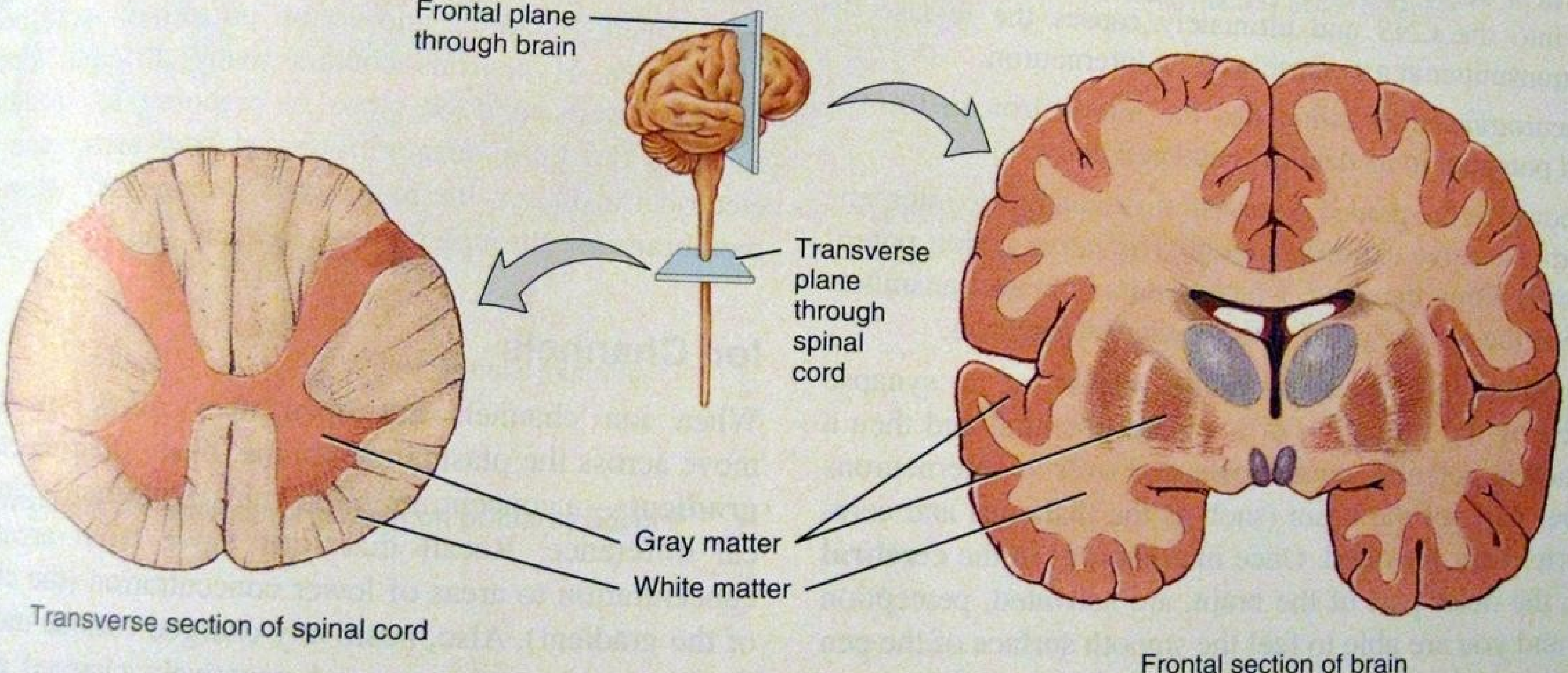
Szomatomotoros Müködések

Molnár Péter, Állattani Tanszék

Figure 12.9 **Distribution of gray and white matter in the spinal cord and brain.**

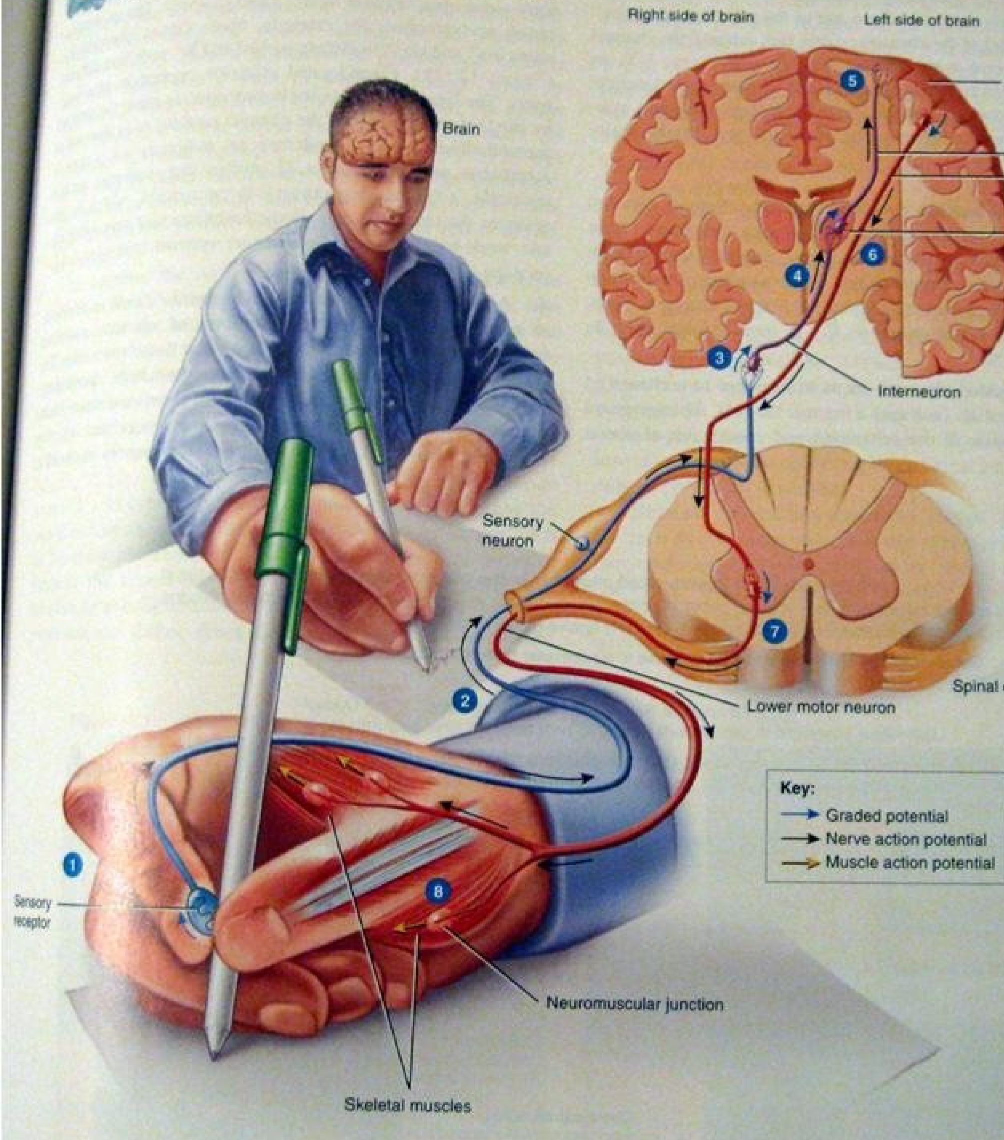
White matter primarily consists of myelinated axons of many neurons. Gray matter consists of neuron cell bodies, dendrites, axon terminals, unmyelinated axons, and neuroglia.



What is responsible for the white appearance of white matter?

Figure 12.10 Overview of nervous system functions.

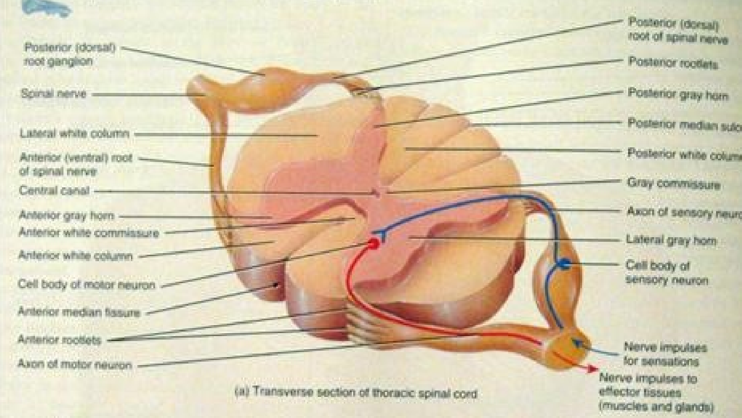
Graded potentials and nerve and muscle action potentials are involved in the relay of sensory stimuli, integrative functions such as perception, and motor activities.



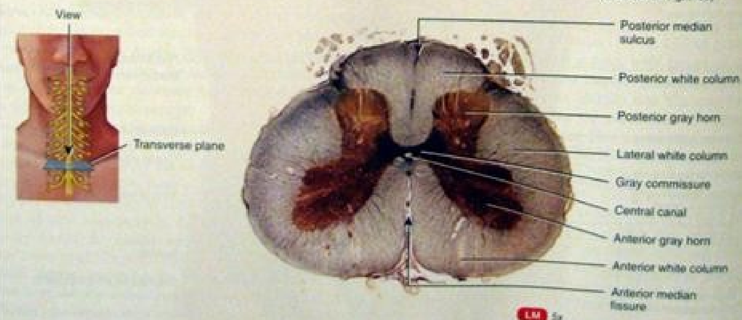
In which region of the brain does perception primarily occur?

Figure 13.3 Internal anatomy of the spinal cord: the organization of gray matter and white matter. For simplicity, dendrites are not shown in this and several other illustrations of transverse sections of the spinal cord. Blue and red arrows in (a) indicate the direction of nerve impulse propagation.

In the spinal cord, white matter surrounds the gray matter.



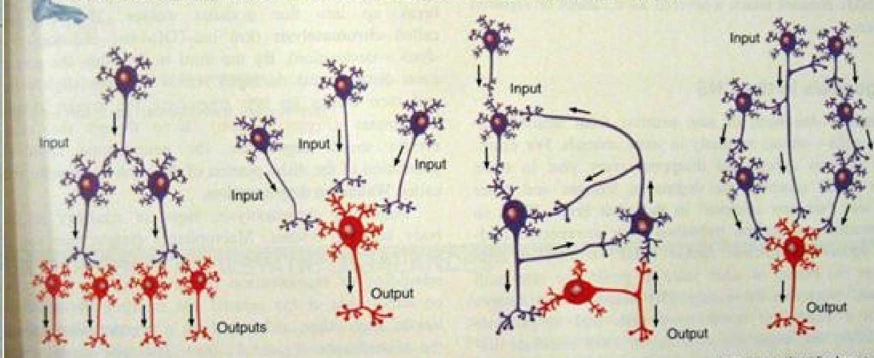
(a) Transverse section of thoracic spinal cord



(b) Transverse section of thoracic spinal cord

Figure 12.19 Examples of neural circuits.

A neural circuit is a functional group of neurons that processes a specific kind of information.

