pathway**. Therefore, this pathway is **Inhibitory to extensors** and **excitatory to flexors.**
    - The **pontine reticulospinal pathway** is part of the **medial system pathway**. Therefore, it's **inhibitory to the flexors** and **excitatory the extensors**.
    - The pontine reticulospinal tract is intrinsically active ( inhibiting the flexor muscles and exciting the extensors).
    - Medullary reticulospinal tract is inhibitory to the pontine reticulospinal tract ( which is intrinsically active)
    - The medullary reticulaospinal pathway rec by the cortex itself receives its stimulation from the cortex itself.

Cortical simulation — Intrinsic activity

**(1)** (+) — **Inhibitory (-)**

Medullary reticular nucleus → pontine reticular nucleus

- **Now,  read the following carefully:**

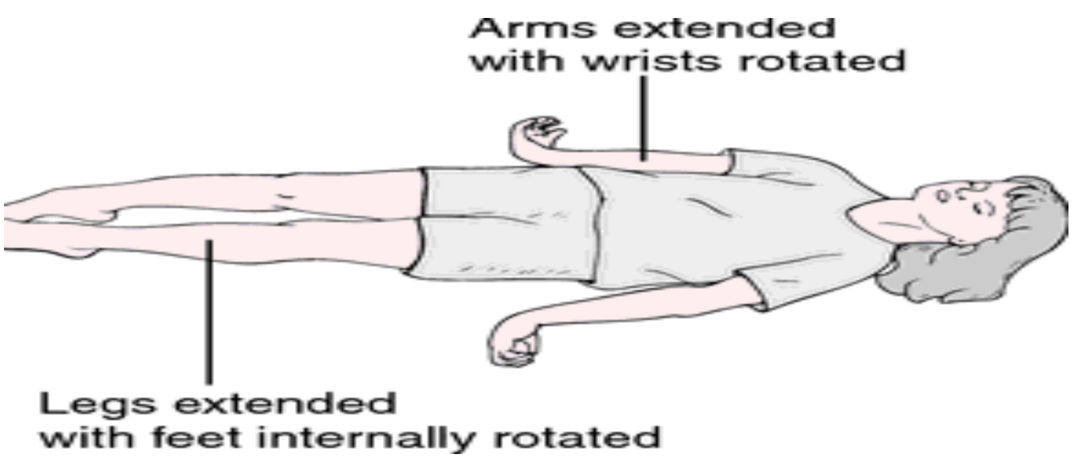
→ If there is a cut above the level of brainstem and medulla, there will be a **disruption** at the level of **cortico-medullary stimulation**; the medullary reticular nucleus will no longer get stimulated. (1)

→ **No stimulation** of the **medullary reticular formation** means **No inhibition** of the **pontine reticular nucleus.**

→ Since the **pontine reticulospinal pathway** is **intrinsically** active, **release of inhibition** from the **pontine pathway** will result in **over activity of this tract** and thus **over contraction** of the **extensor muscles** it normally supplies.

→ This condition is referred to as **Decerebrate rigidity (**you remove the effect of cerebral cortex)

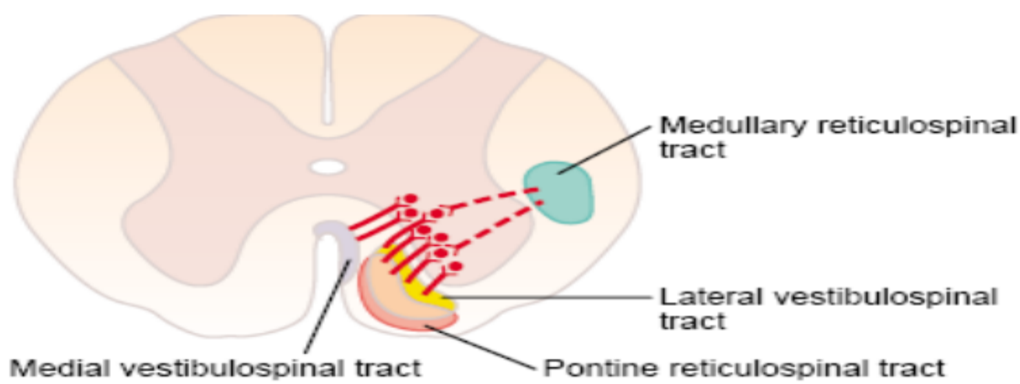
- The typical clinical manifestation of **decerebrate rigidity** is a patient whose extensor muscles are all over stimulated.




**Decerebrate rigidity**

→ Another type of rigidity is the one caused by defects in the basal ganglia. This type is associated with over-stimulation of **flexor muscles**. Thus, clinical presentation is different.

