

5th Lecture

Physiology of Motor Tracts

PHYSIOLOGY TEAM – 430

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Definitions:

Upper motor neurons

are motor neurons that originate in the motor region of the cerebral cortex or the brain stem and carry motor information down to the final common pathway

another definition: any motor neurons that are **NOT** directly responsible for stimulating the target muscle.

Lower motor neurons

are the motor neurons connecting the brainstem and spinal cord to muscle fibers, bringing the nerve impulses from the upper motor neurons out to the muscles. A lower motor neuron's axon terminates on an effector (muscle).

Upper motor neurons ----(NT: Glutamate)----> Lower motor neuron ----(NT: Acetylcholine)----> effector muscle

NT: Neurotransmitter

The activity of the lower motor neurons (LMN, spinal motoneurons) is influenced by:

- (1) afferent inputs (sensory nerves) .
- (2) spinal neuronal pools (spinal centers) .
- (3) supraspinal areas where descending motor tracts originate . These constitute upper motor neurons .

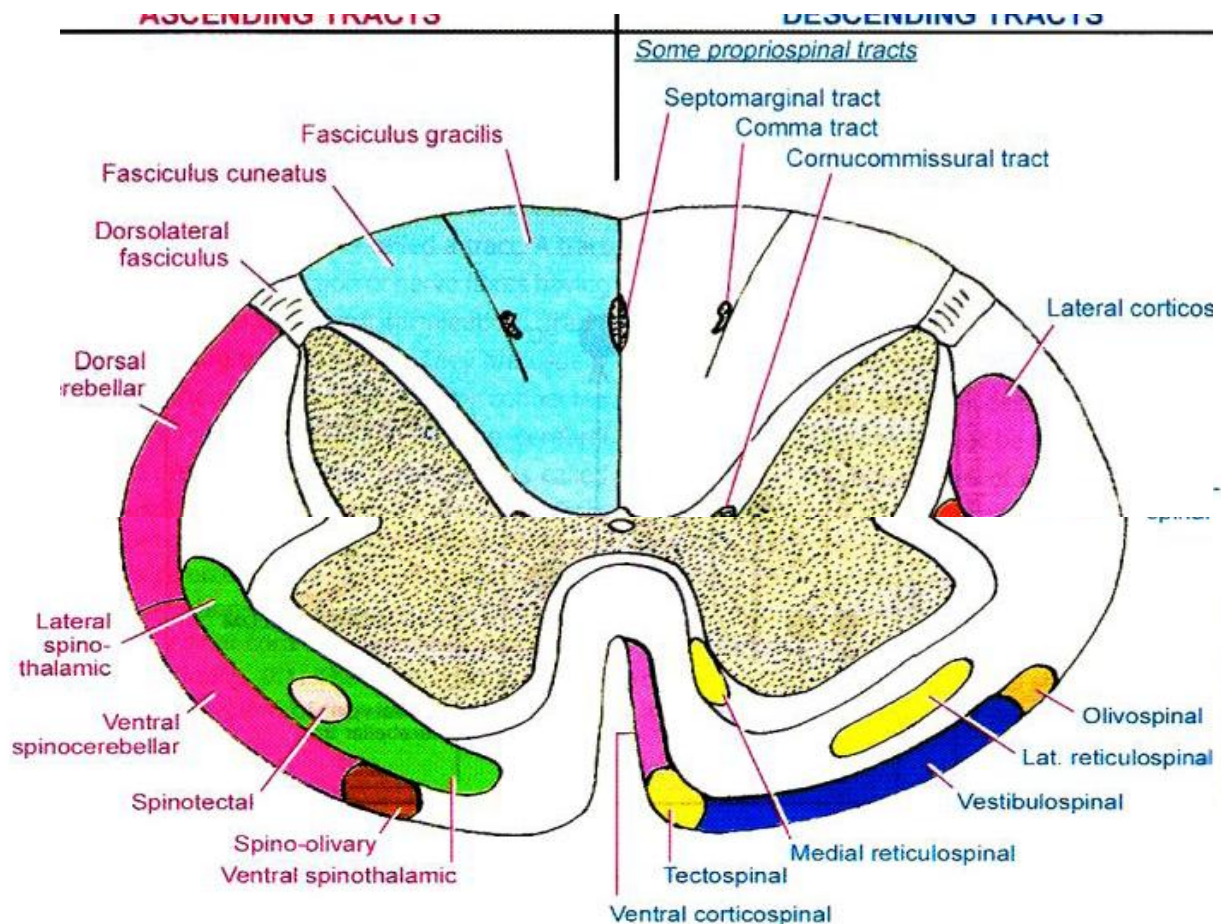
There are two UMN Systems :

