Descending pathways (Essay)

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- Supraspinal influences occurs through descending pathways
- Supraspinal center controlling motor activity- motor cortex and brain stem centers
- Motor cortex- corticospinal tract
- Brainstem motor nuclei- rubrospinal, reticulospinal and vestibulospinal tract

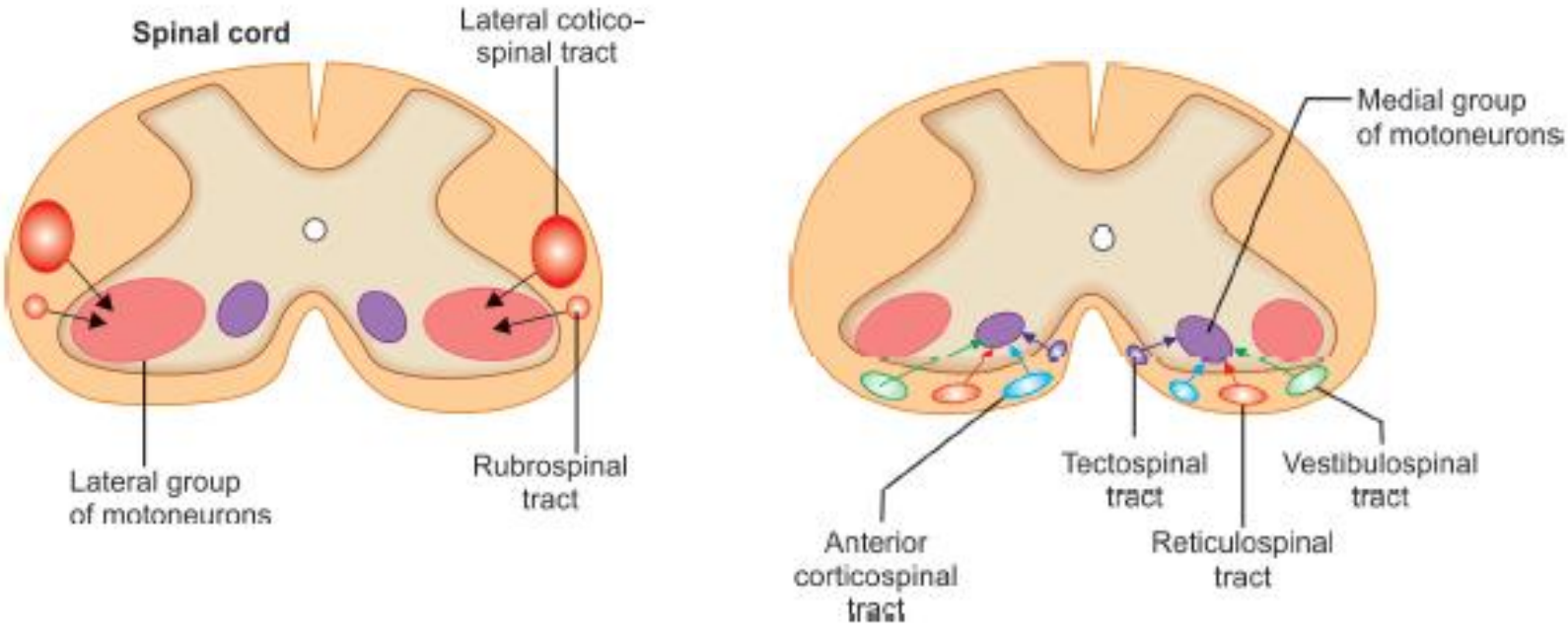
Classification

1. Pyramidal and extrapyramidal tract

- Pyramidal- pass through pyramid of medulla
  - Corticospinal tract, corticobulbar tracts
- Extrapyramidal tract- do not pass through pyramid
  - Reticulospinal, vestibulospinal, rubrospinal and tectospinal

2. Physiological classification

- Lateral system and medial system pathways



2. Physiological classification

- Lateral system and medial system pathways
- **Lateral system**

✓ Descend down in the lateral column of the spinal cord

✓ Lateral corticospinal tract and rubrospinal tract

✓ Terminate on lateral group of motor neuron

✓ Innervates distal limb muscles

✓ Regulation of skilled voluntary movement

- **Medial system pathways**

✓ Descend down in the medial and anterior column

✓ Reticulospinal tract

✓ Vestibulospinal tract

✓ Tectospinal tract

✓ Anterior corticospinal tract

✓ Terminate on medial motor neurons

✓ Innervates proximal limb muscle and axial skeletal muscles

✓ Involved in the regulation of posture

Pyramidal tracts (Short essay)

- Pass through pyramid of medulla
  - Corticospinal tract – Lateral and anterior
  - Corticobulbar tracts

Corticospinal tract (Short Essay)

