MEDICAL UNIVERSITY - PLEVEN
FACULTY OF MEDICINE
DEPARTMENT OF NEUROLOGY AND NEUROSURGERY
DIVISION OF NEUROLOGY

Lecture № 10

Motor Systems. Muscle tone. Syndromes of Upper and Lower Motor Neuron lesions

Assoc. Prof. Maya Danovska, M.D.
Department of Neurology and Neurosurgery

DEFINITION

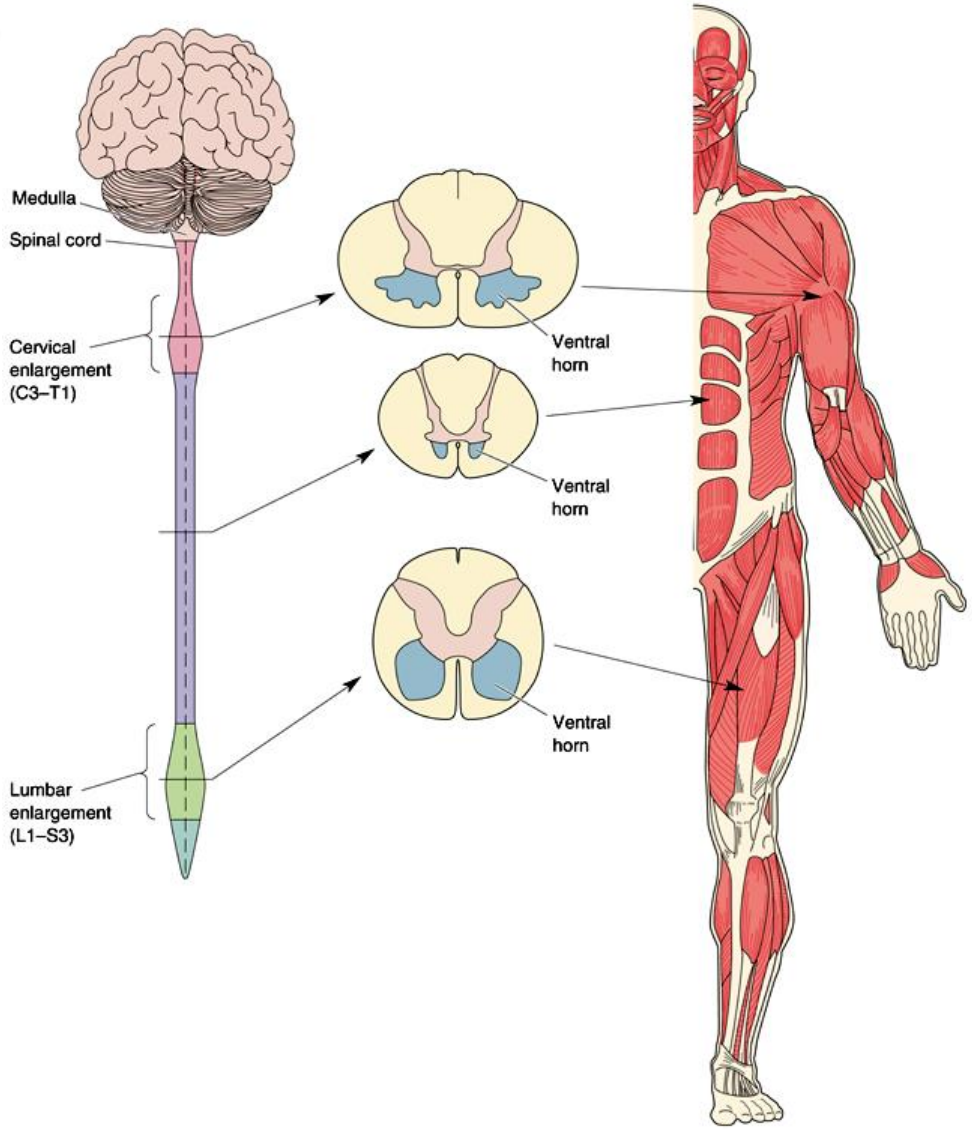
- Motor system is that part of the nervous system involved with movement and posture;
- Control of the motor function (alteration of the position of the limbs and stabilizing of posture) is accomplished through the integrated action of segmental and supra-segmental motor neurons, located in the:
  - cerebral cortex,
  - basal ganglia,
  - cerebellum,
  - brain stem,
  - spinal cord,
  - feedback' via sensory pathways, particularly conveying information about joint position.

Somatic Motor System

- Primary Motor Cortex
- Basal Ganglia
- Cerebellum
- Descending Pathways
- Ventral Horns
- Motor Nerves

Muscles

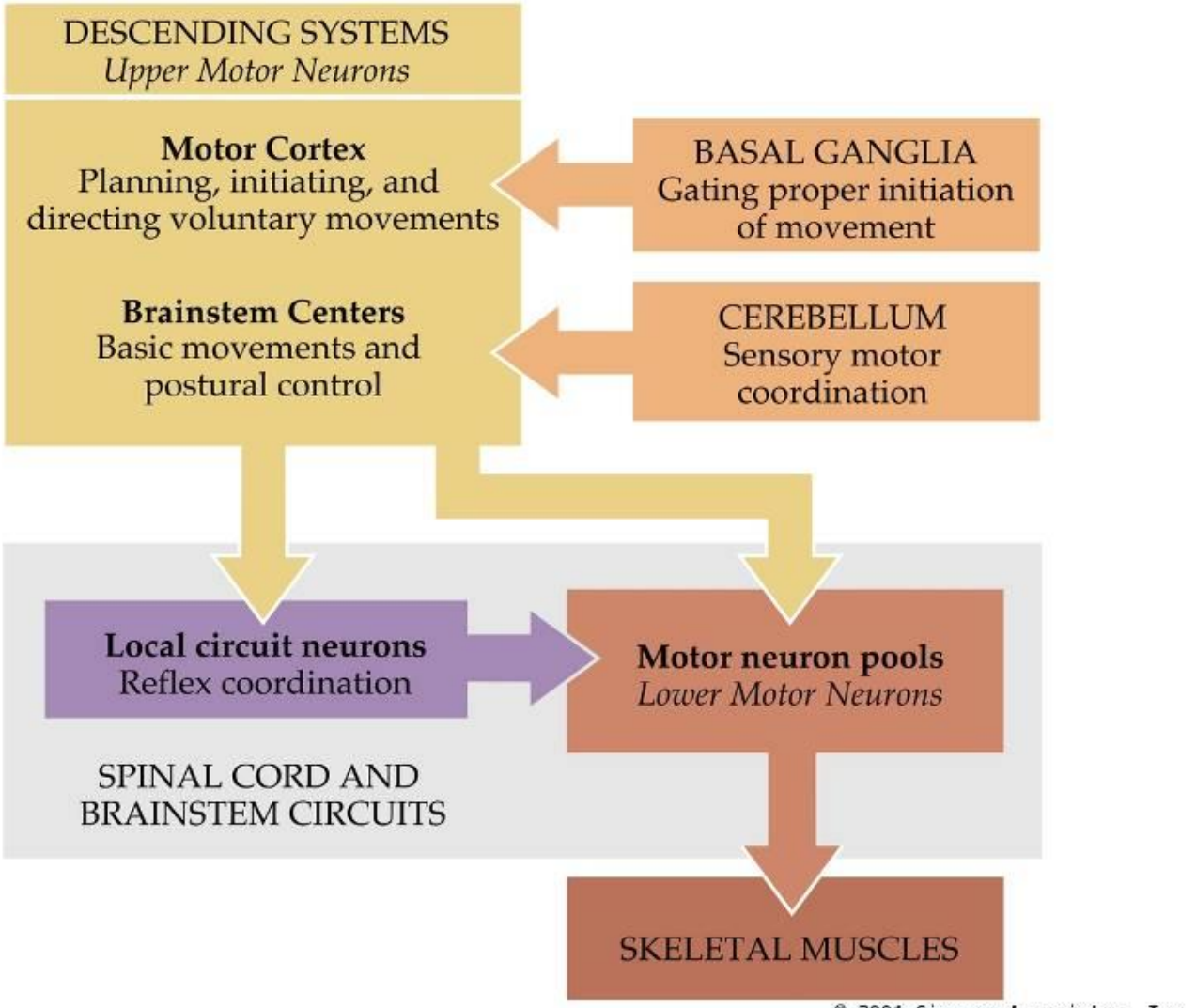
- Smooth
- Striated
- Groups (Axial, Proximal, Distal)



