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Autonomic Nervous System

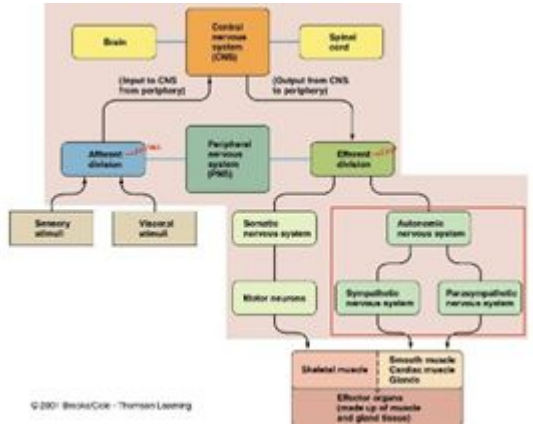
Learning Objectives

- 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

helpful video

Introduction

The nervous system monitors and controls almost every organ/system through a series of positive and negative feedback loops.

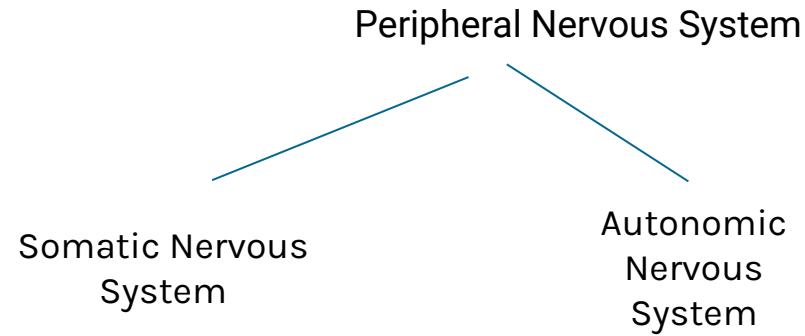


Graph from girls slides

helpful video

Introduction

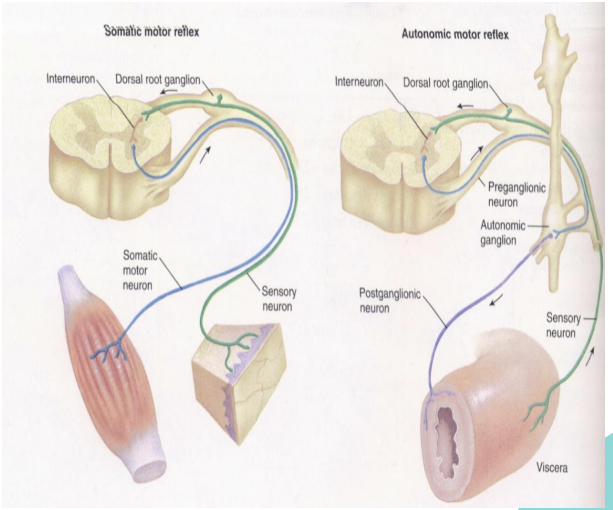
•The nervous system monitors and controls almost every organ / system through a series of positive and negative feedback loops.
•The Central Nervous System (CNS): Includes the brain and spinal cord.
•The Peripheral Nervous System (PNS): Formed by neurons & their process present in all the regions of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



SOMATIC AND AUTONOMIC NERVOUS SYSTEM

The motor efferent **nervous system** has two components:

- Somatic
- Autonomic



SOMATIC NERVOUS

a voluntary nervous system under conscious control.

consists of a single motor neuron fiber 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

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, brainstem and hypothalamus.

ANS is **operated** by visceral reflex.

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Visceral motor innervates non-skeletal (non-somatic) muscles (F):

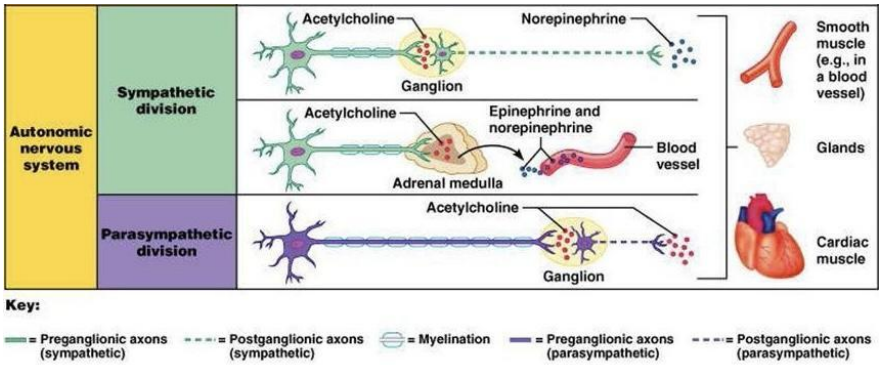
- **Cardiac muscle (the heart)**
- **Smooth muscle (walls of viscera and blood vessels)**
- **Internal organs**
- **Skin**

Girl's Slides

Autonomic Nervous System (ANS)

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

- Preganglionic neuron
- Postganglionic neuron



All preganglionic neurons release **Acetylcholine** (**Ach**).
Postganglionic neurons release either **Ach**, or **norepinephrine**.

