

Spinal reflexes

By Herman Mageli

Overview:

Definition

Organization of motor function

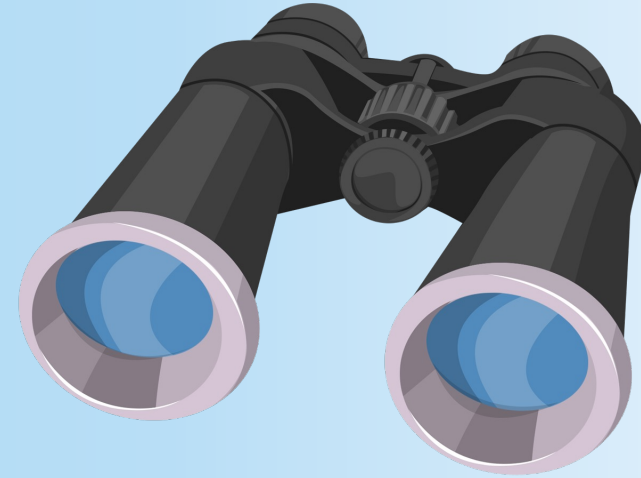
Reflex arc

Monosynaptic reflexes

Polysynaptic reflexes

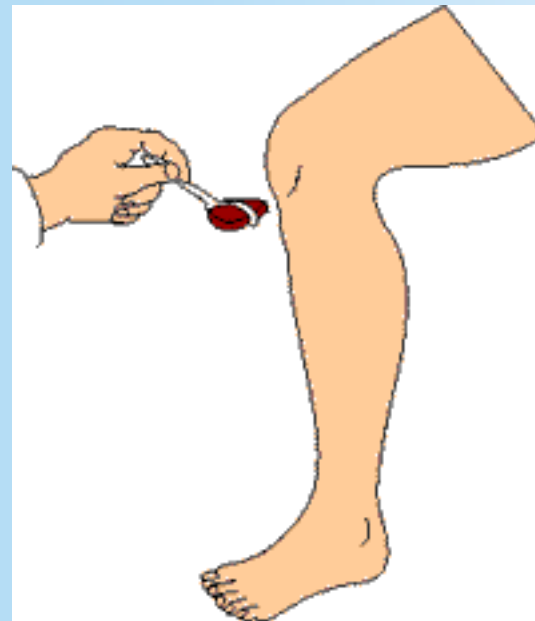
Regulatory mechanisms

Example reflexes



Definition spinal reflex

A reflex is a rapid, involuntary response to a stimulus. Most reflexes are spinal reflexes, with pathways that traverse only in the spinal cord.



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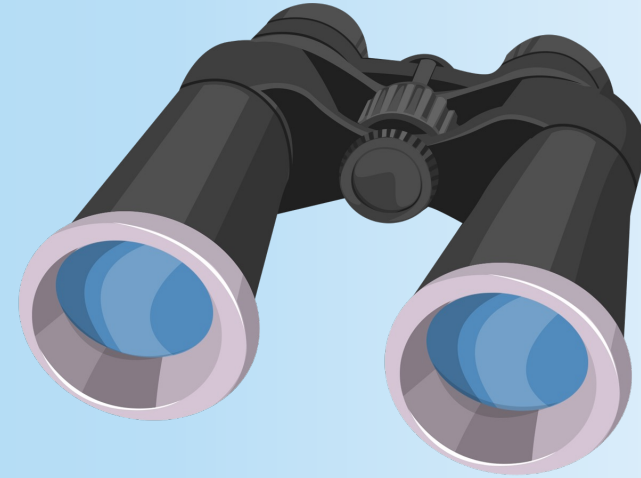
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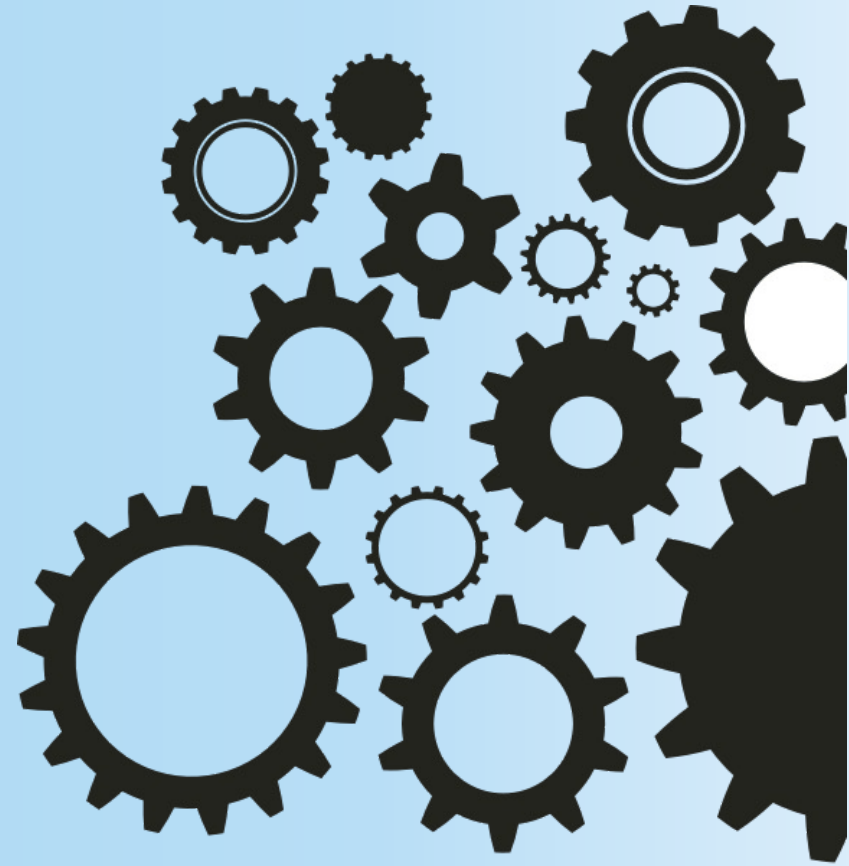
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Example reflexes



