1. Nutrition in Plants

Introduction

All living organisms need food for their existence. Food provides us with energy to carry out various life sustaining activities. Energy is locked in the form of chemical energy in food. To release this energy, the complex food that we eat must be converted to simple substances. This happens during the process of nutrition. Plants being living organisms also perform the process of nutrition. They also need energy to perform various life sustaining activities in their body. As plants do not have mouth or digestive system like we have they take their nutrients from soil and carry them towards leaves to make their food. Nitrogen, phosphorus and potassium are the major nutrients in the bodies of plants.

Nutrition

Nutrition has been derived from the word 'nutrient'. **Nutrient** is a substance which the organisms obtain from the surroundings to derive energy for their maintenance and growth. Thus, the term nutrition refers to the means by which an organism obtains its food and also the process by which nutrients in food are broken down to simpler molecules for utilisation by the body. Various inorganic and organic raw materials are required for building the structure and maintaining the body functions of an organism. They are broken down by different modes of nutrition.

Different Modes of Plant Nutrition

The mechanisms by which organisms obtain their food are referred to as the **modes of nutrition**. Organisms either synthesise their own food or obtain the food prepared by other organisms in various ways. There are basically two modes of nutrition—**autotrophic nutrition** and **heterotrophic nutrition**.

Autotrophic nutrition

'Auto' means self and 'trophic' means food. The organisms which synthesise their own food are called **autotrophs** and this process of synthesising food is called **autotrophic nutrition**. All green plants and cyanobacteria are called the autotrophs. They make their own food with the help of light energy of the Sun, carbon dioxide from the air and water from the soil. This process is called **photosynthesis**.

Photosynthesis: **Photosynthesis** (Fig. 1.1) is the process by which a plant uses the energy from the light of the Sun to make its own food. The conditions required for photosynthesis are:

1. water from the soil
2. sunlight
3. carbon dioxide in the air
4. a green pigment called chlorophyll

Photosynthesis is a complex process. A series of chemical reactions change the raw materials like carbon dioxide and water to the food product **glucose**. The process can be shown simply by looking at the starting materials and the end products. Let us look at the following reaction of photosynthesis.

$$\text{Carbon dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Glucose} + \text{Oxygen}$$

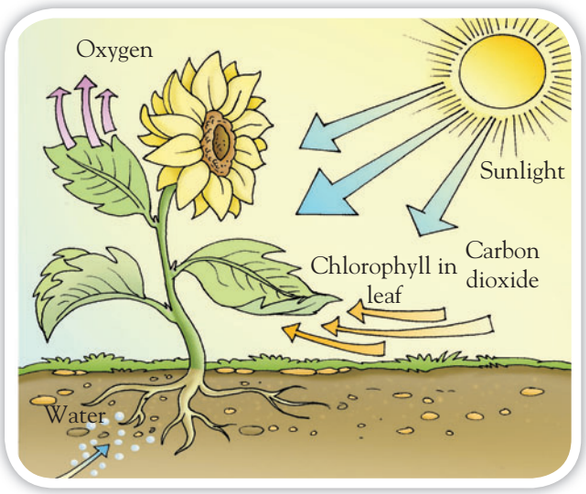

Fig. 1.1 *Photosynthesis*

Sunlight is the major source of energy for photosynthesis. Leaves are the site where photosynthesis takes place. Leaves have some special organelles called **chloroplast** which contains the green pigment **chlorophyll**. Some plants like cacti do not have any leaves. They perform photosynthesis using their green stem.

Carbon dioxide enters the leaf through tiny pores called **stomata**. They are found in the underside of leaves. Gases move in and out through stomata (singular: stoma). Look at Fig. 1.2 to see open and closed stomata.

Water is absorbed from the soil by small root hairs in the ground. There are special conducting tubes called **xylem** which carry water to the food-making cells in the leaves. Carbon dioxide combines with water using the stored energy in the chloroplasts through a chemical reaction to produce the food, i.e. glucose.