Organization of motor system

Upper motor neuron

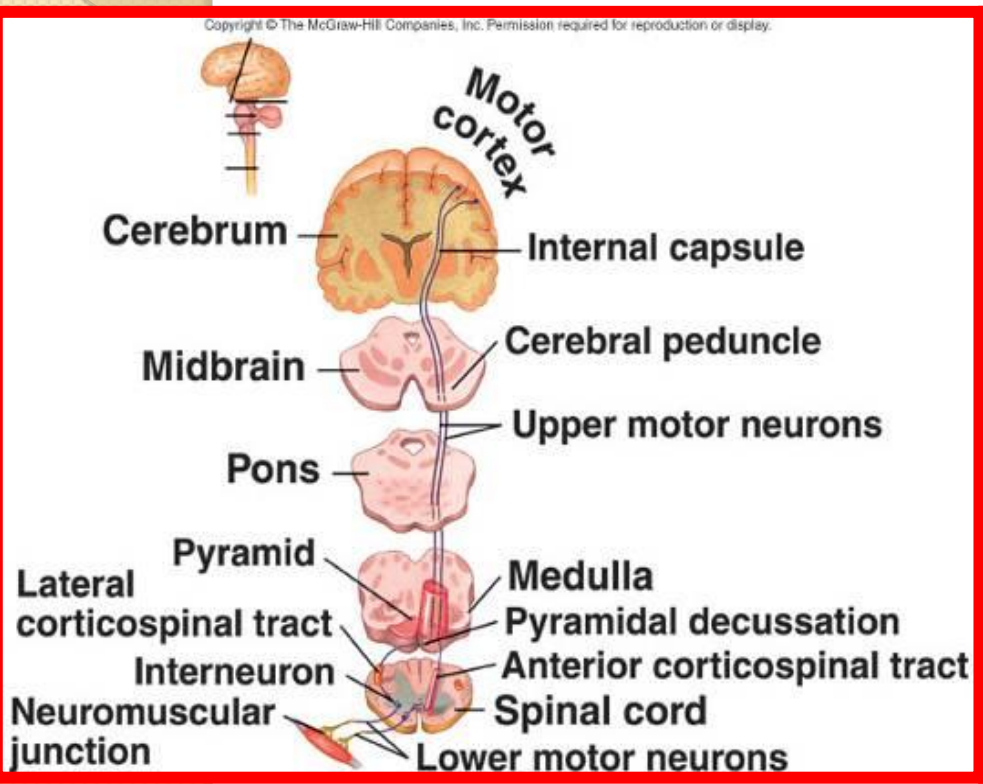
Lower motor neuron



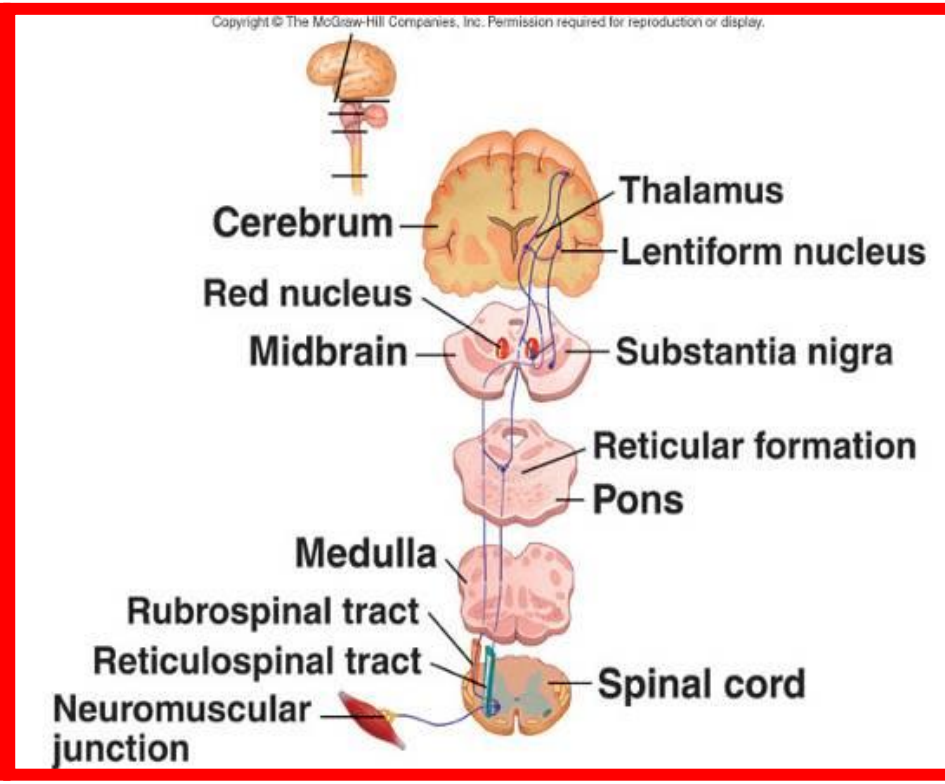
Tracts of the motor systems

Two types of Motor systems

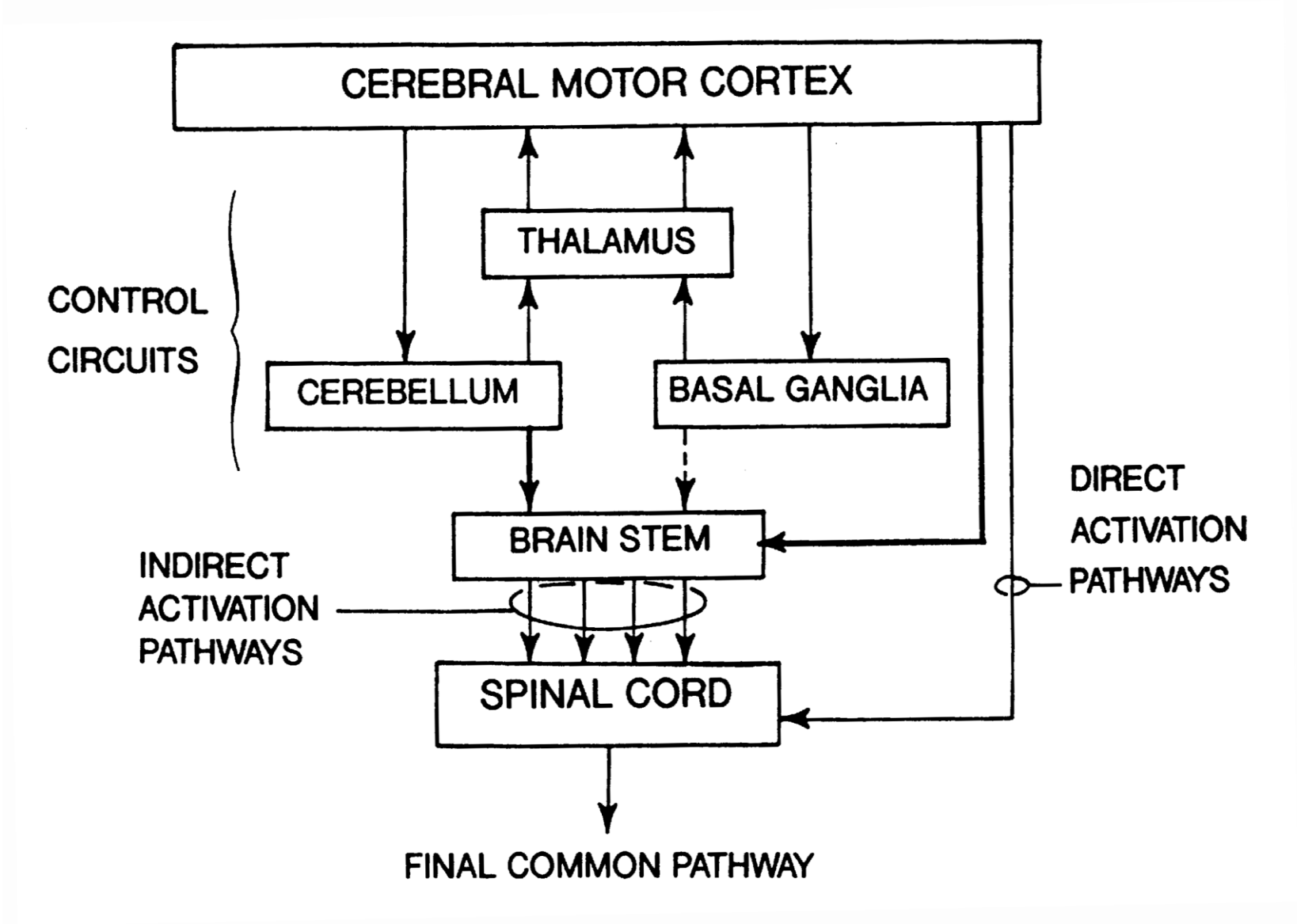
Pyramidal system



Extrapyramidal system



Motor Hierarchy and Loops

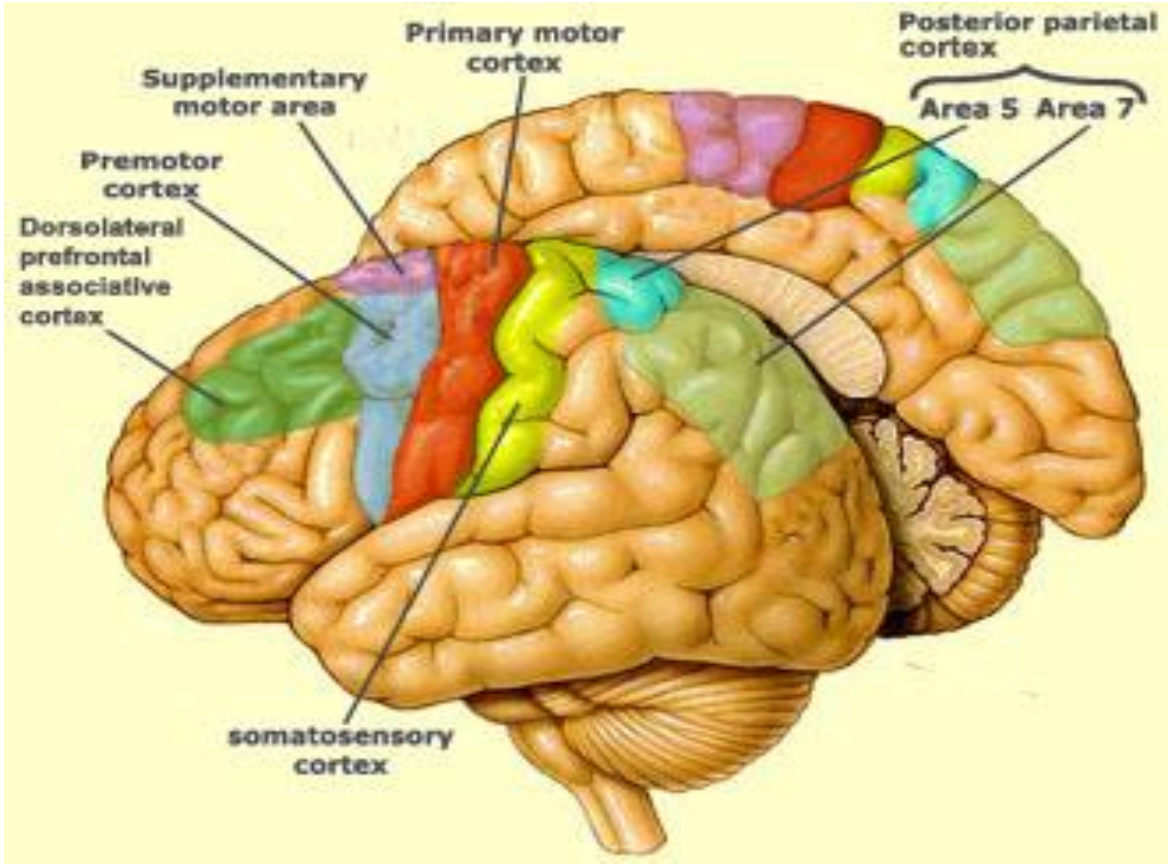


Pyramidal system: anatomy and physiology of the motor act

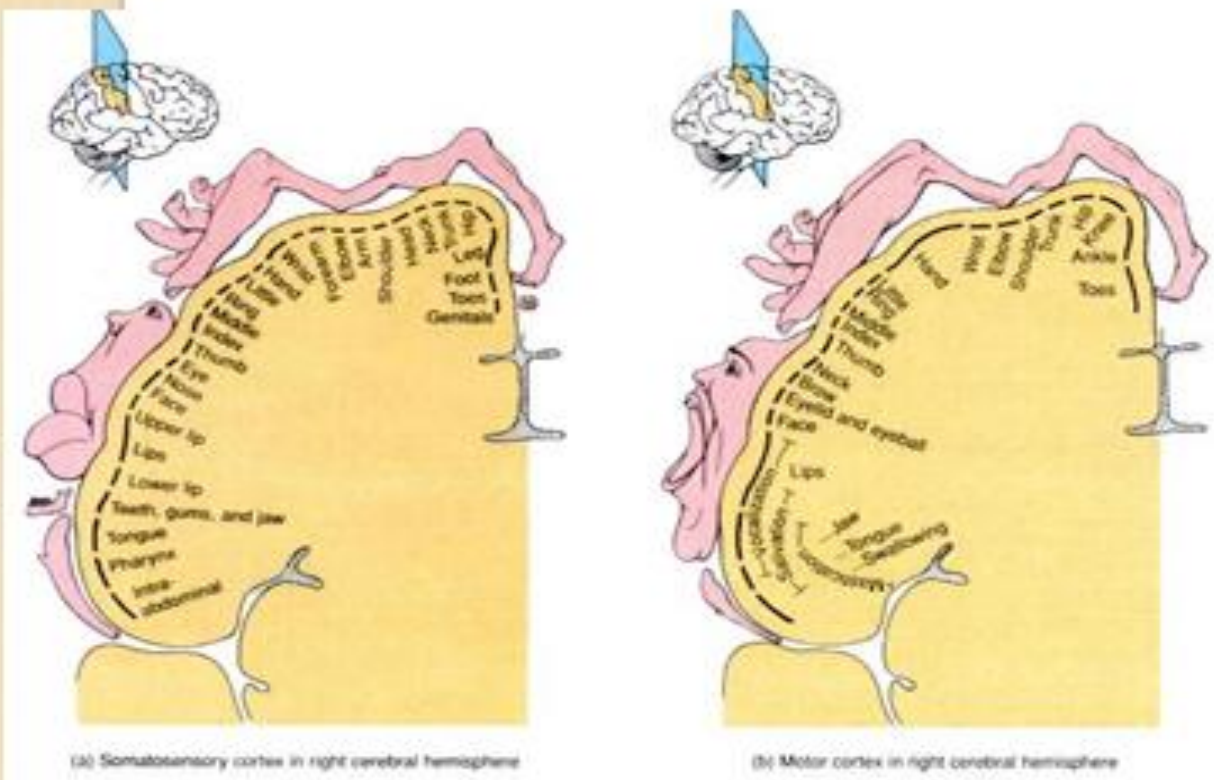
- **Cortical motor areas**

  -Precentral gyrus (Brodmann's area 4)

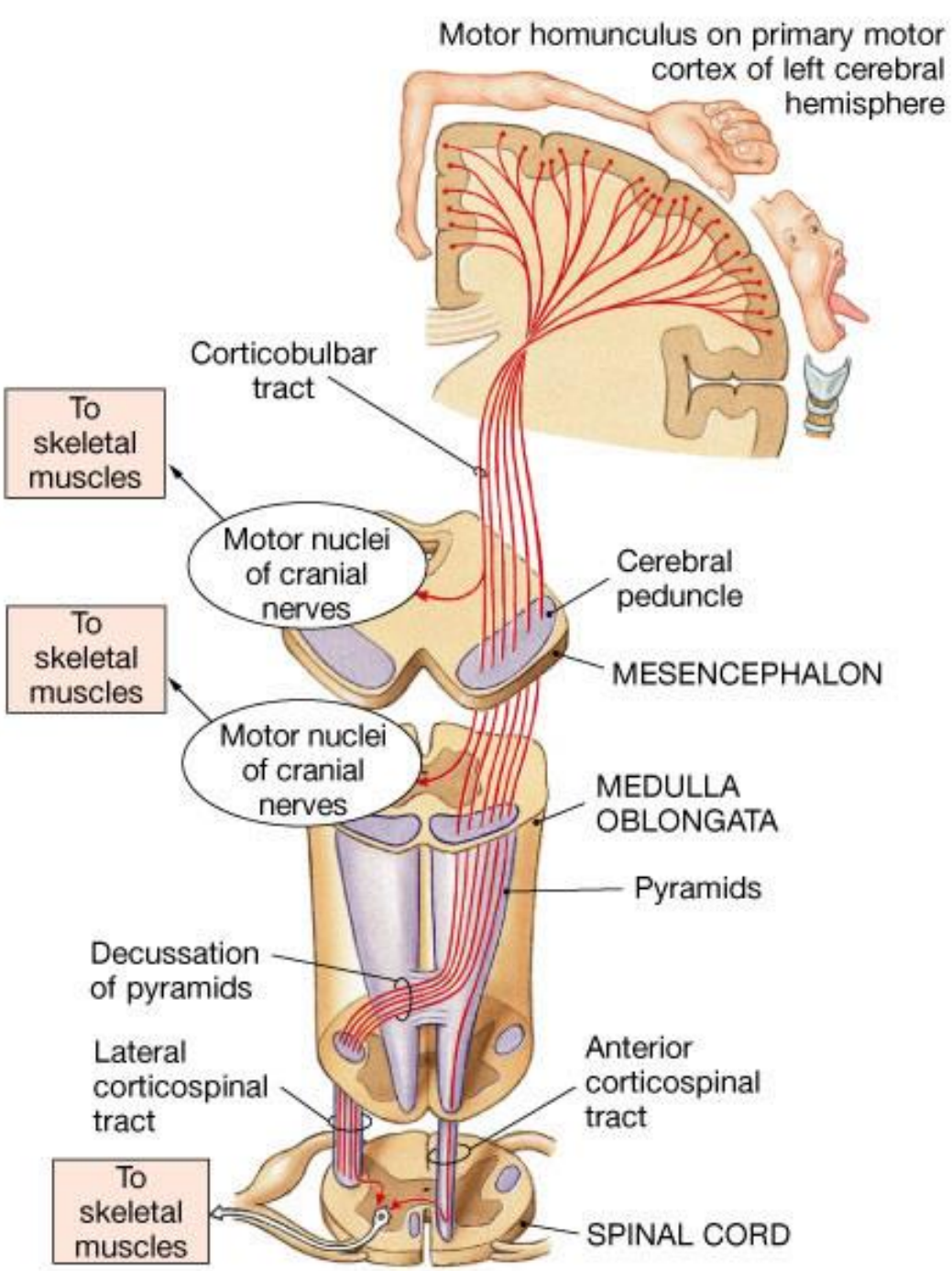
