((Introduction))

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-Physiology is the study of the function of living organisms & their parts.

-In human physiology, we are concerned with characteristics of the human body that allow us to sense our environment, to move about , to think & communicate , to reproduce & to perform all of the functions that enable us to survive & thrive as living beings.

-The very broad subject of human physiology includes the functions of molecules & sub cellular components of the human body ; functions of organs such as heart ; organ systems such as the cardiovascular system ; as well as the interaction & communication between the various organ system .

-Homeostasis:-

-Is the maintenance of a stable internal environment.

-So , homeostasis means simply the maintenance of constant conditions in the internal environment of the body.

-Essentially , all organs & tissues of the body perform functions that help to maintain these stable conditions.

-The body can be divided into several major functional system , each of which performs a particular task in maintaining homeostasis as follows:-

-The cardiovascular system transports fluid & solutes , including nutrients & waste products through all parts of the body.

-It keeps the fluids of the internal environment continually mixed by pumping blood through the vascular system .
-As the blood passes through the capillaries , a large portion of its fluid diffuses back & forth into the interstitial fluid that lies between the cells , allowing continuous exchange of substances between the cells & interstitial fluid & between the interstitial fluid & the blood .
-The respiratory system provides oxygen for the body & removes carbon dioxide .
-The gastrointestinal system digest food & absorbs different nutrients , including carbohydrates , fatty acids , & amino acids into the extracellular fluid .
-The kidneys regulate the extracellular fluid composition by controlling excretion of salts , water , & waste products of the chemical reactions of the cells. By controlling body fluid volumes & composition , kidneys also regulate blood volume & blood plasma .
-The nervous system directs the activity of the muscular system , thereby providing locomotion . It also controls the function of many internal organs through the autonomic nervous system , & it allows us to sense our external & internal environments & to be intelligent beings so that we can attain the most advantageous conditions for survival.
-The endocrine glands secrete hormones that control many of the metabolic functions of the cells , such as growth , rate of metabolism & special activities associated with reproduction .
-The musculoskeletal system consists of skeletal muscle , bones , tendons , joints , cartilage &

ligaments . This system provides protection of internal organs as well as support & movement of the body.

-The integumentary system , composed mainly of skin , provides protection against injury & defense foreign invaders as well as dehydration of underlying tissue . In addition , the skin acts as an important means of maintaining a constant temperature in the body .

-The immune system also acts as one of the body's chief defense mechanism , providing protection against foreign invaders , such as bacteria & viruses , that the body is exposed to daily .

-The reproductive system provides for formation of new beings like ourselves ; even this can be considered a homeostatic function for it generates new bodies in which trillion of additional cells can exist in a well regulated internal environment.

((Cell Physiology))

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-The basic living unit of the body is the cell , & each organ is an aggregate of many different cells held together by intercellular supporting structures .

-Each type of cells is especially adapted to perform one or a few particular functions .

-In unicellular organisms , all vital processes occur in a single cell . As the evolution of multicellular organisms has progressed , various cell groups have taken over particular functions.

-Although the many cells of the body often differ markedly from each other , the general mechanisms

for changing nutrients into energy are basically the same in all cells , & the cells also deliver the end products of their chemical reactions into the surrounding fluids .
-Atypical cell , as seen by light microscope have two major parts , which are the nucleus & cytoplasm .
-The nucleus is separated from the cytoplasm by a nuclear membrane , & cytoplasm , that is separated from the surrounding fluid by a cell membrane .
-Both nucleus & cytoplasm are filled with highly viscous fluid containing water , proteins , carbohydrates , electrolytes , lipids & other substances .

-The water:-

-The principle fluid medium of the cell is water , which is present in most cells besides fat cells in a concentration of between 70 & 85% . Many cellular chemicals are dissolved in the water , whereas other are suspended .

-Electrolytes:-

-The most important electrolytes in the cell are potassium , magnesium , phosphate , sulfate , bicarbonate & small quantities of sodium , chloride & calcium . The electrolytes provide inorganic chemical for cellular reactions .
-Also electrolytes acting at the cell membrane allow transmission of electrochemical impulses in nerve & muscle fibers .

Proteins:-

-Next to water , the most abundant substance in most cells is proteins ,which normally constitute 10 to 20% of the cell mass .
-Protein can be divided into two types , *structural proteins* which are present in the cell mainly in the form of long thin filaments & microtubules that provide the cytoskeletons of such organelles as cilia , nerve axons & mitotic spindles of mitosing cells . The other type is *globular proteins* , which are mainly enzymes .

Lipids:-

-The most important lipids in most cells are phospholipids & cholesterol which together constitute about 2% of the total cell mass .
-These lipids are mainly insoluble in water & therefore , are used to form the cell membrane as well as intracellular membranous barriers that separate the different cell compartments .
-In addition to these lipids some cells contain large quantities of triglycerides (neutral fat) .
-In fat cells , triglycerides often account for as much as 95% of the cell mass .