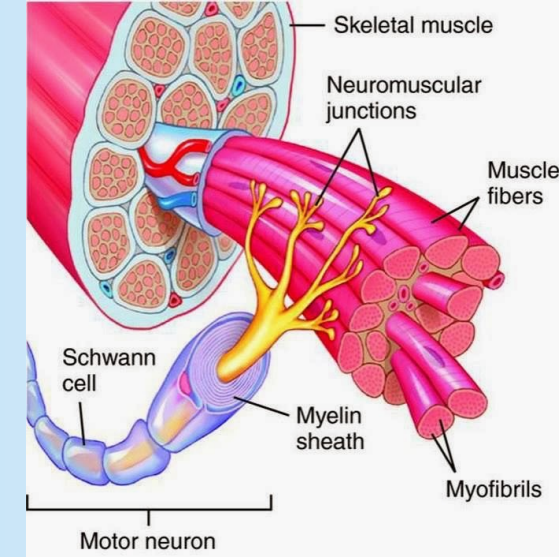
Organization of motor function

- Motor units
- Types of motoneurons
- Types of muscle fibers
- Muscle spindles
- Innervation of muscle spindles



Motor units

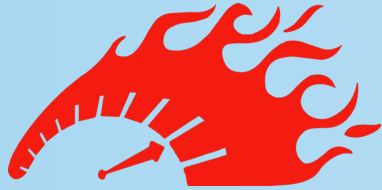
- **Motor units** = A single motoneuron and the muscle fibers it innervates
 - Can vary from a few to thousands of muscle fibers
 - Motorneuron pool = All the motoneurons innervating the same muscle



Types of motoneurons

- 2 types

1. Alpha motoneurons



- Innervate extrafusal muscle fibers
- Action potentials in alpha motoneurons cause action potential in extrafusal muscle fibers → contraction
- Biggest, fastest

2. Gamma motoneurons

- Innervate intrafusal muscles fibers
- Adjust the muscles spindles to muscle length changes.



- ❖ Coactivation!



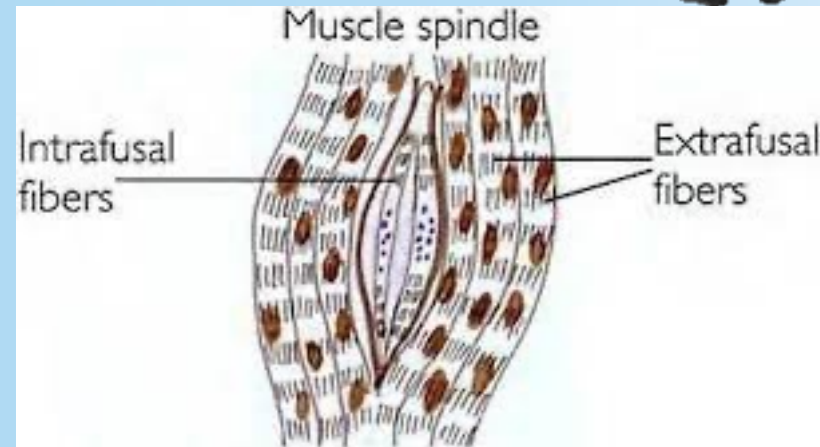
Extrafusal muscle fibers

- Constitute the majority of skeletal muscle
- Generate **force**
- Attached to bones through **tendons**
- Innervated by **alpha motoneurons**



