Foundation Block

Physiology team 441

6-

Physiology of autonomic nervous system

Team Leaders

★ Alanoud albawardi

★ Nawaf alshehri

MED441
KING SAUD UNIVERSITY

physiology 441

Abdulaziz & Bahammam
Faye Wael Sendi

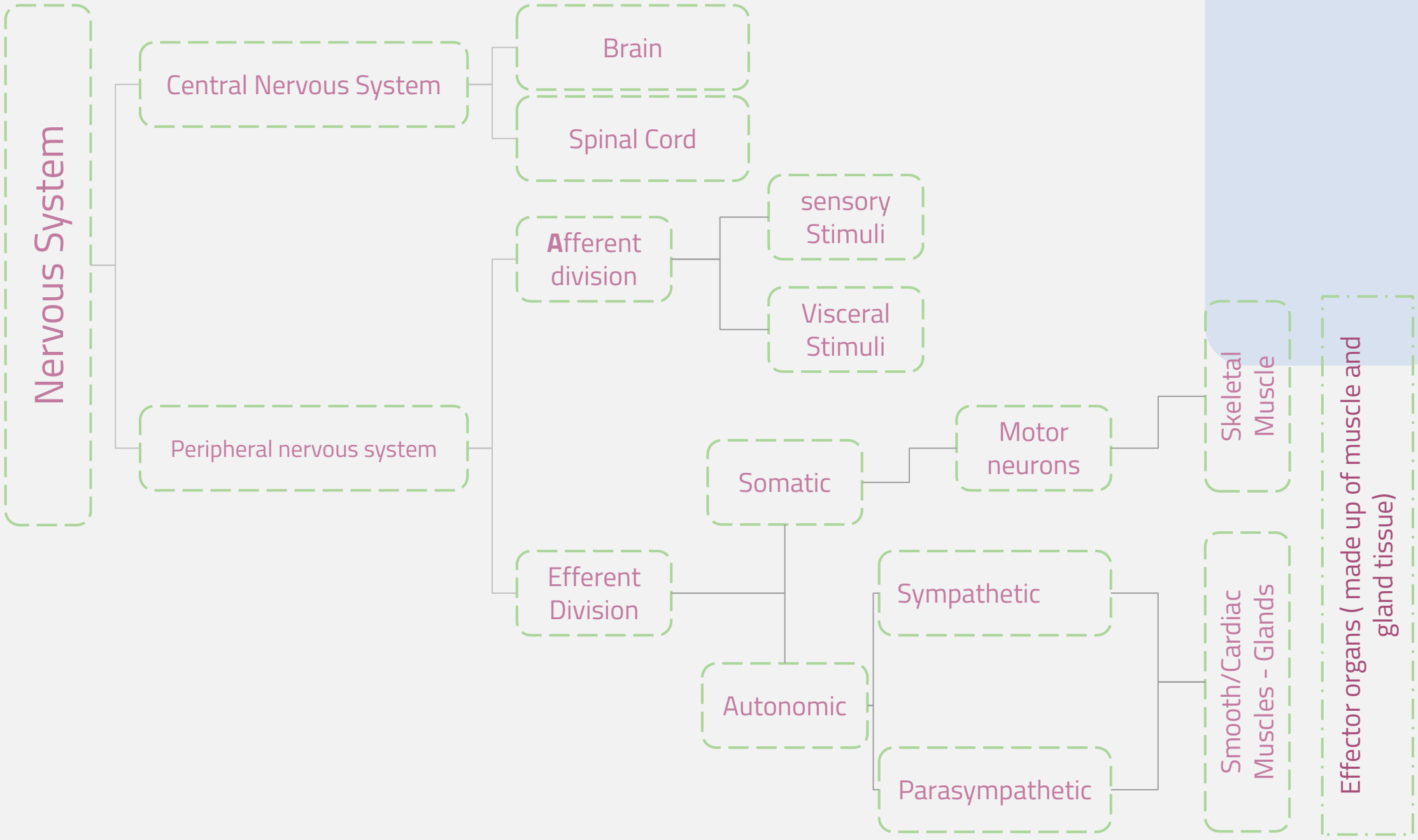
Editing File

Color index

- Main Text
- Important
- Dr's notes
- Female
- Male
- Extra

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.



Terminology:

Sympathetic	Anatomic terms and refer to anatomic origin of preganglionic neurons in the central nervous system (CNS)
Parasympathetic	
Adrenergic	Terms 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 adrenoceptor.
Cholinergic neurons	Release Acetylcholine (Ach) and the receptor is Cholinergic receptor.