-Carbohydrates:-

-Carbohydrates have little structural function in the cell except as part of glycoprotein molecules , but they a play a major role in nutrition of the cell .
-Most human cells do not maintain large stores of carbohydrates , usually averaging about 1% of their total mass but increasing to as mush as 3% in muscle cells & 6% in liver cells .
-Carbohydrate are present as dissolved form such as glucose or as insoluble form that stored as glycogen .

-The nucleus:-

-Act as control center of the cell .
-The nucleus contains large amounts of DNA , also called genes , which determines the characteristics of the cells' proteins , including the enzymes of the cytoplasm .
-Genes also control reproduction , first reproducing themselves through a process called mitosis in which two daughter cells are formed , each of which receives one of the two sets of genes .
-Separating the nucleus from the cytoplasm is a nuclear membrane , which is actually two separate membranes .
-The outer membrane is continuous with the E. R , & the space between the two nuclear membranes is also continuous with the compartment inside the E. R .
-Both layers of the membrane are penetrated by several thousand nuclear pores , almost 100 nanometers in diameter .

-The nuclei of most cells contain one or more structures called nucleoli , which , unlike many of the organelles , do not have a surrounding membrane .
-The nucleoli contain large amounts of RNA & proteins of the type found in ribosomes .
-Ribosome RNA is stored in the nucleolus & transported through the nuclear membrane pores to the cytoplasm , where it is used to form mature ribosome's that play an important role in the formation of proteins .
-It is estimated that there are about 100,000 different types of genes in the nucleus .
-Therefore one can understand that a large number of different types of proteins can also be formed in each cell .
-So , the genes control the structural of the cell through the types of *structural proteins* formed , & the genes control the function of the cell mainly through the types of *protein enzymes* that are formed.
-Each gene is a double – strands helical molecule of DNA composed of multiple units of sugar deoxyribose , phosphoric acid & four nitrogenous bases including two purines , adenine & guanine &two pyrimidines thymine & cytosine .
-Three successive bases in the DNA strand are each called a code word (adenine , thymine & guanine ; cytosine , guanine & thymine).
-These code words control the sequence of amino acids in the protein to be formed in the cytoplasm .
-The sequence of successive code words on the DNA strand is known as the genetic code .

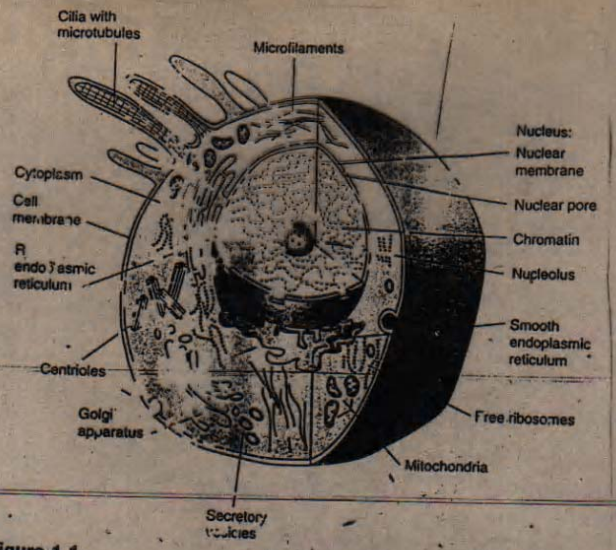

Figure 1-1.
Organization of a typical cell showing organelles in the cytoplasm and in the nucleus. Adapted from Bu[illegible] E.: *Pathophysiology: Adaptations and Alterations in Function*, 4th ed. Philadelphia: Lippincott-Raven Publishers, 1996.)

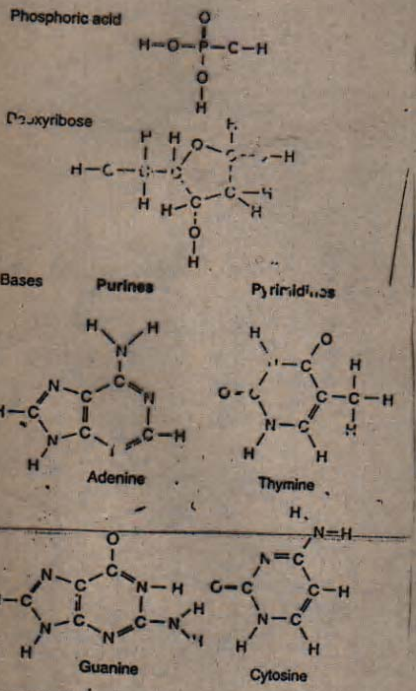

Figure 1-4.
The basic building blocks of deoxyribonucleic acid (DNA)—phosphoric acid, deoxyribose, and purine and pyrimidine bases.