- 2 groups
- **Lateral corticospinal tract**

✓80% of fibers

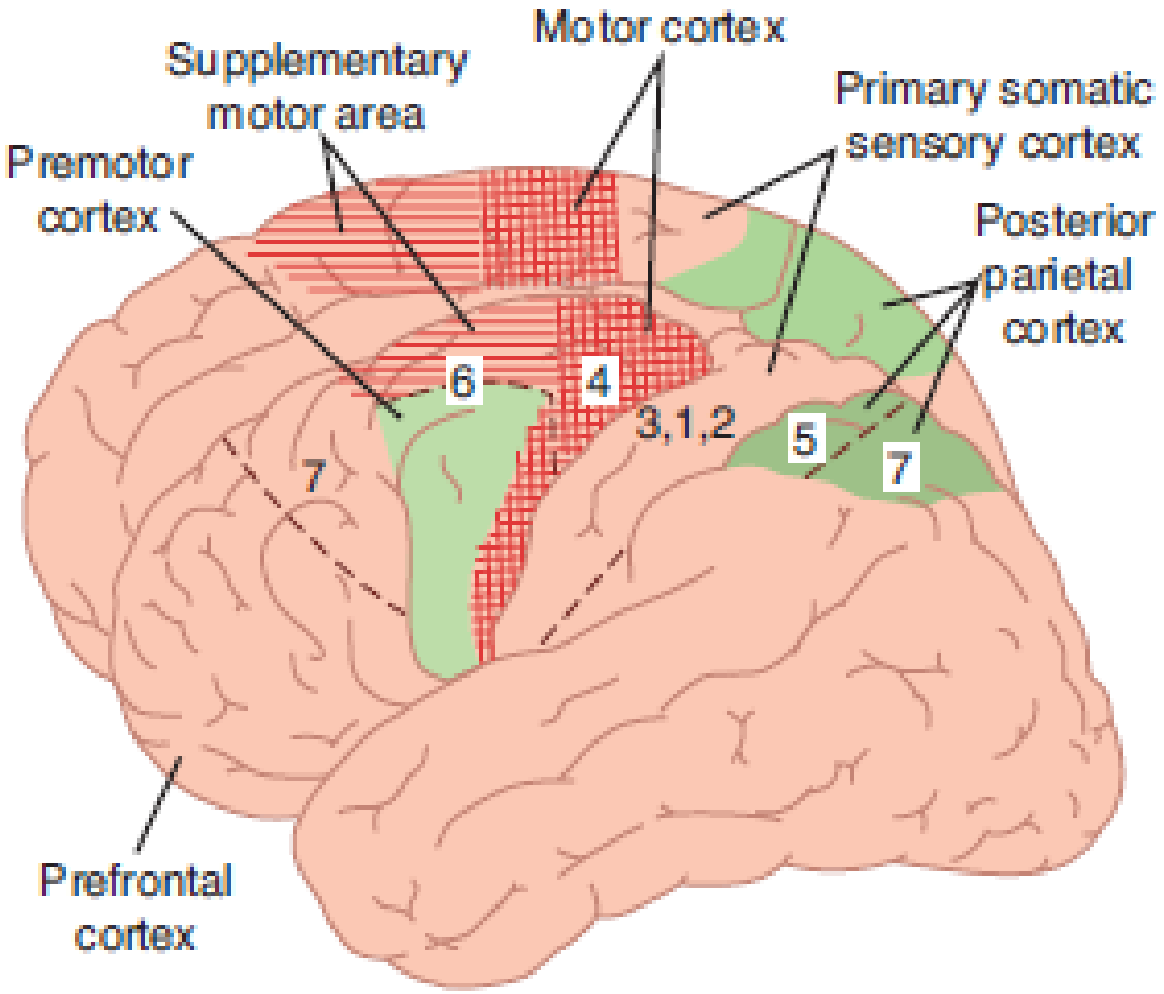
✓Control skilled movements

- **Anterior corticospinal tract**

✓20%

✓Control of posture

Origin

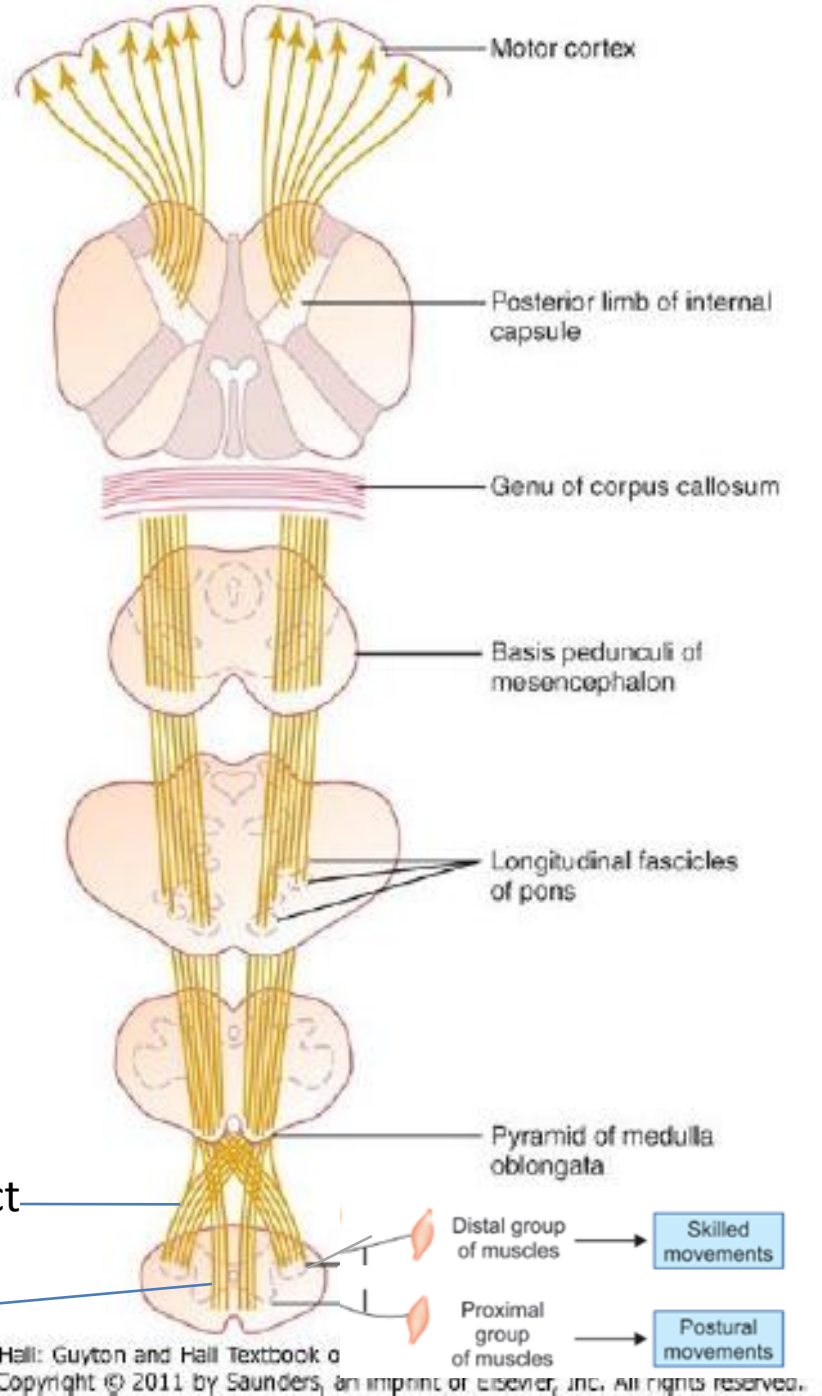

Supplementary motor area
Motor cortex
Primary somatic sensory cortex
Premotor cortex
Posterior parietal cortex
6
4
3,1,2
5
7
7
Prefrontal cortex

Origin

- Motor cortex (60%) and sensory cortex (40%)
- Primary motor cortex- Area 4 (Betz cell)
- Premotor cortex (Area 6)
- Supplementary motor cortex (Area 6)
- Primary somatosensory cortex (Area 3,1,2)
- Parietal cortex (Area 5,7)

