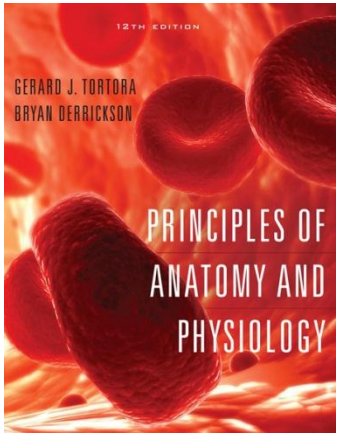
Chapter 15: The Autonomic Nervous System



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Comparison of Somatic and Autonomic Nervous Systems

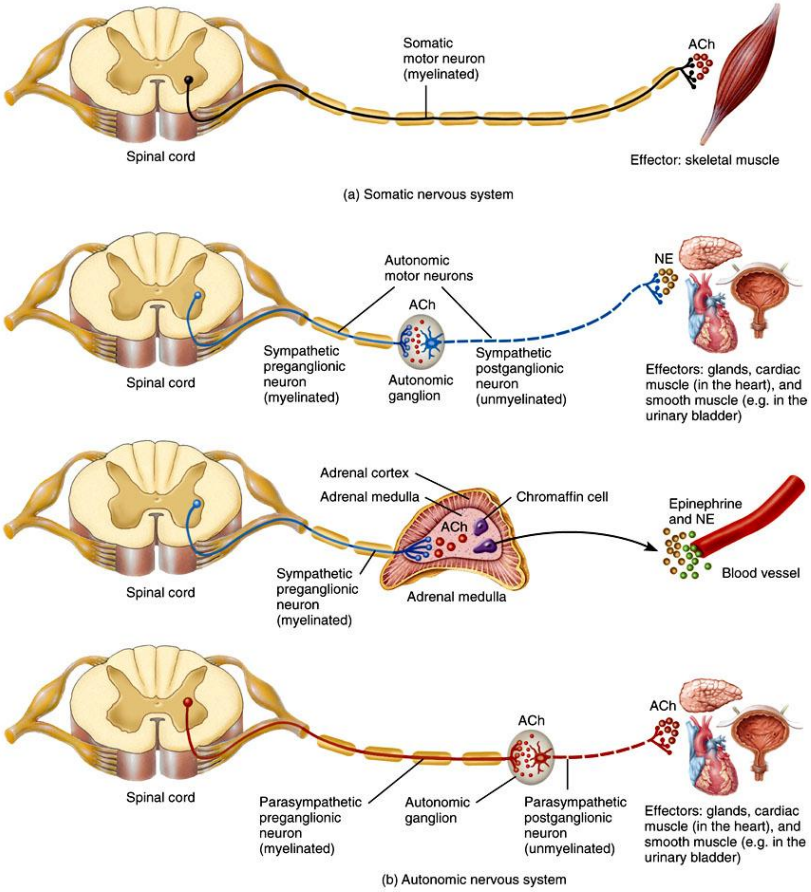

Figure 15.01 Tortora - PAP 12/e

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Comparison of Somatic and Autonomic Nervous Systems

TABLE 15.1

Comparison of the Somatic and Autonomic Nervous Systems

	SOMATIC NERVOUS SYSTEM	AUTONOMIC NERVOUS SYSTEM
Sensory input	Somatic senses and special senses.	Mainly from interoceptors; some from somatic senses and special senses.
Control of motor output	Voluntary control from cerebral cortex, with contributions from basal ganglia, cerebellum, brain stem, and spinal cord.	Involuntary control from hypothalamus, limbic system, brain stem, and spinal cord; limited control from cerebral cortex.
Motor neuron pathway	One-neuron pathway: Somatic motor neurons extending from CNS synapse directly with effector.	Usually two-neuron pathway: Preganglionic neurons extending from CNS synapse with postganglionic neurons in an autonomic ganglion, and postganglionic neurons extending from ganglion synapse with a visceral effector. Alternatively, preganglionic neurons may extend from CNS to synapse with chromaffin cells of adrenal medullae.
Neurotransmitters and hormones	All somatic motor neurons release ACh.	All sympathetic and parasympathetic preganglionic neurons release acetylcholine (ACh). Most sympathetic postganglionic neurons release norepinephrine (NE); those to most sweat glands release ACh. All parasympathetic postganglionic neurons release ACh. Chromaffin cells of adrenal medullae release epinephrine and norepinephrine.
Effectors	Skeletal muscle.	Smooth muscle, cardiac muscle, and glands.
Responses	Contraction of skeletal muscle.	Contraction or relaxation of smooth muscle; increased or decreased rate and force of contraction of cardiac muscle; increased or decreased secretions of glands.

