Overview of autonomic nervous system (function of parasympathetic system)

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The parasympathetic cranial outflow

1-The Oculomotor nerve (3rd cranial nerve)

- Motor to the constrictor pupillae muscle ⇒ miosis.
- Motor to the ciliary muscle ⇒ accommodation for near vision.
- Contraction of ciliary muscle ⇒ relaxation of suspensory ligament ⇒ ↑convexity of the eye lens ⇒ ↑ its dioptric power ⇒ falling the image of near object on retina)

DIFFERENCE BETWEEN SYMPATHETIC AND PARASYMPATHETIC

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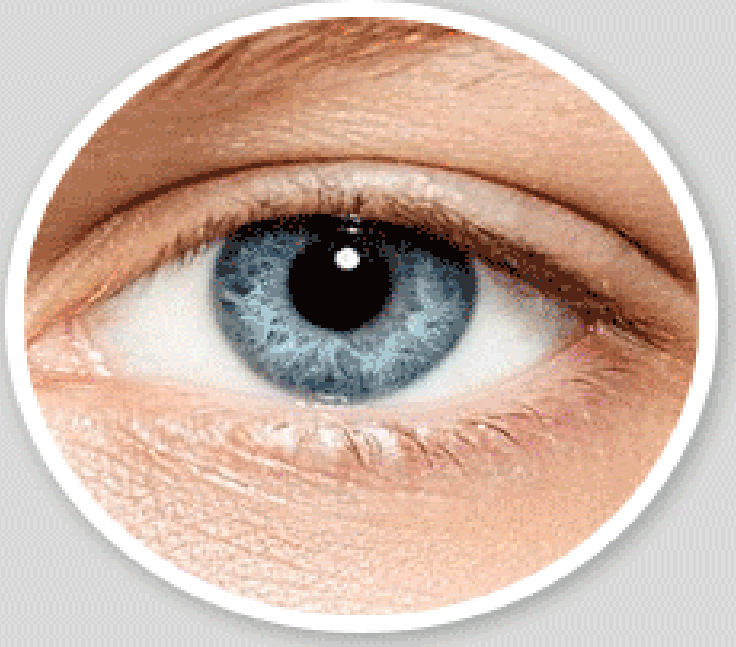
SYMPATHETIC

THE SYMPATHETIC NERVOUS SYSTEM (SNS) IS ONE OF THE TWO MAIN DIVISIONS OF THE AUTONOMIC NERVOUS SYSTEM. THE SYMPATHETIC NERVOUS SYSTEM'S PRIMARY PROCESS IS TO STIMULATE THE BODY'S FIGHT-OR-FLIGHT RESPONSE.



PARASYMPATHETIC

THE PARASYMPATHETIC NERVOUS SYSTEM (PSNS) IS ONE OF THE TWO DIVISIONS OF THE AUTONOMIC NERVOUS SYSTEM. THE PARASYMPATHETIC SYSTEM IS RESPONSIBLE FOR STIMULATION OF "REST-AND-DIGEST" OR "FEED AND BREED" ACTIVITIES.

[II] facial (7^{th} carnial) nerve

Functions:

(I) Chorda tympani:

- Secretory & V.D. to the submandibular & sublingual salivary glands $\Rightarrow$ large amount of watery saliva (profuse secretion).
- V.D. to blood vessels of the anterior 2/3 of tongue.

