





Physio L1 : Functional organisation of the human body

- Outlines:

1. Definition of physiology
2. Composition of the human body
3. Organisation of the human body
4. Body water & its distribution

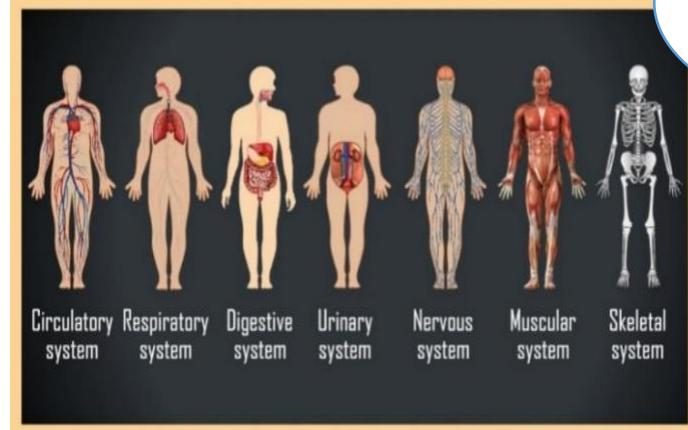
- Human physiology:

It is the science concerned with studying the **normal functions** of the different parts of the human body and to **explain mechanisms** that keep the human being **alive**

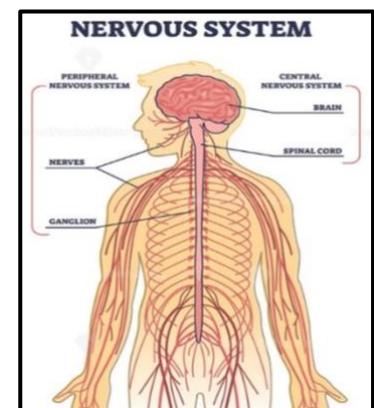
Organisation of the human body:

Cell > Tissue > Organs > System > Body

- Body systems:



*Each of the body systems is formed of a group organs



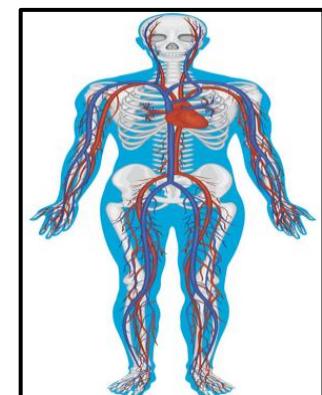
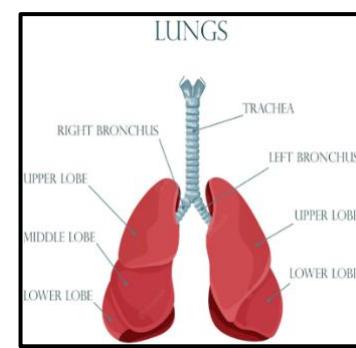
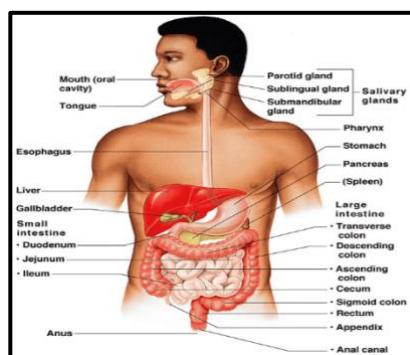
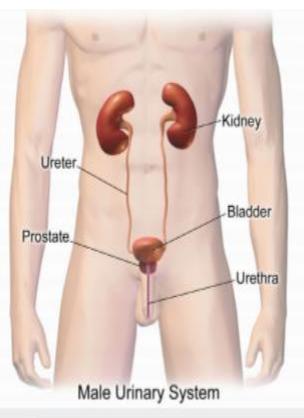
-Nervous system is formed of brain , spinal cord and nerves

-Cardiovascular system is formed of heart and blood vessels

-Respiratory System is formed of nose, pharynx, larynx, trachea, bronchi, bronchioles and alveoli.

-Gastrointestinal (digestive) system is formed of mouth, pharynx, esophagus, stomach, small intestine and large intestine.

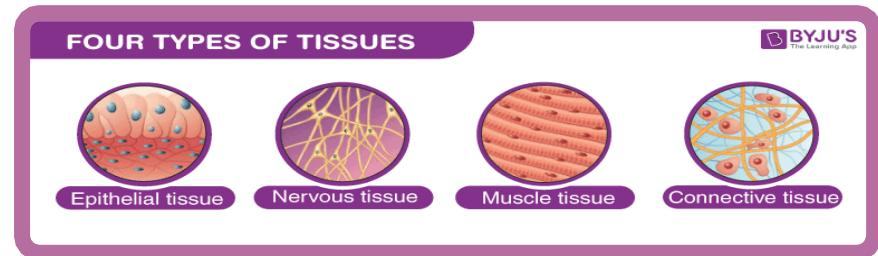
-Urinary system is formed of;2 kidneys, 2 ureters, urinary bladder and urethra.





- **Tissues:** Each of the body organs is formed of a group of tissues. Tissues may be:

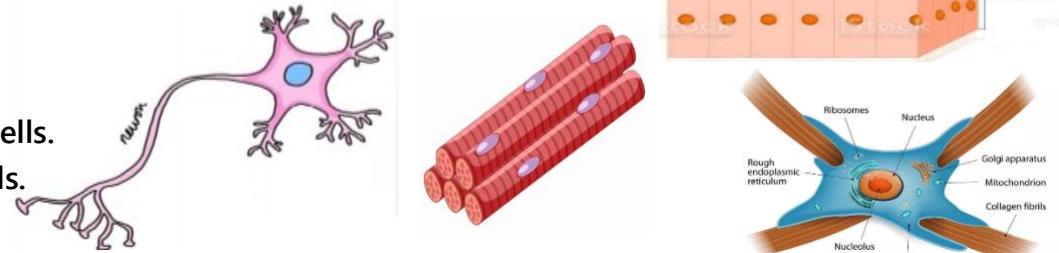
- Nervous tissue.
- Muscular tissue.
- Fibrous tissue.
- Connective tissue.
- Epithelial tissue.



- **Cells:** The cells is the basic living unit of the human body.

Each of the body tissues is formed of a group of cells. Cells may be:

- Nerve cells.
- Muscle cells.
- Connective tissue cells.
- Epithelial tissue cells.

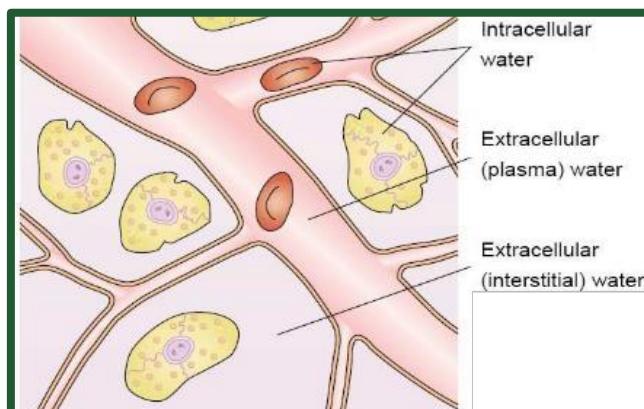
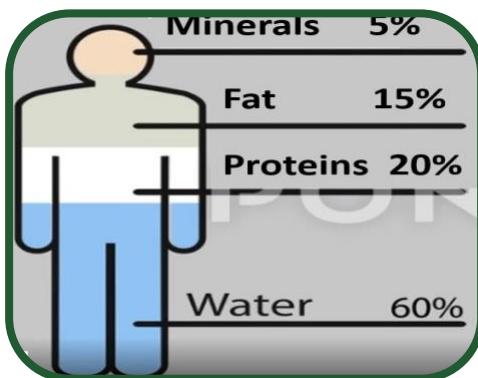
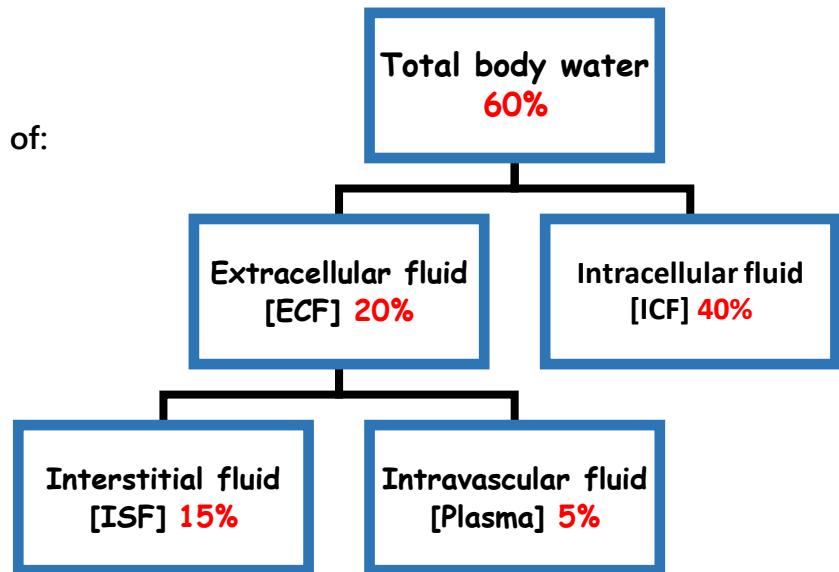


The human body contains about 100 trillion cells that work together for the maintenance of the living organism.

Composition of the human body

In average adult male, the body is composed of:

Water	60%
Protein	20%
Fat	15%
Minerals	5%
Carbohydrates	Very little





Normal variation of body water:

- Body water is **more** in infants and children (about 75% of body weight).
- Body water is **less** in old age (about 45% of body weight).
- Body water is **less** in females (about 50% of body weight) due to high fat content as body fat is relatively free of water.
- Body water is **less** in obese person.

• NB: The increase of total body water in children is mainly in ECF.

As ECF is easier to be lost in dehydration ,thus dehydration develops **more rapid** and **more sever** in children than adults

Cations	ECF	ICF
Na ⁺	140 mEq/L	14 mEq/L
K ⁺	4 mEq/L	140 mEq/L
Ca ⁺⁺	2.4 mEq/L	0.0001 mEq/L
Mg ⁺⁺	1.2 mEq/L	58 mEq/L
Anions		
Cl ⁻	104 mEq/L	4 mEq/L
HCO ₃ ⁻	28 mEq/L	10 mEq/L
Po ₄ ⁻⁻⁻	4 mEq/L	75 mEq/L
Proteins	2 mg%	16 mg%

The main cation in ICF is **K** and in ECF is **Na**.

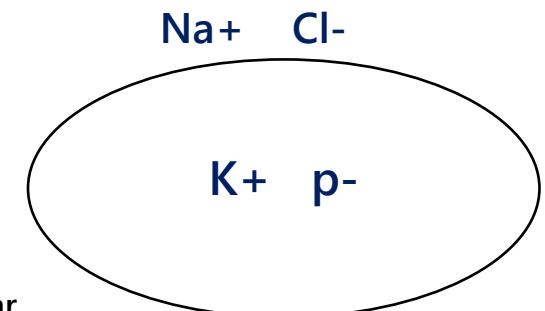
The main anion in ICF are phosphate then proteins.

The main anion in ECF are **Cl⁻** then **HCO₃⁻**

Tonicity is **the same** between ICF and ECF.

The two components of ECF (ISF and plasma) are nearly similar

in ionic composition except for protein which is higher in plasma.





Physiology L2: Cell Membrane and Intercellular Communication

What is the cell?

The cell is the basic living unit of the human body.

The human body contains about 100 trillion cells that work together for the maintenance of the living organism.

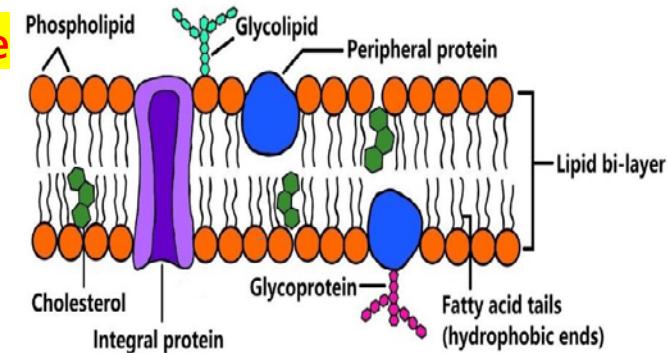
The typical cells have 2 major parts:

- I- The nucleus. II- The cytoplasm.

N.B.:

- The nucleus is separated from the cytoplasm by **the nuclear membrane**.
- The cytoplasm is separated from the surrounding fluids by **the cell (plasma) membrane**.

Cell membrane



Characters:

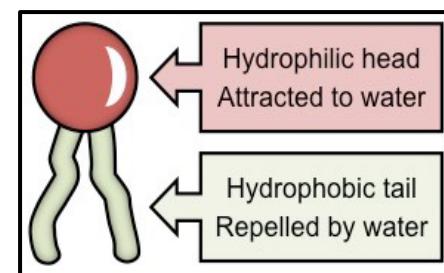
- It is the envelop of the cell.
- It is thin elastic semipermeable structure.

Structure: It is composed of:

- Lipids 42% (25% phospholipids, 13% cholesterol and 4% other lipids).
- Proteins 55%.
- Carbohydrates 3%.

1- Lipid bilayer (42%):

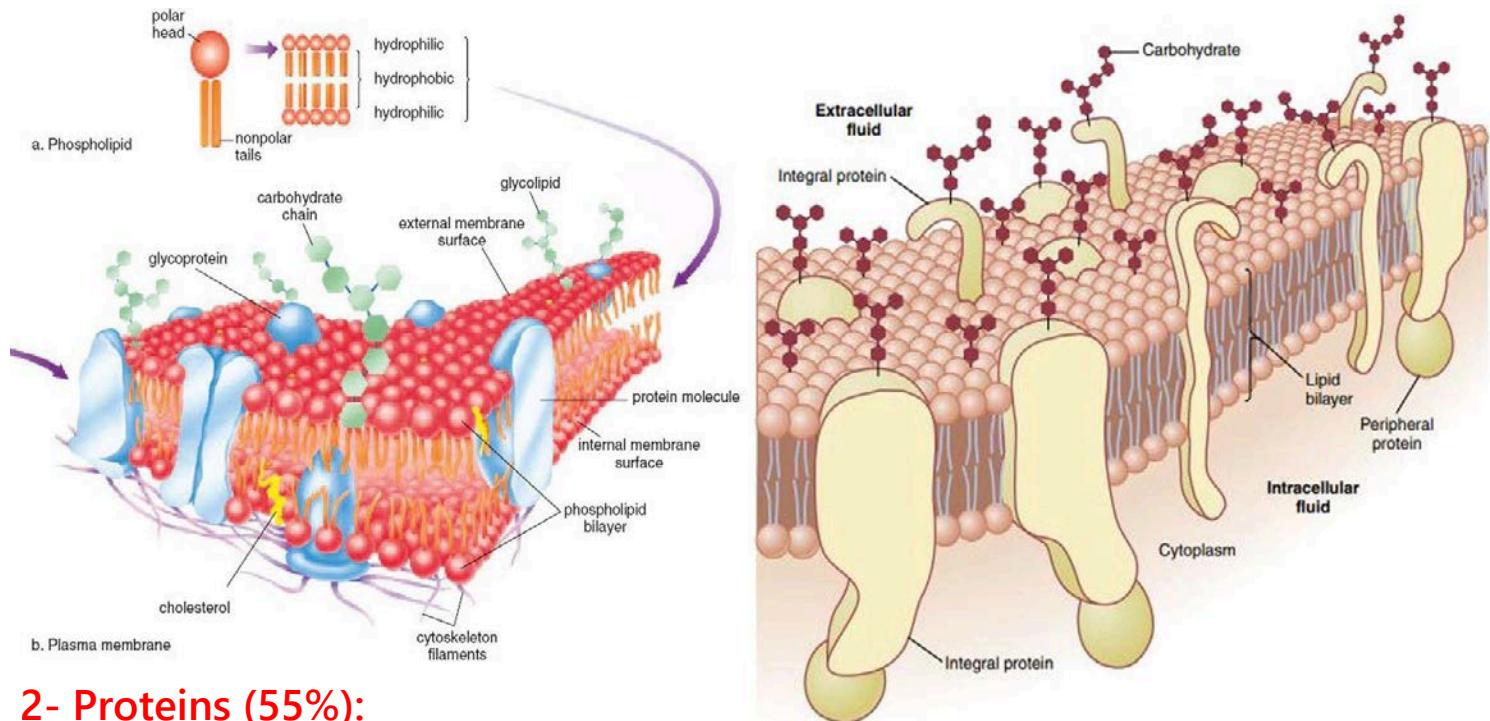
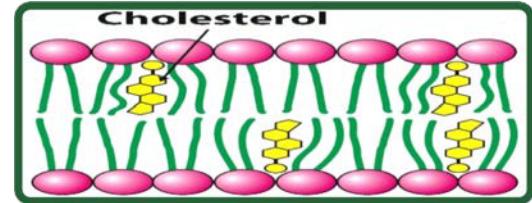
- Thin, double layered film of lipids.
- It is continuous over the whole surface.
- Each layer is formed of:
 - **Head:** Contains phosphate radical of phospholipid which is hydrophilic thus it is exposed to water present outside the cell (E.C.F.) or inside the cell (I.C.F)
 - **Tail:** Contains free fatty acid radical of phospholipid which is hydrophobic thus it is present in the inner parts of the membrane.





N.B.: Cholesterol:

- represents 13% of the lipid in the cell membrane.
- It is dissolved in the phospholipid bilayer.
- It determines the permeability and fluidity of the cell membrane



2- Proteins (55%):

It is not a continuous layer but present as masses floating in the lipid bilayer.

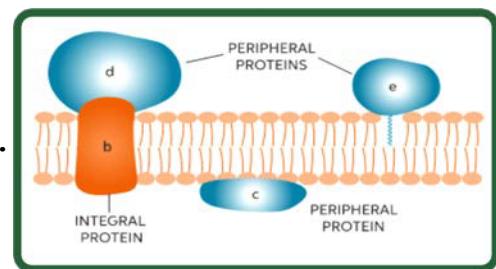
It may be:

Integral proteins:

They extend through the whole thickness of the membrane.

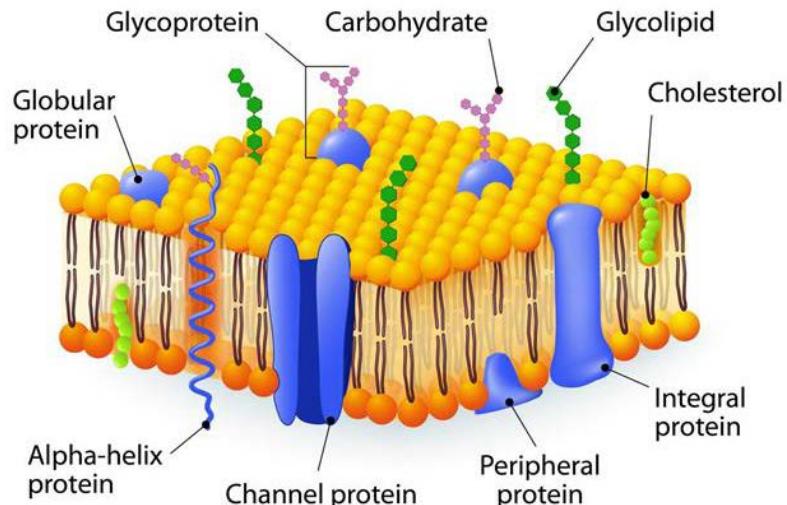
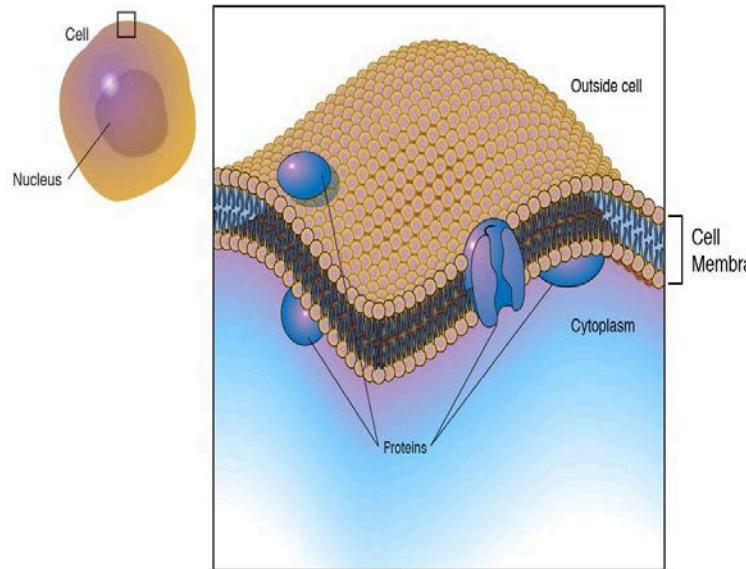
They act as:

1. ion channels for passage of ions.
2. Carriers for transport of substances as glucose and amino acids.
3. Receptors for action of substances e.g. hormones.
4. Enzymes.



Peripheral proteins:

- They are attached to the cell membrane either from outside or more commonly from inside.
- They are not extended through the whole thickness of the membrane.
- They are often attached to one of the integral proteins.
- They act mainly as enzymes.

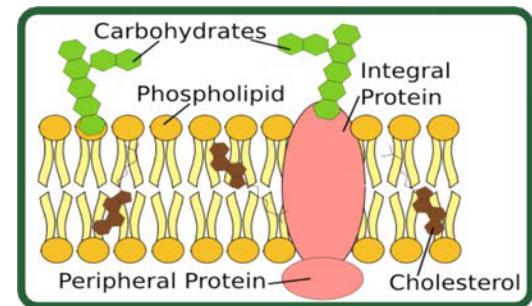


3- Carbohydrates (3%):

- It is present on the outer surface of the cell membrane.
- They may be combined with proteins (glycoproteins) or lipids (glycolipid).

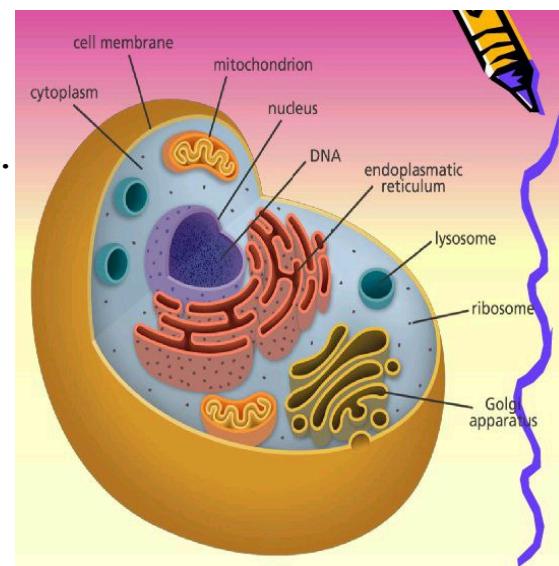
Functions:

- They give most cells a surface negative charge.
- Attach the cells to each other.
- Act as receptors.
- Some of them enter in the immune response.



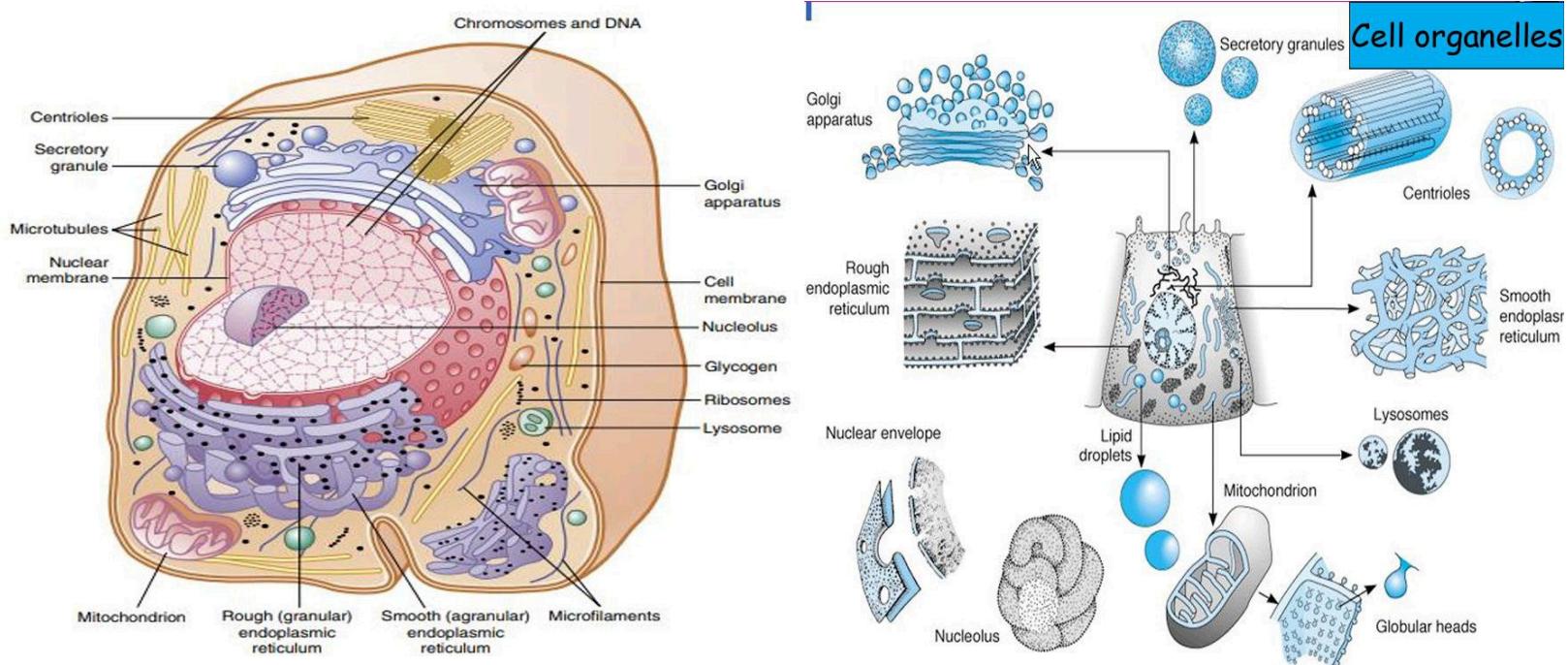
The cytoplasm contains cell organelles as:

1. Mitochondria.
2. Golgi apparatus.
3. Endoplasmic reticulum.
4. Microtubules.
5. Microfilaments.
6. Lysosomes.
7. Peroxisomes.
8. Centrioles.





Structure	Function
Nucleus	Cell division
Mitochondria	The power (ATP) house
Golgi apparatus	Package & storage of proteins
Endoplasmic reticulum	Smooth ER \rightarrow Lipid and steroid synthesis Rough ER \rightarrow Protein synthesis
Microtubules	Involved in the movement of cells
Microfilaments	Support cell shape
Lysosome	Breaks down large molecules & foreign bodies



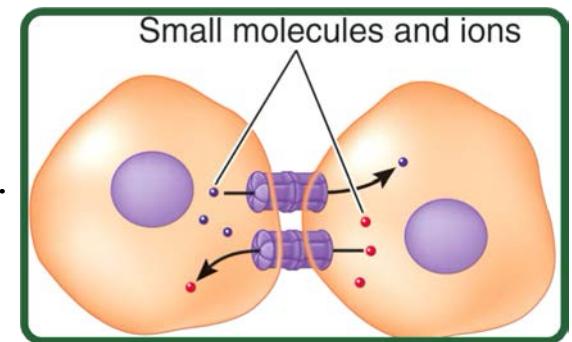


Intercellular Communication

Cells communicate with each other either directly or indirectly;

- **Direct (Electrical) communication:**

In which the messenger (ions) moves directly from cell to cell through gap junctions without entering the ECF. They are present in **cardiac** and **smooth** muscles.



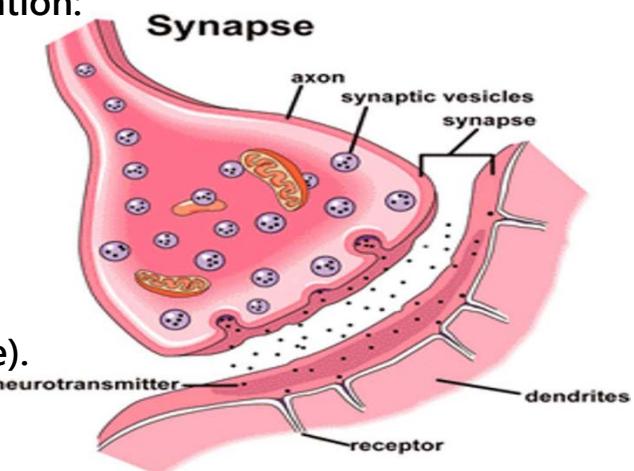
- **Indirect (Chemical) communication:**

It is the most common type of communication in which the cell secretes chemical messenger to extracellular fluid (E.C.F) to affect other cells (target cells) by binding to a receptor protein on cell membrane, cytoplasm or nucleus.

