AUTONOMIC NERVOUS SYSTEM

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Learning Objectives

- **Organization of the Autonomic Nervous System.**
- **Terminology.**
- **Sympathetic Nervous System (SNS).**
- **Neurotransmitters and Types of Receptors.**
- **Parasympathetic Nervous System.**
- **Autonomic Receptors: Adrenoreceptors, Cholinorecptors**
- **Prototypes of Agonists and Antagonists to Autonomic Receptors.**
- **Sympathetic and Parasympathetic Tone.**
- **Function of Adrenal Gland.**
- **Examples of The Effects of Sympathetic and Parasympathetic.**

SOMATIC AND AUTONOMIC NERVOUS SYSTEM

The motor efferent nervous system has two components:

- Somatic

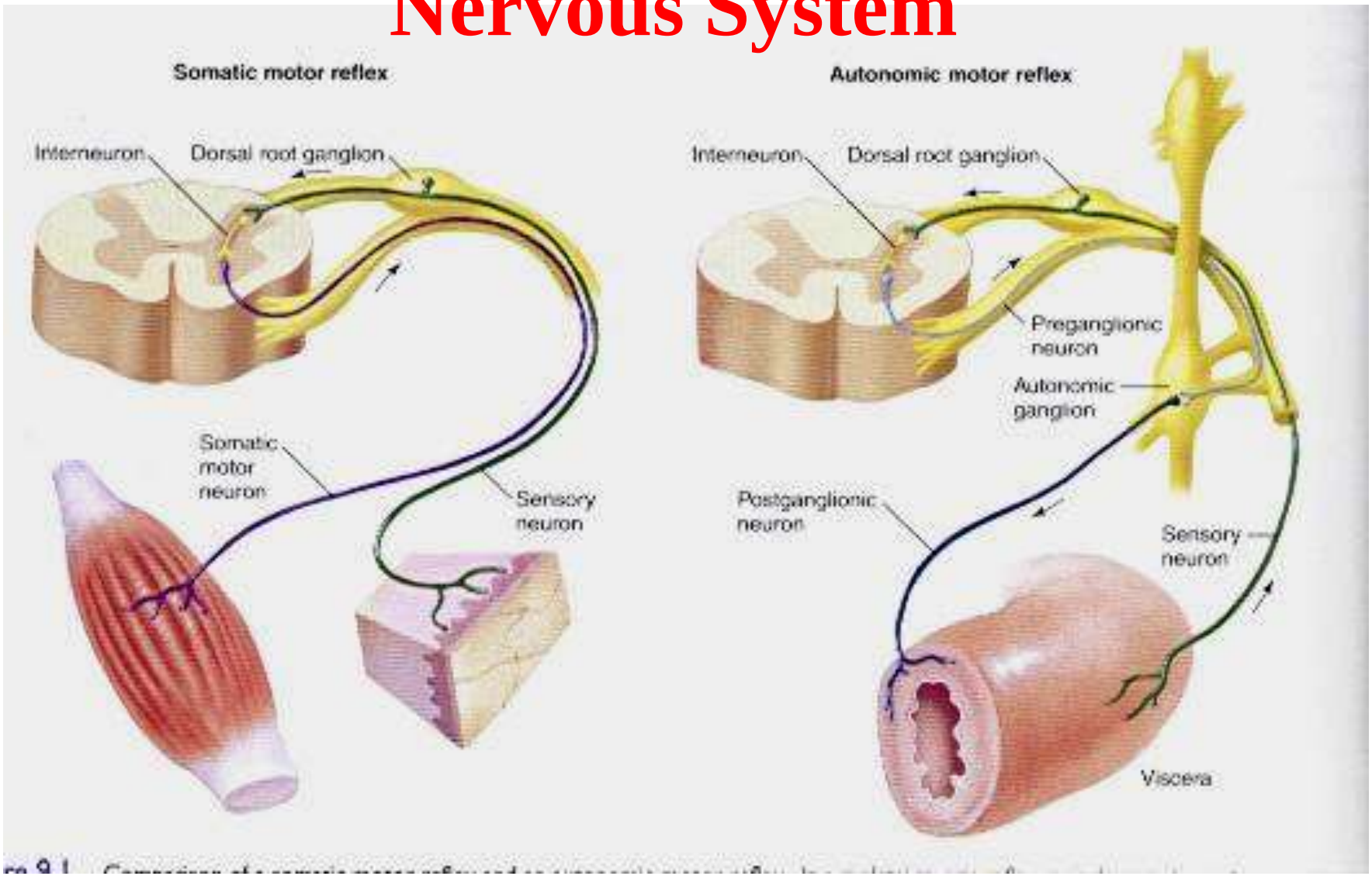