First: Pyramidal system :

- Initiates & controls voluntary , fine , skilled movement.
- Output goes to the brainstem nuclei (**corticobulbar tracts**) & spinal cord (**corticospinal tracts**).
- Pyramidal fibres are comparatively **slow** conducting , because at least half of the pyramidal tract fibers are unmyelinated .

Second: Extrapyramidal system :

- sets the postural background needed for performance of skilled movements.
- controls **subconscious gross movements**. Such movements Occurring in groups of muscles such as the associated movements which underlie voluntary actions e.g. **swinging of arms while walking**.
- they modulate motor activity without directly innervating motor neurons.



The Difference between the pyramidal and extra-pyramidal tracts:

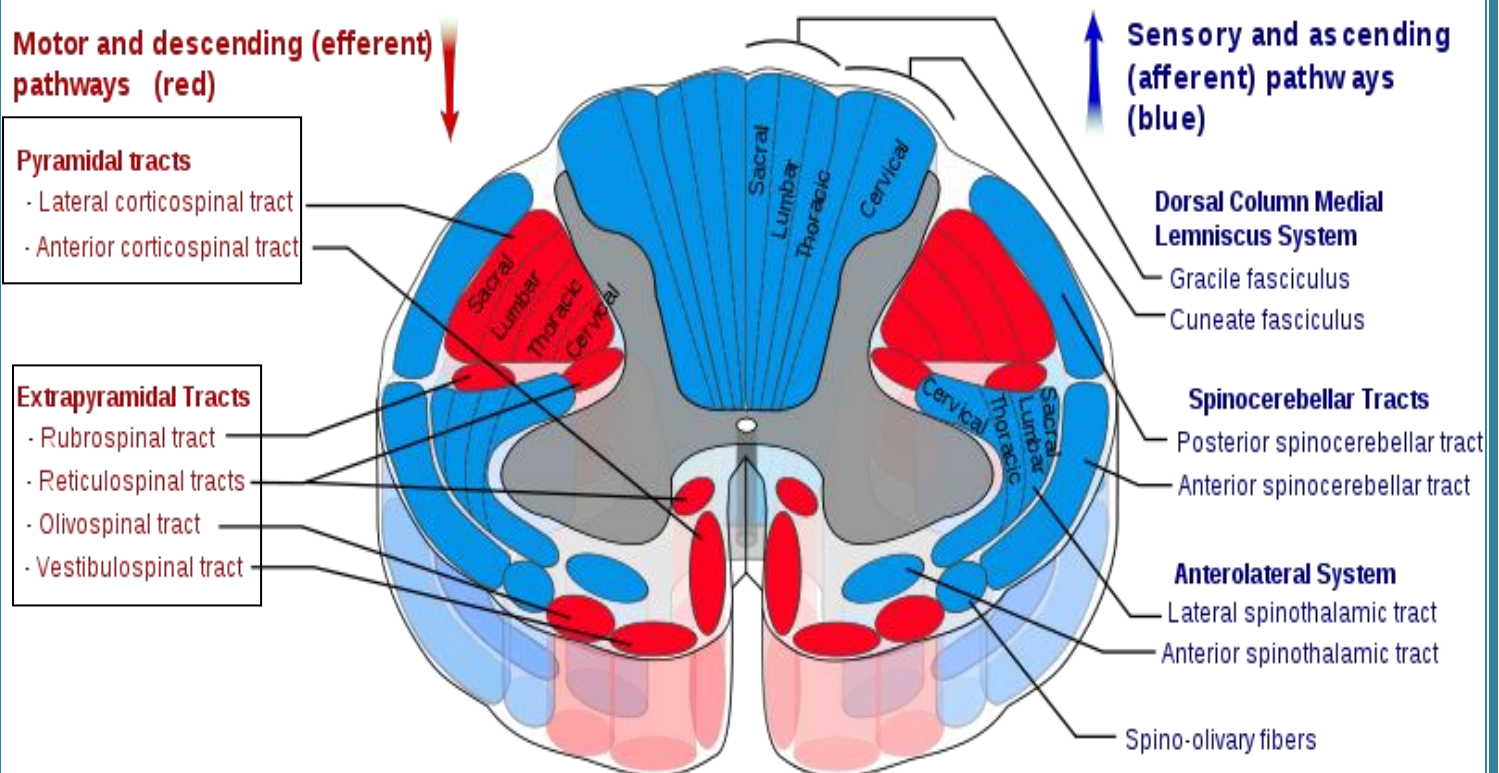
1) Their tracts:

- **Pyramidal system** = lateral and anterior corticospinal tracts + corticobulbar tract
- **Extra-pyramidal system** = rubrospinal + olivospinal + lateral and medial reticulospinal + tectospinal + vestibulospinal tracts

2) "**Extrapyramidal tracts**" don't reach their targets by traveling through the "pyramids of medulla". Pyramidal tracts go through the pyramids of medulla.

3) **Pyramidal tracts** may **directly** innervate motor neurons of spinal cord or brainstem (anterior horn cells or certain cranial nerve nuclei). But, **extrapyramidal tracts indirectly** control the anterior horn cells (for modulation and regulation)

4) **Pyramidal system** is responsible for fine, isolated, precise and specific movements. **Extrapyramidal system** is responsible for gross, synergic movements which require the activity of large groups of muscle.



Pyramidal Tracts :

Areas Contributing Pyramidal (Corticospinal) Fibers

(1) The primary motor area (M1):

occupies the precentral gyrus & contains large , highly excitable Betz cells. MI of one side controls skeletal muscles of the opposite side of the body

(2) The Supplementary Motor Area (MII):

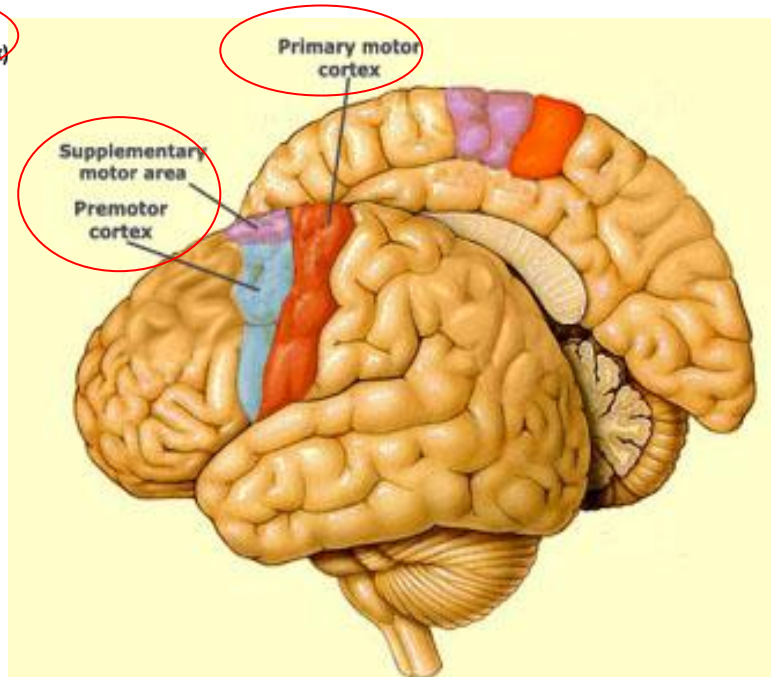
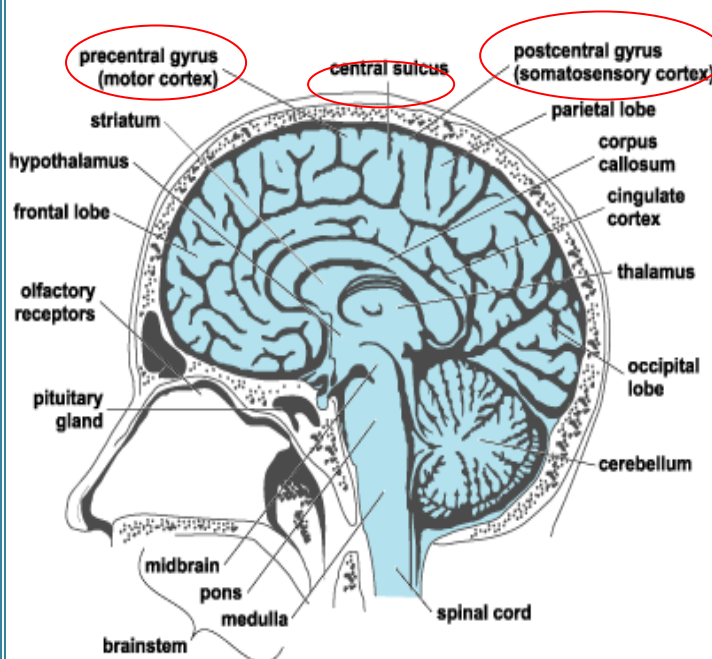
- is a small area located on the lateral side of the brain in front of area 4 and above the pre-motor area . This area projects mainly to M1 and is concerned with planning and programming motor sequences.

