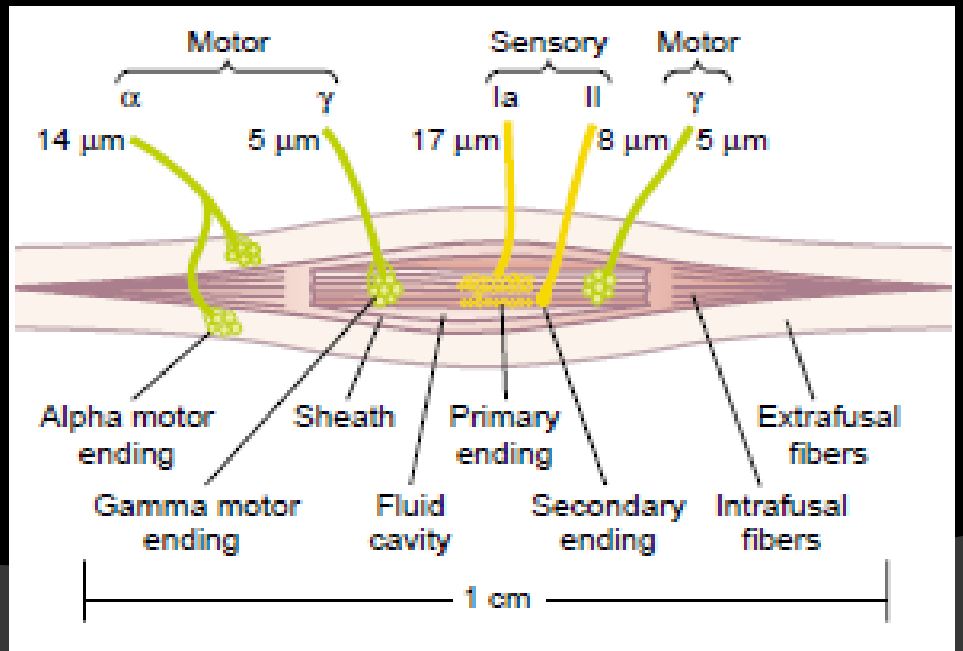
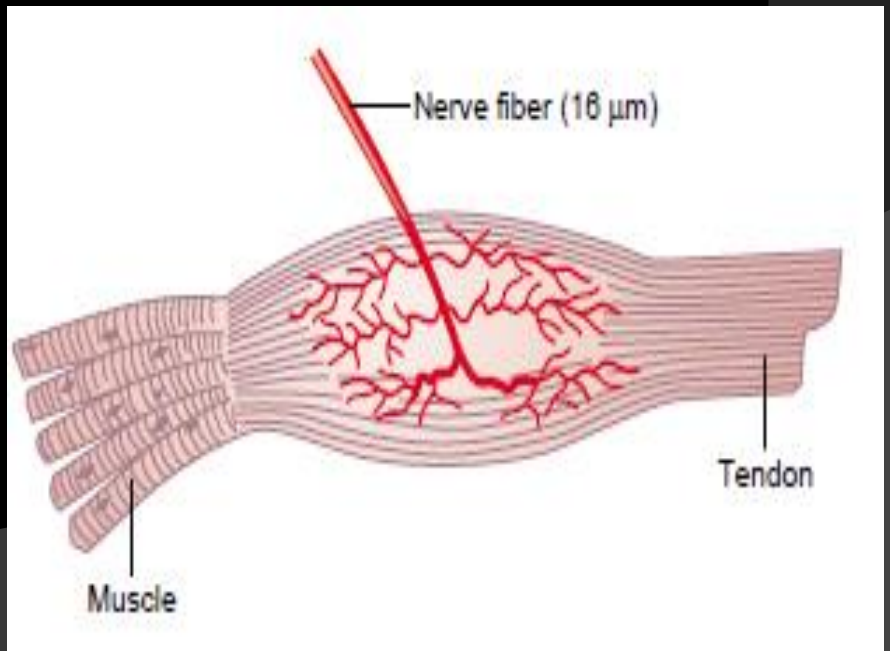
The role of spinal cord in the regulation of motor and autonomic functions

Muscle spindles

The muscles and their tendons are supplied abundantly with two special types of sensory receptors:

1) ***muscle spindles***, which are distributed throughout the belly of the muscle and send information to the nervous system about muscle length or rate of change of length, and
2) ***Golgi tendon organs***, which are located in the muscle tendons and transmit information about tendon tension or rate of change of tension.





Comparative characteristics of alpha-and gamma-motoneurons

Alpha-motoneurons	Gamma-motoneurons
Innervation of the extrafusal fibers	Innervation of the intrafusal fibers
Have a large size (d of body = 60-120 mm)	Have a small size (d of body =14-30 mkm)
Give rise to thick myelin fibers type Aα (v = 70-120m / s)	Give rise to thin myelin fibers typeA γ (v=15-30m/s)
Significantly expressed revealing hyperpolarization, so the frequency of impulses is low (10-20 imp/s)	Revealing hyperpolarization is brief, so the frequency of impulses is high (300-500 imp/s)
have a large number of synapses on soma and dendrites (10-20 thousands) with parenthetic neurons, primary afferents from muscle tension receptors, fibers descending tracts	Have no direct contacts with primary afferents, but activated by fibers of descending tracts

Proprioceptors of the muscles

Proprioceptors – receptors that perceive a deep sensitivity (muscles, tendons, joints)

Proprioceptors

Muscular spindle

Respond to changes muscle length and rate of change length

Tendon Golgi's bodies

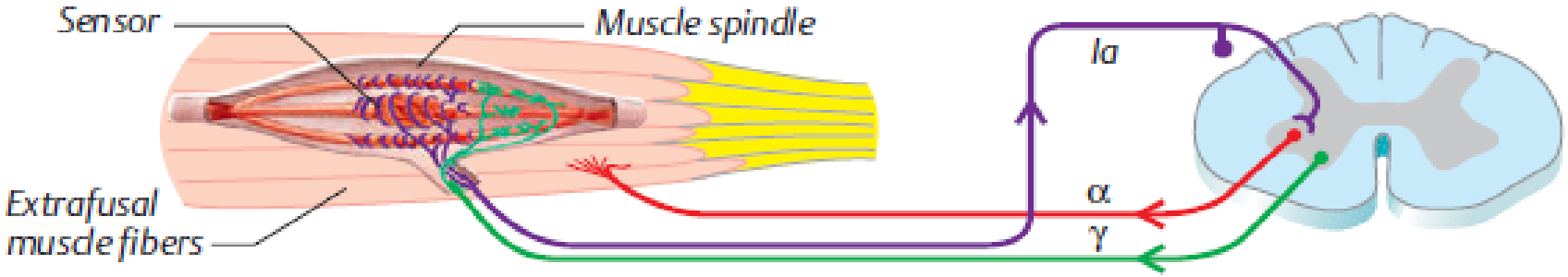
Respond to changes muscle tension and rate of change voltage

Receptors of joints

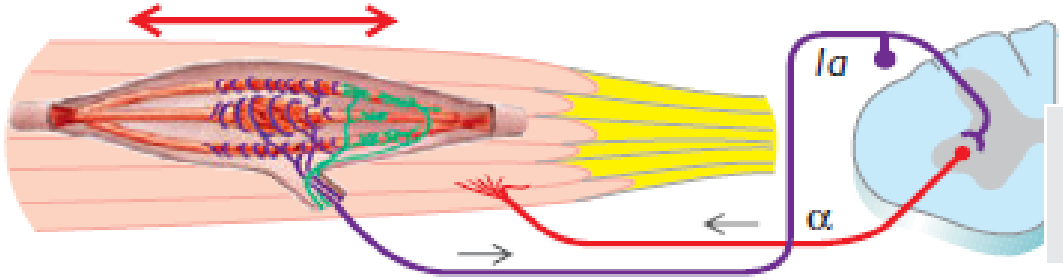
Respond to the degree of flexion and extension in the joint

Muscle spindle function

1 Initial length of muscle



2 Spindle activated by "involuntary" muscle stretching



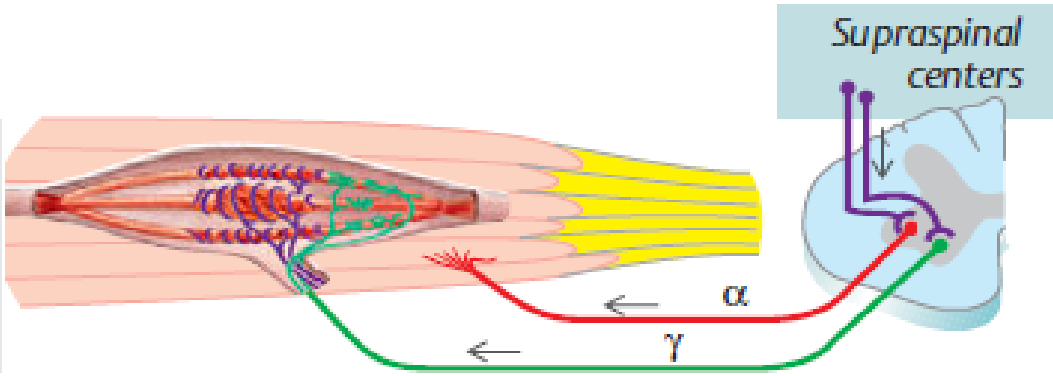
Reflex contraction of skeletal muscle to bring muscle back to initial length

