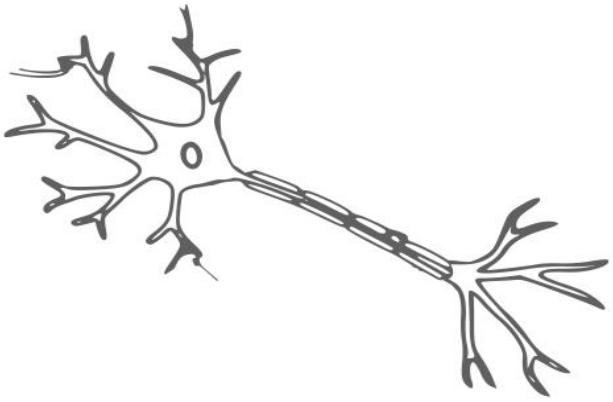
Sheet no.8

Physiology



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Topics discussed in this lecture:

1) Introduction:

a) definition / b) General functions of ANS/ c) Characteristics of ANS/ d) Physiological anatomy

2) Sympathetic nervous system

a) Anatomy/ b) Effector functions

3) Parasympathetic nervous system

a) Anatomy/ b) Effector functions

4) Organization of the autonomic neuroeffector junction

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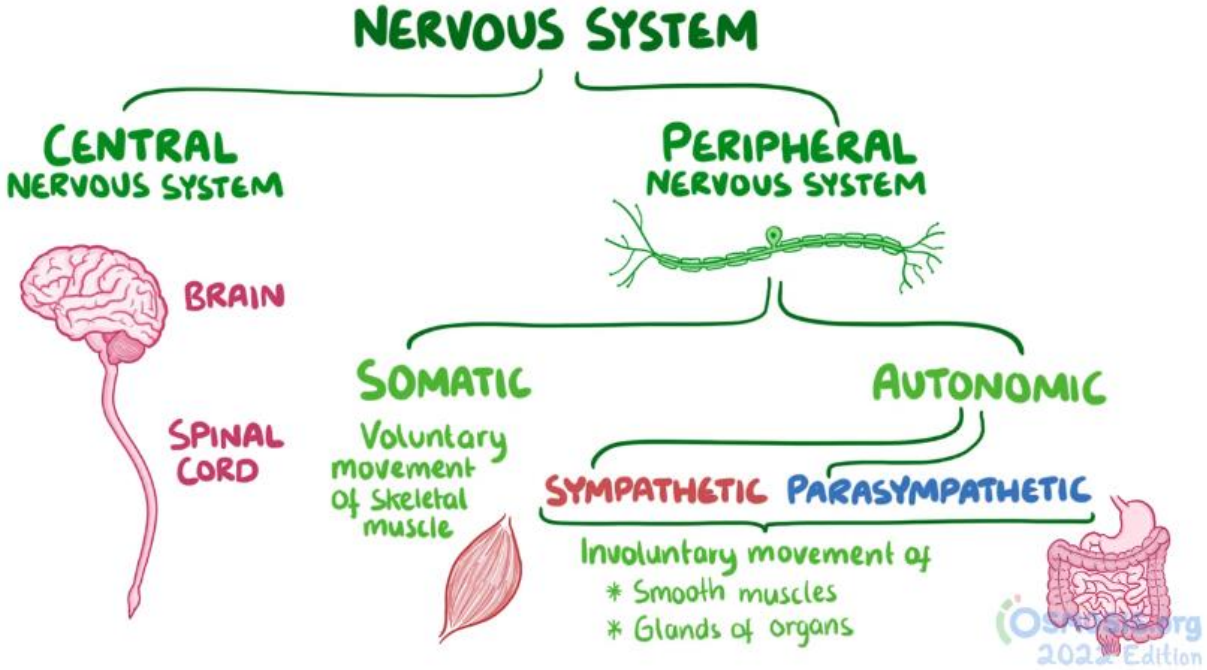
1) Introduction/ a) definition



Autonomic nervous system (ANS): This nervous division is anatomically distinct from the motor somatic nervous system, which innervates skeletal muscle. This group of efferent paths originates from the central nervous system and innervates heart, smooth muscle, glandular tissue and enteric nervous system. ANS has two subdivisions, sympathetic and parasympathetic

