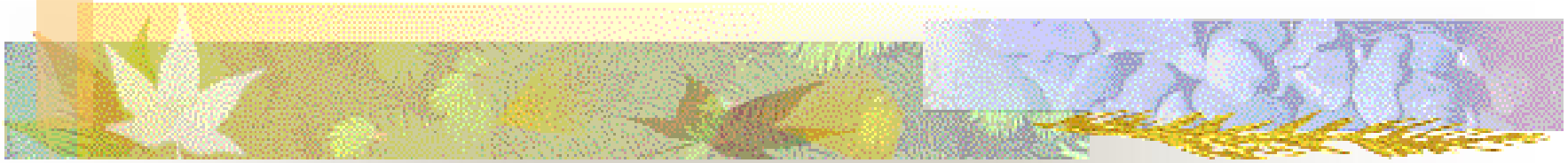
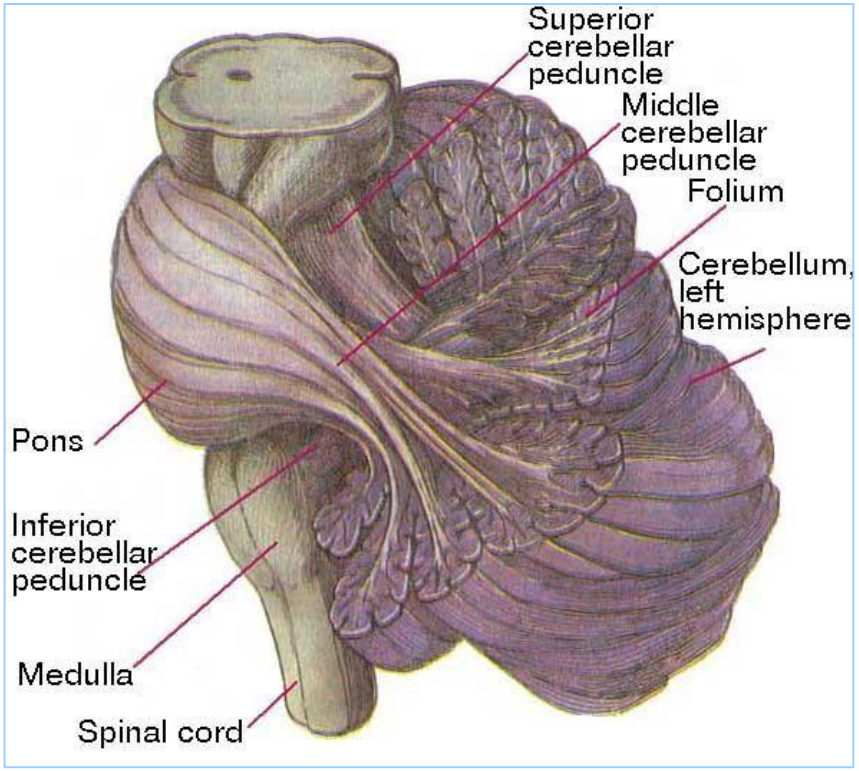
Role of different levels of CNS in motor function regulation. (III)



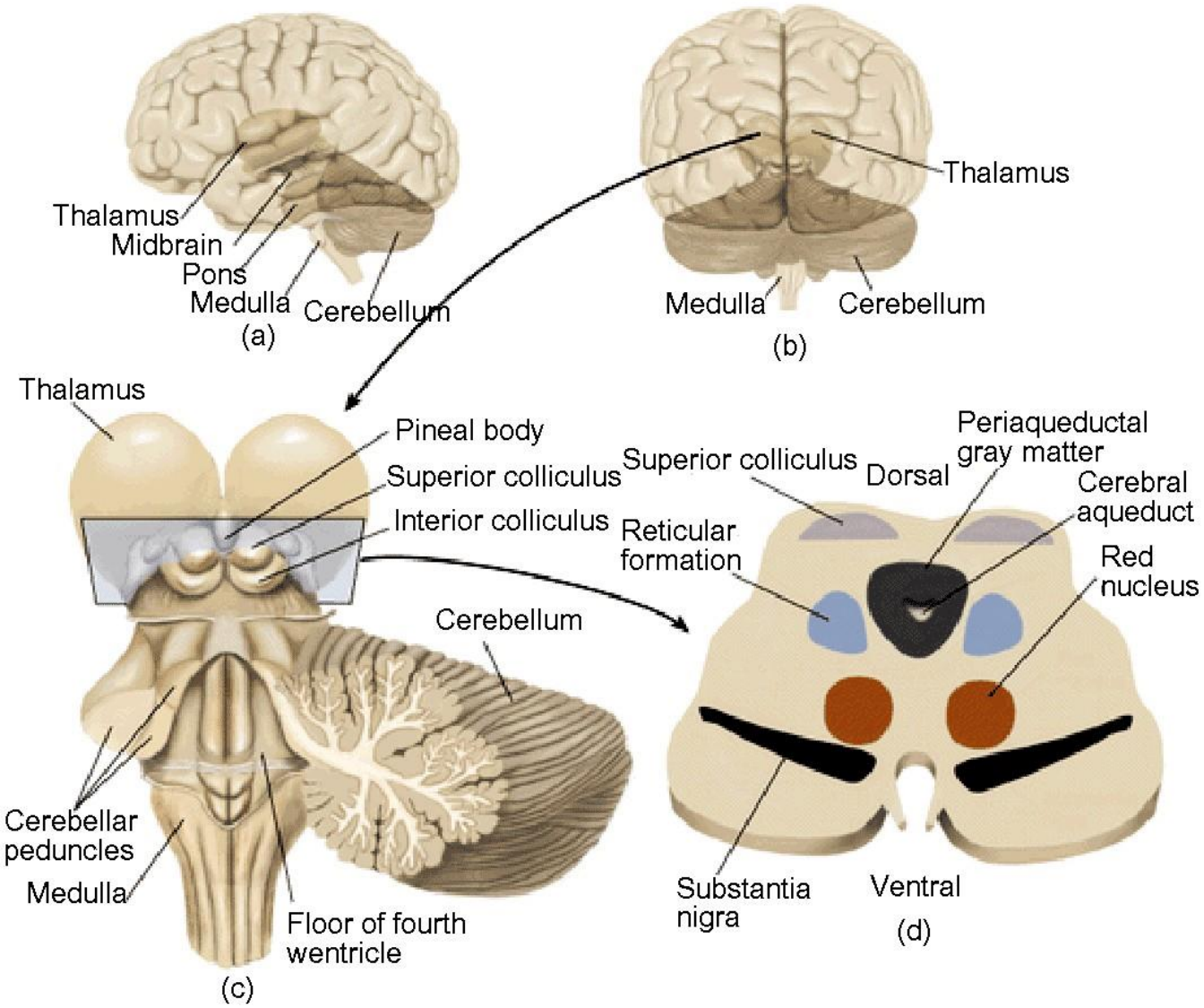
Prof. Zaporozhets
T.Viber +380972420098

Structural organization of cerebellum

- It is located above medulla oblongata and pons cerebri. It consists of two hemispheres, vermis and three pedunculi pairs (nervous fibers).
- Hemispheres are divided into **anterior** and **posterior lobes**. They consist of cortex of cerebellum and nuclei (nervous cells).
- Superior peduncles connect with midbrain, middle peduncles connect with pons, inferior peduncles connect with medulla oblongata.



