Functions of the peripheral nervous system

6.2.2024

Learning outcomes

Recognize the essential anatomical structures of the peripheral nervous system and their functions

Understand the structural and functional division within the peripheral nervous system

Recognize the functions of cranial nerves and spinal nerves

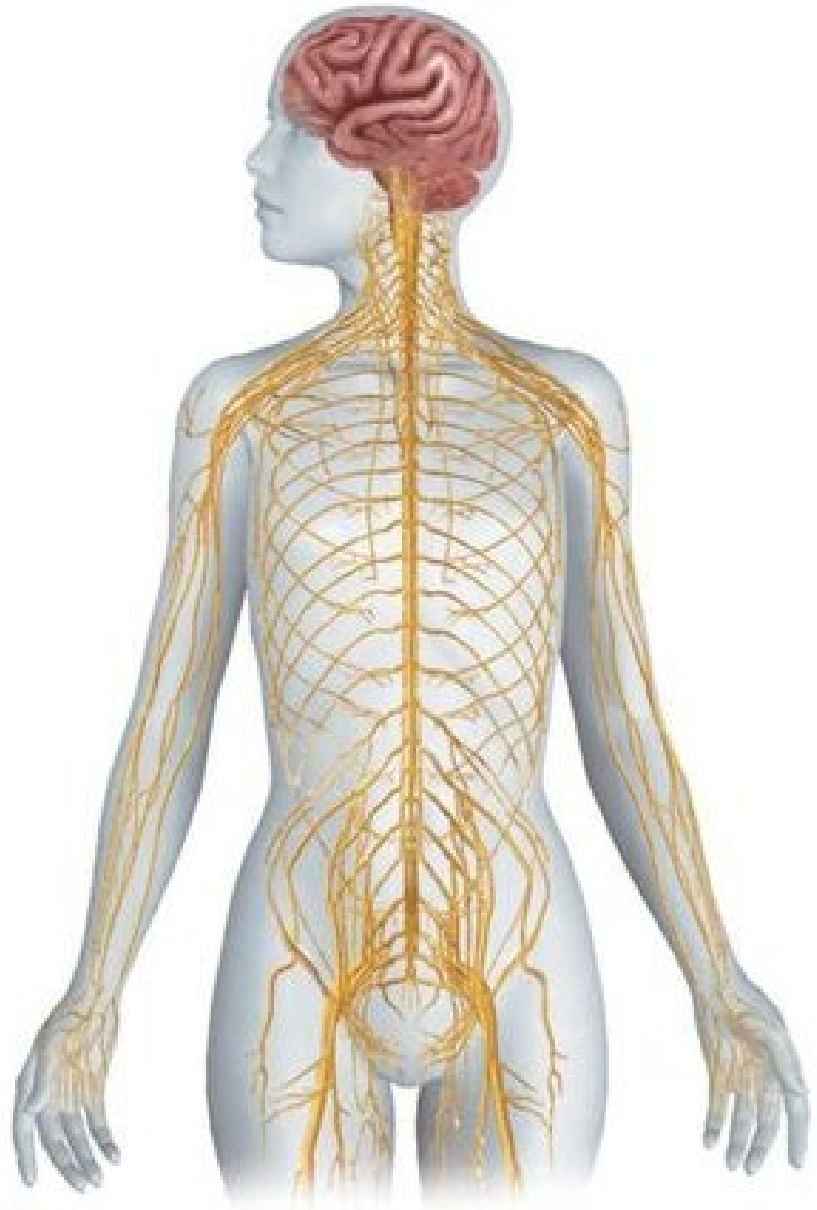
Autonomic nervous system will be covered later during the course

Structure of the peripheral nervous system

= efferent + afferent nerves

= somatic and autonomic nervous system

Somatic nervous system = 12 cranial nerves +
31 spinal nerves



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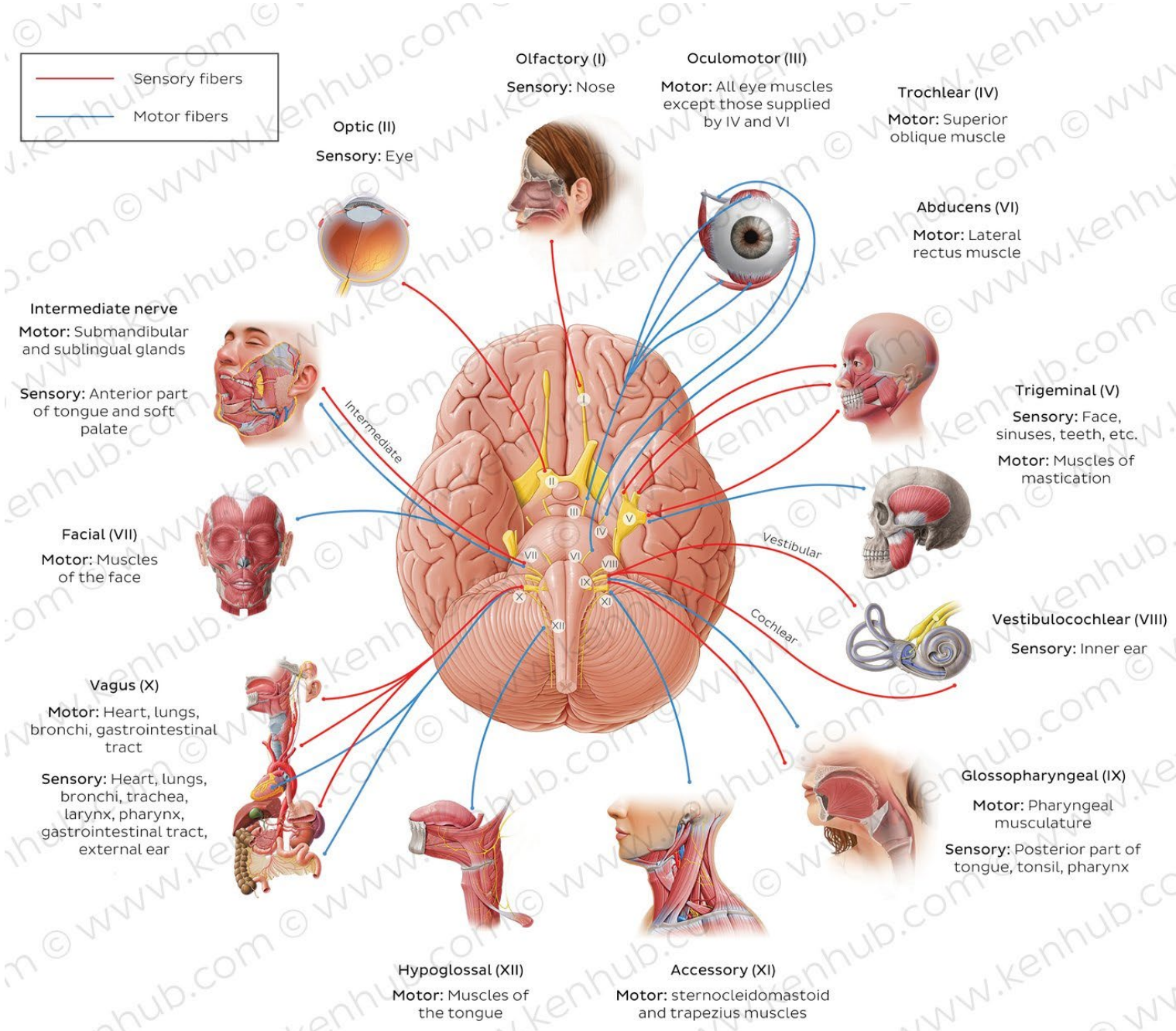
Cranial nerves

- 12 pairs
- Apart from I and II cranial nerves, all originate at the brain stem
- Mainly provide sensory and motor innervation for the brain
- Abnormal function of several cranial nerves points to brain stem lesion



https://thumbor.kenhub.com/

Cranial nerves

I **Smell**

II Vision

III, IV, VI Eye movements

V Facial sensation and muscles of mastication

VII Facial expression

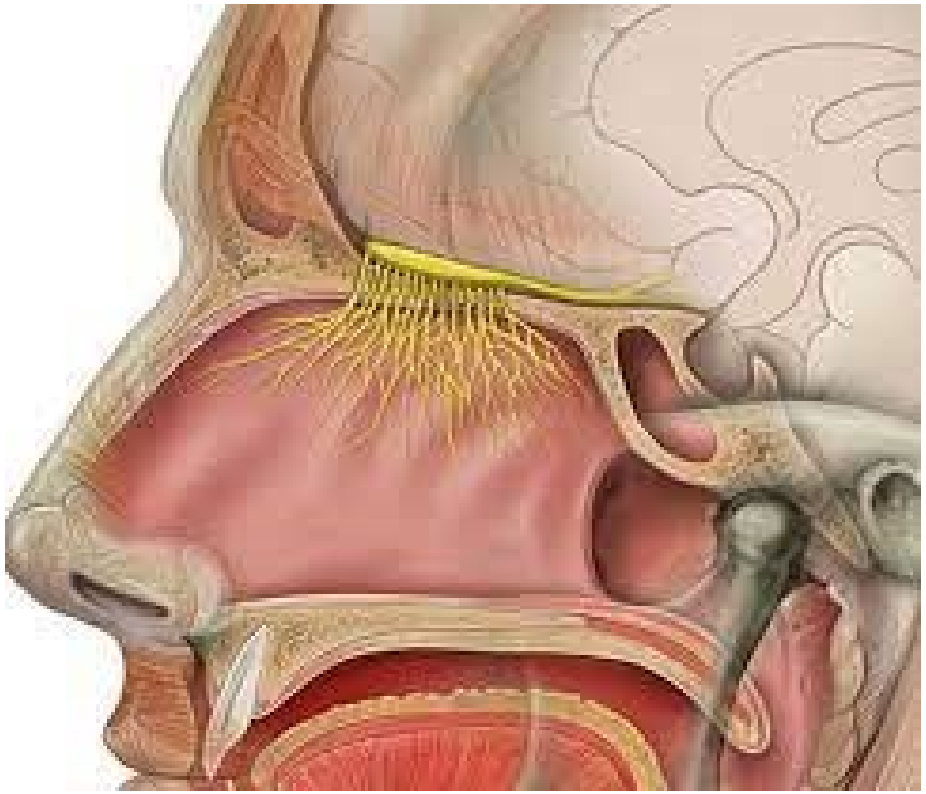
VIII Hearing, equilibrium

IX Reflex for swallowing, taste and sensation in pharynx and back portion of the tongue

X Parasymphatetic innervation of lungs, heart, glands of gastrointestinal tract, and the smooth muscles of esophagus, stomach etc., larynx, vocal cords

