AUTONOMIC NERVOUS SYSTEM

Objectives:

- **The anatomy of** somatic and autonomic nervous system.
- **Sympathetic** and **parasympathetic** nerves.
- **Pre** and **post**ganglionic neurons
- **Functions of** sympathetic and parasympathetic nerves in head & neck, chest, abdomen and pelvis
- **Neurotransmitters** release at pre and post ganglionic sympathetic / parasympathetic nerves endings
- Various **responses** due to stimulation of the sympathetic / parasympathetic nervous system.

Done by:

- **Team leaders:**

Shahad AlEnezi - Omar AlOtaibi

- **Team members:**

Abdulaziz Alhammad - Wael Aloud - Ammar Almansour - Abdulrahman Alsayyari
Munira Alhussaini - Mai Alageel - Lama Alzamil - Munerah alOmari - Munirah Alsalman

Edited by: Shahad AlEnezi

Revised by: Norah AlRomaih - Shahad AlEnezi.

Revised by
خولة العماري & هشام الغفيلي

Color index: Important - Further explanation - Doctors Notes - Numbers.

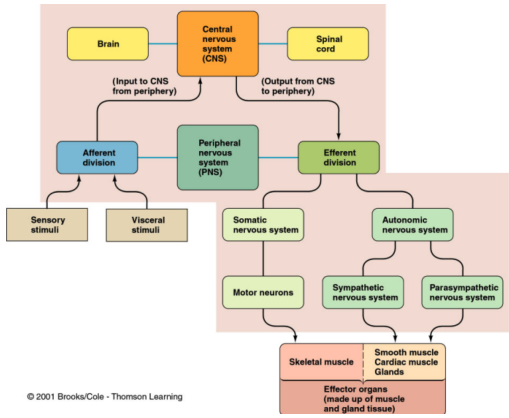
*Please check out this link before viewing the file to know if there are any additions or changes.

Introduction to the Nervous system:

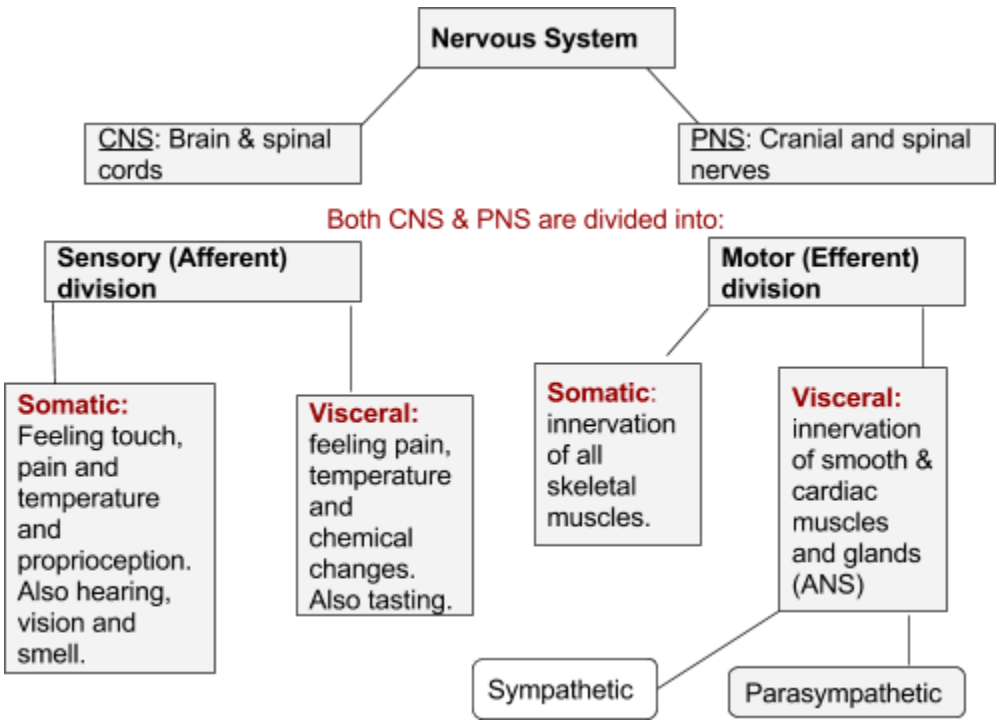
- **The nervous system:** monitors and controls almost every organ / system through a series of positive and negative feedback loops.
- **It is divided into:**
  1. **The Central Nervous System (CNS):** Includes the **brain and spinal cord**.
  2. **The Peripheral Nervous System (PNS):**
     - **Formed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

       A- Somatic Nervous system

       B- Autonomic nervous system



Anatomical Divisions of the Nervous System:



What is Autonomic nervous system ?

