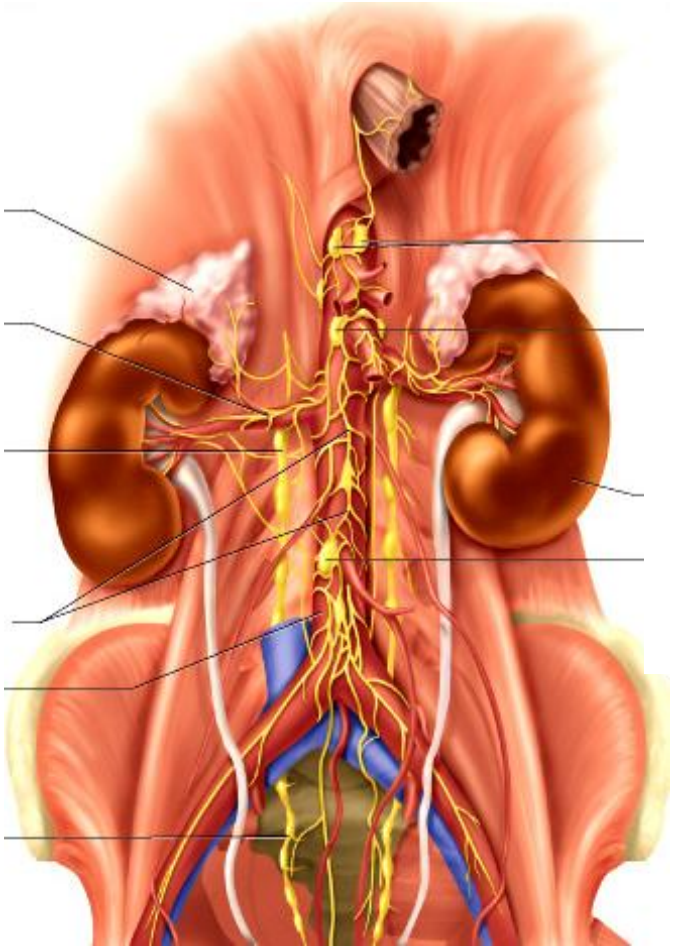
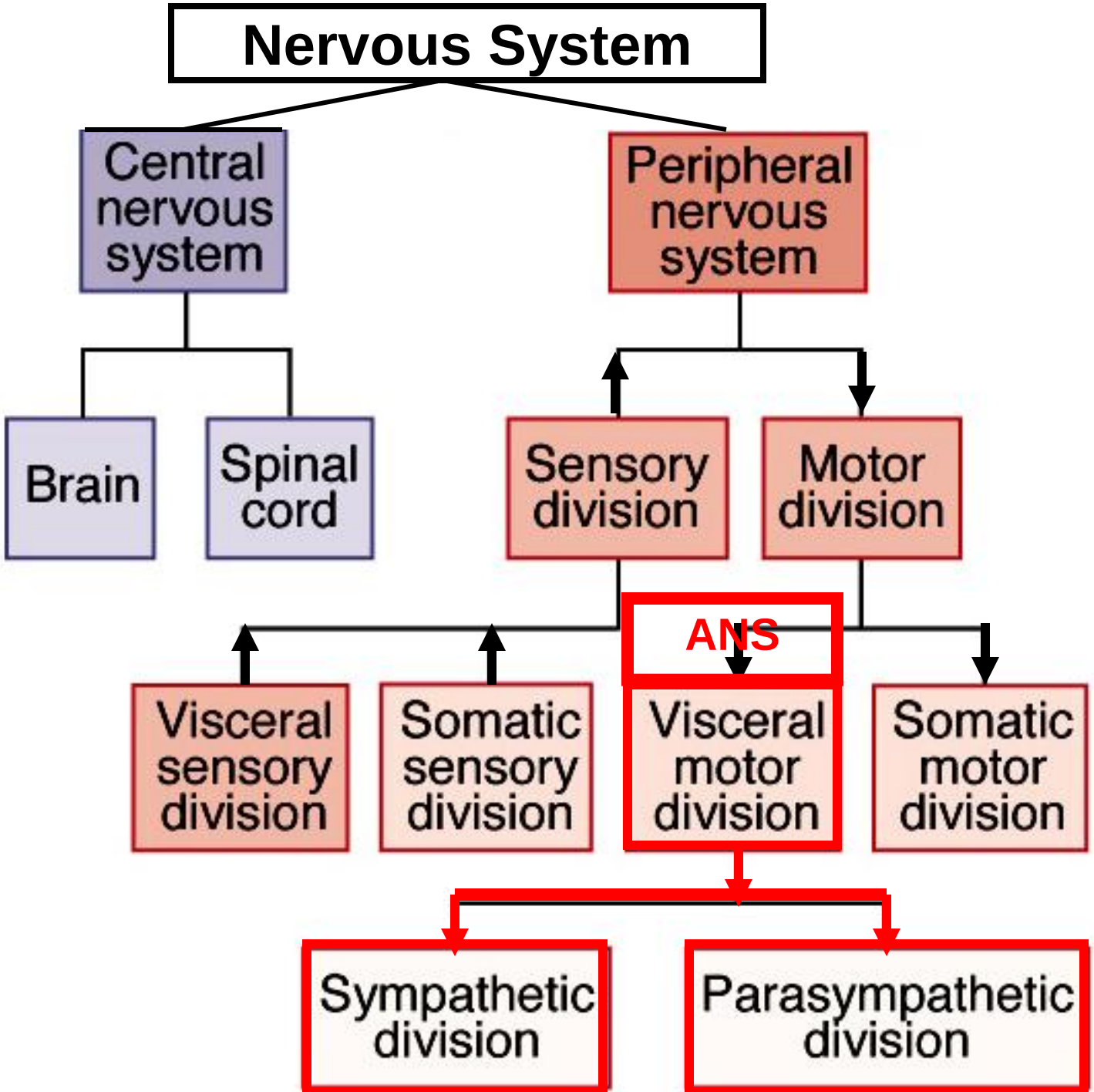
Autonomic Nervous System

Chapter 15

- Anatomy of the Autonomic Nervous System
- Physiology of the Autonomic Nervous System
- Innervation and Control of Autonomic Function




Nervous System
Central nervous system
Peripheral nervous system
Brain
Spinal cord
Sensory division
Motor division
ANS
Visceral sensory division
Somatic sensory division
Visceral motor division
Somatic motor division
Sympathetic division
Parasympathetic division

Functional Divisions of PNS

- **Sensory (Afferent) Division** brings visceral (thoracic and abdominal organs) and somatic (skeletal muscle, skin, bone and joints) sensory information into the CNS
- **Motor (Efferent) Division** sends out information from the CNS.
  - **somatic motor division** innervates skeletal muscle
    - Voluntary movement of skeletal muscles
  - **The Autonomic Nervous System is the visceral motor division of the PNS that innervates cardiac muscle, smooth muscle and glands**
    - **sympathetic division** (active, arousing responses)
    - **parasympathetic division** (calming, maintenance functions like digestion)

