جامـــعـة المــســتـقـبـل
AL MUSTAQBAL UNIVERSITY

كلية العـــــــلوم
قـســـــــم الكيمياء الحياتية

LECTURE(6)

Subject :**Photosynthesis and Light Energy Conversion**

Level: second

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Photosynthesis and Light Energy Conversion

photosynthesis, the process by which green plants and certain other organisms transform light energy into chemical energy.

During photosynthesis, light energy is captured and used to convert water, carbon dioxide, and minerals into oxygen and energy-rich organic compounds.

It involves multiple biochemical reactions that can be broadly divided into two stages: the light-dependent reactions and the light-independent reactions (also known as the Calvin cycle).

In chemical terms, photosynthesis is a light-energized oxidation–reduction process.

(Oxidation refers to the removal of electrons from a molecule; reduction refers to the gain of electrons by a molecule.)

In photosynthesis steps

1- The energy of light is used to drive the oxidation of water (H_2O), producing oxygen gas (O_2), hydrogen ions (H^+), and electrons.
2- Most of the removed electrons and hydrogen ions ultimately are transferred to carbon dioxide (CO_2), which is reduced to organic products.
3- Other electrons and hydrogen ions are used to **reduce nitrate and sulfate to amino and sulfhydryl groups in amino acids**, which are the building blocks **of proteins**.
4- The carbohydrates—especially starch and the sugar sucrose—are the major direct organic products of photosynthesis. The overall reaction in which carbohydrates—represented by the general formula (CH_2O)—are formed during photosynthesis can be

indicated by the following equation:

$$CO_2 + 2H_2O \xrightarrow[\text{green plants}]{\text{light}} (CH_2O) + O_2 + H_2O.$$

Chemical equation of photosynthesis:

<u>Word Equation</u>: Carbon dioxide + water + light energy → glucose + oxygen.

<u>Chemical Equation</u>: 6 CO_2 + 6 H_2O + light energy → $C_6H_{12}O_6$ + 6 O_2.

This equation is merely a summary statement, for the process of photosynthesis actually involves numerous reactions catalyzed by enzymes (organic catalysts).

These reactions occur in two stages:

1- the "light" stage, consisting of photochemical (i.e., light-capturing) reactions
2- the "dark" stage, comprising chemical reactions controlled by enzymes.

Events of the stages

- During the first stage(light), the energy of light is absorbed and used to drive a series of electron transfers, resulting in the synthesis of ATP and the electron-donor-reduced nicotine adenine dinucleotide phosphate (NADPH).
- During the (dark) stage, the ATP and NADPH formed in the light-capturing reactions are used to reduce carbon dioxide to organic carbon compounds. This assimilation of inorganic carbon into organic compounds is called carbon fixation.

Enzyme :- a substance that acts as a catalyst in living organisms, regulating the rate at which chemical reactions proceed without itself being altered in the process.

Light Energy Conversion

The Light Energy Conversion by **Chlorophyll**

The of chlorophyll Role: Chlorophyll transfers light energy into chemical energy, facilitating the formation of glucose and other carbohydrates.

Function of Chlorophyll and Accessory Pigments

Chlorophyll, the primary pigment in chloroplasts, plays a **vital role in energy absorption.** It primarily captures light in the blue and red wavelengths, reflecting **green light,** which is why plants appear green. However, chlorophyll cannot absorb all light wavelengths effectively. This is where accessory pigments come into play.

Importance of Chloroplasts in Energy Conversion

Chloroplasts hold immense significance in the **Metabolic Processes** of plants. Through their intricate structures carry out the chemical reactions necessary for the **transformation of light into chemical energy**. This energy subsequently fuels various cellular activities. An essential

byproduct of these reactions is oxygen, vital for the survival of aerobic organisms.

These reactions occur in the **thylakoid membranes** of the **chloroplasts** and require light. **The main purpose is to convert light energy into chemical energy in the form of ATP and NADPH**.

Explain the process photosynthesis?