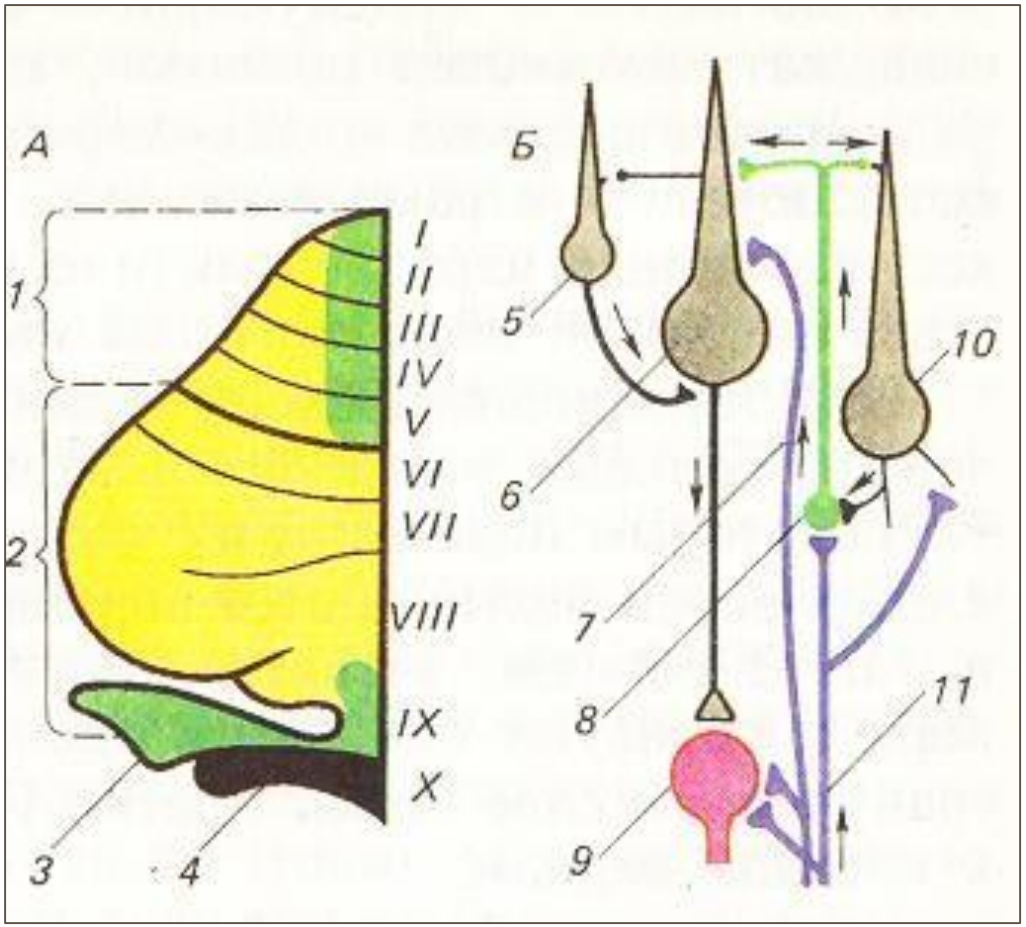
► **Cerebellum and Brain Stem. (a) Lateral View. (b) View from Back. (c) Dorsal View. (d) Cross Section of Midbrain**



NEURONIC STRUCTURE OF A CEREBELLUM CORTEX

The cortex consists of three layers:

- 1-st – molecular;
- 2-nd – ganglionic;
- 3-rd – granular.

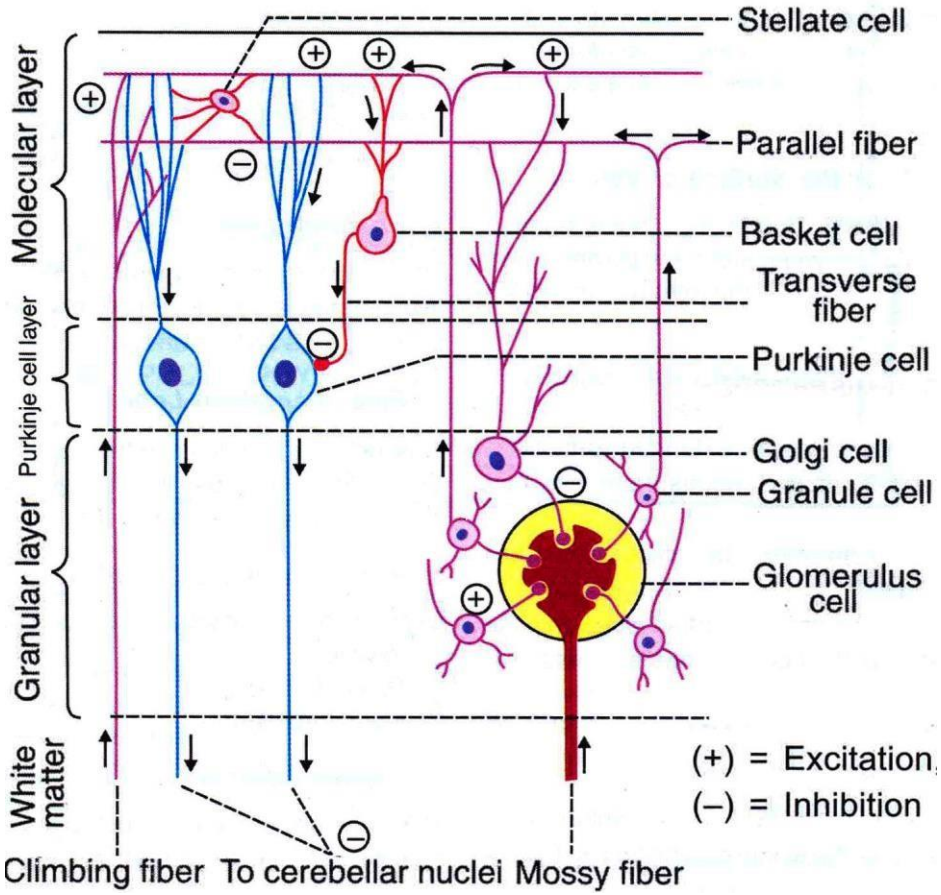


NEURONIC STRUCTURE OF CEREBELLAR CORTEX

The cortex consists of three layers:

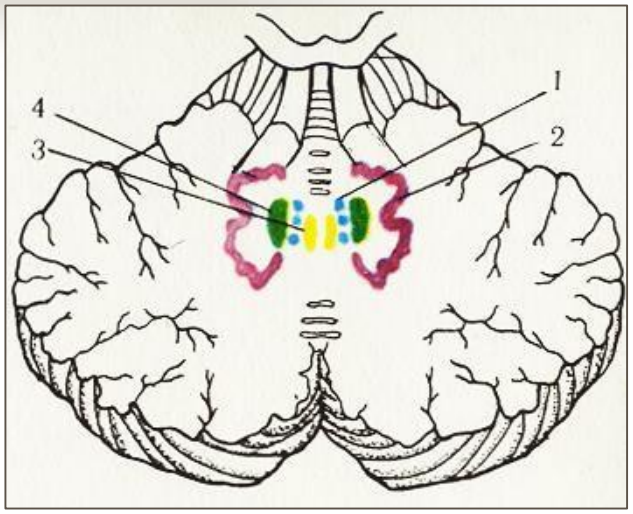
- 1-st – molecular: dendrites of Purkinje cells, piriform cells (Purkinje's cells), bodies of basket cells, stellate cells.
- 2-nd – ganglionic: bodies of piriform cells;
- 3-rd – granular: bodies of association [intercalary, internuncial] neurons.

Two types of afferent fibers (climbing and mossy) come to cortex.