Somatic vs Autonomic Pathways

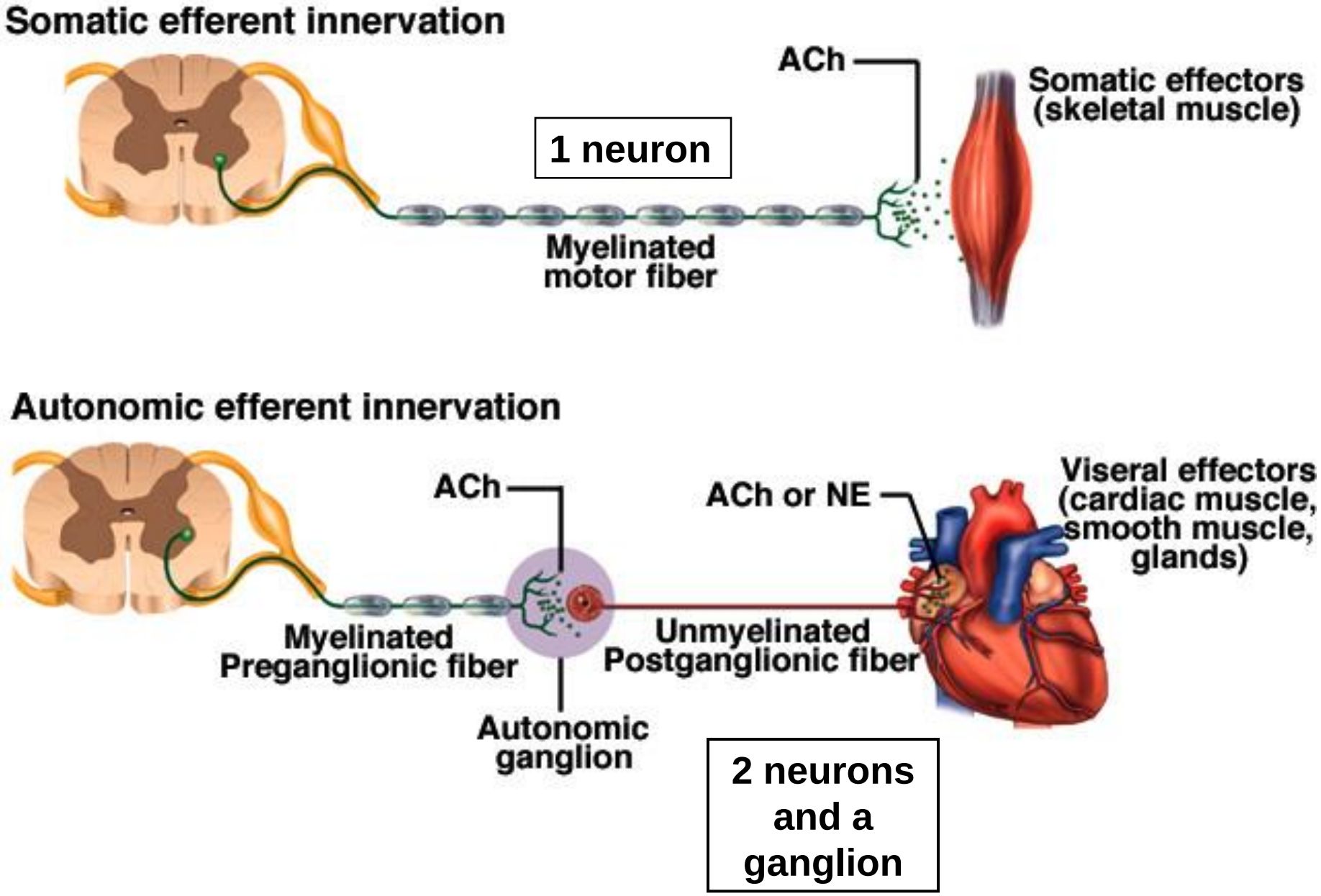
Somatic Pathway uses only one motor neuron

Autonomic Pathway uses a series of two neurons:

1) presynaptic autonomic neuron cell body is in the CNS

2) postsynaptic autonomic neuron cell body is in a ganglion

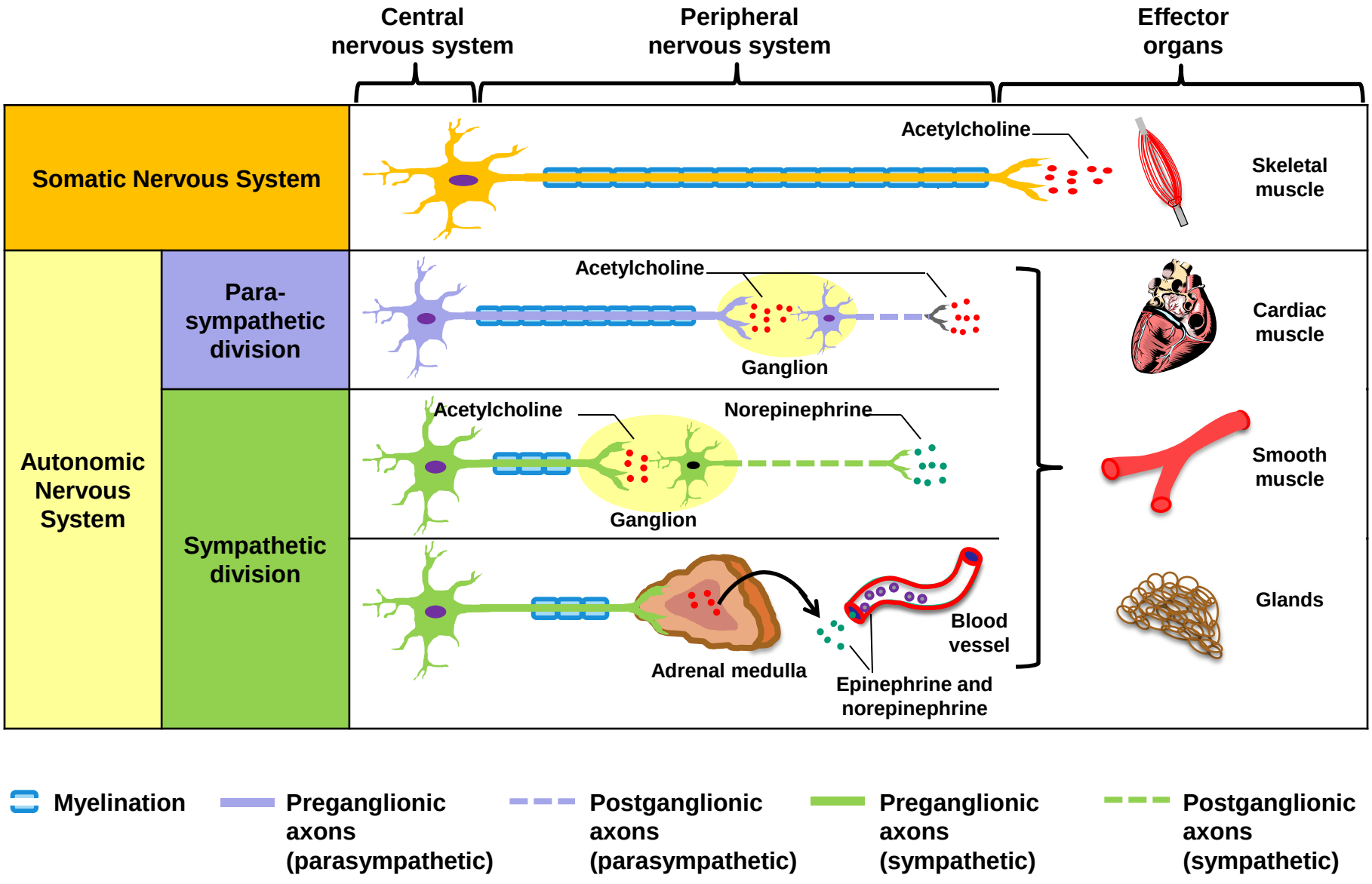
Somatic vs Autonomic Pathways

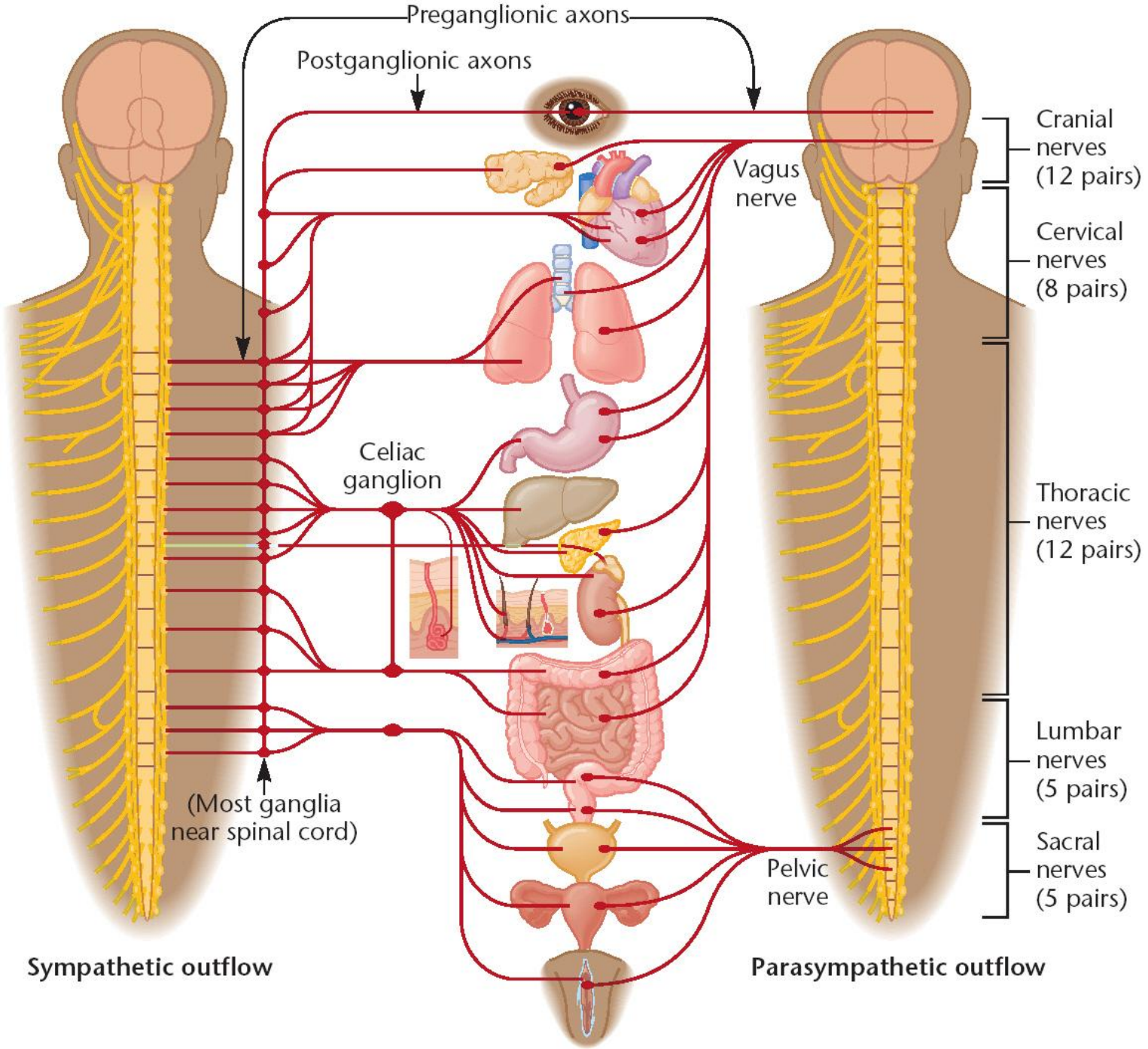


The ANS has Two Divisions

1. **Sympathetic Division** prepares body for physical activity.
   - increases heart rate, BP, airflow, blood glucose levels and other functions
2. **Parasympathetic Division** has calming affect on many body functions and assists in maintenance and repair of tissues.
   - increases digestion and waste elimination

- The two divisions may innervate the same target organ and may have contrasting effects.
- Effects of each depend upon which neurotransmitters are released.