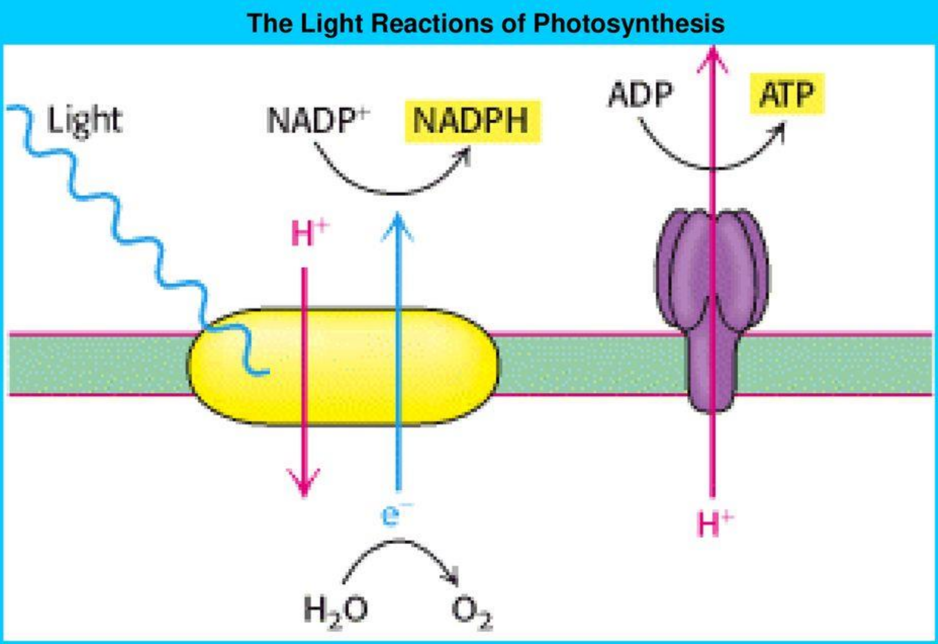


Figure 19.2. The Light Reactions of Photosynthesis. Light is absorbed and the energy is used to drive electrons from water to generate NADPH and to drive protons across a membrane. These protons return through ATP synthase to make ATP.

1. Light-Dependent Reactions

a. Photon Absorption:

Chlorophyll and other pigments in the photosystems (Photosystem II and Photosystem I) absorb light energy.

This absorbed energy excites electrons to a higher energy state.

b. Water Splitting:

In Photosystem II, the energy from the excited electrons is used to split water molecules (H_2O) into oxygen (O_2), protons (H^+), and electrons.

The oxygen is released as a byproduct.

c. Electron Transport Chain (ETC):

The excited electrons from Photosystem II are transferred through a series of proteins in the thylakoid membrane, known as the electron transport chain.

As electrons move through the ETC**, their energy is used to pump protons (H^+) from the stroma into the thylakoid lumen**, creating a proton gradient.

d. ATP Synthesis:

The proton gradient **drives the enzyme ATP synthase to produce ATP** from ADP and inorganic phosphate (Pi).

This process is called **chemiosmosis.**

e. NADPH Formation:

Electrons from Photosystem II are eventually passed to Photosystem I, to form NADPH.

2. Light-Independent Reactions (Calvin Cycle)

These reactions **occur in the stroma** of the chloroplasts and do not require light. They use the ATP and NADPH produced in the light-dependent reactions to fix carbon dioxide (CO_2) into organic molecules. The Calvin cycle consists of **three main phases**:

a. Carbon Fixation:

CO_2 is fixed into a five-carbon sugar called **ribulose-1,5-bisphosphate** (RuBP) by the enzyme ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO).

This reaction produces two molecules of **3-phosphoglycerate (3-PGA).**

b. Reduction:

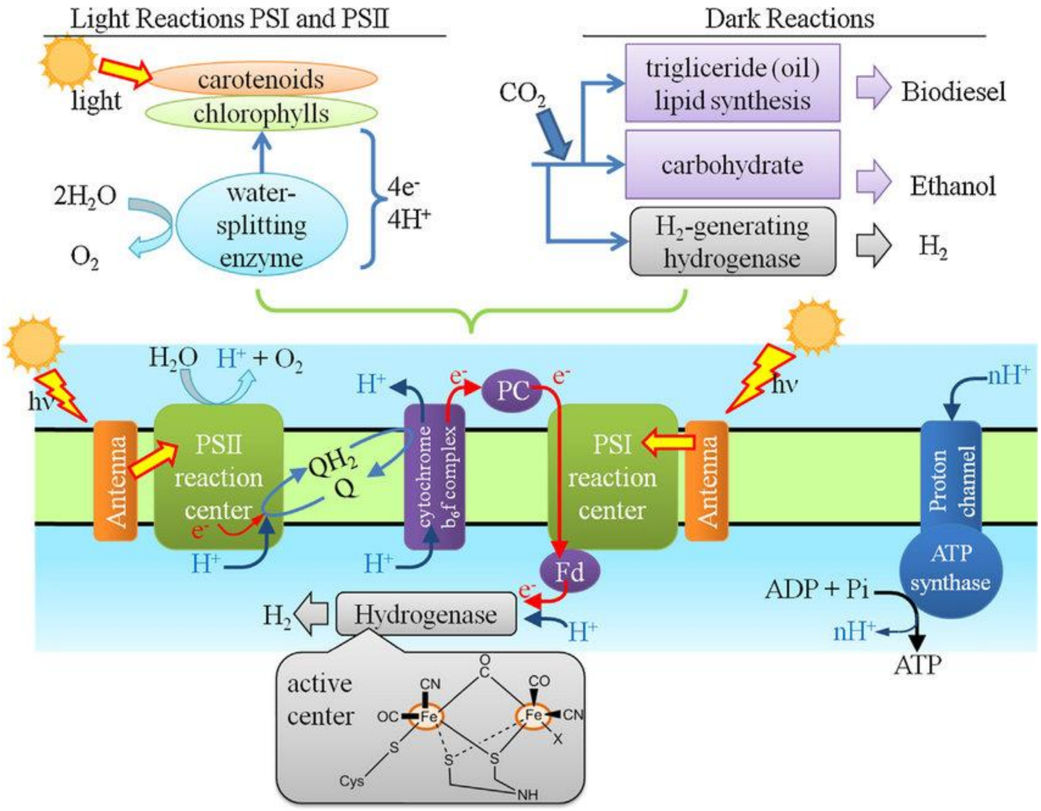
ATP and NADPH are used to **convert 3-PGA into glyceraldehyde-3-phosphate (G3P), a three-carbon sugar.**

