Peer Teaching Society: Neuro

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What we are going to cover?

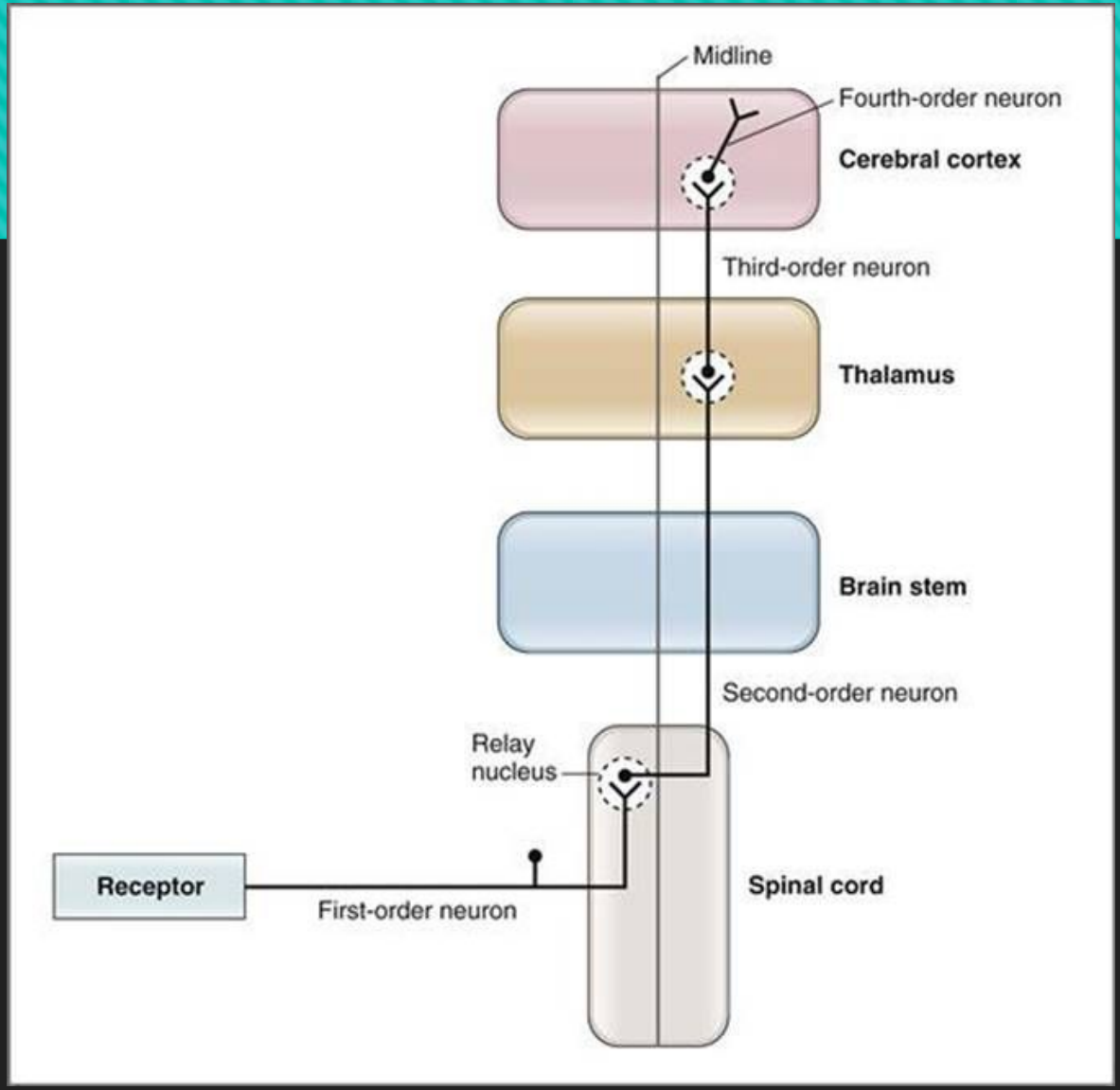
- Spinal Tracts
- Muscle spindles
- Golgi tendons
- Neuromuscular junctions
- Axons and axon transmission
- Basal ganglia

Spinal tracts: what do you need to know?

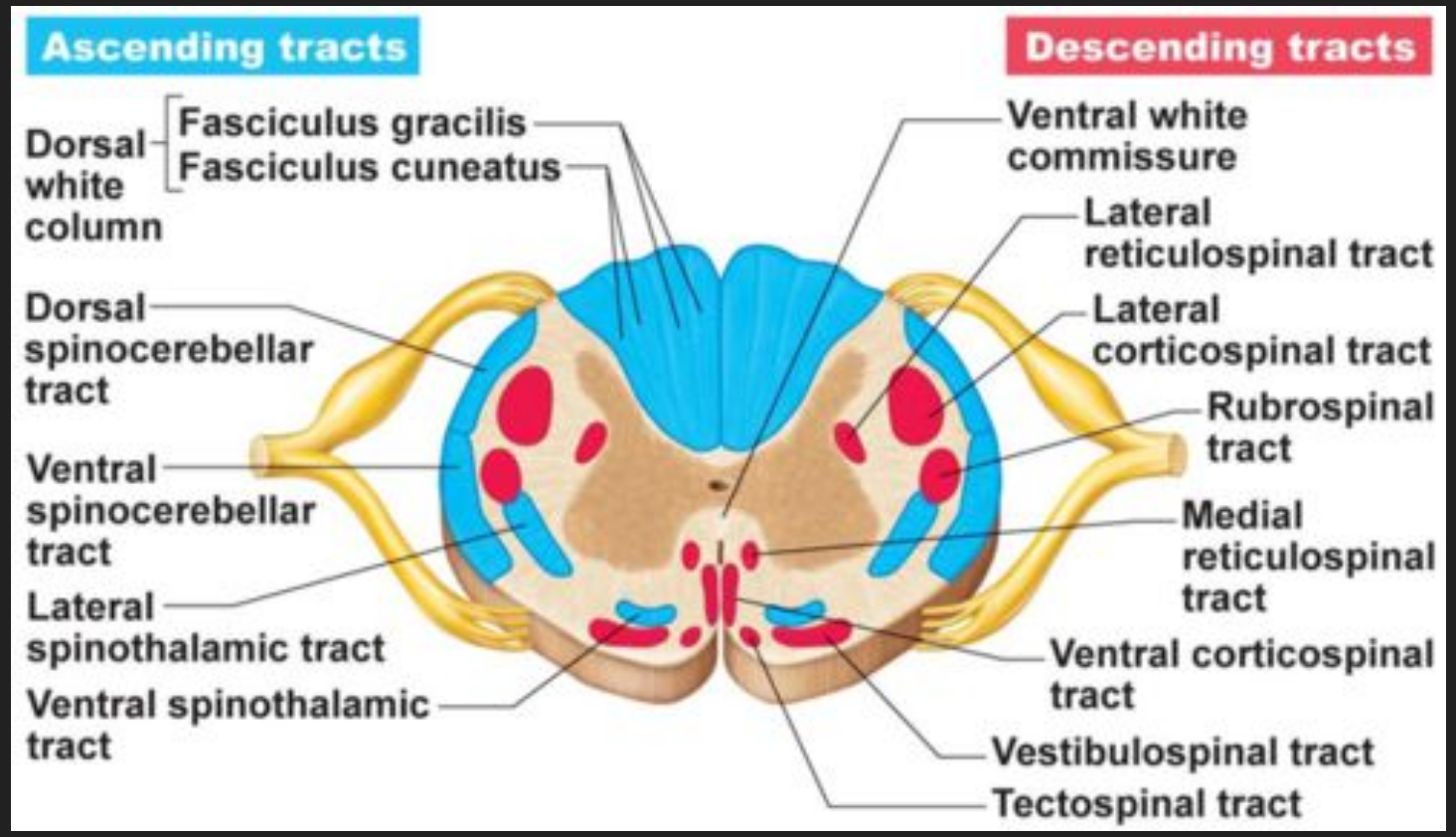
- **Ascending tracts:**
  - DCML (fasciculus cuneatus and fasciculus gracilis) □ fine touch, proprioception, vibration
  - Spinothalamic □ crude touch, pain, temperature
  - Spinocerebellar □ unconscious proprioception
- **Descending tracts:**
  - Corticospinal □ conscious muscle movement
  - Corticobulbar □ voluntary movement of face and neck muscles
  - Extra pyramidal tracts
  - Pyramidal vs extra pyramidal: voluntary + fine control vs coordination, posture and muscle tone

Spinal Tracts

- Ascending: sensory information towards the brain (4 orders of neuron)
- Descending: motor information towards the muscles (2 orders of neuron)



Spinal Tracts: Location.



