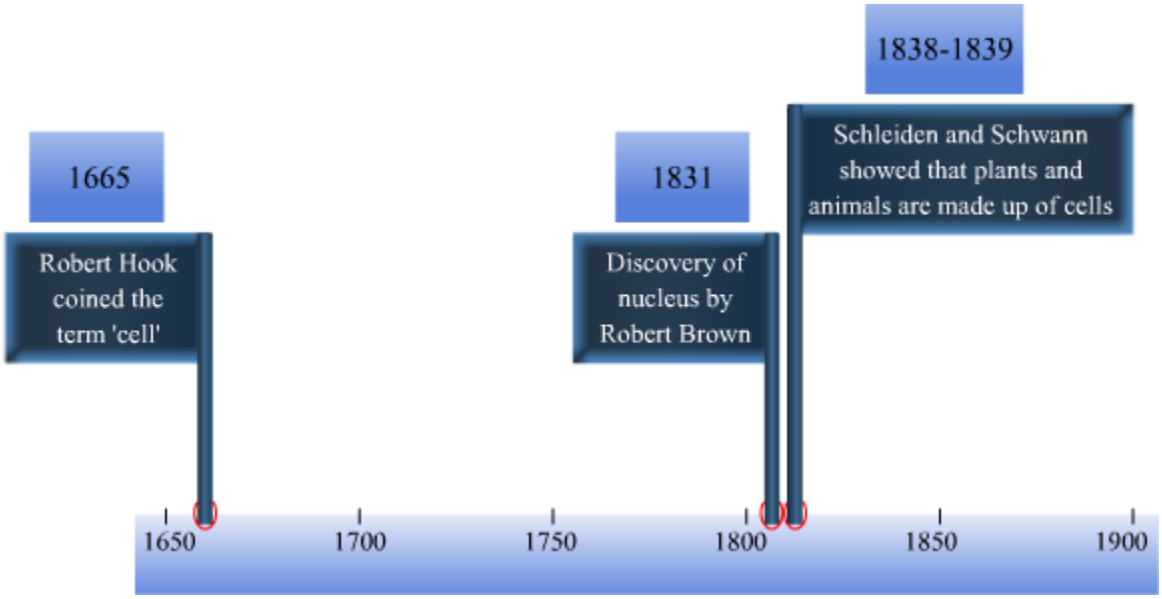
Cell

Cells: An Overview

Diverse forms of living organisms are present in our surroundings. Like ourselves, all of them are made up of tiny structures called **cells**. Cells are the building blocks of life. They are the basic structural and functional units from which life takes shape. A cell is the smallest living entity in a living organism.



How cells are formed

In 1838 & 1839, the two German scientists **Matthias Schleiden (1838)** and **Theodor Schwann (1839)** proposed the cell theory and formulated that all plant and animal tissues are made up of cells. They, however, were unsuccessful in explaining how new cells are formed. Later, in 1855, Rudolf Virchow further expanded the **cell theory** by suggesting that all cells arise from pre-existing cells. The cell theory states that:

- All living organisms are composed of cells and products of cells.
- Cells are the basic units of structure and function in an organism.
- All cells arise from pre-existing cells.

Know Your Scientist

Robert Hooke (1635-1703)

The term ‘cell’ was introduced by Robert Hooke in **1665** after observing the cellular structure of cork (a substance obtained from the bark of a tree). While examining a thin slice of cork under a compound microscope, Hooke observed many small compartments resembling honeycombs. These he termed as cells.

Robert Brown (1773-1858)

In **1831**, Robert Brown discovered the presence of nucleus in the centre of a plant cell.

Theodor Schwann (1810-1882) and Matthias Schleiden (1804-1881)

In **1838**, Matthias Schleiden, a German physiologist, discovered that all plant tissues are made up of cells, i.e., cells are the fundamental units of all plants. In the next year**(1839)**, Theodor Schwann, a German physiologist, discovered that all animal tissues are made up of cells, i.e., cells are the fundamental units of all animals.

Invention of Microscope

Cells are very small living entities that are not visible to the naked eyes. The invention of microscopes hence played the key role in the discovery of cells.