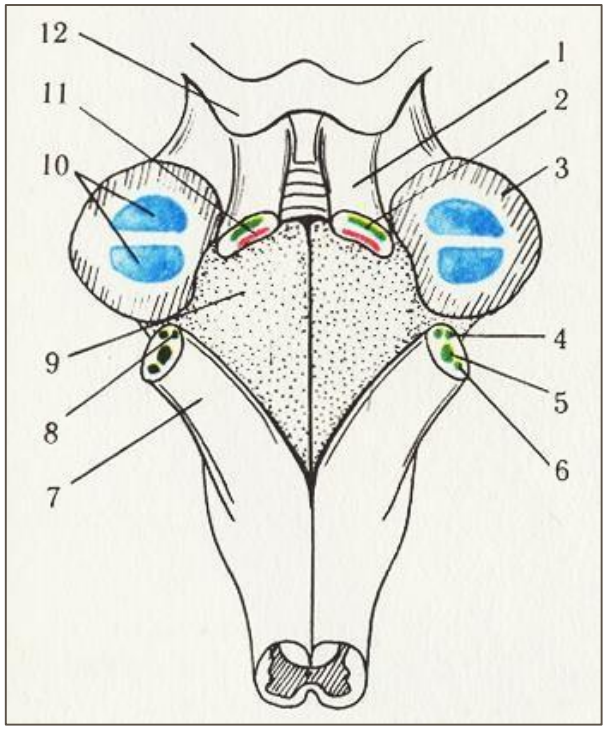


Structure of cerebellar cortex

There are nuclei in white matter of hemisphere and vermis of cerebellum:
fastigial (3),
globosus (1),
emboliformis (4),
dentatus nuclei (2).



Pedunculi of cerebellum are conductive ways.
Upper (1) are directed to corpora quadrigemina of midbrain;
middle (3) bind cerebellum to pons;
inferior (7) bind with medulla oblongata.



Somatotopic projection in cortex of vermis and hemispheres of cerebellum

Collector of afferent impulses in cerebellum is fastigial nucleus, which sends them to piriform neurones (Purkin'e cells) of cerebellar cortex according to the somatic projection.

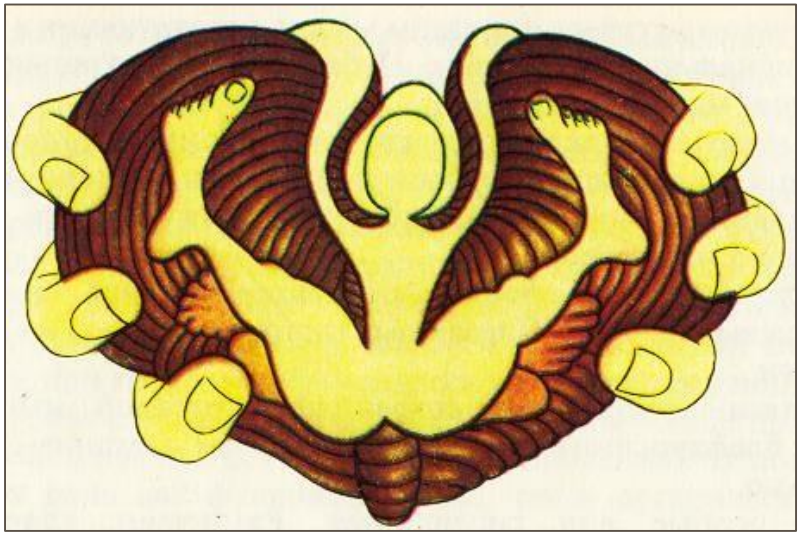
Upper extremities are represented in anterior departments of hemispheres;

Inferior ones are represented in posterior departments,

Head and neck are represented in anterior parts of *vermis cortex* and **trunk** is represented in posterior part.

The **proximal parts** of extremities are projected more medially, **distal parts** – more laterally.

Hemispheres are responsible for coordination of movements of extremities, **vermis** – of trunk.

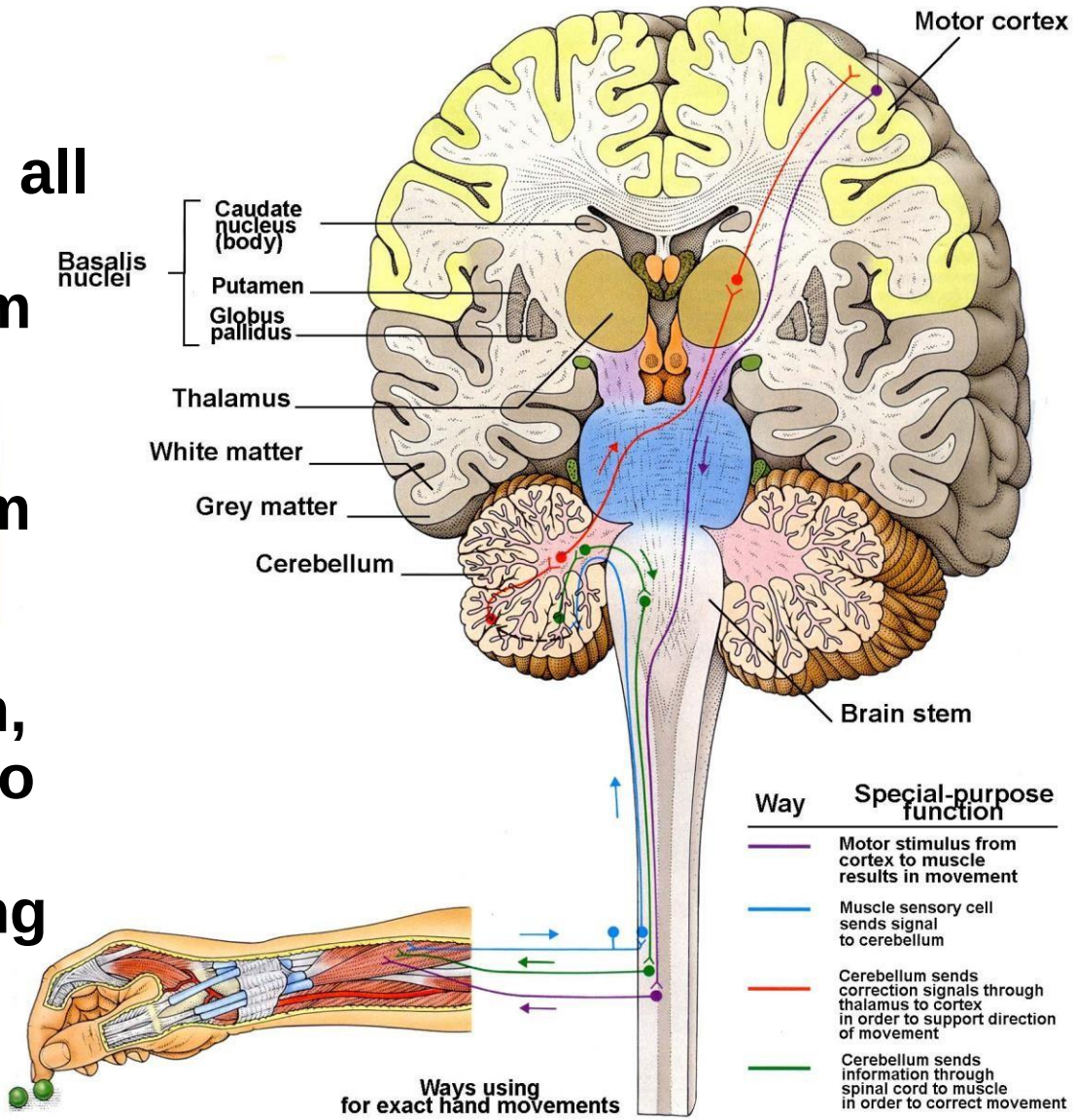


Functions of cerebellum

1. Center of movements coordination.
2. Control of posture and muscle tone.
3. Senso-motor coordination of posture and purposive movements.
4. Participation in arbitrary movements and coordination of fast (phasic) and slow (tonic) components of motor act.
5. Coordination of fast purposive movements.

