Al-Mustaqbal University

Pharmacology I

3rd stage

Autonomic Nervous System

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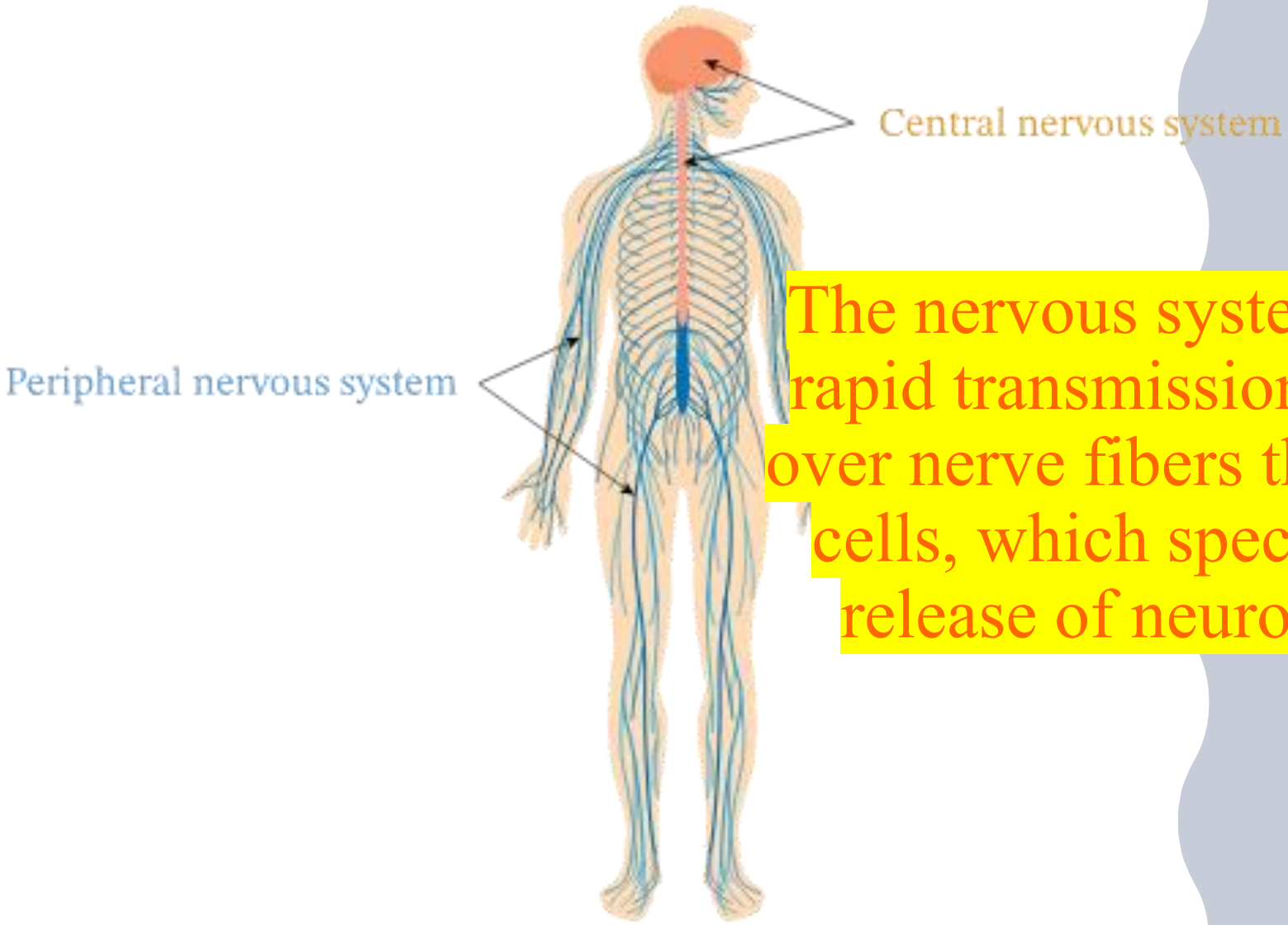
Nervous System



The nervous system exerts effects by the rapid transmission of electrical impulses over nerve fibers that terminate at effector cells, which specifically respond to the release of neuromediator substances.

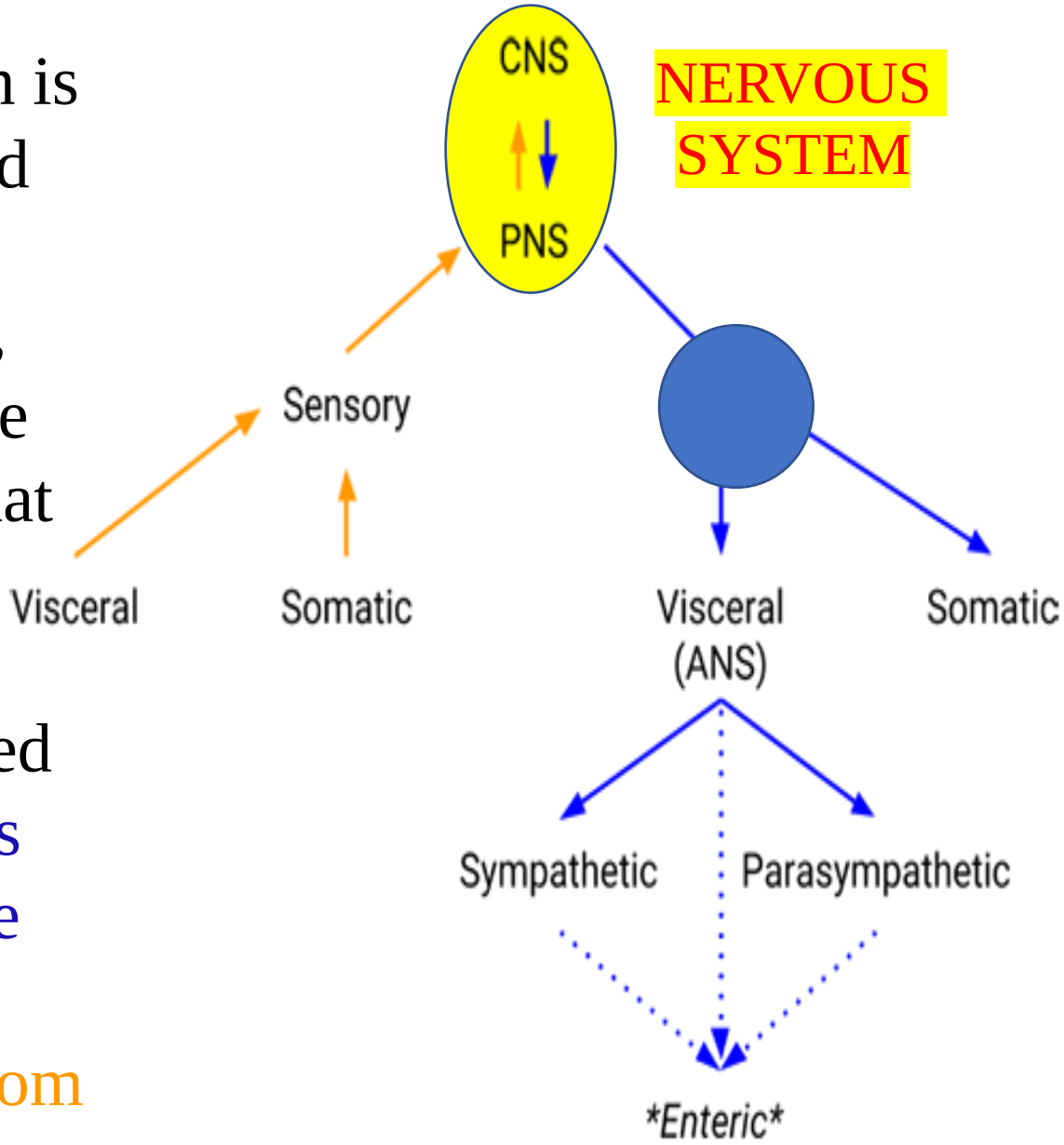
The nervous system is divided into:

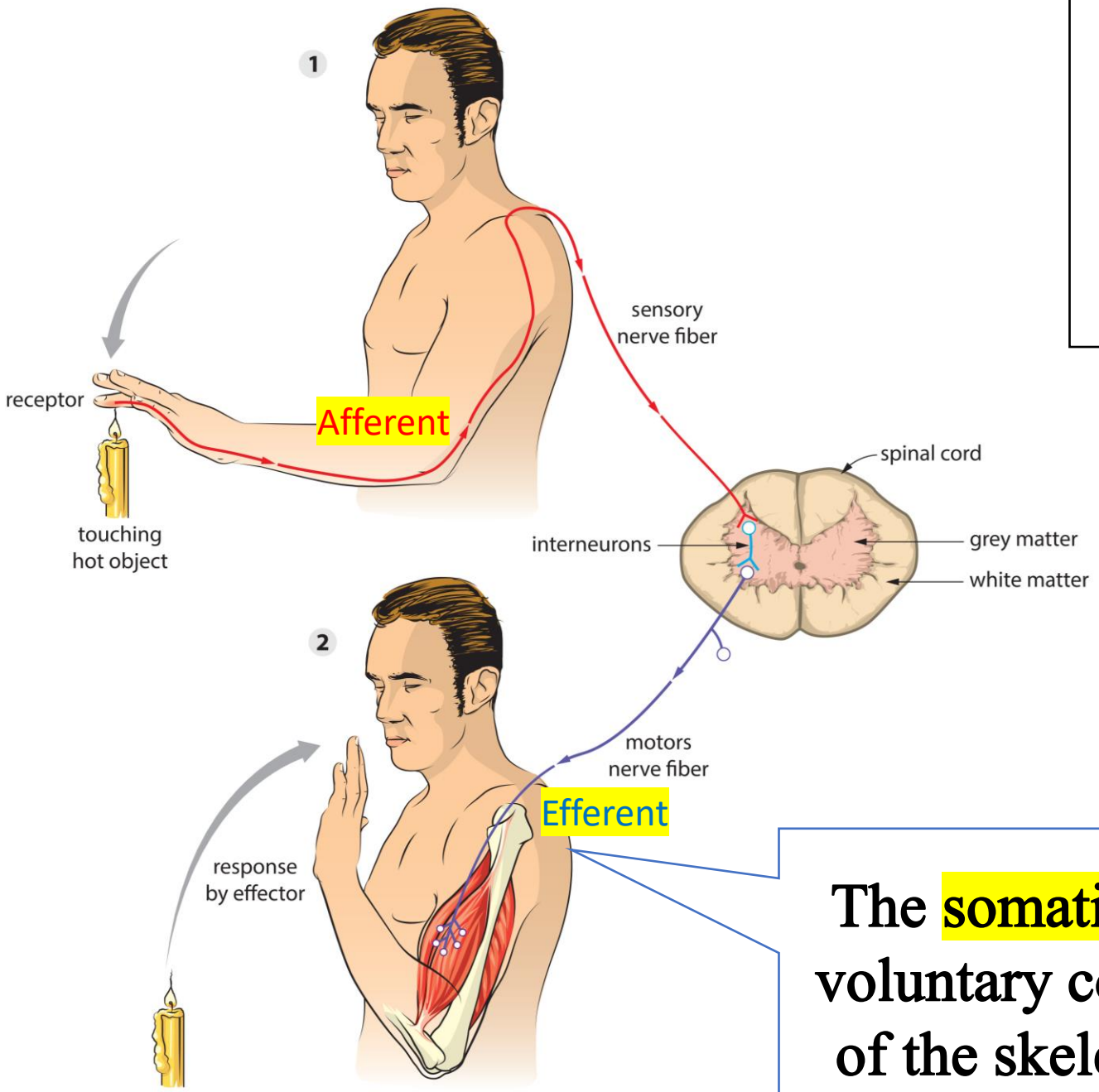
I- The central nervous system (CNS): which is composed of the brain and spinal cord, and

II- The peripheral nervous system (PNS), which includes neurons located outside the brain and spinal cord, that is, any nerves that enter or leave the CNS.

The peripheral nervous system is subdivided into: A- The efferent neurons carry signals away from the brain and spinal cord to the peripheral tissues, and

B- the afferent neurons bring information from the periphery to the CNS.

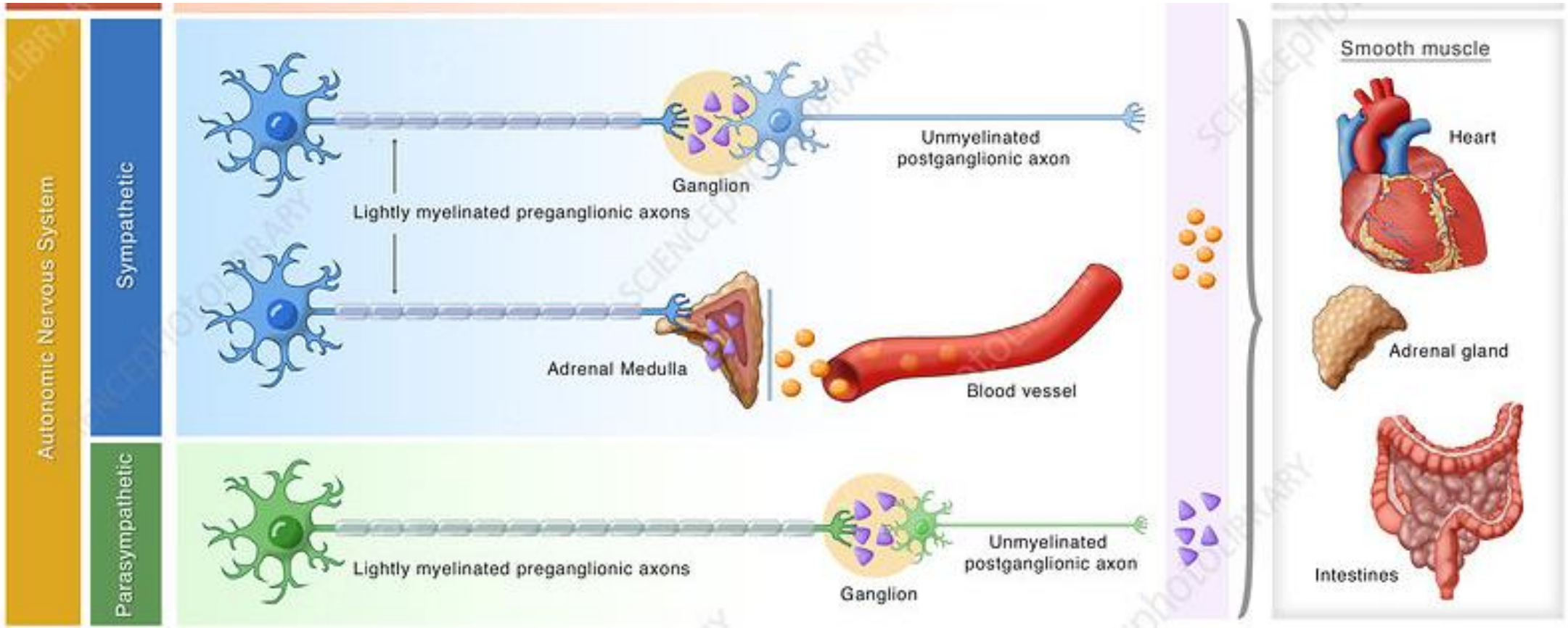




The efferent portion of the peripheral nervous system is further divided into somatic and the autonomic systems.

The somatic efferent neurons are involved in the voluntary control of functions such as contraction of the skeletal muscles essential for locomotion.

The autonomic system regulates the everyday requirements of vital bodily functions without the conscious participation of the mind. It is composed of efferent neurons that innervate smooth muscle of the viscera, cardiac muscle, vasculature, and the exocrine glands, thereby controlling digestion, cardiac output, blood flow, and glandular secretions.

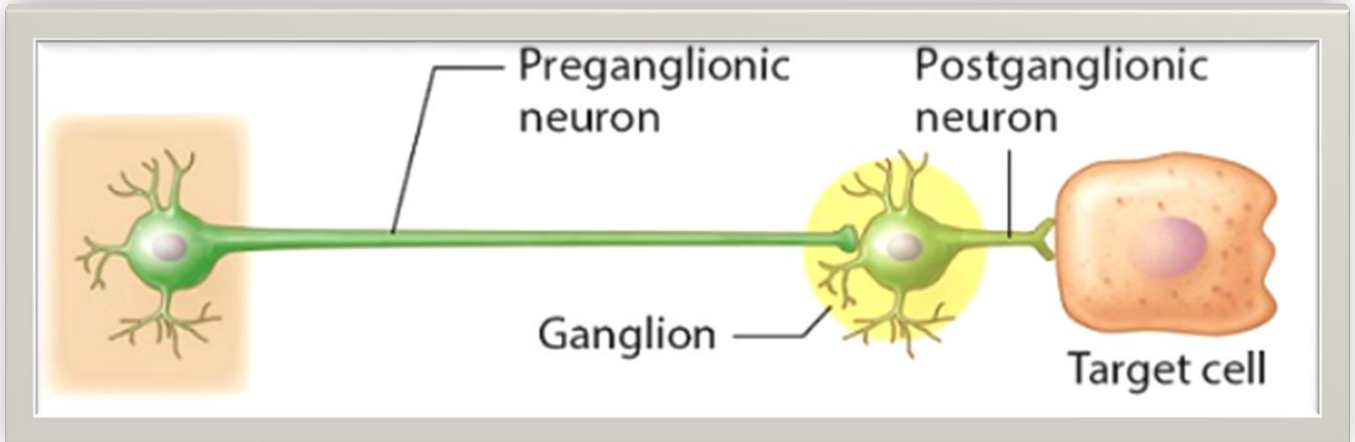


Anatomy of the autonomic nervous system

Efferent neurons:

preganglionic neuron, and its cell body is located within the CNS. Preganglionic neurons emerge from the brainstem or spinal cord and make a synaptic connection in ganglia (an aggregation of nerve cell bodies located in the peripheral nervous system).

