The cell

The Galaxy Education System
# Table of contents

## Cell contents

**SCOPE OF SYLLABUS**  
02

**INTRODUCTION**  
03

**PROKARYOTIC AND EUKARYOTIC**  
04

---

## CELL

**CELL - BASIC UNIT OF LIFE**  
06

**CELL ORGANELLES**  
10

**PLANT CELL VS ANIMAL CELL**  
17

**CELL DIVISION**  
17

**SPECIALIZATION OF CELLS**  
19
Scope of the syllabus

Basic Biology

The cell, a unit of life, protoplasm, basic difference between prokaryotic and eukaryotic cell, differences between an animal and a plant cell. A basic understanding of the cell theory, Structure of plant and animal cell with functions of various cell organelles. (Protoplasm, Cytoplasm, Cell Wall, Cell Membrane, Nucleus, Nucleolous, Mitochondria, Endoplasmic Reticulum, Ribosome, Golgi bodies, Plastids, Lysosomes, Centrosome and Vacuole). Difference between a plant cell and an animal cell should be mainly discussed with respect to cell wall, centrosome and vacuoles and plastids.

- Prokaryotic cells, eukaryotic cells (including those from plants and animals)
- Eukaryotic cells - cytoskeleton, cell wall
- Cell Structure
- Role of the endoplasmic reticulum
- Golgi apparatus
- Usable energy captured from sunlight by chloroplasts
- Role of the mitochondria
Cell and Cell Structure Introduction

The cells that make up our body are so small that you would fit over 200 of them on the full stop at the end of this sentence.

The word cell is derived from the Latin word “cellula” which means “a little room”.

It was the British botanist Robert Hooke who, in 1664, while examining a slice of bottle cork under a microscope, found its structure resembling the box-like living quarters of the monks in a monastery, and coined the word “cells”.

In the year 1838, Matthias Schleiden, a German botanist, first proposed the idea that all plants consist of cells.

The Dutch scientist A.V. Leenwenhock, in 1674, discovered the minute forms of life such as bacteria and single celled animals in a drop of water.

In 1839, Theodor Schwann, another German botanist, asserted that all plants and animals are made up of cells.

In 1831, Robert Brown discovered the nucleus in the cell. J.E. Purkinje, in 1840, used the term protoplasm to describe the juicy, slimy gelatinous contents of the cell.

In 1885, Rudolf Virchow expressed that all cells arise from pre-existing cells.

In 1932, two German Scientists, Ruska and Knoll, invented the electron microscope.

Man is estimated to have about 100 trillion \(10^{14}\) cells in number.
Based on the complexity of organization, especially nuclear organization, the cells are classified into two types.

1. **Prokaryotic cells.**
2. **Eukaryotic cells.**

**Prokaryotic cells**

The cells of Bacteria and Cyano Bacteria (blue green algae) lack a well organised nucleus and are called prokaryotic cells. Their DNA (Deoxyribo Nucleic Acid) is not enclosed by a nuclear membrane. They also lack membrane bound organelles. The organisms which possess prokaryotic cells are called prokaryotic organisms or prokaryotes. They are considered to be primitive organisms.

**Eukaryotic Cells**

The cells of all plants (except bacteria and cyano bacteria) and animals possess a well organised nucleus and are called Eukaryotic cells. Their genetic material is enclosed by a nuclear membrane. They possess membrane bound organelles like Endoplasmic reticulum, golgi body, mitochondria, plastids and vacuoles. The organisms which possess eukaryotic cells are called Eukaryotic organisms or eukaryotes.
### Differences between Prokaryotic cell and Eukaryotic cell

<table>
<thead>
<tr>
<th></th>
<th>Prokaryotic Cell</th>
<th>Eukaryotic Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>It is generally smaller (1-10 micro meter) in size</td>
<td>1. It is comparatively larger (5-100 micro meter) in size.</td>
</tr>
<tr>
<td>2.</td>
<td>It lacks a well-organized nucleus as its nuclear material is not surrounded by a nuclear membrane.</td>
<td>2. It contains a well-organized nucleus as its nuclear material is surrounded by a nuclear membrane.</td>
</tr>
<tr>
<td>3.</td>
<td>It has a single chromosome</td>
<td>3. It has more than one chromosome.</td>
</tr>
<tr>
<td>4.</td>
<td>Nucleolus is absent</td>
<td>4. Nucleolus is present</td>
</tr>
<tr>
<td>5.</td>
<td>It lacks membrane bound cell organelles.</td>
<td>5. It possesses membrane bound cell organelles.</td>
</tr>
<tr>
<td>6.</td>
<td>Cell division occurs by fission or budding. Mitotic and meiotic divisions are absent</td>
<td>6. Cell division takes place by mitosis and meiosis.</td>
</tr>
<tr>
<td>7.</td>
<td>Ribosomes are smaller</td>
<td>7. Ribosomes are larger</td>
</tr>
</tbody>
</table>