  -Premotor cortex



Somatotopic arrangement of the precentral gyrus



Right – primary motor cortex – zones, homunculus



Corticospinal & corticobulbar tracts

Upper Motor Neuron

- **Corticospinal (pyramidal) tract:**

- motor neurons from the 5-th layer (giant pyramidal Betz's cells + small pyramidal and fusiform cells in motor areas 4 and 6;

- posterior limb of the internal capsule;

- pyramidal decussation - **85%** of the fibers decussate

- lateral corticospinal tract (decussated);

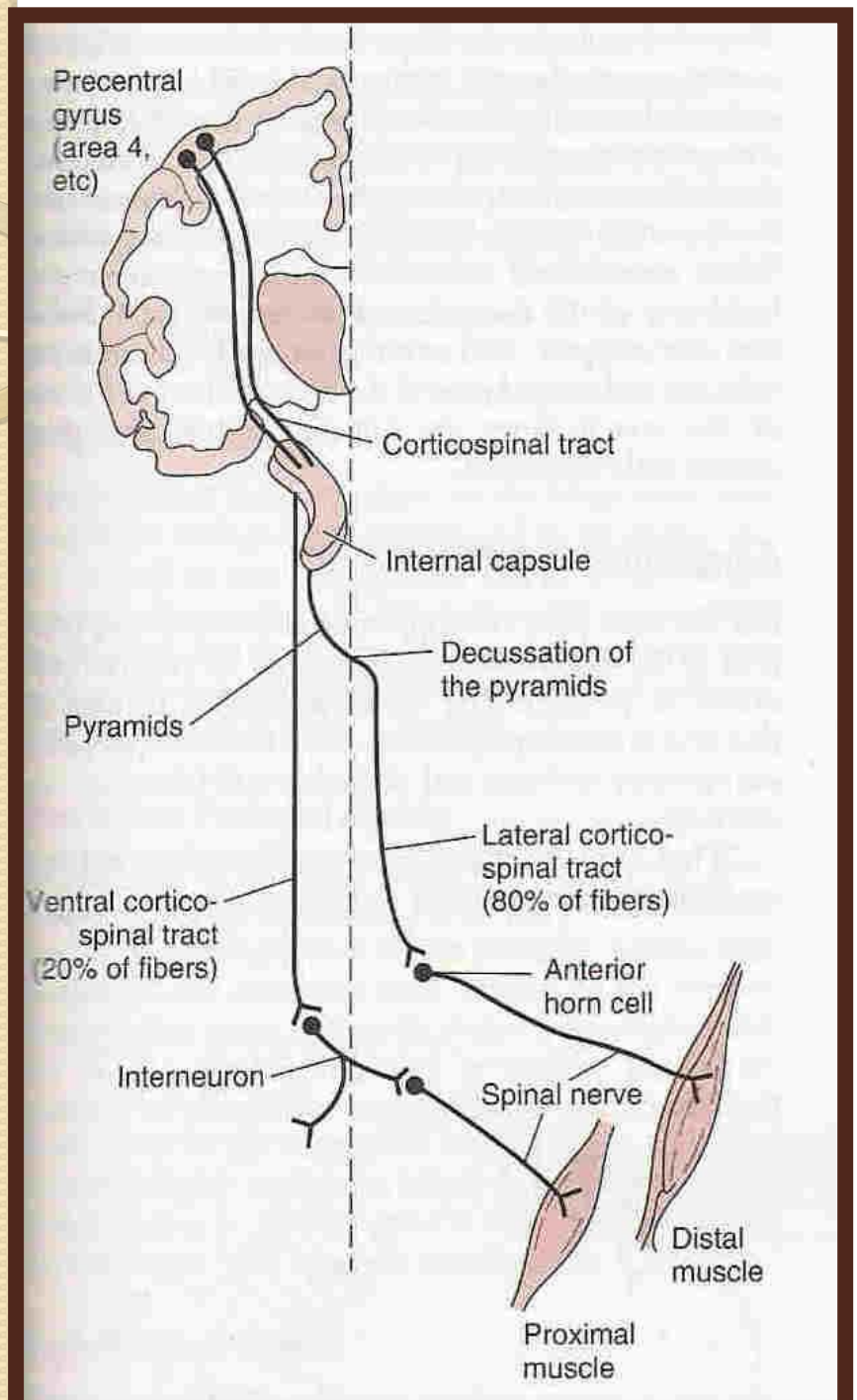
- anterior corticospinal tract (nondecussated)

