Autonomic Nervous System

Introduction

2020

Modified by Dima Rafaiah

The nervous system is divided into:

1- CNS; the brain and spinal cord

2- The peripheral nervous system

Afferent neurons

Somatic neurons
Autonomic neurons
] efferent neurons

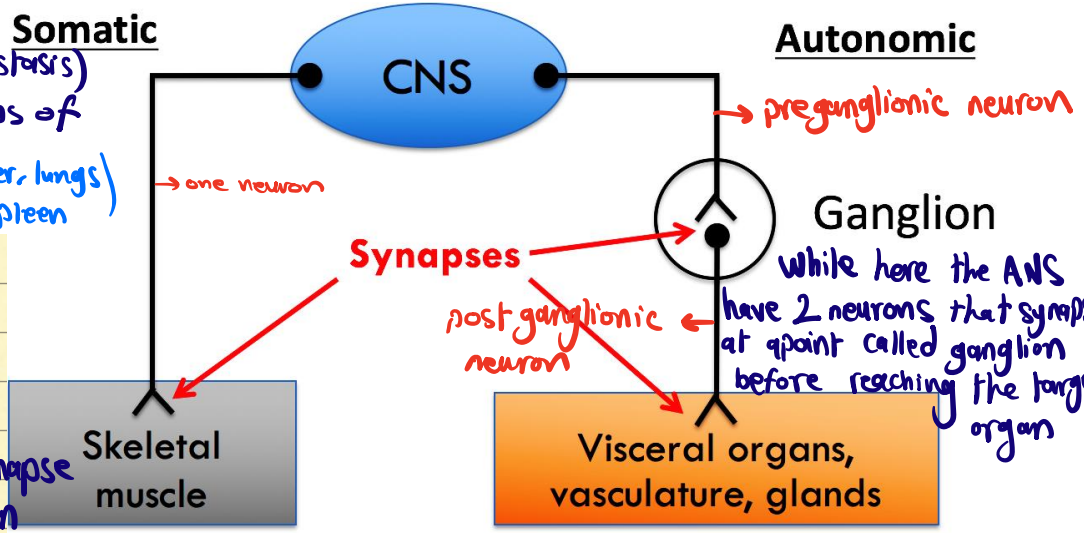
The motor (efferent) portion of CNS can be divided into: **Autonomic** and **Somatic**.

(innervates skeletal muscles)

we can't change the functions of ANS by conscious thoughts.

The **autonomic nervous system (ANS)** is largely independent (autonomous), its activities are not under direct conscious control.

↳ It maintains consistancy of the internal environment (homeostasis)
So it controls the vital functions of the body (vital organs: heart, liver, lungs, kidneys, spleen)



The main difference between Somatic and ANS is that the Somatic neurons carries info from CNS directly to skeletal muscles without any synapse before reaching the target organ

The Autonomic nervous system has 3 subdivisions:

1. The sympathetic nervous system
2. The parasympathetic nervous system
3. The enteric nervous system. controls the activity of GI tract

The **enteric nervous system** (ENS) is one of the main divisions of the autonomic **nervous system** (ANS) and consists of a mesh-like **system** of neurons that governs the function of the gastrointestinal tract.

Many transmitter & neuromodulator substances have been identified in the ENS. (contains so many neurons that it's called the second brain)

It is modulated by the sympathetic (inhibits ENS) & parasympathetic (stimulates ENS) systems That's why it's considered a path of the ANS, though it can control its function by it self.

