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6,7 Autonomic nervous system

Simple quote:

No matter how long the river, the river will reach the sea.

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Objectives

- appreciate the anatomy of sympathetic & parasympathetic nervous System.
- explain physiological functions of Sympathetic &parasympathetic nerves in head & neck,chest,abdomen and pelvis.
- Describe neurotransmitters that can release at pre and post ganglionic of autonomic NS.
- Describe Autonomic NS receptors.

These objectives have been taken from 433 team work.
Thx 433 ☺

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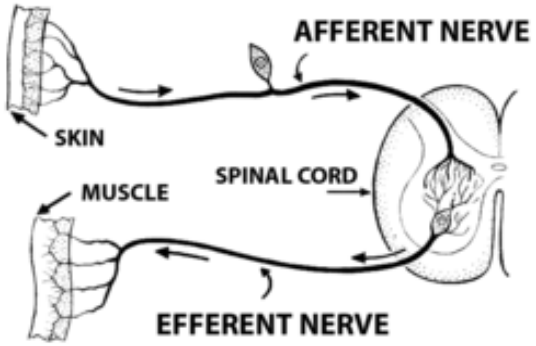
Things you should know!

Before you study this lecture, we recommend you to study the third lecture of anatomy.

Medical Terminology



- **Afferent Nerve:**

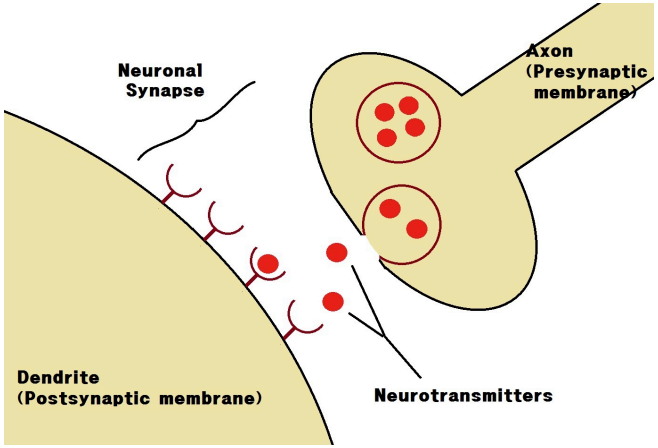
sensory nerve that carry nerve impulses from receptors or sense organs toward the central nervous system.

- **Efferent Nerve:**

a nerve that conveys impulses toward or to muscles or glands.

- **Neurotransmitters:**

A chemical substance, such as acetylcholine or dopamine, that transmits nerve impulses across a synapse.



- **Synapse:**

The junction across which a nerve impulse passes from an axon terminal to a neuron, muscle cell, or gland cell.

- **ganglia :**

an encapsulated collection of nerve-cell bodies, usually located outside the brain and spinal cord.

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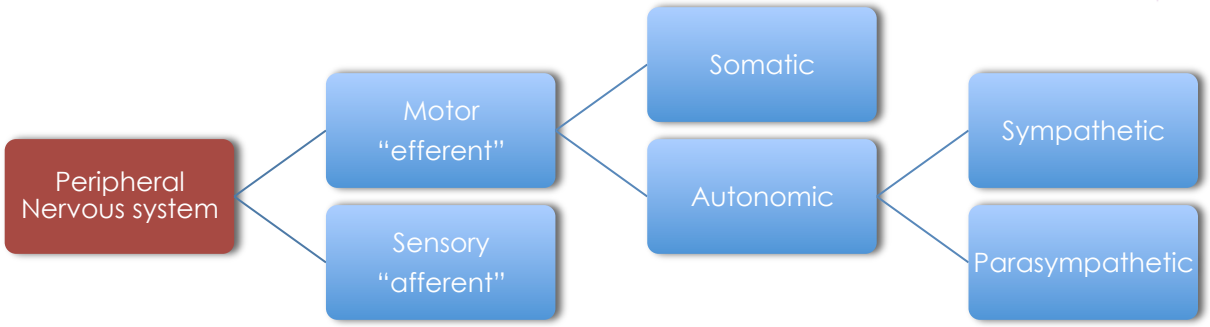
Mind Maps



Feature	Somatic 'Voluntary'	Autonomic 'involuntary'
Effector organs	Skeletal muscles	Cardiac muscle, smooth muscle, and glands
Presence of ganglia	No ganglia	Has chain ganglia present along its pathway.
Number of neurons from CNS to effector	One	Two
Neurotransmitters	Acetylcholine	Acetylcholine, adrenaline, nor-epinephrine ,more…
Further Subdivision	No further subdivision	Sympathetic, parasympathetic nervous systems