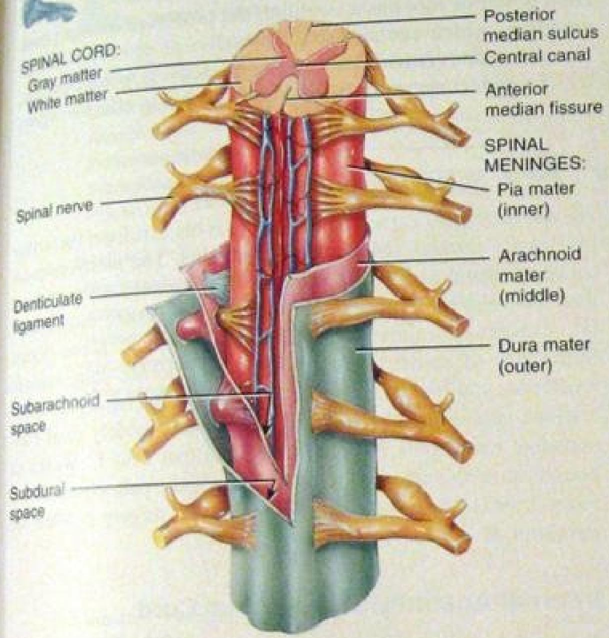


(a) Diverging circuit (b) Converging circuit (c) Reverberating circuit (d) Parallel after-discharge circuit

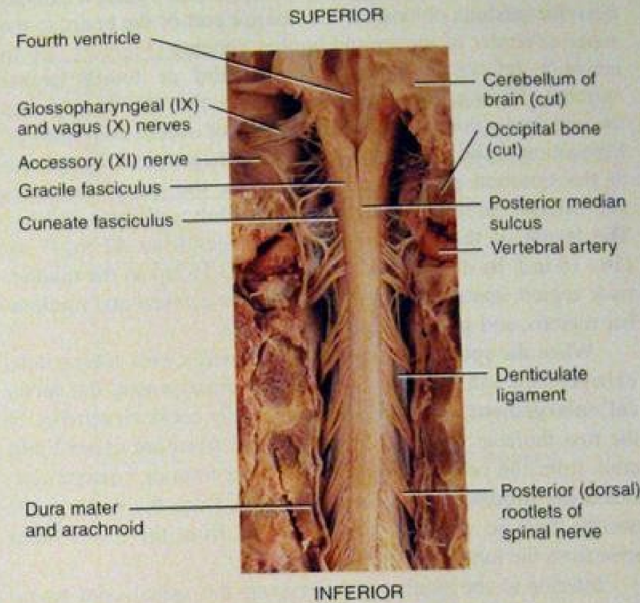
A motor neuron in the spinal cord typically receives input from neurons that originate in several different regions of the brain. Is this an example of convergence or divergence?

Figure 13.1 Gross anatomy of the spinal cord. The spinal meninges are evident in parts (a) and (c).

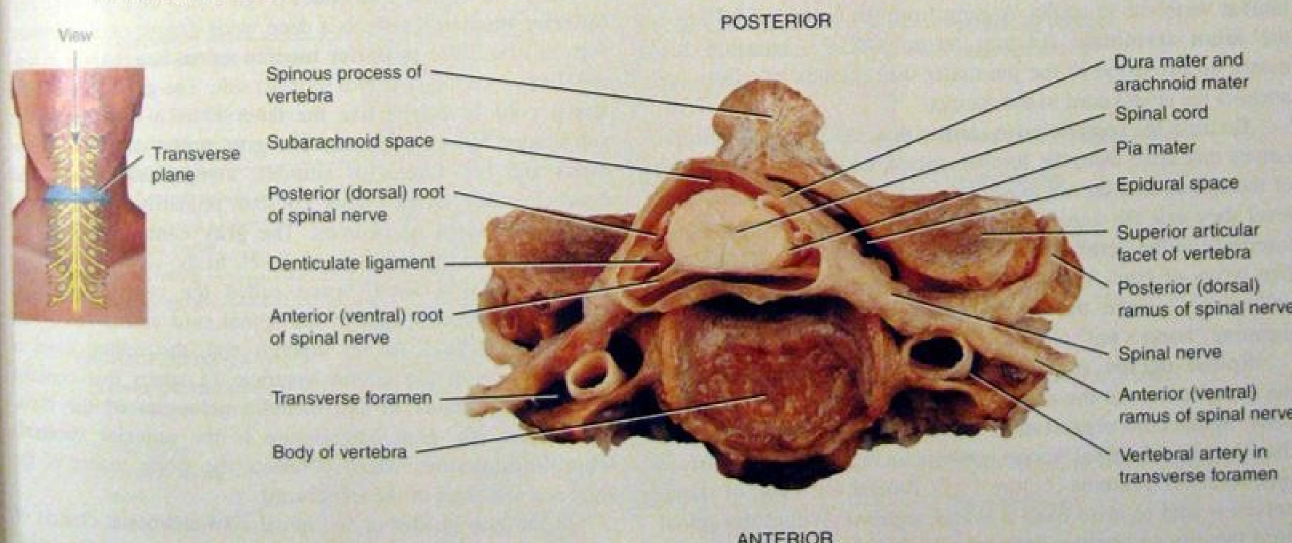
Meninges are connective tissue coverings that surround the spinal cord and brain.



(a) Anterior view and transverse section through spinal cord



(b) Posterior view of cervical region of spinal cord

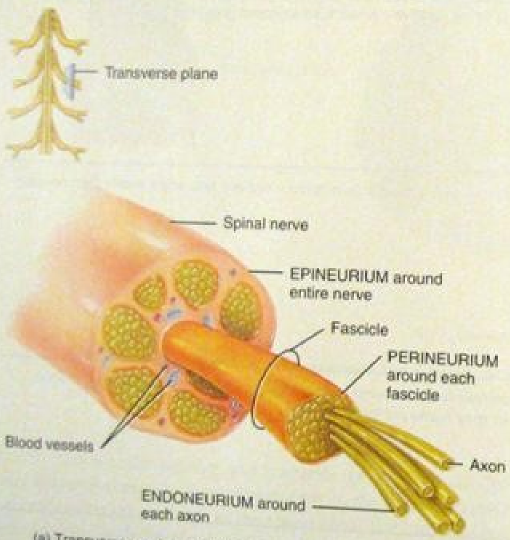


(c) Transverse section of the spinal cord within a cervical vertebra

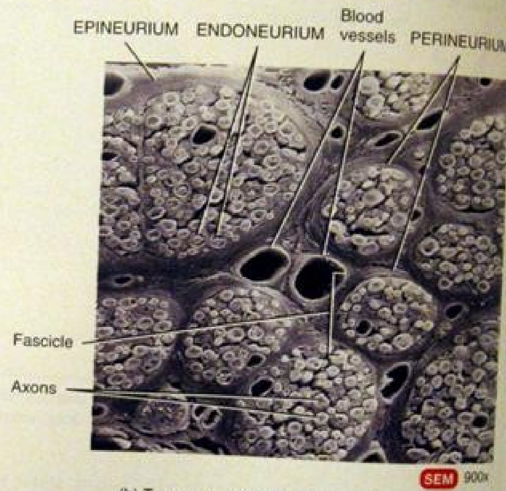
What are the superior and inferior boundaries of the spinal dura mater?

Figure 13.4 Organization and connective tissue coverings of a spinal nerve. (Part (b): From Richard G. Kessel and Randy H. Kardon, *Tissues and Organs: A Text-Atlas of Scanning Electron Microscopy.* Copyright © 1979 by W. H. Freeman and Company. Reprinted by perimission.)

Three layers of connective tissue wrappings protect axons: Endoneurium surrounds individual axons, perineurium surrounds bundles of axons (fascicles), and epineurium surrounds an entire nerve.



(a) Transverse section showing the coverings of a spinal nerve

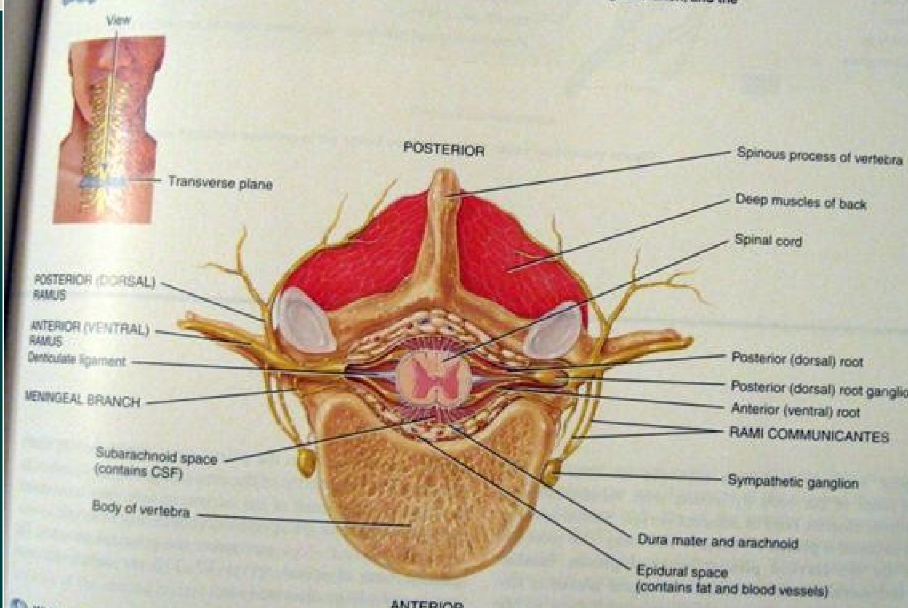


(b) Transverse section of 12 nerve fascicles

Why are all spinal nerves classified as mixed nerves?

Figure 13.5 Branches of a typical spinal nerve, shown in transverse section through the thoracic portion of the spinal cord. (See also Figure 13.1c.)

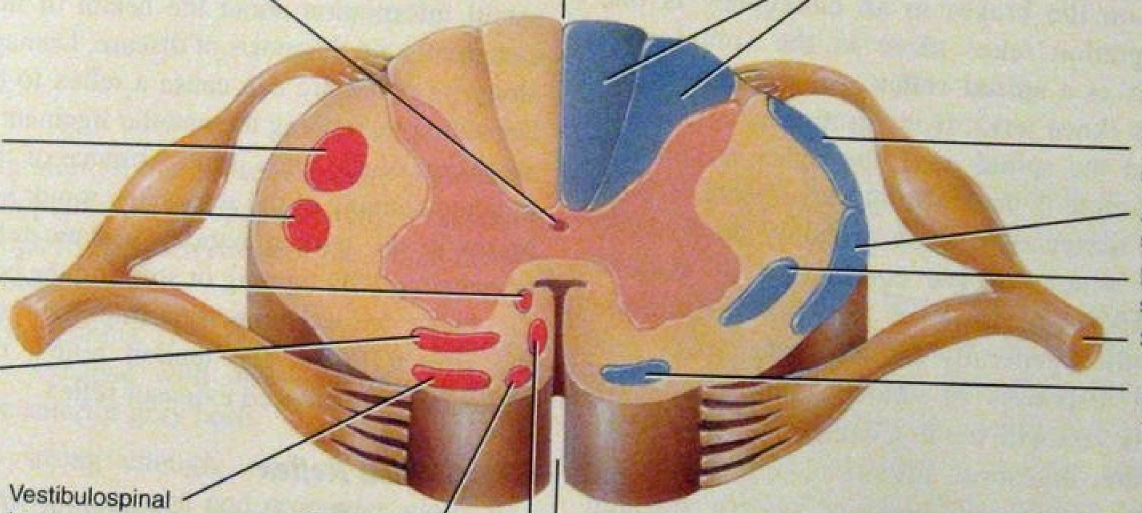
The branches of a spinal nerve are the posterior ramus, the anterior ramus, the meningeal branch, and the rami communicantes.



