محاضرات مادة الخلية النظري

المرحلة الأولى

قسم الكيمياء

للدراستين الصباحية والمسائية

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Lecture 1

Cell Biology

Introduction:-

Cells are the basic building blocks that build of all organisms. They are the smallest units of a living organism whether made of one cell like bacteria or many cells like human. Cell biology means studying the structure and function of cells. Cells that cannot be seen by naked eyes and we need use microscope. In general, cells grouped into two categories :- prokaryotic and eukaryotic cells. Prokaryotic cells involve bacteria . But eukaryotic cells involve both animal and plant cells .

In 1665, term —cell used for the first time by Robert Hooke when he observed boxlike structure of cork tissue by using a lens. Furthermore, in the 1670s, Van Leeuwenhoek discovered bacteria and protozoa. By the late 1830s, botanist Matthias Schleiden and zoologist Theodor Schwann were studying tissues and proposed the unified cell theory. The unified cell theory states that:- all living things are composed of one or more cells; the cell is the basic unit of life; and new cells arise from existing cells. Later, Rudolf Virchow had added important contributions to this theory .

Cell theory:-

1-The cell is the fundamental unit of structure and function in organisms .

2- All organisms are made up of one or more cells .

3- Cells arise from other cells through cellular division .

4- Cells carry genetic material passed to daughter cells during cellular division.

5- All cells are essentially the same in chemical composition .

Types of cells :-

All cells that exist on earth belong to one of two categories: prokaryotic and eukaryotic cells. Prokaryotic cells are unicellular cells consisting of a single cell for example bacteria. Eukaryotic cells are multicellular cells or have many cells for example human.

Prokaryotic cells

The word prokaryote comes from Greek (pro) means before and (karyote) means nucleus. Prokaryotic cells are smaller and more simple than eukaryotic cells such as bacteria and cyanobacteria (blue green algae). They do not have nucleus and instead they have free-genetic material (DNA) floating in the area of the cytoplasm called nucleoid. They also lack the intracellular organelles .

Eukaryotic cells

The word eukaryote comes from Greek (eu) means true and (karyote) means nucleus. Eukaryotic cells have complex cells and the genetic material (DNA) located in the nucleus. They have the intracellular organelles. Cells of human, animals, plants, fungi and Protists are example of eukaryotic cells.

Prokaryotic and eukaryotic cells share some common features, including the following :-

1- DNA:- Genetic coding that determines all the characteristics of living things .

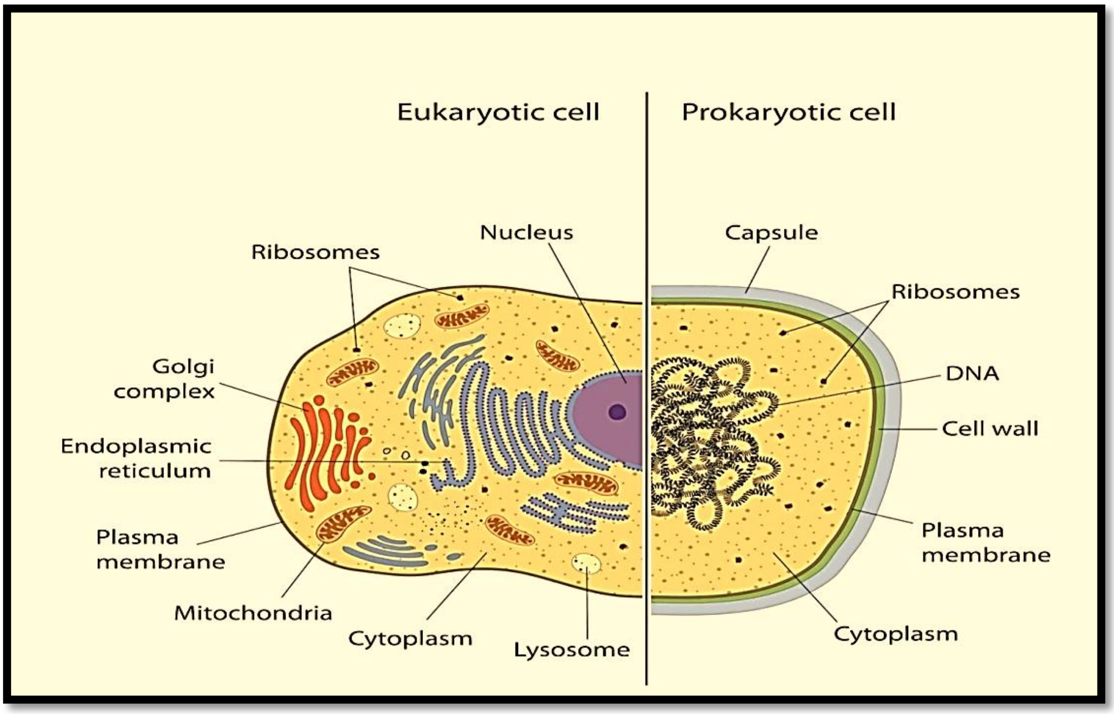
2- Cell (or plasma) membrane:- Outer layer that separates the cell from the surrounding environment and acts as a selective barrier for incoming and outgoing materials .

3- Cytoplasm:- Jelly-like fluid within a cell that is composed primarily of water, salts and proteins .

4- Ribosomes :- Organelles that make proteins.

<u>Following are the substantial difference between Prokaryotic Cells and Eukaryotic Cell:-</u>

Characteristics	**Prokaryotic cells**	**Eukaryotic cells**
Organisms	Bacteria and cyanobacteria (blue green algae)	Human, animal, plant, fungi and protists
Organization	Unicellular	Multicellular
Cell size	Small (0.1 – 10 µm)	Larger (10-100 µm)
Membrane – bound organelles	Absent	Present
DNA	Circular located in the nucleoid	Linear located in the nucleus
Ribosomes	70S	80S



Lecture 2

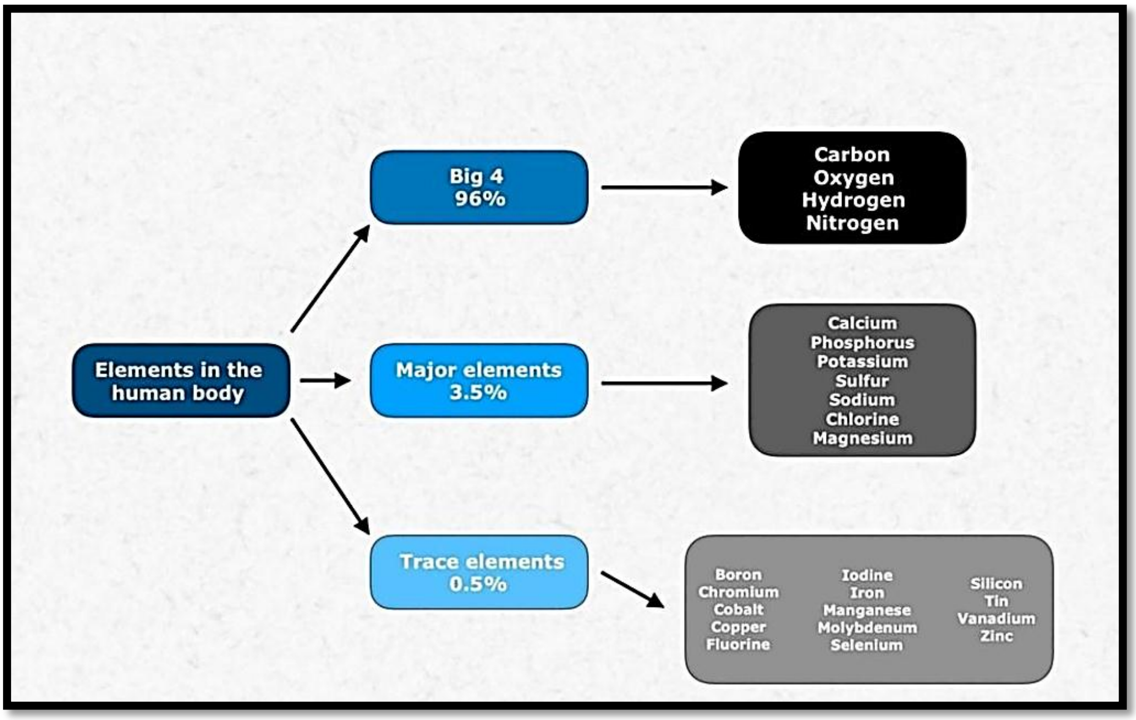
Chemical composition of Cell

All living organisms, prokaryotic and eukaryotic cells, are composed of chemical substances. Elements are the basic or pure chemical substances that cannot be broken down into other substances by chemical means. For example, Carbon, oxygen, hydrogen, nitrogen, sulfur, calcium, sodium and iron and they perform the same general tasks. About 25 elements are essential to life and these elements are divided into three groups depending on the amount needed :-

1- 4 of these elements—oxygen (O), carbon (C), hydrogen (H), and nitrogen (N)- make up about 96% and called **big elements** .

2- Calcium (Ca), phosphorus (P), potassium (K), sulfur (S), sodium (Na), chlorine (Cl) and magnesium (Mg) make up about 3.5% and called **major elements** .

3- 14 elements such as copper (Cu), iodine (I), iron (Fe), zinc (Zn) and a few other elements make up about 0.5% and called **trace elements**.



Two or more elements are covalently bonded to form Molecules. Molecules are divided into organic and inorganic compounds:-

1- Organic compounds always contain carbon such as carbohydrates, fats, proteins and nucleic acids.

2- Inorganic compounds not contain carbon such as water and ions (salts, acids and bases).

Water

Water accounts for approximately 70% of the mass of a cell. Water plays an important role in the maintenance of biological systems.

Functions of water:-

1- Temperature regulation:- in humans, the sweat glands produce sweat which cools the body as it evaporates from the body surface in a process called perspiration. In a similar way, plants are cooled by the loss of water vapour from their leaves, in a process called transpiration .

2- **Form and support**: water is an important constituent of the body and plays an important role in providing form and support in animals and plants. Animals such as worms and jellyfish, use water in special chambers in their body to give their bodies support. This use of water pressure to provide body form, and enable movement is called a hydrostatic skeleton. Plants grow upright and keep their shape due to the pressure of water (turgor pressure) inside the cells .

3- Transport medium:- water transports substances around the body. For example water is the main constituent of blood and enables blood cells, hormones and dissolved gases, electrolytes and nutrients to be transported around the body .

4- Lubricating agent:- water is the main constituent of saliva which helps chewing and swallowing and also allows food to pass easily along the alimentary canal. Water is also the main constituent of tears which help keep the eyes lubricated .

5- Solvent for biological chemicals:- the liquid in which substances dissolve is called a solvent. Water is known as the universal solvent as more substances dissolve in water than in any other liquid .

6- Medium in which chemical reactions occur:- all chemical reactions in living organisms take place in water.

Protein

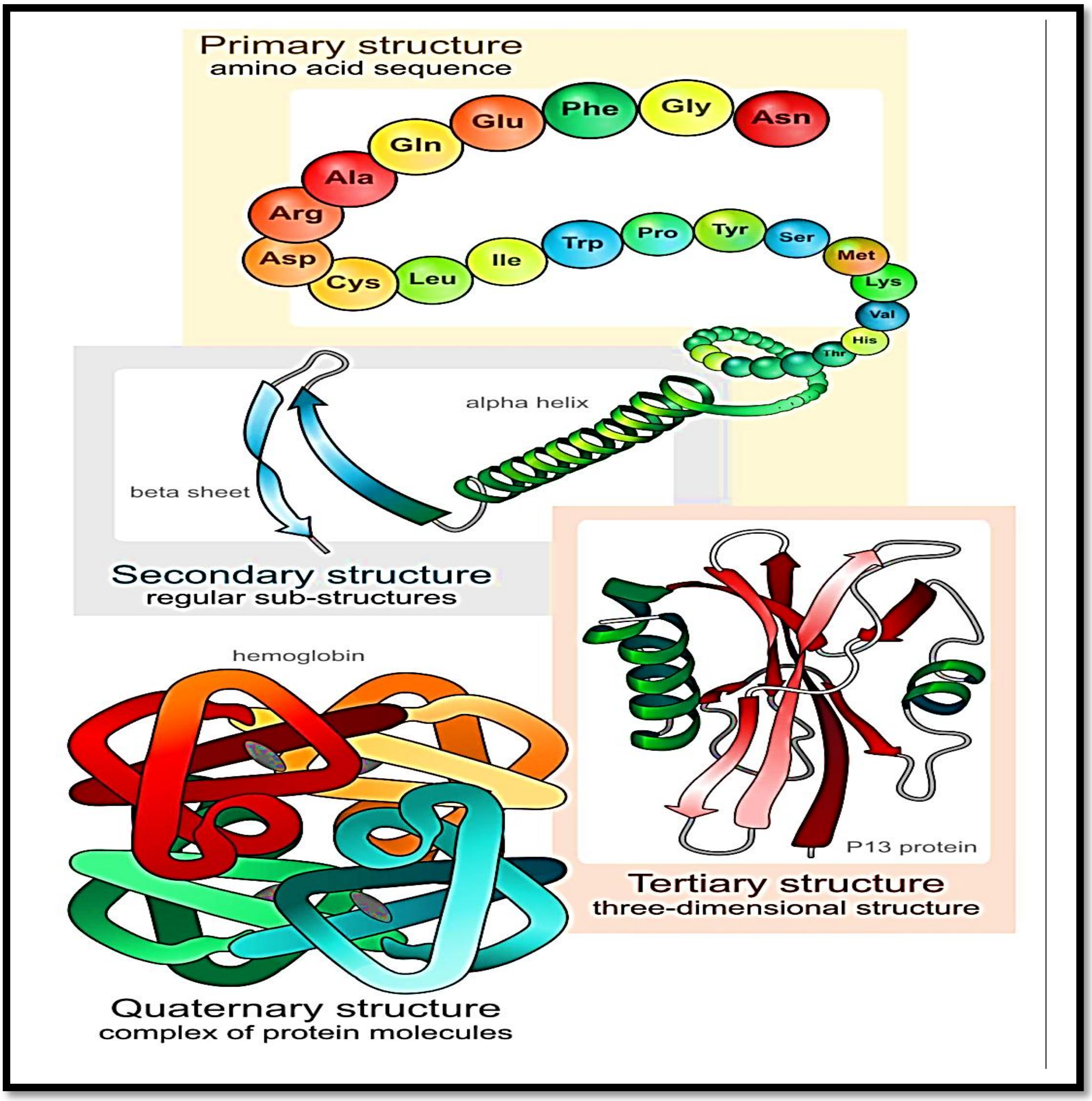
Proteins are made of amino acids. There are 20 common amino acids from which all proteins in living organisms are made. Nine of them are considered essential amino acids, as they cannot by synthesized in the body from other compounds, and must be obtained from the diet. Amino acids are bonded together by peptide bonds to form peptides. A long peptide chain forms a protein, which folds into a very specific three dimensional shape. This three-dimensional shape is completely determined by the identity and order of the amino acids in the peptide chain. We often refer to four different levels of protein structure :-

1- Primary structure:- This refers to the sequence of amino acids joined together by peptide bonds to form a polypeptide chain.

