

Neurophysiology

Spinal cord

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Functions of the spinal cord

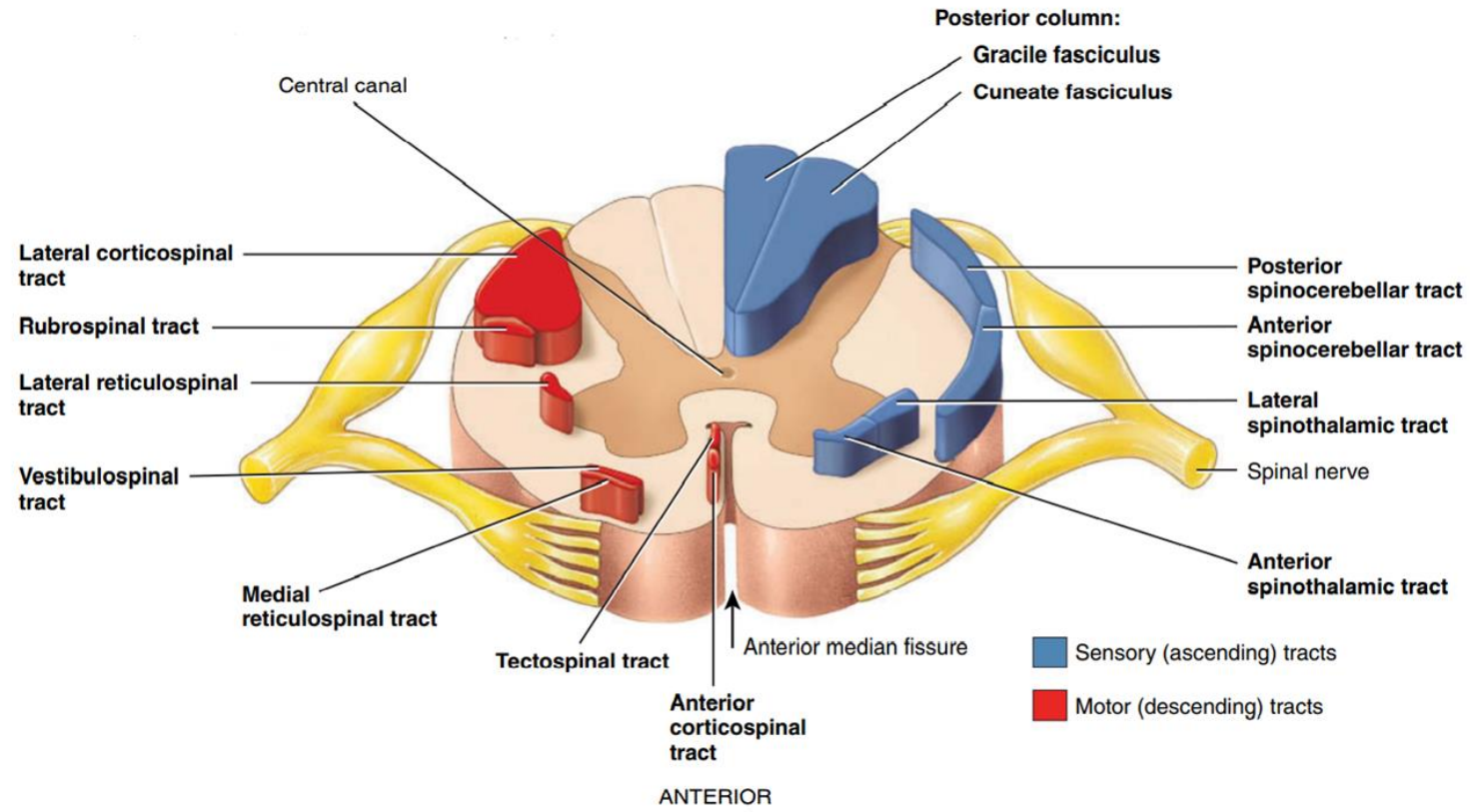
Nerve impulse propagation:

The white matter tracts in the spinal cord are highways for nerve impulse propagation.

Sensory input travels along these tracts toward the brain, and motor output travels from the brain along these tracts toward skeletal muscles and other effector tissues.



Tracts in the spinal cord



Functions of the spinal cord

Integration of information:

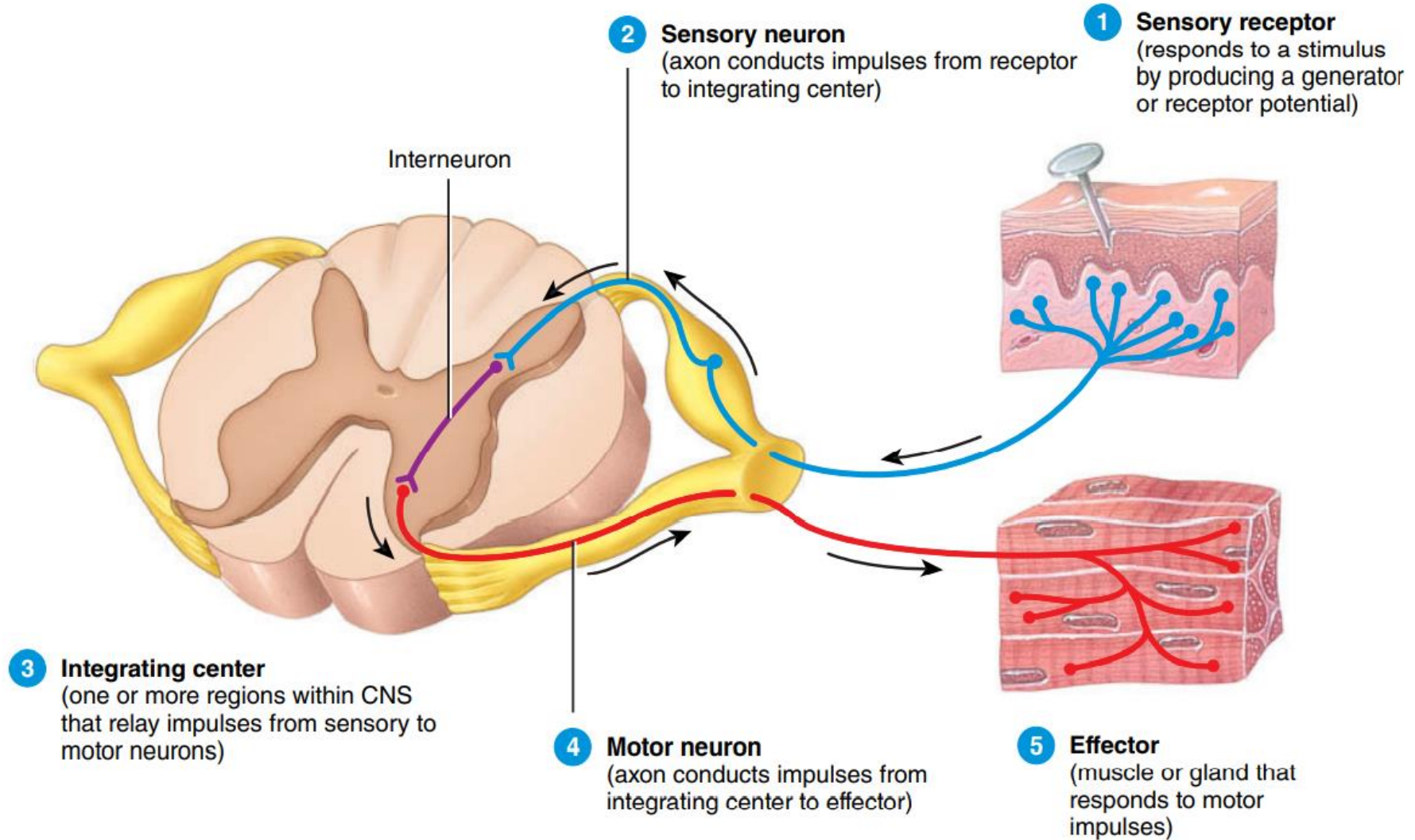
The gray matter of the spinal cord receives and integrates incoming and outgoing information mainly for some reflexes.

A reflex is a fast, involuntary, unplanned sequence of actions that occurs in response to a particular stimulus.

Reflex arc

- The pathway followed by nerve impulses that produce a reflex is a **reflex arc** (reflex circuit).
- A reflex arc includes five functional components.

