



ChapterNotes

chapternotes.in · free NEET & JEE prep

CHAPTER NOTES

Photosynthesis in Higher Plants

Class 11 Notes | CBSE Biology

Chapter 11

- ✓ Chapter-wise notes & important questions
- ✓ Free gamified practice app — streaks, levels, revision
- ✓ Free mock & prediction papers with answer keys

Source: <https://chapternotes.in/cbse/class-11-biology/photosynthesis-in-higher-plants-class-11-notes/>



Scan to practice this
chapter free in the app

Photosynthesis in Higher Plants Class 11 Notes | CBSE Biology Chapter 11

Photosynthesis in Higher Plants is Chapter 11 of CBSE Class 11 Biology — the chapter that explains how green plants trap sunlight and turn it into the food that powers almost all life on Earth. It connects physics (light), chemistry (redox reactions), and biology (cell organelles) into one elegant story that runs inside the chloroplast.

By the end of these notes you will be able to locate the site of photosynthesis, name the pigments, walk through the light reaction and the two photosystems, explain cyclic and non-cyclic photophosphorylation, state the chemiosmotic hypothesis for ATP synthesis, trace the Calvin cycle, compare C3 with C4 plants, explain photorespiration, and list the factors affecting the rate of photosynthesis. This is a high-weightage NEET chapter and a reliable source of board questions worth roughly 5–7 marks.

Table of Contents

- Key Concepts — Site, pigments, light & dark reactions, C3/C4, photorespiration, limiting factors
 - Weightage in Board & Entrance Exams
 - Important Definitions
 - Solved Examples
 - Important Questions for Board Exams
 - Quick Revision Points
-

Key Concepts

1. What is Photosynthesis?

Photosynthesis is the anabolic (building-up) process by which green plants, algae, and some bacteria synthesise organic food (glucose) from carbon dioxide and water using light energy, releasing oxygen as a by-product.

The overall balanced equation is:



- Water is both a reactant and a product; the O_2 released comes from water, not CO_2 (proven by Ruben and Kamen using the isotope ^{18}O).
 - It is the only major process that converts solar energy into chemical energy stored in food.
-

2. Site of Photosynthesis — The Chloroplast

Photosynthesis occurs in the **chloroplast**, a double-membrane organelle found mainly in mesophyll cells of the leaf.

[DIAGRAM: A chloroplast — outer and inner membrane, stroma (fluid matrix), and grana (stacks of disc-shaped thylakoids) connected by stroma lamellae.]

- **Grana (thylakoids):** site of the **light reaction** — they contain chlorophyll and trap light.
- **Stroma:** site of the **dark reaction** (Calvin cycle) — the enzymatic, light-independent carbon fixation.

Key idea: The membrane (thylakoid) handles light capture and ATP/NADPH formation; the stroma handles sugar synthesis.

3. Photosynthetic Pigments

Pigments are substances that absorb light. Leaf pigments can be separated by paper chromatography into four groups.

Pigment	Colour	Role
Chlorophyll a	Bright/blue-green	Chief pigment; the reaction-centre that drives photochemistry
Chlorophyll b	Yellow-green	Accessory pigment; passes energy to chlorophyll a
Xanthophylls	Yellow	Accessory pigment
Carotenoids	Yellow to orange	Accessory; also protect chlorophyll from photo-oxidation

Chlorophyll a absorbs maximally in the **blue (around 430 nm)** and **red (around 660 nm)** regions. The **action spectrum** of photosynthesis closely matches the **absorption spectrum of chlorophyll a**, proving it is the main pigment.

4. The Two Stages of Photosynthesis

Photosynthesis has two phases that occur in sequence.

- **Light reaction (photochemical phase):** light-dependent; occurs in the thylakoid membrane; produces ATP, NADPH, and O₂.
 - **Dark reaction (biosynthetic phase):** light-independent; occurs in the stroma; uses ATP and NADPH to fix CO₂ into sugar.
-

5. The Light Reaction and Photosystems

Pigments are organised into two light-harvesting complexes called **photosystems**, named in the order they were discovered.

- **Photosystem I (PS I):** reaction-centre chlorophyll a absorbs at **700 nm (P700)**.

- **Photosystem II (PS II)**: reaction-centre chlorophyll a absorbs at **680 nm (P680)**.

Each photosystem has a central **reaction centre** surrounded by a **light-harvesting complex (LHC)** of hundreds of accessory pigment molecules that funnel absorbed energy to the reaction centre.

6. Electron Transport — Non-Cyclic Photophosphorylation

In non-cyclic flow, electrons travel in a one-way path through both photosystems — drawn as the famous **Z-scheme**.

[DIAGRAM: Z-scheme — PS II (P680) → electron acceptor → plastoquinone → cytochrome b6-f → plastocyanin → PS I (P700) → ferredoxin → NADP⁺ reductase → NADPH.]

