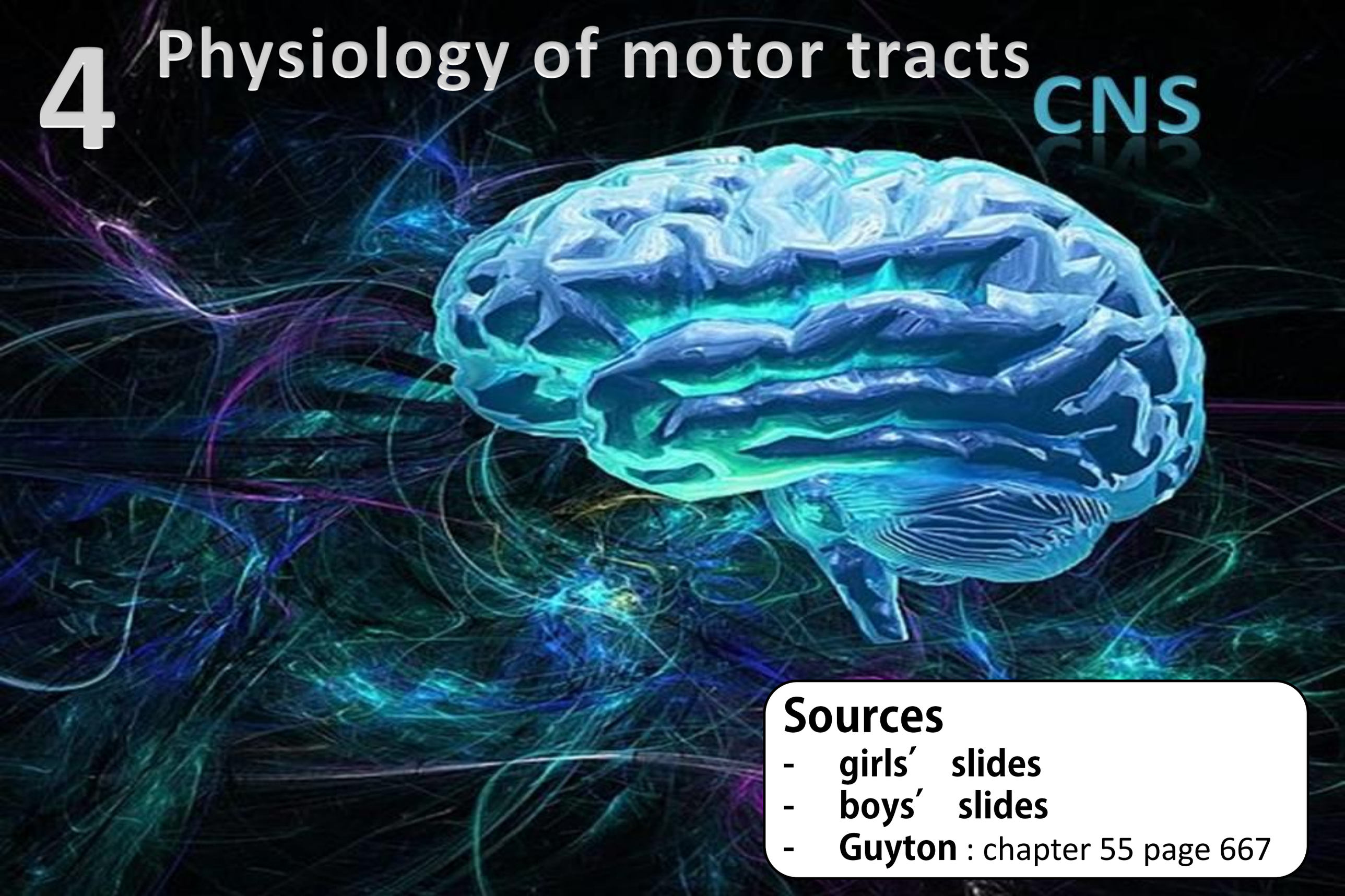
4 Physiology of motor tracts



Sources

- **girls' slides**
- **boys' slides**
- **Guyton** : chapter 55 page 667

Objectives

(1) Describe the upper and lower motor neurons.

(2) Understand the pathway of Pyramidal tracts (Corticospinal & corticobulbar tracts).

(3) Understand the lateral and ventral corticospinal tracts.

(4) Explain functional role of corticospinal & corticobulbar tracts.

(5) Describe the Extrapyramidal tracts as Rubrospinal, Vestibulospinal, Reticulospinal and Tectspinal Tracts.

The name of the tract indicate its pathway, for example Corticobulbar :

- cortico: cerebral cortex.
- Bulbar: brainstem.

*So it starts at cerebral cortex and terminate at the brainstem.

Terms:

Decustation: crossing.

Ipsilateral : same side.

Contralateral: opposite side.

CNS influence the activity of skeletal muscle through two set of neurons :

1- Upper motor neurons (UMN)

They are neurons of **motor cortex & their axons** that pass to brain stem and spinal cord to activate:

- cranial motor neurons (in brainstem)
- spinal motor neurons (in spinal cord)

- Upper motor neurons (UMN) are responsible for **conveying impulses for voluntary motor activity** through descending motor pathways that make up by the upper motor neurons.

