THE CELL

Cytology is a science that is about the structure and functions of cells and their derivatives, reproduction and interactions. The cell is the structural and functional unit of the organism.

There are two types of cells: prokaryotic and eukaryotic cells.

PROKARYOTIC CELLS. They are single-celled organisms that lack a membrane-bound nucleus and membrane-bound cell organelles. Example: Bacteria.

EUKARYOTIC CELLS. Eukaryotic cells have two important features that prokaryotic cells lack: a nucleus and cell organelles with membranes around them. All eukaryotic cells consist of cytoplasm and cell organelles, bounded by plasma membrane.

The cell is composed of 3 basic parts:

1- Plasma membrane
2- Cytoplasm
3- Nucleus.

Cell membrane. Cell membrane consists of lipids, proteins, and saccharides under the electron microscope (EM) cell membrane consists of 2 densely stained layers separated by a lighter zone. The basic structure of the membrane is the arrangement of phospholipids' molecules.

Each molecule consists of:

1- Enlarged polar hydrophilic head

2- Thin non-polar hydrophobic tail.

Functions of the cell membrane:

1. Maintaining the structural integrity of the cell.

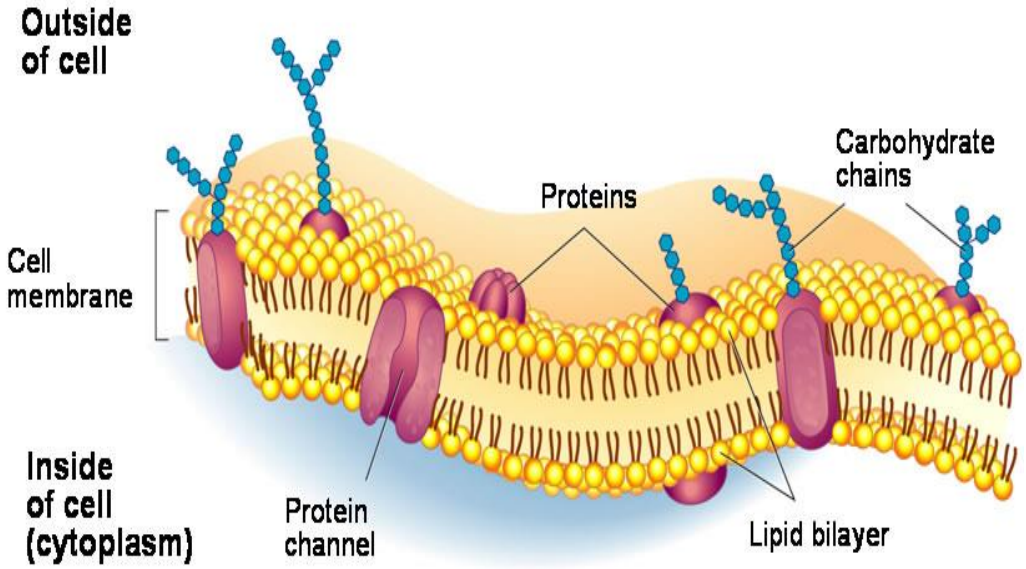
2. Regulating of cellular interactions.

3. Recognition of antigens and foreign cells.

4. Interaction between the cytoplasm and the external environment.

5. Movements of the cell (cilia, flagella).

6. Transport of substances into and from the cell.



Cytoplasm

The cytoplasm is the part of the cell lying between the cell membrane and nucleus. It consists of the matrix, in which several components such as

1- **Cytoplasmic organelles**

(Mitochondria, endoplasmic reticulum, Golgi complex, lysosomes, centrioles)

2- **Cytoplasmic inclusions.**

Small particles seen temporarily in the cytoplasm. They may or may not be membrane-bound, and are metabolically inactive. For example, lipid droplets, glycogen granules and pigment granules.

