Exercise Questions

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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 climate 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 and 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 than C_3 plants. C_4 plants also have specialised cells called a bundle sheath cell 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 less intercellular spaces while there is normal occurrence of chloroplasts in the mesophyll cells. But in C_3 plants, the bundle shealth 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 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:

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 enzyme.
- Mesophyll cells are broken down in the bundle sheath cells that results in CO_2 release which inturn increases the intracellular CO_2 concentration .
- Rubisco functions as a carboxylase minimizing the oxygenase activity.
- Increase in photosynthesis make 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 to serve as an oxygenase.

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:
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 but 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:

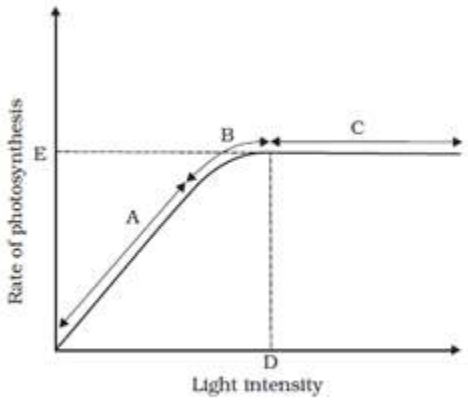
Chlorophyll fails to absorb the energy in the absence of light; hence it loses stability to give the leaf yellow colouration. This proves that carotenoids which imparts yellow color is more stable.

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:

Leaves in the shade get less sunlight to carry out photosynthesis than the 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 shade have dark green leaves due to 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 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	Oxalo-acetic acid is the first stable product
Occurs in mesophyll cell of the leaves	Occurs in mesophyll cells and bundle sheath
Process of Carbon fixation is slower	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	Phtolysis 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, organized centripetally. Size of bundle sheaths are larger
Mesophyll cells possess intercellular space.	Mesophyll cells do not possess intercellular space.