There are two UMN Systems through which (UMN) control (LMN):

1- Pyramidal system (corticospinal tracts).
2- Extrapyramidal system

2- lower motor neuron (LMN)

They are Spinal motor neurons in the spinal cord & cranial motor neurons in the brain stem which **innervate muscles directly.**

- These are the only neurons that innervate the skeletal muscle fibers, they function as the final common pathway, the final link between the CNS and skeletal muscles.

Lower motor neurons are classified based on the type of muscle fiber the innervate:

1- alpha motor neurons
2- gamma motor neurons

The activity of the lower motor neuron (LMN, spinal or cranial) is influenced by:

1. Upper Motor Neurons (UMNs) coming from supraspinal centers via descending motor tract .
2. Interneurons.
3. Afferent (sensory nerves).

According to	Upper motor neuron	Lower motor neuron
Cell bodies	UMN cell bodies located in the cortex of the brain	Are located in the grey matter of the spinal cord and brain stem.
synapse	Upper motor neurons from synapses with the lower motor neurons	Lower motor neurons form synapses with the muscles in the body.

Descending Tracts

1- Corticospinal (Pyramidal tracts) & corticobulbar tracts

Corticospinal tracts divides into :

A- lateral corticospinal tracts.

B- Ventral (anterior) corticospinal tracts.

2- Extrapyramidal tracts:

A- Rubrospinal tracts (INHIBITORY)

B- Vestibulospinal tracts.

C- Tectospinal tracts (Excitatory)

D- Reticulospinal Tract

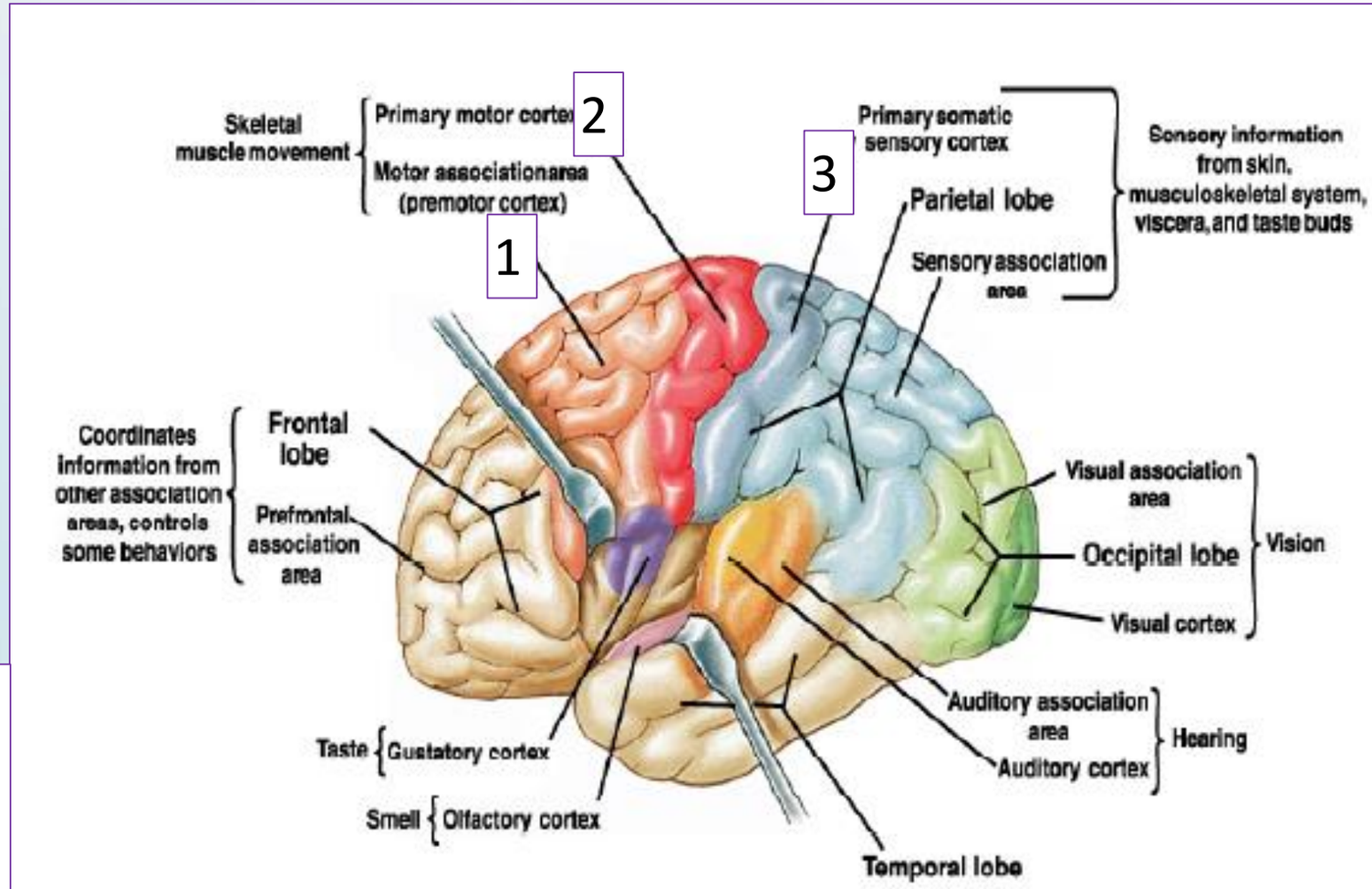
E- Olivospinal Tract

1- Corticospinal (Pyramidal tracts) & corticobulbar tracts:

Origin:

1. 30% from **primary motor area motor area 4 (M1)** . Occupies the **precentral gyrus**.
2. 30% from the **premotor areas (M3) & supplemetary cortex (M2)**.
3. 40% **parietal cortex** (somatic sensory area 3,1,2).

