# INDIAN SCHOOL AL WADI AL KABIR

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| **Class: XI** | **DEPARTMENT OF SCIENCE: 2025 – 2026**<br>**SUBJECT: BIOLOGY** | **Date: 27.01.2026** |
| **Worksheet: 18** | **UNIT- IV- PLANT PHYSIOLOGY**<br>**CHAPTER 11 Photosynthesis in higher plants** | **Note:**<br>**A4 FILE FORMAT** |
| **CLASS & SEC:** | **NAME OF THE STUDENT:** | **ROLL NO.** |

I.**MULTIPLE CHOICE QUESTIONS (1M)**

1. Where do the light-dependent reactions of photosynthesis occur in higher plants?
   A. Stroma
   B. Mitochondrial surface
   C. Thylakoid membranes (grana)
   D. Cytoplasm
2.Which pigment acts as the reaction centre during photosynthesis?
   A. Carotene
   B. Chlorophyll b
   C. Chlorophyll a
   D. Xanthophyll
3.The primary carbon dioxide acceptor molecule in $C_3$ plants is:
   A. Phosphoenolpyruvate (PEP)
   B. Ribulose-1,5-bisphosphate (RuBP)
   C. 3-phosphoglyceric acid (PGA)
   D. Oxaloacetic acid (OAA)
4.Which process makes an important difference between $C_3$ and $C_4$ plants?
   A. Photosynthesis
   B. Transpiration
   C. Glycolysis
   D. Photorespiration
5.Blackman's Law of Limiting Factors is related to which of the following?
   A. Respiration
   B. Transpiration
   C. Photosynthesis
   D. Growth

Two statements are given - one labelled as **Assertion (A)** and the other labelled as **Reason (R)**. Select the correct answer to these questions from the codes (A), (B), (C), and (D) as given below.

A. Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of the Assertion (A).

B. Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

C. Assertion (A) is true, Reason (R) is false.
D. Assertion (A) is false, Reason (R) is true.

6. **Assertion (A):** The $C_4$ pathway is a more efficient $CO_2$ fixation process than the $C_3$ pathway in hot, dry climates.
**Reason (R):** $C_4$ plants have a mechanism to minimize photorespiration and ensure high $CO_2$ concentration at the site of the enzyme RuBisCO.
7. **Assertion(A):** The absorption spectrum of chlorophyll a shows a close correlation with the action spectrum.
**Reason(R):** Chlorophyll a is present in both pigment systems I and II.
8. **Assertion (A):** Water stress causes the stomata to close, which drastically reduces the rate of photosynthesis.
**Reason (R):** Closed stomata limit the availability of light needed for the light-dependent reactions.

## II. VERY SHORT ANSWER TYPE QUESTIONS(2M)

9. Differentiate between $C_3$ and $C_4$ plants based on their $CO_2$ fixation process and leaf anatomy.
10. Describe the significance of the light-dependent reactions in photosynthesis.
11. Explain the process of photolysis of water. What is its significance in photosynthesis?
12. Explain Blackman's Law of Limiting Factors with an example related to photosynthesis.
13. Briefly explain the role of ATP synthase in chemiosmosis during photosynthesis.

## III. SHORT ANSWER TYPE QUESTIONS (3M)

14. Explain the three main stages of the Calvin cycle.
15. Describe the role of different photosynthetic pigments in a plant cell.
16. **A.** 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?
B. By looking at the internal structure of a plant, can you tell whether a plant is $C_3$ or $C_4$? Explain.
17. A. 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?
B. Why is the colour of a leaf kept in the dark frequently yellow, or pale green? Which pigment do you think is more stable?

## IV. CASE STUDY BASED QUESTIONS (4M)

18. Plants in tropical regions, such as maize and sugarcane, have developed a specialized photosynthetic pathway known as the $C_4$ pathway, which involves a unique leaf anatomy called "Kranz anatomy". These plants are better adapted to high temperatures, high light intensities, and low water availability compared to $C_3$ plants. $C_4$ plants lack photorespiration, a process that reduces photosynthetic efficiency in $C_3$ plants under certain conditions.
A. What is "Kranz anatomy," and in which type of plants is it typically found?
B. Why are $C_4$ plants considered more efficient in tropical regions than $C_3$ plants?
C. What inefficient process that occurs in $C_3$ plants is lacking in $C_4$ plants?
OR
D. Why does the lack of photorespiration contribute to the overall efficiency of $C_4$ plants?

