

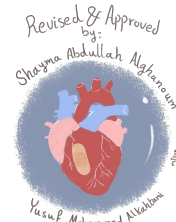
# Autonomic Nervous system



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**Red: Important**

**Black: In Male & Female slides**

**Blue: In male slides**

**Pink: In female slides**

**Green: Notes & extra information**

# Objectives

- appreciate the anatomy of sympathetic & parasympathetic nervous system.
- explain physiological functions of Sympathetic & parasympathetic nerves in the head & neck, chest, abdomen and pelvis.
- describe neurotransmitters that can release at pre and postganglionic of Autonomic NS.
- Describe Autonomic NS receptors.
- Organization of the Autonomic Nervous System.
- Terminology.
- Sympathetic Nervous System (SNS).
- Neurotransmitters and Types of Receptors.
- Parasympathetic Nervous System.
- Autonomic Receptors: Adrenoreceptors, Cholinoreceptors.
- Prototypes of Agonists and Antagonists to Autonomic Receptors.
- Sympathetic and Parasympathetic tone.
- Function of Adrenal Gland.
- Examples of the Effects of Sympathetic and Parasympathetic.



[A helpful video](#)

# Nervous System

Consists of cranial nerves arises from the brain and spinal nerves arising from the spinal cord.

WE WILL TALK ABOUT THIS PART

## Peripheral nervous system (PNS)

Formed by neurons and their process present in all regions of the body.

## Central nervous system (CNS)

Includes the brain and spinal cord.

### Autonomic Nervous system (involuntary control)

Sympathetic nervous system

Parasympathetic nervous system

### Somatic Nervous system (voluntary control)

A voluntary nervous system under conscious control consists of a single motoneuron and skeletal muscle fibers.

Sensory

Motor

## Brain



## Spinal cord



Cell bodies of motor neurons reside in CNS (Brain or spinal cord). Their axons (sheathed in spinal nerves) extend all the way to their skeletal muscles.

# Terminology

Sympathetic	Anatomical terms that refer to anatomic origin of preganglionic neurons in the central nervous system (CNS)
Parasympathetic	
Adrenergic	Terms that are used to describe neurons of either division, according to which neurotransmitter they synthesize and release.
Cholinergic	
Adrenergic neurons	Release norepinephrine and the receptor is <b>adrenoreceptor</b> .
Cholinergic neurons	Release Acetylcholine (ACh) and the receptor is <b>Cholinergic</b> .

# Autonomic nervous system

It's an involuntary nervous system that modulates and controls the function of visceral organs.

Or it's the subdivision of the peripheral nervous system that regulates body activities that are generally not under conscious control.

\*\*Visceral motor innervates non-skeletal (non-somatic) muscles.

• Autonomic nervous system (ANS) consists of two major divisions:  
**Sympathetic & Parasympathetic .**

- ANS is activated by centers in spinal cord, brainstem and hypothalamus
- ANS is operated by visceral reflex

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

- Preganglionic neuron. (Release Acetylcholine (Ach) )
- Postganglionic neuron. (Release either Ach, or norepinephrine )

\*\*Axon of 1st (preganglionic) neuron leaves CNS to synapse with the 2nd (ganglionic) neuron.

\*\*Axon of 2nd (ganglionic) neuron extends to the organ it serves.

**Composed of a special group of neurons serving**

Cardiac muscle (the heart)

Smooth muscle (walls of viscera and blood vessels)

Internal organs

Skins

MALES DEFINITION

FEMALES DEFINITION

## PERIPHERAL NERVOUS SYSTEM

NERVES THAT CONNECT CNS TO MUSCLES & ORGANS

~ SOMATIC → CONTROLS SKELETAL MUSCLES

~ AUTONOMIC

SYMPATHETIC PARASYMPATHETIC

SMOOTH MUSCLES & GLANDS

# Sympathetic nervous system

Operate continuously to modulate the functions of many organ systems.  
( Heart, blood vessels, gastrointestinal tract, bronchi, and sweat gland )

- Stressful stimulation activates SNS leads to a response known as "fight or flight" that increases arterial pressure, blood flow, blood glucose, metabolic rate, and mental activity.
- Sympathetic nervous system is regulated by neurons in the Posterior part on the hypothalamus.
- Sympathetic preganglionic neurons originate from thoracolumbar spinal cord (T1-L3).
  - 1- Thoracolumbar lateral horns of the spinal segments T1-L2.
  - 2- Nerve fibers originate between T1 and L2.
- SNS ganglia are located near the spinal cord either in the paravertebral ganglia (Sympathetic chain) or in the prevertebral ganglia.
- Preganglionic neurons are short, lightly myelinated.
- Postganglionic neurons are long, unmyelinated.

