Autonomic Nervous SYSTEM

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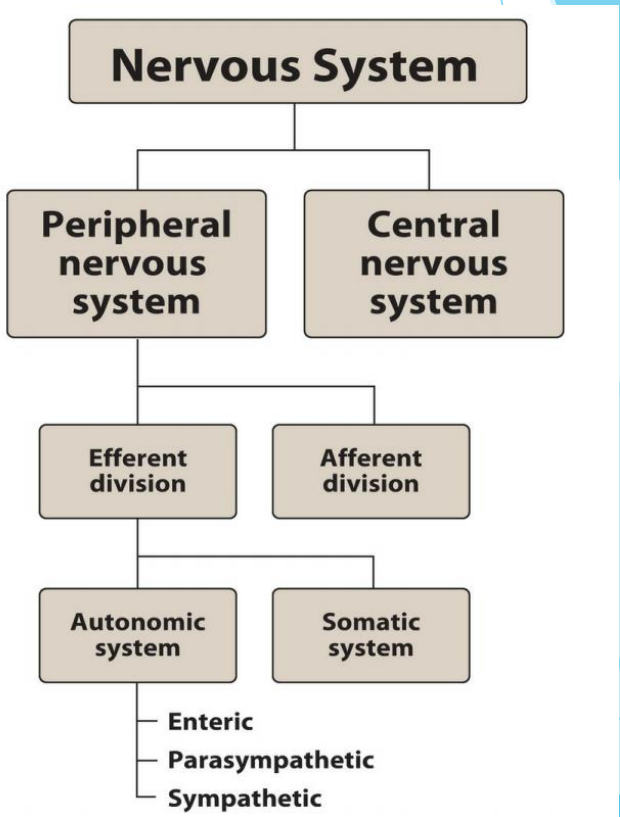
The Autonomic Nervous System

*The nervous system is divided into two anatomical divisions: the central nervous system (CNS), which is composed of the brain and spinal cord, and the peripheral nervous system, which includes neurons located outside the brain and spinal cord—that is, any nerves that enter or leave the CNS

*The efferent neurons carry signals away from the brain and spinal cord to the peripheral tissues.

*the afferent neurons bring information from the periphery to the CNS. Afferent neurons provide sensory input to modulate the function of the efferent division through reflex arcs or neural pathways that mediate a reflex action.



