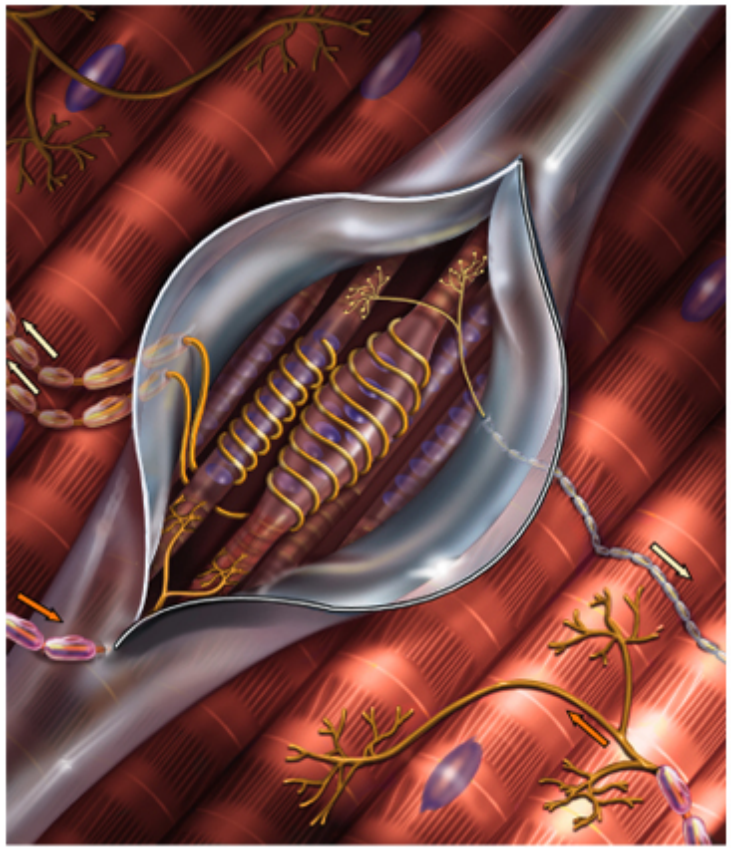
Peripheral Nervous System & Reflexes

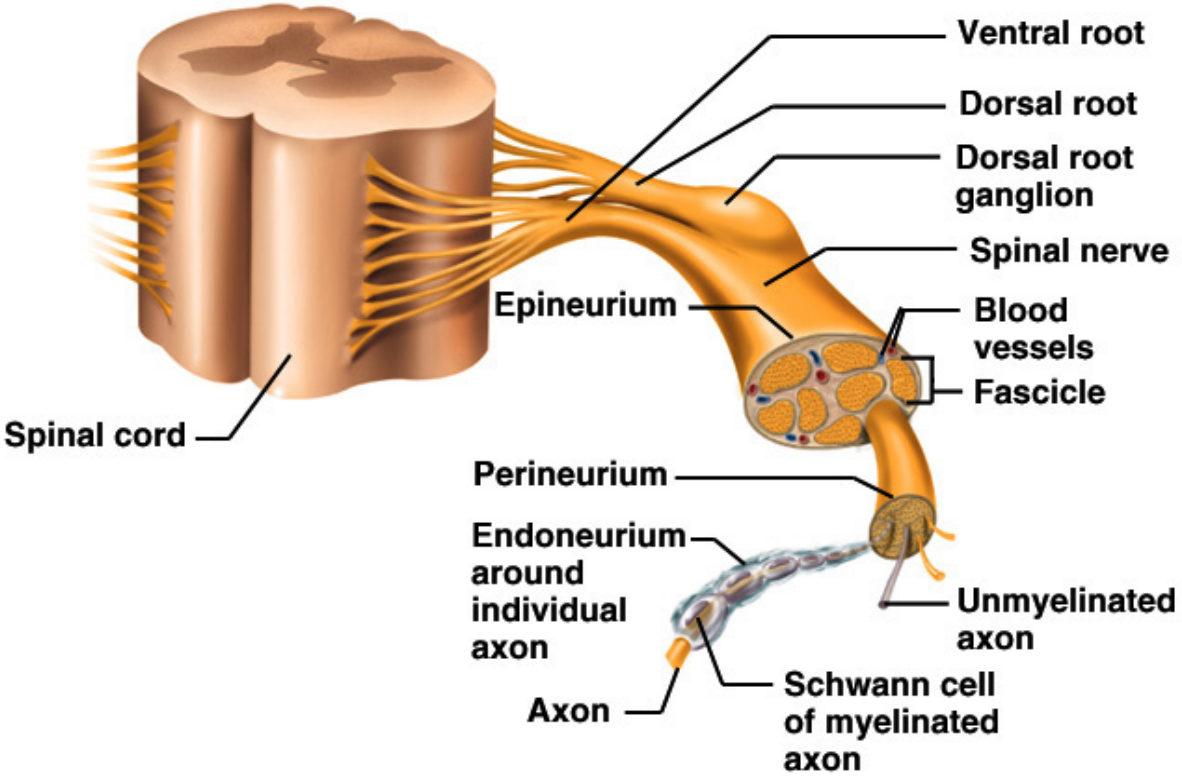
- General anatomy of PNS
- Cranial nerves
- Somatic reflexes
- Autonomic NS: anatomy
- Autonomic NS: physiology



Subdivisions of the PNS

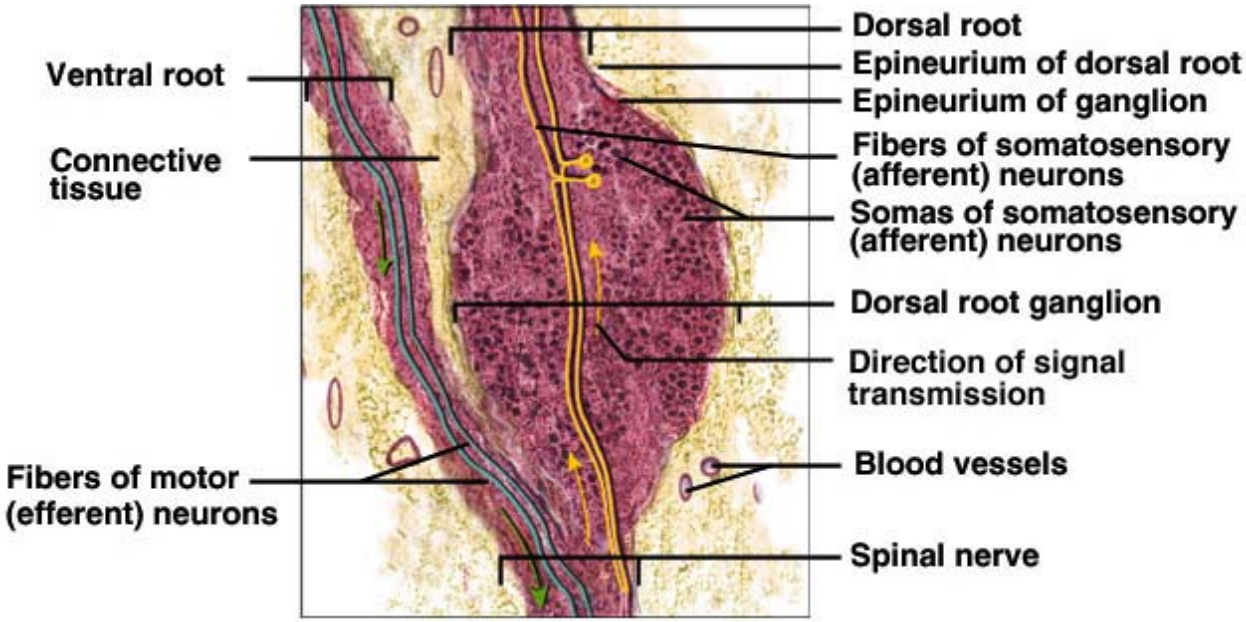
- Sensory (afferent) division carries sensory signals from receptors to CNS
  - somatic sensory -- skin, muscles, bones & joints
  - visceral sensory -- viscera
- Motor (efferent) division carries motor signals from CNS to effectors (glands and muscles)
  - somatic motor supplies skeletal muscles
  - visceral motor supplies cardiac, smooth & glands
    - sympathetic division -- tends to arouse
    - parasympathetic division -- tends to calm
- Mixed nerves carry sensory & motor signals

Anatomy of Nerves



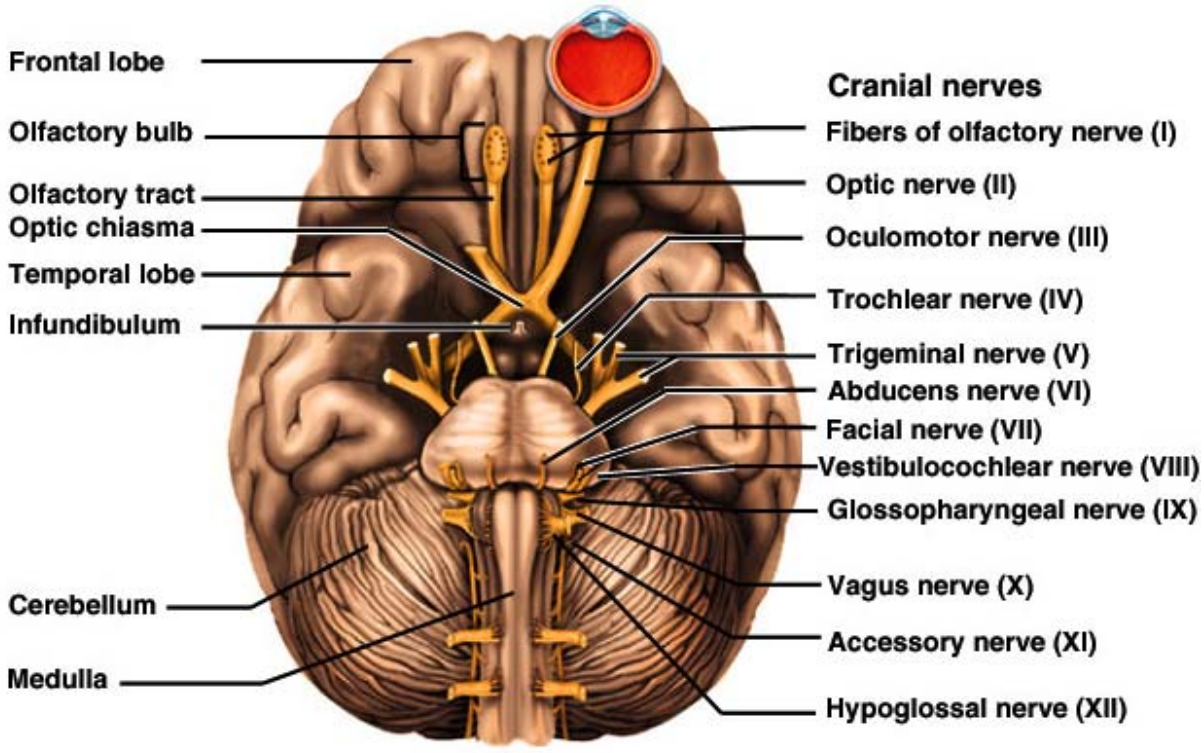
- A nerve is a bundle of nerve fibers (axons)
- Epineurium covers nerves, perineurium surrounds a fascicle and endoneurium separates individual nerve fibers creating room for capillaries