### MULTICELLULARITY

**Do you know?**
1. What is meant by unicellular organism?
2. Give one example for unicellular organism.
3. What are multicellular organisms?

The organisms having many cells in their body are called multicellular organisms. E.g. Most plants and animals.

Multicellular level of organization represents an advanced state among living organisms. Multicellular organisms have different kinds of cells to perform different functions.
CELL AS A BASIC UNIT OF LIFE

Higher organisms contain organs; organs are composed of tissues; tissues are made up of cells and cells are formed from molecules. However, in all living organisms the cell is the functional unit. All biological activities revolve around the activity of the cell. Cell is defined as a unit of an organism delimited by a plasma membrane in animal cells, and cell wall and plasma membrane in plant cells. Thus, cell forms the basic unit of life.

CELL SIZE, SHAPE AND NUMBER

There is much variation in size, shape and number of cells in different organisms, and also in various parts of the body. Most of the cells are only a few micrometres in diameter and are visible only with the help of a microscope.

Cells may be spherical, spindle shaped, elongated, polyhedral or irregular in shape. The shape of the cells is determined by the specific function they perform.

The number of cells is related to the size of the organ or body. Thus, small organisms have limited number of cells, while the larger ones such as elephant, whale or banyan tree have a countless number of cells.

STRUCTURAL ORGANIZATION OF A CELL

A cell is made of life giving substance called protoplasm. The protoplasm is a highly organized jelly like, viscous, semifluid, composed of molecules of various chemicals. Most of these are organic molecules such as proteins, carbohydrates, fats, nucleic acid etc. Protoplasm is commonly called the ‘physical basis of life’.

For your info

The study of cell is not possible without a microscope, Robert Hooke in 1665 coined the term cell.

- Anton van Leeuwenhoek (1674), studied the structure of bacteria, protozoa, etc. under the simple microscope which he himself designed.
- Robert Brown discovered that all cells contain nucleus.
- Purkinje coined the term, ‘protoplasm’ for the living substance present inside the cell.
A plant cell consists of a cell wall and protoplast. Cell wall is absent in animal cells. Protoplast denotes the whole of protoplasm present in a cell. It is differentiated into plasma membrane, nucleus and cytoplasm.

Various cell organelles are suspended in the cytoplasm. Plant cells differ from animal cells in many ways.

**A Typical Animal Cell**
A Typical Plant Cell

Cell Membrane (Plasma membrane or Plasmalemma)

The contents of the cell are enclosed by a thin, delicate living membrane called cell membrane. It is the outer boundary of the cell. Cell membrane is flexible and is made up of a continuous bilayer of lipid molecules and protein molecules on both of its surfaces and also embedded in it. These organelles are found in the liver and kidney cells. They are small, membrane-bound sacs, and contain powerful oxidative enzymes. Their chief function is to remove toxic substances.

Function

1. Plasma membrane selectively regulates the entry and exit of the substances into and out of the cell. Therefore it is called selectively permeable membrane or semipermeable membrane.
2. It provides an outer boundary to the cell and protects the cell from injury.
3. It allows the flow of materials and information between different organelles of the same cell, as well as between the adjacent cells.
4. It provides some organic connections between the adjacent cells.
CELL WALL

Cell wall is present only in plant cells. It is a rigid protective covering outside the plasma membrane. Presence of cell wall in plant cells distinguishes them from animal cells. Most of the plant cell walls are made of cellulose.

The cell wall consists of three layers namely, middle lamella, primary wall and secondary wall. The middle lamella is thin amorphous cement like layer between two adjacent cells. Primary wall is the first formed wall of the cell and is produced inner to the middle lamella. The secondary wall is a thick layer found inner to the primary wall.