*Maybe you will understand this diagram after going through the slides

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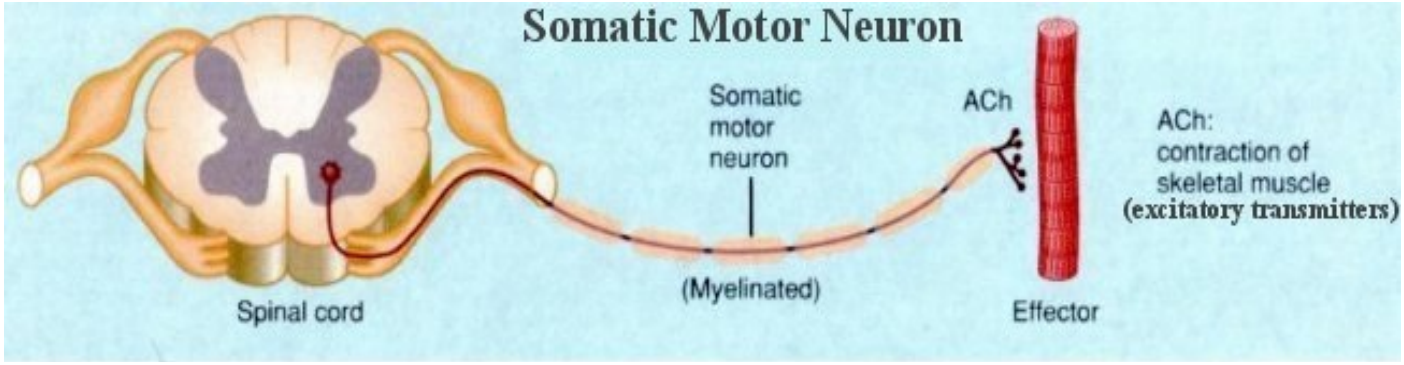
Somatic nervous System



- A voluntary nervous system under conscious control.
- It has No ganglia (an encapsulated collection of nerve-cell bodies, usually located outside the brain and spinal cord(.
- Somatic motor neurons have their cell bodies within the CNS and send axons to skeletal muscles.

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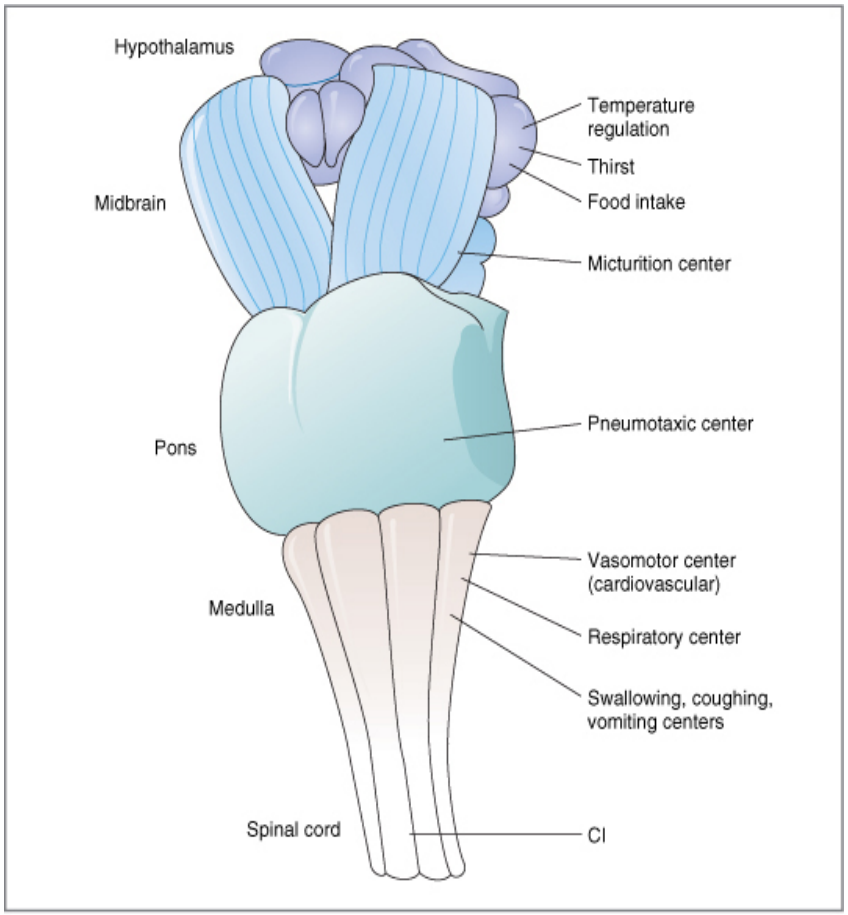
Autonomic Nervous System

- An involuntary nervous system that modulates and controls the function of visceral organs
  (Organs located in the large cavity of body trunk are termed as visceral organs).

- Autonomic nervous system (ANS) consists of two major divisions:
  1)Sympathetic
  2)Parasympathetic

- ANS is activated by centers in spinal cord, brain stem and hypothalamus.



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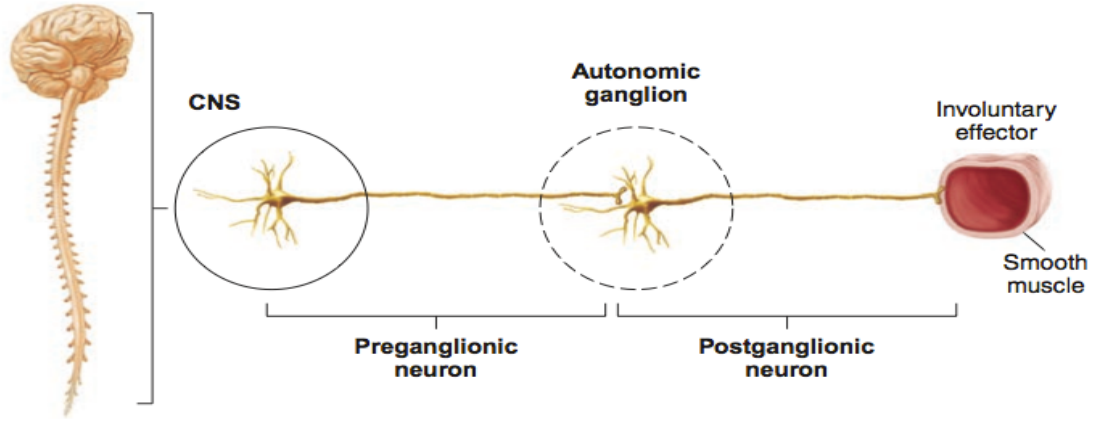
Autonomic Neurons

- Autonomic motor control involves two neurons in the efferent pathway.
  1)**Preganglionic neuron**.
  2)**Postganglionic neuron**.



