# 8 Plastids

Plastids are large cytoplasmic organelles. They synthesize and store carbohydrate. Plastids are present only in plant cells. Hence plastids distinguish plants from animals.

The term plastid is derived from the Greek word ***plastikas*** meaning ***formed*** or ***moulded.*** This term was coined by ***Schimper*** in 1885.

The plastids are broadly classified into two main types, namely ***chromoplasts*** and ***leucoplasts***.

## 1. Chromoplasts

These are coloured plastids (***Chroma*** = colour; ***plast*** = living). They contain various pigments. They synthesize food materials by photosynthesis.

- **Plastids**
  - Chromoplasts (Synthesis)
    - Chloroplast
    - Phaeoplast
    - Rhodoplast
  - Leucoplasts (Storage)
    - Amyloplast
    - Elaioplast
    - Proteinoplast

*Fig.8.1: Classification of plastids.*

The chromoplasts are further subdivided into three types based on their colour. They are the following:



1. *Chloroplast,*
2. *Phaeoplast and*
3. *Rhodoplast.*

### 1. Chloroplast

This plastid is ***green*** in colour (***chlor*** = green; ***plast*** = living). It contains green pigments called ***chlorophylls.*** It is found in higher plants and green algae.

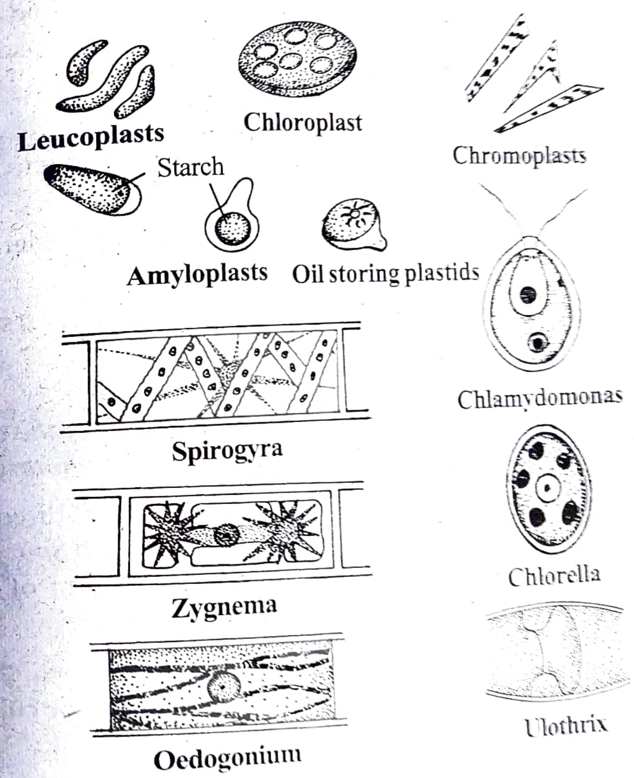


*Fig.8.2: Different types of plastids.*

### 2. Phaeoplast

This plastid is ***dark brown*** in colour (***phaeo*** = dark brown; ***plast*** = living). It contains a dark brown pigment called *fucoxanthin*. Its main function is to absorb light and transfer the energy to chlorophyll. The phaeoplasts are found in brown algae, diatoms and dinoflagellates.

### 3. Rhodoplast

This plastid is ***red*** in colour (***rhode*** = red; ***plast*** = living). It contains a red pigment called ***phycoerythrin***. Its main function is to absorb light. This type of plastid is found in red algae (Rhodophyceae).

