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Autonomic Nervous System

- Very important
- Extra information
- Terms

Intelligence without ambition is like a bird without wings.

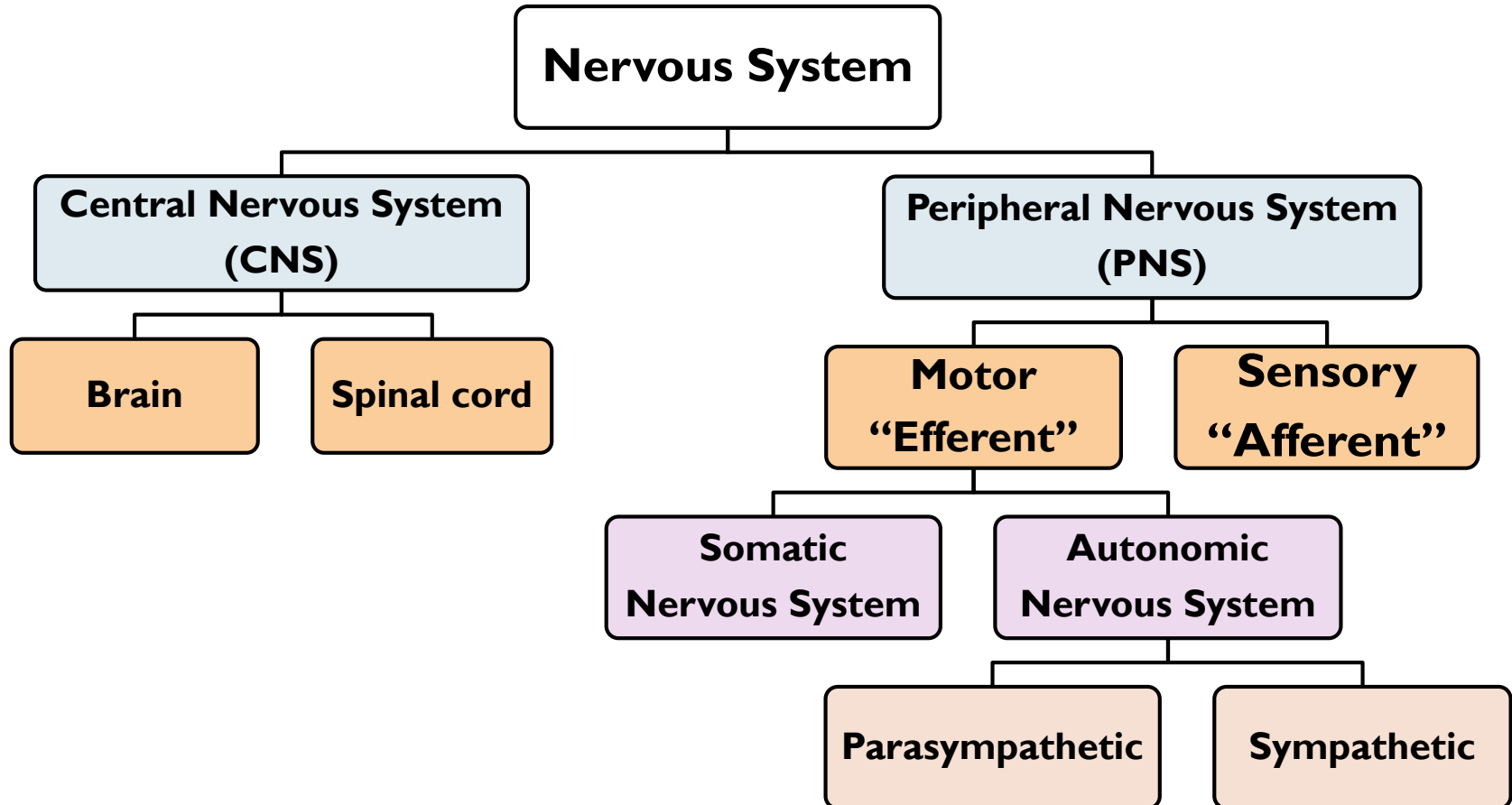


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Objectives

- ▶ **Organization of the Autonomic Nervous System.**
- ▶ **Terminology.**
- ▶ **Sympathetic Nervous System (SNS).**
- ▶ **Neurotransmitters and Types of Receptors.**
- ▶ **Parasympathetic Nervous System.**
- ▶ **Autonomic Receptors:**
 - **a. Adrenoreceptors**
 - **b. 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.**
- ▶ **Appreciate the anatomy of sympathetic & parasympathetic nervous system.**
- ▶ **Explain physiological functions of Sympathetic & parasympathetic nerves in head, neck, chest, abdomen and pelvis.**

- ▶ The nervous system monitors and controls almost every organ / system through a series of positive and negative feedback loops.
- ▶ **The Central Nervous System (CNS):** Includes the brain and spinal cord.
- ▶ **The Peripheral Nervous System (PNS):** Formed by neurons & their process present in all the regions of the body.
- ▶ **PNS** consists of cranial nerves arises from the brain & spinal nerves arising from the spinal cord.
- ▶ **The peripheral NS is divided into :**
 - **Somatic Nervous system**
 - **Autonomic nervous system**



▶ **Ganglia :**

a structure containing a number of nerve cell bodies, typically linked by synapses, usually located outside the brain and spinal cord.

▶ **Neuron:**

a specialized cell transmitting nerve impulses.

▶ **Sensory axon:**

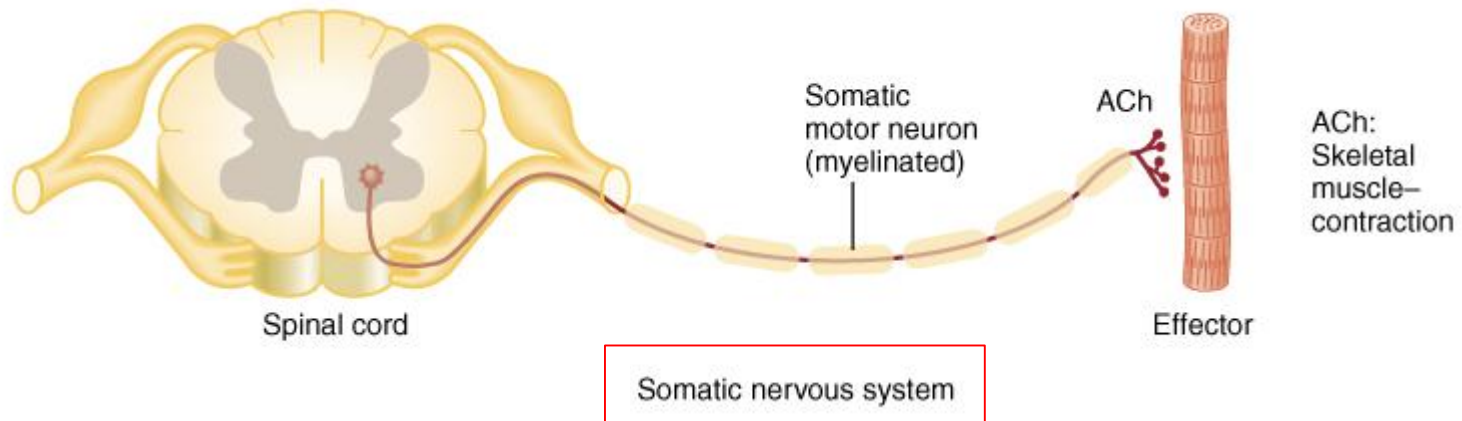
sensory nerve cell process, conducting impulses from the periphery toward the nerve cell body.