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

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

1 Sympathetic Nervous System (SNS)

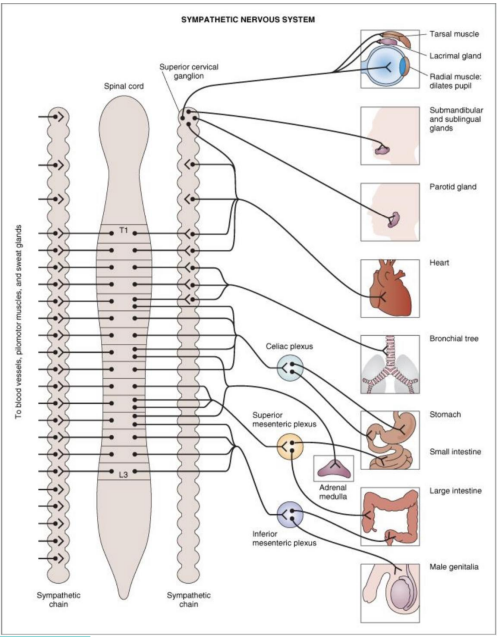
Operates **continuously** to modulate the functions of many organ systems **e.g;** heart, blood vessels, gastrointestinal tract, bronchi and sweat glands.

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.

"E" division

Exercise, excitement, emergency, and embarrassment

1 Sympathetic Nervous System (cont.)



Sympathetic preganglionic neurons **originate** in the lateral horn of **thoracolumbar** spinal cord (**T1-L2 or L3**).

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

Trunk (chain) ganglia near vertebral bodies

Prevertebral ganglia near large blood vessel in gut :celiac ,superior mesenteric & inferior mesenteric

Preganglionic neurons are **short myelinated**, and the **postganglionic** neurons are **long unmyelinated**.

1

Sympathetic Nervous System (cont.)

Helpful Video!

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 (muscarinic,cholinergic) also blood vessels to skeletal muscles

- Adrenergic neurons affect adrenoreceptors: $alpha_1$, $alpha_2$, $beta_1$, $beta_2$

2 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). Known as "Rest and digest".

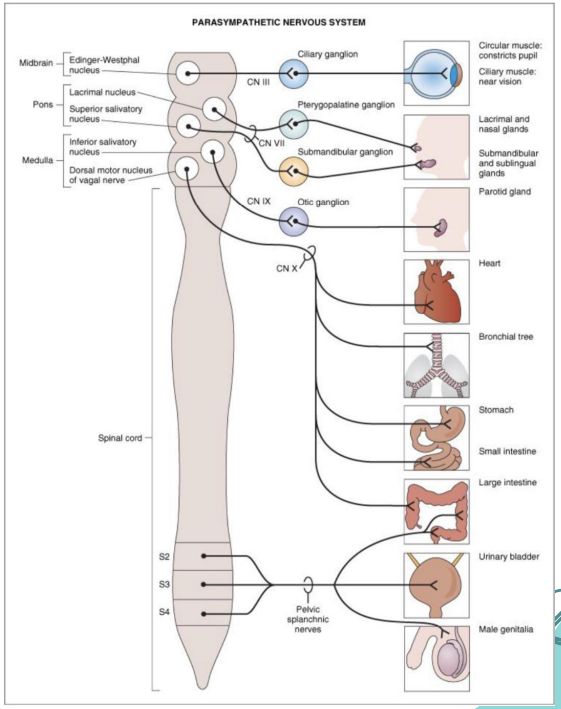
Nerve fibers emerge from
brain & sacrum cranio-sacral outflow.

Parasympathetic ganglia are <u>located</u> on or in the affected organs.

Preganglionic neuron has **long axon**, and **postganglionic** neuron has **short axons**.