2- Secondary structure:- This is the first level of three dimensional folding. It is driven completely by hydrogen bonding .

3- Tertiary structure:- This is the second level of three dimensional folding and is the overall final shape of the protein molecule. The secondary structures and unstructured regions of the chain further fold into a globular shape, driven by hydrophobic interactions (non-polar regions trying to escape the water in the cell environment) and electrostatic interactions (polar and charged regions wanting to interact with the water environment and each other).

4- Quaternary structure:- Some proteins are complex: two or more peptide chains . fold into their tertiary structures, then these complete structures associate together by hydrophobic and electrostatic interactions to form the final protein.



Proteins are important in several crucial biological functions. Proteins are found in hair skin, bones, muscles, tendons, ligaments and other structures and perform key structural and mechanical functions. Proteins are also important in cell communication and in the immune system. Proteins can also act as an energy reserve when broken down through digestive processes. Certain proteins called enzymes are important in catalyzing cellular reactions that form part of metabolism Enzymes are biological molecules (typically proteins) that significantly speed up the rate of virtually all of the chemical reactions that take place within cells .

They are vital for life and serve a wide range of important functions in the, body such as aiding in digestion and metabolism .

Some enzymes help break large molecules into smaller pieces that are more easily absorbed by the body. Other enzymes help bind two molecules together to produce a new molecule. Enzymes are highly selective catalysts, meaning that each enzyme only speeds up a specific reaction .

Carbohydrates

Carbohydrates form about 2% of body mass. **structure of carbohydrates** :-

1-Carbohydrates are made up of monomers known as monosaccharides. The monosaccharide that makes up most carbohydrates is glucose. Other monosaccharides include fructose, galactose and deoxyribose.

2- These monomers can be joined together by glycosidic bonds. When two monosaccharides are chemically bonded together, they form disaccharides. An example of a disaccharide is sucrose (table sugar), which is made up of glucose and fructose. Other disaccharides include lactose, made up of glucose and galactose, and maltose, made up of two glucose molecules .

3- Several monosaccharides join together to form polysaccharides. Examples of polysaccharides include glycogen, starch and cellulose .

The main function of carbohydrates:- is as energy storage molecules and as substrates (starting material) for energy production. Carbohydrates are broken down by living organisms to release energy. Starch and glycogen are both storage polysaccharides and thus act as a store for energy in living organisms. Starch is a storage polysaccharide in plants and glycogen is the storage polysaccharide for animals. Cellulose is found in plant cell walls and helps gives plants strength .

Lipids

Triglycerides are one of the most common types of lipids. Triglyceride molecules are made up of glycerol and three fatty acids. The fatty acid tails are made up of many carbons joined together.

Functions of fatty acids are:-

1- Lipids are an important energy reserve. Triglyceride lipids are broken down to release glycerol and fatty acids .

2- Glycerol can be converted to glucose and used as a source of energy, however the majority of energy provided by lipids comes from the breakdown of the fatty acid chains .

3- Lipids are important for the digestion and transport of essential vitamins, help insulate body organs against shock and help to maintain body temperature.

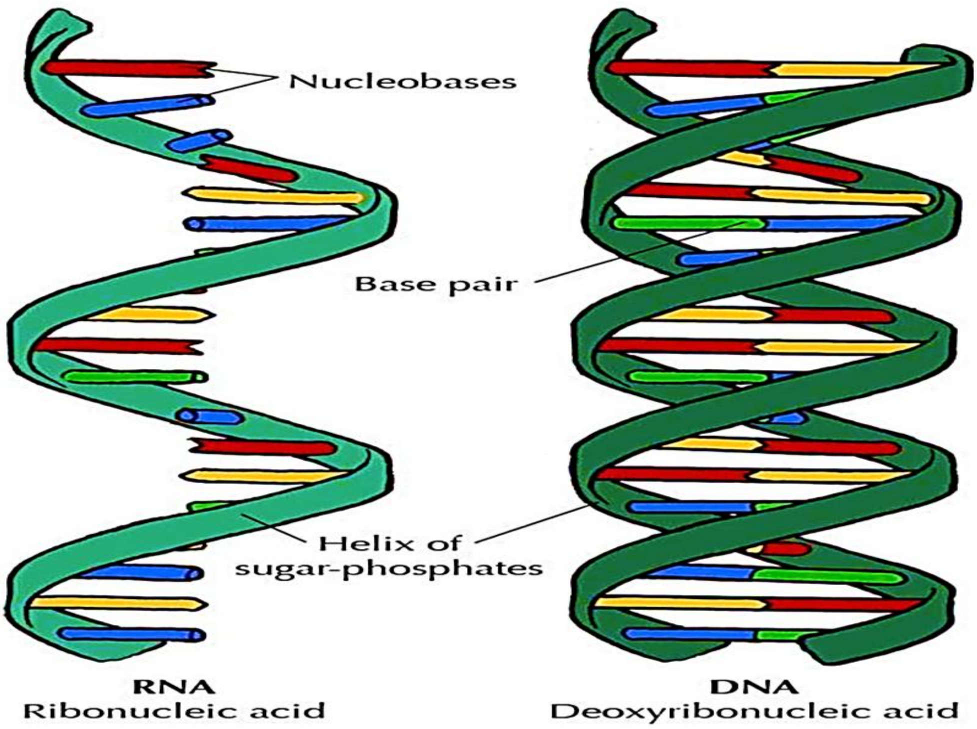
4- Lipids also play an important role in cell membranes .

Nucleic acids

Nucleic acids, such as DNA and RNA, are large organic molecules that are key to all living organisms. The building blocks of nucleic acids are called nucleotides. Each nucleotide is made up of a sugar, a phosphate and a nitrogenous base. Nucleotides are joined together by phosphodiester bonds,which join the phosphate of one nucleotide to the sugar of the next. The phosphate -sugar-phosphate-sugar strands form a" backbone" upon which the nitrogen-containing bases are exhibited. DNA is a double stranded polymer, due to hydrogen bonding between the nitrogenous bases of two compleme-ntary strands. RNA is a single-stranded polymer. Nucleic acids do not need to be obtained from the diet because they are synthesized using intermediate products of carbohydrate and amino acid metabolism . **Nucleic acids include:-**

- **Deoxyribonucleic acid (DNA)**:- which contains the 'instructions' for the synthesis of proteins in the form of genes. DNA is found in the nucleus of every cell, and is also present in smaller amounts inside mitochondria and chloroplasts .

- **Ribonucleic acid (RNA)**:- is important in transferring genetic information from DNA to form proteins. It is found on ribosomes, in the cytoplasm and in the nucleus .



Lecture 3

The cell membrane structure

The cell membrane

The cell membrane also known as the plasma membrane or cytoplasmic membrane. The cell's organelles and its intracellular solutes (some inorganic and some organic) are contained within the cell by its membrane. The membrane has limited and selective permeability; it maintains the intracellular concentration of electrolytes and biologic compounds that is distinctly different from that of the extracellular fluid. Cell membrane function is thus an essential one for the health and survival of the cell.

Historical view

1-The first insights into the chemical nature of the outer boundary layer of a cell were obtained by Ernst Overton of the University of Zürich during the 1890s. Overton knew that nonpolar solutes dissolved more readily in nonpolar solvents than in polar solvents, and that polar solutes had the opposite solubility.

2-The first proposal that cellular membranes might contain a lipid bilayer was made in 1925 by two Dutch scientists, E. Gorter and F. Grendel. These researchers extracted the lipid from human red blood cells and measured the amount of surface area the lipid would cover when spread over the surface of water. Since mature mammalian red blood cells lack both nuclei and cytoplasmic organelles, the plasma membrane is the only lipid-containing structure in the cell. Consequently, all of the lipids extracted from the cells can be assumed to have resided in the cells' plasma membranes .

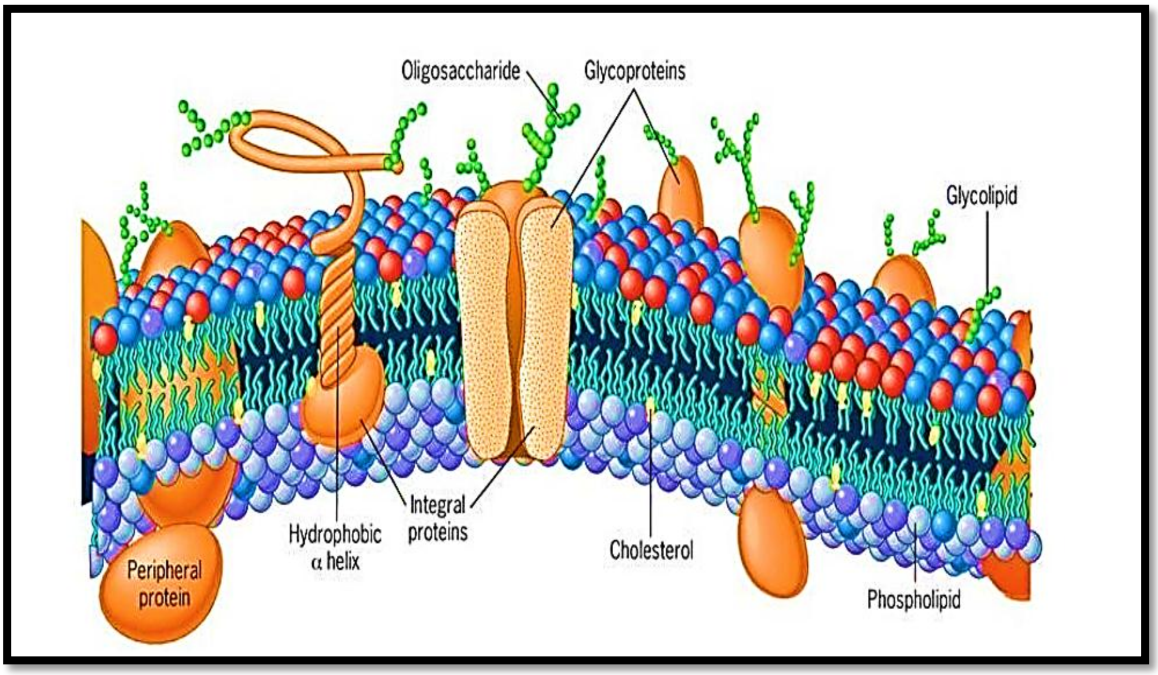
3- In the 1920s and 1930s, cell physiologists obtained evidence that there must be more to the structure of membranes than simply a lipid bilayer .

4-In 1935, Hugh Davson and James Danielli proposed that the plasma membrane was composed of a lipid bilayer that was lined on both its inner and outer surface by a layer of globular proteins. They revised their model in the early 1950s to account for the selective permeability of the membranes they had studied .

5- Experiments conducted in the late 1960s led to a new concept of membrane structure, as detailed in the fluid mosaic model proposed in 1972 by S. Jonathan Singer and Garth Nicolson of the University of California, San Diego.

The Chemical Composition of Membranes

Membranes are lipid–protein assemblies in which the components are held together in a thin sheet by noncovalent bonds. The lipid bilayer serves primarily as a structural backbone of the membrane and provides the barrier that prevents random movements of water-soluble materials into and out of the cell. The proteins of the membrane, on the other hand, carry out most of the specific functions. Each type of differentiated cell contains a unique complement of membrane proteins, which contributes to the specialized activities of that cell type. The ratio of lipid to protein in a membrane varies, depending on the type of cellular membrane (plasma vs. endoplasmic reticulum vs. Golgi), the type of organism (bacterium vs. plant vs. animal), and the type of cell (cartilage vs. muscle vs. liver). For example, the inner mitochondrial membrane has a very high ratio of protein/lipid in comparison to the red blood cell plasma membrane, which is high in comparison to the membranes of the myelin sheath that form a multilayered wrapping around a nerve cell. To a large degree, these differences can be correlated with the basic functions of these membranes. The inner mitochondrial membrane contains the protein carriers of the electron-transport chain, and relative to other membranes, lipid is diminished. In contrast, the myelin sheath acts primarily as electrical insulation for the nerve cell it encloses, a function that is best carried out by a thick lipid layer of high electrical resistance with a minimal content of protein. Membranes also contain carbohydrates, which are attached to the lipids and proteins .



Cell membrane Structure

Membrane Lipids

Membranes contain a wide diversity of lipids, all of which are amphipathic. They contain both hydrophilic and hydrophobic regions. The hydrophilic (polar) region is their globular head; the hydrophobic (nonpolar) regions are their fatty acid tails. There are three main types of membrane lipids:- phosphoglycerides, sphingolipids and cholesterol .

1- Phosphoglycerides Most membrane lipids contain a phosphate group, which makes them phospholipids. Because most membrane phospholipids are built on a glycerol backbone, they are called phosphoglycerides .

2- Sphingolipids A less abundant class of membrane lipids, called sphingo-lipids, are derivatives of sphingosine, an amino alcohol that contains a long hydrocarbon chain. Sphingolipids consist of sphingosine linked to a fatty acid by its amino group.

3- Cholesterol Another lipid component of certain membranes is the sterol cholesterol, which in certain animal cells may constitute up to 50 percent of the lipid molecules in the plasma membrane. Plant cells contain cholesterol-like sterols, but biologists disagree as to whether or not they completely lack cholesterol .

Membrane protein

Depending on the cell type and the particular organelle within that cell, a membrane may contain hundreds of different proteins. Each membrane protein has a defined orientation relative to the cytoplasm, so that the properties of one surface of a membrane are very different from those of the other surface. Membrane proteins can be grouped into three distinct classes distinguished by the intimacy of their relationship to the lipid bilayer

1- Integral proteins that penetrate the lipid bilayer. Integral proteins are transmembrane proteins. They pass entirely through the lipid bilayer and thus have domains that protrude from both the extracellular and cytoplasmic sides of the membrane .