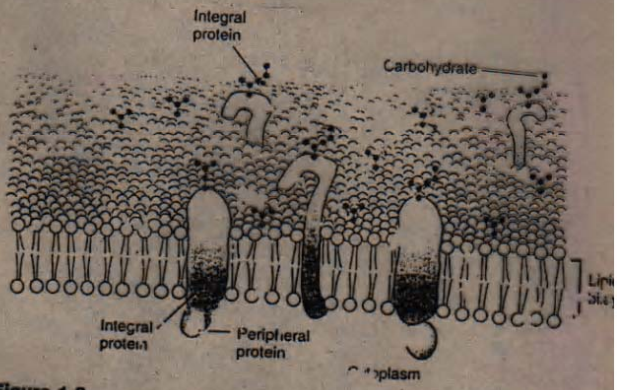

Figure 1-2.
The structure of the cell membrane showing its lipid bilayer with protein molecules protruding through the layer. Also, carbohydrate moieties are attached to the protein molecules on the outside of the membrane and additional protein molecules on the inside.

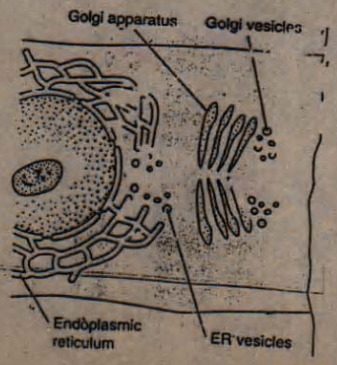

Figure 1-3.
A typical Golgi apparatus and its relationship to the endoplasmic reticulum (ER) in the nucleus.

((Physical structure of the cell))

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-The cell is not merely a bag of fluid , enzymes & chemicals , but it also contains highly organized physical structures , many of which are called organelles , including the followings :-

Cell membrane:-

-The cell membrane , which envelope the cell , is a thin elastic structure , generally about 7. 5 nm thick . It is generally referred to as plasma membrane .
-It is not only semipermeable , allowing some substances to pass through it & excluding others , but its permeability can be varied .
-It is composed almost entirely of proteins (about 55%), phospholipids (25%) ; cholesterol (13%) , other lipid (4%) & carbohydrates (3%) .
-Its basic structure is a lipids are bilayer , interspersed with large globular protein molecules .
-The major lipids are phospholipids such as phosphotidylcholine & phosphotidylethanolamine .
-The head end of lipid bilayer molecule contains the phosphate portion & is relatively soluble in water (polar hydrophilic) . While the tails are relatively insoluble (nonpolar hydrophobic).
-The hydrophilic ends of molecules are exposed to the environment that bathes the exterior of the cells and the aqueous cytoplasm ; while the hydrophobic ends meet in the water – poor interior of membrane .
-The lipid bilayer membrane is highly permeable to lipid – soluble substances such as oxygen , carbon

dioxide & alcohol , but acts as a major barrier to water – soluble substances such as ions & glucose .
-Lipid bilayer is a fluid & not a solid . Floating in the fluid lipid bilayer membrane are proteins , most of which are glycoprotein .
-<u>There are two types of membrane proteins :-</u>
(1):-The <u>integral proteins</u> , which protrude all the way through the membrane .
-Many of the integral proteins provide structural <u>channels</u> (pores) , through which water – soluble substances , especially ions can diffuse .
-Other integral proteins acts as <u>carrier proteins</u> for transporting substances ; sometimes against their natural gradient for diffusion .
(2):-The <u>peripheral proteins</u> , which are attached to the inner surface of the membrane & do not penetrate .
-The peripheral proteins are normally attached to one of the integral proteins & usually function as enzymes that catalyze chemical reactions in the cell .

-The mitochondria:-

-The mitochondria are often called the " powerhouses " of the cell .
-The mitochondria contain large quantities of oxidative & other enzymes that are responsible for supplying energy to the cells .
-The basic structure of the mitochondrion is composed of two lipid bilayer – protein membranes , an outer membrane & an inner membrane .
-The space between the two membrane is called the intracristal space .

-Many infolding of the inner membrane form shelves onto which oxidative enzymes are attached .
-In addition the inner cavity of mitochondrion is filled with a matrix that contains large quantities of dissolved enzymes that are necessary for extracting energy from nutrients .
-Mitochondria are present in basically all portions of the cytoplasma , but the total number per cell varies from less than hundred to several thousand depending on the amount of energy required by each cell .
-After entering the cell , the foods are split into smaller molecules , which inturn enter the mitochondria , where other enzymes remove CO2 & hydrogen ions in the process called the citric acid cycle .
-Then an oxidative enzyme system , also in the mitochondria causes progressive oxidation of the hydrogen atoms .
-The end products of the reaction of the mitochondria are water & CO2 & the energy liberated is used by the mitochondria to synthesize still another substance , adenosine triphosphate (ATP) , a highly reactive chemical that can diffuse through the cell to release it energy whenever it is needed for performing cellular functions .
-Mitochondria are self – replicative , means that one mitochondrion can form a second one , a third one & so on , since the mitochondria contain DNA similar to that found in the nucleus.