D division

Digestion, defecation, and diuresis (F)



Neurotransmitters and types of receptors

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

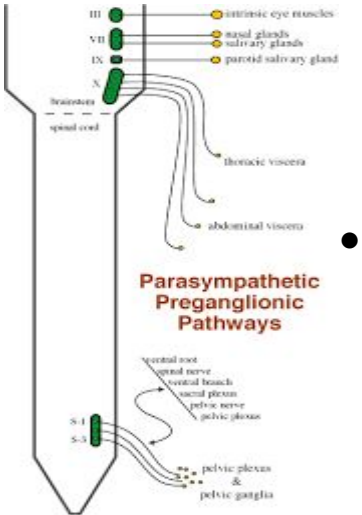
Postganglionic neurons are cholinergic, release Ach which interacts with muscarinic receptors.

2 Parasympathetic Nervous System

Craniosacral Cell bodies of the motor nuclei of the cranial nerves III, VII, IX and X 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

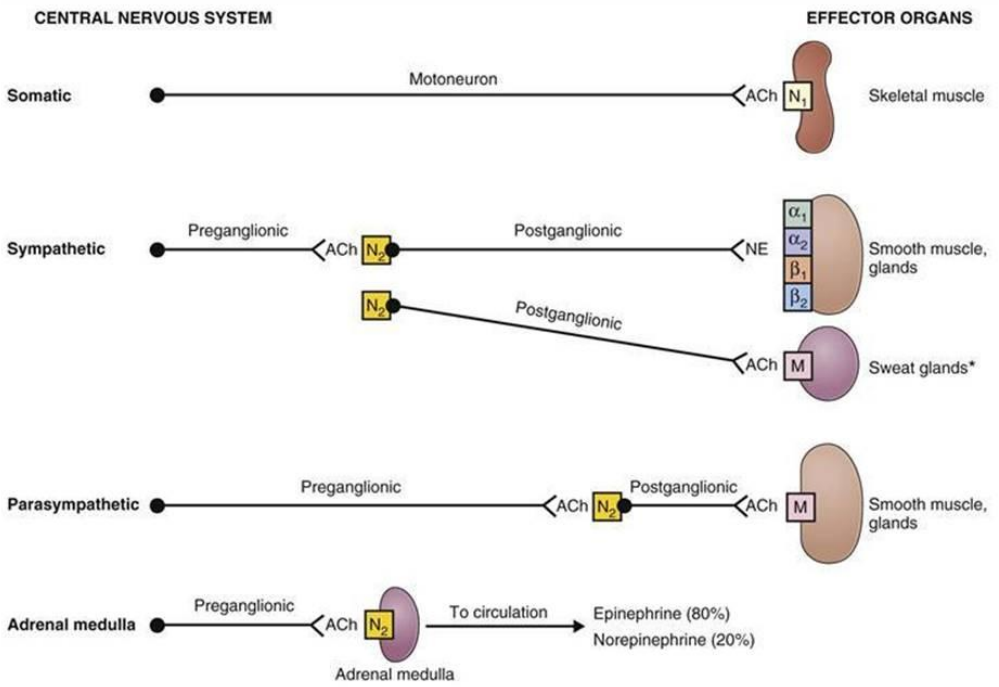


- The cranial nerves III, VII and IX affect the pupil and salivary gland secretion
- Vagus nerve (X) carries fibres to the heart, lungs, stomach, upper intestine and ureter
- The sacral fibres form pelvic plexuses which innervate the distal colon, rectum, bladder and reproductive organs.

