Chapter 5 : The Fundamental Unit of Life

Introduction :

The bodies of living organisms are made up of microscopic units called cells. The cell has same central position in biology as an atom in physical sciences. The cell is the basic structural and function unit of living organisms.

Q) Who discovered cells and how ?

Ans) Cells were discovered in 1665 by an English Botanist, Robert Hook. He used a primitive microscope to observe cells in a cork slice.

Difference between unicellular and multicellar organism

	Unicellar organisms		Multicellar Organism
1.	An unicellular organism is represented by a single cell	1.	A multicellar organism consists of large number of cells
2.	All activity of the organism are performed by a single cell	2.	A single cell performs one or few activities of the organisms.
3.	There is no division of labour as the single cell perform all the life activities	3.	Cells are specialised to perform different functions of the body so that there is a division of labour within cells.
4.	Reproduction consume a single cell	4.	Only some cells of the body called germ cells take part in reproduction. Other cells remain inert.
5.	The life span of an individual is short	5.	The life span of an individual is long.

Q) Why is the cell called the structural and fundamental unit of life?

Ans) All living organisms are made up of cells. This shows that the cell is the structural unit of life. Each cell has the capacity to perform certain basic functions that are characteristic of all living forms. For example, phagocytic cells eat and kill unwanted or foreign particles inside the body (e.g. WBCs). Some cells eg. pancreatic cells, small intestinal cells, liver cells secrete enzymes and hormones. That is why cell is called the structural and fundamental unit of life.

What is a cell made up of? What is structural organisation of a cell?

Cell is made up of cell components and organelles. All the cells have three basic cell components which are nucleus, plasma membrane and cytoplasm.

Cell is basically made up of protein, carbohydrates and lipids and half of it is water. Structural organisation of cell is that cells organism into tissues and tissues into organ and organ into organ system.

Q) What are the functional region of a cell?

Ans) There are the three major functional region of cells:
(i) Cell membrane or plasma membrane (ii) Nucleus
(iii) Cytoplasm.

What is Plasma Membrane ? [Cell Membrane]

This is the outermost covering of the cell that separates the contents of the cell from its external environment. The plasma membrane allows or permits the entry and exit of some material in and out of the cell.

Q) Why is plasma membrane called a selectively permeable membrane ?

Because it allows the movement of only selected molecules across it.

Q) How do substances like CO_2 and water move in and out of the cell ? Discuss.

Ans) CO_2 and water move across a cell by the process of diffusion and osmosis respectively. When the concentration of CO_2 is low outside the cells as compared to inside, it moves out i.e. from a region of high concentration to a region of low concentration.

Also when concentration of water increases inside the cell as compared to its exterior, it moves across the plasma region from a region of its high concentration to its low concentration.

Movement Across Membranes

There are two ways in which substances can enter or leave a cell :

1) Passive
   a) Simple Diffusion
   b) Facilitated Diffusion
   c) Osmosis (water only)

2) Active
   a) Molecule
   b) Particle.

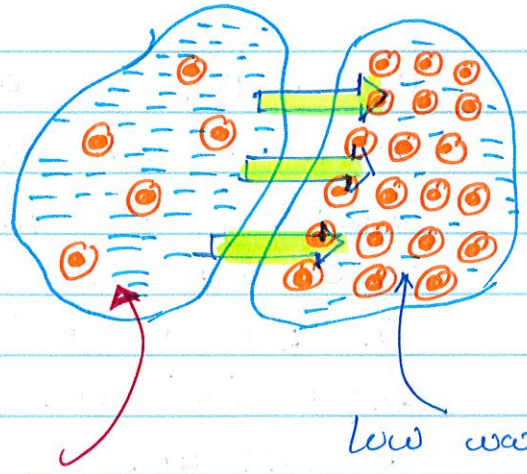
Diffusion: is the net passive movement of particles (atoms, ions or molecules) from a region in which they are in higher concentration to region of lower concentration. It continues until the concentration of substances is uniform throughout

Example :

a) Due to difference of concentration of CO_2 inside and outside cell, CO_2 moves out of the cell, from a region of high concentration to a region of low concentration outside cell by the process of diffusion.

b) Similarly, O_2 enters the cell by process of diffusion when level or concentration of O_2 inside the cell decreases.