Cerebellum and it connections

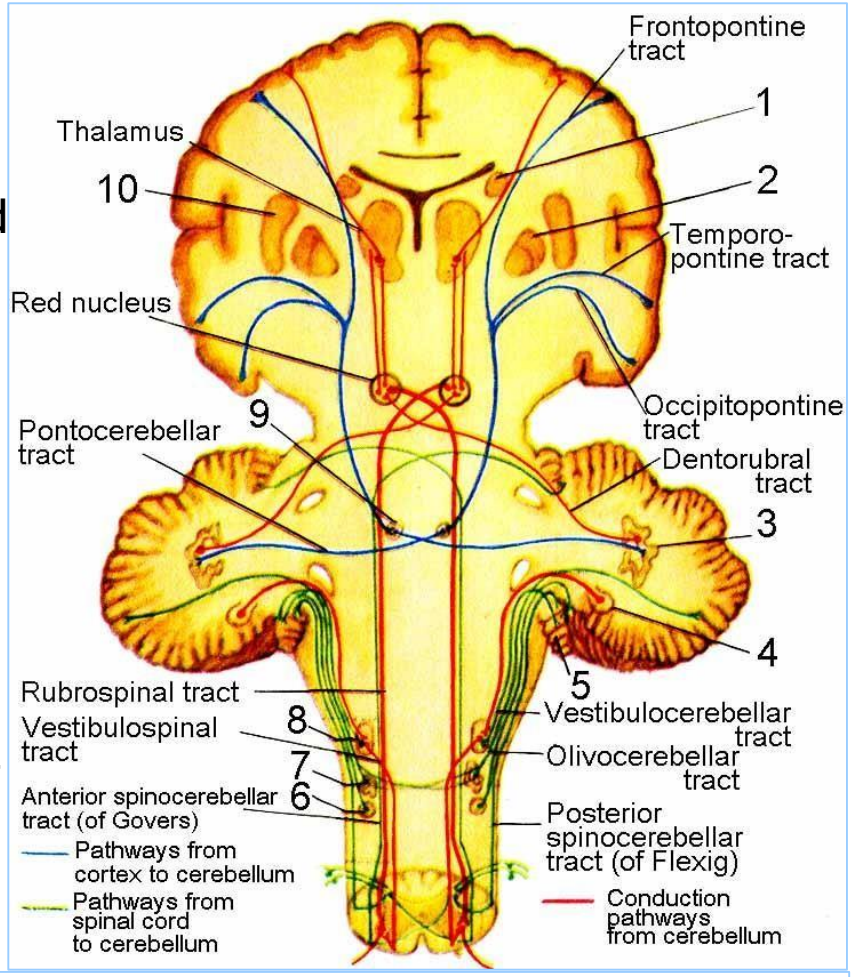
Cerebellum receives afferent impulses from all receptors stimulating during movement (from proprioreceptors, vestibular, visual, and acoustical). Cerebellum influences onto red nucleus and reticular formation of brainstem, which send impulses to spinal cord gamma-motoneurons regulating muscle tone.



THE BASIC AFFERENT TRACTS TO CEREBELLUM

Posterior and anterior spinocerebellar tracts (of Flexig and of Govers respectively) conduct the impulses from proprioreceptors to spinal nodes (1-st neuron), axons of which enter in spinal cord through posterior roots.

- In the base of posterior roots there are 2 neurons, from which spinocerebellar tracts begin.
- Tract of Flexig goes up to medulla oblongata in lateral cord without crossing and consisting of inferior pedunculi it reaches vermis of cerebellum.
- Tract of Govers transfers to the opposite side, passes spine, medulla oblongata, pons and consisting of superior pedunculi it enters in vermis of cerebellum. It makes a decussation twice.



Afferent and efferent connections of cerebellum:

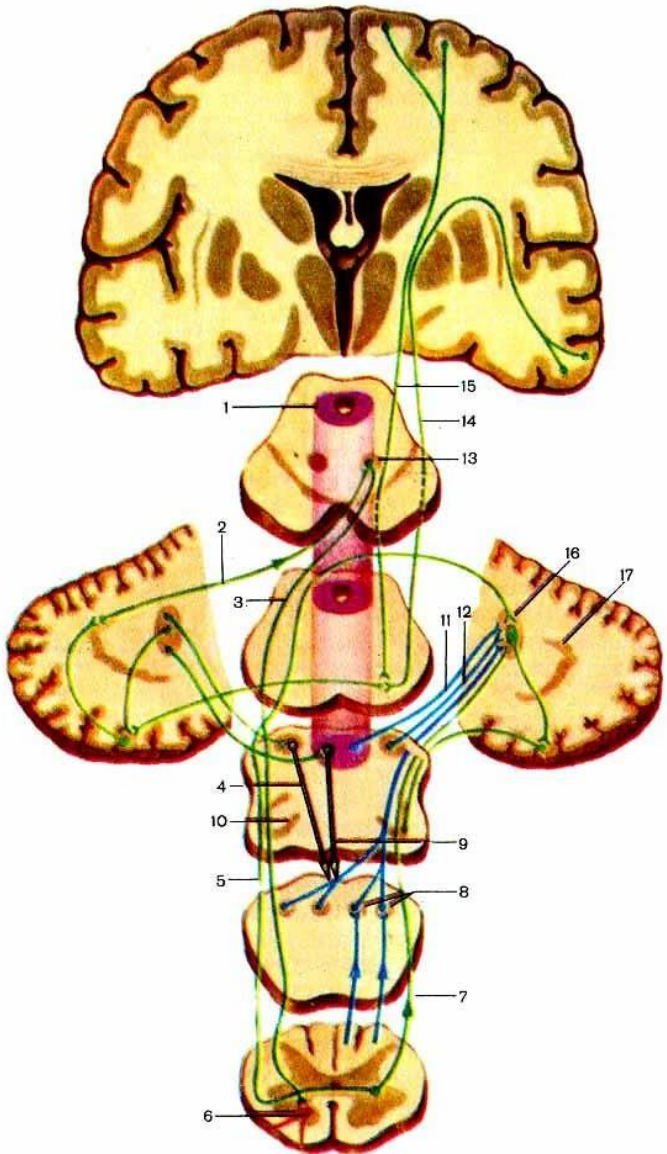
1 – caudate nucleus, 2 – globus pallidus, 3 - dentatus nucleus, 4 – flocculus , 5 – vermis, 6 – posterior column nuclei, 7 – inferior olive, 8 – vestibular nuclei, 9 – pons nuclei, 10 – putamen.

AFFERENT CORTICOCEREBELLAR TRACTS

Fronto-ponto-cerebellar and occipito-temporo-ponto-cerebellar pathways consists of two-neurons. Axon of the 1-st neuron comes from the upper parts of frontal lobe to internal capsule; it ends in own nuclei of pons on its side, axon of the 2-nd neurone begins from own nuclei of pons.

At pons base level it is crossed and through medium pedunculi goes to cerebellar cortex. Thus big hemispheres are connected to opposite hemispheres of cerebellum.

In case of a lesion of big hemispheres cortex coordination disorders arise on the side, opposite to the locus.

