

Gomel State Medical University
Department of Neurology and neurosurgery

Lecture 1

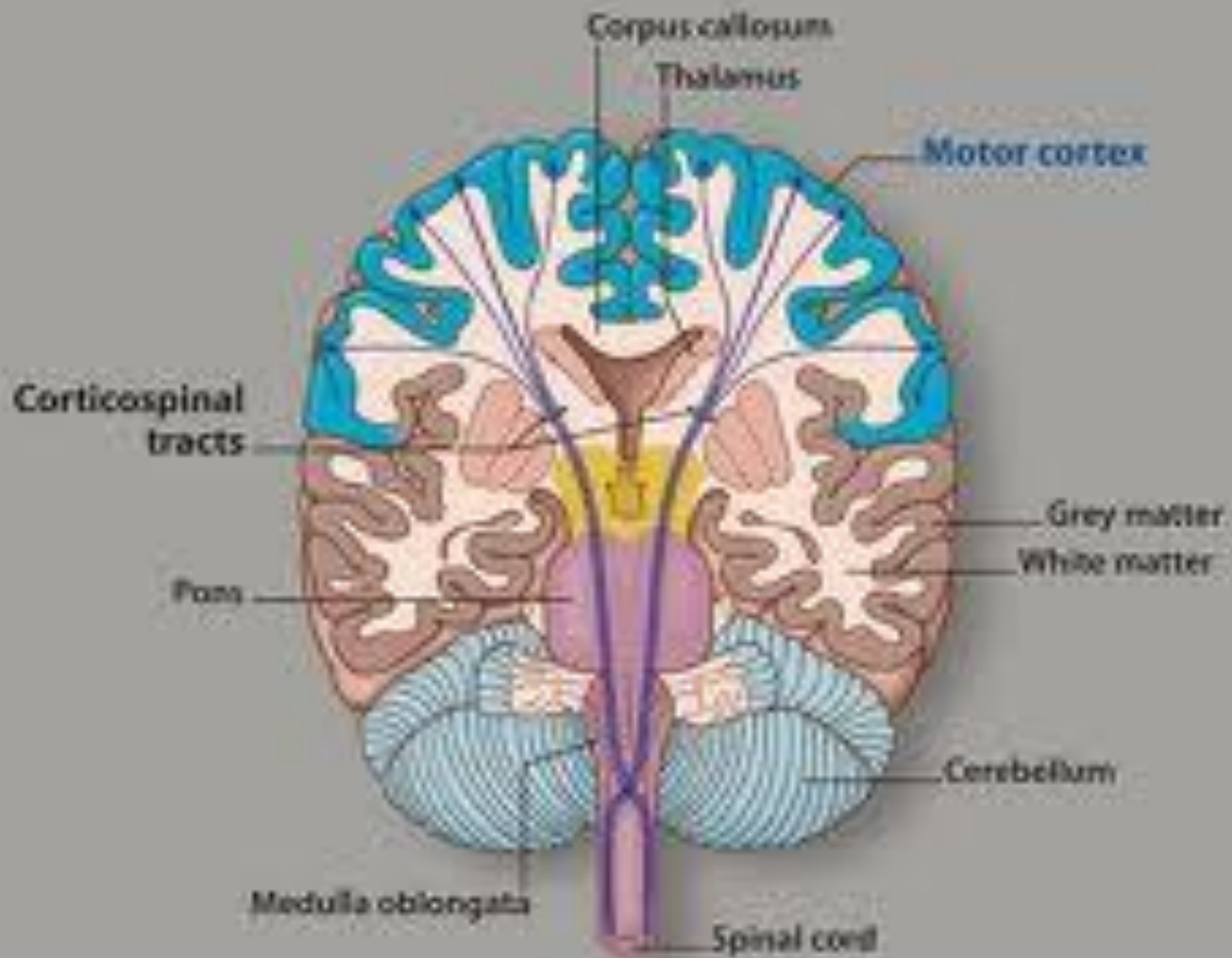
**THEME 2. MOTOR SYSTEM AND
MOTOR DISORDERS**

The faculty of general medicine

There are two kinds of movements: involuntary and voluntary.

Involuntary movements are the simple automatic movements (as the simple reflex) which are realised by means of a spinal cord and a brainstem.

Voluntary movements are those which are carried out by the motor cortex, extrapyramidal system and the spinal cord.



Cerebral Cortex

**Corpus
Callosum**

Midbrain

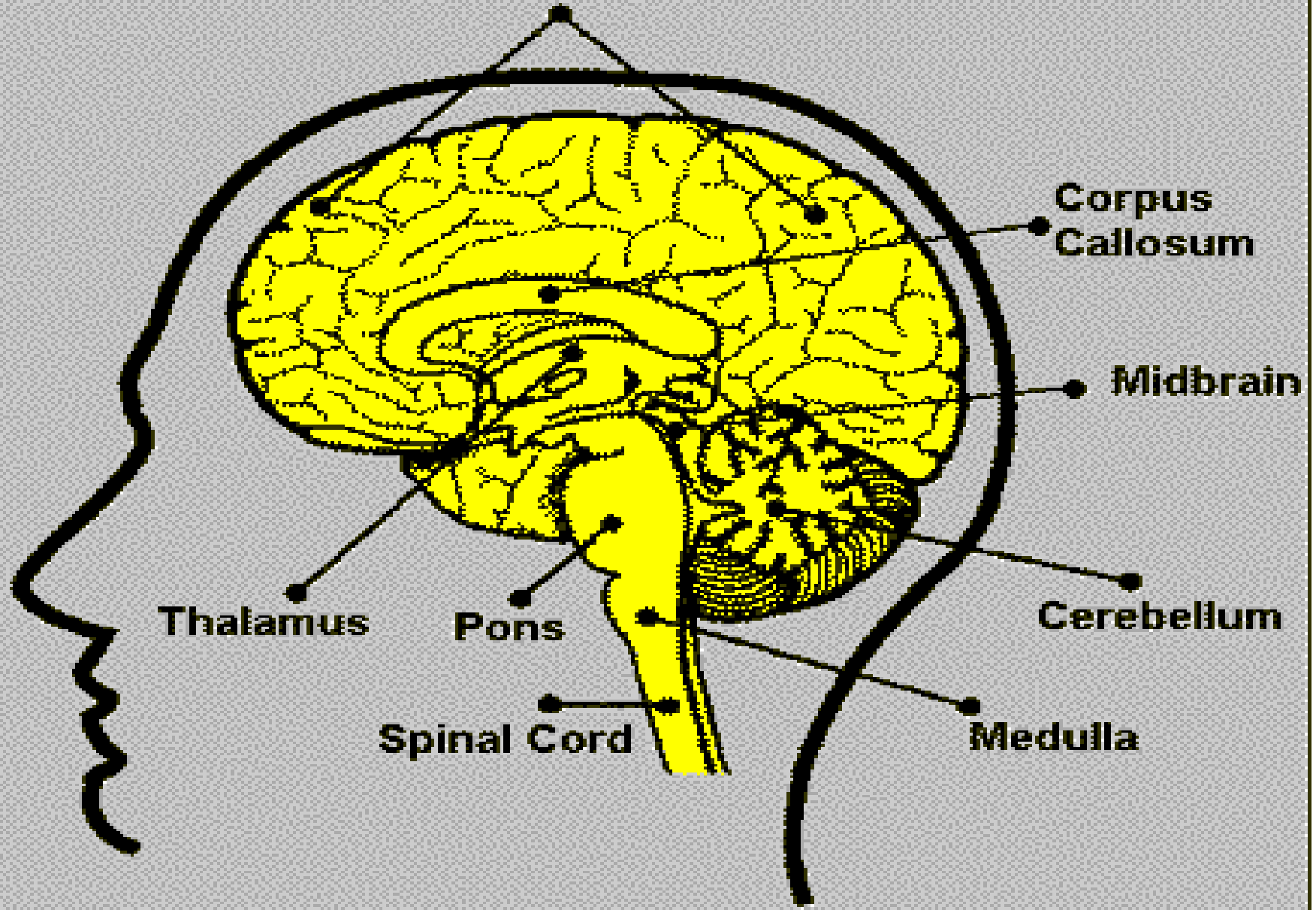
Cerebellum

Medulla

Spinal Cord

Pons

Thalamus



The corticospinal, or pyramidal, tract is the main motor pathway for control of voluntary movement in humans. It originates in the motor cortex and descends to the striated muscles of the opposite side.