Osmosis : is a special example of diffusion. It is a diffusion of water through a partially permeable membrane from a more dilute solution to a more concentrated solution.



Thus, osmosis is the passage of water from a region of high water concentration through a semi-permeable membrane to a region of low water concentration

a) Unicellular fresh water organisms and most plant cells tend to gain water through osmosis.

b) Absorption of water by plant roots is also example of osmosis.

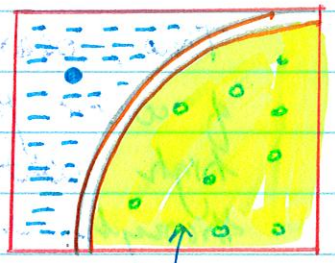
Difference between diffusion and osmosis :

Diffusion	Osmosis
1) It can occur in any media	1) It occurs only in liquid medium
2) The diffusing molecule may be solids, liquid or gases.	2) It involves movement of solvent molecules only.
3) Semi-permeable membrane is not required.	3) Semi-permeable membrane is required.
4) It depends upon the free energy of the molecule of diffusing substance only.	4) It is influenced by the presence of other substance (solutes) in the system.
5)	

Hypotonic Solution

The medium surrounding the cell has a higher water concentration than the cell. Outside solution is very dilute, the cell will gain water by osmosis.

Water molecules are free to pass across the cell membrane in both direction, but more water will come into the cell than will leave. The net result is that water enters the cell. The cell is likely to swell up.

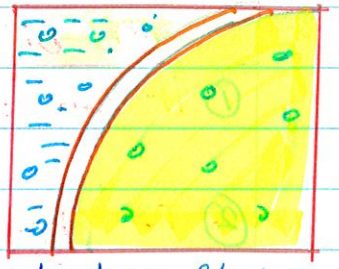


Hypotonic solution

Isotonic Solution

The medium has exactly the same water concentration as the cell, there will be no net movement of water across the cell membrane.

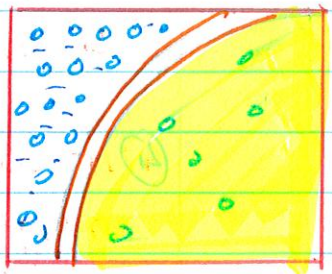
Water crosses the cell membrane in both directions, but the amount going in is the same as the amount going out, so there is no overall movement of water. The cell will stay the same size.


Isotonic Solution

Hypertonic Solution

: If the medium has a lower concentration of water than cell, meaning that it is a very concentrated solution, the cell will lose water by osmosis.

Water crosses the cell membrane in both directions, but this time more water leaves the cell than enters it. Therefore the cell will shrink.


Hypertonic Solution

Q) What would happen if the plasma membrane ruptures or breaks down?

Plasma membrane is the selectively permeable membrane that surrounds the cell and allows the entry and exit of selected materials of the cell. If it ruptures, the contents of the cell will come in direct contact with the surrounding medium and not only unwanted material will be able to enter freely into the cell, but useful material will also find its way out of the cell easily. This will seriously disrupt the various metabolic activities of the cell and will result in its eminent death.

Difference between plant cells and animal cells:

PLANT CELLS	ANIMAL CELLS.
1) Larger in size	1) comparatively in size
2) They contain Cell wall made of cellulose, which is present outside the plasma membrane.	2) Cell wall is absent. Only plasma membrane is present.
3) They contain plastids, i.e. chloroplasts, leucoplasts and chromoplast	3) Plastids are absent
4) Centrosome is absent	4) Centrosome is present
5) Larger vacuoles are present	5) Vacuoles either absent or very small in size.
6) Food is stored in the form of starch	6) Food is stored in the form of glycogen
7) Lysosomes are absent	7) Lysosomes are present.

Differences between prokaryotic cell and eukaryotic cell :

Prokaryotic cell	Eukaryotic Cell
1) Smaller in size (1–10 μm)	1) Comparatively in size (5–100 μm)
2) The nuclear material is undefined having no nuclear membrane and is called nucleoid.	2) A true nucleus having a nuclear membrane is present.
3) A single chromosome is present	3) More than one chromosome is present.
4) It does not contain membrane - bound cell organelles.	4) It contains membrane-bound cells organelles like mitochondria, plastids
5) Cell division takes place by fission or budding or fragmentation	5) Cell division takes place by mitosis or meiosis.

