Chapter 5

0964CH05

THE FUNDAMENTAL UNIT OF LIFE

While examining a thin slice of cork, Robert Hooke saw that the cork resembled the structure of a honeycomb consisting of many little compartments. Cork is a substance which comes from the bark of a tree. This was in the year 1665 when Hooke made this chance observation through a self-designed microscope. Robert Hooke called these boxes cells. Cell is a Latin word for 'a little room'.

This may seem to be a very small and insignificant incident but it is very important in the history of science. This was the very first time that someone had observed that living things appear to consist of separate units. The use of the word 'cell' to describe these units is being used till this day in biology.

Let us find out about cells.

5.1 What are Living Organisms Made Up of?

Activity 5.1

- Let us take a small piece from an onion bulb. With the help of a pair of forceps, we can peel off the skin (called epidermis) from the concave side (inner layer) of the onion. This layer can be put immediately in a watch-glass containing water. This will prevent the peel from getting folded or getting dry. What do we do with this peel?
- Let us take a glass slide, put a drop of water on it and transfer a small piece of the peel from the watch glass to the slide. Make sure that the peel is perfectly flat on the slide. A thin camel hair paintbrush might be necessary to help transfer the peel. Now we put a drop of safranin solution on this piece followed by a cover slip. Take care to avoid air bubbles while putting the cover slip with the help of a mounting needle. Ask your teacher for help. We have prepared a temporary mount of onion peel. We can observe this slide under low power followed by high powers of a compound microscope.

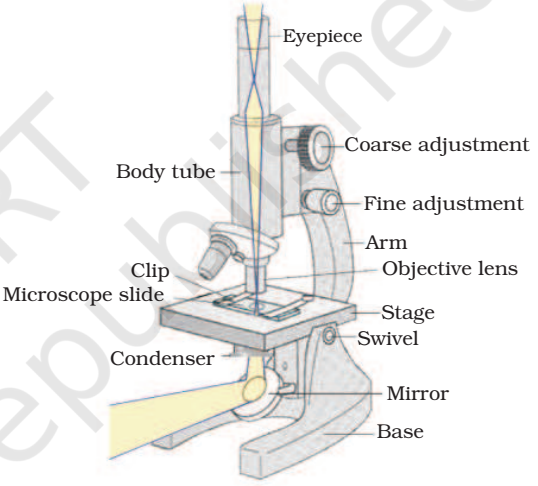

Fig. 5.1: Compound microscope

What do we observe as we look through the lens? Can we draw the structures that we are able to see through the microscope, on an observation sheet? Does it look like Fig. 5.2?

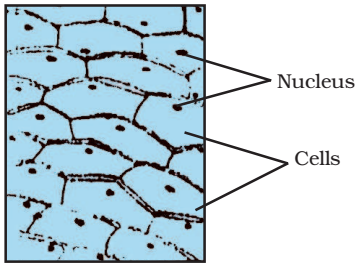

Fig. 5.2: Cells of an onion peel

We can try preparing temporary mounts of peels of onions of different sizes. What do we observe? Do we see similar structures or different structures?

What are these structures?

These structures look similar to each other. Together they form a big structure like an onion bulb! We find from this activity that onion bulbs of different sizes have similar small structures visible under a microscope. The cells of the onion peel will all look the same, regardless of the size of the onion they came from.

These small structures that we see are the basic building units of the onion bulb. These structures are called cells. Not only onions, but all organisms that we observe around are made up of cells. However, there are also single cells that live on their own.

More to know

Cells were first discovered by Robert Hooke in 1665. He observed the cells in a cork slice with the help of a primitive microscope. Leeuwenhoek (1674), with the improved microscope, discovered the free living cells in pond water for the first time. It was Robert Brown in 1831 who discovered the nucleus in the cell. Purkinje in 1839 coined the term 'protoplasm' for the fluid substance of the cell. The cell theory, that all the plants and animals are composed of cells and that the cell is the basic unit of life, was presented by two biologists, Schleiden (1838) and Schwann (1839). The cell theory was further expanded by Virchow (1855) by suggesting that all cells arise from pre-existing cells. With the discovery of the electron microscope in 1940, it was possible to observe and understand the complex structure of the cell and its various organelles.

The invention of magnifying lenses led to the discovery of the microscopic world. It is now known that a single cell may constitute a whole organism as in *Amoeba*, *Chlamydomonas*, *Paramoecium* and bacteria. These organisms are called unicellular organisms (uni = single). On the other hand, many cells group together in a single body and assume different functions in it to form various body parts in multicellular organisms (multi = many) such as some fungi, plants and animals. Can we find out names of some more unicellular organisms?

Every multi-cellular organism has come from a single cell. How? Cells divide to produce cells of their own kind. All cells thus come from pre-existing cells.

Activity 5.2

- We can try preparing temporary mounts of leaf peels, tip of roots of onion or even peels of onions of different sizes.
- After performing the above activity, let us see what the answers to the following questions would be:
  (a) Do all cells look alike in terms of shape and size?
  (b) Do all cells look alike in structure?
  (c) Could we find differences among cells from different parts of a plant body?
  (d) What similarities could we find?

Some organisms can also have cells of different kinds. Look at the following picture. It depicts some cells from the human body.

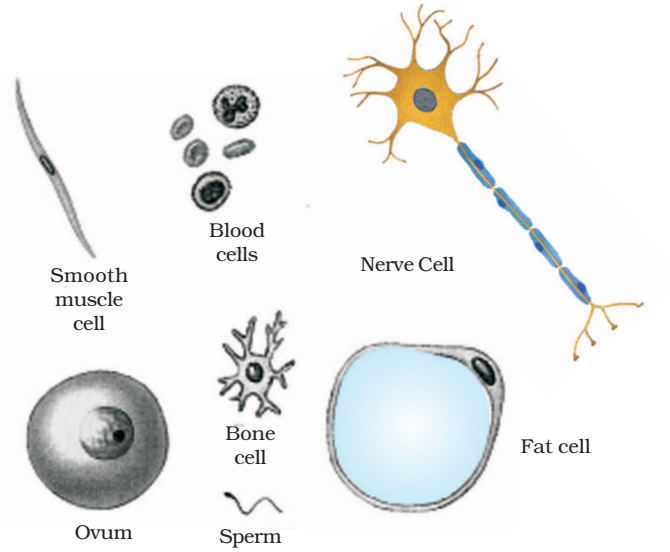

Fig. 5.3: Various cells from the human body

The shape and size of cells are related to the specific function they perform. Some cells like *Amoeba* have changing shapes. In some cases the cell shape could be more or less fixed and peculiar for a particular type of cell; for example, nerve cells have a typical shape.

Each living cell has the capacity to perform certain basic functions that are characteristic of all living forms. How does a living cell perform these basic functions? We know that there is a division of labour in multicellular organisms such as human beings. This means that different parts of the human body perform different functions. The human body has a heart to pump blood, a stomach to digest food and so on. Similarly, division of labour is also seen within a single cell. In fact, each such cell has got certain specific components within it known as cell organelles. Each kind of cell organelle performs a special function, such as making new material in the cell, clearing up the waste material from the cell and so on. A cell is able to live and perform all its functions because of these organelles. These organelles together constitute the basic unit called the cell. It is interesting that all cells are found to have the same organelles, no matter what their function is or what organism they are found in.

Questions

1. *Who discovered cells, and how?*
2. *Why is the cell called the structural and functional unit of life?*

5.2 What is a Cell Made Up of? What is the Structural Organisation of a Cell?

We saw above that the cell has special components called organelles. How is a cell organised?

If we study a cell under a microscope, we would come across three features in almost every cell; plasma membrane, nucleus and cytoplasm. All activities inside the cell and interactions of the cell with its environment are possible due to these features. Let us see how.

5.2.1 Plasma membrane or cell membrane

This is the outermost covering of the cell that separates the contents of the cell from its external environment. The plasma membrane allows or permits the entry and exit of some materials in and out of the cell. It also prevents movement of some other materials. The cell membrane, therefore, is called a selectively permeable membrane.

How does the movement of substances take place into the cell? How do substances move out of the cell?

Some substances like carbon dioxide or oxygen can move across the cell membrane by a process called diffusion. We have studied the process of diffusion in earlier chapters. We saw that there is spontaneous movement of a substance from a region of high concentration to a region where its concentration is low.

Something similar to this happens in cells when, for example, some substance like CO_2 (which is cellular waste and requires to be excreted out by the cell) accumulates in high concentrations inside the cell. In the cell's external environment, the concentration of CO_2 is low as compared to that inside the cell. As soon as there is a difference of concentration of CO_2 inside and outside a cell, CO_2 moves out of the cell, from a region of high concentration, to a region of low concentration outside the cell by the process of diffusion. Similarly, O_2 enters the cell by the process of diffusion when the level or concentration of O_2 inside the cell decreases. Thus, diffusion plays an important role in gaseous exchange between the cells as well as the cell and its external environment.

Water also obeys the law of diffusion. The movement of water molecules through such a selectively permeable membrane is called osmosis.

The movement of water across the plasma membrane is also affected by the amount of substance dissolved in water. Thus, osmosis is the net diffusion of water across a selectively permeable membrane toward a higher solute concentration.

What will happen if we put an animal cell or a plant cell into a solution of sugar or salt in water?

One of the following three things could happen:

1. If the medium surrounding the cell has a higher water concentration than the cell, meaning that the outside solution is very dilute, the cell will gain water by osmosis. Such a solution is known as a hypotonic solution.

   Water molecules are free to pass across the cell membrane in both directions, but more water will come into the cell than will leave. The net (overall) result is that water enters the cell. The cell is likely to swell up.
2. If the medium has exactly the same water concentration as the cell, there will be no net movement of water across the cell membrane. Such a solution is known as an isotonic solution.

   Water crosses the cell membrane in both directions, but the amount going in is the same as the amount going out, so there is no overall movement of water. The cell will stay the same size.
3. If the medium has a lower concentration of water than the cell, meaning that it is a very concentrated solution, the cell will lose water by osmosis. Such a solution is known as a hypertonic solution.

   Again, water crosses the cell membrane in both directions, but this time more water leaves the cell than enters it. Therefore the cell will shrink.

Thus, osmosis is a special case of diffusion through a selectively permeable membrane. Now let us try out the following activity:

Activity 5.3

(a) Remove the shell of an egg by dissolving it in dilute hydrochloric acid. The shell is mostly calcium carbonate. A thin outer skin now encloses the egg. Put the egg in pure water and observe after 5 minutes. What do we observe?
The egg swells because water passes into it by osmosis.

(b) Place a similar de-shelled egg in a concentrated salt solution and observe for 5 minutes. The egg shrinks. Why?
Water passes out of the egg solution into the salt solution because the salt solution is more concentrated.

We can also try a similar activity with dried raisins or apricots.

Activity 5.4

- Put dried raisins or apricots in plain water and leave them for some time. Then place them into a concentrated solution of sugar or salt. You will observe the following:
  (a) Each gains water and swells when placed in water.
  (b) However, when placed in the concentrated solution it loses water, and consequently shrinks.

Unicellular freshwater organisms and most plant cells tend to gain water through osmosis. Absorption of water by plant roots is also an example of osmosis.

Thus, diffusion is important in exhange of gases and water in the life of a cell. In additions to this, the cell also obtains nutrition from its environment. Different molecules move in and out of the cell through a type of transport requiring use of energy.

The plasma membrane is flexible and is made up of organic molecules called lipids and proteins. However, we can observe the structure of the plasma membrane only through an electron microscope.

The flexibility of the cell membrane also enables the cell to engulf in food and other material from its external environment. Such processes are known as endocytosis. *Amoeba* acquires its food through such processes.

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Activity 5.5

- Find out about electron microscopes from resources in the school library or through the internet. Discuss it with your teacher.

Questions

1. *How do substances like CO_2 and water move in and out of the cell? Discuss.*
2. *Why is the plasma membrane called a selectively permeable membrane?*

5.2.2 Cell Wall

Plant cells, in addition to the plasma membrane, have another rigid outer covering called the cell wall. The cell wall lies outside the plasma membrane. The plant cell wall is mainly composed of cellulose. Cellulose is a complex substance and provides structural strength to plants.