- **Preganglionic neuron** : has its cell body in the gray matter of the brain or spinal cord, and the axon of this neuron *does not directly innervate the effector organ* but instead *synapses* with a second neuron within an *autonomic ganglion*.

- **postganglionic neuron**, has an axon that extends from the autonomic ganglion to an effector organ, where it synapses with its target tissue.

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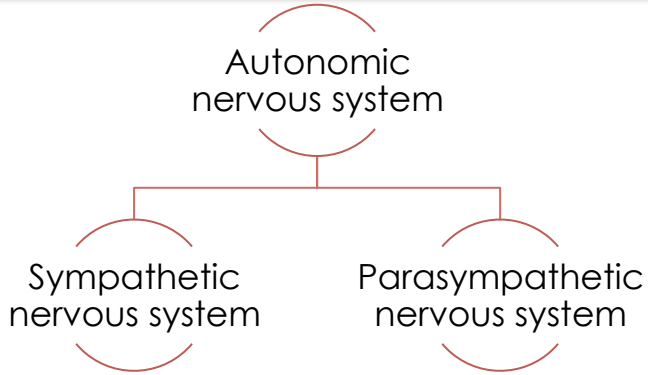
DIVISIONS OF THE AUTONOMIC NERVOUS SYSTEM



-The origin of the preganglionic fibers and the location of the autonomic ganglia help to distinguish the *sympathetic* and *parasympathetic* *divisions* of the autonomic system.

Comparison between the Sympathetic and Parasympathetic nervous systems.

	Sympathetic nervous system	Parasympathetic nervous system
Origin of the preganglionic fibers.	***thoracic and lumbar levels of the spinal cord "Thoracolumbar spinal cord" (T1-L3)***	***brain and in the sacral level of the spinal cord "Craniosacral spinal cord" (S2-S4)***
Location of autonomic ganglia.	***Near and parallel to the spinal cord.***	***in or near the effector organs***

* You will understand this table clearly after you going through next slides.

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Sympathetic Nervous System

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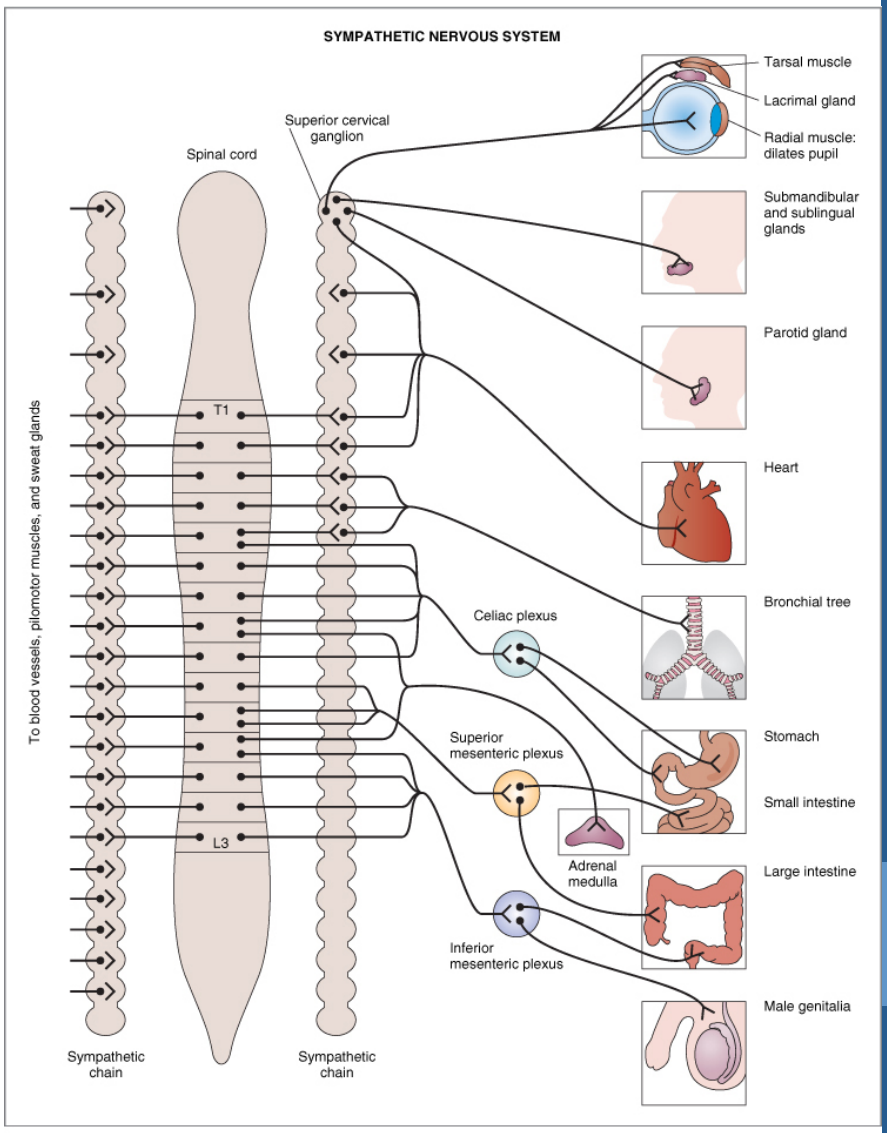
- **Sympathetic Nervous System :**
  - Operates continuously to modulate the functions of many organ systems e.g; heart, blood vessels, gastrointestinal tract, bronchi and sweat glands.
  - Stressful stimulation activates SNS leads to a response known as"fight or flight": increased arterial pressure, blood flow, blood glucose, metabolic rate and mental activity.
  - Sympathetic preganglionic neurons originate from thoracolumbar spinal cord (T1-L3).
  - Preganglionic neurons are short and the postganglionic neurons are long