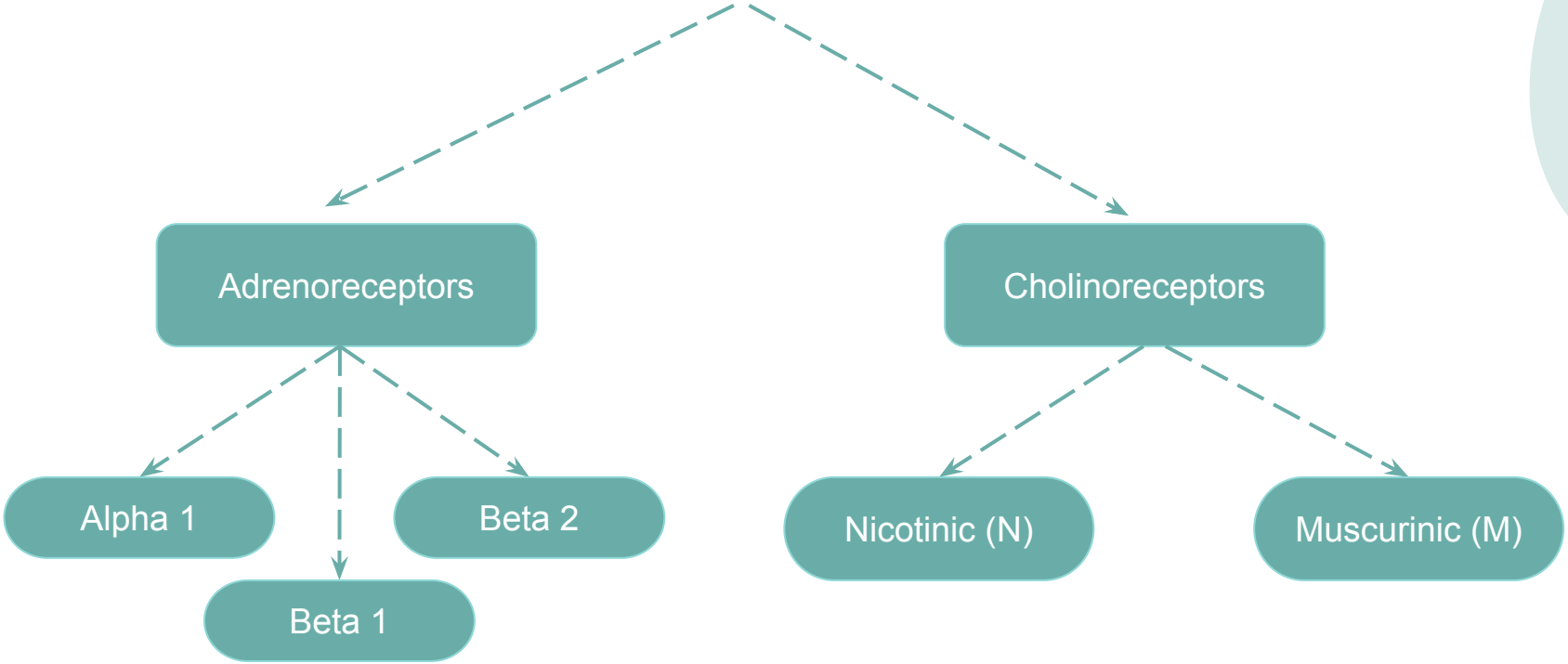
Summary of neurotransmitters and types of receptors

	Sympathetic	Parasympathetic
Preganglionic	Cholinergic	
Postganglionic	Adrenergic, except in thermoregulatory sweat glands (muscarinic, cholinergic).	Cholinergic
Receptor	**Adrenoreceptors:** alpha$_1$, alpha$_2$, beta$_1$, beta$_2$	**Cholinoreceptors:** muscarinic and nicotinic

