Chapter 1

Cell - Structure and Functions

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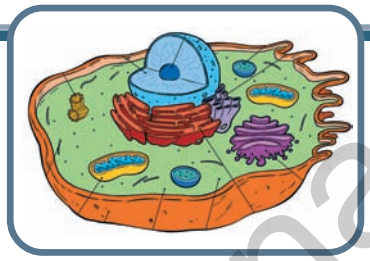

In the previous class you have already learnt about cells and their structure. You have also learnt about discovery of the cell, its size and shape, unicellular and multicellular organisms.

Let us recall some of the activities related to these aspects. For example :

Onion cells are nearly rectangular while the cheek cells are irregular in shape.

Add other examples as the one given above.

1) _____

2) _____

3) _____

Primarily, cells are studied under the microscope. When we observe the cell under a compound microscope, we can see some parts like cell wall, cytoplasm, nucleus, chloroplast and the mitochondria. However, when the same cells are observed under the electron microscope, a few other structures are also visible.

To study various cells scientists have been trying to observe cells from different parts of plants and animals, draw their structures, take photograph of them and make models of them. These have given valuable information about plant and animal cells. Here we will try to study the model diagram of the cell.

Typical Cell

All the organelles shown in the typical cell of plant or animal will not exist in every cell. For example, chloroplasts are always shown in the typical plant cell, yet all the plant cells do not have chloroplasts. They are mostly found in the cells of green leaves, tender stems etc. The organelles that feature in most of the cells are included in this model. The typical cell provides a way to study cells. Once we arrive at such a model, we can compare any cell with it. Observe the given diagrams of typical plant and animal cells (Fig-1 & 2).

1. What common features do you see in both the cells?
2. Which cell organelles are found exclusively in plant cell?
3. Compare the parts of plant and animal cells, note down the differences.

Let us study the different parts of plant and animal cells.

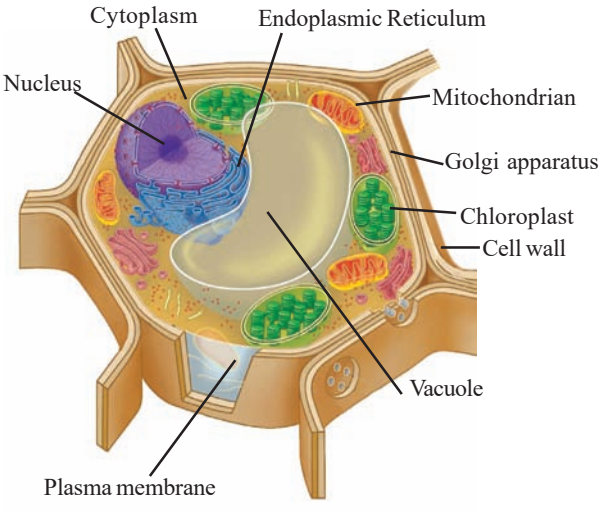

Fig-1 : Typical Plant cell

Cell membrane or Plasma membrane

In your earlier classes, you have already studied that cell membrane is the covering of the animal cell. In plant cell there is another layer present over the cell membrane known as the cell wall. With the help of the given activity you will be able to see a cell membrane.

Activity-1

Observing the cell membrane

Take *Rheo* leaf, tear the leaf in a single stroke. Observe it against the light. Take a small piece of leaf peel with light coloured transparent portion. Put it on slide and put a drop of water on it. Cover it with cover slip and observe the lighter portion of leaf under the microscope.

Draw the diagram of what you have seen?

Now put 1-2 drops of dilute salt solution on the membrane and leave it for 5 to 10 minutes.

