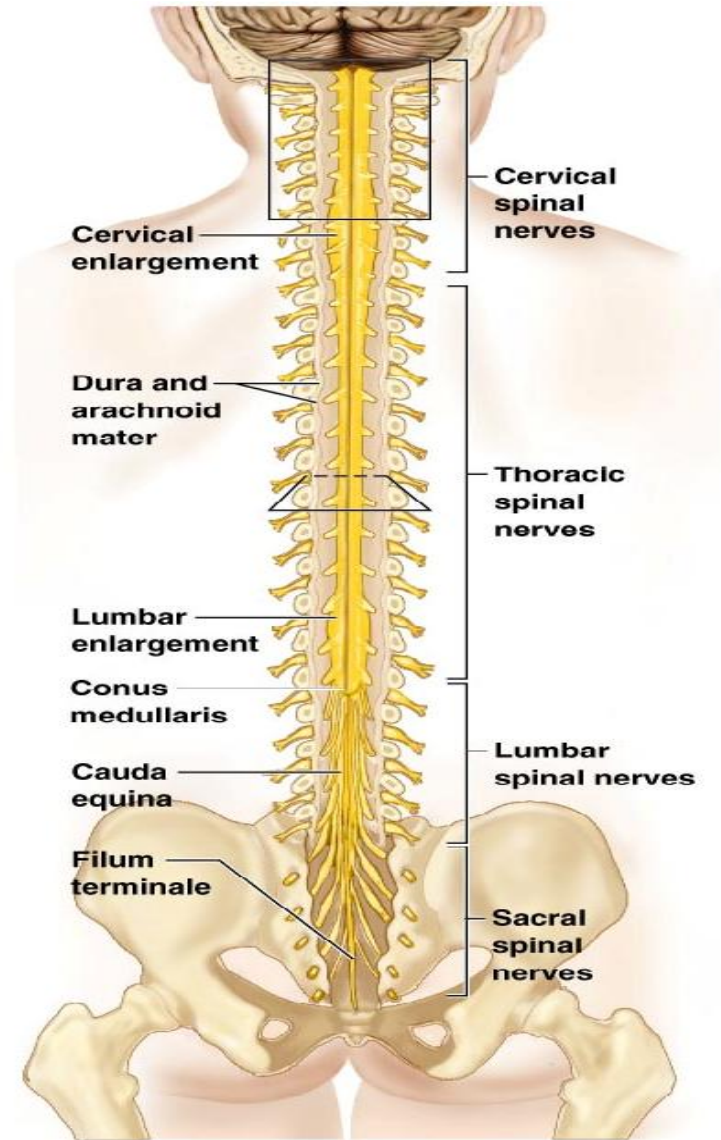


# Spinal Cord



**(a)**

Figure 12.29a

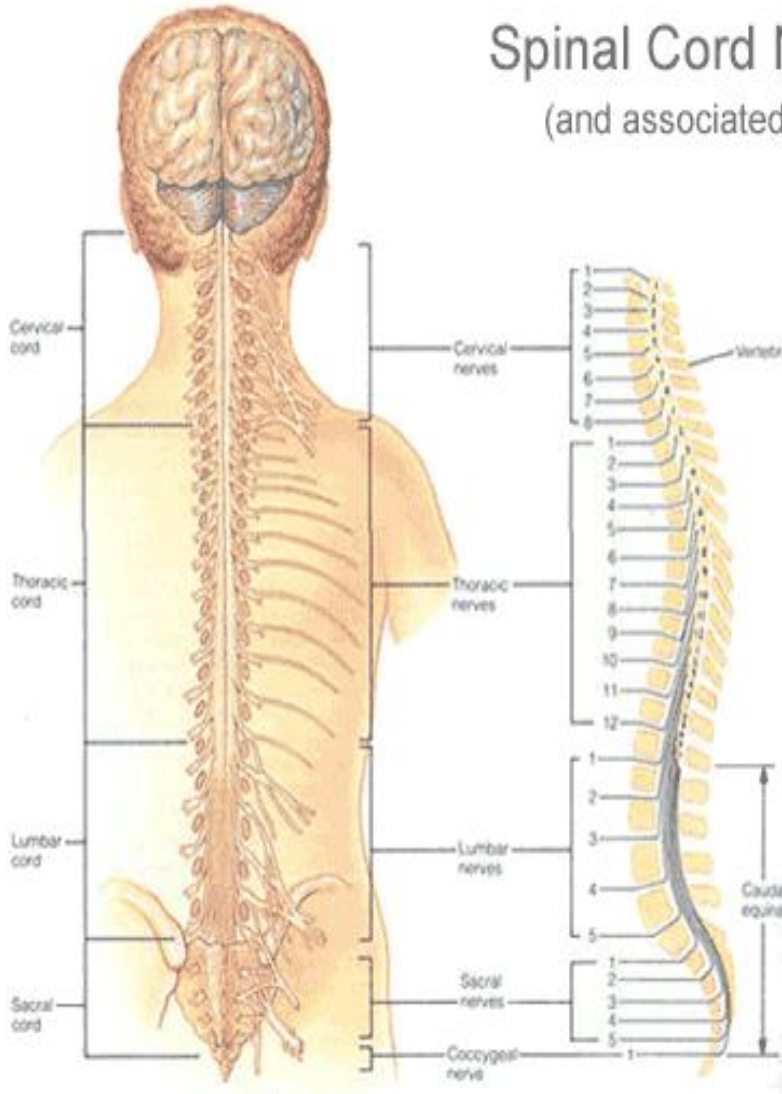
**There are 31 spinal cord segments:**

- 8 cervical segments
- 12 thoracic segments
- 5 lumbar segments
- 5 sacral segments
- 1 coccygeal segment

**There are two regions where the spinal cord enlarges:**

•**Cervical enlargement** - corresponds roughly to the brachial plexus nerves, which innervate the upper limb. It includes spinal cord segments from about C4 to T1. The vertebral levels of the enlargement are roughly the same (C4 to T1).

•**Lumbosacral enlargement** - corresponds to the lumbosacral plexus nerves, which innervate the lower limb. It comprises the spinal cord segments from L2 to S3, and is found about the vertebral levels of T9 to T12.



# Spinal Cord Nerve Anatomy

(and associated spinal cord injuries)

**CERVICAL**  
C4 - C6 - **Tetraplegia (Quadriplegia)**  
paralysis of arms and legs

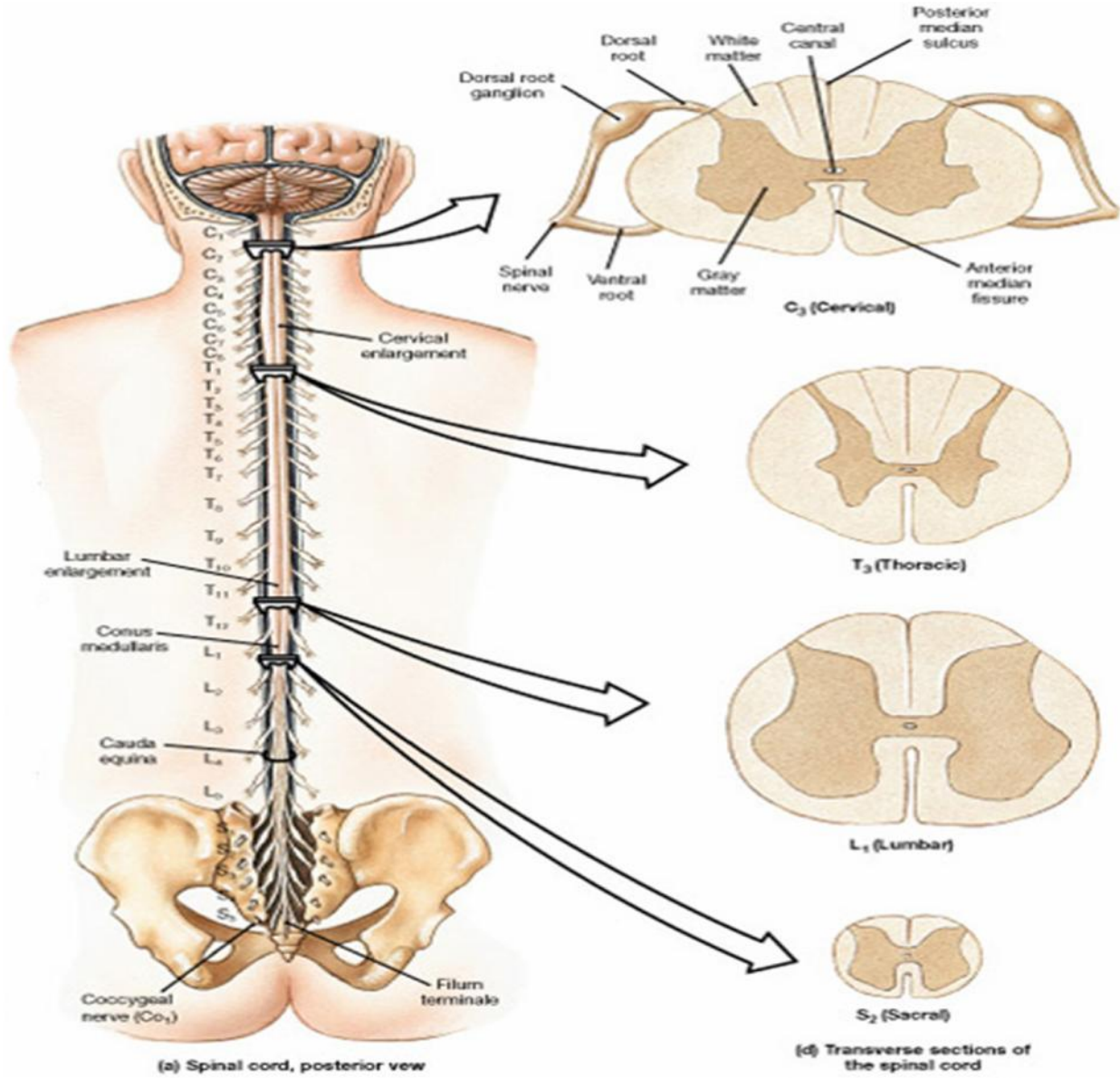
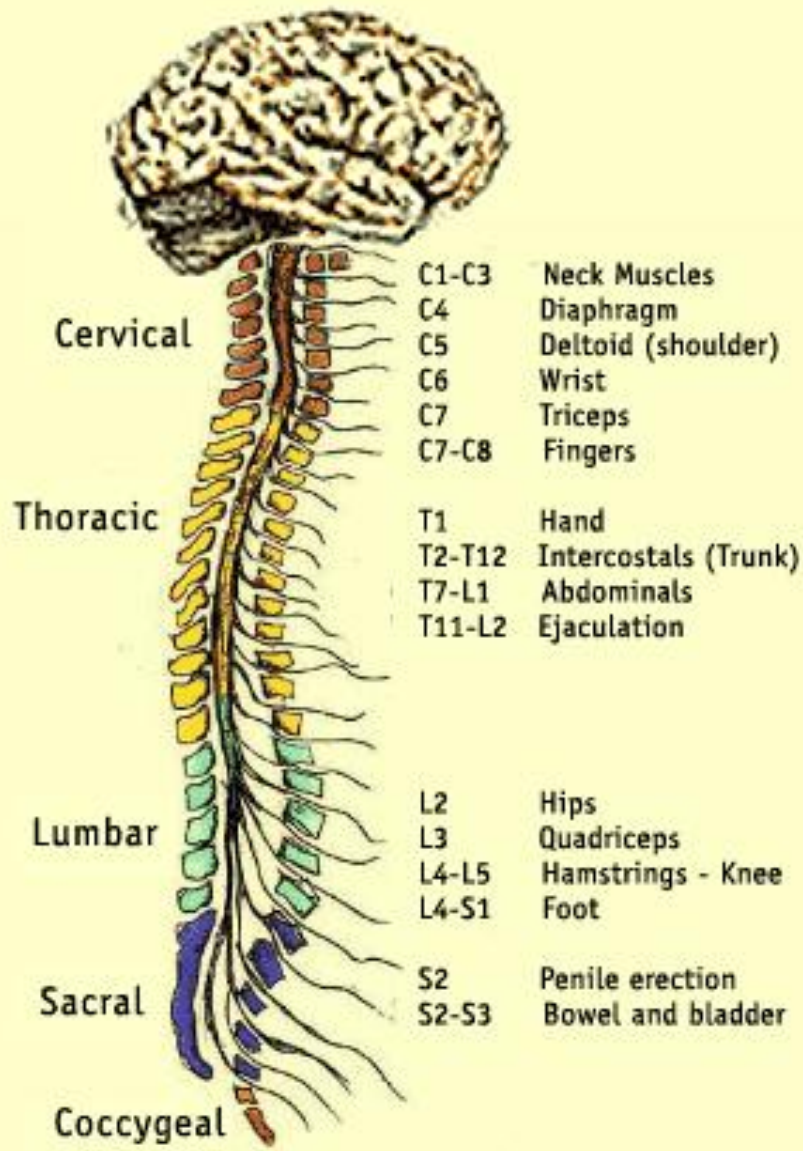


**THORACIC**  
T1 and below - **Paraplegia** occurs when the spinal cord is damaged below the cervical spine. It may be injured in the thoracic spine (mid-back), or lumbar (low back).

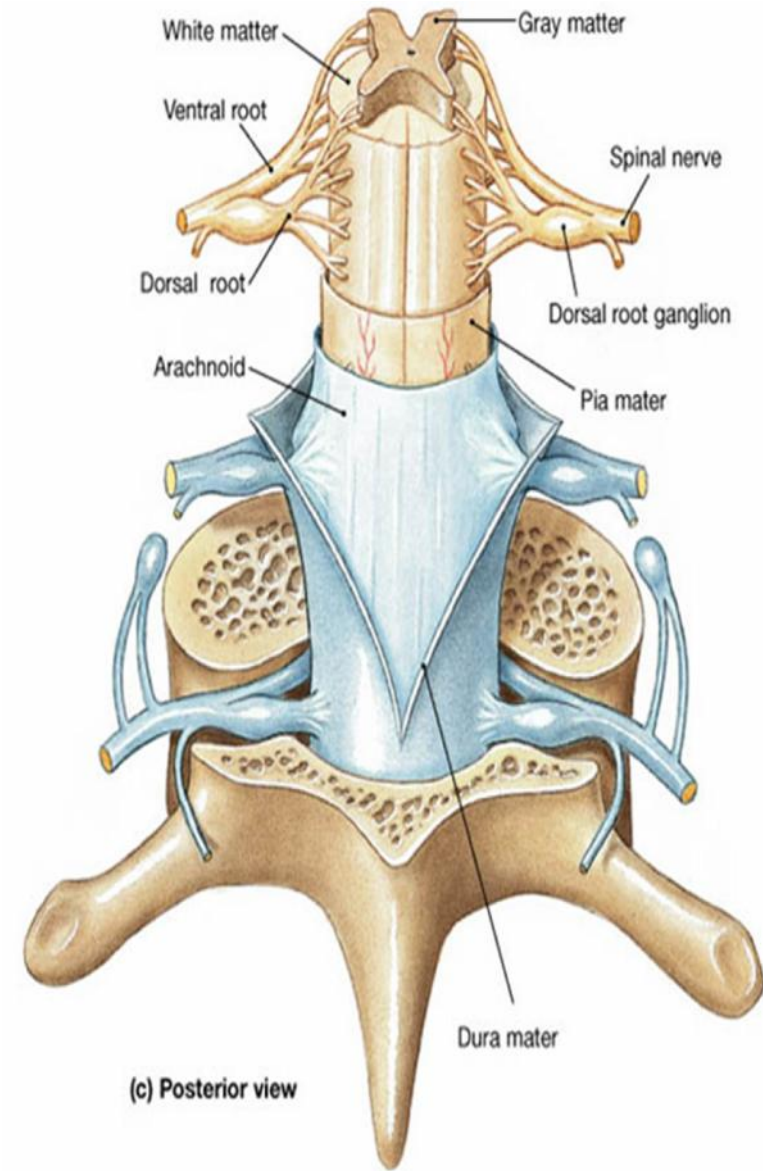
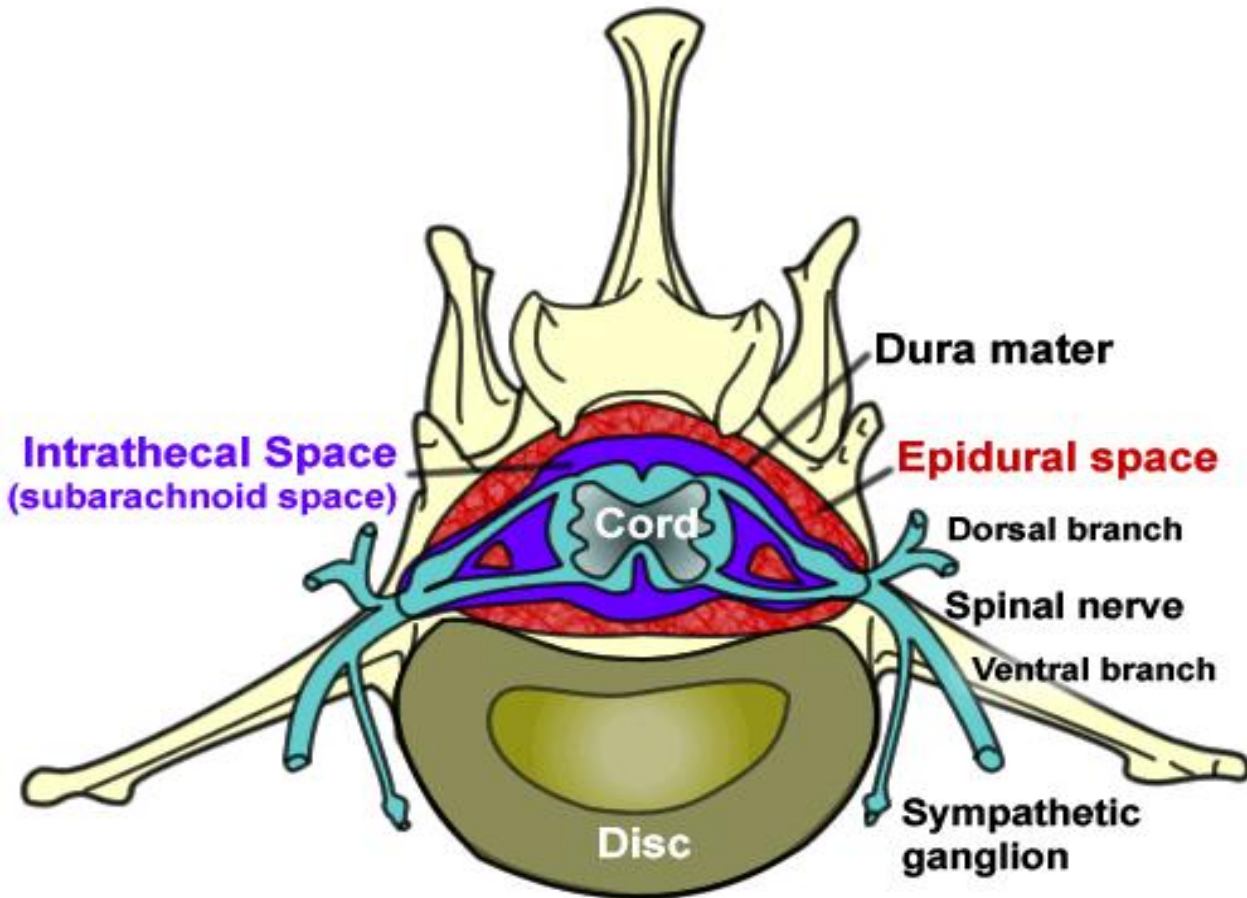


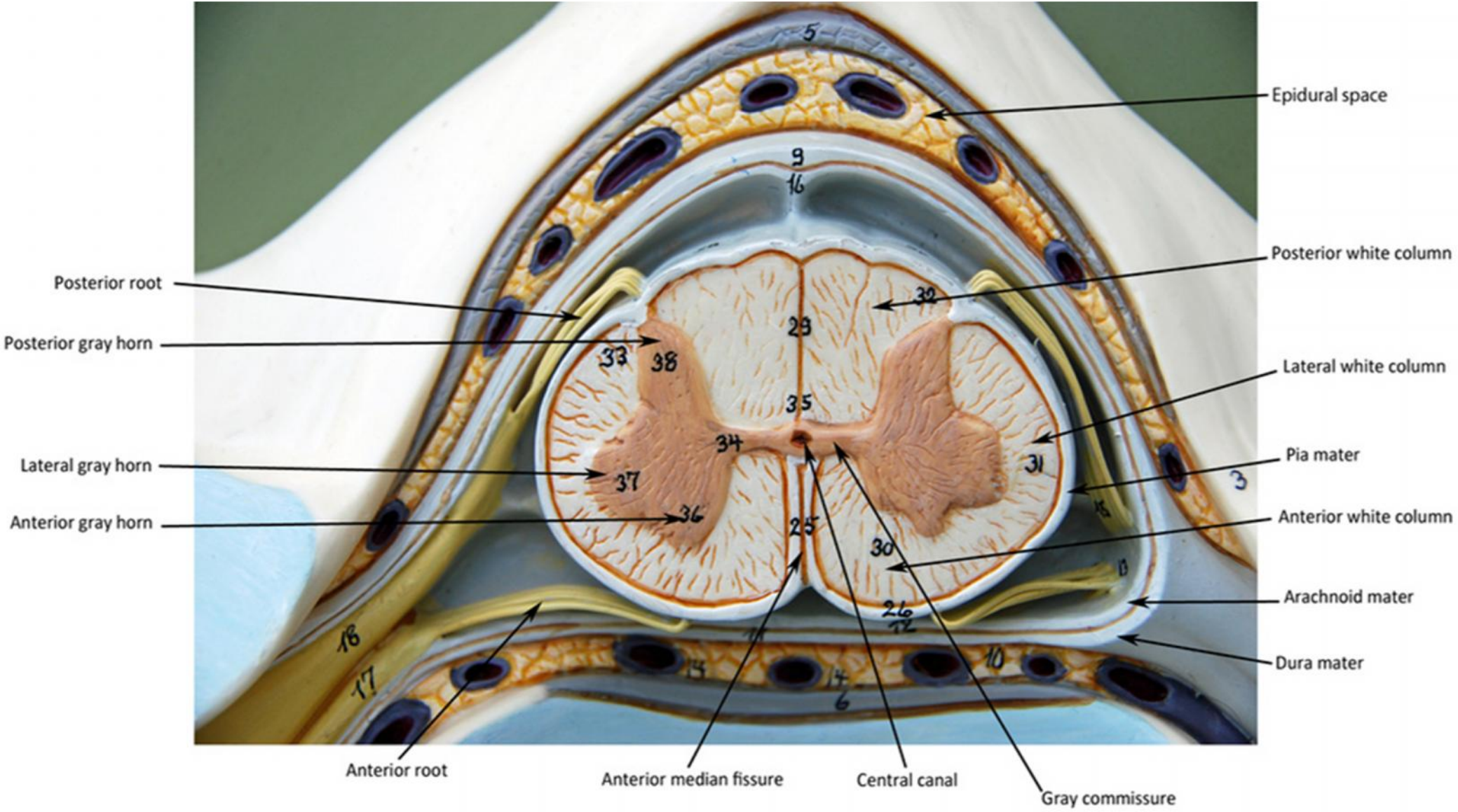
**LUMBAR SACRAL COCCYX**  
The spinal cord ends at L2, but SC1 injuries are possible below the end of the spinal cord. This area is called the cauda equina. The cauda equina is a bunch of spinal nerves resembling a horse's tail.