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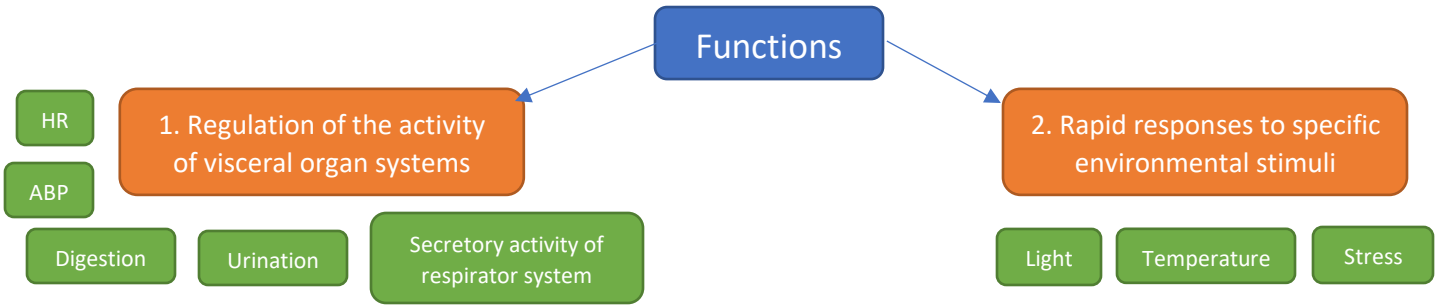
1) Introduction/ b) General functions of ANS:



B1. Regulation of the activity of visceral organ systems:
→ examples of functions under ANS control include:
- heart rate
- arterial blood pressure
- digestion, intestinal motility, secretions (these functions are controlled in conjunction with hormones).
- emptying of urinary bladder
- secretory activity of respiratory tract and airways resistance (by regulation of diameter of bronchioles).
→ By regulation of these functions, ANS plays an important role in maintaining constancy of internal environment (homeostasis).

B2. Rapid responses to specific environmental stimuli, these include:
- Light: constriction of the pupil to bright light (miosis), and dilation of pupil to low light (mydriases).
- Temperature: cutaneous vasodilation and sweating in a warm environment, and vasoconstriction in cold.
- Stress: The ANS (mainly the sympathetic and the adrenal medulla) mediates the immediate response (fight or flight response) to threatening stimuli. This involves a series of well coordinated responses to meet the metabolic demands for severe physical exertion. The features of this response include:

- increase heart rate and force of contraction.
- Widely dilated pupils.
- Pallor (pale of fear) as blood is directed to the skeletal muscle.(In "fight and flight" reactions the blood circulation is redistributed *higher amount of blood is directed to muscles, lower amount is directed to unnecessary tissues in the response such as the skin and GI tract (vasodilation(توسع الأوعية الدموية)for muscles blood vessels and vasoconstriction(تضيق الأوعية الدموية)for unnecessary tissues' vessels)*.
- Goose pimple: a state of the skin caused by cold, fear, or excitement, in which small bumps appear on the surface as the hairs become erect; goosebumps *it is caused by the contraction of smooth muscle cells found in the root of the hair*.
- Cold sweat. (it is cold because of the low amount of blood that is delivered to the skin)
- Dry mouth.*decreased secretion of salivary glands because u are reducing the blood flow*

* On the other hand during ordinary situation the parasympathetic division conserves and restores , it :

- Slow heartbeat
- Decreases respiratory rate
- Stimulates digestion
- Removes waste
- Store energy

1) Introduction / c) Characteristics of ANS

Characteristics of autonomic responses:

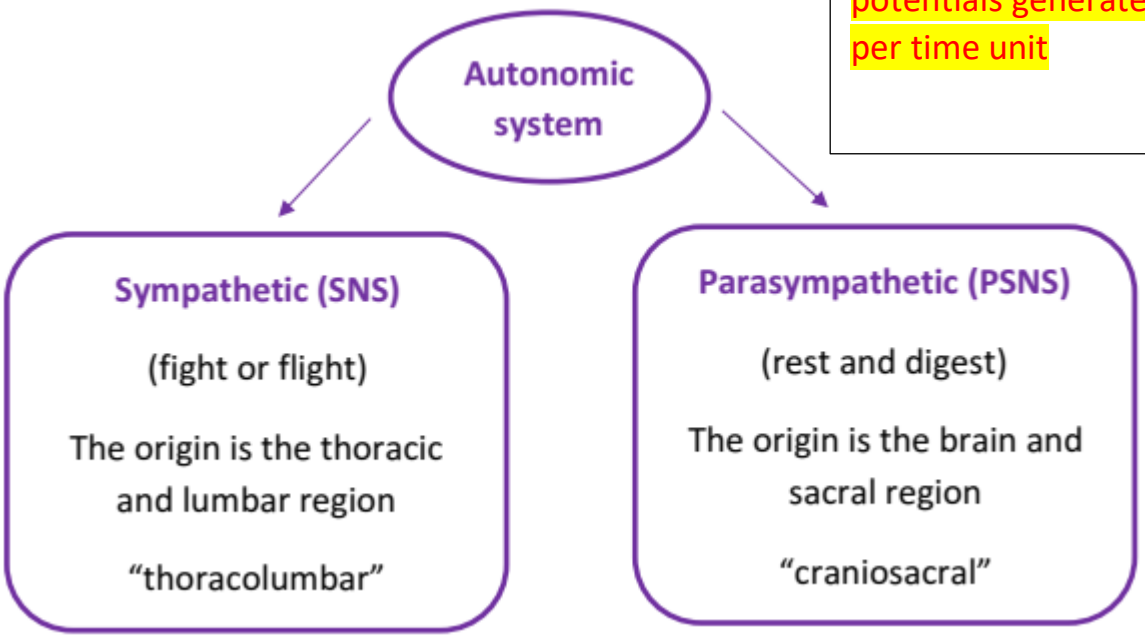
C1. Speed of onset: ANS can produce dramatic changes in the level of activity of organs they innervate within seconds. Changes in heart rate, sweating, goose pimples, and rise or fall in blood pressure can take place within few seconds (3-5 sec).

C2. Automatic nature: regulation of visceral functions occurs without conscious control. Some functions are brought under voluntary control such as urination and defecation through the participation of voluntary muscles. The impulses in ANS to target organs are set up reflexively in response to specific type of sensory information. The reflex responses are sensitive to emotional states of the body. Stress, excitements, euphoria, fear, anxiety or anger can influence reflexes and induce a variety of symptoms, such as sweating, palpitation, or digestive disturbances.

