General Physiology
Second semester 2024
Lectures 21
Autonomic Nervous System I

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Lecture objectives

- Define the autonomic nervous system
- Describe the functional anatomy ANS
- Describe the autonomic nervous system efferent pathways from the CNS to effector organs and explain how these differ from the pathway of a motor neuron.
- Describe the location of the cell bodies and axonal trajectories of preganglionic sympathetic and parasympathetic neurons.
- Describe the location and trajectories of postganglionic sympathetic and parasympathetic neurons.
- Name the neurotransmitters that are released by preganglionic and postganglionic autonomic neurons Name the neurotransmitters that are released by preganglionic autonomic neurons, postganglionic sympathetic neurons, postganglionic parasympathetic neurons, and adrenal medullary cells.
- Identify the main types of cholinergic and adrenergic receptors .

Lecture objective

- List the major functions of the autonomic nervous system.
- Identify some of the neural inputs to sympathetic and parasympathetic neurons from higher brain structures
- Describe the location of the cell bodies and axonal trajectories of preganglionic and postganglionic sympathetic and parasympathetic neurons.
- Name the types of receptors on autonomic ganglia and on various target organs and list the ways that drugs can act to alter the function of the processes involved in transmission within the autonomic nervous system.
- Describe functions of the sympathetic and parasympathetic nervous systems and their effects on target organs .
- Describe the location of some forebrain and brainstem neurons that are components of central autonomic pathways.

Major subdivisions of the Nervous system

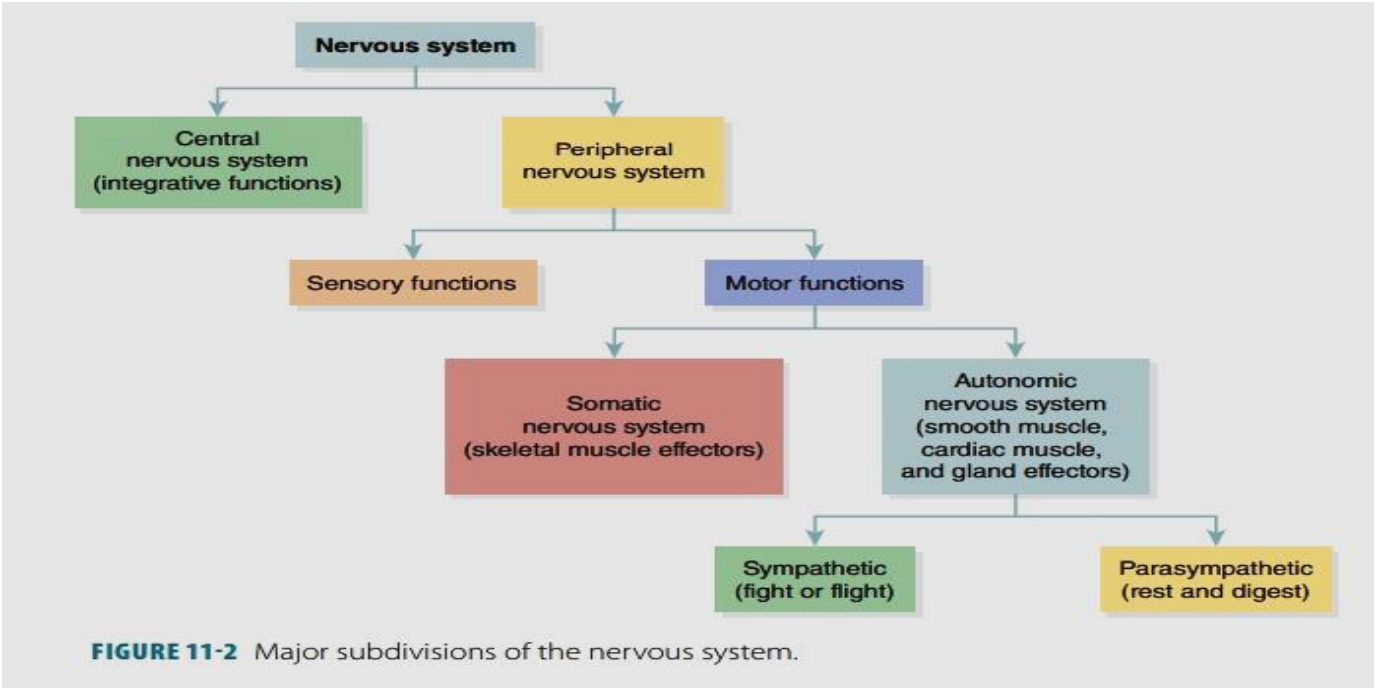
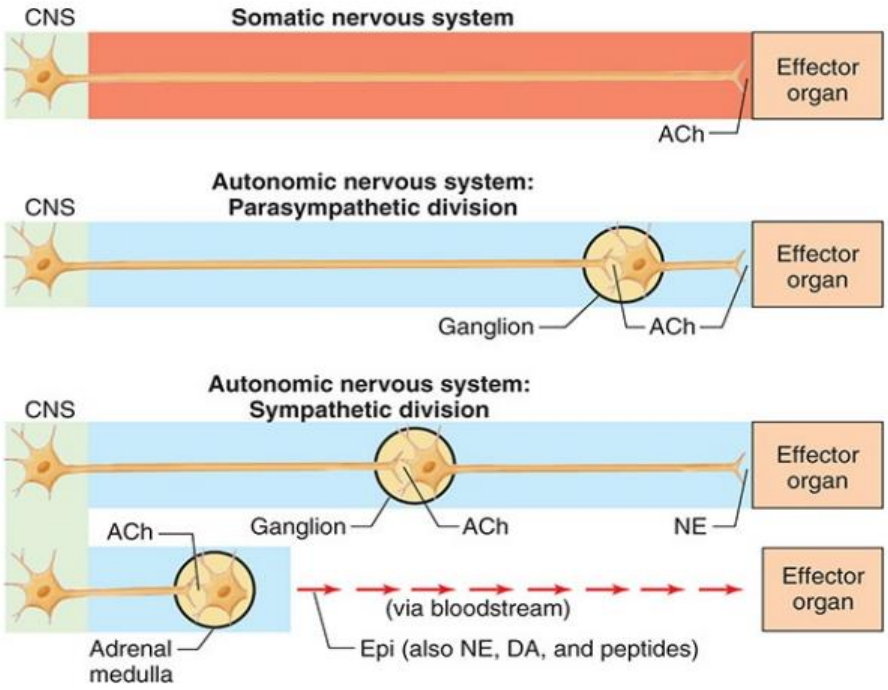