Anatomy of Ganglia in the PNS



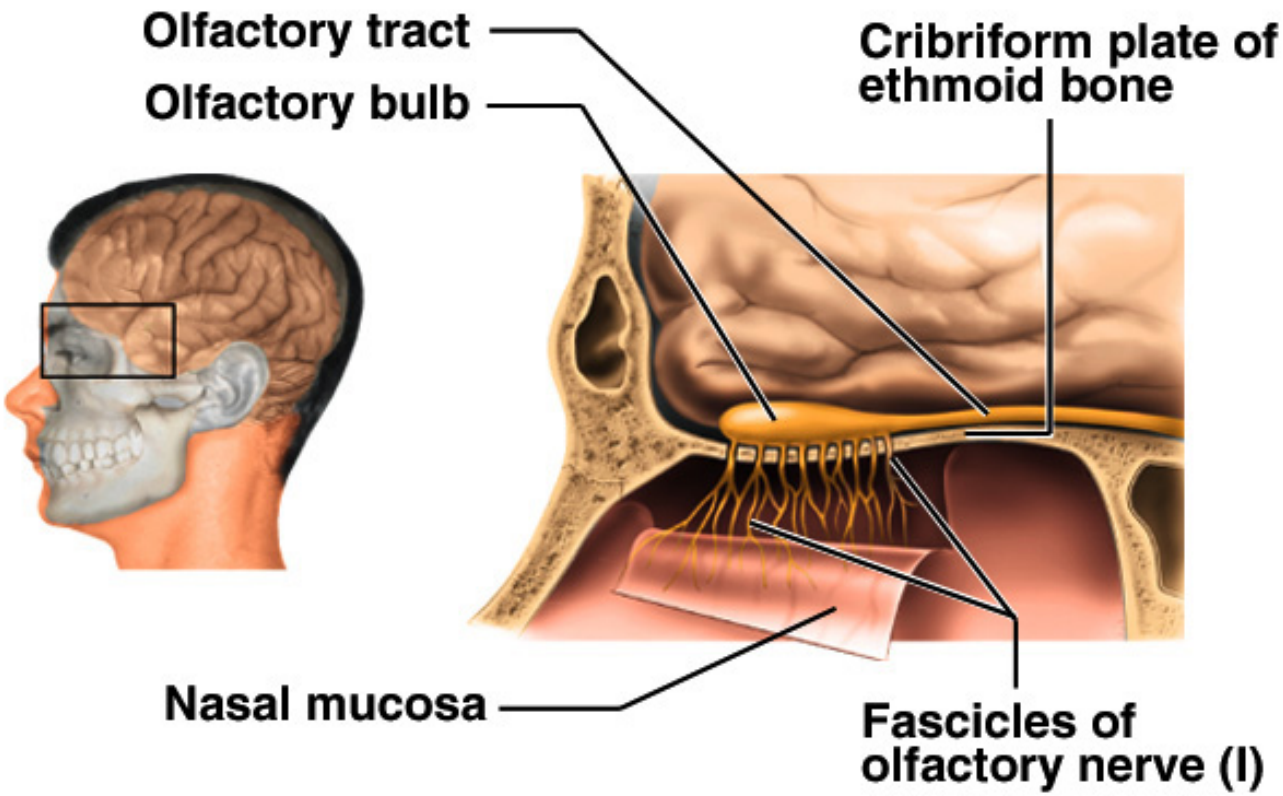
- Cluster of neuron cell bodies in nerve in PNS
- Dorsal root ganglion is sensory cell bodies
  - fibers pass through without synapsing
- Autonomic ganglion does contain synapse of preganglionic fiber onto postganglionic cell body

The Cranial Nerves



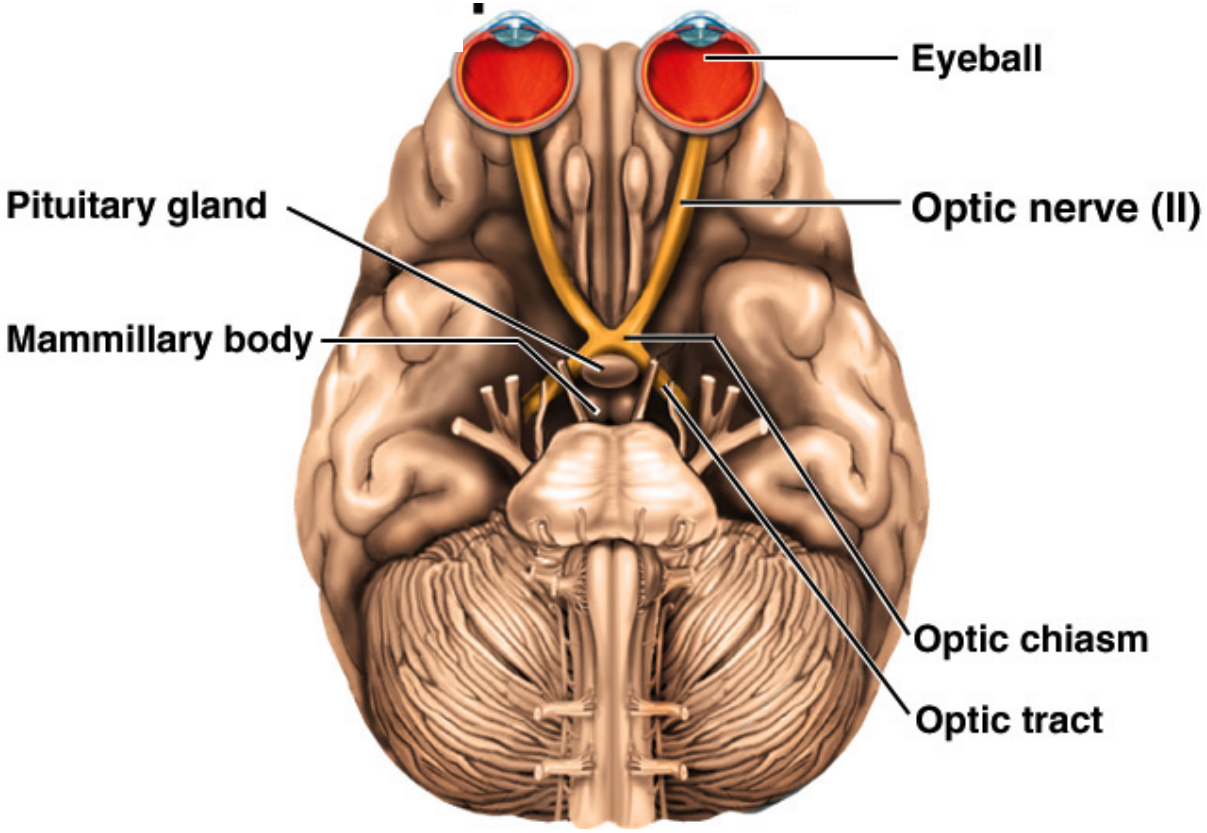
- 12 pair of nerves that arise from brain & exit through foramina leading to muscles, glands & sense organs in head & neck
- Input & output remains ipsilateral except CN II & IV

Olfactory Nerve



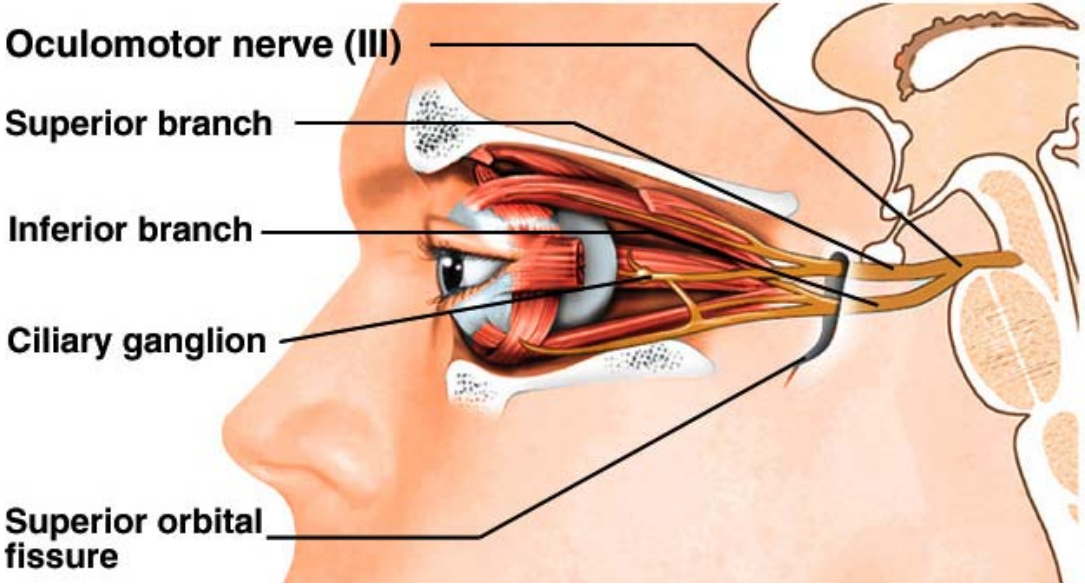
- Provides sense of smell
- Damage causes impaired sense of smell

Optic Nerve



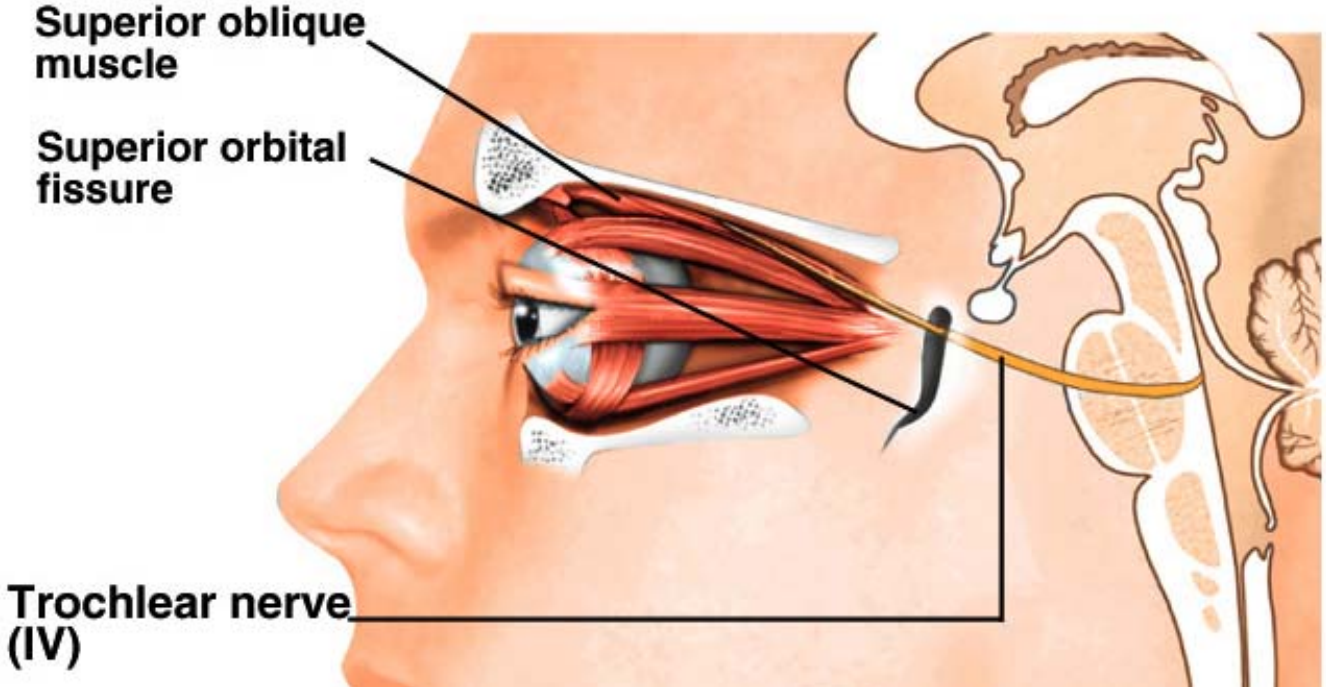
- Provides vision
- Damage causes blindness in visual field