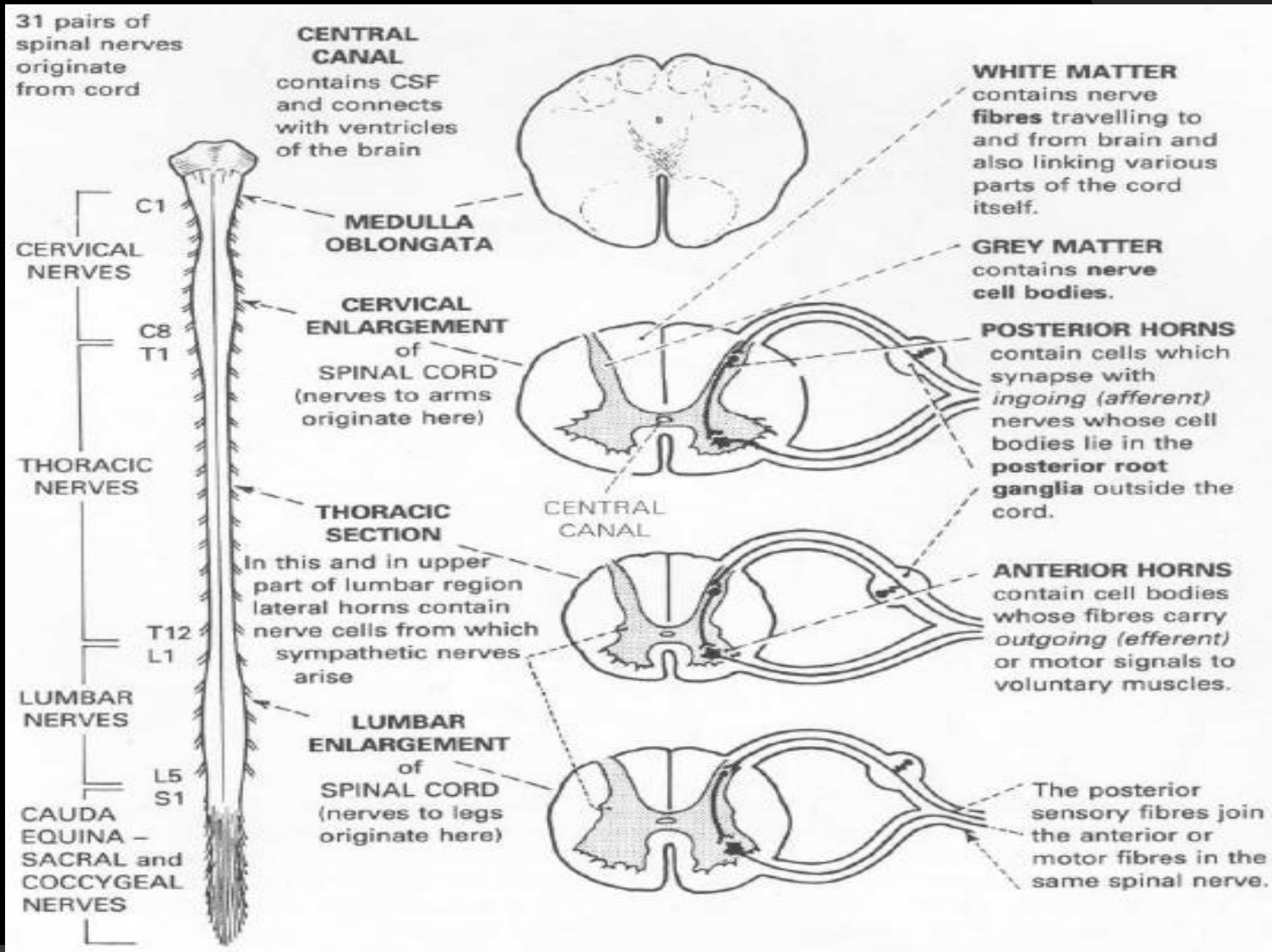
3 Supraspinal activation

"Voluntary" change in muscle length with pre-setting (via fibers)

a. A set-point for length (α/γ co-activation)

b. An increased receptor sensitivity (fusimotor set)

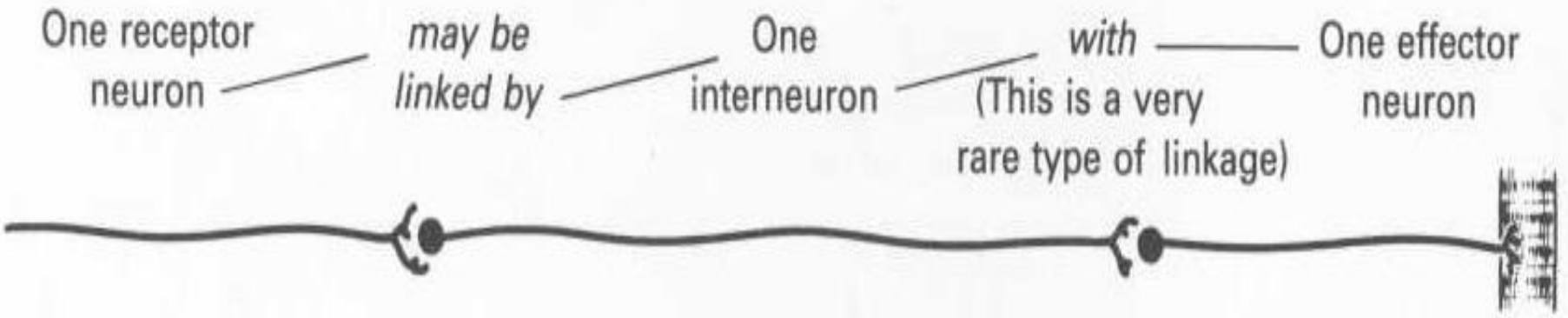


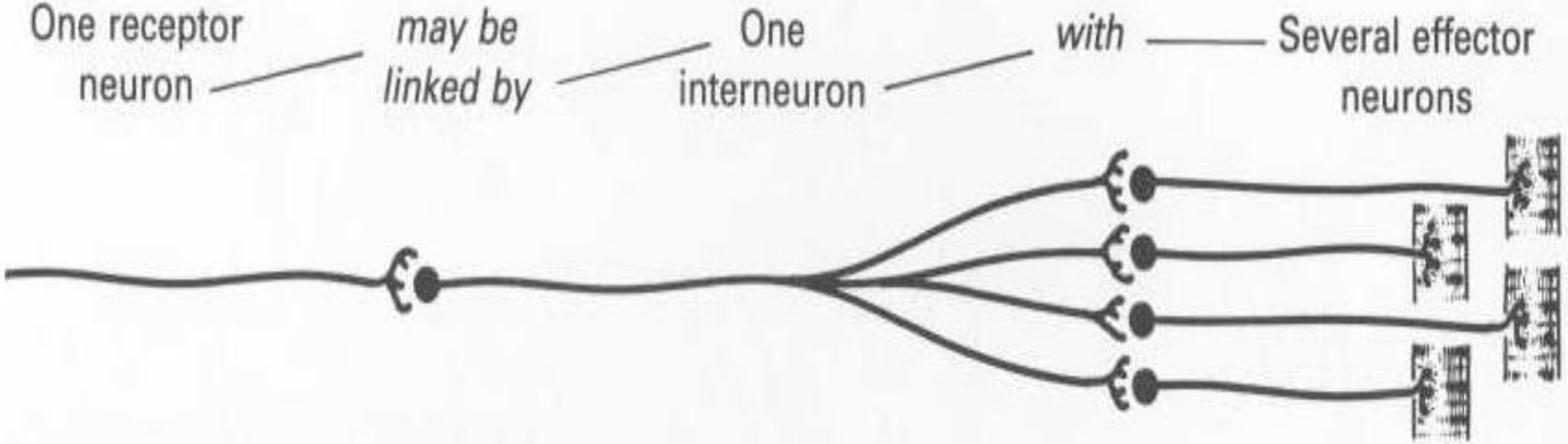


The spinal nerves travel to all parts of the trunk and limbs.