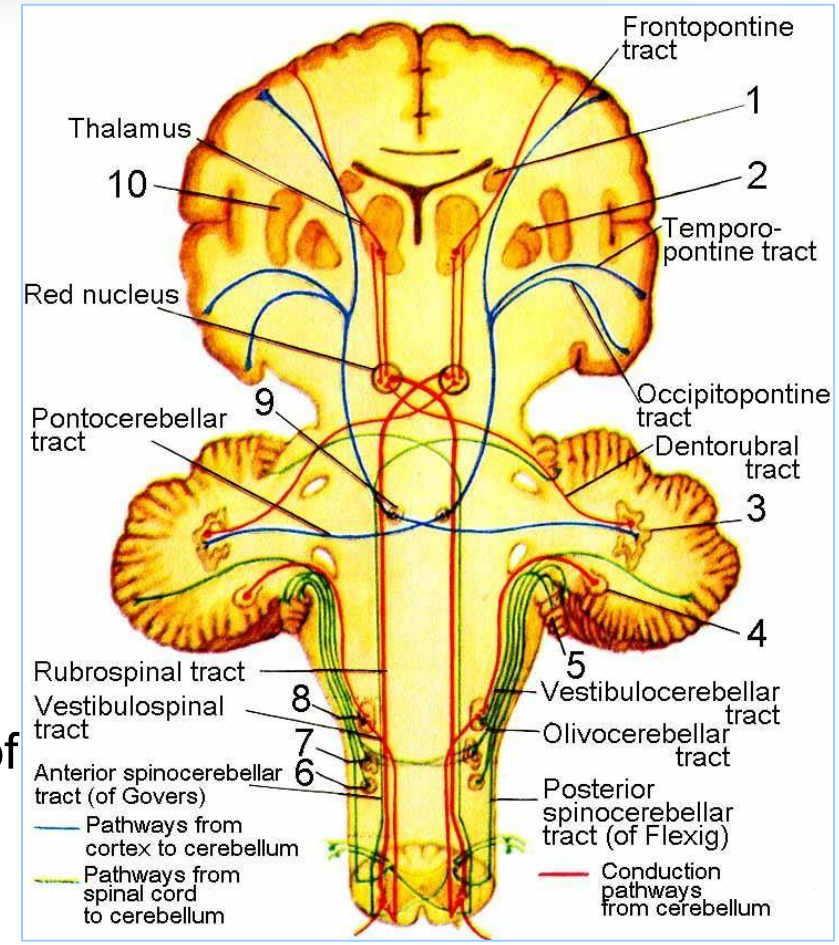


EFFERENT TRACTS:

dentorubrospinal tract

It passes from dentate nucleus to red nucleus of opposite side (decussation of Vernekink). Part of fibers goes from red nucleus to thalamus and big brain. Other part consisting of nuclear-spinal tract (of Monakov) again transfers to the opposite side (decussation of Forel), goes through stem in lateral funicle, runs out at cells of peripheral motor neuron. That is why in case of cerebellar hemispheres lesion coordination disorders arise on the side of the focus.

Cerebellum has own connections with vestibular system and reticular formation.

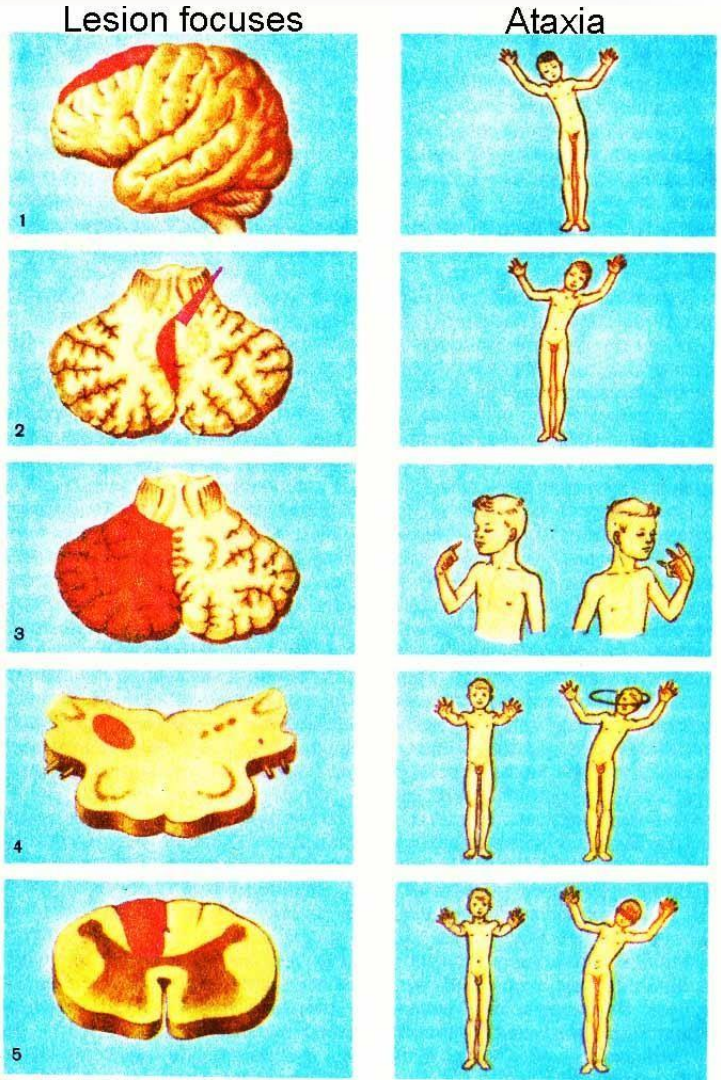


Afferent and efferent connections of cerebellum:

1 - caudate nucleus, 2 - globus pallidus, 3 - dentatus nucleus, 4 - flocculus, 5 - vermis, 6 - posterior column nuclei, 7 - inferior olive, 8 - vestibular nuclei, 9 - pons nuclei, 10 - putamen.

SIGNS OF A CEREBELLUM LESION

- **Static ataxy** – it is infringement of statics in rest (shaking).
- **Dynamic ataxy** is locomotion coordination disturbance during performance of targeted movements. A tremor of extremities – so-called ***intentional tremor*** – is observed. Walking is shaky, “drunk”.
- Cause of cerebellar ataxy is the infringement of conjugative work of muscles – agonists and antagonists, disproportion of movements – **dysmetria**. Rapid change of one movement by others, inverse ones – **adiadohokinesis** (pronation and supination) is impeded.



Cortex, cerebellar, vestibular and spinap ataxia.
Lesion focuses: 1 – superior frontal gyrus at the left, 2 – cerebellar vermis at the left, 3 – left cerebellar hemisphere, 4 – left vestibular nuclei, 5 - posterior column of spinal cord at the left.