FIGURE 11-2 Major subdivisions of the nervous system.

Comparison of peripheral organization and transmitters released by somatomotor and autonomic nervous systems



Subdivision of ANS

- The efferent autonomic signals are transmitted to the various organs of the body through two major subdivisions
- **Sympathetic** nervous system
- **parasympathetic** nervous system.
- **Dual innervation**: Most visceral organs are innervated by both sympathetic and parasympathetic nerve fibers.
- **Antagonist action**
- Two neuronal chains: In Both the sympathetic and parasympathetic pathways the signal reaches visceral organs through two neuronal
- Preganglionic
- Postganglionic

Introduction and general characteristics of the ANS

The autonomic nervous system (ANS) is the portion of the nervous system that controls most visceral functions of the body.

Regulates the cardiovascular and respiratory systems, gastrointestinal tract, exocrine and endocrine glands throughout the body

The ANS also includes the enteric nervous system that functions within the gastrointestinal tract and influences the pancreas, liver, and gallbladder, thereby controlling gastrointestinal motility, secretion.

The two divisions counterbalance each other's activity and most glands & organs are innervated by both. Dual innervations which are usually antagonistic

The output of the autonomic system is divided functionally and pharmacologically into two divisions: the parasympathetic and sympathetic systems

PSN is also know as cholinergic and sympathetic nervous system is also known as adrenergic systems