Components of the reflex arc

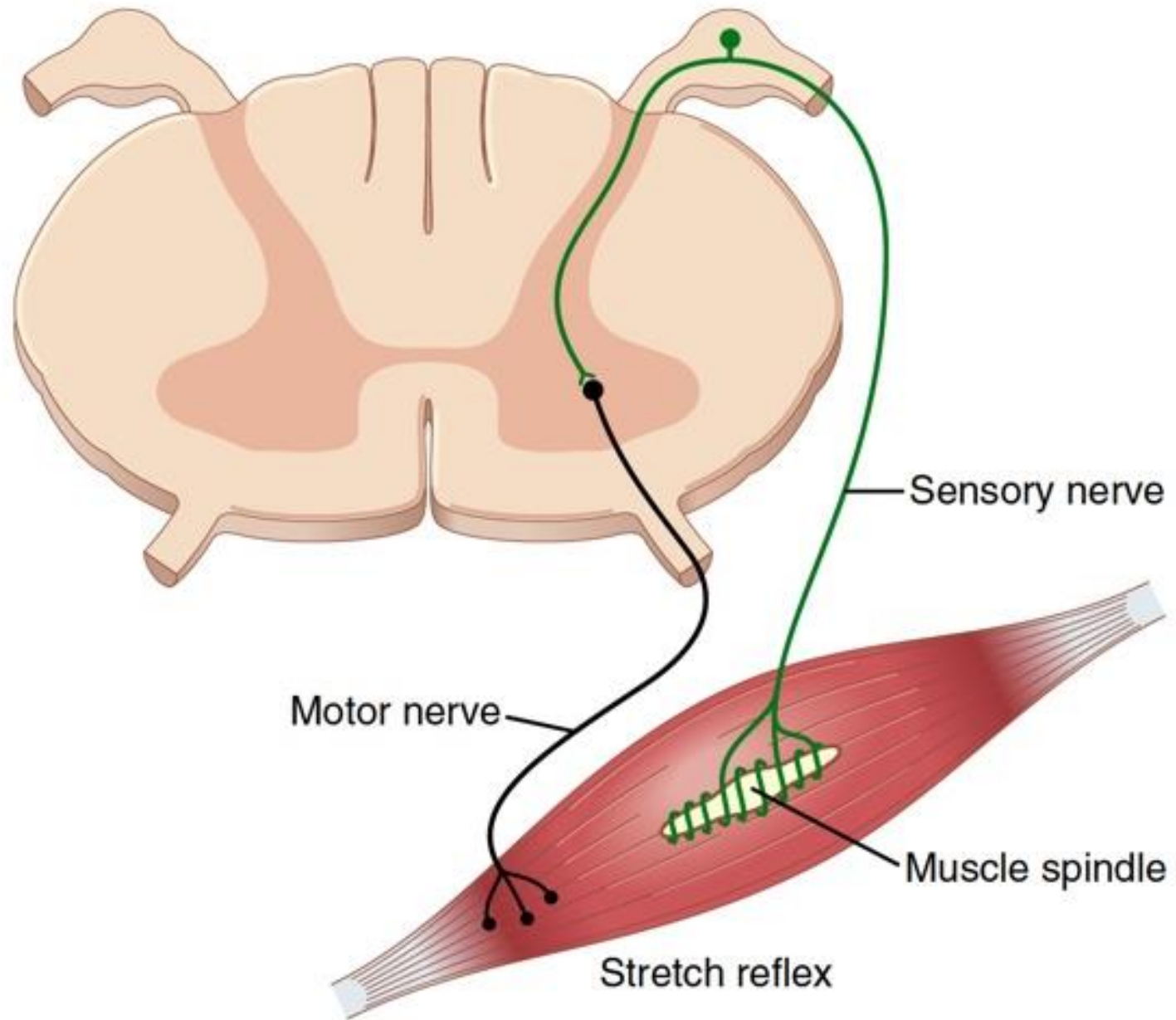


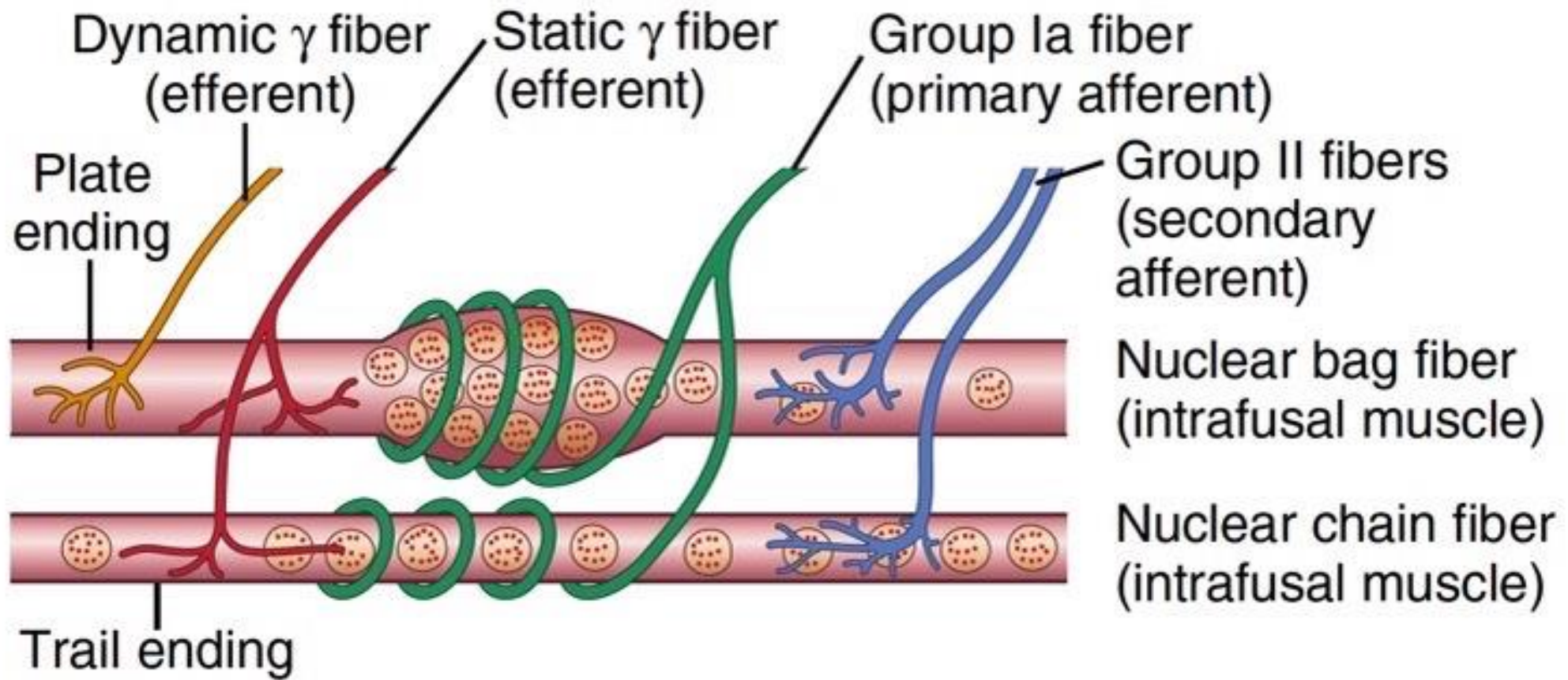
Sensory receptors in muscles

- 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.
- (2) Golgi tendon organs, which are located in the muscle tendons and transmit information about tendon tension or rate of change of tension.

Motor innervation of muscle fibers

- A α motor nerve fibers innervate the large skeletal muscle fibers (motor unit).
- type A gamma (A γ) motor nerve fibers, go to small, special skeletal muscle fibers called intrafusal fibers.
- They constitute the middle of the muscle spindle, which helps control basic muscle “tone”.
- Interneurons are present in all areas of the cord gray matter.





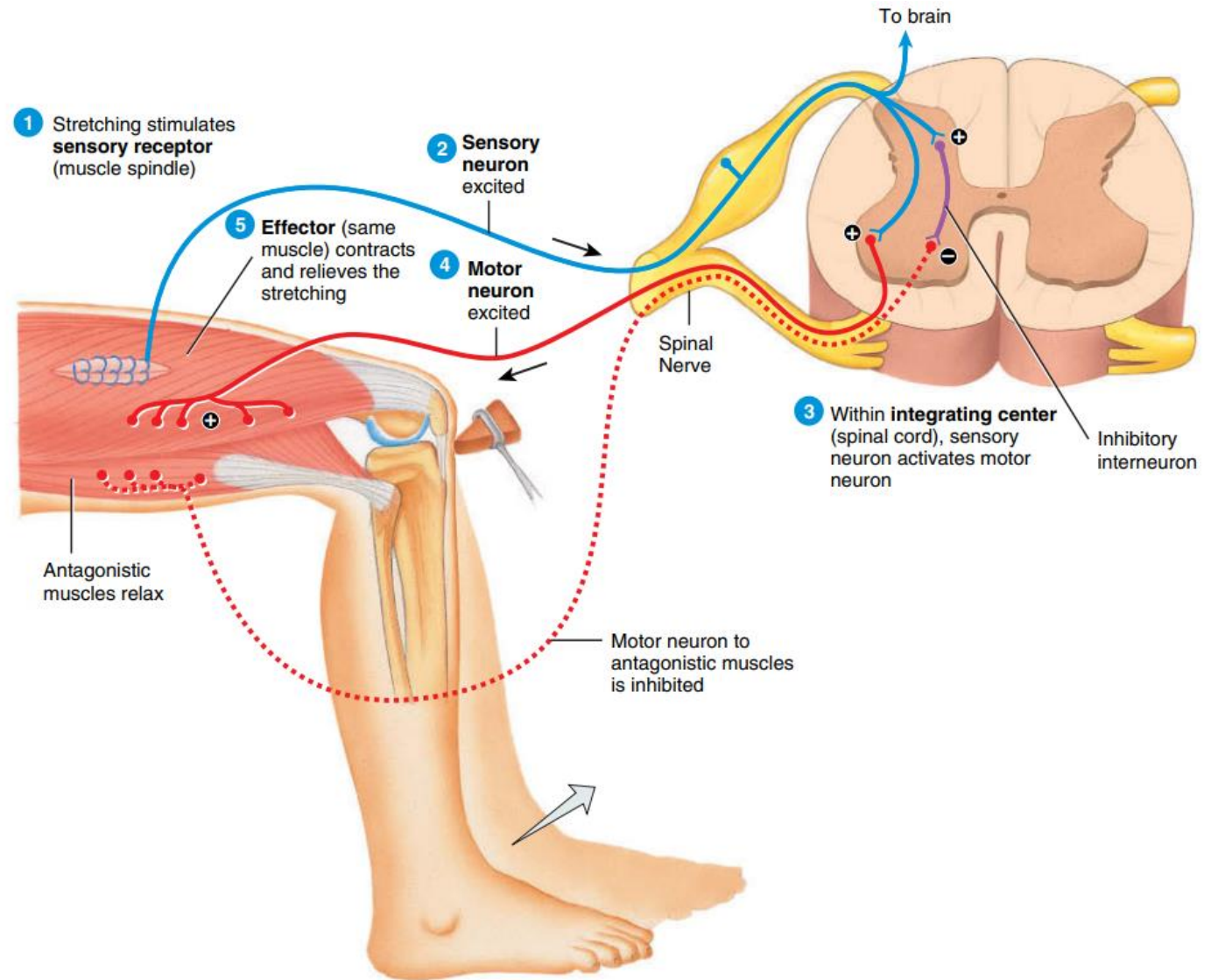
Muscle spindle

- Normally, when there is some degree of gamma nerve excitation, the muscle spindles emit sensory nerve impulses continuously.
- Stretching the muscle spindles increases the rate of firing, whereas shortening the spindle decreases the rate of firing.
- Thus, the spindles can send to the spinal cord either positive signals (increased numbers of impulses to indicate stretch of a muscle) or negative signals (reduced numbers of impulses) to indicate that the muscle is unstretched.

