جامـــــعة شط العرب
كلية التقنيات الصحية والطبية
قسم تقنيات الأشعة والسونار

Biology

First Year

Prof. Abdullah H. Abdullah

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What is Biology?

The word biology is derived from the Greek words

bios- meaning life

logos - meaning study

Biology is defined as the study of life and living organisms.

History and general concepts of biology:

- The history of biology traces the study of the living world from ancient to modern times.
- The biological sciences emerged through the contributions of Assyrians, Babylonians, Egyptians, Chinese, Indians, Greeks, Romans and Muslims in the Middle Ages.
  The concept of biology as a single coherent field arose in the 19th century.

Some men of biology:

- Avicenna who wrote on human anatomy, physiology, medicine and genetics (heredity)
- Al-Dinawari who wrote on botany.
- Rhazes who wrote on anatomy and physiology
- Robert Hooke : First used the term "cell" to describe cork's structure.
- Anton van Leeuwenhoek : Observed living cells which he called "animalcules".
- Mattias Schleiden: Proposed that plant tissues are made of cells.
- Theodor Schwann : Extended Schleiden’s findings to animals
- Rudolf Virchow: Added the principle that cells come from pre-existing cells.

- Biology began to quickly develop and grow with Anton van Leeuwenhoek's dramatic improvement of the microscope.
  Anton van Leeuwenhoek revealded by means of microscopy the previously unknown world of microorganisms, laying the growndwork for cell theory

Cell theory:

Stating that:

1. All living organisms are made of one or more cell.
2. The cell is the basic (smallest) unit of life
3. All cells come from pre-existing cells

Fields of Biology:

Three major divisions

1. Botany - the scientific study of plants
2. Zoology - deals with the study of all aspects of animal life
3. Microbiology is the scientific study of microorganisms (microbes) .

Branches of Zoology:

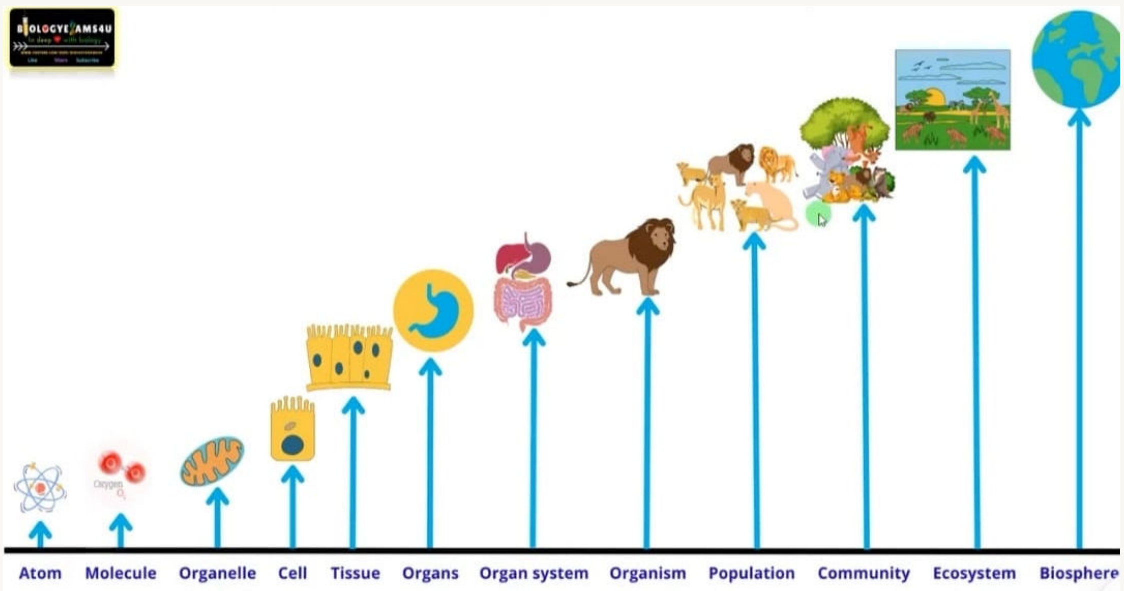
1. Anatomy - the study of the internal structure of organisms
2. Cytology - study of cells and cell organelles
3. Histology - the microscopic study of tissues
4. Physiology - deals with the functions of cells and organs.
5. Embryology- study the development of an embryo to new individual.
6. Evolution - the study of the change undegone by species through the age
7. Genetics deals with genes, heredity, and variation.

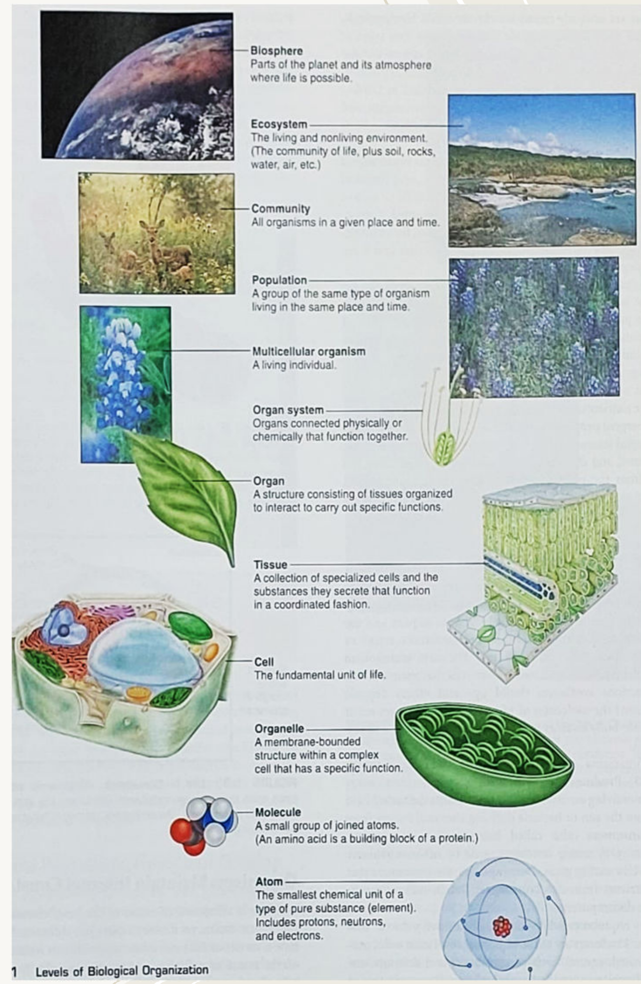
Cell: from Latin cella, meaning "small room"

- The study of cell is called cell biology, cellular biology, or cytology.

The qualities that constitute life:

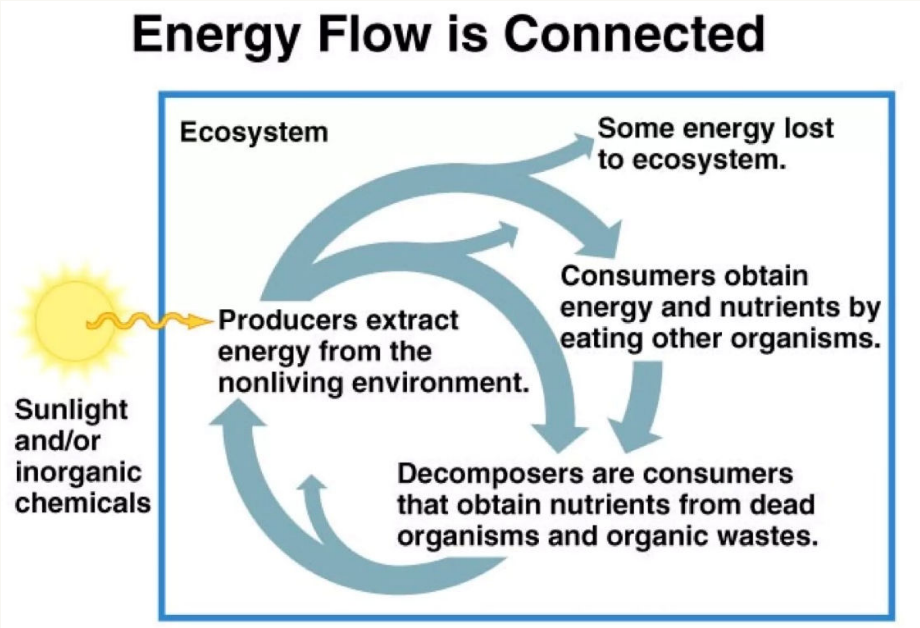
1. Organization





2. Energy use and metabolism

- Energy enables organisms to build new structures, repair or break down old ones, and reproduce.
- Metabolism refers to the chemical reactions within cells that maintain life.
- Some reactions synthesize(build up) and others degrade(break down) the molecules of life.
- All organisms extract energy from their environment



3. Maintenance of internal constancy (Homeostasís)

- To keep metabolic processes running smoothly, organisms must maintain a certain temperature and the proper amount of water, salts, minerals, and so on. This ability to keep conditions constant is called homeostasis.

4. Reproduction, growth and development

- To maintain a population ,or even life on a planet, organisms must reproduce, that is, make other individuals like themselves. Offspring then grow(increase in size) and develop, adding anatomical detail and taking on specialized functions until they resemble the parent and reproduce.

5. Irritability and adaptation (response to stimuli)

- Irritability: is the tendency to respond immediately to stimuli.
- In contrast to the rapid ,transient nature of irritability ,adaptation is a response that develops over time.

Each cell has three things in common:

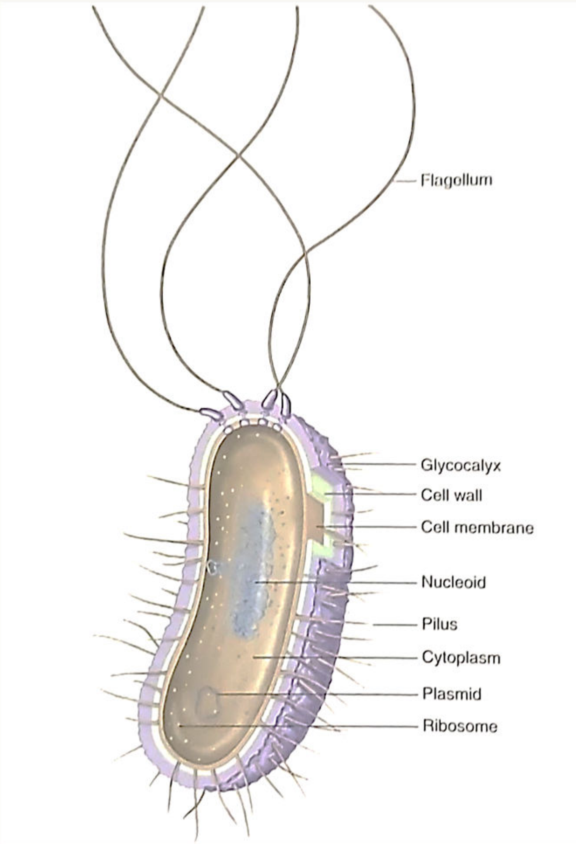
1. Cell membrane
2. Cytoplasm
3. DNA

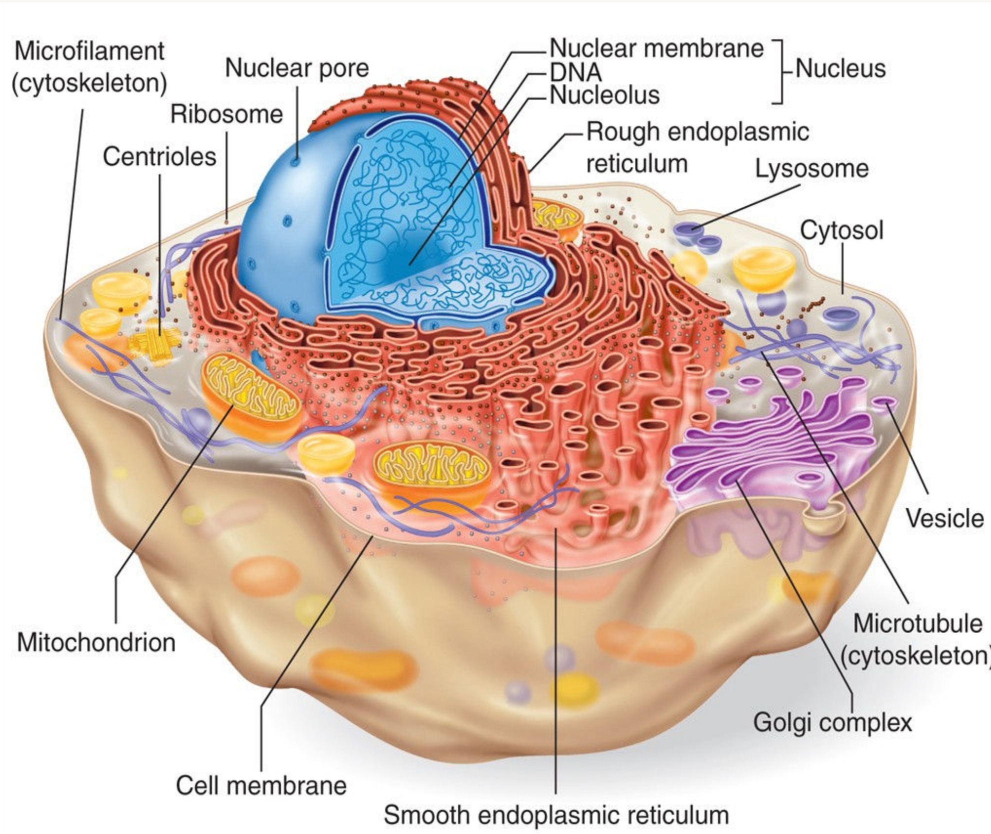
There are two broad categories of cells

1. Prokaryotic cell
2. Eukaryotic cell

Comparison between prokaryotic and eukaryotic cells

Prokaryotic	Eukaryotic
Rigid cell walls present built of peptidoglycan	Cell wall absent
Lack distinct membrane-enclosed nuclei	Prominent nucleus
Single circle of DNA (single chromosome) located in region called the nucleoid	linear chromosomes
Lack organelles	Organelles present
Unicellular	Usually multicellular
Small size, 1-10 μm	Small size, 1-100 μm
Asexual reproduction	Asexual and sexual reproduction
Ribosomes 70S	Ribosomes 80S
Cytoskeleton absent	Cytoskeleton present


Flagellum
Glycocalyx
Cell wall
Cell membrane
Nucleoid
Pilus
Cytoplasm
Plasmid
Ribosome


Microfilament (cytoskeleton)
Nuclear pore
Ribosome
Centrioles
Nuclear membrane
DNA
Nucleolus
Nucleus
Rough endoplasmic reticulum
Lysosome
Cytosol
Vesicle
Microtubule (cytoskeleton)
Golgi complex
Mitochondrion
Cell membrane
Smooth endoplasmic reticulum

- **Plasmid**: is a genetic structure in a cell that can replicate independently of the chromosomes, typically a small circular DNA strand in the cytoplasm of bacterium or protozoa. Plasmids are much used in the laboratory manipulation of genes.

- **Glycocalyx**: is a thick or thin sticky layer surrounfed the prokaryotic cell wall, which is composed of protein and/or polysaccharides.

- **Pili:** are short hairlike projections present in some prokaryotic cells. Attachment pili enable the cells to attach to objects.

Introduction to chemistry of life:

Cells chemistry:

- Life is based on chemical principles.
- The chemistry of life explores how atoms form essential biological molecules, such as proteins, lipids, carbohydrates ,and nucleic acids.
- These biomolecules are made from Carbon, Hydrogen, and Oxygen. Proteins and nucleic acids have nitrogen

Atoms and Elements:

- Organisms consist of matter(material that takes up space) and energy(the ability to do work).
- All matter can be broken down into pure substances called elements.
- Elements required in large amounts such as C , H , O , N , S , and P are termed bulk elements
- Elements required in small amounts are called trace elements.

Atoms:

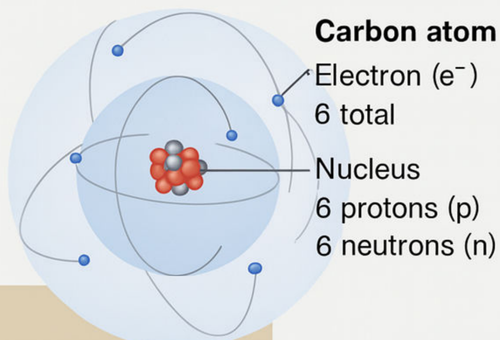
- An atom is the smallest unit of an element.