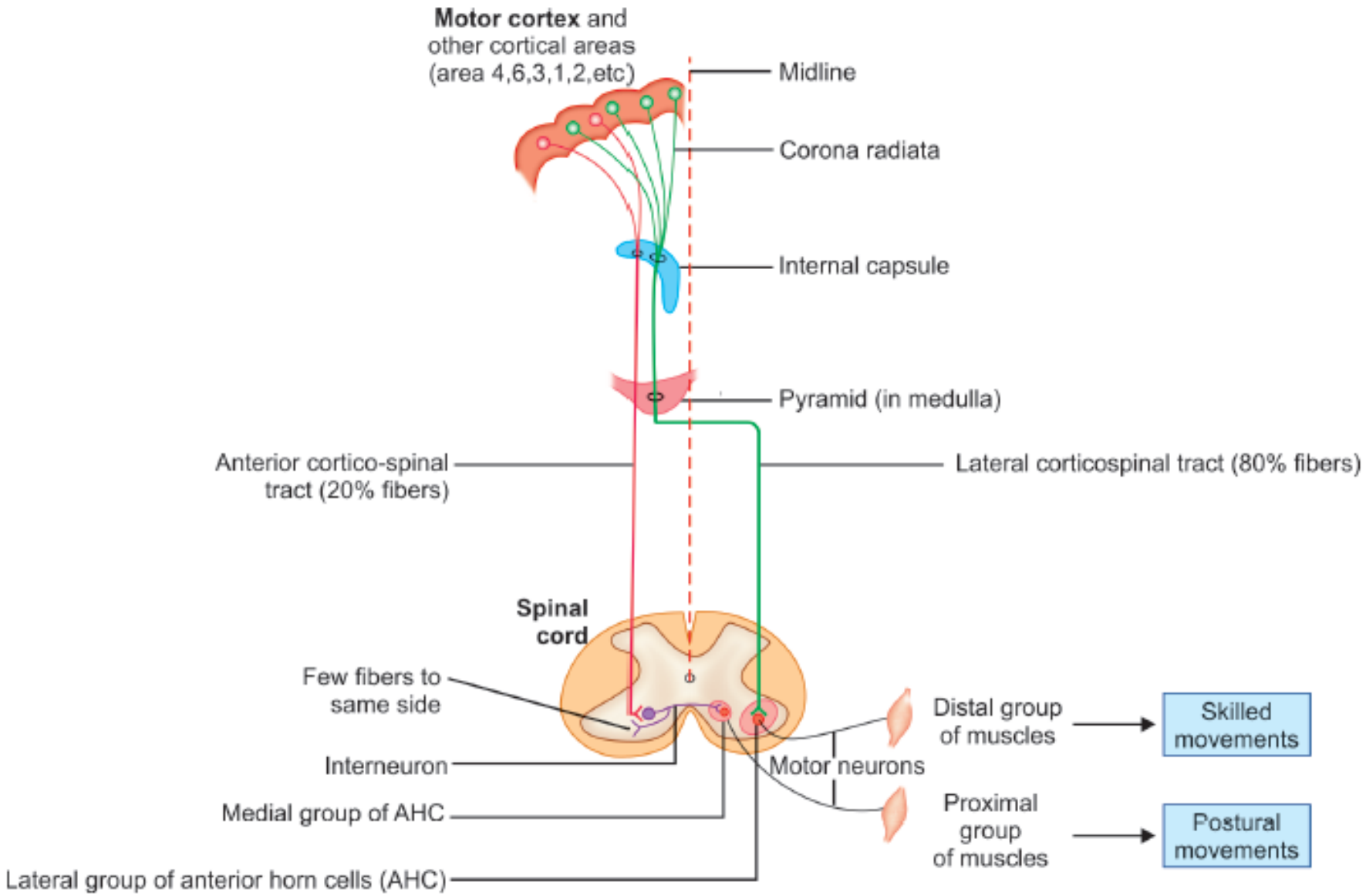
Course

- Draw diagram

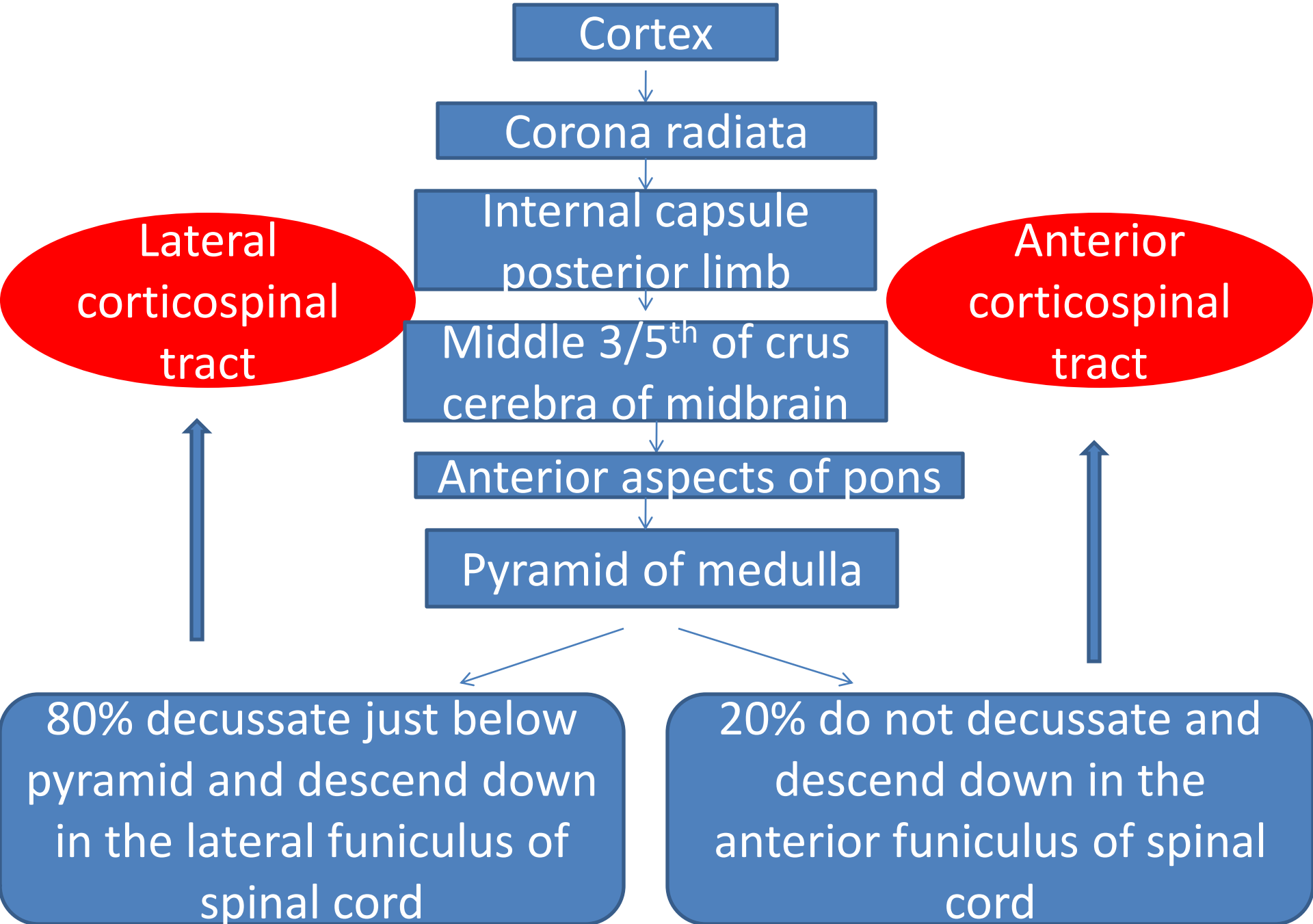


Lateral corticospinal tract

Anterior corticospinal tract


Motor cortex and other cortical areas (area 4,6,3,1,2,etc)
Midline
Corona radiata
Internal capsule
Pyramid (in medulla)
Anterior cortico-spinal tract (20% fibers)
Lateral corticospinal tract (80% fibers)
Spinal cord
Few fibers to same side
Interneuron
Medial group of AHC
Lateral group of anterior horn cells (AHC)
Motor neurons
Distal group of muscles
Skilled movements
Proximal group of muscles
Postural movements

Course


Cortex
Corona radiata
Internal capsule posterior limb
Middle 3/5th of crus cerebra of midbrain
Anterior aspects of pons
Pyramid of medulla
Lateral corticospinal tract
Anterior corticospinal tract
80% decussate just below pyramid and descend down in the lateral funiculus of spinal cord
20% do not decussate and descend down in the anterior funiculus of spinal cord

Termination

- Lateral corticospinal tract terminate on lateral group of motor neuron
- 30 % directly
- 70 % through interneuron
- Innervates distal limb muscles

- Ventral/ Anterior corticospinal tract end on interneuron in same side of spinal cord and cross over to opposite side to terminate on medial group of motor neuron
- Few interneuron terminate on medial group of neuron on same side
- Supply proximal limb muscle and axial muscle