CELL WALL

Plant cells, in addition to the plasma membrane, having another rigid outer covering called the **cell Wall**. The cell wall lies outside the plasma membrane. The plant cell wall is mainly composed of cellulose. Cellulose is a complex substance and provides structural strength to plants.

Function of Cell Wall :

1) It permit the plant cell to become turgid. As water enters the vacuole through osmosis, the plant cell expands. The cell wall has to be strong enough to resist this expansion and so enables the cell to become turgid.

(Turgid refers to cells or tissue that are swollen from water uptake).

2) It provide mechanical strength to support the cell.

3) It is freely permeable to water and substances in solution.

Q) What is a cell wall and how is it formed?

Ans) Cell wall is non-living and freely permeable rigid structures bounding the plant cell. It is secreted by the cell itself for the protection of its plasma membrane and cytoplasm.

Q) Why do the animal cells not have cell wall?

Ans) Animals do not have rigid walls because cell walls are incompatible with the way in which an animal move and grow. The flaccid cell membrane provide the animals cell freedom of mobility and formation of different tissues which is not present in plants.

Nucleus Cellular Structure

Cell Biology / Genetics

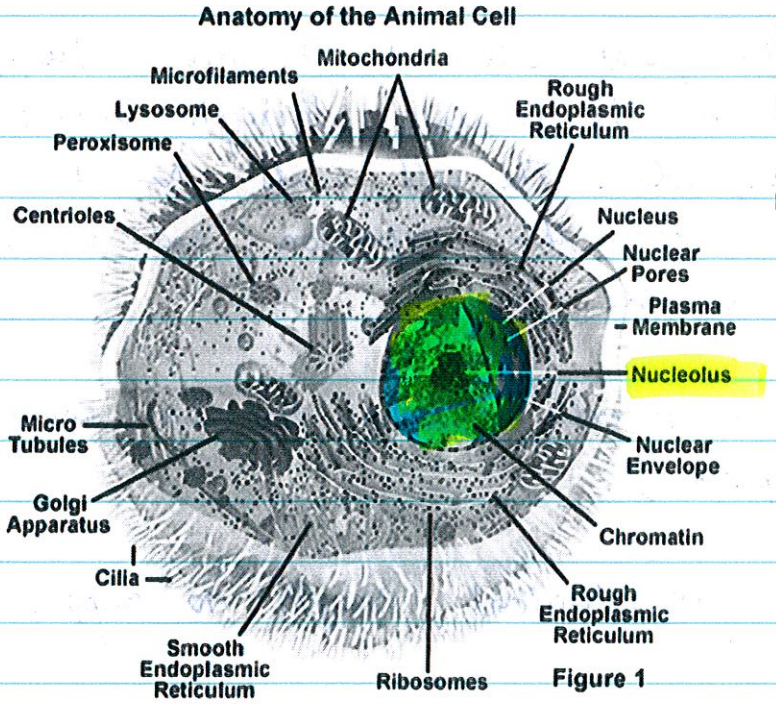


Figure 1

1) The nucleus is a membrane bound structure that contains the cell's hereditary information and controls the cells growth and reproduction. It is the command center of a eukaryotic cell and is commonly the most prominent organelle in a cell.

Thus, the cell nucleus is a kind of "command center" containing all the chromosomal and genetic information needed for the reproduction of life.

2) The nucleus has a double layered covering called nuclear membrane. The nuclear membrane has pores which allow the transfer of material from inside the nucleus to its outside, that is, to the cytoplasm (discussed later).

3) The nucleus contain chromosomes, which are visible as rod-shaped structures only when the cell is about to divide. Whenever the cell is about to divide, the chromatin material gets organised into chromosomes. Chromosomes are composed of DNA (Deoxyribo Nucleic Acid) and protein. DNA molecules contain the information necessary for constructing and organising cells. Functional segments of DNA are called genes.

4) The nucleus plays a central role in cellular reproduction.

