Chapter 13
Photosynthesis in Higher Plants

Question 1:
By looking at a plant externally can you tell whether a plant is C_3 and C_4 ? Why and how?

Solution 1:
We can't tell whether a plant is C_3 or C_4 by looking a plant externally. However, plants which are adapted to dry climates follow C_4 pathway. Unlike C_3 plants, the leaves of C_4 plants have a special anatomy, but these differences can only be observed at the cellular level.

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

Solution 2:
As leaves of C_4 plants have special anatomy called Kranz anatomy, this makes them different from C_3 plants. C_4 plants also have special cells, known as bundle-sheath cells that surround the vascular bundles. These cells have a large number of chloroplasts. They are thick-walled and have no intercellular spaces. Therefore, we can tell whether a plant is C_3 or C_4 through internal structure.

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

Solution 3:
In C_4 plants, photorespiration does not occur because they have a mechanism that increases the concentration of CO_2 at the enzyme site. This takes place when the C_4 acid from the mesophyll is broken down in the bundle sheath cells to release CO_2 that results in increasing the intracellular concentration of CO_2. In turn, this ensures that the RuBisCO functions as a carboxylase minimising the oxygenase activity. Thus, the photosynthesis rate increases and makes C_4 plants more productive.

Question 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 4:
The enzyme RuBisCo is absent from the mesophyll cells of C_4 plants. It is rather present in the bundle-sheath cells surrounding the vascular bundles. Thus in C_4 plants, the Calvin cycle occurs in the bundle-sheath cells. The primary CO_2 acceptor in the mesophyll cells is phosphoenol pyruvate – a three – carbon compound. It is converted into the four-carbon compound oxaloacetic acid (OAA). OAA is further converted into malic acid. Malic acid is transported to the bundle-sheath cells, where it undergoes decarboxylation and CO_2 fixation occurs by the Calvin cycle. This prevents the enzyme RuBisCo from acting as an oxygenase.

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

Solution 5:
If there were complete absence of chlorophyll a in a plant, it would not carry out photosynthetic activity at all because chlorophyll a is the chief pigment associated with photosynthesis as it traps light. Other accessory pigments like chlorophyll b, xanthophylls and carotenoids are equally essential as they also absorb light and transfer energy to chlorophyll a. They also enable a wider range of wavelength of incoming light to be utilised for photosynthesis and protect chlorophyll a from photo-oxidation.

Question 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 6:
Chlorophyll or green pigment is unable to absorb energy in the absence of light therefore losses its stability. Thus, the colour of leaf changes of yellow or pale green. This shows that the accessory pigments - Carotenoids and Xanthophyll are more stable.

Question 7:

Look at leaves of the same plant on the shady side and compare it 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 7:

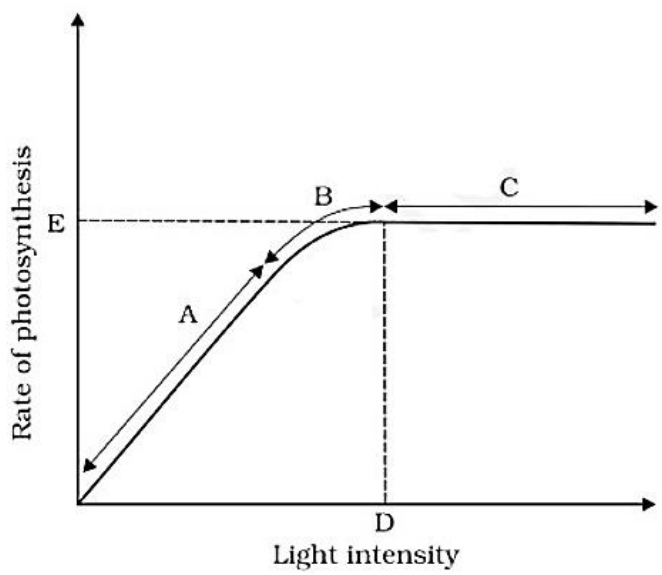
As leaves in shade get lesser light for photosynthesis so they perform lesser photosynthesis as compared to the leaves or plants kept in sunlight. To increase the rate of photosynthesis, the leaves present in shade have more chlorophyll pigments. This increase in chlorophyll content increases the amount of light absorbed by the leaves, which in turn increases the rate of photosynthesis which makes the leaves or plants in shade greener than the leaves or plants kept in the sun.

Question 8:

Given below 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?

Solution 8:



Graph of light intensity on the rate of photosynthesis

(a) In the given graph, light is the limiting factor where photosynthesis is minimum. Hence, at point A light is the limiting factor.
(b) Light is a limiting factor; water, temperature, and the concentration of carbon dioxide could also be limiting factors in the region A.
(c) C represents the stage beyond which light is not a limiting factor. D represents the stage beyond which intensity of light has no effect on the rate of photosynthesis as the maximum rate of photosynthesis has been attained at this point.

Question 9:
Give 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 9:
(a) C_3 and C_4 pathways

C_3 **pathways**	C_4 **pathways**
The primary acceptor of CO_2 is RUBP – a five-carbon compound.	The primary acceptor of CO_2 is phosphoenol pyruvate – a three-carbon compound.
The first stable product is 3 phosphoglycerate.	The first stable product is oxaloacetic acid.
It occurs only in the mesophyll cells of the leaves.	It occurs in the mesophyll and bundle-sheath cells of the leaves.
It is a slower process of carbon fixation and photo-respiratory losses are high.	It is faster process of carbon fixation and photo-respiratory losses are low.

(b) Cyclic and non-cyclic photophosphorylation

Cyclic photophosphorylation	No-cyclic photophosphorylation
It occurs only in photosystem I.	It occurs both in photosystems I and II.
It involves only the synthesis of ATP.	It involves the synthesis of ATP and $NADPH_2$.
In this process, photolysis of water does	In this process, photolysis of water takes

not occur. Therefore, oxygen is not produced.	place and oxygen is liberated.
In the process, electrons move in a closed circle.	In this process, 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**
Bundle-sheath cells are absent	Bundle-sheath cells are present
RuBisCo is present in the mesophyll cells	RuBisCo is present in the bundle-sheath cells.
The first stable compound produced is 3-phosphoglycerate-a three-carbon compound.	The first stable compound produced is oxaloacetic acid-a four-carbon compound.
Photorespiration occurs	Photorespiration does not occur