## V. LONG ANSWER TYPE QUESTIONS (5M)

19. Explain the "Z-scheme" of electron transport with a suitable diagram.

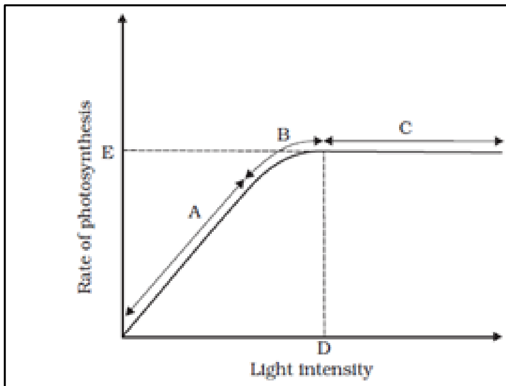
20. **A.** The figure shows the effect of light on photosynthesis. Based on the graph, answer the following questions:

(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?

B. Discuss the effect of light intensity and $CO_2$ concentration as a limiting factor on the rate of photosynthesis.



Graph of light intensity on the rate of photosynthesis

**Answer Key**

<table>
<tr><th>Q. No.</th><th>Answer</th></tr>
<tr><td>I.</td><td>MULTIPLE CHOICE QUESTIONS (1M)</td></tr>
<tr><td>1</td><td>C. Thylakoid membranes (grana).</td></tr>
<tr><td>2</td><td>C. Chlorophyll a.</td></tr>
<tr><td>3</td><td>B. Ribulose-1,5-bisphosphate (RuBP)</td></tr>
<tr><td>4</td><td>D. Photorespiration</td></tr>
<tr><td>5</td><td>C. Photosynthesis.</td></tr>
<tr><td></td><td>ASSERTION & REASONING</td></tr>
<tr><td>6</td><td>A. Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of the Assertion (A.</td></tr>
<tr><td>7</td><td>C. Assertion (A) is true, Reason (R) is false.</td></tr>
<tr><td>8</td><td>C. Assertion (A) is true, Reason (R) is false.</td></tr>
<tr><td>II</td><td>VERY SHORT ANSWER TYPE QUESTIONS(2M)</td></tr>
<tr><td>9</td><td>
<table>
<tr><th>Feature</th><th>$C_3$ Plants</th><th>$C_4$ Plants</th></tr>
<tr><td>Primary $CO_2$ Acceptor</td><td>Ribulose-1,5-bisphosphate (RuBP)</td><td>Phosphoenolpyruvate (PEP)</td></tr>
<tr><td>Leaf Anatomy</td><td>Lack specialized Kranz anatomy</td><td>Possess Kranz anatomy (prominent bundle sheath cells)</td></tr>
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</td></tr>
<tr><td>10</td><td>1. These reactions capture light energy and convert it into chemical energy stored in two vital molecules: ATP (adenosine triphosphate) and NADPH (nicotinamide adenine dinucleotide phosphate).<br>2. Fueling $CO_2$ Fixation: ATP and NADPH are used during the subsequent light-independent reactions (Calvin cycle) to fix $CO_2$ into carbohydrates (glucose).</td></tr>
<tr><td>11</td><td>Photolysis of water is the light-dependent splitting of a water molecule ($H_2O$) into protons ($H^+$), electrons, and nascent oxygen. This reaction occurs on the inner side of the thylakoid membrane in the chloroplasts, facilitated by an oxygen-evolving complex associated with Photosystem II (PS II) and manganese ions ($Mn^{++}$).<br>Significance:<br>• It provides the electrons needed to replace those lost by the reaction center of PS II, ensuring the continuous flow of electrons through the electron transport chain.</td></tr>
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| | • It releases the oxygen we breathe into the atmosphere.<br>• It provides protons ($H^+$) that accumulate in the lumen of the thylakoid, contributing to the proton gradient necessary for ATP synthesis via chemiosmosis. |
