Introduction to the Peripheral Nervous System

Biology 260

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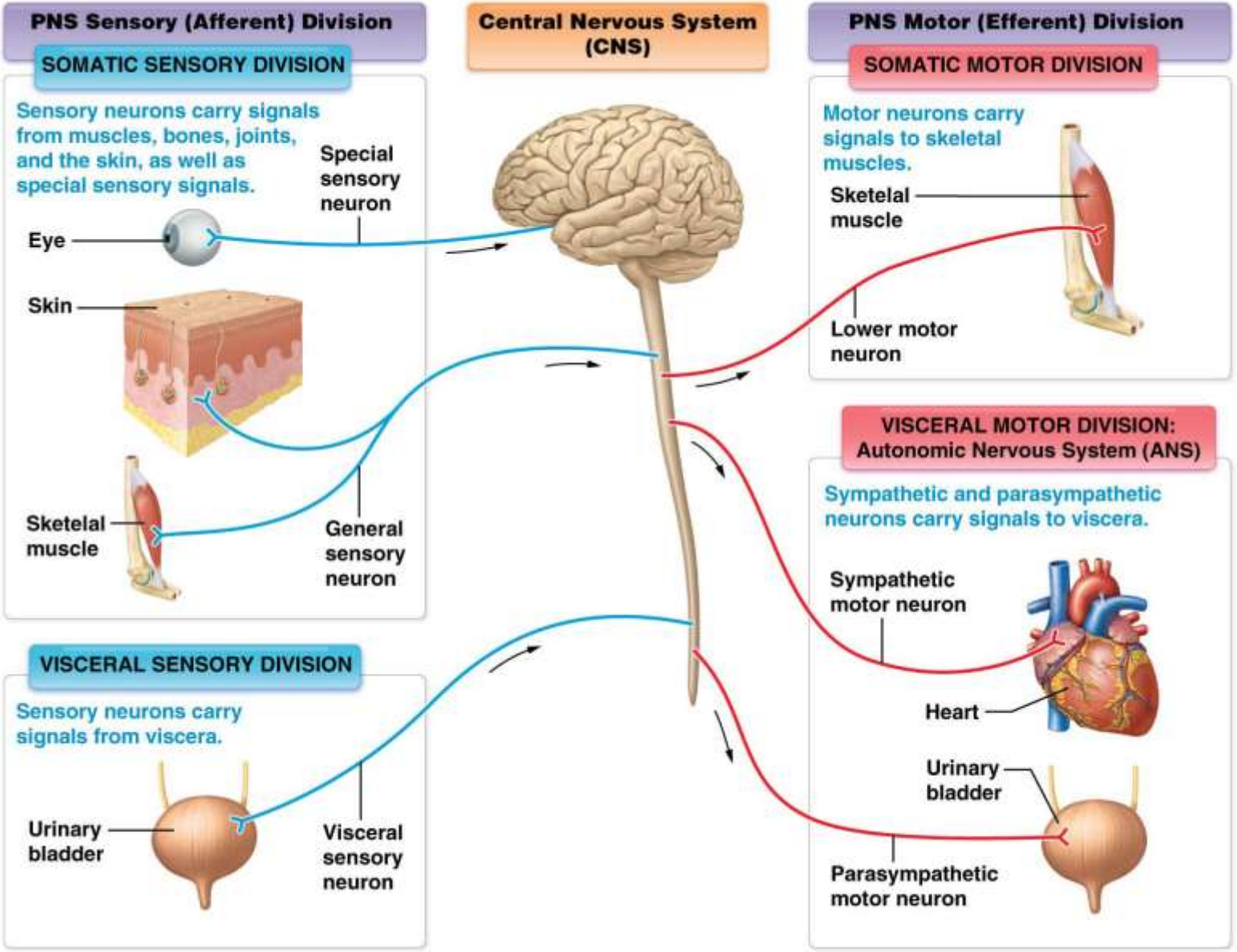
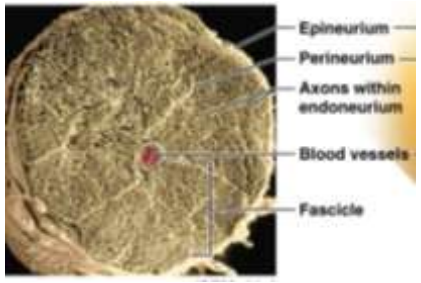
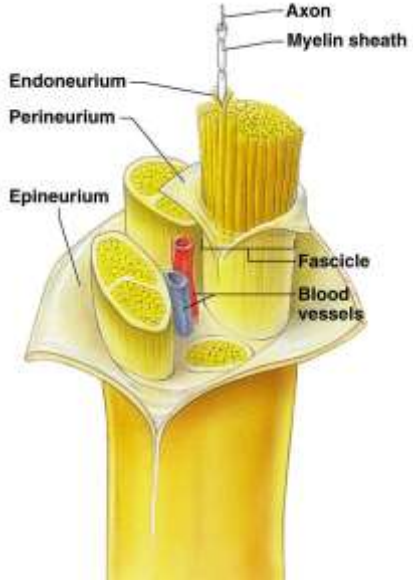
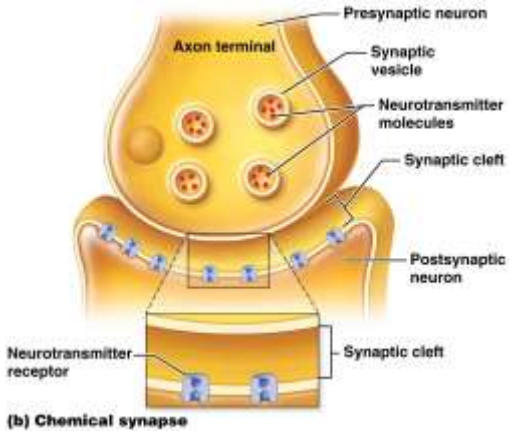
Structural organization of the NS