▶ **Motor axon :**

single nerve cell process, conducting impulses from the nerve cell body toward a muscle.

Somatic nervous system (SNS)

- **Voluntary** nerves that supply skeletal muscles .
- Has only one axon.
- Cell bodies of motor reside in **CNS** (brain or spinal cord)
- Myelinated .
- Has **No** ganglia.



Autonomic Nervous System (ANS)

- **Involuntary** and regulate the function of visceral organs.

(smooth and cardiac muscles)

- **Consist of 2 division :**

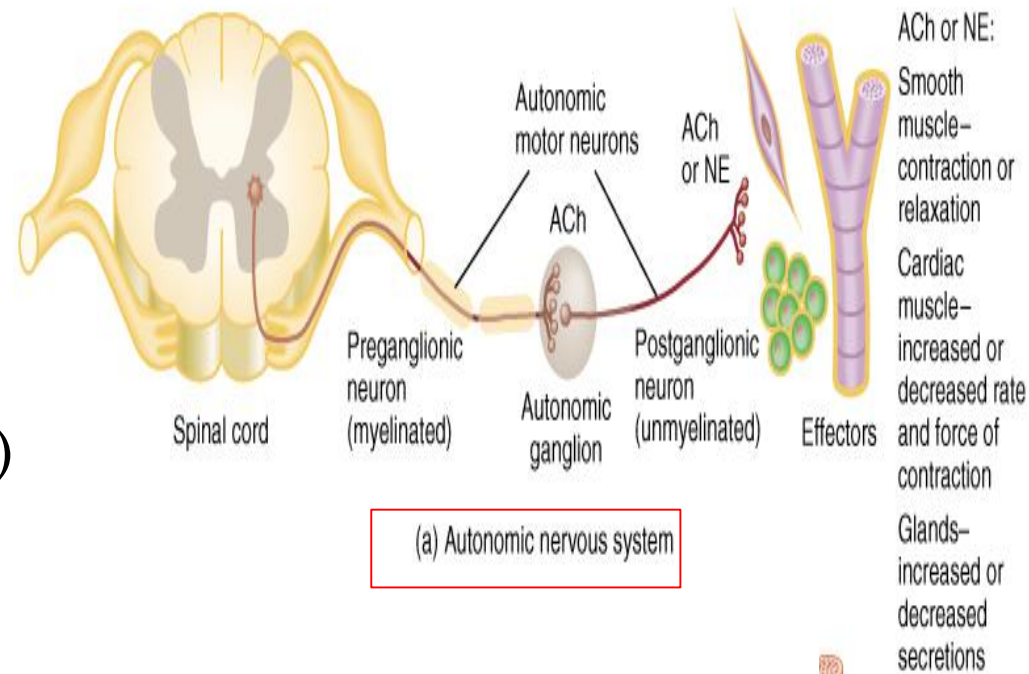
- **Sympathetic**
- **parasympathetic**

- **Has 2 axons (2 neurons) :**

- **Preganglionic** (inside CNS)
- **Postganglionic** (outside CNS)

- **Activated by centers in :**

- **Spinal cord**
- **Brain stem**
- **Hypothalamus**



	Somatic	Autonomic
Control	Voluntary	Involuntary
Affect organs	Skeletal Muscles	Cardiac , Smooth Muscles And Glands
Number of neurons	One	Two
Neurons	Somatic Motor Neuron	Preganglionic Postganglionic
Origin	In CNS	Preganglionic (Inside CNS) Postganglionic (Outside CNS)
Ganglia	Absent	Present
Myelinated	Yes	Pre (lightly myelinated) Post (unmyelinated_)

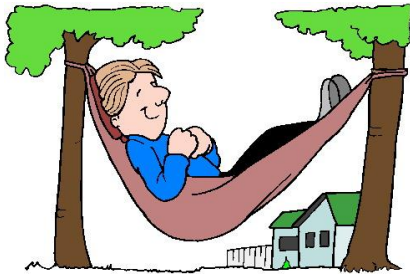
Note: ANS slower because lightly or unmyelinated

Comparison between somatic and autonomic NS in a [vedio](#)

Autonomic NS

Parasympathetic

Consisting of nerves and ganglia that arise from the **cranial** and **sacral** regions



“Rest & Digest”

Sympathetic

Consisting of nerves that arise from the **thoracic** and **lumbar** regions of the spinal cord



“Flight & Fight”

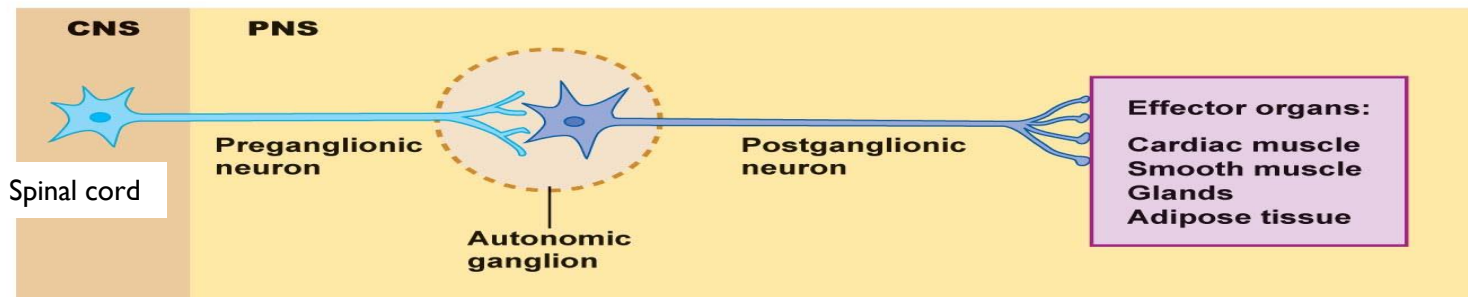
Sympathetic & Parasympathetic both have Preganglionic fibers and Postganglionic fibers (what does that mean ?)