Atom — Protons, Neutrons, Electrons

Protons, Neutrons — Nucleus

- Protons carry positive charge
- Electrons carry negative charge
- Neutrons are electrically neutral

Atoms Have Structure. An atom is composed of a nucleus, made of protons and neutrons, surrounded by a cloud of electrons.



Subatomic particles

Particle	Charge	Mass	Function	Symbol	Location
Electron	–	0	Bonding	e^-	Orbitals
Neutron	0	1	Nuclear stability	n	Nucleus
Proton	+	1	Identity	p	Nucleus

Molecules:

- Molecules are atoms bound together.

  O + **O** = **O_2**

- Atoms of two or more elements often exist joined together as a compound.

  2H + **O** = **H_2O**

- A molecule is the smallest unit of a compound.

Methane>>**CH_4**>>**1 carbon** atom joined to **4 hydrogen** atoms.
Glucose>>**$C_6H_{12}O_6$**>>has **6 atoms** of carbon,**12** of **hydrogen**, and **6** of **oxygen**.

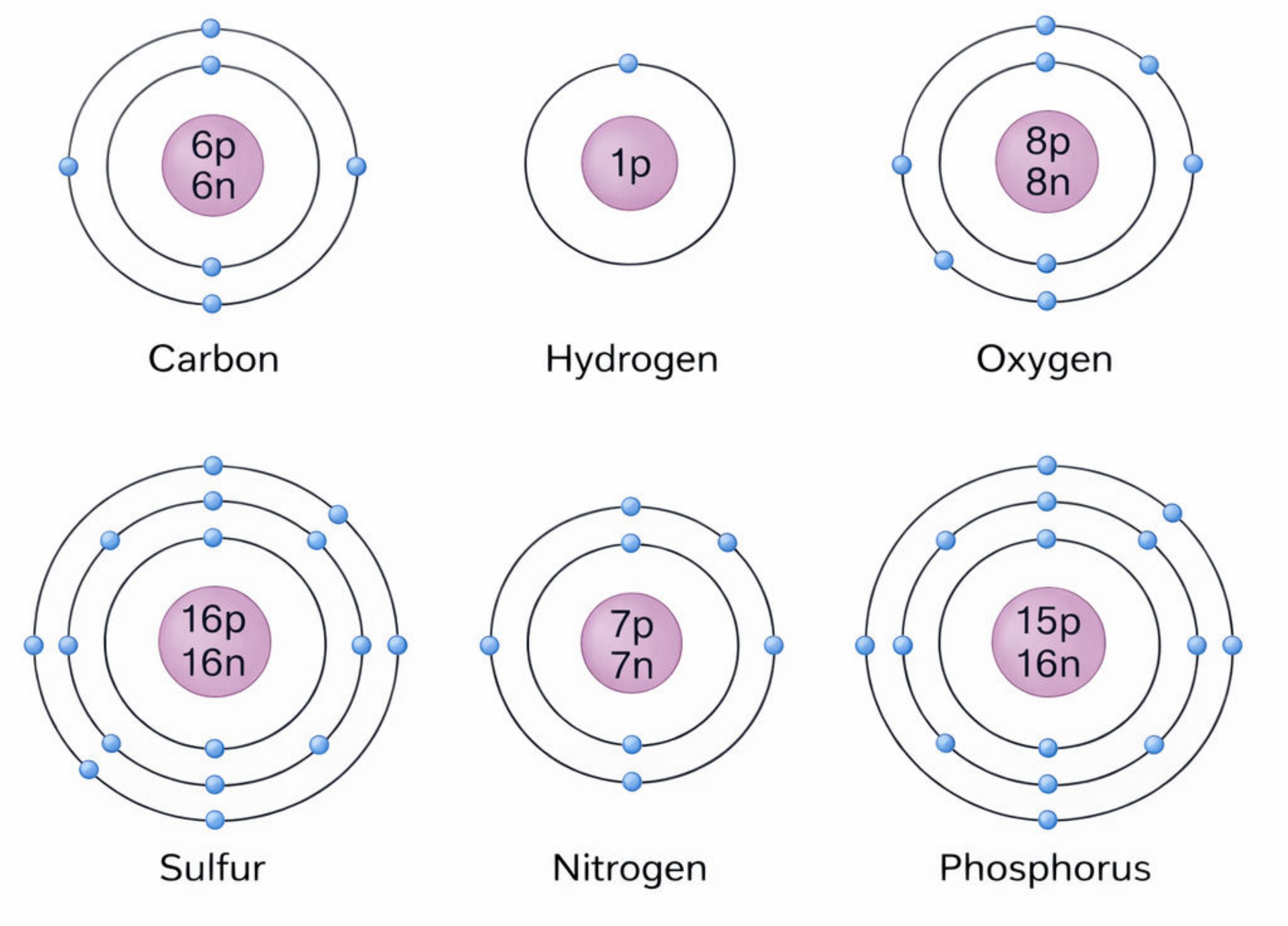
- **Chemical reactions:**

  Tow or more molecules interact with each other to yield different molecules.

- Organisms are composed mostly of water and carbon containing molecules.
- Most the carbon-based molecules are organic molecules which contain carbon and hydrogen.
- Some organic molecules of life are so large that they termed macromolecules. For example chlorophyll, protein,......

Chemical bonds:

- Atoms can combine to form complex molecules of an infinite variety
- Often electrons are illustrated as dots moving in concentric circles around the nucleus, much like planets moving around a sun, with the orbits symbolizing the enery shell. These depictions, called Bohr models, are useful for visualizing the interactions between atoms to form bonds



Structures of the Atoms Prevalent in Life. Shown here are Bohr models of the six most common atoms that make up organisms

- Valence shell is most actively involved in chemical reactions because it is most likely to be only partially filled with electrons.
- Strong chemical bonds are formed when atoms share electrons.
- Weaker bonds form from the attraction between atoms that have, respectively, given up or taken electrons from each other.

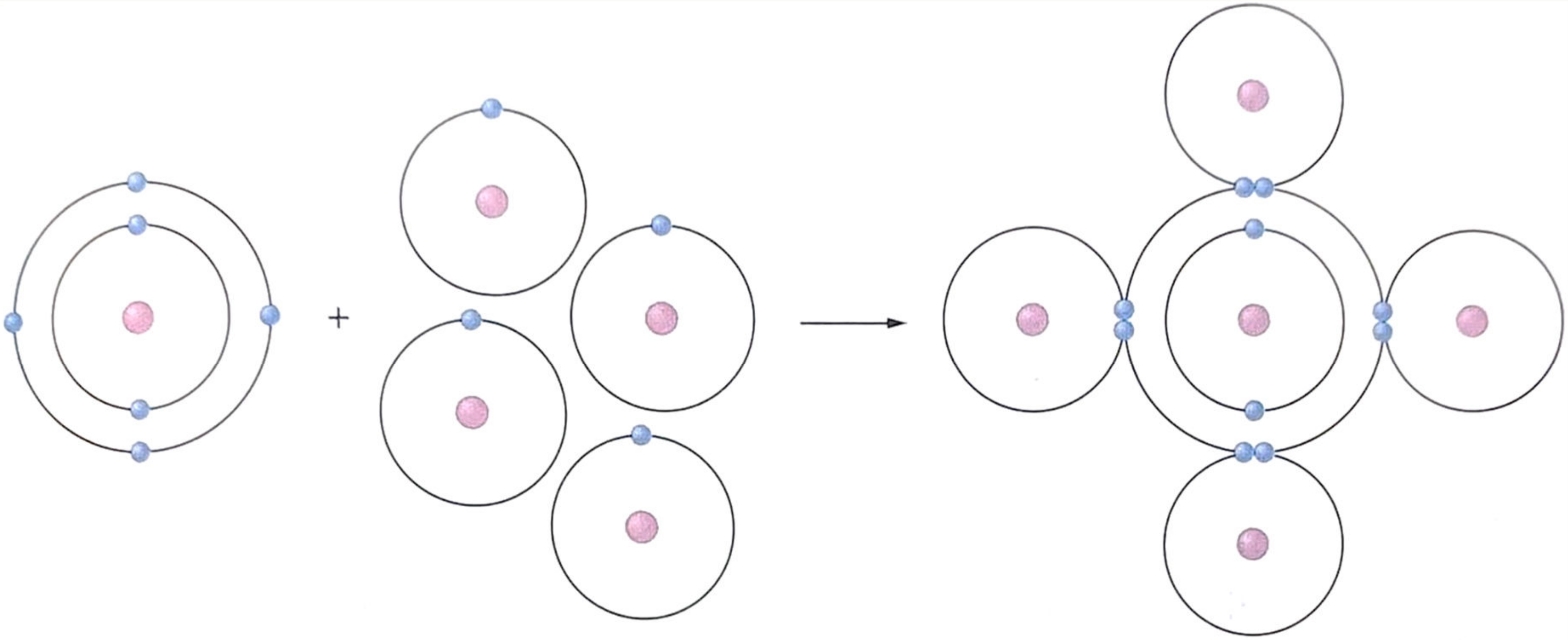
Types of chemical bonds:

1. Covalent bonds:

- Hold together most the molecules of life.
- These strongest of bonds form when two atoms share pairs of valence electrons, and tend to form among atoms that have three , four , or five valence electrons
- Sharing electrons enables both atoms to fill their outermost shells with eight electrons.

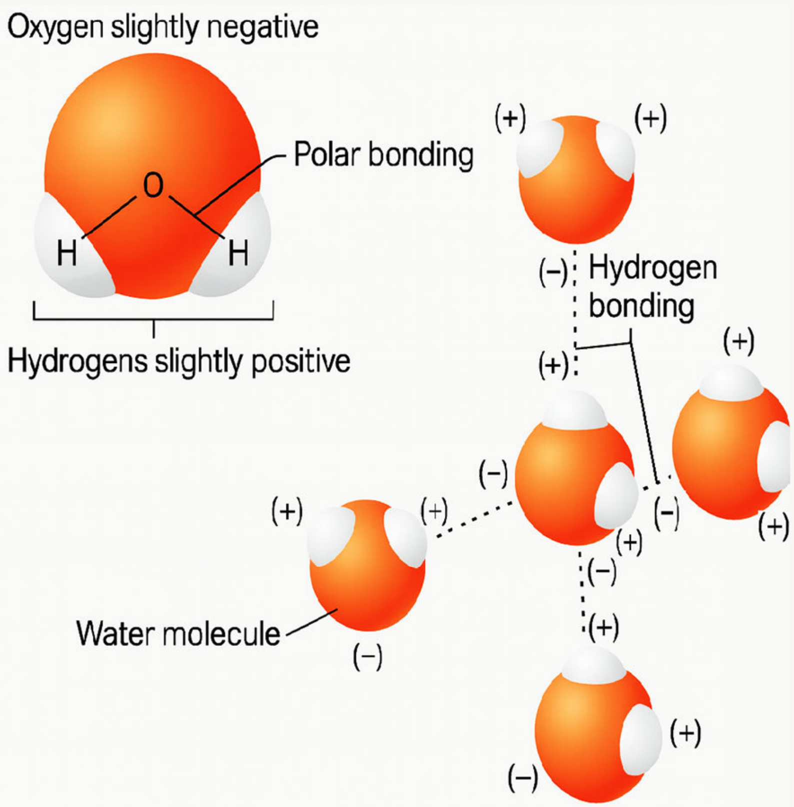
Example:

- Carbon has four electrons in its outermost shell, therefore, it requires four more electrons to satisfy the octet rule. A carbon atom can attain the stable eight-electron configuration in its outer shell by sharing electrons with four hydrogen atoms, each of which has one electron in its only shell.
- The resulting molecule is the swamp gas methane(CH_4).



C + 4H → CH_4

- Since the electrons are shared equally in methane, these bonds are nonpolar covalent bonds.
- In contrast, in polar covalent bond, electrons draw more toward one atom's nucleus than the other.
- The term polar means there is a difference between opposite ends of molecules, usually formed by opposite charged.
- Water(H2O), which consist of two hydrogen atoms bonded to an oxygen atom, is molecule with polar covalent bonds.



Polar Covalent Bonds. Polar covalent bonds hold together the two hydrogen atoms and one oxygen atom of (H_2O). Because the oxygen attracts the negatively charged hydrogen electrons more strongly than the hydrogen nuclei do, the oxygen atom bears a partial negative charge, and the hydrogens carry a partial positive charge in hydrogen bonds.

- Oxygen is highly electronegatively.
- Its ability to accept electrons is crucial in helping organisms extract energy from nutrients.
- Polar covalent bonds form when less electronegatively atoms, such as carbon and hydrogen, bond with electronegatively atoms, such as oxygen and nitrogen.

2. Ionic bonds:

- Atoms share electrons in covalent bonds.
- But sometimes, the electronegatively of one atom is so great that the atom takes an electron from the other atom.
- The two atoms then have opposite charged and attract. This attraction is an ionic bond and can be a very strong attraction, though not as strong as covalent bond.
- An atom with one electron in the outermost shell might lose it to an atom with seven valence electrons in an attempt to fill all of the valence shells, or eliminate them.
- Once an atom loses or gains electrons, it has an electric charge and is called an ion.
- Atoms that lose electrons lose negative charges and thus carry a positive charge.
- Atoms that gain electrons become negatively charged.

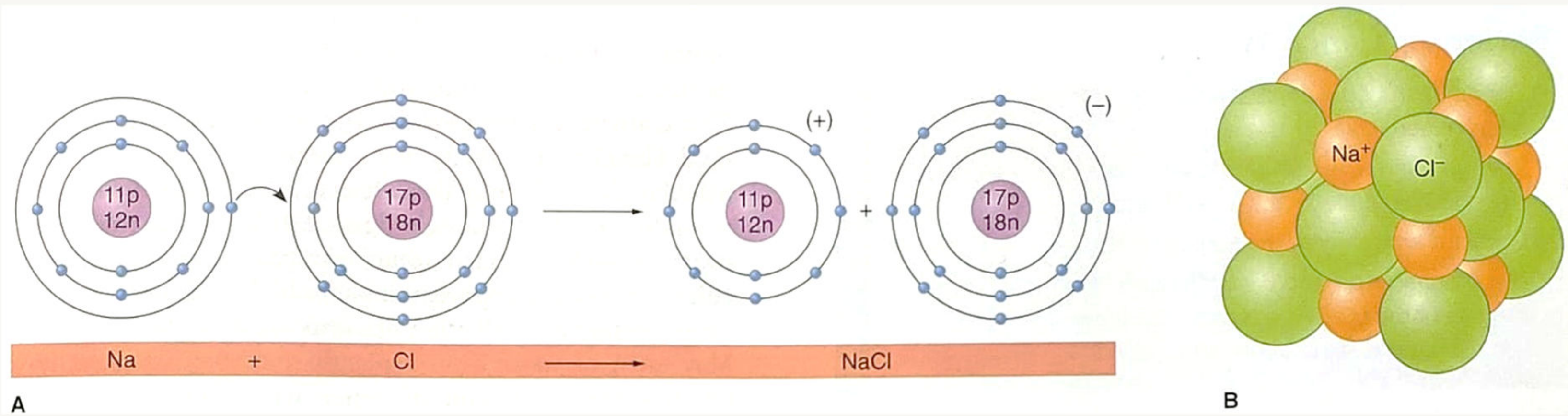


Table Salt. an Ionically Bonded Molecule. (A) A sodium atom [Na] can donate the one electron in its valence shell to a chlorine atom [Cl], which has seven electrons in its outermost shell. This satisfies the octet rule for both atoms. The resulting ions [Na* an Cl] bound to form the compound sodium chloride [NaCl]. Better known as table salt. **(B)** the ions that constitute NaCl occur in a repeating pattern that produces crystals.

Salt :

is a compound composed of oppositely charged ions like NaCl. A salt can consist of any number of ions.
In NaCl, the oppositely charged ions Na^+ and Cl^- attract in such an ordered manner that a crystal results.