(3) Premotor Area (MIII):

lies in front of the primary motor area & below supplementary motor area. Stimulation of the premotor area produces complex coordinated movements, such as setting the body in a certain posture to perform a specific task.

(4) Parietal lobe :

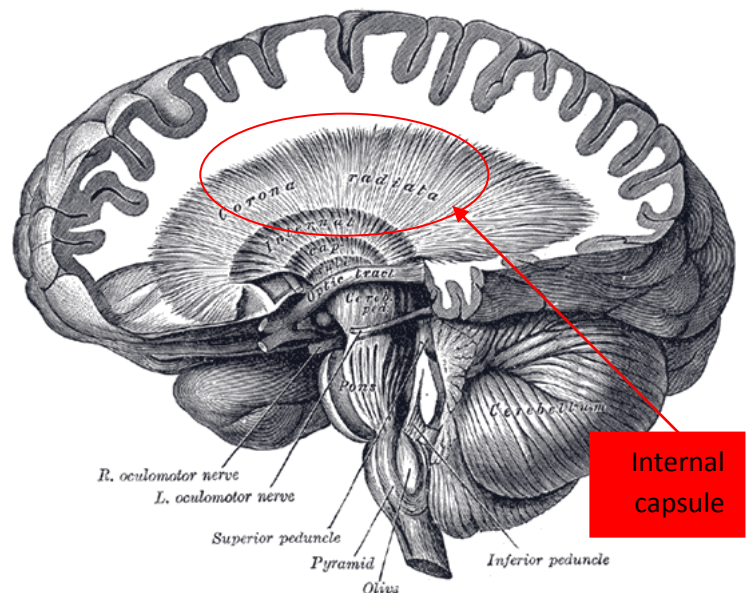
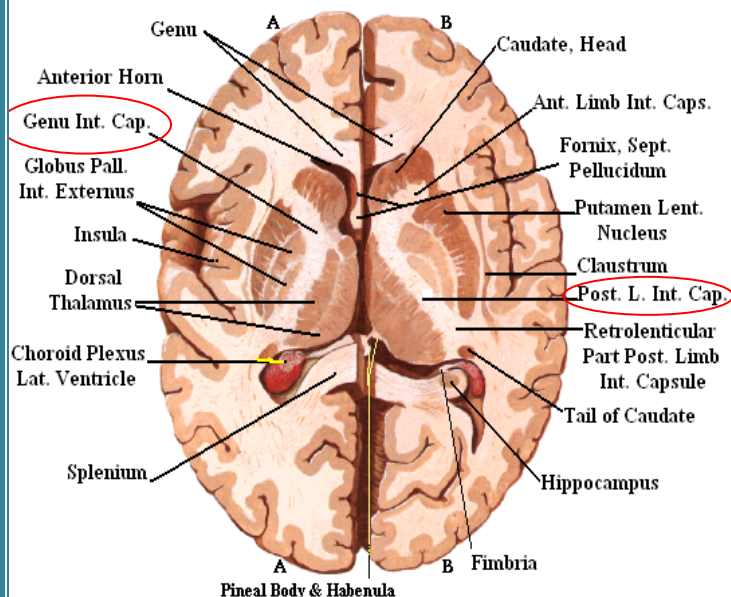
The Parietal lobe contributes about 40% of the fibers that run in the pyramidal tracts