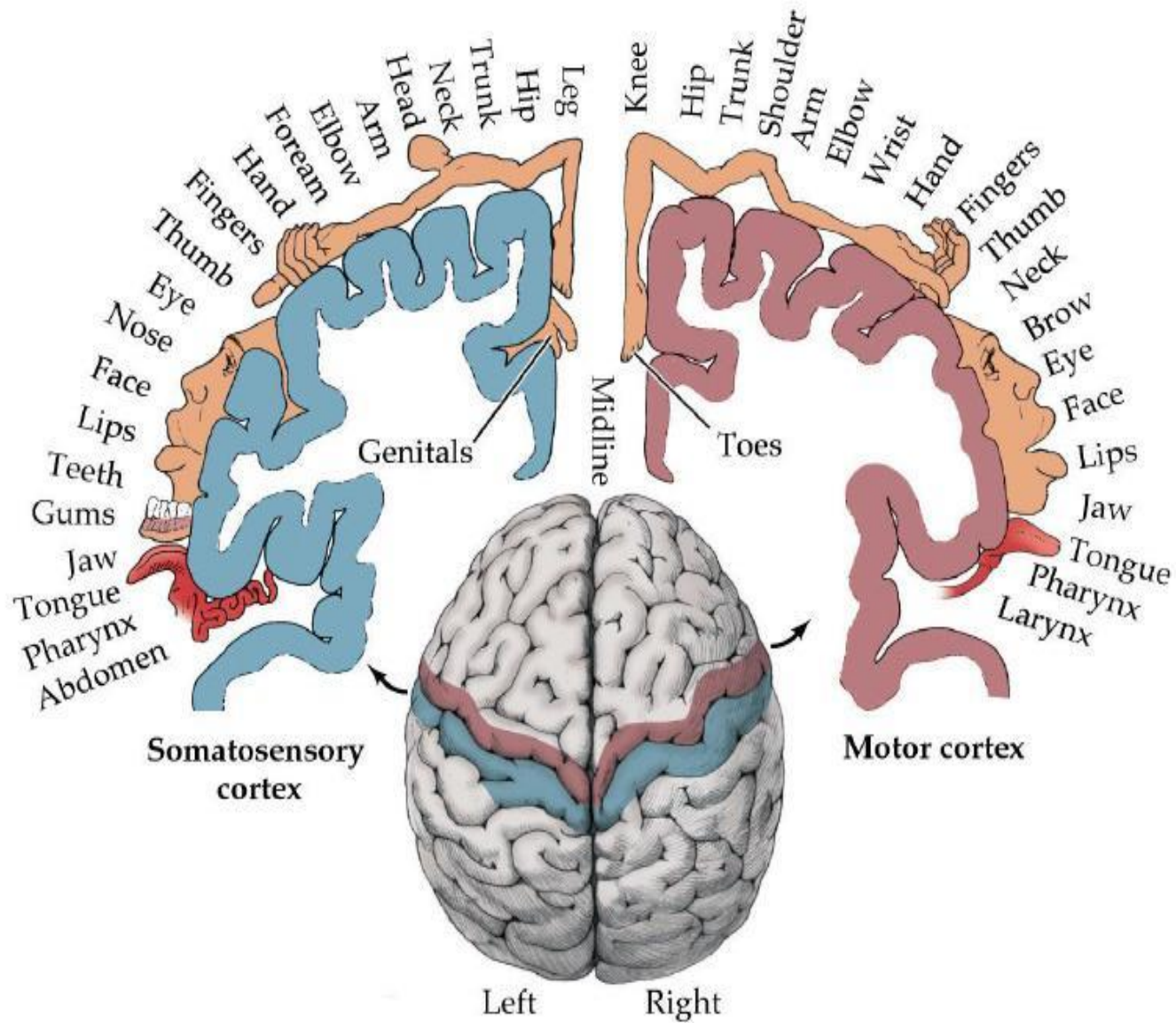
The corticospinal tract consists of two neurons. The upper (*primary*) motor neuron is located in the precentral gyrus of the frontal lobe. The axons of the upper motor neuron are connected with the lower motor neurons, located in the ventral horn of the spinal cord and in the motor cranial nerve nuclei.

Structure of the pyramid system

1. Precentral gyrus, where the first neuron is located (layer 5, large Betz cells).

The location of function in exitable area is of inverse somatotopical projection: those neurons that innervate pharynx and gorge are located in the lowest area of precentral gyrus and those neurons that innervate muscles of face, arms, body and legs follow them in the ascending order.

Inverse somatotopical projection has derived its name from such a location of neurons, that could be visualized as a human standing on his head.



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Figure showing body representation in the cortex

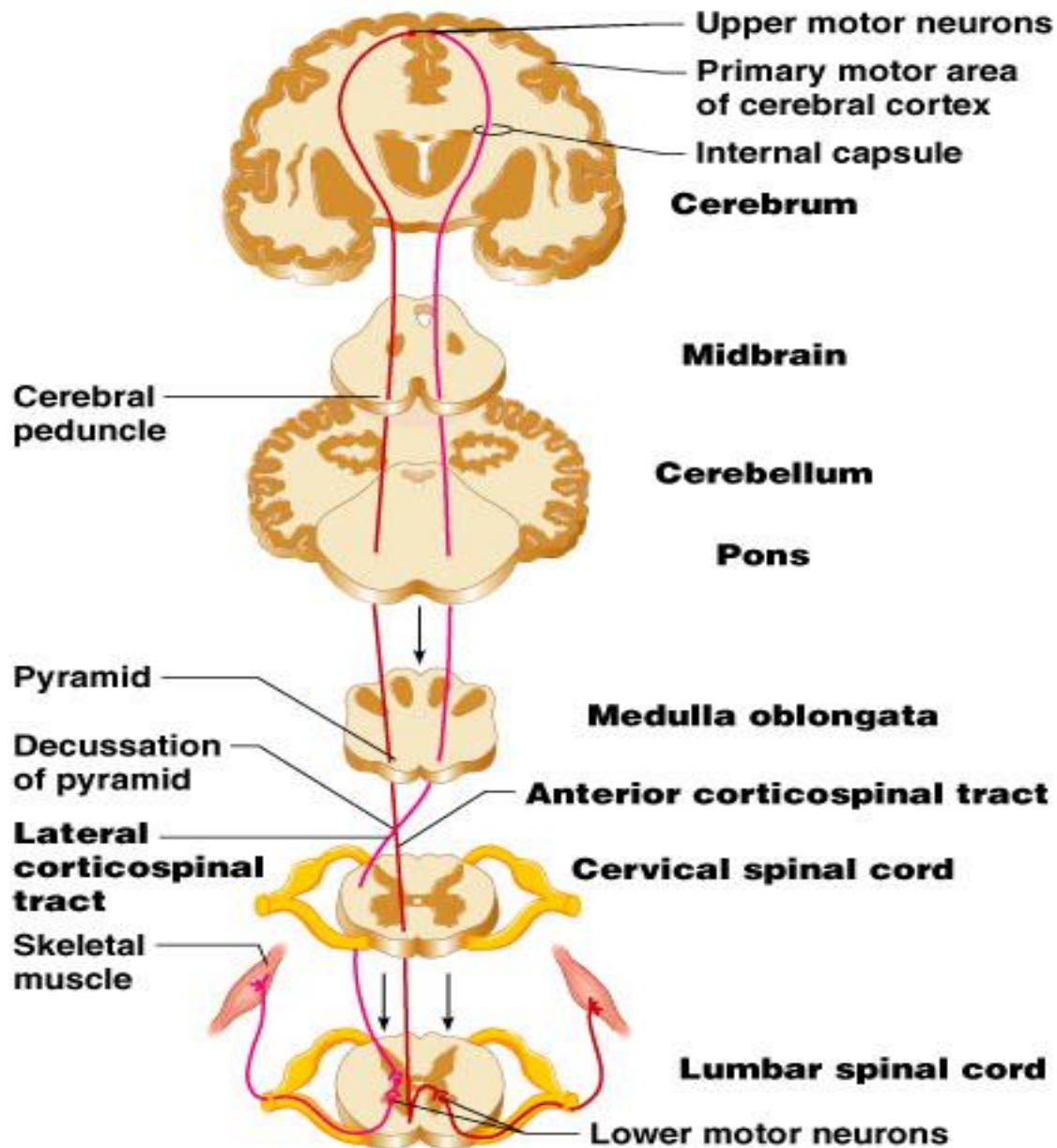
2. Radiant crown.