Arrangement of neurons

Some of the ways in which neurons can be linked are indicated here: –



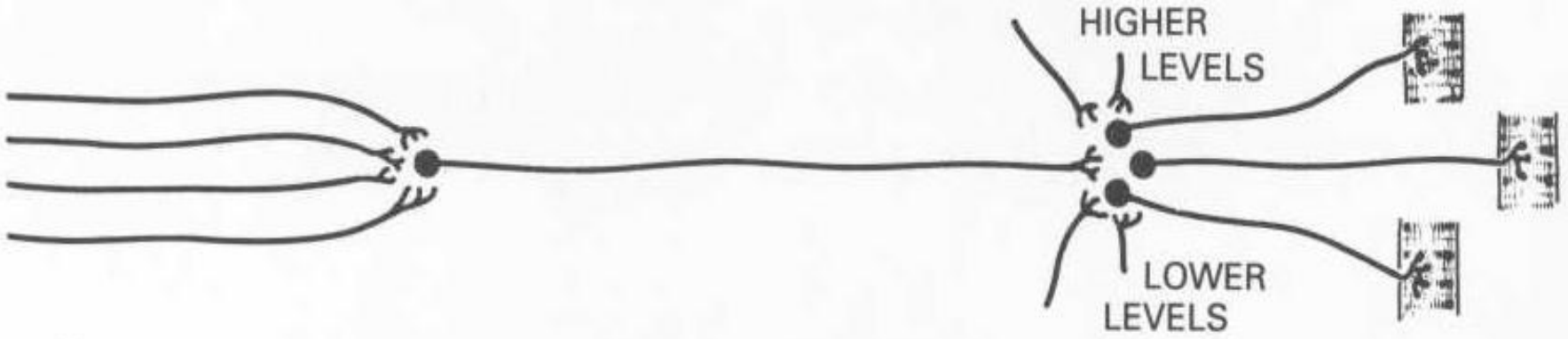


Arrangement of neurons

Many receptor neurons — *may be linked by* — One interneuron — *with* — One effector neuron

One or more receptor neurons — *may be linked by* — One interneuron — *with* — One or more effector neurons

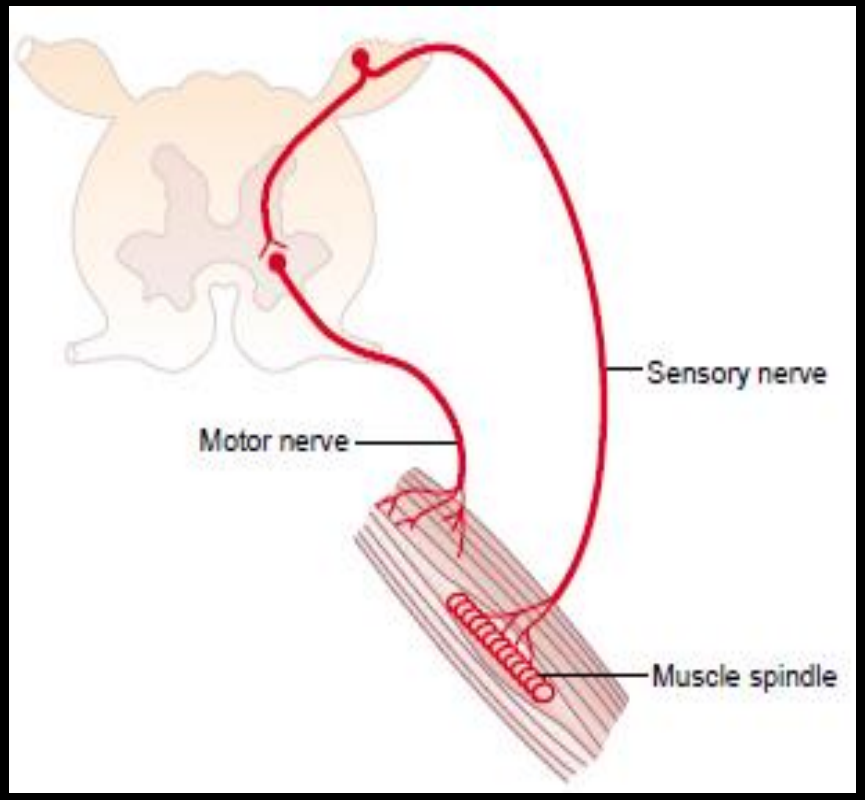
Other neurons synapsing with the effector neuron(s) may give a complex link-up with centres at higher and lower levels of the brain and spinal cord.



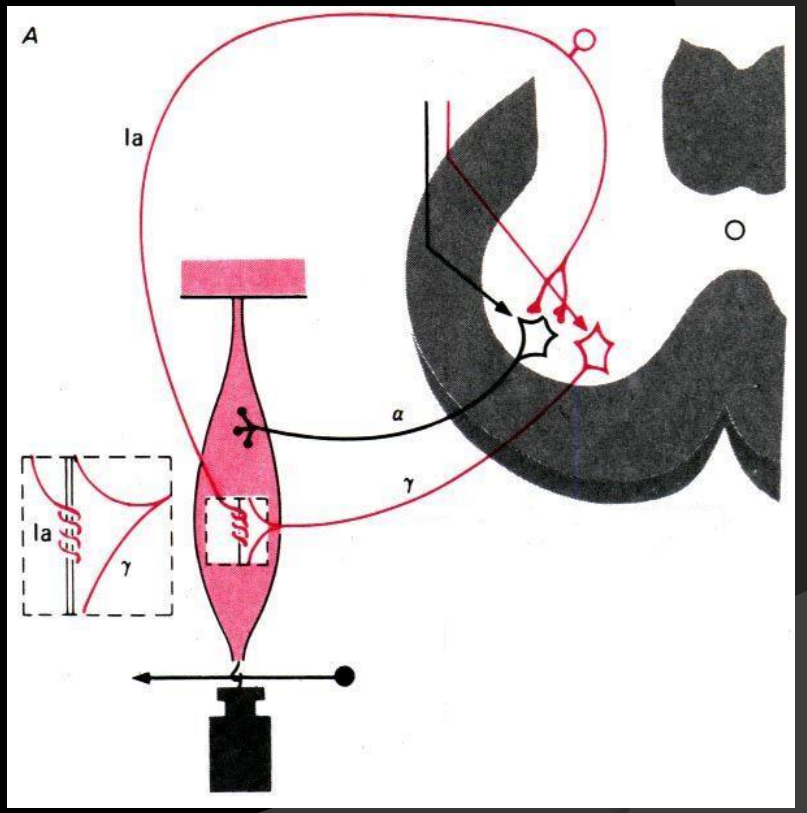
Such reflexes probably form the basis of all training so that it becomes difficult to say where **reflex** (or **involuntary**) behaviour ends and purely **voluntary** behaviour begins.

Mechanisms of excitation of muscle spindles

1. Muscle strain
(extrafusal muscle spindles)



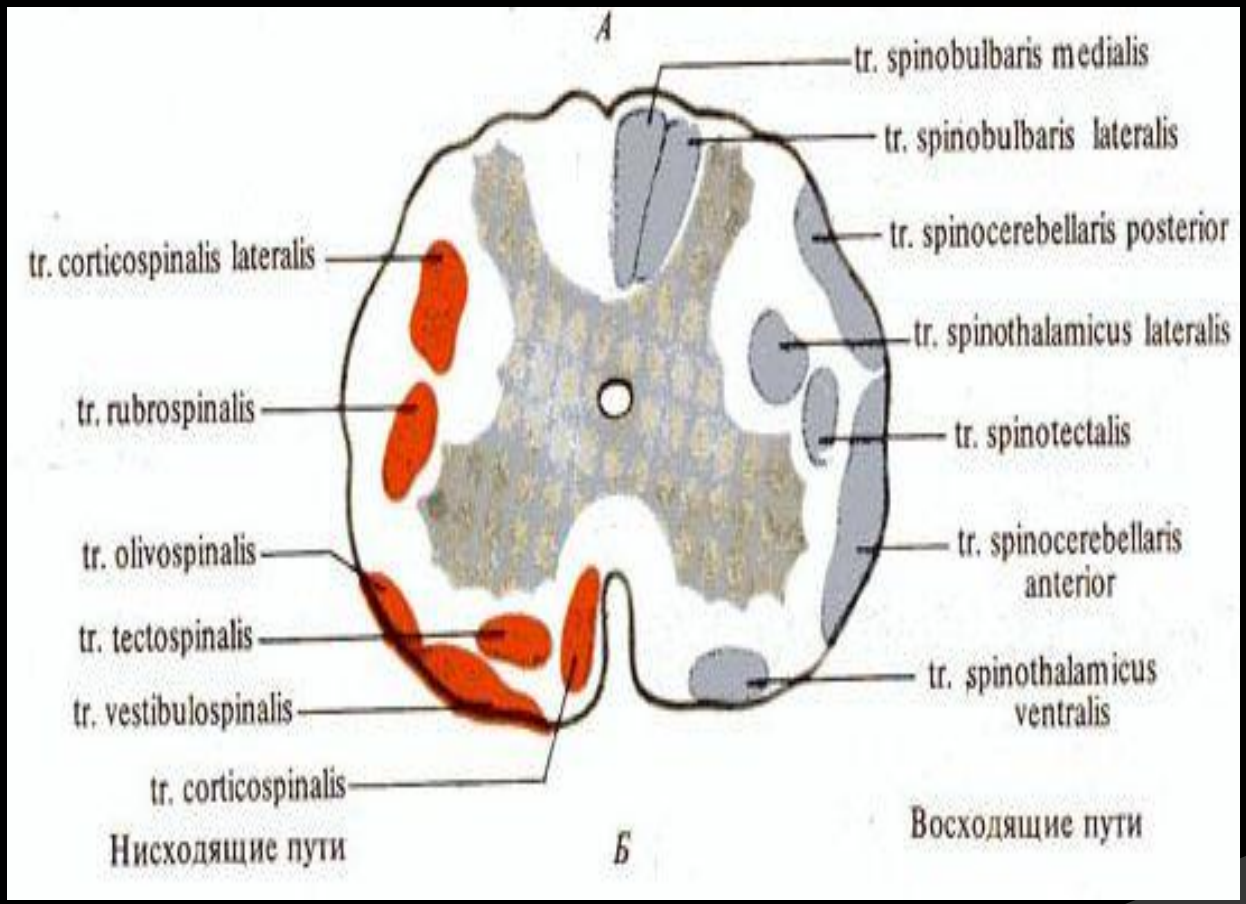
2. Reduce of intrafusal fibers
(γ-efferent loop)



