LECTURE 9 and 10

Version 2

AUTONOMIC NERVOUS SYSTEM (I) & (II)

Physiology

Team 438

KSU

- Red : important
- Black : in male / female slides
- Pink : in girls slides only
- Blue : in male slides only
- Green : notes, Extra

Reviewed by Razan AlRabah & Khalid Alkhani

Objectives

- At the end of this lecture, students should be able to:

1. Appreciate the anatomy of the Sympathetic & Parasympathetic nervous system
2. Explain Physiological functions of Sympathetic & Parasympathetic nerves in the head, neck, chest, abdomen, and pelvis.

3. Organization of the Autonomic Nervous system
4. Neurotransmitters and Receptors
5. Agonists and Antagonists to Autonomic receptors
6. Sympathetic & Parasympathetic Tone
7. Examples

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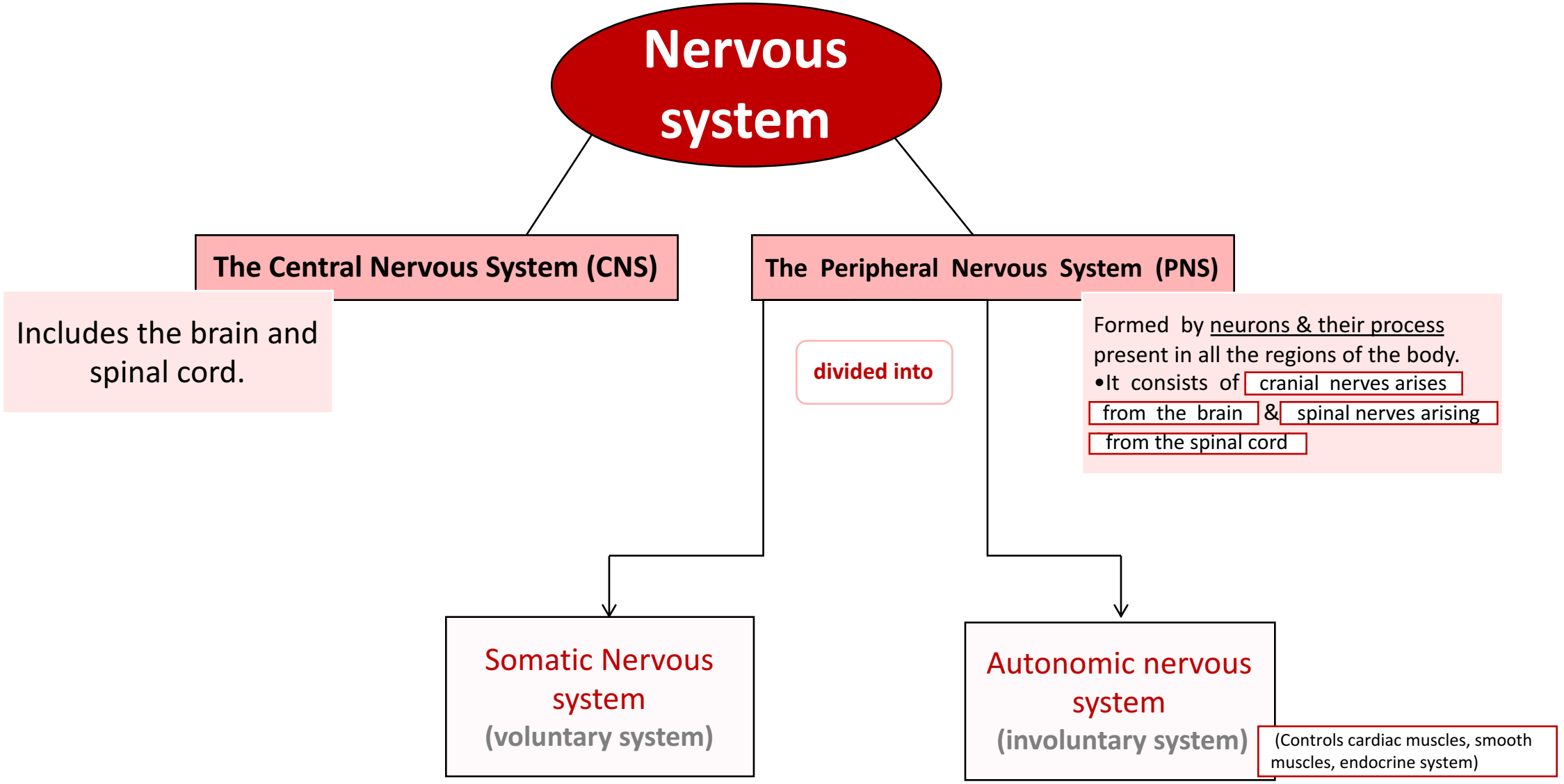
The nervous system



SOMATIC AND AUTONOMIC NERVOUS SYSTEM

The motor efferent nervous system has two component :

SOMATIC	AUTONOMIC
❖ A voluntary nervous. ❖ Consist of single motoneuron and skeletal muscle fibers. ❖ 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	❖ An involuntary nervous, that controls the function of visceral organs. ❖ Consist of two major divisions : 1- Sympathetic 2- Parasympathetic ❖ Activated by centers in spinal cord, brain stem and hypothalamus. ❖ Operated by visceral reflex

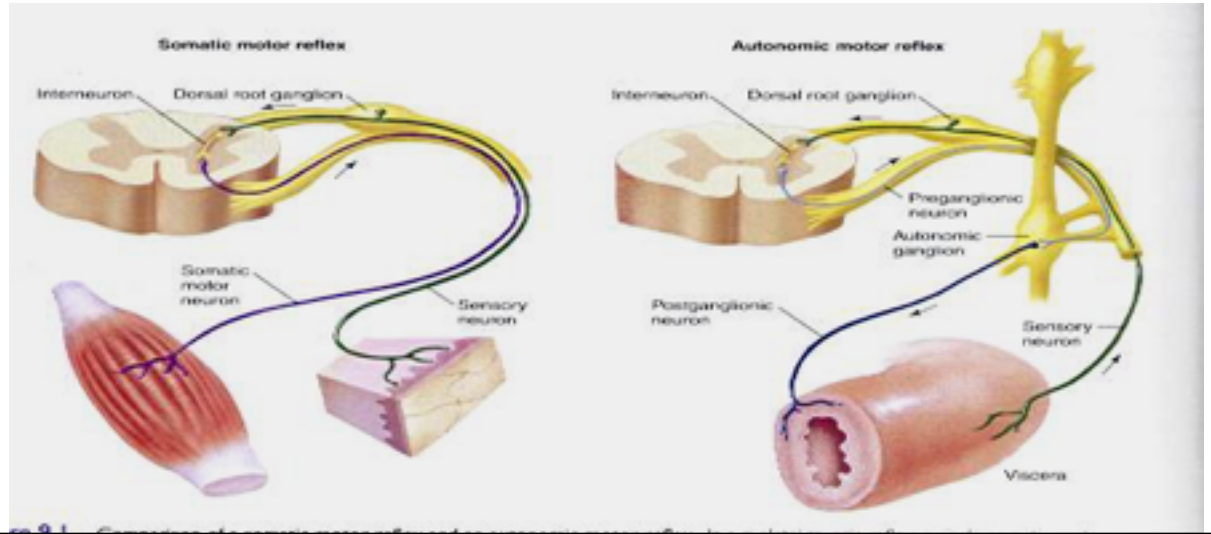
Autonomic nervous system (ANS)

- **Organization of autonomic nervous system motor pathway consists of two neurons:**
  - **Preganglionic neuron. (cell body inside CNS "in brain or cord")**
  - **Postganglionic neuron. (cell body in ganglion outside CNS)**

