Lec -1- The cell

The cell (from Latin *cella*, meaning "small room") **is the basic structural, functional, and biological unit of all known living organisms.** A cell is the smallest unit of life that can replicate independently, and cells are often called the "building blocks of life". The study of cells is called cell biology or cytology.

Cell biology or **cytology**, (from the Greek, *kytos*, "vessel") **is a branch of biology that studies the different structures and functions of the cell and focuses mainly on the idea of the cell as the basic unit of life.**

Cell biology explains the structure, organization of the organelles they contain, their physiological properties, metabolic processes, signaling pathways, life cycle, and interactions with their environment.

Organisms can be classified as

- **unicellular**
- **multicellular**

Cell types

There are two distinctive types of cells

1. **Prokaryotic cells**: Prokaryotes lack a nucleus (though they do have circular DNA) and other membrane-bound organelles (though they do contain ribosomes).
   EX: Bacteria and Archaea are two domains of prokaryotes.
2. **Eukaryotic cells**: have nuclei bound by a nuclear membrane and membrane-bound organelles (mitochondria, chloroplasts, lysosomes, rough and smooth endoplasmic reticulum, vacuoles).
   EX: Protists, fungi, animals, and plants all consist of eukaryotic cells. ("**Protist**" is a term referring to a group of mostly **unicellular** eukaryotes) .

Table 1: Comparison of features of prokaryotic and eukaryotic cells

	Prokaryotes	**Eukaryotes**
Typical organisms	bacteria, archaea	protists, fungi, plants, animals
Type of nucleus	nucleoid region; no true nucleus	true nucleus with double membrane
DNA	circular (usually)	linear molecules (chromosomes) with histone proteins
Ribosomes	50S and 30S	60S and 40S
Cell movement	flagella	Flagella and cilia
Mitochondria	none	one to several thousand
Chloroplasts	none	in algae and plants
Organization	usually single cells	single cells, multicellular organisms
Cell division	binary fission (simple division)	mitosis (fission or budding) meiosis
Chromosomes	single chromosome	more than one chromosome
Membranes	cell membrane	Cell membrane and membrane-bound organelles

Cell theory

The cell was discovered by Robert Hooke in (1665) who described the cella (open spaces) of plant tissues.

The cell theory is a widely accepted explanation of the relationship between cells and living things.

The cell theory states:

1. **all organisms are composed of cells.**
2. **cell is the structural and functional unit of life.**
3. **cells arise from pre-existing cells.**

The cells vary considerably, in shape and size.

Nerve cells of animals have long extensions. They can be several feet in length. Muscle cells are elongated in shape. Some plant cells have thick walls. There is also wide variation in the number of cells in different organisms.

Components of cell

- **Cell wall** – extra layer of protection and gives structural support (only found in plant cells).
- **Cell membrane**: **The biological structure that separates the interior of a cell from its outer environment, all living cells, prokaryotic and eukaryotic, are surrounded by a plasma membrane. As well as regulating what goes in and out of the cell.**

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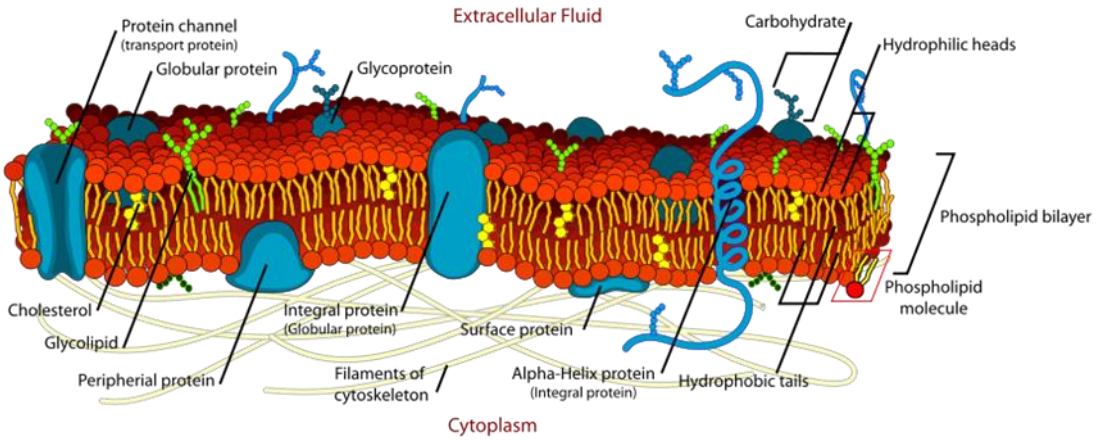


Figure:The plasma membrane

Structure:

Cell membrane is complex structures composed of two layers, known as the phospholipid bilayer that associated integral and peripheral proteins, and carbohydrates.