Functions of the spinal cord

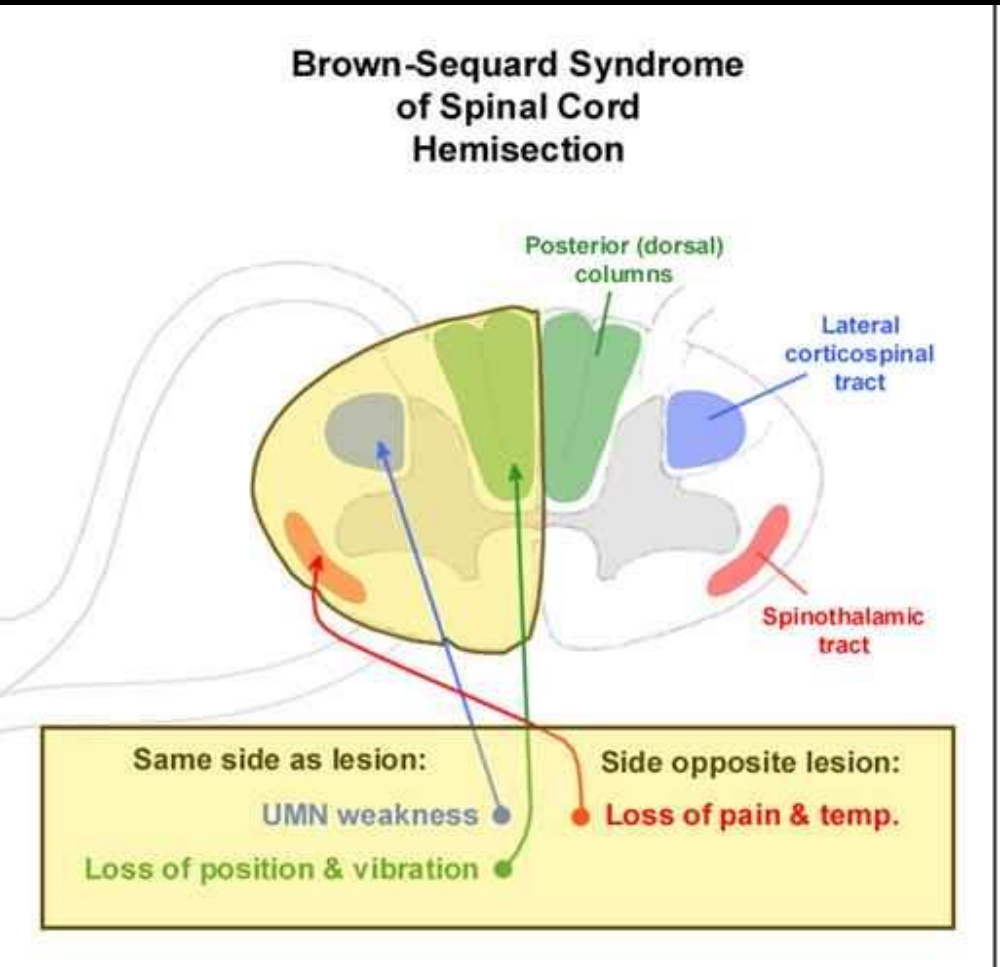
- Sensory
- Conduction
- Vegetative
- Reflex

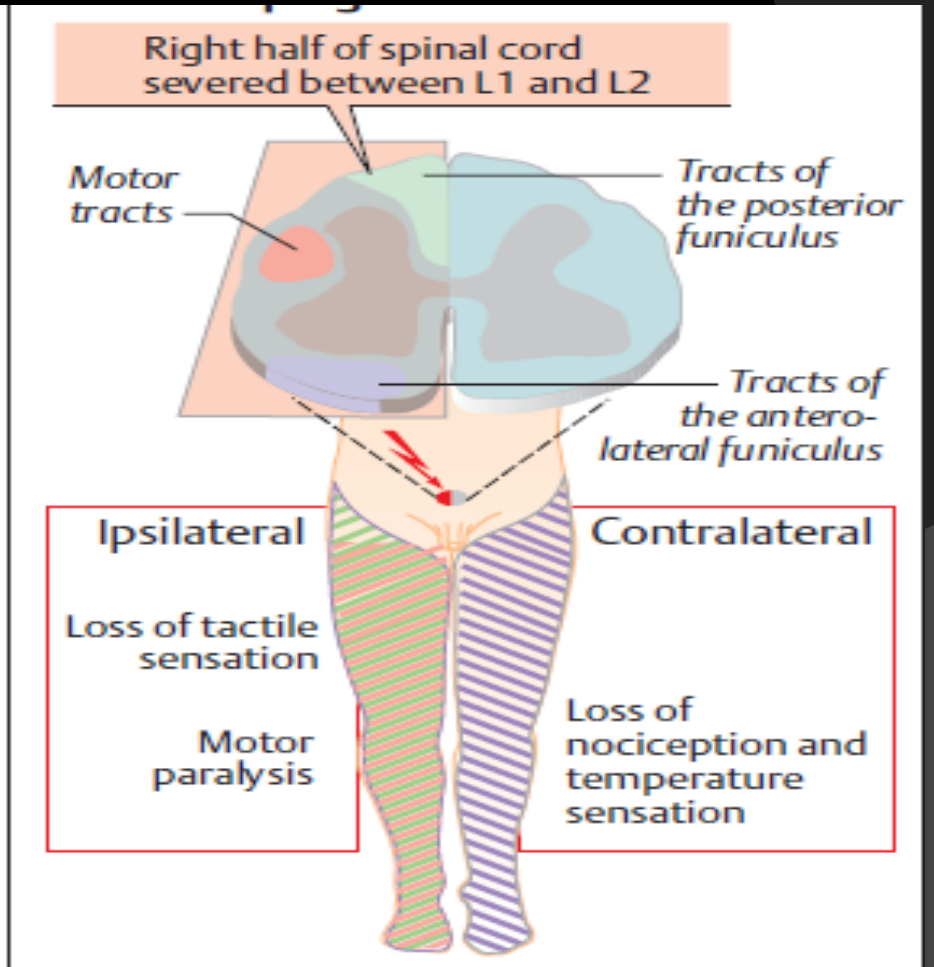
Conductor functions of spinal cord



Brown-Sequard Syndrome

is a loss of sensation and motor function (paralysis and ataxia) that is caused by the lateral hemisection (cutting) of the spinal cord.