→ The following figure shows that the **pontine reticular nucleus** is part of the **medial system pathway**, while the **medullary reticular nucleus** is part of the **lateral system pathway**.

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## ❖ Vestibular apparatus

- The vestibular apparatus is composed of **Four vestibular nuclei** located in the brain stem.
- **Four vestibular nuclei**: superior, inferior, lateral and medial nuclei.
- **Where do these nuclei take their commands from?**
  They receive them from the vestibular apparatus in the inner ear.
- In the inner ear, there are receptors for hearing located in the **cochlea**, and receptors for balance located in the vestibule.
- The vestibule is made up of two parts :

  **1. maculae receptors** → located in the utricle and saccule. Their function is to predict the Orientation of head with respect to gravity ( linear acceleration).

  2. **semicircular canals** → we have three semicircular canals in each ear :

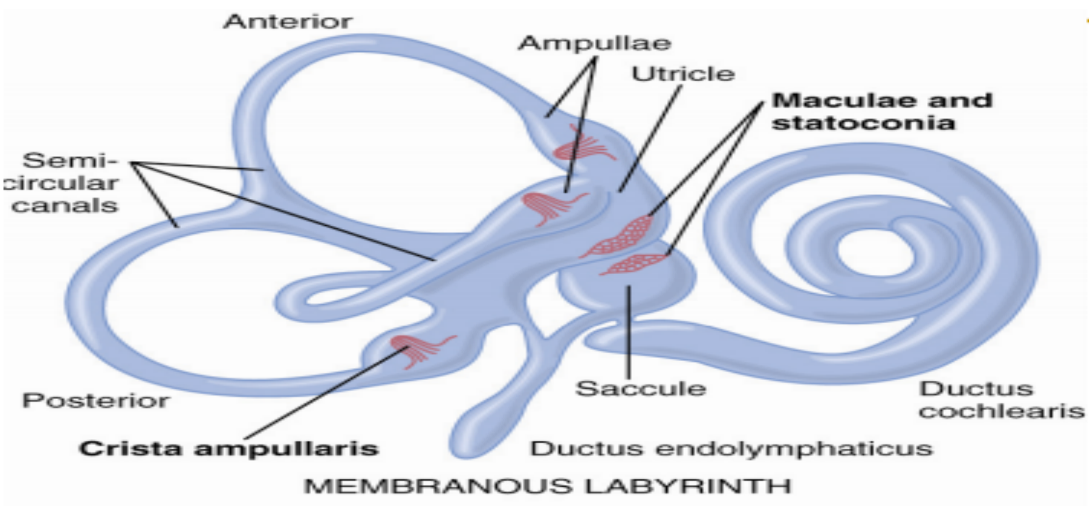
  - Lateral semicircular canals

- Anterior semicircular canals

- Posterior semicircular canals

- They are arranged in a manner where the **anterior semicircular canal** on the right side lies in the **same plane** with the **posterior semicircular canal** on the **left side**, and vice versa. The three canals are almost perpendicular to each other in three planes.

  - Semicircular canals contain receptors called **cristae ampullaris**.Their function is to detect **rotational movements** of the head (rotational acceleration).

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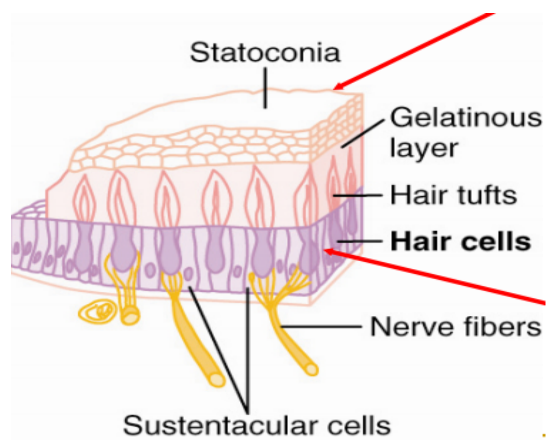



→ maculae receptors contain **Hair cells**. These cells are connected to and send their impulses through the **vestibular branch of vestibulocochlear nerve.**

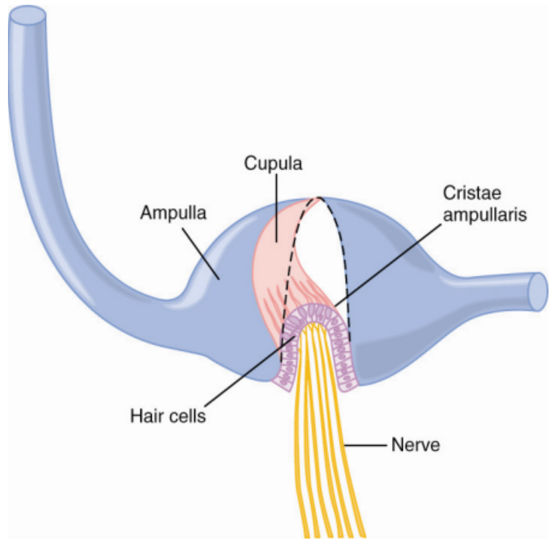
→ Above hair cells, exists a layer of calcium carbonate called **statoconia** . it makes the structure top heavy so that it is capable of responding to head changes.

