# Neuropsychiatry Block
# 1-Physiology of Motor Tracts

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## Objectives:

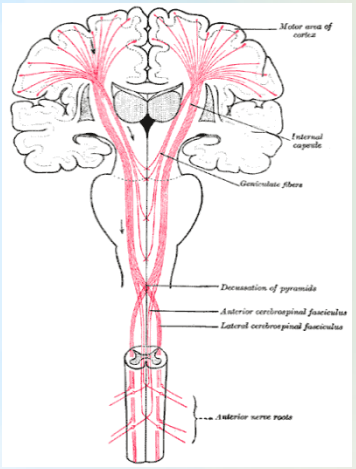
Upon completion of this lecture, students should be able to describe :

- the upper and lower motor neurons
- the pathway of pyramidal tracts (corticospinal & corticobulbar tracts)
- the lateral and ventral corticospinal tracts.
- functional role of corticospinal & corticobulbar tracts
- the extrapyramidal tracts as rubrospinal , vestibulospinal ,reticulospinal and Tectspinal Tracts& their function

# Upper & lower motor neurons

## 1-Upper motor neurons (UMN):-

- Neurons of motor cortex & their axons that pass to brain stem and spinal cord to activate brain stem neurons (cranial) & spinal motor neurons



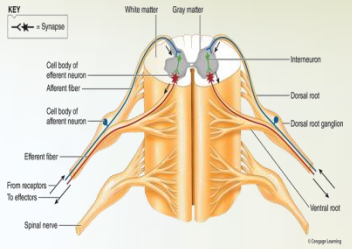

-**There are two UMN Systems :**

1- Pyramidal system (corticospinal tracts ).

2- Extrapyramidal system

## 2- lower motory neurons(LMN)

Spinal motor neurons (AHCs)in the spinal cord & cranial motor neurons in the brain stem that innervate muscles directly



# Descending Tracts

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* **1-Corticospinal (Pyramidal tracts )& corticobulbar tracts;-**

## -Origin/

**1- 30% motor area 4 ( the primary motor area)** ( M1) .Occupies the precentral gyrus.

**2- 30% from the premotor areas & supplemetary cortex**

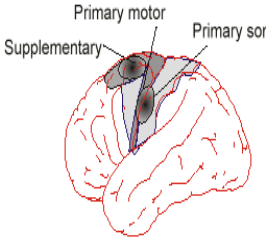
- **Premotor area:- (motor association area)** lies in front of the primary motor area & below supplementary motor area. Its stimulation produces complex coordinated movements, such as setting the body in a certain posture to perform a specific task.

- **Supplemetary cortex /**located on the lateral side of the brain in front of area 4 and above the pre-motor area & extends on medial side of the cerebral hemisphere.

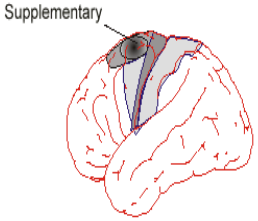
• Concerned with planning and programming motor sequences.•

**3- 40% parietal cortex ( somatic sensory area 3,1,2)**

b) When the subject makes a complex finger movement sequence, such as opposing thumb with each finger in turn, activity is seen in the finger area of the primary motor cortex, the primary somatic sensory cortex, and the supplementary motor area.

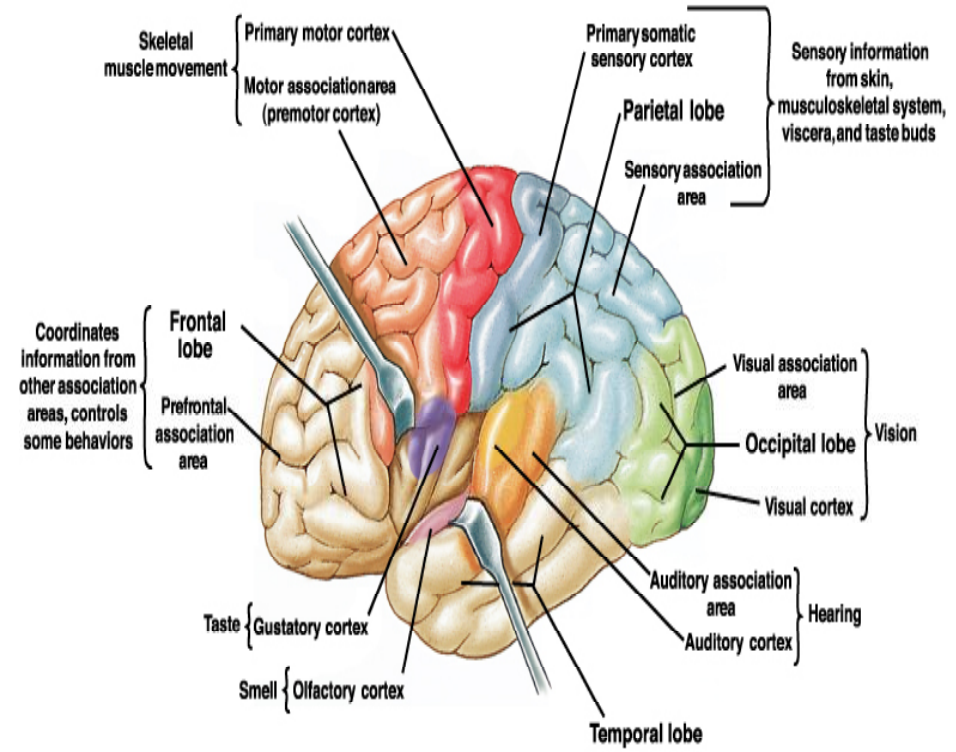



c) When the subject imagines the complex finger movement sequence, activity is seen only in the supplementary motor area.




Supplementary activity seen when making a sequence with either hand (as apposed to primary motor activity which is always contra lateral).

This bilateral activity is useful in movements that require both hands eg tying one's shoe laces.



