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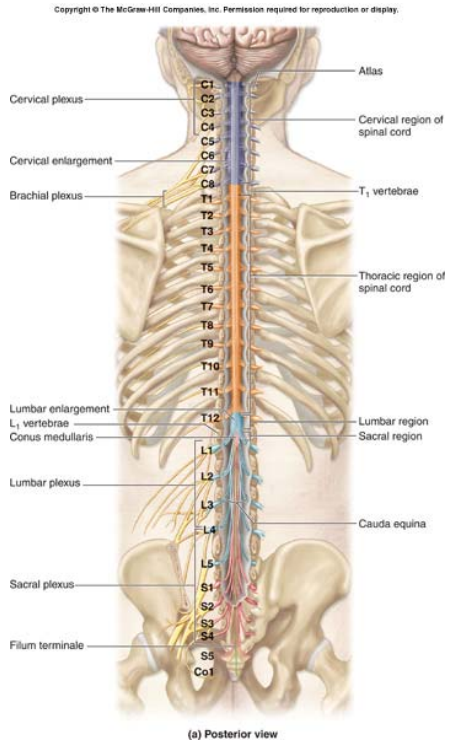
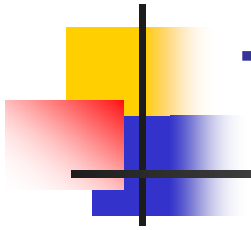
Human Anatomy



Spinal Cord and Spinal Nerves



The Spinal Cord

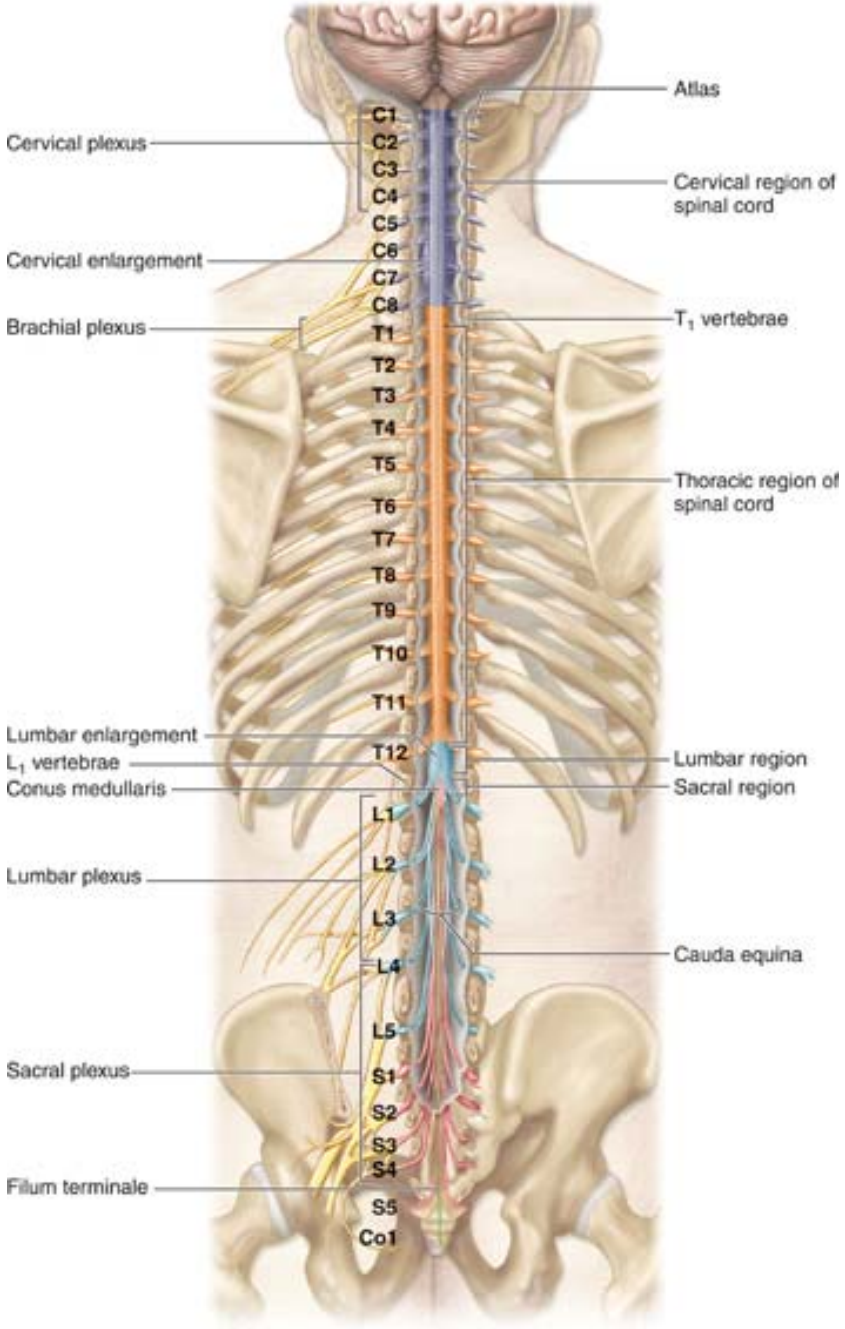
- Link between the brain and the body.
- Exhibits some functional independence from the brain.
- The spinal cord and spinal nerves serve two functions:
  - pathway for sensory and motor impulses
  - responsible for reflexes

Structure of the Spinal Cord

- Typical adult spinal cord
  - ranges between 42 and 45 centimeters (cm) (16 to 18 inches) in length.
- In cross section
  - roughly cylindrical
  - slightly flattened both posteriorly and anteriorly.
- External surface has two longitudinal depressions:
  - the posterior (dorsal) median sulcus
  - the anterior (ventral) median fissure

Regions of the Spinal Cord

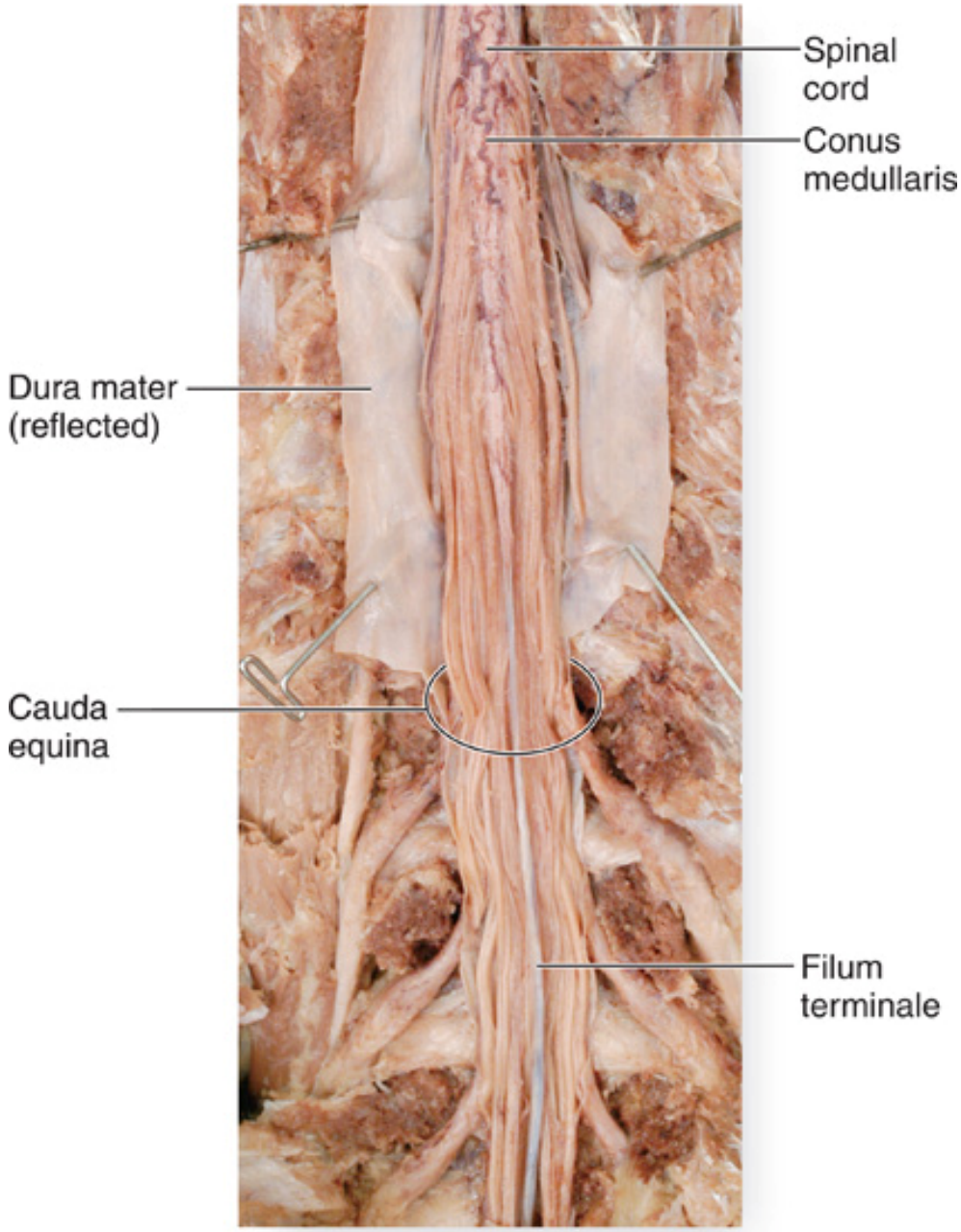
- The cervical region
  - continuous with the medulla oblongata
  - contains neurons whose axons form the cervical spinal nerves (8)
- The thoracic region
  - attached to this region are the thoracic spinal nerves (12)
- The lumbar region
  - contains the neurons for the lumbar spinal nerves (5)
- The sacral region
  - contains the neurons for the sacral spinal nerves (5)
- The coccygeal region
  - one pair of coccygeal spinal nerves arises from this region



(a) Posterior view

Structure of the Spinal Cord

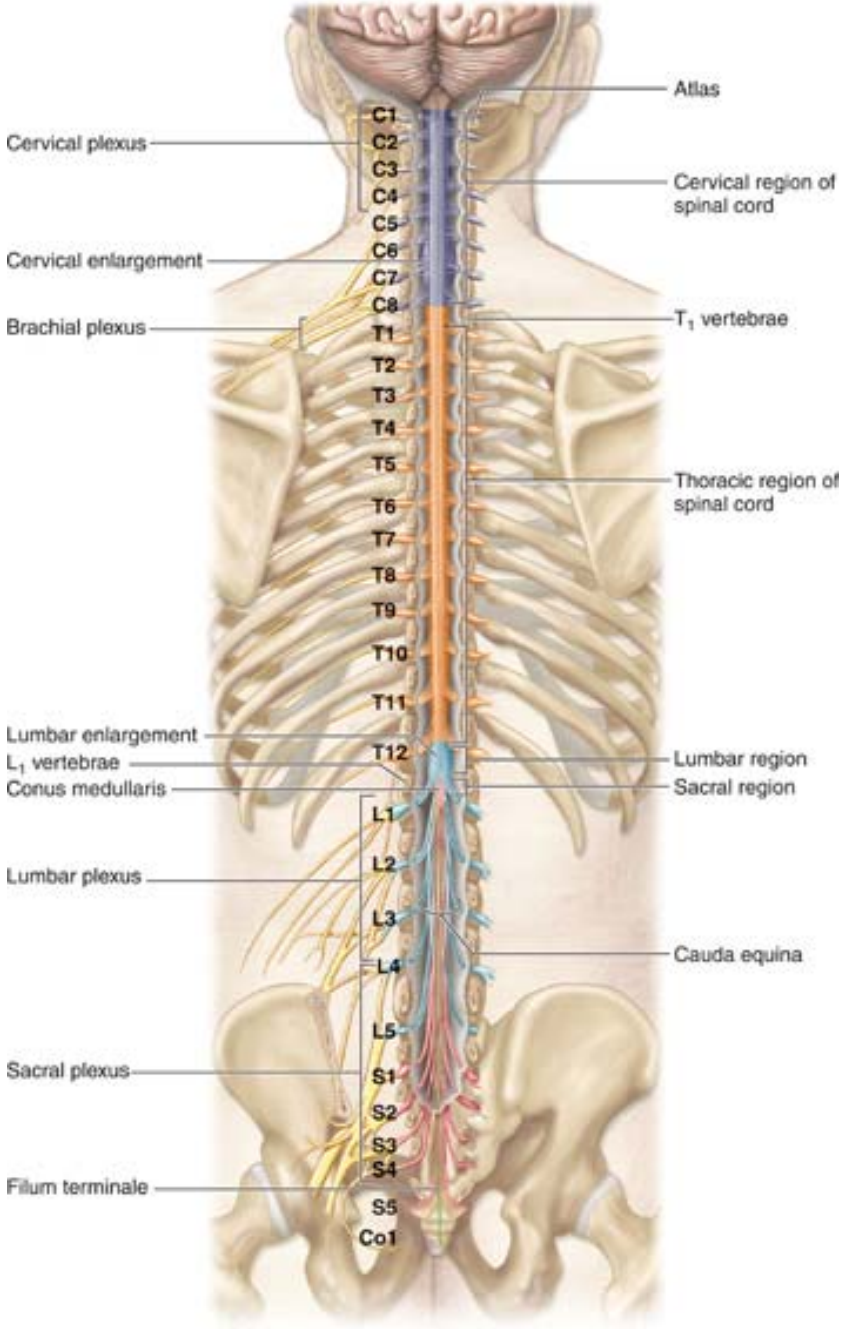
- The spinal cord is shorter than the vertebral canal that houses it.
- Conus medullaris:
  - tapered inferior end of the spinal cord
  - marks the official “end” of the spinal cord proper.
- Cauda equina
  - Inferior to conus medularis
  - nerve roots (groups of axons) that project inferiorly from the spinal cord.
- Filum terminale
  - Within the cauda equina
  - thin strand of pia mater
  - helps anchor the conus medullaris to the coccyx.