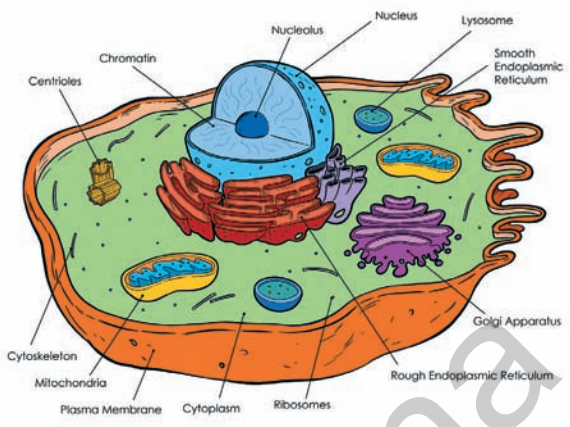

Fig-2 : Typical Animal cell

(For preparing salt solution take 50 ml of water and dissolve one tea spoon of salt in it. Stir it well.)

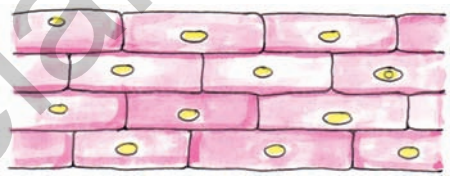

Fig-3(a) : Rheo leaf peel cells

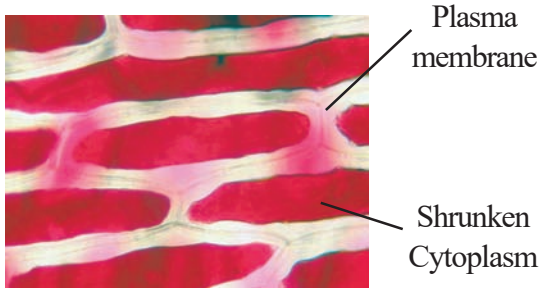

Fig-3(b) : Cell membrane

- Observe it under microscope. Draw your observation in your note book.
- Compare the observations of both activities or fig-3(a) and 3(b) and note down the differences?
- Can you guess the reason for the differences?

When we put salt solution over the peel of *Rheo* leaf, water present inside the *Rheo* leaf cells comes out. It results in the shrinking of the cytoplasm along with cell membrane. The outer boundary of coloured area is actually the **Cell membrane** or plasma membrane (fig-3(b)) which became separated from the cell wall.

However, we can observe the structure of cell membrane only through an electron microscope. Cell membrane is flexible and is made up of mainly lipids and proteins.

In animals the cell membrane is the outermost layer of the cell that separates cytoplasm from the external environment. This is also known as the **plasma membrane**. The cell membrane defines the shape and size of the cell, encloses the cytoplasm and protects it from the external environment. The internal environment of the cell is different from that of outside. Inside a cell, one finds a very specific composition of various substances which maintain a balance. The cell membrane plays a crucial role in maintaining this balance.

Any substance entering or leaving the cell can do so only through this membrane. The uniqueness of this membrane lies in the fact that it does not allow every substance to pass through it. The exchange of substances through the cell membrane takes place very selectively. Hence it is known as selectively permeable membrane. This characteristic of the membrane enables it to control the exchange of substances between the cell and its external environment. You will learn more about the function of cell membrane in the Chapter "Plasma membrane".

Cell wall

This is a unique feature seen in plant cells. While the cell membrane acts as the outer layer in an animal cell, in a plant cell there is an extra layer (mainly of cellulose) outside the cell membrane which is known as the cell wall. This is considered to be one of the major difference between a plant and an animal cells.

The cell wall is a tough but flexible porous layer that lends a definite shape and gives protection to the cell. Earlier it was believed to be inactive, but now it is considered to be one of the most significant parts of the cell that continuously exchanges information with other cells during growth and development.

What are the functions of the cell wall in plant cells?

It exerts an inward wall pressure to resist the outward pressure exerted by the cytoplasm. Hence, the plant cells can withstand much greater changes of surrounding medium than the animal cells.

Nucleus

Lab Activity

Aim: To observe the nucleus in cheek cells.