▶ **Preganglionic:**

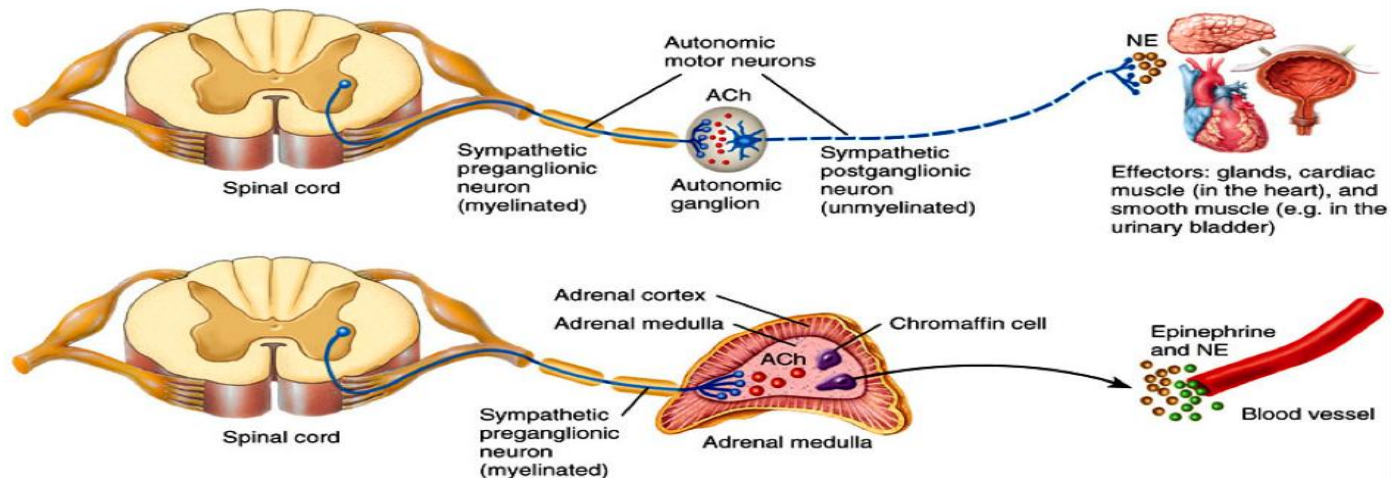
Situated proximal to or preceding a ganglion, especially a ganglion of the autonomic nervous system, myelinated nerve fiber. The axon of this neuron does not directly innervate the effector organ but instead synapses with a second neuron within an autonomic ganglion.

▶ **Postganglionic:**

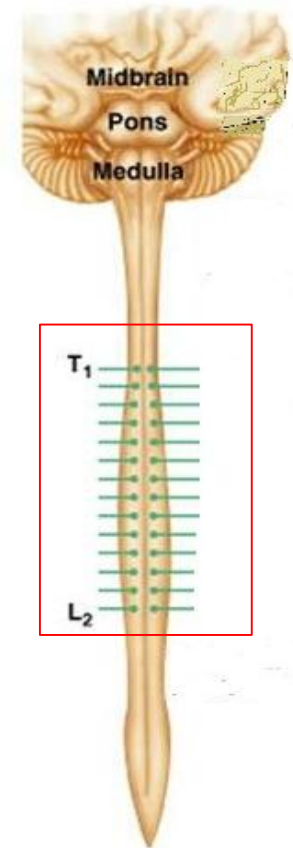
unmyelinated nerve fibers from an autonomic ganglion to the target tissue, e.g. gland. It synapses with its target tissue.



- Operates continuously to modulate “adjust” the functions of many organ systems.
- Stressful stimulation activates SNS leads to a response known as “**fight or flight**”.
- Preganglionic neurons are **short & lightly myelinated**.
- postganglionic neurons are **long & unmyelinated**.
- Ganglia located **near the spinal cord**.

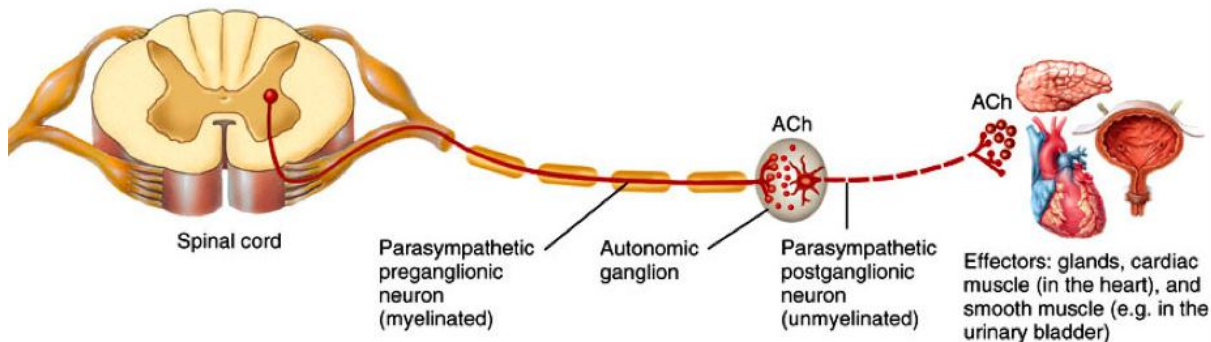


SNS is located at **Thoracolumbar
lateral horns of the spinal
segments **(T1-L2)**.
“ L3 in some references “**



Parasympathetic Nervous System

- Responsible for activities that occur when the body is at rest “**rest and digest**” .
- Preganglionic neuron are **long**.
- postganglionic neuron are **short**.
- Ganglia located **in** or **on** the affected organ. (close to the target organ)