3- Cytoskeletal substances

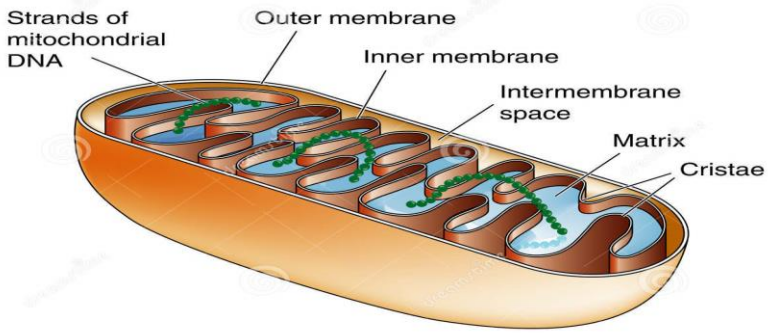
(Microtubules, Microfilaments)

Mitochondria

Mitochondria are spherical or cylindrical organelles, which are composed of an outer membrane and inner membrane.

The inner membrane projects folds, termed cristae. The space located between the two membranes, is termed the intermembrane space. Matrix contains mitochondrial DNA,

ribosomes, tRNA, and the enzyme system. Generate ATP through of the citric acid cycle, oxidative phosphorylation, and P-oxidation of fatty acids.



Endoplasmic reticulum

The endoplasmic reticulum (ER) is the site of the lipid and carbohydrate synthesis, protein aggregation from the cytoplasm.

With electron microscope it appears as a rich network of membrane bound flattened tubules and sacs.

There are two types of endoplasmic reticulum: rough and smooth ER

Rough (granular) endoplasmic reticulum (RER)

It is prominent in cells specialized for the protein secretion, such as pancreatic acinar cells (digestive enzymes), fibroblasts (collagen), plasma cells (immunoglobulin). The rough endoplasmic reticulum consists of tubules and flattened cisterns.

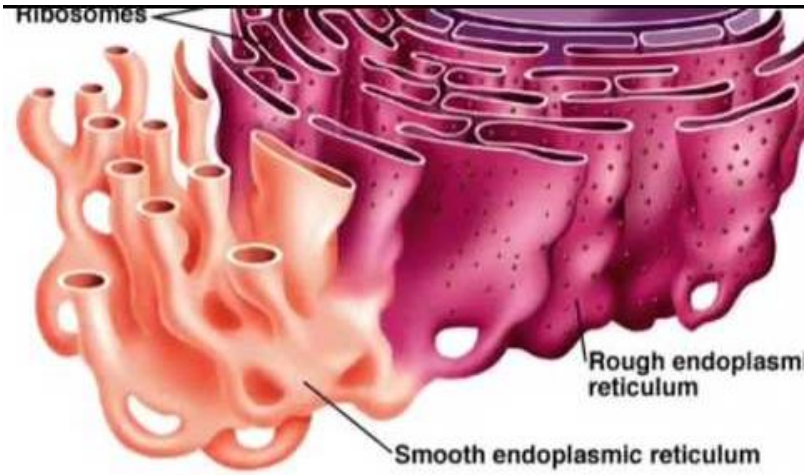
On the cytoplasmic surface of the endoplasmic reticulum there are polyribosomes, giving them granular appearance.

The principal function of the rough endoplasmic reticulum is to synthesis and aggregate proteins destined for export or intracellular use.

Smooth (a granular) endoplasmic reticulum (SER)

Is the membranous network within the cell. These are devoid of ribosome

They are concerned with steroid synthesis, lipid metabolism and detoxication processes.