- **PS II** absorbs light, P680 emits an excited electron passed down the electron transport chain.
- The lost electron is replaced by the **photolysis (splitting) of water**, which releases O₂ and protons: $2\text{H}_2\text{O} \rightarrow 4\text{H}^+ + \text{O}_2 + 4\text{e}^-$.
- Electrons reach **PS I**, are re-energised, and finally reduce **NADP⁺ to NADPH**.
- Both ATP and NADPH are formed; this is called **non-cyclic photophosphorylation**.

Note: Photolysis of water is associated with PS II and occurs on the inner side of the thylakoid membrane.

7. Cyclic Photophosphorylation

When only **PS I** is functional (light beyond 680 nm, or when NADP⁺ is unavailable), electrons cycle back to P700 instead of going to NADP⁺.

- Only **ATP is synthesised** — no NADPH and no O₂.
 - It occurs in the **stroma lamellae**, which lack PS II and NADP reductase.
 - It helps balance the ATP : NADPH ratio needed by the Calvin cycle.
-

8. Chemiosmotic Hypothesis & ATP Synthesis

The **chemiosmotic hypothesis** (Peter Mitchell) explains how ATP is actually made — by a **proton gradient** across the thylakoid membrane.

- Splitting of water inside the lumen, and proton pumping by the electron transport chain, build a high H⁺ concentration in the **thylakoid lumen**.
- This proton gradient (high inside, low in stroma) stores potential energy.
- Protons flow back to the stroma through the **F₀-F₁ ATP synthase** (CF₀ channel), and this flow drives the synthesis of **ATP from ADP + iP**.

Key idea: ATP formation needs a membrane, a proton pump, a proton gradient, and ATP synthase — exactly the chemiosmotic requirements.

9. Biosynthetic Phase — The Calvin Cycle (C3 Pathway)

The **dark reaction** uses ATP and NADPH from the light reaction to fix CO₂ into sugar in the **stroma**. It was traced by Melvin Calvin, hence the **Calvin cycle**. The first stable product is a 3-carbon acid (3-PGA), so it is the **C3 pathway**.

The cycle has three stages:

- **Carboxylation:** CO₂ combines with the 5-carbon acceptor **RuBP**, catalysed by the enzyme **RuBisCO**, forming two molecules of 3-PGA.
- **Reduction:** 3-PGA is converted to **G3P (sugar)** using 2 ATP and 2 NADPH per CO₂ fixed.
- **Regeneration:** RuBP is regenerated using ATP so the cycle can continue.

To make **one glucose**, the cycle turns **6 times**, using **18 ATP and 12 NADPH** and fixing 6 CO₂.

10. C4 Pathway (Hatch and Slack Pathway)

C4 plants (maize, sugarcane, sorghum) have a special leaf anatomy and fix CO₂ twice to avoid photorespiration.

- **Kranz anatomy:** large bundle-sheath cells with many chloroplasts surround the vascular bundles.
- The **first stable product is a 4-carbon acid (oxaloacetic acid, OAA)** formed in mesophyll cells; the primary acceptor is **PEP** and the enzyme is **PEP carboxylase**.
- The C4 acid moves to bundle-sheath cells, releases CO₂ for the **Calvin cycle** there, raising CO₂ around RuBisCO.

Advantage: C4 plants show no photorespiration, higher productivity, and tolerate higher temperatures and lower CO₂ better than C3 plants.

11. Photorespiration

Photorespiration is a wasteful process in C3 plants where RuBisCO fixes O₂ instead of CO₂ when O₂ concentration is high.

- RuBisCO has a **dual nature** — it can act as a carboxylase or an oxygenase; high O₂ favours oxygenation.
- It produces one molecule of **phosphoglycolate (2-C)** and leads to release of CO₂.
- There is **no synthesis of sugar, ATP, or NADPH** — it lowers the net yield of C3 plants.

Note: C4 plants avoid photorespiration because their bundle-sheath cells keep CO₂ high around RuBisCO.

12. Factors Affecting Photosynthesis

The rate of photosynthesis depends on internal factors (chlorophyll, leaf area) and external factors (light, CO₂, temperature, water).

Blackman's Law of Limiting Factors

Blackman's law (1905): when a process is governed by several factors, the rate is limited by the factor that is in shortest supply (the **limiting factor**). Changing only the limiting factor will change the rate.

Factor	Effect on Photosynthesis
Light	Rate rises with intensity, then plateaus; very high light causes photo-oxidation (breakdown)
CO ₂ concentration	Major limiting factor; raising CO ₂ increases rate up to a saturation point
Temperature	Dark reaction is enzyme-controlled; C4 plants have a higher optimum than C3
Water	Stress closes stomata, reduces CO ₂ intake and leaf area

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	5–7 marks	Light vs dark reaction, Calvin cycle, C3 vs C4, photorespiration
NEET	2–4 questions (high yield)	Photosystems, Z-scheme, photophosphorylation, RuBisCO, C4 anatomy
CUET / State Boards	2–3 questions	Pigments, site of photosynthesis, limiting factors

[TABLE: Question-type split — VSA (1 mark): pigments, P700/P680, first product; SA (2–3 marks): cyclic vs non-cyclic, C3 vs C4, photorespiration; LA (5 marks): Calvin cycle, chemiosmotic ATP synthesis.]