Stretch reflex arc

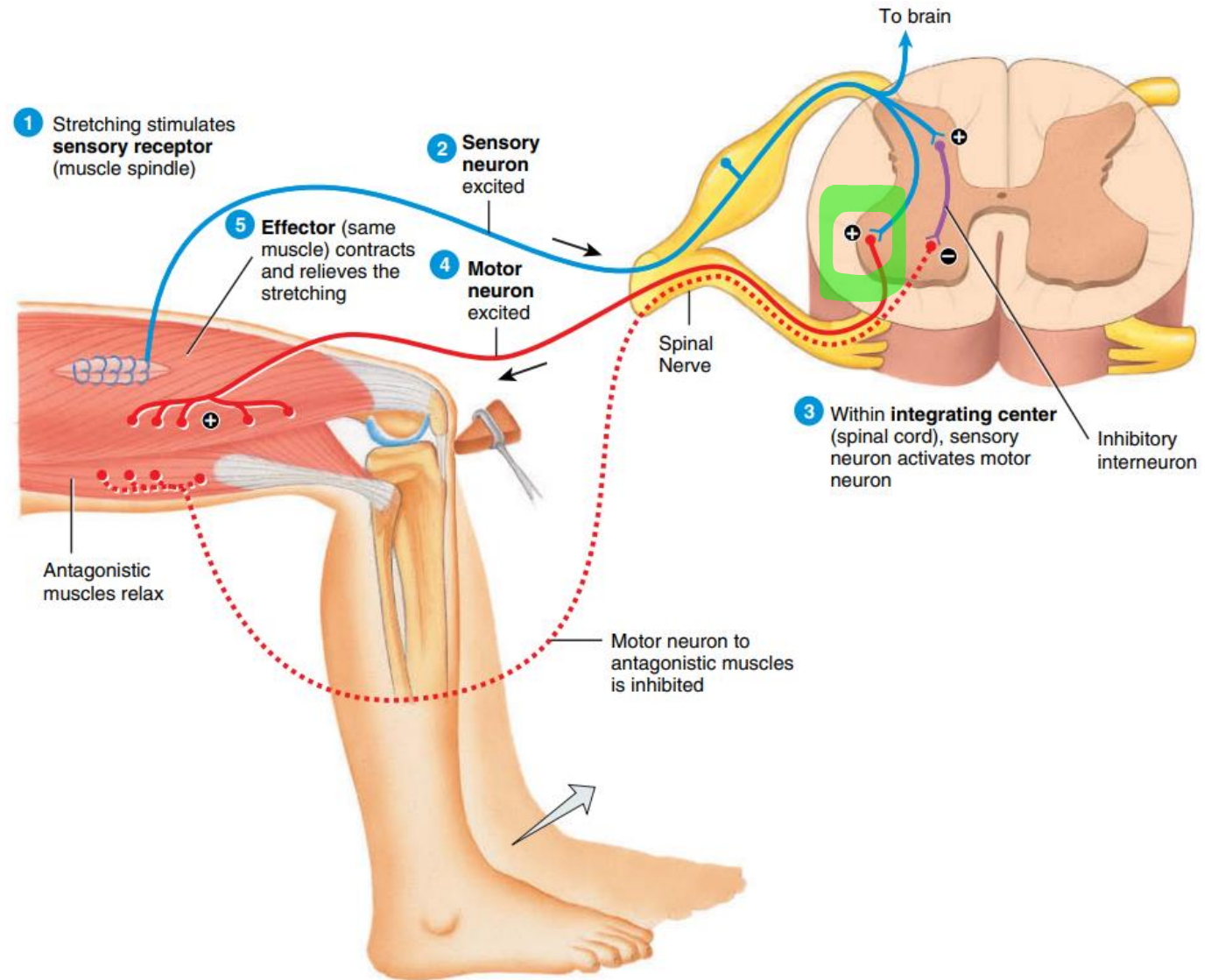
Stretch

Spindle



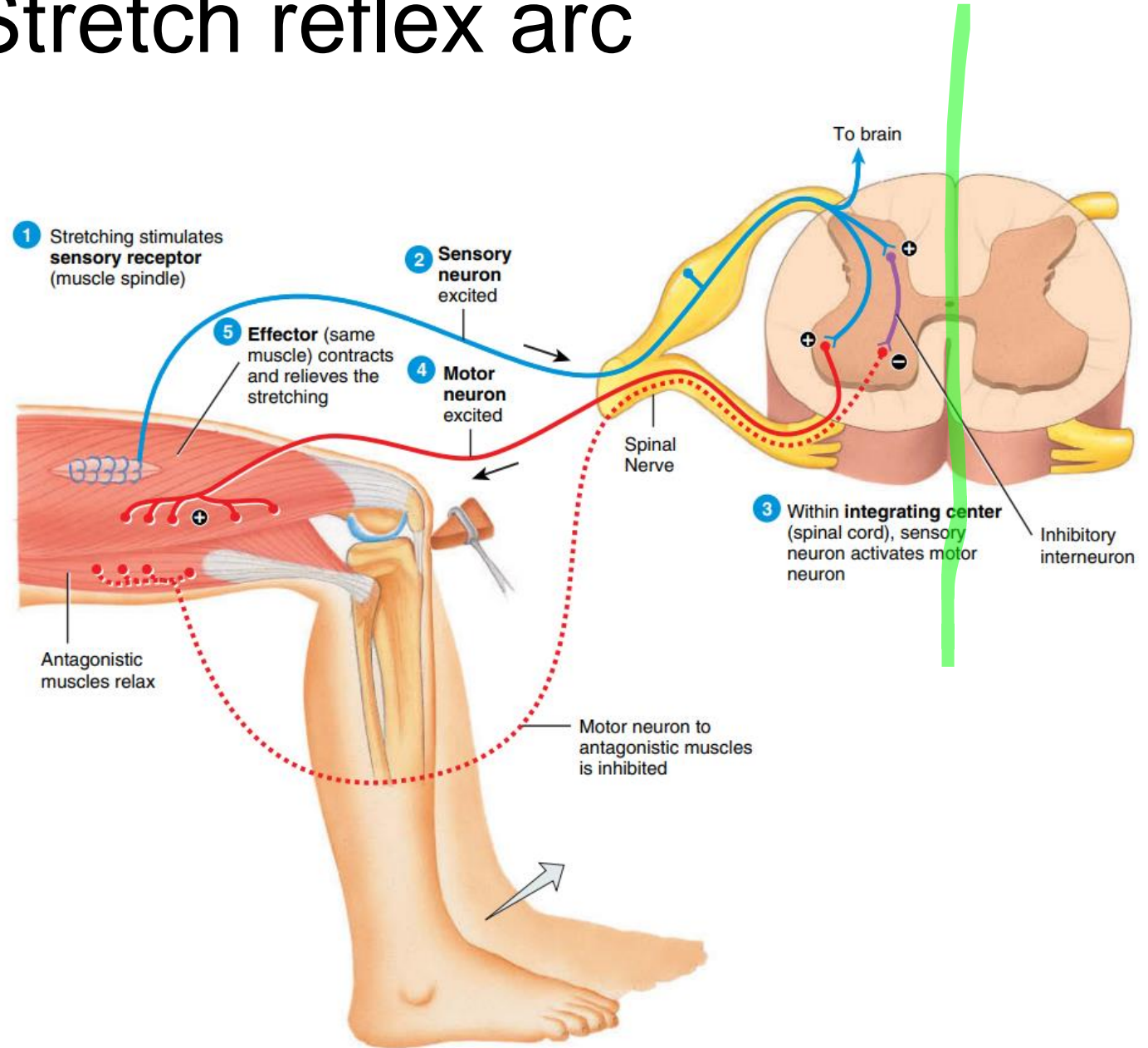
Stretch reflex arc

Monosynaptic



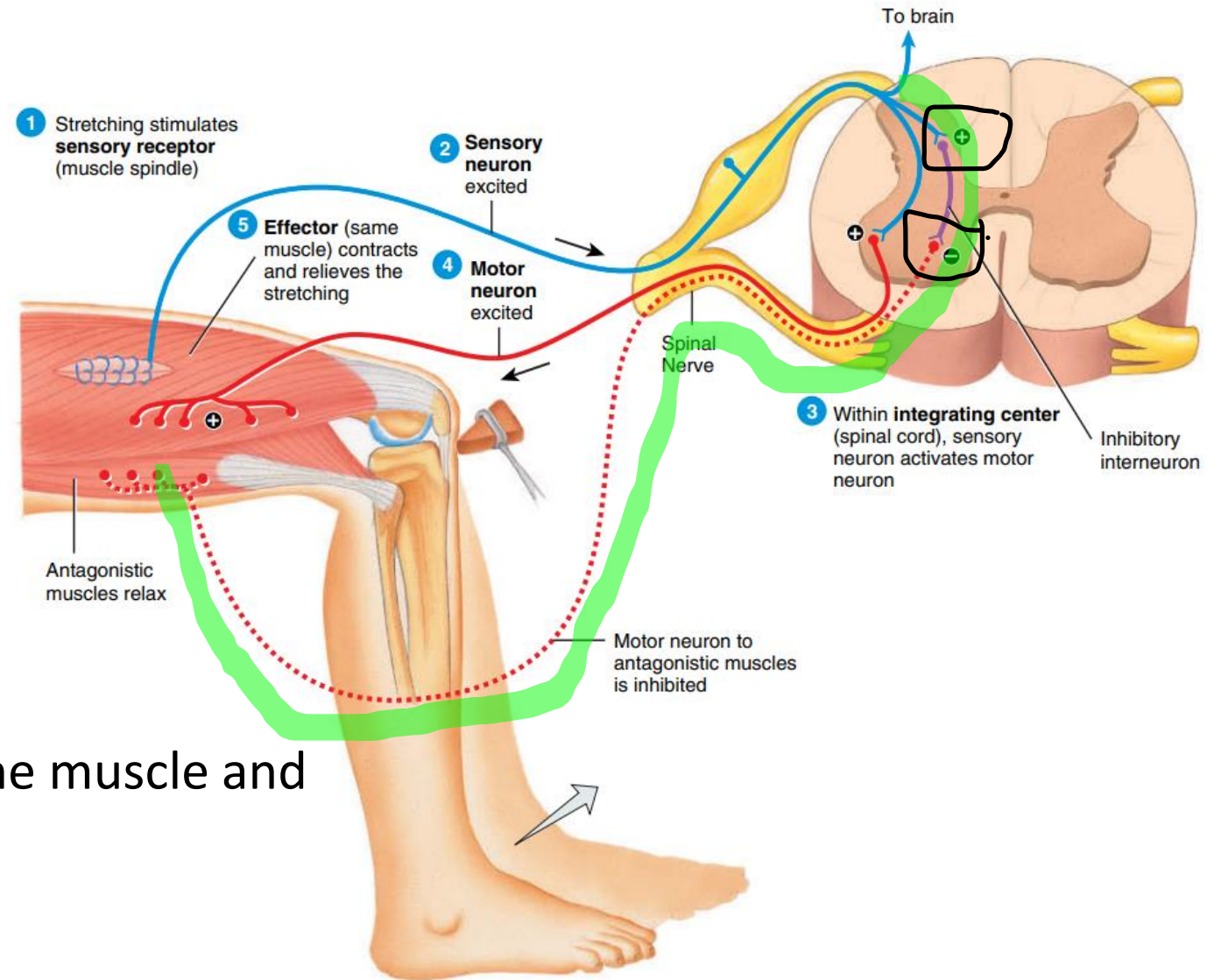
Stretch reflex arc

Ipsilateral



Stretch reflex arc

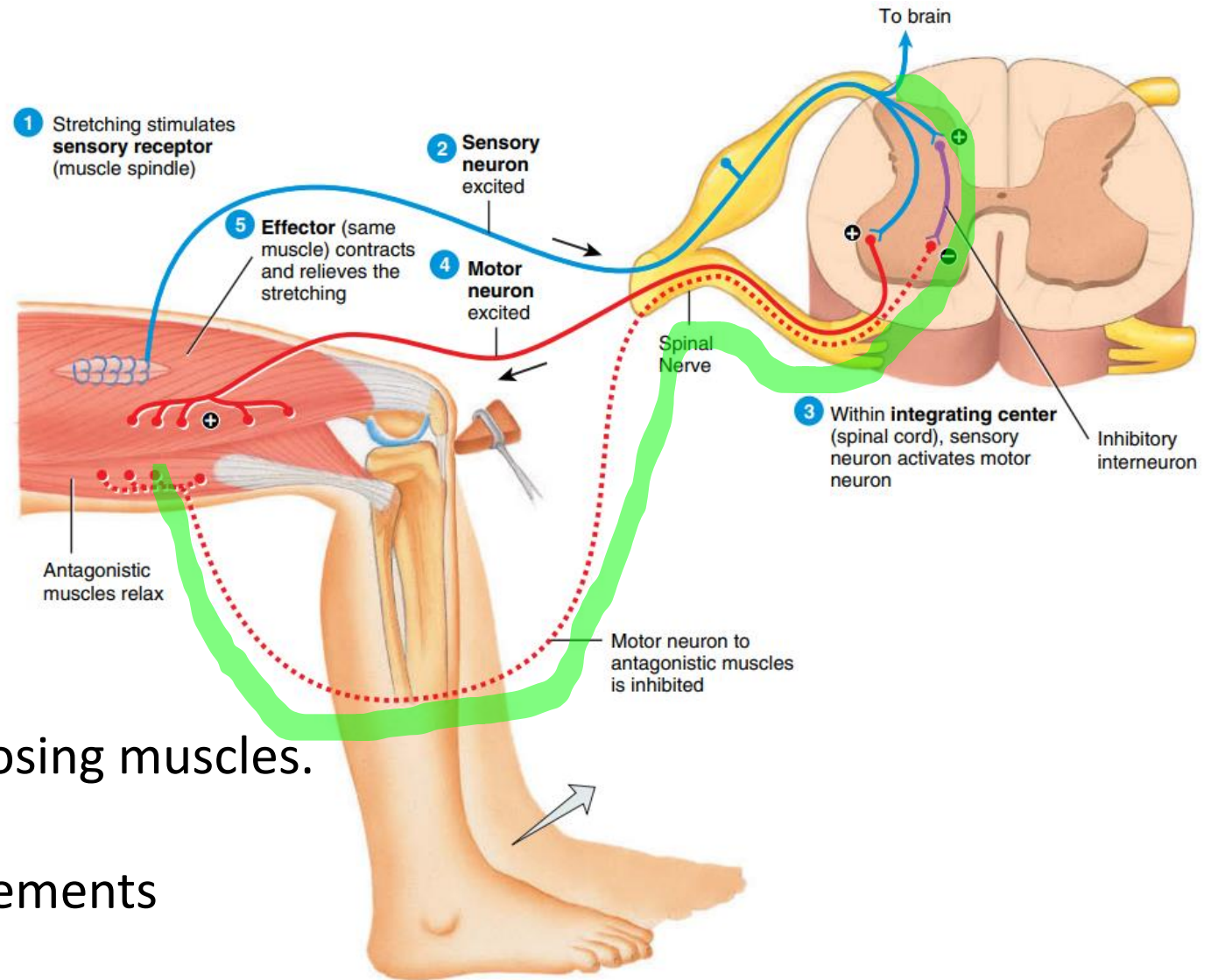
Reciprocal
innervation



Simultaneous contraction of one muscle and relaxation of its antagonist.

Stretch reflex arc

Reciprocal
innervation



Prevents conflict between opposing muscles.

Vital in coordinating body movements

Muscle stretch reflex

- The stretch reflex can be divided into two components:
- The **dynamic stretch reflex** is elicited by potent dynamic signals transmitted from the primary sensory endings of the muscle spindles, caused by rapid stretch or unstretch.
- That is, when a muscle is suddenly stretched or unstretched, a strong signal is transmitted to the spinal cord, which causes an instantaneous strong reflex contraction (or decrease in contraction) of the same muscle from which the signal originated.
- Thus, the reflex functions to oppose sudden changes in muscle length.

Muscle stretch reflex

- The dynamic stretch reflex is over within a fraction of a second after the muscle has been stretched (or unstretched) to its new length, but then a weaker **static stretch reflex** continues for a prolonged period thereafter.
- This reflex is elicited by the continuous static receptor signals transmitted by both primary and secondary endings.
- The importance of the static stretch reflex is that it causes the degree of muscle contraction to remain reasonably constant, except when the person's nervous system specifically wills otherwise.

Role of muscle spindle in voluntary movements

- Whenever signals are transmitted from the motor cortex or from any other area of the brain to the alpha motor neurons, in most instances the gamma motor neurons are stimulated simultaneously, an effect called **coactivation of the alpha and gamma motor neurons**.
