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CYTOLOGY

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رؤية الكلية

التميز فى تعليم العلوم الأساسية والبحث العلمى للمساهمة في بناء اقتصاد الوطن

رسالة الكلية

تقديم تعليم متميز فى مجالات العلوم الأساسية وإنتاج بحوث علمية تطبيقية تدعم اقتصاد الوطن من خلال إعداد خريجين متميزين طبقا للمعايير الأكاديمية القومية وتطوير مهارات وقدرات الموارد البشرية وتوفير خدمات مجتمعية وبيئية تلبى طموحات مجتمع جنوب الوادى وبناء الشراكات المجتمعية

رؤية القسم

خريجون وباحثون متميزون علميا وبحثيا محليا ودوليا خدمة للمجتمع وتنمية للبيئة

رسالة القسم

يسعى قسم علم الحيوان بكلية العلوم من خلال ما يقدمه من برامج تعليمية متطورة وبحث علمى تطبيقى وبنية أساسية مناسبة إلى خريجين متميزين محليا ودوليا فى مجالات العلوم البيولوجية ينتفع بهم المجتمع وسوق العمل

Course Description

A-Theoretical

Evolution of the cell - Cell organization and subcellular structure - macromolecular structure, synthesis and processing- Plasma membrane structure and behaviors - Transport across cell membrane – Chromosomes - Mechanics of cell division- Cell dynamics - Organelle biogenesis and cell specialization.

B- Practical

Experimental techniques used in cell biology to study cell growth, manipulation and evaluation.

The aims of the course study

1-Giving the student abundant information about a cell, studying living cells; its properties, structure and components, the organelles present in it, its interaction with the environment, its life cycle, division and death.

2-Introduce the student to the chemical and macromolecular composition of the cell.

3- Introducing the student to the genetic content of the organism and the role of the cell in the inheritance of hereditary trait

بسم الله الرحمن الرحيم

الحمـد لله و الصلاة و السلام على رسول الله و على آله وصحبة و سلم تسليما كثيرا
وبعـــــــــــد،،،،،

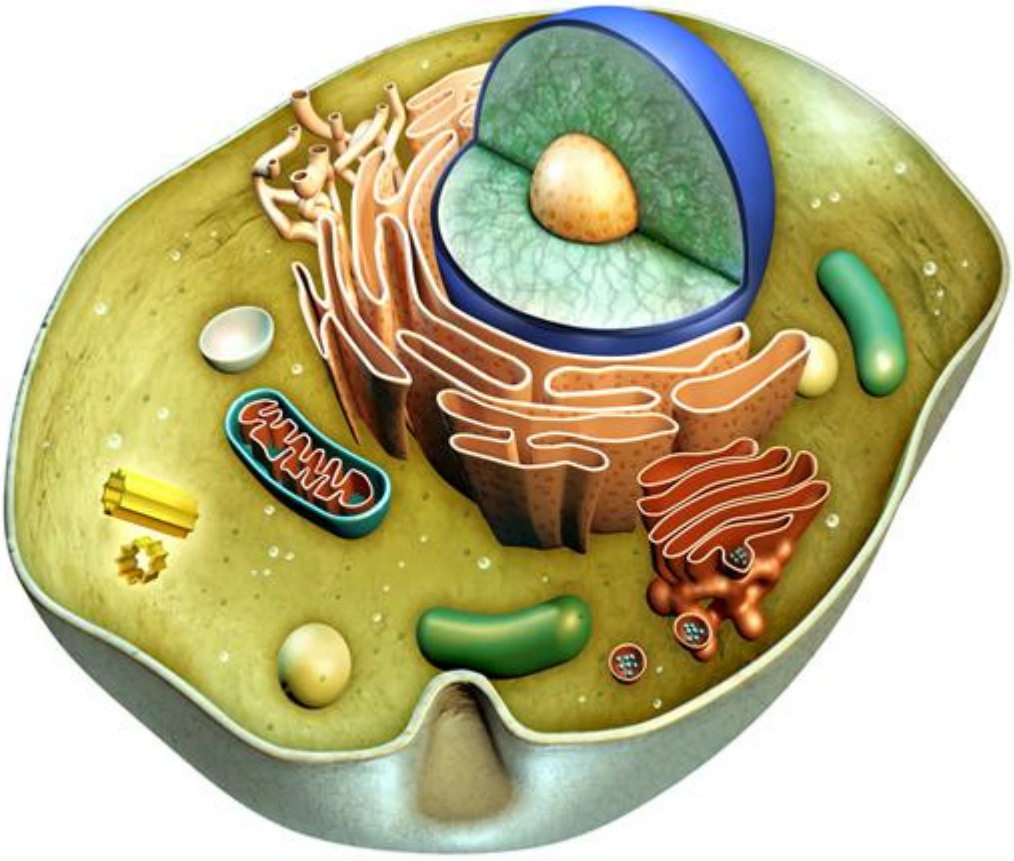
جميل جدا أن يرتبط الايمان بعلم له عمقه ومغزاه .... خاصة اذا كان هذا العلم فى آيات الله .... فعالم الدين الورع تسعده آيات القرآن الكريم سعادة لا تدانيها سعادة أخرى ..... خاصة اذا تأمل فى معانيها و تذوق جمالها و كذلك يكون رجل العلم التجريبى المتأمل فى آيات الخلق الكثيرة التى تنظم تواجد مخلوقات الله كما يشاء المولى عز و جل و التى تمتد حوله بلا حدود. اذ يسعد و يخشع لنظمها المتقنة و دقتها المتناهية. لذا فما أجمـل ما عبـر القــرآن الكريم أروع تعبيـــر (و فى الأرض آيات للموقنين و فى أنفسكم أفلا تبصرون). لذا فالآيات القرآنية كثيرة الإشارة إلى الحض على التأمل فى الآيات الكونية و البحث فى النواميس الطبيعية، لأن مغزى ذلك لا يخفى على لبيب ، اذ بقدر ما نكتشف من بديع صنع الله بقدر ما تتجلى لنا عظمته و دقته ، خلق فسوى و قدر فأبدع (الذى خلق فسوى و الذى قدر فهدى)، و عندئذ نتقرب اليه أكثر و أكثر و نعبده عبادة قائمة على علم و هدى خير و أبقى من عبـــادة لا تساندها معرفة حقـــه بالله سبحانه فى قدره و شأنه.

الانسان بلا شك خلق عظيم، ولكن ذلك لا يتجلى لنا الا بالبحث فى أصول هذا الخلق والتطلع الى تكويناته المذهلة التي أعيت العقول. ولا شك أننا كلما تعمقنا في دراسة الجسم البشرى كلما أدركنا المعنى العظيم الذي تنطوي عليه بعض الآيات القرآنية والتي أشارت الى ضرورة التأمل في أنفسنا و فى كل شئ حولنا، فهذا يوضح لنا ما خفى علينا من أسرار و ما أكثر ما يخفى علينا من أسرار. فهل ندرك بحق كيف تعمل هذه الأعضاء (السمع والحس، الابصار والفؤاد) فلو عرفنا ذلك حق المعرفة لاستقر الايمان بقلب المسلم. ايمانا بالله تعالى منزل القرآن ومرسل الرسل ومجازى الناس على اعمالهم كلا بما كسبت جوارحه.

والله أسأل أن يتقبل هذا العمل والجهد فانه جهد المقل. وأسأله أن ينفع به ويجعله خالصا لوجهه الكريم. و يجعله ذخرا لي عند انقطاع عملي و انتهاء أجلى و يتجاوز به عن ذلتي و يمحو به خطيئتي، انه أهل التقوى و أهل المعرفة.

أ.د / عبد الباسط مسعود عبيـد

CYTOLOGY



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Introduction

What kind of science is this that we are talking about, it is the science of creation, survival, existence for any being? It is the science of the beginning and the end of creatures, the cytology. Also it is defined as the science that deals in detail with the study of the cell and its contents and what goes on inside it of the various vital processes. In other words, it is the science that deals with structural and functional system of protoplasm and its relationship to various vital activities including growth of cells and development, genetics and other different processes. Therefore, cytology is one of the branches of biological sciences that specializes in studying the composition, chemistry and functions of cells. The cell is the unit structure and functional of living organism.

After the invention of the light microscope, scientists were able to see tiny units that could not be seen with the naked eye, and they called them cells. Cells are considered to be the essential units of living organisms. Therefore, the discovery of the cell is a very important matter and has a great impact, because we are living in these days the revolution of technological progress, biotechnology, which is the accurate analytical period of science, and therefore it has become almost certain to identify the vital activities and the various processes that occur within this delicate entity that is not seen with the naked eye. Here the hand of divine power is manifested in this delicate structure, so that every intelligent person can contemplate who created this entity and commanded it to work non-stop, without maintenance, without spare parts. After identifying the accurate analysis of the cell, its main elements are separated so that scientists can identify the different forms of energy that exist inside the cell, which are called manifestations of cell life.

Evolution of the cell

Life on Earth 4 billion years ago was very different than they are today. The atmosphere lacked oxygen, and an ozone layer did not yet protect Earth from harmful radiation, heavy rains, lightning and volcanic activity were common. Yet the earliest cells originated in this extreme environment. Today, a group of single-celled organisms called archaeabacteria, or archaea, still thrive in extreme habitats.

Astrobiologists are now using archaea to study the origins of life on Earth and other planets. Because archaea inhabit places previously considered incompatible with life, they may provide clues that will improve our ability to detect extraterrestrial life. Interestingly, current research suggests archaea may be capable of space travel by meteorite. Such an event could have seeded life on Earth or elsewhere.

The oldest cells on Earth are single-cell organisms called bacteria. Fossil record indicate that mounds of bacteria once covered young Earth. Some began making their own food using carbon dioxide in the atmosphere and energy they harvested from the sun. This process (called photosynthesis) produced enough oxygen to change Earth's atmosphere. Soon afterward, new oxygen-breathing life forms came onto the scene. With a population of increasingly diverse bacterial life, the stage was set for some amazing things to happen.

There is compelling evidence that mitochondria and chloroplasts were once primitive bacterial cells. This evidence is described in the endosymbiosis theory. Symbiosis occurs when two different species benefit from living and working together. When one organism actually lives inside the other it's called endosymbiosis. The endosymbiosis theory describes how a large host cell and ingested bacteria could easily become

dependent on one another for survival, resulting in a permanent relationship. Over millions of years of evolution, mitochondria and chloroplasts have become more specialized and today they cannot live outside the cell.

Mitochondria and chloroplasts have striking similarities to bacteria cells. They have their own DNA, which is separate from the DNA found in the nucleus of the cell. And both organelles use their DNA to produce many proteins and enzymes required for their function. A double membrane surrounds both mitochondria and chloroplasts, further evidence that each was ingested by a primitive host. The two organelles also reproduce like bacteria, replicating their own DNA and directing their own division.

Mitochondrial DNA (mtDNA) has a unique pattern of inheritance. It is passed down directly from mother to child, and it accumulates changes much more slowly than other types of DNA. Because of its unique characteristics, mtDNA has provided important clues about evolutionary history. For example, differences in mtDNA are examined to estimate how closely related one species is to another.

History of cytology

Our knowledge of animal and plant organisms did not go beyond the apparent or morphological description of the animal or plant, which is seen with the naked eye, but after the discovery of the light microscope, we can study the fine structure of these organisms. In the year (1665-1668) Robert Hooke examining a thin section of cork plant under a light microscope, and noticed that it compose of small hollow chambers, which he called cells because they resemble honey bee cells, Therefore, Robert Hooke became the first scientist to use the term cell and defined it as a chamber, cavity surrounded by a wall.

In the year 1700, Leiuwin Hooke discovered the nucleus inside red blood cells in salmon, and thus the definition of the cell became as a cavity containing a nucleus and surrounded by a wall, while Robert Brown (1831) confirmed the presence of the nucleus inside every animal cell. In 1835, also Dejardin said cell contents a jelly-like substance, elastic, contracted, clear, homologous, and insoluble in water, it named as sarcod.

While in 1838, Schleidin, explained that plant cells are the structural units of plants, he is the first scientist to introduce the term plant cell to plant organisms, and therefore plant tissues are nothing but aggregations of cells. And so the cell became the structural unit of the plant, and also after one year, in 1839, Schwann reached the same conclusion for the animal, the animal cell is the structural unit of the animal, and Schwann was the first to use the concept of cell theory, which is that "cells are living organisms, and that plants and animals are aggregations of these organisms arranged according to special laws, all living organisms may be animals or plants are composed of cells.

In 1840 Perkeinje called the contents of the animal cell protoplasm, and six years later (1846) Vonn endorsed Perkeinje's opinion and used the concept of protoplasm on the contents of the plant cell. The cell was defined as a mass of protoplasm containing a nucleus and surrounded by a membrane, but this definition lacks accuracy for the following reasons; some cells contain two nuclei or more and in contrast a mature red blood corpuscles in human do not contain a nucleus. In the year (1841) Rimac discovered direct cell division (amitosis), while Schneider in the same year was able to discover mitosis for the first time also in the year (1854), Newport was able to see the entry of the sperm into the ovum of the frog, while Hertwig (1875) explained the fusion of the sperm with the egg.

Thus, the organic organization of the cell is recognized. One of the technical tools (electron microscope), which changed a lot of our previous knowledge about some scientific concepts, especially the cell, hence, we had to study the cell from two different concepts in order to properly identify the cell. The first concept is the living cell, and the second is the fixative cell. This is only possible in the presence of microscopes.

What meaning the cell?

A cell is a living organism that cannot be seen with the naked eye. It consists of three basic components, mass of protoplasm, with one or more nuclei or without, and surrounded by a membrane. It is the basic unit from which the bodies of all living organisms are composed, and it is small in size, the largest of which does not exceed 100 micrometers in size. A cell was defined as **"**unit of biological activity delimited by a semi permeable membrane and capable of self-reproduction in a medium free of other living systems. It is of two types: eukaryotic cells, which are cells whose nuclei are surrounded by a membrane (fungi, plants, and animals), but prokaryotic cells do not contain a nucleus surrounded by a membrane, (bacteria and archaea). Components of an animal cell from which the bodies of animals are composed. Animal cells contain organelles, such as cytoplasm, nucleus, mitochondria, endoplasmic reticulum, Golgi bodies, ribosomes, and others. They also contain special organelles that are not found in plant cells, such as the centrosome, lysosomes, cilia, flagella and surrounded by membrane.

Cell types

There are three types, first in terms of the nucleus: prokaryotic (bacterial cell) and eukaryotic cell (animal and plant cell), second in terms of

chromosome number: somatic cell, sexual cell, and three in terms of organ, and all of this shows the concept of cellular organization.

Cellular organization

The cell is the structural and functional unit of living organisms, and there is no typical cell because cells differ in shape, size, and function. So, there must be three main characteristics in the cell in order for it to live a free: the presence of the plasma membrane, the enzyme system for energy production necessary for construction processes, and the ability to reproduce. After that, cell science developed, and a modern classification of living organisms was developed, based on me.

Cellular organization, in which all organisms except viruses were included in two groups

1-Organisms with prokaryotic cells

2-Organisms with eukaryotic cells

Viruses are left out of this division and do not belong to any of the six known kingdoms as self-contained units.

Comparison of prokaryotic and eukaryotic cells

eukaryotic cells	Prokaryotic cells	Adjective
Mostly large (10-100 microns)	Mostly small (1-10 microns)	cell size
DNA is associated with histone and non-histone proteins	DNA with non-histone proteins	Genotype
Mitosis and meiosis	Direct binary division or budding	cell division
They are distributed in the cytoplasm and the ribosomes are larger in size	There are no..... except for some ribosomes	cytoplasmic organelles

It occurs as a result of complete fusion of the nuclei	By transferring genes in one direction	sexual system
flagella or complex cilia	Simple flagella in some bacterial species	movement members
Absorption, ingestion and photosynthesis relate to each other	Most of them are absorbed, and some are photosynthesized	nutrition
Mitochondria are present	Mitochondria are not present	Metabolic energy

Prokarytic cell

Bacteria

They are the largest of the prokaryotic families, it belong to the Monera kingdom and can be divided according to their forms or according to the type of their nutrition, or according to their movement.... etc. All types of bacteria reproduce asexually, although sexual reproduction has been observed in some types. The bacterial cell consists of the following:- nuclear material (the bacterial ring chromosome) that contains the genetic information, Plasma juice (cytosol) and contains ribosomes and organic matter, cell wall gives the cell its well-known shape, and it is thin but solid and semi-permeable, plasma membrane is a semi-permeable membrane contains respiration enzymes, capsule is found in some bacteria but not in all, also some bacteria do not have flagella used for locomotion and may be have cilia are minute extensions located around the cell.

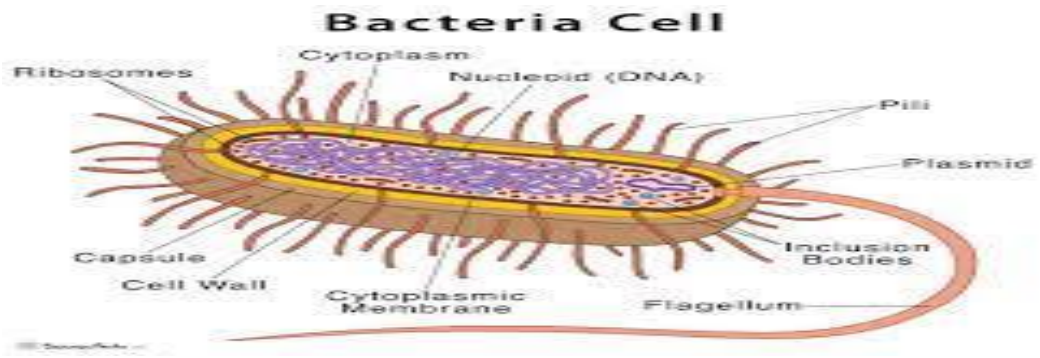
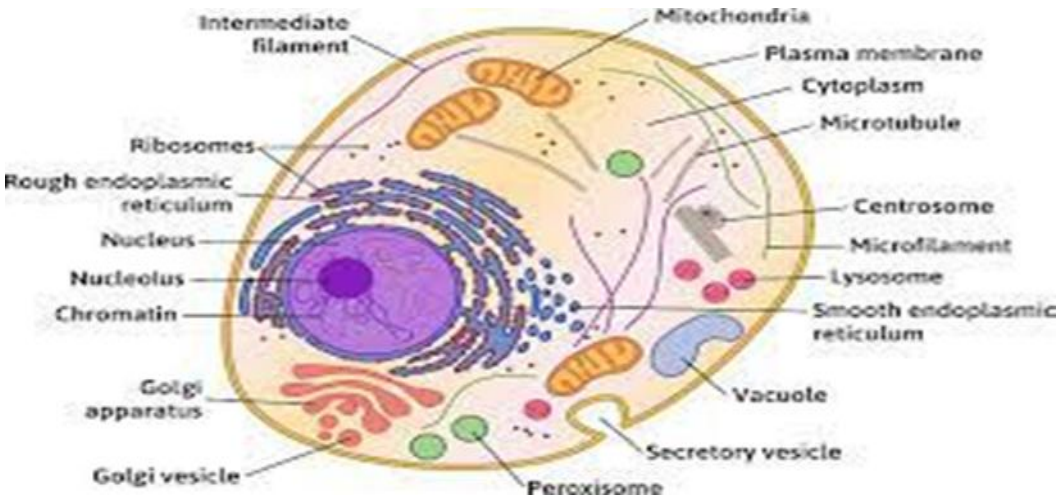


Fig (1): Bacteria cell

Eukaryotic Cell

The eukaryotic cell consists of a mass of protoplasm that contains one or more nuclei or not and is surrounded by a membrane (animal cell) or a wall (plant cell).



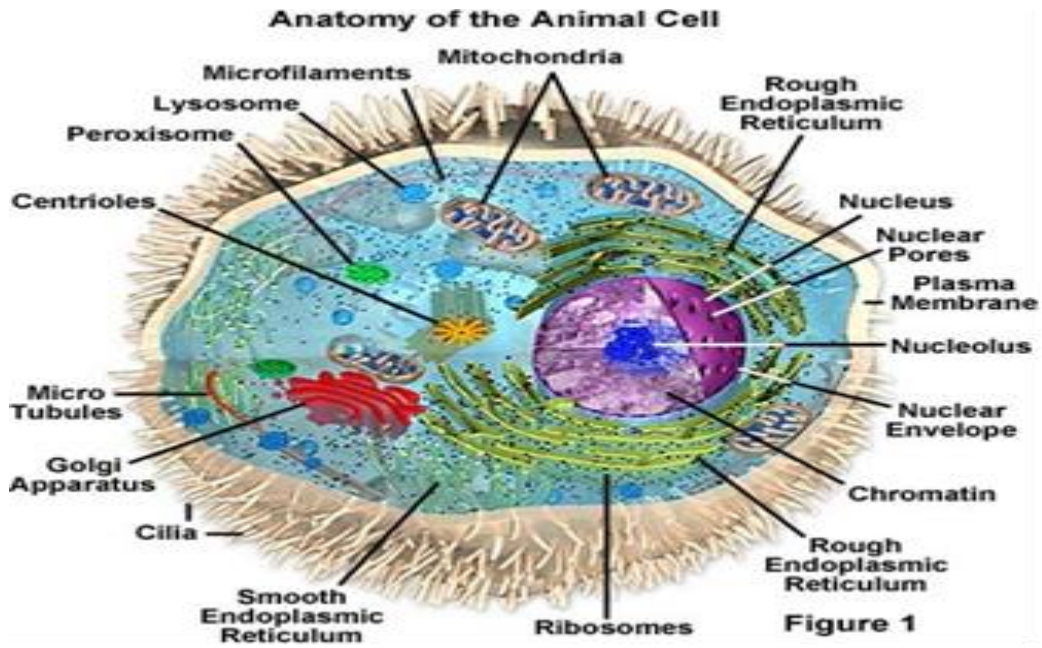


Fig (2): Animal cell

Chemistry of cell and macromolecules structure

Protoplasm

Protoplasm is the living substance of which all living animal and plant organisms are composed. Without protoplasm, there is no life at any level. Therefore, Huxley said in the year (1868) protoplasm is the physical basis of life. This means that all vital activities that are carried out the living organism is caused by the chemical and physical changes that occur in the physical basis of life (protoplasm). The term protoplasm means cytoplasm and nucleus.

Chemical composition of protoplasm

It is not possible to identify the exact chemical composition of protoplasm, fine chemical composition of protoplasm, as it is not possible to analyze the protoplasm without killing it by chemicals, and therefore chemical changes occur that result in new substances or the disappearance of substances from the basic components of the protoplasm. Also, the protoplasm during the normal activity of the cell secretions, thus, it analysis is not an accurate analysis. In addition protoplasm differs from one cell to another, for example, the protoplasm of the hepatic cell differs that of the nerve cell, and so on. Other elements as potassium, sulfur, sodium, magnesium, phosphorus, contains carbon, hydrogen, oxygen, and nitrogen, together form two types of organic compounds (proteins - fats or lipids - carbohydrates - nucleic acids) and inorganic components (water and mineral salts).

Organic components of the cell

Organic compounds, mean compounds that must contain both hydrogen H and carbon C together with the presence of any other elements. The animal cell contains four types of organic compounds:-

Proteins

Proteins are the most common widespread organic materials in animal protoplasm and among the distinctive forms of living matter are protein. protein include the following components: - Carbon (C), hydrogen (H), oxygen (O) and nitrogen (N), in addition to other elements such as sulfur (S), phosphorus (PH), calcium (Ca), and other elements. Protein molecules are complex in structure, their simplest structural units are amino acids.

Proteins - proteoses - peptones - polypeptides - dipeptides - amino acids.

These amino acids pass into the blood circulation, which carries them to the cells that convert them into animal proteins similar to body proteins, under the influence of special cellular enzymes. Hence, we find that each cell has a set of free proteins, from which the cell chooses what it needs to build for itself of necessary proteins, and these proteins are called the "cell pool".

Amino acids and their types

Amino acids are the main building blocks of proteins and peptides. Amino acids are a group of organic compounds consisting of at least an amine group (–NH2) linked to a carboxyl group (–COOH). Metabolism in the human body produces a large number of different amino acids.

1- Essential amino acids: live organism cannot produce within his body and must be added to food in order for the body to receive enough of them. They are eight acids (valine, leucine, and tryptophan).

2- Semi-essential amino acids: The body can produce them, but in insufficient quantities (histidine and arginine).

3- Non-essential amino acids: These are normal amino acids that the body can produce or take from food and represent the rest of the amino acids.

4- Anti-amino acids, which are ordinary amino acids, but their structure is changed, thus disrupting the chemical reactions of the amino acid. For example, ethionine, in which an ethyl group replaces a methyl group in methionine acid.

Types of proteins

Classification of proteins based on

First: The nature of the decomposition products of various complex substances into three types:

Simple proteins

The analysis of this type of protein gives amino acids only, for examples

A- Histones: - they dissolve in water, but do not dissolve in diluted ammonia. This protein is the main component of chromosomes. Organisms differ according to the difference in their contents of proteins.

B - Albumins: - Proteins that dissolve in water and also coagulate if exposed to heat. It is found in blood serum and transports fatty acids between tissues and organs.

C - Globulins: This type of protein is soluble in acids, alkalis and salt solutions, but it does not dissolve in water. It is a group of blood proteins made in the liver by the immune system. Globulins play an important role in liver function, blood clotting, and fighting infection. Globulin tests can be used to help diagnose a variety of conditions, such as liver damage or disease, kidney disease, autoimmune disorders and certain types of cancer.

D - Protamine: - dissolve in water, but do not coagulate with heat. It plays a very important role in the process of transferring genetic characteristics from one cell to another, as well as in regulating some biological reactions.

Conjugated proteins

In which simple proteins can be combined with other substances, and it has the following types:

A- Glycoproteins: In which proteins are bound together with carbohydrates

B - Nucleoproteins: - They result from the union of a protein with nucleic acid.

C- Lipoproteins, which result from the union of protein with fat.

Derived proteins

They are complex proteins that have undergone partial degradation, such as the decomposition of proteins into proteases, and proteoses into peptones, and so on.