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Anatomy of Autonomic Motor Pathways

- Preganglionic neuron
- Postganglionic neuron

- Two divisions:
- Sympathetic
- Parasympathetic

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Structure of the Sympathetic Division

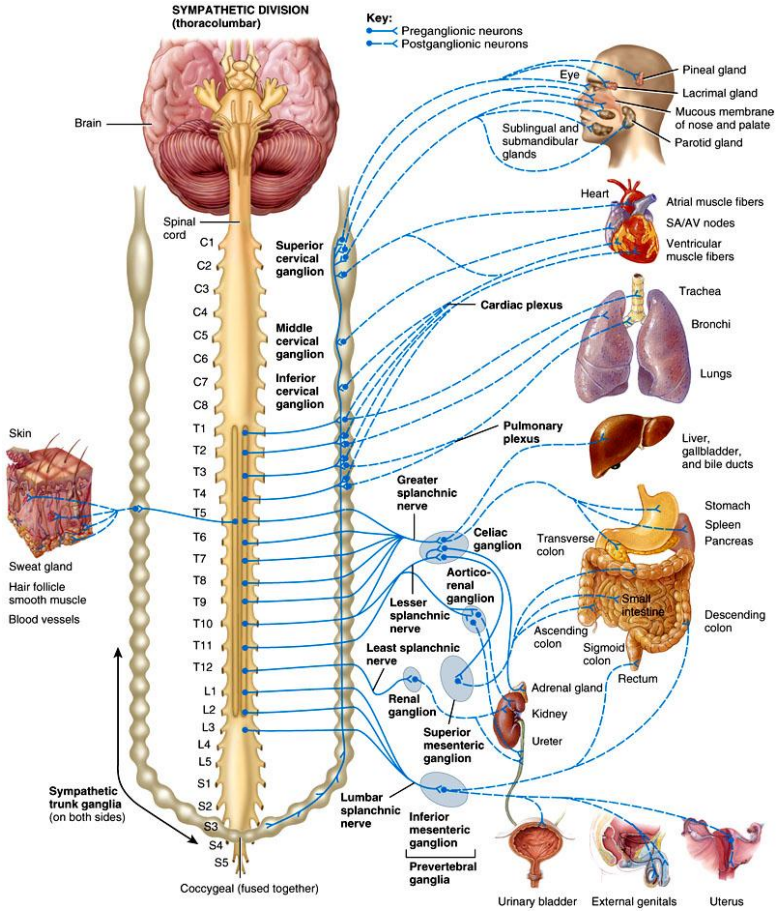

Figure 15.02 Tortora - PAP 12/e

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Sympathetic Division

- Thoracolumbar division- Preganglionic neurons originate from the thoracic and lumbar levels of the spinal cord (T1-L2).
- Sympathetic ganglia:

  Sympathetic trunk (vertebral chain) ganglia.

  Prevertebral (collateral) ganglia: celiac, superior mesenteric, inferior mesenteric, aorticorenal and renal.

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Postganglionic neurons in the Sympathetic Division

