UNIT 19

PLANT PHYSIOLOGY

Learning Objectives

After completing this lesson, students will be able to:

- know that plants too have certain autonomic movements.
- understand different types of movement in plants.
- differentiate tropic movement from nastic movement.
- gain knowledge on transpiration.
- understand that plants produce their food through the process of photosynthesis.
- understand the process of transpiration.

Introduction

Animals move in search of food, shelter and for reproduction. Do plants show such movement? Have you observed the leaves of *Mimosa pudica* (touch-me-not plant) closes on touching, whereas *Helianthus annuus* (sunflower) follows the path of the sun from dawn to dusk, (from east to west). These movements are triggered by an external stimuli. Unlike animals, plants do not move on their own from one place to another, but can move their body parts for getting sunlight, water and nutrients. They are sensitive to external factors like light, gravity, temperature etc. In this lesson, we will study about various movements in plants, photosynthesis and transpiration.

19.1 Tropism in Plants

Tropism is a unidirectional movement of a whole or part of a plant towards the direction of stimuli.

19.1.1 Types of Tropism

Based on the nature of stimuli, tropism can be classified as follows.

Phototropism: Movement of a plant part towards light. e.g. shoot of a plant.

Geotropism: Movement of a plant in response to gravity. e.g. root of a plant.

Hydrotropism: Movement of a plant or part of a plant towards water. e.g root of a plant.

Thigmotropism: Movement of a plant part due to touch. e.g. climbing vines.

Chemotropism: Movement of a part of plant in response to chemicals. e.g growth of a pollen tube in response to sugar present on the stigma.

Tropism is generally termed **positive** if growth is **towards the signal** and **negative** if it is **away from the signal**. Shoot of a plant moves towards the light, the roots move away. Thus the shoots are **positively phototropic.**

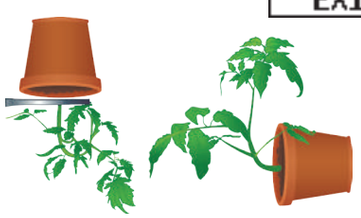


Figure 19.1 Positive phototropism (Negatively geotropic)

Usually shoot system of a plant is positively phototropic and negatively geotropic and root system is negatively phototropic and positively geotropic.

Figure 19.2 Negative phototropism (Positively geotropic)

DO YOU KNOW?

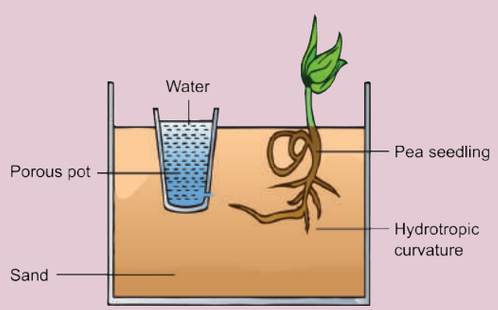
Some halophytes produce negatively geotropic roots (e.g. Rhizophora). These roots turn 180° upright for respiration.

19.2 Nastic Movements

Nastic movements are non-directional response of a plant or part of a plant to stimulus. Based on the nature of stimuli, nastic movements are classified as follows.

Activity 1

Take a glass trough and fill it with sand. Keep a flower pot containing water, plugged at the bottom at the centre of the glass trough. Place some soaked pea or bean seeds around the pot in the sand. What do you observe after 6 or 7 days? Record your observation.



Activity 2

Take pea seeds soaked in water overnight. Wait for the pea seeds to germinate. Once the seedling has grown put it in a box with an opening for light on one side. After few hours, you can clearly see how the stem has bent and grown towards the light.

Photonasty: Movement of a part of a plant in response to light. e.g.*Taraxacum officinale*, blooms in morning and closes in the evening. Similarly, *Ipomea alba* (Moon flower), opens in the night and closes during the day.

Night

Day

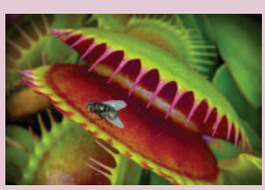
Figure 19.3 Photonasty in Moon flower

Thigmonasty: Movement of a part of plant in response to touch. e.g. *Mimosa pudica*, folds leaves and droops when touched. It is also known as Seismonasty.

