Cell - Structure and Functions

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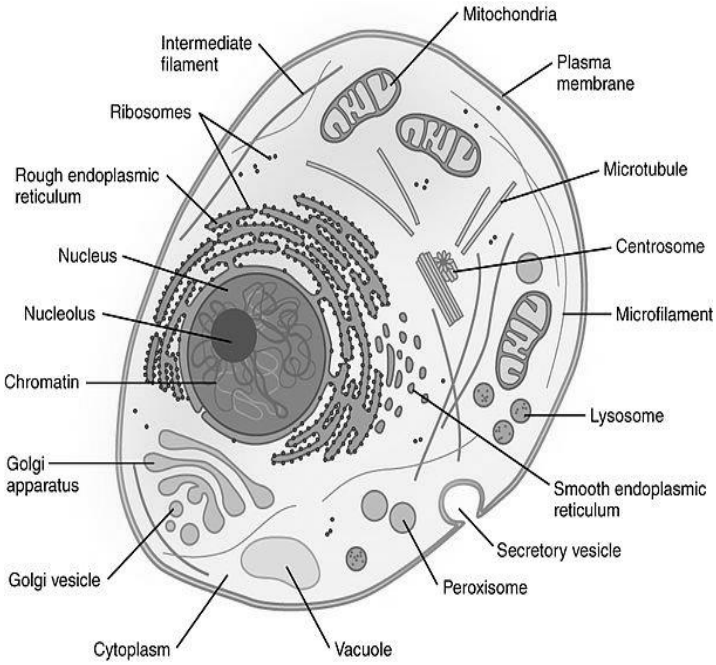
Introduction:

The cell is the basic structural, functional, and biological unit of all known living organisms. A cell is the smallest unit of life. Cells are often called the "building blocks of life". The study of cells is called cell biology.

Cells are the basic building blocks or structural and functional unit of all living beings. The human body is composed of trillions of cells. They provide structure for the body, take in nutrients from food, convert those nutrients into energy, and carry out specialized functions.



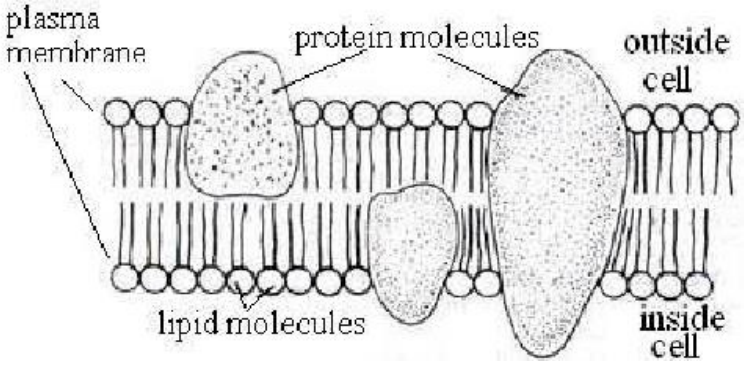
Core **organelles** are found in virtually all eukaryotic **cells**. They carry out essential functions that are necessary for the survival of **cells** – harvesting energy, making new proteins, getting rid of waste and so on. Core **organelles** include the nucleus, mitochondria, endoplasmic reticulum and several others.

1. Cell membrane:

The cell membrane (also known as the plasma membrane or cytoplasmic membrane, and historically referred to as the plasmalemma) is a biological membrane that separates the interior of all cells from the outside environment (the extracellular space). [Singleton P] It consists of a lipid bilayer with embedded proteins. The basic function of the cell membrane is to protect the cell from its surroundings. The cell membrane controls the movement of substances in and out of cells and organelles. In this way, it is selectively permeable to ions and organic molecules. **[Alberts, B. 2002]**

It is composed of four different types of molecules:

- Phospholipids
- Cholesterol
- Proteins
- Carbohydrates



Functions:

- The main functions of the cell membrane are:
- It is a physical barrier to maintain the physical integrity of the cell - that is to mechanically enclose the contents of the cell, and also
- It controls the movement of particles e.g. ions or molecules, into and out of the cell.
- Passive osmosis and diffusion: Some substances (small molecules, ions) such as carbon dioxide (CO2) and oxygen (O2), can move across the plasma membrane by diffusion
- It regulates exchange of materials with its surroundings.
- Bulk Transport: *Exocytosis* is the process by which a cell moves the contents of secretory vesicles out of the cell via the cell membrane. *Endocytosis* is the opposite process by which the contents of secretory vesicles are moved into the cell via the cell membrane.