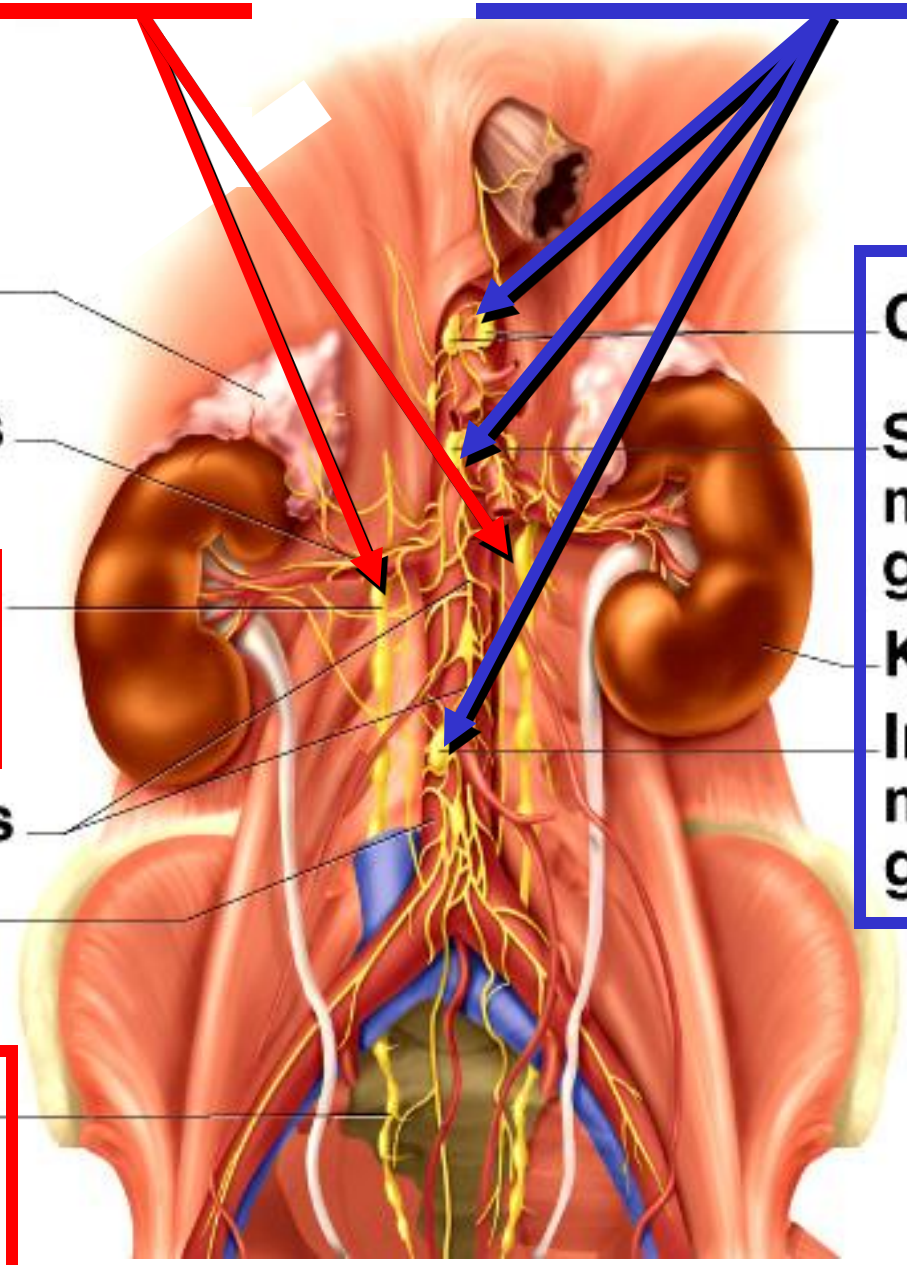

Central nervous system
Peripheral nervous system
Effector organs
Somatic Nervous System
Acetylcholine
Skeletal muscle
Autonomic Nervous System
Para-sympathetic division
Acetylcholine
Ganglion
Cardiac muscle
Sympathetic division
Acetylcholine
Norepinephrine
Ganglion
Smooth muscle
Adrenal medulla
Blood vessel
Glands
Epinephrine and norepinephrine
Myelination
Preganglionic axons (parasympathetic)
Postganglionic axons (parasympathetic)
Preganglionic axons (sympathetic)
Postganglionic axons (sympathetic)


Preganglionic axons
Postganglionic axons
Vagus nerve
Cranial nerves (12 pairs)
Cervical nerves (8 pairs)
Thoracic nerves (12 pairs)
Lumbar nerves (5 pairs)
Sacral nerves (5 pairs)
Celiac ganglion
(Most ganglia near spinal cord)
Pelvic nerve
Sympathetic outflow
Parasympathetic outflow

Sympathetic Division of the ANS

- Somas of preganglionic sympathetic neurons are in the lateral horn gray matter of the thoracic to lumbar (thoracolumbar) spinal cord regions T1-L2
- Somas of postganglionic sympathetic neurons are in sympathetic ganglia that run along either side of the vertebral column.
  - chain ganglia
  - collateral ganglia