Figure 19.4 Thigmonasty in Mimosa pudica

DO YOU KNOW?

The Venus Flytrap (*Dionaea muscipula*) presents a spectacular example of thigmonasty. It exhibits one of the fastest known nastic movement.



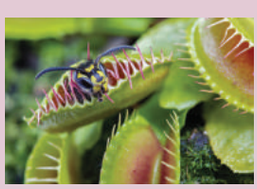


Table 19.1 Differences between Tropic and Nastic movements

Tropic movements	Nastic movements
Unidirectional response to the stimulus.	Non-directional response to the stimulus.
Growth dependent movements.	Growth independent movements.
More or less permanent and irreversible.	Temporary and reversible.
Found in all plants.	Found only in a few specialized plants.
Slow action.	Immediate action.

Thermonasty: Movement of part of a plant is associated with change in temperature. e.g. *Tulip* flowers bloom as the temperature increases.

Figure 19.5 Thermonasty in Tulip

19.3 Photosynthesis

'Photo' means 'light' and 'synthesis' means 'to build'. Thus photosynthesis literally means 'building up with the help of light'. During this process, the light energy is converted into chemical energy. Green plants are autotrophic in their mode of nutrition because they prepare their food materials through a process called photosynthesis. The overall equation of photosynthesis can be given as below:

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6H_2O + 6O_2\uparrow$$

Carbon dioxide — Water — Gluose — Water — Oxygen

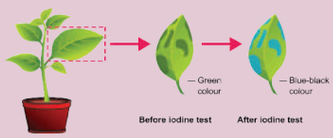
Do the insects also trap solar energy? Tel Aviv University Scientists have found out that *Vespa orientalis* (Oriental Hornets) have similar capabilities to trap solar energy. They have a yellow patch on its abdomen and an unusual cuticle structure which is a stack of 30 layers thick. The cuticle does not contain chlorophyll but it contains the yellow light sensitive pigment called xanthopterin. This works as a light harvesting molecule transforming light energy into electrical energy.

The end product of photosynthesis is glucose which will be converted into starch and stored in the plant body. Plants take in carbon dioxide for photosynthesis; but for its living, plants also need oxygen to carry on cellular respiration.

19.3.1 Requirements for Photosynthesis'

Activity 3

Pluck a variegated leaf from *Coleus* plant kept in sunlight. De-starch it by keeping in dark room for 24 hours. Draw the picture of this leaf and mark the patches of cholorphyll on the leaf. Immerse the leaf in boiling water followed by alcohol and test it for starch using iodine solution.Record your observation.



Activity 4

Place a potted plant in a dark room for about 2 days to de-starch its leaves. Cover one of its leaves with the thin strip of black paper as shown in the picture. make sure that the leaf is covered on both sides. Keep the potted plant in bright sunlight for 4 to 6 hours. Pluck the selected covered leaf and remove the black paper. Immerse the leaf in boiling water for a few minutes and then in alcohol to remove chlorophyll. Test the leaf now with iodine solution for the presence of starch. The covered part of the leaf does not turn blue-black whereas the uncovered part of the leaf turns blue-black colour.

Why are the changes in colour noted in the covered and uncovered part of the leaf?

These activities show that certain things are necessary for photosynthesis. They are:

1. Chlorophyll - Green pigment in leaves
2. Water
3. Carbon dioxide (from air)
4. Sun light

19.4 Transpiration

The loss of water in the form of water vapour from the aerial parts of the plant body is called as transpiration. The leaves have tiny, microscopic pores called **stomata**. Water evaporates through these stomata. Each stomata is surrounded by guard cells. These guard cells help in regulating the rate of transpiration by opening and closing of stomata.