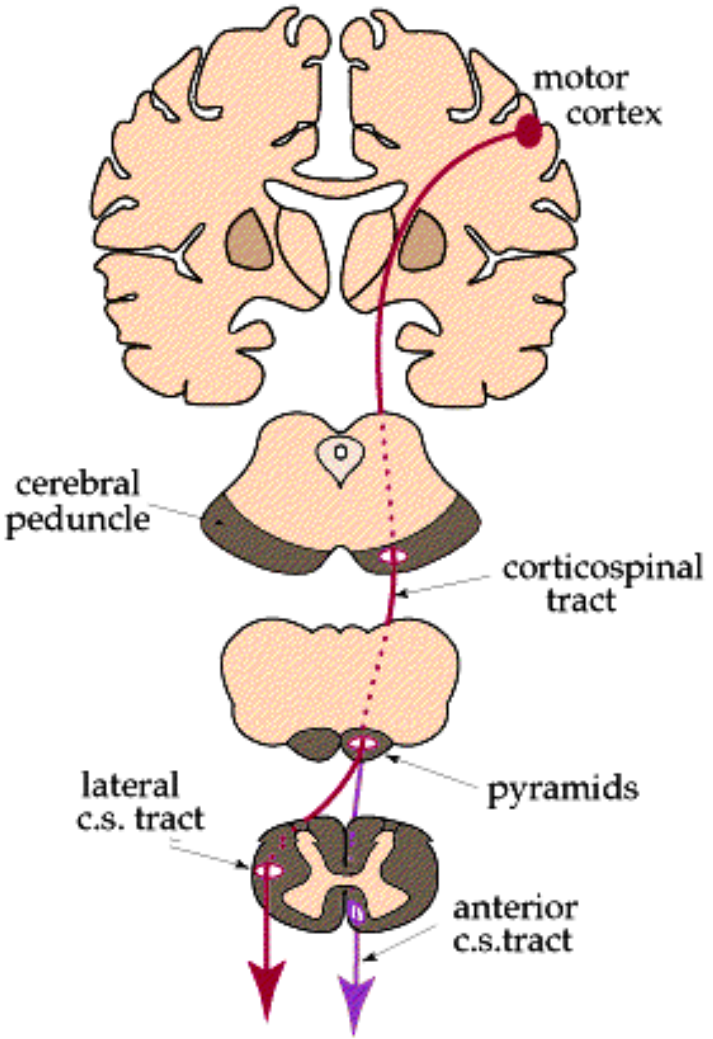
- **Corticonuclear/corticobulbar tract:**

- cortical presentation of face;

- knee of internal capsule;

- efferent nuclei of cranial nerves in the brain stem


Precentral gyrus (area 4, etc)
Corticospinal tract
Internal capsule
Decussation of the pyramids
Pyramids
Lateral cortico-spinal tract (80% of fibers)
Ventral cortico-spinal tract (20% of fibers)
Anterior horn cell
Interneuron
Spinal nerve
Distal muscle
Proximal muscle


motor cortex
cerebral peduncle
corticospinal tract
pyramids
lateral c.s. tract
anterior c.s.tract

BRAINSTEM MOTOR SYSTEM

- **Reticulospinal tract** (pontine and medullar RF – gamma motor neurons)
- **Vestibulospinal tract** (vestibular nuclei - spinal interneurons)
- **Rubrospinal tract** (nucleus Rubber - alpha motor neurons)
- **Tectospinal tract** (colliculi superiors -spinal interneurons)

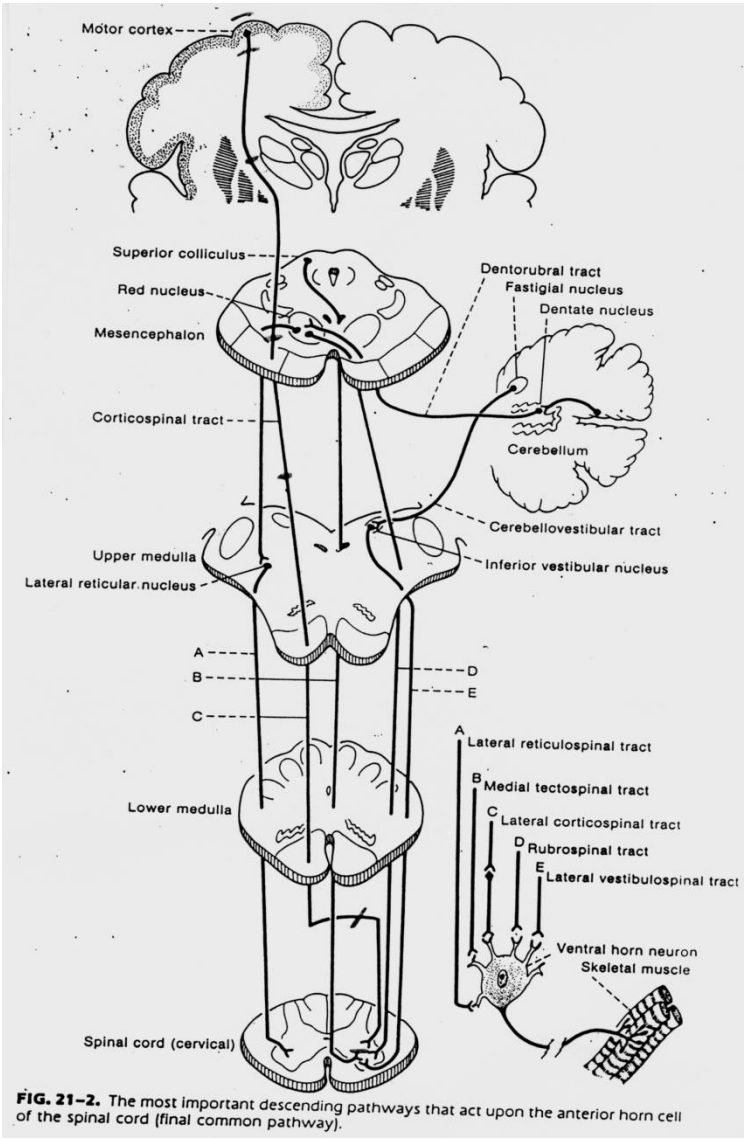
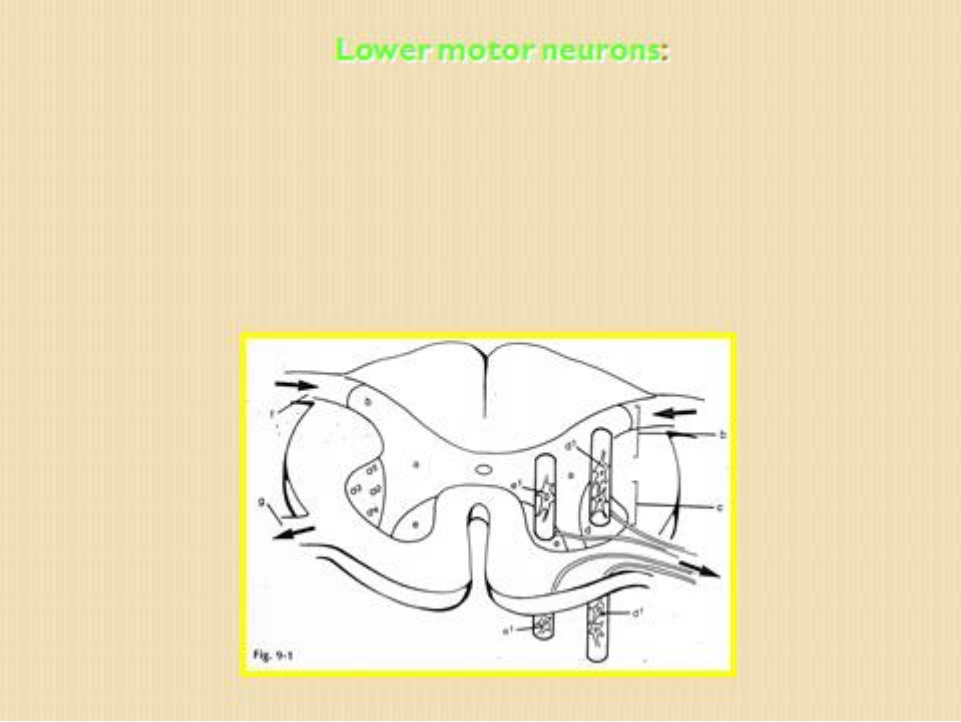


FIG. 21–2. The most important descending pathways that act upon the anterior horn cell of the spinal cord (final common pathway).

Lower Motor Neuron- the "final common path" of the motor system

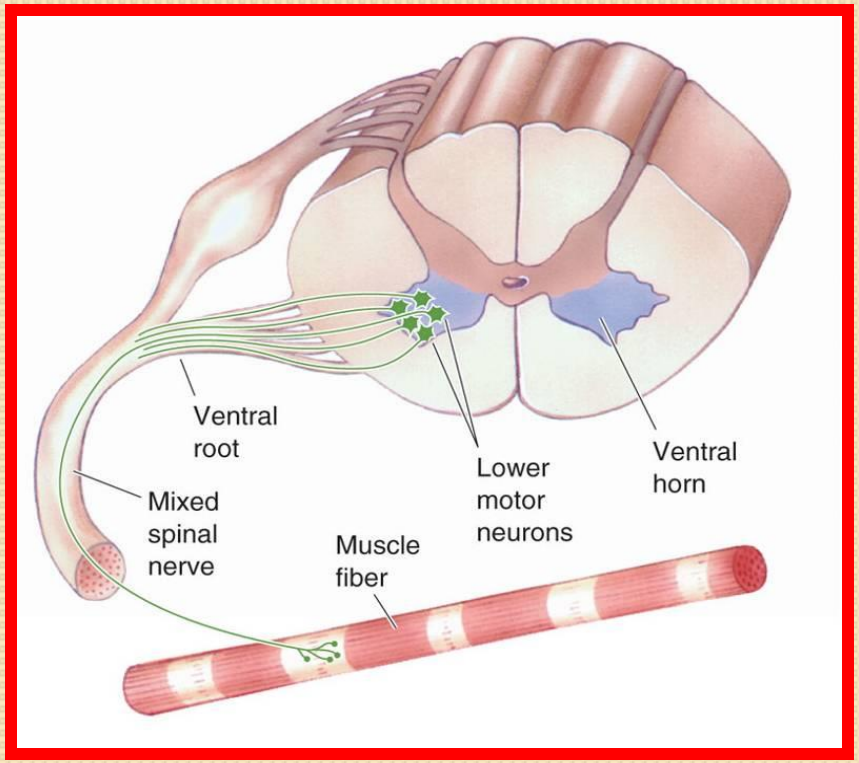
- Anterior horn of the spinal cord
- Motor nuclei of the cranial nerves (V, VII, IX, X, XII, XI).