There are 4 types of indirect (chemical) communication:

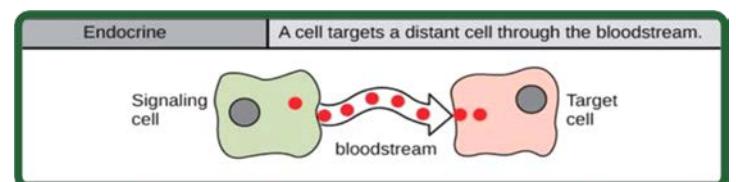
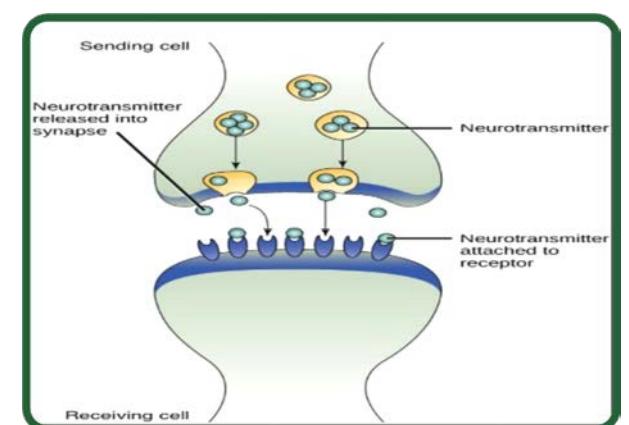
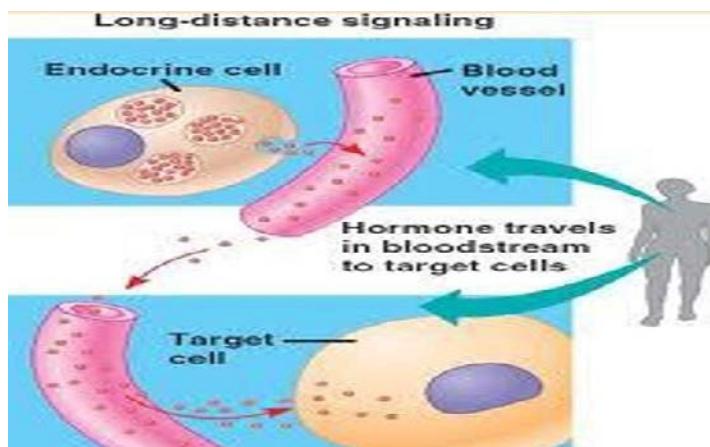
1- Neural (Synaptic) communication:

In which the chemical messenger (neurotransmitter) is released from presynaptic neuron, passes the synaptic cleft and binds to a receptor on postsynaptic neuron
e.g. acetylcholine or norepinephrine (noradrenaline).



2-Endocrine (Hormonal) communication:

In which the chemical messenger (hormone) is released from endocrine glands to the blood stream to affect **far (distant) cells**.

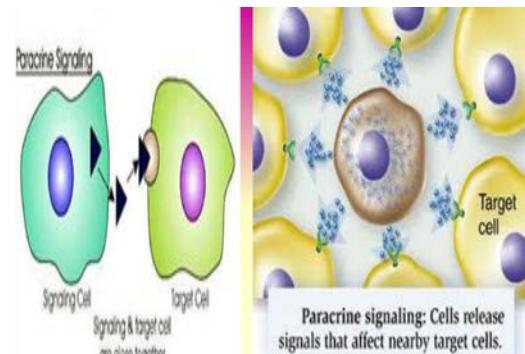




3-Paracrine communication:

In which the chemical messenger (metabolic products of the cell as histamine and prostaglandins) is secreted to the interstitial fluid to affect the nearby cells. e.g. histamine is released during the inflammatory response of an injured tissue to dilate blood vessels and increase the blood flow to that tissue.

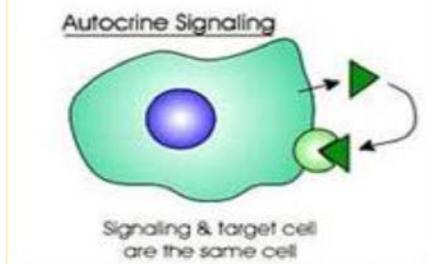
Paracrine	A cell targets a nearby cell.
	<p>The diagram illustrates paracrine signaling. On the left, a green, irregularly shaped cell is labeled "Signaling cell". Inside this cell is a grey nucleus and two red dots representing secreted signaling molecules. To the right, a pink, irregularly shaped cell is labeled "Target cell". Inside this cell is a grey nucleus and three red dots representing receptors. The red dots from the signaling cell are shown near the surface of the target cell, indicating that the signal is transmitted over a short distance between adjacent cells.</p>

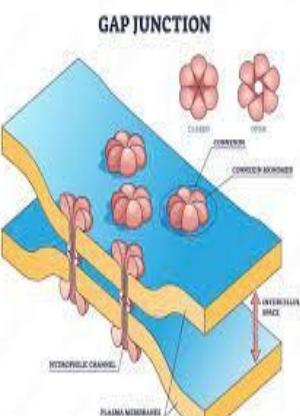
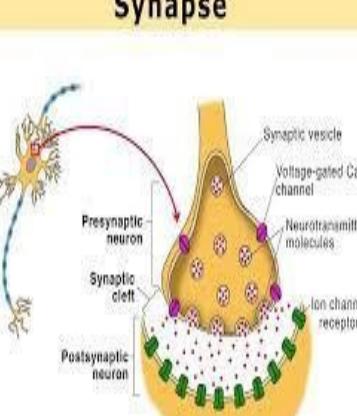
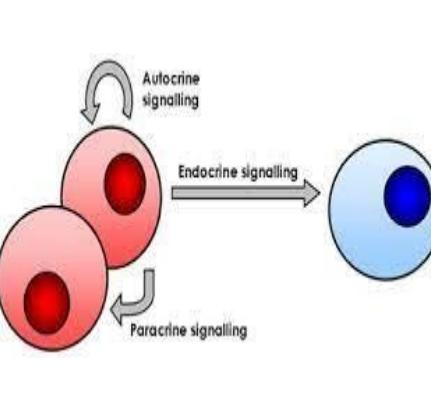


4- Autocrine communication:

In which the chemical messenger binds to a receptor on the same cell to affect the **same cells that secrete it**.

Autocrine	A cell targets itself.
	



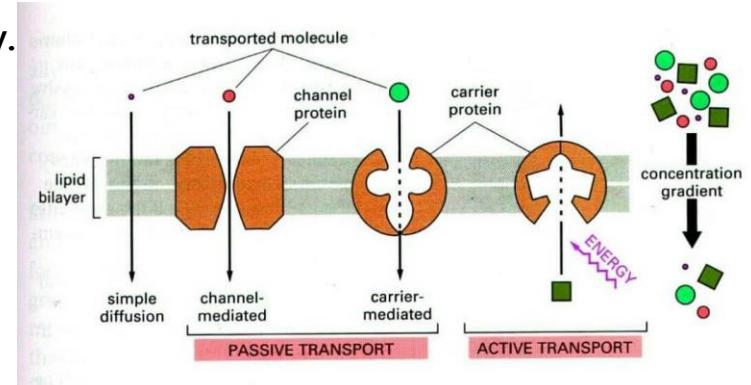
	Gap junction	Synaptic transmission	Autocrine and paracrine	Endocrine
Message transmission	Directly from cell to cell	Through synaptic cleft	Diffusion in the interstitial fluid	Circulating in the blood stream
Action	Local	Local	Local	General
	 <p>GAP JUNCTION</p>	 <p>Synapse</p>	 <p>Autocrine signalling</p> <p>Endocrine signalling</p> <p>Paracrine signalling</p>	



Physio Tut1: Methods of transport1 (passive transport)

There are two main types of transport through cell membrane:

- a) Passive transport (Diffusion): simple & facilitated.
- b) Active transport: primary & secondary.



A. Passive transport (Diffusion)

Definition:

It is transport of a substance across a semipermeable membrane down its electrochemical gradient.

Criteria of passive transport:

- 1) Occurs down concentration (chemical), electrical or pressure gradient.
- 2) Does not need energy.

Factors affecting rate of diffusion:

a. Directly proportional with:

- 1) The gradient for diffusion whether chemical, electrical or pressure.
- 2) Temperature: increases the random motion of the molecules.
- 3) Surface area of the membrane available for diffusion.
- 4) Permeability of the membrane.
- 5) Lipid solubility of the substance or number of protein channels according to the type of diffusion.

b. Inversely proportional with:

- 1) Molecular weight (molecular size) of the substance.
- 2) Thickness of the membrane.



Types of diffusion:

1- Simple diffusion:

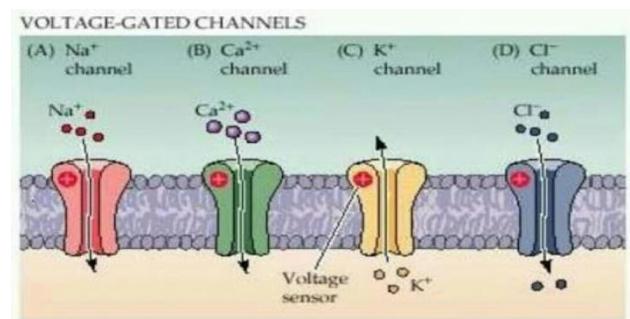
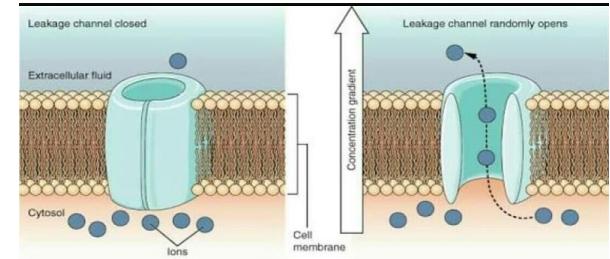
- **Definition:** Diffusion without a need for carrier.
- **It is concerned with:**
 - Lipid soluble substances.
 - Small water soluble substances, e.g. ions.
- **It occurs through:**
 - Lipid bilayer:**

This is for lipid soluble substances, e.g. O₂, CO₂, fatty acids, glycerol and urea.

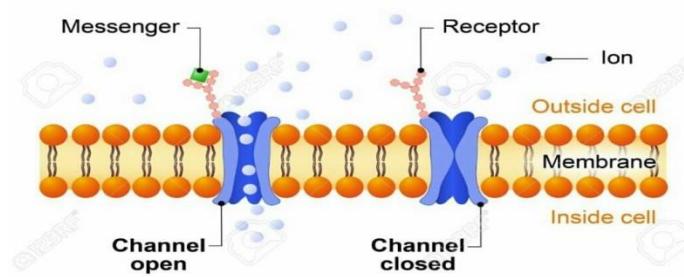
b) Protein channels (permeation).

This is for small water soluble substance e.g. ions (Na⁺, K⁺, Cl⁻ etc). The types of channels in the cell membrane include:

1. **Leak channels:** has no gate (continuously opened), e.g. Na⁺ & K⁺ leak channels.
2. **Gated channels:** have gates (open and close) and are of 2 types:
 - **Voltage – gated channels:** their gates open as a result of change in the electric potential across the cell membrane, e.g., voltage gated Na⁺ channel, K⁺ channel and Ca²⁺ channel.
 - **Ligand – gated channels:** their gates open as a result of binding (ligation) of a chemical substance with receptor on the channel protein, e.g., acetylcholine – gated ion channel at motor end plate (neuromuscular junction).



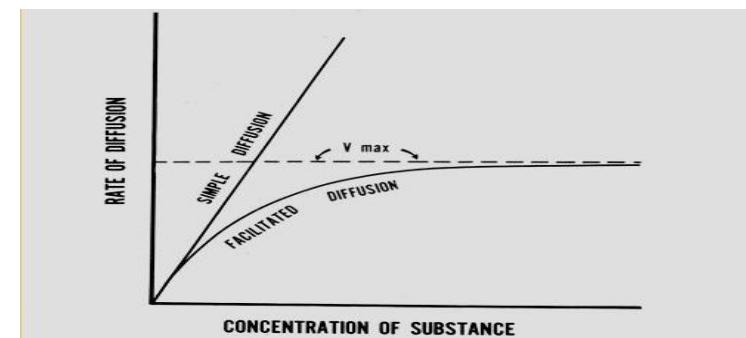
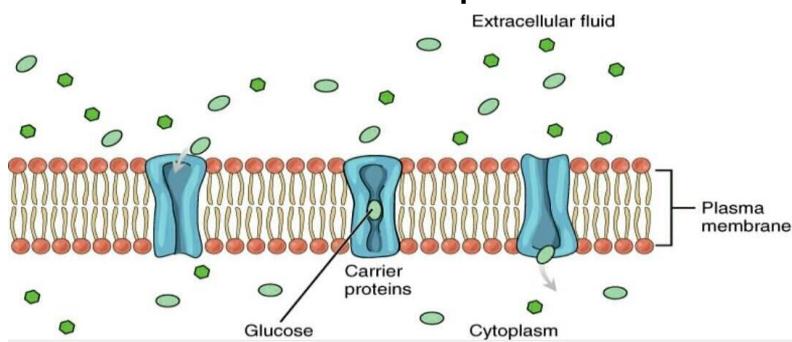
Ligand-gated ion channel





2- Facilitated (carrier mediated) diffusion:

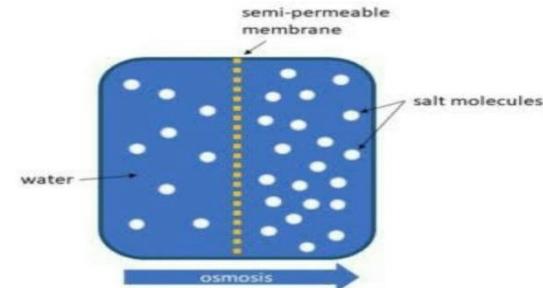
- **Definition:** diffusion that needs carrier protein.
- **It is concerned with:** lipid insoluble large molecules, e.g. glucose and most amino acids.
- **Mechanism:**
 - The carrier protein has a channel large enough to transport the specific molecule.
 - Binding of the specific molecule, e.g., glucose with a receptor on the carrier protein (a type of integral proteins) → widening of the inner part of the channel of the carrier protein → facilitation of transport of the molecule across the membrane.



Special types of Passive Transport:

A. Osmosis:

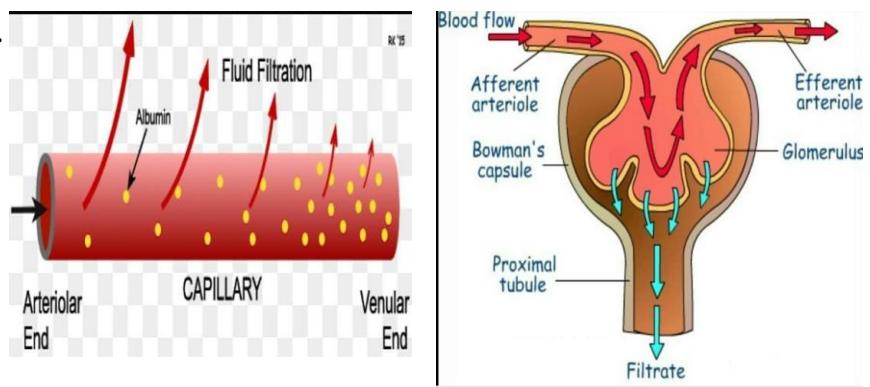
- ❖ It is the diffusion of water (the solvent) from area of less concentrated solution (more solvent) to the area of more concentrated solution (less solvent).
- ❖ Osmotic pressure is the pressure needed to stop osmosis. Osmotic pressure depends on number rather than the size of particles in a solution.
- ❖ Diffusion of water (osmosis) takes place through both lipid bilayer and protein channels (specific protein channels called aquaporin). This is because water molecules have very small size and high kinetic energy; so that the molecules penetrate the lipid bilayer like bullets before hydrophobic characters of lipid layer stop them.





B. Filtration (Bulk flow):

- Means diffusion of fluid through a membrane that is caused by difference in hydrostatic pressure.
- Examples:**
 - Filtration at arterial end of systemic capillaries to form interstitial fluid.
 - Filtration through glomerular capillaries in the kidney to form glomerular filtrate.



Differences between simple and facilitated diffusion

Simple diffusion	Facilitated diffusion
1. For lipid soluble and small lipid insoluble	1- For lipid insoluble large molecule.
2. Does not need carrier.	2- Needs carrier.
3. No structural specificity because there is no carrier.	3- High structural specificity: - each carrier is specific for one or very few substances.
4. No competitive inhibition because there is no carrier	4. Competitive inhibition: similar molecules compete with each other for the same carrier and the transport of each other.
5. No saturation, i.e. it ↑ with increasing the concentration gradient without limit (no carrier).	5- Saturation: has a maximum limit (v.max) or transport maximum (Tm) i.e. the rate of diffusion is directly proportional to the concentration gradient till a certain limit Tm.
6. Less sensitive to temperature changes (no carrier).	6- More sensitive to temperature changes (3 times that of simple diffusion) because binding of the substance with the carrier is through an enzyme.



T2: Active transport

- **Definition:** Transport of a substance against its electro-chemical Gradient,
- **Criteria of active transport:**
 - 1- Occurs against concentration (chemical), electrical or pressure gradient i.e. up hill,
 - 2- Needs energy.
 - 3- Needs carrier.

Types of active transport:

1. Primary active transport:

Definition: Transport of a substance against its Electrochemical gradient by a Specific carrier and this carrier has ATPase activity i.e., hydrolyse ATP and produces energy (direct release of energy).

Examples:

A. Na⁺- K⁺ Pump: a pump present in all Cells of the body that pumps 3 Na⁺ to Outside the cell coupled with pumping 2 K⁺ to the inside of the cell.

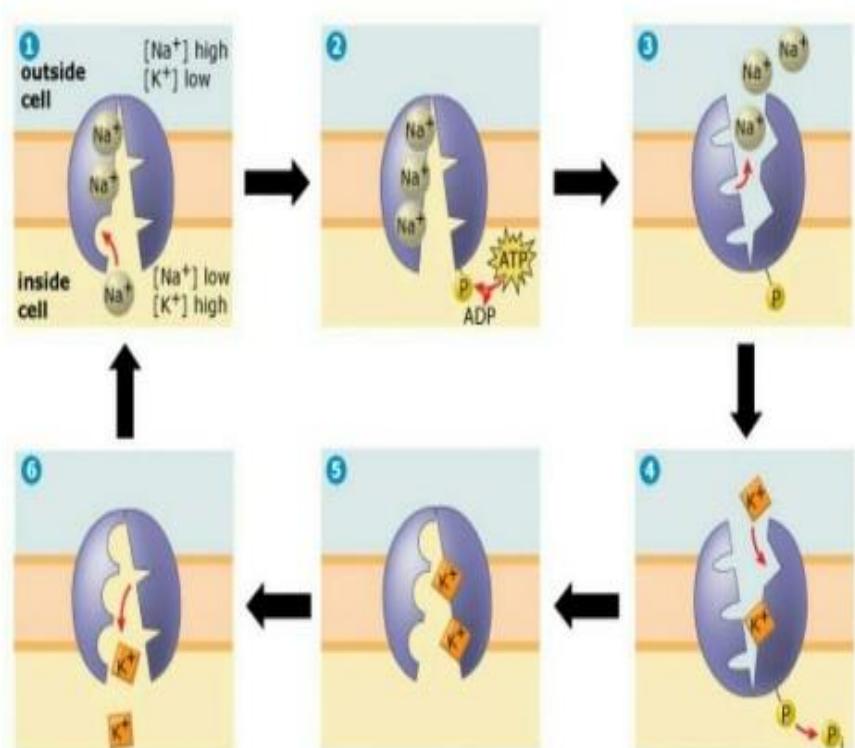
B. Calcium pump: In all cells, 2 pumps are present:

1- In the cell membrane and pumps Ca²⁺ to outside the cell.

2- In the mitochondria and pumps to the inside of mitochondria.

• In muscle fibers: in addition to the Previous pumps, another pump is present in the Sarcoplasmic reticulum that pumps Ca²⁺ to the inside of Sarcoplasmic reticulum

C. H⁺ pump: In parietal cells of the stomach & in intercalated Cells in the renal tubules (second half of distal tubules and collecting ducts) And pumps H⁺ from the cell to the tubular lumen.





2. Secendry active transport

Definition: Transport of a substance actively (against its electrochemical Gradient) secondary to passive transport Of another substance (down its Electro chemical gradient) by a specific carrier.

The carrier has no ATPase activity as it depends on energy released

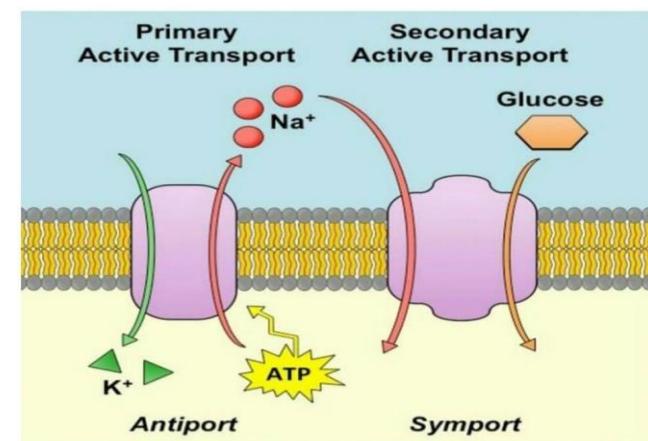
Another site by 1ry active transport producing ionic concentration Difference
(Indirect release of energy),

Types: two types:

a) Co-transports (symport).

- In which the two substances are transported in the same direction.

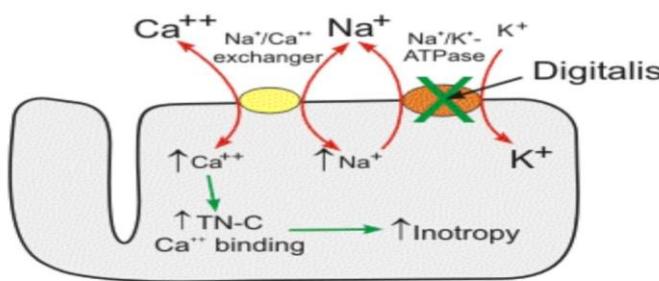
Example: sodium-glucose and sodium-amino acids co-transport that occurs in epithelial cells of the intestine and renal tubules. In this mechanism, glucose and Na^+ bind to a common carrier and Glucose is carried into the cell (against its electrochemical gradient) As Na^+ moves to the inside of the cell (down its electrochemical Gradient).



b) Counter transport (Antiport):

- In which the two substance are transported in opposite directions,

Example: sodium-calcium counter transport in Cardiac myocytes ($\text{Na}^+-\text{Ca}^{++}$ exchanger) & sodium-hydrogen counter transport in the renal tubular epithelium. In this mechanism, there is a common Carrier for Na^+ and H^+ , Na^+ binds to a receptor on the outer surface Of the carrier and H^+ binds to a receptor site on the inner surface of The carrier. H^+ is carried outside the cell (against its Electrochemical gradient) as Na^+ moves passively to the inside of The cell (down its electrochemical gradient).



Secondary active transport





3. Endocytosis (cell ingestion):

Definition: Is an active process by which macromolecules, e.g., protein and large particles, e.g., bacteria are transported to the inside of the cell.

Types: 2 types:

a) Pinocytosis (cell drinking):

• **Definition:** It is the process by which macromolecules, e.g., Proteins are transported to the inside of the cell It is transported in Vesicles containing ECF, thus the name cell drinking.

• It occurs in most body cells.

• **Mechanism:**

1- Attachment of the substance to a specific receptor on the cell membrane. The receptors are concentrated in small pits called coated pits.

2- The entire pit invaginates inwards by action of contractile Elements.

3- The borders of the invaginated pit close over the attached Substance with some ECF and form a vesicle (pinocytic Vesicle).

4- The vesicle separates from the cell membrane and pass to the Cytoplasm.

b) Phagocytosis (cell eating):

Definition: It is the process by which large particles e.g. bacteria Are transported to the inside of the cell.

• It occurs only in some specific cells of the body (phagocytic cell)

1. white blood cells: mainly neutrophils (microphages) and Monocytes (macrophages).

2. Tissue macrophages.

Mechanism: Essentially the same as pinocytosis, but differs in two Aspects:

I- The phagocytic vesicle contains only particle without ECF & hence the name cell eating

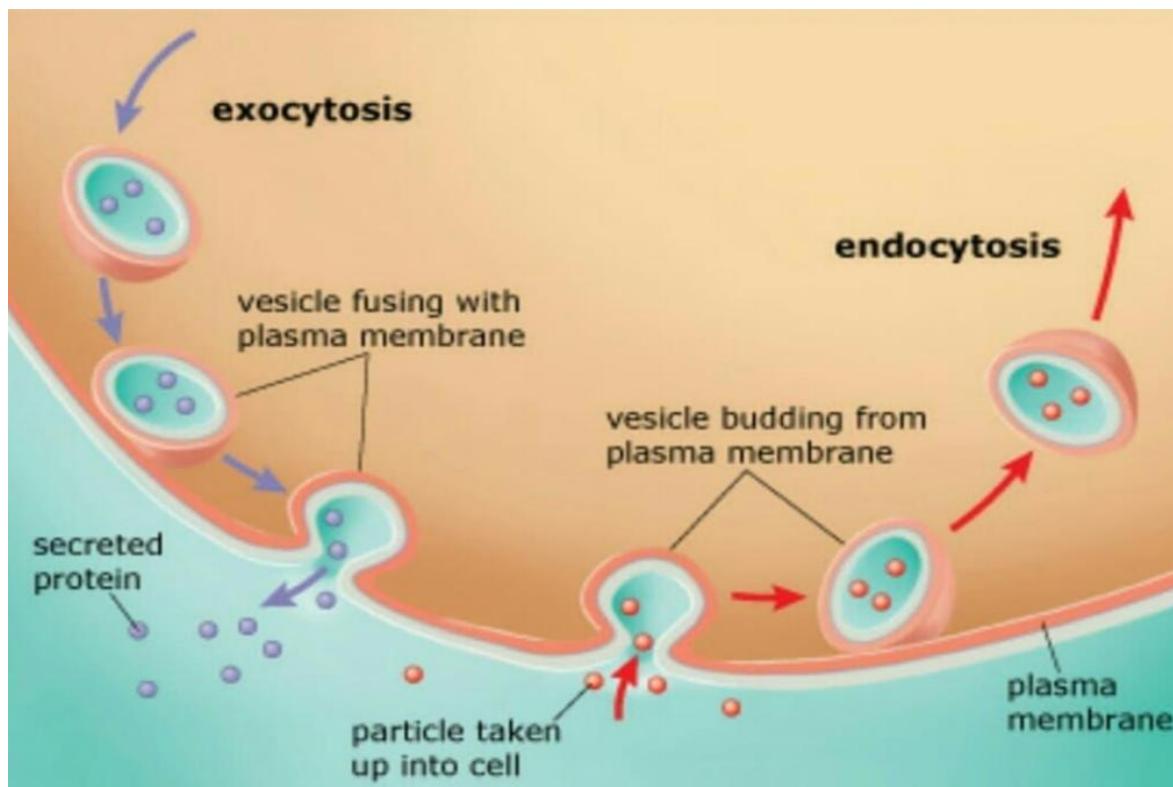
2. If the ingested substance is digestible, there will be an Additional step in which lysosomes come in contact with the Phagocytic vesicles and release its digestive enzymes into the Vesicle to digest the ingested substance.