XI Trapezius and sternocleidomastoid muscles

XII Muscles of the tongue



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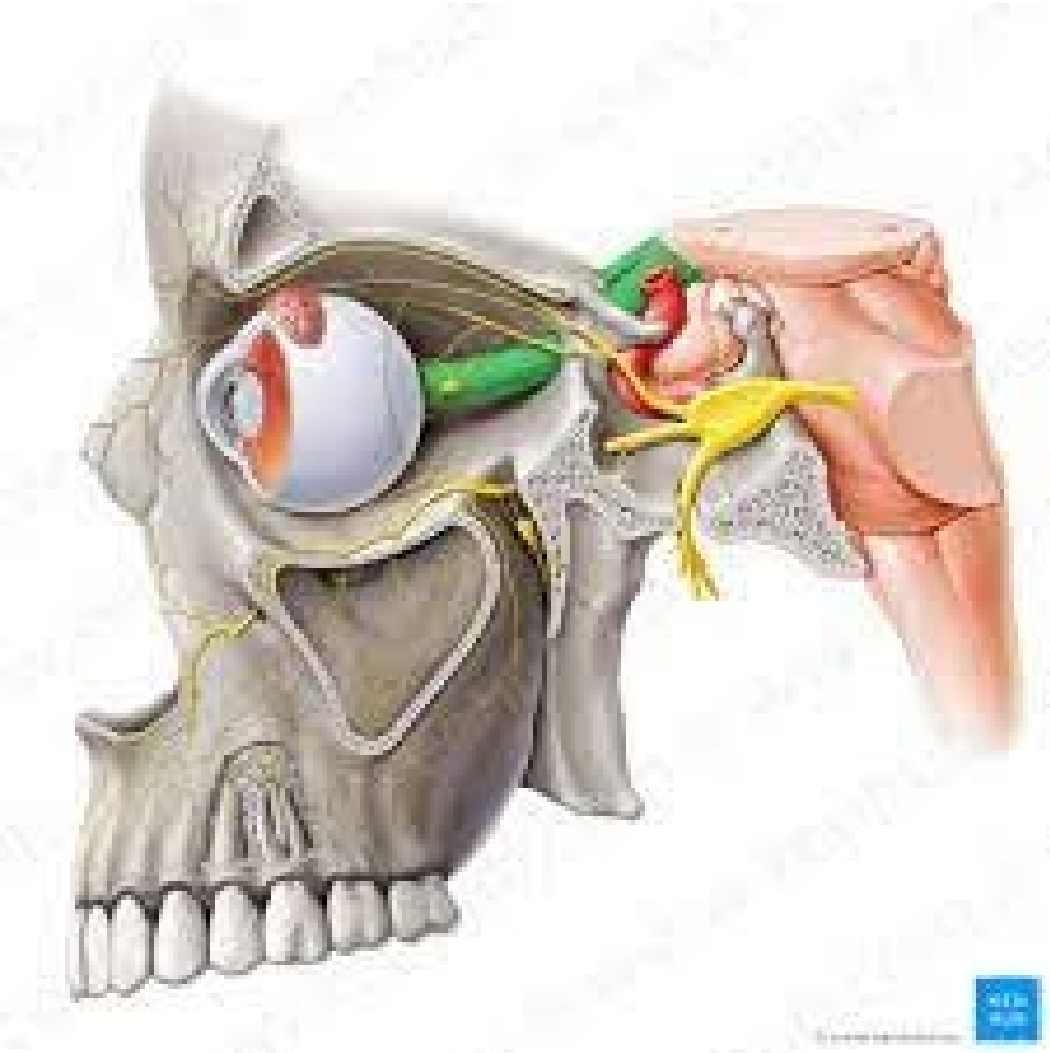

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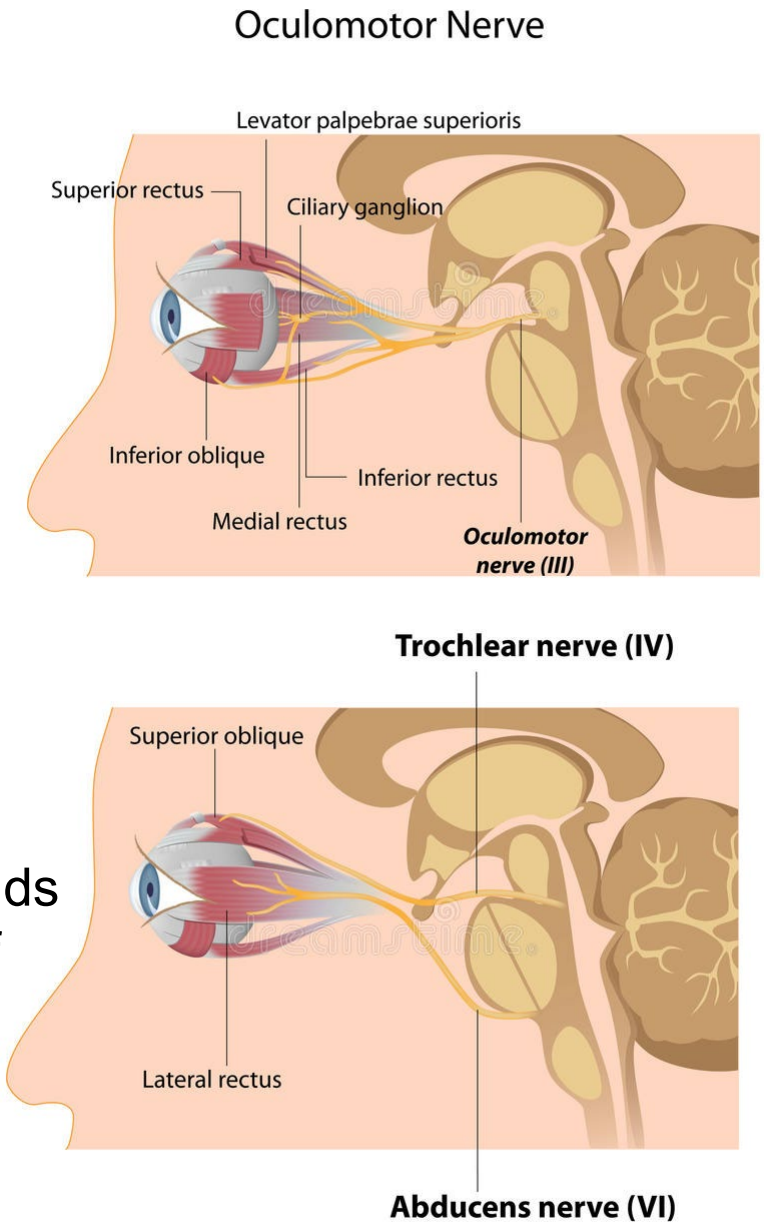

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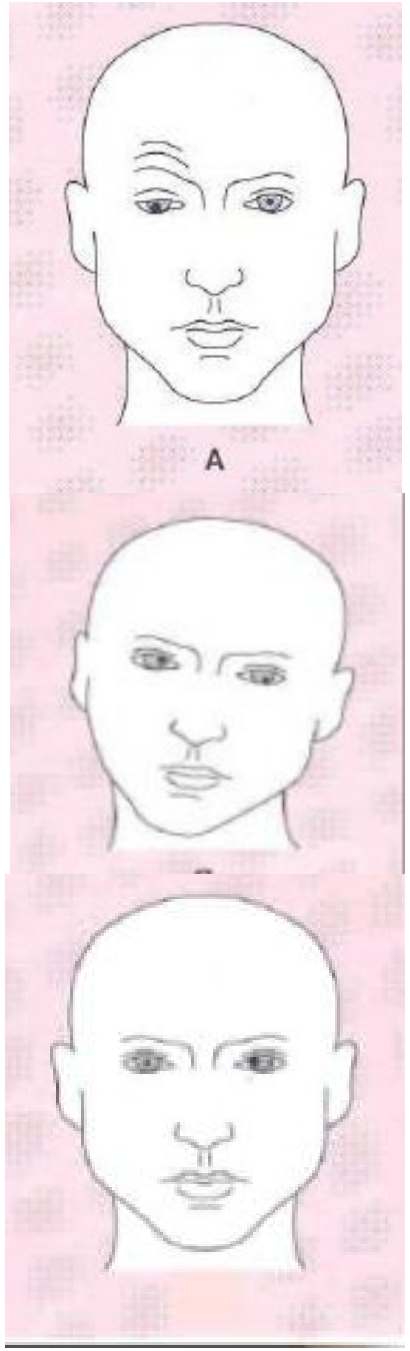

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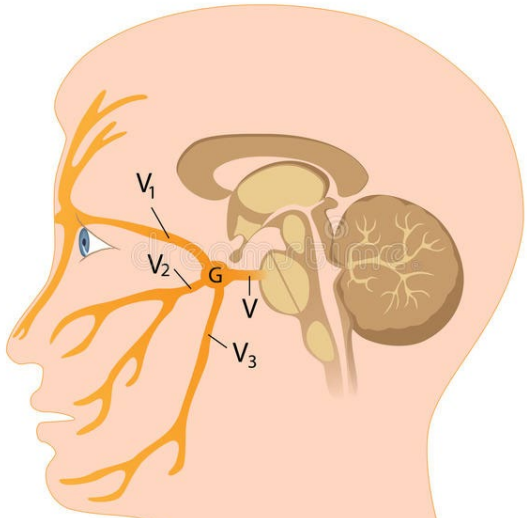
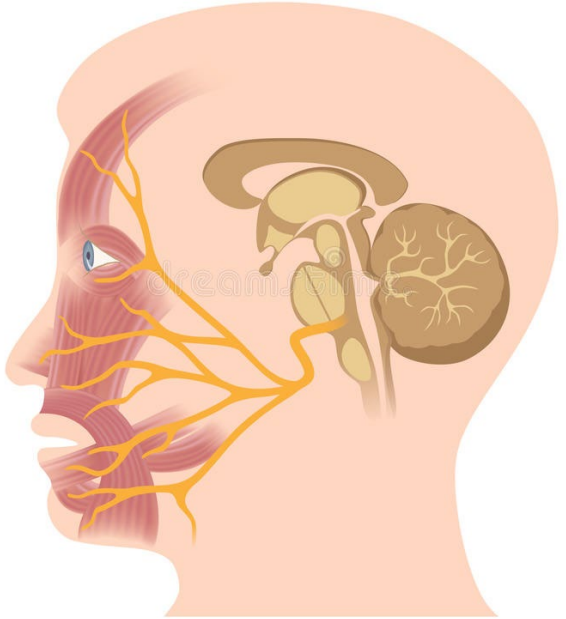
The Trigeminal Nerve



The Facial Nerve



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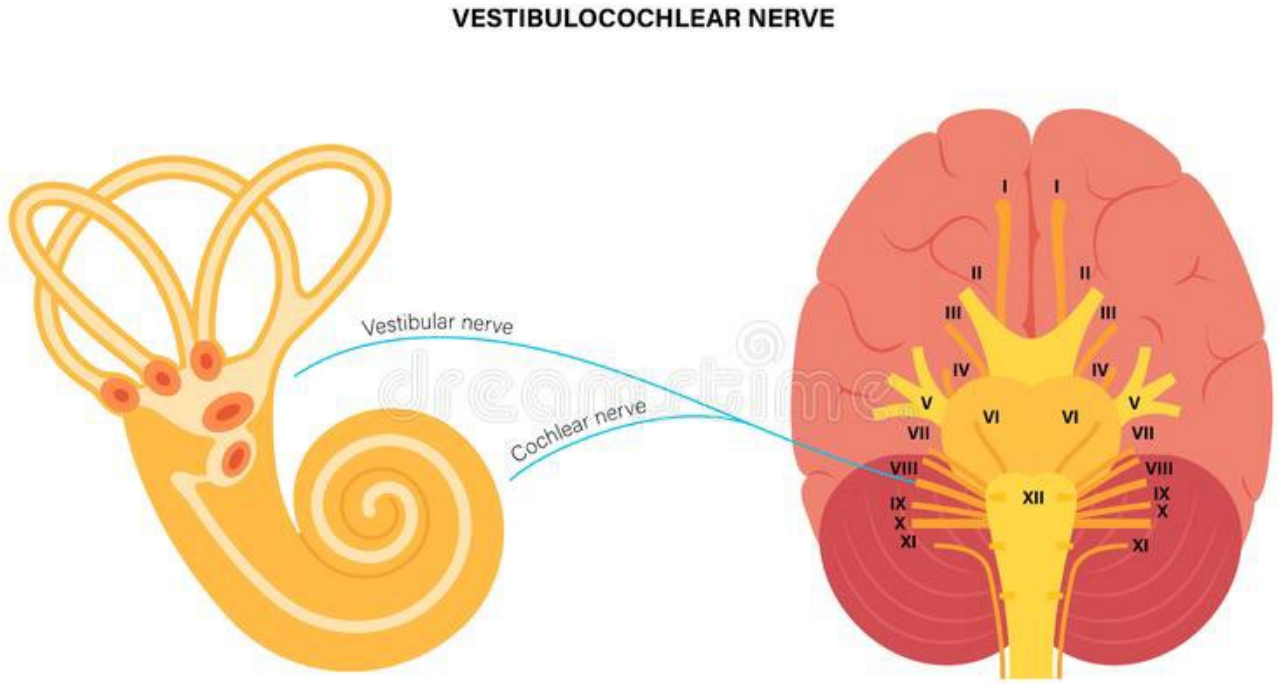

