14.2: Divisions of the Autonomic Nervous System

Learning Objectives

By the end of this section, you will be able to:

- Describe the functional differences between the sympathetic and parasympathetic divisions
- Compare and contrast the anatomic components of the sympathetic and parasympathetic divisions
- Explain the differences in output connections within the two divisions of the autonomic nervous system
- Describe the signaling molecules and receptor proteins involved in communication within the two divisions of the autonomic nervous system

The nervous system can be divided into two functional parts: the somatic nervous system and the autonomic nervous system. The major differences between the two systems are evident in the responses that each produces. The somatic nervous system causes contraction of skeletal muscles. The autonomic nervous system controls cardiac and smooth muscle, as well as glandular tissue. The somatic nervous system is associated with voluntary responses (though many can happen without conscious awareness, like breathing), and the autonomic nervous system is associated with involuntary responses, such as those related to homeostasis.

The autonomic nervous system regulates many of the internal organs through a balance of two aspects, or divisions. In addition to the endocrine system, the autonomic nervous system is instrumental in homeostatic mechanisms in the body. The two divisions of the autonomic nervous system are the sympathetic division and the parasympathetic division. The sympathetic system is associated with the fight-or-flight response, and parasympathetic activity is referred to by the epithet rest and digest. Homeostasis is the balance between the two systems. At each target effector, dual innervation determines activity. For example, the heart receives connections from both the sympathetic and parasympathetic divisions. One causes heart rate to increase, whereas the other causes heart rate to decrease.
Sympathetic Division of the Autonomic Nervous System

To respond to a threat—to fight or to run away—the sympathetic system causes diverse effects as many different effector organs are activated together for a common purpose. More oxygen needs to be inhaled and delivered to skeletal muscle. The respiratory, cardiovascular, and musculoskeletal systems are all activated together. Additionally, sweating keeps the excess heat that comes from muscle contraction from causing the body to overheat. The digestive system shuts down so that blood is not absorbing nutrients when it should be delivering oxygen to skeletal muscles. To coordinate all these responses, the connections in the sympathetic system diverge from a limited region of the central nervous system (CNS) to a wide array of ganglia that project to the many effector organs simultaneously. The complex set of structures that compose the output of the sympathetic system make it possible for these disparate effectors to come together in a coordinated, systemic change.

The sympathetic division of the autonomic nervous system influences the various organ systems of the body through connections emerging from the thoracic and upper lumbar spinal cord. It is referred to as the thoracolumbar system to reflect this anatomical basis. A central neuron called preganglionic neuron in the lateral horn of any of these spinal regions projects to ganglia adjacent to the vertebral column through the ventral spinal roots ("preganglionic" means before the ganglion). The majority of ganglia of the sympathetic system belong to a network of sympathetic chain ganglia that runs alongside the vertebral column. The ganglia appear as a series of clusters of neurons linked by axonal bridges. There are typically 23 ganglia in the chain on either side of the spinal column. Three correspond to the cervical region, 12 are in the thoracic region, four are in the lumbar region, and four correspond to the sacral region. The cervical and sacral levels are not connected to the spinal cord directly through the spinal roots, but through ascending or descending connections through the bridges within the chain. The peripheral neuron called ganglionic neuron in the ganglia sends its axon to the target effector (the organ, tissue, or gland to be innervated).

A diagram that shows the connections of the sympathetic system is somewhat like a circuit diagram that shows the electrical connections between different receptacles and devices. In Figure 1, the "circuits" of the sympathetic system are intentionally simplified.
Figure \(\PageIndex{1}\): Sympathetic Innervation. Neurons from the lateral horn of the spinal cord (preganglionic nerve fibers - solid lines) project to the chain ganglia on either side of the vertebral column or to collateral (prevertebral) ganglia that are anterior to the vertebral column in the abdominal cavity. Axons from these ganglionic neurons (postganglionic nerve fibers - dotted lines) then project to target effectors throughout the body. (Credit: OpenStax / adrenal connection edited by Chiara Mazzasette).