Oculomotor Nerve



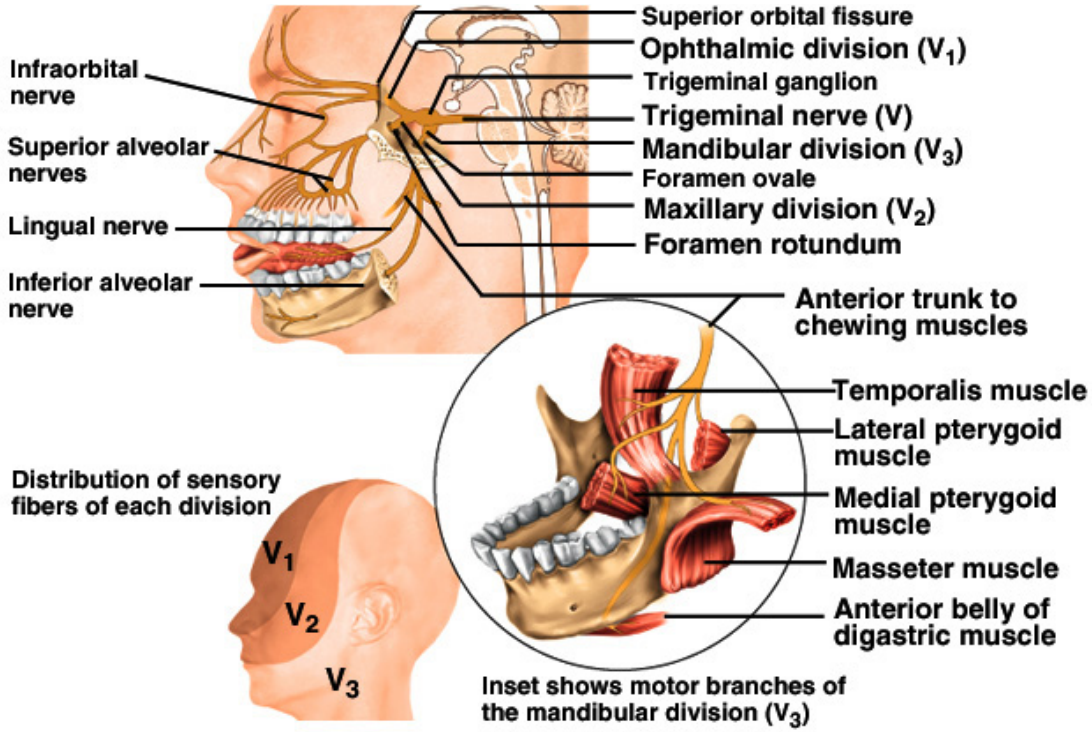
- Provides some eye movement, opening of eyelid, constriction of pupil, focusing
- Damage causes drooping eyelid, dilated pupil, double vision, difficulty focusing & inability to move eye in certain directions

Trochlear Nerve



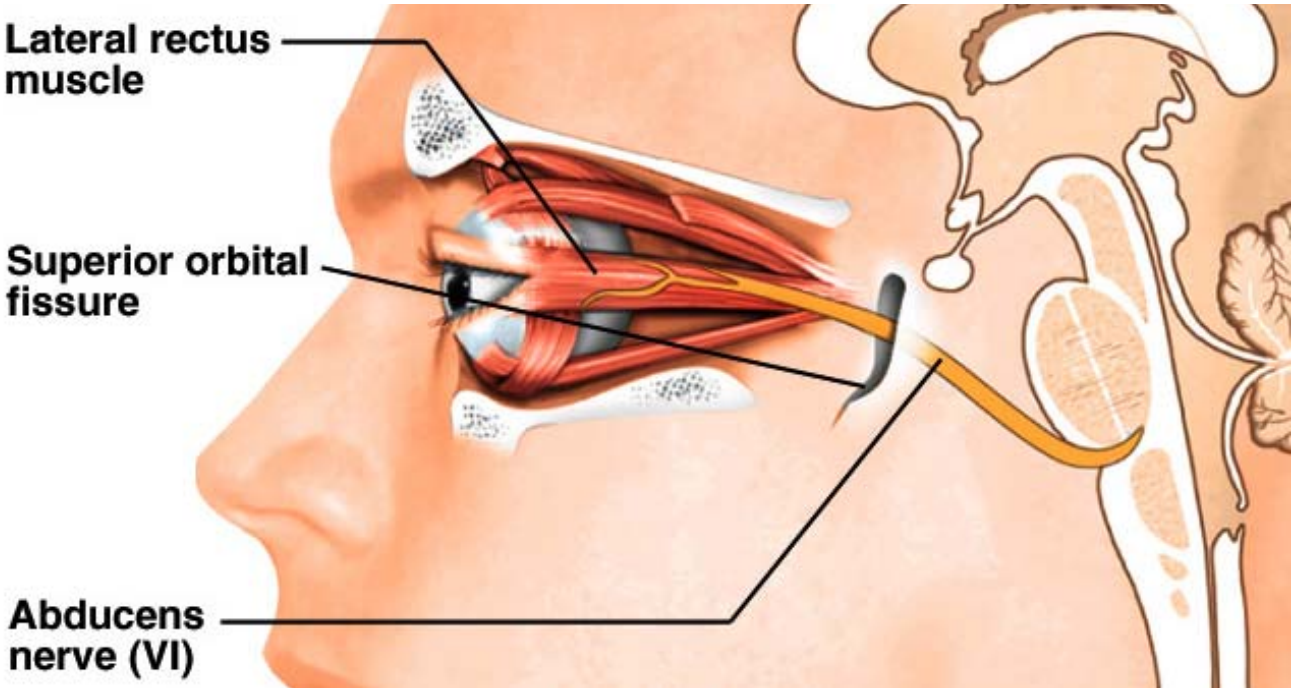
- Provides eye movement
- Damage causes double vision & inability to rotate eye inferolaterally

Trigeminal Nerve



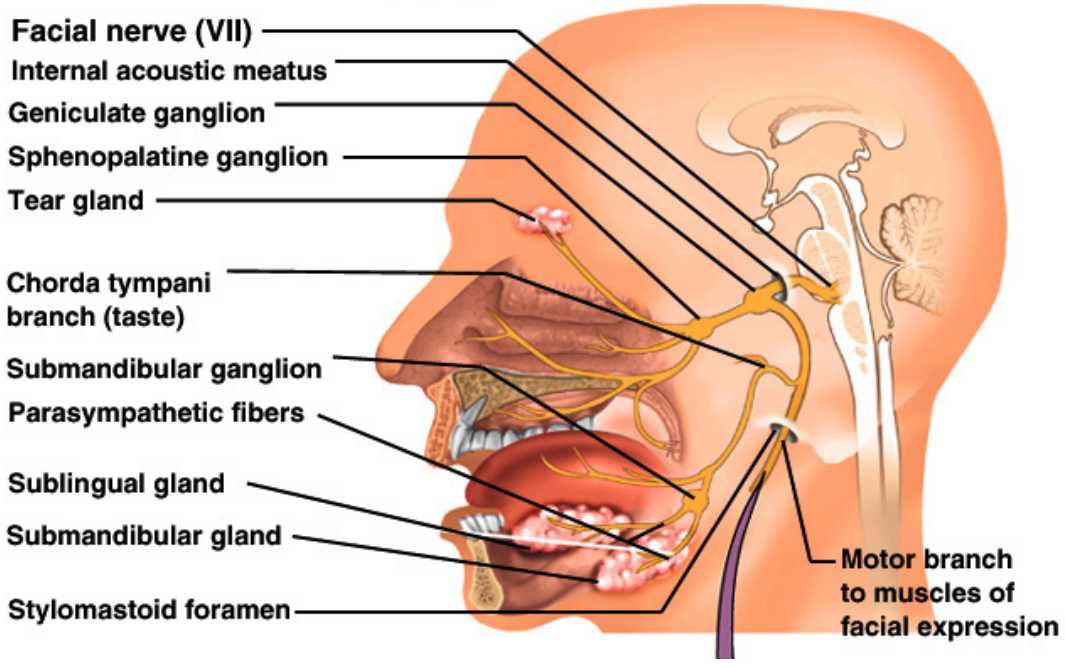
- Main sensory nerve to face (touch, pain and temperature) and muscles of mastication
- Damage produces loss of sensation & impaired chewing

Abducens Nerve



- Provides eye movement
- Damage results in inability to rotate eye laterally & at rest eye rotates medially

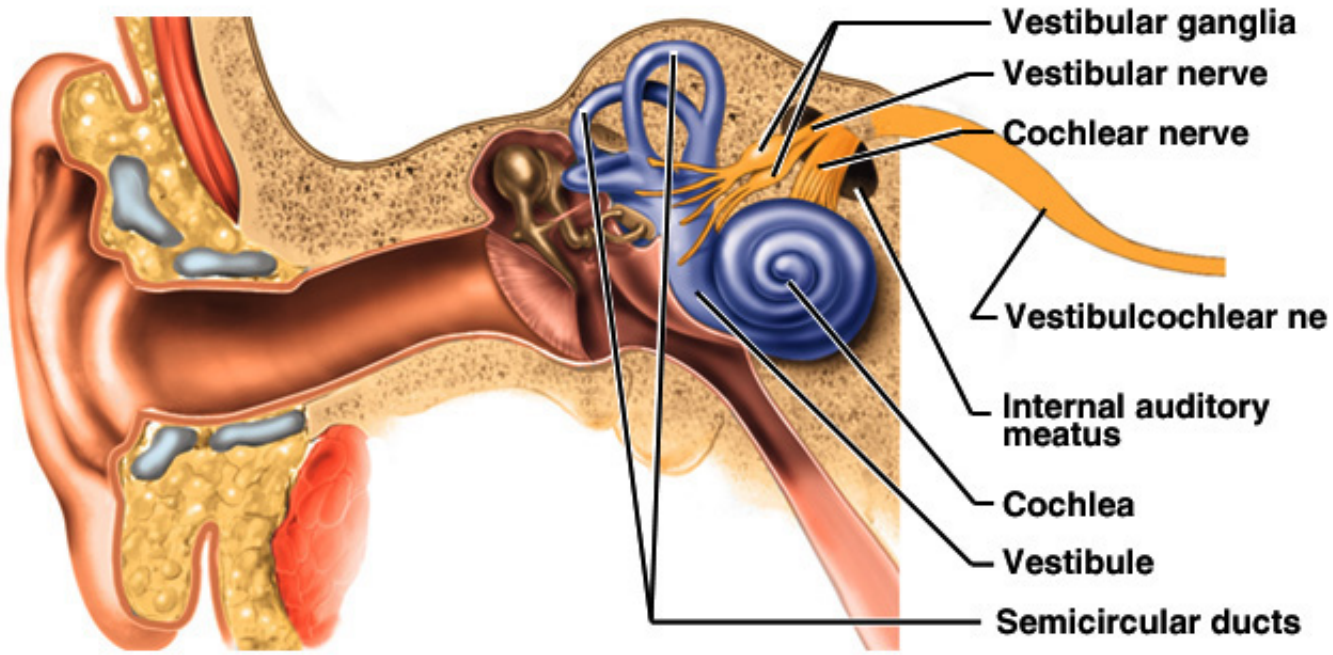
Facial Nerve



- Provides facial expressions, sense of taste on anterior 2/3's of tongue, salivary glands and tear, nasal & palatine glands
- Damage produces sagging facial muscles & disturbed sense of taste (missing sweet & salty)

