Physiology
Sheet **No.**

18

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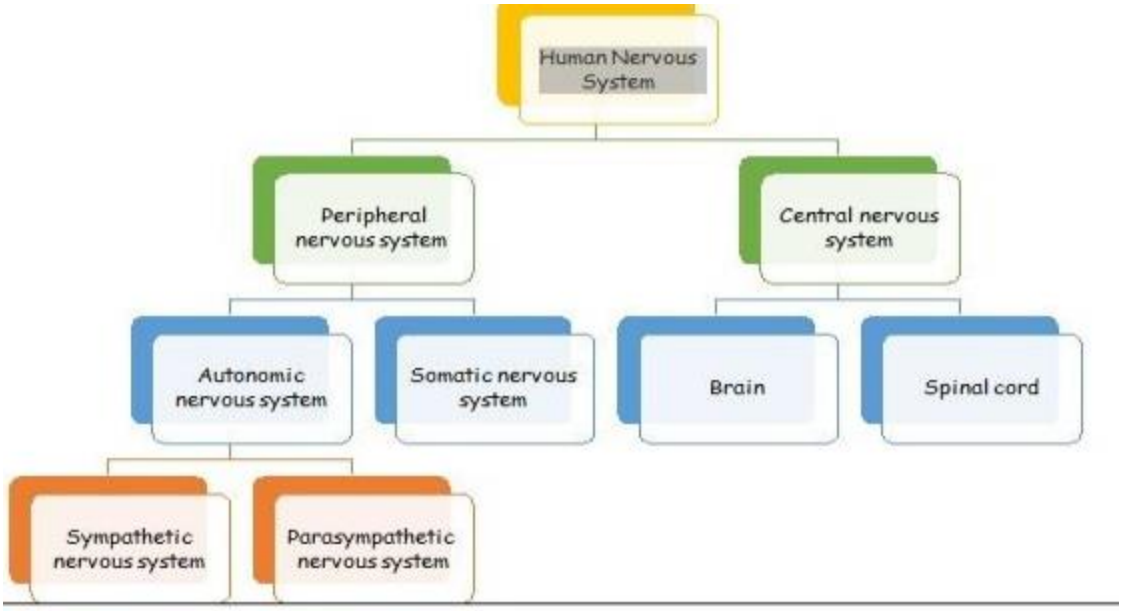
INTRODUCTION



Autonomic nervous system (ANS) is what we are EXPLAINING in this sheet

Autonomic nervous system: Portion of the nervous system that controls most of the visceral functions of the body.

examples of functions under ANS control in general:

- 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).

***The body tries to adapt and control the changes that happen and affect the homeostasis (either internal or external) most of these changes are controlled by ANS, for example:

- 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.

All of these adaptations (deals with changes) in our body are controlled through the ANS.

Autonomic system

Sympathetic

(SNS) (fight or flight)

The origin is the thoracic and lumbar region "**thoracolumbar**"

T1-L3

Parasympathetic

(PSNS) (rest and digest)

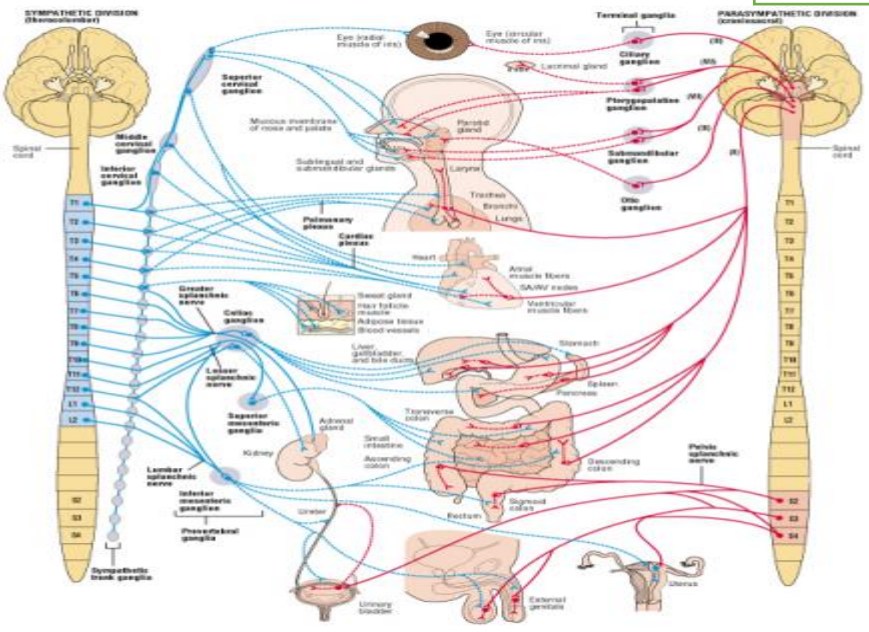
The origin is the brain and sacral region