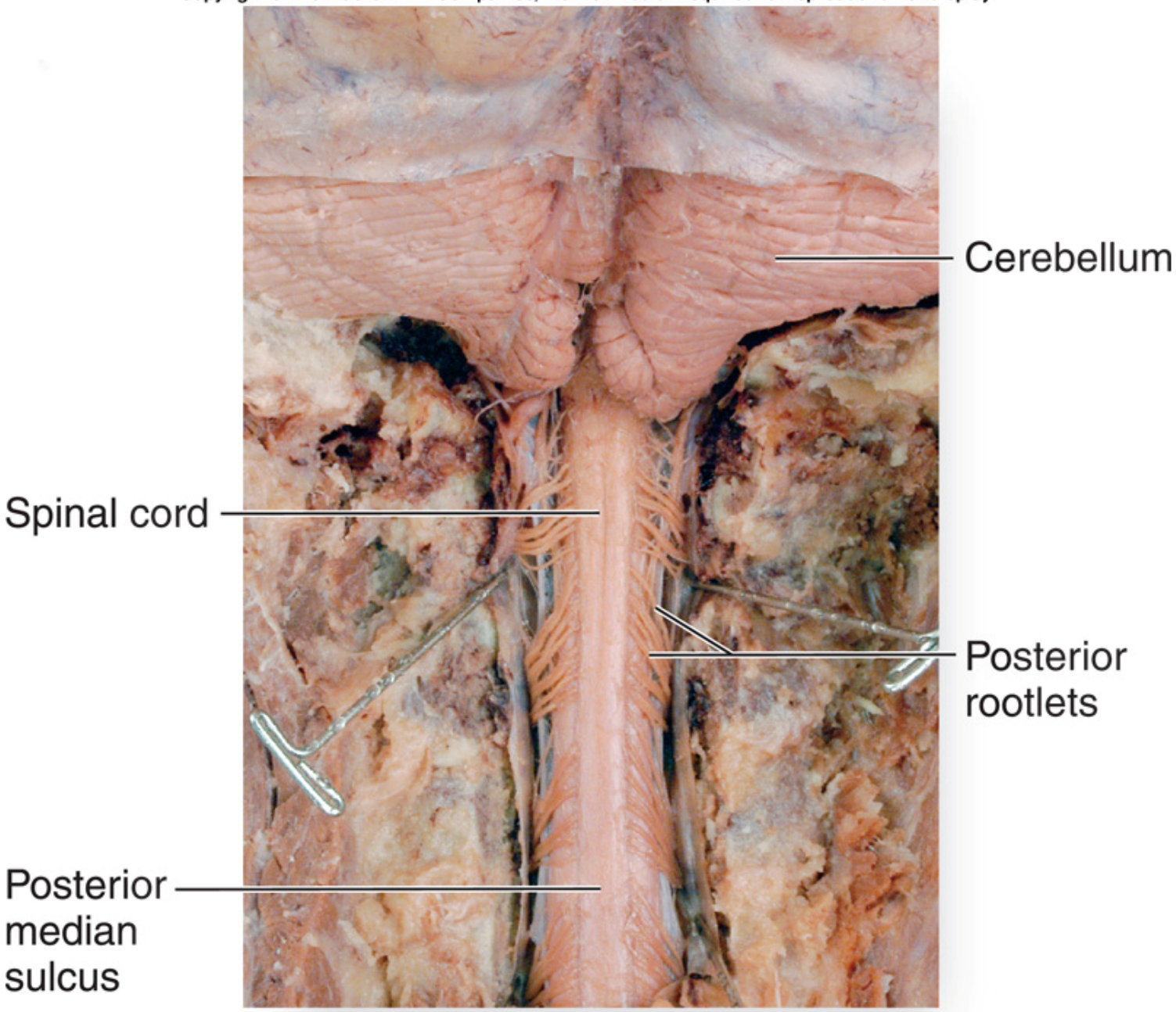
(c) Conus medullaris and cauda equina

Structure of the Spinal Cord

- The spinal cord is associated with 31 pairs of spinal nerves
- Connect the CNS to:
  - receptors
  - effectors (muscle and glands)
- Each side of the spinal cord contains:
  - 8 cervical nerves (called C1–C8)
  - 12 thoracic nerves (T1–T12)
  - 5 lumbar nerves (L1–L5)
  - 5 sacral nerves (S1–S5)
  - 1 coccygeal nerve (Co1)



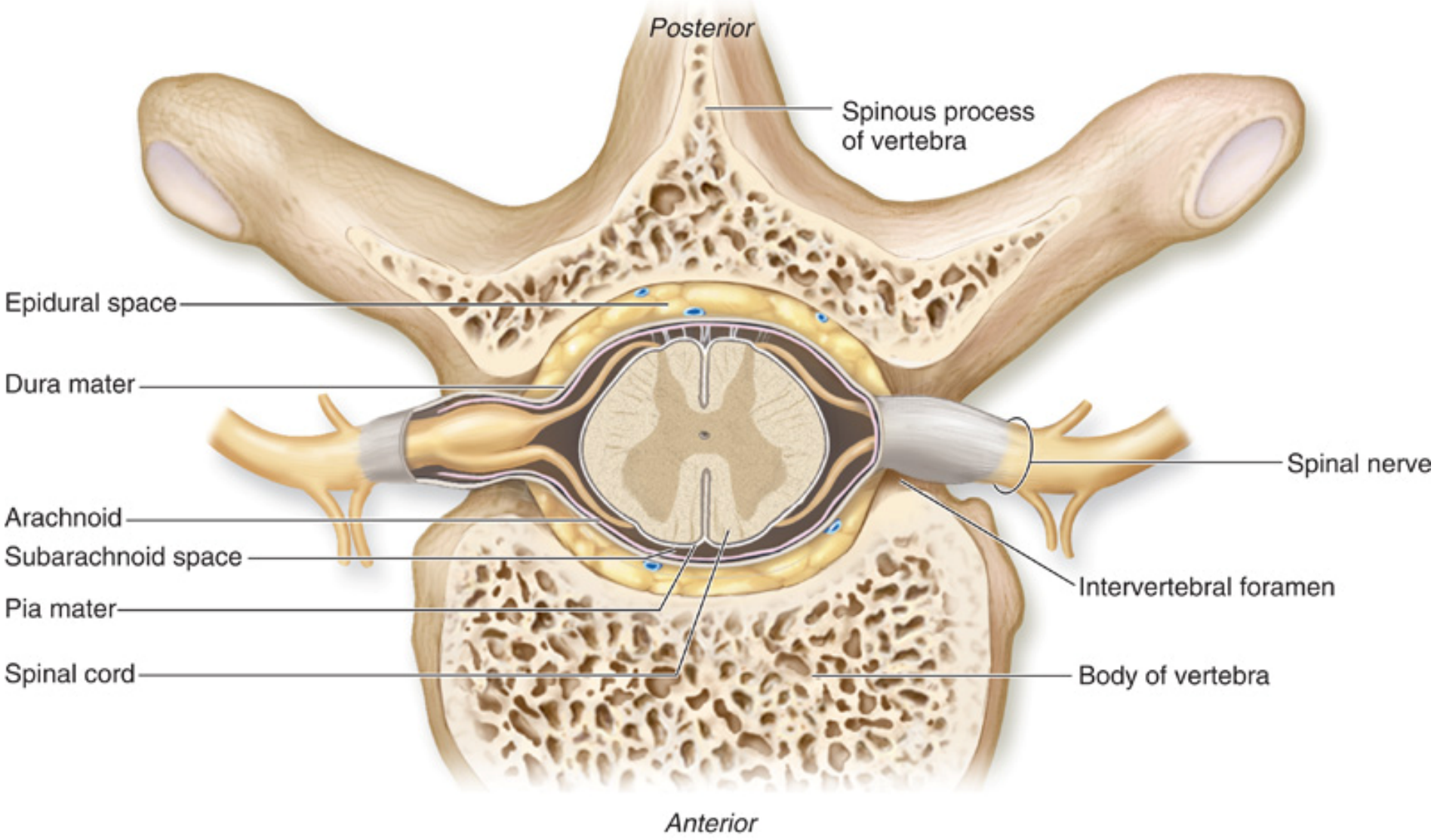
(a) Posterior view



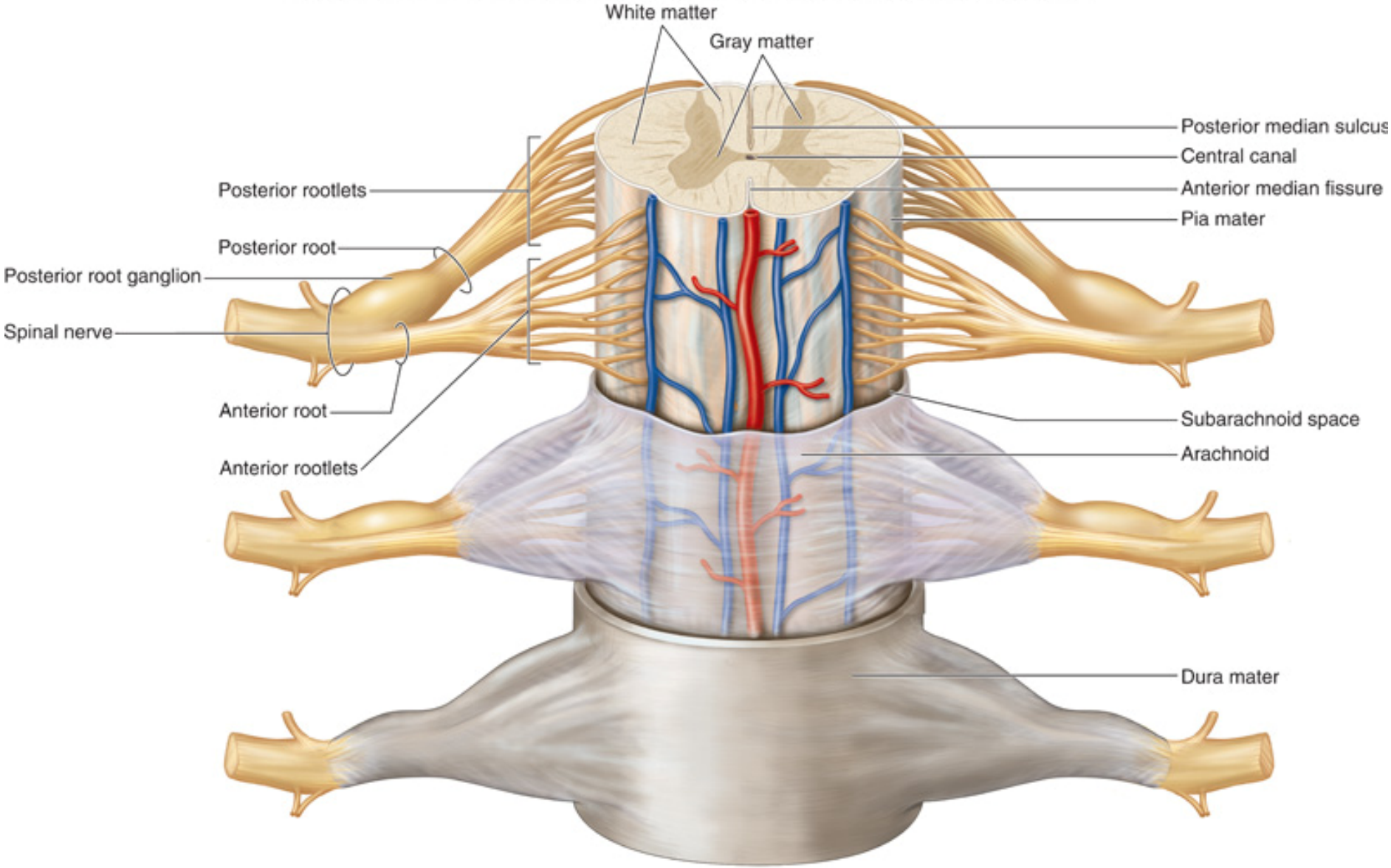
(b) Cervical region

Arrangement and Functions of the Spinal Meninges

- Are continuous with the cranial meninges.
- Structures that encircle the spinal cord, listed from superficial to deep are:
  - vertebra
  - epidural space
  - dura mater
  - subdural space
  - arachnoid
  - subarachnoid space
  - pia mater