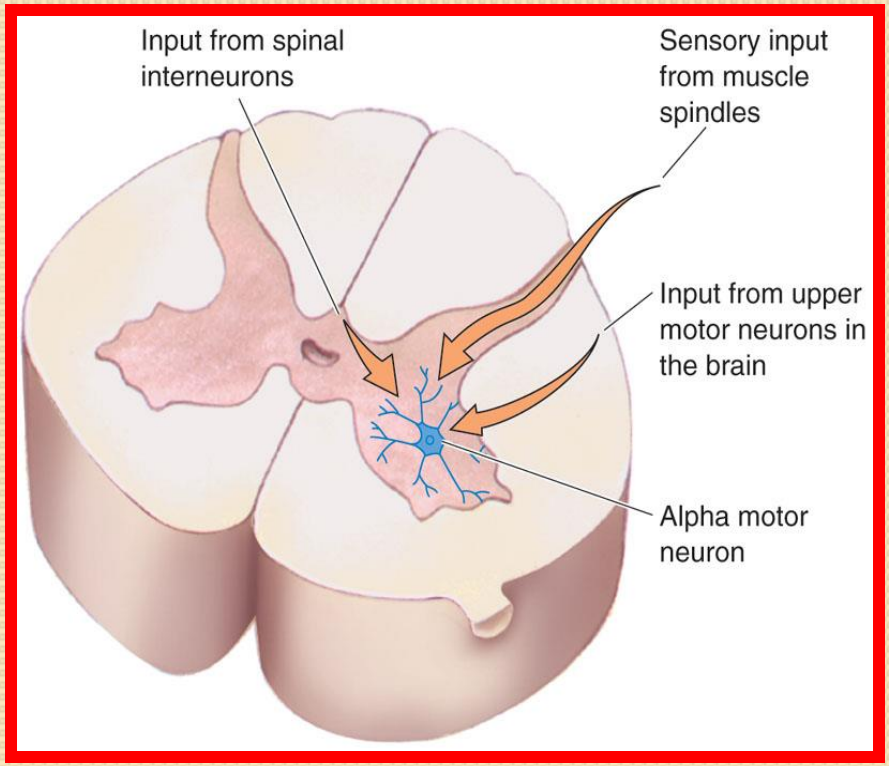


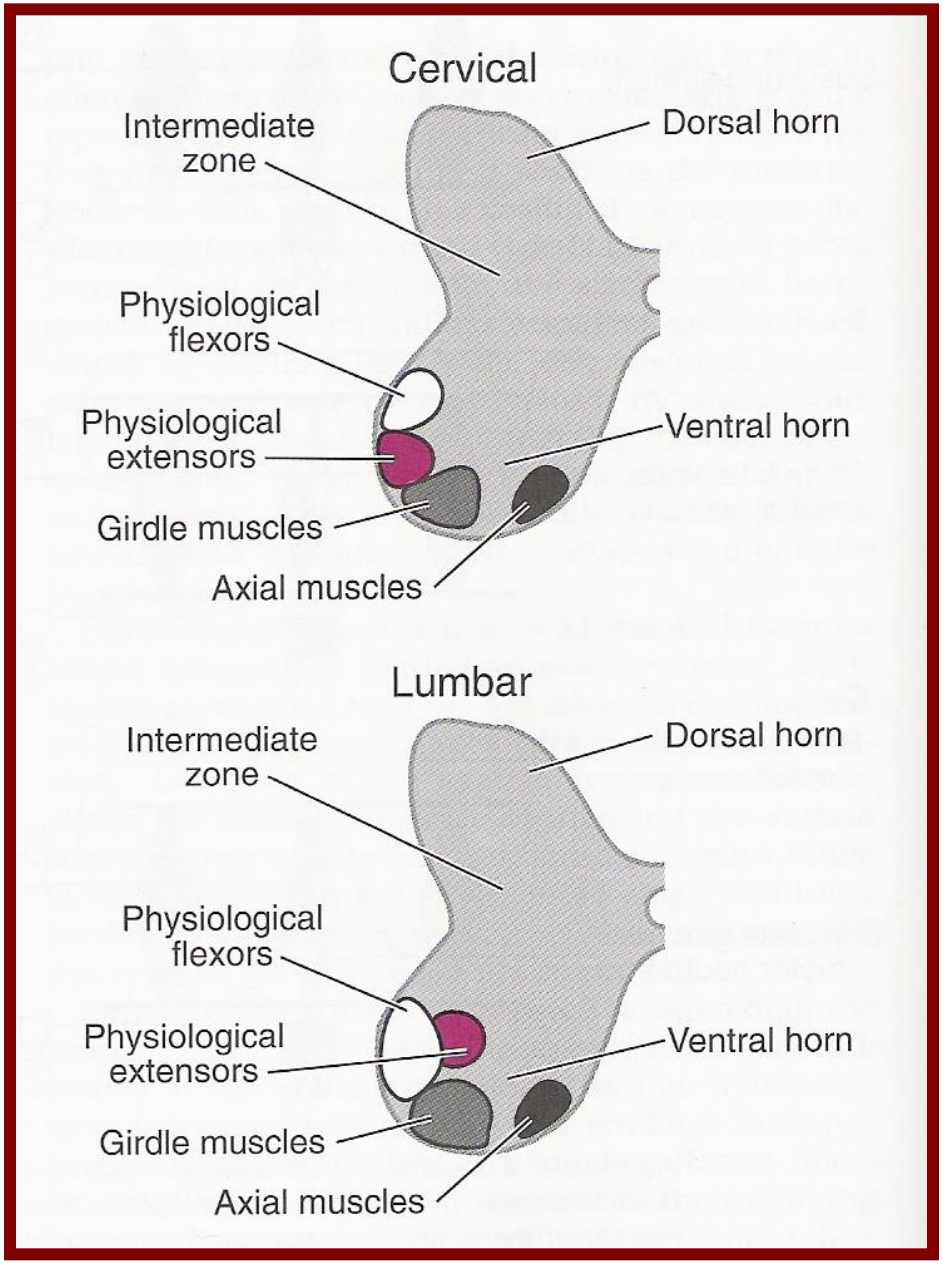
Lower Motor Neuron - the final way of Sherrington

- **Alpha motor neurons – muscle contractions**
- **Gamma motor neurons – muscle tonus**

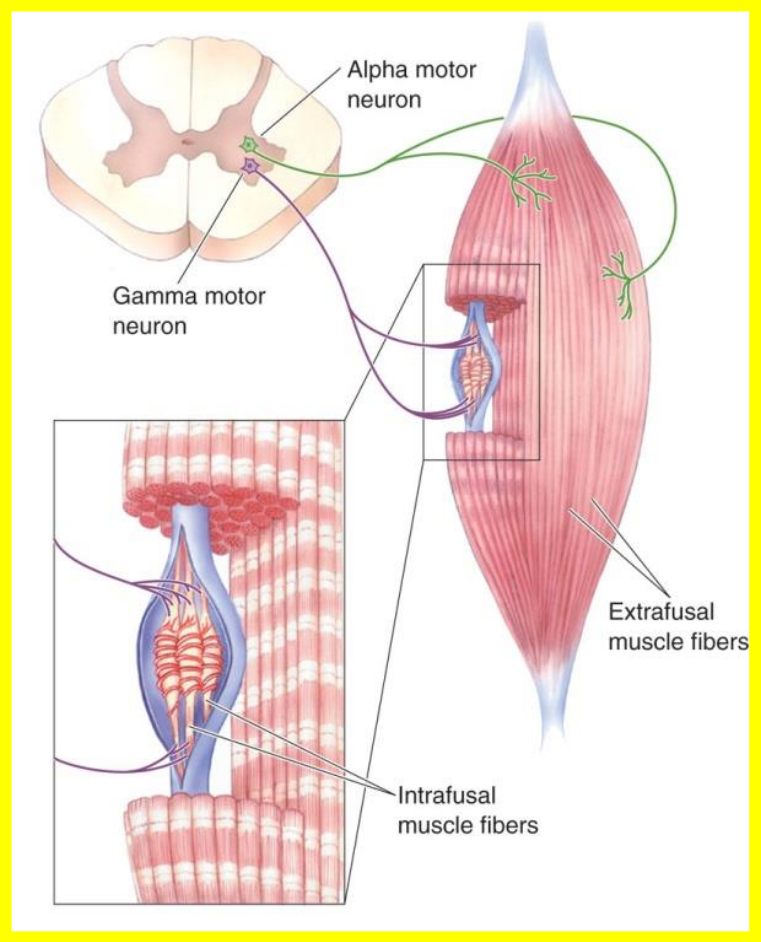
Motor unit/= motor cell, axon, muscle fibers.