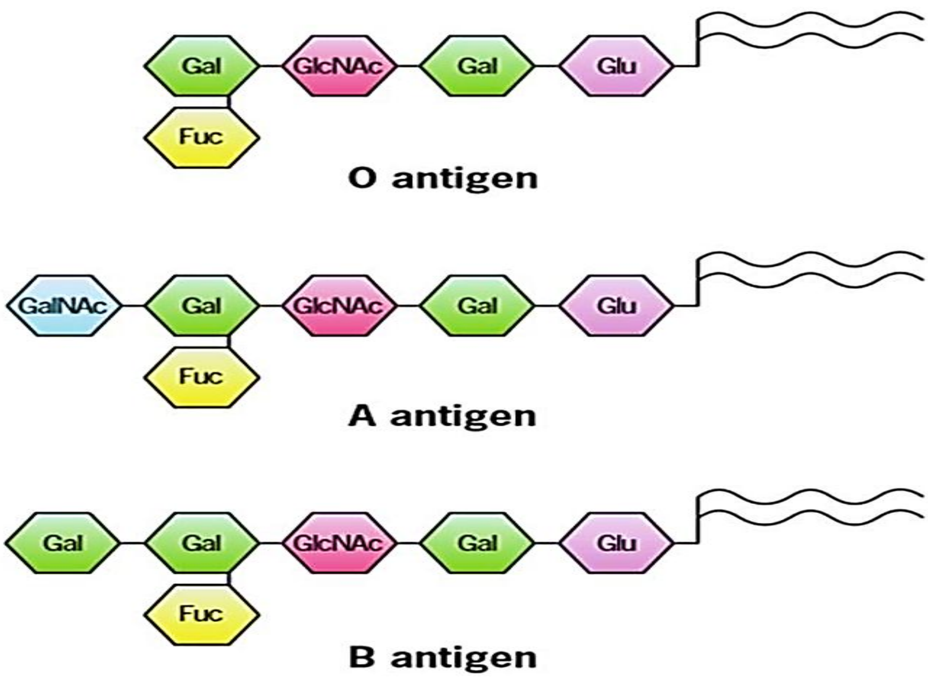
2- Peripheral proteins that are located entirely outside of the lipid bilayer, on either the cytoplasmic or extracellular side, yet are associated with the surface of the membrane by noncovalent bonds .

3- Lipid-anchored proteins that are located outside the lipid bilayer, on either the extracellular or cytoplasmic surface, but are covalently linked to a lipid molecule that is situated within the bilayer.

Membrane Carbohydrates

The plasma membranes of eukaryotic cells also contain carbohydrate. Depending on the species and cell type, the carbohydrate content of the plasma membrane ranges between 2 and 10 percent by weight. More than 90 percent of the membrane's carbohydrate is covalently linked to proteins to form glycoproteins; the remaining carbohydrate is covalently linked to lipids to form glycolipids .

The carbohydrates of the glycolipids of the red blood cell plasma membrane determine whether a person's blood type is A, B, AB, or O. A person having blood type A has an enzyme that adds an N-acetylgalactosamine to the end of the chain , whereas a person with type B blood has an enzyme that adds galactose to the chain terminus. These two enzymes are encoded by alternate versions of the same gene, yet they recognize different substrates. People with AB blood type possess both enzymes, whereas people with O blood type lack enzymes capable of attaching either terminal sugar. The function of the ABO blood-group antigens remains a mystery.



Lecture 4

Cell membrane functions

All cell membranes have the following functions :-

1- Providing a selectively permeable barrier:- Membranes prevent the unrestricted exchange of molecules from one side to the other. At the same time, membranes provide the means of communication between the compartments they separate .

2- Transporting solutes:- The plasma membrane contains the machinery for physically transporting substances from one side of the membrane to another, often from a region where the solute is present at low concentration into a region when that solute is present at much higher concentration.

3- Responding to external stimuli:- The plasma membrane plays a critical role in the response of a cell to external stimuli, a process known as signal transduction. Membranes possess receptors that combine with specific molecules (ligands) or respond to other types of stimuli such as light or mechanical tension .

4-Intercellular interaction:- Situated at the outer edge of every living cell, the plasma membrane of multicellular organisms mediates the interactions between a cell and its neighbors .

5- Energy transduction:- Membranes are intimately involved in the processes by which one type of energy is converted to another type (energy transduction).

Protein function:-

<u>**Integral proteins serve as**</u> **(1) channels**, which permit the passage of selected ions through the membrane; **(2) carriers (or transporters)**, which translocate

substances across the membrane by binding to them; **(3) pumps**, which are carriers that split adenosine triphosphate (ATP) and use the energy derived for membrane transport of substrates; **(4) receptors** (located on the outside), which bind to specific molecules and generate a chemical signal initiating intracellular reactions; and **(5) enzymes** catalyzing reactions at the membrane surfaces, both outer and inner .

<u>Peripheral proteins serve as</u> **(1) cell adhesion molecules (CAMs)** that anchor cells to neighboring cells and to the basal lamina. **(2) They also contribute to the cytoskeleton** when present on the cytoplasmic side of the membrane .

Membrane Transport

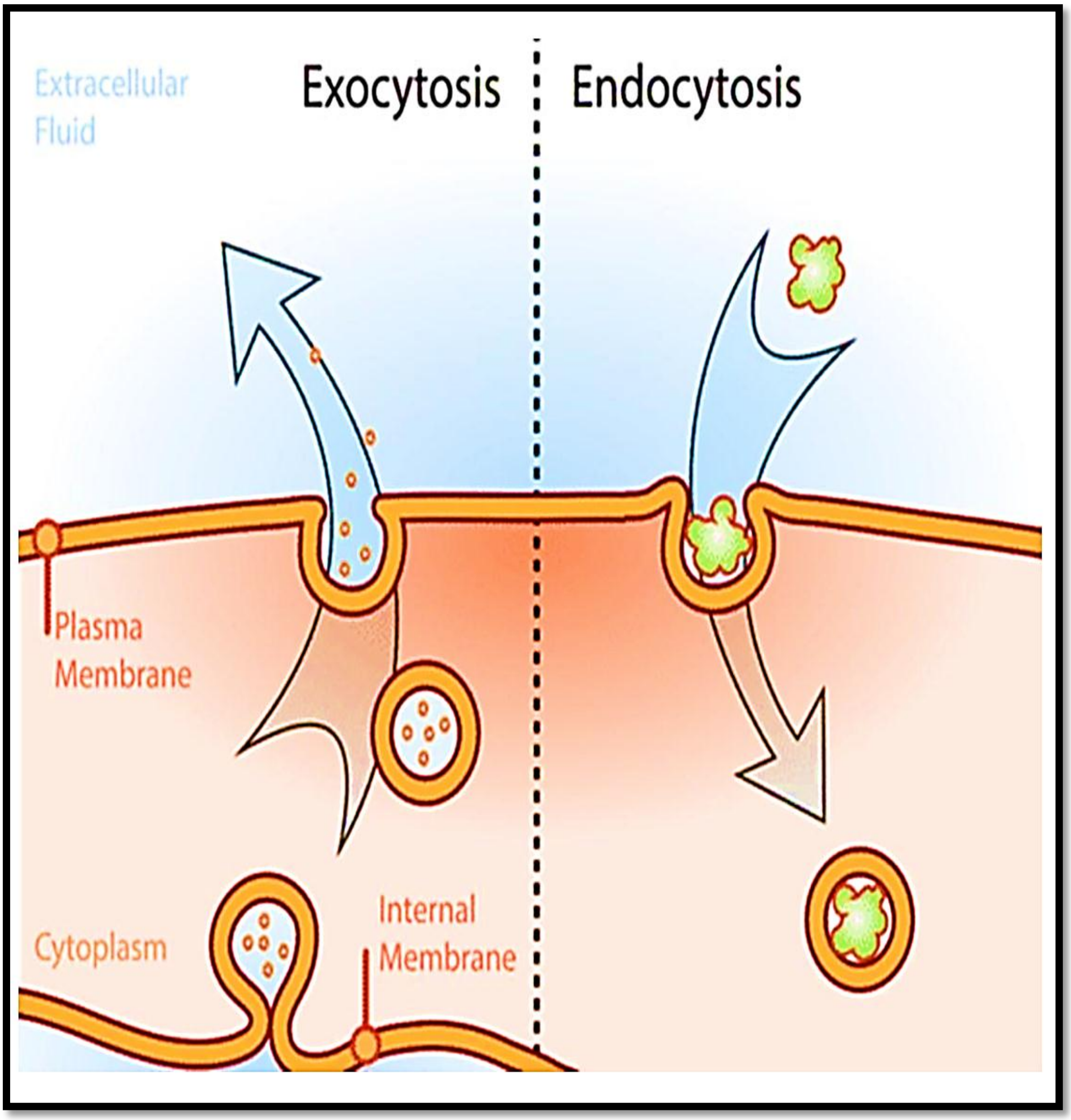
Simple Diffusion:- It can occur only from a region of high solute concentration to a region of low solute concentration and no needs energy. Simple diffusion is the result of the random motion of molecules, and it occurs in both directions across the membrane. The membrane permeability to a substance depends on the molecule's size, lipid solubility, and electrical charge .

Carrier-mediated Transport Membrane:- transport can also occur through carrier-mediated transport, which employs certain integral membrane proteins as carriers or transporters for specific substrates. It may occur without any energy expenditure (facilitated diffusion) or may involve energy expenditure (active transport).

Endocytosis:- Endocytosis is the process by which cells take up macromolecules and large particles from the extracellular environment. The process requires ATPase, Ca^{+2} and microfilaments. Endocytosis of cells, bacteria, viruses, or debris is called phagocytosis. Endocytosis of water, nutrient molecules, and parts of the cell membrane is called pinocytosis .

Exocytosis:- Exocytosis is the process for release of macromolecules formed in the cell to the exterior .

Endocytosis and exocytosis processes are active transport processes, requiring energy .



Lecture 5

Junctions between cells

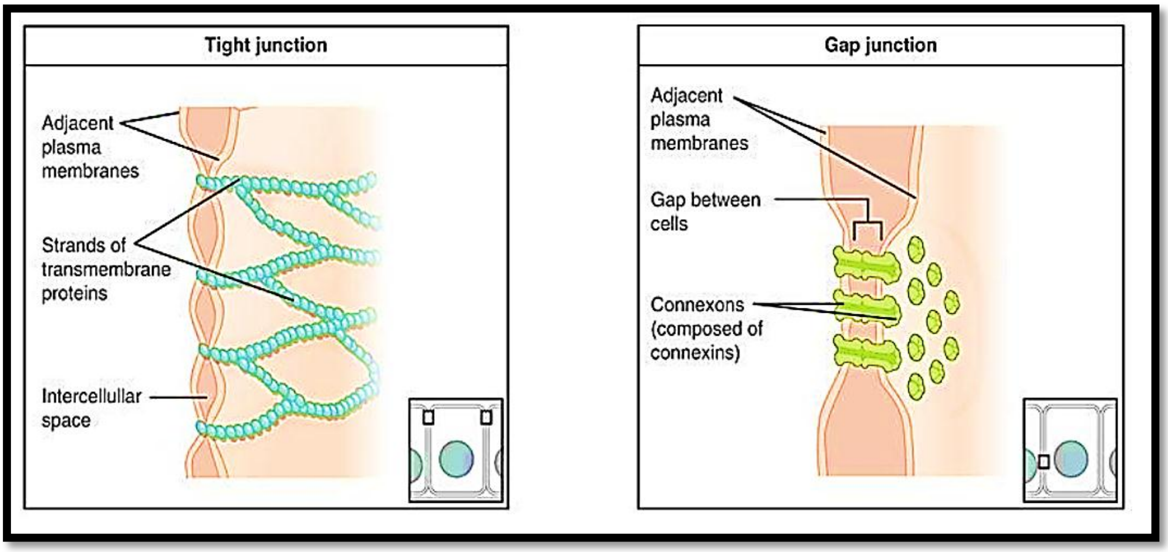
Intercellular junctions are structures which provide adhesion and commun-ication between cells. They are mostly present in epithelial cells that are especially characterized by their strong attachment one to another and to extracellular matrix. The different multiprotein complexes each of these junctions have, allow also intercellular transport with the neighboring cell.

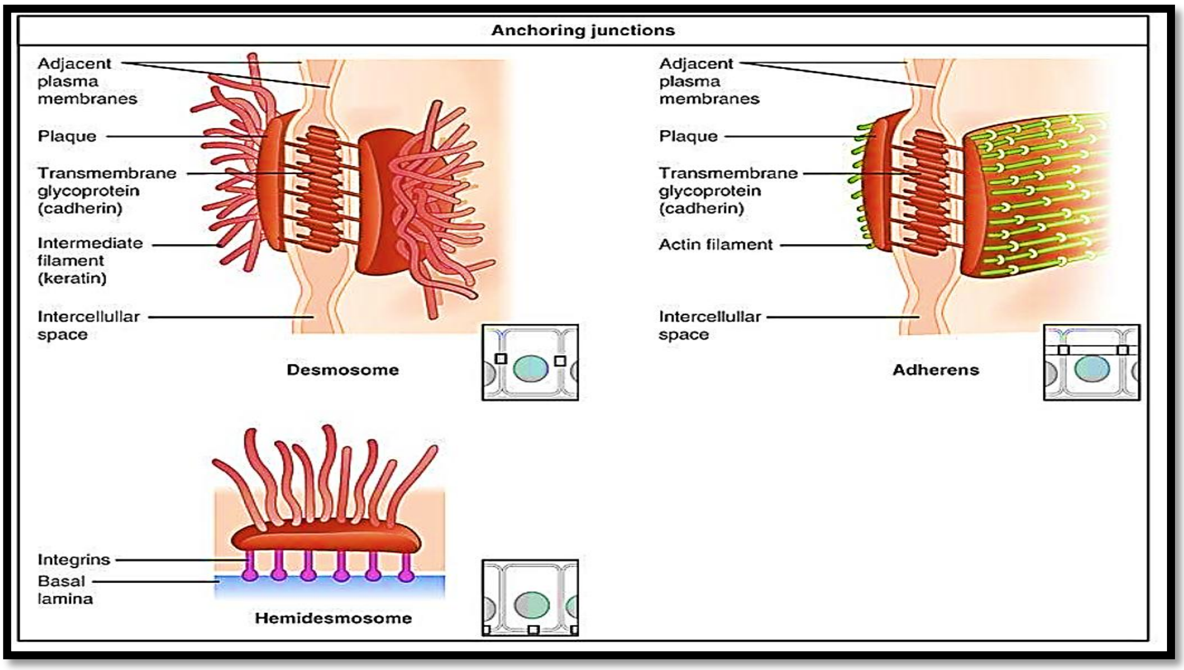
Three different types of intercellular junctions can be distinguished according to their function :-

1-Tight or occluding junctions:- provide transcellular and paracellular transport of molecules, but prevent passive flow between cells.

2- Adherent or anchoring junctions, including desmosomes and hemi-desmosomes:-provide strengthening and stabilizing the circular occluding bands. Another important function is the linking cytoskeletons of adjacent cells.

3- Gap junctions:- The major function of gap junctions is the direct transfer and exchange of nutrients and signal molecules between the cells.





Appendages on Cell membrane

1- Cilia- short, hairlike, motile cellular extensions that occur on the surfaces of certain cells; ex. some protozoa (called Ciliates) use cilia for motility and feeding .

2- Flagella – in humans, the single, long, hairlike cellular extension that occurs in sperm cells, beat in waves (prokaryotic flagella rotate); some protozoans use flagella for motility .

