Autonomic Nervous System

The nervous system is the major control system in the body which regulates **many body functions** necessary for life.

Nerve Cell (Neuron)

- It is **the structural unit** of nervous system.

Structure:

It is formed of:

a) Cell body (soma): controls the activity of the whole neuron.

b) Cell processes: 2 types axis and dendrites

The axon near its termination either joins:

- Muscle → **neuromuscular junction.**
- Gland→ **neuroepithelial junction.**
- Dendrites or soma of another neuron → **neuro-neural junction.**

c) Types

a. **Afferent (sensory) neuron**→ carries impulses **from receptors to** CNS.

b**. Efferent (motor) neur**on→ carries **impulses from CNS to** effector organs.

c. **Interneuron (associative**) →located **entirely within CNS.**

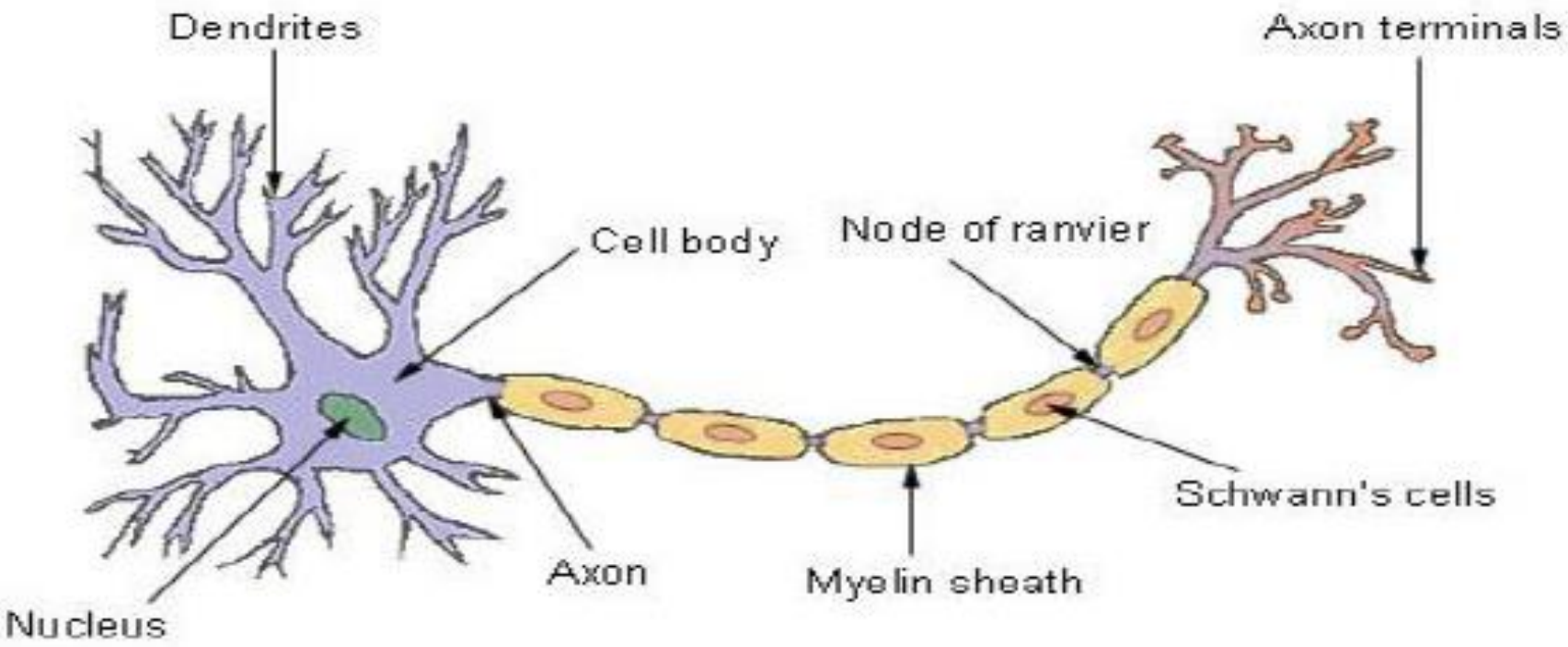


Fig. (9): Structure of neuron

Reflex Action

Definition

- **It is an involuntary reaction of the body to sensory stimulus**

Pathway (reflex arc):

- It is carried out **through pathway** called **reflex arc** which is considered **the functional or physiological unit of the nervous system**

Components of reflex arc are:

i- **Receptors.**

ii- Afferent (sensory) neuron

iii- Center (in CNS).

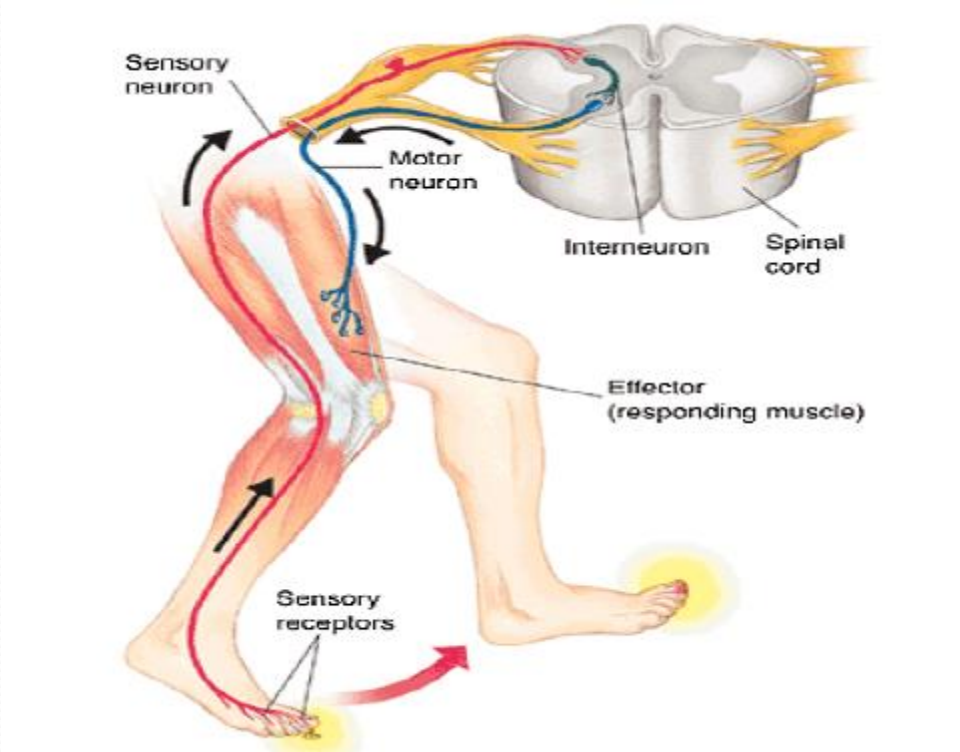
iv. Efferent (motor) neuron

v. Effectors (muscles or glands).

Types:

i) **Somatic reflex;** e.g. flexion withdrawal reflex.

ii) **Autonomic reflex;** e.g. micturition reflex.



Reflex arc (flexion withdrawal reflex)

Divisions of Nervous System

The nervous system is divided into:

i) **Central nervous system (CNS).**

ii) **Peripheral nervous system (PNS).**

Central Nervous System (CNS)

It is the part of the NS which **is protected by bone (skull and vertebral column).**

Parts:

It consists of 2 parts;

1) Brain

- **It is located in the skull**
- It consists of 3 parts;

I. Cerebrum (2 cerebral hemispheres); consists of;

- **Cerebral cortex**
- **Subcortical centers**: include

1- Thalamus 2- Hypothalamus 3- Basal ganglia.

