WJEC (Wales) Biology GCSE

Topic 1.5: Plants and Photosynthesis

Notes

('Higher Tier only' in **bold**)

Photosynthesis

Photosynthesis is a chemical reaction that takes place inside photosynthetic organisms (e.g. green plants, algae) and converts light energy into chemical energy. It occurs within the chloroplasts of a cell.

Requirements

Photosynthesis requires:

- Carbon dioxide - provides carbon (C) and oxygen (O) found in glucose
- Water - provides hydrogen (H) found in glucose
- Light - provides energy
- Chlorophyll - green pigment found in chloroplasts that absorbs light

Process

Photosynthesis involves a series of endothermic reactions in which carbon dioxide and water is converted to glucose and oxygen (the waste product) in the presence of light.

This reaction can be described in the word equation:

carbon dioxide + water → glucose + oxygen

Importance

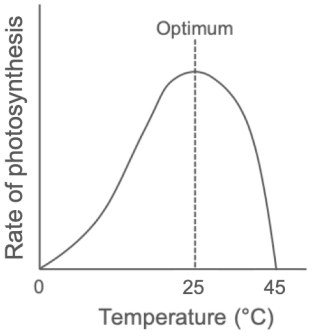
Photosynthesis is important in organisms for a variety of reasons:

- Produces glucose which is used in respiration to release energy
- Glucose used to make complex organic molecules which are used for growth in plants
- These organic molecules are transferred between organisms through food chains
- Produces oxygen which is required by organisms for respiration

Factors affecting the rate of photosynthesis

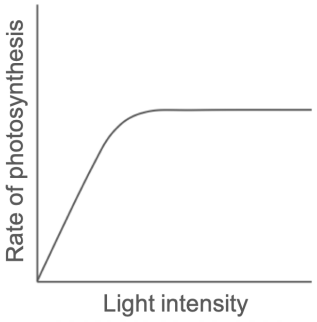
The rate of photosynthesis is influenced by different factors including temperature, light intensity, and carbon dioxide. **The limiting factor, the variable that limits the rate of a particular reaction, determines the rate of photosynthesis.**

Temperature



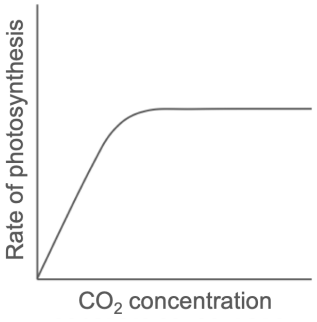
- Higher temperatures provide more KE for enzymes involved in photosynthesis so the rate increases as temperature rises.
- The optimum temperature is usually 25°C.
- If the temperature becomes too high (around 45°C) enzymes become denatured and the rate of photosynthesis decreases.
- **Temperature becomes a limiting factor when it drops too low on cold winter days.**

Light intensity



- The rate of photosynthesis is directly proportional to light intensity ∴ as light intensity increases, the rate of photosynthesis increases.
- **The rate will eventually plateau (even as light intensity continues to increase) as another factor such as temperature becomes limiting.**
- **Light intensity becomes a limiting factor at night and in the winter.**

Carbon dioxide



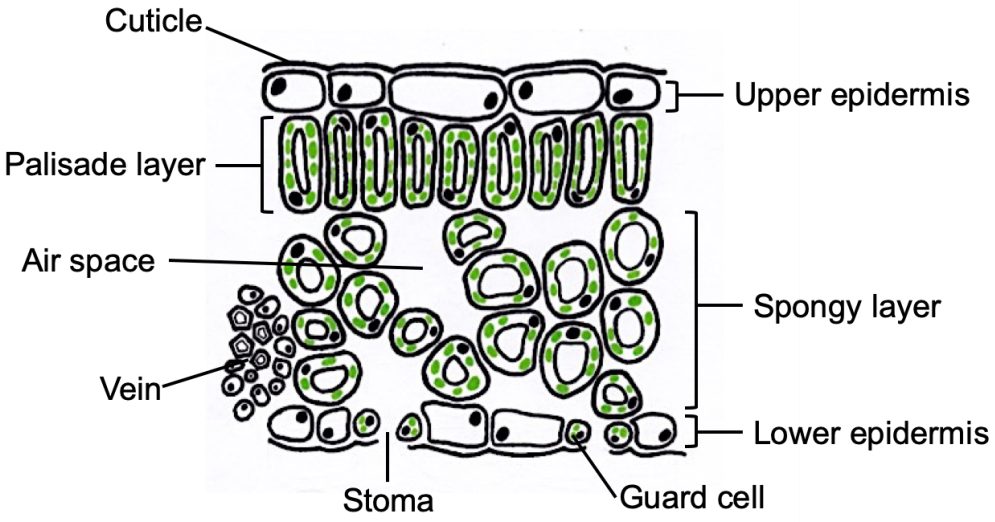
- As carbon dioxide concentration increases, the rate of photosynthesis increases.
- **The rate will eventually plateau (even as carbon dioxide concentration continues to increase) as another factor such as light intensity becomes limiting.**
- **Atmospheric carbon dioxide concentrations generally remain constant so it only becomes a limiting factor when light intensity and temperature are not limiting.**

Uses of glucose

- Used in respiration to release energy.
- Converted to starch or oils and stored.
- Converted to sucrose and transported to other plant areas.
- Converted to cellulose which is used in cell walls.
- Formation of proteins which requires nitrates from the soil.

