REVISION: PHOTOSYNTHESIS & CELLULAR RESPIRATION

12 JUNE 2013

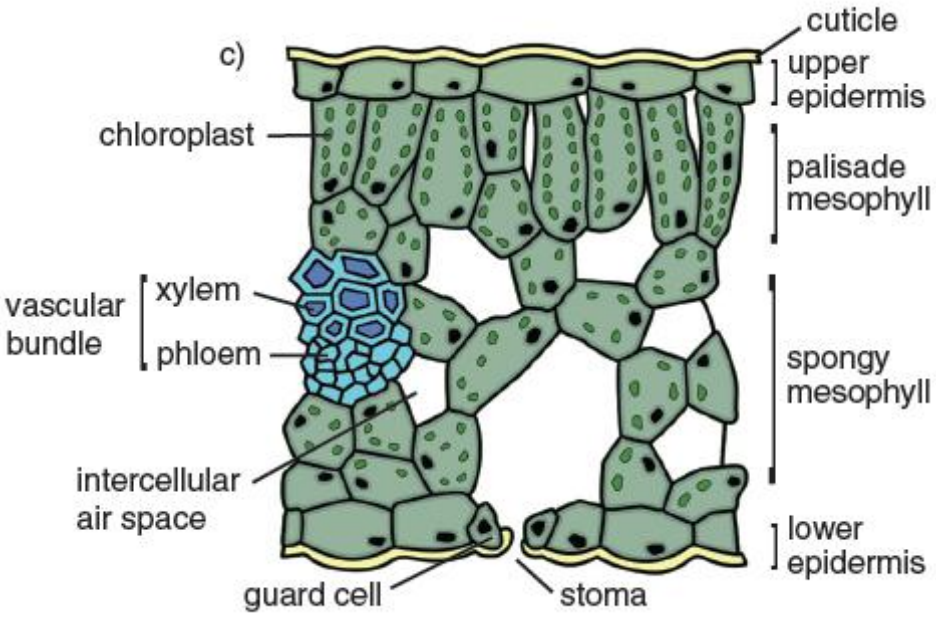
Lesson Description

In this lesson, we revise:

- the process of photosynthesis and cellular respiration
- the practical procedures for testing for starch in green leaves
- the process of cellular respiration

Key Concepts

Structures of the Leaf



(Solutions for all Life Sciences, Grade 11, Macmillan, p119)

Process of Photosynthesis

- Photosynthesis is a process whereby light is converted into chemical energy. Sunlight is changed into the chemical energy of sugars and other organic compounds. This process consists of a series of chemical reactions that require carbon dioxide (CO_2) and water (H_2O) and store chemical energy in the form of sugar.
- Photosynthesis occurs in the chloroplast. It is an anabolic process and requires enzymes.

$$\text{water + carbon dioxide} \xrightarrow{\text{light, chlorophyll and enzymes}} \text{glucose + oxygen}$$

$$6H_2O + 6CO_2 \xrightarrow{\text{light, chlorophyll and enzymes}} C_6H_{12}O_6 + 6O_2$$

(Solutions for all, Life Sciences, Grade 11, Macmillan, p121)

Light and Dark Phases

- **Light phase** – this occurs in the grana of the chloroplast. It contains chlorophyll that absorbs the light energy.
- Some of the light energy is used to make **ATP** (Adenosine triphosphate).
- The rest of the energy is used to split water molecules and make energy-rich Hydrogen atoms. Oxygen is released.
- The ATP and the hydrogen are used in the dark phase.

- **Dark phase – this occurs in the stroma of the chloroplast.**
- Glucose molecules are produced from the carbon dioxide, ATP and energy-rich hydrogen atoms.
- The light energy absorbed in the light phase is stored in the bonds of the glucose molecule