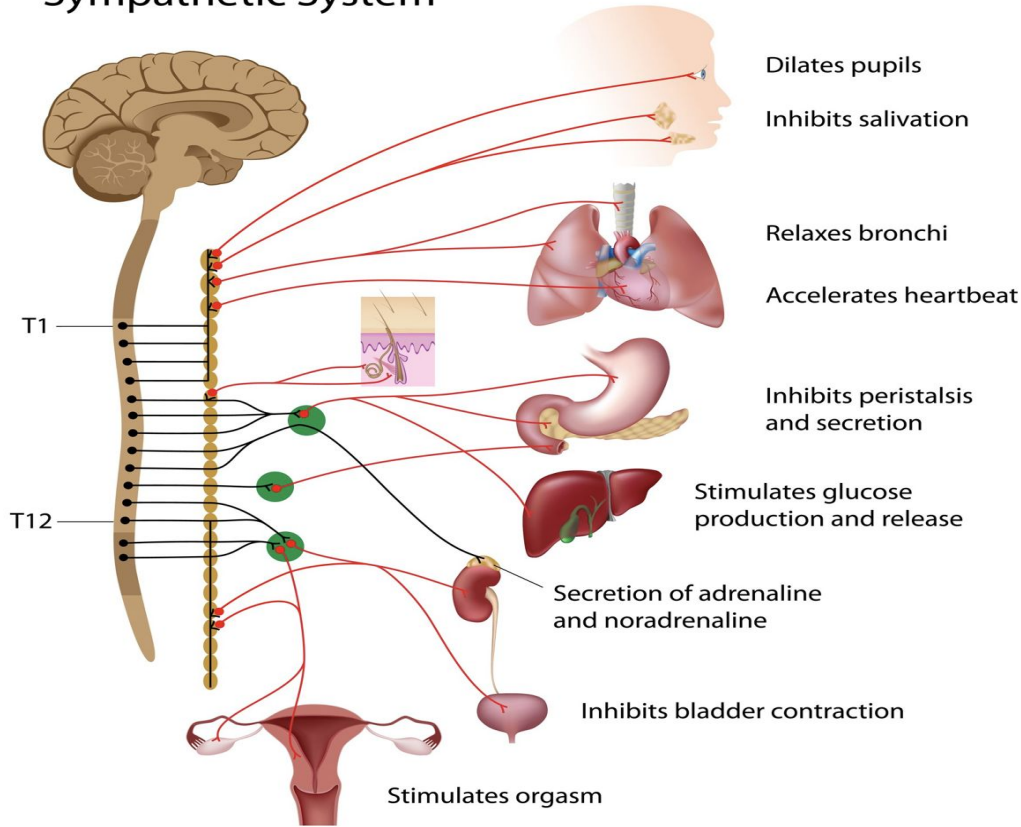
FROM MALES SLIDES

FROM FEMALES SLIDES

EXTRA INFORMATION:  
Most people stop at L2, But  
some other people stop at L3

Next slide

# Sympathetic System

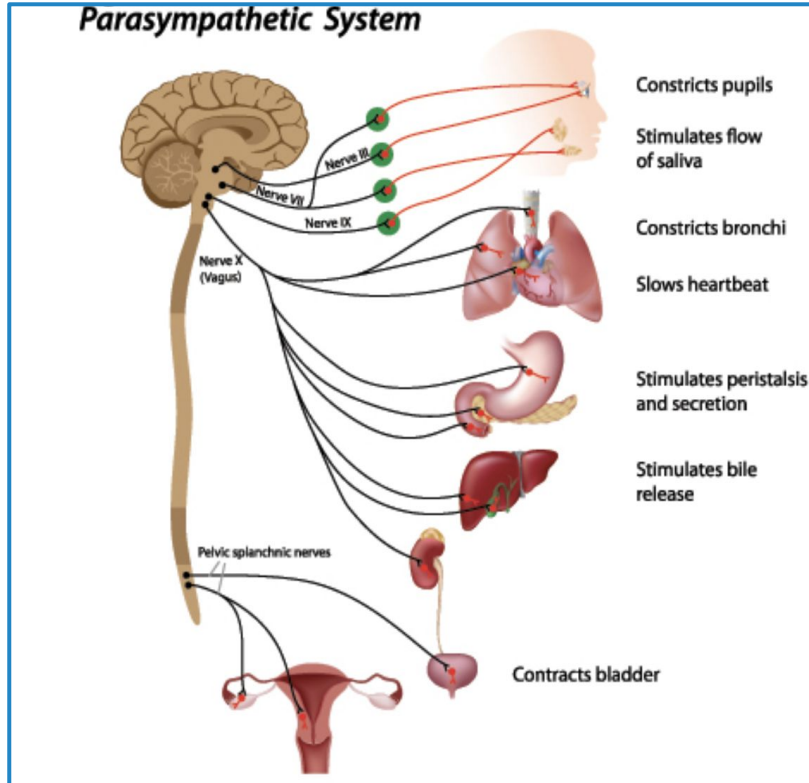


The sympathetic nervous system inhibits all of the glands secretion except sweat glands.

1- **Paravertebral Ganglia:** (sympathetic chain) near vertebral body.

2- **Prevertebral Ganglia:** Ganglia between Paravertebral Ganglia and the target organ near large blood vessel in gut: celiac, superior mesenteric & inferior mesenteric

# Parasympathetic nervous system



- Ganglia close to or on target organs.
- **Origin:**
  - 1- Craniosacral cell bodies of the motor nuclei of cranial nerves **III, VII, IX, and X** in the **brain stem**
  - 2- Second, third, and fourth sacral segments of the spinal cord (**S2-S4**).