## 2. Leucoplasts

These are colourless plastids (***leuco*** = white; ***plast*** = living). They do not contain colour pigments. Their main function is to store food materials. They do not involve in synthetic activities. The leucoplasts are sub-divided into three types, namely

*1. Amyloplast* *3. Proteinoplast*
*2. Elaioplast*

**1. Amyloplast:** This colourless plastid (***amyl*** = starch; ***plast*** = living) is found in tubers, cotyledons and endosperm. It stores ***starch.***

**2. Elaioplast:** This colourless plastid is found in the epidermal cells of ***Orchidaceae*** and ***Liliaceae.*** It stores ***oils.***

**3. Proteinoplast:** This colourless plastid is found in seeds and nuts. It stores ***protein.***

## Structure of Chloroplast

***Chloroplasts*** *are green, discoid, self-propagating bodies in the cytoplasm of plant cells.* They are ***green plastids.*** They are concerned with ***photosynthesis.***

Chloroplasts vary in shape. They are spheroid or ovoid or discoid in higher plants. They are ***cup-shaped*** in *Chlamydomonas*, ***spirally coiled*** in *Spirogyra*, ***girdle-shaped*** in *Ulothrix*, ***star shaped*** in *Zygnema* and in the form of ***network*** in *Oedogonium*.

The size of the chloroplasts varies from species to species. In higher plants, it is 4-5 microns in length and 1-3 microns in thickness. Generally the chloroplasts of plants growing in shady places are larger in size.


*Fig.8.3: Electron micrograph of pea leaf chloroplast.*



The number of chloroplasts varies from plant to plant, but it remains constant in all cells of a plant. In higher plants, there are 20 to 40 chloroplasts per cell. The algal cells contain one or a few large chloroplasts.

### Ultra Structure

A chloroplast is bounded by two unit membranes, namely an ***outer membrane*** and an ***inner membrane.*** The two membranes are separated by a space called ***periplastidial space.*** The periplastidial space is 70-100 A° in diameter and is filled with a watery fluid. Each membrane is about 40-60 A° in thickness. Both the membranes resemble the plasma membrane in their structure. They are formed of proteins and lipids. They are unit membranes. The outer membrane is freely permeable to small molecules. The inner membrane is selectively permeable.

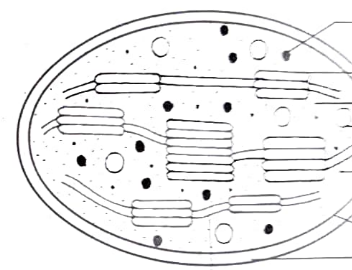


*Fig.8.4: Cross section of a chloroplast*

The interior of the plastid is filled with a colloidal substance called ***matrix*** or ***stroma.*** The matrix is colloidal, transparent and proteinaceous in nature. It contains circular double stranded DNAs, 70S ribosomes, many *enzymes* and starch grains.

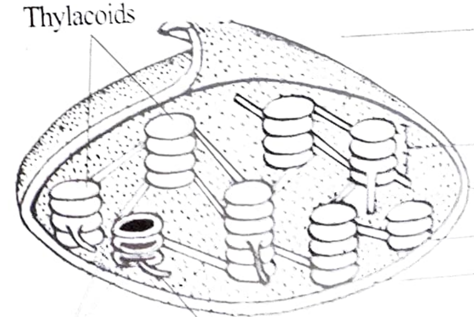


*Fig.8.5: 3D structure of chloroplast*

In the matrix, there are many closed flattened sacs called ***thylacoids*** (thylacoid= sac-like). Each thylacoid is bounded by a single ***unit membrane*** and it encloses a cavity called ***loculus.*** The thylacoid is 0.25-0.8 mm in diameter.

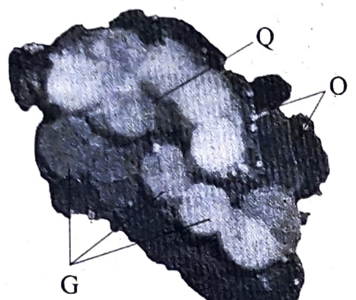


*Fig.8.6: Electron micrograph of Vicia leaf chloroplast showing grana in surface view. [O - Osmophilic granules ; G - grana ; Q - Granal lamellae].*