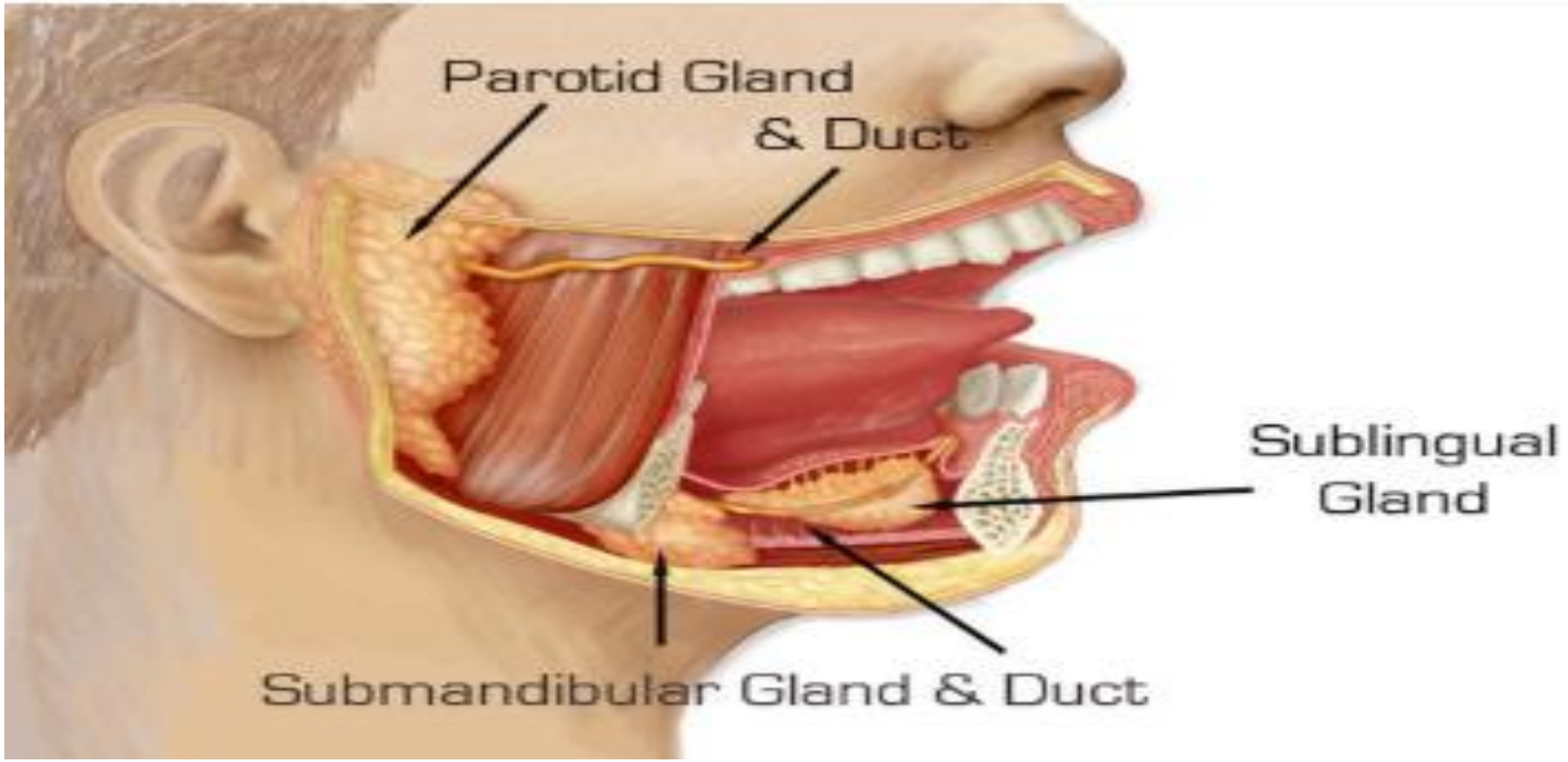
(II) Greater superficial petrosal nerve:

- Secretory & V.D. to Lacrimal glands, soft palate & nasopharynx.

[III] The glossopharyngeal (9th carnial) nerve

Functions:

- Secretory & V.D. to parotid salivary gland.
- V.D. to blood vessels of the posterior 1/3 of the tongue.



[IV] The vagus (10th carnial) nerve

Functions:

(1) Heart: acts only on atria

- Inhibition all cardiac properties; ↓ contractility, ↓ excitability, ↓ rhythmicity, ↓ conductivity.
- V.C. of coronary B.Vs due to ↓ O_2 consumption of heart and ↓ cardiac metabolism → ↓metabolites → ↓ coronary blood flow. .

(2) Lungs:

- Bronchoconstriction → ↓ air entry.
- V.D. of pulmonary B.Vs.
- ↑ mucus secretion.

(3) G.I.T.:

- Motor to smooth muscles in wall of esophagus, stomach, small intestine & proximal large intestine but inhibitory to their sphincters ⇒ ↑ evacuation of food from G.I.T and so accelerates empty of GIT.

Secretory to glands of stomach, intestine, pancreas, liver and Brunner's glands of the duodenum ⇒ ↑ their secretions.

- Vasodilatation of GIT BVs.

(4) Gall bladder (G.B.):

- Motor to G.B. wall & inhibitory to sphincter of oddi ⇒ evacuation of G.B and so ↑ bile flow .

[V] The sacral autonomic = pelvic nerve

Functions:

(1) Defecation:

- Contraction of smooth muscle of the wall of the distal part of large intestine & rectum & relaxation of internal anal sphincter.