ANS Neurons

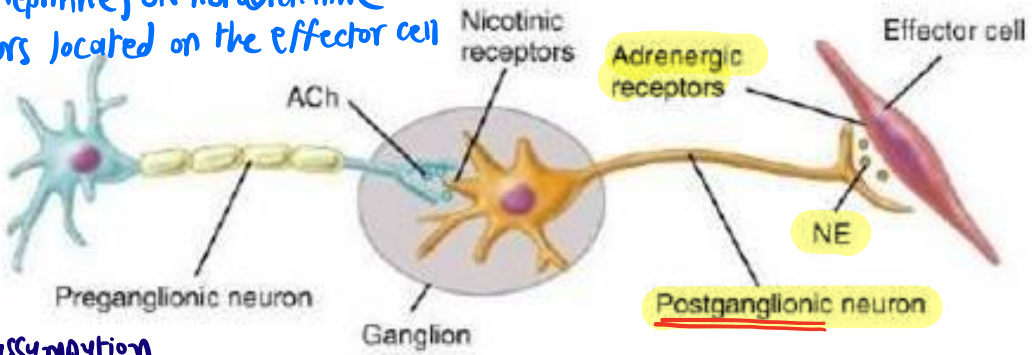
- Classified as either cholinergic or adrenergic neurons based upon the neurotransmitter released

Ach Epi, NE

→ Releases either adrenaline (epinephrine) OR noradrenaline that binds to adrenergic receptors located on the effector cell

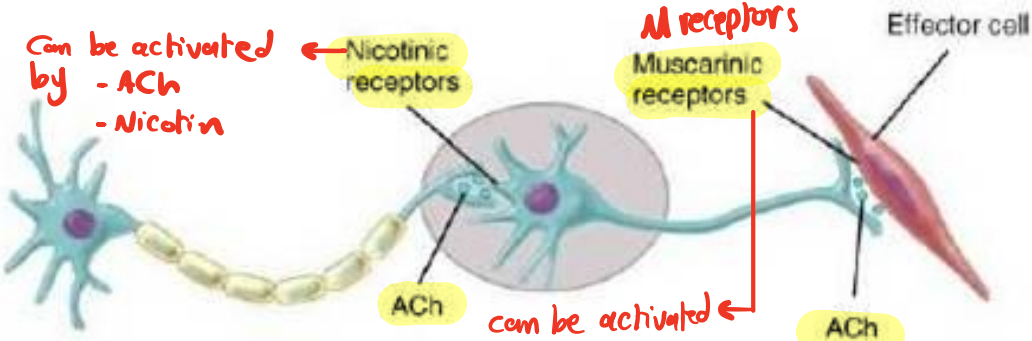
Adrenergic

it was thought that "adrenaline" was the only transmitter released from that nerve, that's why it's called adrenergic though they realized their assumption wasn't quite right later.