Although parietal cortex are sensory neurons, they give origin for motor tract to make balance between the sensory and motor impulses.



1- Motor association area.
2- Primary motor cortex.
3- Primary somatic sensory cortex.

What do you know about Premotor area & Supplemetary cortex ?

Premotor area:

- (motor association area) lies in **front of the primary motor area & below supplemetary 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.
- Ex : if we want to sit properly and write, it help to make suitable muscle tone to have a good hand writing.

Supplemetary cortex:

- It's a small 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.

- This area projects mainly to M1 and is concerned with:
  - planning and programming motor sequences.
  - It is also responsible for bilateral movement. Ex: typing with both hands.

1- Corticospinal (Pyramidal tracts) & corticobulbar tracts:

Fibers :

- 3% of the pyramidal fibers are large myelinated, derived from the large, giant, highly excitable pyramidal Betz cells in motor area 4.
- form monosynaptic connections (without interneurons) with motor neurons of the spinal cord "only the lateral Corticospinal tract"

Pathway: Fibers from the cerebral cortex descend in → CORONA RADIATA → INTERNAL CAPSULE genu & the anterior 2/3 of the posterior limb → BRAIN STEM (midbrain, pons, medulla oblongata)

A- lateral corticospinal tracts:

Corticospinal tracts (pyramidal) descends through the midbrain and pons. Then 80% of them will decussating in the lower medulla oblongata and these fibers will form pyramids called pyramidal tract. And continue as **"lateral Corticospinal tract"** laterally in spinal cord white matter and ends as monosynaptic neuron (without interneuron)

2- Ventral (anterior) corticospinal tracts:

Corticospinal tracts (pyramidal) descends through the midbrain and pons. And Remaining 20% fibers that does not decussate continues as "ventral Corticospinal track" medially in ventral horn and at level of termination to synapse with interneurons, that synapse with motor neurons (AHCs) of opposite side

Corticobulbar tract terminates on LMNs and decussating **just before they reach their target nuclei**

The corticobulbar tract carries information to motor neurons of **the cranial nerve nuclei "in brain - stem"** , rather than the spinal cord.

Pathway of the Corticospinal tract

Origin – Sensory cortex, primary Motor Cortex, premotor & supplementary cortex
(40%) (30%) (30%)

Internal Capsule

Cerebral Peduncle (midbarain)