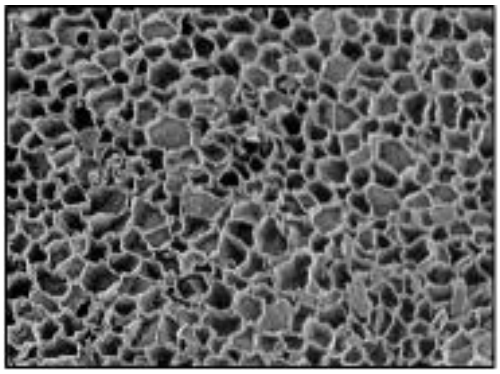
Simple Microscopes

- First simple microscopes were constructed by **Antony van Leeuwenhoek** (1632-1723).
- They consisted of single biconvex lens.
- Their magnifying power was up to 200 times.

Compound Microscopes

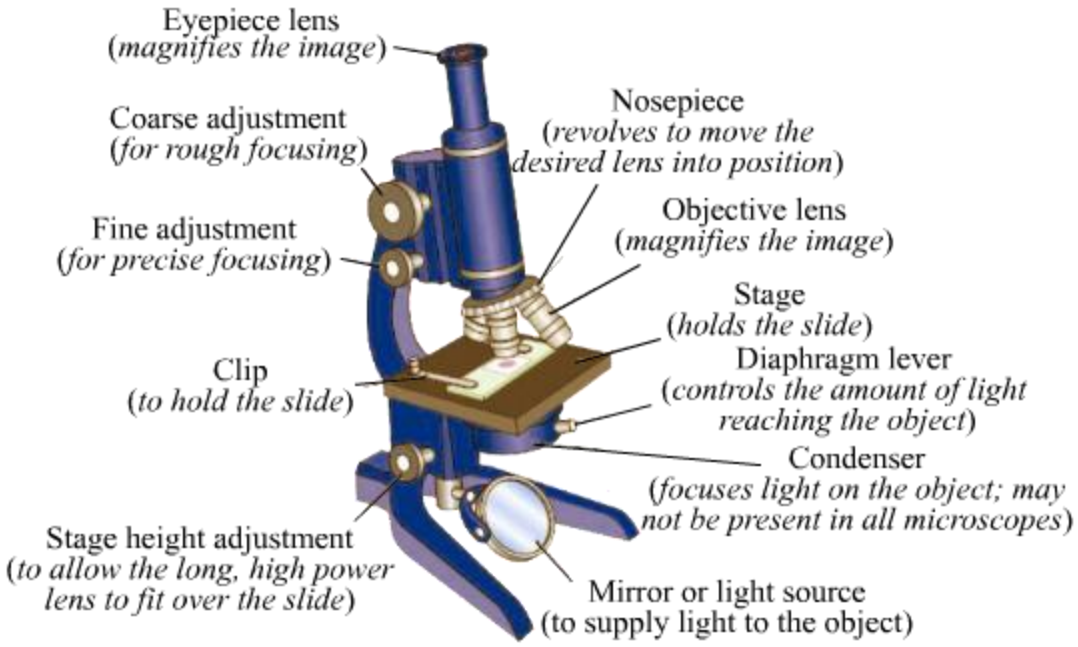
- These were first constructed by Robert Hooke (1635-1703).
- He developed the compound microscope using two lenses for increasing the magnifying power.
- He examined a thin slice of cork under it and observed tiny, box-like compartments, that he named 'cells'.

Microscope Constructed by Robert Hooke



Thin Slice of Cork As Observed Under Microscope

The modern ordinary compound microscope has greatly improved in design and magnification power (up to 2,000 times).



Compound Microscope

Electron Microscopes

- The invention of electron microscope has led to great advancements in the study of cells.
- Electron microscopes use beams of electrons which are bent by magnets to magnify the images.
- They can magnify an object up to 200,000 times.

Cell-The Basic Unit of Life

Properties of Living Cells

Some important properties of living cells are as follows:

- Generally, a cell is so small that it is not visible to the naked eye.
- Cell shape and size vary both within an organism and between different organisms. The shape and size of a cell is related to the specific function it performs.
- All living cells exhibit certain basic properties like respiration, growth and metabolism.
- Nerve cells are some of the longest cells.

Examples of cells with different shapes and sizes

Red blood cells (Round and biconcave) | White blood cells (Amoeboid) | Columnar epithelial cells (Long and narrow) | Nerve cell (Branched and long)

Did You Know?

- **The smallest unicellular organism we know is the *Mycoplasma*, a type of bacteria. Its diameter is 0.1 µm.**
- There are more red blood cells in our body than any other type of cell.