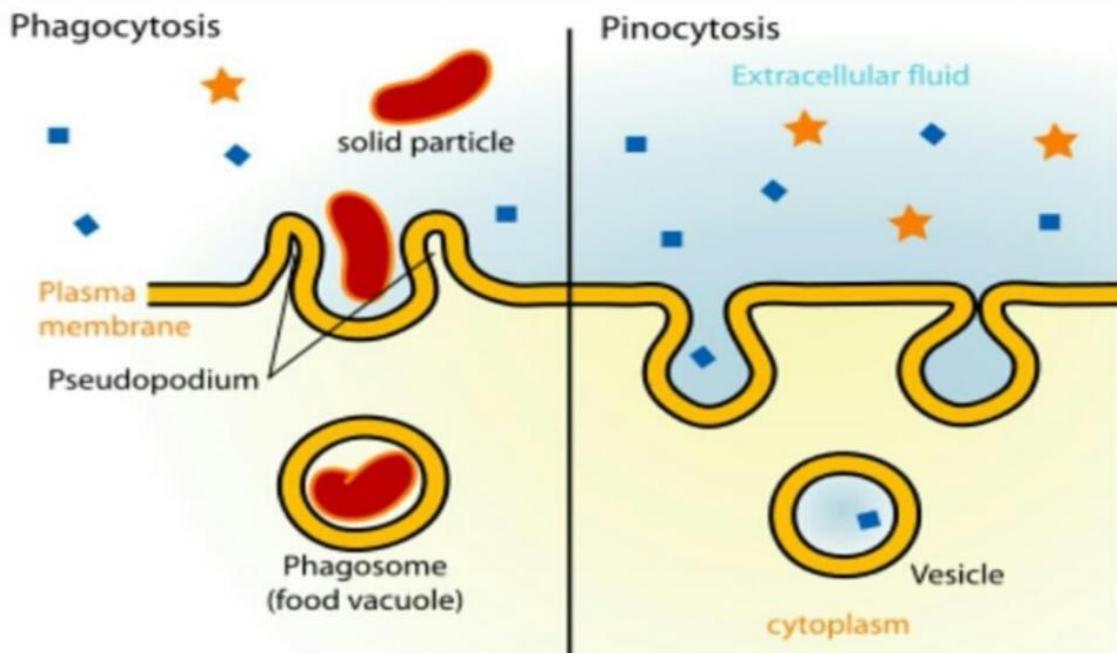
4.Exocytosis (cell excretion):

Definition: Is a process by which macromolecules and large particles are transported to the outside of the cell.

Mechanism: Reverse to endocytosis.



Endocytosis





Tut3 Functions of cellular organelles

cellular organelles:

Definition:

Organelles are **bodies** embedded in the **cytoplasm** that serve to physically separate the various metabolic activities that occur within cells.

Function:

The organelles are **like** separate little **factories**, each organelle is responsible for producing a **certain product** that is used elsewhere in the cell or body.

The most important organelles:

- The Following organelles are present in the Cytoplasm:-
1. Nucleus 2. Centrioles 3. Mitochondria 4. Lysosomes 5. Peroxisomes
6. Endoplasmic Reticulum 7. Golgi Apparatus 8. Ribosomes 9. Cytoskeleton
- Each organelle is bounded by a lipid membrane, and has specific functions.

1. Nucleus:

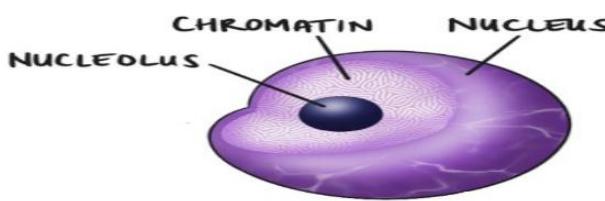
Definition:

The nucleus is the **largest** of the cells organelles. Cells can have **more than one nucleus** or **lack a nucleus** all together. Skeletal muscle cells contain more than one nucleus whereas red blood cells do not contain a nucleus at all.

Function:

Controls the cell; houses the genetic material (DNA).

- The nucleus contains the DNA, the hereditary information in the cell. Normally the DNA is spread out within the nucleus as a threadlike matrix called chromatin.
- Also visible within the nucleus are one or more **nucleoli**, each consisting of DNA in the process of manufacturing the components of ribosomes. Ribosomes are shipped to the cytoplasm where they assemble amino acids into proteins. The nucleus also serves as the site for the separation of the chromosomes during cell division.

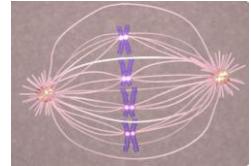




2. Centrioles:

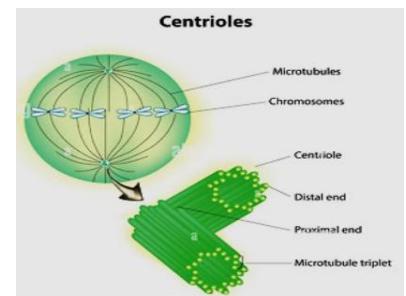
Definition:

Centrioles are rod like structures composed of 9bundles which contain three microtubules each. Two perpendicularly placed centrioles surrounded by proteins make up the centrosome.



Function:

Centrioles are very important in cellular division, where they arrange the mitotic spindles that pull the chromosome apart. Also gives rise to the microtubules that make up the spindle apparatus used during cell division.



3. Ribosomes:

Definition:

A ribosome is a complex molecular machine found inside the living cells that produce proteins from amino acids during a process called protein synthesis or Ribosomes play an active role in the complex process of protein synthesis, where they serve as the structures that facilitate the joining of amino acids. Each ribosome is composed of a large and small subunit which are made up of ribosomal proteins and ribosomal RNAs. They can either be found in groups called polyribosomes within the cytoplasm or found alone. Occasionally they are attached to the endoplasmic reticulum .

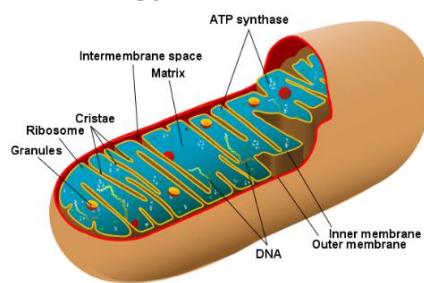


4. Mitochondria:

Definition:

Tiny **sac-like** structures found near the nucleus. Little shelves called **cristae** are formed from folds in the inner membrane.

- Cells that are metabolically active such as muscle, liver and kidney cells have high energy requirements and therefore have more mitochondria.





- Mitochondria are unique in that they have their own mitochondrial DNA
Function:

- Power generating units of the cells.

- Important to maintain proper concentration of calcium ions within the various compartments of the cell.

- Energy transduction through respiration.

- Responsible for thermogenesis.

5. Endoplasmic Reticulum:

Definition:

A complex three dimensional internal membrane system of flattened sheets, sacs and tubes, that play an important role in making proteins and shuttling cellular products; also involved in metabolisms of fats, and the production of various materials.

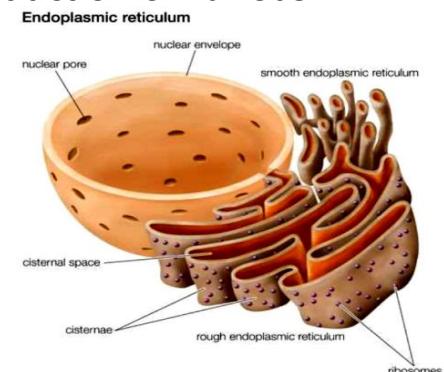
Function:

- Synthesis of proteins.

- Protein segregation.

- Unsaturation of fatty acid.

- Muscle contraction. ER is commonly known as Sarcoplasmic Reticulum in muscle fibers.



Types:

Smooth Endoplasmic Reticulum	Rough Endoplasmic Reticulum
<p>Ribosomes absent.</p> <p>Site of synthesis of lipid and steroid hormones.</p> <p>Mainly present in lipid forming cells such as adipocytes, interstitial cells of testis, glycogen storing cells of liver, adrenal cortex cells, muscle cells, leucocytes etc.</p>	<p>Contains ribosomes.</p> <p>Site of protein synthesis, processing and packaging.</p> <ul style="list-style-type: none"> Mainly present in protein forming cells such as pancreatic acinar cells, Goblet cells, antibody producing plasma cells, Nissl's granules of nerve cells etc.



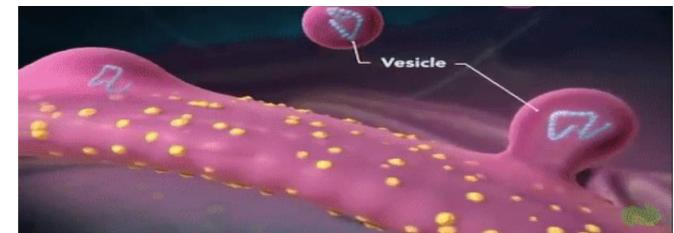
6. Golgi Apparatus:

Definition:

The Golgi apparatus is the central delivery system for the cell. It is a group of flattened sacs arranged much like a stack of bowls.

Function:

1. They function to modify and package proteins and lipids into vesicles so that these products can cross the cell membrane and exit the cell.
2. Produces secretion granules i.e. membrane enclosed complexes, which store hormones and enzymes in the protein secreting cells.
3. Site of formation of lysosomes.
4. It adds certain carbohydrates to form glycoproteins, which play an important role in the association of the cells to form tissues.



7. Lysosomes:

Definition:

Sac-like compartments that contain a number of powerful degradative enzymes that break down harmful cell products and waste materials, cellular debris, and foreign invaders such as bacteria, and then force them out of the cell.

Function:

1. Acts as a form of digestive (lytic system) of the cell, because enzymes present in it can digest essentially all macromolecules.
2. Engulf worn out components of the cells in which they are located.
3. Engulf exogenous substances e.g. bacteria and degrade them.
4. When a cell dies ,lysosomal enzymes causes autolysis of the remnant, That's why lysosomes are called as Suicidal Bag.

Anatomy of the Lysosome

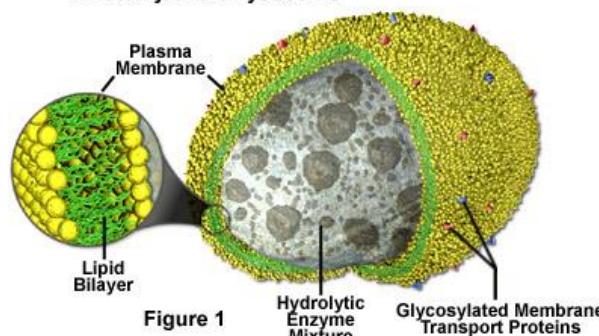


Figure 1



8. Peroxisomes:

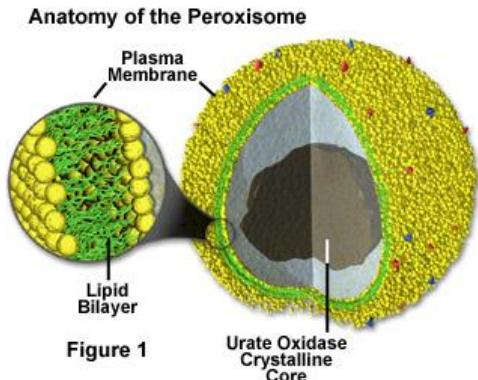
Definition:

Organelles in which oxygen is used to oxidize substances, breaking down lipids and detoxifying certain chemicals.

- Structure is similar to that of the lysosomes but with a different composition.

Function:

- H₂O₂ metabolism and detoxification.
- Biosynthesis of lipids.
- Cholesterol and dolichol are synthesized in animals.
- Synthesis of bile acids in liver.
- Synthesis of plasmalogens (myelin sheath).



9. Cytoskeleton:

Definition:

System of fibers that not only maintains the structure of the cell but also permit it to change shape and move.

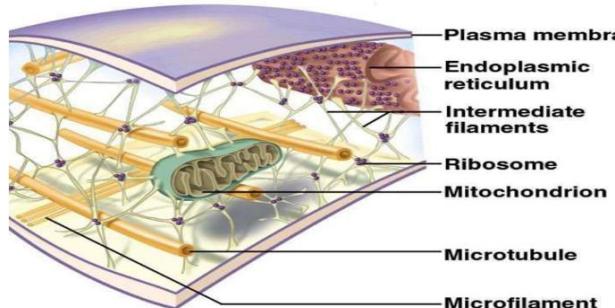
Structure:

The cytoskeleton is made up primarily of:

- Microtubules
- Intermediate Filaments
- Microfilaments

Function:

- Movement of the chromosomes.
- Cell movement.
- Processes that move secretion granules in the cell.
- Movement of proteins within the cell membrane.





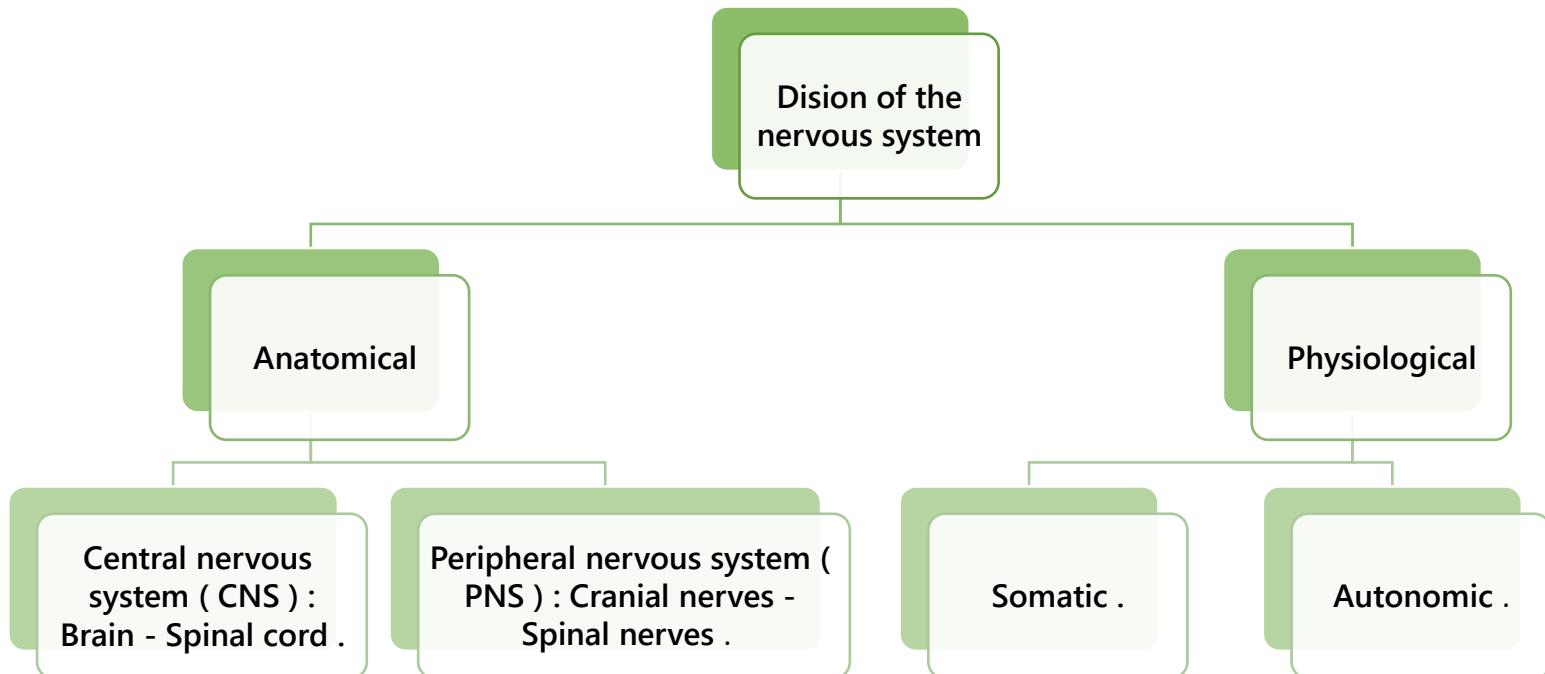
Microtubules	Intermediate Filaments	Microfilaments
<p>These are long hollow structures approx. 25nm in diameter.</p> <p>Determine shape of the cell, role in the contraction of the spindle and movement of chromosomes and centrioles as well as in ciliary and flagellar motion.</p>	<p>They are 8-14nm in diameter and are made up of various subunits.</p> <p>They form a flexible scaffolding or cell and help it resist external pressure. In their absence cell ruptures more easily and when they are abnormal in human, blistering is common. The proteins that makeup intermediate filament are cell types specific and are thus frequently used as cellular markers.</p>	<p>They are long solid fibers 46 nm in diameter. They comprise the contractile protein actin and are responsible for the cell motion.</p>



L3 : Division of the nervous system

- outlines :

- 1- Division of nervous system .
- 2- The structural (anatomical) unit of the nervous system (neuron) .
- 3- The physiological (functional) unit of the nervous system (reflex action) .

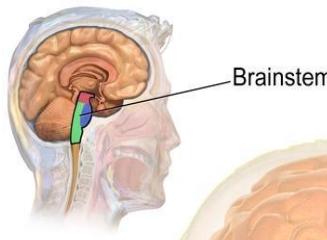


Anatomical division of the nervous system

	Central Nervous system (CNS)	Peripheral Nervous system (PNS)
Site	It lies <u>inside</u> a Bony cavity	It lies <u>outside</u> a Bony cavity
Includes	Brain Spinal cord	Cranial nerves Spinal nerves



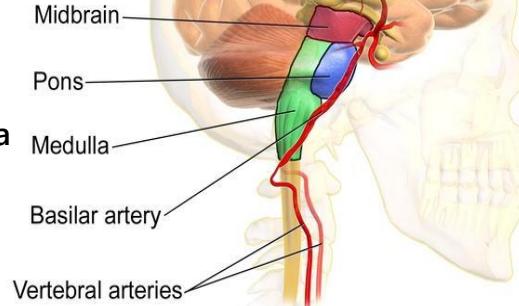
Central Nervous system (CNS)



1- The Brain

- It lies inside the **Skull** and composed of :

- 2 cerebral hemispheres (Cerebrum) .
- Brain stem: Midbrain – Pons - Medulla Oblongata .
- Cerebellum .

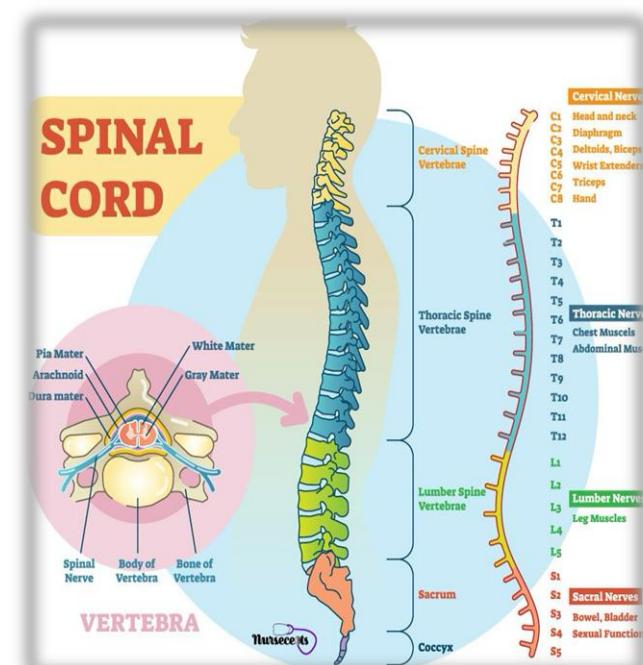
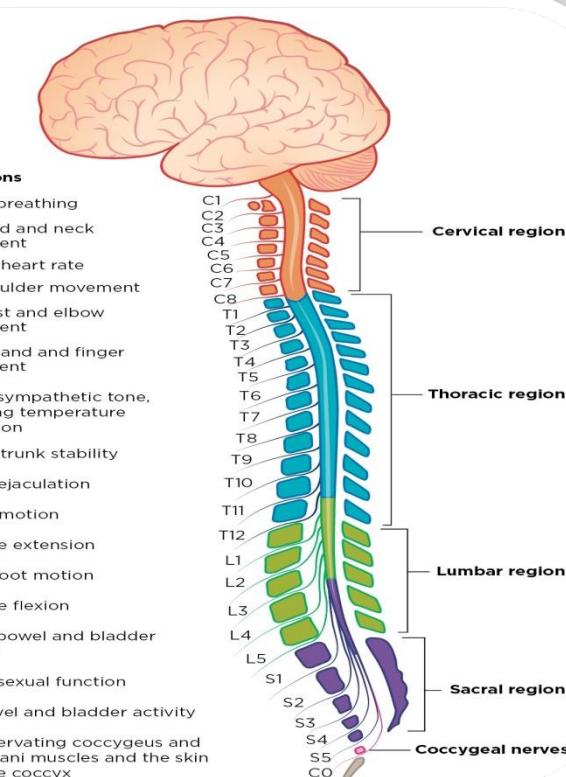
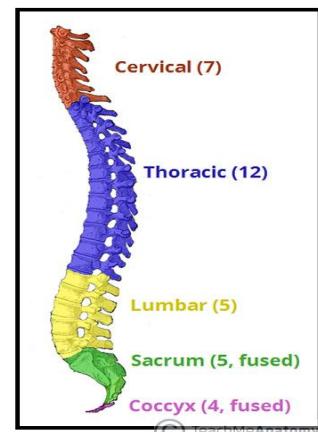
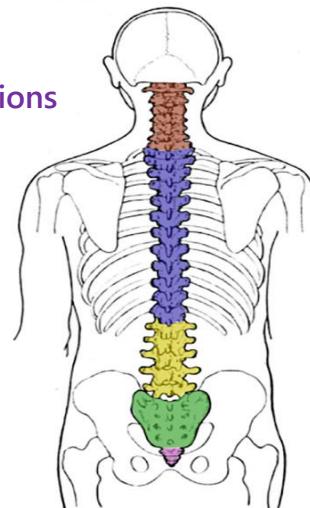


2- The spinal cord :

- It lies inside the **Vertebral column** and composed of **5 regions**

Each region : A number of segments (**31 segments**) .

- Cervical region : 8 segments (C1 – C8) .
- Thoracic region : 12 segments (T1 – T12) .
- Lumbar region : 5 segments (L1 – L5) .
- Sacral region : 5 segments (S1 – S5) .
- Coccygeal region : 1 segment (Coc. 1) .



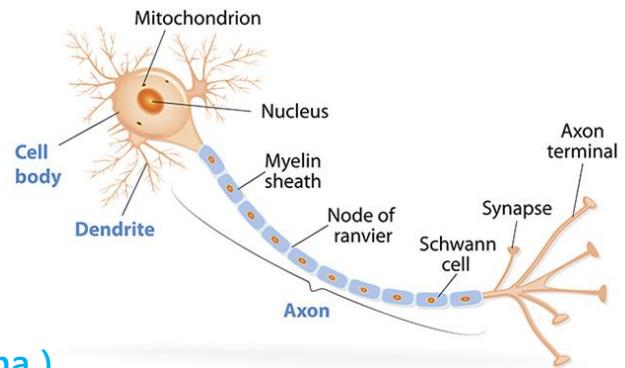


Neurons (Nerve cells)

- Formed of :

1- Cell processes(Dendrites & axon) .

2- Cell body(Soma)



1- Cell body (Soma)

- It contains **Nucleus & cytoplasm** surrounded with a **cell membrane** . The cytoplasm contains cell organelles : endoplasmic reticulum , Ribosomes, golgi apparatus, mitochondria, microtubules, microfilaments, neurofibrils, nissil bodies .

* **N.B :** The cytoplasm does not contain centrosome (**Centrioles**) so the nerve cells cannot divide .

Cell Processes (Dendrites & axon)

Point of difference	Axon (Nerve fiber)	Dendrites
Number	Single	Multiple
Length	Long	Short
Function	Conduct impulses away from cell body (Soma)	Conduct impulses towards cell body (Soma)
Covered by	<p><u><i>It is covered by 2 Sheathes:</i></u></p> <p>1- Neurilemmal sheath (The outer sheath)</p> <p>2- Myelin sheath (The inner sheath)</p> <p><u><i>Nerves may be:</i></u></p> <ul style="list-style-type: none"> ● Myelinated nerves: Covered with both myelin & neurilemmal sheaths ● Un myelinated: Covered with neurilemmal sheath only 	<p><u><i>Not covered</i></u></p>



Differences between Neurilemmal & myelin sheaths		
Type	Neurilemmal sheath	Myelin sheath
Site	It's the Outer Sheath	It's the Inner Sheath
Nature	It's a single layer of Schwann cells	It's Lipoprotein In nature formed by wrapping of the cell membrane of schwann cells around the axon
It covers	<ul style="list-style-type: none"> All axons The whole axon 	<ul style="list-style-type: none"> only myelinated nerves whole axon Except at its Origin, its end & nodes of Ranvier
function	Regeneration of injured axons	<ul style="list-style-type: none"> Acts as Insulator Preventing current flow. It's responsible for the white color of myelinated nerves & white matter of CNS

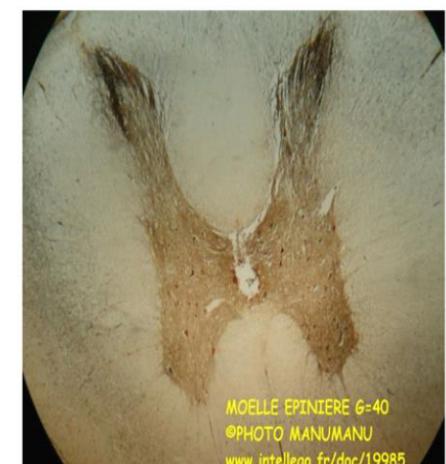
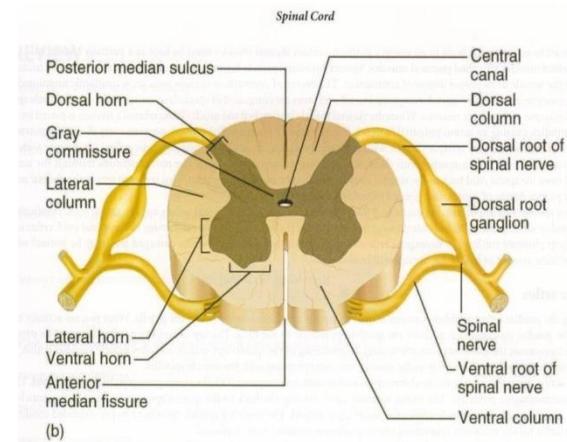
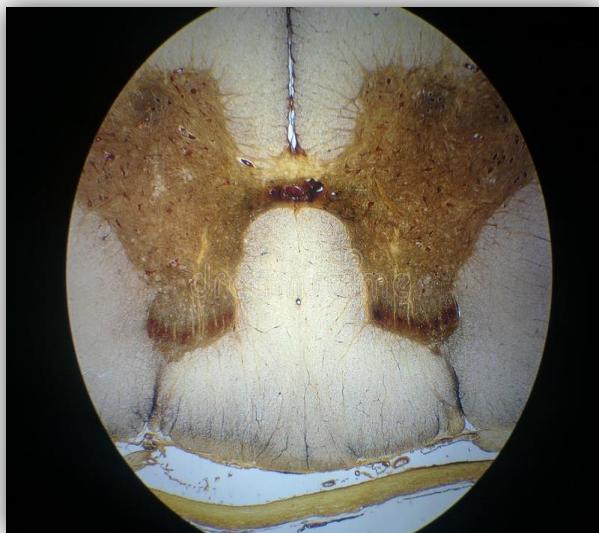
Cross section of the spinal cord shows :

1- Central mass of grey matter :

- It's **H-shaped** Is divided into Anterior, posterior & lateral horns .
- It's formed of Nerve cells & unmyelinated nerve fibers .

2- peripheral white matter :

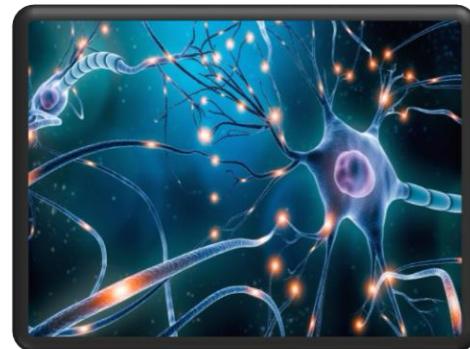
- It surrounds the grey matter .
- It's formed of **Myelinated nerve fibers** .





Peripheral Nervous system (PNS)

1- Cranial nerves : There are 12 pairs That arise from the brain (Mainly brain stem) .