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Parasympathetic Nervous System

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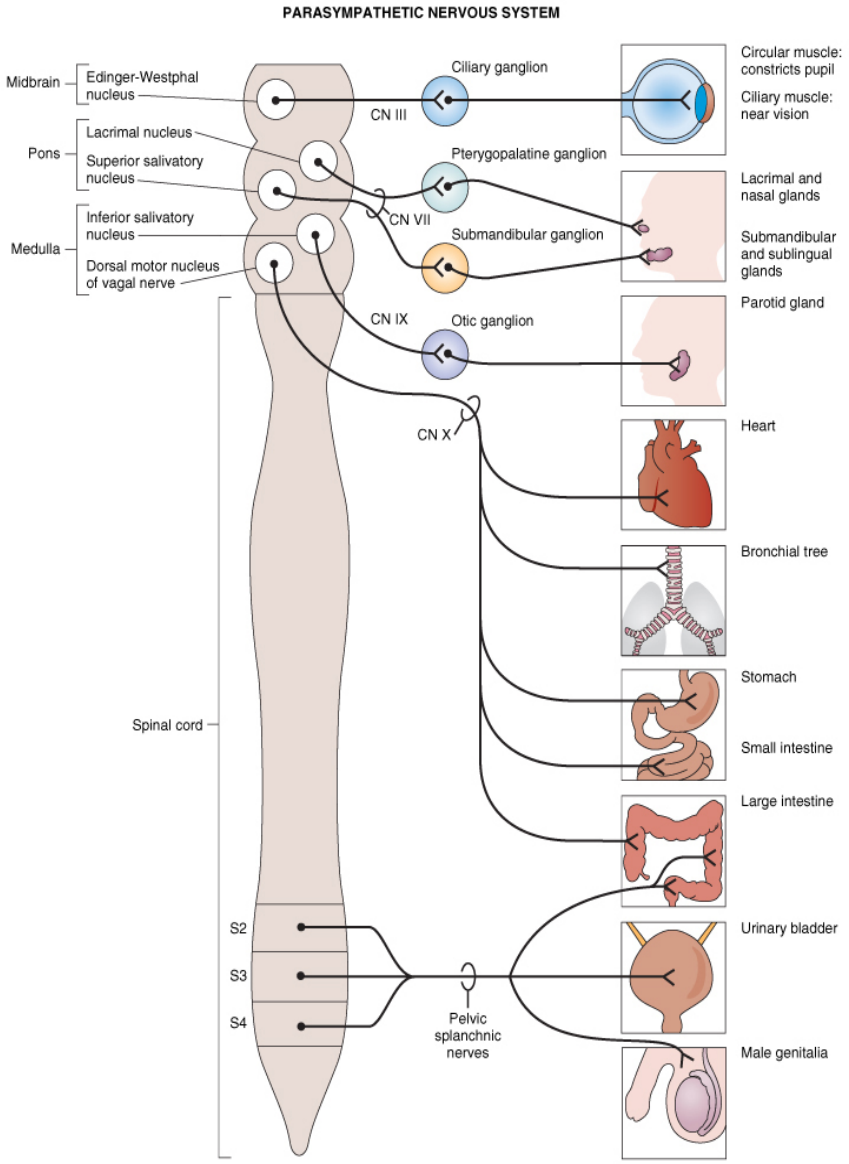
Parasympathetic Nervous System :

- The parasympathetic system is responsible for stimulation of "rest and-digest" activities that occur when the body is at rest .
- Preganglionic fibers originate from cranial nuclei in brain stem (mid brain, pons, medulla) and in sacral segments (S2-S4) (Craniosacral).
- Parasympathetic ganglia are located on or in the affected organs.
- Preganglionic neuron has long axon and postganglionic neuron has short axon.



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Adrenergic and Cholinergic neurons

Adrenergic and Cholinergic terms are used to describe neurons of either division, according to which neurotransmitter they synthesize and release.

Adrenergic neurons

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

Cholinergic neurons

Cholinergic neurons release Acetylcholine and the receptor is cholinergic

	Adrenergic	Cholinergic
neurotransmitter	nor-epinephrine …	Acetylcholine (Ach)
receptor	Adrenoreceptors "α1,β1, β2 "	Nicotinic & Muscurinic receptor

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Neurotransmitters of neurons

1) All preganglionic neurons either in the sympathetic or parasympathetic systems are **Cholinergic**.