3. Internal capsule (anterior 2/3 of the hind leg — corticospinal pathway; knee-corticonuclear pathway)

4. Cerebral peduncle.

5. Midbrain.

6. Pons.



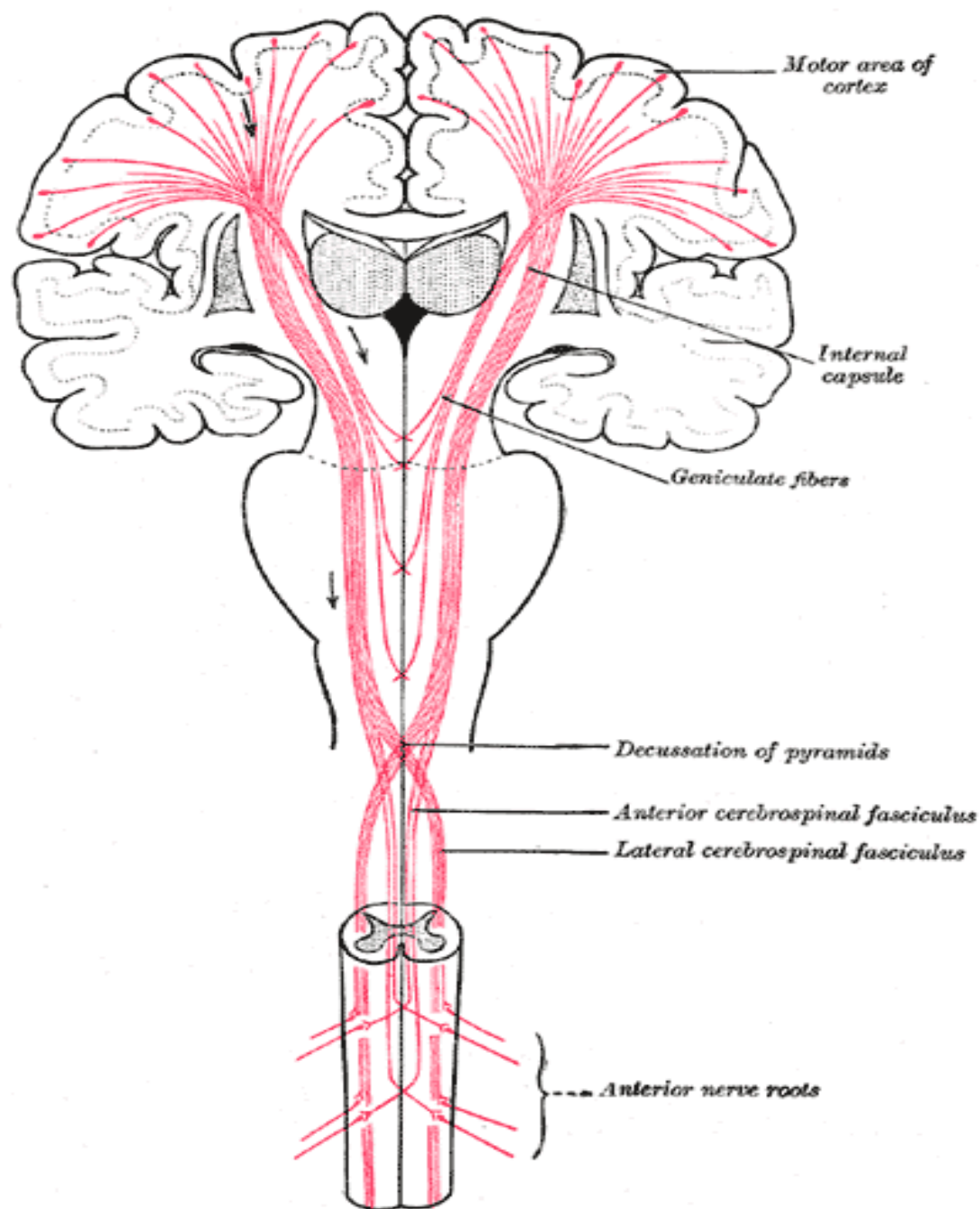
(a) Pyramidal (lateral and anterior corticospinal) tracts

7. Medulla oblongata.

The corticonuclear pathway ends in the cranial nerve nuclei (III, IV, V, VI, VII, IX, X, XI, XII).

8. At the level of the transition of the medulla oblongata to the spinal cord, the pyramidal pathway intersects.

9. 80% of the corticospinal pathway passes to the opposite side and lies in the lateral cord (lateral), 20% - in the anterior cord.