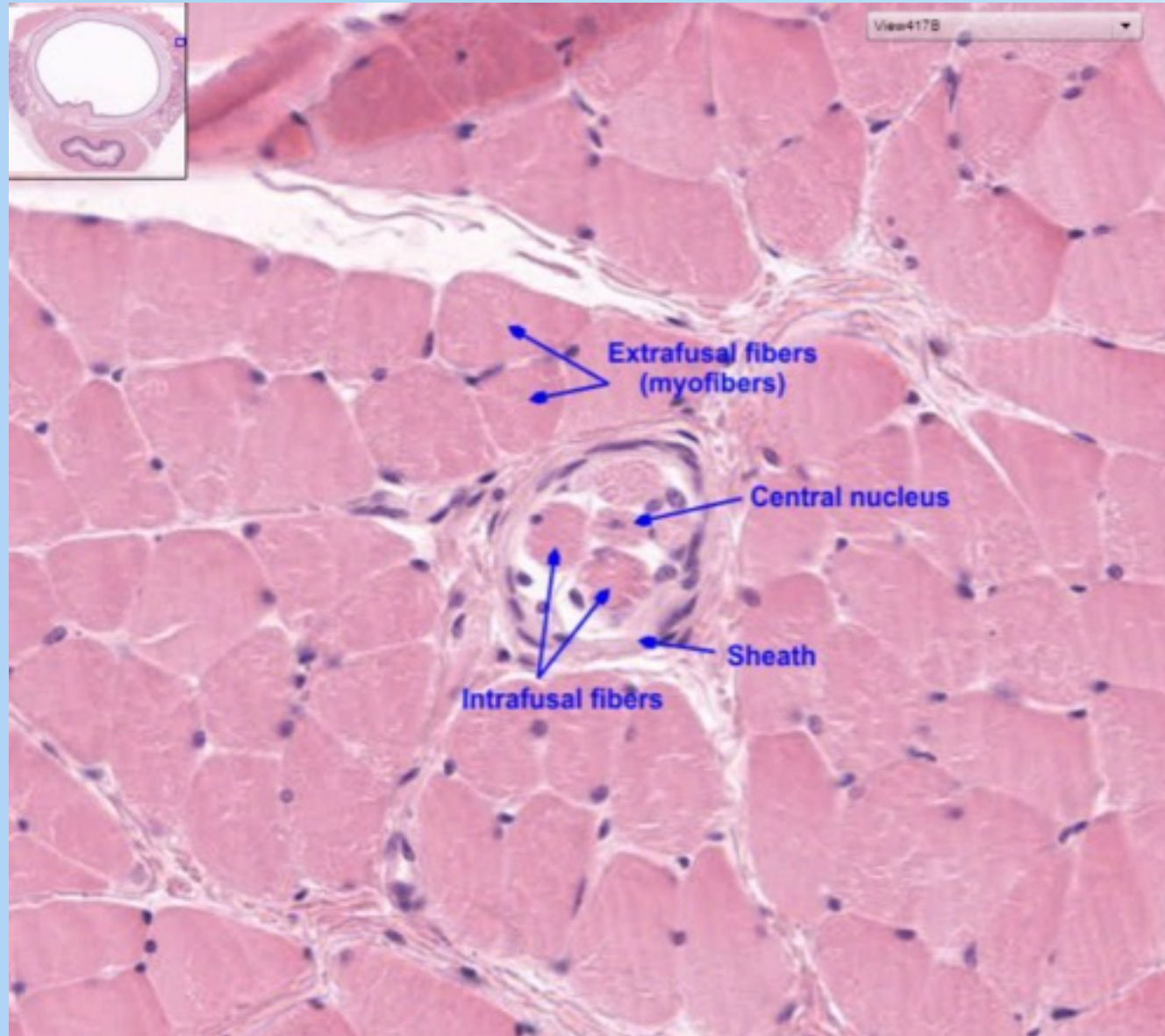
Intrafusal muscle fibers

- Encapsulated in sheaths, forming muscle spindles - run parallel to extrafusal fibers
- Too small to create significant force





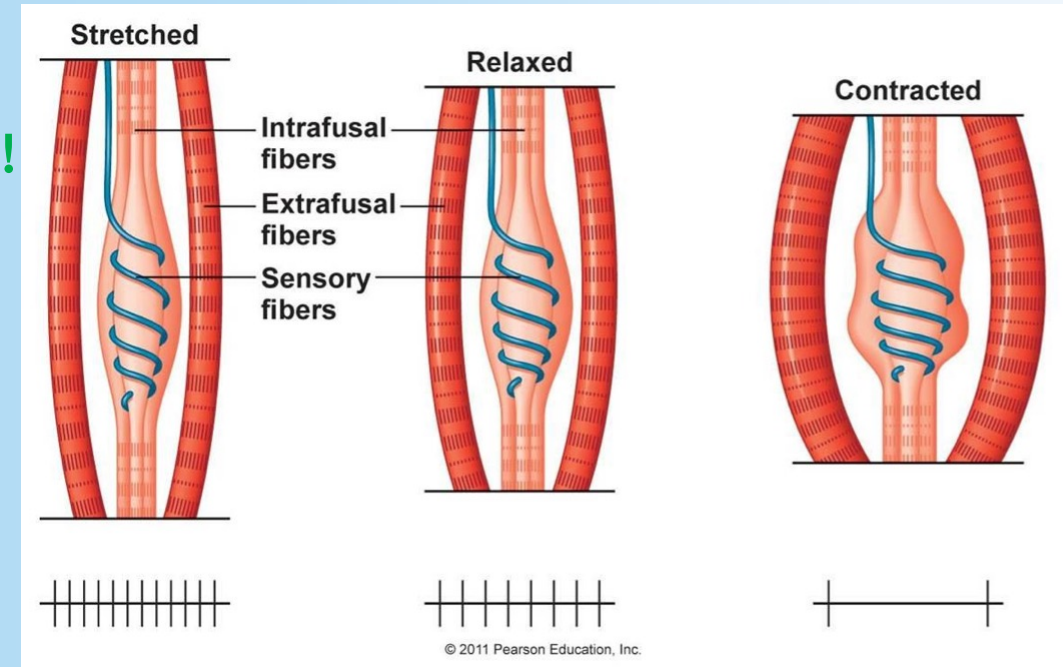
	Nuclear bag fibers	Nuclear chain fibers
Sensory innervation	<ul style="list-style-type: none">• Ia nerve fiber	<ul style="list-style-type: none">• Ia nerve fiber• II nerve fiber
Motor innervation	<ul style="list-style-type: none">• Dynamic gamma motoneurons	<ul style="list-style-type: none">• Static gamma motoneurons
Numbers	<ul style="list-style-type: none">• Less plentiful (2 per spindle)	<ul style="list-style-type: none">• More plentiful (5-6 per spindle)
Placement of nuclei	<ul style="list-style-type: none">• In «bag region»	<ul style="list-style-type: none">• In rows «chains»
Size	<ul style="list-style-type: none">• Larger	<ul style="list-style-type: none">• Smaller, but longer



Muscle spindles

- Intrafusal muscle fibers enclosed in connective tissue sac
 - Sensory organ
- **Detect velocity and length of muscle movement !**
- Especially abundant in muscles used for fine movements (eye)
- They are stretch receptors = **proprioceptor!**

