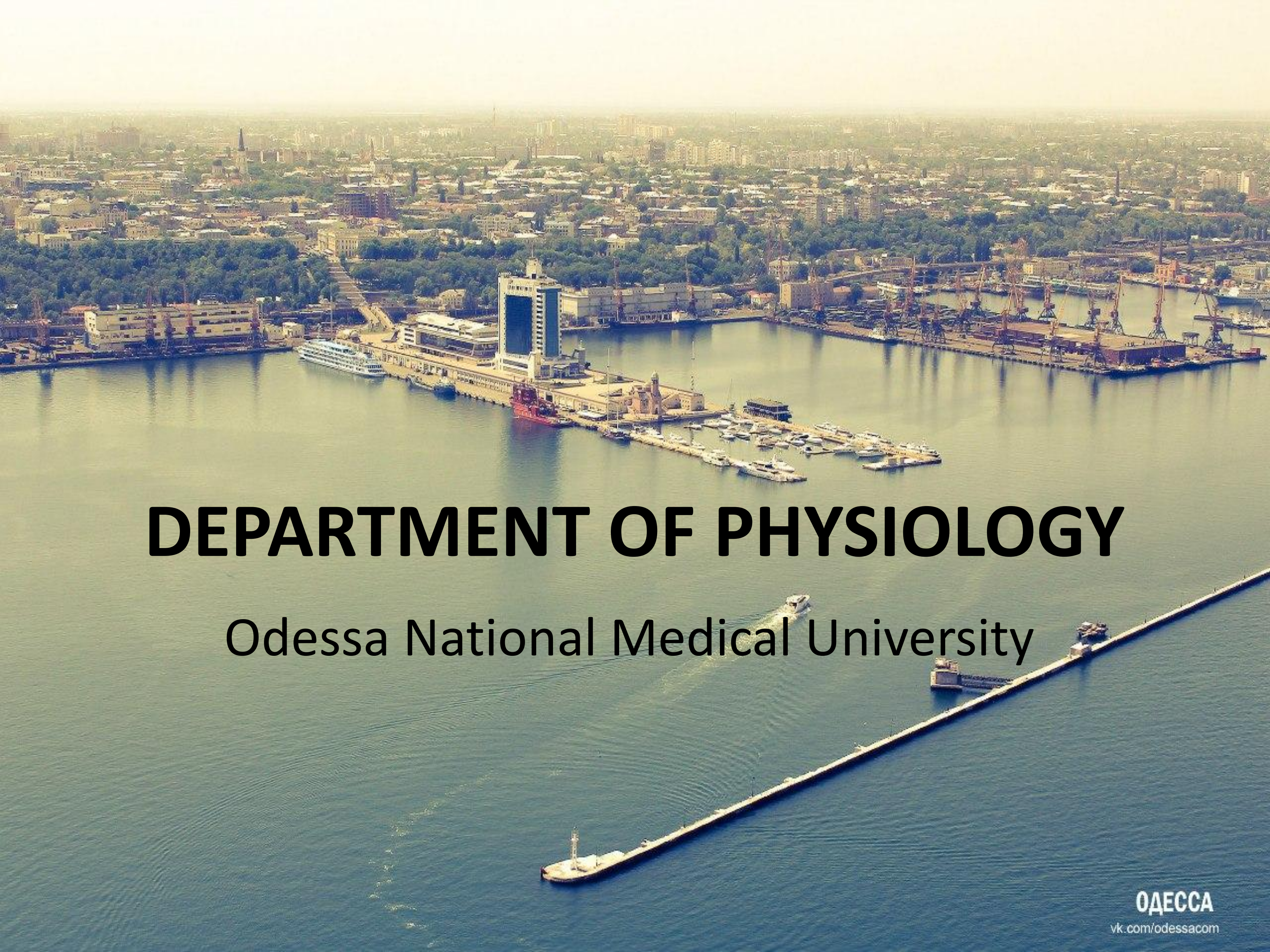
DEPARTMENT OF PHYSIOLOGY

Odessa National Medical University



Lecture № 3

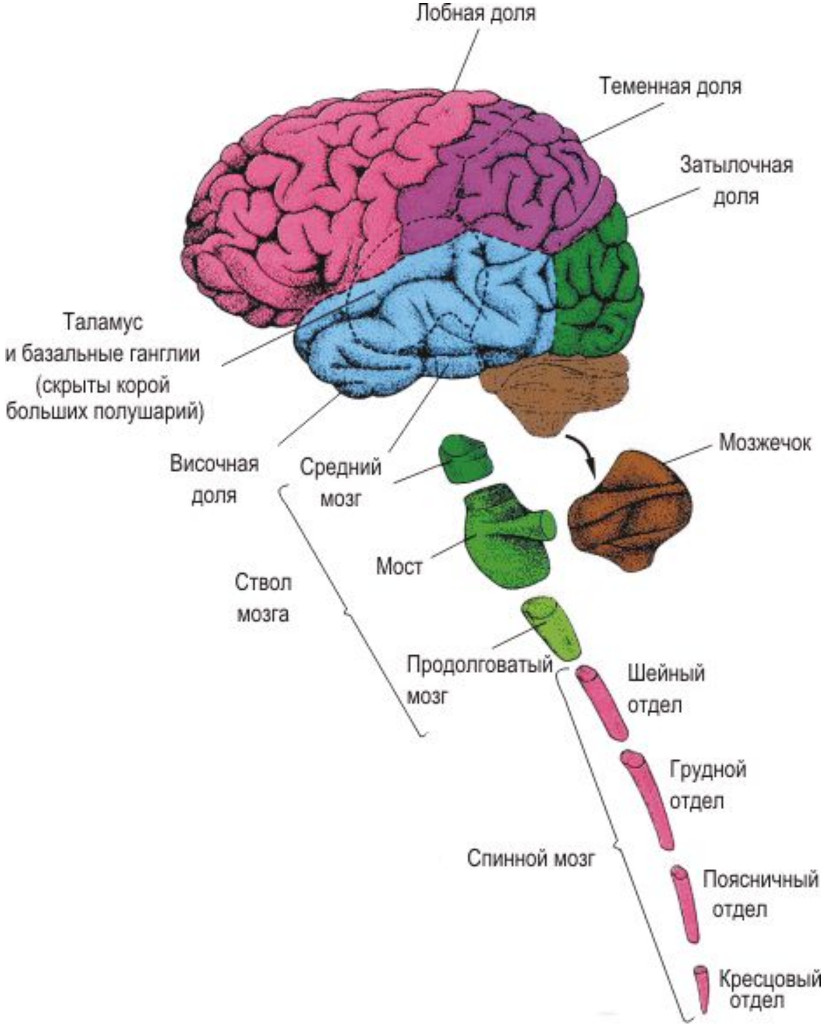
THE ROLE OF DIFFERENT LEVELS OF THE CENTRAL NERVOUS SYSTEM IN THE REGULATION OF BODY FUNCTIONS. FUNCTIONS OF THE SPINAL CORD, BRAIN STEM, RETICULAR FORMATION AND CEREBELLUM.

as. DENYSENKO Oksana

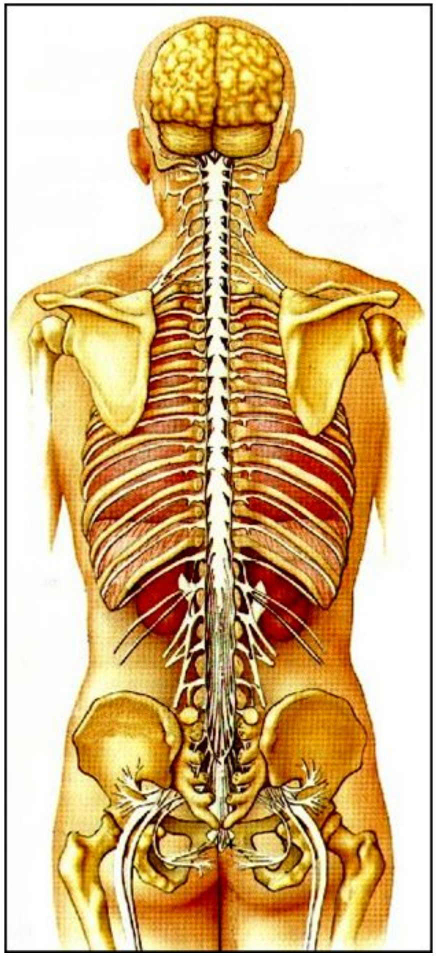
5 levels of regulation of human motor function:

1. spinal cord;
2. the medulla oblongata and the pons;
3. midbrain and cerebellum;
4. Diencephalon (thalamus, hypothalamus);
5. Telencephalon (striopaladar system of subcortical nuclei + cortex)

The highest level is the cortex of the cerebral hemispheres!



SPINAL CORD

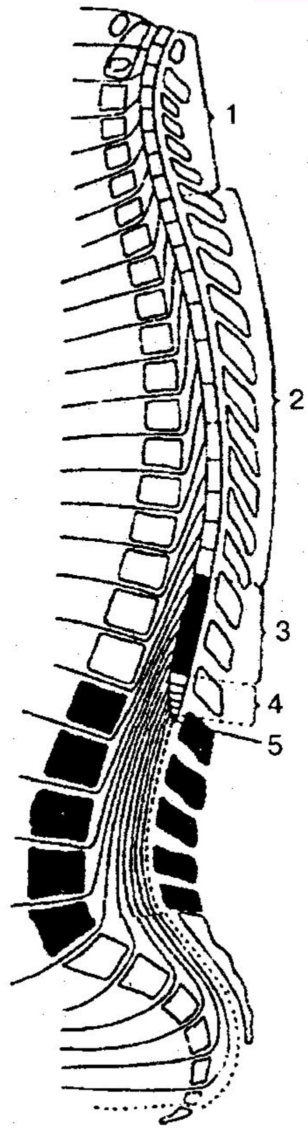


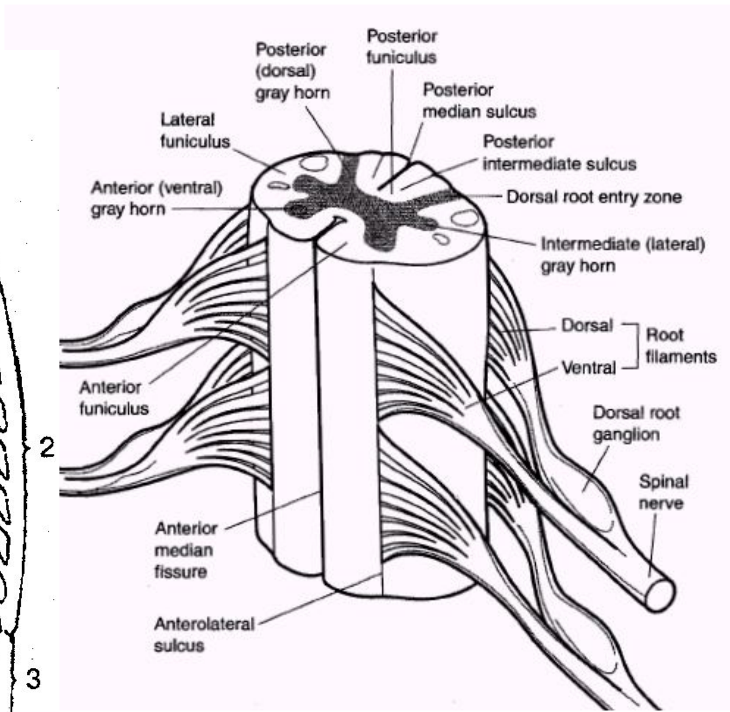
The caudal part of the central nervous system, located in vertebral canal.
The length is about 45 cm, the thickness is about 1 cm.

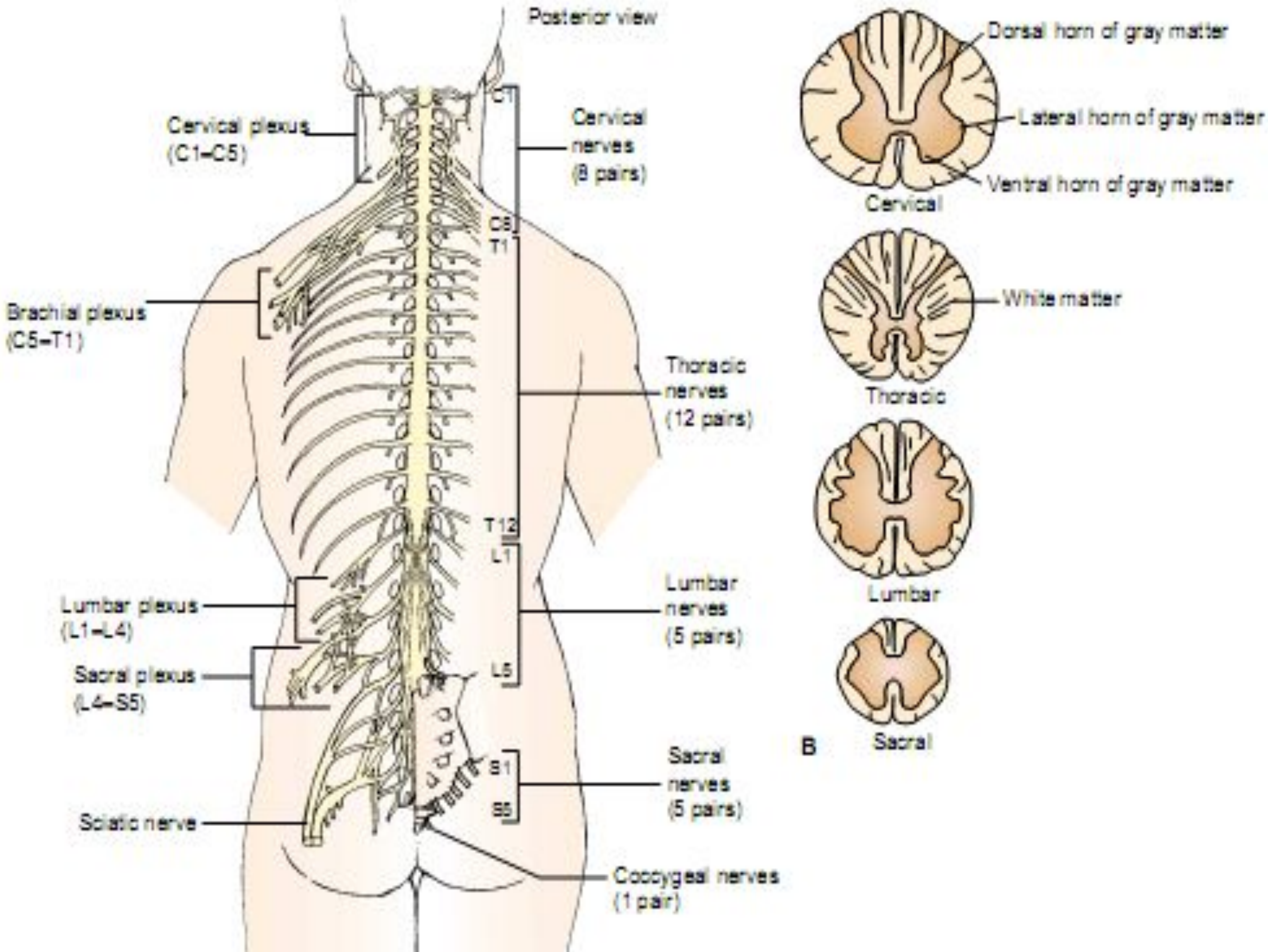
- The segment is a transverse fragment of the spinal cord that has a radix apparatus. There are 31-33 segments in total:

8 cervical - CI-CVIII,
12 thoracic (thoracic) - ThI-ThXII,
5 lumbar (lumbar) - LI-LV,
5 sacral (sacral) - SI-SV,
1-3 coccygeal - C1-3.

In the spinal canal, the spinal cord is shifted upward, therefore, at the level of LII and below, the spinal canal is filled with spinal nerves that form the *cauda equina* (until the 3rd month of fetal life, the spinal cord fills the entire vertebral canal, then the bone grows faster and the canal is empty) .



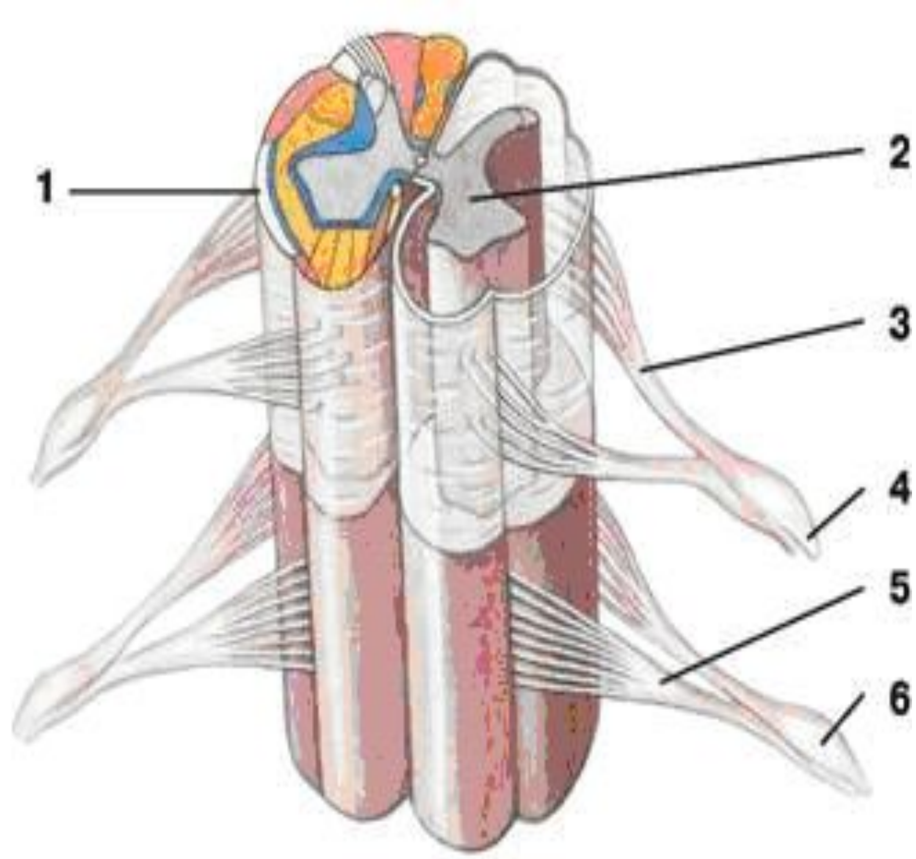




Posterior view
Cervical plexus
(C1–C5)
Brachial plexus
(C5–T1)
Lumbar plexus
(L1–L4)
Sacral plexus
(L4–S5)
Sciatic nerve
C1
C8
T1
T12
L1
L5
S1
S5
Cervical
nerves
(8 pairs)
Thoracic
nerves
(12 pairs)
Lumbar
nerves
(5 pairs)
Sacral
nerves
(5 pairs)
Coccygeal nerves
(1 pair)
Dorsal horn of gray matter
Lateral horn of gray matter
Ventral horn of gray matter
Cervical
White matter
Thoracic
Lumbar
B
Sacral

SPINAL CORD COMPOSITION

- According to the structure in the segment, the following substances are distinguished: - gray matter - formed by demyelinated elements of neurons and neuroglia, white matter - mainly myelinated nerve fibers. Radix apparatus: - radix dorsalis - axons of afferent neurons of spinal ganglia, the radix ventralis are the axons of efferent and vegetative neurons.



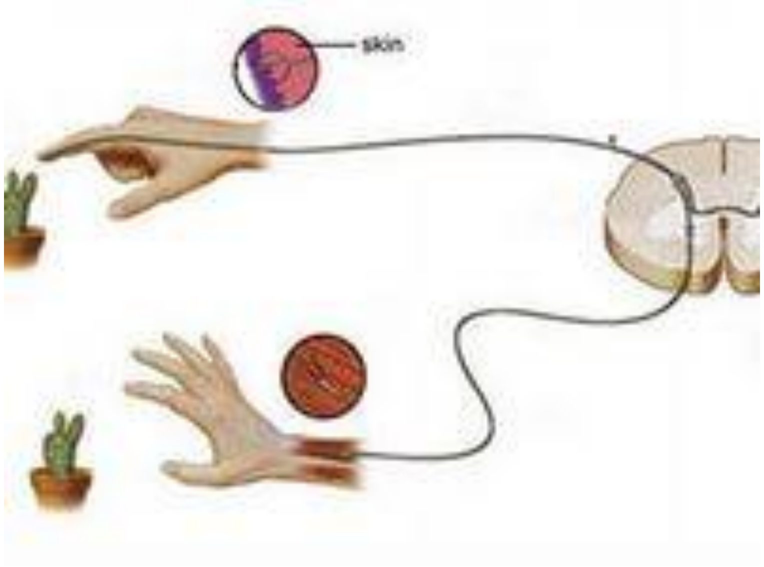
1 Shells of the spinal cord
2 Gray matter
3 radix dorsalis
4 nervus spinal e
5 radix ventralis
6 ganglion spinale

The law of Bell - Mazhandi

- Charles Bell (1811), F. Mazhandi (1822). The Bell-Mazhadi law: the posterior roots are sensitive, afferent, sensory; anterior - motor, efferent.

cutting of the posterior roots of the spinal cord leads to loss of sensitivity;

cutting of the anterior roots of the spinal cord leads to loss of motor function (to paralysis);



- Rear sensitive roots. According to the works of C. Sherrington, the distribution of sensitive innervation:

each metamer of the body sends afferentation to 3 consecutive segments of the spinal cord;

each segment of the spinal cord innervating 3 different metamer of the body.