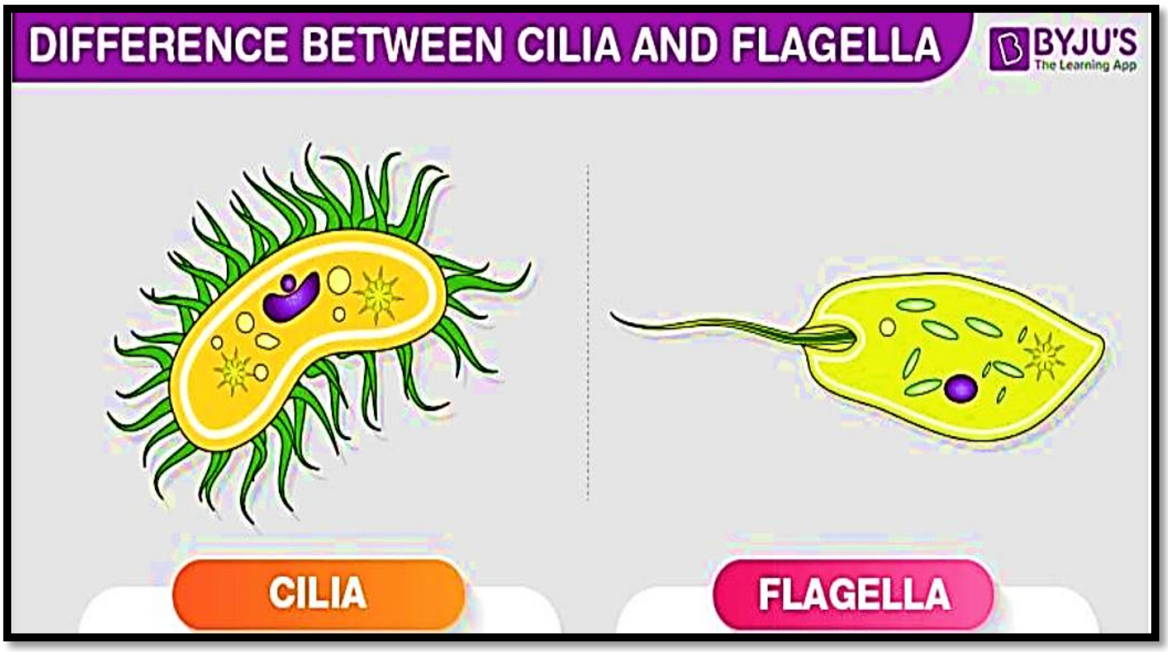
Cilia and flagella are cell organelles that are structurally similar but different in the length and functions. Cilia are present in organisms such as paramecium while flagella can be found in bacteria and sperm cells. Cilia are shorter and numerous than flagella.

3-Stereocilia:- are also organelle of cells, but typically of hair cells. Because it is mechano-sensing function, these are present in the inner ear, epididymis and ductus deferens.

4- Microvilli :- is the protrusions of cellular membrane in eukaryotic cells . the role of microvilli is to facilitate cellular adhesion, secretion, absorption and mechanco-transduction. These are non-motile organelle and present in the sensory organs like nose, mouth and ears.

Difference Between Cilia And Flagella

Cilia	Flagella
The number of cilia is comparatively more (typically ranges in the thousands)	The number of flagella is comparatively less (usually ranges from 1 to 8)
Cilia is usually shorter in length	Flagella is comparatively longer in length
Beating pattern of cilia is very complicated – Can move in a wide range of motions	Beating pattern of Flagella involves circular, wave-like or propeller-like motion
Found in Eukaryotic cells	Found in prokaryotic cells and eukaryotic cells
Cilia are of two types: Non-motile cilia and Motile cilia	Flagella are of three types: Bacterial flagella, Archaeal flagella and Eukaryotic flagella



Lecture 6

cellular organelles

We will now look at the key organelles that make up the cell. It is important to bear in mind that structure and function are closely related in all living systems .

Cytoplasm

The cytoplasm is the jelly-like substance that fills the cell. It consists of up to 90% water. It also contains dissolved nutrients and waste products. Its main function is to hold together the organelles which make up the cytoplasm. It also nourishes the cell by supplying it with salts and sugars and provides a medium for metabolic reactions to occur.

All the contents of prokaryotic cells are contained within the cytoplasm. In eukaryotic cells, all the organelles are contained within the cytoplasm except the nucleolus which is contained within the nucleus .

Functions of the cytoplasm

1- The cytoplasm provides mechanical support to the cell by exerting pressure against the cell's membrane which helps keep the shape of the cell. This pressure is known as turgor pressure .

2- It is the site of most cellular activities including metabolism, cell division and protein synthesis .

3-The cytoplasm contains ribosomes which assist in the synthesis of protein.

4- The cytoplasm acts a storage area for small carbohydrate, lipid and protein molecules.

5- The cytoplasm suspends and can transport organelles around the cell .

Type of cellular organelles

Mitochondria

A mitochondrion is a membrane bound organelle found in eukaryotic cells. This organelle generates the cell's supply of chemical energy by releasing energy stored in molecules from food and using it to produce ATP (adenosine triphosphate). ATP is a special type of "energy carrying" molecule.

Structure and function of the mitochondrion

Mitochondria contain two phospholipid bilayers:- there is an outer membrane, and an inner membrane. The inner membrane contains many folds called cristae which contain specialized membrane proteins that enable the mitochondria to synthesis ATP. Inside the inner membrane is a jelly-like matrix. Listed from the outermost layer to the innermost compartment, the compartments of the mitochondrion, are :-

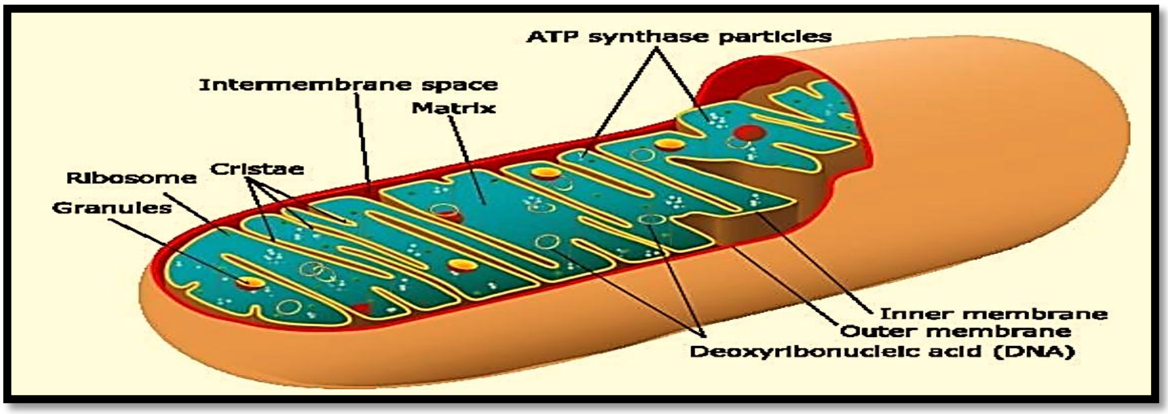
1- Outer mitochondrial membrane

2- Intermembrane space

3- Inner mitochondrial membrane

4- Cristae folds of the inner membrane

5- matrix (jelly-like substance within the inner membrane)

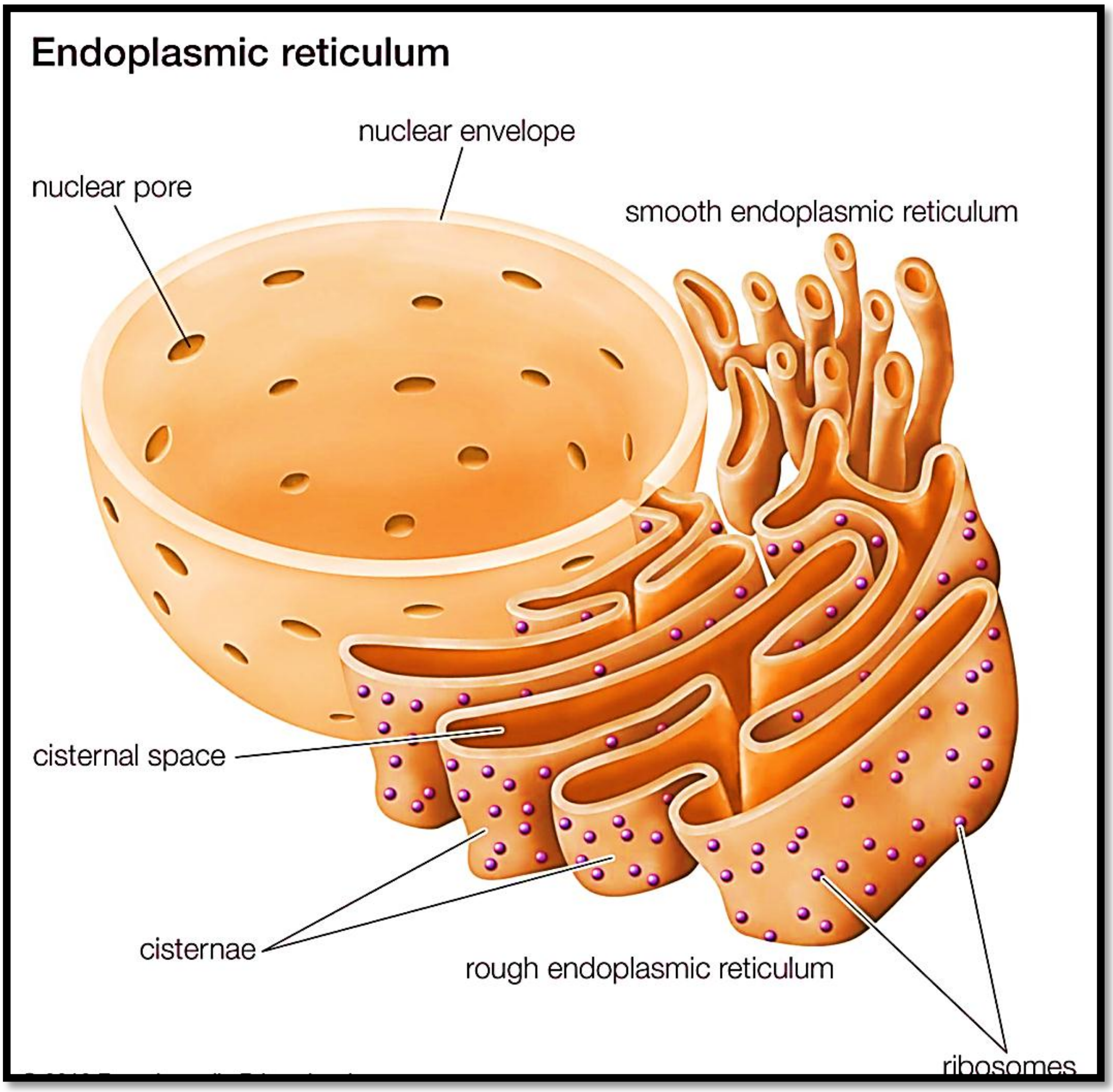


The table below relates each structure to its function.

Structure	Function	Adaptation to function
Outer mitochondrial membrane	Transfer of nutrients (e.g lipids) to mitochondrion.	Has large number of channels to facilitate transfer of molecules.
Intermembrane space	Stores large proteins allowing for cellular respiration.	Its position between two selectively permeable membranes allows it to have a unique composition compared to the cytoplasm and the matrix.
Inner membrane	Stores membrane proteins that allow for energy production.	Contains folds known as *cristae* which provide increased surface area, thus enabling production of ATP (chemical potential energy).
Matrix	Contains enzymes that allow for the production of ATP (energy).	The matrix is contains a high quantity of protein enzymes which allow for ATP production.

Endoplasmic reticulum

The endoplasmic reticulum (ER) is an organelle found in eukaryotic cells only. The ER has a double membrane consisting of a network of hollow tubes, flattened sheets, and round sacs. These flattened, hollow folds and sacs are called cisternae. The ER is located in the cytoplasm and is connected to the nuclear envelope. There are two types of endoplasmic reticulum:- smooth and rough ER . smooth endoplasmic reticulum (ER):- does not have any ribosomes attached . It is involved in the synthesis of lipids, including oils, phospholipids and steroids. It is also responsible for metabolism of carbohydrates, regulation of calcium concentration and detoxification of drugs. Rough ER: is covered with ribosomes giving the endoplasmic reticulum its rough appearance. It is responsible for protein synthesis and plays a role in membrane production. The folds present in the membrane increase the surface area allowing more ribosomes to be present on the ER, thereby allowing greater protein production.



Ribosomes

Ribosomes are composed of RNA and protein. They occur in the cytoplasm and are the sites where protein synthesis occurs. Ribosomes may occur singly in the cytoplasm or in groups or may be attached to the endoplasmic reticulum thus forming the rough endoplasmic reticulum. Ribosomes are important for protein production. Together with a structure known as messenger RNA (a type of nucleic acid) ribosomes form a structure know as a polyribosome which is important in protein synthesis .

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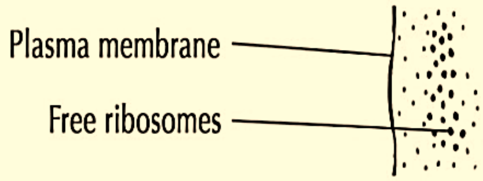
<tr><td>

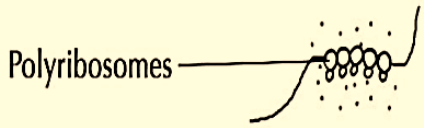
Figure 2.23: Free ribosomes found within cytoplasm.</td><td>

Figure 2.24: Diagram of several ribosomes joined together on a strand of mRNA to form a polyribosome.</td></tr>
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Golgi body

The Golgi body is found near the nucleus and endoplasmic reticulum. The Golgi body consists of a stack of flat membrane-bound sacs called cisternae. The cisternae within the Golgi body consist of enzymes which modify the packaged products of the Golgi body (proteins).

Functions of the Golgi body

It is important for proteins to be transported from where they are synthesized to where they are required in the cell. The organelle responsible for this is the Golgi Body. The Golgi body is the sorting organelle of the cell . Proteins are transported from the rough endoplasmic reticulum (RER) to the Golgi. In the Golgi, proteins are modified and packaged into vesicle. The Golgi body therefore receives proteins made in one location in the cell and transfers these to another location within the cell where they are required. For this reason the Golgi body can be considered to be the 'post office' of the cell.

Lecture 7

cellular organelles

Vesicles and lysosomes

Vesicles are small, membrane-bound spherical sacs which facilitate the metabolism, transport and storage of molecules. Many vesicles are made in the Golgi body and the endoplasmic reticulum, or are made from parts of the cell membrane. Vesicles can be classified according to their contents and function. Transport vesicles transport molecules within the cell.