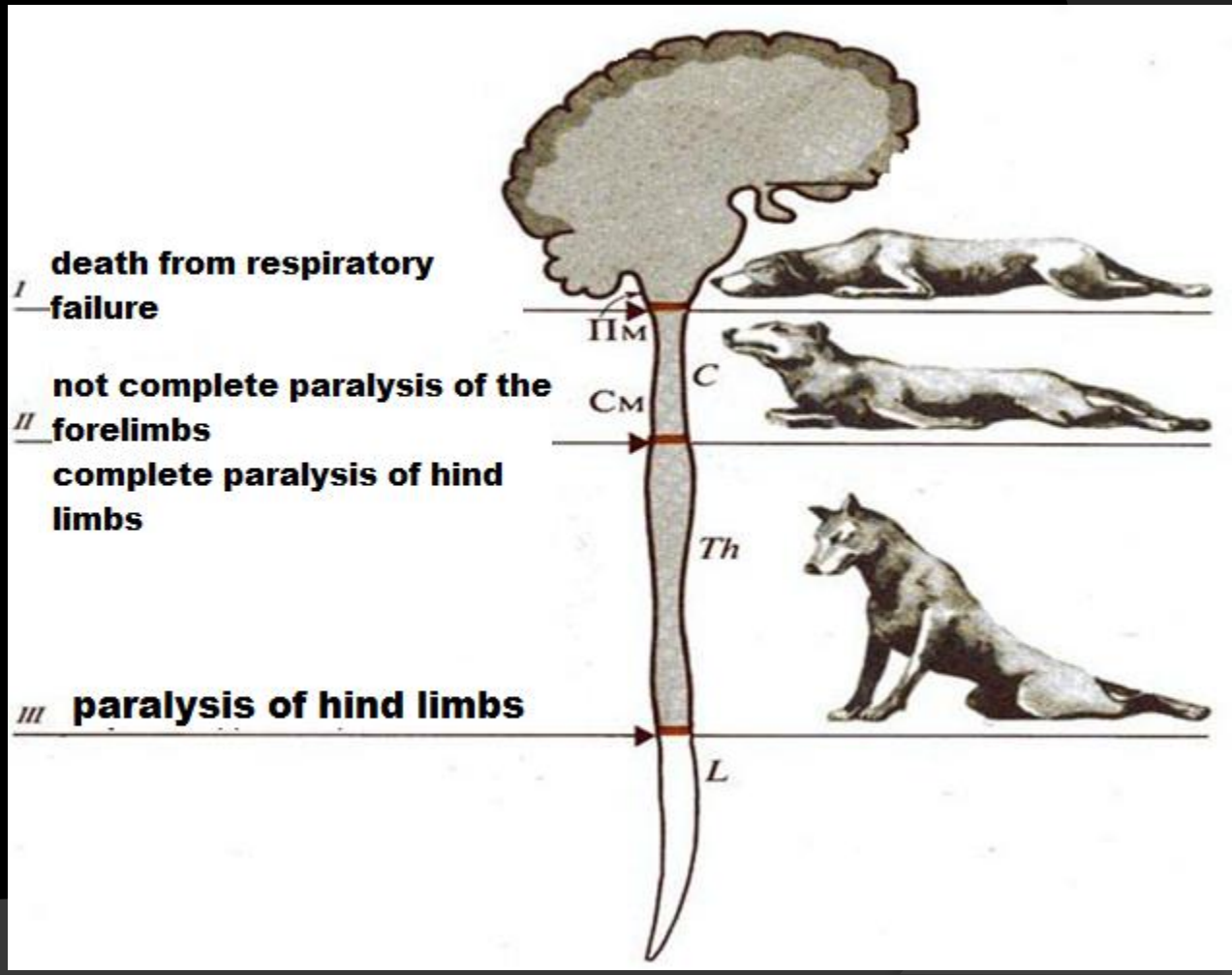




- Brown-Séquard syndrome is characterized by loss of motor function (i.e. hemiparaplegia), loss of vibration sense and fine touch, loss of proprioception (position sense), loss of two-point discrimination, and signs of weakness, on the ipsilateral (same side) of the spinal injury. This is a result of a lesion through the corticospinal tract, which carries motor fibers, and through the dorsal column-medial lemniscus tract, which carries fine (or light) touch fibers. On the contralateral (opposite side) of the lesion, there will be a loss of pain and temperature sensation and crude touch.

Spinal shock

spinal shock the loss of spinal reflexes after injury of the spinal cord that appears in the muscles innervated by the cord segments situated below the site of the lesion.



Vegetative functions of the spinal cord

- Sympathetic innervation of the eye
- Sympathetic innervation of the heart
- Sympathetic innervation of the bronchi
- Sympathetic innervation of vascular
- Sympathetic innervation of sweat glands

- Parasympathetic micturition center
- Parasympathetic defecation center
- Parasympathetic erection center
- Parasympathetic center of ejaculation

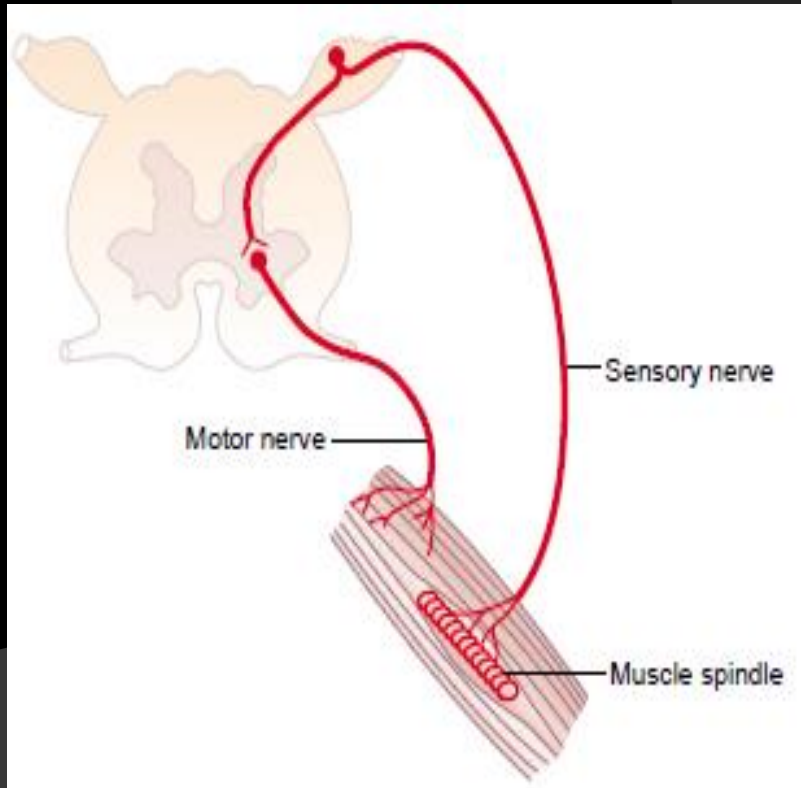
Reflex function of the spinal cord

- Tonic reflexes
  - Myotatic reflex
  - Tonic neck reflexes
- Phase reflexes
  - Tendon reflexes
  - Skin reflexes
  - Bending reflex
  - Cross-extensor reflex
  - Rhythmic reflexes

Myotatic reflexes

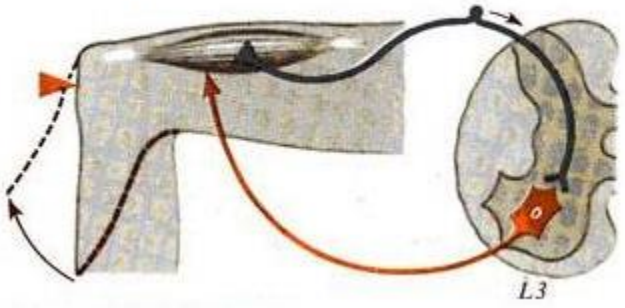
A stretch reflex (myotatic) is a muscle contraction in response to stretching within the muscle. It is a monosynaptic reflex which provides automatic regulation of skeletal muscle length.

When muscle lengthens, the spindle is stretched and the activity increases. This increases alpha motor neuron activity. Therefore the muscle contracts and the length decreases as a result. The gamma co-activation is important in this reflex because this allows spindles in the muscles to remain taut therefore sensitive even during contraction.