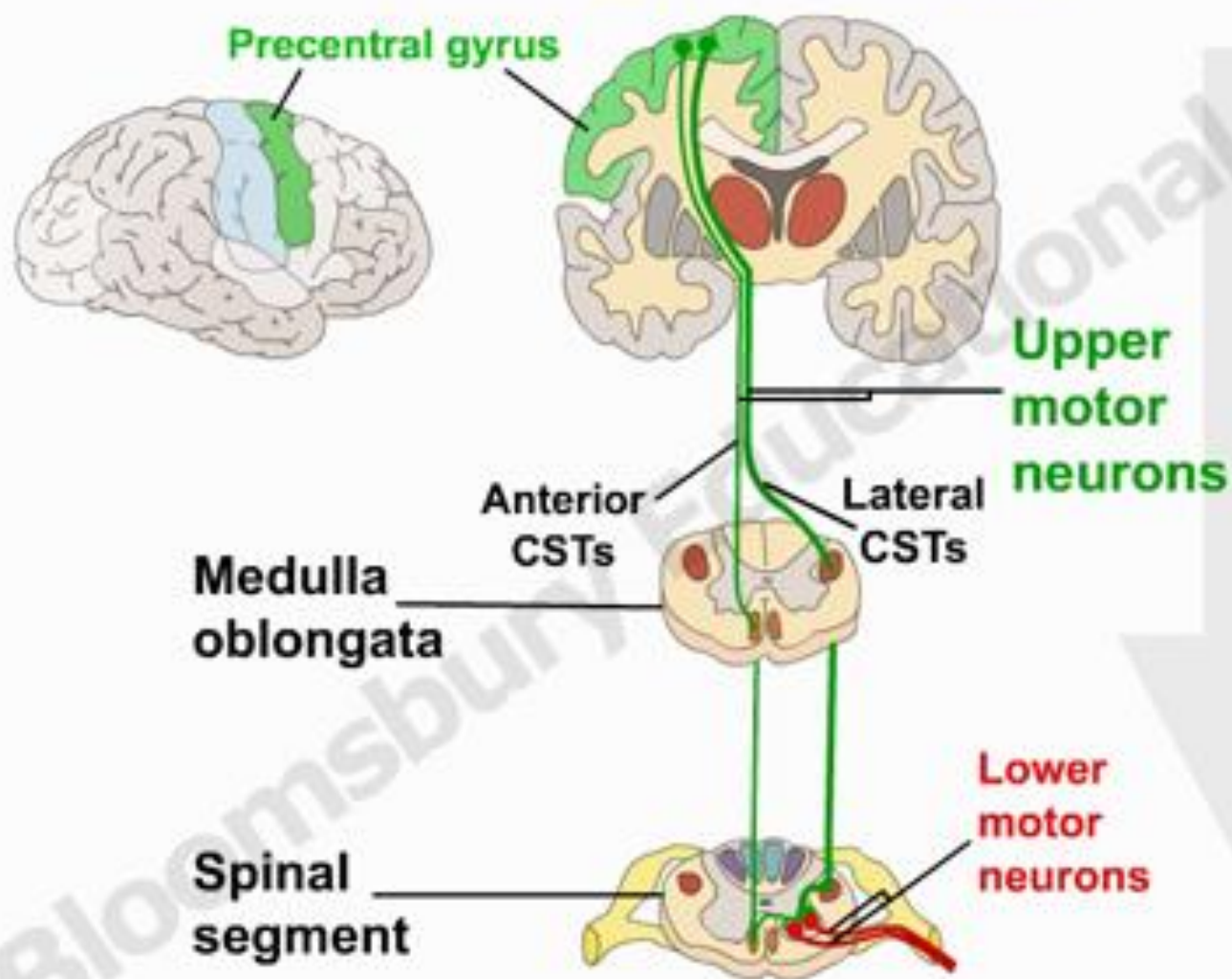


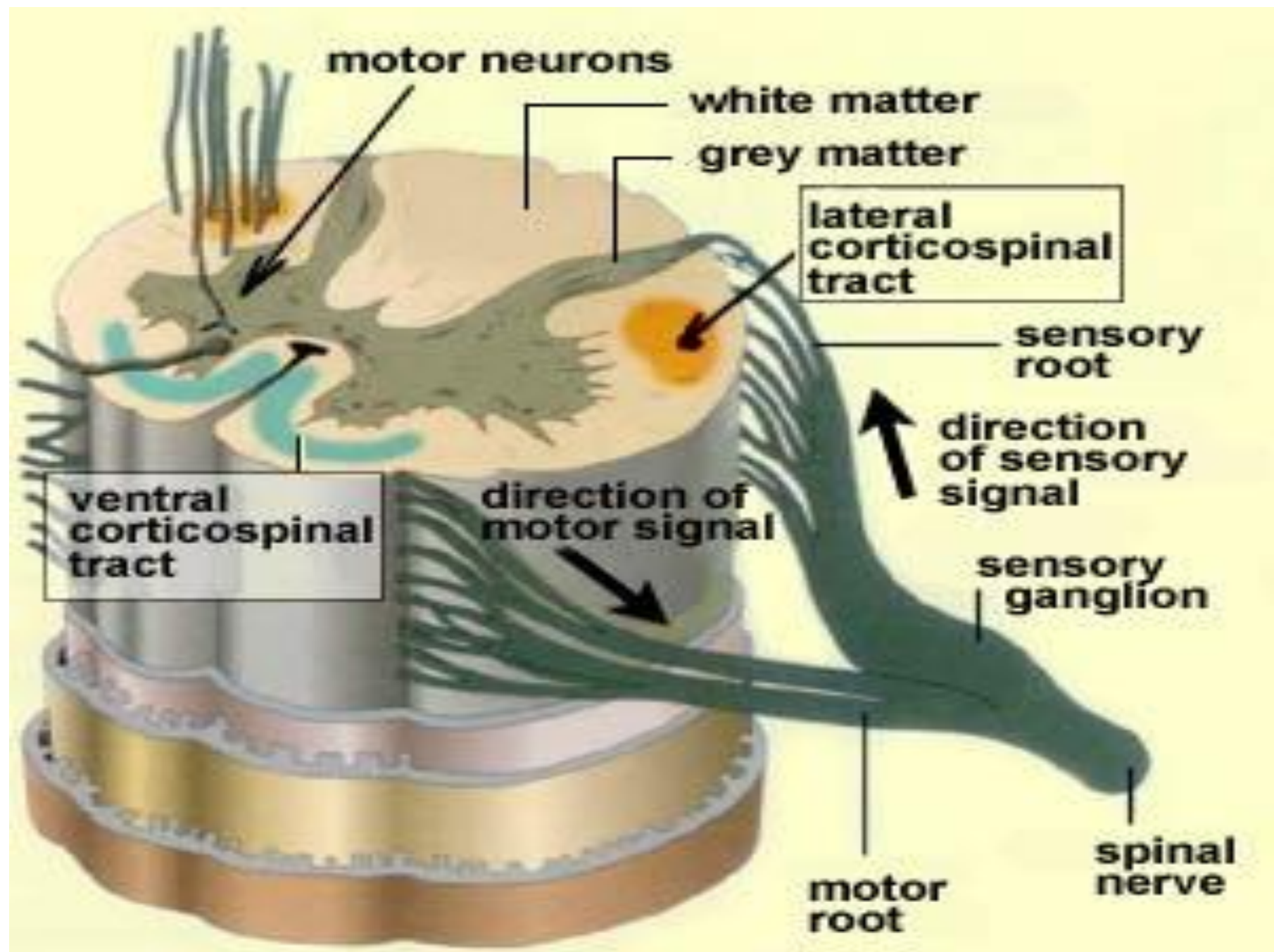
10. From the lateral and anterior cord, nerve fibers go to the anterior horns, where the second motor neuron is located.

11. From the anterior horns, the axons come out, forming an anterior motor root, which, connecting with the posterior (sensitive) one, forms the spinal nerve (there are 32 of them on both sides).

12. At the top, the spinal roots form the cervical (C1–C4) and brachial (C5–Th1) plexus, which form the median, radial, ulnar, and other nerves of the hand.

Corticospinal tracts



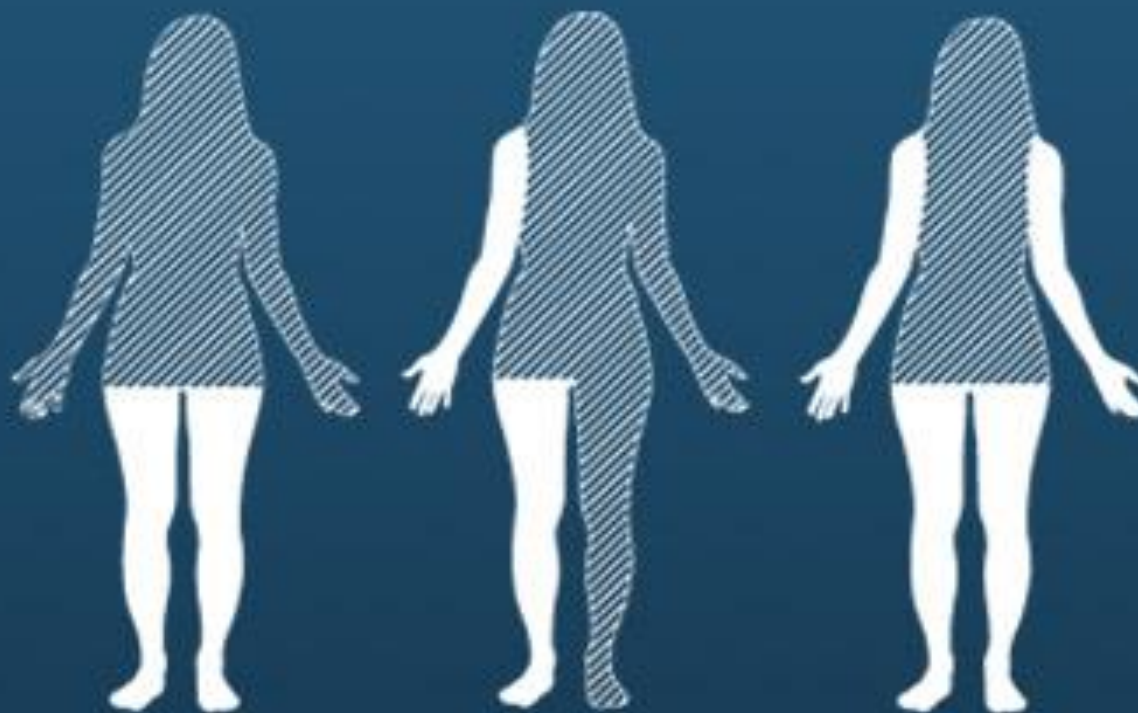


13. In the lower part of the body spinal roots form the lumbar (Th12–L4) and sacral (L5–S4) plexus, which is formed at the front of the thigh — femoral nerve posterior — sciatic, which in the popliteal fossa divides into tibial (L5–S2 — posteromedial localization) and peroneal (L4–S1 — the anterolateral localization) nerves.

Clinical localization of the motor lesion

Disorders of voluntary movements include paralysis (plegia) and paresis. Paralysis is a complete loss of muscle strength and active movements. Paresis is a decrease of muscle strength and reduction of active range of motion.

The upper motor neuron lesions produce spastic paralysis. The lower motor neuron lesions (ventral horn of the spinal cord, ventral root, plexus, peripheral nerve) cause peripheral, or flaccid, paralysis.