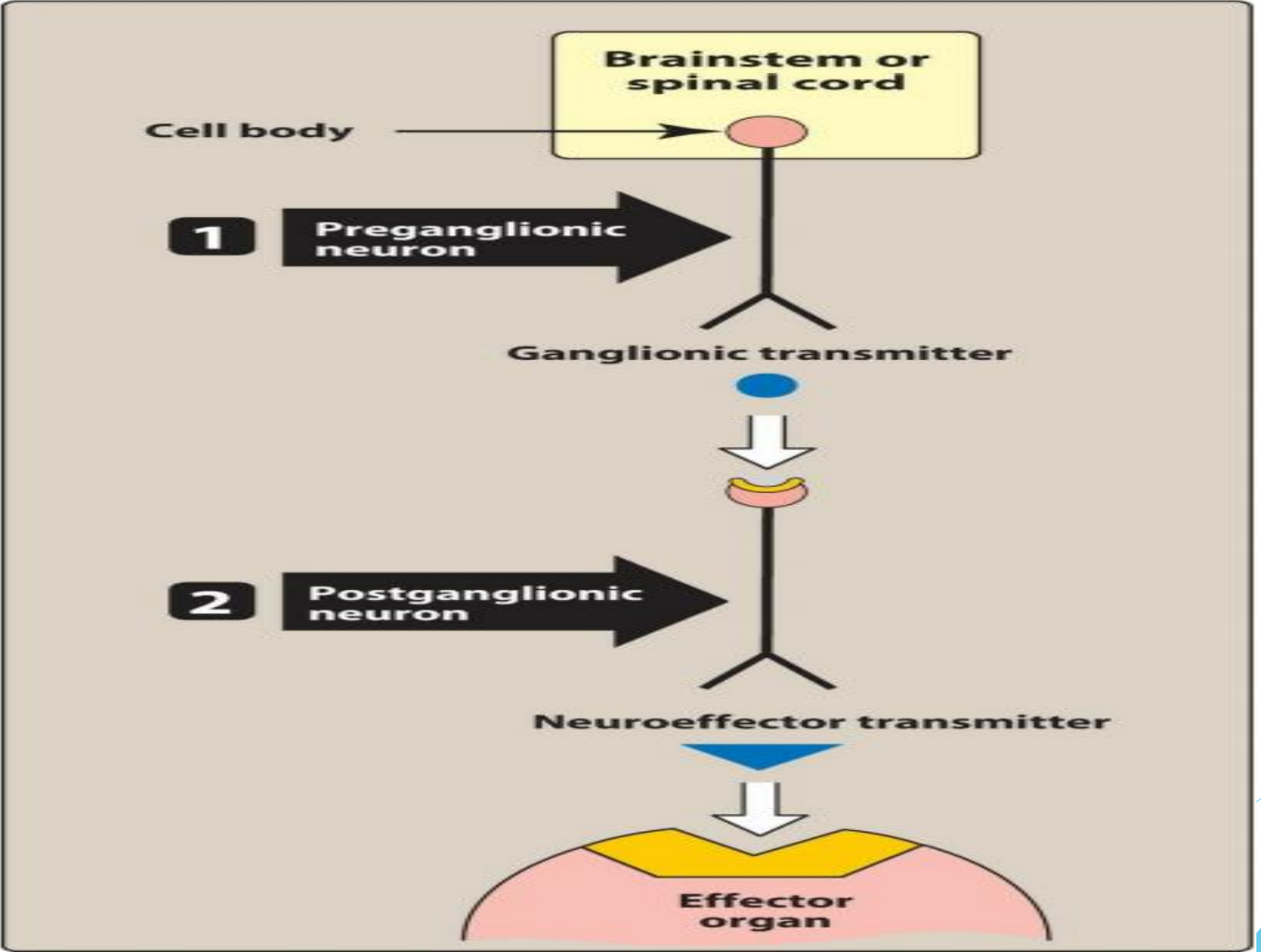
A. Functional divisions within the nervous system

- * The efferent portion of the peripheral nervous system is further divided into two major functional subdivisions: the somatic nervous system and the ANS
- * The somatic efferent neurons are involved in the voluntary control of functions such as contraction of the skeletal muscles essential for locomotion.
- * The ANS, conversely, regulates the everyday requirements of vital bodily functions without the conscious participation of the mind. Because of the involuntary nature of the ANS as well as its functions, it is also known as the visceral, vegetative, or involuntary nervous system. It is composed of efferent neurons that innervate visceral smooth muscle, cardiac muscle, vasculature, and the exocrine glands, thereby controlling digestion, cardiac output, blood flow, and glandular secretions.

B. Anatomy of the ANS

- 1. Efferent neurons
- The ANS carries nerve impulses from the CNS to the effector organs through two types of efferent neurons: the preganglionic neurons and the postganglionic neurons
- The cell body of the first nerve cell, the preganglionic neuron, is located within the CNS.
- The preganglionic neurons emerge from the brainstem or spinal cord and make a synaptic connection in ganglia

- The ganglia is an aggregation of nerve cell bodies located in the peripheral nervous system
- The ganglia function as relay stations between the preganglionic neuron and the second nerve cell, the postganglionic neuron.
- . The cell body of the postganglionic neuron originates in the ganglion. It is generally nonmyelinated and terminates on effector organs, such as visceral smooth muscle, cardiac muscle, and the exocrine glands.