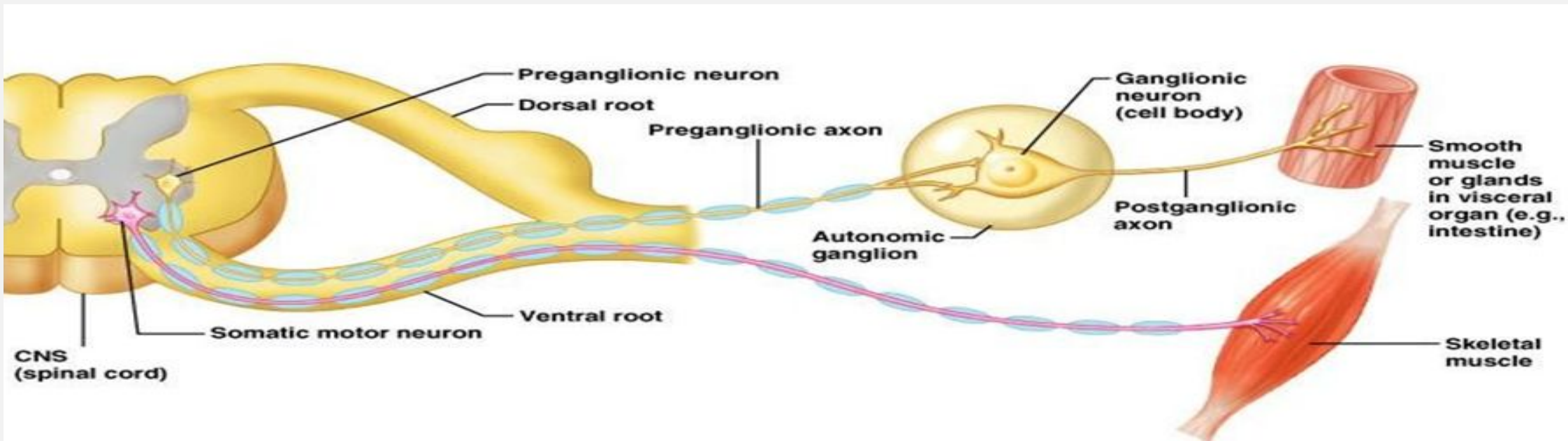
- The nervous system **monitors and controls** almost every organ / system through a series of positive and negative feedback loops.
  - **The Central Nervous System (CNS):** Includes the brain and spinal cord.
  - **The Peripheral Nervous System (PNS):** Formed by **neurons & their process** present in all the regions of the body.
    - It 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.
    - The motor efferent nervous system has two components :
      1- Somatic 2- Autonomic

The Endocrine also control our body system.
The CNS is more faster than Endocrine.

★ Basic anatomical difference between the motor pathways of the voluntary somatic nervous system (to skeletal muscles) and those of the autonomic nervous system

- **Somatic system:**
  - 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.
  - a voluntary nervous system under conscious control.
  - consists of a single motor neuron and skeletal muscle fibers.
- **Autonomic system:** chains of two motor neurons
  - 1st = preganglionic neuron (in brain or cord).
  - 2nd = ganglionic neuron (cell body in ganglion outside CNS).
  - Slower because lightly or unmyelinated.
  - An involuntary nervous system that modulates and controls the function of visceral organs.
  - ANS is activated by centers in spinal cord, brainstem and hypothalamus and operated by visceral reflex

In the Autonomic motor neuron there is Ganglia while in the Somatic motor neuron there is no Ganglia.

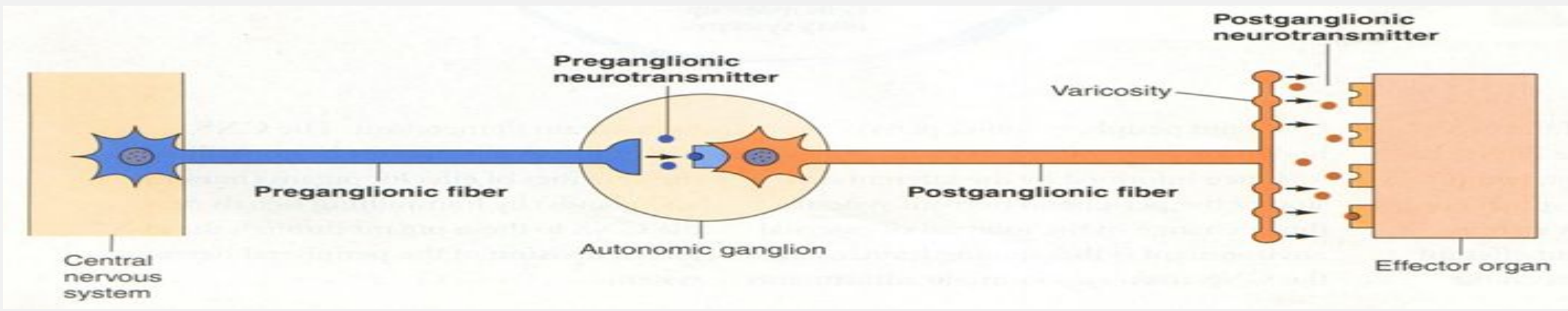


- ANS is the subdivision of the peripheral nervous system that regulates body activities that are generally **not under conscious control**.
- **Visceral motor** innervates **non-skeletal (non-somatic) muscles**.
- Composed of a special group of neurons serving:
  - Cardiac muscle (the heart) - Internal organs
  - Smooth muscle (walls of viscera and blood vessels) -Skin
- Organization of ANS motor pathway consists of two neurons:
  - Preganglionic neuron.
  - Postganglionic neuron.
- All **pre**ganglionic neurons release Acetylcholine (Ach).
- **Post**ganglionic neurons release either Ach, or norepinephrine.

★ Autonomic Nervous System Axons

➢ **Axon of First (Preganglionic) Neuron:** Leaves CNS to synapse with the 2nd (ganglionic) neuron

➢ **Axon of Second (Postganglionic) Neuron:** extends to the organ it serves



★ Locations of Sympathetic Ganglia

➢ **Trunk (sympathetic chain)(Paravertebral ganglia)**

Ganglia near vertebral bodies

➢ **Prevertebral Ganglia**

Near large blood vessels in gut:

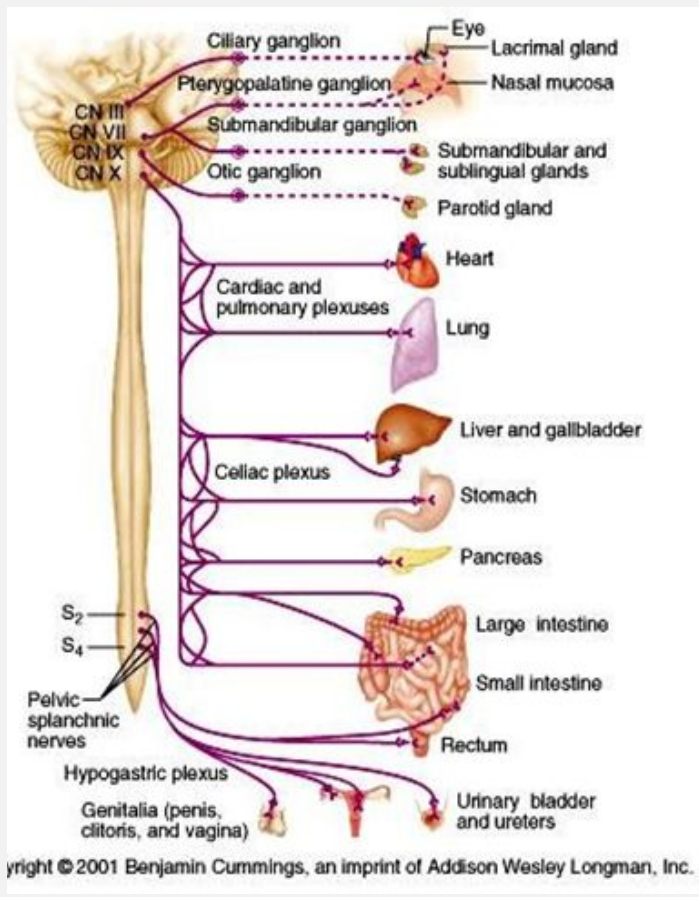
Celiac, Superior mesenteric and Inferior mesenteric

★ Locations of Parasympathetic Ganglia

➢ Terminal Ganglia

➢ In the wall of the organ

Parasympathetic ganglia are located on or in the affected organs.



Autonomic receptors

Type	Examples			
Adrenoreceptors Release (norepinephrine)	α1 receptor	α2 receptor	β1 receptor	β2 receptor
Cholinoreceptors Release (Ach)	Nicotinic receptor (N)	Muscarinic receptor(M)		

- Type of receptor and its mechanism of action determine the physiological response

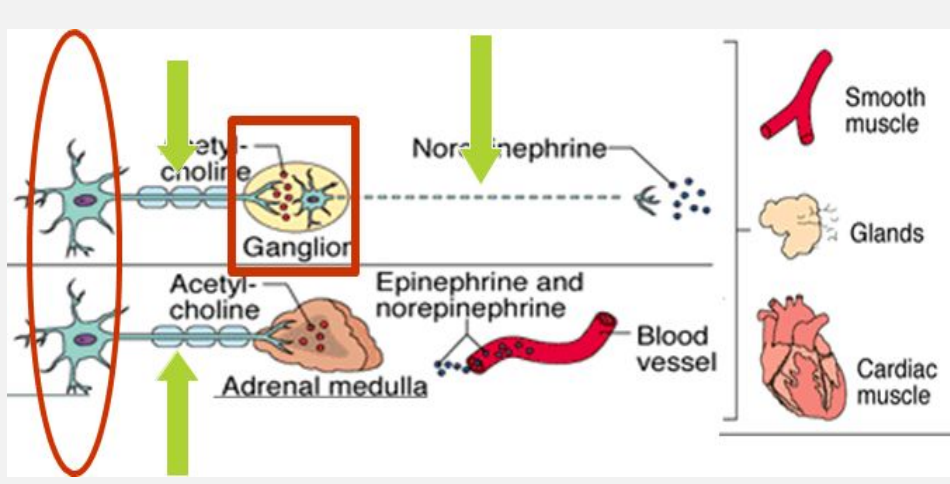
- B1 receptor in SA node and in ventricular muscle:
- SA node: activation of SA node by the agonist (Norepinephrine) increases the heart rate.
- Very muscles increase the contractility

★ Sympathetic Innervation of Visceral Targets

➢ Short, lightly myelinated Preganglionic neurons that are Cholinergic (release Ach) interacts with nicotinic receptors on the cell body of postganglionic neurons.

➢ Long, unmyelinated Postganglionic neurons that are Adrenergic (release norepinephrine) with adrenoreceptors **EXCEPT** in thermoregulatory sweat glands they are Cholinergic (release Ach) with muscarinic receptors