Which spinal nerve branches serve the upper and lower limbs?

Figure 13.12 Locations of major sensory and motor tracts, shown in a transverse section of the spinal cord. Sensory tracts are indicated on one half and motor tracts on the other half of the cord, but actually all tracts are present on both sides.

The name of a tract often indicates its location in the white matter and where it begins and ends.



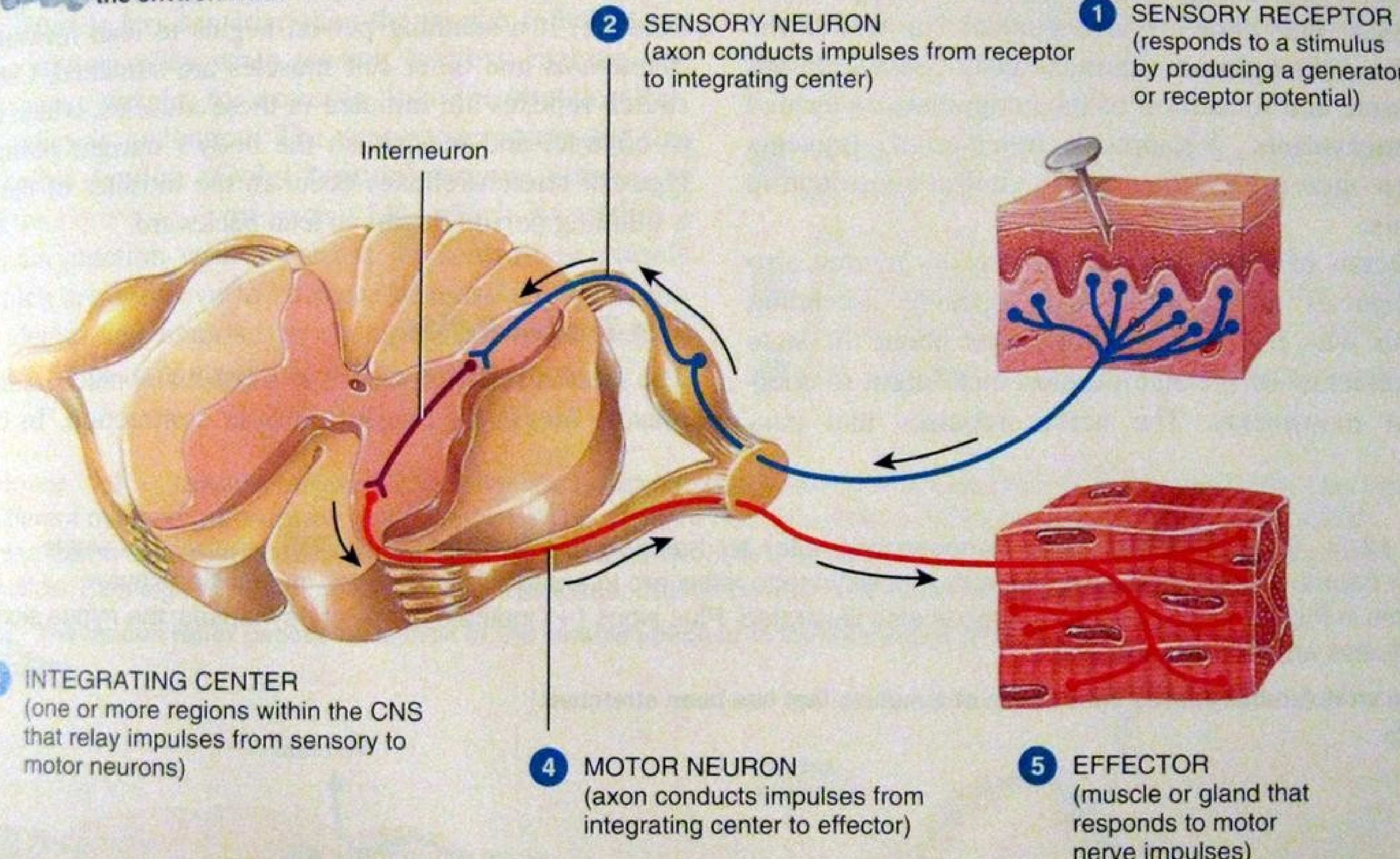
Functions of the Spinal Cord and Spinal Nerves

1. **The white matter of the spinal cord contains sensory and motor tracts, the "highways" for conduction of sensory nerve impulses toward the brain and motor nerve impulses from the brain toward effector tissues.**
2. **The spinal cord gray matter is a site for integration (summing) of excitatory postsynaptic potentials (EPSPs) and inhibitory postsynaptic potentials (IPSPs).**
3. **Spinal nerves and the nerves that branch from them connect the CNS to the sensory receptors, muscles, and glands in all parts of the body.**

Based on its name, what are the position in the spinal cord, origin, and destination of the anterior corticospinal tract? Is this a sensory or a motor tract?

Figure 13.13 General components of a reflex arc. The arrows show the direction of nerve impulse propagation.

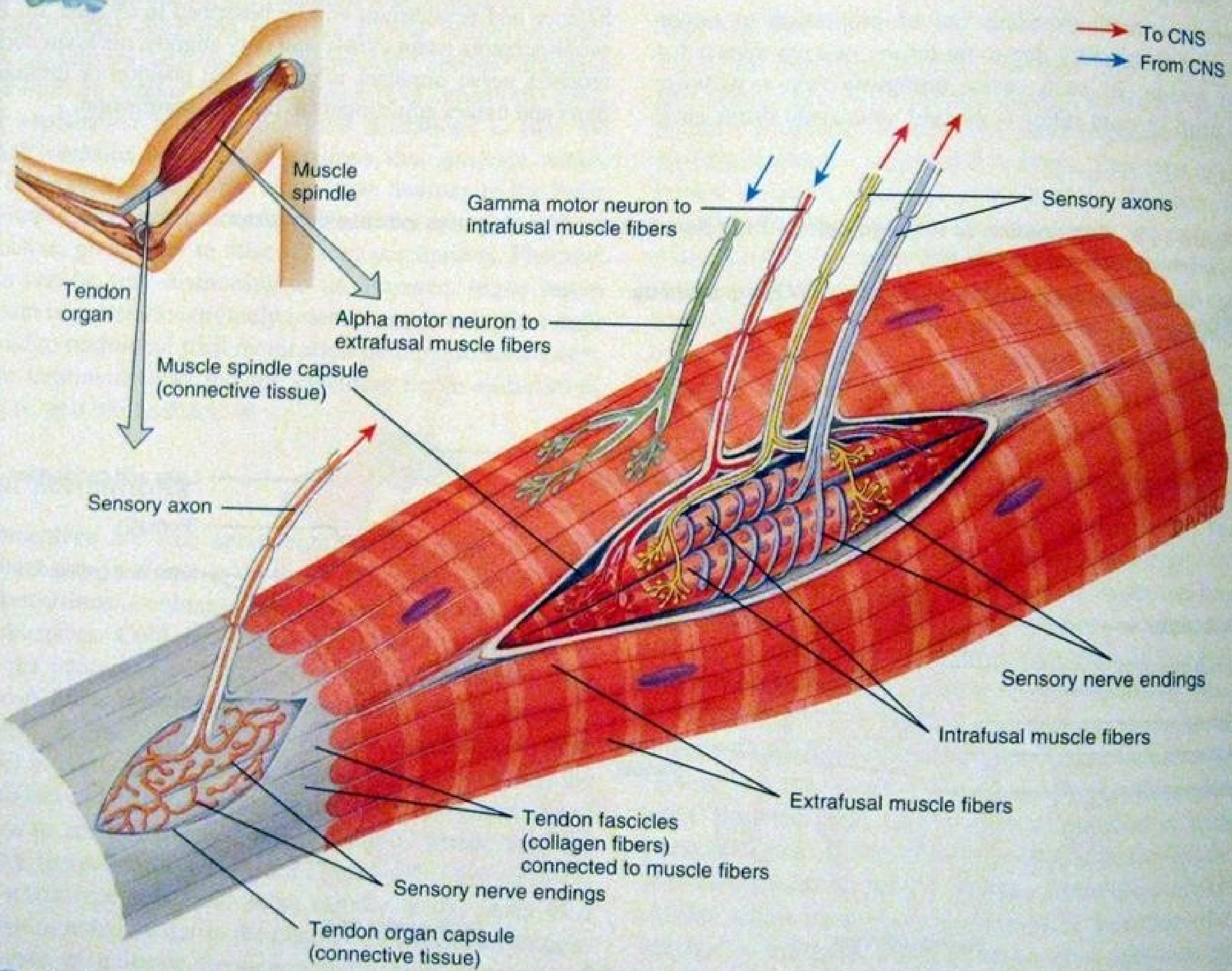
A reflex is a fast, predictable sequence of involuntary actions that occur in response to certain changes in the environment.



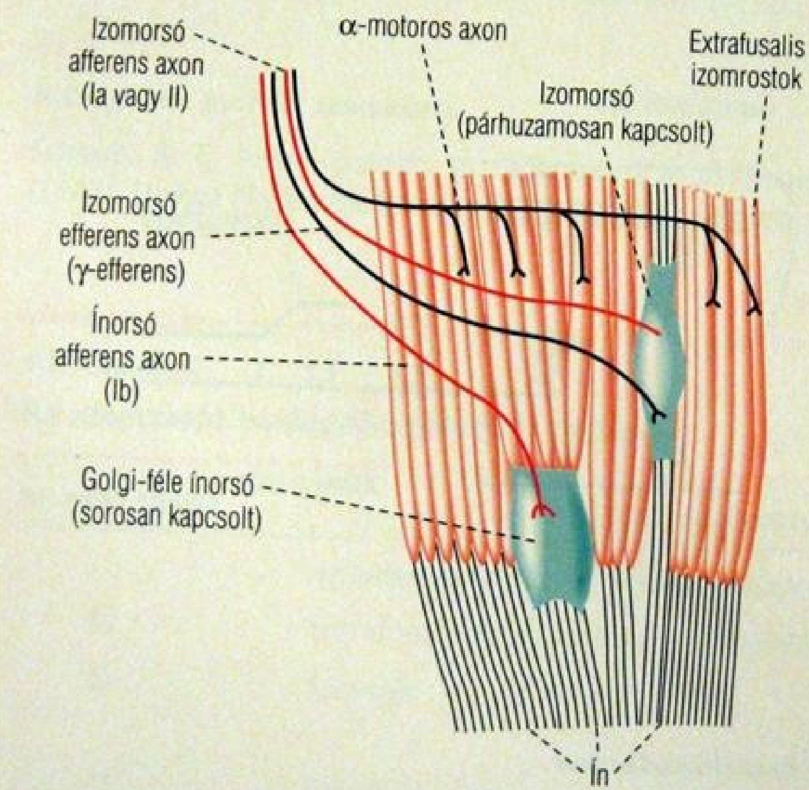
What initiates a nerve impulse in a sensory neuron? Which branch of the nervous system includes all integrating centers for reflexes?