Organization of the Autonomic Nervous System



Autonomic Receptors

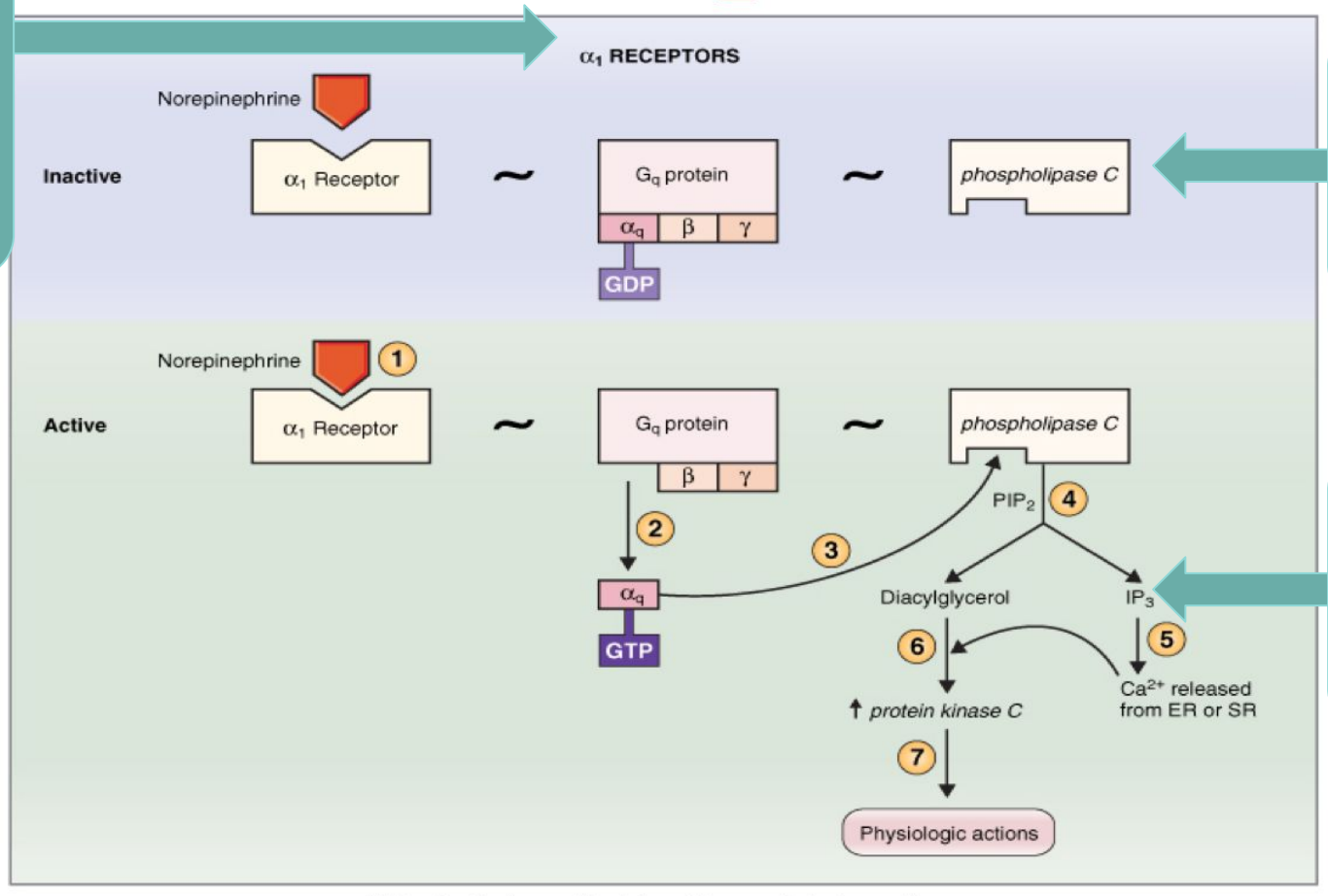


Adrenoreceptors

Adrenoreceptor	Sites	Effects of activation
Alpha 1 found in smooth muscle (contraction)	1)Vascular smooth muscle. found in : 2)Gastrointestinal(GI) sphincters. 3)bladder. 4)Radial muscle of iris.	contraction
Beta 1 found in smooth muscle mainly the heart (contraction)	1)Sainoatrail node (S.A node) found in: 2)Atrioventricular node (AV node) 3)Ventricular muscle 4)Salivary gland	heart rate conduction velocity contractility salivary secretions
Beta 2 found in smooth muscle (relaxation)	found in vascular smooth muscle wall of : 1) bladder 2) GI	Relaxation

α1 receptor

- Couple with G protein then it will dissociate
- GDP converts to GTP



Second Messenger

Chemical reactions are not important

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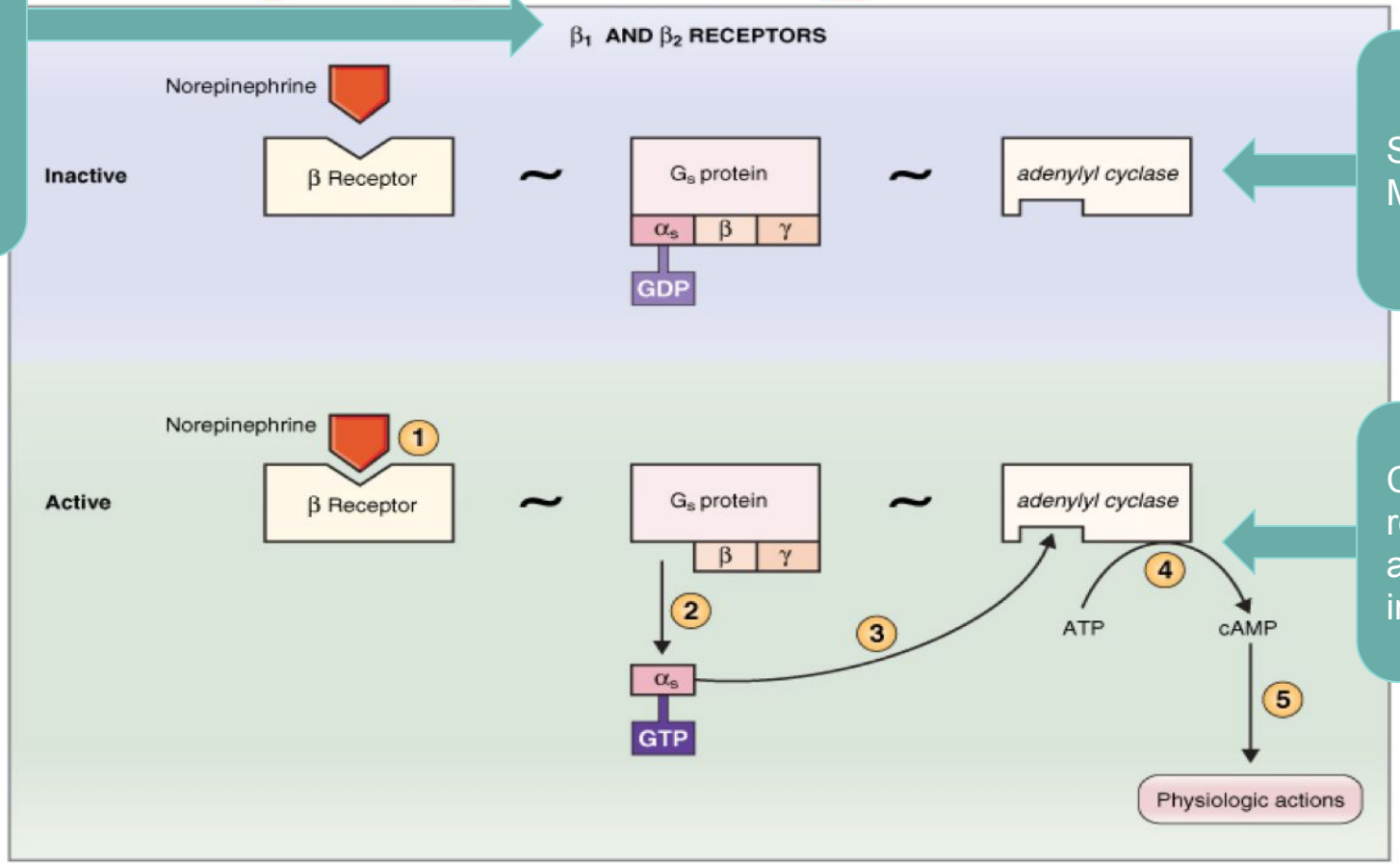
β1, β2 receptors