Endoplasmic reticulum (E.R):-

-Is large network of tubules & vesicles , penetrates almost all parts of the cytoplasm .
-E.R provides an extensive surface area for manufacturing multiple substances that can use inside the cells & released from some cells .
-These substances include proteins , carbohydrates , lipids & structures such as lysosomes , peroxisomes & secretory granules .
-In rough or granular endoplasmic reticulum , granules called ribosomes are attached to the cytoplasmic side of the membrane .
-The granular E.R is concerned with protein synthesis
-Smooth or a granular E.R the granules are absent .
-Smooth E.R is the site of steroid synthesis in steroid - secreting cells & the site of detoxification processes in other cells .

Ribosomes:-

-The ribosomes are about 15 nm in diameter .
-Each is made up of a large & small subunit called , on the basis of their rate of sedimentation in the ultracentrifuge , the 50S & 30S subunits .
-They contain about 65% RNA & 35% protein .
-They are the site of protein synthesis .
-Attached ribosomes to E.R synthesis proteins such as hormones & the cell membrane proteins.
-While , the free ribosomes synthesize cytoplasmic proteins such as hemoglobin & the proteins found in peroxisomes & mitochondria .

Lysosomes:-

-Lysosomes are vesicular organelles formed by the golgi apparatus . The lysosomes provide an intracellular digestive system , contains digestive enzymes that allow lysosomes to digest intracellular substances & structures ,especially damages cell structure , food particles & un wanted materials , such as bacteria .
-Lysosomes is quite different from one cell to another , but it usually is 250 to 750 nm in diameter. It is surrounded by Atypical lipid bilayer membrane & filled with large numbers of small granules 5 to 8 nm in diameter , which are protein aggregates of hydrolytic (digestive)enzymes :
-About 40 acid hydrolase enzymes have been found in lysosomes & the principal substances that they digest are proteins ,carbohydrates ,lipids & derivatives of these .
-Ordinary the membrane surrounding the lysosome prevents digestive of other substances of their cell .

Golgi apparatus :-

-The Golgi apparatus is a collection of membrane-enclosed sacs (cisterns)that are stacked like dinner plates.
-There are usually about 6 sacs in each apparatus, but there may be more .
-One or more Golgi apparatus are present in all eukaryotic cells, usually near the nucleus.
-The Golgi apparatus functions in association with the E.R

-Substances entrapped in the E.R vesicles are transported from the E.R to the Golgi apparatus.
-This substances are then processed in the Golgi apparatus to form lysosomes , secretory vesicles or other cytoplasmic components .

Cytoskeleton:-

-All cells have a cytoskeleton ,a system of fibers that not only maintains the structure of the cell but also permits it to change shape &move .
-A cytoskeleton is made up primary of microfilaments, intermediate filaments and microtubules.
-Most , if not all , eukaryotic cells contain microfilaments ,which are long solid fibers 4-6nm in diameter ,&microtubules ,which are hollow structures with 5nm walls surrounding a cavity 15 nm in diameter.

Microfilaments :-

-Are made up of actin ,the protein that by its interaction with myosin bring about contraction of muscles.
-Actin & its mRNA are present in all types of cells.
-Myosin is difficult to observe in cells other than muscle &is not arranged with actin in orderly arrays but is also present .
-Large numbers of actin filaments frequently occur in the outer zone of the cytoplasm (ectoplasm) to form an elastic support for the cell membrane .

-Microtubules:-

-Is a special type of filament composed of polymerized tubulin molecules (a , b & gamma tubulin) is used in all cells to construct tubular structures , the microtubules .
-Most often these contain 13 tubulin protofilaments lying parallel to one another in a circle to form a long hollow cylinder 1 to many micrometer in length .
-These cylinders are often arranged in bundles that give them more strength .
-The primary function of microtubules is to act as a cytoskeleton , providing rigid physical structures for certain parts of cells .
-They also provide the tracks for transport of vesicles , such as secretory granules & organelles such as mitochondria from one part of the cell to another .
-Cells also contain intermediate filament that are 8-10 nm in diameter , some of these filament connect the nuclear membrane to the cell membrane .
-Intermediate filament appear to be part of cytoskeleton .

Intercellular connections:-

-Two types of junctions form between the cells that make up tissues: -
-Junctions that fasten the cells to one another & to surrounding tissues. And junctions that permit transfer of ions & other molecules from one cell to another.
-The junctions that tie cells together & endow tissues with strength & stability include tight junctions ,

which are also known as the zonula occludens .
-While other type of junction by which molecules are transferred are gap junctions , the intercellular space narrows from 3nm to 25nm , as a channel , the diameter of this channel about 2nm which permits the passage of ions , sugars , amino acids & other solutes with a molecular weight up to about 1000.
-The diameter of each channel is regulated by intracellular Ca^{+2} ($\uparrow Ca^{+2}$ reducing the diameter of the channel)

-Exocytosis:-

-Proteins that are secreted by cells move from the E.R to golgi apparatus & then extruded into secretary granules or vesicles .
-This secretory granules & vesicles move to the cell membrane .
-Their membrane then fuses to the cell membrane & the area of fusion breaks down .
-This leaves the contents of granules or vesicles outside the cell & the cell membrane intact .
-This extrusion process is called exocytosis .
-It requires Ca^{+2} & energy , but the mechanism responsible for the break down of the membrane are unknown .