PNS Structures

All the structures outside the brain and spinal cord

Sensory Receptors	*Nerves*	*Motor Endings*

• Monitor and respond to changes in the environment (**stimuli**)
 	
Stimulus
• Five senses
• Pain
• Temperature
 	
Receptor location
• Exteroceptors
• Interoceptors
• Proprioceptors
 	
Receptor structure
• Special organs
• General senses
  • Free or Encapsulated
	• Bundle of myelinated and nonmyelinated axons enclosed by CT
	 
	 
		• PNS neurons that activate effectors by releasing neurotransmitters
		• Effector includes:
		  • skeletal muscle, visceral muscle, and glands
		 

Nerve Structure

- **Nerve**: cord-like PNS organs
  - Bundle of axons enclosed by connective tissue
  - Blood vessels run parallel to axon bundles

- **Ganglia**: enlarged area that contains the cell bodies
  - Dorsal root ganglia
    - Associated with afferent (toward) nerve fibers
    - Somatic and visceral sensory cell bodies
  - Autonomic ganglia (motor, visceral)
    - Associated with efferent (away) nerve fibers
    - Visceral motor cell bodies

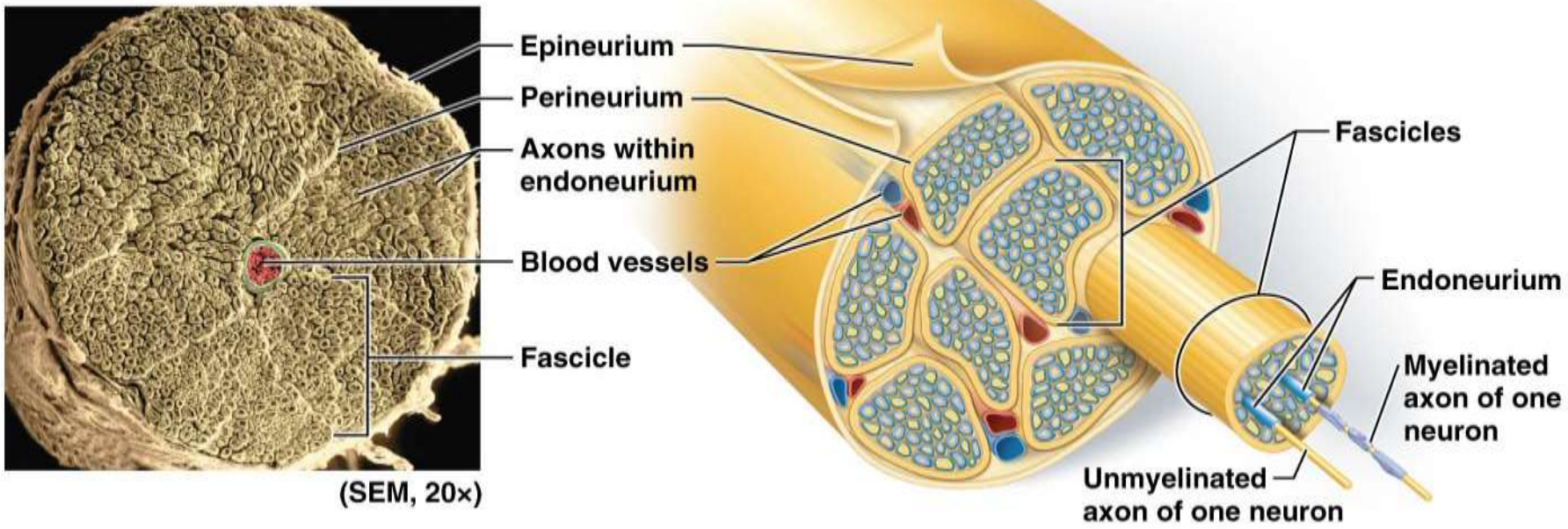
Structure of PNS Nerves

LARGE-
Gross

- **Nerve –** many fascicles + large blood vessels surrounded by the *epineurium* (CT)
  - **Fascicles** – collection of axons surrounded by a *perineurium* (CT)
    - **Axon** (neuron extension) – axon + myelin sheaths surrounded by *endoneurium*
      - **Myelin sheath** (Schwann cells) – insulated layer around the axon