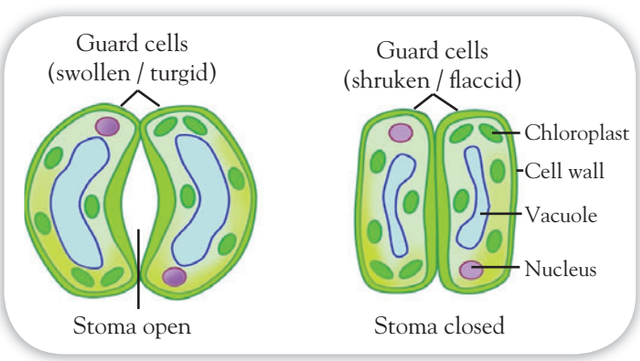

Fig. 1.2 *Open and closed stomata*

The glucose is then transported through special conducting tubes called **phloem** to different parts of the plant. Some of the glucose is used immediately by the plant for energy; some is stored as starch; and some changes to a more complex substance, like cellulose. The vegetables that we eat contain this stored food. The oxygen released during photosynthesis is required for living beings on the Earth. During breathing, we take in oxygen and give out carbon dioxide. Therefore, photosynthesis is a necessary phenomenon on the Earth. It maintains the carbon dioxide-oxygen balance.

Activity 1

The following activity will help you understand that the sunlight is necessary for photosynthesis.

You need some twigs of an aquatic plant (like *Hydrilla),* a dish, a test tube be fitted with a cork and a funnel and water for this experiment. Keep the twigs in a dish filled with water. Invert a test tube be fitted with a cork and a funnel over the twigs (Fig. 1.3).

Keep this set-up in sunlight for some time. Note down your observation.

Next, keep the set-up in shade for some time and note down your observation.

Now, keep the set up in dark and note down your observations.

What do you observe?

When the set-up is kept in sunlight, you find more number of air bubbles (these are oxygen bubbles) coming out from the twigs, than when it is kept in shade. In dark, no air bubbles come out.

This experiment proves that sunlight is necessary for photosynthesis.

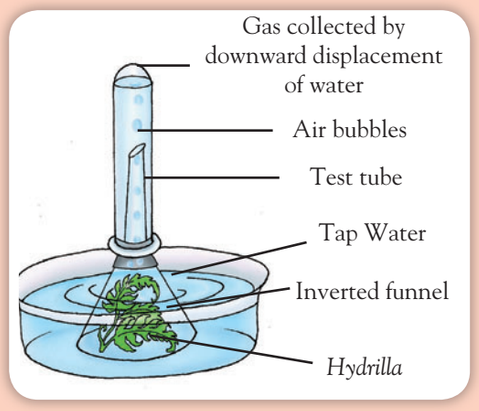

Fig. 1.3 *Beaker with twigs covered by glass funnel. Air bubbles come out through the funnel.*

Joseph Priestley (1733–1804)

Joseph Priestley was an English chemist. He discovered the presence of oxygen in air. Priestley was a brilliant teacher and Unitarian minister. He learned the theories of electricity from Benjamin Franklin. Although Priestley was an amateur scientist, his experiments with electricity and later with gases contributed enormously to the field of chemistry.

Activity 2

The following activity will help you understand that plants cannot make their food without enough sunlight. You need the following:

- a small plant in a tub
- cardboard or aluminium foil
- a pair of scissors
- paper clips

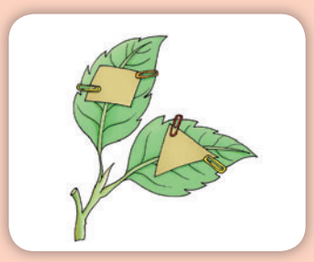

Fig. 1.4 *Cardboard pieces covering the parts of leaves*

Cut out two geometrical shapes like circle, square or triangle from a cardboard or aluminium foil. Make sure that your shapes are big enough to cover nearly half of the plant leaf. Attach the two shapes to two leaves using paperclips (Fig. 1.4). Now keep the plant in a place where it will get plenty of sunlight. Observe the plant for four days. Make notes about weather conditions every day and add them to your observations. After four days, remove the shapes and observe the leaves that were covered by the cut-outs. You see that the areas covered are less green than rest of the green part. This proves that those areas could not take part in photosynthesis as they were covered by cut-outs. This experiment proves that sunlight is essential for photosynthesis.