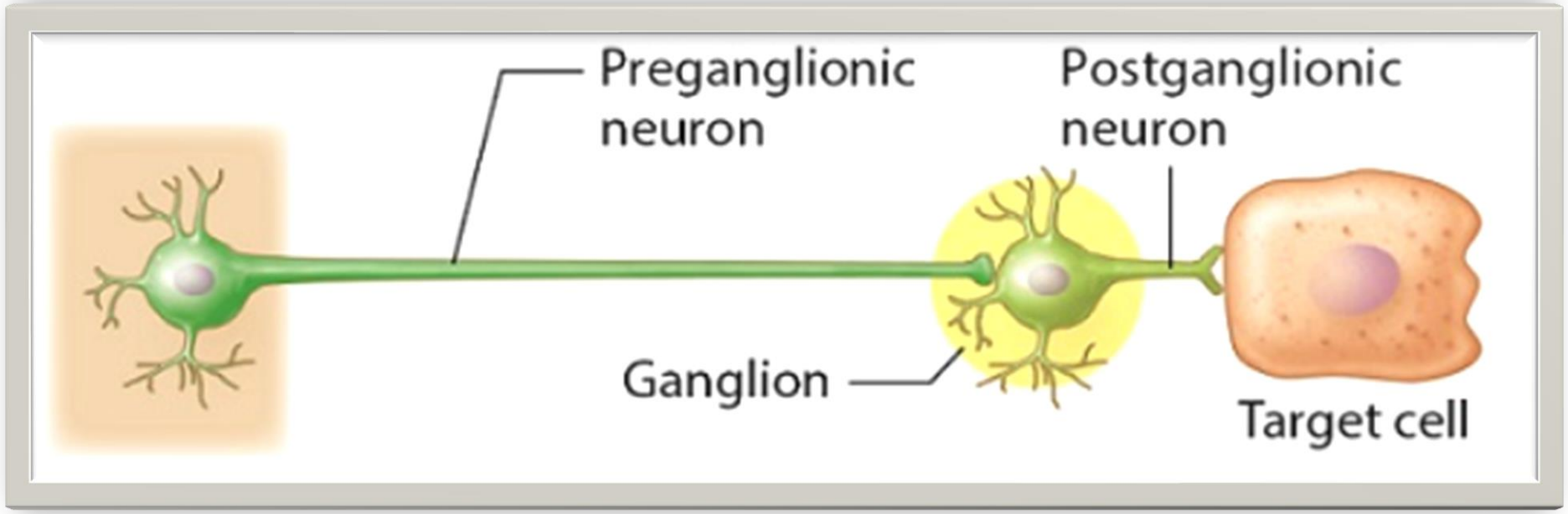
These ganglia function as relay stations between a preganglionic neuron and a second nerve cell, the postganglionic neuron.



Anatomy of the autonomic nervous system

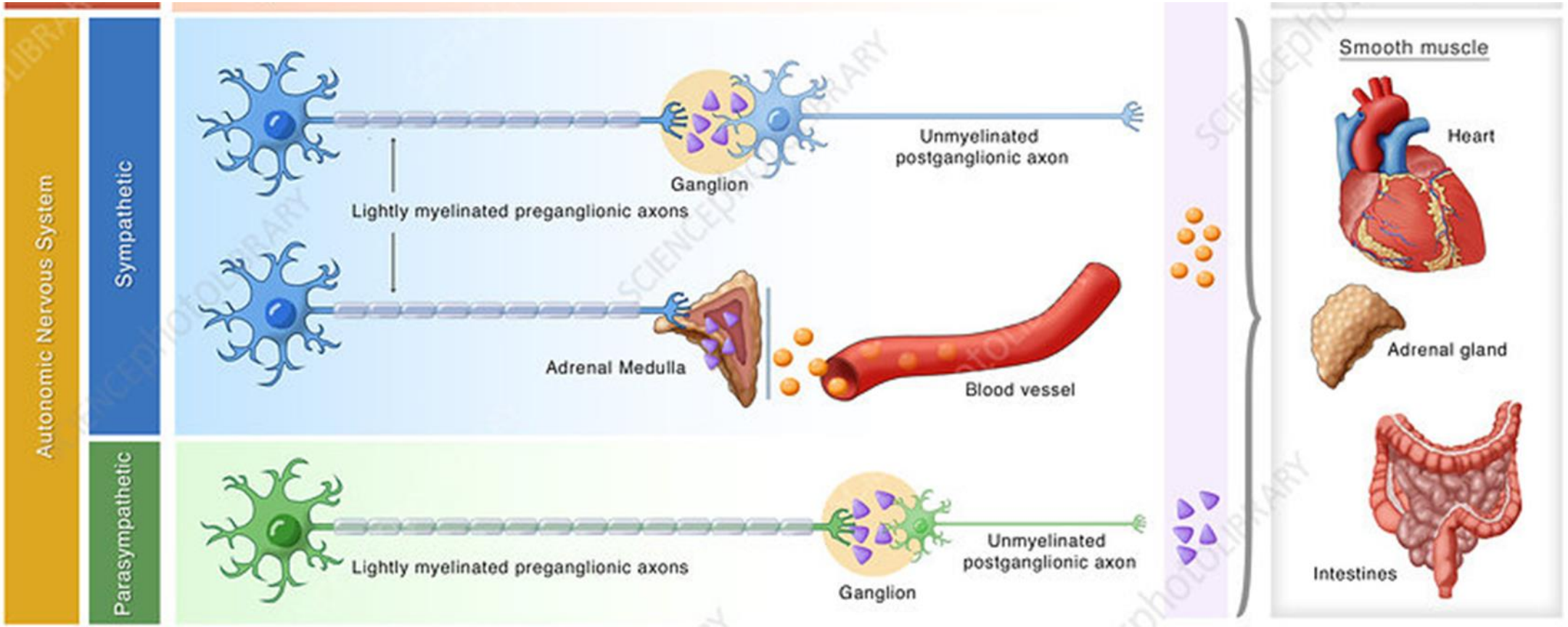
Efferent neurons:

Postganglionic neuron, has a cell body originating in the ganglion. It terminates on effector organs, such as smooth muscles of the viscera, cardiac muscle, and the exocrine glands.

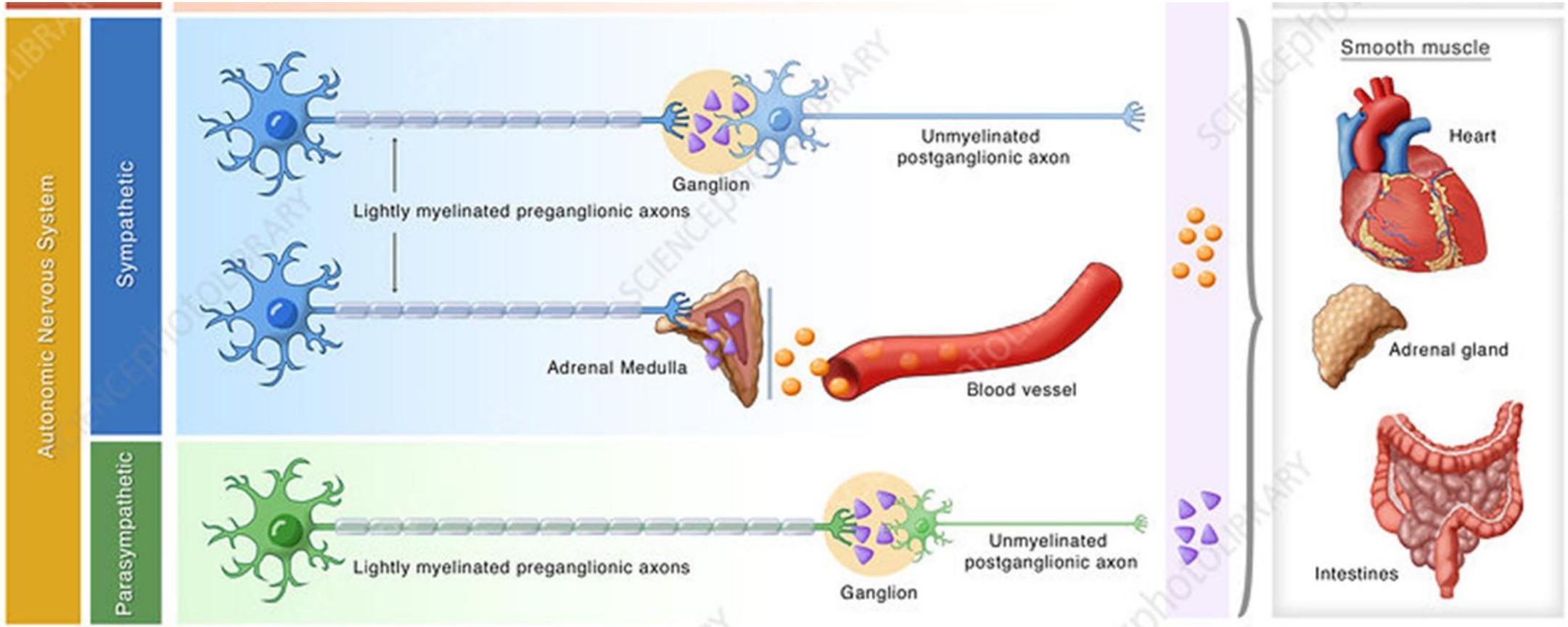


Sympathetic neurons:

The preganglionic neurons of the sympathetic system come from thoracic and lumbar regions of the spinal cord. The preganglionic neurons are short in comparison to the postganglionic ones. Axons of the postganglionic neuron extend from these ganglia to the tissues that they innervate and regulate.