Materials required: A tooth pick or ice-cream spoon or spatula, glass slide, coverslip, watch glass, needle, blotting paper, 1% methylene blue, normal saline, glycerine, microscope, etc.

Procedure:

1. Wash your mouth and scrape a little of the internal lining of your cheek inside your mouth with a clean

tooth pick or spatula or ice-cream spoon.

2. Place the scraped material in a watch glass containing a very small quantity of normal saline.
3. Then place the material on a glass slide.
4. Put a drop of methylene blue and wait for a couple of minutes.
5. Put a drop of glycerine over it.
6. Place a coverslip. Tap the coverslip with the blunt end of needle so as to spread the cells.
7. Wipe off the extra stain with a fine cloth or blotting paper.

Precautions:

1. Do not scrape the cheek too hard as it may injure your buccal mucosa.
2. Scraped material should be spread uniformly on the slide.
3. Excess stains should be drained off.
4. There should be no air-bubbles under the cover slip

Observe the temporary mount under low and high power of microscope. Draw your observations in your notebook.

1. What is the shape of the cells that you have observed?
2. Are these cell structures similar to the structure in onion peel cell?
3. Is there any dark coloured spherical or oval dot like structure near the centre of the cell?

You have already studied about this dark coloured dot in cells. This is the nucleus. It was named by Robert Brown in the year 1831.

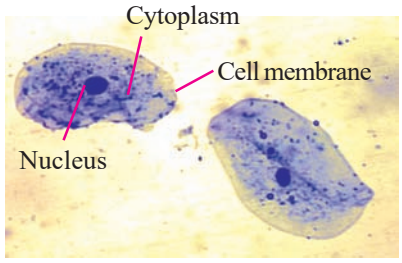

Fig-4 : Nucleus in cheek cells

Brown had no idea about its functions. This is one of the most important organelles of the cell. This is also known as the cell's control room. The nucleus is the largest and the most distinct of all cell organelles. Schleiden, who was one of the proponents of cell theory, thought that new cells were created from the nucleus and he called it as cytoblast.

Except a few, almost all eukaryotic cells have a nucleus. Red blood cells in mammals and phloem sieve tubes in plants are examples of cells that do not have a nucleus. Even these cells do have nuclei in the beginning, but it is later out of the cells and destroyed.

The nucleus regulates and controls all the functions of a cell and determines the characteristics of the organism. It consists of all genetic information. The nucleus is also closely involved in the process of cell division.

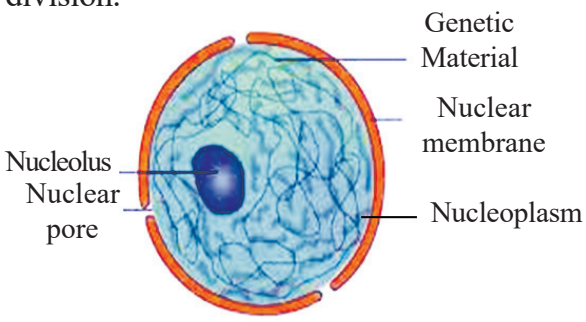

Fig-5 : Nucleus
(view through Electron Microscope)

The membrane that encloses the nucleus and separates it from contents of cytoplasm is known as the nuclear

membrane. This is very similar to the cell membrane. Almost the entire genetic material of the cells is found in the nucleus.

On the basis of the presence or absence of the organised nucleus, cells are categorized into two types, i.e. Prokaryotic cell (without organised nucleus) and Eukaryotic cell (with organised nucleus).

The Cells that do not have a membrane bound nuclear material are called **prokaryotic** cells. Bacterium is a prokaryotic cell. Cyanobacteria (blue-green algae) also belong to this category.

The cells that have membrance bound nuclear material are called Eukaryotic cells. ex. Plant cells, Animal cells.

Cytoplasm

When we look at the temporary mounts of onion peel, we can see a large region of each cell enclosed by the cell membrane. This region takes up very little stain. It is called the cytoplasm. The cytoplasm is the fluid content bounded by the plasma membrane. It also contains many specialised cell organelles. Each of these organelles performs specific function for the cell.