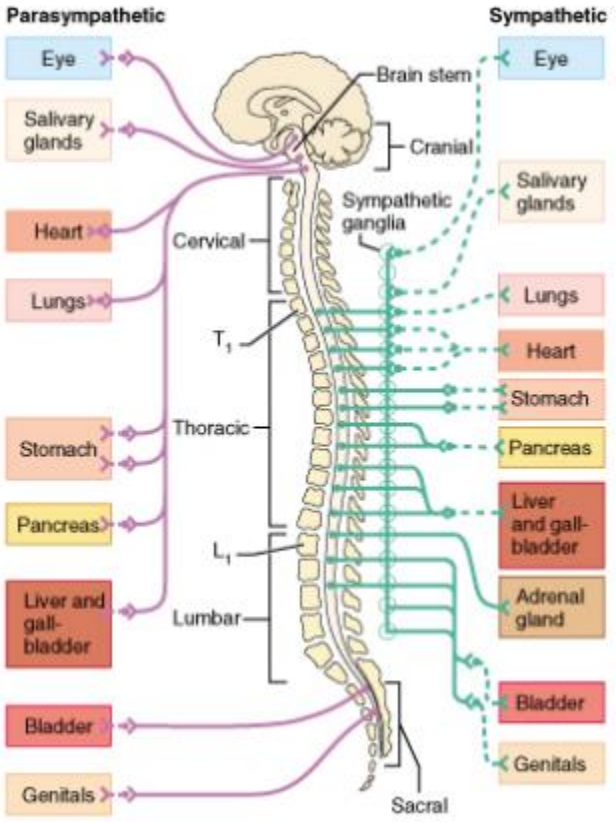
"**craniosacral**"

Cranial 3,7,9,10

Sacral 3,4 (sometimes 2,5)

NOTICE THE ORIGIN





There are **different origins for both divisions to provide a huge control for a lot of systems and allow the body to adapt with internal and external changes.

There are some charecteristics for both sympathetic and parasympathetic nervous systems:

1- Speed of onset: ANS can make changes in the activity of the organs it innervates within seconds (3-5), because you must respond in a fast way if you are facing a danger.
2- Automatic nature: you cann't control the activity of the organs that are innervated by the ANS, they are being controlled without your consciuos using involuntary muscles, but the urination process is an exeption, because it has some voluntary muscles.

3- Tonic activity: Increasing or decreasing generation of action potential

Tonic= generation of action potential

That means we haven't zero activity in any time but the level of activity can increase or decrease , so we have certain level for (PSNS) and (SNS)

EXAMPLE OF ADAPTING WITH CHANGES IN EXTERNAL ENVIRONMENT:

Imagine that you are in a forest and you face a bear, so you have two choices: fight or run (flight).

In the previous scenario, the body is going to increase **the breathing** to supply the muscles (heightening the rate of **CO2 and O2 exchange**). Also speeds up **metabolic reactions** to generate more nutrients to supply the whole body. (carbs and other energy-rich macromolecules breakdown will increase).

Generally, **"fight or flight"** reactions are group of reactions that take place in body response to face the terrifying things or for getting stressed (harmful stimulus), in addition they push the body to speed up its metabolic processes, as well as the following reactions:

Sympathetic (fight or flight) Example of adaptation to external stimuli (Fight and Flight Reaction)

1 – increasing heart rate and force of contractions; to deliver more blood to cells.

2 – mydriasis, (dilation of pupils).

3 – pallor (pale of fear): paling of the face or the skin; happens as a result of decreasing the amount of blood that goes to the skin. In "fight and flight" reactions the blood circulation is redistributed (higher amount of blood is directed to muscles, lower amount is directed to skin and unnecessary tissues in the response. (vasodilation for muscles blood vessels and vasoconstriction for unnecessary tissues' vessels).

