Chapter 1

Cell its structure and functions

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

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

- Onion cells were nearly rectangular while the cheek cells were circular in shape.

Add other examples as the one given above.

1) _____

2) _____

3) _____

Primarily, cells are studied under the optical microscope. When we observe the cell under a compound microscope, we can see following organelles: cell wall, cytoplasm, nucleus, chloroplast and the mitochondria. However, when the same cells are observed under the electron microscope, a few other structures become 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 of them. These have given valuable information about the typical plant and animal cells. Here we will try to study the diagram of models of the cell.

Typical Cell

All the organelles shown in the typical plant or animal cell will not exist in every cell. For example, chloroplasts are always shown in the typical plant cell, yet all plant cells do not have chloroplasts. chloroplasts only in the cells of green plant parts like the leaf, tender stem 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. What cell organelles are found exclusively in plant cell?
3. Compare the vacuoles of plant and animal cells, note down the differences.

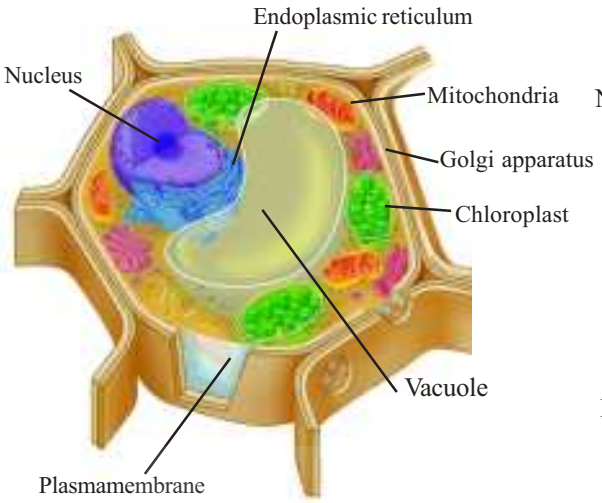

Fig-1 Typical Plant cell

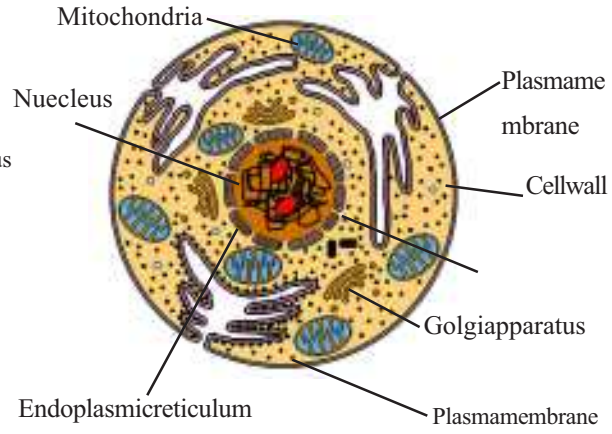

Fig-2 Tipical Animal cell

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

Cell membrane or Plasma membrane

In your earlier class 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 cell membrane

Take Rheo leaf, tear the leaf in single stroke. Observe it against the light. Take a small piece of leaf peal 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 light 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.

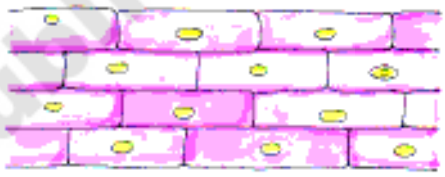

Fig-3(a) Rheo leaf peel cells with membrane

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

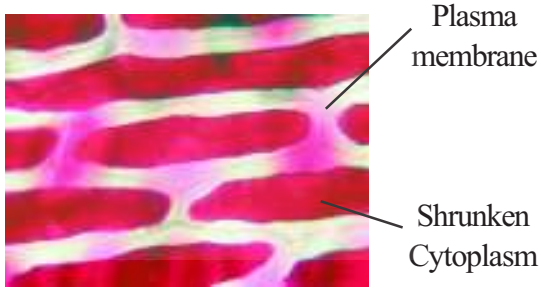

Fig-3(b) Cell membrane

- 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 of the differences?

When we put salt solution over the peel of rheo leaf, water present inside the rheo leaf cells come out. It results in the shrinking of the cytoplasm along with cell membrane. The outer boundary of coloured area is actually the **cell 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.

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 substances and balance of various substances is maintained. 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 happens 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 "Movement of material across the cell 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 differences between plant and animal cells.

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

What is the role of cell wall in plant cells?

It exerts an inward wall pressure to resist the outward directed pressure exerted by cell sap hence; the plant cells can withstand much greater changes in surrounding medium than animal cells.

Nucleus

Lab Activity

Aim: To observe the nucleus in cheek cells.

Material 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 scrap a little of the internal lining of your mouth

with a clean tooth pick or spatula or ice-cream spoon.

