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CLASS 11&12th

CLASS 11th

Photosynthesis

01. Introduction

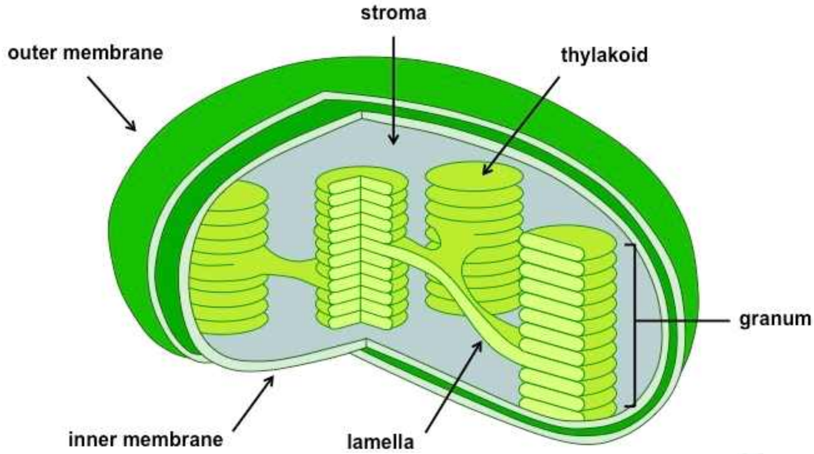
Autotrophic organisms have the ability to synthesise organic food from inorganic raw materials. In this process, they consume physical and chemical forms of energy. One such group of organisms are called **photoautotrophs.** They manufacture organic compounds, i.e. carbohydrates inside the chlorophyll containing cells from CO_2 by utilizing light energy. This process is known as **photosynthesis.** It takes place in plants, phytoplanktons, cyanobacteria, algae, etc. *A simple equation of photosynthesis is as follow*

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

02. Site of Photosynthesis

Chloroplasts

The most active photosynthetic tissue in higher plants in the mesophyll cells of leaves. These have many chloroplasts, which contain the specialised light absorbing pigment, the chlorophylls.



Structure of chloroplast

03. Photosynthetic Pigments

(i) Chlorophylls

It is a green pigment, which traps solar radiations and converts it into chemical energy. The molecular structure of chlorophyll consists of a porphyrin head (ring) and a phytol tail.
Porphyrin head contains four pyrrol rings with one Mg–atom in its centre. It is the site of electron rearrangements when the chlorophyll is excited.
Phytol tail is a long hydrocarbon tail, which always remain attached to the ring structure. Phytol tail interacts with the hydrophobic regions of proteins. These proteins are present in thylakoids. Most of the chlorophyll molecules are found to be immersed in the hydrophobic core of the membrane. Chlorophyll can be of several types. These include Chl–*a,* Chl–*b,* Chl–*c,* Chl–*d,* Chl–*e,* bacteriochlorophyll–*a* and *b,* etc.

(a) **Chlorophyll-a** ($C_{55}H_{72}O_5N_4Mg$) It is a bluish−green pigment that reflects green light. It has a methyl group bonded to the porphyrin. Chl−*a* is the primary photosynthetic pigment.

(b) **Chlorophyll-*b*** ($C_{55}H_{70}O_6N_4Mg$) It is olive−green in colour. It has an aldehyde group instead of a methyl group bounded to the porphyrin. Chlorophyll−*a* and *b,* both are soluble in organic solvents like alcohol, acetone, etc.

(ii) Carotenoids

These are yellow, brown and orange pigments. These absorb light strongly in the blue−violet region. These prevent photo−oxidation of chlorophyll pigments. These are called **lipochromes** because of their fat−soluble nature. Chl−*b* carotenoids are also called as **accessory pigments.** They absorb light energy and transfer it to chlorophyll−*a.i*

Carotenoids are of two types

(a) **Carotenes** They are hydrocarbons with molecular formula $C_{40}H_{56}$. Carotenes are orange in colour. Carotenes are mostly tetraterpenes. The red colour of tomato and chillies is because of carotene called **lycopene.**

(b) **Xanthophylls** They are yellow coloured carotenoids also called as **carotenols** or **xanthols.** They differ from carotenes in having two additional oxygen atoms. Their molecular formula is $C_{40}H_{56}O_2$, e.g. lutein and zeaxanthin. The yellow colour of autumn leaves is due to lutein. The characteristic xanthophyll of brown algae is fucoxanthin.

