JSR IAS ACADEMY

GENERAL SCIENCE

BIOLOGY

Main concepts of

Life Science

Cell Respiration

Plastids

Plastids are **double membrane bound organelles found in plants and some algae.**

They are **responsible for preparation and storage of food.**

There are three types of plastids.

1. **Chloroplast** - green coloured plastids
2. **Chromoplast** - yellow, red, orange coloured plastids
3. **Leucoplast** - colourless plastids

Type	Pigment	Functions
Chloroplast	Chlorophyll - green pigment	gives green colour to the stem and leaves
Chromoplast	Carotene - orange pigment Xanthophyll - yellow pigment	gives colour to flowers and fruits
Leucoplast	No pigments - colourless	found in roots and underground stems

Structure of Chloroplast

Diameter 2-10 micro meter,1-2 thickness,Cylinder shape cell

Chloroplasts are **green plastids containing green pigment called chlorophyll.**

Chloroplasts are **oval shaped organelles** having a diameter

1.Envelope:

Chloroplast **envelope has outer and inner membranes** which is seperated by intermembrane space.

2. Stroma:

Matrix present inside to the membrane is called stroma.

It **contains DNA, 70 S ribosomes and other molecules** required for protein synthesis.

3. Thylakoids:

It consists of thylakoid membrane that encloses thylakoid lumen.

Thylakoids forms a stack of disc like structures called a **grana (singular-granum).**

4. Grana:

These stacks are termed as grana, they are interconnected to each other by membranous lamellae called Fret channels.

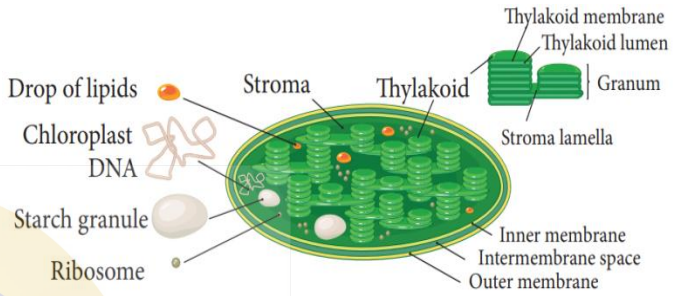


Figure 12.8 Ultrastructure of Chloroplast

Functions of Chloroplast

1. Photosynthesis
2. Storage of starch
3. Synthesis of fatty acids
4. Storage of lipids
5. Formation of chloroplasts

Mitochondria

- Mitochondria are **filamentous or granular cytoplasmic organelles present in cells.**
- The mitochondria were first discovered by **Kolliker in 1857** as granular structures in striated muscles.
- Mitochondria produce **adenosine triphosphate (ATP)** which form the energy currency of the cell, for this reason, the mitochondria is referred to as the **"Power house of the cell".**
- Mitochondria vary in size from **0.5 µm to 2.0 µm.**

Mitochondria contain

- 60-70% protein,
- 25-30% lipids,
- 5-7% RNA and
- small amount of DNA and minerals.

Structure of Mitochondria

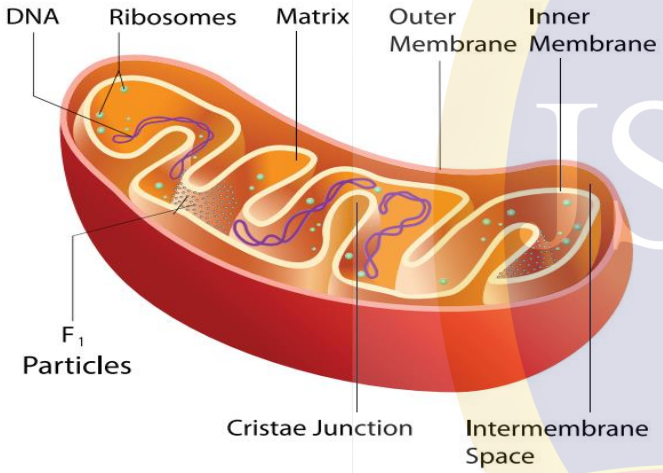
Mitochondrial Membranes:

- It **consists two membranes called inner and outer membrane.**
- Each membrane is **60-70A° thick.**
- Outer mitochondrial membrane is smooth and freely permeable to most small molecules.
- It **contains enzymes, proteins and lipids.**

- It **has porin molecules (proteins) which form channels for passage of molecules through it.**
- Inner **mitochondrial membrane is semi permeable membrane** and **regulates the passage of materials into and out of the mitochondria.**
- It is **rich in enzymes and carrier proteins.**
- It **consists of 80% proteins and lipids.**

Cristae:

- The **inner mitochondrial membrane gives rise to finger like projections called cristae.**
- These **cristae increase the inner surface area (fold in inner membrane) of the mitochondria to hold variety of enzymes.**