- Nerve fibers emerge from **brain** and **sacrum** **craniosacral outflow**.

- Preganglionic fibers originate from cranial nuclei in brain stem (midbrain, pons, medulla) and in sacral segments (**S2-S4**) (**Craniosacral**).
- Parasympathetic ganglia are located on or in the affected organs.
- **Preganglionic** neuron has a **long** axon.
- **Postganglionic** neuron has a **short** axon.

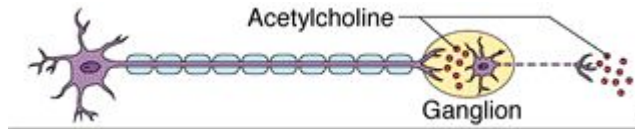


# ANS Neurotransmitters

ANS Neurotransmitters:  
Classified as either cholinergic or adrenergic neurons based upon the neurotransmitter released  
Adrenergic

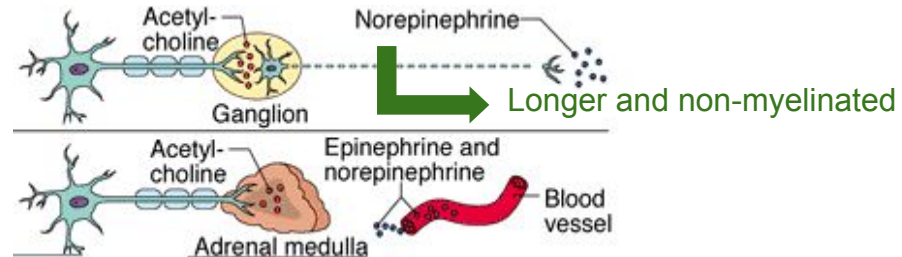
## Parasympathetic:

- Pre & Postganglionic neurons are Cholinergic
- preganglionic neurons are **always** cholinergic, release Ach which interacts with nicotinic receptors.
- Postganglionic neurons: are cholinergic, release Ach which interacts with muscarinic receptors.