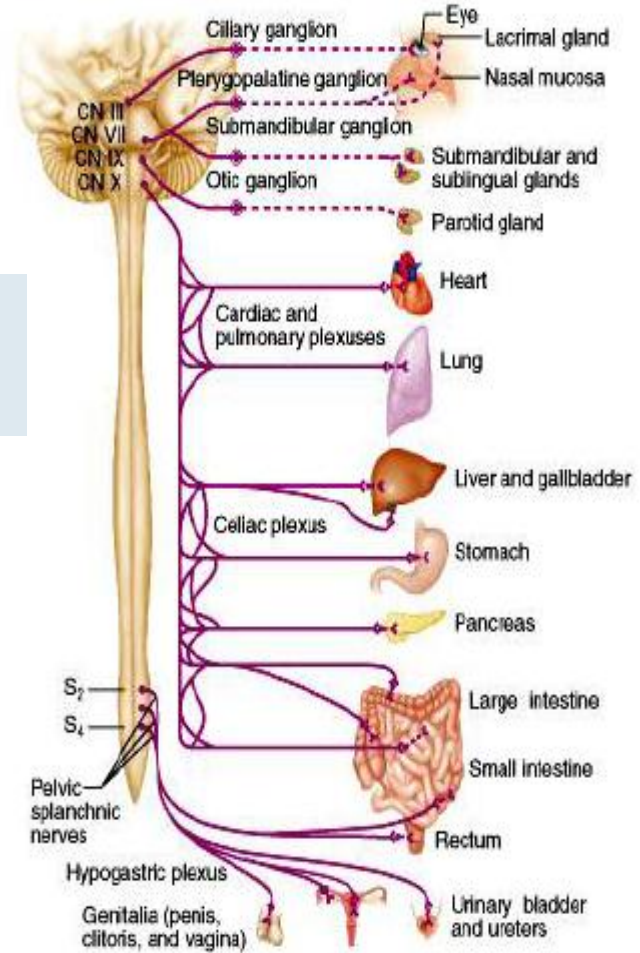


“ Preganglionic fibers originate from **cranial nuclei** in **brain stem** (mid brain, pons, medulla) and in **sacral segments (S₂-S₄) (Craniosacral)** “

Craniosacral:

Denoting the cranial and sacral origins of the parasympathetic division of the autonomic nervous system)

- **Craniosacral** Cell bodies of the motor nuclei of the cranial nerves **III (3)** , **VII (7)** , **IX(9)** and **X (10)** in the brain stem.
- **Second, third and fourth [S2-S4]** sacral segments of the spinal cord
- **Nerve fibers emerge from brain & sacrum (cranio-sacral outflow)**.



رقم 5 باللغة اللاتينية يرمز له V وعندما تكون قبلها | يصبح 4 أما إذا كانت | بعدها فيصبح الرقم 6 وإذا أصبحت || بالتالي 7 ، III تصبح 8 أما الرقم 10 فيرمز له بالرمز X وبالمثل إذا كانت قبله | يصبح 9 ، بعد || يصبح 11.

	sympathetic	parasympathetic
Preganglion	Short	Long
Postganglion	Long	short
Origin	thoracolumbar spinal cord (T₁-L₂)	brain stem and in sacral segments (S₂-S₄)
Ganglia	near the spinal cord	in or on the affected organ
Function	fight or flight	rest and digest

Comparison between **sympathetic** & **parasympathetic** in a [vedio](#)



Effects of sympathetic & parasympathetic

Structure	Sympathetic stimulation	Parasympathetic stimulation
Iris (eye muscle)	Pupil dilation	Pupil constriction
Salivary Glands	Saliva production reduced	Saliva production increased
Oral/Nasal Mucosa	Mucus production reduced	Mucus production increased
Heart	Heart rate and force increased	Heart rate and force decreased
Lung	Bronchial muscle relaxed	Bronchial muscle contracted
Stomach	Peristalsis reduced	Gastric juice secreted; motility increased
Small Intestines	Motility reduced	Digestion increased
Large Intestines	Motility reduced	Secretions and motility increased
Liver	Increased conversion of glycogen to glucose	-
Kidney	Decreased urine secretion	Increased urine secretion
Adrenal medulla	Norepinephrine and epinephrine secreted	-
Bladder	Wall relaxed Sphincter closed	Wall contracted Sphincter relaxed

Effects of sympathetic & parasympathetic

Structure	Sympathetic stimulation	Parasympathetic stimulation
Glands	Decrease by vasoconstriction, except sweat glands (Increase).	Increase their secretion.
Blood vessels	Constricted to $1/2$	No effect, except in certain areas like blushing of the face.
Arterial pressure	Increase cardiac output and blood flow and resistance to pressure	decrease cardiac output. No effect on blood vessels.

* (GIT) undergoes to Enteric nervous system which it's third division of (ANS).

Neurotransmitters:

Chemicals within the nervous system that transmit information from or between nerve cells and give the action of Autonomic nervous system (ANS).

Sympathetic Neurotransmitters

- The preganglionic neurons : release **Acetylcholine (Ach)** = Cholinergic .
- Postganglionic neurons : release **Norepinephrine** at target organs = Adrenergic

Parasympathetic Neurotransmitters

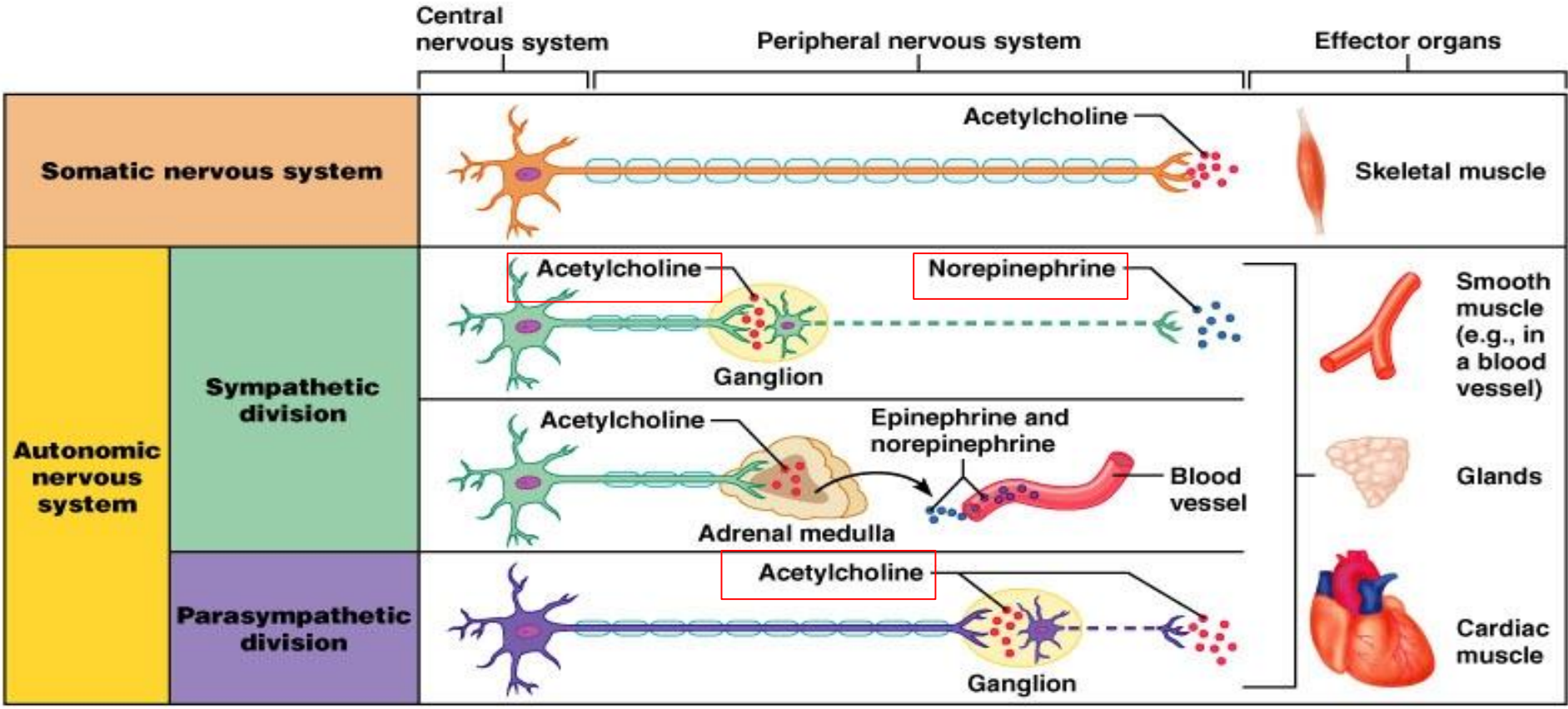
Pre & Postganglionic neurons release **Acetylcholine** = Cholinergic. which interacts with **muscarinic receptors**