Functions of cell wall

1. Cell wall gives a definite shape to the plant cells.
2. It provides mechanical strength to the cell.
3. It protects the protoplasm against injury.
4. It gives rigidity to the cell

CYTOPLASM

Cytoplasm is a viscous, translucent, homogeneous and semifluid mass of protoplasm excluding the nucleus. The portion of cytoplasm immediately below the cell membrane is gel like and is called ectoplasm. The cytoplasm between the ectoplasm and nuclear membrane is liquefied and is called endoplasm.

Cytoplasm consists of vital molecules such as carbohydrates, lipids, proteins, amino acids, minerals and water. It is the seat of cellular metabolism. Different types of cell organelles are embedded within the cytoplasm. Each type of organelle performs specific functions in the cell.

Functions of Cytoplasm

1. Cytoplasm helps in intracellular distribution of enzymes, nutrients and other biomolecules within the cell.
2. Synthesis of different types of biomolecules such as proteins, nucleotides, fatty acids etc., takes place in the cytoplasm.
CELL ORGANELLES

A cell performs a variety of functions such as
1. Synthesis of complex molecules and their breakdown
2. Production of energy,
3. Secretion of certain substances, etc..

These activities of the cell are performed by different cell organelles. These organelles are enclosed by membranes. To understand the functioning of the cell, it is necessary to know briefly about the structure of cell organelles.

Endoplasmic Reticulum

Endoplasmic reticulum is a complicated and interconnected system of membrane bound channels and tubules. It is spread throughout the cytoplasm and is continuous with the plasma membrane and nuclear membrane.

There are two types of Endoplasmic Reticulum.

a. Rough Endoplasmic Reticulum (RER)

b. Smooth Endoplasmic Reticulum (SER)

Rough endoplasmic reticulum (Granular endoplasmic reticulum)

They are found in cells which synthesize proteins. This type of endoplasmic reticulum possesses rough walls because the ribosomes remain attached with membrane of endoplasmic reticulum. Smooth endoplasmic reticulum (Agranular endoplasmic reticulum) they are found in cells which synthesize lipid. The walls are smooth and ribosomes are not attached to its membrane

Functions

1. Endoplasmic Reticulum (E.R) provides large surface area for the metabolic activities of the cell.
2. Rough endoplasmic reticulum plays an important role in protein synthesis.
3. Smooth endoplasmic reticulum is involved in the synthesis of steroid, hormones and lipids.

**Golgi Complex or Golgi apparatus**

The Golgi apparatus was first described by Camillo Golgi. Golgi complex consist of saucer-like compartments called cisternae, network of interconnecting tubules, vesicles and vacuoles at the peripheral regions. In plant cells, Golgi apparatus is referred to as dictyosomes.

**Functions**

1. Golgi apparatus is involved in the formation of lysosomes.
2. It is also responsible for the synthesis of cell wall and cell membrane.

**Lysosomes**

Lysosomes are small membrane bound vesicles which contain various types of digestive enzymes. These serve as intracellular digestive system, hence they are called digestive bags. They are produced by the joint activity of Endoplasmic reticulum and Golgi apparatus. If the membrane of Lysosome happens to get ruptured, the enzymes of Lysosome would digest the entire cellular structure causing death of the cell. So Lysosomes are called ‘suicide bags’

**Functions**

1. Lysosomes are involved in the intracellular digestion of food particles ingested by the cell through endocytosis.
2. The lysosomes of WBCs (White blood cells) destroy pathogens and other foreign particles and thus take part in natural defense of the body.

**Ribosomes**

Ribosomes are small granular structures made up of ribo nucleic acids (RNA) and proteins. They occur free in the cytoplasm as well as attached to the outer surface of the rough endoplasmic reticulum.

**Functions**

Ribosomes play an important role in protein synthesis. So they are called, ‘protein factories’ of the cell

**Vacuoles**

Vacuoles are fluid–filled sacs bound by a single membrane and are present in plant cells as well as in certain protozoans as food vacuoles and contractile vacuoles. In plant cells, major portion of the cell is occupied by vacuoles and are bound by the definite membrane called tonoplast. Vacuoles of plants are filled with cell sap containing minerals, sugars, amino acids and dissolved waste products.