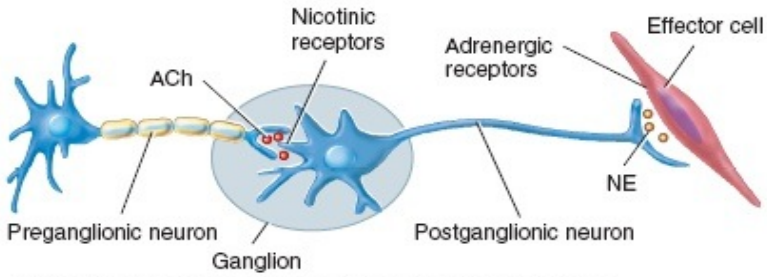
2) The difference between the two systems in the postganglionic neuron.

Sympathetic: Postganglionic neurons are adrenergic except in thermoregulatory sweat glands.

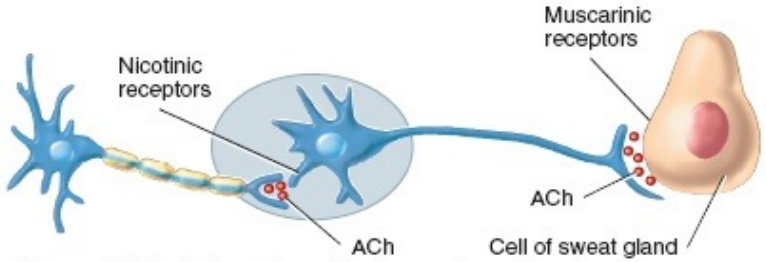
Parasympathetic: Postganglionic neurons are cholinergic, release Ach which interacts with muscrinic receptors

AS we can see…

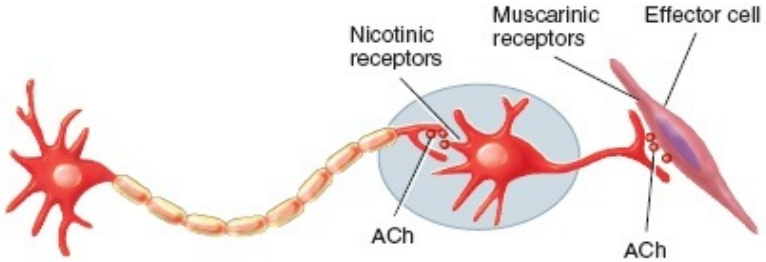
Preganglionic is myelinated, Postganglionic not, in both sympathetic and parasympathetic systems



(a) Sympathetic division—innervation to most effector tissues



(b) Sympathetic division—innervation to most sweat glands



(c) Parasympathetic division

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Neurotransmitters and types of receptors

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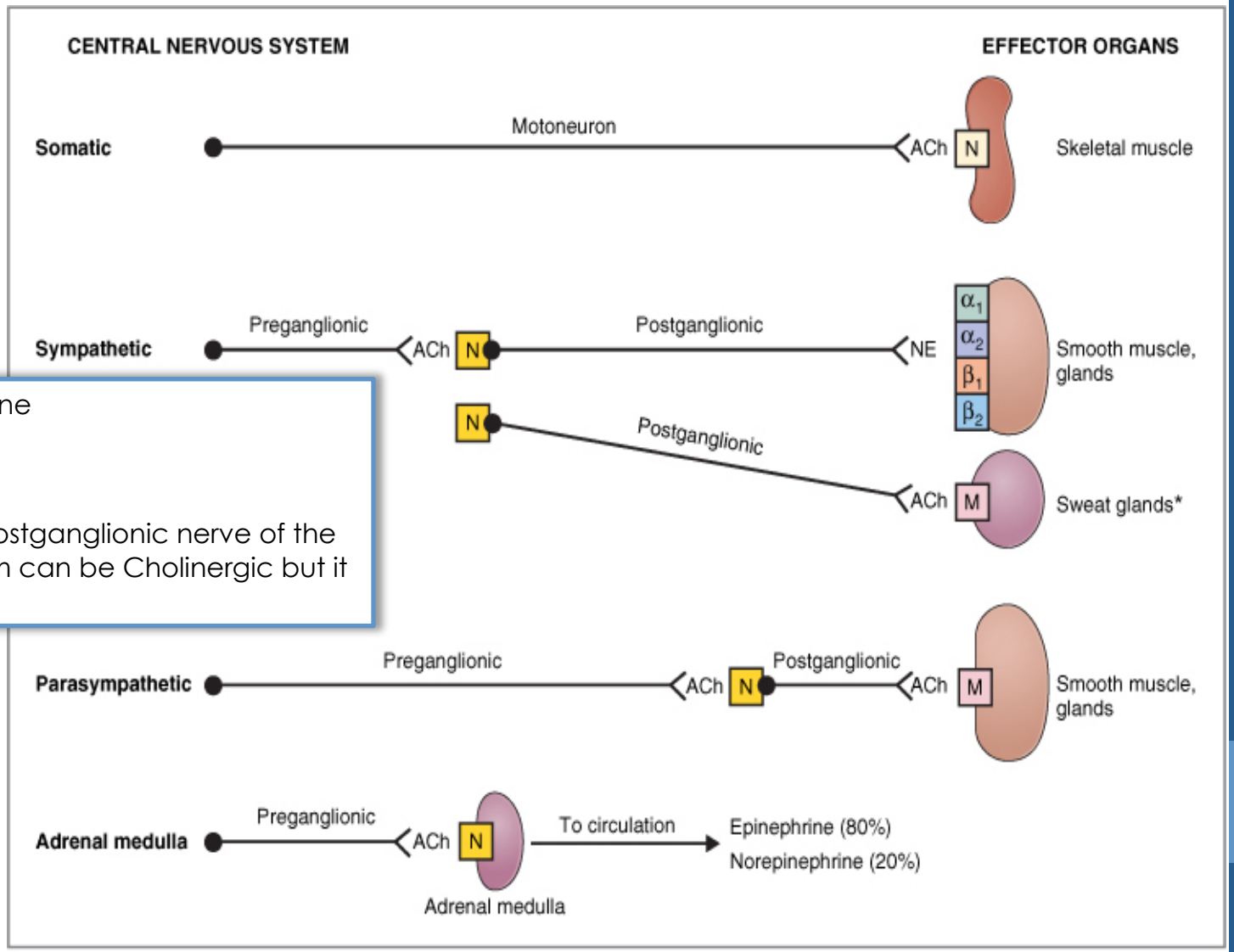

ACh → Acetylcholine
N → Nicotinic
M →Muscurinic

We can see that Postganglionic nerve of the Sympathetic system can be Cholinergic but it is very rare.