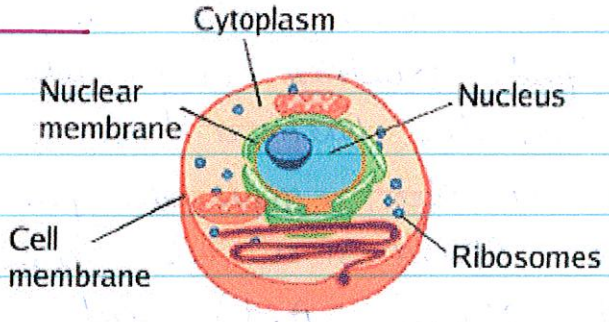
5) Nucleoplasm is the gelatinous substance within the nuclear envelope.

6) In some organism like bacteria, the nuclear region of the cell may be poorly defined due to absence of a nuclear membrane. Such an undefined nuclear region containing only nucleic acids is called a nucleoid.

7) Such organism, whose cell lack a nuclear membrane are called prokaryotes.

8) Organism with cells having a nuclear membrane are called eukaryotes.

Cytoplasm



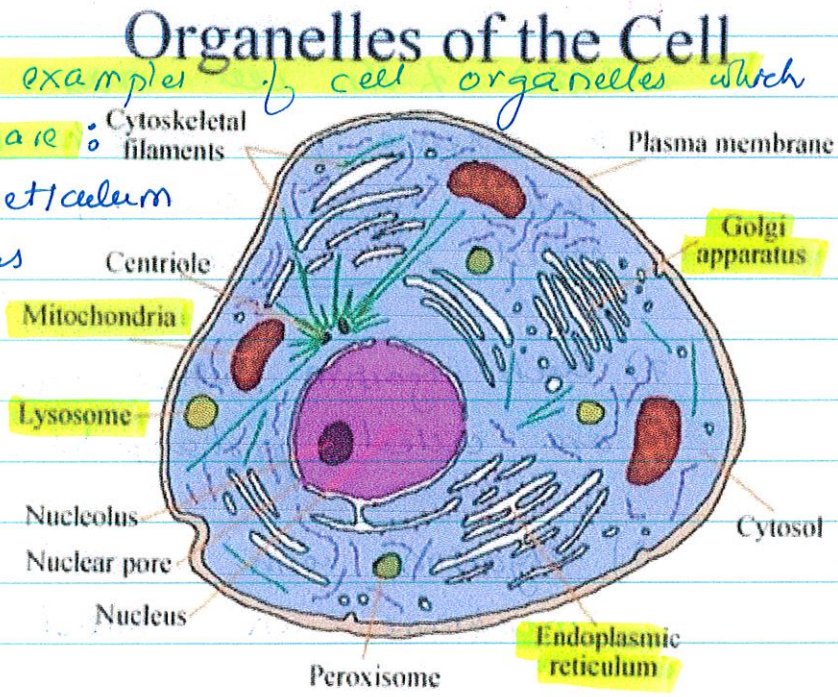
The part of the cell which occurs between the plasma membrane and nuclear envelope is called the cytoplasm.

The cytoplasm is the fluid content inside the plasma membrane. It also contains many specialised cell organelles. Each of the organelles perform a specific function for the cell.

Cell organelles

Some important examples of cell organelles which we discuss now are:

(i) Endoplasmic reticulum
(ii) Golgi apparatus
(iii) lysosomes
(iv) Mitochondria
(v) plastids and
(vi) Vacuoles.



1. Endoplasmic Reticulum (ER)

The endoplasmic reticulum (ER) is a large network of membrane - bound tubes and sheets. The ER membrane is similar in structure to the plasma membrane.

There are two types of ER -

(a) Rough endoplasmic reticulum (RER)
(b) Smooth endoplasmic reticulum (SER)

RER has particles called ribosomes attached to its surface, which are present in all active cells, are the sites of protein manufacture.

SER helps in the manufacture of fat molecules, or lipids, important for cell function. Some of the these proteins and lipids help in building the cell membrane. This process is known as membrane biogenesis.

One function of the ER is to serve as channel for the transport of materials (especially protein) between various regions of the cytoplasm or between the cytoplasm and the nucleus.

The ER also functions as cytoplasmic framework providing a surface for some of the biochemical activities of the cell.

SER plays a crucial role in detoxifying many poisons and drugs.

