Neuropsychiatry Block
1-Physiology of Motor Tracts

Prof. Faten Zakareia

Professor of physiology&Consultant of clinical physiology

Physiology Department

College of Medicine

King Saud University

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)

- functional role of corticospinal & corticobulbar tracts

- The pathway & functional role of the extrapyramidal tracts as rubrospinal , vestibulospinal ,reticulospinal and Tectspinal Tracts

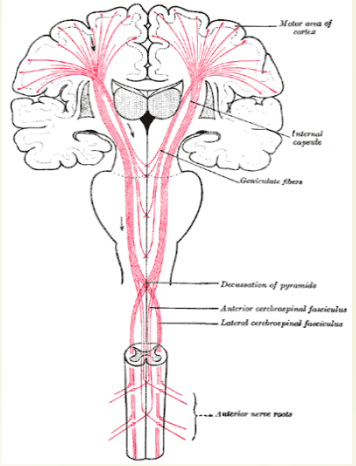
Reference book/ Gyton of human physiology& human medical physiology of Ganong

Upper & lower motor neurons

For performance of motor acts we need

1-Upper motor neurons (UMN):-

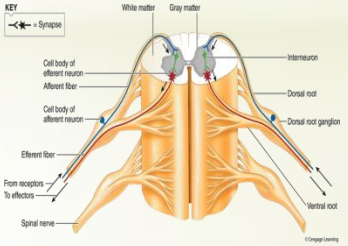
- Neurons of motor cortex & their axons that pass
to brain stem and spinal cord to activate brain stem neurons (cranial) & spinal motor neurons.



-There are two UMN Systems :

1- Pyramidal system (corticospinal tracts).

2- Extrapyramidal system



2- lower motorv neurons(LMN)

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

Descending Tracts

The following are the important sets of descending motor tracts, named according to the origin of their cell bodies and their final destination:

Pyramidal tract

1) **Corticospinal tract =Pyramidal tract**

2)Corticobulbar tract.

Extrapyramidal tracts

1) **Rubrospinal tract,**
2) **Reticulospinal tracts**
3) **Vestibulospinal tracts**
4) **Tectospinal tract**
5) **5) Olivspinal tract .**

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Motor areas

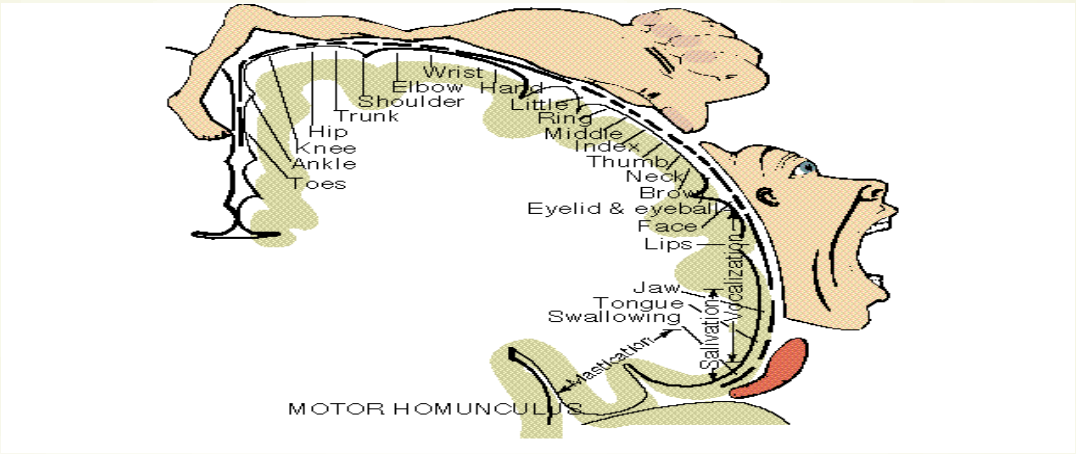
(1) The primary motor area (M1 . Motor area 4)

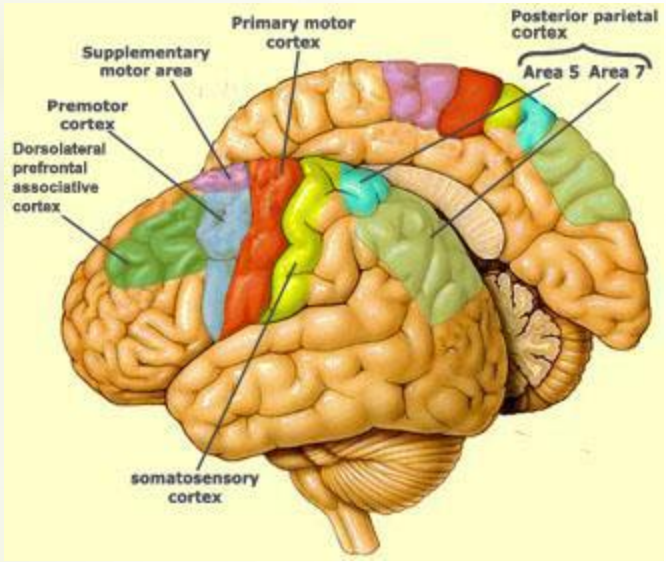
Occupies the precentral gyrus & contains large , giant highly excitable Betz cells.
-MI of one side controls skeletal muscles of the opposite side of the body
-Area of representation is proportional with the complexity of function done by the muscles. So, muscles of hands and speech occupies 50% of this area

