1. By looking at a plant externally, can you tell whether a plant is C_3 or C_4? Why and how?

Solution:

Though plants which are adapted to dry tropical climates have the C_4 pathway, they do not show any external morphologic characteristics. Hence, it is not possible to say whether the plant is C_3 or C_4 by looking at its external appearance.

2. By looking at which internal structure of a plant can you tell whether a plant is C_3 or C_4? Explain.

Solution:

Leaves of C_4 plants have kranz anatomy, which makes them different from C_3 plants. C_4 plants also have specialised cells called bundle sheath cells which surround the vascular bundles. Every cell of the bundle sheath has chloroplasts. The mesophyll cells of leaves do not differentiate into the spongy and palisade parenchyma possessing fewer intercellular spaces, while there is a normal occurrence of chloroplasts in the mesophyll cells. But in C_3 plants, the bundle sheath does not exhibit chloroplast, and the mesophyll cells of the leaves are differentiated into the spongy and palisade parenchyma. Hence, by examining the internal structure, we can tell whether the plant is C_3 or C_4.

3. Even though very few cells in a C_4 plant carry out the biosynthetic – Calvin pathway, yet they are highly productive. Can you discuss why?

Solution:

Plant productivity can be estimated by the rate at which photosynthesis takes place. The amount of carbon dioxide in a plant is directly proportional to the rate of photosynthesis. In C_4 plants, very few of the cells carry out the biosynthetic pathway, yet they are highly productive for the following reasons:

- They have a mechanism that increases the CO_2 concentration at the site of the enzyme.
- Mesophyll cells are broken down in the bundle sheath cells, resulting in CO_2 release, which, in turn, increases the intracellular CO_2 concentration.
- Rubisco functions as a carboxylase, minimising oxygenase activity.
- An increase in photosynthesis makes C_4 plants more productive.

4. RuBisCO is an enzyme that acts both as a carboxylase and oxygenase. Why do you think RuBisCO carries out more carboxylation in C_4 plants?

Solution:

The affinity of RUBISCO is much higher than its affinity for Oxygen. It is the concentration of Oxygen and CO_2 that determines the binding of the enzyme. Mesophyll cells of C_4 plants lack this enzyme but are found in the bundle sheath cells that girdle the vascular bundles where the Calvin cycle occurs.

RuBisco functions as oxygenase when the concentration of Oxygen is higher, and it acts as carboxylase when the concentration of CO_2 is high. In the mesophyll cells, the primary carbon dioxide acceptor is a three-carbon compound – phosphoenol pyruvate, which is converted into a four-carbon compound, oxaloacetic acid or OAA. This is converted further into malic acid, which is transported to the bundle-sheath cells where it undergoes decarboxylation, and carbon fixation takes place through the Calvin cycle, which prevents RuBisCo from serving as an oxygenase.

5. Suppose there were plants that had a high concentration of Chlorophyll b but lacked chlorophyll a. Would they carry out photosynthesis? Then, why do plants have chlorophyll b and other accessory pigments?

Solution:

In the absence of chlorophyll-a, photosynthesis will not take place because chlorophyll-a is a reaction centre responsible for the conversion of solar energy into chemical energy. Although chlorophyll is the primary pigment that traps sunlight, accessory pigments like chlorophyll-b, xanthophylls and carotenoids also absorb sunlight and transfer energy to chlorophyll-a.

6. Why is the colour of a leaf kept in the dark, frequently yellow or pale green? Which pigment do you think is more stable?

Solution:

Chlorophyll fails to absorb the energy in the absence of light; hence, it loses stability to give the leaf yellow colouration. This proves that carotenoids, which impart yellow colour, are more stable.

7. Look at the leaves of the same plant on the shady side and compare them with the leaves on the sunny side. Or, compare the potted plants kept in the sunlight with those in the shade. Which of them has leaves that are darker green? Why?

Solution:

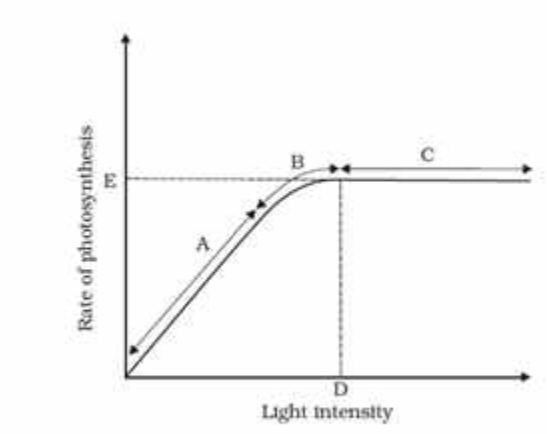
Leaves in the shade get less sunlight to carry out photosynthesis than plants kept in sunlight. In leaves that get less sunlight, more chlorophyll is present to carry out photosynthesis efficiently. In the presence of strong light, the orientation of the chloroplasts in the mesophyll cells is irregular and in vertical files along the walls. Also, in bright light, photooxidation of chloroplasts takes place, while non-oxidation takes place in shaded regions. Hence, the plants kept in the shade have dark green leaves due to the high concentration of chlorophyll.

8. Figure shows the effect of light on the rate of photosynthesis. Based on the graph, answer the following questions:

(a) At which point/s (A, B or C) in the curve is light a limiting factor?

(b) What could be the limiting factor/s in region A?

(c) What do C and D represent on the curve?



Graph of light intensity on the rate of photosynthesis

Solution:

a) Light is a limiting factor at A and 50% of B, which is due to the increase in the photosynthetic rate with an increase in the intensity of light.

b) Light, CO_2 and H_2O could be the limiting factor/s in region A.

c) C indicates a stage beyond which light is not a limiting factor, and D is the line beyond which the intensity of light does not affect the photosynthetic rate.

9. Give a comparison between the following:

(a) C_3 and C_4 pathways

(b) Cyclic and non-cyclic photophosphorylation

(c) Anatomy of leaf in C_3 and C_4 plants

Solution:

a) **C_3 and C_4 pathways**

C_3 Pathway	**C_4 Pathway**
RUBP is the primary acceptor of CO_2.	PEP is the primary acceptor of CO_2
3- Phosphoglycerate is the first stable product.	Oxaloacetic acid is the first stable product.
Occurs in the mesophyll cell of the leaves.	Occurs in mesophyll cells and bundle sheath.
The process of Carbon fixation is slower.	The process of Carbon fixation is faster.

b) **Cyclic and non-cyclic photophosphorylation**

Cyclic photophosphorylation	**Non-cyclic photophosphorylation**
Occurs only in photosystem-I.	Occurs both in Photosystem-I and II.

ATP is produced.	ATP and $NADPH_2$ are produced.
Photolysis of water does not occur; hence, Oxygen is not produced.	Photolysis of water occurs; hence, Oxygen is produced.
Electrons move in a closed circle.	Electrons do not move in a closed circle.

c) **Anatomy of leaf in C_3 and C_4 plants**

Anatomy of leaf in C_3	**Anatomy of leaf in C_4**
Do not possess Kranz anatomy.	They have Kranz anatomy.
Chloroplasts are not dimorphic.	Chloroplasts are dimorphic and organised centripetally. The size of bundle sheaths is larger.
Mesophyll cells possess intercellular space.	Mesophyll cells do not possess intercellular space.