Cell - Structure and Functions

Cell: The Basic Structural and Functional Unit

You know that in order to build a house, bricks are arranged in a certain pattern. Similarly, our body is made up of similar structures called **cells,** which assemble to form our body. Hence, cells are the structural units of our body.

But who discovered and coined the term 'cells'? Let us explore.

The discovery of cells was first made by Robert Hooke. While examining a section of a cork tree under the microscope, he observed small compartment-like structures and named them cells. But, Hooke observed dead cells under the microscope as cork is made up of dead cells. After the discovery made by Hooke, very little came to be known about cells for a long time. This is because better microscopes were needed to study cells of living organisms.

With the discovery of advanced microscopes (like electron microscopes), a study of the structure of cells and various cell organelles was made possible.

Properties of cell

- The cell is the smallest living unit of life.
- The shape of the cell varies in different organisms and within an organism.
- Size of cells also differs.
- All living cells exhibit certain basic characteristics like respiration, growth, metabolism, etc.
- Cells originate from a pre-existing cell. A mother cell divides to produce daughter cells. Hence, cells exhibit cell division.

Cell Theory

The cell theory that all plants and animals are composed of cells and that cell is the basic unit of life was presented by two biologists, **Schleiden (1838) and Schwann (1839).**

The cell theory was further expanded by **Rudolf Virchow** in 1855. He suggested that all cells arise from pre-existing cells.

Principles of cell theory

1. All living organisms are composed of one or more cells.

2. Cells are the basic structural and functional units of all living organisms.

3. All cells come only from the division of pre-existing cells.

Microscope

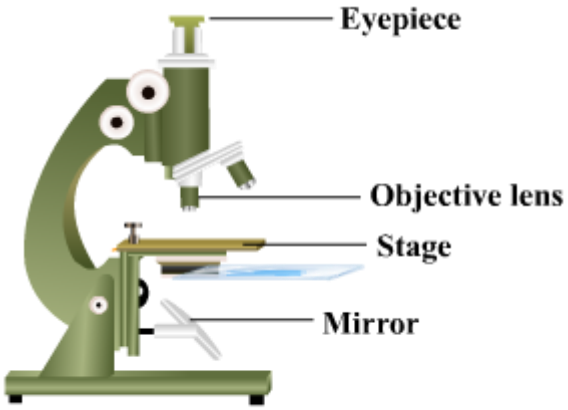
You might know that most of the cells are too small to be visible to the naked eye, so these cells need to be magnified.
How are these cells magnified? These cells can be magnified with the help of an instrument called **microscope**.

What is a microscope?
A microscope is an instrument used to see the objects that are not visible to the naked eye. It magnifies the object several hundred times and makes it clearly visible.

Parts of Microscope

The important parts of the microscope are:

- **Eye piece:** It is the lens through which we see and is located at the top. It is usually 10X (X= magnification) and 15X.
- **Objective lens:**It is the lens that is facing the object. They are usually 10X, 40X or 100X.
- **Mechanical stage:** It is the flat platform where slides are kept. It has clips for holding slide and moving it left, right and up or down.
- **Mirror:** It is located near the base and directs the light through the microscope. The light makes the objects visible.



Compound Microscope

How to use a microscope?
Following is the procedure to view an object under the microscope.

1. Place the object or specimen in a drop of water on a clean glass slide.
2. Spread the specimen on the glass slide and cover it with the help of a coverslip.
3. Place the glass slide on the stage of the microscope.
4. View the specimen through the eye piece. Use the coarse adjustment to focus.
5. Bring the specimen into better focus using the fine adjustment knob.

Something You Should Know
A compound microscope is an improvised design of the early microscope, developed by Robert Hooke. It magnifies the image about 2000 times more than its original size.

Magnification of Compound Microscope:

Do you know how to find the magnification of a compound microscope? Let us find out with the help of an example.

In order to find the total magnification while observing image with the help of compound microscope, the power of eye piece which is typically 10X or 15X is multiplied by the power of objective lens which is at 10X, 40X or 100X.