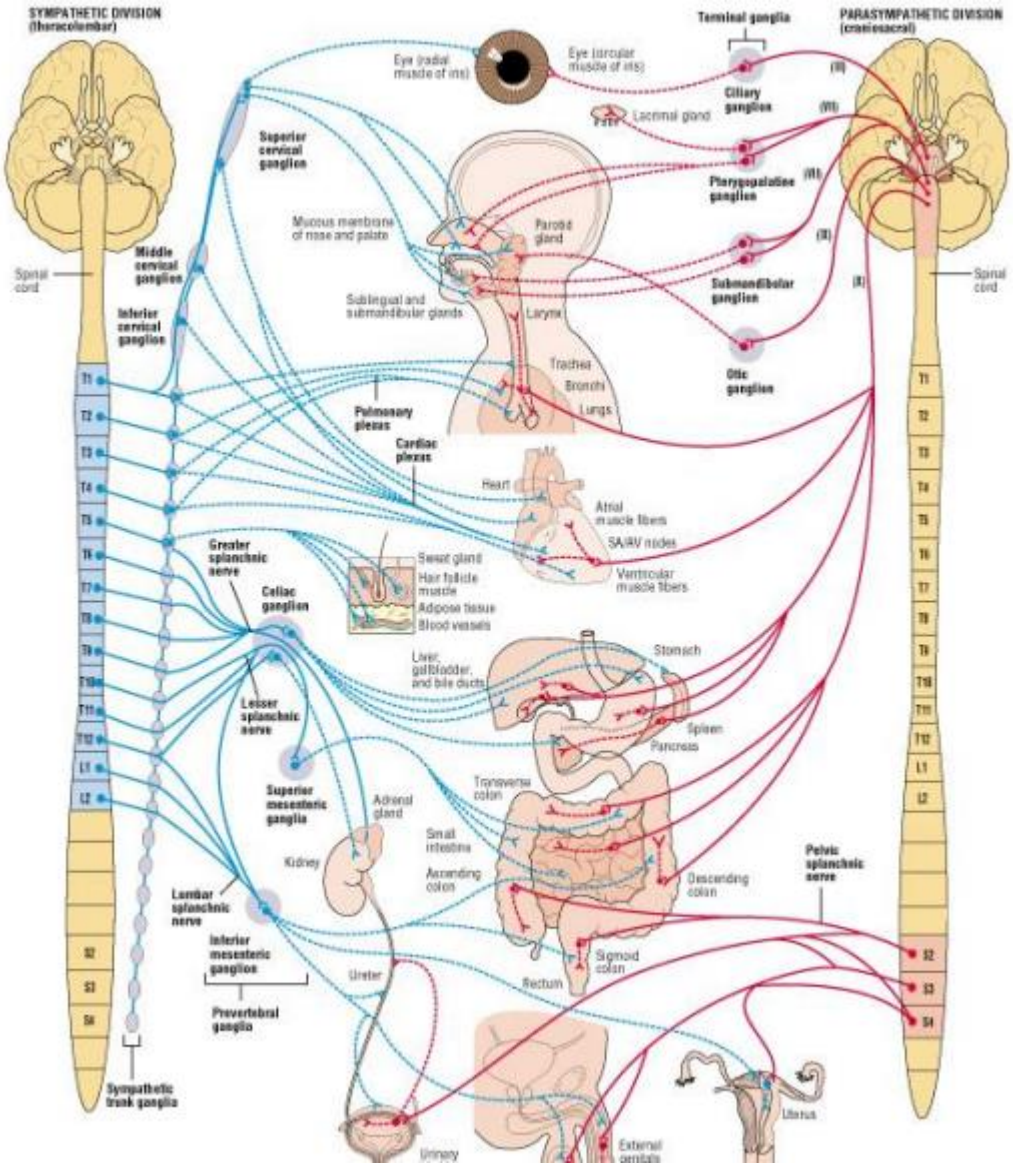
C3. Tonic activity: The ANS fires continuous impulses to target organs at very low rate. The basal rate of firing is called "sympathetic tone" and "parasympathetic tone". These tones establish basal rate of contractile activity in smooth muscle cells, and secretory activity of glandular tissues. The activity of these effector cells can be changed as a result of an increase or a decrease in the activity of any divisions of the ANS.

Tonic activity= the number of action potentials generated per time unit

1) Introduction / d) Physiological anatomy



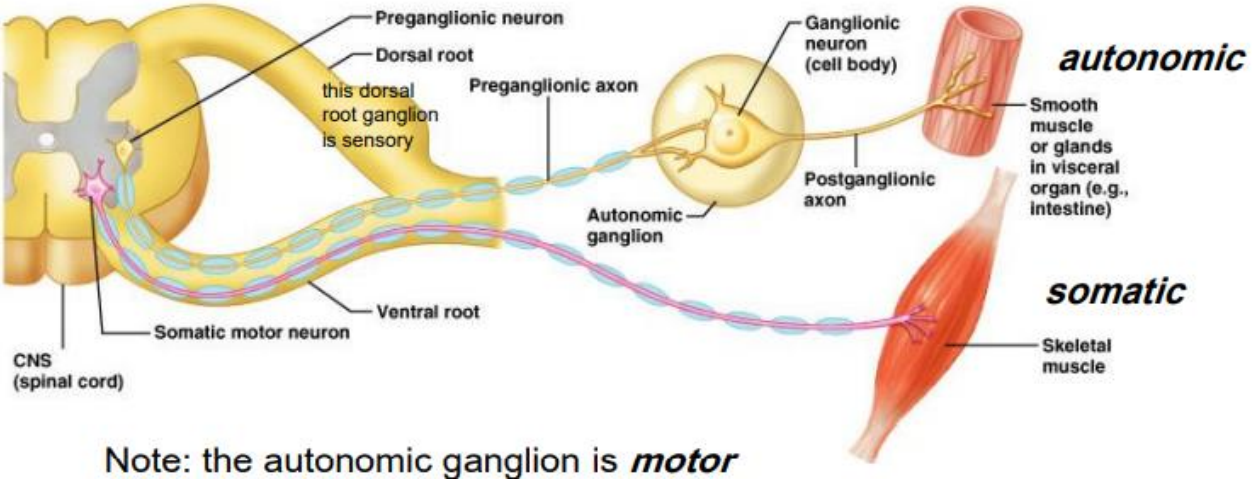
Two neurons carry impulses of the ANS from the CNS to the effector organs. The first is known as preganglionic neuron, the cell body is located in the CNS (in appropriate nucleus in the brain or in the lateral gray of the spinal cord). The fibres of preganglionic are small and myelinated, and usually end within a ganglion where they synapse with the second neuron called postsynaptic neuron. The second neuron (postsynaptic) carries impulses to target organ.