Diplegia

Hemiplegia

Quadriplegia



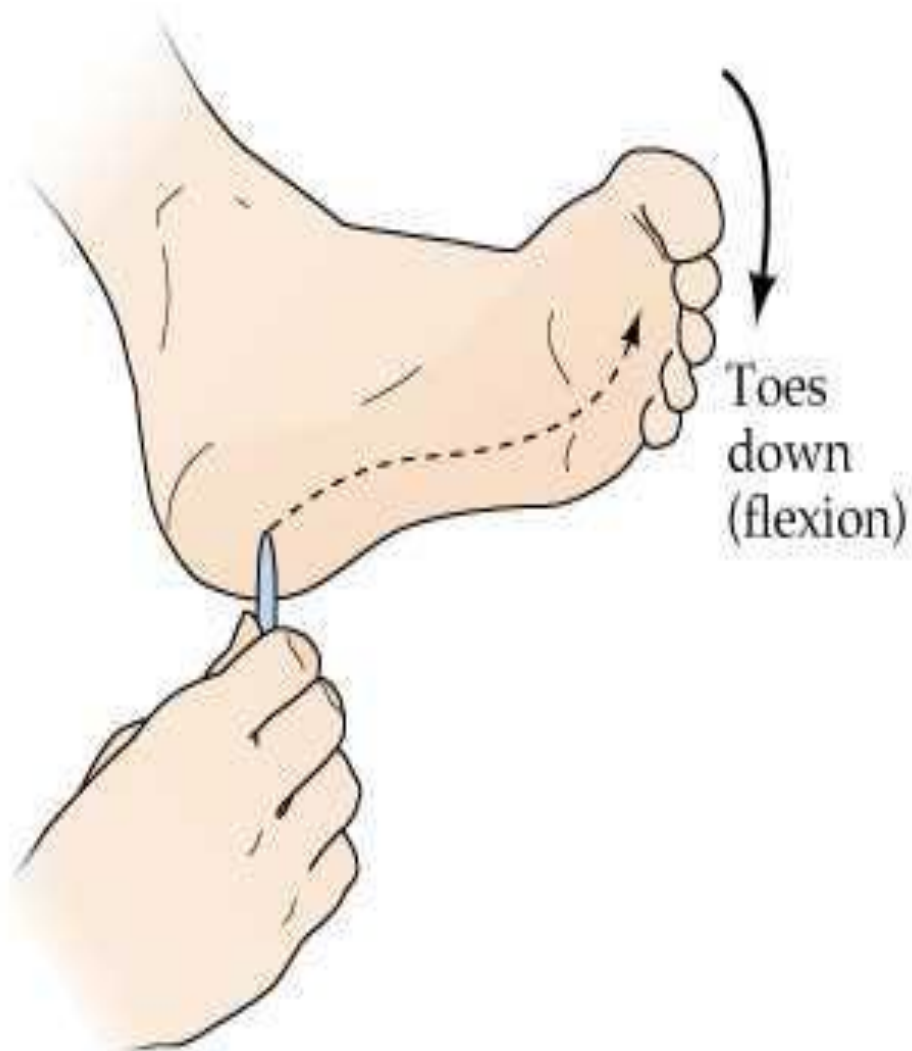
Less affected areas



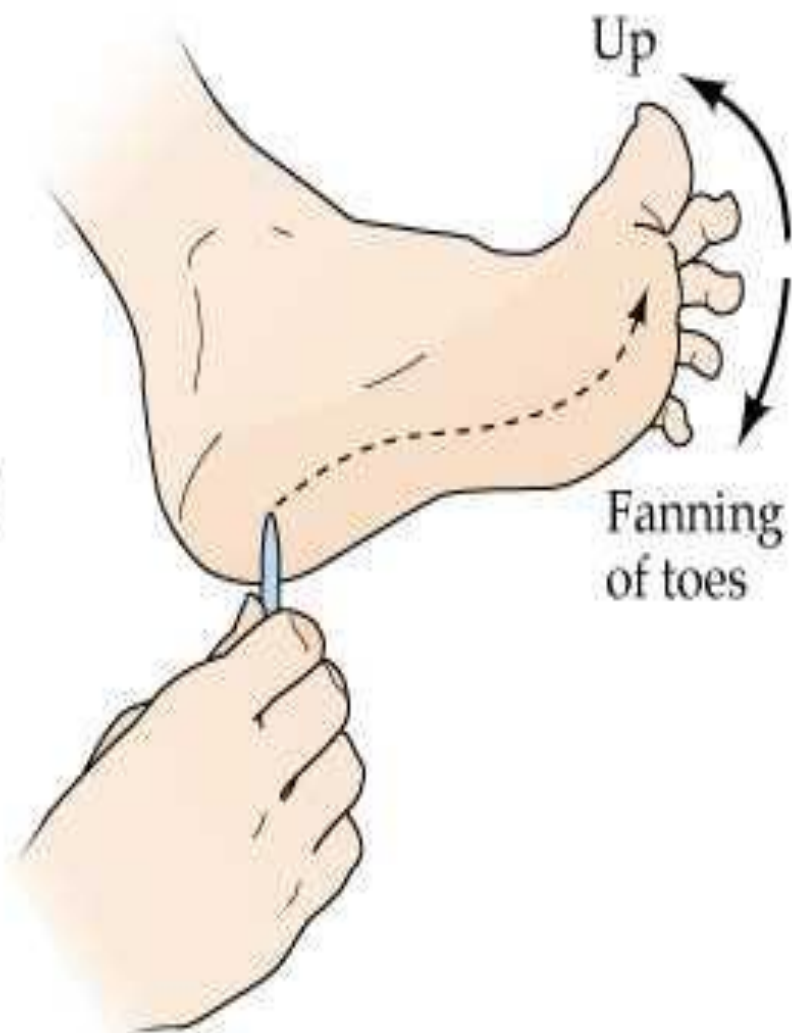
More affected areas

Signs of central paralysis are the following:

- **decrease of the active range of motion;**
- **decrease of passive movements;**
- **diminution of strength and loss of fine motor activity;**
- **spasticity, a velocity-dependent change in muscle tone;**
- **hyperreflexia (increased tendon reflexes) and clonus;**
- **loss or decrement of superficial abdominal reflexes;**
- **pathological reflexes;**
- **little, if any, muscle atrophy;**
- **absence of fasciculations or fibrillations;**
- **absence of reaction of muscle degeneration.**



Normal plantar response



Extensor plantar response
(Babinski sign)

Signs of flaccid paralysis are the following:

- **decrease of active movements;**
- **increase of passive movements;**
- **paresis or paralysis; weakness is limited to segmental or focal pattern, root innervated pattern;**
- **diminution of muscle strength;**
- **hypotonia or atonia;**
- **areflexia or hyporeflexia;**
- **normal superficial reflexes;**
- **atrophy of the affected muscles;**
- **fibrillations and fasciculations;**
- **reaction of muscle degeneration in an electromyogram.**



Flaccid paralysis of the right leg

The extrapyramidal system is a neural network in the hemispheres and brainstem involved in the central control of movements without the participation of the corticospinal, or pyramidal, system. It also includes nigrostriatal pathway, the reticular formation, the basal ganglia, the cerebellum.

The extrapyramidal system plays an important role in:

- coordination of movements;**
- maintenance and arrangement of regular muscle tone;**
- regulation of involuntary automatic movements.**

The extrapyramidal system also guarantees:

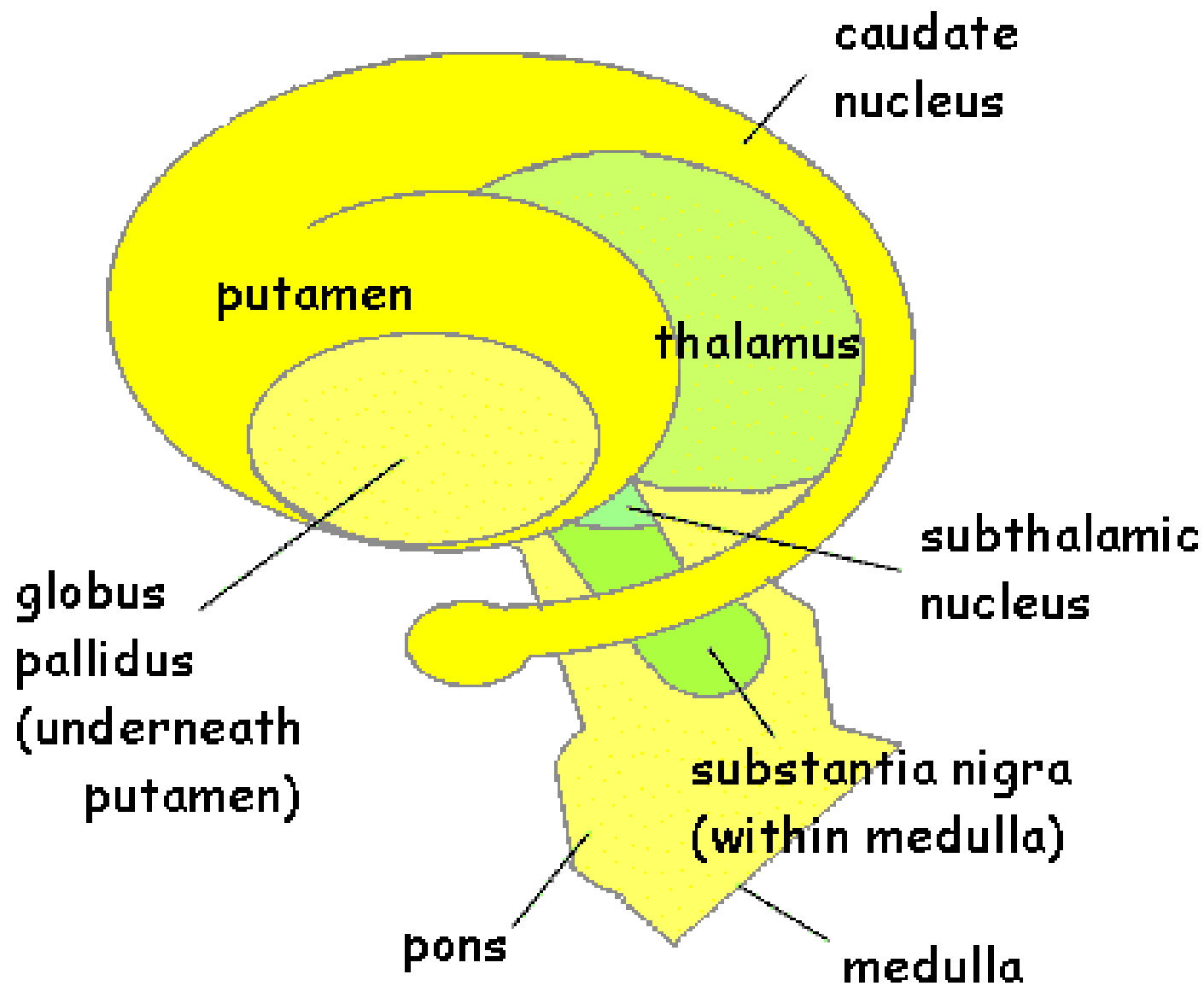
- ability of muscular system to perform voluntary movements;**
- maintenance of posture and muscle tone.**