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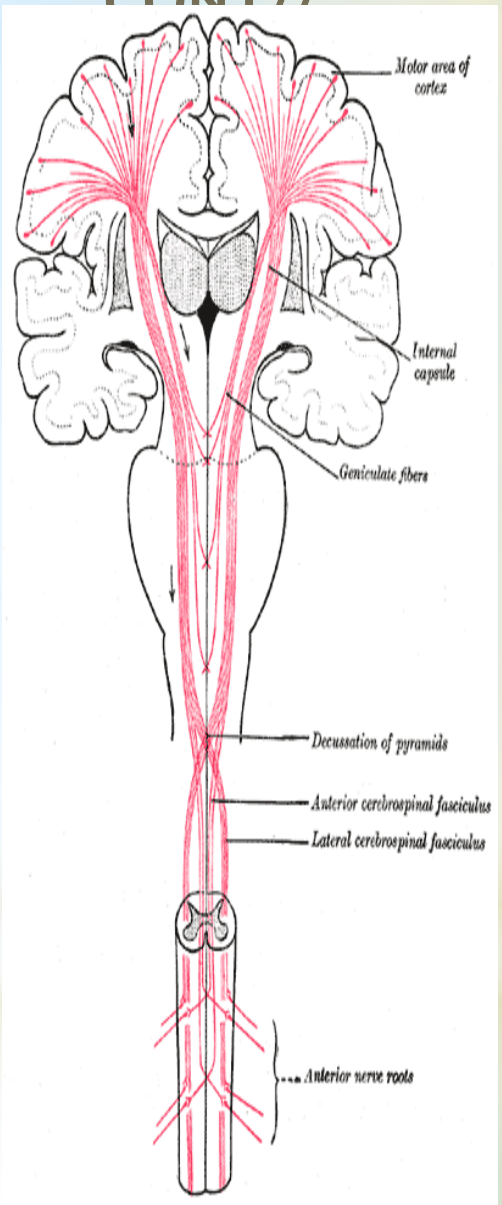
- **3% of the pyramidal fibres are large myelinated, derived from giant, highly excitable pyramidal Betz cells in motor area 4.**
- -The Betz cells fibers transmit nerve impulses to the spinal cord at a velocity of about 70 m/sec, the most rapid rate of transmission of signals from the brain to the cord.
- Giant Betz cells axons send short collaterals back to the cortex to inhibit adjacent regions of the cortex when the Betz cells discharge, thereby "sharpening" the excitatory signal.
- **- Fibers from the cerebral cortex descend in >>>>CORONA RADIATA to >>>>INTERNAL CAPSULE genu and the anterior two-third of the posterior limb then to >>>>>>BRAIN STEM ( midbrain,pons,medulla oblongata)**



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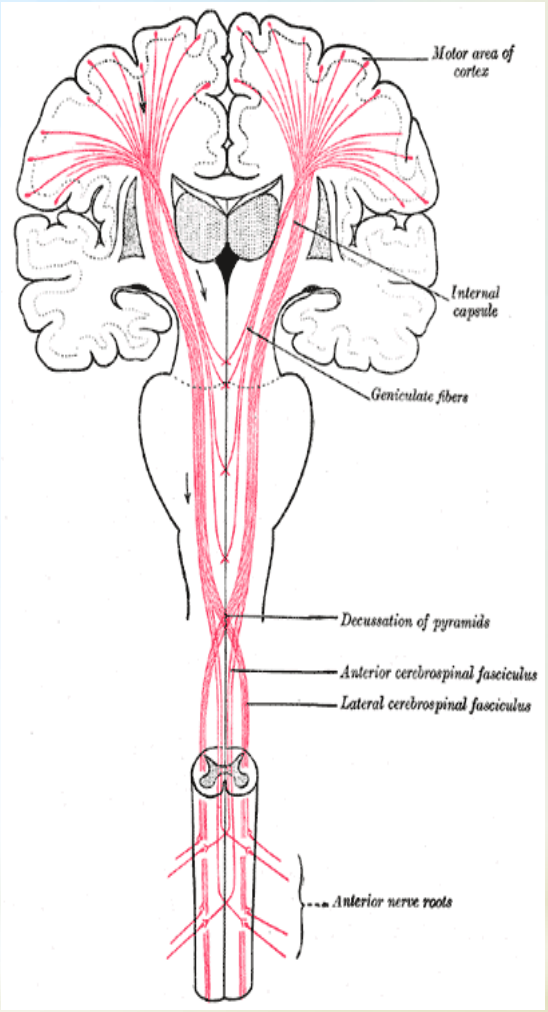
**-In the brain stem midbrain, pons & medulla oblongata**

**1-Corticobulbar tract terminates on cranial nerve nuclei of opposite side ) (decussating just before they reach their target nuclei .)**