2. Golgi Apparatus

The Golgi Apparatus consist of a system of membrane - bound vesicles arranged approximately parallel to each other in stacks called cisterns. These members often have connection with the membranes of ER and therefore constitute another portion of complex cellular membrane system.

The material synthesised near the ER is packaged and dispatched to various targets inside and outside the cell through the Golgi apparatus.

Its function include the storage, modification and packaging of products in vesicles. Complex sugars may be made from simple sugars in the Golgi apparatus. The Golgi apparatus is also involved in the formation of lysosome.

(8) What would happen to the life of a cell if there were no Golgi apparatus?

Ans) If there were no Golgi apparatus, the material synthesised by endoplasmic reticulum would not be carried to the various parts inside and outside the cell. Also as Golgi apparatus perform the function of storage and modification of the material synthesised in the cell, these material could not be stored and modified further.
Moreover, there will be no production of lysosome which will cause the accumulation of waste material, viz, worn out and dead cell organelles within the cell which will ultimately lead to cell death.

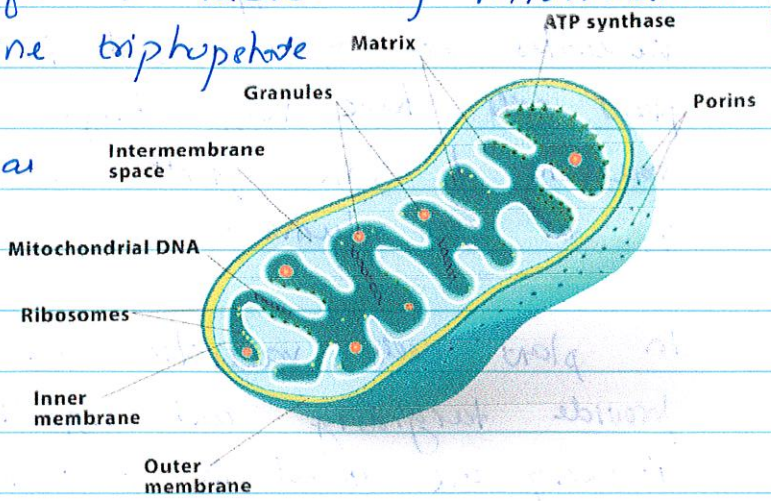
3. Lysosomes

Lysosomes are a kind of waste disposal system of the cell. Lysosomes help to keep the cell clean by digesting any foreign material as well as worn-out cell organelles. Lysosomes contain powerful digestive enzymes capable of breaking down all organic material.

Why are lysosomes known as suicidal bags?
Because when cell gets damaged during the disturbance in cellular metabolism, lysosomes may burst and digestive enzymes thus released digest their own cell.

4) Mitochondria

Mitochondria is known as the powerhouses of the cell. The energy required for various chemical activities needed for life is released by mitochondria in form of ATP (Adenosine triphosphate molecule).
ATP is known as energy currency of the cell.



Mitochondria has two membrane : (i) The outer membrane is very porous (ii) Inner membrane is deeply folded. These folds create a large surface area for ATP generating chemical reactions.
Mitochondria have their own DNA and ribosomes. Therefore, mitochondria are able to make some of their own proteins.

5) PLASTIDS

Plastids are present only in plant cells. There are two types of plastids - chromoplasts (coloured plastids) and leucoplasts (white or colourless plastids).
Plastids containing the pigment chloroplasts are important for photosynthesis in plants.

Leucoplasts are primarily organelles in which material such as starch, oils and protein granules are stored.
Plastids are similar to mitochondria in external structure and also have their own DNA and ribosomes.

6) Vacuoles

Vacuoles are storage sacs for solid or liquid contents. Vacuoles are small sized in animal cells while plant cells have very large vacuoles. The central vacuole of some plant cells may occupy 90-50% of the cell volume.

In plant cells vacuoles are full of cell sap and provide turgidity and rigidity to the cell.
Following are stored in vacuoles - amino acids, sugars, various organic acids and some proteins.

In single-celled organism like Amoeba, the food vacuole contains the food item that Amoeba has consumed.

Q) Two organelles in a plant cell that contain their own genetic material and ribosome.

Ans) Plastids and mitochondria

Q) If the organisation of a cell is destroyed due to some physical or chemical influence, what will happen?