Chain Ganglia and Collateral Ganglia



Adrenal gland

Renal plexus

First lumbar sympathetic ganglion

Aortic plexus

Aorta

Pelvic sympathetic chain

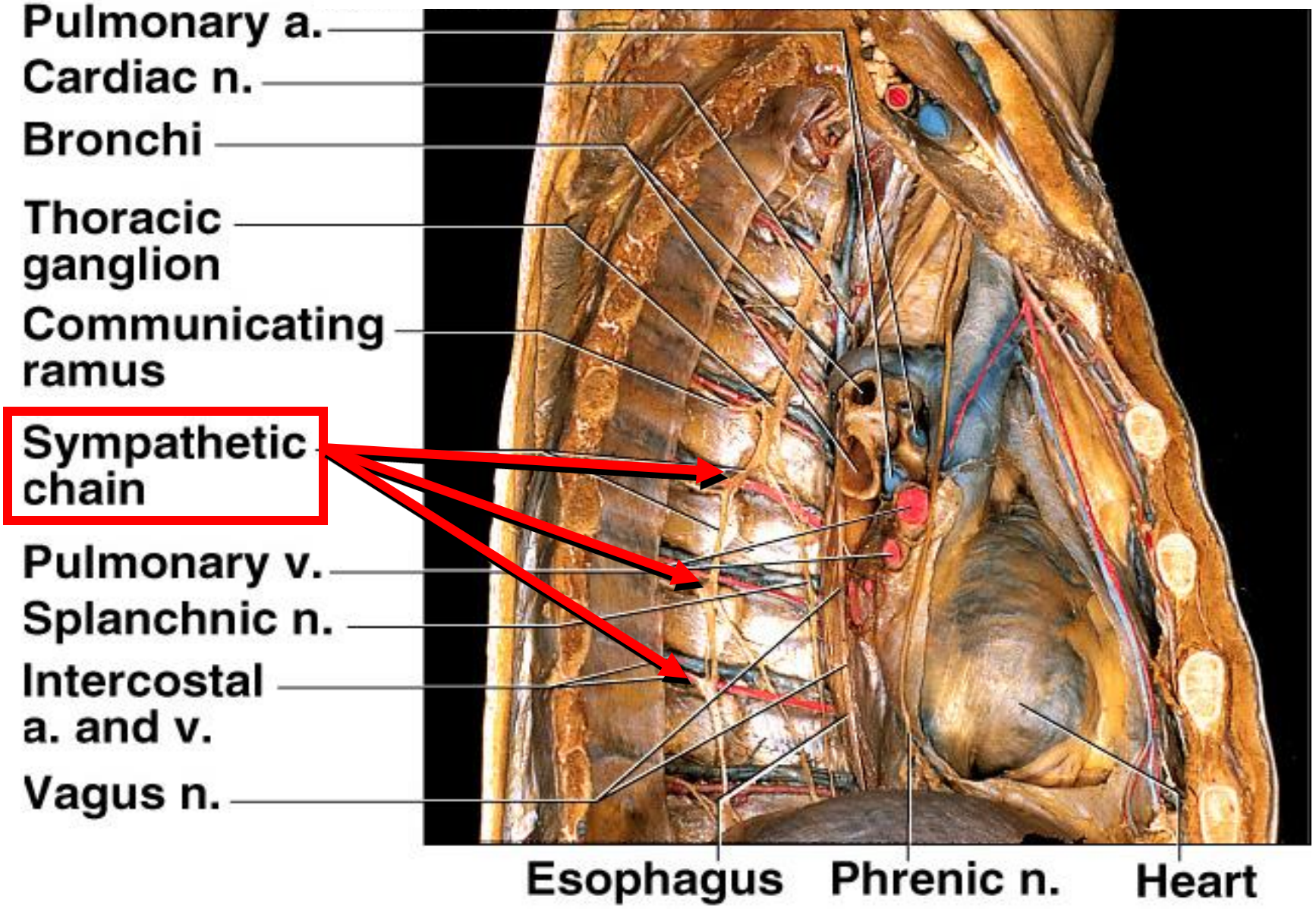
Celiac ganglia

Superior mesenteric ganglion

Kidney

Inferior mesenteric ganglion

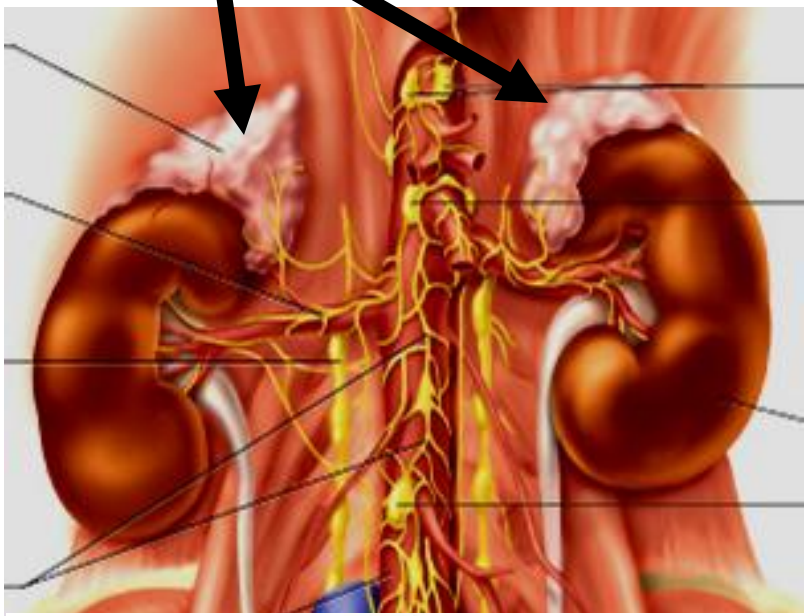
The Sympathetic Chain Ganglia

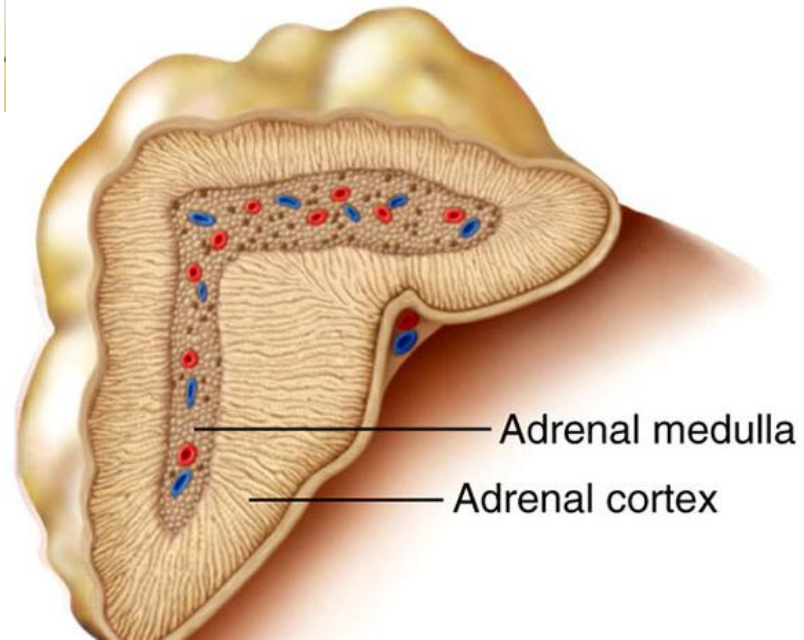


Adrenal Glands

- An Adrenal Gland sits above each kidney
- Adrenal Cortex secretes steroid hormones for chronic stress
- Adrenal Medulla is a modified sympathetic ganglion that secretes neurotransmitters (catecholamine hormones) into the blood in response to acute stress.
  - catecholamines secreted by the adrenal medulla are:

    epinephrine (85%) and norepinephrine (15%)

