Autonomic nervous system 1

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Autonomic nervous system

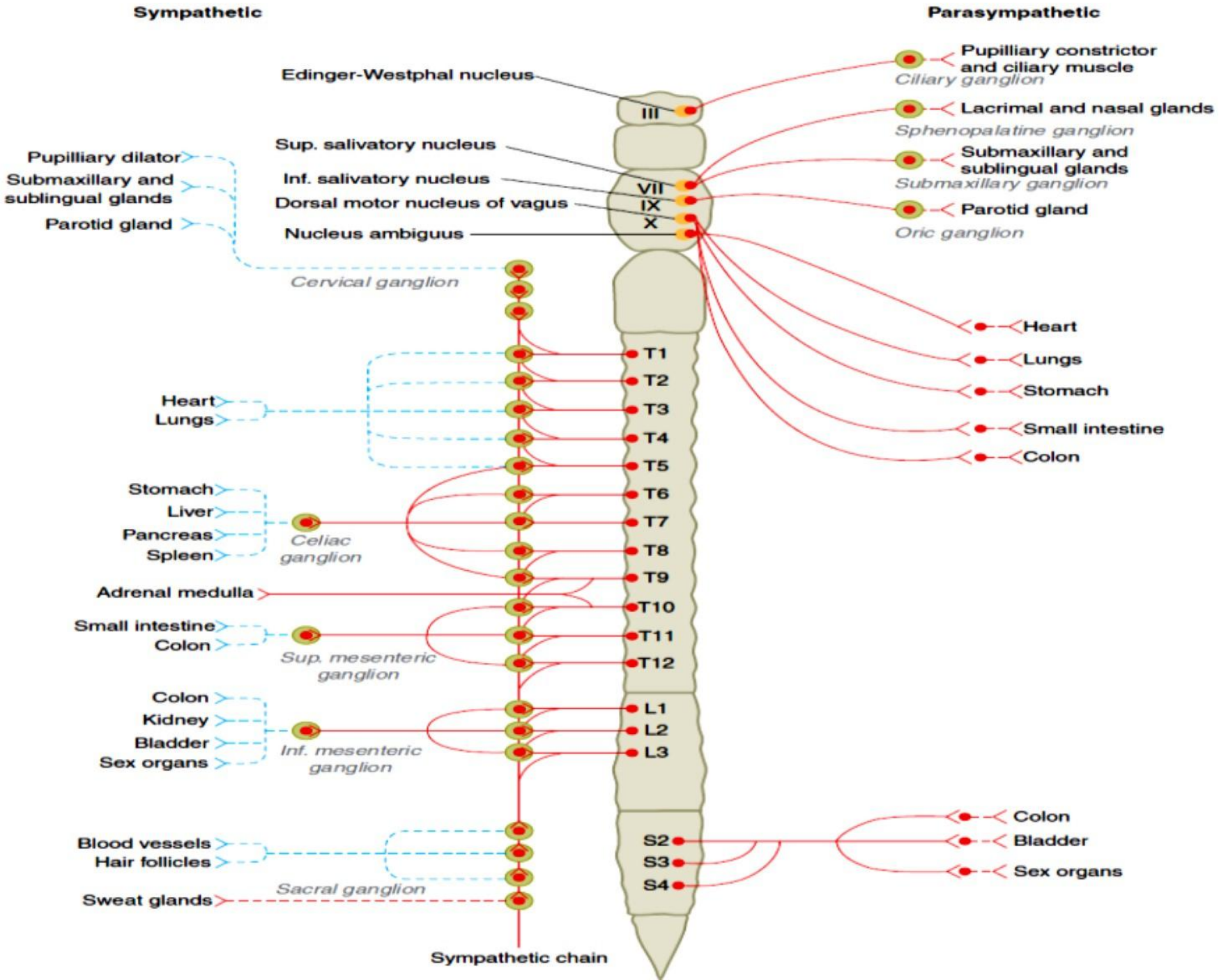
The autonomic nervous system (ANS) is the part of the nervous system that controls the involuntary functions. The ANS has two major and anatomically distinct divisions: the sympathetic and parasympathetic nervous systems.

1- The Sympathetic Nervous System:

It arises from the lateral horn cells (L.H.Cs) of **all thoracic and upper 3 or 4 lumber segments of the spinal cord.** So, it is called the thoraco-lumbar outflow.