Brainstem or spinal cord
Cell body
1
Preganglionic neuron
Ganglionic transmitter
2
Postganglionic neuron
Neuroeffector transmitter
Effector organ

2. Afferent neurons The afferent neurons (fibers) of the ANS are important in the reflex regulation of this system

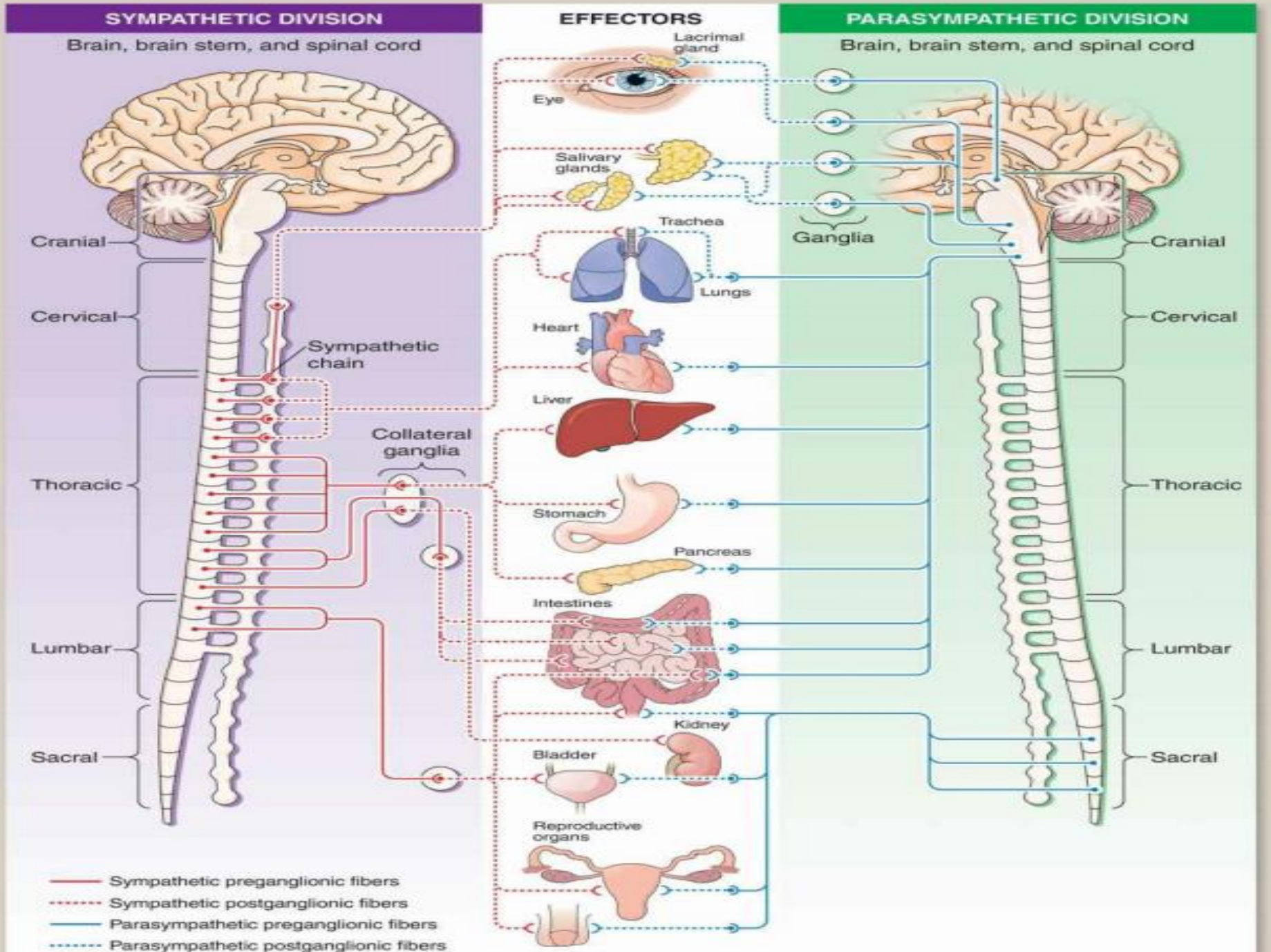
3. Sympathetic neurons

* The efferent ANS is divided into the sympathetic and the parasympathetic nervous systems