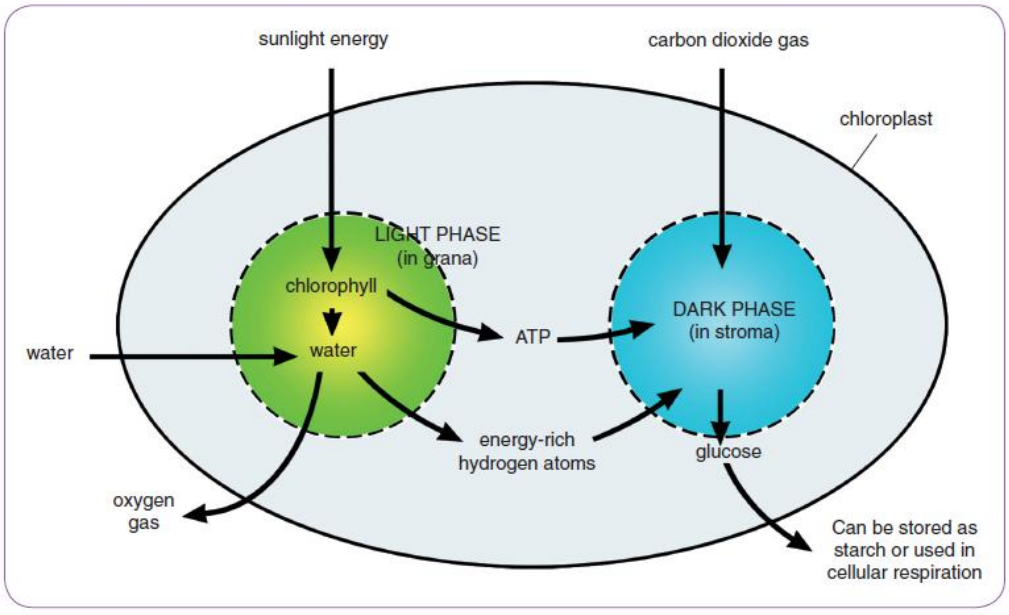


Fig. 4.4 The light phase and the dark phase of photosynthesis

(Solutions for all, Life Sciences, Grade 11, Macmillan, p125)

Importance of Photosynthesis

- Production of oxygen
- Absorption of carbon dioxide
- Production of food

Factors affecting the Rate of Photosynthesis

- Light intensity – the greater the intensity of light, the greater the rate of photosynthesis

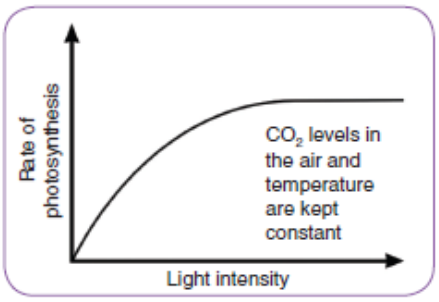


Fig. 4.12a) Effect of light intensity on the rate of photosynthesis

(Solutions for all,Life Sciences, Grade 11, Macmillan, p135)

- Concentration of carbon dioxide – an increase in carbon dioxide will increase the rate of photosynthesis

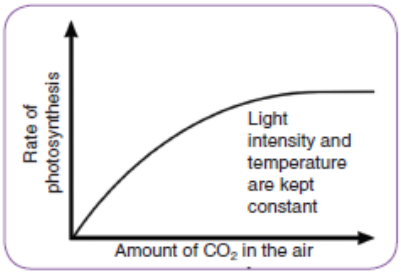


Fig. 4.12b) Effect of the amount of carbon dioxide on the rate of photosynthesis

(Solutions for all, Life Sciences, Grade 11, Macmillan, p135)

- Temperature– enzymes work optimally at 37°C. Lower temperatures mean lower rate of photosynthesis

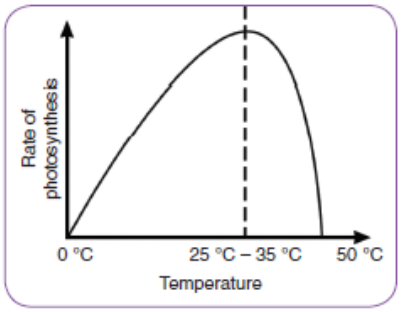
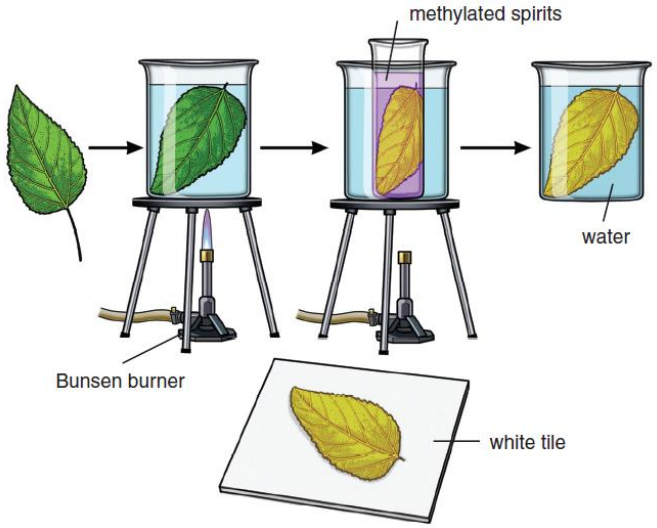


Fig. 4.12c) Effect of temperature on the rate of photosynthesis

(Solutions for all, Life Sciences, Grade 11, Macmillan, p135)