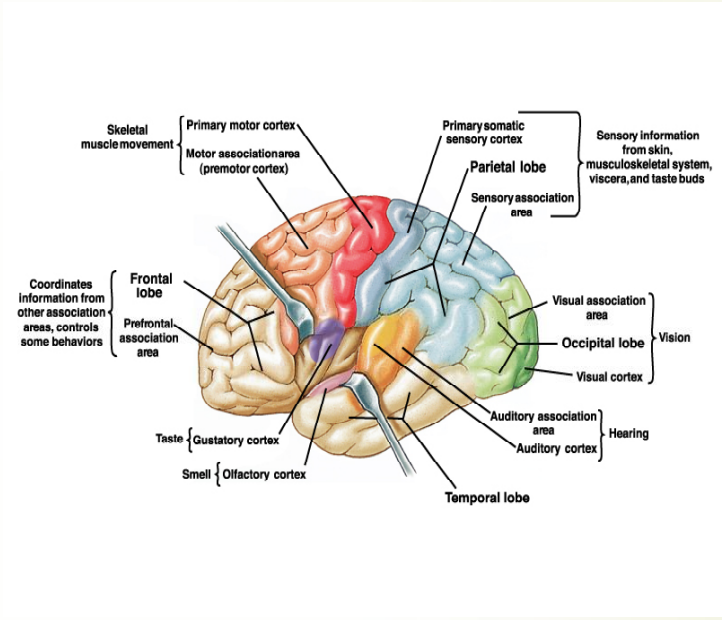
-Its neurons of this area arranged in vertical Columns. Each column has six distinct layers of cells, The pyramidal cells that give rise to the to the corticospinal fibers all lie in the fifth layer

--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

-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.


Wrist
Elbow
Hand
Shoulder
Little
Trunk
Ring
Hip
Middle
Knee
Index
Ankle
Thumb
Toes
Neck
Brow
Eyelid & eyeball
Face
Lips
Jaw
Tongue
Swallowing
Salivation
Vocalization
Mastication
MOTOR HOMUNCULUS


Primary motor cortex
Posterior parietal cortex
Supplementary motor area
Area 5
Area 7
Premotor cortex
Dorsolateral prefrontal associative cortex
somatosensory cortex


Skeletal muscle movement
Primary motor cortex
Motor association area (premotor cortex)
Primary somatic sensory cortex
Parietal lobe
Sensory association area
Sensory information from skin, musculoskeletal system, viscera, and taste buds
Coordinates information from other association areas, controls some behaviors
Frontal lobe
Prefrontal association area
Visual association area
Occipital lobe
Visual cortex
Vision
Taste
Gustatory cortex
Auditory association area
Auditory cortex
Hearing
Smell
Olfactory cortex
Temporal lobe

(2) Premotor Area

- lies infront 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.

- It works in association with the supplemental motor area, establishing the motor programs necessary for execution of complex movements

A few highly specialized motor centers have been found in the premotor areas of the human cerebral cortex:

-Broca's Area for Speech

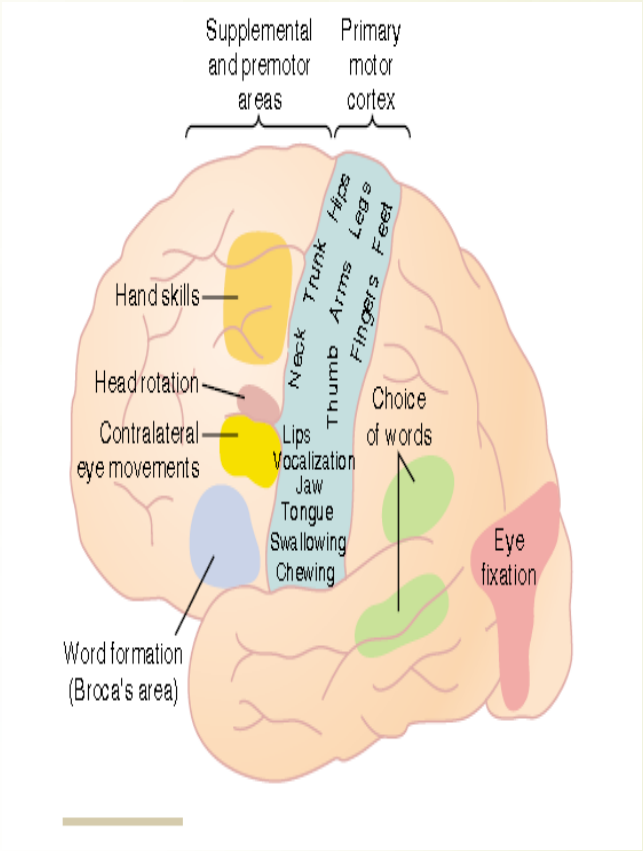
-The Frontal Eye Movements Area:

- located above Broca's area in the frontal lobe
- controls voluntary movements of the eyes toward different objects in the visual field.

-Head Rotation Area:

- located just above the eye movement area in the motor cortex .
- directing the head toward different visual objects .

-Area for Hand Skills



(3) The Supplementary Motor Area

- 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
- Stimulation of this area leads to bilateral (bimanual)grasping movements of both hands simultaneously.

-This area make motor programs for axial muscles. It provides background adjustment for finer motor control of the arms and the hands by the premotor area and primary motor cortex

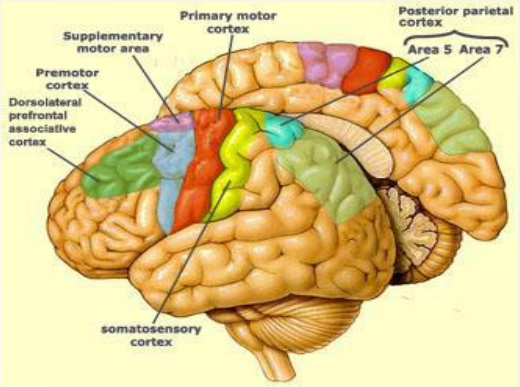
1-Corticospinal (Pyramidal tracts)&corticobulbar tracts;-

Origin/

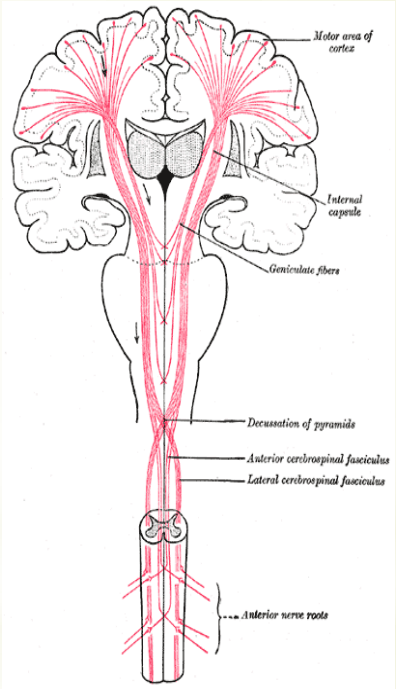
1- **30% motor area 4 (the primary motor area) (M1)**

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

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



- **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)**



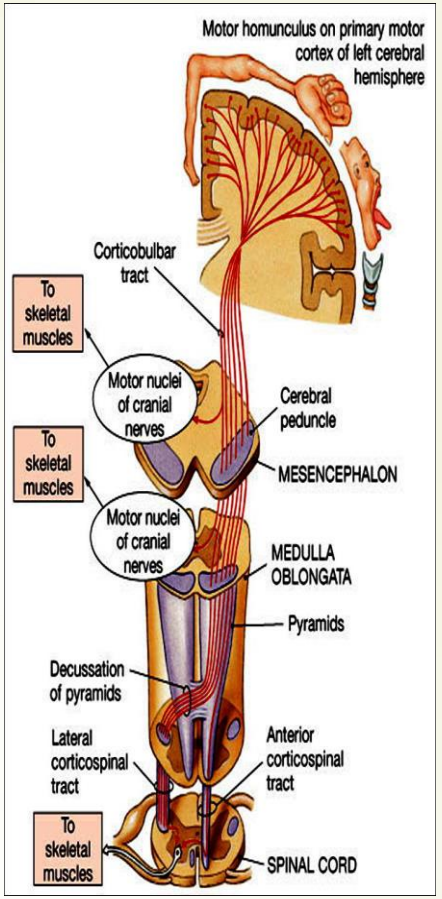
CONT//

-In the brain stem midbrain, pons & medulla oblongata

1-Corticobulbar tract carries information to motor neurons of the cranial nerve

2- Corticospinal tracts (pyramidal)