Do You Know?

- The largest leaves are found in the raffia palm which grows in the islands of the Indian Ocean. Their leaves can reach up to 19.8 m in length.
- In a single year, one hectare of forest absorbs about 22 tonnes of carbon dioxide and gives out 16 tonnes of oxygen.
- When a wheat seed germinates and grows into a fully mature wheat plant, it increases its mass 325 times.
- A farmer who sows 100 kg of seeds per hectare in the spring will harvest 7.5 tonnes of seeds per hectare in the next autumn.

Activity 3

Take two potted plants of the same kind. Keep them in a dark room for 2–3 days before you begin the experiment. Keep pot A in sunlight (Fig. 1.5), and pot B in dark (Fig. 1.6) (or in a dark box) for 3–4 days. After that, pluck out two leaves each from the two plants and test them for the presence of starch.

Boil the leaves in water first. Then boil them in alcohol over a water bath. Note down the colour of the leaves. Now add a few drops of iodine on them. What do you see?

The leaf of pot A turns blue black. This proves the presence of starch in it. The leaf of pot B does not turn blue black. As the plant was kept in dark the leaves could not produce starch. This proves that starch is produced only in the presence of sunlight.

Fig. 1.5 *Pot A kept in sunlight*

Fig. 1.6 *Pot B kept in a dark box*

Do You Know?

Forests are called the 'lungs of the Earth' as they provide us with enormous amount of oxygen for breathing. They also take in carbon dioxide which is harmful for our health and produce oxygen during the exhalation process.

But every year, over 28 million acres of tropical forests are destroyed to create land for farming. The process of cutting down forests is called deforestation. It leads to global warming.

A forest

Activity 4

Do you know where are stomata mostly found? What side of a plant leaf takes in gases? Let us do the following activity.

You need two types of potted plants and Vaseline for this experiment. Coat the top layer of four leaves of one plant with a heavy layer of Vaseline and the bottom layer of four leaves of the other plant with the same amount of Vaseline. Keep the plants in sunlight and observe them daily for one week.

Do you find any difference in the two sets of leaves?

You would see that three of the four leaves that had Vaseline on the underside died, whereas only one leaf with Vaseline on the top layer died.

Therefore, it is proved from this experiment that plant leaves take in gases from their bottom surface, not from the top surface. The Vaseline layer blocked the openings and the leaves could not take in necessary carbon dioxide gas or eliminate excess oxygen gas. Thus the leaves died. This experiment also proves that stomata are present on the bottom surface of the leaves.

Formative Assessment

1. State if the following sentences are True or False.
   a. Carbon dioxide is released during photosynthesis.
   b. Plants which synthesise their own food are called saprotrophs.
   c. The product of photosynthesis is not a protein.
   d. Solar energy is converted into chemical energy during photosynthesis.
   e. Glucose is transported through protein.
2. Choose the correct answer.
   a. Which part of the plant releases oxygen during photosynthesis?
      i. Root hair ii. Stomata
      iii. Leaf veins iv. Sepals
   b. Plants take in carbon dioxide from the atmosphere mainly through their _____.
      i. roots ii. stem
      iii. flowers iv. leaves
   c. The substance which the organisms obtain from the surroundings to derive energy for its maintenance and growth is known as _____.
      i. nutrient ii. sunlight
      iii. chlorophyll iv. soil
   d. The process by which green plants derive their nutrition is _____.
      i. transpiration ii. respiration
      iii. photosynthesis iv. absorption
3. Why is nutrition essential for us?
4. Define nutrition.
5. Give two characteristic features of autotrophic nutrition.
6. Name the raw materials required for autotrophic nutrition.
7. Name the by-product of photosynthesis.