➢ **Ganglia is close to the spinal cord**



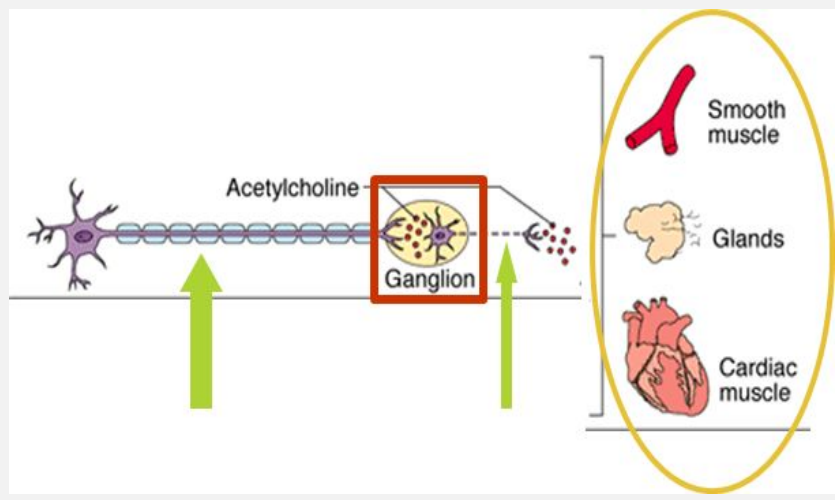
Helpful video

★ Parasympathetic Innervation of Visceral Targets

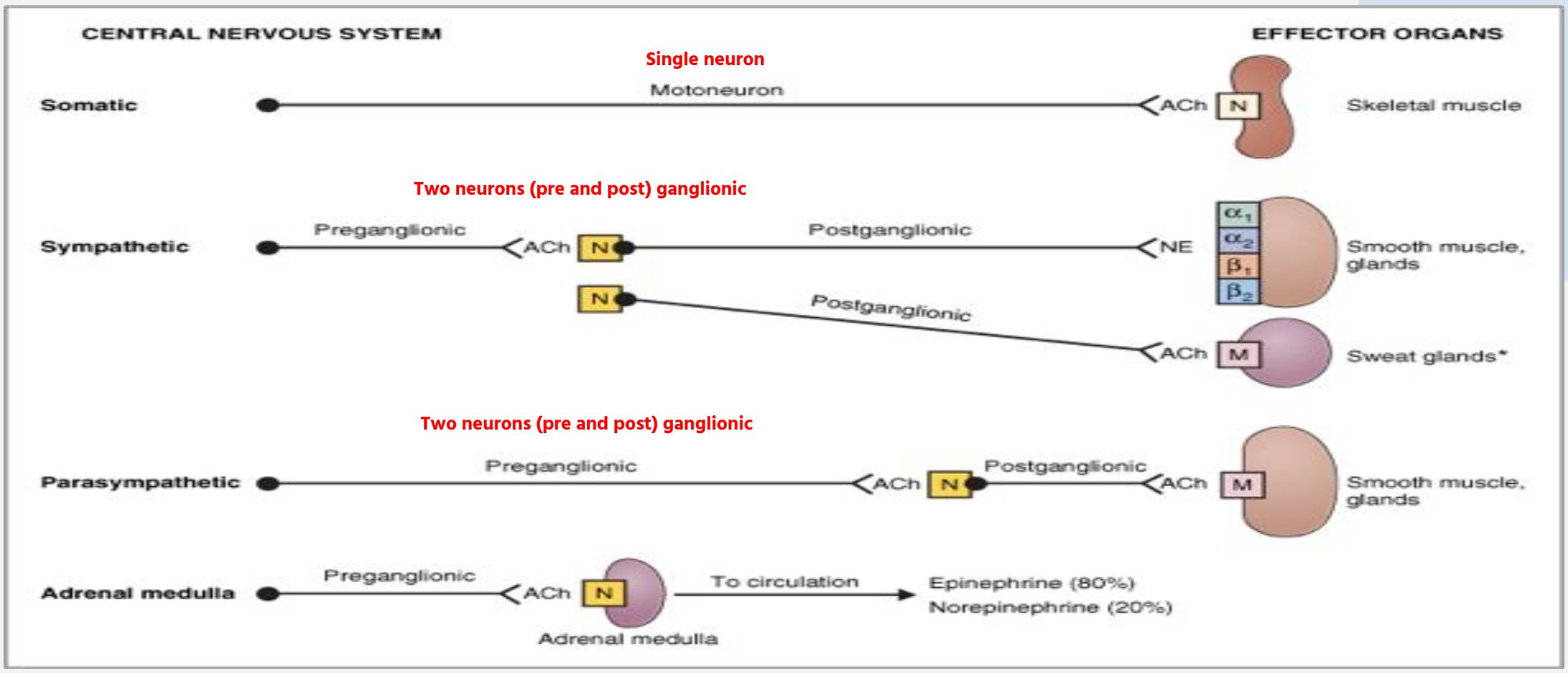
➢ Preganglionic neurons are **long(long axons)**, Cholinergic (release Ach) which interacts with nicotinic receptors

➢ Postganglionic neurons are **short(short axons)**, Cholinergic (release Ach) which interacts with muscarinic receptors

➢ **Ganglia is close to or on the target**



★ Organization of the Autonomic nervous system



★ Origin of Sympathetic

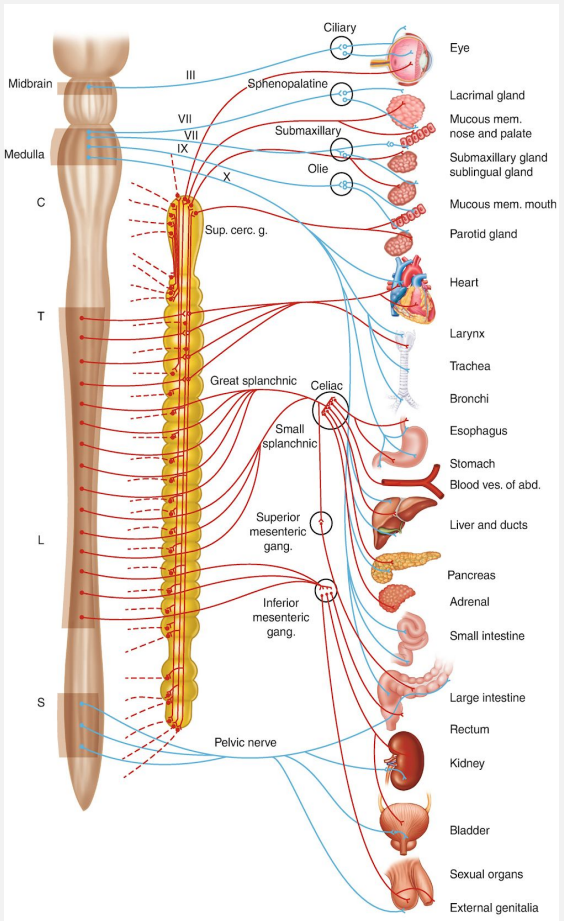
- Thoracolumbar: Lateral horn of the spinal segment T1-L3

➢ Nerve fibers originate between T1 and L3

★ Origin of Parasympathetic

- Craniosacral: Cranial nerves (3-7-9-10) in the brain stem (midbrain ,pons and medulla)/ Sacral segments of the spinal cord (S2-S3-S4)

➢ Nerve fibers emerge from Brain & Sacrum craniosacral outflow



★ Parasympathetic Nervous System

➢ The cranial nerves 3, 7 and 9 affect the pupil and salivary gland secretions

➢ Vagus nerve (X) carries fibres to the heart, lungs, stomach, upper intestine and ureter

➢ The sacral fibres from pelvic plexuses which supply the distal colon, rectum, bladder and reproductive organs

★ Sympathetic Nervous System Functions

- ➢ Stressful stimulation activates SNS leads to a response known as "fight or flight" ("fear,flight or fight" as said in female slides) : increased arterial pressure, blood flow, blood glucose, metabolic rate , mental activity , heart rate, blood pressure and cardiac output.
- ➢ SNS Increases pupil size, bronchiolar dilation, contraction of sphincters and metabolic changes such as the mobilisation of fat and glycogen.
- The sympathetic nervous system inhibits all of the glands secretion except sweat glands.