Therefore, total magnification = Power of eye piece used x Power of the Objective lens used

For example, while viewing a slide, a student used the eye piece lens with 10X power and objective lens 40X. The total magnification will be 10X x 40X = 400X.

This means that the object seen by a student will appear 400 times larger than the original size.

Electron microscope:

The electron microscope is a type of a microscope that uses the beams of electrons to illuminate the object and gets a magnified image. Its magnification power is 200000 times more than the compound microscope and has a maximum magnification of 500000 times.

Electron Microscope

Variations In Cell Number, Shape, Size And Type

There are millions of organisms living on earth. **Do you think all these organisms are made up of similar types of cells? What about the human body? Are all cells in the human body similar in shape, size, and structure?** Let us explore.

(I) Number of cells in different organisms

You know that humans, and many plants and animals are made up of a large number of cells. Organisms which are made up of a large number of cells are known as **multicellular organisms.**

But there are some other organisms, which are made up of only one cell. These organisms are called **unicellular organisms.** The example includes bacteria, *Amoeba* etc. In these organisms, a single cell performs all the necessary functions like excretion, respiration, digestion etc.

(II) Shape of the cells in different organisms

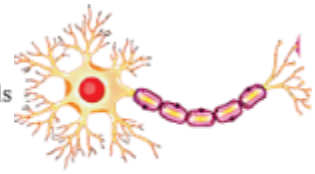
All cells do not have a similar shape. The shape of each cell varies. It can be rounded, spherical, or elongated in shape. In some cases, cells may not even have a definite shape.

Red blood cell

- **Round shaped:** Red blood cells are spherical in shape.
- **Elongated spindle shaped:** Muscle cells are elongated in shape.

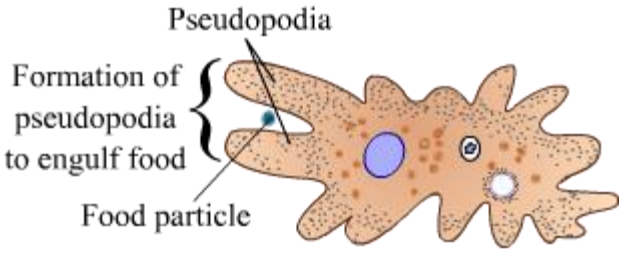
Muscle cells

- **Long and branched:** Nerve cells are long and have branches.



Nerve cells

- **No particular shape:** White blood cells and *Amoeba* do not have a definite shape; their cells have the ability to change their shape. For example, *Amoeba* keeps on changing its shape by producing various projections across its cell surface, which are called pseudopodia. These projections help *Amoeba* in feeding and moving.



Amoeba

Both plant and animal cells have a cell membrane, which gives shape to the cell.

In plants as well as bacteria, a cell wall is present surrounding the cell, which gives shape and rigidity to the cells.

(III) Size of the cell in different organisms

The size of the cell also varies in different organisms. Some cells like eggs of birds can be seen with the naked eye, but some other cells are so small that an electron microscope is required to observe them.

The smallest cell measures around 0.1 to 0.5 micrometer. It is present in bacteria.

The largest cell measures around 170× 130 mm, and is the egg of an ostrich

The size of the cell is not dependent on the size of the body of an organism. It depends on the function of the cell.

Types of cells in different organisms

Cells in living organisms are of two types:

(I) Prokaryotic cells

The cells in which there is no well-defined nucleus and the nuclear material is present without a nuclear membrane are called **prokaryotic cells**. The example of prokaryotic cell includes bacteria and blue-green algae. These organisms are known as prokaryotes.

(II) Eukaryotic cells

The cells in which a well defined nucleus is present are called eukaryotic cells. The example includes all organisms except prokaryotes. These organisms are known as eukaryotes.