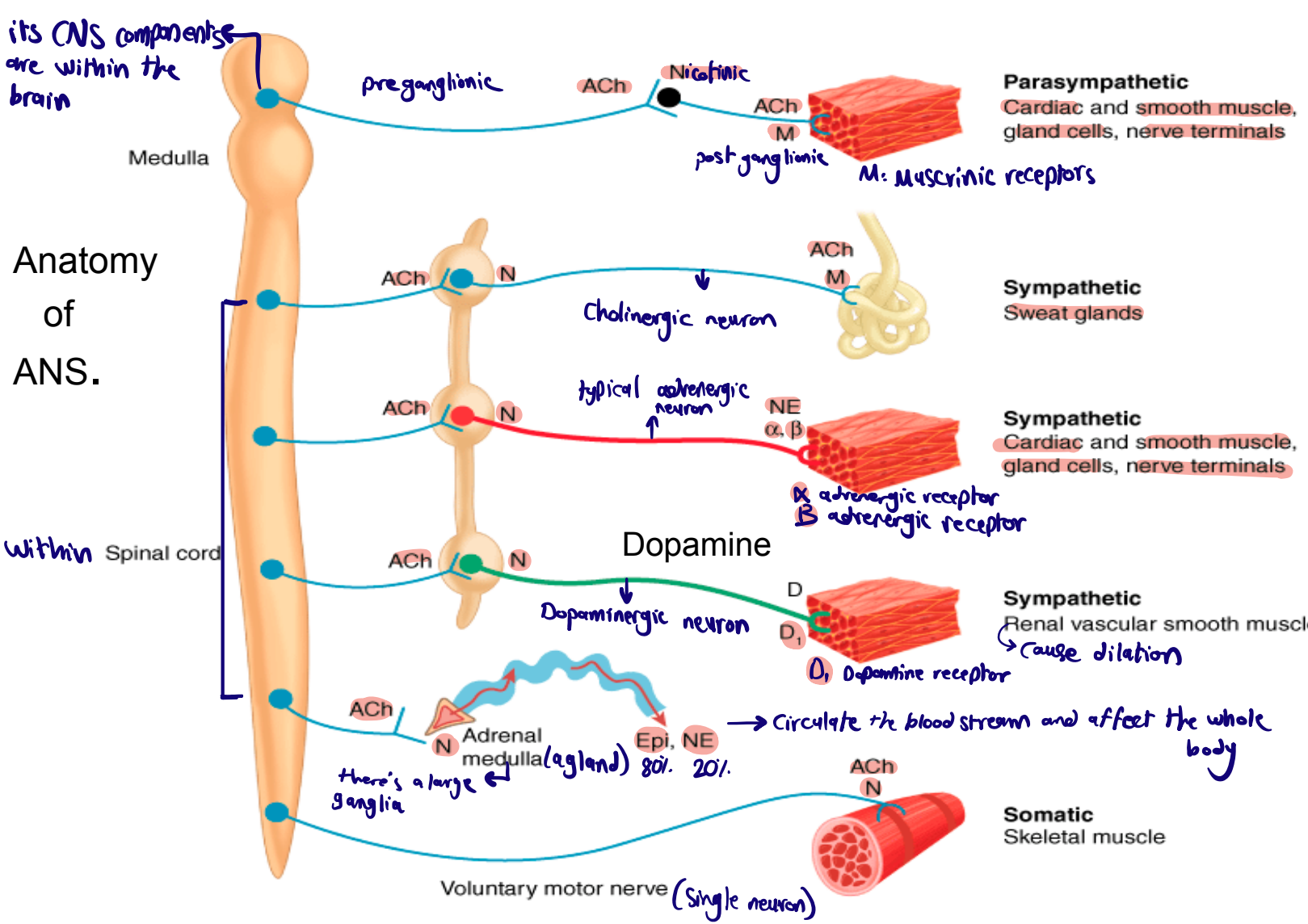


Cholinergic

→ Releases Acetylcholine that binds either to Nicotinic Receptors or Muscarinic receptors depending on the site of release.



Anatomy of ANS.



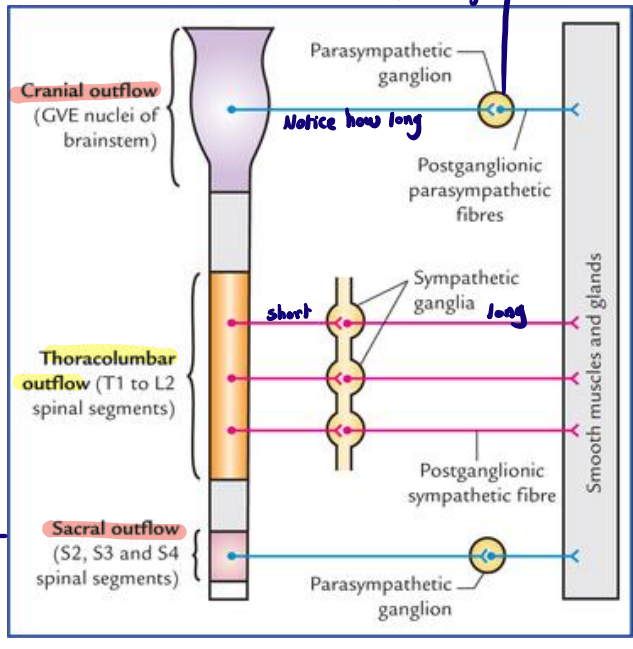
originates from 2 different regions in the body < Cranial (Brain) Spinal