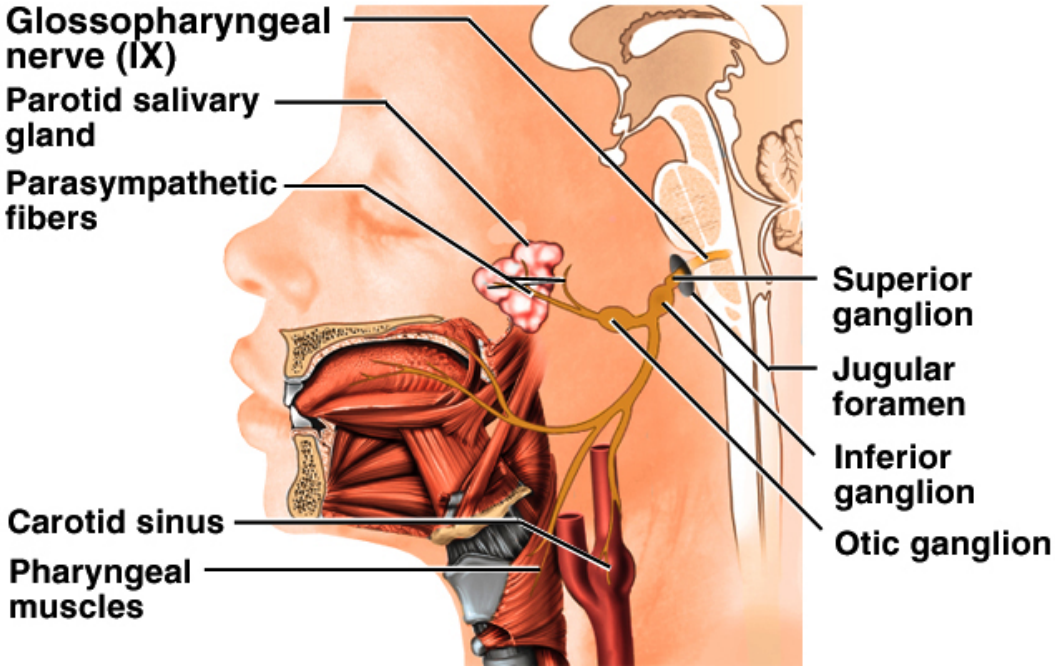
Branches of Facial Nerve

Vestibulocochlear Nerve



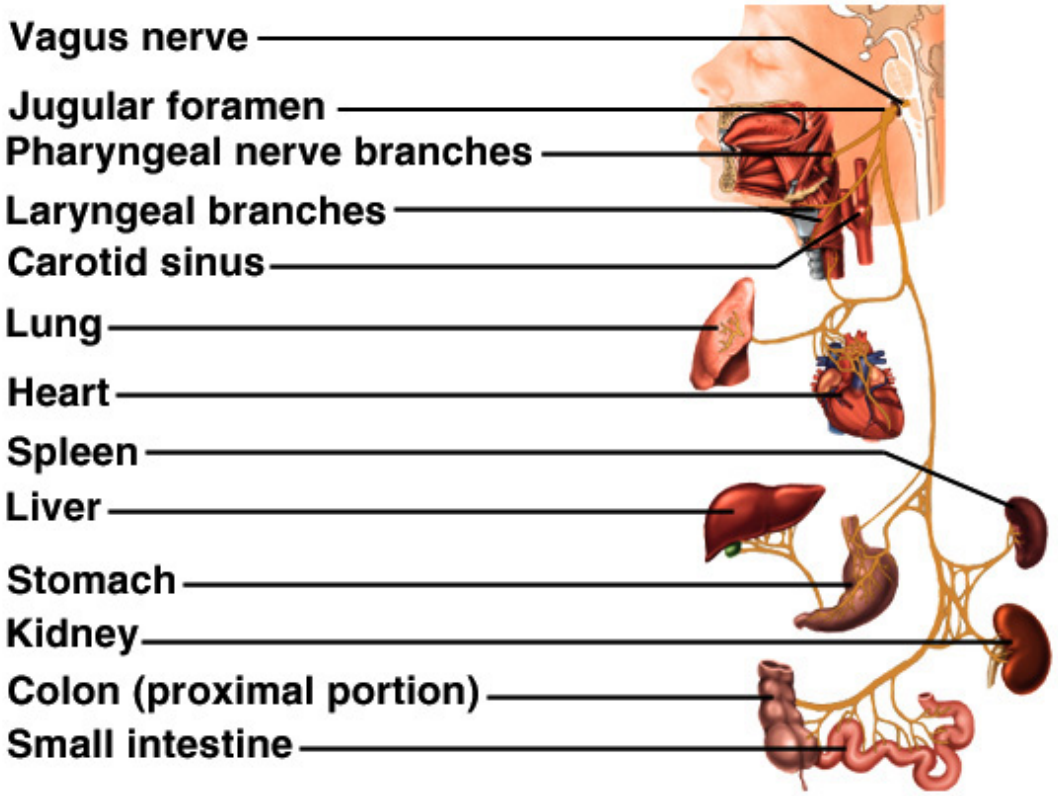
- Provides hearing & sense of balance
- Damage produces deafness, dizziness, nausea, loss of balance & nystagmus

Glossopharyngeal Nerve



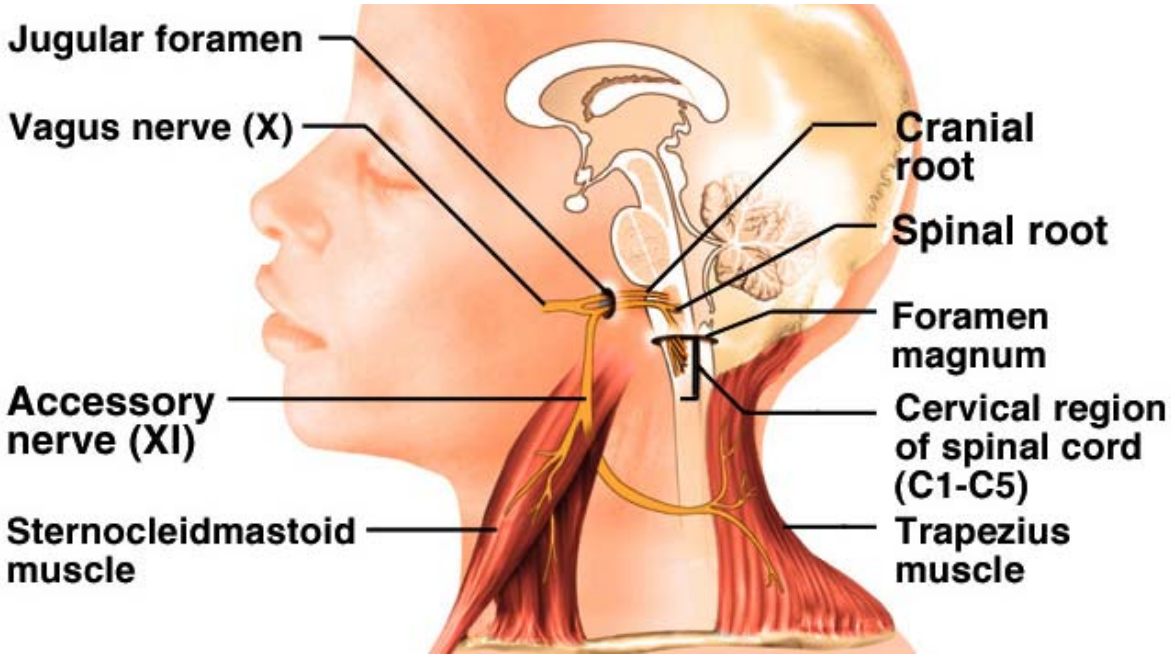
- Provides control over swallowing, salivation, gagging, sensations from posterior 1/3 of tongue, control of BP and respiration
- Damage results in loss of bitter & sour taste & impaired swallowing

Vagus Nerve



- Provides swallowing, speech, regulation of most of major viscera
- Damage causes hoarseness or loss of voice, impaired swallowing & fatal if both are cut

Accessory Nerve



- Provides swallowing, head, neck & shoulder movement
- Damage causes impaired head, neck & shoulder movement, head turns towards injured side

Hypoglossal Nerve

- Provides tongue movements of speech, food manipulation & swallowing
- Damage results in inability to protrude tongue if both are damaged or deviation towards injured side & ipsilateral atrophy if one side is damaged

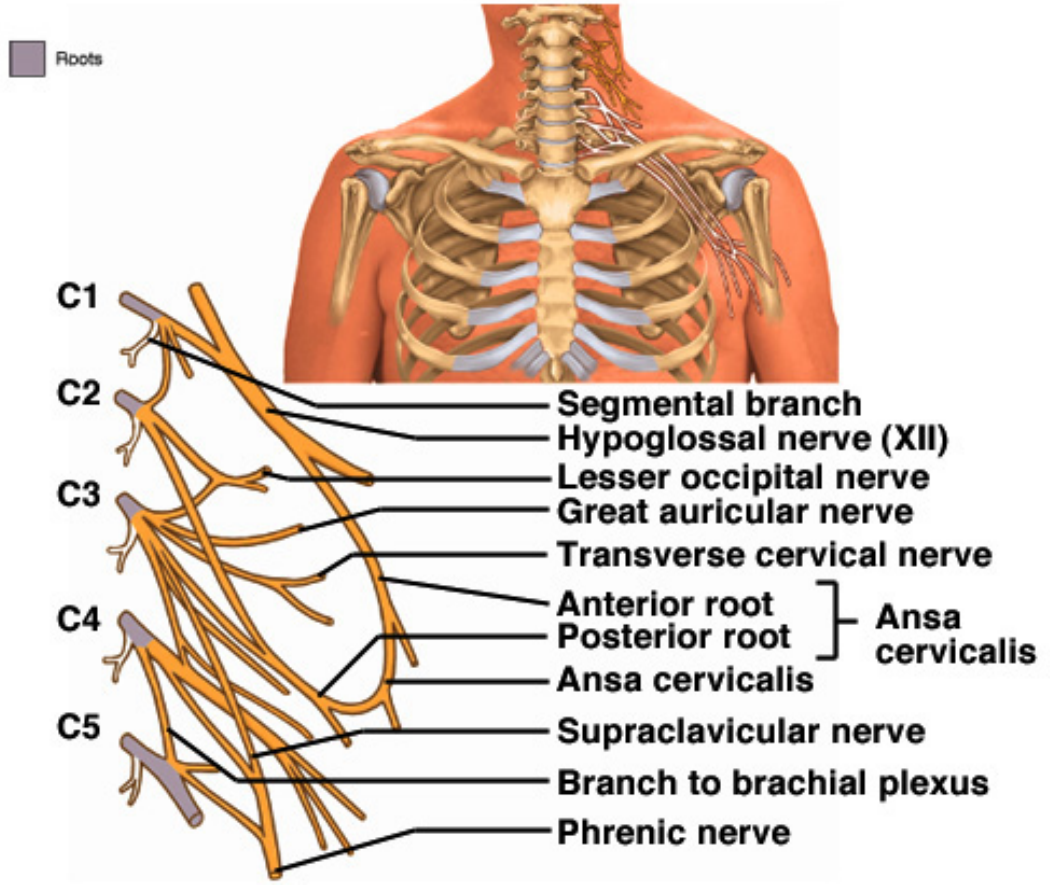
The Spinal Nerves

- 31 pairs of spinal nerves (1st cervical above C1)
  - mixed nerves exiting at intervertebral foramen
- Proximal branches
  - dorsal root is sensory input to spinal cord
  - ventral root is motor output of spinal cord
  - cauda equina is roots from L2 to C0 of the cord
- Distal branches
  - dorsal ramus supplies dorsal body muscle & skin
  - ventral ramus to ventral skin & muscles & limbs
  - meningeal branch to meninges, vertebrae & ligaments

Nerve Plexuses

- Ventral rami branch & anastomose repeatedly to form 5 nerve plexuses
  - cervical in the neck, C1 to C5
    - supplies neck and phrenic nerve to the diaphragm
  - brachial in the armpit, C5 to T1
    - supplies upper limb and some of shoulder & neck
  - lumbar in the low back, L1 to L4
    - supplies abdominal wall, anterior thigh & genitalia
  - sacral in the pelvis, L4, L5 & S1 to S4
    - supplies remainder of butt & lower limb
  - coccygeal, S4, S5 and C0