→ Upon head movement, they will excite the hair cells. This excitation will lead to transfer of the signal through the vestibular branch of vestibulocochlear nerve all the way to the vestibular nuclei.

→ Same concept of activation of Hair cells applies in the semicircular canals, with some differences.

→ Instead of statoconia, here exists the cristae ampullaris. Bending of **cristae ampullaris** in a particular direction excites the hair cells.

→ Bending of cristae ampullaris occurs upon rotatory movement.

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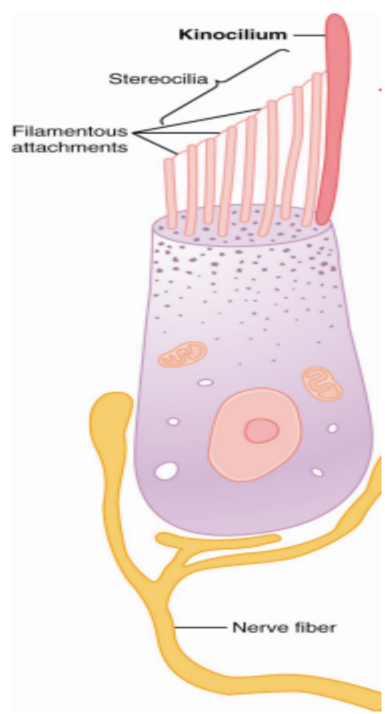
❖ **Hair cell**

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

→ Bending of stereocilia in one direction( towards the kinocelleum) causes depolarization, bending in the opposite direction( away from the kinocelleum) causes hyperpolarization.



## ❖ Response of hair cells when the semicircular canals are stimulated

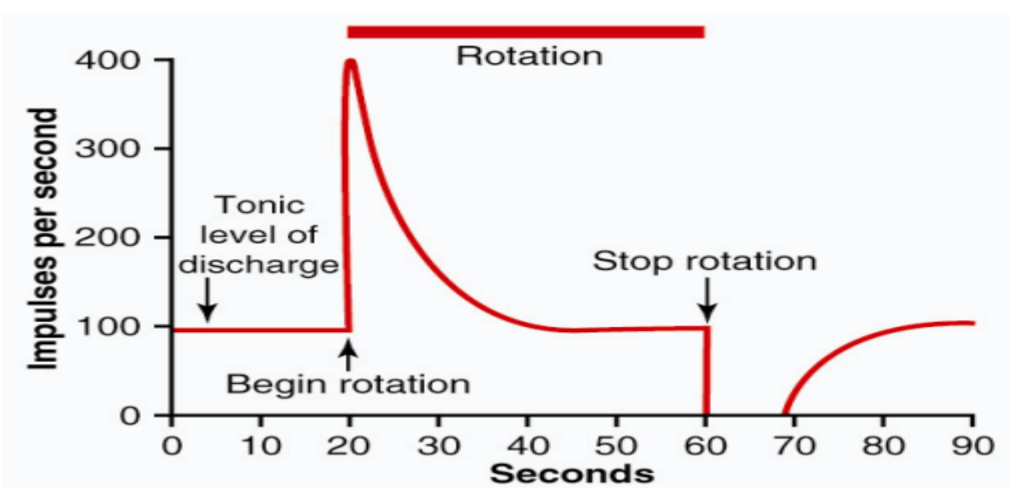
**-** Hair cells have **intrinsic activity**( a basal rate of activity). This basal rate of discharge is important for positive and negative control.

**-** at the beginning of rotation, semicircular canals are stimulated leading to depolarization of hair cells. You feel that you are rotating.

- then continuous increase in discharge rate causes constant increment in discharge rate. You don't feel that you are rotating.

-when one stops rotating, the discharge rate drops suddenly thus you feel dizzy again.

- The semicircular canal mainly senses the rate of  change movement. This is important to predict the position after a certain period of time.
    → Rate * Time = Distance




➢ Signals from the vestibular nuclei then pass through the vestibulospinal tracts to the anti-gravity muscles, so that you can correct your posture and maintain your balance.

**The End**

**Wish you all the best of luck**