II. Brain stem: consists of;

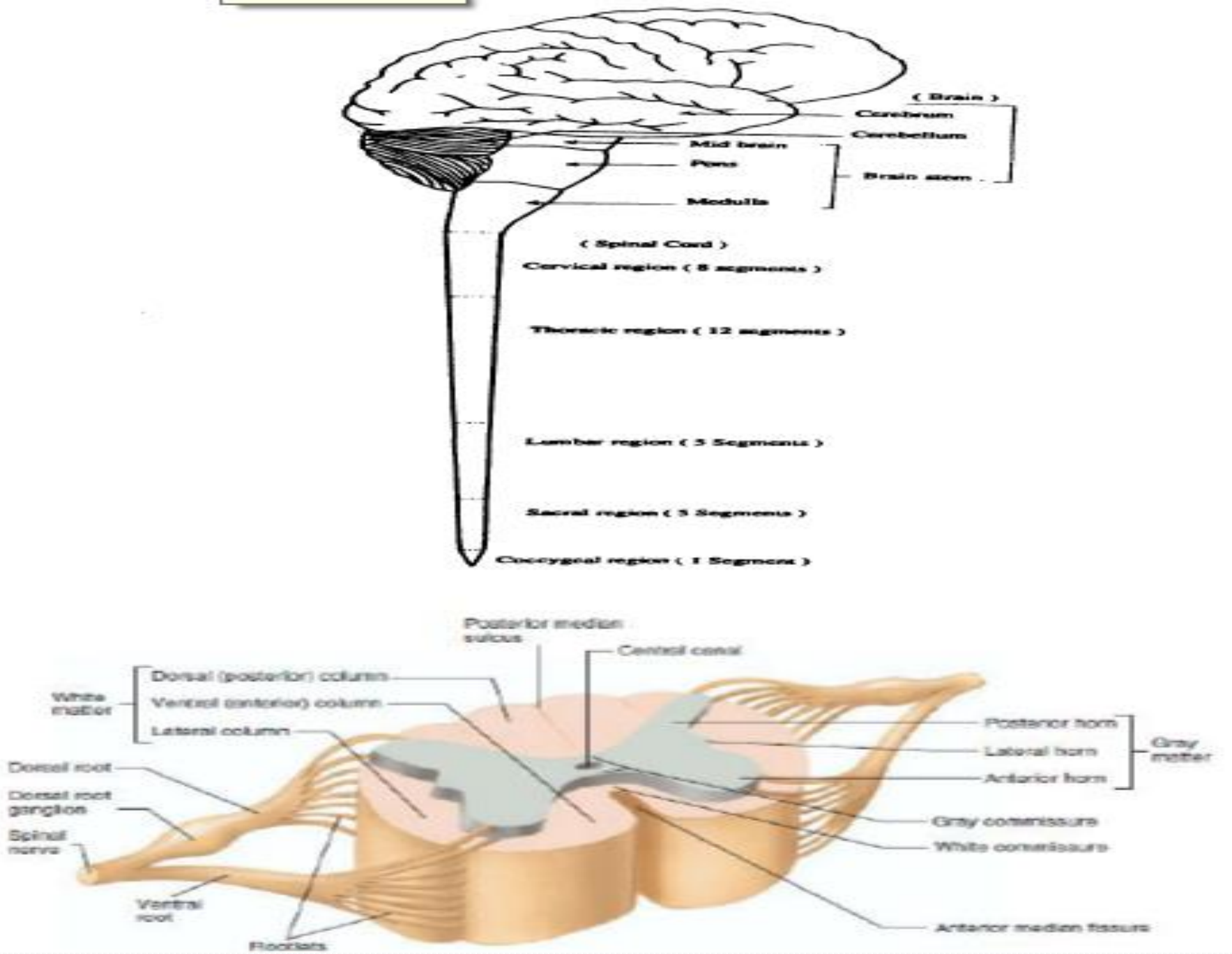
1. Midbrain 2. Pons 3. Medulla oblongata.

i- Cerebellum.

2) Spinal cord:

- **It is located in the spine (vertebral column**
- It is subdivided into 31 segments; **8 cervical segments,12 thoracic segments, 5 lumbar segments, 5 sacral segments and one coccygeal segment.**
- The spinal cord consists of 2 parts:

1. **Outer white matter**: **anterior, posterior and lateral column**
2. **Inner gray matter**: **anterior, posterior and lateral horns**



Structure of central nervous system and cross section of spinal cord

Peripheral Nervous System (PNS)

- It is the part of NS which communicate between the CNS and peripheral tissues.

Divisions:

A) Anatomical divisions:

- PNS is composed of 12 pairs of **cranial nerves** and 31 pairs of **spinal nerves** which contain:

1- Afferent (sensory) nerve fibers→ conduct impulses from surface or inside of body to CNS

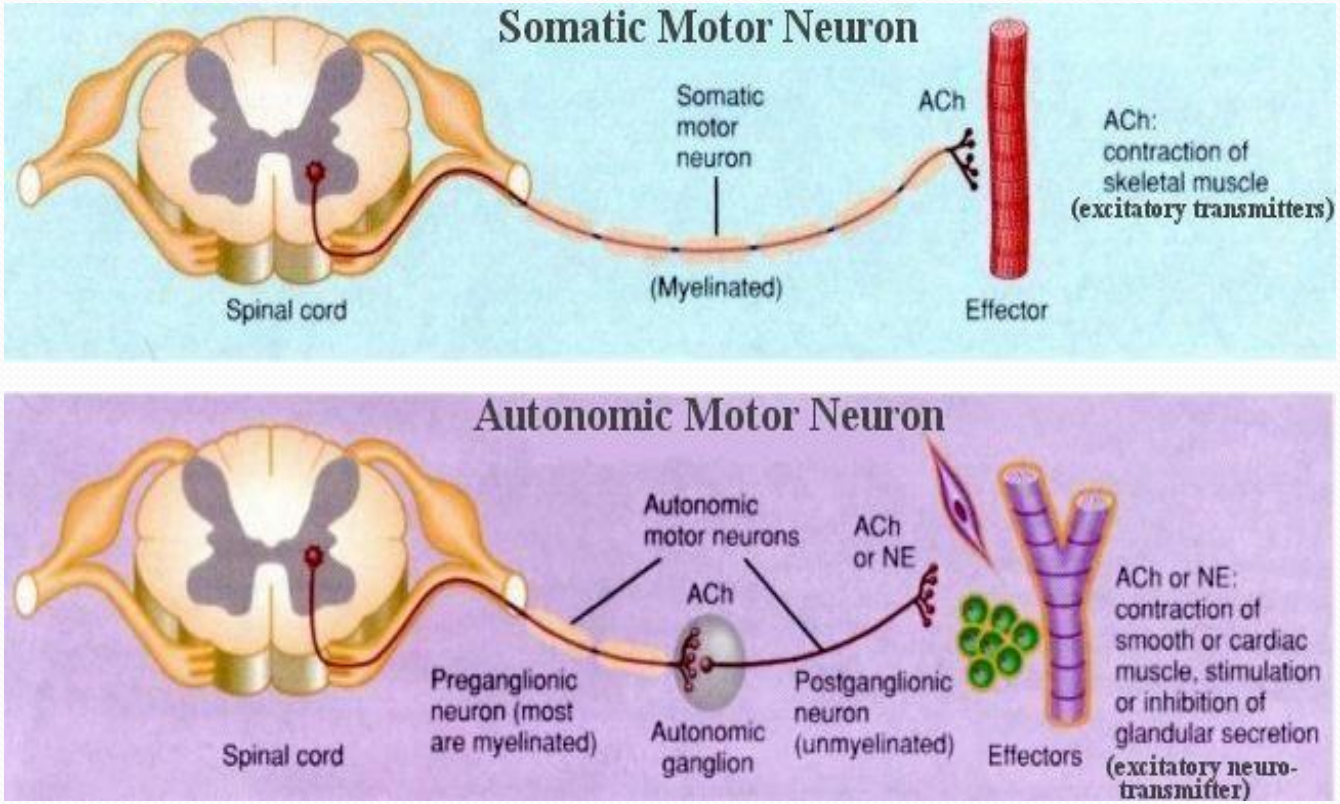
2- Efferent (motor) nerve fibers → conduct impulses from CNS to various organs of the body (effectors).

B) Physiological Divisions:

PNS is divided into;

i) **Somatic N S** →controls voluntary actions.

ii) **Autonomic N S** →controls involuntary actions



Somatic and autonomic nervous systems

Table 1: Comparison between somatic and autonomic nervous systems

	Somatic N S	Autonomic N S
Control	**Voluntary functions**	Involuntary functions
Connections	With skin, skeletal muscles, bones and joints.	**With smooth muscles, glands and cardiac muscle.**
Center	**Spinal cord →AHCs** **Brain stem→ somatic motor nuclei**	**Spinal cord →LHCs** **Brain stem→ visceral motor nuclei**

	Somatic N S	Autonomic N S
Efferent (motor) fibers	– One neuron. – **No ganglia i.e. not synapse outside CNS).** – **Thick myelinated nerve fibers (type A)** – **Excitatory to skeletal muscle i.e.** muscle contraction	- Two neurons. – **Presence of ganglia (i. e. synapse outside CNS).** – **Preganglionic is thin myelinated nerve fibers (type B)** – **Postganglionic is non-myelinated nerve fibers (type C)** – Either excitatory or inhibitory to effector organs.
Effects of denervation	Paralysis and atrophy	No paralysis (smooth muscles are myogenic).
Chemical transmitters	**Acetylcholine**	– **At preganglionic nerve endings: acetylcholine.** – **At postganglionic nerve endings: acetylcholine or nor epinephrine.**

AHCs= anterior horn cells, LHCs= lateral horn cells.