(2) Micturition:

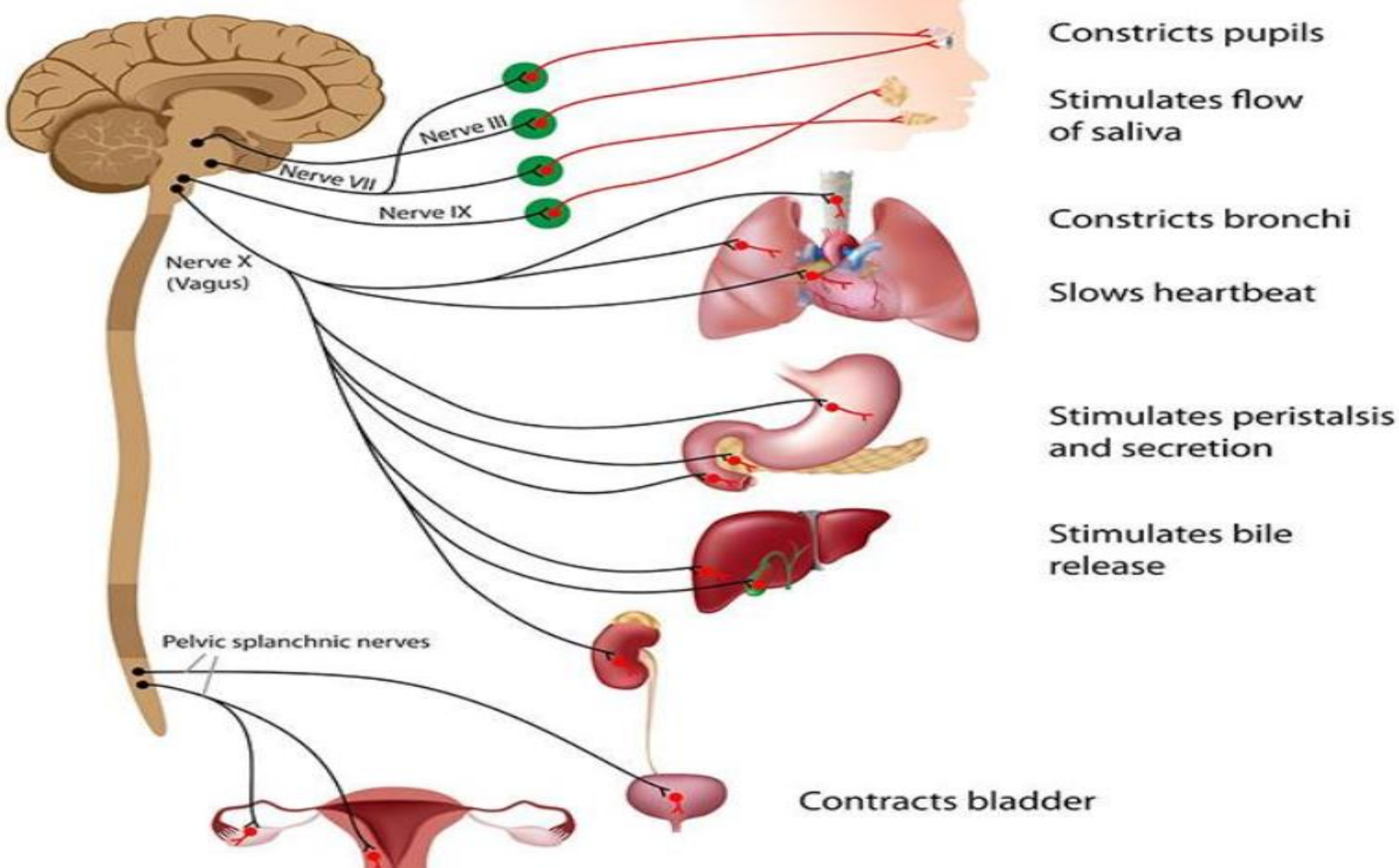
- Contraction of smooth muscle of the wall of the urinary bladder & relaxation of internal urethral sphincter.

(3) Erection:

- V.D. of the blood vessels of the pelvic viscera & the external genitalia ⇒ erection of penis & clitoris.

(4) Secretion:

- Of seminal vesicles & prostate.


Nerve III
Nerve VII
Nerve IX
Nerve X
(Vagus)
Pelvic splanchnic nerves
Constricts pupils
Stimulates flow of saliva
Constricts bronchi
Slows heartbeat
Stimulates peristalsis and secretion
Stimulates bile release
Contracts bladder

Mode of autonomic action

1- <u>Reciprocal action</u>:

- When one system is stimulated ⇒ the other system is inhibited.

2- <u>Antagonistic action</u>:

- Both systems are usually antagonistic in function.
- Symp. stimulation ⇒ pupillary dilatation (Mydriasis).
- Parasympathetic stimulation ⇒ pupillary constriction (Miosis).

3- <u>Complementary action</u>:

- **<u>Weeping</u>**: lacrimation (parasympathetic) & emotion (sympathetic).
- **<u>During sexual intercourse (coitus):</u>** erection (parasympathetic) while ejaculation (Symp.).