Oxysomes:

- The inner mitochondrial membrane bear minute regularly spaced **tennis racket shaped particles** known as oxysomes (F1particle).
- They **involve in ATP synthesis.**

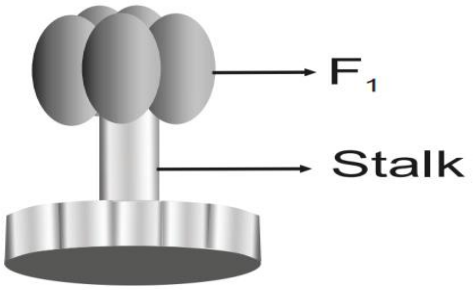


Figure 12.11 Structure of Oxysomes

Mitochondrial matrix

- It is a **complex mixture of proteins and lipids.**
- Matrix **contains enzymes for Krebs cycle, mitochondrial ribosomes(70 S), tRNAs and mitochondrial DNA.**

Functions of Mitochondria

- It helps the cells to **maintain normal concentration of calcium ions.**
- It **regulates the metabolic activity of the cell.**

Types of Tissues

tissues can be classified into four types

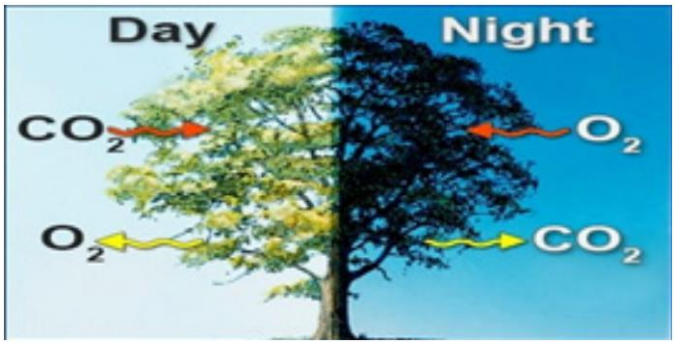
1. **Epithelial (covering) tissue** for protection,
2. **Muscular (contractile) tissue** for movements and locomotion,
3. **Connective (supporting) tissue** for binding different structures of body
4. **Nervous tissue** for conduction of nerve impulses.

Cellular respiration

- Cellular respiration is the process by which organisms **break down glucose into a form that the cell can use as energy.**
- Cellular respiration takes place in **the cytoplasm and mitochondria of the cells.**
- The substance that is used in respiration is known as **respiratory substrate.**
- Respiratory substrates are of **three kinds viz., carbohydrates, fats and proteins.**

TYPES OF RESPIRATION

- Respiration involves **exchange of gases between the organism and the external environment.**
- The plants **obtain oxygen from their environment and release carbon dioxide and water vapour.**
- This exchange of gases is known as **external respiration.** It is **a physical process.**
- Biochemical process occurs within cells where the food is oxidized to obtain energy, this is known as **cellular respiration**



The Cellular respiration is classified into two types:

Aerobic respiration

- Respiration that **uses oxygen is** known as aerobic respiration.
- In this type of respiration, **the food substances are completely oxidized into H2O and CO2 with the release of energy.**

It requires atmospheric oxygen

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$$

Glucose + Oxygen → Carbon dioxide + Water + Energy

The process of Aerobic Respiration takes place in four stages:

1. Glycolysis
2. Oxidative decarboxylation of pyruvic acid
3. Kreb's cycle
4. Electron transport chain.

Stages of Aerobic respiration

a. Glycolysis (Glucose splitting):

- It is the breakdown of **one molecule of glucose (6 carbon) into two molecules of pyruvic acid (3 carbon).**
- Glycolysis takes place in **cytoplasm of the cell.**
- It is the **first step of both aerobic and anerobic respiration.**

b. Krebs Cycle:

- This cycle **occurs in mitochondria matrix.**
- At the **end of glycolysis, 2 molecules of pyruvic acid enter into mitochondria.**
- The oxidation **of pyruvic acid into CO2 and water takes place through this cycle.**
- It is also called **Tricarboxylic Acid Cycle (TCA).**

c. Electron Transport Chain:

- This is accomplished through a system of electron carrier complex called **electron transport chain (ETC)** located on the inner membrane of the mitochondria.
- **NADH2 and FADH2** molecules formed during glycolysis and Krebs cycle are oxidised to **NAD+ and FAD+** to release the energy via electrons.
- The electrons, as they move through the system, release energy which is **trapped by ADP to synthesize ATP.**
- This is called **oxidative phosphorylation.**
- In this **process, O2 the ultimate acceptor of electrons gets reduced to water.**
- Complete oxidation of a glucose molecule in aerobic respiration produces 38 ATP molecules.