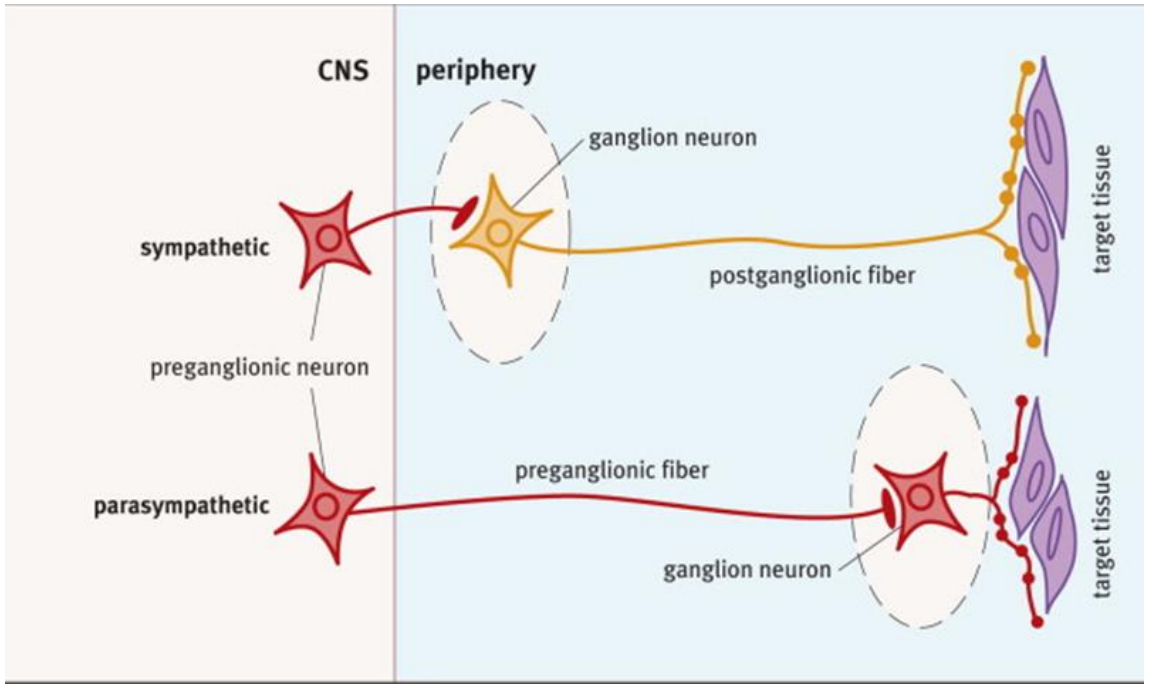


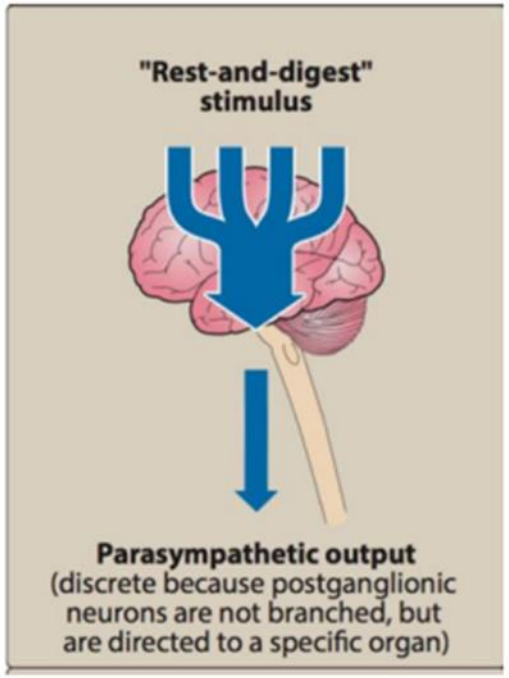
The adrenal medulla, like the sympathetic ganglia, receives preganglionic fibers from the sympathetic system. Lacking axons, the adrenal medulla, in response to stimulation by the ganglionic neurotransmitter acetylcholine, influences other organs by secreting the hormone epinephrine, also known as adrenaline, and lesser amounts of norepinephrine into the blood

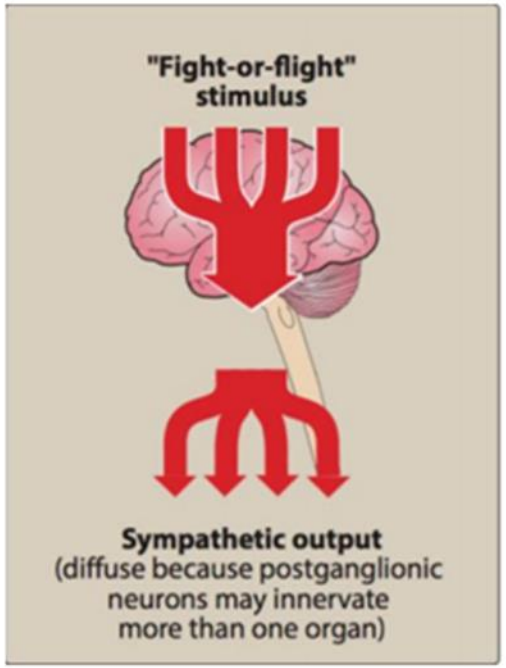


Parasympathetic neurons:

The parasympathetic preganglionic fibers arise from the cranial nerves (III, VII, IX, and X) and from the sacral region of the spinal cord and synapse in ganglia near or on the effector organs.







In most instances, there is a one-to-one connection between the preganglionic and postganglionic neurons, enabling discrete response of parasympathetic system.

Enteric neurons:

The enteric nervous system a collection of nerve fibers that innervate the gastrointestinal tract, pancreas, and gallbladder, controls the motility, exocrine and endocrine secretions, and microcirculation of the gastrointestinal tract. It is modulated by both the sympathetic and parasympathetic nervous systems.

Afferent neurons:

The afferent neurons are important in the reflex regulation of the autonomic nervous system (**for example, by sensing pressure in the carotid sinus and aortic arch**) and signaling the CNS to influence the efferent branch of the system to respond.

Functions of the sympathetic nervous system

1. increase heart rate and blood pressure,
2. mobilize energy stores of the body,
3. increase blood flow to skeletal muscles and the heart.
4. dilation of the pupils and the bronchioles.

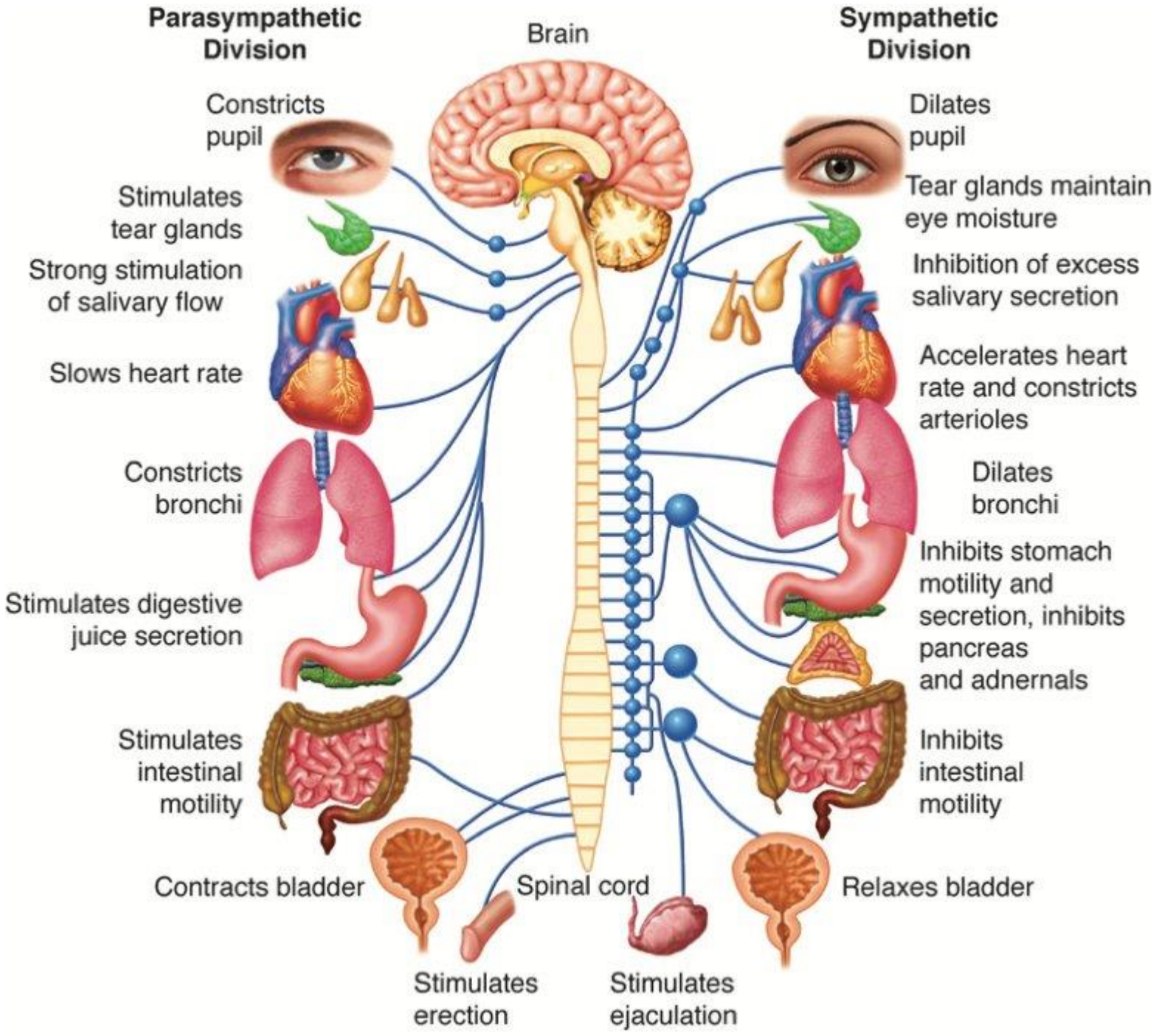
5. reduces gastrointestinal motility and affects the function of the bladder (sphincter contraction) and sexual organs (stimulate ejaculation).