- Autonomic

❖**Somatic Nervous System:**

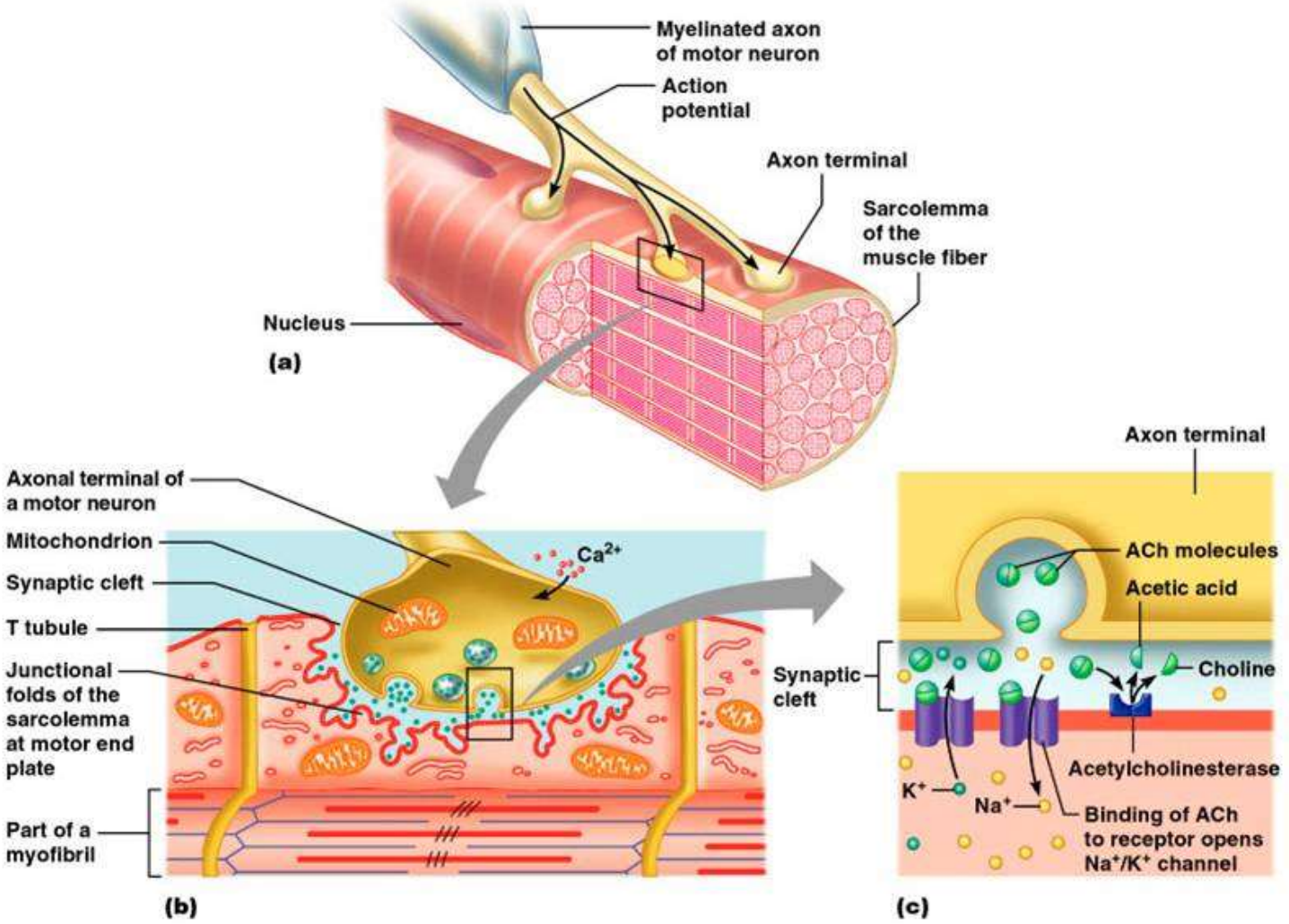
➢**a voluntary nervous system under conscious control.**

➢**consists of a single motoneuron and skeletal muscle fibers.**

Organization of the Autonomic Nervous System

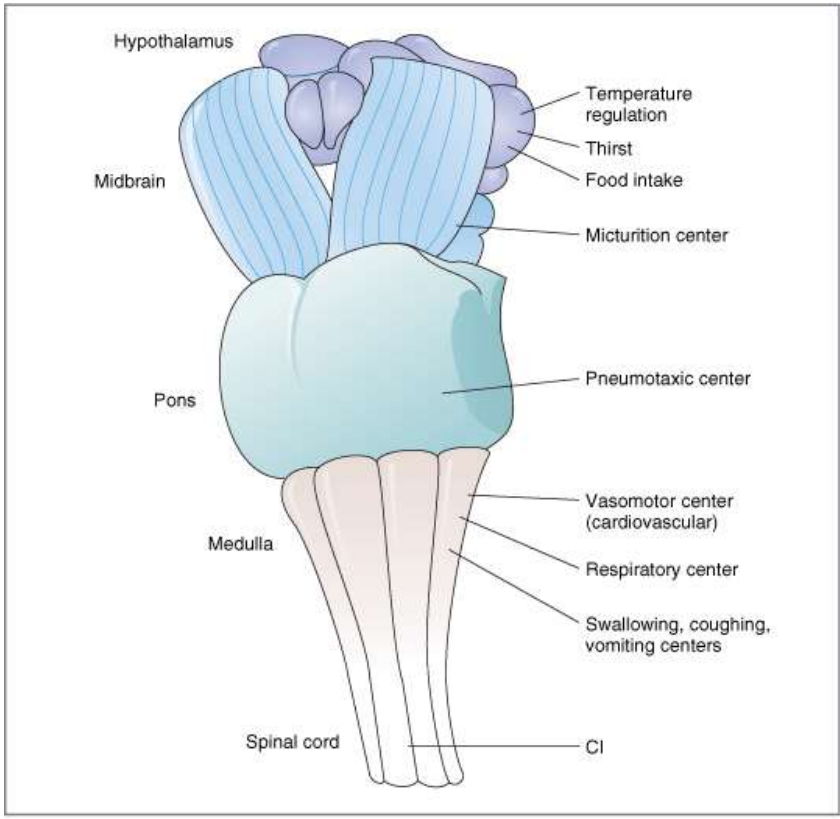


Somatic Nervous System



Organization of the Autonomic Nervous System

- **An involuntary nervous system that modulates and controls the function of visceral organs.**
- **Autonomic nervous system (ANS) consists of two major divisions: (1) Sympathetic; (2) Parasympathetic.**
- **ANS is activated by centers in spinal cord, brain stem and hypothalamus.**
- **ANS is operated by visceral reflex.**