Heterotrophic nutrition

'Hetero' means different and 'trophic' refers to food. The organisms that obtain their food from other organisms are called **heterotrophs** and this process of obtaining food is called **heterotrophic nutrition**. All the heterotrophs depend directly or indirectly on the autotrophic organisms for their food and energy requirements. Although most of the plants have chlorophyll and thus they can manufacture their own food, there are some plants which do not have chlorophyll. Like humans and other animals, such plants depend on the food prepared by other green plants. These plants use heterotrophic mode of nutrition.

According to the mode of nutrition, heterotrophic plants can be classified into the following types:

1. parasitic plants 2. saprophytic plants 3. symbiotic plants 4. insectivorous plants

Parasitic plants

These plants get their food from another green plant known as **host**. Parasitic plants (Fig. 1.7) suck the sap from the stems of the host using their special parasitic roots called **haustoria**. Haustoria penetrate into the host tissue and make connections with the conducting elements of host and draw nourishment.

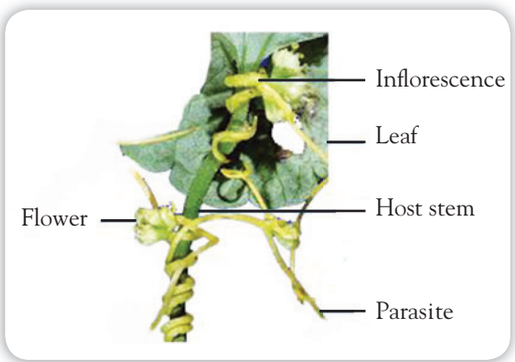

Fig. 1.7 *Parasitic plant*

Only the parasitic plant benefits from this relationship. Such a mode of nutrition is called **parasitic nutrition**.

The common examples of parasitic plants are *Cuscuta* (Dodder), *Orobanche* and *Viscum* (Mistletoe). They do not have chlorophyll in their body and thus they get all their food from the host plants. Let us study about these plants.

Fig. 1.8 *A picture showing haustoria in Cuscuta*

Cuscuta: *Cuscuta* can be identified by its thin stems with the leaves reduced to minute scales. A *Cuscuta* attaches itself to an adjacent plant and wraps itself around it. If the host contains food beneficial to *Cuscuta*, the latter produces haustoria that penetrates vascular system of the host (Fig. 1.8). The original root of the *Cuscuta* in the soil then dies and it gets all the nourishment from the body of the host plant. One *Cuscuta* plant can attach to a number of host plants such as alfalfa, clover, potatoes, *Chrysanthemum*, *Dahlia*, ivy, petunias, etc.

Orobanche: *Orobanche* (broomrapes) are the root parasites of a wide range of plants having broad leaves. They lack chlorophyll and appear above the ground only when they flower. Like *Cuscuta*, broomrapes also have a number of hosts that include pea, bean, lentil, tomato, potato, capsicum, lettuce, etc. *Orobanche* cannot make its own food by photosynthesis as it does not have chlorophyll. Thus, it obtains all its nutrition from the host plant. Its long-lived seeds germinate in response to chemicals coming out from the roots of its potential host plants. The seedling does not emerge above the ground, but forms a haustorium connecting it to the root of the host root and develops into tissues integrated into the host root.

Fig. 1.9 *Orobanche on a sunflower stem*

Viscum: The common name of *Viscum* is mistletoe (Fig. 1.10). It is a parasitic evergreen shrub that grows high up in the branches of old trees. The plant extracts its essential mineral nutrients and water by sending out roots into the bark of the host trees. The most common host of mistletoe is apple tree, though it can also grow on other trees with soft bark, like oak, chestnut, black poplar, and various fruit trees.

Fig. 1.10 *Viscum*

Saprophytic plants

Saprophytic plants get their nutrition from dead and decaying organic matter. They are usually white in colour, although they can have bright colourful flowers. The common examples of saprophytic plants are *Rhizopus* (bread mould), *Mucor* (pin mould), Yeast (Fig. 1.11) and *Agaricus* (mushroom).

These plants grow on rotting material and suck their nutrients using tiny hairs.