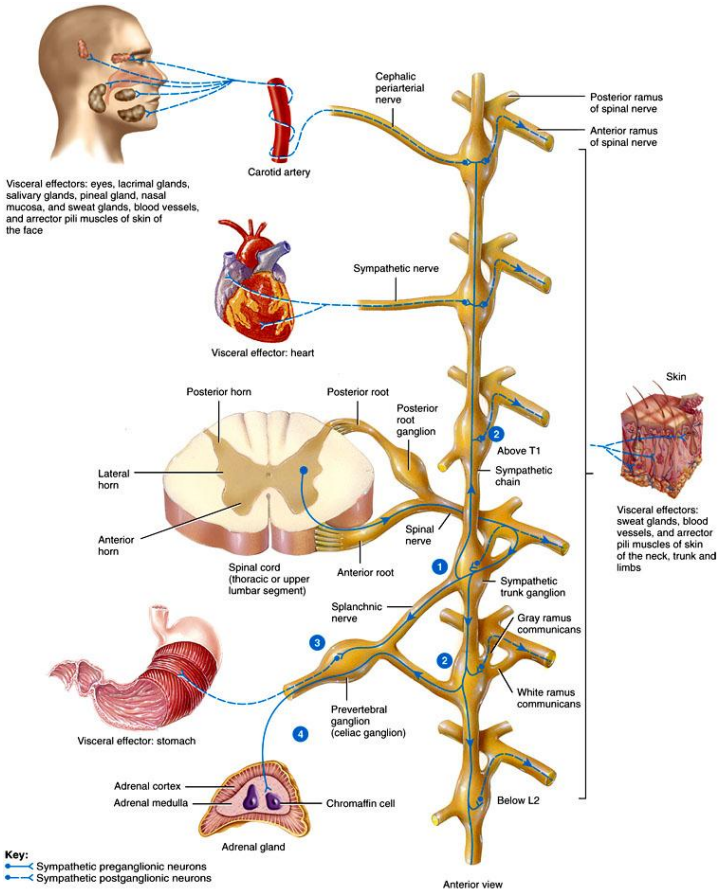

Figure 15.04 Tortora - PAP 12/e

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Postganglionic Neurons in the Sympathetic Division

- An axon may synapse with postganglionic neurons in the ganglion it first reaches or
- Sympathetic chains or
- An axon may continue, without synapsing, through the sympathetic trunk ganglion to end at a prevertebral ganglion and synapse with postganglionic neurons there or
- An axon may pass through the sympathetic trunk ganglion and a prevertebral ganglion and then to the adrenal medulla.

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Sympathetic Division

- A single sympathetic preganglionic fiber has many axon collaterals and may synapse with 20 or more postganglionic neurons.

- The postganglionic axons typically terminate in several visceral effectors and therefore the effects of sympathetic stimulation are more widespread than the effects of parasympathetic stimulation.

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Structure of the Parasympathetic Division

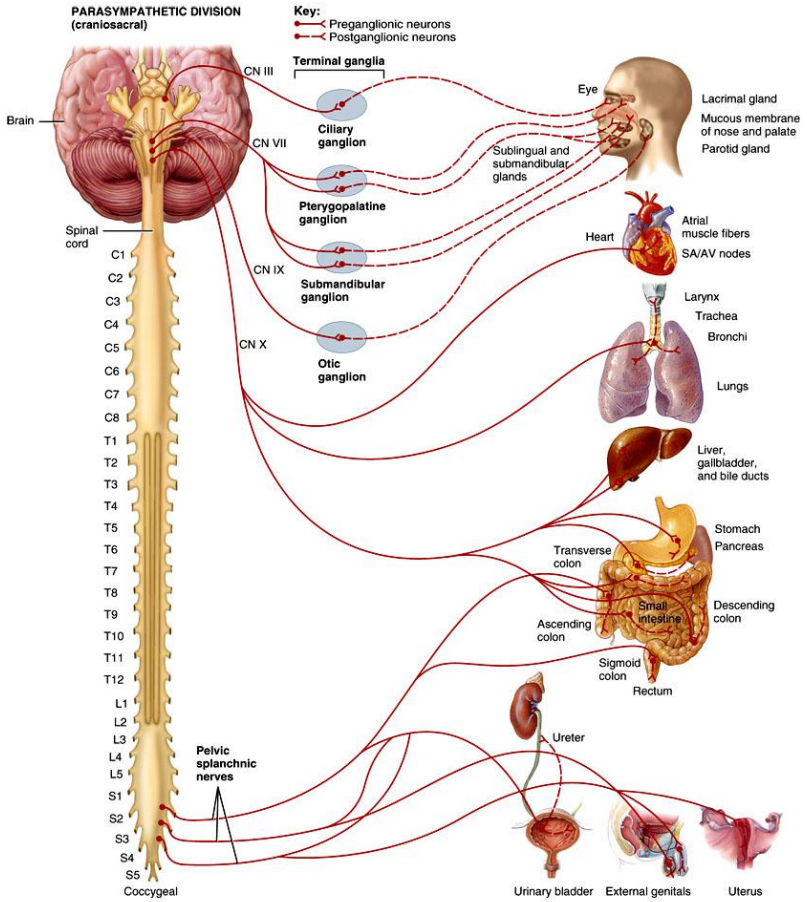

Figure 15.03 Tortora - PAP 12/e

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Parasympathetic Division

- Craniosacral division: Preganglionic neurons originate from the cranial nerves III, VII, IX and X and sacral spinal nerves S2-S4.
- Parasympathetic ganglia: terminal ganglia.
- Presynaptic neuron usually synapses with 4-5 postsynaptic neurons all of which supply a single visceral effector.