Autonomic Nervous System (ANS)

Organization of autonomic nervous system motor pathway consists of two neurons:

- **Preganglionic neuron.**
- **Postganglionic neuron.**

Autonomic Nervous System (ANS)

- **All preganglionic neurons release Acetylcholine (Ach).**
- **Post ganglionic neurons release either Ach, or norepinephrine.**

Terminology

- **Sympathetic and parasympathetic are anatomic terms and refer to anatomic origin of preganglionic neurons in the centeral nervous system (CNS).**

- **Adrenergic and Cholinergic terms are used to describe neurons of either division, according to which neurotransmitter they synthesize and release.**

Terminology

- **Adrenergic neurons release nor-epinephrine and the receptor is adrenoreceptor.**

- **Cholinergic neurons release Ach and the receptor is cholinergic receptor.**

Sympathetic Nervous System (SNS)

Sympathetic Nervous System (SNS)

- **Operates continuously to modulate the functions of many organ systems e.g; heart, blood vessels, gastrointestinal tract, bronchi and sweat glands.**

- **Stressful stimulation activates SNS leads to a response known as "fight or flight": increased arterial pressure, blood flow, blood glucose, metabolic rate and mental activity.**

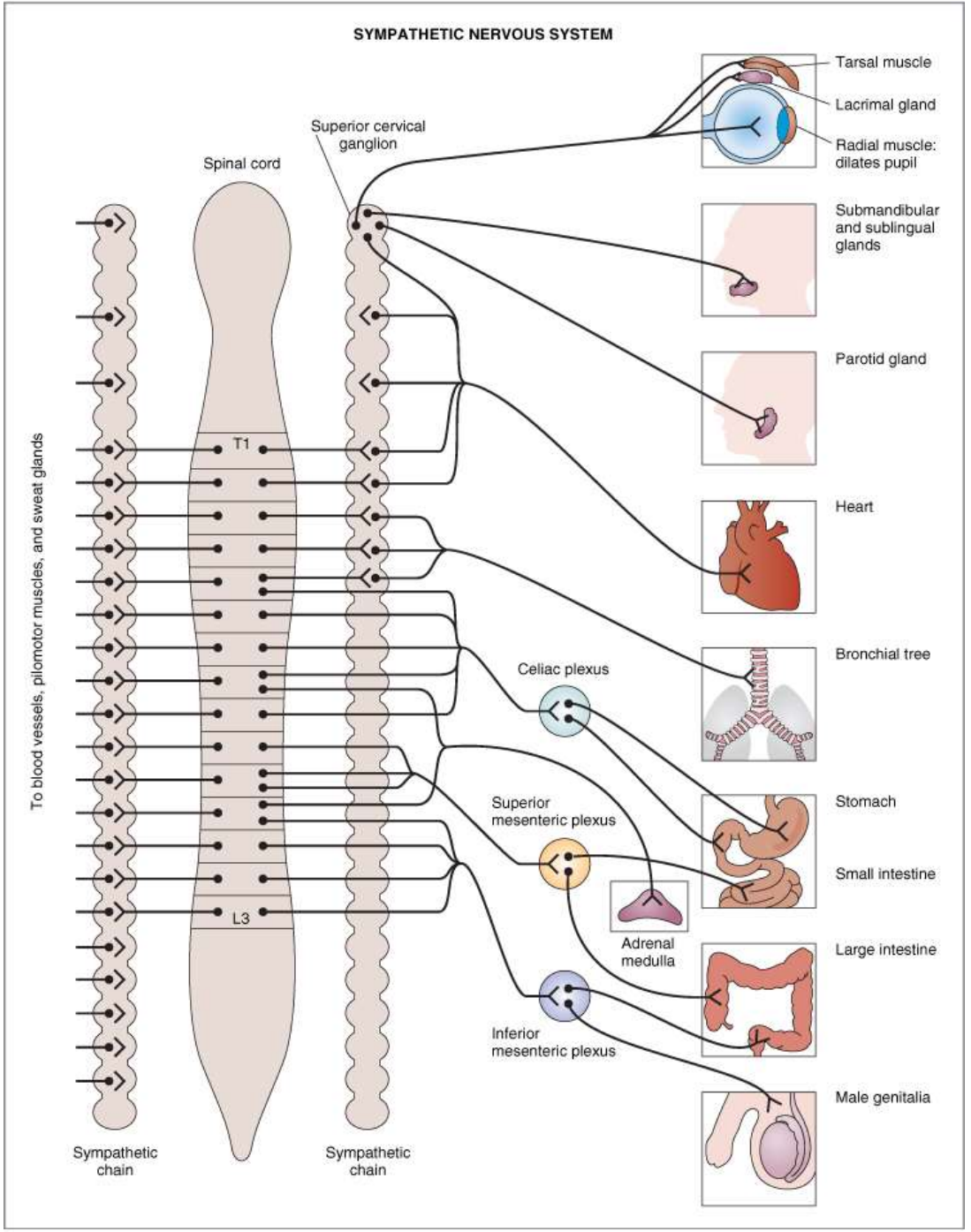
Sympathetic Nervous System (cont.)

- **Sympathetic preganglionic neurons originate from thoracolumbar spinal cord (T1-L3).**

- **SNS ganglia are located near the spinal cord either in the paravertebral ganglia (sympathetic chain) or in the prevertebral ganglia.**

- **Preganglionic neurons are short and the post ganglionic neurons are long.**

Sympathetic Nervous System (cont.)