1. **The phospholipid bilayer contain of**
   - **A. The hydrophilic heads (water loving) polar of the phospholipid molecules attracted to water outside and inside of the cell**

B. The hydrophobic tails (water fearing) nonpolar tails repelled by water areas face away

In addition to phospholipids, there are two other types of lipids in the plasma membrane.

A. Glycolipids

B. Cholesterol is another lipid component of animal cell membranes, present in both layers, **and helps maintain the structural integrity of the membrane.**

2. Proteins are found inserted into this lipid bilayer and are classified into **integral proteins and peripheral proteins.**
3. The carbohydrate chains of the glycolipids and proteins occur only on the **outside surface** and the **cytoskeletal filaments** attach to proteins only on the **inside surface**.
4. The plasma membrane is **asymmetrical** (the two halves are not identical).

Function of cell membrane:

1- **The cell membrane is the interface between a cell and its environment.**
2- **The plasma membrane envelops the cell and maintains its structural and functional integrity.**
3- **It assists in controlling interaction between cells.**
4- **Regulating what goes in and out of the cell.**

- **Cytoplasm** – contents of the main fluid-filled space inside cells, chemical reactions also happen in this jelly-like substance.

- **Nucleus** is structure bound by a double membrane called the nuclear envelope in eukaryotic cells. This membrane separates the contents of the nucleus from the cytoplasm, and its contains most of the cell's genetic material, organized to form chromosomes, and controls the cell's growth and reproduction.

The function of the nucleus is to maintain the integrity of genes and to control the activities of the cell by regulating gene expression

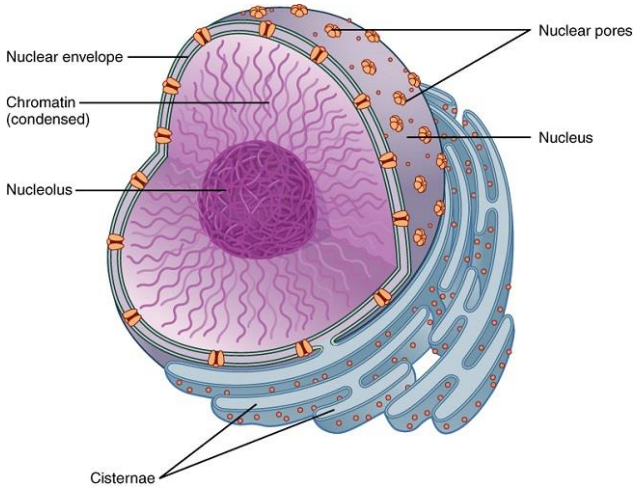
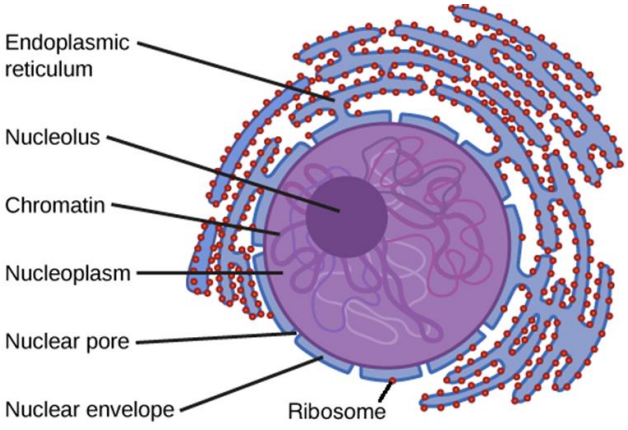


Figure: Nucleus

- **Nucleolus** is the largest structure in the cell nucleus**. The nucleolus is responsible for the production of ribosomes, this process is referred to as the ribosome biogenesis**it is made up of DNA, RNA and associated proteins.