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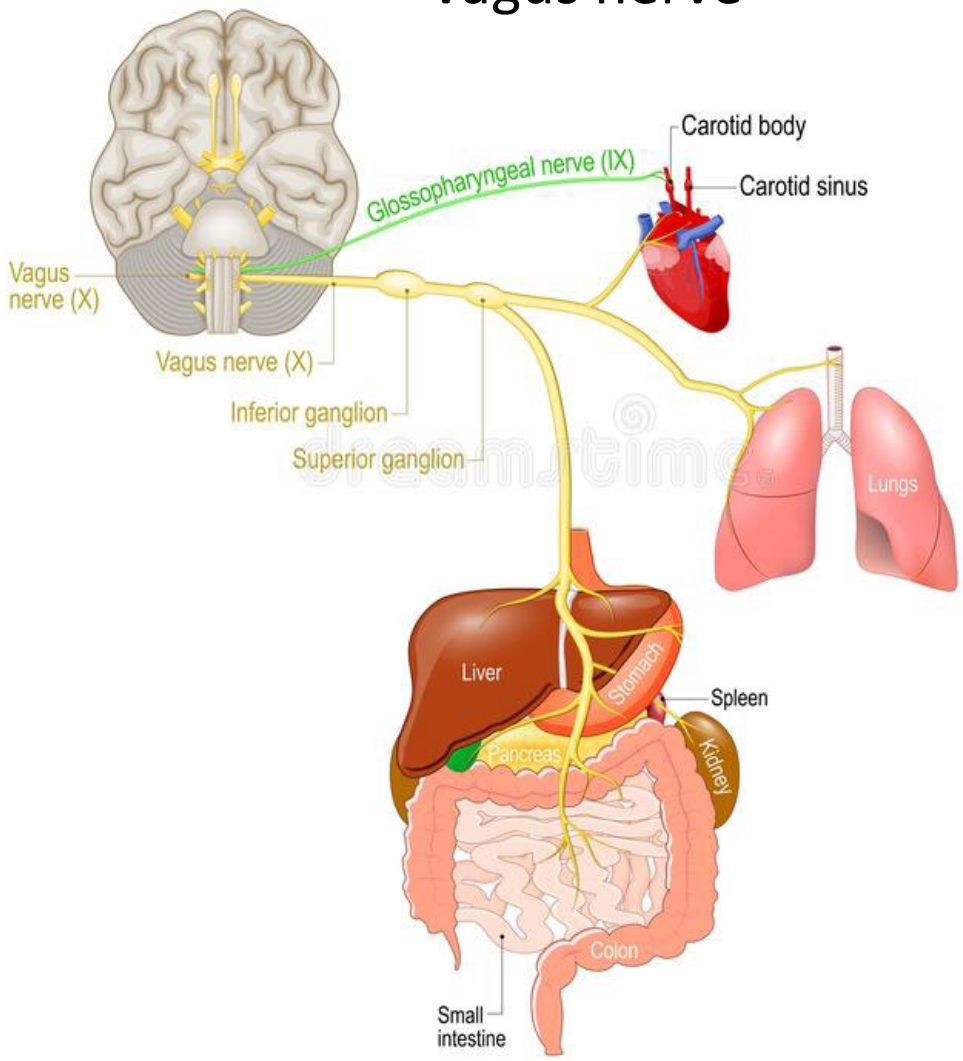
Vagus nerve



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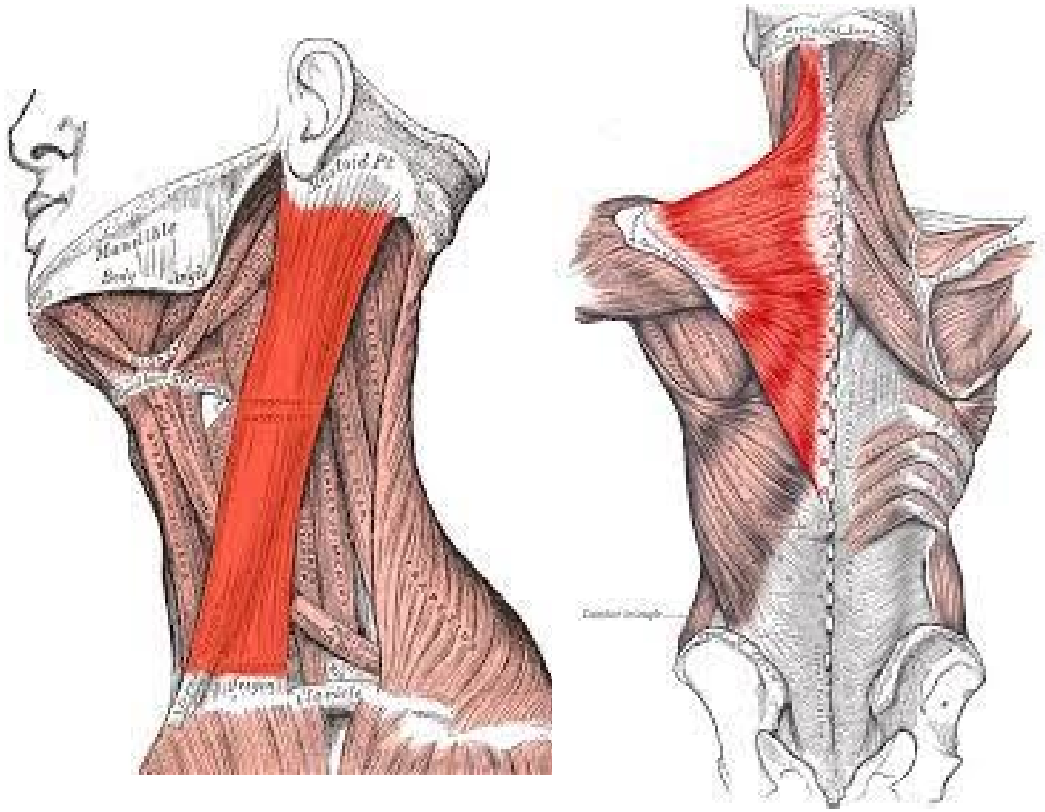
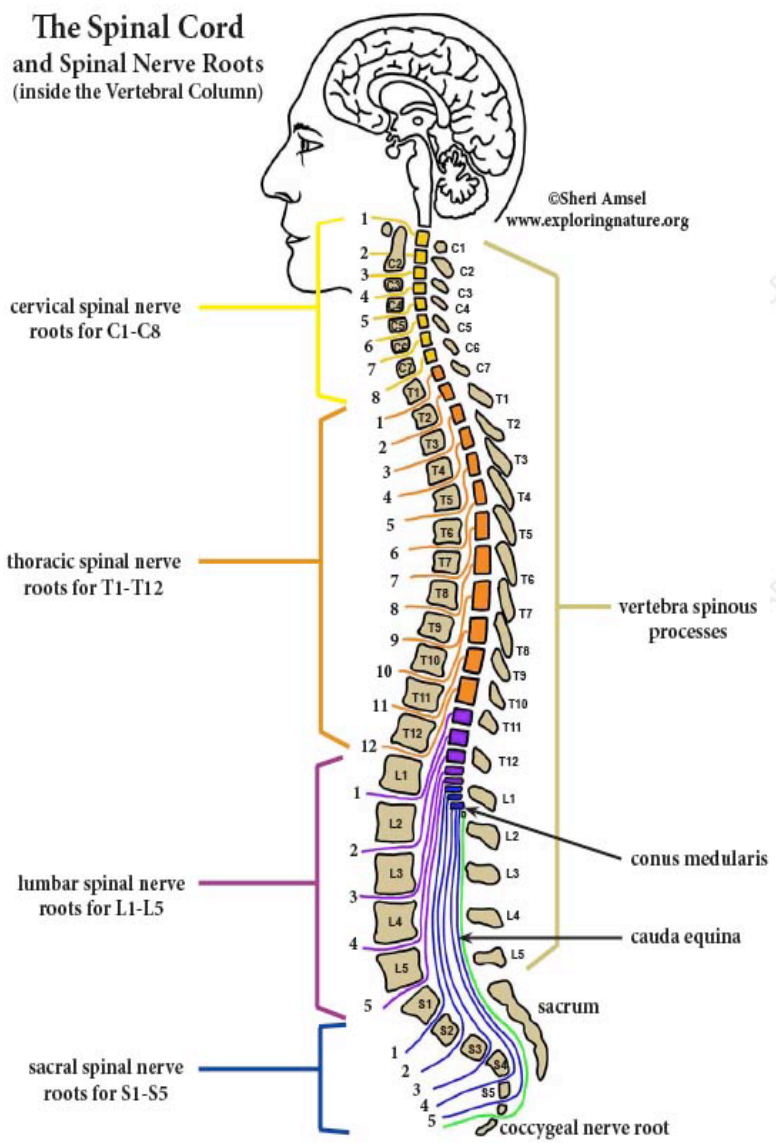
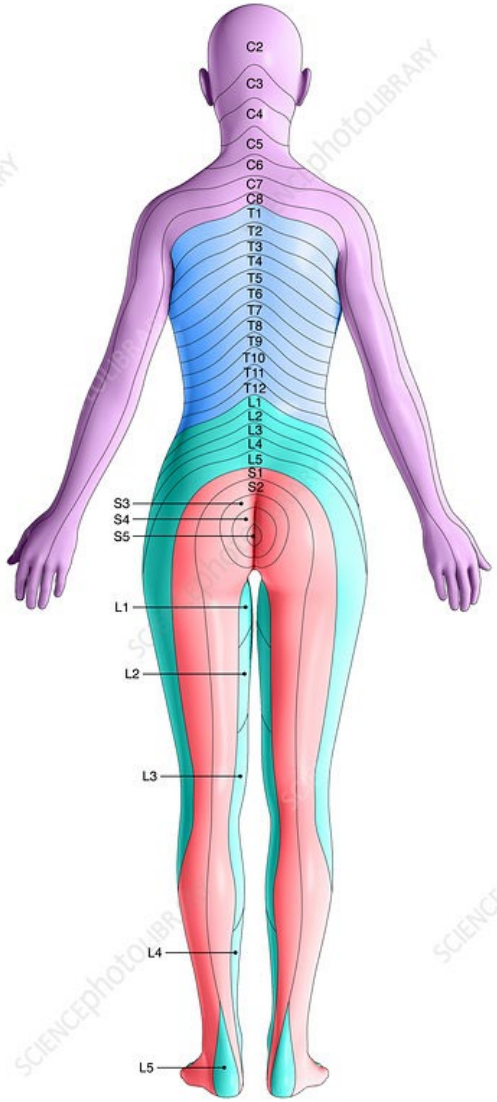