★ Parasympathetic Nervous System Functions

- ➢ The parasympathetic nervous system has "rest and digest" activity.
- ➢ In physiological terms, the parasympathetic system is concerned with conservation and restoration of energy, as it causes a reduction in heart rate and blood pressure, and facilitates digestion and absorption of nutrients, and consequently the excretion of waste products.

★ Summary of the ANS

	Sympathetic	**Parasympathetic**
Nerve Employed	Thoracolumbar (T1-L3).	Craniosacral (S2-S4)
Location of ganglia	Alongside vertebral column	On or near an effector organ
Chemical messenger	Preganglionic: ACh Postganglionic: NE and (ACh for sweat gland)	Both preganglionic and postganglionic: ACh
General Function	Fight or flight	Conservation of body energy

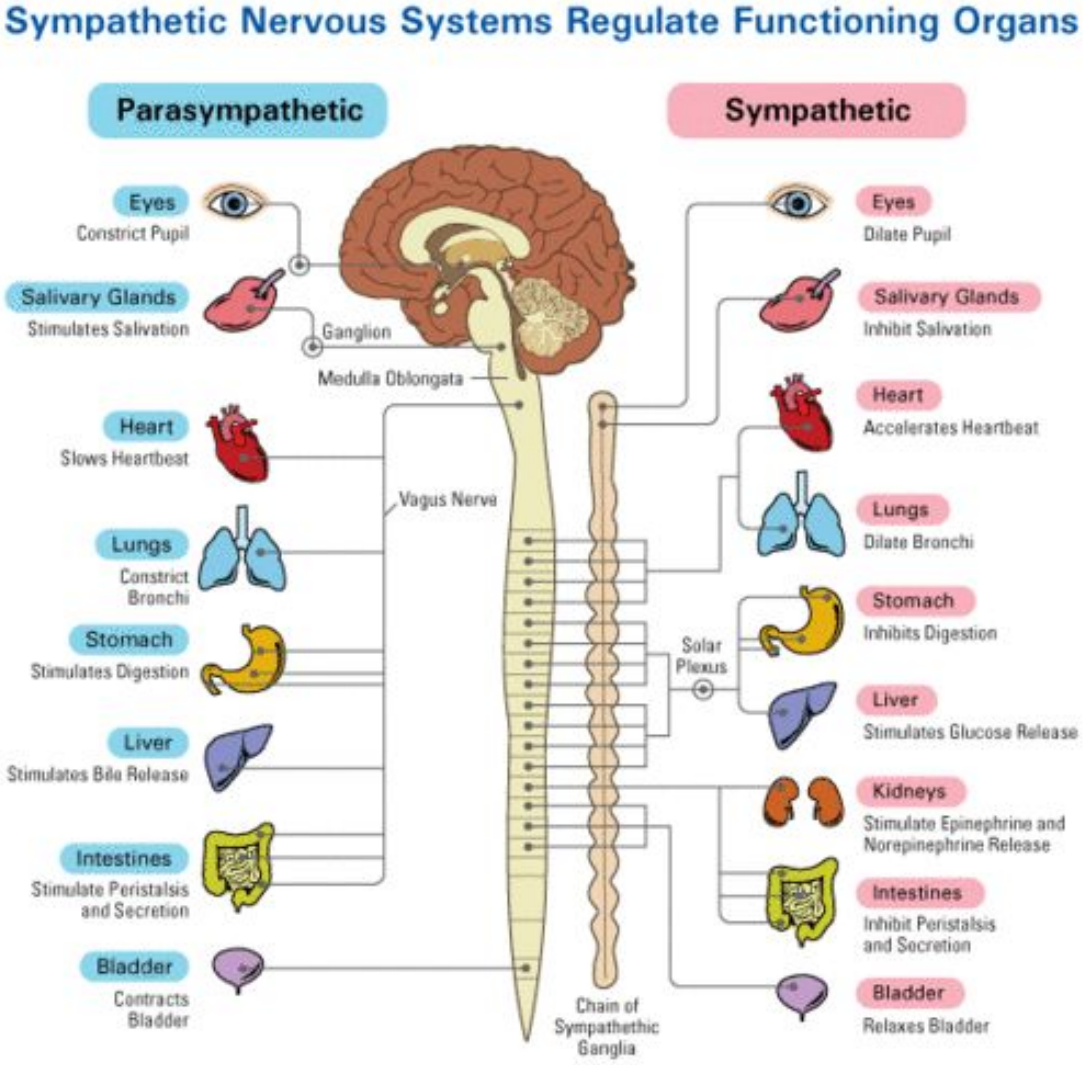
ACh: Acetylcholine
NE: norepinephrine

Click here for a summary !