When a living plant cell loses water through osmosis there is shrinkage or contraction of the contents of the cell away from the cell wall. This phenomenon is known as plasmolysis. We can observe this phenomenon by performing the following activity:

Activity 5.6

- Mount the peel of a Rhoeo leaf in water on a slide and examine cells under the high power of a microscope. Note the small green granules, called chloroplasts. They contain a green substance called chlorophyll. Put a strong solution of sugar or salt on the mounted leaf on the slide. Wait for a minute and observe under a microscope. What do we see?
- Now place some Rhoeo leaves in boiling water for a few minutes. This kills the cells. Then mount one leaf on a slide and observe it under a microscope. Put a strong solution of sugar or salt on the mounted leaf on the slide. Wait for a minute and observe it again. What do we find? Did plasmolysis occur now?

What do we infer from this activity? It appears that only living cells, and not dead cells, are able to absorb water by osmosis.

Cell walls permit the cells of plants, fungi and bacteria to withstand very dilute (hypotonic) external media without bursting. In such media the cells tend to take up water by osmosis. The cell swells, building up pressure against the cell wall. The wall exerts an equal pressure against the swollen cell. Because of their walls, such cells can withstand much greater changes in the surrounding medium than animal cells.

5.2.3 Nucleus

Remember the temporary mount of onion peel we prepared? We had put iodine solution on the peel. Why? What would we see if we tried observing the peel without putting the iodine solution? Try it and see what the difference is. Further, when we put iodine solution on the peel, did each cell get evenly coloured?

According to their chemical composition different regions of cells get coloured differentially. Some regions appear darker than other regions. Apart from iodine solution we could also use safranin solution or methylene blue solution to stain the cells.

We have observed cells from an onion; let us now observe cells from our own body.

Activity 5.7

- Let us take a glass slide with a drop of water on it. Using an ice-cream spoon gently scrape the inside surface of the cheek. Does any material get stuck on the spoon? With the help of a needle we can transfer this material and spread it evenly on the glass slide kept ready for this. To colour the material we can put a drop of methylene blue solution on it. Now the material is ready for observation under microscope. Do not forget to put a cover-slip on it!
- What do we observe? What is the shape of the cells we see? Draw it on the observation sheet.

- Was there a darkly coloured, spherical or oval, dot-like structure near the centre of each cell? This structure is called nucleus. Were there similar structures in onion peel cells?

The nucleus has a double layered covering called nuclear membrane. The nuclear membrane has pores which allow the transfer of material from inside the nucleus to its outside, that is, to the cytoplasm (which we will talk about in section 5.2.4).

The nucleus contains chromosomes, which are visible as rod-shaped structures only when the cell is about to divide. Chromosomes contain information for inheritance of characters from parents to next generation in the form of DNA (Deoxyribo Nucleic Acid) molecules. Chromosomes are composed of DNA and protein. DNA molecules contain the information necessary for constructing and organising cells. Functional segments of DNA are called genes. In a cell which is not dividing, this DNA is present as part of chromatin material. Chromatin material is visible as entangled mass of thread like structures. Whenever the cell is about to divide, the chromatin material gets organised into chromosomes.

The nucleus plays a central role in cellular reproduction, the process by which a single cell divides and forms two new cells. It also plays a crucial part, along with the environment, in determining the way the cell will develop and what form it will exhibit at maturity, by directing the chemical activities of the cell.

In some organisms like bacteria, the nuclear region of the cell may be poorly defined due to the absence of a nuclear membrane. Such an undefined nuclear region containing only nucleic acids is called a nucleoid. Such organisms, whose cells lack a nuclear membrane, are called prokaryotes (Pro = primitive or primary; karyote ≈ karyon = nucleus). Organisms with cells having a nuclear membrane are called eukaryotes.

Prokaryotic cells (see Fig. 5.4) also lack most of the other cytoplasmic organelles present in eukaryotic cells. Many of the functions of such organelles are also performed by poorly organised parts of the cytoplasm (see section 5.2.4). The chlorophyll in photosynthetic prokaryotic bacteria is associated with membranous vesicles (bag like structures) but not with plastids as in eukaryotic cells (see section 5.2.5).

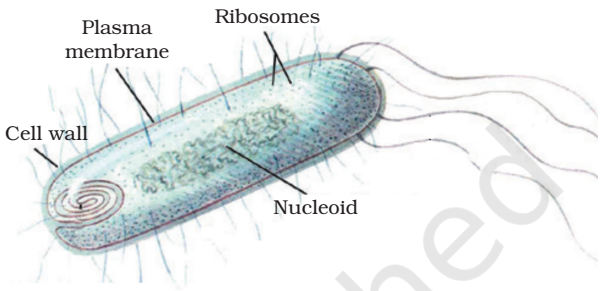


Fig. 5.4: Prokaryotic cell

5.2.4 Cytoplasm

When we look at the temporary mounts of onion peel as well as human cheek cells, 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 a specific function for the cell.

Cell organelles are enclosed by membranes. In prokaryotes, beside the absence of a defined nuclear region, the membrane-bound cell organelles are also absent. On the other hand, the eukaryotic cells have nuclear membrane as well as membrane-enclosed organelles.

The significance of membranes can be illustrated with the example of viruses. Viruses lack any membranes and hence do not show characteristics of life until they enter a living body and use its cell machinery to multiply.

Question

1. *Fill in the gaps in the following table illustrating differences between prokaryotic and eukaryotic cells.*

Prokaryotic Cell	Eukaryotic Cell
1. Size : generally small (1-10 μm) 1 μm = 10^{-6} m	1. Size: generally large (5-100 μm)
2. Nuclear region: _____ _____ and known as__	2. Nuclear region: well defined and surrounded by a nuclear membrane
3. Chromosome: single	3. More than one chromosome
4. Membrane-bound cell organelles absent	4. _____ _____ _____

5.2.5 Cell Organelles

Every cell has a membrane around it to keep its own contents separate from the external environment. Large and complex cells, including cells from multicellular organisms, need a lot of chemical activities to support their complicated structure and function. To keep these activities of different kinds separate from each other, these cells use membrane-bound little structures (or 'organelles') within themselves. This is one of the features of the eukaryotic cells that distinguish them from prokaryotic cells. Some of these organelles are visible only with an electron microscope.

We have talked about the nucleus in a previous section. Some important examples of cell organelles which we will discuss now are: endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria and plastids. They are important because they carry out some very crucial functions in cells.

5.2.5 (i) *Endoplasmic reticulum (ER)*

The endoplasmic reticulum (ER) is a large network of membrane-bound tubes and sheets. It looks like long tubules or round or oblong bags (vesicles). The ER membrane is similar in structure to the plasma membrane. There are two types of ER– rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER). RER looks rough under a microscope because it has particles called ribosomes attached to its surface. The ribosomes, which are present in all active cells, are the sites of protein manufacture. The manufactured proteins are then sent to various places in the cell depending on need, using the ER. The SER helps in the manufacture of fat molecules, or lipids, important for cell function. Some of these proteins and lipids help in building the cell membrane. This process is known as membrane biogenesis. Some other proteins and lipids function as enzymes and hormones. Although the ER varies greatly in appearance in different cells, it always forms a network system.

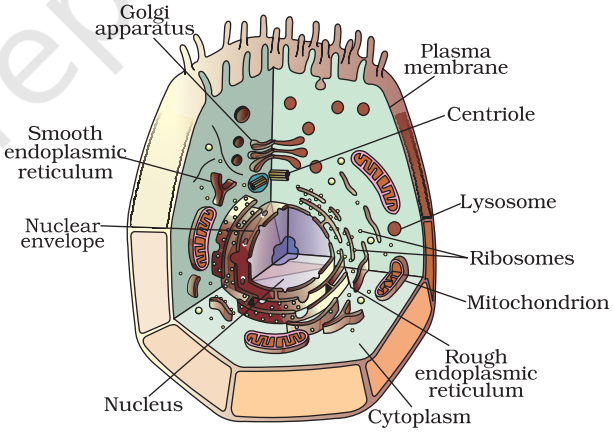


***Fig. 5.5:** Animal cell*

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. The ER also functions as a cytoplasmic framework providing a surface

for some of the biochemical activities of the cell. In the liver cells of the group of animals called vertebrates (see Chapter 7), SER plays a crucial role in detoxifying many poisons and drugs.

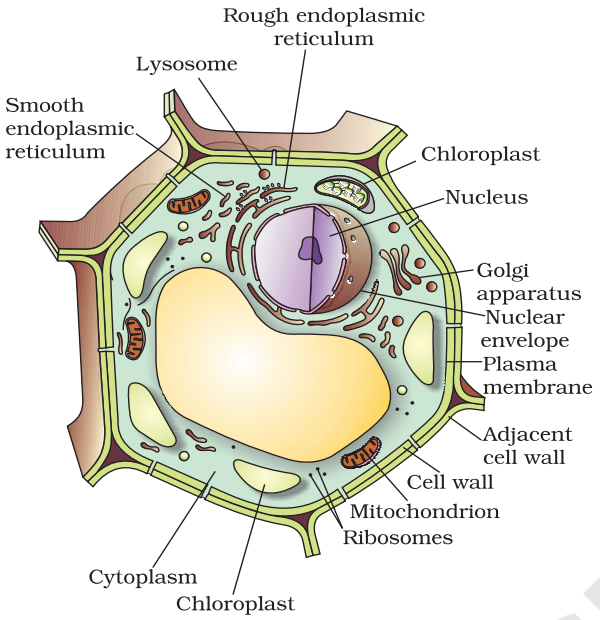
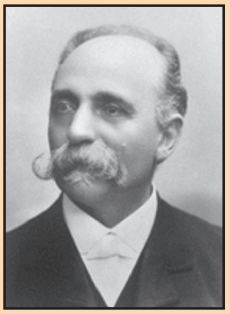


Fig. 5.6: *Plant cell*

5.2.5 (ii) *Golgi apparatus*

The Golgi apparatus, first described by Camillo Golgi, consists of a system of membrane-bound vesicles (flattened sacs) arranged approximately parallel to each other in stacks called cisterns. These membranes often have connections with the membranes of ER and therefore constitute another portion of a complex cellular membrane system.

The material synthesised near the ER is packaged and dispatched to various targets inside and outside the cell through the Golgi apparatus. Its functions include the storage, modification and packaging of products in vesicles. In some cases, complex sugars may be made from simple sugars in the Golgi apparatus. The Golgi apparatus is also involved in the formation of lysosomes [see 5.2.5 (iii)].



Camillo Golgi was born at Corteno near Brescia in 1843. He studied medicine at the University of Pavia. After graduating in 1865, he continued to work in Pavia at the Hospital of St. Matteo. At that time most of his investigations were concerned with the nervous system, In 1872 he accepted the post of Chief Medical Officer at the Hospital for the Chronically Sick at Abbiategrasso. He first started his investigations into the nervous system in a little kitchen of this hospital, which he had converted into a laboratory. However, the work of greatest importance, which Golgi carried out was a revolutionary method of staining individual nerve and cell structures. This method is referred to as the 'black reaction'. This method uses a weak solution of silver nitrate and is particularly valuable in tracing the processes and most delicate ramifications of cells. All through his life, he continued to work on these lines, modifying and improving this technique. Golgi received the highest honours and awards in recognition of his work. He shared the Nobel prize in 1906 with Santiago Ramony Cajal for their work on the structure of the nervous system.

5.2.5 (iii) *Lysosomes*

Structurally, lysosomes are membrane-bound sacs filled with digestive enzymes. These enzymes are made by RER. Lysosomes are a kind of waste disposal system of the cell. These help to keep the cell clean by digesting any foreign material as well as worn-out cell organelles. Foreign materials entering the cell, such as bacteria or food, as well as old organelles end up in the lysosomes, which break complex substances into simpler substances. Lysosomes are able to do this because they contain powerful digestive enzymes capable of breaking down all organic material. During the disturbance in cellular metabolism, for example, when the cell gets

damaged, lysosomes may burst and the enzymes digest their own cell. Therefore, lysosomes are also known as the 'suicide bags' of a cell.