Starch Test in Leaves

- The first thing you need to be able to do is to test for starch. The test for starch goes as follows:
- You will need the following:
  - A beaker containing water
  - Tripod stand and wire gauze
  - Bunsen burner or spirit burner
  - Test tube containing methylated spirits
  - Forceps
  - White tile
  - Iodine solution
  - Dropper or pipette



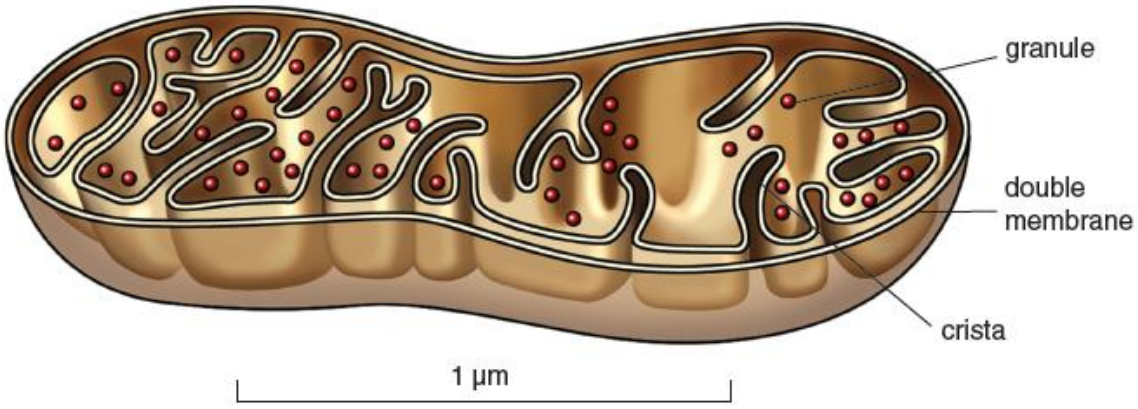
(Solutions for all Life Sciences, Grade 11, Macmillan, p128)

- If you don't have access to a laboratory you can still perform the experiment but with a few changes:
  - A small pot containing water
  - A stove or gas stove
  - Some methylated spirits (keep away from the flame – always!)
  - Something to take the leaf out of the hot water – fork or tweezers
  - White paper with plastic over it
  - Iodine solution (from pharmacy)
  - Dropper

- Method:
  - Remove a leaf from a healthy growing plant.
  - Put the leaf in boiling water
  - When the leaf has gone soft (flaccid) take it out of the water and put it into methylated spirits. (Keep the spirits away from flame.)
  - The chlorophyll will move out of the leaf and into the methylated spirits.
  - Remove the leaf from the methylated spirits and wash it in the boiling water.
  - Put the leaf onto the white tile and flatten it out.
  - Drop a few drops of iodine solution onto the leaf and watch for a colour change.

Cellular Respiration

- Cellular respiration is defined as a series of metabolic processes that take place within a cell in which biochemical energy is harvested from organic substance (e.g. glucose) and stored as energy carriers (ATP) for use in energy-requiring activities of the cell (http://www.biology-online.org/dictionary/Cell_respiration).
- Simply put chemical energy is transferred to ATP and the ATP molecules provide energy to all the processes of the cells.
- The transformation of energy occurs in the mitochondrion in the cells. The mitochondrion is specially adapted for this.



(Solutions for All, Life Sciences, Grade 11, Macmillan, p183)

Recap from Grade 10

- A mitochondrion has two membranes – an inner and an outer membrane. Between the membranes is a space. The inner membrane is folded and these folds are called cristae and the space in the centre of the inner membrane is called the matrix.
- The cristae increase the surface area of the inner membrane and so increase ATP production.

Aerobic Respiration

- Aerobic respiration occurs when glucose is broken down in the presence of oxygen. A lot of energy (many ATP molecules) is produced
- Aerobic respiration is summarised in the equation below.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{enzymes}} 6H_2O + 6CO_2 + 38ATP$$

glucose + oxygen → water + carbon dioxide + energy

(Solutions for All, Life Sciences, Grade 11, Macmillan, p184)