## Sympathetic:

- Preganglionic neurons are always Cholinergic = (release acetylcholine that interacts with nicotinic receptors on the cell body of postganglionic neurons)
- Postganglionic neurons are adrenergic = (release norepinephrine)
  - Except in thermoregulatory sweat glands (muscarinic, cholinergic)
- Adrenergic neurons affect adrenoceptors: alpha1, alpha 2, beta 1, beta 2



### Chemical or neural transmitter:

- All preganglionic fibers release acetylcholine (Ach).
- All parasympathetic postganglionic release Ach.
- All sympathetic postganglionic release noradrenalin except sweat glands & bl vessels to skeletal muscles

# Receptors

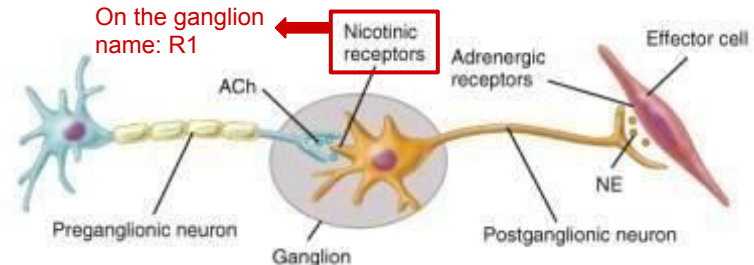
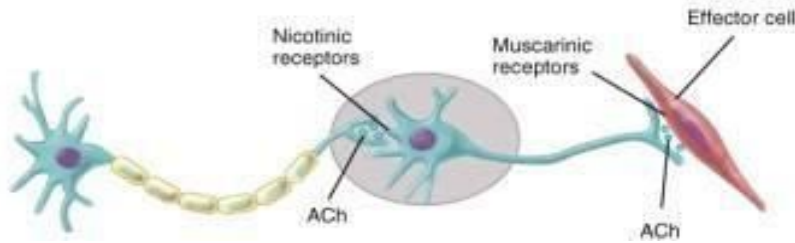
And could be classified as either parasympathetic or sympathetic

There are two types of receptors:

1. Adrenoreceptors:  $\alpha 1$ ,  $\alpha 2$ ,  $\beta 1$ ,  $\beta 2$ . Activated by: (adrenaline, noradrenaline)(epinephrine, norepinephrine).
2. Cholinergic receptors: nicotinic and muscarinic. Activated by: acetylcholine

Receptors:

- The parasympathetic nervous system uses only acetylcholine (ACh) as its neurotransmitter.
- The ACh acts on two types of receptors, the muscarinic and nicotinic cholinergic receptors.
- Most transmissions occur in two stages: When stimulated, the preganglionic nerve releases ACh at the ganglion, which acts on nicotinic receptors of the postganglionic nerve.
- The postganglionic nerve then releases ACh to stimulate the muscarinic receptors of the target organ.



## Adrenoreceptors

- $\alpha 1$  receptor:** found in vascular smooth muscle, gastrointestinal (GI) sphincters and bladder, radial muscle of iris:  
➤ Activation of  $\alpha 1$  ➔ ↑ contraction.
- $\beta 1$  receptor:** is found in the following tissues:
  - Sinoatrial (S.A) node ➔ ↑ heart rate.
  - Atrioventricular (AV) node ➔ ↑ conduction velocity.
  - Ventricular muscle ➔ ↑ contractility.
  - Salivary glands ➔ ↑ salivary secretions, (enzymes only)➤ Activation of  $\beta 1$  ➔ excitation.
- $\beta 2$  receptors:** found in vascular smooth muscle wall of bladder, and wall of GI.  
➤ Activation of  $\beta 2$  ➔ relaxation.
  - $\beta 2$  more sensitive to Epinephrine than Norepinephrine.