Pons

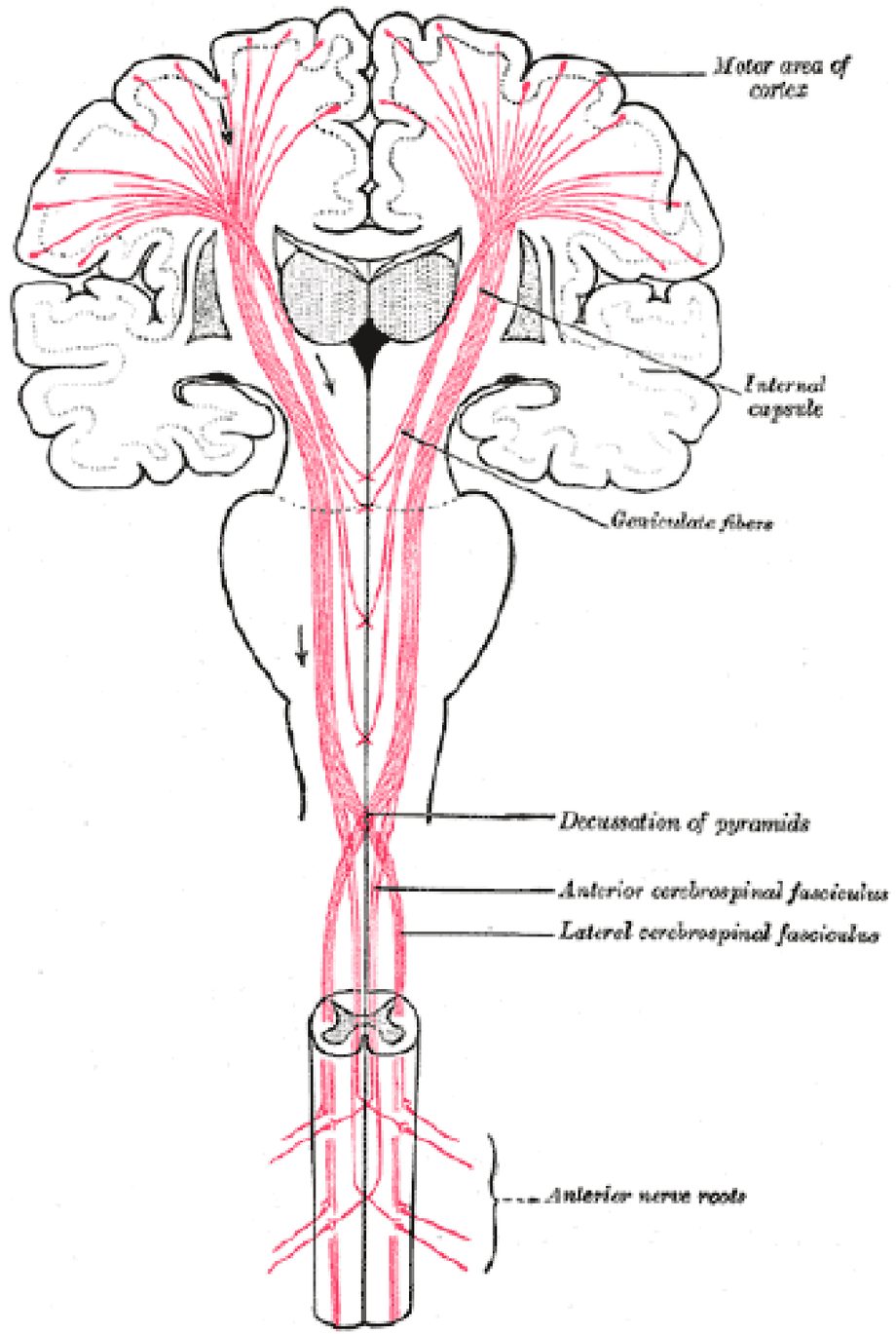
Medullary Pyramid

Pyramidal Decussation

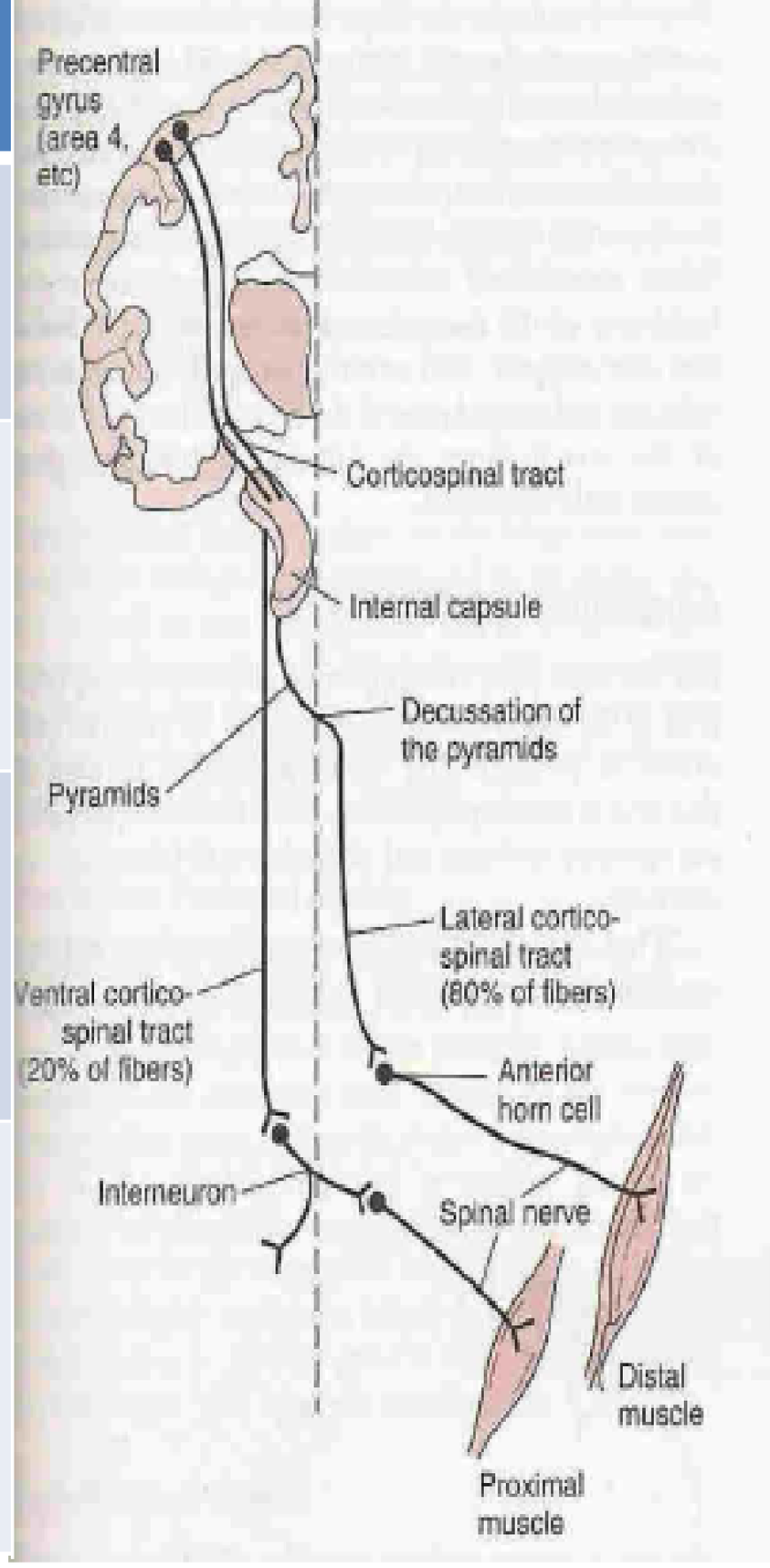
Lat.Cross & Vent. Uncross White matter in spinal cord