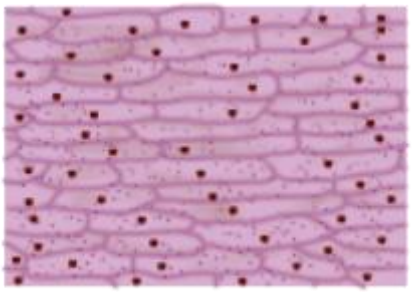
Cell Organelles:Their Structure and Functions

We know that cell is the basic structural and functional unit of life**. But what is present inside a cell? How does it perform its various functions?**

A cell consists of three essential parts: cell membrane, cytoplasm and nucleus. Let us know more about these parts.

Cell membrane:

Take a peel of onion by separating it from the fleshy portion. Add a drop of methylene blue on a slide containing the peel, put cover slips, and observe it under a microscope. **What do you observe?** Note your observations and draw a diagram of the structure you have observed.

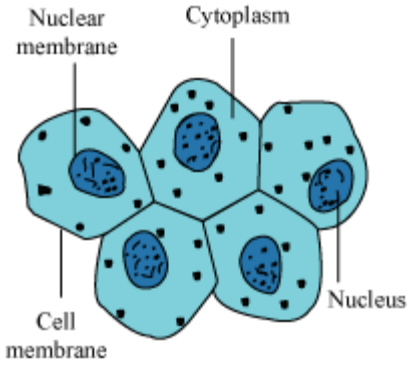


Cells observed in an onion peel

You will observe brick-like cells placed one over the other with a round ball-like nucleus at the centre. The boundary of the onion cells is known as the **cell membrane** or **plasma membrane** and it is covered by another thick layer called the **cell wall.**

The cell membrane is porous in nature and helps in the inward and outward movement of substances. However, it is selectively permeable in nature, which means that it allows the in and out movement of only certain substances.

Let us now observe how animal cells look under a microscope. Given below is an image of human cheek cells as observed under a microscope.



Human cheek cells

Do you notice any difference between these cells and onion cells? The cell membrane in this case is not surrounded by any other layer!

Hence, in plants, cell membrane is surrounded by another layer known as **cell wall** whereas animal cell contain only cell membrane.

Cell wall:

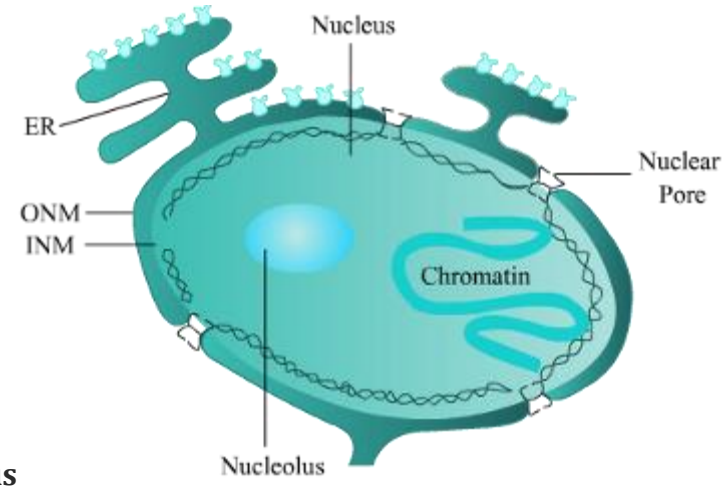
The cell wall is an additional protective, rigid structure present outside the cell membrane. It is present only in plant cells. It protects them from heat, humidity, pressure, etc. It also gives the plant cells their characteristic shape and rigidity. It is freely permeable in nature.

Cytoplasm:

The jelly-like substance present between the cell membrane and the nucleus is called the **cytoplasm**. It is an important component of the cell as various cell organelles such as mitochondria, ribosomes, etc. are present in it.

Nucleus:

Nucleus is a spherical structure, which is generally present at the centre of the cell.



Parts of Nucleus

- **Nuclear membrane**: The nucleus is enclosed by a double-walled cellular membrane called the nuclear envelope. The nuclear envelope separates the contents of the nucleus from the cytoplasm. The nuclear membrane is pierced with holes known as the nuclear pores. These pores allow the nucleus to communicate with the rest of the cell.

