Autonomic Nervous System

Outline

- Review of preganglionic and post ganglionic fibres
- Cholinergic and Adrenergic Fibres
- Autonomic Functions
- Mechanism of Neurotransmitter Secretion and Removal

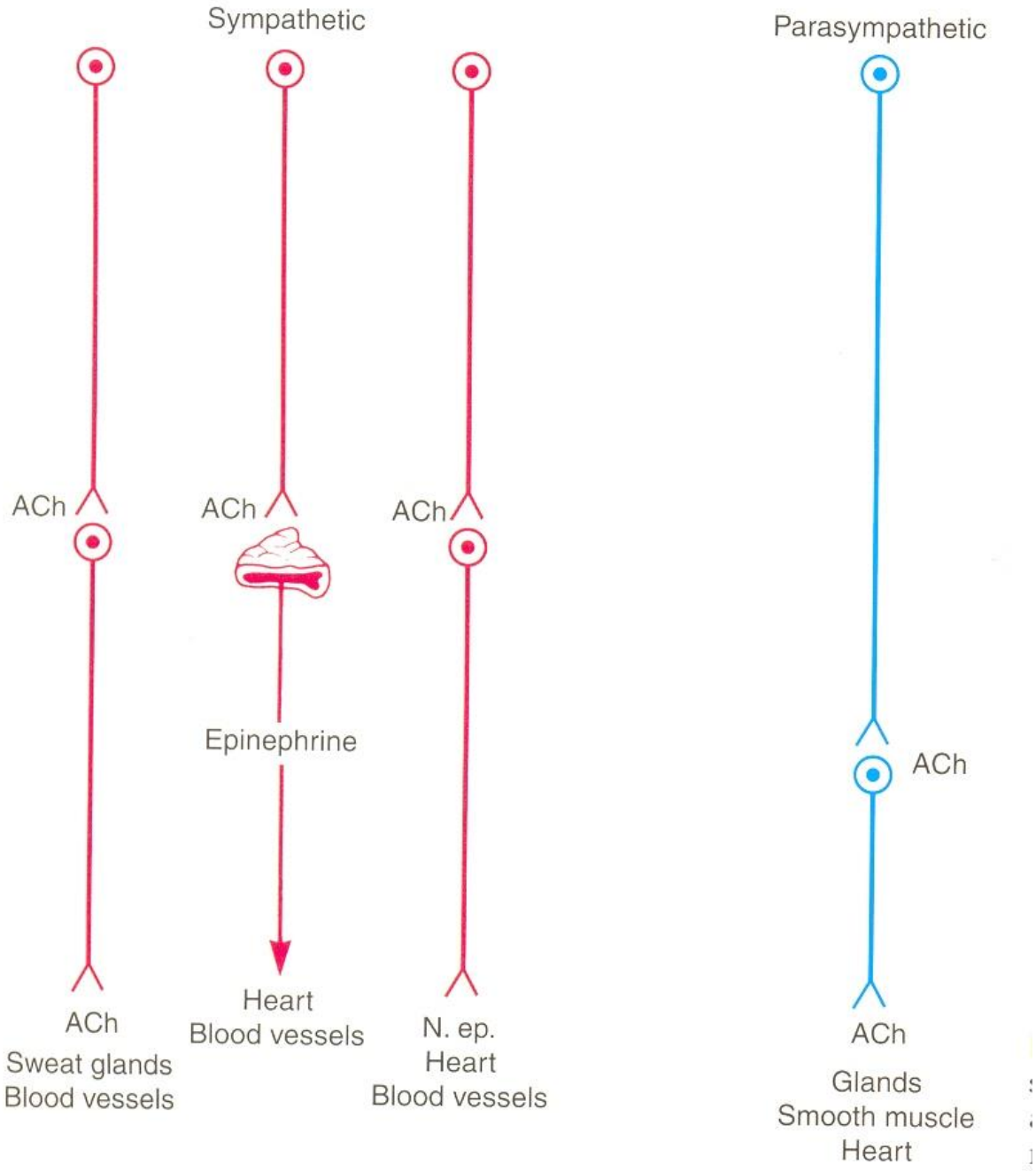
Preganglionic and Postganglionic Parasympathetic Neurons