Cell organelles are enclosed by membranes. In prokaryotes, besides the absence of a defined membrane bound nucleus (or nuclear region), the membrane-bound cell organelles are also absent. Except membraneless Ribosomes.

Protoplasm vs. cytoplasm

For a long time it was believed that the essence of life was stored in the fluid found inside the cell. Hence this was named protoplasm which means life fluid. But when it became clear that the fluid is basically a medium in which various particles and membranes float around and that the functions of the cell actually take place in these organelles, it began to be understood that life resided in these organelles. In particular, the material inside and outside the nuclear membrane was differentiated after the discovery of nucleus. Hence, protoplasm was differentiated into cytoplasm and nucleoplasm. The substance present between nuclear membrane and plasmamembrane is called cytoplasm. The fluid inside the nucleusis known as nucleoplasm.

Cell organelles

Now let us discuss some important cell organelles. 1. Mitochondria, 2. Plastids, 3. Ribosomes, 4. Endoplasmic Reticulum, 5.Golgi apparatus, 6.Lysosomes, 7. Vacuoles.

They are important because they carry out very crucial functions in the cells.

Endoplasmic Reticulum (ER)

When the cell was observed under the electron microscope, a network of membranes was observed throughout the cytoplasm. This network creates passages

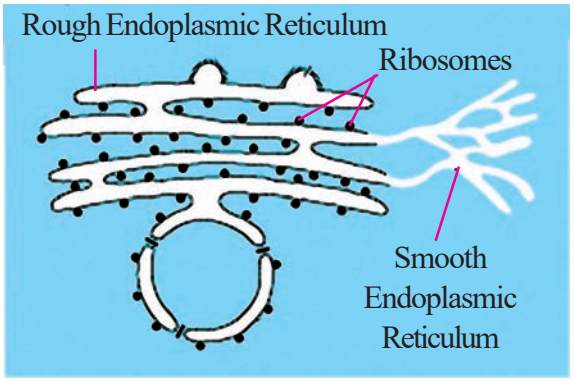

Fig-6: Endoplasmic Reticulum under microscope

within the cytoplasm for the transport of substances from one part of the cell to another. This network of membranes is known as the Endoplasmic Reticulum.

The Endoplasmic Reticulum (ER) is a large network of membrane-bound tubes and tubules. The ER membrane is similar in structure to the plasmamembrane. Endoplasmic Reticulum may have some granule like structure on its surface which are called ribosomes, Such ER is called Rough Endoplasmic Reticulum (RER). Areas/sections of ER that do not have ribosomes on them are called Smooth Endoplasmic Reticulum (SER). Rough Endoplasmic Reticulum is the site of protein manufacturing. The SER helps in the manufacture of fat molecules or lipids, important for cell function. The manufactured proteins and lipids are then sent to various places in the cell depending on need, using the ER. Some of these proteins and lipids help in building the cell membrane.

Thus, one function of the ER is to serve as channels for the transport of materials (especially proteins) between various regions of the cytoplasm or between the cytoplasm and the nucleus. It also functions as a cytoplasmic framework providing a surface for some of the biochemical activities of the cell. In liver cells SER plays a crucial role in detoxifying many poisons and drugs.

Golgi body or Golgi complex

However Camillo Golgi had observed this organelle in the year 1898 using a compound microscope, its finer structure could be observed only under an electron microscope.