Autonomic Nervous System

Definition:

It is the part of the PNS which supplies and regulates the functions of internal organs i.e. viscera of the body.

Divisions of ANS

ANS is subdivided into 2 systems;

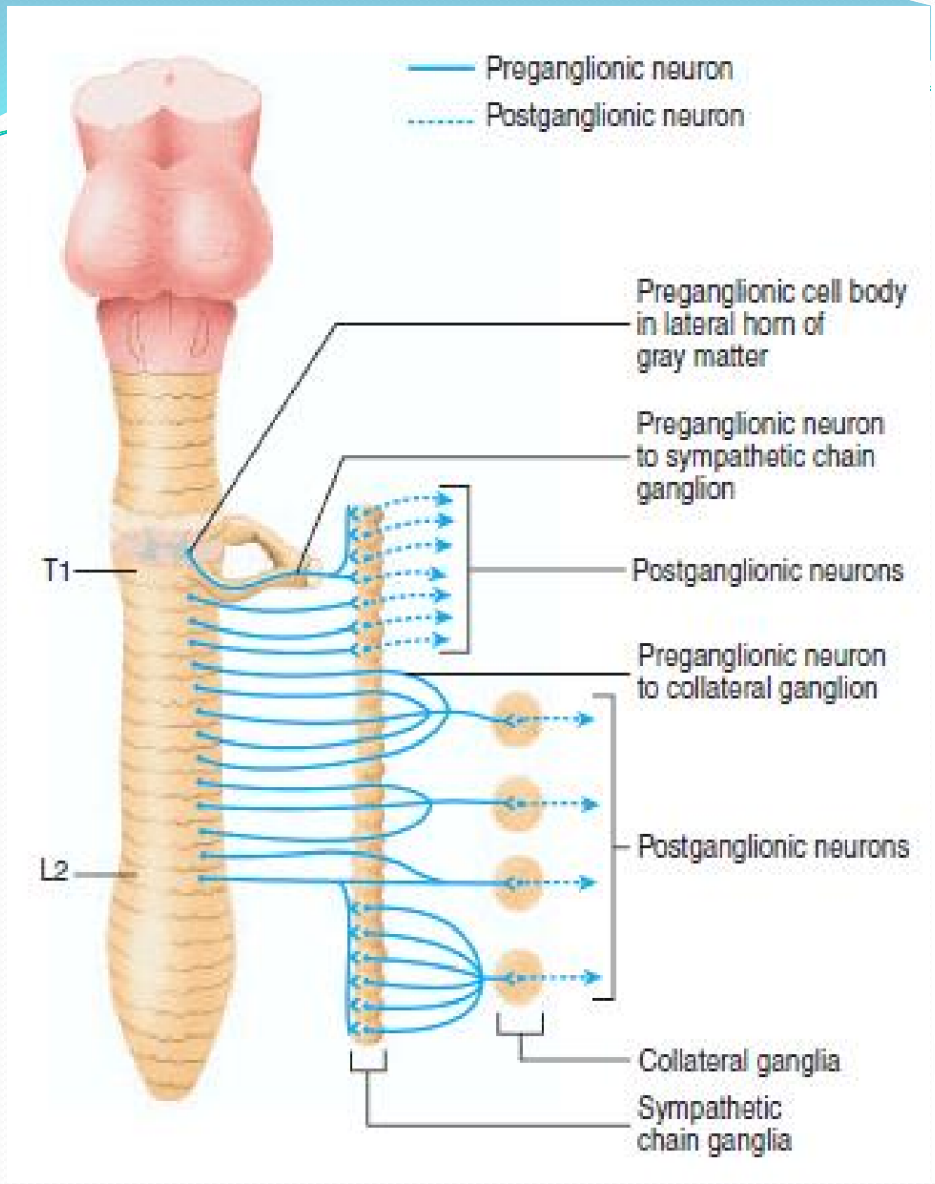
i) **Sympathetic** (thoracolumbar) NS : **originates from LHCs of all thoracic and upper 3 lumbar segments of the spinal cord**

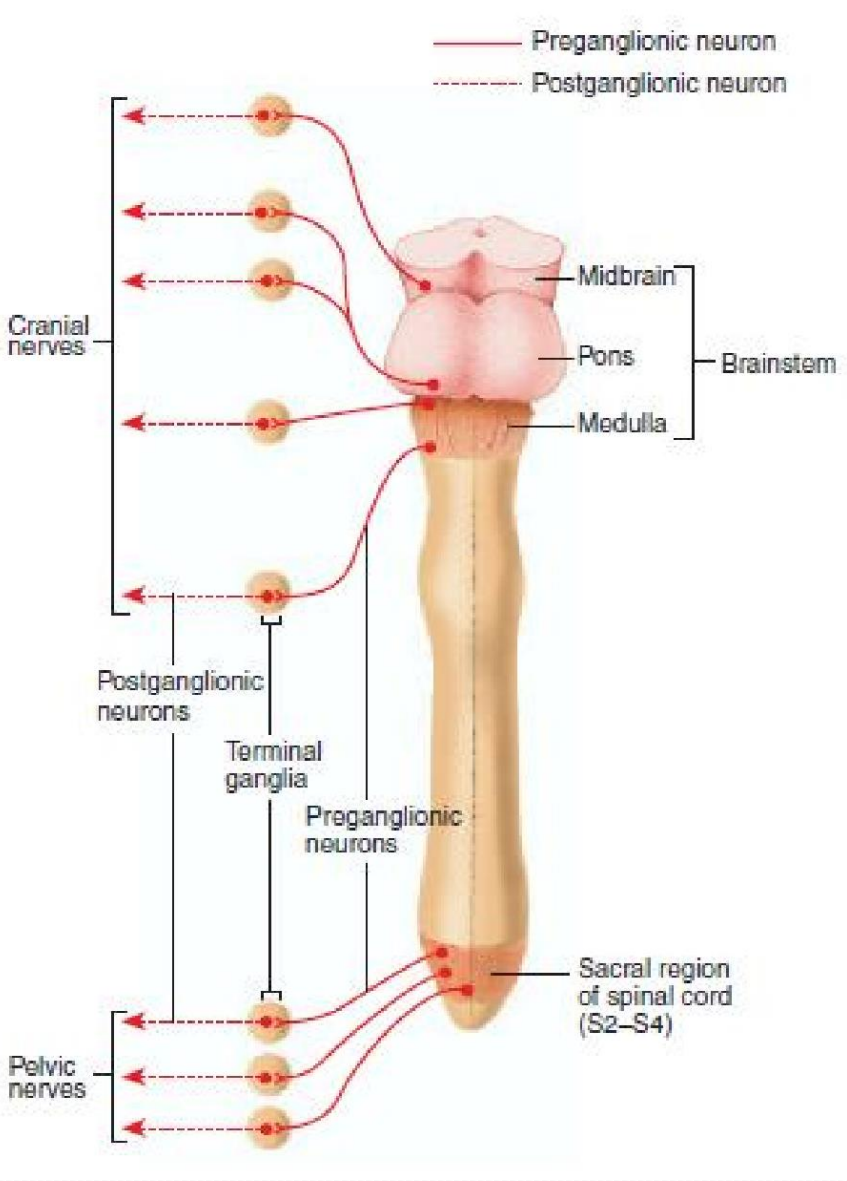
ii) **Parasympathetic** (craniosacral) NS: **originates from 2 parts**;

A- Cranial part: arises from visceral motor of the following cranial nerves:

1. **Oculomotor nerve in midbrain.**
2. **Facial nerve in pons.**
3. **Glossopharyngeal nerve in the medulla oblongata.**
4. **Vagus nerve in the medulla oblongata.**

B-Sacral part: arises **from 2nd, 3rd and 4th sacral segments of the spinal cord and forms pelvic nerve**





sympathetic (a) and parasympathetic (b) division16 s of autonomic nervous system

Autonomic Ganglia

Def,

- They are **collection of cell bodies of neurons outside the central nervous system (CNS).**

Functions:

- Act as a **relay station** for **autonomic preganglionic** nerve fibers

Functions of autonomic ganglia

Types:

a) Lateral (paravertebral) ganglia:

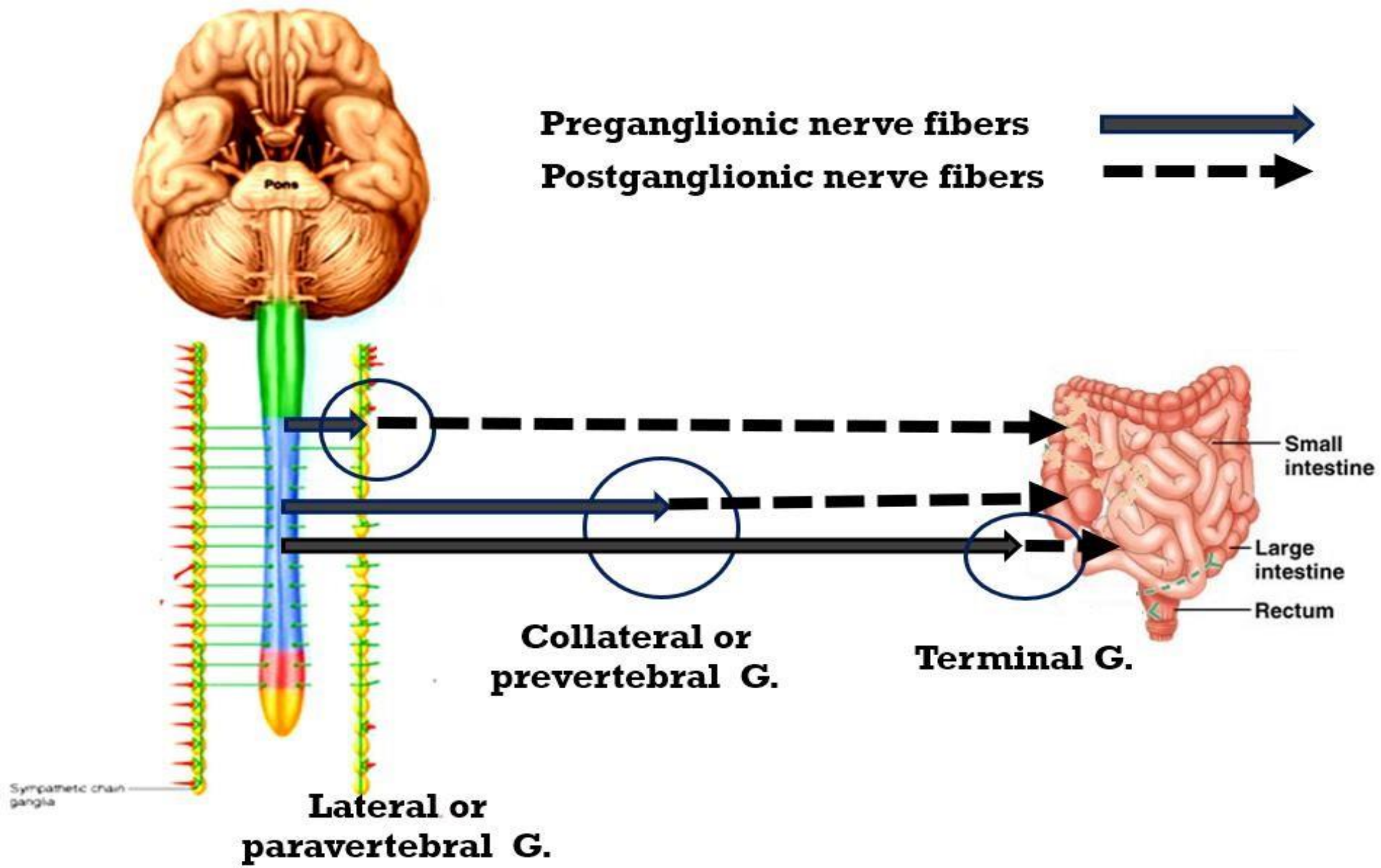
- Located **on either side of the spinal cord.**
- About 22-24 ganglia on each side.
- Form **2 rows of sympathetic chain of ganglia.**
- Act as a relay station for preganglionic sympathetic nerve fibers only.

b) Collateral (prevertebral) ganglia:

- Present mainly in the abdomen, **midway between spinal cord and viscera.**
- Act as a relay station for **sympathetic preganglionic nerve fibers**.

c) Terminal ganglia:

- Present **close to or at the wall the effector organs** especially rectum; urinary bladder reproductive organs in the pelvis.
- **Act as a relay station of:**
  - **All parasympathetic preganglionic fibers.**
  - Some sympathetic preganglionic fibers.



Types of autonomic ganglia

(I) Functions of Sympathetic NS

A) Sympathetic Supply to Head and Neck:

Origin:

- LHCs of **first and second thoracic segments**

Functions:

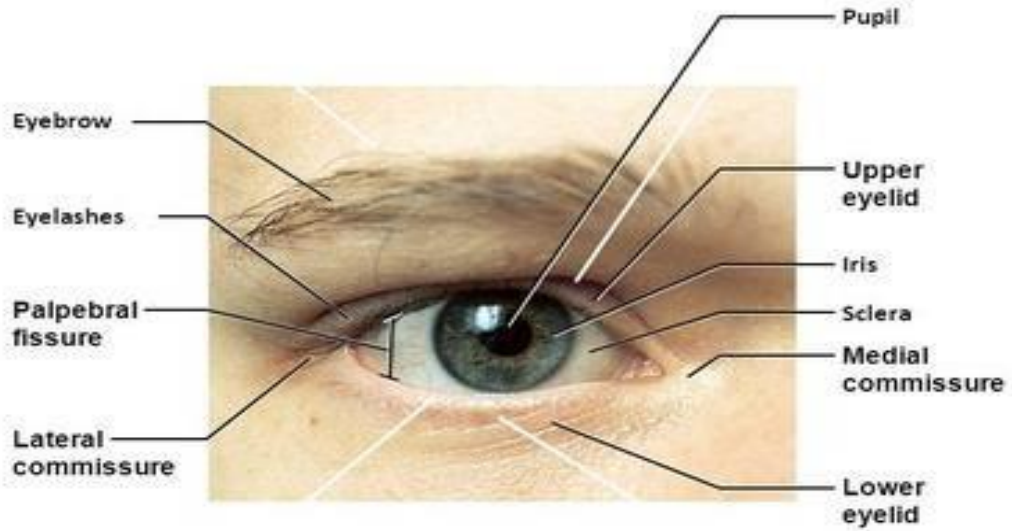
1) Eye:

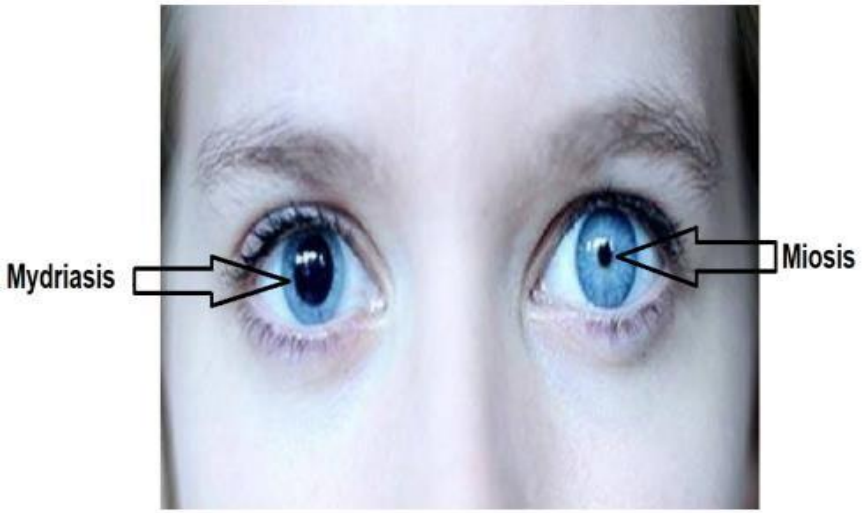
a. Causes **dilatation of pupil (mydriasis)**

b. Causes widening of palpebral fissure.

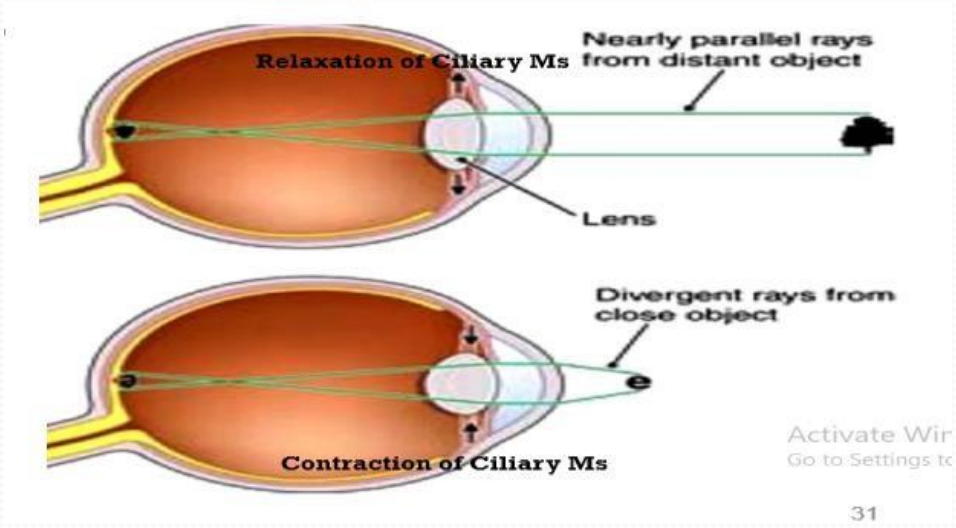
c. Causes **exophthalmos.**

d. Helps the eye to see far objects





Palpebral fissure and dilatation of pupil (mydriasis) and constriction of pupil (miosis)



showing exophalamos and relaxation of ciliary ms to see far objects

2) Salivary Glands:

a. Vasoconstriction **(V.C.) of salivary gland blood vessels**.