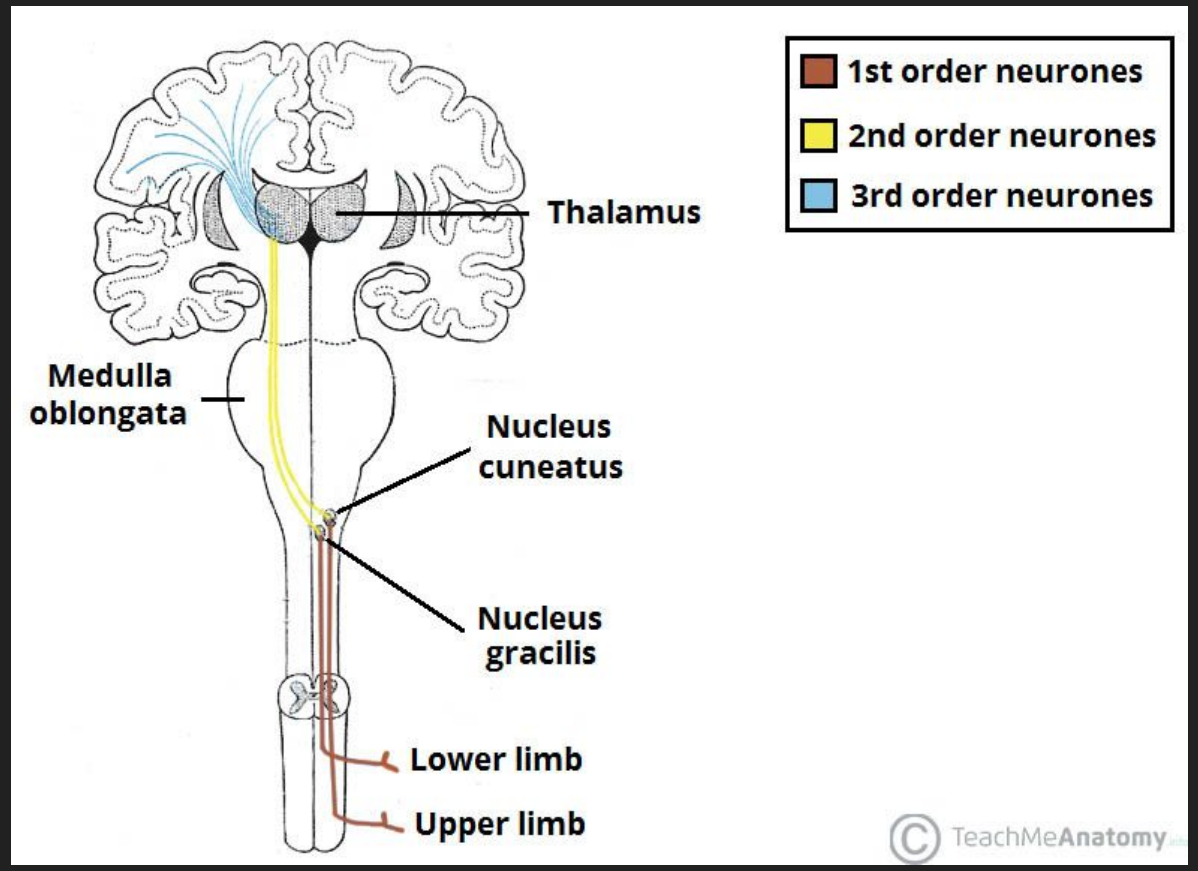
Ascending tracts: DCLM

- **Dorsal Column Medial Lemniscus:**

- fasciculus cuneatus (upper limbs) vs gracilis (lower limbs) … walk gracefully!

- Fine touch (tactile sensation), vibration and proprioception
- Travels via the ipsilateral side to the nucleus

1. 1st - Dorsal root ganglion, enters posterior column and ascends
2. SYNAPSE to 2nd.
3. Decussate at medulla
4. SYNAPSE to 3rd in Thalamus
5. Primary somatosensory cortex to 4th.

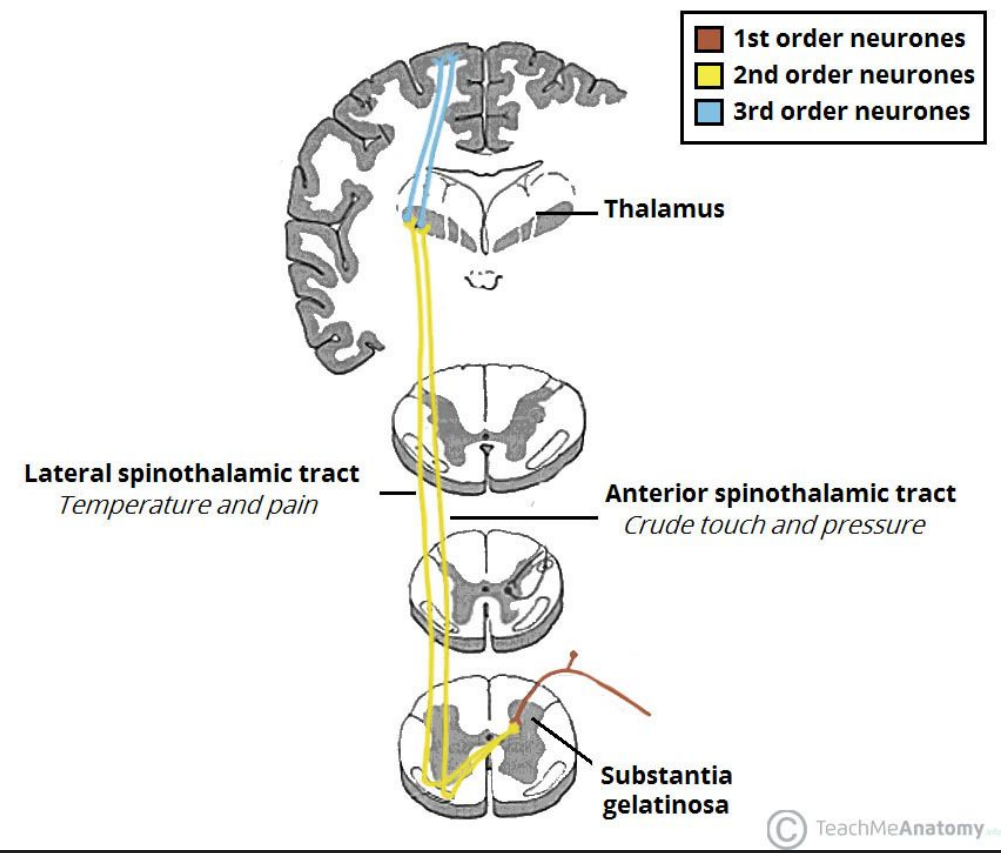


Ascending Tracts: Spinothalamic

Spinothalamic:

- **Anterior**: crude touch and pressure. **Lateral**: pain and temperature

1. 1st - Dorsal root ganglion, enter spinal cord and ascend together ipsilaterally for 1-2 segments.
2. SYNAPSE. 2nd order decussate across anterior white commissure
   - Split into anterior and lateral.
   - Ascend on contralateral spinal cord.
   - DOES NOT decussate at medulla.
3. SYNAPSE in Thalamus to 3rd order.
   - Fibres travel to primary somatosensory cortex.
4. Synapse to 4th order which carry messages to various points in the cortex.