4- Similar action:

- The sympathetic & parasympathetic produce the same action in some organs as in salivary secretion.
- The parasympathetic produce profuse excessive watery salivary secretion poor in enzyme while the sympathetic produce salivary secretion of small amount and rich in enzymes.

5- Single innervation:

a) Structures supplied by Sympathetic only:

- Blood vessels of skeletal muscle & skin.
- Muscle of ventricles of heart.
- Dilator pupillae muscle.
- Erector pillae muscle of the hair.
- Sweat glands.
- Suprarenal medulla.

b) structures supplied by Parasympathetic only:

- Sphincter (constrictor) pupillae muscle.
- Ciliary muscle.

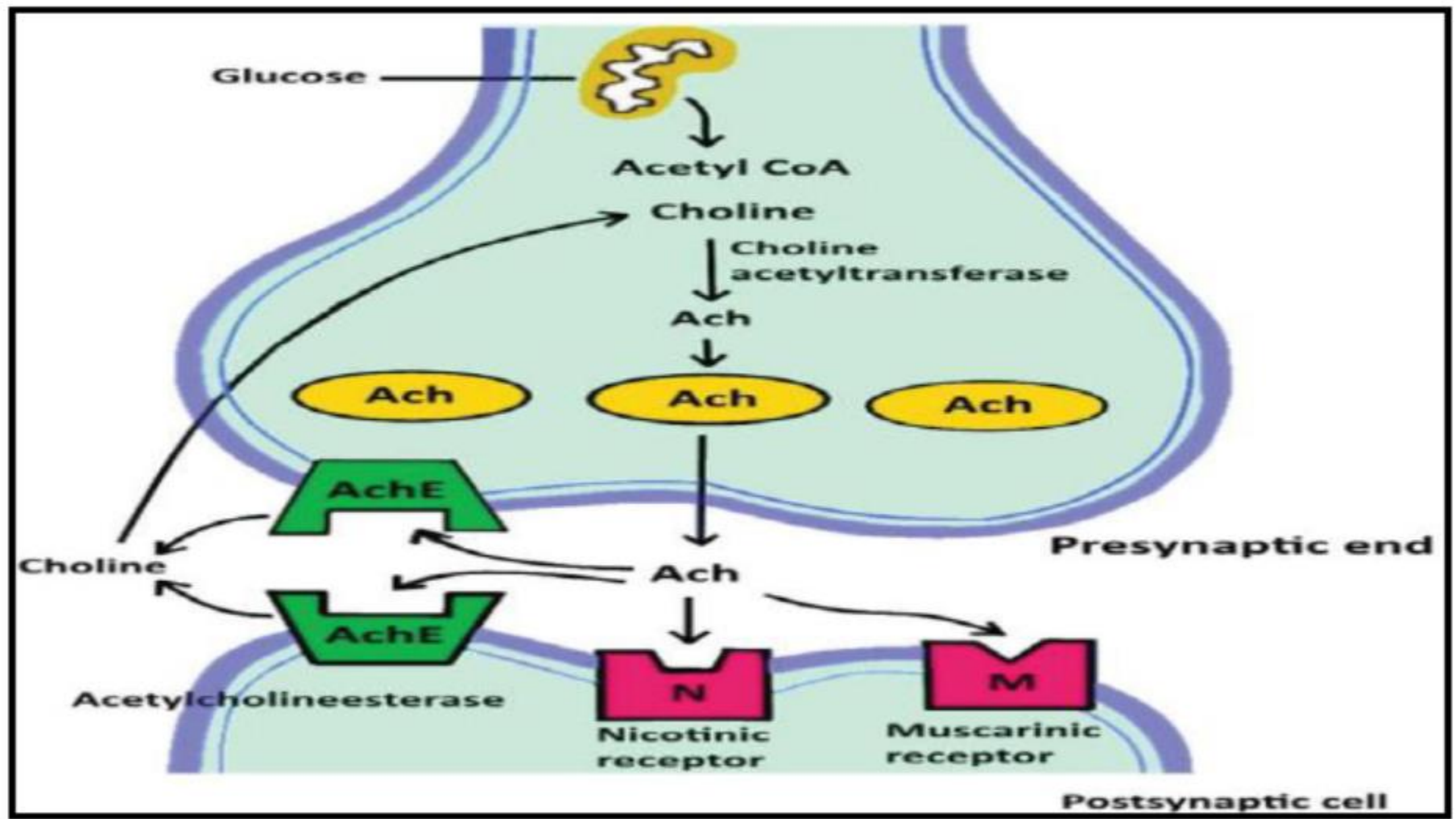
Chemical transmission

Mechanism of chemical transmitter secretion:

- When the nerve impulse spreads along the nerve fiber ⇒ the activity is transmitted from the nerve ending to the cell of another nerve fiber (neuro-neuronal junction) or to cell of effector organ (neuro-effector junction).
- This transmission of nerve impulse is done by a chemical substance = (chemical transmitter) released from vesicles at the nerve endings as a result of arrival of the nerve impulse to the nerve endings
- This chemical substance combines with specific receptors present on the effector cell or nerve cell to stimulate it & produce its action.
- The chemical transmitters in the A.N.S. are:
  - Acetyl choline (A.Ch.) ⇒ Which is the parasympathetic transmitter.
  - Noradrenaline (N.A.) ⇒ Which is the sympathetic transmitter.

Acetyl choline

- **Biosynthesis:** It is synthesized in the cytoplasm of cholinergic neurons by conjugation of active acetate with choline by the enzyme **choline acetyl transferase.**
- **Storage:** Acetylcholine is then stored inside **clear vesicles** in the nerve terminals until released by a nerve impulse.
- **Release:** The nerve impulse →↑Calcium entry into cholinergic nerve terminals→ rupture of vesicles→ exocytosis.


Glucose
Acetyl CoA
Choline
Choline acetyltransferase
Ach
Ach
Ach
Ach
AchE
Choline
Ach
AchE
Acetylcholineesterase
N
Nicotinic receptor
M
Muscarinic receptor
Presynaptic end
Postsynaptic cell

Sites of formation of A.Ch.:

- At all preganglionic nerve endings whether sympathetic or parasympathetic (all autonomic ganglia).
- At all parasympathetic postganglionic nerve endings.
- At the sympathetic postganglionic nerve endings in sweat glands & skeletal muscle blood vessels = sympathetic cholinergic fibers.
- At the sympathetic preganglionic nerve endings in the adrenal medulla.
- At the motor end plate of skeletal muscle.
- At certain places in C.N.S.

Cholinergic receptor

- **<u>Definition</u>:** These are receptors respond to acetyl choline.
- **<u>Types</u>:**

1) <u>Central cholinergic receptors</u>: (Nicotinic receptors)

a-Autonomic ganglia. (N_N)

b-Suprarenal medulla.(N_N)

c-Motor end plate.(NM)

- **Mechanism of stimulation:** Opens ligand gated Na^+ channels →↑ Na^+ entry → depolarization → nerve impulse → effects.

2) <u>Peripheral cholinergic receptors</u>: (muscarinic receptors)

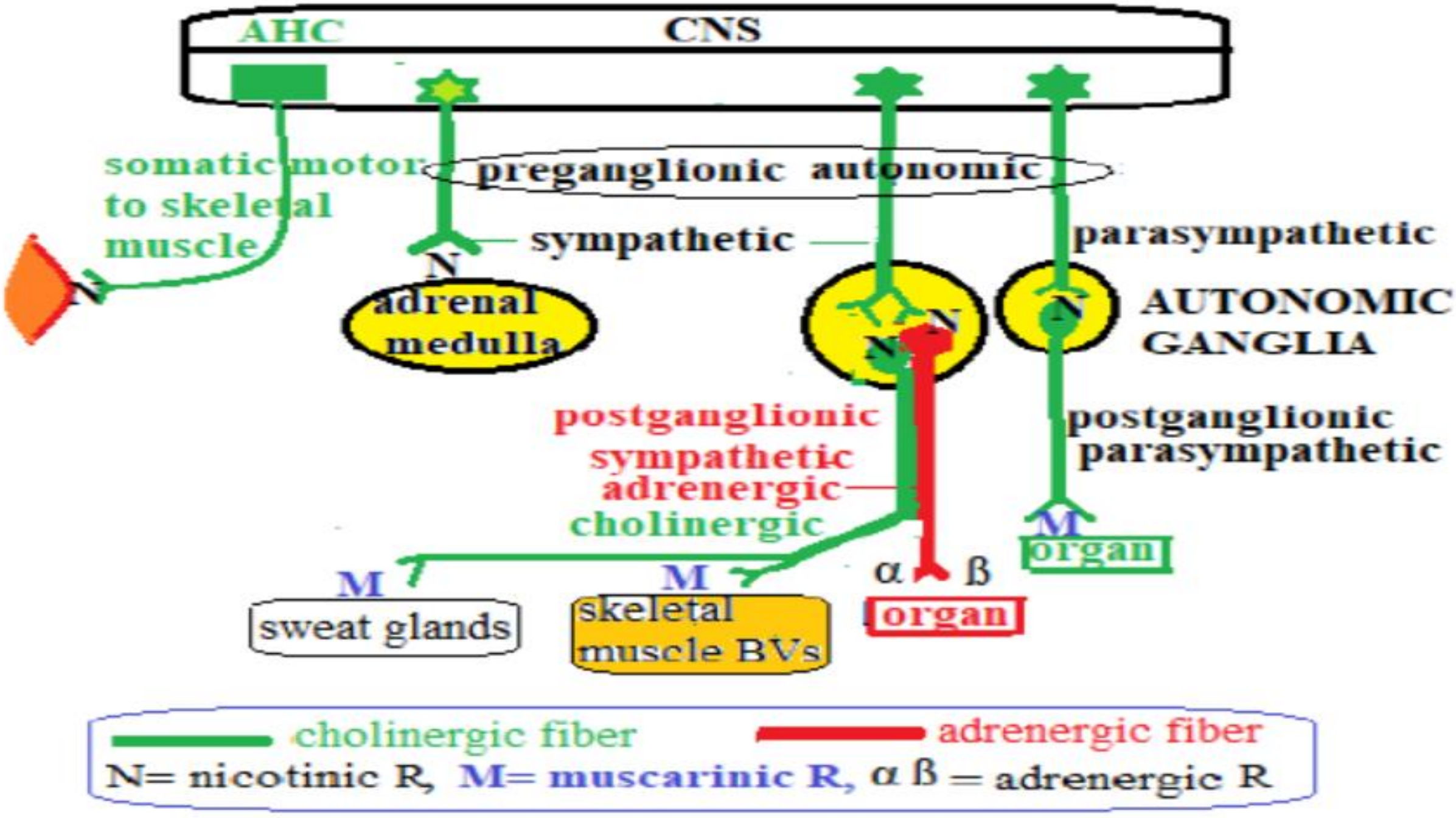
a- Organs receiving **All postganglionic parasympathetic fibers**.