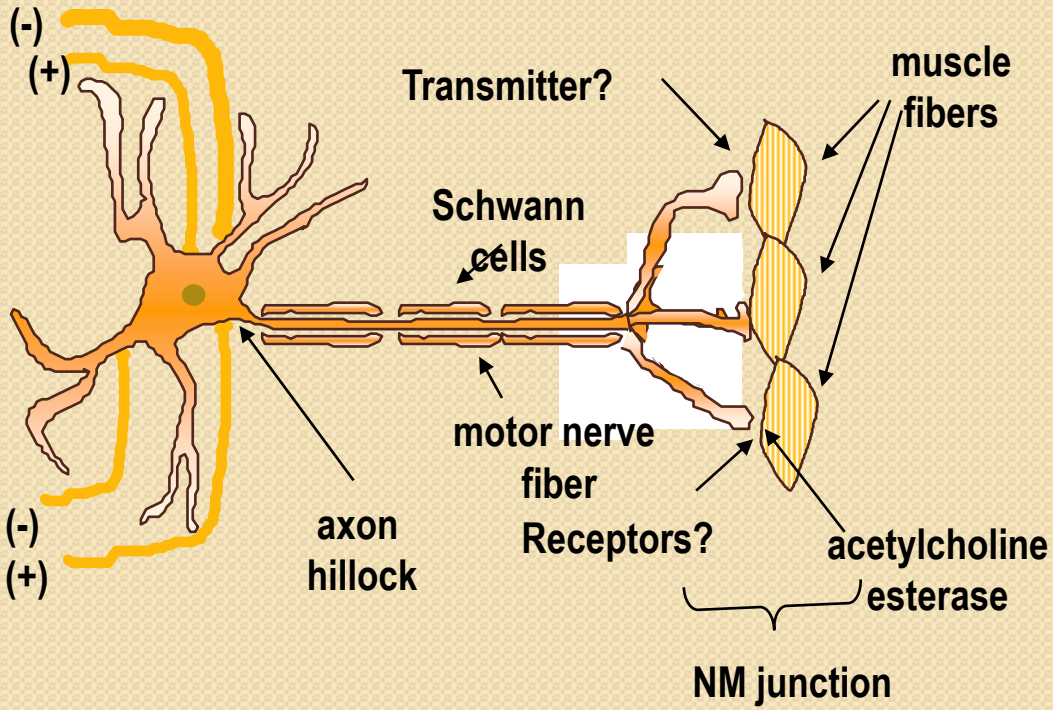





Cervical
Intermediate zone
Dorsal horn
Physiological flexors
Physiological extensors
Ventral horn
Girdle muscles
Axial muscles
Lumbar
Intermediate zone
Dorsal horn
Physiological flexors
Physiological extensors
Ventral horn
Girdle muscles
Axial muscles

Motor Neuron

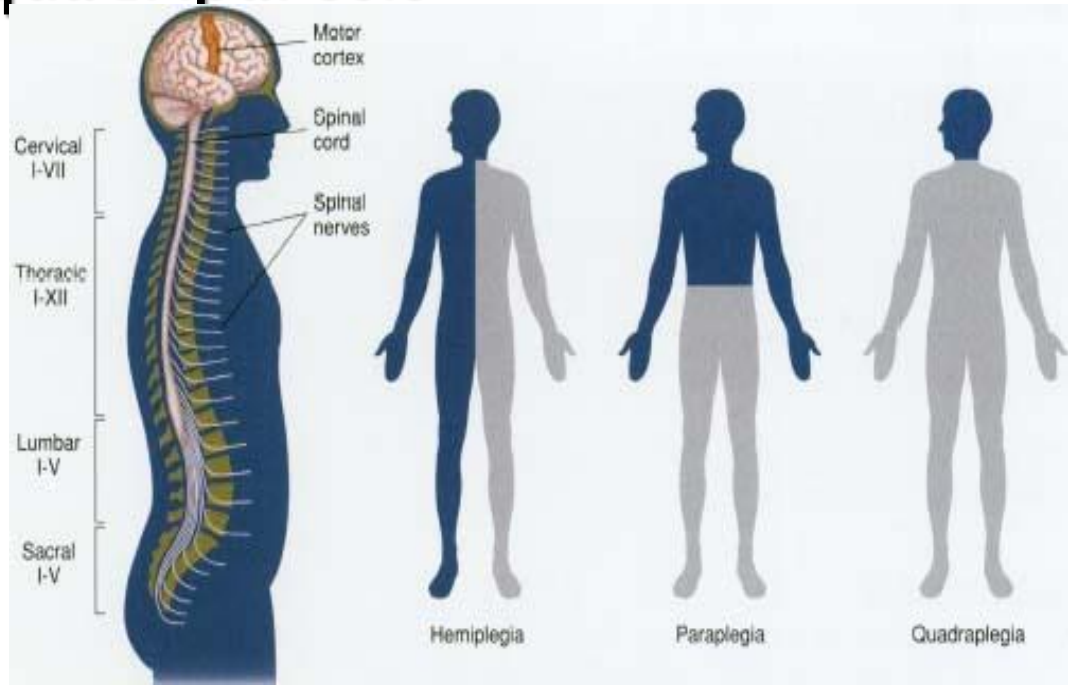




White muscle fibers – clonic contraction
Red muscle fibers – tonic contraction

Terms for designation of motor deficit

- Paralysis / plegia, palsy/ paresis
- Monoplegia / monoparesis
- Hemiplegia / hemiparesis-left or right
- Paraplegia / paraparesis-superior or inferior
- Quadriplegia / quadriparesis



EXAMINATION OF THE MOTOR SYSTEM

- **Muscle volume:** wasting, atrophy, hypertrophy;
- **Muscle strength** (muscle power);
- **Muscle tone** (a tension present in resting muscle)
- **Coordination** (a harmonious action of several muscles or groups in execution of complicated movements)
- **Gait** (manner of walking)
- **Involuntary movements** (dyskinesias)

Muscle strength examination

- By watching patient walking, standing, dressing and undressing;
- By asking the patient to move actively against resistance and rating after MRCS (Medical Research Council Scale):

Grade	Strength
5	Normal muscle strength
4	Active movements against gravity and some resistance
3	Active movement against gravity
2	Active movement of body part when gravity is eliminated
1	Only a trace of contraction is evident, no active movement
0	No muscle contraction is evident

Muscle strength examination

- Examination of upper extremities;
- Examination of lower extremities;
- Tests for examination of latent paresis:

  - Mingazzini - Strumpell's test

Muscle strength examination

Hysterical Paralysis

- Hysterical paralysis may involve one arm or leg, both legs, or all of one side of the body;
- Tendon reflexes are retained and atrophy is lacking in hysterical paralysis, features that distinguish it from chronic lower motor neuron disease;
- Diagnostic difficulty arises only in certain acute cases of upper motor neuron disease that lack the usual changes in reflexes and muscle tone;
- The hysterical gait is often diagnostic problem;
- Sometimes there is loss of sensation in the paralyzed parts and loss of sight, hearing, and smell on the paralyzed side—a pattern of sensory changes that is never seen in organic disease of the nervous system.

Muscle Tone

- The amount of tension or resistance to movement in a muscle.
- Muscle tonus helps in maintaining body posture.
- For clinical purpose: resistance of muscles to passive movement of each joint.

Components of Muscle Tone

- Passive /Static/– in rest
- Active /Dynamic/ - resistance to passive contraction

Control of muscle tone

- Cortical
- Subcortical
- Reflex – at the level of spinal cord

Anatomy&Physiology

1. Segmental mechanisms of regulation- stretch reflex

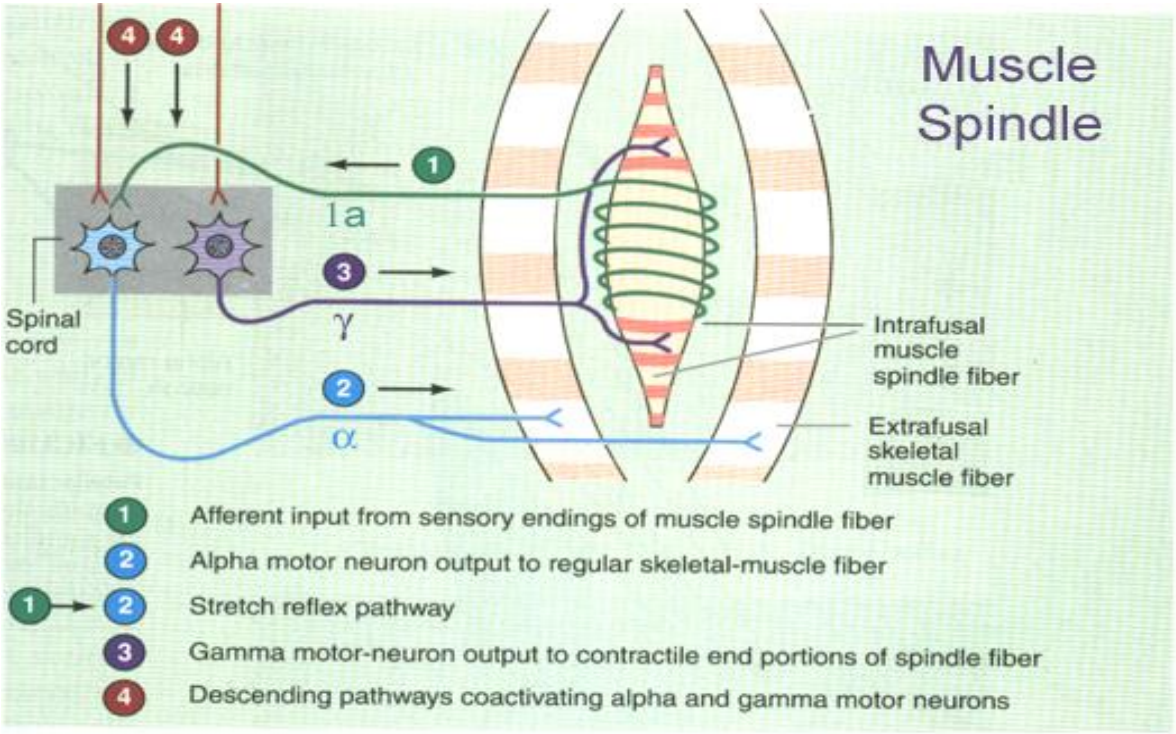
- Stretched muscle at rest → muscle spindle (stretch receptor that keeps constant muscle length)→ sensory fibers → alpha motor neurons → extrafusal muscles → contraction (restoration of length).
- Active contraction (muscle tension) → Golgi organ → sensory fibers → alpha motor neurons (inhibitory effect)