# SPINAL CORD ANATOMY





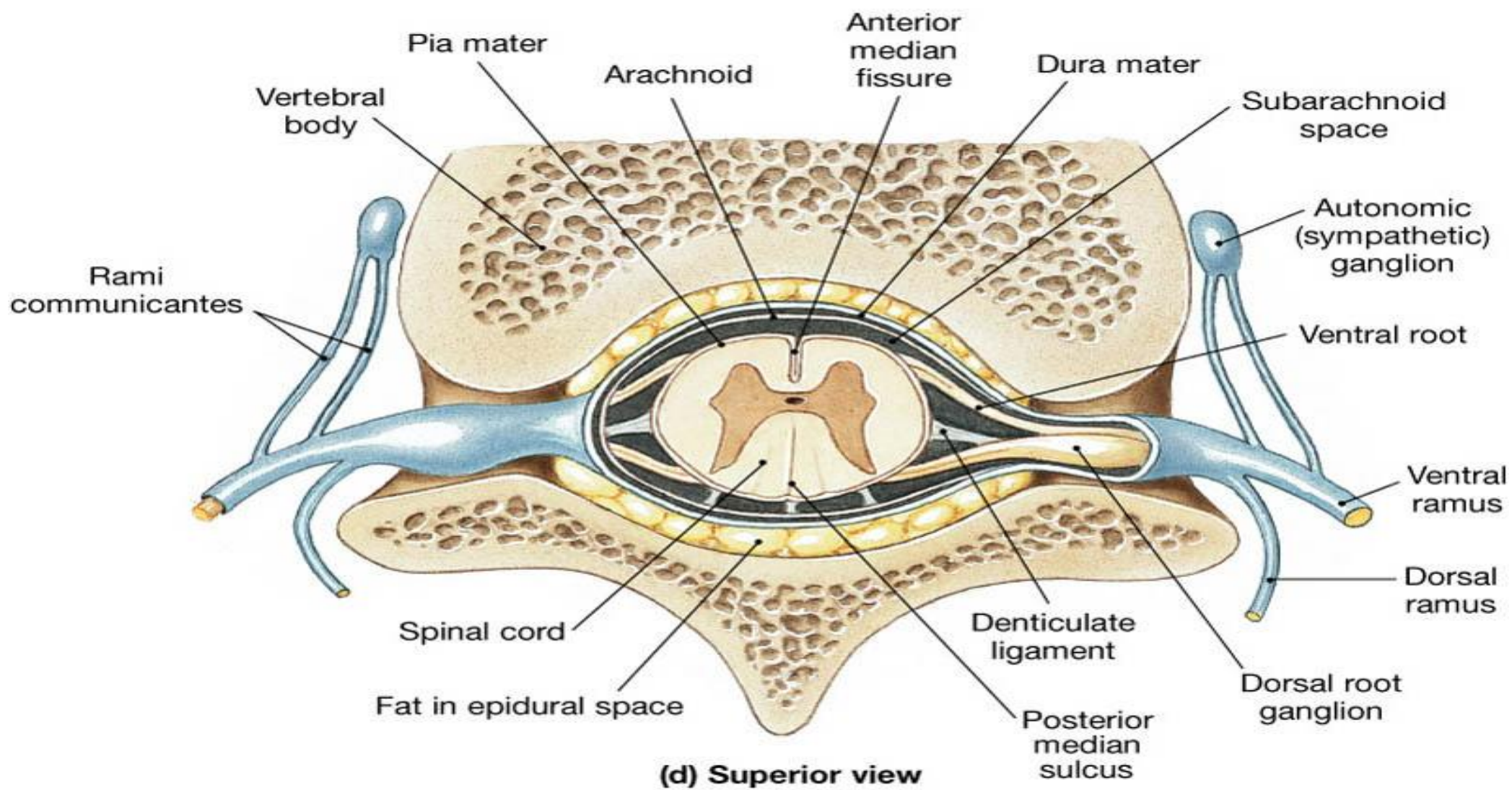
5  
9  
16  
Epidural space

Posterior root  
Posterior gray horn  
Lateral gray horn  
Anterior gray horn

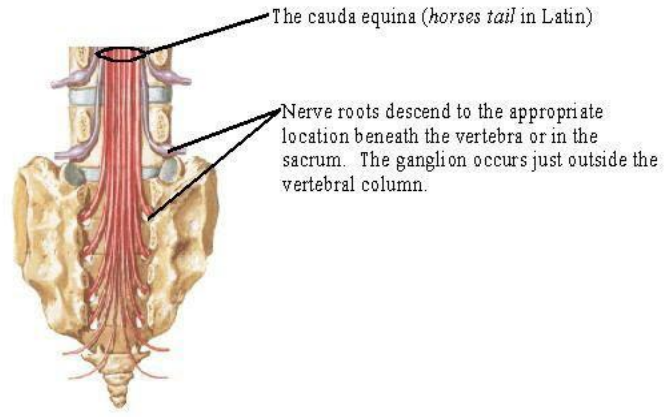
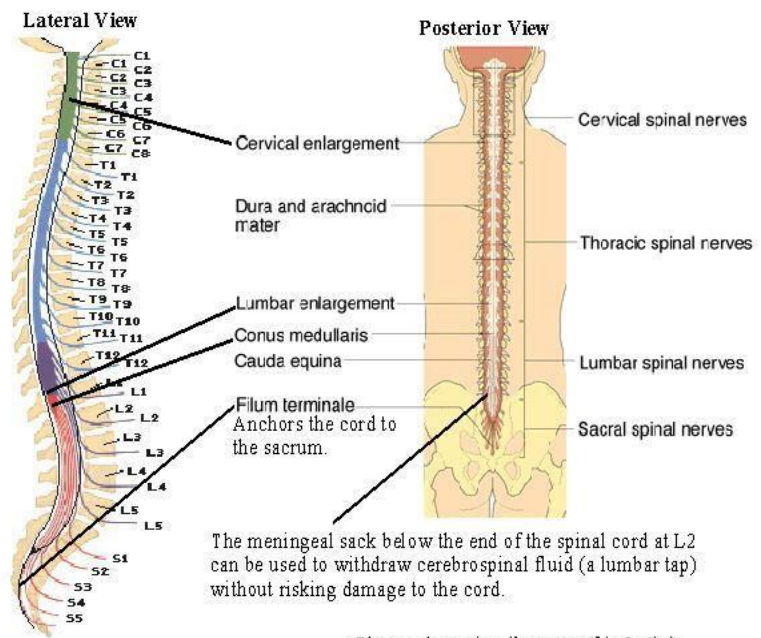
Posterior white column  
Lateral white column  
Pia mater  
Anterior white column  
Arachnoid mater  
Dura mater

16  
17  
Anterior root  
Anterior median fissure  
Central canal  
Gray commissure

33  
38  
37  
36  
23  
35  
34  
25  
30  
30  
26  
12  
31



# The Spinal Cord and Spinal Nerves

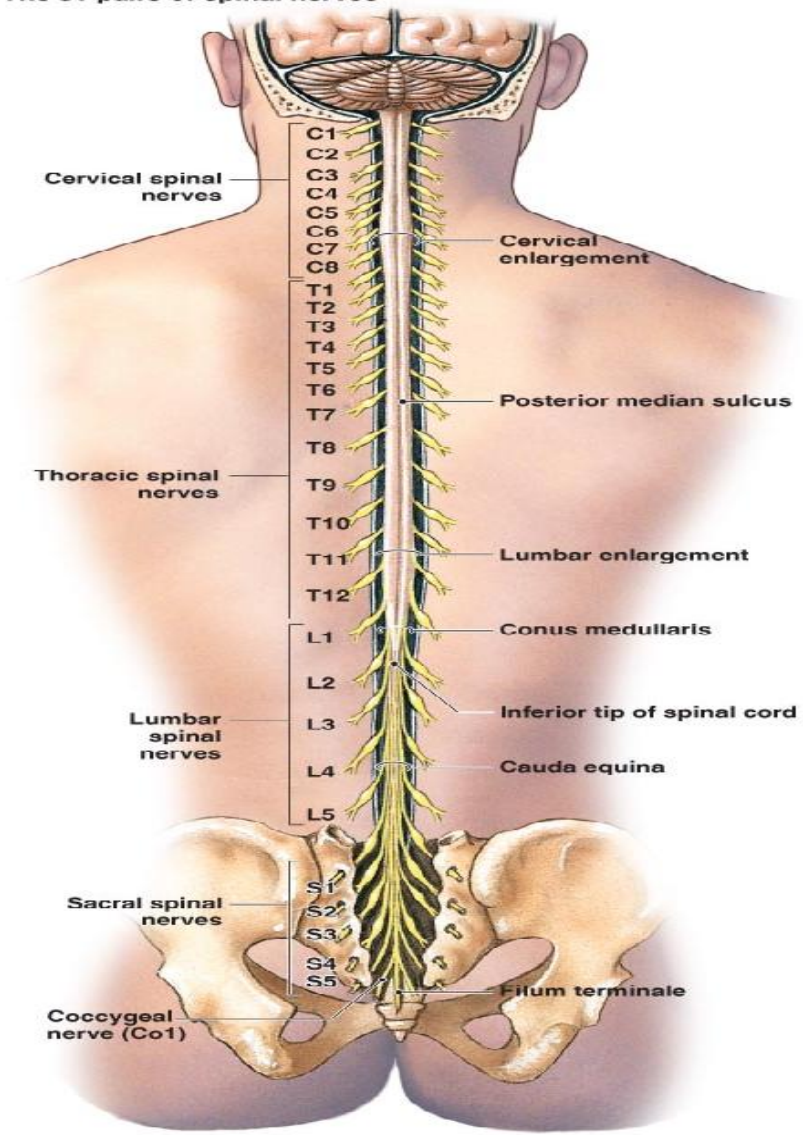


**Conus medullaris** – terminal portion of the spinal cord

**Filum terminale** – fibrous extension of the pia mater; anchors the spinal cord to the coccyx

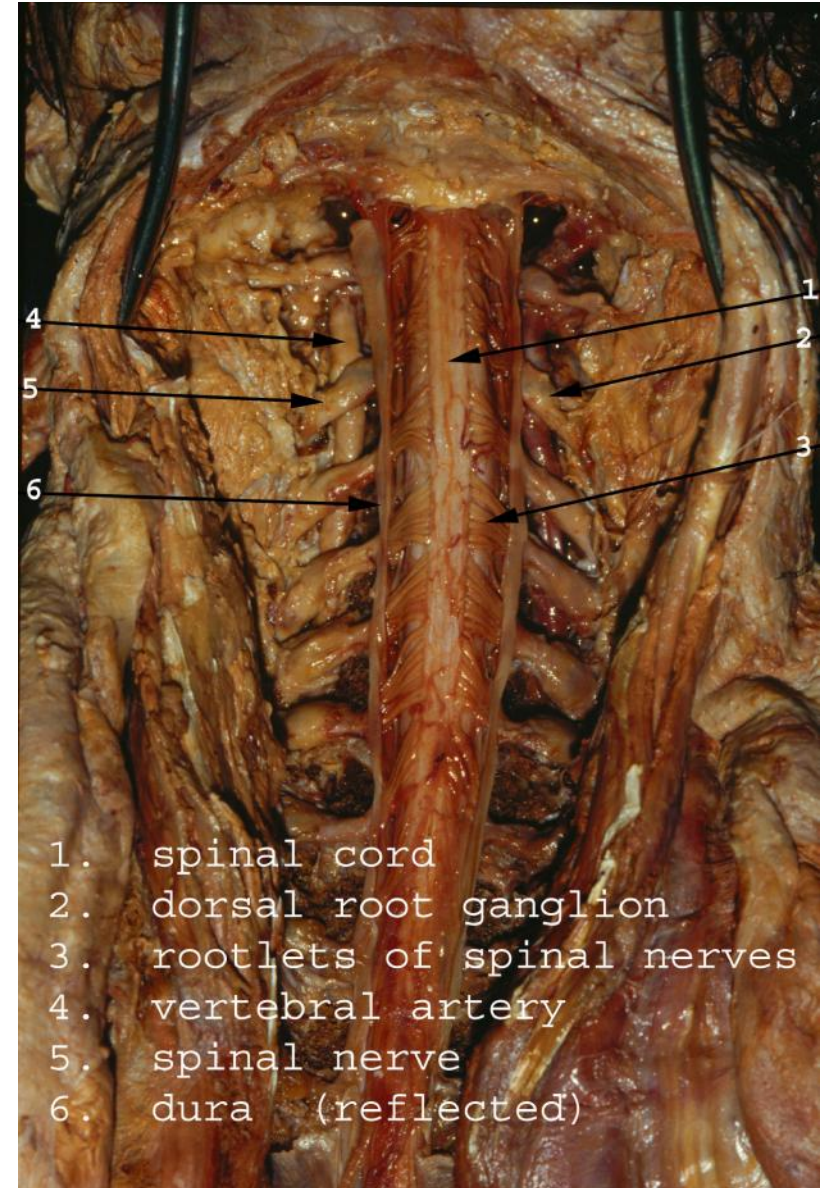
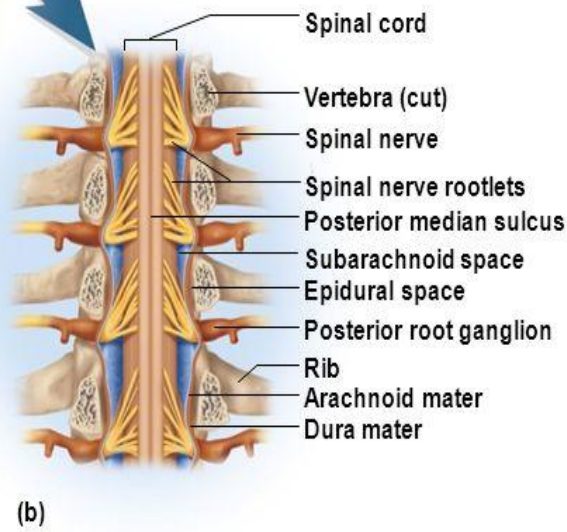
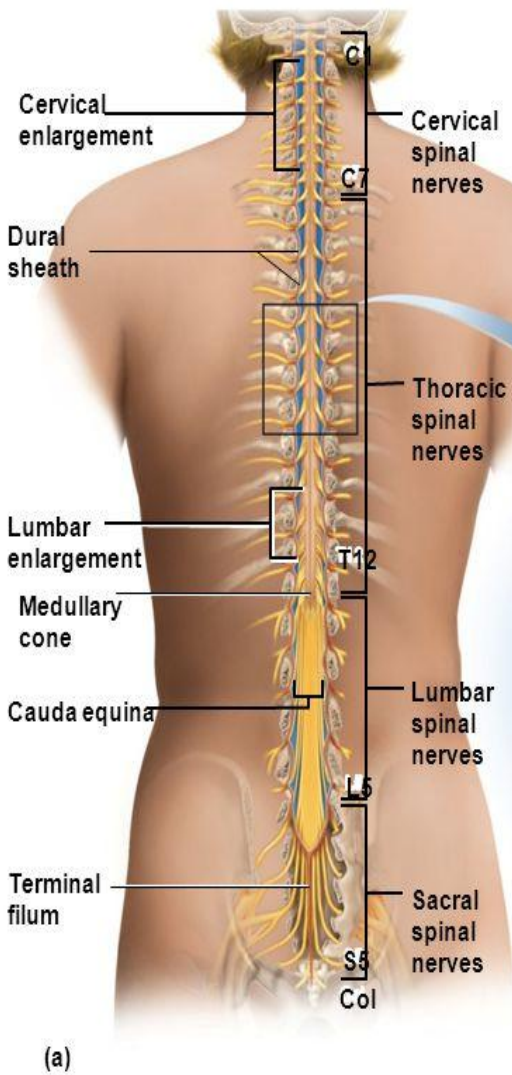
**Denticulate ligaments** – delicate shelves of pia mater; attach the spinal cord to the vertebrae

The 31 pairs of spinal nerves





# Anatomy of Spinal Cord



**ganglion** - a collection of cell bodies located outside the Central Nervous System. The spinal ganglia or dorsal root ganglia contain the cell bodies of sensory neurons entering the cord at that region.

**nerve** - a group of fibers (axons) *outside* the CNS. The spinal nerves contain the fibers of the sensory and motor neurons. A nerve does not contain cell bodies. They are located in the ganglion (sensory) or in the gray matter (motor).

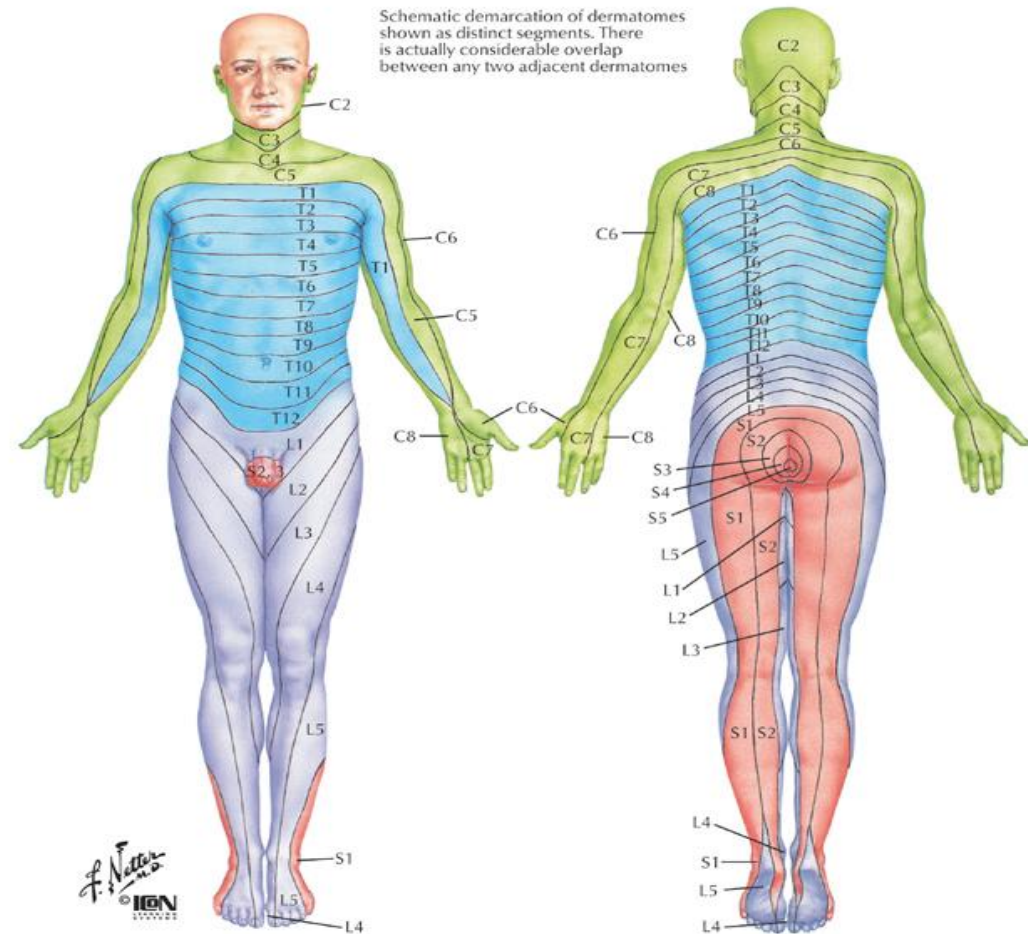
**tract** - a group of fibers *inside* the CNS. The spinal tracts carry information up or down the spinal cord, to or from the brain. Tracts within the brain carry information from one place to another within the brain. Tracts are always part of white matter.

**gray matter** - an area of unmyelinated neurons where cell bodies and synapses occur. In the spinal cord the synapses between sensory and motor and interneurons occurs in the gray matter. The cell bodies of the interneurons and motor neurons also are found in the gray matter.