Function

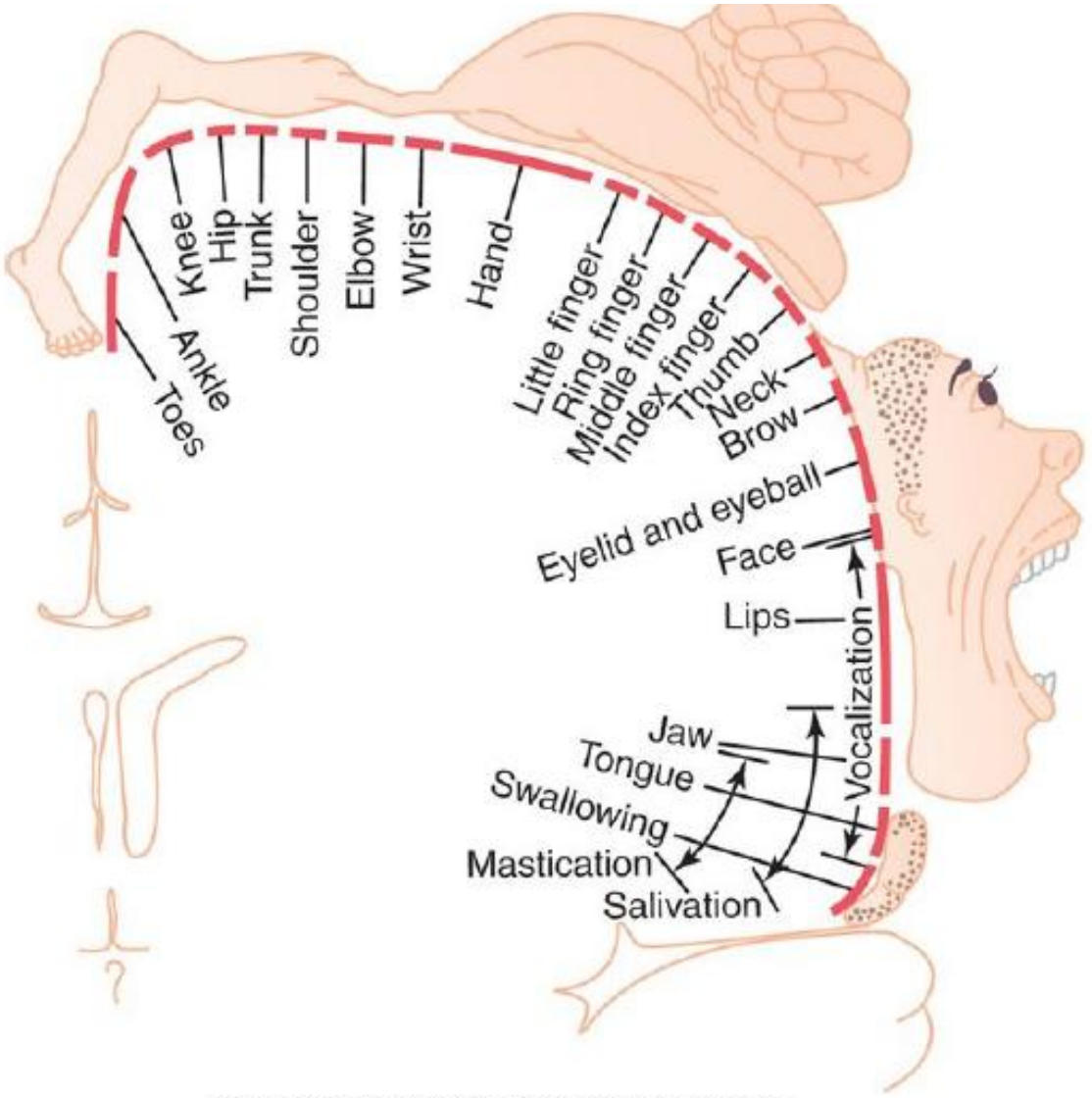
- Motor cortex- initiation, planning and control of movements
- Lateral corticospinal tract- skilled voluntary movement
- Anterior corticospinal tract- controls posture
- Tracts arising from sensory cortex help in sensory-motor coordination

Effect of lesion

- Lesion of lateral corticospinal tract- Impairment of skilled voluntary activity
- Lesion of anterior corticospinal- inability to maintain posture
  - But this tract is not well developed in human
  - Other tracts to maintain posture- reticulospinal and vestibulospinal tracts

- Most common site of lesion- internal capsule
- As fibers come through a narrow tunnel in the posterior limb of internal capsule- complete interruption of corticospinal tract
- Leads to contralateral hemiplegia
- Extrapyramidal system can also get affected
- Also called as complete upper motor neuron paralysis
- Cause- rupture of Charcot’s artery