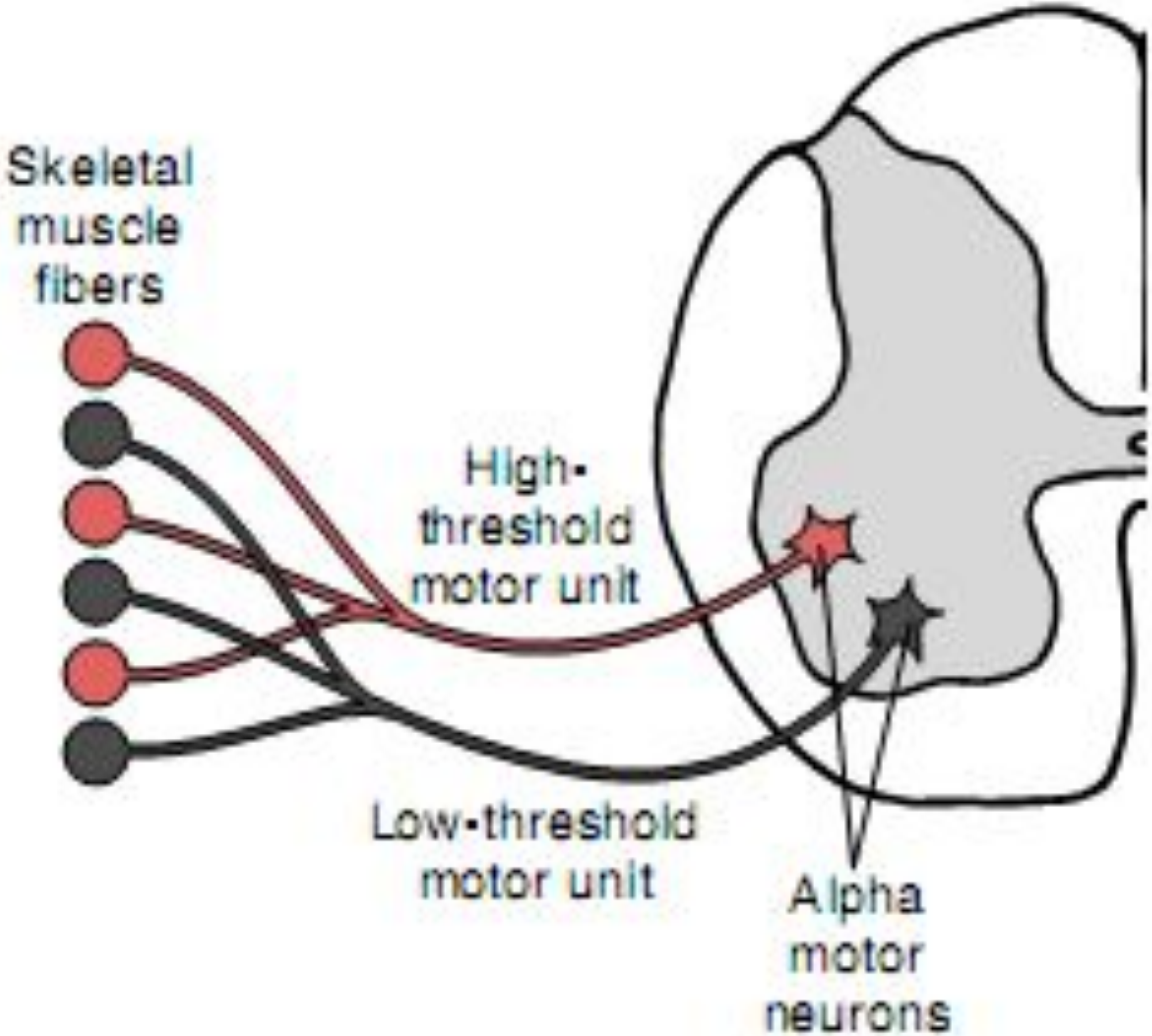
A metamer is a body site (skin and muscle mass under it) that have a common innervation.

Spinal Cord Neurones

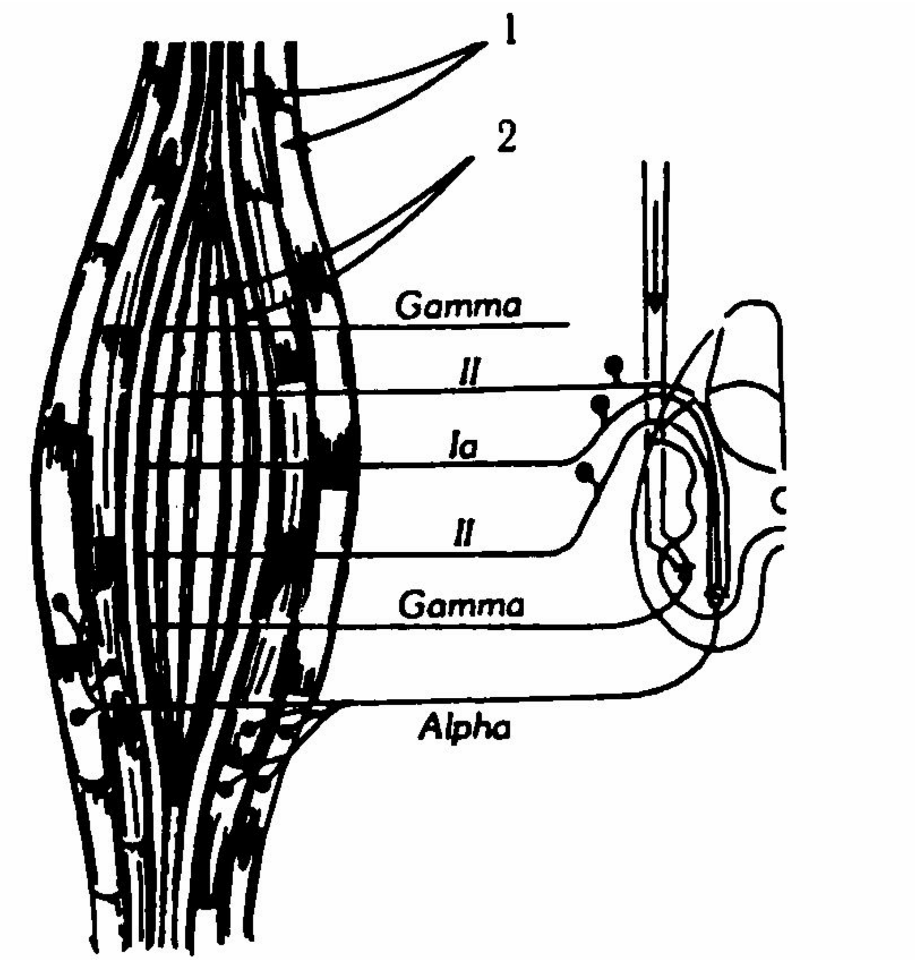
- Reksed described the layered topography of the gray matter of the spinal cord. It consists of 10 plates. The neurons of each plate differ in structure and function. In gray matter, the posterior, the anterior horns are distinguished, and the lateral horns in the Th and L segments.

According to the functions posterior horns include:
interneurons - small associative neurons (within the given half of the segment) and commissural (between neurons of different halves of the segment),
Clarke's motor nucleus (nucleus dorsalis) - the second neuron of the tractus spinocerebralis dorsalis (Flexing tractus).
Lateral horns:
neurons of the medial nucleus - the 2nd neuron of tractus spinocerebralis ventralis (Hovers tractus),
neurons of the lateral nucleus - sympathetic vegetative neurons Th and L.
Anterior horns:
effector neurons α- and γ-motoneurons (their only 3% of all neurons of the spinal cord)

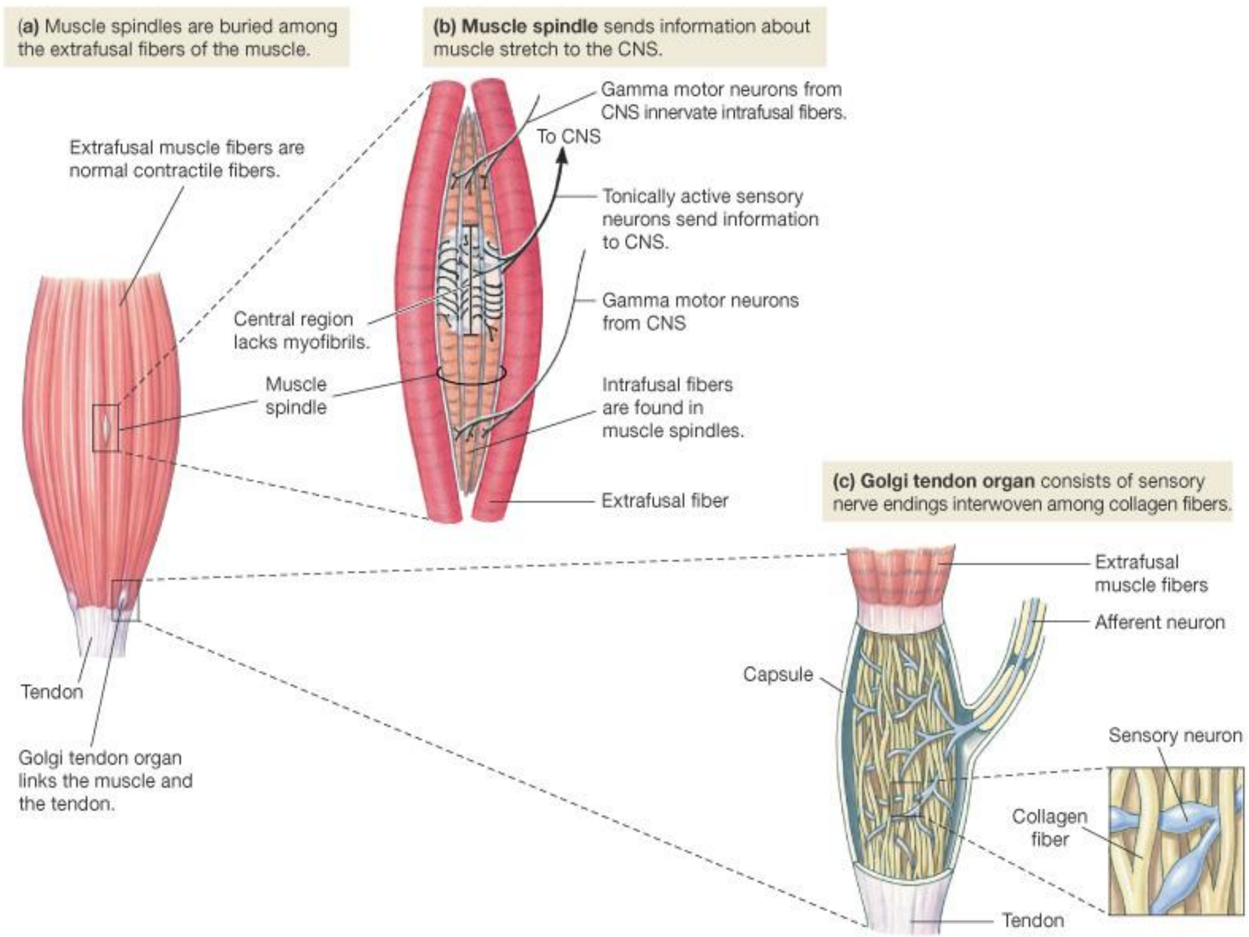
Sensitive neurons → **are located in the spinal cord ganglia**


Skeletal
muscle
fibers
High-
threshold
motor unit
Low-threshold
motor unit
Alpha
motor
neurons

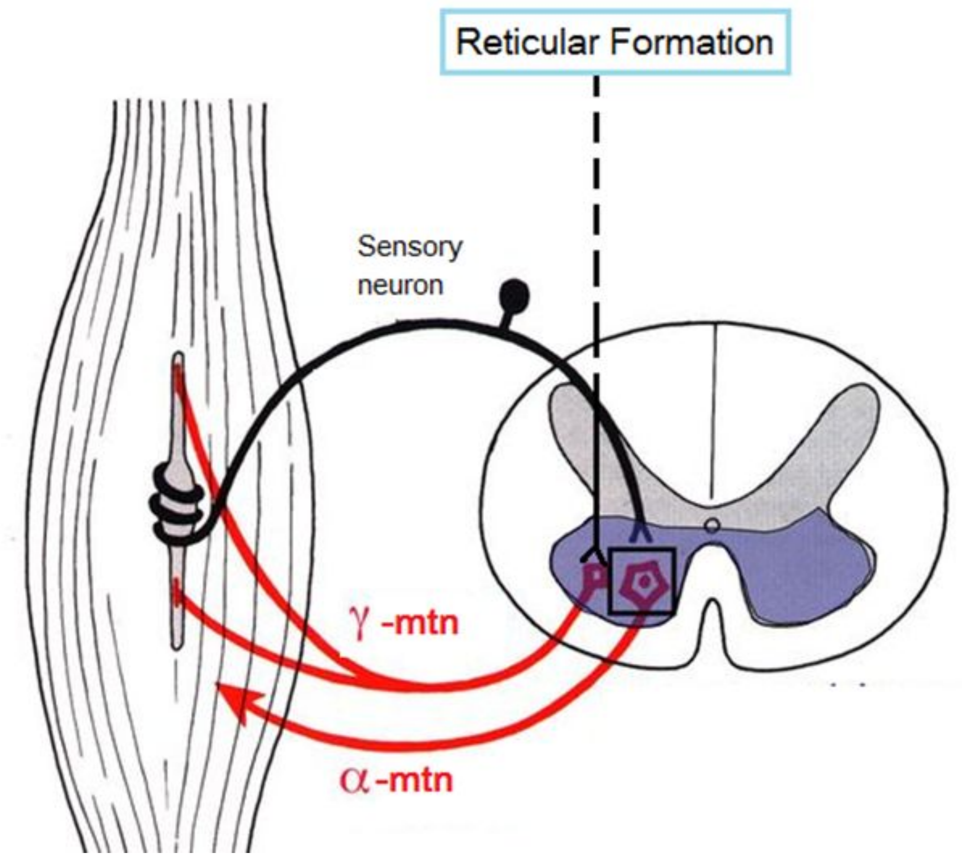
α-Motoneurons - the largest, have up to 10-20 thousand synapses on their bodies.



Muscle Spindle & Golgi Tendon Organ



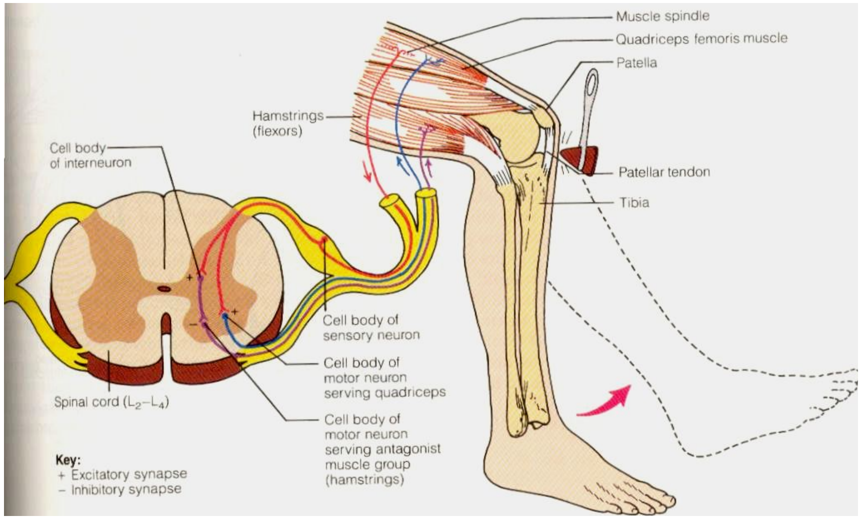
γ-motoneurons innervate the intramuscular muscle fibers of the muscle spindles. The smaller. The speed is 10-40 m / s. Direct synapses with afferent nerve fibers do not have, but have monosynaptic activation from descending pathways (reticulospinal, pyramidal) - the possibility of conjugate activation of α- and γ-motoneurons via the γ-loop



Functions of the spinal cord:

- 1. Reflex.
- 2. Conductor
- 3. Trophic.

Reflexes of the spinal cord is an innate response to internal or external irritation.
All reflexes in complexity of reflex arcs are divided into monosynaptic and polysynaptic.



Spinal Cord Reflexes

1. Stretch reflex (phasic)

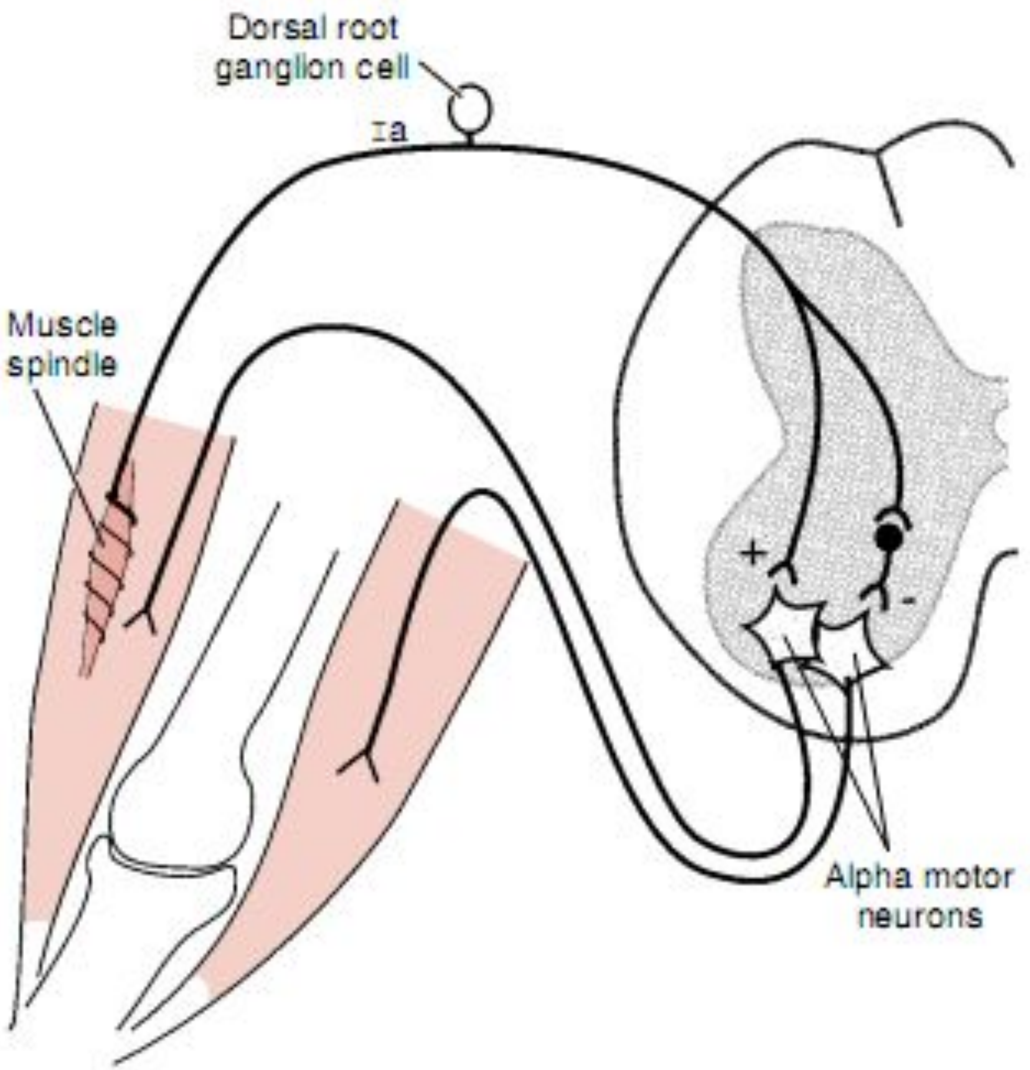
2. Withdrawal reflex (tonic)

