UNIT: Basic Biology

CELL-THE STRUCTURAL AND FUNCTIONAL UNIT OF LIFE

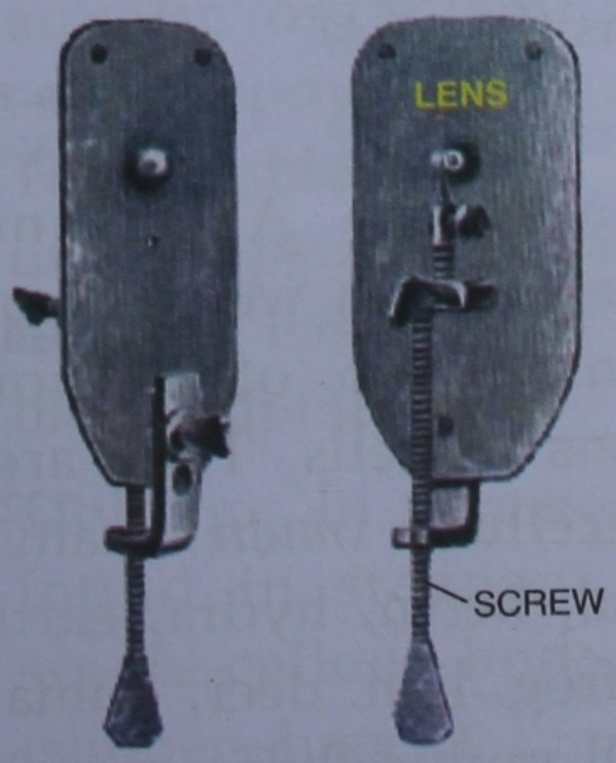
1

SYLLABUS

1. The cell — the basic unit of life — its structure.
   Cell organelles — cell membrane, plastids, mitochondria, vacuole, centrosomes, nucleus — their functions (in brief).
   Differences between plant and animal cells.
   Cell division — needed for growth and repair in both plants and animals.
   (Note : Mitosis and meiosis need not be mentioned).
   * Looking at onion peel and cheek cells under a microscope and drawing the same (D/E).
   (D = *demonstration*; E = *experiment*).

You have learnt from your previous class that all living organisms, whether plants, animals or human beings, are made up of minute cells. Of these, some are single-celled *i.e.*, **unicellular**, *e.g.* amoeba, while others are many-celled *i.e.*, **multicellular**, e.g. rose, frog, etc.

Every organism starts life as a single cell. Even the largest banyan tree, or an elephant or we ourselves start life as a single cell. This single cell undergoes repeated divisions to become a complete living organism. Thus, we say that the cell is the basic unit of life, both structurally as well as functionally. For this reason, cells are also known as the building blocks of life.



Simple microscope means using a single lens.

Fig. 1.1 A simple microscope.

DISCOVERY OF CELLS

- **First Discovery :** Antony Von Leeuwenhoek (1632-1723) developed a **simple microscope** (Fig. 1.1), using only a single biconvex lens. He was the first to see the cells (blood cells in the capillaries of the foot-web of frog) and recognized them as living units of all living beings. However, he did not call them cells.
- **First to coin the term "cell" :** In 1660, Robert Hooke developed a

microscope to observe different objects using two lenses, hence his microscope was called a **compound microscope** (Fig. 1.2).