Important Definitions

Term	Definition
Photosynthesis	Synthesis of food from CO ₂ and water using light energy, releasing O ₂
Photolysis	Light-driven splitting of water in PS II releasing O ₂ , H ⁺ , and electrons
Photosystem	Light-harvesting complex with a reaction centre (PS I = P700, PS II = P680)
Non-cyclic photophosphorylation	One-way electron flow through PS II and PS I making ATP + NADPH + O ₂
Cyclic photophosphorylation	Electron flow only in PS I making ATP alone (no NADPH, no O ₂)
Chemiosmosis	ATP synthesis driven by a proton gradient across the thylakoid membrane
Calvin cycle (C3)	Dark-reaction pathway fixing CO ₂ via RuBP; first product is 3-PGA
RuBisCO	Enzyme of carboxylation; acts as both carboxylase and oxygenase
Kranz anatomy	Special leaf structure of C ₄ plants with bundle-sheath cells
Photorespiration	Wasteful O ₂ fixation by RuBisCO in C ₃ plants; no ATP/NADPH/sugar made

Solved Examples

Example 1

How many ATP and NADPH molecules are needed to make one glucose molecule in the Calvin cycle?

Answer: The cycle turns 6 times for one glucose. Per CO₂: 3 ATP + 2 NADPH. So total = **18 ATP and 12 NADPH**.

Example 2

Name the first stable products of the C₃ and C₄ pathways and the number of carbons in each.

Answer: C₃ — **3-PGA (3 carbons)**; C₄ — **oxaloacetic acid, OAA (4 carbons)**.

Example 3

Which products of the light reaction are used in the dark reaction, and which is released into the air?

Answer: **ATP and NADPH** are used in the Calvin cycle; **O₂** is released into the atmosphere.

Example 4

Why is non-cyclic photophosphorylation called “non-cyclic”?

Answer: Electrons travel a one-way path from water through PS II and PS I to NADP^+ and do not return to their source — hence non-cyclic. The lost electrons are replaced by photolysis of water.

Example 5

A C₃ and a C₄ plant are kept in identical bright light, high temperature, and low CO₂. Which fixes carbon more efficiently and why?

Answer: The **C₄ plant**, because Kranz anatomy concentrates CO₂ around RuBisCO in bundle-sheath cells, preventing photorespiration even at high temperature and low CO₂.

Example 6

In an experiment, light intensity is increased but the photosynthesis rate stops rising. According to Blackman’s law, what is happening?

Answer: Light is no longer the limiting factor; another factor (usually **CO₂ concentration**) has become the limiting factor, so increasing light alone cannot raise the rate.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. Name the pigment that forms the reaction centre of PS I.
2. From which molecule is the oxygen released during photosynthesis derived?
3. What is the primary CO₂ acceptor in the C₄ pathway?
4. Name the enzyme responsible for photorespiration.
5. In which part of the chloroplast does the Calvin cycle occur?

2–3-Mark Questions (SA)

1. Differentiate between cyclic and non-cyclic photophosphorylation.
2. Compare C₃ and C₄ plants with respect to first product, CO₂ acceptor, and photorespiration.
3. Explain why RuBisCO is described as having a dual nature.
4. State Blackman’s law of limiting factors with one example.

5-Mark Questions (LA)

1. Describe the three stages of the Calvin cycle and state how many ATP and NADPH are needed per glucose.

2. Explain the chemiosmotic hypothesis of ATP synthesis in the chloroplast.
 3. Draw and explain the Z-scheme of non-cyclic electron transport, naming the products formed.
-

Quick Revision Points

- Overall: $6\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}$; O_2 comes from water
 - Site: chloroplast — grana (light reaction), stroma (dark reaction)
 - Pigments: chlorophyll a (chief), chlorophyll b, xanthophylls, carotenoids
 - PS I = P700, PS II = P680; LHC funnels energy to the reaction centre
 - Non-cyclic: PS II + PS I $\rightarrow$ ATP + NADPH + O_2 (Z-scheme; water split in PS II)
 - Cyclic: only PS I $\rightarrow$ ATP alone; occurs in stroma lamellae
 - Chemiosmosis: H^+ gradient in thylakoid lumen drives ATP synthase
 - Calvin cycle (C3): $\text{RuBP} + \text{CO}_2 \rightarrow 2 \times 3\text{-PGA}$ via RuBisCO; 18 ATP + 12 NADPH per glucose
 - C4: Kranz anatomy; first product OAA (4-C); PEP carboxylase; no photorespiration
 - Photorespiration: RuBisCO fixes O_2 ; no sugar/ATP/NADPH; only in C3
 - Blackman's law: rate set by the factor in shortest supply (often CO_2)
-

Next Chapter: Chapter 12 — Respiration in Plants



Got this PDF from a friend?

Everything here is free at **chapternotes.in** — 134 chapters of notes, a gamified practice app, and full NEET mock & prediction papers.



Scan to practice this chapter free in the app