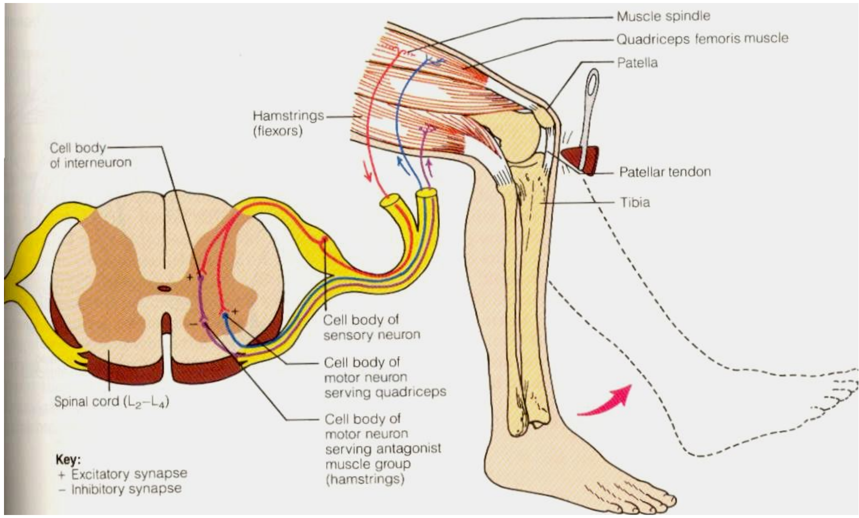
3. Reflex of muscle-antagonists

4. Viscero-motor reflexes

5. Vegetative reflexes.

Stretch reflex (knee reflex) scheme





Spinal Cord Reflexes

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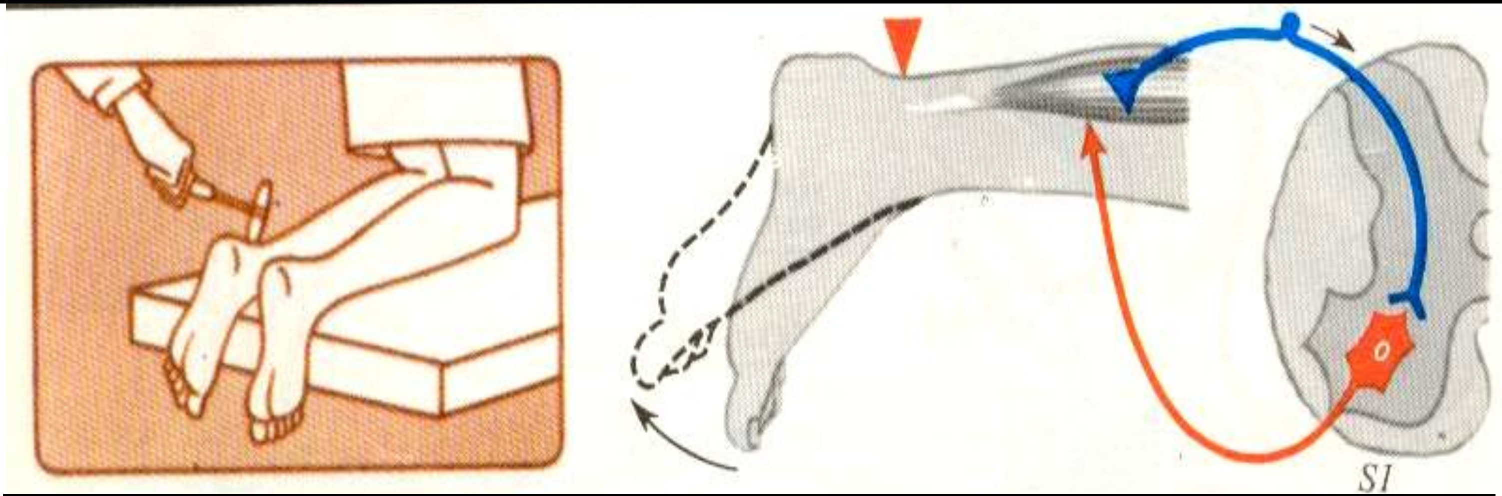

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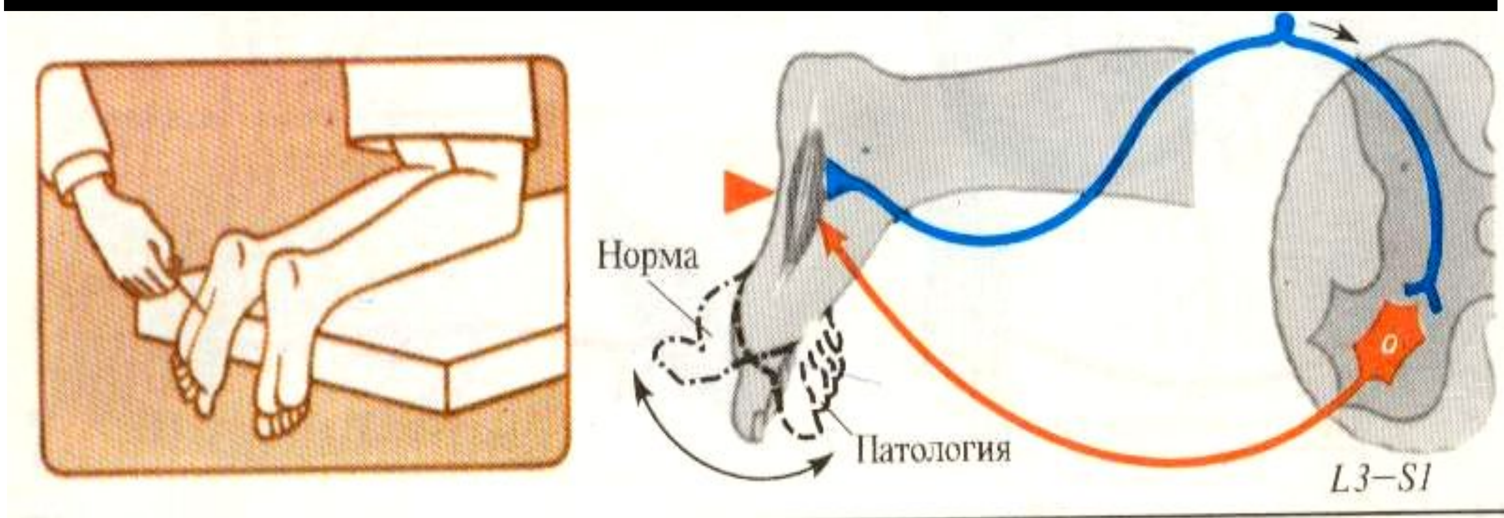

Spinal Cord Reflexes

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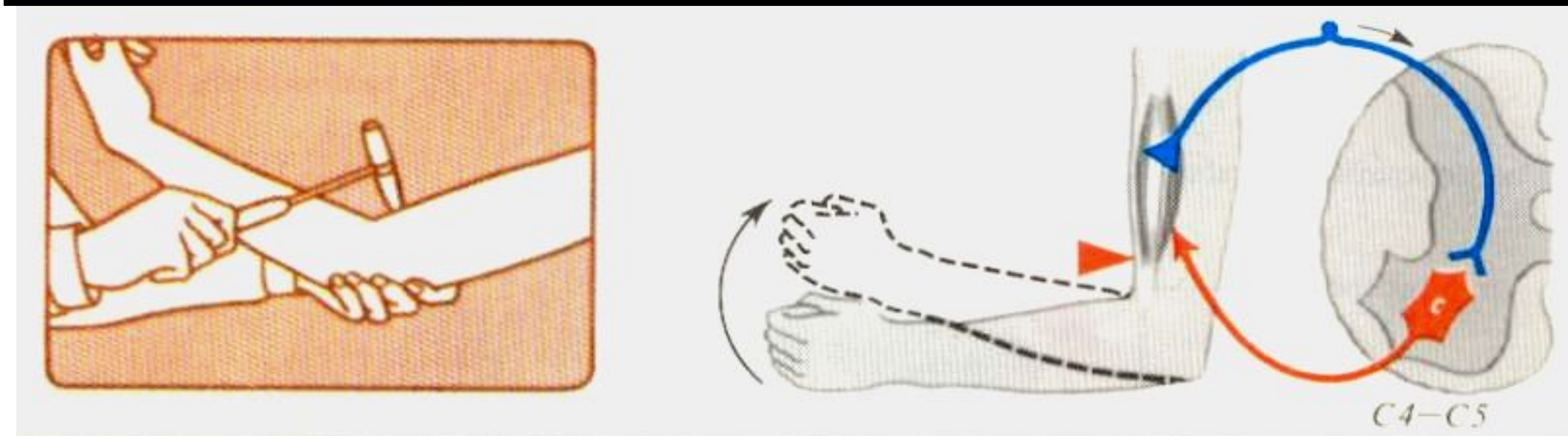

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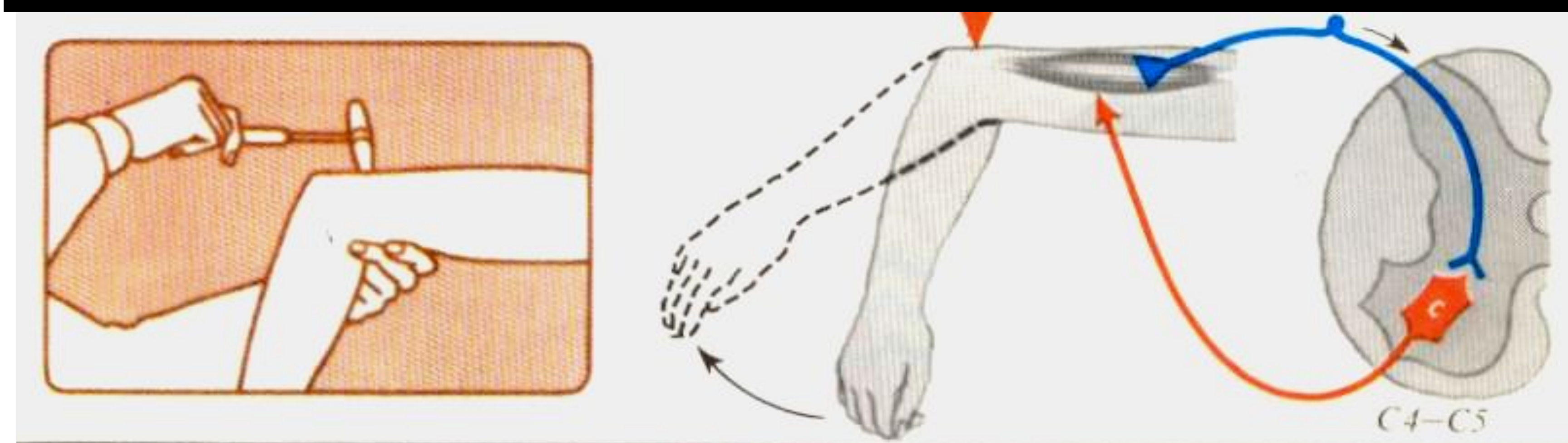
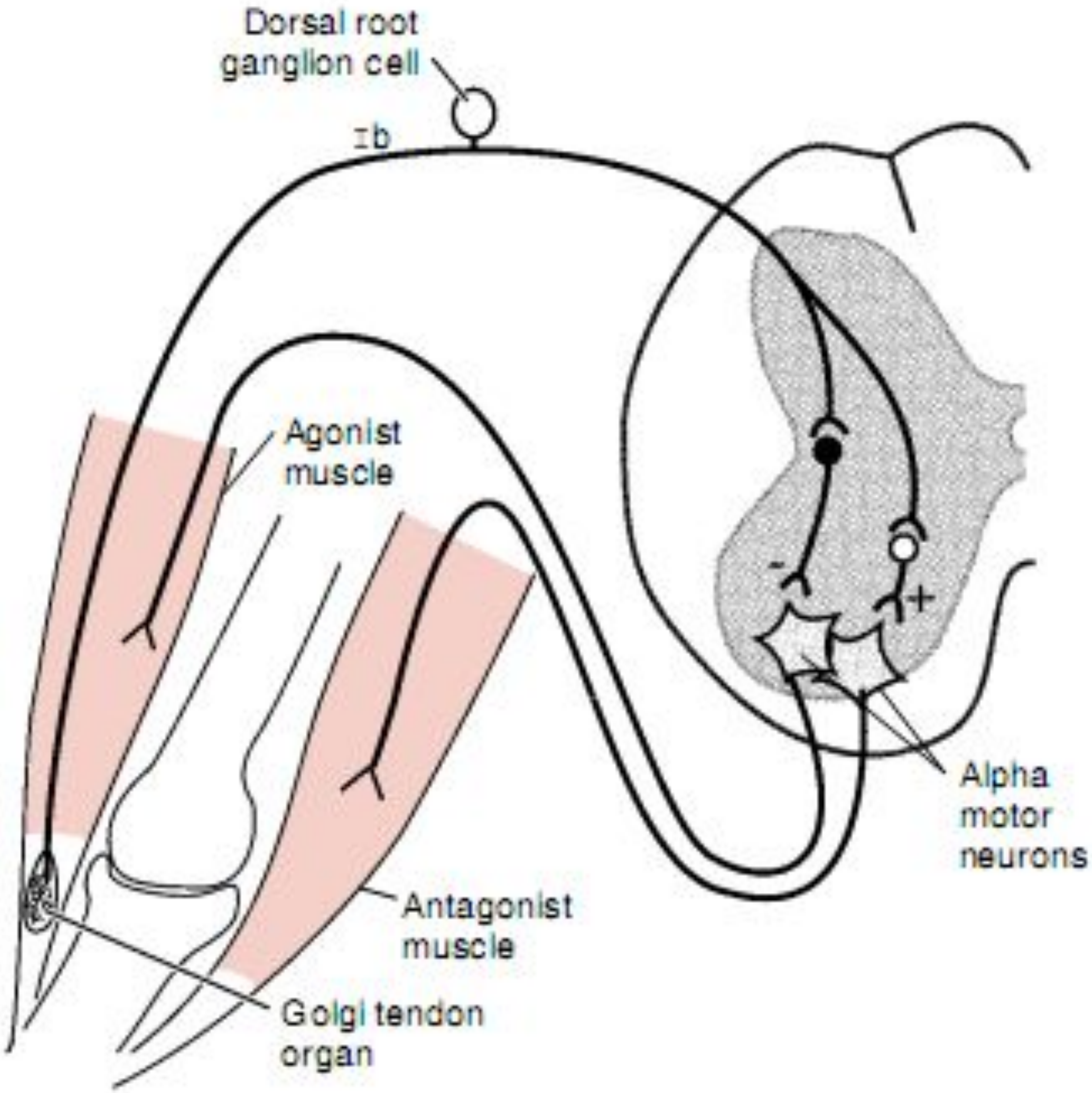


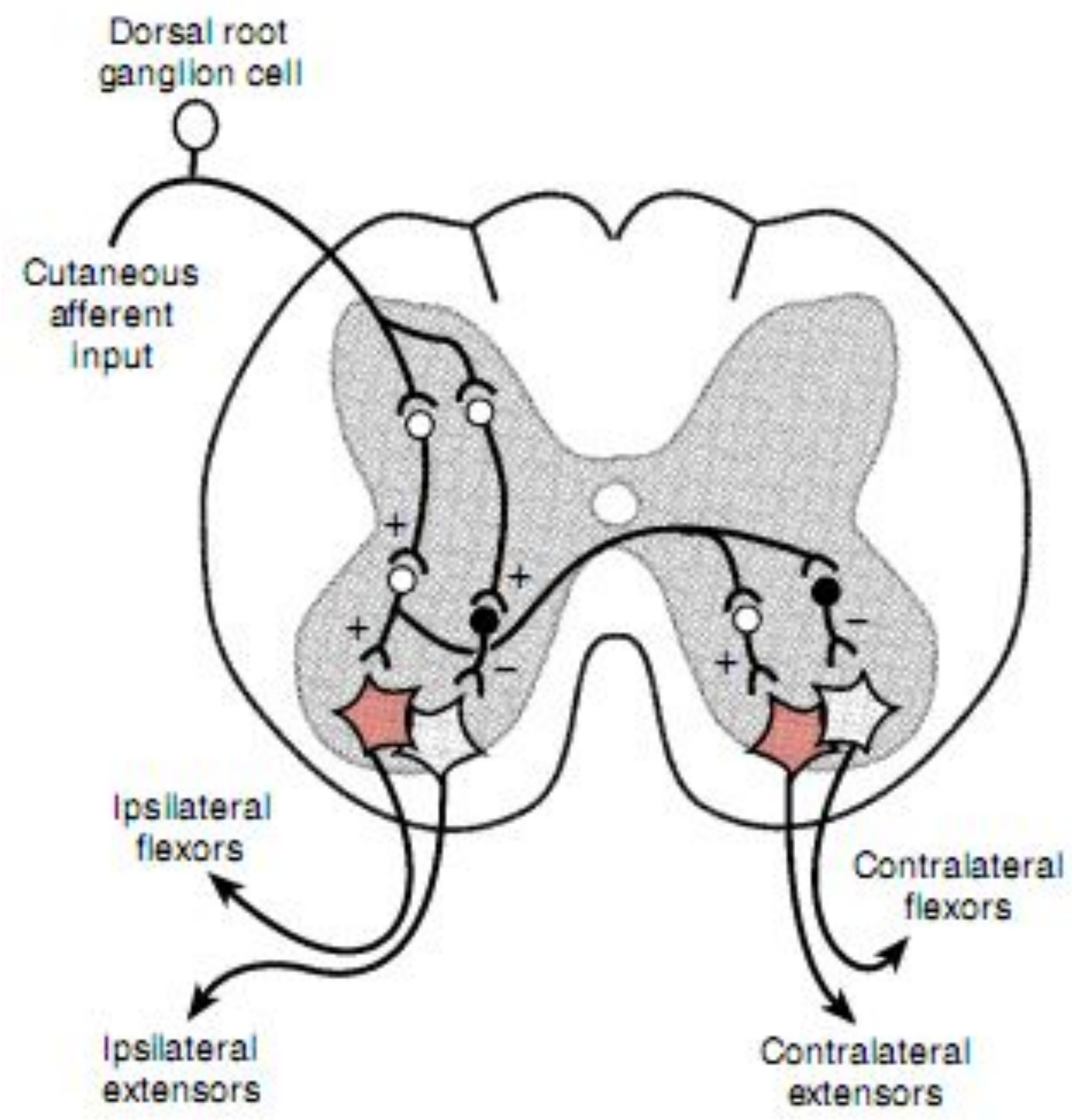
Tendon reflexes (stretching reflexes) in a clinic can be determined:

- 1. At what level of the spinal cord is the pathological process localized
- 2. The level of excitation of the nerve centers.
- 3. The side of the spinal cord lesion.

Withdrawal reflex scheme

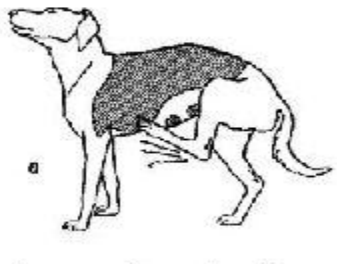


Muscle – antagonists reflex scheme



Complex / polisinapticheskie spinal cord reflexes

- Rhythmic (walking, carding reflex of animals)
- Pose poses (maintaining posture)
- Neck / Tonic

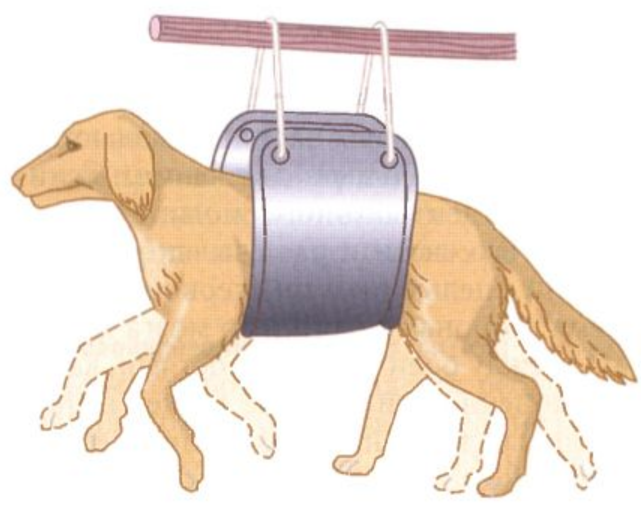


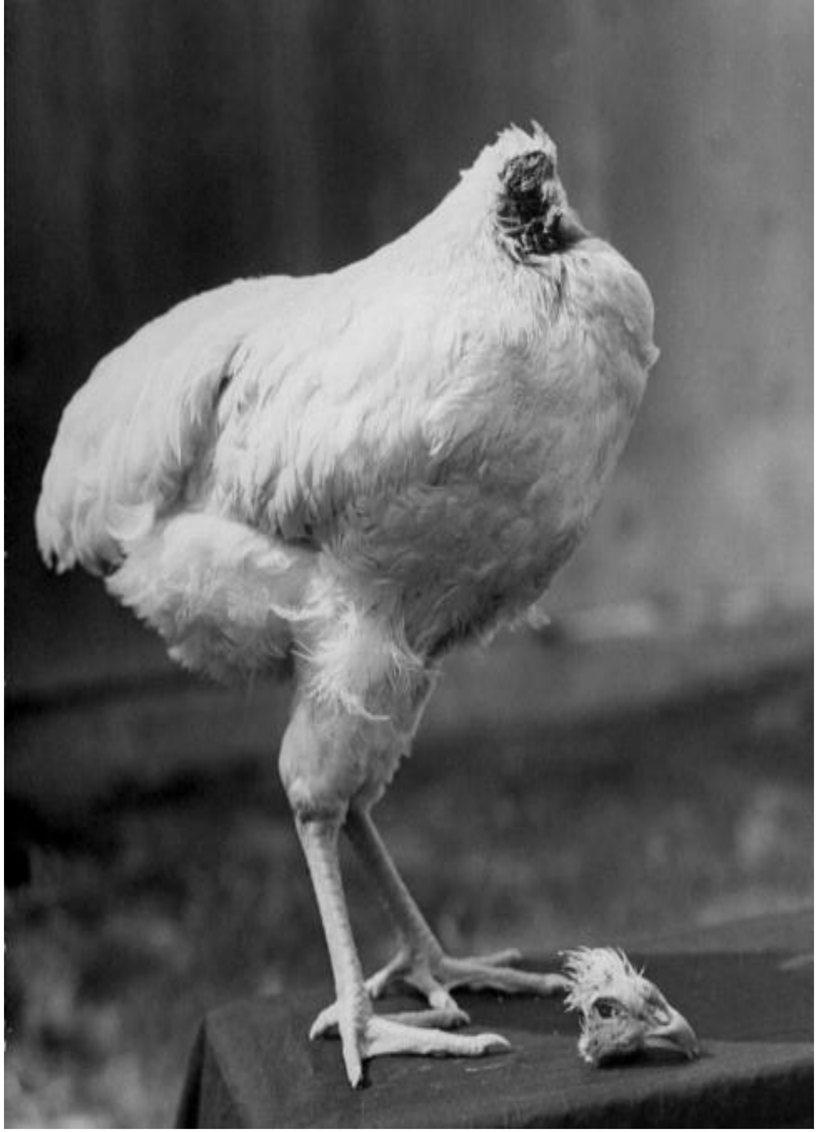
When the head is bent, the hands are reflexively flexed and the legs are extended.