(a) Cross section of vertebra and spinal cord



(b) Anterior view

Location and Distribution of Gray Matter

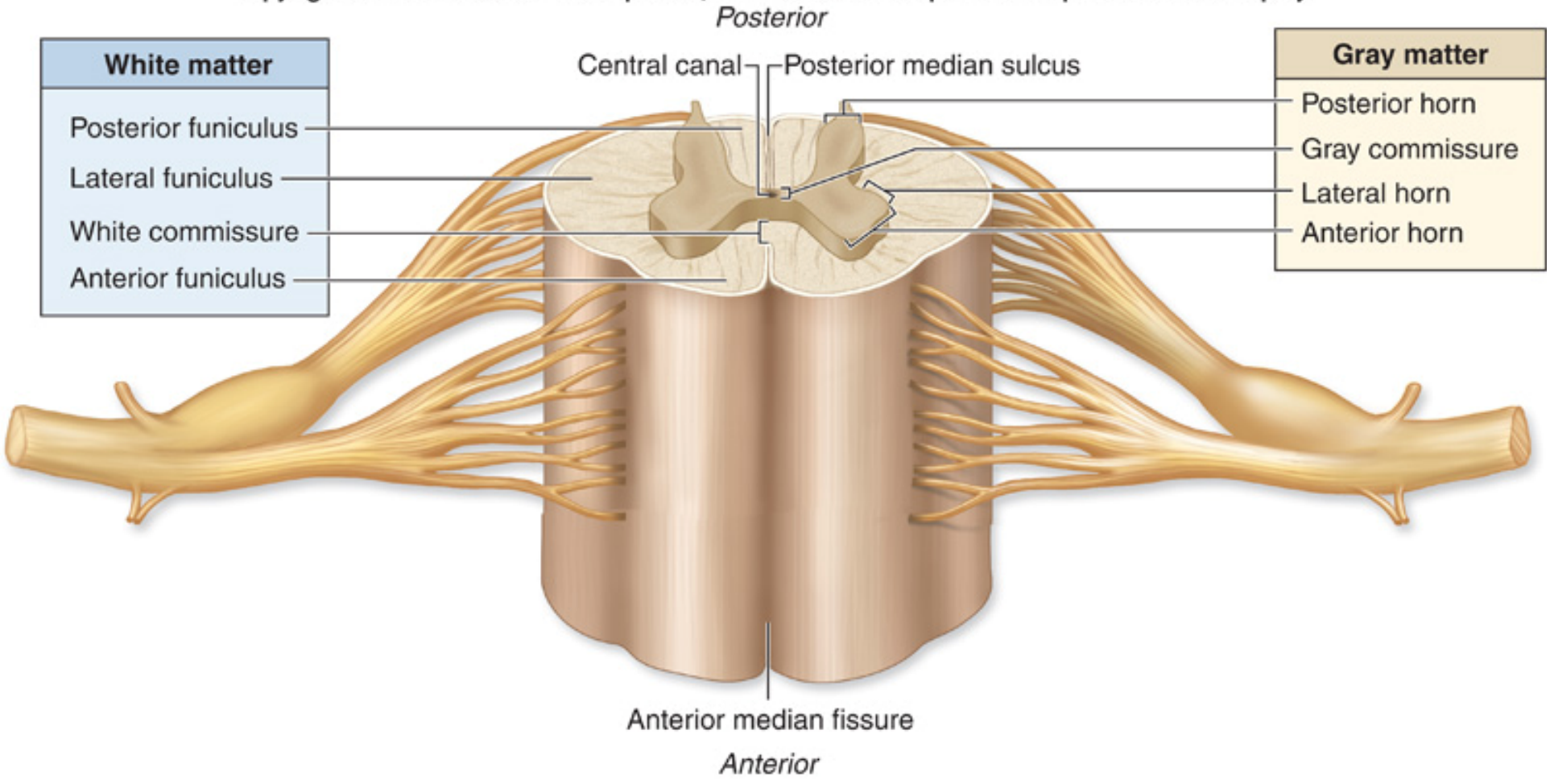
- In the spinal cord, it is centrally located.
- Its shape resembles a letter H or a butterfly.
- The gray matter may be subdivided into the following components:
  - anterior horns
  - lateral horns
  - posterior horns
  - the gray commissure

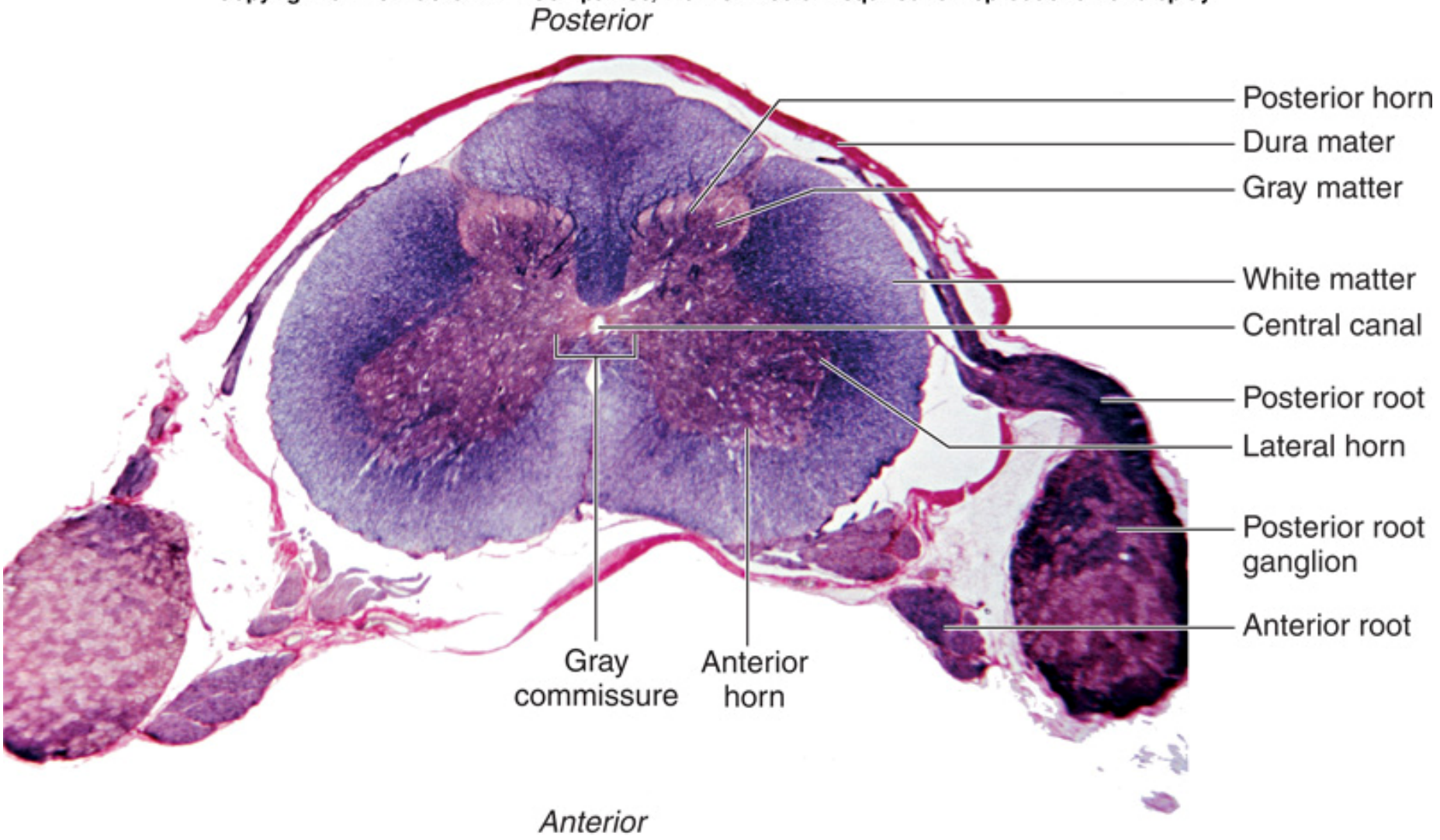
Location and Distribution of White Matter

- The white matter of the spinal cord is external to the gray matter.
- Three regions.
  - Composed of tracts
    - Ascending
    - Descending
  - A posterior funiculus:
    - lies between the posterior gray horns and the posterior median sulcus.

Location and Distribution of White Matter

- Lateral funiculus.
- Anterior funiculus
  - between the anterior gray horns and the anterior median fissure.
- The anterior funiculi are interconnected by the white commissure.





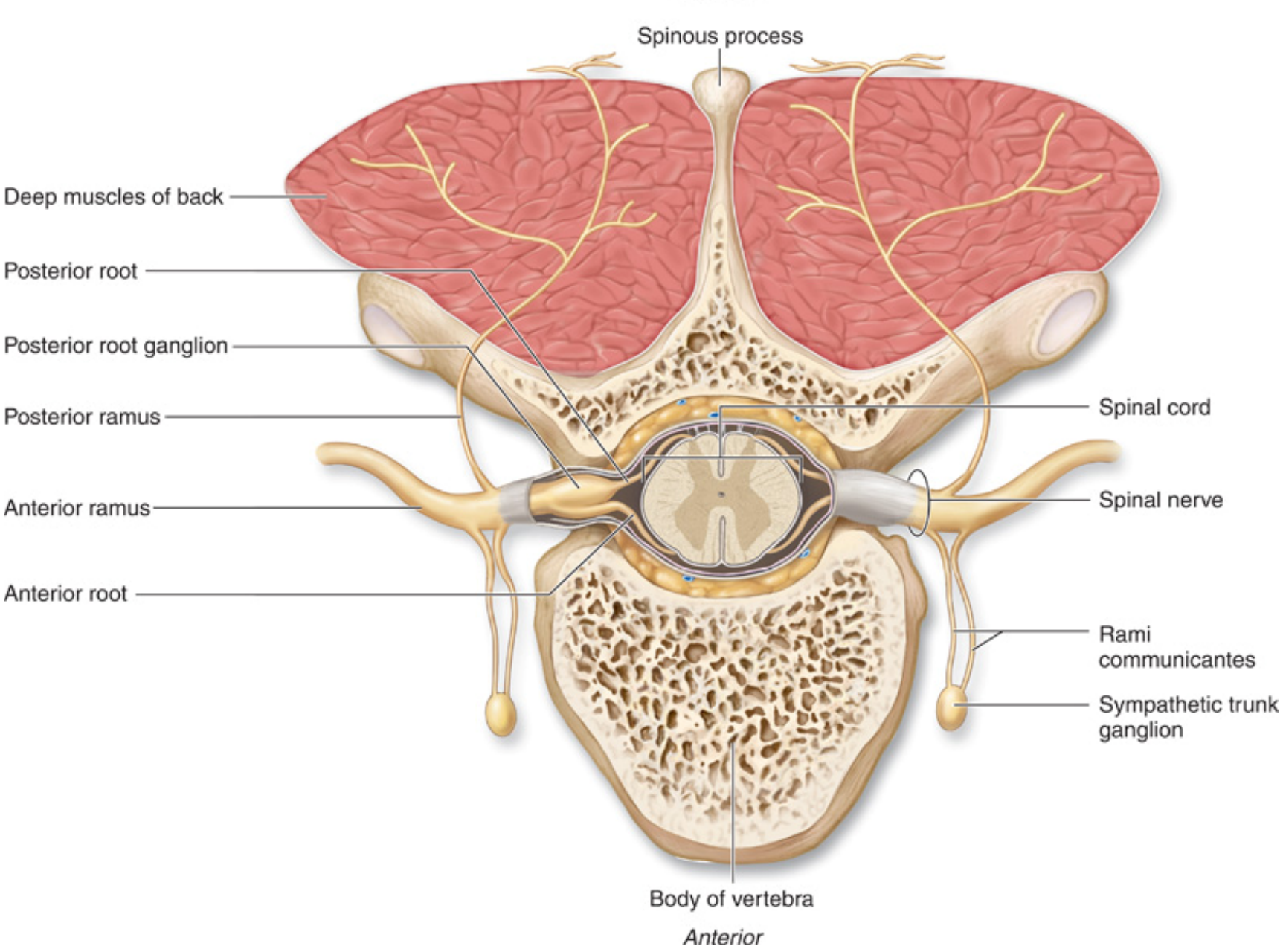
(b)

Spinal Nerves

- 31 pairs
  - connect the CNS to:
    - receptors
    - muscles, glands
- Each spinal nerve is mixed:
  - thousands of motor and sensory axons.
  - Sensory axons originate from receptors
  - Motor axons originate from the spinal cord.
- Anterior root and posterior root unite within the intervertebral foramen
  - become a spinal nerve.
- Spinal nerve is associated with the vertebra of the same number.

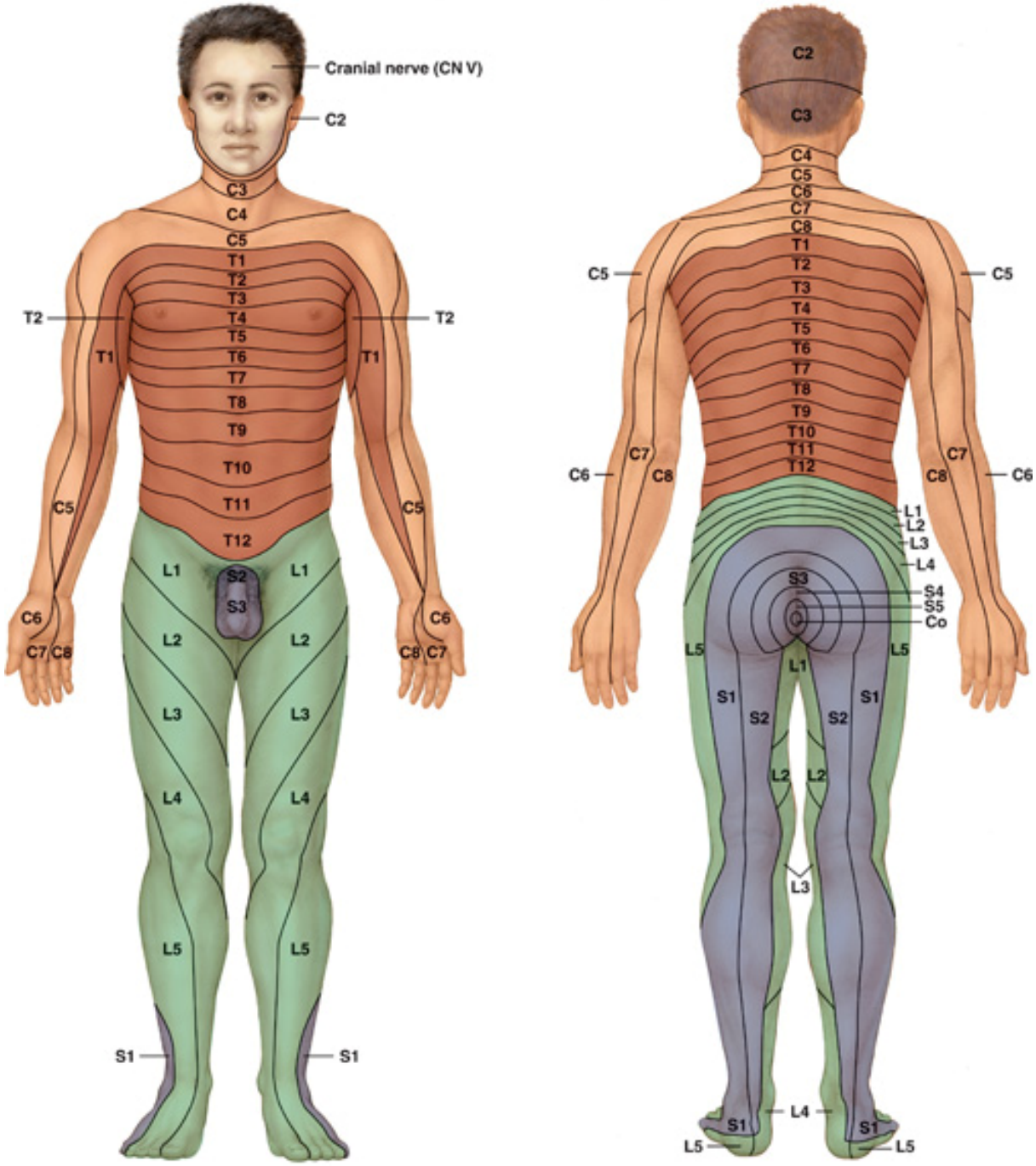
Rami of Spinal Nerves

- Posterior (or Dorsal) ramus
  - Innervates muscles and skin of the back
- Anterior Ramus
  - Largest branch
  - Forms plexuses
  - Innervates anterior and lateral trunk, upper and lower limbs
- Rami communicantes
  - Autonomic nervous system (sympathetic)