Second: proteins according to shape

A - Fibrous proteins, which consist of several peptide chains that converge longitudinally, and each chain is coiled spirally along its length. They are characterized by a high molecular weight and resistance to dissolution in aqueous solutions. Examples of this type include wool, hair, and skin keratin, silk protein, myosin, and muscle lactin, which perform the mechanical work of muscle contraction, including: Blood brinogen is responsible for the formation of a blood clot, and in general proteins in which the axial ratio between the length and width of the molecule is more than ten are considered fibrous in shape.

B- Globular proteins consisting of several peptide chains stacked and fused together. They are characterized by a relatively small molecular weight compared to fibrous ones and are easy to crystallize. Examples of these

include insulin, hemoglobin, enzymes and hormones. They are often dissolved in aqueous solutions of salts, acids and alkalis. In general, their axial length/width ratio is less than ten and is usually less than ten, between (2-4).

Each organ in the body has the ability to choose the amino acids necessary for it, through which it can build its own protein. As for the rest of the amino acids in excess of the need, they are transformed into nitrogenous compounds, especially urea, which the body gets rid of by excreting it in the urine. It must be noted that the amino acids as well as the protein compounds in excess The body's need to build the cells necessary for its growth is not stored at all in the body, but rather gets rid of them constantly. Since amino acids are the only source of nitrogen necessary for humans or animals, they are therefore involved in the formation of some non-protein nitrogenous compounds necessary for the body, such as bile salts, creatine, pyrimidine, hormones, amino sugars, and others.

Sources of proteins

There are two sources of proteins, one of which is animal, such as meat of all kinds, fish, birds, and eggs, while the second source is vegetarian, such as various types of legumes; Beans - lentils - peas - beans - cowpeas and others.

The functions of proteins

Proteins play an important role of the organism, as

1-They are used as a real source of growth by adding it to the structure of the body.

2-Protein works to replace damaged protein fibers in the body

3- Contribute to the synthesis of hormones.

4-It has the ability to form important compounds for the body, such as hemoglobin and others.

Carbohydrates

They are compounds consisting of oxygen, hydrogen, and carbon. The first two elements are found in the same proportion in water. These substances are found in a complex form, such as animal starch (glycogen); disaccharides (sucrose, maltose and lactose), and other monosaccharides (glucose, fructose and galactose).

Types of carbohydrates

Carbohydrates can be divided into three types: Monosaccharide's, disaccharides, and polysaccharides. Monosaccharides and disaccharides are known as sugars due to their sweet taste. Therefore, they also have the ability to spread through saturated membranes. They also have solubility in water. As for the polysaccharides, they do not spread through the saturated membranes and do not crystallize and form colloidal solutions with water.

Monosaccharides are simple sugars, and the most important of these compounds in the animal cell are pentose and hexose sugars. Ribonucleic acid and Deoxyribonucleic acid, while the hexose sugars are responsible for providing the vital energy needed for the body. Monosaccharides, like most nutrients are absorbed in the small intestine. They can be absorbed without previously being broken down by the intestinal enzymes. Glucose and galactose are absorbed easily, completely and faster than other carbohydrates, while fructose can be absorbed slowly and incompletely. After ingestion, glucose and galactose quickly raise the blood sugar, while fructose raises blood sugar only mildly and slowly. During digestion, all

carbohydrates have to be broken down into monosaccharides in order to be absorbed.

Disaccharides consist of the union of two parts of monosaccharide's with the loss of a part of water and the most important of these types is milk sugar (lactose) and consists of two parts of glucose and galactose; Maltose consists of two parts of glucose, while cane sugar (sucrose) consists of two parts, glucose and fructose.

Polysaccharides are consists of the union of several molecules of monosaccharide's with the loss of molecules of water. One of the most important polysaccharides is plant starch (which represents the reduced carbohydrate substances in plant cells and is formed from carbon dioxide and water in the presence of chlorophyll) and plant cellulose (which is the main component of the plant cell wall and animal starch, which represents the reduced carbohydrates in animal cells, which It is of great importance to the animal, the largest part of it is found in the liver, which represents 3% of the weight of the liver, and the muscles, it known as glycogen.

Function of Carbohydrates

1-Although most body cells can break down other organic compounds for energy, all body cells can use glucose. Moreover, nerve cells (neurons) in the brain, spinal cord, and through the peripheral nervous system, and red blood cells, can use only glucose for energy.

2-Formation of the structural framework of RNA and DNA (ribonucleic acid and deoxyribonucleic acid).

3-Form structural elements in the cell walls of plants (cellulose) and cell membrane of animals.

4-Carbohydrates are present in very small amounts in cells' structure for instance, some carbohydrate molecules bind with proteins to produce

glycoproteins, and others combine with lipids to produce glycolipids, both of which are found in the membrane that encloses the contents of body cells.

5- Eating approximately 25 to 29 grams of dietary fiber daily can reduce the risk of developing some chronic diseases, such as type 2 diabetes, cardiovascular disease, breast cancer, and colorectal cancer.

6- Drinking fluids rich in carbohydrates before surgery reduces energy loss in the body after surgeries, while maintaining stomach pH and blood glucose levels.

7- Eating dietary fiber, both soluble and insoluble carbohydrates, helps reduce the risk of obesity.

Nucleic acids

Nucleic acids are very important chemical compounds, and found in all living organisms, at least found one acid, bacteria (deoxyribonucleic acid), but higher plants and animals contain both ribonucleic acid (DNA&RNA). These occur in the nucleus and mitochondria only, and formed most of the chromosomal composition. Deoxyribonucleic acid combines with proteins (peptones and protamine's) to form nucleoprotein.

The nucleic acids represent the identity card for every living organism through which the genes responsible for showing the hereditary characteristics (physical and sexual) of each organism are carried.

Components of nucleic acids

The simple unit of nucleic acids is nucleotide, which consist of three molecules: a pentose sugar (ribose or deoxyribose), a phosphoric acid, and a base nitrogen (pyrimidine or purine bases). The pentose sugar and basic nitrogen's are known as nucleosides, and the pyrimidine nitrogenous bases

are cytosine, thymine, and uracil, while the purine nitrogenous bases consist of adenine and guanine, and both DNA and RNA contain adenine, cytosine and guanine, in addition to thymine (DNA), while RNA contains uracil.

Function of DNA

DNA is genetic material which able to store information used to control both the development and metabolic activities of cells. DNA can be replicated accurately during cell division and transmitted for generations. Crossing over during meiosis produces natural recombination of DNA which is passed on to next generation to produce variants in all sexually reproducing organisms. DNA able to undergo mutations providing genetic variability required for evolution. Differentiation of various body parts is due to differential functioning of specific parts of DNA. Developmental stages occur in the life cycle of an organism by an internal clock of DNA functioning.

Function of RNA

The RNA plays important role in protein synthesis. RNA picks up a specific amino acid from the cytoplasm carries it to the site of protein synthesis and attaches itself to ribosome in accord with the sequence specified by mRNA. It transmits its amino acid to the polypeptide chain. In protein synthesis tRNA acts an adaptor molecule which is meant for transferring amino acids to ribosomes for synthesis of polypeptides. There are different tRNAs for different amino acids. Codons are recognized by anticodons of tRNA.

Lipids

They are a substances that represent another source of energy, and therefore consist of the same elements that make up carbohydrates,

namely: Hydrogen, oxygen, carbon, and other elements. Lipids insoluble in water, but soluble in organic solvents such as petrol and some other solvents. Lipids include a diverse group of compounds that are largely nonpolar in nature. This is because they are hydrocarbons that include mostly nonpolar carbon–carbon or carbon–hydrogen bonds. Non-polar molecules are hydrophobic ("water fearing"), or insoluble in water. Lipids perform many different functions in a cell. Cells store energy for long-term use in the form of fats. Lipids also provide insulation from the environment for plants and animals. For example, they help keep aquatic birds and mammals dry when forming a protective layer over fur or feathers because of their water-repellant hydrophobic nature. Lipids are also the building blocks of many hormones and are an important constituent of all cellular membranes. Lipids include fats, oils, waxes, phospholipids, and steroids.

There are two types of fats in the tissues of the body: neutral fats and phospholipids, and the second represents the true fat of the protoplasm and true fats are not affected by various factors. For example, the fats that are found in brain tissues are real fats, and therefore during the fasting period they are not affected, and we also find that the liver represents the main axis of fats inside the body. Importance in the process of fat metabolism. The liver naturally contains 4% lipids (1:3 fats Essential and phospholipids) and the rate of fat in the liver increases during the first period of the fasting process, because the fatty substances move from the body stores to the liver to oxidize them, and then the fat in the liver begins to gradually decrease.

The importance of lipids

Fats play a vital and important role within the tissues of the body, and this role depends on their location and the image on them. For example, glycerides act as a source of thermal energy and a safety bulwark against

cold and help resist any harm to the body, while phospholipids are found within the nervous tissue. it is responsible for the formation of the myelin substance, through which the nerve fibers know whether they are myeline or not. Regulating the mechanical functioning of the skin and hair, such as cholesterol.

Second - inorganic components

Protoplasm contains inorganic components in the form of water and salts. Salts united with organic components, as they combine with protein materials (amino acids) forming some hormones (thyroxin) or some other compounds (hemoglobin & haemocyanine) and the concentration varies these elements are inside the cell rather than outside it.

Mineral salts

They are inorganic salts that are found dissolved in protoplasm and bodily fluids, constituting approximately 1% of body weight. Examples of these are potassium chloride, sodium chloride, calcium phosphate, carbonate, and other salts. Mineral salts play an important and vital role, For example, if the amount of calcium decreases from its normal rate in the blood, it may lead to death. Also, in the case of a deficiency of sodium and potassium from their usual percentage in the body, the heart and muscles cannot perform their functions in a natural way. It is accepted by specialists that the teeth and bones consist mainly of calcium salts.

Salts dissociate into ions, these ions are electrolytes; they are capable of conducting an electrical current in solution. This property is critical to the function of ions in transmitting nerve impulses and prompting muscle contraction. Many other salts are important in the body. For example, bile salts produced by the liver help break apart dietary fats, and calcium phosphate salts form the mineral portion of teeth and bones

Water

God Almighty says in His Noble Book: “In the name of God, the Most Gracious, the Most Merciful, and We made from water every living thing”. Water almost, for example but not limited to, water is used as a solvent for many different compounds, as it is the medium that is essential for the occurrence of most, if not all, of the bodily physiological processes such as digestion, respiration, excretion, absorption, excretion, and other various processes, along with This works to protect the body from sudden changes in temperature.

The amount of water varies from one tissue to another, as the human bone tissue contains approximately 10%, while the muscle tissue contains approximately 75%. Even in one organ, the amount of water varies from tissue to tissue, for example, the white matter tissue in the brain contains 68 % while the tissue of the gray matter of the brain contains approximately 84% of water. Also, the amount of water for the same tissue varies according to the age of the tissue, as the tissue in the embryonic stages contains a higher percentage of water (to 90%) than in the aging stage (to 75%), of the mouse brain weight. Therefore the percentage of water inside the tissue is related to the functional performance of the tissue.

Cytoplasm

Cytoplasm is a viscous (gel-like) substance surrounded by the cell membrane. It consists of cytosol as well as inclusions and a number of cellular organelles with different functions.

Components of the cytoplasm

A- Cytoplasm: a sticky substance that contains water, proteins, carbohydrates, enzymes and inorganic salts.

b- Cytoplasmic organelles: living structures that float in the cytoplasm and perform certain functions that serve the life of the cell. It is divided into membranous organelles and non-membranous organelles.

C- Cytoplasmic Inclusions: Non-living substances stored in the cytoplasm. It includes storage nutrients such as glycogen, fats, and pigments such as hemoglobin, melanin, etc. It also includes some crystals.

Function

If the cell is devoid of cytoplasm, it will not be able to maintain its shape, it will be hollow and flat, and the organelles will not remain suspended in the cell solution without the support of the cytoplasm. Most of the enzymatic reactions and metabolic activity of the cell occur in the cytoplasm. The cytoplasm helps move substances, such as hormones, around the cell and also dissolves cellular waste.

The living components of the cell protoplasm

The cell protoplasm includes many living components, including:-

The plasma membrane

Daniele (1952) dealt with the structure of the cell membrane in the form of a model known as Daniele's model of the cell membrane, in which he shows that the cell membrane consists of three layers and not one layer, the outer and inner layer are proteins, while the middle layer is lipids (fats), but this structure did not explain how substances that are not soluble in fats enter the cell, then Danielle (1954) developed his idea, explaining that the cell membrane is a non-continuous structure and that it contains bores through which substances that do not soluble in lipids pass into the cell. Robertson (1959) said that the cell membrane is a three-layered structure and the double layer of lipids has a hydrophilic outer part while its inner part is hydrophobic, and that the cell membrane is surrounded from the

outside by a thin surface layer of mucous sugary substances called the goblet envelope or sugar coat.

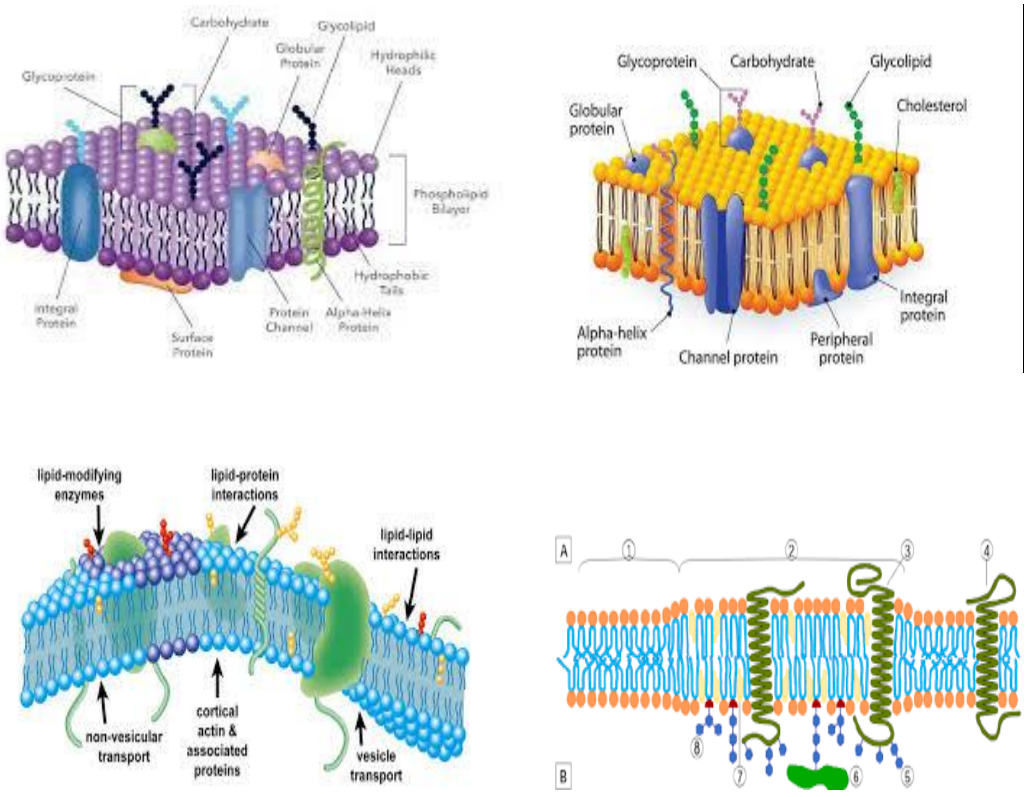


Fig (4): cell membrane

Chemical composition of plasma membrane

The cell membrane is composed of two basic chemical compounds, in addition, some cell membranes contain a third chemical compound. The cell membrane is composed mainly of lipids at a rate of up to 30% and proteins at a rate of up to 70%, and it also contains carbohydrates from 1% to 5% according to Robertson in 1959. About 30 enzymes have been found in various membranes. Those most constantly found are 5'-nucleotidase, Na^+-K^+ activated ATPase, alkaline phosphatase

Lipids

The cell membrane consists of three classes of lipids: phospholipids, glycolipids, and cholesterols. The amount of each depends upon the type

of cell, but in the majority of cases phospholipids are the most abundant. Cholesterol molecules scatter between phospholipids, thus maintaining the plasticity of the plasma membrane, and preventing the cell membrane from being filled with phospholipids. Cholesterol is found only in animal cell membranes, and it is not found in plant cell membranes. Glycolipids are found on the outer surface of the plasma membrane, and they have a role in distinguishing cells from other cells that make up the body. Fatty acids may be saturated or unsaturated.

Plasma membrane lipids are arranged in two layers, and are facultative permeable; That is, it allows certain molecules to pass through it and not others, depending on the cell's need for them. Among the types of fats in the plasma membrane are phospholipids, which are an essential part of the bilayer plasma membrane lipids, and they consist of two parts; Hydrophilic heads, and therefore are arranged so that they face the cytosol (the watery part of the cytoplasm), the fluids that exist outside the cell, and hydrophobic tails; Therefore, there are two layers of water-loving heads; This is so that it is far from the cytosol and the fluids that exist outside the cell.

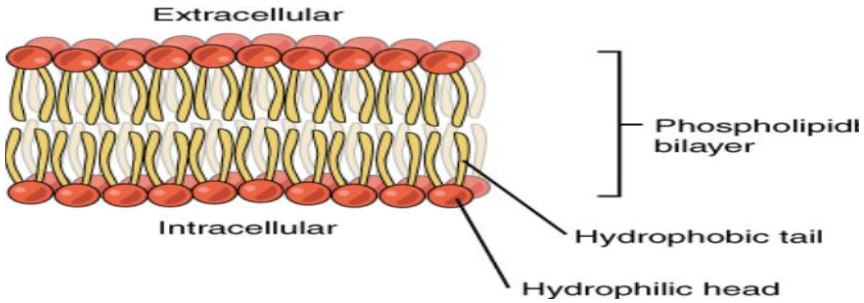


Fig (4): cell membrane

Proteins

Proteins are the second major component of plasma membranes. There are two main types of membrane proteins: integral and peripheral. In addition

to lipids, membranes are loaded with proteins. There are two types of proteins: Peripheral membrane proteins and integrated membrane proteins.

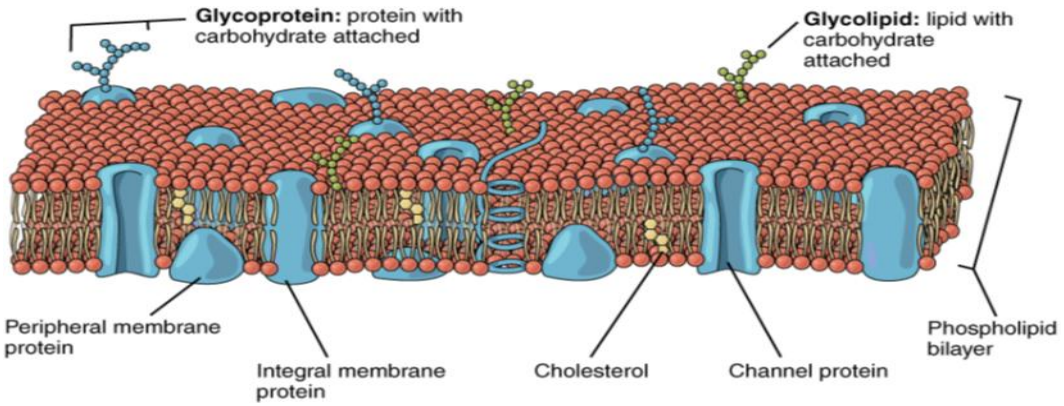


Fig (4): cell membrane

a- Peripheral membrane proteins

Peripheral membrane proteins are proteins that are not directly related to cellular communication, but rather related to other proteins that are found in the membrane.

b- Integrated membrane proteins

The second type of proteins are the integrated membrane proteins, which are embedded in the plasma membrane, and their tips extend to appear on either side of the membrane. Types of protein in cell membrane.

Proteins can be divided according to the function they perform into the following types

1-Structural proteins have several properties, their building begin immediately after DNA replication. Structural proteins are divided into three major types, and eight minor ones. Structural proteins provide support for bone, cartilage, hair and muscle Structural proteins include collagen, actin, and keratin proteins.

2- Receptor proteins are a special type of proteins that support the life of the cell, and work by providing special places on them (receptors) that are

ready to bind to various molecules, as this receptor, when associated with a specific molecule, can change its shape and send a signal that carries a specific meaning to the cell to cause specific response. Receptor proteins are characterized by staying most of the time on the surface of the cell, and in some other cases moving around, performing a series of complex functions.

3- Transport proteins are a type of proteins found in the cell membrane, which facilitate the process of transport and diffusion of materials, and one of its most prominent characteristics is the transportation of materials from inside to outside the cell through the plasma membrane. They are found in cell membranes, mitochondria, and chloroplasts.

4-Glycoproteins are molecules composed of both proteins and carbohydrates. It is characterized by the following: Glycoproteins are involved in many physiological functions; as the secretion of globin, which is necessary for the immune system. Glycoproteins help the body produce collagen and myosin. Glycoproteins in red blood cells determine blood type. Interferes with the synthesis of some gonadal hormones, such as; Hormones of growth, puberty, and reproduction.

Carbohydrates

Carbohydrates are the third major component of plasma membranes. In general, they are found on the outside surface of cells and are bound either to proteins (forming glycoproteins) or to lipids (forming glycolipids). These carbohydrate chains may consist of 2-60 monosaccharide units and can be either straight or branched. Along with membrane proteins, these carbohydrates form distinctive cellular markers, sort of like molecular ID badges, that allow cells to recognize each other. These markers are very important in the immune system, allowing immune cells to differentiate

between body cells, which they shouldn't attack, and foreign cells or tissues, which they should.

Function of plasma membrane

It maintains the individuality and form of the cell, keeps the cell contents in place and distinct from the environmental materials, protects the cell from injury, regulates the flow of materials into and out of the cell to maintain the concentration and types of molecules. Plasma membrane is infolds help in the intake of materials by endocytosis, It's out folds (microvilli) increase the surface area for absorption of nutrients. The out folds also form protective sheaths around cilia and flagella, receptor molecules permit flow of information into the cell, oligosaccharide molecule helps in recognizing self from non-self, permits exit of secretions and waste by exocytosis, it controls cellular interactions necessary for tissue formation and defense against microbes and It helps certain cells in movement by forming pseudopodia as in Amoeba and leucocytes.

Transport across cell membrane

When cells and their extracellular environments are isotonic, the concentration of water molecules is the same outside and inside the cells, and the cells maintain their normal shape (and function). Osmosis occurs when there is an imbalance of solutes outside of a cell versus inside the cell. A critical aspect of homeostasis in living things is to create an internal environment in which all of the body's cells are in an isotonic solution. Various organ systems, particularly the kidneys, work to maintain this homeostasis.

One of the great wonders of the cell membrane is its ability to regulate the concentration of substances inside the cell. These substances include ions such as Ca^{++} , Na^{+} , K^{+} , and Cl^{-}; nutrients including sugars, fatty acids, and

amino acids; and waste products, particularly carbon dioxide (CO2), which must leave the cell. The membrane's lipid bilayer structure provides the first level of control. The phospholipids are tightly packed together, and the membrane has a hydrophobic interior. This structure causes the membrane to be selectively permeable. One of the important functions of the plasma membrane is the transport of materials to and from the cell, and among the most important methods of transporting materials across the plasma membrane are the following

1-Diffusion: Diffusion is the movement of solutes across the plasma membrane from an area of high concentration to an area of low concentration to reach a state of equilibrium. That is, the presence of equal concentration on both sides of the plasma membrane, without the need for energy, or transport materials, such as: enzymes. Because cells rapidly use up oxygen during metabolism, there is typically a lower concentration of O2 inside the cell than outside. As a result, oxygen will diffuse from the interstitial fluid directly through the lipid bilayer of the membrane and into the cytoplasm within the cell. On the other hand, because cells produce CO2 as a byproduct of metabolism, CO2 concentrations rise within the cytoplasm; therefore, CO2 will move from the cell through the lipid bilayer and into the interstitial fluid, where its concentration is lower.

2-Facilitated diffusion the transfer of solutes from an area of high concentration to an area of low concentration with the help of transport proteins, without the need to expend energy. Facilitated diffusion is the diffusion process used for those substances that cannot cross the lipid bilayer due to their size and/or polarity. A common example of facilitated diffusion is the movement of glucose into the cell, where it is used to make ATP. Although glucose can be more concentrated outside of a cell, it cannot cross the lipid bilayer via simple diffusion because it is both large

and polar. To resolve this, a specialized carrier protein called the glucose transporter will transfer glucose molecules into the cell to facilitate its inward diffusion.

3- Active transport of substances across the plasma membrane against the direction of concentration; That is, from the region of low concentration to the region of high concentration with the help of transport proteins that act as a pump, and this type of transportation needs energy . During active transport, ATP is required to move a substance across a membrane, often with the help of protein carriers, and usually against its concentration gradient. One of the most common types of active transport involves proteins that serve as pumps.

Similarly, energy from ATP is required for these membrane proteins to transport substances molecules or ions across the membrane, usually against their concentration gradients (from an area of low concentration to an area of high concentration). The sodium-potassium pump, which is also called Na^{++}/K^{+} ATPase, transports sodium out of a cell while moving potassium into the cell. The Na^{++} /K^{+} pump is an important ion pump found in the membranes of many types of cells. These pumps are particularly abundant in nerve cells, which are constantly pumping out sodium ions and pulling in potassium ions to maintain an electrical gradient across their cell membranes.

An electrical gradient is a difference in electrical charge across a space. In the case of nerve cells, for example, the electrical gradient exists between the inside and outside of the cell, with the inside being negatively charged (at around -70 mV) relative to the outside. The negative electrical gradient is maintained because each Na /K pump moves three Na ions out of the cell and two K ions into the cell for each ATP molecule that is used. This

process is so important for nerve cells that it accounts for most of their ATP usage.