Parasympathetic cell bodies in brainstem & sacral spinal cord: ***craniosacral outflow.***

The preganglionic neuron stimulates only one post- So the ratio is pre 1 : 1 post

Parasympathetic : postganglionic neurons are short (ganglia located near effectors) stimulation involves only one visceral effector (organ)

Sometimes the ganglia is located inside the organ



Sympathetic cell bodies located T1-L2 levels: ***thoracolumbar outflow.*** (originates only from the spinal cord)

One sympathetic preganglionic neuron may have many branches and may synapse with 20+ postganglionic neurons. So the ratio is not necessarily 1:1

Rest and digest parasympathetic system dominates unless there is an emergency situation

Projection of divergence explains why sympathetic responses can affect many effectors at once

"fight or flight"

Consistent with the diverse function of sympathetic system.

- Some of the sympathetic system effects

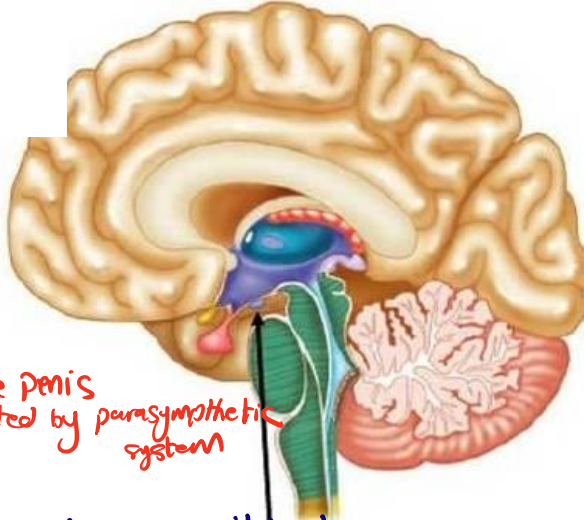
it's mainly stimulated in the fight or flight situations, activation of this system will result in releasing neurotransmitters like EPi that is capable of:

- increase heart rate (palpitation of the heart)
  - Allowing for increased cardiac output to supply the body with oxygenated blood
- Increase blood pressure
- increase blood sugar conc. (glucogenesis)
- increase blood fatty acid conc. (lipolysis)
  - At such situations, the body needs energy obtained from these molecules
- increase blood flow for the heart, brain, skeletal muscles, lungs
  - to redirect oxygen-rich blood to areas of the body needed during intense physical demand
- decrease blood flow for the gastrointestinal tract
- increase bronchial passages (bronchodilation) ⇒ More airflow through lungs
- pupil dilation
- activate goose bumps
- Increase sweating