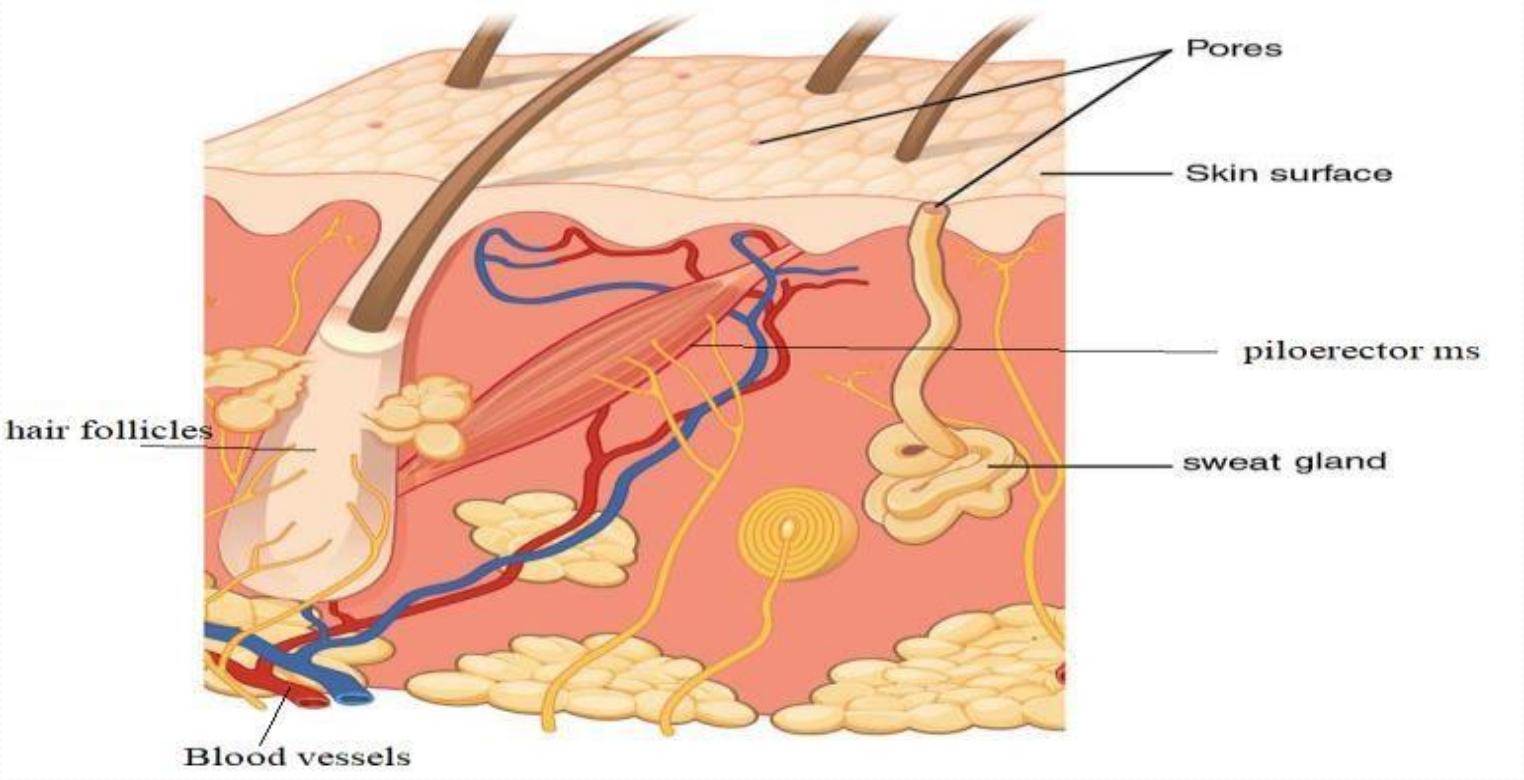
b. **Trophic secretions**: little, **viscous,** concentrated secretion; poor in water and **rich in enzymes**

3) Skin:

I. **V.C** of skin blood vessels.

II. **Hair erection**

III. **Sweat secretion.**



Structure of skin

B) Sympathetic Supply to Thorax:

Origin:

- **LHCs of upper 4 or 5 thoracic segments of spinal cord.**

Functions:

1) Heart:

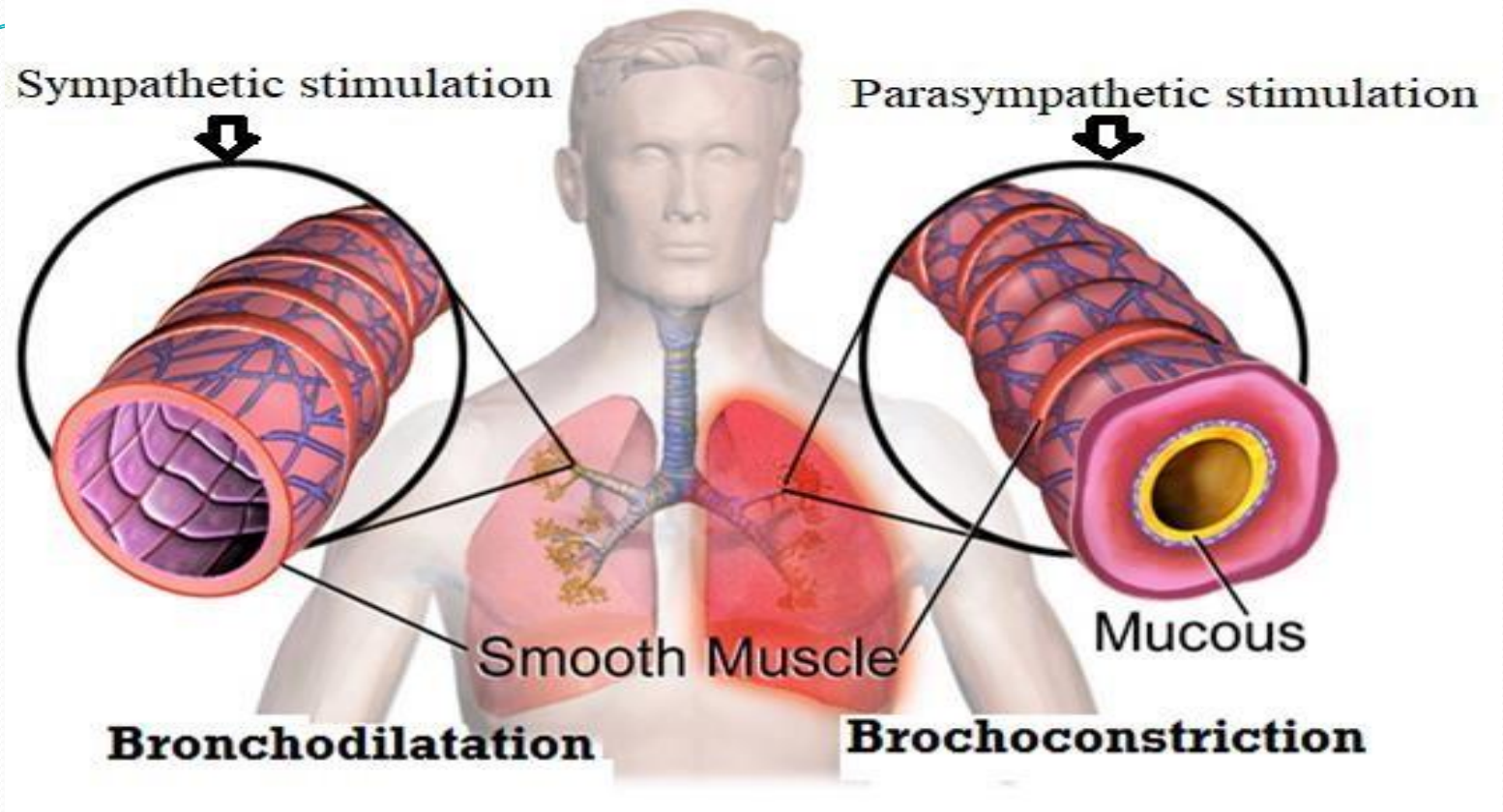
I. **It ↑es the heart rate and force of contraction**

II. vasodilatation of coronary vessels

2) Lungs:

I. Bronchodilatation.

II. **Decreases mucus secretion of air passages.**



Sympathetic stimulation to lungs and air passages

C) Sympathetic Supply to Abdomen:

Origin:

- **LHCs of T6-12 segments of spinal cord (splanchnic nerves).**

Functions:

1. GIT

Relaxation **of their walls and contraction of their sphincters**

2. Gall bladder:

Relaxation of its wall and contraction of **sphincter of Oddi** → retention of bile

3. Spleen:

Contraction of **smooth muscles in splenic capsule and trabeculae** → pouring of about 250 ml of stored blood into the general circulation.