- This effect causes both the extrafusal skeletal muscle fibers and the muscle spindle intrafusal muscle fibers to contract at the same time.
- coactivation keeps the muscle spindle reflex from opposing the muscle contraction.

Role of muscle spindle in voluntary movements

- The gamma efferent system is excited specifically by signals from the bulboreticular facilitatory region of the brain stem and, secondarily, by impulses transmitted into the bulboreticular area from the following: (1) the cerebellum; (2) the basal ganglia; and (3) the cerebral cortex.

Clinical significance of stretch reflex

- The muscle jerks are used by neurologists to assess the degree of facilitation of spinal cord centers.
- When large numbers of facilitatory impulses are being transmitted from the upper regions of the central nervous system into the cord, the muscle jerks are greatly exaggerated.
- Conversely, if the facilitatory impulses are depressed or abrogated, the muscle jerks are considerably weakened or absent.
- These reflexes are used most frequently in determining the presence or absence of muscle spasticity caused by lesions in the motor areas of the brain or diseases that excite the bulboreticular facilitatory area of the brain stem.

Significance of stretch reflex

- Because the stimulus for the stretch reflex is stretching of muscle, this reflex **helps avert injury by preventing overstretching of muscles.**

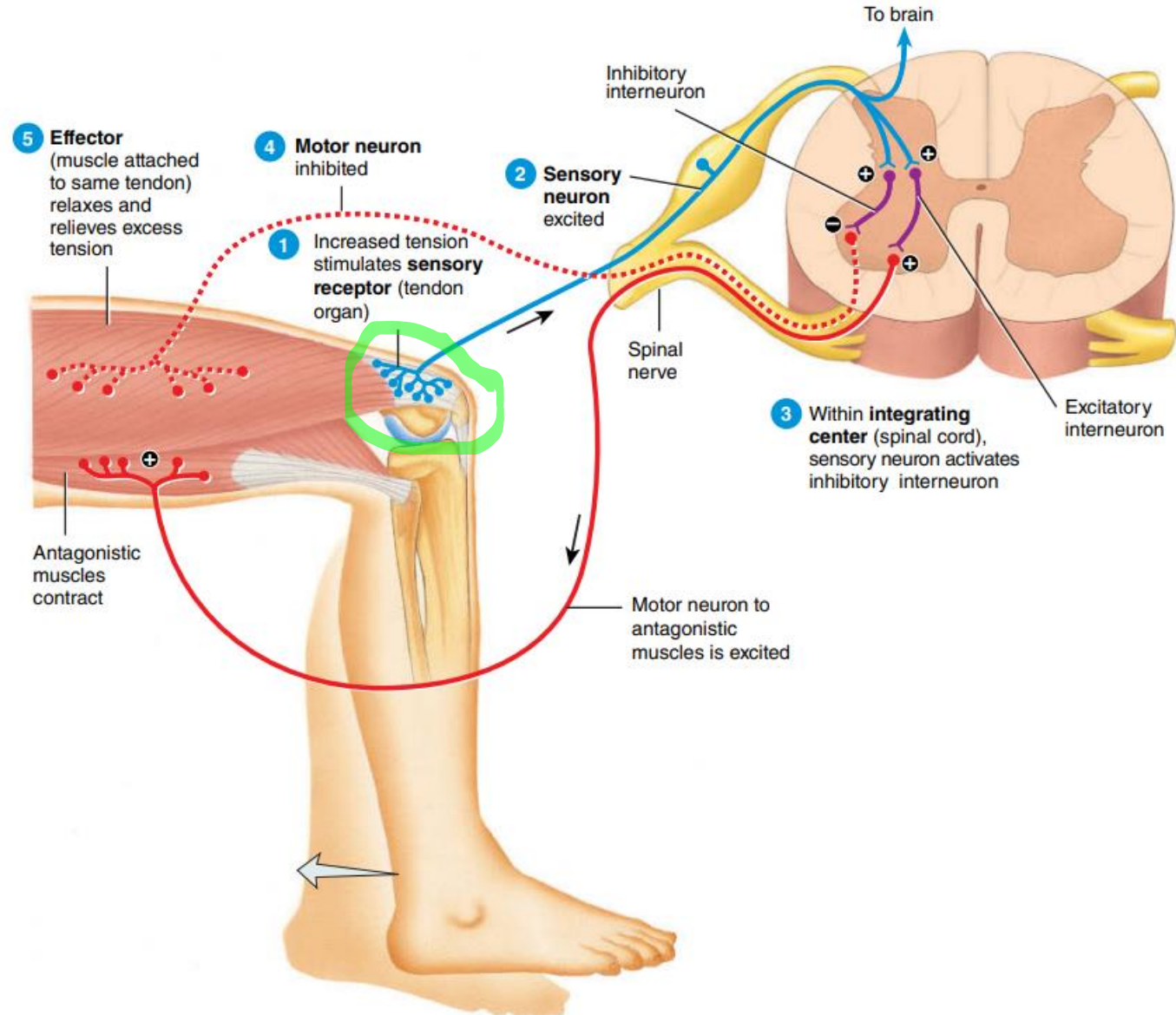
Stretch reflex

- The stretch reflex can also **help maintain posture**.
- For example, if a standing person begins to lean forward, the gastrocnemius and other calf muscles are stretched. Consequently, stretch reflexes are initiated in these muscles, which cause them to contract and reestablish the body's upright posture.

Tendon reflex

Tension

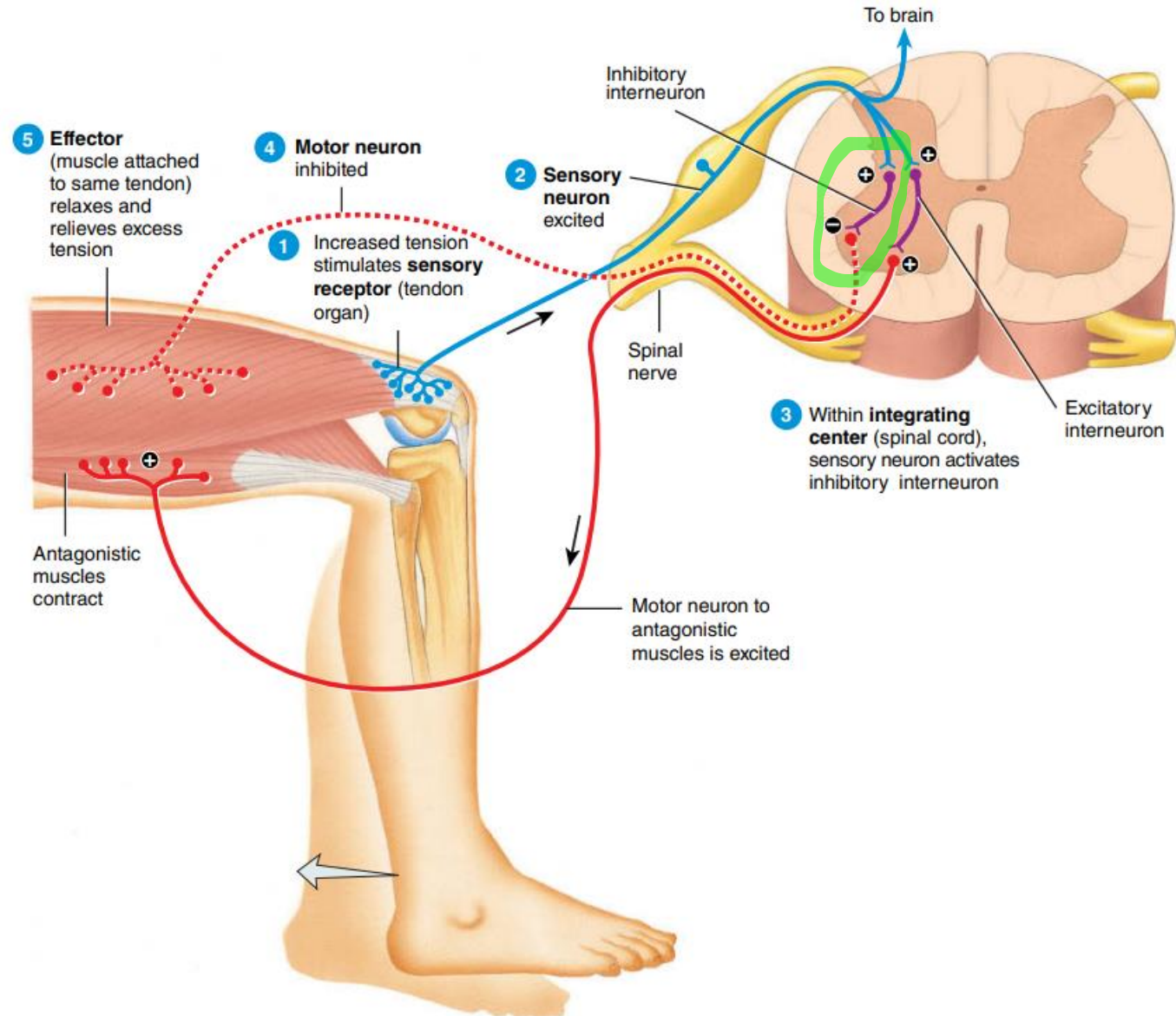
Tendon organ (Golgi)