Solved Examples

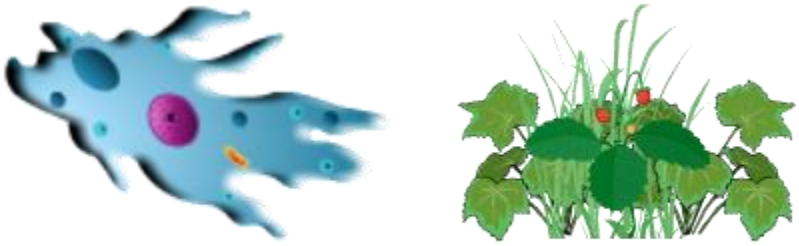
Medium

Example 1: Illustrate how the shape and size of a cell is related to the specific function it performs.

Solution: Different types of cells with different shapes and sizes are present in our body. A cell's shape and size are relevant to the specific function it performs. The irregularly shaped white blood cell is a case in point. A white blood cell protects the body by killing harmful foreign bodies. Whenever it encounters any antigen, it changes its shape accordingly and engulfs the antigen. Thus, the shape of the white blood cell is directly related to the function it performs.

Classification of Cells

<u>Based on the number of cells: Unicellular and multicellular</u>



Unicellular organism | Multicellular organism

As you now know, a cell is the smallest living entity capable of independent existence. There are certain organisms that are made **up of only a single cell**; such organisms are known as **unicellular organisms**. Examples of unicellular organisms include *Amoeba* and yeast. All

other organisms (i.e. those **made up of more than one cell**) are known as **multicellular organisms**. Examples of multicellular organisms include humans, plants and animals.

- Multicellular organisms can perform a variety of tasks efficiently due to **division of labour**. This gives the organisms a wide range of adaptabilities to survive.

- In multicellular organisms, dead cells play an important role. For example, the dead epidermal cells in animal skin protect the underlying cells.

Division of labour

Divisio12701n of labour refers to the specialized roles of the different organs present in a multicellular organism. All organs, tissues or cells of a multicellular organism cannot carry out all the functions.

Each of them is evolved to carry out a specific set of tasks. Each organ system coordinates with the others to perform the activities required for life. This division of labour minimizes the load of carrying out all the functions and, consequently, it allows the organs to operate efficiently.

Concept Builder

Let us understand this concept of division of labour using the example of a cricket team. As you know, in a cricket team, some members specialize in batting while some specialize in bowling. Each member is assigned a specific set of functions in the team. More often than not, the team that wins a game is one whose members perform their specific tasks efficiently.

In the same way, the different organ systems in the human body are assigned different functions. For example, the digestive system is assigned to carry out digestion, while the excretory system is assigned to carry out excretion.

This is division of labour. Ultimately, a healthy body is one in which the different organ systems perform their respective functions properly.

Classification of Cells

<u>Based on the cellular complexity: prokaryotes and eukaryotes</u>

This type of classification is based on the sub-cellular organization of a cell.

The given table lists the characteristic features of prokaryotes and eukaryotes.

Characteristics	**Prokaryotes**	**Eukaryotes**
Size of the cell	Cells are small in size.	Cells vary in size and are generally larger than those in prokaryotes.

Nucleus	No nucleus with a nuclear membrane is present.	There is a well-defined nucleus with a nuclear membrane.
Membrane-enclosed organelles	Organelles having a membrane around them (e.g., mitochondria, plastids) are absent.	Membrane-enclosed organelles are present.
Cell wall	Cell wall is usually present. It is composed of **peptidoglycan**.	Cell wall is usually present in plant cells. It is composed of **cellulose**.
Genetic material	The genetic material is present as nucleoid, i.e., a properly defined nucleus is absent.	The genetic material is present inside the well-defined nucleus.