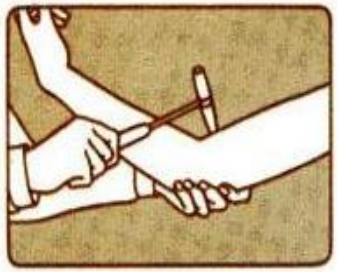


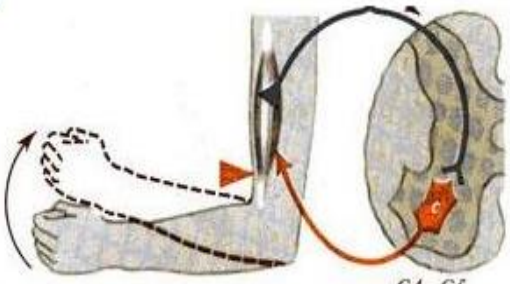
Tendon reflexes

Knee (patelar) reflex

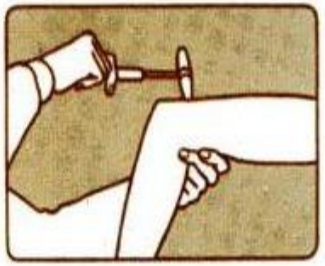


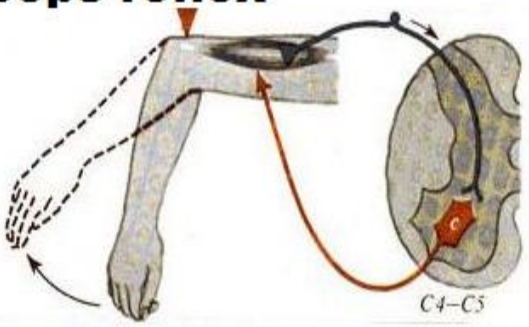
Biceps reflex



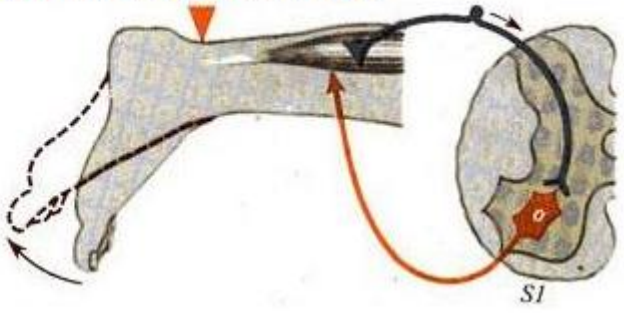


Triceps reflex

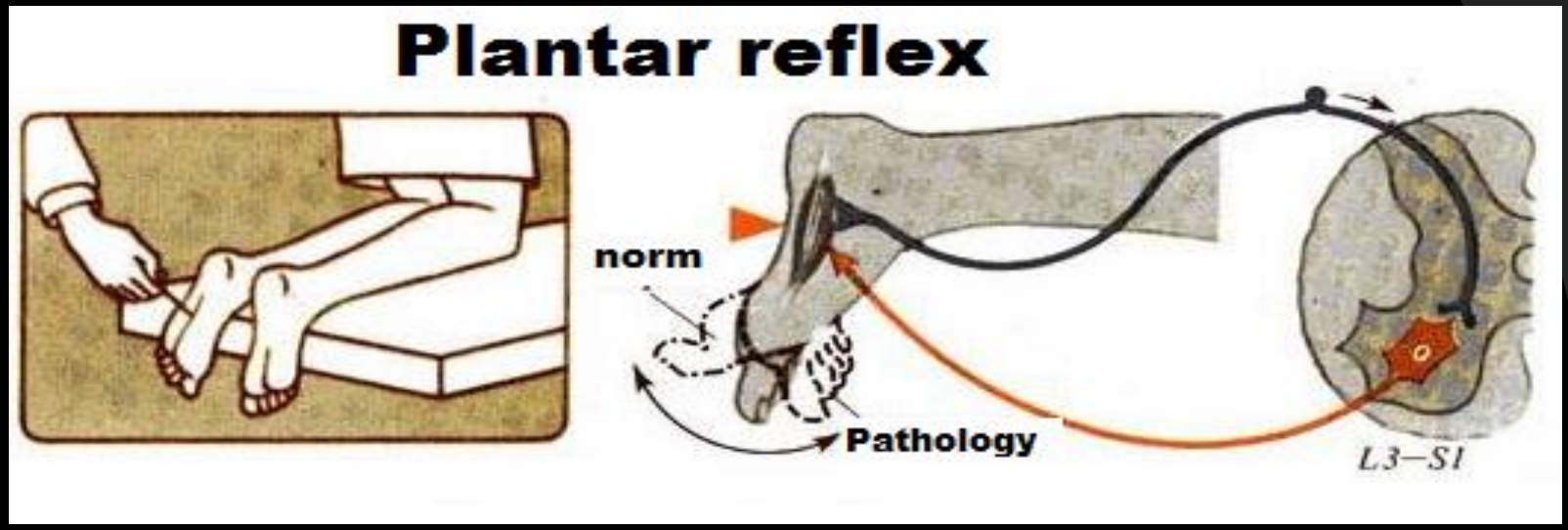


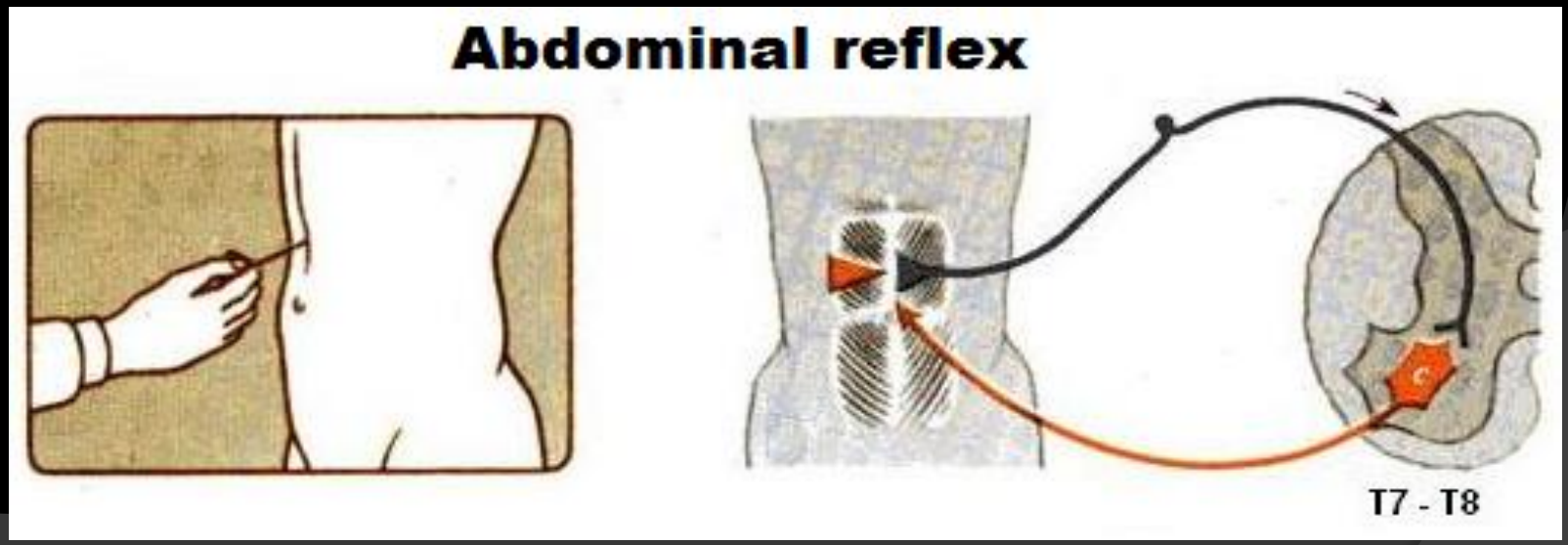


Ankle (Achilles) reflex

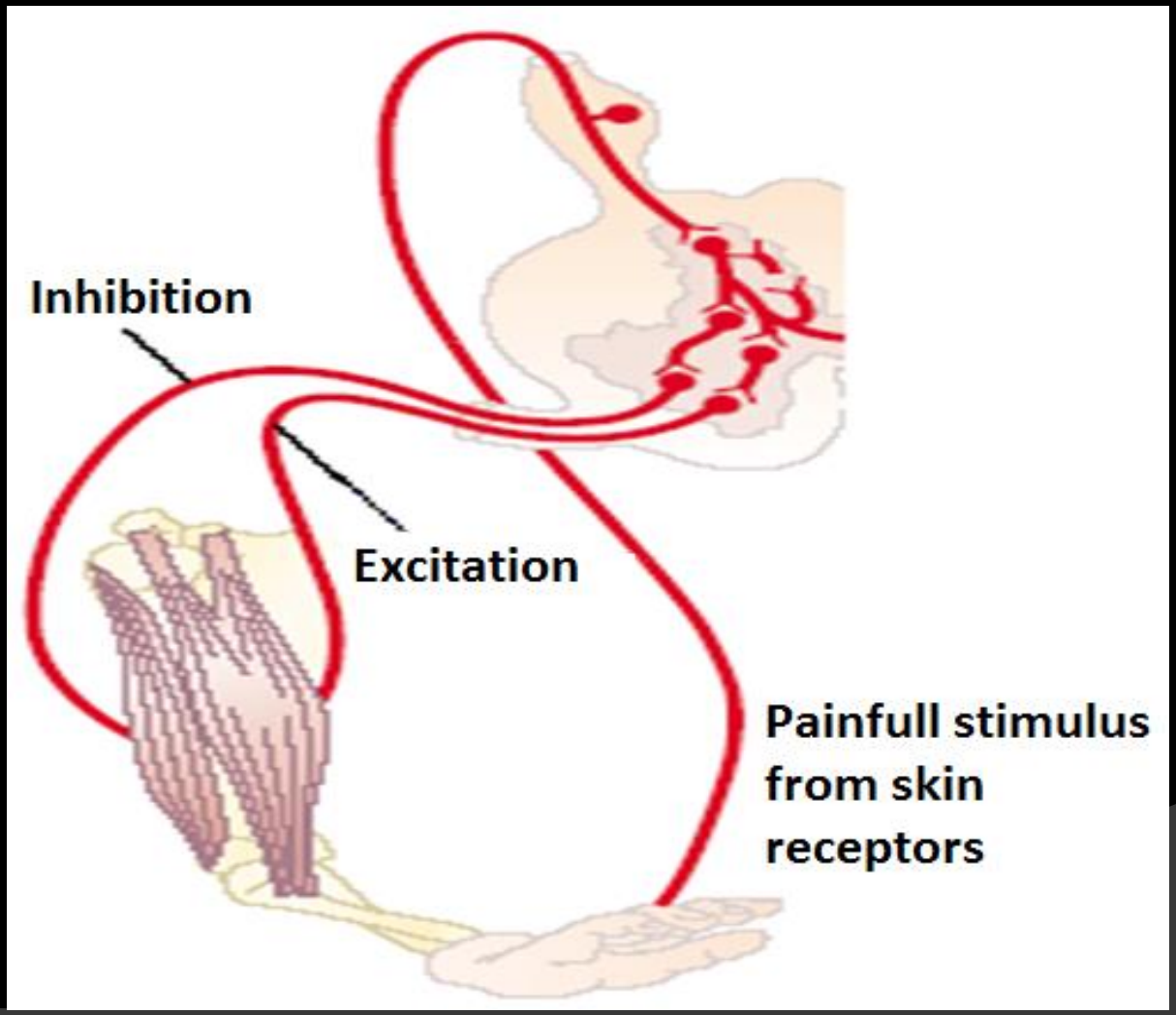


Skin reflexes



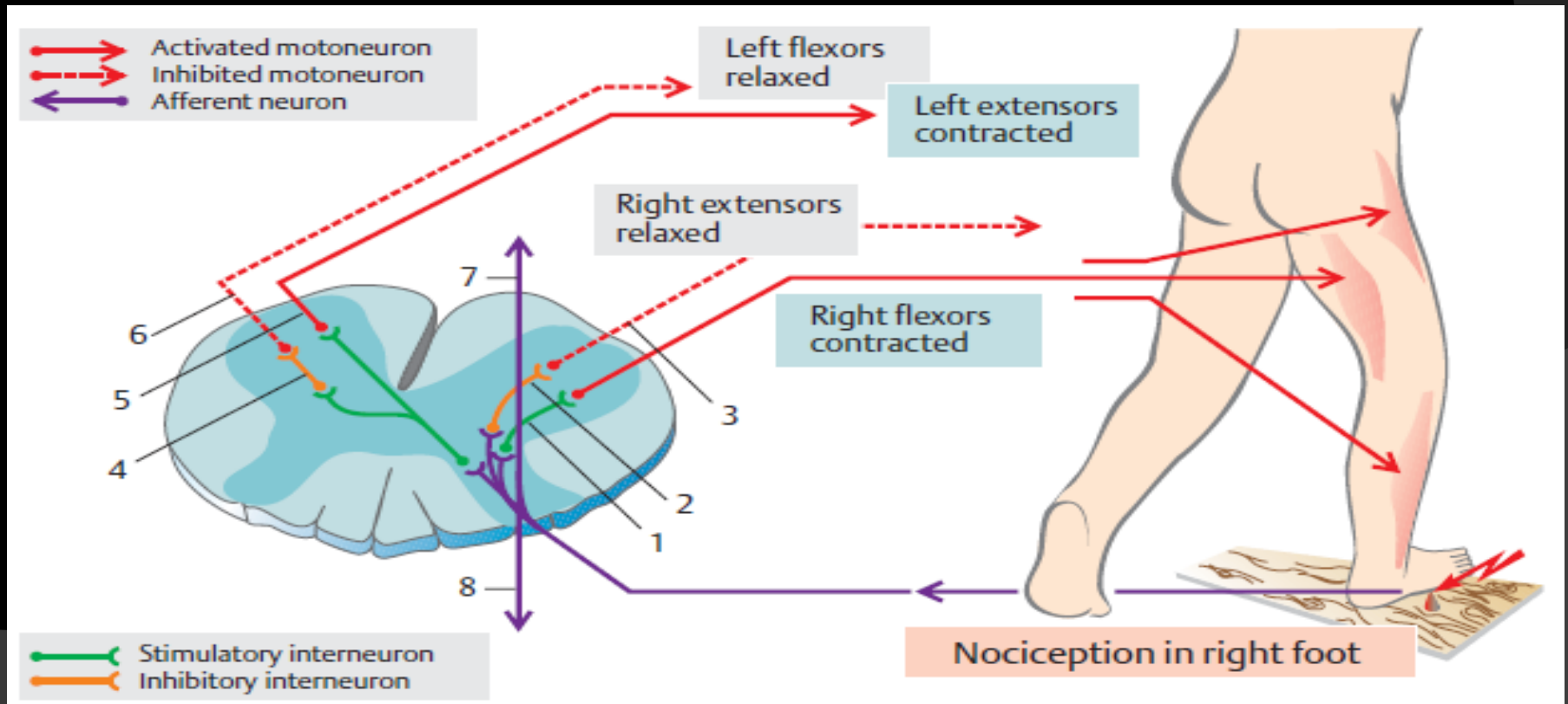