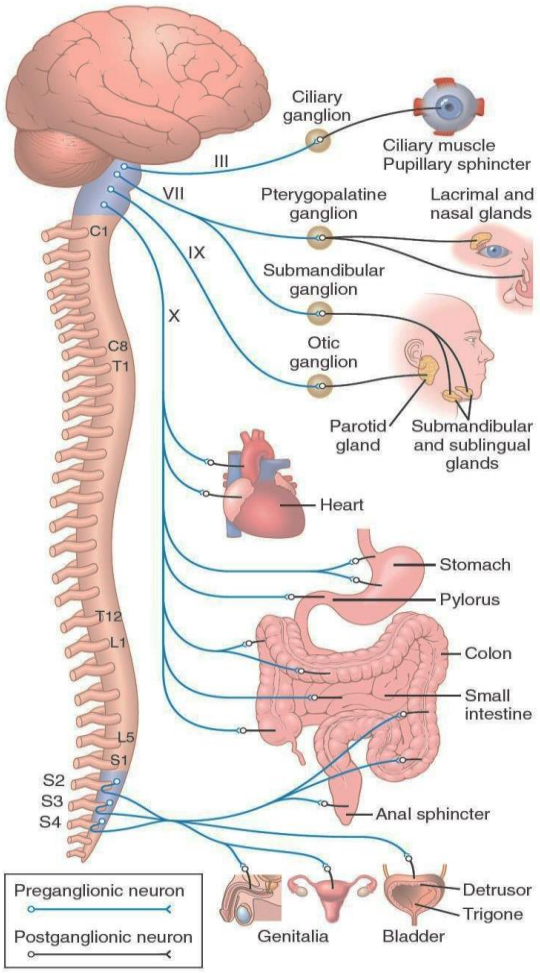
Most of the action of the ANS are mediated through autonomic reflexes The ANS operates through **subconscious sensory signals** and **subconscious reflex responses** to control visceral activities

Introduction and general characteristics of the ANS

- ANS is activated mainly by centers located in the spinal cord, brain stem, and its activity is affected and hypothalamus and its activity is affected by brain stem, limbic system and frontal lobes, which are concerned with arousal and behavioral responses to threat.
- These central regulators of the ANS also adjust the secretion of hormones that influence blood volume and total peripheral resistance.
- The central regulators of the ANS also coordinate the stress response (e.g., fight-or-flight response), reproduction, and thermoregulation.
- At the conscious level, the limbic cortex transmit signals to the lower centers and can, as such, influence autonomic control.
- The sympathetic is usually activated during stress , excitement
- The parasympathetic performs maintenance activities and conserves body energy – “Resting and Digesting”
- The two divisions counterbalance each other’s activity and most glands & organs are innervated by both. Dual innervations which are usually antagonistic
- The ANS is characterized by its rapid and intense control of visceral functions
- Sympathetic effects are usually widespread and parasympathetic are more localized
- ANS cooperation is best seen in control of the external genitalia
- Parasympathetic fibers cause vasodilation and are responsible for erection of the penis and clitoris
- Sympathetic fibers cause ejaculation of semen in males and reflex peristalsis rhythmic vaginal contractions during orgasm in females
- Sympathetic and parasympathetic tone

PHYSIOLOGICAL ANATOMY of PSN

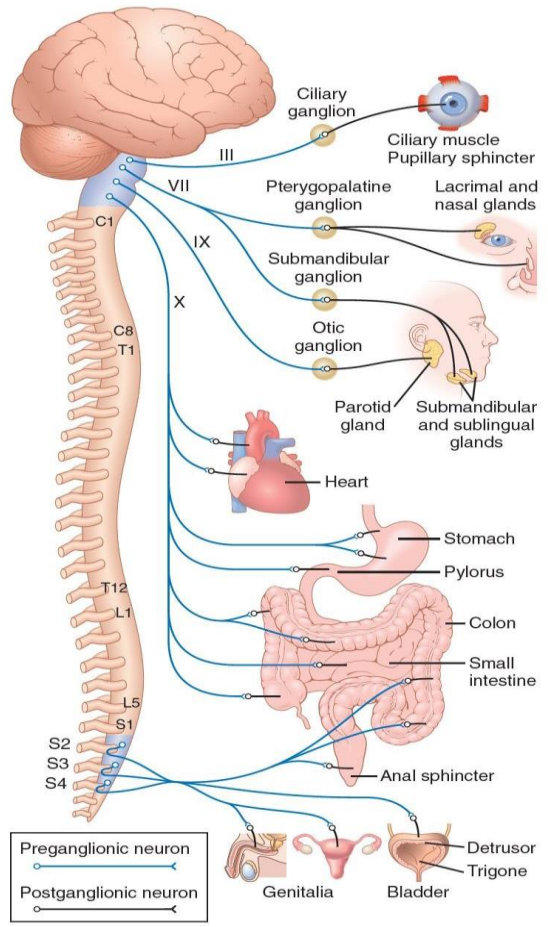
- The parasympathetic nerve fibers leave the CNS through two divisions; **cranial nerves** III, VII, IX, and X. And through the **second and third sacral spinal nerves** and occasionally the first and fourth sacral nerves.
- These fibers are longer than sympathetic preganglionic fibers because they do not end until they reach terminal ganglia that lie in or near the effector organs.
- About 75% of all parasympathetic nerve fibers are in the vagus nerves (cranial nerve X).
- The vagus nerves supply parasympathetic nerves to the heart, lungs, esophagus, stomach, entire small intestine, proximal half of the colon, liver, gallbladder, pancreas, kidneys, and upper portions of the ureters.
- Parasympathetic fibers in the III cranial (oculomotor) nerve go to the pupillary sphincter and ciliary muscle of the eye



The parasympathetic nervous system. The blue lines represent preganglionic fibers and the black lines show postganglionic fibers.