- Couple with G protein then it will dissociat e
- GDP converts to GTP



Second Messenger

Chemical reactions are not important

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Cholinorecepters

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Nicotinic Receptor (N)

Description: an ion channel for Na+ and K+.

Sites: In all postganglionic neurons, motor end plate at:

1) skeletal muscle.
2) chromaffin cells (في الغدة الكظرية).

Effects: (Na+ in ,K+ out) changing in the amount of +ve charge **depolarization** **Excitation** .

Muscurinic Receptor (M)

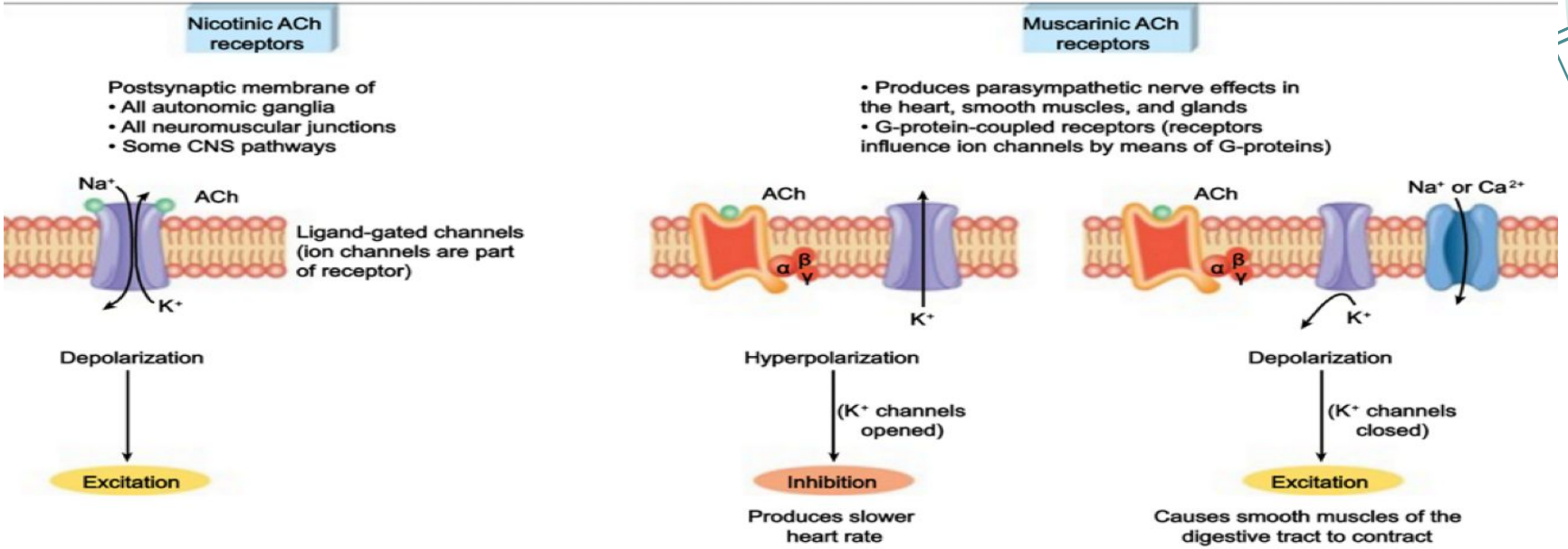
Description: Has two cases :