❖**All preganglionic neurons release Acetylcholine (Ach).**

❖**Postganglionic release either Ach or norepinephrine.**

Organization of the Autonomic Nervous System



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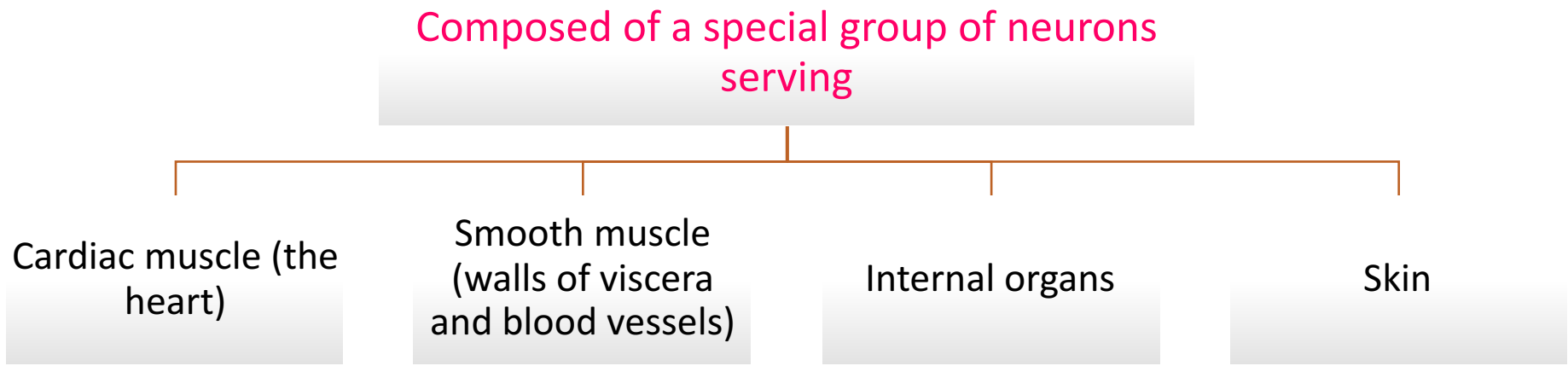
Autonomic nervous system

- ANS: is 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.**



Terminology

SYMPATHETIC AND PARASYMPATHETIC	ADRENERGIC AND CHOLINERGIC
anatomic terms and refer to anatomic origin of preganglionic neurons in the central nervous system.	**terms are used to describe neurons of either division, according to which neurotransmitter they synthesize and release.**
	❖ **Adrenergic neurons release nor-epinephrine and the receptor is adrenoreceptor** ❖ **Cholinergic neurons release Ach and the receptor is cholinergic**

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Higher control of the autonomic Nervous System

- **- Sympathetic NS** is regulated by neurons in the **Posterior** part of the **hypothalamus**.
- **- Parasympathetic NS** is regulated by neurons in the **Anterior** part of the **hypothalamus**.

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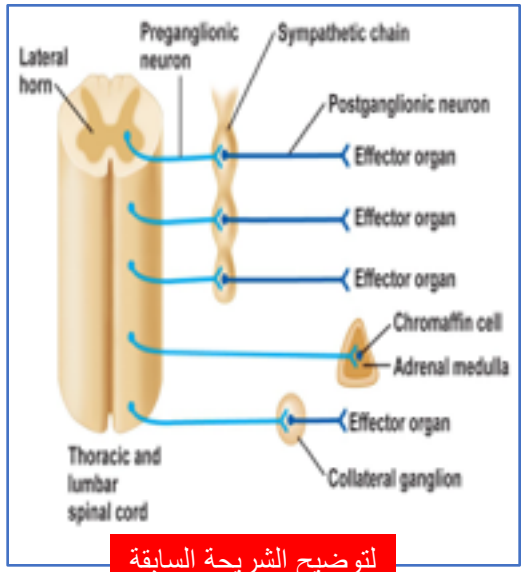
Sympathetic Nervous System (SNS)

- 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" / "E" division : increased arterial pressure, blood flow, blood glucose, metabolic rate and mental activity.

(Exercise, Excitement, Emergency, and Embarrassment)



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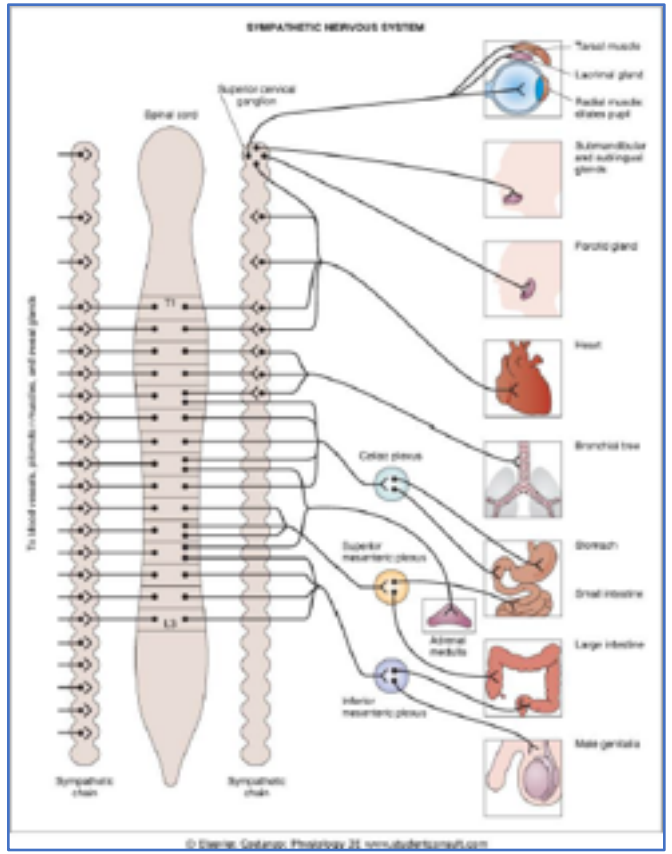


(SNS location)

Origin: Sympathetic preganglionic neurons originate from **thoracolumbar** lateral horns of the spinal cord (T1-L3) (T1-L2).

T1 = Thoracic
L2~L3 = Lumber

(SNS nerve fiber)

Preganglionic neurons: short , lightly myelinated
Postganglionic neurons: long , unmyelinated

(SNS ganglia)

Paravertebral Ganglia: (sympathetic chain) near vertebral body

(على امتداد العمود الفقري جنب العمود الفقري من الجهتين)

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

PARASYMPATHETIC NERVOUS SYSTEM

Responsible for activities that occur when the body is at rest "rest and digest"/ "D" division (Digestion, Defecation, and Diuresis)

(Parasympathetic NS location)

Origin: Their fibers originate from brain&sacrum (**Craniosacral**)

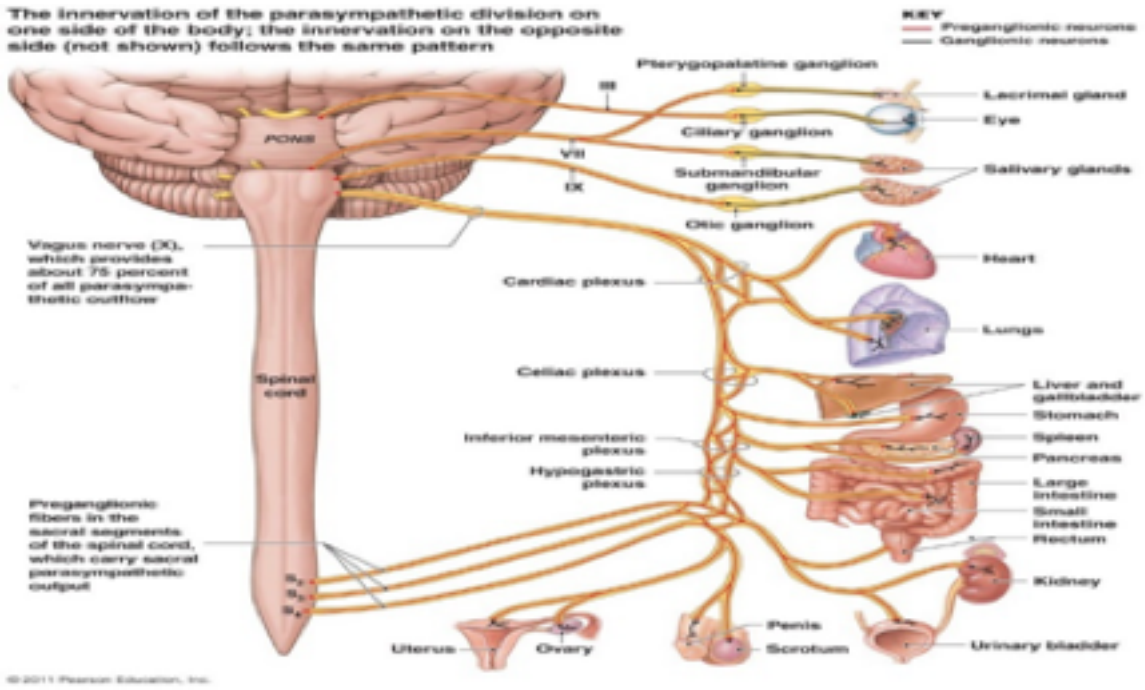
1. cranial nuclei Cell bodies of the motor nuclei of the cranial nerves III, VII, IX and X (3rd,7th.9th.10th) in brain stem (mid brain, pons, medulla)
2. sacral segments of the spinal cord (S2 -S4) Gives: (**cranio-sacral** outflow)

(Parasympathetic NS fiber)

1- preganglionic neurons
has long axon

2- Postganglionic neurons
short axon

(Length of Pre and Post is Parasympathetic is the opposite of the sympathetic NS)



(Parasympathetic NS ganglia)

Close to or on the affected organ:

- Terminal ganglia
- in the wall of organ

- **The cranial nerves III, VII and IX affect** the pupil and salivary glandsecretion
- **Vagus nerve (X) carries fibres to** the heart, lungs, stomach, upper intestine and ureter
- **The sacral fibres form pelvic plexuses which innervate the** distal colon, rectum, bladder and reproductive organs.