b-Organs receiving exceptional **postganglionic cholinergic sympathetic fibers:** - sweat glands and skeletal muscle blood vessels

N.B.: <u>There are 3 subtypes of muscarinic receptors</u>:

- M1 ⇒ present in brain & gastric parietal cells.
- M_2 ⇒ present in heart.
- M_3 ⇒ present in smooth muscle & glands.

- **Mechanism of stimulation:** Change activity of membrane enzymes→↑or↓ cAMP or ↑or↓ cellular Ca^{2+}


AHC
CNS
somatic motor
to skeletal
muscle
N
preganglionic autonomic
sympathetic
parasympathetic
N
adrenal
medulla
N
N
N
AUTONOMIC
GANGLIA
postganglionic
sympathetic
adrenergic
cholinergic
postganglionic
parasympathetic
M
organ
M
M
α
ß
sweat glands
skeletal
muscle BVs
organ
cholinergic fiber
adrenergic fiber
N= nicotinic R, M= muscarinic R, α ß = adrenergic R

Destruction (inactivation) of A.Ch.:

- The secreted A.Ch. is hydrolyzed rapidly by an enzyme called **cholinesterase (Ch.E.) into** Choline + acetic acid.

- **Types of cholinesterase:**

True cholinesterase:

- Present in:

a) cholinergic nerve endings.

