CLASS: 11 SUB: BIOLOGY

CHAPTER -13

PHOTOSYNTHESIS IN HIGHER PLANTS

Photosynthesis is a physico-chemical process by which green plants use light energy to synthesize organic compounds (sugar).

$6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6H_2O + 6O_2$

IMPORTANCE OF PHOTOSYNTHESIS:

1) It is the primary source of all food in earth.

2) Release of oxygen into the atmosphere.

SITE OF PHOTOSYNTHESIS:

- Photosynthesis occurs in mesophyll cell of the green leaves in a cell organelle called chloroplast.
- Within the chloroplast there is a membranous system consisting of grana, the stroma lamellae and the fluid stroma.
- The membrane system trap the light energy and synthesizes ATP and NADPH. This set of reaction reaction which depends on light is called light reaction.
- In stroma, enzymatic reactions incorporate CO2 into the plant leading to the synthesis of sugar which in turn forms starch. This set of reactions which are not directly dependent on light but are dependant on the products of light reactions. (ATP and NADPH) is called dark reaction.

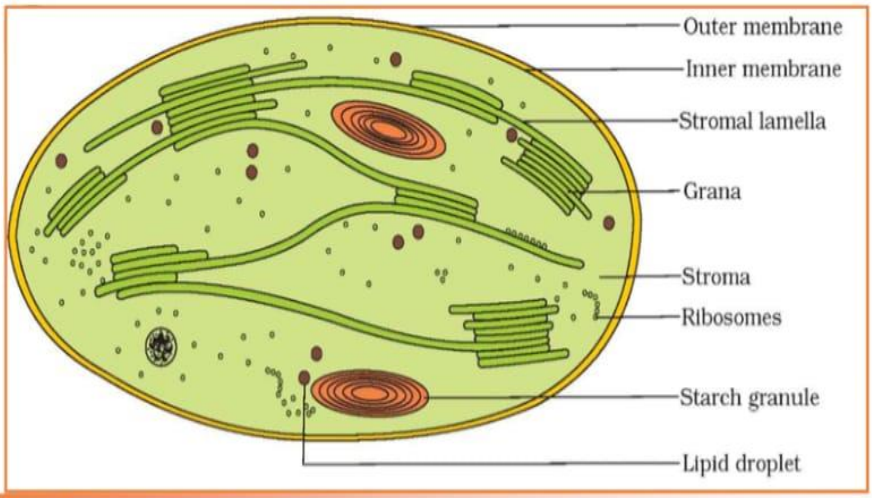
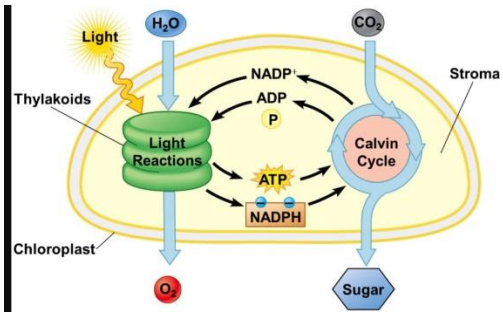


Fig: Diagrammatic representation of an electron micrograph of a section of chloroplast

OVERVIEW OF PHOTOSYNTHESIS



PIGMENTS INVOLVED IN PHOTOSYNTHESIS

Four pigments are involved in photosynthesis

- Chlorophyll a is the main pigment .
- Pigments like chlorophyll b , xznthophylls and carotenoids are called accessory pigments.
- Accessory pigments absorb light and transport the energy to chlorophyll a.

LIGHT REACTION (PHOTOCHEMICAL PHASE)

- Light reactions include light absorption, water splitting, oxygen release and the formation of high energy chemical intermediates, ATP and NADPH.
- The pigments are organized into two discrete photo chemical light harvesting complexes within the photosystem I (PS I) and photosystem II (PS II)
- In PS I the reaction centre chloroohyll a has an absorotion peak at 700 nm, hence is called P700 while the PS II has an absorption peak at 680 nm and is called P680.

THE ELECTRON TRANSPORT

- Absorption of light by PS II causes the electron to move to excited state.
- The excited electrons are picked up by an electron acceptor which passes them to an electron transport system consisting of cytochromes.
- The electrons are then passed on to photosystem I.
- Just like in photosystem II, absorption of light by PS I causes the electrons to move to excited state.
- The excited electrons are passed on to another cytochrome with greater electron affinity.
- The electrons are then passed on to energy rich molecules called NADP+ which after receiving the electrons gets reduced to NADPH + H+.
- Z scheme – This whole scheme of transfer of electrons from PS II to cytochrome to PS I to another cytochrome to NADP+ to form NADPH + H+ is called the Z scheme..