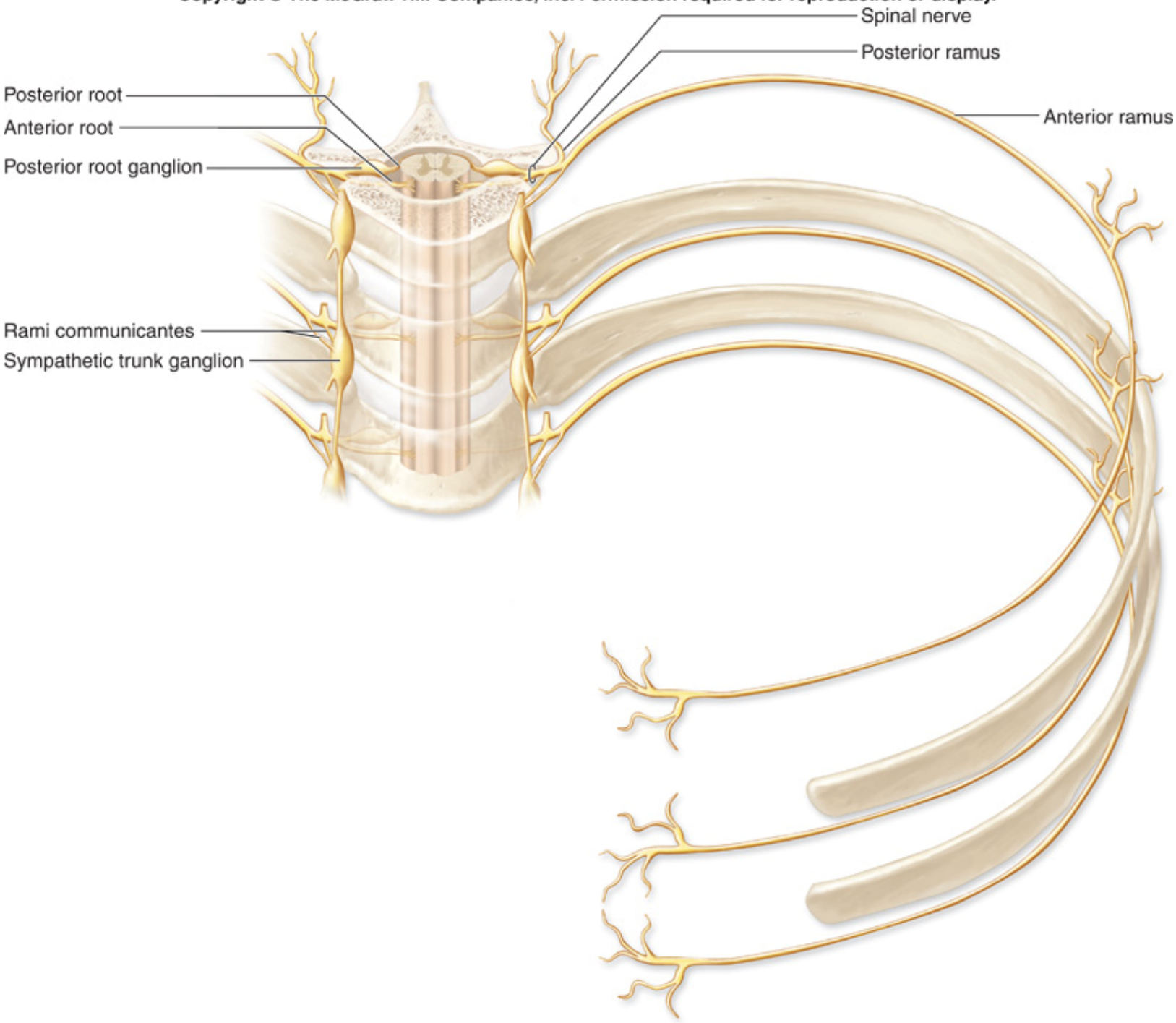
Dermatomes

- A specific segment of skin supplied by a single spinal nerve.
- All spinal nerves
  - innervate a segment of skin and are associated with a dermatome.
  - except for C1
- Dermatome map:
  - sensory segments: skin of the body associated with a spinal nerve



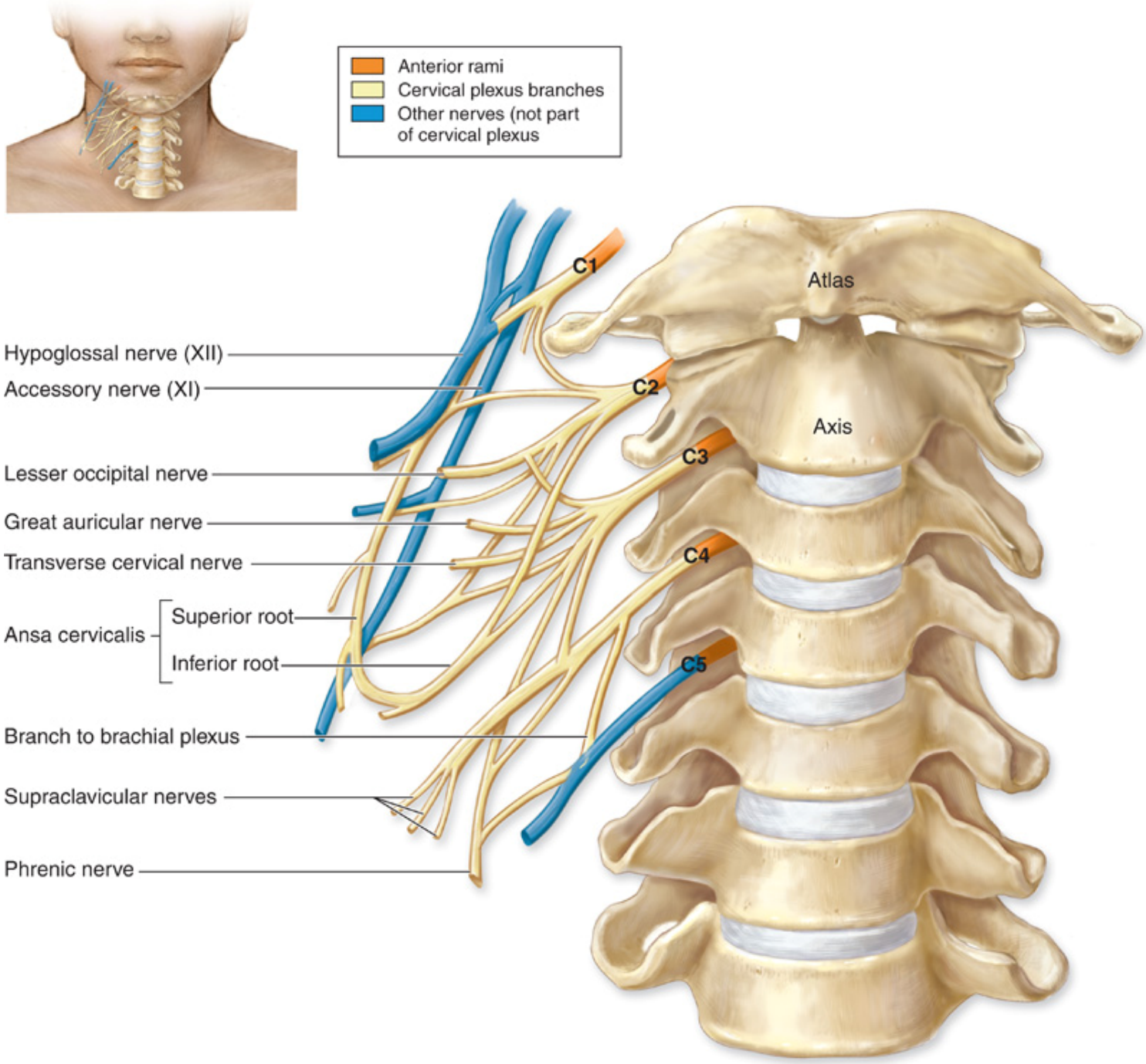
Intercostal Nerves

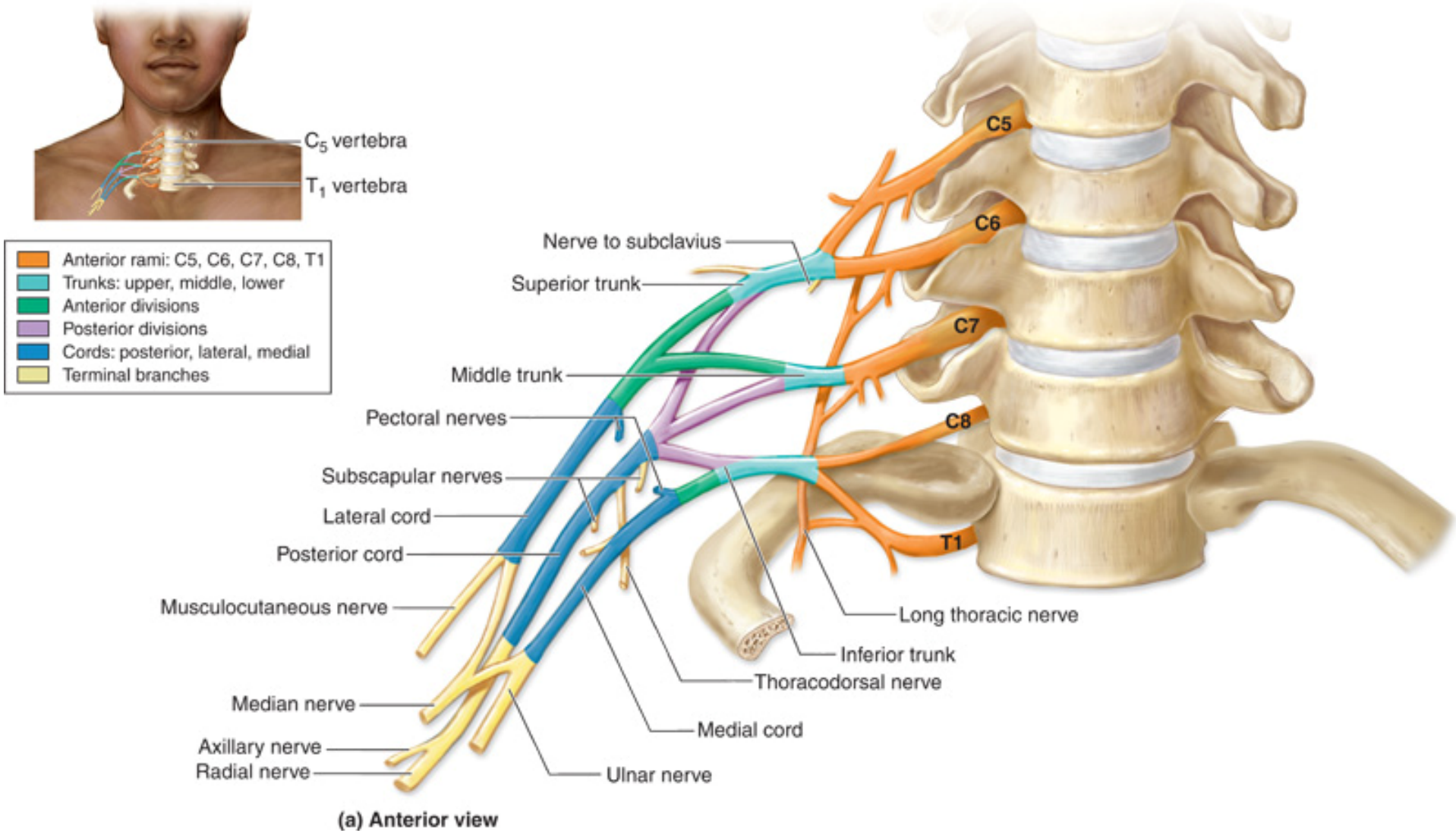
- Anterior rami of spinal nerves T1–T11.
- Travel in the intercostal space sandwiched between two adjacent ribs