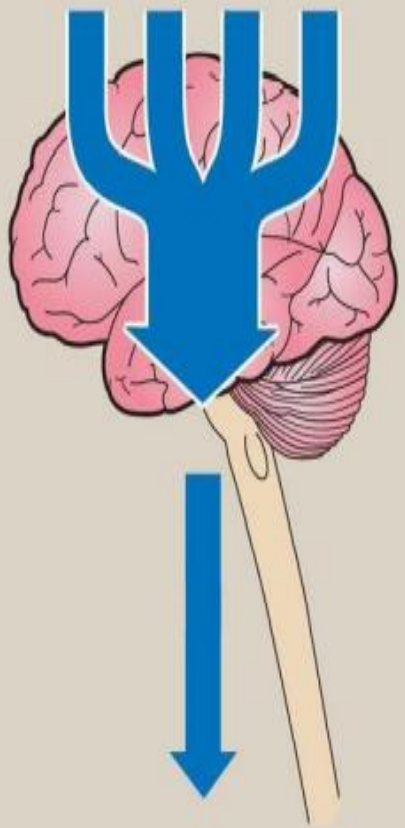
* the sympathetic and the parasympathetic neurons originate in the CNS and emerge from two different spinal cord regions

4. Parasympathetic neurons

	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


SYMPATHETIC DIVISION
Brain, brain stem, and spinal cord
EFFECTORS
PARASYMPATHETIC DIVISION
Brain, brain stem, and spinal cord
Lacrimal gland
Eye
Salivary glands
Trachea
Lungs
Heart
Liver
Collateral ganglia
Stomach
Pancreas
Intestines
Kidney
Bladder
Reproductive organs
Ganglia
Cranial
Cervical
Thoracic
Lumbar
Sacral
Sympathetic chain
Sympathetic preganglionic fibers
Sympathetic postganglionic fibers
Parasympathetic preganglionic fibers
Parasympathetic postganglionic fibers

"Rest-and-digest" stimulus

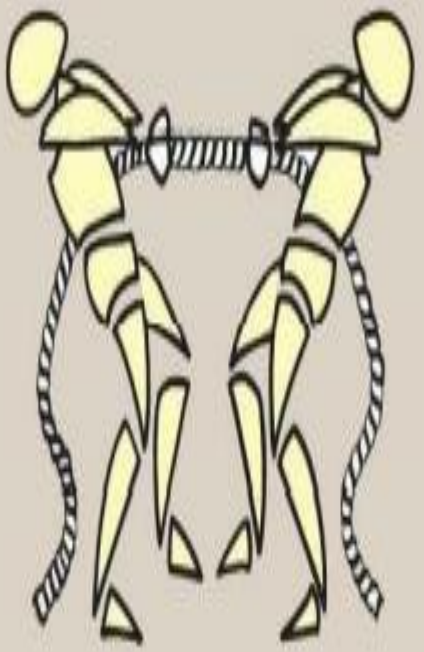


Parasympathetic output
(discrete because postganglionic neurons are not branched, but are directed to a specific organ)

"Fight-or-flight" stimulus

Sympathetic output
(diffuse because postganglionic neurons may innervate more than one organ)

Sympathetic and para-sympathetic actions often oppose each other



5. Enteric neurons : The enteric nervous system is the third division of the ANS. It is a collection of nerve fibers that innervate the gastrointestinal (GI) tract, pancreas, and gallbladder, and it constitutes the “brain of the gut.” This system functions independently of the CNS and controls motility, exocrine and endocrine secretions, and microcirculation of the GI tract. It is modulated by both the sympathetic and parasympathetic nervous systems.