Bending reflex



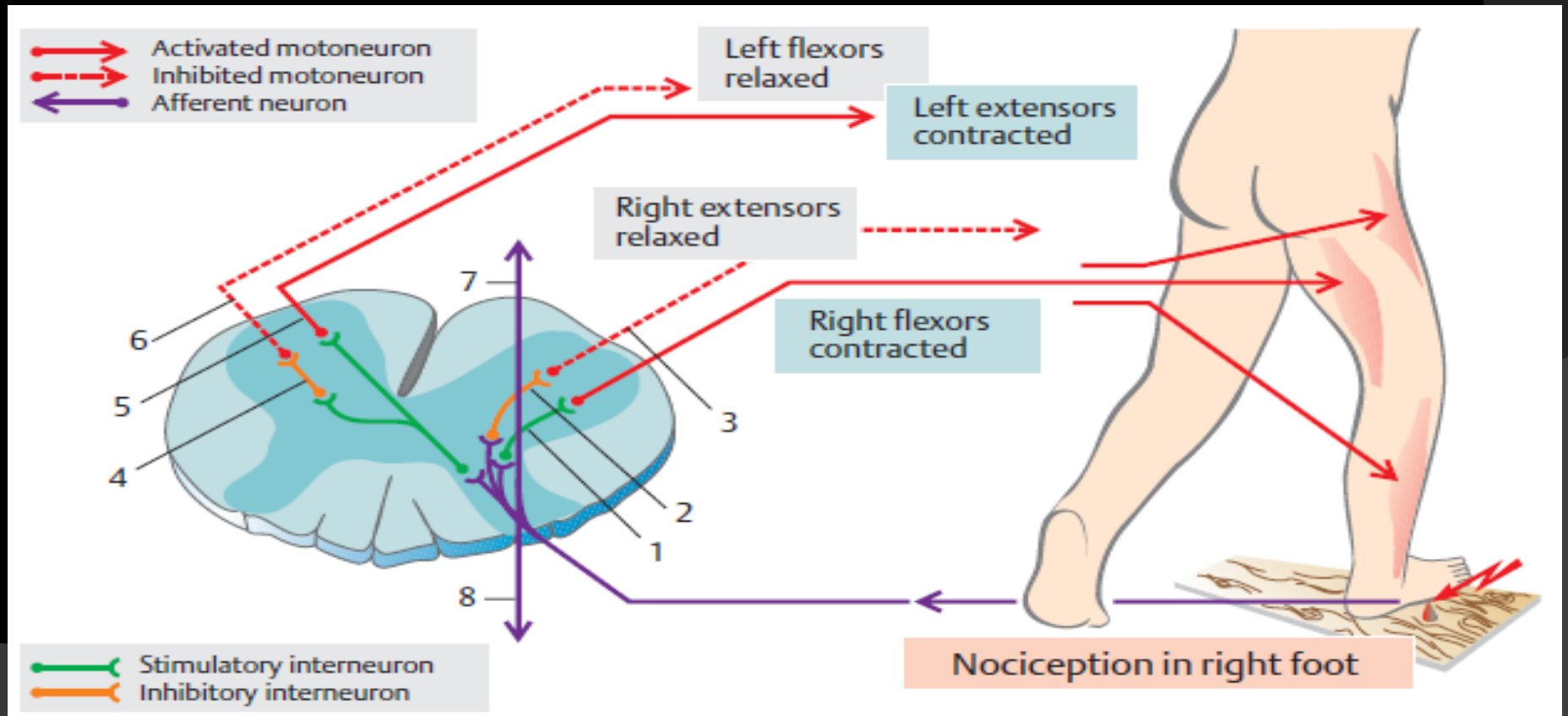
Withdrawal reflex

- A painful stimulus in the sole of the right foot (e.g., stepping on a tack) leads to flexion of all joints of that leg (**flexion reflex**). Nociceptive afferents are conducted via stimulatory interneurons (1) in the spinal cord to motoneurons of ipsilateral ***flexors*** and via inhibitory interneurons (2) to motoneurons of ipsilateral ***extensors*** *(3),* leading to their relaxation; this is called *antagonistic inhibition*.