**white matter** - an area of myelinated fiber tracts. Myelination in the CNS differs from that in nerves.

The **dermatomes** are somatic or musculocutaneous areas served by fibers from specific spinal nerves.

**Referred pain** is caused when the sensory fibers from an internal organ enter the spinal cord in the same root as fibers from a dermatome. The brain is poor at interpreting visceral pain and instead interprets it as pain from the somatic area of



**Levels of principal dermatomes**

- C5 Clavicles
- C5, 6, 7 Lateral parts of upper limbs
- C8, T1 Medial sides of upper limbs
- C6 Thumb
- C6, 7, 8 Hand
- C8 Ring and little fingers
- T4 Level of nipples

**T10**

- T10 Level of umbilicus
- T12 Inguinal or groin regions
- L1, 2, 3, 4 Anterior and inner surfaces of lower limbs
- L4, 5, S1 Foot
- L4 Medial side of great toe
- S1, 2, L5 Posterior and outer surfaces of lower limbs
- S1 Lateral margin of foot and little toe
- S2, 3, 4 Perineum

**Cervical Plexus** - the **phrenic nerve** travels through the thorax to innervate the diaphragm.

### **Brachial Plexus** -

**Axillary nerve** - innervates the deltoid muscle and shoulder, along with the posterior aspect of the upper arm.

Musculocutaneous nerve - innervates anterior skin of upper arm and elbow flexors. **Radial nerve** - innervates dorsal aspect of the arm and extensors of the elbow, wrist, and fingers, abduction of thumb.

**Median nerve** - innervates the middle elbow, wrist and finger flexors, adducts the thumb.

**Ulnar nerve** - innervates the medial aspect wrist and finger flexors.

**Celiac plexus or the solar plexus:** under the **aortic hiatus** of the diaphragm along with ganglia connected with the roots of the **celiac trunk** and **superior mesenteric artery**. Ganglia related to the celiac plexus consist of two celiac ganglia, a single superior mesenteric ganglion, and two aorti-corenal ganglia.

### **Lumbar Plexus**

**genitofemoral** - to the **external** genitalia

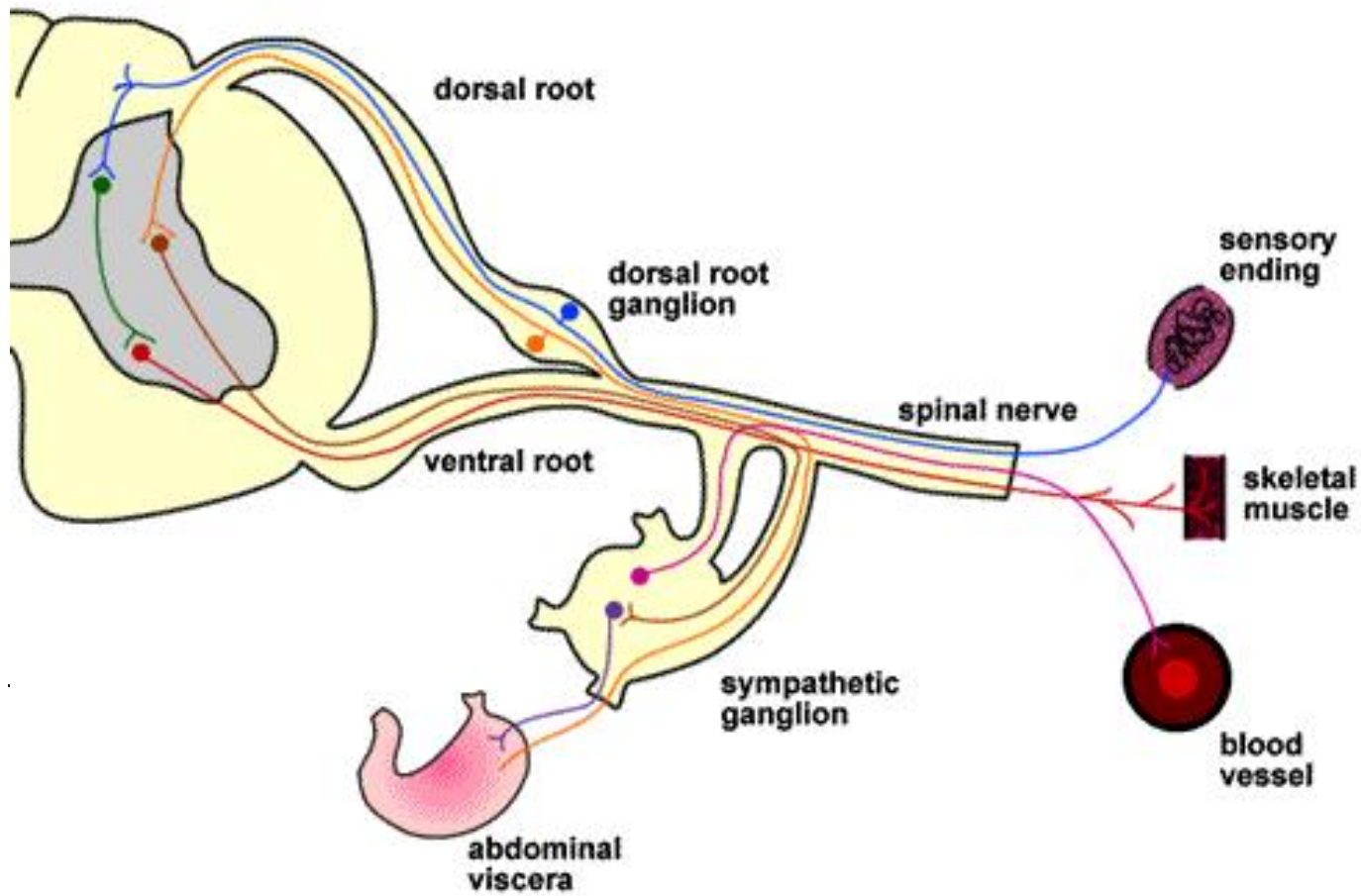
**obturator** - to the adductor muscles

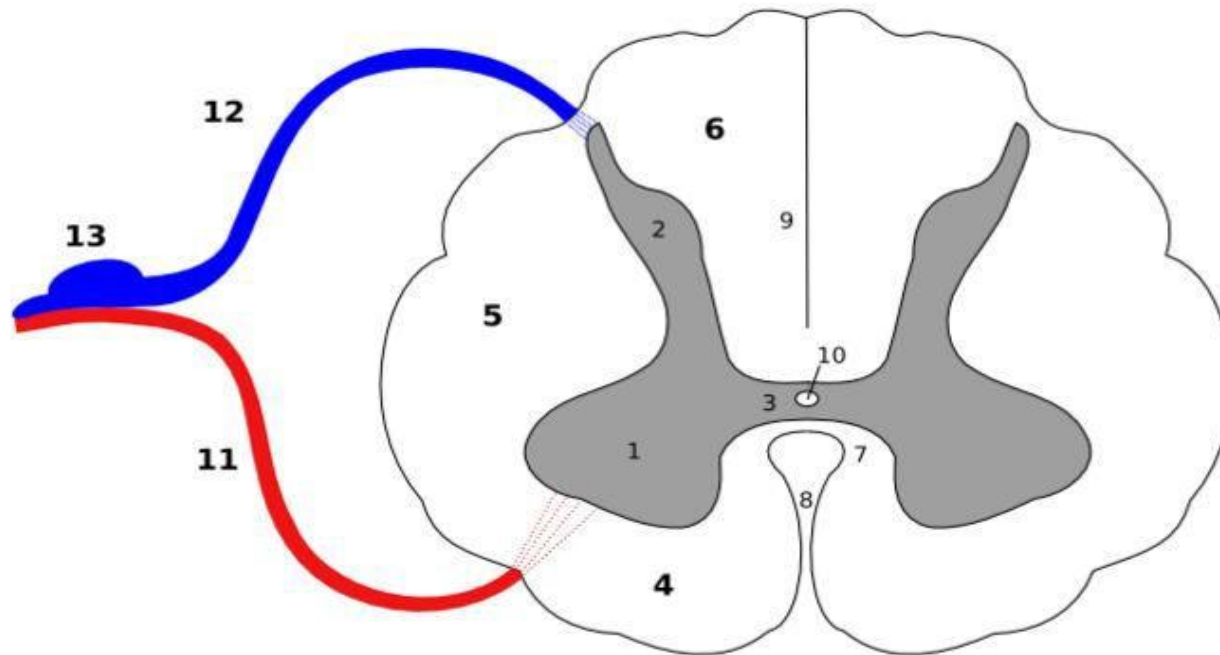
### **Sacral Plexus** –

contains fibers from the ventral rami of L<sub>4</sub> – S<sub>4</sub>.

The sciatic nerve is a major nerve of this plexus.

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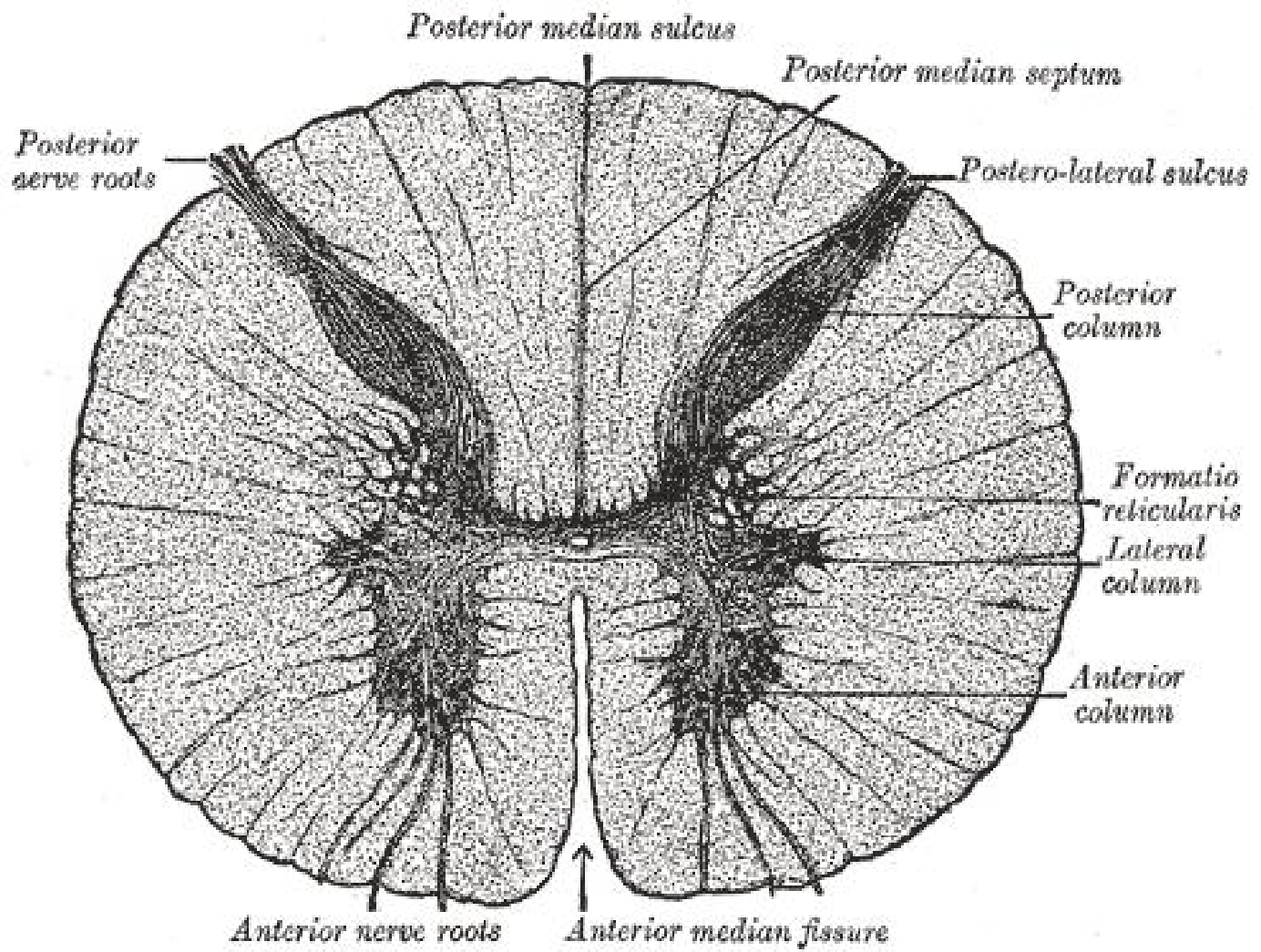
**Substantia grisea**

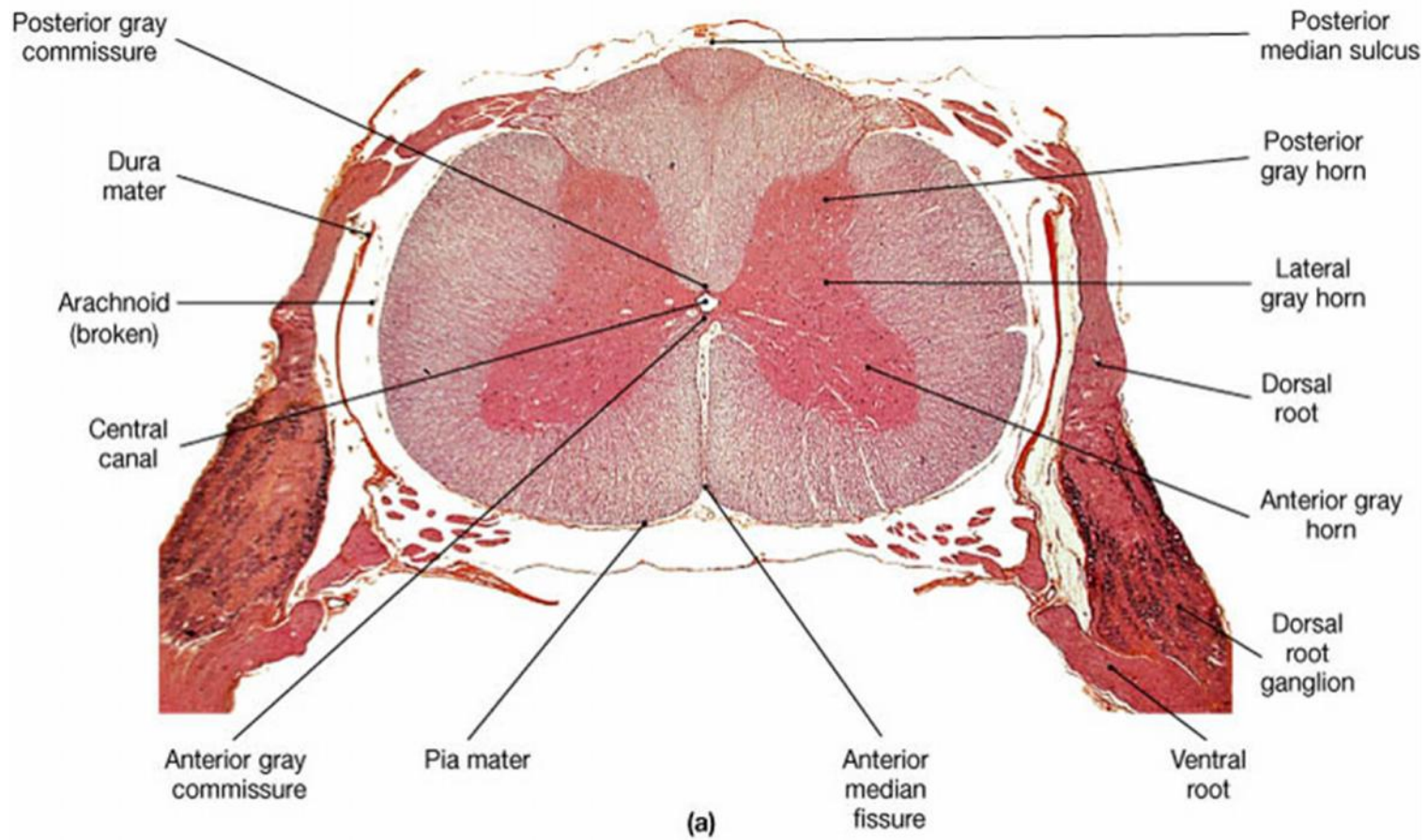
- 1. Cornu anterius
- 2. Cornu posterius
- 3. Commissura grisea

**Substantia alba**

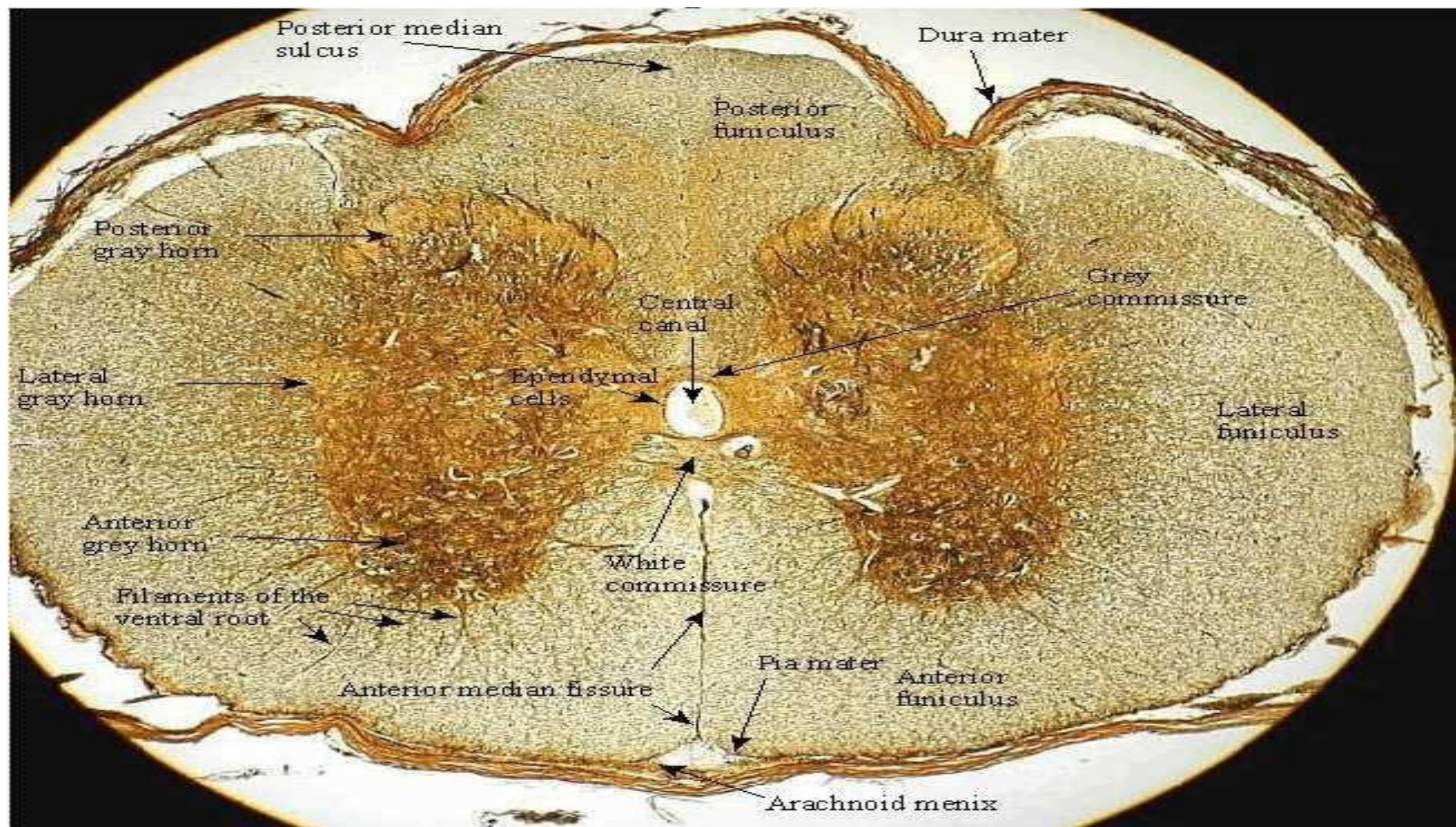
- 4. Funiculus anterior
- 5. Funiculus lateralis
- 6. Funiculus posterior
- 7. Commissura alba anterior
- 8. Fissura mediana anterior
- 9. Sulcus medianus posterior

- 10. Canalis centralis
- 11. Radix anterior
- 12. Radix posterior
- 13. Ganglion sensorium nervi spinalis