Ascending tracts: Spinocerebellar

- **Spinocerebellar:** unconscious proprioception of trunks and limbs

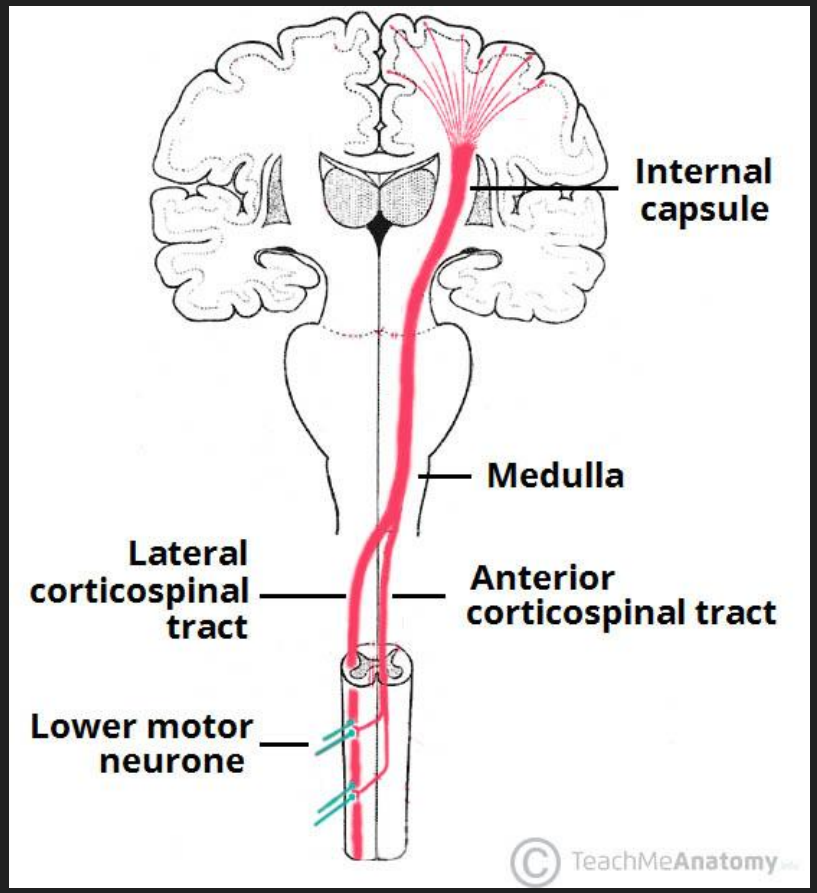
1. First order: dorsal root ganglion into the spinal cord.
2. Synapse to a second order neuron.
   - Splits and either crosses the spinal cord and goes up the ventral tract CONTRALATERALLY. Or doesn't cross and ascends up the dorsal tract ipsilaterally.
3. Dorsal into inferior cerebellar peduncle.
4. Ventral into superior. Decussates within the cerebellum.
5. BOTH END UP IPSILATERAL.

Descending tracts

- Have 2 neurons: upper and lower motor neurons.
- Pyramidal vs extrapyramidal: voluntary + fine control vs balance, coordination, posture and muscle tone.

Pyramidal = direct movement innervation through the medullary pyramids.

- Corticospinal tracts: anterior and lateral tracts. **10%** stay ipsilateral, **90% decussate** at medulla. Supplies musculature of the body.
- Corticobulbar tracts: supplies the musculature of the head and neck. Neurons terminate on the motor nuclei of the cranial nerves

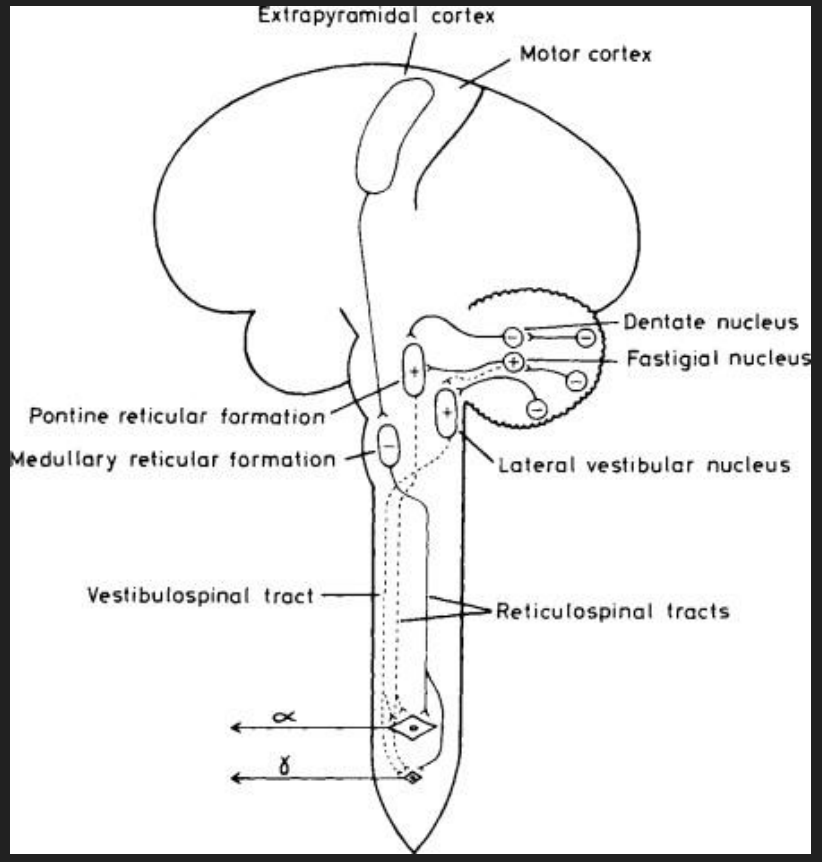


Descending tracts

- Extra pyramidal tracts: responsible for the involuntary and automatic control of all musculature.
- Do not originate from motor cortex!

- 4 tracts in total: vestibulospinal, reticulospinal, tectospinal, rubrospinal

- The **vestibulospinal** and **reticulospinal** tracts do not decussate, providing ipsilateral innervation.
  The **rubrospinal** and **tectospinal** tracts do decussate, and therefore provide contralateral innervation

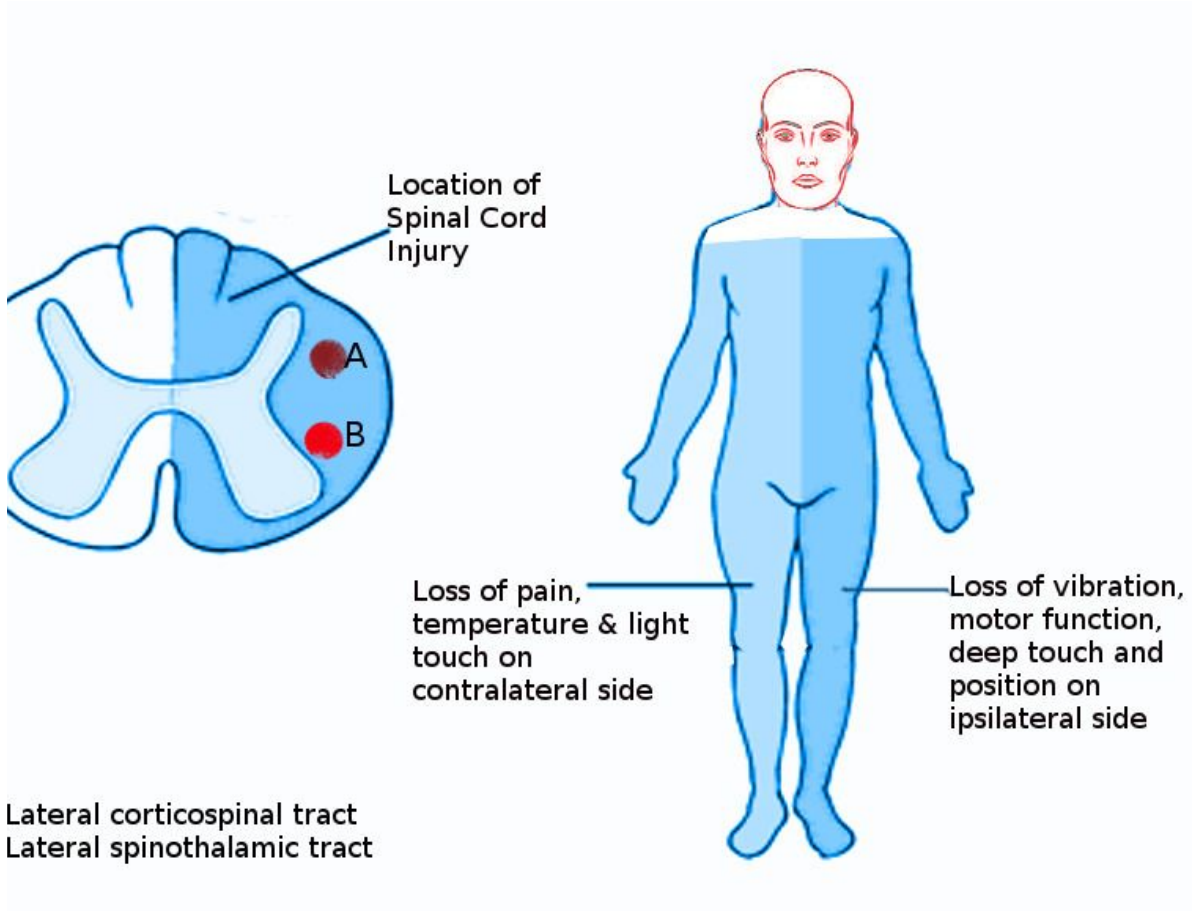


Summary of descending:

Pathway	Function
Direct	
Lateral corticospinal	Muscle tone and skilled movements, especially of hands
Anterior corticospinal	Muscle tone and movement of trunk muscles
Indirect	
Rubrospinal	Movement coordination
Reticulospinal	Posture adjustment, especially during movement
Vestibulospinal	Posture and balance
Tectospinal	Movement in response to visual reflexes