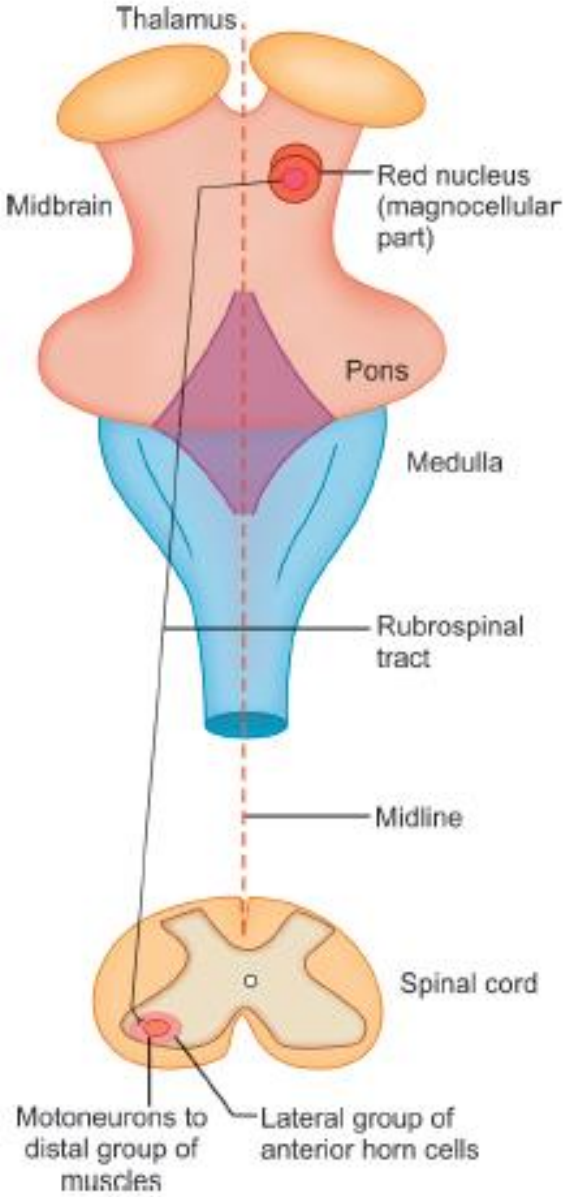
Motor homunculus

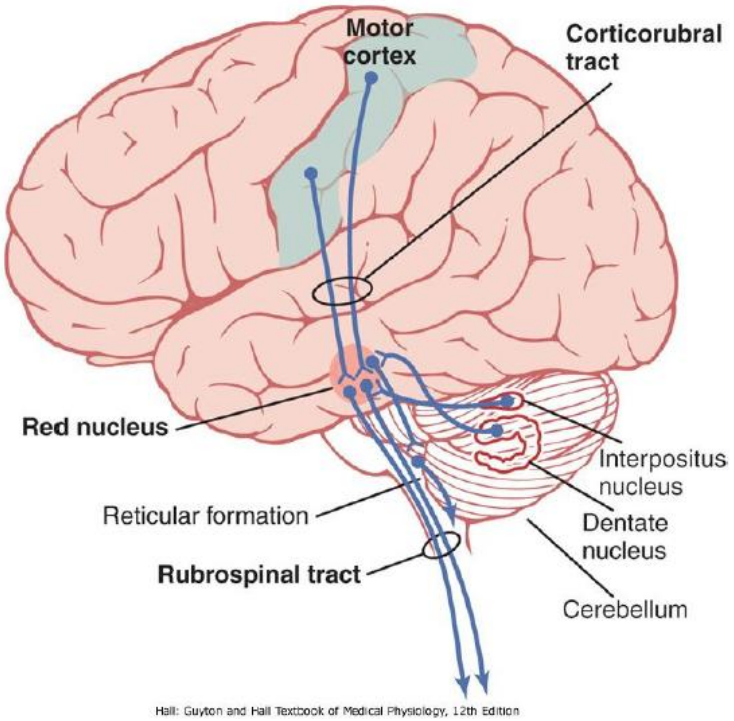


Corticobulbar/ corticonuclear tract

- Pyramidal tract fibers ending in the motor cranial nerve nuclei
- Ends in brainstem
- Innervates voluntary muscles of eye, face, tongue, throat, neck
- Fibers to motor cranial nerve nuclei III and IV end in midbrain
- V, VI and VII in pons
- VII at the junction of pons and medulla
- IX, X, XI, XII in medulla

Rubrospinal tract





Rubrospinal tract

- **Origin**

✓ Originates from red nucleus located in the midbrain

✓ Receives strong excitatory input from motor cortex and cerebellum

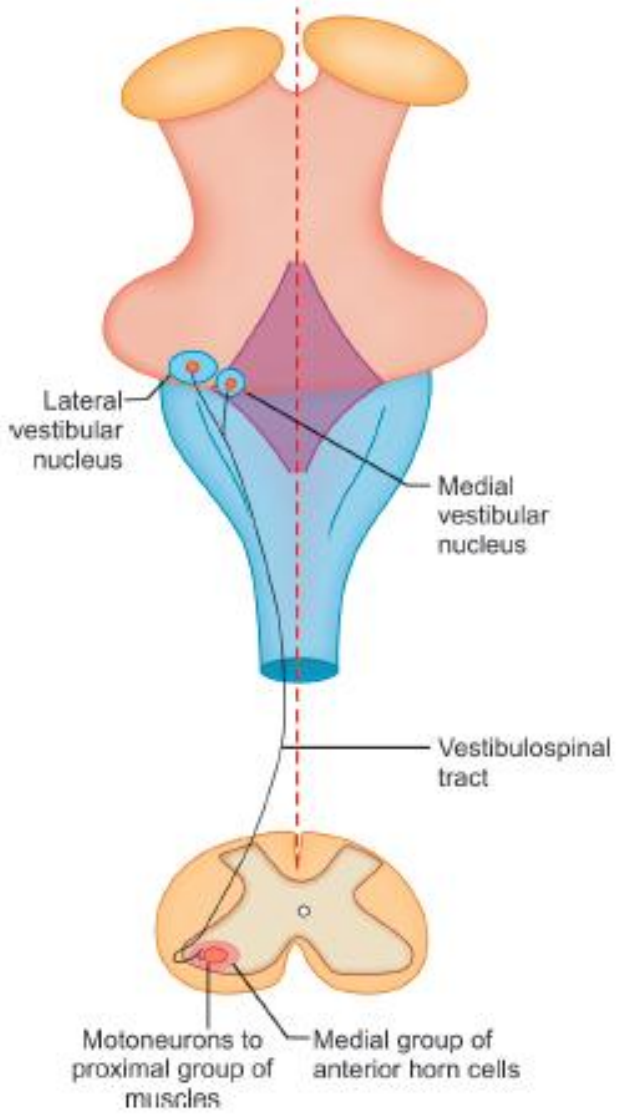
Course

- Fibers cross over to the opposite side at the same level
- Descend down through contralateral brainstem
- Fibers occupy the lateral column of spinal cord
- Terminates on lateral group of motor neurons
- Innervates distal limb muscles
- Excites flexor group of muscles and inhibits extensor muscles

Function

- Controls skilled voluntary movement

Vestibulospinal tracts



Vestibulospinal tracts

- Originates from vestibular nuclei
- 4 vestibular nuclei
- Lateral, medial, superior and inferior
- Nuclei receive input from otolith organs and semicircular canals
- Also connected to superior colliculi, cerebellum and reticular formation

Vestibulospinal tracts

- Two tracts
- Lateral vestibulospinal tract
- Medial/Anterior vestibulospinal tract

Lateral vestibulospinal tract

- **Origin**
- Originates from lateral vestibular nucleus (Deiter's nucleus) in the brainstem
- **Course**
- Descend down ipsilaterally through brainstem and spinal cord
- Terminates on medial group of interneuron and motor neuron

- **Function**
- Excites proximal group of muscle
- Controls posture
- Input to lateral vestibulospinal tract is from semicircular canal and otolith organs
- LVST controls body posture in relation to angular and linear acceleration of the head
- Facilitate the activity of extensor group of muscles

Medial/Anterior vestibulospinal tract

- **Origin**

✓ Medial vestibular nuclei

- **Course**

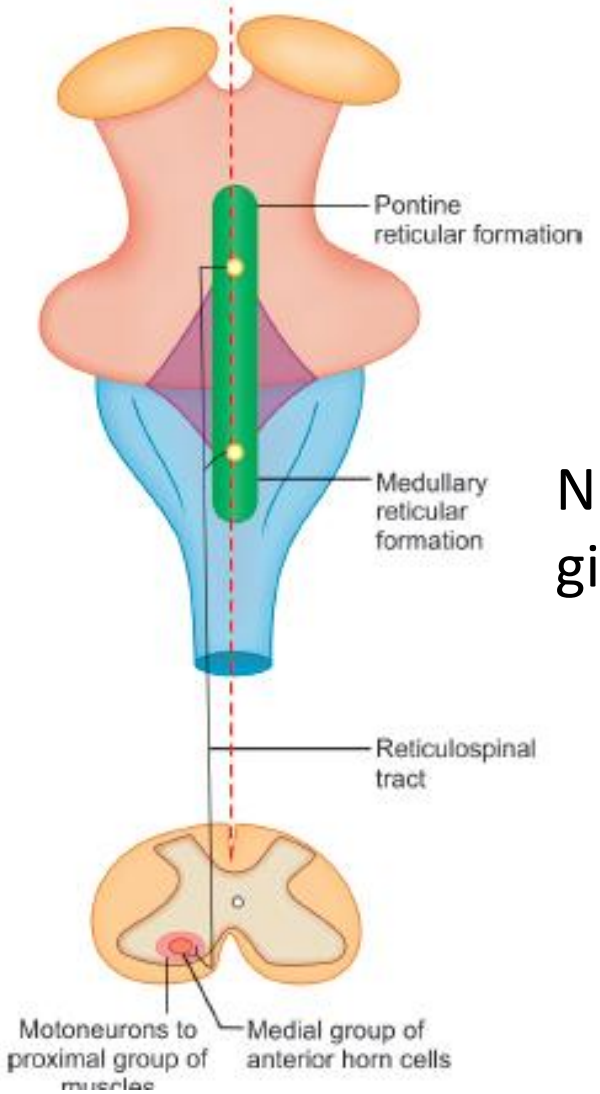
✓ Descend down ipsilaterally in the brainstem and anterior funiculus of spinal cord