Lysosomes are formed by the Golgi body and contain powerful digestive enzymes that can potentially digest the cell. Lysosomes are formed by the Golgi body or the endoplasmic reticulum. These powerful enzymes can digest cell structures and food molecules such as carbohydrates and proteins. Lysosomes are abundant in animal cells that ingest food through food vacuoles. When a cell dies, the lysosome releases its enzymes and digests the cell .

Vacuoles

Vacuoles are membrane-bound, fluid-filled organelles that occur in the cytoplasm of most plant cells, but are very small or completely absent from animal cells. Plant cells generally have one large vacuole that takes up most of the cell's volume. A selectively permeable membrane called the tonoplast, surround the vacuole. The vacuole contains cell sap which is a liquid consisting of water, mineral salts, sugars and amino acids .

Functions of the vacuole

1- The vacuole plays an important role in digestion and excretion of cellular waste and storage of water and organic and inorganic substances .

2- The vacuole takes in and releases water by osmosis in response to changes in the cytoplasm, as well as in the environment around the cell .

3- the vacuole is also responsible for maintaining the shape of plant cells . When the cell is full of water, the vacuole exerts pressure outwards, pushing the cell membrane against the cell wall. This pressure is called turgor pressure.

4- If there not sufficient water, pressure exerted by the vacuole is reduced and the cells become flaccid causing the plant to wilt .

Centrioles

Animal cells contain a special organelle called a centriole. The centriole is a cylindrical tube-like structure that is composed of 9 microtubules arranged in a very particular pattern. Two centrioles arranged perpendicular to each other are referred to as a centrosome. The centrosome plays a very important role in cell division. The centrioles are responsible for organizing the microtubules that position the chromosomes in the correct location during cell division .

Plastids

Plastids are organelles found only in plants. There are three different types :-

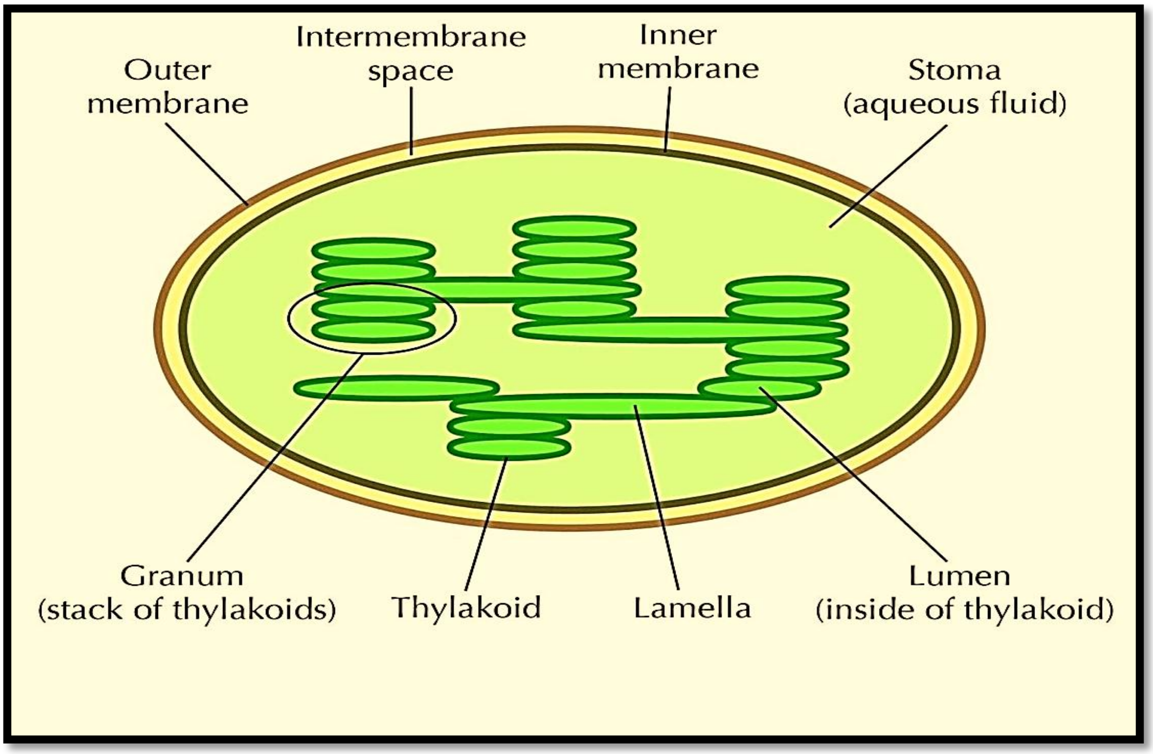
1- Leucoplasts:- White plastids found in roots .

2- Chloroplasts:- Green-coloured plastids found in plants and algae .

3- Chromoplasts:- Contain red, orange or yellow pigments and are common in ripening fruit, flowers or autumn leaves .

Chloroplast

The chloroplast is a double-membraned organelle. Within the double membrane is a gel-like substance called stroma. Stroma contains enzymes for photosynthesis. Suspended in the stroma are stack-like structure grana (singular = granum). Each granum is a stack of thylakoid discs. The Chlorophyll molecules (green pigments) are found on the surface of the thylakoid discs. Chlorophyll absorbs energy from the sun in order for photosynthesis to take place in the chloroplasts. The grana are connected by lamellae (intergrana). The lamellae keep the stacks apart from each other . The structure of the chloroplast is neatly adapted to its function of trapping and storing energy in plants. For example, chloroplasts contain a high density of thylakoid discs and numerous grana to allow for increased surface area for the absorption of sunlight, thus producing a high of food for the plant. Additionally, the lamellae keeping the thylakoids apart maximize Chloroplast efficiency, thus allowing as much light as possible to be absorbed in the smallest surface area .



The differences between plant and animal cells

There are key differences between plant and animal cells. The table below summarizes these differences

Animal Cells	Plant Cells
Do not contain plastids.	Almost all plants cells contain plastids such chloroplasts, chromoplasts and leucoplasts.
No cell wall.	Have a rigid cellulose cell wall in addition to the cell membrane.
Contain centrioles.	Do not contain centrioles.
Animals do not have plasmodesmata or pits.	Contain plasmodesmata and pits.
Few vacuoles (if any).	Large central vacuole filled with cell sap in mature cells.
Nucleus is generally found at the centre of the cytoplasm.	Nucleus is found near the edge of the cell.
No intercellular spaces found between the cells.	Large intercellular air spaces found between some cells.

Lecture 8

Nucleus

The nucleus is the largest organelle in the cell and contains all the cell's genetic information in the form of DNA. The presence of a nucleus is the primary factor that distinguishes eukaryotes from prokaryotes. The structure of the nucleus is described below :-

Nuclear envelope:-there are two lipid membranes that are studded with special proteins that separates the nucleus and its contents from the cytoplasm .

Nuclear pores:-there are tiny holes called nuclear pores are found in the nuclear envelope and help to regulate the exchange of materials (such as RNA and proteins) between the nucleus and the cytoplasm .

Chromatin:- thin long strands of DNA and protein.

Nucleolus:- the nucleolus makes RNA another type of nucleic acid .

During cell division, DNA contracts and folds to form distinct structures called chromosomes. The chromosomes are formed at the start of cell division. The genetic material of eukaryotic organisms is separated from the cytoplasm by a membrane whereas the genetic material of prokaryotic organisms (like bacteria) is in direct contact with the cytoplasm .

Chromosome part

1- Telomeres: the tips part of chromosome .

2- Centromeres: middle part of chromosome, in this region the spindle fibers attach .

3- p arm:- the smaller of the two arms.

4- q arm:- the longer of two arms .

Chromosome types :-

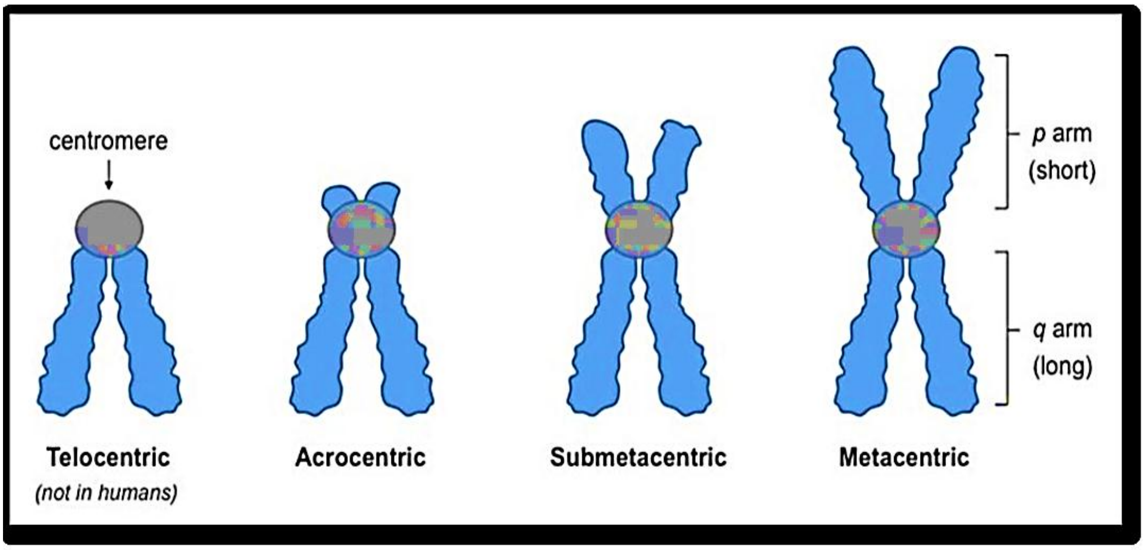
The centromere can be located in different positions and this forms the basis for the four different classes of chromosome :-

1- Metacentric:- centromere is in middle, meaning p and q arms are of comparable length (e.g. chromosomes 1, 3, 16, 19, 20) .

2- Submetacentric:- centromere off-centre, leading to shorter p arm relative to q arm (e.g. chromosomes 2, 4 - 12, 17, 18, X).

3- Acrocentric:- centromere severely off-set from centre, leading to much shorter p arm (e.g. chromosomes 13 - 15, 21, 22, Y).

4- Telocentric:- centromere found at end of chromosome, meaning no p (arm exists chromosome not found in humans) .



Cell cycle

Is the series of events that take place in a cell leading to its division and duplication of its DNA (DNA replication) to produce two daughter cells .

Cell cycle Phases

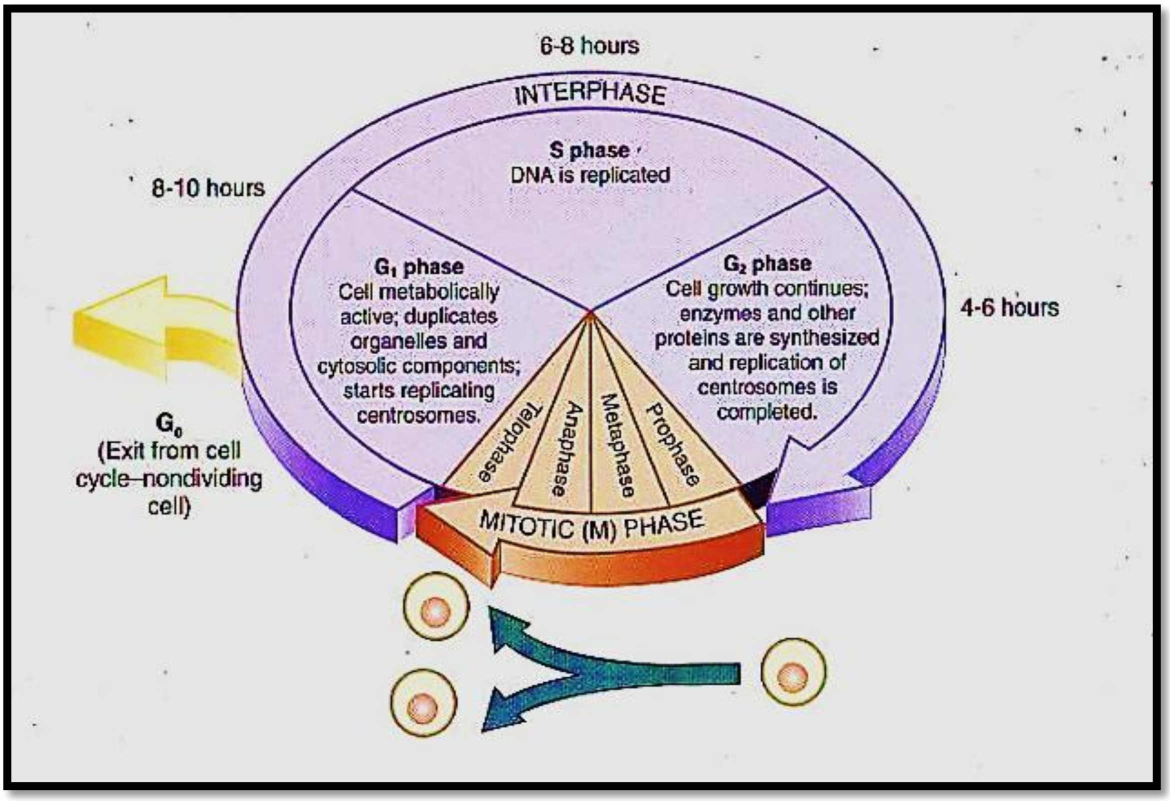
The cell cycle consists of four distinct phases:-

1- G1 phase:- Metabolic changes prepare the cell for division. Cells increase in size in Gap 1. The G1 checkpoint control mechanism ensures that everything is ready for DNA synthesis .

2- S phase:- DNA replication occurs during this phase.. Each chromosome now consists of two sister chromatids .

3- G2 phase:- During the gap between DNA synthesis and mitosis, the cell will continue to grow. The G2 checkpoint control mechanism ensures that everything is ready to enter the M (mitosis) phase and divide .

4- M phase:- A nuclear division (mitosis) followed by a cell division (cytokinesis).