Fig. 1.11 *Yeast*

Fig. 1.12 *Magnified yeast cell*

Activity 5

Take a piece of bread and sprinkle a little water on it. Leave it for 2–3 days.

What do you find after 2 to 3 days? There is a cotton-like black coloured growth on the bread. These are saprophytic plants. For example, bread moulds sucking their food material from the rotting bread (Fig. 1.13).

Fig. 1.13 *Bread mould*

Fig. 1.14 *Agaricus*

Symbiotic plants

There are certain plants that grow on other plants and share their food material. None of the plants is harmed from this association. Such plants are called **symbiotic plants**. One of the plants of a symbiotic association is autotroph and thus it can manufacture its food from sunlight. The other plant gets its food from this partner.

Lichen (Fig. 1.15) is a good example of symbiotic plant. The body of lichen consists of algae and fungi. They live in close physical

Fig. 1.15 *Lichen*

contact with each other. Algae being green provide food material to the fungal component in the lichen. In return, the fungi provides shelter, water and minerals to the algae.

Another good example of symbiotic relationship is mycorrhiza. *Myco* means 'fungus' and *rhiza* means 'root' in Greek. So the word mycorrhiza literally means 'fungus-root'. Mycorrhiza is the symbiotic association between the roots of some plants and fungi. The hyphae (root like organs) of certain fungi form specialised sheaths around the roots of certain plants. This fungal root-coating is called mycorrhiza. The plant provides its food to the fungi and the fungi help the plant by providing it with the necessary nutrients and by improving the plant's ability to store carbohydrates. Mycorrhiza is seen in some mushrooms and orchids.

Fig. 1.16 *Hyphae as seen under an overturned log*

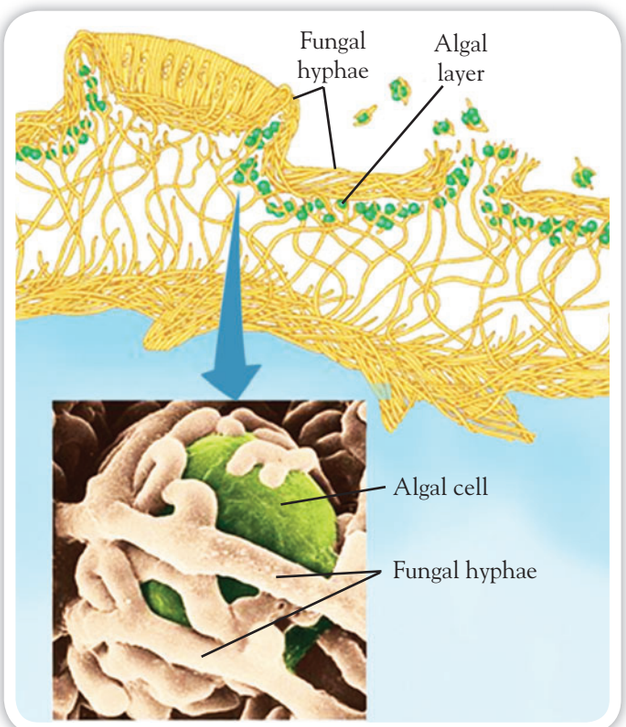

Fig. 1.17 *Fungal hyphae and algal cell*

Fig. 1.18 *Bladderwort suction trap in action*

Insectivorous plants

There are some plants that feed on the insects trapped within their leaves. The soil where they grow does not have enough nutrients, especially nitrogen. Therefore they obtain their nutrients from insect's bodies. Thus they are called **insectivorous plants** or **carnivorous plants**.

The leaves of insectivorous plants are modified in several ways for trapping insects. The trapped insects are killed by these plants and the nutrients of the insects' bodies are sucked by the plants.

The common examples of insectivorous plants are pitcher plant, sundew, bladderwort (Fig. 1.18) and venus flytrap (Fig. 1.19).