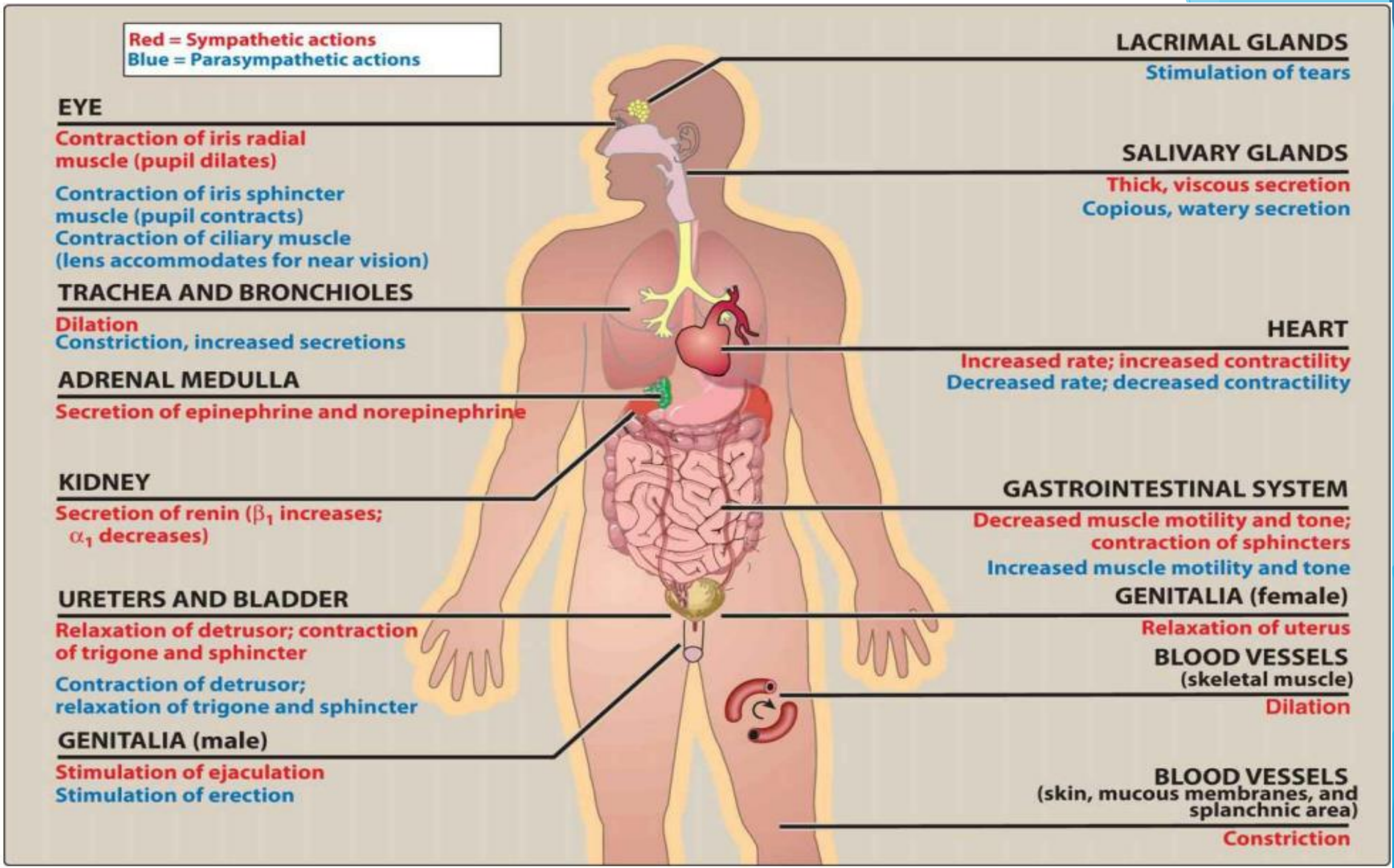
C. Functions of the sympathetic nervous system

1. Effects of stimulation of the sympathetic division The effect of sympathetic stimulation is an increase in heart rate and blood pressure, mobilization of energy stores, and increase in blood flow to skeletal muscles and the heart while diverting flow from the skin and internal organs.