6. Fight or flight response: during emergencies, during severe exercise or in reactions to fear, a- the sympathetic system activates the effector organs. b- stimulation of the adrenal medulla lead to release epinephrine and lesser amounts of norepinephrine into bloodstream and promote responses in effector organs that contain adrenergic receptors.

7- The sympathetic nervous system tends to function as a unit and often discharges as a complete system.

Functions of the parasympathetic nervous system

The parasympathetic division maintains essential bodily functions, such as digestive processes and elimination of wastes, and is required for life. It usually acts to oppose or balance the actions of the sympathetic division and is generally dominant over the sympathetic system in rest and digest situations.



- Why does the somatic nervous system enable a faster response compared to the ANS?

A. Somatic motor neurons have ganglia where neurotransmission is mediated by ACh.

B. Somatic motor neurons have ganglia where neurotransmission is mediated by NE.

C. Somatic motor neurons are not myelinated.

D. Somatic motor neurons are myelinated and do not have ganglia.

- Which physiological change occurs when the parasympathetic system is activated?

A. Increase in heart rate
B. Inhibition of lacrimation (tears)
C. Dilation of the pupil (mydriasis)
D. Increase in gastric motility
E. Increase in blood pressure

- Which physiological change is expected when the sympathetic system is inhibited using a pharmacological agent?

A. Reduction in heart rate
B. Increase in blood pressure
C. Decrease in fluid secretions
D. Constriction of blood vessels

- Which statement concerning the parasympathetic nervous system is correct?

A. The parasympathetic system often discharges as a single, functional system.

B. The parasympathetic division is involved in near vision, movement of food, and urination.

C. The postganglionic fibers of the parasympathetic division are long, compared to those of the sympathetic nervous system.

D. The parasympathetic system controls the secretion of the adrenal medulla.

Activation of sympathetic neuron causes all the following except:

energy stores of the body.

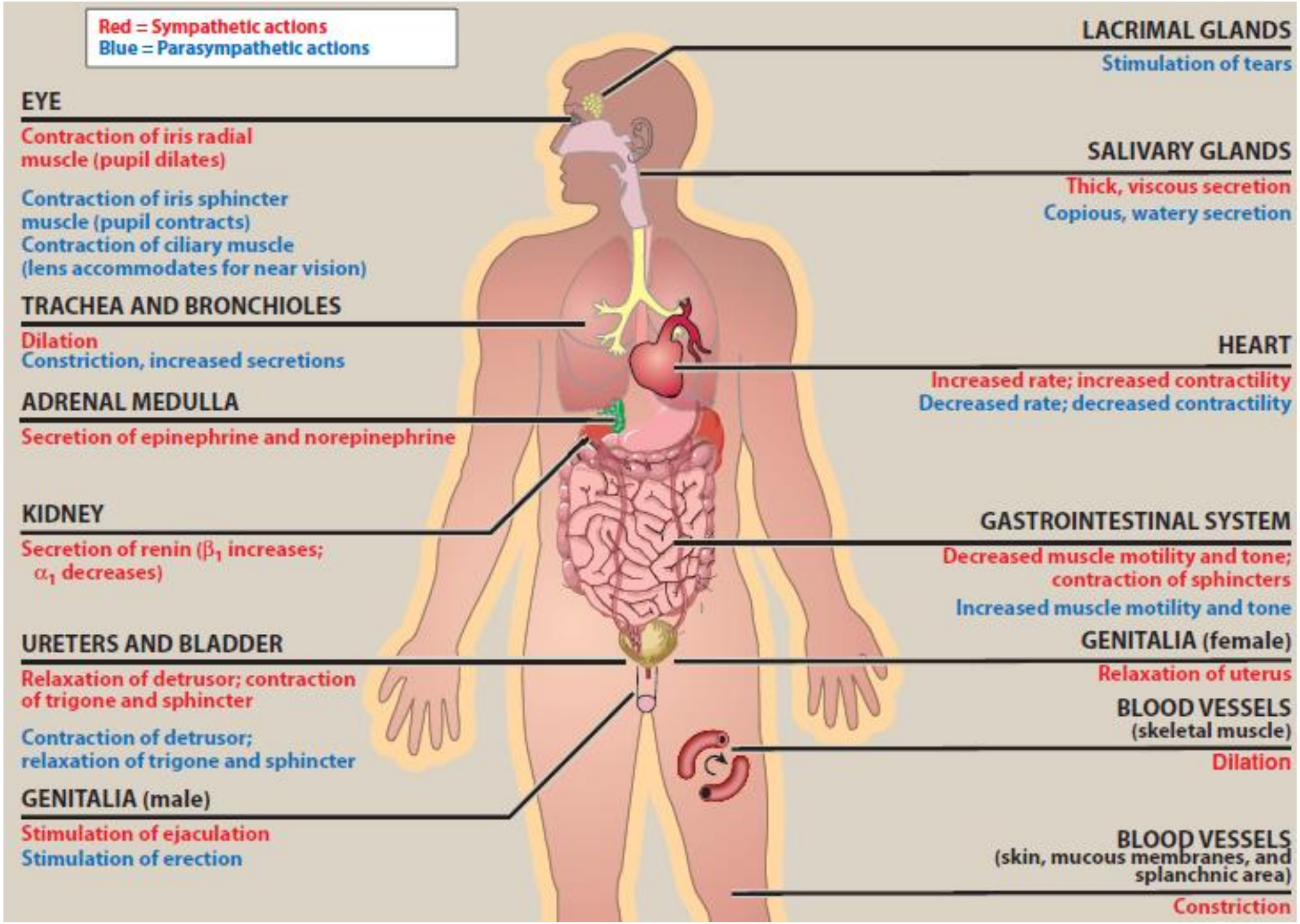
e- Dilationa- Increases heart rate.

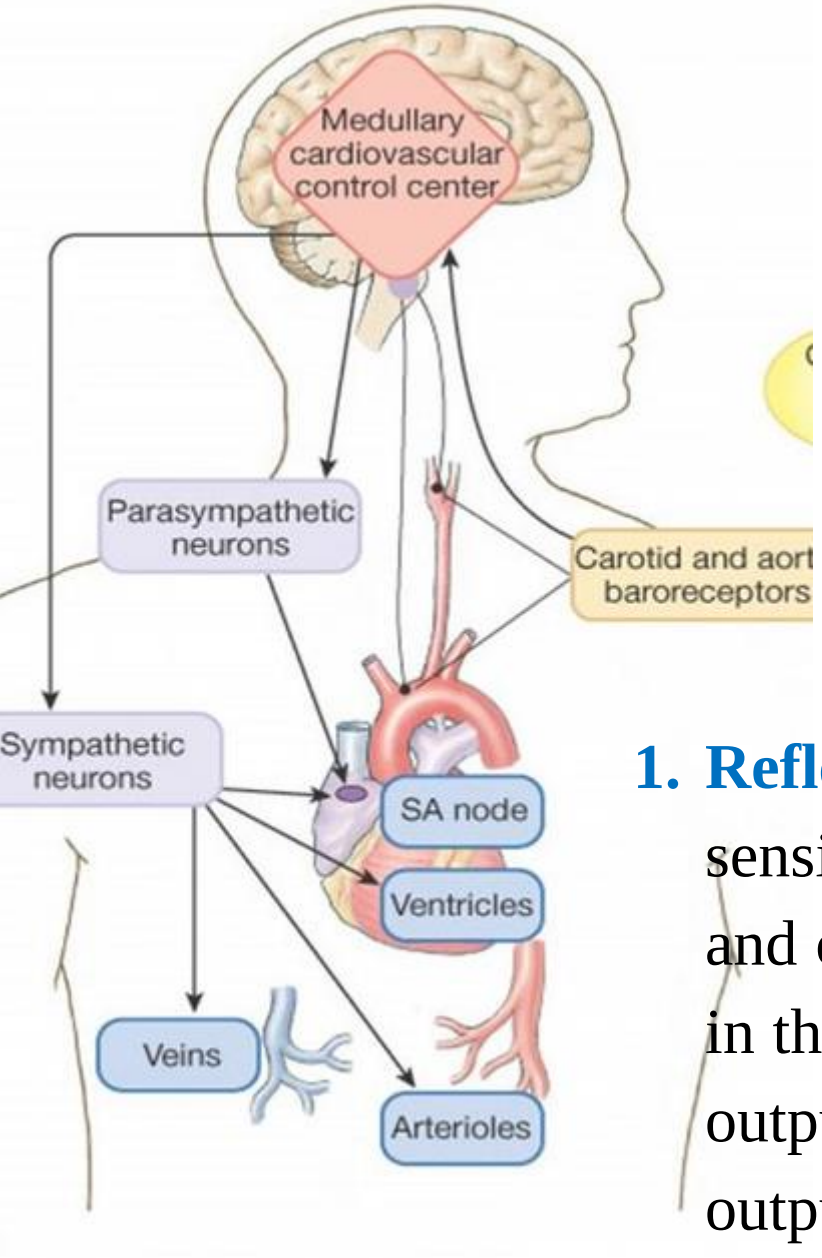
b- Decreases blood pressure.

c- Slows heart rate.

d- Mobilizes of the pupils.