❖ **Coactivation!**



Muscle spindle innervation



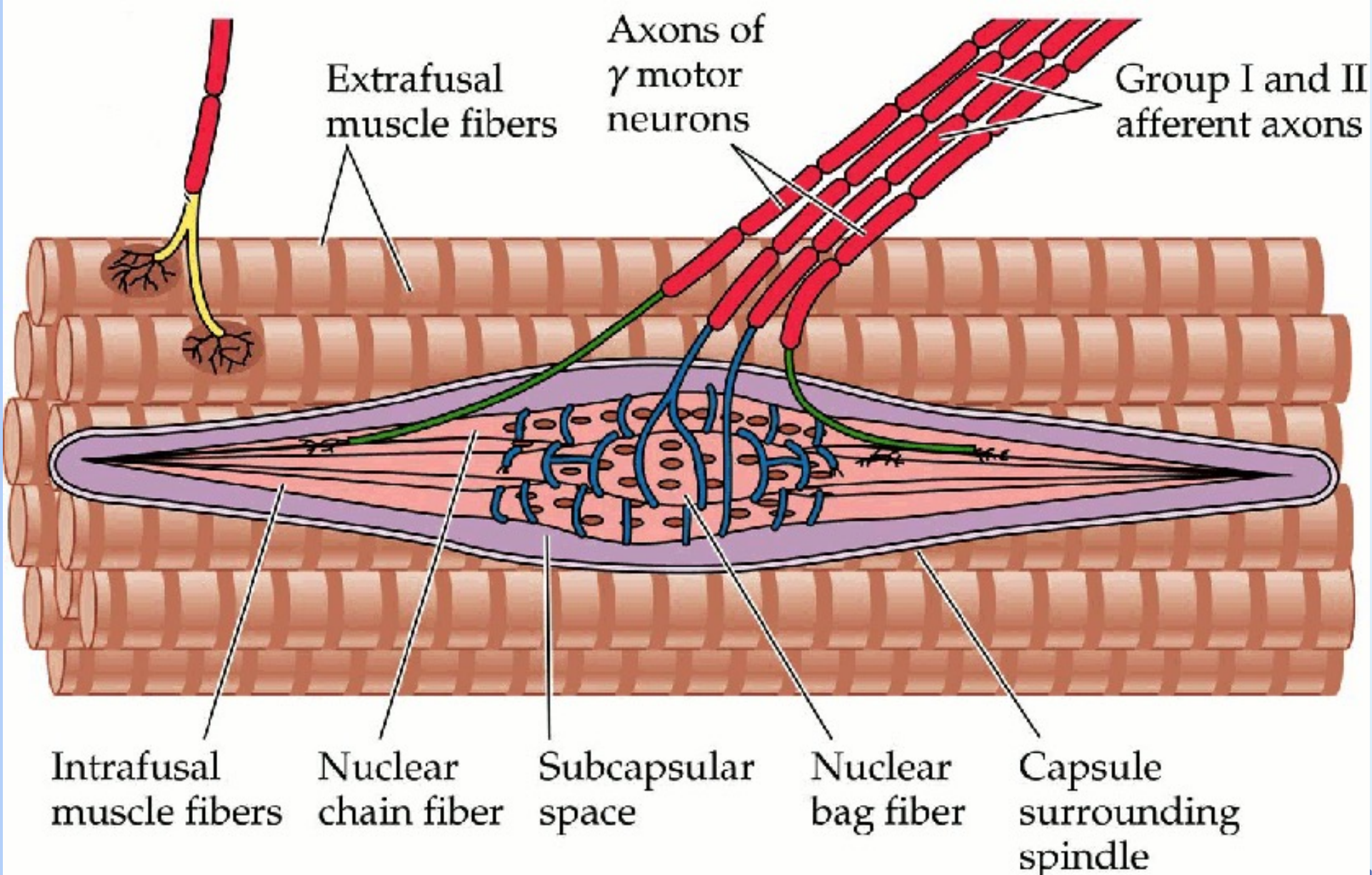
Sensory innervation

- Consist of **Ia afferent nerve**.
 - Innervate central region of both nuclear chain and bag fibers
 - Detect **velocity** of length change
- **Group II aff. Nerves**
 - Primarily innervate nuclear chain fibers
 - Detect **length** of muscle fibers

Motor innervation

- Consist of two types of **gamma motoneurons**
 1. **Dynamic**
 - Synapse on nuclear bag fibers
 2. **Static**
 - Synapse on nuclear chain fibers





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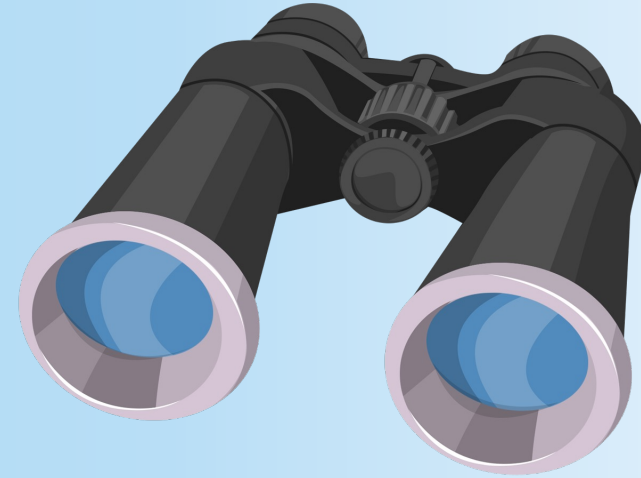
Reflex arc