Figure 16.4 Two types of proprioceptors: a muscle spindle and a tendon organ. In muscle spindles, which monitor changes in skeletal muscle length, sensory nerve endings wrap around the central portion of intrafusal muscle fibers. In tendon organs, which monitor the force of muscle contraction, sensory nerve endings are activated by increasing tension on a tendon. If you examine Figure 13.14 on page 462, you can see the relationship of a muscle spindle to the spinal cord as a component of a stretch reflex. In Figure 13.15 on page 463, you can see the relationship of a tendon organ to the spinal cord as a component of a tendon reflex.

Proprioceptors provide information about body position and movement.



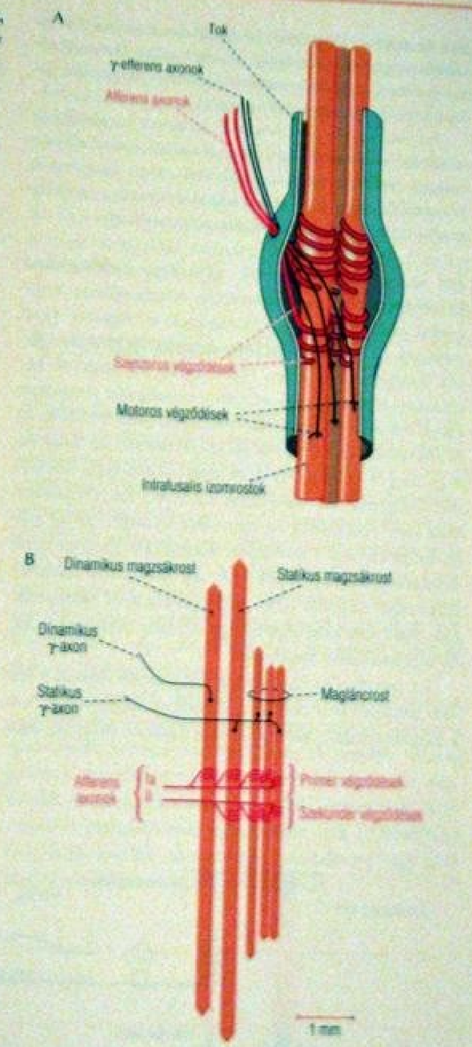
How is a muscle spindle activated?



42-2. ábra

Az izomorsók és a Golgi-féle ínorsók elhelyezkedésének összehasonlítása

Kandel, E. R., Schwartz, J. H. és Jessel T. M. (1991): Principles of Neural Science. 3. kiadás, Prentice-Hall International Inc. London alapján



42-3. ábra

Az izomorsó vázlatos szerkezete

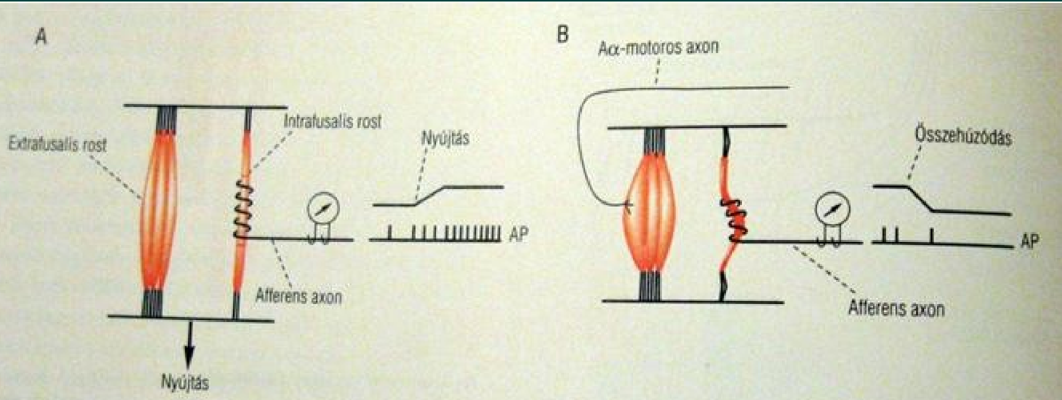
A) Az intrafusalis izomrostok kontraktilis és nem kontraktilis szakaszai és beidegzésük

Hullinger, M. (1984): The mammalian muscle spindle and its central control. Rev. Physiol. Biochem. Pharmacol., 101, 1–110. alapján

B) A statikus és dinamikus magzsákrostok, magláncrostok és beidegzésük

Boyd, I. A. (1980): The isolated mammalian muscle spindle. Trends Neurosci., 3, 258–265. alapján

Az efferens axonok feketék, az afferens axonokat és végződéseiket piros szín jelzi



42-4. ábra

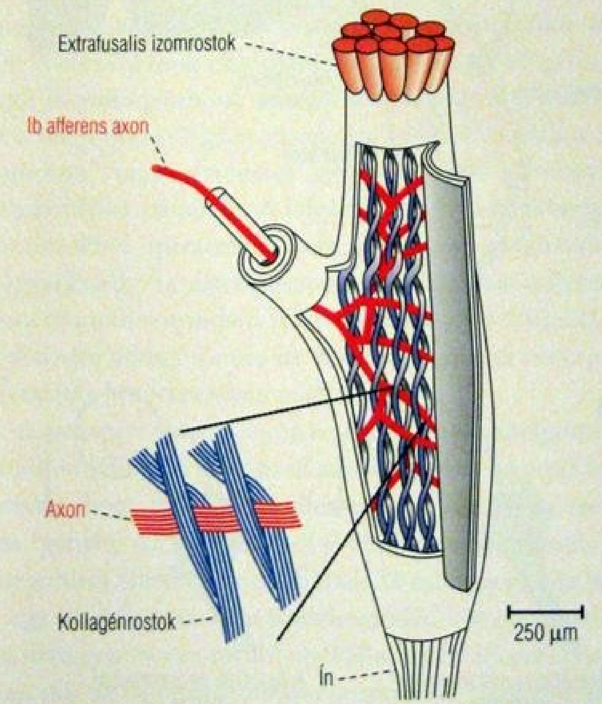
Az izomorsók feszítettségének csökkenése az extrafusalis rostok aktív összehúzódásakor

Kandel, E. R., Schwartz, J. H. és Jessel, T. M. (1991): Principles of Neural Science. 3. kiadás, Prentice-Hall International Inc. London alapján]

A) Az izom extra- és intrafusalis rostjainak passzív nyújtására az izomorsók afferens axonjairól elvezetett akciós potenciálok frekvenciája nő

B) Az izom aktív összehúzódásakor a párhuzamosan kapcsolódó intrafusalis rostokra nehezedő terhelés együtt csökken az elvezetett akciós potenciál frekvenciájával

AP: akciós potenciál



42-5. ábra

A Golgi-féle ínorsók szerkezete

Schmidt, R. F.: Motor systems. In: Schmidt, R. F. és Thews, G. (1983): Human Physiology. Springer, Berlin alapján módosítva

42-1. táblázat

Az izomzatot beidegző axonok és funkcióik

Az axon típusa	A beidegzett struktúra	Funkció
	Afferens rostok (Lloyd–Hunt-szerinti osztályozás)	
Ia	Intrafusalis izomrostok (valamennyi)	Fázisos és statikus nyújtás
Ib	Ínorsók	Az ín nyújtása; aktív izom-összehúzódás
II	Intrafusalis izomrostok (statikus magzsák- és magláncrostok)	Statikus nyújtás
	Efferens rostok (Erlanger–Gasser-szerinti osztályozás)	
$A\gamma$	Intrafusalis izomrostok	Az érzékenység szervokontrollja
$A\alpha$	Extrafusalis izomrostok	Izom-összehúzódás

Figure 13.14 Stretch reflex. This monosynaptic reflex arc has only one synapse in the CNS—between a single sensory neuron and a single motor neuron. A polysynaptic reflex arc to antagonistic muscles that includes two synapses in the CNS and one interneuron is also illustrated. Plus signs (+) indicate excitatory synapses; the minus sign (−) indicates an inhibitory synapse.

The stretch reflex causes contraction of a muscle that has been stretched.

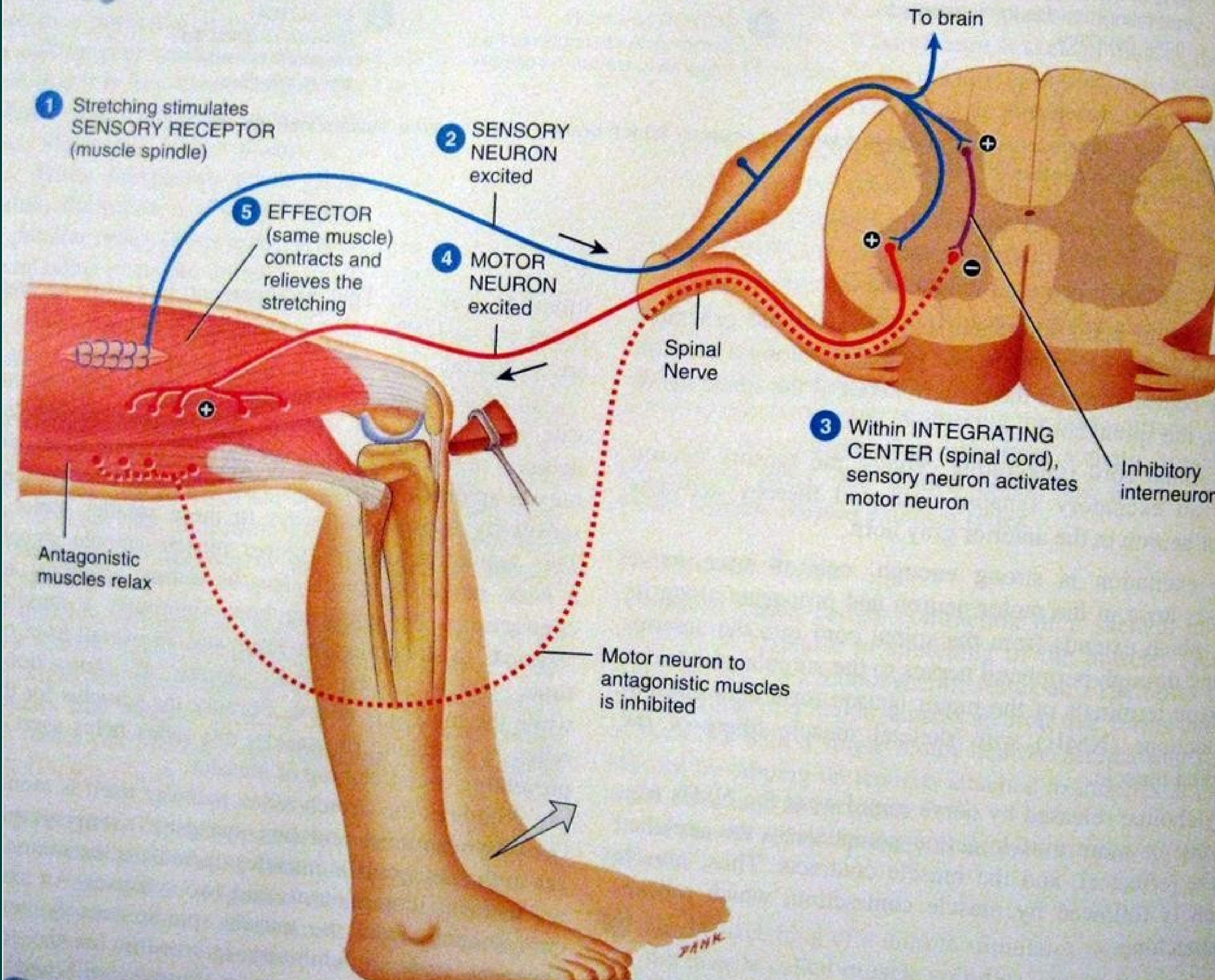


Figure 13.15 Tendon reflex. This reflex arc is polysynaptic—more than one CNS synapse and more than two different neurons are involved in the pathway. The sensory neuron synapses with two interneurons. An inhibitory interneuron causes relaxation of the effector, and a stimulatory interneuron causes contraction of the antagonistic muscle. Plus signs (+) indicate excitatory synapses; the minus sign (−) indicates an inhibitory synapse.