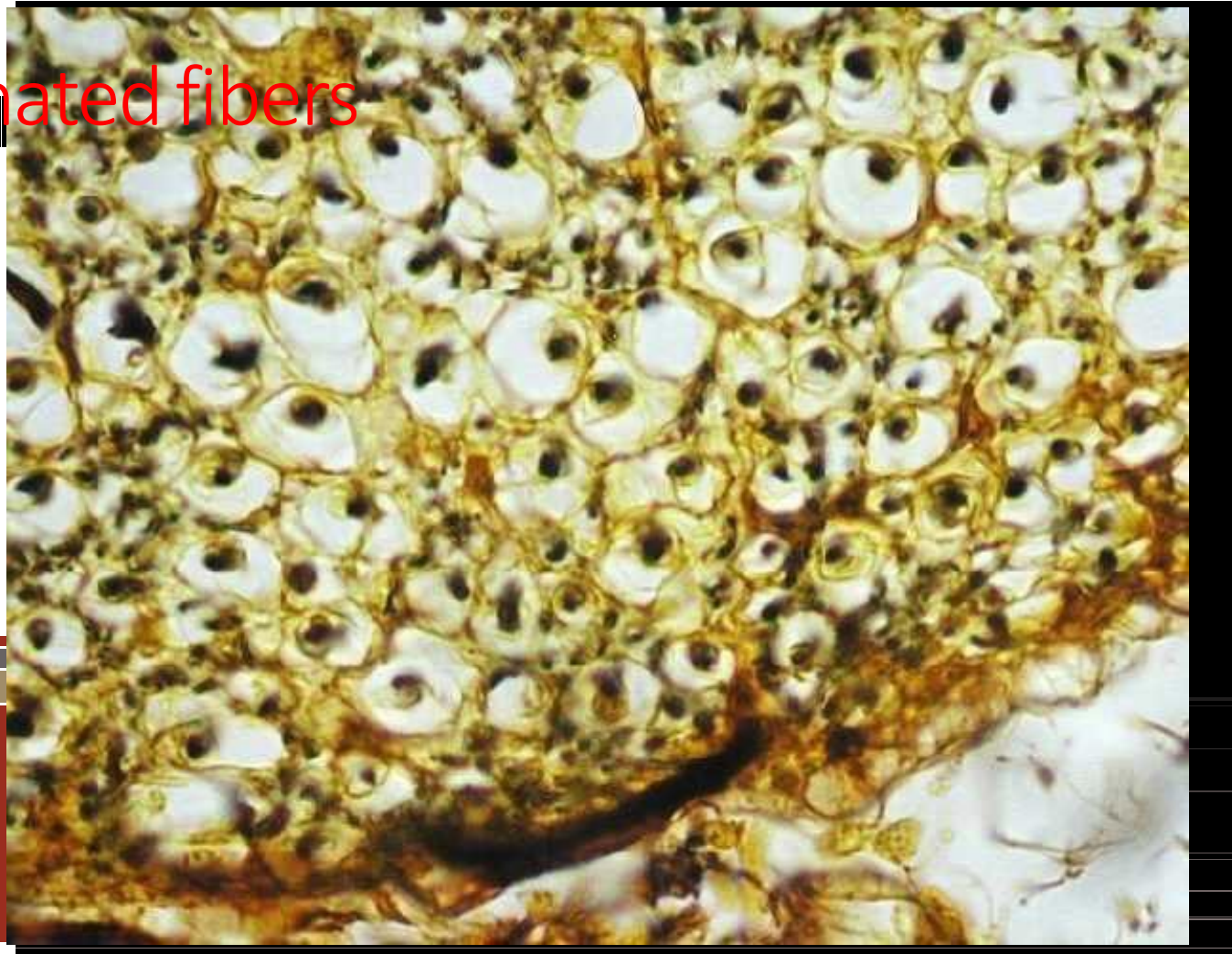




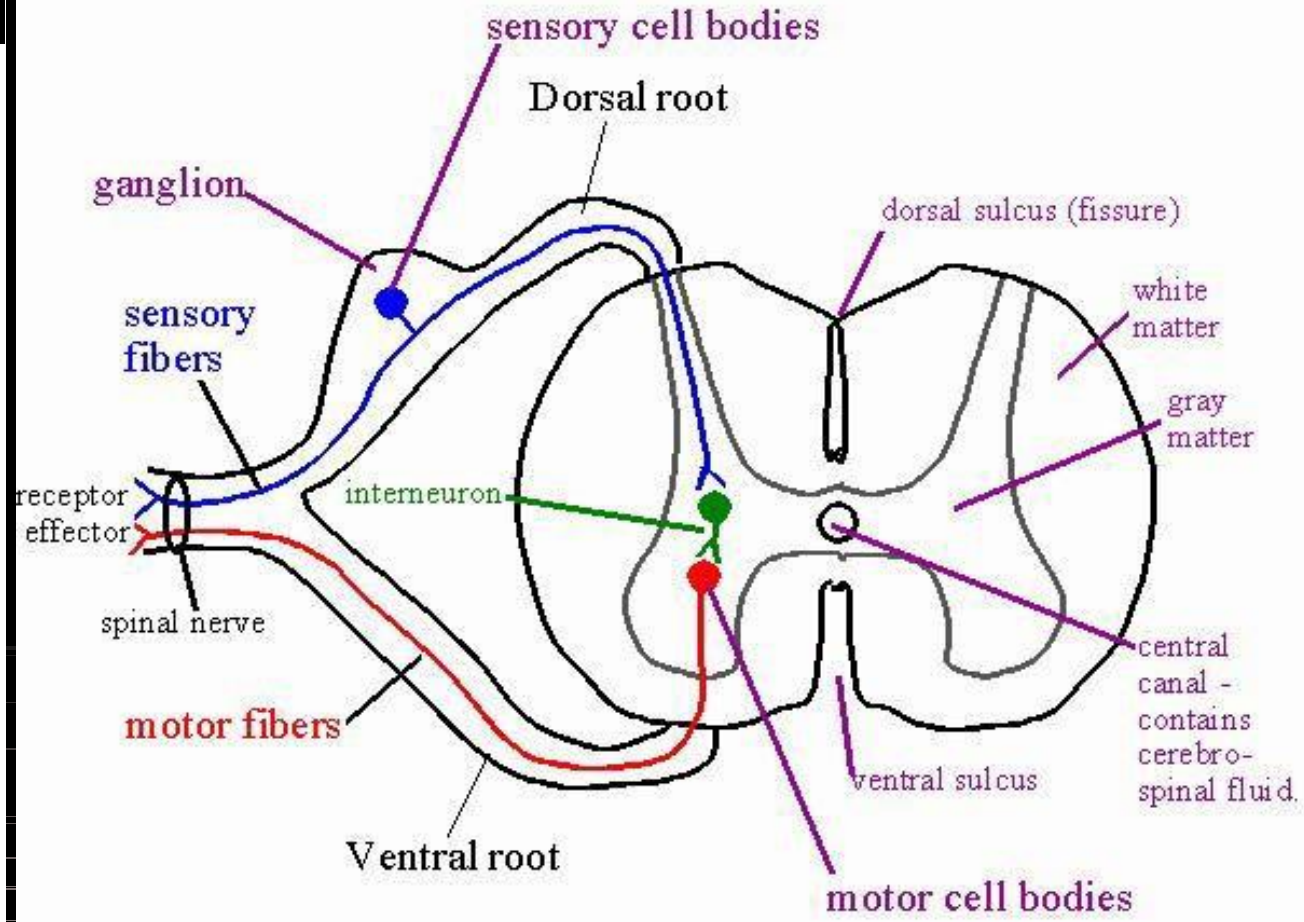


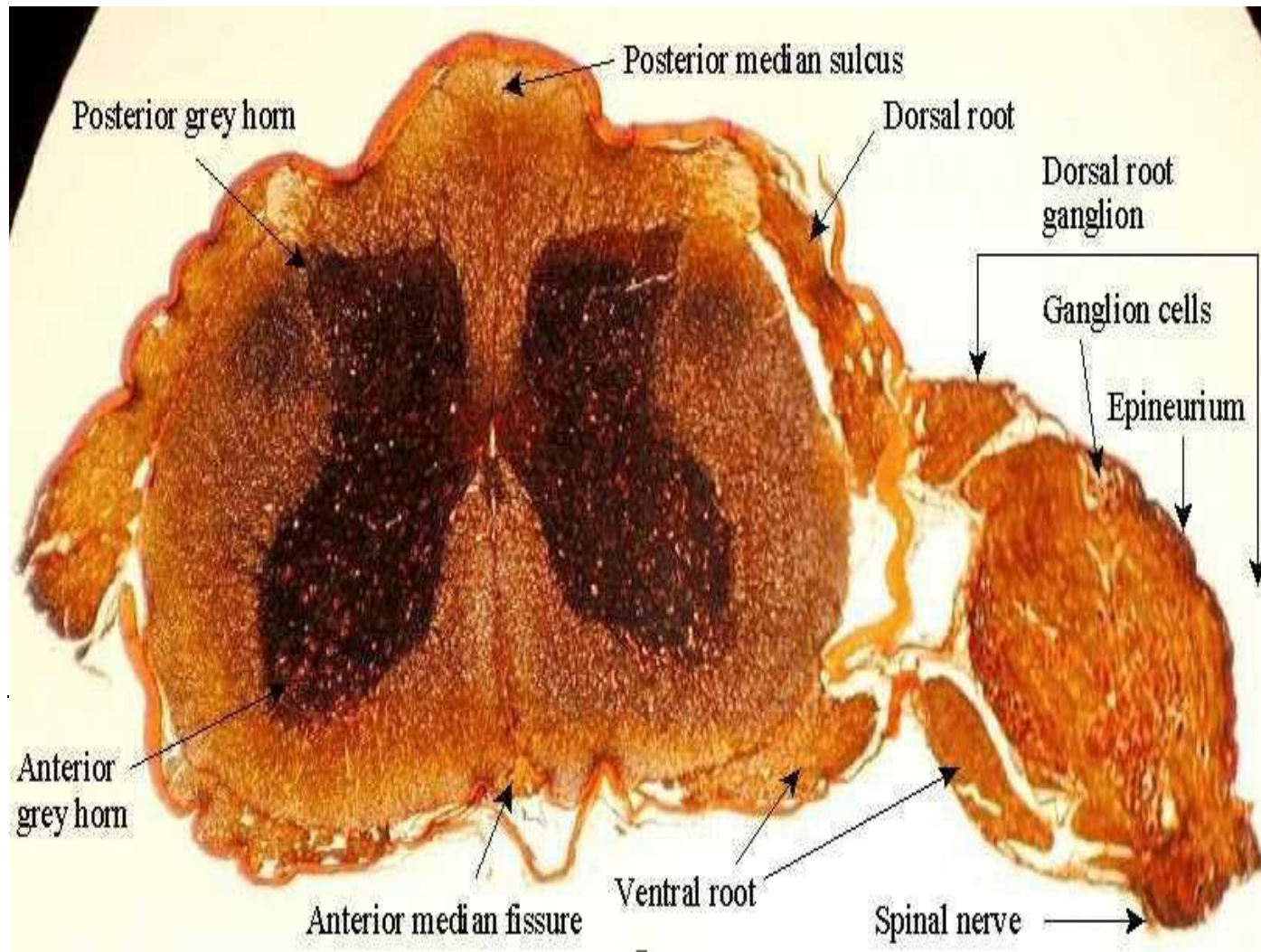


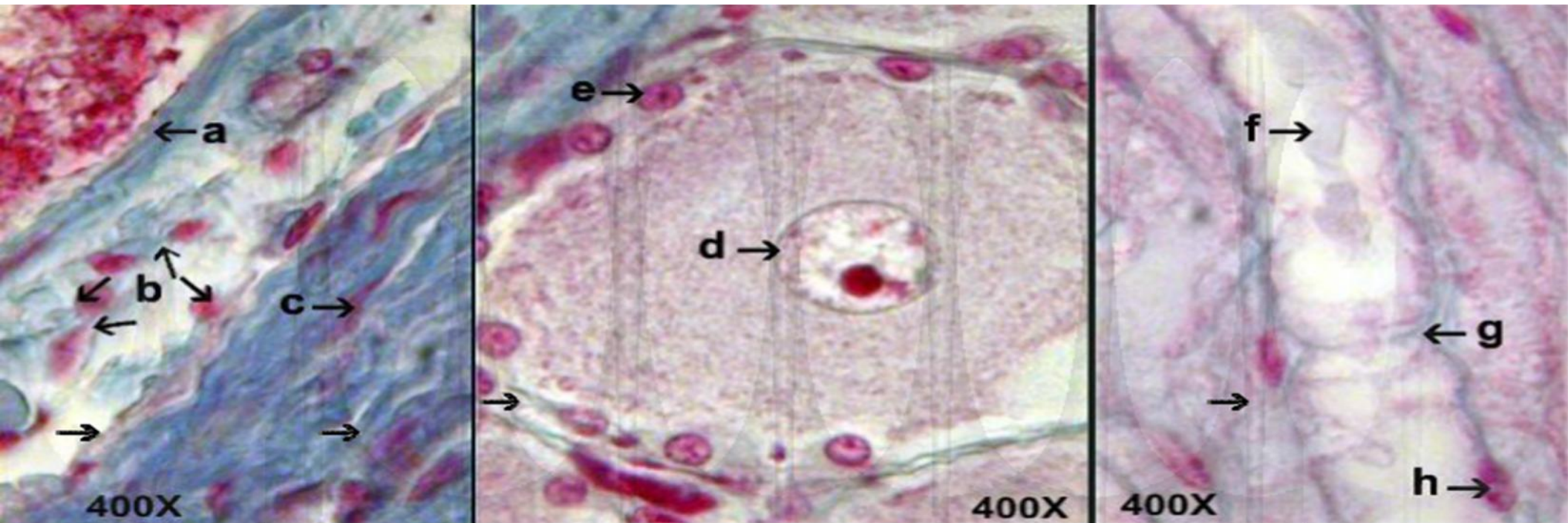
Myelinated fibers



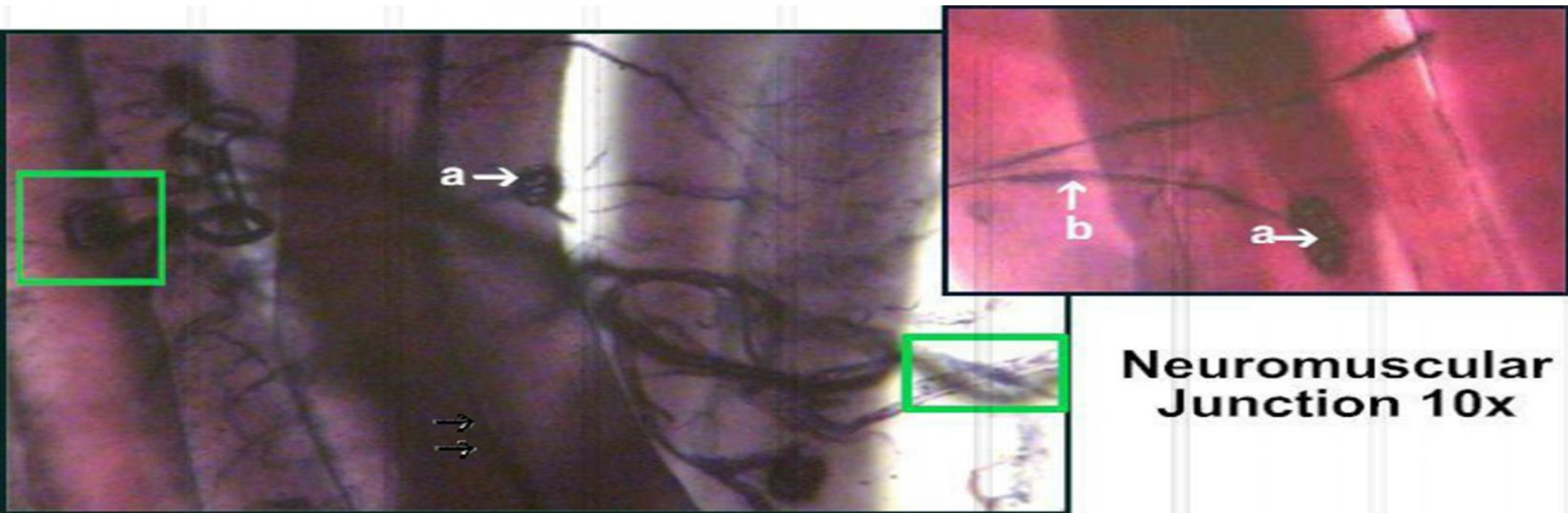
# Spinal Cord - Neuron Relationships







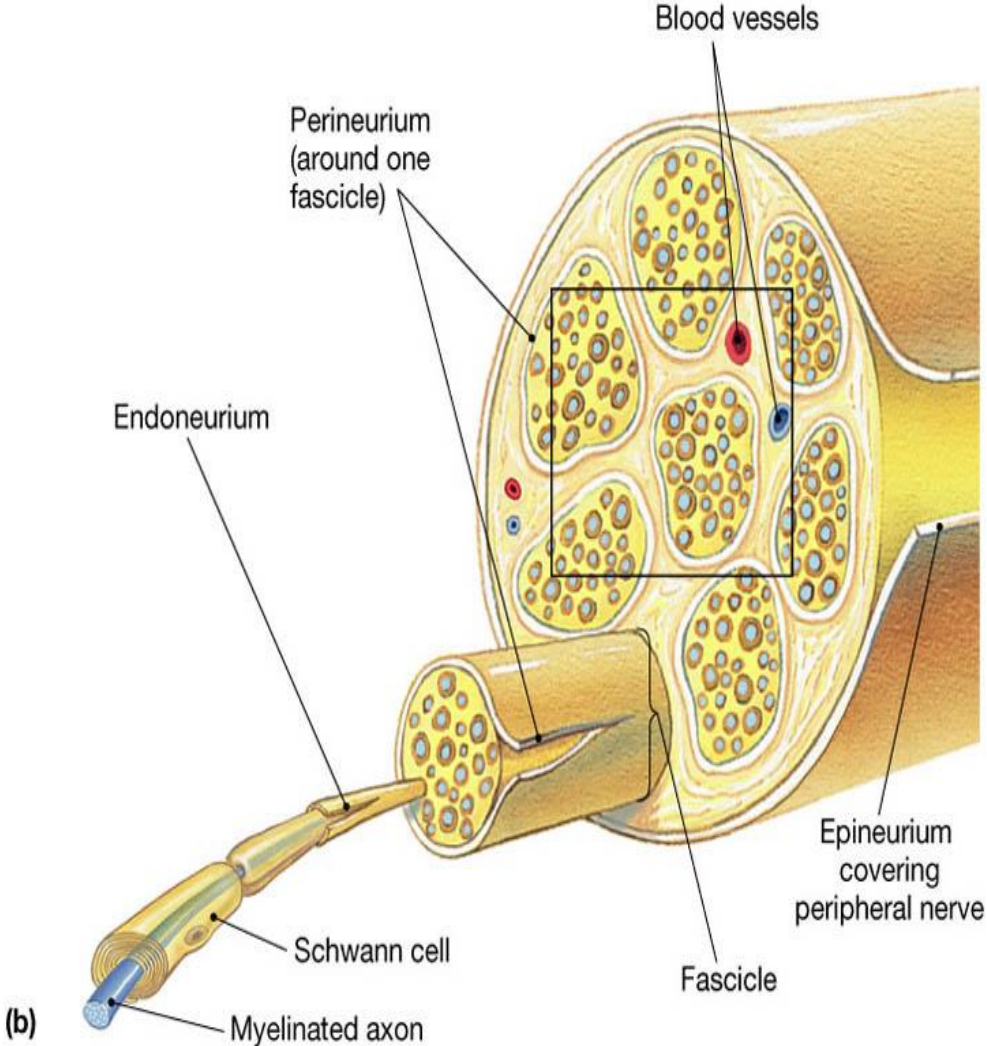
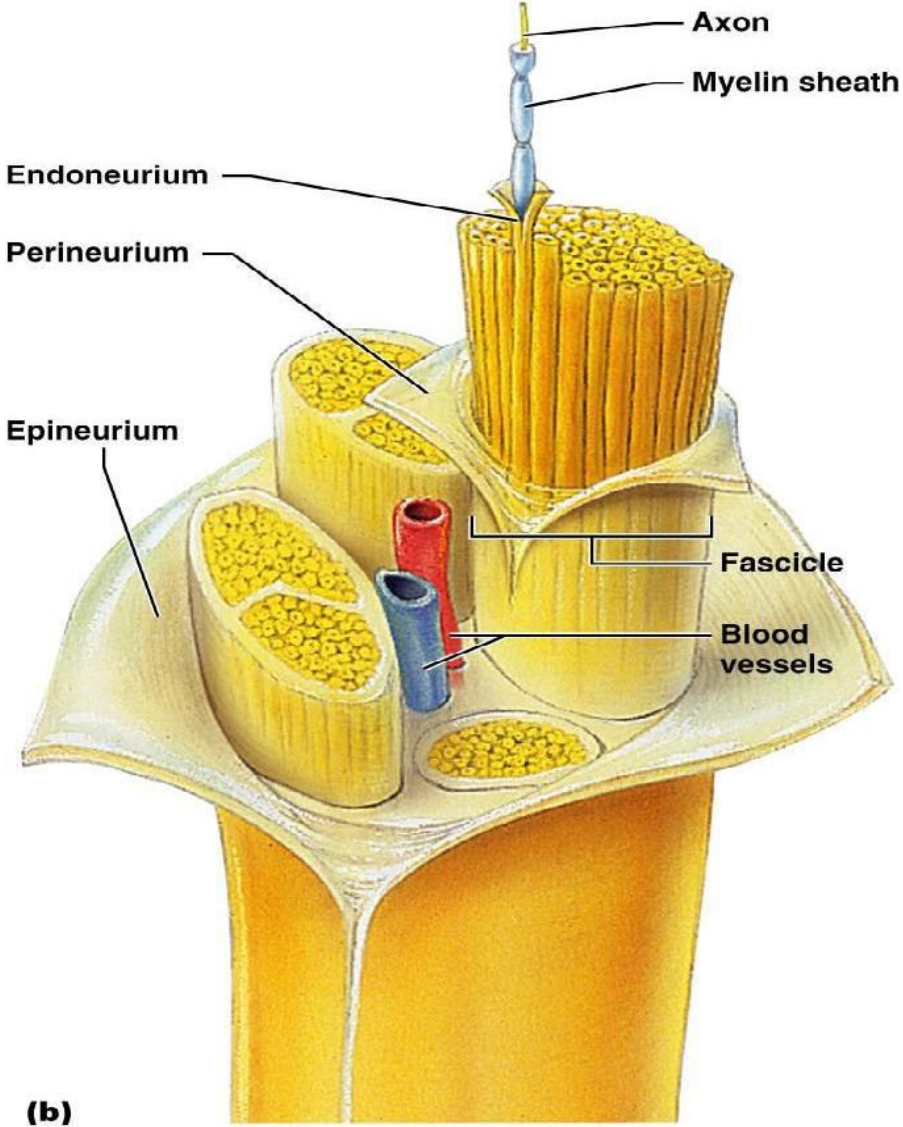
a — Pia mater b — Subarachnoid space filled with cerebral spinal fluid, wastes and various cells. c — Fibrocyte mixed in the blue collagen fibers of the dura mater.  
 d — Nucleus & nucleolus of unipolar neuron e — Nucleus of one of many tiny satellite cells surrounding the large unipolar neuron. f — Myelinated axon g — Node of Ranvier h — Nucleus of white Schwann cell