1) works like alpha 1 adrenoreceptor via **DAC,DKC** and **IP3.**

1) Via **G protien** which has alpha subunit that **binds K+ channel and open it .**

Effects: Case 1 : Depolarization ⟹ Excitation

Case 2: Hyperpolarization ⟹ Inhibition



Note that : **1)**Changing in the amount of +ve charge inside the cell causes either:
Depolarization or **hyperpolarization.**

2) if +ve charge inside the cell > outside the cell → Depolarization
if +ve charge inside the cell < outside the cell → Hyperpolarization

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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	

Autonomic Receptors: (In summary)

The type of receptor and its mechanism of action determine the *physiologic response (not only sympathetic or parasympathetic).*

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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)(منقبض/يتقلص) of its normal diameter.**

1) **Removal of vagus nerve —--> atony—--> loss of peristalsis (contraction of small intestine)--> constipation(مساك).**

Effect of loss of sympathetic and parasympathetic tone after denervation.

Loss of sympathetic tone on blood vessel causes severe **vasodilatation**

(increasing in the diameter of blood vessels).

After sometime, intrinsic tone increases **by chemical adaptation.**

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Function of Adrenal Gland

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

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

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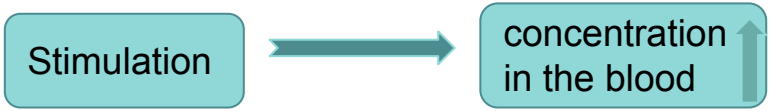

Effects of Sympathetic and Parasympathetic stimulation on specific organs.

Organ	Sympathetic	Parasympathetic
The eyes	**Contracts** the meridional fibers of the iris (radial muscles) to dilate the pupil.	**Contracts** the circular muscle of the iris to constrict the pupil.
The glands	causes vasoconstriction of the blood vessels to the glands which causes **reduction** in their secretion.	**Increase** their secretions.

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Effects of Sympathetic and Parasympathetic stimulation on specific organs.

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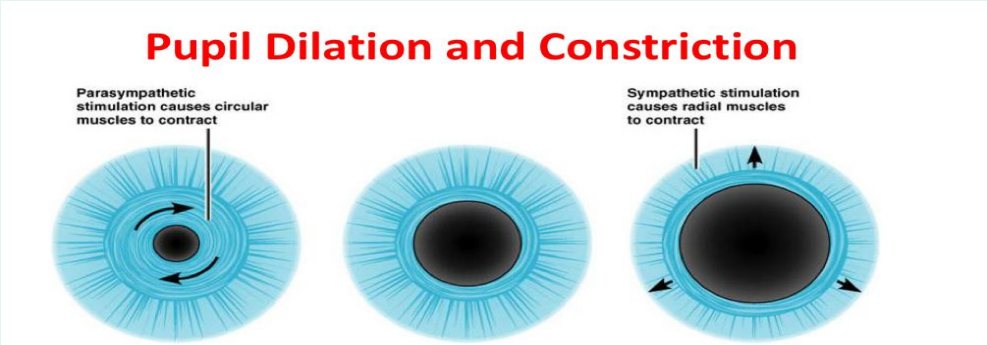
NOTES :

1) Focusing of the lens is **controlled by parasympathetic** through **contraction of ciliary muscle.**

1) **The secretions of the glands increased by parasympathetic except the sweat glands increased by sympathetic.**



Effects of Sympathetic and Parasympathetic stimulation on specific organs.

Organ	Sympathetic	Parasympathetic
The Gastrointestinal tract (GI)	**Decreases** the activity of GI.	**Increases** the activity of GI. (increase peristaltic contraction and sphincter relaxation).
The heart	**Increase** the activity of the heart.	**Decrease** the activity of the heart.

Effects of Sympathetic and Parasympathetic stimulation on specific organs.

Organ	Sympathetic	Parasympathetic
Systemic Blood Vessels	constricted.	No effect except in certain areas, such as blushing of the face.
Arterial Pressure	increase the cardiac output and increase resistance to the blood flow and blood pressure.	**Decrease the cardiac output** and has no effect on blood vessels.

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Effects of Sympathetic and Parasympathetic stimulation on specific organs.