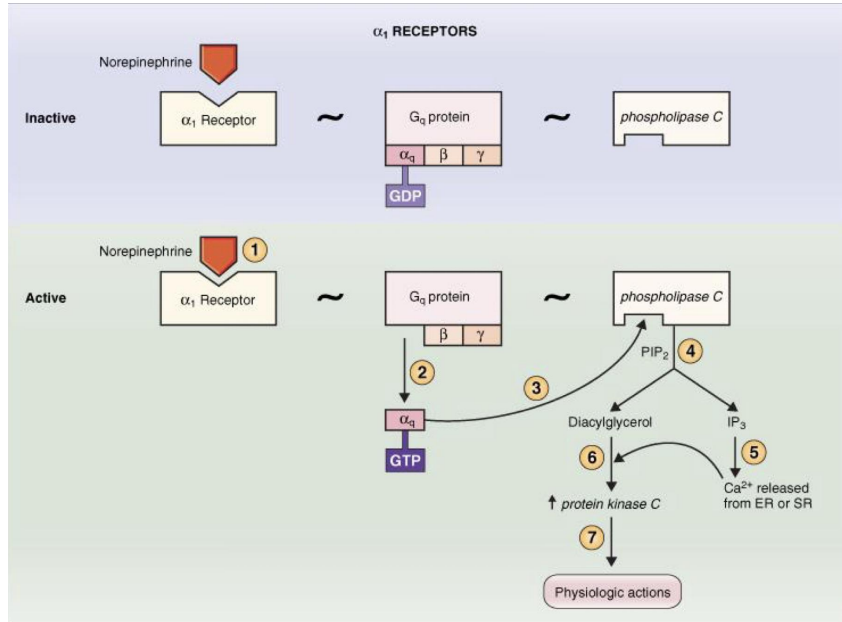
## Cholinoreceptors

- Nicotinic Receptor (N):**
  - an ion channel for  $\text{Na}^+$  and  $\text{K}^+$ .
  - in all postganglionic neurons, motor end plate at skeletal muscle and chromaffin cells (of the medulla of the adrenal gland).
- Muscarinic Receptor (M):**
  - Works either like 1 adrenoreceptor via DAC, PKC and IP3 or via G protein which has subunit that binds  $\text{K}^+$  channel and open it.

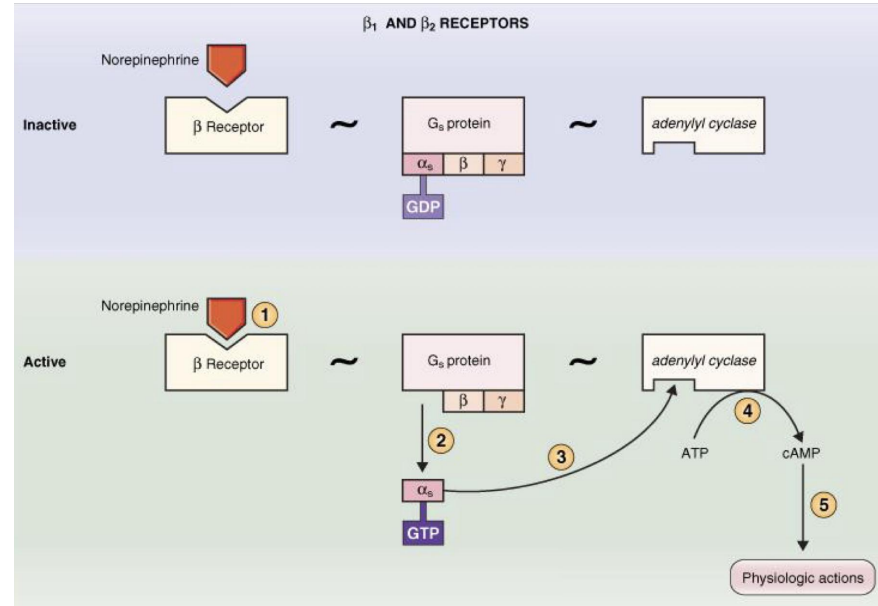
# Adrenoreceptors

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## $\alpha_1$ Receptors



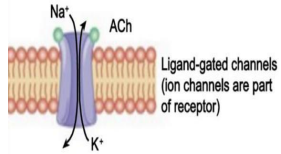
## $\beta_1$ & $\beta_2$ Receptors



# Cholinoreceptors

## Nicotinic ACh receptors

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

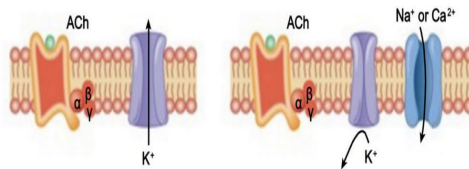


Depolarization

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

Inhibition

Produces slower heart rate

Depolarization

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.  $\beta_1$  receptor in SA node and in ventricular muscle:

- SA node: activation of SA node by the agonist (Norepinephrine)  $\Rightarrow$   $\uparrow$  heart rate.
- ventricular muscles  $\Rightarrow$   $\uparrow$  contractility.

# Prototypes of Agonists and Antagonists to Autonomic Receptors

This slide was found only in male slides

Receptor	Agonists	Antagonists
<b>Adrenoreceptors</b>		
$\alpha_1$	Norepinephrine	Phenoxybenzamine
	Phenylephrine	Prazosin
$\alpha_2$	Clonidine	Yohimbine
$\beta_1$	Norepinephrine	Propranolol
	Isoproterenol	Metoprolol
$\beta_2$	Epinephrine	Propranolol
	Isoproterenol	Butoxamine
	Albuterol	

Receptor	Agonists	Antagonists
<b>Cholinoreceptors</b>		
Nicotinic	ACh	Curare
	Nicotine Carbachol	Hexamethonium (blocks ganglionic receptor but not neuromuscular junction)
Muscarinic	ACh	Atropine
	Muscarine	
	Carbachol	

# The Sympathetic ANS Acts on two types of receptors : $\alpha$ and $\beta$ .

## What do the receptors do?

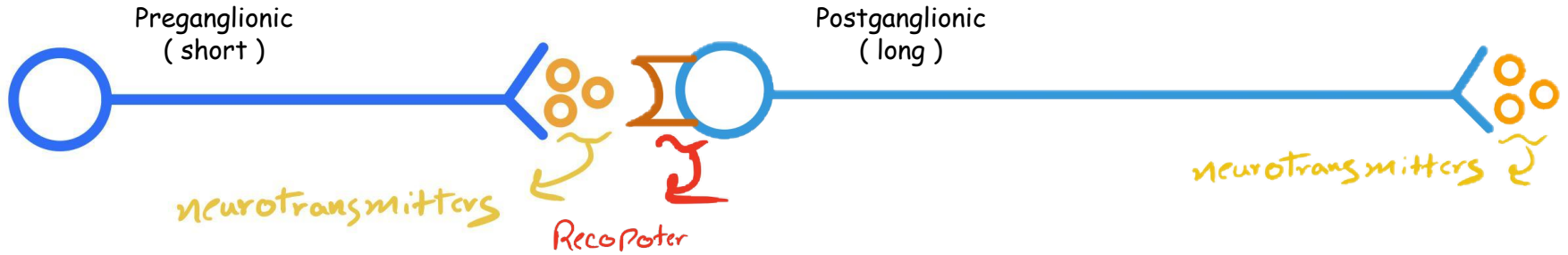
Activation of  $\alpha$  receptors leads to smooth muscle contraction.

Activation of  $\beta_2$  receptors leads to smooth muscle relaxation.

Activation of  $\beta_1$  receptors leads to smooth muscle contraction (especially in heart).