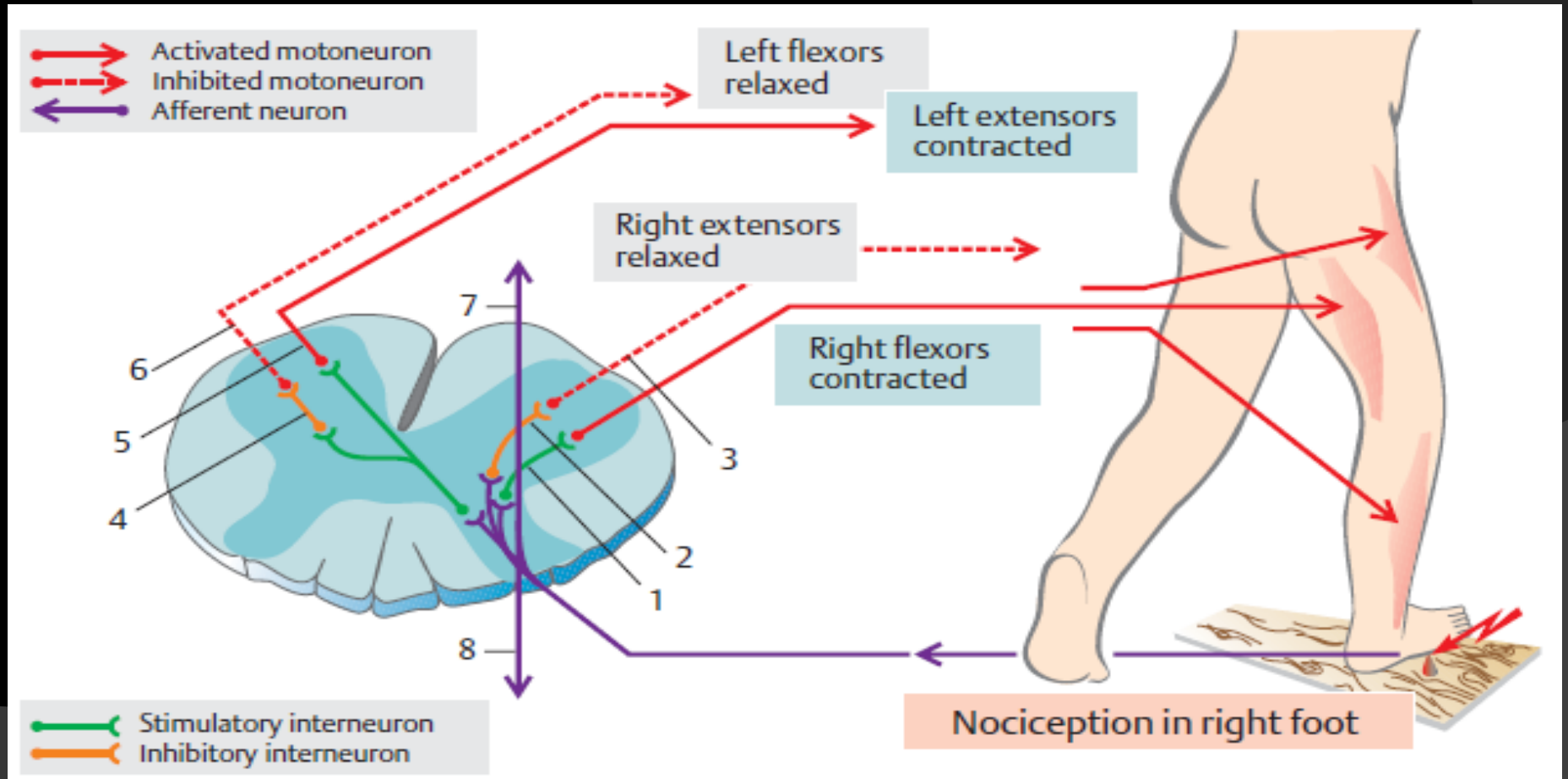
Withdraval reflex

One part of the response is the **crossed extensor reflex**, which promotes the withdrawal from the injurious stimulus by increasing the distance between the nociceptive stimulus (e.g. the tack) and the nocisensor and helps to support the body. It consists of contraction of extensor muscles (5) and relaxation of the flexor muscles in the contralateral leg (**4, 6**).

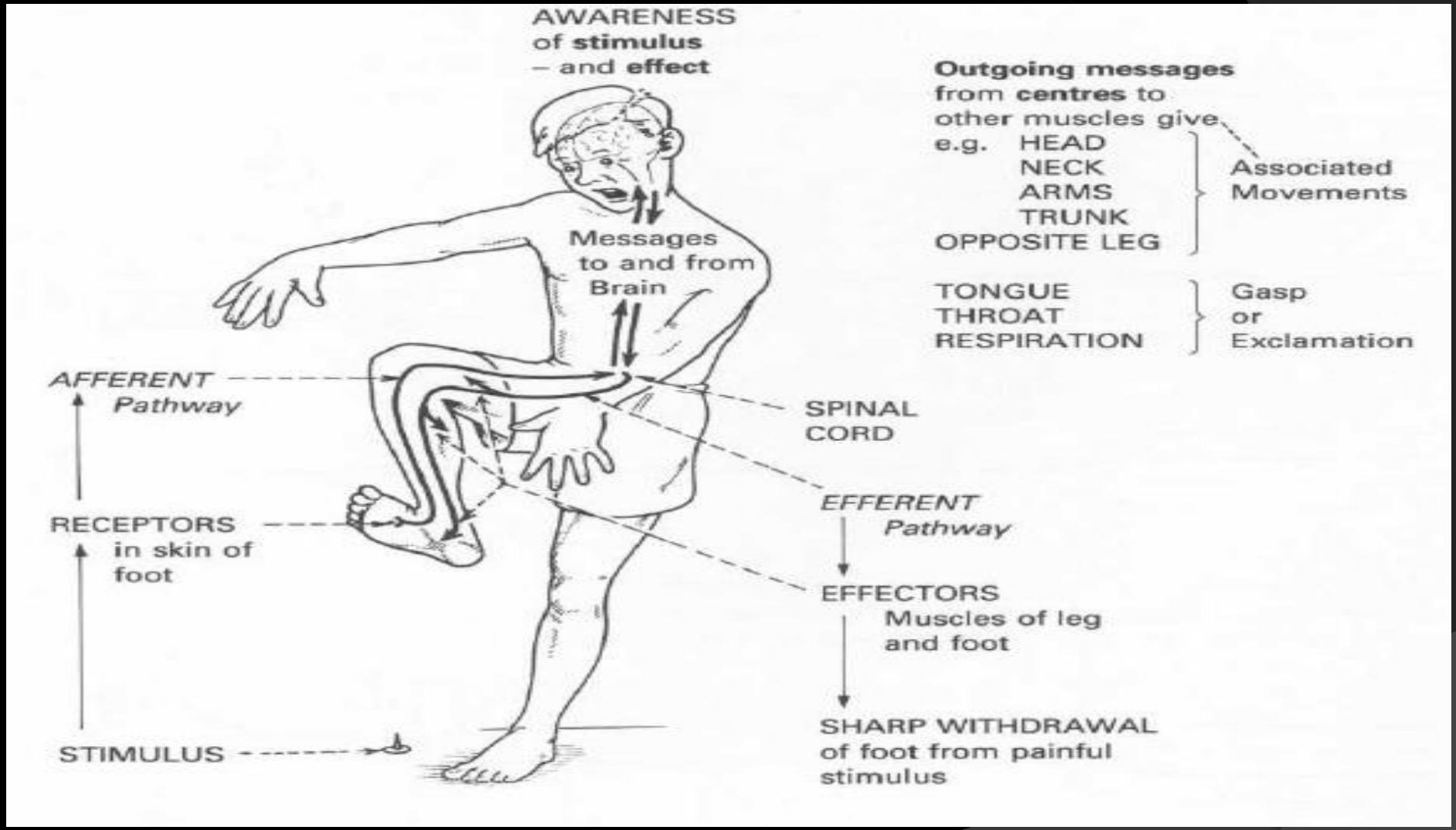


Withdraval reflex

- Nociceptive afferents are also conducted to other segments of the spinal cord (ascending and descending; **7, 8**) because different extensors and flexors are innervated by different segments. A noxious stimulus can also trigger flexion of the ipsilateral arm and extension of the contralateral arm (***double crossed extensor reflex***).



Most reflex actions in man involve several reflex arch



This is possible because each receptor neuron
is potentially connected within the CNS to many effector neurons.