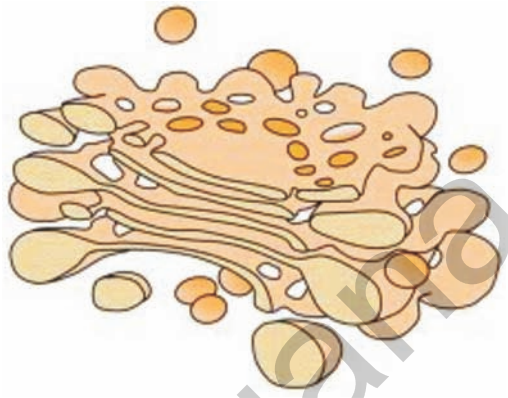

Fig-7 : Golgi Complex

This organelle is also made up of several membranes. These membranes create sac-like structures around which many fluid-filled vesicles abound. The proteins and other substances produced in the ribosome reach the golgi body through these vesicles. Here, these substances are altered slightly. In one sense, the function of the golgi bodies is to pack various substances before they are transported to other parts of the cell. From here these substances are either sent towards the cell membrane or to another organelle, the lysosome. After reaching the cell membrane these substances are secreted from the cell, and sometimes even used to regenerate or repair the membrane.

The number of golgi bodies varies from cell to cell. Their number is particularly large in those cells that secrete hormones and enzymes.

Lysosome

One of the facts that troubled the scientists for a long time was that, certain enzymes present in the cell have the ability

to destroy almost all the structures in the cell but didn't damage it. This puzzle was solved when lysosomes were discovered as tiny particles visible in the cytoplasm. It was found that they contained the destructive enzymes. These enzymes normally do not come in contact with the rest of the cell. The materials that need to be destroyed are transported to the lysosomes. Then the lysosomes get them digested at times, the lysosomes burst and the enzymes are released to digest the cell. Hence, lysosomes are also known as the suicidal bags of the cell.

Mitochondria

Activity -2

Observing Mitochondria

Let us do this activity with onion peel.

i) Make a fresh solution of Janus Green-B in a Beaker

ii) Mix 200mg Janus Green-B in 100ml of water

iii) Take a watch glass pour some solution. Put the onion peel in this solution and keep it for about half an hour.

iv) Keep a piece of onion peel on the slide and wash thoroughly with water.

v) Cover the slide with a cover slip and observe it under microscope at high magnification.

Observe and make a sketch of the same in your note book. Compare it with the given diagram.

You can do this activity by taking other available material like leaves of *Cassia tora* or Cheek cells.

You may have observed green oval (or) cylindrical grains scattered in the cytoplasm. These are the mitochondria.

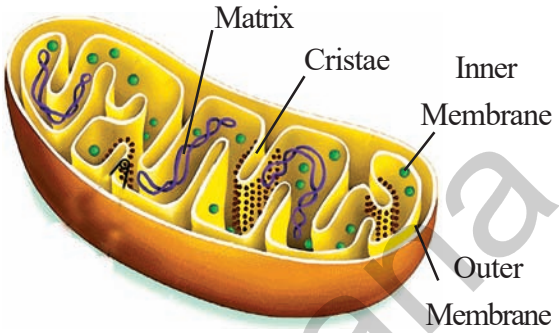

Fig-8 : L.S. of Mitochondrian

Mitochondria are small, spherical or cylindrical organelles. Generally a mitochondrion is 2-8 micron long and about 0.5 micron wide. It is about 150 times smaller than the nucleus. There are about 100-150 mitochondria in each cell. When seen under the compound microscope, the mitochondria appear as oval or cylindrical dots in the cell. The diagram of mitocondria shown in typical cell is hypothetical. Electron Microscope reveals their unique internal structure in great detail.

Information derived from the Electron Microscope tells us that the mitochondria are made up of a double-membrane wall. The inner membrane of the wall protrudes into the interior in folds and forms structures called cristae; the space between cristae is found filled with a substance known as the matrix.

Mitochondria are responsible for cellular respiration, a process through which the cell derives its energy to do work. Because of this, mitochondria are also known as the **powerhouses** of the cell.

Ribosomes

There are small granule like structures in the cytoplasm of the cell. They are called ribosomes. They are formed of RNA and protiens. They are of two types- 70S, 80S. Free ribosomes are scattered in cytoplasm. Attached ribosomes are on the surface of Rough Endoplasmic Reticulum. Ribosomes are the sites for protein synthesis.