SIGNS OF A CEREBELLUM LESION

continuation

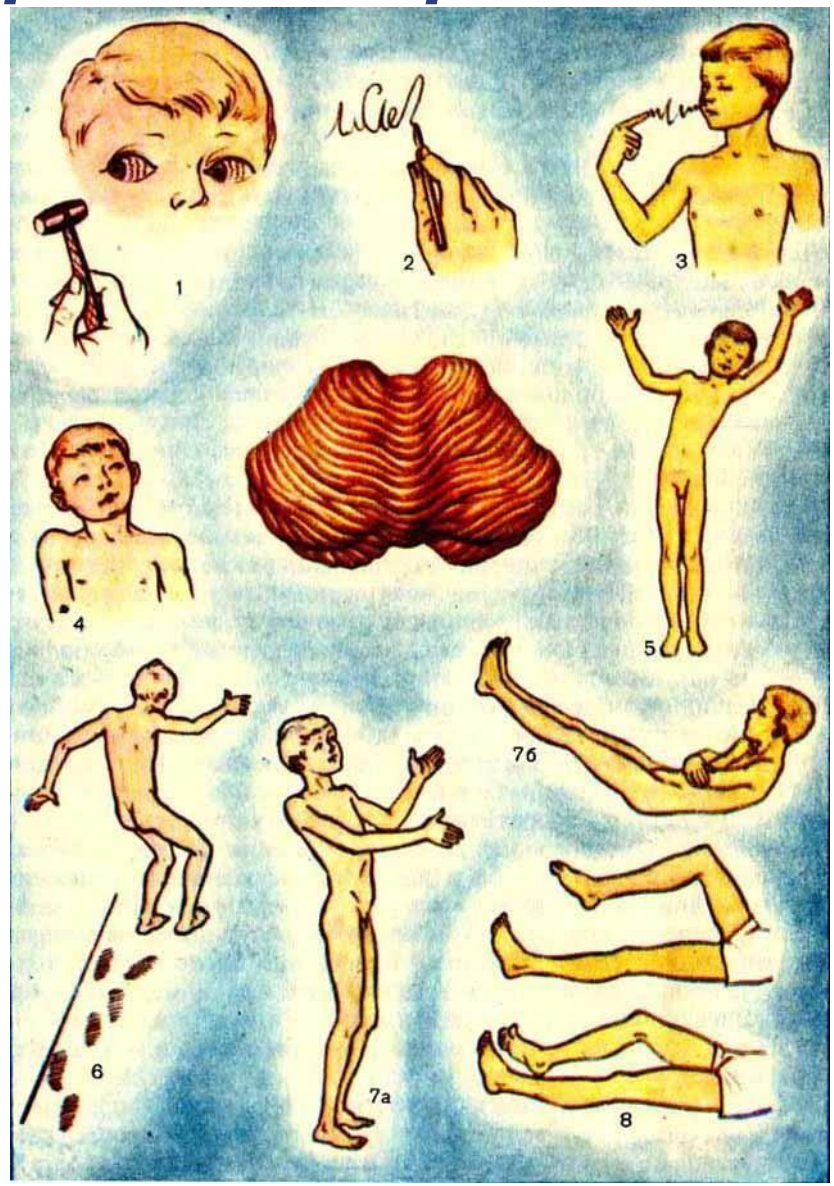
- Asynergia is disturbance of mutual conjugated movements.
- Atony is loss of muscle tone (anterior part of cerebellar posterior lobe is responsible).
- Astasia is impaired ability to stand.
- Tremor is trembling of the head, arms and legs

The excision of cerebellum does not cause the disappearance of reflectory responses; tonic reflexes of brainstem are non-changed.

Tests for an examination of cerebellar functions.

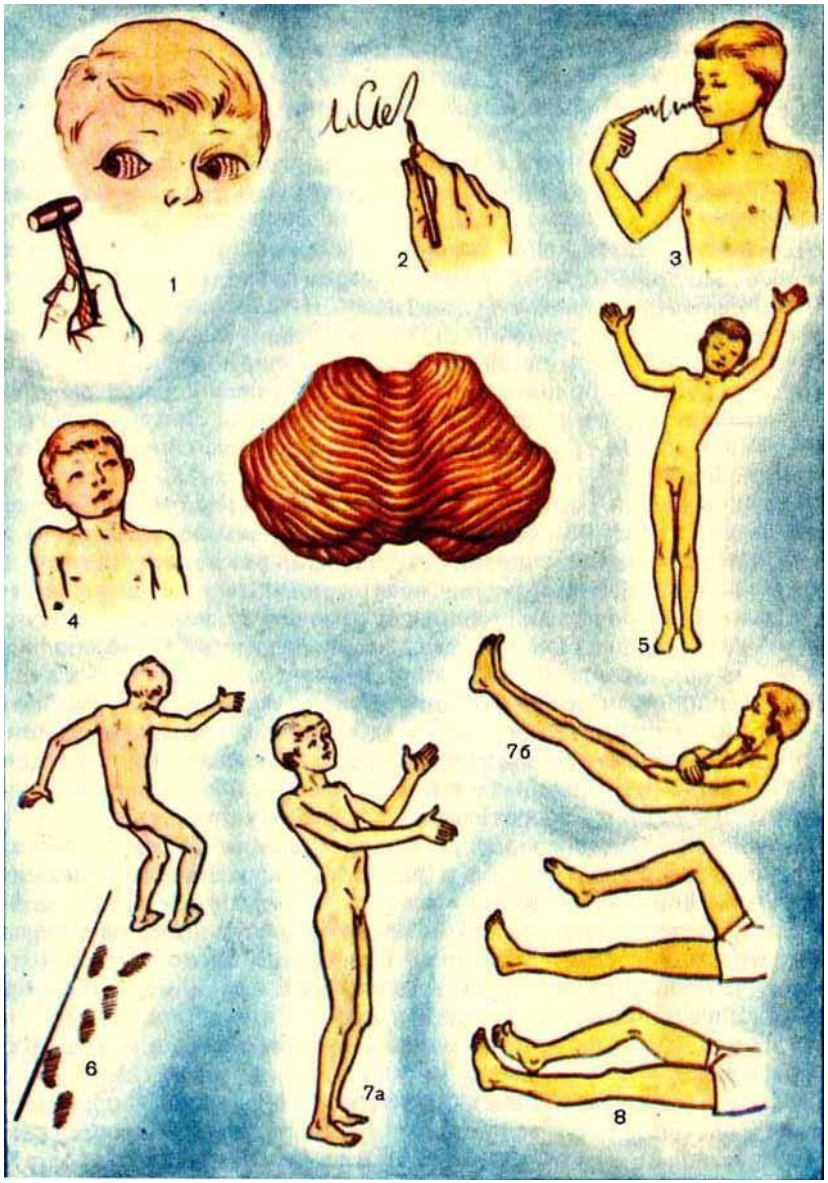
Examination of coordination and dynamic ataxy

- **Romberg's test** is the examination of equilibrium in rest. Ataxias arise at a lesion of spinal cord posterior funicles and vestibular apparatus. In case of a cerebellar hemispheres lesion the patient is inclined to the side of a lesion focus. In case of a lesion of big hemispheres cortex patient falls to the side opposite to the focus.
- **Phalanx walking** is step-by-step movements sideways. In case of a lesion leg are excessively extended and are thrown out forward.



Tests for an examination of cerebellar functions. *Examination of coordination and dynamic ataxy*

- **Finger-nose test** (digitonasal sign) – locomotor ataxia, dysmetrias, tremor of fingers are detected.
- **Genucalcaneal (heel-knee) test** – presence of locomotor ataxia and dysmetrias of lower extremities are detected.
- **Diadochokinesia test** – synchronism and uniformity of movements are detected. On the side of a cerebellum lesion the lag of extremities is determined.



Examination of asynergia

- **Babynsky test**. In reclining position with crossed arms it is necessary to get up. At a cerebellum lesion leg rise, and the body is remained to lie.
- **Ozhehovsky test**. Support by palms of stretched arms should be done. In case of sudden disappearance of support the examinated person in norm is inclined back, the patient falls forward.
- **Stuart-Holms test.** Forearm and hand are in position of pronation, hand is clenched in fist. The doctor tries to extend patient's forearm. Healthy person's muscles-antagonists contract quickly and stroke is prevented.