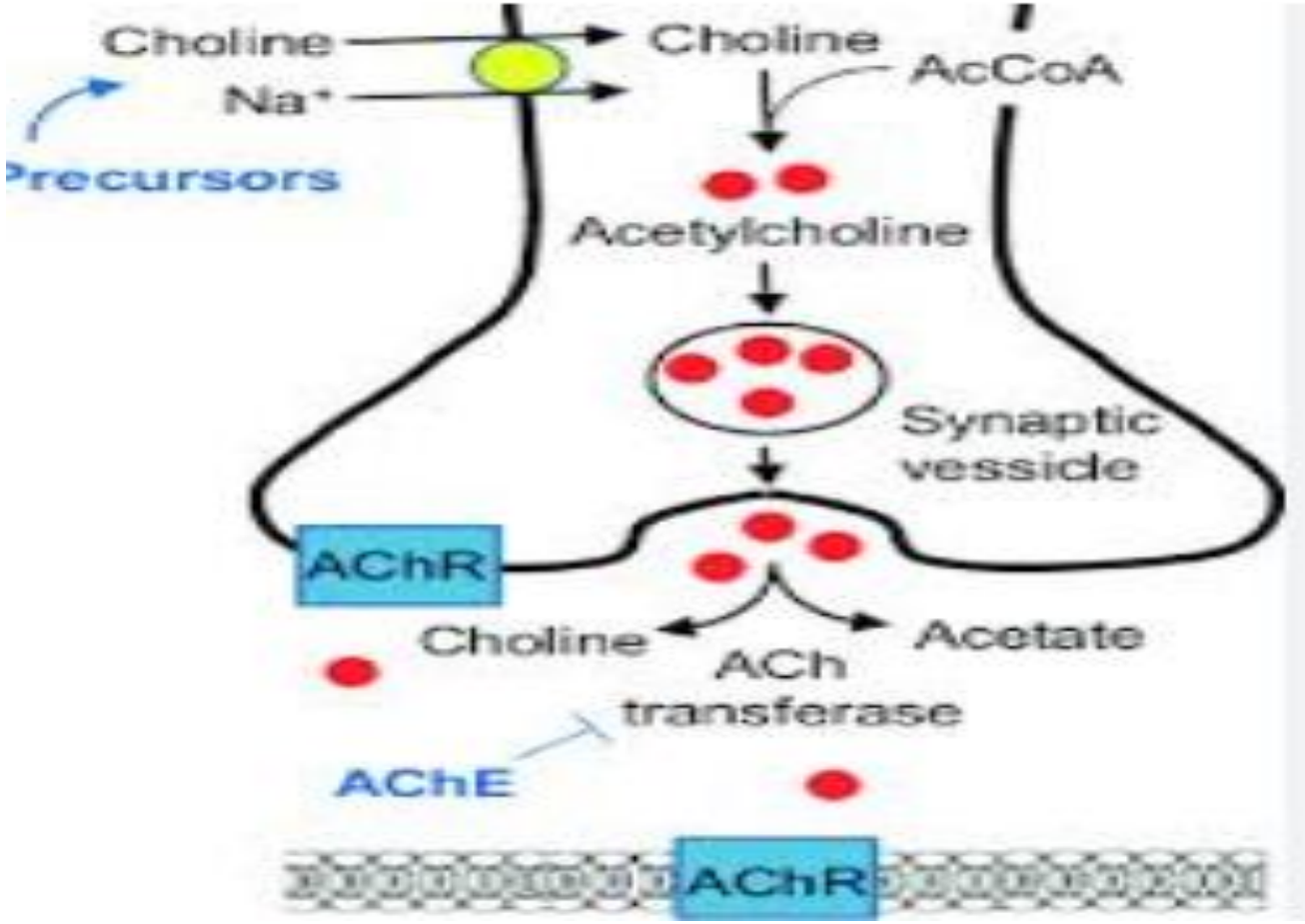
b) R.B.Cs.

Pseudo cholinesterase:

- Present in:

a) Liver.

b) Plasma.



- **<u>Value of cholinesterase</u>:**

- Is to keep the action of A.Ch. localized in the place of liberation, otherwise it may accumulate & pass to blood & produce generalized parasympathetic effects which produce undesirable effects as excessive salivation, erection & micturition and also dangerous effects due to bradycardia & hypotension.

Catecholamines

➢**These are**

Adrenaline (Epinephrine).

Noradrenaline (Norepinephrine).

➢***Storage and Release:***

• Noradrenaline or adrenaline are then stored inside **granular vesicles** in the nerve terminals of adrenergic neurons or cells of adrenal medulla till released by a nerve impulse.

• The nerve impulse →↑Ca^{2+}entry into adrenergic nerve terminals → rupture of vesicles→ exocytosis.