5.2.5 (iv) *Mitochondria*

Mitochondria are known as the powerhouses of the cell. Mitochondria have two membrane coverings. The outer membrane is porous while the inner membrane is deeply folded. These folds increase surface area for ATP-generating chemical reactions. The energy required for various chemical activities needed for life is released by mitochondria in the form of ATP (Adenosine triphosphate) molecules. ATP is known as the energy currency of the cell. The body uses energy stored in ATP for making new chemical compounds and for mechanical work.

Mitochondria are strange organelles in the sense that they have their own DNA and ribosomes. Therefore, mitochondria are able to make some of their own proteins.

5.2.5 (v) *Plastids*

Plastids are present only in plant cells. There are two types of plastids – chromoplasts (coloured plastids) and leucoplasts (white or colourless plastids). Chromoplasts containing the pigment chlorophyll are known as chloroplasts. Chloroplasts are important for photosynthesis in plants. Chloroplasts also contain various yellow or orange pigments in addition to chlorophyll. Leucoplasts are primarily organelles in which materials such as starch, oils and protein granules are stored.

The internal organisation of the Chloroplast consists of numerous membrane layers embedded in a material called the stroma. These are similar to mitochondria in external structure. Like the mitochondria, plastids also have their own DNA and ribosomes.

5.2.5 (vi) *Vacuoles*

Vacuoles are storage sacs for solid or liquid contents. Vacuoles are small sized in animal cells while plant cells have very large vacuoles. The central vacuole of some plant cells may occupy 50-90% of the cell volume.

In plant cells vacuoles are full of cell sap and provide turgidity and rigidity to the cell. Many substances of importance in the life of the plant cell are stored in vacuoles. These include amino acids, sugars, various organic acids and some proteins. In single-celled organisms like *Amoeba*, the food vacuole contains the food items that the *Amoeba* has consumed. In some unicellular organisms, specialised vacuoles also play important roles in expelling excess water and some wastes from the cell.

Questions

1. *Can you name the two organelles we have studied that contain their own genetic material?*
2. *If the organisation of a cell is destroyed due to some physical or chemical influence, what will happen?*
3. *Why are lysosomes known as suicide bags?*
4. *Where are proteins synthesised inside the cell?*

Each cell thus acquires its structure and ability to function because of the organisation of its membrane and organelles in specific ways. The cell thus has a basic structural organisation. This helps the cells to perform functions like respiration, obtaining nutrition, and clearing of waste material, or forming new proteins.

Thus, the cell is the fundamental structural unit of living organisms. It is also the basic functional unit of life.

Cell Division

New cells are formed in organisms in order to grow, to replace old, dead and injured cells, and to form gametes required for reproduction. The process by which new cells are made is called cell division. There are two main types of cell division: mitosis and meiosis.

The process of cell division by which most of the cells divide for growth is called mitosis. In this process, each cell called mother cell

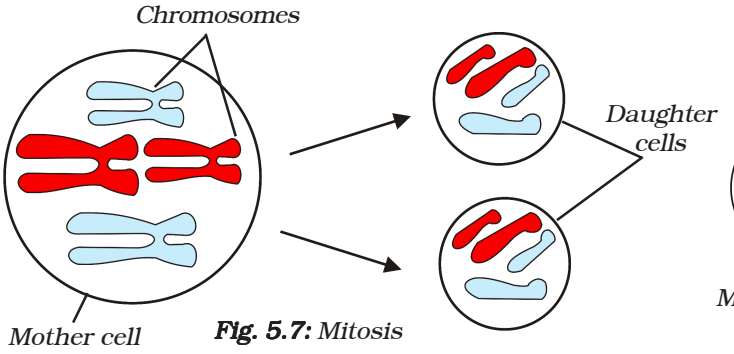


Fig. 5.7: *Mitosis*

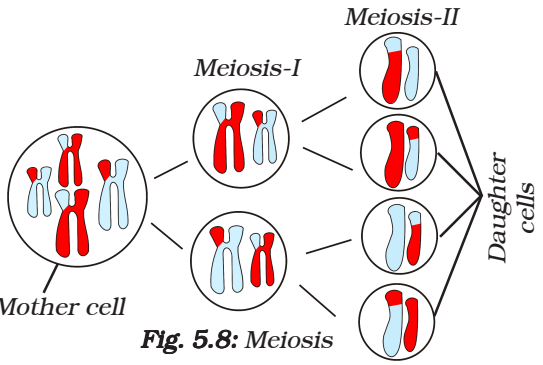


Fig. 5.8: *Meiosis*

divides to form two identical daughter cells (Fig. 5.7). The daughter cells have the same number of chromosomes as mother cell. It helps in growth and repair of tissues in organisms.

Specific cells of reproductive organs or tissues in animals and plants divide to form gametes, which after fertilisation give rise to offspring. They divide by a different process called meiosis which involves two consecutive divisions. When a cell divides by meiosis it produces four new cells instead of just two (Fig. 5.8). The new cells only have half the number of chromosomes than that of the mother cells. Can you think as to why the chromosome number has reduced to half in daughter cells?

What you have learnt

- The fundamental organisational unit of life is the cell.
- Cells are enclosed by a plasma membrane composed of lipids and proteins.
- The cell membrane is an active part of the cell. It regulates the movement of materials between the ordered interior of the cell and the outer environment.
- In plant cells, a cell wall composed mainly of cellulose is located outside the cell membrane.
- The presence of the cell wall enables the cells of plants, fungi and bacteria to exist in hypotonic media without bursting.
- The nucleus in eukaryotes is separated from the cytoplasm by double-layered membrane and it directs the life processes of the cell.
- The ER functions both as a passageway for intracellular transport and as a manufacturing surface.
- The Golgi apparatus consists of stacks of membrane-bound vesicles that function in the storage, modification and packaging of substances manufactured in the cell.
- Most plant cells have large membranous organelles called plastids, which are of two types—chromoplasts and leucoplasts.

- Chromoplasts that contain chlorophyll are called chloroplasts and they perform photosynthesis.
- The primary function of leucoplasts is storage.
- Most mature plant cells have a large central vacuole that helps to maintain the turgidity of the cell and stores important substances including wastes.
- Prokaryotic cells have no membrane-bound organelles, their chromosomes are composed of only nucleic acid, and they have only very small ribosomes as organelles.
- Cells in organisms divide for growth of body, for repalcing dead cells, and for forming gametes for reproduction.

Exercises

1. Make a comparison and write down ways in which plant cells are different from animal cells.
2. How is a prokaryotic cell different from a eukaryotic cell?
3. What would happen if the plasma membrane ruptures or breaks down?
4. What would happen to the life of a cell if there was no Golgi apparatus?
5. Which organelle is known as the powerhouse of the cell? Why?
6. Where do the lipids and proteins constituting the cell membrane get synthesised?
7. How does an *Amoeba* obtain its food?
8. What is osmosis?
9. Carry out the following osmosis experiment:
   - Take four peeled potato halves and scoos each one out to make potato cups. One of these potato cups should be made from a boiled potato. Put each potato cup in a trough containing water. Now,
     (a) Keep cup A empty
     (b) Put one teaspoon sugar in cup B
     (c) Put one teaspoon salt in cup C
     (d) Put one teaspoon sugar in the boiled potato cup D.

     Keep these for two hours. Then observe the four potato cups and answer the following:
     (i) Explain why water gathers in the hollowed portion of B and C.
     (ii) Why is potato A necessary for this experiment?
     (iii) Explain why water does not gather in the hollowed out portions of A and D.
10. Which type of cell division is required for growth and repair of body and which type is involved in formation of gametes?

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Chapter 6

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TISSUES

From the last chapter, we recall that all living organisms are made of cells. In unicellular organisms, a single cell performs all basic functions. For example, in *Amoeba*, a single cell carries out movement, intake of food, gaseous exchange and excretion. But in multi-cellular organisms there are millions of cells. Most of these cells are specialised to carry out specific functions. Each specialised function is taken up by a different group of cells. Since these cells carry out only a particular function, they do it very efficiently. In human beings, muscle cells contract and relax to cause movement, nerve cells carry messages, blood flows to transport oxygen, food, hormones and waste material and so on. In plants, vascular tissues conduct food and water from one part of the plant to other parts. So, multi-cellular organisms show division of labour. Cells specialising in one function are often grouped together in the body. This means that a particular function is carried out by a cluster of cells at a definite place in the body. This cluster of cells, called a tissue, is arranged and designed so as to give the highest possible efficiency of function. Blood, phloem and muscle are all examples of tissues.

A group of cells that are similar in structure and/or work together to achieve a particular function forms a tissue.

6.1 Are Plants and Animals Made of Same Types of Tissues?

Let us compare their structure and functions. Do plants and animals have the same structure? Do they both perform similar functions?

There are noticeable differences between the two. Plants are stationary or fixed – they don't move. Since they have to be upright, they have a large quantity of supportive tissue. The supportive tissue generally has dead cells.

Animals on the other hand move around in search of food, mates and shelter. They consume more energy as compared to plants. Most of the tissues they contain are living.

Another difference between animals and plants is in the pattern of growth. The growth in plants is limited to certain regions, while this is not so in animals. There are some tissues in plants that divide throughout their life. These tissues are localised in certain regions. Based on the dividing capacity of the tissues, various plant tissues can be classified as growing or meristematic tissue and permanent tissue. Cell growth in animals is more uniform. So, there is no such demarcation of dividing and non-dividing regions in animals.

The structural organisation of organs and organ systems is far more specialised and localised in complex animals than even in very complex plants. This fundamental difference reflects the different modes of life pursued by these two major groups of organisms, particularly in their different feeding methods. Also, they are differently adapted for a sedentary existence on one hand (plants) and active locomotion on the other (animals), contributing to this difference in organ system design.

It is with reference to these complex animal and plant bodies that we will now talk about the concept of tissues in some detail.

Questions

1. *What is a tissue?*
2. *What is the utility of tissues in multi-cellular organisms?*

6.2 Plant Tissues

6.2.1 Meristematic tissue

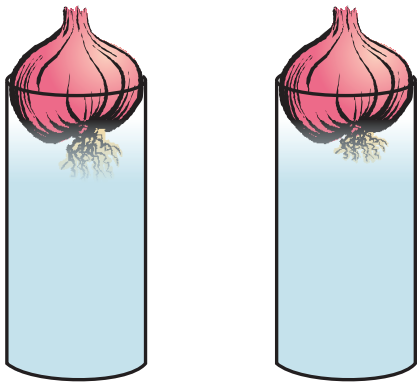


Fig. 6.1: *Growth of roots in onion bulbs*

Activity 6.1

- Take two glass jars and fill them with water.
- Now, take two onion bulbs and place one on each jar, as shown in Fig. 6.1.
- Observe the growth of roots in both the bulbs for a few days.
- Measure the length of roots on day 1, 2 and 3.
- On day 4, cut the root tips of the onion bulb in jar 2 by about 1 cm. After this, observe the growth of roots in both the jars and measure their lengths each day for five more days and record the observations in tables, like the table below:

Length	Day 1	Day 2	Day 3	Day 4	Day 5
Jar 1					
Jar 2					

- From the above observations, answer the following questions:
  1. Which of the two onions has longer roots? Why?
  2. Do the roots continue growing even after we have removed their tips?
  3. Why would the tips stop growing in jar 2 after we cut them?

The growth of plants occurs only in certain specific regions. This is because the dividing tissue, also known as meristematic tissue, is located only at these points. Depending on the region where they are present, meristematic tissues are classified as apical, lateral and intercalary (Fig. 6.2). New cells produced by meristem are initially like those of meristem itself, but as they grow and mature, their characteristics slowly change and they become differentiated as components of other tissues.