2- The Parasympathetic Nervous System:

It arises from the **nuclei of 3^{rd}, 7^{th}, 9^{th} and 10^{th} cranial nerves and from the lateral horn cells of the 2^{nd}, 3^{rd} and 4^{th} sacral segments of the spinal cord.** So, it is called the cranio-sacral outflow.


Sympathetic
Parasympathetic
Edinger-Westphal nucleus
Sup. salivatory nucleus
Inf. salivatory nucleus
Dorsal motor nucleus of vagus
Nucleus ambiguus
III
VII
IX
X
Pupilliary dilator
Submaxillary and sublingual glands
Parotid gland
Cervical ganglion
Pupilliary constrictor and ciliary muscle
Ciliary ganglion
Lacrimal and nasal glands
Sphenopalatine ganglion
Submaxillary and sublingual glands
Submaxillary ganglion
Parotid gland
Oric ganglion
Heart
Lungs
Stomach
Small intestine
Colon
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
S2
S3
S4
Heart
Lungs
Stomach
Liver
Pancreas
Spleen
Celiac ganglion
Adrenal medulla
Small intestine
Colon
Sup. mesenteric ganglion
Colon
Kidney
Bladder
Sex organs
Inf. mesenteric ganglion
Blood vessels
Hair follicles
Sweat glands
Sacral ganglion
Colon
Bladder
Sex organs
Sympathetic chain

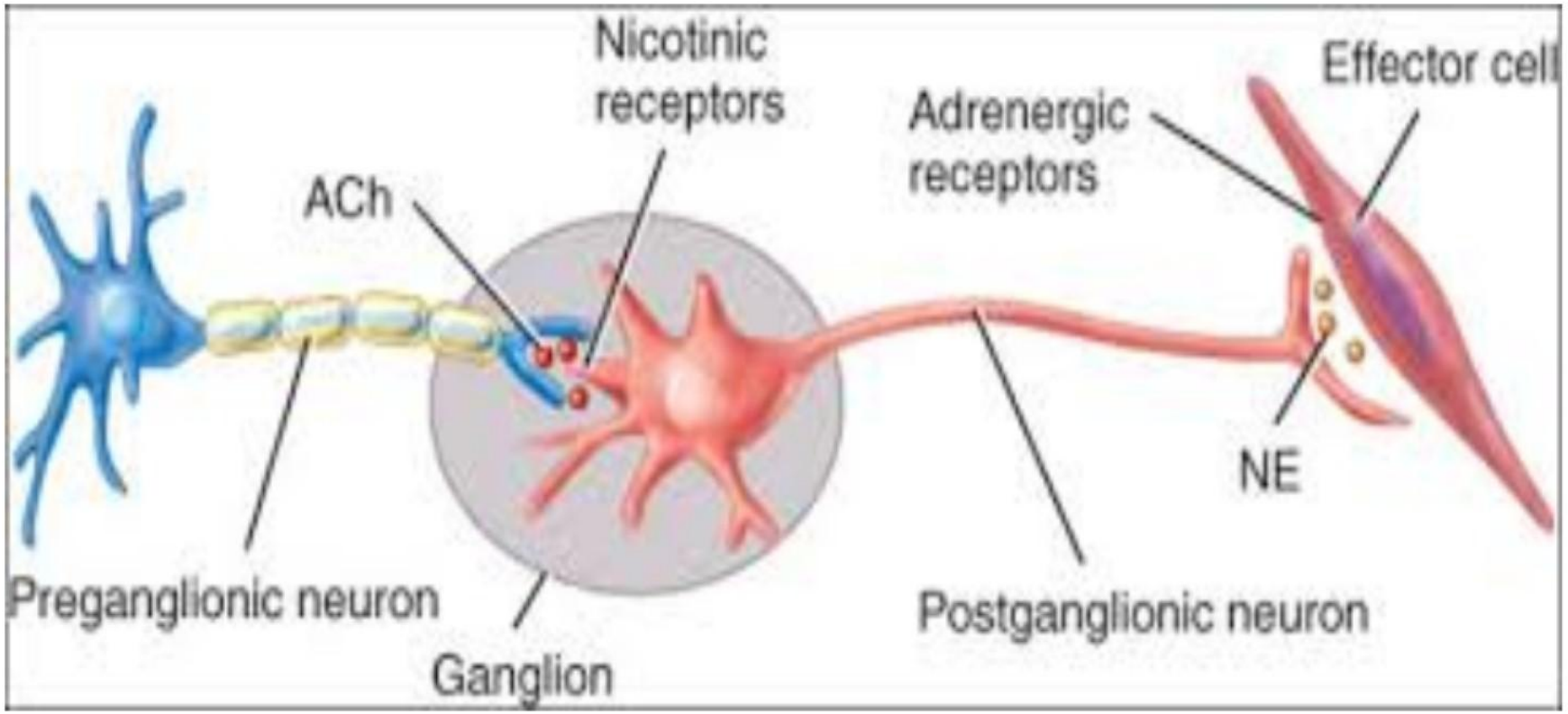
- **Characters of the autonomic nervous system:**