Monosynaptic reflexes

Polysynaptic reflexes

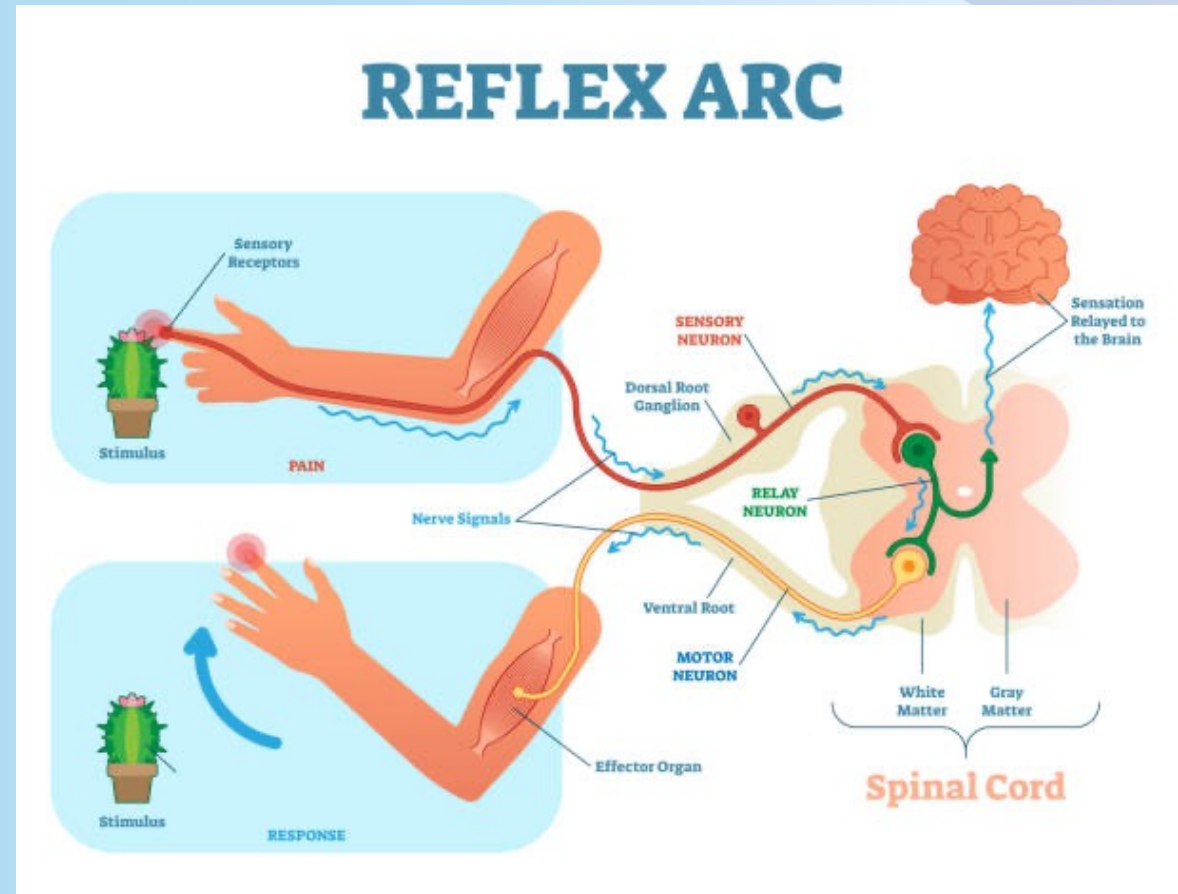
Regulatory mechanisms

Example reflexes



Reflex Arc

1. Receptor
2. Sensory neuron (afferent pathway)
3. Integration center (interneurons)
4. Motor neuron (efferent pathway)
5. Effector (muscle)



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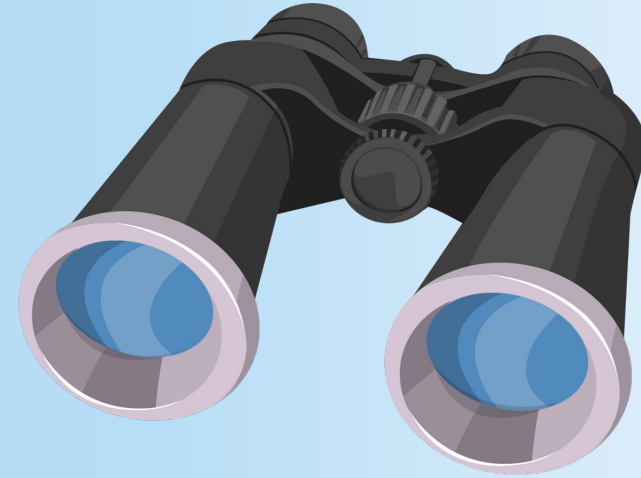
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Monosynaptic reflexes

