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Unit-I

Chloroplast

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- Plants form the basis of all life on earth and are known as producers.
- Plant cells contain structures known as plastids which are absent in animal cells. These plastids are double-membraned cell organelles which play a primary role in the manufacturing and storing of food.
- There are three types of plastids –
- **Chromoplasts**- They are the color plastids, found in all flowers, fruits and are mainly responsible for their distinctive colors.
- **Chloroplasts**- They are green colored plastids, which comprises green-coloured pigments within the plant cell and are called as the chlorophyll.
- **Leucoplasts**- They are colorless plastids and are mainly used for the storage of starch, lipids, and proteins within the plant cell.

- “Chloroplast is an organelle that contains the photosynthetic pigment chlorophyll that captures sunlight and converts it into useful energy, thereby, releasing oxygen from water.”
- Chloroplasts are found in all green plants and algae. They are the food producers of plants. These are found in the guard cells located in the leaves of the plants. They contain a high concentration of chlorophyll that traps sunlight. This cell is organalle not present in animal cells.
- Chloroplast has its own DNA and can reproduce independently, from the rest of the cell. They also produce amino acids and lipids required for the production of chloroplast membrane.

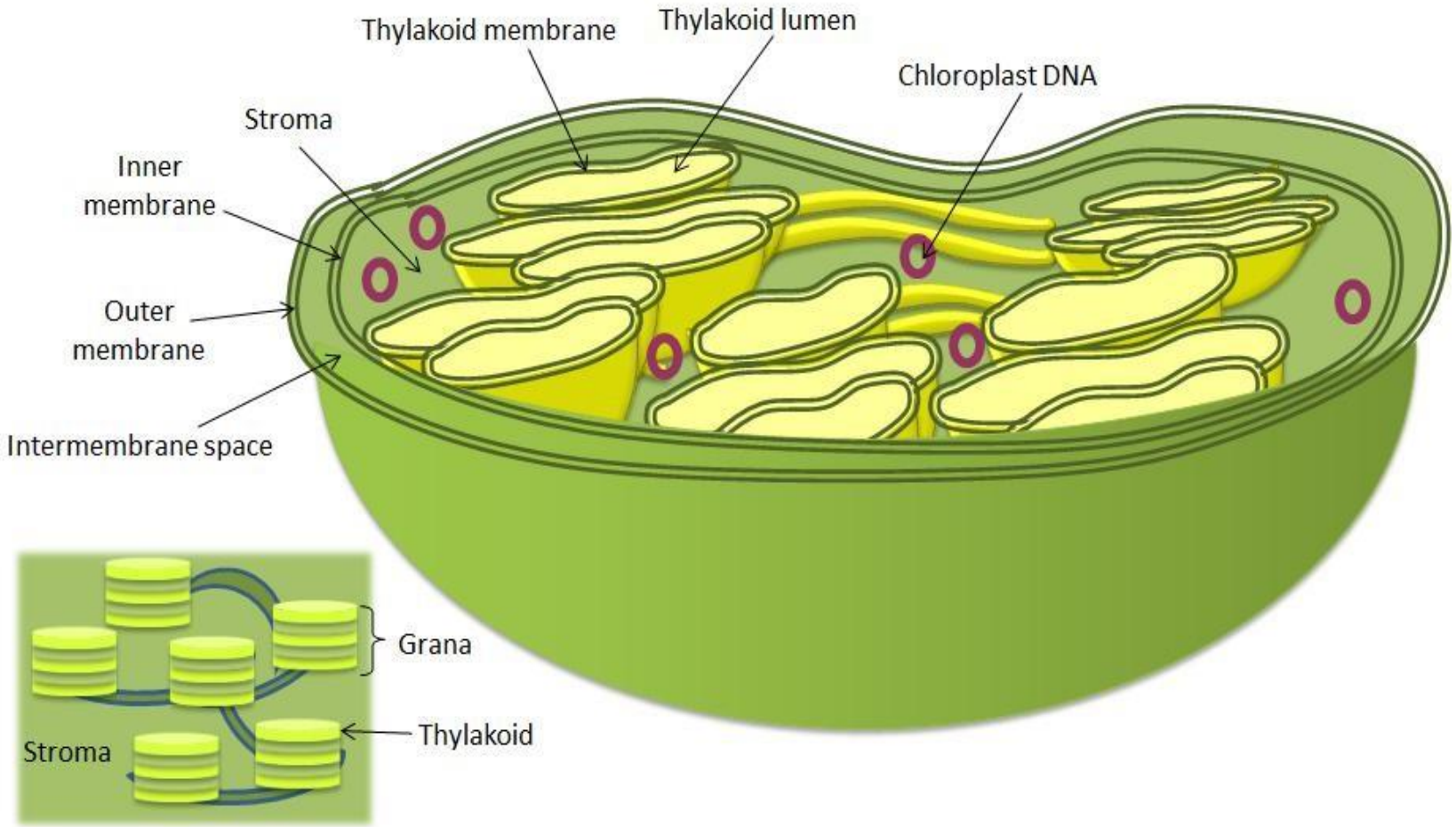


Fig. 1: Ultrastucture of chloroplast showing two membranes. The chloroplast differs from mitochondria in having a third membrane system, the thylakoid membrane which contain green pigment chlorophyll.