2. Suprasegmental mechanisms of regulation

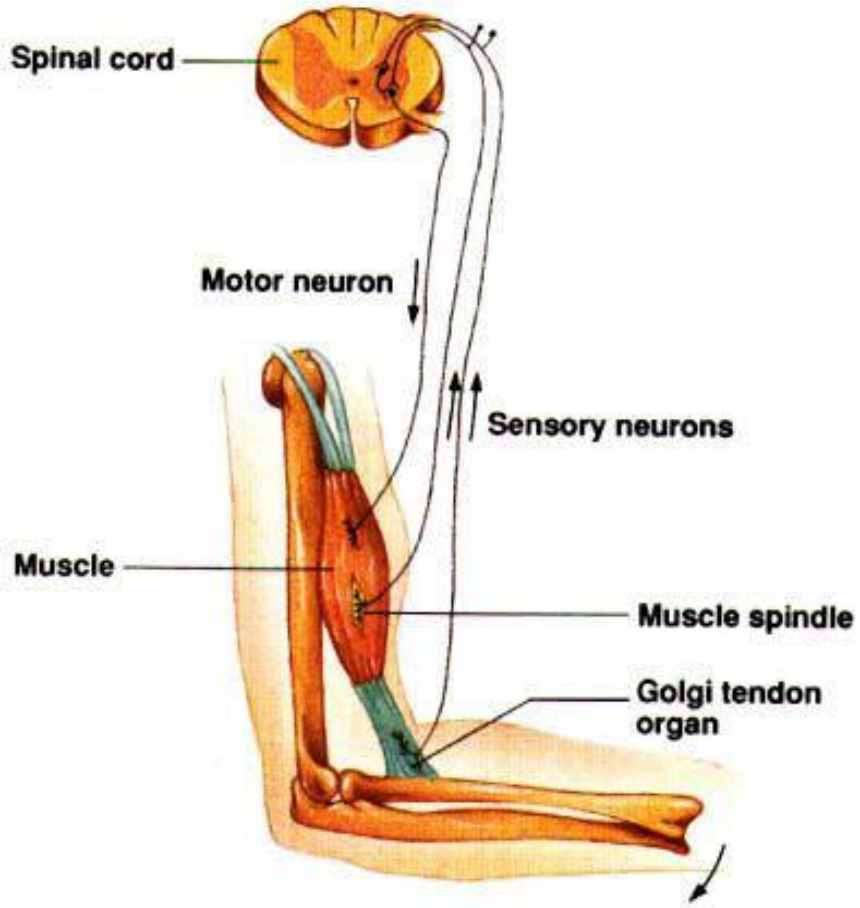
- Reticulospinal central impulses → gamma moto neurons → gamma fibers → intrafusal muscles (increase of tension)
- Corticospinal tract
- Rubrospinal tract

Muscle tone is maintained by reflex and is adjusted to the needs of posture and movement by stretch or myotatic reflex!

Regulation of the muscle tone
Segmental - stretch reflex



Segmental Regulation of the muscle tone - stretch reflex



Examination of muscle tone

- Ask the patient to relax;
- Palpate the muscle belly;
- Flex and extend the patient's fingers, wrist, and elbow;
- Flex and extend patient's ankle and knee;
- There is normally a small, continuous resistance to passive movement;
- Observe for decreased (flaccid) or increased (rigid/spastic) tone.

SYNDROMES OF DISORDERED MUSCLE TONE

- **Decreased** muscle tone (hypotonia, flaccidity)
  Indicates lower motor neuron lesion

- **Increased** muscle tone (hypertonia)

- increased tone in certain muscle groups (flexors of the arm and extensors of the legs) and increase of resistance linearly in relation to velocity of stretch. Indicates upper motor neuron lesion;

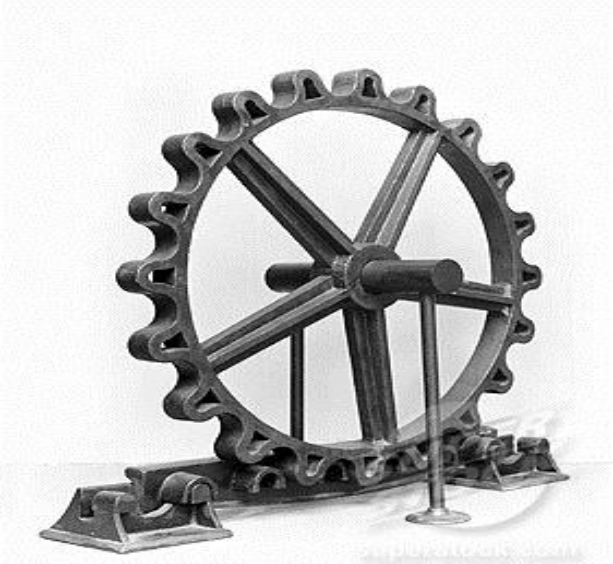
- increased tone with continuous or intermittent muscle tension. Indicates extrapyramidal dysfunction.

Muscle hypertonia

- **Spasticity** has been defined as an increase in muscle tone due to upper motor neuron lesion that is characterized by a velocity-dependent increase in tonic stretch reflexes - ”clasp-knife phenomenon”
- **Rigidity** - continuous firm, tense muscles with marked resistance to passive movement, velocity independent increase; flexors more than extensors -”cogwheel rigidity”

Basal ganglia

- Damage of substantia nigra /inhibition of direct tract/ causes **Parkinson disease** – rigidity
- **Muscle rigidity** is a state of continuous firm, tense muscles with marked resistance to passive movement,
- reduced ability of a muscle to stretch.
- Negro's phenomenon - rack-wheel phenomenon



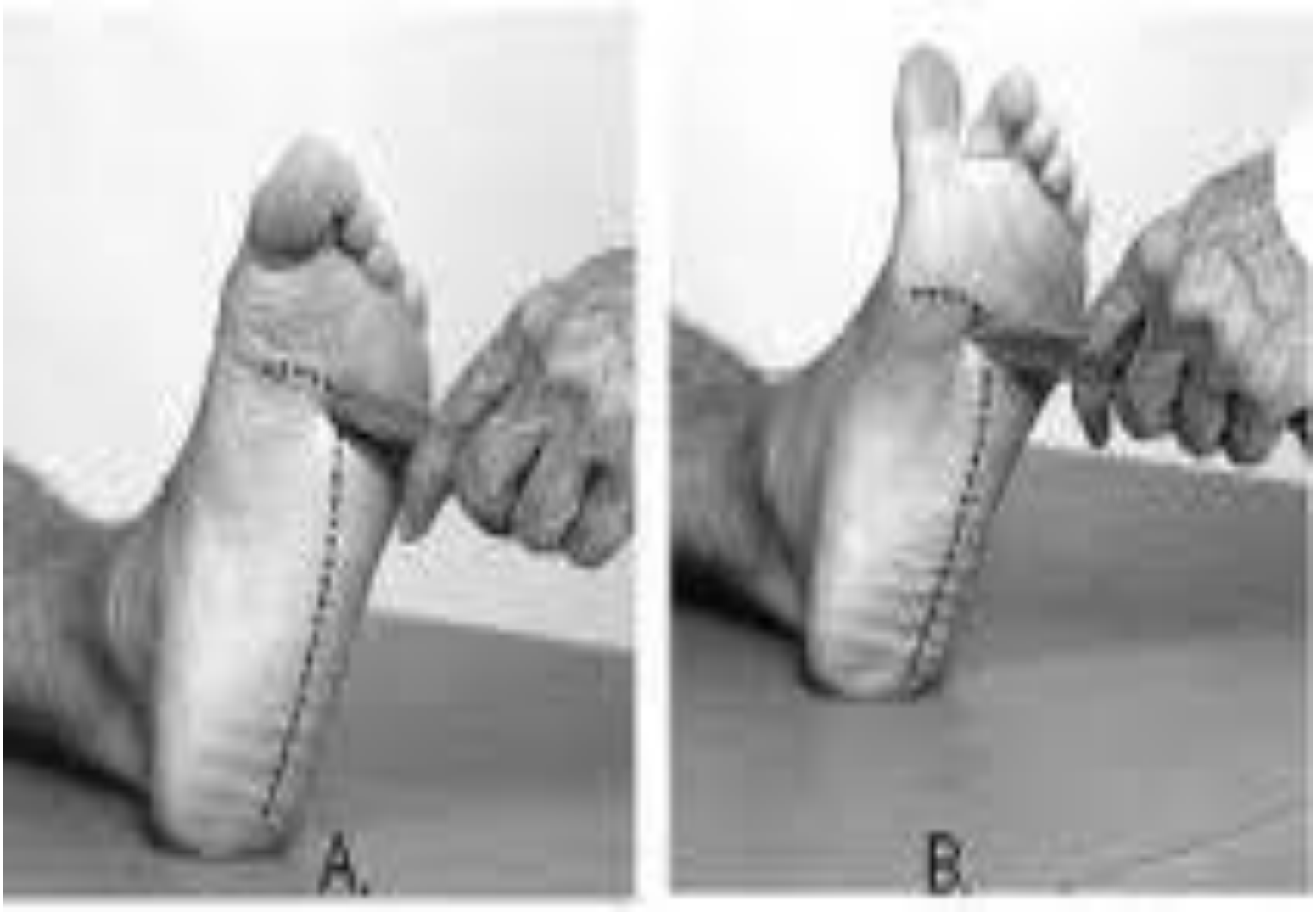
SYNDROMES OF DISORDERED MOTOR FUNCTION /motor deficit/

- **UMN syndrome (interruption of the pyramidal tract)**

  1. **Decrease of muscle strength=paresis**
  2. **Spastic increase of muscle tone=spasticity**
  3. **Increased tendon reflexes (hyperreflexia)**
  4. **Decrease or loss of exteroceptive reflexes** (abdominal, cremaster, plantar)
  5. **Appearance of pathologic reflexes**
  6. **Absence of degenerative muscle atrophy**

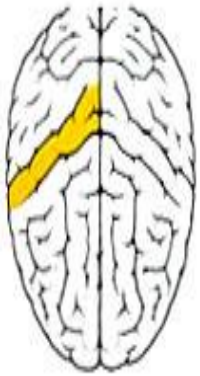
Contracture

Babinski sign



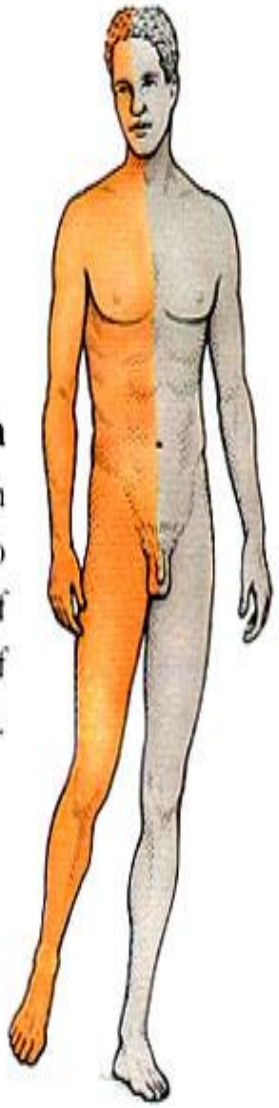
Specific syndromes according to the location of lesion