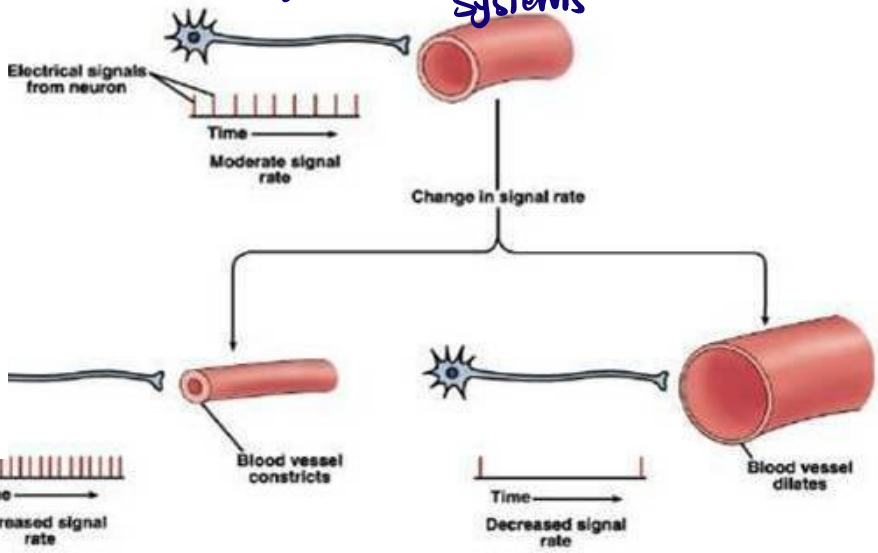
Physiological Effects of the ANS

- Some organs have only sympathetic innervation
  - sweat glands, adrenal medulla, arrector pili mm & many blood vessels → exceptions: blood vessels of the penis they are also stimulated by parasympathetic system
  - controlled by regulation of the "tone" of the sympathetic system ⇒ Hypothalamus is responsible of increasing or decreasing this tone.
- Most body organs receive dual innervation
  - innervation by both sympathetic & parasympathetic
- Hypothalamus regulates balance (tone) between sympathetic and parasympathetic activity levels (ex) high tone → vasoconstriction
  low tone → vasodilation

– the effects of the two systems are usually antagonistic



Controls both of Sympathetic and para systems ← Hypothalamus



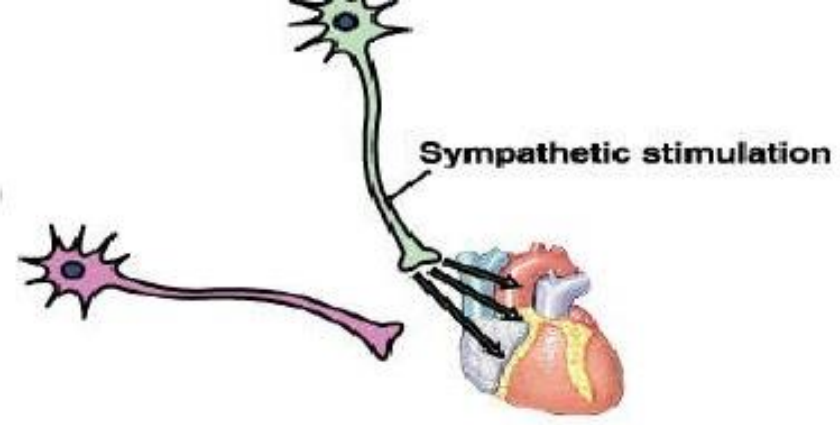
– Parasympathetic
  - S(alivation) L(acrimation) U(rination) D(efecation)
  - metabolic "business as usual"
  - rest and digest - basic survival functions
– Sympathetic
  - fight or flight = "survival"
  - any increase in skeletal muscular activity

for these activities - increase heart rate, blood flow, breathing

decrease non-survival activities - food digestion, etc. GI functions

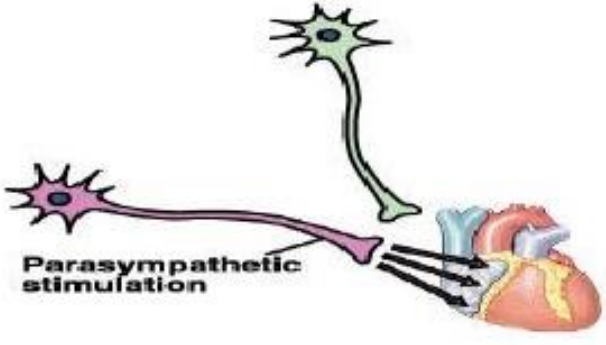
Sympathetic and parasympathetic systems have antagonistic effects

Antagonistic Control



- Most internal organs are innervated by both branches of the ANS which exhibit antagonistic control