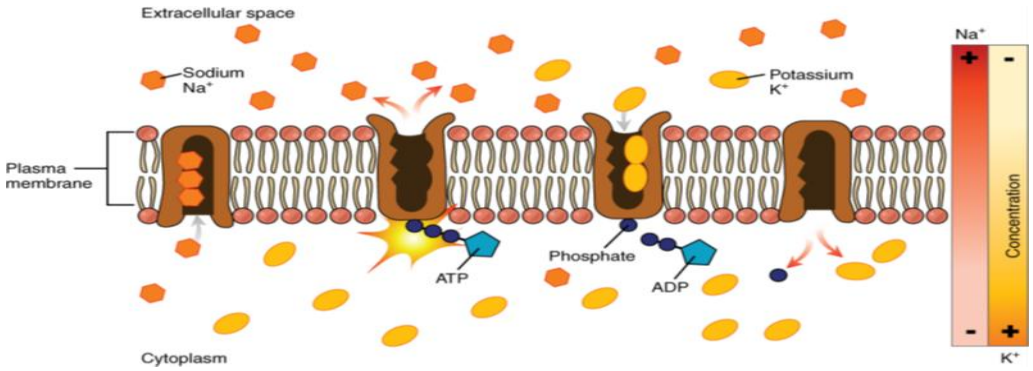


Fig (4): cell membrane

4-Filtration The transport of solutes, solvents, and ions across a membrane; with the help of hydraulic pressure. Another mechanism besides diffusion to passively transport materials between compartments is Filtration. Unlike diffusion of a substance from where it is more concentrated to less concentrated, filtration uses a hydrostatic pressure gradient that pushes the fluid and the solutes within it from a higher-pressure area to a lower pressure area. Filtration is an extremely important process in the body. For example, the circulatory system uses filtration to move plasma and substances across the endothelial lining of capillaries and into surrounding tissues, supplying cells with the nutrients. Filtration pressure in the kidneys provides the mechanism to remove wastes from the bloodstream.

5-Osmosis is the movement of a solvent from a lower concentration of a salute to a higher concentration.

6-Endocytosis (bringing "into the cell"): It is a method for transporting large-sized materials into the cell, and it takes place as follows: the cell membrane folds around the material that the cell needs inside, and a sheath or a small pocket is formed that begins to shorten and deepen to form a vesicle, which then separates from the cell membrane, thus becoming inside the cell, which is a process completely opposite to the method

cellular output. The cell will endocytose the part of the cell membrane containing the receptor-ligand complexes. Iron, a required component of hemoglobin, is endocytosed by red blood cells in this way. Iron is bound to a protein called transferrin in the blood. Specific transferrin receptors on red blood cell surfaces bind the iron-transferrin molecules, and the cell endocytosis the receptor-ligand complexes

7-Exocytosis (taking "out of the cell") the third major component of plasma membranes and it is the process of exporting material using vesicular transport.

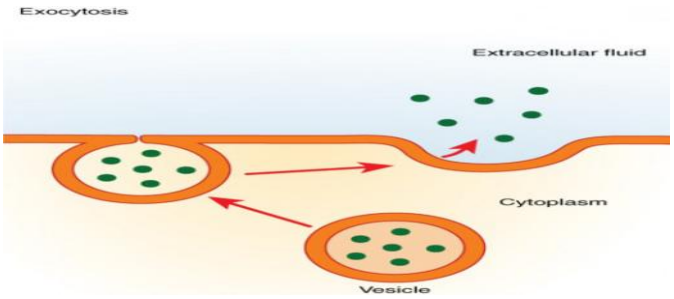


Fig (5): Endocytosis

Many cells manufacture substances that must be secreted, like a factory manufacturing a product for export. These substances are typically packaged into membrane-bound vesicles within the cell. When the vesicle membrane fuses with the cell membrane, the vesicle releases it contents into the interstitial fluid. The vesicle membrane then becomes part of the cell membrane. Cells of the stomach and pancreas produce and secrete digestive enzymes through exocytosis. Endocrine cells produce and secrete hormones that are sent throughout the body, and certain immune cells produce and secrete large amounts of histamine, a chemical important for immune responses.

Modification of plasma membrane

Plasma membrane shows some specialized structures to perform some additional functions plasma membrane shows some changes

1-Free Surface Modification

Microvilli

The plasma membrane forms finger-like structures on one of the cell surfaces. Microvilli are very fine growths. Single cell contains more than 3000 microvilli.The plasma membranes of cells specialized for absorption fold into finger-like protrusions that we call microvilli. These cells normally found in epithelial cells of intestine, kidney tubules, gall bladder and hepatic cells, the organ that absorbs nutrients from digested food. This is an excellent example of the following function of the form. People with celiac disease have an immune response to gluten, found in barley. The immune response damages the microvilli, so affected individuals cannot absorb nutrients. This leads to malnutrition, cramps and diarrhea.Function of microvilli increase the surface area for absorption.

2-Junctional Complex

a-Inter digitations

Plasma membrane of adjacent cells project into cytoplasm as finger-like projections. Found in lymph nodes and lymphoid tissues. Function increase surface area for exchange of substance between the cells.

b-Tight junction

Plasma membrane of adjacent cells fuses by extrinsic proteins. Found in brain cells, gall bladder and intestinal cells .Function adhesion.

c-Gap junction

Gap junction is channel through two cell membranes across the intercellular space between two adjacent cells. Found in cardiac muscles. Function conduct electrical signals & passage of ions, sugar, vitamin and metabolites.

D-Desmosomes

Desmosomes are thickened areas of plasma membrane of two adjacent cells. Found in cardiac muscle and skin cells. Function: help to glue the cells together.

e-Plasmodesmata

Cytoplasm of adjacent cell connected with cytoplasmic strands. Function: exchange of materials between two cells.

Cell organelles

There are many cellular organelles within the cell which are divided into two types:

1-Membranous organelles: They are surrounded by a membrane and include: endoplasmic reticulum - Golgi apparatus - mitochondria - lysosomes - vacuoles – peroxisomes.

2-Non-membranous organelles: do not contain membranes and include: ribosomes - centrosome - cytoskeleton (microtubules and filaments) - cilia and flagella.

Membranous organelles

There are many cellular membranous organelles within the cell as

Mitochondria

Many scientific researches were conducted dealing with the animal cell as well as the plant, starting from the end of the nineteenth century and until this day, advanced research is still being conducted with the development of modern technologies. Kölliker (1880) was the first who observed the mitochondria in insects muscle cells. He called them as 'sarcosomes'. Flemming (1882) named the mitochondria as fila. Altmann in 1894 observed them and named them Altmann's granules or bioblasts. The term

'mitochondria' was applied by Benda (1897-98). They were recognized as the sites of respiration by Hogeboom and his coworkers in 1948.

The cytoplasm of the cell contains mitochondria in the form of living organisms, and they were identified through the light microscope, which showed them in the form of small granules, short rods, vesicles, or fine filaments, and these shapes took different names. It bears the shape of short rods and small threads in chondrioconts, while mitochondria are granular in shape, called chonderiomites, while mitochondria in vesicular shape are known as chondriospheres. Mitochondria are the plant generators of energy, power plants in the cells, or divine factories within which the chemical energy present in food is converted into a type of energy that is used by the various cells of the body.

Morphology of mitochondria

Is it necessary for a cell to contain only one form of mitochondria?

Each cell contains one or more distinct forms of mitochondria. For example, pancreatic cells contain the filamentous form of mitochondria, while the genital cells (Sperms & Eggs) contain the granular form of mitochondria, while nerve cells contain two forms of mitochondria, which are short rods and small threads (Chonderioconts). We also find that the intestinal epithelial cells contain the vesicular, granular and filamentous forms within a single cell, and this means that the cell can have one form or several forms.

Size , number and position of mitachondria

Animal cells do not contain a single size of mitochondria, but the size of

mitochondria varies according to cell activity, but it is noted that the width of mitochondria is almost constant, while its length varies from cell to cell

and the user installer. Their number is related to the activity, age and type of the cell. Growing, dividing and actively synthesizing cells contain more mitochondria than the other cells. In Amoeba, there may be as many as 50,000 mitochondria. In rat liver cells, these are few in number, about 1000 to 1600. Some Oocytes contain as many as 3, 00,000 mitochondria, the liver cell of mammals, Mammalian hepatic cells, contains about 2500, while this number decreases and may reach approximately 200 in hepatoma cells.

Mitochondria are spread in normal conditions throughout the cytoplasm, but in other cases, it may be concentrated in certain regions. We find that mitochondria in kidney cells are clustered in the basal region of the cell, while in other types of cells the location of mitochondria varies according to their function as an energy source. In retinal cells, mitochondria occupy the inner region of the cell's precise structure, while they occupy the edge of the cytoplasm in neurons.

Structure of mitochondria

We discuss the exact structure and chemical composition of mitochondria:-

Ultra structure

The use of an electron microscope, through which it appears in the form of a cavity surrounded by a smooth outer membrane, the outer mitochondrial membrane that surrounds and envelops the entire organelle is 60 to 70 angstroms thick. This membrane has a protein-to-phospholipid ratio equal to that of the cell membrane (about 1:1 by weight, i.e. 50% by weight protein and 50% lipid) and contains large numbers of compact membrane proteins called purines, and inside this membrane there is another membrane called inner membrane that extends inside the mitochondrial

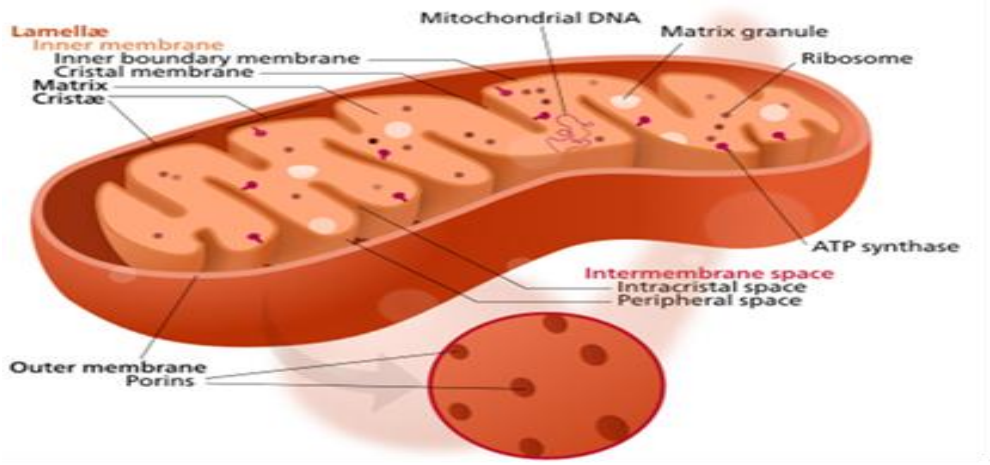
cavity in the form of a group of crests, separators, or barriers that divide the cavity into a group of small chambers. This membrane contains over 151 different polypeptides and has a high protein-to-phospholipid ratio (more than 3:1 by weight, which is approximately one protein for every 15 phospholipids). The inner membrane is home to one-fifth of all the proteins in mitochondria. In addition, this membrane is rich in phospholipids.

We also note that the inner membrane divides the mitochondria into two chambers, an outer chamber located between the outer and inner membranes, and an inner chamber bordered by the inner membrane and filled with a substance known as the interstitial substance of mitochondria. Also, mitochondrial barriers divide the inner chamber incompletely, and the existence of such barriers and their forms is considered a kind of mutation to obtain an ample surface area on which vital processes take place. Therefore, we find that the mitochondria contain very fine granules distributed regularly on the mitochondrial barriers, and these granules represent gatherings of respiratory enzymes and the liver cell contains about 15,000 respiratory enzymes, while in the cells of the bird's muscles, each cell may contain 100,000 respiratory enzymes.

The matrix is the space surrounded by the inner membrane, and contains about two-thirds of all the proteins in mitochondria. The matrix is important in the production of ATP. The matrix contains a highly concentrated mixture of hundreds of enzymes, mainly mitochondrial ribosomes, rRNA, and several copies of the mitochondrial DNA genome.

The inner mitochondrial membrane carry minute regularly spaced particles known as the inner membrane subunits or elementary particles (EP) or oxysomes. An oxysome consists of three parts- a rounded head piece or F1 subunit joined by a short stalk to a base piece or F0 subunit located in the

inner membrane. There may be 100,000 to 1000,000 oxysomes in a single mitochondrion.



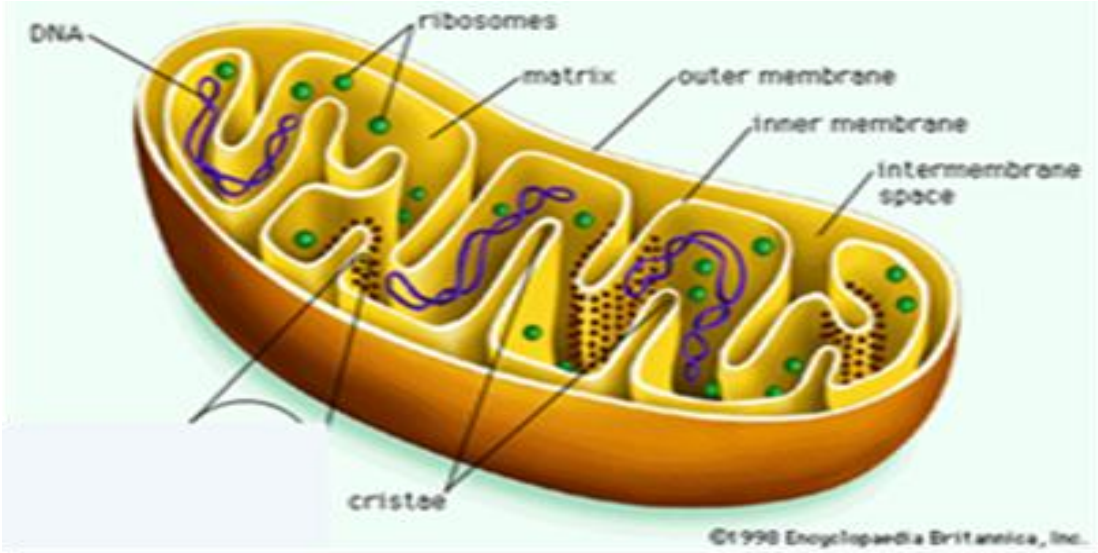


Fig (6): mitochondria

Chemical composition

The chemical composition of mitochondria differs from one cell to another according to the conditions and the extent to which they are affected by pathological changes. Mitochondria are chemically composed of lipids (about 30%) and proteins (about 70%).

Demonstration of mitochondria

In order for mitochondria to be identified and explained inside the cell by providing a modern technical means represented by the use of a phase contrast microscope, due to the inability to view them with a regular optical microscope, so mitochondria can be seen in the cell either.

1-Live cell, by injecting the cell with a specific dye that affects only the mitochondria, such as the green or black Janus stains. The green Janus stains the mitochondria in a bluish-green color, while this dye does not appear in the other contents of the cytoplasm, and that to reduce it to a base substance.

2-Fixative cell image: - In this case, the cell must be fixed with a suitable fixative (Chromic acid or Osmium tetroxide) so that the components of the cell do not decompose, especially the lipoprotein structure, and after that the cell is dyed with a suitable dye. It only dyes mitochondria without dyeing other components of the cell, such as Altmann acid fuchsin, Regaud's iron-alum haematoxylin, Benda's crystal violet solution, and other dyes.

Heterogeneity of mitochondria

The different shapes of mitochondria within the different cells and how the cell must contain one or several different shapes in which the condition of homogeneity between these shapes is met in one organ, however, there may be more than one pattern or shape in the cells of one organ, as is the case in mammalian hepatic cells this phenomenon is called Phenomenon, "heterogeneity of mitochondria," and this difference may be attributed to the activity of the different cells. Mitochondria are filamentous, while cells in the central lobules contain a mixture of mitochondrial forms (granular and filamentous).

Genesis of Mitochondria

The formation of new mitochondria has been explained with the following hypothesis: De Novo Synthesis: According to this hypothesis mitochondria arises de novo from precursors in the cytoplasm. Origin from membrane: This hypothesis proposes that the mitochondria arises from the invaginations of plasma membrane, endoplasmic reticulum, Golgi apparatus or nuclear envelop. The membrane invigilates and extends into the cytoplasm as a tubular structure. It gradually becomes curved and folded and forms a double walled structure, the mitochondrion. Develop from Micro bodies: It is held that they mitochondria are developed by the accumulation of micro bodies in the cytoplasm. A micro body consists of a single outer membrane and a dense matrix with a few cristae which eventually develops into fully formed mitochondria.

Prokaryotic Origin: It is believed that mitochondria are originated from bacteria. It is supported by many evidences. First is the localization of enzymes of respiratory chain, which in case of bacteria, are localized in plasma membrane which can be compared with the inner membrane of the mitochondrion. In some bacteria, plasma membrane forms membranous projections called mesosomes like cristae of mitochondria. These mesosomes possess respiratory chain enzymes. The mitochondrial DNA is circular as it is in bacteria. Replication process of mitochondria is similar to bacteria. Ribosomes in mitochondria are smaller and similar in size to that of bacterial ribosomes.

Replication: It is held that mitochondria are self-replicating organelles. New mitochondria arise by some type of splitting process from pre-existing mitochondria. The last hypothesis seems probable. Since the mitochondria have their own DNA and ribosomes, they can replicate new mitochondria. However, there is a nuclear control over the process as the mitochondria

synthesize some of their proteins themselves and get others from the cytoplasm of the cell formed under the direction of the nuclear DNA

Functions of mitochondria

Mitochondria have many functions, including:

1 - Because it contains many respiratory enzymes, it is considered one of the respiratory centers for cell.

2- Mitochondria contain enzymes that perform a contradictory function, i.e. carry out a process construction in plant protozoa and catabolism in animal protozoa.

3 - It is believed that mitochondria are responsible for the production of zymogen granules in cells, therefore, the pancreas plays an important role in extracellular digestion.

4 - Mitochondria play an important role in the process of fat metabolism.

5- Mitochondria play an important role in the formation of albuminuria in oocytes.

6- Mitochondria form the envelope of the axial filament of the mid segment of the sperm.

7-The main role of mitochondria is to produce the cell's energy currency, adenosine triphosphate (ATP), by phosphorylating adenosine diphosphate (ADP) through cellular respiration.

8-Mitochondria play a vital role in programmed cell death.

Mitochondrial diseases

Mitochondrial damage and resulting dysfunction is an important factor in a range of human diseases due to its influence on cell metabolism. Mitochondrial disorders usually manifest as neurological disorders such as

autism. It can also manifest as: myopathy, diabetes, multiple endocrine disorders, and many other systemic disorders. Diseases caused by a mutation in mitochondrial DNA include Kearns-Sayre syndrome, MELAS syndrome and Leber hereditary optic neuropathy. In most cases, these diseases are transmitted by the mother to her children because the zygote gets its mitochondria - including mitochondrial DNA - from the egg. Diseases such as Kearns-Sayre syndrome, Pearson syndrome and chronic external progressive ophthalmoplegia are caused by large-scale mitochondrial DNA reorganizations, while others such as Melas syndrome, Leber hereditary optic neuropathy, MERRF and others are caused by mutations.

Golgi apparatus

In 1898, Camillo Golgi, while studying the nerve cells of some vertebrates, noticed the presence of a network or reticular structure, which he called the Golgi apparatus. Then many scientists conducted many studies that showed that all animal cells contain this structure. The Golgi apparatus is part of the endomembrane system in the cytoplasm.

Structure

Animal kingdom have animals that contain a vertebral column and are called vertebrates and other animals without vertebral column known as Invertebrates. There are also two types of cells based on the number of chromosomes or genetic chromosomes, The first type contains the diploid number of chromosomes (2n) called somatic cells, while the second type contains the haploid number of chromosomes (n) called the reproductive cells or sex cells. Therefore, Golgi apparatus with form of a network or reticular structure in the somatic cells of vertebrates and it described as a canal system consists of vesicles and tubes whose cavity contains Golgi

apparatus material (Gatinbi and Tohamy Moussa 1949), while The Golgi apparatus appears the shape of vesicles or crescents in the somatic and genital cells of invertebrates and the reproductive cells of vertebrates. The Golgi apparatus is also known as Lipochondria, Golgiosomes, and Dictyosomes.

The Golgi apparatus is composed of units known as cisternae or elongated flattened sacs, a group of large vacuoles that lie at the edge of the cisterns, and clusters of small vesicles that exist between the large vacuoles.

The Golgi apparatus of most eukaryotes consists of a group of flat, compact membranous vacuoles known as cisternae (also called synapses), arising from stacks of vesicles budding from the endoplasmic reticulum. They are usually equally spaced in pile so that they are nearly parallel to one another, having 200-300Å wide inter-cisternal spaces containing a layer of parallel fibers called inter-cisternal elements. These support the cisternae and maintain regular spacing between them. The cisternae may be flat, but are often curved, having a distinct polarity with a convex face towards the cell membrane and concave face towards the nucleus. They are free of ribosomes and have swollen ends.

Mammalian cells usually contain about 40 to 100 cisternae bundles. There are four to eight cisterns per bundle, but some protests have been observed with up to sixty cisterns. This group of cisternae is divided into three parts: conjugated, medial and unbranched forming two primary networks, the conjugate-Golgi network (CGN) and the branching-Golgi network. The coupled network (TGN) is the first cisterna and the transversal network is the last cisterna in which proteins are collected inside vesicles that leave for secretory vesicles or the cell surface. Beside cisternae it consists of short tubules arise from the periphery of the cisternae. Some of these enlarge at their ends to form vesicles. The vesicles lie near the ends and

concave surface of the Golgi complex. They are pinched off from the tubules of the cisternae. They are of three types: transitional, smooth or secretary and coated vesicles. The Golgi apparatus tends to be larger in size and number in cells that synthesize and excrete large amounts of compounds. For example, a B cell that secretes immune system antibodies has many Golgi complexes.

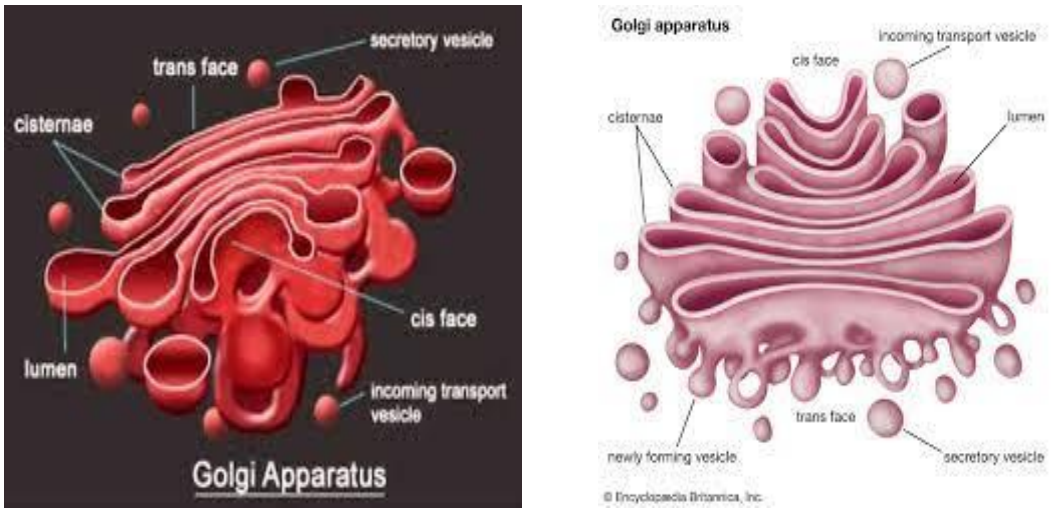


Fig (7): Structure of Golgi apparatus

Types of Golgi apparatus vacuoles

There are three types of Golgi apparatus vacuoles as following:-

1-Formative vesicles containing proteins whose destination is outside the cell. After aggregation, the vesicles bud and translocate directly to the plasma membrane and fuse with it, releasing their contents into the extracellular periphery in a process known as secretion. Antibodies secreted by B plasma cells.

2-Secretory vesicles are vesicles that contain proteins whose destination is outside the cell. After aggregation, the vesicles bud and are stored in the cell until signaled for secretion. Upon receiving this signal, the vesicles

move towards the membrane and fuse with it to release their cargo. This process is known as regulated secretion.

3-Lysosome vesicles containing proteins and ribosomes destined for the lysosome, a lysosome organelle containing several acid hydrolases, or lysosome-like storage organelles. These proteins include both digestive and membrane proteins. The vesicle first fuses with the entry and then the content is transferred to the lysosome by unknown mechanisms. Digestive proteases directed by lysosomes.

Chemical composition

The Golgi apparatus is composed of proteins and fats, and the fats are present in a masked form, that is, they are united with the proteins, but in a specific way, so that they do not give positive results when they are dissolved in fat solvents or dyed with fat dyes, but in some cases In animals, fat is unmasked, as in the reproductive cells of annelids and molluscs, sex cells of Annelid & Mollusca.

Pathological changes of the Golgi apparatus

The Golgi apparatus is a vital organ that responds to different types of vital activities. Different physiological and pathological conditions affect the size, function, composition and location of the organ. Many morphological changes have been observed, including:-

1- Vitamin B complex deficiency causes the breakdown and fragmentation of the Golgi apparatus in mammalian neurons into small particles concentrated around the nucleus, and with continued deficiency of this vitamin, the Golgi apparatus continues to break down into particles that are difficult to see.

2- The Golgi apparatus of neurons migrates from its original location around the nucleus to the edge of the cell when the sciatic nerve is cut.

3- When cells are treated with pesticides, changes occur in the morphology of the Golgi apparatus, where the organ fragments, and continuous use of insecticides begins the Golgi apparatus gradually disappears.

4- The Golgi apparatus also breaks down into small particles when the cell is exposed to morphine poisoning, and with the continuity of morphine poisoning, the particles of the Golgi apparatus begin Golgi gradually disappear.

Form, size and distribution

Each type of animal cell contains a distinctive and special form of the Golgi apparatus, and this shape differs within a single cell according to its activity and also its age. But when the animal is fed, the Golgi apparatus returns to its normal shape, which it was in before the starvation process. Also, the Golgi apparatus breaks down into small particles when the cell enters the process of preserving the type. They spread evenly within the cytoplasm of the cell, and this leads to the distribution of these particles equally between the two cells resulting from the division process, although the size of the Golgi apparatus varies from one cell to another.

Depending on the type of cell and its activity, in active cells it is larger in size than in other cells that are less active. While the distribution of the Golgi apparatus inside the cells is constant and distinctive for each type of cell, for example it is spread in the cytoplasm as in the nerve cells of invertebrates or it is surrounding the central body as in the reproductive cells or in the form of a network surrounding the nucleus as in the neurons of vertebrates, as well as It is located between the nucleus and the excretory pole, as in the cells of the ductal glands.

Function of Golgi apparatus

1- The Golgi apparatus is associated with the formation of secretions in different types of exocrine glands, such as the secretion of the enzyme pepsin by pepsin cells in the stomach, bile in hepatocytes, and zymogen in pancreatic cells.