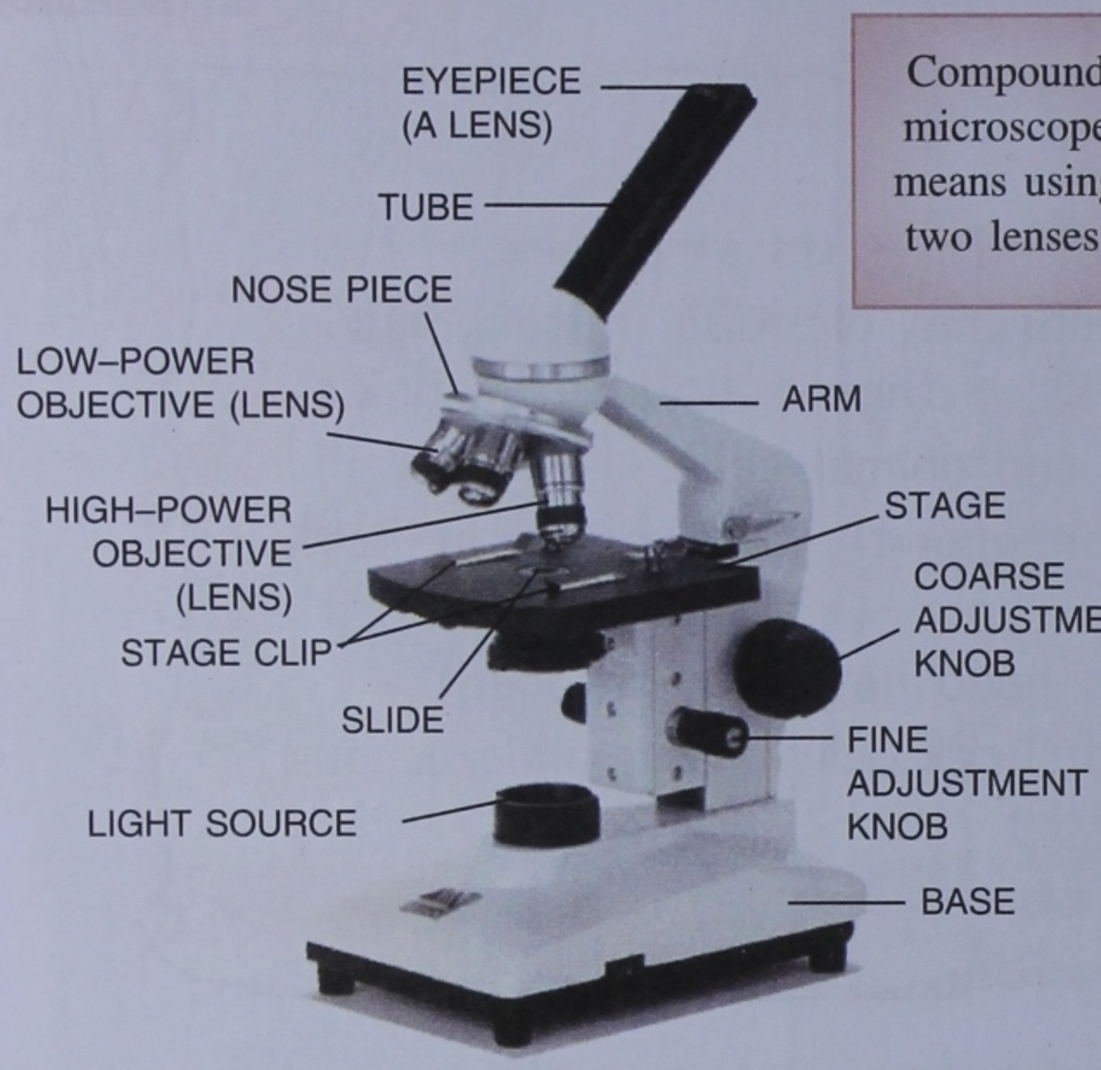


Fig. 1.2 A compound microscope

Compound microscope means using two lenses.

He examined a very thin slice of a dead cork and observed a cluster of box-like cubicles piled up together (Fig. 1.3). This reminded him of "cells" of monks in a monastery, and he was the first to call them **cells**.

DO YOU KNOW ?

The word cell is derived from the latin word cella (compartment).

The branch of biology which deals with the study of cells is called **cytology**.

Robert Hooke had only seen the walls of dead cells that had once surrounded the **living portion** of cells. This living substance is called **"protoplasm"**, and it has two portions—the **cytoplasm** and the **nucleus.**

Fig. 1.3 Cork cells : dead and empty

CELLS — THEIR NUMBERS, SHAPES AND SIZES

Cells — how numerous ? On the basis of the number of cells, the organisms are categorised as unicellular or multicellular.

(i) **Unicellular (single-celled) organisms :** Many tiny plants and animals are formed of just one single cell. Such organisms are called **unicellular** (*uni* : single). Examples — Bacteria, Yeast, Amoeba, Paramecium, Chlamydomonas (Fig. 1.4).

(ii) **Multicellular (many-celled) organisms :** All ´plants and animals, which we see around us, are made up of millions and billions of cells. They are called **multicellular** (*multi* : many). Rose, peepal, neem, hydra, earthworm, fish, frog, lion, deer, humans, etc., are all multicellular organisms.

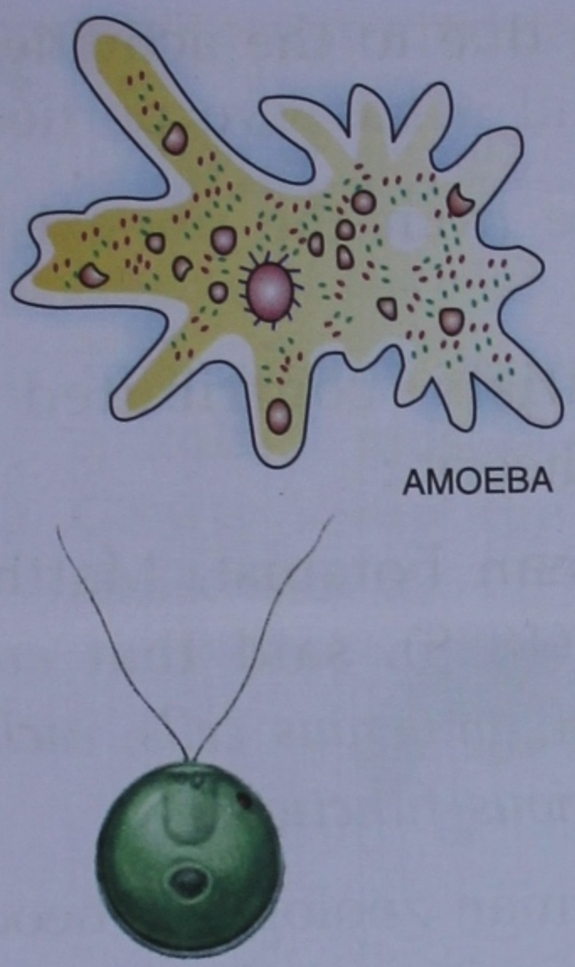


Fig. 1.4 Three single-celled organisms — Amoeba, Chlamydomonas and Paramecium

Cell Shape (Fig. 1.5)

There is a great variety in the shape of cells — oval, spherical, rectangular, irregular, elongated, etc. The cell shape is also determined by the function of the cell.

(i) **Irregular :** The single-celled body of fresh water *Amoeba*, is irregular in shape.

(ii) **Oval :** In *Chlamydomonas* (an aquatic organism), the single-celled body has an oval shape. The red blood cells are thin and oval shape so that they can slide through easily even in the finest blood capillaries.

(iii) **Oblong :** In *Paramecium* (usually found in stagnant water), the single-celled body is oblong (slipper-shaped).

(iv) **Elongated :** The muscle cells are elongated and contractile, thus enabling them to provide movements to the bones.

(v) **Very long (thread-like) :** The nerve cells are long. Their long shape enables them to send messages over long distances in the body. Imagine the length of a nerve fibre running from your toe in the foot, upto the brain inside the head.