Actions of sympathetic and parasympathetic nervous systems on effector organs





Role of the CNS in autonomic control functions

The autonomic nervous system requires sensory input (afferent impulses) from peripheral structures to provide information on the state of affairs in the body. CNS that responds to the stimuli by sending out efferent reflex impulses via the autonomic nervous system.

1. **Reflex arcs:** For example, a fall in blood pressure causes pressure-sensitive neurons (baroreceptors in the heart, vena cava, aortic arch, and carotid sinuses) to send fewer impulses to cardiovascular centers in the brain. This prompts a reflex response of increased sympathetic output to the heart and vasculature and decreased parasympathetic output to the heart, which results in a compensatory rise in blood pressure and tachycardia.

2- Emotions and the autonomic nervous system: Stimuli that evoke feelings of strong emotion, such as rage, fear, or pleasure, can modify the activity of the autonomic nervous system.

Innervation by the autonomic nervous system

1. **Dual innervation:** Most organs in the body are innervated by both divisions of the autonomic nervous system. Thus, vagal parasympathetic innervation slows the heart rate, and sympathetic innervation increases the heart rate.

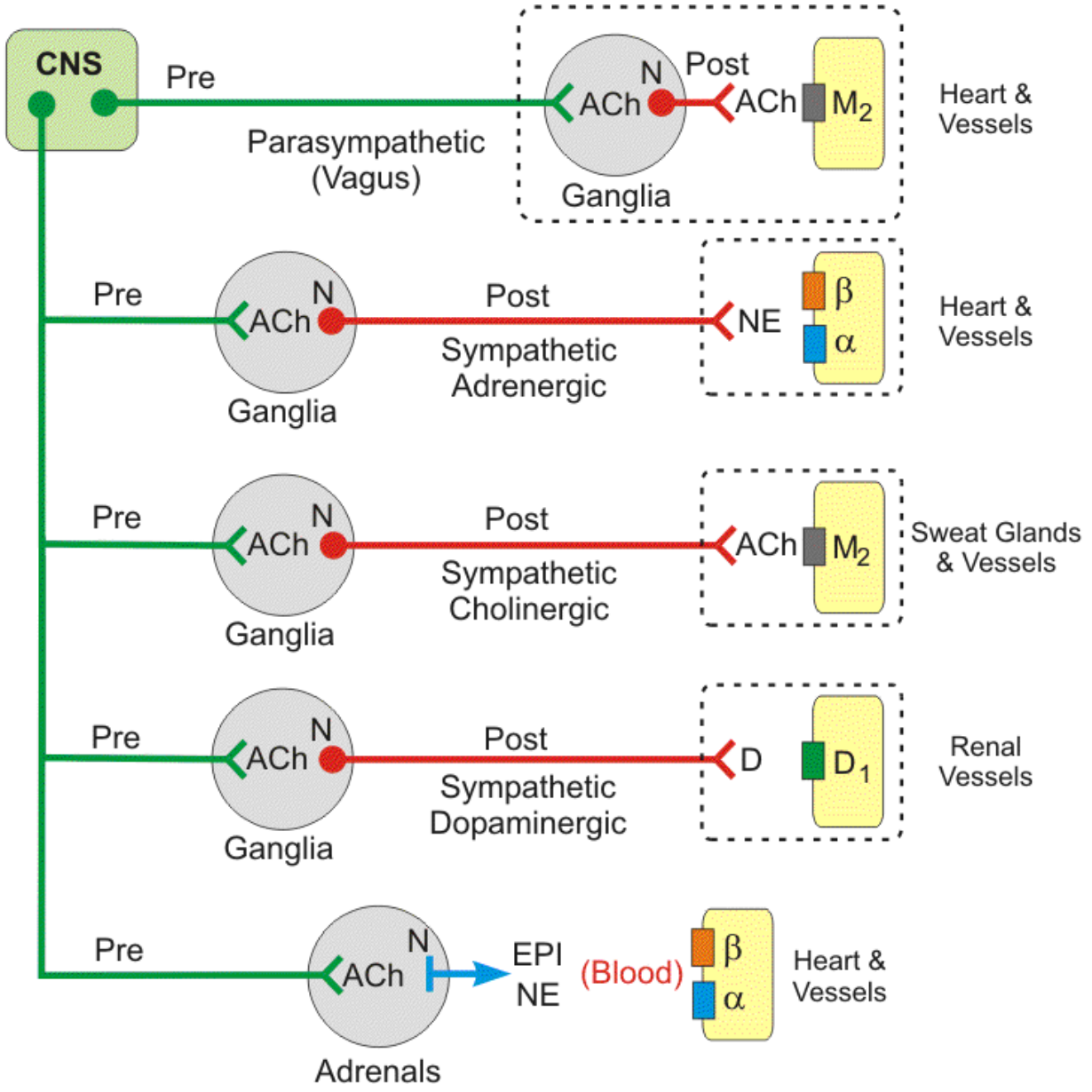
Despite this dual innervation, one system usually predominates in controlling the activity of a given organ.

For example, in the heart, the vagus nerve is the predominant factor for controlling rate.

2- Organs receiving only sympathetic innervation:

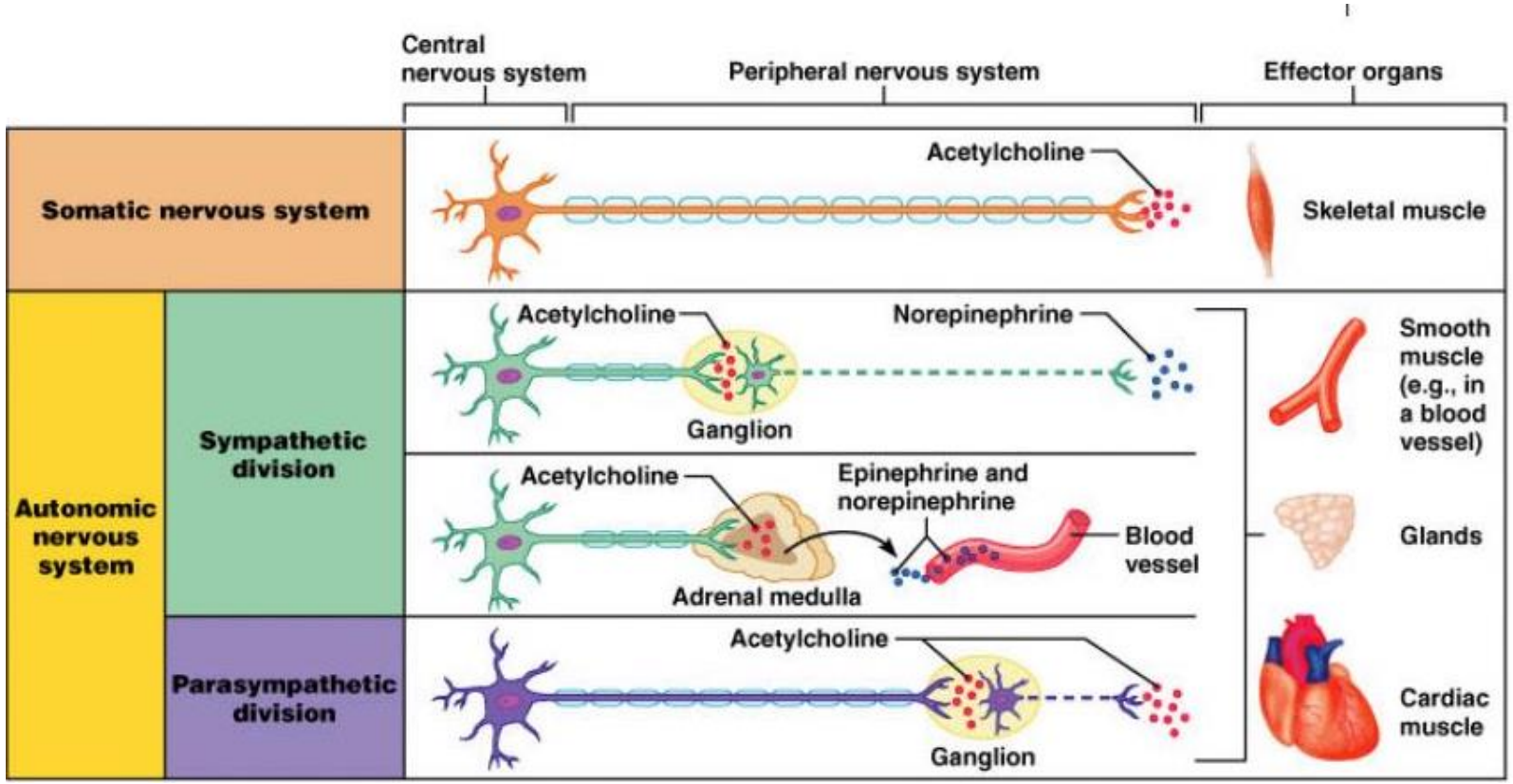
Although most tissues receive dual innervation, some effector organs, such as the adrenal medulla, kidney, and sweat glands, receive innervation only from the sympathetic system.