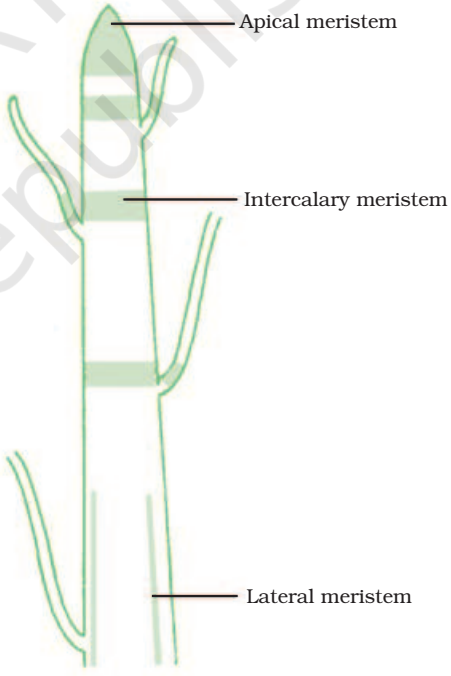


Fig. 6.2: *Location of meristematic tissue in plant body*

Apical meristem is present at the growing tips of stems and roots and increases the length of the stem and the root. The girth of the stem or root increases due to lateral meristem (cambium). Intercalary meristem seen in some plants is located near the node.

Cells of meristematic tissue are very active, they have dense cytoplasm, thin cellulose walls and prominent nuclei. They lack vacuoles. Can we think why they would lack vacuoles? (You might want to refer to the functions of vacuoles in the chapter on cells.)

6.2.2 Permanent tissue

What happens to the cells formed by meristematic tissue? They take up a specific role and lose the ability to divide. As a result, they form a permanent tissue. This process of taking up a permanent shape, size, and a function is called differentiation. Differentiation leads to the development of various types of permanent tissues.

6.2.2 (i) *Simple permanent tissue*

A few layers of cells beneath the epidermis are generally simple permanent tissue. Parenchyma is the most common simple permanent tissue. It consists of relatively unspecialised cells with thin cell walls. They are living cells. They are usually loosely arranged, thus large spaces between cells (intercellular spaces) are found in this tissue (Fig. 6.4 a). This tissue generally stores food.

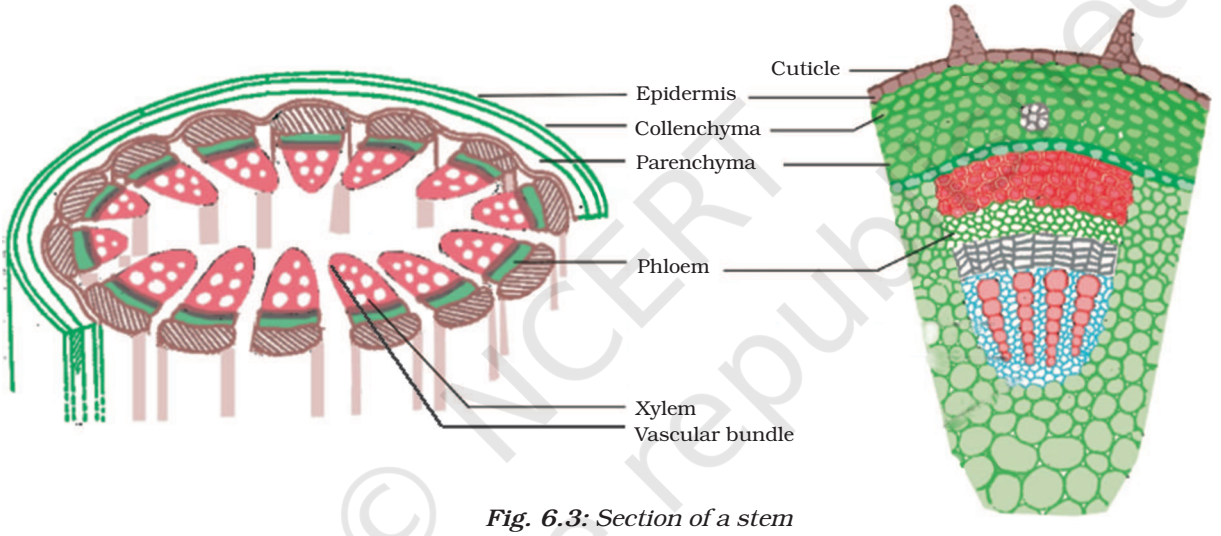


Fig. 6.3: *Section of a stem*

Activity 6.2

- Take a plant stem and with the help of your teacher cut into very thin slices or sections.
- Now, stain the slices with safranin. Place one neatly cut section on a slide, and put a drop of glycerine.
- Cover with a cover-slip and observe under a microscope. Observe the various types of cells and their arrangement. Compare it with Fig. 6.3.
- Now, answer the following on the basis of your observation:
  1. Are all cells similar in structure?
  2. How many types of cells can be seen?
  3. Can we think of reasons why there would be so many types of cells?
- We can also try to cut sections of plant roots. We can even try cutting sections of root and stem of different plants.

In some situations, it contains chlorophyll and performs photosynthesis, and then it is called chlorenchyma. In aquatic plants, large air cavities are present in parenchyma to help them float. Such a parenchyma type is called aerenchyma.

The flexibility in plants is due to another permanent tissue, collenchyma. It allows bending of various parts of a plant like tendrils and stems of climbers without breaking. It also provides mechanical support. We can find this tissue in leaf stalks below the epidermis. The cells of this tissue are living, elongated and irregularly thickened at the corners. There is very little intercellular space (Fig. 6.4 b).

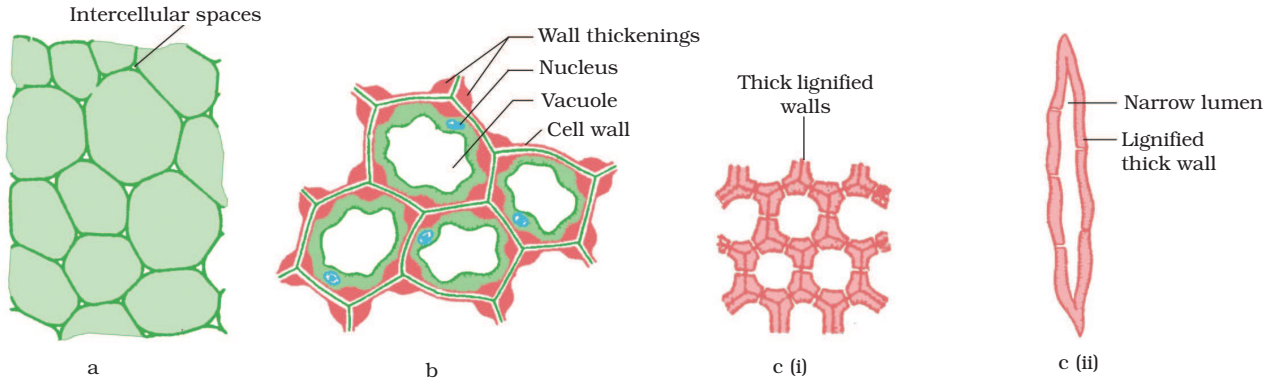


Fig. 6.4: Various types of simple tissues: (a) Parenchyma (b) Collenchyma (c) Sclerenchyma (i) transverse section, (ii) longitudinal section.

Yet another type of permanent tissue is sclerenchyma. It is the tissue which makes the plant hard and stiff. We have seen the husk of a coconut. It is made of sclerenchymatous tissue. The cells of this tissue are dead. They are long and narrow as the walls are thickened due to lignin. Often these walls are so thick that there is no internal space inside the cell (Fig. 6.4 c). This tissue is present in stems, around vascular bundles, in the veins of leaves and in the hard covering of seeds and nuts. It provides strength to the plant parts.

Activity 6.3

- Take a freshly plucked leaf of Rhoeo.
- Stretch and break it by applying pressure.
- While breaking it, keep it stretched gently so that some peel or skin projects out from the cut.
- Remove this peel and put it in a petri dish filled with water.
- Add a few drops of safranin.
- Wait for a couple of minutes and then transfer it onto a slide. Gently place a cover slip over it.
- Observe under microscope.

What you observe is the outermost layer of cells, called epidermis. The epidermis is usually made of a single layer of cells. In some plants living in very dry habitats, the epidermis may be thicker since protection against water loss is critical. The entire surface of a plant has an outer covering epidermis. It protects all the parts of the plant. Epidermal cells on the aerial

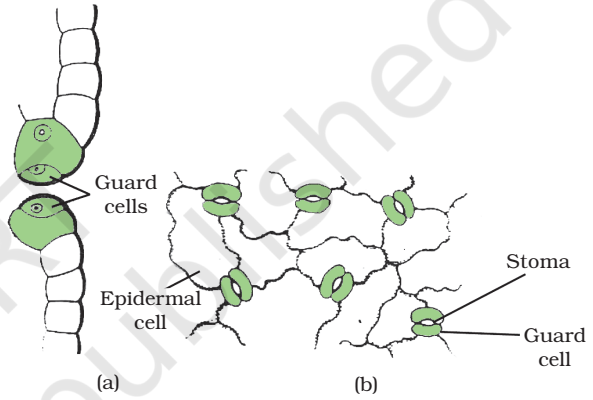


Fig. 6.5: Guard cells and epidermal cells: (a) lateral view, (b) surface view

parts of the plant often secrete a waxy, water-resistant layer on their outer surface. This aids in protection against loss of water, mechanical injury and invasion by parasitic fungi. Since it has a protective role to play, cells of epidermal tissue form a continuous layer without intercellular spaces. Most epidermal cells are relatively flat. Often their outer and side walls are thicker than the inner wall.

We can observe small pores here and there in the epidermis of the leaf. These pores are called stomata (Fig. 6.5). Stomata are enclosed by two kidney-shaped cells called guard cells. They are necessary for exchanging gases with the atmosphere. Transpiration (loss of water in the form of water vapour) also takes place through stomata.

Recall which gas is required for photosynthesis.
Find out the role of transpiration in plants.

Epidermal cells of the roots, whose function is water absorption, commonly bear long hair-like parts that greatly increase the total absorptive surface area.

In some plants like desert plants, epidermis has a thick waxy coating of cutin (chemical substance with waterproof quality) on its outer surface. Can we think of a reason for this?

Is the outer layer of a branch of a tree different from the outer layer of a young stem?

As plants grow older, the outer protective tissue undergoes certain changes. A strip of secondary meristem located in the cortex forms layers of cells which constitute the cork. Cells of cork are dead and compactly arranged without intercellular spaces (Fig. 6.6). They also have a substance called suberin in their walls that makes them impervious to gases and water.

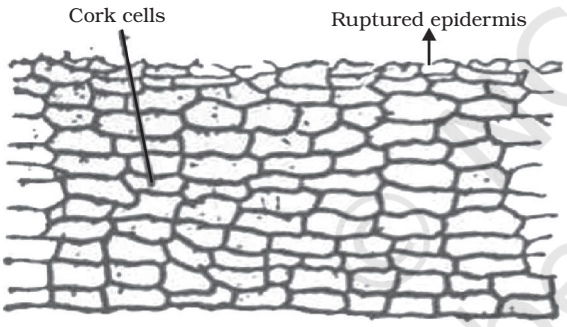


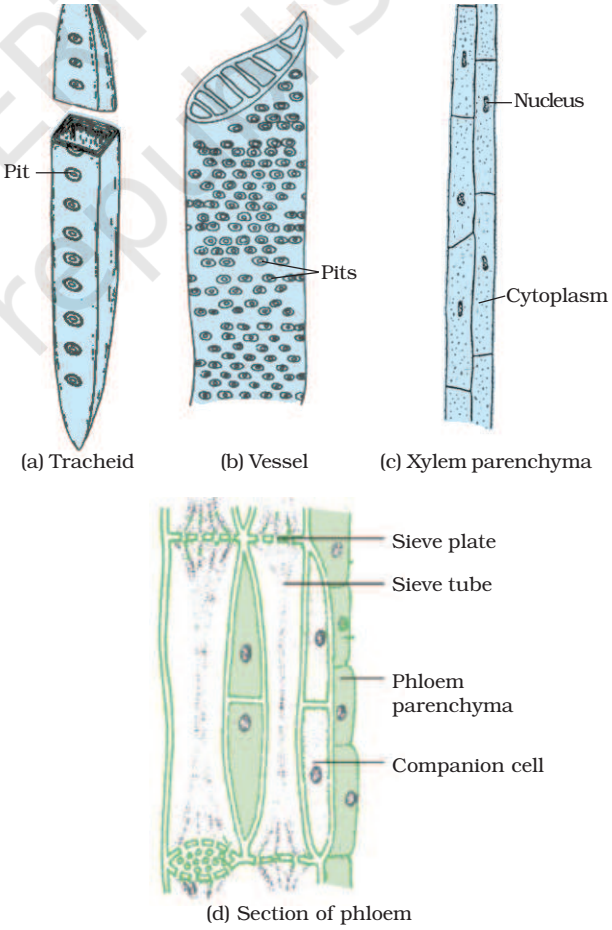
Fig. 6.6: Protective tissue

6.2.2 (ii) *Complex permanent tissue*

The different types of tissues we have discussed until now are all made of one type of cells, which look like each other. Such tissues are called simple permanent tissue. Yet another type of permanent tissue is complex tissue. Complex tissues are made of more than one type of cells. All these cells coordinate to perform a common function. Xylem and phloem are examples of such complex tissues. They are both conducting tissues and constitute a vascular bundle. Vascular tissue is a distinctive feature of the complex plants, one that has made possible their survival in the terrestrial environment. In Fig. 6.3 showing a section of stem, can you see different types of cells in the vascular bundle?