Leaf structure

The internal structure of a leaf:



The functions of the different leaf structures are outlined below:

Structure	Function
Waxy cuticle	• Waterproof to reduce water loss • Transparent allowing light to reach the palisade layer
Upper epidermis	• Transparent allowing light to reach the palisade layer
Palisade layer	• Receives the most light so contains the greatest concentration of chloroplasts for photosynthesis
Spongy layer	• Contains air spaces to allow the diffusion of carbon dioxide to chloroplasts in the palisade layer for photosynthesis • Also contains some chloroplasts
Lower epidermis	• Contains many stomata to allow gas exchange

Stomata	• Pores found in the lower epidermis that allow gas exchange
Guard cells	• Surround the stomata • Change shape to control the size of the stomatal pore enabling the regulation of water loss by the plant
Veins	• Contain xylem and phloem • Form a large network to deliver water and remove glucose

Transport in plants

Veins

Plants have a transport system made up of xylem and phloem vessels.

Transport system	Function	Structure
Xylem	Transports water and minerals up the plant, from the roots to the leaves via the transpiration stream.	Composed of dead cells laid end-to-end to form a long, hollow, continuous column.
Phloem	Transports sugars up and down the plant from photosynthetic tissues (e.g. mature green leaves) to non-photosynthetic tissues (e.g. developing seeds).	Composed of living cells arranged in columns with perforated end plates to enable the flow of sugars.

Importance of water

Water is important to plants for a variety of reasons including:

- Used in photosynthesis
- Enables chemical reactions to take place within cells
- Transport medium for minerals, sugars etc.
- Support (turgidity)
- Cooling effect

Absorption of water and minerals

Water is absorbed into the root at the root hair cells:

Process	Explanation
Uptake of water into the root	Lower concentration of water in root hair cell sap than in the soil. Water diffuses down its concentration gradient into root hair cells by osmosis.
Movement of water across the root	Water entering the root hair cell dilutes its cell sap. Higher concentration of water in root hair cell sap than in the adjacent cell. Water diffuses down its concentration gradient into the adjacent cell by osmosis.
Uptake of mineral ions into the root	**Lower concentration of mineral ions in the soil than in the root. Root hair cells take up mineral ions by active transport (uses energy).**

Root hair cells are adapted for the efficient uptake of water and mineral ions. They have:

- Long hairs that extend from the cell body, increasing the surface area for absorption.
- **Many mitochondria which produce energy for the active transport of mineral ions.**

Transpiration

Transpiration is the loss of water from the parts of a plant exposed to the air (i.e. leaves) due to evaporation and diffusion. The process of transpiration is as follows:

- Water evaporates from the mesophyll layer and diffuses out of the stomata.
- Water molecules (which have cohesive properties) are drawn up the xylem vessels to replace the water that has been lost.
- This causes more water molecules to be absorbed from the soil into root hair cells.

The rate of transpiration is influenced by different factors including temperature, humidity and air movement:

Factor	Effect on the rate of transpiration
Temperature	As temperature increases, water molecules have more KE so the rate of diffusion increases. More water vapour diffuses out of the stomata ∴ rate of transpiration increases.
Humidity	As humidity increases, the water concentration gradient between the air spaces in the leaf and atmosphere decreases. Decreased rate of diffusion of water molecules out of the stomata ∴ rate of transpiration increases.
Air movement	As air movement increases, a high water concentration gradient is maintained

	between the air spaces in the leaf and the atmosphere. Increased rate of diffusion of water molecules out of the stomata ∴ rate of transpiration increases.

Importance of sugars

Sugars (e.g. sucrose) transported by the phloem to non-photosynthetic tissues are:

- Used immediately in respiration to release energy
- Converted to starch and stored

Minerals

Plants require a variety of minerals (including nitrogen, potassium and phosphorus) for healthy growth. If a plant is lacking in one of these nutrients, deficiency symptoms will appear.

Mineral	Function	Deficiency symptoms
Nitrogen	Used to produce amino acids which join to form proteins	Poor growth, yellow leaves
Potassium	Activates enzymes involved in photosynthesis and respiration	Poor flower growth, poor fruit growth, yellow leaves
Phosphorus	Used to form DNA and cell membranes	Poor root growth, discoloured leaves

NPK fertilisers are a type of fertiliser containing nitrogen (N), phosphorus (P) and potassium (K). They can be used to artificially increase the concentrations of mineral ions in the soil.