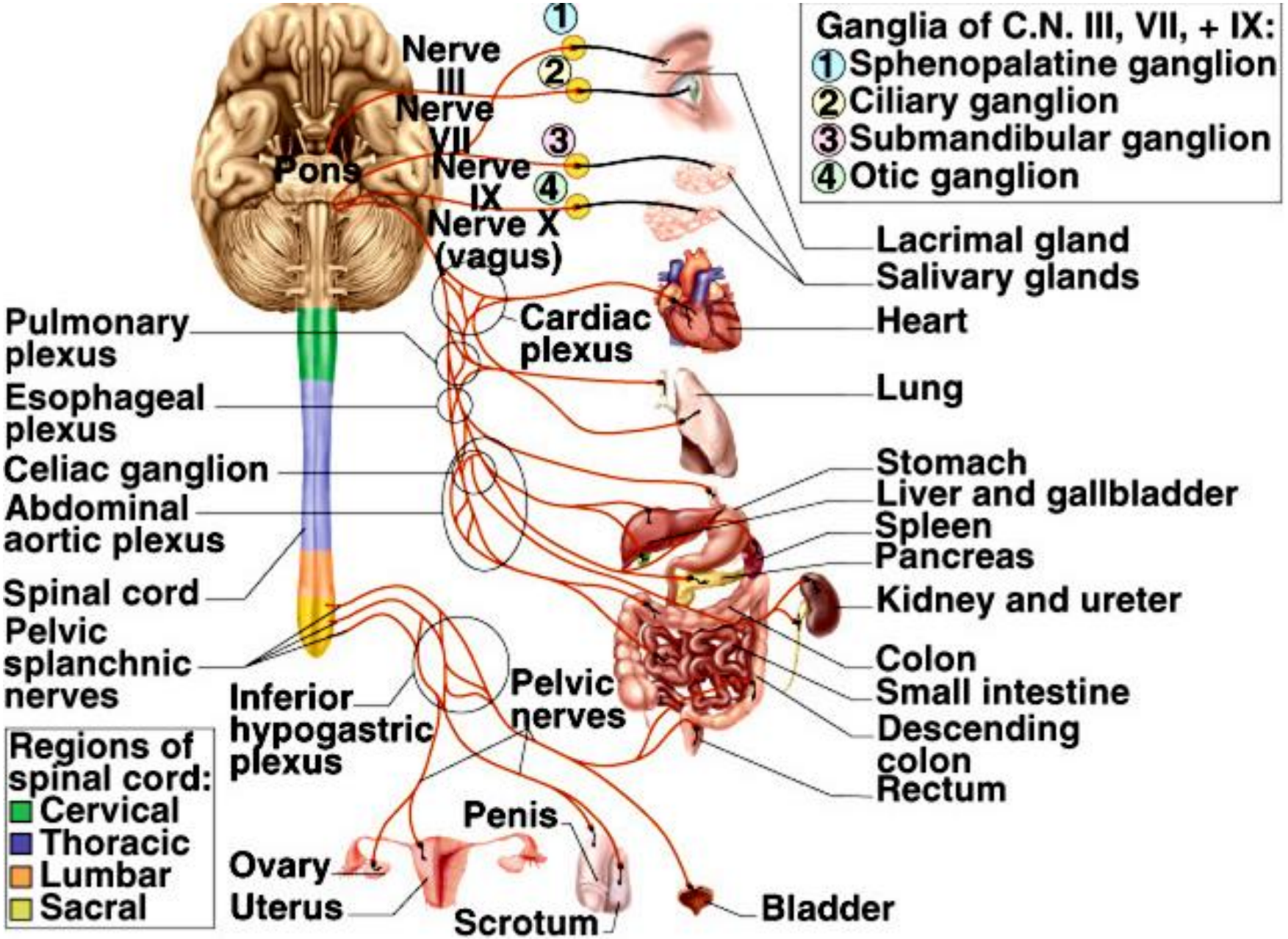




Parasympathetic Division

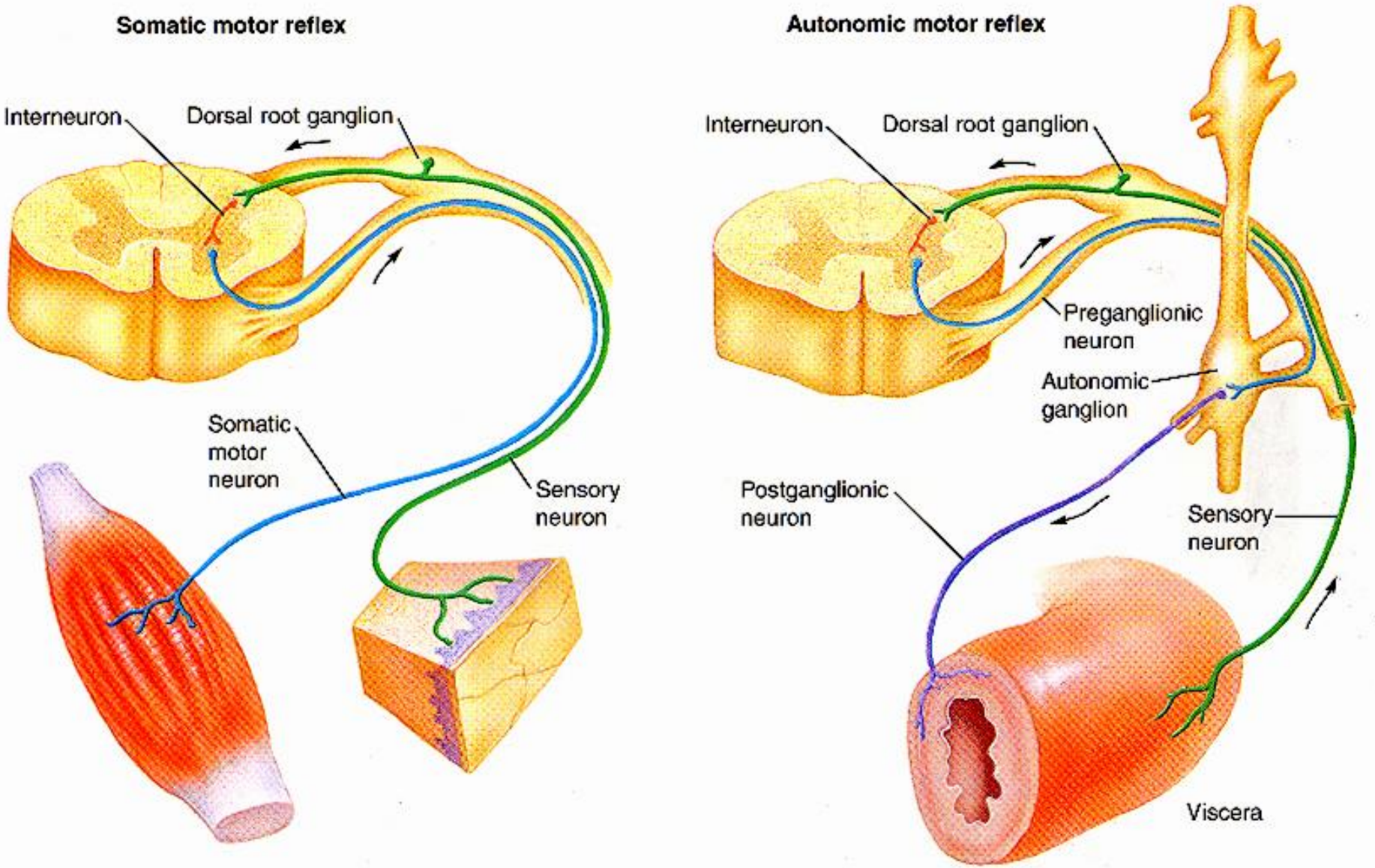
- Preganglionic Parasympathetic Neurons originate from **cranial** and **sacral** levels of the CNS.
- Long preganglionic axons synapse with short postganglionic fibers in ganglia in target organs.