Heart rate increases



Heart rate decreases

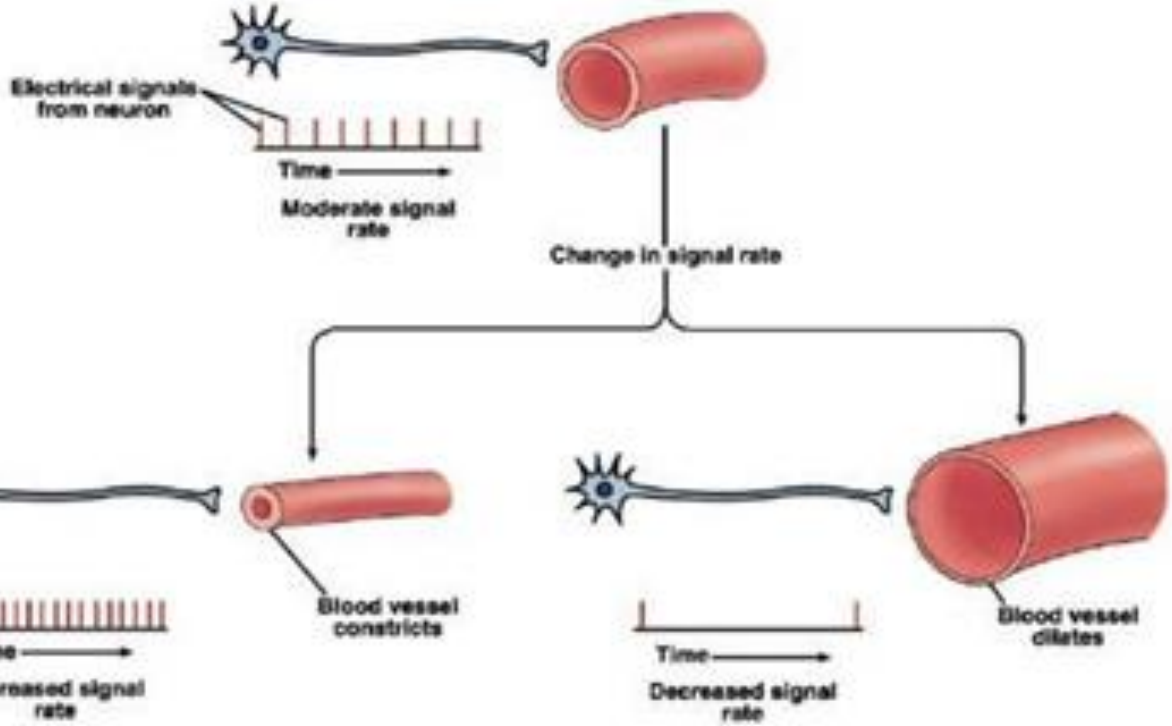
A great example is heart rate. An increase in sympathetic stimulation causes HR to increase whereas an increase in parasympathetic stimulation causes HR to decrease

Exception to the dual innervation rule:

Sweat glands and blood vessel smooth muscle are only innervated by symp and rely strictly on up-down control. Other examples :Adrenal glands, Piloerector muscles of hair

Exception to the antagonism rule:

Symp and parasymp work cooperatively to achieve male sexual function. Parasymp is responsible for erection while symp is responsible to ejaculation. There's similar ANS cooperation in the female sexual response.



synthesis - storage - release - binding - hydrolysis

Cholinergic transmission

of the transmitter

1-Synthesis: choline uptake from the blood

inside the neuron

Choline + acetylCo -A +

Choline acetyltransferase. ChAT

2-transported to vesicles, by vesicle associated transporter VAT

Stored quantas (up to 50000)