Fig. 1.19 *Venus flytrap with insect*

Pitcher plant: In the pitcher plants, leaves are modified to form pitchers or cup-like structures (Fig. 1.20). These pitchers are hollow tubes which open at the top and are completely or partially covered by a specialised flap or hood. The brightly coloured hood often secretes nectar and attracts insects or other preys. The inside of the pitchers is lined with downward pointing hair. Once an insect is trapped by the pitcher (Fig. 1.21), the hood closes down and the hair prevent the insect from crawling out. There is a small pool of water at the bottom of the pitcher. The insect drowns here and its body is decomposed by digestive acids secreted into the water by the plant. The result is a nitrogen-rich 'liquid food' available to the plant.

Fig. 1.20 *Pitcher plant*

Fig. 1.21 *Pitcher plant with insect*

Fig. 1.22 *Sundew plant*

Do You Know?

Not all insects fall prey to the pitcher plant. Some aquatic flies spend their aquatic larval stage in the watery stomach of the pitcher plant. But they are not attacked by this plant. Adults of these flies being small enough can simply fly up through the tube and escape. These flies feed on the bacteria living in the drowned insects in the nitrogen-rich liquid.

Sundew: The sundews are named so because their glandular leaf hairs glisten like dew in the Sun (Fig. 1.22). These plants are found on sandy banks and other mineral soils poor in organic nitrogen and phosphorus. The leaves of sundew have tentacles with a sticky substance called **mucilage**. The leaf hair of these plants also contain stalked glands. These glands produce digestive juices and decompose the trapped prey. The digestive enzymes increase in production once a prey has been captured, reaching its maximum concentration about the fourth day.

Formative Assessment

1. Choose the correct answer.
   a. Which one of the following is not an insectivorous plant?
      i. Bladderwort ii. Lichen iii. Pitcher plant iv. Sundew
   b. Stomata are surrounded by _____.
      i. guard cells ii. chlorophyll iii. carbohydrates iv. epidermal cells
   c. Which of the following is a parasitic plant?
      i. *Cuscuta* ii. Algae iii. Pitcher plant iv. Lichen
   d. *Orobanche* is the example of a/an _____ plant.
      i. parasitic ii. saprophytic iii. symbiotic iv. insectivorous

2. Match the correct answer.

a. nutrition	i. organism deriving its food from dead and decaying plants and animals
b. parasite	ii. association of two different organisms in which both are benefited
c. saprophyte	iii. process of obtaining and utilising food
d. symbiosis	iv. organism that derives its food from the living body of another organism

3. What is lichen?
4. Why in the rainy season does a loaf of bread turn blue, brown or greenish?
5. Why does the pitcher plant feed on insects though it is green?
6. Give an example of a symbiotic association.

Points to Remember

- All living organisms carry out various life sustaining activities for their existence.
- Energy is required to carry out the life sustaining activities.
- Nutrient is a substance which the organisms obtain from the surroundings to derive energy for their growth and maintenance.
- Autotrophic organisms synthesise food with the help of light energy of the Sun, carbon dioxide and water.
- Photosynthesis is the process by which a plant uses the energy from the sunlight to make its food.
- There are special conducting tubes called xylem which carries water to the food-making cells.
- The plant food glucose is transported through special conducting tubes called phloem.
- The organisms which obtain their food from other organisms are called heterotrophs and the process of obtaining the food from other organisms is called heterotrophic nutrition.
- Saprotrophic nutrition is the process by which the organisms feed on dead and decaying matter.
- In a symbiotic association, two organisms live in close physical contact with each other and are mutually benefited.
- Insectivorous plants trap insects to get nutrients that are deficient in soil.

Important Definitions

- **Enzymes** chemicals present in living organisms that help in digestion
- **Xylem** special conducting tubes present in plants that transport water from roots to other parts of plant
- **Phloem** special conducting tubes present in plants that transport food from leaves to other parts of plant
- **Autotrophic nutrition** nutrition in organisms (mostly green plants) where they can prepare their own food from simple inorganic molecules
- **Autotrophs** organisms which synthesise their own food
- **Chlorophyll** the green pigment present in the leaves
- **Heterotrophic nutrition** nutrition derived from dead or living organisms
- **Heterotrophs** the organisms that obtain their food from other organisms
- **Insectivorous plants** insect-eating plants