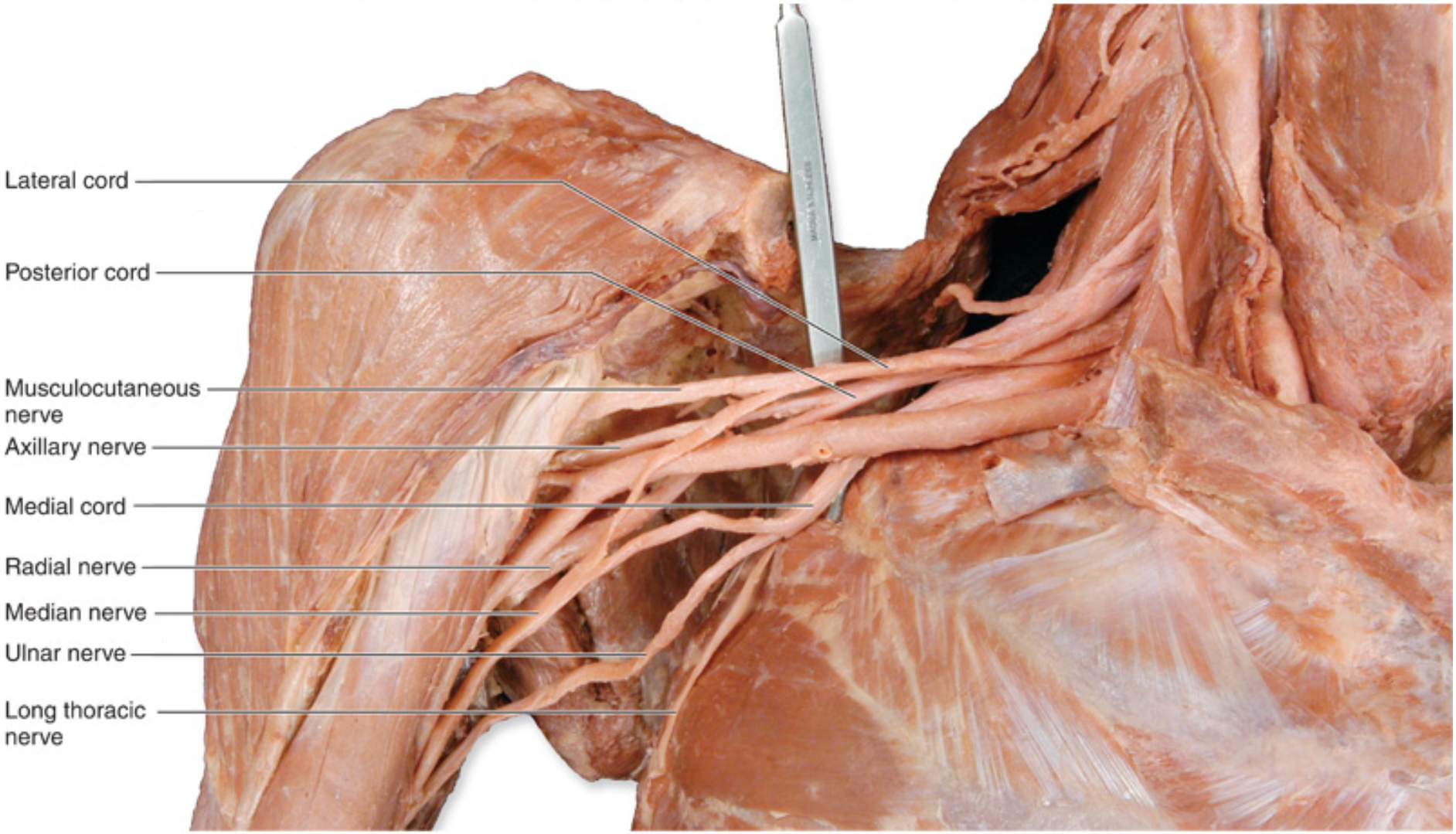
Nerve Plexuses

- A network of interweaving anterior rami of spinal nerves.
  - nerve plexuses on both the right and left sides of the body.
- Nerve plexuses then split into multiple "named" nerves that innervate various body structures.
- Principal plexuses
  - cervical plexuses
  - brachial plexuses
  - lumbar plexuses
  - sacral plexuses.