Preganglionic fibers pass uninterrupted

all the way to the organ that is to be controlled,

In the wall of the organ are located the **Postganglionic neurons**

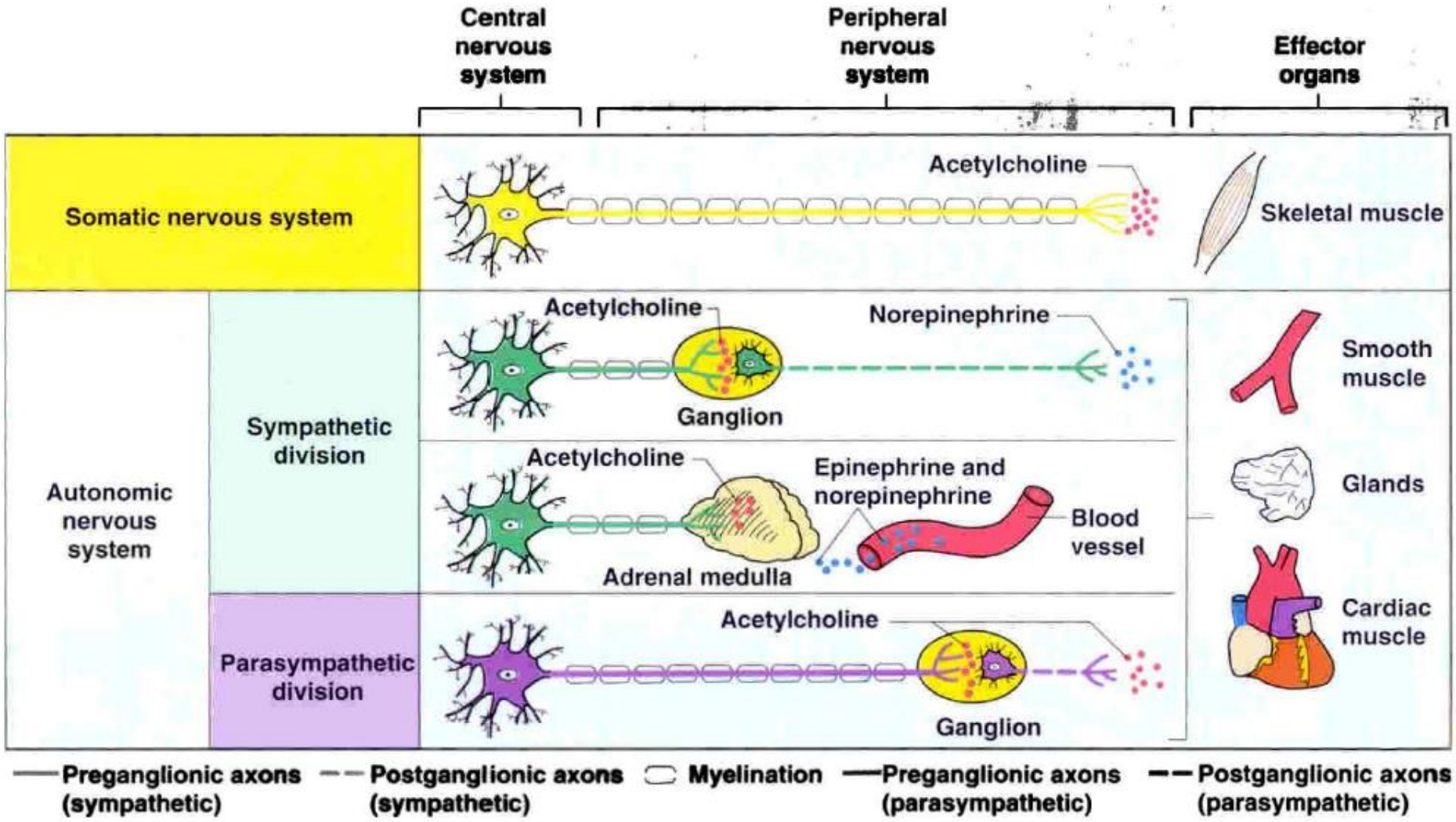
very short postganglionic fibers, leave the neurons to innervate the tissues of the organ


Sympathetic
Parasympathetic
ACh
ACh
ACh
ACh
Epinephrine
ACh
Sweat glands
Blood vessels
Heart
Blood vessels
N. ep.
Heart
Blood vessels
ACh
Glands
Smooth muscle
Heart

PARASYMPATHETIC NERVOUS SYSTEM	PREGANGLIONIC	POSTGANGLIONIC	EFFECTOR
	ACETYLCHOLINE	ACETYLCHOLINE	HEART SMOOTH MUSCLE LACRIMAL AND SALIVARY GLANDS

SYMPATHEIC NERVOUS SYSTEM	PREGANGLIONIC	POSTGANGLIONIC	EFFECTOR
	ACETYLCHOLINE	ACETYLCHOLINE→ OR NOREPINEPHRINE →	SWEAT GLANDS HEART, SMOOTH MUSCLE, VESSELS, GLANDS