Structure of Chloroplast

- Chloroplasts are found in all higher plants. It is oval or biconvex, found within the mesophyll of the plant cell.
- The size of the chloroplast usually varies between 4-6 μm in diameter and 1-3 μm in thickness.
- They are double-membrane organelle with the presence of outer, inner and intermembrane space.
- There are two distinct regions present inside a chloroplast known as the grana and stroma.
- The outer chloroplast membrane has porin proteins (like found on the outer mitochondrial membrane) and therefore is freely permeable to small molecules.
- In contrast to this, the inner chloroplast membrane is highly impermeable (like inner mitochondrial membrane) and restricts the passage of molecules.

- The inner membrane contains various transporters through which the passage of molecules take place.
- The chloroplast stroma contains double strande, circular, naked DNA (**plastidome**), 70S ribosomes (**plastidoribosome**) and variety of metabolic enzymes.
- The stroma is the site for dark reaction that fixes CO_2 to produce carbohydrates. The stroma in green algae also contain **pyrenoids** which store starch.
- Grana are made up of stacks of disc-shaped structures known as thylakoids.
- The grana of the chloroplast consists of chlorophyll pigments and are the functional units of chloroplasts.
- Stroma is the homogenous matrix which contains grana and is similar to the cytoplasm in cells in which all the organelles are embedded.
- Stroma also contains various enzymes, DNA, ribosomes, and other substances. Stroma lamellae function by connecting the stacks of thylakoid sacs.

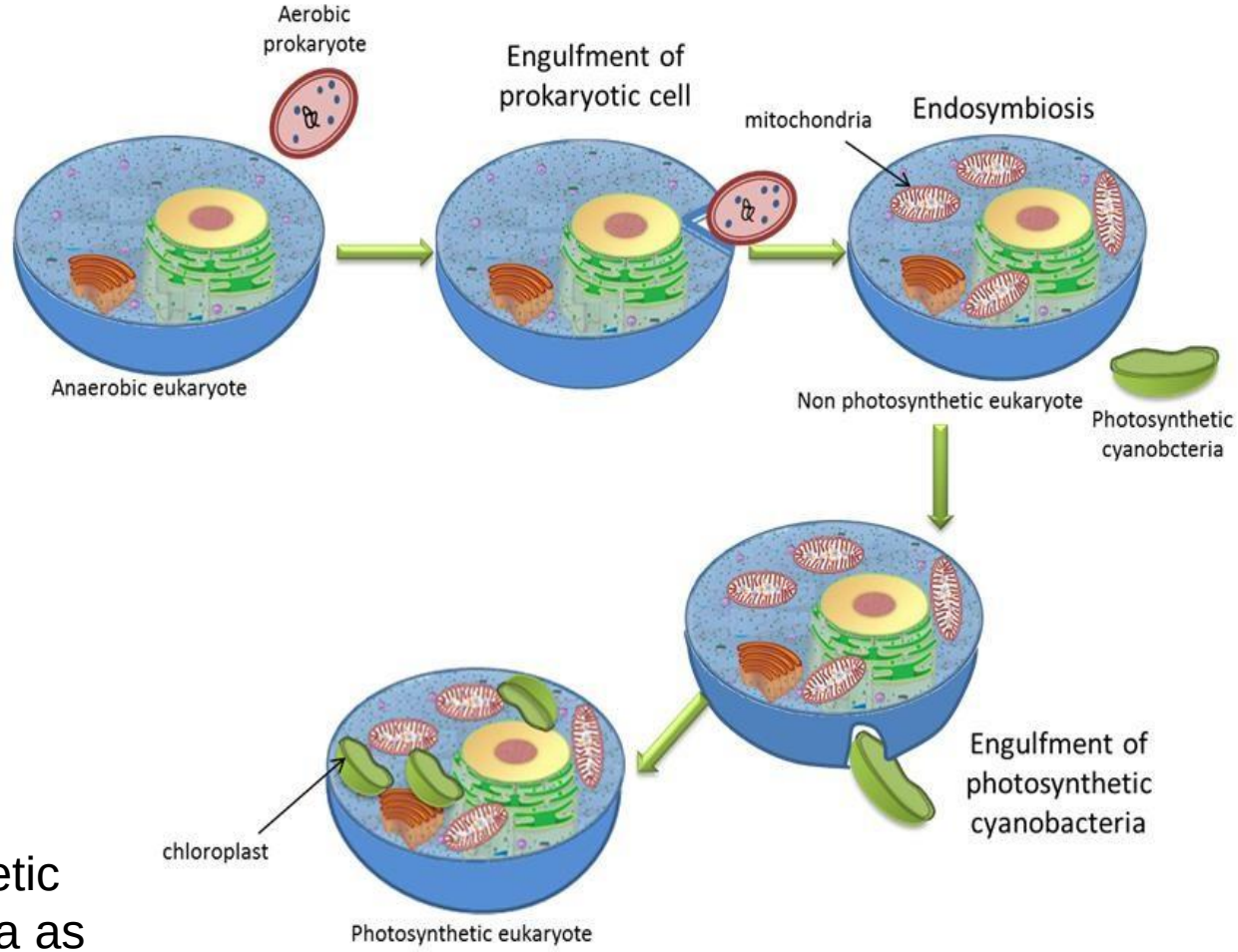
- **Membrane Envelope** – It comprises inner and outer lipid bilayer membranes. The inner membrane separates the stroma from the intermembrane space.
- **Intermembrane Space–** The space between inner and outer membranes.
- **Thylakoid System–** The system is suspended in the stroma. It is a collection of membranous sacs called thylakoids. The green coloured pigments called chlorophyll are found in the thylakoid membranes. It is the sight for the process of light-dependent reactions of the photosynthesis process. The thylakoids are arranged in stacks known as grana and each granum contains around 10-20 thylakoids.
- **Stroma-** It is a colourless, alkaline, aqueous, protein-rich fluid present within the inner membrane of the chloroplast present surrounding the grana.
- **Grana-** These are the sites of conversion of light energy into chemical energy.
- **Chlorophyll-** It is a green photosynthetic pigment that helps in the process of photosynthesis.