✓ Terminates on medial group of interneuron and motor neuron

- **Function**

✓ Adjust body posture especially the head position in response to angular acceleration

Reticulospinal tract



Nucleus reticularis pontis

Nucleus gigantocellularis

Reticulospinal tract

- Core of brainstem contains reticular formation
- 2 reticular nuclei
- Nucleus reticularis pontis in pons
- Nucleus gigantocellularis in medulla

Pontine reticulospinal tract/Anterior reticulospinal tract

- **Origin**

✓ Originates from pontine reticular formation

- **Course**

✓ Descend down ipsilaterally and terminates on medial group of interneurons and motor neurons that innervates proximal and axial group of muscles

- **Function**

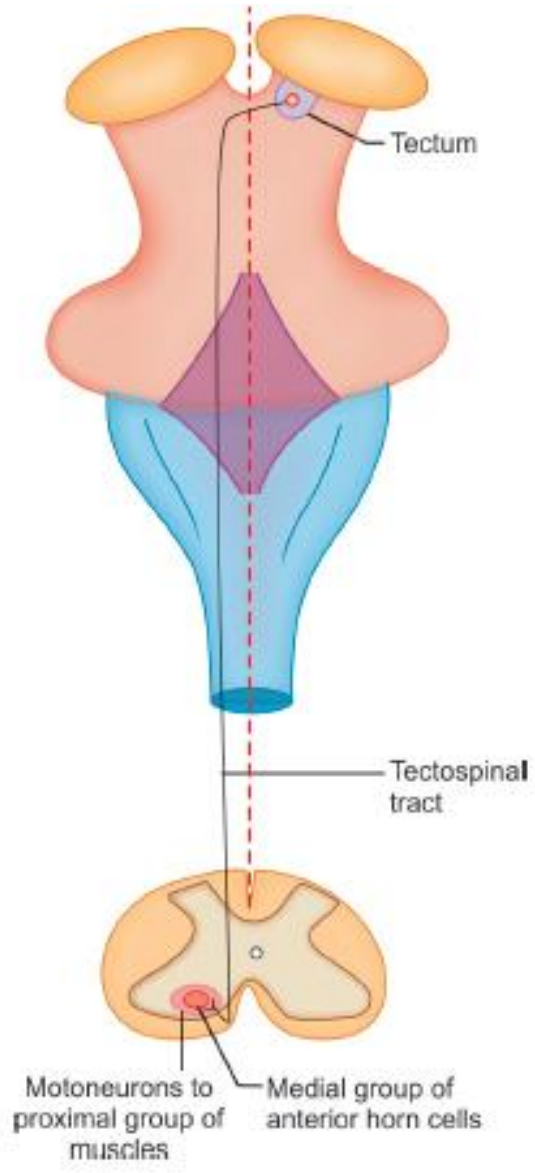
✓ Regulation of posture

✓ Primarily excitatory to flexor muscles

Medullary reticulospinal tract/ Lateral reticulospinal tract

- **Origin**
- Originates from reticular formation in medulla
- **Course**
- Descend down ipsilaterally to terminate on medial group of interneuron and motor neuron
- Innervates proximal group muscles
- **Function**
- Mainly inhibitory
- Inhibits motor neuron that innervates extensor muscle

Tectospinal tract



Tectospinal tract

- **Origin**

✓ From the tectum or superior colliculus of midbrain

- **Course**

✓ Fibers cross over to opposite side below the periaqueductal gray

✓ Descend down in the ventral funiculus of spinal cord

✓ Terminates on medial group of interneurons and motor neurons

- **Function**

✓ Receive visual inputs

✓ Regulates contralateral movement of head in response to visual stimuli

Olivospinal tract

- Arising from inferior olivary nucleus in the medulla
- Function is not clearly understood

Other descending pathways

- Includes monaminergic pathways
- Raphespinal tract
- Cerulospinal tract

Raphespinal tract

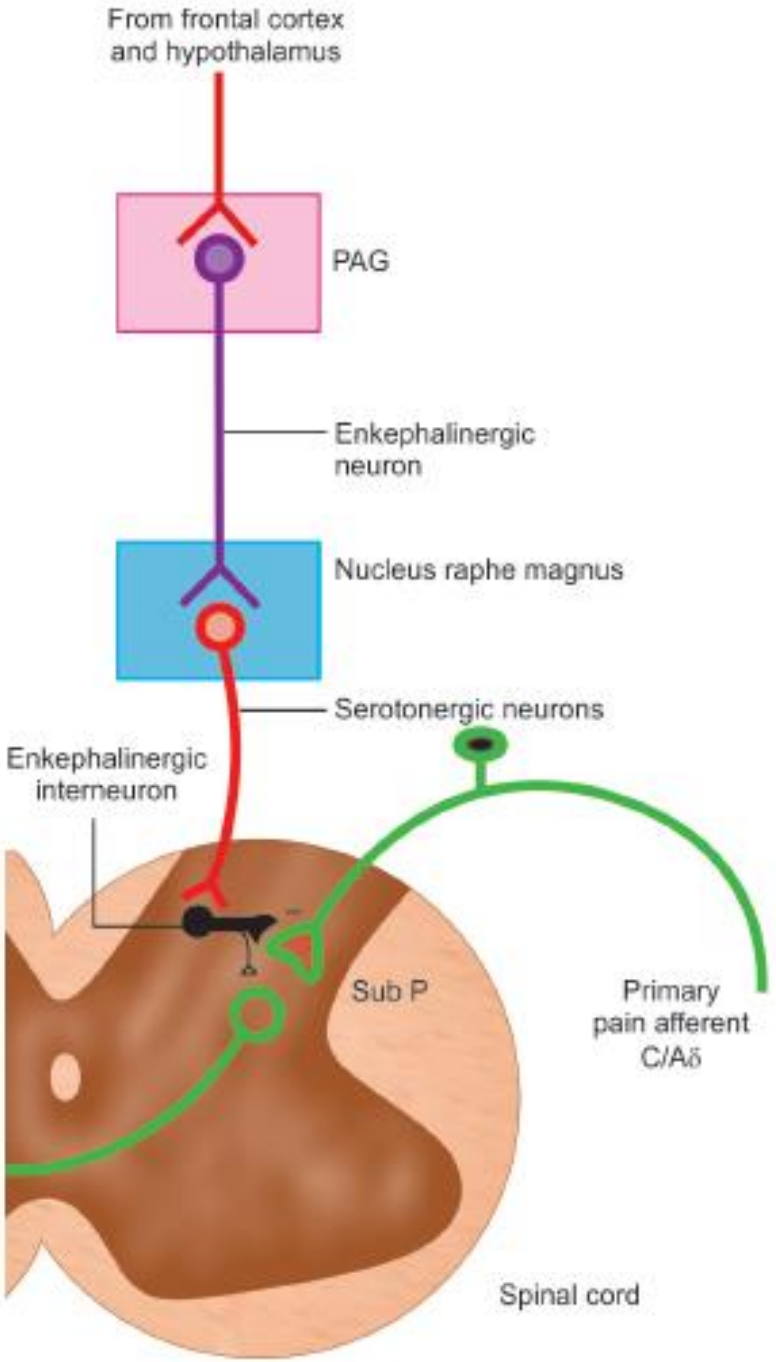


Fig. 120.7: Endogenous neural analgesia system.