**Neuromuscular  
Junction 10x**

- a    Synaptic bulbs over the motor end plate - neuromuscular junction
- b    Neuron axon terminal - black fibers

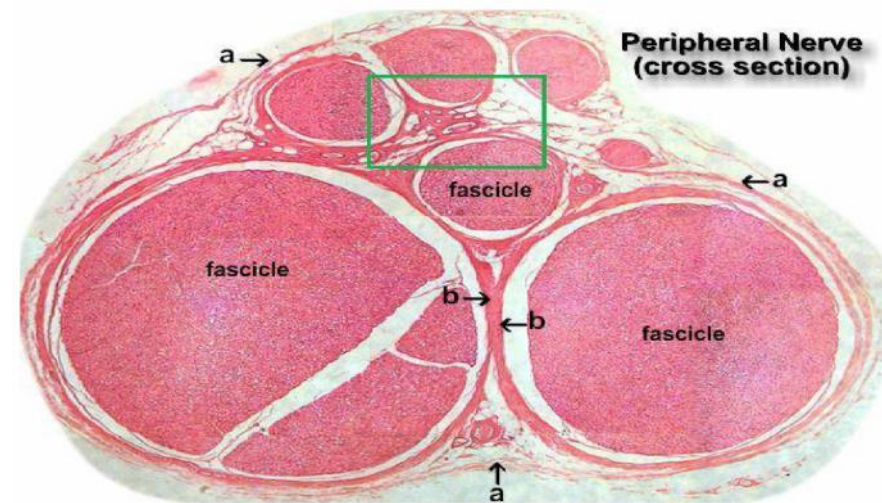
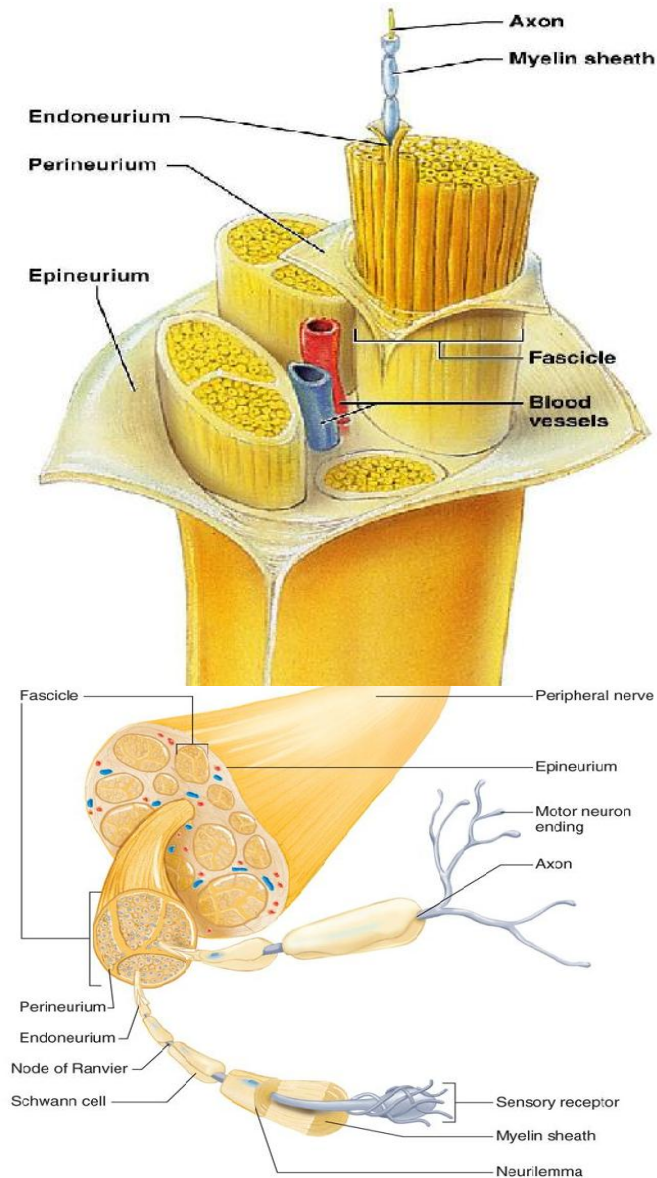
# Structure of a Nerve





## Structure of a Nerve

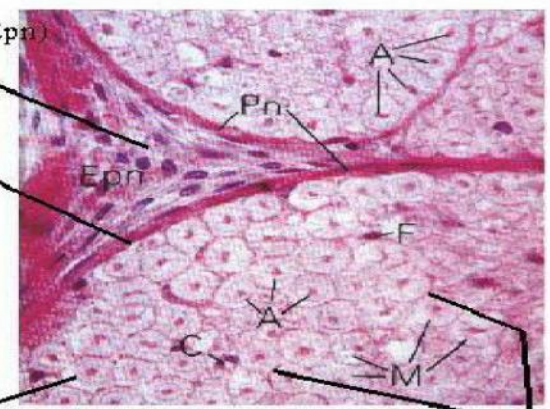
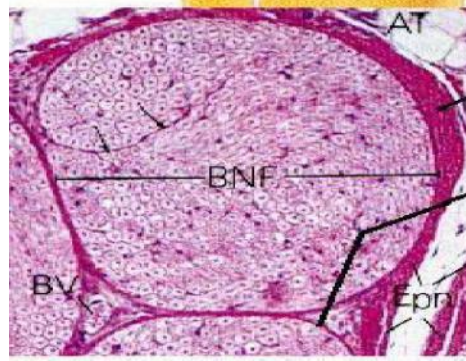
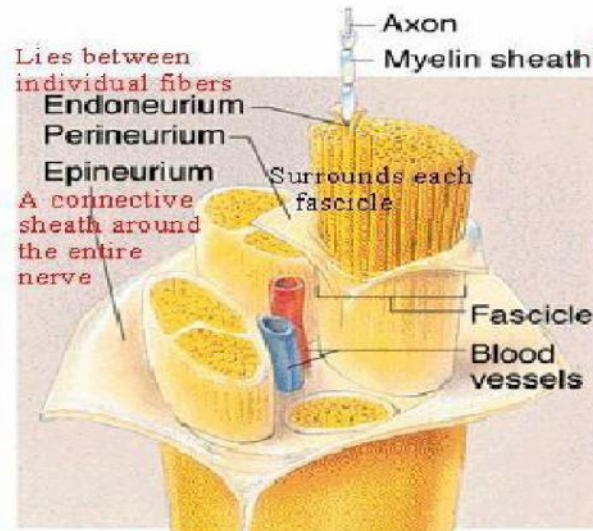
- Nerve – cordlike organ of the PNS consisting of peripheral axons enclosed by connective tissue
- Connective tissue coverings include:
  - **Endoneurium** – loose connective tissue that surrounds axons
  - **Perineurium** – coarse connective tissue that bundles fibers into fascicles
  - **Epineurium** – tough fibrous sheath around a nerve



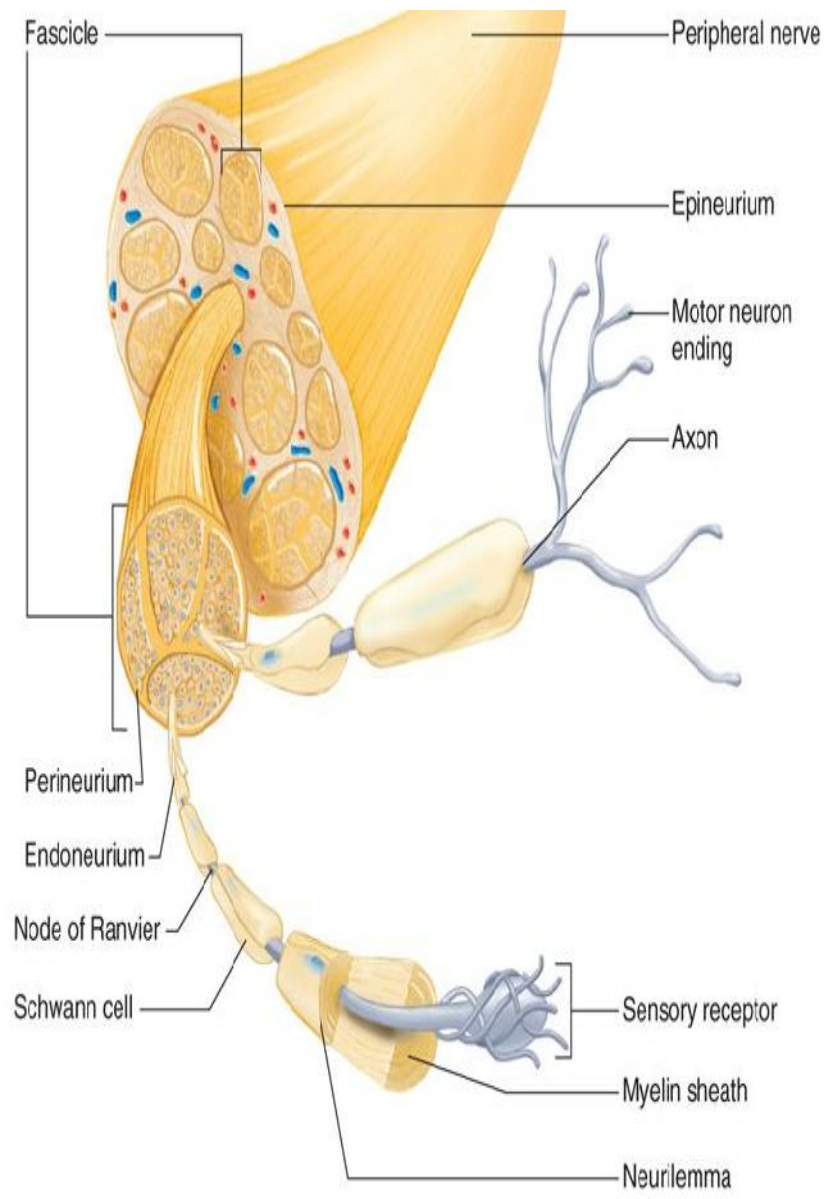
# Structure of a Nerve

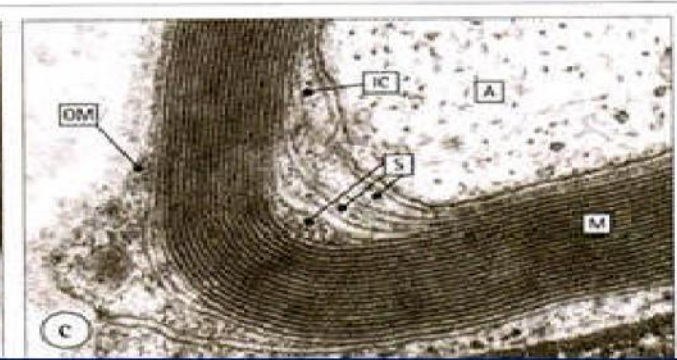
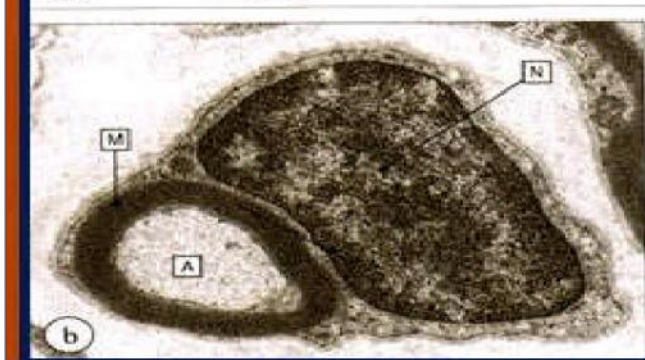
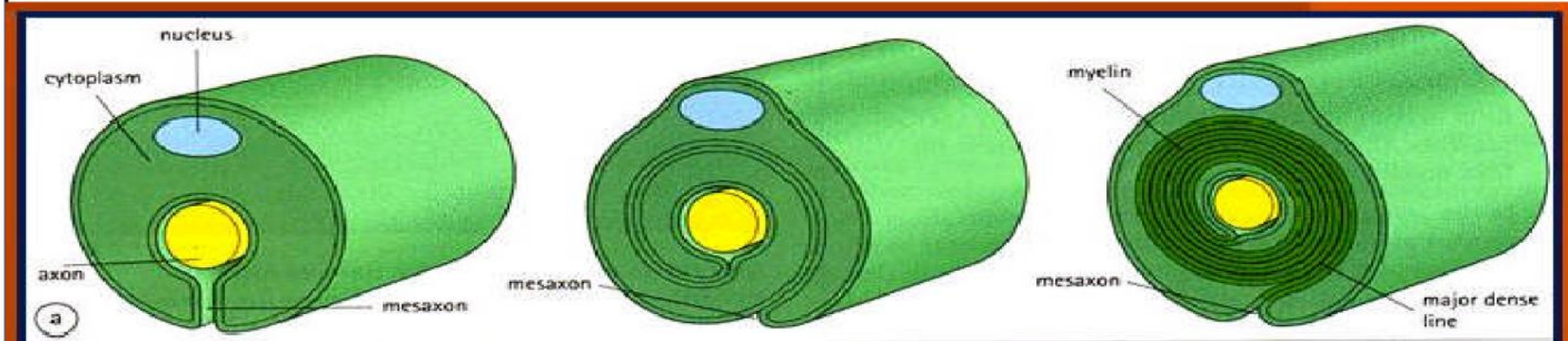
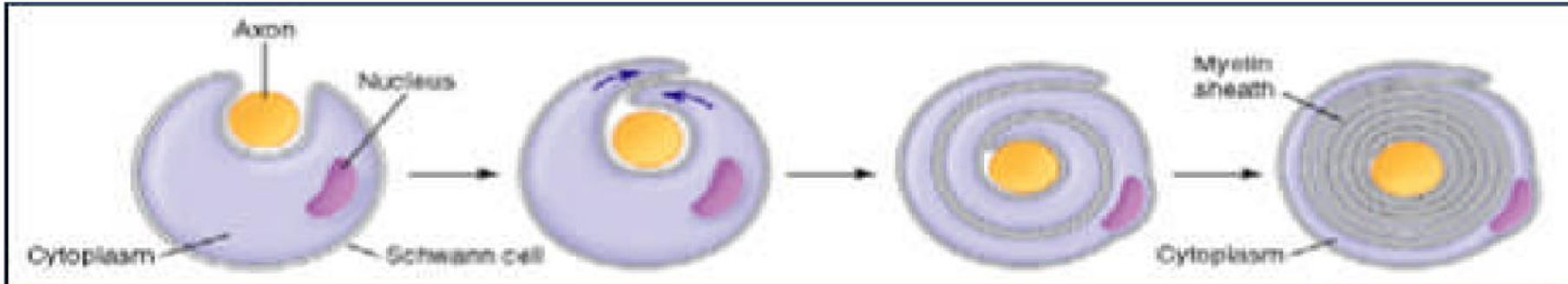
Consists of a continuous series of Schwann cells wrapped around the fiber.

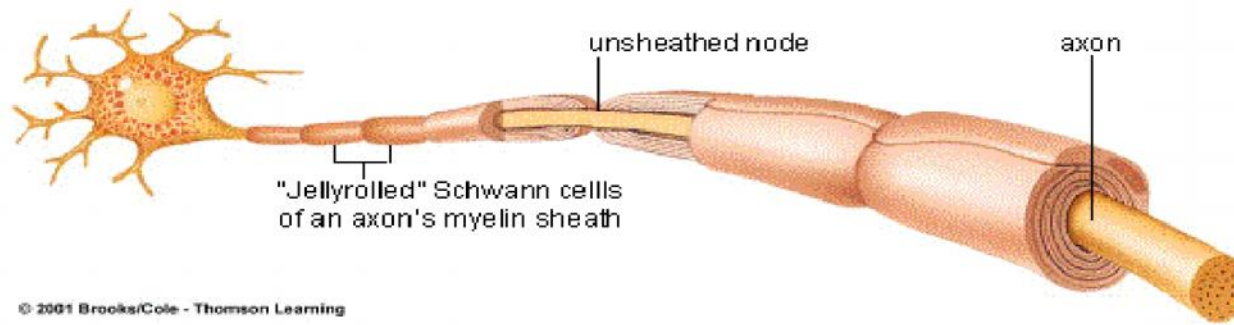
A nerve is a group of axons (nerve fibers) outside the CNS. These fibers are bundled together with connective layers. Many of the fibers are myelinated, which means they have a covering made from successive wrappings of Schwann cells.



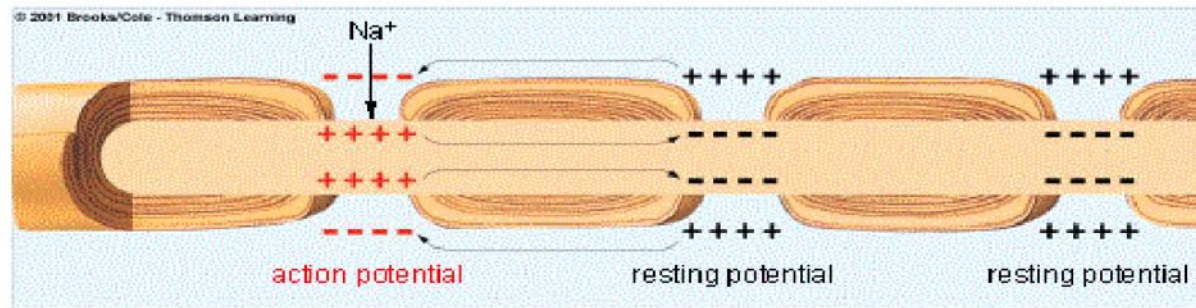
**M** = the myelin sheath, composed of wrappings of a Schwann cell. The outer membrane or layer of the myelin sheath is called the neurilemma.



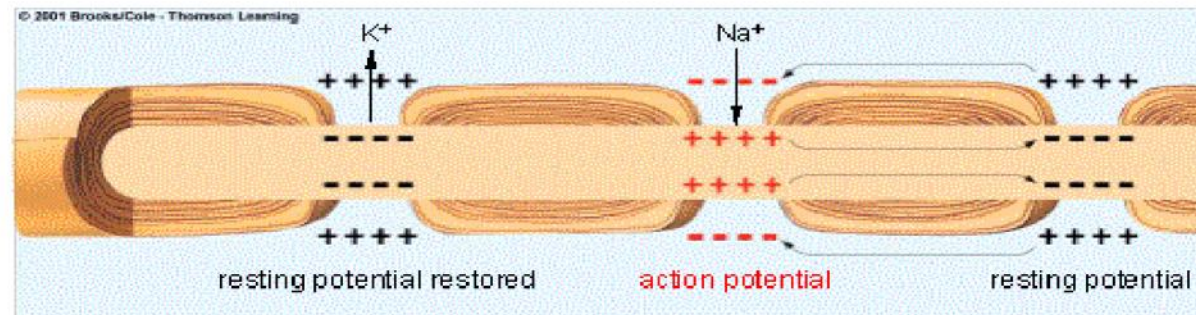




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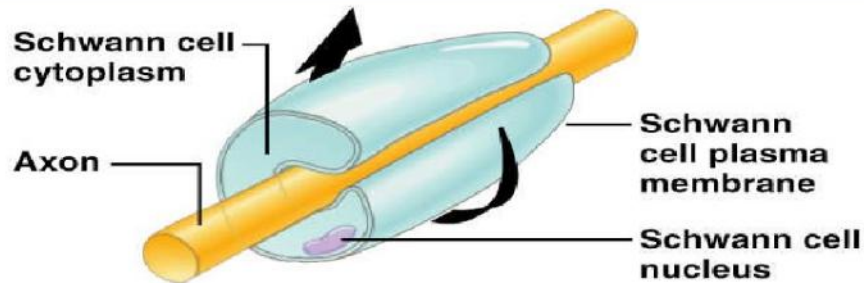


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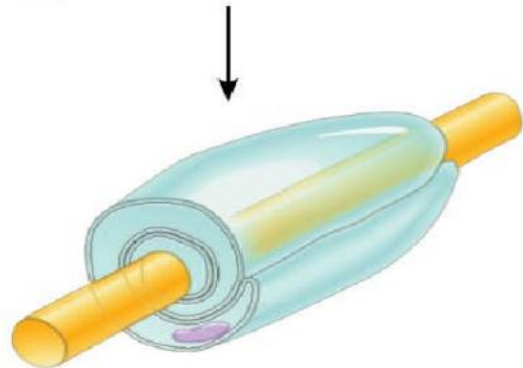


# Myelin Sheath

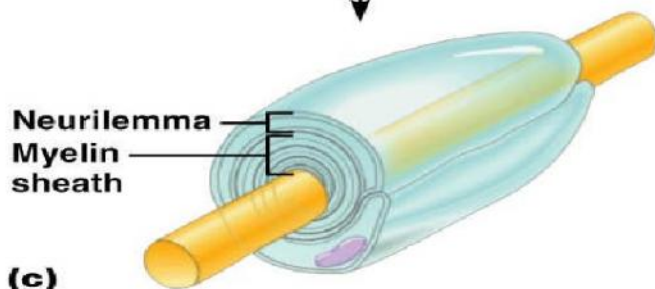
A series of Schwann cells  
 Sheath blocks ion movements  
 Action potential must "jump" from node to node



(a)



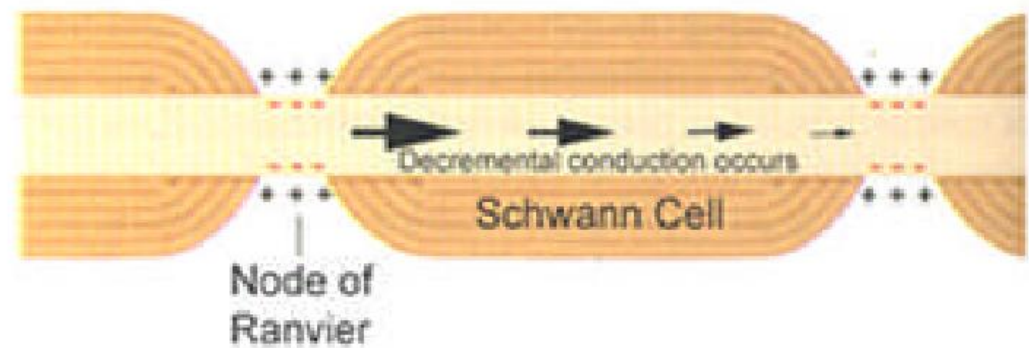
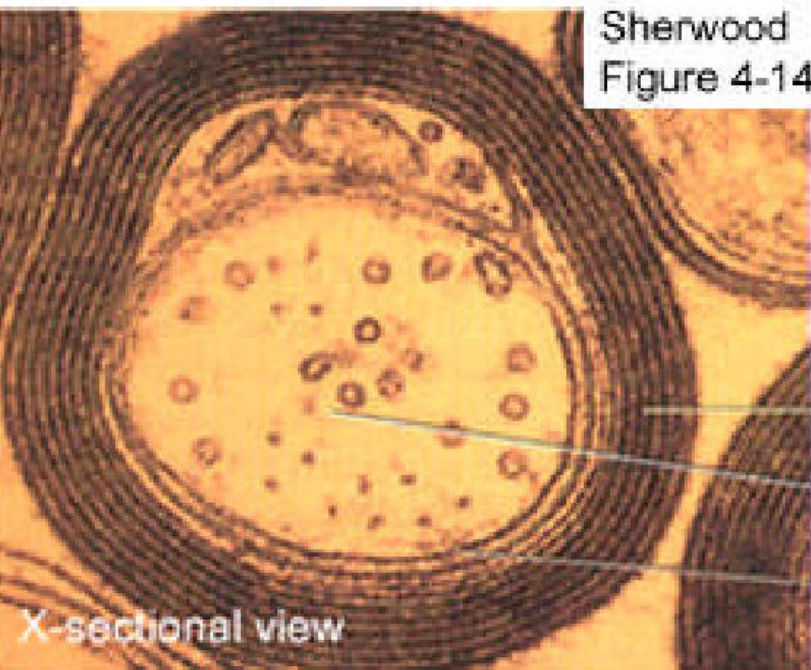
(b)



(c)

The outer nucleated cytoplasmic layer of the neurolemmocyte, which encloses the myelin sheath, is called the neurolemma (sheath of Schwann). A neurolemma is found only around the axons in the PNS. When an axon is injured, the neurolemma aids in the regeneration by forming a regeneration tube that guides and stimulates regrowth of the axon. At intervals along an axon, the myelin sheath has gaps called neurofibral nodes (nodes of Ranvier).

