Autonomic Nervous System

By

Dr. Nour A. Mohammed

Associate professor of physiology
Faculty of Medicine, Mutah University

2024-2025

Divisions of autonomic N.S.

- **Sympathetic nervous system**

  Arising from the lateral horn cells of all the thoracic segments and the upper two lumbar segments. So, it is called the thoraco-lumbar outflow

- **Parasympathetic nervous system**

  Arising from 2 distant parts

  (a) From some cranial nerves, i.e. III.VII. IX & X

  (b) From the lateral horn cells of the 2nd , 3rd and 4th sacral segments of the spinal cord. So, it is called the cranio-sacral outflow.

The functions of the A.N.S

- **Prepare the body to face emergencies (stresses).**
- **Regulate the process of food digestion.**
- **Regulation of the body temperature.**
- **Regulation of heart rate, blood pressure.**
- **Control some hormonal secretion as catecholamines.**
- **Regulation of vital excretory processes as micturition & defecation.**

The autonomic nervous system includes two types of fibers

- **Afferent fibers:**

  which carry sensations from viscera to the C.N.S.

  This system is widely distributed

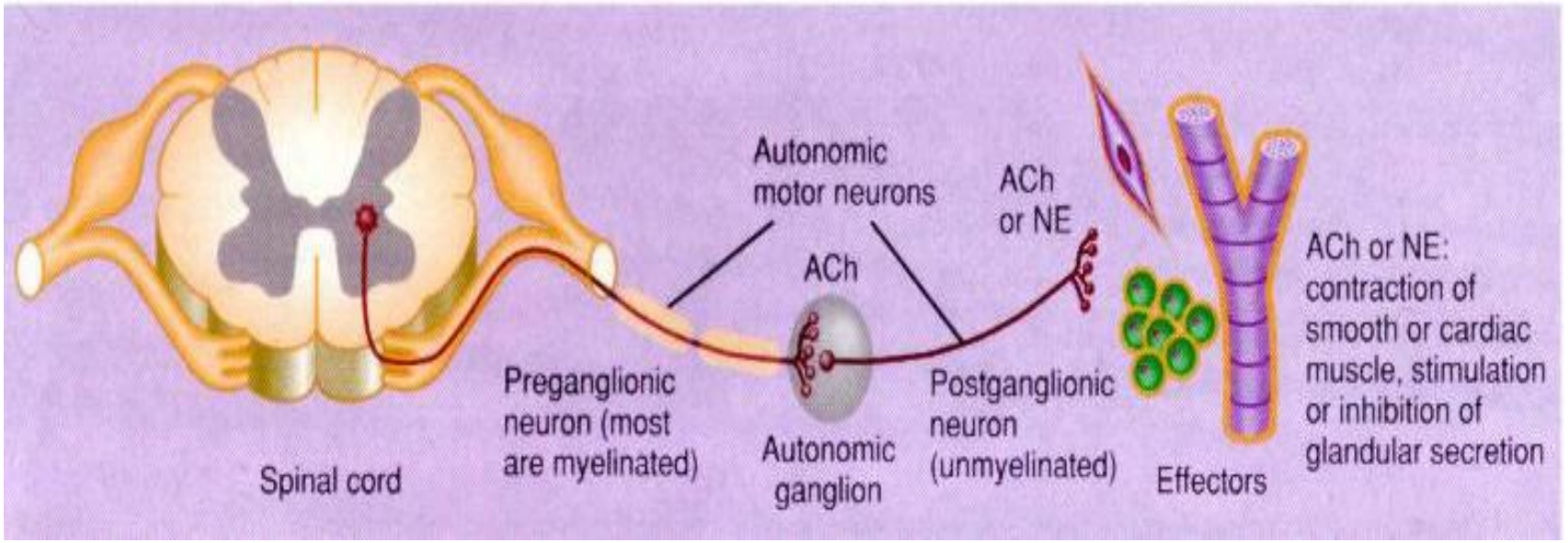
- **Efferent fibers**

  which emerges from the C.N.S. to reach visceral

  organs and the smooth muscle

- Autonomic N.S. has **2 Efferent** neurons:

	Pre-ganglionic fiber	Post-ganglionic fiber
Cell body	In spinal cord or brain stem.	In autonomic ganglia.
Axon	From CNS to ganglia.	From ganglia to organs.
Type	B & Myelinated & White (**BMW**)	C & Unmyelinated & Gray



Autonomic ganglia

- **Definition**

A ganglion is a collection of nerve cells outside the C.N.S surrounded by connective tissue capsule. It contains the nerve fibre of the pre-ganglionic neurons and cells of the post-ganglionic neurons

Types of autonomic ganglia

- **Lateral (Paravertebral)**

form the sympathetic chains lying on both sides of the vertebral column

Each chain is formed of 23 ganglia connected to each other by nerve fibers i.e. 3 cervical (superior, middle and inferior), 12 thoracic, 4 lumbar and 4 sacral ganglia.

Sometimes, the inferior cervical ganglia fuses with the upper thoracic one to form the "stellate ganglion"

Lateral ganglia are only sympathetic.

Collateral (Prevertebral)

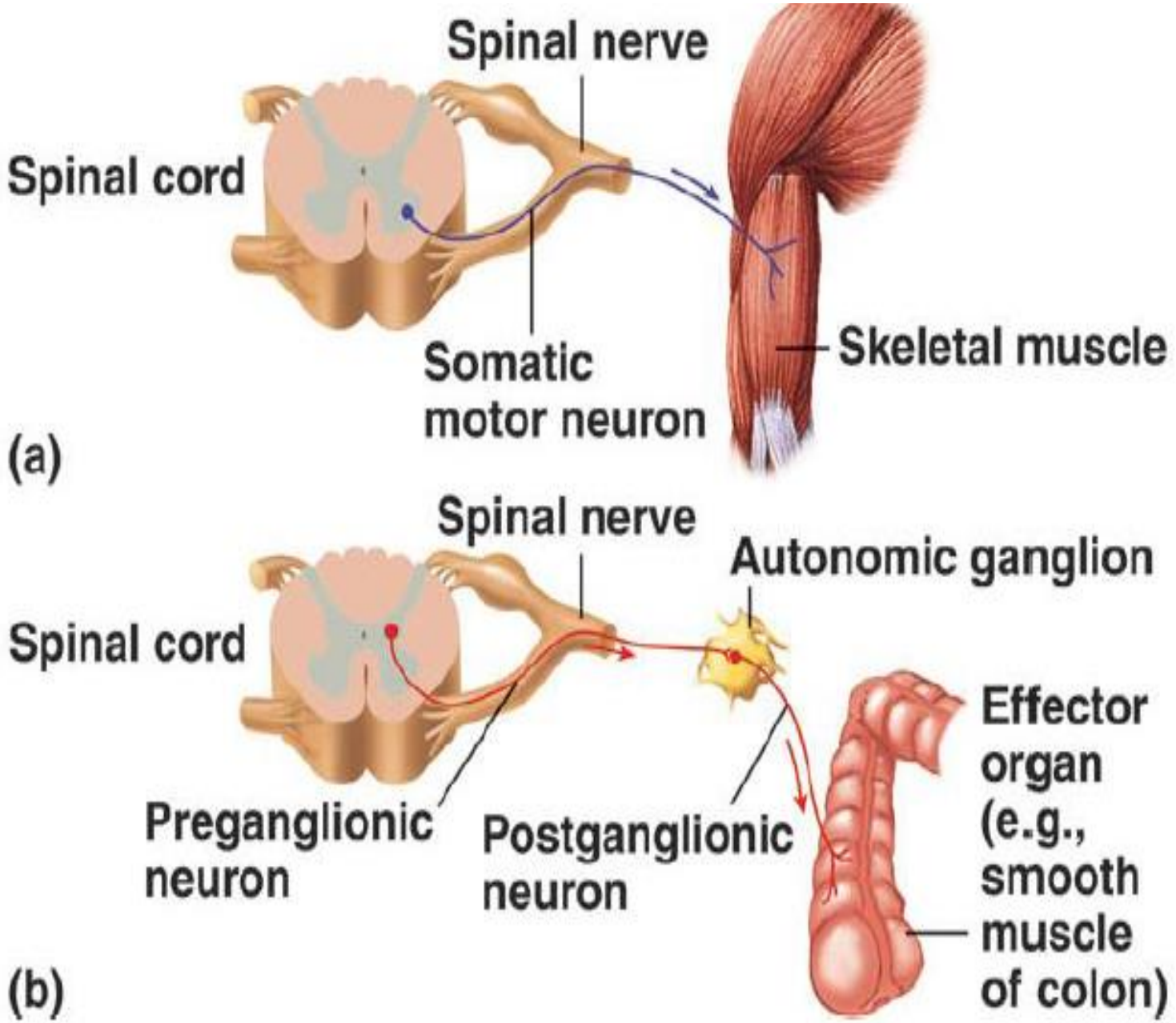
- These are the celiac, the renal, the superior and inferior mesenteric ganglia (sympathetic) and otic, ciliary, sphenopalatine and submandibulare ganglia (parasympathetic).