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

Precautions:

1. Do not scrap the cheek too hard as it may injure you (buccal mucosa).
2. Scrapped material should be spread uniformly on the slide.
3. Excess of stain should be drained off.
4. There should be no air-bubble under the cover slip

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

1. What was the shape of the cells that you have observed?
2. Were these cells structure similar to the structure in onion peel cell?
3. Was there any darkly 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

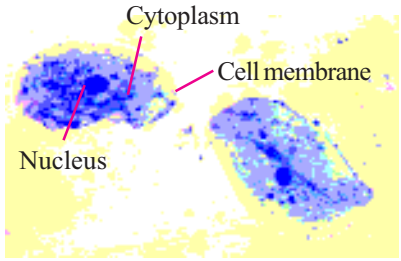

Fig-4 Nucleus cheek cells

1831. Brown had no idea about its function. 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 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 the cytoblast.

Barring a few exceptions, almost all eukaryotic cells have a nucleus. Red blood cells in some mammals and phloem sieve tube 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 thrown 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.

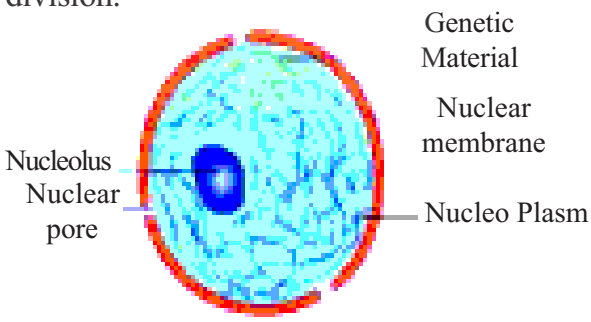

Fig-5 Nucleus
(view through Electron microscope)

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 absense of the organised nucleus cells are categorized into two types, i.e. Prokaryotic cells (without organised nucleus) and Eukaryotic cells (with organised nucleus).

The above description was primarily about eukaryotic cells that contained a membrane bound nucleus. Cells that do not have a nuclear membrane bound nuclear material are called prokaryotic cells. We have mentioned earlier that the bacterium is a prokaryotic cell. Cyanobacteria, blue-green algae also belong to this category.

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 inside 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, beside the absence of a defined membrane bound nucleus (or nuclear region), the membrane-bound cell organelles are also absent.

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 this organization. In particular, the material inside and outside the nuclear membrane was differentiated after the discovery of nucleus. Hence, protoplasm was renamed as cytoplasm, that is, cell fluid. The fluid inside the nucleus came to be known as the nuclear fluid or nucleoplasm.

Cell organelles

Now let us discuss about some important cell organelles. 1. Mitochondria, 2. Plastids, 3. Ribosoms, 4. endoplasmic reticulum, 5.Glogi apparatus, 6.Lysosomes, 7. vacuoles.

They are important because they carry out very crucial functions in 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

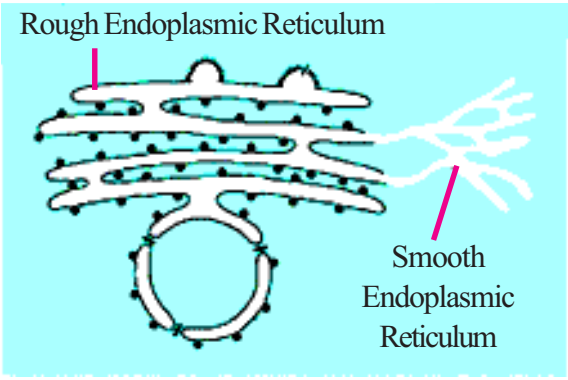

Fig-6 Endoplansmic Reticulum

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 sheets. The ER membrane is similar in structure to the plasma membrane. Endoplasmic reticulum may have some granule like structure on there surface called as ribosomes, such parts are called as rough endoplasmic reticulum (RER). Areas/sections that do not have ribosomes on them are smooth endoplasmic reticulum (SER). Rough endoplasmic reticulum is sites of protein manufacture. 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 vertebrate liver cells SER plays a crucial role in detoxifying many poisons and drugs.

Golgi body or Golgi apparatus

Although Camillo Golgi had observed this organelle in the year 1898 using an optical microscope, its finer structure came to be observed only under an electron microscope.

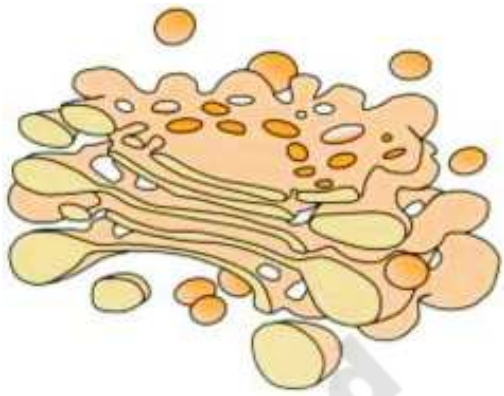

Fig-7 Golgi apparatus

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 reaches the golgi body through these vesicles. Here, these substances are altered slightly. In one sense, the function of the golgi bodies is to package 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 numbers are 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 that had the

ability to destroy almost all the structures in the cell 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. Thus the 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. At times, the lysosomes burst and the enzymes are released to digest the cell. Hence, lysosomes are also known as the suicide 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.