Cholinergic:

Relating to nerve cells or fibers that use acetylcholine as their neurotransmitter.

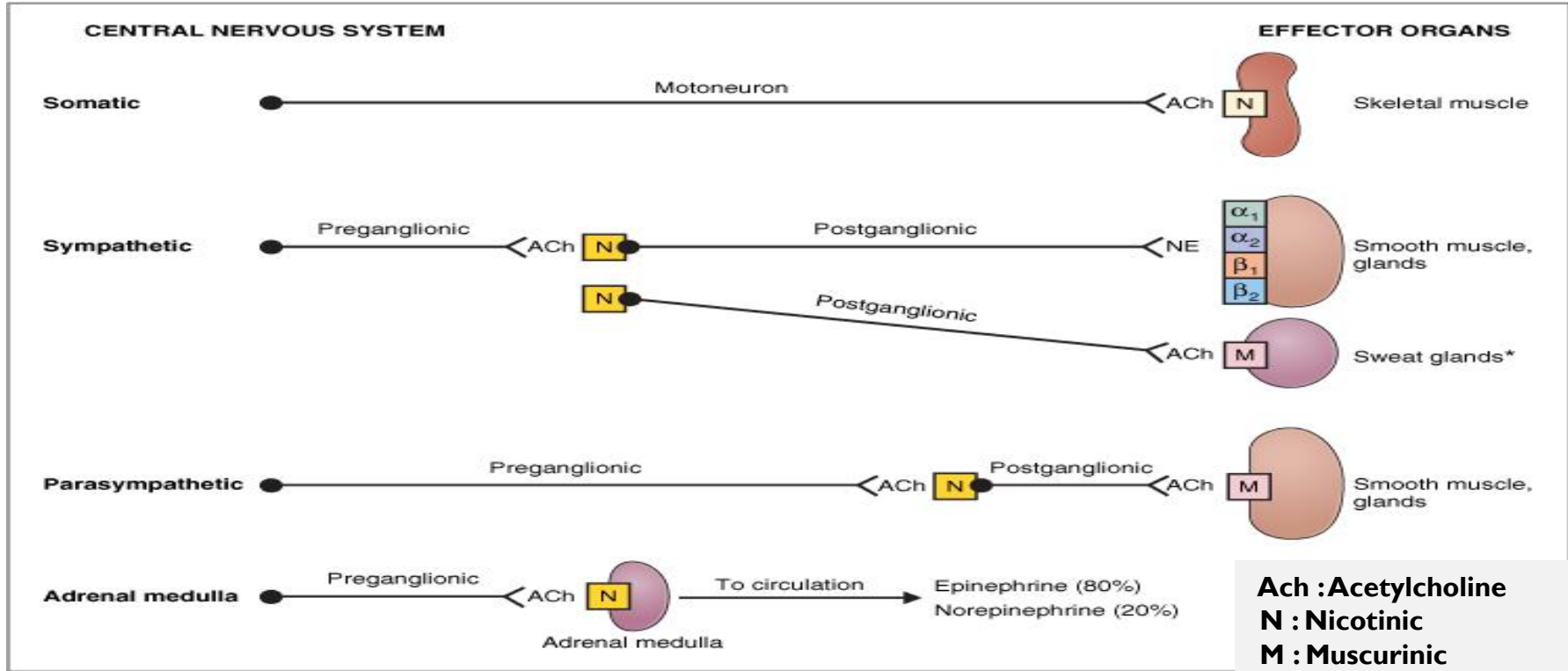
All preganglionic fibers release acetylcholine which interacts with nicotinic receptors.

Neurotransmitters



Key:
 = Preganglionic axons (sympathetic)
 = Postganglionic axons (sympathetic)
 = Myelination
 = Preganglionic axons (parasympathetic)
 = Postganglionic axons (parasympathetic)