Terminal (Peripheral)

- They are present near or in the wall of the autonomic organ, e.g. the eye, the heart, the stomach and the urinary bladder.
- Terminal ganglia are only parasympathetic

Difference between autonomic & somatic nerves

	Somatic nerves	Autonomic nerves
Function	Control voluntary or skeletal muscles.	Control involuntary organs.
Cell body	1 neuron: present in anterior horn cells. (AHCs)	2 neurons: 1st preganglionic present in lateral horn cells. (LHCs). 2nd postganglionic present in ganglion
Axon	Reach the muscle directly.	Reach the organs via ganglia.
Impulses	Always carry excitatory impulses.	Carry excitatory or inhibitory impulses.


Spinal nerve
Spinal cord
Somatic motor neuron
Skeletal muscle
(a)
Spinal nerve
Autonomic ganglion
Spinal cord
Preganglionic neuron
Postganglionic neuron
Effector organ (e.g., smooth muscle of colon)
(b)

Distributions of the sympathetic system

- **[A] Cervical division**

which supplies structures in the head and neck

Preganglionic fibers

arise from the upper 2 thoracic segments and relay in the superior cervical sympathetic ganglion.

Postganglionic fibers

follow the course of carotid arteries to:

1-Eye

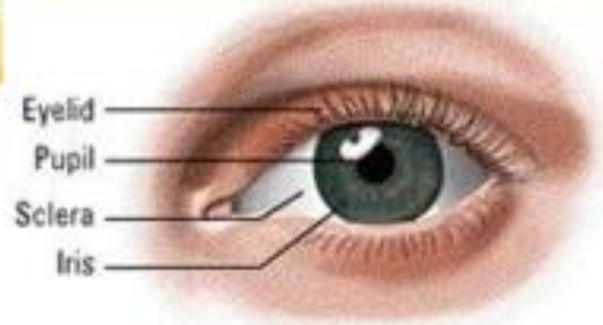
- **Motor to dilator pupillae muscle → mydriasis (dilatation of the pupil)**