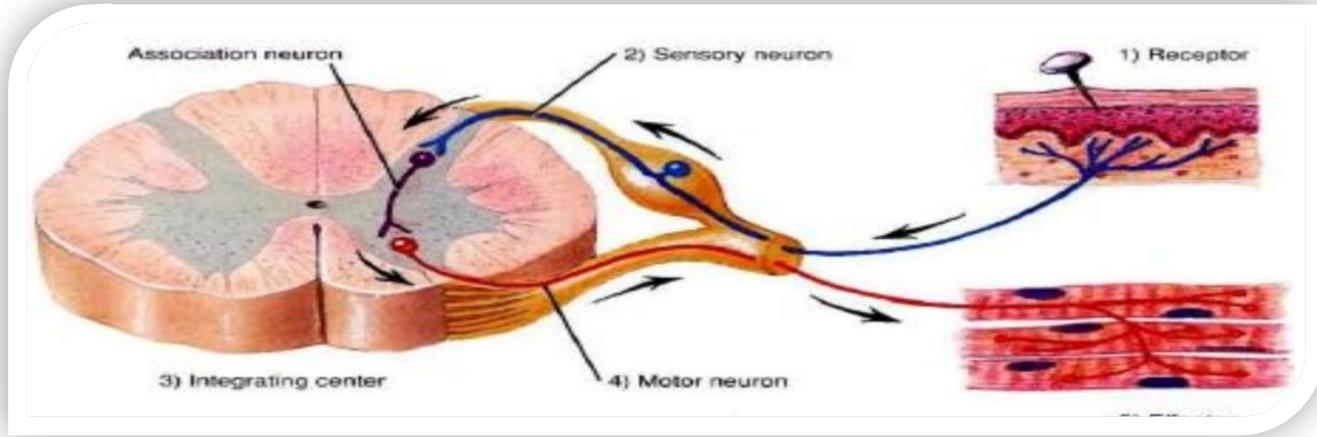
Nerve	Name	Nerve	Name
I	Olfactory N.	VII	Facial N.
II	Optic N.	VIII	Vestibulocochlear N.
III	Occulomotor N.	IX	Glossopharyngeal N.
IV	Trochlear N.	X	Vagus N.
V	Trigeminal N.	XI	Accessory N.
VI	Abducent N.	XII	Hypoglossal N.

I		VII	
II		VIII	
III		IX	Class 9
IV		X	
V		XI	
VI	6 APP	XII	



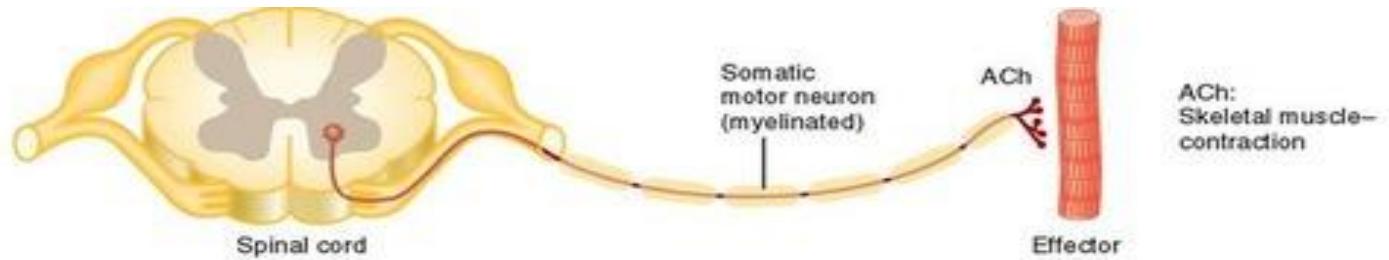
2- Spinal nerves : There are 31 pairs That arise from the spinal cord . The nerve fibers may be:

- **Sensory (Afferent) nerve :** It enters the spinal cord from the Posterior (dorsal) horn Of spinal cord . Its mother cell is in the dorsal root ganglion.
- **Motor (Efferent) nerve :** It leaves the spinal cord . Its mother cell is in the Ventral horn (Somatic motor) or in lateral horn (Autonomic motor) .

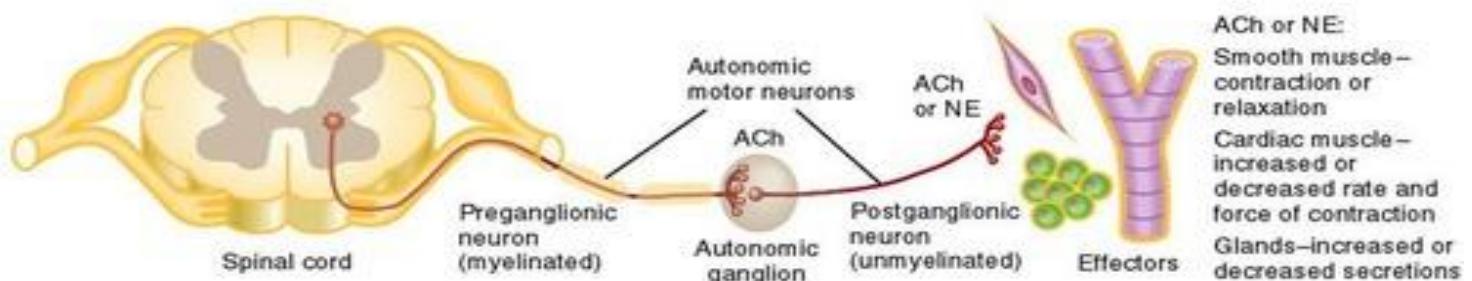


Physiological (Functional)division of the nervous system

Type	Somatic (Voluntary) Nervous system	Autonomic (Involuntary) Nervous system
Function	Controls the Voluntary actions e.g Skeletal muscle Contraction	Controls the Involuntary actions e.g Smooth & cardiac muscle Contraction & Secretion of glands.
Origin	- It has wide origin from: •All motor cranial nerve nuclei . • All spinal segments .	<p>Recall:</p> <p>A Two Neuron Pathway</p> <p>CNS</p> <p>Preganglionic fiber</p> <p>Postganglionic fiber</p> <p>Smooth muscle</p> <p>Gland cell</p> <p>Cardiac muscle</p>
Efferent	<ul style="list-style-type: none"> • originates from AHC. • one neuron from AHC to the effector organ (No ganglia) . 	<ul style="list-style-type: none"> • originates from LHC . • Efferent to the effector organ is divided by Autonomic ganglia Into preganglionic & postganglionic fibers .



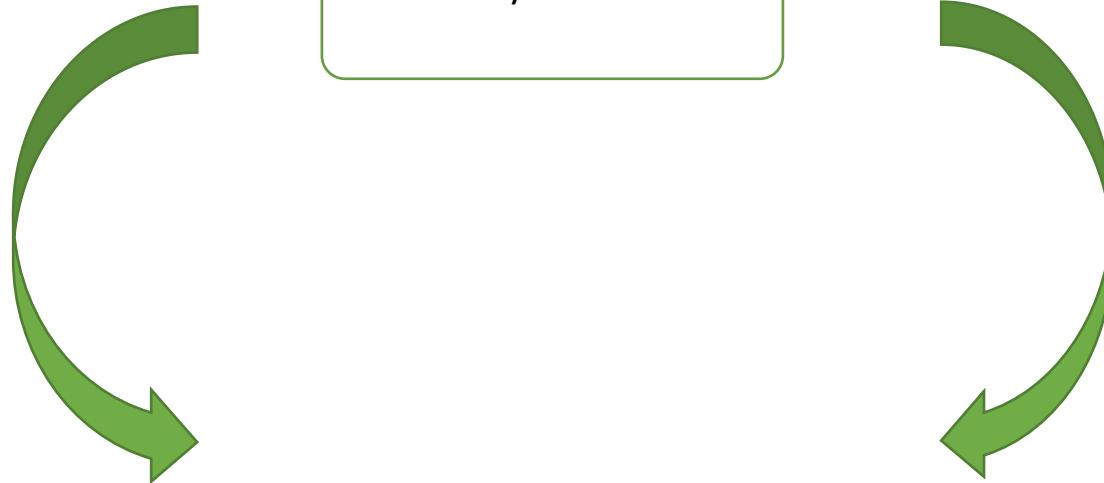
(a) Somatic nervous system



(b) Autonomic nervous system

17.01

Units of the nervous system



The structural (anatomical unit) of the nervous system is the neuron (nerve cell).

The physiological (Functional unit) of the nervous system is the reflex action .



- The reflex action :

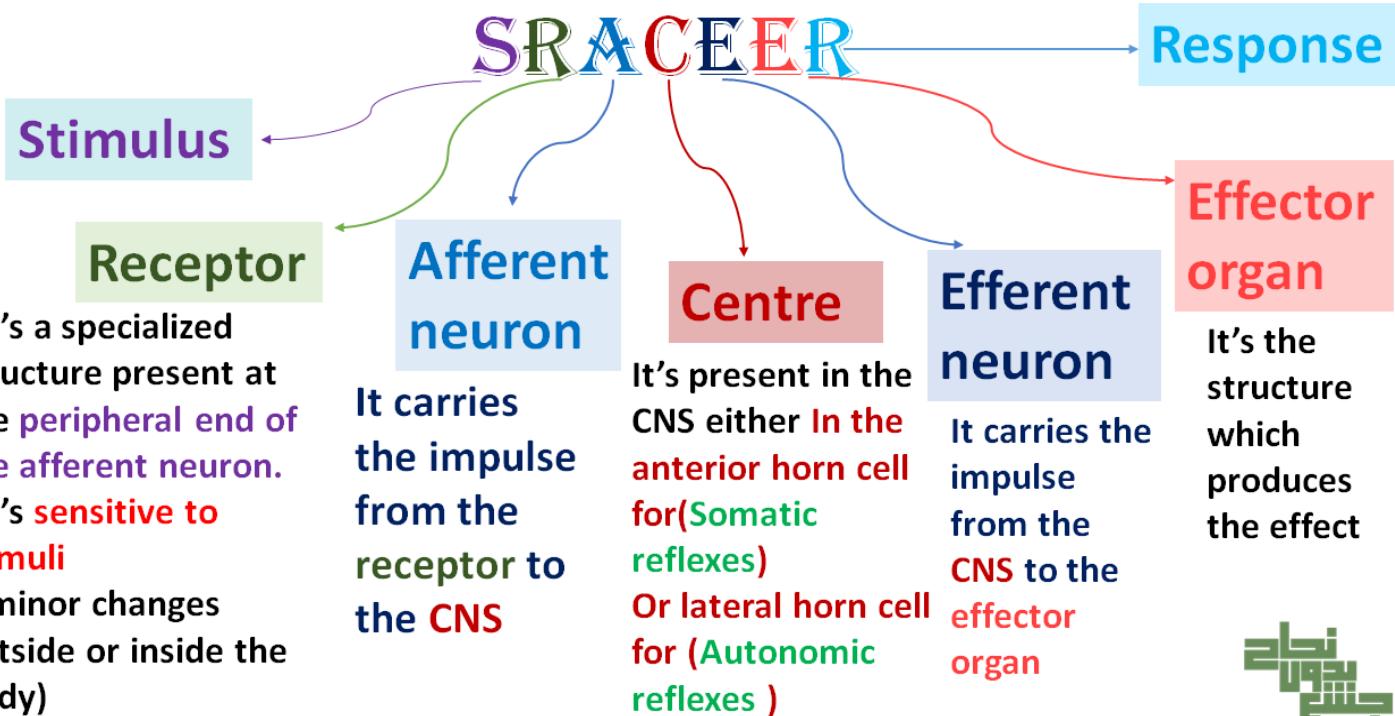
- Involuntary .
 - useful action .
 - occurs in response to a stimulus
- e.g

Reflex closure of the eye on moving an object in front of it .

- mediated through reflex arc (the pathway of the reflex action) .

Types of reflex action	
Somatic reflex action	Autonomic reflex action
<p>They regulate the activity of skeletal muscles. e.g Withdrawal reflex (When a pin pricks the hand , the arm is withdrawn rapidly away from the pricking pin to protect the hand from the harm of the pricking pin.</p>	<p>They regulate the activity of the viscera. e.g Micturition reflex.</p>

Components of the reflex arc



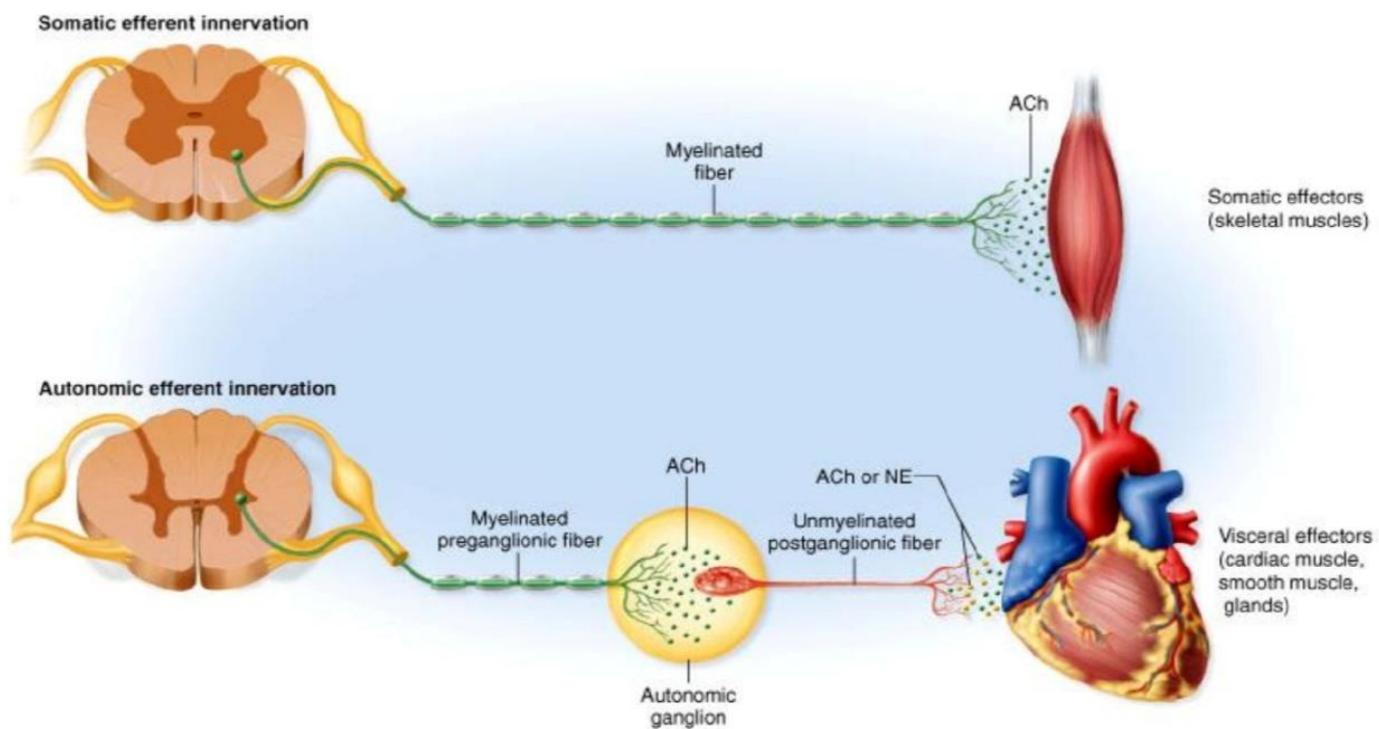


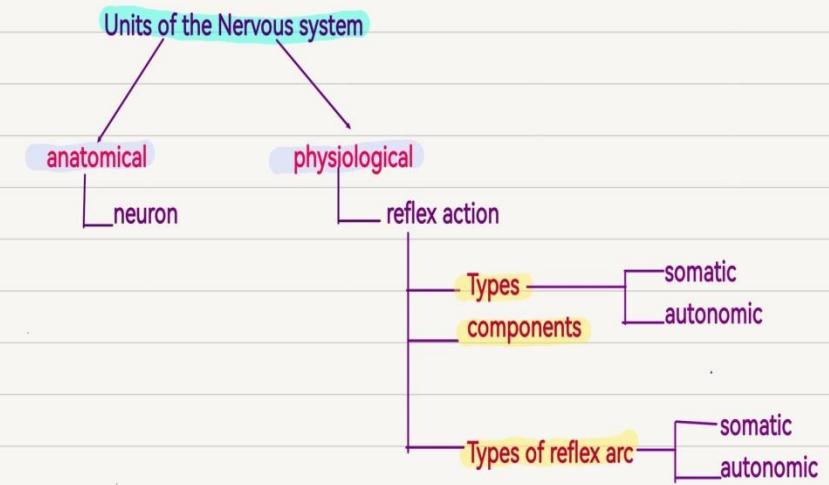
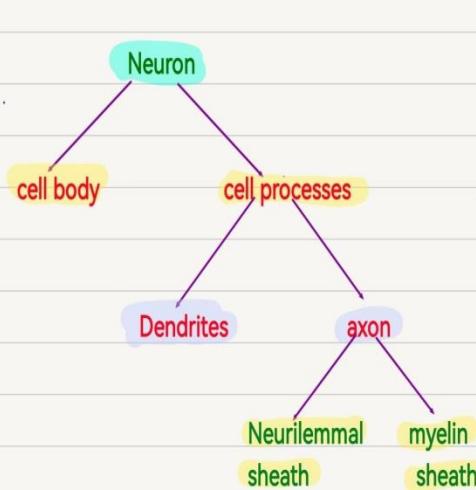
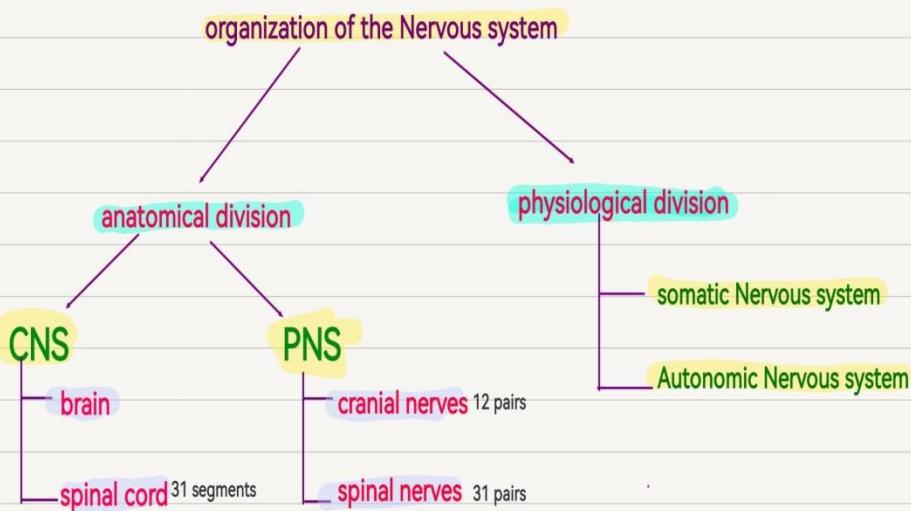
Types of the reflex arc

	Somatic reflex arc	Autonomic reflex arc
Receptor	In the skin	In the visceral (viscous) wall
Afferent	The mother cell of the afferent neuron is present in the dorsal root ganglia	
Centre	Anterior horn cell (AHC)	Lateral horn cell (LHC)
Efferent	One neuron from AHC to the effector organ	Divided by autonomic ganglia into 2 neurons: <ul style="list-style-type: none"> • preganglionic neuron From LHC to the autonomic ganglia • postganglionic neuron From the autonomic ganglia to the effector organ
Effector organ	Skeletal muscle	Smooth muscle, cardiac muscle or glands



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N.B spinal segment



اللهم إنا

نستودعك بيت المقدس وأهل القدس وكل
فلسطينيين اللهم كن لهم عونانا اللهم إنا لا نملك إلا
الدعاء فيارب لا ترد لنا دعاء ولا تخيب لنا
رجاء ، اللهم أنصر ضعفهم فإن ليس لهم سواك



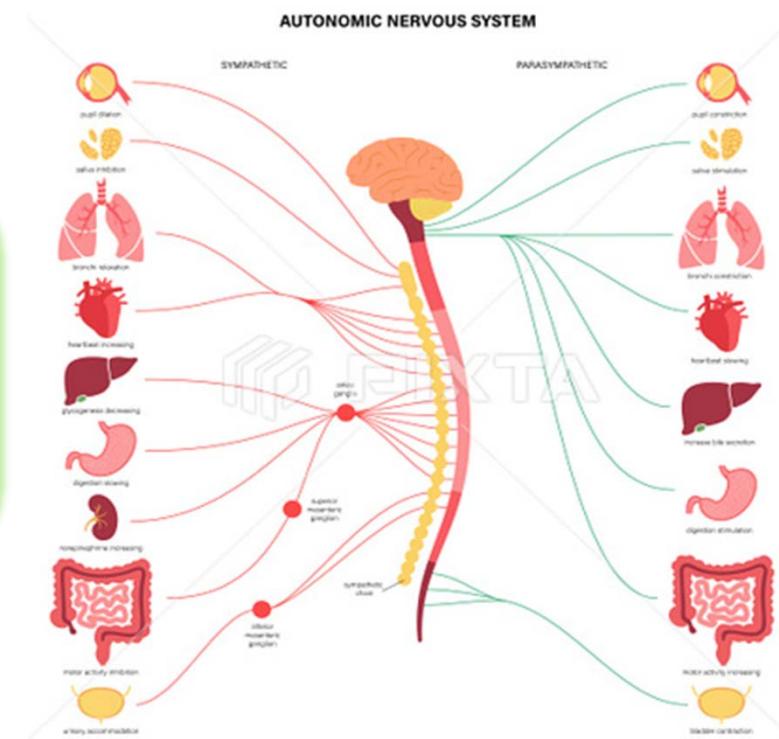
Physio L4 : Autonomic nervous system

- outlines

1-Definition of A.N.S

2-Division of A.N.S

3-Autonomic Ganglia



Definition of A.N.S

♥ The autonomic nervous system regulates the activities of involuntary acts in our bodies:

♥ cardiac muscle contraction smooth muscle contraction secretion of glands

Division of A.N.S

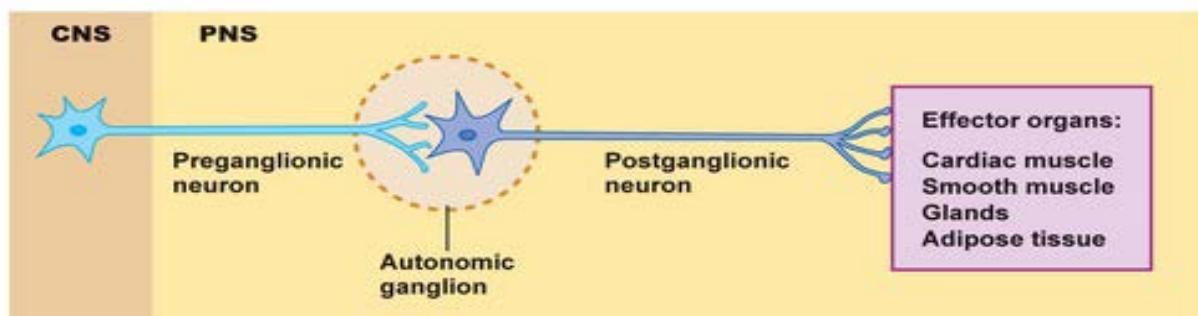
Autonomic nervous system is divided into 2 systems

1*Sympathetic

2*parasympathomimetic

Autonomic Ganglia

Definition: collection of nerve cell (soma of neurons) located outside the CNS.





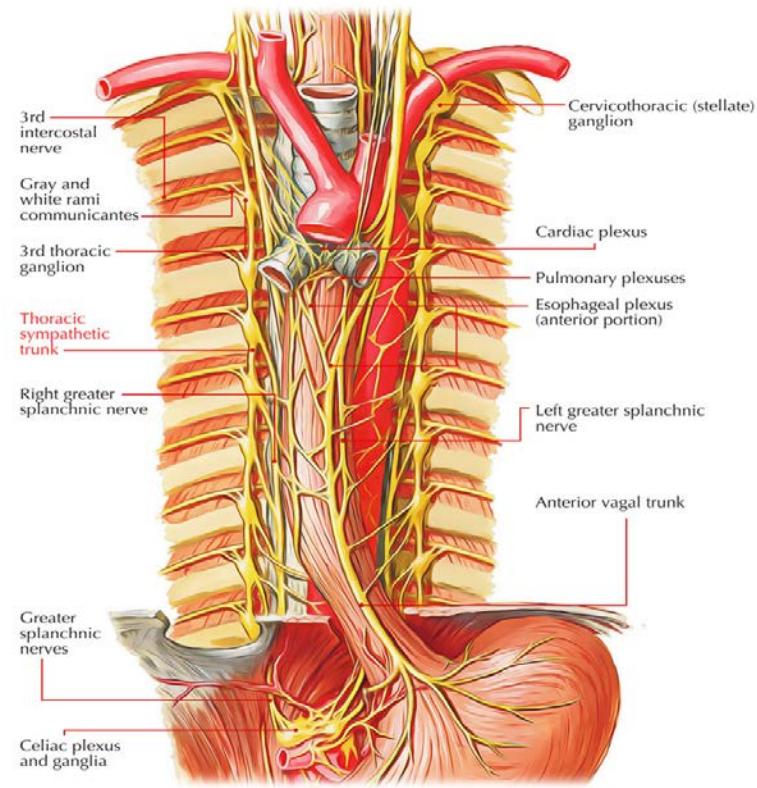
N.B: a collection of nerve cell (soma of neurons) located inside the CNS
is called Center or Nucleus

Types of autonomic ganglia:

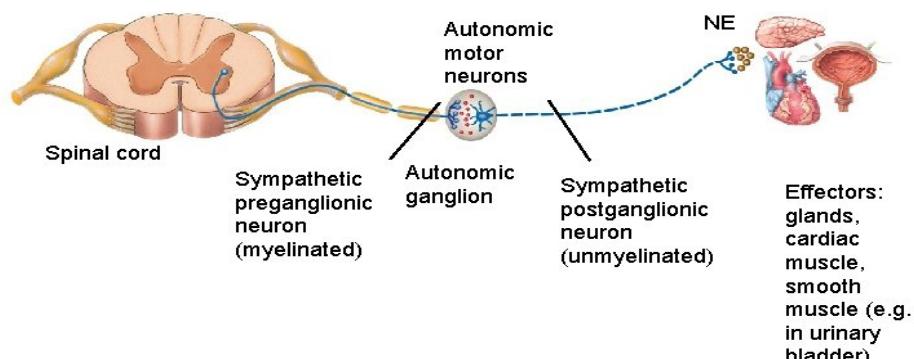
- 1- lateral (paravertebral)ganglion.
- 2- Collateral (prevertebral)ganglion.
- 3- Terminal ganglion.

1- lateral(paravertebral) ganglia

- ♥ Lie on both sides of vertebral column.
- ♥ Form the sympathetic chain.
- ♥ Each chain is formed of 26 ganglia
(3 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal).

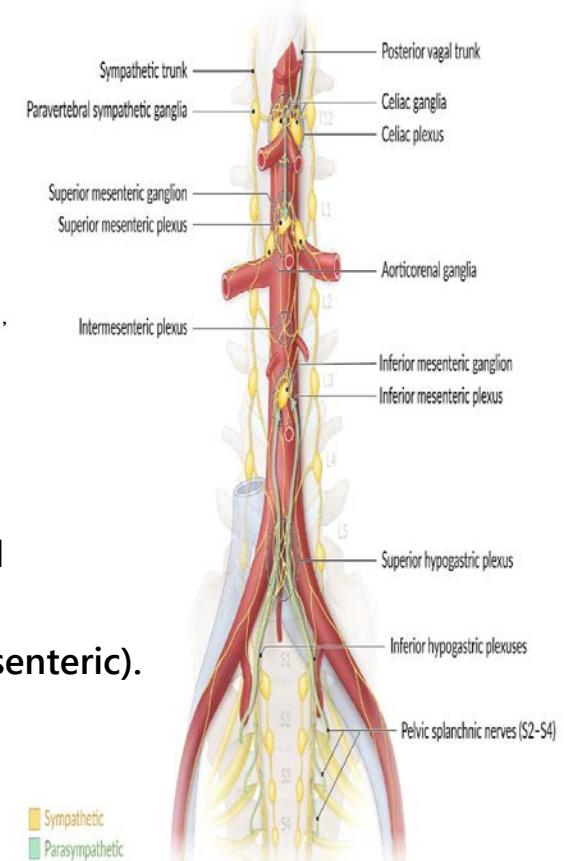


- ♥ Lateral ganglia are site of relay of preganglionic sympathetic fibers only.



2- Collateral (prevertebral) ganglia

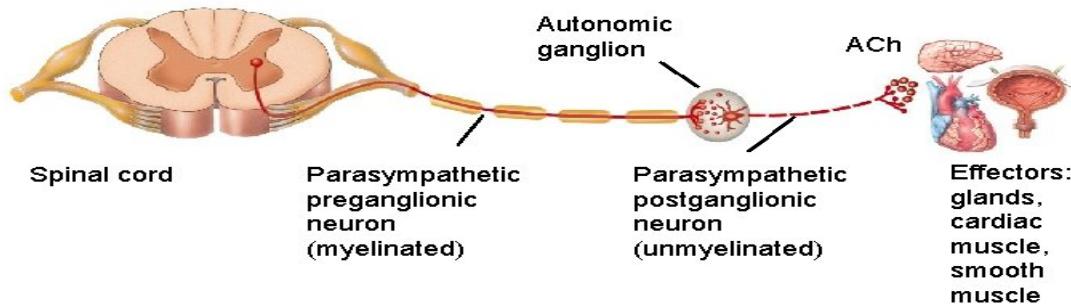
- ♥ Found midway between spinal cord and viscera.
- ♥ lie at origin of big arteries from abdominal aorta and are named after them
e.g., (celiac, renal, superior mesenteric and inferior mesenteric).
- ♥ They are site of relay of preganglionic sympathetic and parasympathetic fibers.