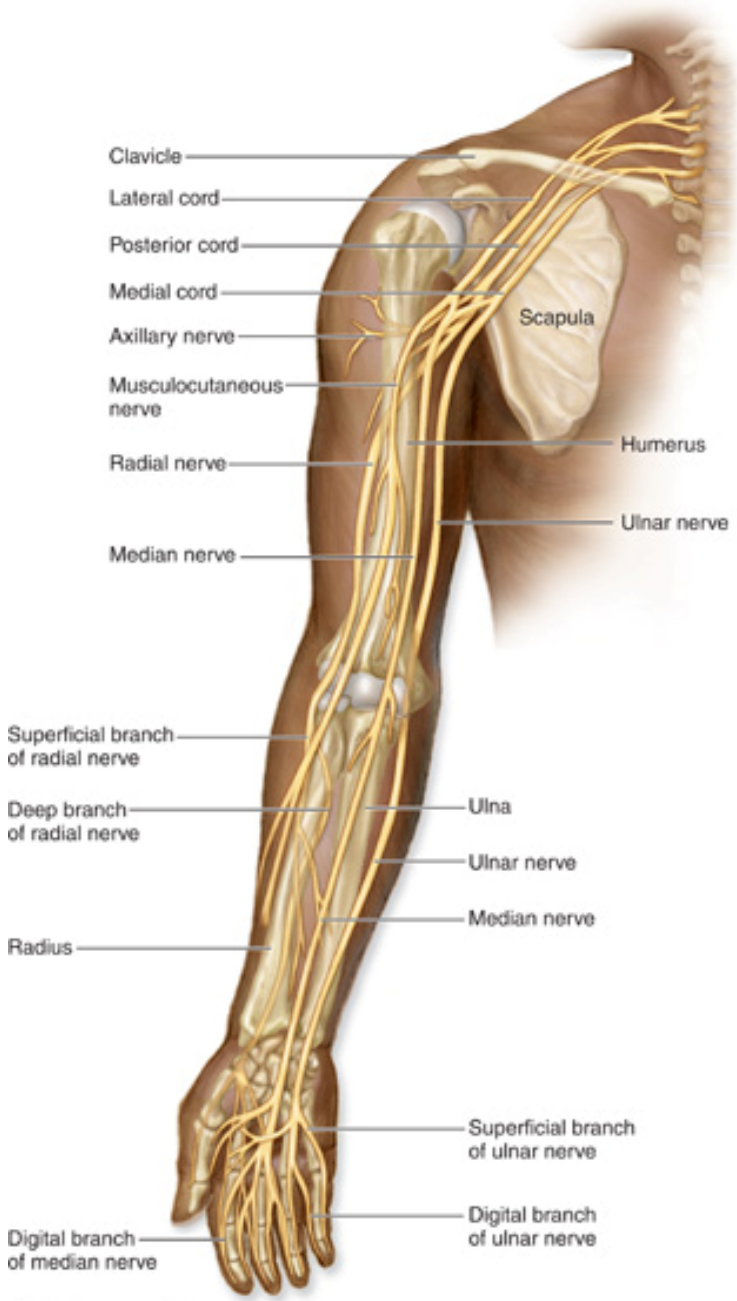




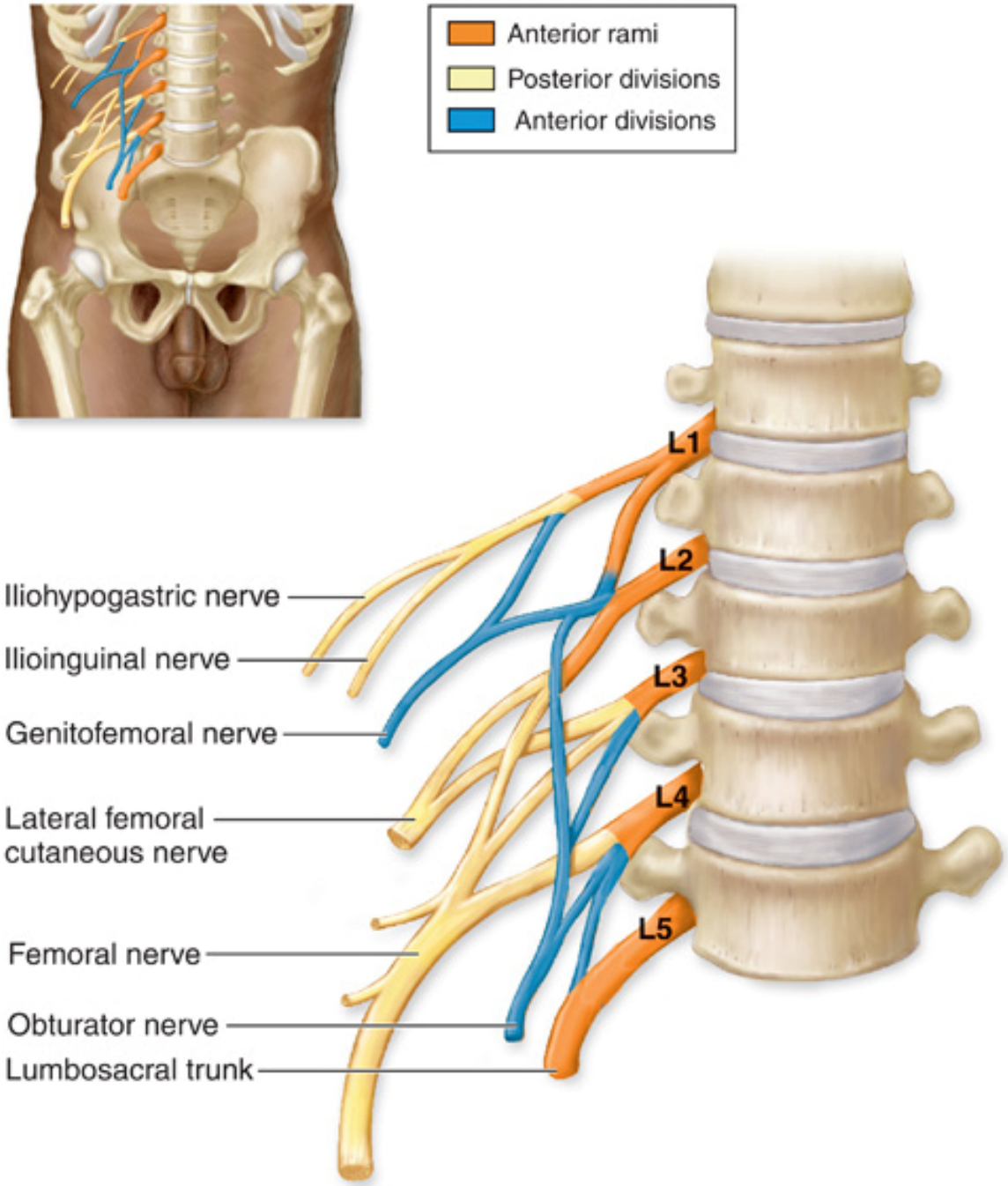
(a) Anterior view



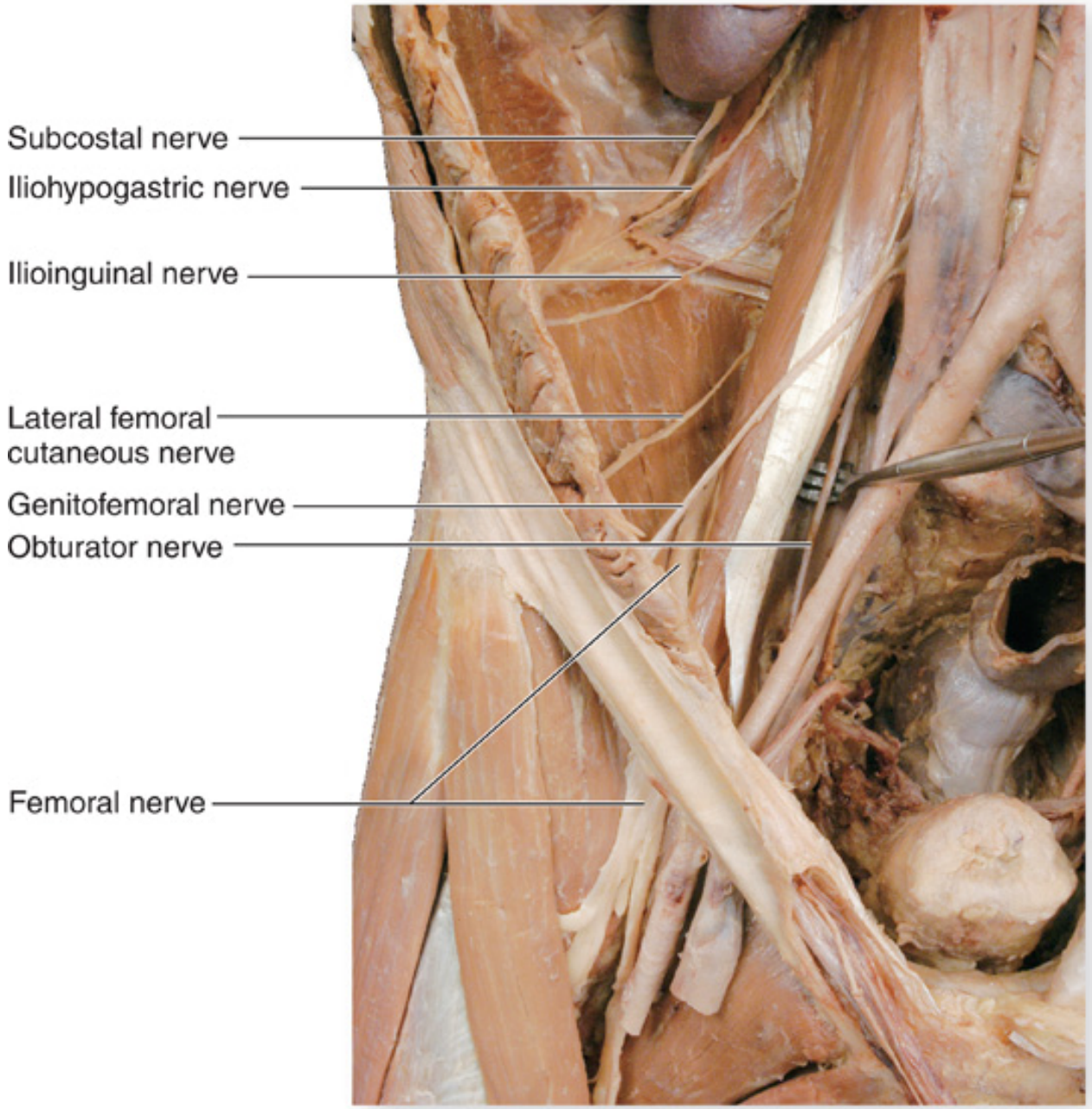
(b) Right axilla, anterior view



(c) Right upper limb, anterior view

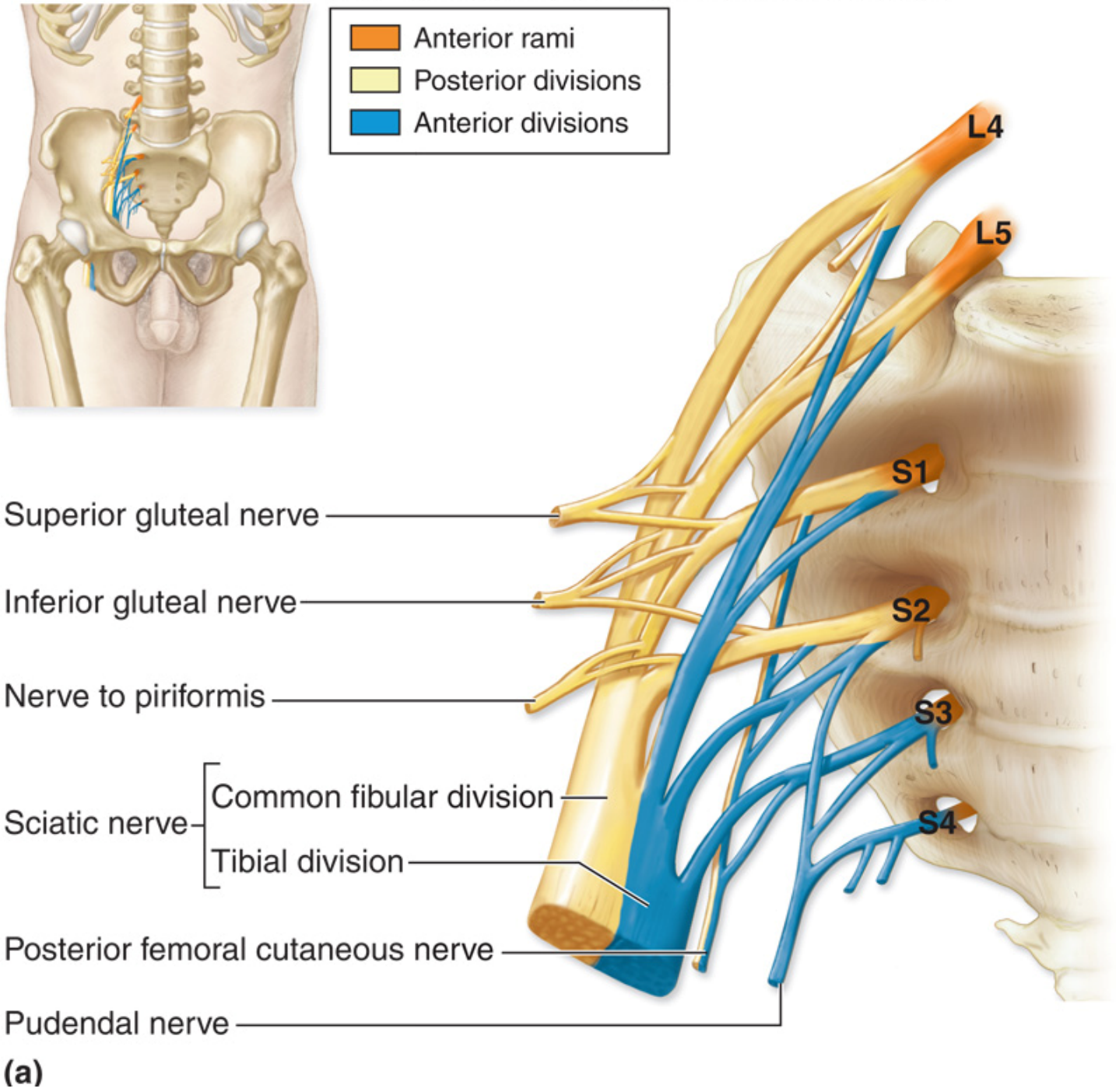


(a) Anterior view



(b) Right pelvic region, anterior view

(c) Right lower limb, anterior view



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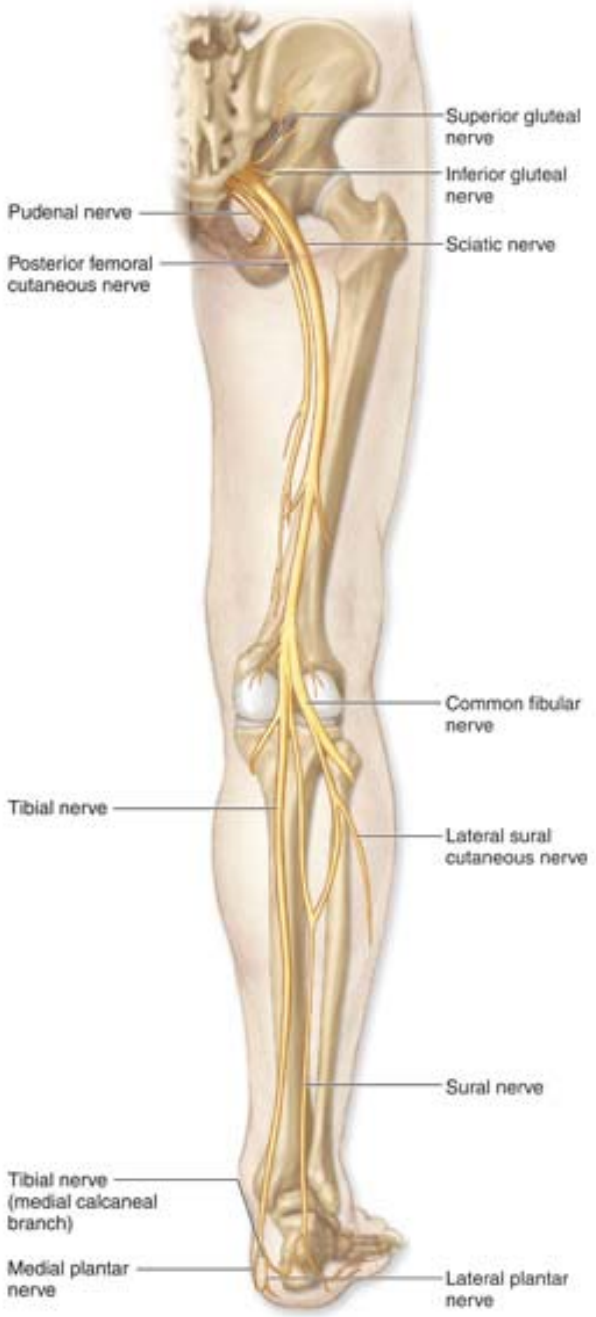
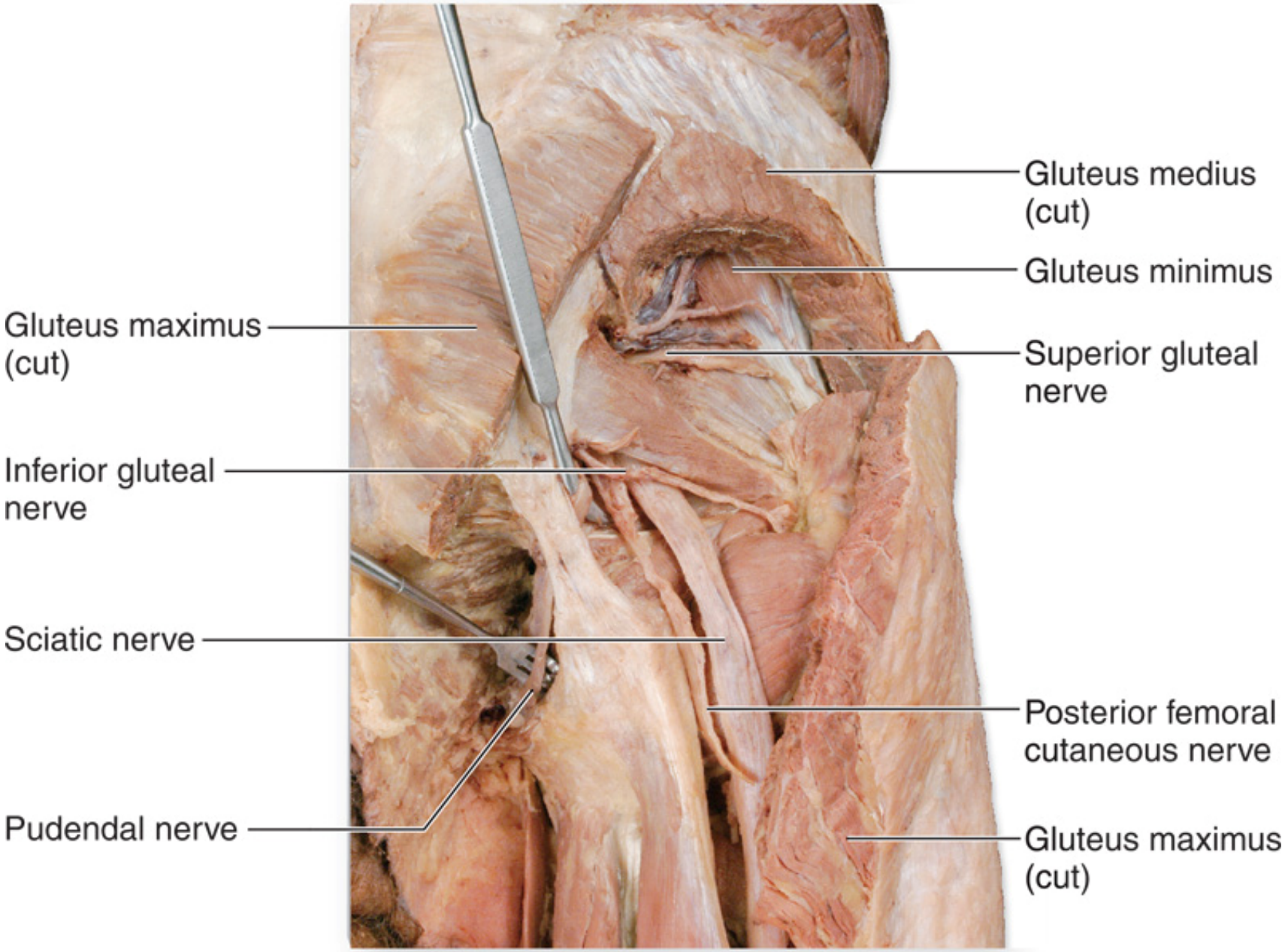
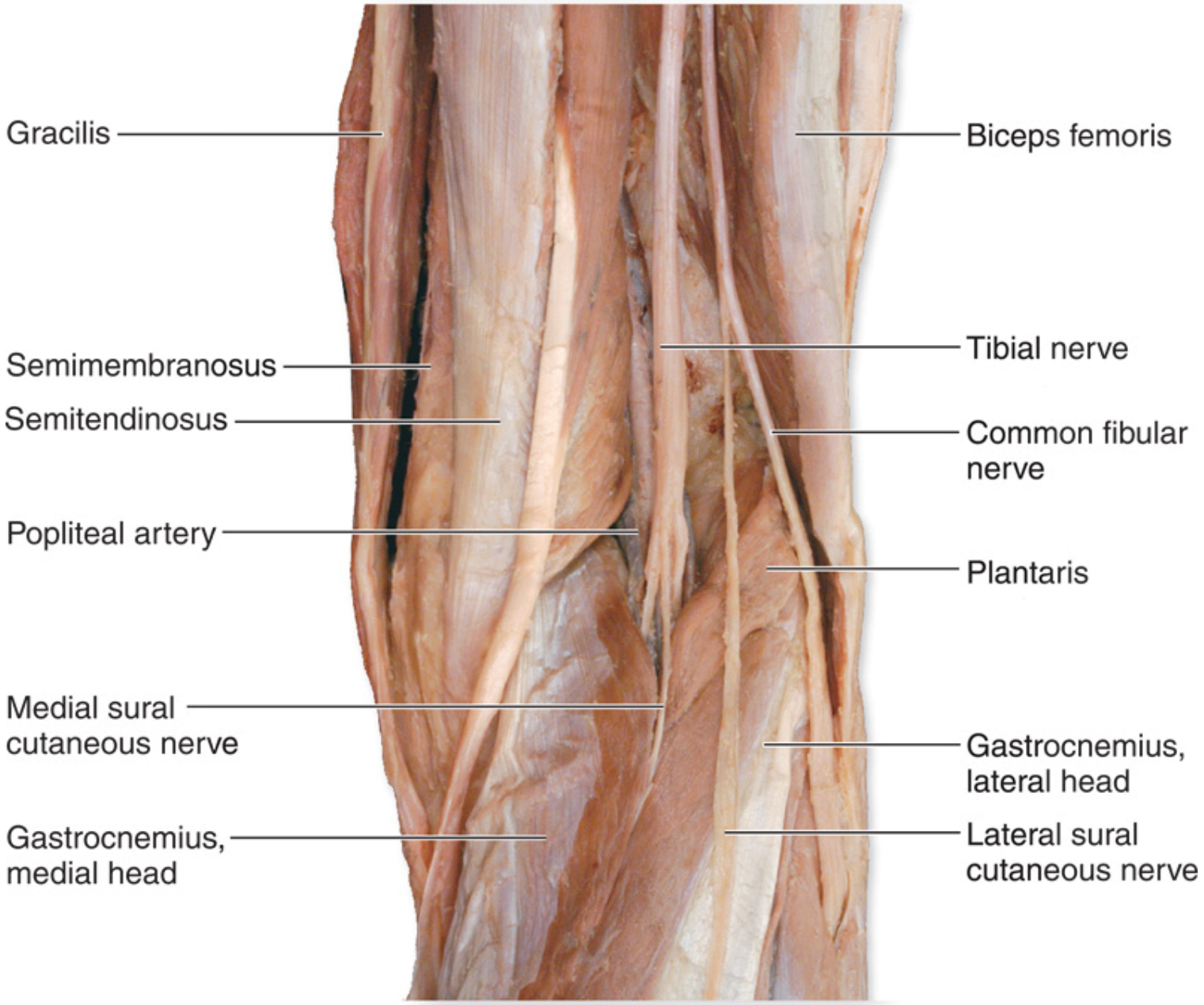