PHYSIOLOGICAL ANATOMY of PSN

- Fibers from the VII cranial (facial) nerve pass to the lacrimal, nasal, and submandibular glands, and fibers from the IX cranial (glossopharyngeal) nerve go to the parotid gland.
- The sacral parasympathetic fibers are in the pelvic nerves, which pass through the spinal nerve sacral plexus on each side of the cord at the S2 and S3 levels.
- The sacral division of the parasympathetic innervates the descending colon, rectum, urinary bladder, and lower portions of the ureters. Also, this sacral group of parasympathetics supplies nerve signals to the external genitalia to cause erection.
- Like the sympathetic system, the parasympathetic system has both preganglionic and postganglionic neurons. However, the preganglionic fibers pass uninterrupted all the way to the organ that is to be controlled (except for few cranial parasympathetic nerves).
- The **extremely short postganglionic** neurons are located in the wall of the organ



The parasympathetic nervous system. The blue lines represent preganglionic fibers and the black lines show postganglionic fibers.

Physiological anatomy of Sympathetic nervous system (Thoracolumbar division)

- Preganglionic neurons originate in spinal cord segments between cord segments **T1 and L2**
- **Preganglionic fibers leaves the spinal cord and make synapses in the sympathetic ganglia**
- Sympathetic ganglia
- Two **paravertebral sympathetic chains** of ganglia (also called the **sympathetic trunk**), that are interconnected with the spinal nerves on the side of the vertebral
- **Prevertebral ganglia** or **collateral ganglia** (the celiac, superior mesenteric, aortico-renal, inferior mesenteric, and hypogastric ganglia
- Postganglionic fibers leaves ganglia and terminate and synapse with visceral organs

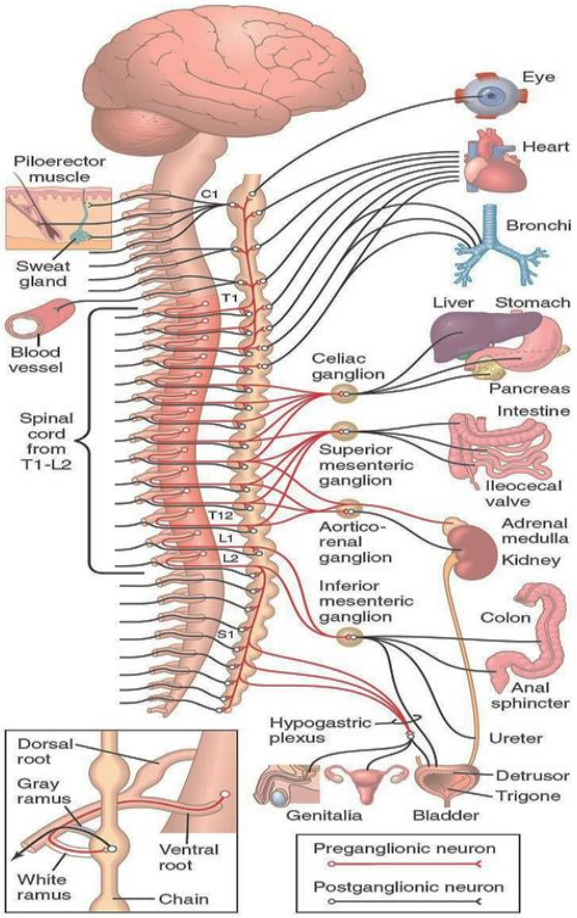


Figure Sympathetic nervous system. The black lines represent postganglionic fibers, and the red lines show preganglionic fibers.