When the head is extended, the arms are extended, and the legs are flexed.

Spinal Locomotion (Automatism)

- The main characteristics of locomotion, i.e. movement of a person or animal in the environment using coordinated movements of the limbs, programmed at the level of the spinal cord.
- Pain irritation of any limb of the spinal animal causes reflex movements of all four limbs; if such stimulation continues, rhythmic flexor and extensor movements of non-irritated limbs may occur.
- If a spinal animal is put on a treadmill, it will make coordinated walking movements that are very similar to natural ones.





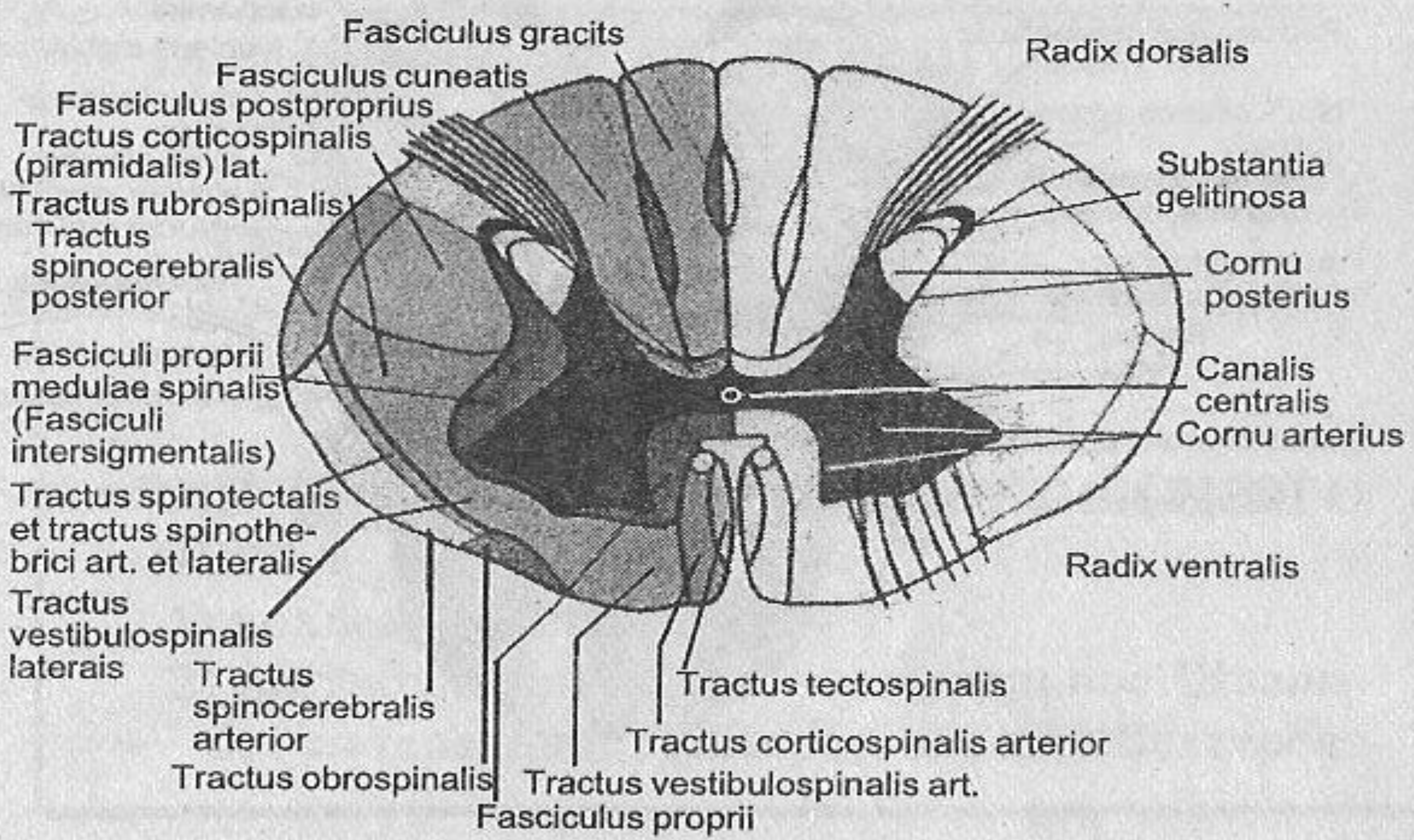
The activity of the centers is coordinated by propriospinal systems and tracts crossing the spinal cord within some segments.

In more primitive animals, spinal locomotion can manifest itself - in running without a head.

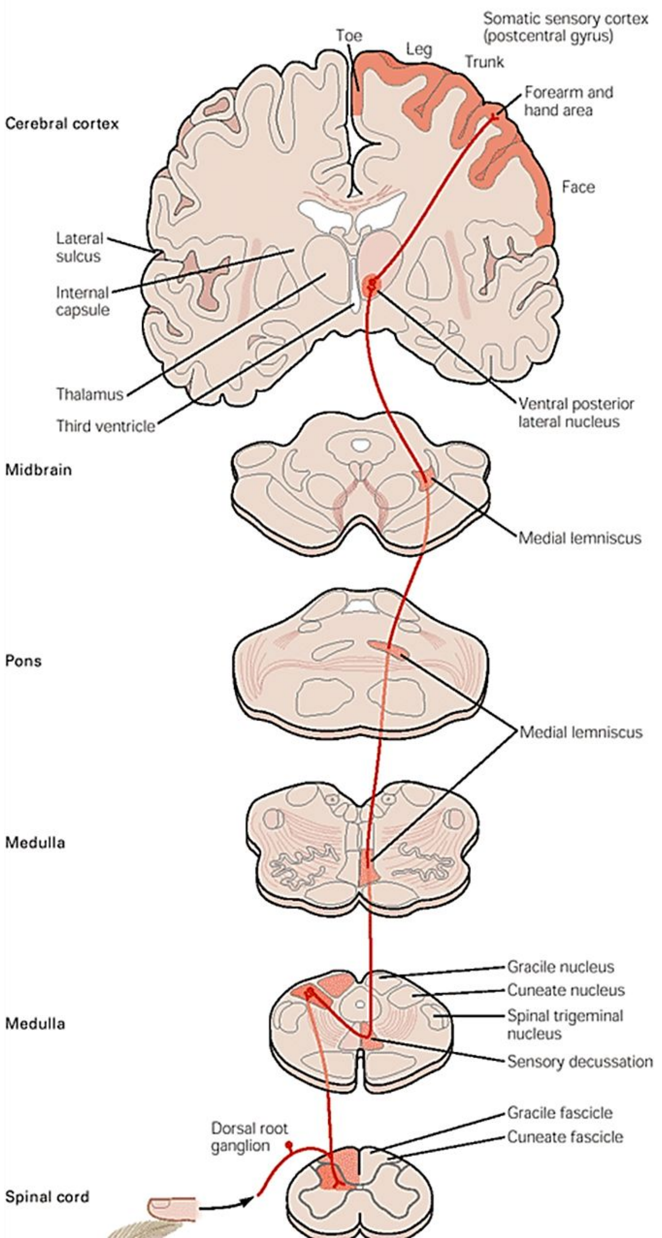
An assumption that a human also has spinal locomotor centers.

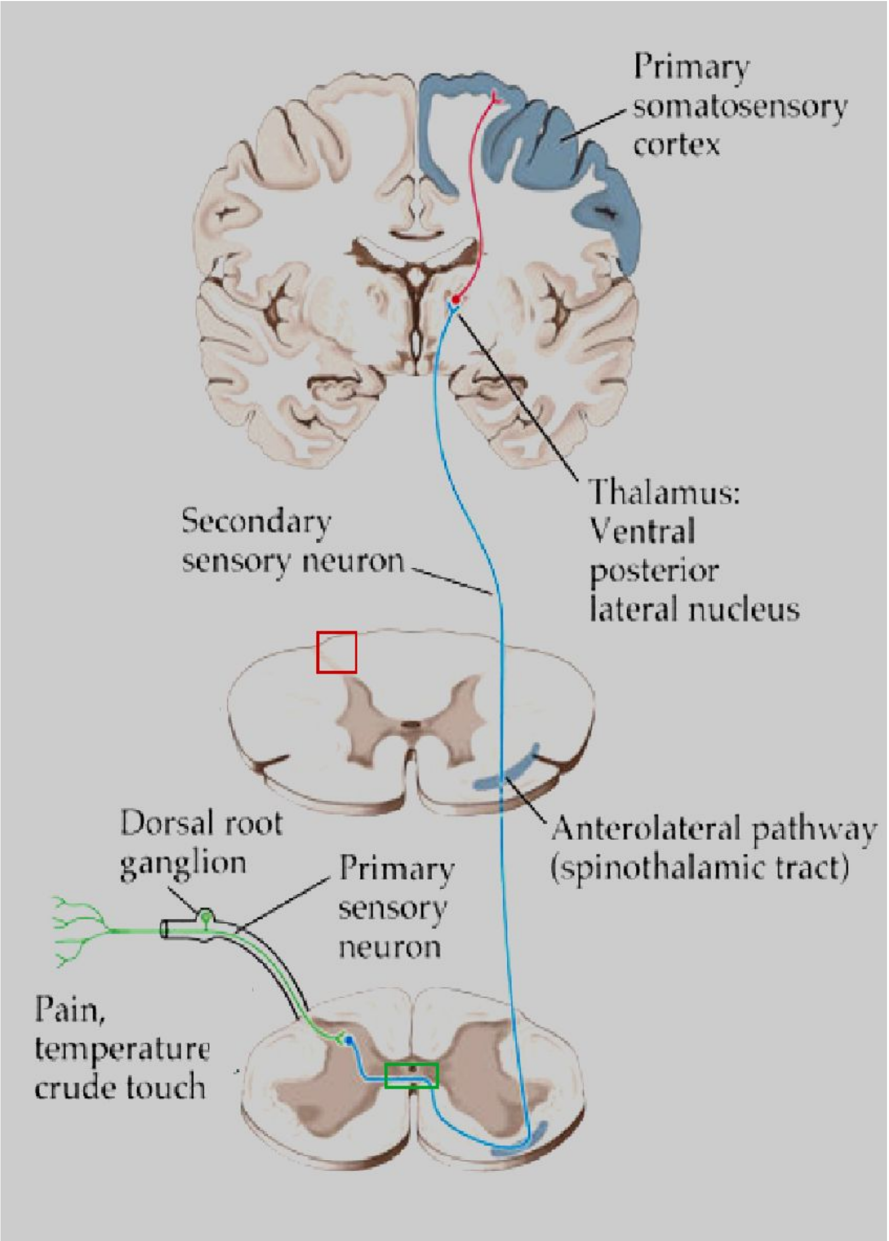
- Apparently, their activation during skin irritation manifests itself in the form of a pacing reflex of the newborn (lasts up to 2 months).
- However, as the central nervous system matures, the supraspinal regions subordinate such centers to themselves, and in an adult they lose the ability for independent activity.

Spinal Cord Cross-Section.
The view of the conductive pathways.

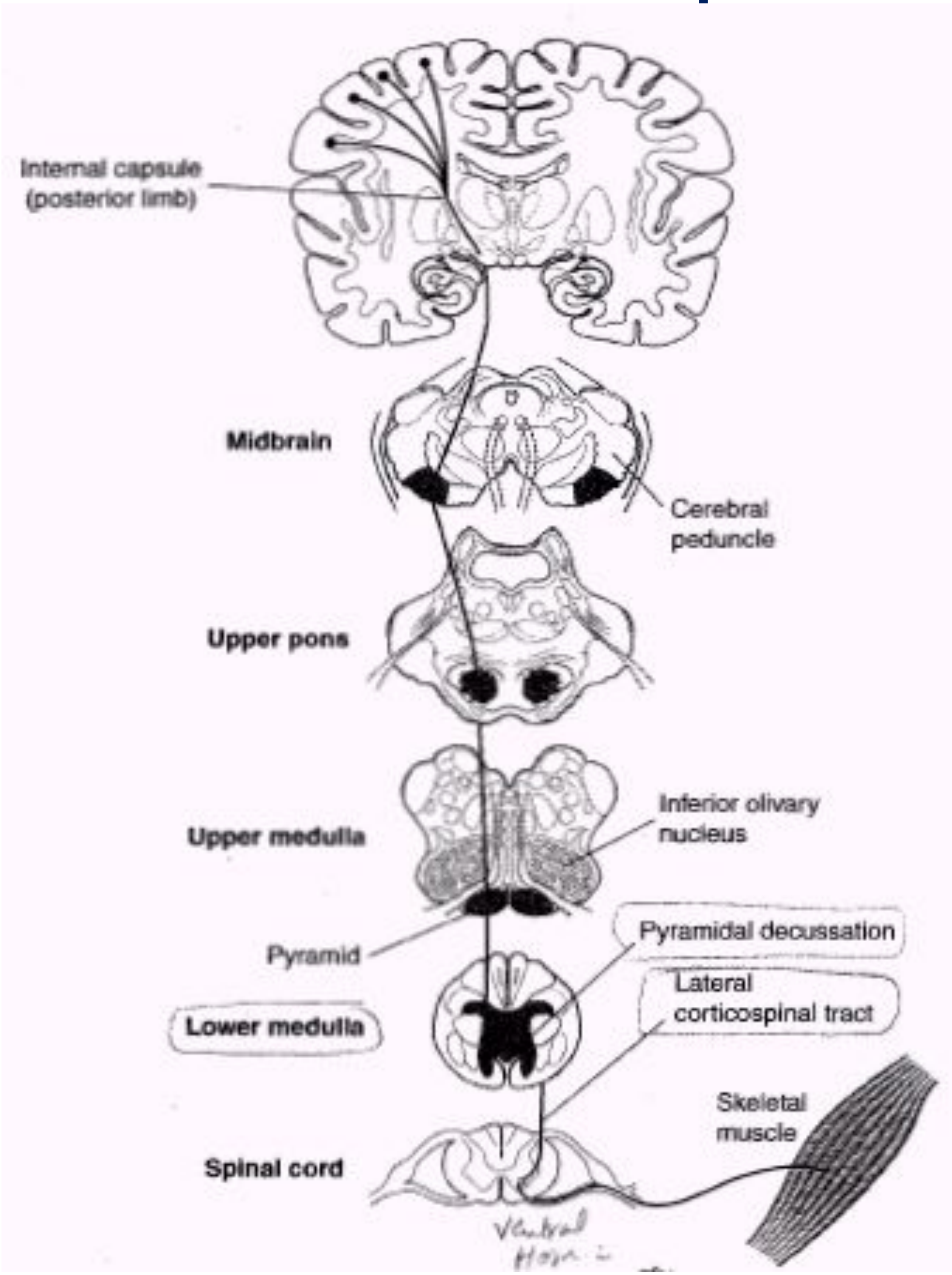


The uscendent pathways of the spinal cord

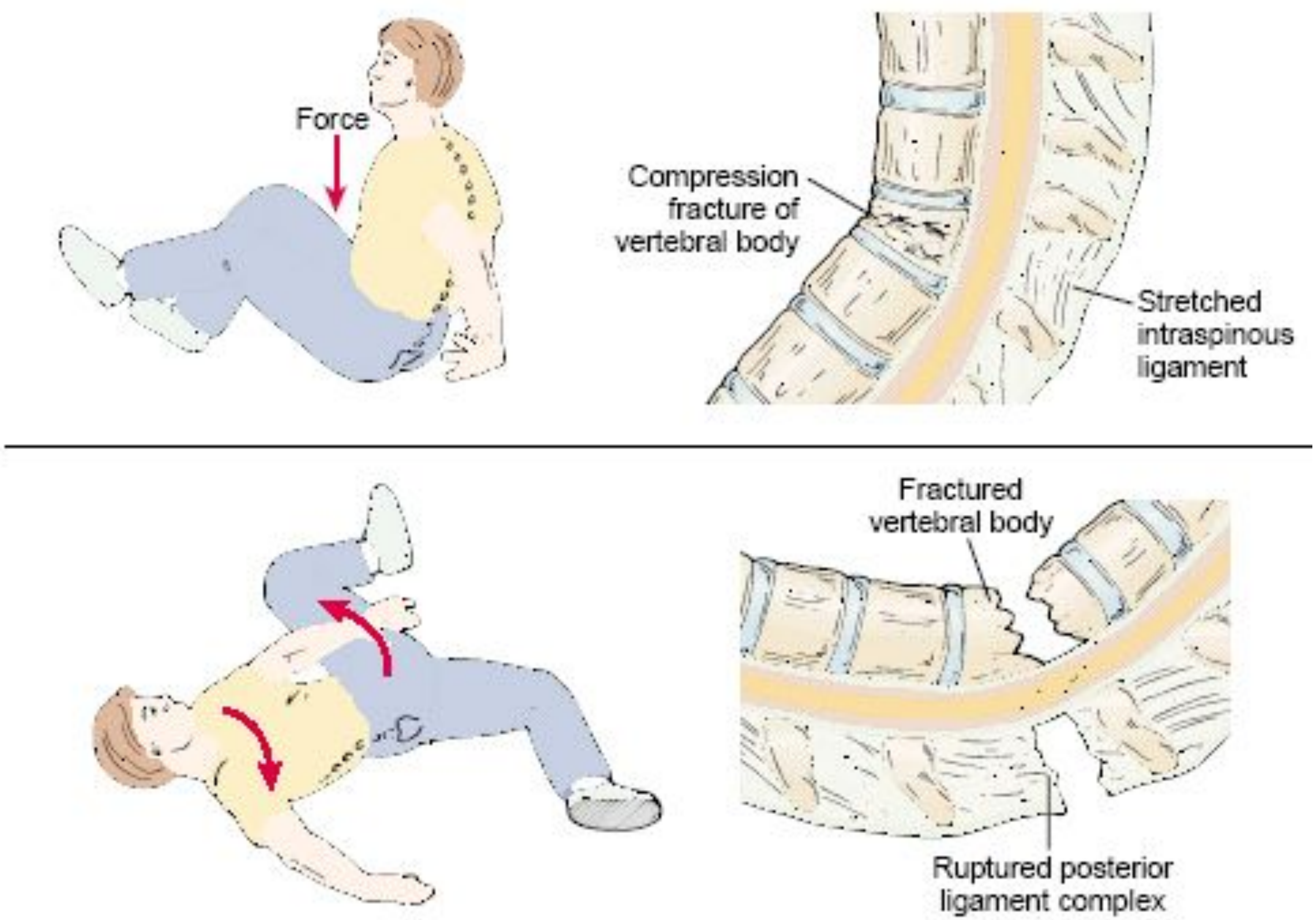




Tractus corticospinalis



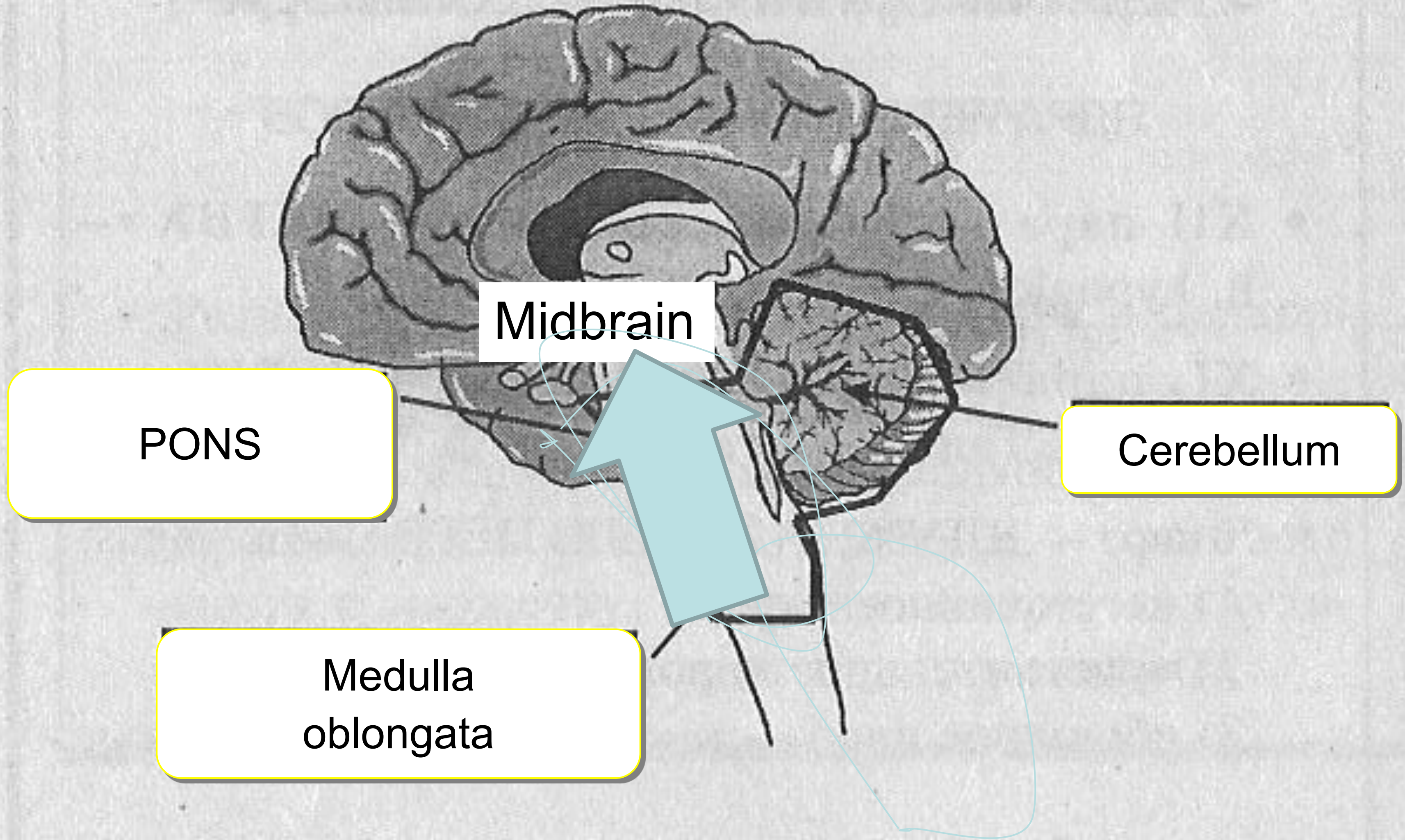
Descending motor tracts lesions



SPINAL SHOCK

- temporary pathologic condition characterizes by spinal cord connections rupture with upper brain after trauma or surgical intersection that follows by the lower spinal reflexes dissappearing.