(b) Right lower limb, posterior view



(c) Right gluteal region



(d) Right popliteal region

Reflexes

- A reflex is a response:
  - Rapid, automatic
  - involuntary reactions of effectors to a stimulus.
- Properties.
  - a stimulus
    - required to initiate a response to sensory input
  - a rapid response
    - requires that few neurons be involved
    - synaptic delay be minimal
  - an automatic response occurs the same way every time
- An involuntary response requires no intent or pre-awareness of the reflex activity.
- Reflexes usually can not be suppressed.
- Awareness of the stimulus occurs after the reflex action
  - in time to correct or avoid a potentially dangerous situation.

Components of a Reflex Arc

- The neural “wiring” of a single reflex.
- Always begins at a receptor in the PNS
  - Sensory afferent
- Communicates with the CNS.
  - May involve interneurons
- Ends at a peripheral effector (muscle or gland)
  - Motor efferent

Ipsilateral and Contralateral Reflex Arcs

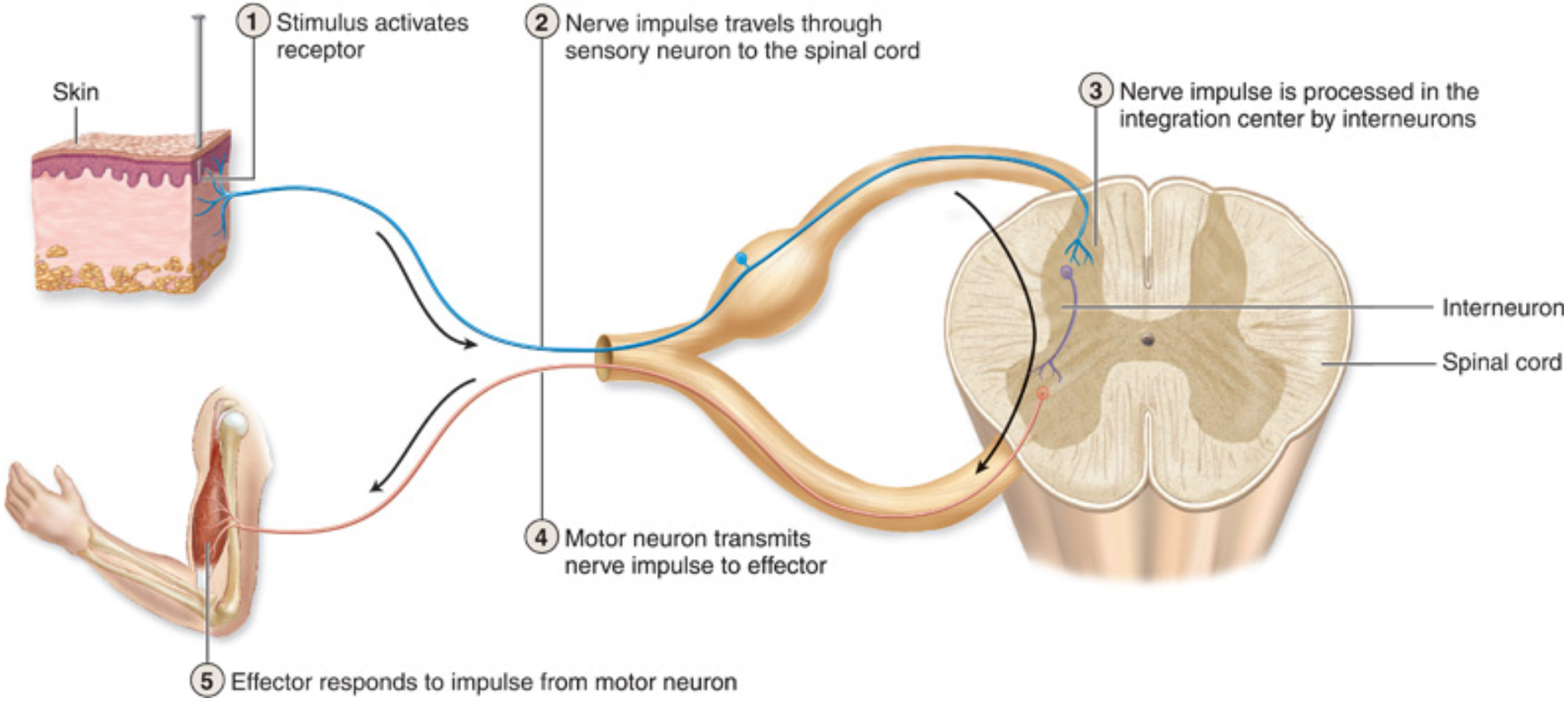
- Ipsilateral:
  - both the receptor and effector organs of the reflex are on the same side of the spinal cord.
- Contralateral
  - the sensory impulses from a receptor organ cross over through the spinal cord to activate effector organs in the opposite side

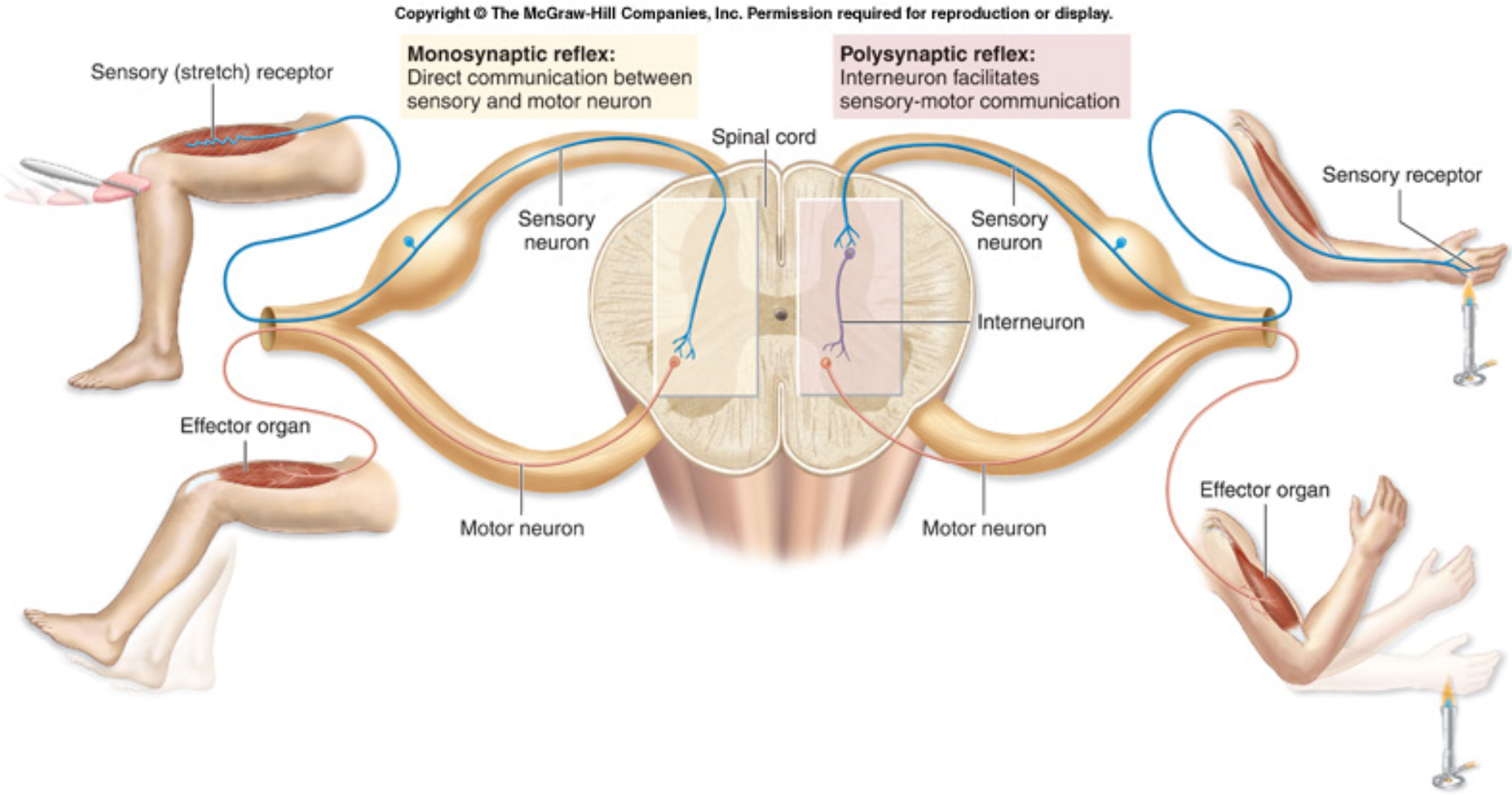
Monosynaptic Reflexes

- The simplest of all reflexes.
- No interneurons.
- The patellar (knee-jerk) reflex is a monosynaptic reflex
  - physicians use to assess the functioning of the spinal cord.
  - tap the patellar ligament with a reflex hammer
  - muscle spindles in the quadriceps muscles are stretched.
- Produces a noticeable kick of the leg.

Polysynaptic Reflexes

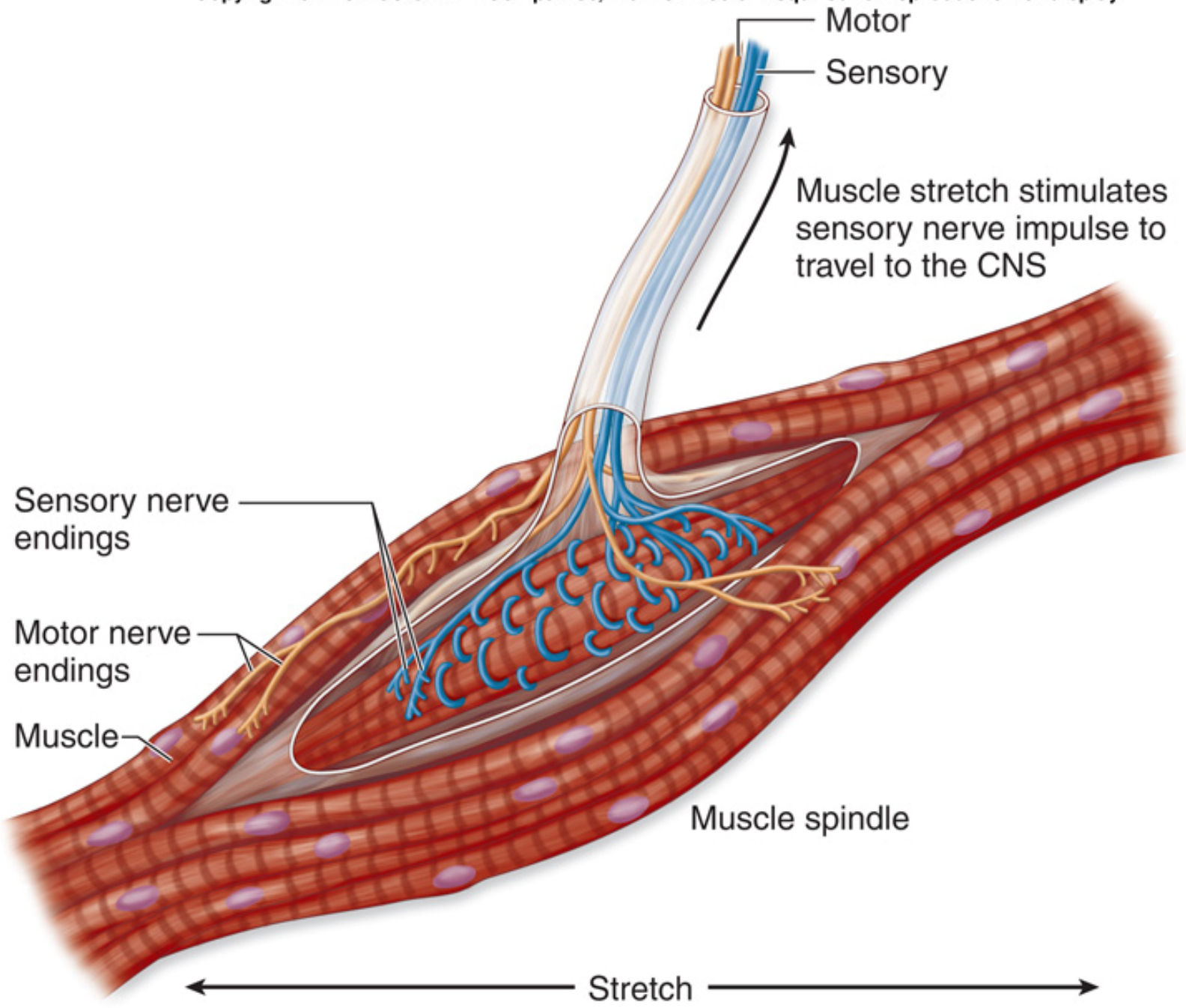
- Have more complex neural pathways
  - exhibit a number of synapses
  - involve interneurons within the reflex arc.
- Has more components
  - more prolonged delay between stimulus and response.