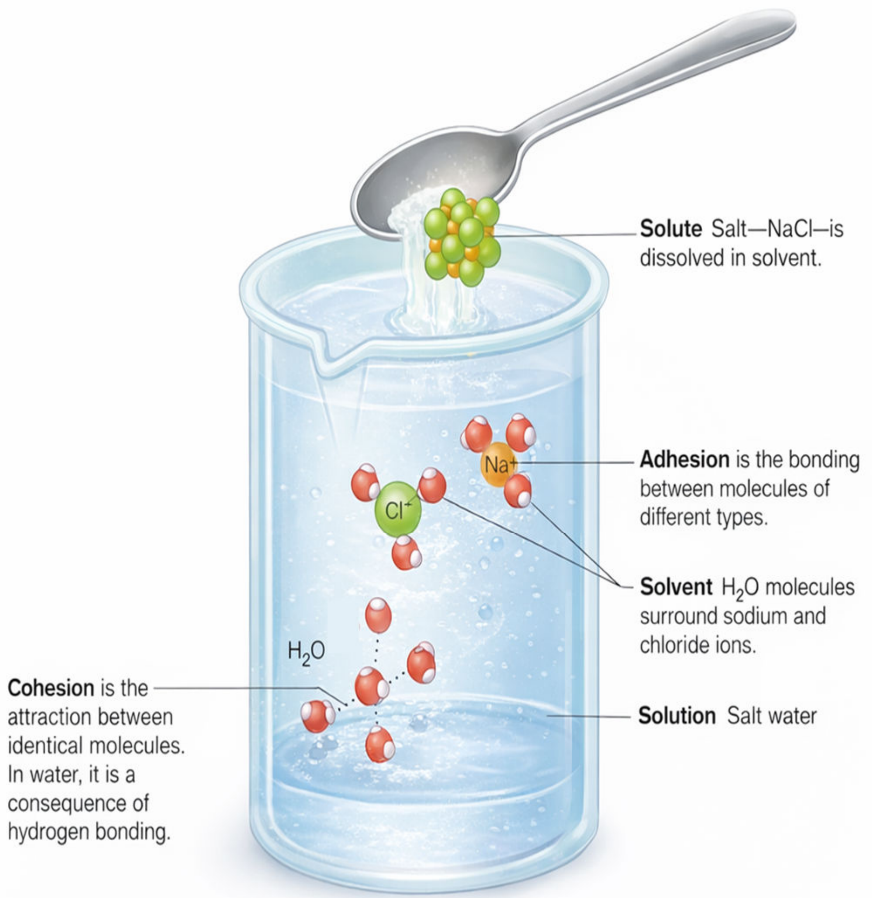
- When salts are placed in water, the ionic bonds are often disrupted by the charges in water.
- Atoms behave very differently as ions than they do normally.
- Native sodium is lethal if ingested but is vital to life as an ion.

3.Weak chemical bonds:

- When two molecules contain polar covalent bonds, part of each atom have small partial charges. The opposite charges on two molecules attract each other and form hydrogen bonds.

Water :

- All life processes take place in solutions.
- A molecule of water consist of two atoms of hydrogen and one atom of oxygen
- The attraction between identical molecules, which accounts for water's constant rebonding, is called cohesion
- Water also readily forms hydrogen bonds to many other compounds, a property called adhesion.
- The ability to separate charge atoms or molecules makes water a strong solvent.
- Nonpolar molecules, such as fats and oils ,do not carry a charge and thus do not usually dissolved in water
  This is why oil on the surface of cup of coffee forms a visible drop and a drop of water on an oily surface beads up.



Solutions Are Mixtures of Molecules.

Interactions between solutes and solvents allow solutes to dissolve by forming bonds with the solvent.

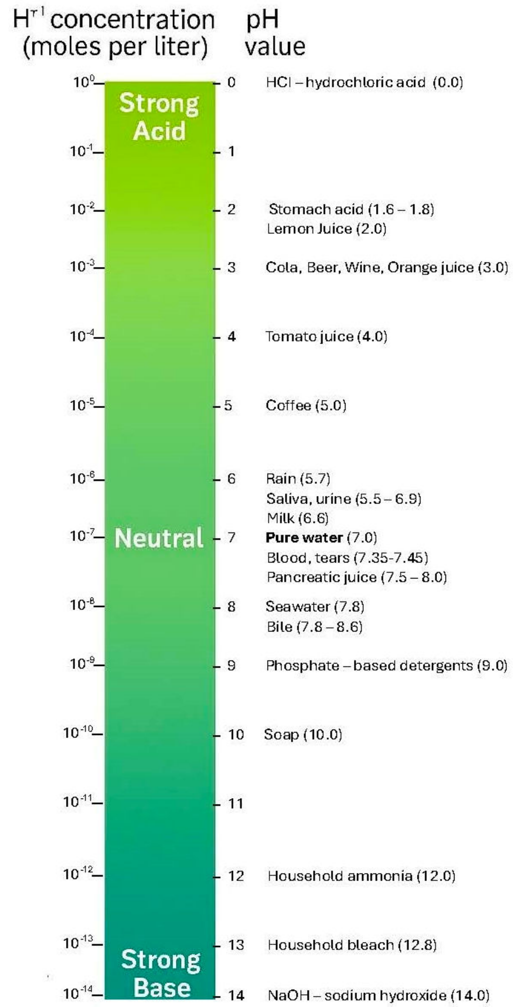
pH:

- Substances that add more H+ to a solution are acid.
  HCl , H2SO4 , H3PO4 , HNO3
- Substances that decrease the number of H+ are bases and alkaline(also called basic).
  NaOH or tye

The pH scale:

Scientists use a system of measurement called the pH scale to gauge how acidic or alkaline a solution is in terms of its H+(hydrogen ion) concentration.

- The pH scale ranges from 0 to 14,with 0 representing strong acidity(high H+ concentration).
- 14 representing strong alkalinity(low H+ concentration).
- The neutral solution, such as pure water ,has pH of 7.



The pH Scale. The pH scale is commonly used to indicate the strength of acids and bases as a function of the number of hydrogen ions present. The lower the pH, the higher the concentration of free hydrogen ions becomes and the more acidic the solution. Conversely, the higher the pH, the more free hydroxyl (OH) ions there are and the more alkaline the solution.

Biologically important molecules :

Carbon :

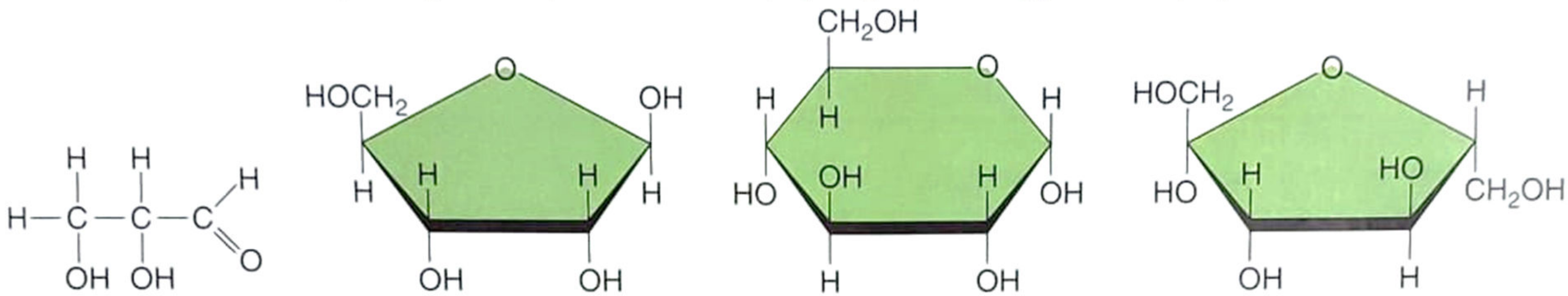
is the basis of life's chemistry.

- A carbon is able to form bonds with four other atoms, including itself, resulting in an infinite variety of shapes and functions.
- By adding functional groups to a carbon skeleton,life can change the functions of the carbon molecule.
- Functional groups are atoms or groups of atoms that add functions by combining oxygen, phosphorus, sulfur and nitrogen to larger carbon skeletons.
- All living organisms are composed of four classes of carbon molecules:

1. Carbohydrates
2. Lipids
3. Proteins
4. Nucleic acids

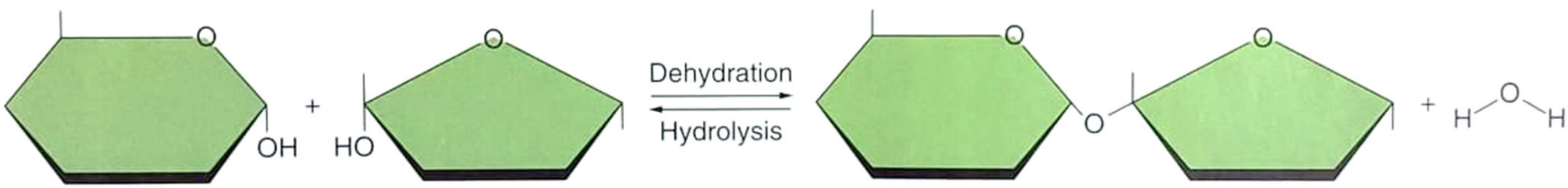
- The biologically important molecules are compounds made from small, single unite molecules called monomers.
- Linked monomers form polymers.
- Polymers are classified by the numbers of unit monomers they contain:
  mono-,one
  di- ,two
  tri -, three
  oligo - , 5 to 100
  poly - , more than 100 units
- Chemical reaction in the cell either dehydration(losing water) to join monomers , or hydrolysis(addition of water) to separate monomers.

Monosaccharides—simple sugars composed of carbon, hydrogen, and oxygen in the proportions 1:2:1.



Glyceraldehyde $C_3H_6O_3$ | Ribose $C_5H_{10}O_5$ | Glucose $C_6H_{12}O_6$ | Fructose $C_6H_{12}O_6$

Disaccharides—molecules composed of two monosaccharides joined by dehydration synthesis. Hydrolysis converts disaccharides into their component monosaccharides. (The structures of the molecules are simplified to emphasize the joining process.)



Glucose $C_6H_{12}O_6$ + Fructose $C_6H_{12}O_6$ $\rightleftharpoons$ Sucrose $C_{12}H_{22}O_{11}$ + Water H_2O

Carbohydrates:

consist of carbon, hydrogen, and oxygen in the ratio of 1:2:1 $(CH_2O)_n$

- The term saccharide (sugar) is used to describe carbohydrates.

Simple carbohydrates:

1. Monosaccharides are the smallest carbohydrates
   - Contain three to seven carbons
   - They differ in how atoms bonded.

   Example: Three monosaccharides with the same molecular formula($C_6H_{12}O_6$),but different chemical structure

   Glucose (blood sugar)

   Galactose

   Fructose (fruit sugar)

2. Disaccharides: are the smallest complex carbohydrates.
   - Two monosaccharides link through dehydration synthesis

   Example:

   Glucose + Fructose > Sucrose (table sugar)

   Glucose + Glucose > Maltose

   Glucose + Galactose > Lactose (milk sugar)

Oligosaccharides :

are moderately sized carbohydrates.

- Oligosaccharides are attached to:
  Proteins > Glycoproteins
  Or
  Lipids > Glycolipids

Complex carbohydrates:

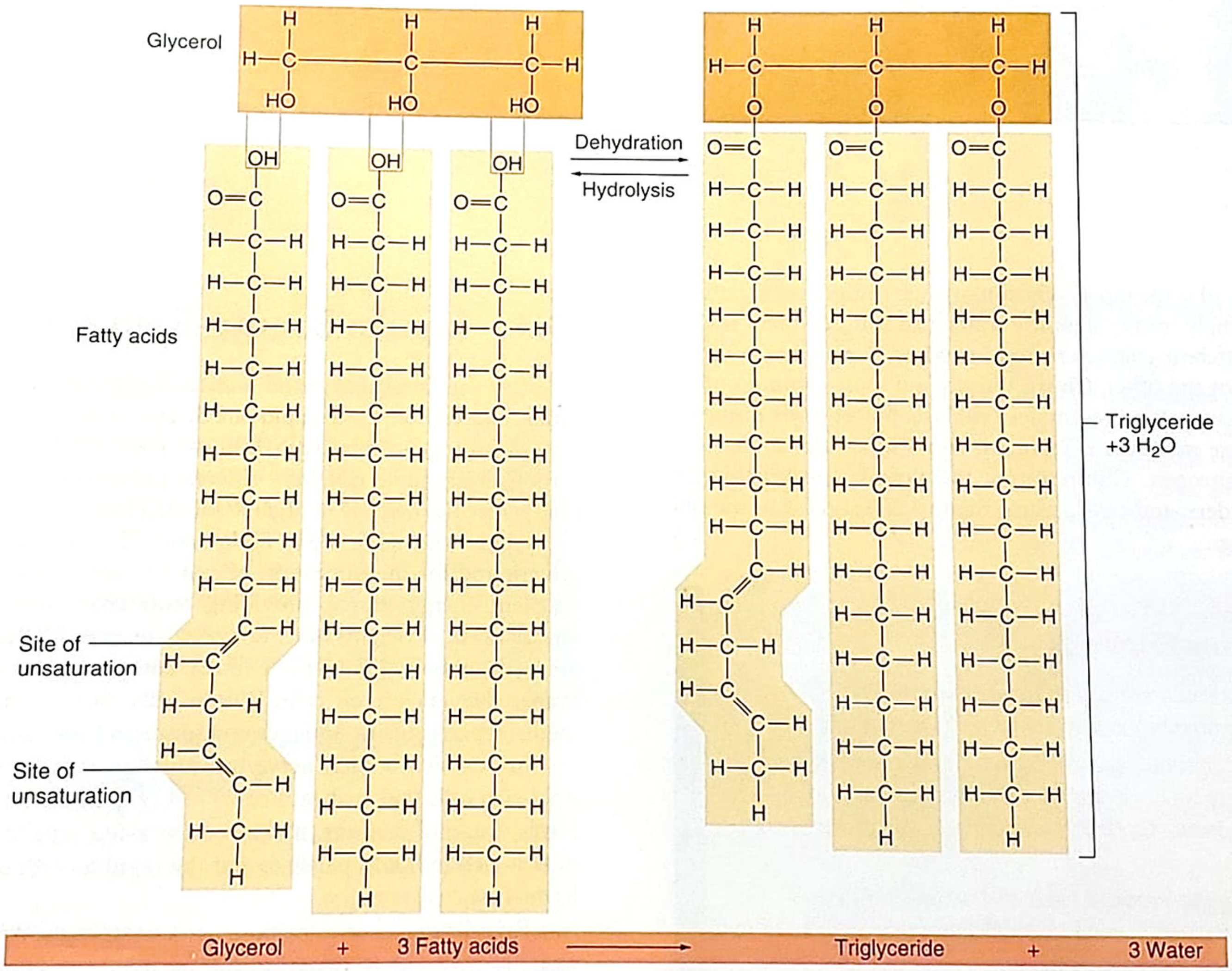
Usually made of polysaccharides containing hundreds of glucose monomers or modified sugar.

Examples: Cellulose, Starch, Chitin

Lipids:

are molecules containing carbon, hydrogen, and oxygen.

- Lipid molecules dissolved in organic solvents but not in water.
- Lipids are a major component of the membranes that enclose all cells, because they are hydrophobic
- The simplest type of lipid in nature, fatty acids are long hydrocarbons of up 36 carbon atoms with an acidic functional group at one end.



Lipids Form Complex Molecules. A triglyceride is formed by bonding fatty acids to glycerol. This triglyceride is tripalmitin. The double bonds bend the fatty-acid tails, making the lipid more fluid. The bend is shown schematically here.

- Saturated fatty acid: no double bonds in fatty acid chains(solid at room temperature).
- Unsaturated fatty acid has one or more double bonds(liquid at room temperature).

Triglyceride:

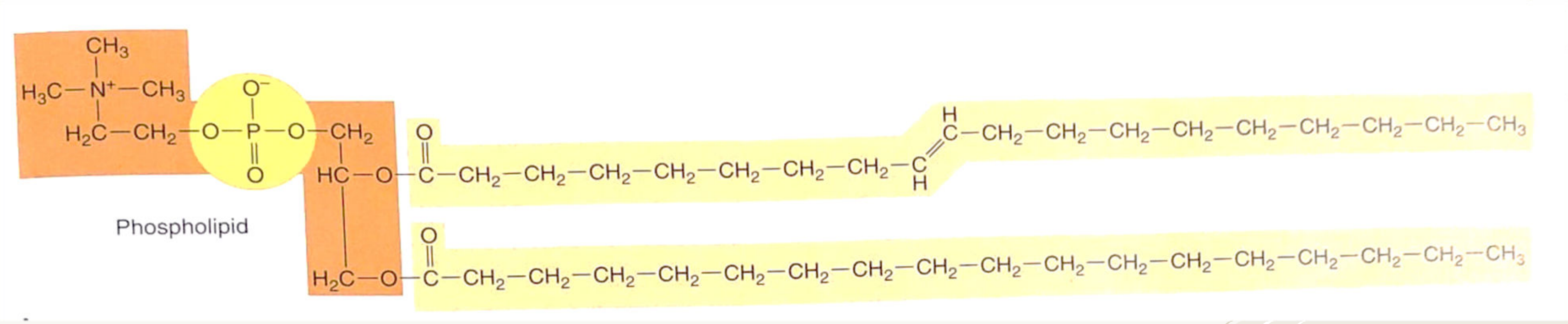
Consist of three fatty acids joined to a three carbon molecules called glycerol.