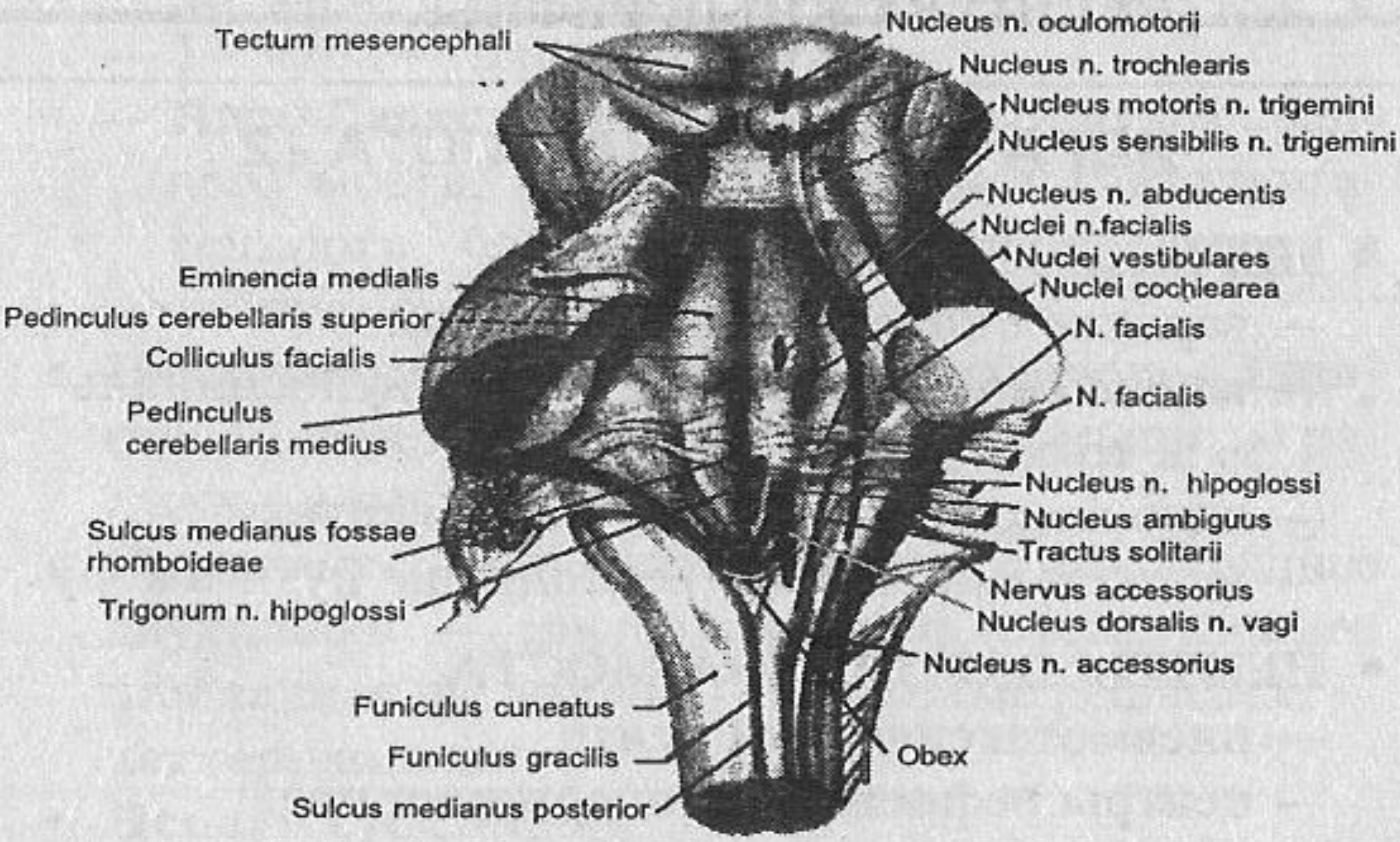
BRAINSTEM



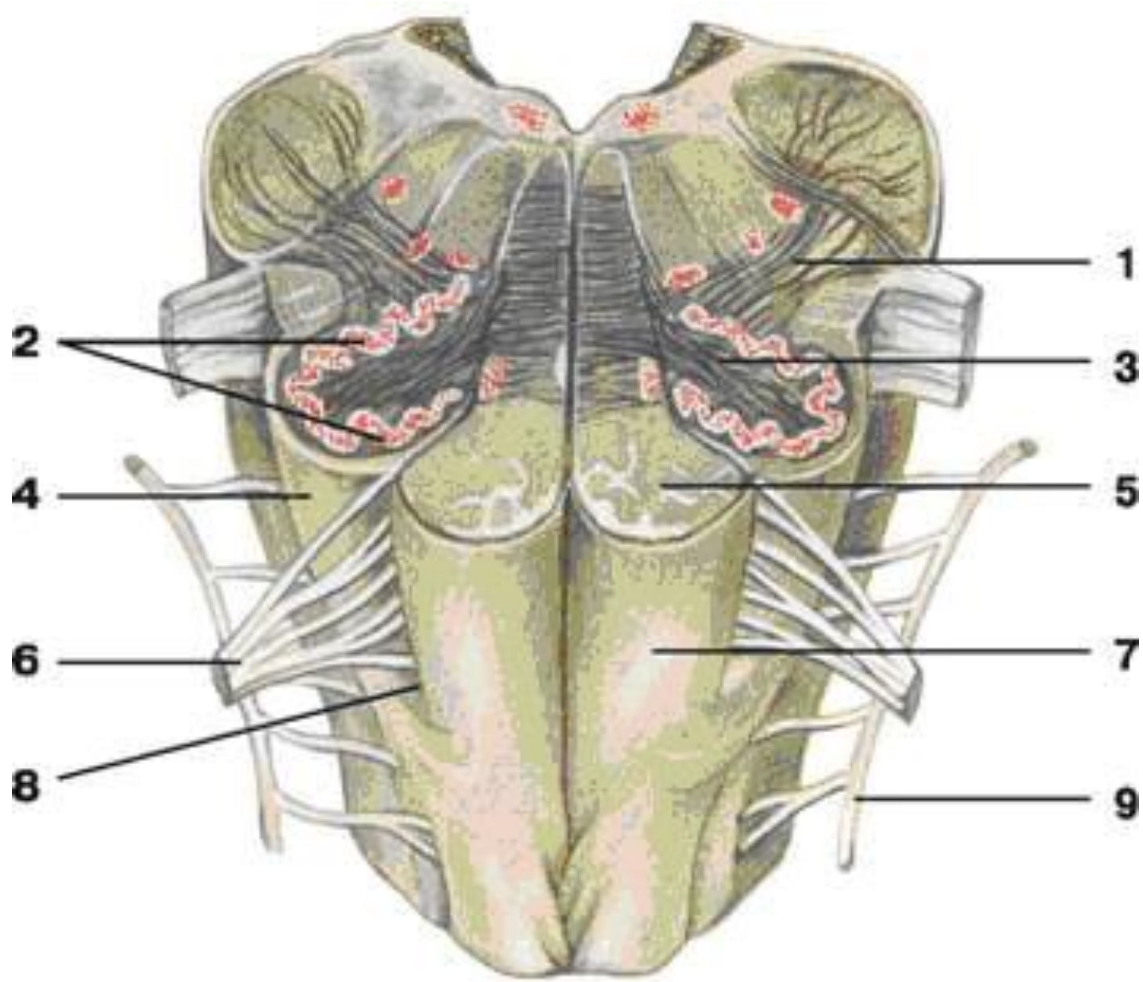
Functions of the medulla oblongata

- Reflectory
- Conductive
- Tonic

FOSSA RHOMBOIDALIS



Medulla oblongata. Structural and functional organization.



1 - tractus olivocerebellaris;
2 – nucleus olivaris;
3 - hilus nuclei olivaris;
4 - oliva;
5 - tractus pyramidales;
6 – n. hypoglossus;
7 - pyramis;
8 –sulcus lateralis anyerior;
9 – n. accessorius,

Nucleus of the medulla oblongata

1. Nuclei of cranial nerves

- XII pair - *n. hypoglossus* - motor nuclei
- XI pair - *n. accessorius* - motor nuclei
- X pair - *n. vagus*:

  1) vegetative nucleus

  2) the sensitive nucleus - *nucleus tractus solitarii*

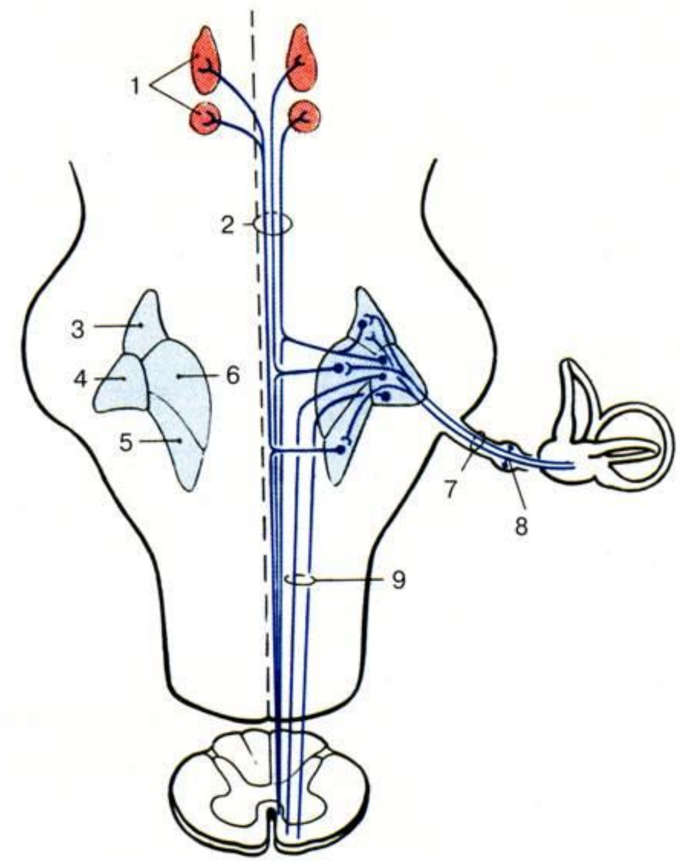
  3) *nucleus ambiguus* - regulation of motor functions of pharynx and larynx

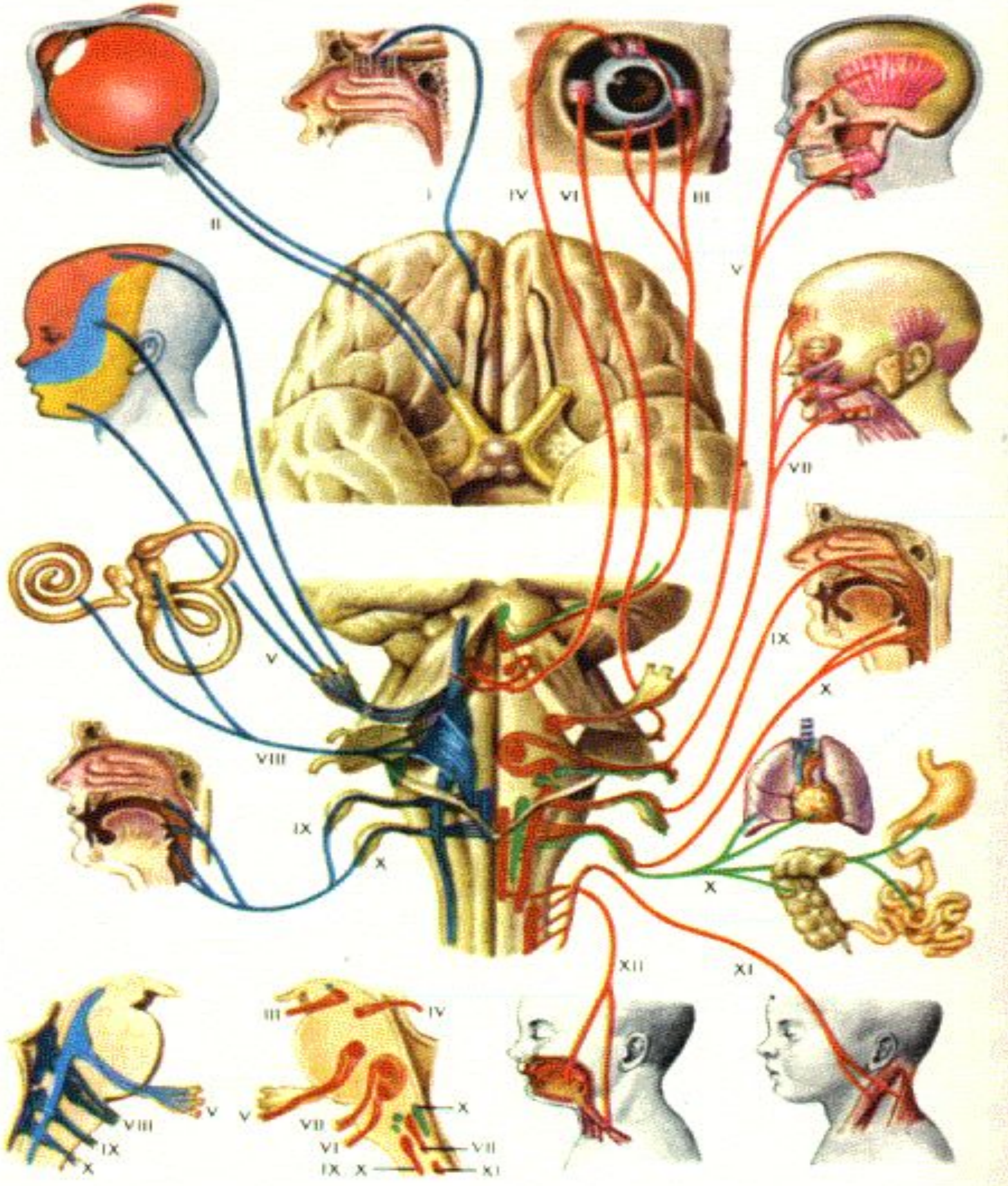
- IX pair – *n. glossopharyngeus*:
  1) motor nucleus - mouth and pharynx
  2) sensitive nucleus - taste of the back third of the tongue
  3) vegetative nucleus - salivary glands

On the border with the pons:

- YIII pair – *n. vestibulocochlearis*
  1) cochlear nuclei
  2) vestibular nuclei - medial Schwalbe , lateral Deiters, superior, inferior

medial Schwalbe ,
lateral Deiters,
superior,
Inferior Roller





II
I
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X
VII
IX
X
XI

Nucleus of the medulla oblongata (2)

CONDUCTIVE NUCLEUS:

- - *nucleus gracillis* and *nucleus cuneatus* - to the thalamus
- - Reticular formation - from the cortex and subcortical ganglia to the spinal cord
- - *nuclei olivaris* - from the cortex, subcortical nuclei and the cerebellum to the spinal cord and from the spinal cord to the cerebellum, thalamus and cortex; from the *cochlear nuclei* to the midbrain and *tectum mesencephali*

Reflexes of the medulla oblongata

- Vital
- Protective reflexes
- Reflexes maintaining posture
- Vegetative reflexes
- Vestibulo-vegetative reflexes

Centers of the medulla oblongata

LIVING
1) Respiratory
2) Cardiovascular
3) Digestion
   Salivation
   Sucking
   Chewing
   Swallowing

PROTECTIVE:
1) lacrimation
2) sneezing
3) cough
4) flashing
5) gagging

Postural reflexes (maintaining posture)

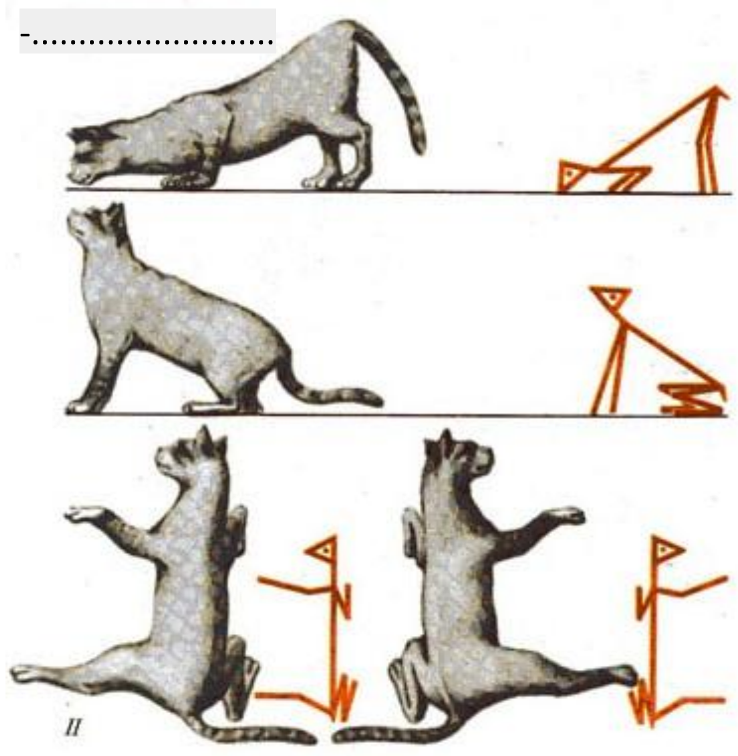
1. Static (maintaining posture alone) :
position reflexes
straightening reflexes
labyrinth reflexes
neck reflex
2. Statokinetic (maintaining posture when changing the speed of movement):
nystagmus
lift reflexes

Postural (static) reflexes (R. Magnus):

1. neck tonic - activated when proprioreceptors of the neck muscles are excited:

- head down - hypertonus of the extensors of the hind limbs,
- head back - hypertonus of the extensors of the forelimbs,
- head to the right - hypertonus of the extensors of the right limbs,
- head to the left - hypertonus of the extensors of the left limbs,

Any deviation of the head causes the movement of the eyeballs in the opposite direction.



(in its pure form in the destruction of the vestibular apparatus, which gives additional information about the position of the head)

- vestibular tonic reflexes associated with the excitation of receptors of the vestibule of the labyrinth, is inextricably connected with neck tonic reflexes.

- They do not depend on the position of the head relative to the body, but depend on the position of the head in space (without bending in the neck).

- Subdivided into:
- - vestibulo-neck reflexes are responsible for the vertical position of the head.
- - vestibulospinal reflexes adjust the position of the limbs to the position of the head.

....

(in its pure form when the head is fixed in relation to the body or when the proprioreceptors of the neck muscles are turned off by the novocain).

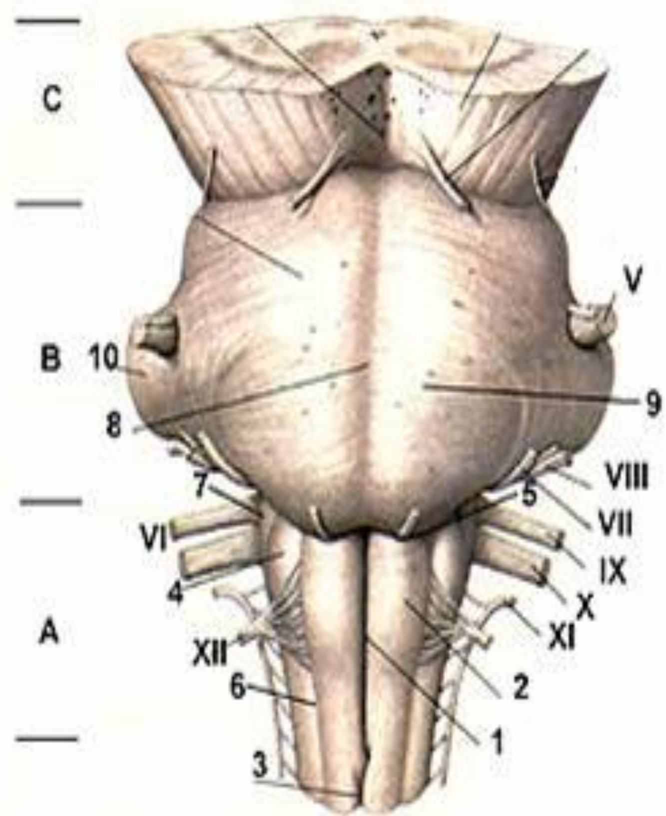
PONS

In the *pons* are located nuclei of cranium nerves :

- V pair – *n. trigeminus*,
- VI pair – *n. abducens*,
- VII pair – *n. facialis*,
- VIII pair – *n. vestibulocochlearis*.