Xylem consists of tracheids, vessels, xylem parenchyma (Fig. 6.7 a,b,c) and xylem fibres. Tracheids and vessels have thick walls, and many are dead cells when mature. Tracheids and vessels are tubular structures. This allows them to transport water and minerals vertically. The parenchyma stores food. Xylem fibres are mainly supportive in function.

Phloem is made up of five types of cells: sieve cells, sieve tubes, companion cells, phloem fibres and the phloem parenchyma [Fig. 6.7 (d)]. Sieve tubes are tubular cells with perforated walls. Phloem transports food from leaves to other parts of the plant. Except phloem fibres, other phloem cells are living cells.



(a) Tracheid (b) Vessel (c) Xylem parenchyma

(d) Section of phloem

Fig. 6.7: Types of complex tissue

Questions

1. *Name types of simple tissues.*
2. *Where is apical meristem found?*
3. *Which tissue makes up the husk of coconut?*
4. *What are the constituents of phloem?*

6.3 Animal Tissues

When we breathe we can actually feel the movement of our chest. How do these body parts move? For this we have specialised cells called muscle cells (Fig. 6.8). The contraction and relaxation of these cells result in movement.

Fig. 6.8: *Location of muscle fibres*

During breathing we inhale oxygen. Where does this oxygen go? It is absorbed in the lungs and then is transported to all the body cells through blood. Why would cells need oxygen? The functions of mitochondria we studied earlier provide a clue to this question. Blood flows and carries various substances from one part of the body to the other. For example, it carries oxygen and food to all cells. It also collects wastes from all parts of the body and carries them to the liver and kidney for disposal.

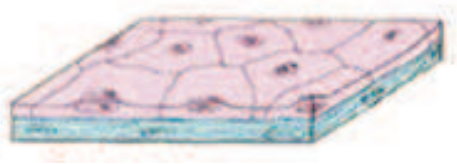
Blood and muscles are both examples of tissues found in our body. On the basis of the functions they perform we can think of different types of animal tissues, such as epithelial tissue, connective tissue, muscular tissue and nervous tissue. Blood is a type of connective tissue, and muscle forms muscular tissue.

6.3.1 Epithelial Tissue

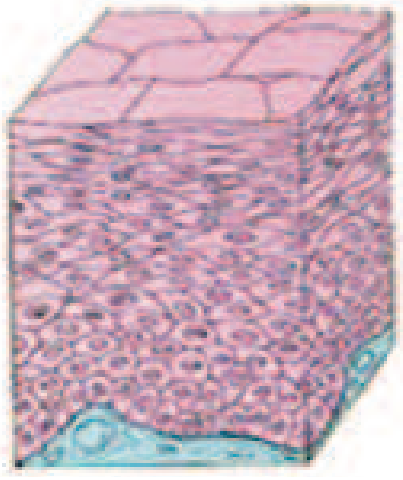
The covering or protective tissues in the animal body are epithelial tissues. Epithelium covers most organs and cavities within the body. It also forms a barrier to keep different body systems separate. The skin, the lining of the mouth, the lining of blood vessels, lung alveoli and kidney tubules are all made of epithelial tissue. Epithelial tissue cells are tightly packed and form a continuous sheet. They have only a small amount of cementing material between them and almost no intercellular spaces. Obviously, anything entering or leaving the body must cross at least one layer of epithelium. As a result, the permeability of the cells of various epithelia play an important role in regulating the exchange of materials between the body and the external environment and also between different parts of the body. Regardless of the type, all epithelium is usually separated from the underlying tissue by an extracellular fibrous basement membrane.

Different epithelia (Fig. 6.9) show differing structures that correlate with their unique functions. For example, in cells lining blood vessels or lung alveoli, where transportation of substances occurs through a selectively permeable surface, there is a simple flat kind

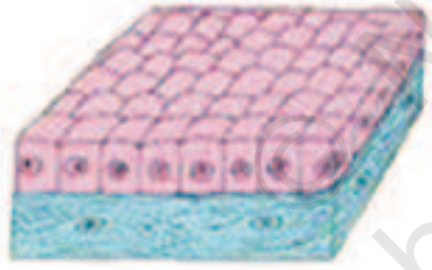
of epithelium. This is called the simple squamous epithelium (squama means scale of skin). Simple squamous epithelial cells are extremely thin and flat and form a delicate lining. The oesophagus and the lining of the mouth are also covered with squamous epithelium. The skin, which protects the body, is also made of squamous epithelium. Skin epithelial cells are arranged in many layers to prevent wear and tear. Since they are arranged in a pattern of layers, the epithelium is called stratified squamous epithelium.



(a) Squamous



(b) Stratified squamous



(c) Cuboidal

(d) Columnar (Ciliated)

Fig. 6.9: *Different types of epithelial tissues*

Where absorption and secretion occur, as in the inner lining of the intestine, tall epithelial cells are present. This columnar (meaning 'pillar-like') epithelium facilitates movement across the epithelial barrier. In the respiratory tract, the columnar epithelial tissue also has cilia, which are hair-like projections on the outer surfaces of epithelial cells. These cilia can move, and their movement pushes the mucus forward to clear it. This type of epithelium is thus ciliated columnar epithelium.

Cuboidal epithelium (with cube-shaped cells) forms the lining of kidney tubules and ducts of salivary glands, where it provides mechanical support. Epithelial cells often acquire additional specialisation as gland cells, which can secrete substances at the epithelial surface. Sometimes a portion of the epithelial tissue folds inward, and a multicellular gland is formed. This is glandular epithelium.

6.3.2 Connective tissue

Blood is a type of connective tissue. Why would it be called 'connective' tissue? A clue is provided in the introduction of this chapter! Now, let us look at this type of tissue in some more detail. The cells of connective tissue are loosely spaced and embedded in an intercellular matrix (Fig. 6.10). The matrix may be jelly like, fluid, dense or rigid. The nature of matrix differs in concordance with the function of the particular connective tissue.

Activity 6.4

- Take a drop of blood on a slide and observe different cells present in it under a microscope.

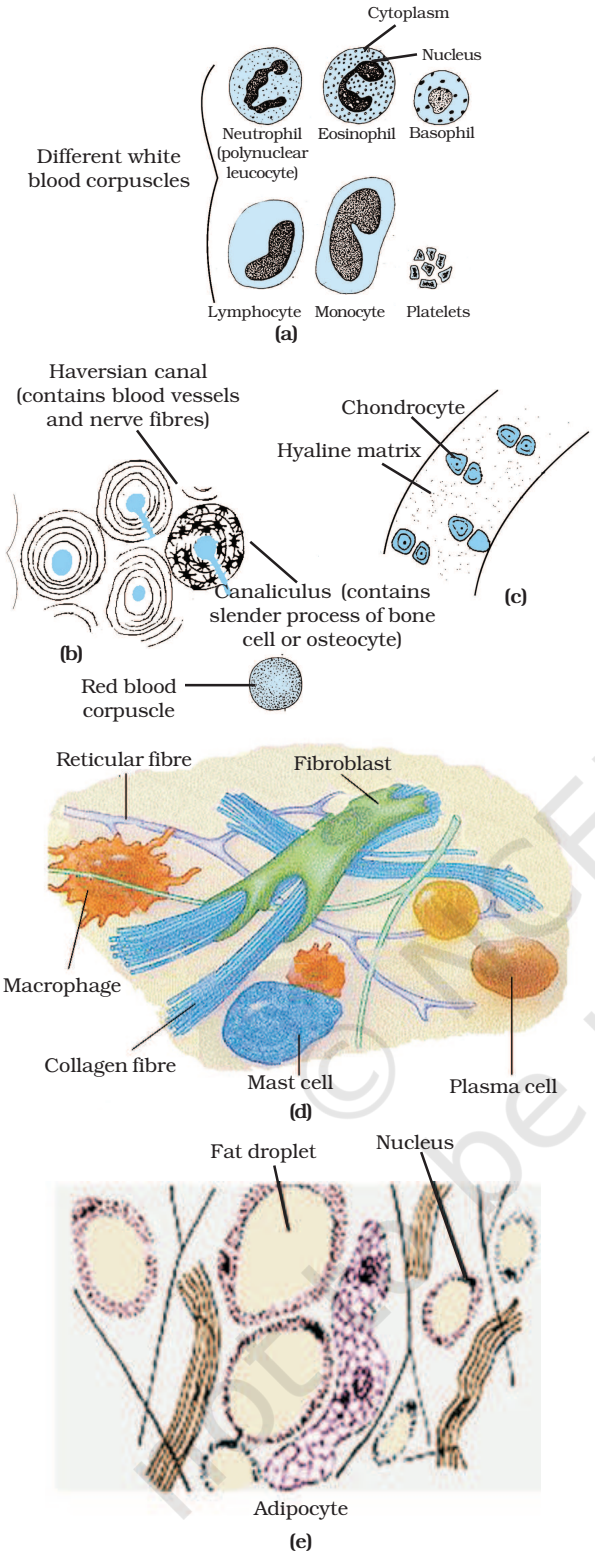


Fig. 6.10: *Types of connective tissues: (a) types of blood cells, (b) compact bone, (c) hyaline cartilage, (d) areolar tissue, (e) adipose tissue*

Blood has a fluid (liquid) matrix called plasma, in which red blood corpuscles (RBCs), white blood corpuscles (WBCs) and platelets are suspended. The plasma contains proteins, salts and hormones. Blood flows and transports gases, digested food, hormones and waste materials to different parts of the body.

Bone is another example of a connective tissue. It forms the framework that supports the body. It also anchors the muscles and supports the main organs of the body. It is a strong and nonflexible tissue (what would be the advantage of these properties for bone functions?). Bone cells are embedded in a hard matrix that is composed of calcium and phosphorus compounds.

Two bones can be connected to each other by another type of connective tissue called the ligament. This tissue is very elastic. It has considerable strength. Ligaments contain very little matrix and connect bones with bones. Tendons connect muscles to bones and are another type of connective tissue. Tendons are fibrous tissue with great strength but limited flexibility.

Another type of connective tissue, cartilage, has widely spaced cells. The solid matrix is composed of proteins and sugars. Cartilage smoothens bone surfaces at joints and is also present in the nose, ear, trachea and larynx. We can fold the cartilage of the ears, but we cannot bend the bones in our arms. Think of how the two tissues are different!

Areolar connective tissue is found between the skin and muscles, around blood vessels and nerves and in the bone marrow. It fills the space inside the organs, supports internal organs and helps in repair of tissues.

Where are fats stored in our body? Fat-storing adipose tissue is found below the skin and between internal organs. The cells of this tissue are filled with fat globules. Storage of fats also lets it act as an insulator.

6.3.3 Muscular Tissue

Muscular tissue consists of elongated cells, also called muscle fibres. This tissue is responsible for movement in our body.

Muscles contain special proteins called contractile proteins, which contract and relax to cause movement.