Endocytosis:-

-Endocytosis is the reverse of exocytosis .
-One form of endocytosis , called *phagocytosis* (cell eating) is the process by which bacteria , dead tissues are engulfed by tissue macrophages & some of the white blood cells .

-The second form , called *pinocytosis* (cell drinking) is essentially the same process , the only difference being that the substances ingested are in solution & hence not visible under the microscope .
-The engulfed materials makes contact with the cell membrane which then invaginates , the invagination is pinched off , leaving the engulfed material in the membrane – enclosed vacuole & the cell membrane intact .
-In the cell , the membrane around apinocytic or phagocytic vacuole generally fuses with that of a lysosome mixing the digestive enzymes in the lysosome with the contents of the vacuole .

(Body fluids):-

-In the average young adult male , 18% of the body weight is protein & related substances , 7% is mineral & 15% is fat .
-The remaining 60% is water .
-Total body water is comprised of extracellular & intracellular fluid.
-The extracellular fluid can be subdivided into two main subcompartments :-
-The plasma , Which makes up almost one – fourth of the extacellular fluid .
-And the interstitial fluid which lies between the tissue cells & amounts to more than three – fourths of the extracellular fluid .
-The extracellular fluid , Which is about 20% of total body weight .

-Approximately 25% of the extracellular fluid is in the vascular system (plasma = 5% of body weight) & 75% outside the blood vessels (interstitial fluid = 15% of body weight) .
-Whereas , the intracellular fluid acounts for about 40% of body weight .
-The percentage of total body water is greater in newborns & lean persons , & is lower in adult females , elderly persons , or adults with a large amount of adipose tissue .
-Because the plasma & interstitial fluids are separated only by highly permeable capillary membranes , their ionic compositions are similar & they are often considered together as one large compartment of homogeneous fluid .
-The most important difference between plasma & interstitial fluid is the higher concentration of protein in the plasma , which exists because the capillaries have a low permeability to the plasma proteins .
-Both extracellular & intracellular fluid contain nutrients that are needed by the cells , including glucose , amino acids , oxygen & other nutrients.
-Extracellular fluid contains large quantities of sodium and chloride ions ,but only small amounts of potassium ,magnesium and phosphate ions (the major cation is Na^{+} and the major anions are Cl^{-} & $HCO3^{-}$) .
-In contrast, intracellular fluid contains large amounts of K^{+} & phosphate ions , moderate amounts of Mg^{+2} ions & few Ca^{+2} ions (The major cations are K^{+} & Mg^{+2} & the major anions are protein & organic phosphates such as ATP, ADP & AMP) .

-These differences in the ionic composition of the fluids cause a membrane potential to develop across the two sides of the cell membrane – negative on the inside and positive outside .

-(Measurement of body fluid volumes):-

-The volume of a fluid compartment in the body can be measured :- by placing a substance in the compartment , allowing it to disperse throughout the compartment's fluid & then analyzing the extent to which it has become diluted in the compartment.
-Thus ,the unknown volume of a compartment can be calculated by knowing the total mass of substance injected into the compartment Q dividing by the concentration of the substance after dilution in the compartment.

Volume =Q / concentration

-For this method to be used properly , the substance must be uniformly distributed in the compartment ,& only in the compartment that is being measured .

Substances used for major fluid compartments:-

-Total body water (TBW) :-

-Is measured using substances that disperse throughout the body fluids ,such as a radioactive water ($3H_2O$) or heavy water (deuterium,$2H_2o$).

-Extracellular fluid (ECF) :-

-Is measured using several substances that disperse in the plasma & interstitial fluid but do not permeate

the cell membrane , such as radioactive sodium , inulin , & thiosulfate .

-Intracellular volume (ICF):-

-Cannot be measured directly , but can be calculated as the difference between total body water & extracellular volume (TBW-ECF volume) .

-Plasma volume :-

-Is measured by injecting substances, such as radioactive albumin (RISA) , that do not penetrate capillary membranes & therefore remain in the vascular system .

-Interstitial fluid volume (TCF) :-

-Cannot be measured directly but can be calculated as the difference between extracellular fluid volume & plasma volume (ECF volume – plasma volume).

-Transport across cell membranes :-

-Simple diffusion :-

-Occurs down an electrochemical gradient ("downhill") which is the net movement of molecules through the cell membrane along chemical or electrical gradients.
-Molecules migrate from a region of high concentration to one lower concentration .
-This form of transport is not carrier mediated .
-Not require metabolic energy , therefore is passive .
-The rate of diffusion across the cell membrane is directly related to :-

-(1):-The electrical potential &chemical concentration differences across the membrane
(2):-The surface area of the membrane .
(3):-The permeability of the membrane for the solute.
-The permeability of membrane for solute is inversely related to the size of the solute & the membrane thickness.