**-The Corticobulbar tract carries information to motor neurons of the cranial nerve nuclei**

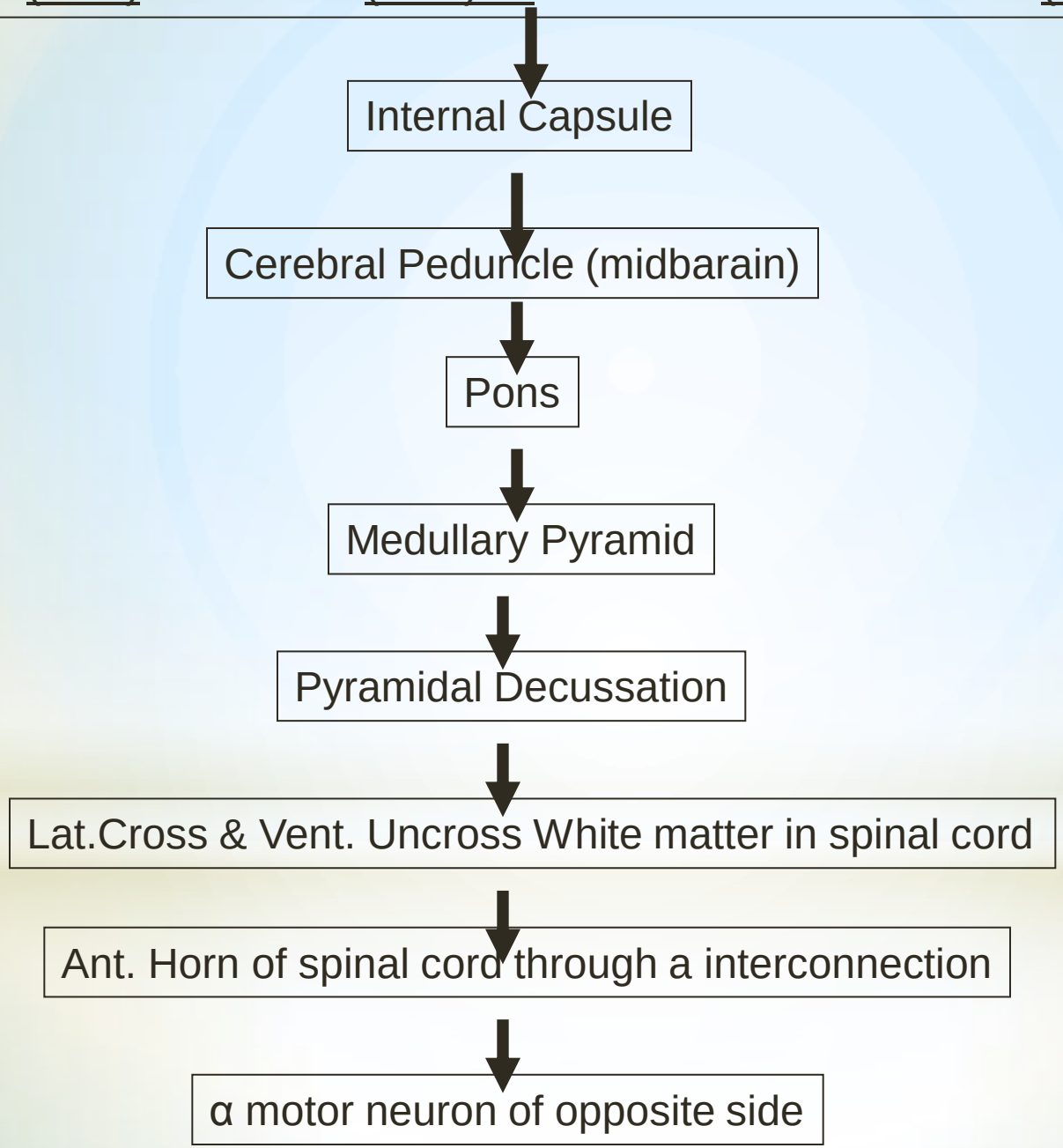
**2- Corticospinal tracts (pyramidal)**

**-Descends through the midbrain and pons, Then in the lower medulla oblongata the fibers form pyramids so called pyramidal tract**



Origin – Sensory cortex, primary Motor Cortex, premotor & supplementary cortex

(40%) (30%) (30%)



**-Corticospinal tracts ( pyramidal) divides into:**

**1- lateral corticospinal tracts :-**

**- 80% of fibers cross midline in pyramids**

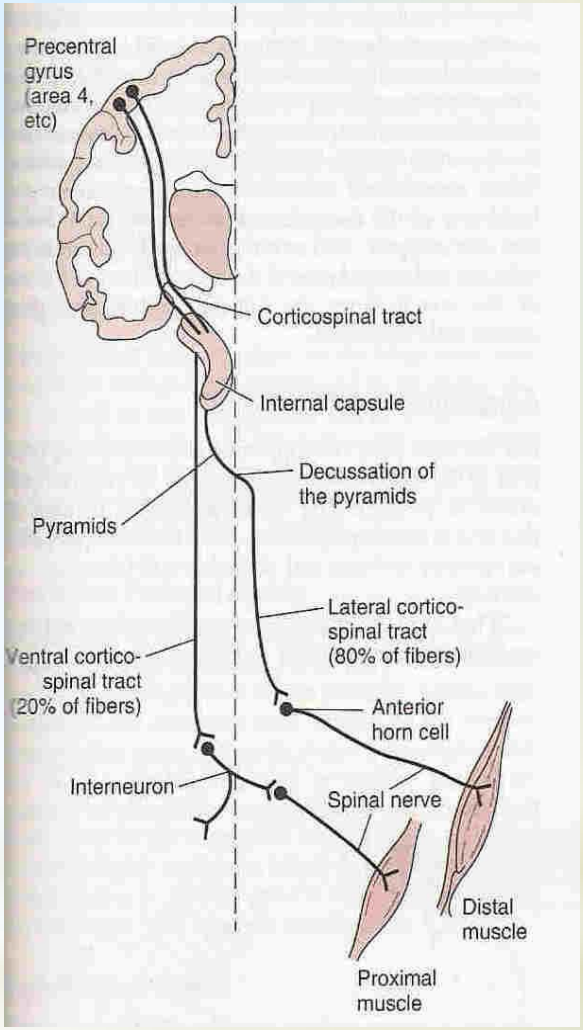
**- Pass laterally in spinal cord white matter**

**- Ends directly ( not via interneurons = monosynaptic connections) on motor neurons (AHCs) of the opposite side here the lower motor neurons (LMNs) of the corticospinal cord are located.**