Corticospinal (Pyramidal) Tracts cells of origins are as follow:

- 30% originate from the primary motor area.
- 30% from the premotor areas.
- 40% from the somatosensory areas in parietal lobe.

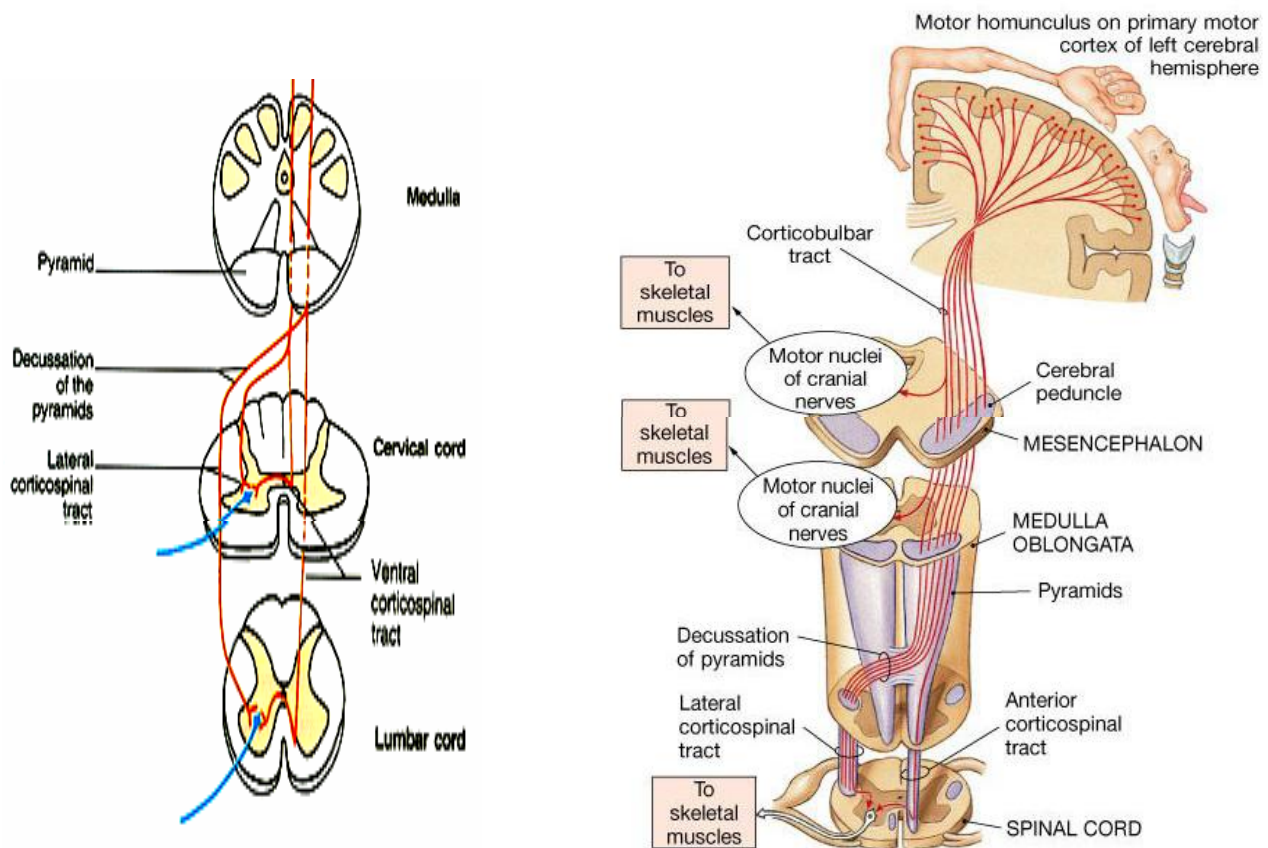
- 3% of the fibres are large myelinated fibres, derived from the large , highly excitable pyramidal Betz cells of MI.
- These fibers form monosynaptic connections with motor neurons of the spinal cord.
- Fibers from the cerebral cortex descend in corona radiata to reach the internal capsule (occupying the genu and the anterior two-thirds of the posterior limb).