| 12 | Blackman's Law of Limiting Factors states that if a chemical process is affected by more than one factor, then its rate will be determined by the factor nearest to its minimal value; it is the factor that directly affects the process when its quantity is changed. This factor is known as the limiting factor.<br><br>For example, in photosynthesis, the rate can be limited by carbon dioxide concentration, light intensity, or temperature. If a plant has optimal light and temperature but low $CO_2$ levels, $CO_2$ is the limiting factor. Increasing $CO_2$ concentration will increase the rate until either light or temperature becomes the new limiting factor. |
| 13 | During the light reactions of photosynthesis, chemiosmosis occurs across the thylakoid membrane, driven by a proton gradient ($H^+$ ions) built up within the thylakoid lumen.<br>The ATP synthase complex facilitates the movement of these protons across the membrane down their concentration gradient (from lumen to stroma). This flow of protons through the channel of ATP synthase provides the necessary energy to trigger a conformational change in the enzyme, which catalyzes the synthesis of adenosine triphosphate (ATP) from adenosine diphosphate (ADP) and inorganic phosphate ($Pi$). This process is called photophosphorylation. |
| **III** | **SHORT ANSWER TYPE QUESTIONS (3M)** |
| 14 | **Carboxylation (Carbon Fixation):** The primary $CO_2$ acceptor molecule, ribulose-1,5-bisphosphate (RuBP), is combined with carbon dioxide ($CO_2$) from the atmosphere. This reaction is catalyzed by the enzyme RuBisCO (Ribulose bisphosphate carboxylase-oxygenase) and results in the formation of two molecules of 3-phosphoglycerate (3-PGA).<br>**Reduction:** The molecules of 3-PGA are converted into glyceraldehyde-3-phosphate ($G_3P$, a three-carbon sugar phosphate). This stage consumes energy from ATP and reducing power from NADPH, both produced during the light reactions of photosynthesis. For every three molecules of $CO_2$ fixed, one molecule of $G_3P$ is produced.<br>**Regeneration:** The remaining $G_3P$ molecules are used to regenerate the original $CO_2$ acceptor, RuBP. This regeneration process requires ATP and ensures the cycle can continue fixing more $CO_2$. |
| 15 | Plant cells contain different photosynthetic pigments embedded in the thylakoid membranes, each playing a crucial role in capturing light energy:<br>**Chlorophyll a:** This is the primary photosynthetic pigment and the reaction center molecule. It absorbs light primarily in the blue and red regions of the spectrum and is directly responsible for converting light energy into chemical energy during the light-dependent reactions.<br>**Accessory Pigments (e.g., Chlorophyll b, Carotenoids, Xanthophylls):** These pigments act as antenna molecules, forming a light-harvesting complex around the reaction center. They absorb light at different wavelengths than chlorophyll a (e.g., yellow, orange, green regions), broadening the spectrum of light that can be used for photosynthesis.<br>• They efficiently transfer the absorbed energy to the chlorophyll a reaction center.<br>• Carotenoids also provide photoprotection by dissipating excess light energy that would otherwise cause damage to the plant cell. |