❖ ANS is:

- The efferent portion of the peripheral nervous system that controls involuntary (subconsciously) visceral functions**, such as:**
    - **Blood pressure.**
    - **GI motility and secretion.**
    - **Sweating , body temperature and many other activities.**
- Visceral motor innervates non-skeletal (non-somatic)(NOT under conscious control) muscles Composed of a special group of neurons serving:
    - **Cardiac muscle (the heart).**
    - **Smooth muscle (walls of viscera and blood vessels).**
    - **Internal organs.**
    - **Skin.**

❖ Structure:

- Chains of two motor neurons:
    - Axon of **1st** (preganglionic) neuron leaves CNS to synapse with the 2nd (ganglionic) neuron.
    - Axon of **2nd** (ganglionic) neuron extends to the organ it serves.

❖ Key characteristics of the ANS:

The ANS is capable of rapidly and intensely changing visceral functions, for ex:

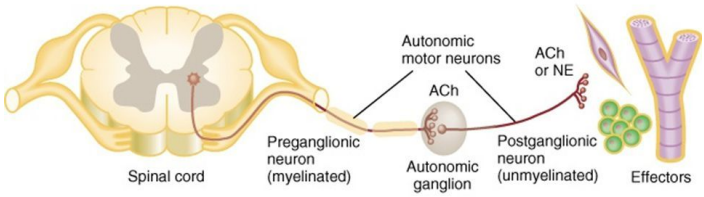
- Heart rate can be doubled within 3-5 seconds.
- Blood pressure can be doubled/decreased to fainting level within 10-15 seconds.
- Sweating can begin within seconds.
- Urinary emptying can begin within seconds.

Basic Anatomy of ANS

	Preganglionic neuron	Postganglionic neuron
Cell body location:	in **the brain or spinal cord.**	Cell body is **outside of the CNS** in an autonomic ganglion.
Axon:	- **Myelinated** (Type A β). - Extends to autonomic ganglion.	- U**nmyelinated** (Type C). - Terminates on an effector cell.

- A single preganglionic neuron synapses with 8-9 postganglionic neurons.

Basic anatomy of ANS

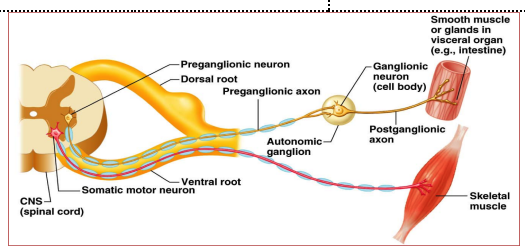


Course of Preganglionic Fibers: (from boys' slides)

1. Synapse in chain ganglion at same level or different level (up or down).
2. Synapse in a peripheral (prevertebral) ganglion.
3. Synapse in adrenal gland.
4. Adrenal gland (on top of each kidney) is a **major organ of ANS.**
5. Release **adrenaline** (80%) & **noradrenaline** (20%) in emergencies.

Comparison between Autonomic and Somatic motor systems:

Somatic motor system	Autonomic motor system
One motor neuron extends from the CNS to skeletal muscle.	**Chain of two motor neurons:** ● Preganglionic neuron. ● Postganglionic neuron.
Axons are thickly myelinated so it conduct impulses **rapidly**.	Conduction is **slower** due to thinly or unmyelinated axons.



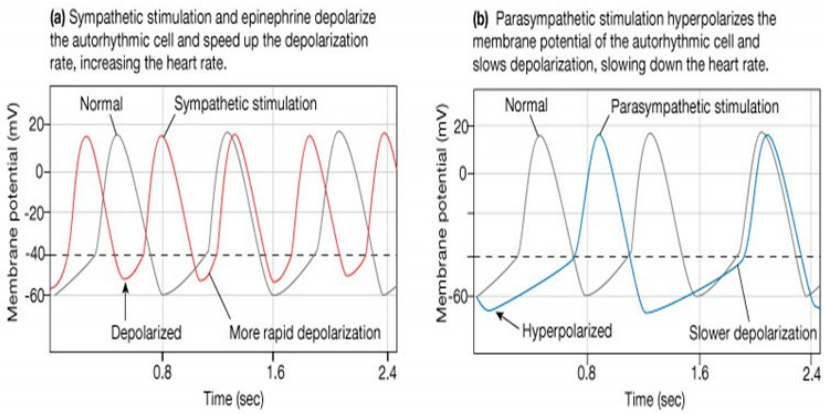
Sympathetic and Parasympathetic NS:

		Sympathetic	Parasympathetic
Ganglia:		Two (bilateral) sympathetic trunk (chain) ganglia: **1- paravertebral ganglia:** Near vertebral bodies. **2- Prevertebral ganglia:** Near large blood vessel in gut. (e.g. celiac ,superior mesenteric and inferior mesenteric)	**- Terminal ganglia:** On or near the wall of organ(effector).
Innervation of Visceral Targets:	Preganglionic neurons	**- Short**, lightly myelinated preganglionic neurons. - Acetylcholine (**cholinergic**).	**- Long.** - Acetylcholine (Ach) (**Cholinergic**).
	postganglionic neurons	**- Long**, unmyelinated postganglionic neurons. - Norepinephrine & epinephrine (**Adrenergic**), **except Sweat glands and blood vessels to skeletal muscles where they release Ach.** epinephrine is secreted from adrenal gland in sympathetic discharge. but the main neurotransmitter is norepinephrine	**- Short.** - Acetylcholine (Ach) (**Cholinergic**). So The parasympathetic nervous system uses **only** Ach as its neurotransmitter.
	Ganglia	Ganglia close to spinal cord.	Ganglia close to or on target organs.
Origin:		**Thoracolumbar outflow.** • Thoracolumbar **lateral horns** of the spinal segments T1-L2. • Nerve fibers originate between T1 &	**Craniosacral outflow.** * Craniosacral Cell bodies of the motor nuclei of: **1- The cranial nerves:**

	L2.	- **III, VII and IX :** In the brainstem, Affect the **pupil** and **salivary gland** secretion. - **X (vagus nerve) :** In the brainstem, and carries fibres to the **heart**, **lungs**, **stomach**, **upper intestine** and **ureter.** **2- Sacral segments of the spinal cord:** - Second, third and fourth [S2-S4] . - Form **pelvic plexuses** which innervate the distal colon, rectum, bladder and reproductive organs.
General function	Dominates during "**fight-or-flight**" response *(E division) *** Examples:** Exercise, Excitement, Emergency, Embarrassment.. Metabolic changes (metabolism of fat and glycogen).	Dominates during "**rest-and-digest**" or "**feed-and-breed**" response *(D division) *Concerned with **conservation** and **restoration** of energy.. *** Examples:** Digestion, Defecation, Diuresis...

Effects of Sympathetic and parasympathetic NS

	Sympathetic	Parasympathetic
Cardiovascular system:		
Heart rate & contractility of cardiac cells (myocytes)	Increased (to enhance blood flow to skeletal muscles)	Decreased But has **not** effect on contraction

Blood Pressure & Cardiac output	Increased (to give more blood to organs)	decreased
Mechanism	- Activation of β 1-receptors by NE - **Increase permeability of Na+and Ca^{2+} channels** causing depolarization and increased contractile strength	- Release of Ach which **increases permeability of K^+ channels** (hyperpolarization) via activation of Muscarinic receptors .
Modulation of Heart Rate by ANS		
Eyes		
Pupil size	Dilated	Constricted
ciliary muscles " iris"	Relaxed for Far vision "To allowing more light to enter the eye"	Constricted for Near vision
Kidney		
Urine secretion:	Decreased	Increased
Wall contracted , Sphincter	Wall relaxed Sphincter closed	Wall contracted. Sphincter relaxed.
Adrenal medulla	Norepinephrine and epinephrine secreted.	-
GIT		
Stomach	Peristalsis reduced	Gastric juice secreted; motility increased.
Small intestine	Motility Decreased	Digestion increased.

Large intestine	Motility Decreased	Secretion and motility increased
liver	Increased conversion of glycogen to glucose.	-
Glands		
Salivary Glands	Reduced (not the perfect time to eat)	Increased
Oral/Nasal Mucosa	Reduced	Increased
lungs		
Bronchioles	Dilated alveolar oxygen exchange ↑	Constricted
Bronchial muscles	Relaxed.	Contracted.