Carrier –mediated transport:-

-Apply to facilitated diffusion & primary & secondary active transports .

-Facilitated diffusion: -

-Occurs down an electrochemical gradient ("downhill"), similar to simple diffusion.
-Does not require metabolic energy & therefore is passive.
-Is more rapid than simple diffusion.
-Is carrier – mediated.
-Ex. Glucose transport in muscle & adipose cells is "downhill" is carrier – mediated.
-In diabetes mellitus , glucose uptake & use by muscle & adipose cells are impaired because the carriers facilitated diffusion of glucose require insulin .

-Primary active transport:-

-Occurs against an electrochemical gradient ("uphill").
-Requires direct input of metabolic energy in form of ATP & is active.
-Is carrier – mediated.

-Examples of primary active transport:-

(a):- Na^+, K^+- ATPase (or Na^+- K^+pump) in the cell membrane transports Na^+ from intracellular to extracellular fluid & K^+ from extracellular to intracellular fluid ; It maintains low intracellular Na^+& high intracellular K^+.

-Both Na^+ & K^+ are transported against their electrochemical gradients .

-Energy is provided from ATP.

(b):- Ca^{+2}- ATPase (or Ca^{+2} pump) in the sarcoplasmic reticulum (SR) or cell membranes transports Ca^{+2} against electrochemical gradient .

(c):- H^+, K^+ – ATPase (or proton pump) in gastric parietal cells transports H^+ into lumen of the stomach against its electrochemical gradient .

-Secondary active transport: -

-In this transport ; transport of two or more solutes is coupled .

One of the solutes (usually Na^+) is transported "downhill" & provides energy for the "uphill" transport of the other solute .

-Metabolic energy is not provided directly , but indirectly from the Na^+ gradient , which is maintained across cell membranes . Thus , inhibition of Na^+, K^+- ATPase will decrease transport of Na^+ out of the cell , decrease the transmembrane Na^+ gradient , & eventually inhibit secondary active transport .

-If the solutes move in the same direction across the cell membrane , it is called co transport or symport .

-Example … are Na^+- glucose cotransport in the small intestine .

-If the solutes move in opposite directions across the cell membranes , it is called *counter transport* , *exchange* or *antiport* .

-Example … Na^+ – Ca^+ exchange or Na^+ – H^+ exchange .

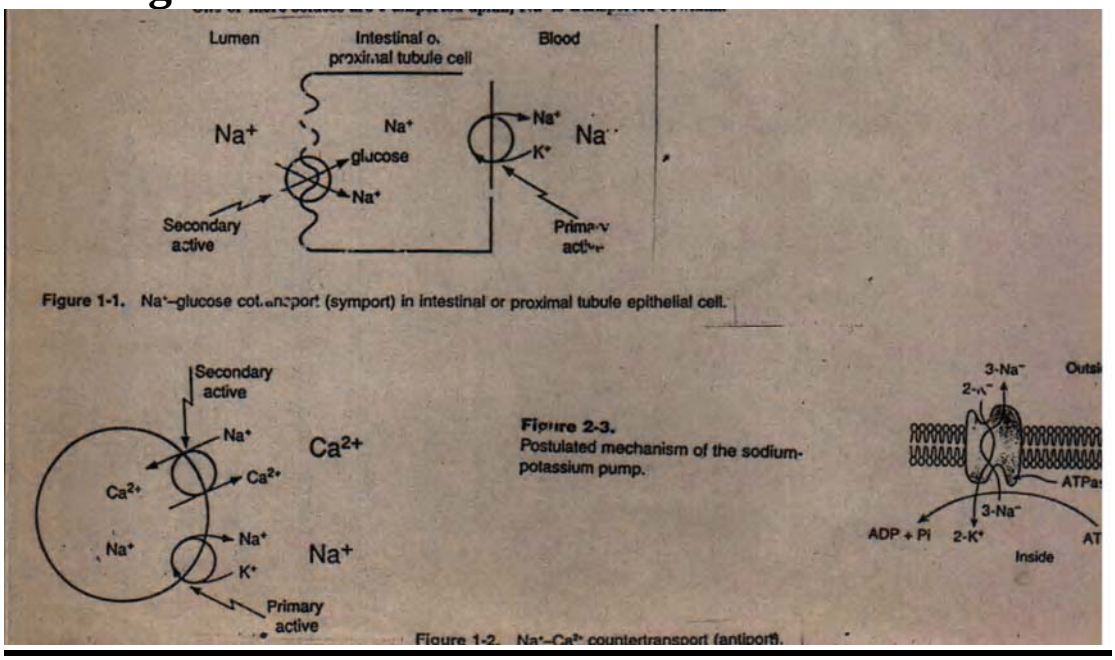


Figure 1-1. Na+–glucose cotransport (symport) in intestinal or proximal tubule epithelial cell.