4. Pancreas:

- It inhibits **both endocrine and exocrine pancreatic secretion.**

5. Kidneys:

- It decreases renal blood flow.
- **It decreases urine output.**

6. Suprarenal medulla

- It releases large quantities **of adrenaline (80%) and noradrenalin (20%)** into the circulating blood.
- In stress conditions, **SRM** acts together with **sympathetic nervous system** (**sympatho-adrenal system**).

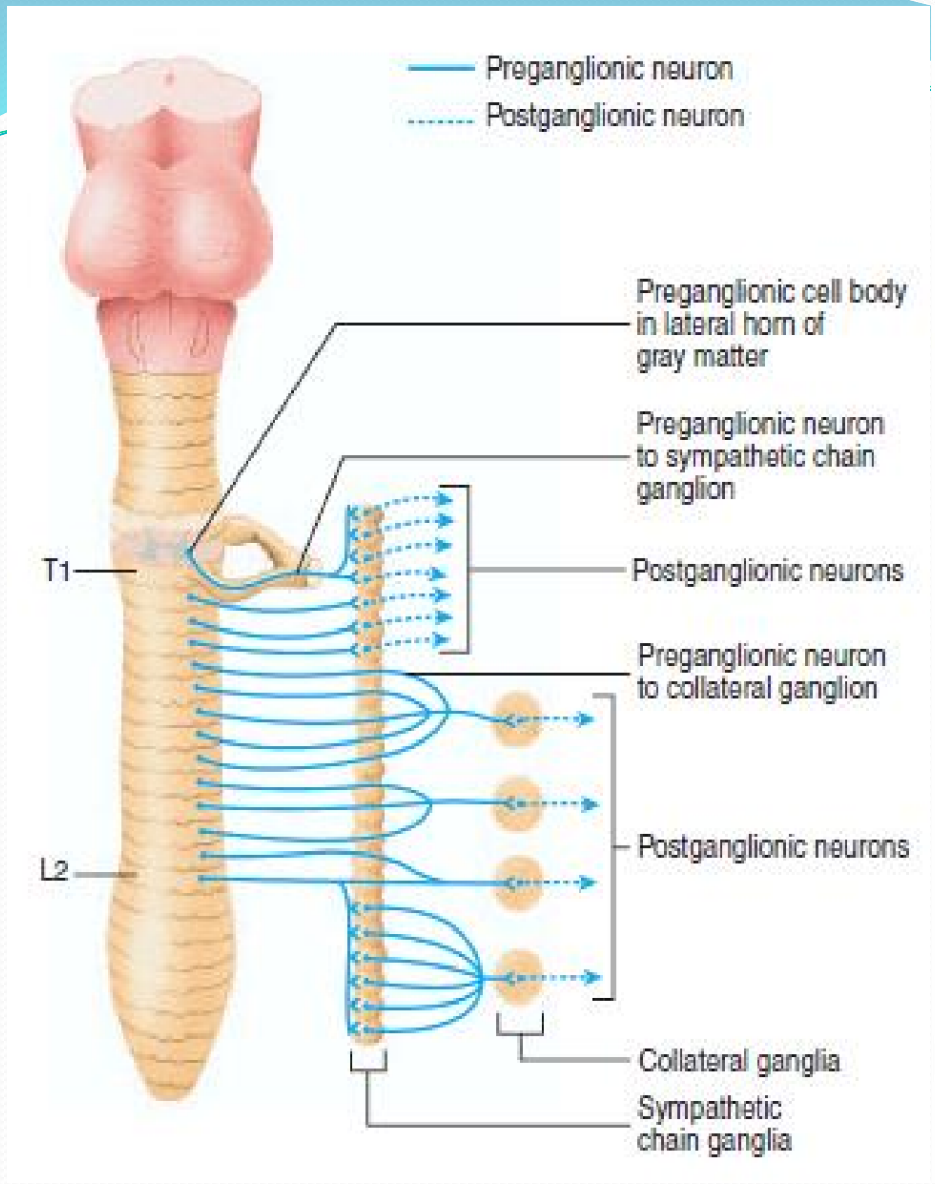
D) Sympathetic Supply to Pelvis:

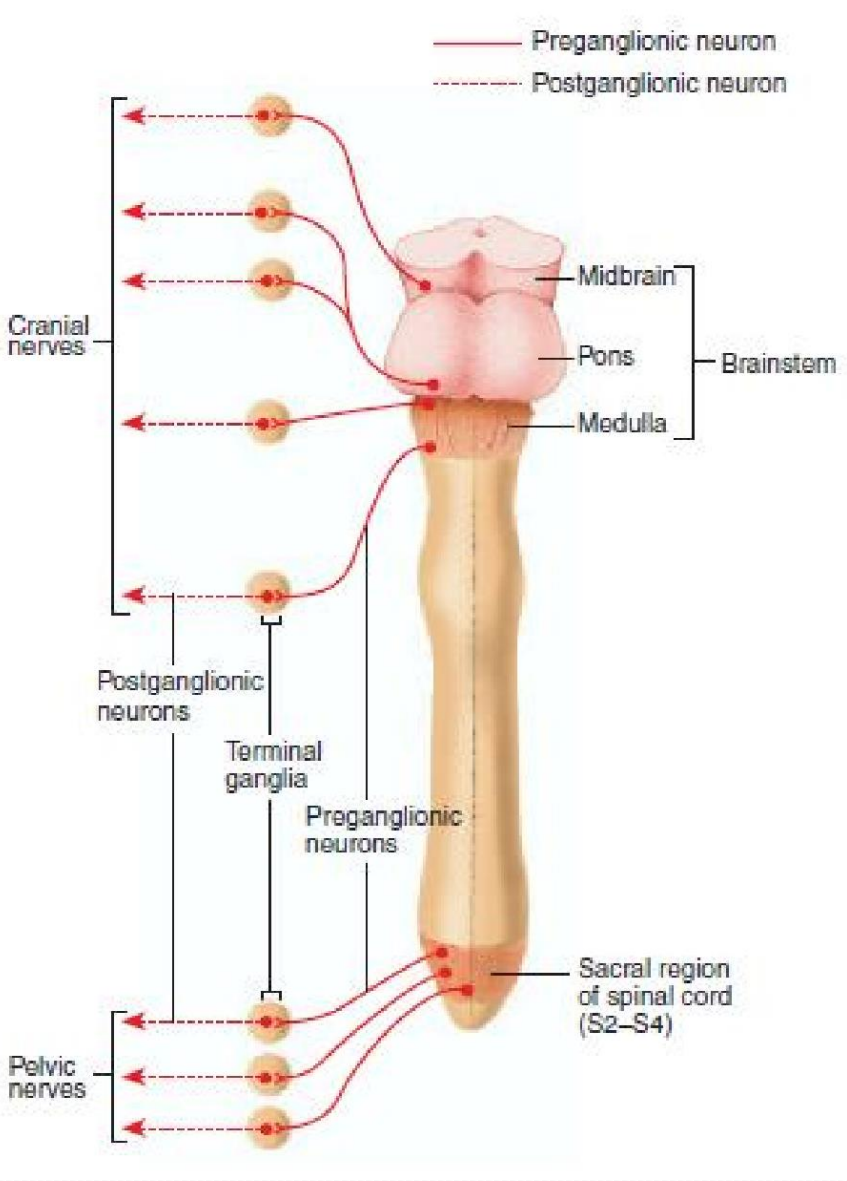
Origin:

- **LHCs of L1, L2, and L3 segments of spinal cord.**

Functions:

1. **Urinary bladder:** **causes relaxation of its wall and contraction of internal** urethral sphincter → retention of urine.
2. **Rectum:** causes relaxation of its wall and contraction of internal anal sphincter → **retention of faces.**
3. **Sex organs**
   I. It causes contraction of smooth muscle of seminal vesicle, **vas deferens and ejaculatory duct → ejaculation of semen.**
   II. It causes VC of blood vessels of pelvic viscera → **shrinkage of external sex organs e.g. penis.**





sympathetic (a) and parasympathetic (b) division16 s of autonomic nervous system

(II) Functions of Parasympathetic NS

A) Cranial part

1) Oculomotor nerve:

Origin:

- **From midbrain.**

Functions:

a. Causes contraction of constrictor pupilae muscle → **narrowing of pupil (miosis)**

b. Causes contraction of ciliary muscle → **helps eyes to see near objects**

2) Facial Nerve

Origin:

- From Pons

Functions:

1. **Lacrimal glands: i) Vasodilatation. ii) Secretion of tears.**
2. **Submandibular and sublingual salivary glands**:

I. Vasodilatation.

II. **True salivary secretion (large in volume, watery, rich in electrolyte and poor in enzymes).**

3) Glossopharyngeal Nerve:

Origin:

From medulla oblongata.