To continue with the analogy of the circuit diagram, there are three different types of "junctions" that operate within the sympathetic system (Figure \(\PageIndex{2}\)). The first type is most direct: the sympathetic nerve projects to the chain ganglion at the same level as the target effector. An example of this type is spinal nerve T1 that synapses with the T1 chain ganglion to innervate the trachea. The fibers of this branch are called white rami communicantes (singular = ramus communicans); they are myelinated and therefore referred to as white. The axon from the central neuron (the preganglionic fiber shown as a solid line) synapses with the ganglionic neuron (with the postganglionic fiber shown as a dashed line). This neuron then projects to a target effector—in this case, the trachea—via gray rami communicantes, which are unmyelinated axons.

In some cases, the target effectors are located superior or inferior to the spinal segment at which the preganglionic fiber emerges. With respect to the "wiring" involved, the synapse with the ganglionic neuron occurs at chain ganglia superior or inferior to the location of the central neuron. An example of this is spinal nerve T1 that innervates the eye. The spinal nerve tracks up through the chain until it reaches the superior cervical ganglion, where it synapses with the ganglionic
neuron (see Figure \(\PageIndex{2}\)). The cervical ganglia are referred to as **paravertebral ganglia**, given their location adjacent to vertebrae.

Not all axons from the central neurons terminate in the chain ganglia. Additional branches from the ventral nerve root continue through the chain and on to one of the collateral ganglia as the **greater splanchnic nerve** or **lesser splanchnic nerve**. For example, the greater splanchnic nerve at the level of T5 synapses with a collateral ganglion outside the chain before making the connection to the postganglionic nerves that innervate the stomach (see Figure \(\PageIndex{2}\)).

**Collateral ganglia**, also called **prevertebral ganglia**, are situated anterior to the vertebral column and receive inputs from splanchnic nerves as well as central sympathetic neurons. They are associated with controlling organs in the abdominal cavity, and are also considered part of the enteric nervous system. The three collateral ganglia are the **celiac ganglion**, the **superior mesenteric ganglion**, and the **inferior mesenteric ganglion** (see Figure \(\PageIndex{1}\)).

The word celiac is derived from the Latin word “coelom,” which refers to a body cavity (in this case, the abdominal cavity), and the word mesenteric refers to the digestive system.

![Connections to Sympathetic Chain Ganglia](https://med.libretexts.org/Sandboxes/Team_Sandbox%3A_Anatomy_(OERI)/14%3A_Autonomic_Nervous_System/14.02%3AAutonomic_Nervous_System/fig04_02_01a.png)

Figure \(\PageIndex{2}\): Connections to Sympathetic Chain Ganglia. The axon from a central sympathetic neuron in the spinal cord can project to the periphery in a number of different ways. (a) The fiber can project out to the ganglion at the same level and synapse on a ganglionic neuron. (b) A branch can project to more superior or inferior ganglion in the chain. (c) A branch can project through the white ramus communicans, but not terminate on a ganglionic neuron in the chain. Instead, it projects through one of the splanchnic nerves to a collateral ganglion or the adrenal medulla (not pictured). (Credit: OpenStax / labels edited by Chiara Mazzasette).

An axon from the central neuron that projects to a sympathetic ganglion is referred to as a **preganglionic fiber**, and represents the output from the CNS to the ganglion. Because the sympathetic ganglia are adjacent to the vertebral...
column, preganglionic sympathetic fibers are relatively short, and they are myelinated. A postganglionic fiber—the axon from a ganglionic neuron that projects to the target effector—represents the output of a ganglion that directly influences the organ. Compared with the preganglionic fibers, postganglionic sympathetic fibers are long because of the relatively greater distance from the ganglion to the target effector. These fibers are unmyelinated. (Note that the term “postganglionic neuron” may be used to describe the projection from a ganglion to the target. The problem with that usage is that the cell body is in the ganglion, and only the fiber is postganglionic. Typically, the term neuron applies to the entire cell.)