2- The Golgi apparatus forms the apical body of the sperm.

3- The Golgi apparatus is the center of mucosal formation in mucosal cells.

4- The presence of vitamin A in animal cells is linked to the Golgi apparatus. For example, the Golgi apparatus secretes or concentrates vitamin A in mammalian brain cells, while the Golgi apparatus isolates or separates vitamin A in renal cells.

5- The Golgi apparatus in gastric cells is specialized in the synthesis of fats from acids Fatty and glycerin.

6- The Golgi apparatus within the cells that make up the synovial membrane of the joints, associated with secretion Synovial fluid between joints.

The Golgi apparatus plays a vital role in the formation of tooth enamel from cells Responsible for the formation of the year.

8- The Golgi apparatus is associated with the formation of colored or pigmented granules in the iris of the eye.

9- The Golgi apparatus plays an active role in preserving offspring by forming yolk sebum in oocytes.

10- The Golgi apparatus contributes to the secretion of the enzymes acid and alkaline phosphatase.

11- The Golgi apparatus plays a role in the appearance of aging manifestations when the animal ages.

12- The Golgi apparatus is involved in the maturation of proteins and their subsequent release into cytoplasm.

13- The Golgi apparatus removes excess water from the secretory material formed and converted into cohesive granules.

14 - Did you know, my student brother, my student sister, that the Golgi apparatus is the factory? The only divine responsible for the synthesis of complex polysaccharides?

15- The Golgi apparatus plays an important role in the differentiation of embryonic cells, due to its presence in active state during cell differentiation.

16-The Golgi apparatus processes proteins coming from the endoplasmic reticulum, assembles them, and ships them to their various destinations inside and outside the cell.

17- The Golgi apparatus is often referred to as the "traffic police" of the cell because its enzymes sort out and modify cell's secretary proteins passing through its lumen and membrane proteins in its membranes and directs them to their proper destination.

Endoplasmic reticulum (ER)

The electron microscope played an important and vital role in identifying

the exact structure of the components of the cell. The ribbon membranes of the reticulum were first seen with an electron microscope in 1945 by in 1953 to describe the structure of these membranes.

The endoplasmic reticulum is a cellular organelle found in eukaryotic cells that consists of an interconnected network of tubules, vesicles, and flat membrane sacs or tube-like units called cisterns. They are associated in certain regions with the plasma membrane and with the nuclear membrane in others. Membranes in the endoplasmic reticulum are an extension of the outer nuclear membrane. The endoplasmic reticulum is present in most types of eukaryotic cells but absent in red blood cells and sperm cells.

There are two types of endoplasmic reticulum: the rough endoplasmic reticulum and the smooth endoplasmic reticulum. The outer face of the rough reticulum is studded with ribosomes which are the sites of protein synthesis. The rough reticulum is prominent and abundant in more cells, especially hepatocytes. The smooth reticulum does not have ribosomes on its surface and is few in most cells. It functions in the synthesis of lipids, the production of steroids and hormones, and the detoxification of natural products of metabolism, alcohol and drugs. It is abundant in the cells of the testis, ovary and sebaceous gland.

Ultra-structure of Endoplasmic Reticulum

The membrane bounding the cisternae, tubules and vacuoles of the ER is similar to the cell membrane. It is 50-60Å thick. The membranes of endoplasmic reticulum are composed of two layers of phospholipids molecules sandwiched by two layers of protein molecules like other membranes in the cell (Robertson, 1959). The ER membrane has a relatively high protein/lipid ratio. It is continuous with the cell membrane, Golgi membranes and outer membrane of the nuclear envelope. Certain cisternae open out by pores in the cell membrane. In the lumen of endoplasmic reticulum, secretary granules were observed by Palade (1956). The lumen acts as a passage for the secretary products. About 30-40 different enzymes are associated with the ER for the various synthetic

activities. These may be located on the cytoplasmic surface or luminal surface or both. Membrane bound endoplasmic reticulum spaces varies in shape and sizes in different cell types (Figure 49). On the basis of absence or presence of ribosomes, two kinds of ER are found in cells.

Rough endoplasmic reticulum (RER)

The surface of the rough endoplasmic reticulum (also called the granular endoplasmic reticulum) is studded with protein-synthesizing ribosomes, giving it a "rough" appearance, hence its name. The site of attachment of the ribosome in the endoplasmic reticulum, however, the ribosomes are not stable parts of the structure of this organelle because they are in a continuous state of attachment and separation of the membrane. The ribosome binds to the rough reticulum only when a special protein-DNA complex is formed in the cytosol. This special complex is formed when a free ribosome begins translating mRNA for a protein whose target is the secretory pathway. Synthesis of enzymes for lysosomes and Synthesis of secreted proteins, either constitutively or systemically secreted.

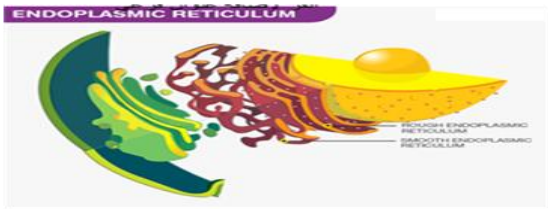
RER occurs largely in the cells that are actively involved in the synthesis of proteins such as enzymes (e.g., pancreatic cells, plasma cells and liver cells) or mucus (goblet cells). In exocrine cells of pancreas, RER consists of reticular sheets and fenestrated cisternae in the basal region of the cell. These cisternae measures about 5-10 micron in length and their groups are 400-1000Å in diameter. In apical region of the cells, granular reticulum occurs in the form of vesicles. Granular and granular ER are in continuity of their membranes in the regions of contact.

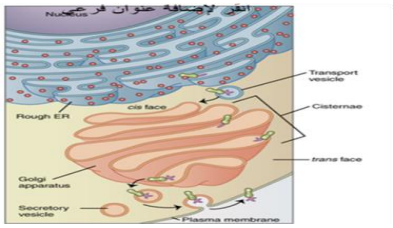
Smooth endoplasmic reticulum

The smooth endoplasmic reticulum is sparse in most cells, and instead there are regions in the reticulum that are partly smooth and partially rough,

and these regions are called the transitional endoplasmic reticulum because they contain sites for leaving the endoplasmic reticulum. Golgi apparatus. Specialized cells can have a lot of smooth lattice and in these cells smooth lattice has multiple functions, they synthesize lipids, phospholipids, and steroids. The cells that secrete these outgrowths such as those of the testis, ovary, and sebaceous gland have an abundant smooth endoplasmic reticulum. The smooth network also metabolizes carbohydrates, detoxifies natural metabolites, alcohol and drugs, and connects to receptors on cell membrane proteins and steroid metabolism. In muscle cells, it regulates the concentration of calcium ions. Allows for an increase in the area allocated for the storage of essential enzymes and the products of these enzymes. Secreted proteins are transported predominantly glycoproteins along the membrane of the endoplasmic reticulum.

Because it does not have ribosomes, the endoplasmic reticulum is the cellular site for lipid and steroid synthesis, cellular detoxification, carbohydrate metabolism, and calcium ion storage. Cells specialized in secreting hormones tend to be abundant in the smooth endoplasmic reticulum. Likewise, liver detoxification cells are rich in smooth endoplasmic reticulum. The smooth endoplasmic reticulum is also the cellular storage site for toxic calcium ions. It even contributes to Alzheimer's disease and many genetic skeletal disorders cause abnormal bone growth, weak joints, and susceptibility to joint dislocation and the endoplasmic reticulum occasionally induces apoptosis in response to an increased amount of unfolded proteins.





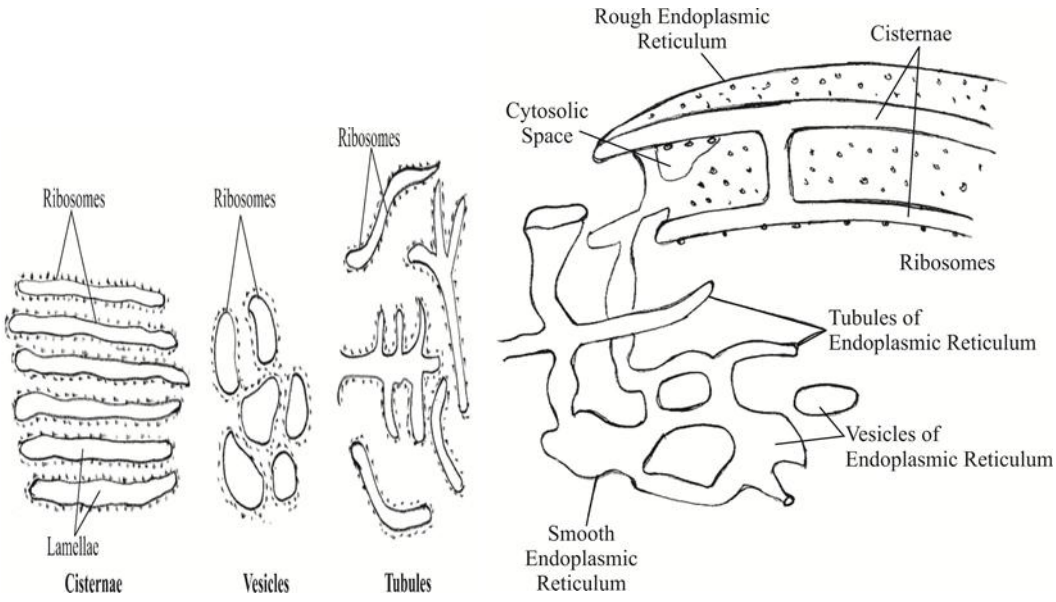


Fig (8): Structure of Endoplasmic Reticulum

Functions of Endoplasmic Reticulum

A-Functions of smooth endoplasmic reticulum

1- Surface for Synthesis: The SER provides surface for the synthesis of fatty acids, phospholipids, glycolipids, steroids and visual pigments.

2- Glycogen Metabolism: The SER carries enzymes for glycogen metabolism in liver cells. Glycogen granules are attached in larger numbers to the outside of the SER's membranes in liver cells.

3- Detoxification: The SER has enzymes that are involved in the detoxification in the liver, i.e., converts harmful materials such as carcinogens and pesticides, into harmless ones for excretion by cell.

4-Formation of organelles: The SER produces Golgi apparatus, lysosomes, micro bodies and vacuoles.

1- Transport route: The proteins shift from RER through SER to Golgi apparatus for further processing.

2- Skeletal Muscle Contraction: The sarcoplasmic reticulum in skeletal muscle cells release Ca2+ ions to cause contraction and absorbs Ca2+ ions to bring about relaxation.

3- Fat Oxidation: The SER membranes carry out the initial reactions in the oxidation of fats.

B-Functions of rough endoplasmic reticulum

1- Surface for Ribosomes: The RER provides a large surface for the attachment of ribosomes.

2- Surface for synthesis: The RER offers extensive surface on which protein synthesis can be conveniently carried on by ribosomes. The newly formed proteins may enter the ER membranes, becoming a part of the membrane structure or pass into the ER lumen. The proteins becoming a part of ER membrane eventually move from the ER via membranes of other cell organelles, namely Golgi apparatus, secretary vesicles to become permanent plasma membrane proteins. The proteins entering ER lumen are packed for export.

3- Packaging: The proteins in ER lumen are processed and get enclosed in spherical membrane bound vesicles which get pinch off from the ER. These vesicles have various fates. Some remain in the cytoplasm as storage vesicles while others migrate to the plasma membrane and expel their contents by exocytosis. Some fuse with Golgi apparatus for further processing of their proteins for storage or release from the cell.

4- Smooth ER Formation: The RER gives rise to the smooth ER by loss of ribosomes.

5- Formation of Nuclear Envelope: The RER forms nuclear envelope around daughter cells in cell division.

6- Formation of Glycoproteins: The process of linking sugars to proteins to form glycoproteins starts in the RER and is completed in Golgi apparatus.

Importance of Endoplasmic Reticulum

1- Transport of Materials: The ER facilitates transport of materials from one part of the cell to another thus forming the cell's circulatory system.

2- Support: The ER acts as an intracellular supporting framework, the cytoskeleton that also maintains the form of the cell.

3-- Localization of Organelles: It keeps the cell organelles properly stationed and distributed in relation to one another.

4- Surface for Synthesis: The ER offers extensive surface for the synthesis of a variety of materials.

5- Storage of Materials: The ER provides space for temporary storage of synthetic products such as proteins and glycogen.

6-Exchange of materials: The ER helps in the exchange of materials between the cytoplasm and the nucleus.

7- Location of Enzymes: A variety of enzymes is located in the ER membranes to catalyze the biochemical reactions.

Ribosomes

Palade (1953) was the first to observe dense particles or granules in animal cells under electron microscope. These were thus called as Palade's Particles. Roberts named them "ribosomes" in 1958. It was shown that ribosomes contain approximately equal amount of RNA and proteins.

The ribosome is an organelle of living cells that is composed of ribosomal proteins and ribosomal RNA. Its main job is to translate messenger RNA

into peptide chains that are then cross-linked to form proteins. Thus, it is one of the important centers in the process of converting genetic information into proteins encoded within the genetic formula.

Ribosomes consist of two protein units, which do not come together except in the case of protein formation. One of these units is larger than the other, these two units come together when the ribosome is ready to make a new protein.

The ribosome is the factory that converts the encoded genetic information into a peptide sequence of amino acids. Ribosomes can swim in the cell freely, as in prokaryotes. In eukaryotes, however, they may be found free in the cytoplasm or attached to the cytoplasmic face of the endoplasmic reticulum membranes (specifically rough) or attached to the nuclear envelope. The ribosomes scattered in the cytoplasm produce the proteins of the cell. As for the ribosomes that are linked to the endoplasmic reticulum and the nuclear envelope, they produce the proteins of the cell membrane or those that may not belong to the cell itself, such as hormones.

The ribosome is made inside the nucleolus of the nucleus. Once it is manufactured, it is sent out of the nucleus through the pores in the nucleus membrane. Ribosomes differ from most organelles in that they are not surrounded by a protective membrane. The main job of the ribosome is to make proteins for the cell. There can be hundreds of proteins that must be made for a cell, so the ribosome needs specific instructions on how to make each type of protein. These instructions come from the nucleus in the form of RNA.

Ultra-structure of ribosome

The ribosomes are composed of two subunits (one subunit is almost twice in size than the other) fitted together to form a complete unit of about 300Å

in diameter. In 70S ribosome the 50S subunit is pentagonal compact particle of 160 to 180Å bearing a round concave area in its center of about 40 to 60Å that accommodates the small subunit. A small pore like transparent area is also present that inhibits the entrance of enzyme ribonuclease. Similar pores are present in 60S subunit of 80S ribosomes. The smaller subunits 30S of 70S and 40S of 80S ribosomes have irregular forms and are often divided into two portions which are interconnected by a strand of 30 to 60 Å thicknesses. Ribosomes have a groove at the junction of large and small subunits. The mRNA is seated in the gap between both ribosomal subunits, where the ribosome protects a stretch of some 25 nucleotides of mRNA from degradation by ribonuclease. From this groove, a canal or tunnel extends through the large subunit and opens into the lumen of the endoplasmic reticulum. Polypeptides are synthesized in the groove between the two ribosomal subunits and pass through the tunnel of the large subunit into the endoplasmic reticulum.

Types of ribosomes

1-Prokaryotic cell ribosomes: 70S Ribosome, These are found in bacterial cells and have the molecular wt. 2.7×10^{-6} daltons and sedimentation coefficient 70S. 70S ribosome consists of a large 50S subunit and a small 30S subunit. Each subunit is composed of rRNA and several basic proteins. The 50S subunit has two species of RNA: 23S and 5S and about 34 different ribosomal proteins. The 30S subunit has only one species of rRNA, i.e., 16S and about 21 different ribosomal proteins. They also occur in mitochondria and chloroplasts of eukaryotic cells.

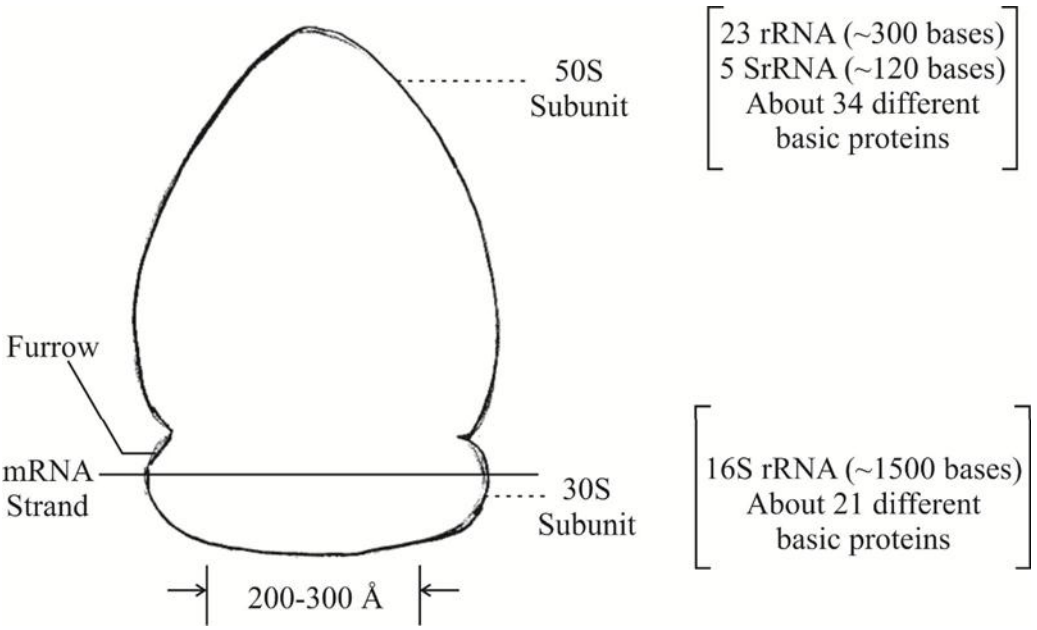
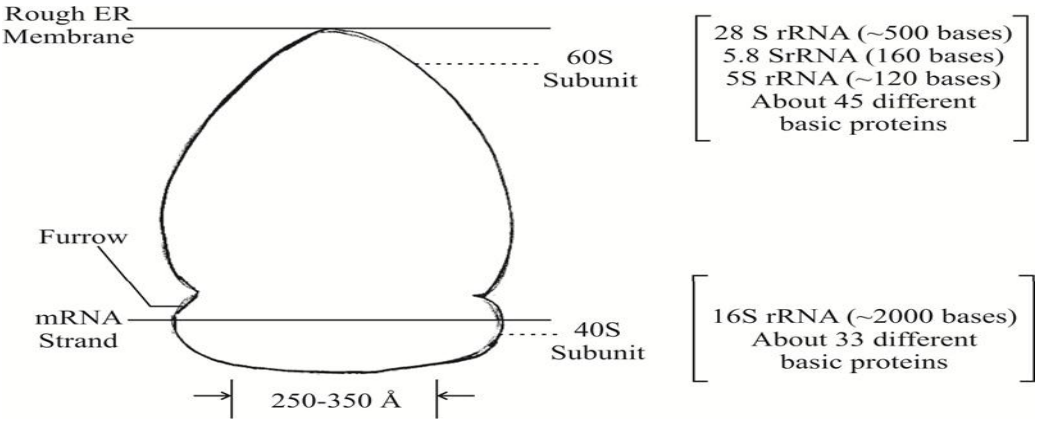


Fig (9): structure of lysosome

2-Eukaryotic cell ribosomes consists of 80S Ribosome: Having the sedimentation coefficient 80S, these are somewhat larger and contain more RNA and proteins than 70S ribosomes. An 80S ribosome is over 250 to 300Å in diameter. Their mol. wt. is 4×10^{-6} Daltons. It consists of a large 60S subunit and a small 40S subunit. Each subunit is composed of rRNA and several specific basic proteins. The 60S subunit has three species of rRNA: 28S, 5.8S and 5S and over 45 different ribosomal proteins. The 40S subunit has only one species of rRNA, i.e., 18S and over 33 different ribosomal proteins. They are found in eukaryotic cells.



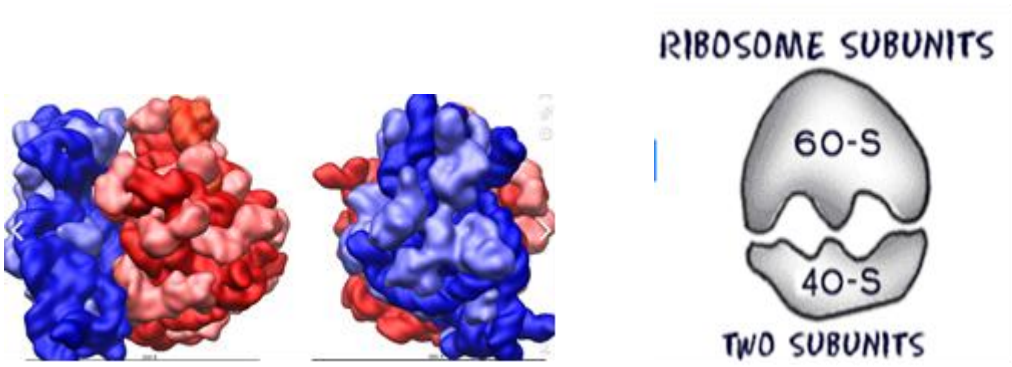


Fig (9): Structure of ribosome Large (red) and small (blue)

Functions of Ribosome

1- Attached Ribosomes: The ribosomes provide space and enzymes for the synthesis of proteins in the cell. The ribosomes bound to the ER membranes synthesize: integral proteins for cellular membranes, lysosomal proteins and secretary proteins for export as secretions.

2- Free Ribosomes: The free ribosomes produce structural and enzymatic proteins for use in the cell itself. These proteins include glycolytic enzymes and most extrinsic membrane proteins, such as spectrin.

Importance of Ribosome

1- Ribosomes are known as protein factories. Ribosomal RNA molecules possibly serve as a skeletal framework in the ribosomes.

2- Smaller ribosomal subunit is required for the formation of initiation complex at the start of the protein synthesis. Whereas larger ribosomal subunit is necessary for peptide bond formation and the elongation for the polypeptide.

3- The ribosome function as a template in order to bring together various components involved in the synthesis of proteins. Ribosomes co-ordinate the interaction of t-RNA

4- Amino acid complex with m-RNA. This co-ordination results in the translation of genetic code forming specific proteins.

5- Since free ribosomes are not involved in protein synthesis, they are transported through endoplasmic reticulum membranes and assembled into globules within the cisternae and canals in the cells that produce 'proteins for transport'. Proteins later appear in the form of granules outside the Golgi complex.

Lysosomes

It was discovered in 1949 by the Belgian scientist De Duffy**,** Later on, Novikoff in 1956 observed these lysosomes as distinct cell organelles with the help of electron. It initially consists of adding hydrolytic enzymes to endosomes produced from the Golgi apparatus. The size of lysosomes ranges from 0.1 μm to 1.2 μm. With a pH ranging from 4.5 to 5.0, the interior of the lysosomes is acidic compared to the cellular fluid, pH 7.2. Lysosomes are organelles found in animal cells that contain digestive enzymes that break down excess or dead organelles, food, viruses, and bacteria. The lysosome is surrounded by a membrane that has a very important role in the functioning of the organelles. Lysosomes are round tiny bags filled with dense material rich in acid phosphatase (tissue dissolving enzymes) and other hydrolytic enzymes. They consist of two parts: limiting membrane, this membrane is single and is composed of lipoprotein Chemical structure is homologous with unit membrane of plasma lemma, consisting of bimolecular layer and inner dense mass, this enclosed mass may be solid or of very dense contents. Some lysosomes have a very dense outer zone and a less dense inner zone. Some others have cavities or vacuoles within the inner granular material.

Lysosomes are of various types, and they help in intracellular digestion. Their contents vary with the stage of digestion. They are semi-spherical,

membranous organelles found in the cell, similar in function to the work of the human digestive system, as they contain active enzymes. Lysosomes convert complex substances such as fats, carbohydrates and foreign bodies into simple substances that facilitate their absorption.

Lysosomes are found in almost all animal cells, and are found abundantly in cells that carry out swallowing activity, such as macrophages and white blood cells. It is noted that the proteins of the lysosome membrane are glycosylated, which works to protect this membrane from the influence of enzymes that digest proteins present inside the lysosomes. Lysosome enzymes are built up in the endoplasmic reticulum, then transported to the Golgi apparatus, where they are processed. Vesicles laden with these lytic enzymes travel from the mature face of the Golgi apparatus. These vesicles are known as primary lysosomes. During the process of phagocytosis, bodies are taken from outside the cell to the inside of it in vesicles surrounded by a membrane, which are called "violating phagocytic bodies". Irregular in shape, with inhomogeneous content.

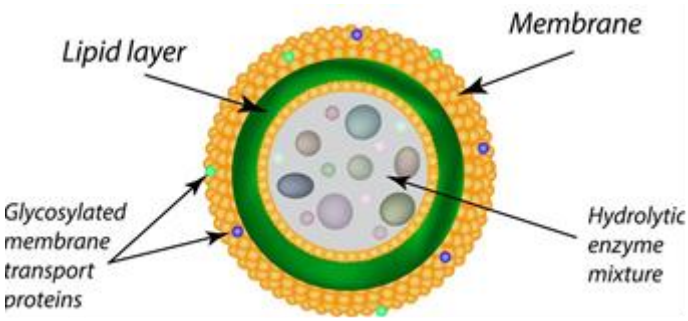


Fig (10): Diagram of Lysosomes

Size and distribution of Lysosomes

Lysosomes are located wherever there are units of the Golgi apparatus, as there is a close relationship between the lysosomes and the location of the

Golgi apparatus in the cell. Studies have shown that primary lysosomes arise partially from the Golgi apparatus, and therefore it is natural that the location of the lysosomes is concomitant with the location of the Golgi apparatus in the cell. The size of the lysosomes varies Depending on the type and activity of the cell, the more active the cell is, the more it contains lysosomes of large sizes.

Types of lysosomes

Four types of lysosomes can be distinguished:

1- Original or primary lysosomes

It means how to form lysosomes. The ribosomes that are found on the membrane of the endoplasmic reticulum synthesize the enzyme acid phosphatase and collect it inside the lumen of the endoplasmic reticulum, then this enzyme is carried out outside the endoplasmic reticulum and is assembled inside the small vesicles of the Golgi apparatus This structure (a small vesicle containing the enzyme acid phosphatase) is known as the primary lysosome. Accordingly, it can be said that the primary lysosomes partially originate from the Golgi apparatus.