Comparison of somatic and autonomic nervous systems



Cholinergic and Adrenergic Fibers

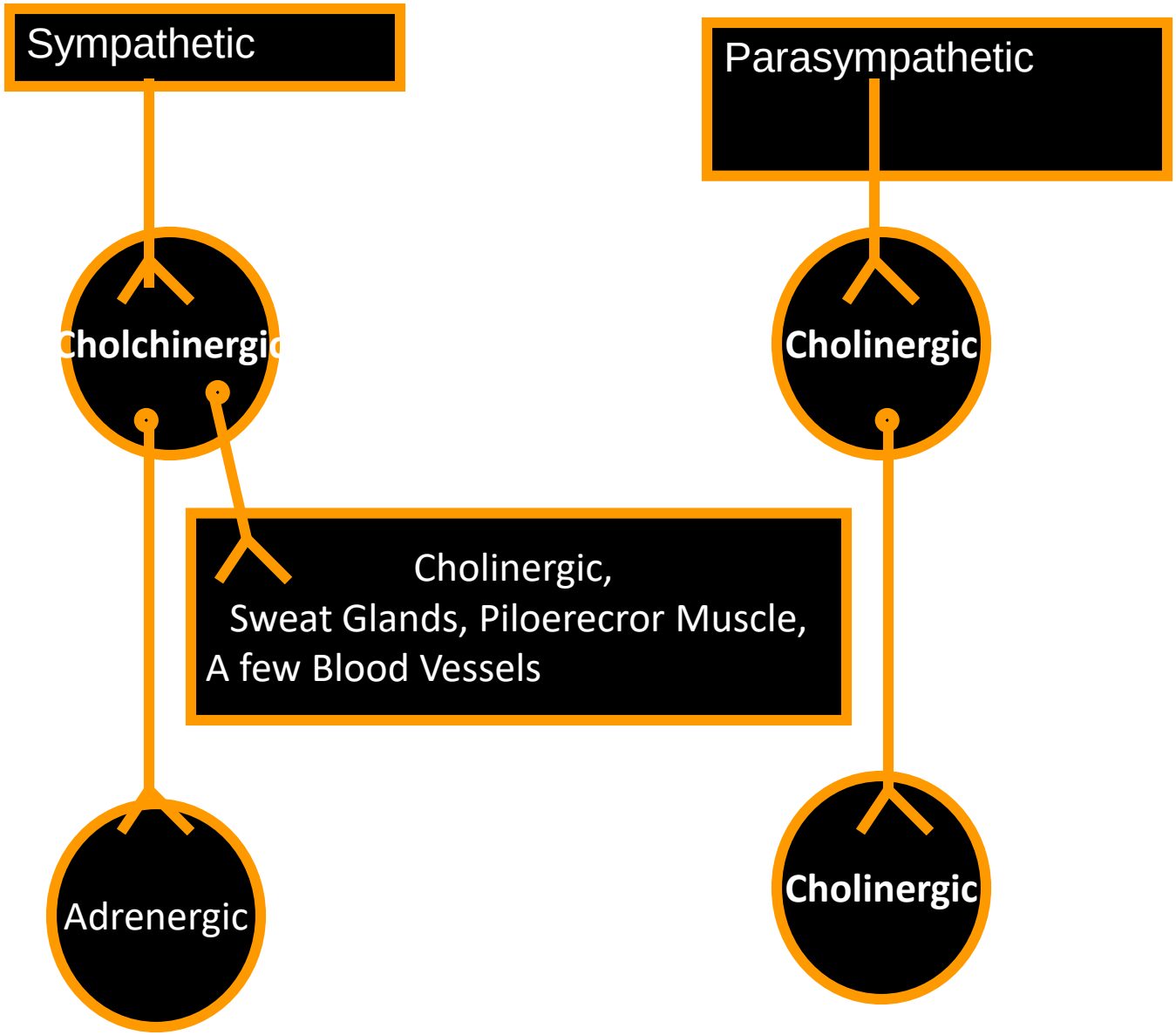
- secrete **acetylcholine** are said to be **cholinergic**

- *secrete* **norepinephrine** *are said* to be **adrenergic**

All **preganglionic neurons** → **cholinergic** in both the sympathetic and the parasympathetic nervous systems

all of the **postganglionic neurons** → **parasympathetic** system are also **cholinergic**

most of the ***postganglionic sympathetic neurons*** *are* ***adrenergic***


Sympathetic
Parasympathetic
Cholchinergic
Cholinergic
Cholinergic,
Sweat Glands, Piloerecror Muscle,
A few Blood Vessels
Adrenergic
Cholinergic