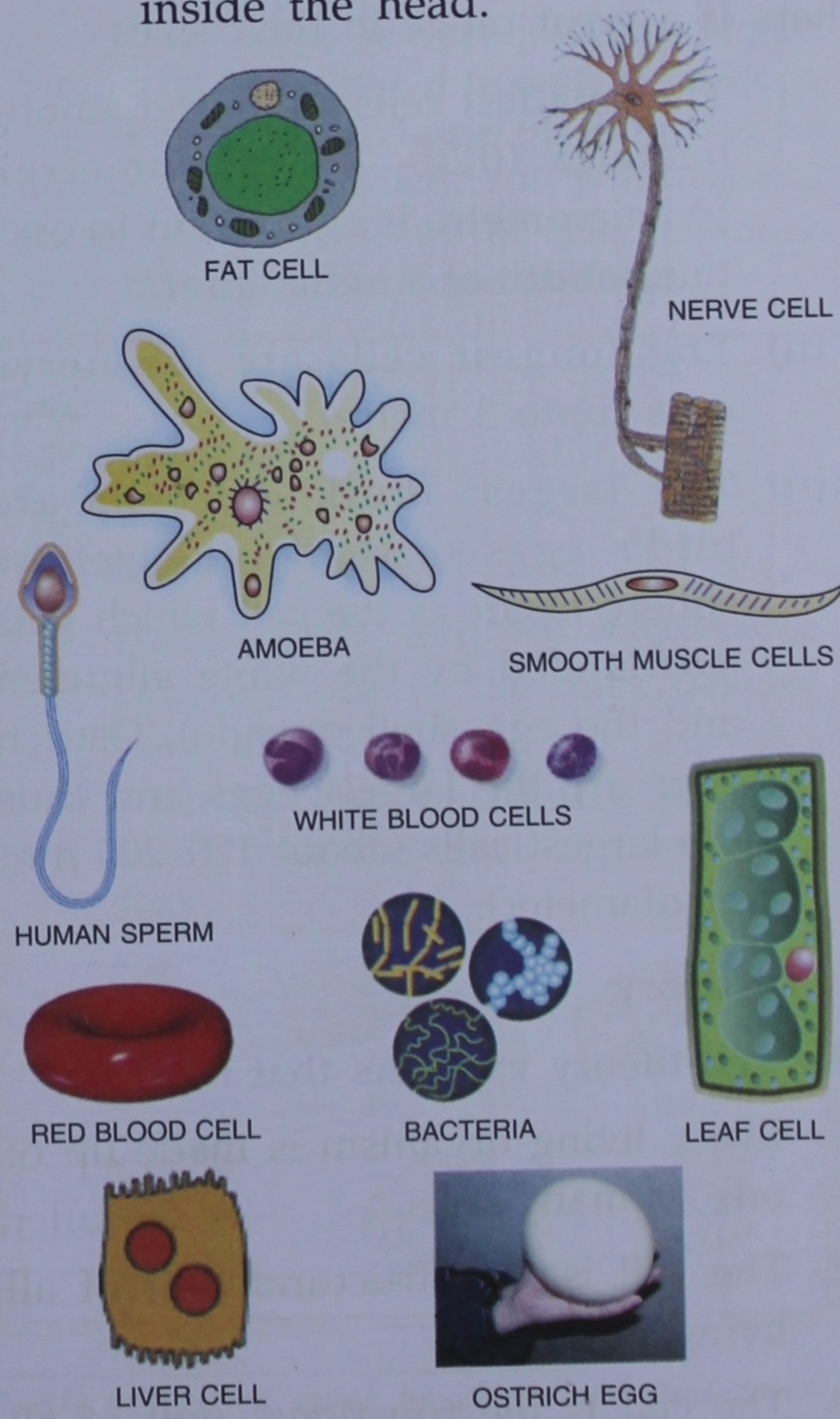


Fig. 1.5 Some of the different kinds of cell shapes

(vi) **Cubical or rectangular :** The cells of the leaf are cubical or rectangular. In fact, plants also have a variety of cell shapes from cubical to polygonal as well as elongated and tubular.

Cell Size

There is a huge variety in the size of the cells. The great majority of cells are very small, and they can be seen only with the help of a microscope. However, there is a great range in their sizes :

(i) **The smallest** cells are found among bacteria (02 – 05 micrometre). (A micrometre is equivalent to one-thousandth of a millimetre).

(ii) **The longest** cells are the nerve cells (upto 3 metre).

(iii) **The largest** (bulkiest) cells are bird's eggs (actually the yellow sphere inside is the cell which gets surrounded by the white albumen and the egg shell outside). Ostrich eggs are the largest eggs and thus the largest cells (about 170-200 mm in diameter).

Cell Theory

The cell-theory explains that :

1. Every living organism is made up of one or many cells.
2. The cell is the structural unit of all living organisms.
3. The cell is the functional unit of all living organisms. Activities of an organism are due to the activities of its cells.
4. All cells arise from the pre-existing cells.

Three scientists contributed in framing the cell theory :

First, a German botanist, Matthias Jacob Schleiden (1838), said that *every plant is made up of numerous cells, each of which performs various functions.*

Second, a German zoologist, Theodor Schwann (1839), confirmed the presence of nucleus surrounded by the cytoplasm and the outer membrane as well. He declared that *all plants and animals are made up of cells which serve as the units of structures and functions.*

Third, Rudolph Virchow (1858) added that *all cells arise from the pre-existing cells.*

CELL — THE STRUCTURAL UNIT OF LIFE

> Every living part of the body of all living organisms (plants and animals) is made up of cells.

Cells may vary in shape and size but basically, they are just the same in their fundamental structure.

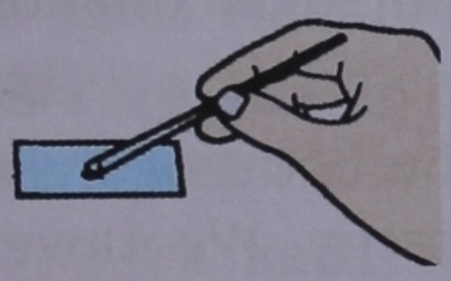
If you examine even a tiny part of a plant or animal's body under a microscope, irrespective of whether it is the root, stem or leaf of a plant, or the skin, muscle or bone of an animal, you will find that they are all made up of cells.

ACTIVITY 1

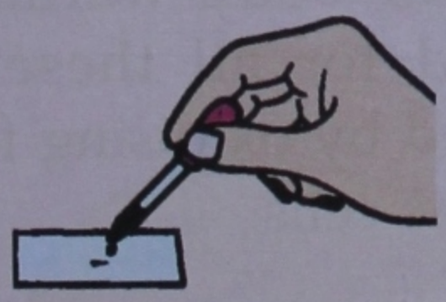
Looking at the cheek cells.

1. Take a blunt instrument such as a spatula. It must be **clean.**
2. Gently scrap the inside of your cheek with it.

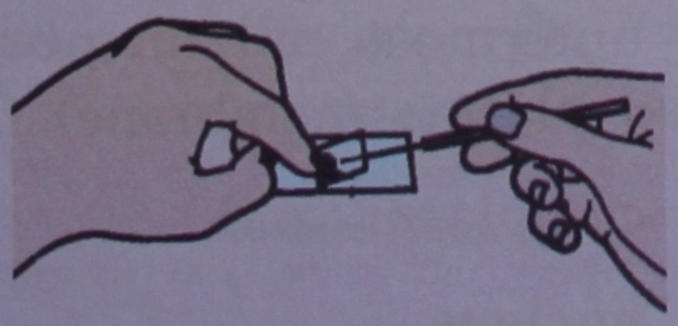
3. Put the scrapings on a glass slide.