- Dehydration synthesis combines the fatty acids and glycerol, releasing water.
- Triglyceride is commonly known as (fat).

Phospholipid :

is the component of cell membranes.

- It is formed when enzymes replace one of the fatty acids in a triglyceride with phosphate (functional group,PO4).
- Hydrophilic because the oxygen-rich phosphate is highly negatively charged.

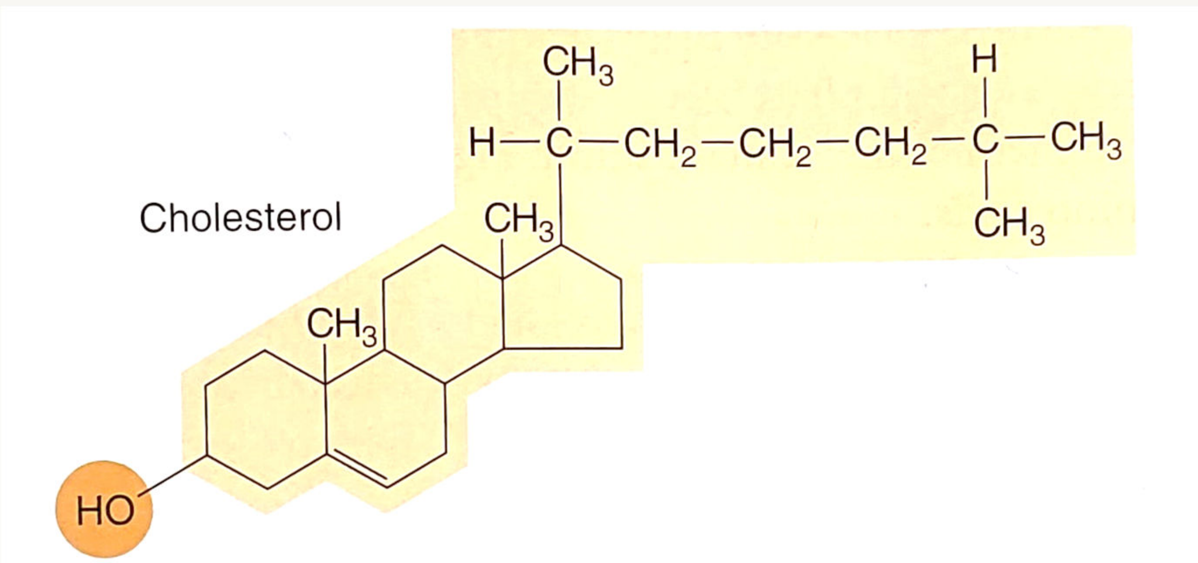


Sterols:

Are lipid molecules based on four interconnected carbon rings.

- Additions or modifications of this basic structures yield cholesterol,hormones ,and vitamins.

Cholesterol: is a vital for cells to maintain the fluidity of cell membranes and can be modified to make other lipids, including the sex hormones testosterone and estrogen.



Proteins:

Consist of monomers of amino acids linked to form one or more polypeptide chains.

- Enzymes are protein that allow biochemical reactions to proceed fast enough to sustain life.

Amino acids:

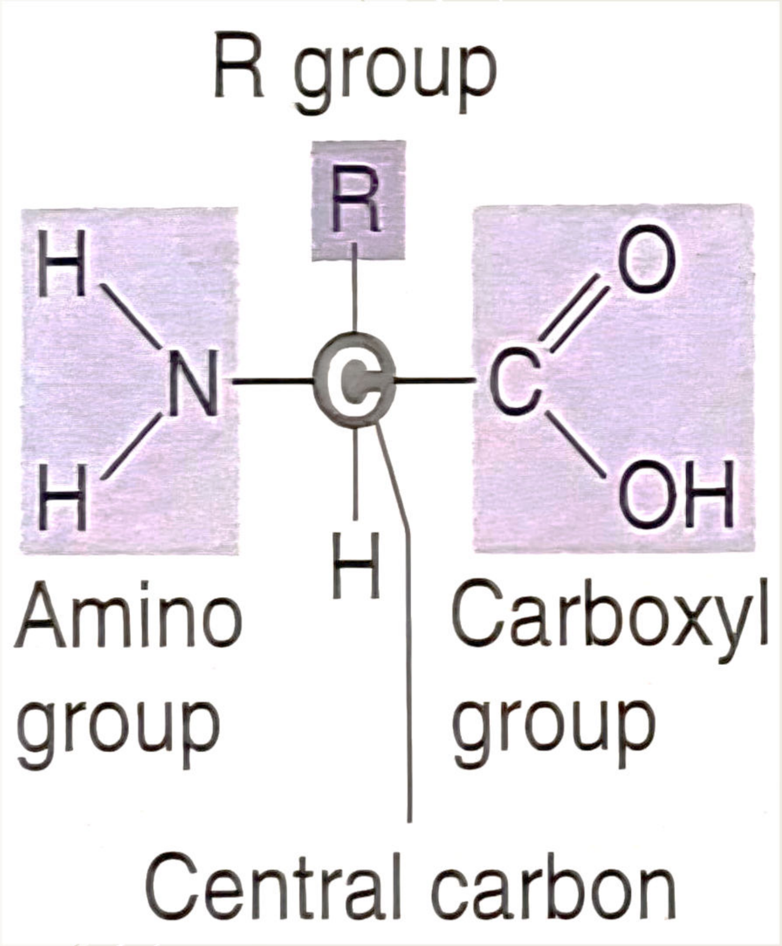
are the monomerd of proteins.

- To build protein, organisms make use of 20 types of amino acids.
- These 20 amino acids make possible a nearly infinite variety of proteins.

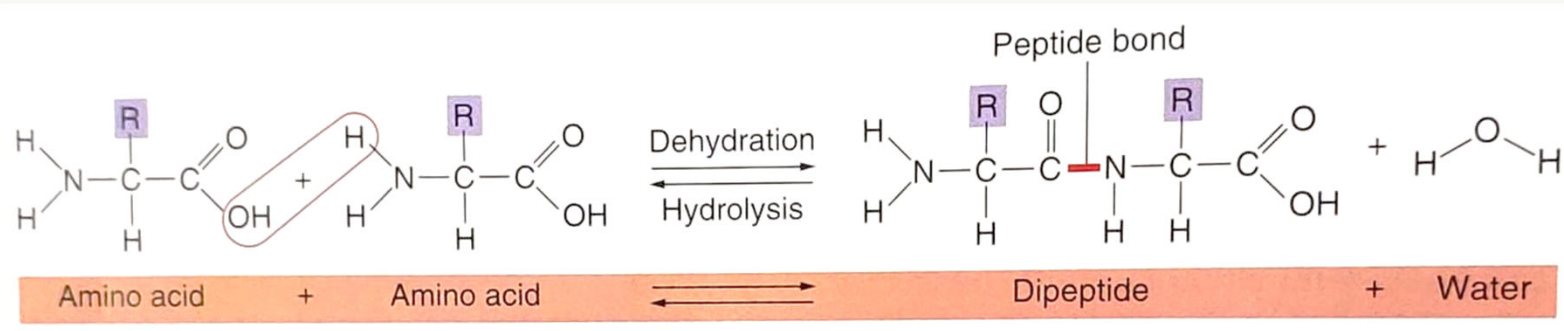
Amino acid structure:

All amino acids contain a central carbon atom bonded to four different functional components:

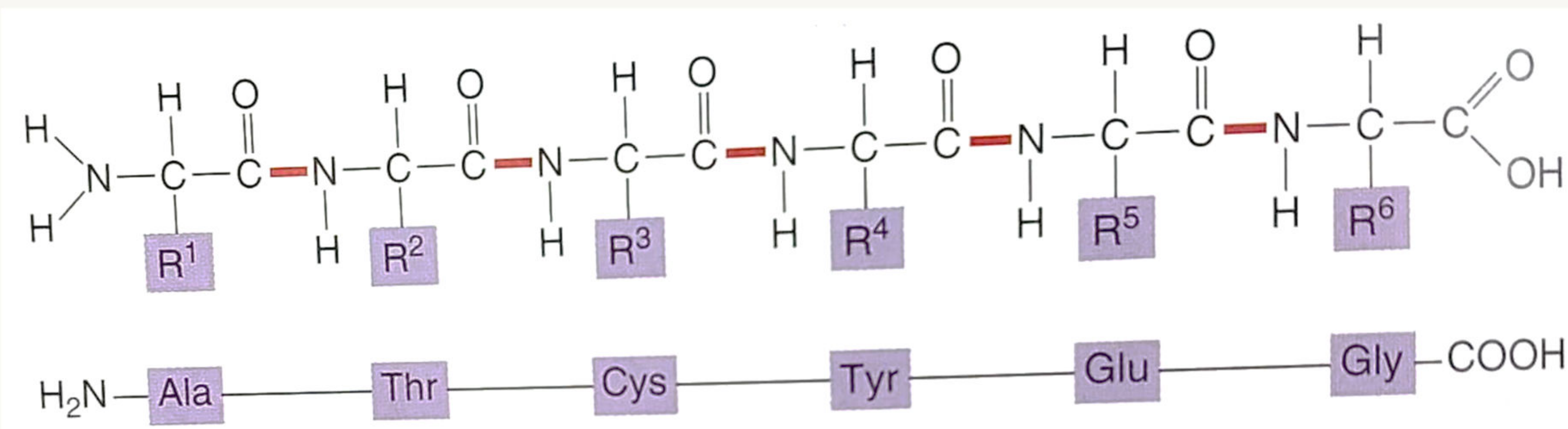
1. a hydrogen atom
2. a carboxyl group(acid)
3. an amino group
4. a side chain, or R group which can be any of several chemical groups.



Peptide bond : To join amino acids, the carboxyl group of one amino acid combines with nitrogen group of the other and forms a peptide bond



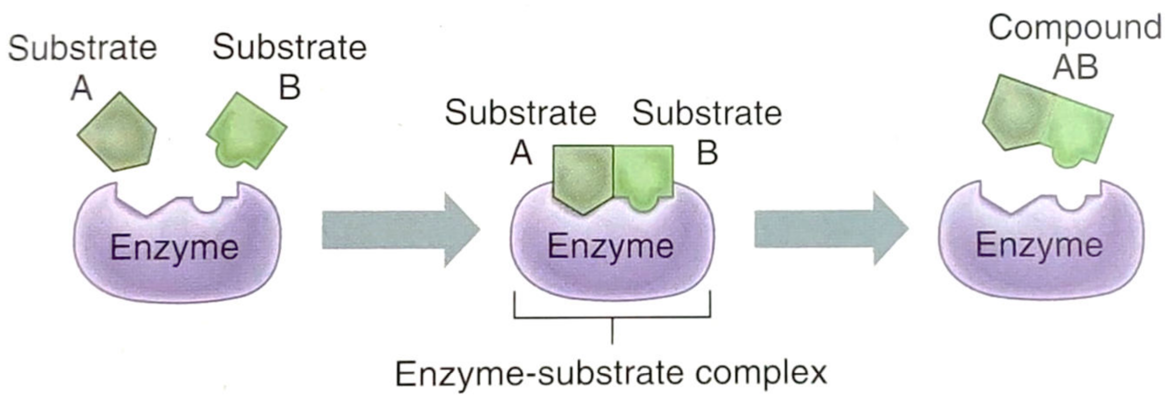
- Two linked amino acids form dipeptide
- Three , a tripeptide
- Fewer than 100 amino acids are oligopeptides
- Those with 100 or more amino acids are polypeptides



Denaturation: a dramatic change in structure that destroys a protein's function.

- Radiation, both ionizing (X-rays , gamma rays) and UV, causes protein denaturation. Radiation provides energy that disrupts hydrogen bonds , ionic interactions , splits water molecules.

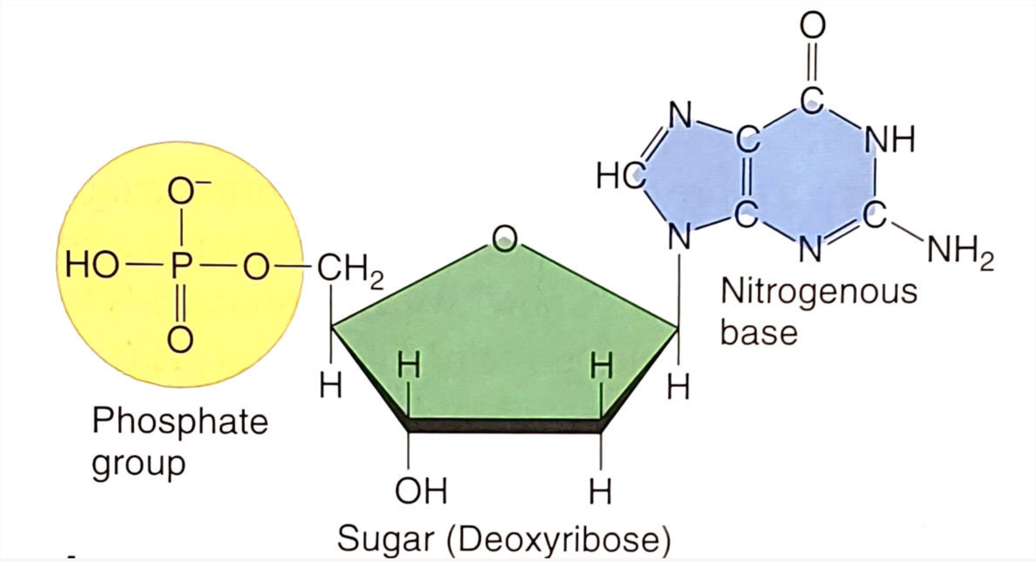
Enzymes : are proteins that speed the rates of specific chemical reactions without being consumed in the process, a phenomenon called catalysis

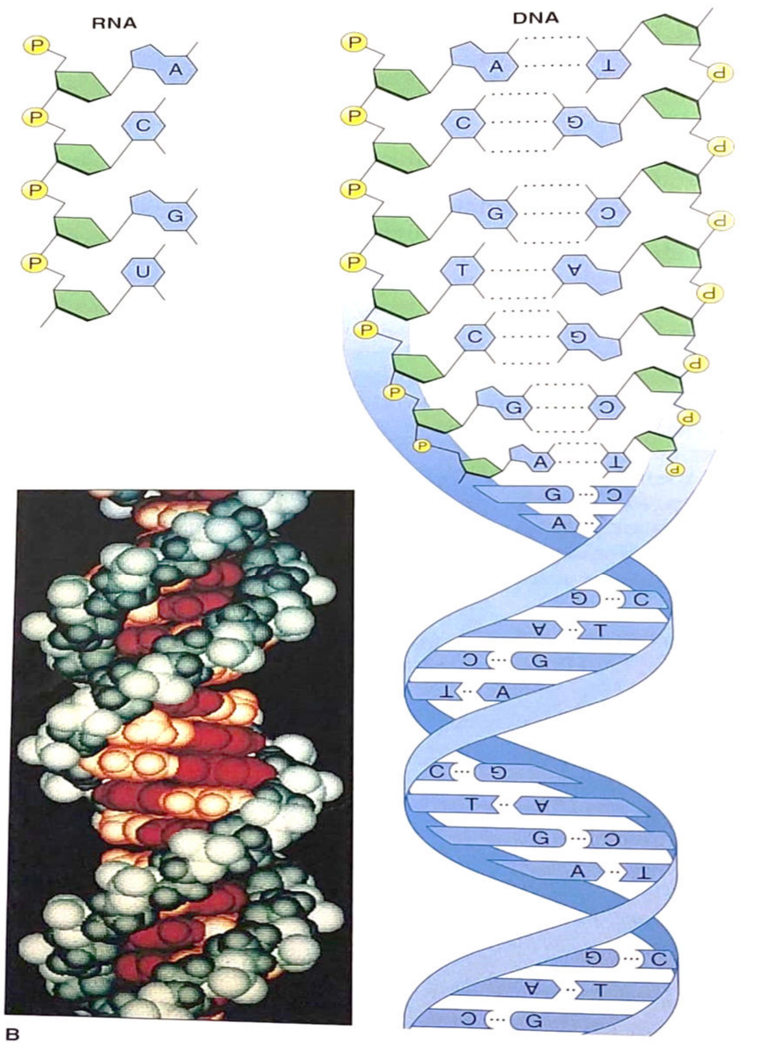


Enzyme Action. In this highly schematic depiction, substrate molecules A and B fit into the active site of an enzyme. An enzyme-substrate complex forms as the active site moves slightly to accommodate its occupants. A new compound, AB, is released, and the enzyme is reused. Enzyme-catalyzed reactions can break down as well as build up substrate molecules.