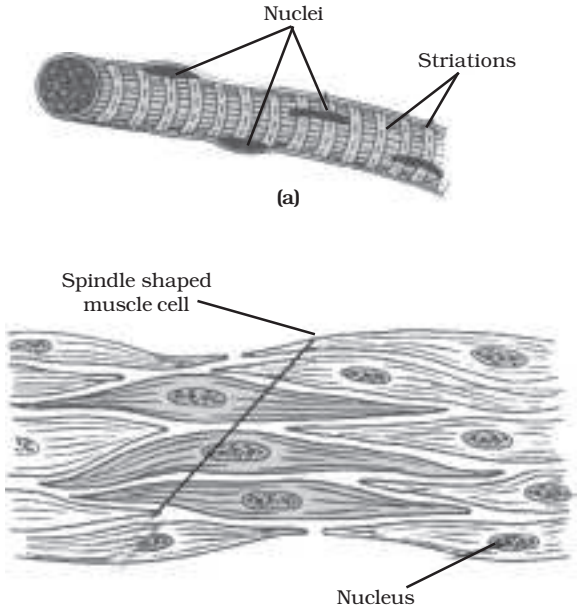


Fig. 6.11: Types of muscles fibres: (a) striated muscle, (b) smooth muscle, (c) cardiac muscle

We can move some muscles by conscious will. Muscles present in our limbs move when we want them to, and stop when we so decide. Such muscles are called voluntary muscles [Fig. 6.11(a)]. These muscles are also called skeletal muscles as they are mostly attached to bones and help in body movement. Under the microscope, these muscles show alternate light and dark bands or striations when stained appropriately. As a result, they are also called striated muscles. The cells of this tissue are long, cylindrical, unbranched and multinucleate (having many nuclei).

The movement of food in the alimentary canal or the contraction and relaxation of blood vessels are involuntary movements. We cannot really start them or stop them simply by wanting to do so! Smooth muscles [Fig. 6.11(b)] or involuntary muscles control such movements. They are also found in the iris of the eye, in ureters and in the bronchi of the lungs. The cells are long with pointed ends (spindle-shaped) and uninucleate (having a single nucleus). They are also called unstriated muscles – why would they be called that?

The muscles of the heart show rhythmic contraction and relaxation throughout life. These involuntary muscles are called cardiac muscles [Fig. 6.11(c)]. Heart muscle cells are cylindrical, branched and uninucleate.

Activity 6.5

Compare the structures of different types of muscular tissues. Note down their shape, number of nuclei and position of nuclei within the cell in the Table 6.1.

Table 6.1:

Features	Striated	Smooth	Cardiac
Shape			
Number of nuclei			
Position of nuclei			

6.3.4 Nervous Tissue

All cells possess the ability to respond to stimuli. However, cells of the nervous tissue are highly specialised for being stimulated and

then transmitting the stimulus very rapidly from one place to another within the body. The brain, spinal cord and nerves are all composed of the nervous tissue. The cells of this tissue are called nerve cells or neurons. A neuron consists of a cell body with a nucleus and cytoplasm, from which long thin hair-like parts arise (Fig. 6.12). Usually each neuron has a single long part (process) in the form of a fibre, called the axon, and many short, branched parts (processes) called dendrites. An individual nerve cell may be up to a metre long. Many nerve fibres bound together by connective tissue make up a nerve.

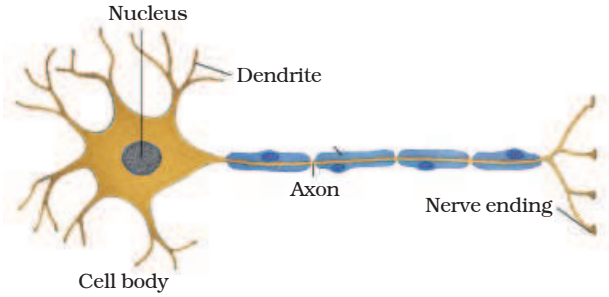


Fig. 6.12: *Neuron—a unit of nervous tissue*

The signal that passes along the nerve fibre is called a nerve impulse. The nerve impulse from the nerve endings in transmitted to the dendrites of the next nerve cell. Nerve impulses allow us to move our muscles when we want to. The functional combination of nerve and muscle tissue is fundamental to most animals. This combination enables animals to move rapidly in response to stimuli.

Questions

1. *Name the tissue responsible for movement in our body.*
2. *What does a neuron look like?*
3. *Give three features of cardiac muscles.*
4. *What are the functions of areolar tissue?*

What you have learnt

- Tissue is a group of cells similar in structure and function.
- Plant tissues are of two main types – meristematic and permanent.
- Meristematic tissue is the dividing tissue present in the growing regions of the plant.
- Permanent tissues are derived from meristematic tissue once they lose the ability to divide. They are classified as simple and complex tissues.
- Parenchyma, collenchyma and sclerenchyma are three types of simple tissues. Xylem and phloem are types of complex tissues.
- Animal tissues can be epithelial, connective, muscular and nervous tissue.
- Depending on shape and function, epithelial tissue is classified as squamous, cuboidal, columnar, ciliated and glandular.

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- The different types of connective tissues in our body include areolar tissue, adipose tissue, bone, tendon, ligament, cartilage and blood.
- Striated, unstriated and cardiac are three types of muscle tissues.
- Nervous tissue is made of neurons that receive and conduct impulses.

Exercises

1. Define the term "tissue".
2. How many types of elements together make up the xylem tissue? Name them.
3. How are simple tissues different from complex tissues in plants?
4. Differentiate between parenchyma, collenchyma and sclerenchyma on the basis of their cell wall.
5. What are the functions of the stomata?
6. Diagrammatically show the difference between the three types of muscle fibres.
7. What is the specific function of the cardiac muscle?
8. Differentiate between striated, unstriated and cardiac muscles on the basis of their structure and site/location in the body.
9. Draw a labelled diagram of a neuron.
10. Name the following.
    (a) Tissue that forms the inner lining of our mouth.
    (b) Tissue that connects muscle to bone in humans.
    (c) Tissue that transports food in plants.
    (d) Tissue that stores fat in our body.
    (e) Connective tissue with a fluid matrix.
    (f) Tissue present in the brain.
11. Identify the type of tissue in the following: skin, bark of tree, bone, lining of kidney tubule, vascular bundle.

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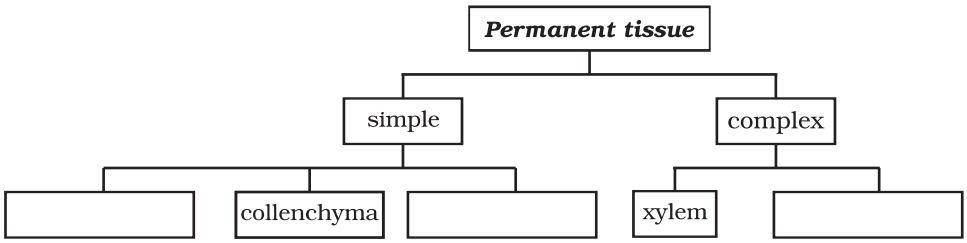
12. Name the regions in which parenchyma tissue is present.
13. What is the role of epidermis in plants?
14. How does the cork act as a protective tissue?
15. Complete the following chart:



Chapter 12

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Improvement in Food Resources

We know that all living organisms need food. Food supplies proteins, carbohydrates, fats, vitamins and minerals, all of which we require for body development, growth and health. Both plants and animals are major sources of food for us. We obtain most of this food from agriculture and animal husbandry.

We read in newspapers that efforts are always being made to improve production from agriculture and animal husbandry. Why is this necessary? Why we cannot make do with the current levels of production?

India is a very populous country. Our population is more than one billion people, and it is still growing. As food for this growing population, we will soon need more than a quarter of a billion tonnes of grain every year. This can be done by farming on more land. But India is already intensively cultivated. As a result, we do not have any major scope for increasing the area of land under cultivation. Therefore, it is necessary to increase our production efficiency for both crops and livestock.

Efforts to meet the food demand by increasing food production have led to some successes so far. We have had the green revolution, which contributed to increased food-grain production. We have also had the white revolution, which has led to better and more efficient use as well as availability of milk.

However, these revolutions mean that our natural resources are getting used more intensively. As a result, there are more chances of causing damage to our natural resources to the point of destroying their balance completely. Therefore, it is important that we should increase food production without degrading our environment and disturbing the balances maintaining it. Hence, there is a need for sustainable practices in agriculture and animal husbandry.

Also, simply increasing grain production for storage in warehouses cannot solve the problem of malnutrition and hunger. People should have money to purchase food. Food security depends on both availability of food and access to it. The majority of our population depends on agriculture for their livelihood. Increasing the incomes of people working in agriculture is therefore necessary to combat the problem of hunger. Scientific management practices should be undertaken to obtain high yields from farms. For sustained livelihood, one should undertake mixed farming, intercropping, and integrated farming practices, for example, combine agriculture with livestock/poultry/fisheries/bee-keeping.

The question thus becomes – how do we increase the yields of crops and livestock?

12.1 Improvement in Crop Yields

Cereals such as wheat, rice, maize, millets and sorghum provide us carbohydrate for energy requirement. Pulses like gram (*chana*), pea (*matar*), black gram (*urad*), green gram (*moong*), pigeon pea (*arhar*), lentil (*masoor*), provide us with protein. And oil seeds including soyabean, ground nut, sesame, castor, mustard, linseed and sunflower provide us with necessary fats (Fig. 12.1). Vegetables, spices and fruits provide a range of vitamins and minerals in addition to small amounts of proteins, carbohydrates and fats. In addition to these food crops, fodder crops like *berseem*, *oats* or *sudan grass* are raised as food for the livestock.

Fig. 12.1: Different types of crops

Question

1. *What do we get from cereals, pulses, fruits and vegetables?*

Different crops require different climatic conditions, temperature and photoperiods for their growth and completion of their life cycle. Photoperiods are related to the duration of sunlight. Growth of plants and flowering are dependent on sunlight. As we all know, plants manufacture their food in sunlight by the process of photosynthesis. There are some crops, which are grown in rainy season, called the *kharif* season from the month of June to October, and some of the crops are grown in the winter season, called the *rabi* season from November to April. Paddy, soyabean, pigeon pea, maize, cotton, green gram and black gram are *kharif* crops, whereas wheat, gram, peas, mustard, linseed are *rabi* crops.

In India there has been a four times increase in the production of food grains from 1952 to 2010 with only 25% increase in the cultivable land area. How has this increase in production been achieved? If we think of the practices involved in farming, we can see that we can divide it into three stages. The first is the choice of seeds for planting. The second is the nurturing of the crop plants. The third is the protection of the growing and harvested crops from loss. Thus, the major groups of activities for improving crop yields can be classified as:

- Crop variety improvement
- Crop production improvement
- Crop protection management.

12.1.1 Crop Variety Improvement

This approach depends on finding a crop variety that can give a good yield. Varieties or strains of crops can be selected by breeding for various useful characteristics such as disease resistance, response to fertilisers, product quality and high yields. One way of incorporating desirable characters into crop varieties is by hybridisation. Hybridisation refers to crossing between genetically dissimilar plants. This crossing may be intervarietal (between different varieties), interspecific (between two different species of the same genus) or intergeneric (between different genera). Another way of improving the crop is by introducing a gene that would provide the desired characteristic. This results in genetically modified crops.

For new varieties of crops to be accepted, it is necessary that the variety produces high yields under different conditions that are found in different areas. Farmers would need to be provided with good quality seeds of a particular variety, that is, the seeds should all

be of the same variety and germinate under the same conditions.

Cultivation practices and crop yield are related to weather, soil quality and availability of water. Since weather conditions such as drought and flood situations are unpredictable, varieties that can be grown in diverse climatic conditions are useful. Similarly, varieties tolerant to high soil salinity have been developed. Some of the factors for which variety improvement is done are:

- Higher yield: To increase the productivity of the crop per acre.
- Improved quality: Quality considerations of crop products vary from crop to crop. Baking quality is important in wheat, protein quality in pulses, oil quality in oilseeds and preserving quality in fruits and vegetables.
- Biotic and abiotic resistance: Crops production can go down due to biotic (diseases, insects and nematodes) and abiotic (drought, salinity, water logging, heat, cold and frost) stresses under different situations. Varieties resistant to these stresses can improve crop production.
- Change in maturity duration: The shorter the duration of the crop from sowing to harvesting, the more economical is the variety. Such short durations allow farmers to grow multiple rounds of crops in a year. Short duration also reduces the cost of crop production. Uniform maturity makes the harvesting process easy and reduces losses during harvesting.
- Wider adaptability: Developing varieties for wider adaptability will help in stabilising the crop production under different environmental conditions. One variety can then be grown under different climatic conditions in different areas.
- Desirable agronomic characteristics: Tallness and profuse branching are desirable characters for fodder crops. Dwarfness is desired in cereals, so that less nutrients are consumed by these crops. Thus developing varieties of desired agronomic characters help give higher productivity.