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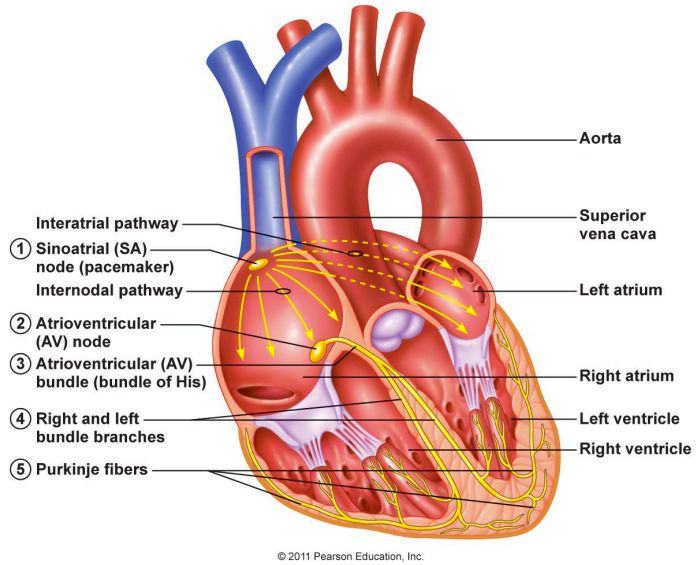
Adrenoreceptors



S.A node → Sinoatrial node

A.V node → Atrioventricular node

IMPORTANT:
The action of sympathetic nervous system can be excitatory or inhibitory. The effect depends on the receptor.

	α1 receptor	β 1 receptor	β 2 receptors
Found in	vascular smooth muscle, GI sphincters and bladder, radial muscle of iris	1) S.A node → increase heart rate 2) A.V node → increase heart rate 3) Ventricular muscles → increase contractility	vascular smooth muscle, wall of bladder, and wall of GI
Function	Contraction of all these organs	4) Salivary gland → increase secretion (but enzymes production)	Relaxation of all these organs

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How Adrenoreceptors work !

1) How alpha receptors work

http://www.youtube.com/watch?v=2bbBrpgeheY

2) How Beta receptors work

http://www.youtube.com/watch?v=ejq99wLEMTw

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Cholinorecepters

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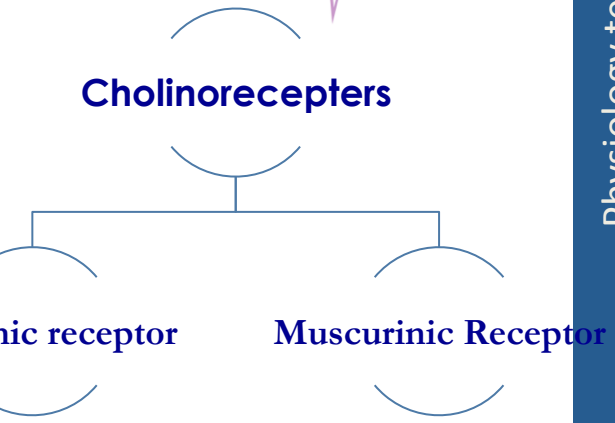
Nicotinic receptor (ion channel) :

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

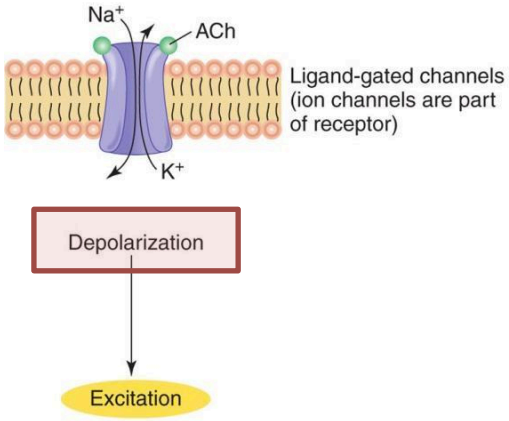
Muscurinic Receptor

- Works either like **α1** adrenoreceptor via PKC, DAC and IP3 or via G protein which has **α1** subunit that binds K+ channel and open it