Tendon reflex

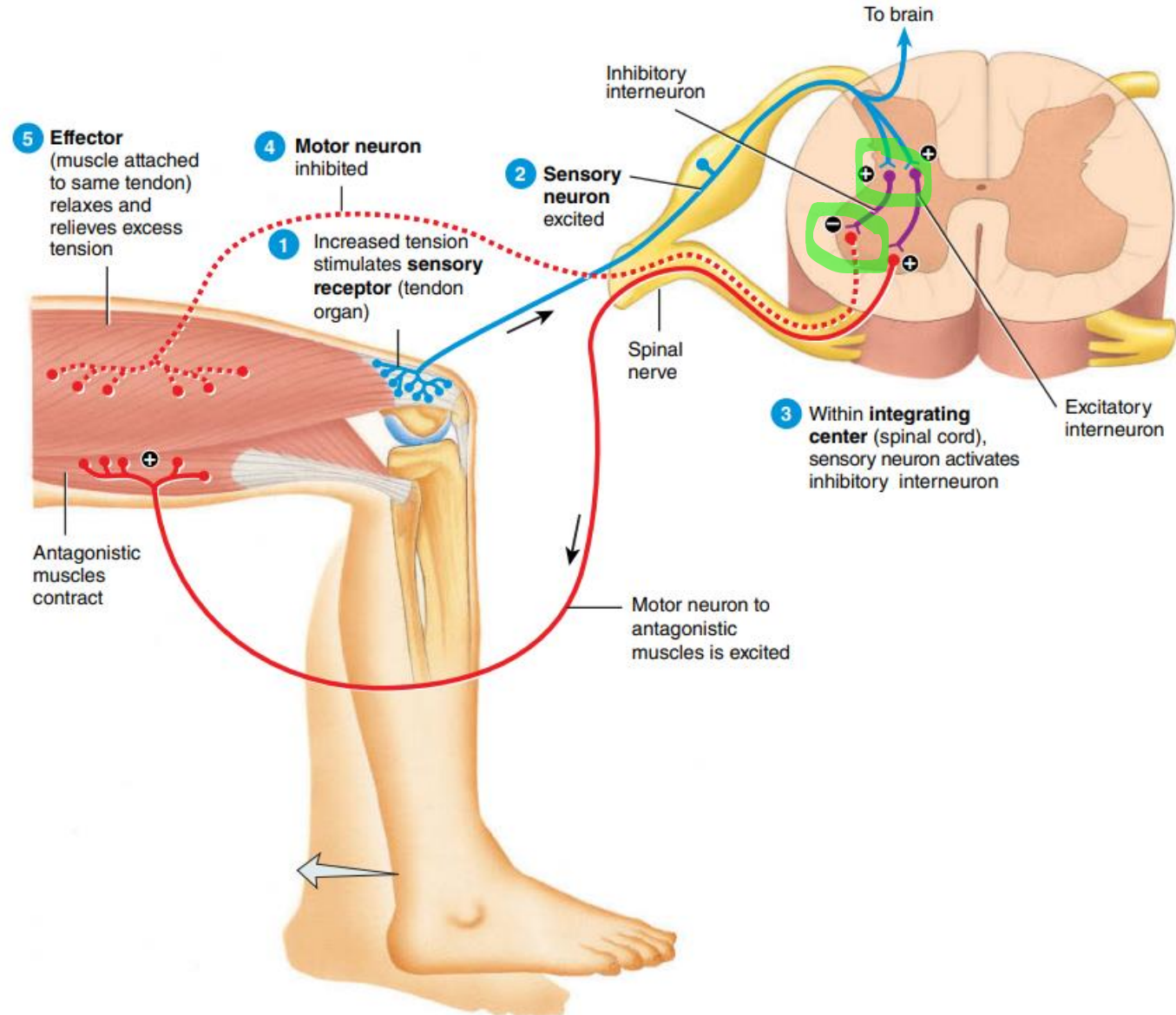
Sensory neuron
activates inhibitory
interneuron