The tendon reflex causes relaxation of the muscle attached to the stimulated tendon organ.

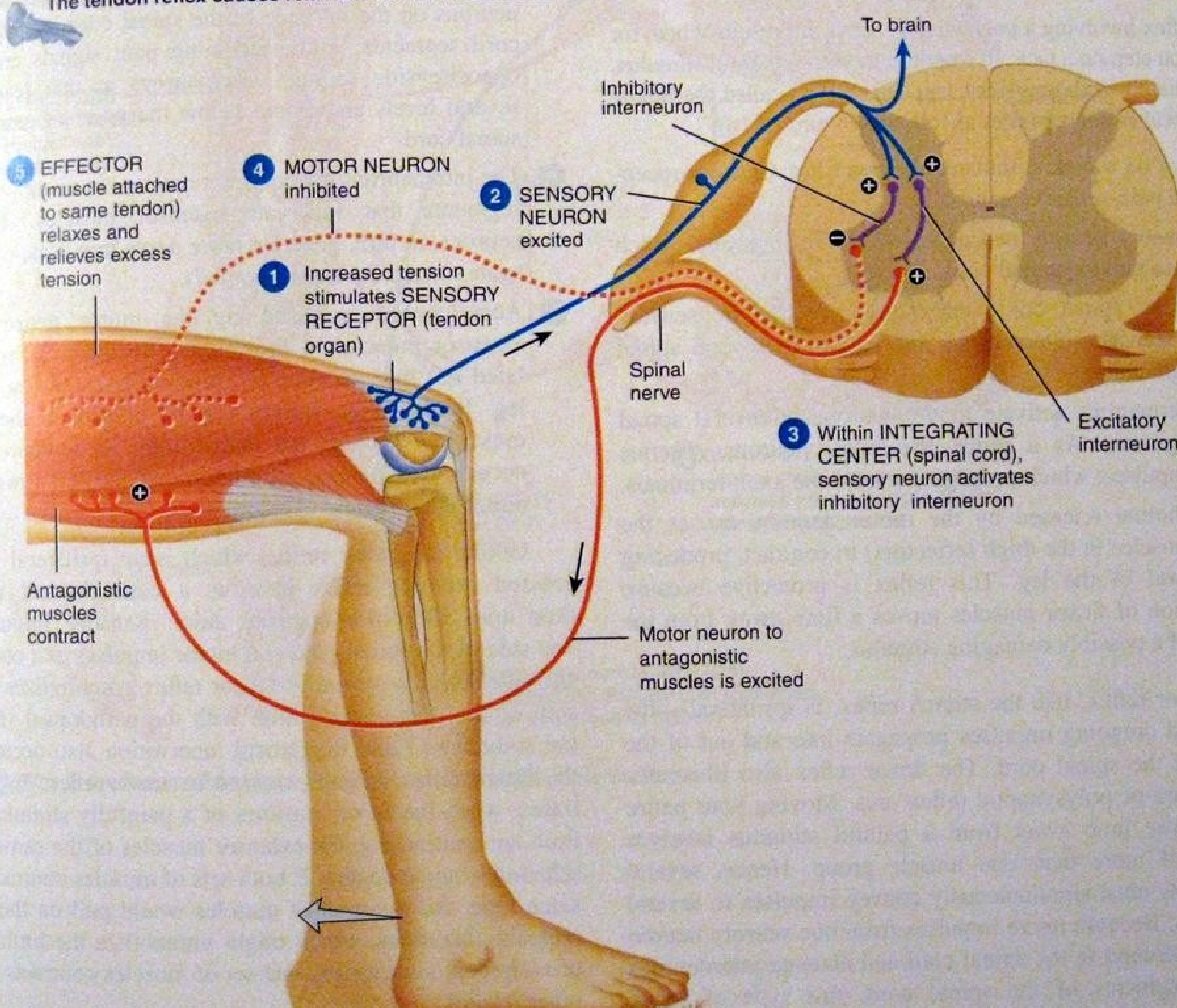
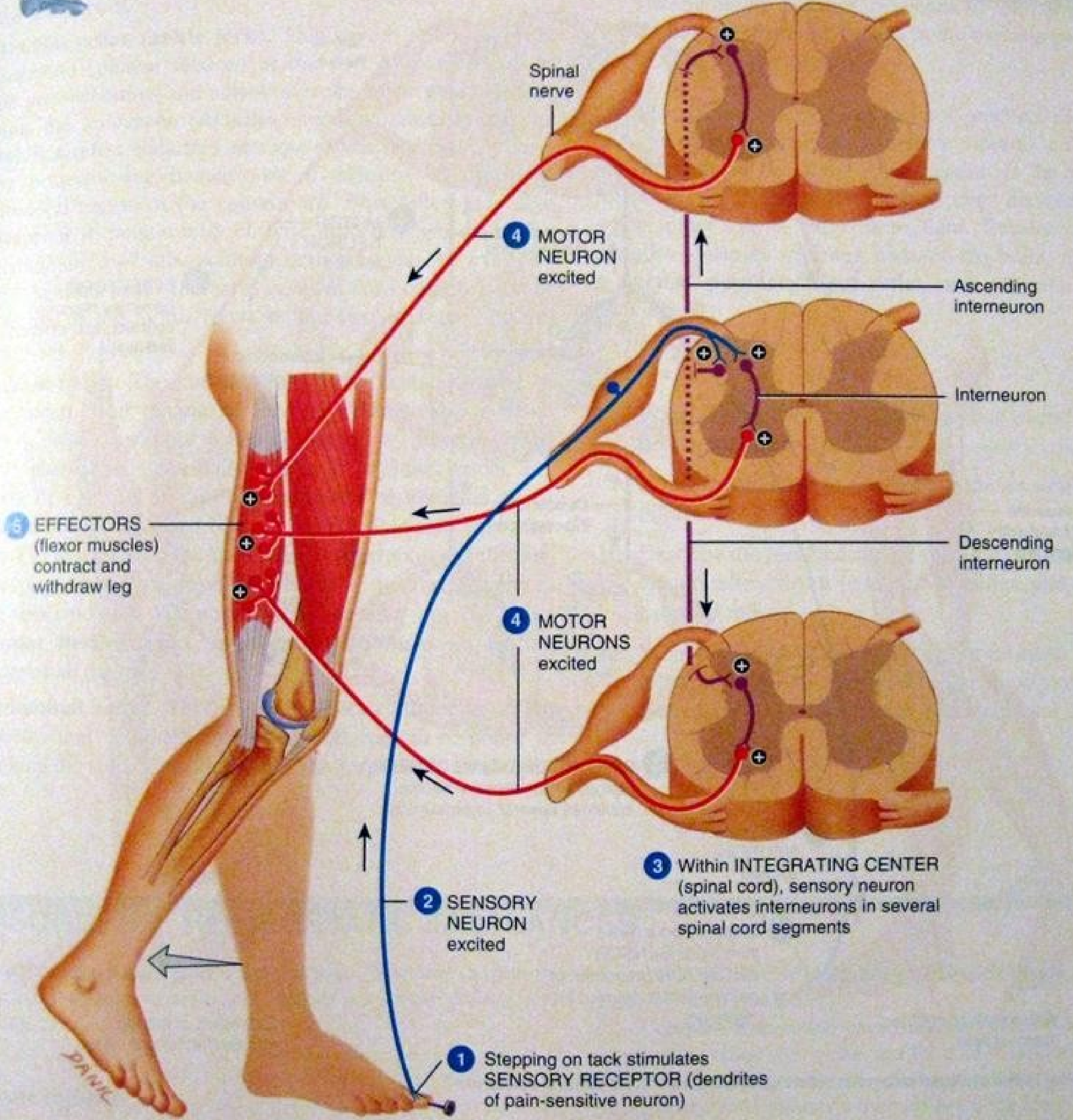


Figure 13.16 **Flexor (withdrawal) reflex.** This reflex arc is polysynaptic and ipsilateral. Plus signs (+) indicate excitatory synapses.