Figure 2-3.
Postulated mechanism of the sodium-potassium pump.

Figure 1-2. Na^+–Ca^{2+} countertransport (antiport).

Figure 1-3. Osmosis of H_2O across a semipermeable membrane.

Table 1-1. Characteristics of Different Types of Transport

Type	Electrochemical Gradient	Carrier-mediated	Metabolic Energy	Na^+ Gradient	Inhibition of Na^+–K^+ Pump
Simple diffusion	Downhill	No	No	No	—
Facilitated diffusion	Downhill	Yes	No	No	—
Primary active transport	Uphill	Yes	Yes	—	Inhibits (if Na^+–K^+ pump)
Cotransport	Uphill*	Yes	Indirect	Yes, same direction	Inhibits
Countertransport	Uphill*	Yes	Indirect	Yes, opposite direction	Inhibits

-Osmosis:-

-Is the diffusion of water across a membrane .

-Cell membranes in the body are highly permeable to water & whenever there is a higher concentration of

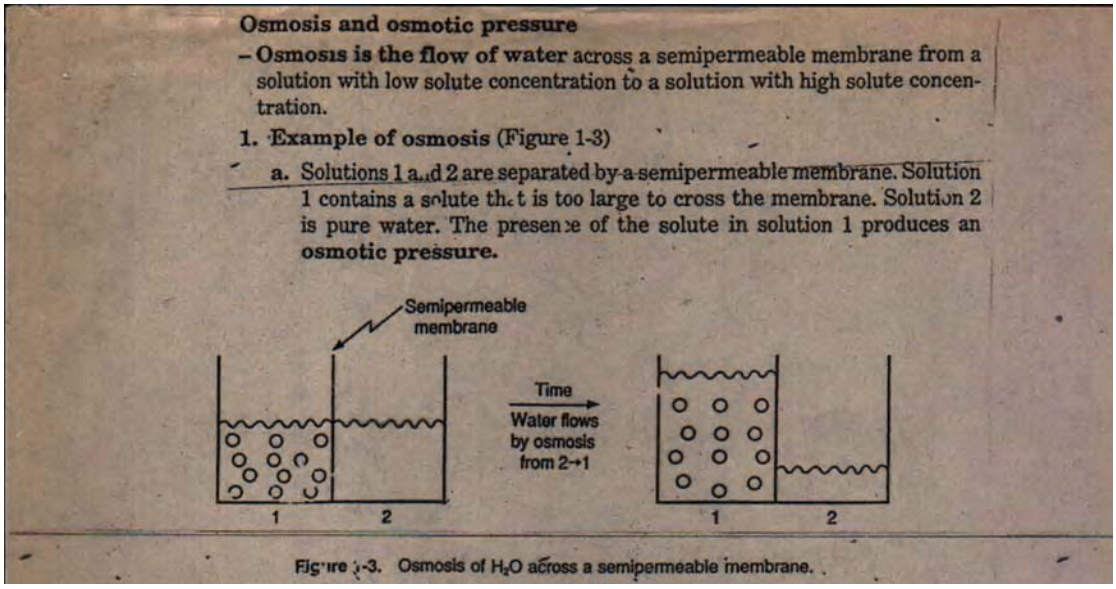
solute on one side of the membrane , water rapidly diffuses across the membrane to ward the region of higher solute concentration .

-So, osmosis is the flow of water across a semipermeable membrane from a solution with low solute concentration to a solution with high solute concentration.

-The osmotic pressure increases when the solute concentration increases.

-The higher the osmotic pressure of a solution, the greater the water flow into it.

-Osmolarity is the concentration of osmotically active particles in a solution.



-Isotonic , hypotonic & hypertonic fluids:-

-A solution is said to be isotonic if no osmotic force develops across the cell membrane when a normal cell is placed in the solution.

-This means that an isotonic solution has the same osmolarity as the cell & that the cells will not shrink or swell is placed in this solution.

-Example of isotonic solutions are: -

-0.9% Nacl & a 5% glucose solution.

-A solution is said to be hypertonic when it contains a higher osmotic concentration of substances than dose the cell.
-In this case , osmotic force develops that causes water to flow out the cell into the solution , thereby greatly concentrating intracellular fluid & shrinking the cell.
-The solution is said to be hypotonic if the osmotic concentration of substances in the solution is less than their concentration in the cell.
-An osmotic force develops immediately when the cell is exposed to the solution , causes water to flow by osmosis into the cell until the intracellular fluid has about the same concentration as the extracellular fluid , or until the cell bursts from excessive swelling.

-Edema:-

-Edema refers to the presence of excess fluid in the body tissues.
-In most instances , edema occur mainly in the extracellular fluid compartment , but it can involve intracellular fluids as well .

-Intracellular edema:-

-Can occur when the cell membrane is damaged or when there is inadequate nutrition to the cells.
-When this happens, sodium ions are no longer efficiently pumped out of the cells , & the excess sodium ions inside the cells cause osmosis of water into the cells.