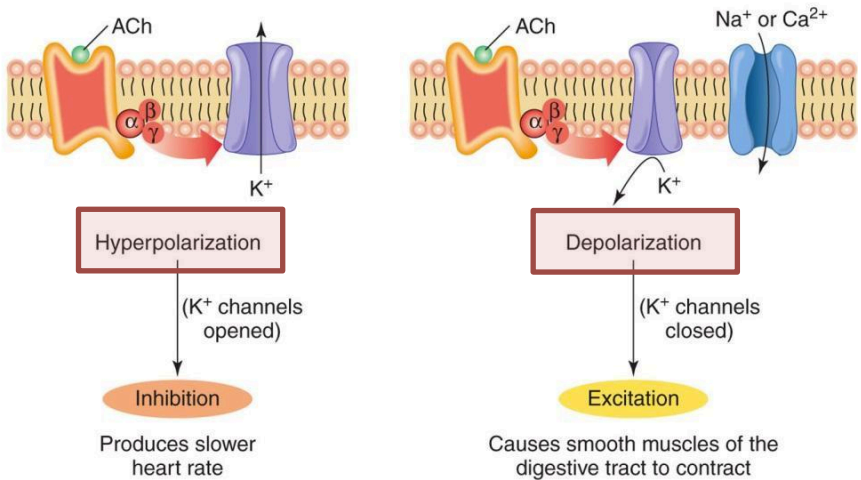
Nicotinic ACh receptors

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



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)



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Cholinorecepters

1) Nicotinic receptor

http://www.youtube.com/watch?v=iZGM5VZyhmc

- What do we mean by Hyperpolarization:
  http://www.youtube.com/watch?v=Wcp2KrAH_iI
- What do we mean by Depolarization:
  http://www.youtube.com/watch?v=qDUjVzVq7xE

The receptors is not in girls slides, and the function of each receptors is not one of the objectives in this lecture. we include it because it is in boys lecture .

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Prototypes of Agonists and Antagonists to Autonomic Receptors

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

These are the important things…

Receptors	Agonist	Antagonist
$\alpha 1$	Norepinephrine Phenylephrine	Phenoxybenzamine
β 1	Isoproterenol Norepinephrine	Propranolol
β 2	Albuterol	Propranolol
Nicotinic	Ach	Curare
Muscarinic	Muscarine	Atropine

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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 of its normal diameter.

2.removal of vagus nerve → atony(Lack of normal muscle tone) → loss of peristalsis → constipation(الامساك)

- Loss of sympathetic tone in blood vessel causes severe vasodilatation(Dilation of a blood vessel) but after sometime, intrinsic tone increases by chemical adaptation.

Function of adrenal gland

- 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.

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The effect of the autonomic nervous system on organ systems.

Very important…

table 2-4 Effect of the Autonomic Nervous System on Organ Systems

Organ	Sympathetic Action	Sympathetic Receptor	Parasympathetic Action	Parasympathetic Receptor
Heart	↑ heart rate	β_1	↓ heart rate	M_2
	↑ contractility	β_1	↓ contractility (atria)	M_2
	↑ AV node conduction	β_1	↓ AV node conduction	M_2
Vascular smooth muscle	Constricts blood vessels in skin; splanchnic	α_1	—	
	Dilates blood vessels in skeletal muscle	β_2	—	
Gastrointestinal tract	↓ motility	α_2, β_2	↑ motility	M_3
	Constricts sphincters	α_1	Relaxes sphincters	M_3
Bronchioles	Dilates bronchiolar smooth muscle	β_2	Constricts bronchiolar smooth muscle	M_3
Male sex organs	Ejaculation	α	Erection	M
Bladder	Relaxes bladder wall	β_2	Contracts bladder wall	M_3
	Constricts sphincter	α_1	Relaxes sphincter	M_3
Sweat glands	↑ sweating	M (sympathetic cholinergic)	—	
Eye				
Radial muscle, iris	Dilates pupil (mydriasis)	α_1	—	
Circular sphincter muscle, iris	—		Constricts pupil (miosis)	M
Ciliary muscle	Dilates (far vision)	β	Contracts (near vision)	M
Kidney	↑ renin secretion	β_1	—	
Fat cells	↑ lipolysis	β_1	—	

AV = atrioventricular; M = muscarinic.

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The effect of the autonomic nervous system on organ systems.

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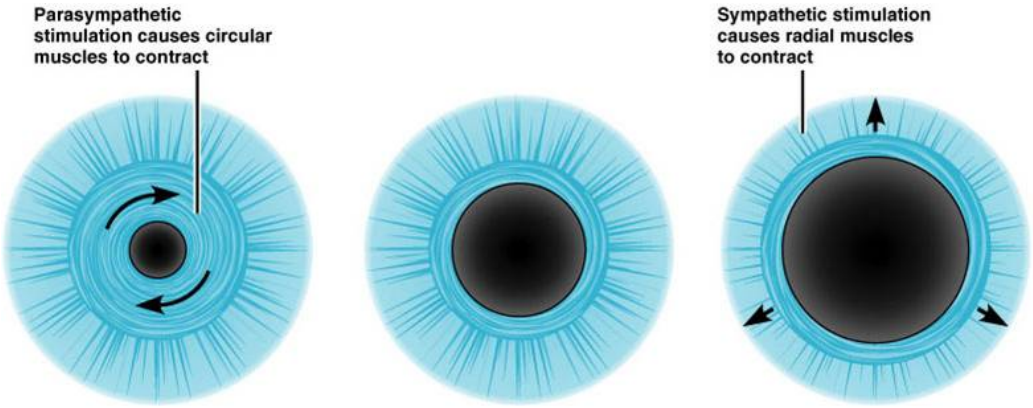
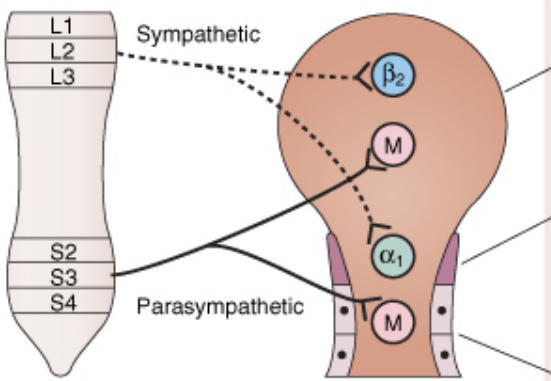
Pupil Dilation and Constriction



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

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Autonomic Reflexes

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

Cardiovascular:

- baroreceptor reflex :

It is stretch reflex in the main arteries such as carotid artery to detect the blood pressure.