The descending fibers in the core of the brain white matter form a large body of converging axons, the **Corona Radiata**, "radiating crown". As you get deeper still into the hemispheres, the corona radiata dives into the deep nuclei of the brain, the caudate and putamen, splitting them in two. **At this point, all of these axons are called the internal capsule.** It is a major two-way highway; very vulnerable to strokes.

Then descend through the midbrain and pons.

- In the lower medulla around 80% of the fibres cross to the opposite side, and descend in the lateral column of spinal cord white matter as the Lateral Corticospinal Tract .
- They synapse on the contralateral spinal motoneurons , or on interneurons in the intermediate region of the cord grey matter.



- The remaining 20% of corticospinal fibers do not decussate in the medulla.
- They descend ipsilaterally in the ventral column of the spinal cord white matter, constituting the ventral corticospinal tract.
- Finally they decussate and synapse on the contralateral spinal motoneurons.

Extrapyramidal Tracts :

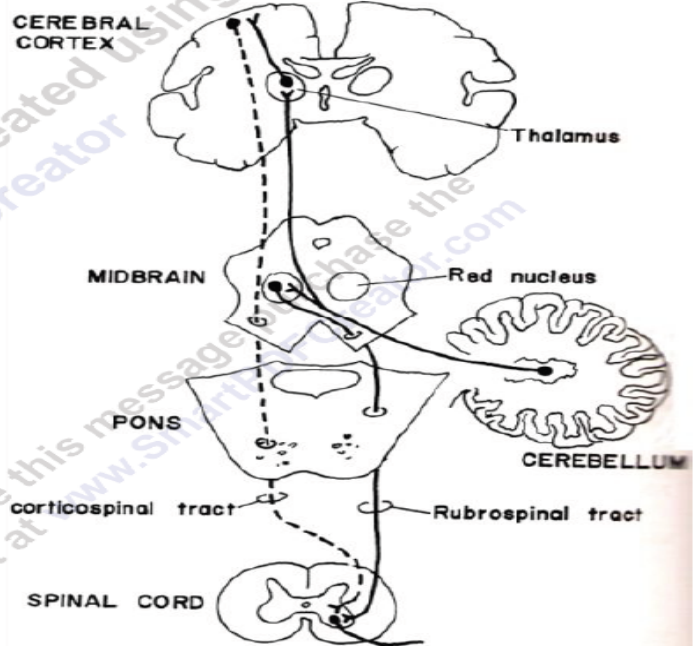
Rubrospinal Tracts

After emerging from Red Nucleus in midbrain , fibers decussate at same level of red nucleus

Descend with the lateral corticospinal tract

In spinal cord tract occupies the lat. white column , & fibers synapse on the contralateral AHCs

- ✓Red nucleus is connected by fibers with with the cerebral cortex & cerebellum ..
- ✓Fibers are inhibitory & distributed, similar to corticospinal fibers (which are largely excitatory) , to distal limb motoneurons that control skilled movement