3- Terminal ganglia

- ♥ Lie within the organ of supply.
- ♥ They are site of relay of preganglionic parasympathetic fibers only.



Functions:

- 1- Autonomic ganglia acts as a distributing center as one preganglionic fiber relay with many postganglionic fibers.

This compensates for the limited origin of autonomic nervous system in relation to its wide distribution .

- 2- Site of action of many drugs(ganglionic blocker).

Comparison between sympathetic and para sympathetic Nervous system

AUTONOMIC NERVOUS SYSTEM

- **SYMPATHETIC**
 - *Fight or Flight*
- **PARASYMPATHETIC**
 - *Rest and Digest*





	SYMPATHETIC	PARASYMPATHETIC
Origin	thoracolumbar outflow: ♥ all thoracic segments ♥ Upper 3 lumbar segments	Craniosacral outflow: ♥ 3,7,9,10 cranial nerves ♥ middle 3 sacral nerves
Ganglia	Lateral and collateral	Collateral and terminal
Distribution	Wider distribution	♥ relatively localized No parasympathetic to: skin, spleen, thoracic and abdominal wall, ventricles of heart& adrenal medulla
Prepare the body for	Increased activity	Recovery & repair
Active during	Stress (emergency conditions) muscular exercise, fight & flight	Rest and relaxation mainly
Relation to energy	Catabolic(energy consuming)	Anabolic(energy preserving)
Form of activity	Usually generalized(all parts are activated together)	Usually localized(each part is activated separately) a generalized parasympathetic stimulation may be fatal.
Chemical transmitter	Noradrenaline	Acetylcholine

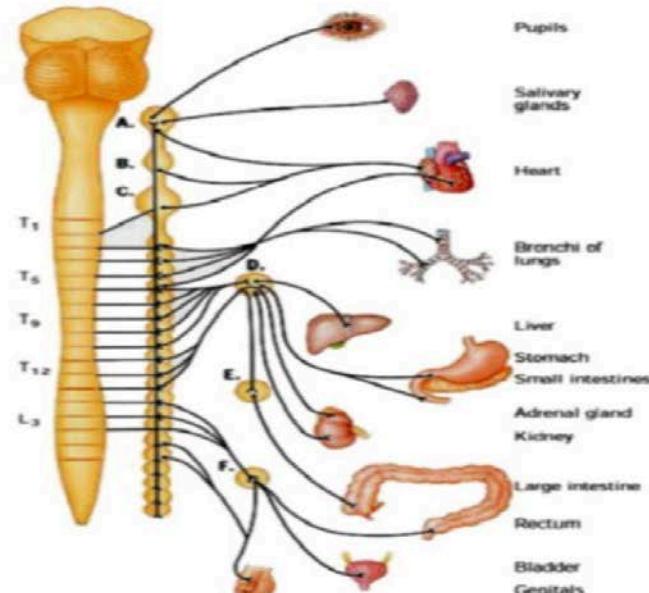


Sympathetic Nervous System

Nerves from spinal cord run to chain ganglia or collateral ganglia and then to glands and smooth muscle

mobilize energy
divert blood to muscle
prepare to fight/flee

"Fight or Flight"



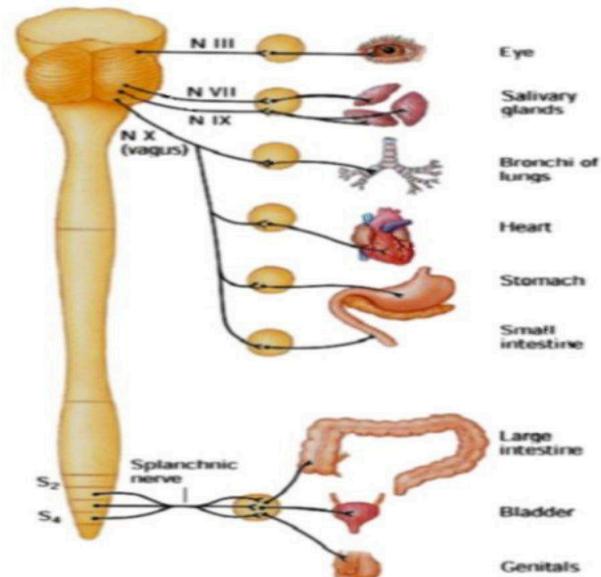
Parasympathetic Nervous System

Nerves from brainstem and spinal cord run to glands and smooth muscle

Prepare for digestion, energy storage, divert blood flow to gut.

opposite effect of sympathetic NS (in most cases)

"Rest and Digest"



اللَّهُمَّ إِنِّي أَسْتَوْدِعُكَ فَلَسْطِينَ وَأَهْلَهَا، أَمْنَهَا
وَآمَانَهَا، لِلَّهِ وَتَهَارَهَا، أَرْضَهَا وَسَماءَهَا،
إِسْلَامَهَا وَمَسَجِدَهَا، فَاحْفَظْهَا يَا اللَّهُ مِنَ
الظُّغَاءِ وَكُلَّ مَنْ يَرِيدُ بِهَا سُوءً وَكُلَّ مَنْ تَعَدَّى
عَلَيْكَ وَعَلَى رُسُلِكَ، أَرِنَا فِيهِمْ عِجَابَ قُدْرَتِكَ،
اللَّهُمَّ إِنِّي أَسْتَوْدِعُكَ رِجَالًا وَطَنِي وَنِسَاءَ،
شَبَابَهُ وَأَطْفَالَهُ يَا مَنْ لَا تُضِيغُ عَنْهُ الْوَدَاعَ.

لاتنسوا الدعاء لزملائنا
و جميع موتى المسلمين



Physio L5 : Sympathetic supply to head & neck

Origin

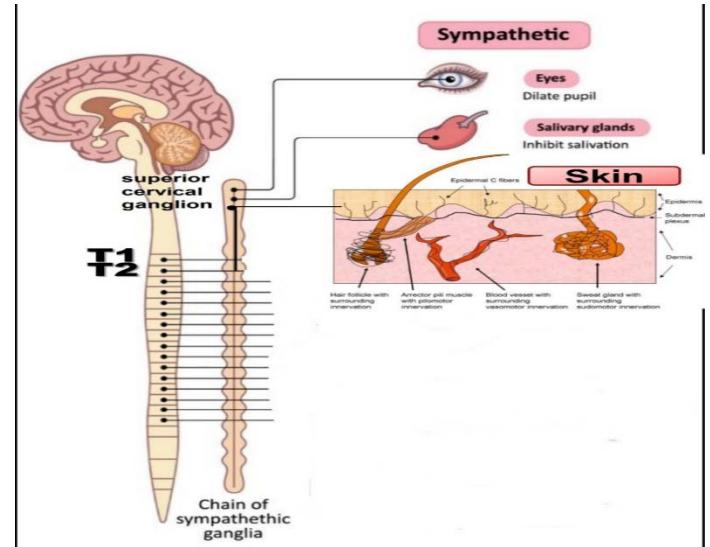
Lateral horn cells (LHCs) of upper two thoracic segments (T1 & T2).

Relay

- **Preganglionic fibers** reach the sympathetic chain then they proceed upwards & relay in the superior cervical ganglion.
- **Postganglionic neurons** arise from this ganglion to supply the following structure:

1-Skin of the head & neck

2-Salivary glands 3- Eyes



Functions

Skin of the head & neck	Salivary glands
1-Vasoconstriction (V.C) of skin blood vessels. 2-Sweat secretion. 3-Hair erection as a result of contraction of erector pilae muscle in the skin.	1-Vasoconstriction (V.C) of salivary glands blood vessels. 2-Trophic secretion (viscid secretion- Little in amount but rich in enzymes).
Eye	
1- Elevation of the upper eye lid due to contraction of levator palpebral muscle of the eye lid. 2-Dilatation of pupil (Mydriasis) due to contraction of dilator pupillae muscle. 3- Exophthalmos (forward protrusion of the eyeball) due to contraction of Muller 's muscle. 4- V.C of the blood vessels of the eye. 5- Relaxation of ciliary muscle to facilitate far vision.	



Lesion (Horner Syndrome)

Cause	Due to an injury to the cervical sympathetic nerve fibers produce a syndrome (a group of symptoms) on the same affected side
Symptoms	<p>1- Miosis i.e. pupilloconstriction due to paralysis of the dilator pupillae muscle.</p> <p>2- Anhydrosis i.e. absence of sweat secretion. MAPLE</p> <p>3- Ptosis: i.e. dropping of the upper eye lid.</p> <p>4- Vasodilation, so the affected side becomes warmer with more redness than the healthy side.</p> <p>5- Enophthalmos i.e. sinking of the eyeball backwards in the orbit, due to paralysis of Muller 's muscle</p>

Q1. To what does the following description apply ? " An unlearned and involuntary but predictable motor response to a stimulus that's rapid and doesn't involve any processing by the brain"

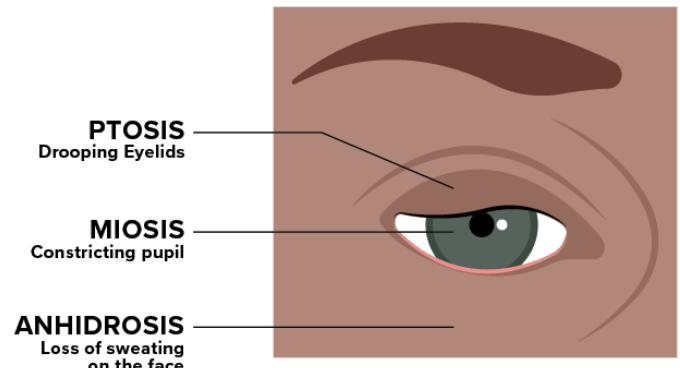
HORNER'S SYNDROME

Spinal reflex action

Autonomic reflex action

Cranial reflex action

Learned reflex action



NO MATTER how mistakes you make or how slow
you progress, you are still way ahead of everyone who isn't trying



Physio L 6 : sympathetic supply of thorax & abdomen

Outlines ; Origin , Relay & Function

1 – Sympathetic supply to thorax

Origin	Relay
From lateral horn cells (LHCs) of the upper four thoracic segments .	Preganglionic fibers : All cervical ganglia and upper four thoracic ganglia . Postganglionic fibers : arise from this ganglion to supply heart & lung

Function :

Heart : * Stimulatory

1. increases heart rate and
2. Increases force of contraction.
3. **Coronary vasodilatation** leading to increase blood supply of the cardiac muscle (indirect effect through accumulation of metabolites).

Lung:

1. Bronchodilatation (widening of air passages) due to relaxation of wall smooth muscle.
2. Vasoconstriction of pulmonary blood vessels.
3. Decreases mucous secretion in the air passages.

2 – Sympathetic supply to abdomen

Origin	Relay
<ul style="list-style-type: none"> - From LHCs of 6-12 thoracic segments (T6- T12) . - The preganglionic fibers form the greater splanchnic nerve 	<ul style="list-style-type: none"> - Celiac ganglion - Renal ganglion - superior mesenteric ganglion



Function :

- Relax wall of stomach, small intestine & proximal part of the large intestine .
- Contraction of sphincters (leading to food retention)
- Liver : stimulation of glycogenolysis leading to increase blood glucose.
- Spleen : contraction of splenic capsule release of stored blood to the general circulation(about 200 ml).
- Suprarenal medulla : secretory to 80% adrenaline and 20% noradrenaline.
- V.C of blood vessels of the stomach, small intestine, proximal part of large intestine, liver, kidney ,and pancreas

3 – Sympathetic supply to pelvis

Origin	Relay
<ul style="list-style-type: none"> - L.H.Cs of the 12th thoracic segment and the upper 3 lumber segments. - The preganglionic fibers form right and left lesser splanchnic nerves which are joined to form the pre-sacral nerve. 	Inferior mesenteric ganglia

Function :

1- Rectum

- a. Relaxation of the wall
- b. Contraction of internal anal sphincter leading retention of stool.

2- Urinary bladder

- a. Relaxation of the wall.
- b. Contraction of internal urethral sphincter leading to retention of urine.

3- genital organs :

- a. Ejaculation of semen due to contraction of vas deferens, seminal vesicle and prostatic muscles.
- b. V.C of blood vessels of pelvic viscera including external genital tract leading to shrinkage of penis.



4 – Sympathetic supply to upper & lower limbs

	Origin	Relay
Upper limb	From LHCs of (5-9) thoracic segments (T5-T9).	Middle and inferior cervical ganglia and upper 2 thoracic ganglia
Lower limb	From LHCs of (10- 12) thoracic segments (T10-T12).	Lumbar, sacral

Function :

In both upper and lowe limbs :

Skeletal muscle blood vessels :

vasodilatation -causing better contraction, delayed fatigue and rapid recovery (Orbelli phenomenon).

Skin :

1. Vasoconstriction.
2. Contraction of piloerector muscles causing erection of hair.
3. Secretory to sweat glands .

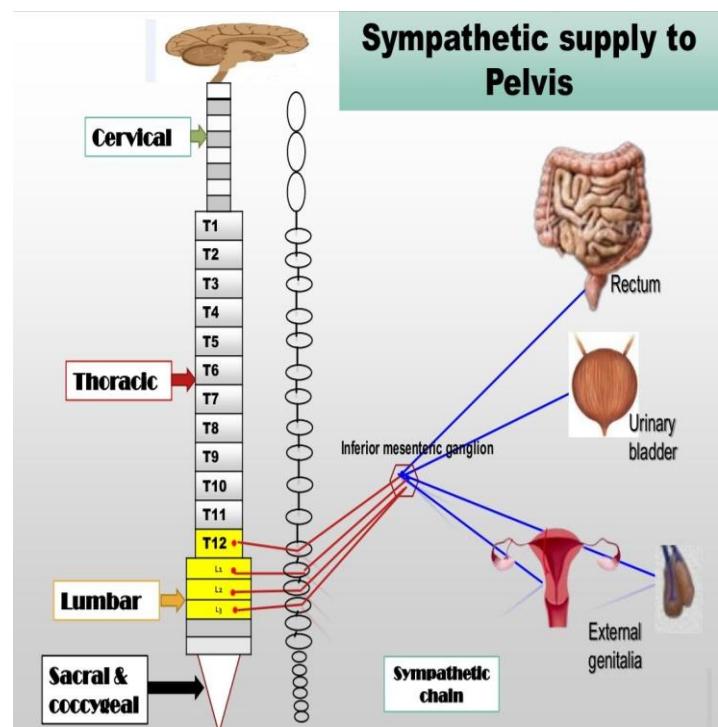
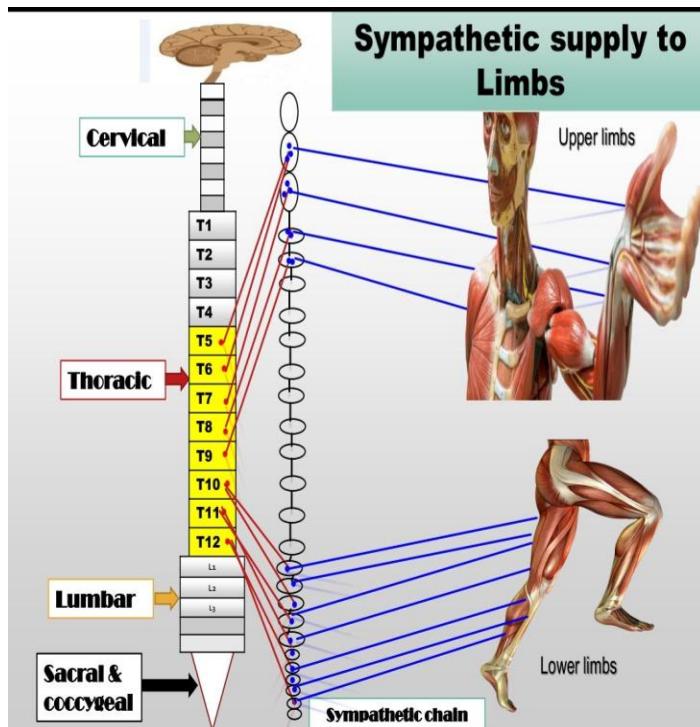
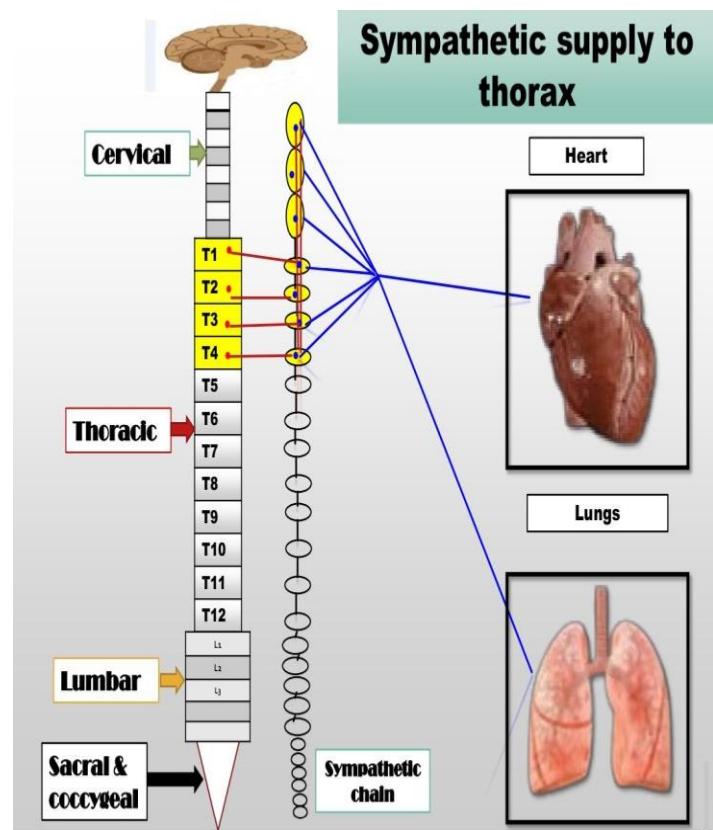
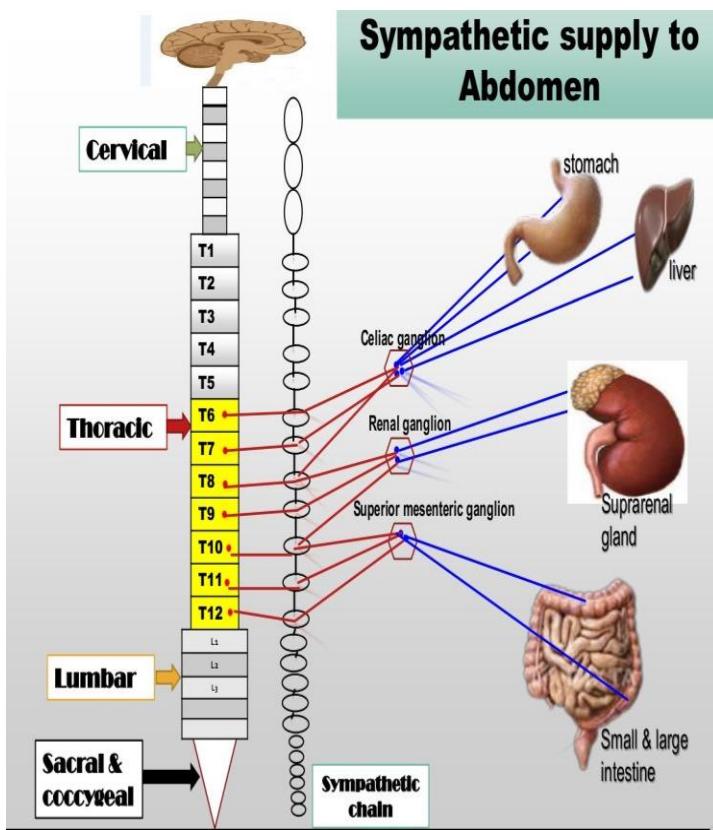
❖ Orbelli phenomenon :

Sympathetic stimulation to skeletal muscles cause:

1. Better contraction.
2. Delayed fatigue.
3. Rapid recovery from fatigue.

➤ Mechanism :

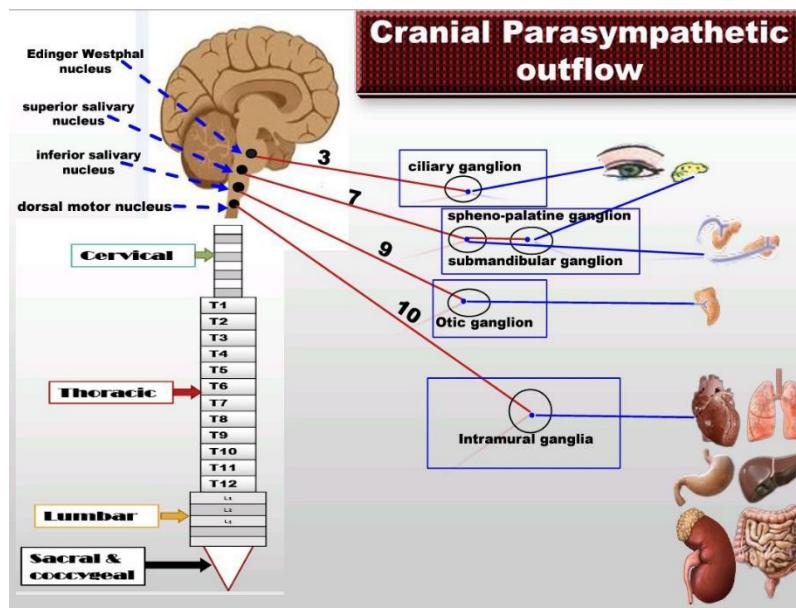
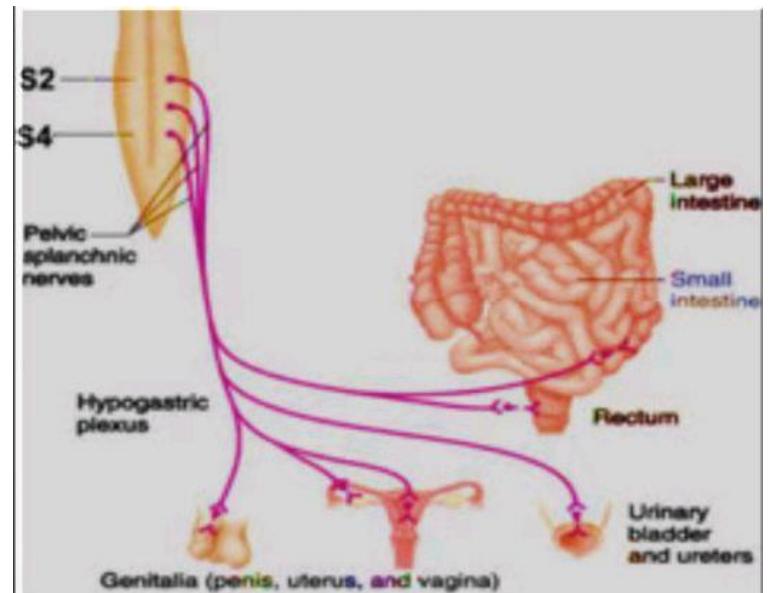
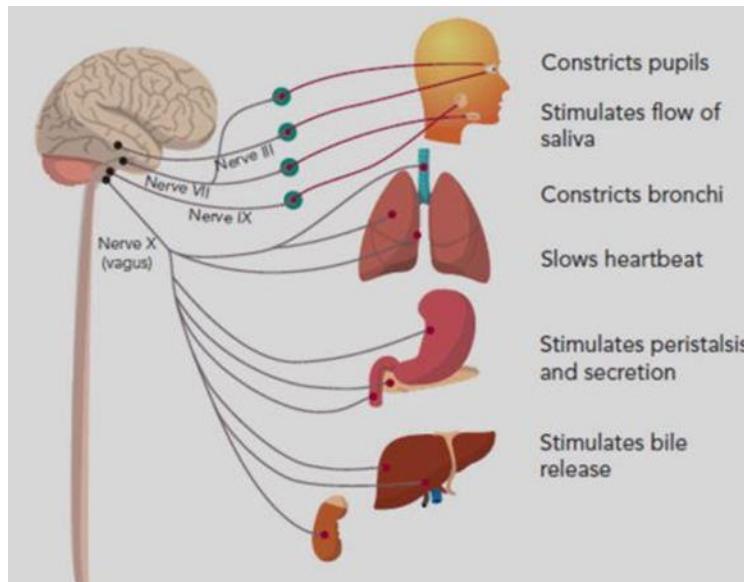
- 1- An increase in blood flow due to vasodilatation this help supply of more oxygen and nutrients and easy removal of waste products.
- 2- Increase sensitivity of the motor end plate to **acetyl choline**.
- 3- Activation of **phosphorylase** enzyme which help **glycogen breakdown** and release of energy in the muscle .





Physio L6: Parasympathetic nervous system

Outlines

Cranial
Parasympathetic
outflowSacral
Parasympathetic
outflow



Cranial parasympathetic outflow

III- Oculomotor nerve

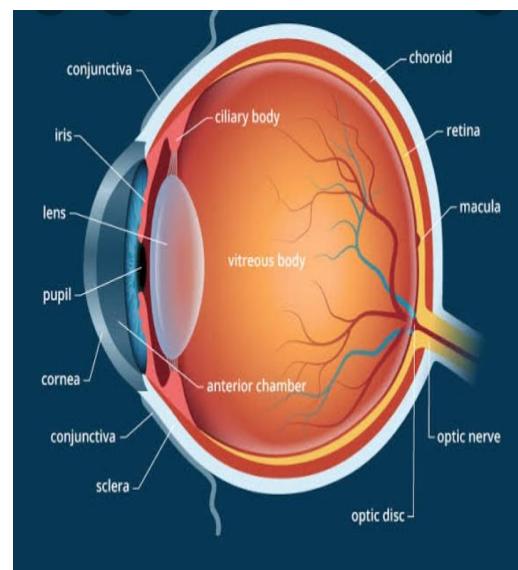
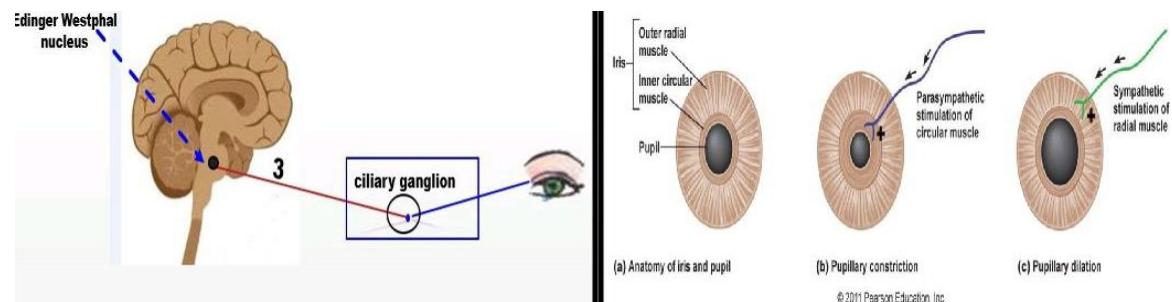
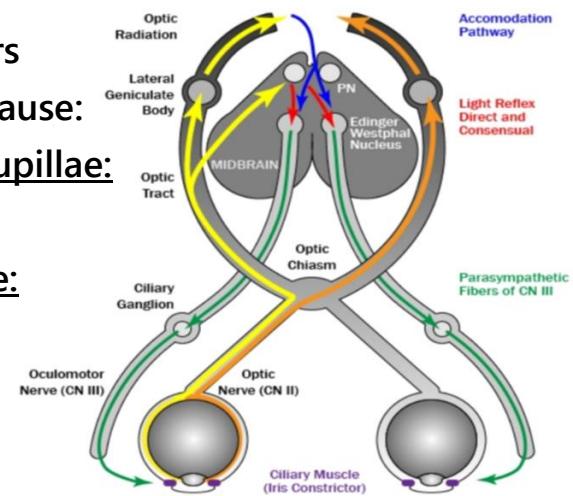
Origin: Edinger Westphal nucleus in the mid brain.

Relay: ciliary ganglion

Function: the postganglionic fibers run in the short ciliary nerves to cause:

1-contraction of the constrictor pupillae: miosis [constriction of the pupil]

2-contraction of the ciliary muscle: increased convexity of the lens of the eye (increased power) responsible for near vision.