10 to 100 thylacoids are arranged one above the other in the form of a stack of discs. This structure is called a ***granum.*** A chloroplast has 40-60 grana in its matrix. The granum may be 0.25-8.0mm in diameter. The thylacoids of adjacent grana are interconnected by branching membraneous tubules called ***frets*** or ***stromal lamellae*** or ***stroma thylacoids.***

The membrane of the thylacoid is a unit membrane. The thylacoid membrane contains minute spherical particles called ***quantosomes.*** Each quantosome is made up of chlorophyll molecules and carotenoids. It absorbs light for photosynthesis. The quantosomes are the real ***photosynthetic units.***

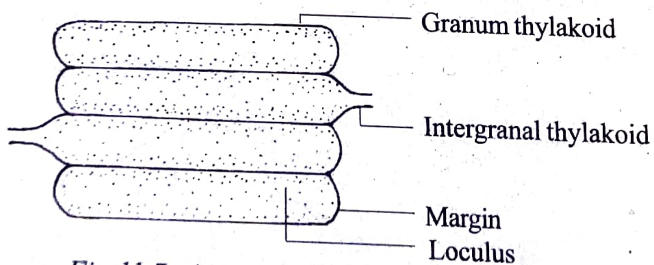


*Fig.11.7: A portion of a granum.*

There are two types of quantosomes. They are ***Pigment system I*** (PSI) and ***Pigment system II*** (PSII). The PS II is found on the inner surface of thylacoid membrane, which has 200 chlorophylls and 200 carotenoids. It is 175 X 90 A° in size. PSII particles are widely spaced on the membrane.



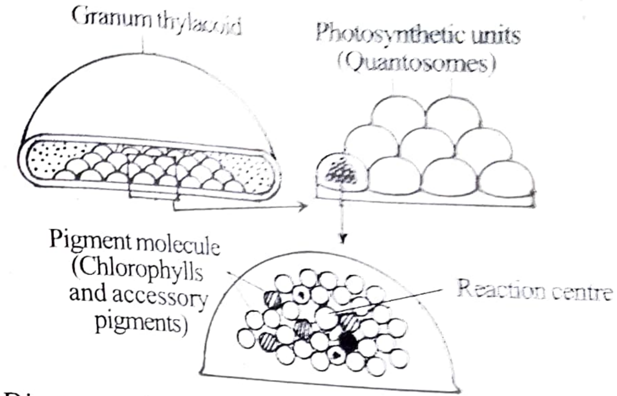


*Fig.8.8: Diagrammatic representation of a portion of granum showing the quantosome.*

PSI is found on the outer surface of thylacoid membrane. It is 100 X 90A° in size and formed of 200 chlorophylls and 50 carotenoids. PSI quantosomes are closely arranged on the membrane.

***Coupling factors I*** (CFI) and *RuDP carboxylase* are also similar spherical bodies present on the outer surface of thylacoid membrane. The CFI is 90 A° in diameter and it has ATPase enzyme for phosphorylation. RuDP carboxylase is the enzyme that accepts $CO_2$ for calvin cycle.

The membrane of thylacoid is a unit membrane. It consists of proteins and lipids arranged in the form of three layers. The photosynthetic pigments such as ***chlorophylls*** and ***carotenoids*** are distributed between the central lipid layer and protein layer. Each chlorophyll molecule is made up of a ***porphyrin head*** and a ***phytol tail.*** The porphyrin head faces the protein and the tail faces the lipid layer. Carotenoids are found alternate with the chlorophyll molecules. Electron acceptors occur in the lipid bilayer.