One type of preganglionic sympathetic fiber does not terminate in a ganglion. These are the axons from central sympathetic neurons that project to the adrenal medulla, the interior portion of the adrenal gland. These axons are still referred to as preganglionic fibers, but the target is not a ganglion. The adrenal medulla releases signaling molecules into the bloodstream, rather than using axons to communicate with target structures. The cells in the adrenal medulla that are contacted by the preganglionic fibers are called chromaffin cells. These cells are neurosecretory cells that develop from the neural crest along with the sympathetic ganglia, reinforcing the idea that the gland is, functionally, a sympathetic ganglion.

The projections of the sympathetic division of the autonomic nervous system diverge widely, resulting in a broad influence of the system throughout the body. As a response to a threat, the sympathetic system would increase heart rate and breathing rate and cause blood flow to the skeletal muscle to increase and blood flow to the digestive system to decrease. Sweat gland secretion should also increase as part of an integrated response. All of those physiological changes are going to be required to occur together to run away from the hunting lioness, or the modern equivalent. This divergence is seen in the branching patterns of preganglionic sympathetic neurons—a single preganglionic sympathetic neuron may have 10–20 targets. An axon that leaves a central neuron of the lateral horn in the thoracolumbar spinal cord will pass through the white ramus communicans and enter the sympathetic chain, where it will branch toward a variety of targets. At the level of the spinal cord at which the preganglionic sympathetic fiber exits the spinal cord, a branch will synapse on a neuron in the adjacent chain ganglion. Some branches will extend up or down to a different level of the chain ganglia. Other branches will pass through the chain ganglia and project through one of the splanchnic nerves to a collateral ganglion. Finally, some branches may project through the splanchnic nerves to the adrenal medulla. All of these branches mean that one preganglionic neuron can influence different regions of the sympathetic system very broadly, by acting on widely distributed organs.

Parasympathetic Division of the Autonomic Nervous System

The parasympathetic division of the autonomic nervous system is named because its central neurons are located away from the thoracolumbar region of the spinal cord (para- = “apart from”). Indeed, the parasympathetic system can also be referred to as the craniosacral system (or outflow) because the preganglionic neurons are located in nuclei of the brainstem and the lateral horn of the sacral spinal cord (S2 to S4).

The connections, or “circuits,” of the parasympathetic division are similar to the general layout of the sympathetic division with a few specific differences (Figure \(\PageIndex{3}\)). The preganglionic fibers from the cranial region travel in cranial nerves, whereas preganglionic fibers from the sacral region travel in spinal nerves. The targets of these fibers are terminal ganglia, which are located near—or even within—the target effector. These ganglia are often referred to as intramural ganglia when they are found within the walls of the target organ. The postganglionic fiber projects from...
the terminal ganglia a short distance to the target effector, or to the specific target tissue within the organ. Comparing the relative lengths of axons in the parasympathetic system, the preganglionic fibers are long and the postganglionic fibers are short because the ganglia are close to—and sometimes within—the target effectors.

The cranial component of the parasympathetic system is based in particular nuclei of the brainstem. In the midbrain, the **Edinger–Westphal nucleus** is part of the oculomotor complex, and axons from those neurons travel with the fibers in the oculomotor nerve (cranial nerve III) that innervate the extraocular muscles. The preganglionic parasympathetic fibers within cranial nerve III terminate in the **ciliary ganglion**, which is located in the posterior orbit. The postganglionic parasympathetic fibers then project to the smooth muscle of the iris to control pupillary size. In the upper medulla, the salivatory nuclei contain neurons with axons that project through the facial and glossopharyngeal nerves to ganglia that control salivary glands. Tear production is influenced by parasympathetic fibers in the facial nerve (CN VII), which activate a ganglion, and ultimately the lacrimal (tear) gland. Neurons in the **dorsal nucleus of the vagus nerve** and the **nucleus ambiguus** project through the vagus nerve (cranial nerve X) to the terminal ganglia of the thoracic and abdominal cavities. Parasympathetic preganglionic fibers primarily influence the heart, bronchi, and esophagus in the thoracic cavity and the stomach, liver, pancreas, gall bladder, and small intestine of the abdominal cavity. The postganglionic fibers from the ganglia activated by the vagus nerve are often incorporated into the structure of the organ, such as the **mesenteric plexus** of the digestive tract organs and the intramural ganglia.
Figure \(\PageIndex{3}\): Parasympathetic Innervation. Neurons from brain-stem nuclei, or from the lateral horn of the sacral spinal cord, project to terminal ganglia near or within the various organs of the body. Axons from these ganglionic neurons then project the short distance to those target effectors (Credit: OpenStax / sacral connection edited by Chiara Mazzasette).