Neurotransmitters and Types of Receptors

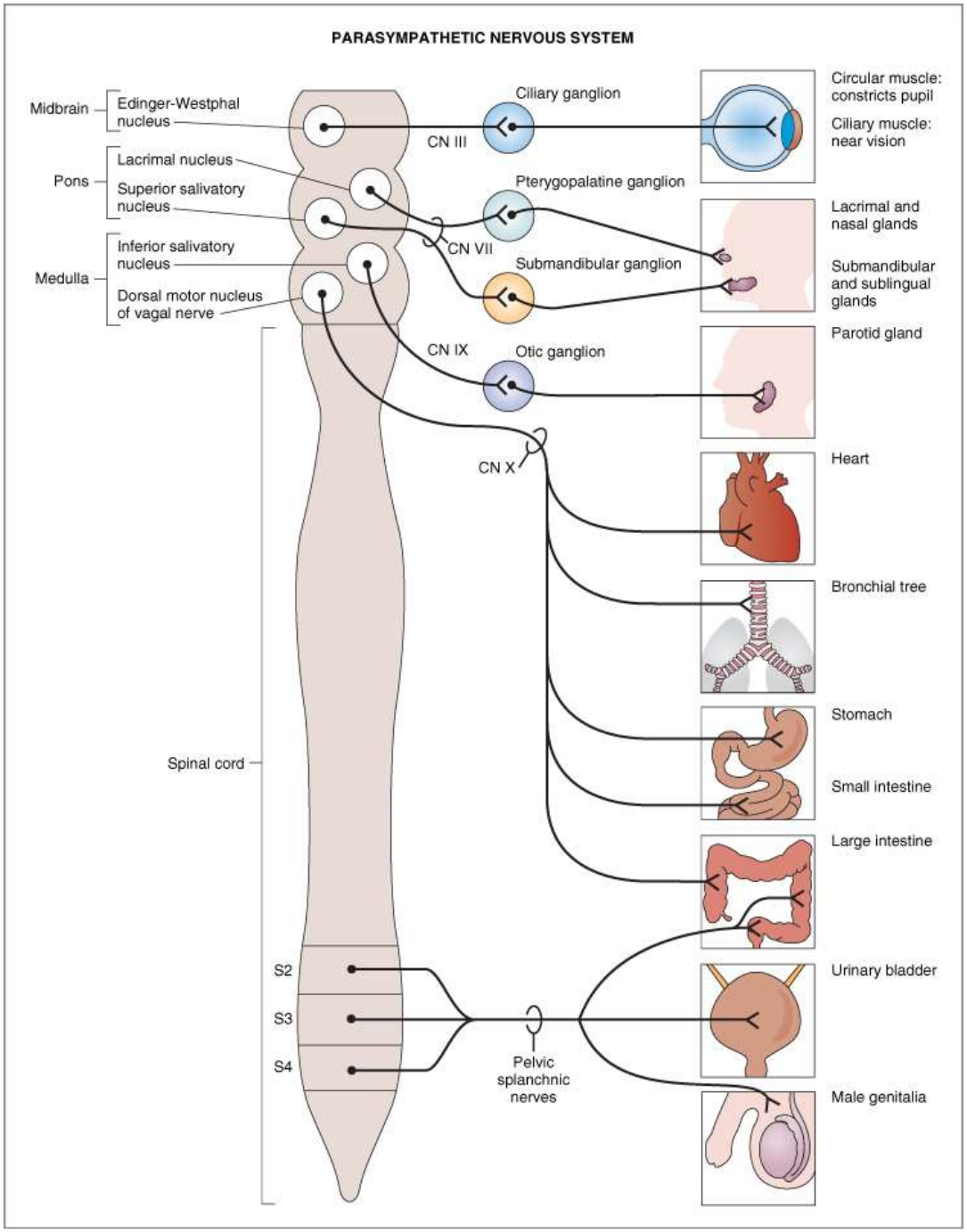
- **Preganglionic neurons are always cholinergic.**
- ✓ **Release Ach, interacts with nicotinic receptors on the cell body of postganglionic neurons.**
- **Postganglionic neurons are adrenergic except in thermoregulatory sweat glands (muscranic, cholinergic).**
- **Adrenergic neurons affect adrenorecepters: $alpha_1$, $alpha_2$, $beta_1$, $beta_2$**

Parasympathetic Nervous System

Parasympathetic Nervous System

- **Preganglionic fibers originate from cranial nuclei in brain stem (mid brain, pons, medulla) and in sacral segments (S_2-S_4) (Craniosacral).**
- **Parasympathetic ganglia are located on or in the affected organs.**
- **Preganglionic neuron has long axon and postganglionic neuron has short axons.**