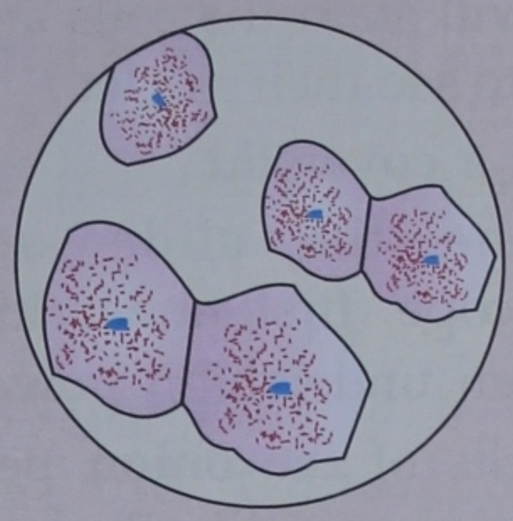
4. Add a drop of **methylene blue** stain to the scrapings on the slide. This will stain the cells and help you to see them.



5. Put a coverslip over the material. Lower the cover slip carefully on the slide. The stain will spread out beneath it.



6. Examine the slide under the microscope. First use low power to find some of the scrapings, then look at one of the cells under high power.*



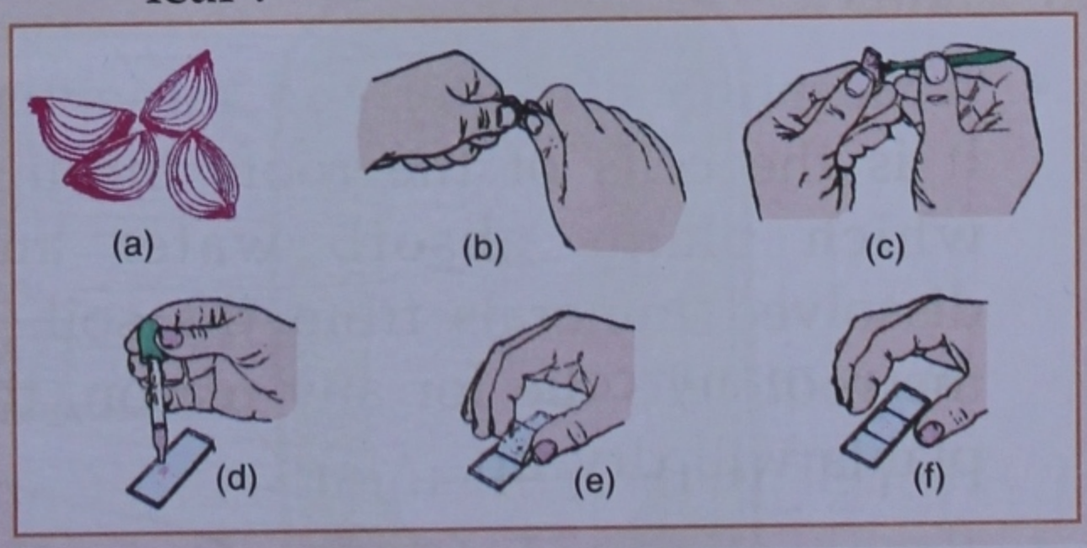
Human cheek cells

Cheek cells are irregular in shape. Similarly, by using different techniques, the skin, muscle, bone or blood of an animal can be studied. You will find that these are all made up of cells, although they may differ in shape and size.

ACTIVITY 2

Looking at plant cells.

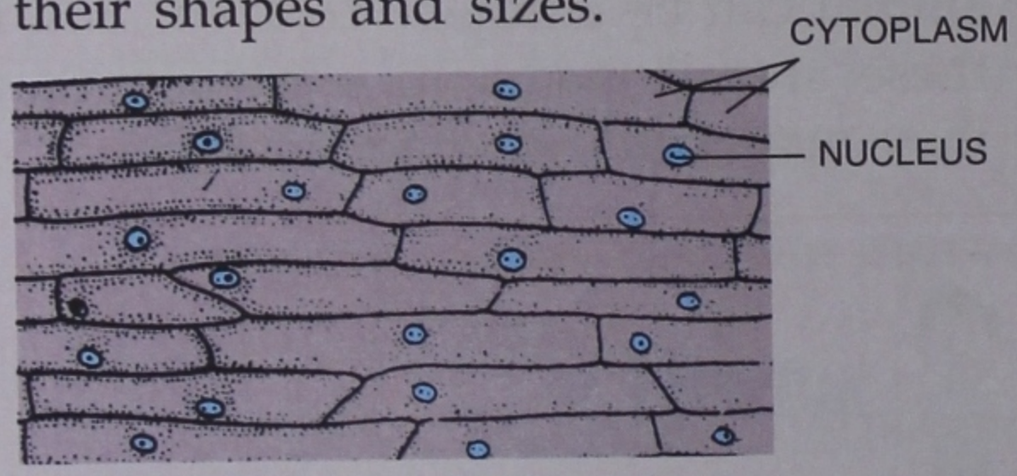
1. Slice an onion into two, lengthwise.
2. Take out one of the thick 'leaves' from inside.
3. With forceps, pull away the thin lining from the inner surface of the 'leaf'.



** All activities must be performed under strict supervision of your teacher. This is important for safety reasons, and to avoid any possible injury or infection during the practical exercise.*

4. Cut a small piece of the lining with scissors, about 5 mm square.
5. Place the piece of lining on a slide and add a drop of dilute iodine solution. (This will stain the cells and make it easier to see their nuclei.)
6. Put on a coverslip.
7. Examine the slide under the microscope, first under low power, and then under high power.

The cells of the **onion peel** have a rectangular shape. Similarly, you can examine thin slices of leaves, stems or roots. You will find that every part is formed of cells, though they may differ in their shapes and sizes.