SMALL -
Microscopic

Structure of PNS Nerves



(b) Photomicrograph of dissected spinal nerve

(c) Detailed structure of spinal nerve

Classification of Nerves

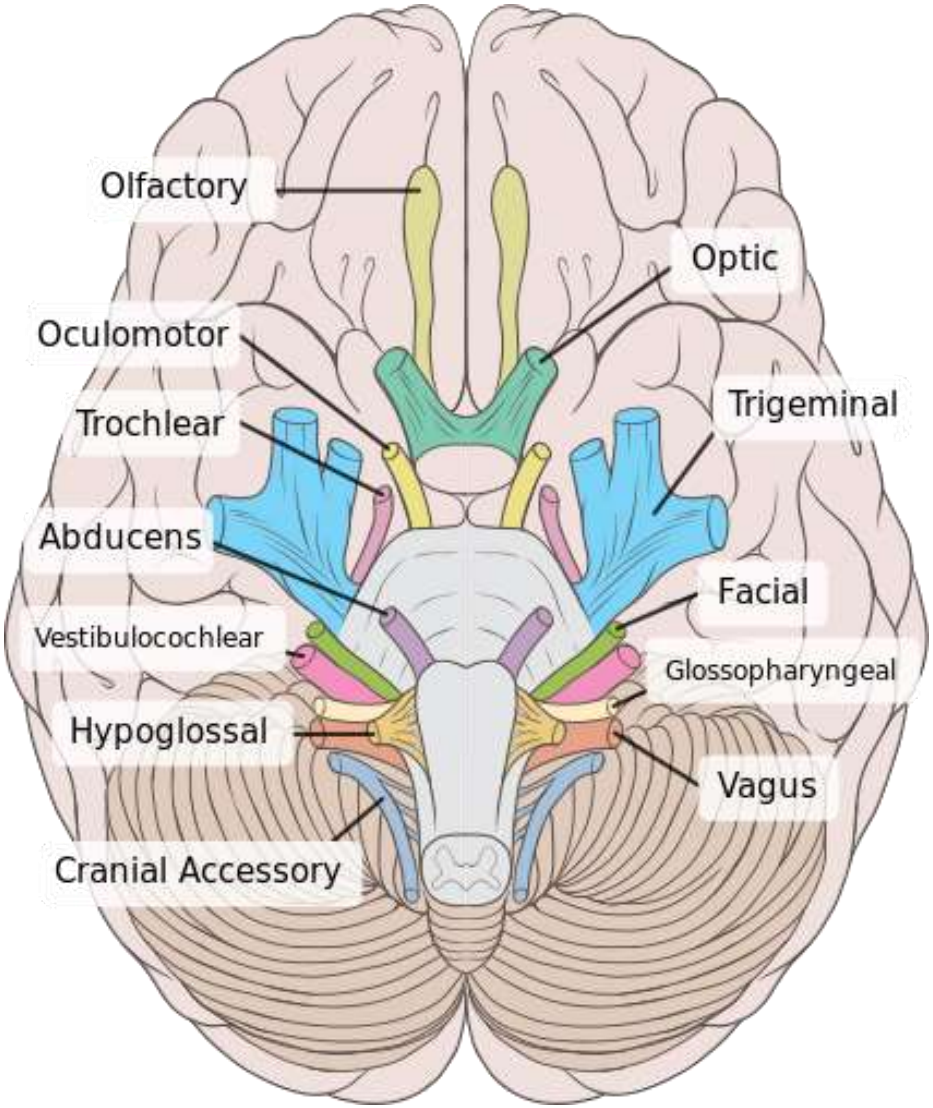
- **Location:**
  - *Cranial* (12 pairs) – bud from the brain and brainstem
  - *Spinal* (31 pairs) – bud from the spinal cord

- **Direction of Transmission:**
  - *Sensory nerves*: impulses toward CNS
  - *Motor nerves:* impulses away from CNS
  - *Mixed nerves*: contain both sensory and motor fibers
    - Impulses travel both to and from CNS

Location of cranial nerves

olfactory nerves

optic nerve



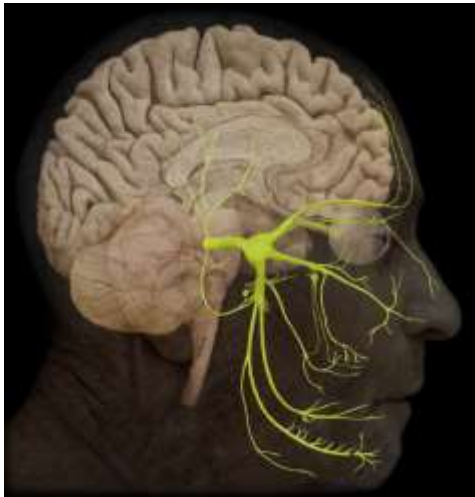
CEREBRUM: 2
CN 1 (Olfactory)
CN 2 (Optic)

MIDBRAIN: 2
CN 3 (Oculomotor)
CN 4 (Trochlear)

PONS: 4
CN 5 (Trigeminal)
CN 6 (Abducens)
CN 7 (Facial)
CN 8 (Vestibulocochlear)

MEDULLA OBLONGOTA: 4
CN 9 (Glossopharyngeal)
CN 10 (Vagus)
CN 11 (Accessory)
CN 12 (Hypoglossal)

trigeminal nerve



Cranial Nerve Functions

Some **s**ay **m**arry **m**oney, **b**ut **m**y **b**rother **b**elieves (it's) **b**ad **b**usiness (to) **m**arry **m**oney

Nerve	Sensory Function	Motor Function
I: Olfactory	Smell	NONE
II: Optic	Vision	NONE
III: Oculomotor "eye mover"	NONE	4, extrinsic eye muscles → move eye in the orbit
IV: Trochlear "pulley"	NONE	directs eyeball
V: Trigeminal "3"	General facial sensations	mastication = chewing muscles
VI: Abducens "lateral"	NONE	abducts the eye, innervating lateral rectus muscle of eye → eye turns laterally
VII: Facial	Taste, Tears, Salivary glands	facial expression muscles
VIII: Vestibulocochlear	Hearing and balance	Adjusts the sensitivity of sensory receptors
IX: Glossopharyngeal	Taste, Touch	swallowing, innervating tongue and pharynx
X: Vagus "vagabond"	Taste, Thoracic & abdominal viscera sensations	parasympathetic fibers help regulate activities of heart, lungs, and abdominal viscera
XI: Accessory	NONE	innervate trapezius and sternocleidomastoid (neck) muscles
XII: Hypoglossal	NONE	extrinsic and intrinsic muscles of tongue that contribute to swallowing and speech