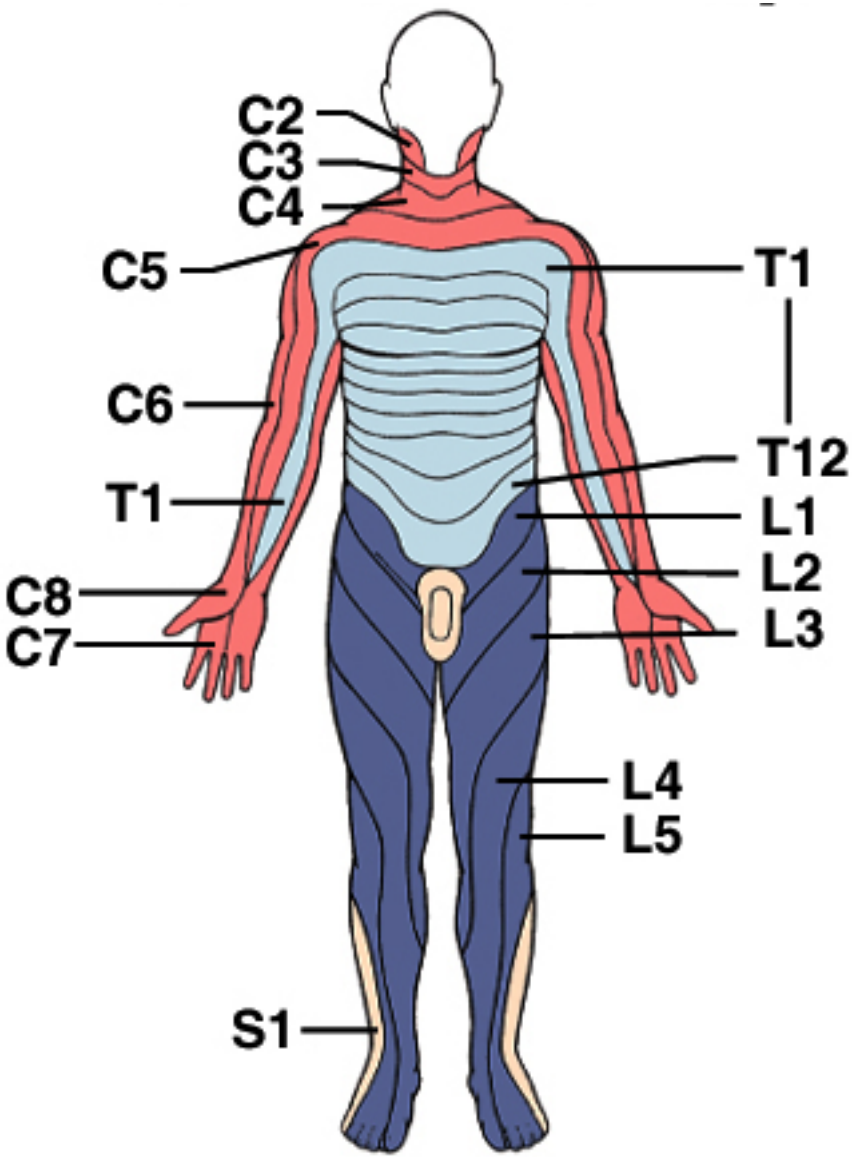
Structure of a Nerve Plexus



- Notice the branching and merging of nerves in this example of a plexus

Cutaneous Innervation & Dermatomes

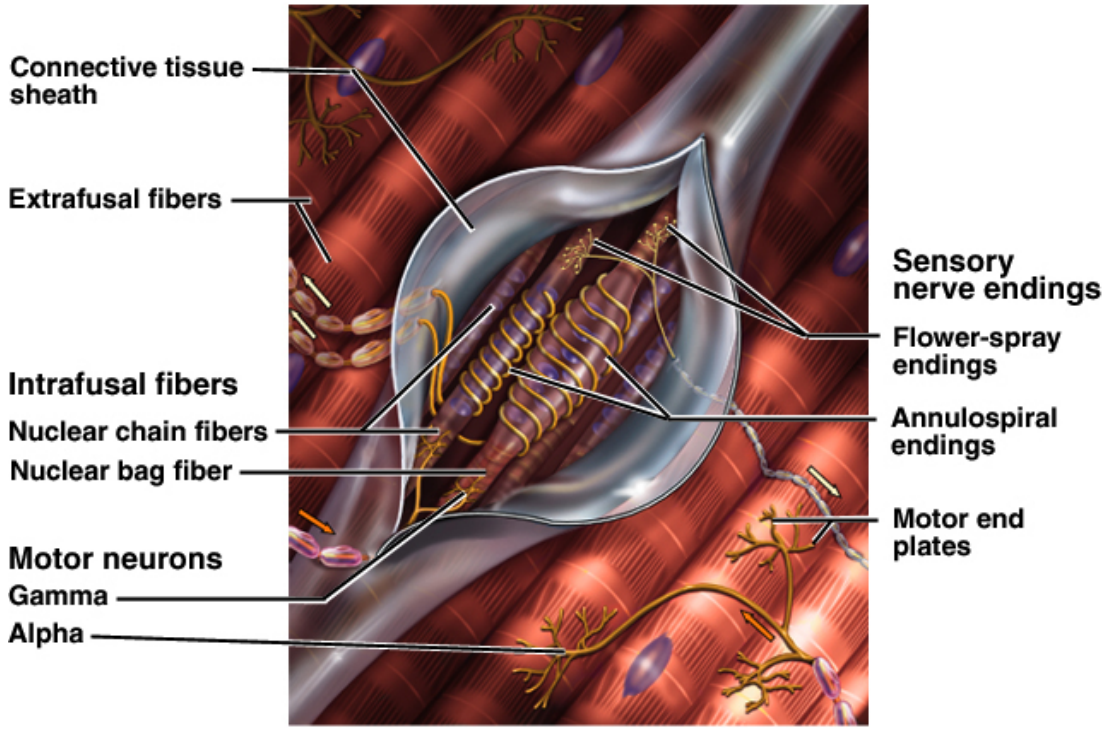
- Each spinal nerve receive sensory input from a specific area of skin called dermatome
- Overlap at edges by 50%
  - a total loss of sensation requires anesthesia of 3 successive spinal nerves



Nature of Somatic Reflexes

- Quick, involuntary, stereotyped reactions of glands or muscle
  - automatic responses to sensory input that occur without our intent or often even our awareness
- Functions by means of a somatic reflex arc
  - stimulation of receptors
  - afferent fibers carry signal to spinal cord
  - interneurons integrate the information
  - efferent fibers carry impulses to effectors
  - skeletal muscles respond

The Muscle Spindle

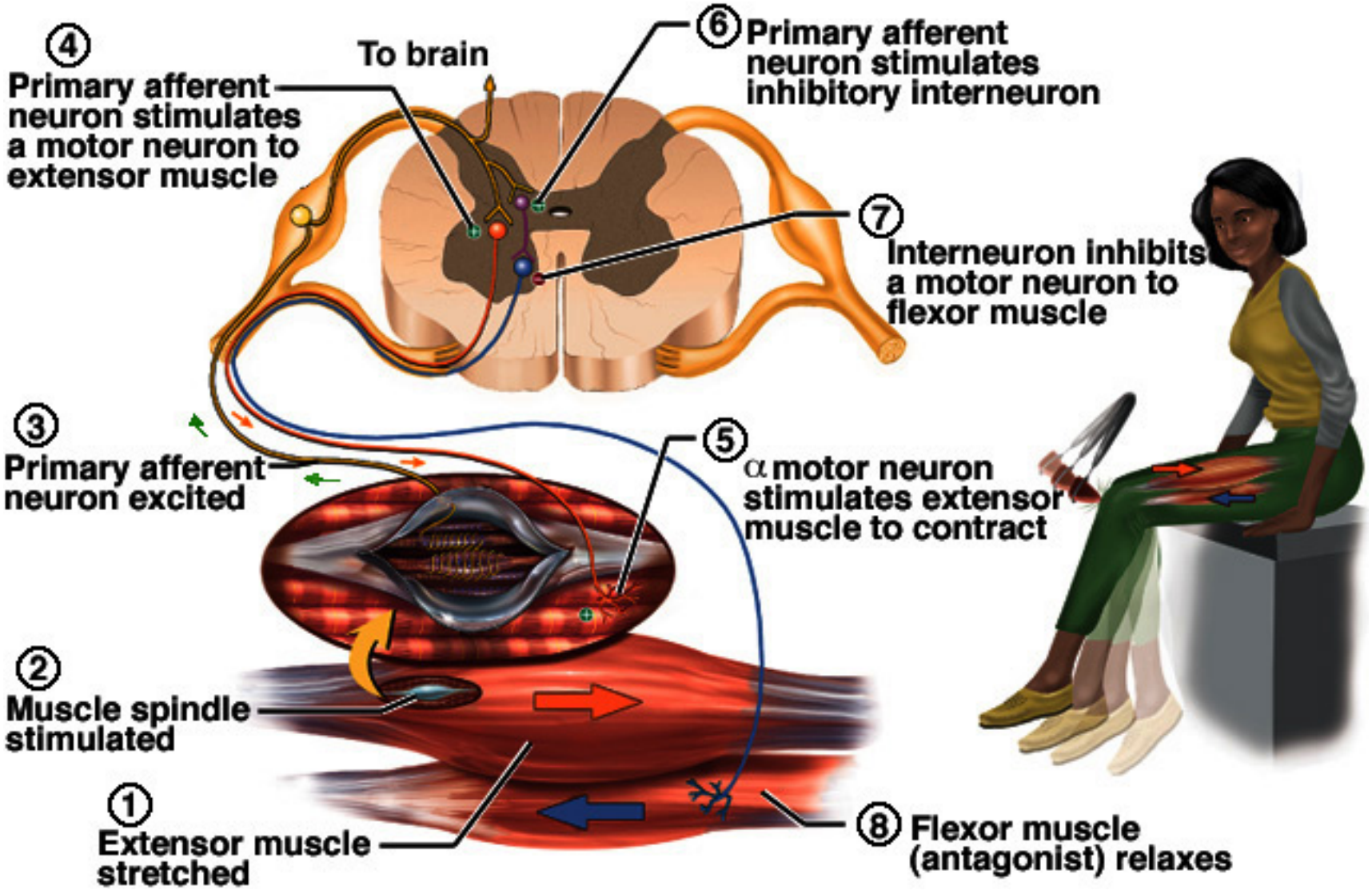


- Sense organs that monitor the length of skeletal muscles (proprioceptors)
- 4 to 10 mm long modified skeletal muscle cells
  - intrafusal fibers that respond to gamma motor neurons & are wrapped with afferent fibers that respond to stretch