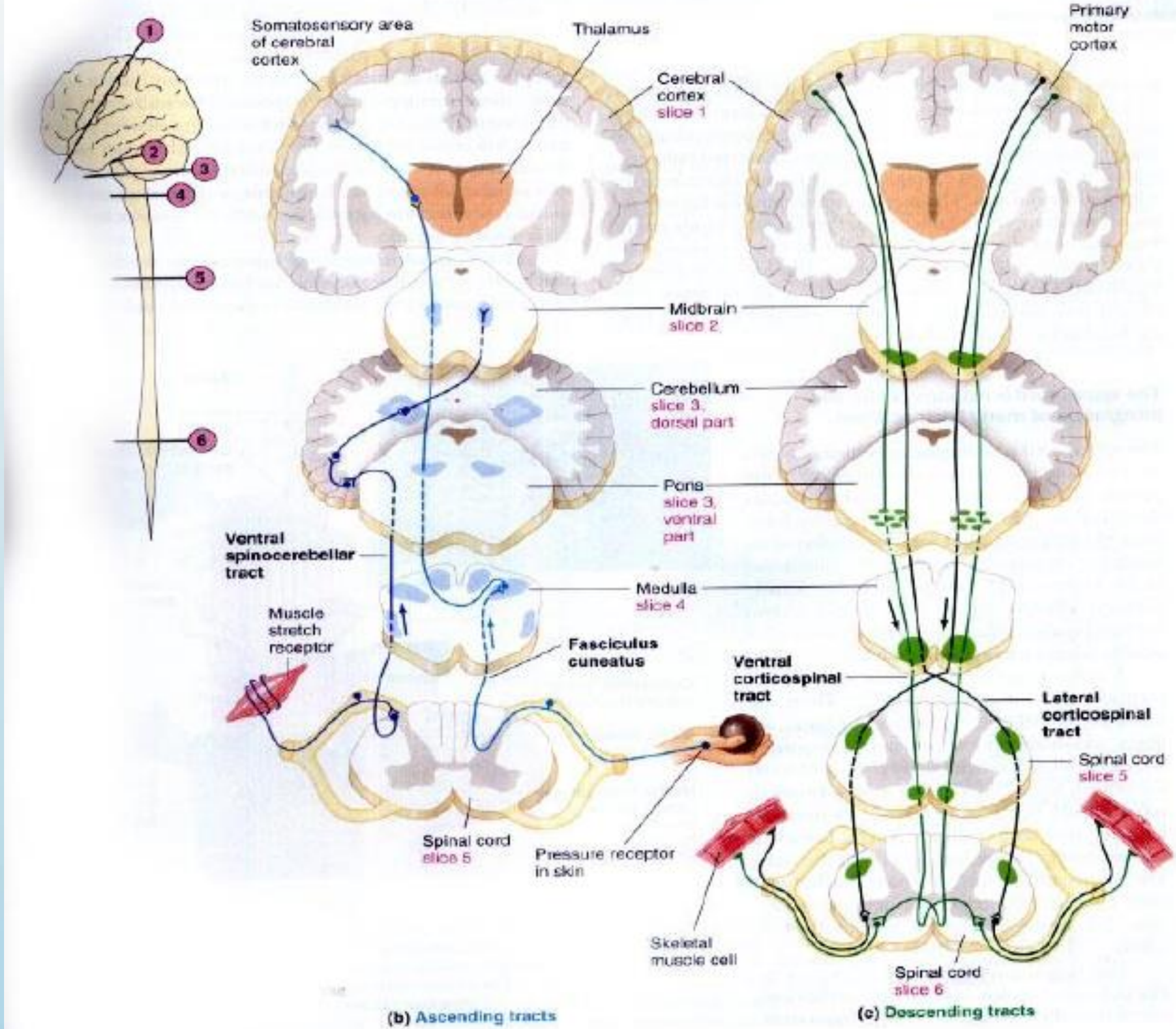
Ant. Horn of spinal cord through a interconnection

α motor neuron of opposite side



lateral corticospinal tract	Ventral corticospinal tract
80% of fibers which pass laterally	Remaining 20% fibers which pass medially
cross midline in pyramids	does not cross midline and cross at level of termination
control fine skilled movements of the distal limb muscles	control axial & proximal limb muscles & control posture.
Ends directly (not via interneurons = monosynaptic connections)	synapse with interneurons, that synapse with motor neurons (AHCs)




1
2
3
4
5
6
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
Spinal cord slice 5
Pressure receptor in skin
Ventral corticospinal tract
Lateral corticospinal tract
Spinal cord slice 5
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? The opposite side).

2- Lateral corticospinal tracts control **Fine discrete skilled movements** of **the distal limb muscles** (fingers and toes).

Such as : ballerina = (باليه), writing and typing

3- Ventral corticospinal tracts control **axial (medial) muscles** (ex. abdomen, chest..) , **proximal limb muscles** , **posture and balance.**