2-The secondary lysosomes (Digestive vacuoles or heterophagosomes)

This type of lysosomes engulfs the foreign organisms that enter the cell and fragments and destroys them with the enzyme acid phosphatase, and in the end the products of the fragmentation process pass through the lysosome membrane to the cytoplasm of the cell, and thus this type of lysosomes acts as a means of defense for the cell.

3-The autophagy lysosomes

This type of lysosomes engulfs parts of the cell such as the mitochondria, the endoplasmic reticulum, the Golgi apparatus, and so on. This process

may lead to cell death, so this type of lysosomes is known as suicide cysts.. For example, liver cell shows numerous autophagosome during starvation among which remnants of mitochondria occur. This is a mechanism by which the cell can achieve degradation of its own constituents without irreparable damage.

4-The residual lysosome bodies

These are formed in case the digestion is incomplete. In some cells, such as Amoeba and other protozoa, these residual bodies are eliminated by defecation. Hence, lysosomes having undigested material or debris are called residual bodies. These bodies are formed due to lack of certain enzymes in lysosomes. These are rejected from the cell by exocytosis and some time in certain cells these bodies remain in cells for long time causing ageing. These residual bodies also cause diseases in man such as fever, hepatitis, polynephritis, hypertension, congested heart failure etc. If the debris which is mostly lipid in nature may accumulate and condense into concentric lamella, it forms myelin.

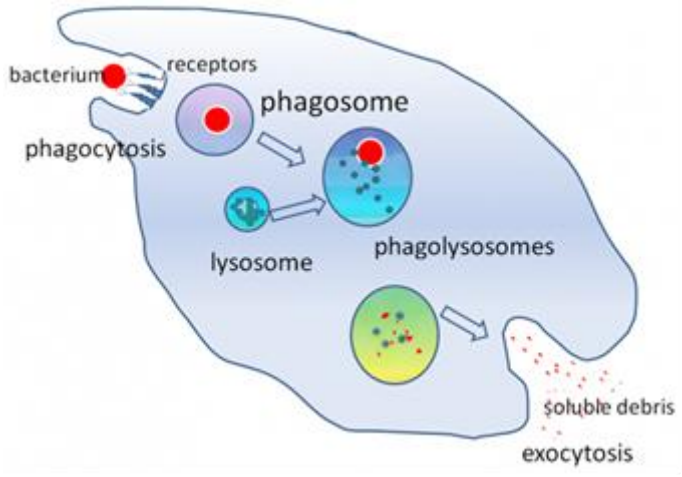


Fig (11): Lysosomes also help to defend against Pathogen

Chemical Nature of Lysosomes

Chemically lysosomes are defined as a body rich in acid hydrolases. Acid phosphatase has been found in many cells of plant roots, fungi, liver,

kidney, and endocrine glands. The lysosomal enzymes can break down all major biological macromolecules present in the cells or entering the cells from outside into their building block subunits by adding water. The common enzymes in the lysosomes are proteases, nucleases (deoxyribonuclease and ribonuclease), glycosidase, lipases, sulphatases and phosphatase, which hydrolyses proteins, nucleic acids, polysaccharides, lipids, organic sulphatases and organic phosphates respectively.

Behaviour of lysosomes

Lysosomes are affected by many abnormal factors, physiologically and structurally, as follows:

1- If the lysosomes are exposed to X-rays, they accumulate in some cells such as nerve cells, or they fragment and disappear in another type of cells such as hepatocytes, while exposing the cells to X-rays for long periods leads to the explosion of the plasma membranes of the cells.

2- Starving the animal leads to a decrease in the number of lysosomes, and as the starvation continues, the lysosomes disappear completely from the cells.

3- When cells prepare to enter the aging phase, this is accompanied by a decrease in the number of lysosomes, especially in hepatocytes.

4- Infection of cells with some diseases leads to a decrease in the number and size of lysosomes. An example of this is the liver cell, when it is infected with cancer, the number of lysosomes decreases.

Functionl significance of lysosomes

1- Lysosomes participate in the intracellular digestion process and the formation of colored fat granules

2- Lysosomes play an essential role in the metabolism of carbohydrates, as they are abundantly present in cells during the metabolism of carbohydrates.

3- Lysosomes play an essential role in getting rid of excess tissue from the animal's body by swallowing it

4- Lysosomes help in the process of facilitating the entry of the sperm into the egg.

5- Lysosomes have a close connection with many biological and pathological phenomena such as morphogenesis, aging, and the transformation of normal cells into cancer cells.

6- Digestion of harmful materials*:* The foreign particles, such as viruses, bacteria, and toxic molecules, are disposed of by hydrolyzing them in certain leucocytes and macrophages. This is called natural defense of the body. This activity of lysosomes is characteristic of higher animals.

7-Feeding of starving animals*:* Food to a starving animal is provided by digesting the stored food materials (proteins, lipids, and glycogen) and even the cells. This is called autophagy.

8-Autolysis*:* Autolysis caused by the lysosomal enzymes plays a role in normal developmental changes in both animals and plants. E.g., in the breakdown and absorption of tail during the metamorphosis of frog's tadpole. In autolysis, lysosome membrane ruptures and releases the enzymes into the surrounding cytoplasm. This kills and lyses the cell.

Nissl bodies

Nissl in 1889 was the first to talk about these tiny organelles, explaining that these bodies are found only in nerve cells. These bodies were described as colored bodies or basal bodies due to their strong susceptibility to dyeing

with basal dyes, and these bodies are not found only in nerve cells, so these bodies are distinguished for nerve cells from others. The offspring's bodies occupy two of the three sites within the nerve cell in each of the cytoplasm and dendrite branches, while they lack presence in the axons of these cells.

Chemical composition of Nissl bodies

The bodies of the offspring consist of a nuclear protein, the nuclear protein is a simple protein such as histamine and nucleic acid RNA, and this is similar to ribosomes that have the same structure, that is, a nuclear protein, but the type of protein is different, Nuclear Be a ribosome so it becomes a ribosome, Be granules or the body of an offspring He said listen and obey And there is a difference between the function of the ribosome and the body of the offspring.

Demonstration of Nissl bodies

We and you, my student brother and sister, can witness the greatness of the Creator, Glory be to Him, the Most High, represented in the presence of such minute organelles within a precise structure (the cell) that can only be seen with binoculars or an optical microscope from two images. Intervention from a human being, and the cell was not stained with any type of dye, by means of a contrast microscope 000 second, and the cell was fixed by a fixative that does not dissolve the bodies of the offspring, then the cell was dyed with a dye that deals only with the bodies of the offspring, such as toluidine blue or Gimsa dye.

Physiological signifance of Nissl bodies

Some workers in the field of scientific research may not give importance to these bodies on the grounds that they are limited to one type of cell 000 and this is the big mistake 0 why? And the answer is crystal clear in its orbit 00 and it is that the nerve cell is not like any type of cell as it consists

of the nervous system that controls and controls all the vital processes that occur within the body of the organism 0 and from this concept we must recognize the physiological importance of bodies offspring, which are as follows:-

1- Some researchers believe that these bodies store oxygen in nerve cells, and therefore it was concluded that there is a close relationship between these bodies and the functional activities of these cells, through the stressful situations that the animal is exposed to, and with which these bodies disappear and return again when something happens. Is the animal resting?

2- The bodies of the offspring are affected by the physiological state of the nerve cell 00. When the nerve is cut, for example, the bodies of the offspring disappear after a few days, and also the amount of nucleic acids decreases to a very large extent, and this indicates that the bodies of the offspring have a close relationship with the process of the presence of nuclear proteins and the motor and sensory functions of the nerve cell.

3- The migration of the bodies of the offspring from their original areas of existence to the axon of the nerve cell after its death is clear and supportive evidence to say that the bodies of the offspring store oxygen, as the migration of these bodies is nothing but a search for oxygen.

The center body

Cleveland (1953) was able to observe it by means of a light microscope in fibrous cells during their division, noting special behavior, general characteristics, and a tendency to a certain type of pigment. All this confirms the fact that it is present in the cytoplasm. The centrosome is one of the cytoplasmic living organelles inside the cell. It is also known as the center of division. It is found in all animal cells except fully formed red

blood cells. It plays an important and vital role in the process of cell division. The centrosome is found in the interstitial cell close to the nucleus and sometimes it occupies the geometric center of the cell and in spite of this, the centrosome has a distinctive location specific to each type of animal cell. During division, the centrosome divides into two parts that migrate to the opposite poles of the achromatic spindle, and there each part is surrounded by a wide clear region called the centrosome, which in turn merges externally into the stellar sphere.

Centrosomes are attached to the nuclear membrane during the prophase of the cell cycle. During mitosis, the nuclear membrane breaks down, and tubules around the centrosome can then interact with chromosomes to form the mitotic spindle. The centrosome is replicated once in each cell cycle, so each daughter cell inherits one centrosome, which contains two structures called centrioles. The centrosome replicates during the S phase of the cell cycle. During prophase in the process of cell division, the two centrosomes migrate to opposite cytosolic poles of the cell. A cleavage spindle then forms between the two centrioles. When dividing, each daughter cell takes on one centrosome. The presence of an abnormal number of centrosomes in the cell is associated with the occurrence of cancers.

Structure of center body

The centriole consists of a pair of interconnected centrioles. The centrioles contain cylindrical arrays of 9 groups of triangular microtubules organized in a circular manner. The centrosome contains a mature centriole called the mother centriole and an immature centriole assembled during the previous cell cycle, the nascent centriole, which is about 80% of the length of the mother centriole, which are believed to be necessary for stabilization of microtubules in the centriole and for anchoring of centrioles to the plasma

membrane during mitosis. Centrosome function, it is the main center for organizing microtubules in human cells and is a very small, yet very important cellular organelle for basic cellular functions, located adjacent to the nucleus. The microtubule of the centriole is composed of a protein tubulin and some lipids having a high concentration of ATPase enzymes. They seem to contain RNA and a small DNA molecule. Proteins encoded by this DNA are presumably translated on cytosolic ribosomes and then incorporated into the centriole.

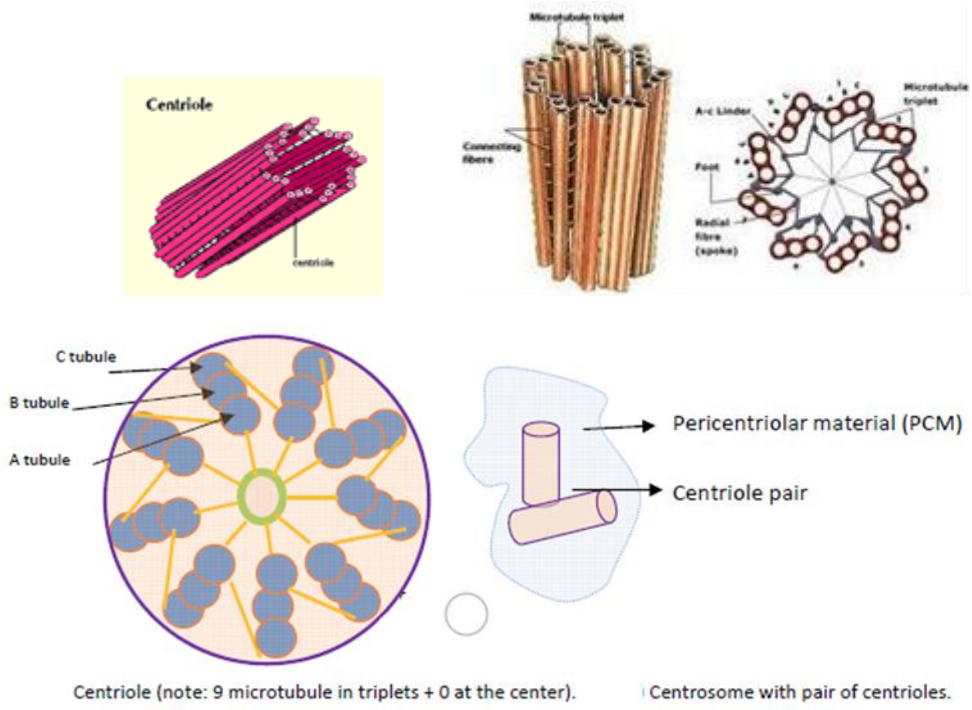


Fig (12): Structure of center body

Function of center body

The main role of the centrosome is as follows:

1-Intracellular organization of microtubules during cell division.

2-The centrosome serves for the proper formation and orientation of spindle filaments to carry out mitosis, ensuring proper segregation of the

sister chromatids of each daughter cell. 3-Control of cellular shape, polarity, reproduction, motility, and cell division.

4-Coordination of a variety of cellular processes, including cell movement, signaling, adhesion and movement of proteins by the micro-cytoskeleton and cell polarity.

5-Determine the pathways by which different cellular components can be transported to different parts of the cell.

6-Help determine the speed at which components move along transport pathways, and act as a signaling center to modify certain components before they are transported to their destinations.

7-Regulating the process of phagocytosis through the role of centrioles in changing the shape of the cell membrane.

The role of center body in cell division

The centrosome and its role in mitosis, the centrosome cycle consists of 4 main phases in both phases, the interphase and the mitotic phase as follows:

G1 stage in which the centrosome is duplicated. G2 stage in which the centrosome matures. The first stages of mitosis (pre-anaphase) where the separation of the two centrioles occurs. The last stages of mitosis (anaphase) in which the chromosomes separate with the help of centrosomes. The centrosome is of great importance in organizing cell division, and regulating the transition between the stages of division in interphase, the most important of which is the transition from the G1 stage to the S phase. In the absence of centrioles, the accuracy of cell division decreases as problems such as meiosis and unequal cell divisions occur, which It leads to chromosomal mutations and sometimes the development of cancer cells.

Cilia and Flagella

Cilia and flagella were discovered by the scientist Antonie van Leeuwenhoek in the late seventeenth century. After the development of the microscope, non-motile cilia, most of which are found in animals, were observed in almost all types of cells. Cilia range from 1-10 micrometers, while the flagellum is 20–50 micrometers in length. Some cilia are also found in plant cells in the form of gametes. Cilia and flagella are two different types of microscopic appendages on cells. Cilia are found in both animals and microorganisms. Bacteria and eukaryotic gametes use flagella for locomotion. Cilia and flagella serve the functions of movement in the cell, but in different ways, and both depend in their work on Diane - a motor protein - and microtubules. Cilia and flagella are organelles in cells that perform propulsion functions, sensory organs, cleaning mechanisms, and many other important functions in living organisms.

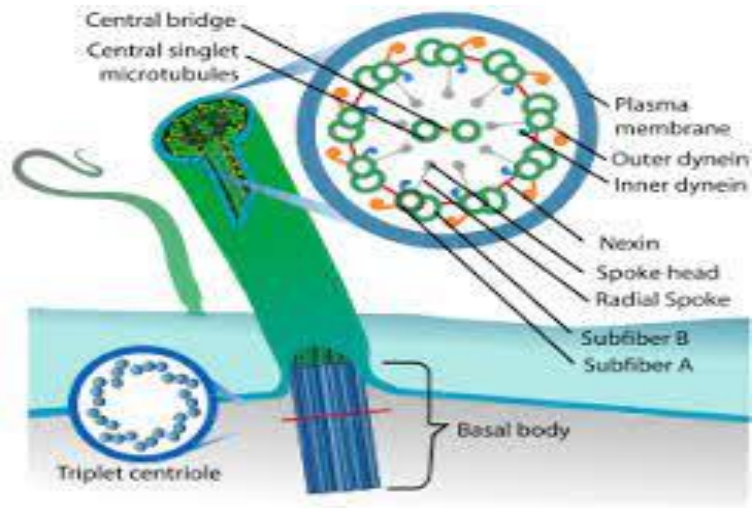


Fig (13): Structure of cilia

Cilia flagella consist of 9 groups of microtubules, each group is two tubules, and in the center there is a pair of tubular groups in an arrangement called the ciliary axoneme, which is covered by the plasma membrane.

Function of cilia and flagella

1-The cell body synthesizes ciliary proteins and transports them to the head of the axonal filament. This process is called intraciliary transport or intraflagellar transport. Scientists currently believe that about 10% of the human genome is dedicated to cilia and their genesis.

2-These hair-like organelles move cells and transport materials. It can also transport fluids in marine organisms, such as oysters, to enable them to transport food and oxygen. Cilia contribute to respiration by preventing debris and potential pathogens from invading the body.

3-Cilia and flagella play an active role in the life cycle of the cell and also play an important role in cellular communication.

Peroxisomes

Peroxisomes are small vesicles, single membrane-bound organelles found in the eukaryotic cells. They contain digestive enzymes for breaking down toxic materials in the cell and oxidative enzymes for metabolic activity , they with 60 known enzymes in the matrix and ,45 documented integral or peripheral membrane proteins, it is a reasonable guess that this organelle has only , 125 proteins, which makes it much less complex than other organelles. They are a heterogeneous group of organelles and the presence of the marker enzymes distinguished them from other cell organelles.

Peroxisomes play an important role in lipid production and are also involved in the conversion of reactive oxygen species such as hydrogen peroxide into safer molecules like water and oxygen by the enzyme catalase.

Mostly peroxisomes occur as an individual organelle, e.g. in fibroblasts. They also exist in the form of interconnected tubules in liver cells known as peroxisome reticulum.

Peroxisome Structure

Peroxisomes vary in shape, size and number depending upon the energy requirements of the cell. These are made of a phospholipid bilayer with many membrane-bound proteins. Peroxisomes are surrounded by a single membrane, and they range in diameter from 0.1 to 1 mm. They exist either in the form of a network of interconnected tubules (peroxisome reticulum), as in liver cells, or as individual micro peroxisomes in other cells such as tissue culture fibroblasts. Peroxisome-Like Organelles Peroxisomes are related to specialized peroxisomes called glycosomes in parasites such as Trypanosomes, and to plant glyoxysomes, but are unrelated to hydro-genosomes, mitochondria, and chloroplasts. Collectively, peroxisomes, glyoxysomes, and glycosomes are also referred to as microbodies.

The enzymes involved in lipid metabolism are synthesized on free ribosomes and selectively imported to peroxisomes. These enzymes include one of the two signaling sequences- Peroxisome Target Sequence one being the most common one.

The phospholipids of peroxisomes are usually synthesized in smooth Endoplasmic reticulum. Due to the ingress of proteins and lipids, the peroxisome grows in size and divides into two organelles.

Peroxisomes do not have their own DNA. Proteins are transported from the cytosol after translation.

Peroxisome Distribution and Origin:

Peroxisomes exist in all eukaryotes from single- and multi- cellular microorganisms, to plants and animals. Unlike mitochondria, nuclei, and chloroplasts, peroxisomes have no DNA. Consequently, all their proteins are encoded by nuclear genes. They are proposed to have originated from endosymbionts that subsequently lost their DNA, but the evidence for an endosymbiont origin is much weaker than it is for mitochondria and chloroplasts.

Peroxisome Function

The main function of peroxisome is the lipid metabolism and the processing of reactive oxygen species. Other peroxisome functions include:

1-They take part in various oxidative processes.

2-They take part in lipid metabolism and catabolism of D-amino acids, polyamines and bile acids.

3-The reactive oxygen species such as peroxides produced in the process is converted to water by various enzymes like peroxidase and catalase.

4-The early steps in the synthesis of ether glycero-lipids.

5-The formation of bile acids, dolichol, and cholesterol.

Metabolism of Peroxisomes

Isolated peroxisomes are permeable to small molecules such as sucrose. During the isolation process, they often lose proteins that are normally confined to the peroxisomal matrix. In all living cells, peroxisomes are the sealed vesicles surrounded by a single membrane.

Relation between Peroxisomes and Lysosomes:

Peroxisome and Lysosome two organelles, filled with enzymes that catalyze different biochemical processes inside the cell. Also, the primary Difference between Peroxisomes and Lysosomes may be the enzymes they consist of and their features. Lysosomes contain enzymes, which degrade biopolymers like proteins, lipids, polysaccharides, and nucleic acids. Peroxisomes have enzymes for the oxidation of organic and natural compounds, the era of metabolic based energy. Both lysosomes and peroxisomes will be related structurally. But you can find the Difference between Peroxisomes and Lysosomes in proportions. Lysosomes are often large in comparison to peroxisomes and their dimensions vary together with the materials that are uptake into the organelle. Both organelles are usually enclosed by way of a single membrane.

Cytoskeleton

The cytoskeleton of a cell is made up of microtubules, actin filaments, and intermediate filaments. These structures give the cell its shape and help organize the cell's parts. In addition, they provide a basis for movement and cell division. The cytoskeleton is a structure that helps cells maintain their shape and internal organization, and it also provides mechanical support that enables cells to carry out essential functions like division and movement. There is no single cytoskeletal component. Rather, several different components work together to form the cytoskeleton.

Cytoskeleton is a group of fibrous proteins that provide structural support for cells, the cytoskeleton forms a complex thread-like network throughout the cell consisting of three different kinds of protein-based filaments: microfilaments, intermediate filaments, and microtubules.

The cytoskeleton of eukaryotic cells is made of filamentous proteins, and it provides mechanical support to the cell and its cytoplasmic constituents. All cytoskeletons consist of three major classes of elements that differ in size and in protein composition. Microtubules are the largest type of filament, with a diameter of about 25 nanometers (nm), and they are composed of a protein called tubulin. Actin filaments are the smallest type, with a diameter of only about 6 nm, and they are made of a protein called actin. Intermediate filaments, as their name suggests, are mid-sized, with a diameter of about 10 nm. Unlike actin filaments and microtubules, intermediate filaments are constructed from a number of different subunit proteins.

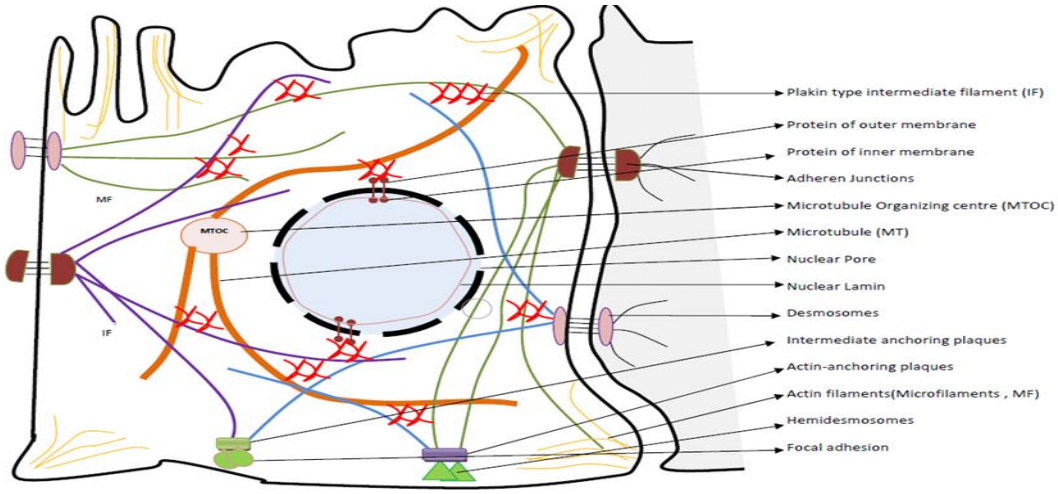


Fig (14): Structure of cytoskeleton

In many types of cells, networks of actin filaments are found beneath the cell cortex, which is the meshwork of membrane-associated proteins that supports and strengthens the plasma membrane. Such networks allow cells to hold — and move — specialized shapes, such as the brush border of microvilli. Actin filaments are also involved in cytokinesis and cell movement.

Intermediate filaments come in several types, but they are generally strong and ropelike. Their functions are primarily mechanical and, as a class,

intermediate filaments are less dynamic than actin filaments or microtubules. Intermediate filaments commonly work in tandem with microtubules, providing strength and support for the fragile tubulin structures. All cells have intermediate filaments, but the protein subunits of these structures vary. Some cells have multiple types of intermediate filaments, and some intermediate filaments are associated with specific cell types.

Structure of cytoskeleton:

1-Microtubules:

Structure of Microtubule:

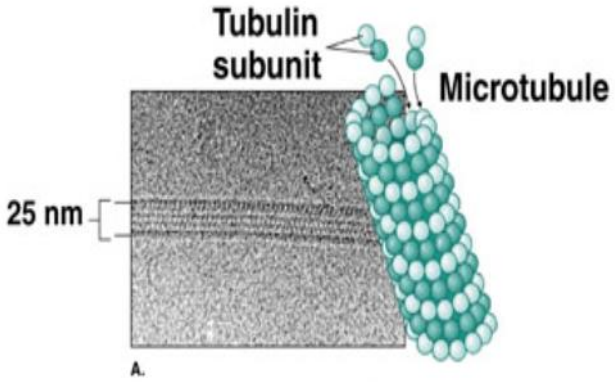


Fig (15): Structure of microtubule

The microtubules are hollow, unbranched cylinders, generally about 200 to 270 Å thick and several micrometers long (the diameter of the microtubule fiber is 25 nm with GTP-αβ tubulin heterodimers as protein subunits (monomers). They may occur singly or in bundles and radiate from the centriole to the periphery of the cell. The microtubule is composed of 13 parallel proto- filaments that run its entire length and enclose a central lumen about 150 Å wide. Each proto filament is made up of a row of globular subunits that have a diameter of about 40 to 50 Å. There may be cross bridges between adjacent microtubules.

2-Microfilament:

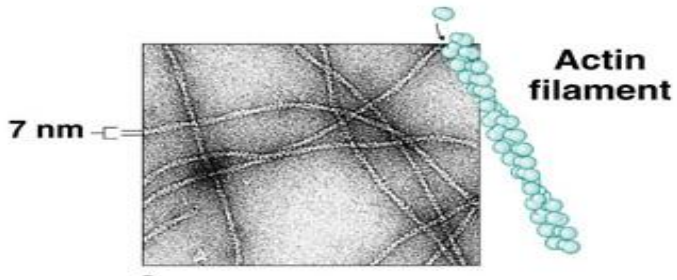


Fig (16): Structure of microfilament

In contrast with microtubules, the microfilament is a thinner type of cytoskeletal filament. The diameter of the microfilament or actin filament is 8 nm with ATP Actin molecules as protein subunits (monomers). Actin, a protein that forms chains, is the primary component of these microfilaments. Actin fibers, twisted chains of actin filaments, constitute a large component of muscle tissue and, along with the protein myosin, are responsible for muscle contraction. Like microtubules, actin filaments are long chains of single subunits (called actin subunits). In muscle cells, these long actin strands, called thin filaments, are "pulled" by thick filaments of the myosin protein to contract the cell. Actin also has an important role during cell division. When a cell is about to split in half during cell division, actin filaments work with myosin to create a cleavage furrow that eventually splits the cell down the middle, forming two new cells from the original cell. The final cytoskeletal filament is the intermediate filament.

