CHAPTER 6

6.0 CHLOROPLASTS

6.1 Introduction

i) Definition: Chloroplast also referred to as plastid are photosynthesis organelles found in plants and prokaryotic organisms. All plastids are surrounded by two envelope membranes and are derived by division from a population of proplastids within the meristematic (stem) cells of the plant.

ii) Organism with chloroplast: They include higher plants, red algae, green algae, diatoms. Also apicomplexan human pathogens like toxoplasma, gondii and plasmodium falciparum contain plastids that are distant cousins of the chloroplast, making fundamental plastid biology relevant to our understanding of human diseases.

iii) Origin of chroloplast
Plastids arose from an endosymbiotic relationship between a primitive biciliate protozoan and an ancient cyanobacterium that began 1.2–1.5 billion years ago. Over time they have greatly changed from origin form due to selection pressure and mutation such that it has lost over 90% of it gene content. Even plastid coding genes, most of them are found in the nucleus.

iv) Shape : it is disk-like in shape
v) Size: vary from 2-4μm in diameter and about10μm in length
vi) Shape and size depends on metabolic state of the cell e.g. chloroplast exposed to light shrink in volume and increase in length to volume ratio.
vii) Chloroplast containing cells are autotrophy (self feeding) cells, that is cells that generate their own reduced carbon by photosynthesis.
viii) Heterotrophy (feeding on others) cells that cannot synthesis and therefore consume foodstuffs containing reduced carbon.

6.2 Photosynthesis.

6.2.1 Overview of photosynthesis

$$CO_2 + H_2O \xrightarrow[\text{Green plant}]{\text{light}} (CH_2O)_n + O_2$$

Principally glucose is produced by this pathway

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

1771 Priesty's experiment

i) Candle was put in a enclosed chamber and burnt until it extinguished.
ii) When a mice was put in this chamber it suffocated
iii) When plant was put in the chamber the mice was able to breath, plant was found to restore normal state of air.

iv) **Jan Ingenhousz** - a Dutchman later discovered that only the green part of plant could restore air and light is required for this restoration.
v) **1782 Jean Senebrier** a Swiss minister discovered restoration is accompanied by Carbon dioxide uptake.
vi) An other discovery (around this time) is that the restoration is based on the ability by green plant to produce oxygen was made.
vii) **Theodore de Saussure** -discovered that synthesis of organic matter involves uptake of water.
viii) By end of 18^{th} century it was clear that photosynthesis converts water and carbon to organic matter and oxygen.
i) **1845 Julius Robert Mayer**, a German, suggested that light provides the energy needed for photosynthesis.

6.2.2 Light and Dark reactions

Light reaction

Light reaction is a temperature insensitive pathway that requires light. It is responsible for absorbing light and producing Oxygen.

6.2.3 Dark reaction

i) It is temperature sensitive process requiring CO_2.
ii) Dark reaction is involved in CO_2 fixation from atmosphere and converting it into organic matter.

Evidence of dark reaction. Photosynthesis is stimulated by flashing than by continuous light are evidence of dark and light reactions.

iii) Dark reaction proceeds driven by energy trapped in light reaction.

6.2.4 **Hill reaction-Robert Hill**, 1930s

i) He used artificial electron acceptor Fe^{3+} (instead of natural one CO_2).

$$4Fe^{3+} \xrightarrow{2H_2O} 4Fe^{2+} + 4H + O_2$$

ii) Hill reaction indicates that;
a) Light requiring steps of photosynthesis can occur in absence of dark reaction of CO_2 fixation.
b) Oxygen atoms produced (liberated) must be from water since during photosynthesis oxygen can be produced in absence of CO_2 fixation.

6.3 Anatomy of Chloroplast

It is a membrane closed organelle.