Polysynaptic reflexes

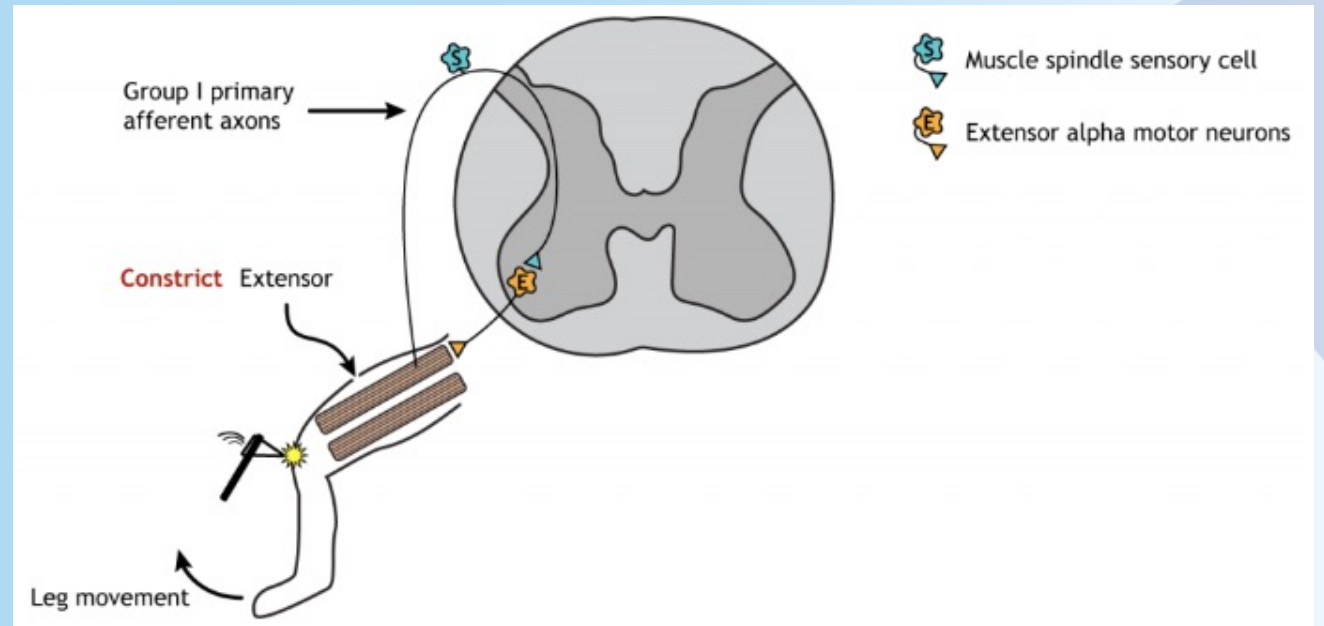
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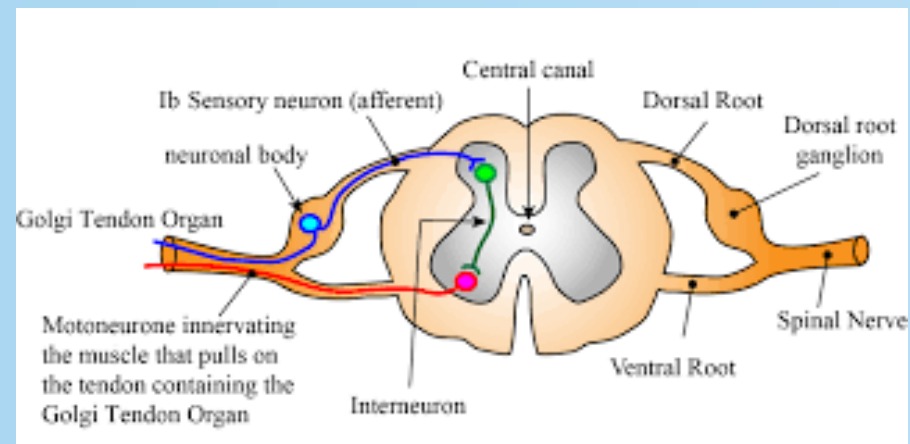
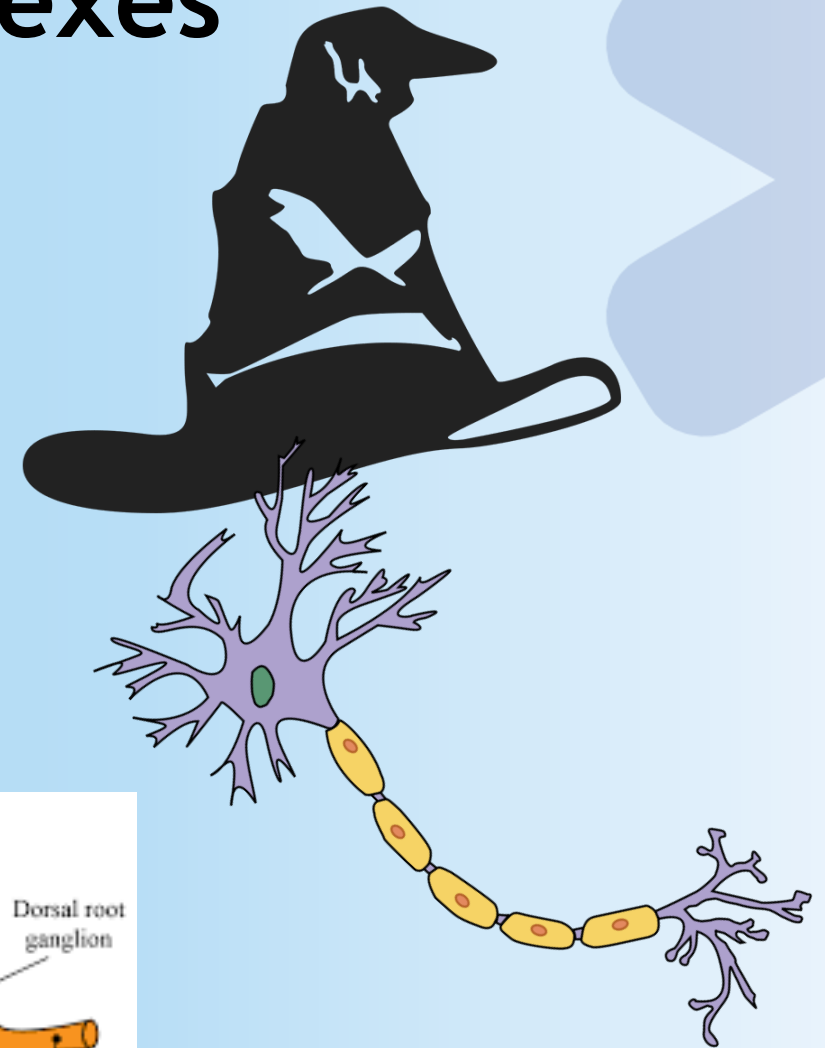
Monosynaptic reflexes

- **Directly** synapse between aff. And eff. Neurons
- **Faster** than polysynaptic



Polysynaptic reflexes

- One or more **interneurons** between aff. And eff. → indirect communication
- Aff. neuron send signal to interneuron in **grey matter**
- Interneurons **direct signals**
- Allow communication between sensory, motor neurons and CNS