**Autonomic Synapses**

What are referred to here as synapses may not fit the strictest definition of synapse. Some sources will refer to the connection between a postganglionic fiber and a target effector as neuroeffector junctions; neurotransmitters at these synapses would be called neuromodulators. The structure of postganglionic connections are not the typical synaptic end bulb that is found at the neuromuscular junction, but rather are chains of swellings along the length of a postganglionic fiber called a **varicosity** (Figure \(\PageIndex{4}\)).

Figure \(\PageIndex{4}\): Autonomic Varicosities. The connection between autonomic fibers and target effectors is not the same as the typical synapse, such as the neuromuscular junction. Instead of a synaptic end bulb, a neurotransmitter is released from swellings along the length of a fiber that makes an extended network of connections in the target effector.

Where an autonomic neuron connects with a target, there is a synapse. The electrical signal of the action potential causes the release of a signaling molecule, which will bind to receptor proteins on the target cell. Signaling molecules can belong to two broad groups. Neurotransmitters are released at synapses, whereas hormones are released into the bloodstream. However, in the sympathetic nervous system, the same molecule (epinephrine) is released by axons or by the adrenal medulla into the bloodstream, blurring the lines between the definitions. Signaling molecules of the autonomic nervous system are acetylcholine (ACh), norepinephrine (or noradrenaline) and epinephrine (or adrenaline). The effects of the autonomic divisions depend on the type of receptor involved.

All preganglionic fibers, both sympathetic and parasympathetic, release ACh (Figure \(\PageIndex{5}\)). All ganglionic neurons—the targets of these preganglionic fibers—have nicotinic receptors in their cell membranes, which would lead to the firing of an action potential from the ganglionic fibers in both sympathetic and parasympathetic divisions. The postganglionic fibers of the sympathetic and parasympathetic divisions both release neurotransmitters that bind to receptors on their targets. Postganglionic sympathetic fibers release norepinephrine, with a minor exception, whereas postganglionic parasympathetic fibers release ACh. For any given target, the difference in which division of the autonomic nervous system is exerting control is just in what chemical binds to its receptors. The target cells will have adrenergic and muscarinic receptors. If norepinephrine is released, it will bind to the adrenergic receptors present on the target cell, and if ACh is released, it will bind to the muscarinic receptors on the target cell.

In the sympathetic system, there are exceptions to this pattern of dual innervation. The postganglionic sympathetic fibers that contact the blood vessels within skeletal muscle and sweat glands in the integument release ACh instead of...
norepinephrine. This does not create any problem because there is no parasympathetic input to the sweat glands. Sweat glands have muscarinic receptors and produce and secrete sweat in response to the presence of ACh.

At most of the other targets of the autonomic system, the effector response is based on which neurotransmitter is released and what receptor is present. For example, regions of the heart that establish heart rate are contacted by postganglionic fibers from both systems. If norepinephrine is released onto those cells, it binds to an adrenergic receptor that causes the cells to depolarize faster, and the heart rate increases. If ACh is released onto those cells, it binds to a muscarinic receptor that causes the cells to hyperpolarize so that they cannot reach threshold as easily, and the heart rate slows. Without this parasympathetic input, the heart would work at a rate of approximately 100 beats per minute (bpm). The sympathetic system speeds that up, as it would during exercise, to 120–140 bpm, for example. The parasympathetic system slows it down to the resting heart rate of 60–80 bpm.