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



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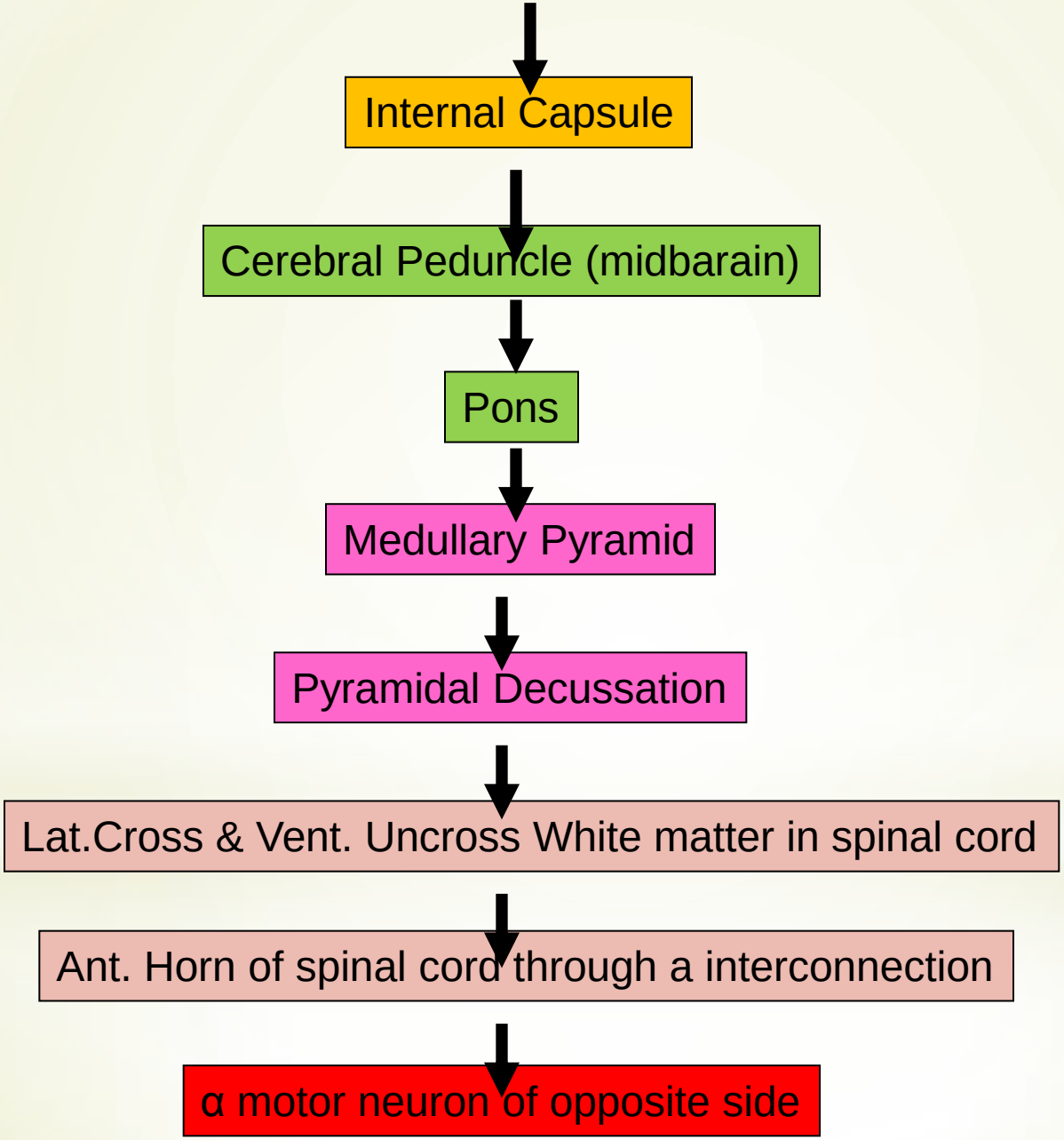
Origin – Sensory cortex, primary Motor Cortex, premotor & supplementary cortex



* Cont-----

-Corticospinal tracts (pyramidal) divides into:

1- lateral corticospinal tracts :-

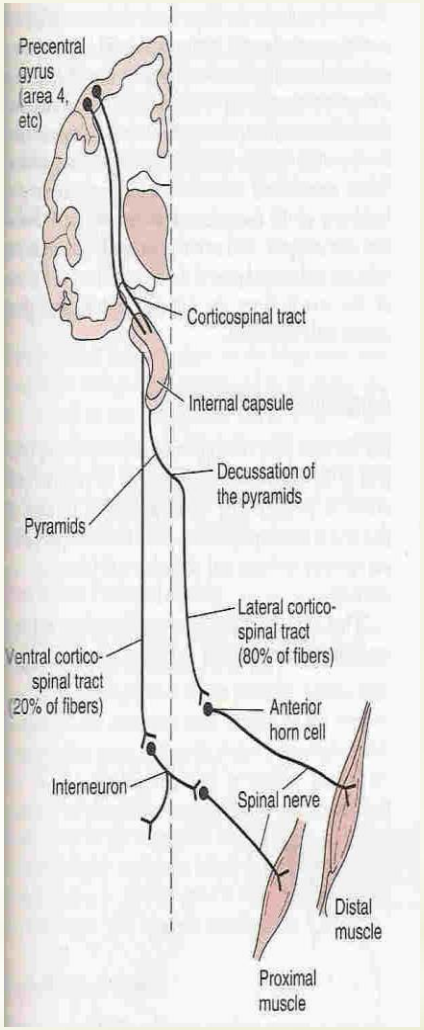
- 80% of fibers cross midline in pyramids