In case of cerebellum lesion

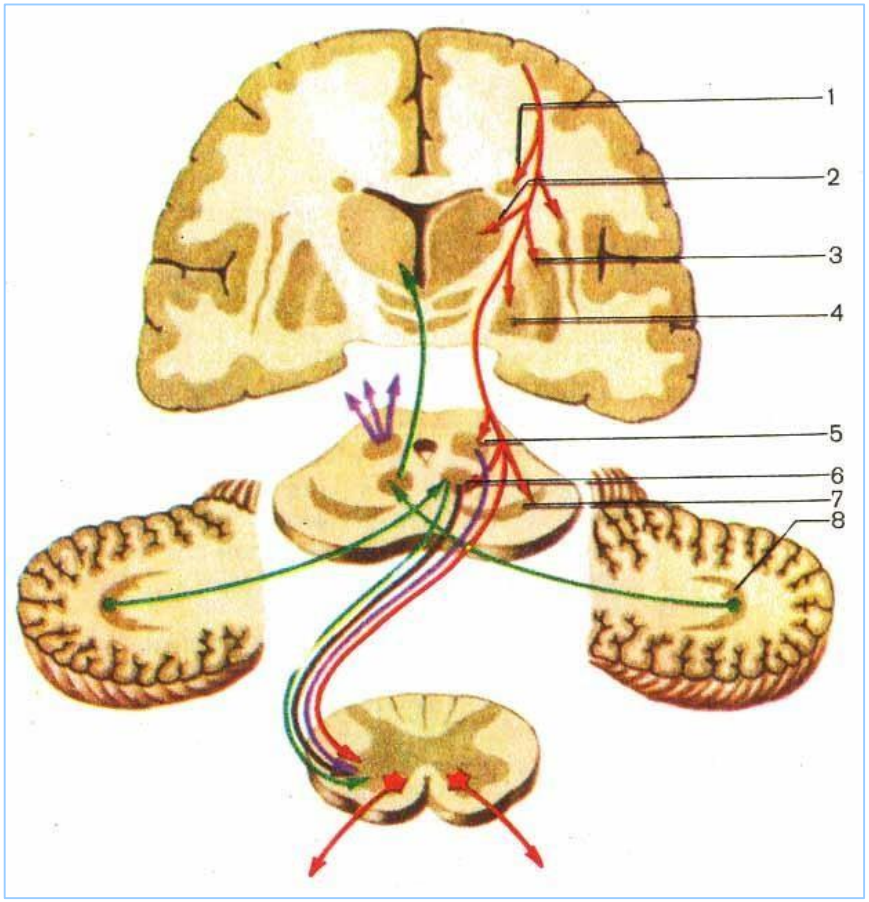
- **Speech** is slowed, explosed (loss of smoothness), scanding (accents are not on necessary syllable) (dysarthria).
- **Nystagmus** is more often horizontal.
- **Hypomyotonia** (muscular hypotonia). Volume of movements is enlarged.
- **Handwriting** disorder is observed. Handwriting is irregular, bold (macrography).

Extrapyramidal part of nervous system

Strio-pallidal part

Extrapyramidal system includes structures of big hemispheres cortex, subcortical ganglions, cerebellum, reticular formation, descending and ascending tracts.

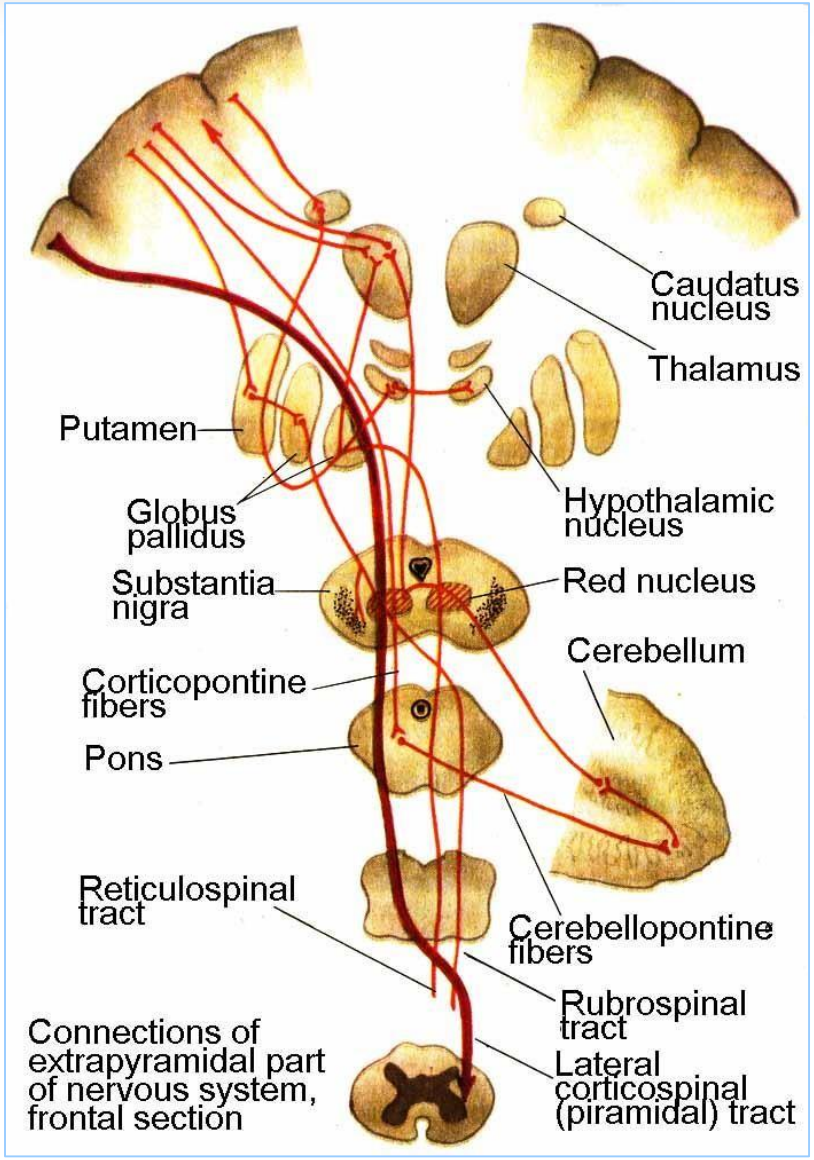
Functions: it provides involvement of all motor systems of brain, perfects movements making them economic and automatic.



Strio-pallidal system:
Striatum (more young formation) includes caudate nucleus and putamen.
Pallidum includes globus pallidus, substantia nigra, red nucleus, subthalamic nucleus.