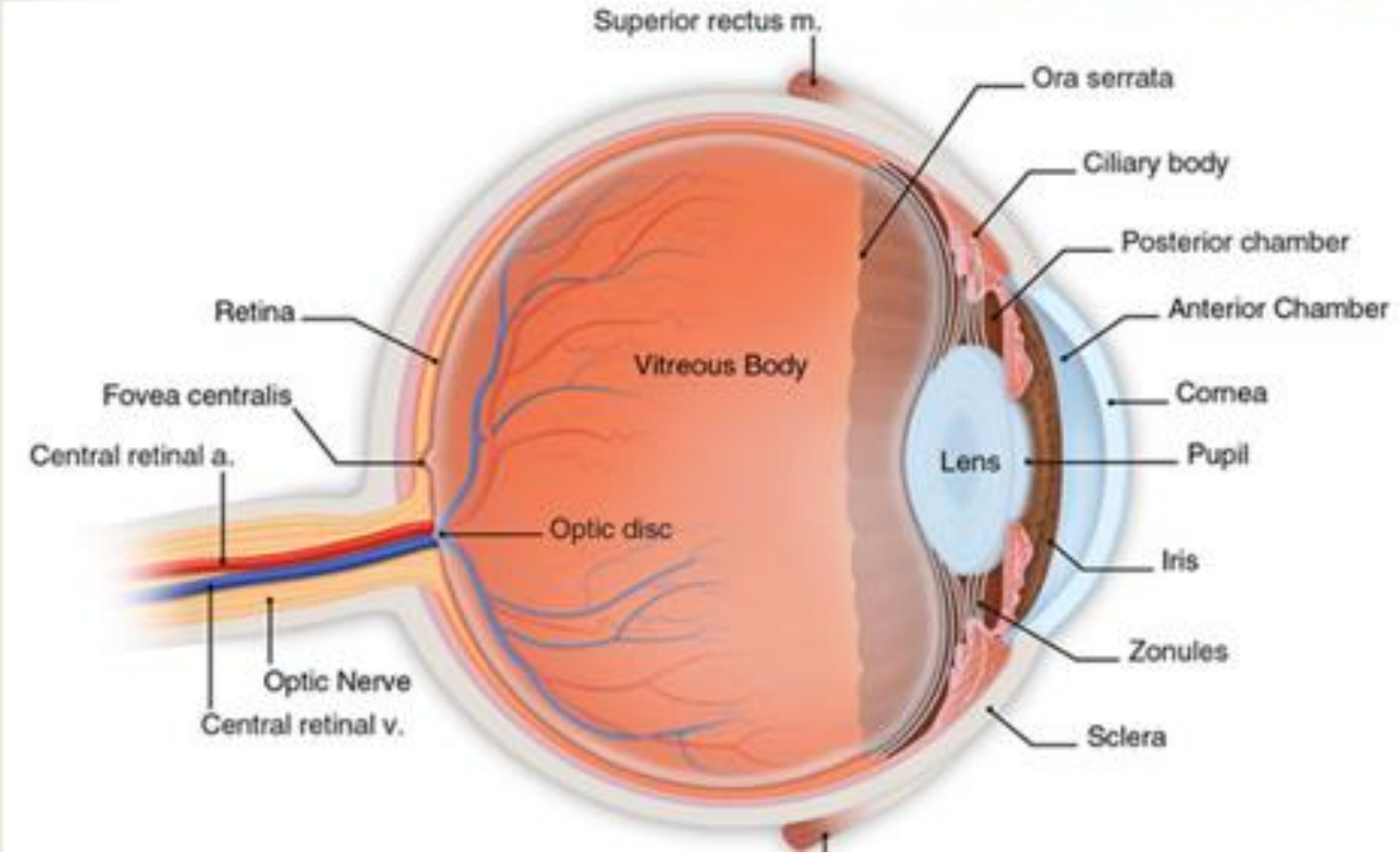
- **Motor to the superior and inferior tarsal muscles → widening of the palpebral fissure. Thus widening the field of vision.**

- **Motor to Muller's muscle (in animals) → exophthalmos (forward protrusion of the eye ball)**

- **Relaxation of the ciliary muscle, decreasing the power of the lens to prepare the eye for far vision.**

1-Eye:


Eyelid
Pupil
Sclera
Iris


Superior rectus m.
Ora serrata
Ciliary body
Posterior chamber
Anterior Chamber
Retina
Vitreous Body
Cornea
Fovea centralis
Central retinal a.
Lens
Pupil
Optic disc
Iris
Zonules
Optic Nerve
Central retinal v.
Sclera

2-Glands

- Lacrimal glands : little secretion of tears and vasoconstriction.