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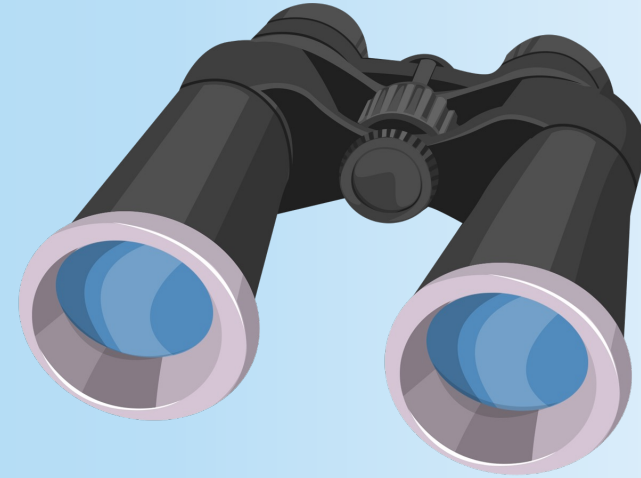
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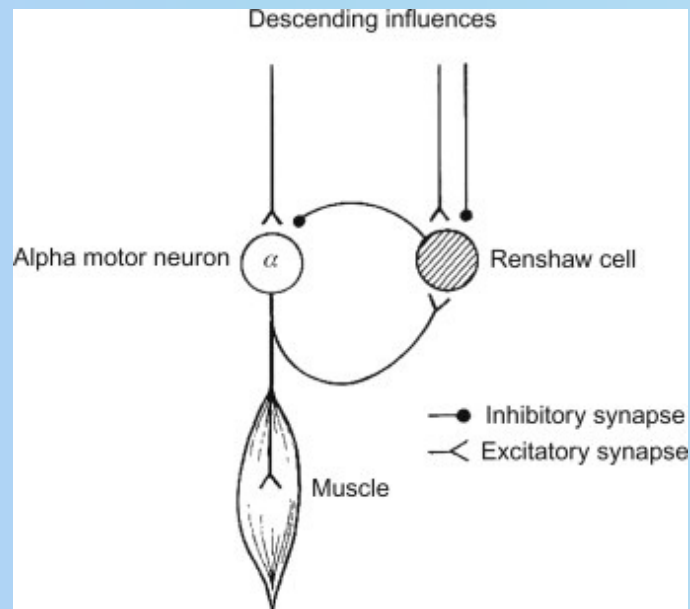
Example reflexes



Regulatory mechanism

Recurrent inhibition

- Renshaw cell
- To **modulate** primary motor neuron
 - Prevent overly exaggerated motor response



Reciprocal inhibition

- Aff. Sens. Neurons synapse on inhibitory interneurons
 - Produce and release GABA
 - Synapse on alpha motoneurons of **antagonizing M.** → relaxation
 - Allow **normal muscle movement.**

Tetanus

- Caused by bacteria **Clostridium tetani**, found - among elsewhere - in soil.
- Block release of **GABA** and **glycine**
 - **Hyperactive** motoneurons
 - **Constant vigorous contraction**



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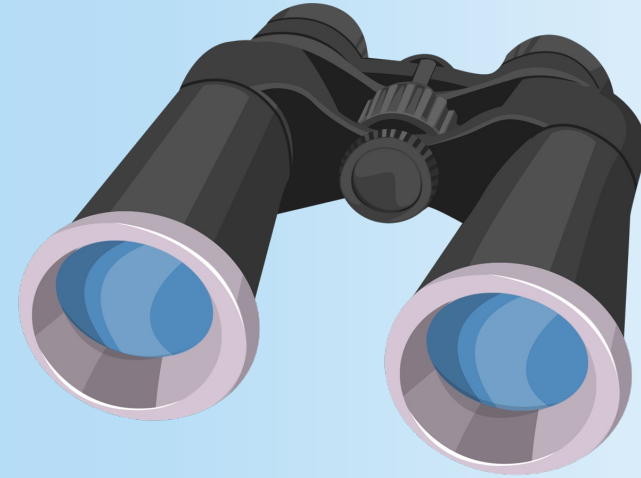
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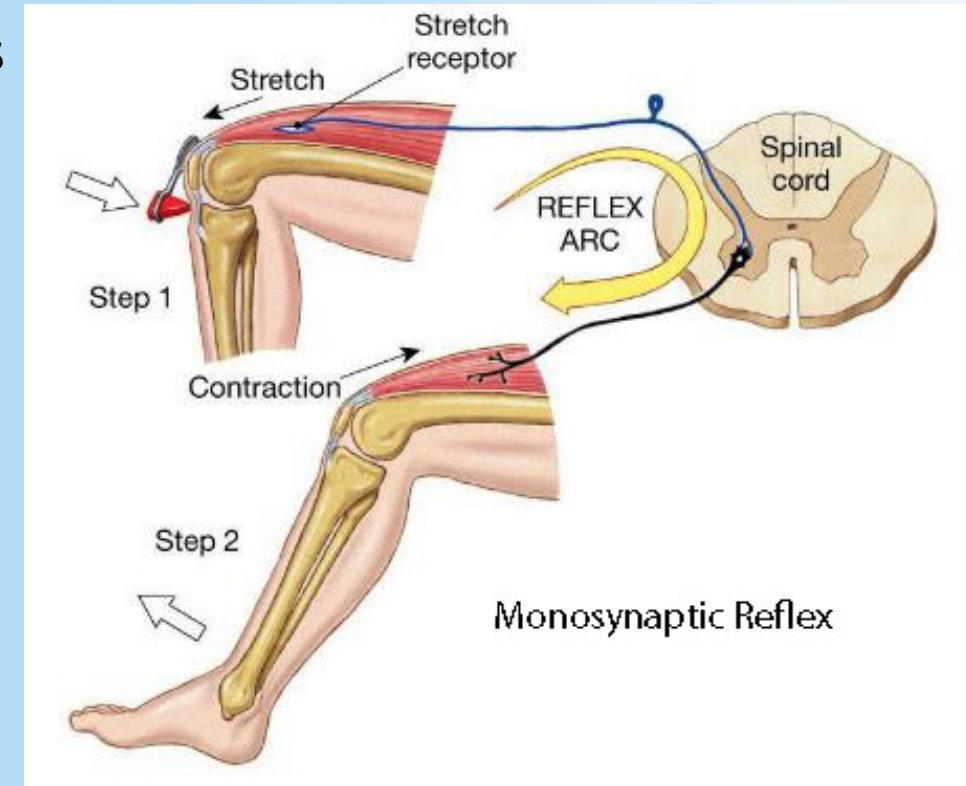