Organization of the Autonomic Nervous System



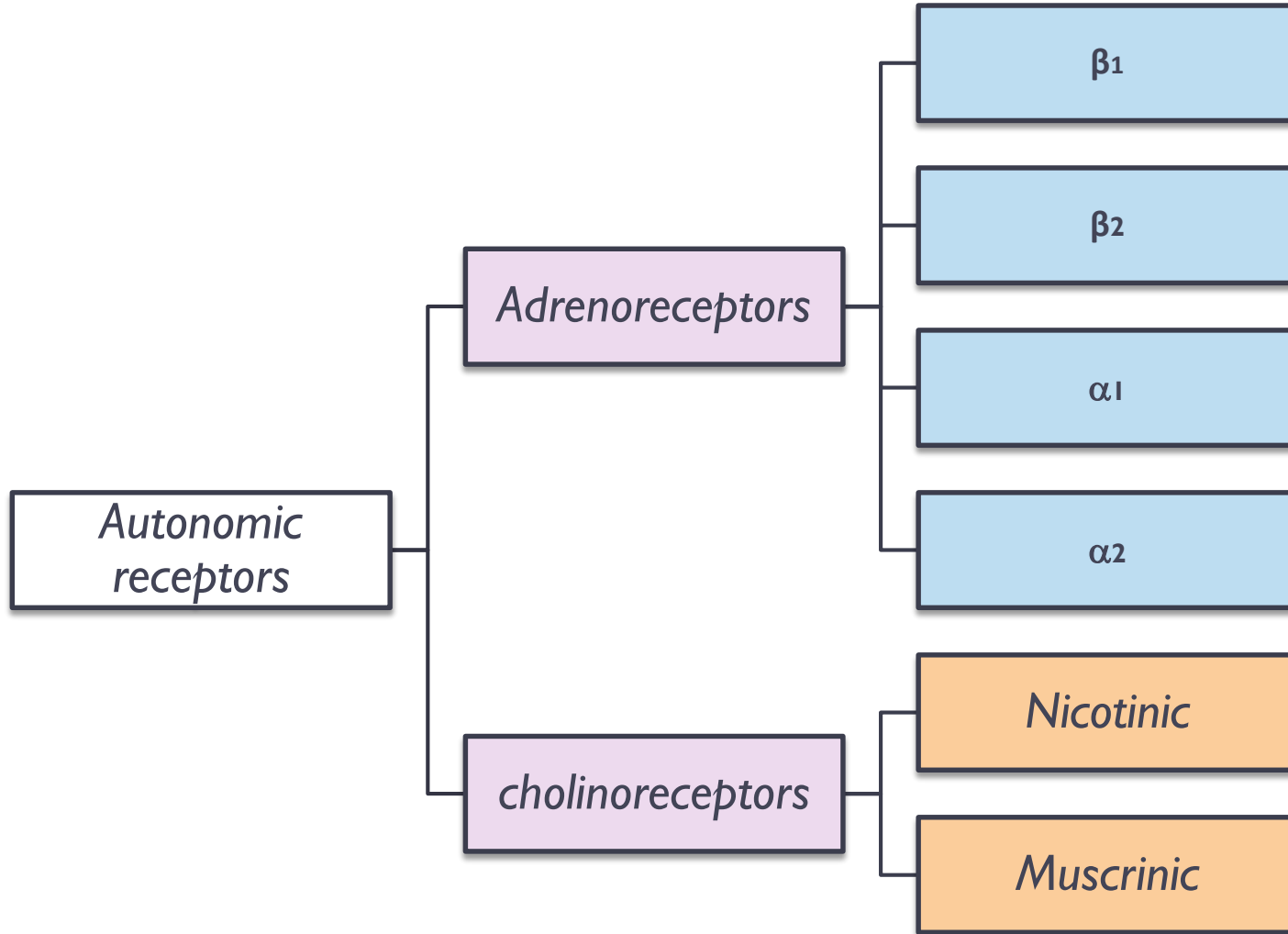
Sympathetic **postganglionic** neurons are **adrenergic** except in thermoregulatory sweat glands (Muscarinic, cholinergic).

“All sympathetic postganglionic release noradrenalin (Norepinephrine) except sweat glands & blood vessels to skeletal muscles “

Autonomic Receptors

- The **parasympathetic nervous system** uses only **acetylcholine (ACh)** as its neurotransmitter.
- The **ACh** acts on two types of receptors : the **muscarinic** and **nicotonic 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.
- The **Sympathetic NS** acts on tow types of receptors : **α** and **β**