- **Endoplasmic reticulum (ER)** is network of membranous canals that shares part of its membrane with that of the nucleus.
  1- **Endoplasmic reticulum (rough)** – major site of membrane protein synthesis.
  2- **Endoplasmic reticulum (smooth)** – major site of lipid synthesis.



- **Lysosome**s – are tiny sacs filled with fluid containing enzymes (i.e. proteins that act as a biological catalysts) **which digest large molecules, also responsible for breaking down and getting rid of waste products of the cell. Lysosomes contain over 60 different enzymes that allow them to carry out these processes.**

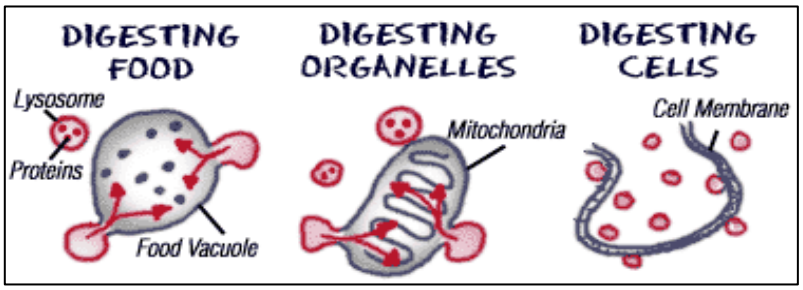


Figure lysosome action

- **Ribosome** – is the site of protein synthesis in the cell. Each ribosome consists of large subunit and a small subunit, **ribosomes synthesize a variety of proteins that are essential to the survival of the cell.**

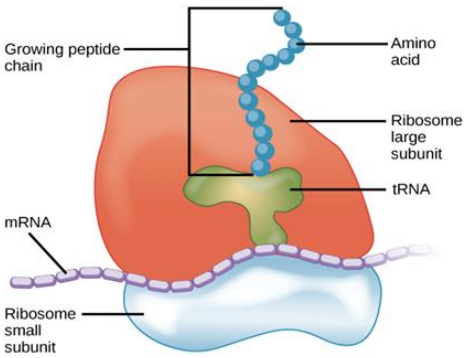


Figure : Ribosome

- **Golgi apparatus**– functions as a factory in which proteins received from the ER are further processed and sorted for transport to their eventual destinations

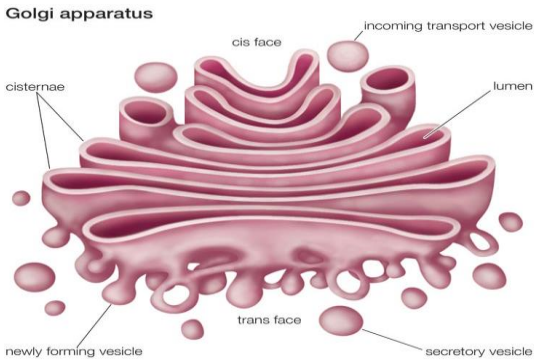
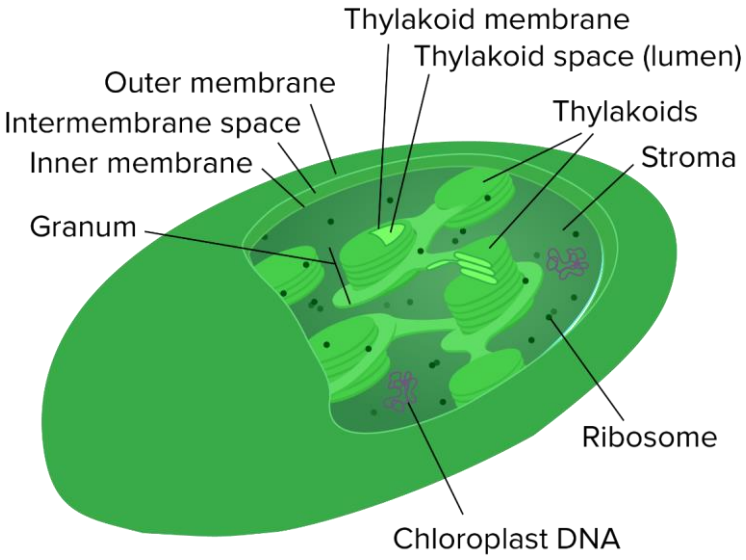


Figure 1 Golgi apparatus

- **Centrosome** – an associated pair of cylindrical shaped protein structures (centrioles) that organize microtubules and aid in **forming the mitotic spindle during cell division in eukaryotes.**
- **Chloroplast** – **key organelle for photosynthesis (only found in plant cells),** are disc-shaped organelles found in the cytosol of a cell.