Cells of the onion peel

CELL — THE FUNCTIONAL UNIT OF LIFE

Every function inside the body of living organisms (plants or animals) is the result of cell activity.

In Plants

- **Absorption of water and minerals :** It is the cells of the roots through which plants absorb water and dissolved minerals from the soil. If the root cells die for any reason, the plants will dry up.
- **Preparation of food :** It is the chlorophyll (green pigment) containing cells of the leaves which utilise sunlight, carbon dioxide and water to prepare food (glucose) for the plant. This process of preparing food by the plants is known as **photosynthesis**.

In Animals

- **Movement :** It is the ability of the **muscle cells** to contract and relax. This enables an animal to move its body as well as *fold* and *unfold* its body parts.
- **Digestion :** It is the cells of various glands which secrete enzymes that digest the food. For example, the saliva in your mouth is the secretion of the cells of the salivary glands, that converts starch, present in the food, into sugar (maltose).
- **Release of energy :** Every activity inside the body of living organisms, needs energy. We move our muscles, our nerves convey messages, our body synthesises a large variety of proteins and other organic compounds. All these need energy. Besides, it also keeps our body warm. The energy required for all these activities is produced by oxidising food (glucose) inside the cells.

STRUCTURE OF A CELL (Fig. 1.6)

An animal cell or a plant cell as seen under a compound microscope show *three* essential basic parts:

1. The outermost **cell membrane** (also called plasma membrane),
2. The **cytoplasm**, and
3. The **nucleus**.

The major features of each of these three parts are as follows :

1. Cell Membrane or Plasma Membrane

Each cell is surrounded by a cell membrane also called plasma membrane.

- It is very thin, delicate and flexible.
- It is a living structure.
- It has fine pores in it, through which only certain substances can pass in and out, while others cannot. Therefore, **the cell membrane is called *selectively permeable*. This allows the entry of certain molecules only, while holding back the others.**

Cell wall

Only the **plant cells** have a cell wall outside in addition to the cell membrane.

- It is made up of ***cellulose***.
- It gives ***shape*** and ***rigidity*** to the plant cell.
- It is a non-living structure.
- It ***protects*** the cell from the entry of disease-causing agents, as well as the underlying protoplasm against mechanical injuries.
- It is ***freely permeable***, allowing substances in solution to enter and leave the cell without any hindrance.

Note : Animal cells have no cell walls.

2. Cytoplasm

The cytoplasm is a semi-liquid, colourless and translucent fluid. It forms the entire living portion of the cell inside the cell membrane, except the nucleus

3. Nucleus (Fig. 1.7)

Nucleus is a small spherical mass located in the centre of the cytoplasm. It is the most important part of the cell.

- It regulates and coordinates various life processes of the cell.
- It plays an important part during cell division.
- It contains genes, which determine the heredity of the organism.