Parasympathetic Nervous System

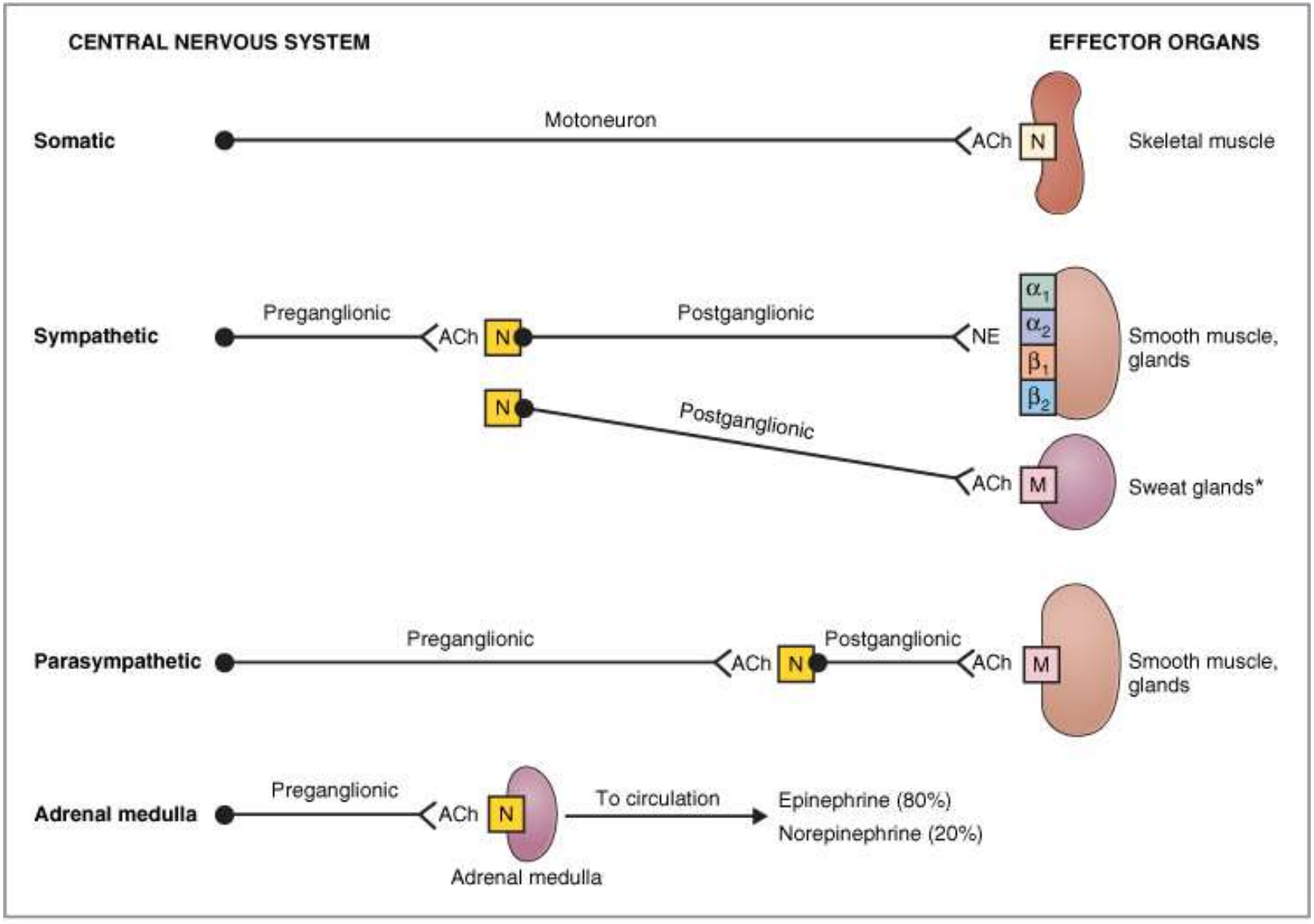


Neurotransmitters and types of receptors

- **All preganglionic neurons are cholinergic, release Ach which interacts with nicotinic receptors.**

- **Postganglionic neurons are cholinergic, release Ach which interacts with muscrinic receptors.**