Plastids

Activity - 3

Observation of chloroplast in *Rheo* leaf

Chloroplasts are a type of green coloured plastids.

1. Take the peel of *Rheo* leaf and mount it in the water drop on a slide.
2. Observe it under compound microscope.

Let us make a drawing of the observations.

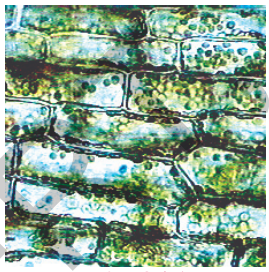

Fig-9(a)

You will observe small green granules called chloroplast. They mainly contain green substance called chlorophyll.

Activity-4

Observing chloroplast in algae

Collect some algae from pond and separate out thin filaments of them. Place a few filaments on a slide. Observe it under the microscope. Take the help of given figure and draw the picture of chloroplast that you have observed under the microscope.

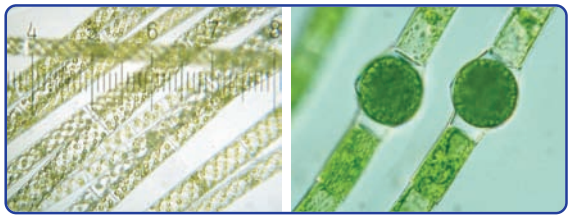

Fig-9(b) : Chloroplasts in Algae

Plastids are present only in plant cells. These are mainly of three types:

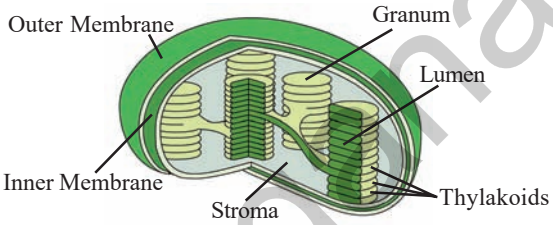

Fig-9(c) : Structure of chloroplast

(i) chromoplasts (coloured)
(ii) leucoplasts (colourless) and
(iii) chloroplasts (green coloured).

Chloroplasts are of different shapes i.e. disc, oval etc. In algae, these can be found as ladders or star or spirally coiled or reticulate structures. The diameter of chloroplasts in higher plants can vary between 4 to 10 micron. The primary function of chloroplasts is to trap the energy from sunlight and transform it to chemical energy, thus helping to carry out photosynthesis.

Do you know?

Certain organelles are present in large number in the cell for example cells involved in photosynthesis may contain around 50 to 200 chloroplasts.

Vacuoles

Activity-5

Observing vacuoles

1. Take the leaf or stem of any succulent plant (like the torch cactus).

2. Take thin cross section of stem of cactus in a watch glass containing water.
3. Stain it with dilute safranine solution.
4. Observe the section under low and high power microscope.

What do you observe?

The large empty spaces present in the cell are vacuoles. These are fluid-filled sac-like structures. In animal cells vacuoles are small in size while in plant cells they are large. In mature plant cells they might occupy almost the entire cell space. Vacuoles maintain turgur pressure within the cell. They export unwanted substances from the cell.

Are the cells flat?

Usually when cells are seen under the microscope, the image appears as flat and two-dimensional. It seems that all the organelles in the cell are situated in one plane.

In reality, cells have length, breadth and thickness. We can easily see the length and breadth. Since we cannot see the thickness of the cells under the microscope, we tend to think that these are flat objects. However, there are a few easy ways to observe the thickness of the cells. The easiest method is to slightly change the focus while viewing plant cells on the slide and look at the cell wall. You'll find that you are able to see the thickness of the wall. This three-dimensional image becomes clear if you reduce the intensity of light as well.

Fig-10: Cell -Three dimensional picture of cell

Each cell thus acquires its structure and ability to function because of the organization of its membrane and organelles in a specific way.