* Sympathetic stimulation results in dilation of the pupils and bronchioles. It also reduces GI motility and affects function of the bladder and sexual organs.

2. Fight or flight response

it is not essential for survival, it is essential in preparing the body to handle uncertain situations and unexpected stimuli.


Red = Sympathetic actions
Blue = Parasympathetic actions
EYE
Contraction of iris radial muscle (pupil dilates)
Contraction of iris sphincter muscle (pupil contracts)
Contraction of ciliary muscle (lens accommodates for near vision)
TRACHEA AND BRONCHIOLES
Dilation
Constriction, increased secretions
ADRENAL MEDULLA
Secretion of epinephrine and norepinephrine
KIDNEY
Secretion of renin (β_1 increases; α_1 decreases)
URETERS AND BLADDER
Relaxation of detrusor; contraction of trigone and sphincter
Contraction of detrusor; relaxation of trigone and sphincter
GENITALIA (male)
Stimulation of ejaculation
Stimulation of erection
LACRIMAL GLANDS
Stimulation of tears
SALIVARY GLANDS
Thick, viscous secretion
Copious, watery secretion
HEART
Increased rate; increased contractility
Decreased rate; decreased contractility
GASTROINTESTINAL SYSTEM
Decreased muscle motility and tone; contraction of sphincters
Increased muscle motility and tone
GENITALIA (female)
Relaxation of uterus
BLOOD VESSELS (skeletal muscle)
Dilation
BLOOD VESSELS (skin, mucous membranes, and splanchnic area)
Constriction

D. Functions of the parasympathetic nervous system

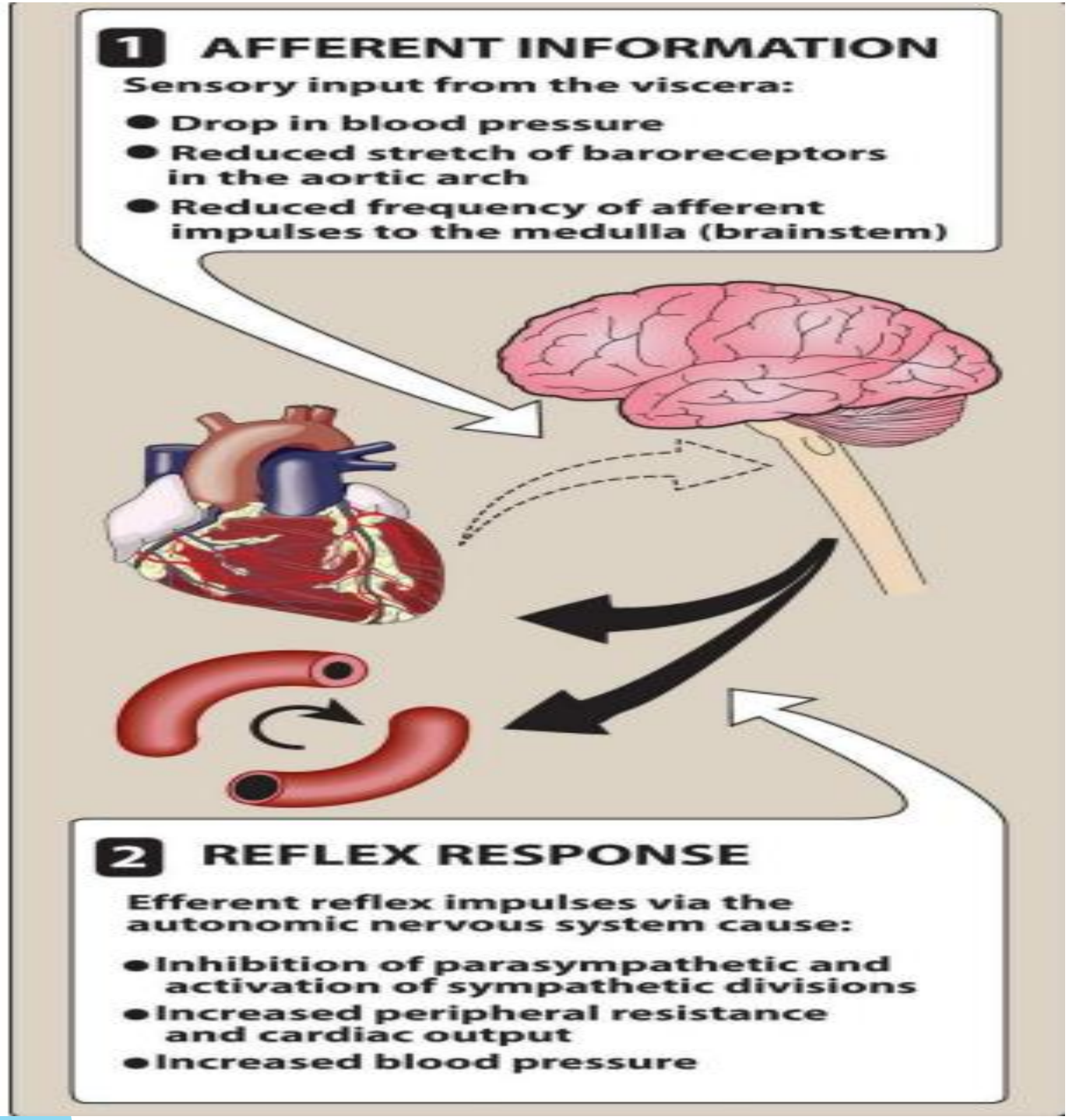
* The parasympathetic division is involved with maintaining homeostasis within the body.
* It is required for life, since it maintains essential bodily functions, such as digestion and elimination .
* The parasympathetic division usually acts to oppose or balance the actions of the sympathetic division and generally predominates the sympathetic system in “rest-and-digest” situations.