★ PHYSIOLOGICAL FUNCTIONS OF THE AUTONOMIC NERVOUS SYSTEM

Structure	Sympathetic stimulation	Parasympathetic stimulation
Iris (eye muscle)	Pupil dilation	Pupil constriction
Salivary gland	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
GI Tract	Decreases activity	Increases activity
Sweat gland	Increases secretion	—
Liver	Increased conversion of glycogen to glucose	—
Kidney	Decreased urine secretion	Increased urine secretion
Adrenal medulla	Norepinephrine and epinephrine secreted	—
Bladder	Relaxes bladder	Inhibits bladder

Schema Explaining How Parasympathetic and Sympathetic Nervous Systems Regulate Functioning Organs



Helpful video

[An illustration for the table above]

★ 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 ½ 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 sympathetic and parasympathetic stimulation

❖ **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 is controlled by parasympathetic through contraction of ciliary muscle

❖ **The Glands:**

➢ Parasympathetic = increase their secretions

➢ Sympathetic causes vasoconstriction of the blood vessels to the gland which causes reduction in their secretion

❖ **The gastrointestinal tract (GI)**

- enteric nervous system

➢ Parasympathetic increases the activity of GI tract (increases the peristaltic contraction, and sphincter relaxation

➢ Sympathetic decreases the activity of GI

❖ **The Heart:**

➢ Sympathetic stimulation = Increase the activity of the heart

➢ Parasympathetic stimulation = does the opposite

Systemic blood vessels:

➢ constricted by stimulation of sympathetic

➢ parasympathetic has no effect, except in certain areas, such as blushing of the face

❖ **Arterial pressure:**

➢ Sympathetic stimulation = increase of :cardiac output and resistance to the blood flow and blood pressure

➢ Parasympathetic = decrease the cardiac output, no effect on blood vessels

★ Autonomic reflexes

- Most of the visceral functions of the body are regulated by Autonomic reflexes

❖ **Cardiovascular:**

➢ Baroreceptor reflex. : a stretch reflex in the main arteries such as carotid artery to detect the blood pressure

Gastrointestinal:

➢ The Receptor in the nose and mouth send signals to parasympathetic to notify the glands of mouth and stomach to secrete their digestive juices.

❖ **Urinary bladder:**

➢ Initiate the urination by parasympathetic innervations

❖ **Sexual reflexes**

➢ Erection = parasympathetic, ejaculation = sympathetic

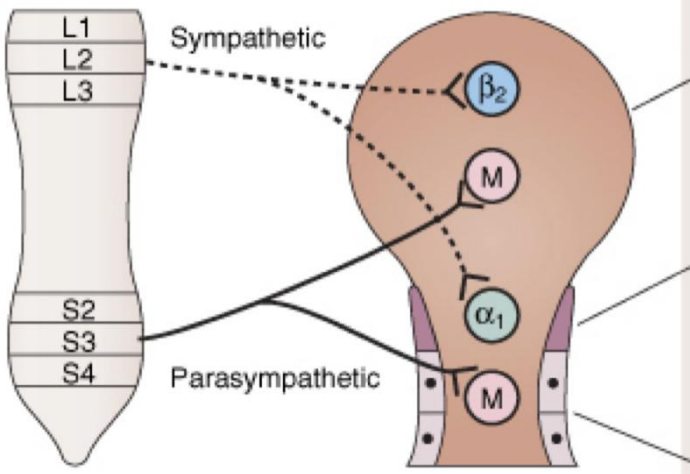
- **sympathetic activation** could occur in isolated portions such as:

1. heart regulation
2. Many sympathetic reflexes that regulates GI functions

- **The parasympathetic** usually causes specific localized responses:

1. the effect of parasympathetic usually specifies to certain organ, but sometimes there is a common effect of parasympathetic activity by affecting the function of some organs together, such as
2. rectal emptying
3. Bladder emptying
4. Salivary secretions and gastric secretions

★ 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

★ 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 & Norepinephrine lasts 5-10 times more than the ones which secreted from sympathetic .

★ Effect of loss of sympathetic and parasympathetic tone after denervation

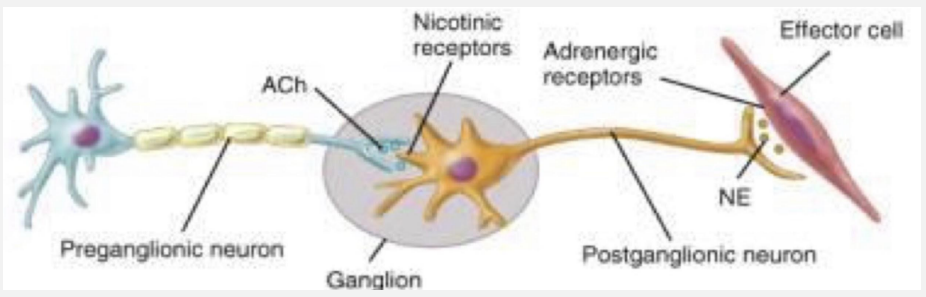
- Loss of sympathetic tone in blood vessel causes severe vasodilation but after sometime, intrinsic tone increases by chemical adaptation.

★ Neurotransmitters

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

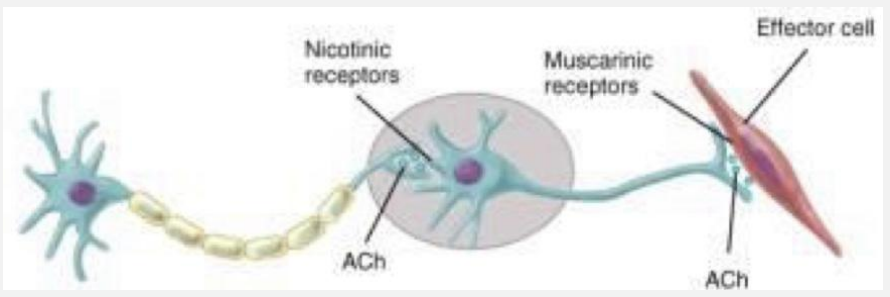
Sympathetic Neurotransmitters:

Preganglionic neurons: Cholinergic =release acetylcholine (that interacts with nicotinic receptors on the cell body of postganglionic neurons)
Postganglionic neurons: release norepinephrine at target organs , ie. Adrenergic except in thermoregulatory sweat glands (muscarinic, cholinergic). Adrenergic neurons affect adrenoceptors alpha1, alpha2, beta1, beta2