1- Intermediate filament:

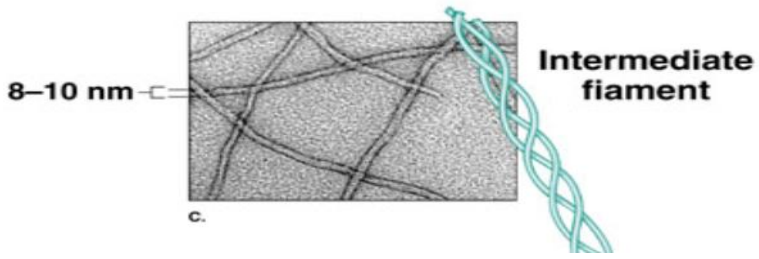


Fig (17): Structure of Intermediate filament

As its name would suggest, an intermediate filament is a filament intermediate in thickness between the microtubules and microfilaments. The diameter of the intermediate filaments is 10-12 nm (Figure 63). Intermediate filaments are made up of long fibrous subunits of a protein called keratin that are wound together like the threads that compose a rope. Intermediate filaments, in concert with the microtubules, are important for maintaining cell shape and structure. Unlike the microtubules, which resist compression, intermediate filaments resist tension the forces that pull apart cells. There are many cases in which cells are prone to tension, such as when epithelial cells of the skin are compressed, tugging them in different directions. Intermediate filaments help anchor organelles together within a cell and link cells to other cells by forming special cell-to-cell junctions.

Cytoskeleton functions

The cytoskeleton plays an important role in maintaining cell shape and structure, promoting cellular movement, and aiding cell division.

1- To provide structural support in maintaining shape of the cells and resilience to tension and stress.

2- Intracellular transport of vesicle and movement of mRNA (refer to vesicular transport: from ER to Golgi apparatus to Plasma membrane) and translocation of organelles (to position various organelles within the cell).

3- The cytoskeletons also function as apparatus for cell motility by crawling movement (filopodia, lamellipodia) on substratum or swimming in aqueous medium through cilia or flagellar movement (microtubules) in single cell animals.

4- Motility: In multi-cellular organism, the contraction of muscles, movement of sperms, neurons, WBC and phagocytes are some mentions.

5- It forms the most essential component of cell division machinery. Cytoskeletons are responsible for the alignment and separation of Chromatids and subsequent cytokinesis to form daughter cells.

Nucleus

The first person to discover the nucleus was the scientist Leeuwenhoek in 1700, then Robert Brown came after him in 1831, confirming that the nucleus is an essential and permanent part of the cell. Since then, studies have been continuing on the anatomical and functional components of the cell. A nucleus, as related to genomics, is the membrane-enclosed organelle within a cell that contains the chromosomes. An array of holes, or pores, in the nuclear membrane allows for the selective passage of certain molecules (such as proteins and nucleic acids) into and out of the nucleus.

The nucleus is one of the most obvious parts of the cell when you look at a picture of the cell. It's in the middle of the cell, and the nucleus contains all of the cell's chromosomes, which encode the genetic material. So this is really an important part of the cell to protect. The nucleus has a membrane around it that keeps all the chromosomes inside and makes the distinction between the chromosomes being inside the nucleus and the other organelles and components of the cell staying outside. Sometimes things like RNA need to traffic between the nucleus and the cytoplasm, and so there are pores in this nuclear membrane that allow molecules to go in and out of the nucleus. It used to be thought that the nuclear membrane only allowed molecules to go out, but now it's realized that there is an active process also for bringing molecules into the nucleus.

The shape of the nucleus

The shape of the nucleus is often linked to the shape of the cell. As a general rule, most of the nuclei are spherical or oval in shape, and this does not preclude the presence of the nucleus in other shapes: elongated, clustered, sticky, pyramidal, pear-shaped, renal, etc.

Nucleus size

Often the size of the nucleus is not fixed or changes frequently. Despite this, there is a general relationship between the size of the nucleus and the size of the cytoplasm of the cell. This relationship is known as the cytoplasmic nuclear coefficient (SN). This means that the cytoplasmic nuclear coefficient has a constant value, meaning that the increase in the volume of the nucleus must be followed by an increase in the size of the cytoplasm, and when there is a failure to maintain the constant value of this coefficient, it is an indication that the cell has entered the process of division.

Number of nucleus inside the cell

The normal image of a cell is that it contains one nucleus, but not all cells have the normal number of nuclei. Some of them contain two nuclei (liver cells, nerve cells, and cartilage cells), and some of them contain a cellular compact, i.e. more than two nuclei, as in bone cells. Bone cells that are found in the bone marrow and also striated muscle fibers.

Nucleus location

It is natural that the nucleus does not exist in one location within the cell, and this is due to the different types of cells, but it is distinct and constant in one type of cell and the nucleus inside the cell has a number of sites

think with me after you put the nucleus in the center of the cell as a location other than this?

Structure

The nucleus goes through two stages in its life history:

A- The interphase, and it is called the metabolic phase, and it means the period that comes between each two successive divisions, and therefore it is called the "resting phase." This does not mean a total resting phase of the nucleus, but resting on division only, and the nucleus performs all its functions except for division.

B- The stage of division, which means the period of division in the cell, i.e. the period occupied by the different stages and forms of division.

The nucleus is a spherical-shaped organelle that is present in every eukaryotic cell. The nucleus is the control center of eukaryotic cells. It is also responsible for the coordination of genes and gene expression. The structure of the nucleus includes nuclear membrane, chromosomes, nucleoplasm, and nucleolus. The nuclear envelope, also known as the nuclear membrane, is made up of two lipid bilayer membranes that in eukaryotic cells surround the nucleus, which encloses the genetic material.

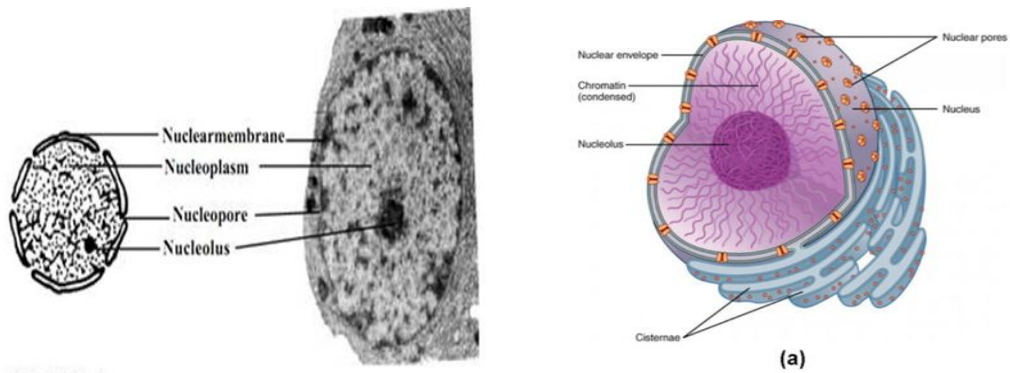


Fig (18): The Nucleus.

The nuclear envelope consists of two lipid bilayer membranes: an inner nuclear membrane and an outer nuclear membrane. The space between the membranes is called the pronuclear space. It is usually about 10–50 nm wide. The outer nuclear membrane is continuous with the endoplasmic reticulum membrane. The nuclear envelope has many nuclear pores that allow materials to move between the cytosol and the nucleus. Intermediate filament proteins called lamina form a structure called the nuclear lamina on the inner aspect of the inner nuclear membrane and give structural support to the nucleus.

The inner nuclear membrane encloses the nucleoplasm, and is covered by the nuclear lamina, a mesh of intermediate filaments which stabilizes the nuclear membrane as well as being involved in chromatin function. It is connected to the outer membrane by nuclear pores which penetrate the membranes. While the two membranes and the endoplasmic reticulum are linked, proteins embedded in the membranes tend to stay put rather than dispersing across the continuum. It is lined with a fiber network called the nuclear lamina which is 10-40 nm thick and provides strength. The nuclear envelope is punctured by around a thousand nuclear pore complexes, about 100 nm across, with an inner channel about 40 nm wide. The complexes contain a number of proteins, proteins that link the inner and outer nuclear membranes.

Nuclear Pores

The nuclear envelope is generally perforated by minute apertures, the nuclear pores that control the passage of some molecules and particles. The pores are formed by fusion of the inner and outer membranes of the nuclear envelope. There may be 1000 to 10,000 pores per nucleus.

Each nuclear pore is fitted with an apparatus called the pore complex which fills considerable part of the pore. The pore complex is nearly cylindrical, projects into both cytoplasm and nucleoplasm, and projects beyond the rim of the pore over the nuclear envelope. The pore complex consists of two rings, the annuli, one located at the cytoplasmic rim of the pore and the other at the nucleoplasm rim. Each annulus comprises eight symmetrically arranged subunits and sends a spoke into the pore. The spoke encloses a channel about 100 to 200 Å wide. Ions and small molecules of the size of monosaccharide, disaccharides or amino acids pass freely between the nucleus and cytoplasm. The pore complexes do control the passage of larger molecules, such as RNA and proteins, and of ribosomal subunits. The pore complexes also act as a barrier to some molecules such as DNA of chromosomes.

Nucleoplasm

Nucleoplasm is a transparent fluid material in the nucleus. The chromatin fibers and nucleoli are suspended in it. It contains raw materials (nucleotides), enzymes (polymerases) and metal ions (Mn^{++}, Mg^{++}) for the synthesis of DNA and RNA. It also contains proteins and lipids. The proteins include basic histones and acidic or neutral non-histones that associate with the DNA molecules. There are proteins for the formation of ribosomal subunits also. The RNAs (rRNAs, tRNAs, mRNAs) and ribosomal subunits synthesized in the nucleoplasm pass into the cytoplasm via nuclear pores.

Chromatin

The term chromatin was first coined by Flemming in 1879. The chromatin occurs in an interphase (non-dividing) nucleus as fine filaments, the chromatin fibers. The fibers lie criss-cross to give the appearance of a

diffuse network often referred to as the nuclear or chromatin reticulum. The chromatin occupies most of the nucleus. The chromatin fibers are simply extremely extended chromosomes. A chromatin fiber is normally about 100Å in diameter. A fiber thicker than 100Å appears to be coiled or folded, a fiber thinner than 100Å seems to have less protein content associated with it. Chromatin fibers typically appear approximately 250Å in diameter. During cell division, the chromatin fibers, by condensing and tight coiling, form short, thick, rod like bodies known as chromosomes.

Chromatin can exit as either euchromatin or heterochromatin. Euchromatin is the form of chromatin present during gene expression, and has a characteristic 'beads on a string' appearance. It is activated by acetylation. In contrast, heterochromatin is the 'inactive' form, and is densely packed. On electron microscopy, euchromatin stains lighter than heterochromatin which reflects their relative densities.

Upon staining, this diffuse network of chromatin material shows light stained and dark stained areas. After cell division, the chromosomes change back into chromatin fibers. Most of the chromatin fibers become uncoiled, extended, and scattered in the nucleoplasm. These represent the euchromatin (true chromatin) of the interphase nucleus. They are stained lightly.

The term heterochromatin is applied to those chromosomal regions that stain darker than others. They remain c**o**iled and compacted in the interphase too. Heterochromatin represents relatively inactive parts of the chromosomes. It contains less DNA and more RNA than the euchromatin. Few mutations occur in this region. Little or no mRNA is synthesized here. Most of the DNA in heterochromatin is highly repeated DNA, which is never, or very seldom, transcribed. Heterochromatin is of two types: constitutive and facultative. The DNA of constitutive heterochromatin is

permanently always inactivated and remains in the condensed state. It occurs at several places: adjacent to the centromere of the chromosome, at the ends (telomeres) of the chromosomes, at certain portions within the euchromatin, and adjacent to the nuclear envelope. Facultative heterochromatin is partly condensed and inactivated. One X-chromosome in female mammals is condensed to form the heterochromatic Barr body.

Nucleosomes

In 1974, Kornberg and Thomas proposed that a chromatin fiber is a chain of similar subunits called nucleosomes. The nucleosome consists of a core particle wrapped by DNA strand. The core particle is an octamer of 8 histone molecules, two each of the histones H2A, H2B, H3 and H4. The DNA strand forms 1½ or 1¾ turns around the core and consists of 140 nucleotides. Each nucleosome is connected to the next by a short DNA linker of 60 nucleotides.

A nucleosome and a linker together have a total average length of 200 nucleotides and are together referred to as a chromatosome. A molecule of histone H1 is associated with each DNA linker, and it serves to pack nucleosomes together. Thus, a chromatin fiber is a chain of beads, a bead (nucleosome) is about 100Å wide and DNA linker is about 140Å long. Nucleosomes represent the lowest level of chromatin organization. Chromatin fiber appears about 250Å thick in electron micrographs. which suggests that the 100Å thick chromatin fiber is either packed into a spiral or solenoids, containing 6 nucleosomes per turn or 6 nucleosomes are organized into a cluster, or super bead, thereby increasing the DNA packing by 5 folds. The thicker filament is maintained by H1 histone protein. The non-histone proteins do not occur in the nucleosome structure of chromatin. Nucleosomes are not formed in prokaryotes.

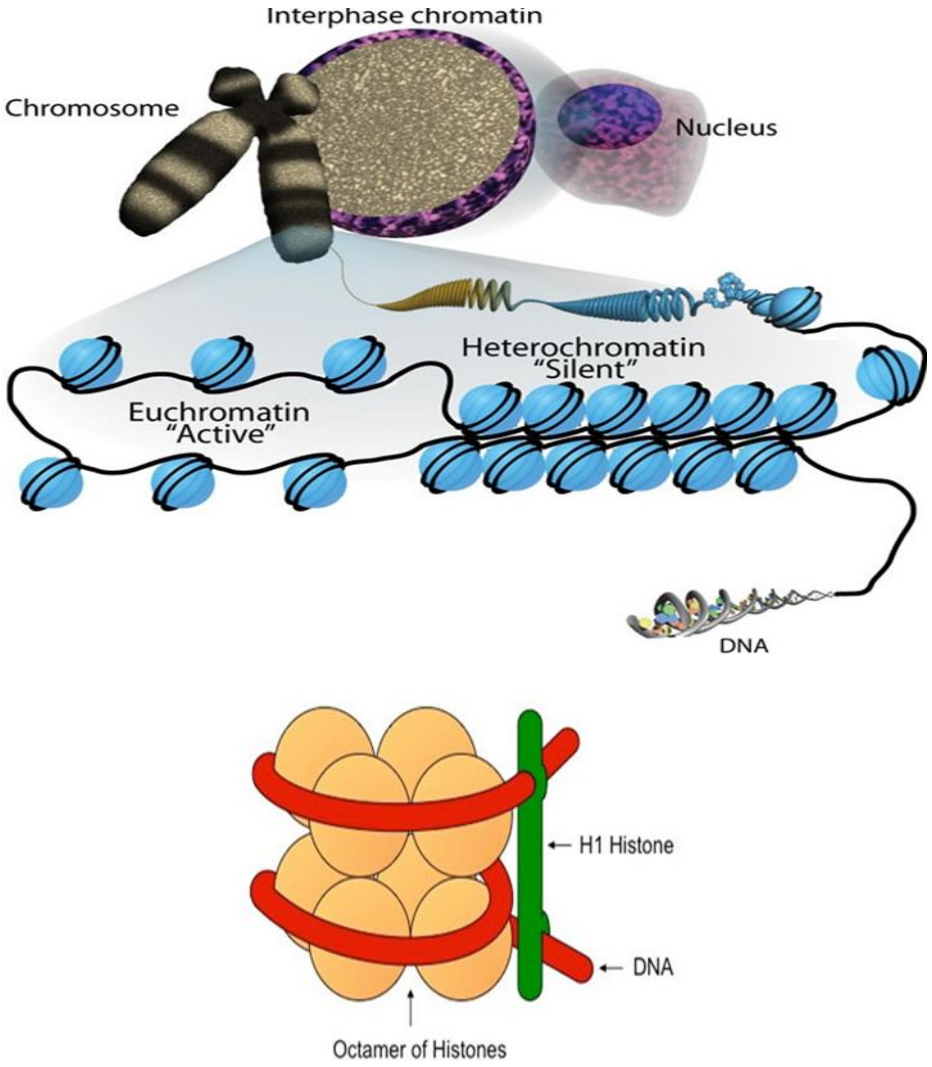


Fig (19): Structure of chromatin

Nucleolus

The nucleolus was discovered in 1781 by F. Fontana in the slime from the eel skin. It is present in the nucleus of most cells, but is inconspicuous or absent in sperm cells and in muscle cells. It is usually spherical but may have other forms. The number of nucleoli in a nucleus varies in different species. The nucleoli disappear during cell division, and are reformed at specific sites, the nucleolar organizers or nucleolar organizer regions (NORs), of certain chromosomes, the nucleolar chromosomes, at the end of cell division before the chromosomes become diffuse. Position of the

nucleolus in the nucleus is often eccentric. However, it occupies a specific position on its chromosome.

The nucleolus is the site of ribosome and ribosomal RNA production. On microscopy, it appears as a large dense spot within the nucleus. After a cell divides, a nucleolus is formed when chromosomes are brought together into nucleolar organizing regions. During cell division, the nucleolus disappears.The nucleolus is a dense, somewhat rounded, dark staining organelle. It is without a limiting membrane. Calcium ions keep it intact. It consists of four regions.

1- Fibrillar Region or Nucleolonema- It contains indistinct fibrils about 50-100Å in diameter. The fibrils represent the long rRNA precursor molecules in early stages of processing before the processing enzymes have cut off segments from them.

2- Granular Region- It contains spherical, electron dense particles, about 150-200 Å in diameter and with fizzy outline. The granules are ribosomal subunits (rRNA + ribosomal proteins) that are nearly ready for transport to the cytoplasm.

3- Amorphous Region or Pars Amorpha- It is a structure-less proteinaceous matrix in which the granular and fibrillar regions are suspended.

4- Nucleolar Chromatin- It consists of 100 Å thick chromatin fibers. The latter are a part of the nucleolar chromosome which follows a tortuous path through the granular and fibrillar components of the nucleolus. This part contains many copies of DNA that directs the synthesis of ribosomal RNA. The rest of the nucleolar chromosome lies in the nucleoplasm.

Functions of Nucleus:

1-The nucleolus synthesizes and stores rRNA.

2-It also stores ribosomal proteins received from the cytoplasm.

3-It forms ribosomal subunits by wrapping the rRNA by ribosomal proteins. The ribosomal subunits pass out through the nuclear pores into the cytoplasm. Here the subunits join to form ribosomes when needed. Thus, it is the nucleolus which provides machinery (ribosomes) for protein synthesis.

4-The nucleolus also plays a role in cell division.

Chemical Composition

The nucleus is composed of about 9-12% DNA, 5% RNA, 3% lipids, 15% simple basic proteins such as histone or protamines, about 65% complex acid or neutral proteins, including enzymes such as polymerases for the synthesis of DNA and RNA, organic phosphates and inorganic salts or ions such as Mg^{++}, Ca^{++} and Fe^{++}.

Nucleus Function

Following are the important nucleus function:

1-It contains the cell's hereditary information and controls the cell's growth and reproduction.

2-The nucleus has been clearly explained as a membrane-bound structure that comprises the genetic material of a cell.

3-It is not just a storage compartment for DNA, but also happens to be the home of some important cellular processes.

4-First and foremost, it is possible to duplicate one's DNA in the nucleus. This process has been named DNA Replication and produces an identical copy of the DNA.

5-Producing two identical copies of the body or host is the first step in cell division, where every new cell will get its own set of instructions.

6-Secondly, the nucleus is the site of transcription. Transcription creates different types of RNA from DNA. Transcription would be a lot like creating copies of individual pages of the human body's instructions which may be moved out and read by the rest of the cell.

7-The central rule of biology states that DNA is copied into RNA, and then proteins.

CHROMOSOMES

Hofmeister in 1848, discovered nuclear filaments in the nuclei of pollen mother cells of Tradescantia. First accurate count of chromosomes was made by Flemming in 1882, in the nucleus of a cell, also he in 1884, demonstrated that the chromosomes double in number by longitudinal division during mitosis. The structure of chromosomes varies in viruses, prokaryotes and eukaryotes as follows:

A- Viral chromosome- In viruses there is a single chromosome bearing a single nucleic acid molecule (RNA) surrounded by a protein coat called Capsid. In RNA viruses, often the RNA directs the synthesis of DNA complementary to itself by reverse transcription in the host. The RNA is then transcribed by DNA for the formation of new virus particles. Such ribovirus is called retrovirus.

B- Prokaryotic chromosomes- Prokaryotic chromosome has asingle and circular two-stranded DNA molecule which is not enveloped by any membrane. It is in direct contact with the cytoplasm, also attached to plasma membrane permanently. In addition to the main chromosome some extra-chromosomal DNA molecules may also be present in most of the bacterial cells, but are much smaller in size. They are known as plasmids.

The plasmid may occur independently in the cytoplasm of cells or may also be found in association of main chromosomal DNA and called as episome.

C- Eukaryotic chromosomes- They are present in nucleus and in certain other organelles, like mitochondria and plastids. These chromosomes are called nuclear chromosomes, they are double stranded long DNA molecules. Proteins are associated with them, they are surrounded by nuclear envelope. More DNA is involved in coding far more proteins than the prokaryotic chromosomes**.** Extra nuclear chromosomes are present in mitochondria and plastids. Other proteins are received from the cytoplasm where they are synthesized under the direction of nuclear chromosomes.

Morphology of Chromosomes

During the interphase stage, the eukaryotic chromosomes are extended into long and thin chromatin fibers where they lie criss-cross to form the chromatin reticulum. They replicate in the S-phase and become double. At this stage they consist of two chromatids that are held together at one point called centromere. At the time of cell division, the chromosomes condense and tightly coil up and become distinct at metaphase stage. The eukaryotic chromosomes vary in number, size, shape and position but they have remarkably uniform structure.

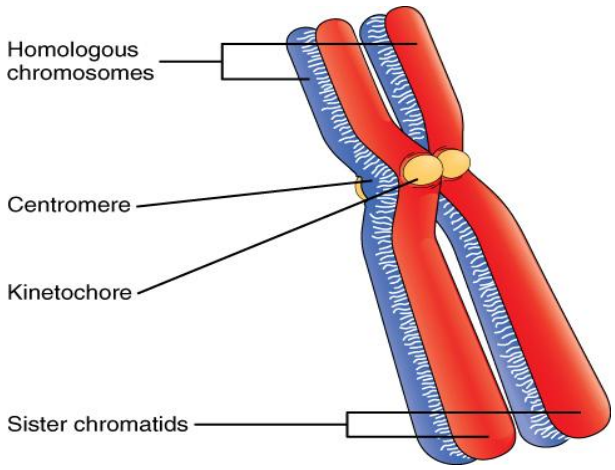


Fig (20): Structure of chromosome

Number: Eukaryotic chromosomes vary in number from two to a few hundred in different species. In a species all the individuals have same number of chromosomes in all of their cells, except the gametes. Since the chromosome number is constant for a species, it is helpful in determining and taxonomic position of the species.

Size: In a **species all the chromosomes are not of the same size.** Their size also varies from species to species. The particular chromosome of a species however has more or less a constant size. The organisms having fewer chromosomes have large sized chromosomes than those having many. Generally, plant chromosomes are larger than animal chromosomes.
Shape: The chromosomes at metaphase stage look like slender rods that may be straight or curved to form an arc or a letter S. In anaphase stage they may assume J or V shapes, depending upon the position of the centromere.

Position: In a nucleus each chromosome is independent of all the other chromosomes in its location. Thus, they may occupy any region of the nucleus.

Structure: At metaphase stage, since the chromosome is a highly condensed nucleoprotein filament, it contains two greatly coiled sister chromatids. These chromatids that lie side by side along their length, are held together at a point called centromere, an area of the narrow region also called primary constriction of the metaphase chromosome. At the centromere each chromatid has a darkly staining, disc like, fibrous structure, called kinetochore, to which spindle microtubules attach during cell division. Kinetochores are the sites where force is exerted to pull the chromatids towards the poles. One or more chromosomes may have additional narrow regions called the secondary constrictions. The part of

the chromosome separated by secondary constrictions is termed as satellite. A chromosome with a satellite is called sat chromosome. The size and the shape of the satellite remain constant for a species. Secondary constrictions are associated with the nucleoli and are known as the nucleolar organizers. The chromosomes which have nucleolar organizing regions are known as the nucleolar chromosomes**.**

Ends- The ends of chromosomes are called telomeres. The function of telomere varies from the rest of the chromosome. On exposure to X-rays a chromosome may break and its pieces may rejoin, but no segment connects to the telomere, showing that the telomere has a polarity, and it, somehow "seals" the end.

Ultra-structure: A chromatid contains a very fine filament called chromonema which is a single, long, double stranded DNA molecule. It is wrapped around histones to form nucleosomes. The nucleosome and non-histone proteins together form the chromatin fiber. The chromatin fiber has reactive groups, probably H1 histone molecules, which act as "folders" and crosslink the chromatin fiber changing it into a great coiled, compact metaphase chromatid.

Chemical composition: The chromatin in the eukaryotic chromosome consists chemically of about 35% DNA, about 60% proteins, about 5% RNA, some metal ions and certain enzymes.