They have outer and inner membranes with an intermembrane space between them. membrane discs known as thylakoids, arranged in interconnected stacks called grana (singular, granum).



- **Cytoskeleton** – protein filaments inside cells (microfilaments, microtubules, and intermediate filaments). **Which together maintain cell shape, anchor organelles, and cause cell movement.**

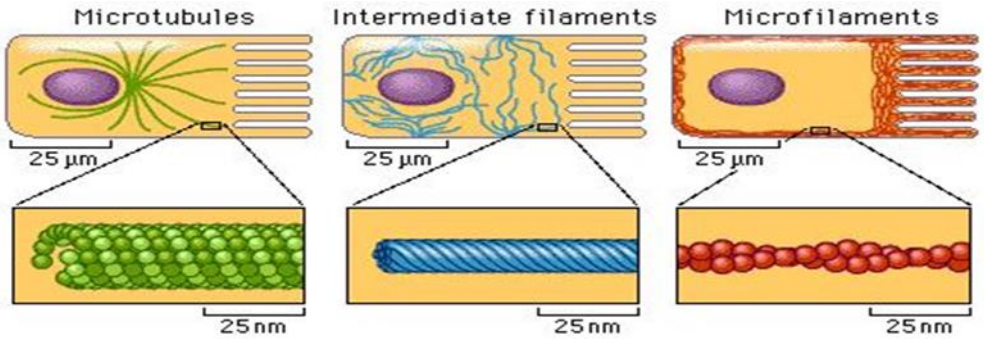
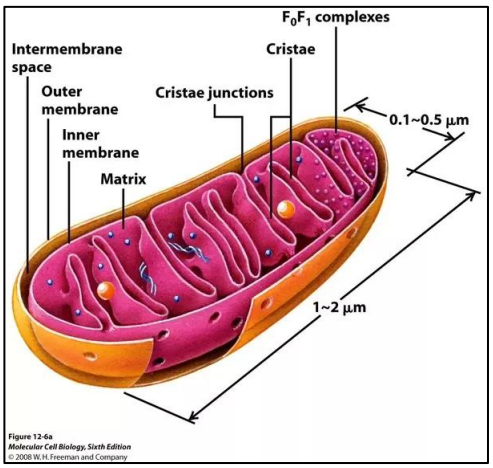


Figure: **Cytoskeleton filaments**

- **Microvilli** – increases surface area for absorption of nutrients from surrounding medium.
- **Mitochondria** – **major energy-producing organelle by releasing energy in the form of ATP by the breakdown of carbohydrates and fatty acids, which is converted to ATP by the process of oxidative phosphorylation**.

- **Structure**

Mitochondria are surrounded by a double-membrane system, consisting of inner and outer mitochondrial membranes separated by an intermembrane space. The inner membrane forms numerous folds (**cristae),** which extend into the interior (or matrix) of the organelle.



- **Vacuole** – A vacuole is an organelle found in plant, fungi cells, animals and many single-cell organisms. **The single large vacuole of the cell is surrounded by a membrane, called the tonoplast, and storage material.**
- **Pili – also called fimbria is used for conjugation and sometimes movement.**
- **Cilia And Flagella**

BASIS FOR COMPARISON	**CILIA**	**FLAGELLA**
Meaning	Cilia are short, hair like appendages extending from the surface of a living cell.	Flagella are long, threadlike appendages on the surface of a living cell.
Found in	Eukaryotic cell.	Prokaryotic cell as well as in eukaryotic cells.
Length	Short.	Longer.
Type of motion	they are very fast moving.	Flagella show slow, wave-like.
Role	They play their primary role in locomotion, aeration (respiration), etc.	They are helpful in locomotion only.
Occurs in	It occurs all over the cell surface.	It is present at both the ends or sometimes all over the surface.