Acetylcholine is called a **Parasympathetic transmitter** *and*

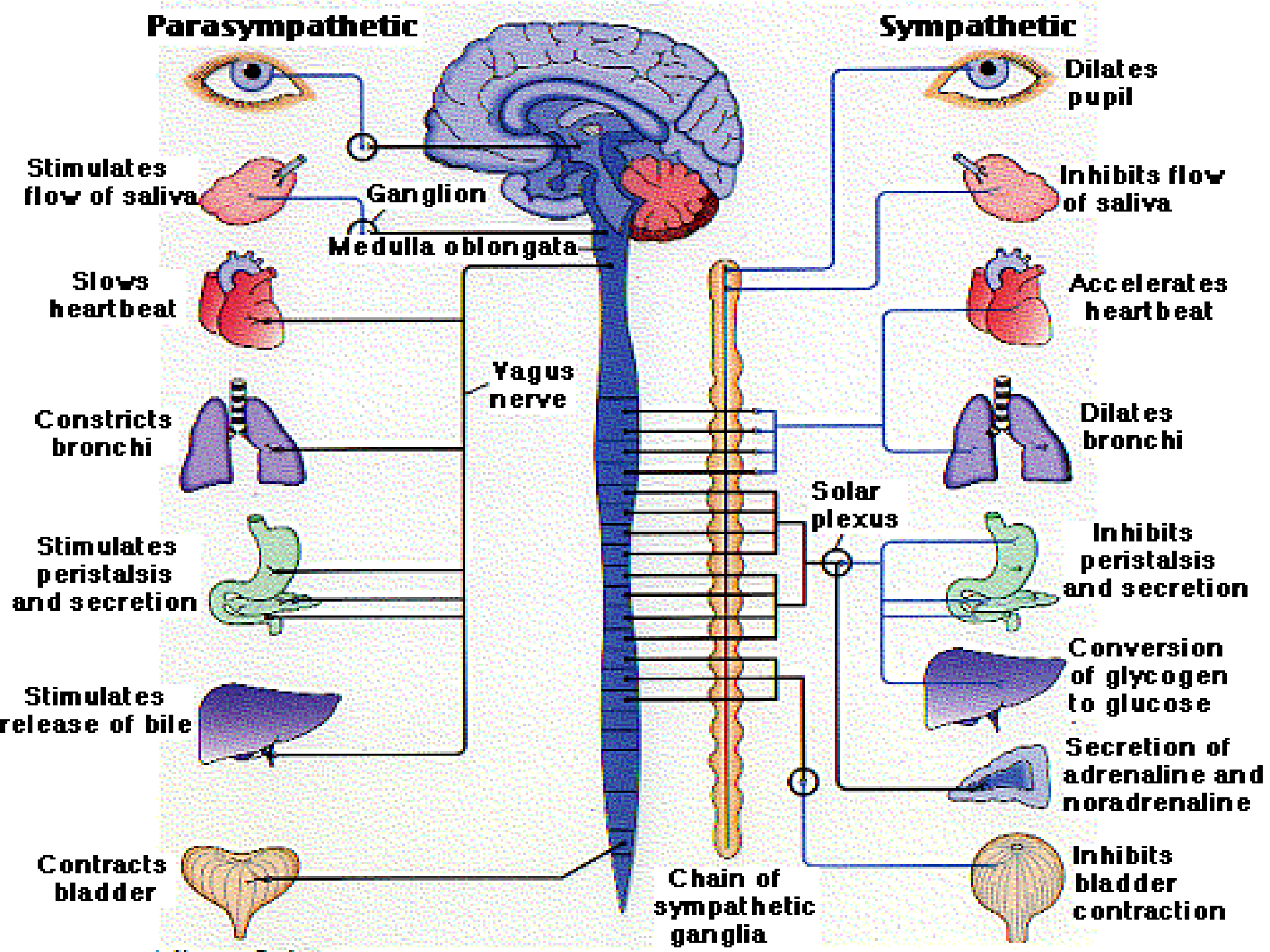
Norepinephrine is called a **Sympathetic transmitter**.

Autonomic functions

Organ	Parasympathetic	Sympathetic
EYE	1. Miosis 2. Near Accommodation	1. Mydriasis(α receptors) 2. Opposite
HEART	1. ↓ Heart rate 2. ↓ force of contraction 3. ↓ Conduction of velocity	Opposite (ß-1 receptors)
BLOOD VESSELS	1. Dilation ?	1. Alpha receptors: Constriction 2. ß-2 receptors : Dilatation e.g. Coronary arteries, skeletal muscles

Organ	Parasympathetic	Sympathetic
Lungs	1. Muscle contraction 2. ↑ secretion	Opposite(ß-2)
GIT	Stomach, Intestine 1. ↑ Motility 2. ↑ Secretions 3. Sphincters relaxed Gall Bladder/Ducts: Contraction	Opposite
URINARY BLADDER	1. Muscle Contraction 2. Sphincter relaxed	Opposite
MTABOLISM	1. Anabolism	Catabolism (ß receptors) • ↑ glycogenolysis • ↑ lipolysis • ↑ BMR

Organ	Parasympathetic	Sympathetic
Kidney	Nil	↑ Renin
Mental activity	Nil	↑
Skeletal Muscle	Nil	↑ Glycogenolysis ↑ Stretch


Parasympathetic
Sympathetic
Dilates pupil
Stimulates flow of saliva
Ganglion
Medulla oblongata
Inhibits flow of saliva
Slows heartbeat
Accelerates heartbeat
Vagus nerve
Constricts bronchi
Dilates bronchi
Solar plexus
Stimulates peristalsis and secretion
Inhibits peristalsis and secretion
Conversion of glycogen to glucose
Stimulates release of bile
Secretion of adrenaline and noradrenaline
Contracts bladder
Chain of sympathetic ganglia
Inhibits bladder contraction

Autonomic Functions

- Opposite
  - Excitatory/Inhibitory
- Parasympathetic:
  - Localized
- Sympathetic:
  - Diffuse

Enteric Nervous System

GIT has its own **intrinsic set of nerves** known as the **intramural plexus** *or the* **intestinal enteric nervous** system → in the walls of the gut

Parasympathetic stimulation → **increases** activity of the GIT by promoting peristalsis and relaxing the sphincters → rapid propulsion of contents along the tract

Only a **strong sympathetic stimulation inhibits** peristalsis and increases the tone of the sphincters→ may cause Constipation