# Summary

رسمه شرح علی ال Sympathetic



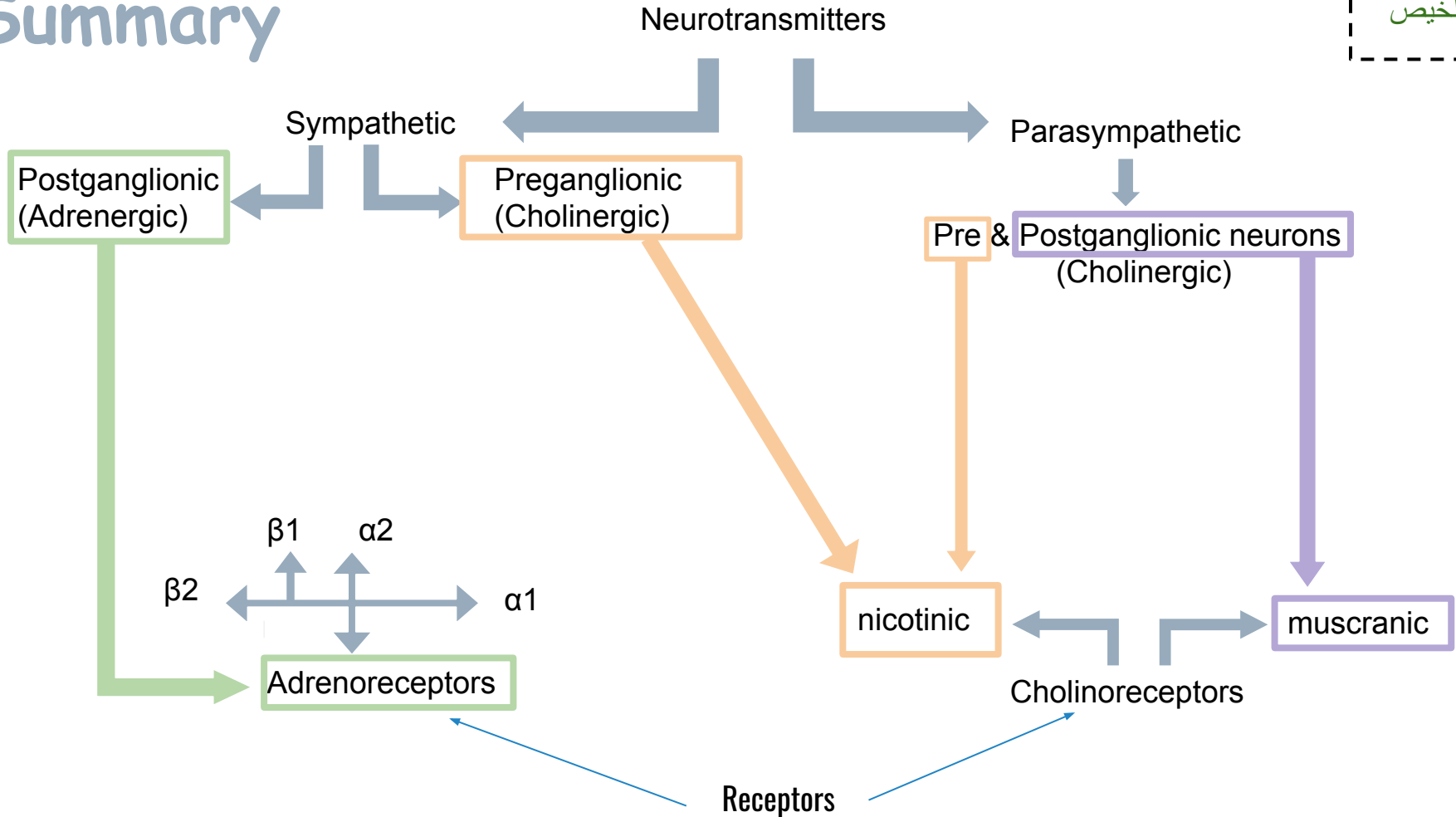
[A helpful video](#)  
[Click](#)

\* كل neurotransmitters له اسم  
\* كل Receptor له اسم والرسم له انواع



# Summary

تلخيص



# 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 constriction  $\frac{1}{2}$  of its normal diameter.
2. removal of vagus nerve > atony > loss of peristalsis (loss of muscle strength).
  - e.g., loss of smooth muscle contraction in small intestine constipation.

## Effect of loss of sympathetic and parasympathetic tone after denervation

**Note:**

loss of sympathetic tone in blood vessel causes severe vasodilation but after sometime, intrinsic tone increases by chemical adaptation.

## Function of Adrenal Gland

Stimulation of sympathetic nerves causes large quantities of Epinephrine and Norepinephrine to be secreted in blood from adrenal gland.

- The effect of Epinephrine & Norepinephrine lasts 5-10 times more than the ones which secreted from sympathetic.