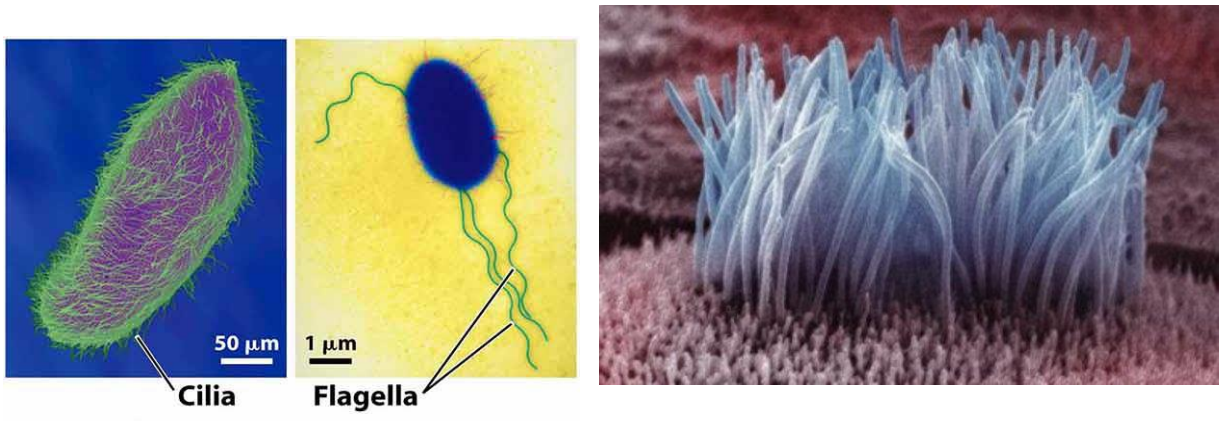


Figure 2 cilia and flagella

Transport through cells

The plasma membrane only allow some substances to pass through but not others, so it can control the entrance and exit of molecules and ions.

Small molecules(such as glucose, amino acids, water, mineral ions etc)can be transported across the plasma membrane by any one of the following three methods:

- **Diffusion**: molecules of substances move from their region of higher concentration to their region of lower concentration. This does not require energy. Example: absorption of glucose in a cell.
- **Osmosis**: movement of water molecules from the region of their higher concentration to the region of their lower concentration through a semipermeable membrane. There is no expenditure (not require) of energy in osmosis.
- **Active transport**: When the direction of movement of a certain molecules is opposite that of diffusion i.e. from region of their lower concentration towards the region of their higher concentration, **do require an expenditure of chemical energy.** The active transport may also be through a carrier molecule.

Transport of large molecules (bulk transport): During bulk transport the membrane changes its form and shape. It occurs in twoways:

- **Endocytosis** (taking the substance in).
- **Exocytosis** (passing the substance out).

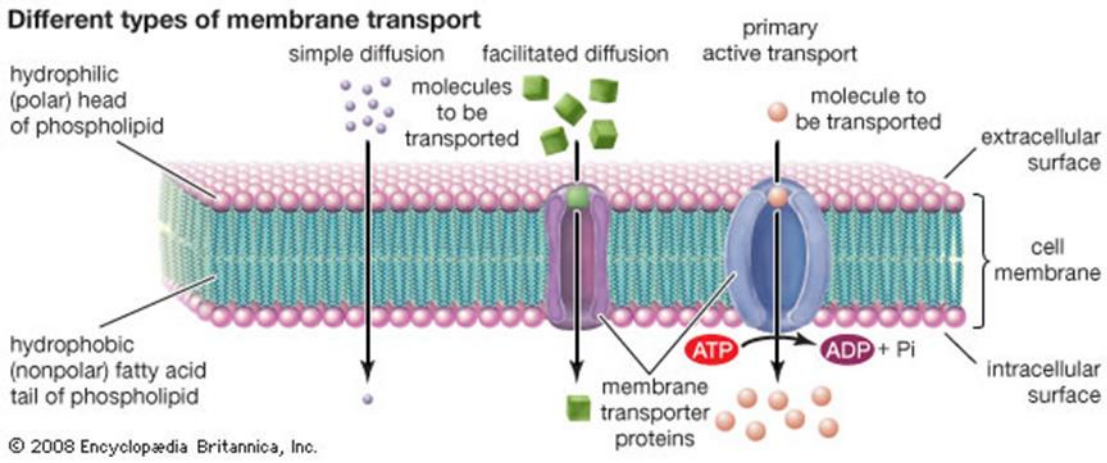


Figure : Passive transport of molecules a cross plasma membrane by simple diffusion (left) and by either of the two types of facilitated diffusion mediated by ion channel proteins (center) and carrier proteins (right).