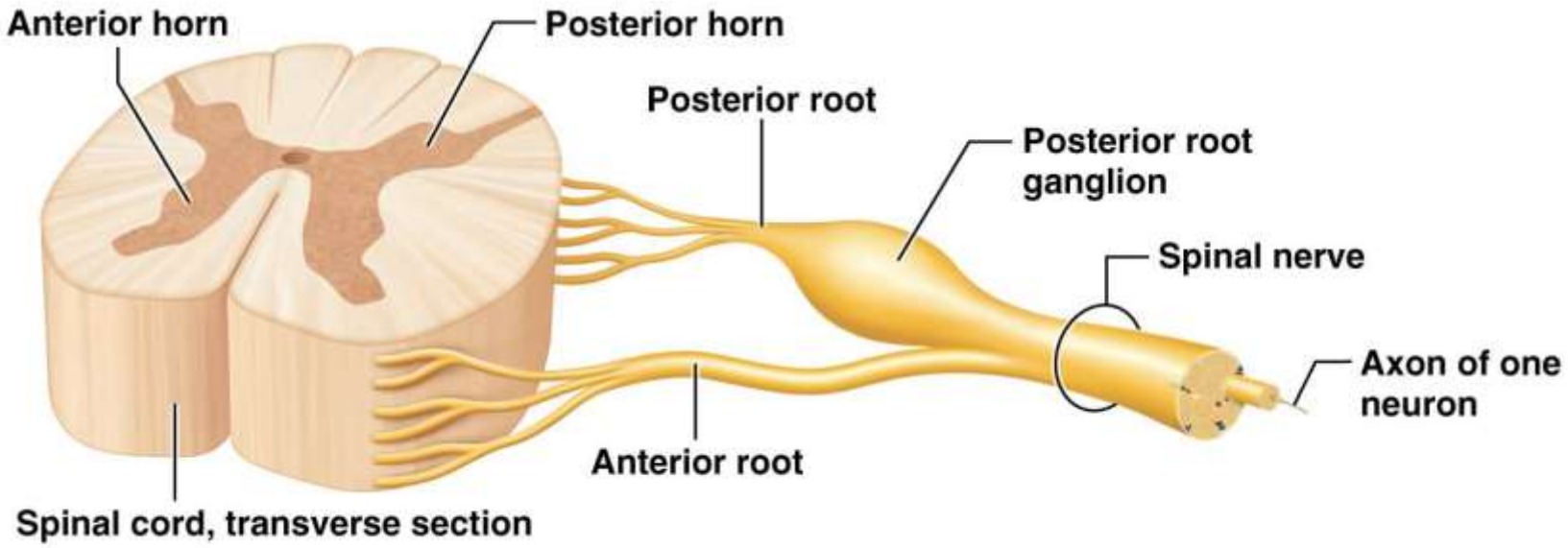
Location of cranial nerves

Draw a face to create a map of what areas cranial nerve innervate.

Spinal Nerve Anatomy

- From the spinal cord neurons bundle medially the meet laterally to form the spinal nerve
  - *dorsal rootlets* → *dorsal root* **strictly sensory**
    - **Dorsal root ganglia**: cell bodies of sensory neurons
  - *ventral rootlets* → *ventral root* **strictly motor**