- **Nucleolus**: It is a spherical structure found inside the nucleus. It plays an important role in protein synthesis.

- **Nucleoplasm**: The nucleus contains a semi-fluid substance known as nucleoplasm or karyoplasm. It holds the nucleolus and the suspended chromatin.

- **Chromatin network**: The nucleus contains the genetic material of an organism in the form of a network of chromatin. This chromatin gets folded and coiled to form chromosomes.

Cell membrane, cytoplasm, and nucleus form the basic components of the cell.

Some interesting facts:

Do you know that the red blood cells of the human body do not have a nucleus?
Paramecium is a unicellular organism having two nuclei.
Some muscle cells in humans have a large number of nuclei.

CELL ORGANELLES

These are the living parts of a cell that have definite shapes, structures and functions. Let us explore all the cell organelles found in a cell.

Vacuole:

When you observe an onion peel under the microscope, you will observe large empty structures in the cells. **Do you know what these structures are?** These empty structures are called **vacuoles**. These vacuoles are larger in plant cells than in animal cells.

Vacuoles are membrane-bound structures, which are believed to store substances in cells. In plant cells, vacuoles are large in size, while in animal cells vacuoles are small. The table given below lists some functions of vacuoles. The membrane of vacuoles is called tonoplast.

Functions of vacuoles:

- They help in the removal of unwanted structural debris.
- They store all the waste products of cells.
- In *Amoeba*, food vacuoles store food.

Plastids:

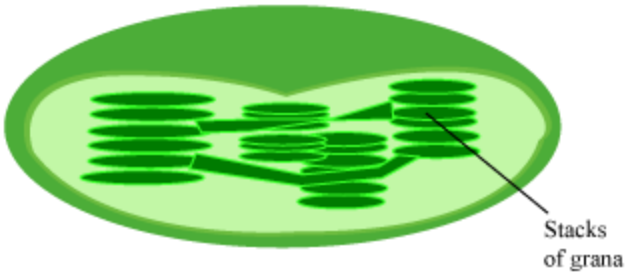
Take a peel of the *Tradescantia* leaf and observe it under the microscope. You will find coloured bodies in the cytoplasm of the leaf cells. **Do you know what these are?** These are called **plastids**. The green coloured plastids in the cell are known as chloroplasts. They are responsible for the green colour of the leaves. They carry out the process of photosynthesis and help plants prepare their own food.

Do you know that some plastids are specialized to store starch, proteins, and lipids?

Plastids are major organelles found in plant cells and algae. There are two major types of plastids, namely **Chromoplasts** and **leucoplasts**.

Chromoplasts are coloured plastids, while leucoplasts are white or colourless plastids. Chromoplasts contain coloured pigments like carotene (orange), xanthophylls (yellow) etc. These pigments are responsible for the colour of plants. Unlike chromoplasts, leucoplasts lack pigments.

Chloroplasts are plastids containing the pigment called chlorophyll. A chloroplast is enclosed by two lipid membranes. They are called the kitchen of the cell.



Chloroplast

The inner matrix is called the **stroma**. **Thylakoids** are the sub-organelles arranged in stacks within the stroma to form **grana.** Plastids also contain their own DNA and ribosomes.

Functions of plastids

- They carry out the process of photosynthesis.
- They contribute to the colour of leaves, flowers etc.

Endoplasmic Reticulum

Endoplasmic reticulum, or **ER**, is an interconnected network of membranous structures like **tubules, vesicles,** and **cisternae**. Cisternae are the flattened disc-like membranous structures. Tubules are tubular in shape, while vesicles are sac-like structures.

There are two types of endoplasmic reticulum, namely **smooth endoplasmic reticulum (SER)** and **rough endoplasmic reticulum (RER)**. When ribosomes get attached to the surface of smooth endoplasmic reticulum, it becomes rough endoplasmic reticulum.

The basic functions of endoplasmic reticulum are

- To help in protein and lipid synthesis.
- To provide internal support to the cells.
- To provide transportation pathway within the cells.

Ribosomes

Ribosomes are the small granular structures that help in the protein synthesis. Hence, they are also known as the **"protein factories"** of the cell.