The control of blood pressure is also mainly a sympathetic activity, with essentially no participation by the parasympathetic system.



Somatic nervous system

The efferent somatic nervous system differs from the autonomic system in that a single myelinated motor neuron, originating in the CNS, travels directly to skeletal muscle without the mediation of ganglia. As noted earlier, the somatic nervous system is under voluntary control, whereas the autonomic is an involuntary system.

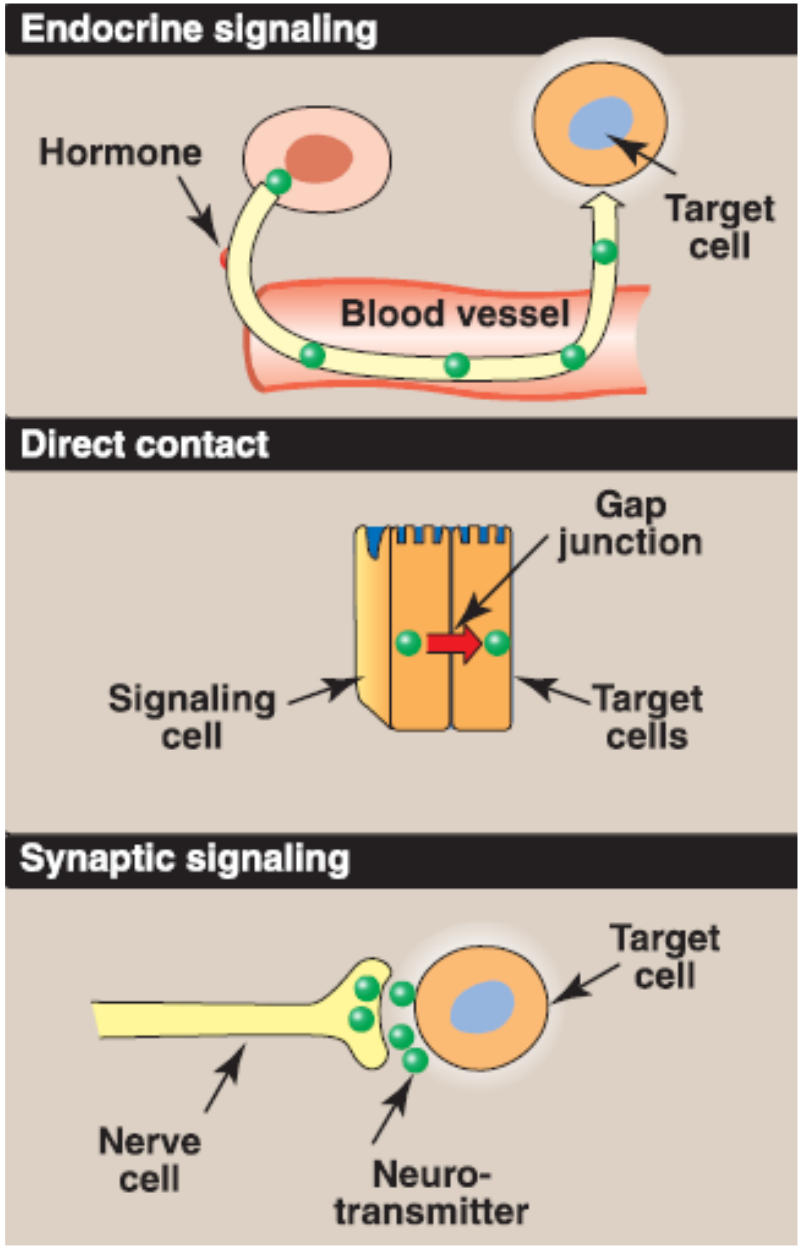


	SYMPATHETIC	PARASYMPATHETIC
Sites of origin	Thoracic and lumbar region of the spinal cord (thoracolumbar)	Brain and sacral area of the spinal cord (craniosacral)
Length of fibers	Short preganglionic Long postganglionic	Long preganglionic Short postganglionic
Location of ganglia	Close to the spinal cord	Within or near effector organs
Preganglionic fiber branching	Extensive	Minimal
Distribution	Wide	Limited
Type of response	Diffuse	Discrete

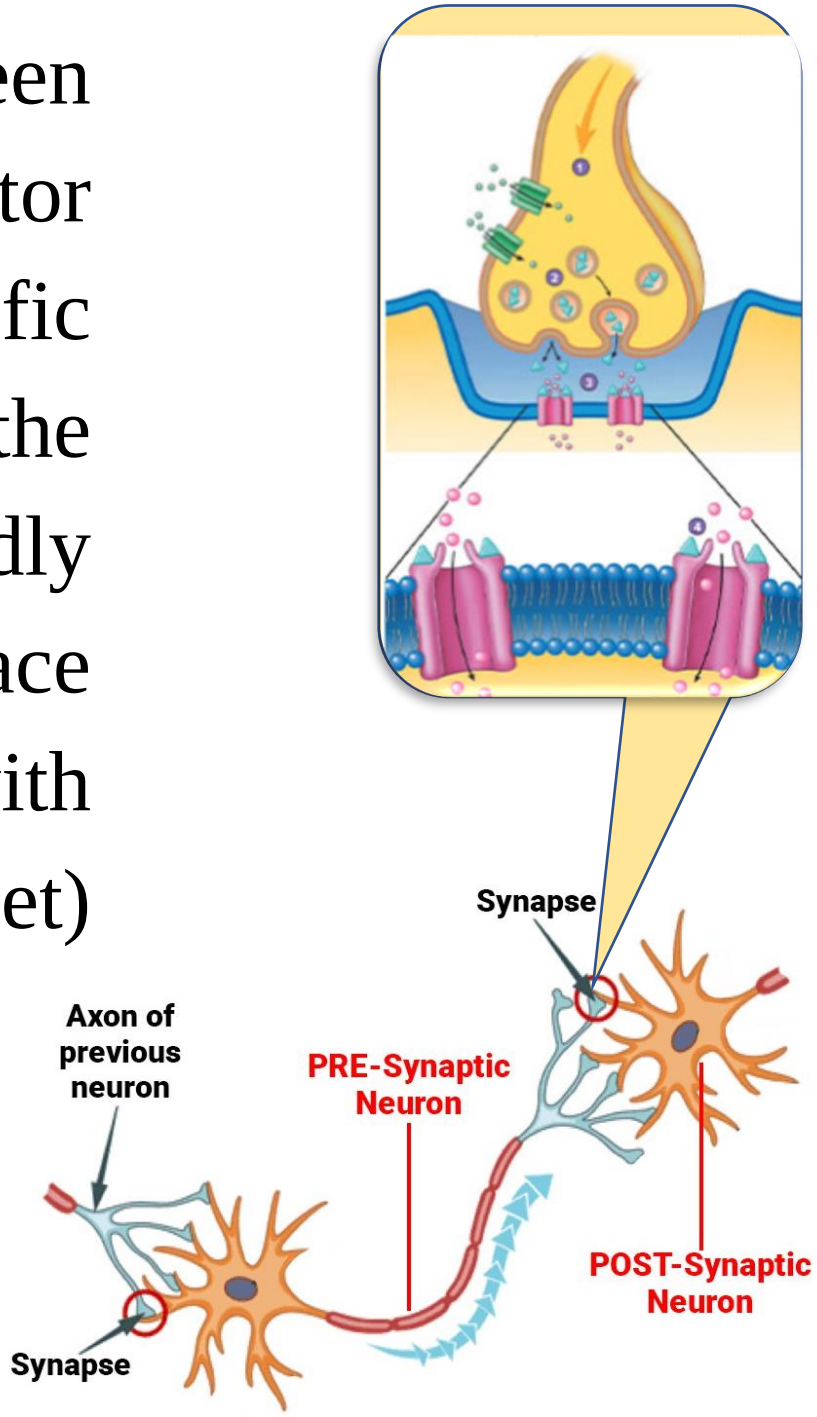
Chemical Signaling Between Cells.

A. Hormones: Glands secrete hormones which travel through bloodstream into target cells.

B. Local mediators: Body cells secrete chemicals (ex. Histamine and the prostaglandins) those act locally, on cells in their immediate environment. Local mediators are rapidly destroyed or removed; therefore, they do not distribute throughout the body.



C. Neurotransmitters: Communication between nerve cells, and between nerve cells and effector organs, occurs through the release of specific chemical signals (neurotransmitters) from the nerve terminals. The neurotransmitters rapidly diffuse across the synaptic cleft, or space (synapse), between neurons and combine with specific receptors on the postsynaptic (target) cell.