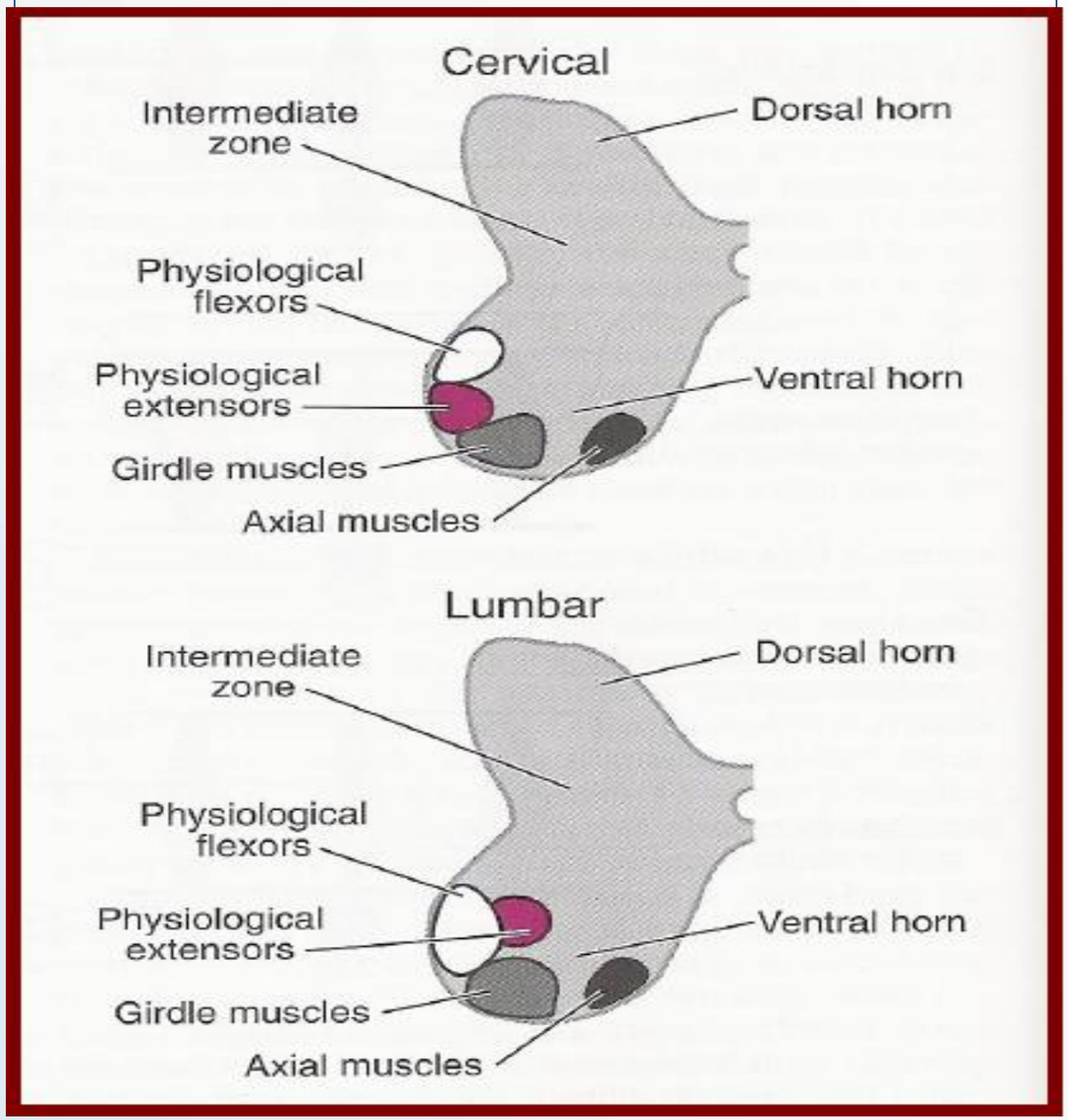
Such as : climbing, walking (need large muscles)

4- Effect on **stretch reflex** by **Facilitating muscle tone** (prevent hypertonia or hypotonia) through **gamma motor neurons.**

5- Those fibers originate from parietal lobe are for what? sensory-motor coordination (i.e. somatosensory coordination) in final common pathway by **alpha motor neuron).**

Functions of Corticobulbar tracts :

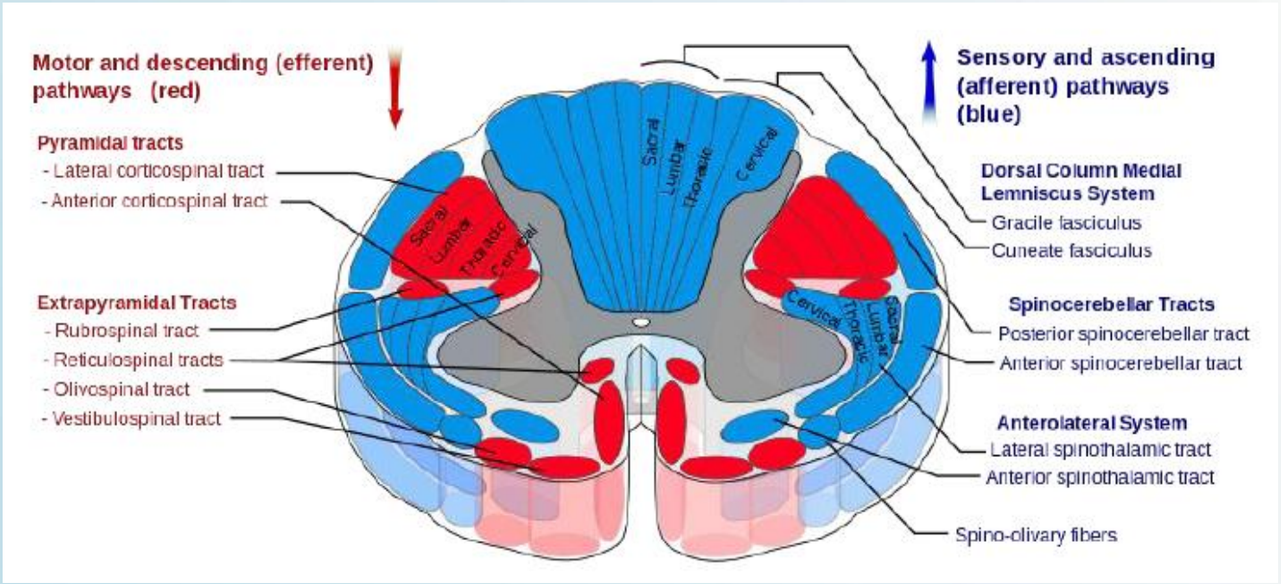
- Control face & neck muscles (talking, smiling..) & facilitate their tone, and are involved in what? (Facial expressions, swallow, mastication).