Wikipedia

Spinal nerves

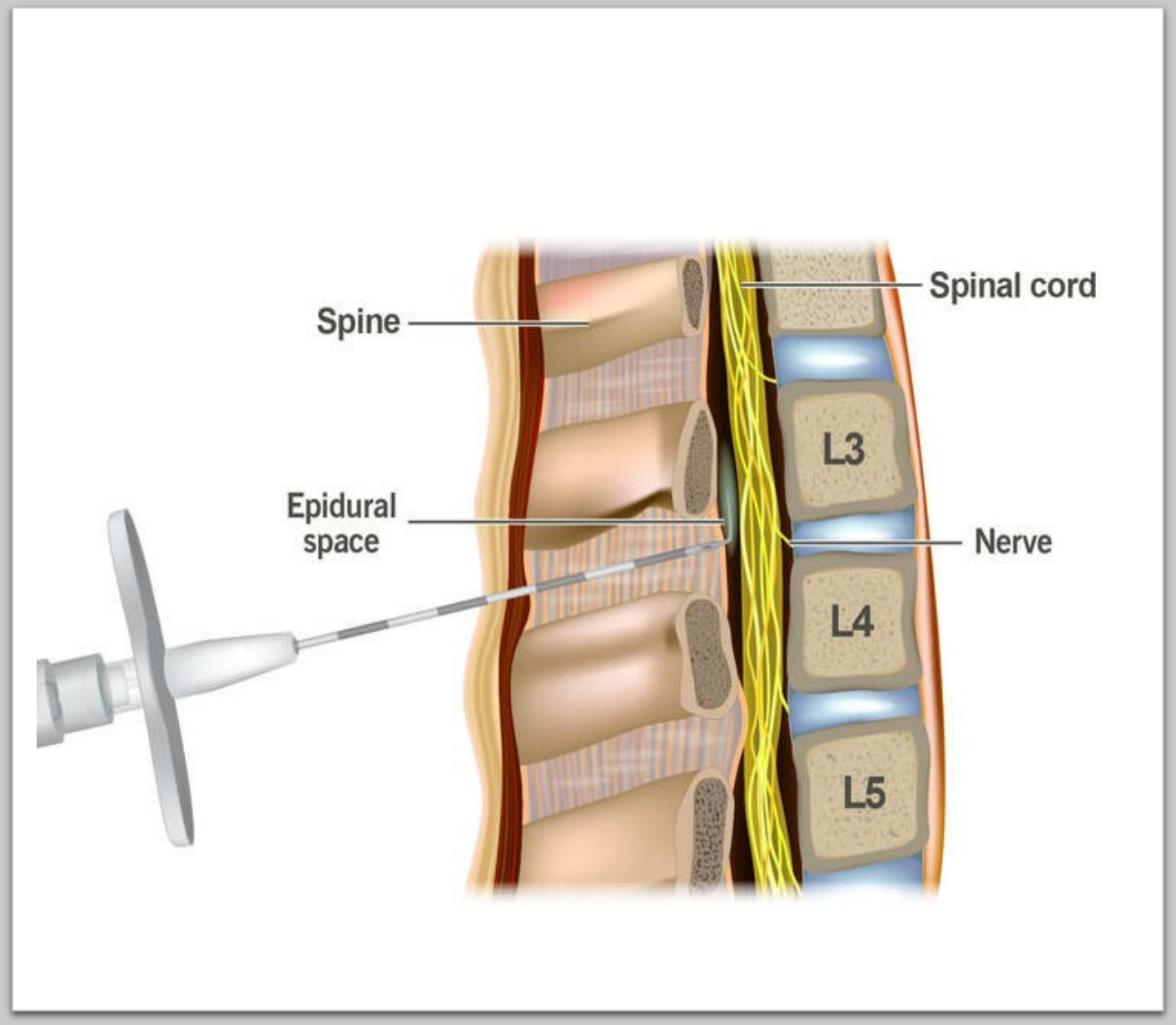
- 31 pairs
- Branch out from the spinal cord
- Carry motor and sensory nerve fibers
- 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal nerve





https://www.exploringnature.org, https://www.sciencephoto.com/

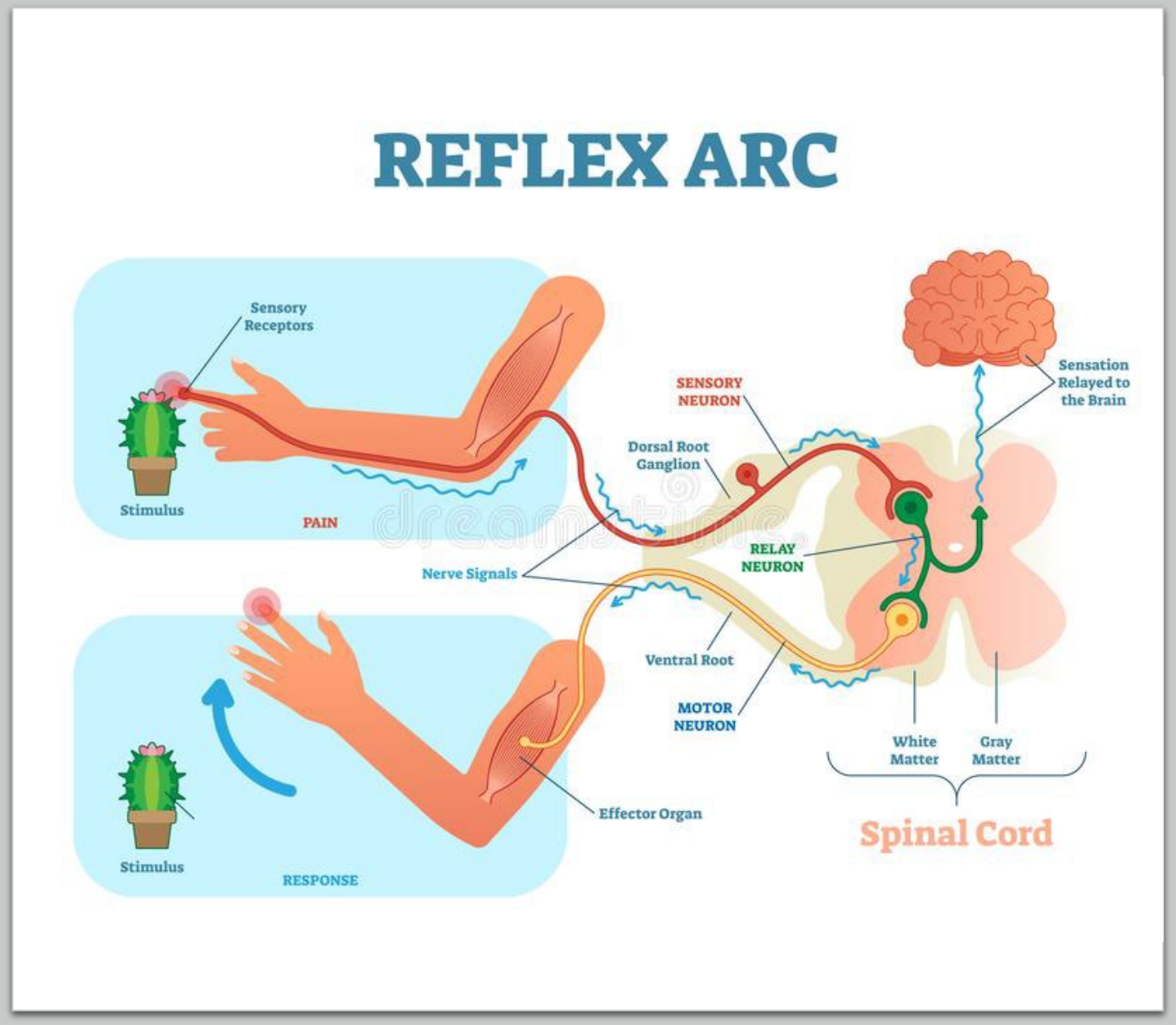
Spinal cord is surrounded by epidural space which contains fat and rich vasculature



https://my.clevelandclinic.org/

Structure of the spinal cord

- Ventral horn: motor neurons that send axons to terminate on striated muscles
- Dorsal horn: sensory neurons



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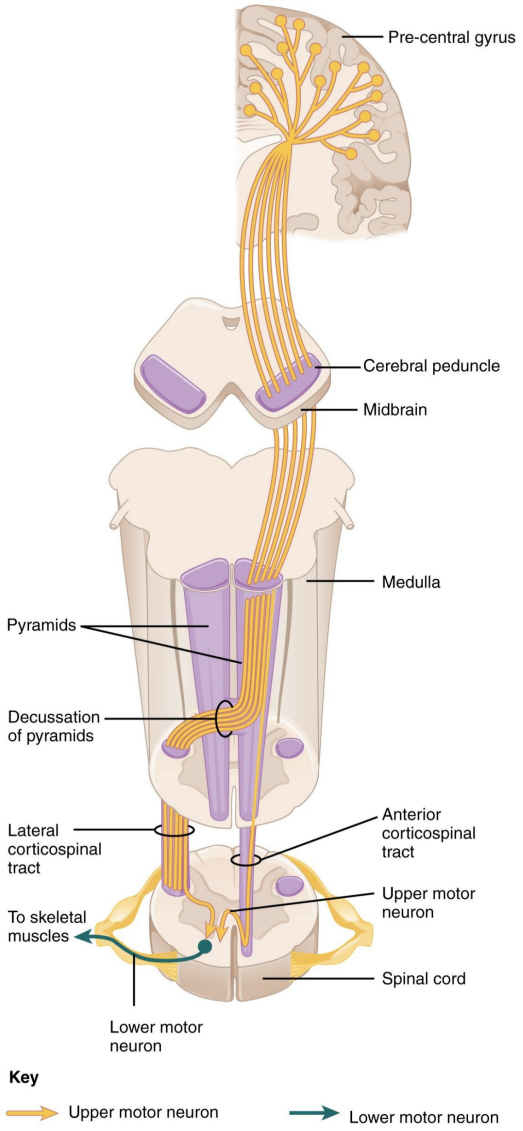
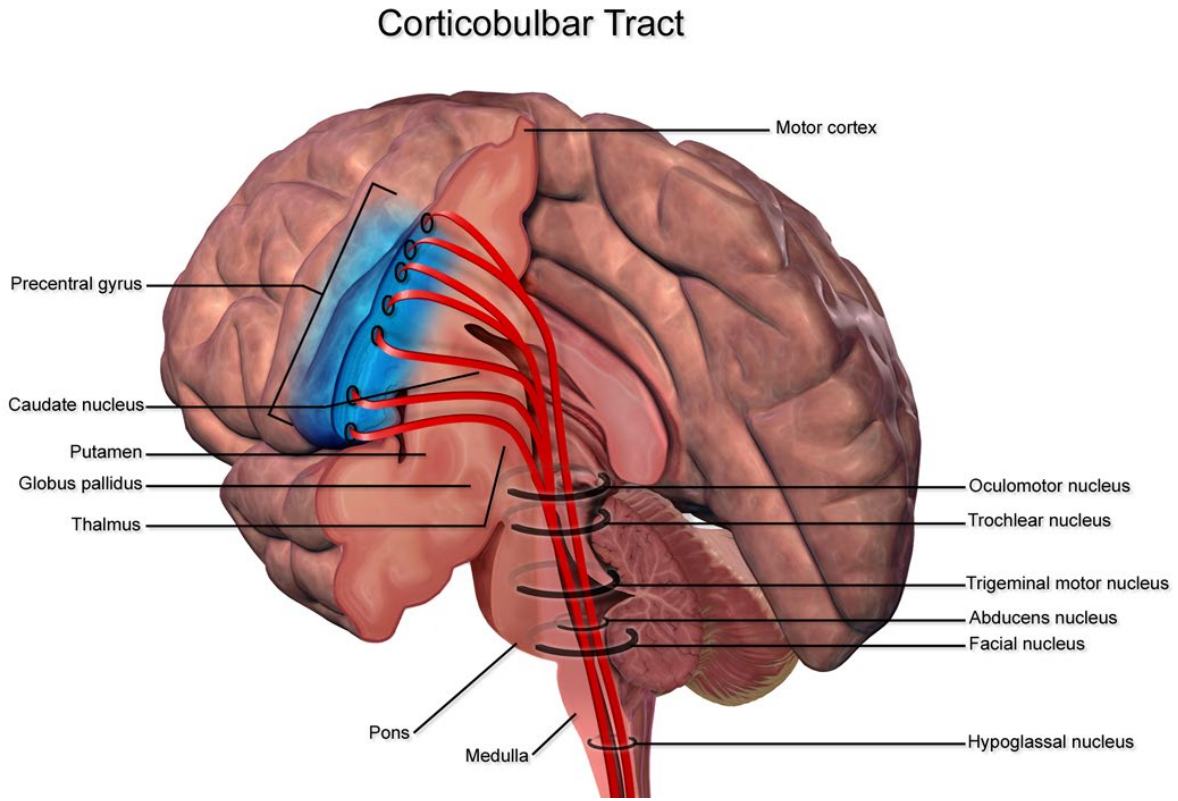
Pyramidal tract divides into two main tracts