Types of chromosomes: On the basis of the position and number of centromeres, chromosomes are classified as below

a- Metacentric: In metacentric chromosomes the centromere is at the middle of the chromosome, and the arms are equal, length of long arm on length of short arm range from 1.0 to 1.7. In anaphase the chromosome appears V-shaped. For example: human chromosome no. 3

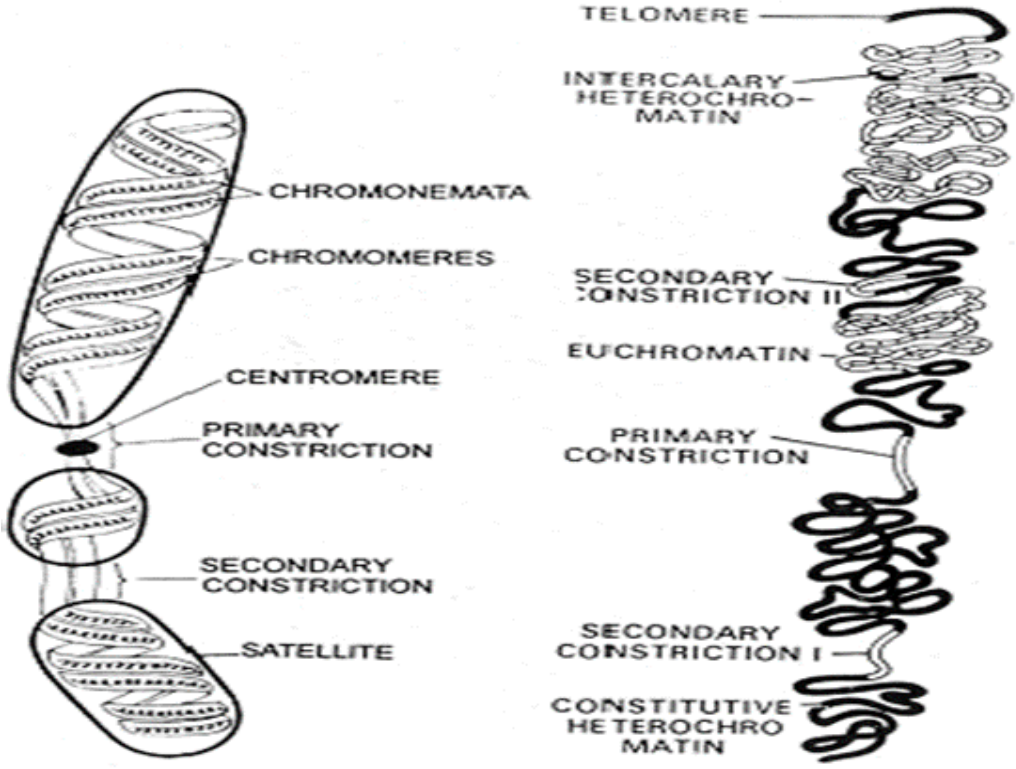


Fig (20): Structure of chromosome

b- Submetacentric: In such chromosome, the centromere is near the center of the chromosome, and the arms are slightly unequal, length of long arm on length of short arm range from 1.7 to 3.0 and in anaphase the chromosome appears J or L shaped. For example: Human chromosome No. 1.

c- Subtelocentric: In this type the centromere is near one end of the chromosome, and the arms are very unequal, length of long arm on length of short arm range from 3.0 to 7.0. For example: Human chromosome No. 4 & 5.

d- Telocentric (Acrocentric): The centromere is at one end in such chromosomes, and the arms are on one side only, length of long arm on length of short arm range from 7.0 to ∞. The chromosome remains rod shaped in anaphase also

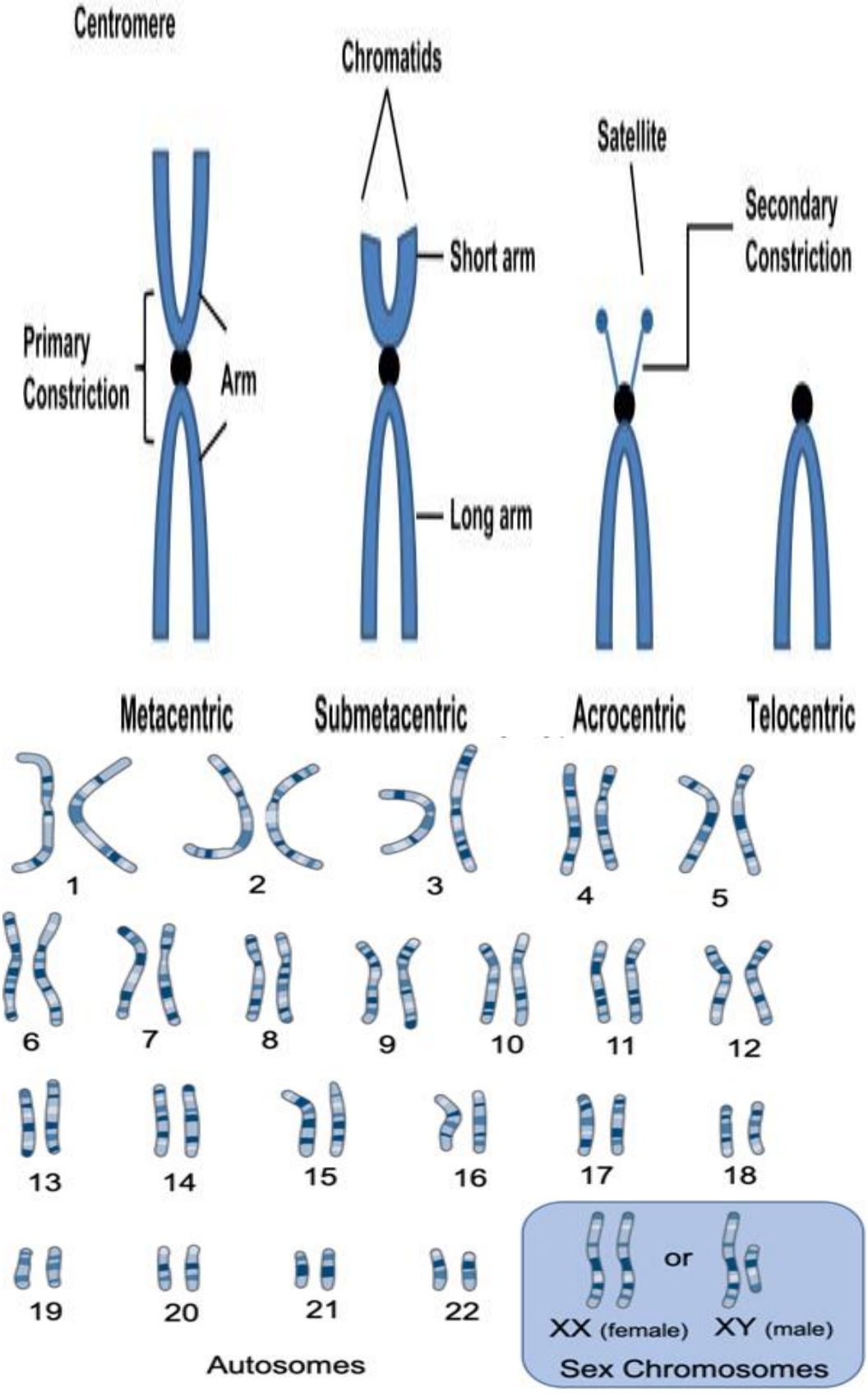


Fig (21): Types and karyotype of human chromosomes

Functions of Chromosomes:

1- Chromosomes carry hereditary characters from parents to offspring.

2- They direct the synthesis of structural proteins and thus, help the cell grow, and divide.

3- By directing the formation of necessary enzymes, they control metabolism.

4- They guide cell differentiation during development.

5- They form nucleoli at nucleolar organizer sites in daughter cells.

6- They produce variations through changes in their genes and contribute to the evolution of the organisms.

7- They play role in sex determination.

8- They maintain the continuity of life by replication.

Giant Chromosomes:

Giant chromosomes are special, enormously enlarged chromosomes about 100 times thicker than the ordinary mitotic chromosomes. These are seen in certain tissues of varied groups of animals and plants. They are easily visible under light microscope. The giant chromosomes are of two types: polytene and lampbrush.

1- Polytene chromosomes

Polytene chromosomes were first observed by Balbiani (1881) in Chironomus (a dipteran larva). Because of their large size showing numerous strands these are named as polytene chromosomes by Kollar. These banded chromosomes occur in the larval salivary glands (salivary gland chromosomes), midgut epithelium, and rectum and Malpighian tubules of various genera of diptera.

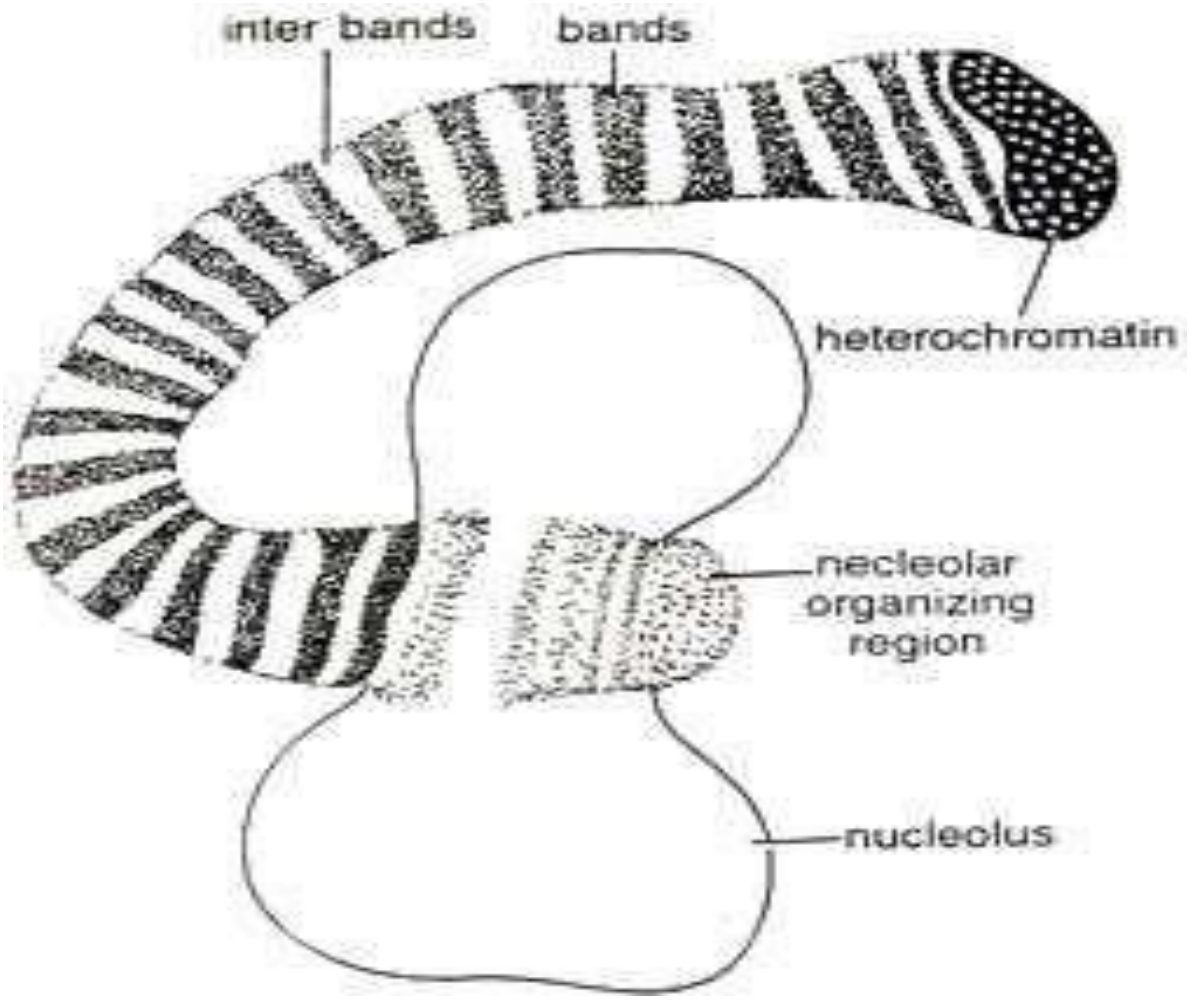


Fig (22): Structure of Polytene chromosome

These chromosomes are about 100-200 times larger than those of somatic chromosomes. They are roughly cylindrical and exhibit a distinct pattern of transverse striated structures consisting of alternate darkly staining band and light staining interbands. Dark bands are rich in DNA along with a small amount of RNA and basic proteins. They are genetically active. The inter-bands contain less of DNA but more acidic proteins and hence they are less active. The polytene chromosomes are formed by repeated replication of DNA without division of chromosome into daughter chromosomes. This amplification without separation is called

polytenization. Thus, there can be as many as several thousands of chromonemata in a giant chromosome.

Functions of the Giant Polytene Chromosomes:

a-Polytene chromosomes carry genes which ultimately control physiology of an organism. These genes are formed of DNA molecules.

b-These chromosomes also help in protein synthesis indirectly. The RNA present in the nucleolus serves as a means of transmission of genetic information to the cytoplasm, leading to the formation of specific protein

2-lampbrush chromosomes

These are the largest chromosomes which can be seen with naked eyes and are found in yolk rich oocytic nuclei of certain vertebrates such as fishes, amphibians, reptiles and birds. They are characterized by the fine lateral loops, arising from the chromomeres, during first prophase of meiosis. Because of these loops they appear like brush; that is why they are called lampbrush chromosomes first discovered by Flemming in 1882 and described in shark oocytes by Ruckert (1892).

Lampbrush chromosome consists of longitudinal axis formed by a single DNA molecule along which hundreds of beads like chromomeres are distributed. Two symmetrical lateral loops (one for each chromatid) emerge from each chromomere, which are able to expand or contract in response to various environmental conditions. About 5 to 10% of the DNA is in the lateral loops. The axis having compacted DNA and tightly associated proteins is transcriptionally inactive. The loops consist of uncompacted DNA and proteins but have a good amount of RNA and they are transcriptionally active. A chromomere and its associated loop correspond with one gene.

In lampbrush chromosomes the DNA loops are the sites of intensive RNA synthesis. rRNA and mRNA are synthesized in large amount and the transcription of rRNA causes the enlargement of nucleolus, or formation of numerous additional nucleoli. Due to the synthesis of large amounts of proteins, fats, carbohydrates, and other molecules in the cytoplasm needed for further development of the embryo, the oocyte grows in size. Synthesis of proteins occurs near the loops.

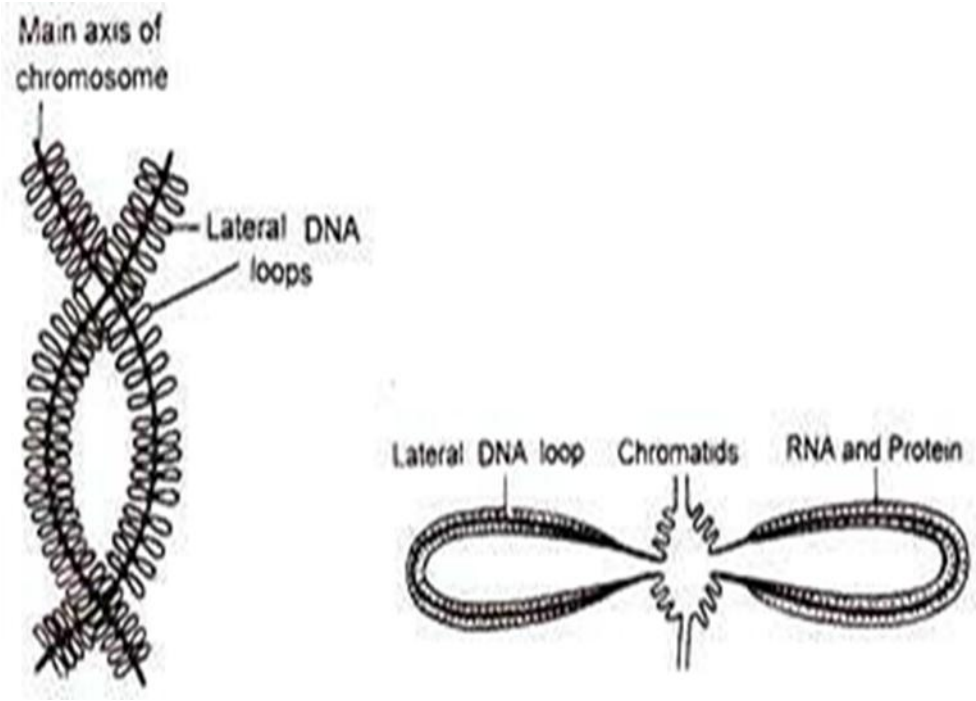


Fig (23): Detailed structure of lampbrush chromosome

Functions of Lampbrush Chromosome:

1-Involved in the synthesis of RNA and proteins by their loops.

2-Probably help in the formation of certain amount of yolk material for the egg.

Shapes and sizes of animal cells

Most animal cells range in size from 10 to 100 microns. The size and shape of cells in organisms varies greatly. The difference reaches its deepest

when we find that there are thousands of shapes, types and sizes of cells in a single organism originating from a single cell. It seems that this difference in the size and shape of cells is due to important reasons such as age, location of cells and their embryonic development, as well as function, which is of great importance in determining size and shape.

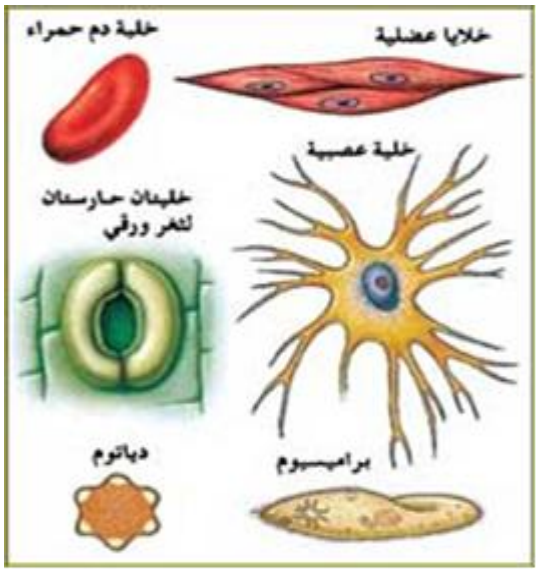
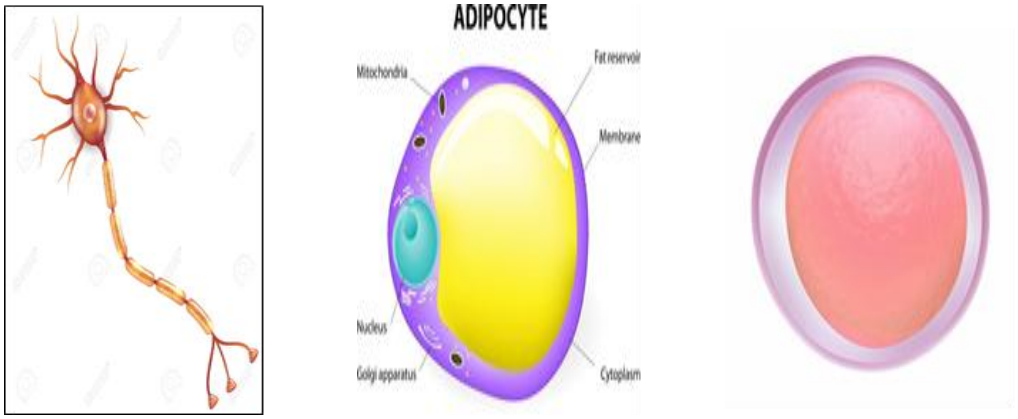


Fig (3): Types of animal cells shapes

Neurons are characterized by their large size and the presence of many prominent appendages from the cell body, in addition to the presence of a long prominent protrusion that is associated with other neurons located far away in another location, and thus they can transmit thousands of nerve

messages through their dendrite appendages associated with thousands of axons of other neurons. Fat cells and eggs are among the largest cells in size, due to the presence of a lot of nutrients stored in these cells.



Nerve cell Fat cell Egg cell

Fig (3): Types of animal cells shapes

Thus, the fusiform shape of smooth muscles, the cylindrical shape of skeletal and cardiac muscles, the fusiform shape of the caudal sperm, and the ciliated cells in the lining of the trachea, intestines, and ovarian channels serve the function of these cells, as well as the amoebic cells and white blood cells adapt in different forms to serve its function.

Cell cycle

The cell cycle is the successive phases of growth and division that occur in the cell during the time period between two successive divisions, and the duration of this period varies from one cell to another. The cell cycle lasts for at least 12 hours, and the cell does not move from the primer stage until it has prepared the chemical compounds it needs for division, including amino acids, lipids, and sugars. Therefore, the time and speed of cell division depends on the amount of nutrients the body receives. Most cells go through four stages, which are the preliminary stage, followed by the

equatorial stage, then the dissociative stage, and finally the final stage. Thus, the cell has divided and formed two daughter cells.

The cell cycle consists of two alternating phases, the interphase and the cell division phase:-

First Interphase

Which takes 90% of the cycle time, and includes three periods:

1- The first growth phase, G1 phase: in which the number of cell organelles and enzymes multiply, and thus the cell size increases

2- The S phase of synthesis, deoxyribonucleic acid doubles

3- The second growth phase, G2 phase: the cell grows rapidly in preparation for division

Second: Cell division

There are two types of cell division: indirect division and meiosis, which ends with the formation of two cells, each of which enters a new metaphase.

G0 rest phase stage

G0 phase is a resting phase, the cell exits the cycle of division and stops dividing. The cell division cycle begins with this phase. The phrase "post-mitotic phase" is sometimes used to refer to both dormant cells and senescent cells. Non-reproducing (non-dividing) cells in multicellular eukaryotes generally enter a dormant G0 phase from G1 and may remain dormant for a long period of time, sometimes possibly indefinitely (as is often the case for nerves). This is very common for fully differentiated cells. Cellular senescence occurs in response to DNA damage and external stress and usually causes G1 phase arrest. Some cells enter the G0 phase

semi-permanently and are considered post-mitotic, such as some cells of the liver, stomach, and kidneys. Many cells do not enter the G0 phase and continue to divide throughout the life of the organism, such as skin cells, for example.

Interphase stage

Interphase is a series of changes that occur in a newly formed cell and its nucleus before it is able to divide again. It is also called prophase between the stages of mitosis. Interphase usually for at least 90% of the total duration of the cell's life cycle. Interphase has three phases namely G1 phase, S phase and G2 phase followed by the cycle of mitosis and cytokinesis. The DNA contents of the cell nucleus duplicate during the S phase (the synthesis phase).

G1 phase stage (post-mitotic vacuolar stage)

The first phase during interphase from the end of the preceding M phase to the beginning of DNA synthesis is called G1 phase during this phase, the vital activities of the cell, which slowed down greatly during the M phase, resume at a high rate. The duration of G1 phase varies greatly, even between different cells of the same type. In this phase, the cell increases its supply of proteins, increases the number of its organelles (such as mitochondria and ribosomes), and increases its size. In front of the cell in the G1 phase, there are three options.

A- Follow the cell cycle and enter the synthesis phase.

b- Stopping the cell cycle, entering the G0 phase and undergoing differentiation.

c- Stop in G1 phase and thus either enter G0 phase or re-enter cell division.

S phase (DNA replication phase)

S phase begins when DNA synthesis begins, all chromosomes have divided, meaning that each chromosome consists of a pair of chromatids. Thus, during this prophase, the amount of DNA in the cell has doubled, although the chromosome formula and number of chromosomes has not changed. Rates of RNA transcription and protein synthesis are very low during this stage. The only exception is histone synthesis, which takes place mostly during this phase.

G2 phase (developmental phase)

The G2 phase occurs after DNA replication and is a stage of protein synthesis and acceleration in cell growth to prepare the cell for mitosis. During this prophase, microtubules begin to reorganize to form a spindle (pre-prophase).

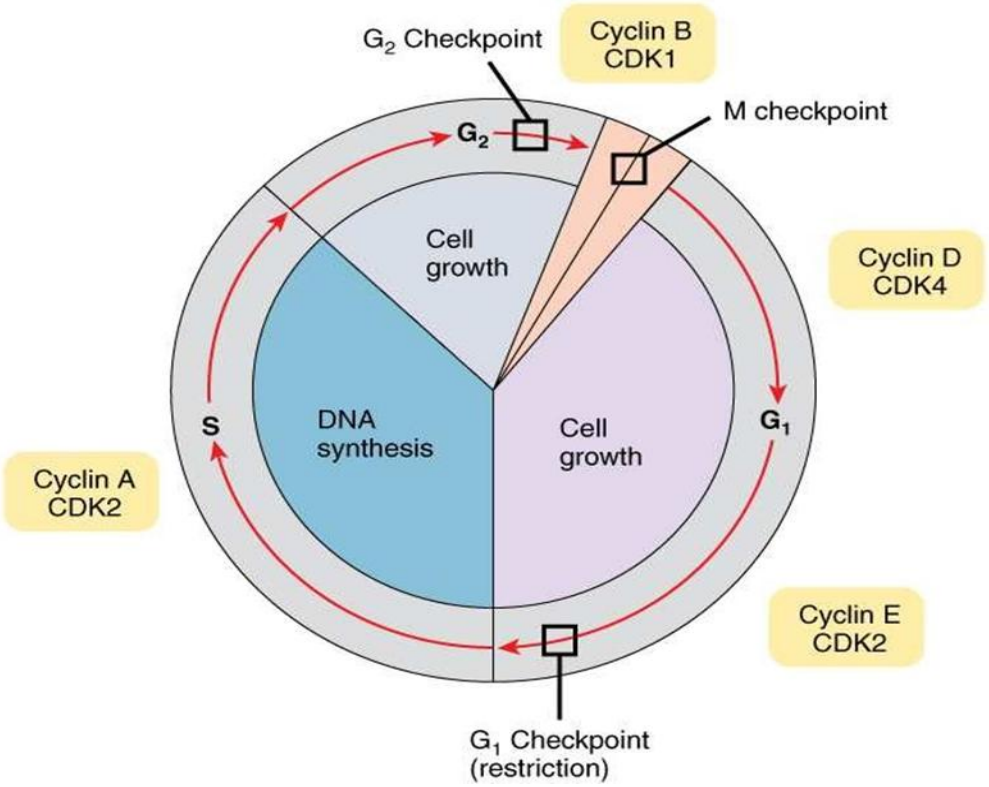


Fig (24): Cell cycle

Cell division

As we said earlier, many scientists were able to witness cell division. In the year (1841) Rimac came to the discovery of direct cell division, while Schneider in the same year was able to discover the mitosis of cell division, and for the first time in the year (1854) the world was able to Newport saw the entry of the sperm into the ovum of the frog, while Herotig (1875) explained the fusion of the sperm with the ovum, and with this characteristic scientists were able to understand the laws of inheritance. It was confirmed during the nineteenth century that life comes through a previous life, and that cells come from previous cells, and that each generation of cells or individuals results from reproduction, as the offspring are similar to parents. In order for this process to take place, the genetic material or genetic chromosomes must be doubled, i.e. there must be a mechanism that guarantees the increase of amino acids and the transfer of genetic information.