E. Role of the CNS in the control of autonomic functions

Although the ANS is a motor system, it does require sensory input from peripheral structures to provide information on the current state of the body.

1. Reflex arcs Most of the afferent impulses are involuntarily translated into reflex responses. For example, a fall in blood pressure causes pressure-sensitive neurons (baroreceptors in the heart) 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 heart rate

2. Emotions and the ANS Stimuli that evoke strong feelings, such as rage, fear, and pleasure, can modify activities of the ANS.


1 AFFERENT INFORMATION
Sensory input from the viscera:
● Drop in blood pressure
● Reduced stretch of baroreceptors in the aortic arch
● Reduced frequency of afferent impulses to the medulla (brainstem)
2 REFLEX RESPONSE
Efferent reflex impulses via the autonomic nervous system cause:
● Inhibition of parasympathetic and activation of sympathetic divisions
● Increased peripheral resistance and cardiac output
● Increased blood pressure

F. Innervation by the ANS

1. Dual innervation

Most organs are innervated by both divisions of the ANS. Thus, vagal parasympathetic innervation slows the heart rate, and sympathetic innervation increases heart rate.

2. Sympathetic innervation

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

G. Somatic nervous system

The efferent somatic nervous system differs from the ANS 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 ANS is involuntary. Responses in the somatic division are generally faster than those in the ANS.