Where do cells come from?

The observations so far made it clear that all living beings are made up of cells and that each cell has a nucleus. Around 1838-39, two scientists expressed this in the form of a theory. The scientists were Matthias Jakob Schleiden (1804-1881) and Theodor Schwann (1810-1882). Schleiden was a Botanist while Schwann was a Zoologist. For the record, it should be mentioned that quite a few scientists had recognized by that time that cells were present in all living organisms and were expressing it in their own ways. However, Schleiden and Schwann were the first to claim that this fact was true for the entire plant and animal kingdom. In other words, they took the first bold step of generalizing from observations and coming up with a theory which was applicable to all living organisms. And because of this, the credit for propounding the cell theory goes to them. What is noteworthy is that there was a gap of about 200 years between Robert Hooke first observing cells and the formulation of the cell theory.

Schleiden and Schwann together formulated the cell theory. This theory however did not explain as to how the new cells were formed. Rudolf Carl Virchow

(1855) first explained that the new cells could be formed only by the division of the pre-existing cells. He modified the hypothesis of Schleiden and Schwann to give the cell theory a final shape. Cell theory as understood today is based on two cardinal principles.

(i) All living organisms are composed of cells and products of cells.

(ii) All cells arise from pre-existing cells.

Key words

Plasmamembrane, Selectively Permeable membrane, Prokaryotic cell, Eukaryotic cell, Chromoplast, Leucoplast, Vesicles, Cristae, Matrix.

What we have learnt?

- The fundamental organizational unit of life is the cell.
- Cells are enclosed by a plasma membrane composed of lipids and proteins.
- Plasma membrane is a selectively permeable membrane.
- In plant cells, a cell wall composed of cellulose is located outside the cell membrane.
- In prokaryotes nuclear membrane is absent.
- The endoplasmic reticulum functions both as passageway for intra cellular transport and manufacturing surface.
- Lysosomes are membrane bound sacs filled with digestive enzymes.
- The Golgi apparatus consists of stacks of membranes bound vesicles that helps in the storage.
- Mitochondria are also known as powerhouse of the cell.
- Three types of plastids are present in the cell;chromoplasts,chloroplasts, leucoplasts.
- Vacuoles are the storage sacs for solids or liquid contents.
- All cells arise from pre-existing cells.

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Improve your learning

1. Differentiate between (A.S 1)
   (a) Plant cell and animal cell (b) Prokaryotic and eukaryotic cells
2. What would happens to the cell if nucleus is removed? Give two reasons to support your answer? (AS 1)

3. Lysosomes are known as suicidal bags of the cell. Why? (AS 1)
4. Why does plant cell possess large sized vacuole? (AS1)
5. “Cell is the basic unit of life”, explain the statement.(AS 1)
6. Who and when was "The cell theory" proposed. When did they prepare it? What are its salient features of it? (AS 1)
7. What happens if plasma membrane ruptures or breaks? (AS 2)
8. What would happen to the life of cell if there was no golgi complex? (AS 2)
9. When you are observing the nucleus of cheek cell in laboratory, what precautions do you take ?
10. Read the chapter carefully collect the information about the functions of different cell organelles and make a table which contains serial number. Cell organelle and their function. Don’t forget to write your specific findings below the table? (AS 4)
11. Prepare a model of plant cell or animal cell with locally available materials. (AS 5)
12. Prepare a temporary mount of any leaf peel, observe the stomata and draw their picture? Write a short note on the same. (AS 5)
13. Draw the Typical Animal Cell and lable it's parts ?
14. Look at the following cartoon of a cell. Find out the functions of cell organelles (AS 5)

15. How do you appreciate about the organization of cell in the living body?(AS 6)
16. If the organization of cell is destroyed due to physical and chemical influence what will happen? (AS 6)
17. How could you appreciate the function of a tiny cell in a large body of an organism (AS 6)