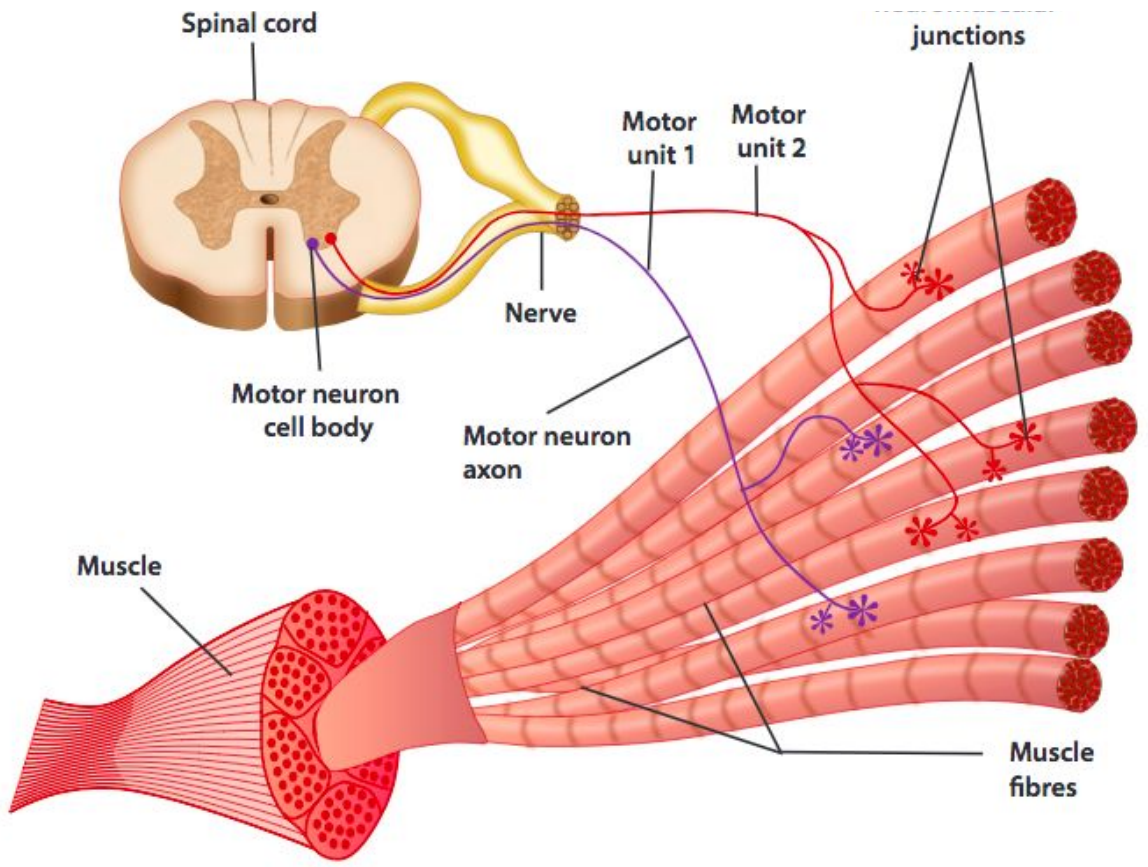
Brown Sequard syndrome:

- Think about path of ascent!
- Corticospinal: ascend **ipsilaterally** up spinal tract = **ipsilateral paralysis**.
- DCML: ascend **ipsilaterally** = **ipsilateral loss** of fine touch, vibration and proprioception.
- Spinothalamic: travels **contralaterally** = **contralateral loss** of pain, temperature and crude touch.



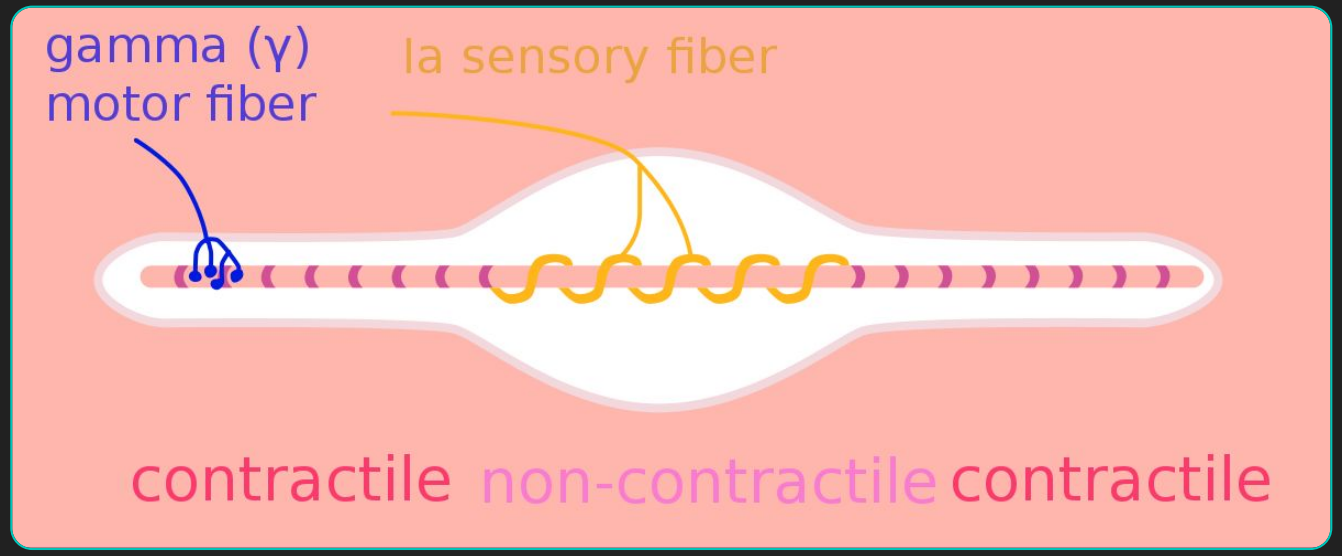
Muscle spindle:

- Motor unit: An Alpha motor neuron + extrafusal skeletal muscle fibres it innervates.
- Alpha motor neuron control muscle contraction involved in voluntary movement, whereas **gamma motor neurons** control muscle contraction in response to external forces acting on the muscle (eg, stretch reflex).
- The smaller the unit, the finer the control

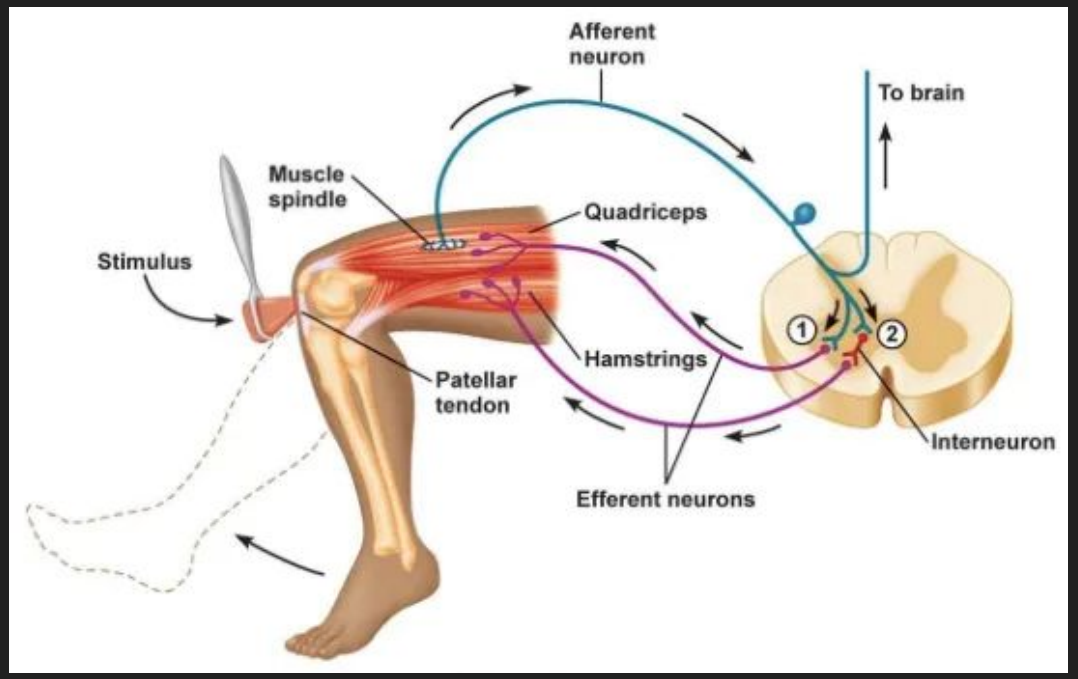


Muscle spindle

- Extrafusal muscle fibres: most of the muscle.
  - innervated by **alpha motor neurons.**
- Intrafusal muscle fibres: regulatory unit surrounded by extrafusal fibres.
  - Sense stretch: monitors **muscle length** and **rate of change**.
  - Help to prevent overstretching of muscles.
  - Type **1a** and type **2** sensory fibres detect these changes.
  - Innervated by **gamma motor neurons** that help keep the intrafusal unit taut so they can keep detecting change.