Enteric Nervous system… a second Brain

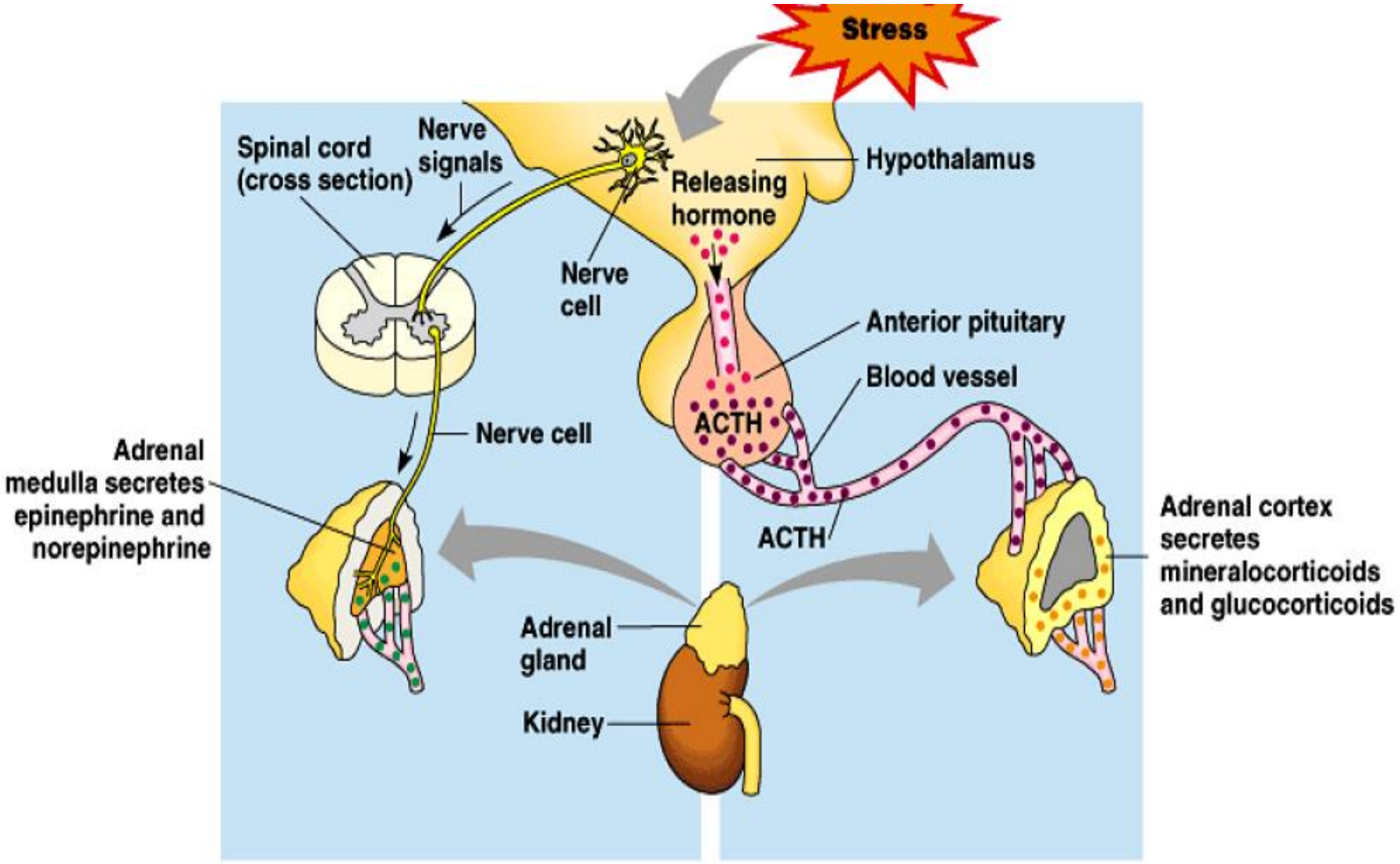
- 500 million neurons
- Can operate autonomously
- Continues to function even if Vagus is severed
- Has efferent, afferent and interneurons
- Auerbach’s and Meissner’s plexus
- More than 30 neurotransmitters in this
- contains support cells similar to astroglia of the brain and a diffusion barrier around the capillaries surrounding ganglia which is similar to the blood–brain barrier of cerebral blood vessels

Adrenal Medullae And Sympathetic Nervous System.

- Epinephrine and norepinephrine are always released by the adrenal medullae at the same time -- organs are stimulated in 2 ways
- **directly** by the sympathetic nerves and

  indirectly by the adrenal medullary hormones
- stimulate structures of the body that **are not** innervated by direct sympathetic fibers→ the metabolic rate of every cell of the body is increased by these hormones

Integration of Nervous and Endocrine Systems



Autonomic Nervous System

Parasympathetic – "Rest and Digest"

Sympathetic – "Fight or Flight"

sympathetic versus parasympathetic

Sympathetic

- Thoracolumbar outflow
- Quick response mobilising system“
- Fight or flight
- Diverts blood flow away from GI tract and skin
- Blood flow to skeletal muscles and lungs is increased
- Dilates bronchioles of the lung, which allows for greater alveolar oxygen exchange
- Increases heart rate and the contractility of cardiac cells
- Dilates pupils and relaxes the ciliary muscle to the lens, allowing more light to enter the eye and far vision
- Provides coronary vasodilation
- Constricts the intestinal and urinary sphincters
- Inhibits peristalsis
- Stimulates orgasm