Basal ganglia include the following:

- **caudate nucleus;**
- **lenticular nucleus, which consists of the putamen and globus pallidus (external and internal).**

The caudate nucleus and the putamen form the striatum.

The globus pallidus, the substantia nigra, the nucleus ruber, the subthalamic nucleus form the Pallidum, which is filogenetically older than the Striatum.



Basal ganglia

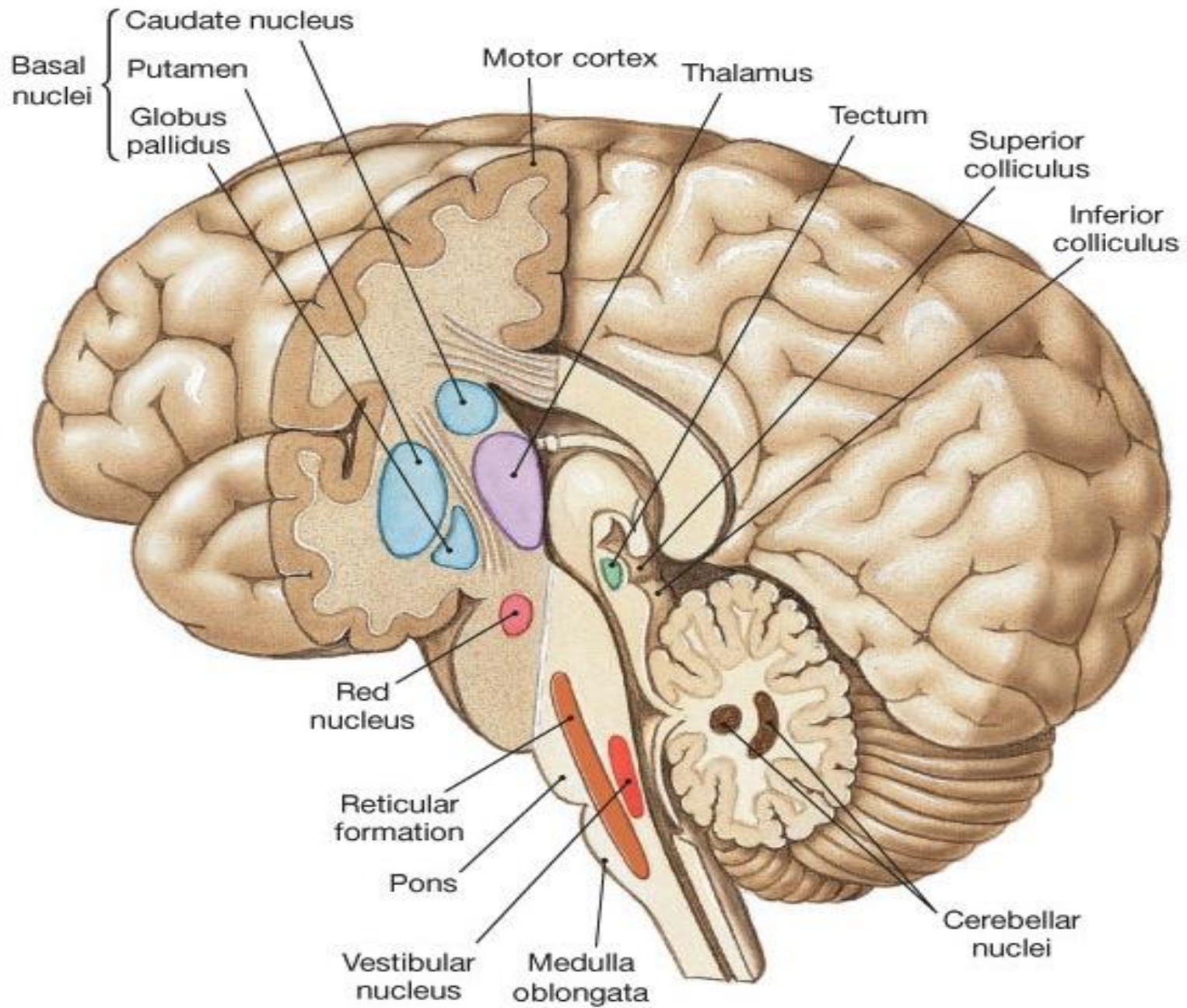
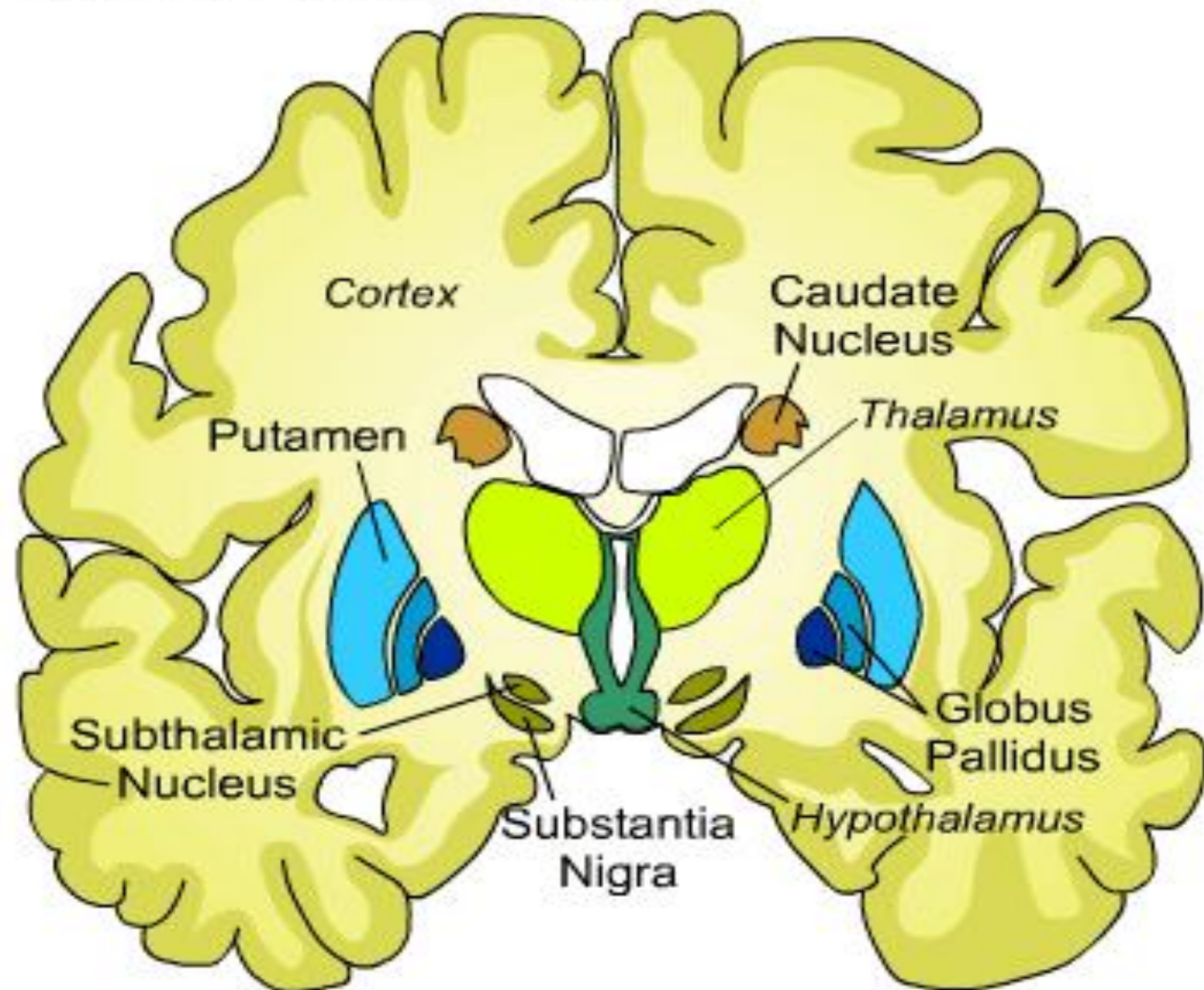