Nucleic acids :
are the carriers of the genetic blueprint.

Two types of nucleic acids:
1. Deoxyribonucleic acid(DNA)
2. Ribonucleic acid (RNA)
- Both are polymers called nucleotides
- A nucleotide consist of a five-carbon sugar (deoxyribose in DNA and ribose in RNA)
- To this sugar are added one or more phosphate groups (PO4) and one of five types of nitrogen - containing compounds called nitrogenous bases. Adenine(A) ,Guanine(G), Thymine(T), Cytosine(C) , Uracil(U) form all nucleic acid.
- Both DNA ,and RNA use A , C , and G, but T is found only in DNA,and U is unique to RNA.
- DNA is a double helix resembling a spiral staircase, with alternating sugars and phosphates forming the rails and nitrogenous bases forming the rungs.





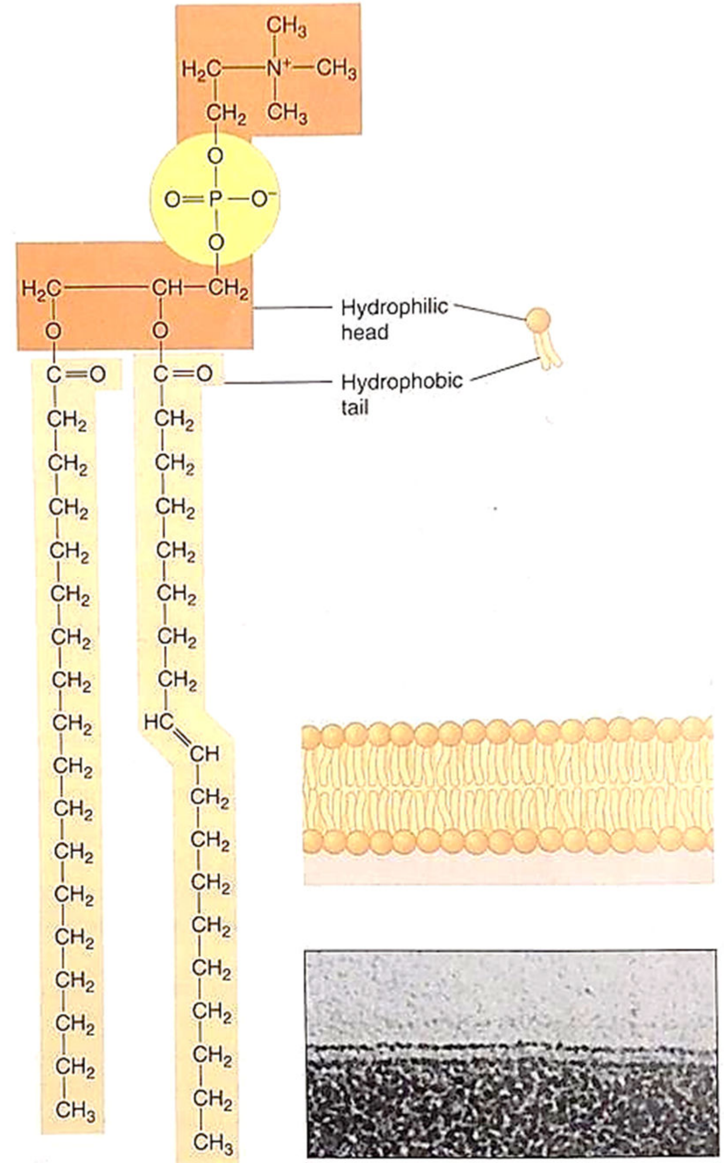
Nucleic acids—nucleotides joined together in long chains to form DNA or RNA. DNA is composed of the nucleotides A, C, T and G. RNA contain: the sugar ribose and the nucleotide U instead of T.

Cell membrane (also called plasma membrane)

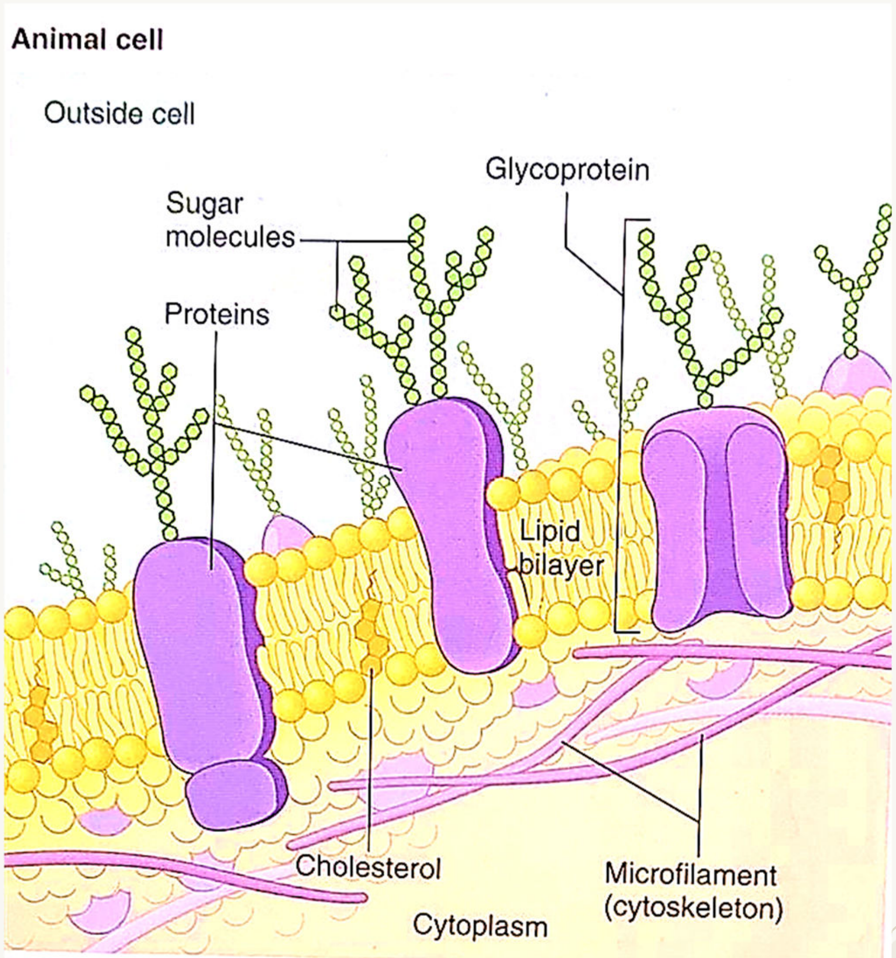
is a phospholipid bilayer that responsible for the cell morphology, movement and transport of ions and molecules. Cell membrane is a semi-permeable or selectively permeable membrane.

- The phosphate end of a phospholipid molecule is hydrophilic and readily associated with water(water-loving).
- The other end, consisting of two fatty acid chains, is hydrophobic and ovoids water(water-fearing).
- In this two-bilayer, sandwich-like structure, the hydrophilic surfaces are on the outsides of the sandwich, exposed to the watery medium outside and inside the cell.

- The hydrophobic surfaces face each other on the inside of the membrane(sandwich),away from water

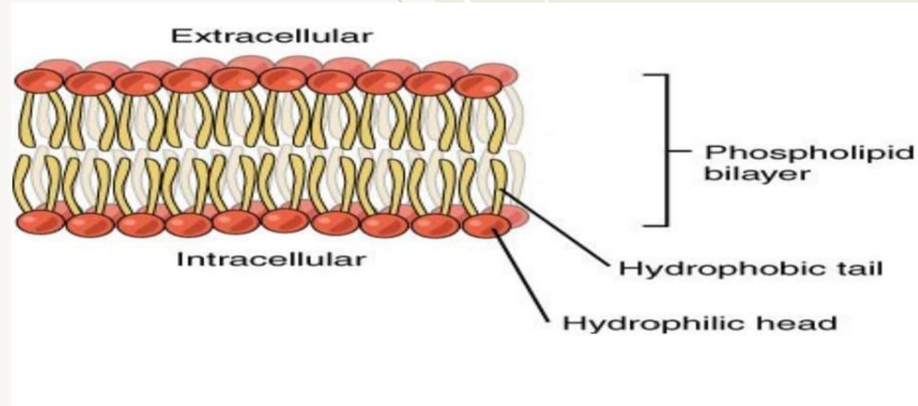


- Anything with a charge cannot cross the hydrophobic interior but can coat the outer surfaces of the bilayer.
- The cell needs to have mechanism to cross this barrier.



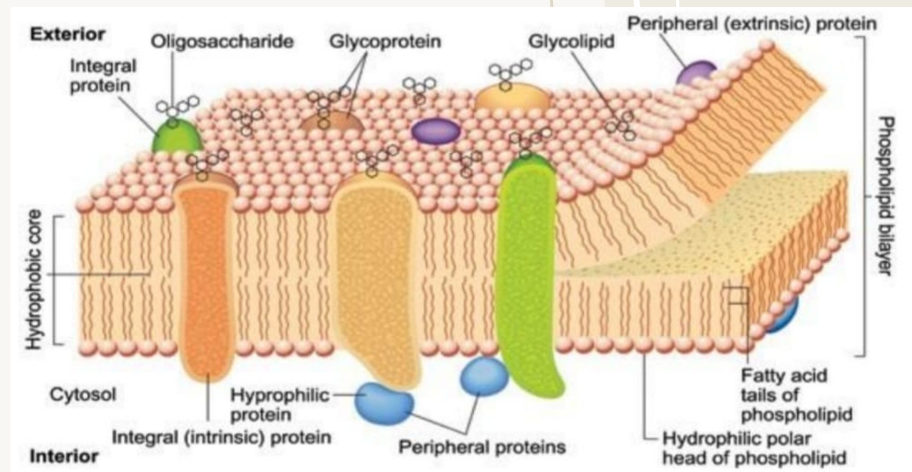
Cell membrane proteins:

- Most of the cell membrane are glycoproteins.
- Two types of protein occur:
- Integral proteins: are embedded in the phospholipid bilayer create passageways through which water-soluble molecules and ions pass.
- Protein within the oily phospholipid bilayer can move laterally within the layer. Because of this movement, the protein-phospholipid bilayer is called a fluid mosaic.
- Peripheral proteins: are attached only to one surface of the membranes. Their functions almost entirely as enzymes or as controllers of transport of substances through the cell membrane pores.



Lipid barrier of the cell membrane:

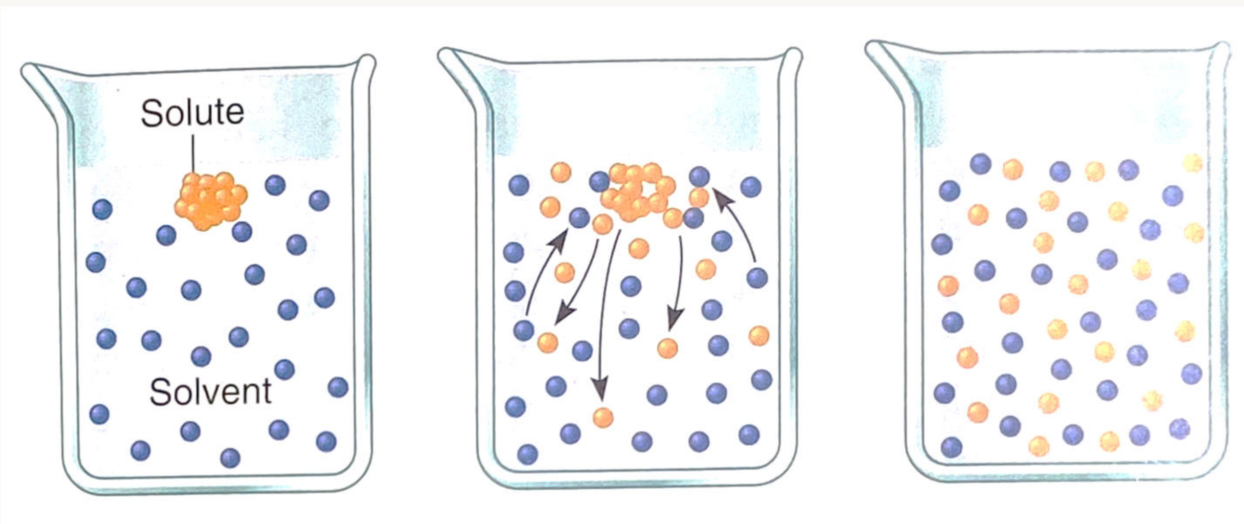
- The lipid layer in middle of the membrane is impermeable to the usual water solute substances, such as ions, glucose, and urea.
- Conversely, fat-soluble substances, such oxygen, carbon dioxide, and alcohol, can penetrate this portion of the membrane with ease.
- Cholesterol molecules are dissolved in the bilayer of the membrane. It controls much of the fluidity of the membrane.



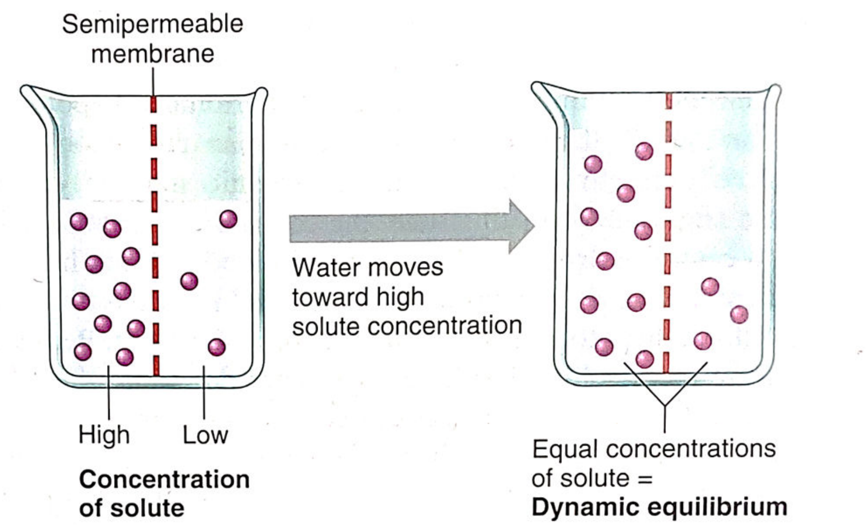
Mechanism of transport:

1.**Passive transport:**

- Diffusion: is the movement of a solute towards regions of lower concentration in an attempt to equalize the concentration.
- Cell membrane is selectively permeable, that is, some molecules can pass freely through the membrane, while others cannot.
  Example:
  Oxygen(O2) , Carbon dioxide(CO2) , and water(H2O) freely cross cell and other biological membranes. They do so by diffusion without using energy.



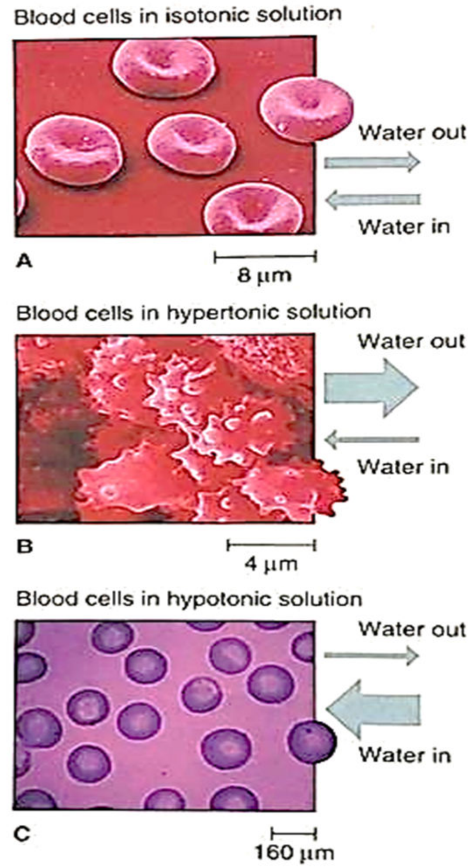
- Osmosis: is the movement of water across biological membranes by simple diffusion.
- Because cells are constantly exposed to water, they must regulate water entry.
- If water enters ,a cell swells; if too much leaves, it shrinks.