Types Of Autonomic Receptors

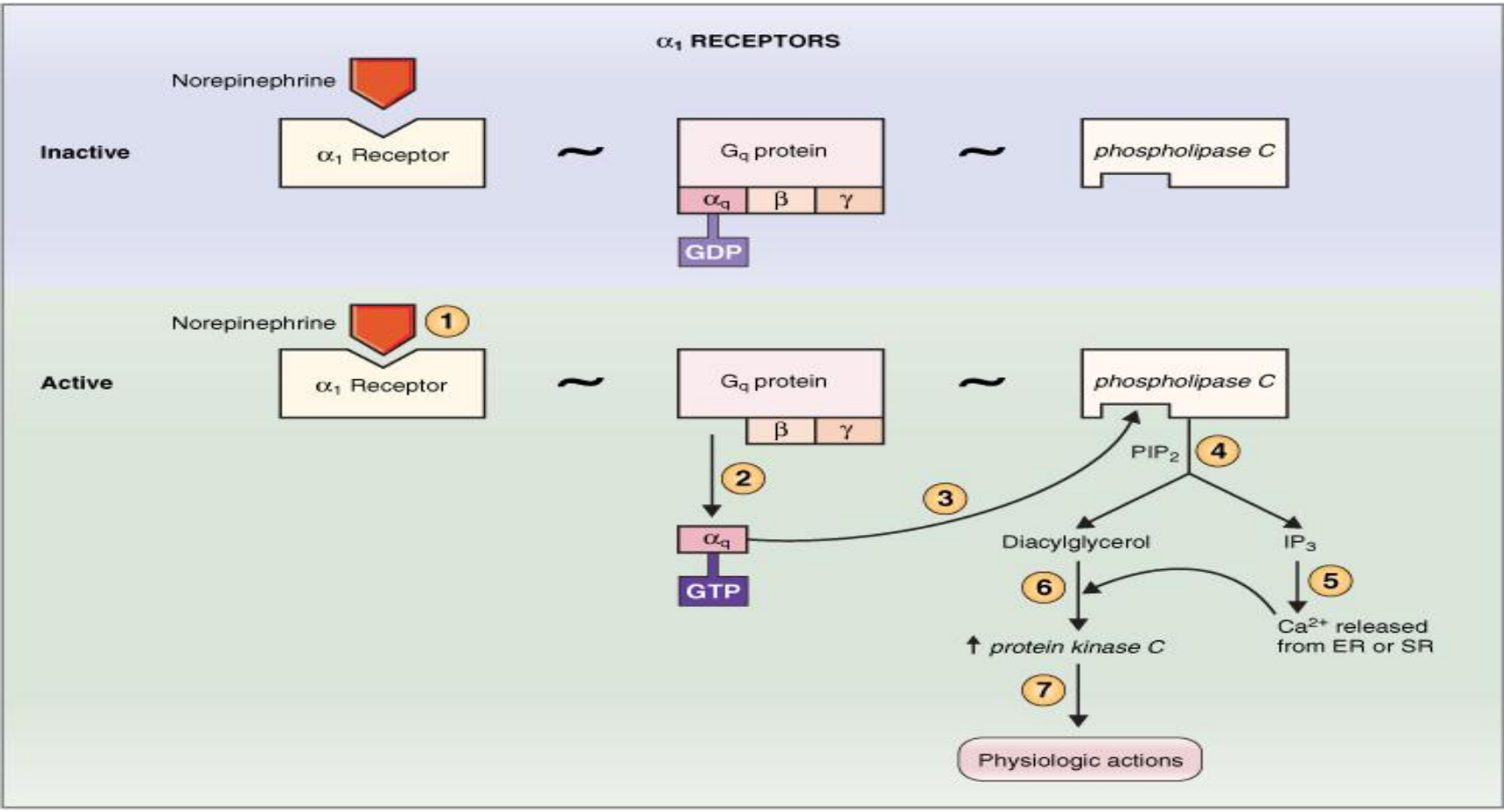


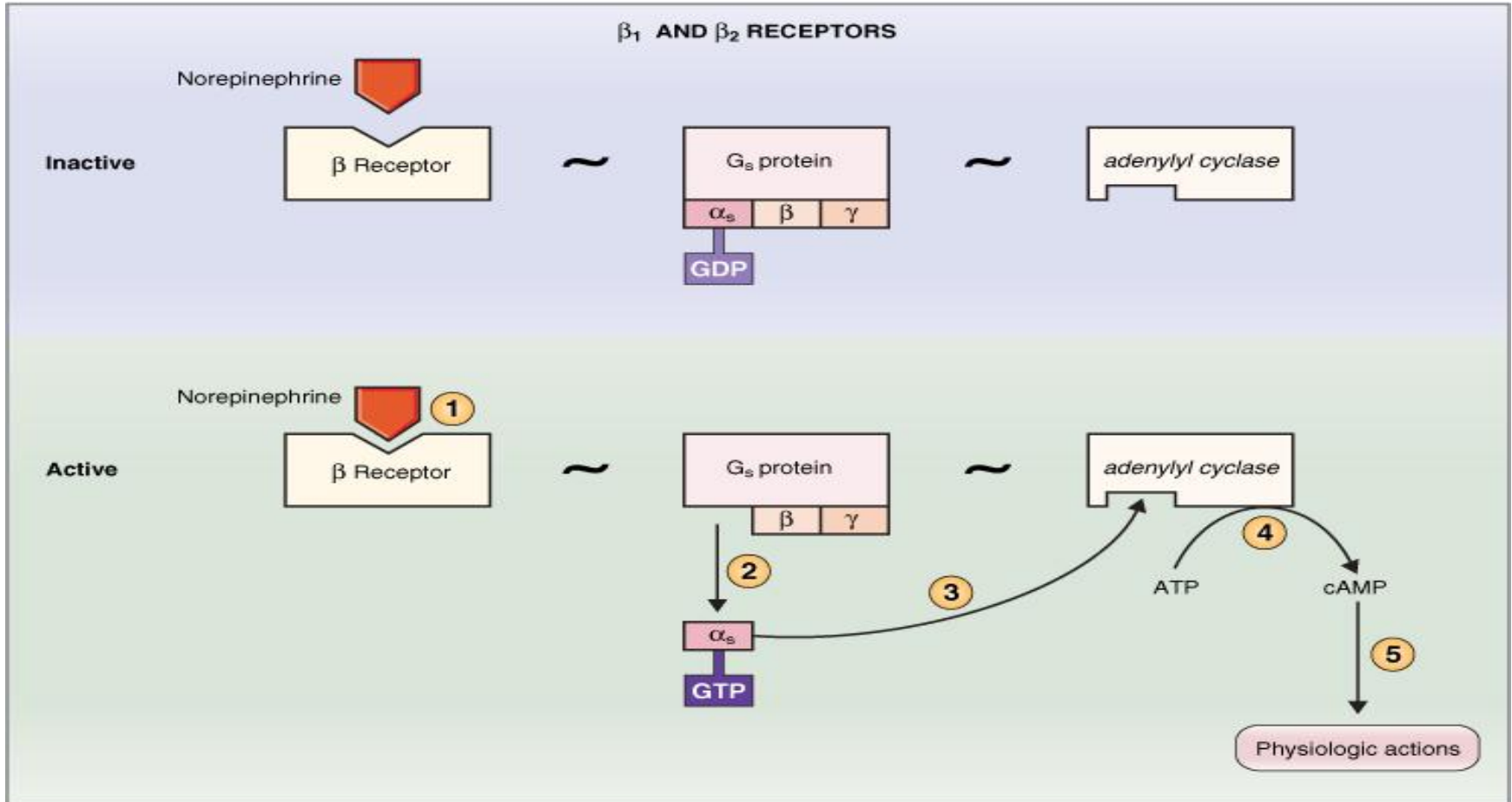
Adrenoreceptors

α_1	<p>Found in vascular smooth muscle, gastrointestinal sphincters and bladder, radial muscle of iris and its function is <u>contraction</u> of all these organs “leads to smooth muscle contraction ”</p>
β_1	<p>Existing in :</p> <ol style="list-style-type: none"> 1) sinoatrial node increases heart rate (S.A node) 2) Atrioventricular node increases conduction velocity (A.V node) 3) Ventricular muscles increases contractility 4) Salivary gland increases secretion (but enzymes production) <p>“leads to smooth muscle contraction (especially in heart) “</p>
β_2	<p>found in vascular smooth muscle wall of bladder, and wall of GI. Activation of β_2 is <u>relaxation</u> β_2 is more sensitive to Epinephrine than Nor-epinephrine “ leads to smooth muscle relaxation “</p>

Note : α_2 receptors are very rare in the body and their role are the same of α_1 .

α_1





Cholinoreceptors

Nicotinic	<ul style="list-style-type: none">• An ion channel for Na⁺ and K⁺• In all postganglionic neurons, motor end plate at skeletal muscle and chromaffin cells.
Muscarinic	Works either like α_1 adrenoreceptors via PKC, DAG and IP3 or via G protein which has α_1 subunit that binds K⁺ channel and open it

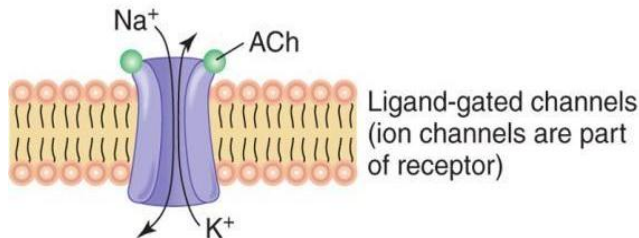
IP3 (Inositol trisphosphate) / DAG (Diacylglycerol) / PKC (Protein kinase C)

Cholinoreceptors

Nicotinic ACh receptors

Postsynaptic membrane of

- All autonomic ganglia
- All neuromuscular junctions
- Some CNS pathways

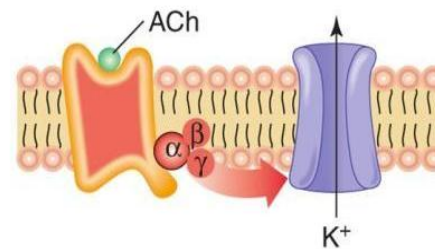


Depolarization

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)

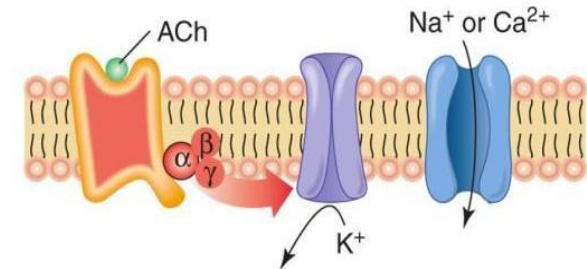


Hyperpolarization

(K⁺ channels opened)