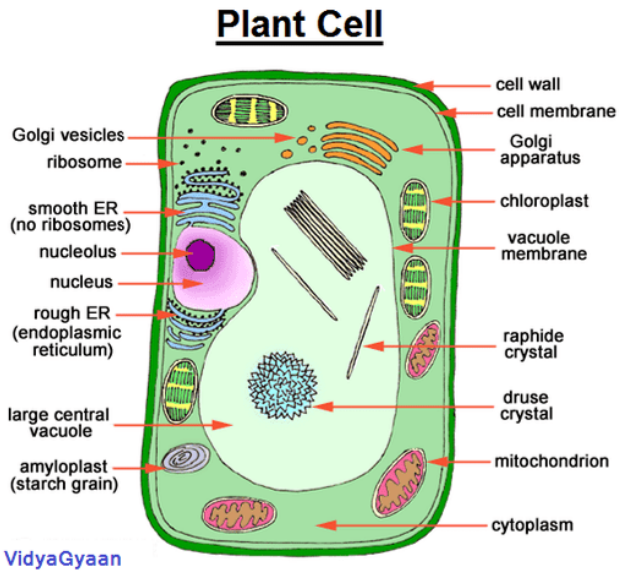
Ans) Cell organelles are responsible for the organisation and proper functioning of a cell, each of them perform some specific function. Naturally, if any of these organelles are destroyed, the functions of the cell will be stopped and it may also result in the death of the cell.

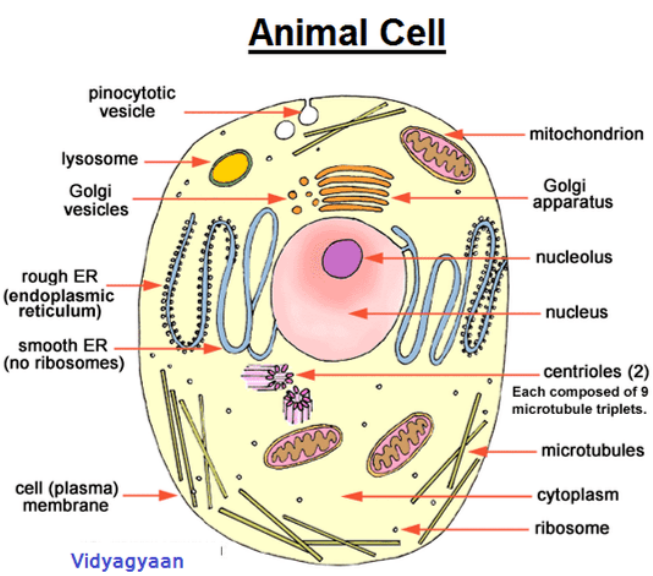
Q) Where are protein synthesised inside the cell?

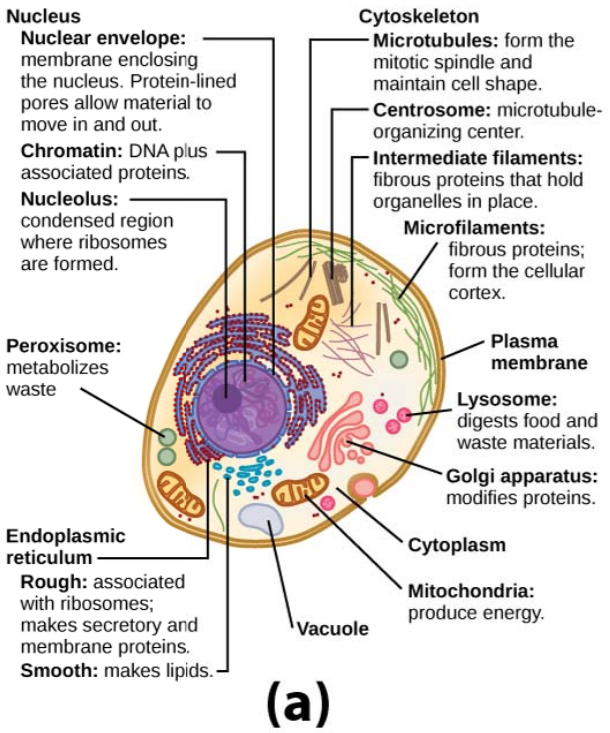
Ans) Ribosomes present in the cell synthesise protein and are called protein factory. These may be attached on the surface of rough endoplasmic reticulum or lie freely in the cell.