2. Cytoplasm:

In cell biology, the cytoplasm is the material within a living cell, excluding the cell nucleus. It comprises cytosol (the gel-like substance enclosed within the cell membrane) and the organelles – the cell's internal sub-structures. All of the contents of the cells of prokaryotic organisms (such as bacteria, which lack a cell nucleus) are contained within the cytoplasm. Within the cells of eukaryotic organisms the contents of the cell nucleus are separated from the cytoplasm, and are then called the nucleoplasm. The cytoplasm is about 80% water and usually colorless. [**Shepherd, V. A. 2006**]

Function of Cytoplasm:

- Most of the important activities of the cell occur in the cytoplasm. Cytoplasm contains molecules such as enzymes which are responsible for breaking down waste and also aid in metabolic activity.
- Cytoplasm is responsible for giving a cell its shape. It helps to fill out the cell and keeps organelles in their place. Without cytoplasm, the cell would be deflated and materials would not be able to pass easily from one organelle to another.
- Cytosol is the part of the cytoplasm that does not contain organelles. Instead, cytosol is confined by the boundaries of a matrix which fills the part of the cell that does not contain organelles.

3. Nucleus:

The **nucleus** is an organelle found in eukaryotic cells. Inside its fully enclosed nuclear membrane, it contains the majority of the cell's genetic material. This material is organized as DNA molecules, along with a variety of proteins, to form chromosomes. **[Lodish, H.]**

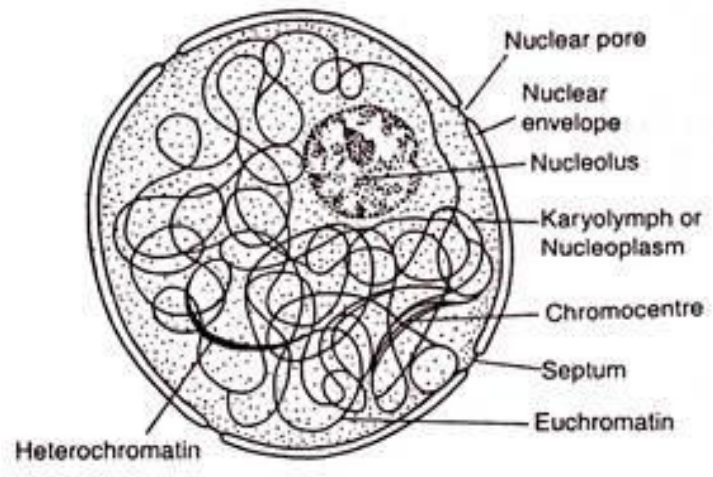


Fig. 8.1 Structure of a nucleus.

The nucleus contains:

Nuclear membrane - The nuclear envelope, also known as the nuclear membrane, encloses the nucleus and nucleolus.

Nucleoplasm - also known as karyoplasm is the matrix present inside the nucleus.

Chromatin Reticulum - Chromosomes are present in the form of strings of DNA and histones (protein molecules) called chromatin.

Nucleolus - The nucleolus (plural nucleoli) is a dense, spherical-shaped structure present inside the nucleus.

Function:

- The many pores in the nuclear membrane allow it to decide what enters and exits the nucleus.
- The nucleolus makes ribosomes. This is a very important job inside of the cell.
- Chromosomes contain the genetic information (DNA) of the cell. The chromosomes are the code for all of the functions that occur in a cell.
- Storage of hereditary material, the genes in the form of long and thin DNA (deoxyribonucleic acid) strands, referred to as chromatin.
- Storage of proteins and RNA (ribonucleic acid) in the nucleolus.
- Nucleus is a site for transcription in which messenger RNA (mRNA) are produced for protein synthesis.
- Exchange of hereditary molecules (DNA and RNA) between the nucleus and the rest of the cell.
- During the cell division, chromatins are arranged into chromosomes in the nucleus.
- Production of ribosomes (protein factories) in the nucleolus.
- Selective transportation of regulatory factors and energy molecules through nuclear pores.