Solved Examples

Medium

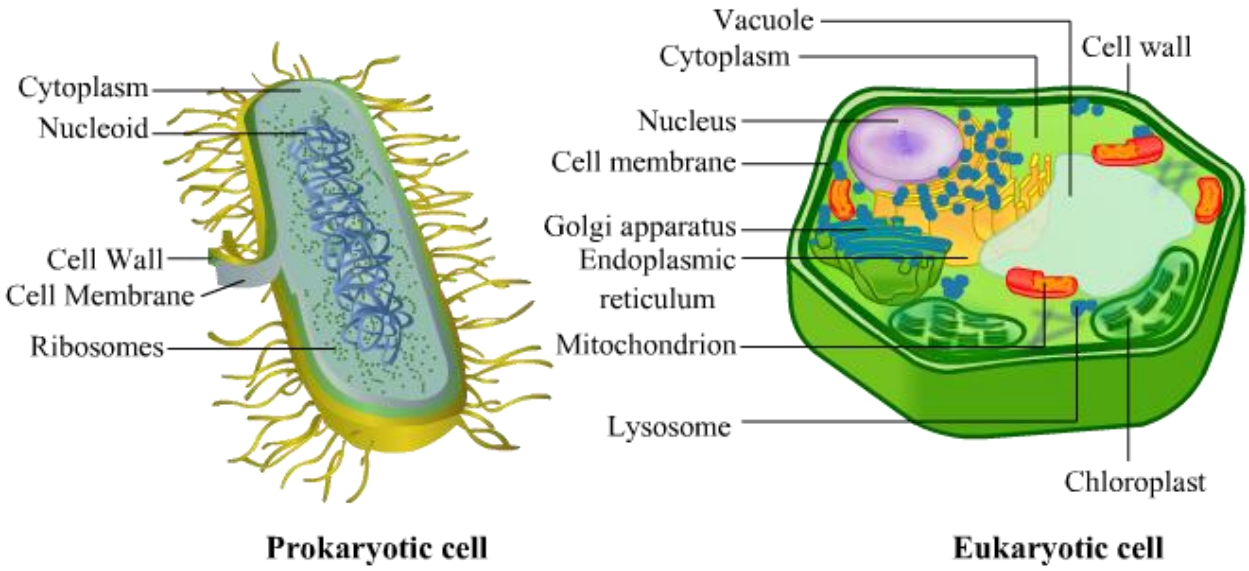
Example 2:

Distinguish between bacteria and yeast.

Solution:

Bacterium	Yeast
It is a unicellular prokaryote.	It is a unicellular eukaryote.
It lacks a well-defined nucleus.	It has a well-defined nucleus
It has no cellular organelles such as mitochondria and endoplasmic reticulum.	It has cellular organelles such as mitochondria and endoplasmic reticulum.

Structure of Eukaryotic and Prokaryotic Cell



Difference between Plant Cell and Animal Cell

Cell Division

Cells undergo division to form new cells. These new cells are used to grow, replace old, dead and injured cells, and to form gametes required for reproduction. There are two types of division a cell undergoes -

Mitosis - Each cell divides to form two daughter cells. The daughter cells have the same chromosome number as the mother cell.

Meiosis - This type of division is shown by specific cells of the reproductive organs or tissues in animals and plants. These cells divide to form gametes, which after fertilisation give rise to new off springs. In meiosis, four cells are produced from a single cell and the new cells have half the chromosome number than the mother cell.

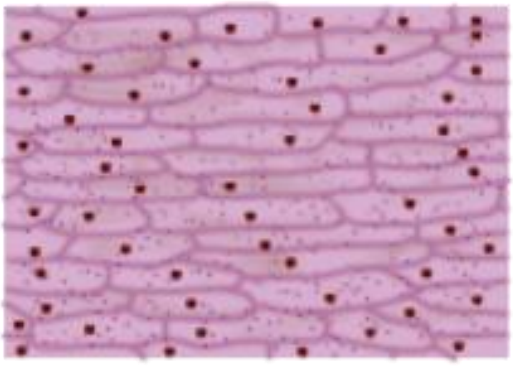
Cell Organelles: Their Structure and Functions

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.

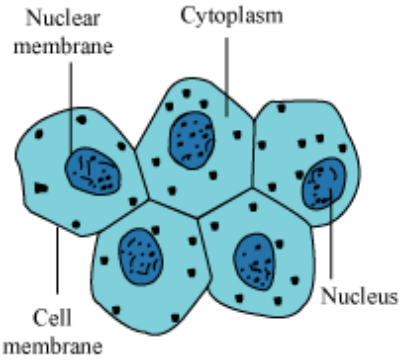


Cells observed in an onion peel

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:

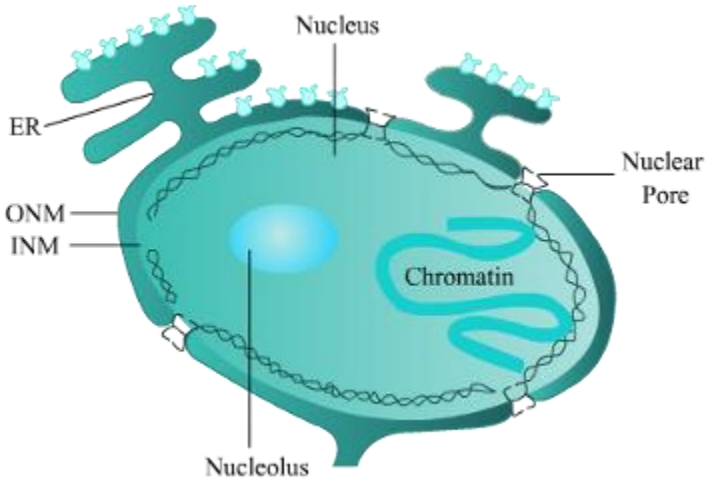
The cell wall is an additional protective, rigid structure present outside the cell membrane. It is present only in plant cells. It protects them from heat, humidity, pressure, etc. It also gives the plant cells their characteristic shape and rigidity. It is freely permeable in nature.

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.

Let us study the components of nucleus by this video.

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:

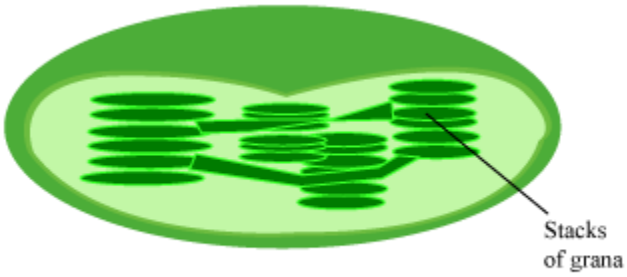
Take a peel of the *Tradescantia* leaf and observe it under the microscope. You will find coloured bodies in the cytoplasm of the leaf cells. **Do you know what these are?** These are called **plastids**. The green coloured plastids in the cell are known as chloroplasts. They are responsible for the 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.

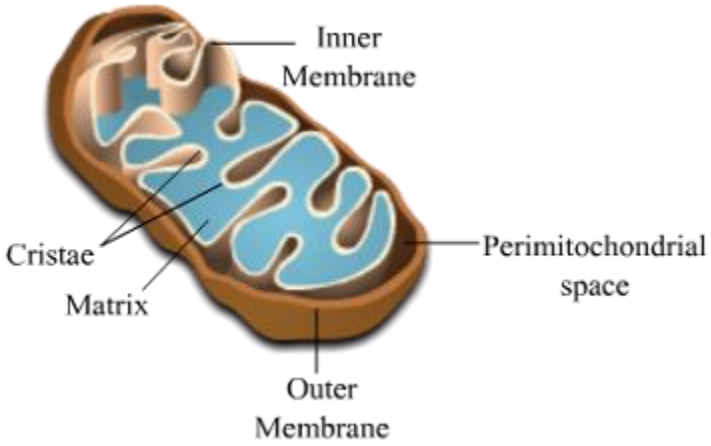
Functions of Golgi apparatus

- 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

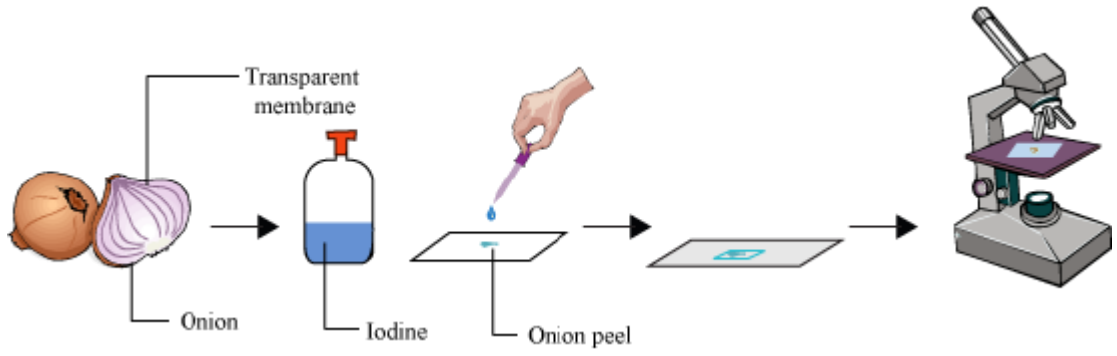
Cell inclusions are the result of various chemical reactions that take place inside the cell, either in the cytoplasm or in the vacuole.