NOTES :

1) GI is supplied by enteric nervous system.

1) parasympathetic has no effect on blood vessels.

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Effects of Sympathetic and Parasympathetic stimulation on specific organs.

Organ	Sympathetic	Parasympathetic
The eyes	Dilate the pupil	Constrict the pupil
The glands	Reduction in their secretions	Increase their secretions
GI(tract)	Activity	Activity
The heart	Activity	Activity
Systemic blood vessels	Constricted	NO EFEECT
Arterial pressure	Output	Output

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Effects of Sympathetic and Parasympathetic stimulation on specific organs.

Structure	Sympathtic stimulation	Parasympathetic stimulation
Oral/Nasal mucosa	Mucus production reduced	Mucus production increased
Stomach	Peristalsis reduced	Gastric juice secreted; motility increased
Small intes	Motility reduced	Digestion increased
Large intes	Motility reduced	Secretions and motility increased
Liver	Increased conversion of glycogen to glucose	—-
Kidney	Decreased urine secretion	Increased urine secretions
Adrenal medulla	Norepinephrine and epinephrine secreted	—
Bladder	Wall relaxed sphincter closed	Wall contracted sphincter relaxed

Autonomic Reflexes

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

Autonomic Reflexes consists of :
Receptor —--> Sensory neuron —------> perhaps (interneuron)
—------>motor—-> Effector (muscle of gland).

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Autonomic Reflexes

-Examples :

1) **Cardiovascular:** baroreceptor ——————>Stretch reflex in the main arteries
(such as carotid artery to detect the blood pressure).

1) **Gastrointestinal (GI):** The receptors in the nose and mouth
send signals to **parasympathetic**
to notify the glands of mouth and stomach
to secrete the digestive juices.

1) **Urinary bladder :** Initiate the urination by **parasympathetic** innervations.

1) **Sexual reflexes:**

Erection ——-> by **parasympathetic**

Ejaculation ——-> by **sympathetic**

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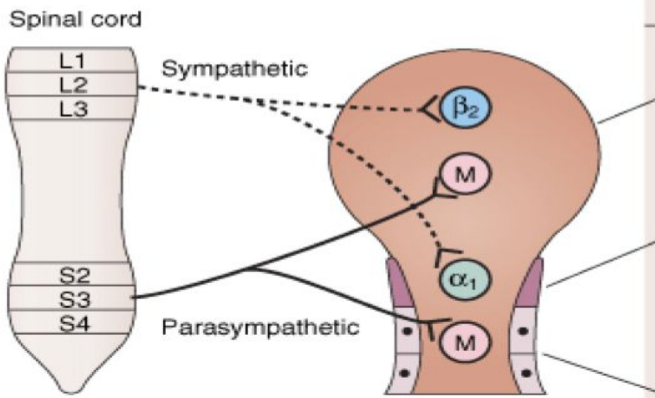
Urinary Bladder



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

Note that : A) 1) Predominant of filling of bladder ——————> **Sympathetic .**
2) Predominant of emptying of bladder ——————> **parasympathetic .**

B) External sphincter muscle controlled **voluntary** (not by ANS).

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Autonomic Reflexes

Boys slides

Sympathetic activation

could occur in isolated portions
(in many organs simultaneously).

-Such as :

1) Heart regulation.

1) many sympathetic reflexes that regulate G.I functions.

Parasympathetic activation

usually causes specific localized responses
(usually specifies to certain organ).

but sometimes there is a common effect of parasympathetic activity by affecting of the functions of some organs together .

-Such as :

1) Rectal emptying and bladder emptying.

1) Salivary secretion and gastric secretion.

MCQs

1) Somatic nervous system consists of a single ..... and skeletal muscle fibers.

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

2) ANS is activated by:

A) Centers in spinal cord	B) Brain stem	C) Hypothalamus	D) All of the above

3) ANS is operated by:

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

4) Preganglionic and postganglionic neurons in parasympathetic are:

A) Nicotinic	B) Cholinergic	C) Muscarinic	D) Adrenergic

1) A 2) D 3) A 4) B

5) Postganglionic neurons in sympathetic are:

A) Cholinergic	B) Muscarinic	C) Nicotinic	D) Adrenergic

6) The receptor in sympathetic NS which is responsible of smooth muscle contraction is:

A) $Alpha_1$	B) $Beta_1$	C) $Alpha_2$	D) $Beta_2$

SAQ

A) Parasympathetic ganglia are located on/in …….

B) How many main types of receptors? And what are they?

5) D **6)** A **7)** x **x)** x

A) Affected organs.

B) 2 types. Adrenoreceptors and cholinoreceptors.

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