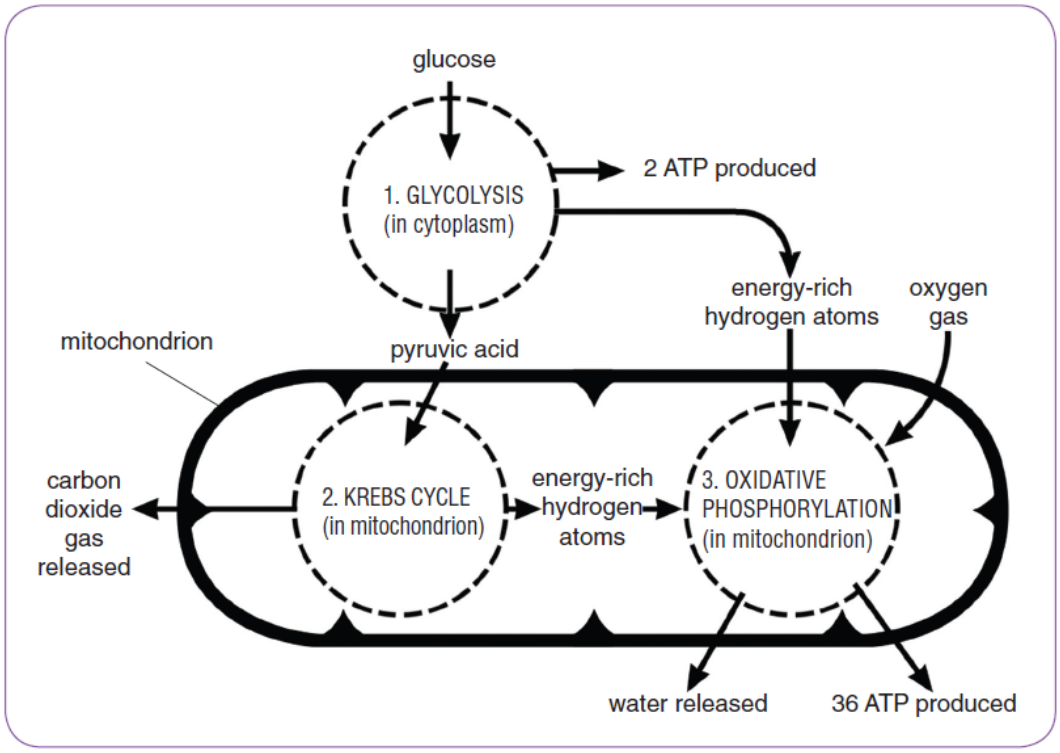
- There are three stages in aerobic respiration, namely glycolysis, the Krebs cycle and oxidative phosphorylation.

- **Glycolysis**: This occurs in the cytoplasm of the cell. Glucose is broken down into **pyruvic acid** and energy-rich hydrogens are given off.

- The hydrogens move into the mitochondria to be used in oxidative phosphorylation.
- Two ATP molecules are produced during glycolysis.

- The **Krebs cycle** breaks down the pyruvic acid completely into energy-rich hydrogens and carbon dioxide. The hydrogens will be used in **oxidative phosphorylation** and the carbon dioxide will be breathed out.

- **Oxidative phosphorylation:** takes the energy from the energy-rich hydrogens to make ATP. The energy depleted hydrogens combine with oxygen to make water. This is either breathed out as water vapour or excreted via the kidneys.



(Solutions for All, Life Sciences, Grade 11, Macmillan, p185)

Anaerobic Respiration

- Anaerobic respiration occurs when glucose is broken down and there is no oxygen present. Very little energy is produced.
- There are two types of anaerobic respiration – the respiration that occurs in organisms that are not human is called alcoholic fermentation. Anaerobic respiration in the human body is called lactic acid fermentation.

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + 2ATP$$

glucose ⟶ alcohol + carbon dioxide + energy

Alcoholic fermentation in primitive organisms
(Solutions for All, Life Sciences, Grade 11, Macmillan, p191)

$$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3 + 2ATP$$
$$\text{glucose} \longrightarrow \text{lactic acid} + \text{energy}$$

Lactic acid fermentation in humans
(Solutions for All, Life Sciences, Grade 11, Macmillan, p191)

- Anaerobic respiration only occurs in humans when the oxygen supplied to muscles is used up and the muscles still require energy. This produces lactic acid and leads to the muscle fatigue during and stiffness after exercising.

Questions

Question 1

(Adapted from Solutions for all, Life Sciences, Grade 11, Macmillan, p141)

a.) Give the correct word or term for each of the following:
   i. the light-independent stage of photosynthesis
   ii. the green pigment found in a chloroplast
   iii. the molecule that is an important energy carrier in a cell
   iv. the liquid inside chloroplasts
   v. the by-product of photosynthesis (5)

b.) List the raw materials that a photosynthesising plant gets from its environment. (3)

c.) Complete the table below that compares the light phase and the dark phase of photosynthesis. (4)

	Light phase	Dark phase
Takes place in the	grana of the chloroplasts	
Raw materials from the environment		
Energy-rich products		glucose

d.) Draw a fully labelled diagram of the apparatus that you would use in an investigation to Find out which gas is needed for the process of photosynthesis. (6)