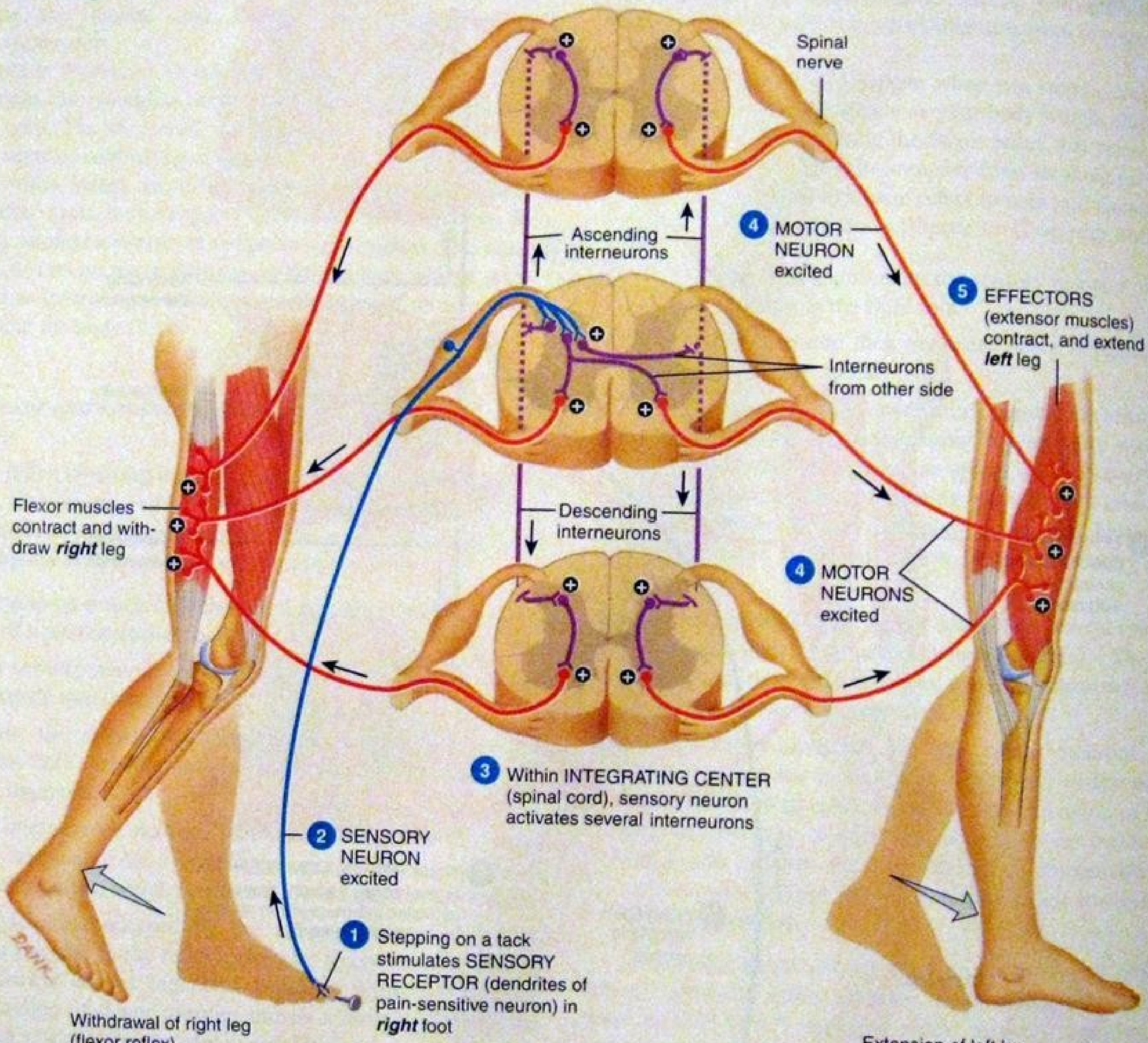
The flexor reflex causes withdrawal of a part of the body in response to a painful stimulus.



Why is the flexor reflex classified as an intersegmental reflex arc?

Figure 13.17 Crossed extensor reflex. The flexor reflex arc is shown (at left) to enable comparison with the crossed extensor reflex arc. Plus signs (+) indicate excitatory synapses.

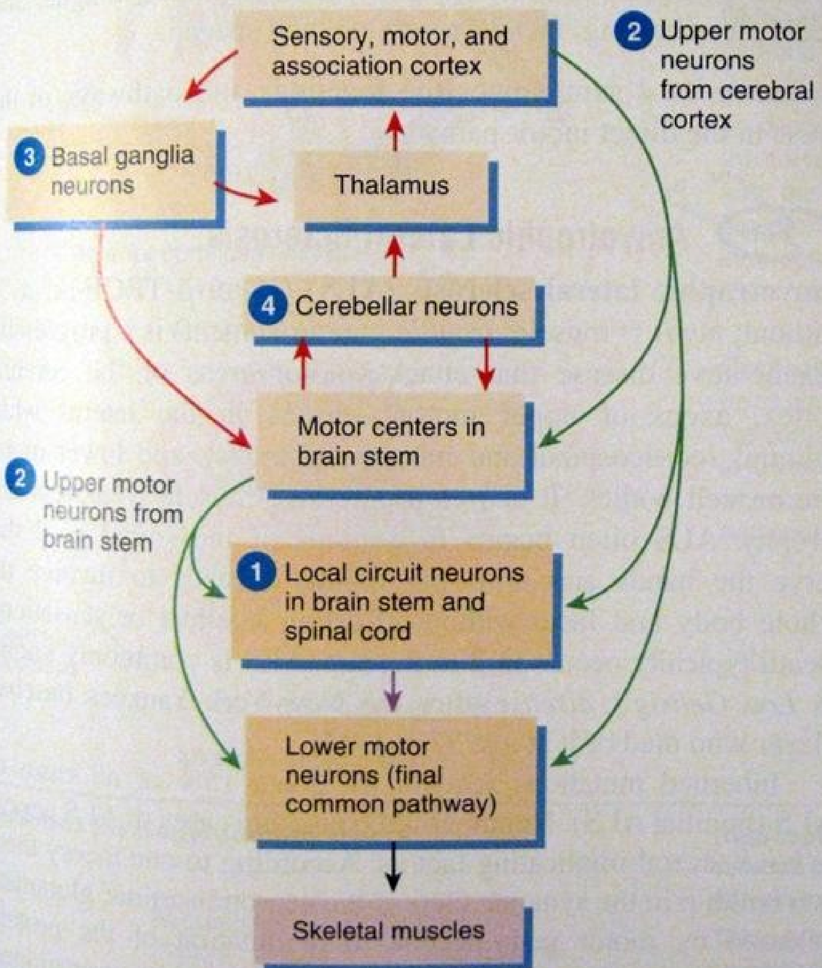
A crossed extensor reflex causes contraction of muscles that extend joints in the limb opposite a painful stimulus.



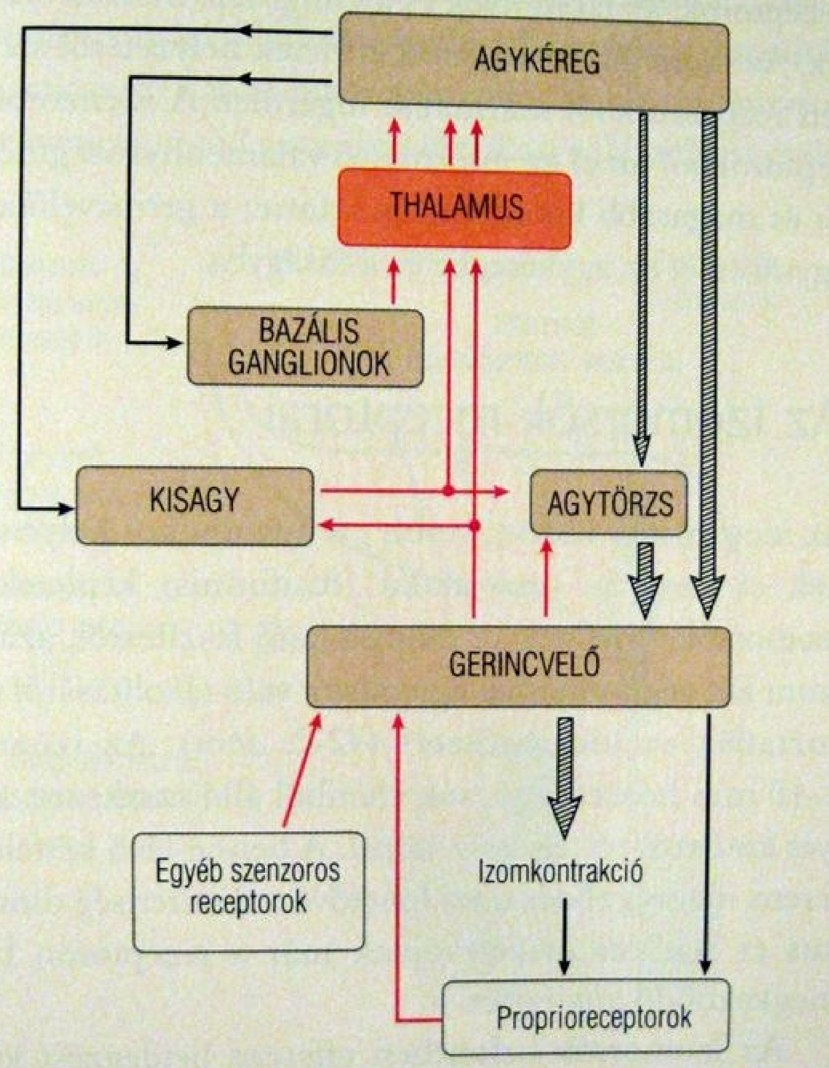
Why is the crossed extensor reflex classified as a contralateral reflex arc?

Figure 16.7 Somatic motor pathways for coordination and control of movement. Lower motor neurons receive input directly from (1) local circuit neurons (purple arrow) and (2) upper motor neurons in the cerebral cortex and brain stem (green arrows). Neural circuits involving basal ganglia neurons (3) and cerebellar neurons (4) regulate activity of upper motor neurons (red arrows).

Because lower motor neurons provide all output to skeletal muscles, they are called the final common pathway.



How do the functions of upper motor neurons from the cerebral cortex and from the brain stem differ?



42-1. ábra

A mozgatórendszer hierarchikus és visszacsatolásos szervezése

Kandel, E. R., Schwartz, J. H. és Jessel T. M. (1991): Principles of Neural Science. 3. kiadás, Prentice-Hall International Inc. London alapján

Figure 16.8 Direct motor pathways in which signals initiated by the primary motor area in the right hemisphere control skeletal muscles on the left side of the body. Spinal cord tracts carrying impulses of direct motor pathways are the lateral corticospinal tract and anterior corticospinal tract.

Direct pathways convey impulses that result in precise, voluntary movements.

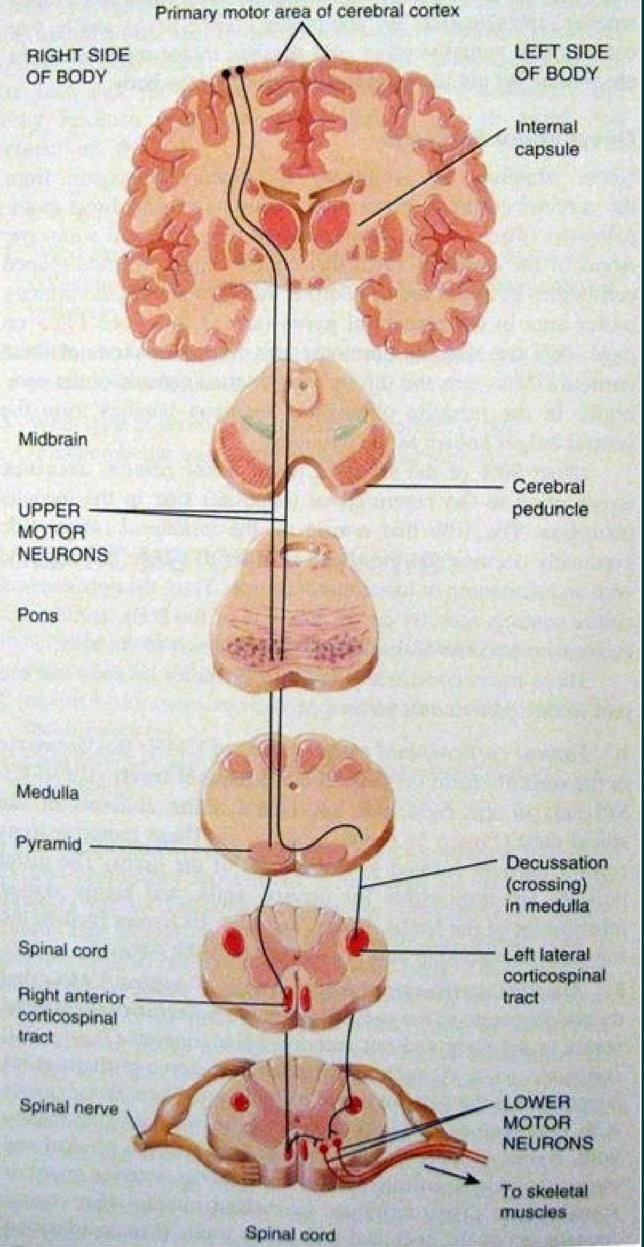
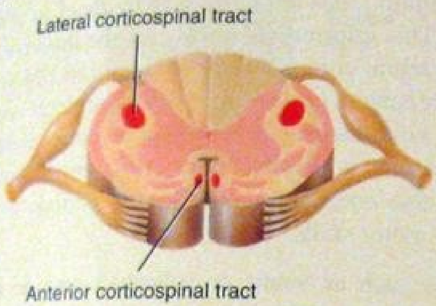