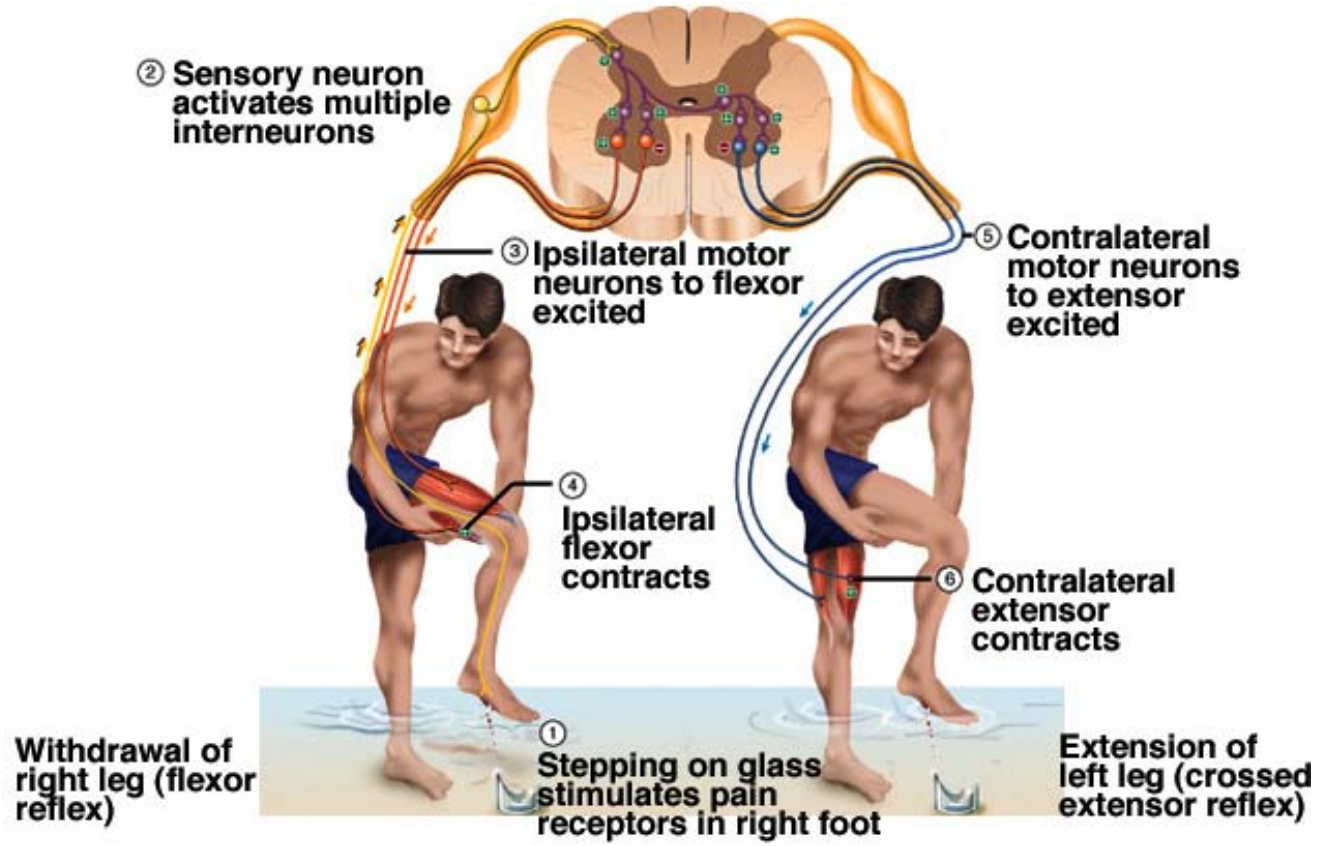
The Stretch Reflex

- When a muscle is stretched, it contracts & maintains increased tonus (stretch reflex)
  - helps maintain equilibrium & posture
    - head starts to tip forward as you fall asleep
  - stabilize joints by balancing tension in extensors & flexors
  - smooth muscle actions
- Very sudden muscle stretch causes tendon reflex
  - knee-jerk (patellar) reflex is monosynaptic reflex
- Reciprocal inhibition prevents muscles from working against each other

The Patellar Tendon Reflex Arc

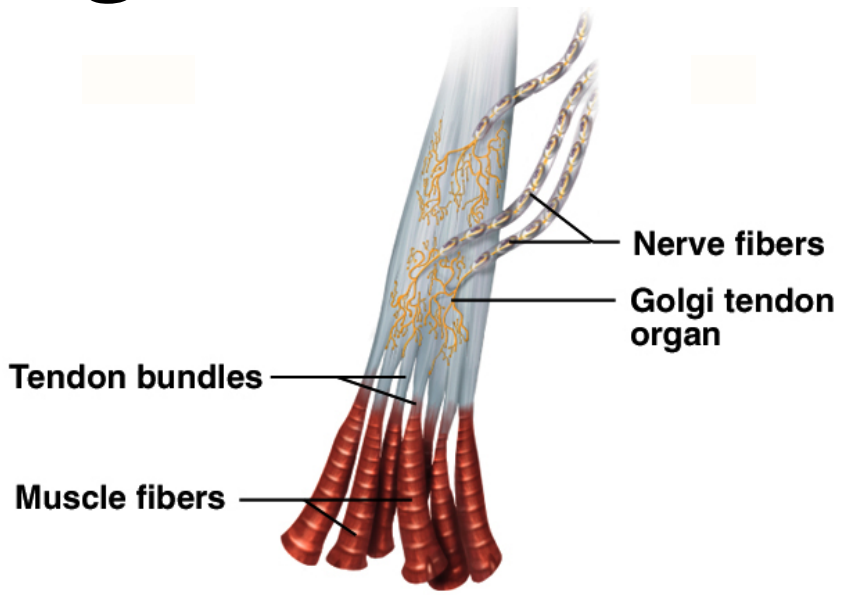


Withdrawal & Crossed Extensor Reflexes



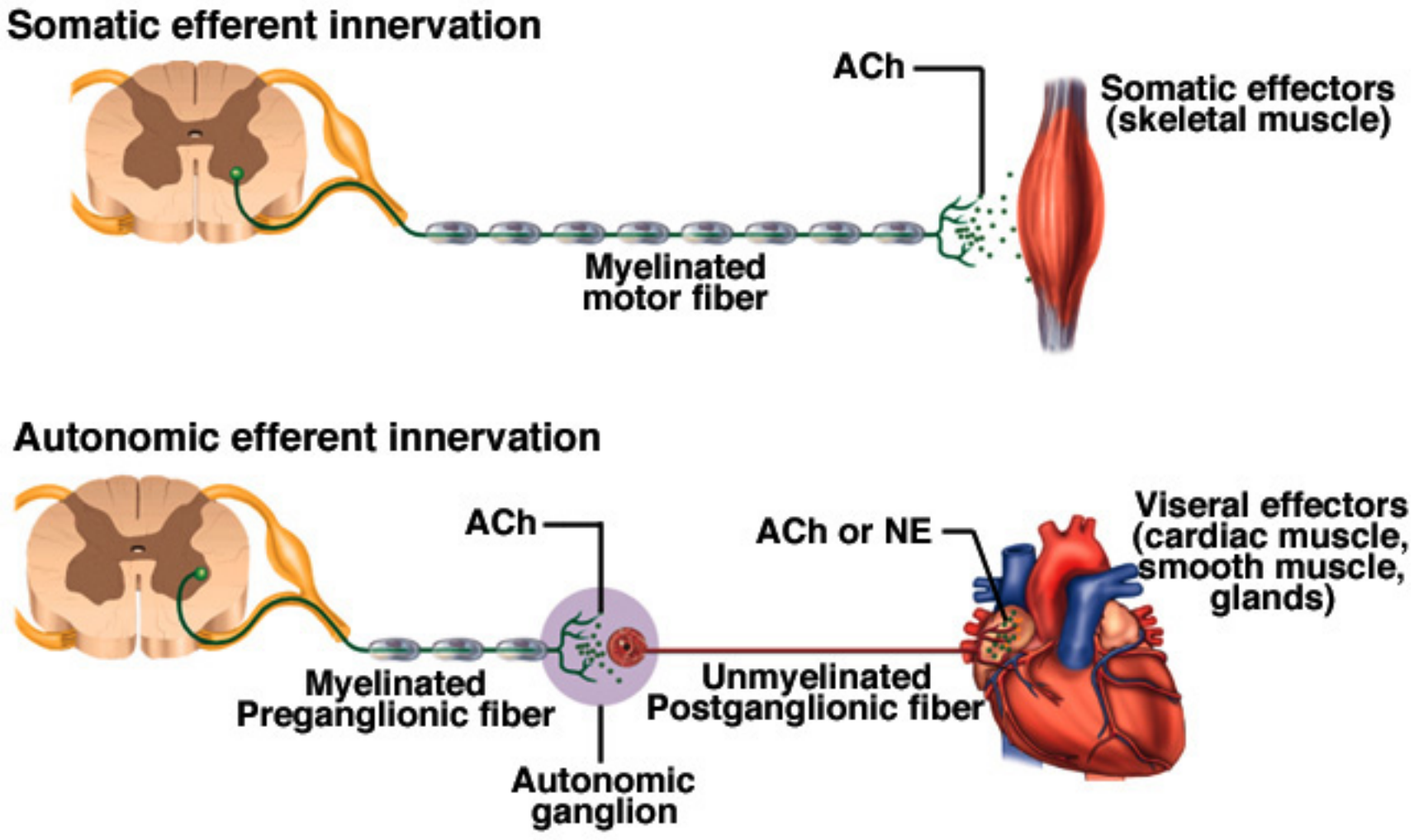
- Flexor(withdrawal) reflex is withdrawal of foot
- Crossed extensor reflex is maintaining balance by extending other leg

Golgi Tendon Reflex



- Proprioceptors in a tendon near its junction with a muscle -- 1mm long, encapsulated nerve bundle
- Excessive tension on tendon inhibits motor neuron
  - muscle contraction decreased
- Also functions when muscle contracts unevenly

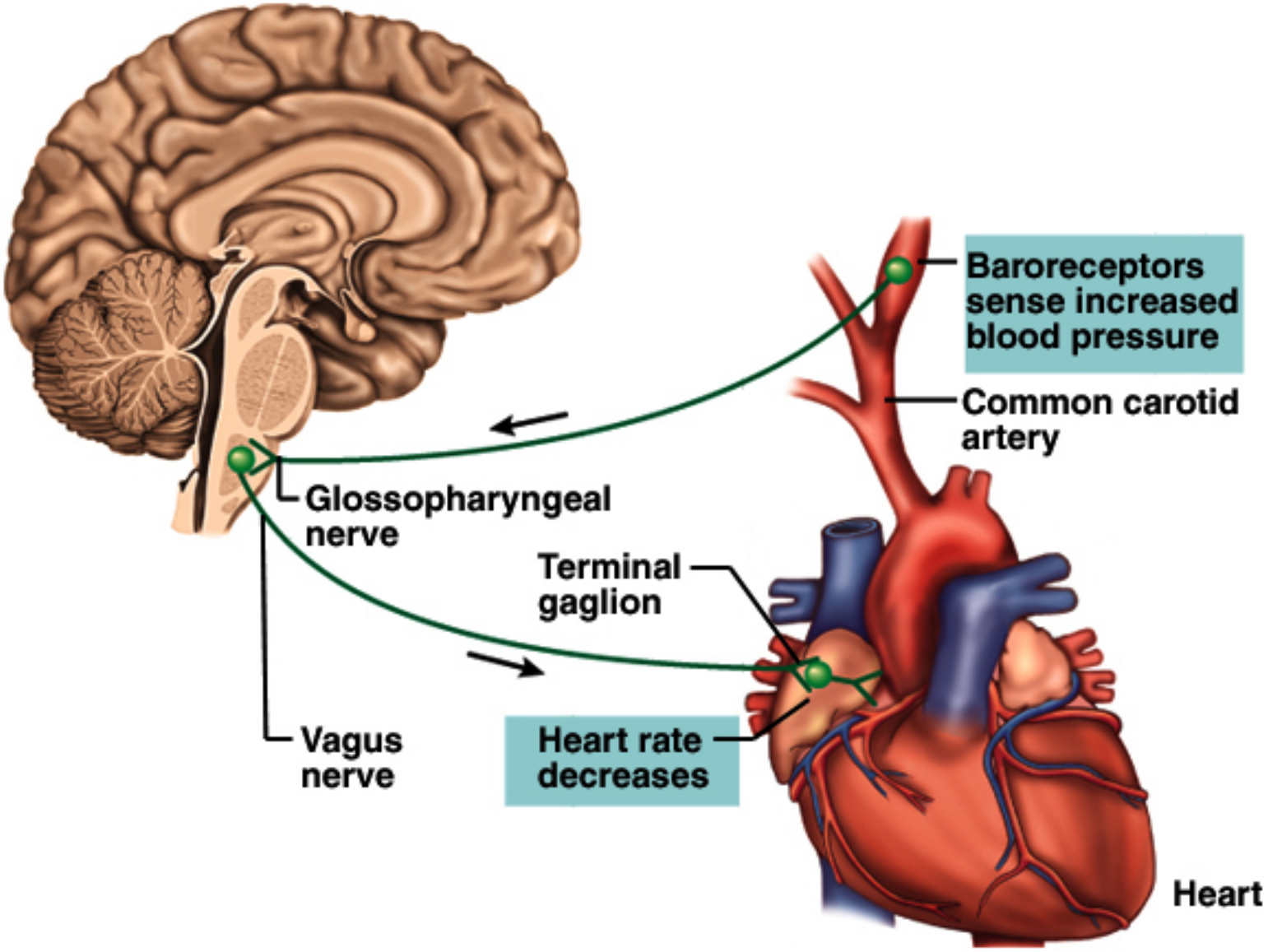
Somatic versus Autonomic Pathways



Autonomic NS: Visceral Reflexes

- Target organs are glands, cardiac & smooth muscle
- Receptors detect internal stimuli -- stretch, etc
  - baroreceptors detect BP, CN IX send signals to medulla, CN X sends signals to heart to reduce BP
- ANS is the efferent neurons of these reflex arcs
  - 2 neurons span the distance from CNS to effectors
    - presynaptic neuron cell body in CNS -- brain or spinal cord
    - postsynaptic neuron cell body in peripheral ganglion
  - ANS modifies effector activity rather than causing it
    - smooth & cardiac muscle show denervation hypertrophy