(iii) Phycobilins (red and blue pigments)

These are proteinaceous pigments found in red algae and cyanobacteria. Phycobilins do not contain magnesium and phytol tail. These are soluble in hot water.

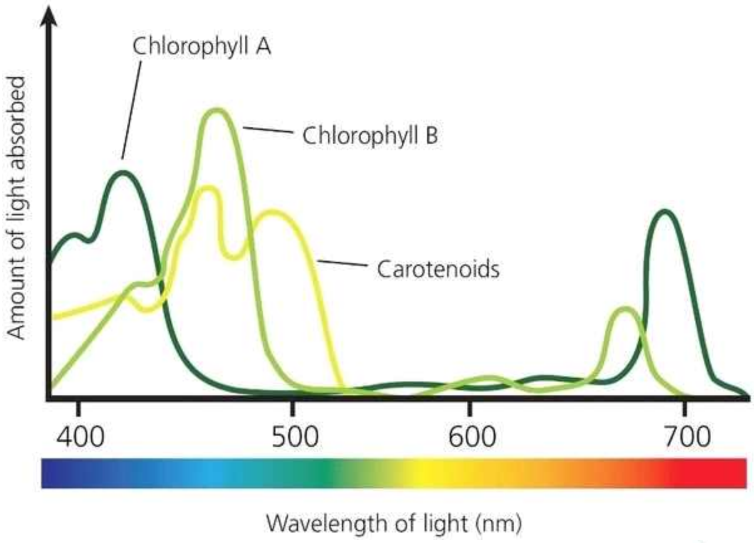
The phycobilin pigments are of two types

(a) **Phycocyanin,** found in blue−green algae.

(b) **Phycoerythrin** found in red algae. Phycobilins are also considered accessory pigments of photosynthesis.

A photosynthetic pigment cannot absorb all the sunlight falling on a green plant. These pigments only absorb a part of light, i.e. visible part (390-760 nm). The remaining light is reflected back to the atmosphere. This visible part of light is called as **Photosynthetically Active Radiation** (PAR).

Absorption Spectrum is a graph, which shows the amount of absorption of different wavelengths of light by a particular pigment.**Action spectrum** is a graph, which shows the degree of different wavelengths affectthe rate of photosynthesis. Action spectrum can be given for any light driven process. It given an idea that, which wavelength is responsible for the onset or shutdown of photosynthesis.



04. Emerson Effect and Red Drop

Emerson (1957) reported that when a monochromatic beam of wavelength more then 680 nm is used, the rate of photosynthesis is reduced. This fall in quantum yield above 680 nm is called red drop. He later on found that if two monochromatic beams of wavelength 650-680 nm and 700-720 nm are used, the rates of photosynthesis increase. This is know as **Emerson's enhancement effect.**

05. Concept of Pigment System

The smallest number of pigment molecules, required as a unit, to carry out the light reaction of photosynthesis is known as **photosynthetic unit.** Park and Biggins named these units as quantasomes. These are present on the thylakoid membranes. Each quantasome consists of 200-240 chlorophyll molecules, carotenoids, quinone compounds, sulpholipids, phospholipids, proteins, etc. Since, these units contain various pigments that harvest light molecules, they are also known as **pigments systems** or **Light Harvesting Complexes** (LHC) or **photosystems**.
A photosystem consists of antenna molecules and a reaction centre. Antenna molecules absorb light energy and transfer it to the chlorophyll–*a* molecule of reaction centre. The two types of photosystems found in the thylakoid membrane are photosystem–I and photosystem–II.