- 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

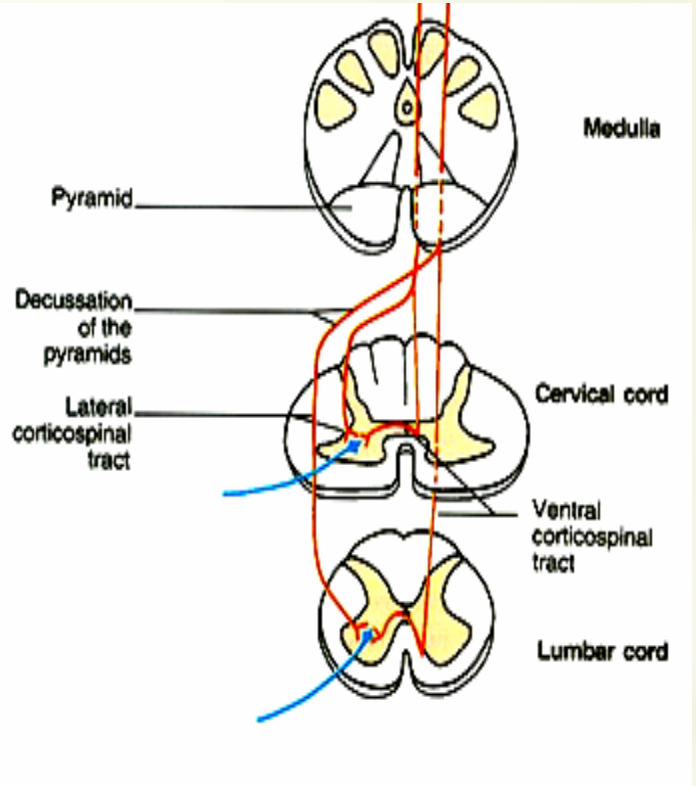


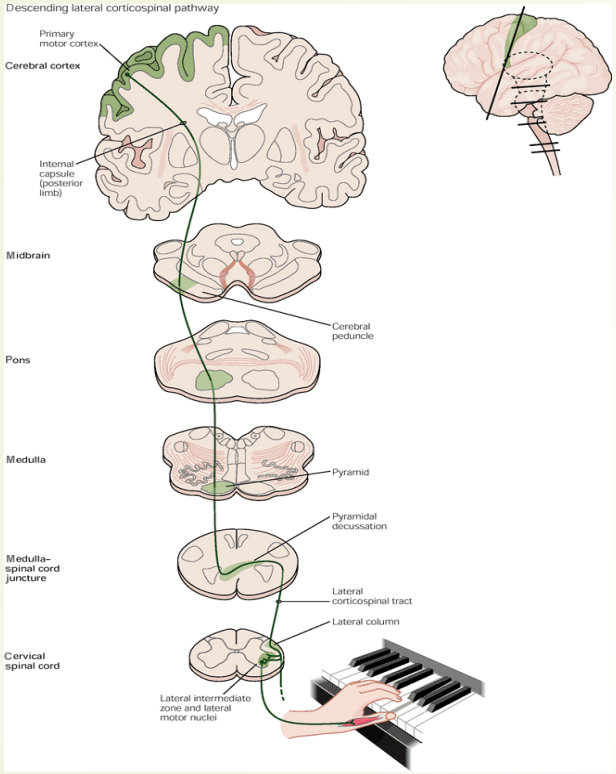
2- Ventral (anterior) corticospinal tracts :-