## Chemical Composition

Chloroplast contains *proteins, lipids, carbohydrates, DNA, RNA,* ***carotenoids, chlorophyll*** and ***minerals.*** These chemicals are present in the following ratios:

| | |
|---|---|
| 1. Proteins | 35-55% |
| 2. Lipids | 20-30% |
| 3. Carbohydrates | Variable |
| 4. Chlorophyll | 9% |

| | |
|---|---|
| 5. Carotenoids | 4.5% |
| 6. RNA | 3 to 4% |
| 7. DNA | 0.5% |
| 8. Minerals | 0.2% |

The chloroplast contains three types of photosynthetic pigments. They are-

*1. Chlorophylls*

*2. Carotenoids and*

*3. Phycobilins*

***Chlorophyll*** is a green pigment present in higher plants and green algae. Structurally it is similar to haemoglobin. In the place of iron, it contains magnesium in the porphyrin ring. There are several kinds of chlorophylls, namely ***chlorophyll a, chlorophyll b, chlorophyll c, chlorophyll d,*** etc. ***Chlorophyll a*** is present in higher plants and algae. It is insoluble in water and it can be extracted only with organic solvents. ***Chlorophyll b*** is present in higher plants and most green algae. ***Chlorophyll c*** is found in diatoms, dinoflagellates and brown algae. ***Chlorophyll d*** is present in red algae.

***Carotenoids*** are yellow or orange pigments. They are found in all photosynthetic plants along with the chlorophylls. There are two kinds of carotenoids, namely ***carotenes*** and ***carotenols*** (xanthophylls). Carotenoids are insoluble in water and can be extracted only with organic solvents.

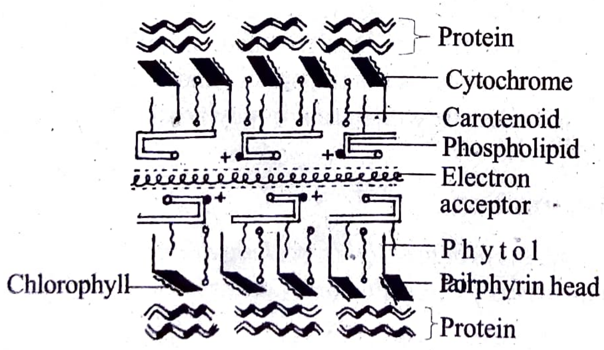


*Fig.8.9: Representation of molecular arrangement of different pigments.*

Phycobilins are the accessory pigments found in red algae and blue green algae. They are conjugated proteins. The phycobilin of red algae is called



***phycoerythrin*** and that of blue green algae is called ***phycocyanin.*** The phycobilins are ***open chain porphyrin type*** while the chlorophyll has ***cyclic porphyrin component.***

DNA of the chloroplast is circular in shape and double -stranded. The DNA is about 25A⁰ wide. The DNA of chloroplast is concerned with ***cytoplasmic inheritance, protein synthesis*** and ***division of chloroplasts.***

The ribosomes of chloroplasts are smaller in size. The ribosomes are 70S type. The 70S ribosome contains two sub-units, namely 50S and 30S. They are involved in ***protein synthesis*** in chloroplasts.

The chloroplasts are partly independent organelles. They can manufacture some of their proteins with the help of their DNA and ribosomes. For example, chloroplasts of maize synthesize about 30 different proteins by their DNA. Other proteins for their requirements, are received from the cytoplasm formed under the control of nuclear DNA.

## Origin

The plastids originate in three ways. They are the following:

*1. From proplastids*

*2. From pre-existing chloroplasts and*

*3. From symbiotic origin.*

### 1. From Proplastids

All plastids develop from small rounded unpigmented bodies called ***proplastids.***

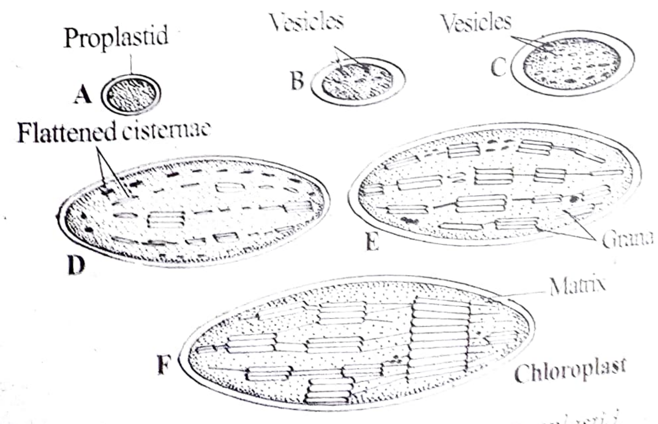


*Fig.8.10: Development of chloroplast from proplastid.*

A proplastid consists of a dense ***matrix***, bounded by two unit membranes. The inner membrane develops infoldings called ***lamellae.*** In the presence of light, its lamellae progressively develop into ***thylacoids*** and the proplastid becomes a plastid.