SPLITTING OF WATER

- Water is split into hydrogen ion(H+), oxygen (o) and electrons
  $2H_2o \rightarrow 4H^+ + o_2 + 4e^-$
- The electrons released from splitting of water is used to replace the electrons lost by photosystem II.

CYCLIC AND NON-CYCLIC PHOTO-PHOSPHORYLATION

- The process of formation of ATP from ADP and inorganic phosphate (iP) in chloroplast in the presence of sun light is called photo-phosphorylation.
- Photo-phosphorylation is of two types :
  1. Non-cyclic photo-phosphorylation
  2. Cyclic photo-phosphorylation

Non-cyclic photo-phorylation	Cyclic photo-phosphorylation
Both PSI and PSII are involved.	Only PS I is involved.
Electrons are not recycled.	Electrons released by PS I is recycled by PS I.
Both ATP and NADPH are produced.	Only ATP is produced.
Photolysis of water takes place.	No photolysis
Oxygen is released.	No oxygen released.

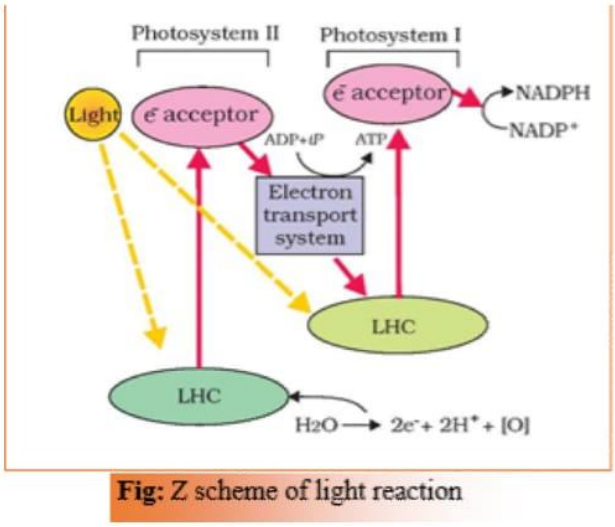


Fig: Z scheme of light reaction

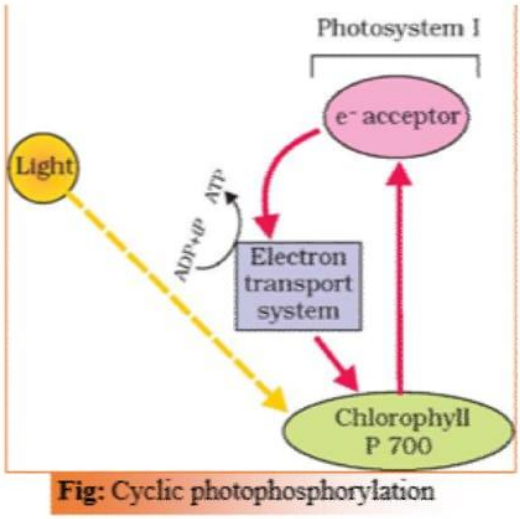
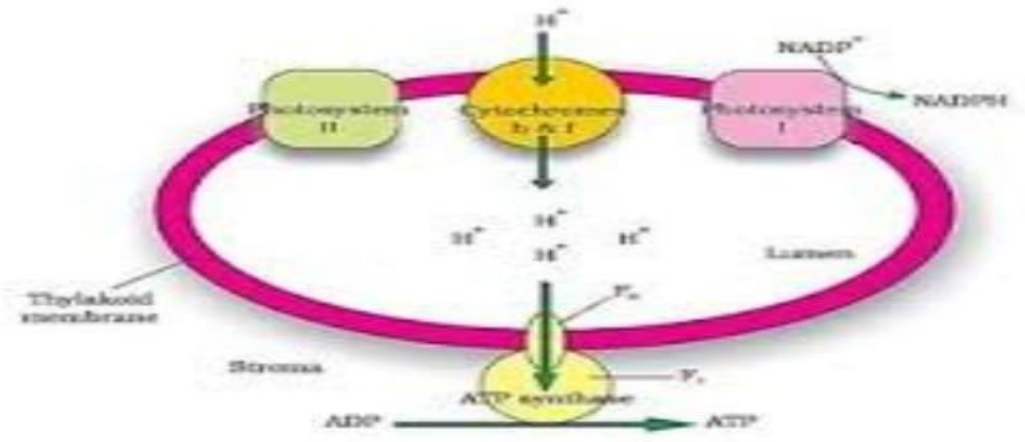


Fig: Cyclic photophosphorylation

CHEMIOSMOTIC HYPOTHESIS:

- The theory which explains how ATP is synthesized in the chloroplast is chemiostic hypothesis.
- ATP is produced due to the proton gradient created across the membrane.The essential components required for chemiosmosis are proton pump,proton gradient and ATP synthase.



