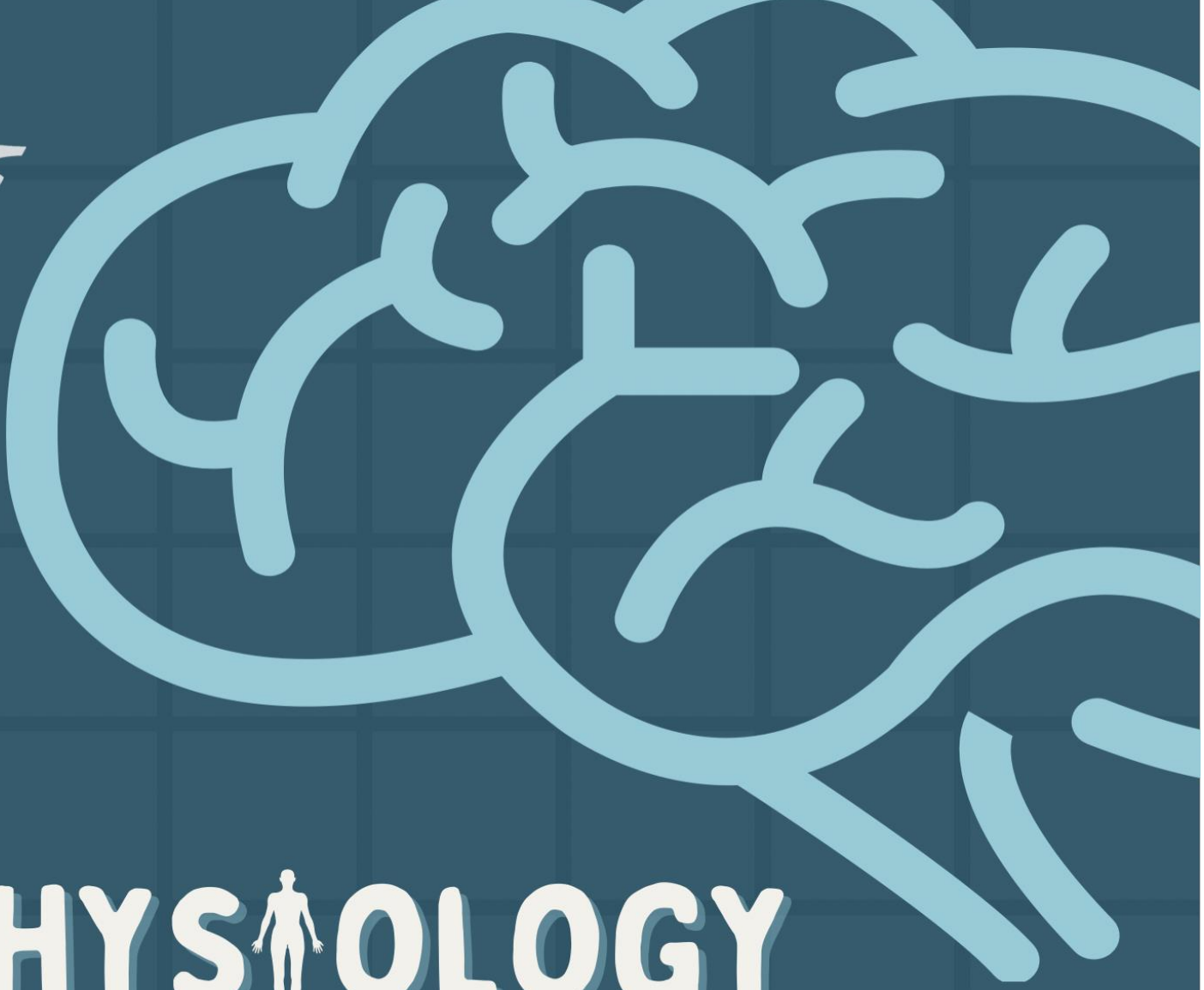

PHYSIOLOGY

SHEET NO. ١٥

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Reflexes in general are very important in testing the functions of the spinal cord because they happen mainly within the spinal cord. so, when we test the reflexes, we're actually testing the integrity of the spinal cord.