Golgi apparatus

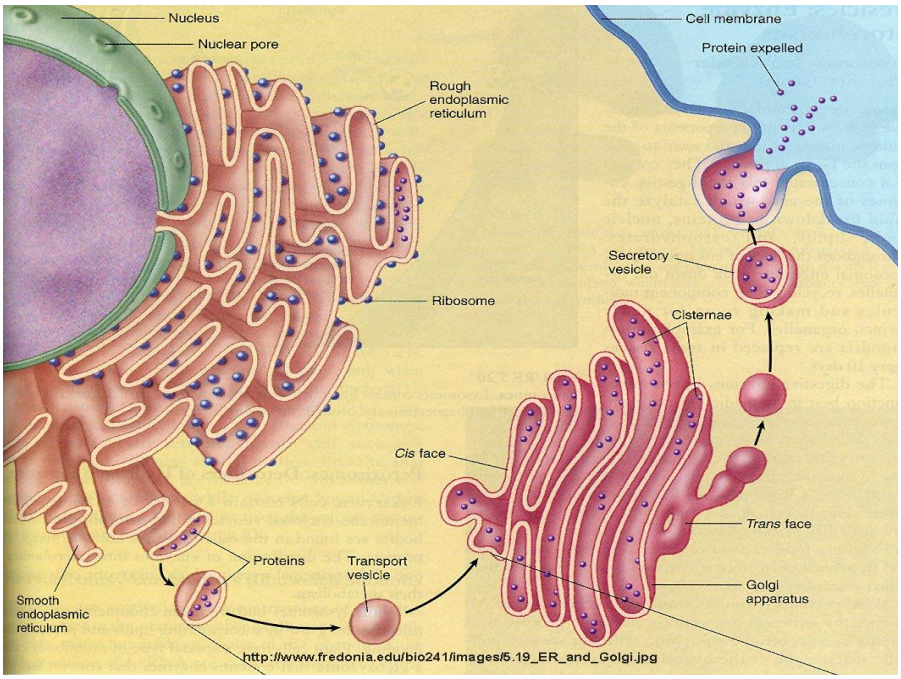
Golgi apparatus is composed of a series of flattened, membrane-limited sacs or cisternae and tubular extensions. Small vesicles are seen in association with the cisternae

Through transport vesicles that fuse with the Golgi face, the complex receives several types of molecules produced in the rough endoplasmic reticulum (RER).

After Golgi processing, these molecules are released from the Golgi transfer in larger vesicles to constitute secretory vesicles, lysosomes, or other cytoplasmic components.

Proteins, which are synthesized in endoplasmic reticulum, migrate to Golgi apparatus, where they are stored and condensed into granular for secretion.

Lysosomes may also be produced in the Golgi apparatus.



Lysosomes

The lysosomes are sites of intracellular digestion and turnover of cellular components. Lysosomes are membrane-limited spherical vesicles that contain a large variety of hydrolytic enzymes (more than 40). Lysosomes are present in almost all cells, but they are particularly abundant in cells with phagocytic activity (macrophages, neutrophilic leukocytes).

Lysosomes that have not entered into a digestive event are called as **primary lysosomes**.

Secondary lysosomes are those in which digestion occurs.

Secondary' lysosomes result from the fusion of endocytosis material with primary lysosomes to form **phagosome**. Secondary lysosome is also known as a phagolysosome.

Following digestion of the contents of the secondary lysosome, nutrients diffuse through the lysosomal membrane and enter the cytoplasm.

Undigestable compounds are retained within the vacuoles, which are now called **residual bodies**.

Importance of intracellular digestion by the lysosomes

1- help in nutrition of the cell by digesting food, as they are rich in various enzymes which enable them to digest almost all major chemical constituents of the living cell.

2- Help in defence by digesting germs, as in white blood cells.

3- Help in cleaning up the cell by digesting damaged material of the cell.

4- Provide energy during cell starvation by digestion of the cells own parts

5- Help sperm cells in entering the egg by breaking through (digesting) the egg membrane.

6- When cells are old, diseased or injured, lysosomes attack their cell organelles and digest them. In other words lysosomes are autophagic.

Ribosomes

Ribosomes are present in concern with rough endoplasmic reticulum. They may also lie free in the cytoplasm. They may be present singly (monosomes) or in groups (polysomes). “Free” ribosomes synthesize proteins that will remain in the cell as cytoplasmic structural or functional elements. Polysomes of the rough endoplasmic reticulum synthesize proteins for export from the cell and integral proteins of the plasma membrane.