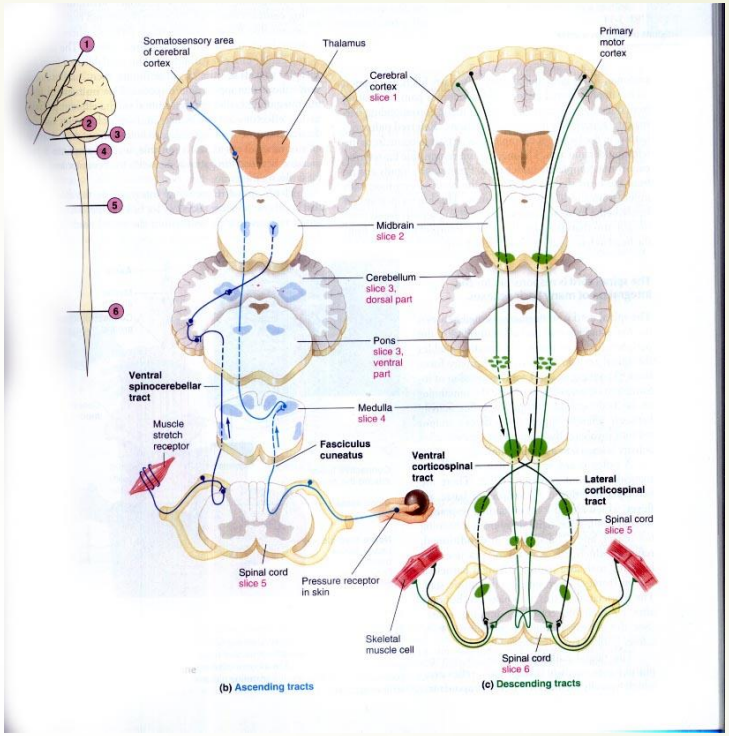
- Remaining 20% fibers does not cross midline at the pyramids but pass directly untill it
Cross at level of their termination to synapse with interneurons , that synapse with motor neurons (AHCs) of opposite side.

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

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




Descending lateral corticospinal pathway
Primary motor cortex
Cerebral cortex
Internal capsule (posterior limb)
Midbrain
Cerebral peduncle
Pons
Medulla
Pyramid
Pyramidal decussation
Medulla–spinal cord juncture
Lateral corticospinal tract
Lateral column
Cervical spinal cord
Lateral intermediate zone and lateral motor nuclei


1
2
3
4
5
6
Somatosensory area of cerebral cortex
Thalamus
Primary motor cortex
Cerebral cortex slice 1
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
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?)

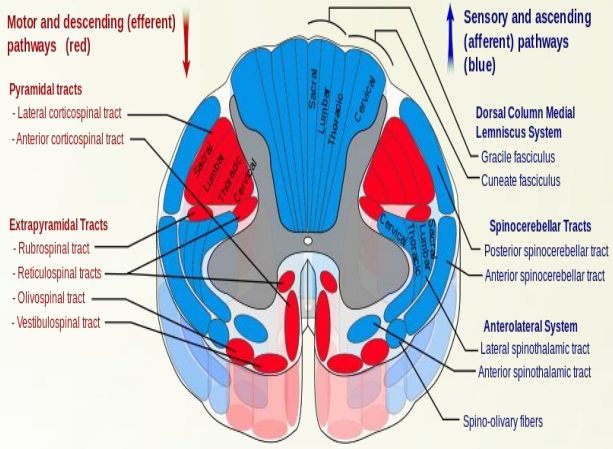
2- lateral corticospinal tracts (main bulk of the tract) control distal muscles of limb as fingers & thumb& toes which concerned
with fine skilled movement) e.g Painting ,writing, picking up of a small object etc.

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.

-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, but 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 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), but 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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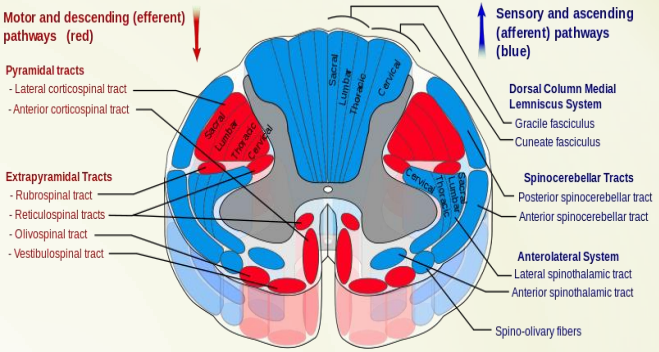

1-Rubrospinal tracts:-

- The red nucleus located in the mesencephalon.(midbrain)
-It receives direct fibers from the primary motor cortex through the corticorubral tract & from the corticospinal tract
-receive afferents from contralateral cerebelum & from basal ganglia

- The rubrospinal tract crosses to the opposite side in the lower brain stem into the lateral columns of the spinal cord together with corticospinal tract

- 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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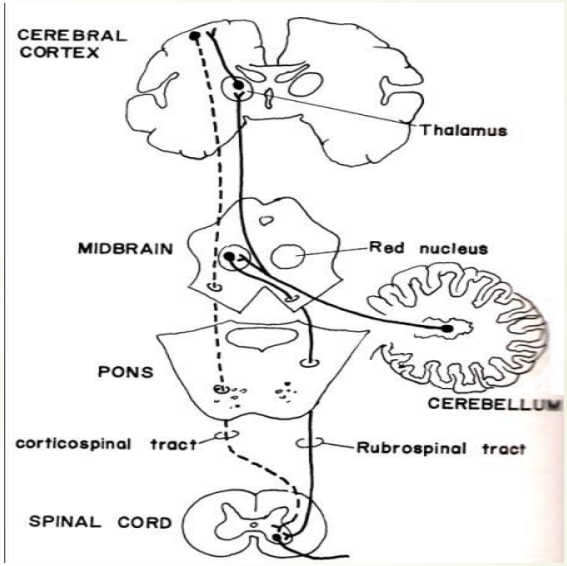

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Function of the Corticorubrospinal System.