Pathways of the Parasympathetic Division

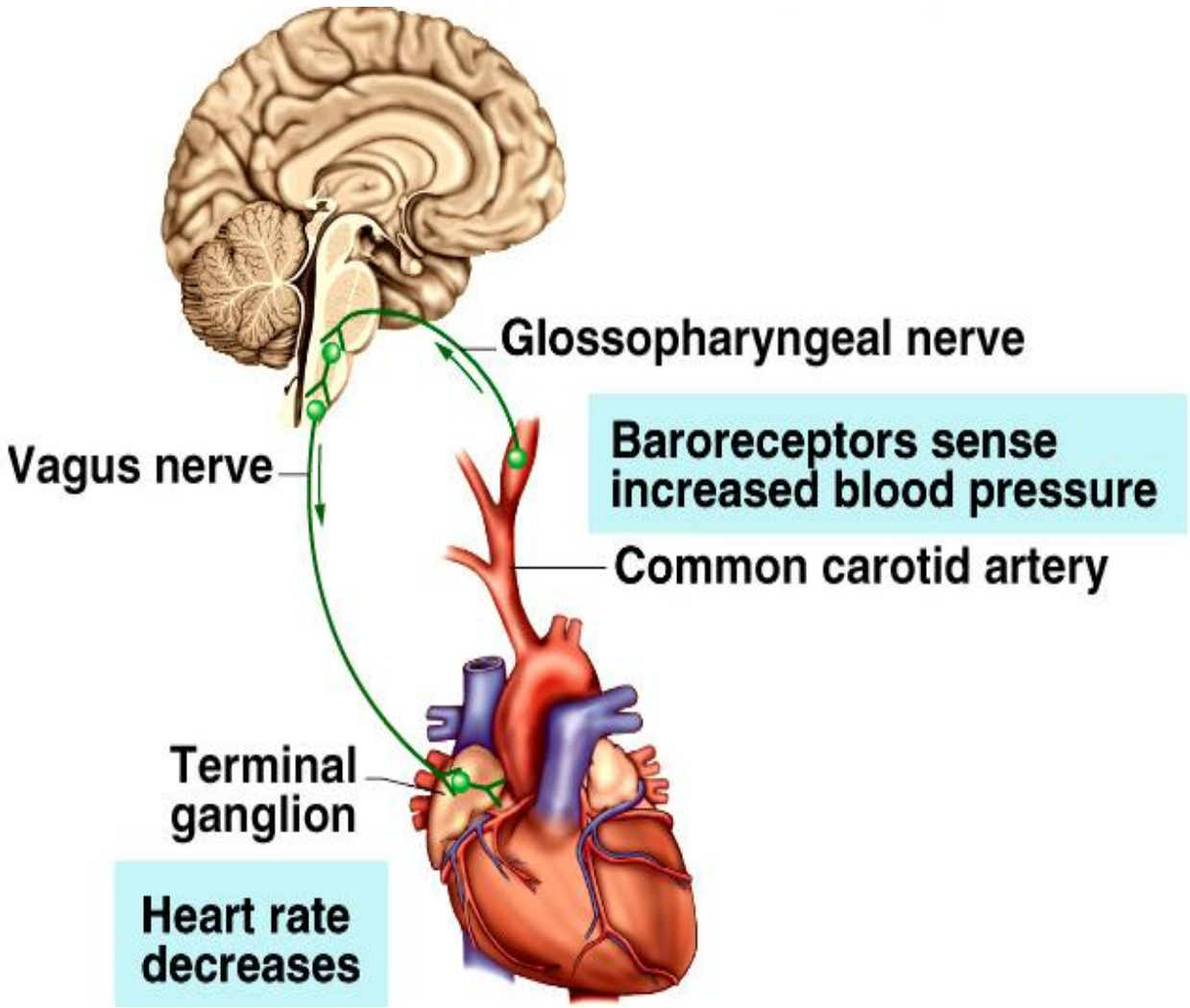


Visceral Reflexes

- Unconscious responses to stimulation of cardiac muscle, smooth muscle or glands.
- Receptors detect internal stimuli such as stretch, chemicals, body temperature, etc.
- Afferent neurons carry signals to interneurons in CNS.
- Efferent autonomic motor neurons carry motor signals from the CNS to the effector organs (cardiac muscle, smooth muscle and glands are the effector organs)
- ANS modifies effector activity.
  - example: response to high blood pressure


Somatic motor reflex
Interneuron
Dorsal root ganglion
Somatic motor neuron
Sensory neuron
Autonomic motor reflex
Interneuron
Dorsal root ganglion
Preganglionic neuron
Autonomic ganglion
Postganglionic neuron
Sensory neuron
Viscera

Example of a Visceral Reflex: response to High Blood Pressure



- Stretch receptors in arteries, called Baroreceptors, sense high blood pressure and send a signal to interneurons in the CNS.
- Autonomic motor neurons send efferent signals to the heart that decreases heart rate and reduces blood pressure

Neurotransmitters and Receptors of the ANS

- Types of neurotransmitters released and types of receptors on target cells determines effects of ANS.
- Parasympathetic is predominantly cholinergic (receptors for acetylcholine).
- Sympathetic Division is cholinergic and adrenergic (receptors for norepinephrine).
- Many other substances are also released as neurotransmitters including:
  - substance P, neuropeptide Y, nitric oxide