The functions of ribosomes:-

- Most abundant in protein-synthesizing cells
- carry genetic messages from nucleus for amino acid sequence of protein synthesis
- Free ribosomes synthesize proteins for cell use
- Attached ribosomes synthesize proteins that are packaged for export .

Centrioles

Are cylindrical structures composed of highly organized microtubules. Each centriole is composed of 9 triplets of microtubules. Centrioles play important role in the formation of the mitotic spindles of dividing cells.

Cilia and flagella are motile processes with highly organized microtubular that extend from the surface of some cell types.

Ciliated cells usually possess a large number of cilia that range 2 to 10. Flagellated cells normally have only 1 flagellum, The core of these structures consists of 9 pairs of microtubules surrounding 2 central tubules (doublets). At the base of each cilium or flagellum is a basal body. This body is identical to a centriole .

The cytoskeleton

The cytoplasmic matrix contains a complex network of microtubules, microfilaments.

These structural proteins not only provide for the form and shaping of the cell but also play an important role in cytoplasmic and cellular movements.the function of cytoskeletal is:-

•Give cell its shape
•Help organelles move within the cell
•Help the cell move

Microtubules

Microtubules are thin elongated elements of cell cytoplasm; they are circular in cross section A total of 13 subunits are present in one complete turn of the spiral. Microtubules provide the basis

of several complex of cytoplasm components, including centrioles, basal bodies, cilia, and flagella.

Microfilaments

Microfilaments are thin protein fibers. The protein forming microfilaments are called actin.

Microfilaments can be organized in many forms:

> In skeletal muscle they integrate with thick (16 nm) myosin filaments;

> In most cells microfilaments are present as a thin sheath just beneath the plasmolemma.

Cytoplasmic inclusions

Inclusions are temporary components of the cytoplasm, mainly composed of accumulated metabolites or deposits of varied nature.

The inclusions are

Lipid droplets

Glycogen.

Protein secretory granules

The pigment inclusions.

NUCLEUS.

The nucleus is an essential component of the cells; it takes a deep base stain. The nucleus is usually spherical; but oval in columnar cells; flattened in squamous cells; rod shaped in smooth muscle cells.

The nuclei are central in most cells; basal in mucous cells; peripheral in skeletal muscle fibers.

Most cells have one nucleus. Occasionally binucleate cells are found in liver and cardiac muscle and osteoclast cell.

The functions of the nucleus

1. Keeping the genetic information (in the molecules of DNA).
2. transfer the genetic information (during the cell division).

The structure of the nucleus

1- Nuclear envelope
2- Chromatin
3- Nucleolus and nuclear matrix

Nuclear envelope

The nucleus is surrounded by 2 parallel unit membranes separated by a narrow space called perinuclear cisternal space.

Together, the paired membranes and inter space make up the nuclear envelope.

The outer layer of the nucleus membrane is continuous with the endoplasmic reticulum.

Around the nuclear envelope, at sites where inner and outer membranes fuse, there are circular gaps, the **nuclear pores.**

Chromatin

A little blue staining particle within the nucleus. Is composed mainly of coiled strands of deoxyribonucleic acid (DNA) bound to basic proteins (histones).

In dividing cells chromatin is condensed and organized into discrete bodies called chromosomes.

Two types of chromatin can be distinguished :-

1- Heterochromatin is coiled segments of chromosomes and stain deep blue.

2- Euchromatin is uncoiled segments of chromosomes and stains poorly or not at all, and appear granular.

Chromosomes are little rod-like bodies in the nucleus, which take a deep basic stain.

Each chromosome is formed by 2 **chromatids** that are joined together at a point called the **centromere.** Each chromatid has 2 **arms,** one on either side of the centromere. Each chromosome differs from one another in total length and in the relative length of the two arms.