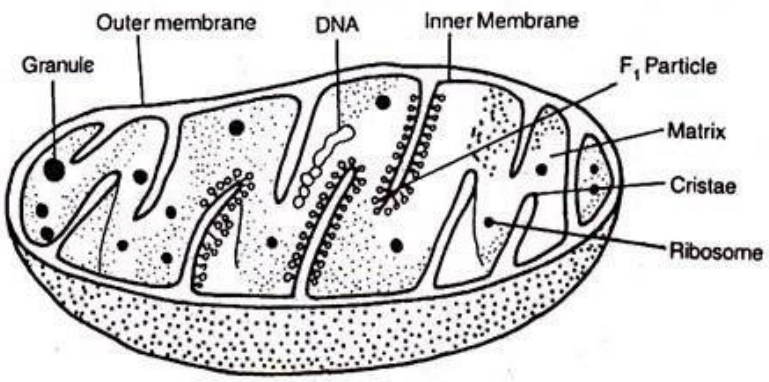
The main function of the cell nucleus is to control gene expression and mediate the replication of DNA during the cell cycle.

4. Mitochondrion:

The mitochondrion is a double-membrane-bound organelle found in most eukaryotic organisms. Mitochondria generate most of the cell's supply of adenosine triphosphate (ATP), used as a source of chemical energy. **[Henze K.]**

Structure:

The number of mitochondria in a cell can vary widely by organism, tissue, and cell type. For instance, red blood cells have no mitochondria, whereas liver cells can have more than 2000. The organelle is composed of compartments that carry out specialized functions. These compartments or regions include the outer membrane, the intermembrane space, the inner membrane, and the cristae and matrix. **[Voet D.]**



Mitochondrion cut open to show the inner structures.

A mitochondrion contains outer and inner membranes composed of

phospholipid bilayers and proteins.[Alberts B.] The two membranes have different properties. Because of this double-membraned organization, there are five distinct parts to a mitochondrion. They are:

- the outer mitochondrial membrane,
- the intermembrane space (the space between the outer and inner membranes),
- the inner mitochondrial membrane,
- the cristae space (formed by infoldings of the inner membrane), and
- the matrix (space within the inner membrane).
- Mitochondria stripped of their outer membrane are called mitoplasts.

Function

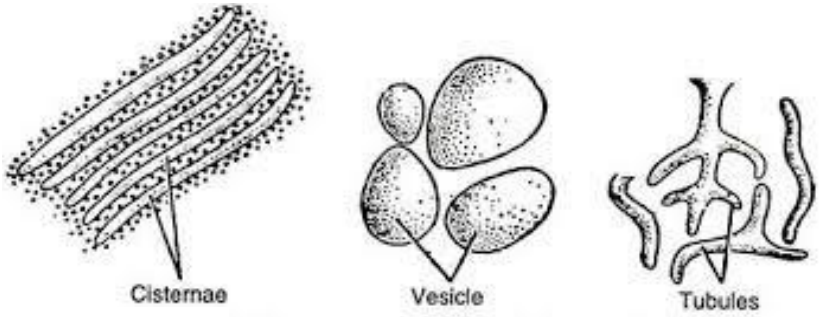
The most prominent roles of mitochondria are to produce the energy currency of the cell and to regulate cellular metabolism. [Voet D.]

- Energy conversion
- Storage of calcium ions
- Regulation of the membrane potential
- Calcium signaling
- Regulation of cellular metabolism
- Steroid synthesis.
- Hormonal signaling

5. Endoplasmic reticulum (ER):

The endoplasmic reticulum (ER) is a type of organelle found in eukaryotic cells that forms an interconnected network of flattened, membrane-enclosed sacs or tube-like structures known as cisternae. The membranes of the ER are continuous with the outer nuclear membrane.

The general structure of the endoplasmic reticulum is a network of membranes called cisternae. These sac-like structures are held together by the cytoskeleton. The phospholipid membrane encloses the cisternal space (or lumen), which is continuous with the perinuclear space but separate from the cytosol.



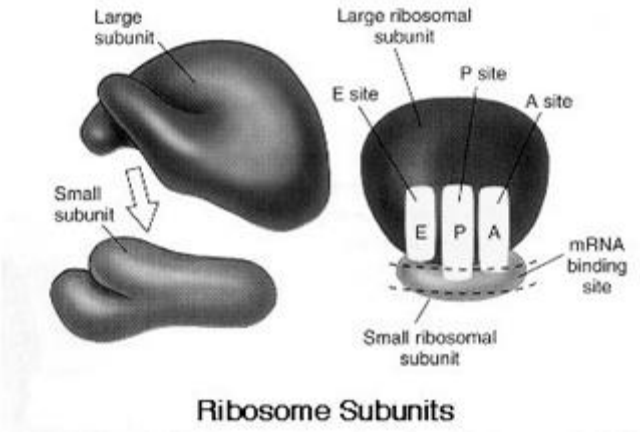
Various components of the endoplasmic reticulum.