VII – Facial nerve

Origin: superior salivary nucleus in the pons
The preganglionic fibers form chorda tympani (branch of facial nerve)

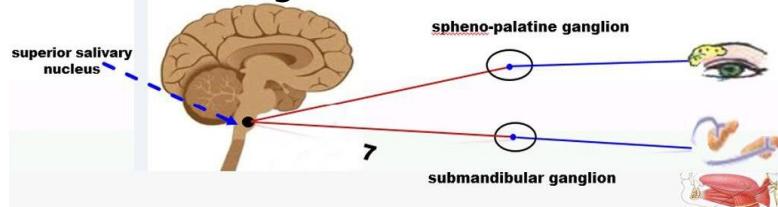
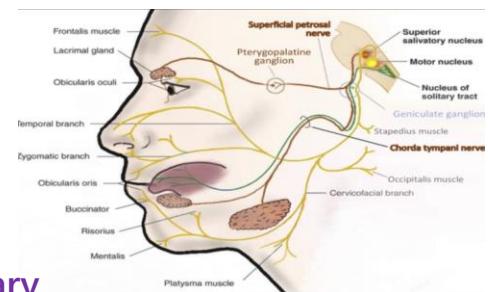
Relay:

1-spheno-palatine ganglion → lacrimal gland and mucosa of nose and mouth, pharynx and palate.

2-submandibular ganglion → submandibular ,sublingual salivary glands and anterior 2/3 of the tongue.

Function:

- ❖ To lacrimal glands: leads to secretion of tears.
- ❖ To submandibular & sublingual salivary glands: causing **True salivary secretion** (large in volume, watery & poor in organic substances).
- ❖ To mucous glands of nose, mouth, pharynx & palate lead to mucous secretion.
- ❖ Vasodilatation of blood vessels of salivary glands, floor of mouth and anterior 2/3 of the tongue.



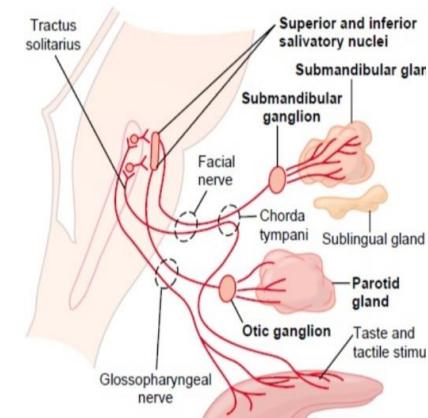
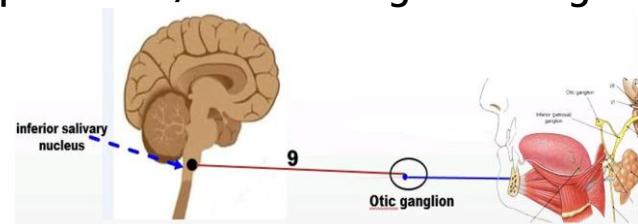
IX – Glossopharyngeal nerve

Origin: inferior salivary nucleus of pons

Relay: inferior salivary nucleus of pons.

Function:

- 1- parotid salivary gland causing true secretion.
- 2- posterior 1/3 of the tongue causing V.D.





X- Vagus nerve

Origin : dorsal motor nucleus of vagus in medulla oblongata .
Relay : terminal ganglia in the thoracic & abdominal viscera.
Function : it represents 75 % of all parasympathetic innervation.

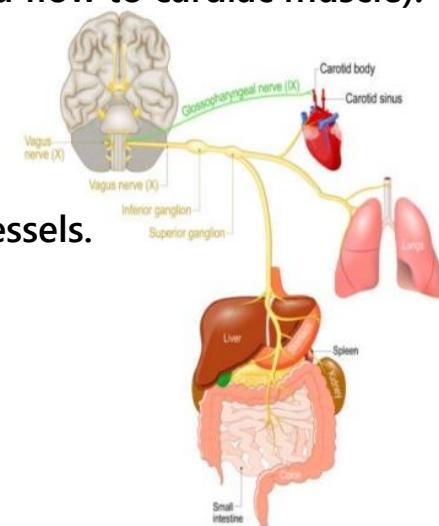
Thorax

[1] The heart

- 1) inhibition of all cardiac properties (decrease conductivity, contractility, excitability & rhythmicity).
- 2) V.C of coronary blood vessels (\downarrow blood flow to cardiac muscle).

[2] The lungs:

- 1-broncho-constriction.
- 2-increase mucous secretion.
- 3-vaso-dilatation of pulmonary blood vessels.



Abdomen

❖ Gastro-intestinal tract (G.I.T.):

1)Smooth muscles: **Contraction** of the wall, **relaxation** of sphincters of: **esophagus, stomach, small intestine & proximal part of large intestine.**

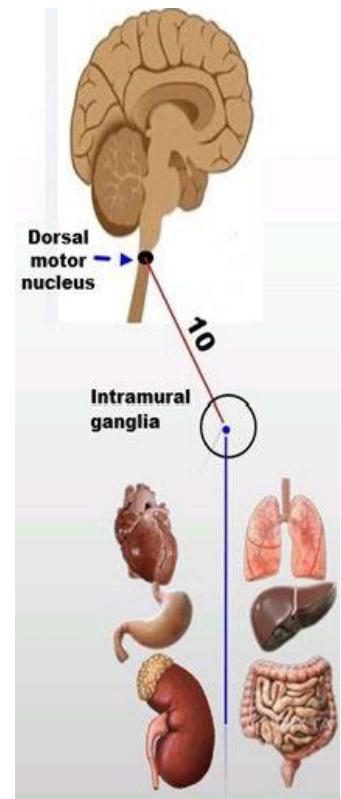
2)Secretory to the gastric glands: increases HCL & mucous secretion
3)Blood vessels causing vasodilatation.

❖ The pancreas:

- 1- Secretion of pancreatic juice rich in **enzymes**.
- 2- Stimulates **insulin** secretion by β - cells of islets of pancreas.

❖ The liver: Stimulate bile secretion.

- **Contraction** of gall bladder wall & **relaxation** of sphincter of oddi leads to its evacuation.





Sacral parasympathetic outflow

Pelvic nerve

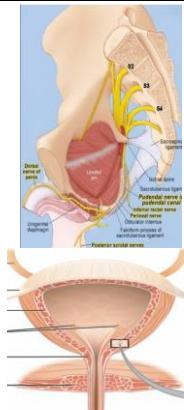
Origin: LH.Cs of 2, 3, 4 sacral segments (S2, 3 &4).

Relay: Terminal ganglia of the organ of supply

Functions:

1. Urinary bladder

- Cause contraction of smooth muscles of the wall.
- Relaxation or inhibitory to the internal urethral sphincter leading to evacuation of the urinary bladder (**micturition**).



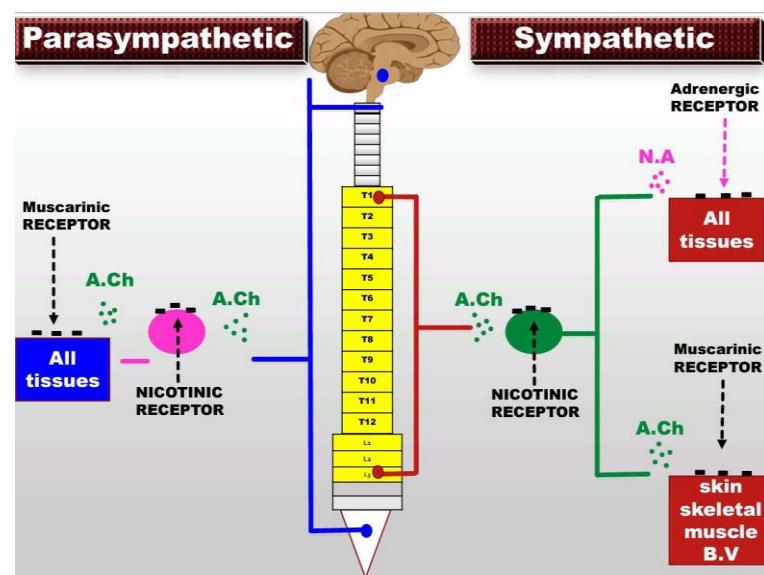
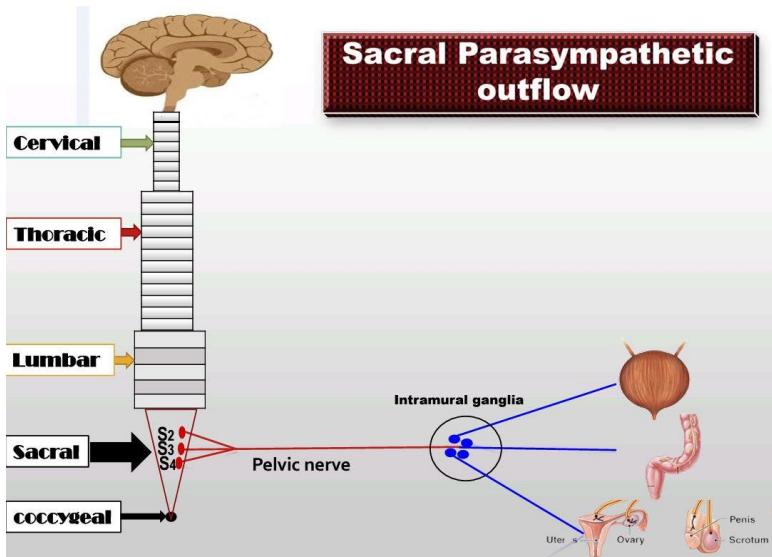
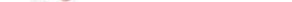
2. Rectum

- Cause contraction of smooth muscles of the wall of the distal part of the large intestine.
- Relaxation or inhibitory to the internal anal sphincter leading to evacuation of the rectum (**defecation**).



3. Male genital organs:

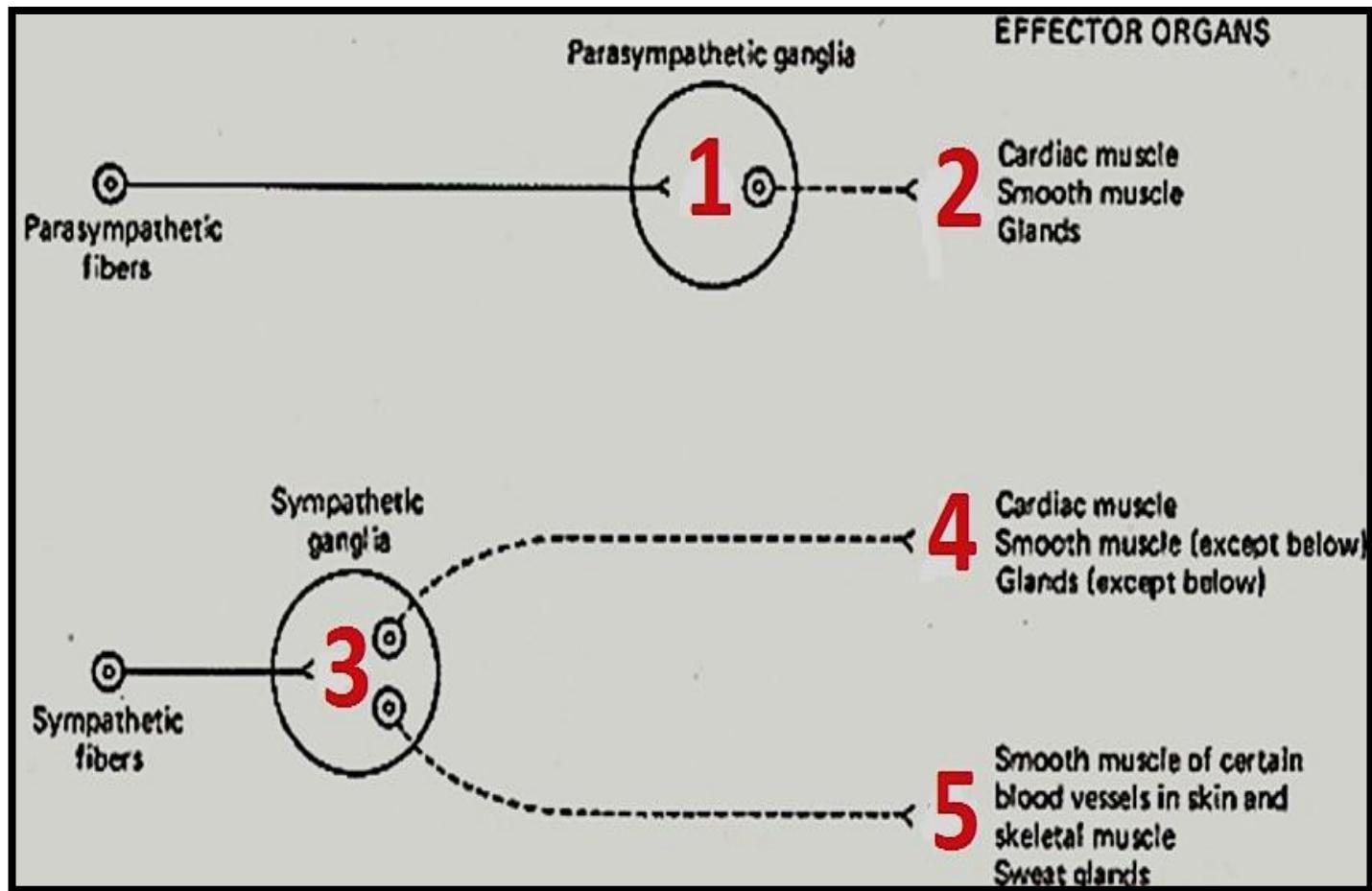
- **Erection** due to V.D of the blood vessels of the penis.
- **Secretory** to seminal vesicle and prostate





Chemical transmission in the autonomic N.S.

	Sympathetic	Parasympathetic
Chemical transmission	<ul style="list-style-type: none"> ❖ Preganglionic fibers secrete acetyl choline (the chemical transmitter at autonomic ganglion), thus they are cholinergic fibers. ❖ Postganglionic fibers secrete noradrenaline in all sites except , postganglionic to <ol style="list-style-type: none"> 1- sweat glands 2- Skeletal muscle blood vessels where they secrete acetyl choline. 	<ul style="list-style-type: none"> ❖ Preganglionic fibers secrete acetyl choline (the chemical transmitter at autonomic ganglion), thus they are cholinergic fibers. ❖ Postganglionic fibers Secrete acetyl choline in all sites (cholinergic fibers)
Receptors	<ul style="list-style-type: none"> ❖ At end of preganglionic fibers (at ganglion) [cholinergic/nicotinic] ❖ At end of postganglionic fibers (at organ of supply): adrenergic receptors at all organs except: <ol style="list-style-type: none"> 1 - sweat glands. 2- skeletal muscle blood vessels. which contain cholinergic/ muscarinic receptors. 	<ul style="list-style-type: none"> ❖ At end of preganglionic fibers (at ganglion): cholinergic /nicotinic. ❖ At end of postganglionic (at organ of supply): cholinergic /muscarinic receptors.



**TEST
YOURSELF**

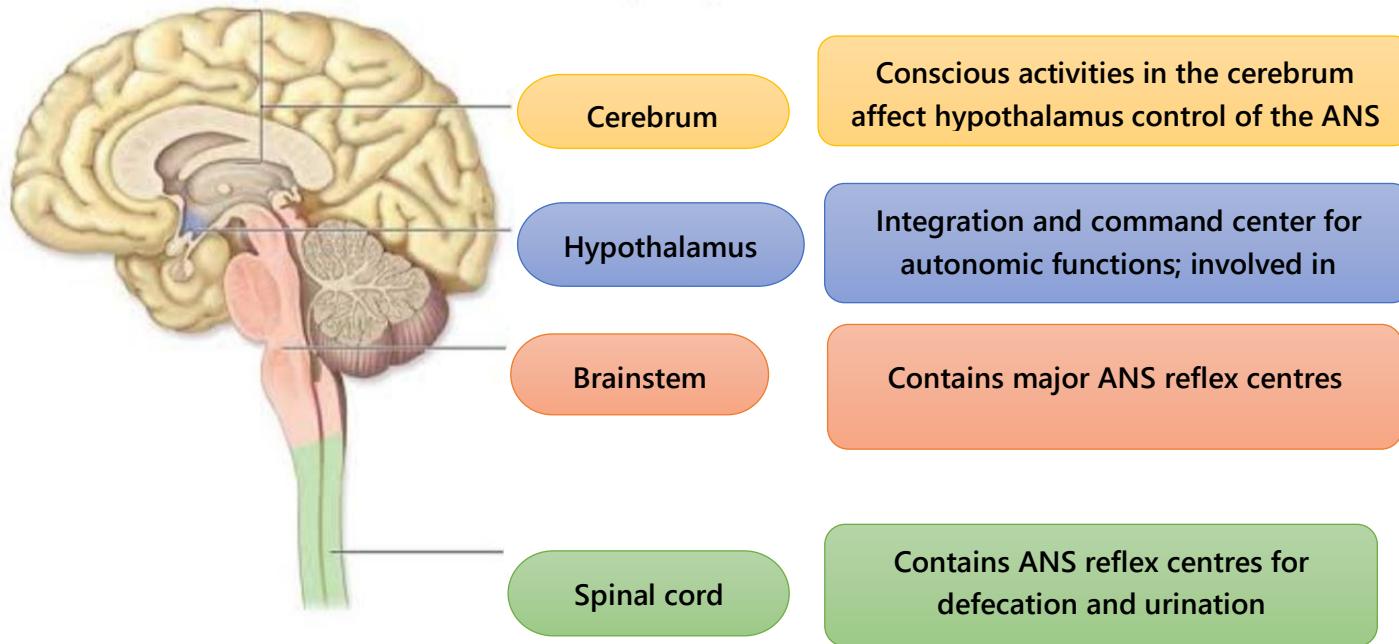


L8:control of autonomic functions

Autonomic reflexes are controlled at different levels of C.N.S:

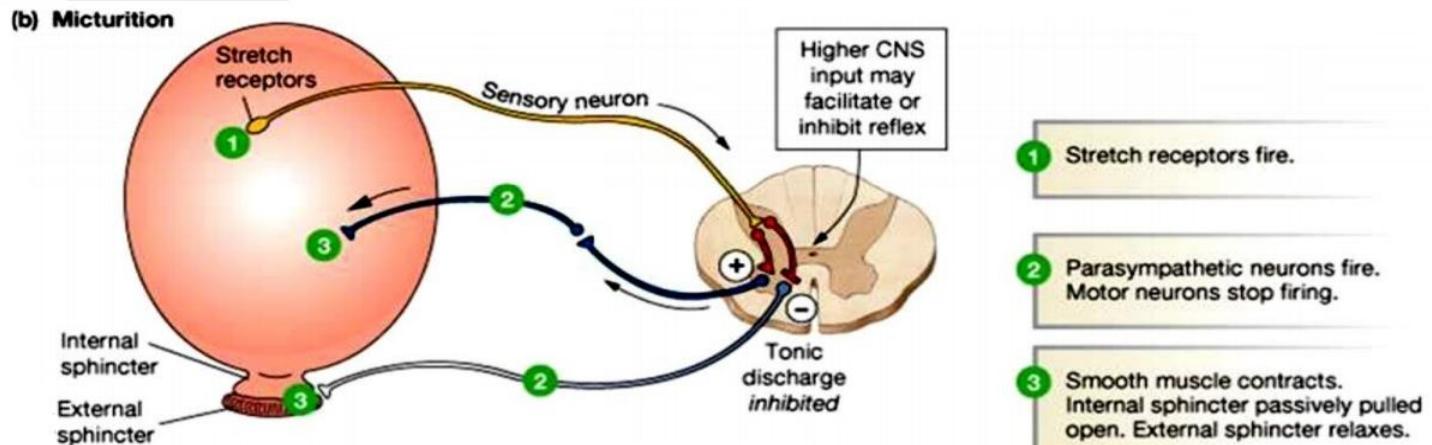
- Spinal cord
- Brainstem
- Hypothalamus
- Cerebral cortex

Higher control of autonomic functions:



1-Spinal cord:

Contains centers for primitive spinal reflexes as micturition reflexes.





2-Brain stem (Reticular formation):

(Higher control for spinal reflexes)

Medulla: Contains centers for control of:

- 1) C.V.S
- 2) Respiration
- 3) GIT motility and secretions

Pons: Contains centers for control of:

- 1) Respiration
- 2) Salivary secretions

Midbrain: Contains centers for control of:

- 1) Micturition
- 2) Pupillary reactions

3-Hypothalamus:

1-The **main centers** within the brain that regulates autonomic nervous system .

2-It receives multiple inputs from:

- Other central nuclei e.g. those of the limbic system linked with emotion.
- The external environment e.g. olfactory mucosa via medial forebrain bundle.
- The internal environment e.g. osmoreceptors, thermoreceptors within hypothalamus

3-It integrates this information and then initiates an appropriate response via:

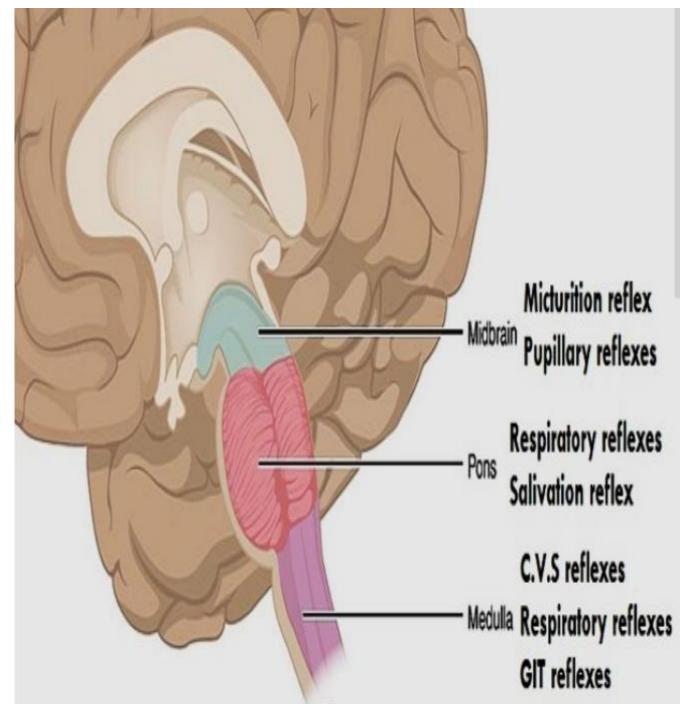
➤ **Sympathetic nervous system:**

- neurons involved with sympathetic responses seem to congregate in the posterior hypothalamic nucleus.
- hence for example, stimulation of the posterior nucleus results in a positive chronotropic cardiac response.

➤ **Parasympathetic nervous system:**

- neurons associated with the anterior nuclei of the hypothalamus.
- hence for example, stimulation of this area produces increased secretion within gastrointestinal tract.

4-Efferent fibers from these nuclei pass to brainstem spinal lemniscus and on the intermediolateral column of the spinal cord.





4-Cerebral cortex:

Modify autonomic functions in certain conditions via projection to hypothalamus and brainstem through limbic system.

Examples:

1-C.V.S, Respiratory and GIT responses to emotions.

Prolonged mental work stimulates the vasomotor center and frequently leads to chronic hypertension.

Thinking of food induces salivation as well as gastric secretion by cortical signals that stimulate the salivary and vagal nuclei in the brain stem (conditioned reflexes).

2-Increase blood flow at the start of exercise.

3-Control of micturition and defecation (voluntary control)

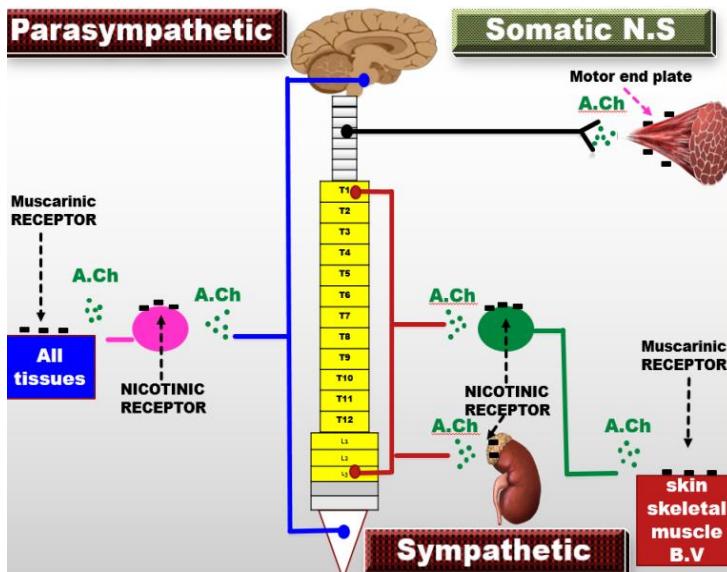




L9 : Cholinergic transmission

* Chemical transmission in autonomic nervous system :

	Sympathetic nervous system	Parasympathetic nervous system
Chemical transmission	<p>1. Preganglionic fibers secrete acetyl choline (the chemical transmitter at autonomic ganglion), thus they are cholinergic fibers.</p> <p>2. Postganglionic fibers secrete noradrenaline in all sites EXCEPT, postganglionic to:</p> <ul style="list-style-type: none"> a. sweat glands b. skeletal muscle blood vessels where they secrete acetyl choline. 	<p>1. Preganglionic fibers secrete acetylcholine (the chemical transmitter at autonomic ganglion), thus they are cholinergic fibers.</p> <p>2. Postganglionic fibers secrete acetylcholine in all sites (cholinergic fibers)</p>
Receptors	<p>1. At end of preganglionic fibers (at ganglion) called [cholinergic/nicotinic] receptors</p> <p>2. At end of postganglionic fibers (at organ of supply): adrenergic receptors at all organs EXCEPT:</p> <ul style="list-style-type: none"> a. sweat glands. b. skeletal muscle blood vessels. <p>called [cholinergic/muscarinic] receptors</p>	<p>1. At end of preganglionic fibers (at ganglion) called [cholinergic/nicotinic] receptors</p> <p>2. At end of postganglionic (at organ of supply): called [cholinergic/muscarinic] receptors</p>



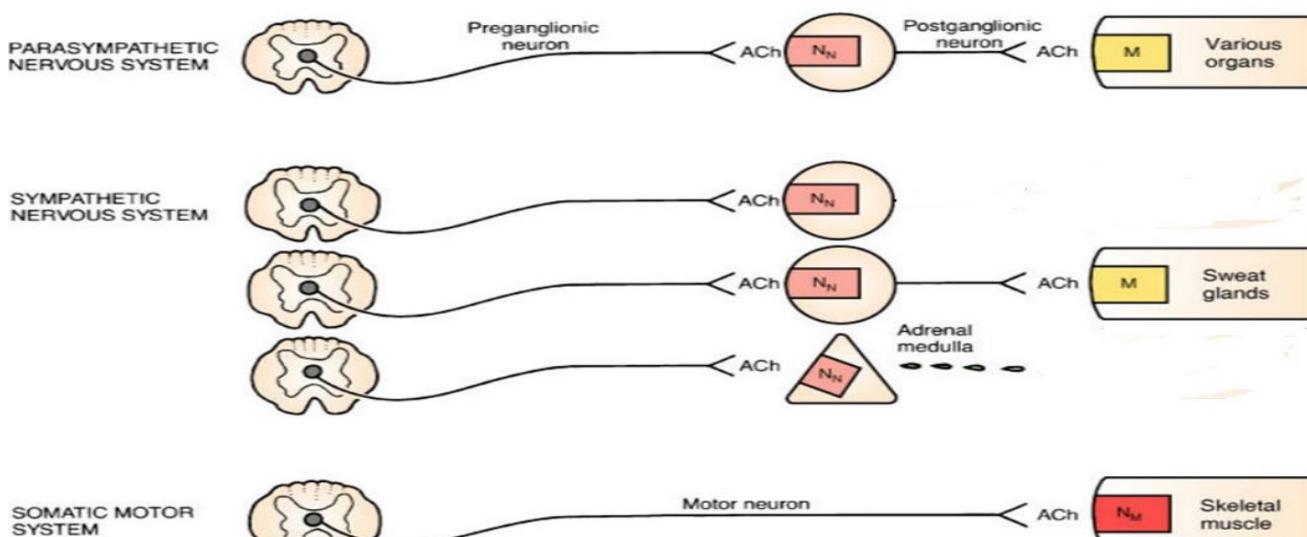


* Acetyl choline synthesis :

Synthesis	<ul style="list-style-type: none"> - It is formed from the reaction of choline and acetate . - This reaction occurs in the presence of choline acetyl transferase enzyme . - Its presence in high concentration in the cytoplasm of cholinergic nerve endings - choline + acetate \longrightarrow Acetyl choline .
Storage and release	<ul style="list-style-type: none"> • A.Ch is stored in clear vesicles in the terminal ends of cholinergic neurons. • A.Ch is released by exocytosis with the help of Ca++.
Removal	<ol style="list-style-type: none"> I. Mainly by enzymatic destruction: The enzyme needed is choline esterase enzyme which converts A.Ch into choline and acetic acid. 2. Small amount by active re-uptake into nerve terminal . 3. By diffusion into surrounding tissue .