Corticospinal tract for controlling limbs and trunk



Corticobulbar tract for cranial nerves



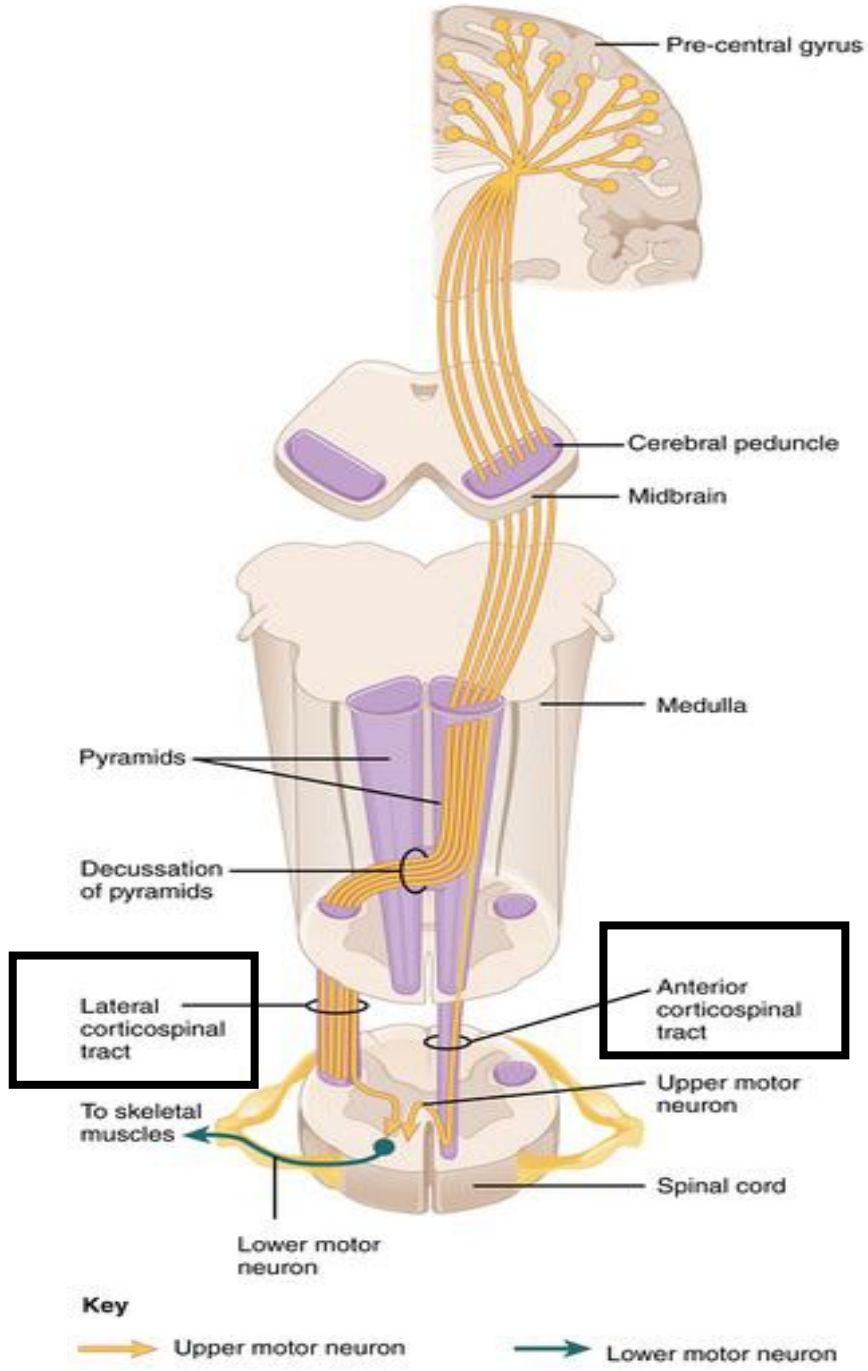
en.wikipedia.org,

By BruceBlaus - Own work, CC BY-SA 4.0, commons.wikimedia.org

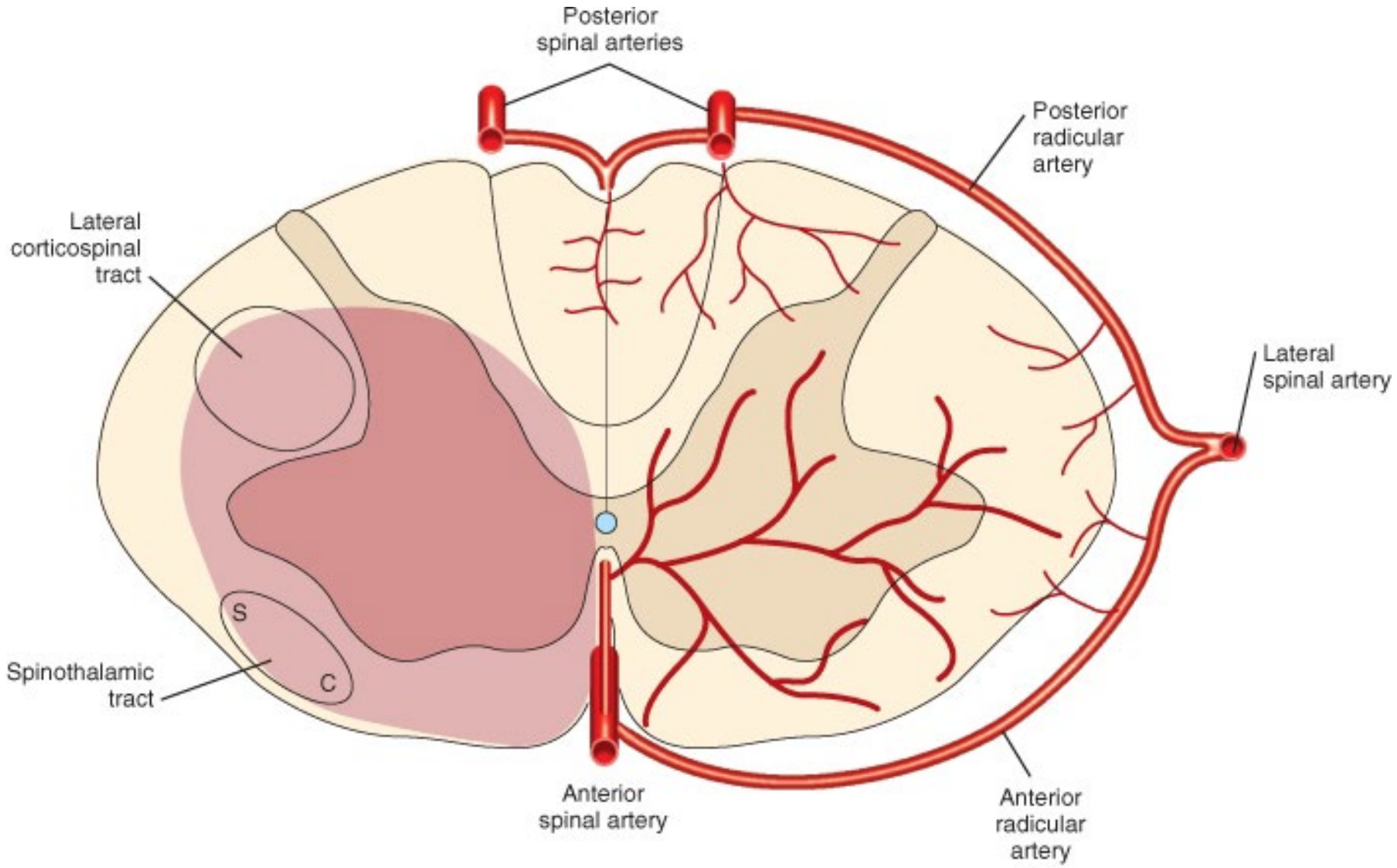
Lateral tract (90%) for limbs, ventral/anterior (10%) tract for trunk

Thick myelinated fibers are the most important subgroup, but make only 3% of the 1 million fibers

97% fibers send background tonic signals to the motor areas of the spinal cord



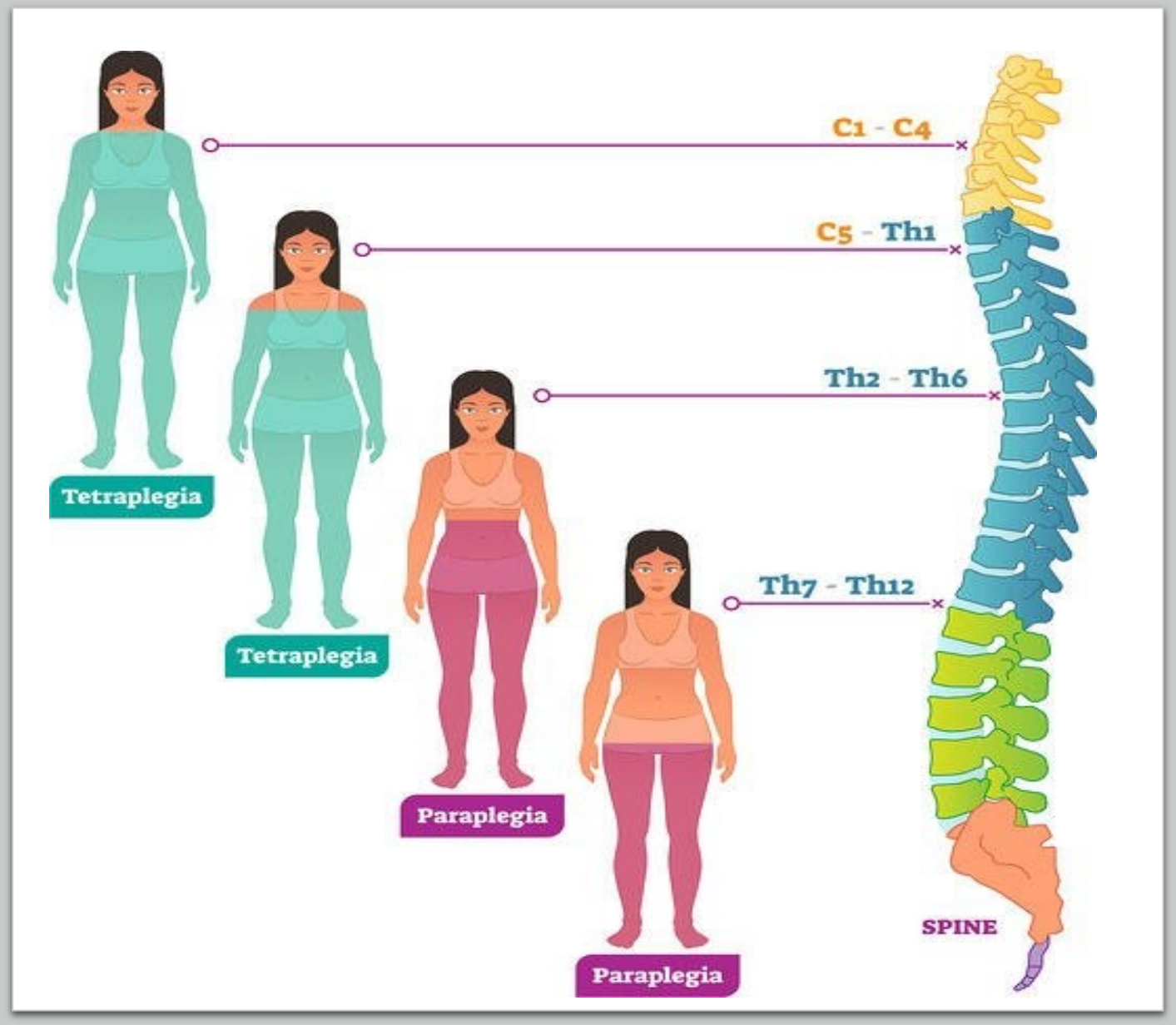
Spinal vasculature



http://www.usmle-forums.com

Spinal levels in “nutshell”