Parasympathetic Neurotransmitters

Pre & Postganglionic neurons release acetylcholine = Cholinergic

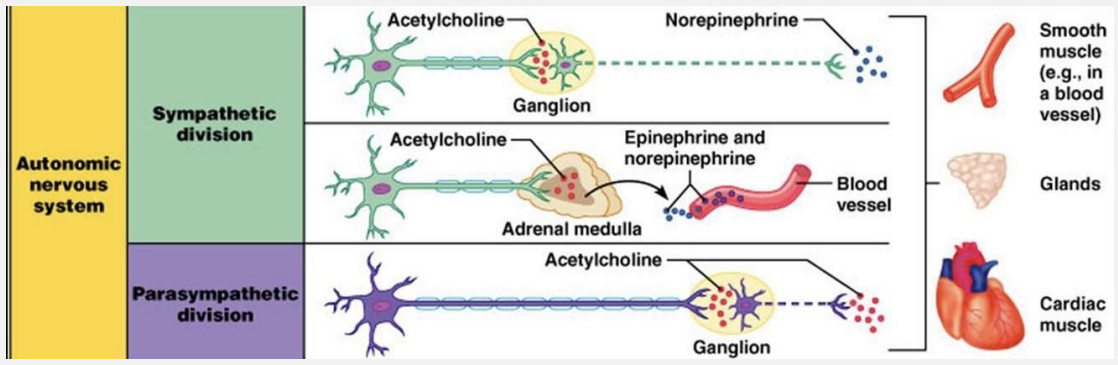


★ Chemical or neural transmitter

All preganglionic fibers release acetylcholine (Ach).

All parasympathetic postganglionic release Ach.

All sympathetic postganglionic release noradrenaline except sweat Glands & blood vessels to skeletal muscles



★ Cholinoreceptors

-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.

•Nicotinic Receptor (N):

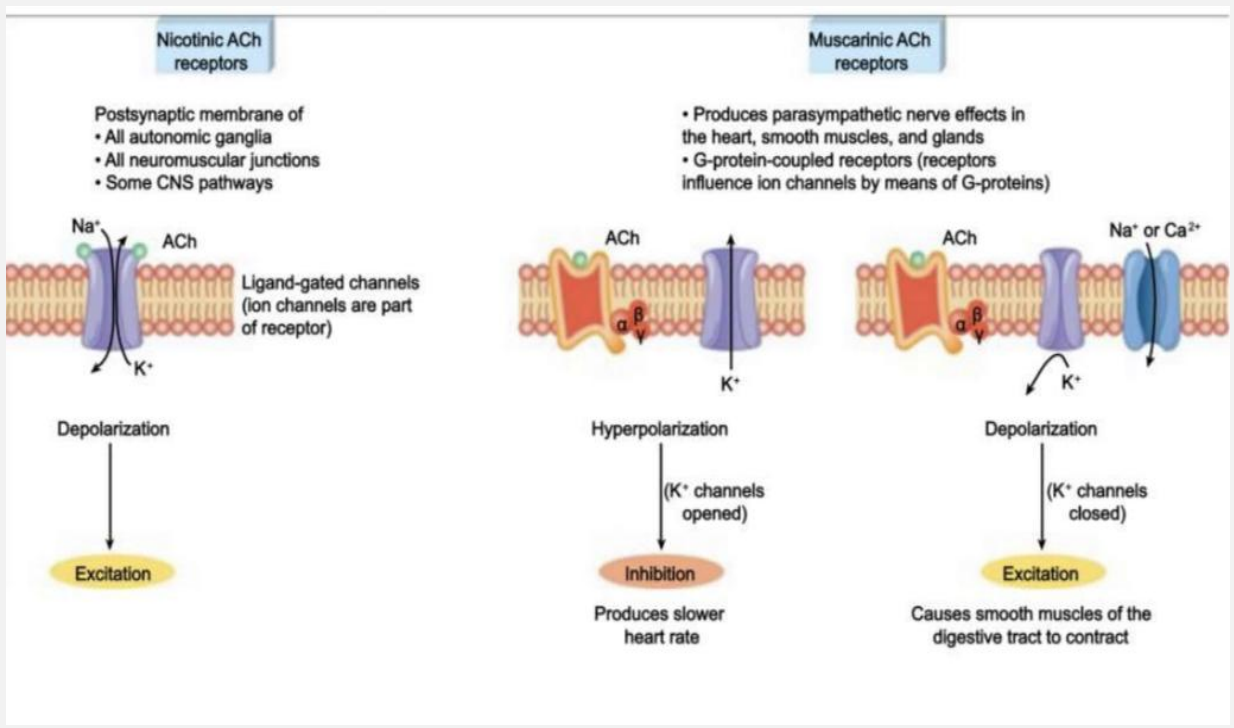
- an ion channel for Na+ and K+
- in all postganglionic neurons, motor end plate at skeletal muscle and chromaffin cells.

• Muscarinic Receptor (M):

- Works either like 1 adrenoreceptor via DAC, PKC and IP3 or via G protein which has subunit that binds K+ channel and open it.

-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

The Sympathetic NS Acts on two types of receptors : α and β.

What do the receptors do?

- α1 receptors: are found in vascular smooth muscle, gastrointestinal (GI) sphincters and bladder, and radial muscle of iris

➢ **Activation** of α receptors leads to smooth muscle contraction

- β2 receptors: are found in vascular smooth muscle wall of bladder, and wall of GI.