Anaerobic respiration:

- In this type of respiration, partial oxidation of food takes place and the **organisms release energy in the absence of oxygen.**
- This type of respiration is known as anaerobic respiration. It is also known as **fermentation**.
- This type of respiration occurs in organisms like **yeast,Bacteria.**
- e.g. Conversion of milk into curd.
- **Ethyl alcohol and carbon dioxide are the by-products of** this process.

$$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH + \text{ஆற்றல்} (ATP)$$

Glucose → Ethanol + Carbon dioxide + Energy

1. Aerobic respiration releases 19 times more energy than anaerobic respiration from the same amount of glucose
2. In aerobic respiration each glucose molecules produce 36 ATPs.

Yeast makes bread soft, puffy when added to wheat flour in the bakery due to the release of CO_2.

AEROBIC	ANAEROBIC
1) Aerobic respiration takes place in the presence of oxygen	1) Anaerobic respiration takes place in the absence of oxygen
2) The end products of aerobic respiration are carbon dioxide and water	2) The end products of anaerobic respiration are CO_2 and ethanol or lactic acid
3) Common in all higher plants and animals	3) Common in certain micro organisms and human muscle cell

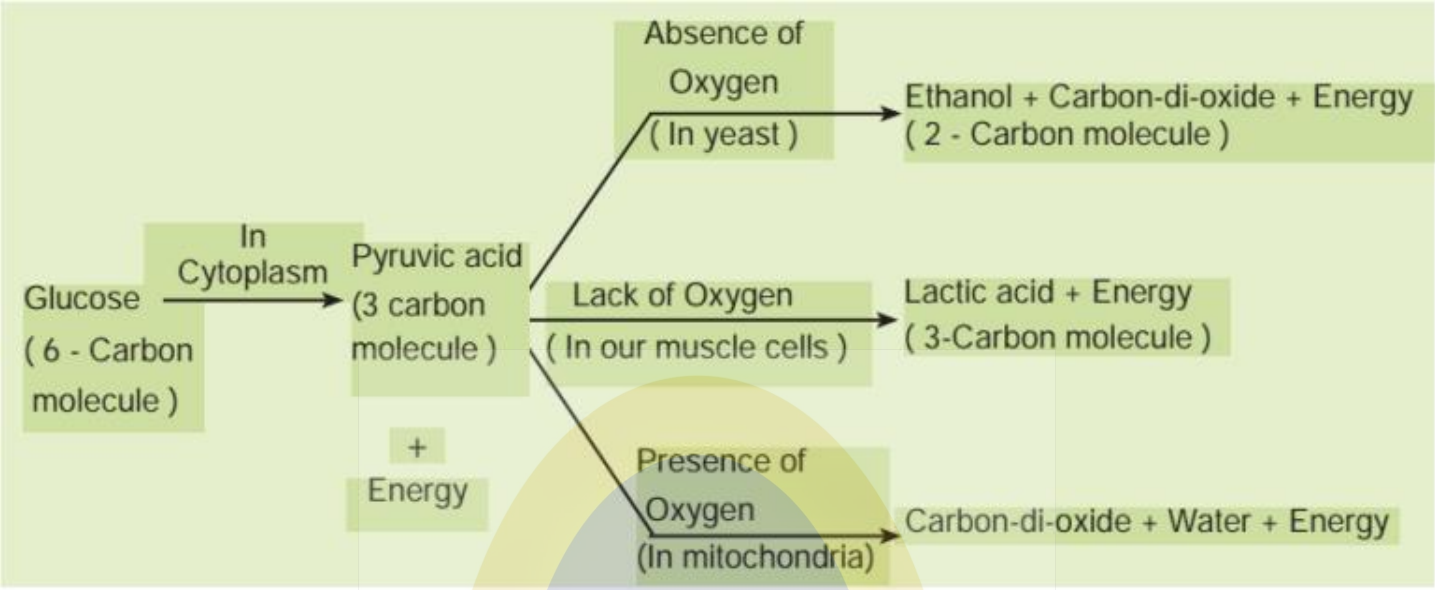


Fig. 6.5 Break-down of glucose by various pathways

Respiratory quotient (R.Q)

Respiratory quotient is the ratio of volume of carbon dioxide liberated and the volume of oxygen consumed during respiration.