-Extracellular edema: -

-Is more common than intracellular edema .

-Occurs with accumulation of fluid in the interstitial spaces.
-There are two general causes of extracellular edema:
(1):- Abnormal leakage of fluid from the plasma to the interstitial spaces across the capillaries.
(2):- Failure of the lymphatics to return fluid from the interstitium back to the blood.
-The most common clinical cause of interstitial fluid accumulation is excessive capillary fluid filtration.

<u>-Factors that can increase capillary filtration & cause interstitial fluid edema:-</u>

-Increased capillary filtration coefficient , which allows leakage of fluid & plasma proteins through the capillary membranes , this can occur as a result of allergic reactions , bacterial infections , & toxic substances that injure the capillary membranes.
-Increased capillary hydrostatic pressure , which can result from obstruction of a vein , excess flow of blood from the arteries into the capillaries , or heart failure , the heart fails to pump blood normally from the veins into the arteries.
-Decreased plasma colloid osmotic pressure , which can occur as a result of failure of the liver to produce sufficient quantities of plasma proteins , loss of large amounts of proteins into the urine in certain kidney diseases , or loss of large quantities of proteins through burned areas of the skin.
-Increased interstitial fluid colloid osmotic pressure , which will draw fluid out of the plasma into the tissue spaces. This results from lymphatic blockage , which

prevents the return of proteins from interstitial spaces to the blood.

-State Fluid Intake and Output Are Balanced During Steady Conditions:-

-The relative constancy of the body fluids is remarkable because there is continuous exchange of fluid and solutes with the external environment as well as within the different compartments of the body. For example, there is a highly variable fluid intake that must be carefully matched by equal output from the body to prevent body fluid volumes from increasing or decreasing.

Daily Intake of Water:-

-Water is added to the body by two major sources:-
(1):- it is ingested in the form of liquids or water in the food, which together normally add about 2100 ml/day to the body fluids.
(2):- it is synthesized in the body as a result of oxidation of carbohydrates, adding about 200 ml/day.
-This provides a total water intake of about 2300 ml/day .
-Intake of water, however, is highly variable among different people and even within the same person on different days, depending on climate, habits, and level of physical activity.

Daily Loss of Body Water:-

-Insensible Water Loss:-

-Some of the water losses cannot be precisely regulated.
-For example, there is a continuous loss of water by evaporation from the respiratory tract and diffusion through the skin, which together account for about *700*ml/day of water loss under normal conditions.
-This is termed insensible water loss because we are not consciously aware of it, even though it occurs continually in all living humans.
-The insensible water loss through the skin occurs independently of sweating and is present even in people who are born without sweat glands; the average water loss by diffusion through the skin is about 300 to *400* ml/day.
-This loss is minimized by the cholesterol-filled cornfield layer of the skin, which provides a barrier against excessive loss by diffusion.
-When the cornfield layer becomes denuded, as occurs with extensive burns, the rate of evaporation can increase as much as 10-*fold, to* 3 *to 5* L/day.
-For this reason, burn victims must be given large amounts of fluid, usually intravenously, to balance fluid loss.
-Insensible water loss through the respiratory tract averages about 300 to 400 ml/day.
-As air enters the respiratory tract, it becomes saturated with moisture, to a vapor pressure of about *4%* mm Hg, before it is expelled.
-Because the vapor pressure of the inspired air is usually less than 4% mm Hg, water is continuously lost through the lungs with respiration.
-In cold weather, the atmospheric vapor pressure decreases to nearly zero , causing an even greater loss of water from the lungs as the temperature

decreases. This explains the dry feeling in the respiratory passages in cold weather.

Fluid Loss in Sweat.

-The amount of water lost by sweating is highly variable , depending on physical activity and environmental temperature.
-The volume of sweat normally is about 100 ml/day, but in very hot weather or during heavy exercise, water loss in sweat occasionally increases to 1 to 2 L/hour.
-This would rapidly deplete the body fluids if intake were not also increased by activating the thirst mechanism .

Water Loss in Feces.

-Only a small amount of water (100 ml/day) normally is lost in the feces.
-This can increase to several liters a day in people with severe diarrhea. For this reason, severe diarrhea can be life threatening if not corrected within a few days.

Water Loss by the Kidneys:-

-The remaining water loss from the body occurs in the urine excreted by the kidneys. There are multiple mechanisms that control the rate of urine excretion.
-In fact, the most important means by which the body maintains a balance between water intake and output, as well as a balance between intake and output of most electrolytes in the body, is by controlling the rates at which the kidneys excrete these substances.
-For example, urine volume can be as low as 0.5 L/day in a dehydrated person or as high as 20 L / day in a person who has been drinking tremendous

amounts of water.
-The kidneys are faced with the task of adjusting the excretion rate of water and electrolytes to match precisely the intake of these substances, as well as compensating for excessive losses of fluids and electrolytes that occur in certain disease states.