ANS Neurotransmitters:

- ANS neurotransmitters are either cholinergic or adrenergic based upon the neurotransmitter released
- All **Preganglionic fibers** release Acetylcholine (Ach).
- All **Parasympathetic postganglionic** release Ach.
- All **Sympathetic postganglionic** release Noradrenalin, **except Sweat glands and blood vessels to skeletal muscles where they release Ach.**

ANS RECEPTORS:

❖ Parasympathetic receptors:

- **The ACh acts on two types of receptors:**
  1. **The Muscarinic cholinergic receptors:** (G-protein coupled) receptor (bind muscarine)
     - **Atropine** blocks M receptors and is used to inhibit salivary and

bronchial secretions before surgery.

- All cholinergic receptors on **EFFECTOR** cells are **muscarinic**.
- (5 types) M1,2,3,4,5.

Note: nicotine is agonist to nicotinic receptor , and antagonist to muscarinic receptor , and vise versa.

2. **The Nicotinic cholinergic receptors:** (bind nicotine)
   - Ligand-gated.
   - All cholinergic receptors on the **post**ganglionic neurons of **sympathetic & parasympathetic** systems , and on the **adrenal gland** are **nicotinic** .

Note: Why are they named nicotinic receptors?

they discover receptors by stimulating or blocking it by a drug. so the nicotinic receptors were stimulated by nicotine when they first discovered it.

- **Most transmissions occur in two stages:** When stimulated,
  1. The **Pre**ganglionic nerve releases **ACh** at the ganglion, which acts on **nicotinic** receptors of the postganglionic nerve.
  2. The **Post**ganglionic nerve then releases **ACh** to stimulate the **muscarinic** receptors of the target organ.

❖ Sympathetic receptors:

- **The sympathetic NT acts on two types of receptors:**
  1. **The Α (alpha) receptors.**
  2. **The β (Betal) receptors.**
- **What do these receptors do?**

a1 receptors:	**excitatory**	lead to smooth muscle **contraction. (most target tissues).**
a2 receptors	**inhibitory**	Digestive organs.
B1 receptors:	**excitatory**	leads to smooth muscle **contraction.** (especially in heart).
B2 receptors	**inhibitory**	smooth muscle **relaxation (blood vessels and airways)**
B3 receptors	**???**	

❖ **Functions of adrenergic receptors: (In boys slides):**

Alpha receptors:	Beta receptors:
Vasoconstriction	Vasodilatation (β 2)
Iris dilation	Cardioacceleration (β 1)
Intestinal sphincter contraction	Increased myocardial strength (β 1)
Bladder sphincter contraction	Bronchodilatation (β 2)
Pilomotor contraction	Glycogenolysis (β 2)

Exception To General Rule Of Dual Innervation: (from boys' slides)

❖ What is "Dual innervations"?

These are innervations affected by two systems, the parasympathetic and sympathetic nerve systems. They are both present in some organs because of the variety of functions that the organs have to perform. Both systems are anti-thesis to each other; their functions are opposites but exist in synergism with the body's health and wellness. . The neurons of these two systems both exist in organs and act as the homeostatic basis of physiologic responses.

❖ Exception to general role of dual innervation:

- Most Innervated **blood vessels** (arterioles and veins) receive **only** sympathetic nerve fibers, except clitoris/penis : **erection** (not ejaculation !) .
- Most **sweat glands** are innervated **only** by sympathetic nerves, except in **hand palms** .
- **Both** ANS subdivisions **stimulate** the activity of some **glands** .

Sweat glands are activated in sympathetic situations because during stressful conditions our body has high temperature, so the sweating release that heat. and also because there is no urination

---

Disorders of the ANS: (from boys' slides)

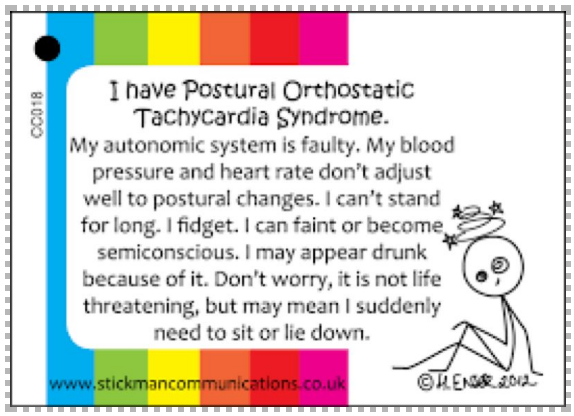
Raynaud's disease	Hypertension
• Characterized by **constriction** of blood vessels. • It is an exaggeration of **vasomotor** responses to cold or emotional stress. • During an attack, the fingers and toes can change colours from white to blue to red.	Result from **overactivation** of sympathetic vasoconstriction.