VIII pair – *n. vestibulocochlearis*

VII pair – *n. facialis*
Is mixed:
Afferent fibers transmit signals from the taste receptors of the front of the tongue.
Efferent fibers innervate the facial muscles of the face

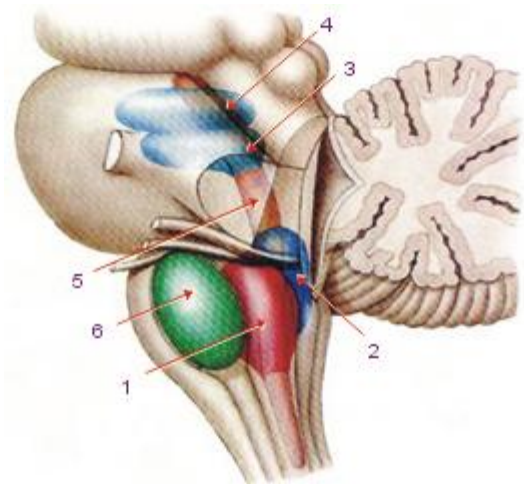


VI pair – *n. abducens*
Is motor
Innervates the rectus lateral muscle, abductor eyeball out.

V pair – *n. trigeminus*
Is mixed:
Afferent fibers transmit signals from receptors of the face skin, the mucous of the nose and mouth, teeth, and tongue.
The efferent fibers innervate the chewing muscles, the muscles of the palatine <u>curtain</u> and the muscle straining the eardrum.

Reflex functions of the pons:

- Localized centers that regulate the work of the respiratory system and gastrointestinal tract;
- The centers of protective reflexes are located: sneezing, coughing, tearing, corneal reflex;
- The centers of complexly coordinated reflexes are located: chewing, swallowing, sucking;
- Reflexes associated with maintaining posture, straightening and body changes in space during human movement.

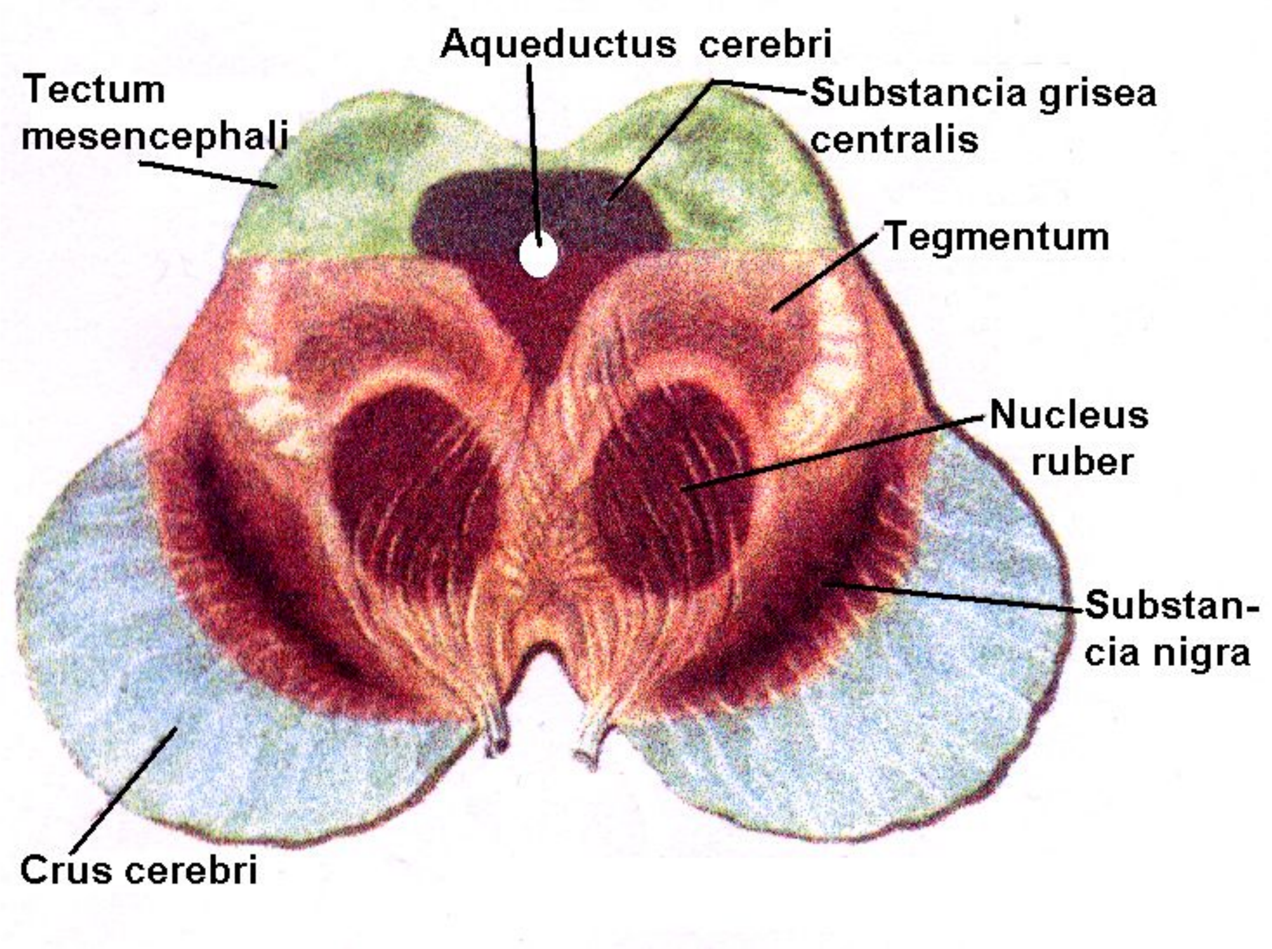


Sensory function of the pons

The following types of sensitivity are analyzed in the sensory nuclei of the pons:

- Primary skin sensitivity (the nucleus of the trigeminal nerve);
- Primary reception of sound signals (nucleus of the cochlear nerve);
- Primary reception of vestibular irritations (superior vestibular nucleus).

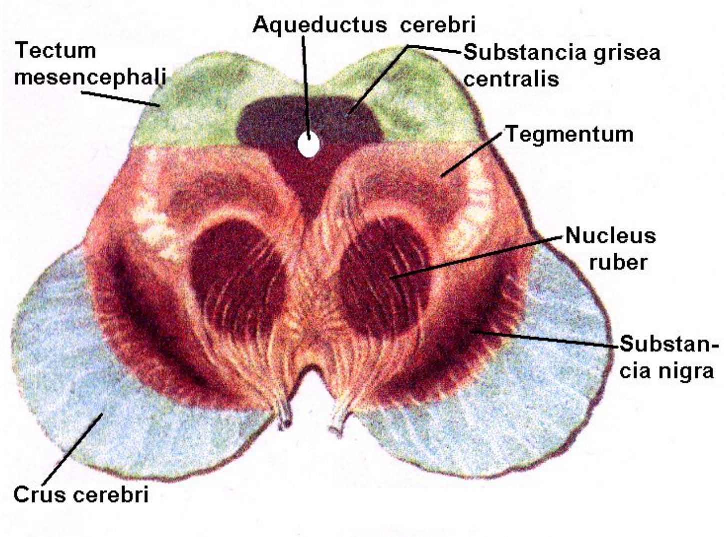
The midbrain. Structural and functional organization.



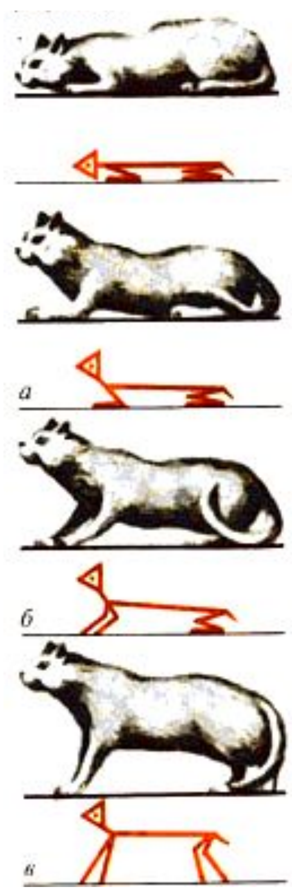
In the midbrain are located:

- cranial nerve nuclei (III and IV pairs);
- Lamina quadrigemina;
- red nucleus;
- substantia nigra;
- blue nucleus;
- reticular formation;

various ascending pathways to the thalamus, cerebellum, and descending pathways pass through the midbrain.



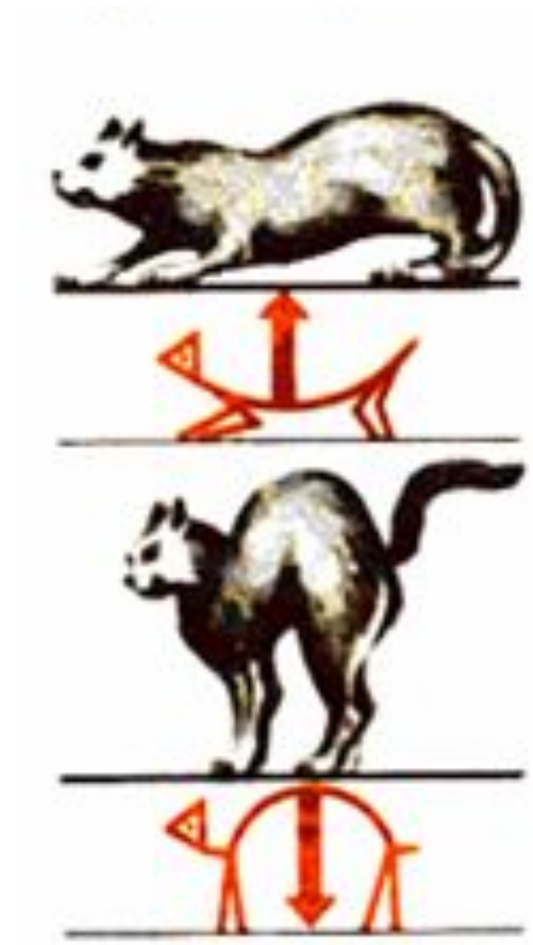
The midbrain motor reflexes:



- STATIC - from vestibule receptors - straightening reflexes (setting)
- the transition of an animal from an unnatural posture to its usual position.

- When falling -
- - first, due to the vestibular rectifying reflex, the normal position of the head is restored - face down.
- - then the repositioning of the head excites the proprioceptors of the neck muscles and they trigger the neck rectifier reflex, as a result of which, following the head, the body also returns to its normal position.

- STATOKINETIC -
- from the semicircular canal receptors
- - reflexes of rectilinear acceleration
- - angular acceleration reflexes



Lamina quadrigemina of the midbrain

Colliculus superior → **Visual subcortical centers**

Colliculus inferior → **Audial subcortical centers**

The function:
  organization of start-reflexes
on sudden, unrecognized visual and sound signals
  participation in the organization of voluntary movements

N. Ruber of the midbrain

Starts the extrapyramidal motor pathway - *Tr. rubrospinalis*

Receives motor inputs from motor cortex, cerebellar nuclei, substantia nigra.

FUNCTIONS:

1. Skeletal muscles tone regulation.
2. Unconsciousness instinctive and precise consciousness movements.

DECEREBRATIVE RIGIDITY

- pathological conditions induced in experiment after brain tissue section with red nucleus connections to vestibular nuclei complete dissection (Ch. Sherringtone experiment).

This condition characterizes by extreme extensor tone prevailing on the flexor tone of the muscles.

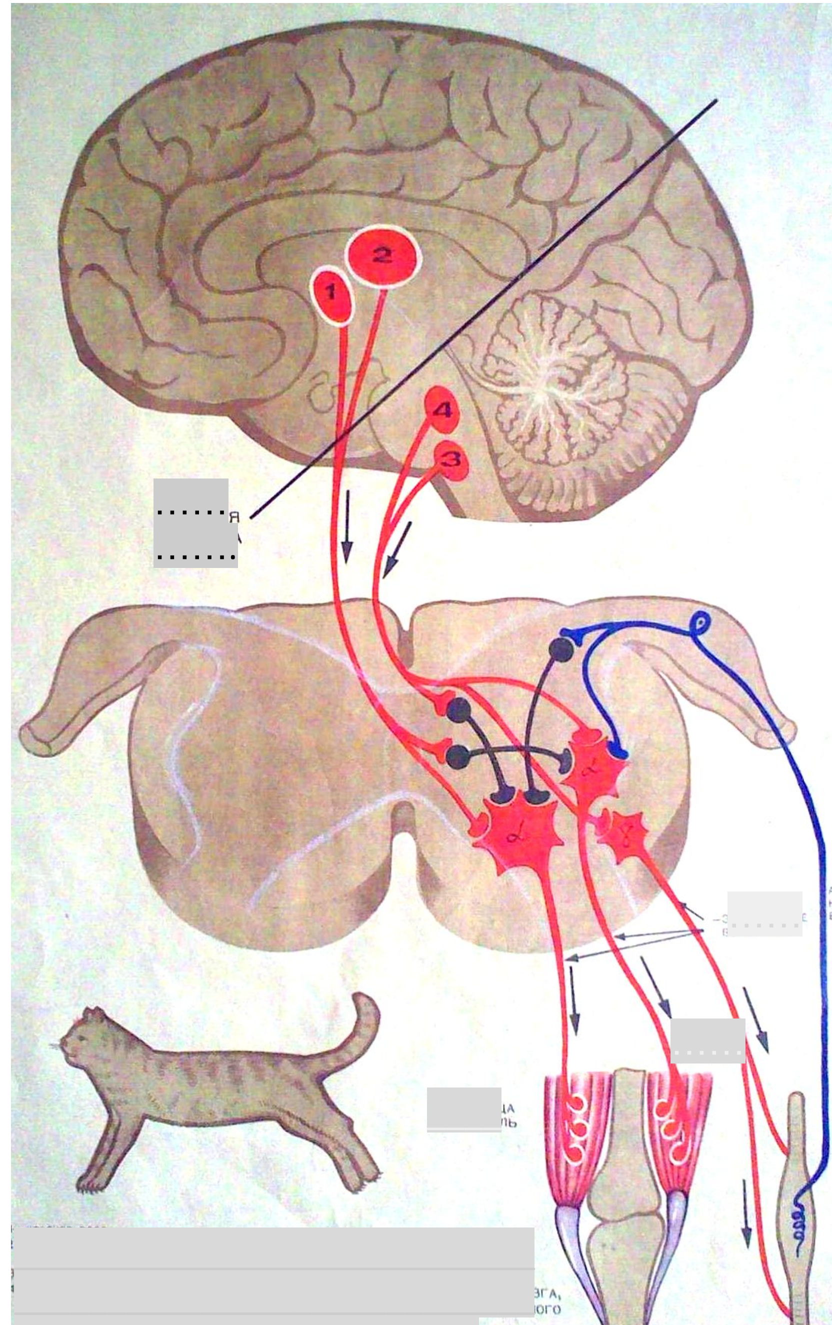
DECEREBRATIVE RIGIDITY

- chaws are clenched;
- neck muscles are extended ;
- the arms are adducted;
- and stiffly extended at the elbows with the forearms pronated;
- wrists and fingers are flexed.

- Mechanism:

- Lateral Deiters nucleus is under the inhibitory effect of the red nucleus.
- After transection below the red nucleus, the inhibitory effect ceases, which leads to hypertonicity of the extensors - decerebration rigidity

- The cerebellum also has a braking effect on the nucleus of Deiters; therefore, the removal of the cerebellum leads to increased decerebration



Substantia nigra

unpigmented neurons and neurons containing melanin pigment.

- Closely related to quadrigemina, red nucleus, reticular formation of the brain stem, thalamus and striopallidarnoy system.
- Participates in the maintenance of plastic tone. Responsible for emotional behavior, precise movements, especially of the fingers; regulate acts of chewing and swallowing (pathology - parkinsonism)
- The black pigment appears in the cells by the age of 2–3 years; its chemical structure is dopamine, which is transported along axons to the basal ganglia.

Mediators of the substantia nigra:
Dopamine (pigmented neurons)
Ach and GABA (non-pigmented neurons)

- The locus ceruleus (blue nucleus) is a dense cluster neurons whose processes form divergent network with one entrance.

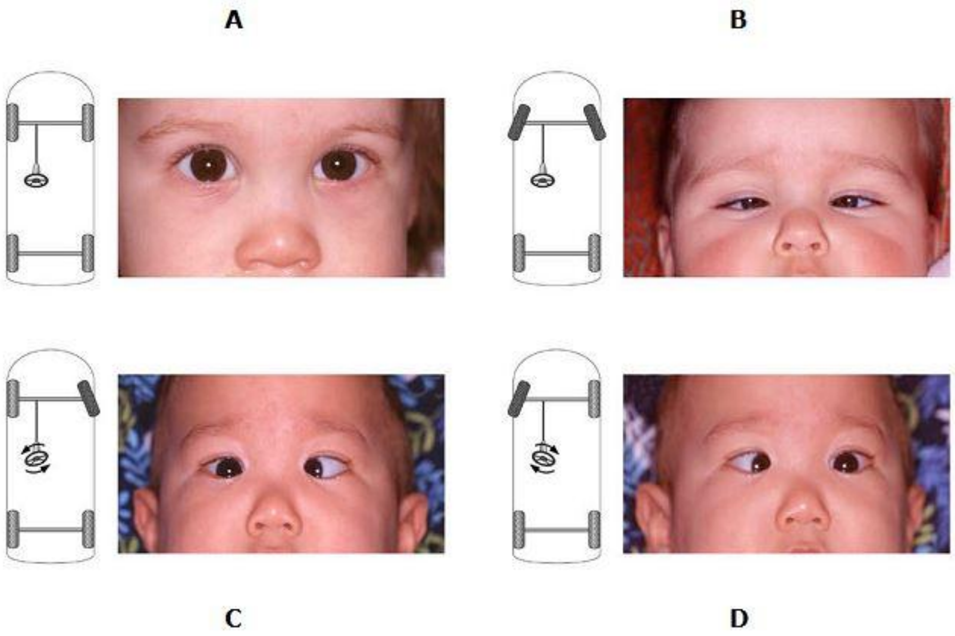
- Its ascending fibers are projected to the structures of the cortex, diencephalon and cerebellum, the descending projections go into the spinal cord to the sympathetic centers and motoneurons.

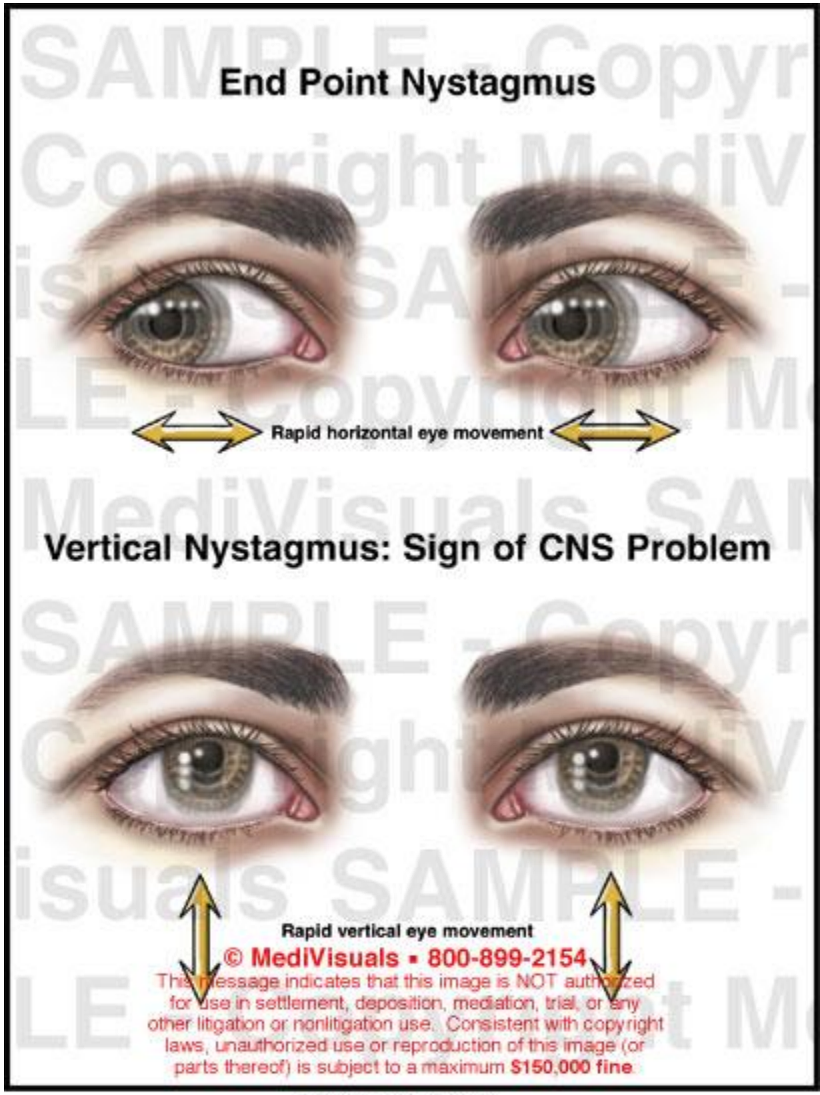
- The mediator is norepinephrine.