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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..

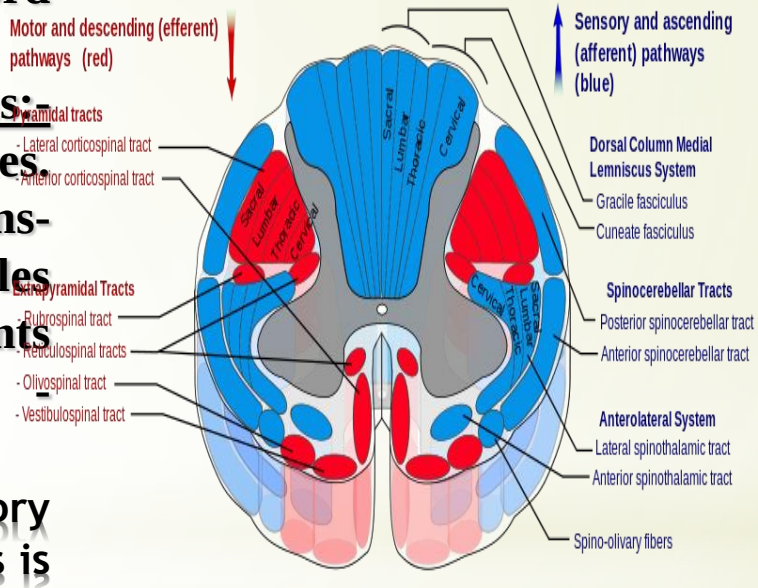
-Rubrospinal tract lies in the lateral columns of the spinal cord, along with the corticospinal tract. Therefore, together are called the **lateral motor system of the cord,** in contradistinction to a vestibulo-reticulospinal system, which lies mainly medially in the cord and is called **the medial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



N.B/Vestibular nuclei tracts are always excitatory to Gamma Efferents (whereas Red nucleus is always inhibitory)

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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

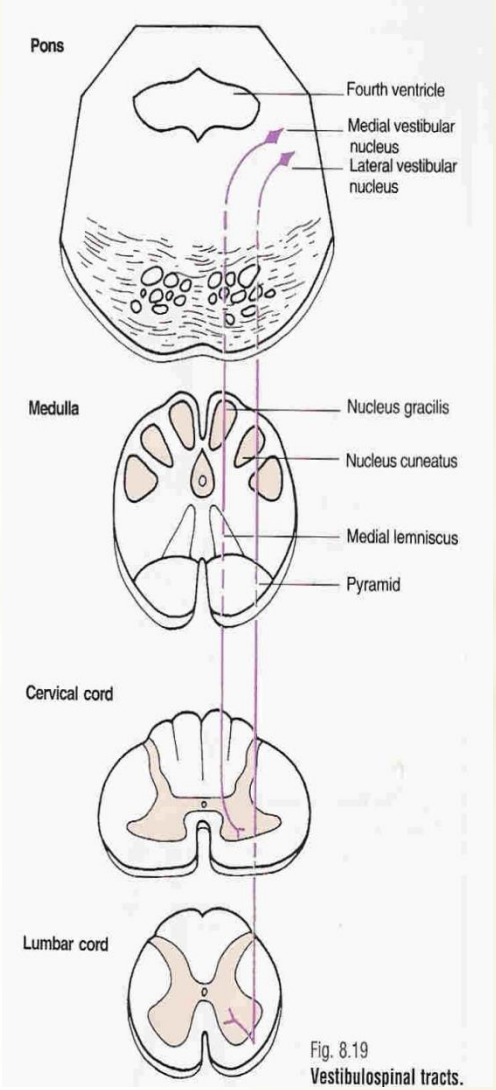

Fig. 8.19
Vestibulospinal tracts.