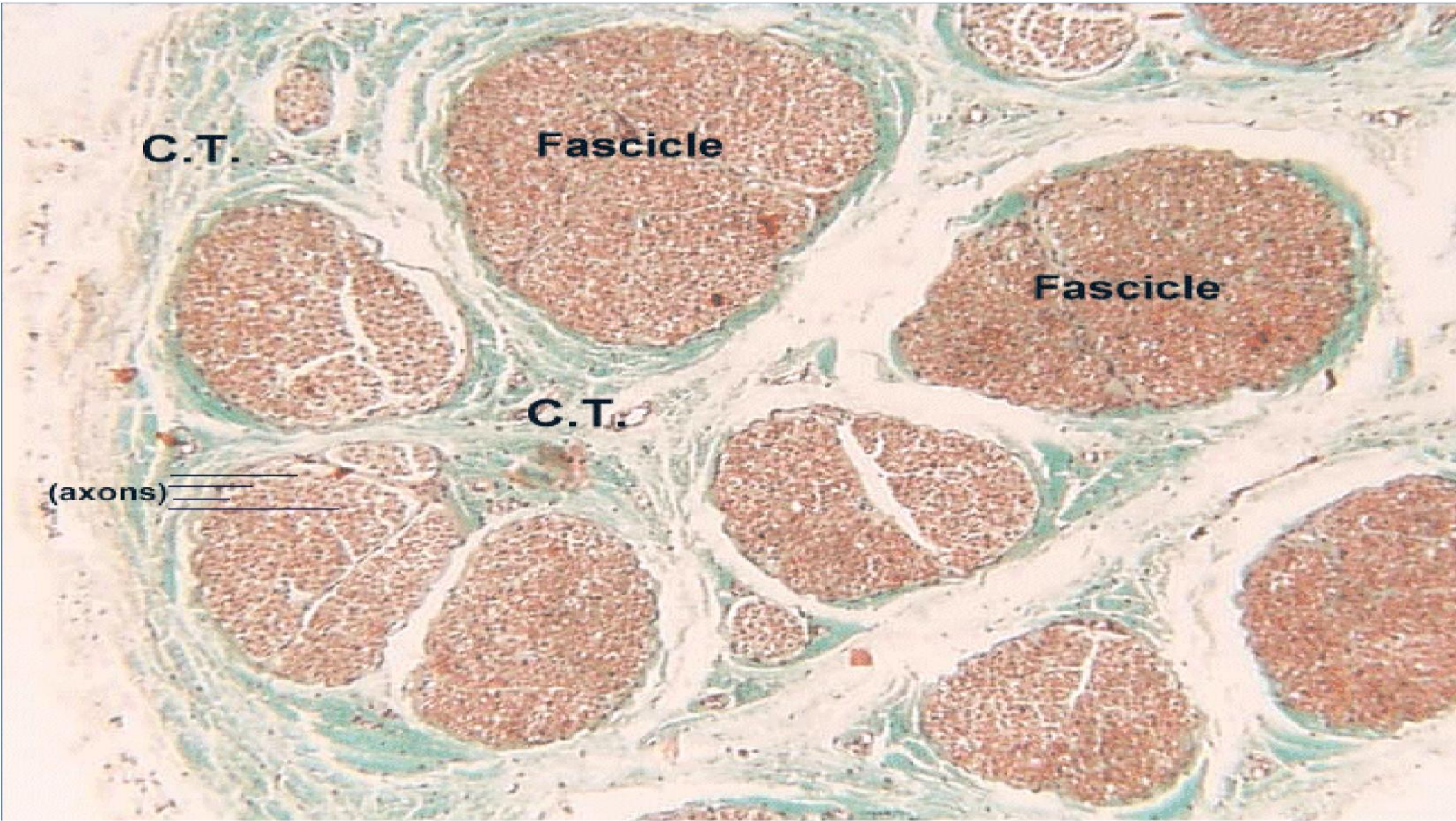
# Action Potential Leaps From Node of Ranvier to Node of Ranvier



Myelin Sheath

Axon

Plasma Membrane



**C.T.**

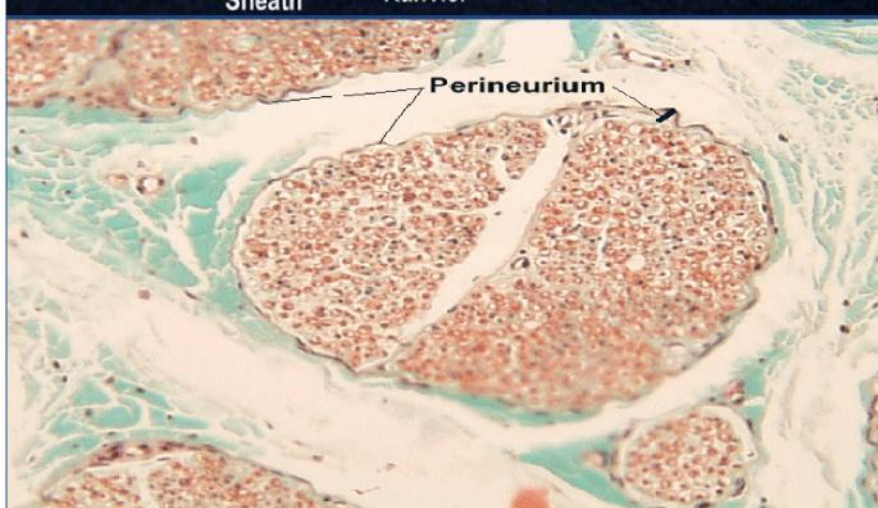
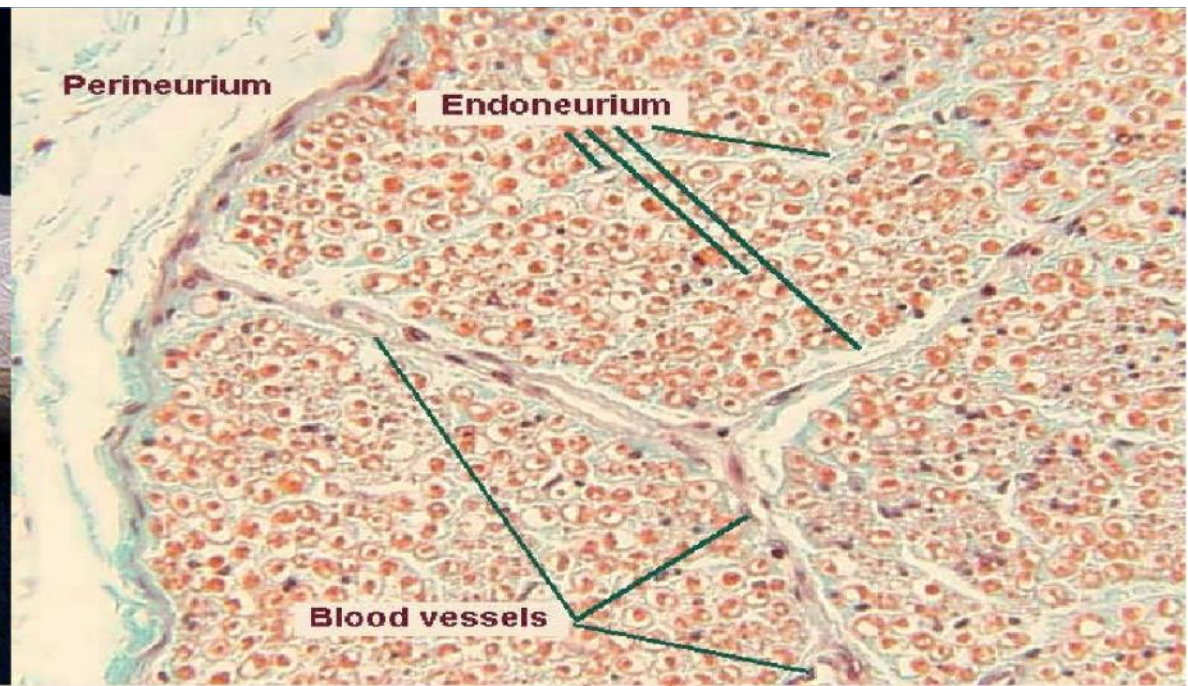
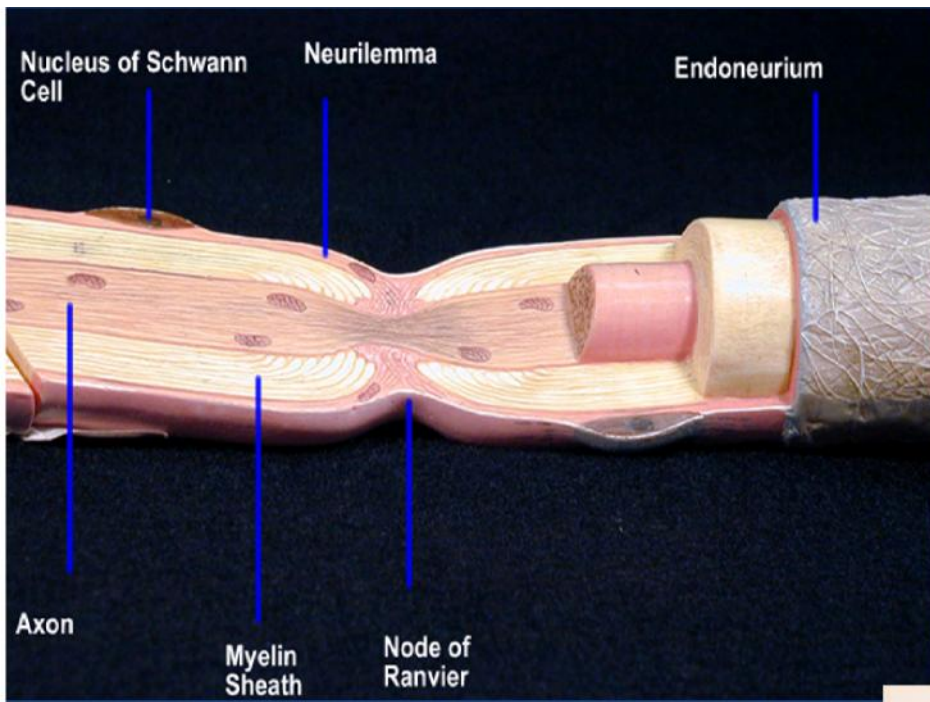
**Fascicle**

**Fascicle**

**C.T.**

**(axons)**







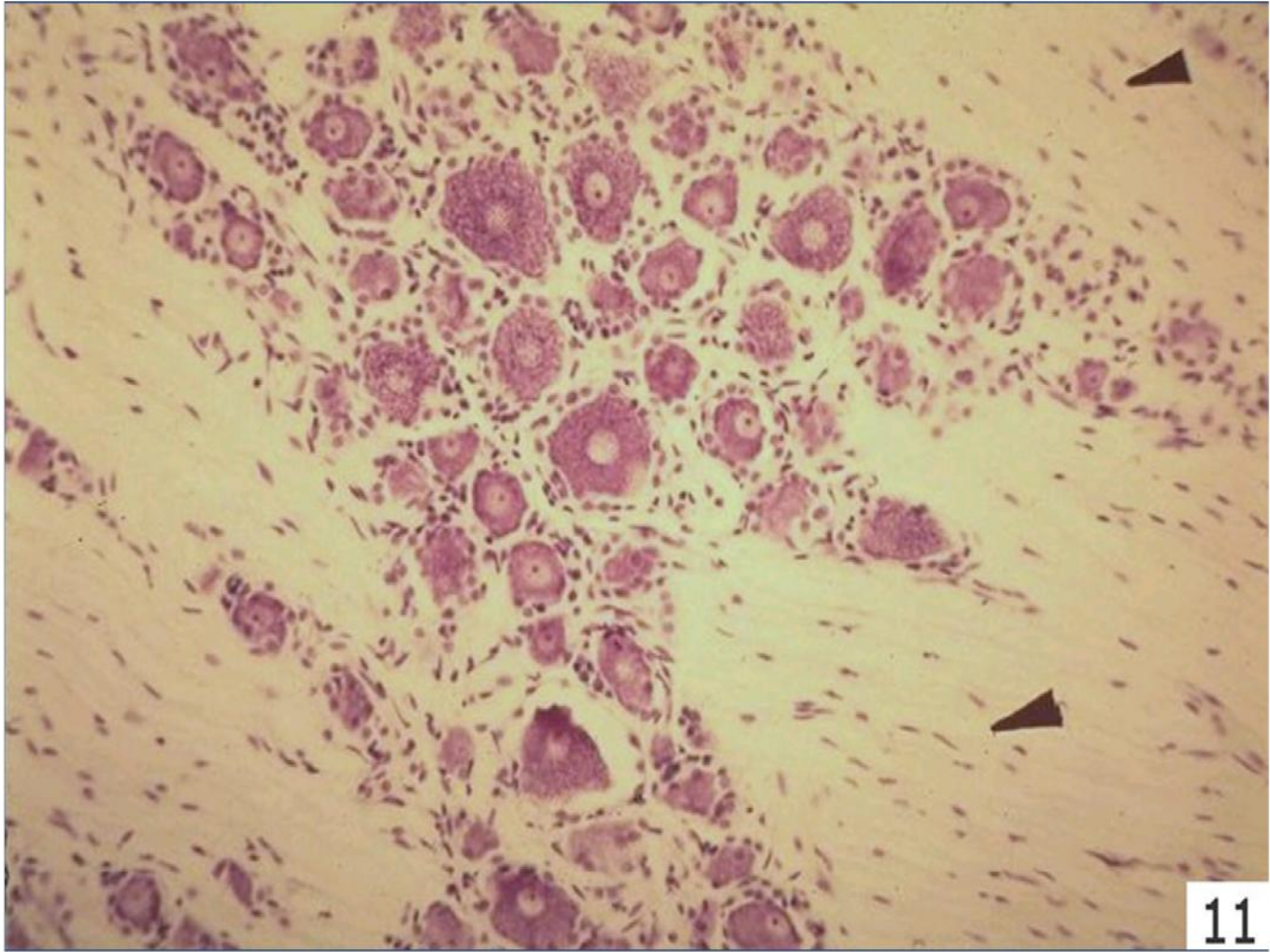
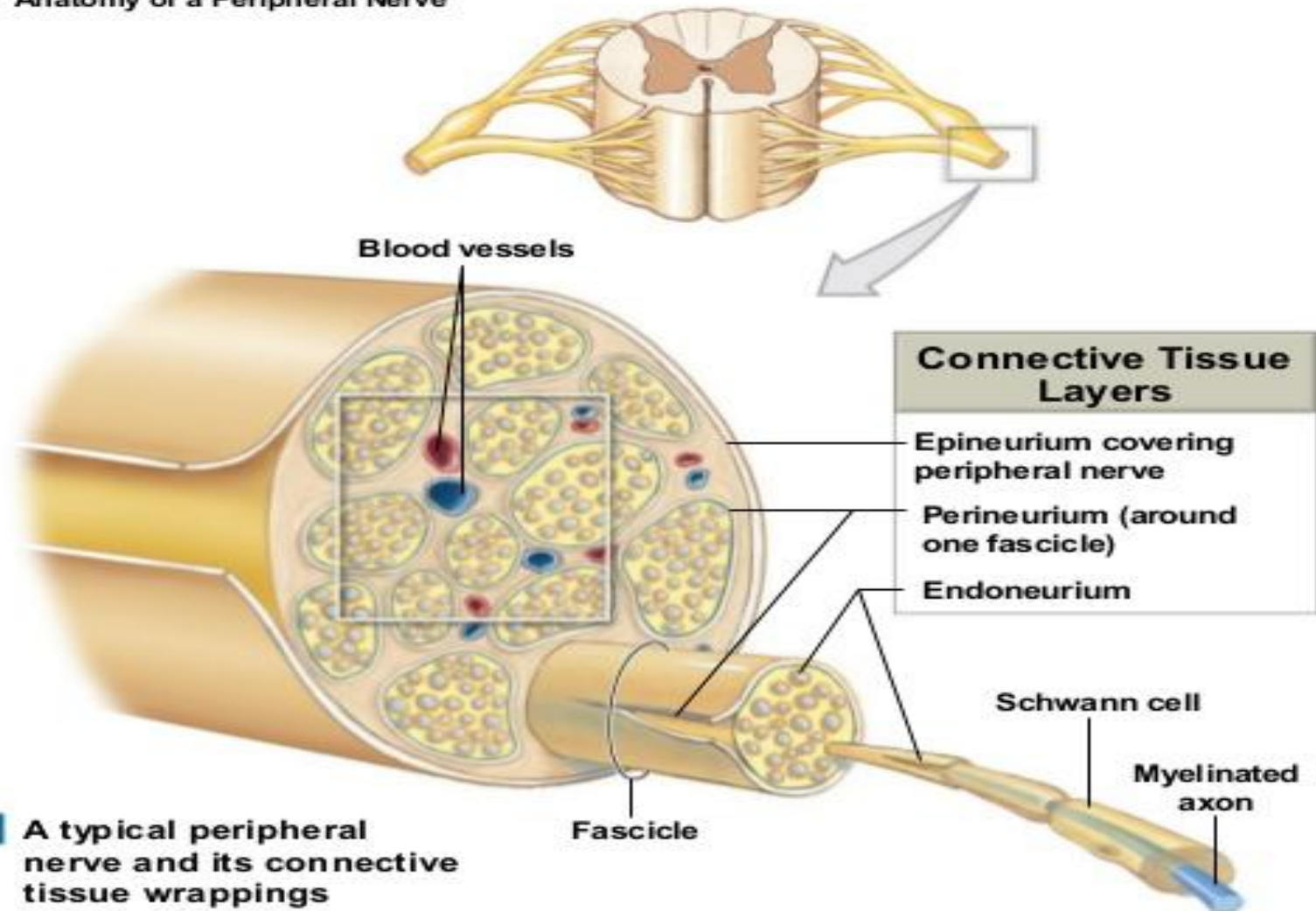
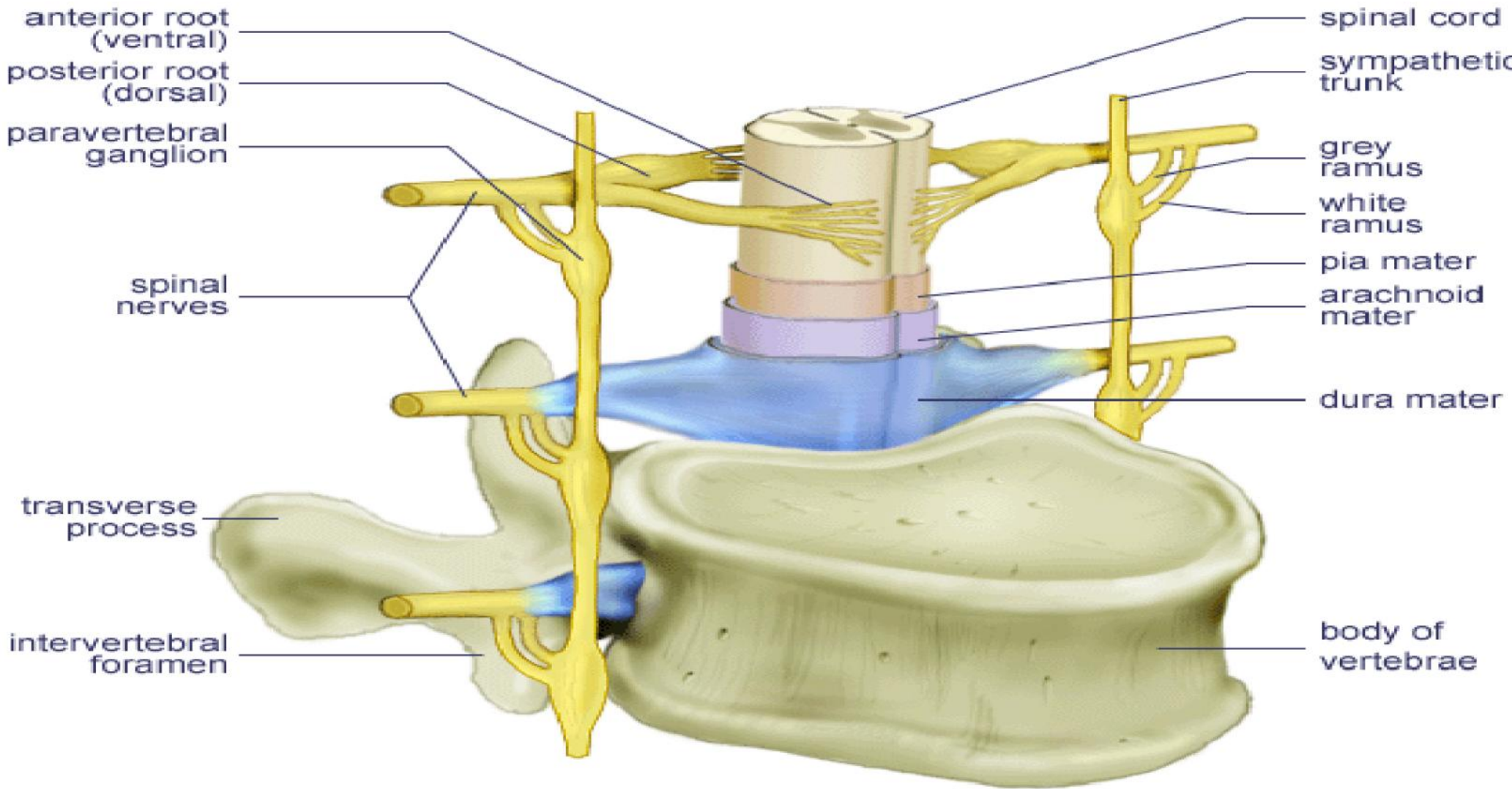