![Comparison of Sympathetic and Parasympathetic Divisions](https://med.libretexts.org/Sandboxes/Team_Sandbox%3A_Anatomy_(OERI)/14%3A_Autonomic_Nervous_System/14.02%3AAutonomic_Nervous_System/parasympathetic.png)

Figure: Comparison of Sympathetic and Parasympathetic Divisions. In the autonomic nervous system, a preganglionic neuron of the CNS synapses with a ganglionic neuron of the PNS. The ganglionic neuron, in turn, acts on a target organ. Autonomic responses are mediated by the sympathetic and the parasympathetic systems, which are antagonistic to one another. The sympathetic system activates the “fight or flight” response, while the parasympathetic system activates the “rest and digest” response (Credit: OpenStax / labels edited by Chiara Mazzasette).

**Everyday Connections**

**Fight or Flight? What About Fright and Freeze?**

The original usage of the epithet “fight or flight” comes from a scientist named Walter Cannon who worked at
Harvard in 1915. The concept of homeostasis and the functioning of the sympathetic system had been introduced in France in the previous century. Cannon expanded the idea, and introduced the idea that an animal responds to a threat by preparing to stand and fight or run away. The nature of this response was thoroughly explained in a book on the physiology of pain, hunger, fear, and rage.

When students learn about the sympathetic system and the fight-or-flight response, they often stop and wonder about other responses. If you were faced with a lioness running toward you as pictured at the beginning of this chapter, would you run or would you stand your ground? Some people would say that they would freeze and not know what to do. So isn’t there really more to what the autonomic system does than fight, flight, rest, or digest. What about fear and paralysis in the face of a threat?

The common epithet of “fight or flight” is being enlarged to be “fight, flight, or fright” or even “fight, flight, fright, or freeze.” Cannon’s original contribution was a catchy phrase to express some of what the nervous system does in response to a threat, but it is incomplete. The sympathetic system is responsible for the physiological responses to emotional states. The name “sympathetic” can be said to mean that (sym- = “together”; -pathos = “pain,” “suffering,” or “emotion”).

Content Review

The primary responsibilities of the autonomic nervous system are to regulate homeostatic mechanisms in the body, which is also part of what the endocrine system does. The key to understanding the autonomic system is to explore the response pathways—the output of the nervous system. The way we respond to the world around us, to manage the internal environment on the basis of the external environment, is divided between two parts of the autonomic nervous system. The sympathetic division responds to threats and produces a readiness to confront the threat or to run away: the fight-or-flight response. The parasympathetic division plays the opposite role. When the external environment does not present any immediate danger, a restful mode descends on the body, and the digestive system is more active.

The sympathetic output of the nervous system originates out of the lateral horn of the thoracolumbar spinal cord. An axon from one of these central neurons projects by way of the ventral spinal nerve root and spinal nerve to a sympathetic ganglion, either in the sympathetic chain ganglia or one of the collateral locations, where it synapses on a ganglionic neuron. These preganglionic fibers release ACh, which excites the ganglionic neuron through the nicotinic receptor. The axon from the ganglionic neuron—the postganglionic fiber—then projects to a target effector where it will release norepinephrine to bind to an adrenergic receptor, causing a change in the physiology of that organ in keeping with the broad, divergent sympathetic response. The postganglionic connections to sweat glands in the skin and blood vessels supplying skeletal muscle are, however, exceptions; those fibers release ACh onto muscarinic receptors. The sympathetic system has a specialized preganglionic connection to the adrenal medulla that causes epinephrine and norepinephrine to be released into the bloodstream rather than exciting a neuron that contacts an organ directly. This hormonal component means that the sympathetic chemical signal can spread throughout the body very quickly and affect many organ systems at once.

The parasympathetic output is based in the brainstem and sacral spinal cord. Neurons from particular nuclei in the brainstem or from the lateral horn of the sacral spinal cord (preganglionic neurons) project to terminal (intramural) ganglia located close to or within the wall of target effectors. These preganglionic fibers also release ACh onto nicotinic
receptors to excite the ganglionic neurons. The postganglionic fibers then contact the target tissues within the organ to release ACh, which binds to muscarinic receptors to induce rest-and-digest responses.

Signaling molecules utilized by the autonomic nervous system are released from axons and can be considered as either neurotransmitters (when they directly interact with the effector) or as hormones (when they are released into the bloodstream). The same molecule, such as norepinephrine, could be considered either a neurotransmitter or a hormone on the basis of whether it is released from a postganglionic sympathetic axon or from the adrenal gland. The synapses in the autonomic system are not always the typical type of connection first described in the neuromuscular junction. Instead of having synaptic end bulbs at the very end of an axonal fiber, they may have swellings—called varicosities—along the length of a fiber so that it makes a network of connections within the target tissue.