Questions

1. *How do biotic and abiotic factors affect crop production?*
2. *What are the desirable agronomic characteristics for crop improvements?*

12.1.2 Crop Production Management

In India, as in many other agriculture-based countries, farming ranges from small to very large farms. Different farmers thus have more or less land, money and access to information and technologies. In short, it is the money or financial conditions that allow farmers to take up different farming practices and agricultural technologies. There is a correlation between higher inputs and yields. Thus, the farmer's purchasing capacity for inputs decides cropping system and production practices. Therefore, production practices can be at different levels. They include 'no cost' production, 'low cost' production and 'high cost' production practices.

12.1.2 (i) Nutrient Management

Just as we need food for development, growth and well-being, plants also require nutrients for growth. Nutrients are supplied to plants by air, water and soil. There are several nutrients which are essential for plants. Air supplies carbon and oxygen, hydrogen comes from water, and soil supplies the other thirteen nutrients to plants. Amongst these, some are required in large quantities and are therefore called macro-nutrients. The other nutrients are used by plants in small quantities and are therefore called micro-nutrients (Table 12.1).

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Table 12.1: Nutrients supplied by air, water and soil

Source	Nutrients
Air	carbon, oxygen
Water	hydrogen, oxygen
Soil	(i) *Macronutrients*: nitrogen, phosphorus, potassium, calcium, magnesium, sulphur (ii) *Micronutrients:* iron, manganese, boron, zinc, copper, molybdenum, chlorine

Deficiency of these nutrients affects physiological processes in plants including reproduction, growth and susceptibility to diseases. To increase the yield, the soil can be enriched by supplying these nutrients in the form of manure and fertilizers.

Questions

1. *What are macro-nutrients and why are they called macro-nutrients?*
2. *How do plants get nutrients?*

Manure

Manure contains large quantities of organic matter and also supplies small quantities of nutrients to the soil. Manure is prepared by the decomposition of animal excreta and plant waste. Manure helps in enriching soil with nutrients and organic matter and increasing soil fertility. The bulk of organic matter in manure helps in improving the soil structure. This involves increasing the water holding capacity in sandy soils. In clayey soils, the large quantities of organic matter help in drainage and in avoiding water logging.

In using manure we use biological waste material, which is advantageous in protecting our environment from excessive use of fertilizers. Using biological waste material is also a way of recycling farm waste. Based on the kind of biological material used, manure can be classified as:

(i) Compost and vermi-compost: The process in which farm waste material like livestock excreta (cow dung, etc.), vegetable waste, animal refuse, domestic waste, sewage waste, straw, eradicated weeds etc. is decomposed in pits is known as composting. The compost is rich in organic matter and nutrients. Compost is also prepared by using earthworms to hasten the process of decomposition of plant and animal refuse. This is called vermi-compost.

(ii) Green manure: Prior to the sowing of the crop seeds, some plants like sun hemp or guar are grown and then mulched by ploughing them into the soil. These green plants thus turn into green manure which helps in enriching the soil in nitrogen and phosphorus.

Fertilizers

Fertilizers are commercially produced plant nutrients. Fertilizers supply nitrogen, phosphorus and potassium. They are used to ensure good vegetative growth (leaves, branches and flowers), giving rise to healthy plants. Fertilizers are a factor in the higher yields of high-cost farming.

Fertilizers should be applied carefully in terms of proper dose, time, and observing pre- and post-application precautions for their complete utilisation. For example, sometimes fertilizers get washed away due to excessive irrigation and are not fully absorbed by the plants. This excess fertilizer then leads to water pollution.

Also, as we have seen in the previous class, continuous use of fertilizers in an area can destroy soil fertility because the organic matter in the soil is not replenished and micro-organisms in the soil are harmed by the fertilizers used. Short-term benefits of using fertilizers and long-term benefits of using

manure for maintaining soil fertility have to be considered while aiming for optimum yields in crop production.

Question

1. *Compare the use of manure and fertilizers in maintaining soil fertility.*

Organic farming is a farming system with minimal or no use of chemicals as fertilizers, herbicides, pesticides, etc., and with a maximum input of organic manures, recycled farm-wastes (straw and livestock excreta), use of bio-agents such as culture of blue green algae in preparation of biofertilizers, *neem* leaves or turmeric specifically in grain storage as bio-pesticides, with healthy cropping systems [mixed cropping, inter-cropping and crop rotation as discussed below in 12.1.2.(iii)]. These cropping systems are beneficial in insect, pest and wheat control besides providing nutrients.

12.1.2 (ii) Irrigation

Most agriculture in India is rain-fed, that is, the success of crops in most areas is dependent on timely monsoons and sufficient rainfall spread through most of the growing season. Hence, poor monsoons cause crop failure. Ensuring that the crops get water at the right stages during their growing season can increase the expected yields of any crop. Therefore, many measures are used to bring more and more agricultural land under irrigation.

More to know

Droughts occur because of scarcity or irregular distribution of rains. Drought poses a threat to rain-fed farming areas, where farmers do not use irrigation for crop production and depend only on rain. Light soils have less water retention capacity. In areas with light soils, crops get adversely affected by drought conditions. Scientists have developed some crop varieties which can tolerate drought conditions.

India has a wide variety of water resources and a highly varied climate. Under such conditions, several different kinds of irrigation systems are adopted to supply water to agricultural lands depending on the kinds of water resources available. These include wells, canals, rivers and tanks.

- Wells: There are two types of wells, namely dug wells and tube wells. In a dug well, water is collected from water bearing strata. Tube wells can tap water from the deeper strata. From these wells, water is lifted by pumps for irrigation.
- Canals: This is usually an elaborate and extensive irrigation system. In this system canals receive water from one or more reservoirs or from rivers. The main canal is divided into branch canals having further distributaries to irrigate fields.
- River Lift Systems: In areas where canal flow is insufficient or irregular due to inadequate reservoir release, the lift system is more rational. Water is directly drawn from the rivers for supplementing irrigation in areas close to rivers.
- Tanks: These are small storage reservoirs, which intercept and store the run-off of smaller catchment areas.

Fresh initiatives for increasing the water available for agriculture include rainwater harvesting and watershed management. This involves building small check-dams which lead to an increase in ground water levels. The check-dams stop the rainwater from flowing away and also reduce soil erosion.

12.1.2 (iii) Cropping patterns

Different ways of growing crops can be used to give maximum benefit.

Mixed cropping is growing two or more crops simultaneously on the same piece of land, for example, wheat + gram, or wheat + mustard, or groundnut + sunflower. This reduces risk and gives some insurance against failure of one of the crops.

Inter-cropping is growing two or more crops simultaneously on the same field in a definite pattern (Fig.12.2). A few rows of one crop alternate with a few rows of a second crop, for example, soyabean + maize, or finger millet (*bajra*) + cowpea (*lobia*). The crops are selected such that their nutrient requirements are different. This ensures maximum utilisation of the nutrients supplied, and also prevents pests and diseases from spreading to all the plants belonging to one crop in a field. This way, both crops can give better returns.

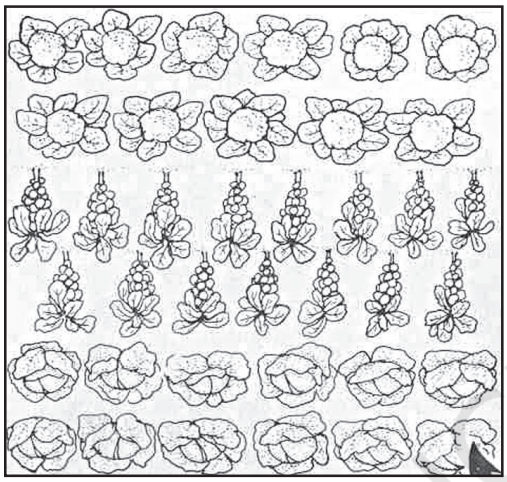

Fig. 12.2 : *Intercropping*

The growing of different crops on a piece of land in a pre-planned succession is known as crop rotation. Depending upon the duration, crop rotation is done for different crop combinations. The availability of moisture and irrigation facilities decide the choice of the crop to be cultivated after one harvest. If crop rotation is done properly then two or three crops can be grown in a year with good harvests.

12.1.3 Crop Protection Management

Field crops are infested by a large number of weeds, insect pests and diseases. If weeds and pests are not controlled at the appropriate time then they can damage the crops so much that most of the crop is lost.

Weeds are unwanted plants in the cultivated field, for example, *Xanthium* (*gokhroo*), *Parthenium* (*gajar ghas*), *Cyperus rotundus* (*motha*). They compete for food, space and light. Weeds take up nutrients and reduce the growth of the crop. Therefore, removal of weeds from cultivated fields during the early stages of crop growth is essential for a good harvest.

Generally insect pests attack the plants in three ways: (i) they cut the root, stem and leaf, (ii) they suck the cell sap from various parts of the plant, and (iii) they bore into stem and fruits. They thus affect the health of the crop and reduce yields.

Diseases in plants are caused by pathogens such as bacteria, fungi and viruses. These pathogens can be present in and transmitted through the soil, water and air.

Weeds, insects and diseases can be controlled by various methods. One of the most commonly used methods is the use of pesticides, which include herbicides, insecticides and fungicides. These chemicals are sprayed on crop plants or used for treating seeds and soil. However, excessive use of these chemicals creates problems, since they can be poisonous to many plant and animal species and cause environmental pollution.

Weed control methods also include mechanical removal. Preventive methods such as proper seed bed preparation, timely sowing of crops, intercropping and crop rotation also help in weed control. Some other preventive measures against pests are the use of resistant varieties, and summer ploughing, in which fields are ploughed deep in summers to destroy weeds and pests.

Question

1. *Which of the following conditions will give the most benefits? Why?*
   (a) *Farmers use high-quality seeds, do not adopt irrigation or use fertilizers.*
   (b) *Farmers use ordinary seeds, adopt irrigation and use fertilizer.*
   (c) *Farmers use quality seeds, adopt irrigation, use fertilizer and use crop protection measures.*

Table 12.2: Nutritional values of animal products

Animal Products	Per cent (%) Nutrients					
	Fat	Protein	Sugar	Minerals	Water	Vitamins
Milk (Cow)	3.60	4.00	4.50	0.70	87.20	B1, B2, B12, D, E
Egg	12.00	13.00	*	1.00	74.00	B2, D
Meat	3.60	21.10	*	1.10	74.20	B2, B12
Fish	2.50	19.00	*	1.30	77.20	Niacin, D, A

*Present in very small amounts

Activity 12.1

- Visit a nearby garden/agricultural field and make a list of the weeds and the flowers/crops found in the area. Also, make a list of insect pests, if any, infesting the flowers/crops.

Storage of grains

Storage losses in agricultural produce can be very high. Factors responsible for such losses are biotic— insects, rodents, fungi, mites and bacteria, and abiotic— inappropriate moisture and temperatures in the place of storage. These factors cause degradation in quality, loss in weight, poor germinability, discolouration of produce, all leading to poor marketability. These factors can be controlled by proper treatment and by systematic management of warehouses.

Preventive and control measures are used before grains are stored for future use. They include strict cleaning of the produce before storage, proper drying of the produce first in sunlight and then in shade, and fumigation using chemicals that can kill pests.

Questions

1. *Why should preventive measures and biological control methods be preferred for protecting crops?*
2. *What factors may be responsible for losses of grains during storage?*

Activity 12.2

- *Collect grains/seeds of cereals, pulses and oil seeds and gather information about the seasons in which they are sown and harvested.*

12.2 Animal Husbandry

Animal husbandry is the scientific management of animal livestock. It includes various aspects such as feeding, breeding and disease control. Animal-based farming includes cattle, goat, sheep, poultry and fish farming. As the population increases and as living standards increase, the demand for milk, eggs and meat is also going up. Also, the growing awareness of the need for humane treatment of livestock has brought in new limitations in livestock farming. Thus, livestock production also needs to be improved.

