

# **CIE Biology GCSE**

## 6: Plant nutrition Notes

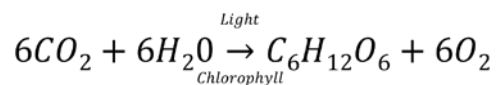
## Photosynthesis

**Photosynthesis** is a metabolic reaction occurring in plants in which **light energy** converts raw materials into **carbohydrates** such as glucose, which can be stored in cells and used as an energy source via respiration.

Photosynthesis occurs in the **chloroplasts** of plant cells. Chloroplasts contain **chlorophyll** that **transfers light energy into chemical energy**.

### Equations for photosynthesis:

*carbon dioxide + water → glucose + oxygen*



### Factors affecting rate of photosynthesis:

The rate of photosynthesis is limited by the **limiting factor**. This is the **factor which is least available** to the plant. For example, at night, light intensity is very low hence the rate of photosynthesis is also very low, regardless of the carbon dioxide concentration and temperature.

- **Carbon dioxide concentration** - as CO<sub>2</sub> concentration increases, rate of photosynthesis also increases.
- **Temperature** - photosynthesis requires enzymes to carry out the reaction. As these enzymes have an optimum temperature, photosynthesis also has an optimum temperature. This is usually about 25°C. At low temperatures, for example in the winter, plants photosynthesize slowly as the enzymes have little kinetic energy, thus few enzyme-substrate complexes are made. At very high temperatures, these enzymes denature, also slowing the rate of photosynthesis.
- **Light intensity** - As the light intensity increases, rate of photosynthesis increases. A high light intensity can sometimes lead to the plant heating up above the optimum temperature. This means that temperature would become the limiting factor and the rate of photosynthesis would not be increased by a further increase in light intensity.

Knowledge of limiting factors is useful for farmers as they can reduce the limitation on the rate of photosynthesis due to these factors. This will mean that the plants have more energy to use for growth, thus the **yield is higher and growth time is shorter**. Farmers can reduce the effects of these limiting factors by placing plants in a **greenhouse**. Greenhouses **trap heat**, thus the plants are always kept at their optimum temperature. In addition, **artificial lighting** can be used so that the plant can photosynthesize during the night as well, and carbon dioxide can be pumped into the greenhouse.

### Leaf structure:

Plant leaves must be **adapted** to allow photosynthesis to occur. This means limiting water loss, absorbing as much light energy as possible and allowing for efficient gas exchange.

- **Chloroplasts** - This is where photosynthesis occurs. Chloroplasts contain chlorophyll which allows light energy to be absorbed and converted to chemical energy.
- **Cuticle** - The cuticle is a clear waxy layer that surrounds the leaf. This provides waterproofing and reduces water loss from the leaf without reducing light absorption.
- **Guard cells and stomata** - Stomata are located on the lower side of the leaf and allow carbon dioxide in by diffusion, and water vapour and oxygen out of the leaf by diffusion. Guard cells surround the stomata and can control the opening and closing of the stomata to limit water loss from the plant; when there is a limited water supply, the guard cells cause the stomata to close to prevent water loss. This, however, also reduces the diffusion of carbon dioxide in through the stomata for use in photosynthesis, so can cause carbon dioxide to become the limiting factor and reduce the rate of photosynthesis. Plants in hot places often have fewer stomata to reduce water loss. Some plants, for example cacti, only open their stomata at night.
- **Upper and lower epidermis** - the epidermis acts as a protective barrier around the leaf to prevent pathogens entering and causing harm to the organism. Epidermis cells are transparent to let light pass through and do not contain chloroplasts.
- **Palisade mesophyll** - these cells are positioned near the top of the leaf where most sunlight hits, thus palisade cells are adapted to absorb light energy efficiently. The palisade layer cells contain many chloroplasts to carry out photosynthesis. There are also gaps between the cells to allow for efficient gas exchange and osmosis to occur. CO<sub>2</sub> and water move into the cells to be used in the photosynthesis reaction.

- **Spongy mesophyll** - This is the lower layer of the leaf. Cells are loosely spaced and have a large surface area to allow rapid diffusion of CO<sub>2</sub>, water and oxygen when the stomata are open.
- **Vascular bundles** - vascular bundles form the plant's transport system. They consist of the xylem and the phloem, as well as other cells around them which provide support.
- **Xylem** - the xylem is used to transport water through plants from the roots in transpiration. The xylem is made from hollowed-out dead cells that have the ends removed to make a tube for water to pass through. They have a thick cell wall to provide structural strength and are thin to allow capillary action.
- **Phloem** - the phloem is made of living cells and is used to transport sugars and food nutrients in translocation. The cells of the phloem are adapted by having no nucleus.

### Minerals in plants:

Minerals are taken up actively by root hair cells and have a variety of important roles in the plant.

- **Nitrate ions** - nitrate ions are used in the plant to build **amino acids**, and thus proteins and enzymes. Without nitrate ions, the plant would not be able to grow or repair itself.
- **Magnesium ions** - magnesium ions are used to make **chlorophyll**; thus, a lack of magnesium ions will lead to a lack of chlorophyll, meaning that photosynthesis cannot occur. This means that sugars cannot be formed through photosynthesis, therefore the plant will not have a sufficient enough energy source to grow and repair itself.

The lack of either of these ions leads to **yellow leaves and poor growth**, eventually leading to the plant's death.