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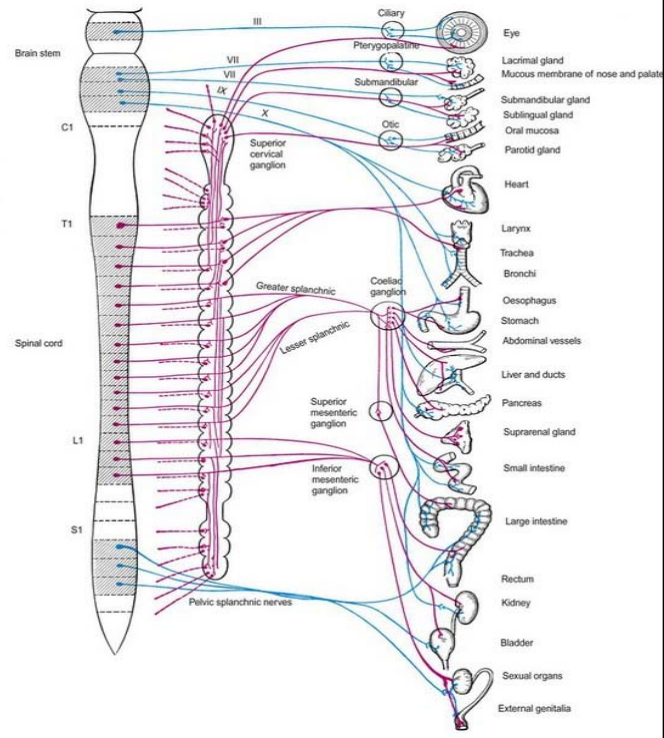
The autonomic nervous system

Subdivision	Nerves Employed	Location of Ganglia	Chemical Messenger	General Function
Sympathetic	Thoracolumbar	**Alongside vertebral column**	Norepinephrine	Fight or flight
Parasympathetic	Craniosacral	**On or near an effector organ**	Acetylcholine	Conservation of body energy

SYMPATHETIC & PARASYMPATHETIC NERVOUS SYSTEM ORIGIN

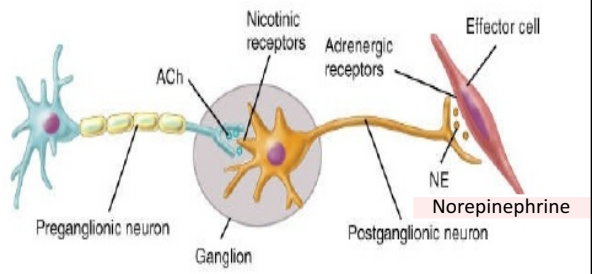
- Blue= Para symp; Red symp



ANS NEUROTRANSMITTERS

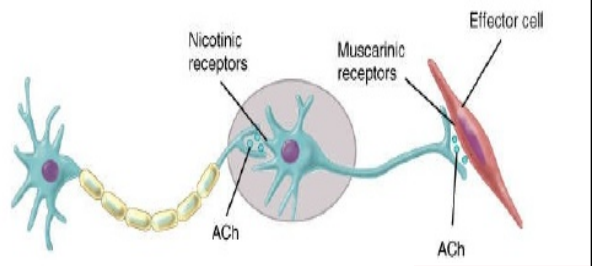
- **ANS Neurotransmitters:** Classified as either **cholinergic** or **adrenergic** neurons based upon the neurotransmitter released.

- Adrenergic



Norepinephrine

- Cholinergic



Acetyl choline

Sympathetic Neurotransmitters

- **Neurotransmitter:** norepinephrine
- **Adreno-receptors:**
  - alpha 1
  - alpha 2
  - Beta 1
  - Beta 2

-Neurotransmitter:
Ach (Acetylcholine)

-Cholinergic-Receptors:

1. Nicotinic
2. Muscarinic

* Remmber: ANS motor pathway consists of two neurons:

- Preganglionic neuron : inside CNS (in brain or spinal cord)
- Postganglionic neuron : outside CNS (cell body in ganglion outside CNS)

Note: they're named after drugs they're sensitive to

Sympathetic Neurotransmitters

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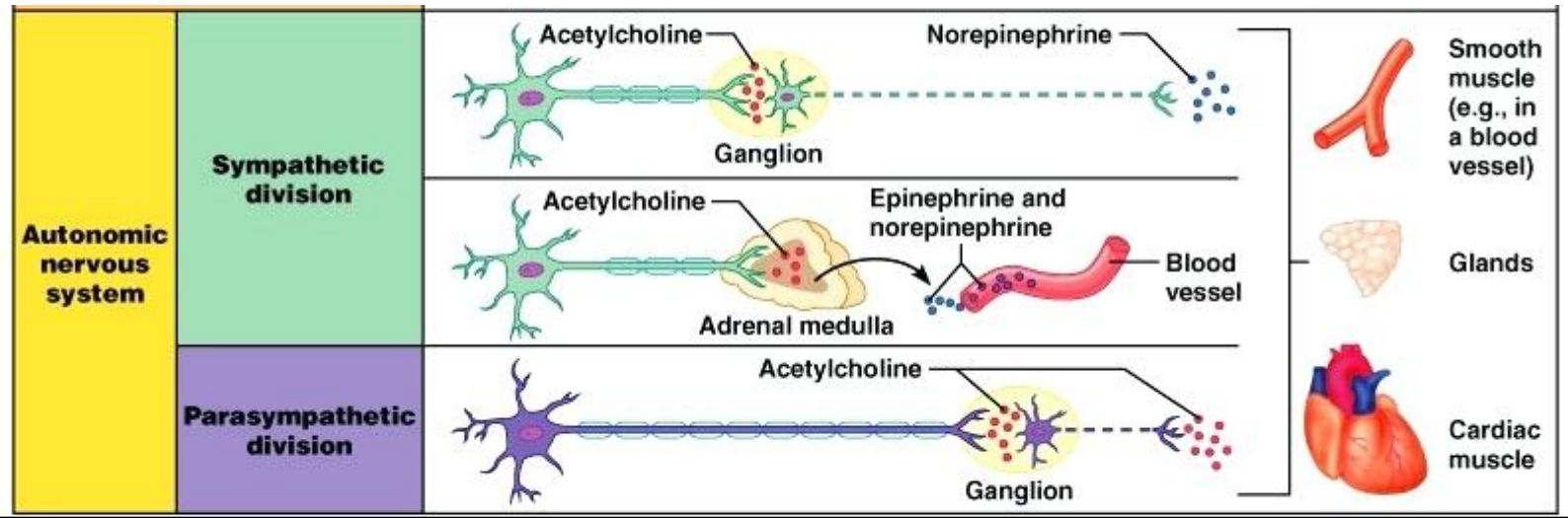
All the green texts are notes or extra information

Acetylcholine works on **increase** secretion and **dilation** of blood vessels

Norepinephrine works on **decrease** secretion and **constriction** of blood vessels

Preganglionic neurones are Cholinergic = (release **acetylcholine** (Ach))

Postganglionic neurons: release **norepinephrine** at target organs.