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

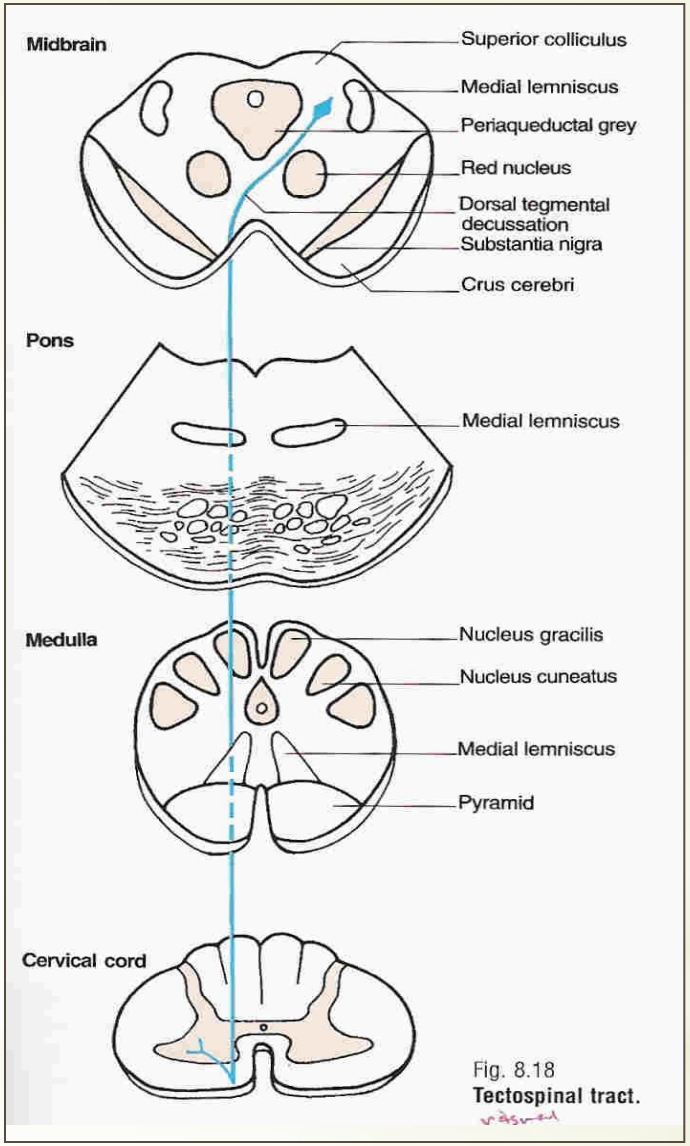

Fig. 8.18
Tectospinal tract.

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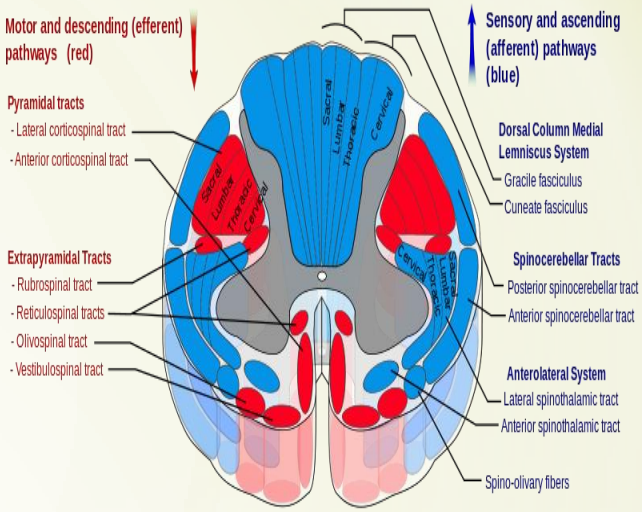
4- Reticulospinal Tract :-

-The reticular formation of the brainstem.
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

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

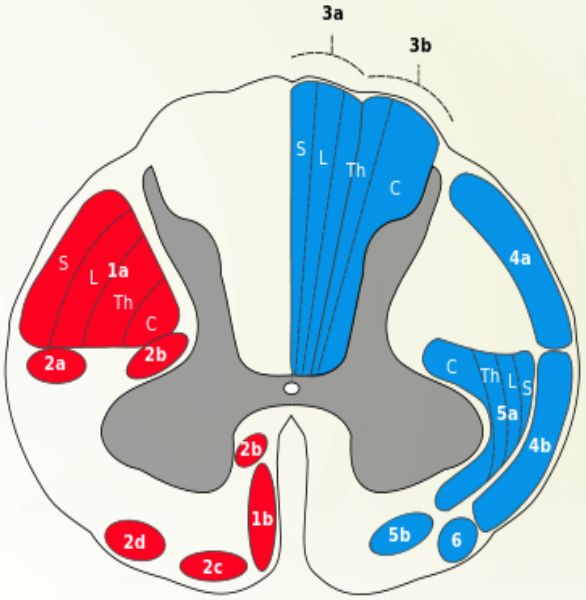
- Medullary Reticulospinal Tract inhibits Gamma efferent activity (transmit *inhibitory* signals to antigravity extensor muscles & decreases muscle tone) .

-

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**	