**Functions**

1. Vacuoles store and concentrate mineral salts as well as nutrients.
2. They maintain proper osmotic pressure in the cell for its turgidity and absorption of water.
**Mitochondria**

Mitochondria are globular or cylindrical organelles. Each mitochondrion is bound by two membranes – an outer continuous membrane and an inner membrane thrown into folds called cristae. These cristae divide the inner chamber incompletely. The inner chamber is filled with homogenous dense material called the matrix. The cristae have pin-headed bodies called F1 particles or Oxysomes which play an important role in respiration.

The matrix of mitochondria contains enzymes necessary for the oxidation of food during respiration and release of energy in the form of ATP molecules. Therefore mitochondria are called **power houses** of the cell. The mitochondria contain proteins, lipids and a small amount of DNA.

**Functions**

1. Mitochondria synthesize energy rich compounds such as ATP.
2. Mitochondria provide important intermediates for the synthesis of several biochemicals like chlorophyll, cytochromes, steroids, aminoacids etc.

**Plastids**

Plastids are disc or oval shaped organelles which occur in plant cells only. Plastids are of three types. They are Leucoplasts, Chromoplasts and Chloroplasts.

1. **Leucoplasts**: These are colourless plastids which store food in the form of starch, lipids and proteins

2. **Chromoplasts**: These are yellow or reddish in colour due to the presence of pigments other than chlorophyll. Chromoplasts provide colour to many flowers and fruits.
3. **Chloroplasts:**

These are green colored plastids which possess the photosynthetic pigment.

Each chloroplast consists of a double membrane envelope and a matrix. The inner membrane is arranged along the length of the plastids as lamellae. At certain regions, the lamellae are thickened and appear like pile of coins. These are called the grana. Each granum consists of disc shaped membranous sacs called thylakoids. Inside these grana, the chlorophyll is located. The non-thylakoid portion of the matrix is called stroma. It contains a number of enzymes involved in photosynthesis.

**Centrosome**

Centrosome is present in animal cells and in certain lower plants. It is absent in prokaryotic cells and in higher plant cells. It is located near one pole of the nucleus. It contains a pair of small, hollow granules called centrioles.
**Functions**

Centrioles play an important role in the formation of spindle fibres during cell division.

**Nucleus**

Nucleus is the major central structure in the cell. It is a dense spherical structure embedded in the cytoplasm. Nucleus has a double membraned envelope called nuclear envelope. Nuclear envelope encloses a ground substance called nucleoplasm or karyolymph. The nuclear envelope possesses many pores called nuclear pores. The nucleoplasm has two types of nuclear structures

**The nucleolus**

The nucleolus is a spherical body rich in protein and RNA. It is the site of ribosome formation. There may be one or more nucleoli in the nucleoplasm.

**Chromatin**

The chromatin is a network of fine threads composed of genetic material DNA (Deoxyribo nucleic acid) and proteins.

During cell division chromatin is condensed into thick cord like structures called Chromosomes.

The chromosomes contain genes and each gene is responsible for one hereditary character of the organism. Genes contain information for inheritance of features from parents to next generation in the form of DNA molecule.
**Functions:**

i) Nucleus controls all the metabolic activities of the cell.

ii) It controls the inheritance of characters from parents to off-springs.

iii) It controls cell division.

**Nuclear membrane**

This is a double-layered membrane which separates the nucleoplasm from the cytoplasm. The nuclear membrane has minute pores which allow the selective transfer of material between the nucleoplasm and the cytoplasm.

**Nucleoplasm**

Within the nuclear membrane, completely filling up the space, is a clear, semi-solid, granular substance or matrix called the nucleoplasm. The nucleolus and the chromatin network lie suspended in the nucleoplasm.

**Nucleolus**

This dense, spherical granule found in the nucleus contains RNA (ribonucleic acid) which is responsible for protein synthesis in the cytoplasm.