-All sympathetic **postganglionic** release noradrenalin (norepinephrine) **except** sweat glands & blood vessels to skeletal muscles **(they release Ach)**

- Because the muscles need more blood to work while running, and the body during heavy activity (high energy and temperature inside) needs to release sweat

-**Stimulation** of adrenal medulla will secrete: epinephrine and norepinephrine

So they are secreted from adrenal medulla

-Adrenal medulla **stimulated** during **sympathetic.**

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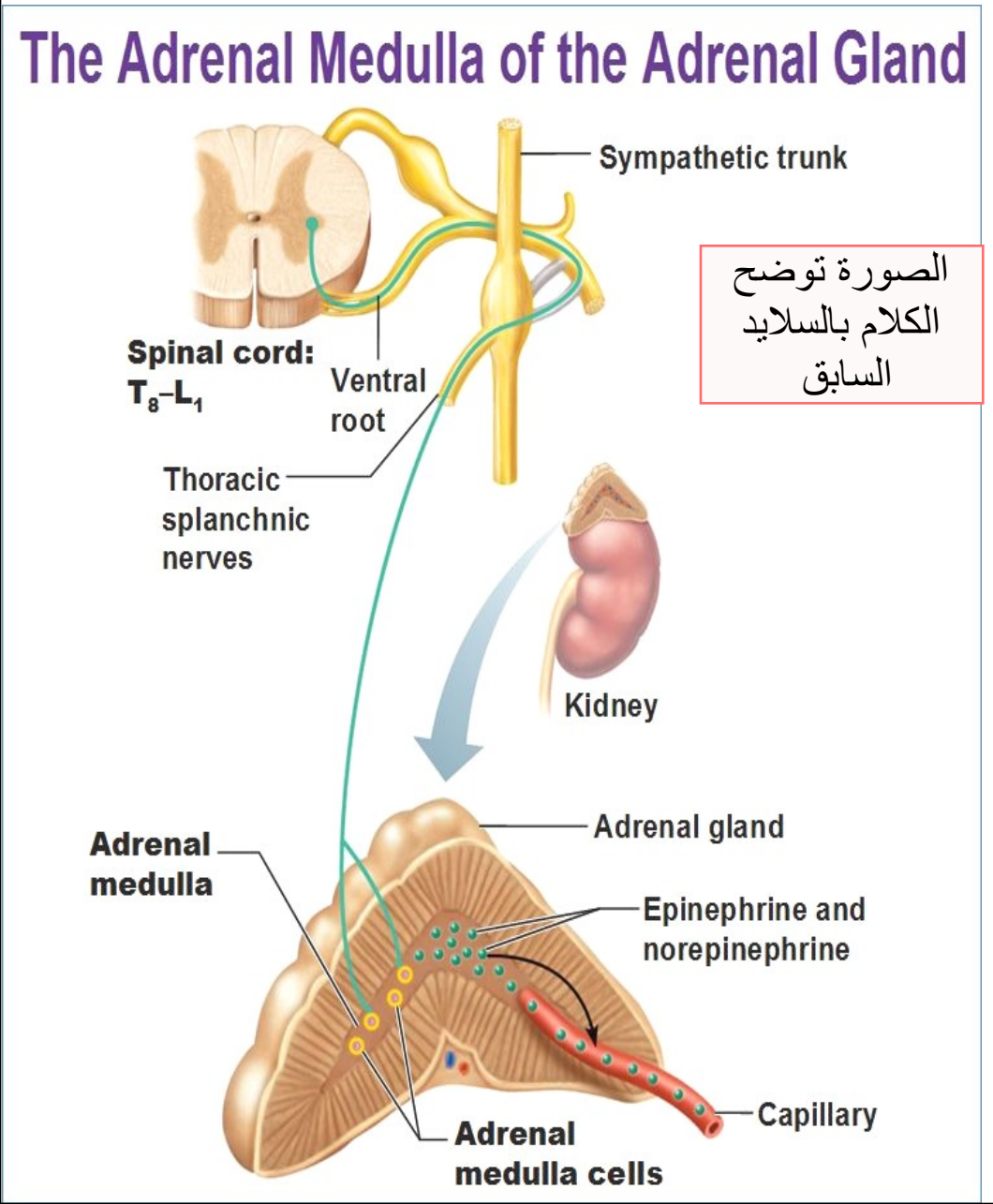

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Response to adrenergic stimulation

The adrenergic neurotransmitters

Norepinepherine

From all post-ganglionic sympathetic nerve fibres except that for: Sweat glands, blood vessels of the skeletal muscles, piloerector muscl of hair cells (Acetylcholin)

Epinephrine

From adrenal medulla which acts as modified sympathetic ganglia

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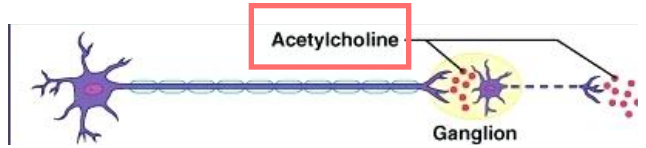
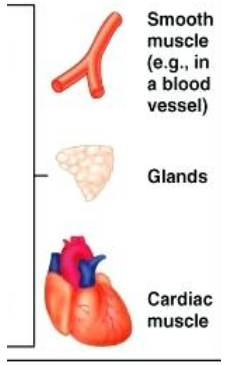
Parasympathetic Neurotransmitters

- **Pre & Postganglionic** neurons release:
- acetylcholine = Cholinergic





Autonomic nervous system: (neurotransmitters)

	preganglionic	postganglionic
parasympathetic	acetyl choline	acetyl choline
sympathetic	acetyl choline	norepinephrine*

Adrenal medulla: **preganglionic** - acetyl choline
postganglionic (chromaffin cell) **- 80%** epinephrine, **20%** norepinephrine

Sympathetic vs. Parasympathetic Receptors

All preganglionic autonomic receptors are nicotinic

In sympathetic nervous system

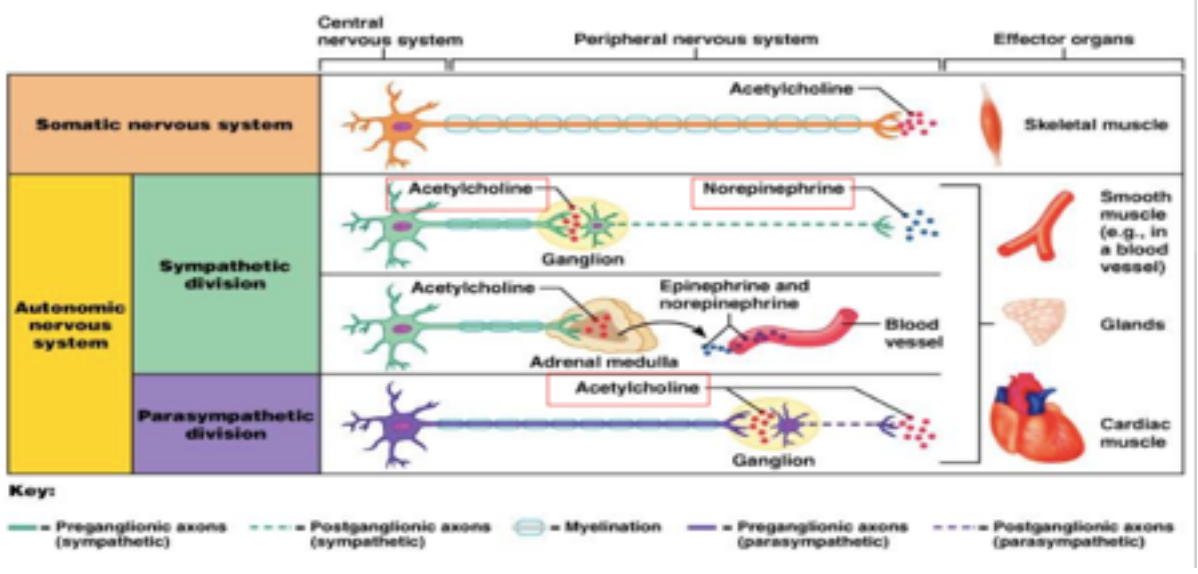
- Pre receptor: Nicotinic
- Post receptor: Adrenoreceptor (α and β)