Lecture 9

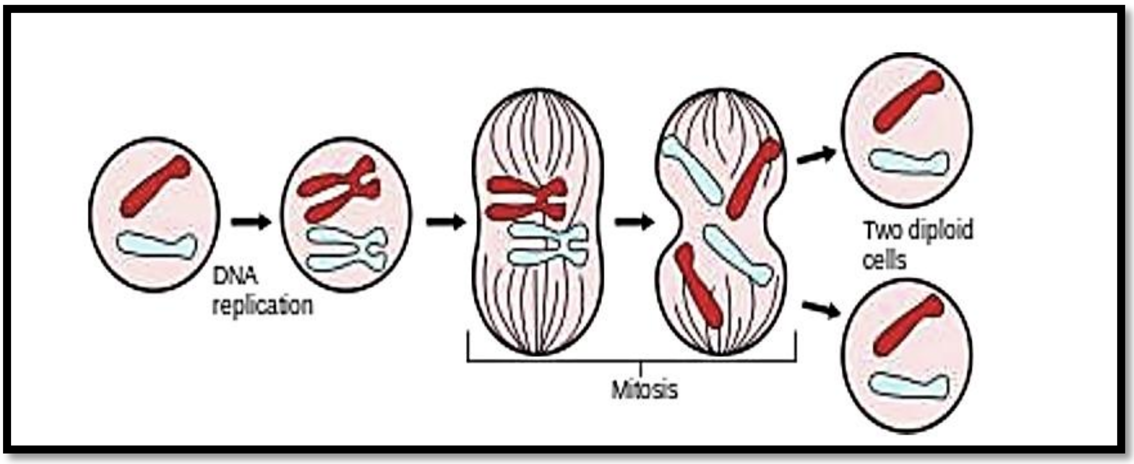
Types of cell division

All livings are made of great number of cells that we cannot estimate. Livings start as single cells and most of time people wonder on develop-pment of a living from a single cell to an organism with trillions of cells. The real response to fill their curious is cell division. Cells take their time to reach on maximum size and enter their division to give new cells. Released new cells are small but they grow rapidly and divide to release other new cells and this process continue by repeating in this way.
Cell division is made simple in prokaryotes but takes process in eukaryotes. Prokaryotic cells simple in their nature, they contain a circular chromo-somes, and organelles like nucleus and some others are absent in pro-karyotic cells. In contrast side Eukaryotic cells, have much number of chromosomes and located in important organelle called nucleus. All these organelles have to duplicate and separation occurs during cell division. Chromosomes are located and always reside in nucleus in eukaryotic cells. Cells are divided in two ways, one is mitosis and another one is meiosis. Mitosis is done on somatic cells while meiosis is done on reproductive cells that will enter gametes formation.

1- Mitosis

cell division is a sequence of process of steps by which living organisms are enabled to grow and have ability of reproduction. During cell division through mitosis, genetic material enters replication in a mature cell and is shared in equal way in two daughter new cells. Before a cell begin its division, it enters interphase state which is a period taken by the cell to grow. There important activities that take place during interphase, the replication of genetic material and organelles organization to be ready for cell division are all take place in interphase. Cell division through mitosis mature cell genome is carried into new formed daughter cells, and new cells are similar for themselves and to their mother cell. By the beginning of mitosis, the cell chromosomes enter condensation.

In most eukaryotic cells, the nuclear membrane separates genetic material (DNA) from the cytoplasm into membrane vesicles. The ribosome dissolves; the chromosomes arranged and align themselves. Microtubules are responsible in pulling apart of the sister chromatids of every chromosome. The homologous chromosomes (daughter chromosomes) are moved towards opposite sides. The formation of nuclear membrane takes place on separated daughter chromosomes. In animal cells, the pinching of cell membrane is done inwards, to create to form two daughter cells. In plant cells, the cell wall that is divided is built in between the daughter cells. The parent cell will split in half and produce to two daughter new cells.

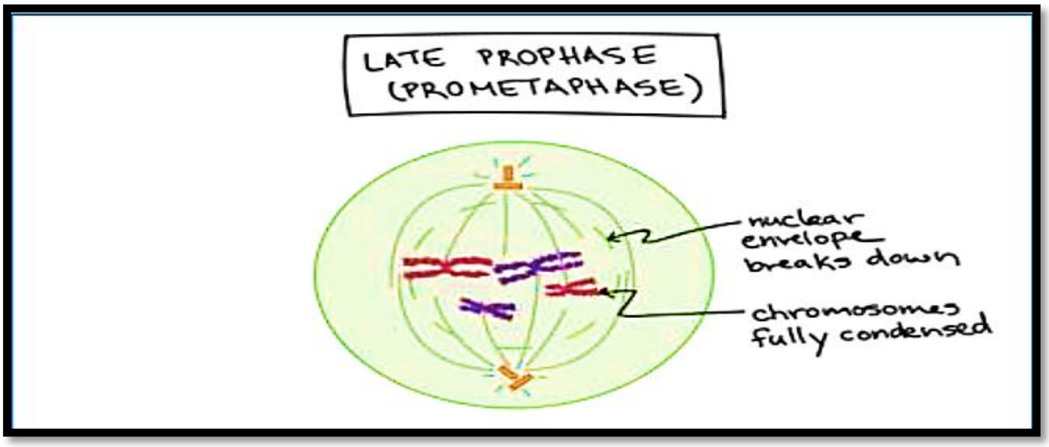


Phases of mitosis

Mitosis is a type of cell division that passes in four phases: prophase, metaphase, anaphase, and telophase. Because of long lasting time, prophase may have two phases prophase and prometaphase. Both Prophase and metaphase prepare the cell for division process. The real division is done on anaphase and telophase. Before it enters prophase, a cell creates a copy of its DNA. At this stage, the cell nucleus is contains chromatids, and two copies of the chromosomes in connection. On this phase, animal cells have already completed creating copies of their centrosome by this stage.

1.1- Prophase

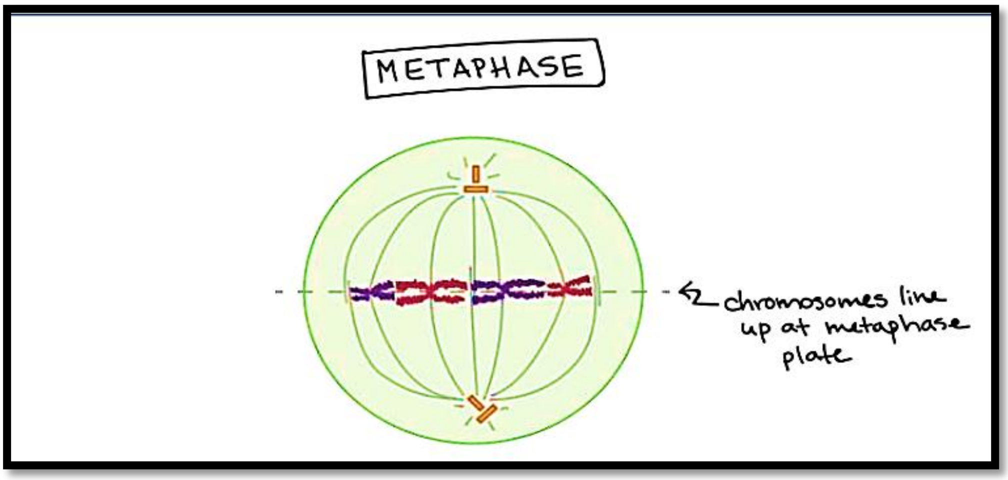
In first stages of prophase, the cell organelles prepare for cell division and chromosomes begin condensation for facilitating its migration to poles when cell dividing. Formation of mitotic spindles takes place by this step of mitosis. Between two centromeres mitotic spindles are formed out micro-tubules. These spindles are responsible in organizing chromosomes when a cell dividing through mitosis.



During prophase, cells do not only create structures, but it enters in breaking down some structures. Ribosomes are created by nucleolus which always resides in cell nucleus. The nucleolus will disappear quickly as a cell ready for division. In later prophase, or prometaphase, the breaking of nuclear membrane take place at this stage and found as a second stage of prophase. As nuclear membrane breaks, chromosomes get of nucleus to cytoplasm. Between centrosomes, there are mitotic spindles and these spindles take their expansion and begin capturing chromosomes. After condensation of chromosomes, chromosomes get compacted. In mitotic spindles, microtubules are found and capture chromosomes and bind them kinetochore. The kinetochore is a structure located on the centromere of the sister chromatids, the region where the chromatids are the most tightly form their bonding and connection.

1.2- Metaphase

The beginning of metaphase, already started with bonding of mitotic spindles and chromosomes. And here they are found on line in the middle of the cell. At this stage, chromosomes have ability to divide. Each chromosome has two kinetochores and facilitate anchoring of chromosomes and microtubules. These are necessary for a cell to divide in proper manner.

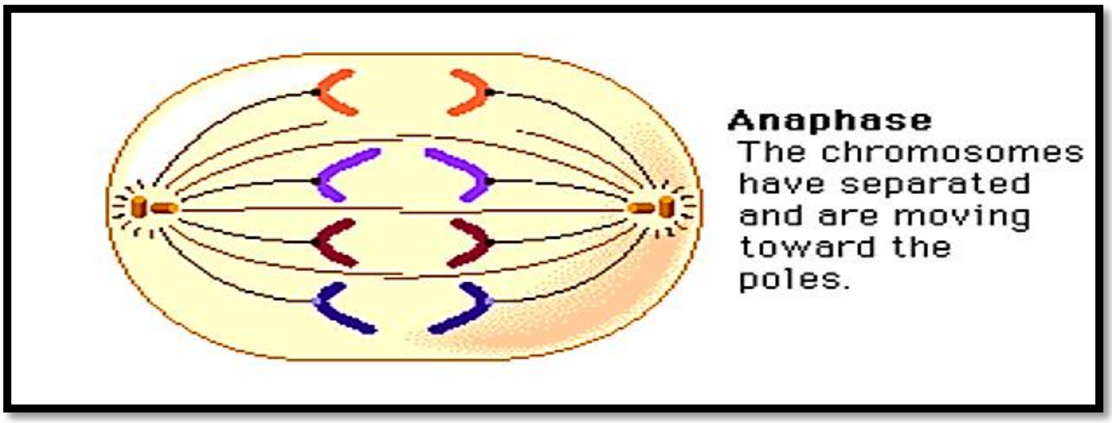


After chromosomes organization, the mature cell enters the process known as spindle checkpoint. Where spindles verify if chromatids are organized in proper way for cell division. Misalignments of chromatids can late cell division and in case cell division takes place with this problem of improperly attachment of chromatids, future problems in individual health.

1.3- Anaphase

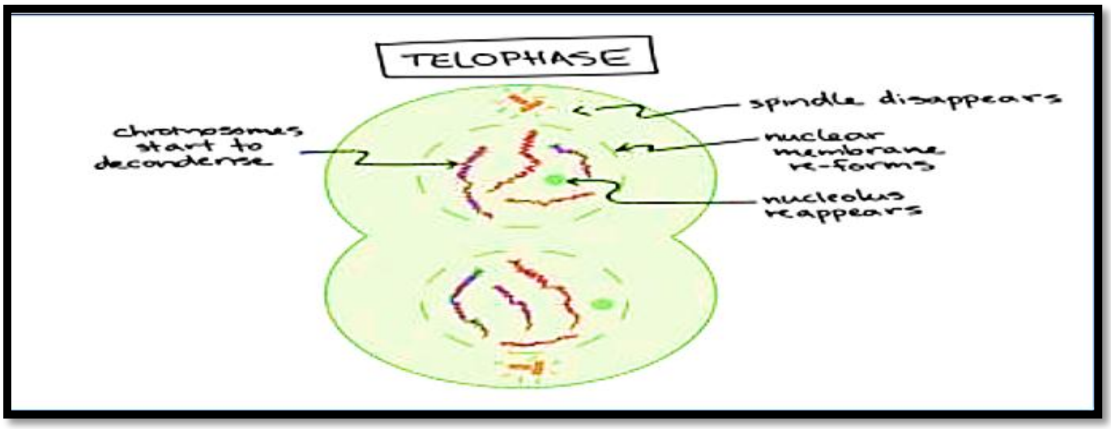
Chromatids have already aligned in central part of the cell, in anaphase, the centrosomes begin pulling on chromatids. During this phase, sister chromatids are pulled by means spindles and leave central part to poles.

They create daughter chromosomes separately. The microtubules, at this stage begin elongating and facilitate a cell to divide in two daughter cells.



1.4-Telophase

Telophase is the last and final step of a cell to divide. When a cell finished dividing in two daughter cells, the formed cells enters the process of living independently and begins establishing new cell structure. Breaking down of mitotic spindles occurs at this stage and these spindles return back in the initial state in its constituents. Chromosomes get unwound and get their form like strings or chains. Nuclei are formed in both new cells already produced and formation of nuclear membrane renew on formed nucleoli. The complete cell division cannot take place until cytokinesis takes place and finishes.



1.5- Cytokinesis

Cytokinesis is the process that assures the division of mature cell into two new daughter cells with the same genome. It occurs in last phases of cell division. During cell division in animals, the cytoplasm is pinched and create cleavage furrow, and this continue up to the end of cytoplasm division. There is a difference on plant cells, they don't use the same process of division like that of animal cells, and one factor that makes difference is that their cell wall makes plant cells to be rigid. They easily make their new cell wall in central part of the cell. The four phases of mitosis are all integral to cell division and replication. Without mitosis, the cells in your body could not replicate, and life as we know it wouldn't exist.

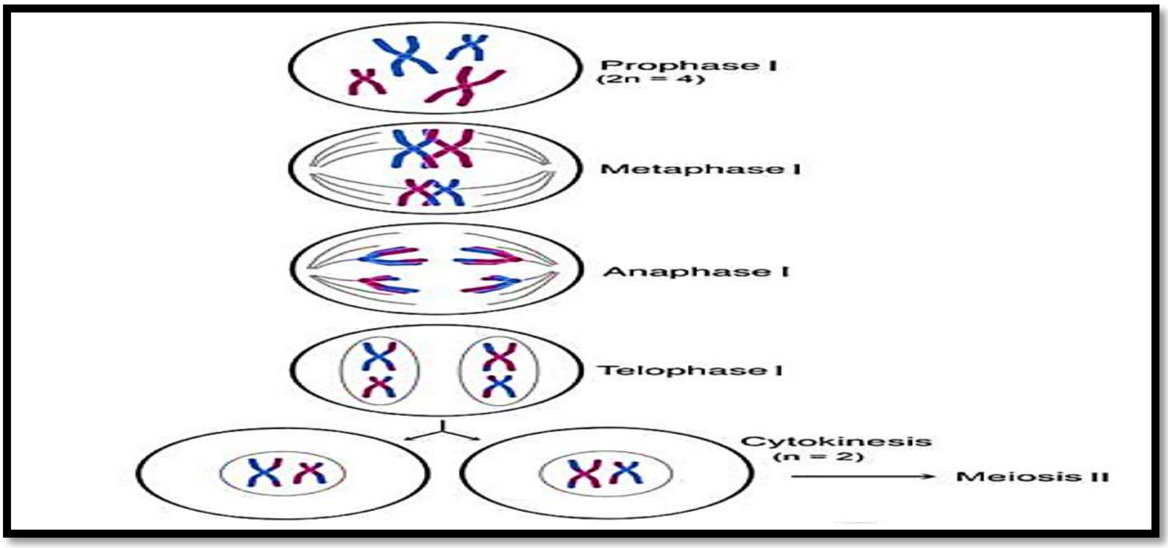
Lecture 10

2- Meiosis

Meiosis is type of cell division exist in cell responsible in gamete formation. Cells with haploid chromosomes enter nuclear division to produce four Haploid cells. It is also known as meiocytes to mean formation of sperms and eggs. Diploid cells enter in meiosis division for the purpose of creating gametes or meiocytes with half of ploidy of their parent cells, and are applied for organisms that reproduce sexually. It is known that the zygote gets half of ploidy of each parent and give a zygote ability to have ploidy information from both parents. Meiosis has no difference with mitosis in phases engaging cell division. The uniqueness that comes in meiosis is genetic recombination through crossing over of homologous chromosomes.