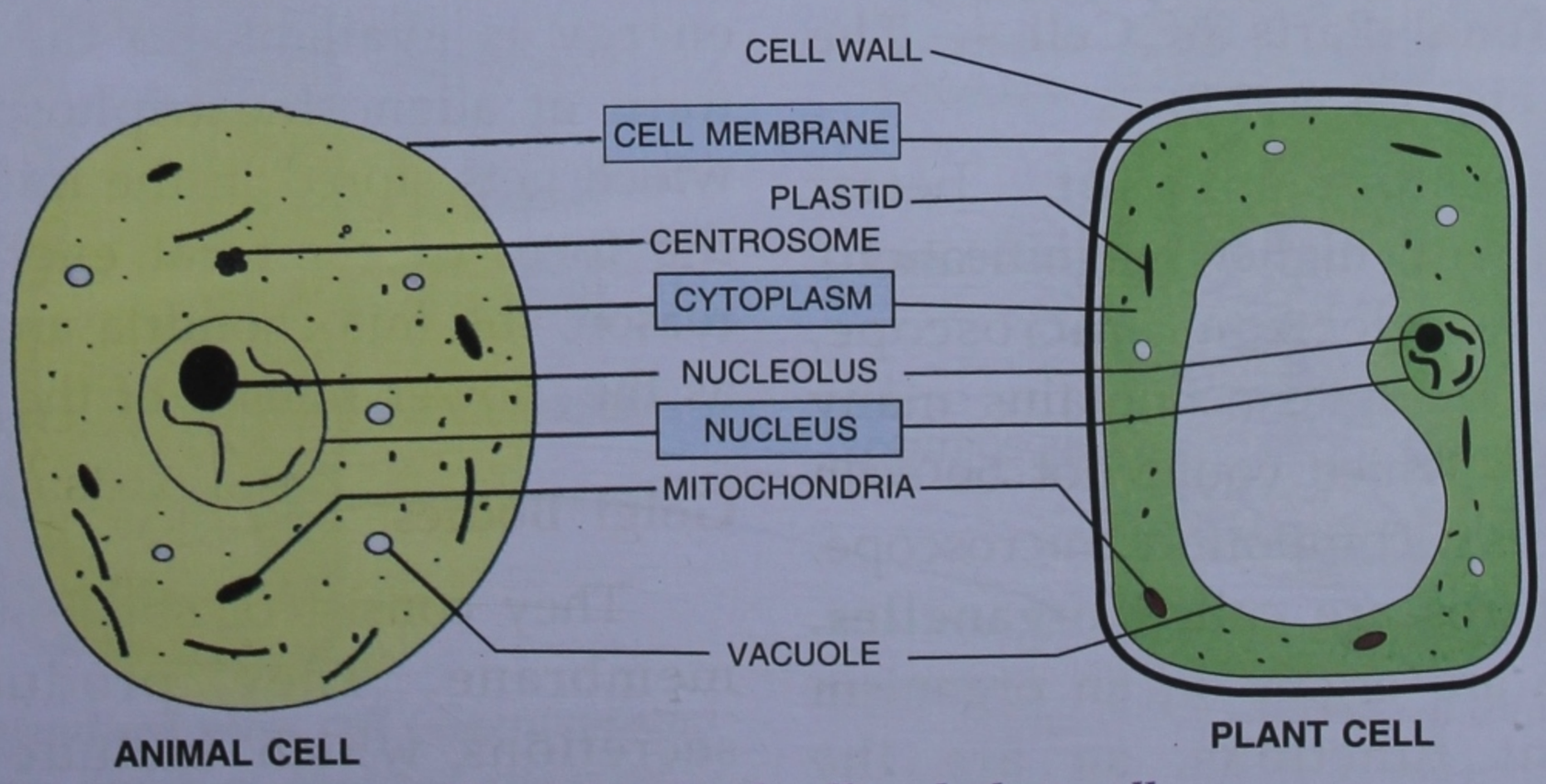


Fig. 1.6 Animal cell and plant cell

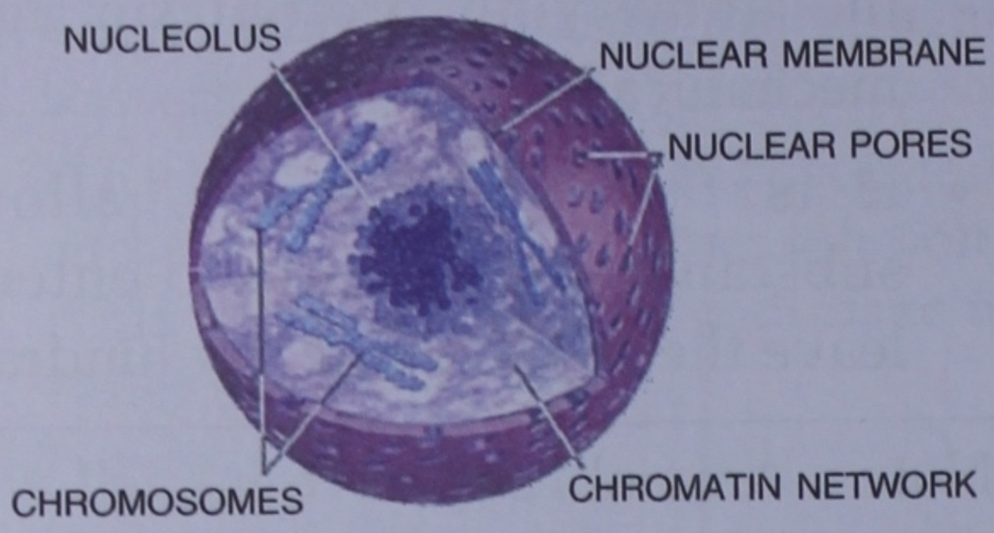


Fig. 1.7 Nucleus

Nucleus has the following parts :

- A delicate **nuclear membrane** which encloses a relatively dense **nucleoplasm**.
- Inside the nucleoplasm is a small darker body called **nucleolus**. The nucleoplasm also contains a network of dark-stained threadlike structures called **chromatin fibres**. During cell division, the chromatin fibres become thick and ribbon-like. These fibres are then called **chromosomes.**

The **number of chromosomes** is definite in each species. Every cell of the human body has 46 chromosomes which occur in 23 pairs.

Finer Functional Parts of Cell — The Organelles (Fig. 1.8 & 1.9)

The development of better microscopes (with higher magnification), specially the electron microscope, revealed that cytoplasm contains many tiny structures which could not be seen by the ordinary compound microscope. These structures are called **organelles.** Just as there are organs in an organism for different functions, so are the organelles inside a cell.

Some organelles synthesise substances like hormones, enzymes, proteins, etc., some produce energy, and some digest the food.

The main organelles found in the cytoplasm are as follows :

Endoplasmic Reticulum

It is an irregular network of fine tubular structure distributed in the entire cytoplasm. It provides a supportive framework and helps in the distribution of various products from one part of the cell to the other.

Ribosomes

They are granules either scattered freely in the cytoplasm or attached to the endoplasmic reticulum. They synthesise proteins.

Mitochondria (sing. mitochondrion)

They are minute bodies scattered in the cytoplasm. They are concerned with the release of energy from food. This energy is available to the cells in the form of adenosine triphosphate (ATP), which gets stored in the mitochondria in the form of chemical energy. For this reason, the mitochondria are also known as the 'power houses of the cell'.

Golgi Bodies

They consist of small stacks of thin membrane. They produce various secretions which include hormones, enzymes, etc.

Lysosomes

These are enzyme-containing bodies capable of digesting various materials. They engulf foreign bodies like germs that get into the cell and also digest or dissolve the old, or injured cell parts.

Centrosome (found only in animal cells)

It is located near the nucleus. It initiates and regulates cell division.

Plastids (only in plant cells)

There are mainly three types of plastids.

(i) **Chloroplasts :** Green plastids, called chloroplast trap the solar energy for photosynthesis.

(ii) **Amyloplasts :** contain pigments other than green. They impart colour effect to flowers and fruits and in

Table 1.1 : Differences between plant and animal cells

PLANT CELL	ANIMAL CELL
1. Size is usually larger, with distinct outlines.	1. Size is usually smaller, with less distinct boundaries.
2. Plant cell has a definite cell wall.	2. No cell wall.
3. Cytoplasm not so dense. Only a thin layer of cytoplasm.	3. Cytoplasm denser and more granular. It fills almost the entire cell.
4. Vacuoles prominent, one or more.	4. Vacuoles, if any, are small and temporary; concerned with excretion or secretion.
5. Usually contain plastids.	5. Do not contain plastids.
6. Centrosome is absent.	6. Centrosome is present.
7. Golgi apparatus has simpler units, called dictyosomes.	7. Golgi apparatus is highly complex and prominent.