**-Then peripheral motor nerves carry the motor impulses from the anterior horn to the voluntary muscles**

**- The fibers pass laterally in spinal cord white matter, so they control distal limb muscles**

**Function//- controls and initiates fine discrete skilled movements of fingers and toes.**

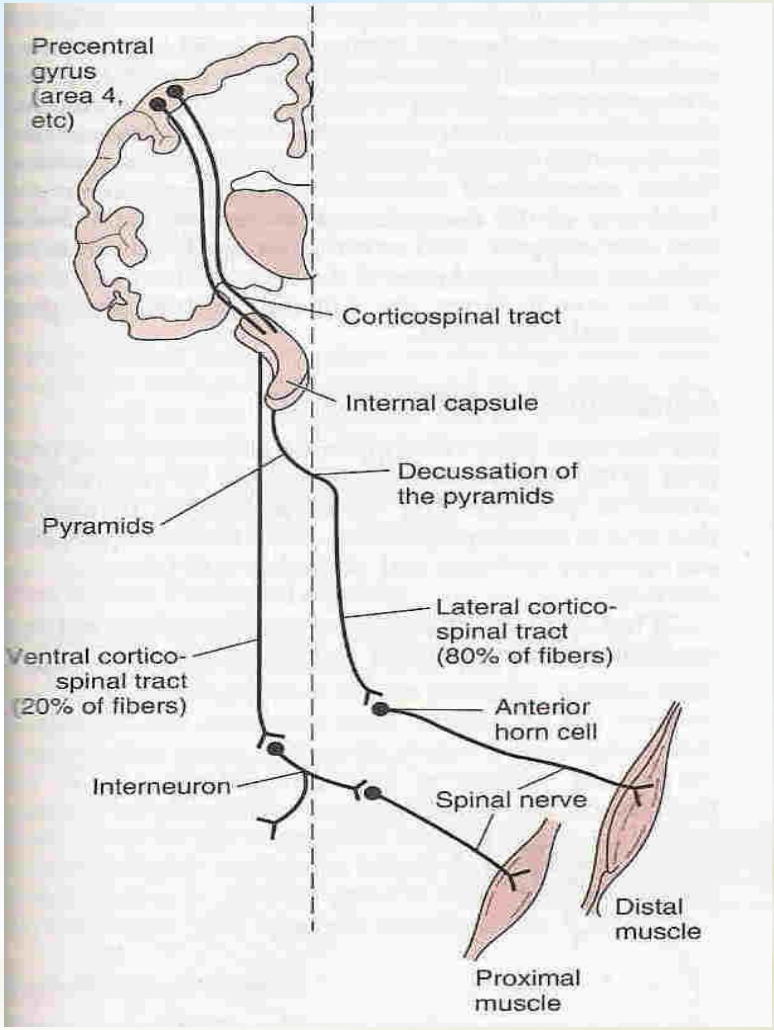


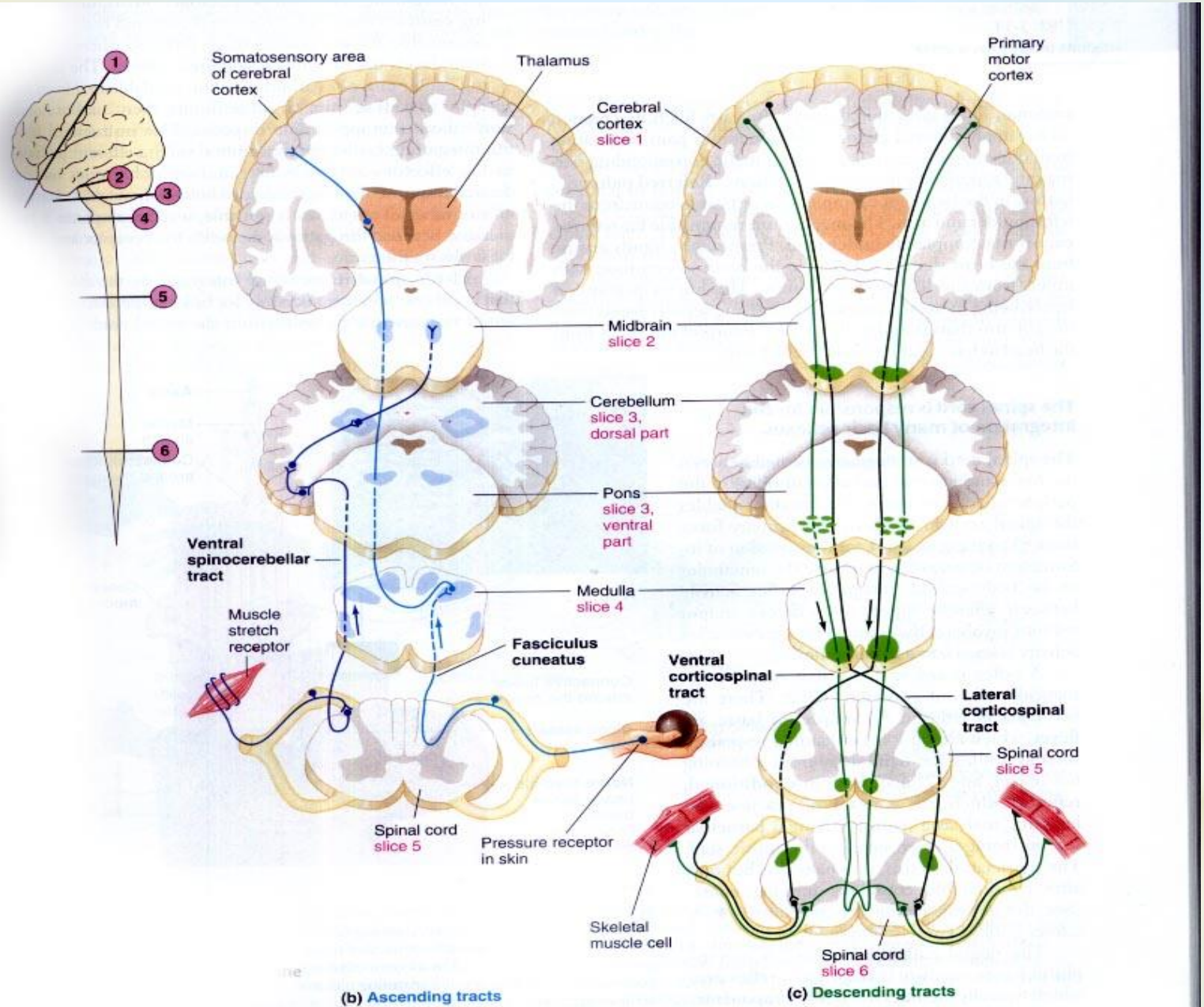
## 2- Ventral (anterior) corticospinal tracts :-