Organization of the Autonomic Nervous System



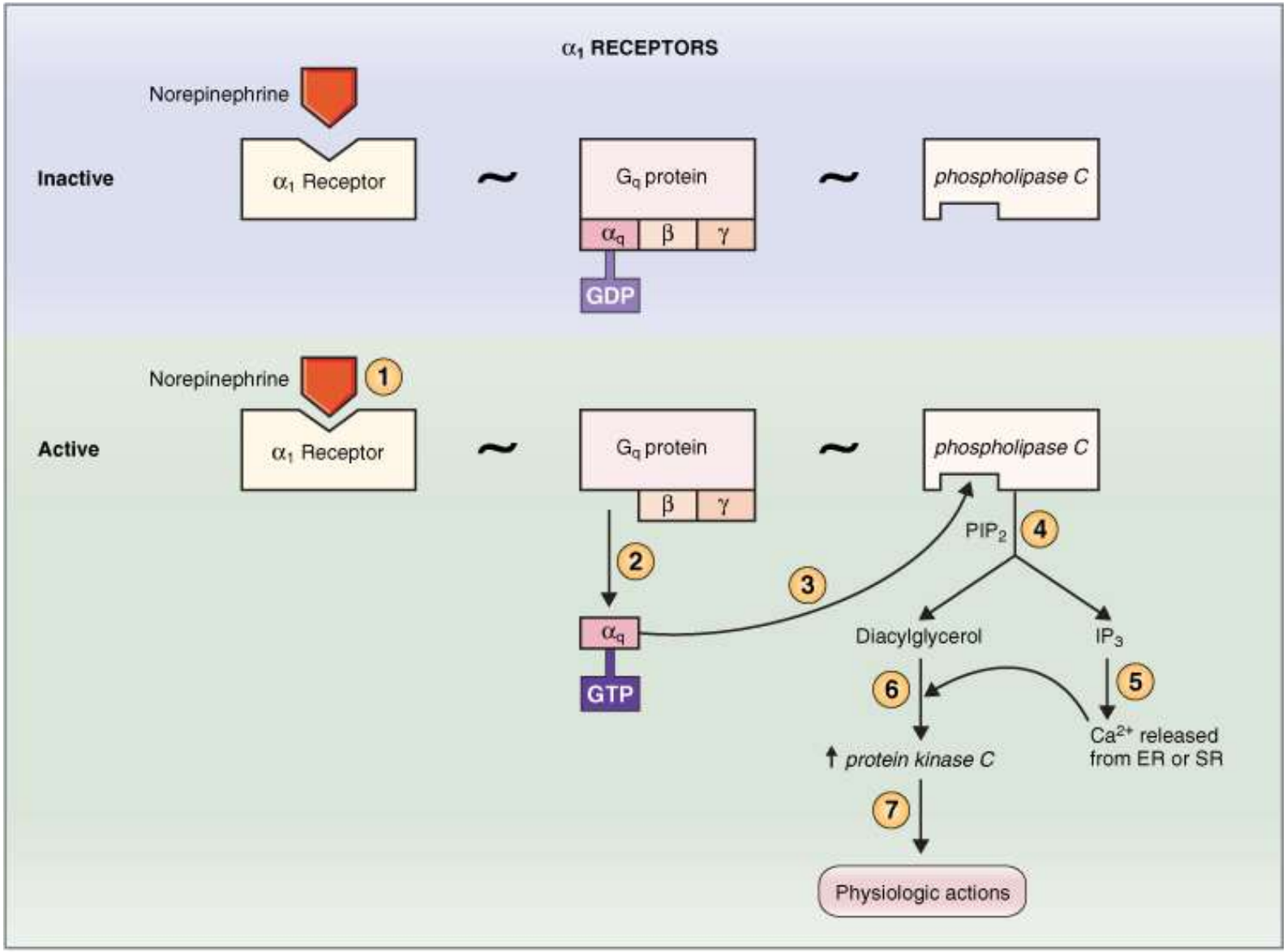
Autonomic Receptors

- **Adrenoreceptors**
- **Cholinoreceptors**

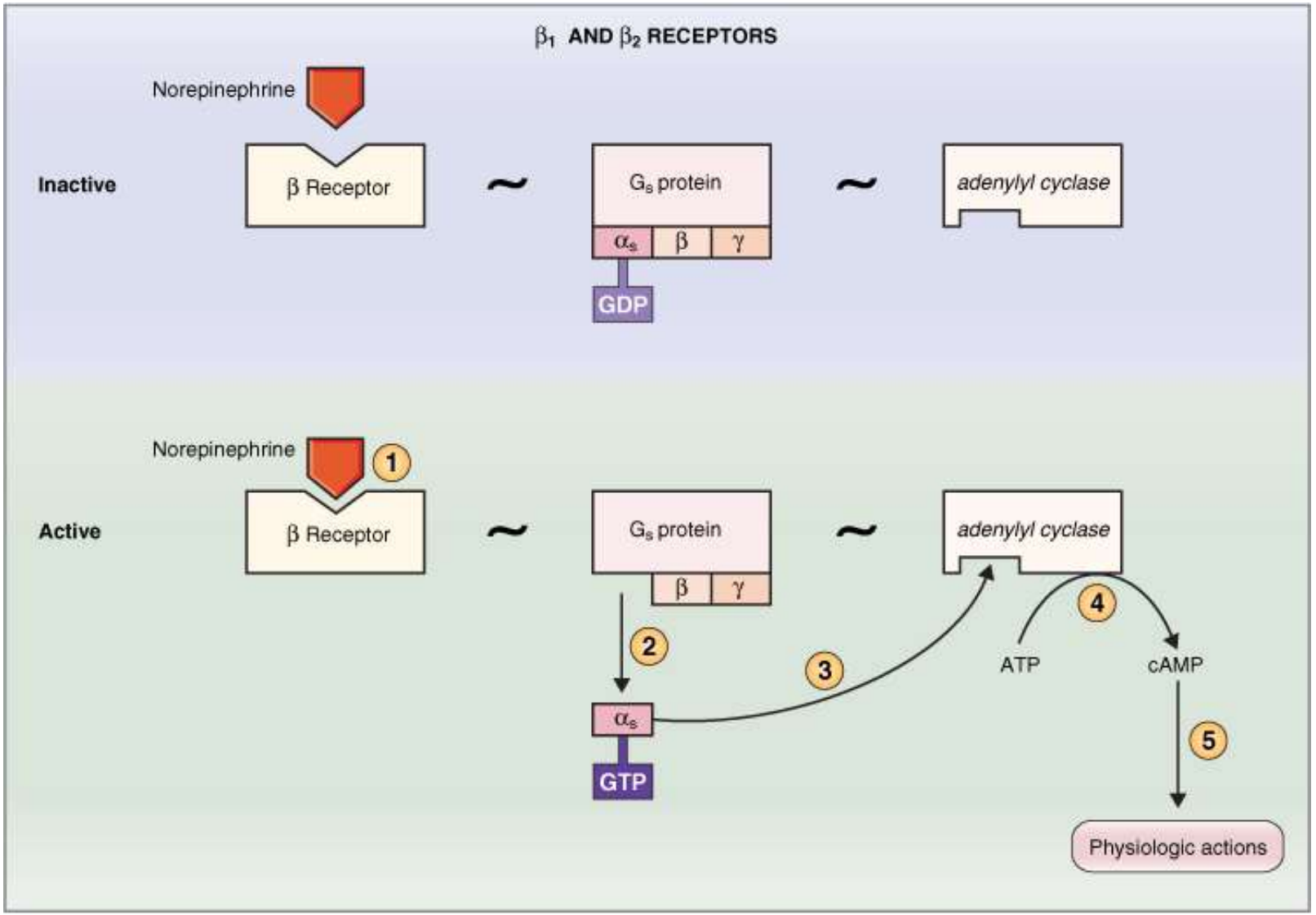
Adrenoreceptors

- **α_1 receptors: are found in vascular smooth muscle, gastrointestinal (GI) sphincters and bladder, and radial muscle of iris:**
  - **Activation of α_1 → ↑contraction.**
- **β_1 receptors: are found in the following tissues:**
  - ✓ **Sainoatrial node (S.A node) → ↑heart rate.**
  - ✓ **Atrioventricular node (AV node) → ↑ conduction velocity.**
  - ✓ **Ventricular muscle → ↑contractility.**
  - ✓ **Salivary gland → ↑salivary secretions.**
- **β_2 receptors: are found in vascular smooth muscle wall of bladder, and wall of GI.**
  - **Activation of β_2 → relaxation.**
  - **β_2 more sensitive to Epinephrine than Nor-epinephrine.**

α1 receptor



β1, β2 receptors



Cholinorecepters

- **Nicotinic Receptor (N):**

- an ion channel for Na+ and K+

- in all postganglionic neurons, motor end plate at skeletal muscle and chromaffin cells.