TABLE 16.4 Major Somatic Motor Pathways in the Brain and Tracts in the Midbrain and Spinal Cord

Tract and Location | **Functions and Pathways**

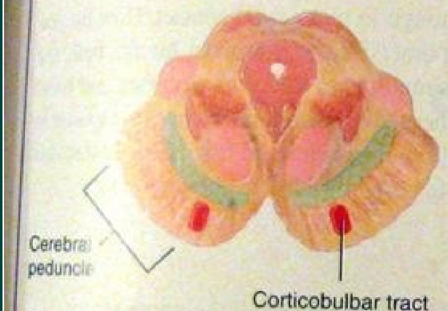
Direct (pyramidal) tracts



Spinal cord

Lateral corticospinal: Conveys nerve impulses from the motor cortex to skeletal muscles on opposite side of body for precise, voluntary movements of the limbs, hands, and feet. Axons of upper motor neurons (UMNs) descend from the precentral gyrus of the cortex into the medulla. Here 90% decussate (cross over to the opposite side) and then enter the contralateral side of the spinal cord to form this tract. At their level of termination, these UMNs end in the anterior gray horn on the same side. They provide input to lower motor neurons, which innervate skeletal muscles.

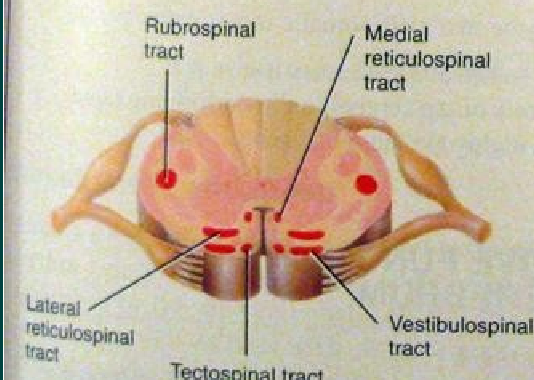
Anterior corticospinal: Conveys nerve impulses from the motor cortex to skeletal muscles on opposite side of body for movements of the axial skeleton. Axons of UMNs descend from the cortex into the medulla. Here the 10% that do not decussate enter the spinal cord and form this tract. At their level of termination, these UMNs decussate and end in the anterior gray horn on the opposite side of the body. They provide input to lower motor neurons, which innervate skeletal muscles.



Midbrain of brain stem

Corticobulbar: Conveys nerve impulses from the motor cortex to skeletal muscles of the head and neck to coordinate precise, voluntary movements. Axons of UMNs descend from the cortex into the brain stem, where some decussate and others do not. They provide input to lower motor neurons in the nuclei of cranial nerves III, IV, V, VI, VII, IX, X, XI, and XII, which control voluntary movements of the eyes, tongue and neck; chewing; facial expression; and speech.

Indirect (extrapyramidal) tracts



Spinal cord

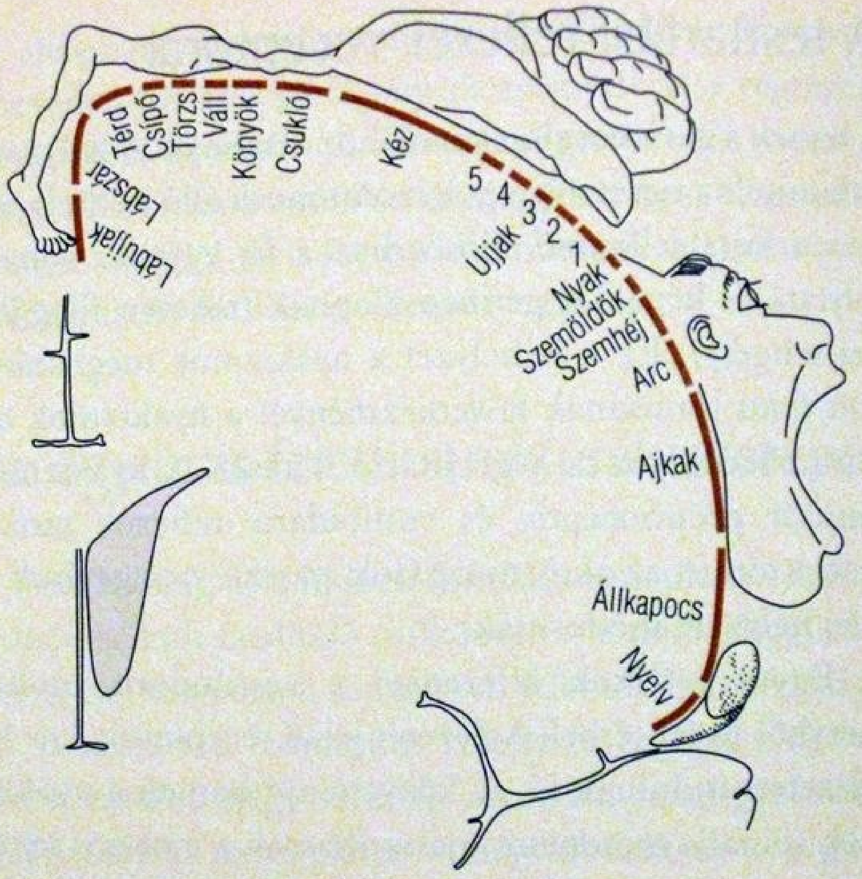
Rubrospinal: Conveys nerve impulses from the red nucleus (which receives input from the cerebral cortex and cerebellum) to contralateral skeletal muscles that govern precise movements of the distal parts of the limbs.

Tectospinal: Conveys nerve impulses from the superior colliculus to contralateral skeletal muscles that move the head and eyes in response to visual stimuli.

Vestibulospinal: Conveys nerve impulses from the vestibular nucleus (which receives input about head movements from the inner ear) to regulate ipsilateral muscle tone for maintaining balance in response to head movements.

Lateral reticulospinal: Conveys nerve impulses from the reticular formation to facilitate flexor reflexes, inhibit extensor reflexes, and decrease muscle tone in muscles of the axial skeleton and proximal parts of the limbs.

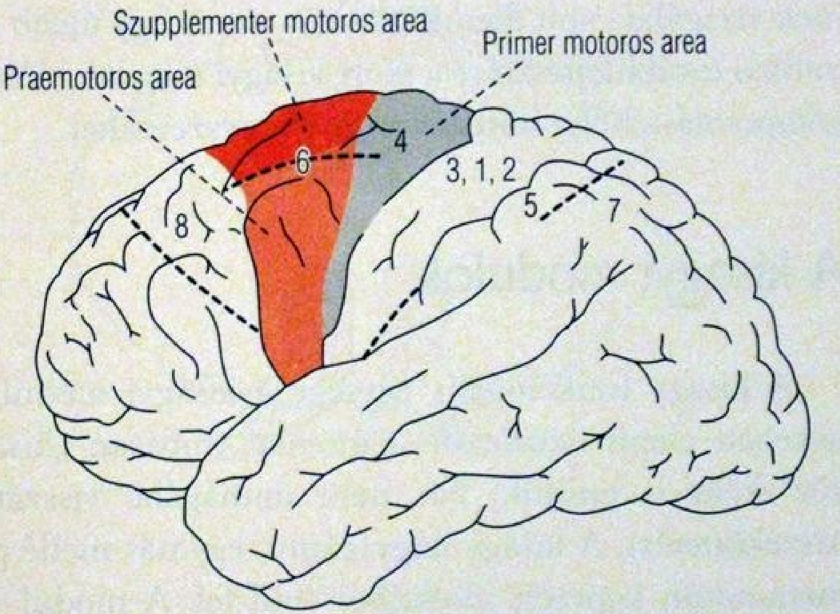
Medial reticulospinal: Conveys nerve impulses from the reticular formation to facilitate extensor reflexes, inhibit flexor reflexes, and increase muscle tone in muscles of the axial skeleton and proximal parts of the limbs.



42-10. ábra

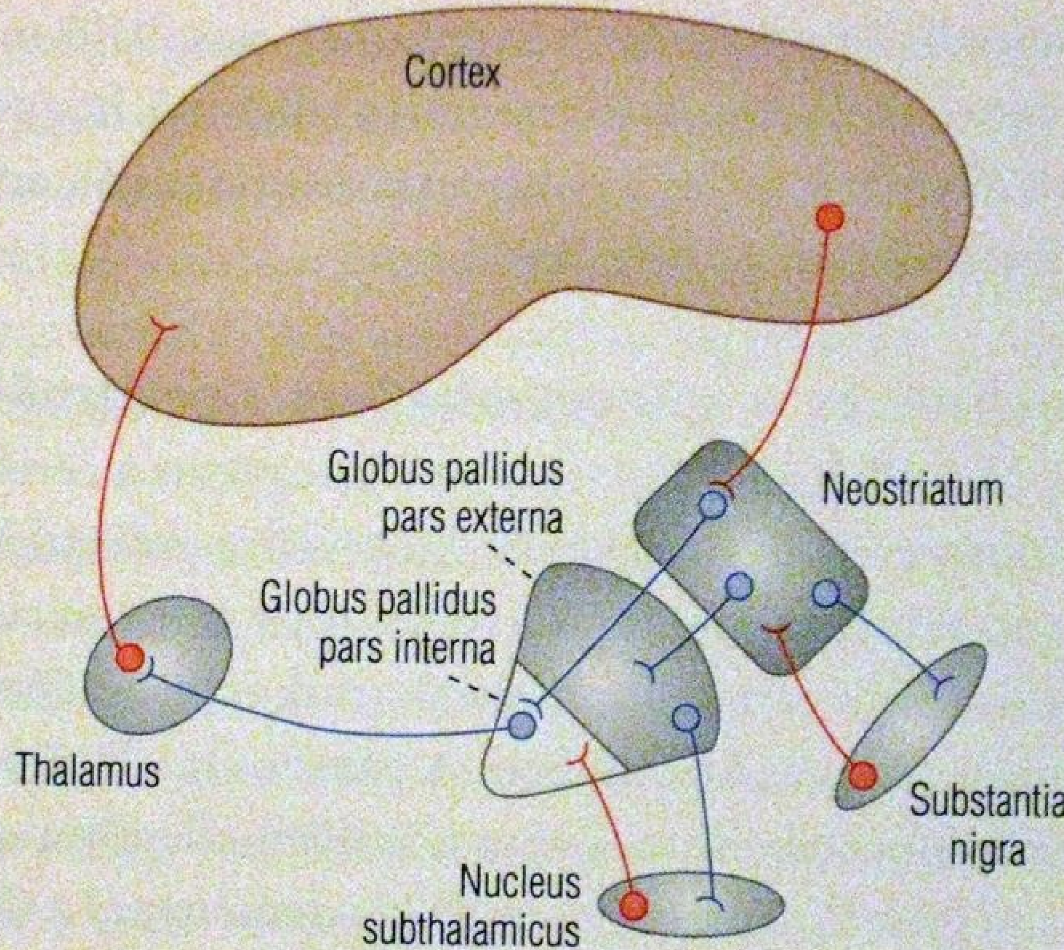
Az agy keresztmetszetére vetített „motoros homunculus" Penfield és Rasmussen nyomán