Muscle relaxes
Less tension



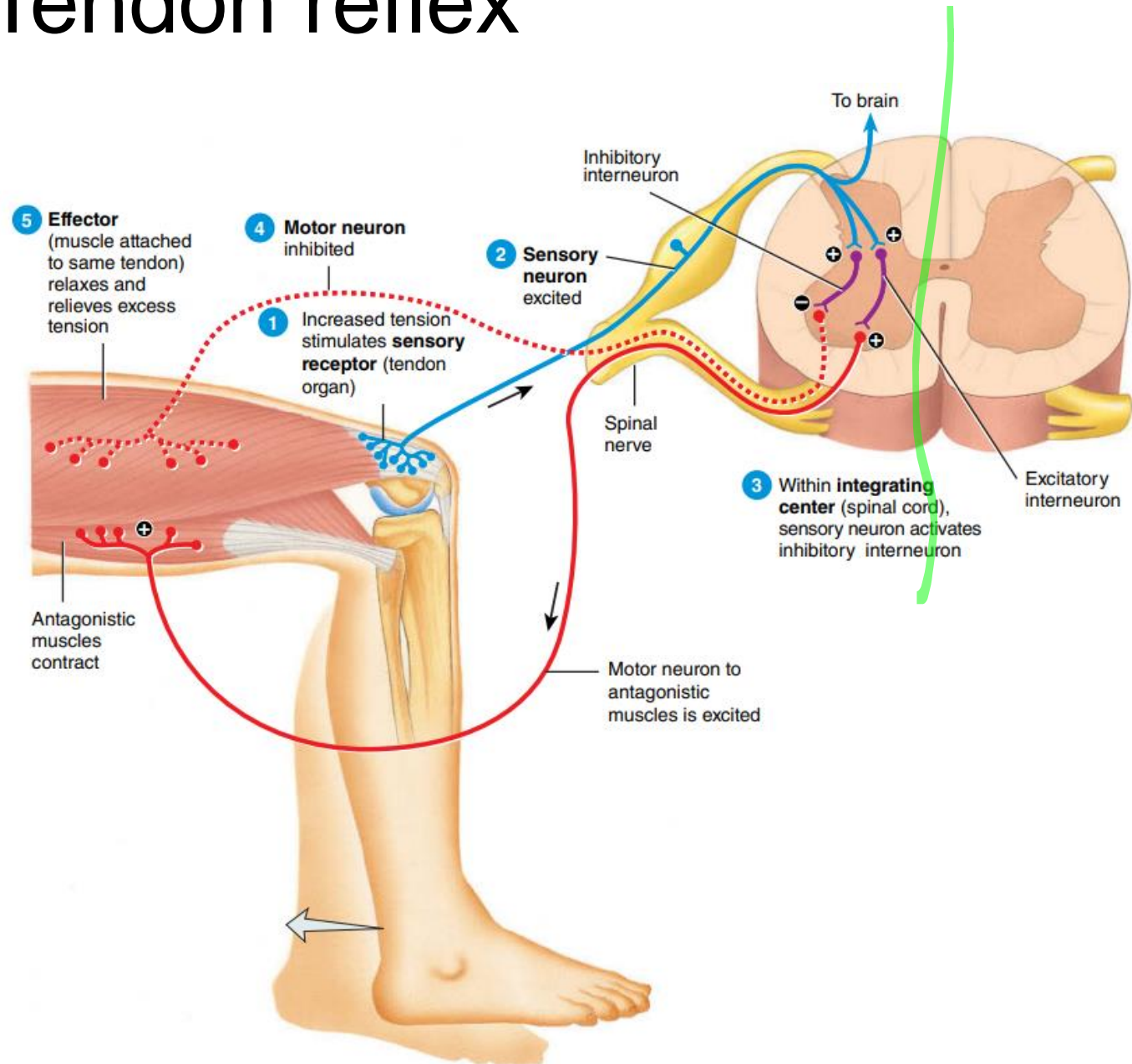
Tendon reflex

Polysynaptic



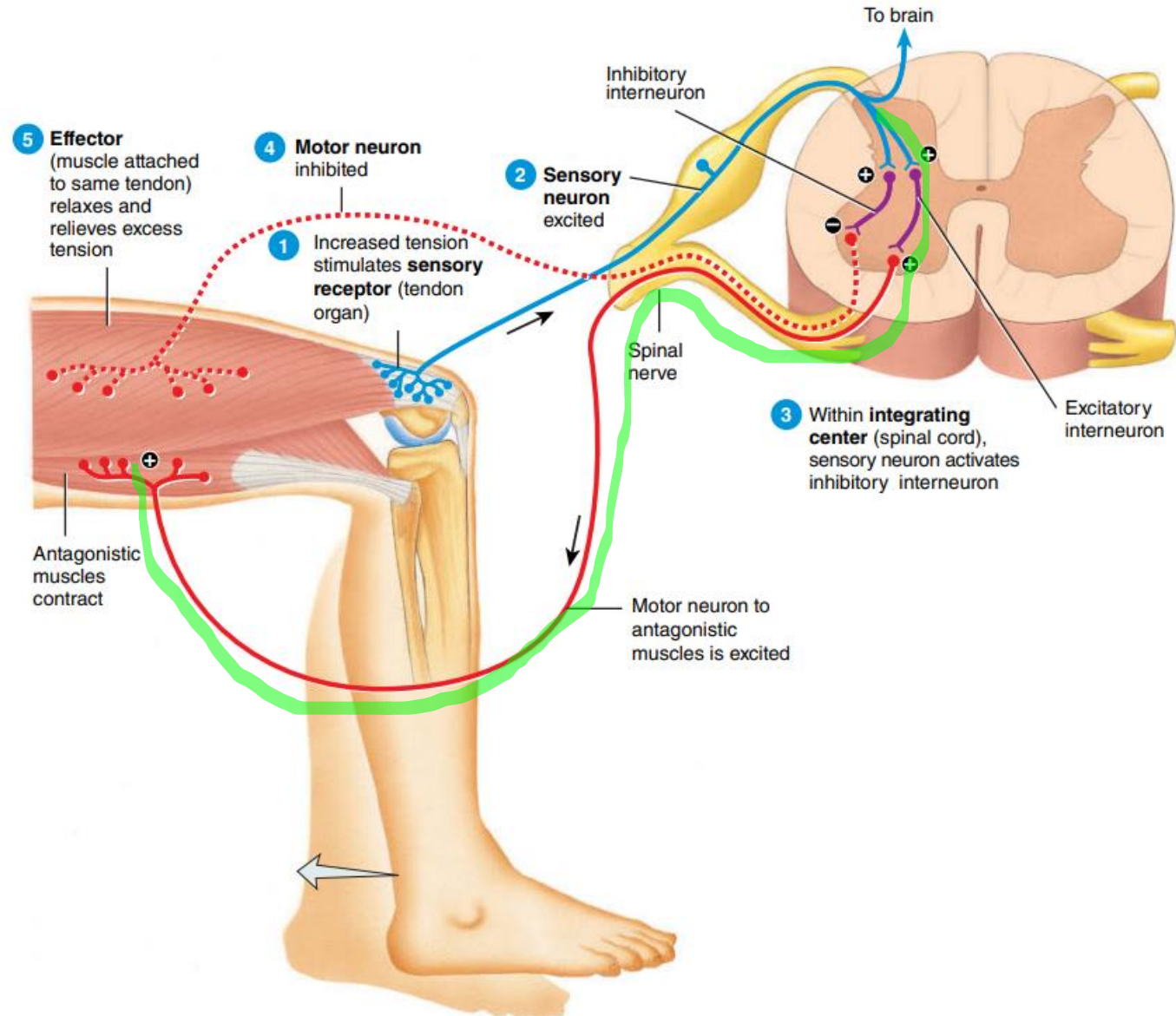
Tendon reflex

Ipsilateral

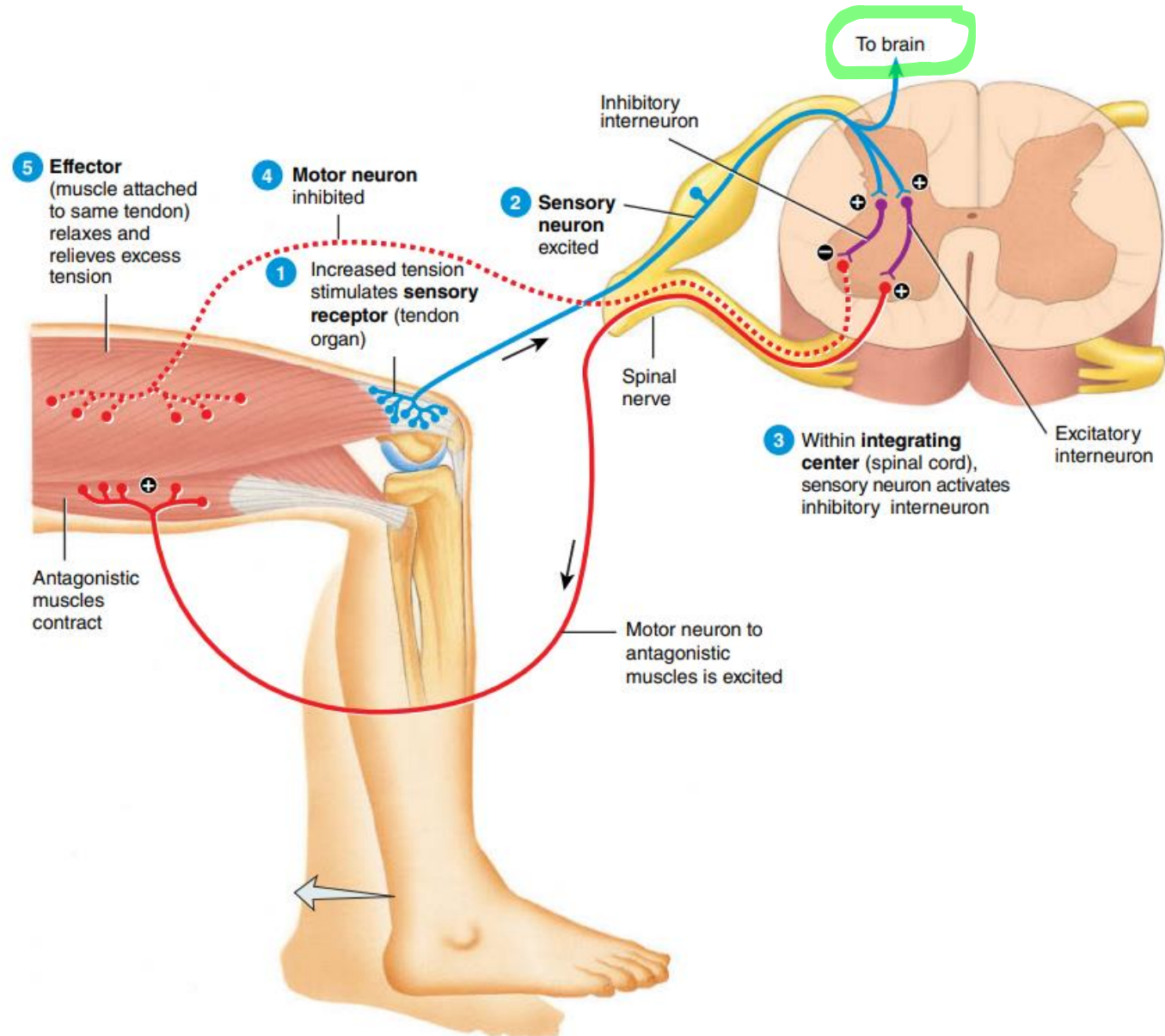


Tendon reflex

Reciprocal
innervation



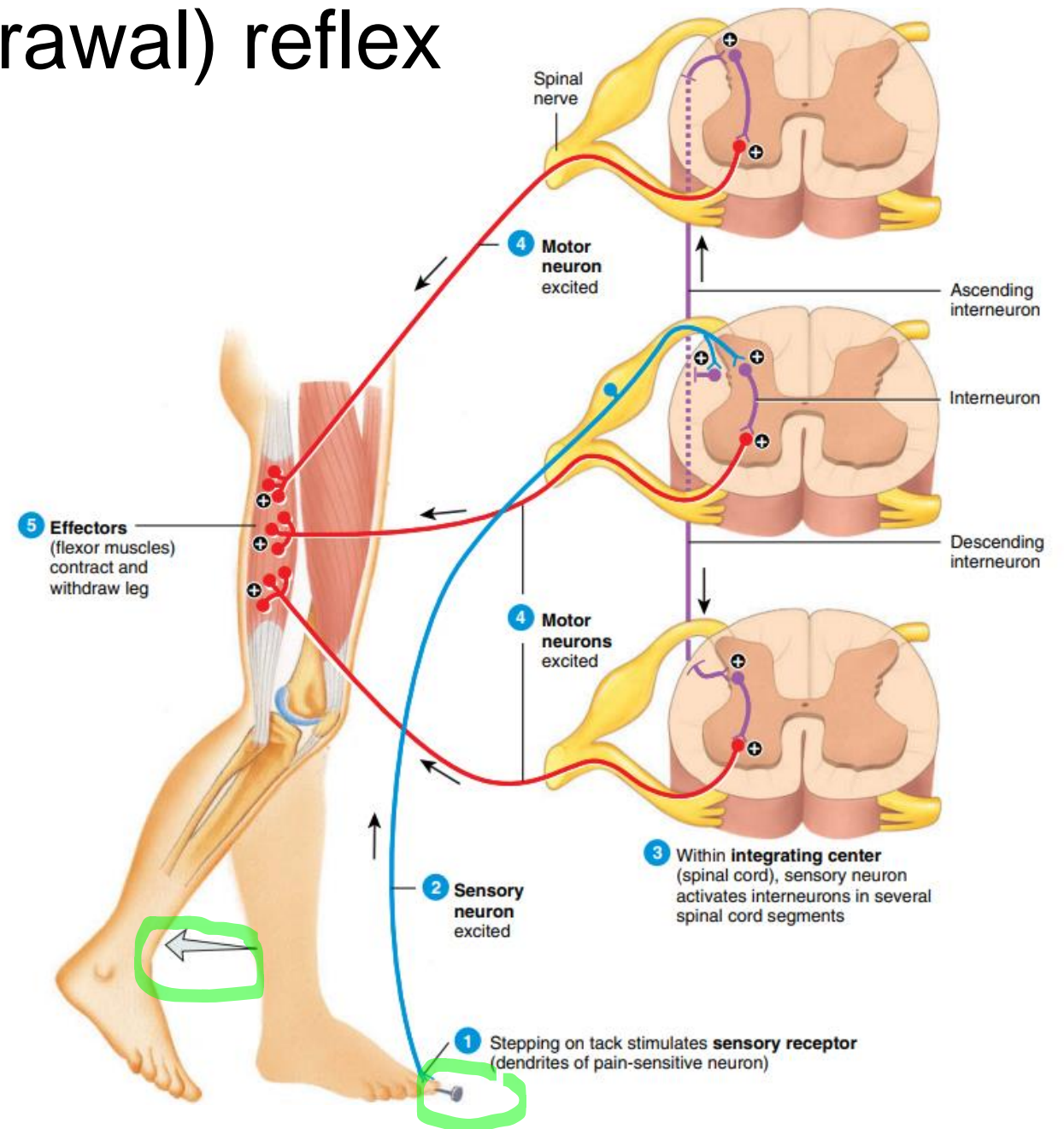
Tendon reflex



Flexor (withdrawal) reflex

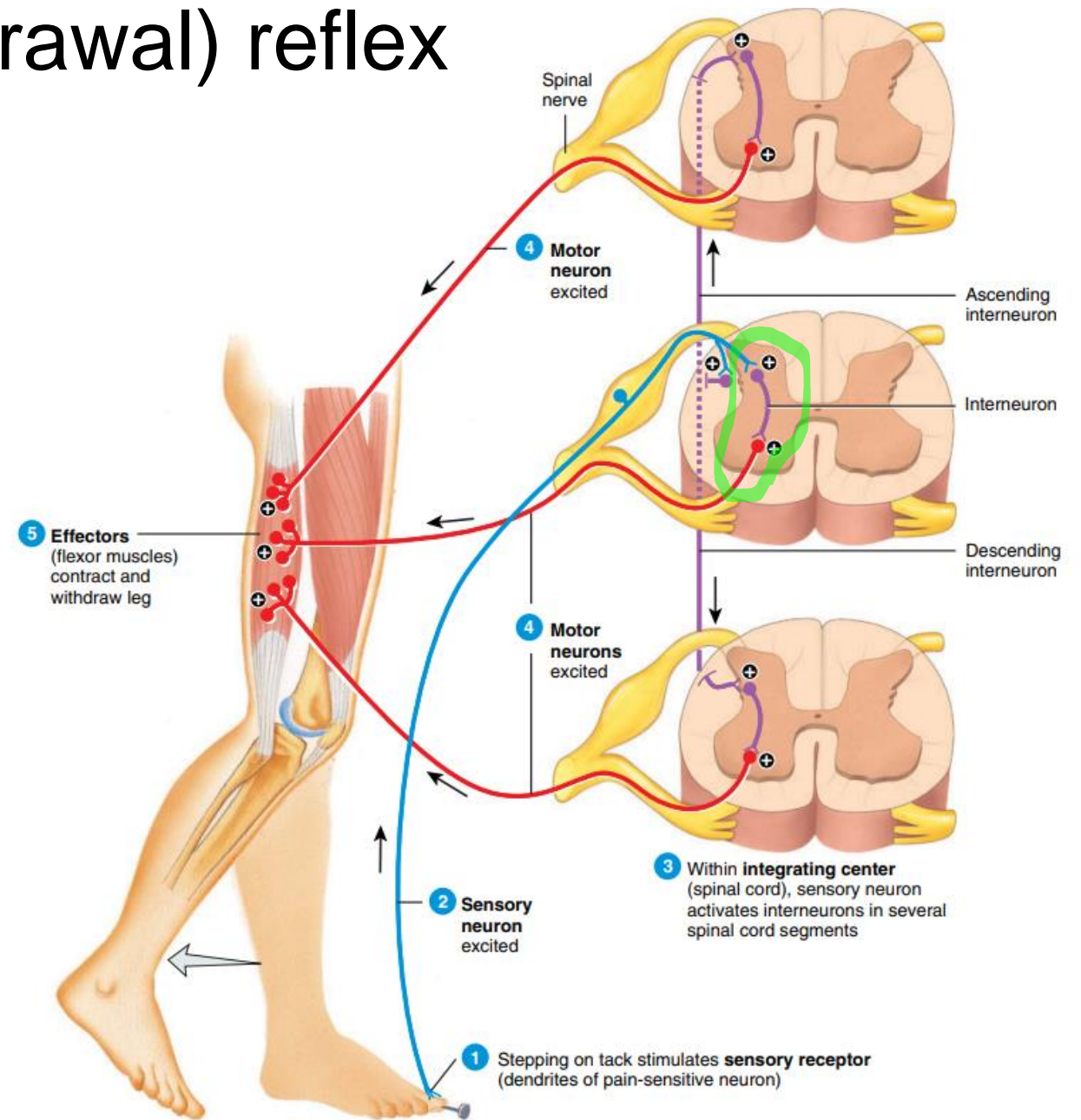
Pain