4 – goose pimpling: contraction of the smooth muscles that are found in the root of the hair which causes hair erection.

5 – cold sweat (it is cold because of the low amount of blood that is delievered to the skin)

6 – dry mouth: inactivation of salivary glands **THE BODY** is trying to shut down all unnecessary tissues by vasoconstriction the blood vessels that supplies these tissues.

Briefly

- Increases cardiac output
- Accelerates respiratory rate
- Releases stored energy and dilates pupils
- Inhibits body processes that are less important in emergencies such as digestion and urination

Important terminology:

1 – Ganglion: Nerve cell cluster, where neurons are typically linked by synapses. Also, it`s the border line between preganglionic and postganglionic and where they synapse.

2 – Preganglionic = presynaptic = first neuron: the neuron which extends from Central nervous system to its synapse with second neuron.

3 – Postganglionic = postsynaptic= second neuron: the neuron that extends from the ganglion to the effectors (usually organs) .

4 – Paravertebral ganglion: ganglion that presents near the vertebral column, found in sympathetic nervous system only.

5 – Prevertebral ganglion: ganglion that presents apart from the vertebral column near the effectors (usually organs in abdomin), found in sympathetic nervous system only, and they are only three:

- celiac ganglion.
- superior mesenteric ganglion.
- inferior mesenteric ganglion.

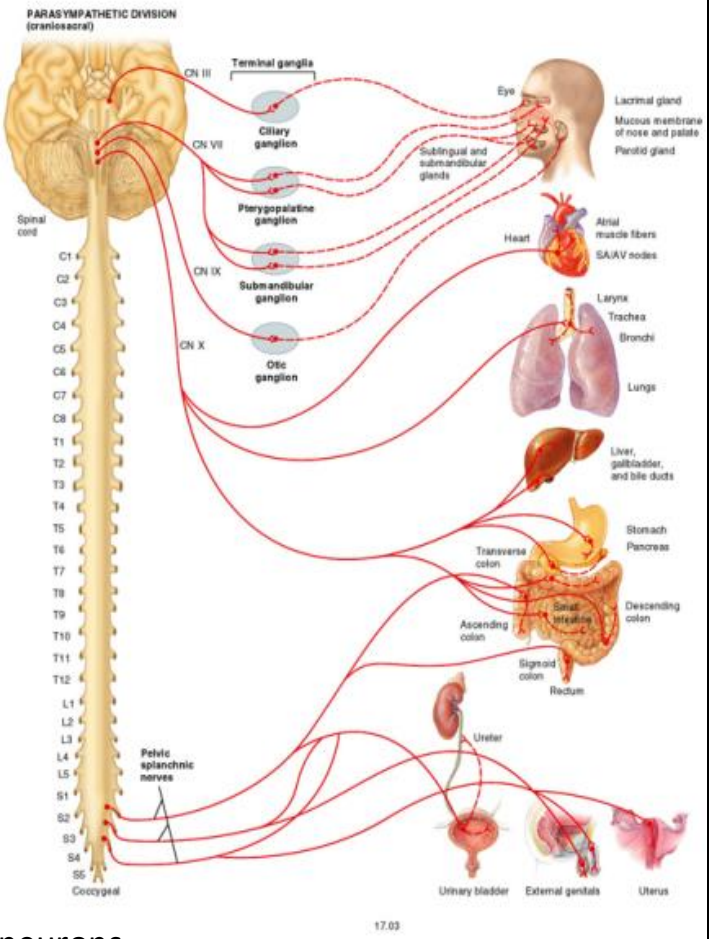
6 – Terminal ganglion: ganglia that are found in the effected organ, only found in parasympathetic nervous system.