- Paraplegia: lesion caudal to 1. thoracic nerve
- Tetraplegia: lesion cranial to 1. thoracic nerve
- Breathing deficiency: Lesion at the level of cervical nerves



https://blog.madeformovement.com/

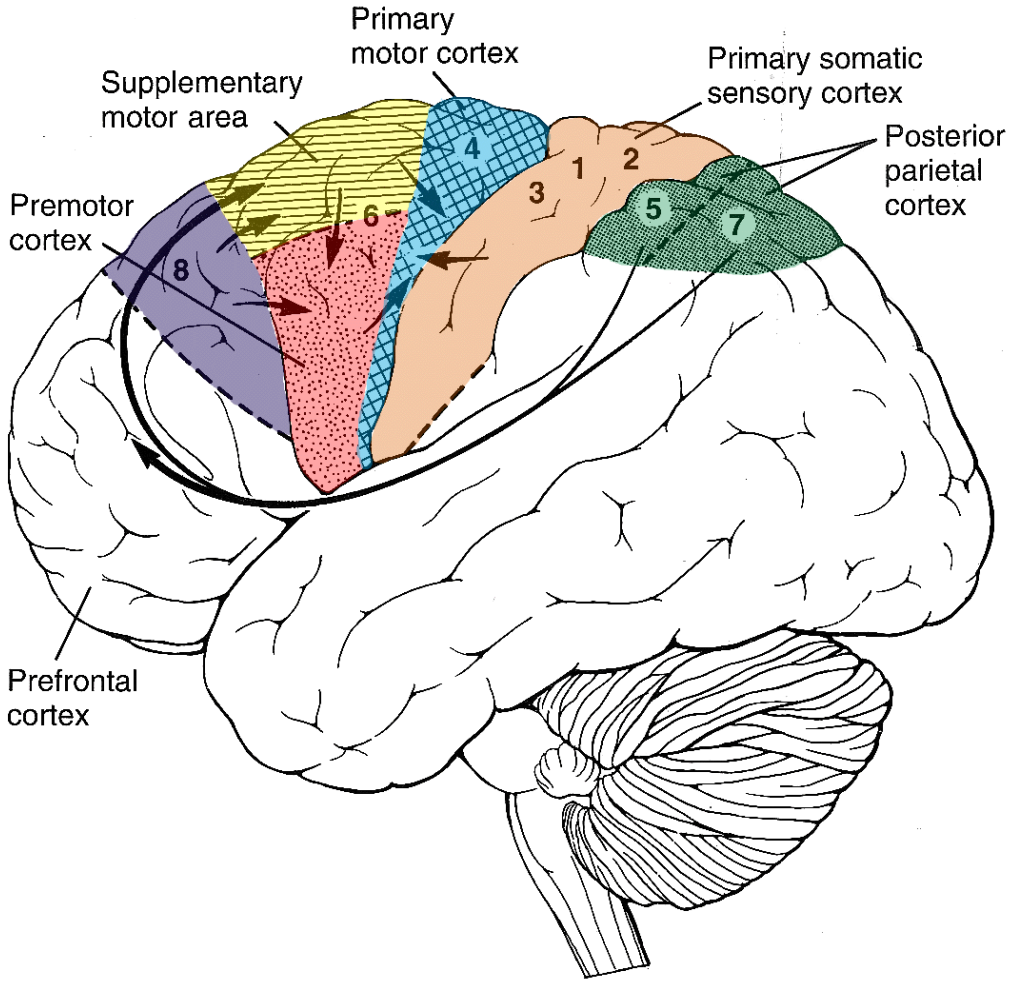
Motor control

- Motor cortex

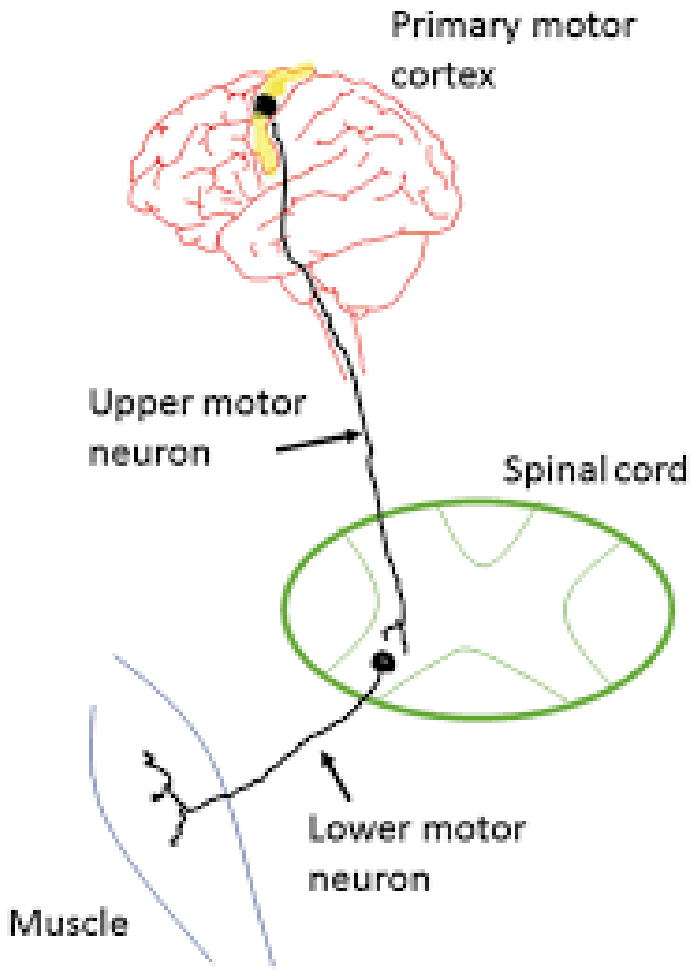
  Connections especially from the somatosensory cortex, but also form other brain areas (auditory visual, association areas)

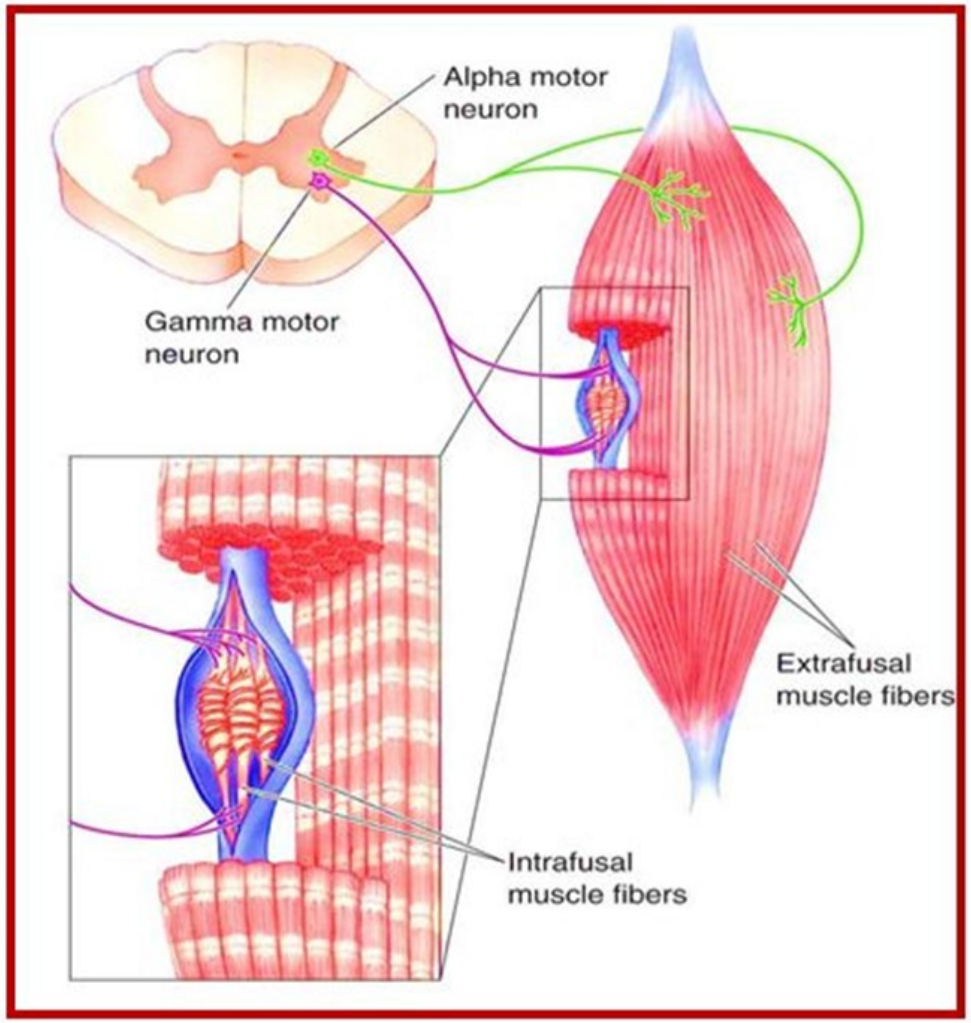
- Cerebellum and basal gaglia important in fine tuning of motor movements

- Brain stem: balance, motor functions in the head, stereotypical movements, breathing



Motor neurons have different functions at different levels





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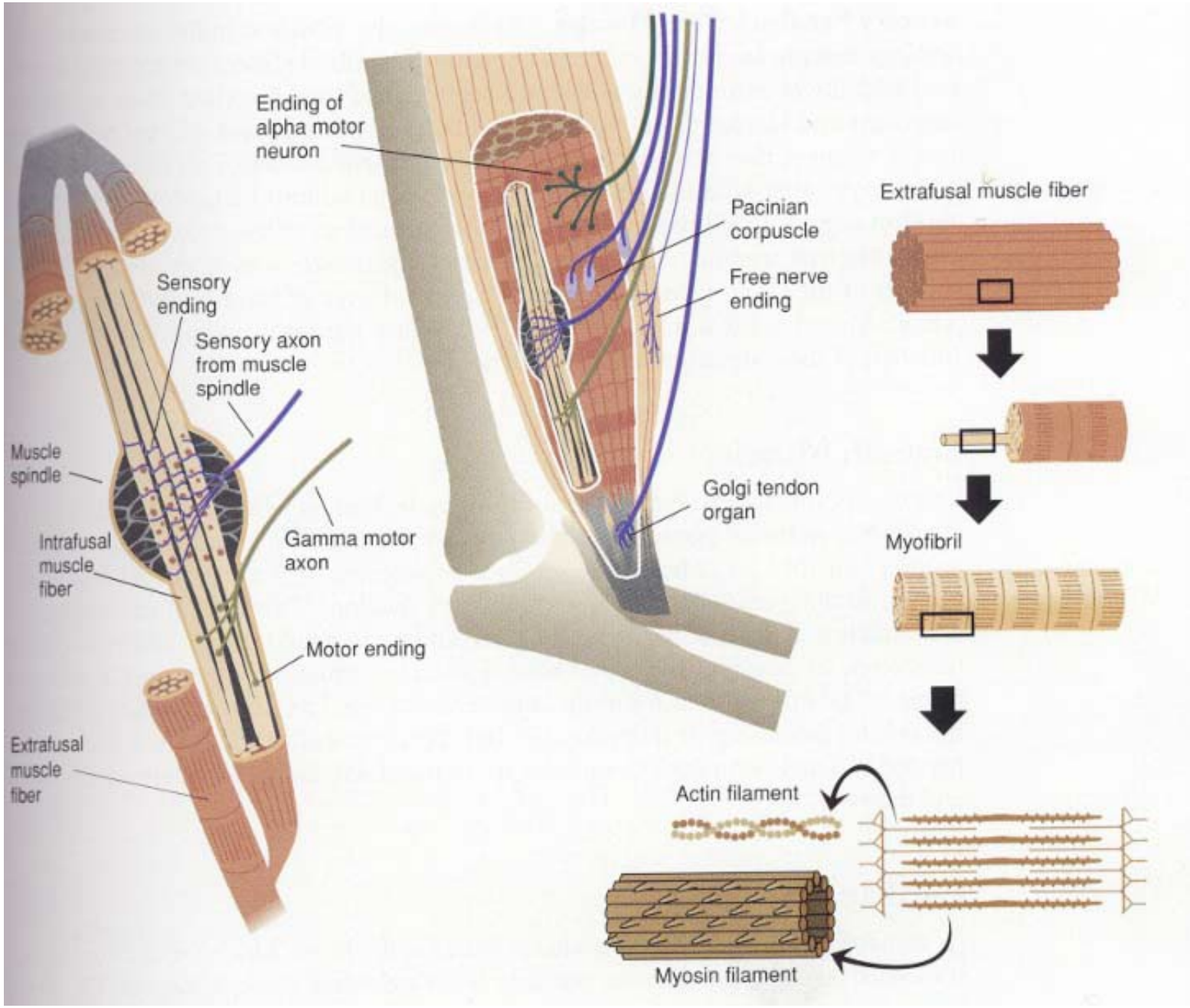
Feedback from the sensory system helps in controlling muscle contractions