2- Extrapyramidal tracts :

Tracts other than corticospinal tract & are outside pyramids.

Origin	Pathway	Function
- Motor area 4 - premotor area 6 - Suppressor area 4	CORONA RADIATA → INTERNAL CAPSULE → BASAL GANGLA (Inhibitory area, the site of parkinsonism) → BRAIN STEM → BULBOSPINAL TRACTS descend to spinal cord : **Depending on the nuclei of the ganglia** it divides to: A. Rubrospinal tract. B. Vestibulospinal Tract. C. Reticulospinal Tract D. Tectspinal Tract. E. Olivospinal Tract	**1. Sets the postural background** needed for performance of skilled movements. **2.** Controls **subconscious gross movements**. (ex. walking, we don't think about which leg we will move).



A- Rubrospinal tracts (INHIBITORY)

origin	Pathway	function
From **Red nucleus** (in midbrain tegmentum) which is connected by fibers with cerebral cortex .	- Red nucleus → decussating at the level of red nucleus → pass down through pons & medulla → ends in anterior horn of spinal cord. - The fibers pass laterally in the spinal cord .	Its motor function is **inhibitory to Distal limb motor neurons & control skilled movements**. (Apposite function of lateral corticospinal tract)

B- Tectospinal tracts (excitatory)

Origin	Pathway	Function
from **superior (VISUAL) & inferior colliculi (AUDITORY) of midbrain.** (Tectum) → midbrain → brainstem)	Superior & inferior colliculi → near medial longitudinal fasciculus → ends on Contralateral cervical motor neurons.	**Mediate/facilitate turning of the head in response to visual or Auditory stimuli.** (Ex. Hearing the sound of a lion)

C- Vestibulospinal tracts

origin	Pathway	function
- From **vestibular nucleus** (situated in the pons & medulla). - fibers originate in vestibular nuclei in pons (which receive inputs **from inner ear, vestibular apparatus and cerebellum**).	- Axons descend in the ipsilateral (same side) ventral white column of spinal cord. - Afferent from cerebellum, vestibular apparatus & vestibular nucli → spinal motor neuron → innervating axial & postural muscles.	1. **Controls eye movements, postural & righting reflexes.** (righting reflexes help you when you're about to fall) 2. Excitatory to ipsilateral spinal motor neurons that supply **axial & postural muscles**.

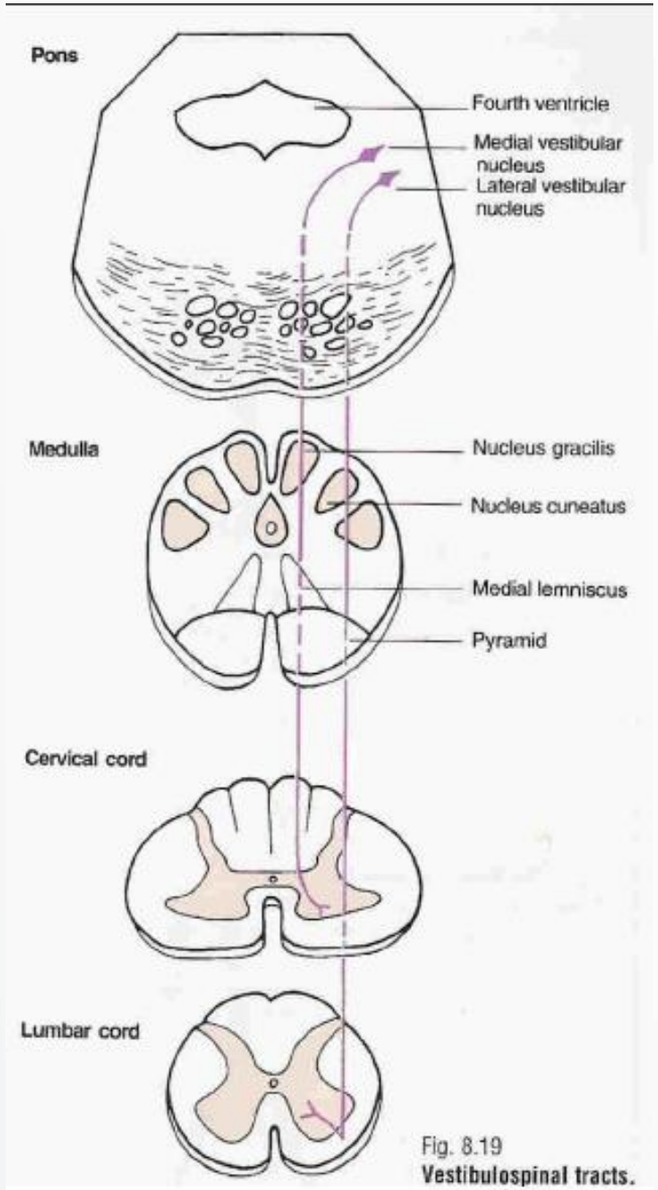


Fig. 8.19 Vestibulospinal tracts.