Review Questions

Q. Which of these physiological changes would not be considered part of the sympathetic fight-or-flight response?

A. increased heart rate
B. increased sweating
C. dilated pupils
D. increased stomach motility

**Answer**

D

Q. Which type of fiber could be considered the longest?

A. preganglionic parasympathetic
B. preganglionic sympathetic
C. postganglionic parasympathetic
D. postganglionic sympathetic

**Answer**

A

Q. Which signaling molecule is most likely responsible for an increase in digestive activity?

A. epinephrine
B. norepinephrine
C. acetylcholine
Q. Which of these cranial nerves contains preganglionic parasympathetic fibers?

A. optic, CN II  
B. facial, CN VII  
C. trigeminal, CN V  
D. hypoglossal, CN XII  

Answer  

B

Q. Which of the following is not a target of a sympathetic preganglionic fiber?

A. intermural ganglion  
B. collateral ganglion  
C. adrenal gland  
D. chain ganglion  

Answer  

A

Critical Thinking Questions

Q. In the context of a lioness hunting on the savannah, why would the sympathetic system not activate the digestive system?

A. Whereas energy is needed for running away from the threat, blood needs to be sent to the skeletal muscles for oxygen supply. The additional fuel, in the form of carbohydrates, probably wouldn’t improve the ability to escape the threat as much as the diversion of oxygen-rich blood would hinder it.

Q. A target effector, such as the heart, receives input from the sympathetic and parasympathetic systems. What is the actual difference between the sympathetic and parasympathetic divisions at the level of those connections (i.e., at the synapse)?

A. The postganglionic sympathetic fiber releases norepinephrine, whereas the postganglionic parasympathetic fiber releases acetylcholine. Specific locations in the heart have adrenergic receptors and muscarinic receptors.
Which receptors are bound is the signal that determines how the heart responds.

**Glossary**

**alpha (α)-adrenergic receptor**
one of the receptors to which epinephrine and norepinephrine bind, which comes in three subtypes: α_1, α_2, and α_3

**acetylcholine (ACh)**
neurotransmitter that binds at a motor end-plate to trigger depolarization

**adrenal medulla**
interior portion of the adrenal (or suprarenal) gland that releases epinephrine and norepinephrine into the bloodstream as hormones

**adrenergic**
synapse where norepinephrine is released, which binds to α- or β-adrenergic receptors

**beta (β)-adrenergic receptor**
one of the receptors to which epinephrine and norepinephrine bind, which comes in two subtypes: β_1 and β_2

**celiac ganglion**
one of the collateral ganglia of the sympathetic system that projects to the digestive system

**central neuron**
specifically referring to the cell body of a neuron in the autonomic system that is located in the central nervous system, specifically the lateral horn of the spinal cord or a brainstem nucleus

**cholinergic**
synapse at which acetylcholine is released and binds to the nicotinic or muscarinic receptor

**chromaffin cells**
neuroendocrine cells of the adrenal medulla that release epinephrine and norepinephrine into the bloodstream as part of sympathetic system activity

**ciliary ganglion**
one of the terminal ganglia of the parasympathetic system, located in the posterior orbit, axons from which project to the iris

**collateral ganglia**
ganglia outside of the sympathetic chain that are targets of sympathetic preganglionic fibers, which are the celiac, inferior mesenteric, and superior mesenteric ganglia

**craniosacral system**
alternate name for the parasympathetic division of the autonomic nervous system that is based on the anatomical location of central neurons in brain-stem nuclei and the lateral horn of the sacral spinal cord; also referred to as craniosacral outflow

**dorsal nucleus of the vagus nerve**
location of parasympathetic neurons that project through the vagus nerve to terminal ganglia in the thoracic and abdominal cavities