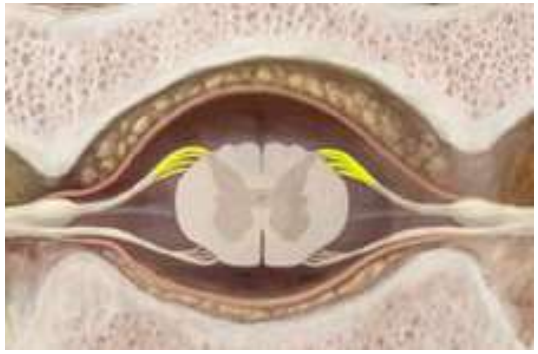
⇨ *Nerve*

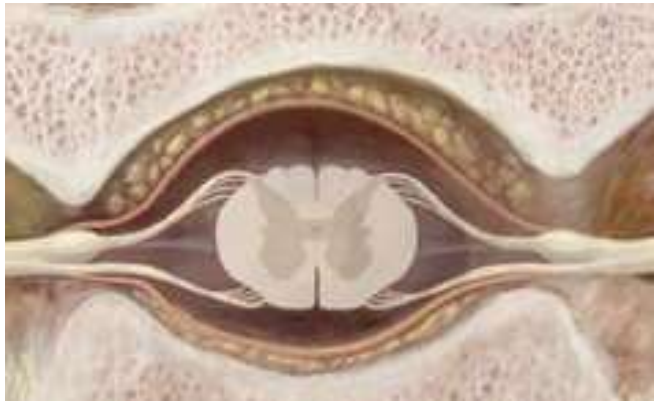


(a) Anterior and posterior roots and spinal nerve

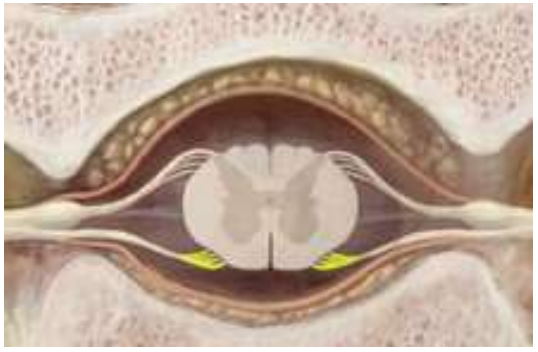
Spinal Nerve Anatomy

dorsal rootlets

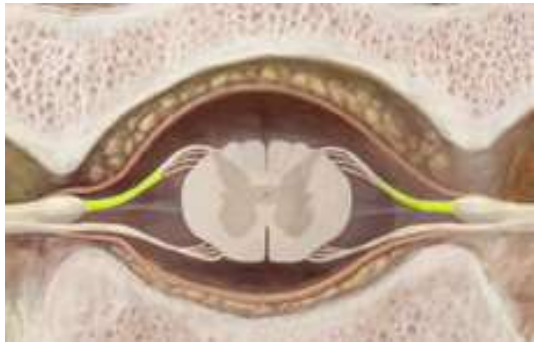


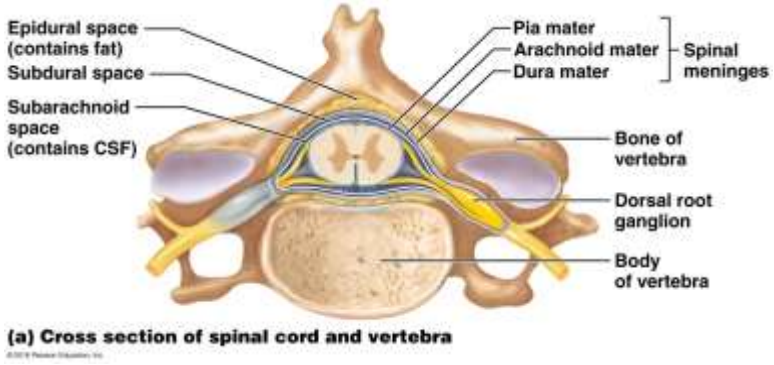


ventral rootlets



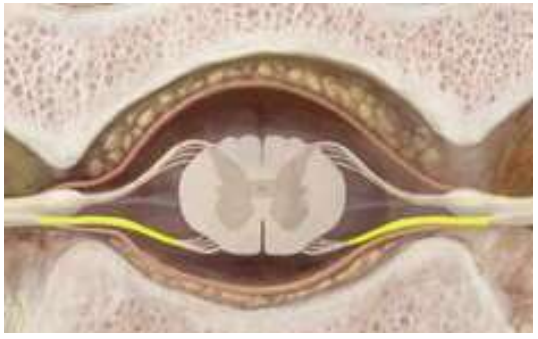
dorsal root



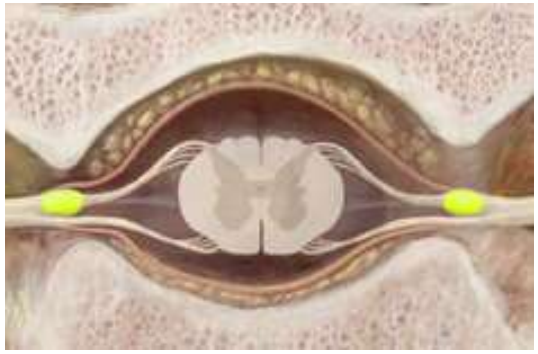


(a) Cross section of spinal cord and vertebra

ventral root



dorsal root ganglion

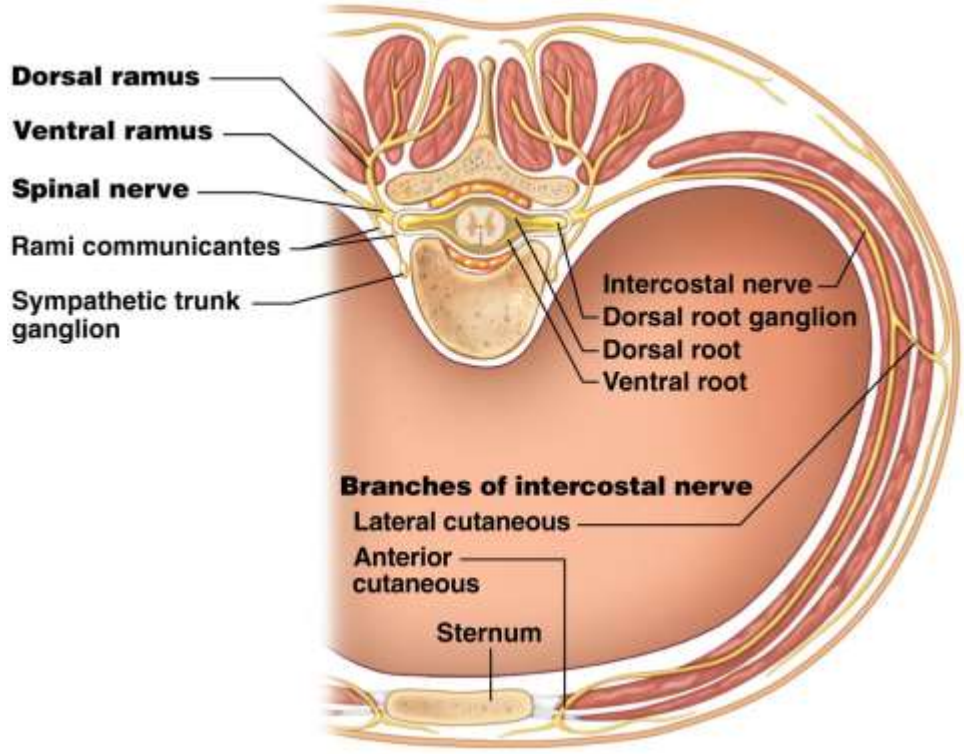


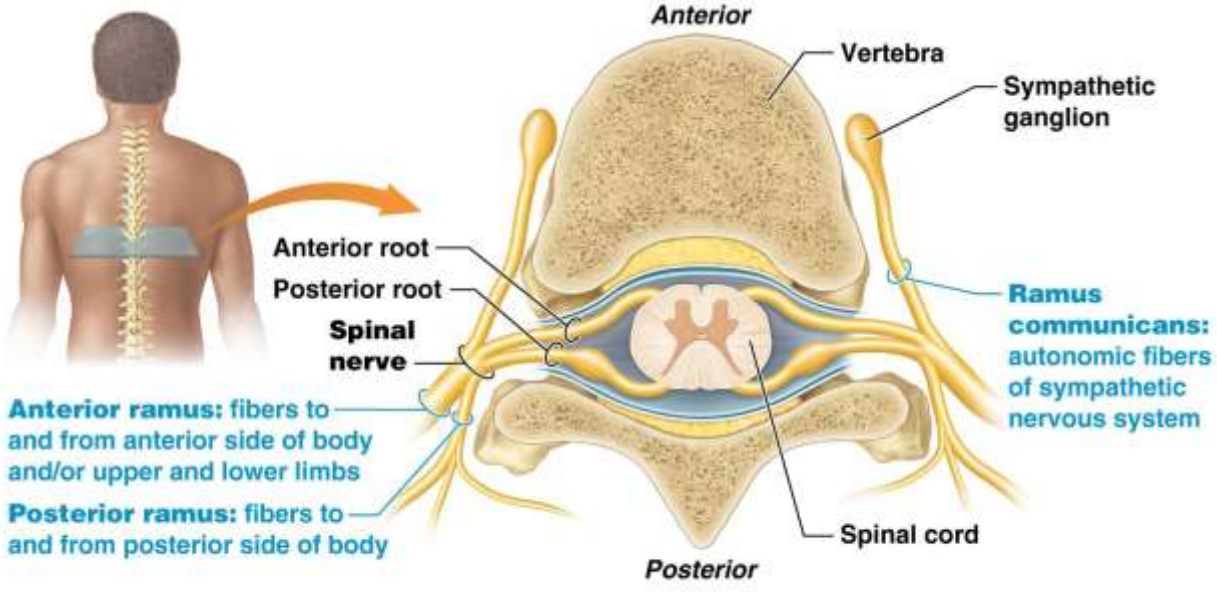
spinal nerve

Spinal Nerve Anatomy

- **Rami (ramus):** nerve branches that contain both **sensory** and **motor** fibers & innervate somatic region, below the neck
  - **Dorsal ramus**
    - fibers to/from the skin & muscles (skeletal & smooth) of the **back**