Golgi Apparatus

Golgi apparatus have the membrane-bound, sac-like structures called cisternae and some small vesicles. They are arranged parallel to each other in stacks. They were discovered by Camillo Golgi in 1898. Golgi body is usually composed of five to eight cisternae in stacks. Some functions of the Golgi apparatus are enlisted below.

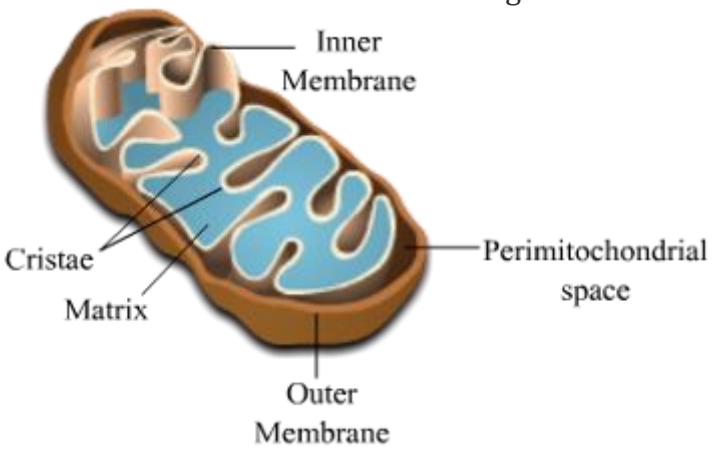
Functions of Golgi apparatus

- It involves the transport of lipids in cells.
- It involves the formation of lysosomes.
- It is involved in the synthesis of cell wall in the plant cell.
- It is involved in the modification, sorting and packaging of proteins.

The golgi apparatus present in the plant cell are called dictyosomes. They are small, unconnected and more in number as compared to the animal cell.

Mitochondria

Mitochondrion is a membrane-enclosed organelle found in eukaryotic



cells.

Mitochondria are responsible for the production of most of the energy (or ATP) in cells. Therefore, mitochondria are also known as the **power house** of cells. A mitochondrion is composed of two lipid membranes, enclosing the matrix. The inner membrane gets folded to form numerous **cristae.** Cristae are the main site for ATP production. Mitochondrial matrix contains mitochondrial DNA and ribosomes.

Functions of mitochondria

- They produce energy required for cells in the form of ATP.
- They also regulate the free calcium ion concentration in the cytosol.
- They participate in apoptosis or programmed cell death.

Lysosomes

Lysosomes are the membrane-bound vesicles, which contain digestive (hydrolytic) enzymes. They digest a variety of substances including worn out organelles, food particles, viruses, and bacteria. They are also known as '**suicide-bags'** of cells as they burst out and release hydrolytic enzymes in the cytosol, causing destruction of the damaged or injured cells.

Functions of lysosomes

- They digest macromolecules by phagocytosis. So, they provide protection to the cell against foreign substances.
- They also take part in auto-cell lysis.

Centrosome

Centrosome is found exclusively in animal cells. It lies very close to the nucleus. It contains two cylindrical structures called **centrioles**.

Both centrioles in a centrosome lie perpendicular to each other. Centrioles have a cartwheel-like organisation.

The centriole has a role in cell division.

Cell Inclusions

Cell inclusions are the result of various chemical reactions that take place inside the cell, either in the cytoplasm or in the vacuole.

Cell inclusions may be the food products like starch or oil globules or the waste materials like gums, resins, tannins, and latex.

Difference Between Animal Cells and Plant Cells

You know that plants and animals are different from each other. Plants can make their own food while animals cannot. Also, plants cannot move from one place to another while animals can.

The differences between plant and animal cells are summarized in the given table.

Cell organelle	Plant Cell	Animal Cell
Cell Wall	Present	Absent

Cell Membrane	Present	Present
Nucleus	Present	Present
Nuclear Membrane	Present	Present
Plastids	Present	Absent
Cytoplasm	Present	Present
Vacuoles	Present	Present