	The lateral Vestibulospinal tract	The medial Vestibulospinal tract
Cells of origin	**Lateral Vestibular Nucleus**	**Medial Vestibular Nucleus**
Pathway	Axons descend in the ipsilateral ventral white column of spinal cord This **tract mediates excitatory influences upon extensor motor neurons to maintain posture**	As its axons descend ipsilaterally in the ventral white column of spinal cord , they form part of the **Medial Longitudinal Fasciculus fibers in brain stem** that link **vestibular nuclei to nuclei supplying the extra-ocular muscles** (i.e. nerve 3,4,6). And **coordination of head and eye movements**

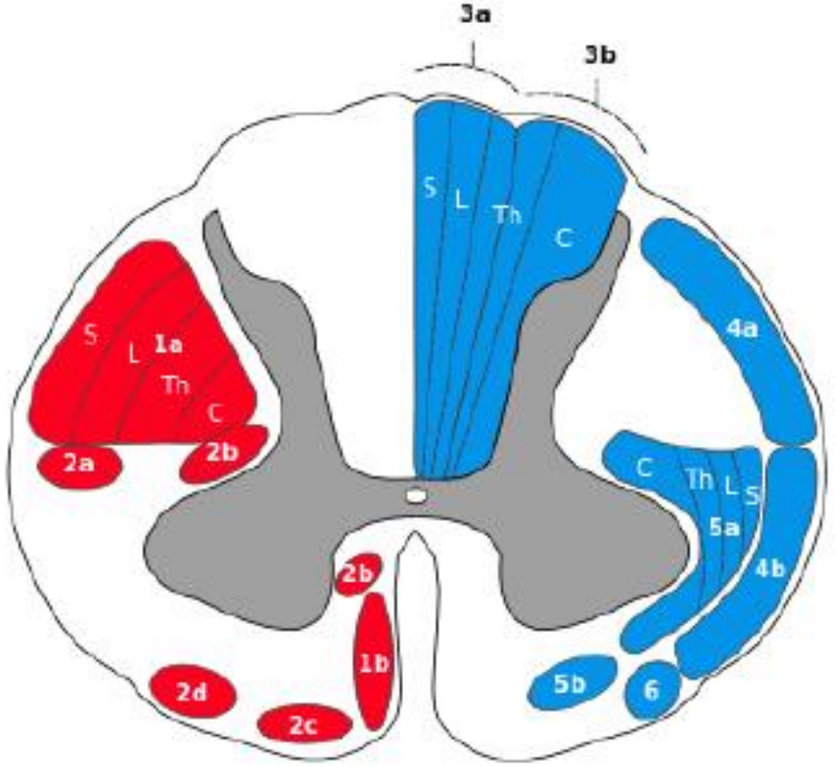
D- Reticulospinal Tract

Formation	Pathway	Function
It makes up **a central core of the brainstem**, contains many different neuronal groups	Pontine and medullary nuclei projects to the AHCs of the spinal cord via Reticulospinal Tract.	1. Influence motor functions as voluntary & reflex movement. 2. Excitatory or inhibitory to muscle tone.

	Pontine (Medial) Reticulospinal Tract	Medullary (Lateral) Reticulospinal Tract
Cells of origin	**Pontine Reticular Formation**	**Medullary Reticular Formation**
Pathway	- Axons descend in ventral white column of spinal cord. - Axons terminate in **ipsilateral** spinal motor neurons.	- Axons descend in ventral white column of spinal cord on both sides. - Axons terminate in **ipsilateral & contralateral** ventral horn cells of spinal cord.
Function	- **Increases Gamma efferent activity**,(**excitatory = increases muscle tone).** - **Exciting anti-gravity, extensor muscles.**	- **Inhibits Gamma efferent activity (inhibitory= decreases muscle tone).** - **Inhibiting anti-gravity, extensor muscles.**

5- Olivospinal Tract:

Origin	Function
It arises from **inferior olivary Nucleus** of the medulla & is found only in the cervical region of the spinal cord (supply neck muscles) .	unknown function (intermediate pathway - in the strio-olivo-spinal connections). function are unknown yet but it is said - **that it make a link between basal ganglia, inferior olivary nucleus and spinal cord**.



Motor and decending (efferent) pathways (left, red)

1. Pyramidal Tracts
1a. Lateral corticospinal tract
1b. Anterior corticospinal tract
2. Extrapyramidal Tracts
2a. Rubrospinal tract
2b. Reticulospinal tract
2c. Vestibulospinal tract
2d. Olivospinal tract

Somatotopy Abbreviations:
S: Sacral, **L: Lumbar**
Th: Thoracic, **C: Cervical**

Sensory and ascending (afferent) pathways (right, blue)

3. Dorsal Column Medial Lemniscus System
3a. Gracile fasciculus
3b. Cuneate fasciculus
4. Spinocerebellar Tracts
4a. Posterior spinocerebellar tract
4b. Anterior spinocerebellar tract
5. Anterolateral System
5a. Lateral spinothalamic tract
5b. Anterior spinothalamic tract

6. Spino-olivary fibers

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CNS Block