➢**Sites of release of catecholamines:**

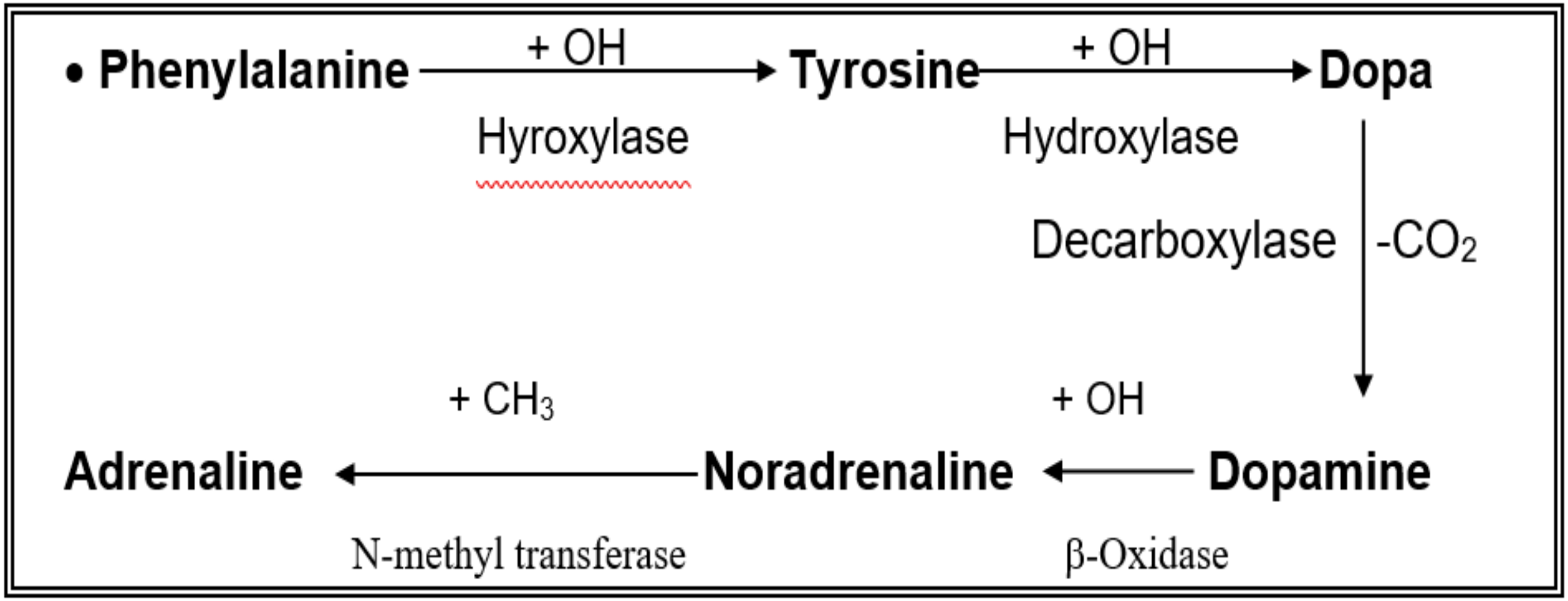
* Most postganglionic sympathetic nerve fibers (only **Noradrenaline**).

*The suprarenal medulla.

* Adrenergic fibers in the CNS secrete catecholamines.

- **Biosynthesis of adrenaline and noradrenaline**

Postganglionic sympathetic adrenergic fibers lack N- methyl transferase (NMT) so, cannot synthetize adrenaline and **secrete noradrenaline only.**



- **Fate or inactivation of adrenaline & Noradrenaline:**

- After secretion of norepinephrine by the terminal nerve endings, it is removed from the secretory site in three ways:

(1) **Reuptake** into the adrenergic nerve endings themselves by an active transport process— accounting for removal of 50 to 80% of the secreted norepinephrine.

(2) **Diffusion** away from the nerve endings into the surrounding body fluids and then into the blood—accounting for removal of most of the remaining norepinephrine.

(3) **Destruction** of small amounts by tissue enzymes

a. **Oxidation by Monoamine oxidase (MAO)** present in the brain, adrenergic nerves, liver, and kidney → Vanillyl mandelic acid (VMA) excreted in urine.

b- Inactivation by the enzyme **catecholamine Orth methyl transferase (COMT) in the liver**, and kidney → metanephrine and normetanephrine (inactive) → excreted in urine.

Adrenergic receptor

Definition: These are receptors present on the effector cells facing all postganglionic sympathetic fibers (except those of sweat glands).

- **Types & actions:**

[I] α-receptors

1- α_1-receptors:

- postsynaptic excitatory receptors wall of blood vessels, dilator pupillae muscles, spleen, sphincters of GIT and urinary bladder.

Mechanism of action: Change activity of membrane enzymes→ α1: ↑ intracellular Ca^{2+}

- **Actions:**

  V.C. of skin & mucous membrane blood vessels.
  Contraction of dilator pupillae muscles.
  Contraction of spleen.
  Contraction of sphincters of GIT & urinary bladder (U.B).

II- α_2-receptors:

a- Inhibitory presynaptic receptors:

- **Action**: ↓ release of N.A.

- Mechanism of action: α2: inhibit adenyl cyclase → ↓ cAMP.

β-receptors

- **β_1-receptors:** increases adenyl cyclase activity→ ↑ cAMP.
    - Postsynaptic excitatory receptors in heart and juxtaglomerular cell of kidney.
    - **Actions**: ↑ cardiac properties and ↑ renin release from kidney.

β_2-receptors: decreases adenyl cyclase activity→ ↓ cAMP

- Postsynaptic inhibitory receptors

1. Smooth muscles of bronchi,
2. Smooth muscles of blood vessels,
3. Smooth muscles in the wall of GIT and urinary bladder.

- **Actions**:

    Bronchodilatation.

    V.D. of blood vessels.

    Glycogenolysis.

    Relaxation of wall of GIT & U.B.

β_3-receptors:

- Present in adipose tissue ⇒ lipolysis(Increases fat breakdown).

Thank You

Feeling gratitude and not expressing it is like wrapping a present and not giving it.