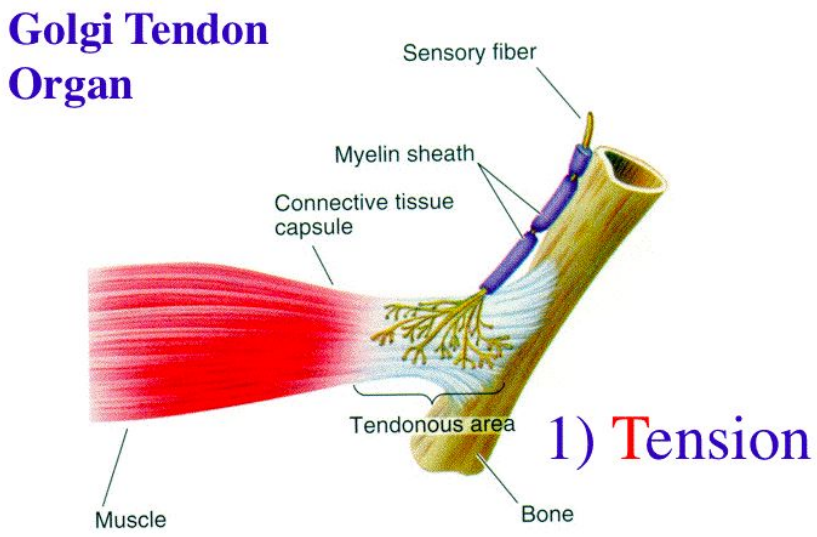
Muscle spindles: stretch (myotatic) reflex



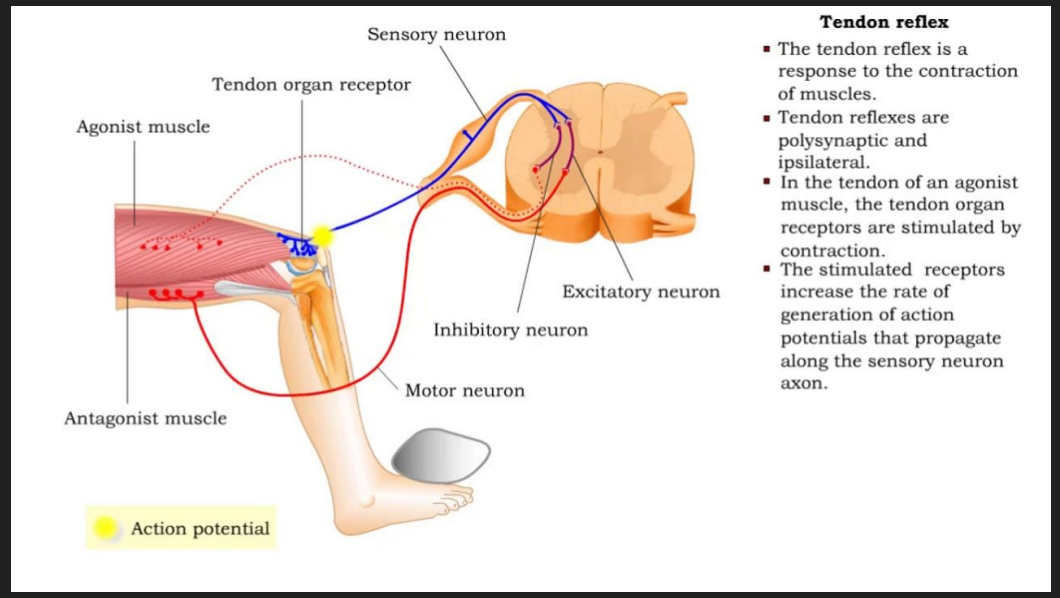
- Stretch reflex: when sensory neurons in an intrafusal unit detect over stretching.
- Type 1a: synapse with and **excite** alpha motor neurons from THE SAME MUSCLE and cause contraction of the muscle to help shorten the length.
- Type 2: synapse with and **inhibit** alpha motor neurons of the **antagonistic** muscle causing relaxation.

Golgi tendons:

- Golgi tendon organ:
- In the tendons at the end of muscles.
- Detect **TENSION.**
- Have type **1B** sensory fibres that are stimulated by the compression of muscle contraction.
- If there is too much muscle tension the golgi tendon organ will inhibit the muscle from creating any force (via a reflex arc), thus protecting you from injuring itself. As well as contracting the antagonistic muscle.



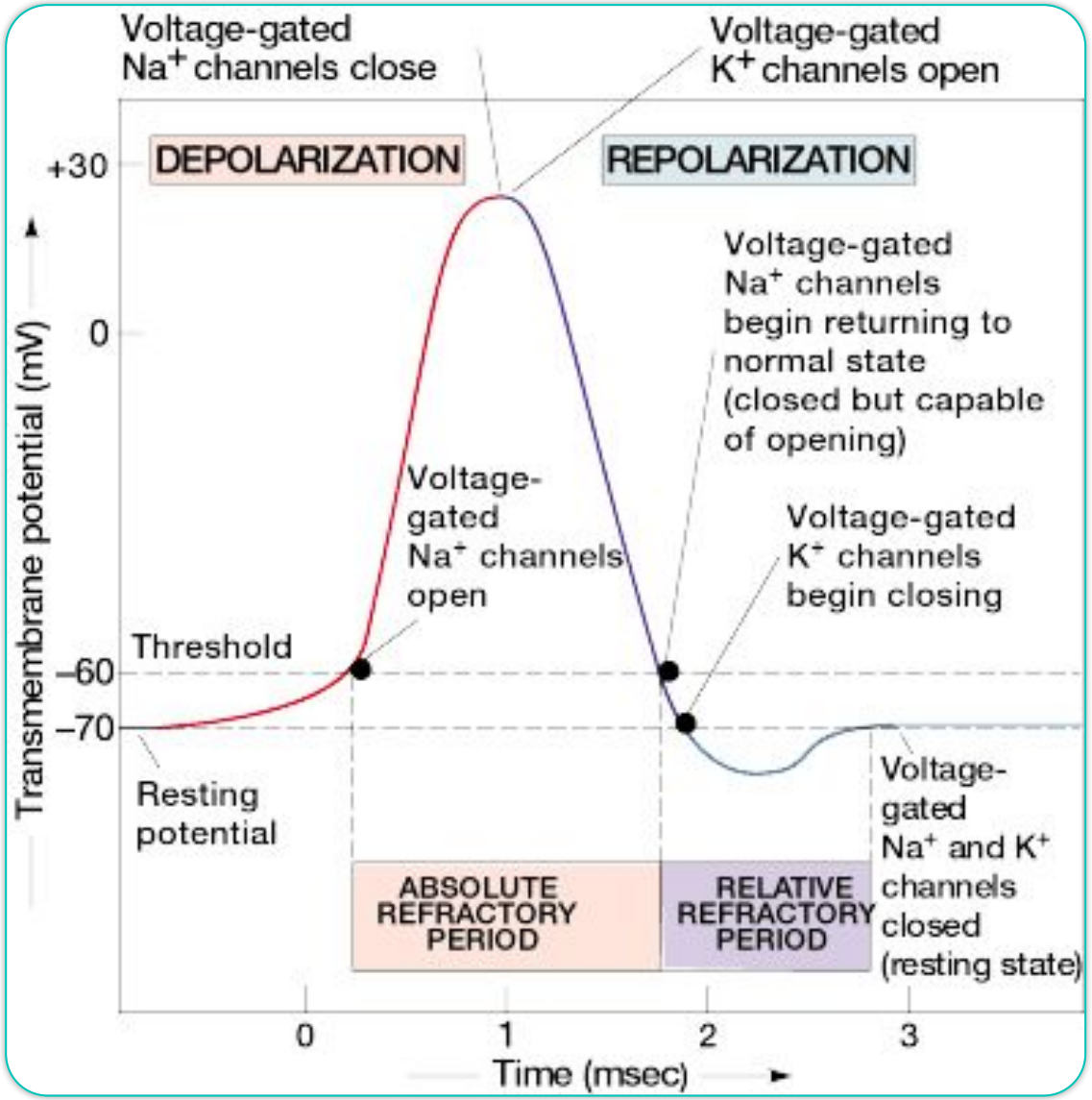
Inverse myotatic reflex:



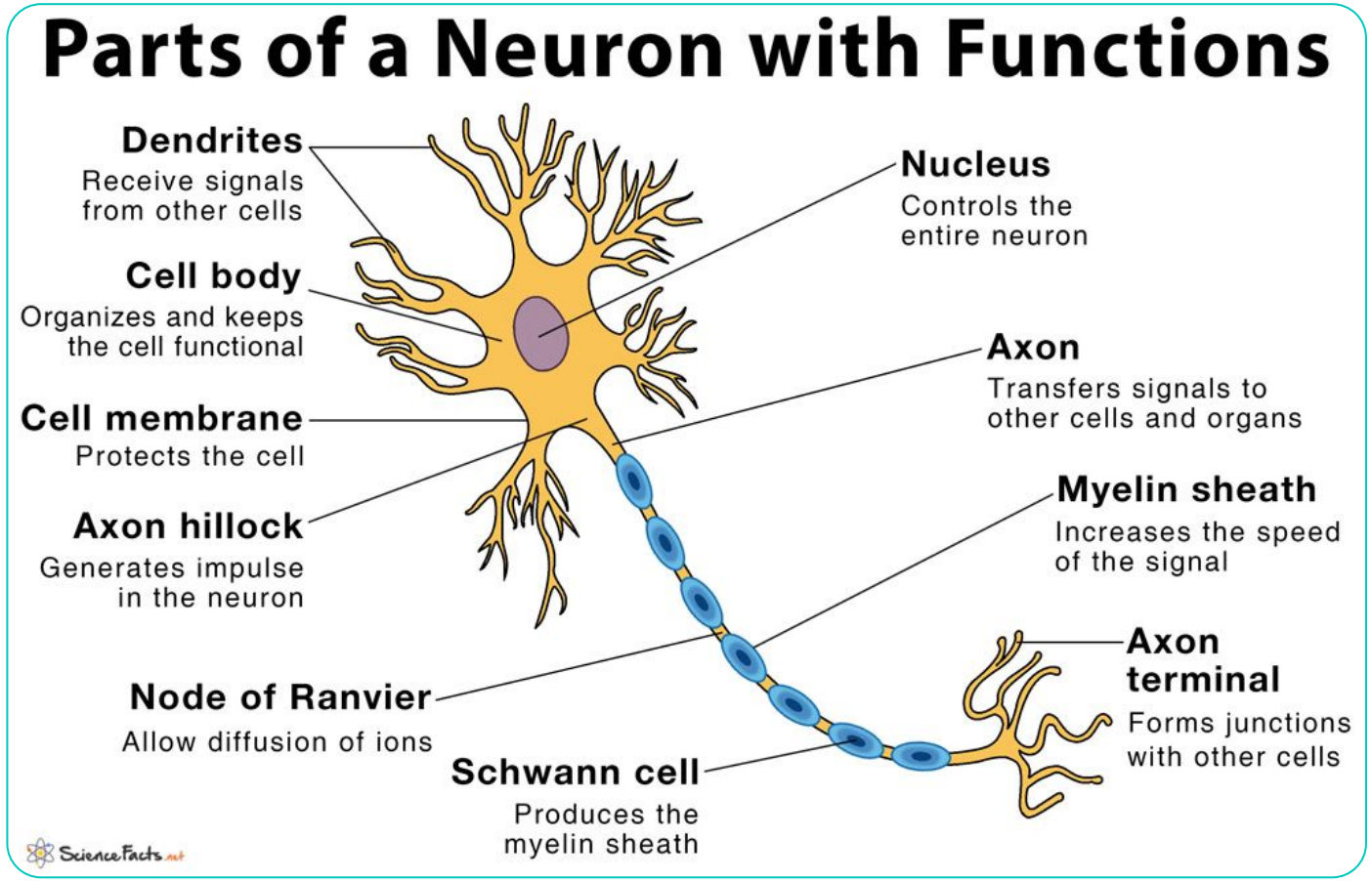
- Inverse stretch reflex: protects from the overload of muscle
- So if stimulated enough, they will cause inhibition/relaxation of the contracting muscle and stimulation of the antagonistic muscle.

Axons and axonal transmission

- Resting potential: -70mV. ECF= 0mV
- Established by Na+/K+ ATPase pump
- Membrane is semi permeable: CL- and K+ cross easily, Na+ less readily
- Diffusion and electrostatic attraction/ repulsion control concentration of ions
- Action potential: occurs in excitable membranes



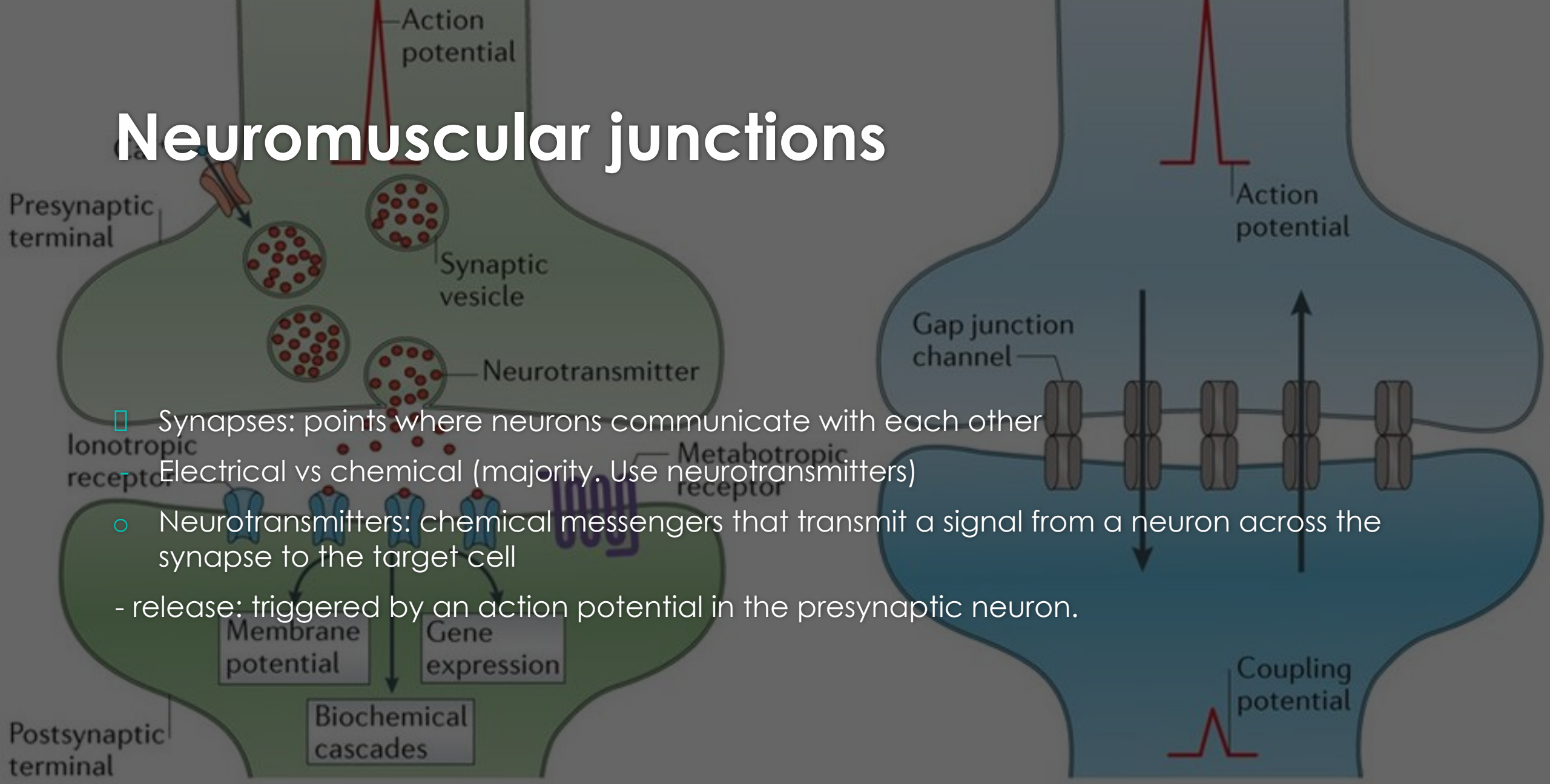
Action potential



Axonal propagation:

- Action potential moves down axon, depolarizing at each point, in a wave like manner
- Saltatory conduction:
  - Myelin sheath insulates the membrane of neurons, preventing charge flow
  - Conduction between nodes of Ranvier
  - Faster conduction
- Refractory period: absolute and relative refractory periods