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

Observation of Plant and Animal Cell

Let us perform an experiment to understand how does a cell look like under microscope?

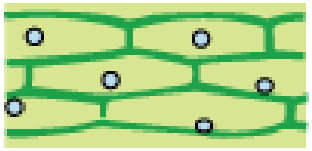
Take an onion and cut it into two halves. Peel off a transparent piece of skin from the inner layer of onion with the help of a forceps. Place this transparent skin on a slide and add a drop of iodine solution to it. Carefully place the cover slip on the slide. Wipe off the excess amount of iodine solution from the slide with the help of tissue paper. Observe the slide under microscope. Carefully have a look on the shape of onion cell.



Experimental set up

Observation:

You can see several rectangular cells, each with a small, spherical nucleus in it. These are called epidermal cells that are found on the surface of the plant body.



Onion cells

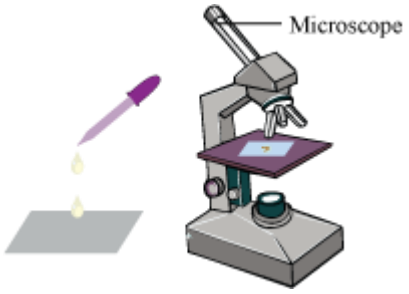
Cells are basic unit of life that is capable of doing all the required biochemical processes that a normal cell requires to do in order to live. The basic need for the survival of all living organism are same. All living organisms need to digest food (to obtain energy), respire and to get rid of metabolic wastes. **Who does all these functions of the body?**

It is the cell that carries all these metabolic function in body. Hence, cell are called **functional unit** of life.

Observing Animal Cell

Take a cotton bud and gently rub it along inside of your cheek. Smear the cotton bud onto a slide. Add a drop of methylene blue on to the smear. Carefully place a covers slip on top of the slide. Now observe the slide under microscope.

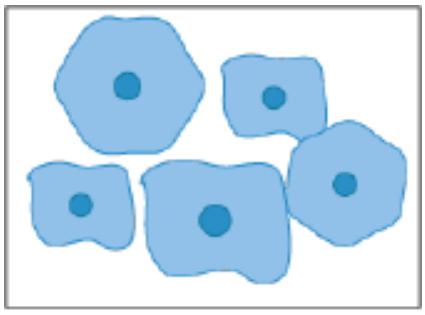
(Note: Methylene blue is a dye used to stain and view animal cells)



Experimental set up

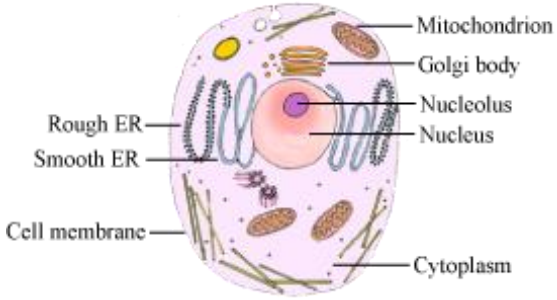
Observation

You can see several polygonal cells lying here and there on slide. This represents the structure of animal cell.

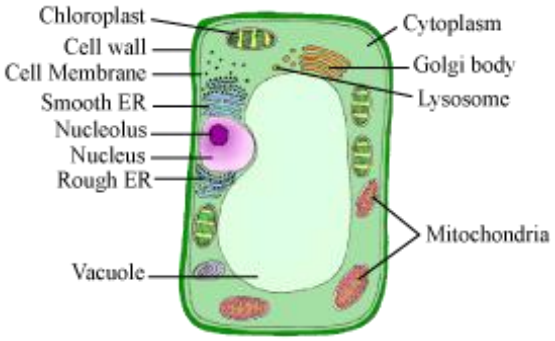


Human cheek cell

Differences between Plant and Animal Cell



Animal cell



Plant cell

Animal cell	**Plant cell**
Generally small in size	Usually larger than animal cells
Cell wall is absent	Cell wall is present
Plastids are absent	Plastids are present
Vacuoles are more in number and smaller in size	Vacuole is single and larger in size
Single, highly complex, and prominent Golgi apparatus is present	Many simpler units of Golgi apparatus, called dictyosomes, are present