Explanation:

Raynaud's phenomenon is excessively reduced blood flow in response to cold or emotional stress, causing discoloration of the fingers, toes, and occasionally other areas.Its pathophysiology includes hyperactivation of the sympathetic nervous system causing extreme vasoconstriction of the peripheral blood vessels, leading to tissue hypoxia.

Postural Orthostatic Tachycardia Syndrome (POT)[1]

- POT: is a condition in which a change from the supine position to an upright position causes an abnormally large increase in heart rate, called tachycardia.



Stress (from girls' slides)

❖ Stress reaction:

1. When stress occurs, the sympathetic nervous system is triggered.

[1] Extra Reading for understanding, click here.

2. **Norepinephrine** is released by **nerves**, and **epinephrine** is secreted by **the adrenal glands.** By activating receptors in blood vessels and other structures, these substances ready the heart and working muscles for action.
3. **Acetylcholine** is released in the parasympathetic nervous system, producing **calming** effects.
    a) The digestive tract is stimulated to digest a meal.
    b) the heart rate slows.
    c) the pupils of the eyes become smaller.
    d) The neuroendocrine system also maintains the body's normal internal functioning.

❖ Chronic stress :

- When **glucocorticoids** or **adrenaline** are secreted in response to **the prolonged psychological stress** commonly encountered by humans, the results are not ideal.
- Normally, bodily systems gear up(Prepare) under stress and release hormones to:
    A. improve memory.
    B. increase immune function.
    C. enhance muscular activity.
    D. restore homeostasis.
- If you are not fighting or fleeing, but standing frustrated in a supermarket checkout line or sitting in a traffic jam, you are not engaging in muscular exercise.
- Yet these systems continue to be stimulated, and when they are stimulated **chronically**(for a long duration), there are different consequences:
    A. Memory is impaired
    B. immune function is suppressed
    C. energy is stored as fat.

❖ Response to stress :

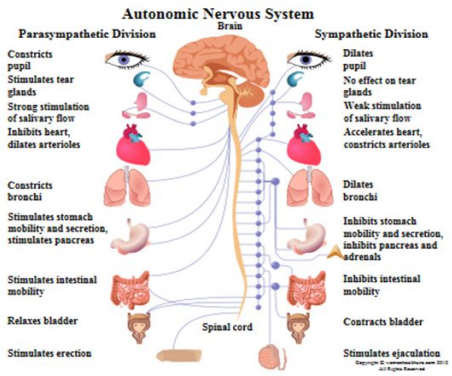
Psychological	Behavioral	Psychosomatic
Short Fuse	Drug/Use Abuse	Ulcers
Irritability	Alcohol Use/Abuse	High Blood Pressure
Depression	Smoking	Insomnia
Frustration	Strained Relationships	Indigestion
Emotional Irritability	Eating Problems	Headaches
Insecurity	Suicide Attempts	Other Cardiovascular
Mental Illness	Violence	Body Infections
Anxiety	Impulsive/ Irrational Behavior	Irregular Pulse rate

ANS response (from boys' slides)

Sympathetic (fight or flight)	Parasympathetic (rest and digest)
Fight or flight (or freeze) response is an **automatic survival mechanism that prepares the body for emergency**. When faced with a danger many changes occur: **1. Sympathetic functions that mobilize energy are initiated rapidly.** (ex: Glycogen conversion to glucose, or increased HR) **2. Parasympathetic functions not important in fight or flight are inhibited.** (ex: Digestion, sexual function) **Response:** (story)	Rest and digest (or feed and breed) is what happens when your body is in a relaxed state, it is **usually opposite** to responses caused by sympathetic division. It's main **goal** is: conservation of body energy. Dual innervation allows for the **precise control** over the activity of a visceral organ. **Exceptions to rule of dual innervation:** Most innervated blood vessels receive only **sympathetic** nerve fibers (except in clitoris/penis: erection)

Threat (bear attack) → signal processing in the brain amygdala/Hypothalamus → activation of sympathetic NS → Superman strength and speed.	Most sweat glands are innervated only by **sympathetic** nerves (except in palms).

Summary of main functions of ANS



★ References:

- 435 girls and boys slides and notes.