- Salivary glands: **trophic** secretion (small in amount, viscid and concentrated) from the submaxillary gland.

3-Skin

- Sweat glands : copious secretion eccrine glands

- Erector pilae muscles→ erection of hair .
- Bloods vessels vasoconstriction.

4-Cerebral vessels

- Mild vasoconstriction. Still during sympathetic excitement, cerebral blood flow increase due to the rise in arterial blood pressure.

Horner's Syndrome

- This occurs due to damage of the **superior cervical sympathetic ganglion** either experimentally or by disease. This leads to:

- **1-Ptosis**

  Drop of upper eye lid, due to paralysis of superior tarsal muscle

- **2-Miosis**

  pupillo-constriction, due to paralysis of the dilator pupillae muscle. The constrictor pupillae muscle acts unantagonized

- **3-Enophthalmos**

  Inward sinking of the eyeball in the orbit due to paralysis of Muller's muscle (in animals).

- **4-Anhydrosis**

  Dryness of the skin due to absence of sweat secretion on the affected side

- **5-Vasodilatation**

  In the affected side, so appearing more red than the normal side. This is due to the absence of the sympathetic vasoconstrictor tone to the skin vessels.

[B] Cardiopulmonary (thoracic) division

To thoracic structures

- **Preganglionic fibers**
  - **Arise from the upper 4 thoracic segments. They relay in the cervical and upper 4 thoracic ganglia**
- **Postganglionic fiber**
  - **Form the superficial and deep cardiopulmonary plexuses which supply:**

1-The heart

a- They stimulate all the properties of the cardiac muscle (contractility, rhythmicity, conductivity and excitability) and increase its metabolism & O_2 consumption .

b- Coronary vessels: Direct effect is vasoconstriction, but coronary vessels dilate due to increased metabolism of the heart that decrease O2 concentration (indirect effect). The metabolites itself cause direct dilatation

2-The Lung

a-Bronchi

Bronchodilation and inhibition of bronchial secretions.

b- Pulmonary vessels

vasoconstriction
(**VC**)

This widens the air passages lead to better ventilation

[C] Splanchnic division

to abdominal and pelvic viscera

- **Abdominal division**
  - **Preganglionic fibers:**

    Arise from the **lower 8 thoracic segments** and pass without relay in sympathetic chain to form

    The **greater splanchnic nerves**

    relay in celiac, renal and superior mesenteric ganglia

  - The postganglionic fibers supply

1-Gastrointestinal tract (GIT):

Relaxation of the wall, but constriction of the sphincters. Leading to delayed evacuation of food.

2-GIT secretions inhibition

3-The splanchinic vessels

- vasoconstrictor and vasodilator the effect is mainly vasoconstriction)

4-The spleen

- Motor to smooth muscle fibers of the capsule and trabeculae → 250 mL of stored blood is poured into the circulation. This action is more prominent in animals

5-The liver

- To stimulate metabolism ,glycogenolysis with increase blood glucose level , lipolysis with elevation of the blood lipid level and dilatation to its vessels.

6-The endocrine pancreas

- Usually inhibition of insulin secretion.

7- The Kidney

- Vasoconstriction of renal blood vessels, decreased renal blood flow, decreased urinary output and stimulation of renin secretion.