Penfield, W. és Rasmussen, T. (1950): The Cerebral Cortex of Man A Clinical Study of Localization and Function. The MacMillan Company, New York alapján



42-11. ábra

Az emberi frontalis kéreg motoros mezői



42-15. ábra

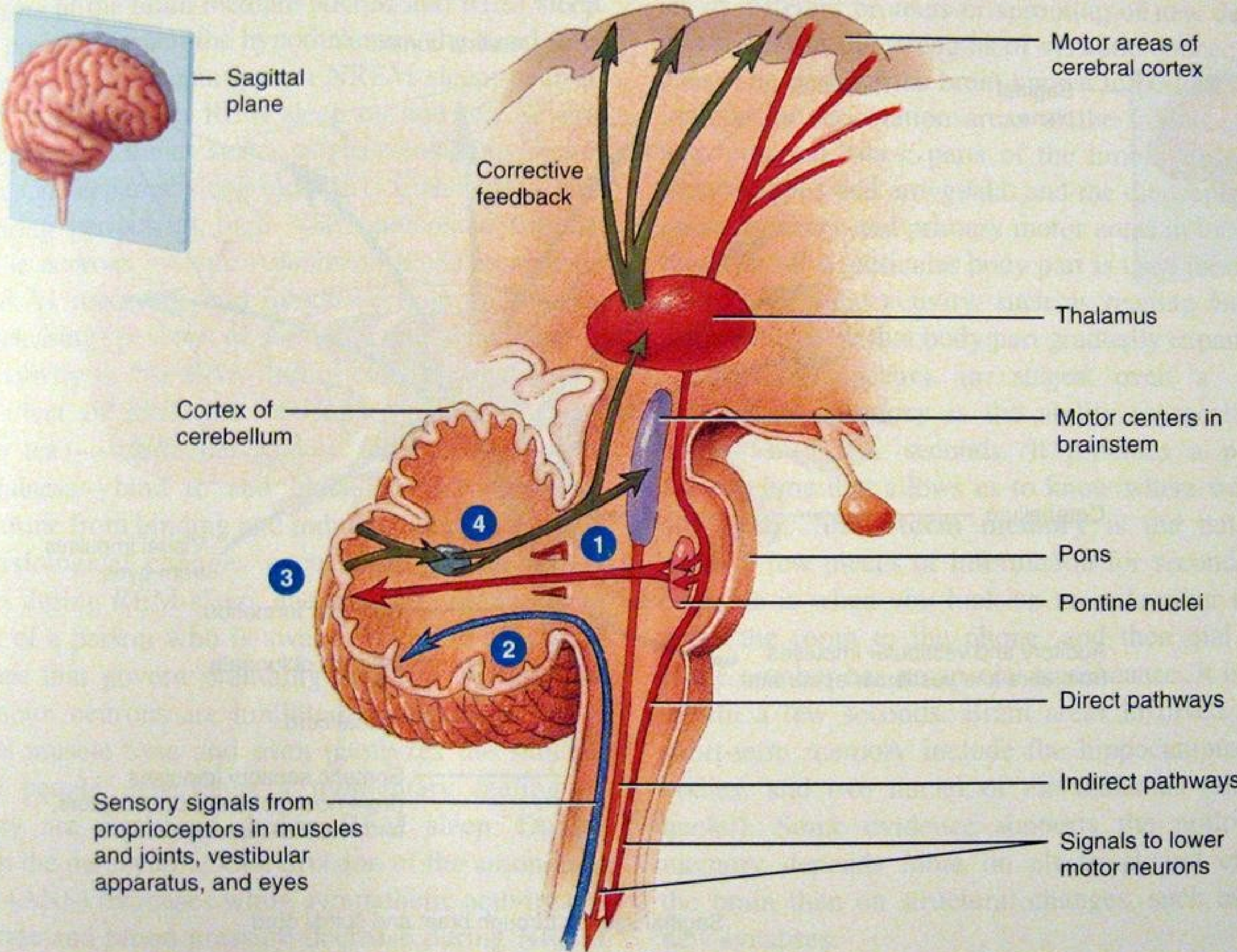
A bazális ganglionok összeköttetései

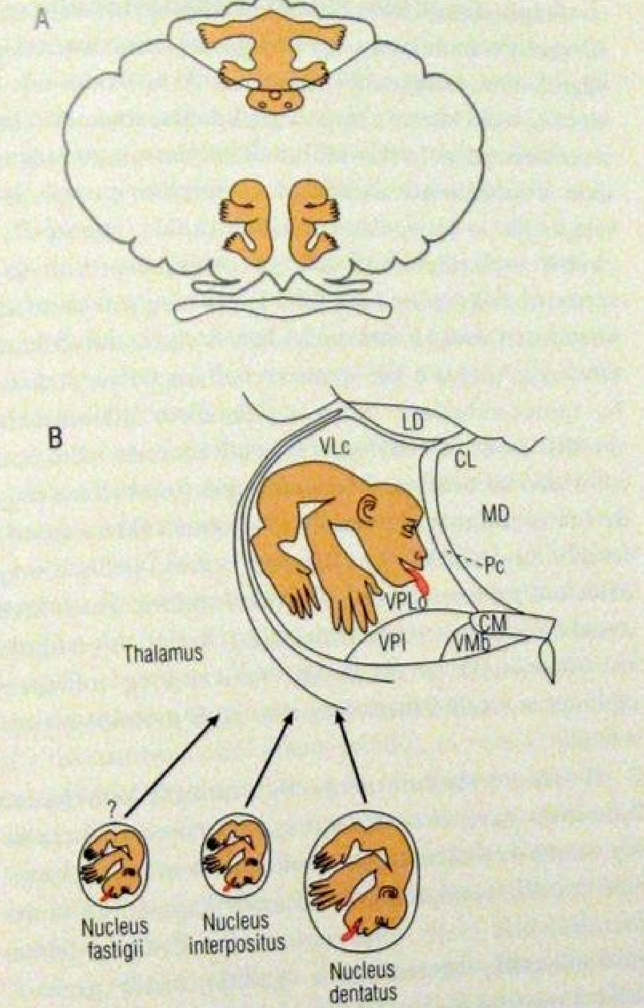
Nicholls, J. G., Martins, A. R. Wallace, B. G. Fuchs, P. A. (2001): From Neuron to Brain. 4. kiadás. Sinauer Associates Inc., Sunderland, Massachusetts alapján

A piros nyilak serkentő, a kékek gátló kapcsolatot jelképeznek.

Figure 16.9 Input to and output from the cerebellum.

The cerebellum coordinates and smoothes contractions of skeletal muscles during skilled movements and helps maintain posture and balance.





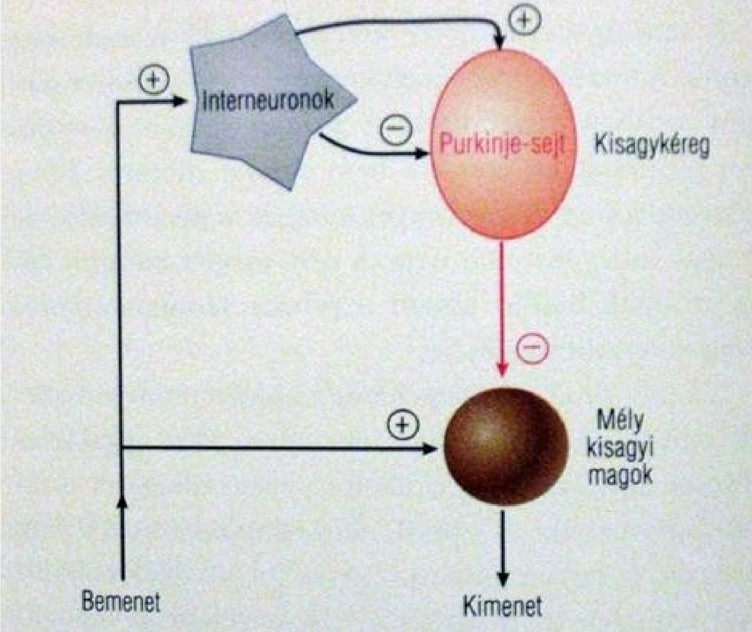
42-13. ábra

A kisagy többszörös szomatotópiás térképei

Kandel, E. R. Schwartz, J. H. és Jessel, T. M. (1991): Principles of Neural Science. 3. kiadás. Prentice-Hall International Inc. London alapján

A) Többszörös szomatotópiás elrendezés a kisagykéregben. A bemenetet a spinocerebellaris pályák képezik

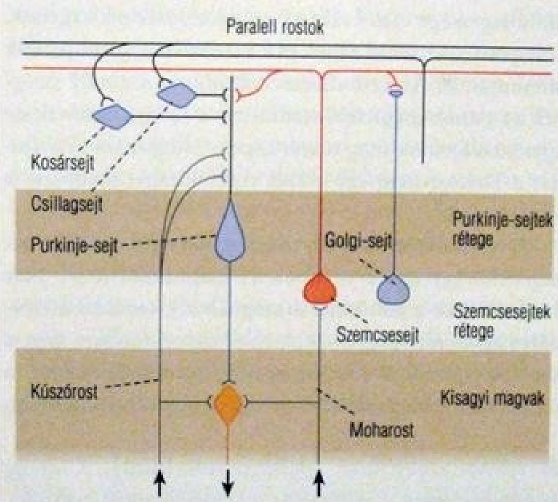
B) Majomban a kisagy nucleus dentatusában, a nucleus interpositusban (nucl. globosus + emboliformis) és a nucleus fastigiiben a teljes szomatotóp reprezentáció megtalálható. A kisagyi bemenet leképeződik a thalamus nucleus ventroposterolateralis oralis részében is



42-12. ábra

A kisagyi információáramlás vázlata

Kandel, E. R., Schwartz, J. H. és Jessel, T. M. (1991 … Neural Science. 3. kiadás, Prentice-Hall Internation … alapján



42-14. ábra

A kisagykéreg neuronalis összeköttetései

Nicholls, J. G., Martins, A. R., Wallace, B. G., Fuchs, P. A. (2001): From Neuron to Brain. 4. kiadás. Sinauer Associates Inc., Sunderland, Massachusetts alapján