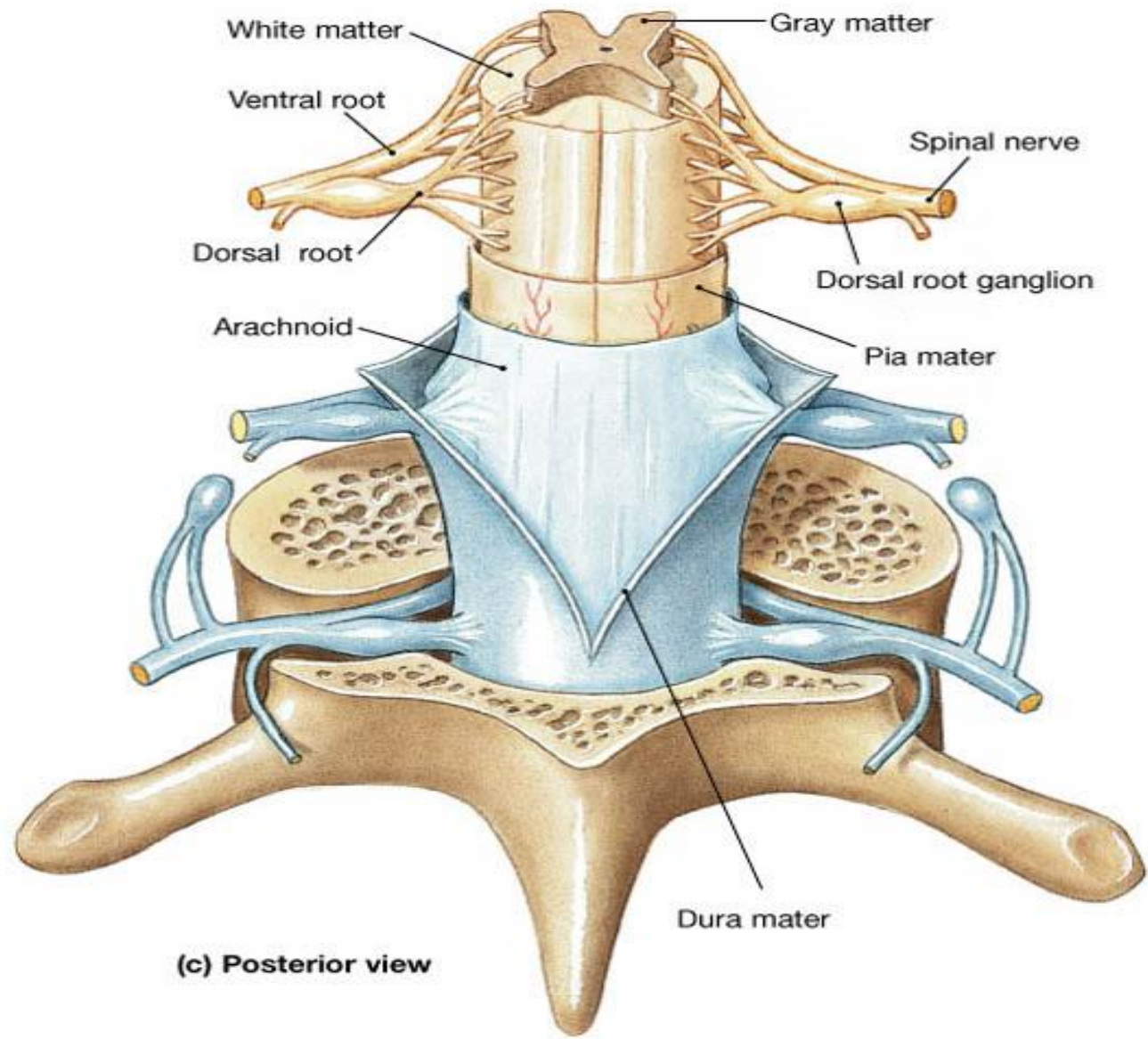
Figure 14.5a Anatomy of a Peripheral Nerve



**a** A typical peripheral nerve and its connective tissue wrappings

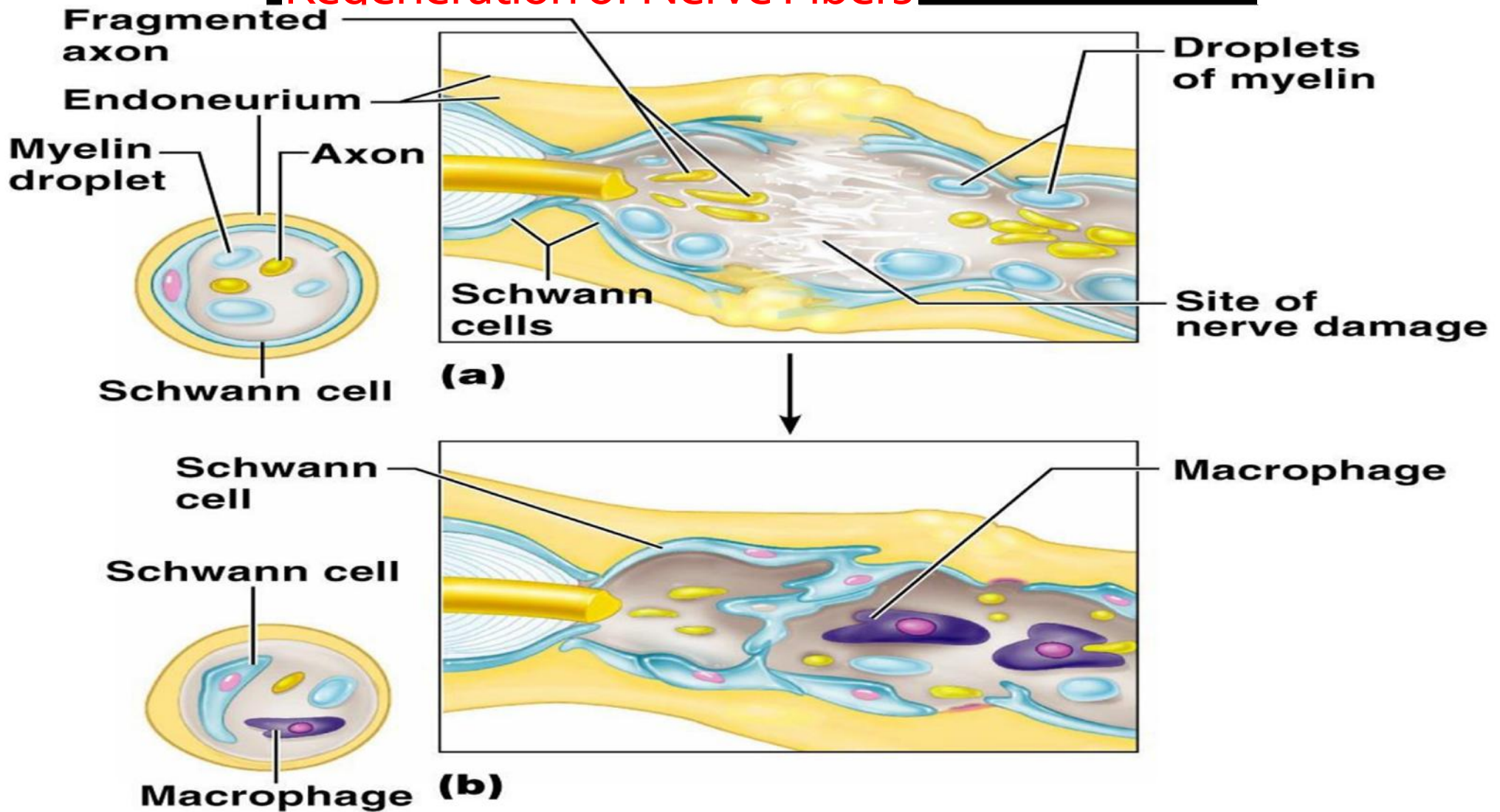
# Autonomic Nervous System



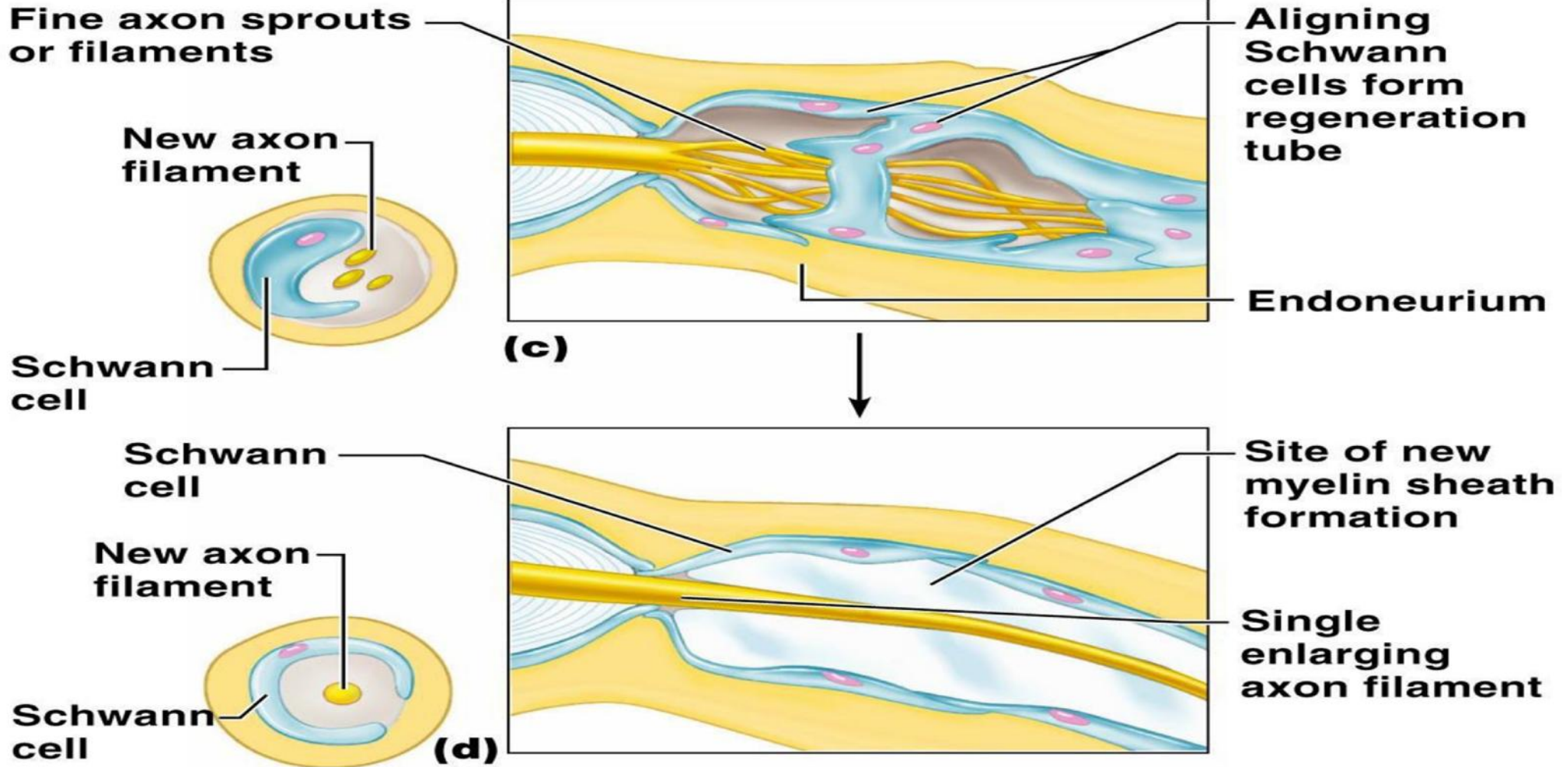


(c) Posterior view

# Regeneration of Nerve Fibers



# Regeneration of Nerve Fibers



## Classification of nerves

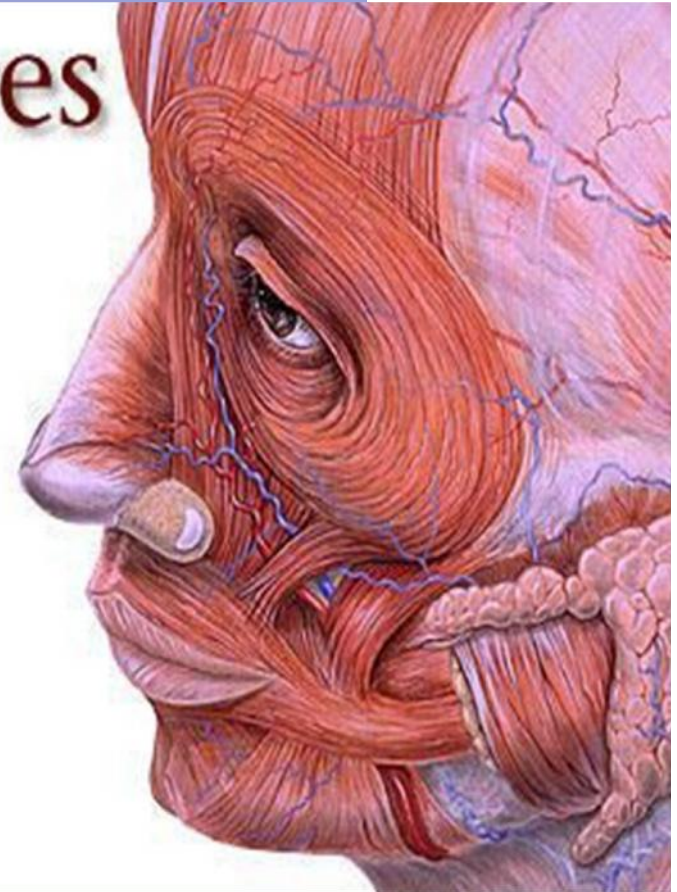
- **Sensory and motor divisions**
- **Sensory (afferent)** – carry impulse to the CNS
- **Motor (efferent)** – carry impulses from CNS
- **Mixed** – sensory and motor fibers carry impulses to and from CNS; most common type of nerve

# Peripheral Nervous System

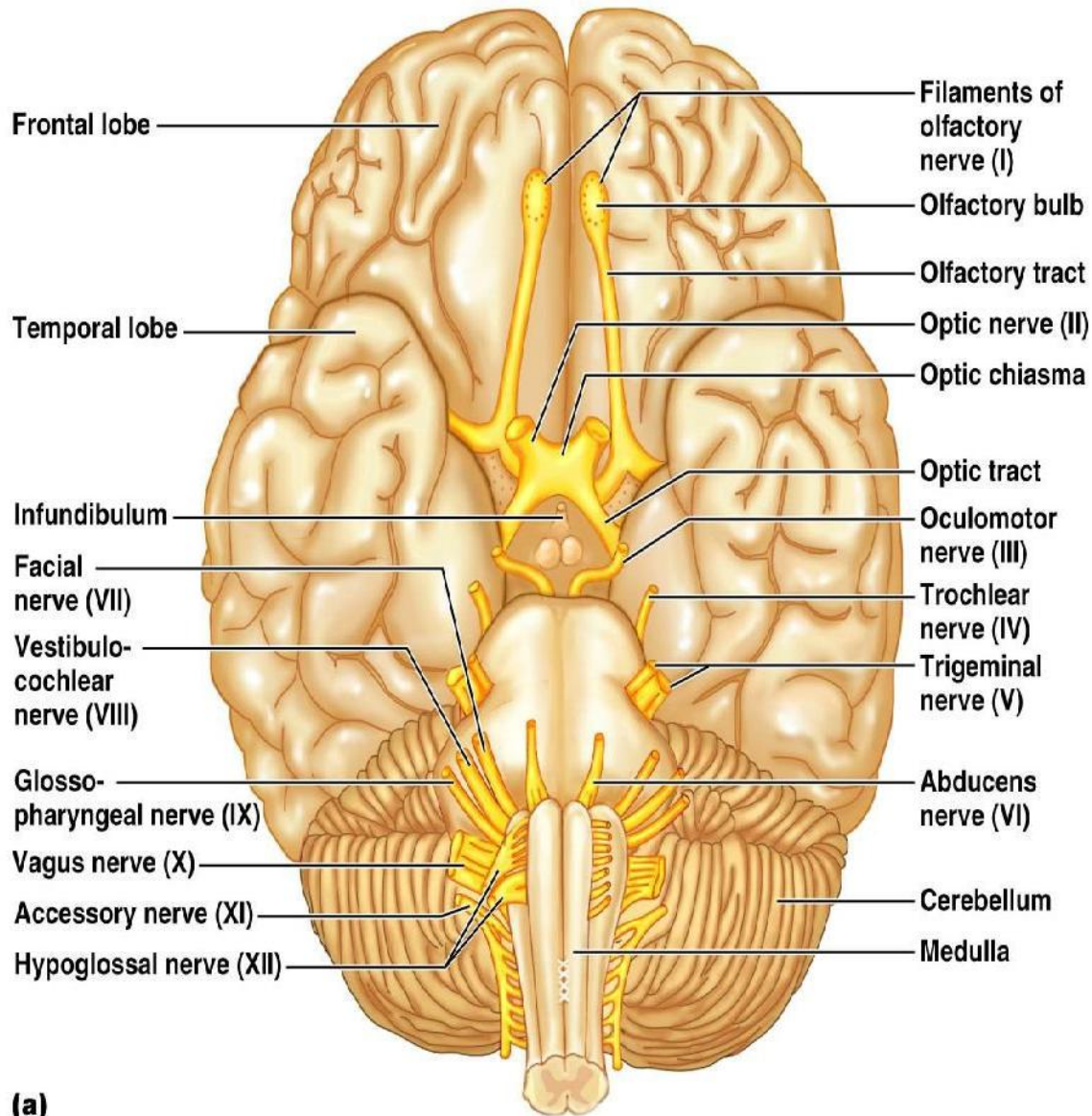
## Cranial Nerves

- 31 spinal nerves
  - We've already discussed their structure
- 12 cranial nerves
  - How do they differ from spinal nerves?
  - We need to learn their:
    - Names
    - Locations
    - Functions