It is expressed as

$$RQ = \frac{\text{Volume of } CO_2 \text{ liberated}}{\text{Volume of } O_2 \text{ consumed}}$$

Metabolism

- The term metabolism is **breakdown of food and its transformation into energy, cellular products and waste elimination.**
- Metabolism **consists of anabolism (the buildup of substances) and catabolism (the breakdown of substances).**

Anabolism

- Anabolism or **constructive metabolism**, is all about **building and storing**
- It **supports the growth of new cells, the maintenance of body tissues, and the storage of energy** for use in the future.
- During anabolism**, small molecules are changed into larger, more complex molecules of carbohydrate, protein, and fat.**

For example,

- ✓ **Glucose** → Glycogen and other sugars
- ✓ **Amino acids** → Enzymes, hormones, proteins
- ✓ **Fatty acids** → Cholesterol and other steroids

Catabolism

- Catabolism or **destructive metabolism,** is the process that **produces the energy** required for all activity in the cells.
- In this **process, cells break down large molecules (mostly carbohydrates and fats) to release energy.**
- This **energy release provides fuel for anabolism, heats the body, and enables the muscles to contract and the body to move**.
- As complex chemical units are broken down into more simple substances, **the waste products released in the process of catabolism are removed from the body through the skin, kidneys, lungs, and intestines**.
- ✓ **Carbohydrates** → Glucose
- ✓ **Glucose** → CO2, Water and heat
- ✓ **Protein** → Amino acid

Photosynthesis

- Algae and chlorophyll containing bacteria **utilize the energy from sunlight to synthesize their own food.**
- In this process, **carbon dioxide combines with water in the presence of sunlight and chlorophyll to form carbohydrates**.

During this process **oxygen is released as a byproduct.**

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

Carbon dioxide + Water ⟶ Glucose + Water + Oxygen

Where does photosynthesis occur?

Photosynthesis occurs in **green parts of the plant such as leaves, stems and floral buds.**

Photosynthetic Pigments

Photosynthetic pigments are of two classes namely,

1. primary pigments
2. accessory pigments.

Chlorophyll a

- ✓ Chlorophyll a is the **primary pigment** that **traps solar energy and converts it into electrical and chemical energy.**
- ✓ Thus it is called the **reaction centre.**

chlorophyll b and carotenoids

are called **accessory pigments as** they pass on the **absorbed energy to chlorophyll a (Chl.a) molecule.**

Photosystems

Reaction centres (Chl. a) and the accessory pigments (harvesting centre) together are called photosystems.

Role of Sunlight in Photosynthesis

The entire process of photosynthesis takes place inside the chloroplast.

1. Light dependent photosynthesis (Hill reaction \ Light reaction)

- ➢ This was discovered by **Robin Hill (1939).**
- ➢ This reaction takes place in the **presence of light energy in thylakoid membranes (grana) of the chloroplasts.**
- ➢ Photosynthetic pigments **absorb the light energy and convert it into chemical energy ATP and NADPH2.**
- ➢ These products of light reaction move out from the thylakoid to the stroma of the chloroplast.

2. Light independent reactions (Biosynthetic phase)

- ❖ The second steps (dark reaction or biosynthetic pathway) is carried out in the stroma.
- ❖ During this reaction **CO2 is reduced into carbohydrates with the help of light generated ATP and NADPH2.**
- ❖ This is also called as **Calvin cycle** and is carried out in the absence of light.
- ❖ In Calvin cycle **the inputs are CO2 from the atmosphere and the ATP and NADPH2 produced from light reaction.**

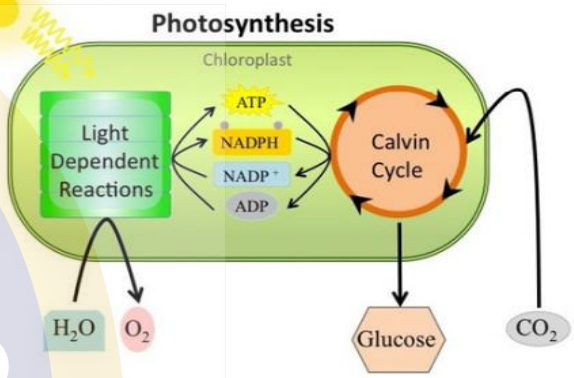


Figure 12.9 Overview of Hill and Calvin cycle

Factors Affecting Photosynthesis

a) Internal Factors:

i) Pigments
ii) Leaf age
iii) Accumulation of carbohydrates
iv) Hormones

b) External Factors:

i) Light
ii) Carbon dioxide
iii) Temperature
iv) Water
v) Mineral elements

ATP	Adenosine Triphosphate
ADP	Adenosine Diphosphate
NAD	Nicotinamide Adenine Dinucleotide
NADP	Nicotinamide Adenine Dinucleotide Phosphate

Melvin Calvin, an American biochemist, discovered chemical pathway for photosynthesis. The cycle is named as Calvin cycle. He was awarded with Nobel Prize in the year 1961 for his discovery.

DO YOU KNOW?

A cell cannot get its energy directly from glucose. So in respiration the energy released from glucose is used to make ATP (Adenosine Triphosphate)

Artificial photosynthesis is a method for producing renewable energy by the use of sunlight. Indian scientist C.N.R. Rao who was conferred the Bharat Ratna (2013) is also working on similar technology of artificial photosynthesis to produce - Hydrogen fuel (renewable energy)