**- Remaining 20% fibers does not cross midline**
**- Cross at level of their termination to synapse with interneurons , that synapse with motor neurons (AHCs) of opposite side.**

**-Pass medially in ventral horn so control axial & proximal limb muscles**

**NB/ So corticospinal tract( ANT& LAT) supply skeletal muscles of the opposite side**

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2
3
4
5
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Somatosensory area of cerebral cortex
Thalamus
Cerebral cortex slice 1
Primary motor cortex
Midbrain slice 2
Cerebellum slice 3, dorsal part
Pons slice 3, ventral part
Medulla slice 4
Ventral spinocerebellar tract
Muscle stretch receptor
Fasciculus cuneatus
Ventral corticospinal tract
Lateral corticospinal tract
Spinal cord slice 5
Spinal cord slice 5
Pressure receptor in skin
Skeletal muscle cell
Spinal cord slice 6
(b) Ascending tracts
(c) Descending tracts

# Functions of corticospinal tracts:-

1-Initiation of fine ,discrete, skilled voluntary movements (on which side?)

2- lateral corticospinal tracts (main bulk of the tract) control distal muscles of limb as fingers & thumb& toes which concerned with fine skilled movement) e.g Painting ,writing, picking up of a small object etc.

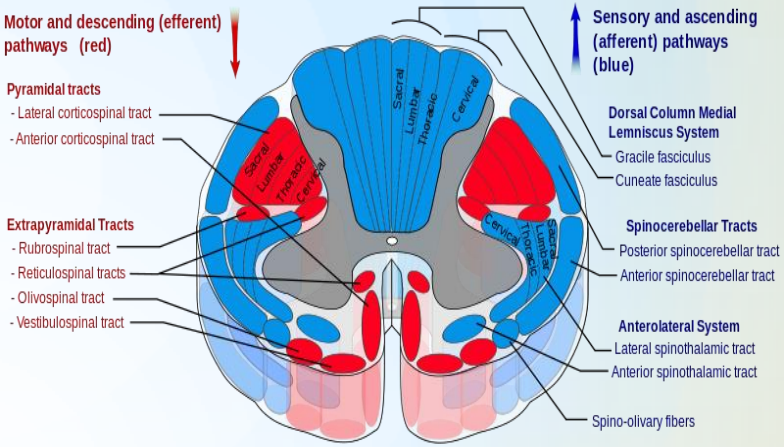
3- Ventral corticospinal tracts control posture of axial & proximal limb muscle for balance, climbing, walking

**4- Effect on stretch reflex:-**

**- Faccilitate muscle tone through gamma motor neurons**

**5- Fibers originate from parietal lobe are for sensory-motor coordination**

**6- Corticobulbar tracts /control face & neck muscles & faccilitate their tone, and are involved in facial expression, mastication& swallowing.**



**Excitation of the Spinal Cord Motor Control Areas by the Primary Motor Cortex and Red Nucleus**

-Vertical Columnar Arrangement of the Neurons in the Motor Cortex.

-Each column has six distinct layers of cells, The pyramidal cells that give rise to the corticospinal fibers all lie in the fifth layer of the cortical surface.

**-Function of Each Column of Neurons.**

-Each column of cells functions as a unit & as integrative processing system, using information from multiple inputs to determine the output response from the column.

- Each column can function as an Amplifying system to stimulate large numbers of pyramidal fibers to the same muscle or to synergistic muscles simultaneously.

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**Dynamic and Static Signals Transmitted by the Pyramidal Neurons.** .

-Each column of cells excites two types of pyramidal cell neurons

***1*-The dynamic neurons** are excited at a high rate for a short period at the beginning of a contraction, causing the initial rapid development of contraction.

***2*- The static neurons** fire at a much slower rate, but continue firing at this slow rate to maintain the force of contraction as long as the contraction is required.

-The neurons of the red nucleus have similar dynamic and static characteristics, -Greater percentage of dynamic neurons is in the red nucleus and a greater percentage of static neurons is in the primary motor cortex.

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**Removal of (Area Pyramidalis) of the Primary Motor Cortex**

-Removal of a the area that contains the giant Betz pyramidal cells (**Area Pyramidalis)** causes ***loss of voluntary control of discrete movements of the distal segments of the limbs, especially of the hands and fingers***

*(*This does not mean that the hand and finger muscles themselves cannot contract ( paralysis) rather, the *ability to control the fine movements is gone)*.

-That is because area pyramidalis is essential for voluntary initiation of finely controlled movements, especially of the hands and fingers

# Extrapyramidal tracts :-

**Tracts other than corticospinal tract & are outside pyramids**

**Origin/ motor area 4, premotor area 6, Suppressor area 4 >>>>CORONA RADIATA to>>>>INTERNAL CAPSULE to>>>>BASAL GANGLA to >>BRAIN STEM >>>BULBOSPINAL TRACTS descend to spinal cord as :-**

**A- Rubrospinal tract.**
**B- Vestibulospinal Tract.**
**C- Reticulospinal Tract**
**D- Tectspinal Tract.**
**E- Olivospinal Tract**

**Extrapyramidal system :**

**(1) sets the postural background needed for performance of skilled movements**
**(2) controls subconscious gross movements**

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# 1-Rubrospinal tracts:-

- The red nucleus located in the mesencephalon.