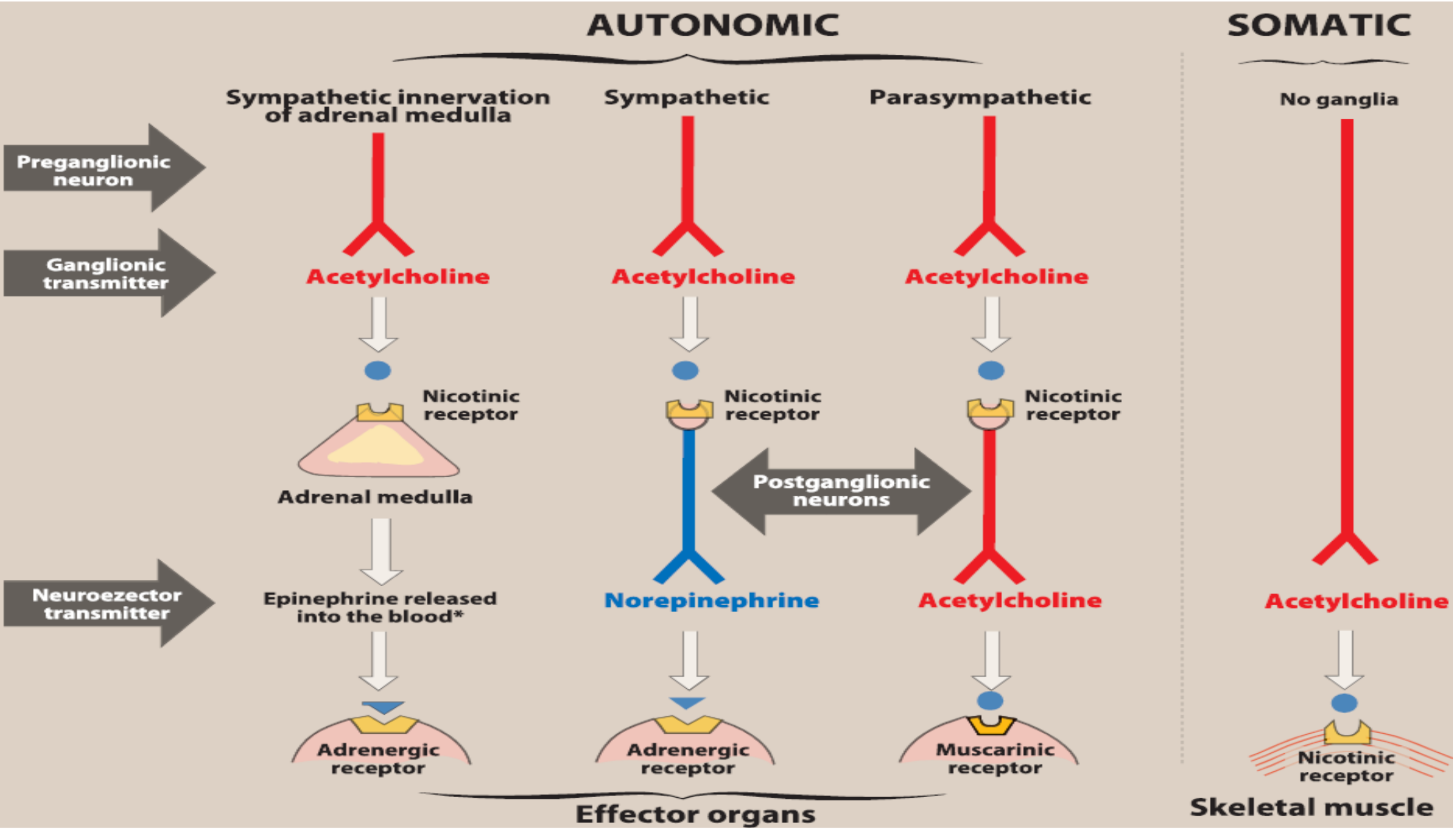
Types of neurotransmitters:

1- Norepinephrine (and the closely related epinephrine),
2- Acetylcholine,
3- Dopamine,
4- Serotonin,
5- Histamine, and
6- α-aminobutyric acid.
7- Glutamate,

Acetylcholine and Norepinephrine are the primary chemical signals in the autonomic nervous system.

Norepinephrine and epinephrine: When norepinephrine or epinephrine is the transmitter, the fiber is termed adrenergic (adrenaline being another name for epinephrine).

In the sympathetic system, norepinephrine mediates the transmission of nerve impulses from autonomic postganglionic nerves to effector organs.


AUTONOMIC
SOMATIC
Sympathetic innervation of adrenal medulla
Sympathetic
Parasympathetic
No ganglia
Preganglionic neuron
Ganglionic transmitter
Neuroezector transmitter
Acetylcholine
Acetylcholine
Acetylcholine
Nicotinic receptor
Nicotinic receptor
Nicotinic receptor
Adrenal medulla
Postganglionic neurons
Epinephrine released into the blood*
Norepinephrine
Acetylcholine
Acetylcholine
Adrenergic receptor
Adrenergic receptor
Muscarinic receptor
Nicotinic receptor
Effector organs
Skeletal muscle

Acetylcholine: If transmission is mediated by acetylcholine, the neuron is termed cholinergic.

Acetylcholine mediates the transmission of nerve impulses across autonomic ganglia in both the sympathetic and parasympathetic nervous systems.

It is the neurotransmitter at the adrenal medulla.

Transmission from the autonomic postganglionic nerves to the effector organs in the parasympathetic system involves the release of acetylcholine.

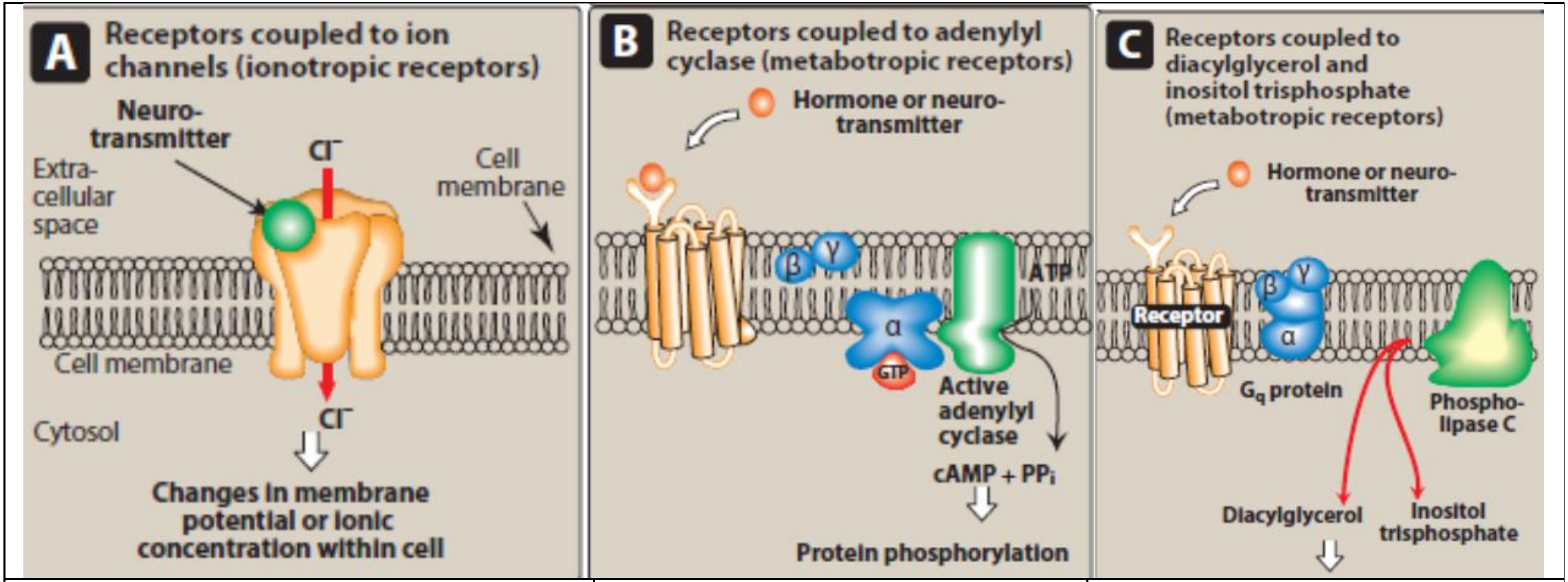
In the somatic nervous system, transmission at the neuromuscular junction (that is, between nerve fibers and voluntary muscles) is also cholinergic.

Signal Transduction in The Effector Cell in ANS (mechanisms)

The chemical signals (ligands) bind to:
1-Membrane receptors affecting ion permeability (ionotropic receptors).
2- Membrane receptors coupled to second messengers (metabotropic receptors)
Epinephrine and norepinephrine bind to adrenergic receptors,
Acetylcholine binds to cholinergic receptors. Cholinergic receptors are further classified as nicotinic or muscarinic.

Postsynaptic cholinergic nicotinic receptors in skeletal muscle cells, are directly linked to membrane ion channels and are known as ionotropic receptors. Binding of neurotransmitter to ionotropic receptors directly affects ion permeability

All adrenergic receptors and cholinergic muscarinic receptors are G protein-coupled receptors (metabotropic receptors)



	adenylyl cyclase system (cAMP)	calcium/phosphatidylinositol system (PI3)
ionotropic receptors	metabotropic receptors	metabotropic receptors

Three mechanisms whereby binding of a neurotransmitter leads to a cellular effect.

References

Lippincott Illustrated Reviews: Pharmacology. 7TH ed, Wolters Kluwer.

Thank you