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| 16 | A. RuBisCO carries out more carboxylation in $C_4$ plants because the enzyme is located exclusively in the bundle sheath cells, where the concentration of carbon dioxide ($CO_2$) is kept very high. $C_4$ plants have a spatial separation mechanism where $CO_2$ is first fixed in the mesophyll cells and actively pumped into the bundle sheath cells, effectively minimising the oxygenase activity (photorespiration) that typically competes with carboxylation under high $O_2$ or low $CO_2$ conditions.<br>B. Yes, by looking at the internal structure (anatomy), you can tell whether a plant is $C_3$ $C_4$ plants exhibit a specialized leaf anatomy called Kranz anatomy, which is identifiable by:<br>1. A prominent ring of large bundle sheath cells tightly packed around the vascular bundles.<br>2. The mesophyll cells are arranged in a concentric layer around these bundle sheath cells.$C_3$ plants lack this distinct Kranz anatomy. |
| 17 A | Light is essential for photosynthesis. Leaves receive less light for photosynthesis when they are in shade. Therefore, the leaves or plants in shade perform less photosynthesis as compared to the leaves or plants kept in sunlight. In order to increase the rate of photosynthesis, the leaves present in shade have more chlorophyll pigments. This increases the chlorophyll content with an increase in the amount of light absorbed by the leaves, which increases the rate of photosynthesis. Therefore, the leaves or plants in shade are greener than the leaves of plants kept in the sun. |
| B. | Chlorophyll is the pigment responsible for the green colour of leaves. Light is essential for the production of chlorophyll, and in the absence of light or in the dark, there is no production of chlorophyll, and the chlorophyll present leaf is degraded. During this process, the xanthophyll and carotenoid pigments become predominant, causing the leaf to become yellow or pale green. These pigments are more stable as light is not essential for their production. |
| **IV** | **CASE STUDY BASED QUESTIONS (4M)** |
| 18. A | Kranz anatomy is a special leaf structure where vascular bundles are surrounded by large bundle sheath cells. It is characteristic of $C_4$ plants like maize and sugarcane. |
| B | $C_4$ plants minimize photorespiration because they maintain a high concentration of $CO_2$ around the RuBisCO enzyme in the bundle sheath cells, leading to increased biomass productivity in hot, dry conditions. |
| C | $C_4$ plants lack photorespiration, which is a process that reduces photosynthetic efficiency in $C_3$ plants. |
| D | Photorespiration is a process that reduces photosynthetic efficiency in $C_3$ plants. Since $C_4$ plants lack this process, they maintain a higher efficiency, especially under conditions of high temperatures and high light intensities. |
| **V** | **LONG ANSWER TYPE QUESTIONS (5M)** |

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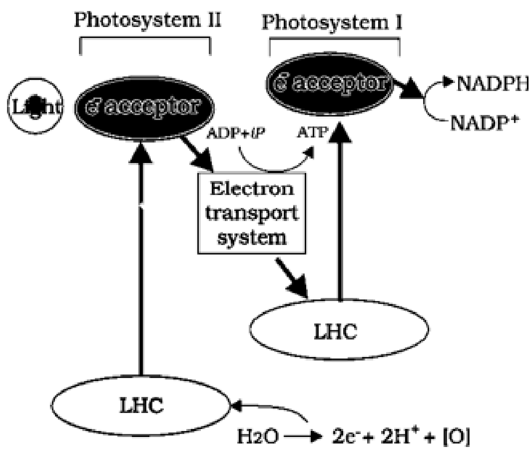
**PS II Excitation & Water Splitting:** Light energy excites electrons in the reaction center P680 of PS II. These electrons are accepted by pheophytin, moving to a higher energy level. Lost electrons from P680 are replaced by the splitting of water (photolysis).
**Electron Transport Chain (ETC):** The electrons pass down an electron transport chain involving plastoquinone, cytochrome b6f complex, and plastocyanin to PS I. This downhill movement in energy generates a proton gradient across the thylakoid membrane.
**PS I Excitation & NADPH Formation:** At PS I, electrons are re-excited by light absorption at P700. They move to another electron acceptor and are then transferred to ferredoxin, eventually reducing $NADP^+$ to NADPH in the stroma.




20.

A.
(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.
B.
**Light Intensity:**

- At low light intensities, the rate of photosynthesis is directly proportional to light intensity; increasing light will increase the rate linearly.
- At higher light intensities, the rate eventually becomes saturated. This plateau occurs because other factors (like $CO_2$ concentration or temperature) become limiting, or the light itself becomes intense enough to damage the chlorophyll.

**$CO_2$ Concentration:**

- $CO_2$ is a major limiting factor as it makes up a very small percentage of the atmosphere (0.03-0.04%).
- Increasing $CO_2$ concentration (up to a certain point) under adequate light and temperature conditions will significantly increase the rate of photosynthesis.
- Beyond a certain optimal concentration, the rate plateaus because the enzyme active sites (like RuBisCO) become saturated, or other factors (like light) become limiting.

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