Autonomic Reflex Arc

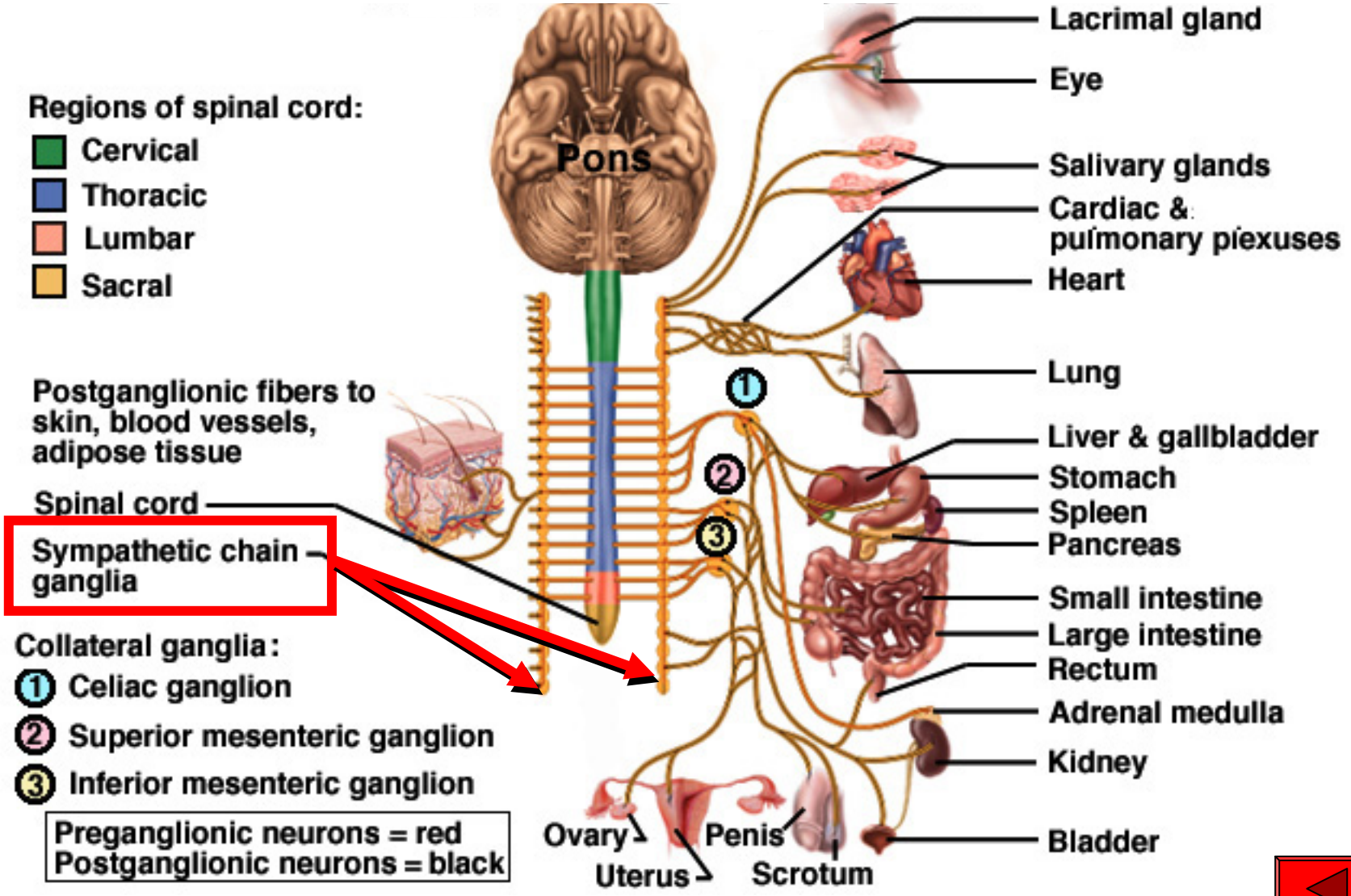


Anatomy of Sympathetic NS

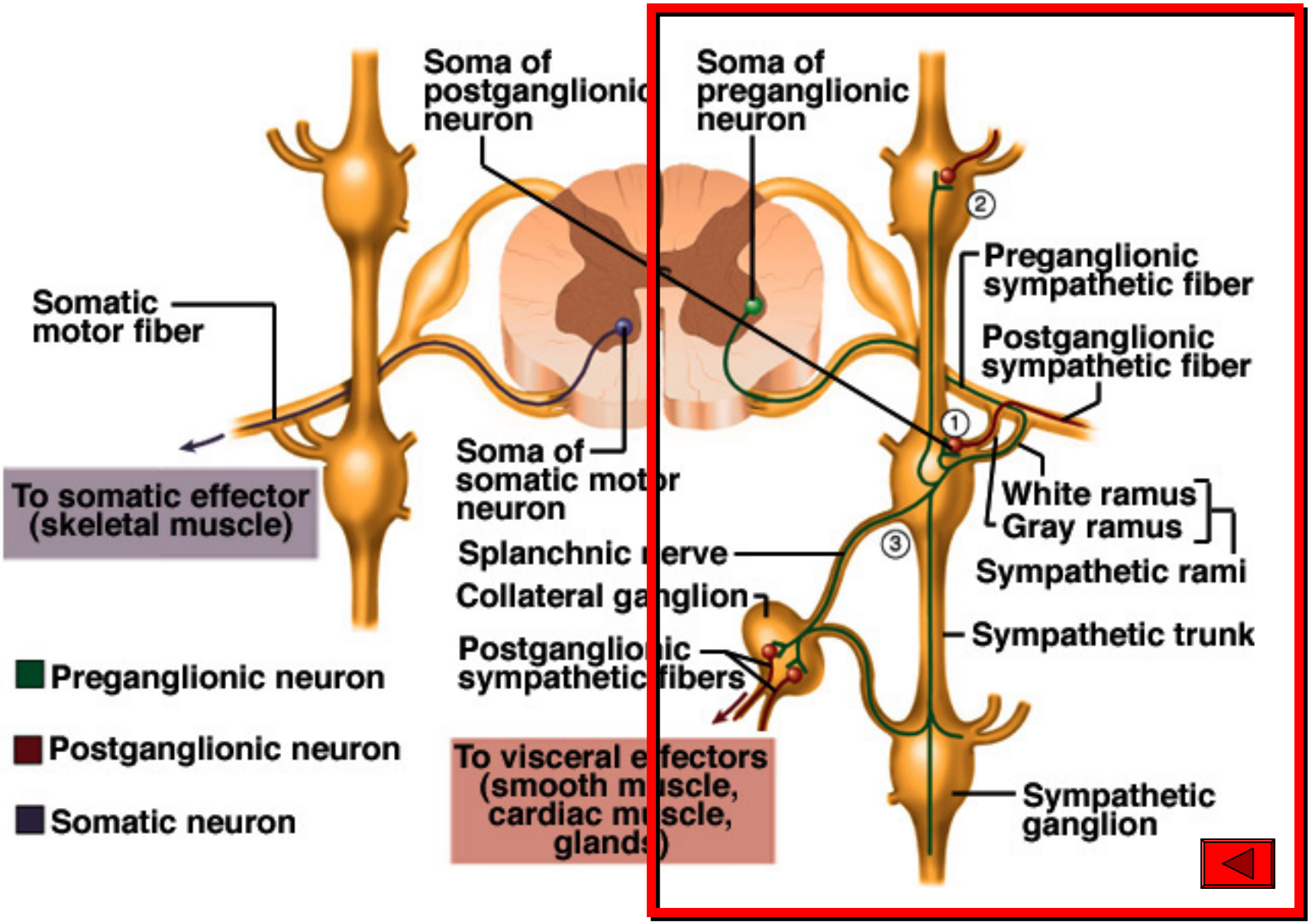
- Origin of presynaptic neurons
  - lateral horns of gray matter of thoracic to lumbar cord
  - fibers exit via spinal nerves T1-L2
- Sympathetic chain ganglia (paravertebral)
  - white and gray communicating rami suspend ganglia from spinal nerve
  - pathways of preganglionic fibers
    - enter ganglia & synapse
    - travel to higher or lower ganglia & synapse
    - pass through chain without synapsing to reach collateral ganglia via splanchnic nerves

CONTINUE

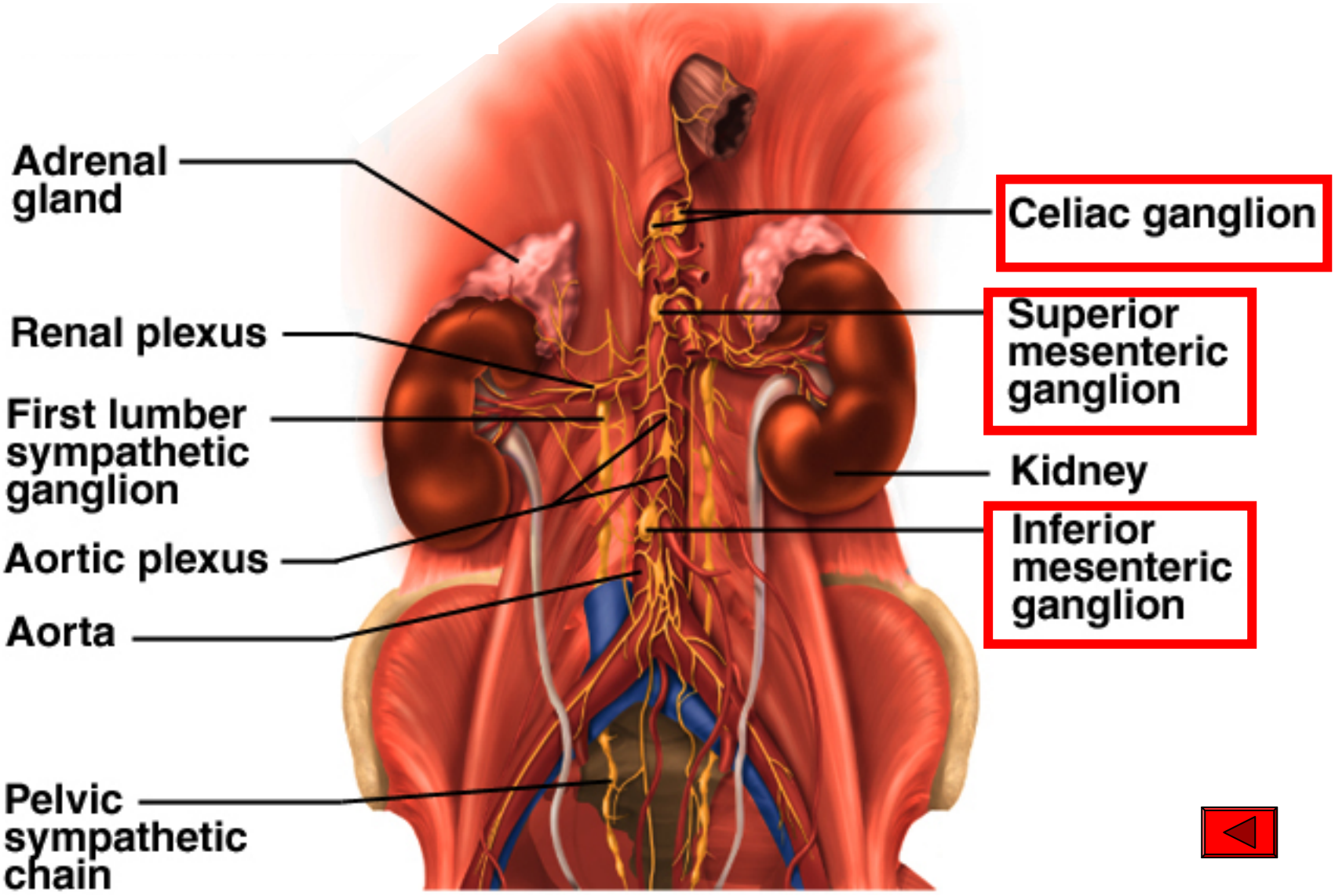
Efferent Pathways of Sympathetic NS



Pathways of Preganglionic Sympathetic Fibers



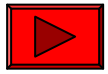
Collateral Ganglia & Abdominal Aortic Plexus