Neuromuscular junctions

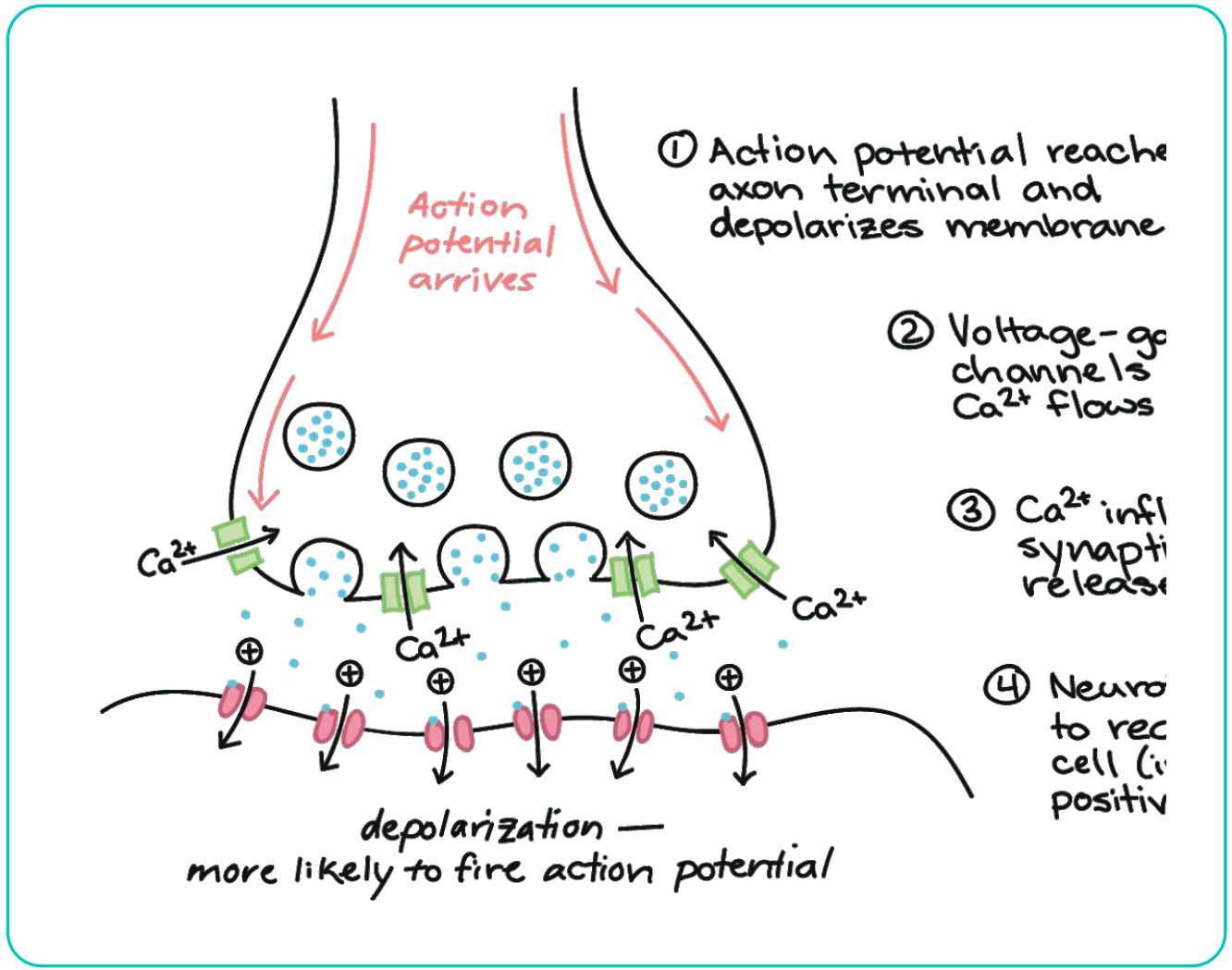


- Synapses: points where neurons communicate with each other
  - Electrical vs chemical (majority. Use neurotransmitters)
- Neurotransmitters: chemical messengers that transmit a signal from a neuron across the synapse to the target cell

- release: triggered by an action potential in the presynaptic neuron.

Synaptic transmission:

1. Manufacture
2. Storage
3. Release
4. Interact with post synaptic receptors
5. Inactivation



Neurotransmitters:

- Excitatory: Results in depolarisation of next neuron by bringing membrane potential closer to threshold potential

- Generate excitatory post-synaptic potentials (EPSPs)

- Eg acetylcholine

- Increase the likelihood of a response

- Inhibitory:

- - Results in hyperpolarisation

- Membrane potential decreased to further from threshold

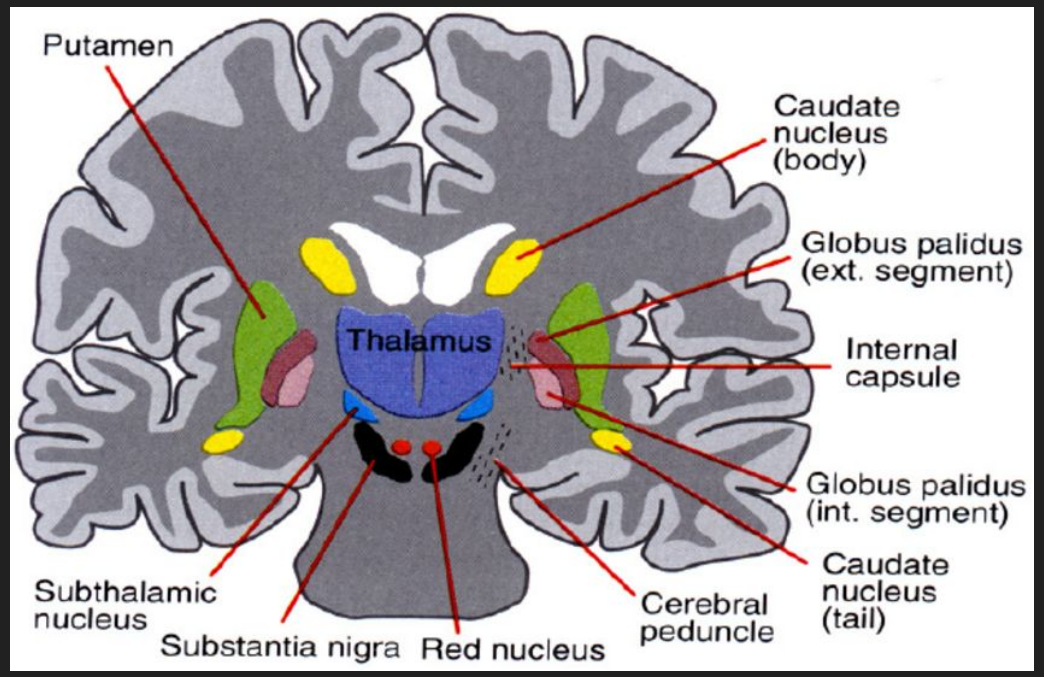
- Harder for action potential to begin

- Generate inhibitory post-synaptic potentials (IPSPs)

- Eg GABA

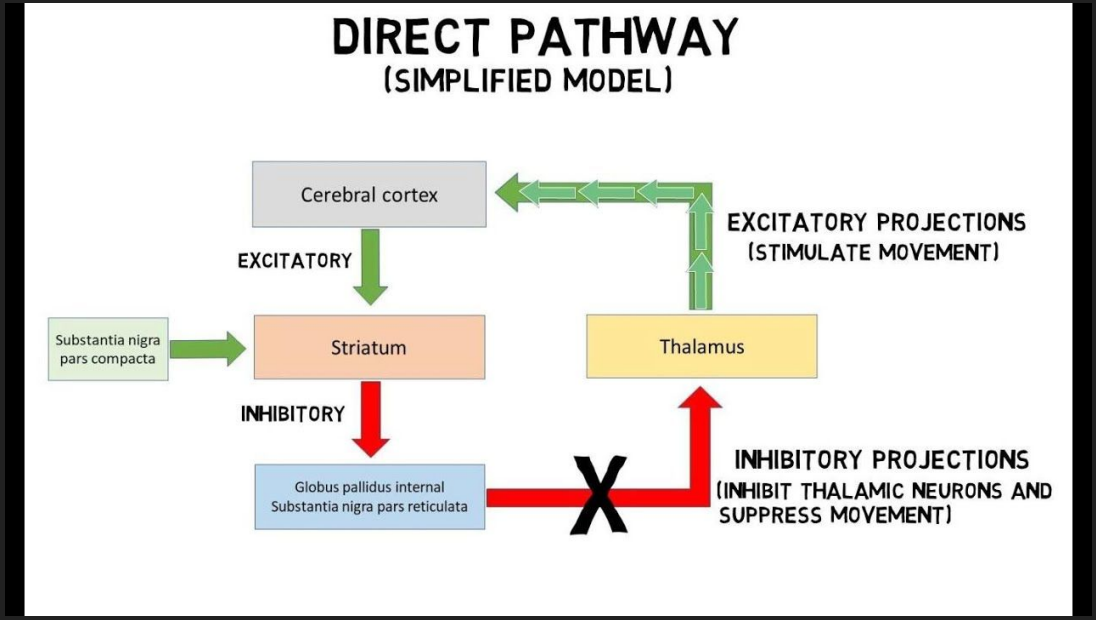
Basal ganglia

- Collection of deep nuclei in the brain
- Consists of the globus pallidus and the striatum. GP can be broken down into external and internal. The striatum can be divided into the caudate nucleus and the putamen.
- Function: help influence the motor cortex by affecting pathways flowing through the thalamus. Aids in execution and controlling the smooth action of the limbs
- Excitatory pathways: glutamate
- Inhibitory pathways: GABA



Basal ganglia: direct pathway

- Excitatory: movement initiation
  - Motor cortex projects excitatory fibers to the striatum
  - Striatum inhibits the INTERNAL globus pallidus
  - Internal GP would normally inhibit the excitatory pathways (via GABA release)
  - When the Internal GP is inhibited the thalamus is free to activate the motor cortex.