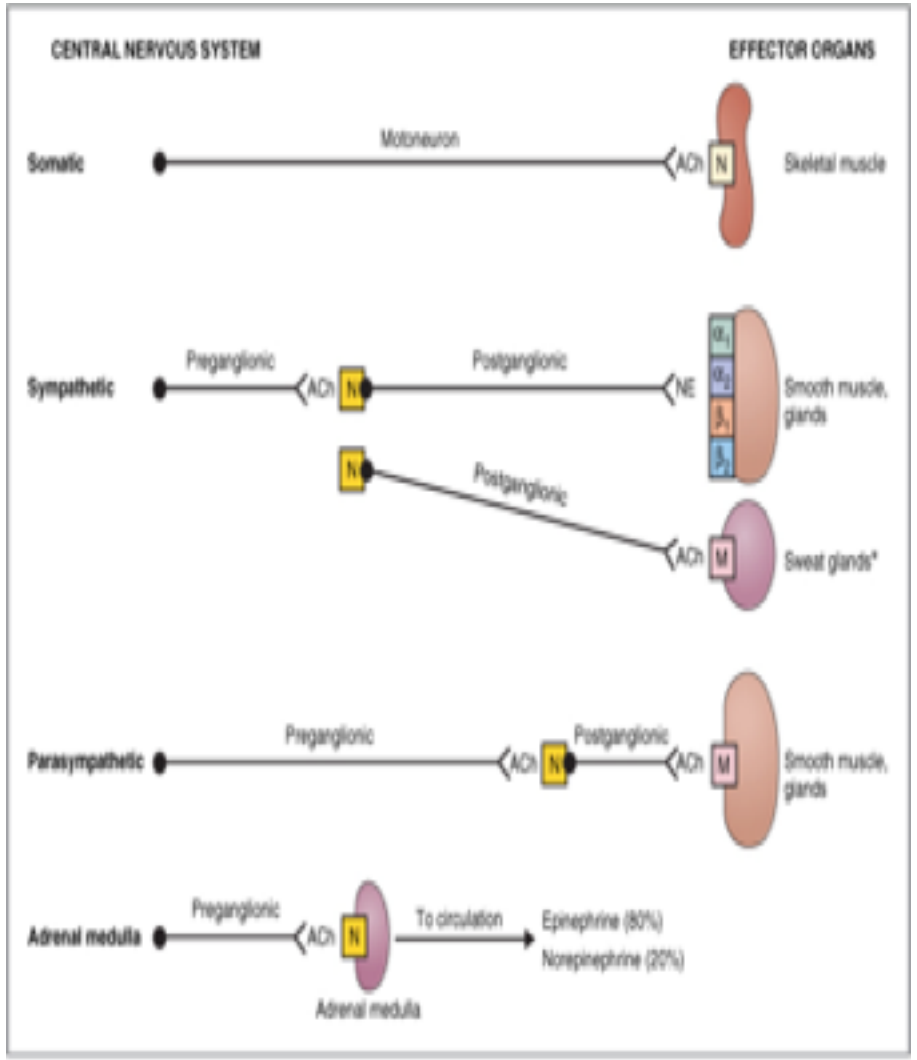
except in sweat glands where it is Muscarinic

In parasympathetic nervous system

- Pre receptor: Nicotinic
- Post receptor: Muscarinic

(Because the ONLY neurotransmitter in parasympathetic: acetylcholine (Ach)





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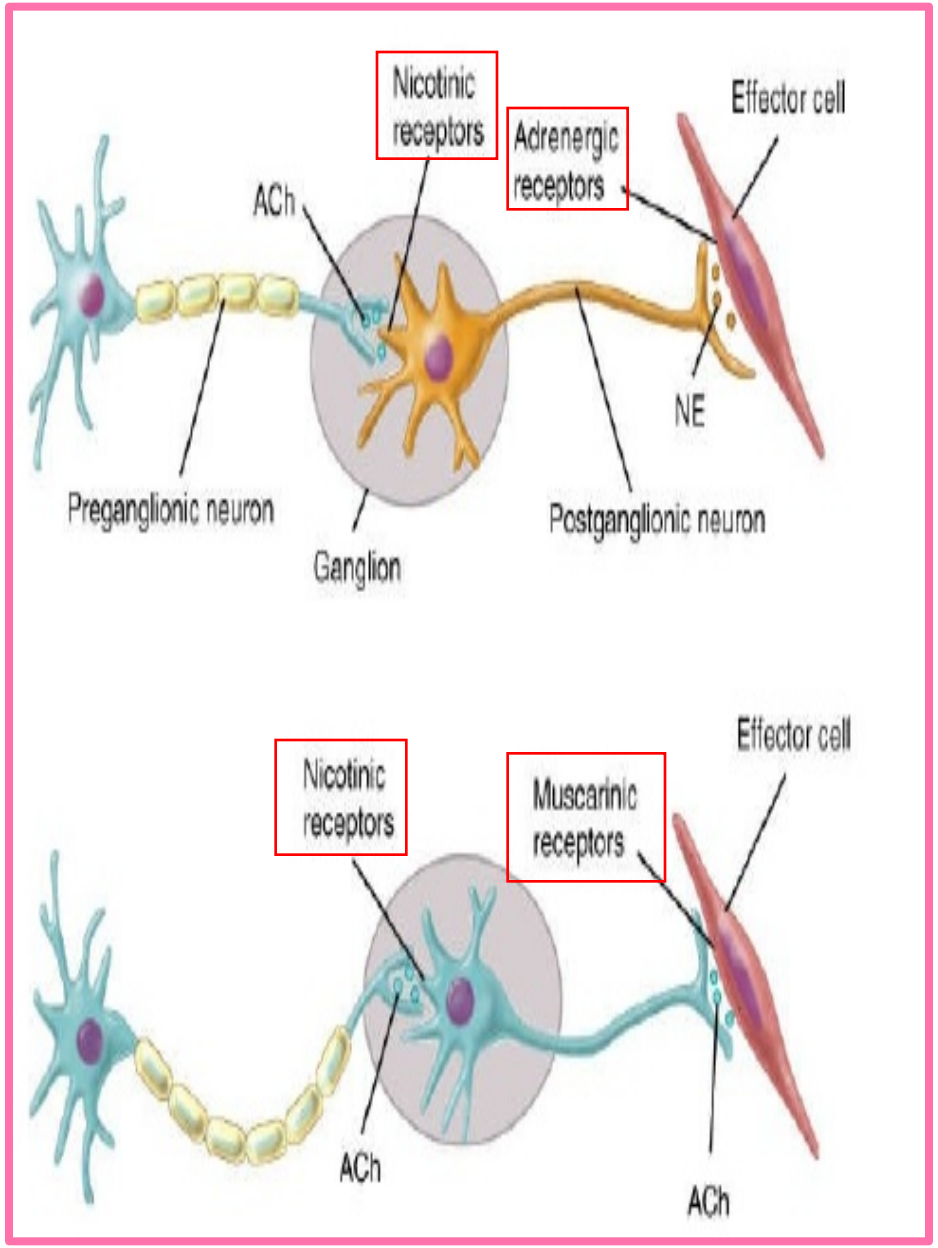
Chemical or neural transmitter