-It receives direct fibers from the primary motor cortex through the
corticorubral tract & some branching fibers from the corticospinal tract

-These fibers synapse in the lower portion of the red nucleus, the magnocellular portion
- The rubrospinal tract, which crosses to the opposite side in the lower brain stem into the lateral columns of the spinal cord.

- The rubrospinal fibers terminate mostly on interneurons of the cord gray matter, along with the corticospinal fibers, but some of the rubrospinal fibers terminate directly on anterior motor neurons

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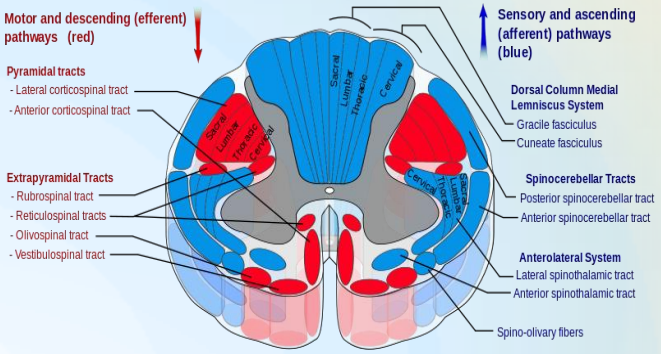


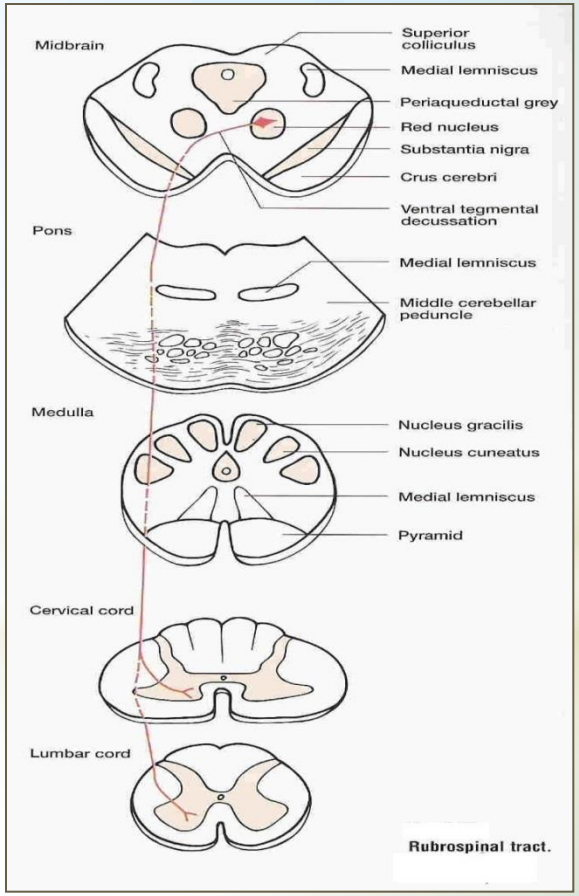

## Function of the Corticorubrospinal System.

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-The corticorubrospinal pathway serves as an accessory route for transmission of discrete signals from the motor cortex to the spinal cord. When the corticospinal fibers are destroyed , discrete fine control of the fingers movements can still occur but impaired..

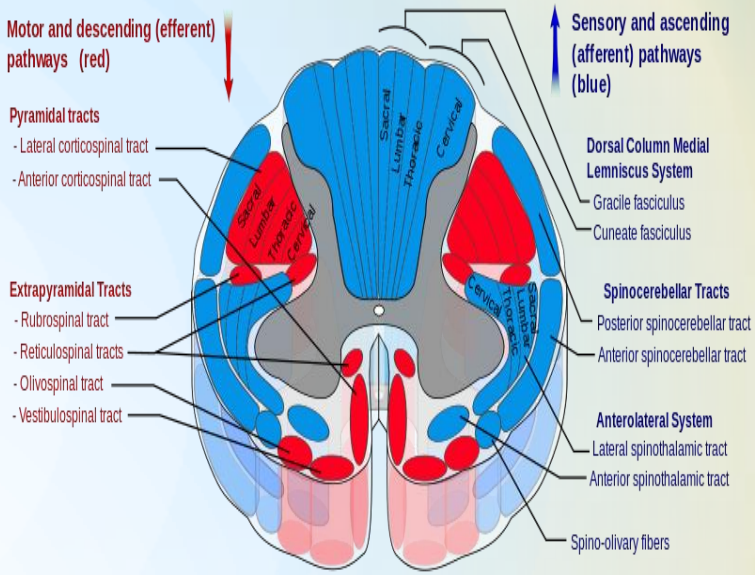
-Rubrospinal tract lies in the lateral columns of the spinal cord, along with the corticospinal tract. Therefore, the corticospinal and rubrospinal tracts together are called the lateral motor system of the cord, in contradistinction to a vestibulo-reticulospinal system, which lies mainly medially in the cord and is called **the medial motor system of the cord**

# * 2- Vestibulospinal tracts:-

-Fibers originate in vestibular nuclei in pons (which receive inputs from inner ear ,VestibularApparatus and cerebellum)
-Axons descend in the ipsilateral ventral white column of spinal cord

**- General Functions:-**

1- Controls Postural & righting reflexes.
2-Excitatory to ipsilateral spinal motor neurons-that supply axial & postural muscles
3- Control eye movements



# Functions of Vestibulospinal Tracts

A- **The lateral vestibulospinal**

- Cells of origin : Lateral Vestibular Nucleus
- Axons descend in the ventral white column of spinal cord
- This tract mediates **excitatory** influences upon extensor motor neurones

to maintain **posture& righting reflexes**

**B- The medial vestibulospinal tract** :

- Cells of origin : Medial Vestibular Nucleus
- As its axons descend in the ventral white column of spinal cord to end at the **cervical segments of the spinal cord**, some fibers form part of the **Medial Longitudinal Fasciculus fibers in brain stem** that link vestibular nuclei to nuclei supplying the extra-ocular muscles.