Motor command → muscle contraction →

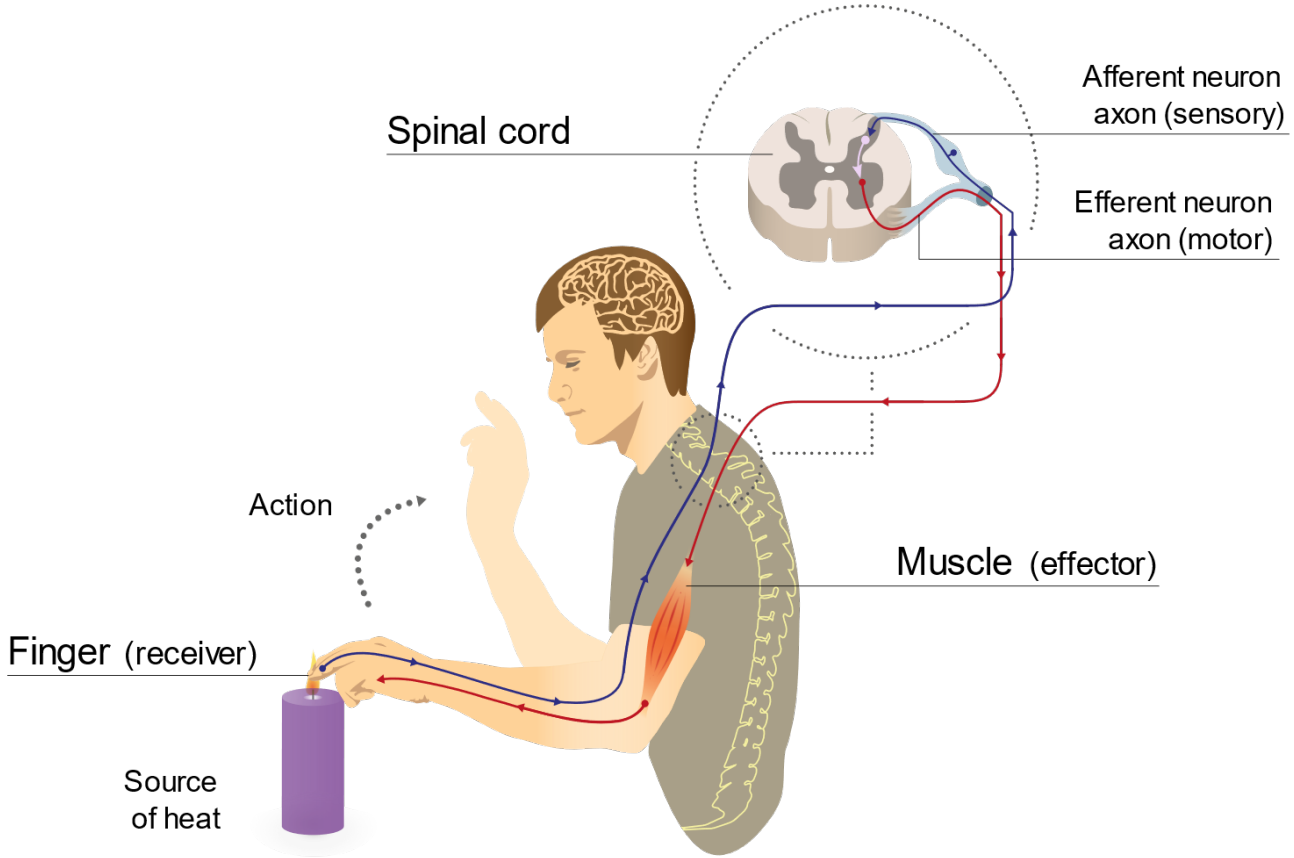
Sensory signals from muscle spindle, tendons and surrounding skin



nawrot.psych.ndsu.nodak.edu/Courses/Psych465.S.02/Movement/Fig.%208-1.jpg

Reflexes

- Important for both voluntary and involuntary movements
- Usually results in muscle contractions
- Purpose:
    - Smoother movements
    - Protective reflexes
    - Position and gait (“spinal cat”)



Wikipedia

Lesion of upper vs. lower motoneuron

Upper

- Muscle weakness
- Spasticity
- Exaggerated reflexes
- Positive Babinski sign
- Voluntary, fine movements are missing

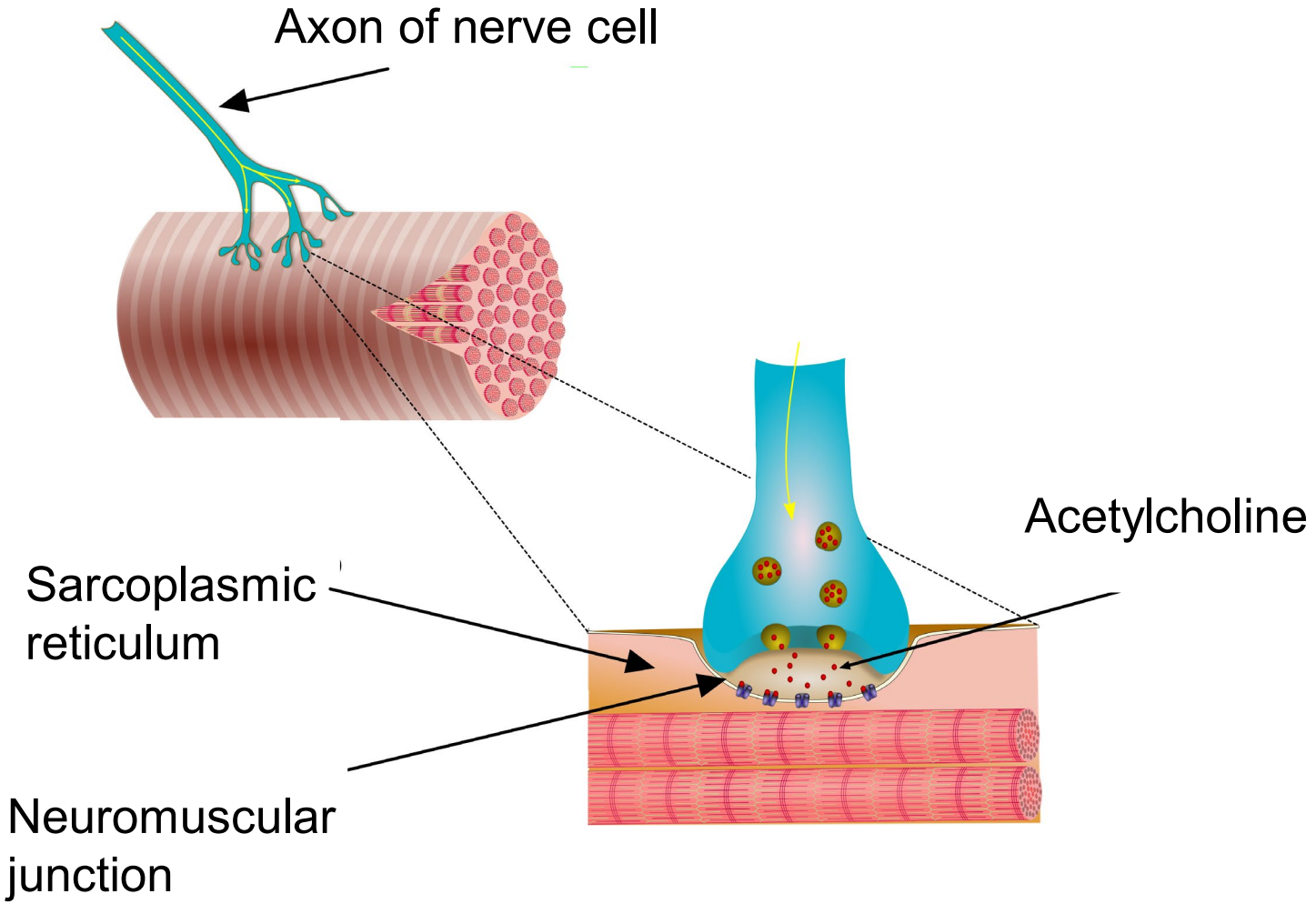
Lower

- Muscle weakness
- Decreased muscle tone
- Missing reflexes
- Fasciculations
- Muscle atrophy

Diseases of motor unit

Usually cause muscle weakness and muscle atrophy

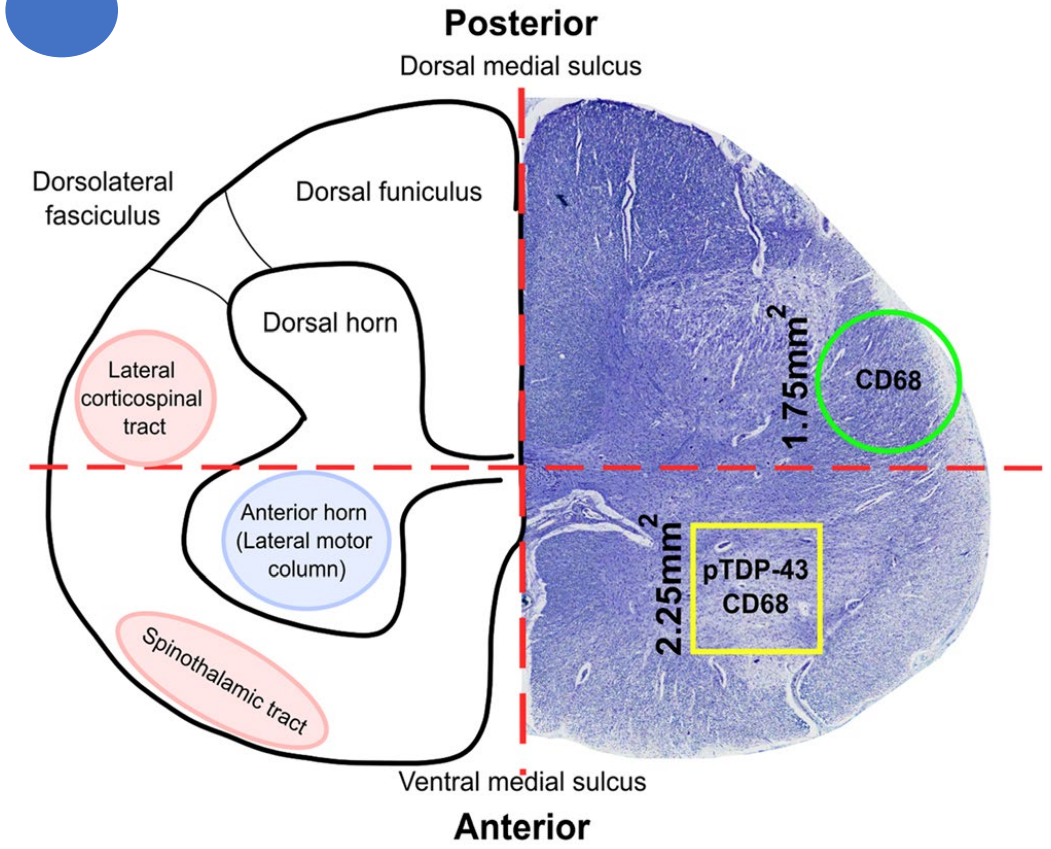
Can target the nerve cell, neuromuscular junction, or muscle cell →
~ different symptoms