# Examples of The Effects of Sympathetic and Parasympathetic stimulation on specific organs

<p><b>The Eyes</b></p>	<ul style="list-style-type: none"> <li>• Sympathetic stimulation contracts the meridional fibers of the iris to dilate the pupil.</li> <li>• Parasympathetic stimulation contracts the circular muscle of the iris to constrict the pupil.</li> <li>• Focusing of the lens is controlled by parasympathetic through contraction of ciliary muscle.</li> </ul>
<p><b>The Glands</b></p>	<ul style="list-style-type: none"> <li>• Controlled by parasympathetic <math>\longrightarrow \uparrow</math> their secretions.</li> <li>• Sympathetic causes vasoconstriction of the blood vessels to the glands which causes reduction in their secretion.</li> <li>• Sweat glands secretion : increased by sympathetic stimulation.</li> </ul>
<p><b>(GI)</b> The Gastrointestinal tract</p>	<ul style="list-style-type: none"> <li>• Enteric nervous system</li> <li>• Parasympathetic nervous system increases the activity of GI tract (increases peristaltic contraction, and sphincter relaxation) .</li> <li>• Sympathetic decreases the activity of GI.</li> </ul>
<p><b>The Heart</b></p>	<ul style="list-style-type: none"> <li>• Sympathetic stimulation <math>\longrightarrow \uparrow</math> activity of the heart.</li> <li>• Parasympathetic stimulation doing the opposite.</li> </ul>
<p><b>Systemic Blood Vessels</b></p>	<ul style="list-style-type: none"> <li>• Constricted by stimulation of sympathetic.</li> <li>• No effect of the parasympathetic except in certain areas, such as blushing of the face.</li> </ul>
<p><b>Arterial Pressure</b></p>	<ul style="list-style-type: none"> <li>• Sympathetic stimulation <math>\longrightarrow \uparrow</math> the cardiac output and <math>\uparrow</math> resistance to the blood flow and blood pressure.</li> <li>• Parasympathetic <math>\longrightarrow \downarrow</math> cardiac output and has no effect on blood vessels.</li> </ul>

# 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 a signal 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.

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.

# QUIZ!

## MCQs

Q1: Somatic nervous system consists of a single ..... and skeletal muscle fibers.

- A) Motoneuron      B) Ganglia      C) Preganglionic      D) Postganglionic

Q2: ANS is activated by

- A) Centers in spinal cord      B) brain stem      C) Hypothalamus      D) All answers

Q3: ANS is operated by

- A) Visceral reflex      B) Midbrain      C) Medulla      D) None

Q4: Sympathetic nervous system is regulated by neurons in the ..... part on the hypothalamus.

- A) Posterior      B) Anterior      C) Lateral      D) None

## SAQ

Q1: Parasympathetic ganglia are located on?

Q2: How many types of receptors & what are they ?

MCQs key answer :  
1) A  
2) D  
3) A  
4) A

SAQ answer key :  
1) Affected organs

2) there are two types :  
Adrenoceptors & Cholinoreceptors

# QUIZ!

## MCQs

Q5: Pre & Postganglionic neurons in parasympathetic are ..... ?

A) nicotinic

B) Cholinergic

C) muscarinic

D) adrenergic

Q6: The receptor in sympathetic NS which is responsible of smooth muscle contraction is ..... ?

A)  $\alpha$ 1

B)  $\beta$ 1

C)  $\alpha$ 2

D)  $\beta$ 2

Q7: Postganglionic neurons in sympathetic are ..... ?

A) Cholinergic

B) muscarinic

C) nicotinic

D) adrenergic

Q8:  $\beta$ 2 more sensitive to ..... than ..... ?

A) Adrenergic - nicotinic

B) Nor-epinephrine - Epinephrine

C) Epinephrine - Nor-epinephrine.

D)  $\alpha$ 2 - Cholinergic

MCQs key answer :  
5) B  
6) A  
7) D  
8) C

# Thank You

## Team members:

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- ▶ سارة القحطاني
- ▶ ريناد الحميدي
- ▶ ياسمين القرني
- ▶ يارا الزهراني
- ▶ لمى الأحمدى
- ▶ ألاء السلمي
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- ▶ بدور العبارك
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