1. Most of organs supplied by the ANS have double autonomic supply; impulses in one nerve produce stimulation, while in the produce inhibition. While in the salivary gland, sympathetic (rich in enzymes) and parasympathetic (large in volume) functions are complementary to each other. Functions of sympathetic and parasympathetic are synergistic (co-operative) during sexual intercourse (Erection by parasympathetic and Ejaculation by sympathetic).
2. The sympathetic nervous system has wider distribution in the body than the parasympathetic nervous system. No parasympathetic fibers supply the skin, skeletal muscle blood vessels, ventricles of the heart, adrenal medulla, spleen and dilator pupillae muscle while sympathetic fibers do.
3. The sympathetic system prepares the body for the process of fight or flight under conditions of stress.

4. Parasympathetic system is anabolic in function (helps digestion, absorption and metabolism of food with energy saving).
5. Sympathetic system is catabolic in function. During muscular exercise for example & stress, blood will be shifted from the less important organs (skin, abdominal and pelvic viscera in which vasoconstriction occurs) to reach the more important organs (heart, brain & muscles). Heart rate (HR), cardiac output (C.O.P)and arterial blood pressure (ABP) increase to produce better perfusion of organs with blood.
6. Any autonomic fiber that arise from the CNS must relay (synapse) inside autonomic ganglion on a second neuron that will transmit the impulse to the effector organ.

- ***Autonomic pathway:***

Preganglionic neuron from the CNS to → autonomic ganglion → postganglionic neuron → effector organ.



AUTONOMIC GANGLIA

They are collection of nerve cells present outside the CNS. Autonomic ganglia are the seat of relay (synapse) of preganglionic fibers over the postganglionic fibers.

- Types:

1. **Lateral or Paravertebral ganglia**: present beside and lateral to the vertebral column. There are pairs of ganglia for each spinal segment, but in the cervical region they are fused to form: superior, middle and inferior cervical ganglia. They are the main site for preganglionic sympathetic neuron relay.
2. **Collateral ganglia**: present at the bifurcation of big arteries from aorta and they carry the name of their corresponding arteries as celiac, superior and inferior mesenteric. They are the main site for preganglionic sympathetic neuron relay.
3. **Terminal ganglia**: situated near (or in the wall) of the effector organs. They are the sites for preganglionic parasympathetic neuron relay only.

Functions of the Autonomic Ganglia:

- **Act as distributing centers** i.e. one preganglionic fiber gives rise to several postganglionic fibers that distribute the autonomic impulses to many organs (this is because autonomic nerves arise from limited origin).

- **Functions of the Sympathetic system:**

I- Sympathetic Supply to Head and Neck (Cervical Division):

A- On the Eye:

- Motor to the dilatory pupillae muscle to produce pupillodiltation (Mydriasis).
- Motor to the eyelid muscles (superior & inferior tarsal muscle) to widening of the palpebral fissure.
- Motor to the Muller's muscle to cause protrusion of the eye ball (Exophthalamus). All these changes increase the field of vision.

B- On Salivary glands:

Trophic secretory fibers to salivary glands (Secretion of concentrated small viscous saliva rich in enzyme).

C- On Skin of the head & neck:

- Vasoconstriction (VC) of all blood vessels of head and neck including cerebral blood vessels, however, cerebral blood flow increases secondary to increased arterial blood pressure.
- Secretory fibers to sweat glands to increase sweat secretion.
- Hair erection due to contraction of erector pillae muscles.

- **Horner's Syndrome**:

This syndrome is due to cutting of the sympathetic supply to head and neck or damage of the superior cervical sympathetic ganglion on one side of the face (unilateral) and it leads to:

1. Miosis: constriction of the pupil (opposite of Mydriasis).
2. Ptosis: drooping of the upper eye lid.
3. Enophthalmos: inward displacement of the eye.
4. Redness or flushing of the face due to persistent vasodilatation.
5. Anhydrosis: dryness of the face due to absence of sweat secretion.