. Neurotransmitters

- 1. Types of neurotransmitters

*Acetylcholine and norepinephrine are the primary chemical signals in the ANS

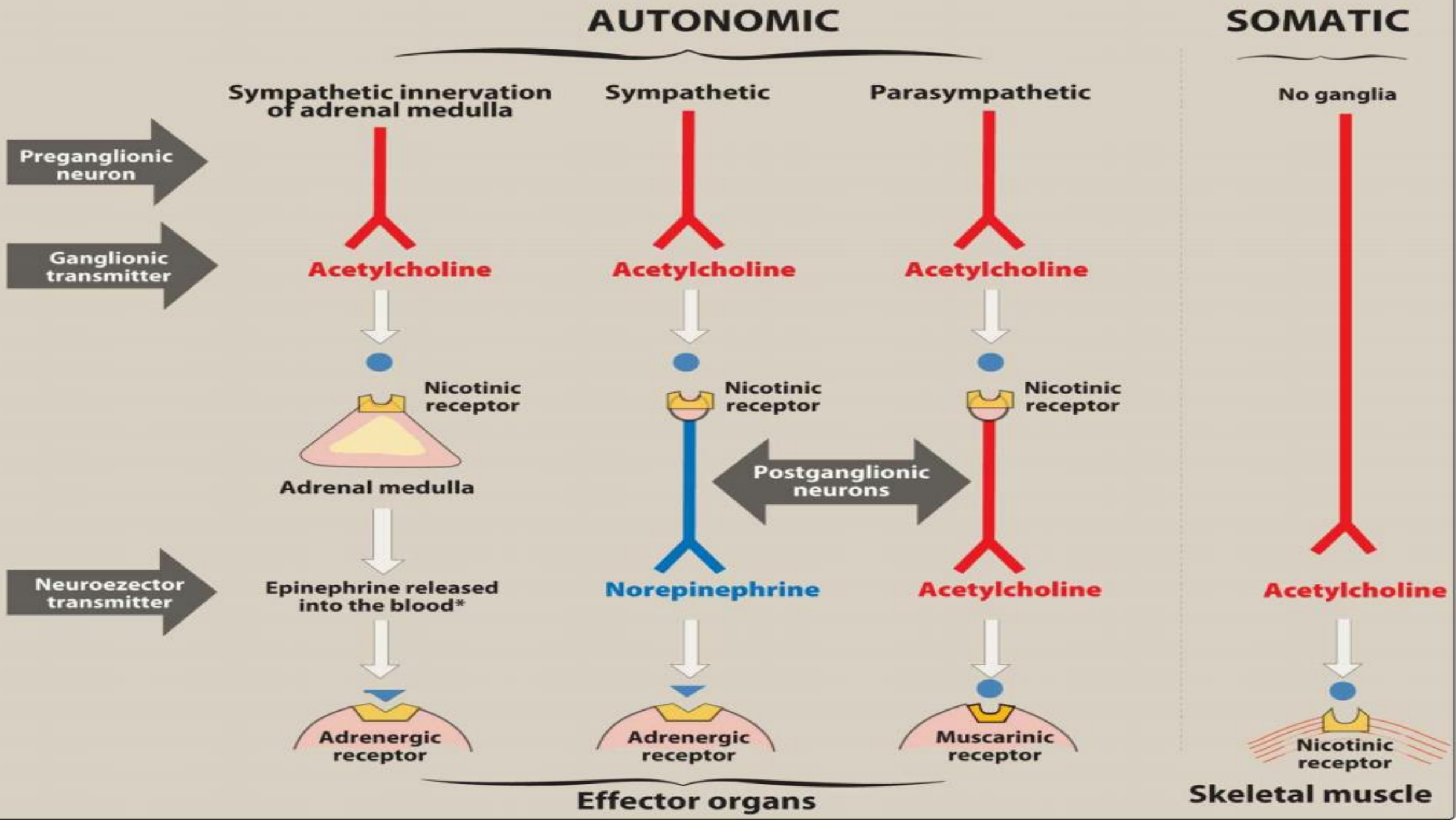
- over 50 signal molecules in the nervous system have been identified, norepinephrine (and the closely related epinephrine), acetylcholine, dopamine, serotonin, histamine, glutamate, and γ-aminobutyric acid are most commonly involved in the actions of therapeutically useful drugs.
- 2. Acetylcholine

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

*in the somatic nervous system, transmission at the neuromuscular junction (the junction of nerve fibers and voluntary muscles) is also cholinergic

3. Norepinephrine and 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