Raphespinal tract

- **Origin**

✓ From nucleus raphe magnus of medulla

- **Course**

✓ Descend down ipsilaterally and terminate on the interneuron in dorsal horn and ventral horn

- **Function**

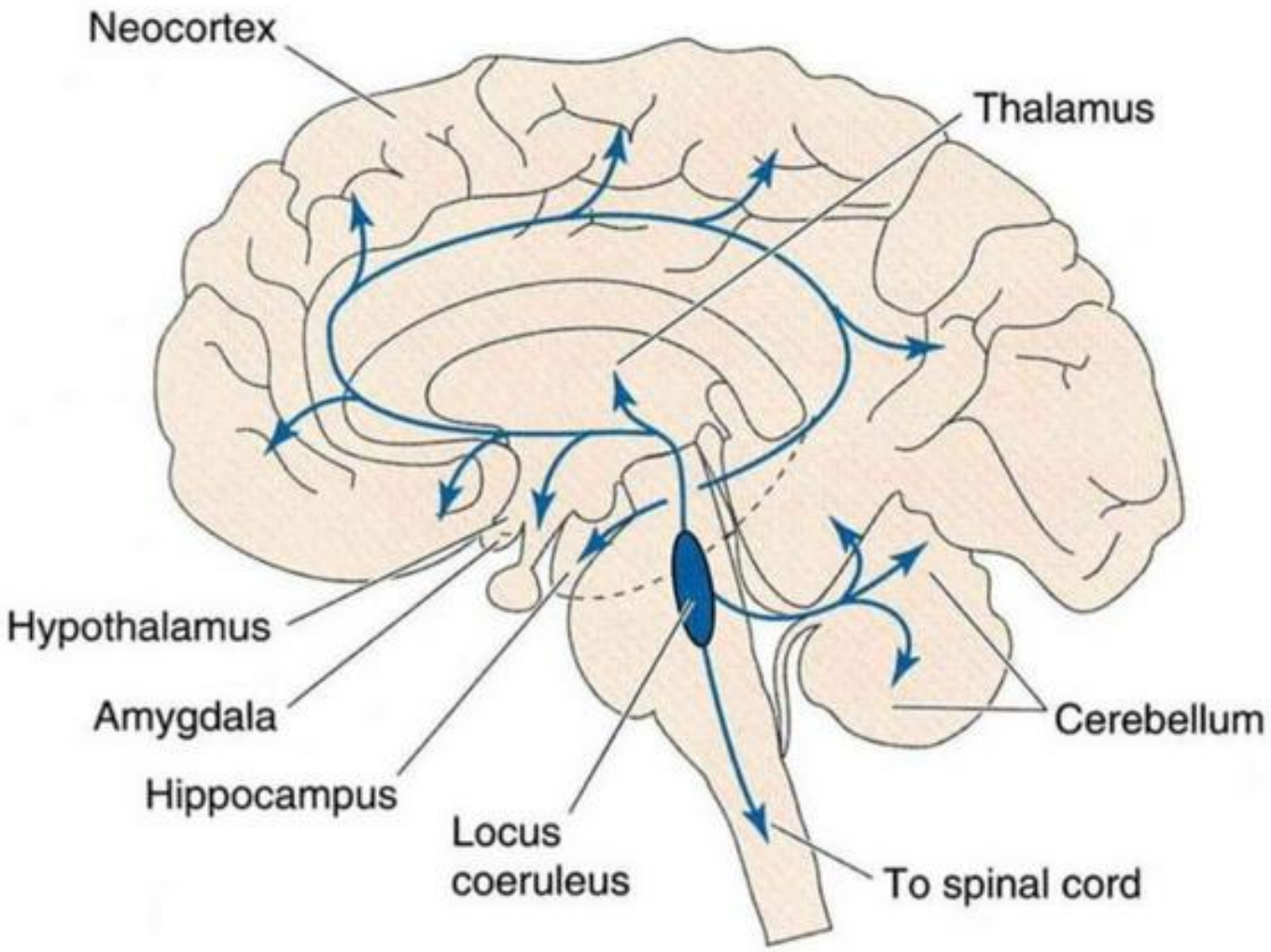
✓ Serotonergic pathway

✓ Excitatory to motor neuron

✓ Inhibit nociceptive transmission in spinal cord (endogenous pain inhibiting mechanism)

✓ Involved in sensory- motor coordination at the level of spinal cord

Cerulospinal tract



Cerulospinal tract

- **Origin**

✓ From nucleus locus ceruleus and nucleus subceruleus of pons

- **Course**

✓ Descend down ipsilaterally in the spinal cord to terminate on interneurons in dorsal horn and interneurons and motor neurons in ventral horn

- **Function**

✓ Contains norepinephrine

✓ Inhibitory to nociceptive afferents and to motor neurons

✓ Bring sensory motor coordination

UMN paralysis (Write briefly)

- Lesion of descending fibers between their origin from cortical motor area and their termination on anterior horn cells in the spinal cord

Features

- Increased muscle tone (spasticity)
- Mild atrophy of muscle may occur due to disuse (disuse atrophy)
- Group of muscles are affected
- Tendon reflexes are exaggerated
- Superficial reflexes are lost
- Extensor plantar response (Babinski's sign positive)
- No fascicular twitches
- No denervation potential in EMG
- Normal nerve conduction studies

Physiological basis

- **Spasticity**

✓ Descending tract directly exerting its effect on gamma motor neuron is reticulospinal tract

✓ Medullary reticulospinal tract- inhibitory to gamma motor neuron

✓ Inhibitory influence is more so that only a minimal degree of firing is seen in resting stage

✓ In UMN lesion reticulospinal tract is damaged

✓ Inhibitory influence is removed

✓ Increased discharge of gamma motor neuron and increased tone of muscle

Physiological basis

- **Absence of muscle atrophy**

✓ In UMN lesion nerve supply to muscle is not affected

✓ On long term disuse atrophy can occur

Physiological basis

- **Exaggeration of deep tendon reflex**

✓ Loss of inhibitory influences to motor neuron

✓ Increased gamma motor neuron discharge increases the sensitivity of muscle spindle to stretch

✓ Increased deep tendon reflex

Physiological basis

- **Loss of superficial reflex**

✓ Efferent pathway of superficial reflexes are the descending motor pathways that terminate in skeletal muscles

✓ In UMN paralysis efferent pathway is disrupted

Physiological basis

- **Extensor plantar response**
- Corticospinal tract excites the flexor motor neurons and inhibit the extensor motor neurons supplying the digit muscles of limb
- In UMN paralysis disruption of corticospinal influence on lumbosacral motor neuron causes dorsiflexion of big toe and fanning of other toes (extensor plantar response, Babinski's sign positive)

Lower motor neuron paralysis

- Destruction of anterior horn cells or their axons in distal root, nerve plexus or peripheral nerves
- Example: nerve injury, poliomyelities, motor neuron diseases