CHLOROPLAST DNA (CPDNA)

- The presence of DNA in chloroplast was first reported by Ris and Plaut in 1962. Chloroplast contain double stranded, circular, naked DNA which is present in multiple copies like mitochondria. The cpDNA from many plants has been sequenced.
- The size of cpDNA ranges from 120-160kb and contains 60-200 genes, more as compared to mitochondria.
- The cpDNA contain genes for four rRNAs (4.5S rRNA, 5S rRNA, 16S rRNA and 23S rRNA), 30 tRNA, 21 ribosomal proteins, RNA polymerase, photosystem I, photosystem II, cytochrome b6f complex, ATP synthase and large subunit of ribulose1,5- bisphosphate carboxylase (Rubisco).

ORIGIN OF CHLOROPLAST

- Just like mitochondria, the evolutionary origin of chloroplast has been described by **endosymbiotic theory** proposed by Lynn Margulis in 1970s. The chloroplast originated from a photosynthetic prokaryote like cyanobacteria that was engulfed by a large non-photosynthetic e



The endosymbiotic origin of chloroplast from photosynthetic prokaryote like cyanobacteria as proposed by Lynn Margulis

Similarities between chloroplast and mitochondria

- Both organelles are enclosed in double membrane
- Both contain 70S ribosomes
- Both contain double stranded, circular, naked DNA
- Both are semi-autonomous organelles
- Both are thought to be evolved by endosymbiosis
- Both produce ATP
- Both can replicate by fission

Differences between chloroplast and mitochondria

- Inner membrane is folded into cristae in mitochondria while in chloroplast cristae are absent.
- Thylakoids are absent from mitochondria while they form the functional unit in chloroplast
- Mitochondria lack pigments while chloroplast contain a variety of pigments
- Mitochondria are catabolic while chloroplast are anabolic

Functions of Chloroplast

- The most important function of the chloroplast is to synthesize food by the process of photosynthesis.
- Absorbs light energy and converts it into chemical energy.
- Chloroplast has a structure called chlorophyll which functions by trapping the solar energy and used for the synthesis of food in all green plants.
- Produces NADPH and molecular oxygen (O_2) by photolysis of water.
- Produces ATP – Adenosine triphosphate by the process of photosynthesis.
- The carbon dioxide (CO2) obtained from the air is used to generate carbon and sugar during the Calvin Cycle or dark reaction of photosynthesis.