  - **Ventral ramus**
    - fibers to/from muscles (skeletal & smooth) in the **ventrolateral body wall**, and the **limbs**.
  - **Communicantes:**
    - autonomic (visceral) nerve fibers
    - Attach to the base of the ventral rami of the thoracic spinal nerves & the sympathetic trunk

Spinal Nerve Anatomy





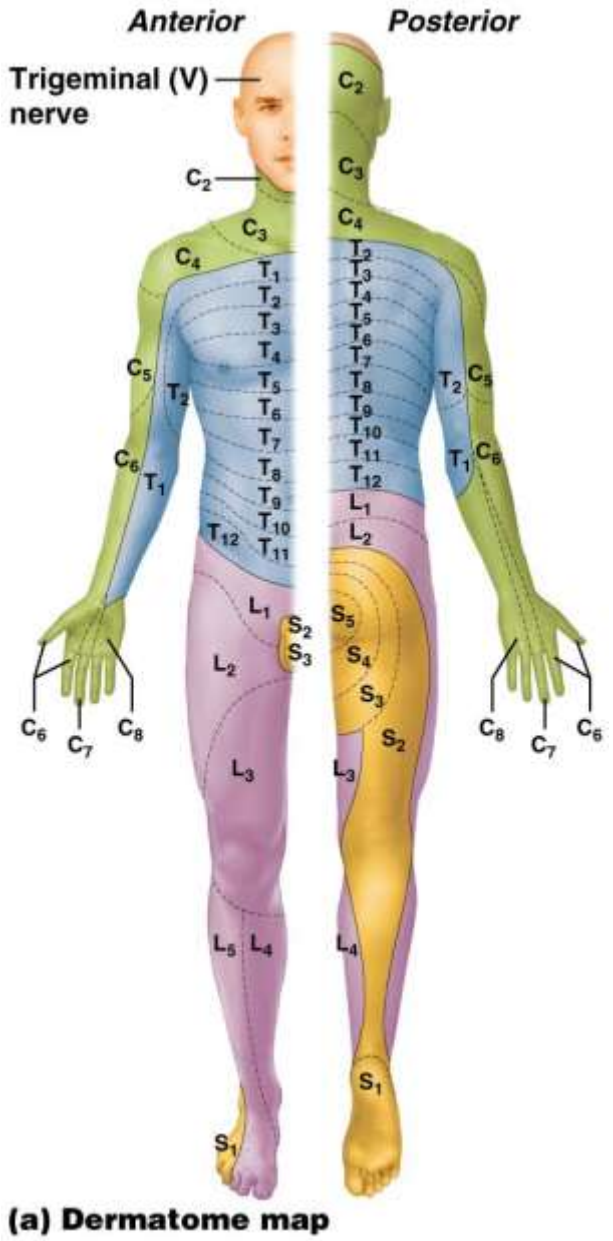
(a) Structure of anterior and posterior rami of spinal nerves

The Spinal Nerves

- 31 pairs of nerves (R&L), all mixed nerves
  - Named based on their vertebrae location
    - 8 pairs of cervical nerves (C_1–C_8)
    - 12 pairs of thoracic nerves (T_1–T_{12})
    - *5 pairs of lumbar nerves (L_1–L_5)
    - *5 pairs of sacral nerves (S_1–S_5)
    - 1 pair of coccygeal nerves (C_0)

*Lumbar and sacral roots are very long and extend through lower vertebral canal as **cauda equina**