Features

- Flaccid paralysis (hypotonic muscle)
- Muscle atrophy
- Individual muscles are affected
- Tendon reflexes are diminished or absent
- Superficial reflexes are lost
- Flexor plantar response
- Involuntary movements like fascicular twitches are observed
- Denervation potentials (fibrillation, fasciculations) are seen in EMG
- Nerve conduction is decreased or absent

Physiological basis

- Muscle atrophy- innervation to muscle is lost which abolishes secretion of nerve growth factors and muscle function is lost
- Only muscles that are innervated by the damaged nerve will be affected
- Disruption of reflex arc- loss of superficial and deep tendon reflexes
- Denervation abolishes gamma motor neuron influence- result in hypotonia

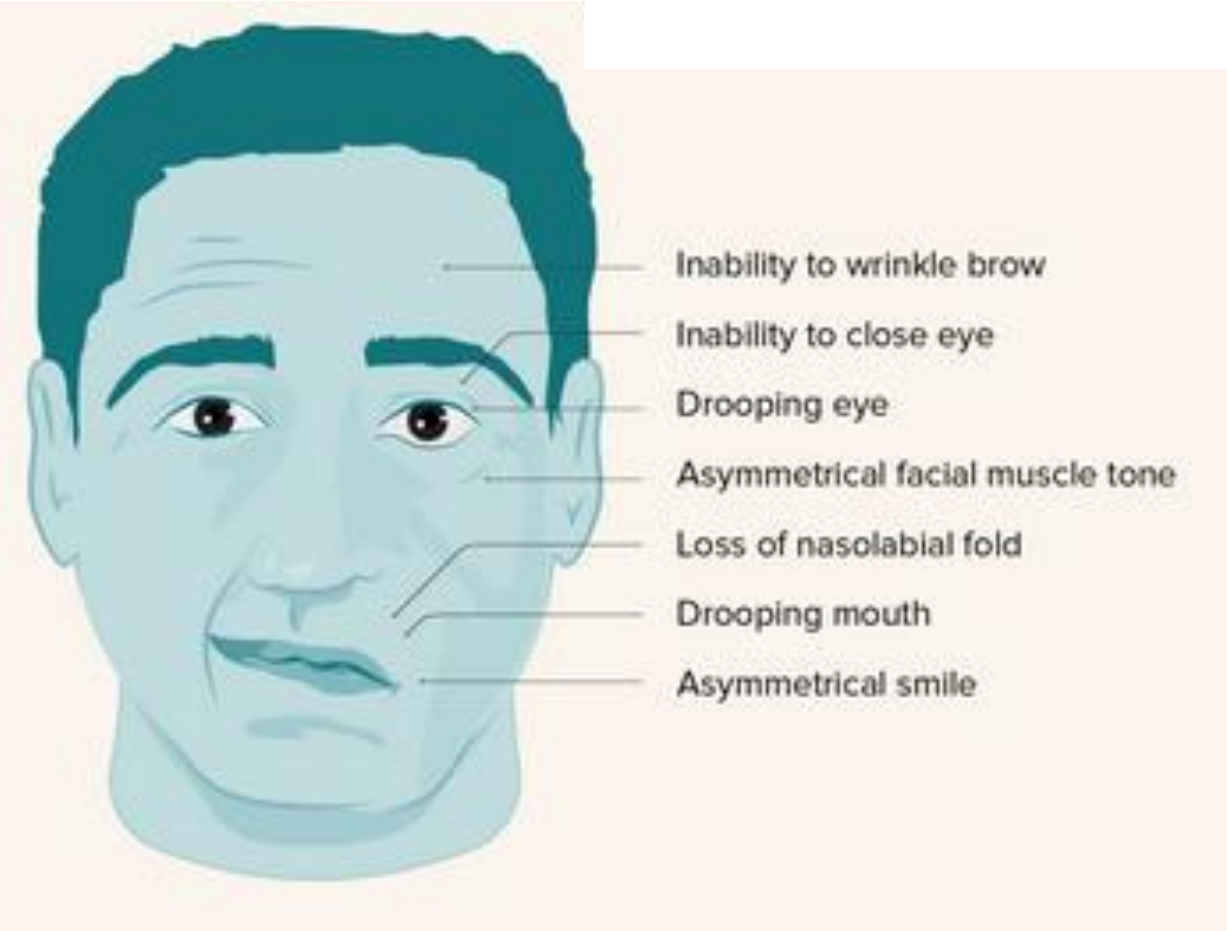
Write briefly

- Differences between UMN and LMN lesions

Table 129.1: Differences between the UMN and LMN paralysis.

	UMN Paralysis	LMN Paralysis
1. Muscles affected	In groups (not individual muscles)	Individual muscles are affected
2. Size of the muscles	No atrophy	Atrophy is a pronounced feature
3. Type of paralysis	Spastic paralysis (hypertonia)	Flaccid paralysis (hypotonia)
4. Tendon reflexes	Exaggerated	Diminished or absent
5. Superficial reflexes	Absent	Absent
6. Babinski's sign	Extensor planter response	Flexor planter response
7. Involuntary movements	Absent	Present (in the form of fascicular twitches)
8. EMG changes	No denervation potential	Denervation potential seen in EMG
9. Nerve conduction study	No abnormalities	Decreased nerve conduction

Bell’s palsy


Inability to wrinkle brow
Inability to close eye
Drooping eye
Asymmetrical facial muscle tone
Loss of nasolabial fold
Drooping mouth
Asymmetrical smile

Bell's palsy

- Sudden weakness of muscles of one side of face
- When seventh cranial nerve is inflamed or compressed
- Idiopathic or Following viral infections like chickenpox, HIV, mononucleosis
- LMN type of facial palsy
- Usually temporary
- Deviation of angle of mouth to opposite side while smiling
- Difficulty to close the eye on affected side
- Drooling of saliva
- No wrinkling of forehead on affected side
- Difficulty in eating
- Treatment- steroids, antiviral therapy

Paralysis or Plegia

- Complete loss of voluntary movements
- Paresis- weakness of muscle
- Monoplegia- paralysis of all the muscles of one limb
- Hemiplegia- paralysis of one half of body
  - Commonest form
  - Lesion of corticospinal tract at the internal capsule results in contralateral hemiplegia
- Paraplegia- paralysis of both lower limbs
  - Seen in spinal cord injury
- Qaudriplegia- paralysis of all four limbs
  - Seen in transection of upper cervical segment of spinal cord

Essay

- A 70 years old hypertensive male has come to the hospital with complaints of inability to use the right upper and lower limb. Physical examination revealed hypertonia and exaggerated deep tendon reflexes on the right side. Babinski's sign was positive on the right side. Answer the following questions based on your knowledge in physiology:
- Name the clinical condition
  - Right sided hemiplegia (lesion in the left internal capsule)
- Explain the physiological basis of the above findings
- Differentiate between upper and lower motor neuron lesion.
- Why Babinski's sign is positive.

A 50 years old patient of hypertension suddenly developed weakness of right upper and lower extremities and difficulty is speaking following a brief episode of loss of consciousness. On examination motor tone of his right extremities was found to be increased. Answer the following questions based on your knowledge in physiology :

- What would an examination of power and deep tendon reflexes of the patient reveal
- What would examination of the plantar reflex of the patient most likely reveal
- Explain the physiological basis of the findings of deep tendon reflexes in this patient
- What is the most likely clinical diagnosis of his condition