It is true that those reflexes work through spinal cord, but they can be affected by the cortex, to avoid the effect of the cortex we ask the patient to hold his hands together and keeps holding them until we finish to distract him.

A reflex is a rapid automatic (involuntary) movement upon a specific stimulus.

Reflex Arc:

for any reflex to occur it needs the following parts:

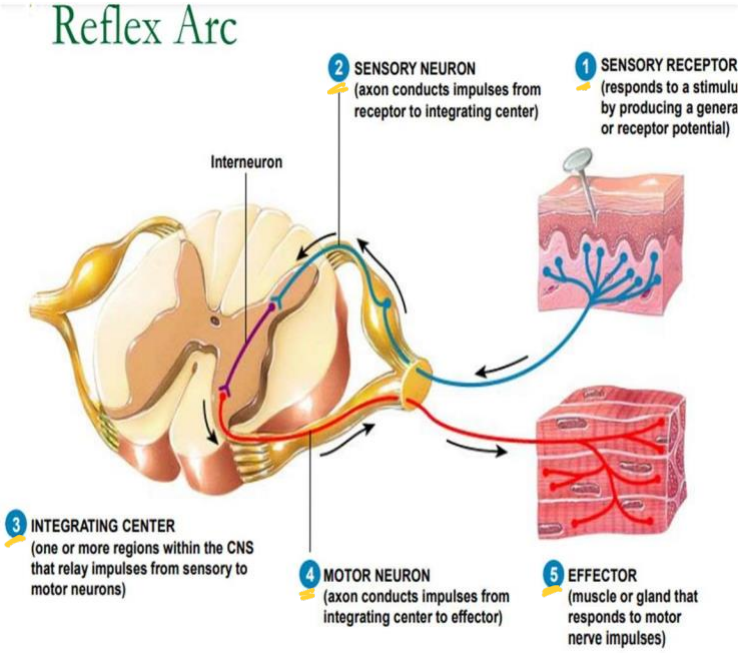
1-receptor

2-sensory (afferent) neuron

3-interneuron (integrating center)

4-motor (efferent) neuron

5-effector



Let's start with our first reflex:

Notice that the start of any reflex which is the stimulus isn't part of the reflex arc and it can be any type of sensation (pain, touch…)

Stretch reflex

This reflex can be done with almost any muscle, as an example we will focus on the **knee jerk reflex**. Jerk means something abnormal or can't be expected. / other examples: ankle reflex [gastrocnemiusmuscle], biceps, triceps…..

In this reflex we will test the movement of the quadriceps muscle around the knee.

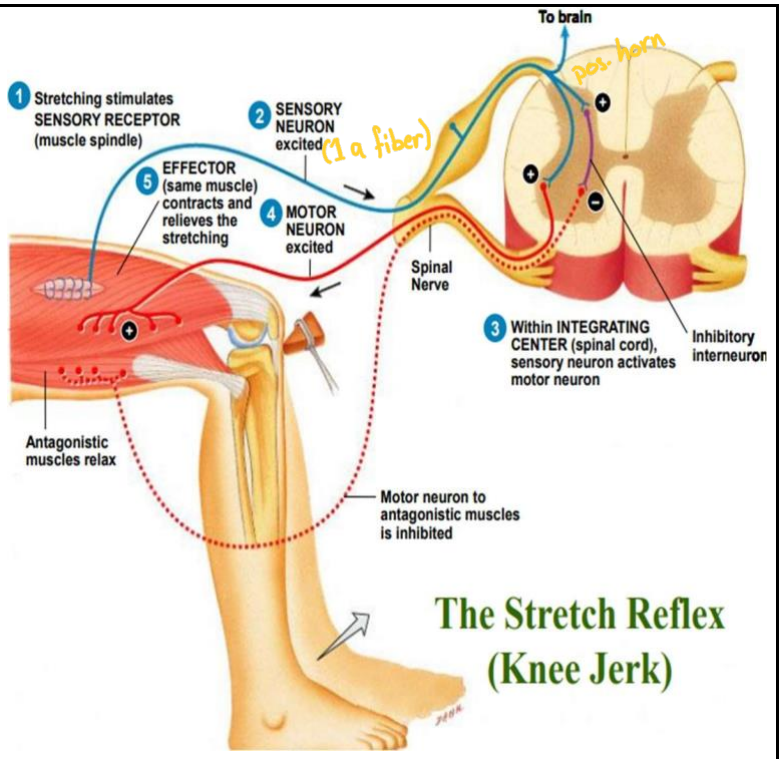
We start by hitting the patellar tendon with a hammer -> this will create an artificial **stretch in the quadriceps muscle** -> the stretch is sensed by the muscle spindles found inside the quadriceps muscle -> the afferent sensory fibers connected with these receptors are going toward the spinal cord to:

1- send information about the stretch to higher centers (brain) and, as we know from the previous sheet, these spinocerebellar fibers are responsible of telling the cerebellum [feedback] what is exactly happing down on the level of the muscle regarding the tension (length).

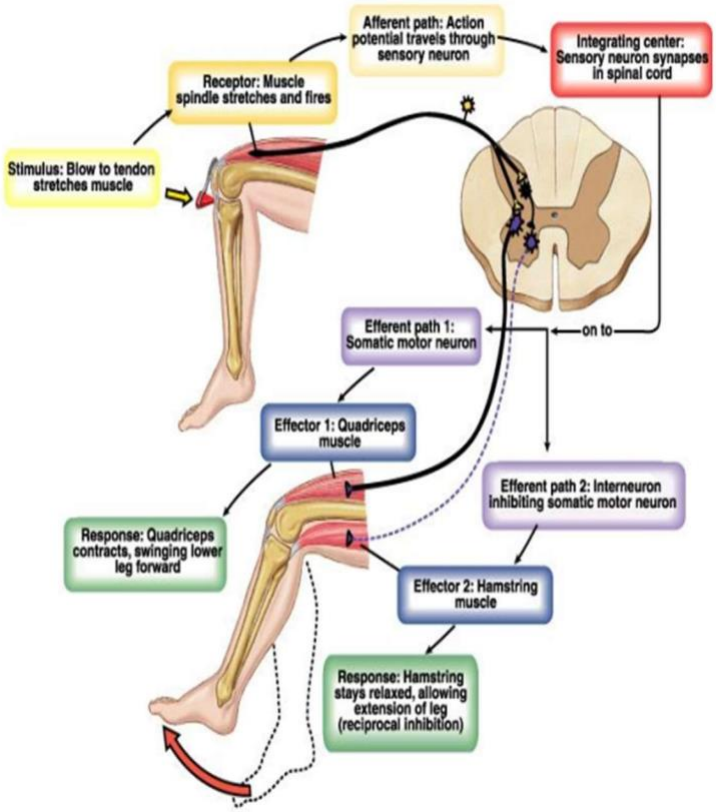
2- Synapse with -> alpha motor fibers that are going to the quadriceps muscle -> **the quadriceps muscle will contract** -> the knee is extended (moves forward)

➔ Index of the facilitation of the gamma efferents. [recall that whenever there is muscle contraction this will shorten the muscle spindles inhibiting them. And gamma motor efferents will stretch the spindles again activating them]

➔ Cortical lesions usually increase muscle stretch reflexes [specifically UMNLs]



- In the pictures to the right, you can find that the antagonistic muscle (hamstring muscle = flexor) is inhibited by the same sensory afferent neurons synapsing with inhibitory interneurons. And that's phenomenon is called **reciprocal inhibition**.
  <u>When the agnostic muscle contracts, the antagonistic muscle relaxes and vice versa.</u>



Special features of stretch reflex:

1- Causes **contraction** of a skeletal muscle in response to stretching of the muscle.