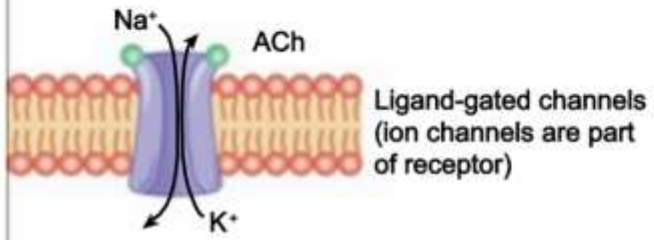
- **Muscurinic Receptor (M):**

- Works either like α_1 adrenoreceptor via DAC, PKC and IP3 or via G protein which has α subunit that binds K+ channel and open it.

Cholinorecepters

Nicotinic ACh receptors

Postsynaptic membrane of
- All autonomic ganglia
- All neuromuscular junctions
- Some CNS pathways



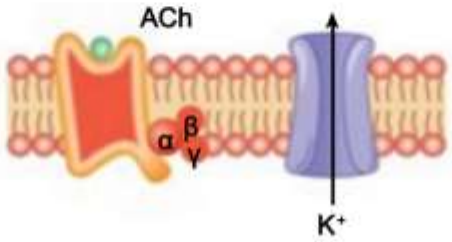
Ligand-gated channels (ion channels are part of receptor)

Depolarization

Excitation

Muscarinic ACh receptors

- Produces parasympathetic nerve effects in the heart, smooth muscles, and glands
- G-protein-coupled receptors (receptors influence ion channels by means of G-proteins)

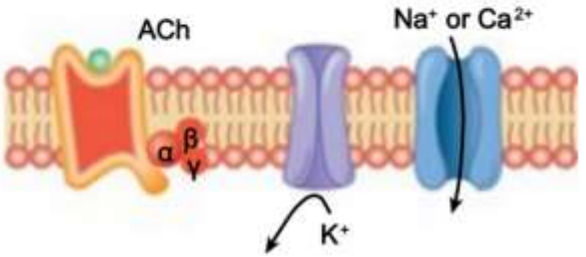


Hyperpolarization

(K+ channels opened)

Inhibition

Produces slower heart rate



Depolarization

(K+ channels closed)

Excitation

Causes smooth muscles of the digestive tract to contract

Autonomic Receptors (in summary)

- **The type of receptor and its mechanism of action determine the physiologic response:**
  e.g. β_1 receptor in SA node and in ventricular muscle:
- **SA node: activation of SA node by the agonist (Norepinephrine) → ↑ heart rate.**
- **ventricular muscles → ↑ contractility.**

Prototypes of Agonists and Antagonists to Autonomic Receptors

Receptor	Agonists	Antagonists
• Adrenoreceptors		
α_1	Norepinephrine	Phenoxybenzamine
	Phenylephrine	Prazosin
α_2	Clonidine	Yohimbine
β_1	Norepinephrine	Propranolol
	Isoproterenol	Metoprolol
β_2	Epinephrine	Propranolol
	Isoproterenol	Butoxamine
	Albuterol	
• Cholinoreceptors		
Nicotinic	ACh	Curare
	Nicotine Carbachol	Hexamethonium (blocks ganglionic receptor but not neuromuscular junction)
Muscarinic	ACh	Atropine
	Muscarine	
	Carbachol	

Sympathetic and Parasympathetic Tone

The role of them is to keep the stimulated organs in normal stage.

Examples:

1. **sympathetic always keeps the blood vessel constricted ½ of its normal diameter.**
2. **removal of vagus nerve → atony → loss of peristalsis (contraction of small intestine) → constipation.**

Effect of loss of sympathetic and parasympathetic tone after denervation

- **Loss of sympathetic tone in blood vessel causes severe vasodilatation but after sometime, intrinsic tone increases by chemical adaptation.**

Function of Adrenal Gland

- **Stimulation of sympathetic nerves causes large quantities of Epinephrine and Nor-epinephrine to be secreted in blood from adrenal gland.**
- **The effect of Epinephrine & Nor-epinephrine lasts 5-10 times more than the ones which secreted from sympathetic.**