Examples of spinal reflexes

1. Stretch reflex
2. Golgi tendon reflex
3. Flexor-withdrawal reflex (touching a hot stove)

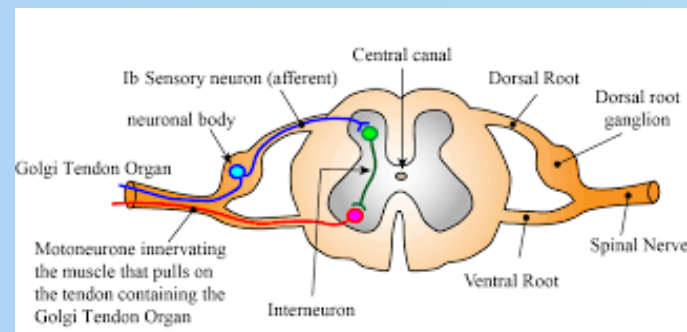
Stretch/myotatic reflex (knee jerk/patellar reflex)

- **Simplest** of all spinal cord reflexes
 - Only one synapse between aff. And eff. Neurons
- Reflex hammer **stretch muscle** → detected by muscle spindles → Ia aff. send signal → alpha motoneurons activated → **contraction**



Golgi tendon reflex/inverse myotatic reflex

- A disynaptic spinal reflex
- **Golgi tendon organ** - proprioceptor found in tendons.
 - Sense tension at the tendon
- Activate Ib aff. Fibers → synapse on **inhibitory interneurons** → inhibit alpha motoneurons



Flexor-withdrawal reflex

- The **most complex** of spinal cord reflexes
- Multiple synapses - **polysynaptic** reflex
- Nociceptor
- Sensory and pain aff. Fibers initiate a flexion reflex → **withdrawal**
 - Ipsilateral observation: flexion → withdrawal
 - Contralateral observation: extension
 - Sensory aff.nerve fibers = II, III, IV → synapse on multiple interneurons



Classification of Nerve Fibers

Classification	Type of Nerve Fiber	Example	Relative Diameter	Relative Conduction Velocity	Myelination
Sensory and Motor	A alpha ($A\alpha$)	α Motoneurons	Largest	Fastest	Yes
	A beta ($A\beta$)	Touch, pressure	Medium	Medium	Yes
	A gamma ($A\gamma$)	γ Motoneurons to muscle spindles (intrafusal fibers)	Medium	Medium	Yes
	A delta ($A\delta$)	Touch, pressure, temperature, fast pain	Small	Medium	Yes
	B	Preganglionic autonomic nerves	Small	Medium	Yes
	C	Slow pain; postganglionic autonomic nerves; olfaction	Smallest	Slowest	No
Sensory Only	Ia	Muscle spindle afferents	Largest	Fastest	Yes
	Ib	Golgi tendon organ afferents	Largest	Fastest	Yes
	II	Secondary afferents of muscle spindles; touch, pressure	Medium	Medium	Yes
	III	Touch, pressure, fast pain, temperature	Small	Medium	Yes
	IV	Pain, temperature; olfaction	Smallest	Slowest	No

Summary of reflexes

	Stretch reflex (myotatic)	Golgi tendon reflex (Inverse myotatic reflex)	Flexor withdrawal reflex
Stimulus	Muscle stretch	Great contraction/tension	Pain
Receptor	Muscle spindle	Golgi tendon organ	Nociceptors
Integration center	Monosynaptic	Disynaptic	Polysynaptic
Afferent pathway	Group Ia fibers (also II)	Group Ib fibers	Group II, III, IV fibers
Efferent pathway	a-motoneurons (remember coactivation gamma motoneurons)	a-motoneurons	a-motoneurons
Effect	Contract stretched M. Relax antagonistic M.	Relax contracted M. Contract antagonistic M.	Flexion ipsilateral side Extension contralateral

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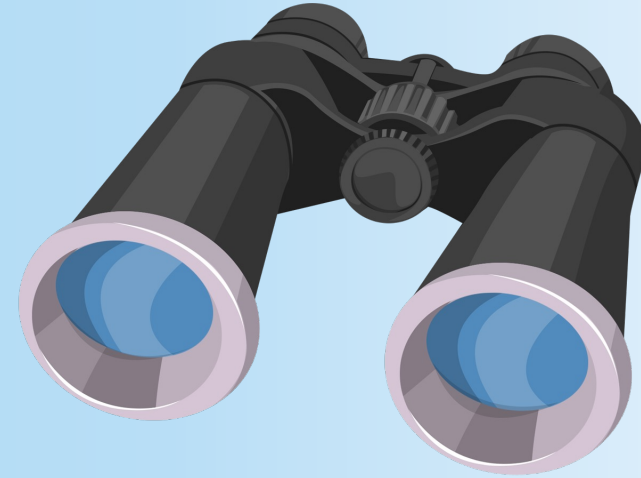
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Good luck!