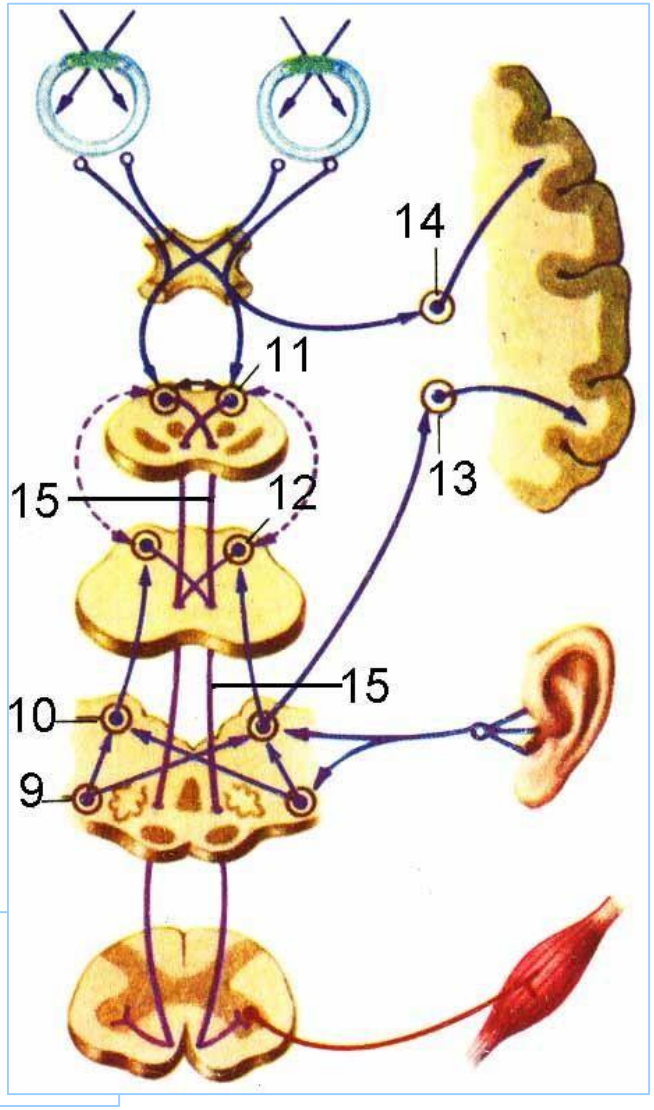
Myelination of striatal tracts comes to end of 5 month age. Newborns possess pallidal features.

Cortical center of extrapyramidal part includes premotor area (field 6), temporal and occipital areas.



Connections of strio-pallidal system

1.Tract is connecting to ending motor tract and muscle.
2.Mutual connections with various parts of extrapyramidal system and big hemispheres cortex.
3. Afferent pathways:
- rubrospinal tract of Monakov,
- reticulospinal tracts,
-tegmental-spinal tract from corpora quadrigemina,
-tracts to motor nuclei of cranial nerves.
Afferent signals from thalamus, cerebellum, reticular formation, great brain cortex create continuous corrective flow.



Extrapyramidal system. Scheme of "start-reflexes".

9 – anterior cochlear nucleus, 10 – posterior cochlear nucleus, 11 – upper mounds, 12 – lower mounds, 13 – medial geniculate body, 14 – lateral geniculate body, 15 – tectospinal tract.

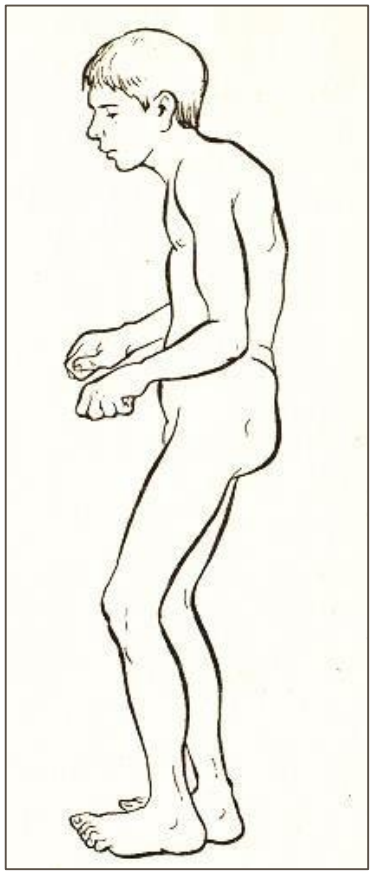
Signs of a pallidum lesion

Lesion of **pale globule and black matter** causes **parkinsonism** – hypertonic-hypokinetic syndrome.

-Total restraint, hypoexpressions of movements (hypokinesia), muscle rigidity are characteristics.

-Static tremor is present. The person has face like mask. Beginning of arbitrary movements is difficult.

-Walking is with shallow steps. Voice is quiet, monotonic. Handwriting is small.



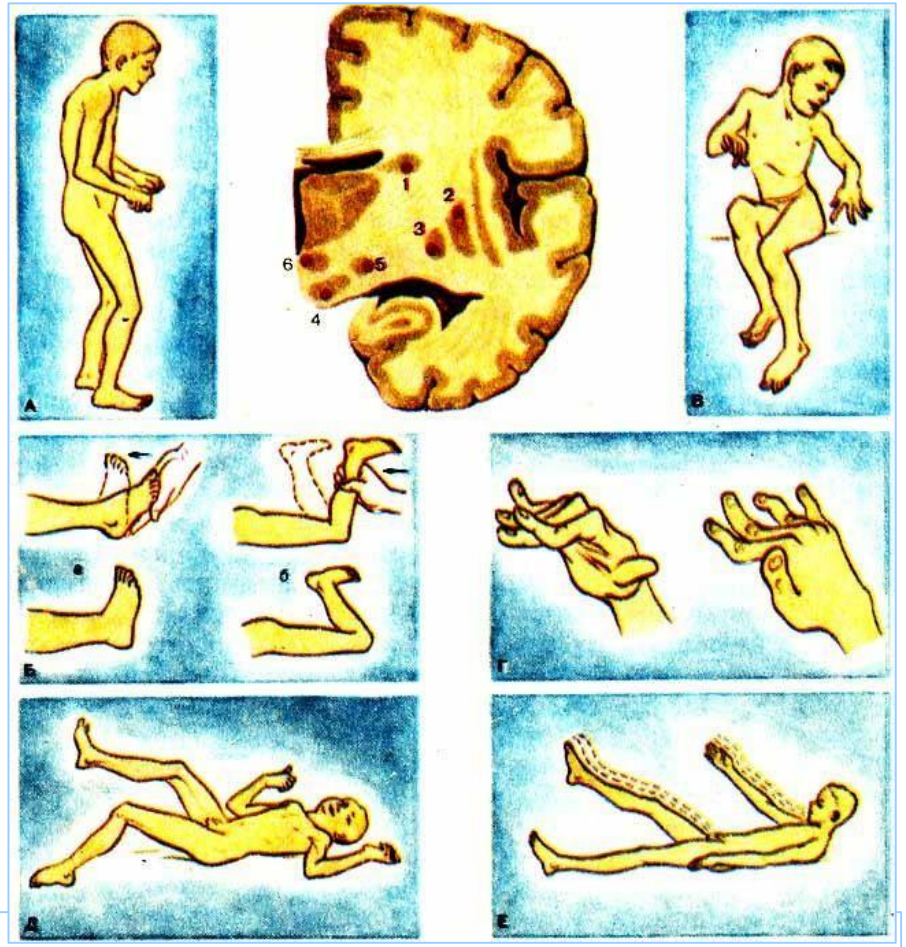
Posture of patient with parkinsonism

Signs of a striate body lesion. Striatic syndrome

Hyperkinetic-hypotonic syndrome includes hypotonia or dystonia and different non-arbitrary violent excessive movements – hyperkinesias.

Chorea is lesion of midbrain tegmentum, lentiform and caudate nuclei. Arhythmic fibrillations are typical.

Myoclonias are arhythmic and non-synchronic contractions of various muscles of trunk, abdomen.



Strio-pallidar syndromes.
А – patient's posture in case of akineticorigid syndrome; Б – postural phenomenons: а – Westphals sign; б – Foix-Th-venard sign; В – torsion hyperkinesis; Г – athetotic hyperkinesia of hand; Д – ballistic hyperkinesis; Е – hemitremor.
1 – caudate nucleus; 2 – putamen; 3 – globosus pallidus; 4 – black substance; 5 – subthalamic nucleus; 6 – red nucleus.