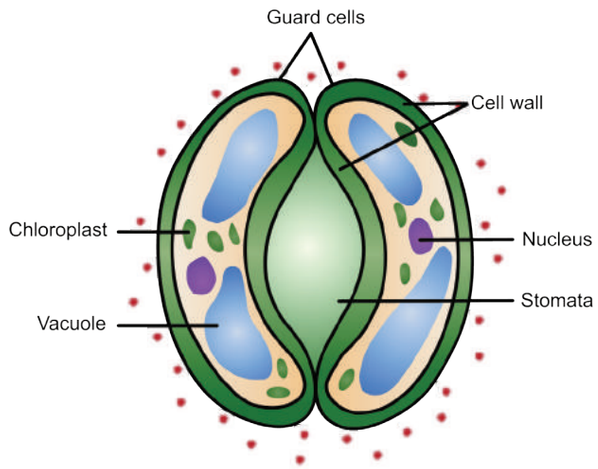


Figure 19.6 Structure of Stomata

19.4.1 Types of Transpiration

There are three types of transpiration:

Stomatal transpiration: Loss of water from plants through stomata. It accounts for 90-95% of the water transpired from leaves.

Cuticular transpiration: Loss of water in plants through the cuticle.

Lenticular transpiration: Loss of water from plants as vapour through the lenticels. The lenticels are tiny openings that protrude from the barks in woody stems and twigs as well as in other plant organs.

But transpiration is necessary for the following reasons.

1. It creates a pull in leaf and stem.
2. It creates an absorption force in roots.
3. It is necessary for continuous supply of minerals.
4. It regulates the temperature of the plant.

Activity 5

Take a plastic bag and tie it over a leaf and place the plant in light. You can see water condensing inside the plastic bag. The water is let out by the leaves. Why does this occur?

19.4.2 Exchange of Gases

How does the plant get air? The leaves have minute pores called **stomata** through which the exchange of air takes place. These minute pores can be seen through a microscope. Air exchange takes place continuously through the stomata. Plants exchange gases (CO_2 to O_2) continuously through these stomata. You will study more about these physiological process in your higher classes.

Points to Remember

- Growth movement whose direction is determined by the direction of the stimulus is called Tropism.
- Non-directional, response of a plant part to stimulus is called nastic movement.
- The process by which plants prepare their food material is called photosynthesis.
- The loss of water in the form of water vapour from the aerial parts of the plant body is called transpiration.
- Stomata are minute opening on the leaves.

A-Z GLOSSARY

Phototropism	Unidirectional movement of a plant part to light stimulus.
Geotropism	Response of a plant part to gravity stimulus.
Hydrotropism	Response of a plant part to water stimulus.
Thigmotropism	Response of a plant part to touch stimulus.
Chemotropism	Response of a plant part to chemical stimulus.
Thigmonasty	Non-directional movement of a plant part in response to touch of an stimulus.
Photonasty	Non-directional movement of a plant part in response to light stimulus.

EXANR9

TEXTBOOK EXERCISES

I. Choose the correct answer.

1. The tropic movement that helps the climbing vines to find a suitable support is _____.
   a. Phototropism b. Geotropism
   c. Thigmotropism d. Chemotropism

2. The chemical reaction occurs during photosynthesis is _____.
   a. CO_2 is reduced and water is oxidized
   b. water is reduced and CO_2 is oxidized
   c. both CO_2 and water are oxidized
   d. both CO_2 and water are produced

3. The bending of root of a plant in response to water is called _____.
   a. Thigmonasty b. Phototropism
   c. Hydrotropism d. Photonasty

4. A growing seedling is kept in the dark room. A burning candle is placed near it for a few days. The tip part of the seedling bends towards the burning candle. This is an example of _____.
   a) Chemotropism b) Geotropism
   c) Phototropism d) Thigmotropism

5. The root of the plant is _____.
   i) positively phototropic but negatively geotropic
   ii) positively geotropic but negatively phototropic
   iii) negatively phototropic but positively hydrotropic
   iv) negatively hydrotropic but positively phototropic
   a) (i) and (ii) b) (ii) and (iii)
   c) (iii) and (iv) d) (i) and (iv)

6. The non-directional movement of a plant part in response to temperature is called _____.
   a) Thermotropism b) Thermonasty
   c) Chemotropism d) Thigmonasty

7. Chlorophyll in a leaf is required for _____.
   a) photosynthesis b) tropic movement
   c) transpiration d) nastic movement

9. Transpiration takes place through _____.
   a) fruit b) seed c) flower d) stomata

II. Fill in the blanks.

1. The shoot system grows upward in response to _____
2. _____ is positively hydrotropic as well as positively geotropic.
3. The green pigment present in the plant is _____
4. The solar tracking of sunflower in accordance with the path of sun is due to _____.
5. The response of a plant part towards gravity is _____.
6. Plants take in carbondioxide for photosynthesis but need _____ for their living.