Sympathetic Adrenergic Receptors

Parasympathetic muscarinic receptors

All **preganglionic** fibers release **acetylcholin (Ach).**

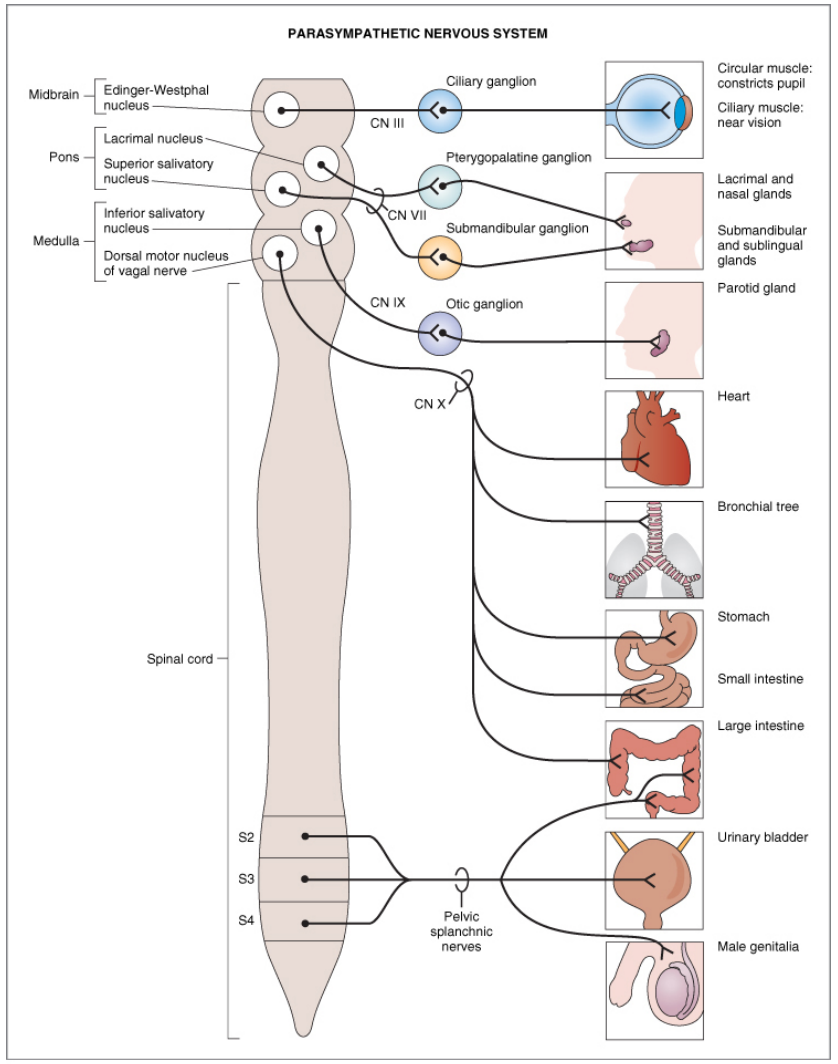
All **parasympathetic postganglionic** release **Ach.**

All **sympathetic postganglionic** release **noradrenalin except sweat glands & blood vessels to skeletal muscles.**

هذا السلايد هو ملخص للي قبل وما يحتوي على معلومات جديدة للفائدة فقط

Parasympathetic Nervous system

Preganglionic fibers	Postganglionic fibers
Originate from: 1. Cranial Nuclei (Brain stem) 2. Sacral **(S_2-S_4)**	Ganglia is located on/in organs
Long Axon	Short Axon
Cholinergic	Cholinergic
Interact with Nicotinic receptors	Interact with Muscarinic receptors



Receptors

Adrenoreceptors

α1

- Vascular smooth muscles
- Activation of α receptors leads to **contraction** of smooth muscles

α2

β1

Found in:

- S.A node
- A.V node
- Ventricular muscle
- Salivary gland
- Activation of β1 receptors leads to smooth muscle **contraction** (especially in heart)

β2

- Activation of β2 receptors leads to smooth muscle **relaxation**
- More sensitive to Epinephrine

Cholinoreceptors

Muscarinic

- Inhibition/ excitation.
- Found in sweat glands
- Found in smooth muscles.

Nictotinic

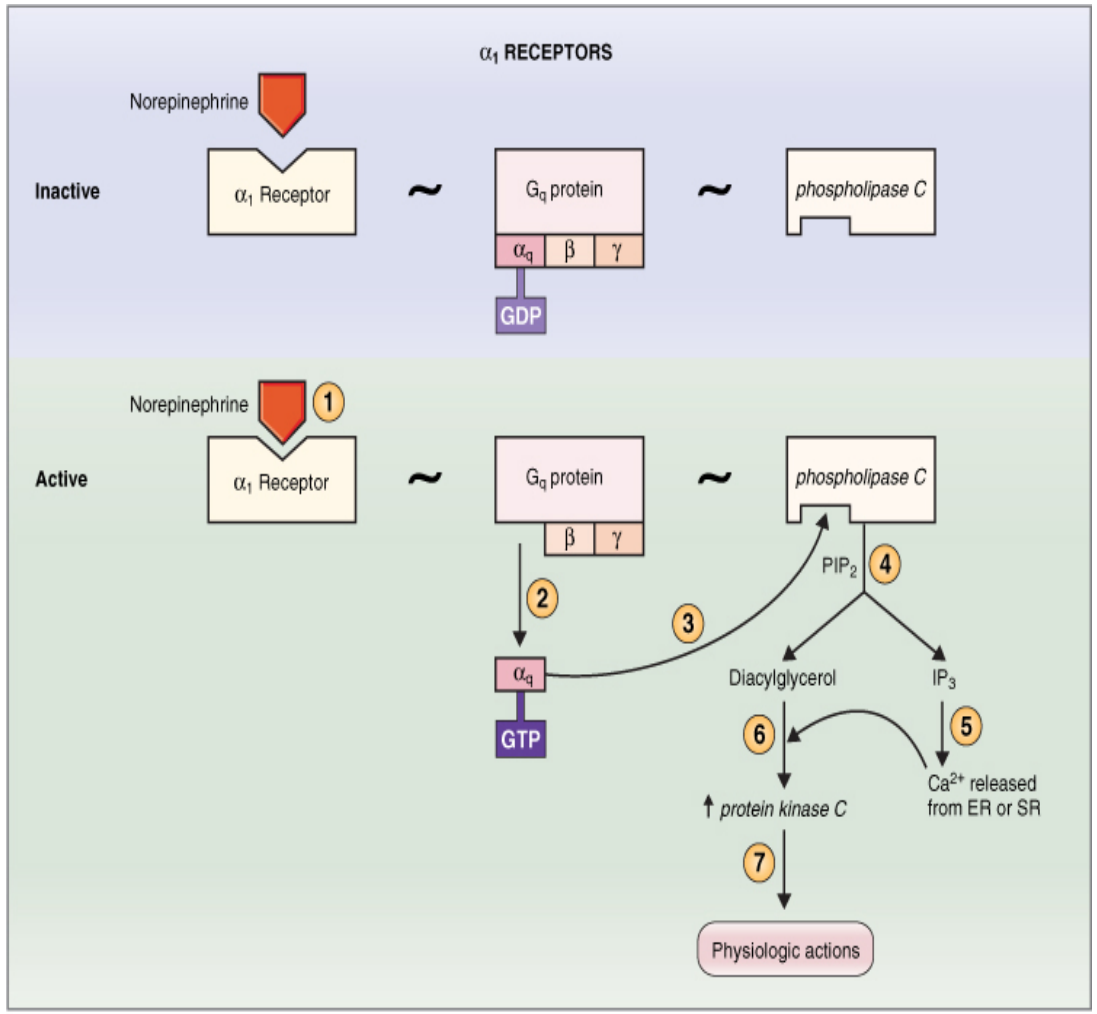
- Ex: Na+/K+ ion channel
- On all postganglionic receptors: neurons, motor, and adrenal medulla

on or for
راح تأثر بمعنى الجملة كامل

Nicotinic receptors **for** all **preganglion**
Nicotinic receptors **on** all **postganglion**