Tectospinal Tract

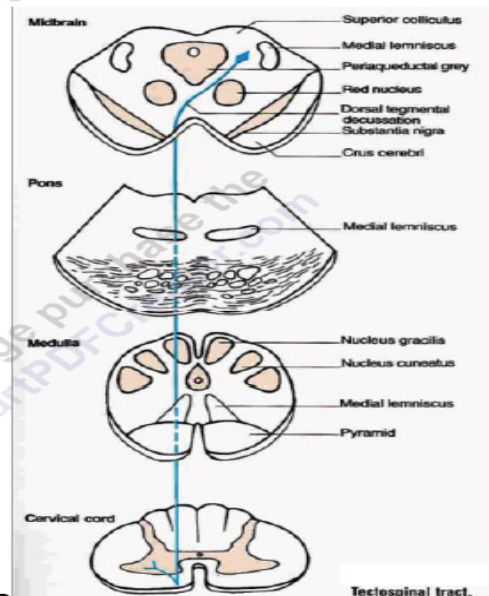
Originates in Superior & Inferior colliculi in midbrain , then decussate in the dorsal tegmentum

Near Medial longitudinal fasciculus

Axons descend in ventral white column of spinal cord

Contralateral cervical motoneurons

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



Tectospinal tract.

Vestibulospinal Tracts

Fibers originate in vestibular nuclei in pons (which receive inputs from inner ear Vestibula Apparatus and Vestibulocerebellum)

Axons descend in the ipsilateral ventral white column of spinal cord

Excitatory to ipsilateral spinal motoneurons (including gamma efferents) that supply axial & postural muscles

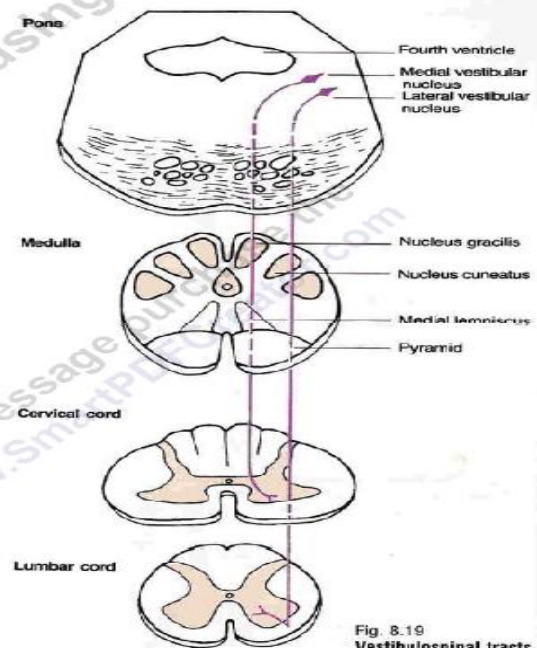


Fig. 8.19
Vestibulospinal tracts.

Functions of Vestibulospinal Tracts

- Vestibulospinal tracts control reflexes e.g. Postural & righting + control eye movements.
- The lateral vestibulospinal
- Cells of origin : Lateral Vestibular Nucleus
- Axons descend in the ipsilateral ventral white column of spinal cord .
- This tract mediates excitatory influences upon extensor motor neurones to maintain posture
- The medial vestibulospinal tract :
- Cells of origin : Medial Vestibular Nucleus
- As its axons descend ipsilaterally in the ventral white column of spinal cord , they form part of the Medial Longitudinal Fasciculus
- The medial longitudinal fasciculus consists of both ascending & descending fibers that link vestibular nuclei to nuclei supplying the extraocular muscles for coordination of head and eye movements

Reticulospinal Tracts

- **Functions :** These tracts influence both Alpha & Gamma motoneuron activities .They regulate muscle tone and inhibit unwanted reflex contractions .

(1) Pontine (Medial) Reticulospinal Tract:

- Cells of origin: Pontine Reticular Formation
- Axons descend in ventral white column of spinal cord
- Axons terminate in ipsilateral spinal motoneurons
- Pontine Reticulospinal Tract increases activity ,
(consequently , increases muscle tone) ,

(1) Medullary (Lateral) Reticulospinal Tract:

- Cells of origin: Medullary Reticular Formation
- Axons descend in ventral white column of spinal cord on both sides (both crossed & uncrossed)
- Axons terminate in ipsilateral & contralateral ventral horn cells of spinal cord
- Medullary Reticulospinal Tract, on the other hand , inhibits Gamma Efferent activity (consequently , decreases muscle tone) .

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Olivospinal Tract

- Originates in Inferior Olivary Nucleus of the medulla is found only in the cervical region of the spinal cord.
- Function is uncertain