NOW LETS START WITH **Anatomical characteristics and Synaptic organization of ANS**

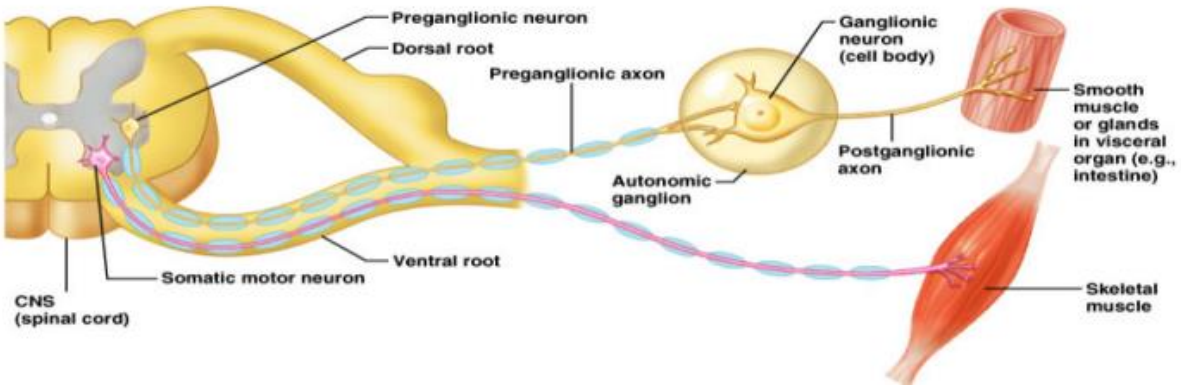
The axon from the origin until the effective structure is composed of two neurons:

1. First neuron: come from the spinal cord and ends in the ganglia.
2. Second neuron: innervates the functional organ of our body, starts from the ganglia until it reaches the organ.

And we have synapses of 1st neuron with 2nd neuron, located at the ganglia



*Ganglia : It is a cluster of the cell bodies of neurons.



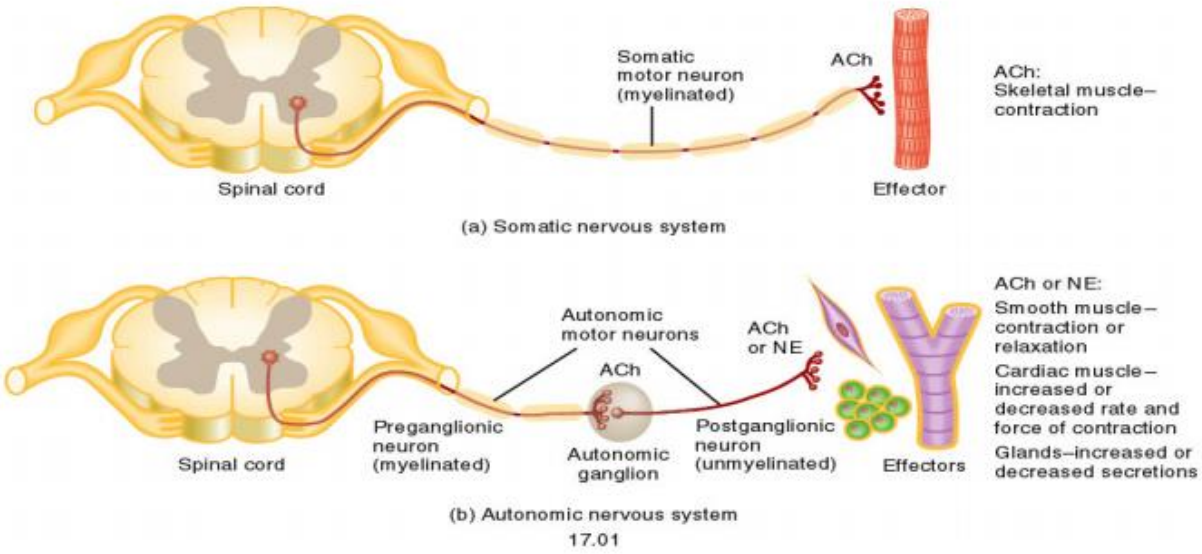
We can see the difference between the somatic neuron and the ANS nuron In the picture above, the somatic is composed of only one fiber, but the autonomic has two fibers, preganglionic and postganglionic.

Parasympathetic (rest and digest) Some difference between SNS and PSNS :

-In SNS, the preganglionic nerve fiber is short and the postganglionic one is long, and this makes the divergence and convergence processes easier.

-In PSNS, the preganglionc nerve fiber is long, and the postganglionic one is short, and this is why we don't have divergence or convergence here.

-remember that the origin is another different between them.