ليش؟ لان الريسبتور راح تكون للبري بس موجودة على البوست

α1 receptor



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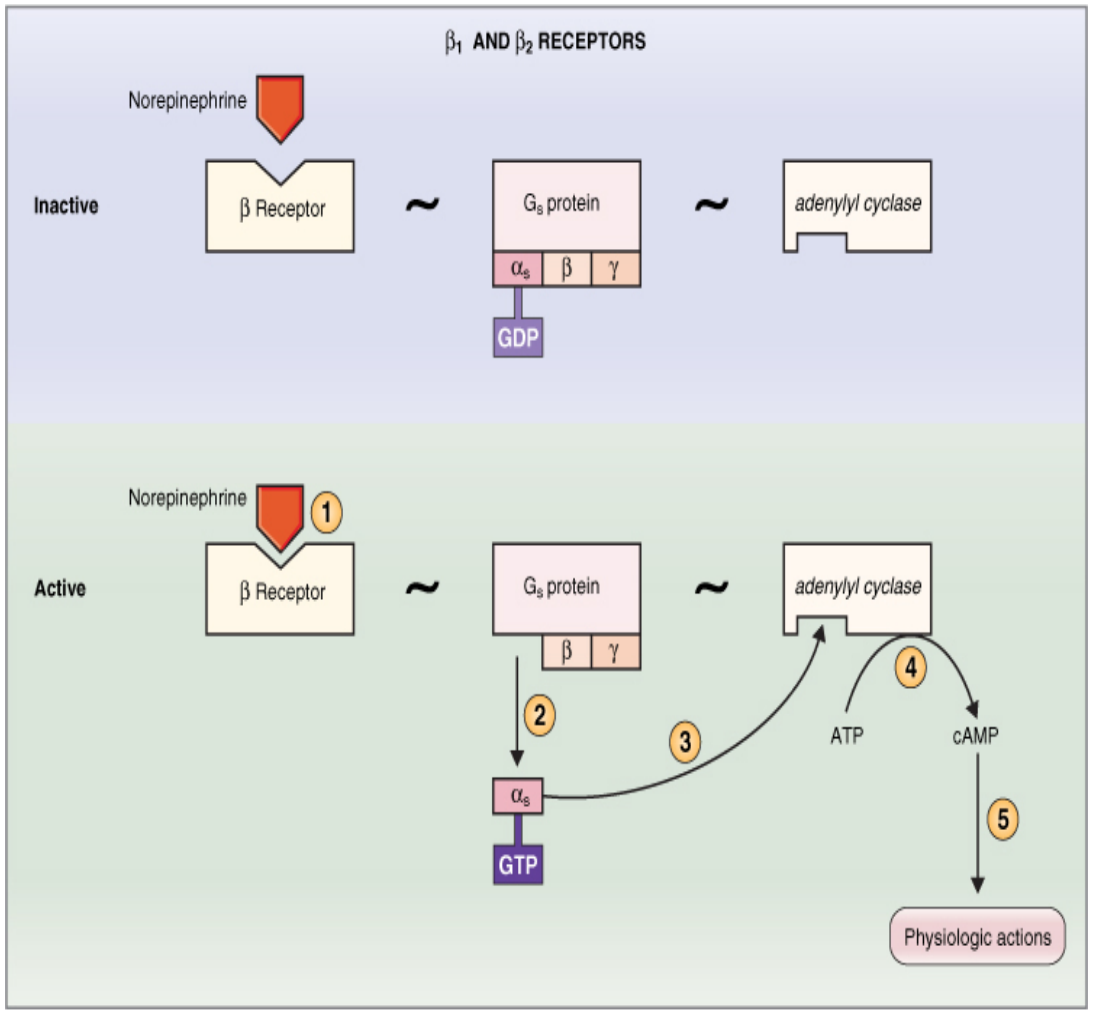
β1, β2 receptors



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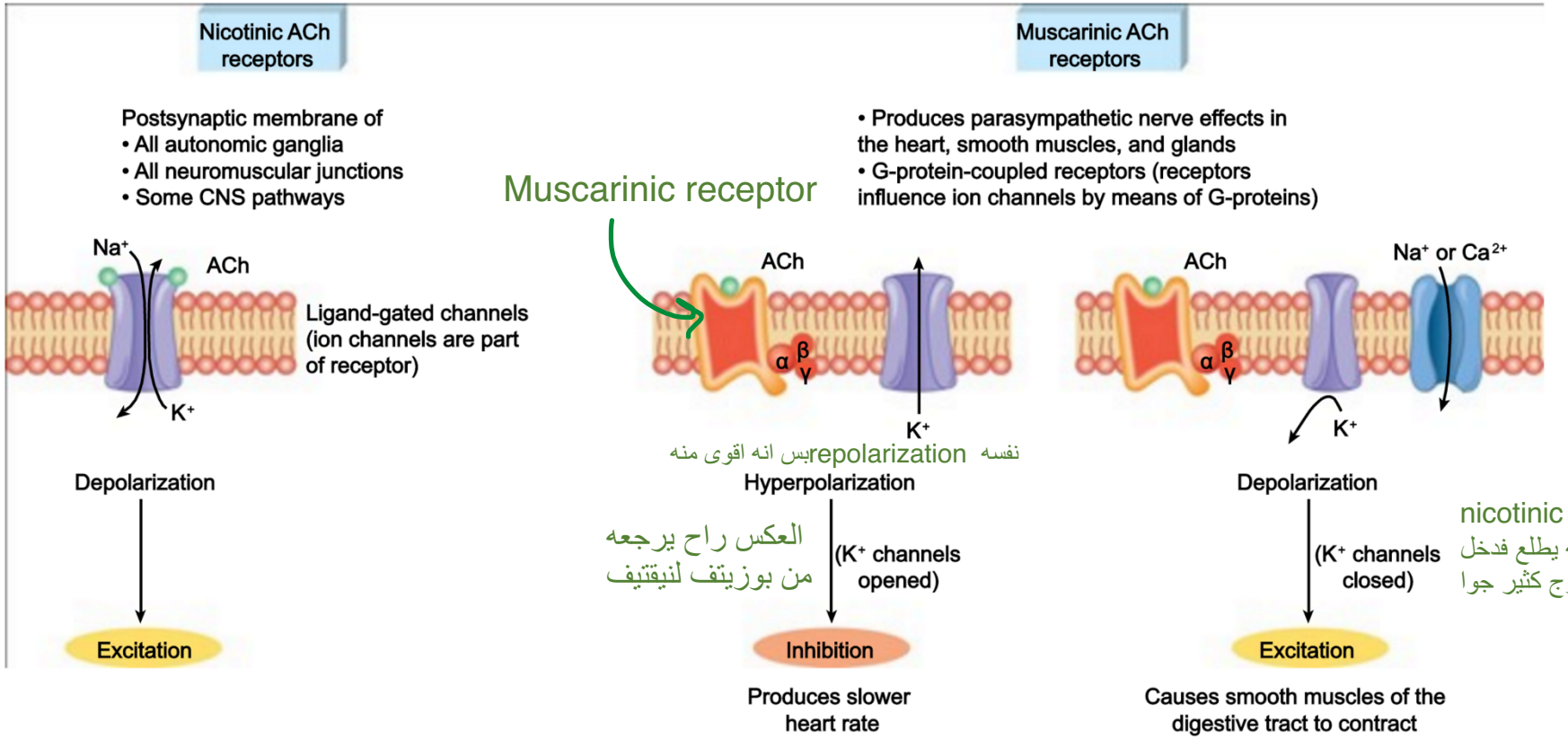
Cholinorecepters

All the green texts are notes or extra information

لما يجي الاسيتايل كولين يمسك بالبروتين (integral protein يفك الباشج ويخلي الصوديوم والبوتاسيوم يتحركوا زي البتاسيوم يطلع على downhill برا والصوديوم يطلع على جوا، عادة جوا الخلية يكون نقيتف بس لما ينفتح التشانيل بيدخل صوديوم اكثر مما يطلع بوتاسيوم فراح تكون الخلية من جوا بوزيتف هذا الشفت من الناقيتف للبوزيتف نسميه depolarization وهو نفسه اللي يحرك السقنيل من خليه لخلية هو اللي يصير بالنيورون والعضلات....



nicotinic ركزي مو مثل وقف البوتاسيوم انه يطلع فدخل بوزيتف شارج كثير جوا

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Prototypes of Agonists and Antagonists to Autonomic Receptors

Adrenoreceptors		
Receptor	Agonists (activator)	Antagonists (inhibitor)
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
	Nicotinic Carbachol	Hexamethonium (blocks ganglionic receptor but not neuromuscular junction)
Muscarinic	ACH	Atropine
	Muscarinic	
	Carbachol	

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Sympathetic and Parasympathetic Tone

Vagus nerve: is the 10th cranial nerve, and interfaces with parasympathetic control of the heart, lungs, and digestive tract.

- The role of them is to keep the stimulated organs in normal stage.
- **Examples:**
- sympathetic always keeps the blood vessel constricted ½ of its normal diameter.
- removal of vagus nerve (Parasympathetic) → atony → loos 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**.

Serve Vasodilatation :
توسع حاد بالأوعية

Function of Adrenal Gland

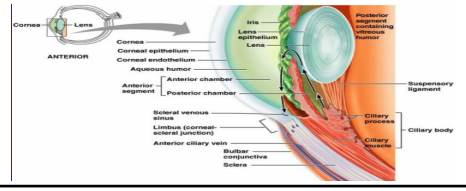
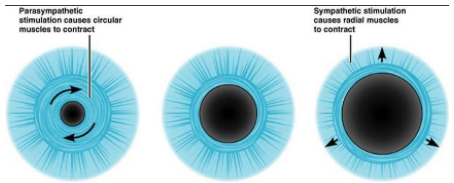
- Stimulation of sympathetic nerves causes large quantities of Epinephrine and Norepinephrine to be secreted in blood from adrenal gland.