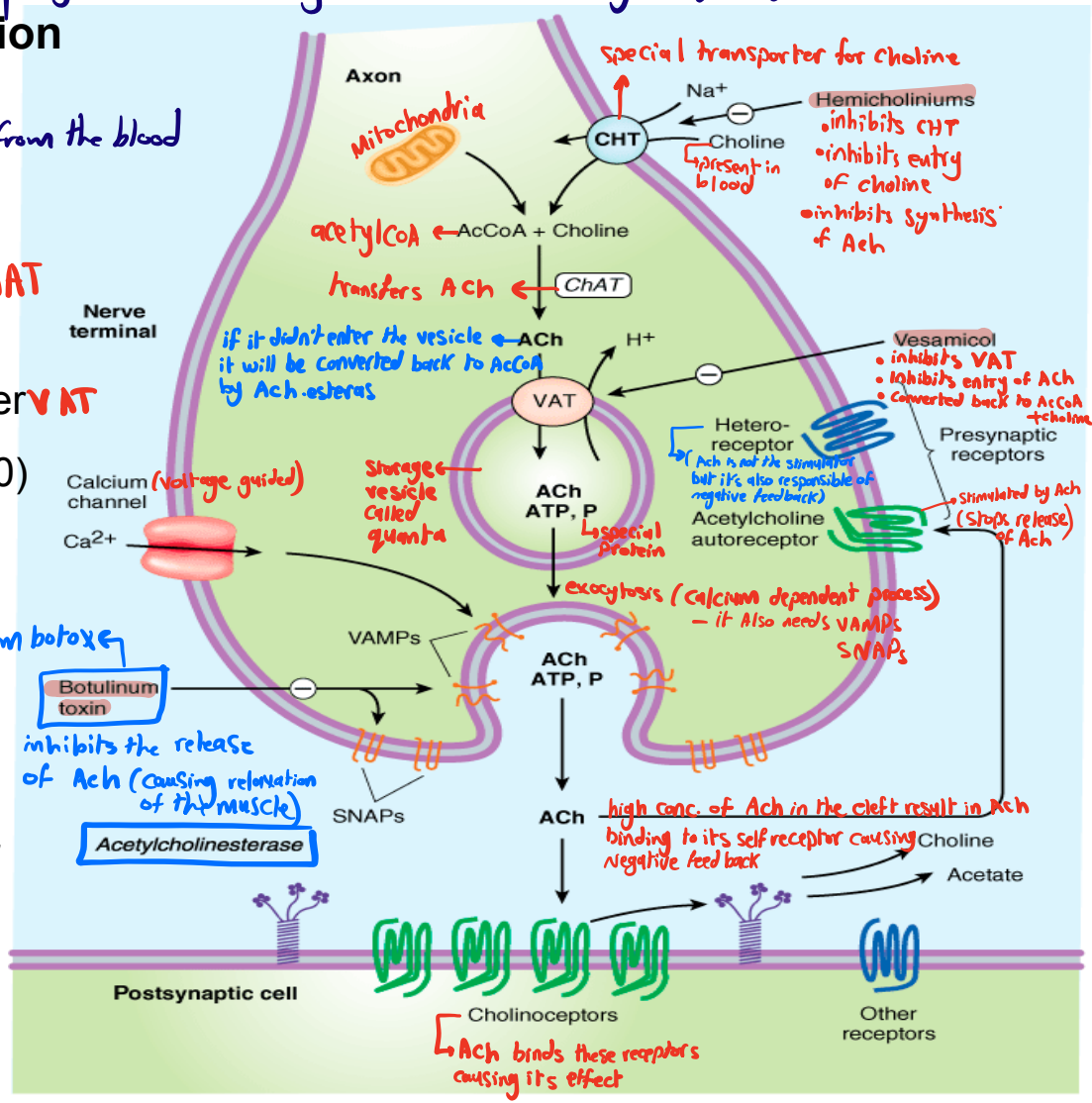
3-Release: exocytosis.

4-Interaction with post synaptic receptors

5- hydrolysis of Ach by Ach.esteras.

Drugs can act on all sites of cholinergic transmission.

VAMPS:vesicle detaicossa-nietorp enarbmem



Adrenergic Transmission

for the next lecture

VAT; vesicular Mono Amine Transporter

SNAPs: synaptosome – Associated proteins.

SNAPs → neuronal membrane
VAMPs → vesicle membrane

Special proteins that binds to each other to anchor the vesicle in a specific place and then open this vesicle to expell its content into the synaptic junction