Function//**for coordination of head and eye movements**

**Role of the Vestibular Nuclei to Excite the Antigravity Muscles**

**The vestibular nuclei, function in association with the pontine reticular nuclei to control the antigravity muscles.**

**- The vestibular nuclei transmit excitatory signals to the antigravity muscles by way of the lateral and medial vestibulospinal tracts**

**-Without this support of the vestibular nuclei, the pontine reticular system would lose much of its excitation of the axial antigravity muscles.**

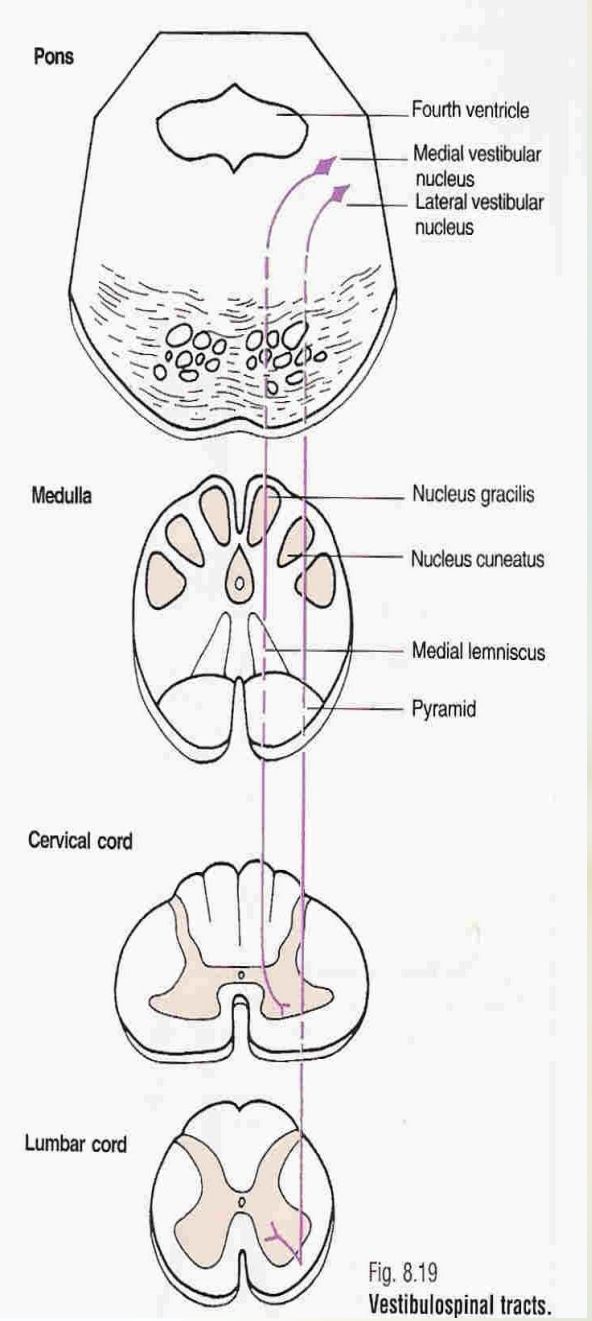



Fig. 8.19 Vestibulospinal tracts.

# 3- Tectospinat tracts:-

-From superior colliculi of midbrain

( for VISUAL reflexes) & from inferior colliculi of midbrain

( for AUDITORY reflexes)