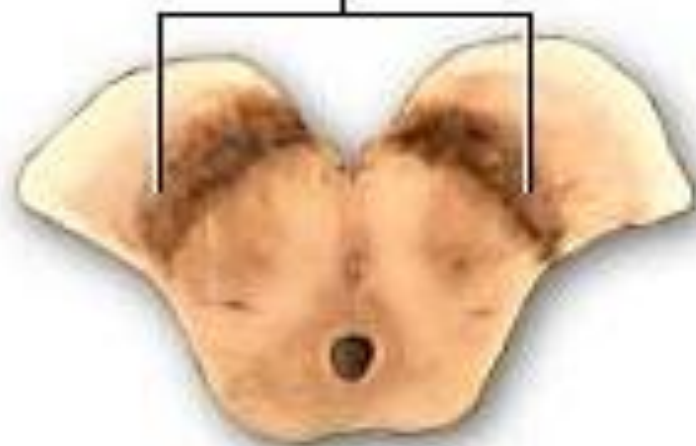
Figure AB-18: Basal Ganglia



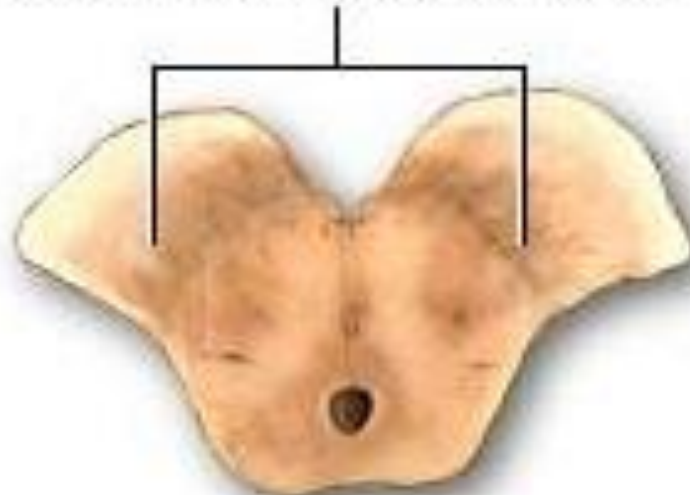
Symptoms of pallidum dysfunction

The globus pallidus, the substantia nigra, the nucleus ruber, the subthalamic nucleus lesion causes hypertonic-hypokinetic syndrome (hypokinetic rigid syndrome/HRS) that leads to the Parkinson's disease or parkinsonian syndrome (parkinsonism).

Substantia nigra



Diminished substantia nigra as seen in Parkinson's disease



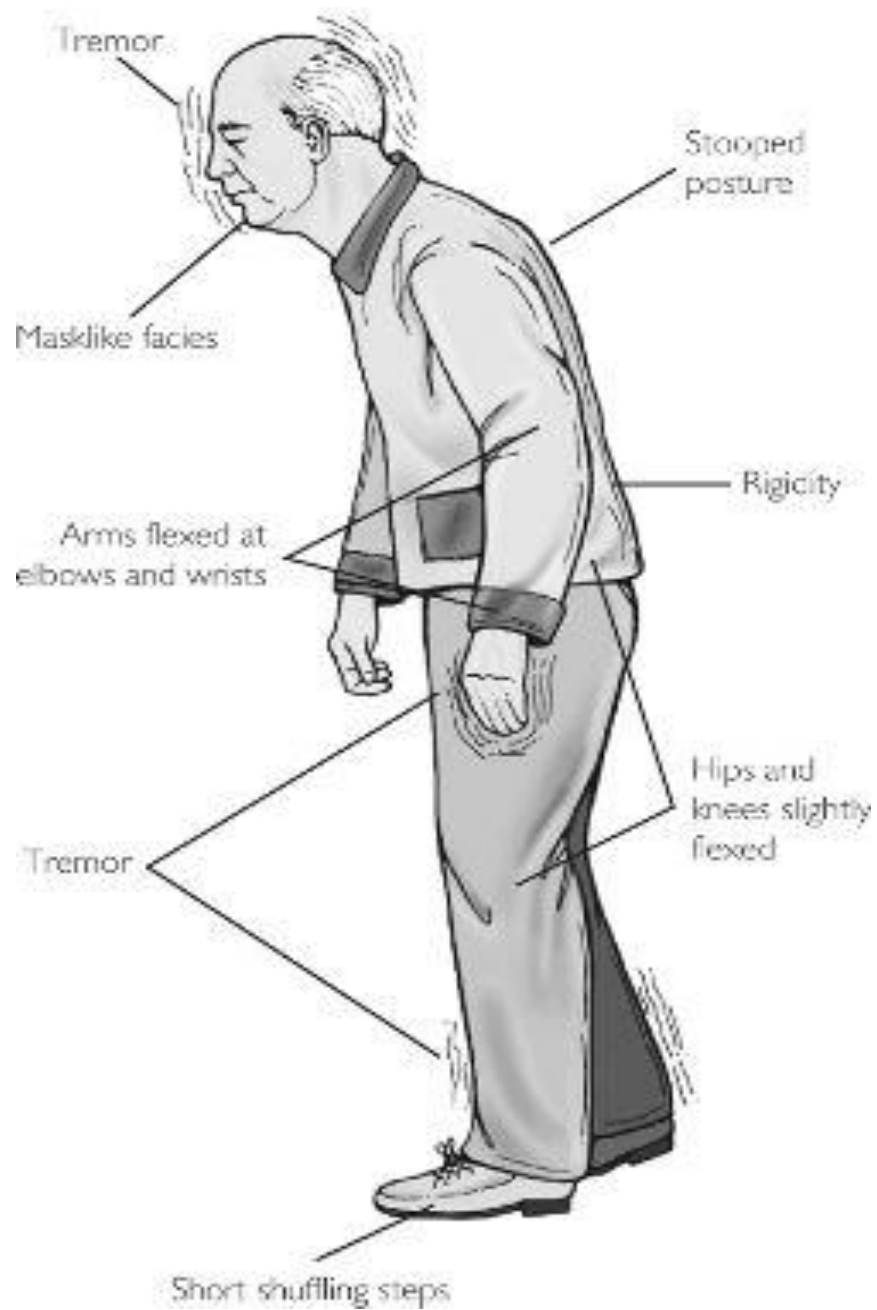
Dopamine levels in a normal and a Parkinson's affected neuron.