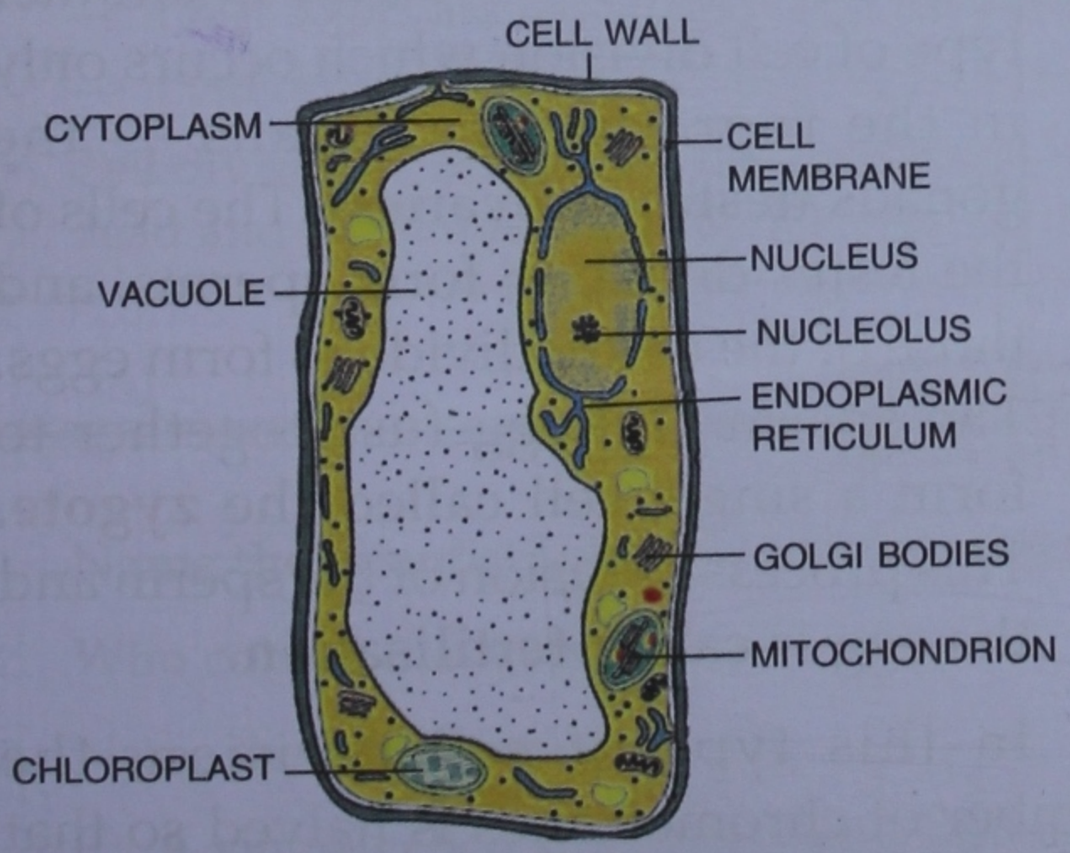


Fig. 1.8 A generalised plant cell (diagrammatic) showing finer details as observed under an electron microscope

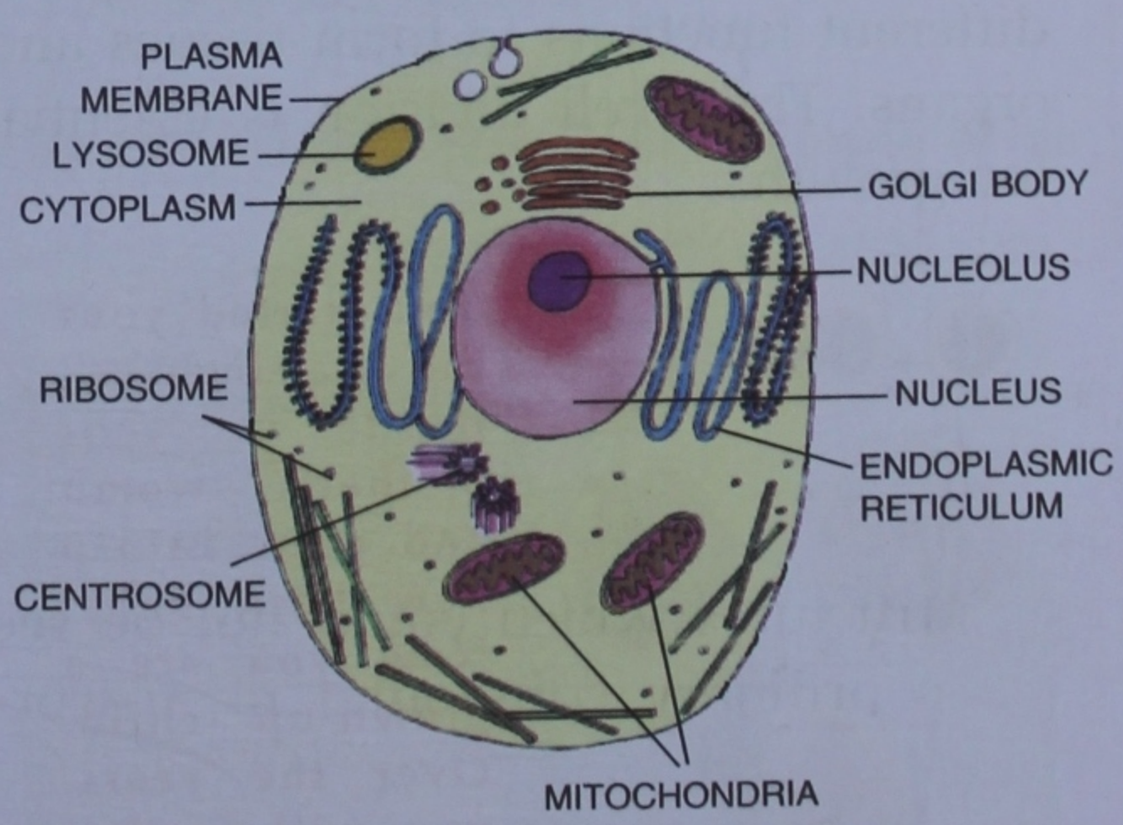


Fig. 1.9 A generalised animal cell showing finer details as observed through an electron microsope

turn, they attract insects to ensure pollination and dispersal.

- **Leucoplasts** are colourless plastids which occur in seeds. They store starch and proteins.