**Eddinger–Westphal nucleus**
location of parasympathetic neurons that project to the ciliary ganglion
endogenous
describes substance made in the human body

epinephrine
signaling molecule released from the adrenal medulla into the bloodstream as part of the sympathetic response

exogenous
describes substance made outside of the human body

fight-or-flight response
set of responses induced by sympathetic activity that lead to either fleeing a threat or standing up to it, which in the modern world is often associated with anxious feelings

G protein–coupled receptor
membrane protein complex that consists of a receptor protein that binds to a signaling molecule—a G protein—that is activated by that binding and in turn activates an effector protein (enzyme) that creates a second-messenger molecule in the cytoplasm of the target cell

ganglionic neuron
specifically refers to the cell body of a neuron in the autonomic system that is located in a ganglion

gray rami communicantes
(singular = ramus communicans) unmyelinated structures that provide a short connection from a sympathetic chain ganglion to the spinal nerve that contains the postganglionic sympathetic fiber

greater splanchnic nerve
nerve that contains fibers of the central sympathetic neurons that do not synapse in the chain ganglia but project onto the celiac ganglion

inferior mesenteric ganglion
one of the collateral ganglia of the sympathetic system that projects to the digestive system

intramural ganglia
terminal ganglia of the parasympathetic system that are found within the walls of the target effector

lesser splanchnic nerve
nerve that contains fibers of the central sympathetic neurons that do not synapse in the chain ganglia but project onto the inferior mesenteric ganglion

ligand-gated cation channel
ion channel, such as the nicotinic receptor, that is specific to positively charged ions and opens when a molecule such as a neurotransmitter binds to it

mesenteric plexus
nervous tissue within the wall of the digestive tract that contains neurons that are the targets of autonomic preganglionic fibers and that project to the smooth muscle and glandular tissues in the digestive organ

muscarinic receptor
type of acetylcholine receptor protein that is characterized by also binding to muscarine and is a metabotropic receptor

nicotinic receptor
type of acetylcholine receptor protein that is characterized by also binding to nicotine and is an ionotropic receptor
norepinephrine
signaling molecule released as a neurotransmitter by most postganglionic sympathetic fibers as part of the sympathetic response, or as a hormone into the bloodstream from the adrenal medulla

nucleus ambiguus
brain-stem nucleus that contains neurons that project through the vagus nerve to terminal ganglia in the thoracic cavity; specifically associated with the heart

parasympathetic division
division of the autonomic nervous system responsible for restful and digestive functions

paravertebral ganglia
autonomic ganglia superior to the sympathetic chain ganglia

postganglionic fiber
axon from a ganglionic neuron in the autonomic nervous system that projects to and synapses with the target effector; sometimes referred to as a postganglionic neuron

preganglionic fiber
axon from a central neuron in the autonomic nervous system that projects to and synapses with a ganglionic neuron; sometimes referred to as a preganglionic neuron

prevertebral ganglia
autonomic ganglia that are anterior to the vertebral column and functionally related to the sympathetic chain ganglia

rest and digest
set of functions associated with the parasympathetic system that lead to restful actions and digestion

superior cervical ganglion
one of the paravertebral ganglia of the sympathetic system that projects to the head

superior mesenteric ganglion
one of the collateral ganglia of the sympathetic system that projects to the digestive system

sympathetic chain ganglia
series of ganglia adjacent to the vertebral column that receive input from central sympathetic neurons

sympathetic division
division of the autonomic nervous system associated with the fight-or-flight response

target effector
organ, tissue, or gland that will respond to the control of an autonomic or somatic or endocrine signal

terminal ganglia
ganglia of the parasympathetic division of the autonomic system, which are located near or within the target effector, the latter also known as intramural ganglia

thoracolumbar system
alternate name for the sympathetic division of the autonomic nervous system that is based on the anatomical location of central neurons in the lateral horn of the thoracic and upper lumbar spinal cord

varicosity
structure of some autonomic connections that is not a typical synaptic end bulb, but a string of swellings along the length of a fiber that makes a network of connections with the target effector
white rami communicantes
(singular = ramus communicans) myelinated structures that provide a short connection from a sympathetic chain ganglion to the spinal nerve that contains the preganglionic sympathetic fiber

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