Hypokinetic rigid syndrome is represented by a spectrum of disorders:

- **rigidity, or increased tone — i. e, increased resistance to passive movement. In some instances, the rigidity in parkinsonism is described as «cogwheel» rigidity because of ratchetlike interruptions of passive movement that may be due to the presence of tremor;**
- **a reduction of voluntary movement — oligokinesia, and its slowness- bradikinesia;**
- **akinesia (inability to initiate movement) and akathisia (inability to remain motionless);**

- **the reduction or loss of involuntary symmetrical movements (synkinesis), such as swinging the arms while walking;**
- **a forward-flexed posture — definitive pose of the patient;**
- **festination, shuffling gait;**
- **tendency to fall forward (propulsion), backwards (retropulsion) or sideward (lateropulsion);**
- **changes in speech: microphonia, soft, faint and hard to understand, the uncontrollable repetition of words (perseveration);**



- **writing changes: writing may appear small (micrography) and become difficult to perform;**

Catherine Nitzger

13 October 1869

- **the patient`s face is relatively immobile (masklike face, «stone face», expressionless face);**
- **tremor: begins distally (fingers, hands, forearm), can involve chin and mouth; pill rolling (4-8 Hz); resting tremor (less prominent with movement);**
- **seborrhea faciei, hypersalivation; excessive sweating (hyperhidrosis);**
- **kinesia paradoxa (patient can perform rapid movements while being in a state of general stiffness).**

Parkinson's Disease



Bradykinesia
(as seen in toe tapping)



Cogwheel Rigidity



Resting Tremor
(pill rolling tremor)

Other motor features:



Shuffling Gait



Mask-like Expression



Postural Instability

Striatum disfunction symptoms

The striatum (caudate nucleus and putamen) lesion causes hypotonic-hyperkinetic syndrome.

Facial paraspasm — is a spasm of facial, mouth, tongue, and soft palate muscles



FIG. 2 *Blepharospasm and spasm of jaw closure and mouth-pursing in a 61 year old lady with symptoms for three years.*



FIG. 3 *Spasm of jaw opening and mouth retraction in a 65 year old lady with symptoms for four years.*

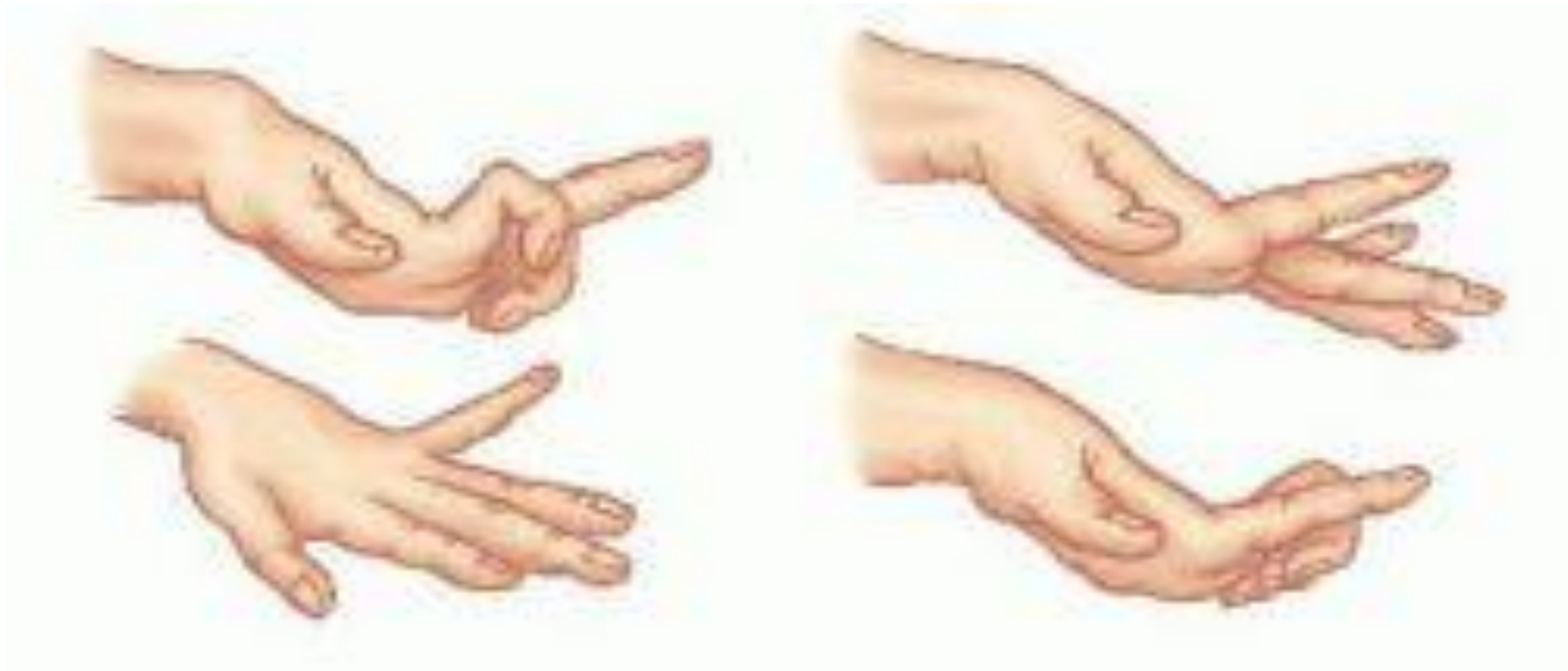
Chorea is characterized by brief, semi-directed, irregular movements of face, tongue and soft palate muscles that are not repetitive or rhythmic but appear to flow from one muscle to the next.



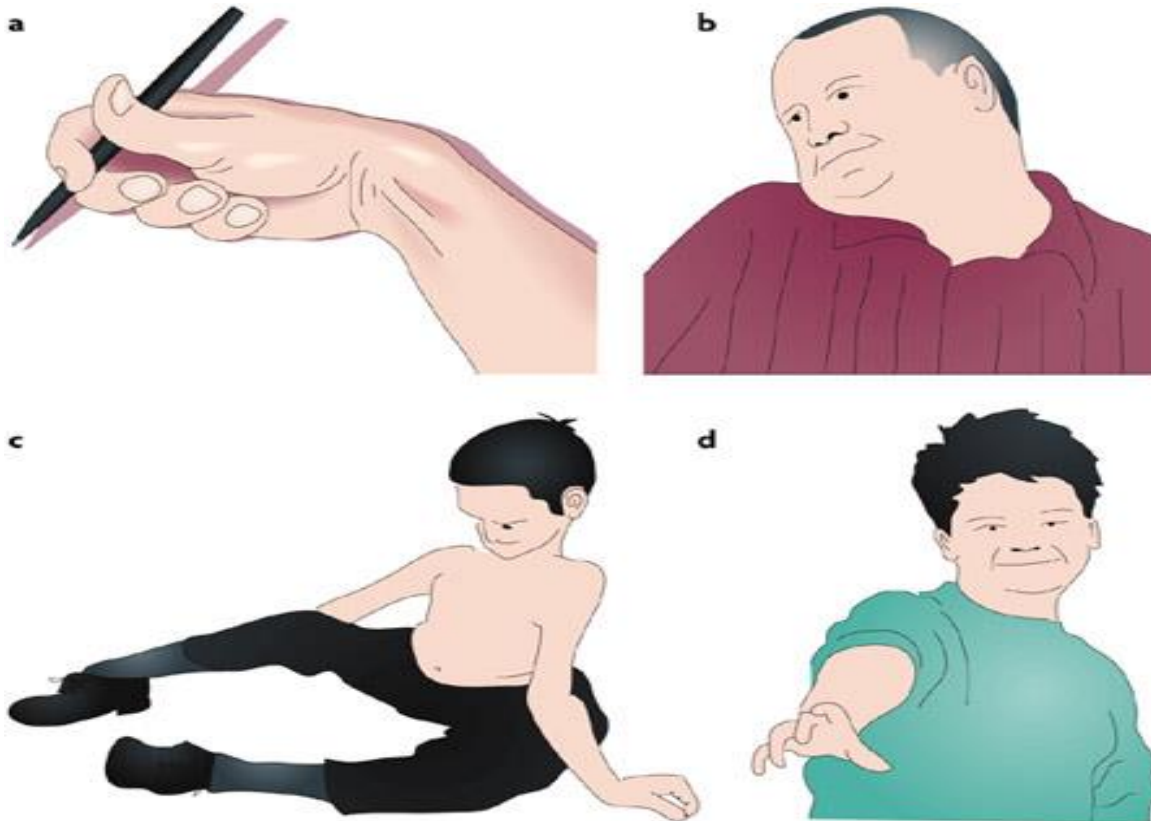
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Athetosis is a symptom characterized by repetitive involuntary, slow, sinuous, writhing movements, especially severe in the hands.



Dystonia is a neurological movement disorder, in which sustained muscle contractions cause twisting and repetitive movements or abnormal postures, which subside in a state of rest.



Hemiballismus is usually characterized by involuntary violent, flinging movements of extremities on one side of the body.



Myoclonus is a brief, involuntary twitching of a muscle or a group of muscles, aggravating during movement and subsiding in a state of sleep.

Tic disorders are characterized by the persistent presence of tics, which are abrupt, repetitive involuntary movement of certain muscular groups.

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