Parasympathetic

- Craniosacral outflow
- more slowly activated dampening system
- Rest and digest or feed and breed
- dilate blood vessels leading to the GI tract, increasing blood flow
- bronchiolar constriction
- Decreases the heart rate and contraction
- constriction of the pupil and contraction of the ciliary muscle to the lens
- stimulates salivary gland secretion, accelerates peristalsis
- erection of genital tissues and stimulating sexual arousal

Mechanism of Neurotransmitter Secretion and Removal

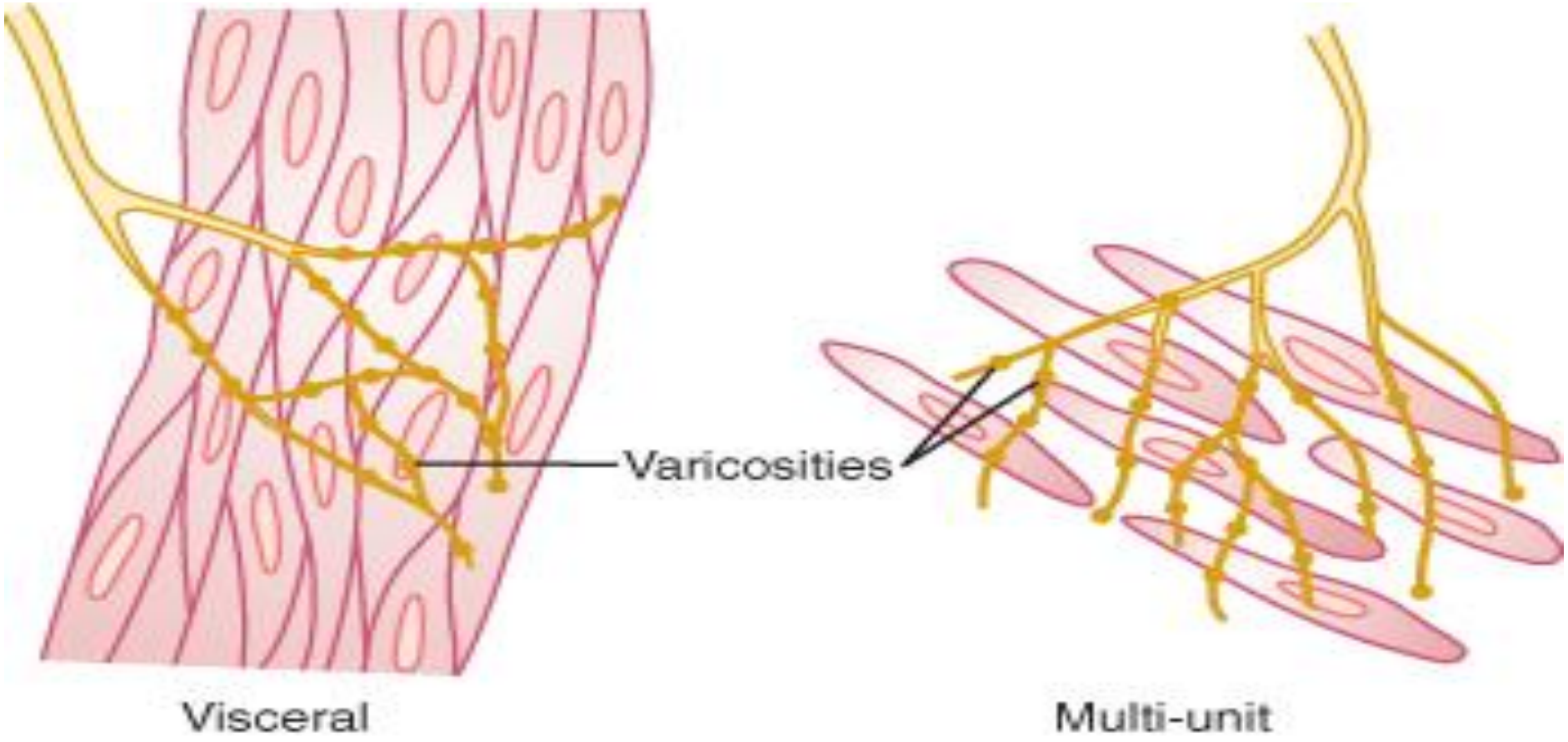
Mechanisms of Neurotransmitter Secretion

- Where autonomic fibres pass over or near cells to be stimulated, they have bulbous enlargements→ **Varicosities**→

- contain neurotransmitter vesicles+ large no of mitochondria

- Action potential spreads over terminal fibres → more Ca++ ions enter → fuse with vesicles emptying their contents to the exterior

Mechanism of neurotransmitters secretion in Smooth Muscle



Circulation of neurotransmitters

- Acetylcholine:
  - Local
- Noradrenaline/ Norepinephrine:
  - Local
  - Blood
    - Hormone
- Adrenaline/ Epinephrine
  - Blood
    - Hormone

Metabolism of Neurotransmitters

- **Acetylcholine**
  - Synthesis
    - From Choline
    - In terminal nerve endings
  - Destruction
    - Acetylcholinesterase
- **Norepinephrine**
  - Synthesis
    - From Tyrosine
    - In axoplasm of nerve endings
  - Removal
    i. Reuptake
    ii. Blood
    iii. Enzymes