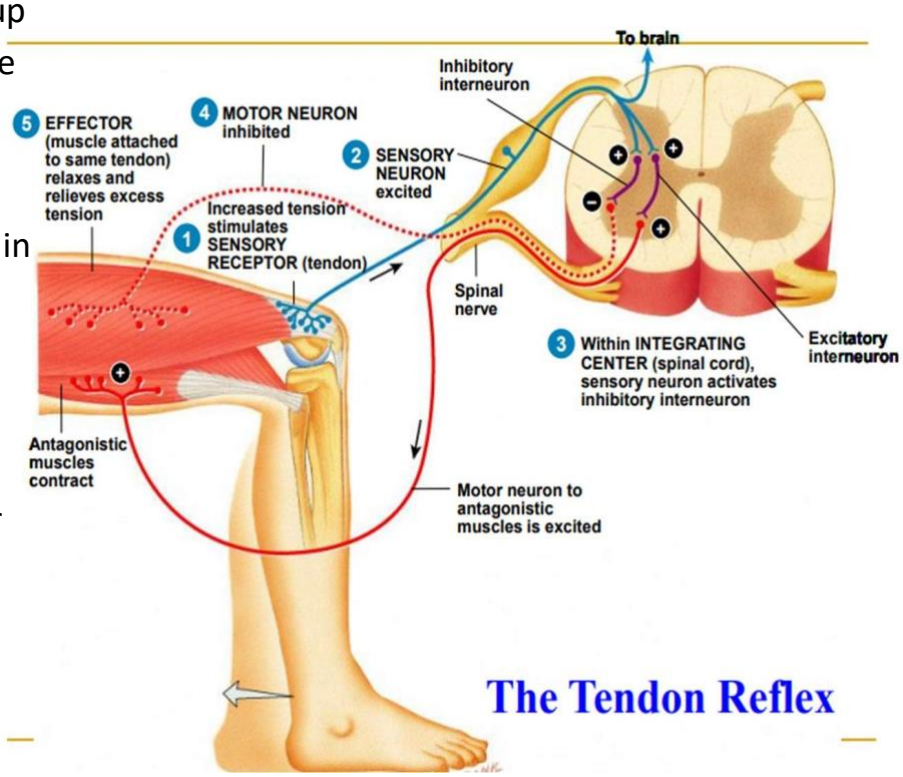
Patellar or knee-jerk reflex: Stretching of a muscle →activation of muscle spindles →sensory neuron → spinal cord → motor neuron → muscle contraction. (**Excitatory** reflex)

2- **Monosynaptic** reflex.
3- **Ipsilateral**. [when you hit the right tendon, the right knee will extend]
4- Receptors are in **the same** muscle stimulated by lengthening of muscle (stretch).

Tendon reflex

Keep in your mind that this reflex is **protective**. Because when the muscle is contracted a lot, this creates a very high stretch on the tendon, so we must inhibit this contraction to keep the tendon safe without torn.

Contraction of a muscle causes too much tension in the tendon which might separate the tendon from the tibia -> Golgi tendon organs (receptors) sense this stretch -> the sensory afferent neurons (group 1b fibers) connected with these receptors will go back to the spinal cord to:

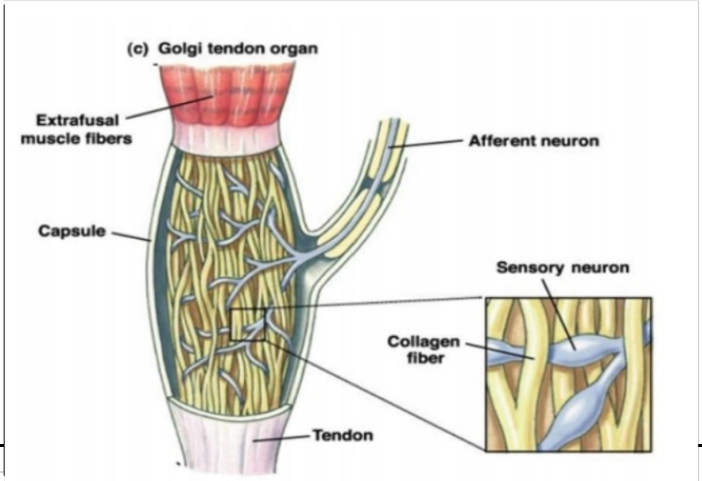


1- send information to the brain about the tension and the rate of change in tension [static/dynamic]
2- synapse with 1. *inhibitory* interneurons that are synapsing with alpha motor fibers -> relaxation in the muscle (tension in the tendon decreases), 2. *excitatory* interneuron that activates alpha fibers that innervate the antagonistic muscle causing its contraction

special features of tendon reflex:

1- **Polysynaptic** reflex. (Di-synaptic)
2- Control muscle tension by causing muscle **relaxation** when muscle tension is great.
↑ Tension applied to the tendon → tendon organ stimulation → nerve impulse → spinal cord → motor neuron causes muscle relaxation and relieves tension (**inhibitory** reflex)
3- Sensory receptors- Golgi tendon organs (**same muscle** stimulated by tension applied on the muscle in series with muscle fibers).
4- Ipsilateral

Just read ☺ Golgi Tendon Reflex: Mediated by the Golgi tendon organ receptor located in the tendon. This receptor responds to tension. When the tension becomes too great the reflex inhibits the motor fibers



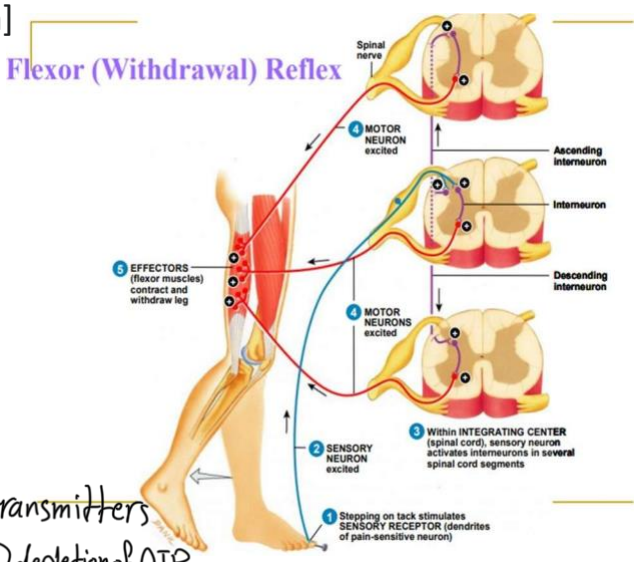
Notes on stretch reflex and Golgi tendon reflex:

- Stretch reflex is faster than tendon reflex that's because stretch reflex is monosynaptic while tendon reflex is polysynaptic
- Both work in the same segment where the interneurons enter the spinal cord [**unisegment**]
- Reciprocal inhibition is present in both
- Transmission of Stretch Information to Higher Centers: Muscle spindle and Golgi tendon signals are transmitted to higher centers. This informs the brain of the tension and stretch of the muscle. Information is transmitted at 120 m/sec. Important for feedback control of motor activity.
- Golgi tendon organs are in series with muscle fibers [tension]
  While muscle spindles are in parallel with muscle fibers [length/stretch]

Flexor (withdrawal) reflex

A **painful** stimulus causes the limb to automatically withdraw from the stimulus.

Here we start with pain receptor (nociceptor) activation, this receptor is present in the skin -> through C and Aδ fibers (slow fibers) this sensation will be transmitted to the spinal cord -> they go up or down (one or two segments) then they synapse with interneurons -> interneurons synapse with alpha motor fibers activating the flexor muscles [group of muscles]-> flexion of the leg. [there is also inhibition of the extensors in the same leg / reciprocal innervation]



nociceptor activation transmitted to the spinal cord -> synapses with pool of interneurons that diverge the to the muscles for withdrawal, inhibit antagonist muscles, and activate reverberating circuits to prolong muscle contraction -> duration of the after discharge depends on strength of the stimulus

what is after discharge? EPSP stays for 20ms while AP occurs within <1ms // if one stimulus gives us an ESPS that is above the threshold generating AP, it will continue producing this AP for 20ms, it is one way to prolong the impulse.

* when does it stop ? in synaptic fatigue → ① depletion of transmitters

special features of flexor (withdrawal) reflex:

② depletion of ATP
③ depletion of Ca^{++}

1- **Polysynaptic** reflex [slower than stretch reflex and tendon reflex]
2- **Ipsilateral**.
3- **Multi segmental**
4- The receptor **isn't present in the same muscle**! It is in the skin. Stepping on a tack (stimulus) → nerve impulse → activation of the interneuron → activation of the motor neuron →muscle **contraction** →withdrawal of the leg (**excitatory** reflex) // There is **reciprocal inhibition**(i.e. inhibition of antagonist group of muscles on the same side)

agonist excited as well

Any synapse has a synaptic delay that is about 0.5ms.