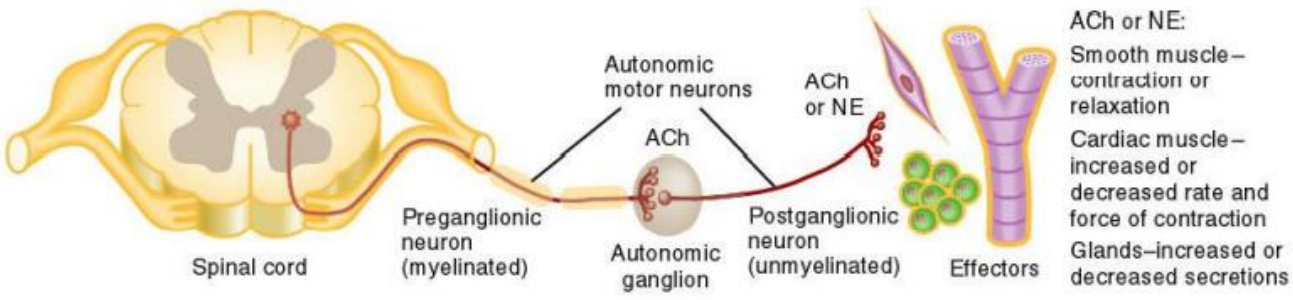
We can notice that preganglionic

Fibers in sympathetic are short while in parasympathetic they are long. and postganglionic fibers are long in sympathetic while in parasympathetic they are short.

Diagram contrasts somatic (lower) and autonomic:



Note: the autonomic ganglion is ***motor***



(b) Autonomic nervous system

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2) Sympathetic nervous system/ a) Anatomy

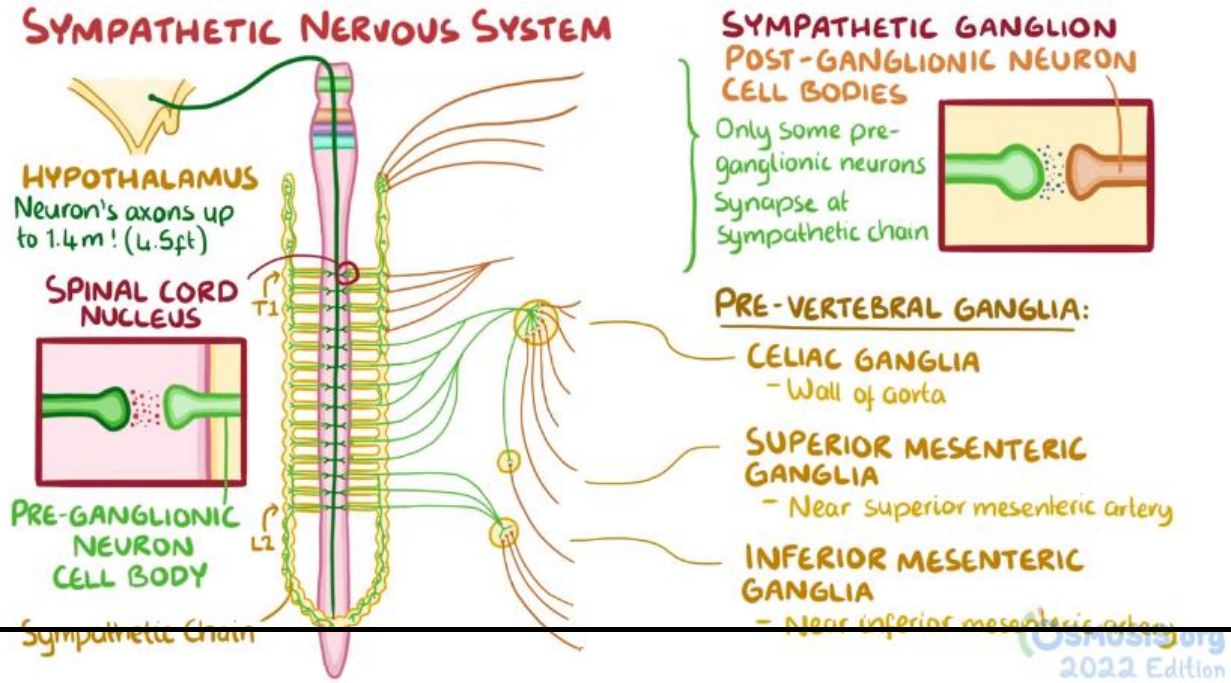
The cell bodies of preganglionic neurons lie in lateral gray of spinal cord at segmental levels of T1 through L3. Axons leaves spinal cord via ventral roots, then leave ventral root via white rami communicans to enter a vertebral ganglion of the sympathetic chain at the same segmental level. The preganglionic axon then can:

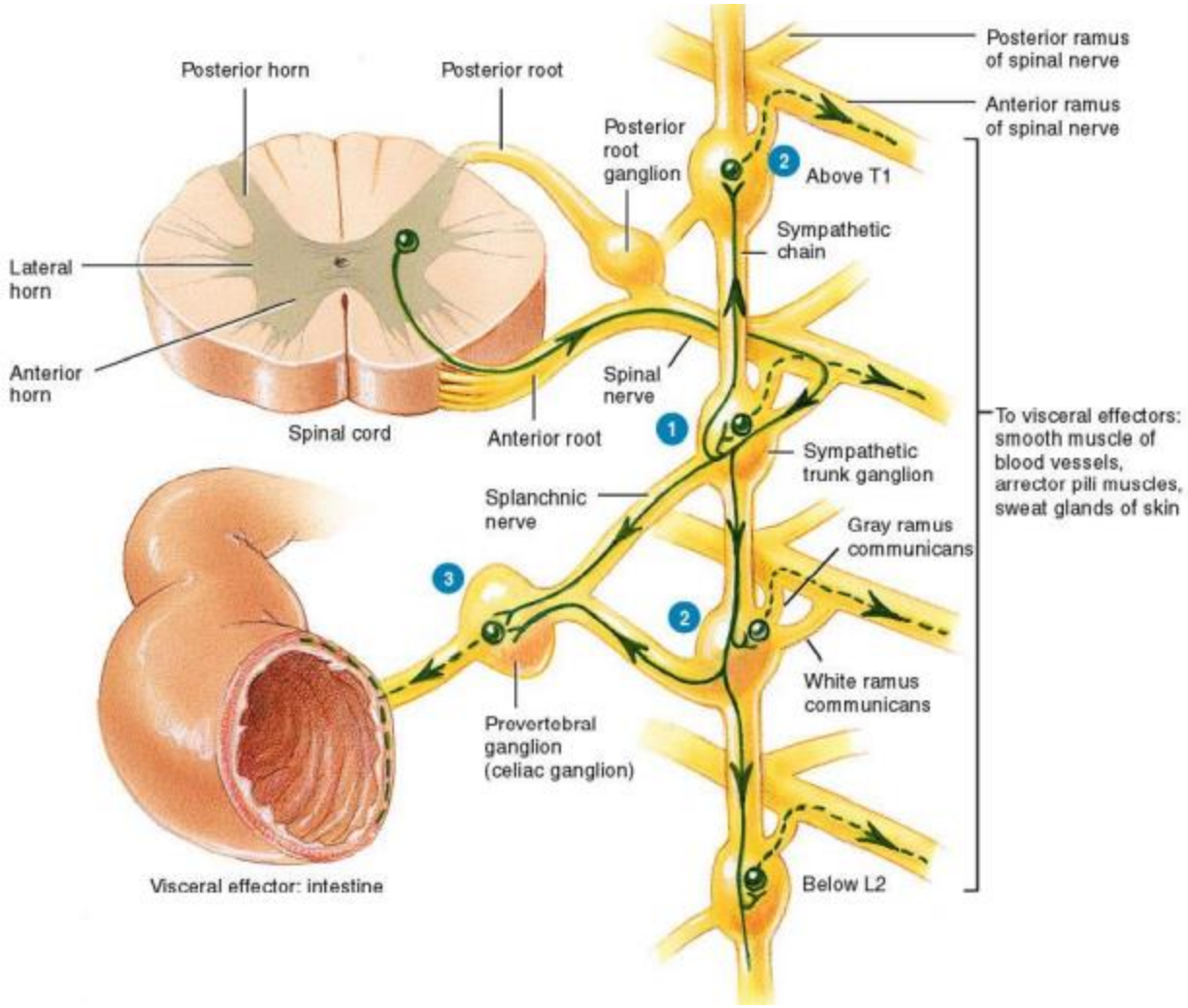
A1- Synapse with postganglionic cells at the same segmental level.