solunetti.fi

Diseases of peripheral nervous system

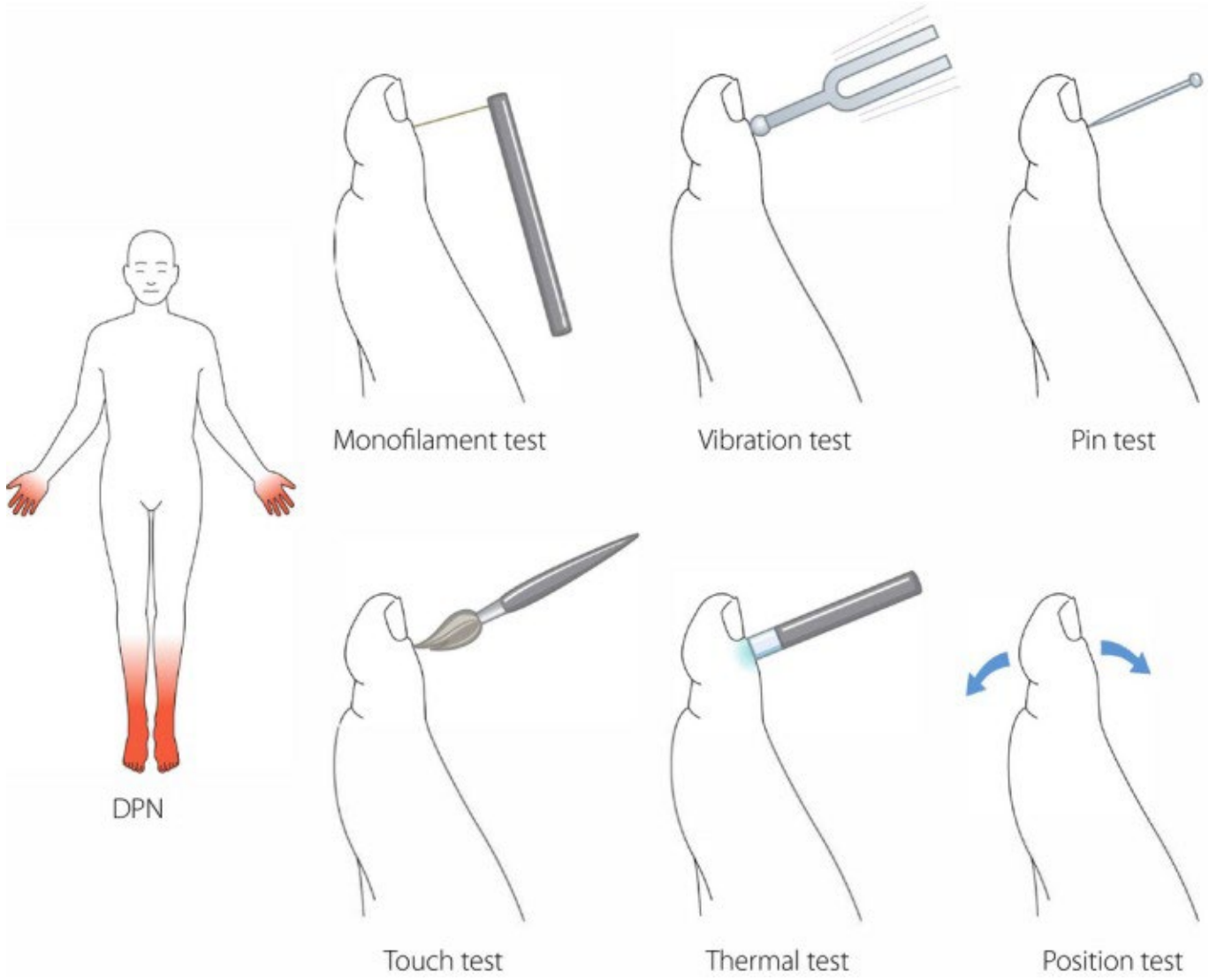
- Amyotrophic lateral sclerosis, ALS
- Premature death of upper and lower motor neurons
- The lateral columns of the spinal cord are scarred
- Familial (rare) ja sporadic form
- Sensory neurons are preserved



Nolan e t al. 2020

Polyneuropathy

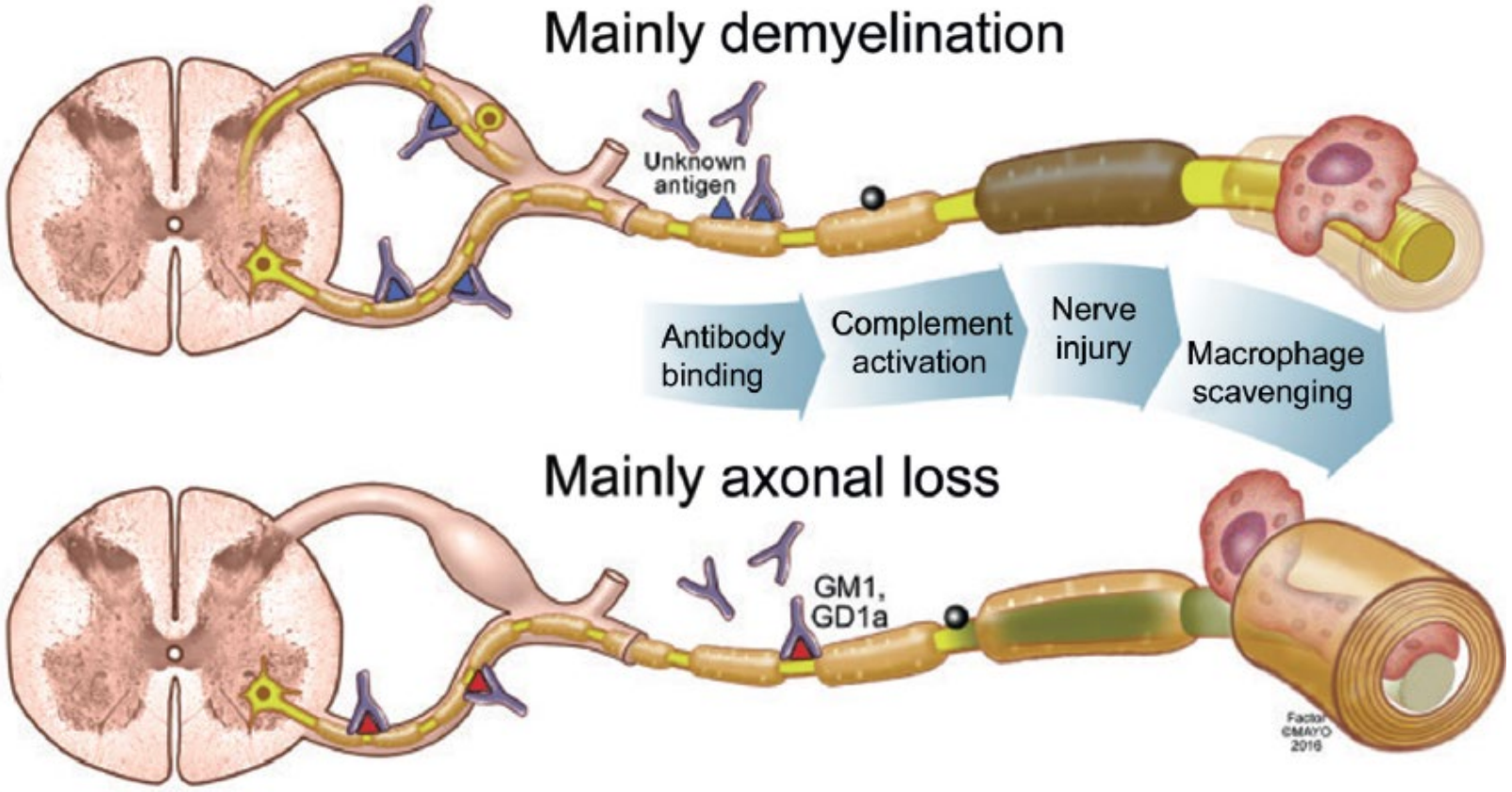
- Affects usually both the motor and sensory neurons
- Often symmetric syptoms: tingling, numbness, weak reflexes
- Several predisposing factors: alcohol, metabolic diseases (diabetes, kidney insuficiency, deficiency of B12 vitamin, celiac disease, thyroid insufficiency), malignancies



Gylfadottir et al. 2019

Polyradiculitis

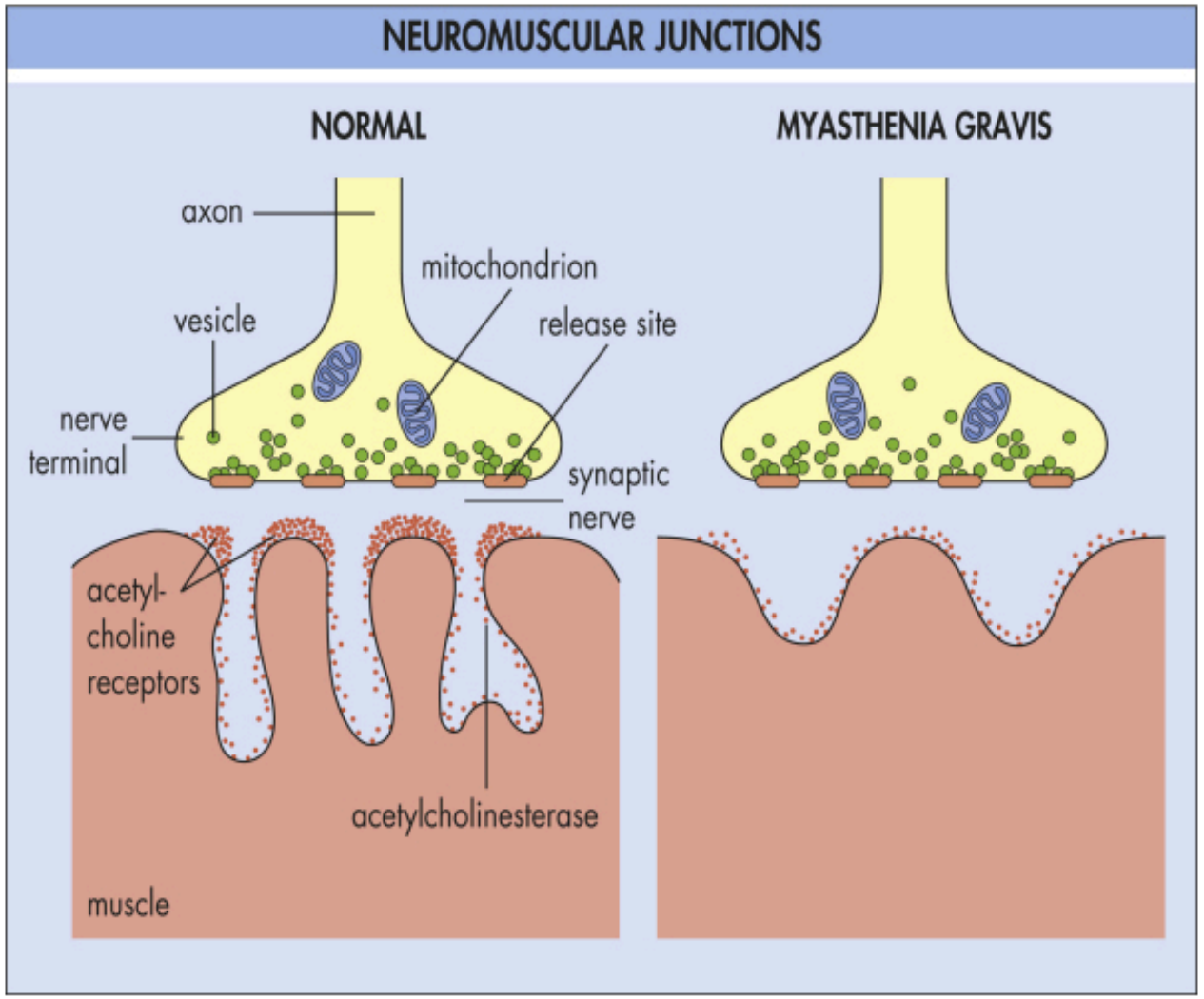
- Often starts with tingling, followed by progressive muscle weakness, can progress within hours to breathing muscles
- Typically occurs after respiratory or gastrointestinal infection: foreign antigens stimulate formation of antibodies that attack own nerve cells



Wijdicks et al. 2017

Myastenia gravis

- Autoimmune disease which affects the neuromuscular junctions in voluntary muscles
- Abnormal muscle weakness and fatigue
- 80% have antibodies directed to postsynaptic acetylcholine receptors in neuromuscular junctions



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