PHYSIOLOGICAL ANATOMY OF THE SYMPATHETIC SYSTEM

- The peripheral portion of the Sympathetic System include:
  - Two **paravertebral sympathetic chains** of ganglia (also called the **sympathetic trunk**), that are interconnected with the spinal nerves on the side of the vertebral column.
  - **Prevertebral ganglia** or **collateral ganglia** (the celiac, superior mesenteric, aortico-renal, inferior mesenteric, and hypogastric).
  - Nerves extending from the ganglia to the different internal organs.
- The sympathetic nerve fibers originate in the spinal cord along with spinal nerves between cord segments **T1 and L2** and pass first into the sympathetic chain and then to the tissues and organs that are stimulated by the sympathetic nerves

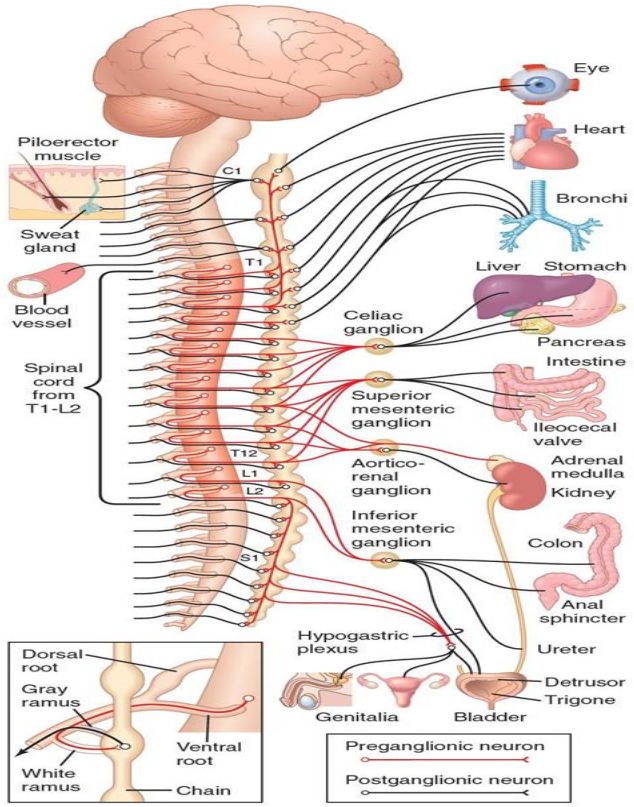


Figure Sympathetic nervous system. The black lines represent postganglionic fibers, and the red lines show preganglionic fibers.

Physiological Anatomy Sympathetic nervous system

- Unlike a single neuron in the skeletal motor pathway, the sympathetic pathway is composed of two neurons, a preganglionic neuron and a postganglionic neuron.
- The cell body of each preganglionic neuron lies in the intermediolateral horn of the spinal cord; its fiber passes through a ventral root of the cord into the corresponding spinal nerve.
- The preganglionic sympathetic fibers leave the spinal nerve and pass through a white ramus into one of the ganglia of the sympathetic chain. Then fibers can take one of the following three courses:
- Synapse with postganglionic sympathetic neurons in the ganglion that they enter.
- Pass upward or downward in the chain and synapse in one of the other ganglia of the chain.
- Pass for variable distances through the chain and then through one of the sympathetic nerves radiating outward from the chain, finally synapsing in a peripheral sympathetic ganglion (collateral ganglia) about halfway between the CNS and the innervated organs.

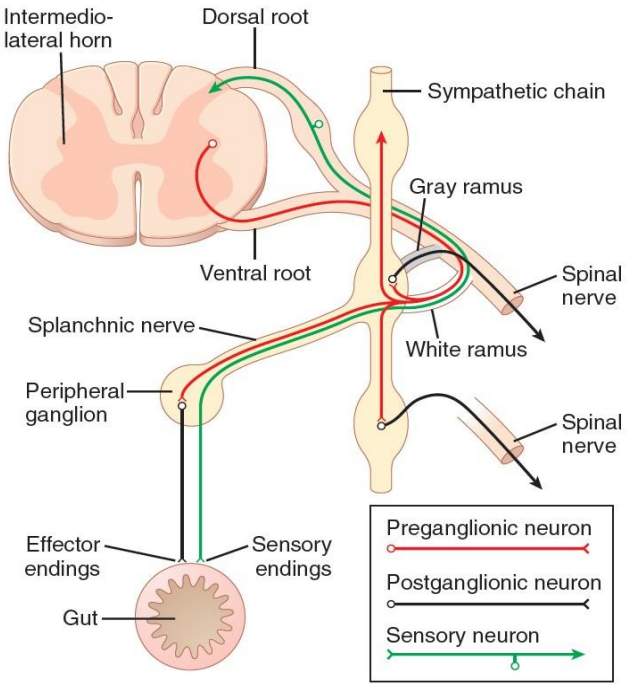


Figure Nerve connections among the spinal cord, spinal nerves, sympathetic chain, and peripheral sympathetic nerves.