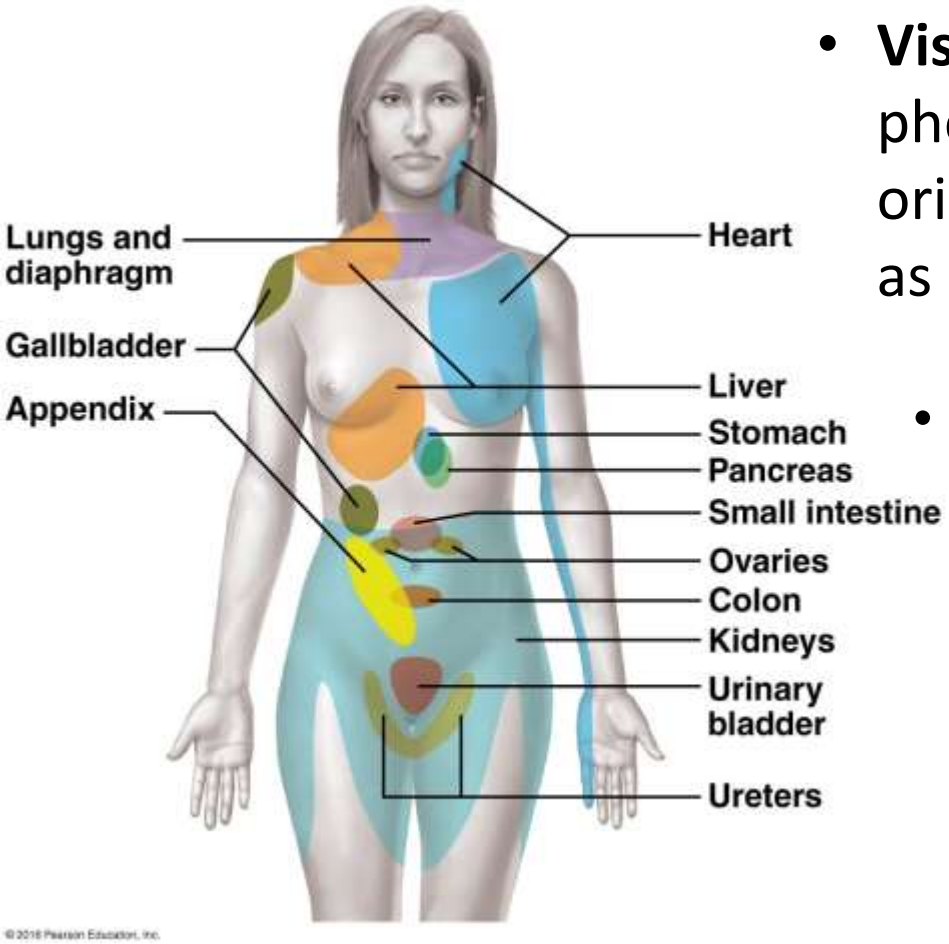
Dermatome



- Skin can be divided into different segments called **dermatomes** based on spinal nerve that supplies region with *somatic sensation*
- Dermatome maps can be used clinically to test *integrity of sensory pathway* to different parts of body

Pain

Warning of actual or impending tissue damage so protective action can be taken

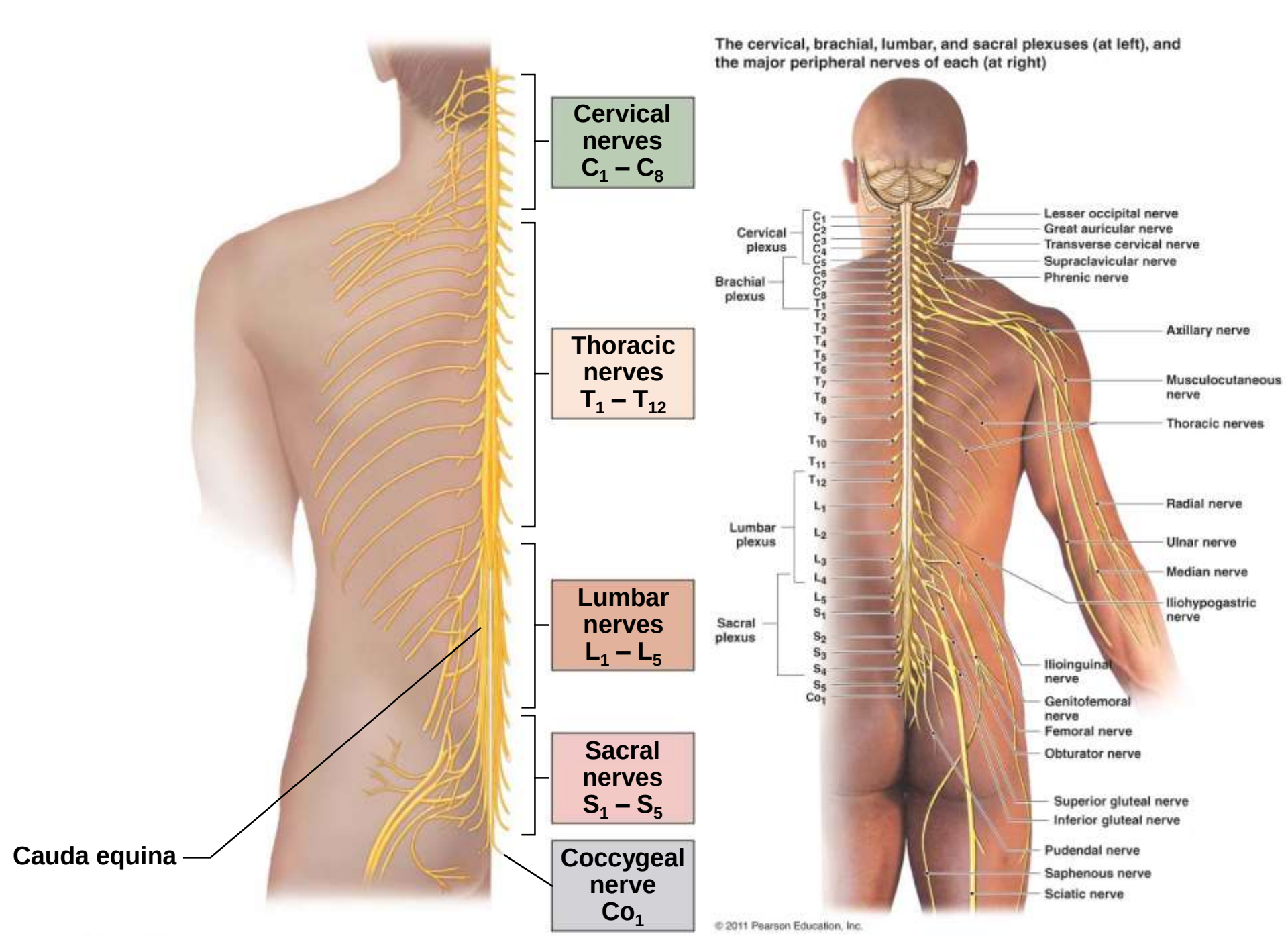


- **Visceral & Referred pain** - phenomenon whereby pain that originates in an *organ* is perceived as *cutaneous* pain
  - Visceral and somatic pain fibers travel along same nerves,
    - Brain assumes stimulus comes from common (somatic) region
    - T1-T5 nerves innervate the heart and arm → heart attack pain is perceived as left arm pain

The Spinal Nerve Plexuses

- Nerve plexuses - Interlacing network of *ventral rami*
  - Each branch carries fibers from several spinal nerves
  - Gives redundancy in case of nerve damage

  - Not associated with T_2-T_{12} nerves
    - **Intercostal nerves** that supply muscles of ribs, anterolateral thorax, and abdominal wall