Nucleolus

The **nucleolus** is a spherical structure, usually basophilic when stained with hematoxylin and eosin.

The nucleolus consists of:

1) Densely packed ribonucleoprotein fibers, which is composed of primary transcripts of rRNA genes, and is situated mainly in the central part of nucleolus;

2) Granules of mature ribosomes.

3) Nucleolar DNA.

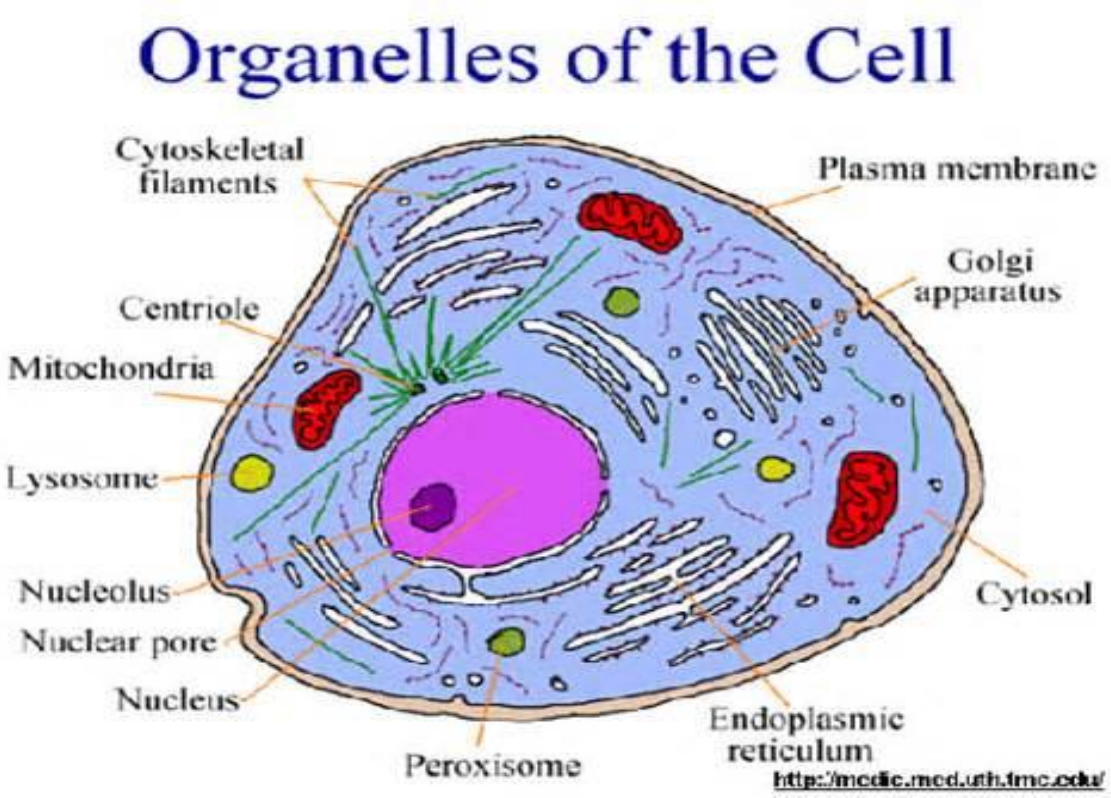
Nuclear matrix

The nuclear matrix is the component that fills the space between the chromatin and the nucleoli in the nucleus. It is composed mainly of proteins, metabolites, and ions.

Cell death

Cell death may occur as a result of acute cell injury or an internally encoded suicide program.

Cell death may result from accidental cell injury (necrosis) or mechanisms that cause cells to self-destruct (apoptosis).


Organelles of the Cell
Cytoskeletal filaments
Plasma membrane
Golgi apparatus
Centriole
Mitochondria
Lysosome
Nucleolus
Nuclear pore
Nucleus
Cytosol
Endoplasmic reticulum
Peroxisome
http://medic.med.uth.tmc.edu/