Responsible for the physiological response of stress and anxiety.

ONE OF THE VERY IMPORTANT MIDBRAIN FUNCTION ! ! ! ! !

eyeballs movement regulation





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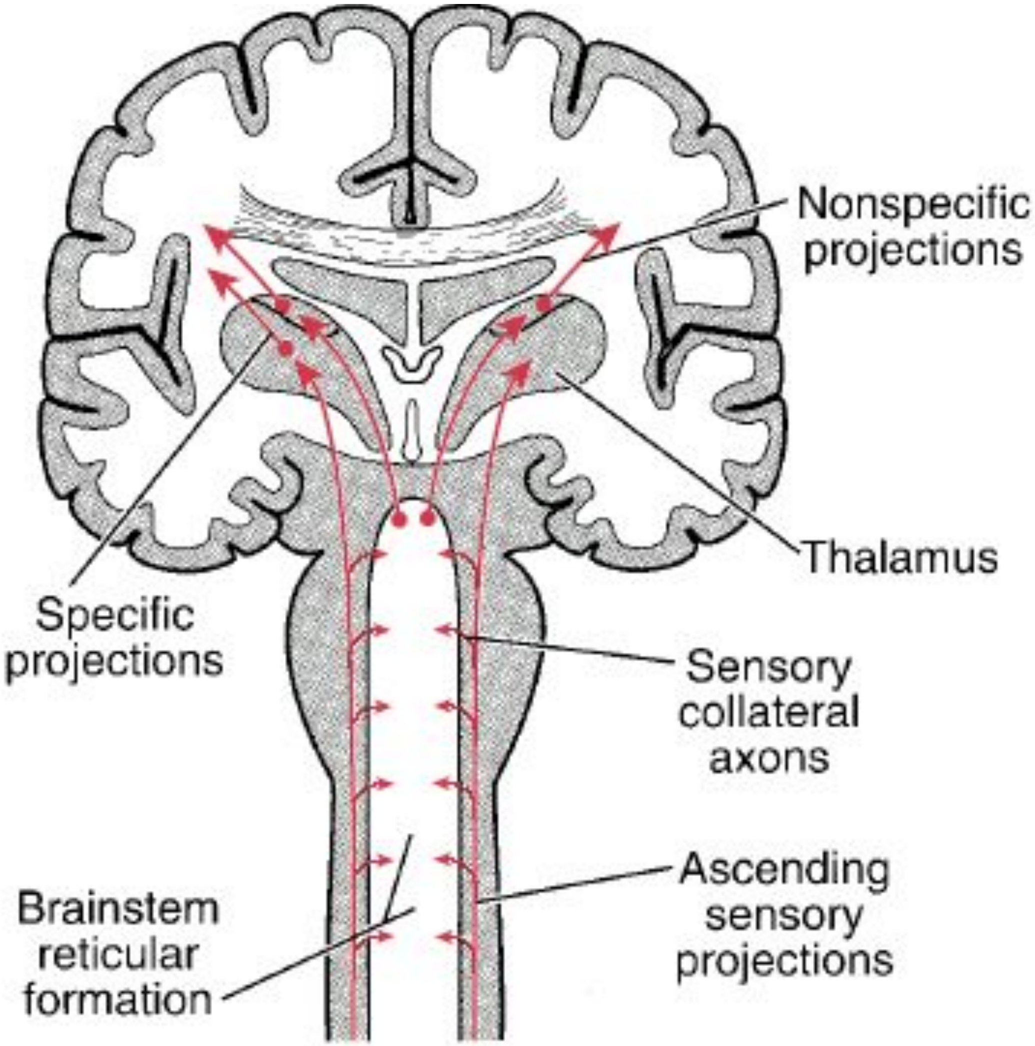
- The midbrain aqueduct surrounds the central gray matter belonging to the reticular formation. Its functions include participation in the regulation of sleep and wakefulness.

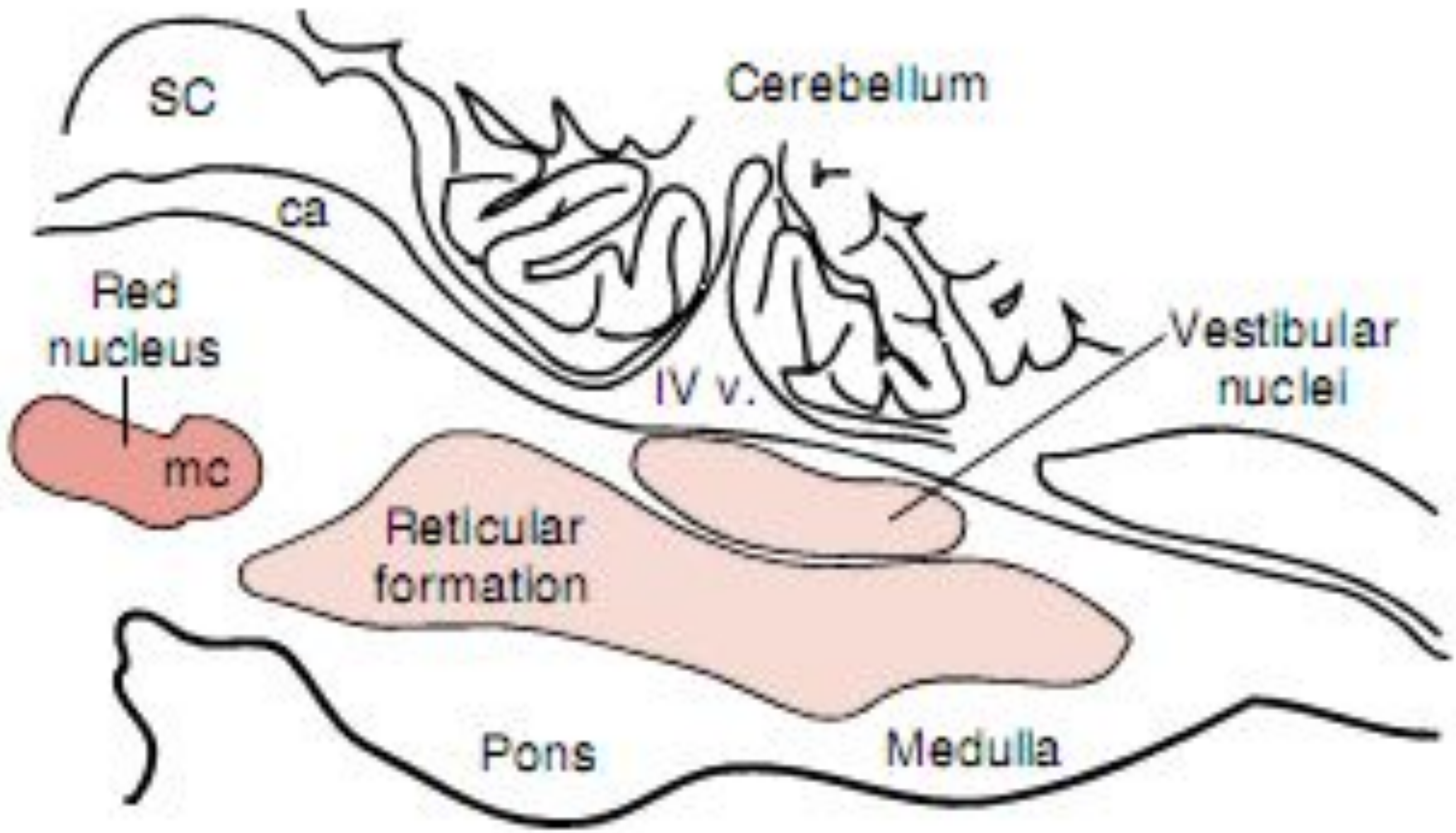
RETICULAR FORMATION

- Phylogenetically ancient brain core - occupies the mediocentral region of the medulla oblongata, the pons and the midbrain.
- It consists of a multitude of network structures forming complexes (for example, adrenergic, serotonergic, and noradrenergic neural systems).
- In the reticular formation are areas associated with the regulation of heart rhythm, blood pressure, respiration and other functions.
- Some of its descending paths block the transmission of impulses in the sensory conductors of the spinal cord and affect the system of stretching reflexes.

RETICULAR FORMATION OF BRAINSTEM



Brain sagittal cross-section on the level of BRAINSTEM



Nonspecificity of the system

- The reticular formation is a complex of polysynaptic pathways. Axons enter it not only from the ascending sensory tracts, but also from the systems of the trigeminal, auditory, and optic nerves. The complexity of neural networks and the degree of convergence of signals led to a violation of modal specificity.
- Therefore, most of the neurons of the reticular system are activated with the same degree of lightness by various sensory stimuli, in this respect the reticular formation is nonspecific.

Functions of reticular formation

1. Respiration regulation (1885, Mislavsky).

2. Heart and vessel activity regulation
(1871, Ovsyannikov).

3. Brain cortex activation via thalamus.
Reaction of desynchronization.

4. Spinal reflexes activation.
N. Reticularis lateralis.

5. Spinal reflexes inhibition.
1862, Sechenov. Reticular giant nucleus.

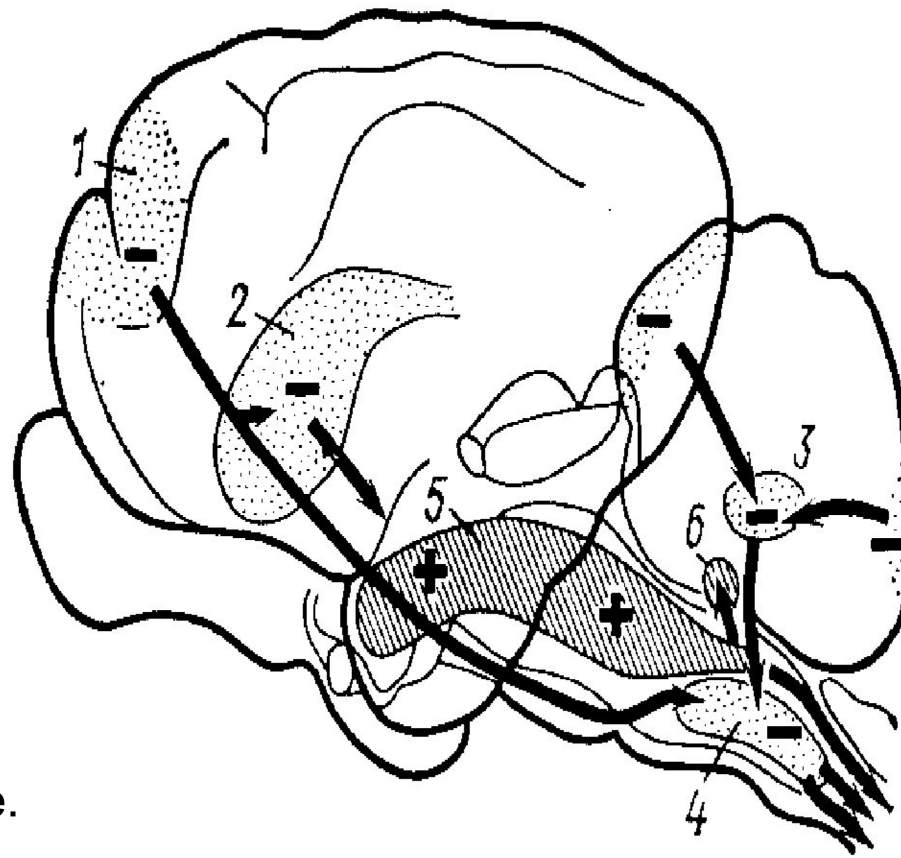
Projections of the ascending reticular activating system

The scheme shows the general system of control of brain activity.

The central component of this system is located in the reticular formation of the pons, midbrain; this is the bulboreticular facilitating area.

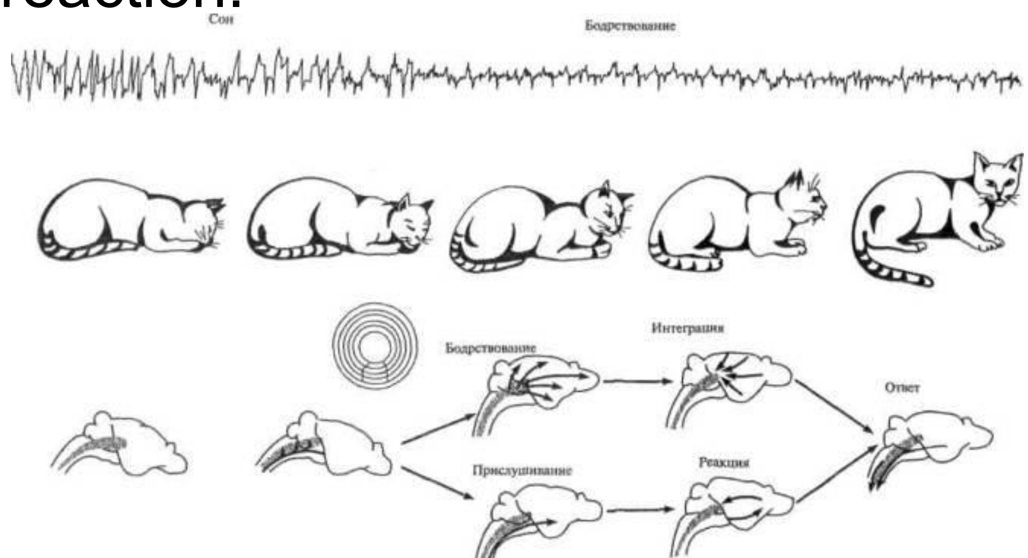
The excitatory signals from this area come primarily to the thalamus, where they excite a new system of neurons.

The reticular formation is a complex of polymorphic neurons of various sizes associated with all CNS structures, between which there are close contacts in the form of chemical and electrical synapses, located from the spinal cord to the thalamus nuclei



RF neurons are highly sensitive to chemical effects;
Neurons of the RF are polysensory, i.e. stimulate stimulation from various receptors.

- Thanks to the works of G. Megun and J. Moruzzi, along with the nonspecific descending effects of the reticular formation of the brainstem, its ascending, activating effects on the cerebral cortex were discovered.
- If through the implanted electrodes to irritate the central parts of the reticular formation of the brainstem, the cat, which is in a sleepy state, awakens. This behavioral awakening response is accompanied by characteristic changes in the frequency spectrum of the electroencephalogram, a transition from regular, high-voltage oscillations of the α-rhythm to low-voltage oscillations (β-rhythm).
- This electroencephalographic reaction is called desynchronization reaction.



- The level of activity of the reticular formation and, therefore, the level of activity of the large brain is largely determined by the number and nature of sensory signals entering the brain from the periphery.
- Thus, pain signals excite extremely strongly the reticular formation of the brain stem, increasing the reactions of attention and anxiety.

- The importance of sensory signals for maintaining the active state of the reticular formation of the brain stem is demonstrated by the intersection of the brain stem above the entry point into the brain of the V pair of cranial nerves. These nerves enter the upper sections of the brain stem and transmit a significant amount of somatosensory signals to the brain.
- Stopping the flow of signals into the reticular formation of the brain stem dramatically reduces its activity, which leads the body to a state of coma (coma is a severe unconscious state). When the brain stem is crossed below the entry point of the V pair of cranial nerves, coma does not occur.

- Blue nucleus and noradrenaline system. Nerve fibers from this region spread to the basal ganglia, olfactory region, cerebellum, brain stem, and cerebral cortex. The endings of fibers secrete norepinephrine, as a rule, stimulating the brain and increasing its activity.

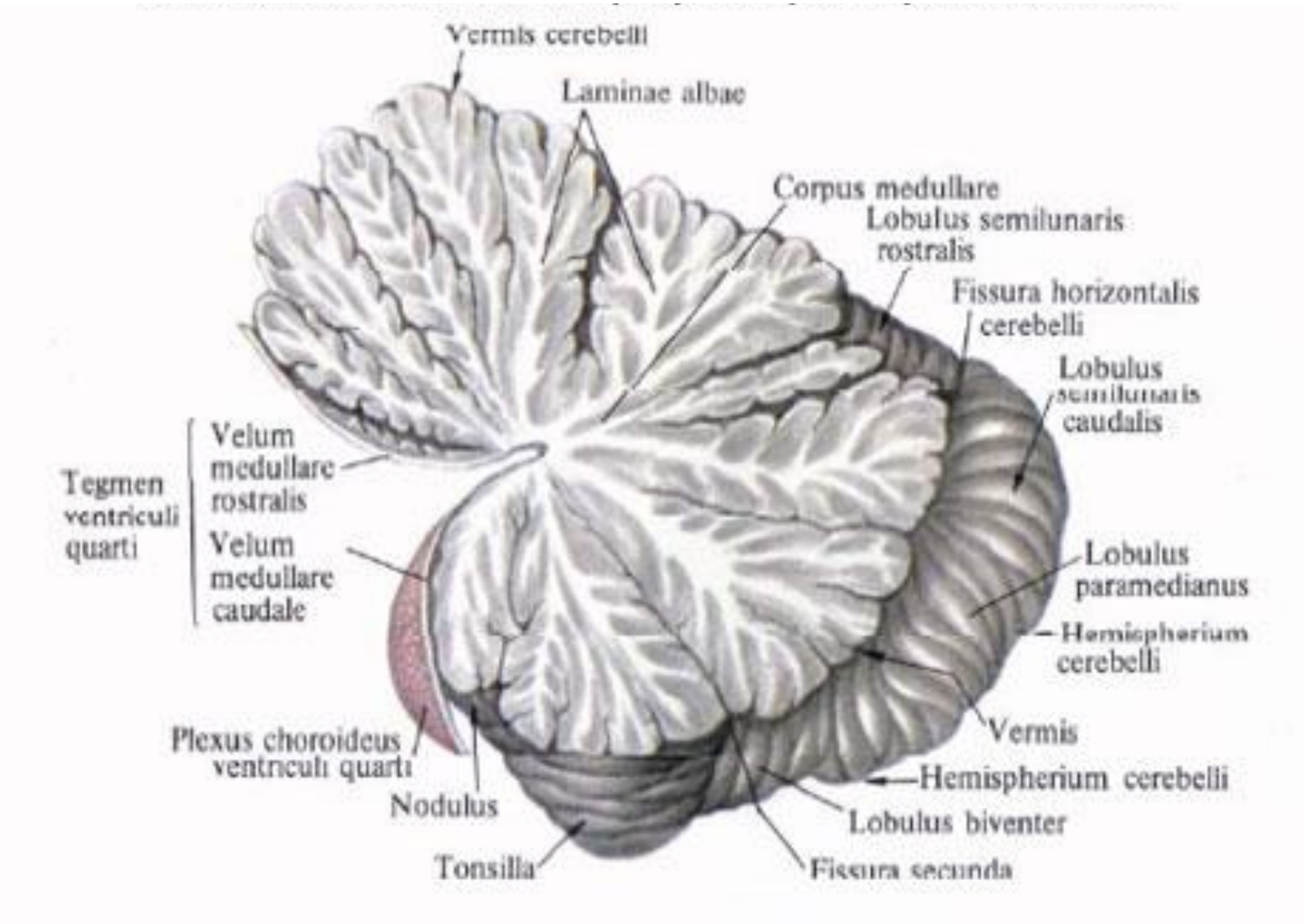
- Substance nigra and dopaminergic system. Nerve fibers go to the caudate nucleus and the shell and release dopamine. Part of the fiber is directed to the hypothalamus and the limbic system. Black pigment (DOPA) appears in cells by 2-3 years. The destruction of dopaminergic neurons of the black substance leads to the development of Parkinson's disease.

- Raphe neurons and serotonergic system.
- Nerve fibers travel to the midbrain, cortex and spinal cord.
- Serotonin is involved in the functioning of the antinociceptive system, sleep mechanisms and the development of a number of neuropsychiatric disorders.
- Giant cell neurons of the reticular formation of the brain stem and cholinergic system.
- Nerve fibers go up (to the diencephalon and cortex) and down (to the spinal cord).
- Acetylcholine is excreted in the terminal axon ramifications, providing excitatory effects.