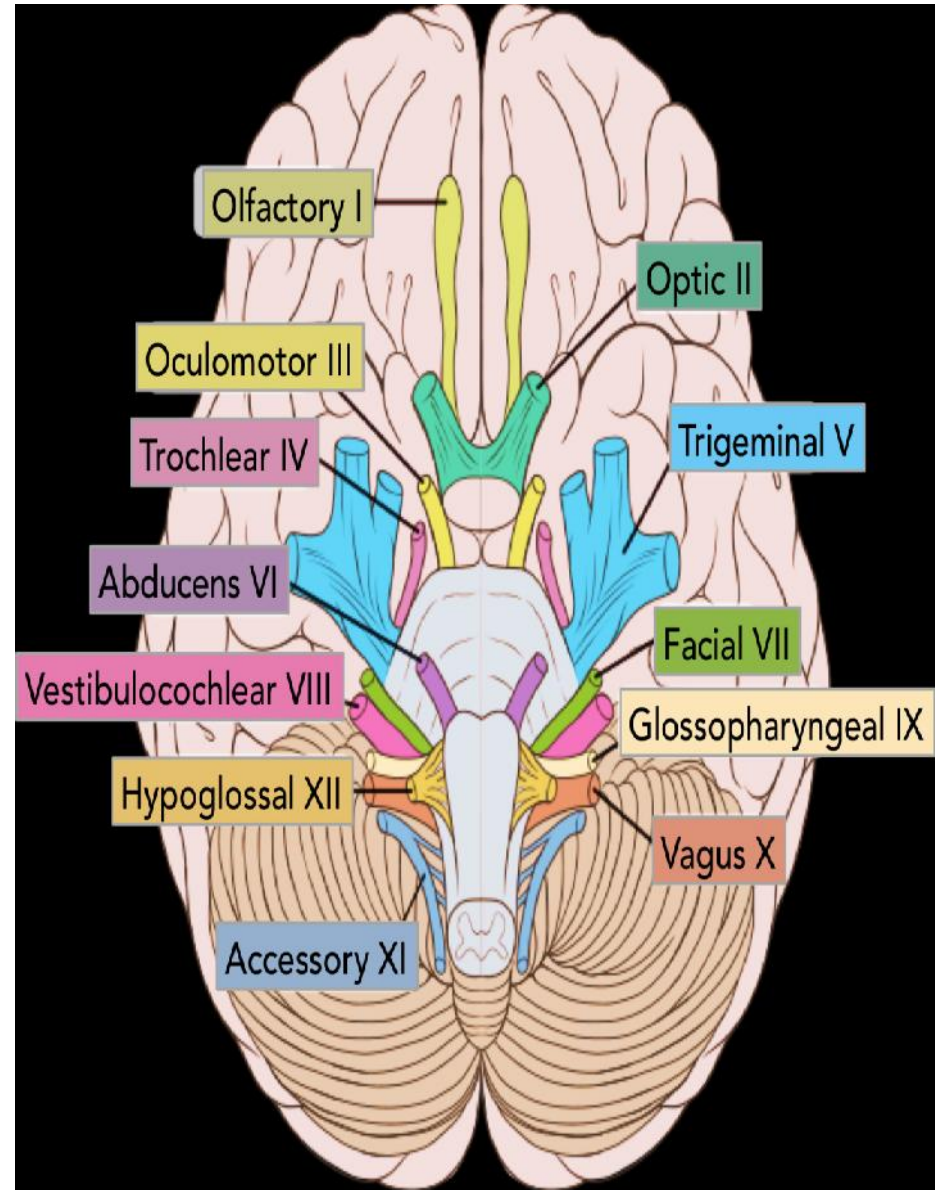
I	Olfactory
II	Optic
III	Oculomotor
IV	Trochlear
V	Trigeminal
VI	Abducens
VII	Facial
VIII	Vestibulocochlear
IX	Glossopharyngeal
X	Vagus
XI	Accessory
XII	Hypoglossal

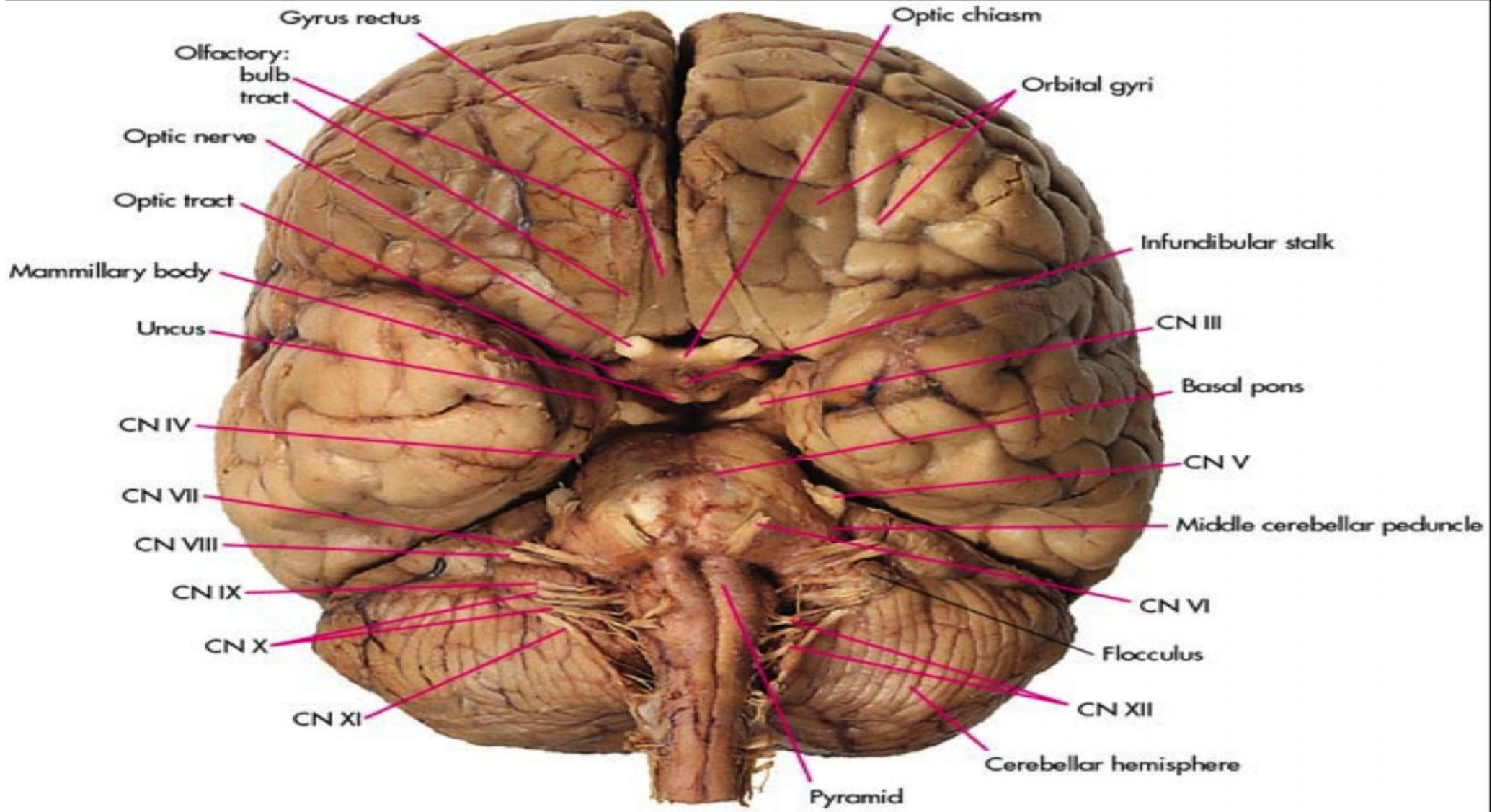






(a)





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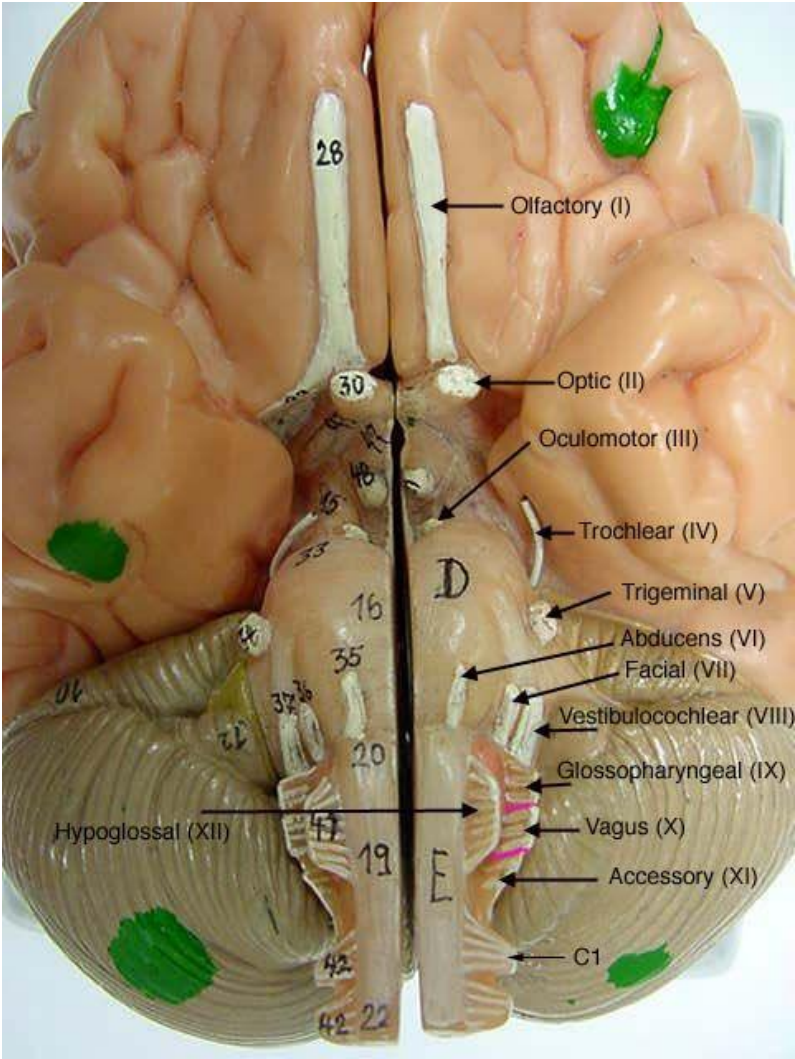
## Cranial nerves

<b>Cranial nerves I – VI</b>	<b>Sensory function</b>	<b>Motor function</b>	<b>PS* fibers</b>
I Olfactory	Yes (smell)	No	No
II Optic	Yes (vision)	No	No
III Oculomotor	No	Yes	Yes
IV Trochlear	No	Yes	No
V Trigeminal	Yes (general sensation)	Yes	No
VI Abducens	No	Yes	No

<b>Cranial nerves VII – XII</b>	<b>Sensory function</b>	<b>Motor function</b>	<b>PS* fibers</b>
VII Facial	Yes (taste)	Yes	Yes
VIII Vestibulocochlear	Yes (hearing and balance)	Some	No
IX Glossopharyngeal	Yes (taste)	Yes	Yes
X Vagus	Yes (taste)	Yes	Yes
XI Accessory	No	Yes	No
XII Hypoglossal	No	Yes	No

**(b)** \*PS = parasympathetic



# CRANIAL NERVE MNEMONIC

S = Sensory

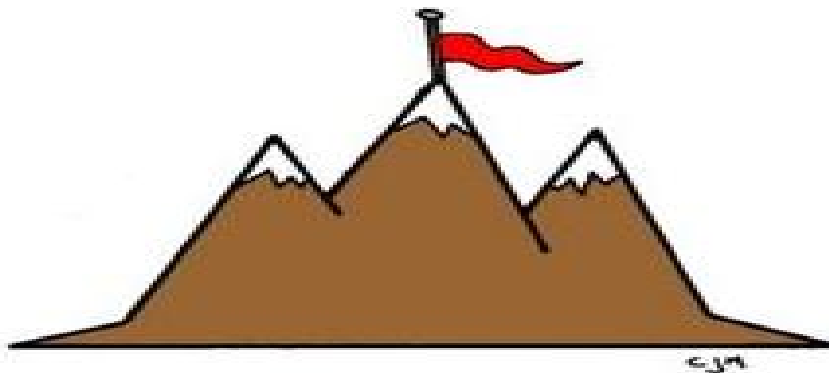
M = Motor

B = Both

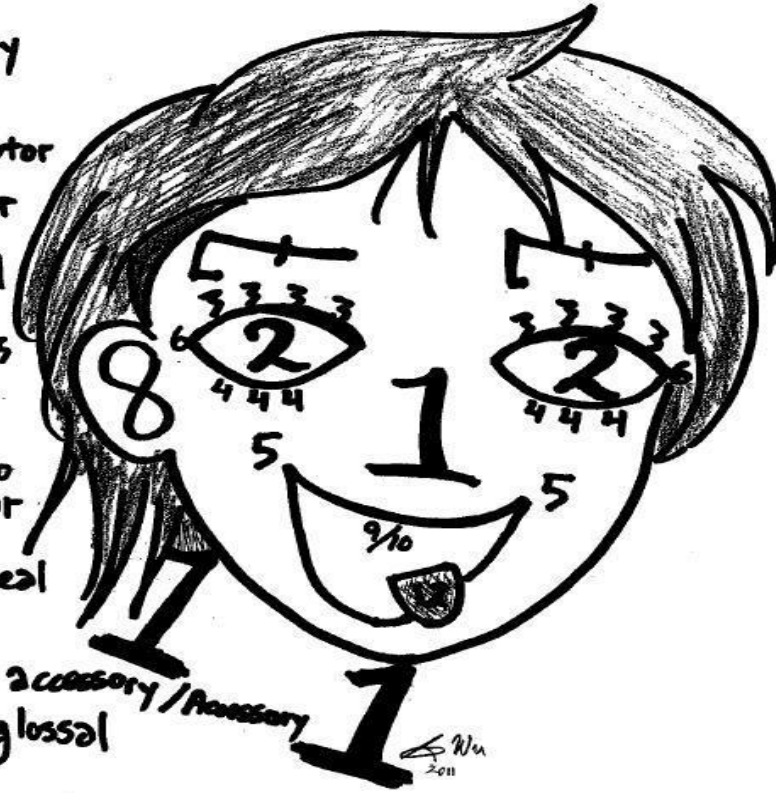
O Olfactory  
O Optic  
O Oculomotor  
T Trochlear  
T Trigeminal  
A Abducens  
F Facial  
V Vestibulocochlear  
G Glossopharyngeal  
V Vagus Nerve  
A Accessory  
H Hypoglossal

O Oo  
O Oo  
O Oo  
T To  
T Touch  
A And  
F Feel  
V Very  
G Good  
V Velvet  
A AH!  
H

S Some  
S Say  
M Marry  
M Money  
B But  
M My  
B Brother  
S Says  
B Bad  
B Business  
M Marry  
M Money

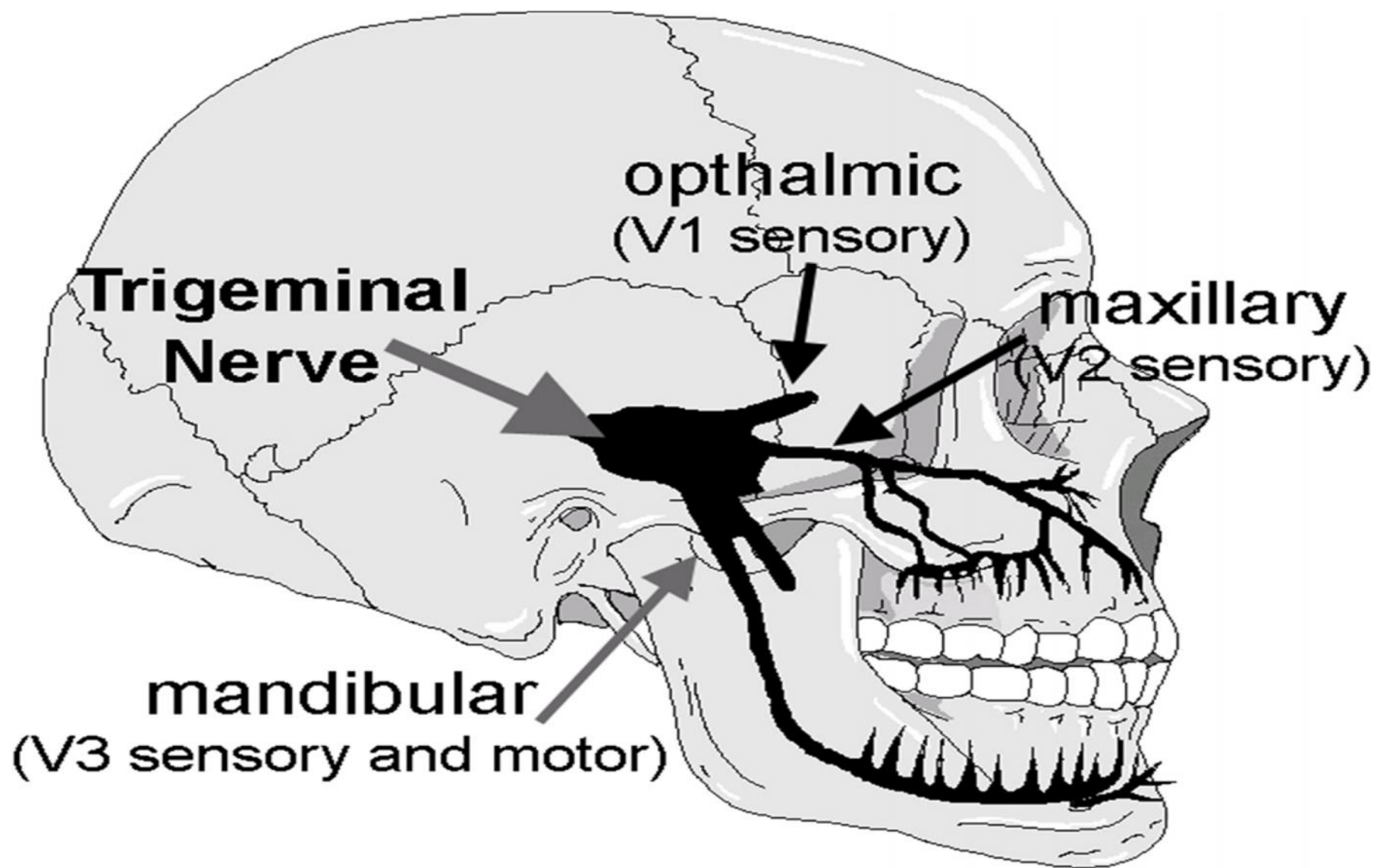


1. Olfactory
2. Optic
3. Oculomotor
4. Trochlear
5. Trigeminal
6. Abducens
7. Facial
8. Vestibulo  
cochlear  
(Auditory)
9. Glosso  
pharyngeal
10. Vagus
11. Spinal accessory / Accessory
12. Hypoglossal



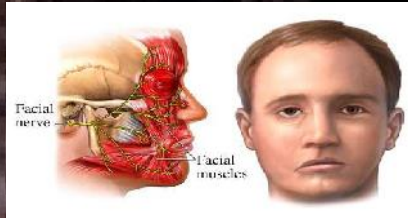
On Old Olympus' Towering Top, A  
Finn And German Viewed Some Hops

Cranial Nerve	Fibres	Structures Innervated	Functions	Brainstem Nucleus
I Olfactory	Sensory	Olfactory epithelium (via olfactory bulb)	Olfaction	-----
II Optic	Sensory	Retina	Vision	-----
III Oculomotor	Motor	Superior/middle/inferior rectus, inferior oblique, levator palpebrae.	Movement of eye ball	Oculomotor nucleus
	Parasympathetic	Pupillary constrictor, ciliary muscle of eyeball. Both via the ciliary ganglion	Pupillary constriction and accommodation	Oculomotor nucleus
IV Trochlear	Motor	Superior oblique	Movement of eyeball	Trochlear nucleus
V Trigeminal	Sensory	Face, scalp, cornea, nasal and oral cavities, cranial dura mater.	General sensation	Trigeminal sensory nucleus
	Motor	Muscles of mastication Tensor Tympani muscle	Opening/closing mouth Tension of tympanic membrane	Trigeminal Motor nucleus Trigeminal Motor nucleus
VI Abducens	Motor	Lateral rectus	Movement of eyeball	Abducens nucleus
VII Facial	Sensory	Anterior 2/3 of tongue	Taste	Nucleus Solitarius
	Motor	Muscles of facial expression Stapedius Muscle	Facial Movement Tension of ossicles	Facial Motor nucleus Facial Motor Nucleus
	Parasympathetic	Salivary and lacrimal glands via submandibular and pterygopalatine ganglia	Salivation and Lacrimation	Superior Salivatory Nucleus
VIII Vestibulocochlear	Sensory	Cochlea	Hearing	Cochlear Nucleus
		Vestibular apparatus	Proprioception of head, balance.	Vestibular nucleus
IX Glossopharyngeal	Sensory	Eustachian tube, middle ear	General Sensation,	Trigeminal Sensory nucleus
		Carotid Body, and sinus	Chemo/baroreception	
		Pharynx, posterior 1/3 of tongue	Taste	Nucleus Solitarius
	Motor	Styropharyngeous	Swallowing	
	Parasympathetic	Salivary glands via the otic ganglion	Salivation	Inferior Salivatory nucleus
X Vagus	Sensory	Pharynx, larynx, oesophagus, external ear	General Sensation	Trigeminal Sensory nucleus
		Aortic bodies and arch	Chemo/baroreception	
		Thoracic and abdominal viscera	Visceral Sensation	Nucleus Solitarius
	Motor	Soft Palate, larynx, pharynx, upper oesophagus	Speech, swallowing	Nucleus Ambiguus
	Parasympathetic	Cardiovascular, respiratory and gastrointestinal systems.	Control of these systems	Dorsal Motor nucleus of Vagus
XI Accessory	Motor	Sternomastoid, trapezius	Movement of head and shoulders	Nucleus Ambiguus, cranial nerves
XII Hypoglossal	Motor	Intrinsic and extrinsic muscles of tongue	Movement of tongue	Hypoglossal nucleus





*Branches of facial nerve in the face*



Temporal  
Zygomatic  
Buccal  
Mandibular  
Cervical