Osmosis. An artificial membrane dividing a beaker demonstrates osmosis by permitting water to pass from one chamber to another, but preventing large solute molecules from doing the same. Water will flow from an area of low salt (solute) concentration toward an area of high salt concentration. Eventually, the volume on each side of the membrane will be different, but the final concentrations (amount of solute per unit of volume) will be the same. Dynamic equilibrium is reached when there is no net tendency for water to flow in either direction.

- Tonicity refers to the differences in solute concentration in two compartments separated by a semipermeable membrane.
- Solutions are classified based on tonicity into:

  1. Isotonic
  2. Hypotonic
  3. Hypertonic



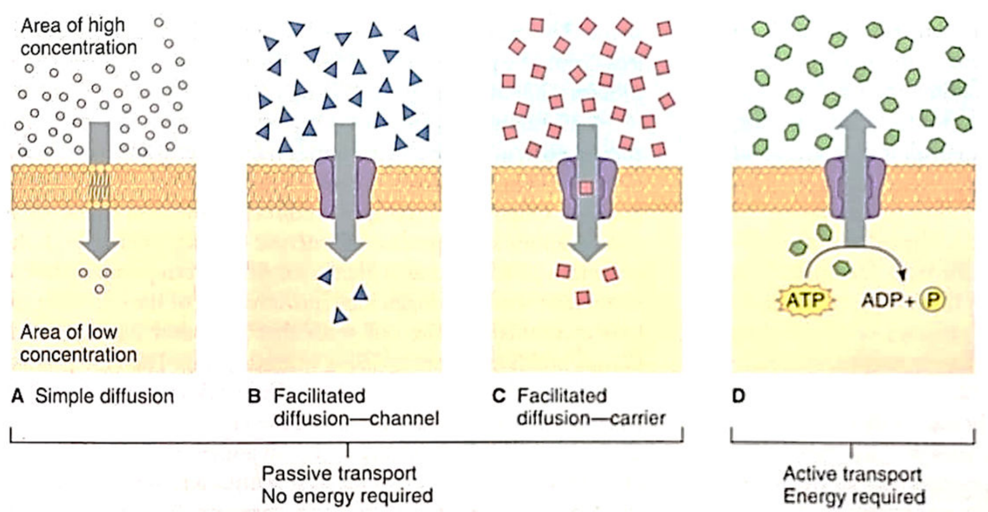
Diffusion Affects Cell Shape. A red blood cell changes shape in response to changing plasma solute concentrations. **(A)** A human red blood cell is normally isotonic to the surrounding plasma. When water enters and leaves the cell at the same rate, the cell maintains its shape. **(B)** When the salt concentration of the plasma increases, water leaves the cells to dilute the outside solute faster than water enters the cell. The cell shrinks. **(C)** When the salt concentration of the plasma decreases relative to the salt concentration inside the cell, water flows into the cell faster than it leaves. The cell swells and may even burst.

Passive transport : No energy required

A. Simple diffusion: molecules move down their concentration gradients by themselves by squeezing through the membrane components.
B. Channel transport protein forms an opening like simple tube through which a solute passes. Transport through a channel protein is fast-100 million ions or molecules a second may enter or exit the cell. It is a form of facilitated diffusion.
C. Carriers protein binds a specific ion or molecule ,which contorts the protein in a way that moves the cargo to the other face of the membrane, where it exits. It is another form of facilitated diffusion.

Active transport : Energy required

- Active transport uses energy to enable a cell to admit a substance that is more concentrated inside than outside.
- Energy for active transport often comes from adenosine triphosphate (ATP)



Transport Moves Substances. Simple diffusion, facilitated diffusion, and active transport move ions and molecules across cell membranes. In passive transport, molecules move down their concentration gradients by themselves by squeezing through the membrane components (**A**), through a channel protein (**B**), or aboard a carrier protein (**C**), without direct energy input. In active transport (**D**), a molecule or ion crosses a membrane against its concentration gradient, using energy and carrier proteins that function as pumps.

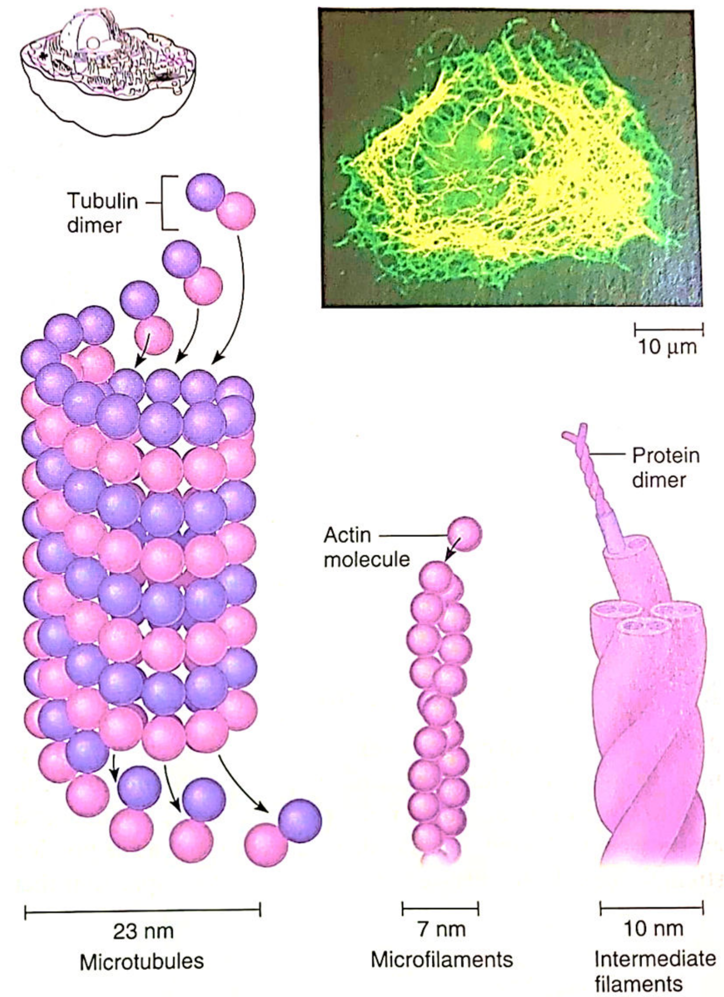
Cytoskeleton :
is a framework of protein rods and tubules that form the structures of eukaryotic cells.

- The cytoskeleton includes three major types of elements:
    1. Microtubules
    2. Microfilaments
    3. Intermediate filaments

They are distinguished by protein type, diameter, and how they aggregate into larger structures.

Microtubules :

- All eukaryotic cells contain long, hollow microtubules that provide movement for the cell, both internally and externally.
- A microtubules is composed of pairs(dimers) of a protein, called tubulin, collected into a hollow tube. The cell can change the length of the tubule rapidly by adding or removing tubulin molecules.



The Cytoskeleton Is Made of Protein Rods and Tubules. The three major components of the cytoskeleton are microtubules, microfilaments, and intermediate filaments. Through special staining, the cytoskeleton in this cell glows yellow under the microscope.

- Microtubules also form locomotor organelles, which move or enable cells to move. The two types are:
  A. Cilia
  B. Flagella

A

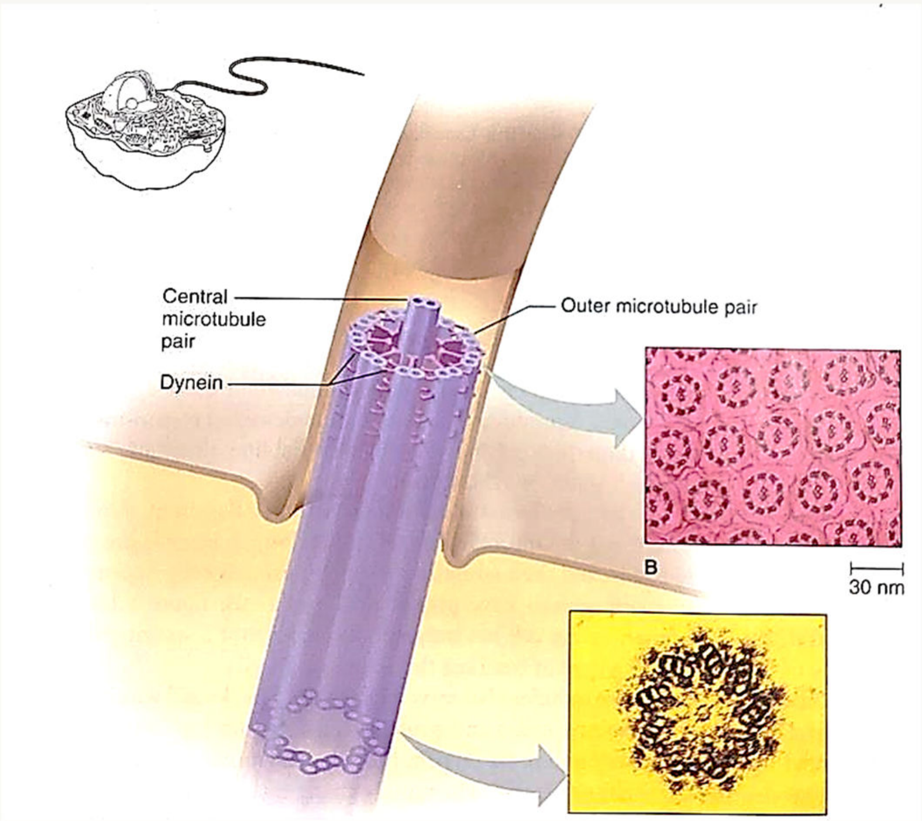
4 µm

B

8 µm

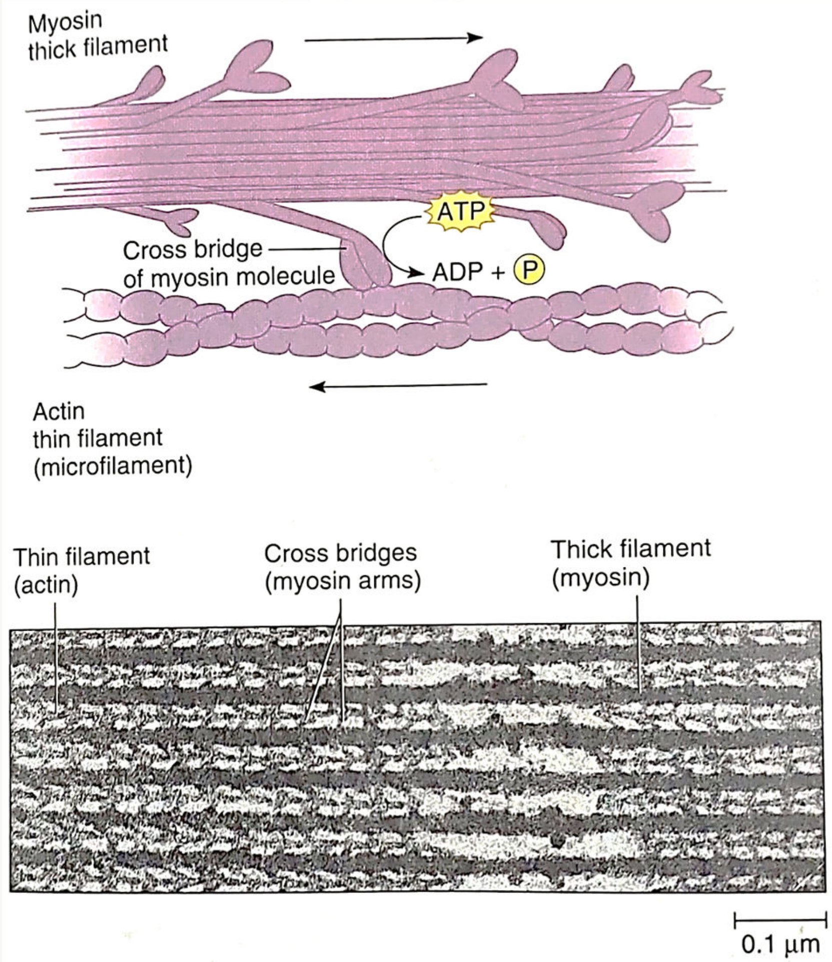
Cilia and Flagella. The cilia in (**A**) line the human respiratory tract, where their coordinated movements propel dust particles upward so the person can expel them. The flagella on human sperm cells (**B**) enable them to swim.

- Cillia :are hairlike and move coordinately, producing a wavelike motion along the cell.
  Cilium is constructed of nine microtubule pairs that surround a central separated pair and form a pattern described as 9+ 2.
  Dynein is a type of motor protein connects microtubule pairs and links them to the central pair, like a wheel.



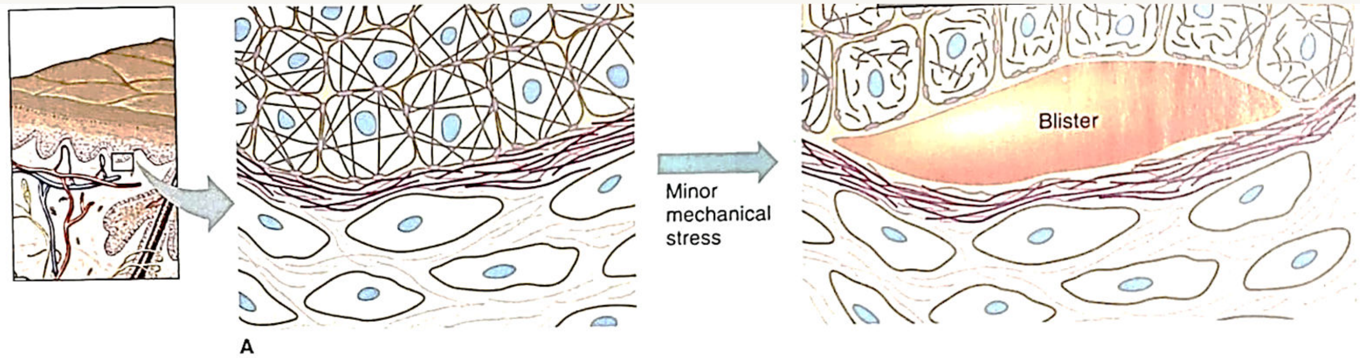
- Flagella :are also built of a 9+2 microtubules pattern, are much longer than cilia. They are like tails, and their whiplike movement propel cells. Example sperm cells.

Microfilaments :are long, thin rods composed of the protein actin. They are not hallow as microtubules. They provide strength for cells and help to anchor one cell to another. Myosin is an actin-binding proteins, which uses energy from ATP to move actin filaments.

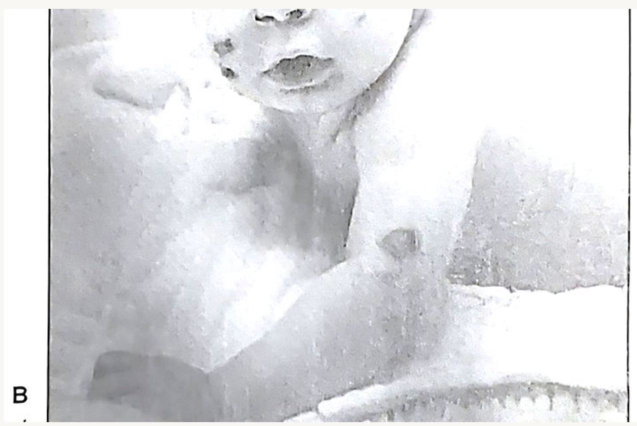


Muscle Acts by Protein Interactions. Actin microfilaments are interspersed with thicker myosin filaments in muscle tissue. The binding of myosin to actin, followed by a change in the shape of myosin, provides the force behind muscle movement.

Intermediate filaments: with diameters of 10 nanometers ,are intermediate between microtubules(23 nm),and microfilaments(7 nm), hence the name.
They are made of different proteins. They are abundant in skin cells and nerve cells, and form scaffold in the cytoplasm and resist mechanical stress. Intermediate filaments form a strong inner framework in actively dividing skin cells in the bottommost layer of the epidermis



Intermediate Filaments in Skin. (A) Keratin intermediate filaments internally support cells in the basal (bottom) layer of the epidermis. (B) Abnormal intermediate filaments in the skin cause epidermolysis bullosa, a disease characterized by easily blistered skin.



Protoplasm: is the entire living substance of cell (Cytoplasm + Nucleus).

Cytoplasm: is everything inside the cell membrane except the nucleus (Cytosol + Organelles)

Cytosol: is the fluid portion of the cytoplasm. It also known as cytoplasmic matrix.