ANS Neurotransmitters and Receptors Summary

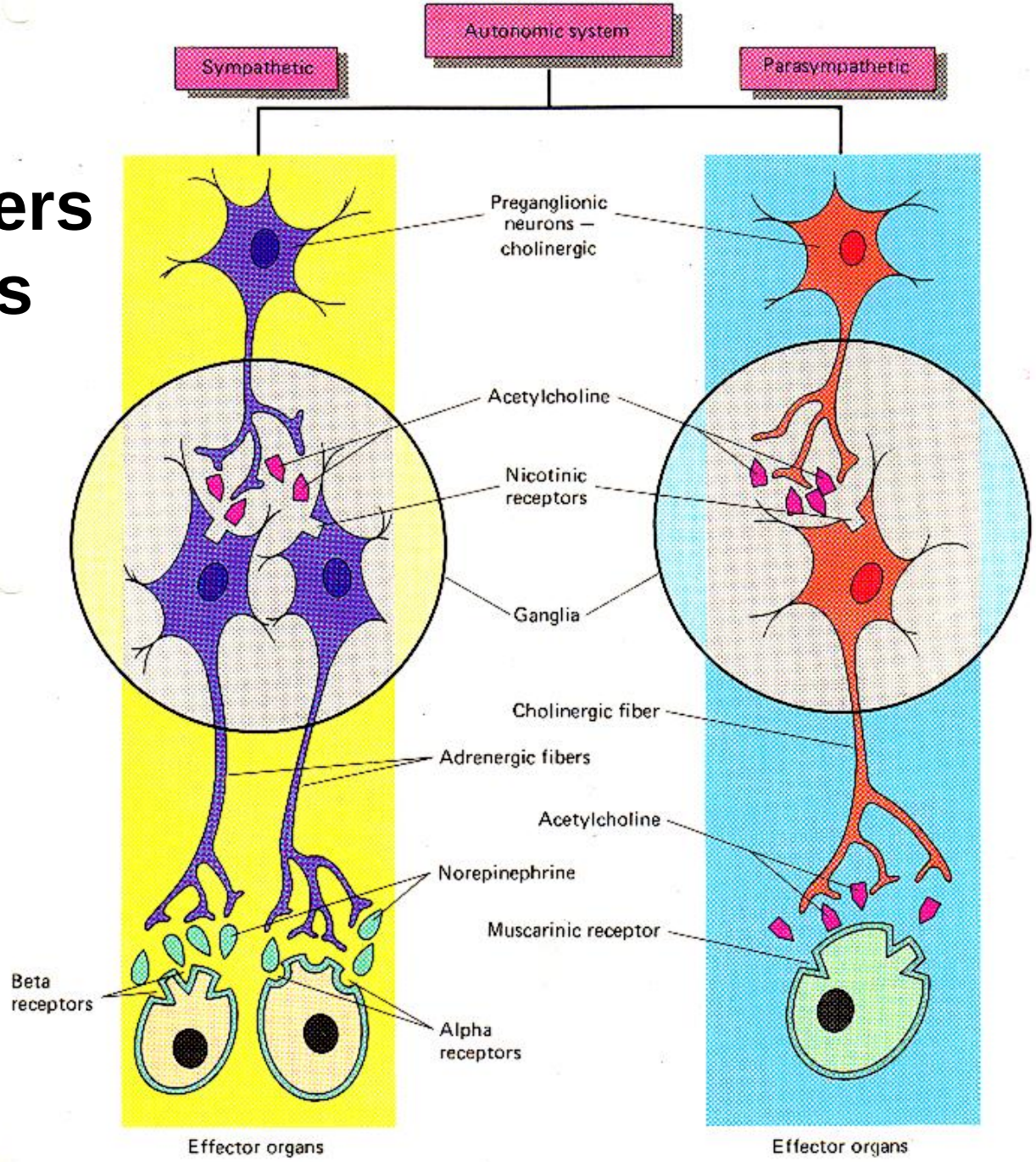
Sympathetic Division

- **preganglionic neurons are cholinergic (release ACh)**
- **postganglionic neurons have nicotinic cholinergic receptors**
- **postganglionic neurons are adrenergic (release norepinephrine)**
- **effector organs have α-adrenergic (stimulatory) or β-adrenergic (inhibitory) receptors**

Parasympathetic Division

- **preganglionic neurons are cholinergic (release ACh)**
- **postganglionic neurons have nicotinic cholinergic receptors**
- **postganglionic neurons are cholinergic (release ACh)**
- **effector organs have muscarinic cholinergic receptors**

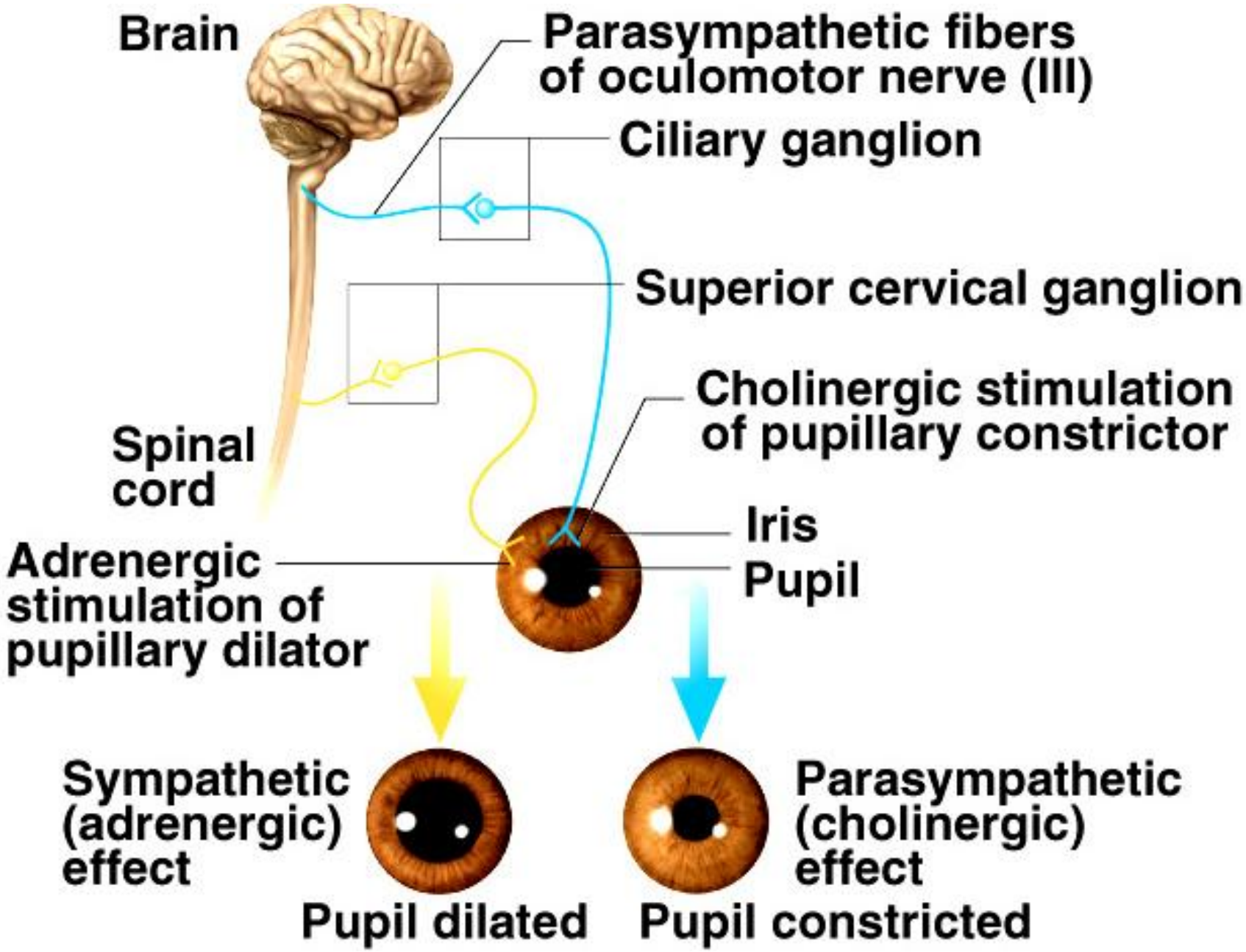
ANS Neurotransmitters and Receptors



Dual Innervation

- Most of visceral organs receive nerve fibers from both parasympathetic and sympathetic divisions
  - antagonistic effects oppose each other:
    - through dual innervation of same effector cells
      - heart slowed down or speeded up
    - through each division innervating different cells
      - pupillary dilator muscle and pupillary constrictor muscle 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

Dual Innervation of the Iris



Control Without Dual Innervation

- Adrenal medulla, arrector pili muscles, sweat glands and many blood vessels receive only sympathetic innervation.
- **Sympathetic Tone** results from neuron firing frequency:
- Increase Sympathetic firing frequency → vasoconstriction
- Decrease Sympathetic firing frequency → vasodilation
- Vasomotor tone can shift blood flow from one organ to another according to changing needs
  - sympathetic stimulation increases blood to skeletal and cardiac muscles while reducing flow of blood to skin

Sympathetic Tone in Blood Vessels