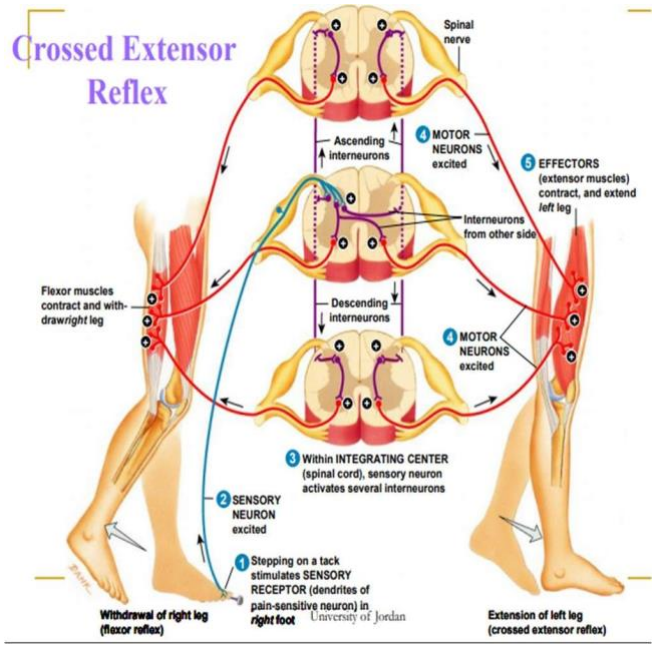
Crossed extensor reflex

latent period is longer a bit than the withdrawal

Look at the next page

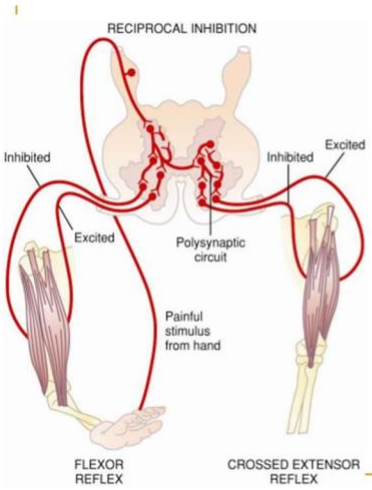
Painful stimulus elicits a flexor reflex in affected limb and an extensor reflex in the opposite limb. Extensor reflex begins 0.2 - 0.5 seconds after the painful stimulus. Serves to push body away from the stimulus, also to shift weight to the opposite limb [so you won't fall down].

we start here also from a pain receptor (nociceptor) activation, this receptor is present in the skin -> through C and Aδ fibers this sensation will be transmitted to the spinal cord -> they go up or down one or two segments then they synapse with interneurons-> these interneurons will cross the midline and synapse with alpha motor fibers that activate the extensors and inhibit the flexor in the other side -> to support the body while it's doing the flexor (withdrawal) reflex

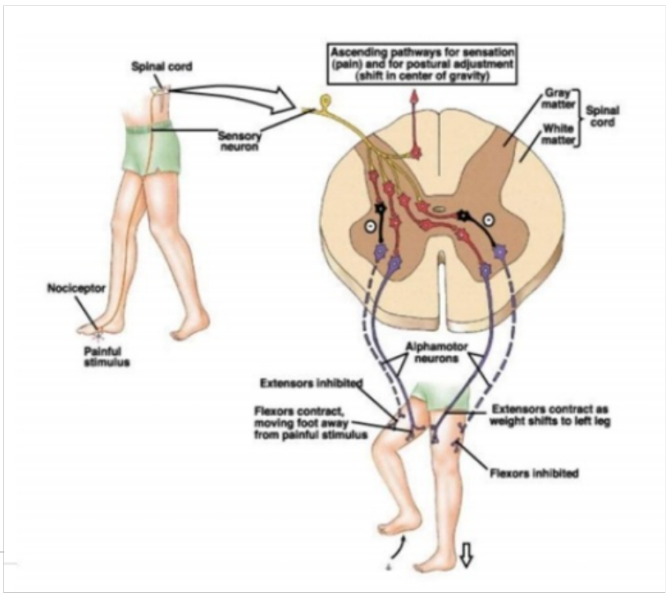


Special features of crossed extensor reflex:

1- **Polysynaptic** reflex. [slower than stretch reflex and tendon reflex]
2- **Contralateral** reflex.
   Contraction of muscles that extend joints **in the opposite** limb in response to a painful stimulus.
   Stepping on a tack (stimulus) → nerve impulse → activation of several interneuron → activation of the motor neurons → muscle contraction causing **flexion** of the leg stepping on a tack & **extension** on the opposite side. There is reciprocal inhibition (i.e. inhibition of antagonist group of muscles on the same side)
3- **Multi segmental**
4- The receptor **isn't present in the same muscle**! It is in the skin



Neuronal Circuits for Withdrawal and Crossed Extensor Reflex



Myograms of flexor and crossed extensor reflexes

The onset of flexor (withdrawal) reflex is faster than crossed extensor reflex. That's crossed extensor reflex needs more time to develop because of having too many synapses.

(in terms of speed: stretch reflex > tendon reflex > flexor (withdrawal) reflex > crossed extensor reflex)

Regarding after discharge, crossed extensor reflex have longer after discharge [more synapses] than flexor (withdrawal) reflex, that is, crossed extensor reflex needs more time to stop.

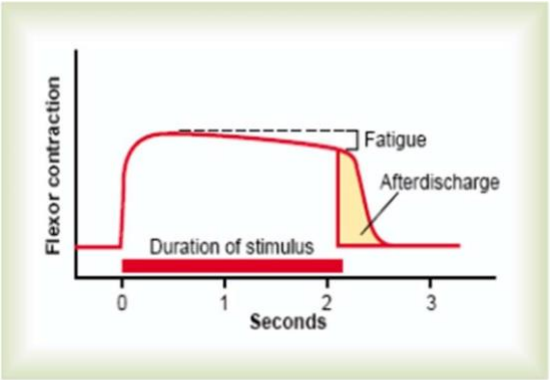


Figure 54–9

Myogram of the flexor reflex showing rapid onset of the reflex, an interval of fatigue, and, finally, afterdischarge after the input stimulus is over.

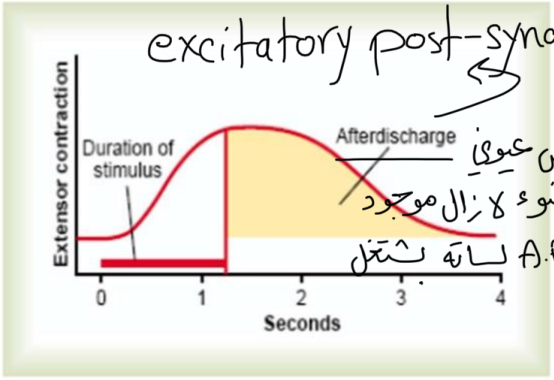


Figure 54–10

Myogram of a crossed extensor reflex showing slow onset but prolonged afterdischarge.

Other Reflexes for Posture and Locomotion [important for babies]

↳ to know if their spinal cord working well.

- Pressure on the bottom of the feet cause extensor reflex - more complex than flexor-crossed extensor reflex
- Basic walking reflexes reside in the spinal cord.

Reflexes that Cause Muscle Spasm

*cortex needs 2 years to be fully mature, you have to be informed that Thyroid hormones affect the maturation process of CNS

- Pain signals can cause reflex activation and spasm of local muscles.
- Inflammation of peritoneum can cause abdominal muscle spasm.
- Muscle cramps caused by painful stimulus in muscle: can be due to cold, ischemia, of overactivity [distension]. reflex contraction increases painful stimulus and causes more muscle contraction.

Examples: when there is inflammation in the appendix, in the beginning the pain will be referred around the umbilicus then when the inflammation increases and reach the peritoneum, the pain will be transmitted to the spinal cord by spinal nerves/sensory neurons, those neurons will cause excitation and spasms in the muscles around the area of the appendix [LRQ]. the same happens when there is inflammation in the gallbladder it starts as referred pain in the right shoulder then it will cause muscle spasm around the area of gallbladder.