Therefore, copies of the genetic information must be made to ensure that the product obtains this information in order to grow and be a product in turn. When the genetic material is multiplied in the parents, it is transmitted to the children (product) so that the generations continue to live and survive. Also, the two processes of doubling the genetic material and transferring it from parents to children must be done with the utmost safety in order for the product to become similar to the parents. The replication of the genetic material occurs when the DNA doubles, and since we know that the new DNA is copied.

Cell division includes the division of the nucleus that precedes the division of the cytoplasm, and scientists have distinguished two basic types of cell division, namely mitosis and meiosis, and this does not preclude the existence of another division, which is direct division Amitosis based on a specific type of cells and also under conditions Especially and therefore cell division depends on the behavior of the nucleus. Cell division: is the stage in which the eukaryotic cell separates the chromosomes within its nucleus into two identical groups within two nuclei. During mitosis, chromosomes condense and attach to microtubules that pull sister chromosomes to either side of the cell.

Mitosis

Mitosis, also known as indirect division, is the division of the nucleus once to give two nuclei, as well as the duplication of chromosomes also once.For student study, the description should be easy, and therefore we must know that this division passes through four different stages, namely: the preliminary stage - the metaphase stage - the anaphase stage - the final stage - the telophase stage.

Prophase stage

This stage is based on the degree of stability of the nucleus and its structures, the most important of which are the chromosomes. When the degree of stability is zero, this means that the nucleus is not stable, and all this is limited to the interphase stage, after which the journey of the preliminary role of division begins, so that we find that the chromosomes have a destiny From stability, as it appears in the form of fine threads inside the nucleus, and these threads are intertwined, and to study this, the cell is dyed with a dye that deals with these threads, giving it a light blue color through which the chromosome can be studied under the microscope.

Where it appears in the form of a long chain of small particles of different sizes known as chromomeric, which are connected to each other by a thin thread lighter than them, and the longitudinal arrangement of these chromosomes is fixed for each chromosome, and adjacent chromomeric have a tendency to gather with each other during the fixation process, after this process and with the progression of the preliminary stage, the chromosomes shorten and increase in thickness gradually, and therefore the preliminary stage takes place with the loss of water to increase the degree of stability, growth, contraction or condensation. It seems that each chromosome at this stage splits longitudinally, meaning that each chromosome consists of two longitudinal halves, each of which is known as the chromatid or the daughter chromosome, and this confirms that the chromosomes are always double since the beginning of the preliminary stage, and the two chromatids are attached along the chromosome and contain a single non-body Able to divide is known as the centromere or the middle piece and it should be noted that the chromosomes are always separate and independent.

When the initial preparations for the preliminary stage are completed, the main steps for division begin, which are as follows: the centriole of the central body of the cell center is divided into two granules if it is not present in the form of two granules. Each granule begins to migrate towards one of the cell poles (the animal pole and the vegetable pole). With the continuation of the migration of the two granules, the sarcoplasm of the central body turns into astral rays that connect the two granules. When each granule approaches the pole to which it is heading, the nucleus and the nuclear membrane begin to disappear, leaving only the components of the nucleus, the nuclear fluid and the chromosomes (chromatid threads). At the end of the preparatory stage, the transparent layer of the central body turns into the spindle threads, with which the preparatory stage stops and the equatorial stage begins.

B- Metaphase stage

This stage begins with the appearance of the spindle threads, noting that near the end of the preliminary stage, we referred to the disappearance of the nuclear membrane and the nucleolus, and we said that the remainder of the structure of the nucleus is the nuclear fluid and the chromatid threads (chromosomes), and with the appearance of the spindle threads, the chromosomes begin to attach the spindle threads by the centromeres and the region to which the chromosomes attach from the spindle threads known as the equatorial plate, noting that the chromosomes at this stage are paired and facing the equatorial plate.

C- Anaphase stage

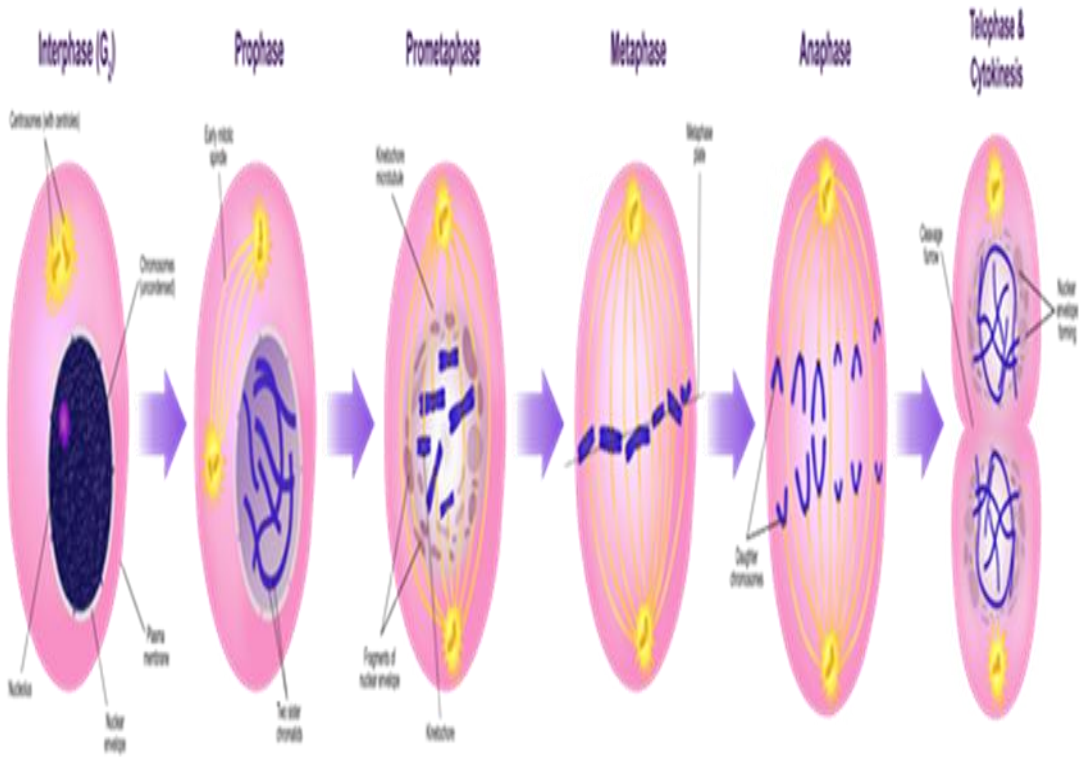
Each chromosome consists of two chromatid strands connected by a centromere or middle piece. With the beginning of the division phase, the chromosome splits longitudinally into two chromatids, each of which has a part of the centromere. Then the two strands separate from each other and

each moves towards one of the opposite poles of the spindle. Then the transcription process occurs, where each chromatid strand copies itself to form a complete chromosome, and thus chromosome duplication

D- Telophase stage

At this stage, each group of chromosomes present at one of the spindle poles begins to gather, then the journey of the appearance of the nucleus and the nuclear membrane begins at each of the spindle poles, and thus two nuclei are formed. …….. How?

In the meantime, a suffocation notch appears around the equatorial region of the cell, and this notch continues to advance inwards until it divides the cell into two sister cells, daughter cells, each of which is an exact copy of the original mother cell, and the difference is only in size 0, and the time period varies Mitosis takes between ten minutes to several hours, depending on the cell type - its functional state - external factors.



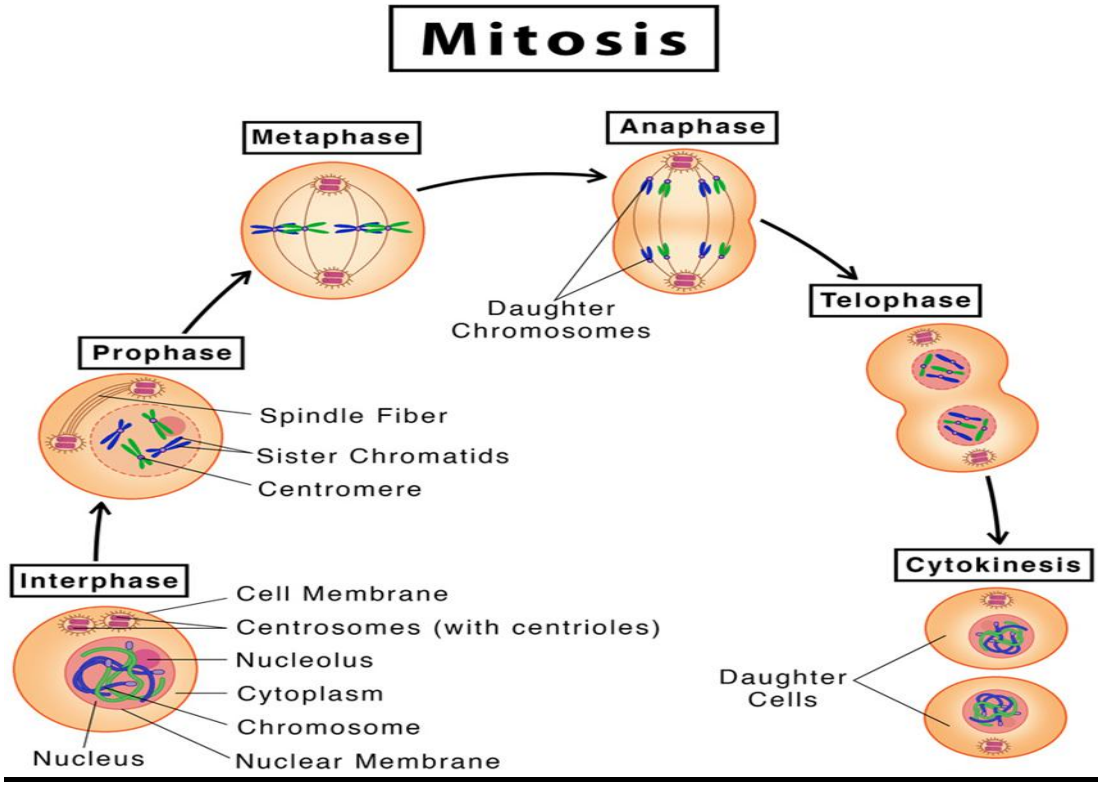


Fig (25): Mitosis division

Cytokinesis

An invagination occurs in cell membrane from top to bottom and from bottom to top until the two ends of the cell membrane meet as it progresses inward until it divides the cell into two sister cells, two daughter cells, each of which is an exact copy of the original mother cell, and the difference is only in size 0, and the period varies. The time period for mitosis takes from ten minutes to several hours, depending on the type of cell - its functional state - external factors. Cytokinesis is the division of cytoplasm. It encloses the daughter nuclei formed by the karyokinesis in separate cells, thus completing the process of cell division. Cytokinesis is signaled at the metaphase by cytoplasmic movements that bring about equal distribution of mitochondria and other cell organelles in the two halves of the cell. Division occurs differently in animal cells and the plant cells.

Significance of Mitosis:

Mitosis has manifold significance-

a- Size- Mitosis helps maintaining the size of the cell. A cell, when full grown, divides by mitosis instead of growing further.

b-Growth- A fertilized egg develops into an embryo and finally into an adult by repeated mitotic cell division.

c- Chromosome Number- Mitosis keeps the number of chromosomes equal in all the cells of an individual. Thus, mitosis provides a complete set of genetic information to each cell, since DNA is duplicated in S phase prior to mitosis.

d-Repair- Mitosis provides new cells to replace the old worn out and dying cells.

e- Regeneration- Mitosis produces new cells for the healing of wounds and regeneration.

f-Reproduction- Mitosis brings about multiplication in the acellular organisms. In multicellular organisms also, it plays an important role in reproduction, asexual as well as sexual.

g-Evidence of Basic Relationship of Organisms- Mitosis, being essentially similar in many kinds of organisms, supports the basic relationship of all living things.

Meiosis (reduction division) Meiosi division

The body of an organism contains a reproductive system with two types of cells, somatic cells that contain the diploid number of chromosomes (2n) and sex cells that contain the haploid number of chromosomes (n). For example, the even number of chromosomes of the human body cell is 46,

while the number of chromosomes in the sex cell is 23, and this confirms the inability of the sex cell alone to divide. A female oocyte to obtain a single cell that contains the double (even) number of chromosomes, and in this case the cell has the ability to divide. The cell division in which the number of somatic chromosomes (2n) is reduced to half (n) is known as meiosis or reduction. Meiosis passes through two level divisions, between which there may or may not be a period of time. During these two divisions, the chromosomes divide once. While the nucleus divides twice, these two divisions are called the first meiotic division and the second meiotic division, and they are separated by a very short interphase, and in some other organisms this interphase is absent.

This division goes through four basic stages:

A- First prophase stage

This stage is characterized by its length and complexity, so we divide it into several stages according to the order of their occurrence.

1- Leptotene stage

This phase begins with simple preparation, which is an attempt to show the chromosomes due to the difficulty of their clarity, then a series of manifestations of the clarity of the chromosome begins until they appear in the form of long and thin threads equal in number to the chromosomes in the somatic cell, and this gave the impression to researchers and scientists that the chromosomes do not divide longitudinally and that the chromosome It is a single chromatid. Chromosomes may exist either in an ordered (polarized) manner or in an unordered (non-polarized) manner.

2-Zygotene stage

Similar or homologous chromosomes are arranged in pairs, whether they are polarized or non-polarized in the case that it is polarized, the process of pairing begins from the centromere, and otherwise, the pairing begins from any point other than the centromere. And duplication also takes place between the chromomeric from the inside, and after that we find that the chromosomes appear thick and short, and coups may occur during the mating process, which leads to the inversion of part of the chromosome. Counterpart is on the other chromosome a', b', c', d', e', f', then duplication of occurs with a' and b with b'. The inverted region will remain unpaired and form a bend in the middle. It seems that the process of duplication results from the force of attraction between homologous chromomeric, and the force of attraction is qualitative, and it performs its role within specific distances, and there is a possibility that the force of attraction coincides with the force that keeps the two chromatids together along the length of the chromosome.

3-Pachytene stage

When a duplication of chromosomes occurs, they become short and thick, number of chromosomes appears to be reduced by half, meaning that the reduction is only apparent, each unit is a pair of chromosomes, four chromatid threads. In the middle of this phase, longitudinal division of each chromosome occurs at a level perpendicular to the duplication process. The connective phase can be called a phase with two straps before fission and a phase with four straps tetrads after fission. After the fission process, each two straps wrap around the other two straps, and it may occur during This is when the homologous internal chromatids break, then an exchange occurs between the broken pieces, and this process is known as crossing over, and the two external chromatids remain as they are.

4-Diplotene stage

This phase begins when the homologous chromosomes fission process and move away from each other, and thus the forces of attraction turn into repulsion forces, and the separation of the homologous chromosomes is not a complete separation, but the chromosomes remain connected to each other through the chiasmata points, which are the exchange points between the chromatids. The analogues, which are between the ends of the chromosomes, are also gradually reduced and move externally, forming what is called terminilization.

5- Diakinesis

This phase corresponds to the late preparatory phase for direct division, and this phase is characterized by the shrinkage of chromosomes and the continuity of the terminal slipping process until the chiasmata completely vanishes, and then the mitotic phase moves to the dispersive phase.

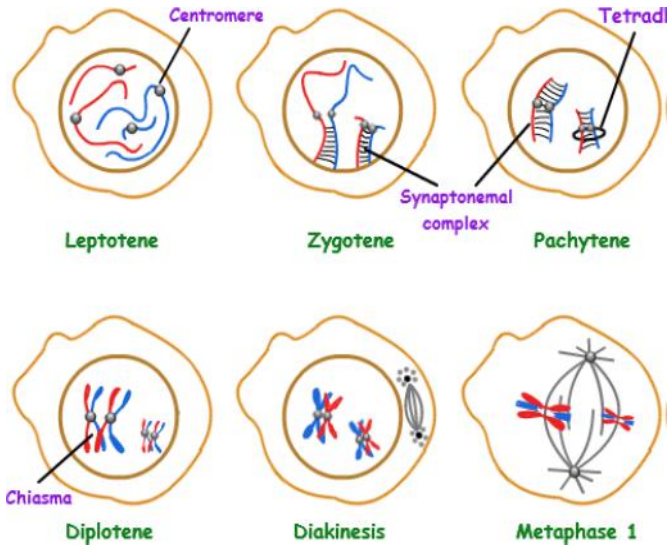


Fig (26): First meiosis division

B-First metaphase stage

The period between the disappearance of the nuclear membrane and the moment in which the formation of the spindle is fully formed is called the equatorial phase, and it differs from the equatorial phase of mitosis in that each contains two centromeres that are independent of each other and not they divide as in mitosis. The centromeres are located above or below the equator, while in mitosis we find that all centromeres are located on the equator because each chromosome contains one centromere.

C- The first anaphase stage

Transformation of the attractive forces into repulsion forces, each centromere is in the direction of the nearest pole and drags behind it the chromosome attached to it. In the late separation phase, the central region of the spindle is elongated, and each pair is separated into two units, that is, into two chromosomes.

D- First telophase stage

Chromosomes close to each pole of the cell begin to move towards this pole with which the first final stage begins, and this is identical to what happens in the separation stage of mitosis, except that each chromosome group is monocentric, and the chromosomes may remain in a combined or condensed form, and thus we find The sister chromatids separate from each other, and the first meiosis results in the formation of secondary mothers of eggs in the female and secondary mothers of sperm in the male.

Second meiotic division

The second meiotic division is similar to mitosis in all stages and events, which are:

A- The second prophase stage

As we mentioned in the prophase stage of meiosis which is the beginning of the clarity of the chromosomes, in this stage the role of the centromere in the division process begins, separates from each other if it consists of two granules, each of which is transferred to one The poles of the cell then begin to disappear, and with it the spindle begins to appear.

B- Second metaphase stage

Chromosomes are arranged on the spindle threads after their formation and appearance at the end of the preliminary stage, and the region occupied by the chromosomes on the spindle threads is called the equatorial lamina.

C- Second anaphase stage

A longitudinal division occurs for each chromosome, and the division includes the centromere, and as a result, each chromosome becomes a pair of separate chromatids, each of which contains part of the centromere, then each chromatid moves towards the pole near it, then each chromatid begins to copy itself Thus, a complete chromosome is formed, and at this stage, the process of doubling the chromosomes occurs.

D- Second telophase stage

Chromosomes gather near the opposite pole, then the components that have disappeared begin to appear again, so the nuclei appear, as well as a nuclear membrane, nucleolus, and nuclear fluid, and the nuclear membrane begins to surround the chromosomes, nucleolus, nuclear juice, and Thus, a nucleus is formed, but it contains an odd number of chromosomes, i.e. the half number of chromosomes. The resulting cell is known as the sperm or egg.

Cytokinesis:

The cytoplasm is divided in its center by contraction in the animal cell and by formation of cell sheets in the plant cell. This produces two daughter cells. As for the latter, it has half the number of chromosomes and half the amount of nuclear DNA, that is, in reduction, division is completed when this point is reached. The cells formed by meiosis in animals are mature gametes. One gamete must fuse with another before a new individual can develop. The cells produced by meiosis II in plants are germs. Spores can develop into new individuals without merging into pairs. In fact, the main difference between spores and gametes is the ability of spores to develop directly into a new individual.

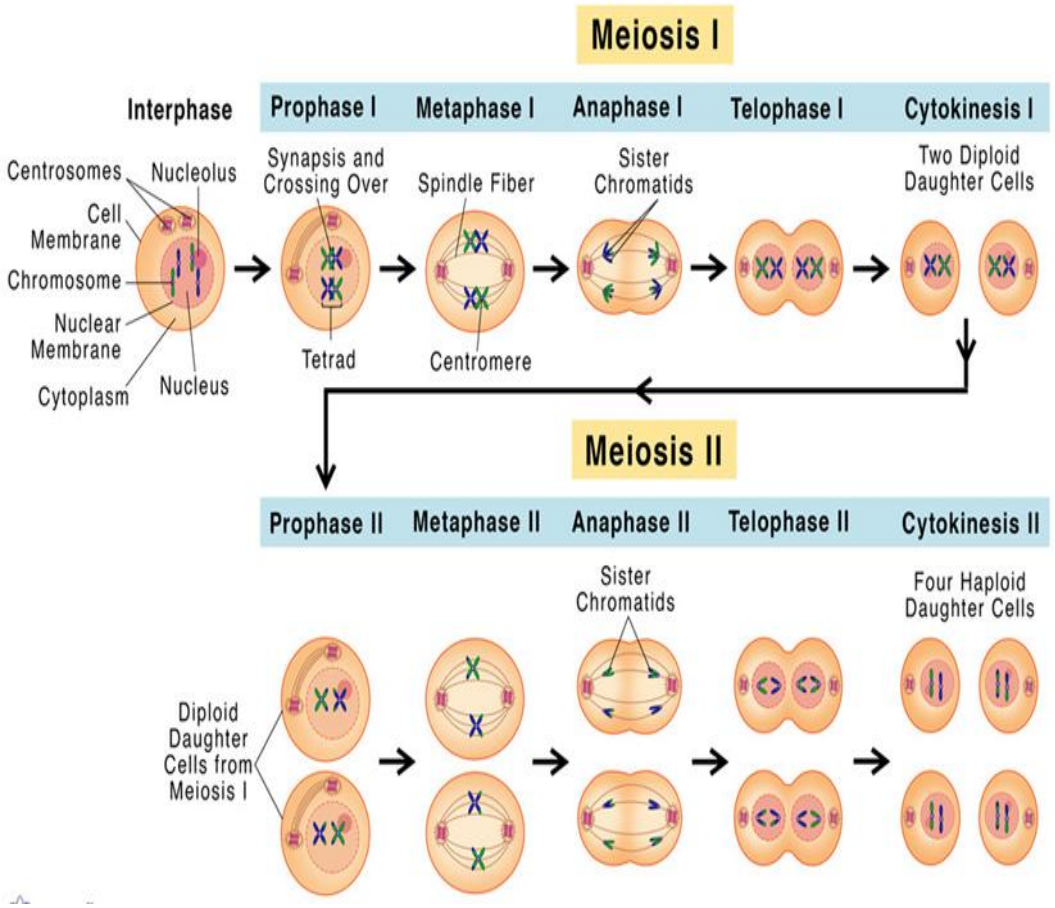


Fig (27): Meiosis division

Cell dynamics

We seek to understand the activity of and interactions between the many molecules that make up the complex world of the cell. They investigate how the molecules and specialized structures inside of our cells work in concert with each other, in a precisely choreographed dance, to ensure that biological processes happen when and how they should, for example dynamic between endoplasmic reticulum, Golgi apparatus and lysosomes. We are studying cell division, an intricate process, every aspect of which must be executed correctly for normal growth and development. Our bodies each began as one cell that had to divide an astounding number of times to create the roughly 30 trillion cells that make up a human body--and billions of these cells continue to divide every day. By identifying the molecules involved in cell division, and determining how cells carry out the process, we are improving our understanding of cell division in normal development and in turn how it may go awry in diseases like cancer.

The Biogenesis of cell organelles

Organelle biogenesis is the process by which new organelles are made. In a few cases, notably mitochondria and chloroplasts, some organelle proteins are encoded by the organelle's own genome. However, the amount of DNA in such organelles can encode only a very small number of the many proteins required. In practice, the study of organelle biogenesis includes the mechanisms by which proteins and lipids, newly synthesized elsewhere in the cell, are delivered to organelles and the process by which organelles are divided between daughter cells during mitosis. In general, it is thought that new organelles are derived by proliferation of preexisting organelles. However, for some organelles on the secretory and endocytic

pathways,e.g., the Golgi complex, the extent to which they can be made de novo by a cell without a preexisting organelle or template remains a subject of controversy.

The mechanisms for organelle biogenesis

The mechanisms for organelle biogenesis in the secretory and endocytic pathways, Includes:

A) Vesicular traffic

A coated vesicle buds from a donor organelle, loses its coat and fuses with an acceptor organelle. The coat made up of cytosolic proteins both deforms the donor membrane to form the vesicle and sorts into the vesicle only those proteins selected for delivery. Vesicle fusion with the acceptor membrane requires formation of a SNARE complex. Thus, the vesicle must contain a v-SNARE which forms a complex with a cognate t-SNARE in the acceptor membrane.

B) Maturation:

An organelle is formed from the preceding organelle in a pathway by retrieval of those proteins which should not be in the final organelle, using retrograde vesicular traffic to deliver them to an earlier stage in the pathway. Additional proteins may be delivered to the organelle by vesicular traffic from other sources (e.g., to endocytic compartments from the biosynthetic/secretory pathway). It should be noted that an organelle may be formed and/ or maintain its composition by a mixture of the two mechanisms. Thus, when organelles are formed by anterograde vesicular traffic, retrieval may still be used to ensure that mis-sorted proteins are returned to their correct residence.

Organization into Complex Structures

Organelle biogenesis is not simply a question of delivering newly synthesized proteins and lipids to a specific intracellular site but may also require the establishment of a complex architecture. in the case of the Golgi complex where it is clear that the observed morphology in part reflects the interaction of the structure with the cytoskeleton via appropriate motor proteins and in part the function of matrix proteins in the organization of the cisternae. A further complication, particularly for organelles on the secretory and endocytic pathways, is the requirement to maintain morphological form and associated functional integrity despite the large volume of through traffic of both proteins and lipids. Vesicles such that the present consensus is that most, if not all, anterograde movement through the Golgi complex is the result of cisternal progression with retrograde vesicular traffic ensuring that the polarized distribution of Golgi enzymes in the cisternal is maintained.

From data obtained by high voltage electron microscopy has suggested that tubular and vesicular structures can bud at every level of the Golgi stack. Structurally, using conventional electron microscopy techniques, and functionally, the trans-Golgi network can be distinguished from the cisternal stack and is defined as the site for sorting to different post-Golgi destinations. Both clathrin-coated vesicles and noncoated tubular structures appear to bud from the trans-Golgi network.

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