Gastrointestine:

The receptors in the nose and mouth send a signal to parasympathetic to notify the glands of mouth & stomach to secrete the digestive juices.

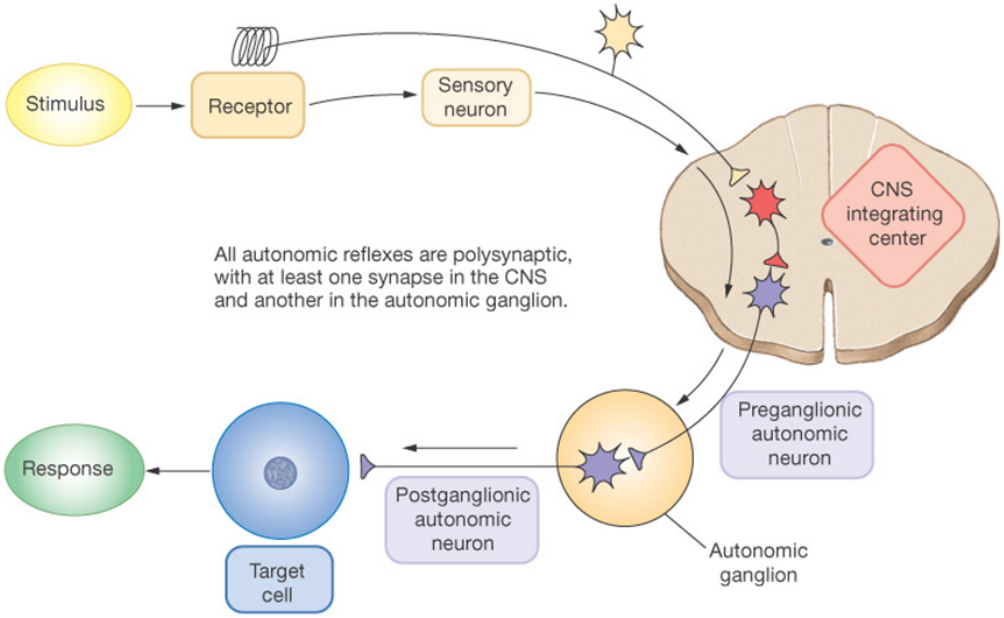
Urinary Bladder:

- Initiate the micturition (urination) by parasympathetic innervations.

Sexual reflexes:

- erection by parasympathetic
- ejaculation by sympathetic

The effect of parasympathetic usually specifies to certain organ , but sometimes th ere 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



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Summary

- The somatic nervous system is under our control.
- The autonomic nervous system is involuntary system.
- We have two neurons in the autonomic nervous system, preganglionic neuron and postganglionic neuron.
- Sympathetic and parasympathetic nervous system has an opposite function to each organ of our body.
- There is a specific site where the sympathetic and parasympathetic nervous system originate from.
- Neurotransmitters and receptor play a major role on transformation of signals.

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Important websites

- YouTube videos : **"Helpful for people who didn't understand"**

1) http://www.youtube.com/watch?v=ylWKrQTznXc
2) http://www.youtube.com/watch?v=0p_HHHOumRo

- Websites : **"Helpful for revision"**

1) http://bk.psu.edu/clt/bisc4/ipweb/systems/systems/nervous1/index.html

2) http://wps.aw.com/bc_goodenough_boh_3/104/26721/6840676.cw/content/index.html

3) http://www.johnwiley.net.au/highered/interactions/media/Regulation/content/Regulation/nerve6a/bot.htm

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Check your understanding!

1) The preganglionic neuron of the sympathetic nervous system originate from throacolumbar spinal cord (T1-L3) :

a. TRUE
b. FLASE

2) Which of these characteristics describe the preganglionic neuron in the parasympathetic System :

a. Long neuron comparing to the postganglionic.
b. Short neuron comparing to the postganglionic.
c. Mylinated
d. Not mylinated
e. A and C

3)We can find the ganglion of the parasympathetic system :

a. Near the spinal cord
b. In the organ or near to the organ

4) Which of these characteristics describe the adrenergic neurons :

a. Release Ach
b. Has adrenoreceptors as a receptor.
c. Found in the sympathetic system
d. B and C

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Check your understanding!

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5) All postganglionic neurons release ACh :
a. TRUE
b. FALSE

Take this Quiz "important"
Click here

6) What nor-epinephrine does to salivry gland which has a B1 receptor :
a. Increase the secretion of hormones
b. decrease the secretion of hormones
c. Increase the production of enzyme in the salviry gland
d. A and C

7) The sympathetic nervous system always activate the organ :
a. TRUE
b. FALSE

8) The effect of sympathetic action on the heart :
a. Increase the heart rate
b. increase the A.V conduction
c. Increase the contractility
d. All of these

Answers :
1) A
2) E
3) B
4) D
5) B
6) C
7) B
8) D

Done by :

- **Moath Aleisa**
- **Some note from:**
  Suhail alghamdi