The adrenal medulla

- **Preganglionic fibers**

- **secretion of catecholamines, adrenaline (80%) and noradrenaline (20%) hormones**

- **The released adrenaline stimulates lipolysis, thermogenesis and enhances blood clotting by releasing blood clotting factors from the liver. It stimulates the reticular formation of the brainstem → increased alertness with lack of sleep (insomnia)**

- **Modified sympathetic ganglia**

- Pelvic division

- **The Preganglionic fibers**

fibers arise from upper 2 lumbar segments and pass without relay to form

lesser splanchnic nerves

The lesser splanchnic nerves on both sides unit to form the **presacral nerve** which **relay** in the **inferior mesenteric ganglion.**

- **The postganglionic fibers supply**

- **The urinary bladder**

inhibitory to the wall and motor to the internal urethral sphincter

→ retention of urine

- **The rectum**

inhibitory to the wall and Motor to the internal anal sphincter

→ retention of feaces

Desire of micturition and defecation disappear

- **The sex organs**

In female It is mainly **inhibitory** on uterus and fallopian tubes, **but** late in pregnancy it is excitatory to the uterus

In male It is mainly **excitatory** on the smooth muscles of epididymis, vas deferens, seminal vesicles and prostate motor fibers with emission of semen during sexual intercourse leading to **ejaculation**.

[D] Somatic division

- **sympathetic supply to skin and blood vessels of skeletal muscles**

  - **To the upper limbs**

Preganglionic fibers arise from **the 4th to 8th thoracic segments**, relay in the lower cervical and upper 4 thoracic ganglia. Postganglionic fibers join the brachial plexus.

- **To the lower limbs**

Preganglionic fibers arise from **10th thoracic to 2nd lumbar** segment, relay in the lumbar and sacral ganglia. Postganglionic fibers join the lumbar plexus

Fibers going to the skin supply

- **Sweat glands**

  Eccrine copious secretion. i.e. found in skin all over the body

  Apocrine thick odoriferous secretion.. i.e. found in axilla and genital areas

- **Cutaneous blood vessels** vasoconstriction

- **Erector pilea muscles** Contraction

→ piloerection, i.e. hair erection. This is more prominent in animals like cats during fighting or cold whether.

Fibers going to the skeletal muscles supply:

- **1-Blood vessels of skeletal muscles causing vasodilatation**
- **2-This vasodilatation increases the blood flow and stimulates metabolic processes needed for energy production leading to increase power of contraction, delay of fatigue and early recovery after exhaustion**
- **This effect is known as "Orbelli phenomenon"**

General function of sympathetic N.S

I-During rest

It causes sympathetic tone on the blood vessels leading to continuous mild vasoconstriction to maintain the blood pressure.

Sympathetic tone to the Adrenal medulla

Maintains basal amount of catecholamine secretion in blood.

& this is important for regulation of blood pressure & blood glucose level.

II-In emergency conditions (The alarm or Stress response)

In cases of fight, flight, muscular excitement occurs to help the person to face the emergency with a better performance.

- Acceleration of the heart: to supply blood to active tissues.
- Vasoconstriction in inactive regions, skin and splanchinic area to divert more blood to active regions e.g. muscles, heart .
- Dilatation of bronchi; facilitating pulmonary ventilation.
- Contraction of spleen: to give more RBCs to carry more oxygen to the active tissues

II-In emergency conditions (The alarm or Stress response)

- Sweat secretion: to get rid of the excess heat by evaporation
- Delay muscle fatigue (Orbelli phenomenon)
- Glycogenolysis: supplying glucose to the active tissues for energy production .Also, lipolysis.
- Adrenal medulla is stimulated to secrete adrenaline and noradrenaline to aid and intensify all the above reaction. Adrenaline stimulates the brain to increase alertness and shorten response time.
- Increase field of vision

II-In emergency conditions (The alarm or Stress response)

- Clotting of the blood is enhanced for more effective hemostasis
- Inhibition of gastrointestinal activities, defecation and micturition.
- All these factors lead to shift of blood from inactive areas as the skin and the gastrointestinal tract to active contracting muscles and heart to enable the body to face emergencies.

Thanks