* Site of release of Acetyl choline :

1. At central cholinergic fibers	2- At peripheral cholinergic fibers
<ul style="list-style-type: none"> • All central fibers (Fibers arise from C.N.S) secrete A.Ch . • These central cholinergic fibers are of 2 types: <ul style="list-style-type: none"> - Autonomic fibers: It includes all autonomic preganglionic fibers whether sympathetic or parasympathetic (at autonomic ganglia) . - Somatic fibers: It arises from A.H.Cs and supply motor end plate of skeletal muscles. 	<ul style="list-style-type: none"> • All parasympathetic post ganglionic fibers. • Post ganglionic sympathetic fibers to sweat glands & blood vessels of skeletal muscles.



Cholinergic receptor subtypes: N_N = nicotinic_N, N_M = nicotinic_M, and M = muscarinic.



* Cholinergic receptors :

Central cholinergic receptors (Nicotine)	Peripheral cholinergic receptors (Muscarinic)
<p>These receptors facing central cholinergic fibers(all autonomic ganglia, adrenal medulla & at motor end plate).</p> <p>They are the following :</p> <ol style="list-style-type: none"> 1. All autonomic ganglia whether sympathetic or parasympathetic 2. at motor end plate, 3. at the adrenal medulla which is considered as sympathetic ganglia. 4- Stimulated by small dose of nicotine Inhibited by large dose of nicotine . 	<p>These receptors are facing the peripheral cholinergic fibers(wall of viscera).</p> <p>They are the following :</p> <ul style="list-style-type: none"> • at organs facing parasympathetic. post ganglionic fibers. • at blood vessels of skeletal muscles and sweat glands that supplied by post ganglionic sympathetic fibers. • Peripheral cholinergic receptor can be stimulated by muscarine . • Stimulated by muscarine , Inhibited by atropine .

* Drugs stimulating cholinergic receptors (Parasympathomimetic) :

Drugs acting on nicotinic receptors	Drugs acting on muscarinic receptors
<p>- Direct action :</p> <p>By direct stimulation of receptors :</p> <ul style="list-style-type: none"> - Acetylcholine . - Nicotine small dose. 	<p>- indirect action :</p> <p>By using anti-choline esterase which prolong the action of A.Ch .</p> <ul style="list-style-type: none"> - Types of anticholine esterase : <ul style="list-style-type: none"> * Reversible anticholine esterase: They combine temporary Ex.: physostigmine, neostigmine . * Irreversible: They combine strongly and for Long time. Ex.: di isopropyl fluorophosphate [D.F.P] & parathion



* Drugs Blocking cholinergic receptors parasympatholytic :

Nicotinic receptors blockers		Muscarinic receptors blockers
Ganglion blocker: -Blocks all autonomic ganglia[symp.parasymp.] - Adrenal medulla considered as modified sympathetic ganglia .	Neuromuscular blocker: Block the action of A.CH. at motor end Plate .	- Block the function of A.CH by competitive inhibition: As atropine and Homatropine .
Types : -Competitive ganglion blocker:hexamethonium. - Depolarizing ganglion blocker : nicotine in large dose . - The block due to maintained Depolarization .	Types : Competitive neuro-muscular . - blocker: curare .	
	Depolarizing neuro -muscular - blocker : succinylcholine.	





L10: Adrenergic transmission

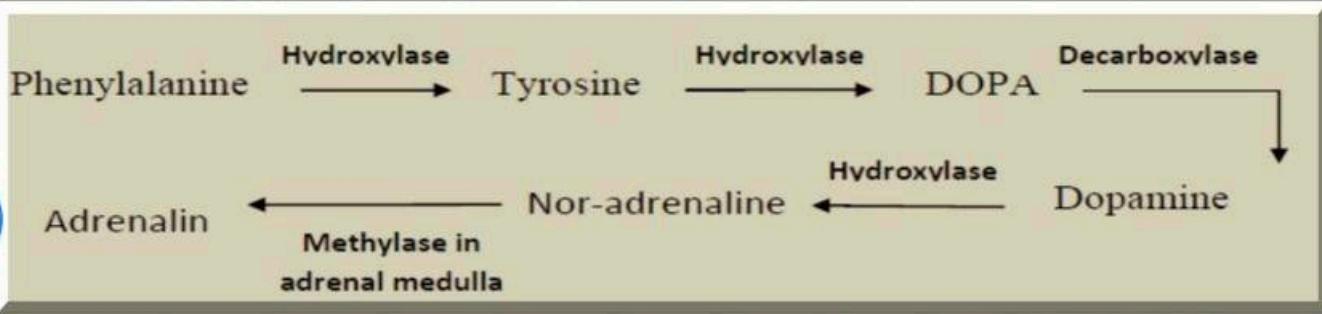
❖ Catecholamines synthesis

➤ Types of catecholamines:

- Noradrenaline: chemical transmitter at postganglionic sympathetic fibers except (sweat gland – skeletal muscle blood vessel) + H
- Adrenaline: hormone secreted by adrenal medulla
- Dopamine: major transmitter in basal ganglia, limbic system, CTZ and anterior pituitary gland.

➤ Synthesis of catecholamines:

Nor-adrenaline is formed from phenylalanine amino acid in adrenergic nerve endings as follow:



➤ Storage & Release of catecholamines:

- Adrenaline: (epinephrine) is formed only in the adrenal medulla not in adrenergic nerve terminal through methylation of nor-adrenaline by methyl transferase enzyme which is deficient in nerve terminal.
- Nor-adrenaline : is stored in dark vesicles in the nerve endings and released by exocytosis by help of calcium.

➤ REMOVAL & INACTIVATION OF noradrenaline

• NEURONAL REUPTAKE : MAIN

About 50-80 % of noradrenaline is removed after performing it's action by active reuptake into the nerve terminal.

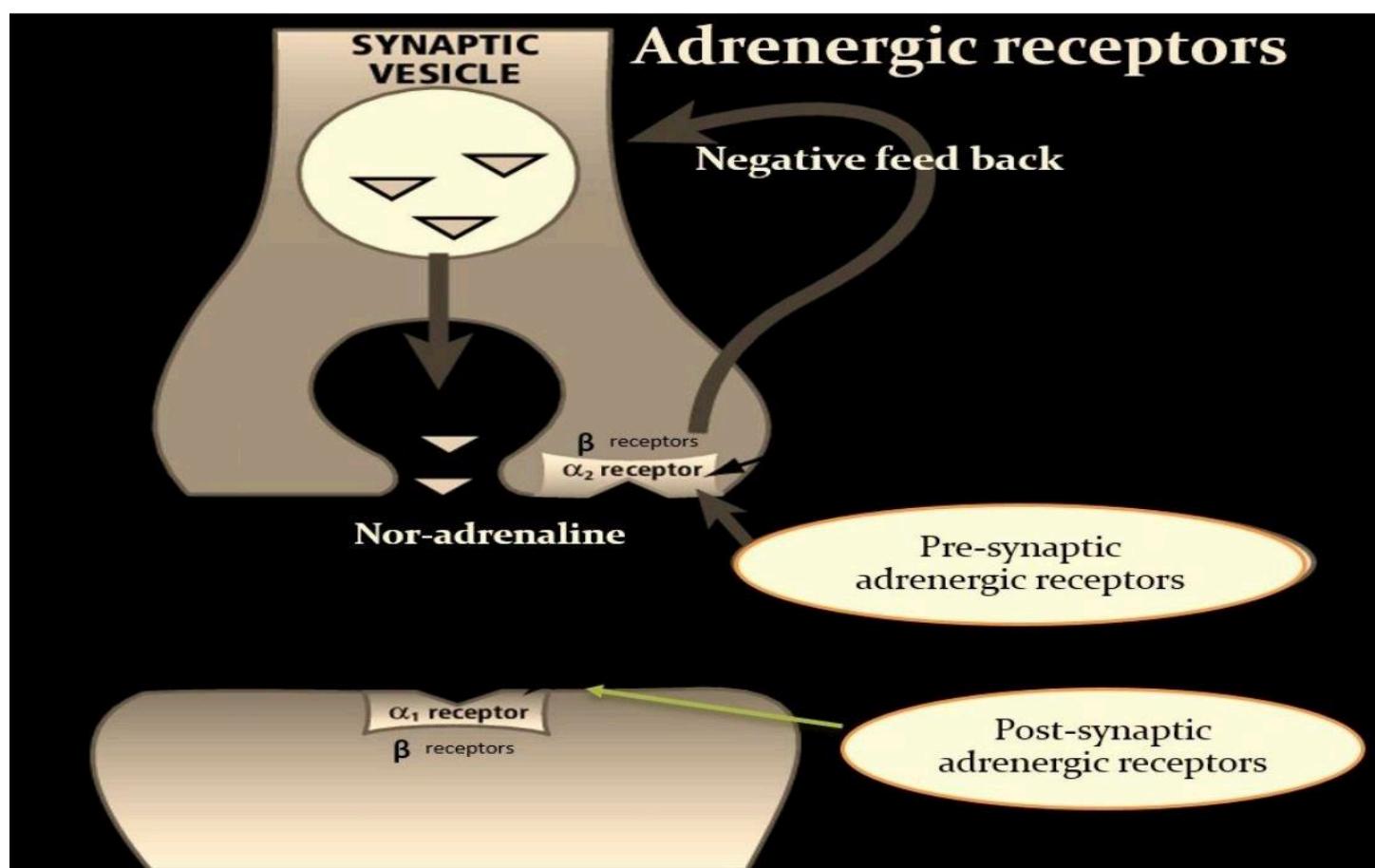
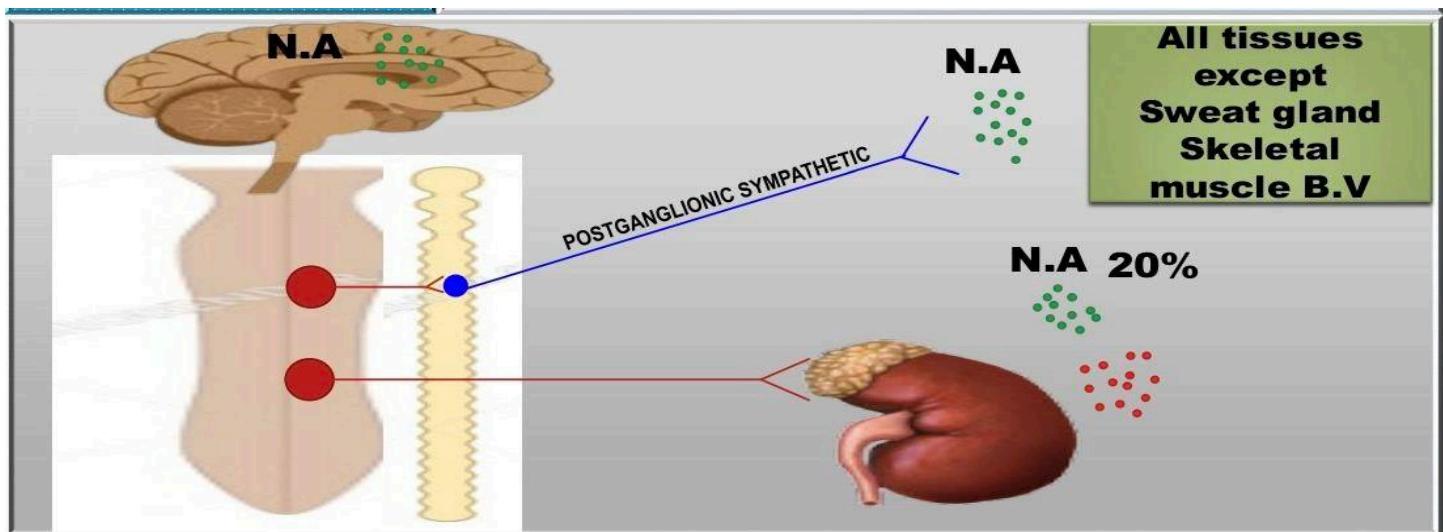
- DIFFUSION : Small amount of noradrenaline is removed by diffusion into the surrounding tissue fluids & then to the blood.
- DESTRUCTION BY ENZYMES: Small amount of catecholamine is destroyed by enzymes
 - a. Oxidation by M.A.O.(monoamine oxidase): Which is present in the mitochondria of the nerve endings.



- b. **Methylation by C.O.M.T**(catechol- O methyl transferase): Which is present diffusely in all tissues.

➤ Site of RELEASE OF noradrenaline

- 1- All postganglionic sympathetic nerve endings except that supply sweat glands and blood vessels of skeletal muscles which are cholinergic.
- 2- In the adrenal medulla: 20 % is noradrenaline and 80% is adrenaline.
- 3- nor-adrenaline is present in C.N.S acting as chemical transmitter.





❖ Presynaptic adrenergic receptors:

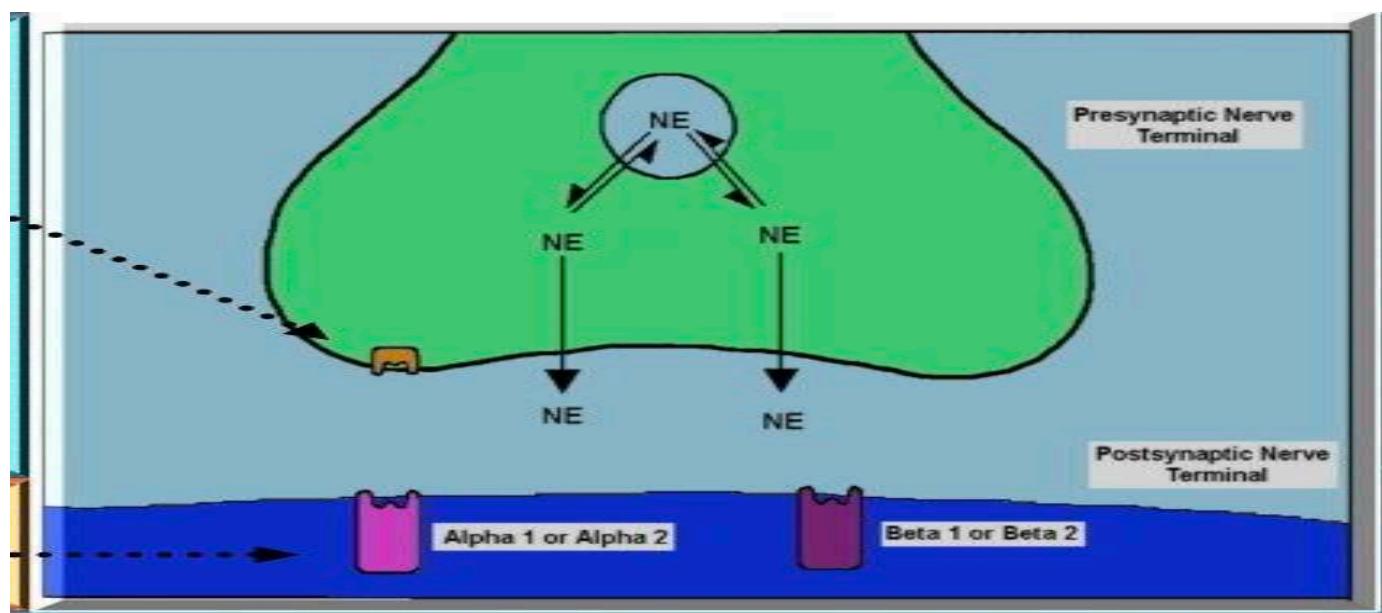
- Site: They are present in the postganglionic nerve ending
- Types: They are of Alpha & Beta types .
- Actions: They act as -ve feed back control of nor adrenaline[NA] release . So, these receptors affect the release of NA from the nerve endings.

❖ Postsynaptic adrenergic receptors:

- -These receptors are present in the wall of effector organs.
- They are two types: Alpha & Beta types

1-Alpha receptors are divided into Alpha 1 & alpha 2

2-Beta receptors are divided into beta 1 & beta 2





	Alpha receptors	Beta receptors
Sup types	Alpha1 and alpha 2	Beta1 and beta2
Function of adrenergic receptors	<p>Alpha 1: is Excitatory, causing:</p> <ul style="list-style-type: none"> 1-Vasoconstriction 2-Contriction of dilator pupillae muscle. 3-contraction of pilo-erector muscle. 4-contraction of sphincters of GIT. 5- Contraction of splenic capsule. 6-Ejaculation. <p>Alpha 2: is inhibitory: present in GIT causing relaxation of its wall</p>	<p>Beta 1: is excitatory:</p> <ul style="list-style-type: none"> -Present only in the heart -Stimulate all cardiac properties <p>Beta 2 : is inhibitory</p> <ul style="list-style-type: none"> 1-Bronchodilatation. 2-G.I.T wall relaxation. 3-Bladder wall relaxation. 4-Vasodilatation of coronary and skeletal muscle blood vessels
Mechanism of action	α_1 : increase intra-cellular calcium α_2 : inhibit adenyl cyclase & decrease cyclic-adenosine monophosphate [cAMP]	β_1 & β_2 : stimulate adenyl cyclase & thus increase cyclic-adenosine mono phosphate [cAMP]
Relative sensitivity	More sensitive to noradrenaline	Equal sensitivity to adrenaline and nor-adrenaline

❖ DRUGS ACTING ON Sympathetic nervous system

Site of action	Stimulant drugs (Sympathomimetic)	Inhibitor drugs (Sympatholytic)
Sympathetic ganglia	1-Nicotine small dose. 2-Anti-choline esterase.	1-Nicotine large dose 2-Hexamethonium
Release of N.A from postganglionic fibers	(increase release) 1-Ephedrine 2-Amphetamine.	(decrease release) 1-Reserpine 2-Alpha methyl dopa.
Alpha receptors	(α stimulants) 1-Nor-adrenaline 2-Adrenaline 3-Phenylephrine	(α blockers) 1-Phentolamine 2-Ergot alkaloids
Beta receptors	(β stimulants) 1-Isoprenaline 2-Adrenaline	(β blockers) 1-Propranolol 2-Atenolol



L 11 physiology : Resting membrane potential

Resting membrane potential (R.M.P.) = Steady potential = Polarization

❖ **Definition:** It is the electric potential difference between the inner & outer surface of the membrane **at rest** (i.e. without stimulation).

❖ **Measurement:** It is measured by special sensitive voltmeter connected by 2 microelectrodes

(One microelectrode is put on the inner surface of the membrane & the other one is put on the outer surface).

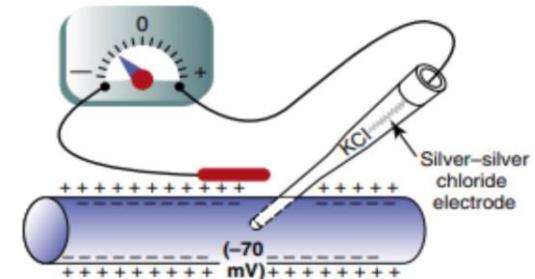


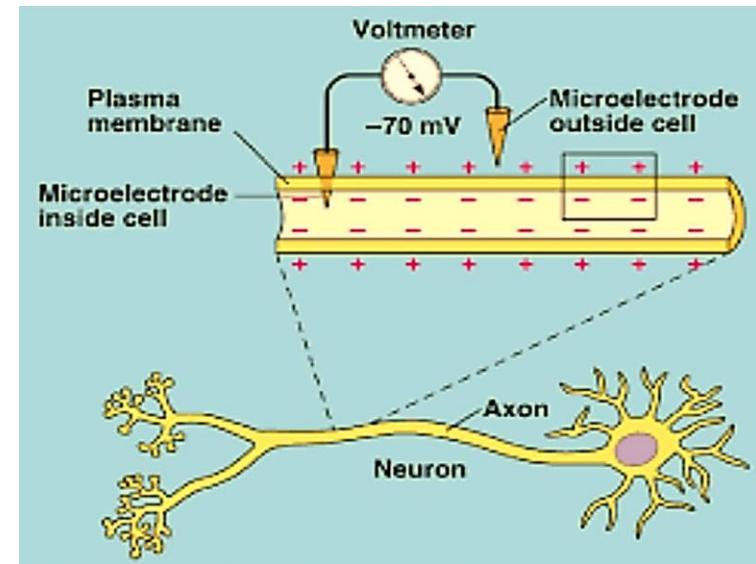
Figure 5-2 Measurement of the membrane potential of the nerve fiber using a microelectrode.

❖ **Value:**

- It is present in all living cells of the body (The inner surface is always negative in relation to the outer surface of the cell).
- It differs from cell to cell ranging from – 9 mV to -100 mV
- In red blood corpuscles (R.B.Cs) it is -9 mV
- In the medium sized nerves, it is about – 70 mV
- In skeletal muscle, it is – 90 mv

Table 5-1 Resting Membrane Potential in Different Cell Types:

Cell Type	Resting Potential (mV)
Neurons	-60 to -70
Skeletal muscle	-85 to -95
Smooth muscle	-50 to -60
Cardiac muscle	-80 to -90
Hair (cochlea)	-15 to -40
Astrocyte	-80 to -90
Erythrocyte	-8 to -12
Photoreceptor	-40 (dark) to -70 (light)



❖ **Causes:**

- 1) Selective permeability of the cell membrane (**The main cause**).
- 2) Sodium - Potassium (Na⁺ - K⁺) pump.



1) Selective permeability of the cell membrane:

Distribution of ions inside and outside the cell membrane:

Cations (+ve ions):

- ✓ The main intracellular cation is Potassium (K+).
- ✓ The main extracellular cation is sodium (Na+).

Anions (-ve ions):

- ✓ The main intracellular anion is protein.
- ✓ The main extracellular anion is Chloride (Cl-) and bicarbonate (HCO3-).

	Intracellular fluid (ICF)	Extracellular fluid (ECF)
+ Ve ions		
K+	140 mEq/L	4 mEq/L
Na+	14 mEq/L	140 mEq/L
- Ve ions		
Proteins	16 grams %	2 grams %
Cl-	4 mEq/L	104 mEq/L
HC03-	10 mEq/L	28 mEq/L

❖ Movement of ions across the cell membrane and creation of RMP:

1) K+ ion: K+ is the most determinant ion in creation of RMP.

Relatively large amounts of K+ diffuse from the inner to outer side of the cell membrane through Na+ - K+ leak channels due to:

- High concentration gradient (30 times).
- High permeability of Na+ – K+ leak channels to K+ (50 times more than Na+ permeability).

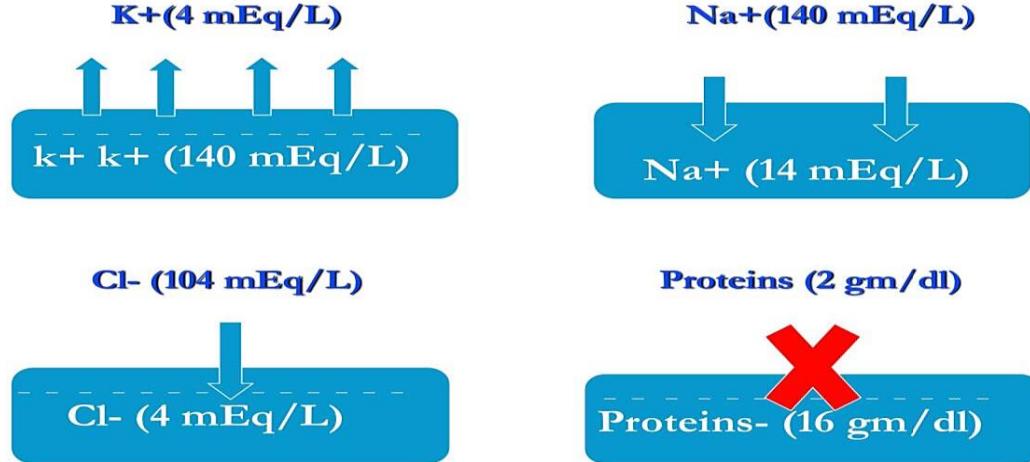
❖ This means removal of +ve charge from inner side to outer side the cell membrane leading to negativity on the inner surface and positivity on the outer surface and creation of RMP.

2) Na+ ion: Relatively small amounts of Na+ diffuse from outer to inner side the cell membrane due to:

- Low concentration gradient (10 times).
- Low permeability of Na+ - K+ leak channels (1/50 times the K+ permeability). This decreases the RMP created by K+.



- 3) **Cl⁻**: The membrane is poorly permeable to Cl⁻ which diffuses from outer to inner side of the cell membrane in very small amounts (adding more -ve charge on the inner side of the cell membrane) thus it has minor role in creation of RMP.
- 4) **Protein**: The membrane is **impermeable** to proteins (due to their large size).



2) Sodium – potassium (Na⁺ - K⁺) pump:

Definition: It is an active pump present in all body cells that pumps 3 Na⁺ ions outside the cell coupled with pumping 2 K⁺ ions inside the cell i.e. pumping more +ve charge outside the cell

It is primary active transport i.e.

- Needs energy.
- Occurs against concentration gradient.
- Needs carrier protein which has 3 specific characters:
 - ✓ It has 3 receptor sites for Na⁺ on the inner surface.
 - ✓ It has 2 receptor sites for K⁺ on the outer surface.
 - ✓ Its inner portion has ATPase activity.

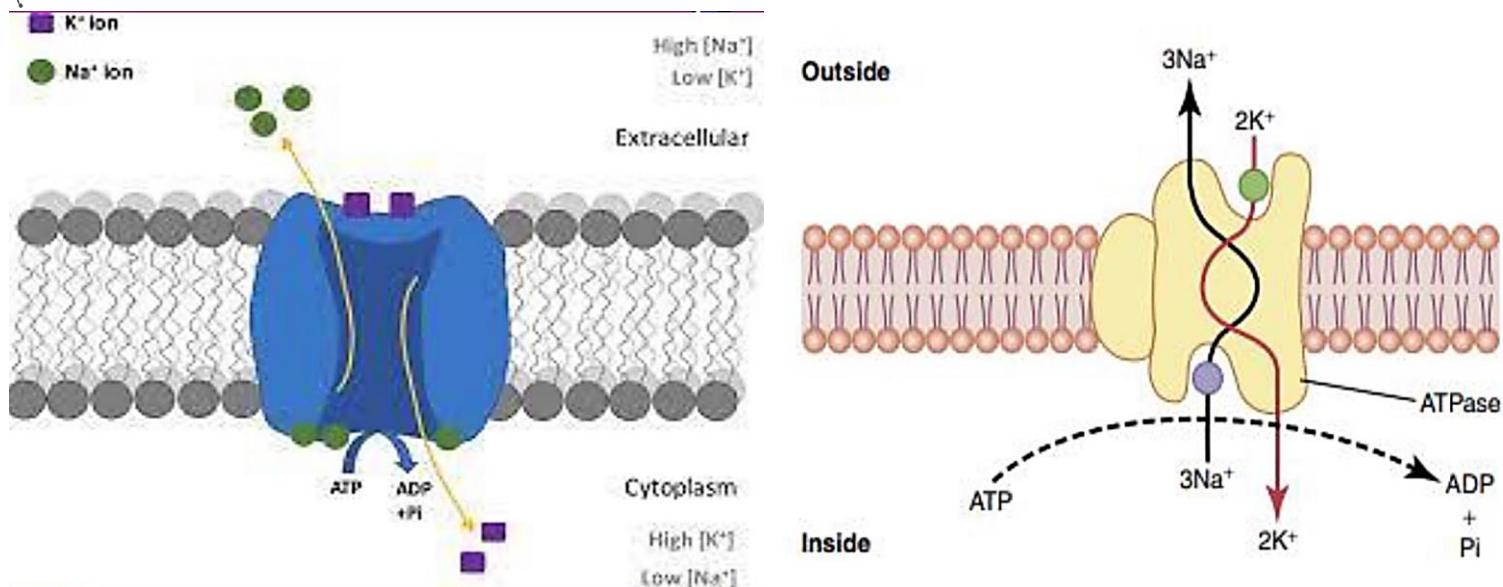
Mechanism: When 3 Na⁺ ions and 2 K⁺ ions bind to the carrier protein, ATPase is activated.

Activated ATPase splits ATP to ADP + Pi and energy is liberated.

This energy causes conformational change in the protein carrier molecule extruding the 3 Na⁺ ions outside and the 2 K⁺ ions inside



خليل واثق من نفسك وكم!



Functions:

- 1) Contribute for – 4 mV of RMP as it pumps more +ve charges to outside than to inside the cell membrane.
- 2) Maintaining the Na⁺ & K⁺ concentration difference across the cell membrane keeping high Na⁺ concentration outside the cell and high K⁺ concentration inside the cell.
- 3) Control cell volume by preventing Na⁺ accumulation inside the cell that can pull large amounts of water by osmosis So without this function, most cells of the body would swell until they burst.





Physio L12&13&14: Action potential & Excitability

Action potential (A.P.):

Definition:

It is the changes occurring in electric potential difference between the inner and outer surface of the membrane during action (as a result of stimulation by an adequate or effective stimulus).