2.1- Meiosis I

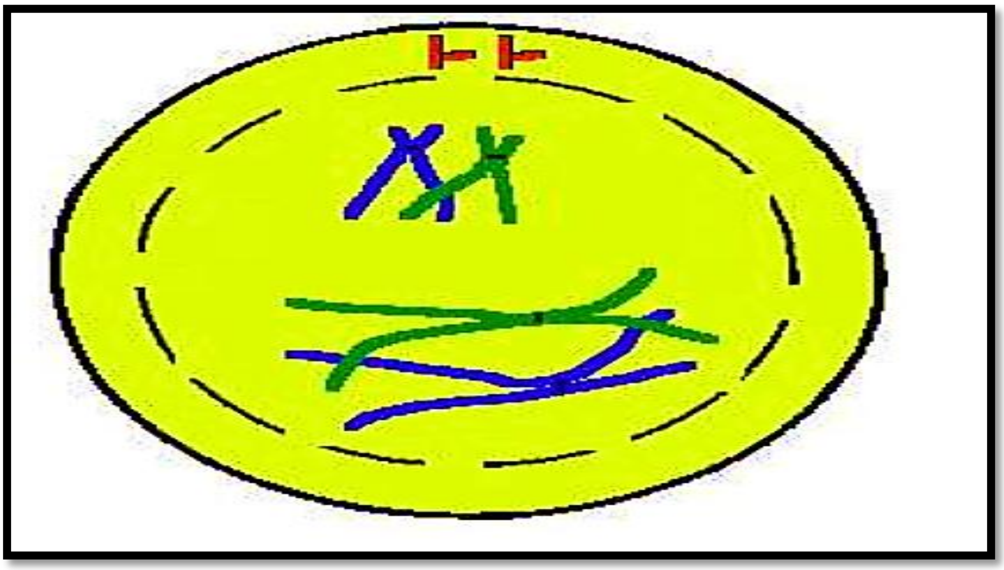
All phases of meiosis seem to be the same as of that of mitosis. Replications of chromosomes are done in the same way in type one of meiosis. The amount of DNA in the cell has doubled, and the ploidy of the cell remains the same as before, at 2*n*. In meiosis I, the phases are analogous to mitosis: prophase I, metaphase I, anaphase I, and telophase I (below figure). Meiosis I proceeds directly to meiosis II without going through interphase.



Meiosis I phases

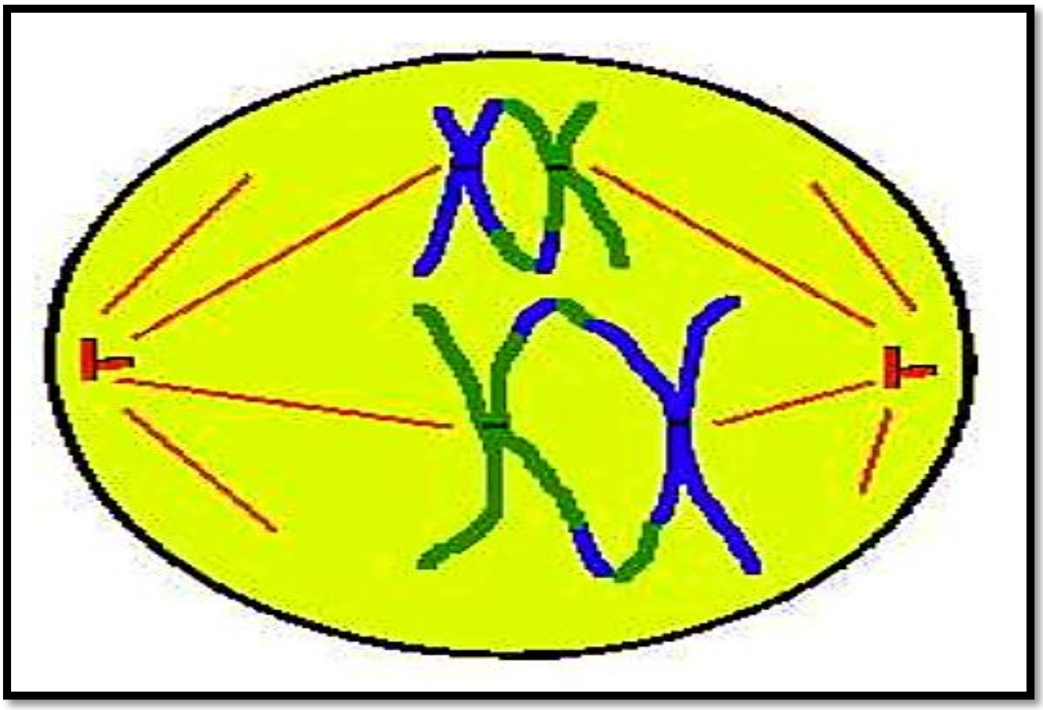
2.1.1- Prophase I

This stage comes up with manifestation of chromosomes that are seen as solely bodies. Centrioles also get arranged in opposite sides of the nucleus. By this stage homologous chromosomes coiled and get zipped to form pairs known as bivalents in the process named synapsis. As chromosomes coiled around each other, chromatids remain connected in joining place known as Chiasmata. By the time of synapsis, chromosomes that are homologous enter an exchange of their genetic material between one another, and This exchange is known as crossing over .



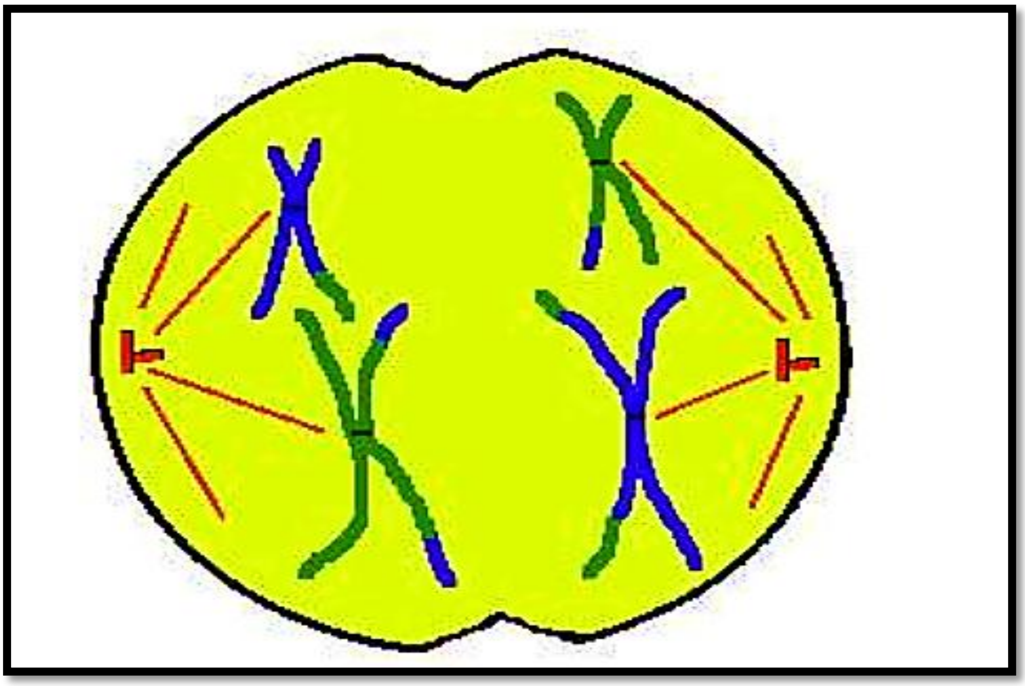
2.1.2 Metaphase 1

During this phase, Nuclear membrane gets disappeared to make freedom to chromosomes by entering cytoplasm. The formation of spindles already done in early stages. Chromosomes that are paired moves to equator and attachment on spindles facilitated by its centromere. During this time homologous chromosomes get orientation in opposite sides of poles.



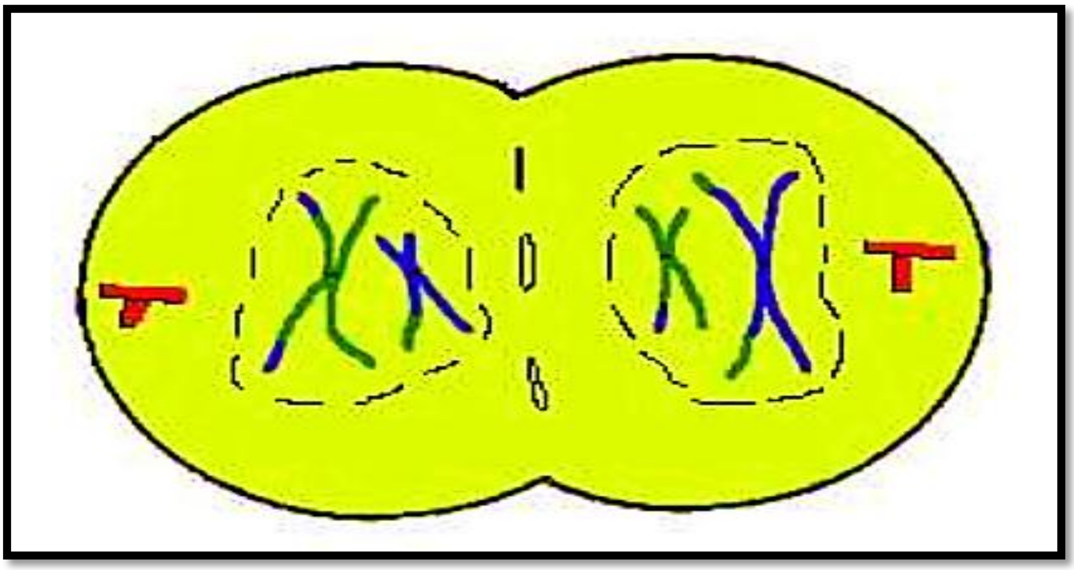
2.1.3 Anaphase 1

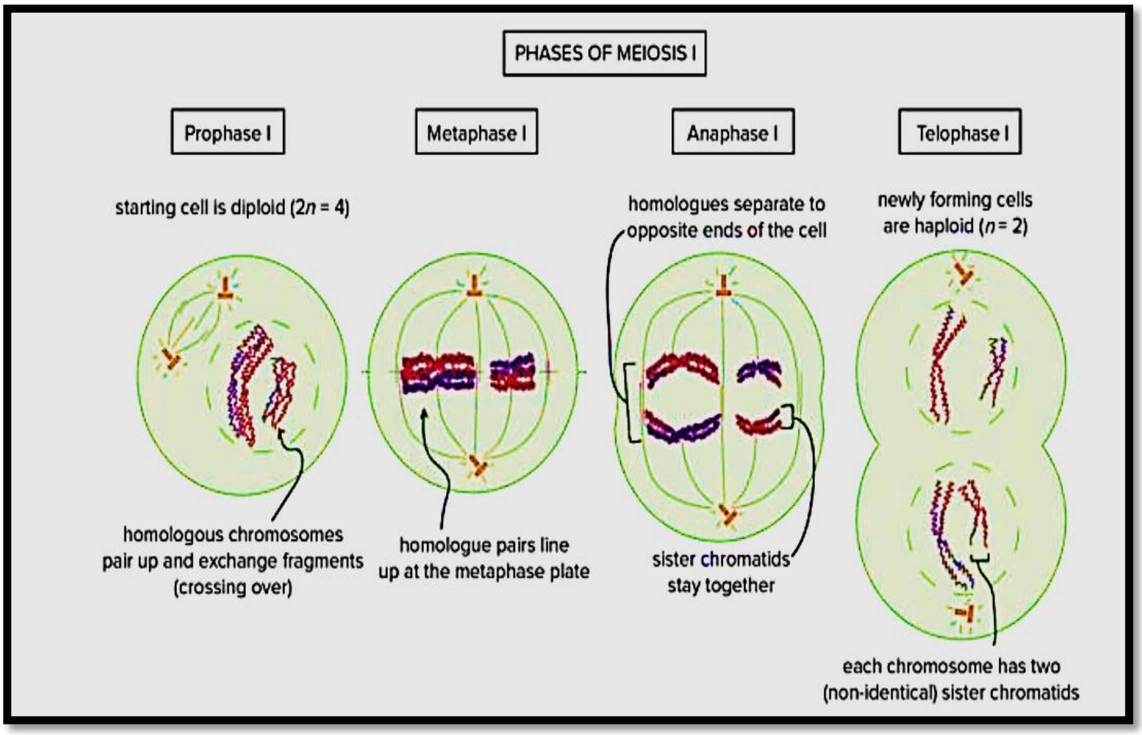
Chromosomes that are Homologous get separation and enter migration in opposite poles. The influence of this migration is facilitated by shortening of spindle fibers and chromosomes get pulled. However, sister chromatids still coiled at this stage.



2.1.4 Telophase 1

When the journey of chromosomes from centre to poles finishes, they densely packed together. Spindles break down and formation of nuclear membrane takes place on each chromosomes and the cell halved divides. However most of organisms do not enter telophase, and scientific evidences shows that they directly enter meiosis 2.





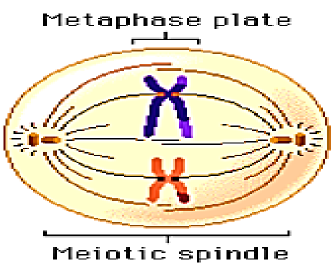
2.2- Meiosis II Phases

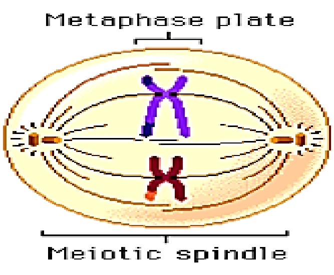
2.2.1- Prophase 2

The thickenings of chromosomes take place at this point and new spindles formation place. You better know that dispersion of chromosomes already taken place in telophase I, thus, they will enter condensation in prophase II. At this early stage of meiosis II, sister chromatids continue coiling together .