12.2.1 Cattle farming

Cattle husbandry is done for two purposes— milk and draught labour for agricultural work such as tilling, irrigation and carting. Indian cattle belong to two different species, *Bos indicus*, cows, and *Bos bubalis*, buffaloes. Milk-producing females are called milch animals (dairy animals), while the ones used for farm labour are called draught animals.

Milk production depends, to some extent, on the duration of the lactation period, meaning the period of milk production after

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Fig. 12.3: Indigenous milch breed of cattle

the birth of a calf. So, milk production can be increased by increasing the lactation period. Exotic or foreign breeds (for example, Jersey, Brown Swiss) are selected for long lactation periods, while local breeds (for example, Red Sindhi, Sahiwal) show excellent resistance to diseases. The two can be cross-bred to get animals with both the desired qualities.

Question

1. *Which method is commonly used for improving cattle breeds and why?*

Activity 12.3

- Visit a livestock farm. Note the following:
  (1) Number of cattle and number of different breeds.
  (2) The amount of daily milk production from the different breeds.

Proper cleaning and shelter facilities for cows and buffaloes are required for humane farming, for the health of the animals and for production of clean milk as well. Animals require regular brushing to remove dirt and loose hair. They should be sheltered under well-ventilated roofed sheds that protect them from rain, heat and cold. The floor of the cattle shed needs to be sloping so as to stay dry and to facilitate cleaning.

The food requirements of dairy animals are of two types: (a) maintenance requirement, which is the food required to support the animal to live a healthy life, and (b) milk producing requirement, which is the type of food required during the lactation period. Animal feed includes: (a) roughage, which is largely fibre, and (b) concentrates, which are low in fibre and contain relatively high levels of proteins and other nutrients. Cattle need balanced rations containing all nutrients in proportionate amounts. Besides such nutritious food material, certain feed additives containing micronutrients promote the health and milk output of dairy animals.

Cattle suffer from a number of diseases. The diseases, besides causing death, reduce milk production. A healthy animal feeds regularly and has a normal posture. The parasites of cattle may be both external parasites and internal parasites. The external parasites live on the skin and mainly cause skin diseases. The internal parasites like worms, affect stomach and intestine while flukes damage the liver. Infectious diseases are also caused by bacteria and viruses. Vaccinations are given to farm animals against many major viral and bacterial diseases.

12.2.2 Poultry Farming

Poultry farming is undertaken to raise domestic fowl for egg production and chicken meat. Therefore, improved poultry breeds are developed and farmed to produce layers for eggs and broilers for meat.

The cross-breeding programmes between Indian (indigenous, for example, *Aseel*) and foreign (exotic, for example, Leghorn) breeds for variety improvement are focused on to develop new varieties for the following desirable traits—

(i) number and quality of chicks;

(ii) dwarf broiler parent for commercial chick production;
(iii) summer adaptation capacity/ tolerance to high temperature;
(iv) low maintenance requirements;
(v) reduction in the size of the egg-laying bird with ability to utilise more fibrous cheaper diets formulated using agricultural by-products.

Aseel

Leghorn

Fig. 12.4

Question

1. *Discuss the implications of the following statement:*
"It is interesting to note that poultry is India's most efficient converter of low fibre food stuff (which is unfit for human consumption) into highly nutritious animal protein food."

Egg and Broiler Production

Broiler chickens are fed with vitamin-rich supplementary feed for good growth rate and better feed efficiency. Care is taken to avoid mortality and to maintain feathering and carcass quality. They are produced as broilers and sent to market for meat purposes.

For good production of poultry birds, good management practices are important. These include maintenance of temperature and hygienic conditions in housing and poultry feed, as well as prevention and control of diseases and pests.

The housing, nutritional and environmental requirements of broilers are somewhat different from those of egg layers. The ration (daily food requirement) for broilers is protein rich with adequate fat. The level of vitamins A and K is kept high in the poultry feeds.

Poultry fowl suffer from a number of diseases caused by virus, bacteria, fungi, parasites, as well as from nutritional deficiencies. These necessitate proper cleaning, sanitation, and spraying of disinfectants at regular intervals. Appropriate vaccination can prevent the occurrence of infectious diseases and reduce loss of poultry during an outbreak of disease.

Questions

1. *What management practices are common in dairy and poultry farming?*
2. *What are the differences between broilers and layers and in their management?*

Activity 12.4

- Visit a local poultry farm. Observe types of breeds and note the type of ration, housing and lighting facilities given to them. Identify the growers, layers and broilers.

12.2.3 Fish Production

Fish is a cheap source of animal protein for our food. Fish production includes the finned true fish as well as shellfish such as prawns and molluscs. There are two ways of obtaining fish. One is from natural resources, which is called capture fishing. The other way is by fish farming, which is called culture fishery.

The water source of the fish can be either seawater or fresh water, such as in rivers and ponds. Fishing can thus be done both by capture and culture of fish in marine and freshwater ecosystems.

12.2.3 (i) Marine Fisheries

India's marine fishery resources include 7500 km of coastline and the deep seas

beyond it. Popular marine fish varieties include pomphret, mackerel, tuna, sardines, and Bombay duck. Marine fish are caught using many kinds of fishing nets from fishing boats. Yields are increased by locating large schools of fish in the open sea using satellites and echo-sounders.

Some marine fish of high economic value are also farmed in seawater. This includes finned fishes like mullets, *bhetki*, and pearl spots, shellfish such as prawns (Fig. 12.5), mussels and oysters as well as seaweed. Oysters are also cultivated for the pearls they make.

Macrobrachium rosenbergii (fresh water)

Peneaus monodon (marine)

Fig. 12.5 : *Fresh water and marine prawns*

As marine fish stocks get further depleted, the demand for more fish can only be met by such culture fisheries, a practice called mariculture.

12.2.3 (ii) Inland Fisheries

Fresh water resources include canals, ponds, reservoirs and rivers. Brackish water resources, where seawater and fresh water mix together, such as estuaries and lagoons are also important fish reservoirs. While capture fishing is also done in such inland water bodies, the yield is not high. Most fish production from these resources is through aquaculture.

Fish culture is sometimes done in combination with a rice crop, so that fish are grown in the water in the paddy field. More intensive fish farming can be done in composite fish culture systems. Both local and imported fish species are used in such systems.

In such a system, a combination of five or six fish species is used in a single fishpond. These species are selected so that they do not compete for food among them having different types of food habits. As a result, the food available in all the parts of the pond is used. As Catlas are surface feeders, Rohus feed in the middle-zone of the pond, Mrigals and Common Carps are bottom feeders, and Grass Carps feed on the weeds, together these species (Fig. 12.6) can use all the food in the pond without competing with each other. This increases the fish yield from the pond.

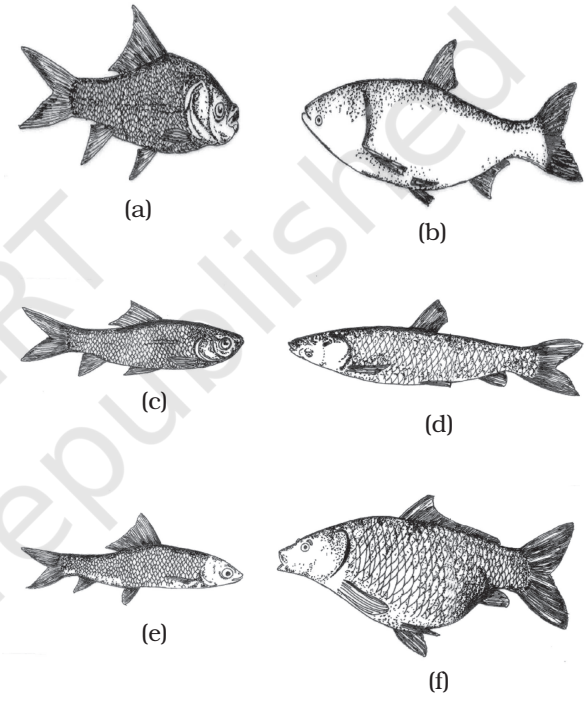

Fig. 12.6: *(a) Catla (b) Silver carp (c) Rohu (d) Grass Carp (e) Mrigal (f) Common Carp*

One problem with such composite fish culture is that many of these fish breed only during monsoon. Even if fish seed is collected from the wild, it can be mixed with that of other species as well. So, a major problem in fish farming is the lack of availability of good-quality seed. To overcome this problem, ways have now been worked out to breed these fish in ponds using hormonal stimulation. This has ensured the supply of pure fish seed in desired quantities.

Questions

1. *How are fish obtained?*
2. *What are the advantages of composite fish culture?*

Activity 12.5

- Visit a fish farm in fish breeding season and note the following:
  (1) Varieties of fish in fish farm
  (2) Types of ponds
  (3) Feed ingredients used
  (4) Production capacity of the farm
  If there are no fish farms close to your locality, gather the above information from Internet, by referring books or talking to people who are engaged in fishery.

12.2.4 Bee-keeping

Honey is widely used and therefore bee-keeping for making honey has become an agricultural enterprise. Since bee-keeping needs low investments, farmers use it as an additional income generating activity. In addition to honey, the beehives are a source of wax which is used in various medicinal preparations.

The local varieties of bees used for commercial honey production are *Apis cerana indica*, commonly known as the Indian bee, *A. dorsata,* the rock bee and *A. florae,* the little bee. An Italian bee variety, *A. mellifera*, has also been brought in to increase yield of honey.

(a) (b)

Fig. 12.7: (a) Arrangement of beehive in an apiary (b) honey extractor

This is the variety commonly used for commercial honey production.

The Italian bees have high honey collection capacity. They sting somewhat less. They stay in a given beehive for long periods, and breed very well. For commercial honey production, bee farms or apiaries are established.

The value or quality of honey depends upon the pasturage, or the flowers available to the bees for nectar and pollen collection. In addition to adequate quantity of pasturage, the kind of flowers available will determine the taste of the honey.

Questions

1. *What are the desirable characters of bee varieties suitable for honey production?*
2. *What is pasturage and how is it related to honey production?*

What you have learnt

- There are several nutrients essential for crops. Of these, some are required in large quantities and are known as macro-nutrients whereas rest of the nutrients are required in small quantities and are known as micro-nutrients.
- Manure and fertilizers are the main sources of nutrient supply to crops.
- Organic farming is a farming system with minimal or no use of chemicals as fertilizers, herbicides, pesticides etc. and

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with a maximum input of organic manures, recyled farm wastes, and bio-agents, with healthy cropping systems.

- Mixed farming is a system of farming on a particular farm which includes crop production, raising of livestock etc.
- Mixed cropping is growing of two or more crops simultaneously on the same piece of land.
- Growing two or more crops in definite row patterns is known as inter-cropping.
- The growing of different crops on a piece of land in pre-planned succession is called crop rotation.
- Varietal improvement is required for higher yield, good quality, biotic and abiotic resistance, shortening the maturity duration, wider adaptability and desirable agronomic characteristics.
- Farm animals require proper care and management such as shelter, feeding, breeding and disease control. This is called animal husbandry.
- Poultry farming is done to raise domestic fowls. Poultry production includes egg production and broiler production for poultry meat.
- To enhance poultry production, cross breeding is done between Indian and exotic breeds for variety improvement.
- Fish may be obtained from marine resources as well as inland resources.
- To increase production of fish, they can be cultured in marine and inland ecosystems.
- Marine fish capture is done by fishing nets guided by echo-sounders and satellites.
- Composite fish culture system is commonly used for fish farming.
- Bee-keeping is done to get honey and wax.

Exercises

1. Explain any one method of crop production which ensures high yield.
2. Why are manure and fertilizers used in fields?
3. What are the advantages of inter-cropping and crop rotation?
4. What is genetic manipulation? How is it useful in agricultural practices?
5. How do storage grain losses occur?
6. How do good animal husbandry practices benefit farmers?
7. What are the benefits of cattle farming?
8. For increasing production, what is common in poultry, fisheries and bee-keeping?
9. How do you differentiate between capture fishing, mariculture and aquaculture?

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