Basic reticular formation systems

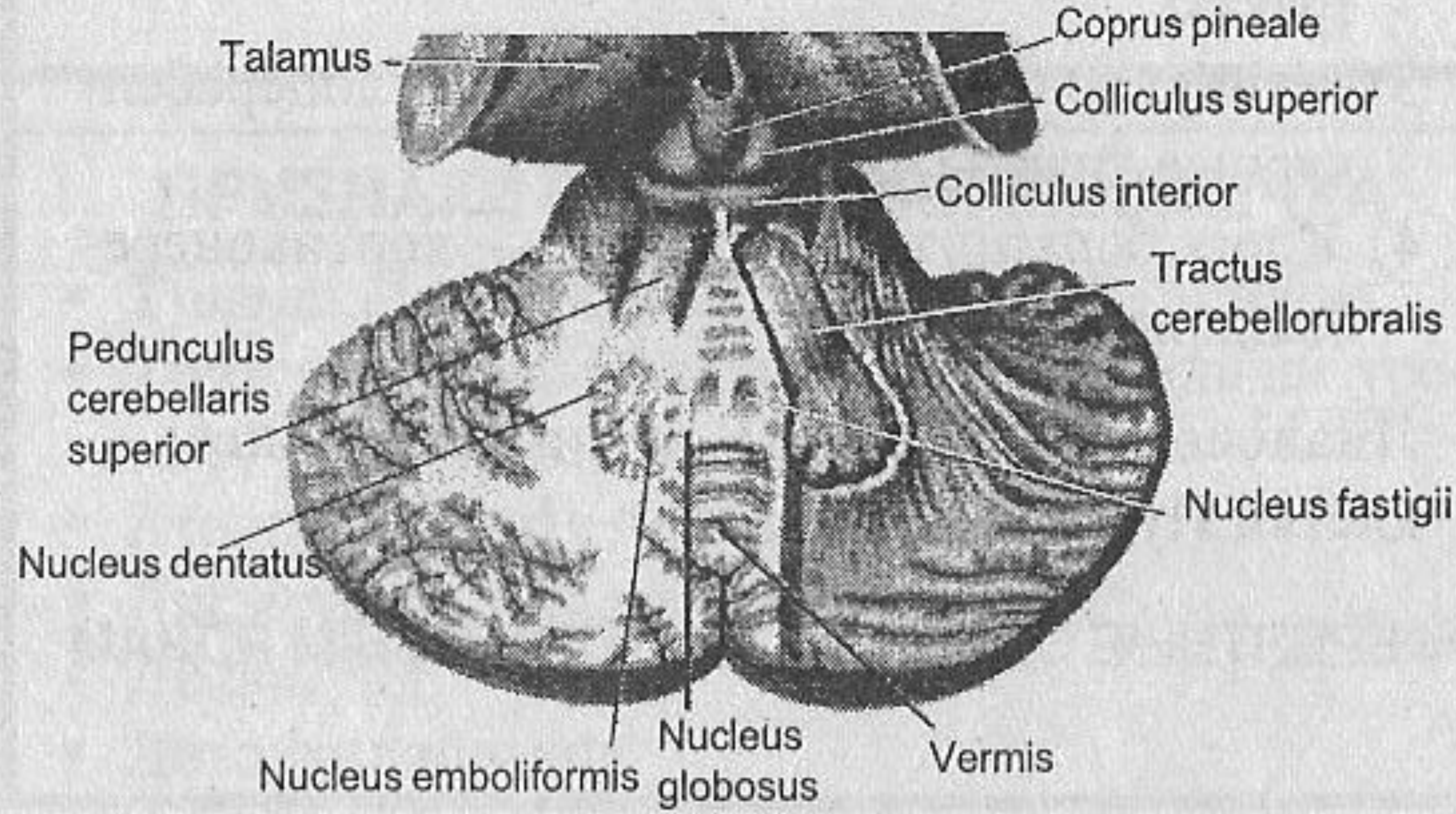
- AFFERENT SYSTEMS:
- from the spinal cord, from the cerebellum, from the quadrilateral, from the cortex,
- from sensitive nuclei of cranial nerves
- EFFECTIVE SYSTEMS:
- Ascending activating system - non-specific toning through the synapses on the dendrites of neurons in the I and II layers of the cortex
- Descending reticulospinal systems:
- - facilitating
- - braking

C E R E B E L L U M



Vermis cerebelli
Laminae albae
Corpus medullare
Lobulus semilunaris rostralis
Fissura horizontalis cerebelli
Lobulus semilunaris caudalis
Tegmen ventriculi quarti
Velum medullare rostralis
Velum medullare caudale
Lobulus paramedianus
Hemispherium cerebelli
Vermis
Plexus choroideus ventriculi quarti
Hemispherium cerebelli
Nodulus
Lobulus biventer
Tonsilla
Fissura secunda

CEREBELLUM



Talamus
Coprus pineale
Colliculus superior
Colliculus interior
Tractus cerebellorubralis
Pedunculus cerebellaris superior
Nucleus fastigii
Nucleus dentatus
Nucleus globosus
Vermis
Nucleus emboliformis

The cerebellum ("small or diminutive brain") consists of two cerebellar hemispheres joined by a vermis.

Cerebellar cortex, only a few mm thick, lies in the surface.

Deep to the cortex lies the white matter. Within the white matter, masses of gray matter, called cerebellar nuclei, are found.

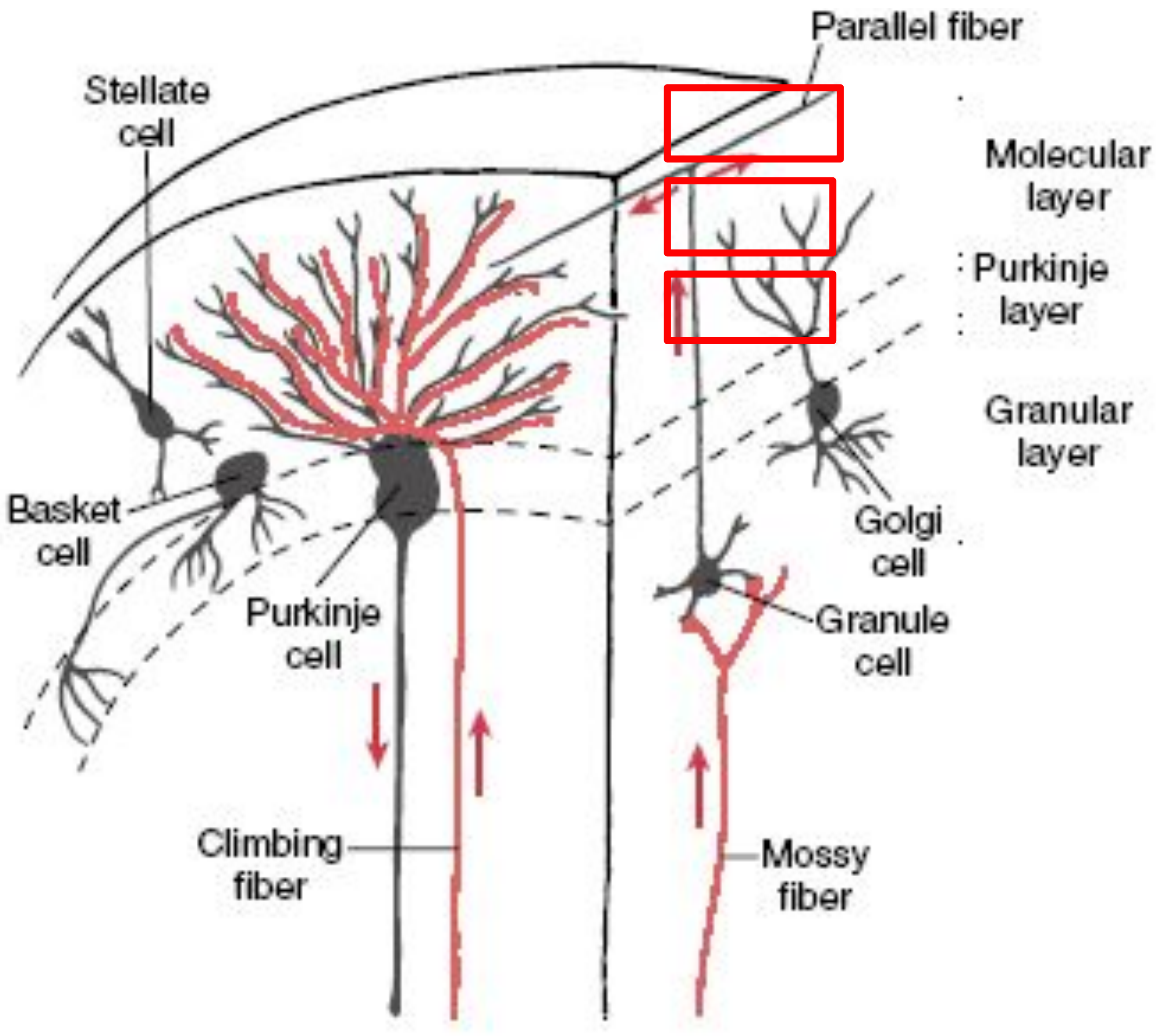
Cerebellar inputs (afferent)

Mossy fibers (spino-, reticulo-, vestibulo- and corticocerebellar) make complex multicontact synapses jn granule cells.

Climbing fibers arise from the infe-rior olive, a nucleus in the medulla. Each climbing fiber synapses directly on the dendrites of a Purkinje cell and exerts a strong excitatory influence.

Adrenergic fibers arise from the locus coeruleus, a basal ganglia structure. These fibers are considered to perform the trophic function.

The layers of cerebellar cortex



Types of the cerebellar cortical cells

Basket cells

their projections terminate on the Purkinje cells bodies

Stellate cells

their projections terminate on the Purkinje cells dendrites

Purkinje cels

their dendrites reach upward into the molecular layer

their axons go downward and make synapses with cerebellar nuclei

some axons terminate on vestibular nuclei

Golgi cells

their dendrites reach upward into the molecular layer,
their axons go the the granular cells

Granular cells

their axons reach upward into the molecular layer and
make synapses with Purkinje, basket and stellate cells

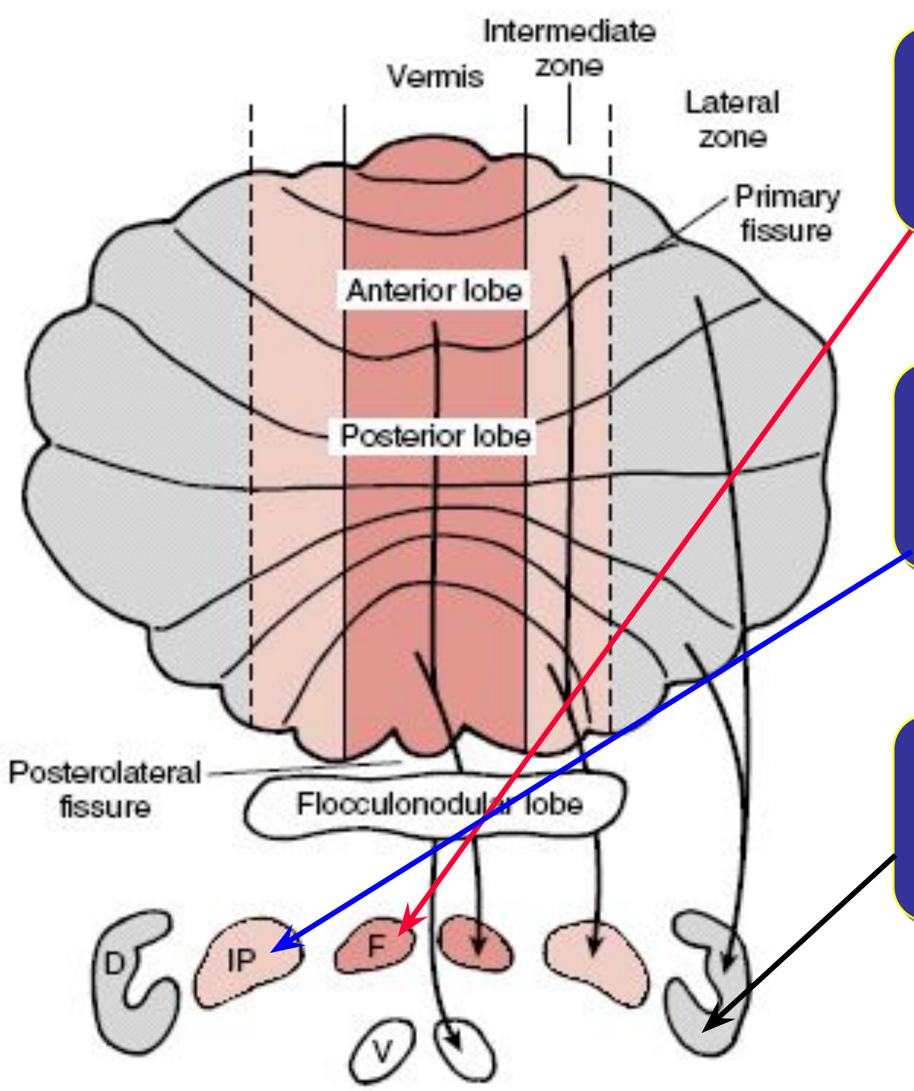
Purkinje cells constantly generate IPSP

This is critically important for the cerebellar nuclei activity inhibition because they are constantly generate tonic activity

Purkinje cells excitation through climbing and mossy fibers results in IPSP generation increasing that lead in turn more expressed cerebellar nuclei activity inhibition.

Both stellate cells and basket cells – induced Purkinje cells activity inhibition results in their activation that lead to cerebellar nuclei activity increasing.

TOPOGRAPHIC CLASSIFICATION OF CEREBELAR CORTEX AND NUCLEI



1. MEDIAL zone –
has projections on the *fastigial n.*

2. INTERMEDIATE zone –
has projections on the *interposed n.*

3. LATERAL zone –
has projections on the *dentate n.*

Functions of cerebellum

1. Posture and muscular tone regulation

2. Slow aimed movements correction and their coordination with the postural reflexes

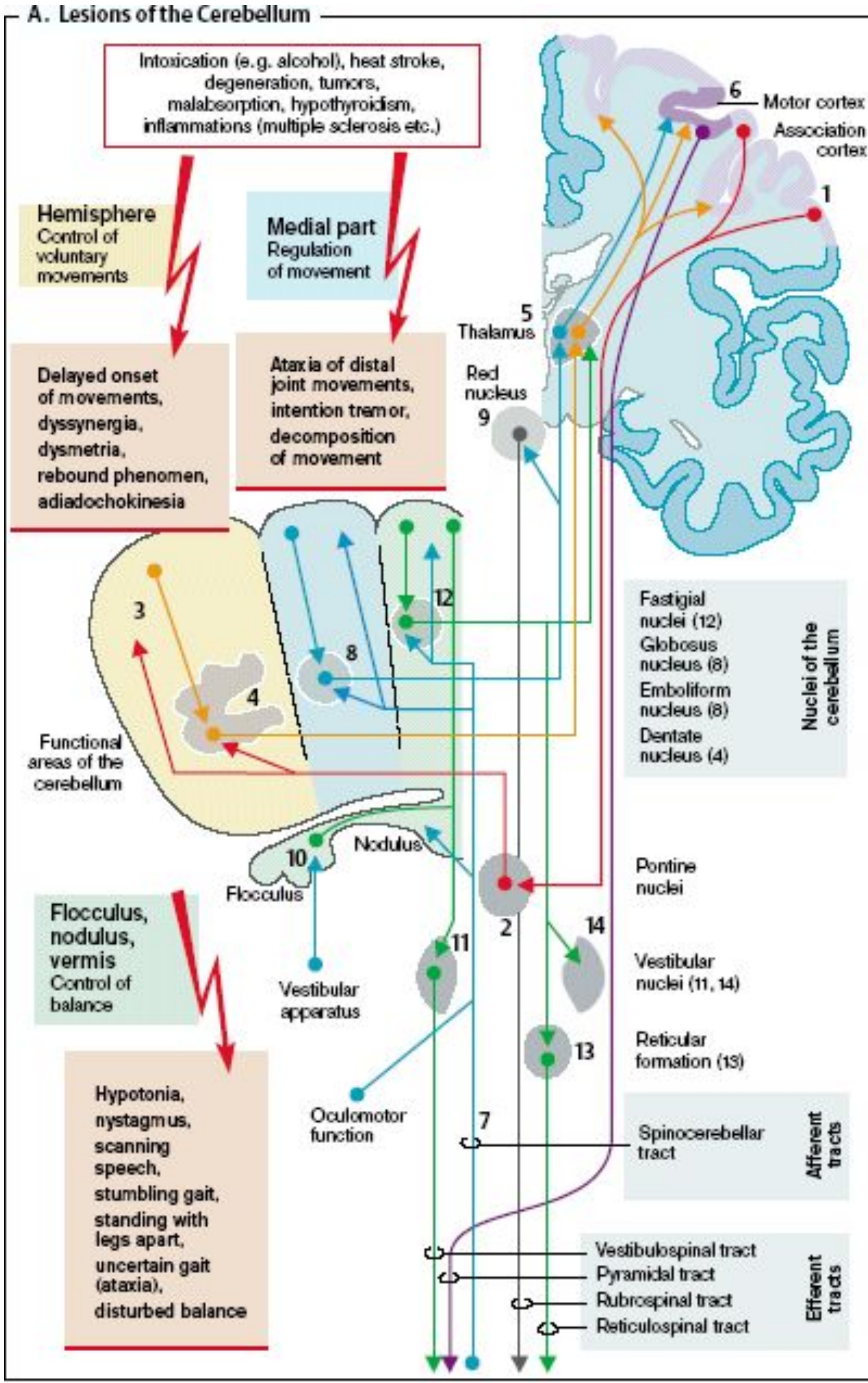
3. Sensorimotor coordination of quick aimed movements performed from the commands out of brain cortex.

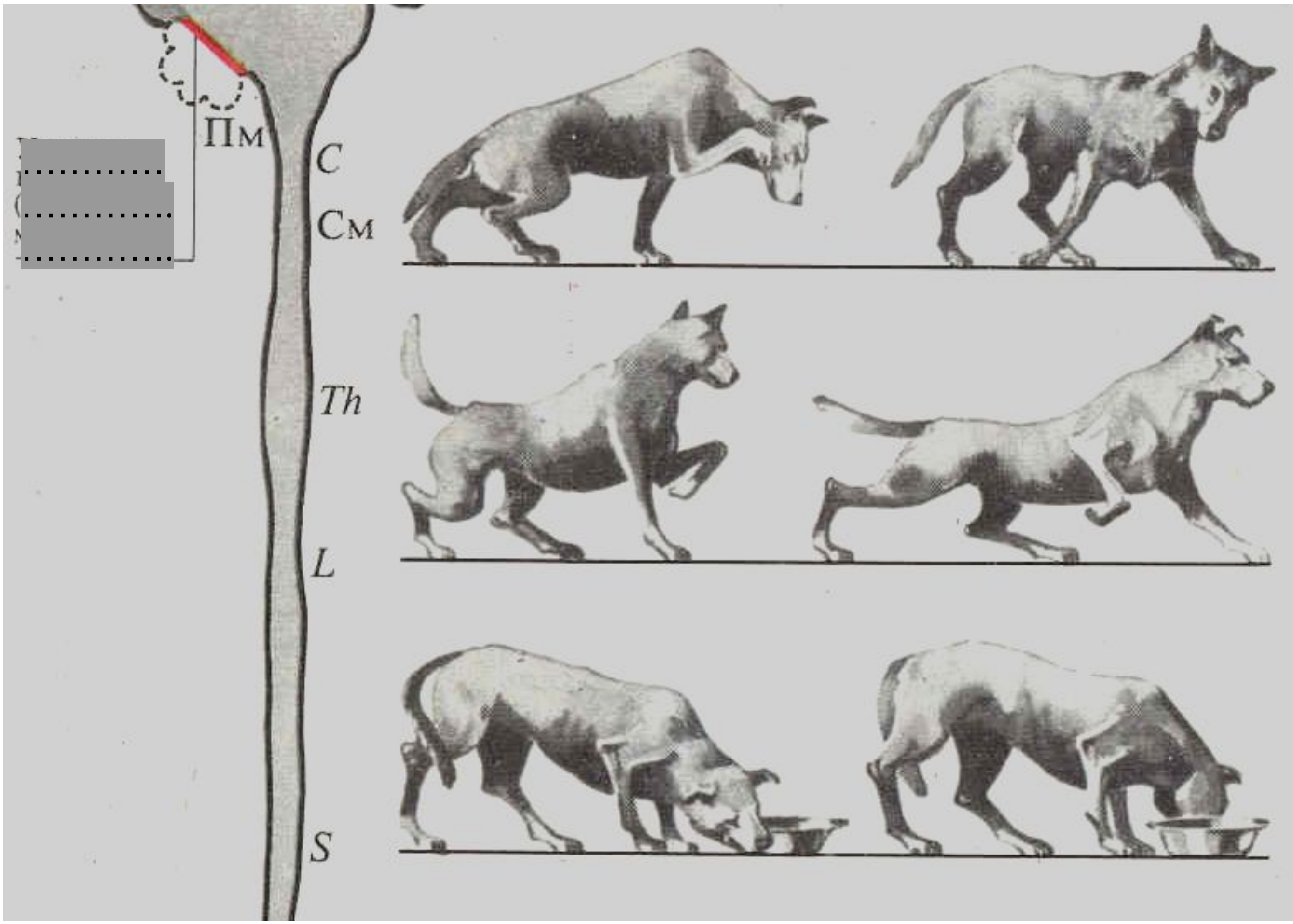
1. MEDIAL zone – n. gastigial – medulla oblongata, vestibular nuclei

2 INTERMEDIATE zone – interposed n. – red n. + brain cortex.

3 LATERAL zone – dentate n. – thalamus – brain cortex motor zone

Cerebellar lesions

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THANKS for attention!