Withdrawal



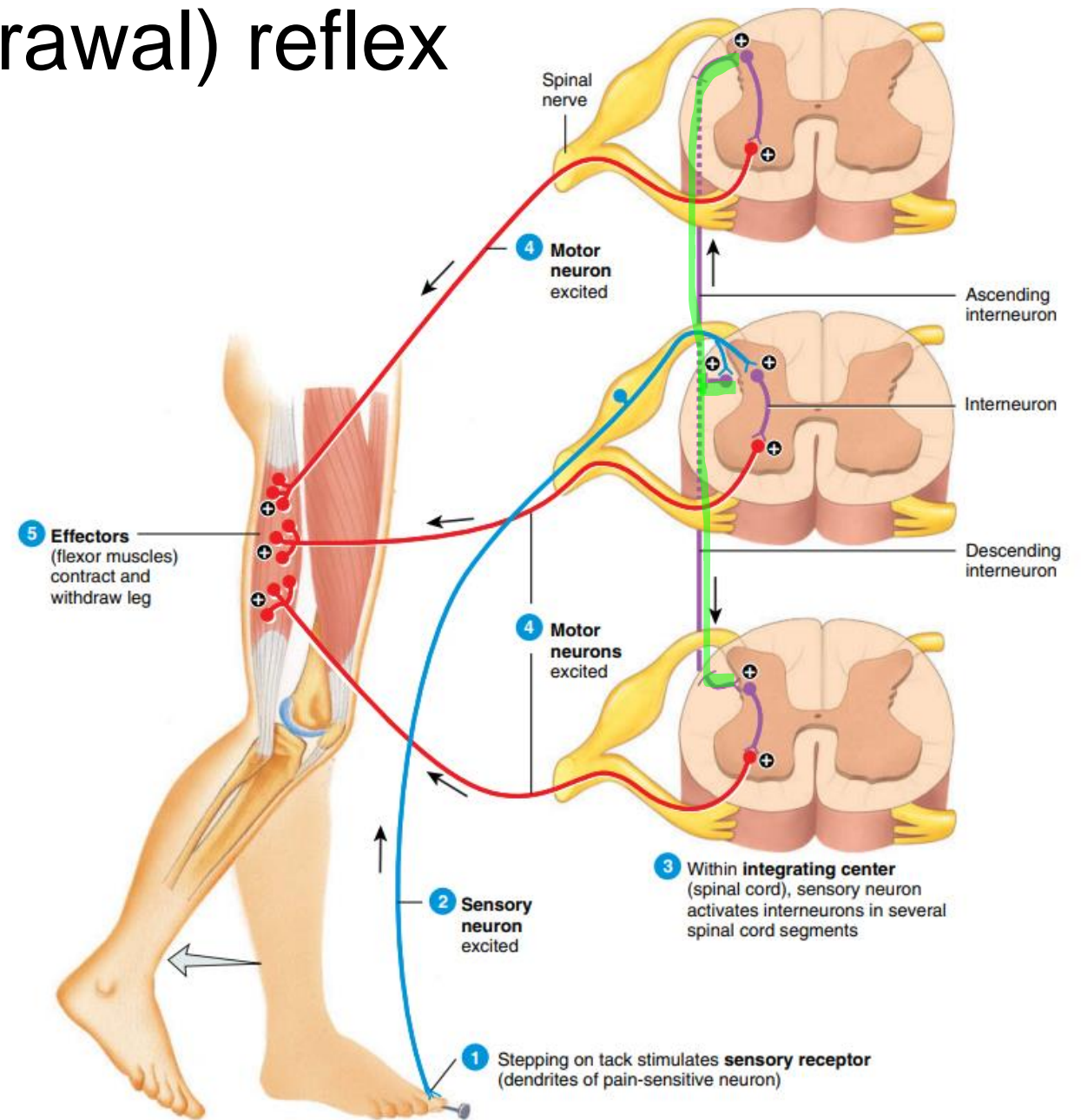
Flexor (withdrawal) reflex

Polysynaptic



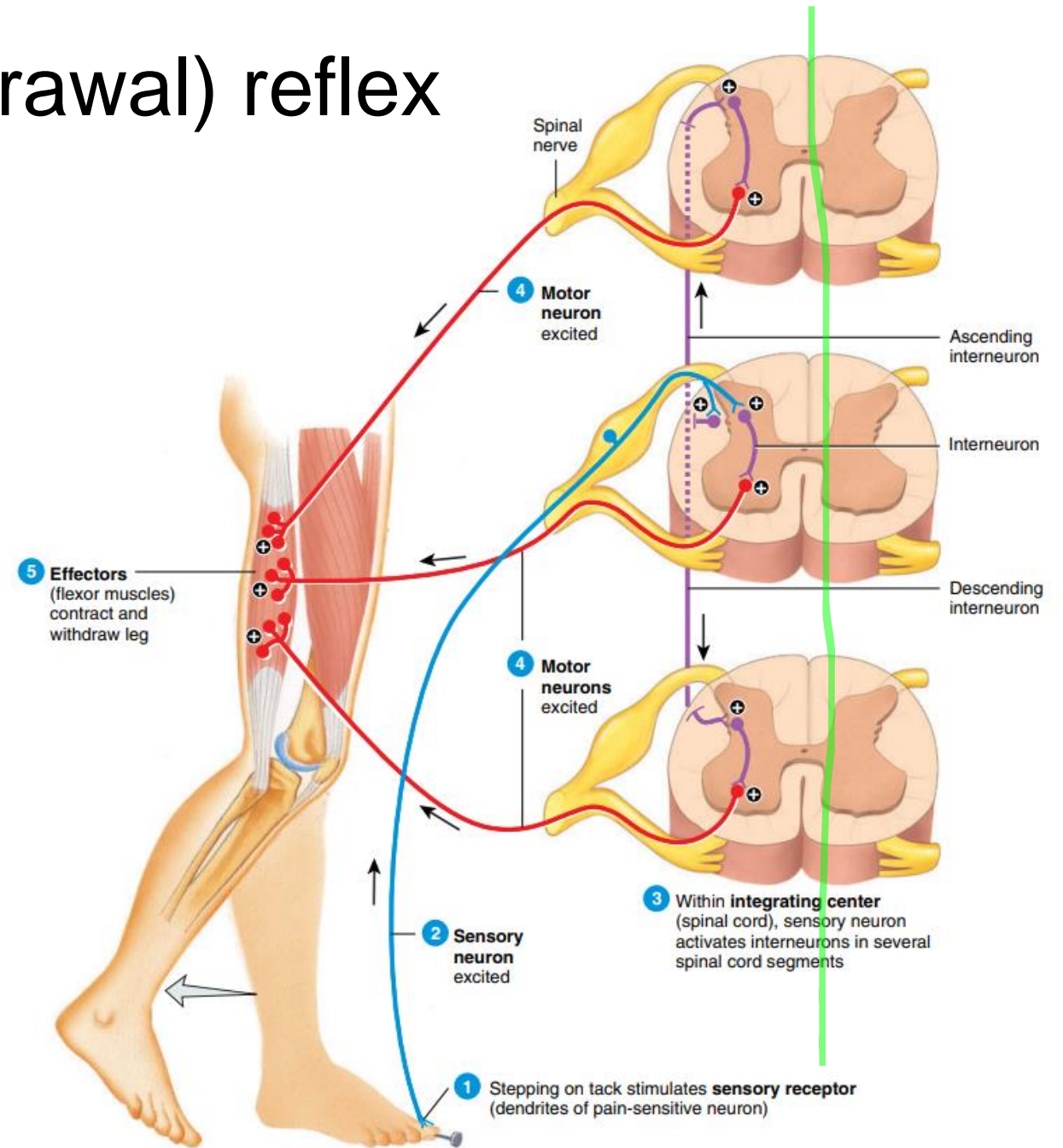
Flexor (withdrawal) reflex

Intersegmental



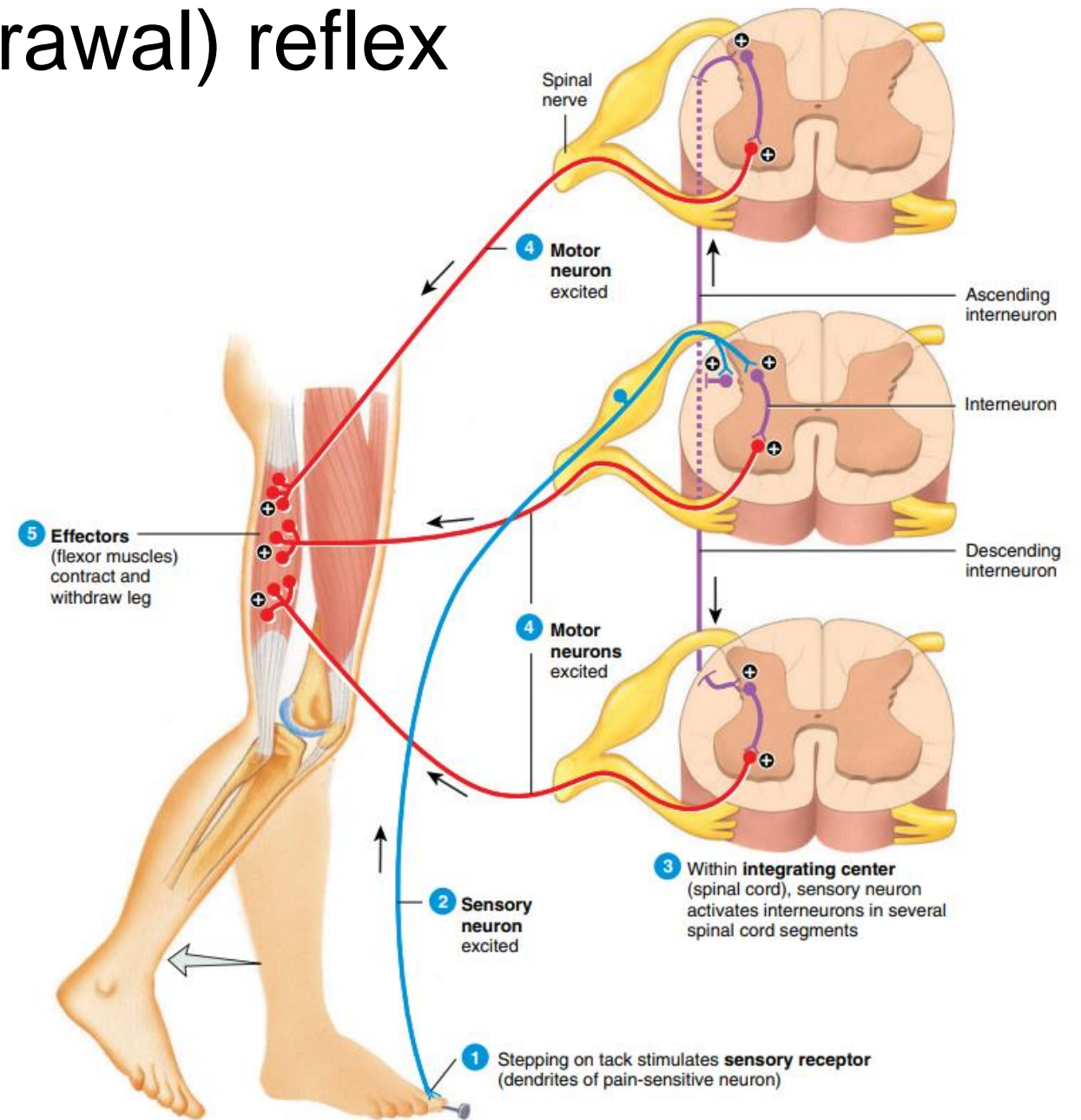
Flexor (withdrawal) reflex

Ipsilateral



Flexor (withdrawal) reflex

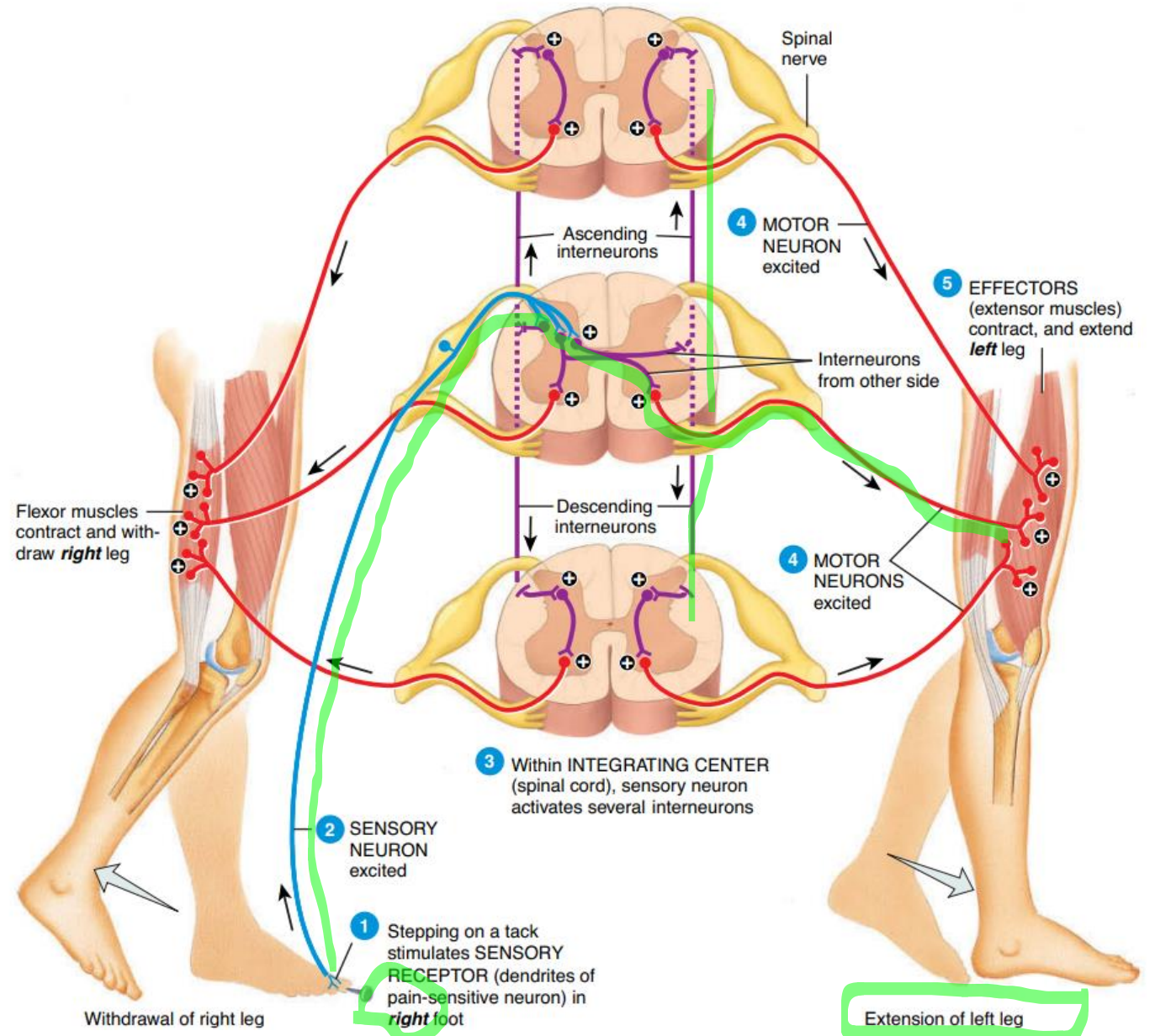
Initiates
crossed
extensor reflex



Crossed extensor reflex