DARK REACTION (Biosynthetic phase)

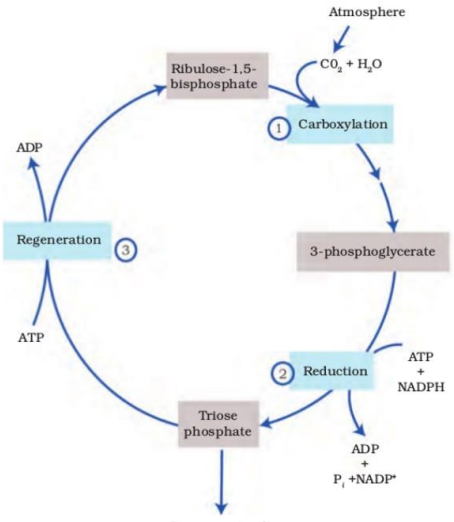
This process occurs in the stroma of the chloroplasts. The following cycles are involved in the process:

CALVIN CYCLE: This cycle involves the following steps:

Carboxylation: Ribulose -1,5 bisphosphate combines with carbon dioxide to form 3-carbon compound 3-phosphoglyceric acid. The enzyme RuBisCO is involved in the process.

Reduction: Reduction is series of reaction that leads to formation of glucose. Two molecule of ATP and two molecules NADPH are required for reduction of one molecules of CO2. Six turn of this cycle are required for removal of one molecule of glucose from pathway.

Regeneration: Regeneration is the generation of RUBP molecules for the continuation of cycle. This process requires one molecule of ATP.



Sucrose, Starch

Sucrose, Starch

IN	OUT
SIX CO_2	One glucose
18 ATP	18 ADP
12 NADPH	12 NADP

Fig : Calvin Cycle

C_4 PATHWAY/ HATCH AND SLACK PATHWAY:

- This pathway is operational in plants growing in dry tropical region like Maize, Sugarcane, Sorghum etc.
- The first stable product is a 4-carbon compound Oxaloacetic acid (OAA).
- The primary CO2 acceptor is 3C Phosphoenol pyruvate(PEP) present in mesophyll cell and enzyme involved is PEP carboxylase.
- OAA is converted to Malic acid which is transported to bundle sheath cells.
- In bundle sheath cell, it is broken into CO2 and a 3C molecule.
- The 3C molecule is transported back to the mesophyll where is converted to PEP again, thus completing the cycle.
- The CO2 released in the bundle sheath cells enters the Calvin cycle, where enzyme RuBisCO is present that forms sugar.

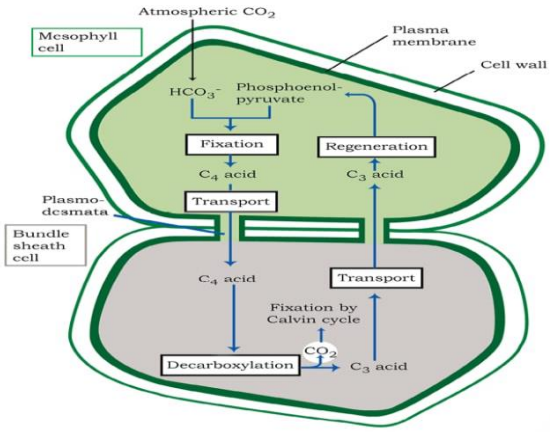


Figure 13.9 Diagrammatic representation of the Hatch and Slack Pathway

C_3 PLANTS	C_4 PLANTS
The leaves do not have kranz anatomy.	The leaves show Kranz anatomy.
RUBP is the first acceptor of CO2.	PEP is the first acceptor of CO2.
PGA is the first stable product.	OAA is the first stable product.
Photosynthesis occurs in mesophyll cells.	Photosynthesis occurs in both mesophyll cells and bundle sheath cells.
Photorespiration occurs.	Photorespiration does not occur.

PHOTORESPIRATION:

Photorespiration is a process that lowers the efficiency of photosynthesis in C_3 plants. In these plants, oxygen binds with RuBisCO during photosynthesis, which results in reduced carbon dioxide fixation. Additionally, this process does not result in the synthesis of sugars nor ATP or NADPH.

FACTORS AFFECTING PHOTOSYNTHESIS:

1. Light
2. Carbon dioxide concentration
3. Temperature
4. Water

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