- Lesion of the cortex area 4: Jacksonian motor epilepsy, contralateral paresis, usually monoparesis;
- Subcortical lesion in the motor area: contralateral monoparesis;
- Internal capsule lesion: contralateral spastic hemiplegia+ Facial and Hypoglossal nerves palsy;
- Peduncle lesion: contralateral hemiparesis+ Oculomotor nerve palsy= alternating syndrome of Weber;
- Pons lesions: contralateral hemiplegia+ Facial and Abducens nerves palsy;
- Cervical lesion: ipsilateral spastic hemiplegia
- Thoracic lesion: ipsilateral spastic monoplegia
- Anterior horn lesion: ipsilateral flaccid paresis



Hemiplegia

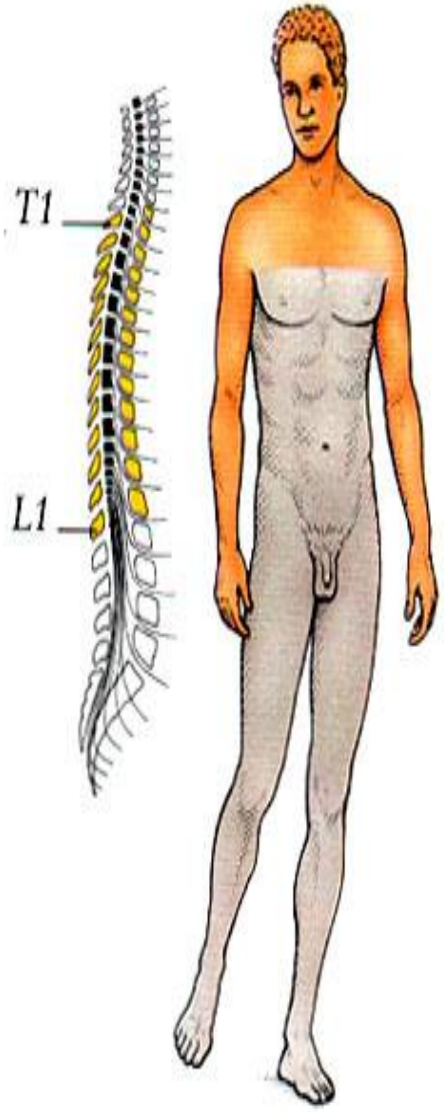
Damage to the motor areas on one side of the brain can lead to paralysis of the opposite side of the body. This one-sided type of paralysis is known as hemiplegia.

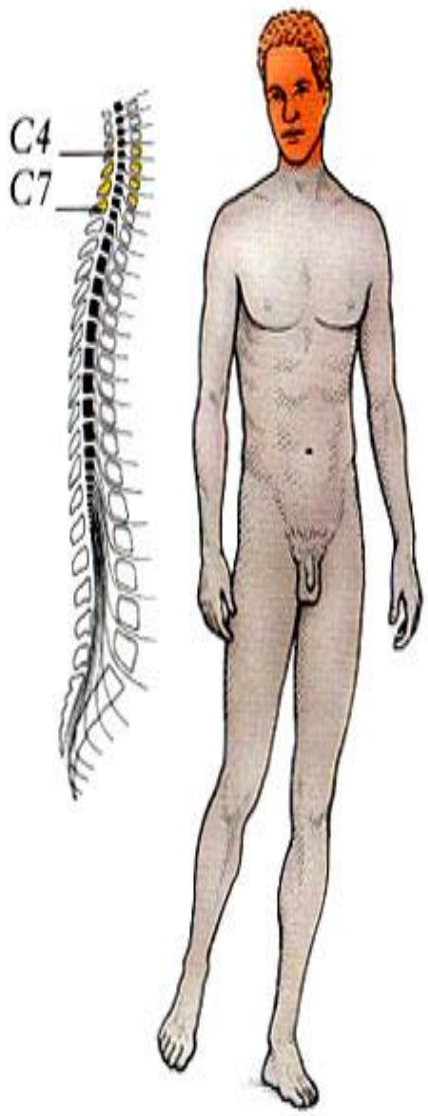


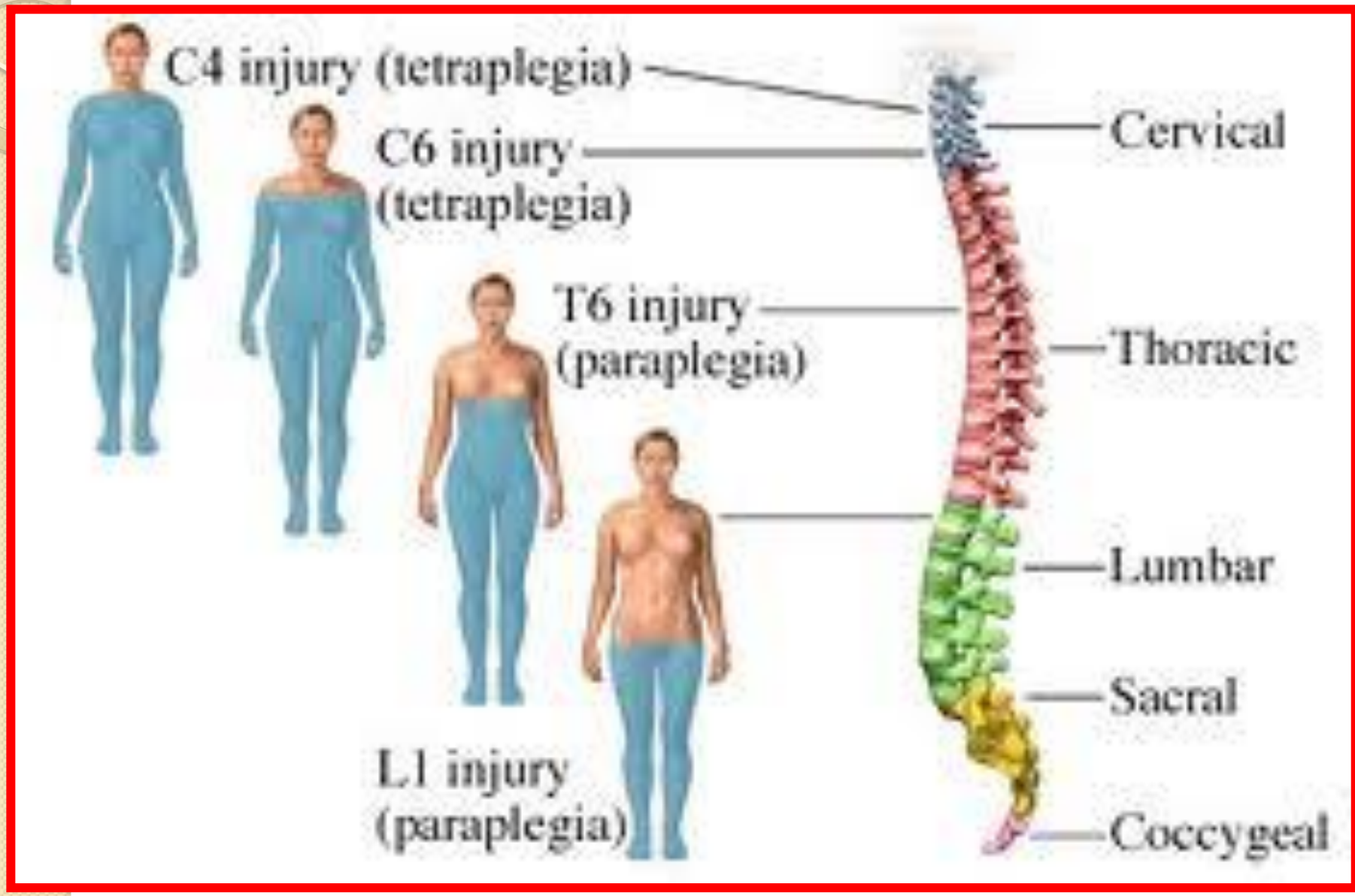
KEY

Area of body affected

Site of damage






C4 injury (tetraplegia)
C6 injury (tetraplegia)
T6 injury (paraplegia)
L1 injury (paraplegia)
Cervical
Thoracic
Lumbar
Sacral
Coccygeal

SYNDROMES OF DISORDERED MOTOR FUNCTION

Syndrome of LMN lesion (anterior horn→neuromuscular junction)

- ✓ **Muscle weakness=paresis**
- ✓ **Decreased muscle tone /hypotonia/**
- ✓ **Muscle hypotrophy or atrophy**
- ✓ **Fasciculations**
- ✓ **Depressed or absent tendon reflexes**

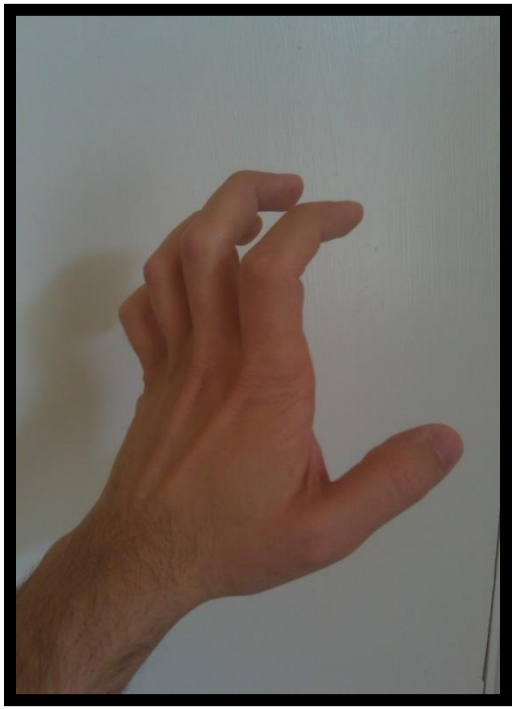
Anterior horn lesion

Poliomyelitis

Hypotrophy of hip muscles

Lesion of lower motor neuron

peripheral paresis



Lesion of ulnar nerve

Lesion of median nerve

Lesion of radial nerve

DIFFERENCES BETWEEN UMN AND LMN PARALYSIS

- **UMN PARALYSIS**

  - Muscles affected in groups
  - Atrophy slight and due to disease
  - Spasticity with hyperactivity of tendon reflexes and extensor plantar reflex (Babinski sign)
  - Fascicular muscle twitches absent
  - Normal nerve conduction studies; no denervation potentials in EMG

- **LMN PARALYSIS**

  - Individual muscles can be affected
  - Atrophy pronounced up to 70% - 80%
  - Flaccidity and hypotonia of affected muscles with loss of tendon reflexes
  - Plantar reflex of normal type
  - Fascicular muscle twitches may be present
  - Abnormal nerve conduction studies; denervation potentials fasciculations, positive sharp waves) in EMG