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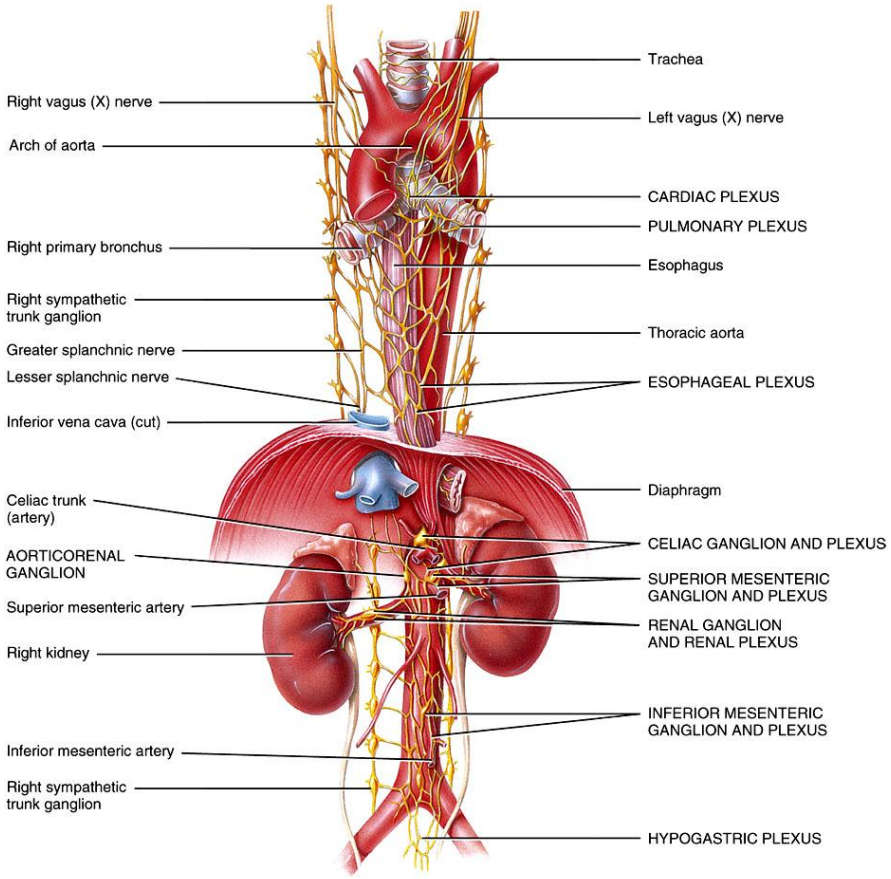
Autonomic Plexuses in the Thorax, Abdomen and Pelvis



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Autonomic Plexuses

- A network of sympathetic and parasympathetic axons.
- Cardiac plexus- heart.
- Pulmonary plexus- the bronchial tree.
- Celiac plexus- largest. Supplies the stomach, spleen, pancreas, liver, gallbladder, and adrenal medullae.

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Autonomic Plexuses Continued..

- Superior mesenteric plexus- small intestine and proximal colon.
- Inferior mesenteric plexus- distal colon and rectum.
- Hypogastric plexus- urinary bladder and genital organs.
- Renal plexus- kidneys and ureters.

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Pathway from Spinal Cord to Sympathetic Trunk Ganglia:

- Preganglionic axons → anterior root of a spinal nerve → white ramus → sympathetic trunk ganglion.
- White rami communicantes: structures containing sympathetic preganglionic axons that connect the anterior ramus of the spinal nerve with the ganglia of the sympathetic trunk.