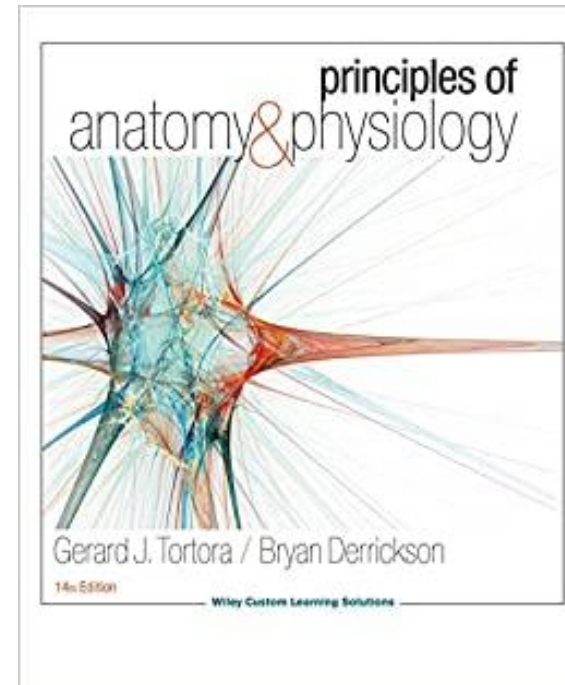
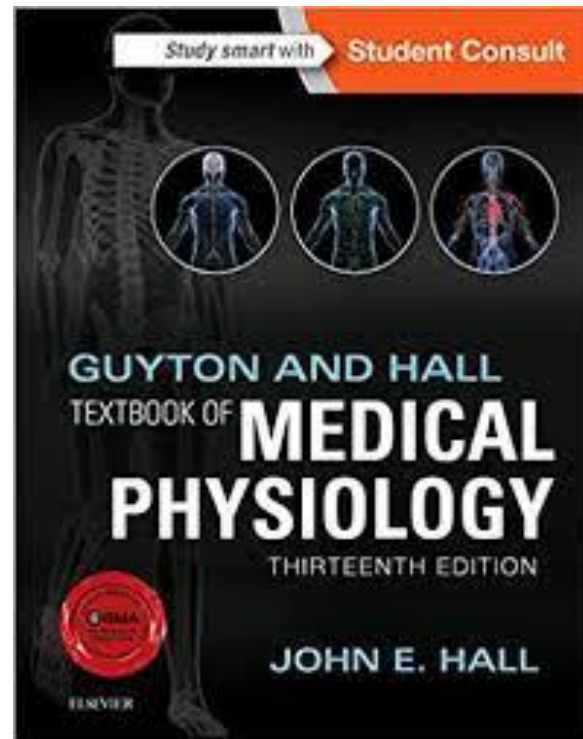
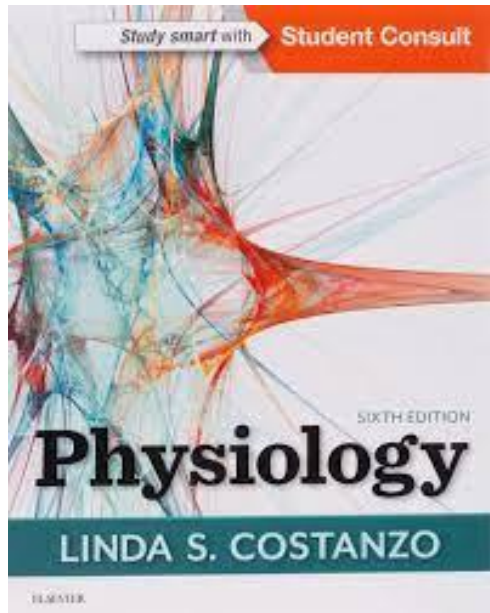
Contralateral
reflex arc

Maintain
balance



Thank you

References



9TH
Edition

Human Physiology From Cells to Systems

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School of Medicine
West Virginia University

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