2.2.2- Metaphase 2

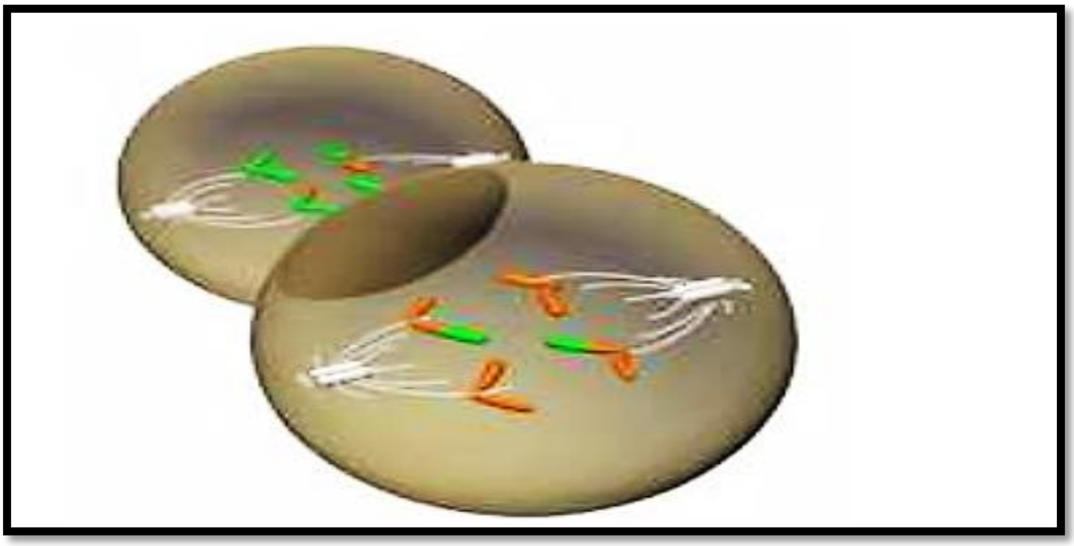
As usual, at this stage chromosomes get arranged in metaphase plate. And attached on new formed spindles. Each new formed cell, enters completion of spindles formation. Alignment of single chromosomes takes place in metaphase plate and seems different with metaphase I where paired chromosomes get alignment in metaphase plate. the kinetochores of each chromosome, of the sister chromatids face the opposite poles to be ready for migration, and each gets its attachment to a kinetochore microtubule that comes from that pole.





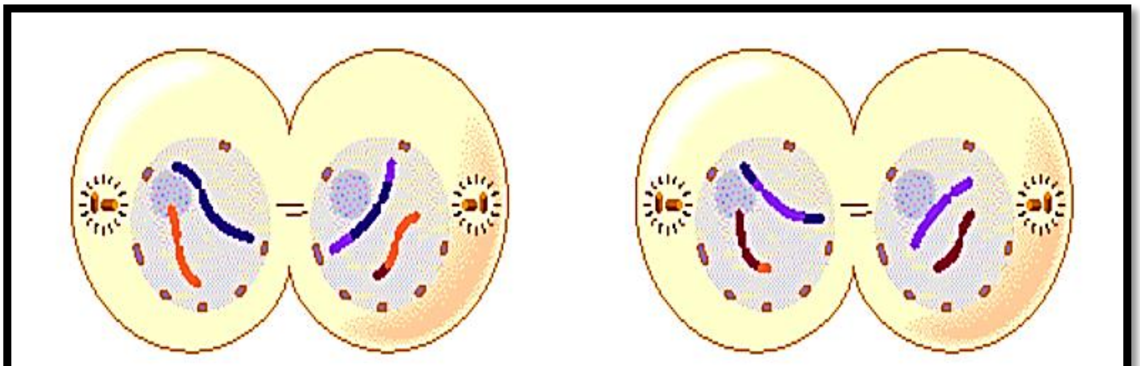
2.2.3- Anaphase II

At this stage separation of centromeres take place as well as that of sister chromatids. Chromosomes take their trip toward opposite poles. This chromatids that are separated are known as chromosomes in their own right.

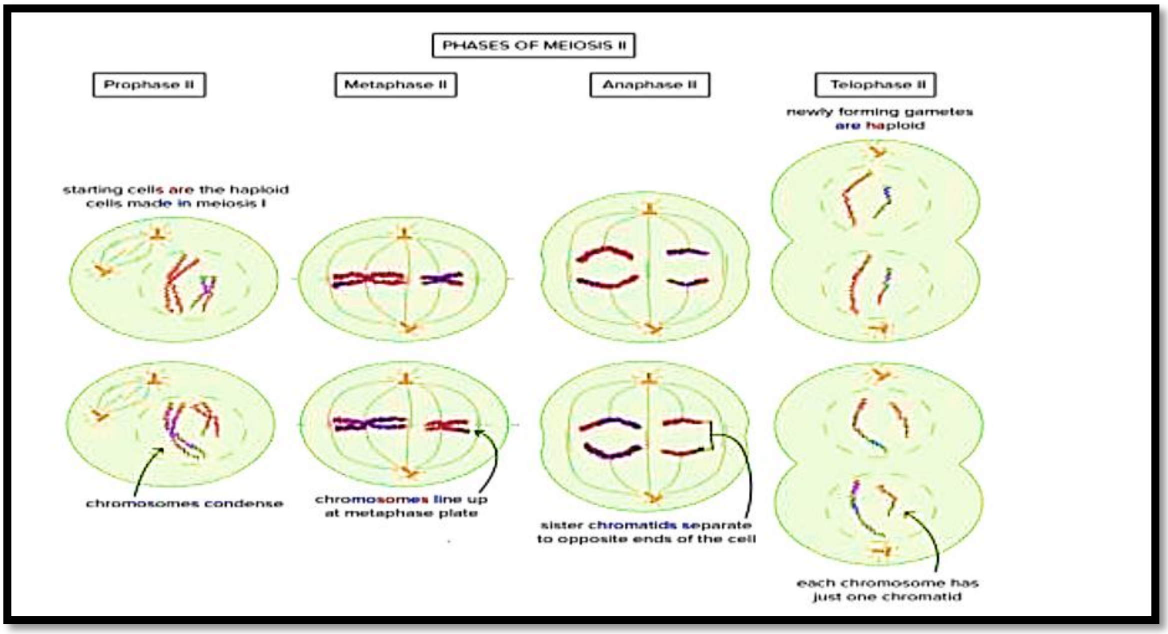


2.2.4-Telophase II

In second telophase, the formation of nuclear envelope take place on each part of chromosomes and time of cytokinesis arrives. Production of four daughter cells take place and diploid already changed to haploid. Crossing happened in meiosis I, allow chromosome to have some characters from parent chromosomes.



Four haploid daughter cells


PHASES OF MEIOSIS II
Prophase II
Metaphase II
Anaphase II
Telophase II
newly forming gametes are haploid
starting cells are the haploid cells made in meiosis I
chromosomes condense
chromosomes line up at metaphase plate
sister chromatids separate to opposite ends of the cell
each chromosome has just one chromatid

Lecture 11

Programmed cell death

The necessity for cell death in multicellular organisms

The ability to undergo programmed cell death is a built-in latent capacity in virtually all cells of multicellular organisms. Cell death is important for embryonic development, maintenance of tissue homeostasis, establishment of immune self-tolerance, killing by immune effector cells, and regulation of cell viability by hormones and growth factors. It has been proposed that most metazoan cells will die if they fail to receive signals from other cells. Abnormalities of the cell death program contribute to a number of diseases, including cancer, Alzheimer's disease, and acquired immune deficiency syndrome (AIDS) .

Programmed cell death :- An active cellular process that culminates in cell death. This may occur in response to development or environmental cues or as a response to physiological damage detected by the cell's internal surveillance networks .

Although cells die in many ways , it is useful to focus on the two poles of this spectrum :- Apoptosis and Necrosis .

Necrosis (Accidental Cell Death):- Cell death that results from irreversible injury to the cell. Cell membranes swell and become permeable . Lytic enzyme destroy the cellular contents, which then leak out into the inter-cellular space, leading to the mounting of an inflammatory response .

Changes that occurs during necrosis:-

1- the loss of plasma membrane integrity induces cellular contents to escape to the extracellular space, causing inflammatory responses.

2- Cell disintegration is preceded by a series of morphological changes, including disruption of cell organelles, such as swelling of the ER and mitochondria, or decay of the Golgi apparatus.

3- An influx of calcium ions from the extracellular matrix activates intracellular nucleases that fragment DNA.

4- Freed lysosomal hydrolases contribute to the degradation of nucleic acids and proteins.

5- Decay products activate leukocytes, lymphocytes, and macrophages that phagocytes the remnants of dead cells.

Apoptosis :- One type of programmed cell death that initially was characterized by a particular pattern of morphologic changes but now is defined by the action of molecular pathways involving cell surface receptors or mitochondria and resulting in the activation of specialized proteases. The name comes from the ancient Greek, referring to shedding of the petals from flowers or leaves from trees . Apoptosis is observed in all metazoans, including both plants and animals .

Apoptosis death occurs in two phases . During the **latent phase**, the cells looks morphologically normal but is actively making preparation for death. And **execution phase** is characterized by a series of dramatic structural and biochemical changes that culminate in the fragmentation of the cell into membrane-enclosed apoptotic bodies .

The dramatic morphological and physiological changes include :-

1- loss of microvilli and intercellular junctions

2- shrinkage of the cytoplasm

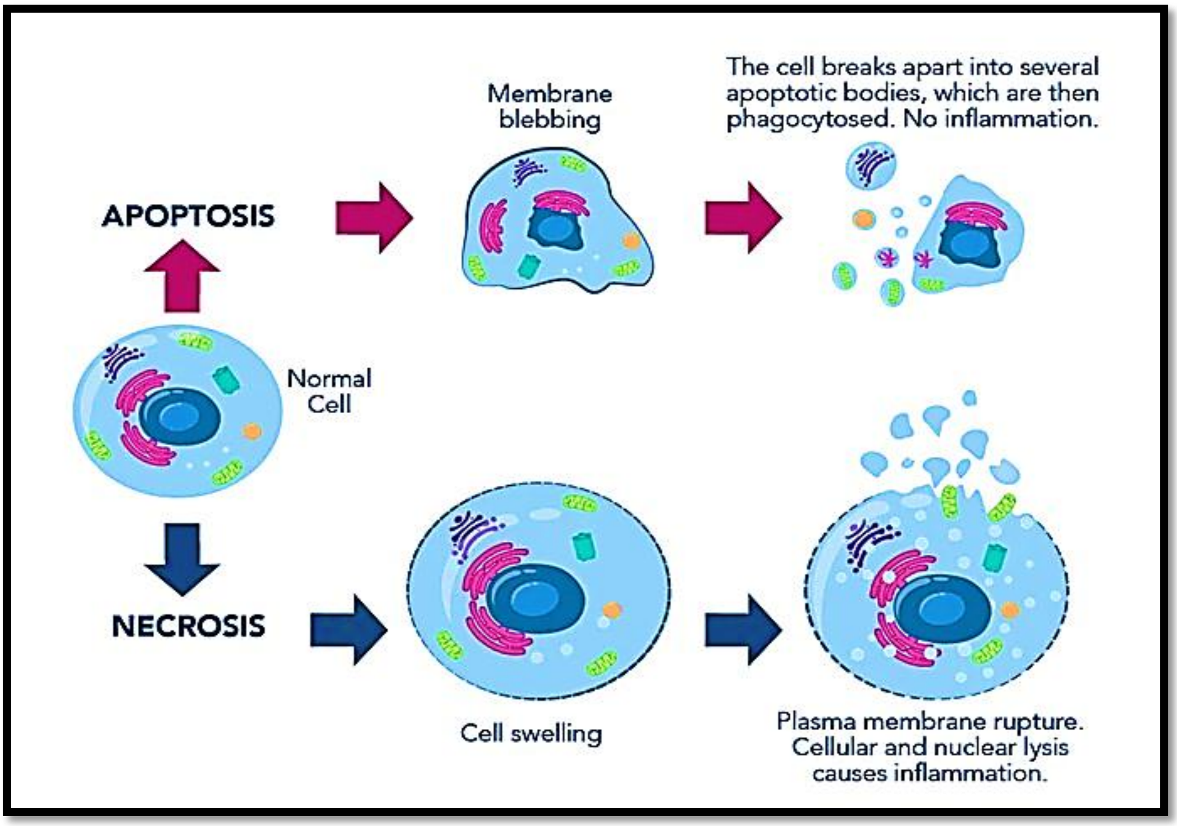
3- dramatic changes in cytoplasmic motility with activation of violent blebbing .

4- loss of plasma membrane asymmetry with the distribution of phosphatidylserine being randomized so that it appears in the outer membrane leaflet .

5- hypercondensation of the chromatin and its collapse against the nuclear periphery.

6- the explosive fragmentation of the cell into membrane-enclosed apoptotic bodies that contain remnants of the nucleus, mitochondria and other organelles.

- Activities that cause cells to undergo apoptotic are said to be pro-apoptotic , and activities that protect cells from apoptosis are said to be anti-apoptotic.



Differential features of apoptosis and necrosis

Apoptosis	Necrosis
Affects single cells	Affects groups of neighboring cells
No inflammatory response	Significant inflammatory response
Cell shrinkage	Cell swelling
Membrane blebbing but integrity maintained	Loss of membrane integrity
Increased mitochondria membrane permeability, release of proapoptotic proteins and formation of apoptotic bodies	Organelle swelling and lysosomal leakage
Chromatin condensation and non-random DNA fragmentation	Random degradation of DNA
Apoptotic bodies ingested by neighboring cells	Lysed cells ingested by macrophages

Classes of cells that undergo programmed cell death

There are six distinct classes of cells undergo programmed cell death :-

1- Developmentally detective cells

2- Excess cells

3- Cells that serve no function

4- Cells whose cell cycle is perturbed

5- Virus- infected cells

6- Chemotherapeutic killing of cells

Physiological events during apoptosis and necrosis

		Apoptosis	Necrosis
Morphological Changes	1- Cell	Shrinkage and loss of cell-cell contacts; apoptotic cells phagocytes neighboring cells	Swelling; cell lysis
	2- Plasma Membrane	Blebbing with intact cell integrity, formation of apoptotic bodies at late stages	Loss of integrity; increased permeability
	3- Organelles	No visible changes	Cell fragmentation
	4- Nucleus	Chromatin condensation, fragmentation	Condensation of chromatin and disintegration of the nucleus
	5- Mitochondrion	Decrease in membrane potential, swelling	Non-functional, swelling and fragmentation
Biochemical changes	1- DNA	Endonuclease-induced cleavage to fragments of specific lengths (DNA laddering)	Random degradation of genomic DNA
	2- Proteins	Kinases activation; phosphatases, caspases, and nucleases	Unspecific degradation
	3- Anti-apoptotic proteins	Bcl-2 family proteins, Inhibitor of Apoptosis Proteins (IAPs), caspase inhibitors	Bcl-2 expression in some cases
	4- Energy	ATP-dependent	ATP-independent
Tissue response		1- Restricted to individual cells 2-Induced by physio-logical changes (e.g., Ca^{2+}, free radicals, hormones, toxins, depletion of growth factors) 3-Usually no inflammatory response	1- Necrosis often affects groups of cells rather than a single cell 2- Induced by external and internal pathological conditions 3- Enhancement of inflammatory response
Post-death clearance		Phagocytosis	Cell lysis