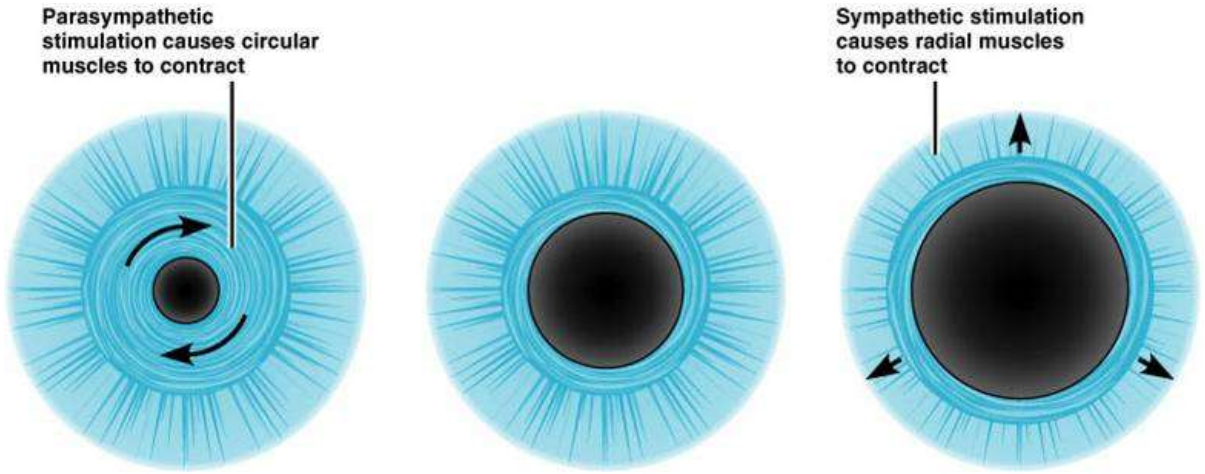
Examples of The Effects of Sympathetic and Parasympathetic

Effects of Sympathetic and Parasympathetic stimulation on specific organs

The Eyes:

- **Sympathetic stimulation contracts the meridional fibers of the iris (radial muscles) to dilate the pupil.**
- **Parasympathetic stimulation contracts the circular muscle of the iris to constrict the pupil.**
- **Focusing of the lens is controlled by parasympathetic through contraction of ciliary muscle.**

Pupil Dilation and Constriction



Effects of Sympathetic and Parasympathetic stimulation on specific organs (continued)

The Glands:

- ✓ Controlled by parasympathetic → ↑their secretions.
- ✓ Sympathetic causes vasoconstriction of the blood vessels to the glands which causes reduction in their secretion.
- ✓ Sweat glands secretion:
  increased by sympathetic stimulation.

Effects of Sympathetic and Parasympathetic stimulation on specific organs (continued)

The Gastrointestinal tract (GI):

- **Enteric nervous system.**
- **Parasympathetic nervous system increases the activity of GI tract (increases peristaltic contraction, and sphincter relaxation).**
- **Sympathetic decreases the activity of GI.**

Effects of Sympathetic and Parasympathetic stimulation on specific organs (continued)

The Heart:

- **Sympathetic stimulation → ↑ activity of the heart.**
- **Parasympathetic stimulation does the opposite.**

Systemic Blood Vessels:

- **Constricted by stimulation of sympathetic.**
- **No effect of the parasympathetic except in certain areas, such as blushing of the face.**

Effects of Sympathetic and Parasympathetic stimulation on specific organs (continued)

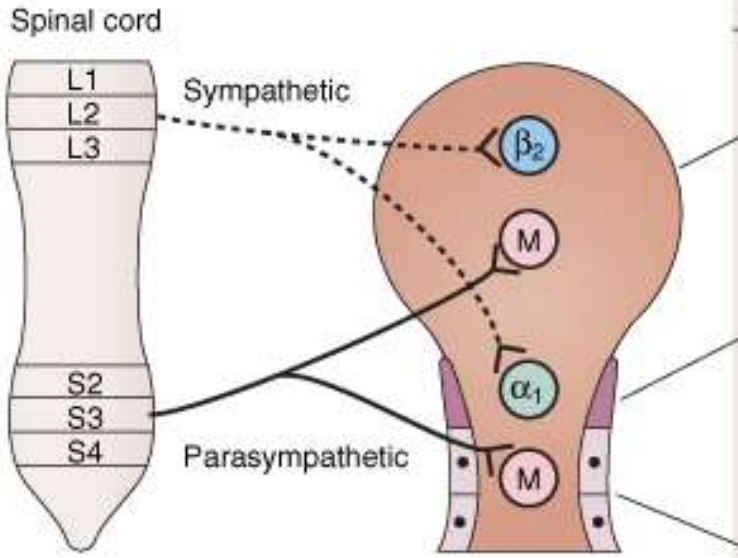
Arterial Pressure:

- **Sympathetic stimulation → ↑ the cardiac output and ↑ resistance to the blood flow and blood pressure.**
- **Parasympathetic → ↓ cardiac output and has no effect on blood vessels.**

Autonomic Reflexes

- **Most of the visceral functions of the body are regulated by autonomic reflexes.**
- **Cardiovascular:**
  baroreceptor reflex: It is a stretch reflex in the main arteries such as carotid artery to detect the blood pressure.
- **Gastrointestinal:**
  The receptors in the nose and mouth send signals to parasympathetic to notify the glands of mouth & stomach to secrete the digestive juices.
- **Urinary Bladder:**
  Initiate the urination by parasympathetic innervations.
- **Sexual reflexes:**
  Erection by parasympathetic, ejaculation by sympathetic.

Urinary Bladder



Muscle	Filling of Bladder		Emptying of Bladder	
	State	Control Mechanism	State	Control Mechanism
Detrusor muscle	Relaxed	Sympathetic (β_2)	Contracted	Parasympathetic (M)
Internal sphincter	Contracted	Sympathetic (α_1)	Relaxed	Parasympathetic (M)
External sphincter	Contracted	Voluntary	Relaxed	Voluntary

Autonomic Reflexes (continued)

- **Sympathetic activation could occur in isolated portions such as:**
  - heart regulation.
  - many sympathetic reflexes that regulate G.I. functions.

- **The parasympathetic usually causes specific localized responses: the effect of parasympathetic usually specifies to certain organ , but sometimes there is a common effect of parasympathetic activity by affecting the functions of some organs together such as rectal emptying and bladder emptying, salivary secretion and gastric secretion.**

The End