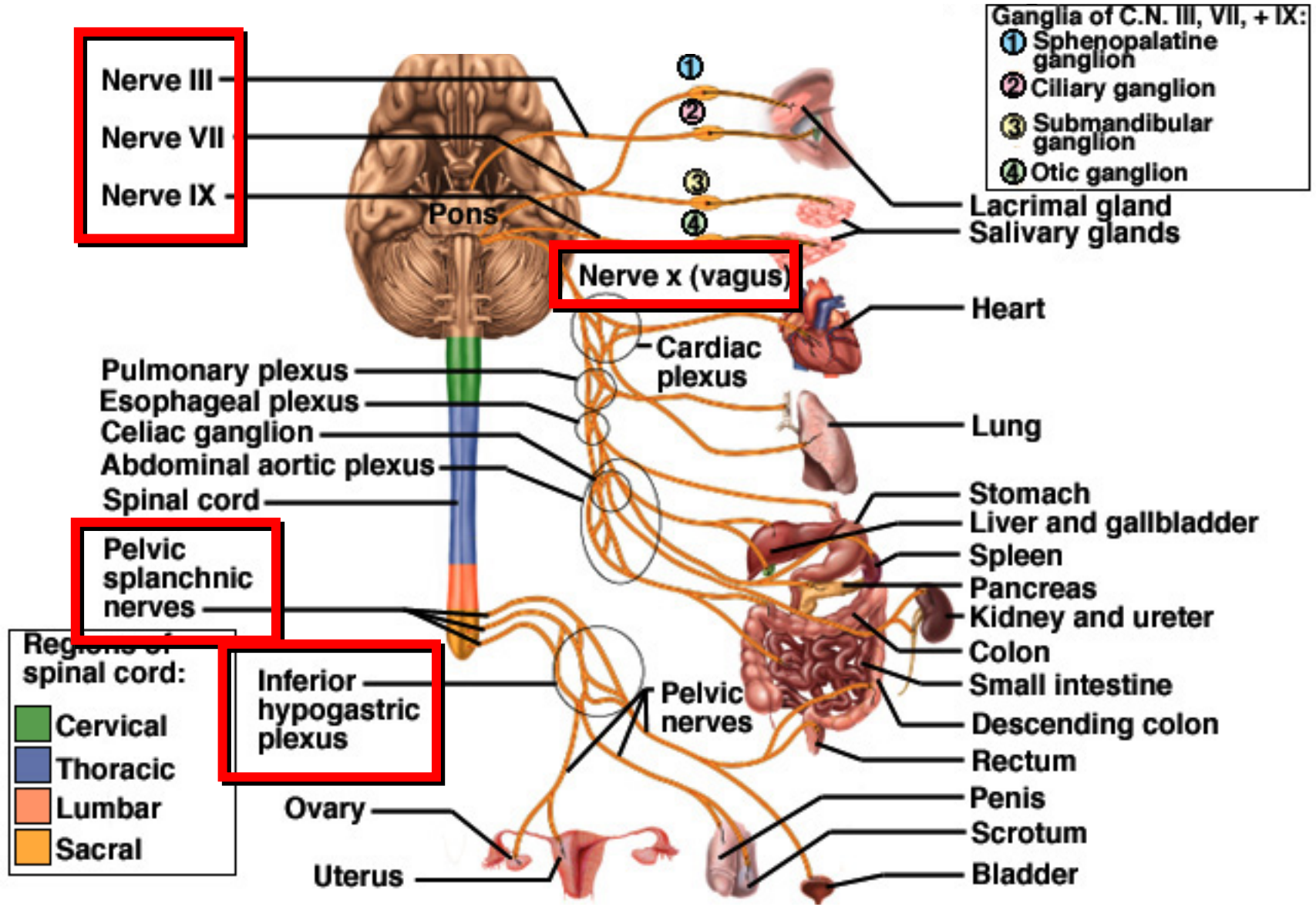
Adrenal Glands

- Paired glands sit on superior pole of each kidney
- Cortex
  - secretes steroid hormone
- Medulla
  - modified sympathetic ganglion that secretes neurotransmitters (hormones) into blood and not onto other neurons
    - 85% epinephrine & 15% norepinephrine
  - complementary involvement in mass activation that occurs during fight or flight reaction

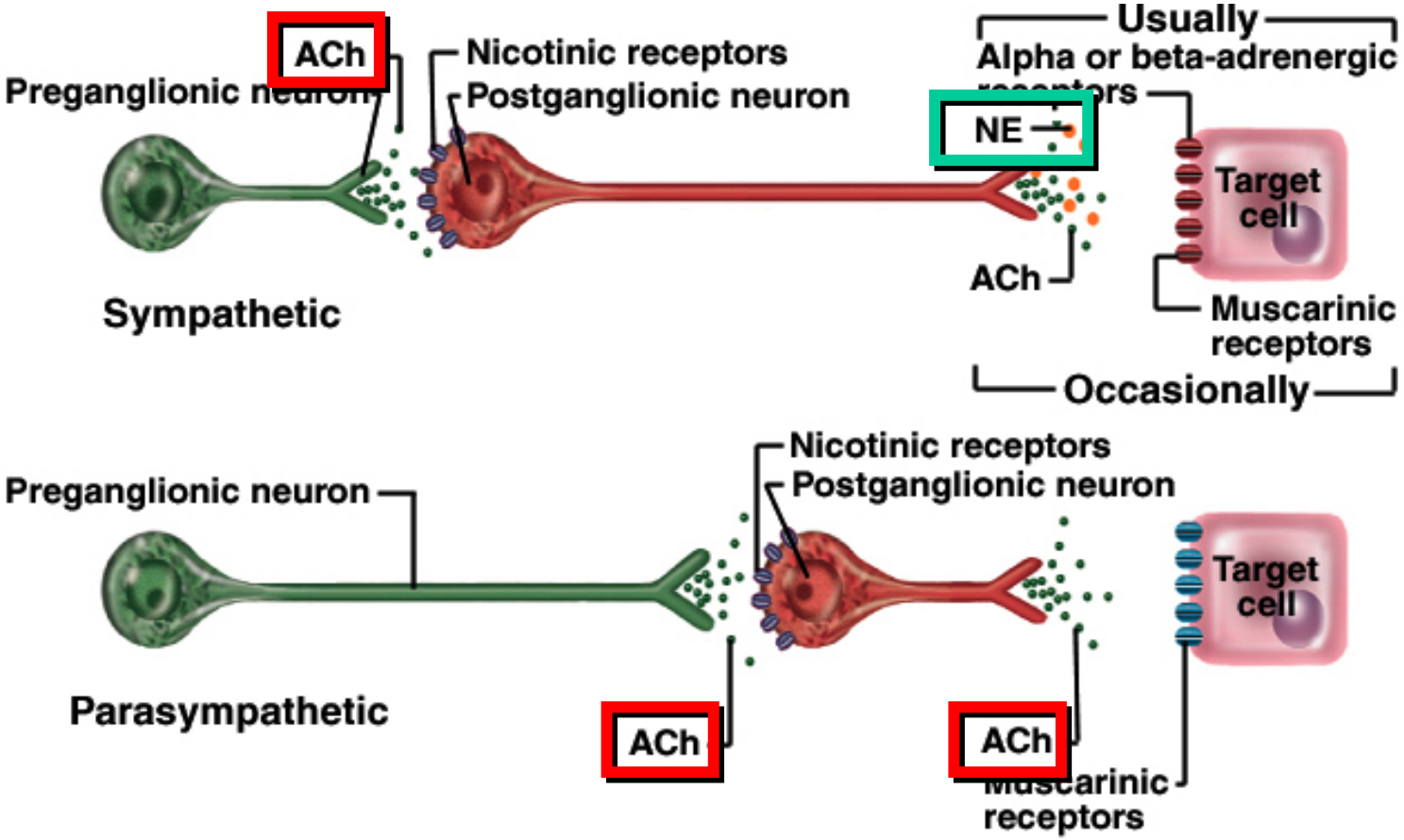
Anatomy of the Parasympathetic NS

- Origin of preganglionic fibers
  - pons and medulla oblongata (cranial nerve nuclei)
  - spinal cord segments S2-S4
- Pathways of preganglionic fibers 
  - cranial nerves III, VII, IX and X
    - cardiac, pulmonary, esophageal, abdominal aortic plexus
  - arising from sacral spinal cord
    - pelvic splanchnic nerves & inferior hypogastric plexus
- Terminal ganglia in target organs due to normally short postganglionic fibers

Efferent Pathways of Parasympathetic NS



Neurotransmitters & Receptors



- Cholinergic fibers secrete ACh while adrenergic fibers secrete NE
  - only postganglionic sympathetic fibers are adrenergic

Cholinergic Receptors

- Acetylcholine binds to 2 classes of receptors
  - nicotinic receptors
    - occur on all ANS postganglionic neurons, adrenal medulla, on skeletal muscle
    - excitatory when ACh binding occurs
  - muscarinic receptors
    - occur on all gland, smooth muscle & cardiac muscle that receives cholinergic innervation
    - either excitatory or inhibitory when ACh binding occurs

Adrenergic Receptors

- 2 categories of NE receptors
  - alpha adrenergic receptors
    - NE binding is excitatory
  - beta adrenergic receptors
    - NE binding is inhibitory
- Exceptions to normal results (EPSP or IPSP)
  - existence of subclasses of each receptor type
    - alpha 1 and 2; beta 1 and 2
- Function by means of 2nd messengers
  - beta receptors activate cyclic AMP, alphas2 receptors suppress it and alpha1 receptors use calcium

Dual Innervation

- Most of viscera receive nerve fibers from both parasympathetic & sympathetic divisions
  - antagonistic effects oppose each other
    - exerted through dual innervation of same effector cells
      - heart slowed down or speeded up
    - exerted because each division innervates different cells
      - pupillary dilator muscle & constrictor pupillae change pupil size
  - cooperative effects seen when 2 divisions act on different effectors to produce a unified effect(salivation)
    - parasympathetic NS increases salivary serous cell secretion
    - sympathetic NS increases salivary mucous cell secretion
- Both divisions do not innervate an organ equally

Control Without Dual Innervation

- Adrenal medulla, arrector pili muscles, sweat glands & many blood vessels receive only sympathetic fibers
- Sympathetic tone is a baseline firing frequency
    - provides partial constriction called vasomotor tone
  - increase in firing frequency = vasoconstriction
  - decrease in firing frequency = vasodilation
- Vasomotor tone can shift blood flow from one organ to another according to changing needs
  - sympathetic stimulation increases blood to skeletal & cardiac muscles -- reduced blood to skin

Central Control of Autonomic Function

- ANS is regulated by several levels of the CNS
  - cerebral cortex
    - influenced by our emotions
  - hypothalamus
    - fight or flight responses originate here
  - reticular formation
    - can respond directly to sensory input from cardiac, vasomotor, & GI tract
  - spinal cord
    - defecation & micturition reflexes are integrated in the spinal cord

Neuropharmacology & Psychopharmacology

- Sympathomimetics enhance sympathetic activity
  - stimulate receptors or ↑norepinephrine release
- Sympatholytics suppress sympathetic activity
  - inhibit norepinephrine release or block receptors
- Parasympathomimetics enhance activity while Parasympatholytics suppress activity
- Management of clinical depression
  - Prozac blocks reuptake of serotonin to prolong its mood-elevating effect
  - MAO inhibitors interfere with breakdown of monoamine neurotransmitters
- Caffeine competes with adenosine (inhibitory causing sleepiness) by binding to its receptors