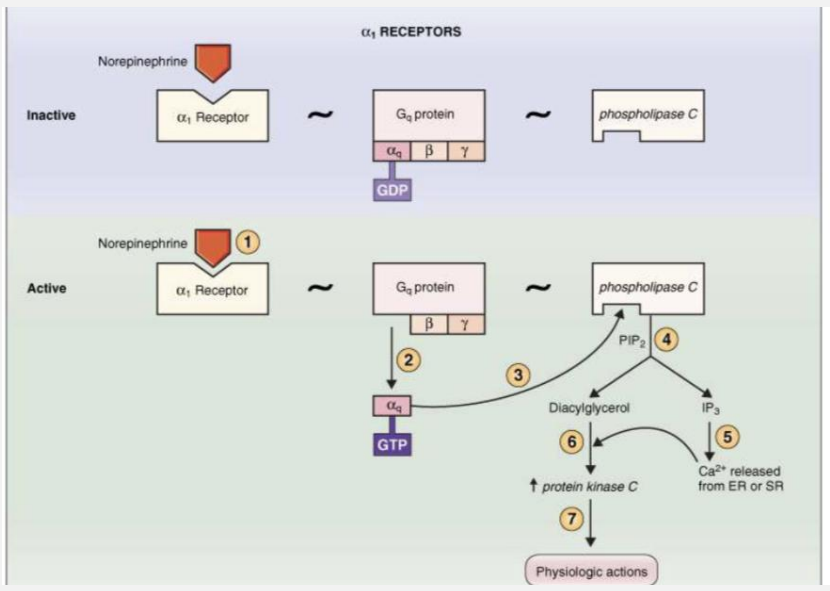
➢ **Activation** of β2 receptors leads to smooth muscle relaxation

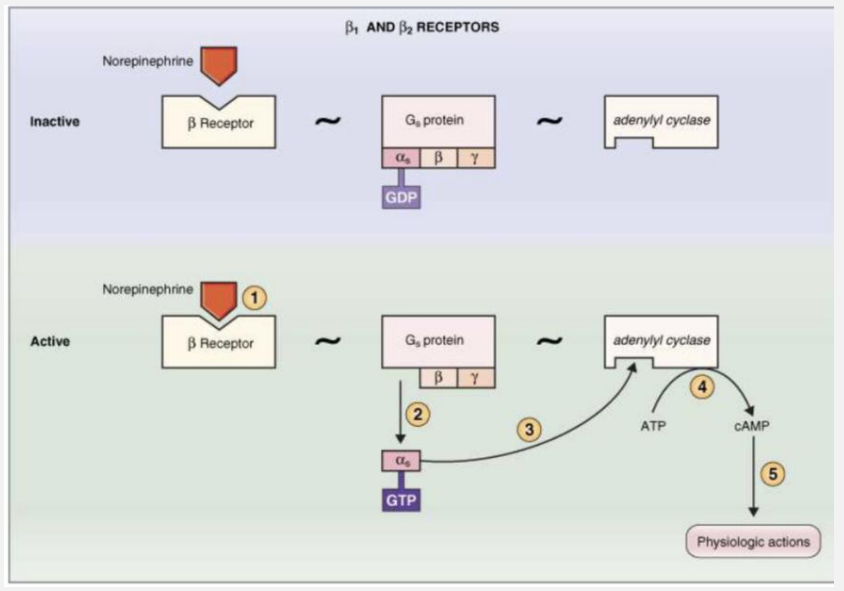
- β1 receptors: are found in the following tissues:

1. Sinoatrial node (S.A node) that will increase heart rate.
2. Atrioventricular node (AV node) that will increase conduction velocity.
3. Salivary gland that will increase salivary secretions.

➢ **Activation** of β1 receptors leads to smooth muscle contraction (especially in heart)(ventricular muscles)

β2 more sensitive to Epinephrine than Norepinephrine





★ Prototypes of Agonists and antagonists to autonomic receptors

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

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	

Thanks to 439 Team❤️

Test yourself

★ MCQs

Q1: Sympathetic preganglionic neurons are located in			
A- craniosacral spinal cord	B-prevertebral ganglia	C-paravertebral ganglia	D- thoracolumbar spinal cord
Q2:Epinephrine and Norepinephrine are secreted in blood from			
A-hypothalamus gland	B-sweat glands	C-Adrenal gland	D-pineal gland
Q3:Which of the following is considered as sympathetic stimulation			
A- Bronchial muscle contracted	B-Bronchial muscle relaxed	C-Increased urine secretion	D-Increased peristalsis
Q4: Pre & Postganglionic neurons in parasympathetic are			
A-Cholinergic	B-adrenergic	C-muscarinic	D-nicotinic

1-D 2-C 3-B 4-A

★ SAQ

Q1: How many types of receptors & what are they?

there are two types, Adrenoreceptors & Cholinoreceptors

MED441
KING SAUD UNIVERSITY

physiology 441

Foundation Block

Physiology team 441

Male Members

Abdulaziz Alassaf
Muan Almoajil
Feras Alzahrani
Meshal Alqahtani
→ Faisal Bin Moammar
Ahmed Bin Radi
Mansour Aldhalaan
Rayan Ali
Saad Alghadir
Naif Al-Hasan
Fahad Alkhattabi
Abdulaziz Alqusiyer
Naif Alfahed
→ Faisal Alshuaibi
Bader Alshahrani
~~Bader Rajeh~~

Female Members

Lama Bin Salamh
Munira Alsharif
Shimah Alsalhi
Albandry Bin Habda
Raaoum Jabor
Arwa Alenzi
Ayah Sayed
Lama Aleyadhy
Lujain Alkhalaf
Layan Almasri
Deema Almuhaimel
Ghadah Alarify
→ Asma Eidah
Reema Alrashedi
→ Sara Alhomaidhi
Raneem Alanazi
Jumana Alqahtani
Sahar Alhakami
Waad Alhowti
Maha Aljarbaa

Team Leaders

★ Alanoud albawardi
★ Nawaf alshehri

Edited by : Faye Wael Sendi

Physiology.team441@gmail.com