Types of nerve action potential:

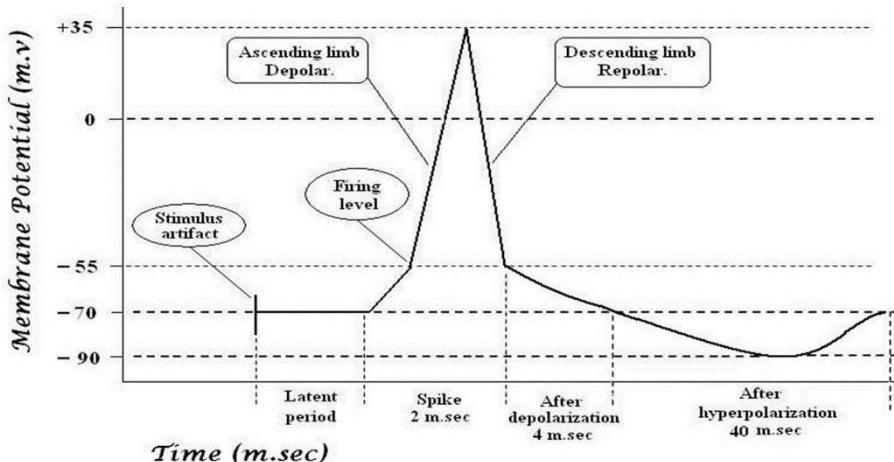
1. Monophasic Action Potential:

- It is recorded by 2 microelectrodes
- one is placed on the inner surface
- and the other on the outer surface of the membrane .

2. Biphasic Action Potential:

- It is recorded by 2 microelectrodes
- Both are placed on the outer surface of the membrane.

Monophasic action potential:



❖ Components:

1. Stimulus artifact.
2. Latent period.
3. Spike potential.
4. After potentials (After depolarization & After hyperpolarization).

1. Stimulus artifact:

- It is the time of application of the stimulus.

2. Latent period:

- It is the time passed between application of the stimulus and recording of the action potential.
- It depends on:
 - o Velocity of conduction of the nerve(inversely proportional with it). i.e. increasing velocity of conduction decreases latent period.
 - o The distance between the stimulus and the recording electrode (directly proportional with it) i.e. increasing the distance increases the latent period.



3. Spike potential:

- It is **rapid** (2 mSec.) and **high magnitude change** (105 mV) i.e. from -70 to +35mV.
- It is composed of:
 - I- Ascending limb (Depolarization).
 - II- Descending limb (Repolarization).

I- Ascending limb (Depolarization):

- In which the membrane potential changes from – 70 to +35 mV.
- It is due to **Na⁺ influx** (inflow) as the result of activation (opening) of the voltage gated Na⁺ channels.
- Its first part is slow (1st 15 mV) i.e. from – 70 to – 55 mV
- At – 55 mV (**firing level**), the rate of depolarization increases as most of the voltage gated Na⁺ channels are opened.
- Entry of Na⁺ in large amount through voltage gated Na⁺ channels (1000 – 5000 times the resting state) causes the inside surface of the membrane to become positive (+ve) in relation to the outer surface (up to + 35 mV).

N.B.: The voltage gated Na⁺ channels. This channel has 2 gates:

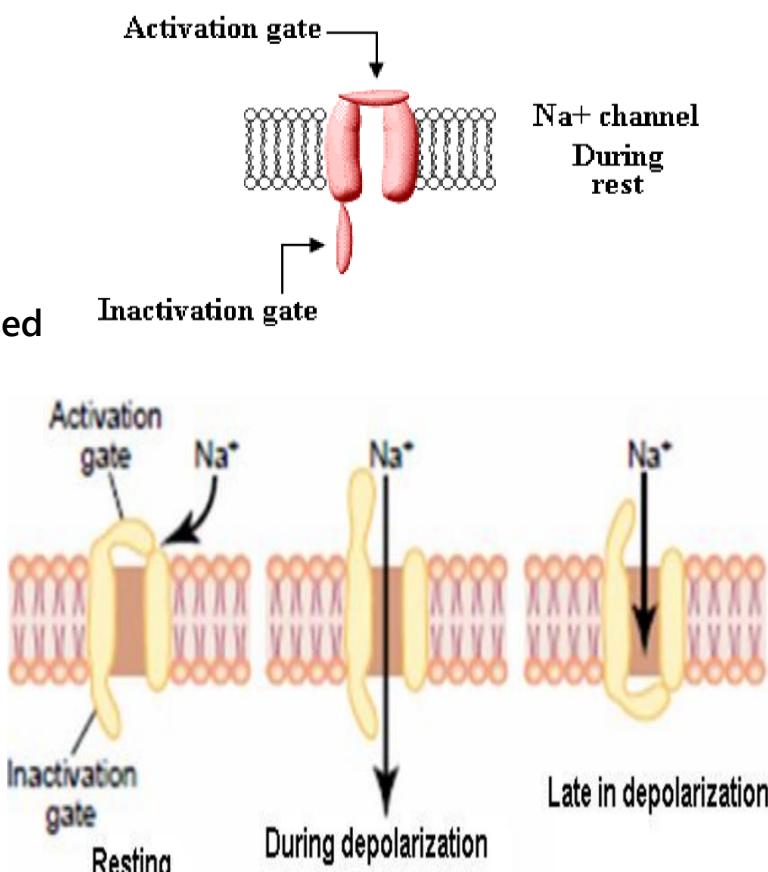
1. Activation gate at the outer surface.

2. Inactivation gate at the inner surface.

- **During rest**, The activation gates are closed preventing Na⁺ entry while inactivation gates are opened.

- **During depolarization**: some of activation gates are opened and at – 55 mV (firing level), most of them are opened increasing Na⁺ influx.

- **Late in depolarization**: some of inactivation gates are closed and by the end of depolarization, most of them will be completely closed stopping Na⁺ influx.



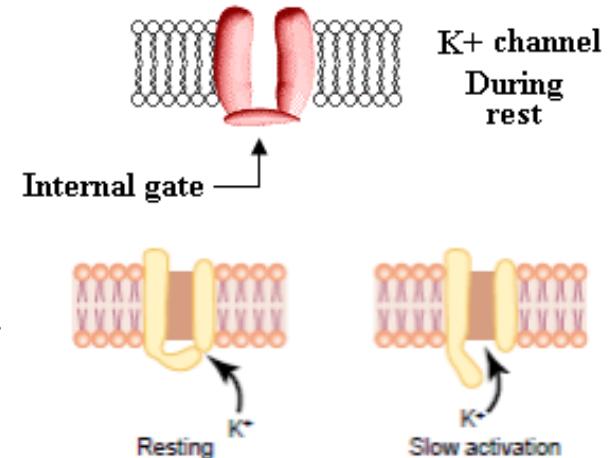


- The inactivation gate will not re-open again until the membrane potential returns to the original resting membrane potential (R.M.P) so it is impossible for Na^+ channels to be activated again without the nerve fiber first repolarizes.

II- The descending limb (Repolarization):

- Represents 70% of repolarization.
- During which the membrane potential changes from +35 mV to near the resting state.
- It is due to:
 - K^+ efflux (outflow) as a result of activation (opening) of the voltage gated K^+ channels.
 - Stoppage of Na^+ influx as the result of closure of the inactivation gates of voltage gated Na^+ channels.

N.B.: The voltage gated K^+ channels. This channel has only one gate at the inner surface.



- During rest:** This gate is closed.
- During repolarization:** The gates of the voltage gated K^+ channels are opened allowing K^+ efflux.

4. After potentials (After depolarization & After hyperpolarization):

- They are slow (long duration) and low magnitude changes.
- It has 2 components:

I- After depolarization.

II- After hyperpolarization.

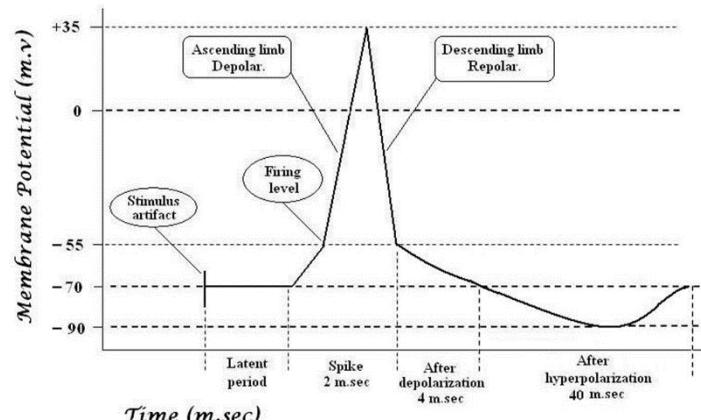
I- After depolarization:

- Its duration is 4 m.Sec
- It represents the last 30 % of repolarization.
- It follows the descending limb of the spike till resting membrane potential (RMP) is reached slowly.
- It is due to:
 - Slow outflow** of the last 30% of K^+ as a result of closure of some voltage gated K^+ channels.
 - Accumulation** of large amounts of K^+ just outside the membrane hindering K^+ efflux.



II- After hyperpolarization:

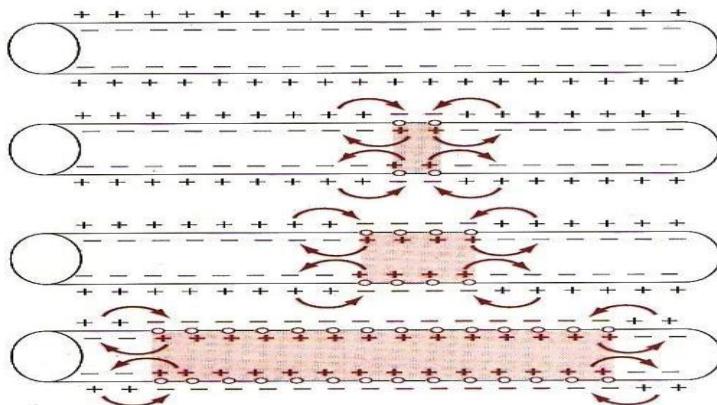
- Its duration is 40 mSec.
- After reaching the resting level, the membrane becomes slightly hyperpolarized (more -Ve) then gradually returns back to the RMP level.
- It is caused by:
 - Some of the voltage gated K⁺ channels remain opened for several seconds allowing excess K⁺ to diffuse out.
 - Hyperactivity of the Na⁺ – K⁺ pump to pump excess Na⁺ from inside the cell.



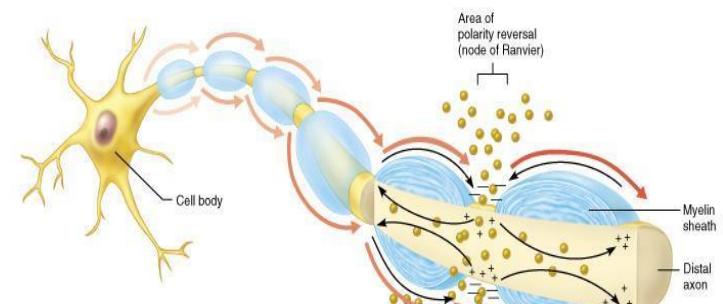
Propagation of the action potential = conduction of the nerve impulse:

- Once action potential is produced, it is rapidly propagated in both direction all over the nerve fiber (axon) away from the stimulated point.
- The method of conduction depends upon the type of the nerve fiber.

	Unmyelinated nerve fibers	Myelinated nerve fibers
Type of conduction	Point to point (local circuit or current sink mechanism)	Saltatory (jumping) occurs at each node of Ranvier
Velocity of conduction	Slow	50 times more rapid
Energy consumption	Consume more energy (more number of action potentials)	Consume less energy (less number of action potentials)



Propagation of action potential in unmyelinated nerve fiber



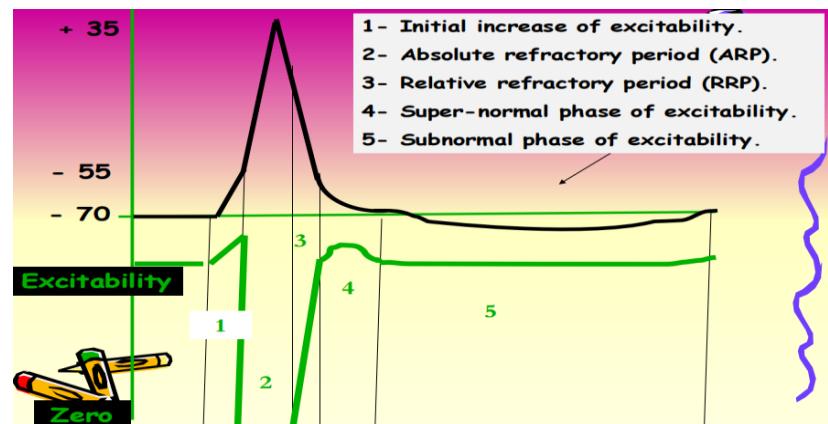
Propagation of action potential in myelinated nerve fiber



Excitability changes during the monophasic action potential:

❖ Excitability:

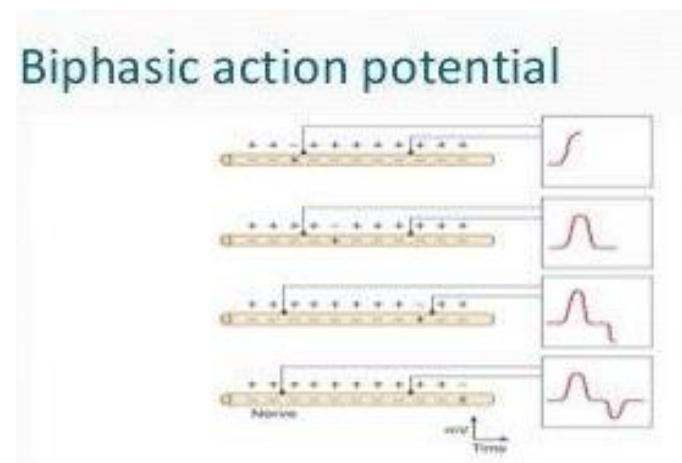
- is the ability of the excitable tissue (nerve or muscle) to respond to adequate stimulus (in both strength and duration).
- From resting membrane potential up to the firing level, the excitability is ↑ (initial increase).
- During the rest of the ascending limb and first 1/3 of the descending limb, the excitability is completely lost (absolute refractory period; ARP) i.e. no stimulus whatever its strength can excite the nerve fiber.
- During the rest of the descending limb up to after depolarization, the excitability recovers but still less than normal (relative refractory period; RRP).
- During after depolarization, the excitability rises above normal (supernormal phase of excitability).
- During after hyperpolarization, the excitability slightly decreases (subnormal phase of excitability).
- When resting membrane potential is reached, excitability recovers back to normal.



N.B.: The presence of absolute refractory period leads to intermittent activity of the nerve i.e. the nerve impulses never fuse.

Biphasic action potential:

- It is recorded by 2 microelectrodes placed on the outer surface of the membrane.
- It shows the following components:
 1. **At rest:** No potential difference is recorded between the 2 electrodes.
 2. When the nerve is stimulated and the depolarization wave reaches the electrode near the stimulator, it becomes – ve in relation to other electrode and upward deflection is recorded.





3. When the depolarization wave reaches the **area of the nerve between the 2 electrodes**, the potential difference returns to zero.
4. When the depolarization wave reaches the **second electrode**, it becomes – ve in relation to the first electrode and downward deflection is recorded.
5. When the depolarization wave **leaves the second electrode**, the potential difference returns again to zero.



Physio TUT4 :

Integration of sympathetic and parasympathetic functions

1. Integration of sympathetic functions

- Sympathetic nervous system is an **emergency system** that prepare the body to face stresses (fear, fight, flight, muscular exercise and exposure to cold).
 - It is usually **discharge as one unit** (mass discharge) leads to widespread response all over the body. Its functions are integrated with each other.
- **This integration occurs as follows :**
1. Increased visual field by **dilation** of the eye pupil and **exophthalmos**.
 2. **Increased** heart rate and force of contraction to increase the arterial pressure and blood flow to the tissues.
 3. **Dilation** of the respiratory passages → better ventilation and more oxygenation to the tissues.
 4. **V.D** of blood vessels of the skeletal and cardiac muscles and **V.C** to other areas.
This help in shifting the blood to these active areas.
 5. **Increased** sweating so helping the body to loss heat.
 6. **Contraction** of the splenic capsule adds more blood to the circulation.
 7. Supplying the body by energy through **glycogenolysis** in the liver and **lipolysis** in adipose tissues increasing blood glucose & free fatty acids.
 8. Other functions of minor importance are temporarily inhibited
e.g. gastrointestinal motility.



2. Integration of parasympathetic functions

- Parasympathetic system is **anabolic system** (preserving energy),

This occurs through:

- 1- **Decreased** Heart rate and force of contraction,
so the heart is at rest and excess energy is stored.
 - 2- **Increased** GIT functions increasing secretion of its hormones and enzymes
to digest the food and supply the tissues with food stuff which store the energy
for the time of need.
- Parasympathetic functions continue or even increased during **sleep** (during **rest**)

3. Sympathetic & Para Sympathetic Tone

- As the sympathetic and parasympathetic systems are **continually active**.

During rest one system is dominant to some organs giving tone
(mild continuous activity during rest).

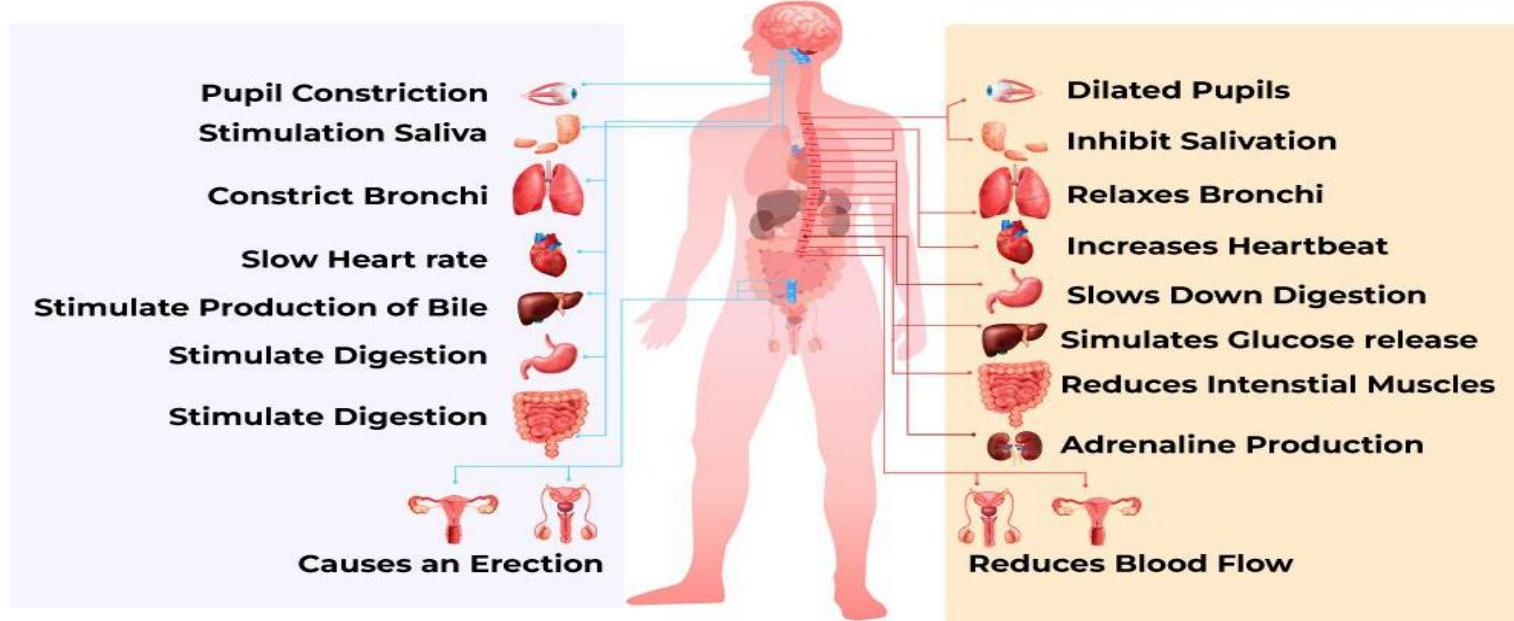
The value of tone is that it allows a single nervous system
to increase or to decrease the activity of a stimulated organ.

Sympathetic tone	Parasympathetic tone
<ul style="list-style-type: none">- keeps most blood vessels partially constricted (approximately half of their maximum diameter) and this maintains ABP.- Loss of sympathetic tone can cause rapid drop in ABP thus a person goes into shock	<ul style="list-style-type: none">- maintains smooth muscle tone in the intestines and holds resting heart rate down to about 70-80 beats/minute in order to decrease the high inherited rhythm of SAN (vagal tone).- If the parasympathetic vagus nerves to the heart are cut, the heart beats by its own intrinsic rate of about 100 beats/minute



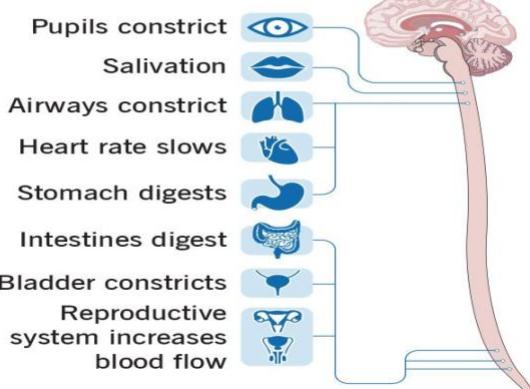
Autonomic Nervous System

PARASYMPATHETIC

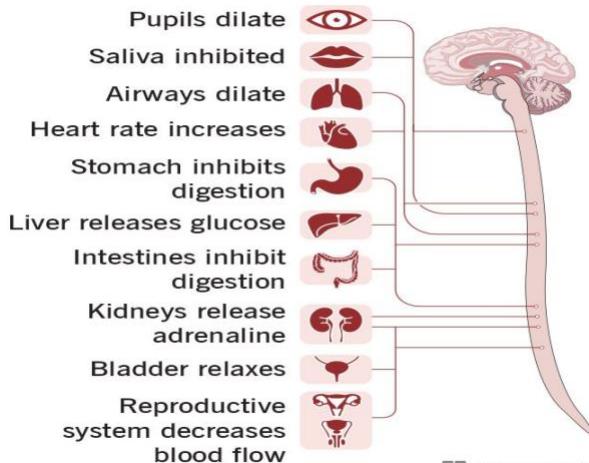


Autonomic Nervous System

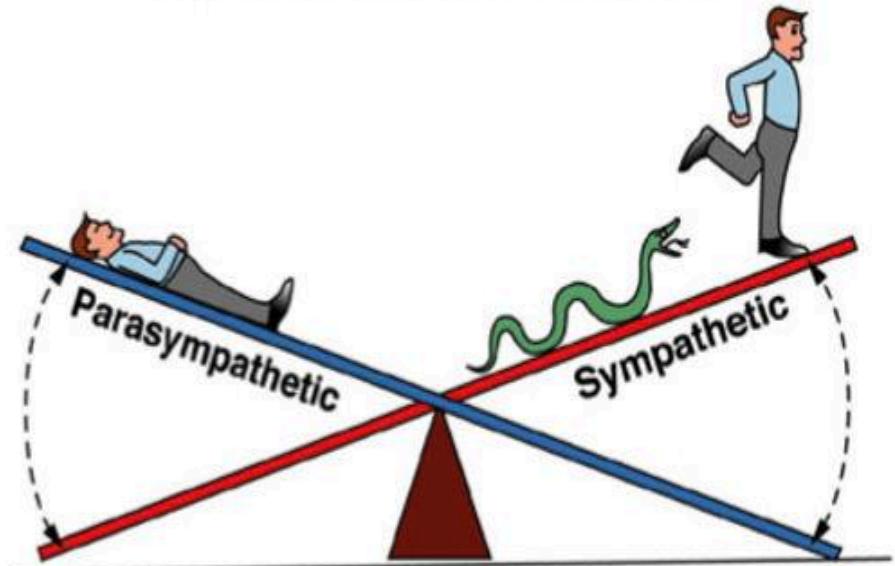
Parasympathetic Division



Sympathetic Division



Homeostasis is a Synergistic Balance between the Autonomic Branches



'Rest, Heal & Digest':
Parasympathetic activity dominates.

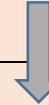
'Fight or Flight':
Sympathetic activity dominates.



TUT 5 physio: Types of nerve fibers

Types of nerves:

1- According to diameter and velocity of conduction nerves are classified into 3 groups:

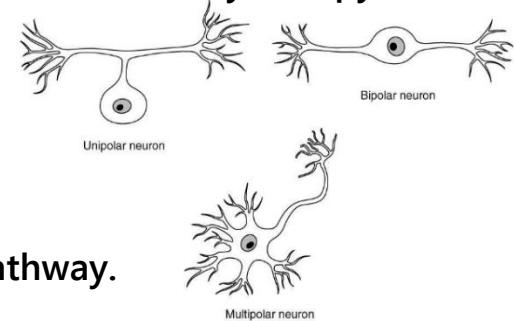
Group	Example (function)	Diameter microns (u)	Velocity meter/sec	Spike duration	Most susceptible to
A Divide into: 	Myelinated afferent and efferent somatic nerves (all somatic eff & Some somatic Aff.)	2-20	10-120	0.5m.sec.	Pressure
Alpha (α)	Somatic motor, proprioception & Annulospiral ending.	10-20	60-120		
Beta (β)	Fine touch, proprioception and flower spray endings.	5-10	30-60		
Gamma (γ)	Motor to muscle spindle.	3-5	15-30		
Delta (δ)	Temperature (cold), crude touch and pricking pain.	2-3	10-15		
B	Myelinated autonomic Preganglionic fibers	1-2	5-10	1	O ₂ lack
C	Unmyelinated fibers Slow pain, temp. (hot) Postganglionic autonomic fibers. More than half the sensory fiber in most peripheral nerves.	Less than 1	0.5-21	2	Local anesthetics



- There is another classification (numerical classification) used by sensory physiologist (i.e. for sensory nerves only)

Group	Origin (nerves)	Corresponding group in general classification
A	Muscle spindle annulospiral endings.	A
B	Golgi tendon	A
	Muscle spindle flower spray ending fine touch, pressure	A β
	Pain & temperature crude touch.	A δ
	Pain and temperature	C

Most nerve fibers in the human body are group C (unmyelinated) as they occupy less space.

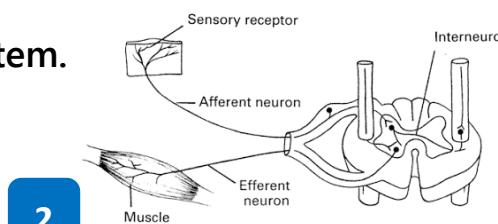


2- According to structure they are classified into:

- Unipolar: present in spinal afferent neurons.
- Bipolar: present in some sensory pathways e.g. visual pathway.
- Multipolar: present in the ventral horn of spinal cord e.g. alpha motor neuron.

3- According to function into:

- Afferent (sensory): conduct impulses from sensory receptor to CNS. Its mother cell is present in dorsal root ganglion in case of spinal nerves.
- Efferent (motor): conduct impulses from CNS to effector organ 2 types:
 - Somatic motor: supply sk.ms. Its mother cell is in ventral horn.
 - Autonomic motor: supply smooth ms, cardiac ms. and glands. Its mother cell in the lateral horn.
- Interneurons (about 99% of all neurons): are located inside the CNS and serve the integrative functions of the nervous system.





Factors affecting nerve excitability:

1- Temperature:

Cooling decreases nerve excitability while warming increase it.

2- pressure:

Mechanical pressure on a nerve reduces its excitability.

3- Blood supply:

Excitability is decreased in case of ischemia.

4- Oxygen supply:

O₂ lack decreases nerve excitability.

5- H⁺ concentration:

Alkalinity increases while acidity decreases the excitability of the nerve.

6- Chemicals:

Nerve excitability is decreased by excess CO₂ and alcohol as well as anesthetic drugs e.g. ether.

7- Electrolytes:

The concentration of Na^+ , K^+ and Ca^{++} in the extracellular fluid affect nerve excitability as follow:

a) Ionic changes that Increase nerve excitability:

i) Increased Na⁺ concentration: this facilitates the process of depolarization.

ii) Increased K⁺ concentration: This induces K⁺ influx which leads to depolarization; thus, the nerve excitability is increased

iii) Decrease Ca^{++} concentration: this increases the membrane permeability to Na^{+}

b) Ionic changes that Decrease nerve excitability:

i) Decrease Na^+ concentration.

ii) Decrease K⁺ concentration.

iii) Increase Ca^{++} concentration.