### 2. From Pre-existing Chloroplasts

In algae and ferns, the new chloroplasts originate by the division of the pre-existing chloroplasts.

### 3. From Symbiotic Origin

Chloroplasts resemble bacteria in having circular DNA, 70S ribosomes and protein synthesizing machinery. It is believed that the ***bacteria***-like organism entered the eukaryotic cells in the early ages of evolution. Inside the eukaryotic cells the organism developed a symbiotic relationship. In due course of time, the symbiotic organism became a photosynthetic organelle.

## Functions of Chloroplast

Chloroplast has the following functions:

### 1. Protein Synthesis

As chloroplast contains DNA and ribosomes, it synthesizes certain proteins.

### 2. Starch Storage

Chloroplasts temporarily store starch during the day time in the ***pyrenoid*** (starch forming organelle). At night, the starch is transferred to regions of growth and storage.

### 3. Oxygen Supply

Chloroplasts utilize carbon dioxide for photosynthesis and release oxygen. This oxygen is used by all animals and plants for respiration.

### 4. Cytoplasmic Inheritance

The DNA present in the chloroplast expresses certain characters in the organisms. It serves as an extra-nuclear genetic material. The transmission of characters by extra nuclear DNA is called ***cytoplasmic inheritance.*** Eg. *Mirabilis jalapa.*

### 5. Photosynthesis

Photosynthesis is a vital ***biological process.*** It takes place in chloroplasts. During photosynthesis, the organisms manufacture glucose with the help of chlorophyll using light, carbon dioxide and water. Photosynthesizing organisms are called ***photo-autotrophs.*** The stored up photosynthetic product is the main food for animals.



**Photosynthesis has the following salient features:**

1. **Visible light** is the source of energy for photosynthesis.
2. **Chlorophyll** traps the light energy.
3. **Inorganic substances** such as water and carbon dioxide are the raw materials.
4. **In photosynthesis,** glucose is synthesized.
5. **Oxygen is released** as the by product.

Photosynthesis is represented by the following equation:

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2$$

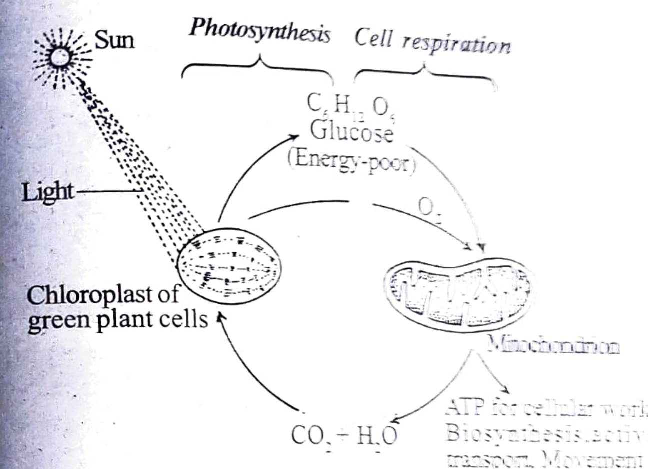


*Fig.8.11: Role of chloroplast and mitochondria in energy cycling via photosynthesis and cell respiration.*

## Mechanism of Photosynthesis

The process of photosynthesis takes place in two steps. They are-

*1. Light reaction* and

*2. Dark reaction*

### 1. Light Reaction

The light reaction occurs only in the presence of light and hence the name light reaction. Here the light energy is trapped by the chlorophyll. This reaction occurs