Vacuoles

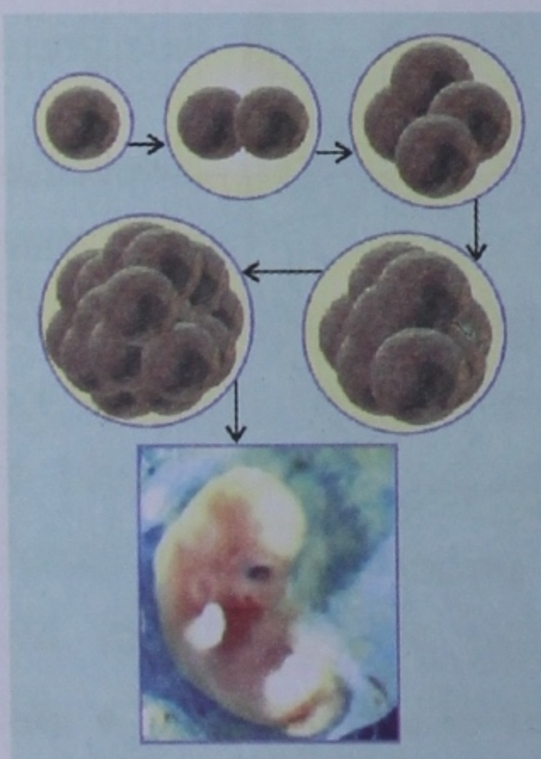
Vacuoles are the clear cavities in the cytoplasm. These are filled with water and various substances in solution.

- In **plant cells**, the vacuoles are usually quite large and the liquid which they contain is called **cell sap**.
- In **animal cells**, the vacuoles are lesser in number and smaller in size.

CELL DIVISION — A NEED TO PRODUCE NEW CELLS

New cells need to be produced for (1) *growth*, (2) *replacement*, (3) *repair* and (4) *reproduction*.

1. **For growth :** Every multicellular organism, including humans begins its life as a single cell (the fertilised egg). This cell divides repeatedly to form a cluster of cells which start shaping for different functions to form tissues and organs. Thus, cell division is essential for growth.



You started your life as a single cell inside your mother's womb and grew into a new born baby. Now you are a grown-up child. Over the years, you will further grow to become an adult.

Fig. 1.10 Cell-division for growth

2. **For replacement :** In an adult living organism, there is always some wear and tear of cells during the normal body functions. For example, about 20 million red blood cells in our body become old and die every minute. These are replaced by new cells formed through the division of their parent cells.

3. **For repair :** Apart from normal wear and tear of the tissues in the body, there may be accidental injuries. One may get cut in the skin or fractures in the bone. Repair of such faults is again done through the cells which divide, cover up the gaps and join the broken ends.

To fulfil the above three requirements in cell divisions, the number of chromosomes contained in the cell remains the same at each division. Here, the chromosomes duplicate and distribute equally in the daughter cells. This kind of division which occurs in the body cells is known as **equational division** or **mitosis.**

4. **For Reproduction :** There is another type of cell division which occurs only in the reproductive organs — the gonads **(testes or ovaries)**. The cells of the testes divide to form sperms, and those of the ovary divide to form eggs. The sperm and egg fuse together to form a single cell called the **zygote.** This process of fusion of the sperm and the egg is called **fertilisation.**

In this type of cell division, the number of chromosomes is halved so that after fertilisation when the sperm fuses with the egg, the normal (double) number is restored, as that of the parent cell.

SUMMARY

- Discovery of cells could be possible only by the invention of microscope.
- Earlier microscopes were simple with only one magnifying lens, their magnifying power was low.
- Robert Hooke developed a compound microscope using two lenses.
- Cells not only differ in their size but also in their shape.
- Three scientists, Schleiden, Schwann and Virchow gave the cell-theory. According to this theory :
  — every living organism is made up of one or many cells.
  — cell is the structural unit of all living organisms.
  — cell is the functional unit of all living organisms.
  — all cells arise from pre existing cells.
- Seen under a compound microscope, an animal or plant cell shows three basic parts — the cell membrane, cytoplasm and nucleus.
- Plant cells have in addition to the cell membrane, an outer cell wall made of cellulose.
- Cytoplasm is the living portion of the cell inside the cell-membrane, excluding the nucleus.
- Nucleus is the most important part of the cell. It regulates and coordinates various life processes of the cell, and plays an important role in cell division. It also contains hereditary material — the chromosomes.
- The development of better microscopes, specially the electron microscope, reveals the presence of tiny structures in the cytoplasm — the organelles.
- Organelles are concerned with specific functions.
- The main organelles are :
  — *Endoplasmic reticulum* which forms the supportive frame work of the cell.
  — *Ribosomes* which synthesise proteins.
  — *Mitochondria* which store and release chemical energy in the form of ATP.
  — *Golgi bodies* are associated with the production of enzymes and hormones.
  — *Lysosomes* which engulf and digest foreign bodies.
- Cell division is needed for the production of new cells, for growth, replacement and repair of the dead and worn out cells, and for reproduction.

REVIEW QUESTIONS

1. Name the scientist who invented the first microscope. .....
2. Who coined the term "cell" ? .....
3. Name the following :
   (i) A single-celled irregularly shaped organism. .....
   (ii) An oval unicellular aquatic organism. .....
   (iii) An oblong, single-celled organism found in stagnant water. .....

4. Name the scientists who formulated the cell-theory, and briefly explain this theory.
5. Briefly describe the three essential basic parts of a cell.
6. The cell membrane is called **selectively permeable**. Why ?
7. State the difference between :
   (i) Nucleus and nucleolus.
   (ii) Golgi bodies and mitochondria.
   (iii) Cytoplasm and protoplasm.
   (iv) Cell wall and cell membrane.
8. List the major differences between a plant cell and an animal cell.
9. Briefly discuss the importance of chromosomes to an organism.
10. Fill up the blanks with the terms given below in the box.

ATP, wall, pre-existing, cell, nucleus.

   (i) The ..... is the structural unit of all living things.
   (ii) All cells arise from ..... cells.
   (iii) Animal cells have no cell ..... .
   (iv) The energy available to the cells is in the form of ..... .
   (v) Initiation and regulation of cell division is done by ..... .

11. Try to find the names of four cell organells hidden in this maze. (hint : The hidden words can appear horizontally or vertically; forwards or backward or even mixed up). Write them in the lines provided. For example : "NUCLEUS" in the last row, seven backward letters.

A	J	F	B	H	E	M	O	E	L	O	U	C	A	V
H	V	G	O	L	G	I	B	O	D	Y	U	N	O	E
C	M	I	T	O	C	H	O	N	D	R	I	A	X	C
S	U	E	L	C	U	N	W	P	L	A	S	T	I	D

   (i) .....
   (ii) .....
   (iii) .....
   (iv) .....

12. What is the significance of cell division ?