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Organization of Sympathetic Trunk Ganglia

- Sympathetic trunk ganglia: 3 cervical, 11 or 12 thoracic, 4 or 5 lumbar, 4 or 5 sacral and 1 coccygeal.
- Postganglionic neurons from the

  superior cervical region-head and heart.

  middle cervical ganglion and the inferior cervical ganglion-heart.
- Thoracic sympathetic trunk- heart, lungs, and bronchi.

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Pathways from Sympathetic Trunk Ganglia to Visceral Effectors: P.553

- Axons leave the sympathetic trunk in 4 possible ways:
  - spinal nerves
  - cephalic periarterial nerves
  - sympathetic nerves
  - splanchnic nerves

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Spinal nerves: P.555

- Gray ramus: Axons of some postganglionic neurons leave the sympathetic trunk by entering a short pathway called a gray ramus and merge with the anterior ramus of a spinal nerve.
- Gray rami communicantes: structures containing sympathetic postganglionic axons that connect the ganglia of the sympathetic trunk to spinal nerves.

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Cephalic Periarterial Nerves: P.555

- Some sympathetic preganglionic neurons that enter the sympathetic trunk ascend to the superior cervical ganglion where they synapse with postganglionic neurons. Some of these leave the sympathetic trunk by forming cephalic periarterial nerves.
- Serve visceral effectors in the skin of the face and head.

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Sympathetic Nerves

- Some axons of the postganglionic neurons leave the trunk by forming sympathetic nerves.
- Innervate the heart and lungs.

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Splanchnic Nerves continued..

- Some sympathetic preganglionic axons pass through the sympathetic trunk without terminating in it. Beyond the trunk they form nerves called splanchnic nerves which extend to prevertebral ganglia.
- T5-T9 or T10- Greater splanchnic nerve.
- T10-T11- Lesser splanchnic nerve.
- L1-L4- Lumbar splanchnic nerve.

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Splanchnic Nerves to the Adrenal Medulla

- Some sympathetic preganglionic axons pass, without synapsing, through the sympathetic trunk, greater splanchnic nerves and celiac ganglion into the adrenal medulla (modified sympathetic ganglia).
- Release hormones into blood- 80% epinephrine, 20% norepinephrine.

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Cranial Parasympathetic Outflow: p.556

- The cranial outflow has four pairs of ganglia and are associated with the vagus nerve.
  1. Ciliary ganglia-
  2. Pterygopalatine ganglia-
  3. Submandibular ganglia-
  4. Otic ganglia-
- Vagus nerve carries nearly 80% of the total craniosacral flow.

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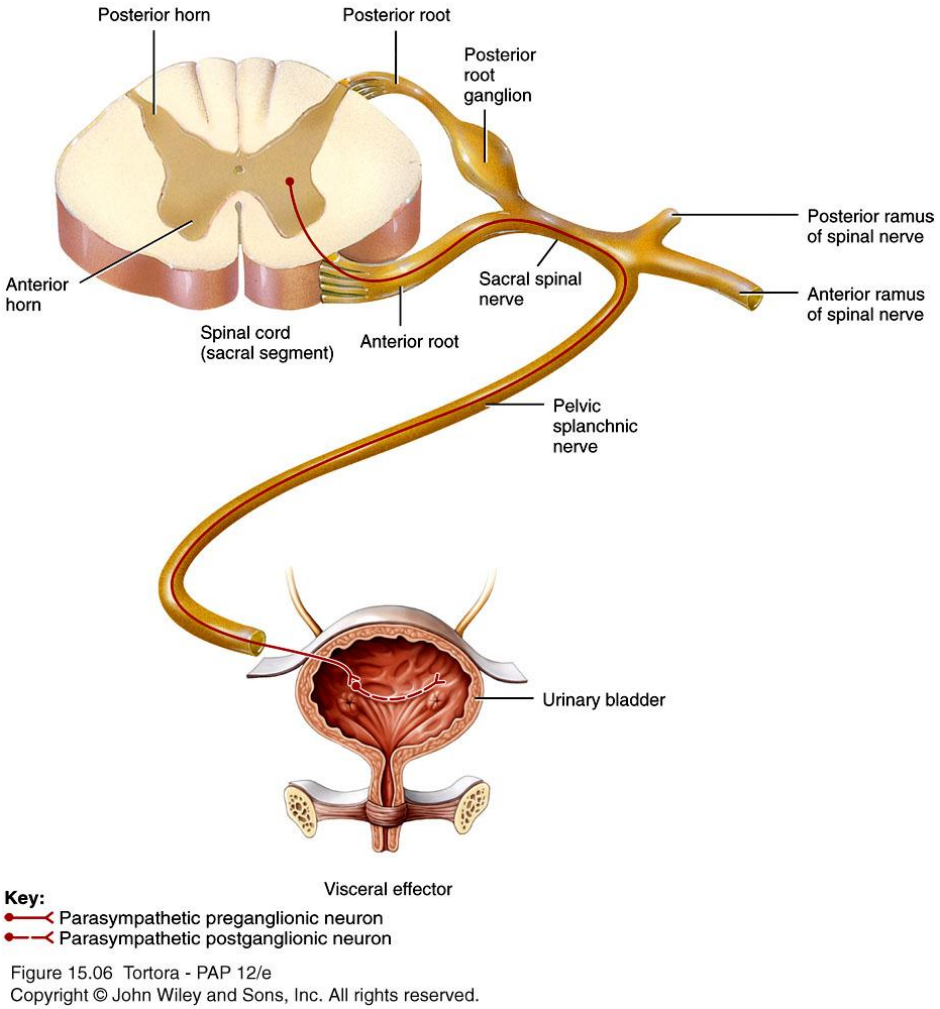
Sacral Parasympathetic Outflow