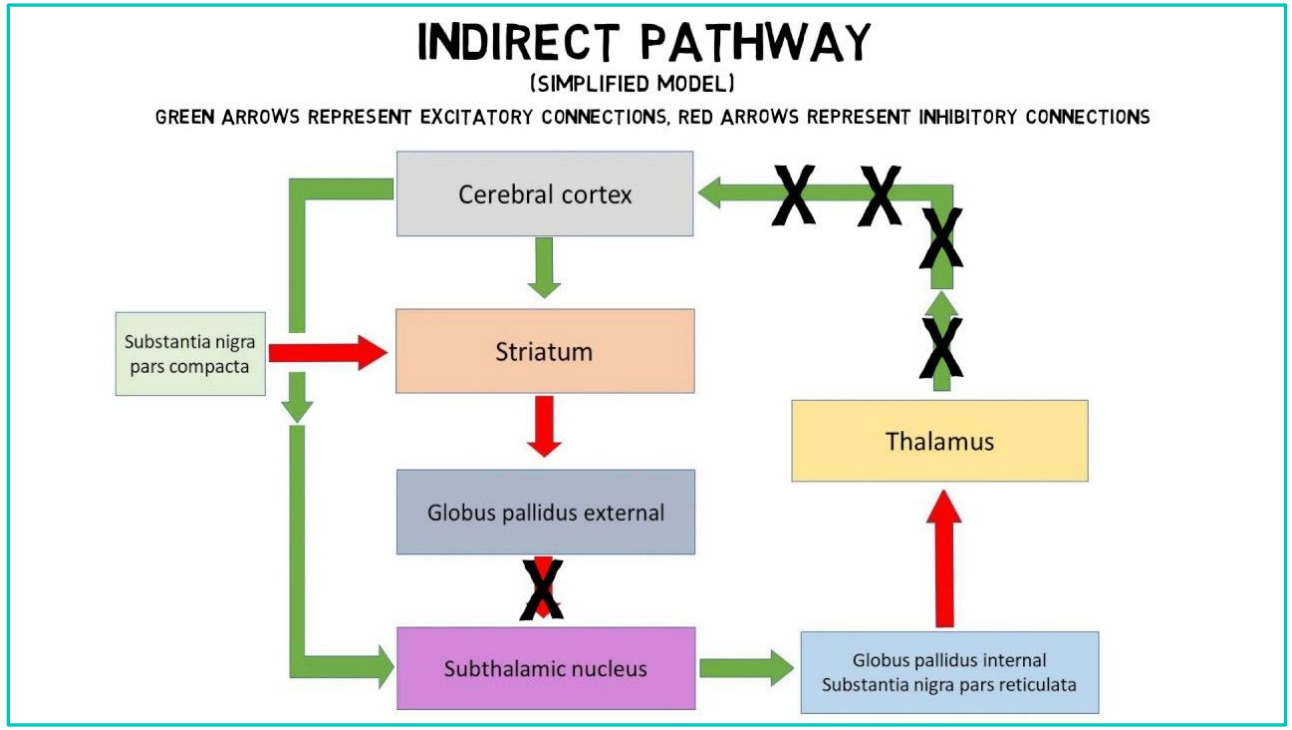


GABA going to thalamus = inhibition of movement.

In via caudate nucleus and putamen.
Out via globus pallidus and substantia nigra

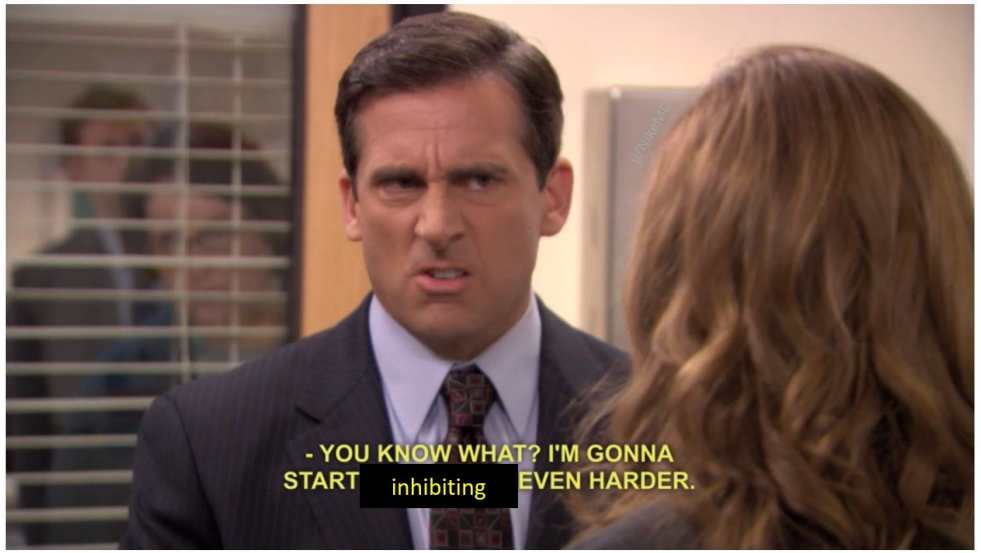
Indirect pathway:

- indirect: inhibitory. Stops movement.
- Motor cortex projects excitatory fibers to the striatum
- This then sends inhibitory signals to the EXTERNAL GP.
- External GP normally sends inhibitory signals to the subthalamic nuclei.
- If external GP is inhibited the subthalamic nuclei are free to send excitatory signals to the internal GP.
- Therefore the internal GP can inhibit the thalamus.
- No excitatory fibers sent to the motor cortex



Summary:

Subthalamic nucleus: sends glutamate
Globus pallidus internus:



	Direct	Indirect
1	Motor cortex excites striatum	Motor cortex excites striatum
2	Striatum inhibits the Internal Globus Pallidus	Striatum inhibits the External Globus Pallidus
3		External globus pallidus is inhibited so can't inhibit the subthalamic nuclei
4	Internal globus pallidus is inhibited so can't inhibit the thalamus	Subthalamic nuclei free to stimulate the Internal globus pallidus
5	Thalamus free to stimulate the motor cortex	Thalamus is inhibited by internal globus pallidus - no stimulation to motor cortex

FEEDBACK FORM THEN QUIZ…

What area of the brain does the DCML pathway decussate at?

1) The anterior horn of the spinal cord
2) The medulla
3) In the thalamus
4) 1-2 levels above innervation

What information does the anterior spinothalamic tract transmit:

1) crude touch and pressure
2) Pain and temperature
3) Proprioception
4) Motor control to legs

What do corticobulbar upper motor neurons synapse onto?

1) LMN in ventral spinal cord
2) 3rd order neurones
3) Cranial nerve nuclei
4) Type 2a neurones

What is a motor unit?

1) Alpha neuron + intrafusal
2) Alpha neuron + extrafusal
3) Gamma neuron + intrafusal
4) Gamma neuron + extrafusal

A 53 year old builder is really struggling with a heavy stack of bricks. His biceps start to relax whilst his triceps start to contract to protect his muscles. What sensory neuron has transmitted this information?

1) Type 1a fibres
2) Type 2 fibres
3) Type 1b fibres
4) Alpha motor fibres

What neurotransmitter does the excitatory pathways in the basal ganglia use?

1) GABA
2) Acetylcholine
3) Glutamate
4) serotonin

Which of these is not involved in the direct pathway for the basal ganglia?

1) Thalamus
2) Motor cortex
3) Internal globus pallidus
4) Sub thalamic nuclei

What cells produce myelin in the CNS?

1) Schwann cells
2) Astrocytes
3) Oligodendrocytes
4) Microglial cells

Which ion is not involved in nervous transmission?

1) Ca++
2) K+
3) Na+
4) Cl-

Thank you!