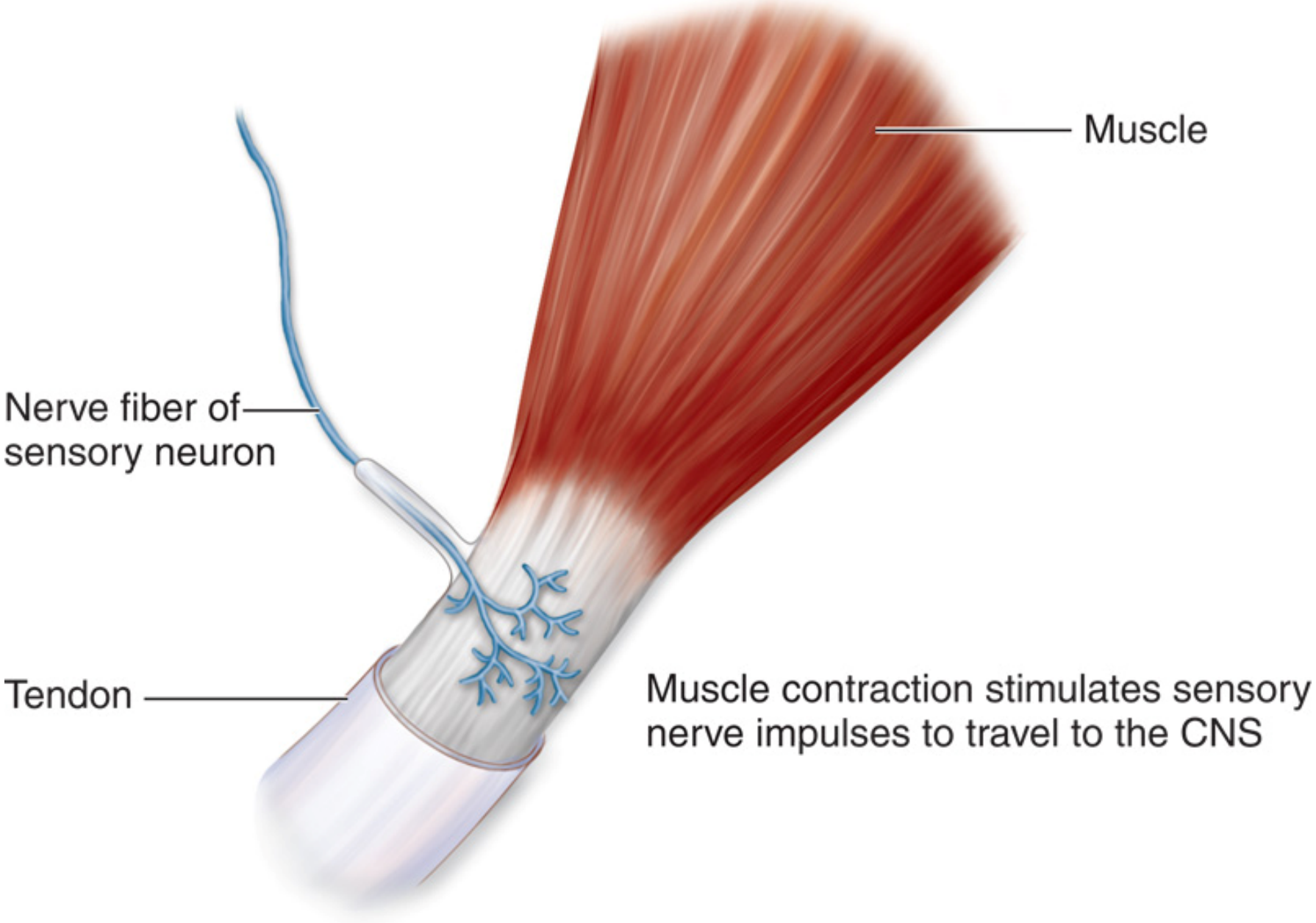
Stretch Reflexes

- Monosynaptic reflex that monitors and regulates skeletal muscle length.
- When a stimulus results in the stretching of a muscle, that muscle reflexively contracts.
- The patellar (knee-jerk) reflex is an example of a stretch reflex.
- The stimulus (the tap on the patellar tendon) initiates contraction of the quadriceps femoris muscle and extension of the knee joint.



Golgi Tendon Reflex

- Prevents skeletal muscles from tensing excessively.
- Golgi tendon organs are nerve endings located within tendons near a muscle–tendon junction.
  - activation of the Golgi tendon organ signal interneurons in the spinal cord, which in turn inhibit the actions of the motor neurons
- The associated muscle is allowed to relax, thus protecting the muscle and tendon from excessive tension damage.

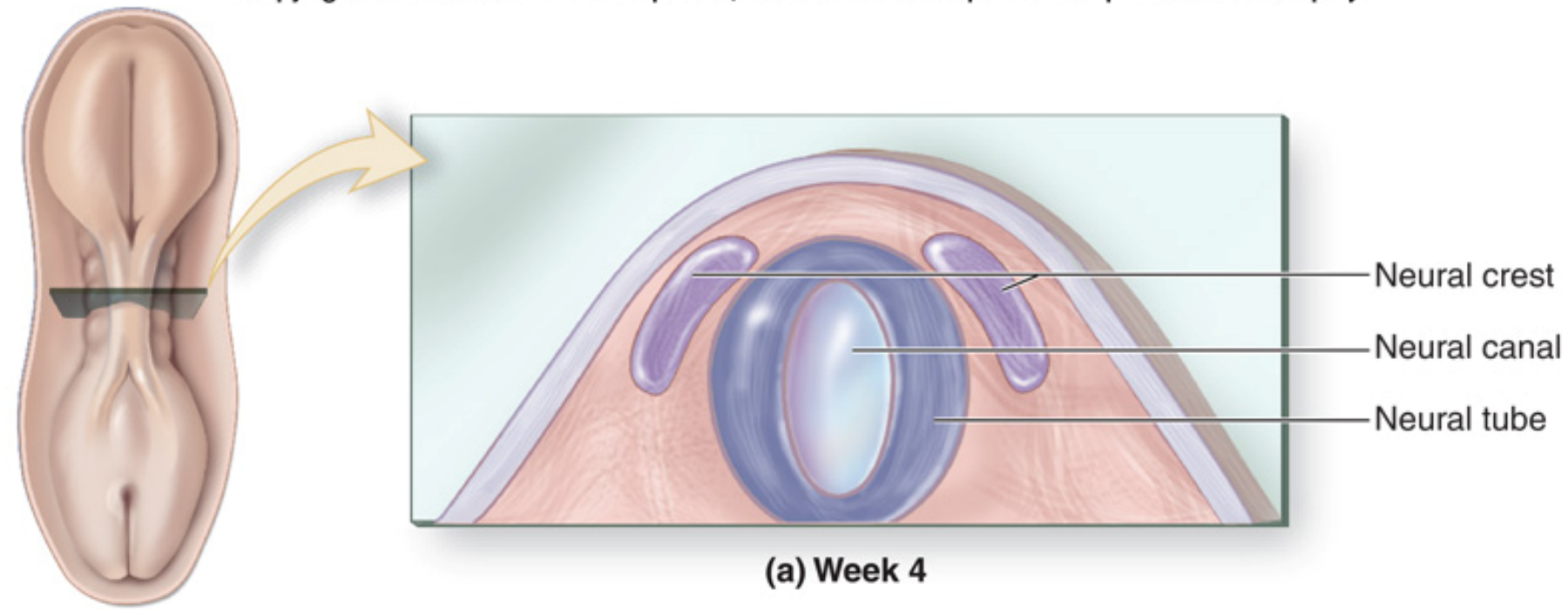


Reflex Testing in a Clinical Setting

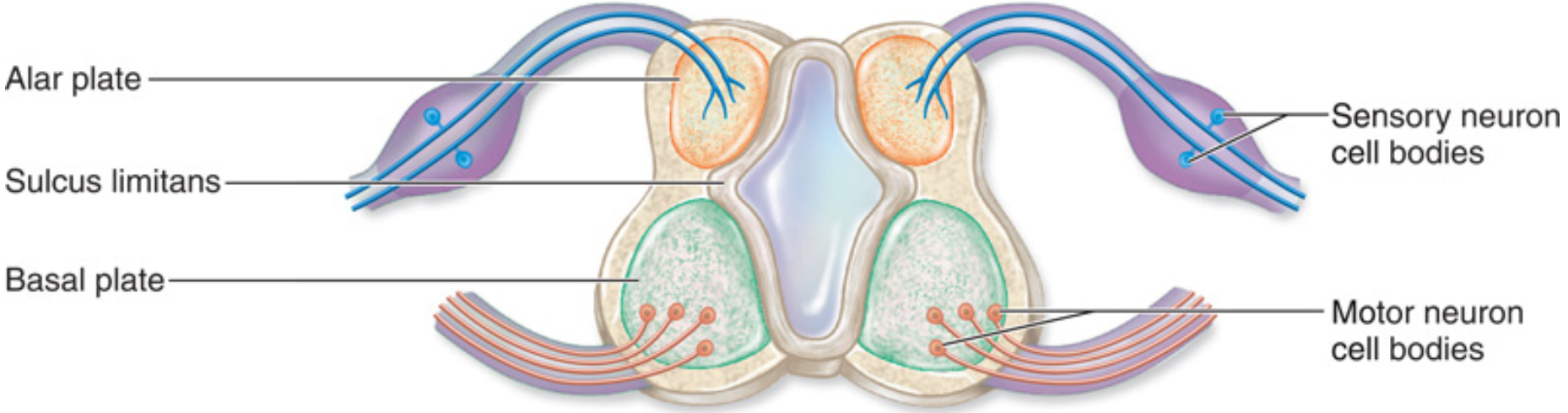
- Reflexes can be used to test specific muscle groups and specific spinal nerves or segments of the spinal cord.
- Consistently abnormal reflex response may indicate damage to the nervous system or muscles.
- A reflex response may be normal, hypoactive, or hyperactive.

Spinal Cord Development

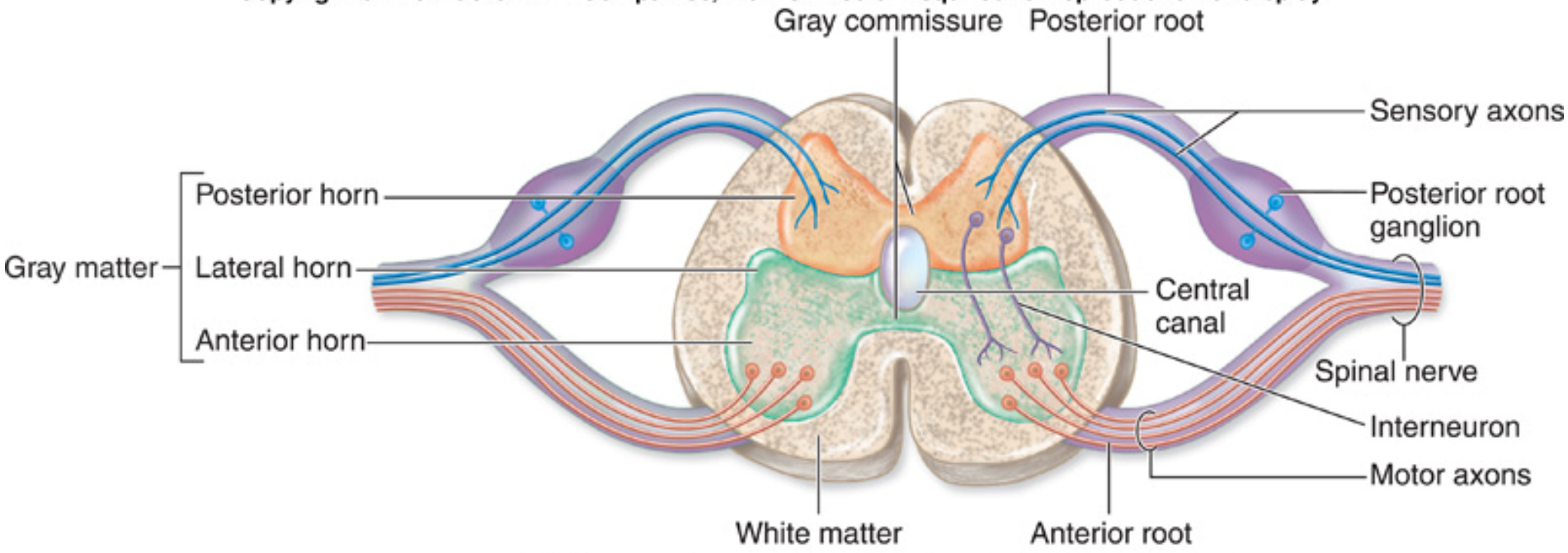
- The central nervous system forms from the embryonic neural tube.
- Cranial and spinal nerves form from neural crest cells that have split off from the developing neural tube.
- The cranial (superior) part of the neural tube expands and develops into the brain.
- The caudal (inferior) part of the neural tube forms the spinal cord.



(a) Week 4



(b) Week 6: Basal and alar plates form



(c) Week 9: Gray horns form from basal and alar plates