Cervical nerves $C_1 – C_8$
Thoracic nerves $T_1 – T_{12}$
Lumbar nerves $L_1 – L_5$
Sacral nerves $S_1 – S_5$
Coccygeal nerve Co_1
Cauda equina
The cervical, brachial, lumbar, and sacral plexuses (at left), and the major peripheral nerves of each (at right)
Cervical plexus
Brachial plexus
Lumbar plexus
Sacral plexus
Lesser occipital nerve
Great auricular nerve
Transverse cervical nerve
Supraclavicular nerve
Phrenic nerve
Axillary nerve
Musculocutaneous nerve
Thoracic nerves
Radial nerve
Ulnar nerve
Median nerve
Iliohypogastric nerve
Ilioinguinal nerve
Genitofemoral nerve
Femoral nerve
Obturator nerve
Superior gluteal nerve
Inferior gluteal nerve
Pudendal nerve
Saphenous nerve
Sciatic nerve
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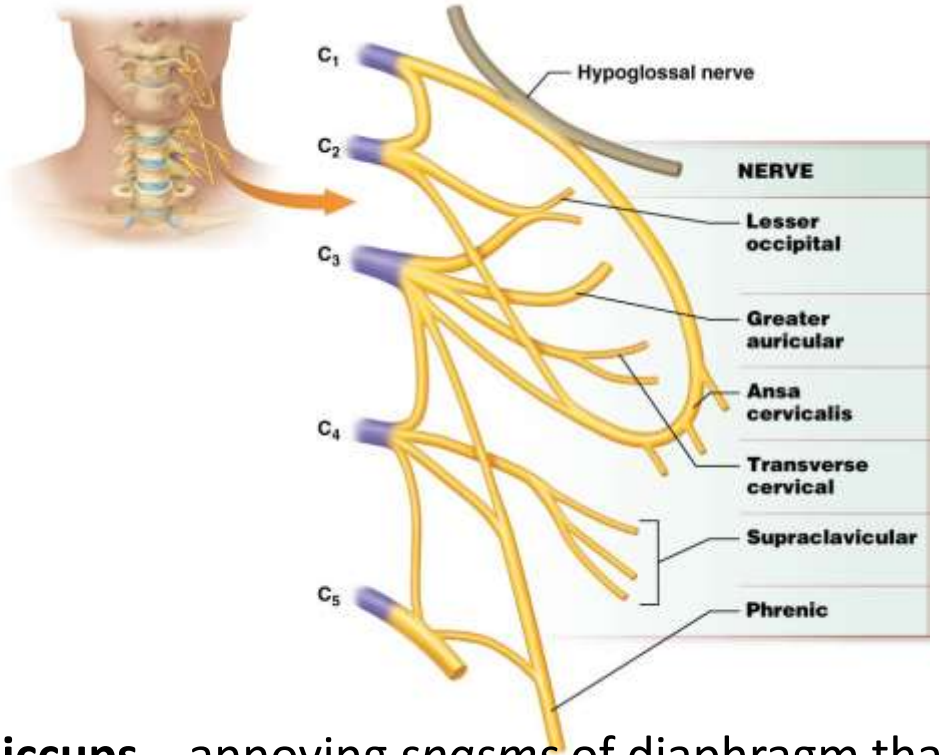
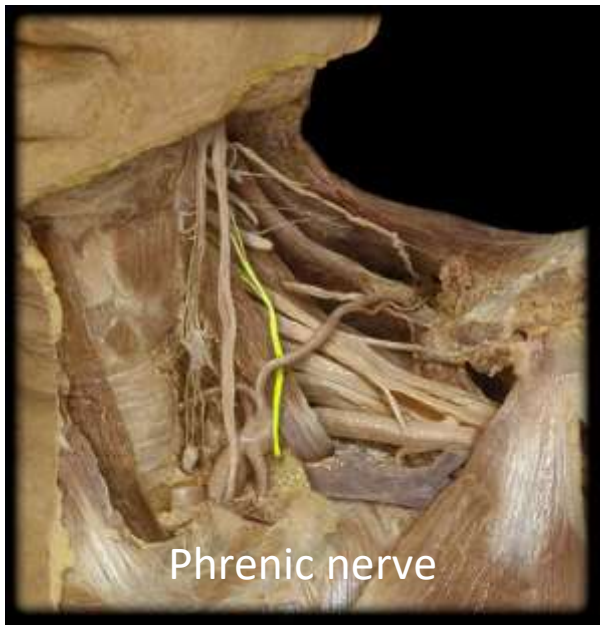
Cervical plexus (C_1–C_5)

- **Cutaneous nerves:** innervate skin of neck, chest, and shoulders; motor nerves innervate neck muscles
- **Phrenic nerve***:* innervates the diaphragm





Hiccups – annoying *spasms* of diaphragm that cause a *forceful inhalation* of air

Apply *firm pressure* to muscles of neck that overlie phrenic nerve until hiccups stop, in about 5–10 seconds

Brachial Plexus C_5–C_8 and T_1

- Innervation to the pectoral girdle and upper limbs

(b) Nerves of brachial plexus, anterior view

- **Radial nerve**- extensor muscles of the posterior arm and forearm
- **Ulnar nerve**-flexor carpi ulnaris, most intrinsic hand muscles, skin of medial aspect of hand, wrist/finger flexion
- **Axillary nerve**- deltoid and teres minor muscles; sensory from the skin of the shoulder
- **Median nerve**- flexor muscles of the anterior forearm & , thumb opposition muscles

Lumbosacral plexus

- **Lumbar plexus** (L_1- L_4)
  - **Femoral nerve**→ Quadriceps, Sartorius, & ½ TFL
  - **Obturator nerve** → Adductors & Gracilis
- **Sacral plexus (**L_4 to S_4)
  - **Sciatic nerve**: Thickest and longest nerve in the body, innervation of all lower limbs
    - Tibial → hamstrings
    - Fibular → Gluteal and ½ TFL muscle