Photosynthesis in Higher Plants

CHAPTER 13

NCERT FOCUS

ANSWERS

Topic 1

1. Plants that do not possess chlorophyll *a* will not carry out photosynthesis because it is the primary pigment and act as the reaction centre. It performs the primary reactions of photosynthesis or conversion of light into chemical or electrical energy. Other photosynthetic pigments are called accessory pigments. They absorb light energy of different wavelengths and hence broaden the spectrum of light absorbed by photosynthetic pigments. These pigments hand over the absorbed energy to chlorophyll *a*. Chlorophyll *b* and other accessory pigments protect chlorophyll *a* reaction centre from nascent oxygen and other destructive radicals.

2. The leaves of the shaded side are darker green than those kept in sunlight due to following reasons:

(i) The chloroplasts occur mostly in the mesophyll cells along their walls for receiving optimum quantity of incident light.

(ii) The chloroplasts align themselves in vertical position along the lateral walls of high light intensity and along tangential walls in moderate light.

(iii) Photooxidation of chlorophyll in bright light occurs which is absent in shaded region.

3. Carotenoid pigments are found in all photosynthetic cells. They are accessory pigments which are also found in roots, petals, etc. These pigments do not breakdown easily thus temporarily reveal their colour due to unmasking, following breakdown of chlorophylls. Thus, the colour of leaf kept in dark is yellow or pale green.

Topic 2

1. It is not possible to distinguish externally between a C_3 and C_4 plant, but generally tropical plants are adapted for C_4 cycle.

2. C_4 plants live in hot, moist or arid and non-saline or saline habitats. Internally the leaves show Kranz anatomy. In Kranz anatomy, the mesophyll is undifferentiated and its cells occur in concentric layers around vascular bundles. Vascular bundles are surrounded by large sized bundle sheath cells which are arranged in a wreath-like manner (Kranz – wreath). The mesophyll and bundle sheath cells are connected by plasmodesmata or cytoplasmic bridges. The chloroplasts of the mesophyll cells are smaller. They have well developed grana and a peripheral reticulum but no starch. Mesophyll cells are specialised to perform light reaction, evolve O_2 and produce assimilatory powers (ATP and NADPH). They also possess enzyme PEPcase for initial fixation of CO_2. The chloroplasts of the bundle sheath cells are agranal.

3. Since, through C_4 cycle, a plant can photosynthesise even in presence of very low concentration of CO_2 (upto 10 parts per million), the partial closure of stomata due to xeric conditions would not bring much effect. Therefore, the plants can adapt to grow at low water content, high temperature and bright light intensities. This cycle is specially suited to such plants which grow in dry climates of tropics and subtropics. Besides, the photosynthetic rate remains higher due to absence of photorespiration in these plants. It can be visualised that both C_4 cycle and photorespiration are the result of evolution or might have been one of the reasons of evolution for the adaptation of plants to different environments. C_4 plants are about twice efficient as C_3 plants in converting solar energy into production of dry matter.

4. RuBisCO is an enzyme which acts both as carboxylase (carboxylation during photosynthesis) and oxygenase (during photorespiration). RuBisCO functions as oxygenase only when there is higher concentration of oxygen and lower concentration of CO_2. Both the conditions do not occur in RuBisCO containing bundle sheath cells of C_4 plants. They do not have photolytic evolution of oxygen. They receive a regular supply of CO_2 even when the stomata are closed. Therefore, RuBisCO of C_4 plants functions only as carboxylase.

5. **(a)** The differences between C_3 and C_4 pathways are as follows :

S.No.	C_3 pathway	C_4 pathway
(i)	Ribulose biphosphate is the first acceptor of CO_2.	Phosphoenol pyruvate is the first acceptor of CO_2, while ribulose biphosphate is the second acceptor.
(ii)	Phosphoglyceric acid is the first product.	Oxaloacetic acid is the first product.

(iii)	The plants operate only Calvin cycle.	Plants operate a dicarboxylic acid cycle in addition to Calvin cycle.
(iv)	CO_2 compensation point is 25 – 100 ppm.	CO_2 compensation point is 0 – 10 ppm.
(v)	Mesophyll cells perform complete photosynthesis.	Mesophyll cells perform only initial fixation.
(vi)	The rate of carbon assimilation is slow.	The rate of carbon assimilation is quite rapid.
(vii)	The plants are unable to perform photosynthesis at very low CO_2 concentration (say 10 – 50 ppm).	Photosynthesis continues even at very low CO_2 concentration of 10 – 50 ppm.
(viii)	The cycle operates in all plants.	The cycle is found only in some plants like maize, sugarcane, etc.
(ix)	Fixation of one molecule of CO_2 uses 3 ATP and 2NADPH.	Fixation of one molecule of CO_2 requires 5 ATP and 2NADPH.

(b) The differences between cyclic and non-cyclic photophosphorylation are as follows :

S.No.	Cyclic photophosphoryaltion	Non-cyclic photophosphorylation
(i)	It is performed by photosystem I independently.	It is performed by collaboration of both photosystems I and II.
(ii)	It is not connected with photolysis of water. Therefore, no oxygen is evolved.	It is connected with photolysis of water and liberation of oxygen.
(iii)	It synthesises only ATP.	Non-cyclic photophosphorylation is not only connected with ATP synthesis but also with production of NADPH as well.
(iv)	It operates under low light intensity, anaerobic conditions or when CO_2 availability is poor.	Non-cyclic photophosphorylation takes place under optimum light, aerobic conditions and in the presence of carbon dioxide.
(v)	It occurs mostly in stromal or intergranal thylakoids.	It occurs in the granal thylakoids.
(vi)	ATP synthesis is not affected by DCMU.	DCMU inhibits non-cyclic photophosphorylation.

(c) Differences between the leaf anatomy of C_3 and C_4 plants are as follows :

S.No.	C_3 plants	C_4 plants
(i)	The leaves do not possess Kranz anatomy.	The leaves have Kranz anatomy.
(ii)	Chloroplasts do not have peripheral reticulum.	Chloroplasts have peripheral reticulum.
(iii)	Chloroplasts are of one type (monomorphic).	There are two types of chloroplasts (dimorphic).
(iv)	Bundle sheath cells usually do not contain chloroplasts.	Bundle sheath cells possess prominent chloroplasts.
(v)	In higher plants, operating C_3 cycle, all the chloroplasts are granal.	There are two types of chloroplasts, granal in mesophyll cells and agranal in bundle sheath cells.
(vi)	Mesophyll cells perform complete photosynthesis.	Mesophyll cells perform only initial fixation.
(vii)	Perform photosynthesis only when stomata are open.	Perform photosynthesis even when stomata are closed (from CO_2 produced in respiration).

Topic 3

1. (a) At regions A and B, light is the limiting factor.

(b) In the region 'A', light can be a limiting factor.

(c) C is the region where the rate of photosynthesis is not increased when light intensity is increased. D is the point where some other factors become limiting.

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