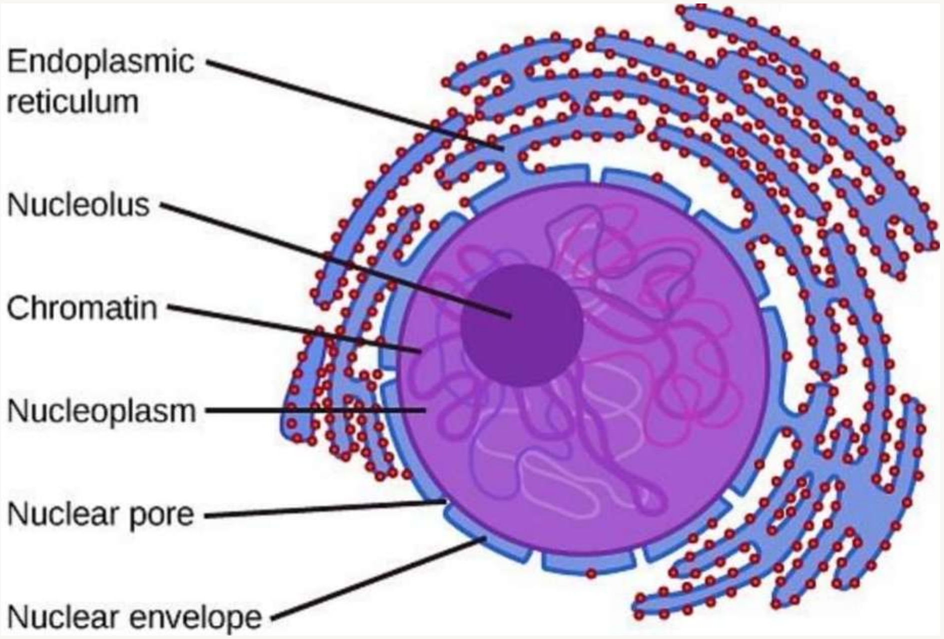
- It is a complex mixture of substance dissolved in water.
- Most of the cytosol is water.
- It contains dissolved ions such as sodium and potassium higher amounts of molecules such as sugars, proteins, and nucleic acids

Nucleus:

- is the most prominent organelle and the control centre of eukaryotic cell.
- The nucleus is bounded a double membrane called nuclear envelope separated by a narrow space and perforated with pores, that regulate the passage of molecules like proteins and RNA into and out of the nucleus.
- Nuclear envelope is connected with ER.
- Nucleus contains chromosomes which consist of the complex of DNA and proteins (histones).

- **Nucleoplasm:** is the jelly-like substance inside the nuclear membrane, containing chromatin and the nucleolus. It is similar to cytoplasm in the cell
  - Nucleoplasm is composed of water and dissolved salts, enzymes and organic molecules.

- **Nucleolus:** is a dark area for rRNA synthesis and ribosome assembly.
  - Nucleolus is made of proteins, DNA and RNA

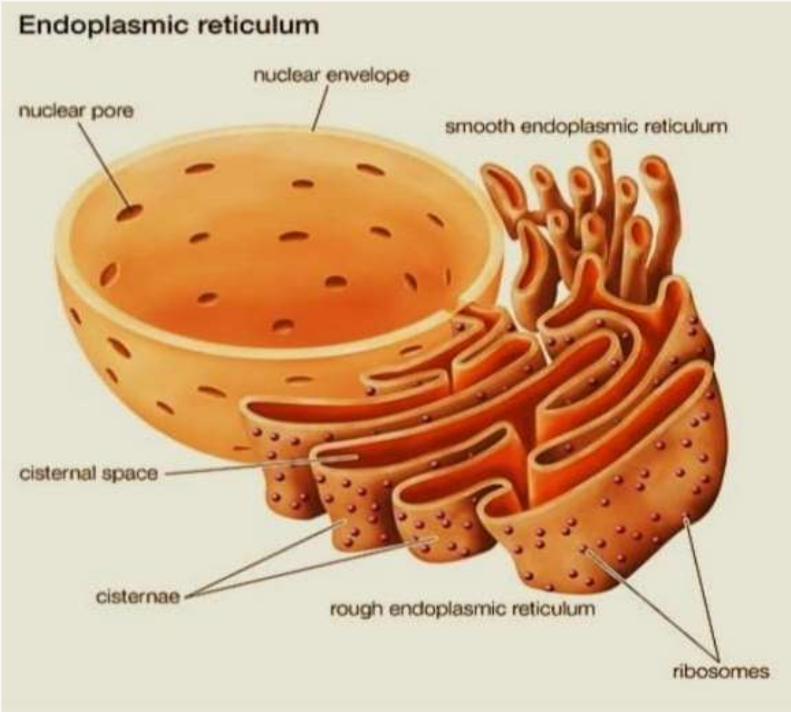


- **Endoplasmic reticulum:** is a system of tubules and vesicles within the cytoplasm. It plays a major role in the production, processing, and transport of proteins and lipids.
  - There are two types of ER
    1. Rough ER: has ribosomes for protein synthesis.
    2. Smooth ER: lacks attached ribosomes, and function in lipid synthesis and calcium storage

Structure and location:

A continuous network of membranes extending throughout the cytoplasm, often connected to the outer membrane of the nucleus.

- composed of flattened sacs known as cisternae, connected to the outer nuclear membrane, enclosing a space called the ER lumen.



- In pancreatic cells, the rough ER produces insulin.
- In leukocytes. (WBC) the RER produces antibodies
- In muscles the smooth ER assists in the contraction of muscle cells.
- In liver cells the SER produces enzymes that help to detoxify certain compounds.
- In brain cells it synthesizes male and female hormones

Ribosomes :

are a complex molecular machine found within all living cells i.e. prokaryotic and eukaryotic cells

- They are the protein synthesizers of the cell
- In eukaryotic cells, ribosomes are either floating around the cytoplasm or attached to ER, while, in prokaryotic cells, they are found freely floating in the cytoplasm.
- Ribosome is largely made up of specialized RNA known as ribosomal RNA (rRNA) as well as dozens of distinct proteins.

- The ribosomal proteins and rRNAs are arranged into two distinct ribosomal pieces of different size, known as the large and small subunit of the ribosome.
- The unit of measurement is the Svedberg unit, used to describe the ribosomal subunits. This unit measures the rate of sedimentation in centrifugation rather than size.
- Eukaryotic have 80s ribosomes, and prokaryotic have 70s ribosomes.

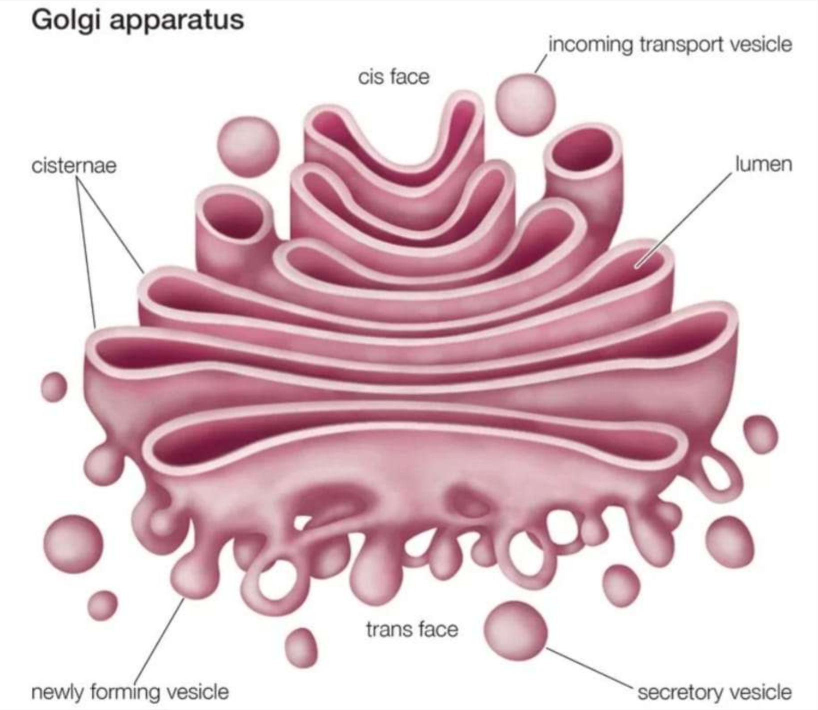
Functions:

- Protein synthesis
- Decoding mRNA
- Catalyzing peptide bonds

Golgi apparatus: is a stack of flat, membrane-enclosed sacs (cisternae) that functions as processing center

Structure:

1. Cisternae: Stacks of flattened, membrane-bound sacs.
2. Cis-face: The receiving side, facing ER, where vesicles fuse to deliver proteins and lipids.
3. Trans-face: The shipping side, where modified products are package into new vesicles for transport.



4. Golgi vesicles: Small, membrane bound sacs that bud off the trans face to carry cargo.

- Molecules synthesized in the ER exit via special transport vesicles, which carry their contents to the Golgi body. Once the molecules reach to the Golgi, vesicles are formed to ship materials to exterior of the cell or to another location.

Lysosomes:

- are single membrane-bounded cell organelle, spherical, contains hydrolytic enzymes responsible for break down proteins, fats and carbohydrates. Lysosomal enzymes also lyse captured bacteria, worn-out organelles, and debris.
- They are found in all types of eukaryotic cells. But RBC does not contain lysosomes.

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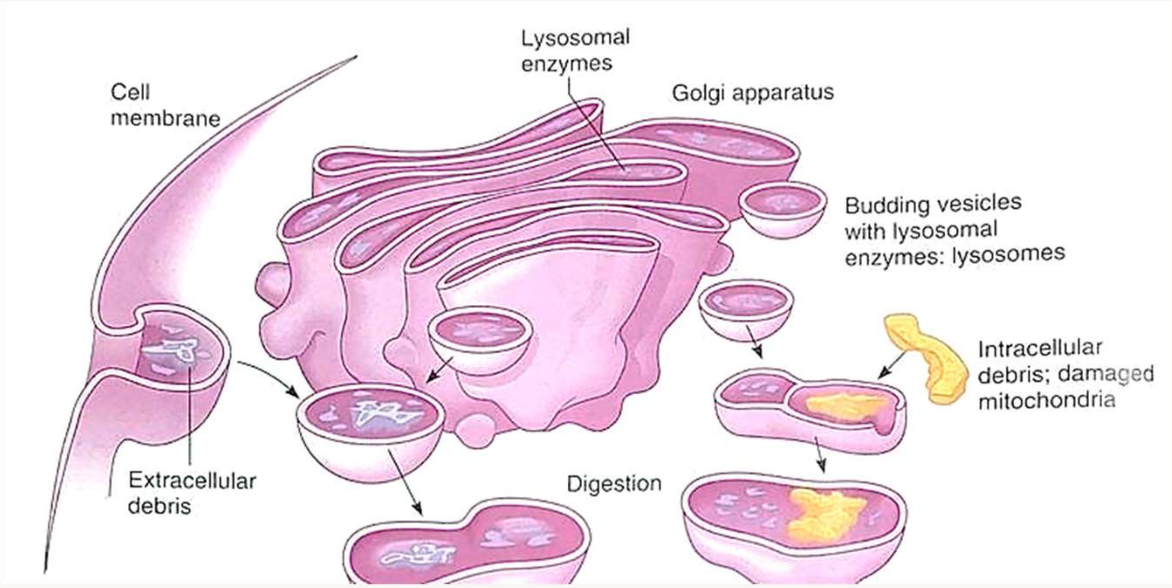
- In human cells, lysosomes contain more than 40 type of digestive enzymes, which synthesized in the RER.
- Lysosomal enzymes can function only in a very acidic environment. These enzymes are enclosed by membrane therefore; the rest of the cell is not damaged.
- White blood cells and liver cells have many lysosomes.
- In simplest form, lysosomes are dense spherical vacuoles . The outer surface is formed by a single membrane, a phospholipid bilayer that can fuse with some other membrane bound organelles.



Functions:

- Exocytosis - releases enzymes outside of the cell
- Autophagy - digestion of materials from inside the cell.
- Heterophagy - digestion of materials from outside the cell.
- Autolysis - completely breakdown cells that have died

Types of lysosomes:

They are of four types.

1. Primary lysosomes.
   They are formed from Golgi body, appearing as small vesicles.
2. Secondary lysosomes are formed by the fusion of the Primary lysosomes with phagosomes, pinosomes and endosomes. Compared to primary lysosomes, secondary are larger in size and releasing their enzymes outside the cells where degrade foreign materials.

3. Tertiary lysosomes

   also known telosomes or residual bodies. They contain undigested food which is expelled by exocytosis.

4. Autolysosomes

   also known as autophagosomes, formed by fusion of primary lysosome with organelles, which is old or damage and need to be digested.

Mitochondria

- Mitochondrion is a double membrane bound organelle found in all eukaryotic organisms.
- They are known as the power house of the cell.
- They are rod shaped.
- The number of mitochondria vary by organism's cells:

  For example: Red blood cells have no mitochondria

  Liver cells have about 1,700 mitochondria

  Muscle cells have loads of mitochondria (thousands)

  Neurons don't need many

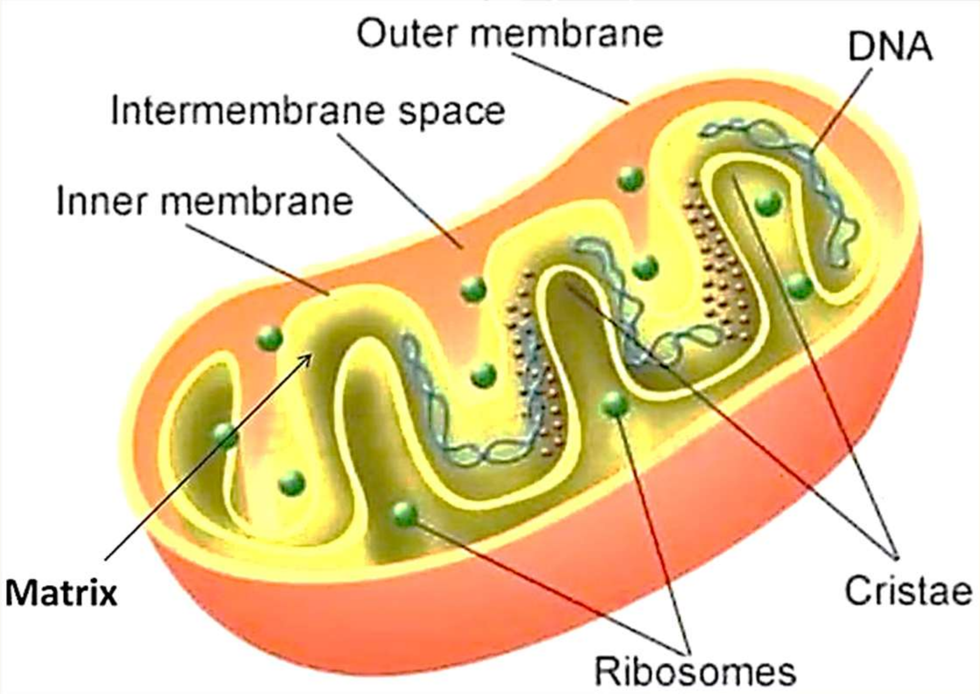
Structure:

- There are five distinct sections within the mitochondrion:
  1. The outer mitochondrial membrane encloses the entire organelle.
     - Made of phospholipid double layers and proteins called porins. These porins allow certain molecules to diffuse freely from one side of the membrane to the other.
     - It also contains various enzymes
  2. The intermembrane space
     - is the space between the outer and the inner membranes
     - the concentrations of small molecules, such as ions and sugars, in the intermembrane space is the same as in the cytoplasm.
  3. The inner mitochondrial membrane
     - has a very high protein to phospholipid ratio (more than 3:1 by weight)
     - It is rich in protein, about 1/5 of the total protein in a mitochondria
     - Also, it rich in a phospholipid called Cardiolipin

- It doesn't contain porins.
- It is highly impermeable to all molecules.
- Ions and molecules require special membrane carriers to enter or exit the inner membrane

4. The cristae
    - formed by infoldings of the inner membrane
    - contain enzymes that catalyze the biochemical reactions that acquire energy.
    - they contain their own genetic material
    - the inner mitochondrial membrane contains numerous compartments of cristae, which expand the surface area of the inner mitochondrial membrane, enhancing its ability to produce ATP.