Functions:

- The endoplasmic reticulum serves many general functions, including the folding of protein molecules in sacs called cisternae and the transport of synthesized proteins in vesicles to the Golgi apparatus. [Ozcan U.]
- Synthesize lipids, oils, Phospholipids.
- Synthesize of Steroids and Sex hormones.
- Hydrolysis of glycogen.

6. Ribosome:

A ribosome is a complex cellular mechanism used to translate genetic code into chains of amino acids. Long chains of amino acids fold and function as proteins in cells. The ribosomes and associated molecules are also known as the translational apparatus.



Ribosome Subunits

The ribosome is a highly complex cellular machine. It is largely made up of specialized RNA known as ribosomal RNA (rRNA) as well as dozens of distinct proteins (the exact number varies slightly between species). The ribosomal proteins and rRNAs are arranged into two distinct ribosomal pieces of different size, known generally as the large and small subunit of the ribosome. [**Jones, D. 2003]**

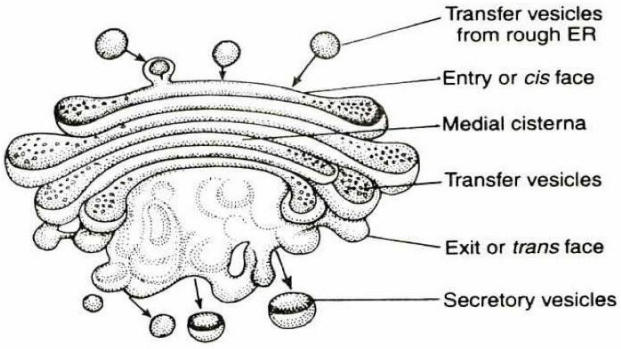
Function:

Ribosomes are minute particles consisting of RNA and associated proteins that function to synthesize proteins. Proteins are needed for many cellular functions such as repairing damage or directing chemical processes. Ribosomes can be found floating within the cytoplasm or attached to the endoplasmic reticulum.

7. Golgi apparatus:

The Golgi apparatus, also known as the Golgi complex, Golgi body, or simply the Golgi, is an organelle found in most eukaryotic cells. **[Pavelk M. 2008]**

In most eukaryotes, the Golgi apparatus is made up of a series of compartments and is a collection of fused, flattened membrane-enclosed disks known as cisternae (singular: cisterna, also called "dictyosomes"), originating from vesicular clusters that bud off the endoplasmic reticulum. A mammalian cell typically contains 40 to 100 stacks of cisternae. [**Duran JM. et. al. 2008**]



Golgi body

Function:

The Golgi apparatus is a major collection and dispatch station of protein products received from the endoplasmic reticulum (ER). Proteins synthesized in the ER are packaged into vesicles, which then fuse with the Golgi apparatus. These cargo proteins are modified and destined for secretion via exocytosis or for use in the cell. In this respect, the Golgi can be thought of as similar to a post office: it packages and labels items which it then sends to different parts of the cell or to the extracellular space. The Golgi apparatus is also involved in lipid transport and lysosome formation. [**Campbell, N.A. 1996**]

8. Lysosome:

Lysosome is an organelle in the cytoplasm of eukaryotic cells containing degradative enzymes enclosed in a membrane. Besides degradation of polymers, the lysosome is involved in various cell processes, including secretion, plasma membrane repair, cell signaling, and energy metabolism. [**Settembre, C. *et. al.* 2013**]

Lysosomes are specialized vesicles within cells that digest large molecules through the use of hydrolytic enzymes. Vesicles are small spheres of fluid surrounded by a lipid bilayer membrane, and they have roles in transporting molecules within the cell.

9. Centrosome:

In cell biology, the centrosome (Latin centrum 'center' + Greek sōma 'body') is an organelle that serves as the main microtubule organizing center (MTOC) of the animal cell as well as a regulator of cell-cycle progression. [**Bornens, M. 2008]**

In cell biology, the centrosome is an organelle that is the main place where cell microtubules are organized. Also, it regulates the cell division cycle, the stages which lead up to one cell dividing in two. Centrosomes are associated with the nuclear membrane during the prophase stage of the cell cycle. In mitosis the nuclear membrane breaks down and the centrosome nucleated microtubules can interact with the chromosomes to build the mitotic spindle.

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