Chloroplast ultra structure

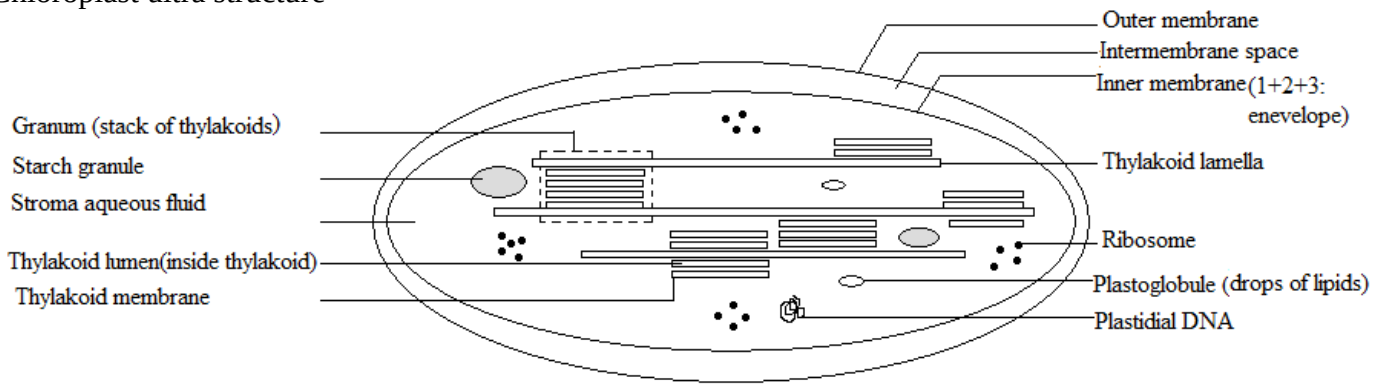

Fig 6.1 Structure of chloroplast

6.2.1 The chloroplast envelope

i) It is a double membrane barrier (inter and outer membrane). Between them is intermembrane space.
ii) Chloroplast envelope readily permeable to small molecules (but the inner membrane is not).

Function of the lipid metabolism.

a) Separates cytoplasm from the interior regions of the chloroplast.
b) Controls movement of the molecular material in and outer of the cell .
a) Contain enzymes that catalyze the synthesis of many of the lipids present within the chloroplast e.g. galactolipids, carotenoids and phenylquinones.

6.2.2 **Chloroplast Stroma.**

i) It is an amorphous, gel-like and enzyme rich material.
ii) Constituents of stroma are;
a) Starch grains- store some of the CHO products produced by the dark reaction of the photosynthesis.
b) Platoglobuli: these are lipid containing deposites. They serve as reservoirs of lipid for thylakoid membrane formation.
c) Stroma centres (in higher plants) are believed to contain ribulose biphosphate carboxylase, an enzyme used in CO_2 fixation.
d) DNA, RNA, and ribosomes are other factors involved in nucleic acid and protein synthesis.
e) Stroma contain all other enzymes involved in dark reaction.

6..2.3 Grana-are small green granules suspended in the stroma

i) Are about 50 or more per cell.
ii) Size ra ge 0.5-2.0 μm in diameter
iii) Grana are made up of Thylakoids.
a) Thylakoids are clusters of flattened membrane sacs (stacked to each other like coins).
b) Stacked thylakoids are membrane that make up thylakoids.

c) Thylakoid sacs.
d) Unstacked thylakoid- are membrane channels (large flattened sheets).
They make connections to many or all of the individual thylakoids or a given granum i.e.(connects grana stack to each other).
e) Peripheral reticulum- are small vesicles and tubules that connect thylakoids and inner membrane and are found only in certain chloroplasts.
f) CF_1 spheres contain a protein complex called CF_1.The CF_1 plays a central role in photosynthesis and ATP formation.

6.2.4 Thylakoid membrane

i) Thylakoid -from Greek word Thylakos, "sac" or "ponch".Thylakoid stacks are called grana (single granum).
ii) Stroma thylakoids are longer thylakoids that connect one granum to another through the stroma.
iii) CF_1 - are found on the stacked thylakoids. They contain light absorbing chlorophyll carotenoids, and xanthopylls.
iv) In thylakoids energy from light is used to oxidize H_2O and form energy rich ATP and NADH which are needed to convert CO_2 to carbohydrates.
v) Chlorophyll consists of chlorophylls a and b.