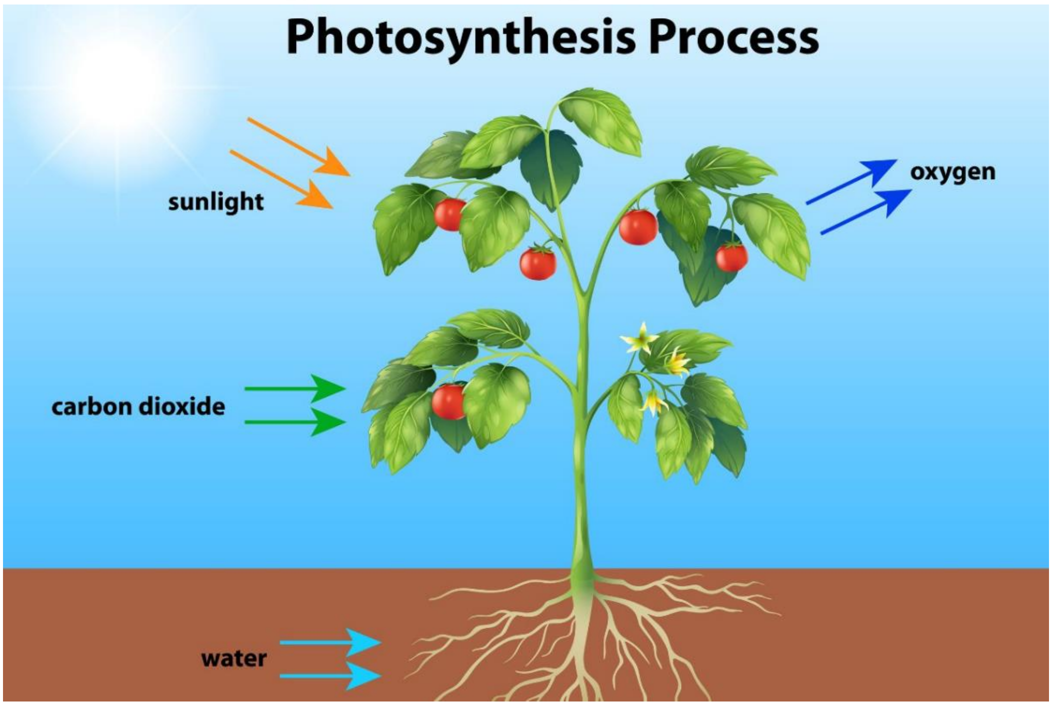
For every three CO_2 molecules fixed, six molecules of G3P are produced, but only one G3P molecule exits the cycle to be used in the synthesis of **glucose and other carbohydrates.**

c. Regeneration:

The remaining five G3P molecules are used to regenerate RuBP, allowing the cycle to continue.

This regeneration process requires ATP


Light Reactions PSI and PSII
light
carotenoids
chlorophylls
2H2O
O2
water-splitting enzyme
4e-
4H+
Dark Reactions
CO2
trigliceride (oil) lipid synthesis
Biodiesel
carbohydrate
Ethanol
H2-generating hydrogenase
H2
hv
H2O
H+ + O2
H+
e-
PC
e-
hv
nH+
Antenna
PSII reaction center
QH2
Q
e-
cytochrome b6f complex
PSI reaction center
Antenna
Proton channel
H+
H+
Fd
ATP synthase
ADP + Pi
e-
H2
Hydrogenase
H+
nH+
ATP
active center
O
C
CN
CO
OC
Fe
Fe
CN
X
S
S
S
Cys
NH


Photosynthesis Process
sunlight
oxygen
carbon dioxide
water