Acetylcholine

- one of many neurotransmitters in ANS
- acts on both the PNS and CNS
- and is the **only neurotransmitter** used in the **motor division of Somatic Motor System**
- is also the **principal neurotransmitter** in all **autonomic ganglia**
- In **cardiac tissue** has an **inhibitory effect** → lowers heart rate
- also behaves as an **excitatory neurotransmitter** at neuromuscular junctions in skeletal muscle

Synthesis and Destruction of Acetylcholine

choline acetyl transferase

- **Acetyl-CoA + Choline** ----------→ **Acetylcholine**

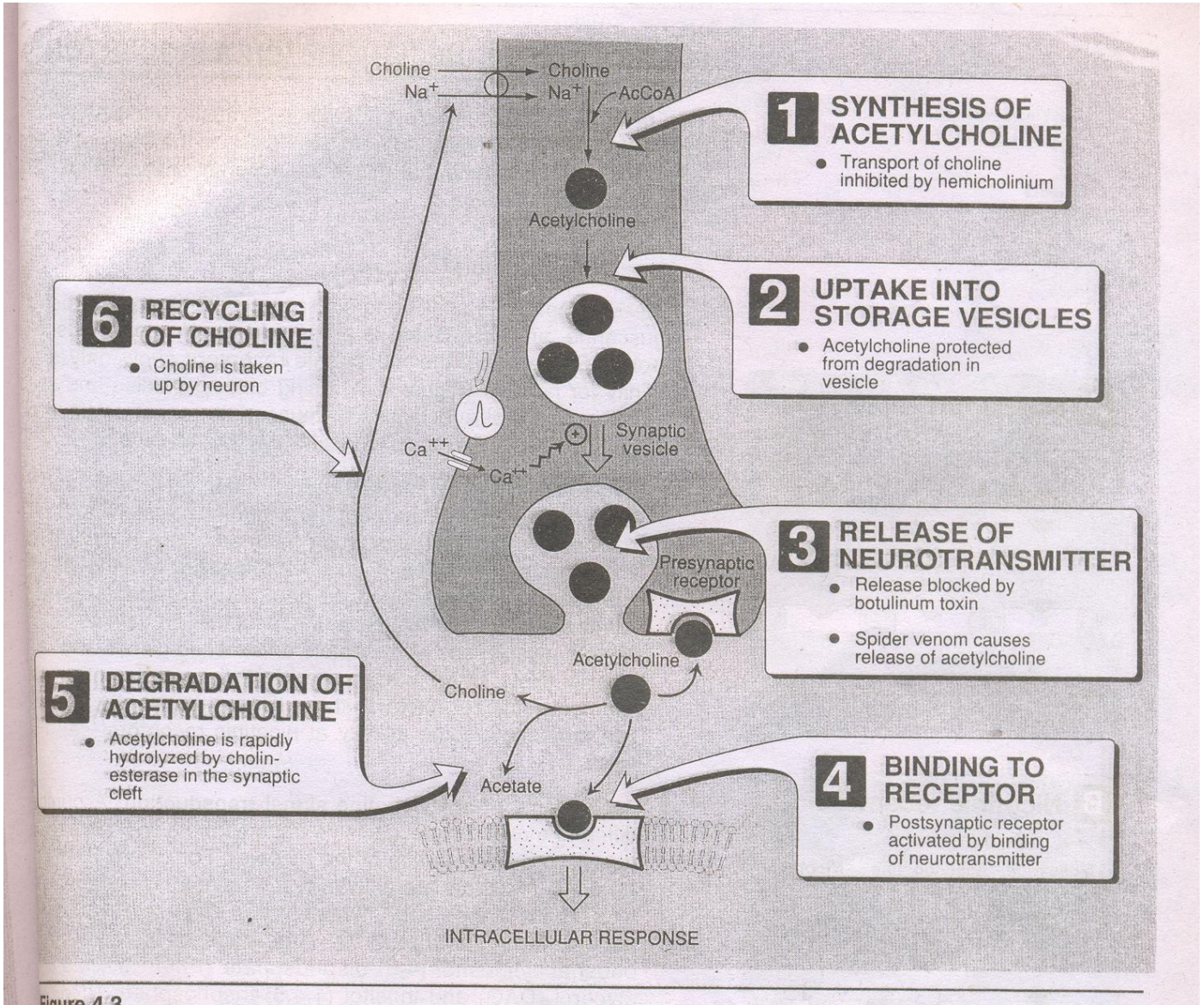
acetylcholinestrase

- **Acetylcholine** ----------→ **acetate + choline**

Choline is transported back into terminal nerve ending used for resynthesis of acetylcholine ,