This represent ganglion where we have the synapses between the postganglionic and preganglionic neurons (in autonomic), and the cell bodies of the postganglionic neurons are located in ganglion which is different from the somatic system .

The somatic system is having cell body at the level of spinal cord (like the motor neuron), long axon towards the effector structure, which is skeletal muscles, and the synapse between the terminal of somatic neuron and effected structure (nuoro-muscular junction).

We don’t have ganglion along the somatic nerve system but we have along autonomic.

Convergence and divergence in sympathetic:

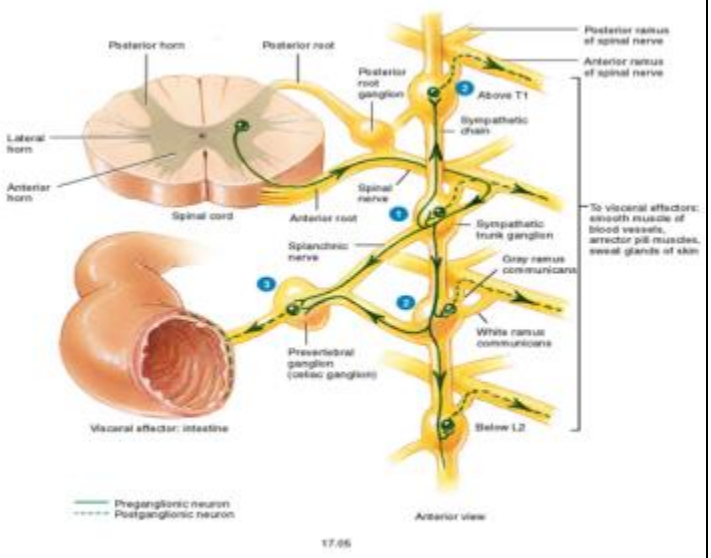
In **convergence**: the cell body of the postganglionic neuron can receive signals from more than one preganglionic neuron.

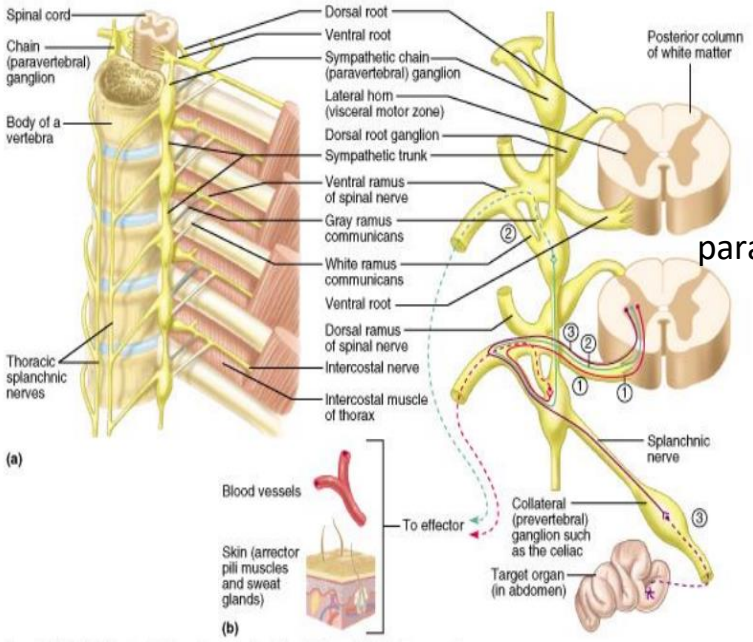
In **divergence** the preganglionic neuron can synapse with more than one postganglionic neuron.

The question is why we want to have one preganglionic synapses with more than one postganglionic, and vice versa?

Because in “fight or flight” reactions the body wants to accelerate the reactions of the targeted effectors, and they give a push to these reactions . In parasympathetic preganglionic and post ganglionic are 1:1 or maximum 2:1 because each change in PANS is localized and specified to a targeted organ, not like SANS.

The axon of the preganglionic neuron does not have only one terminal, it can have many terminals, some of them will synapse with the postgangilionic neurons at the same segmental level, or it may curve downward or upward to synapse with a postganglionic neuron from a lower or hugher segmental level.





This neuron can have some neurons from this significant level so we have a lot of convergence while in parasympathetic you have long axon tour

The responses to parasympathetic stimulation are localized responses while to sympathetic are more generalize responses .