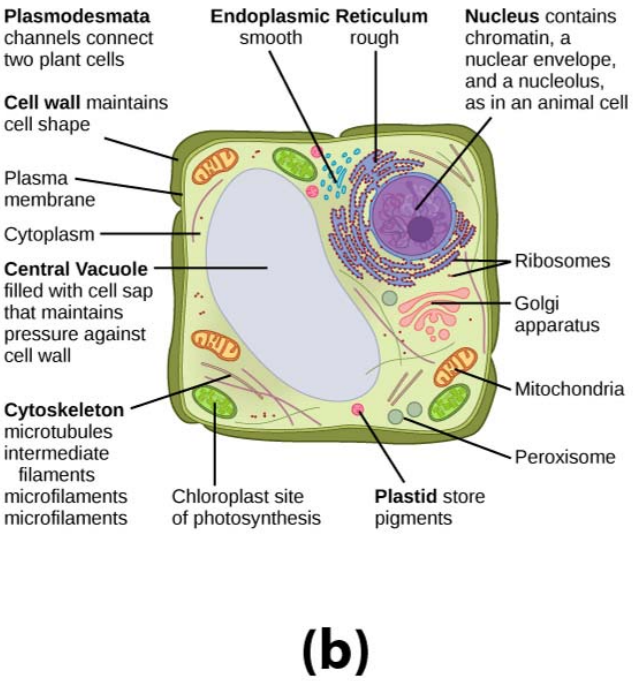
Each cell thus acquires its structure and ability to function because of the organisation of its membrane and organelles in specific ways. The cell thus has basic structural organisation. This helps the cell to perform function like respiration, obtaining nutrition, and clearing of waste material, or forming new protein.

Thus, the cell is the fundamental structural unit of living organism. It is also the basic functional unit of life.


Plant Cell
cell wall
cell membrane
Golgi vesicles
ribosome
Golgi apparatus
smooth ER (no ribosomes)
chloroplast
nucleolus
vacuole membrane
nucleus
rough ER (endoplasmic reticulum)
raphide crystal
druse crystal
large central vacuole
amyloplast (starch grain)
mitochondrion
cytoplasm
VidyaGyaan


Animal Cell
pinocytotic vesicle
mitochondrion
lysosome
Golgi vesicles
Golgi apparatus
nucleolus
rough ER (endoplasmic reticulum)
nucleus
smooth ER (no ribosomes)
centrioles (2)
Each composed of 9 microtubule triplets.
microtubules
cell (plasma) membrane
cytoplasm
ribosome
Vidyagyaan


Nucleus
Nuclear envelope: membrane enclosing the nucleus. Protein-lined pores allow material to move in and out.
Chromatin: DNA plus associated proteins.
Nucleolus: condensed region where ribosomes are formed.
Cytoskeleton
Microtubules: form the mitotic spindle and maintain cell shape.
Centrosome: microtubule-organizing center.
Intermediate filaments: fibrous proteins that hold organelles in place.
Microfilaments: fibrous proteins; form the cellular cortex.
Peroxisome: metabolizes waste
Plasma membrane
Lysosome: digests food and waste materials.
Golgi apparatus: modifies proteins.
Endoplasmic reticulum
Rough: associated with ribosomes; makes secretory and membrane proteins.
Smooth: makes lipids.
Cytoplasm
Mitochondria: produce energy.
Vacuole
(a)


Plasmodesmata channels connect two plant cells
Endoplasmic Reticulum
smooth
rough
Nucleus contains chromatin, a nuclear envelope, and a nucleolus, as in an animal cell
Cell wall maintains cell shape
Plasma membrane
Cytoplasm
Central Vacuole filled with cell sap that maintains pressure against cell wall
Ribosomes
Golgi apparatus
Mitochondria
Peroxisome
Cytoskeleton
microtubules
intermediate filaments
microfilaments
microfilaments
Chloroplast site of photosynthesis
Plastid store pigments
(b)

Chapter-5 (Biology) - The Fundamental Unit of Life.