**Chromatin network**

These are very fine thread-like, coiled filaments uniformly distributed in the nucleoplasm. At the time of cell division, the chromatin becomes thick and ribbon like and are known as chromosomes. The chromosomes contain genes, which are composed of DNA (Deoxy-ribonucleic acid). Genes are responsible for storing and transmitting hereditary characteristics from one generation to another. A gene is the functional unit of a chromosome. Genes are arranged in single linear order along the chromosome. One gene may be responsible for a single characteristic, or a single characteristic may be transmitted by a set of genes.
The main differences between a typical animal cell and a typical plant cell are summarized below:

<table>
<thead>
<tr>
<th>Animal Cell</th>
<th>Plant Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usually smaller in size.</td>
<td>Usually larger in size.</td>
</tr>
<tr>
<td>Cell wall absent. Cellulose in any form is absent.</td>
<td>Cell wall made up of cellulose is present.</td>
</tr>
<tr>
<td>Cytoplasm is denser, more granular and occupies most of the space in the cell.</td>
<td>Cytoplasm is pushed to the periphery and forms a thin lining against the cell wall.</td>
</tr>
<tr>
<td>Vacuoles absent. If present, they are small, temporary and concerned with excretion or secretion.</td>
<td>Vacuoles are large and prominent. May be one or more. The central space in the cell may be occupied by a large, single vacuole.</td>
</tr>
<tr>
<td>Plastids are absent.</td>
<td>Plastids are usually present.</td>
</tr>
<tr>
<td>Centrosome is present.</td>
<td>Centrosome is absent. Instead two small clear areas called polar caps are present.</td>
</tr>
<tr>
<td>Prominent and highly complex Golgi bodies present near nucleus.</td>
<td>Contain several sub units of Golgi apparatus called dictyosomes.</td>
</tr>
</tbody>
</table>

**Types of Cell Division**

Cell division is a method by which new cells are originated from pre-existing cells. The formation of daughter amoebae in amoeba, the development of sex cells and the growth of a young animal or plant into an adult, all involve cell multiplication. In order to multiply in number, cells undergo cell division: one divides into two, two into four, four into eight and so on.
To understand cell division, we must realize that chromosomes occupy a central position. They determine the characteristics of the cell, and it is important that they are correctly distributed between the daughter cells. A cell has a fixed number of chromosomes.

**Example:**

Man has 46 chromosomes, and these occur in pairs i.e., diploid condition.

Two types of cell divisions take place.

- MITOSIS (Diploid division)
- MEIOSIS (Haploid division)

All living beings, plants and animals, start their life with a single cell. Some organisms exist as a single cell and carry out the various metabolic life processes such as assimilation, respiration, reproduction, excretion, etc., that are essential for their survival. These are known as unicellular organisms.

**Specialised Cells:**

**Red Blood Cells:**

Red blood cells are found in the blood of animals, its function is to transport oxygen from the lungs to all the body cells, and carbon dioxide from the body cells to the lungs.

**They are adapted by four ways:**

- They have a biconcave disc shape that gives it a large surface area to carry more oxygen.
- They contain a chemical called hemoglobin that combines with oxygen and carbon dioxide.
- They have no nuclease to carry more oxygen and CO2
- They are tiny enough to squeeze through capillaries.
**Muscle Cells:**

They are cells found in muscles in animals, they contract and relax together to move the organisms. Their function is to contract to support and move the body.

**They are adapted by two ways,**

1. *First, Is that they are made of contractile filament to help in contraction.*
2. *Second is it contains lots of mitochondria to supply the cell with energy.*

**Ciliated Cells:**

Ciliated cells are present in the trachea and bronchi of our respiratory system.

Their function is to use their cilia to move the mucus up the trachea to the throat. The mucus traps bacteria and dust particles. When it reaches the throat, mucus is swallowed to the stomach where the acid kills the bacteria.

They are adapted by the tiny hair like projections called cilia which sweeps the contaminated mucus upwards.

The mucus is secreted by goblet cells which are next to ciliated cells.
Root Hair Cells:

These are cells situated in the roots of plants. They contain no chloroplasts. Their function is to absorb water and minerals from the soil. And to anchor the plant in the soil.

They are adapted by 3 ways.

One, they have an extension that increases the surface area for more water intake.

- Two, they have a large number of mitochondria for respiration to become more active.
- Three a concentrated vacuole to help absorbing water by osmosis.

Xylem Vessels:

These are dead lignified cells that exist in the stem of a plant.

Their function is to transport water and minerals from the roots to the leaves and the rest of the plant through the stem and to support the plant.

They are adapted by 2 ways.

- Firstly, they are hollow to allow water and minerals to pass through them with no resistance.
- Secondly they are strong and lignified to support the plant. The Division Of Labour: the specialization of cells to carry out particular functions in an organism.