Functions:

1. Parotid salivary gland

i) Vasodilatation. ii) True salivary secretion.

A) Vagus (wandering) Nerve:

Origin:

From the medulla oblongata.

Functions:

A) Thorax:

a) Heart:

I. It decreases the heart rate, and force of contraction
II. vasoconstriction of coronary vessels

b) Lungs:

I. Causes **bronchoconstriction.**

II. **Increases the mucus secretion of the air passages.**

B) Abdomen:

a) GIT

• It **causes contraction of their walls and relaxation of their sphincters**.

b) Glands

- Gastric glands→ ↑es gastric juice secretion (rich in HCL).
- Pancreas: **stimulates both endocrine and exocrine components**

c) Liver:

• It **increases hepatic bile flow.**

d) Gall bladder:

• Contraction **of its wall and relaxation of sphincter of Oddi** → helps its evacuation.

e) Blood vessels:

• **Vasodilatation.**

B) Sacral part or outflow: (Pelvic Nerve)

Origin:

- Sacral segments (2nd, 3rd, 4th) of spinal cord.

Functions:

1) Urinary bladder

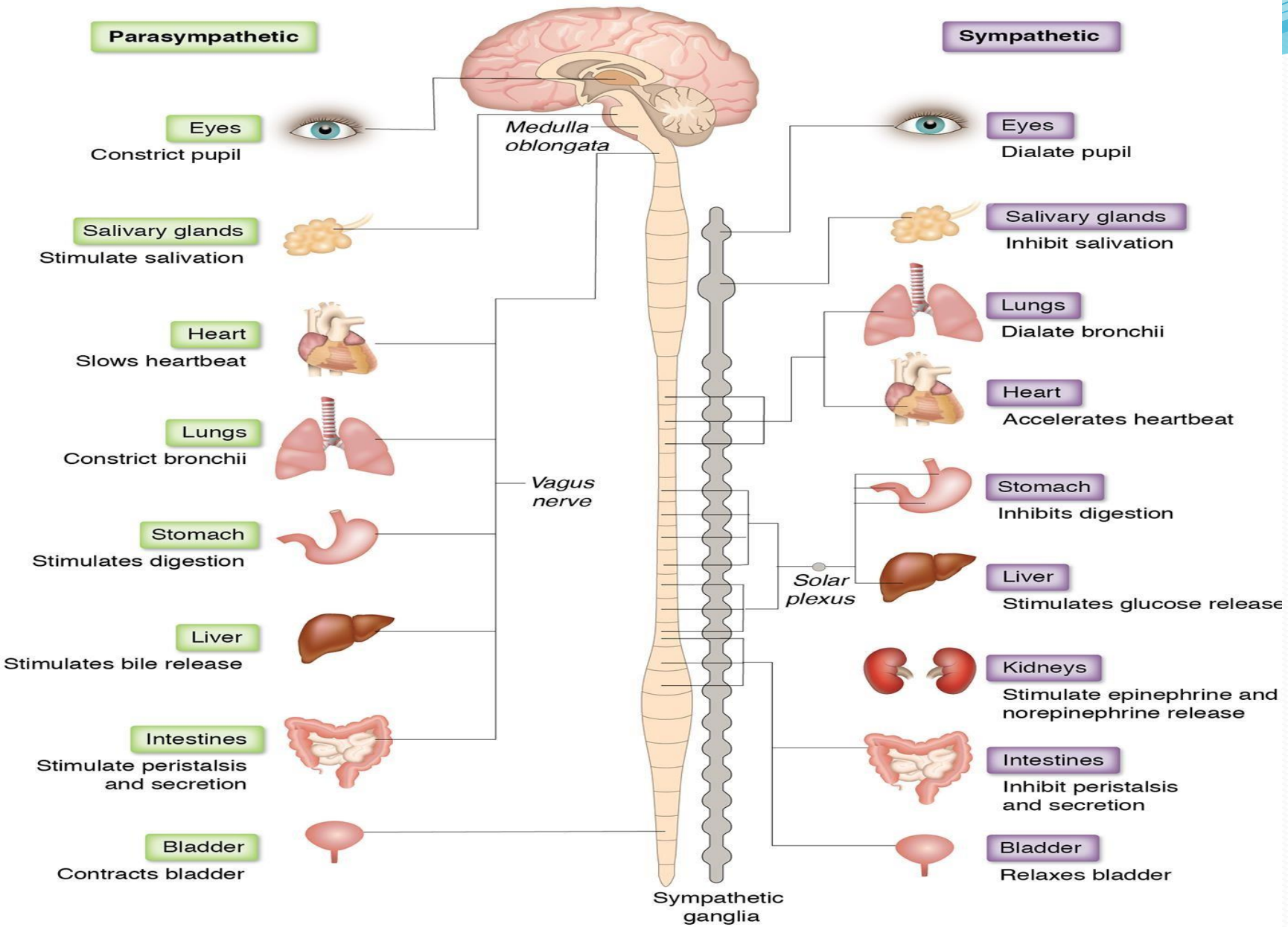
- It causes contraction of its wall and relaxation of internal urethral sphincter → micturition.

2) Rectum

- It causes contraction of its wall and relaxation of internal anal sphincter → defecation.

3) Sex organs

- It causes VC of blood vessels of pelvic viscera → erection of the external sex organs e.g. penis



Summary of the functions of sympathetic and parasympathetic N.S.

Chemical Transmission

Definition

Synapse is **the functional connection between a neuron and second neuron**

Types of Synapses:

- Two main types of chemical transmitters released by autonomic nerve endings:
  I. **Acetylcholine**
  II. **Noradrenaline**

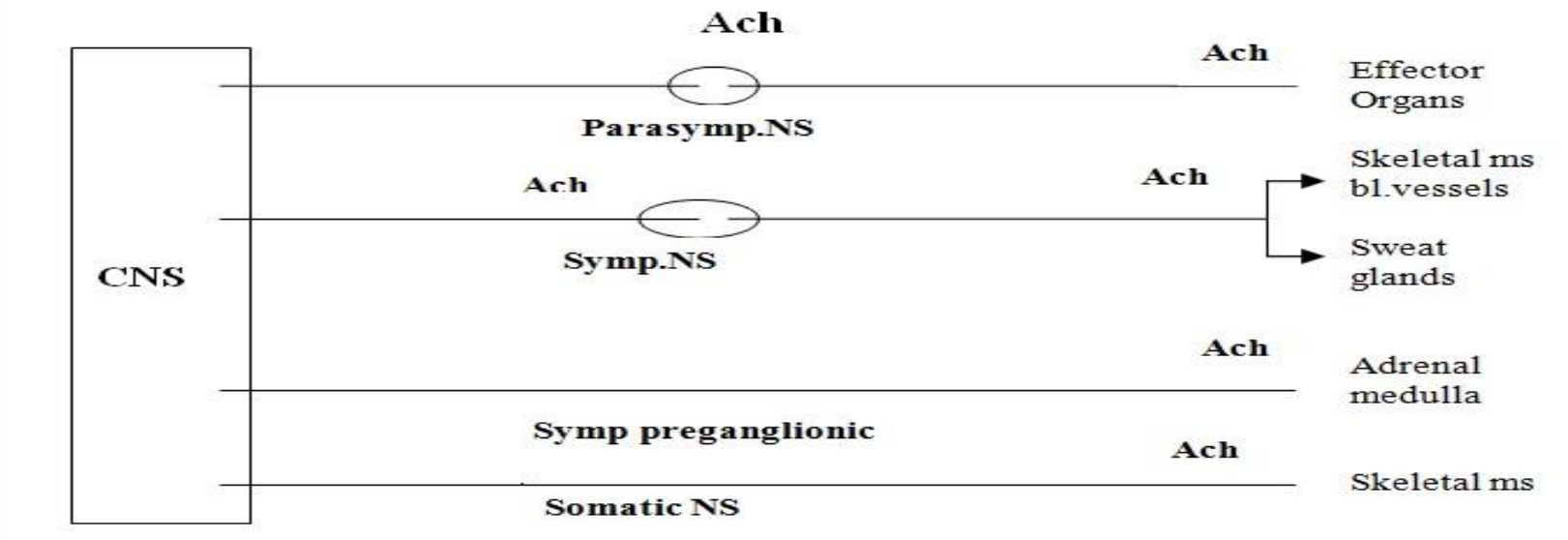
Accordingly, there are two types of autonomic nerve fibers,