II- Sympathetic Supply to the Thorax:

1- Heart:

- Stimulation of all cardiac properties (↑ H.R, ↑ C.O.P & ↑A.B.P).
- V.D (vasodilatation) of the coronary vessels (direct effect is V.C (vasoconstriction) but coronary vessels dilated due to increased metabolism of the heart).

2- Lungs: - Bronchodiltation due to relaxation of the bronchi muscles.

- V.C of the pulmonary vessels to allow lungs to expand.

III- Sympathetic Supply to Abdomen (Greater Splanchnic Nerve):

- V.C of blood vessels of stomach, small intestine and kidney (predominate).
- V.D of hepatic blood vessels.
- Increase the hepatic glycogenolysis to increase the blood glucose which is used as fuel for heart, brain and muscles.
- Contraction of the spleen capsule to squeeze out blood (add 400 ml), which is rich in red blood cells to the general circulation → ↑ O_2 carriage.
- Secretory fibers to the suprarenal medulla (modified sympathetic ganglia). It secretes 80% adrenaline and 20% noradrenaline which circulate in blood and produce generalized sympathetic action all over the body.
- Relaxation of the wall of the GIT till the transverse colon with contraction of its sphincters.

IV- Sympathetic Supply to Pelvis (Lesser Splanchnic Nerve):

- **V.C of the pelvic viscera** including erectile tissue of penis and clitoris leading to their shrinkage.
- Inhibition to the urinary bladder wall and motor to the internal urethral sphincter to delay empty → **retention of urine**.
- Inhibition to the rectum wall and motor to the internal anal sphincter to delay empty →**retention of stool**.
- **Ejaculation of semen** due to contraction of the smooth muscles of epididymis, vas deferens, seminal vesicles and prostate.
- Variable effects (inhibitory or excitatory) on the uterus depending on the stage of menstrual cycle and the level of ovarian hormones.

V- Sympathetic Supply to limbs, thoracic and abdominal walls:

- V.C of skin blood vessels.
- Stimulates of sweat secretion.
- Erection of hair.
- V.D of skeletal blood vessels to increase blood supply to skeletal muscle.
- Delays onset of skeletal muscles fatigue (Orbelle's phenomenon).

Functions of the Parasympathetic system:

I- Cranial Parasympathetic Outflow:

1- The Oculomotor (3rd Cranial) Nerve:

- Motor to the constrictor pupillae muscle → **constriction of the pupil (miosis)**.
- Motor to the ciliary muscle leading to relaxation of the suspensory ligament and lens capsule → **↑ lens power (= accommodation reflex)**.

2- The Facial (7th Cranial) Nerve:

- **Secretory and vasodilator fibers** to sublingual and submaxillary salivary glands. It is true secretion i.e. water, large in amount and little in enzymes.
- **Secretory and vasodilator fibers** to nasopharynx and lacrimal gland.
- **Vasodilation of the anterior 2/3 of the tongue.**

3- The Glossopharyngeal (9th Cranial) Nerve Functions:

- **Secretory (true secretion) and vasodilator fibers** of the parotid gland.
- **Vasodilation of the posterior 1/3 of the tongue.**

4- The Vagus (10th Cranial) Nerve:

A-Thorax:

1-Heart: - **Inhibition of all cardiac properties**; decrease heart rate and force of atrial muscles contraction (no supply to ventricles).

- Decrease of coronary blood flow (V.C) and decrease oxygen consumption by the heart.

2-Lungs: - Constriction of bronchi muscles → ↓ air entry.

- Increase mucous secretion.
- Pulmonary vasodilatation.

3- Abdomen:

- Motor to wall of esophagus, stomach, small and large intestine and relaxation of sphincters.
- Motor to wall of the gall bladder and inhibition of the sphincter of oddi→ **Evacuation of gall bladder (increase bile flow).**
- **Increase all G.I.T secretions** (Stomach and liver).
- **V.D** of GIT blood vessels.

II- Sacral Parasympathetic Outflow (=Sacral or Pelvic Nerve):

- Contraction of the wall of the urinary bladder and relaxation of the internal urethral sphincter leading to **micturition.**
- Contraction of the wall of the colon and rectum and relaxation of the internal anal sphincter leading to **defecation.**
- Secretory to the seminal vesicles and prostate.

Vasodilatation of the blood vessels of external genital organ leading to **erection** of penis (male) and clitoris (female).