A2- Turn cranial or caudal and synapse with sympathetic postganglionic neuron at higher or lower segmental level. Synapse may occur at more than one postganglionic neuron. After synapse with neurons at paravertebral ganglia (beside the vertebral column), axons of second neurons leave ganglia via gray rami communicans to return to the corresponding spinal nerve.

A3- Some preganglionic fibers that enter ganglia pass without any synapse at the paravertebral ganglia and continue to some ganglia located in the abdomen known as prevertebral ganglia (Far away from the vertebral column), where they have the synapse with the second neuron. There are three unpaired prevertebral ganglia: celiac, superior mesenteric and inferior mesenteric ganglia

A4- Some preganglionic fibers pass without synapse in paravertebral ganglia and celiac ganglion. These fibers continue to adrenal gland where they synapse onto chromaffin cells. These cells liberate epinephrine into blood stream. (Dr. mohammed didn't focus on it)





→ Individual postsynaptic neuron in vertebral ganglia can receive signals from many preganglionic fibers (convergence) and one preganglionic neuron can relay impulse to many postganglionic neurons at different segmental levels (divergence). This organization of the sympathetic system induces widespread effects on target cells innervated by sympathetic postganglionic fibers.

2) Sympathetic nervous system/ b) Effector functions

→ Sympathetic system innervates widely distributed tissues. These include, sweat glands, smooth muscle cells of blood vessels supplying skeletal muscle, skin, etc, smooth muscle cells of hair follicles. This innervation is consistent with diffuse projections of the sympathetic postganglionic fibers that originate in vertebral ganglia and distribute with the spinal nerves.

→ In human, the previously mentioned target tissues do not have any parasympathetic innervation. Thus, the sympathetic which has excitatory effects on these tissues regulates:

- Blood pressure (blood vessels supplying skeletal muscle are major players). In addition to that the effect on heart also contributes in regulation of blood pressure.
- Body temperature by sympathetic effects on cutaneous blood vessels + sweat glands.

→ In addition to its effect on widely distributed tissues, sympathetic system is involved in handling stress responses (fight or flight reaction). Together with adrenal gland, the sympathetic system is designed to promote the production of energy for muscular work and to shut down organs which have nonessential functions in reaction to stressful situations. These effects on the following systems include:

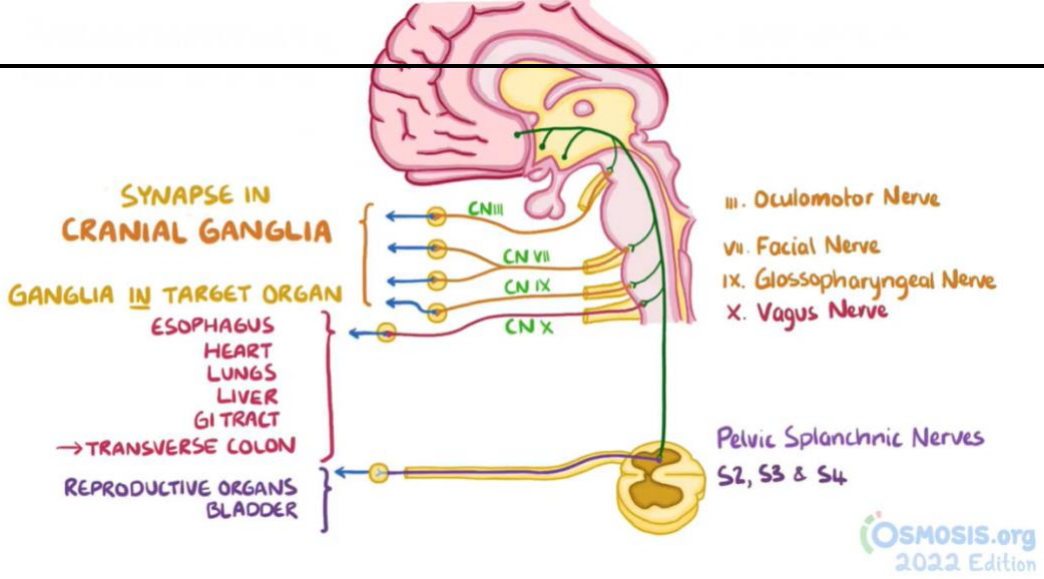
- Cardiovascular system: effects on vessels will result in redistribution of blood by enhancing blood flow to skeletal muscle and reducing blood flow to skin and mesentery.
- Effects on heart: increasing cardiac output (volume of blood pumped per minute).*it is acting over the cardiac muscle to increase the force of contraction*.
- Respiratory system: causes relaxation of bronchial muscle which result in bronchodilation. *more airflow for the lungs and better oxygenation for the blood*.
- Digestive system: inhibition of motility and secretion.
- Metabolic effects:

♣ Mobilization of glucose. ♣ Increased lipolysis. ♣ Increased metabolic rate

3) Parasympathetic nervous system / a) Anatomy

Parasympathetic nervous system: The preganglionic fibers arise in appropriate cranial nuclei and in segments S3 and S4 (sometimes S2, S5 also). These fibers leave the CNS in the III, VII, IX, and X (vagus) nerves for fibers of cranial origin and in pelvic nerve for fibers of sacral origin. The preganglionic fibers are long and go all the way to the effector organ where they synapse with the second postganglionic neuron located within the tissue of the effector organ or to a ganglion located very close to the effector organ. The axons of postsynaptic neurons are short.

Synaptic organization of parasympathetic nervous system: In parasympathetic there is no or little branching of preganglionic fibers (divergence). The ratio of pre to post ganglionic neurons is 1:1 or 1:2. As a result of this arrangement, the parasympathetic actions tend to be more discrete and confined to the innervated organ.



3) Parasympathetic nervous system / b) Effector functions

Overall, the parasympathetic, in contrast to sympathetic system is viewed as regulator of activities involved in replenishment of energy supply and general maintenance of the organism. The control provided by parasympathetic system is discrete and selectively directed to individual organs. The types of actions produced by parasympathetic stimulation include:

- Gastrointestinal system: increases motility and secretory activity.
- Glands: increases secretory activity (but remember sweat glands are under sympathetic control).
- Heart: decrease rate of contraction (bradycardia).

It has no effect on the force of contraction, it is acting only on the conductive tissue not the cardiac muscle itself

- Pupil: control pupil diameter by papillary light reflex (miosis) (regulates the amount of light falling on retina).
- Accommodation of the lens for near vision.
- Voiding the urinary bladder (micturition).

4) Organization of the autonomic neuroeffector junction

The terminals of autonomic nerve fibers are unlike terminals of the somatic motor fibers (skeletal neuromuscular junction). The autonomic terminals are highly branched forming extensive network of fibers beaded with small swellings or varicosities. These varicosities are sites from where transmitter is released.

The receptors on effector cells are scattered widely over the innervated organ. Unlike skeletal muscle, there is no specialized receptive region at the effector cell. The effect of ANS on these cells can be stimulatory or inhibitory. This effect depends on transmitter type, receptor subtype and changes in functional proteins induced in cell by binding of transmitter to its receptor.