1. Cholinergic nerve fibers: **secrete acetylcholine.**
2. Adrenergic nerve fibers: **secrete noradrenalin.**

Cholinergic Transmission

A) Sites of release of Acetylcholine

1. All **preganglionic** sympathetic and parasympathetic NS nerve endings.
2. Preganglionic sympathetic nerve fibers **to suprarenal medulla**.
3. All postganglionic parasympathetic nerve ending.
4. **Somatic motor nerve ending** to skeletal muscle (motor end plate).
5. Some synapses at CNS (**brain and spinal cord).**



sites of release of acetylcholine

Cholinergic Receptors

Definition

They are the receptors which respond to Ach.

Types:

Muscarinic and nicotinic receptors of acetylcholine

	i)Muscarinic receptors	ii) Nicotinic receptors
Site	**Present on smooth muscles and glands**	Present in autonomic ganglia and neuromuscular junction
Types	M1, M2, M3, M4 and M5	**Nn (nicotinic neuronal) and Nm (nicotinic muscular)**

	Muscarinic receptors (M-receptor)	Nicotinic receptors (N-receptor)
Locations	smooth muscle, gland and cardiac muscle • M--- smooth muscle、gland • M1-- ganglia、gland • M2--- heart	skeletal muscle-- motor ending-plate (N2 N2), ganglia-postsynaptic membrane(N1),
Effect	inhibiting the cardiac muscle, exciting the smooth muscle & gland	N2:exciting skeletal muscle , N1 exciting the postsynaptic neuron in ganglia
Antagonist	Atropine	N1:hexamethonium N2:decamethonium

Adrenergic Transmission

- **Noradrenaline and adrenaline are called catecholamines and released from**

Sites of release of catecholamines:

1. **Postganglionic sympathetic fibers**
2. Some synapses in CNS.
3. **Suprarenal medulla: adrenaline (80%) and noradrenaline (20%).**

Adrenergic Receptors

Definition: are the receptors which respond noradrenaline and adrenaline.

Types :

They are classified into 2 major types:

i) α (Alpha) adrenergic receptors (mostly excitatory)

They include many subtypes;

- **α 1 receptors**
- **α 2 receptors**

ii) β (beta) adrenergic receptors (mostly inhibitory)

They are further subdivided into:

β1, β2, β3, β 4, β 5 receptors

Receptor	Major Effector Tissues	Major Functions
$Alpha_1$	SM, sphincters	Contraction (constriction),
$Alpha_2$	Nerve endings	↓ Transmitter release
$Beta_1$	Cardiac muscle, Kidney	↑Heart rate and force, ↑Renin secretion
$Beta_2$	SM including bronchi Liver Skeletal muscle	Relax SM ↑ Gluconeogenesis, glycogenolysis ↑ Glycogenolysis and K+ uptake
$Beta_3$	Adipose	↑ Lipolysis
DA_1	SM especially renal, mesenteric and cardiac	Relax renal vascular SM (higher doses activates β1 and α1 receptors)

Which is the number of spinal cord segments?

20 (a

31 (b

12 (c

40 (d

15 (e

Enumerate types of neurons

Answer

a. Afferent (sensory) neuron→ carries impulses from receptors to CNS.

b. Efferent (motor) neuron→ carries impulses from CNS to effector organs.

c. Interneuron (associative) →located entirely within CNS.

Define autonomic ganglia and mention its function and types

Answer

Def,

- They are collection of cell bodies of neurons outside the central nervous system (CNS).

Functions:

- Act as a **relay station** for **autonomic preganglionic** nerve fibers

Types of ganglia

a) Lateral (paravertebral) ganglia:

- **Located on either side of the spinal cord.**
- **About 22-24 ganglia on each side.**
- **Form 2 rows of sympathetic chain of ganglia.**
- **Act as a relay station for preganglionic sympathetic nerve fibers only.**

b) Collateral (prevertebral) ganglia:

- **Present mainly in the abdomen, midway between spinal cord and viscera.**

Act as a relay station for sympathetic preganglionic nerve fibers.

c) Terminal ganglia:

- **Present close to or at the wall the effector organs especially rectum; urinary bladder reproductive organs in the pelvis.**
- **Act as a relay station of:**
  - **All parasympathetic preganglionic fibers.**
  - **Some sympathetic preganglionic fibers.**

Which is a function of sympathetic nervous system to head and neck?

Decreased sweat secretion (a

Vasodilatation of skin blood vessels (b

Watery salivary secretion (c

Mydriasis(dilatation of eye pupil) (d

Ptosis of eye lid (e

Which is a function of sympathetic to thorax?

Vasoilatation of pulmonary vessels (a

Bronchoconstriction (b

Increased effectiveness of the heart as a pump (c

Increased bronchial secretion (d

Vasoconstriction of coronary vessels (e

Which is a function of sympathetic supply to abdomen?

a-Relaxation of Gastrointestinal walls and contraction of the sphincters

b-↑es gastric juice secretion (rich in HCL).

c-stimulates both endocrine and exocrine componentsof pancreatic secretions .

d-It increases hepatic bile flow.

E- Contraction of wall of gall bladder and relaxation of sphincter of Oddi → helps its evacuation.

Mention function of sympathetic supply to pelvis and kidneys

To pelvis

Origin:

- LHCs of L1, L2, and L3 segments of spinal cord.

Functions:

1. **Urinary bladder:** causes relaxation of its wall and contraction of internal urethral sphincter → retention of urine.
2. **Rectum:** causes relaxation of its wall and contraction of internal anal sphincter → retention of faces.
3. **Sex organs**
   - I. It causes contraction of smooth muscle of seminal vesicle, vas deferens and ejaculatory duct → ejaculation of semen.
   - II. It causes VC of blood vessels of pelvic viscera → shrinkage of external sex organs e.g. penis.

To kidneys

- It decreases renal blood flow.
- It decreases urine output

Mention origin and parasympathetic functions of facial nerve

Answer

Facial Nerve

Origin:

- From Pons

Functions:

1. **Lacrimal glands:** i) Vasodilatation. ii) Secretion of tears.
2. **Submandibular and sublingual salivary glands**:

I. Vasodilatation.

II. True salivary secretion (large in volume, watery, rich in electrolyte and poor in enzymes).

Which is the parasympathetic nerve which (a supply the thoracic and abdominal organs?

(a Glossopharyngeal

(b Vagus

(c Oculomotor

(d Pelvic

(e Sciatic

Mention functions of parasympathetic nervous system to abdomen

Answer:Abdomen:

a) GIT

• It causes contraction of their walls and relaxation of their sphincters.

b) Glands

- **Gastric glands→ ↑es gastric juice secretion (rich in HCL).**

Pancreas: stimulates both endocrine and exocrine components pancreatic secretions .

c) Liver:

• It increases hepatic bile flow.

d) Gall bladder:

• Contraction of its wall and relaxation of sphincter of Oddi → helps its evacuation.

e) Blood vessels:

• Vasodilatation.

Which is the autonomic parasympathetic receptors present in smooth muscles and glands?

Adrenergic B1 receptors (a

Cholinergic nicotinic receptors (b

Adrenergic alpha 1 receptors (c

Adrenergic B2 receptors (d

Cholinergic muscarinic receptors (e

Which is the autonomic receptors which its stimulation leads to increased heart rate and force?

Adrenergic B2 (a

Adrenergic alpha2 (b

Cholinergic nicotinic (c

Adrenergic B1 (d

Cholinergic Alpha 1 (e

Which is the autonomic receptors which its stimulation leads to contraction of sphincters?

Cholinergic muscarinic (a

Adrenergic Alpha 1 (b

Adrenergic alpha2 (c

Cholinergic nicotinic (d

Adrenergic B2 (e

Thank

You