This because of the origination of the fiber , we have more divergence and convergence in the sympathetic system which are depend more diffuse in the responsible stimulation , while for the parasympathetic stimulation you have more drifted responses and related to organ themselves .

Ex. When the food retching to the small intestines, you are getting more activity in the small intestines and reducing the activity in the stomach , so we have limited responsible to parasympathetic system .

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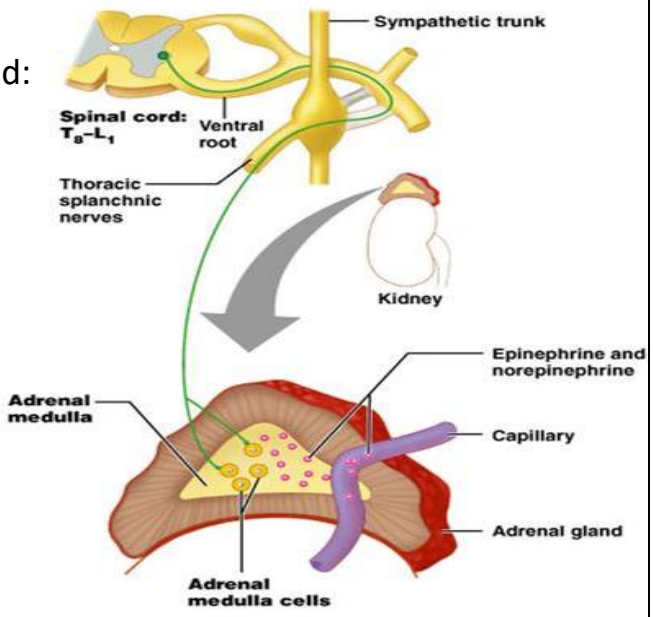
Adrenal medulla=adrenal gland=suprarenal gland:

mainly secretes epinephrine (adrenaline).

And norepinephrine (noradrenaline)

**one neuron passes to the effector

without any synapse(Synapse in gland)**



Effects of sympathetic stimulation :

ONE note before we start : we have some tissue in our body which are widely distributed tissue such as (vessels and sweat glands) .

These widely distributed tissues are need a systemic which can diffuse effect . these structure innervation only by sympathetic system , we don't have parasympathetic control over these function structure .

1. Blood pressure , There are many things involved in regulating blood pressure (vessels , hormones, function of the heart itself and the body fluid) We'll focus on diameter of vessels … Sympathetic is the major in the control of the diameter of vessels by cause of vessels friction which lead to decrease of blood pressure , so the tissue are widely distributed tissue .
2. Body temperature , by the sympathetic effects on cutaneous blood vessels and sweat glands appears as a result of vasodilation and vasoconstriction
   Dilation—losing temperature—sweating (cold sweat)
   Constriction—fixing temperature—no sweating.
3. 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.
4. Effects on heart , by increasing heart rate , causing more powerful contraction (increasing the force of contraction) which lead to more blood distributed to our tissue , more oxidation of these tissues and increasing "cardiac output" : is the amount that can be measured (volume of blood pumped per minute)
5. Respiratory system , causes relaxation of bronchial muscle which result in bronchodilation , getting more oxygen to the smooth muscles ..we needing more air flow .
6. Digestive system , inhibition of motility and secretion, one of the aspect is dry mouth .
7. Metabolic effects , metabolic simply is break down of glycogen to more glucose become available in body fluid , by (SNS) : mobilization of glucose , Increased lipolysis and Increased metabolic rate .

Effects of PANS stimulation:

1.**Gastrointestinal system** , increases motility and secretory activity.

2.**Glands** , increases secretory activity (but remember sweat glands are under sympathetic control).

3. **Heart** , decrease rate of contraction (bradycardia). At conductive tissue ! We have slow depolarization contraction potential by increasing parasympathetic stimulation , the rate of slow depolarization become more slow , so in this case the number of action potential generation per minute will be less in this by the parasympathetic stimulation. While by sympathetic stimulation we have increasing the rate of slow depolarization and we got more frequent generation of action potential.

4.**Pupil** , control pupil diameter by papillary light reflex (miosis) → (regulates the amount of light falling on retina).

5.Accommodation of the **lens** for near vision.

6.Voiding the **urinary bladder** (micturition)