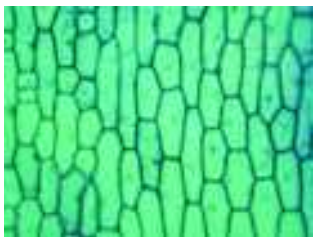

Fig-8(a) Mitochondria in onion peel cell

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

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

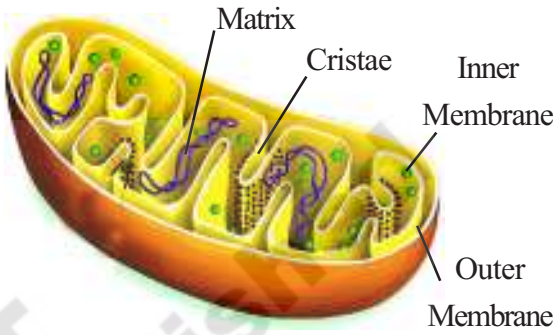

Fig-8(b) L.S. of Mitochondria

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 optical microscope, the mitochondria appear as oval or cylindrical dots in the cell. Electron microscope reveals their unique internal structure in great detail.

Information derived from the electron microscope tells us that the mitochondria are made 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 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 cell's powerhouse of the cell.

Ribosomes

There are small granul like structures in the cytoplasm of the cell. They are called ribosomes. We can see ribosomes on the surface of rough endoplasmic reticulam.

Plastids

Activity - 3

Observation of chloroplast in rheo leaf

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

Let us make a drawing of the observations.

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

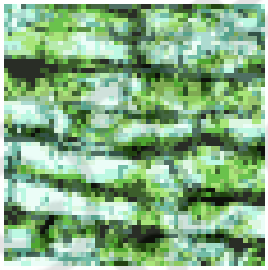

Fig-9(a)

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.

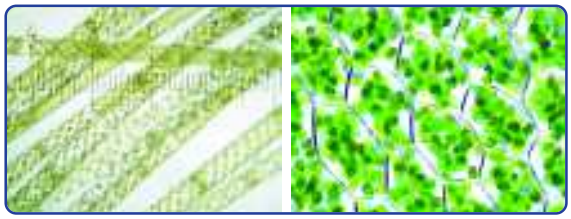

Fig-9(b) Chloroplasts in Algae

Chloroplast is a type of plastid. Plastids are present only in plant cells. Plastids are mainly of two types chromoplasts (coloured) and leucoplasts (colourless).

Chloroplasts are of different shapes

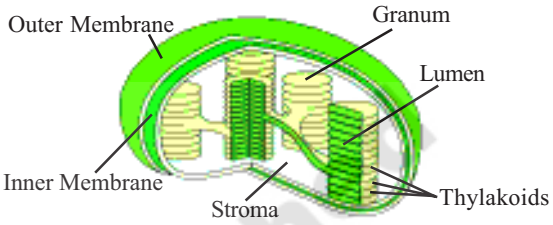

Fig-9(c)

disc, oval etc. In algae, these can be found as ladders, stars, spirals or reticulate. 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.

Vacuole

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.

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.

Are 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

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 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 Von Virchow

(1855) first explained that cells divided and new cells can 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 product of cell.

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

Key words

Plasma membrane, Selectively Permeable membrane, Prokaryotic cell, Eukaryotic cell, Chromoplast, Leucoplast, Cisternae, 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 as manufacturing surface.
- Lysosomes are membrane bound sacs filled with digestive enzymes.
- The Golgi apparatus consists of stacks of membranes bound vesicles that function in the storage.
- Mitochondria are also known as powerhouse of the cell.
- Two types of plastids are present in cell; chromoplastids and leucoplastids.
- Vacuoles are the storage sacs for solids or liquid contents.
- All cells arise from pre-existing cells.

Improve your learning

1. Differentiate between (A.S 1)
   (a) Plant cell and animal cell
   (b) Prokaryotic and eukaryotic cells

2. What happens if plasma membrane ruptures or breaks? (AS 2)
3. Prepare a model of plant cell or animal cell. (AS 5)
4. What would happen to the life of cell if there was no golgi complex? (AS 2)
5. What happen to cell if nucleus is removed? Give reasons to support your answer? (AS 1)
6. Lysosomes are known as suicidal bags of the cell? Why? (AS 1)
7. Why do plant cell posses large sized vacuole? (AS1)
8. Prepare a temporary mount of any leaf peel observe the stomata draw their picture? Write a short note on the same. (AS 5)
9. "Cell is the basic unit of life", explain the statement.(AS 1)
10. How do you appreciate about the organization of cell in the living body?(AS 6)
11. If the organization of cell is destroyed due to physical and chemical influence what will happen? (AS 6)
12. Read the chapter carefully collect the information about the functions of different cell organelles and make a table which contains serial number. Cell organelle, function. Don't forget write your specific findings below the table? (AS 4)
13. How could you appreciate function of tiny cell in a large body of an organism (AS 6)
14. Look at the following cartoon of a cell. Find out the functions of cell organelles (AS 5)

15. Who and when proposed cell theory. What are salient features of it? (AS 1)