5. Matrix
    - is the space enclosed by the inner membrane.
    - It is important in the production of ATP with the aid of ATP synthase enzyme.
    - It contains mixture of enzymes, ribosomes, tRNA and DNA
    - due to presence of DNA, it can manufacture their own RNAs and proteins.



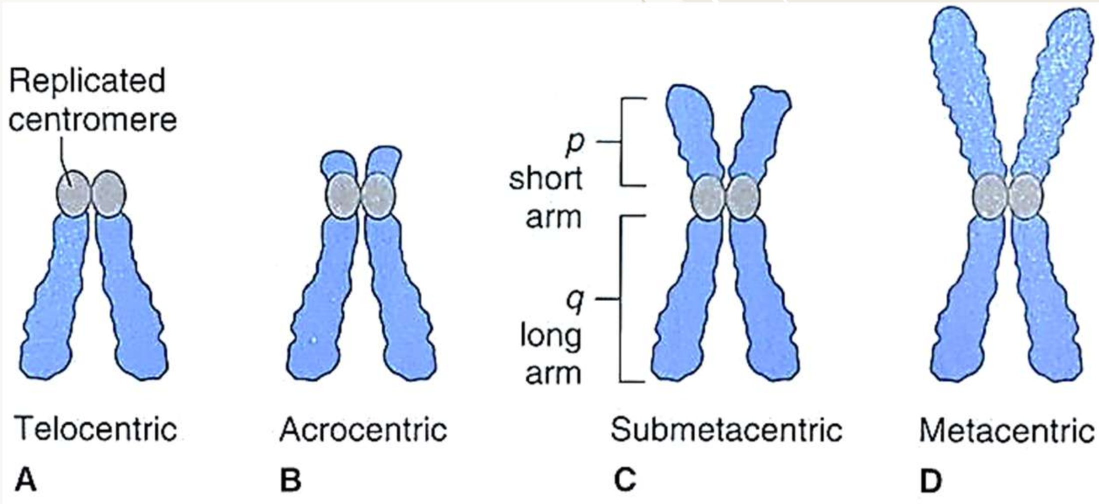
Functions

- Mitochondria are primary sites for ATP synthesis (site of Krebs cycle) from organic material so that known as powerhouse of the cell.
- Cell respiration
- Regulates the metabolic activity of the cell

Chromosome structure

- is a long, continuous piece of DNA, plus RNA and several types of associated proteins.
- humans have 46 chromosomes.
- Each chromosome is distinguished by size and centromere position.

  Types of chromosomes
- chromosomes are divided into parts p and q arms with a constriction point called centromere in the middle
- Centromere position is used to distinguish chromosomes therefore; there are four types of chromosomes:
  1. Telocentric: centromere is very close to one end, meaning no p arm exists (this type not found in humans).
  2. Acrocentric: centromere severely off set from center, leading to much shorter p arm
  3. Submetacentric: centromere establishes one long arm (q) and one short arm (p).
  4. Metacentric: centromere creates equal-sized arms.

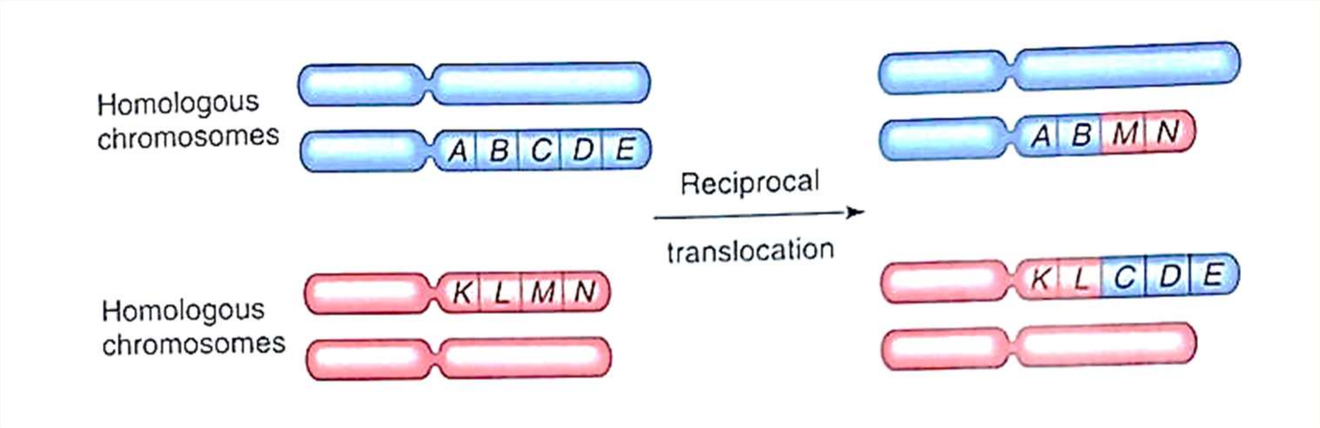


Centromere Position Is Used to Distinguish Chromosomes. (**A**) A telocentric chromosome has the centromere very close to one end. (**B**) An acrocentric chromosome has the centromere near an end. (**C**) A submetacentric chromosome's centromere creates a long arm (*q*) and a short arm (*p*). (**D**) A metacentric chromosome's centromere creates equal-sized arms.

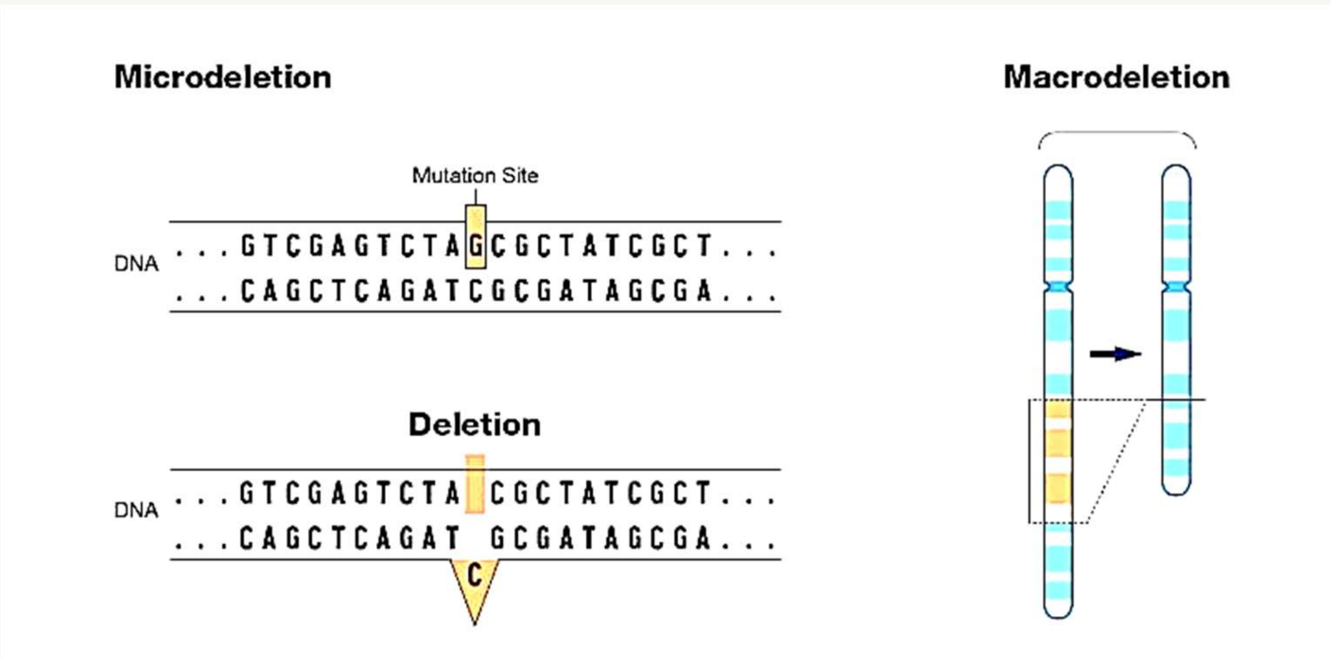
- Change that affect the structure of chromosomes can cause problems with growth, development, and function of the body's systems. These changes can affect many genes along the chromosome and disrupt the proteins made from those genes.

Changes in chromosome structure include the following:

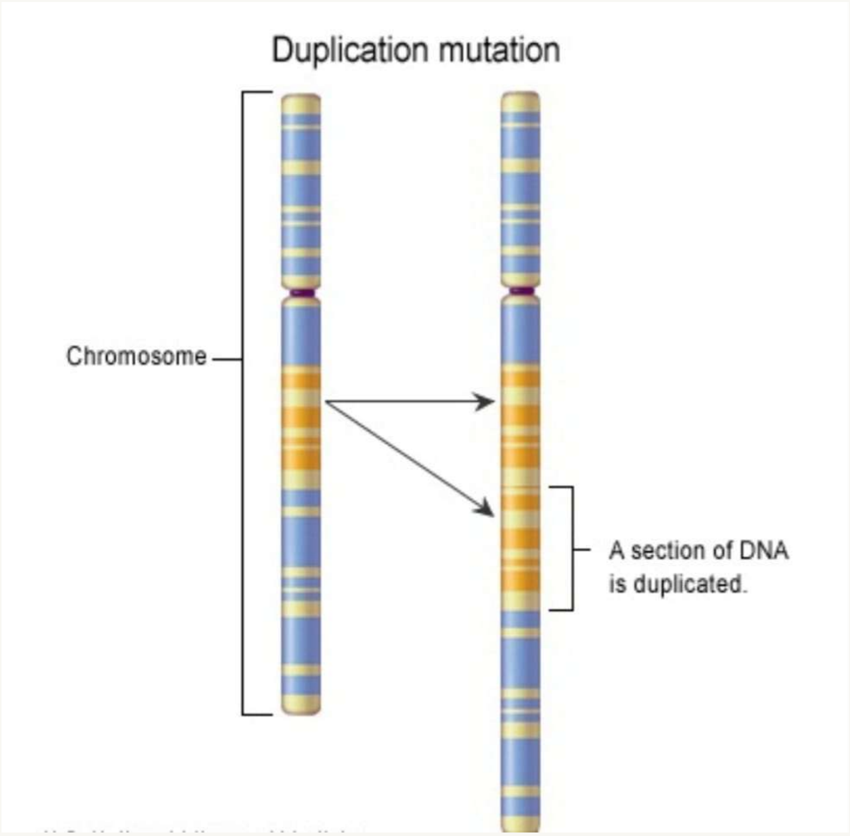
- Translocations:
  means a change in location, most commonly referring to a genetic event where chromosome segment breaks off and attaches to another chromosome, altering gene arrangement and sometimes causing diseases like cancer.



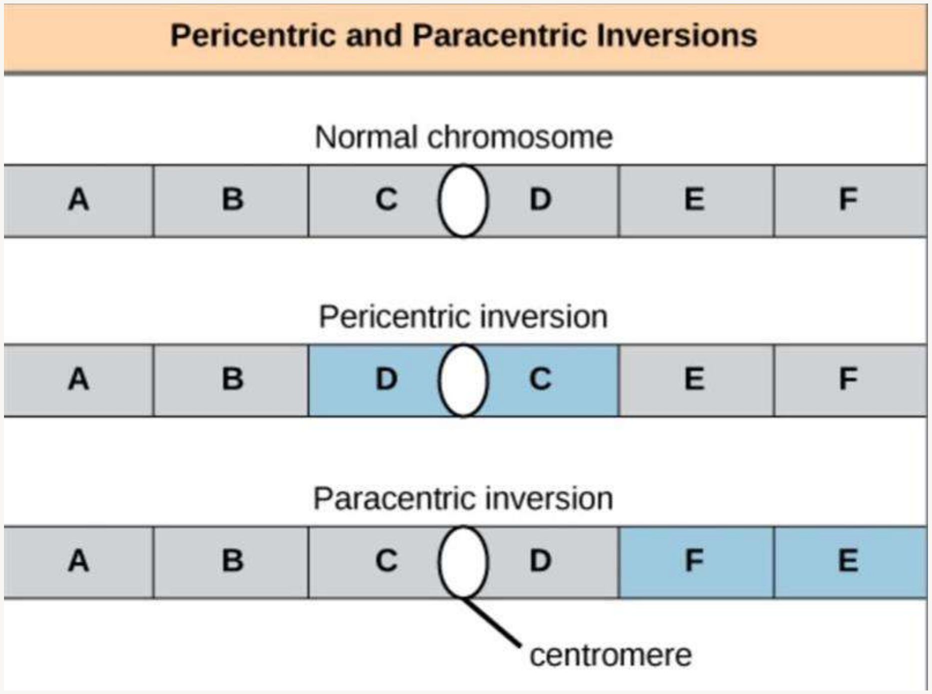
- Deletion:
  is a type of mutation where a segment of DNA, from a single base to an entire chromosome piece, is lost during replication
  - Radiation, viruses, or chemicals can induce breaks in chromosomes that lead to deletions.
  - Deletion can be small (microdeletion) or large (macrodeletion)

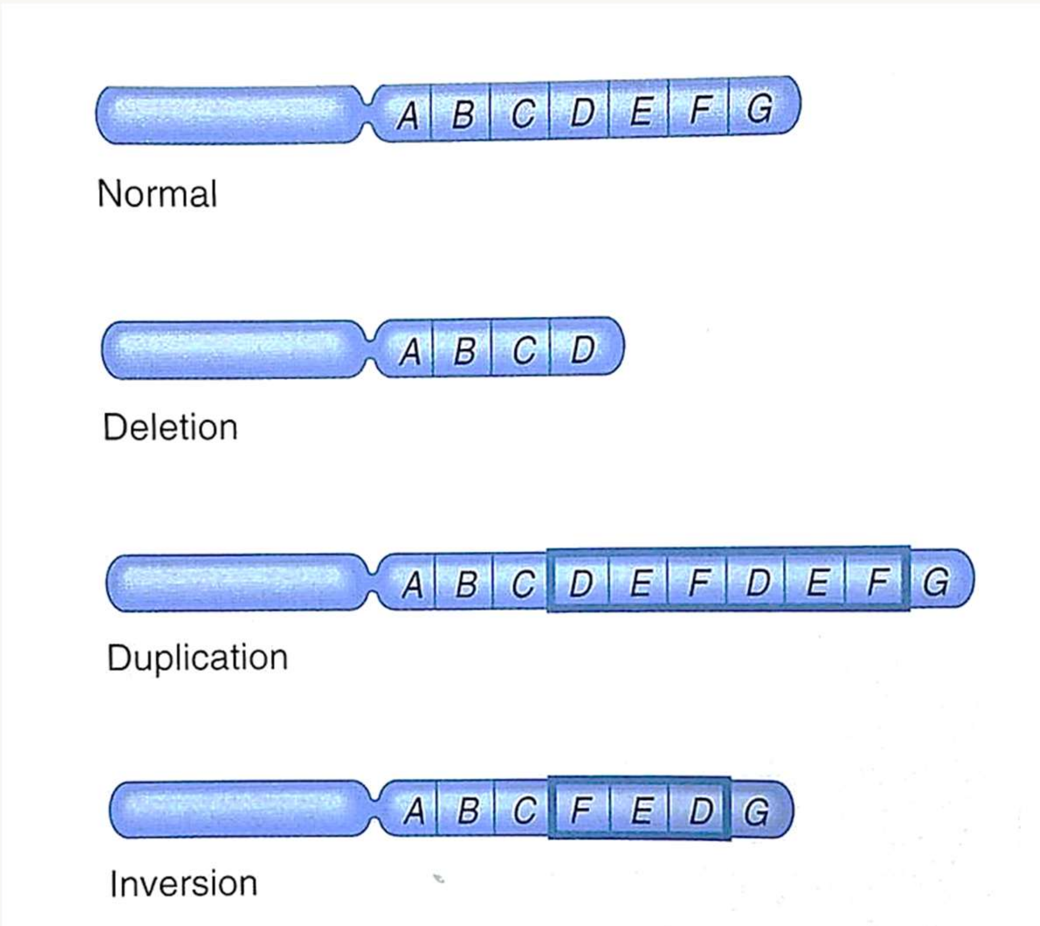


- Duplication:
  occurs when part of chromosome is abnormally duplicated (copied). It is a type of mutation.



- Inversion:
  part of the chromosome flips and reinserts, rearranging the gene sequence.
  - These inversions are classified as:
    1. Paracentric: breaks in one arm, centromere not included
    2. Pericentric: breaks in both arms, centromere included.




A B C D E F G
Normal
A B C D
Deletion
A B C D E F D E F G
Duplication
A B C F E D G
Inversion