Physiological Anatomy Sympathetic nervous system

- The postganglionic sympathetic neuron originates either in one of the sympathetic chain ganglia or in one of the peripheral sympathetic ganglia. From either of these two sources, the postganglionic fibers then travel to their destinations in the various organs.
- Some of the postganglionic fibers pass back from the sympathetic chain into the spinal nerves through **gray rami** at all levels of the cord. These sympathetic fibers are all **very small type C fibers**, and they extend to all parts of the body by way of the skeletal nerves.
- The sympathetic pathways that originate in the different segments of the spinal cord are not necessarily distributed to the same dermatomes as somatic nerves.

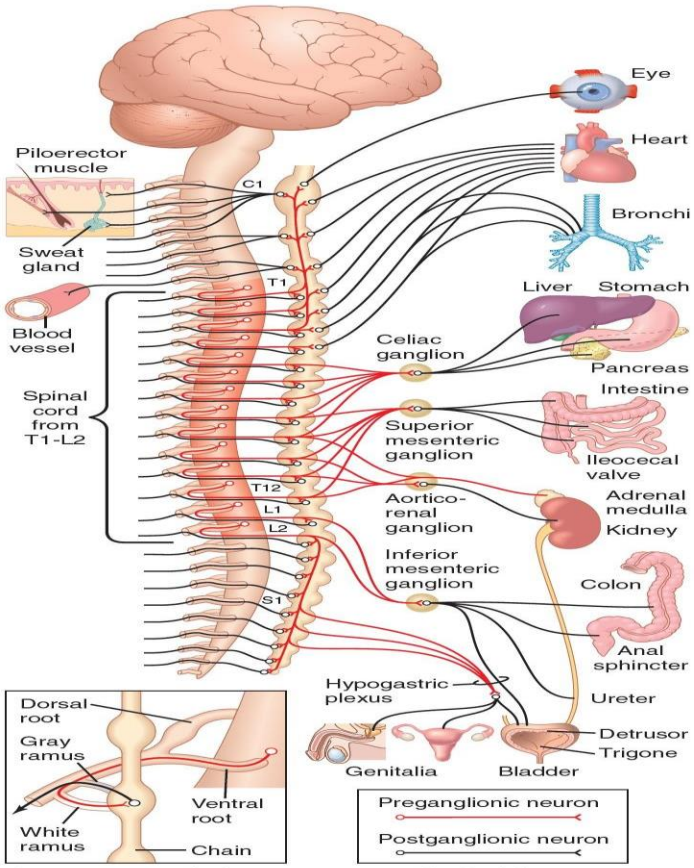
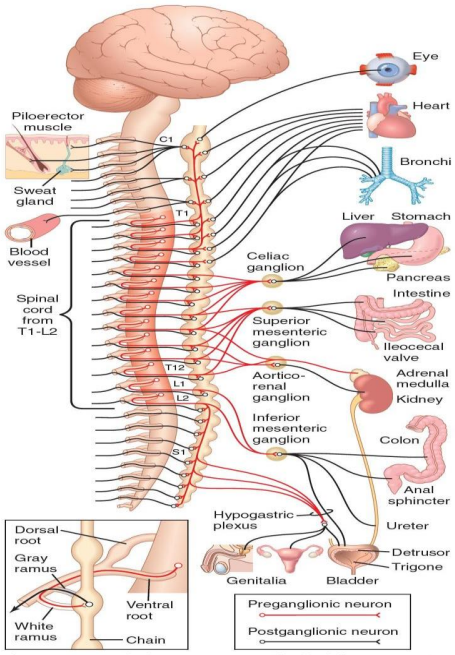


Figure Sympathetic nervous system. The black lines represent postganglionic fibers, and the red lines show preganglionic fibers.

Sympathetic nervous system anatomy

- Instead, the sympathetic fibers from:
  1. Cord segment T1 generally pass up the sympathetic chain to terminate in the head.
  2. Cord segment T2 terminates in the neck.
  3. Cord segments T3, T4, T5, and T6 terminate into the
     1. thorax.
  1. Cord segments T7, T8, T9, T10, and T11 terminate into the abdomen.
  2. Cord segments T12, L1, and L2 terminate into the legs.
- It should be noted that the sympathetic distribution shows great degree of overlaps between humans.



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