III. Match column A with column B.

Column A	Column B
Roots growing downwards into soil.	Positive phototropism
Shoots growing towards the light.	Negative geotropism
Shoots growing upward.	Negative phototropism
Roots growing downwards away from light.	Positive geotropism

IV. State whether true or false. If false, correct the statement.

1. The response of a part of plant to the chemical stimulus is called phototropism.
2. Shoot is positively phototropic and negatively geotropic.
3. When the weather is hot, water evaporates lesser which is due to opening of stomata.
4. Photosynthesis produces glucose and carbon dioxide.
5. Photosynthesis is important in releasing oxygen to keep the atmosphere in balance.
6. Plants lose water when the stomata on leaves are closed.

V. Answer very briefly.

1. What is nastic movement?
2. Name the plant part
   a) Which bends in the direction of gravity but away from the light.
   b) Which bends towards light but away from the force of gravity.
3. Differentiate phototropism from photonasty.
4. Photosynthesis converts energy X into energy Y.
   a) What are X and Y?
   b) Green plants are autotrophic in their mode of nutrition. Why?
5. Define transpiration.
6. Name the cell that surrounds the stoma.

VI. Answer briefly.

1. Give the technical terms for the following:
   a) Growth dependent movement in plants.
   b) Growth independent movement in plants.
2. Explain the movement seen in Pneumatophores of Avicennia.
3. Fill in the blanks:

$$6CO_2 + \_\_\_ \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \_\_\_ + 6O_2\uparrow$$

4. What is chlorophyll?
5. Name the part of plant which shows positive geotropism. Why?
6. What is the difference between movement of flower in sunflower plant and closing of the leaves in the *Mimosa pudica?*

7. Suppose you have a rose plant growing in a pot, how will you demonstrate transpiration in it?
8. Mention the differences between stomatal and lenticular transpiration
9. To which directional stimuli do (a) roots respond (b) shoots respond?

VII. Answer in detail.

1. Differentiate between tropic and nastic movements
2. How will you differentiate the different types of transpiration?

VIII. Higher Order Thinking Skills.

1. There are 3 plants A, B and C. The flowers of A open their petals in bright light during the day but closes when it gets dark at night. On the other hand, the flowers of plant B open their petals at night but closes during the day when there is bright light. The leaves of plant C fold up and droop when touched with fingers or any other solid object.
   a) Name the phenomenon shown by the flowers of plant A and B.
   b) Name one plant each which behaves like the flowers of plant A and B.
   c) Name the phenomenon exhibited by the leaves of plant C.
   d) Name the plant which behaves like the leaves of plant 'C'?
2. Imagine that student A studied the importance of certain factors in photosynthesis. He took a potted plant and kept it in dark for 24 hours. In the early hours of the next morning, he covered one of the leaves with dark paper in the centre only. Then he placed the plant in sunlight for a few hours and tested the leaf which was covered with black paper for starch.
   a) What aspect of photosynthesis was being investigated?
   b) Why was the plant kept in the dark before the experiment?
   c) How will you prove that starch is present in the leaves?
   d) Name the raw materials needed for photosynthesis.

REFERENCE BOOKS

1. Devlin and Witham, 1986. Plant Physiology, 1st edition
2. B.P. Pandey 2003 Modern Practical Botany Vol. II.
3. V.K. Jain 2003 Plant physiology.

INTERNET RESOURCES

http://web.mit.edu/esgbio

http://www.bioedonline.org/

http://www.biology.arizona.edu/default.html

Concept Map