- Consists of S2-S4.
- Pelvic splanchnic nerves



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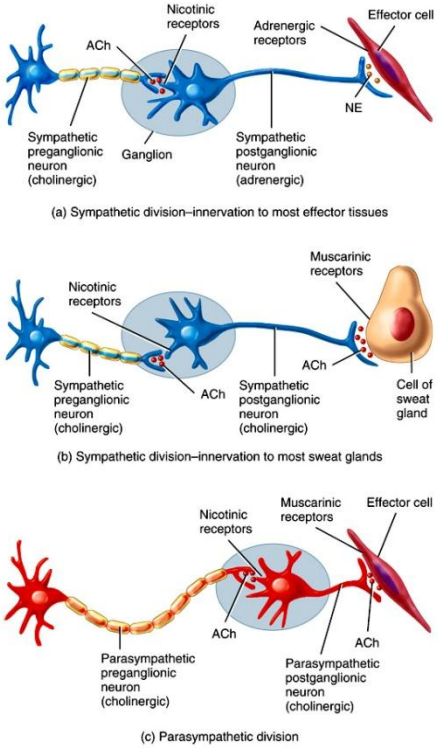
Cholinergic and Adrenergic Neurons in the Autonomic Nervous System : P.558



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Cholinergic Neurons

- Cholinergic neurons → acetylcholine (ACh).
- Cholinergic neurons include-

1. All sympathetic and parasympathetic preganglionic neurons.
2. Sympathetic postganglionic neurons that innervate most sweat glands.
3. All parasympathetic postganglionic neurons.

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Cholinergic Receptors

Cholinergic receptors release acetylcholine.

- Two types:

Nicotinic receptors

Muscarinic receptors

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Adrenergic Neurons and Receptors

- Release norepinephrine (noradrenalin).
- Most sympathetic postganglionic neurons are adrenergic.
- Two types of receptors:

Alpha receptors-

Beta receptors-

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Physiology of the ANS: P.560

- Autonomic tone- a balance between the sympathetic and parasympathetic activity.
- Regulated by the hypothalamus.

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Sympathetic Responses

- Stress ↑ sympathetic system ↑ fight-or-flight response.
- ↑ production of ATP.
- Dilation of the pupils.
- ↑ heart rate and blood pressure.
- Dilation of the airways.
- Constriction of blood vessels that supply the kidneys and gastrointestinal tract.

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Sympathetic Responses continued..

- ↑ blood supply to the skeletal muscles, cardiac muscle, liver and adipose tissue
- ↑ glycogenolysis ↑ blood glucose.
- ↑ lipolysis.

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Parasympathetic Responses

- Rest-and-digest response.
- Conserve and restore body energy.
- ↑ digestive and urinary function.
- ↓ body functions that support physical activity.

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Integration and Control of Autonomic Functions

- Direct innervation- brain stem and spinal cord.
- Hypothalamus is the major control and integration center of the ANS.
- It receives input from the limbic system.

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End of Chapter 15

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