Inhibition

Produces slower heart rate



Depolarization

(K⁺ channels closed)

Excitation

Causes smooth muscles of the digestive tract to contract

Prototypes of Agonists and Antagonists to Autonomic Receptors

- **Agonist** : A drug or other chemical substance that can combine with a receptor on a cell to produce a physiologic reaction.
- **Antagonist** : is a chemical substance that interferes with the physiological action of another, especially by combining with and blocking its nerve receptor

Receptors	Agonist	Antagonist
α_1	- Norepinephrine - Phenylephrine	- Phenoxybenzamine
β_1	- Norepinephrine - Isoproterenol	- Propranolol
β_2	- Albuterol	- Propranolol
Nicotinic	- Ach	- Curare
Muscarinic	- Muscarine	- Atropine

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 $\frac{1}{2}$ of its normal diameter.
 2. removal of vagus nerve \rightarrow atony \rightarrow 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** توسع حاد بالأوعية but after sometime, intrinsic tone increases by chemical adaptation.



Adrenal gland

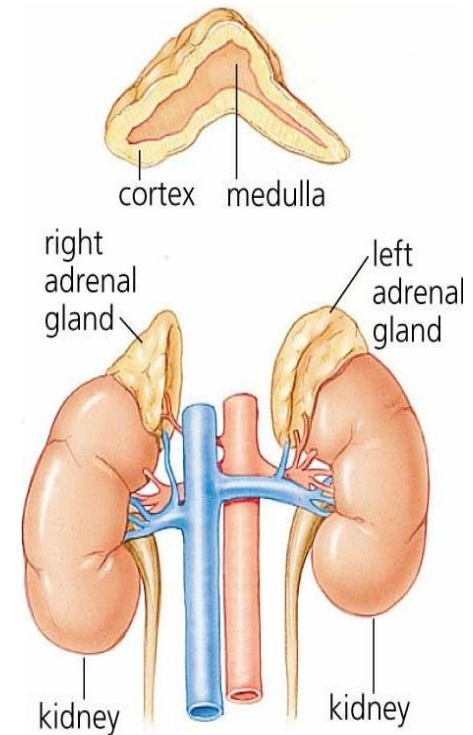
- Adrenal gland triggers the **Adrenal Medulla** to release **Epinephrine & Norepinephrine**.

Stimulation of sympathetic nerves causes large quantities of **Epinephrine** and **Nor-epinephrine** to be secreted in blood.

- The effect of **Epinephrine & Nor-epinephrine** lasts **5-10 times** more than the ones which secreted from sympathetic.

- **Adrenal medulla** will stimulated during **Sympathetic** only.

For more explanation [Click here](#) and [here](#)



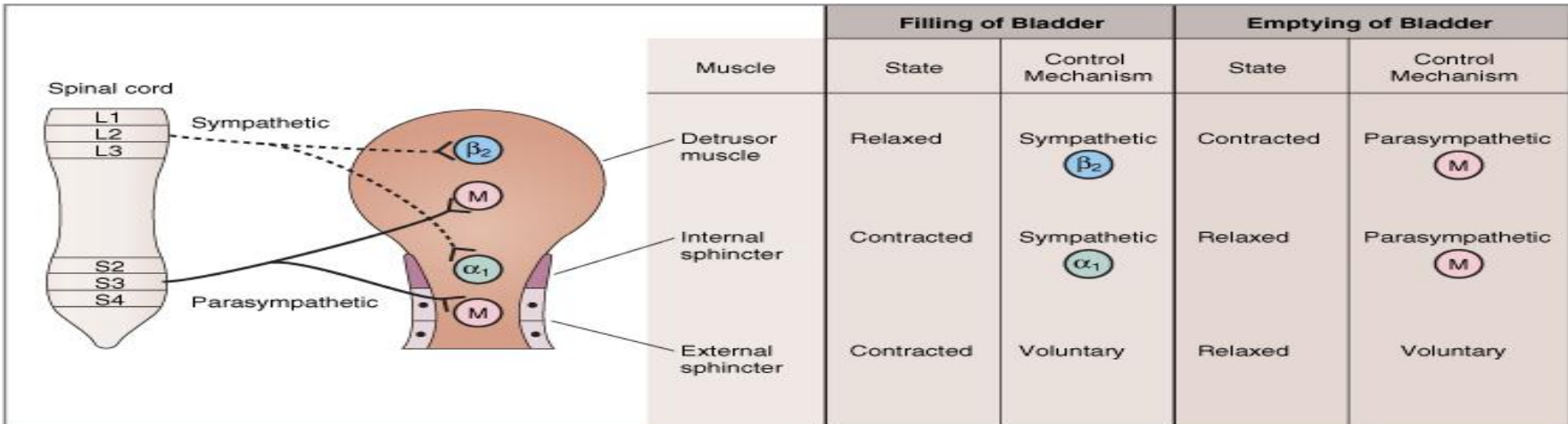
Autonomic reflexes.

Most of the **visceral** functions of the body are regulated by **autonomic reflexes**.

Cardiovascular.	Gastrointestine (GI)	Sexual reflexes
Baroreceptors reflex. It's stretch, in the main arteries to detect blood pressure. Ex.(carotid artery).	Receptors in nose & mouth. Sends a signal to parasympathetic to notify the glands in mouth & stomach to secret digestive juices.	- Erection by Parasympathetic. - Ejaculation by sympathetic.

Urinary Bladder.

Parasympathetic innervation initiates the micturition. “التبول”



Autonomic reflexes.

- **Sympathetic activation could occur in isolated portions.**
such as: (heart regulation, sympathetic reflexes that regulate G.I. functions)
- **Parasympathetic usually causes specific localized responses.**
It 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 and Bladder emptying, salivary and gastric secretion)

- Sympathetic can deal with every single organ alone.
- Parasympathetic can do that, but sometimes not, should be two processes together.

Important

- **What is the Neurotransmitter of the sympathetic NS ? (in general)**
Norepinephrine (Noradrenaline)
- **What are the Neurotransmitters that released during sympathetic stimulation?**
Norepinephrine & Epinephrine.
- **What is the Neurotransmitter that released at the Preganglionic fiber during sympathetic stimulation ?**
Acetylcholine (Ach).
- **What is the Neurotransmitter of the parasympathetic stimulation ?**
Acetylcholine (Ach).
- **What are is Neurotransmitter of the Preganglionic fiber during parasympathetic stimulation ?**
Acetylcholine (Ach).

- **QUIZ :** [Click here](#)

- **Videos :**

[The Autonomic Nervous System](#)

[Receptors: Adrenergic, Cholinergic](#)

[Autonomic Nervous System \(ANS\) - An overview of anatomy, divisions, receptors, and neurotransmitters](#)

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