- Ends on **Contralateral cervical motor neurons**

**Function: Mediate/facilitate turning of the head in response to visual or Auditory stimuli**

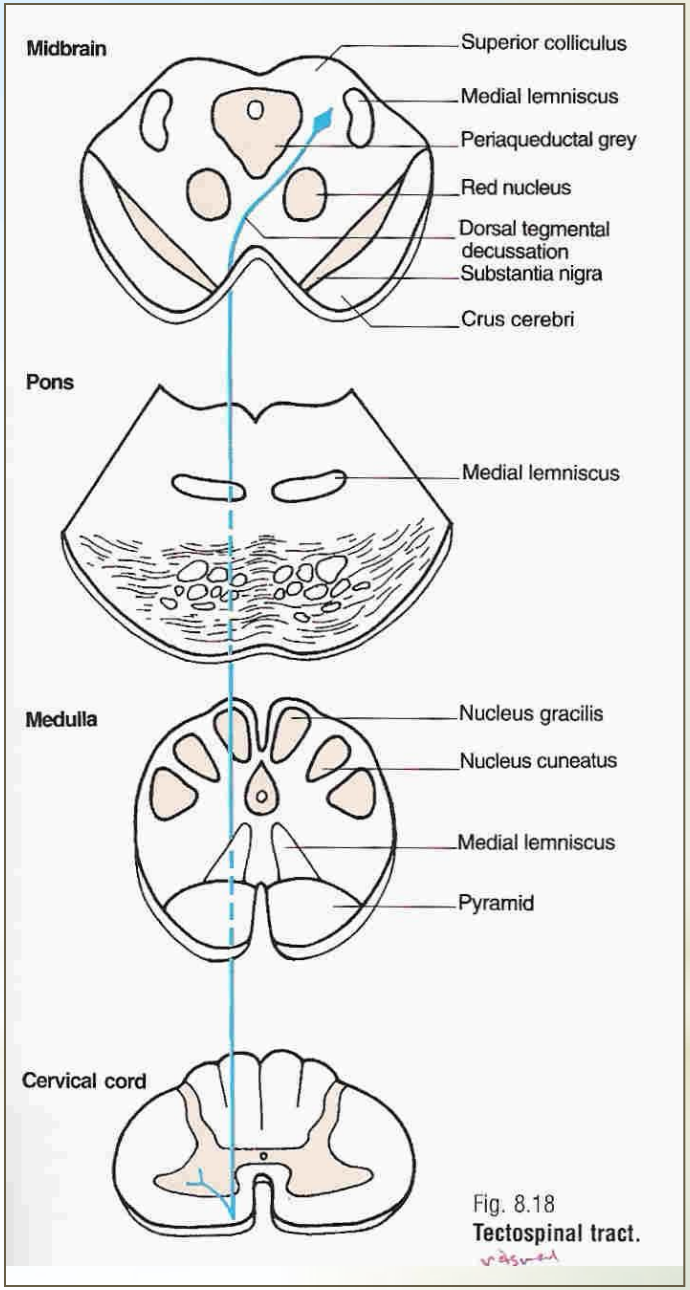


Fig. 8.18
**Tectospinal tract.**

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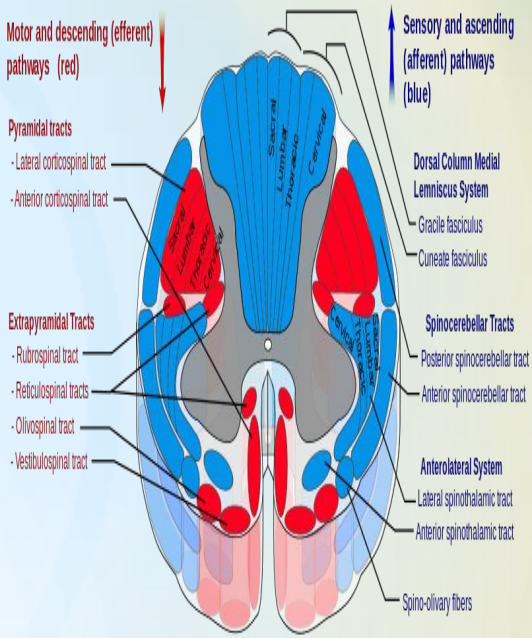
# 4- Reticulospinal Tract :-

-The reticular formation makes up a central core of the brainstem.
- It contains sensory& motor neuronal groups.
-**Pontine and medullary nuclei** projects to the AHCs of the spinal cord via
**Reticulospinal Tract**

## Types of reticulospinal tracts:-

### (1) Pontine (Medial) Reticulospinal Tract:

• Cells of origin: Pontine Reticular Formation which has high excitability & they receive strong excitatory signals from the vestibular nuclei .
• Axons descend in anterior(ventral )white column of spinal cord
• Pontine Reticulospinal Tract increases Gamma efferent activity ( excitatory to axial & antigravity, extensor muscles of the body&increases muscle tone )
-it causes powerful excitation of antigravity muscles



## (2) Medullary (Lateral) Reticulospinal Tract:

- Cells of origin: Medullary Reticular Formation
- Axons descend in lateral white column of spinal cord on both sides

-It receive strong input from (1) the corticospinal tract (2) the rubrospinal tract and (3) other motor pathways .

-These activate the medullary reticular inhibitory system to counterbalance the excitatory signals from the pontine reticular system,

- Medullary Reticulospinal Tract inhibits Gamma efferent activity ( transmit *inhibitory* signals to antigrav ity extensor muscles & decreases muscle tone ) .

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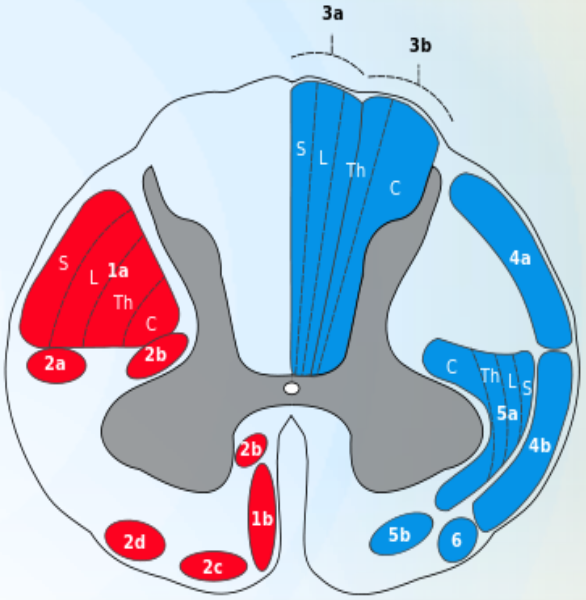
# 5-Olivospinal Tract :-

It arises from **inferior olivary N** of the medulla & is found only in the cervical region of the spinal cord (**supply neck muscles**) of unknown function

- Secondary olivocerebellar fibers transmit signals to multiple areas of the cerebellum.




| Motor and decending (efferent) pathways (left, red) | Sensory and ascending (afferent) pathways (right, blue) |
|---|---|
| **1. Pyramidal Tracts** | **3. Dorsal Column Medial Lemniscus System** |
| 1a. Lateral corticospinal tract | 3a. Gracile fasciculus |
| 1b. Anterior corticospinal tract | 3b. Cuneate fasciculus |
| **2. Extrapyramidal Tracts** | **4. Spinocerebellar Tracts** |
| 2a. Rubrospinal tract | 4a. Posterior spinocerebellar tract |
| 2b. Reticulospinal tract | 4b. Anterior spinocerebellar tract |
| 2c. Vestibulospinal tract | **5. Anterolateral System** |
| 2d. Olivospinal tract | 5a. Lateral spinothalamic tract |
| | 5b. Anterior spinothalamic tract |
| Somatotopy Abbreviations: | |
| **S:** Sacral, **L: Lumbar** | 6. Spino-olivary fibers |
| **Th:** Thoracic, **C: Cervical** | |