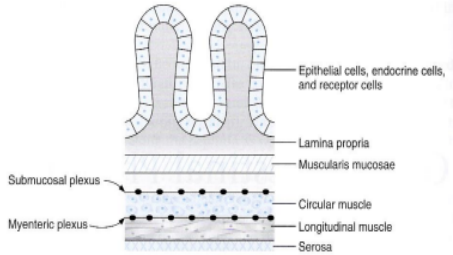
- The effect of Epinephrine & Norepinephrine which secreted from Adrenal gland lasts 5-10 times more than the ones which secreted from sympathetic.

Epinephrine = Adrenaline
Nor-Epinephrine = Nor-Adrenaline

PHYSIOLOGICAL FUNCTIONS OF THE AUTONOMIC NERVOUS SYSTEM

Important

structure	Sympathetic Stimulation	Parasympathetic Stimulation
Iris (eye muscle)	stimulates the contraction of meridional fibers of the iris to **dilate** the pupil.(**for clear and far vision**)  	• stimulates the contraction of circular muscle of the iris to **constrict** the pupil. • Focusing of the lens is controlled by parasympathetic through contraction of ciliary muscle.
Salivary glands	Saliva production **reduced**	Saliva production **increased**
Oral/Nasal Mucosa	Mucus production **reduced**	Mucus production **increased**
Heart	Heart rate, activity and force **increased**	Heart rate, activity and force **decreased**
Lung	Bronchial muscle **relaxed** (تتوسع عشان تسمح بدخول الاكسجين)	Bronchial muscle **contracted**
Stomach	Peristalsis **reduced**	Gastric juice **secreted**; motility **increased** (المعدة تتحرك وتطلع صوت بوقت الجوع)
Small intestines	Motility **reduced**	Digestion **increased**
The Glands	• decreases the secretion rate by causing vasoconstriction (the constriction of blood vessels).	increases the secretion rate.

structure	Sympathetic Stimulation	Parasympathetic Stimulation
Large intestines	**Motility reduced**	**Secretions and motility increased**
Liver	**Increased** conversion of glycogen to glucose (الضغط المستمر ممكن يسبب مرض السكر)	
Kidney	**Decreased** urine secretion	Increased urine **secretion**
Adrenal medulla	Norepinephrine and epinephrine **secrete**	
Bladder	Wall **relaxed** ,Sphincter **closed**	Wall **contracted** ,Sphincter **relaxed**
The Gastrointestinal Tract * Contains the enteric nervous system (one of the main divisions of ANS).	decrease the activity of GI.  	increases the activity of GI tract, peristaltic contraction & sphincter relaxation.
Systematic Blood Vessels	constricts the vessels. - Dilation of skeletal muscles blood vessels - Constriction of skin blood vessels	NO EFFECT except in certain areas. Eg: blushing of the face.
Arterial Pressure	increase of cardiac output + blood and pressure's resistance.	decreases cardiac output, BUT NO EFFECT ON BLOOD VESSELS.

Autonomic reflexes

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

A) Cardiovascular:

Baroreceptor reflex is a stretch reflex - longer & stronger - in the main arteries – such as carotid artery- which detects the blood pressure (When the pressure is high, sympathetic gets inhibited which stops the release of α1).

B) Gastrointestine:

The receptors in the nose & mouth signals the parasympathetic system to notify the glands of mouth & stomach to secrete digestive juices.

C) Urinary Bladder:

Initiates the micturition - discharge of urine - by parasympathetic innervations.

D) Sexual reflexes:

Parasympathetic → erection.
Sympathetic → ejaculation.

Found in males slides only

Autonomic reflexes

- The sympathetic activation could occur in isolated portions, such as:
- Heart regulation.
- Many Reflexes regulating G.I functions.

The parasympathetic usually causes specific localized responses.

Usualy to a certain organ, but sometimes it affects the function of some organs together, such as:

- Rectal emptying **+** Bladder emptying.
- Salivary secretion **+** Gastric secretion.

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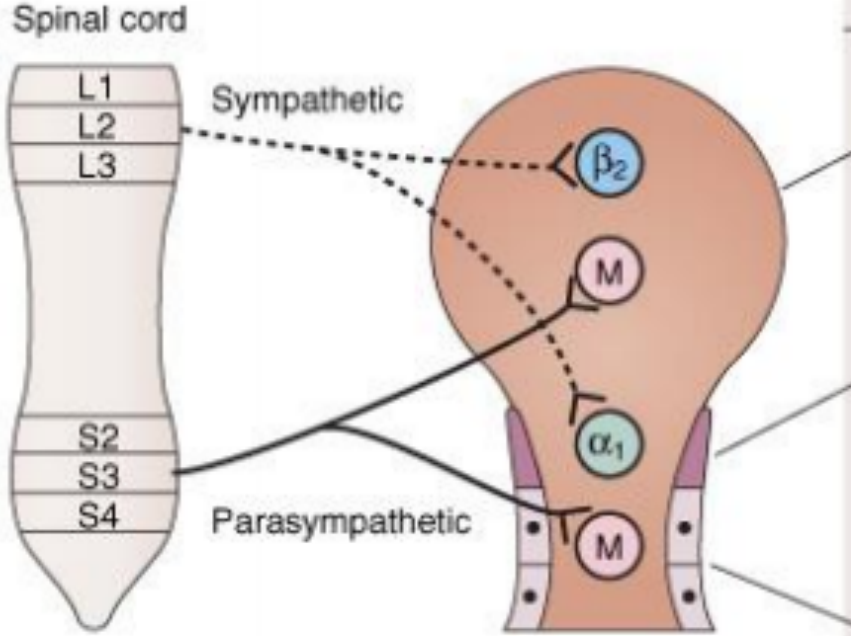
Urinary bladder



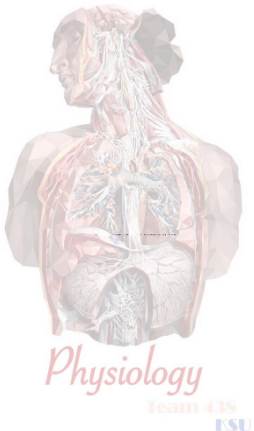
Muscle	Filling of Bladder: State	Filling of Bladder: Control Mechanism	Emptying of Bladder: State	Emptying of Bladder: Control Mechanism
Detrusor muscle	Relaxed	Sympathetic (β_2)	Contracted	Parasympathetic (M)
Internal sphincter	Contracted	Sympathetic (α_1)	Relaxed	Parasympathetic (M)
External sphincter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

Quiz

1) Stimulation of adrenal medulla will secrete:			
A) Epinephrine	B) Norepinepherine	C) Acetyl choline	D) Epinephrine and Norepinepherine
2) The receptors of parasympathetic NS for postganglion is:			
A) Nicotonic receptors	B) Adrenergic receptors	C) Muscrinic receptors	D) None of above
3) The receptor in sympathatic NS which is responsible of smooth muscle contraction is:			
A) Alfa1-receptors	B) Alfa2-recaptors	C) Beta2-receptors	D) None of above
4) The function of sympathatic NS in salivary glands is saliva production.....:			
A) Increased	B) Reduced	C) stimulated	D) Organized
5) The function of parasympathetic NS in arterial pressure ..... of cardiac output:			
A) Increased	B) Reduced	C) stimulated	D) Organized

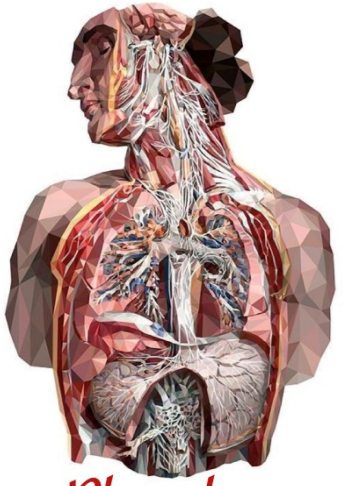
السؤال من الدكتورة قالته اثناء الشرح

key answers:
1) D
2) C
3) A
4) B
5) B



Thank you

Boys team members	Girls team members
• عمر الدوسري	• اروى الامام
• زياد الدوسري	• ديما المزيد
• محمد الحمد	• جود الخليفة
• عوض العنزي	• جود العتيبي
• فيصل القفاري	• رغد المبارك
• عبدالله باسمح	• ريناد المطوع
• جهاد العريني	• ريما المطوع
	• طرفة آل كلثم
	• مي بابعير
	• نجود العلي
	• نورة المزروع



Team leaders:

- **عمر الشيناوي**
- **ايلاف المسيحل**

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