Acetylcholine secreted by the nerve ending persists for a few seconds

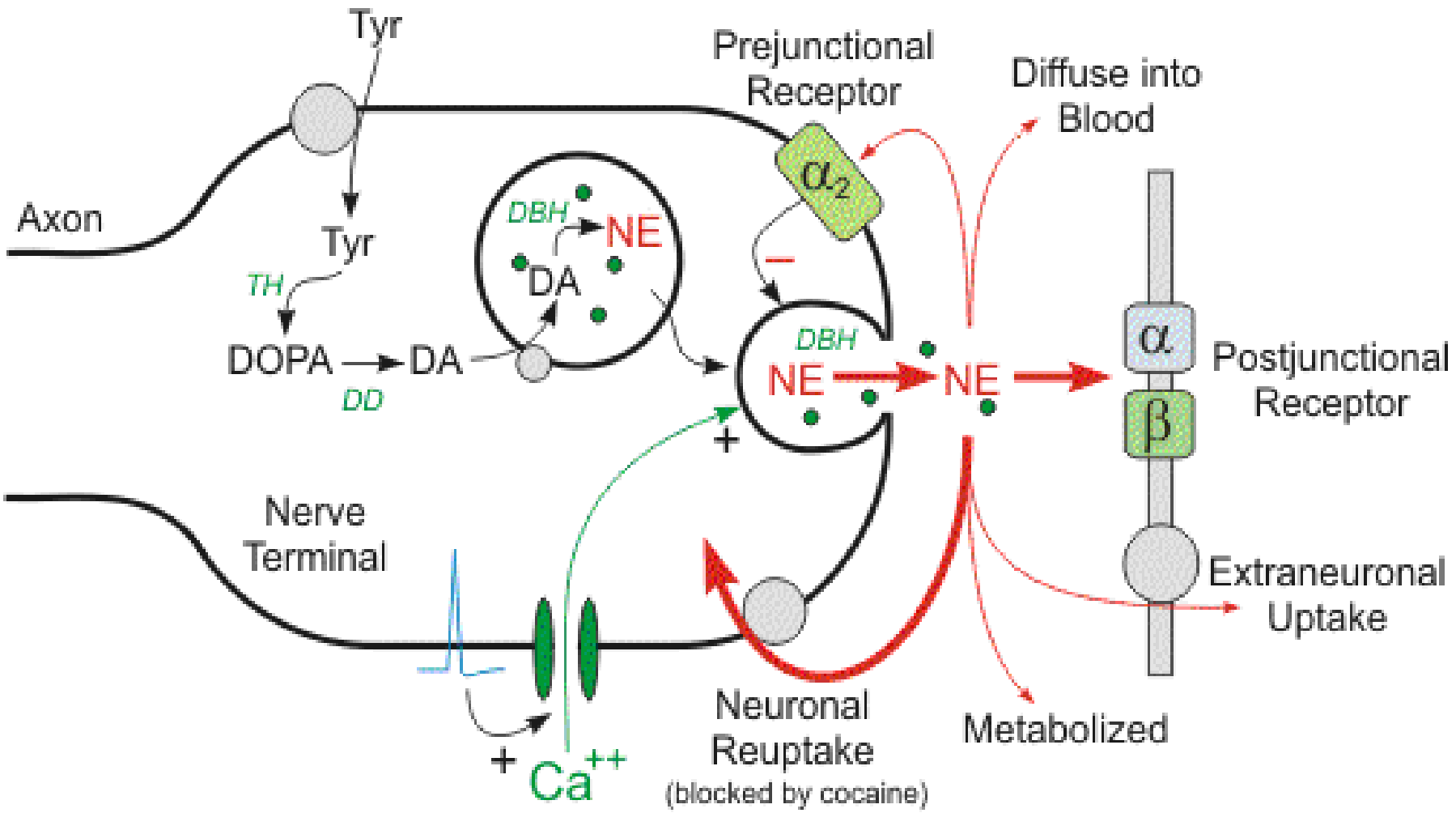
Synthesis & Release of Acetylcholine



Epinephrine and Norepinephrine

- Chemically, the 2 compounds differ only **slightly**
- exert **similar pharmacological actions** resembling the effects of sympathetic stimulation
- So classified as **sympathomimetic agents**
- The active secretion of the **adrenal medulla** → 80 % epinephrine and 20 %norepinephrine
- In the **sympathetic nerves Norepinephrine** is predominant

Synthesis and Removal of Norepinephrine



Tyr = tyrosine; TH = tyrosine hydroxylase; DD = DOPA decarboxylase;
DA = dopamine; DBH = dopamine β-hydroxylase; NE = norepinephrine

Synthesis and Removal of Norepinephine

hydroxylation

- **Tyrosine ----------→ Dopa**

decarboxylation

- **Dopa ----------→ Dopamine**

- Transport of dopamine into vesicles

hydroxylation

- **Dopamine ----------→ Norepinephrine**

methylation

- **Norepinephrine ----------→ Epinephrine**

Removal of Norepinephrine

- 50%- 80% is reuptaken by adrenergic nerve endings by active transport

- Diffusion away from nerve endings into surrounding body fluids and then into blood

- Destruction of small amounts by tissue enzymes like MAO in nerve endings and catechol-O-methyl transferase

Duration of action of Norepinephrine

- When secreted into **tissues** → remains active for a **few seconds**

- In **blood** both norepinephrine and epinephrine remain active for **10-30 seconds** and activity decline in **1 to several minutes**

Receptors on Effector Organs

- **Transmitter+ Receptor** →

- Change in cell membrane permeability to one or more ions

- Activating or inactivating an enzyme attached to the other end of receptor protein

  (2^{nd} messenger enzymes)