CELL : (a) Basic and structural Unit of life.
(b) The cell was first discovered by Robert Hook in 1665.

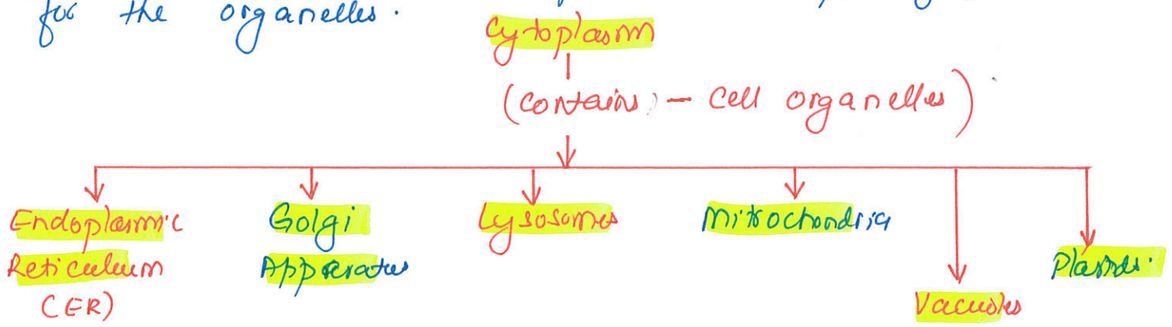
Consists of :

(1) Plasma Membrane / cell membrane :
(a) Plasma membrane is the selectively permeable membrane that surrounds the cell and allows the entry and exit of selected material of the cell.
(b) Plasma membrane is made up of Lipids and protein.

(2) Cell wall : (present only in plant cell) is non-living and freely permeable rigid structure boundry the plant cell.
It is secreted by the cell itself for the protection of the plasma membrane and cytoplasm. Cell wall is made up of cellulose.

(3) Nucleus : Consists of (a) Nuclear membrane having nuclear pores (b) nucleoplasm (c) Nucleolus.
Nucleus contains cell hereditery information and control cell growth and reproduction. Genes are located on chromosomes in the nucleus. Nucleolus is associated with ribsome formation. The nucleus contain chromosome made up of DNA and protein.

(4) Cytoplasm : Fluid content between the plasma membrane and outside the nucleus membrane. Cytosol is the semifluid part of cytoplasm which is embedded in between cell organelle. Cytoskeleton is the network of protein fibres present in the cell which provides a supporting framework for the organelles.



(4a) Endoplasmic Reticulum (ER) : → Rough ER (with ribosomes) / → Smooth ER (No ribosomes)

> RER has particle called ribosomes attached to its surface, are the sites of protein manufacture. Protein are synthesised by ribosomes in cytoplasm.
> SER helps in the manufacture of fat molecules or Lipids. Lipids are synthesided in smooth endoplasmic reticulum.

ER serves as a channel for the transport of materials between cytoplasm and nucleus?

(4b) Golgi Apparatus :
1) It is involved in the transport and modification of protein, Lipids.
2) It is involved in the formation of cell wall, plasma membrane, lysosomes. (3) The material synthesised near endoplasmic reticulum is packaged and dispatched to various targets and outside the cell through the Golgi apparatus.

If there is no Golgi apparatus, the material synthesised by ER would not be carried to the various parts inside and outside cell. Also, as the Golgi apparatus performs the function of storage and modification of the material synthesised in the cell, these material could not be stored and modified further.
Moreover, there will be no production of lysosomes which will cause the accumulation of waste material.

(4c) Lysosomes : Kind of waste disposal system. Called suicidal bags. Digest damaged cells. Contain powerful digestive enzymes.

(4d) Mitochondria : Called powerhouse of the cell. Oxidise food to release energy in the form of ATP (Adenosine Triphosphate). Mitochondria contain own genetic material and ribosome.

(4e) Vacuoles : Liquid content in the vacuoles of plant cells is called cell sap. The cell sap contains sugars, amino acids, protein, minerals and metabolic wastes.
Store water, minerals and reserve foods. Maintain turgidity.

(4f) Plastids : present only in plant cells. Plastids contain pigment chloroplasts which are important for photosynthesis in plants.