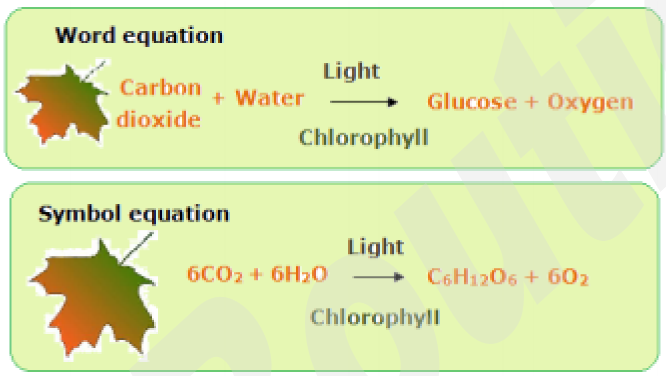
Plant Nutrition

(IGCSE Biology Syllabus 2016-2018)

Photosynthesis

- The fundamental process by which plants manufacture food molecules (glucose) from raw materials (carbon dioxide and water) using energy from light



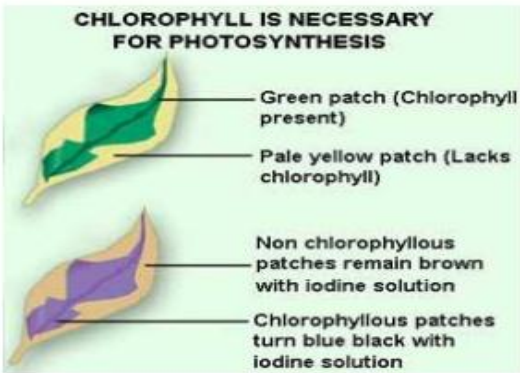
- Green plants take in carbon dioxide through their leaves via stomata (by diffusion)
- Water is absorbed through plants' roots by osmosis and transported to the leaf through xylem vessels
- Chlorophyll traps light energy and absorbs it
- Light energy is used to break up water molecules, then to bond hydrogen and carbon dioxide to form glucose
- Glucose is converted to sucrose for transport around the plant, or to starch for storage
- Oxygen is released as a waste product, or used by plant for respiration
- Light energy is converted to chemical energy for the formation of glucose

Photosynthesis Investigation – Starch Test

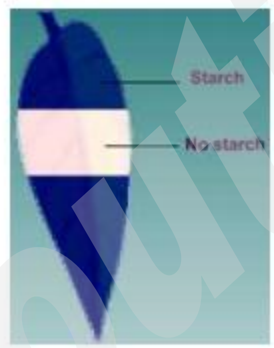
1. Plants must be **destarched**
   - The leaves that involve in testing should not have any starch at the beginning of the experiment
   - Leave the plant in the dark for 48 hours, let the plants used up all stores of starch in its leaves
2. **Starch test** with iodine solution
   - After a few hours, carry out the starch test on both plants: iodine solution is used; a blue-black colour on the leave is positive
   - **Boil the leaf in water for 30 seconds**: to kill the cells in the leaf → break down the membrane → iodine solution get through cell membrane to reach starch inside the chloroplasts and react with them
   - **Boil the leaf in alcohol in a water bath**: to remove chlorophyll by dissolving it out with alcohol. Leave it until all the chlorophyll has come out of the leaf.
   - **Rinse the leaf in water**: boiling the leaf in ethanol makes it brittle, the water softens it
   - **Spread out the leaf on a white tile**
   - **Add iodine solution:** blue-black colour → starch is present

Photosynthesis Investigation – chlorophyll, carbon dioxide, light tests

- **Chlorophyll is necessary for photosynthesis**
  - Take a potted plant with variegated (green and white) leaves
  - Destarch the plant
  - Expose the plant to the sunlight for a few days
  - Test one of the leaves for starch with iodine solution
  - Areas with previously green patches test positive
  - Area with previously pale yellow patches test negative



- **Light is essential for photosynthesis**
  - Take a potted plant
  - Destarch the plant
  - Test one of its leaves for starch to check that it does not contain any
  - Fix a leaf of this plant in between two strips of a thick paper on leaf
  - Place the plant in light for a few days
  - Remove the cover from the leaf and test it for starch
  - Positive result for the portion of the leaf that exposed to light



- **Carbon dioxide is essential for photosynthesis**
  - Take two destarched potted plants
  - Cover both the plants with bell jars and label them as A and B
  - Inside jar A, keep sodium bicarbonate. It produces carbon dioxide
  - Inside jar B, keep sodium hydroxide. It absorbs carbon dioxide
  - Keep both the jars in the sunlight for at least 6 hours
  - Perform the starch test
  - Plants from Jar A shows positive result
  - Plants from Jar B shows negative result

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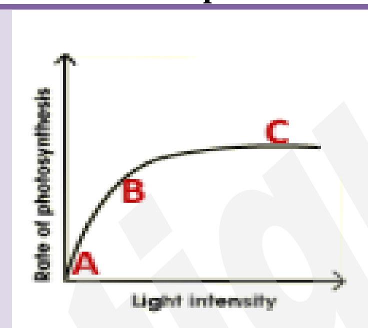
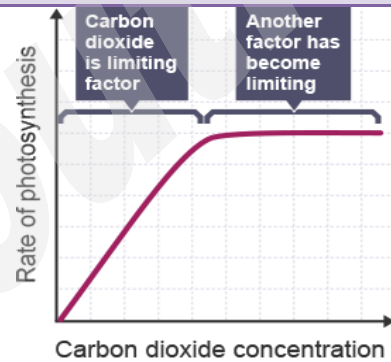
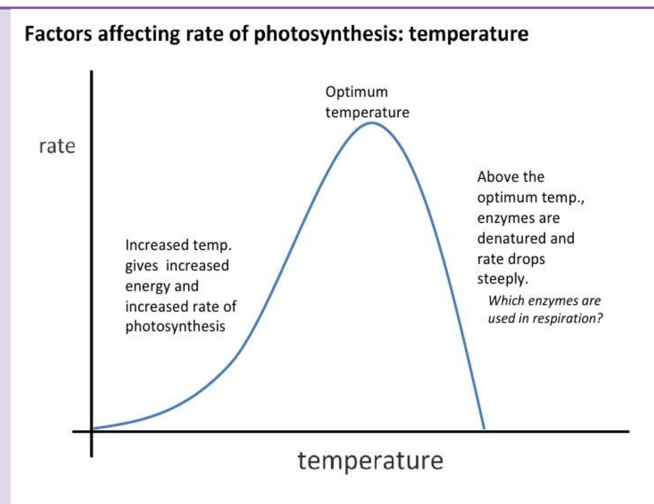
Limiting Factors

Limiting Factor	Graph
Light intensity - As the amount of light increases, the rate of photosynthesis increases (A-B) - The limiting factor is light - Increasing the amount of light after a certain point has no effect on the rate (C) - The limiting factor is now carbon dioxide or temperature	
Carbon dioxide concentration - As the amount of carbon dioxide increases, the rate of photosynthesis increases - The limiting factor is carbon dioxide - Increasing amount of carbon dioxide after a certain point has no effect on rate - The limiting factor is now light or temperature	
Temperature - As temperature increases, the rate of photosynthesis increases until it reaches optimum temperature - The limiting factor is the temperature - Increasing the temperature above optimum temperature will cause the enzymes to denature - This will decrease rate of photosynthesis as enzymes are required for photosynthesis	

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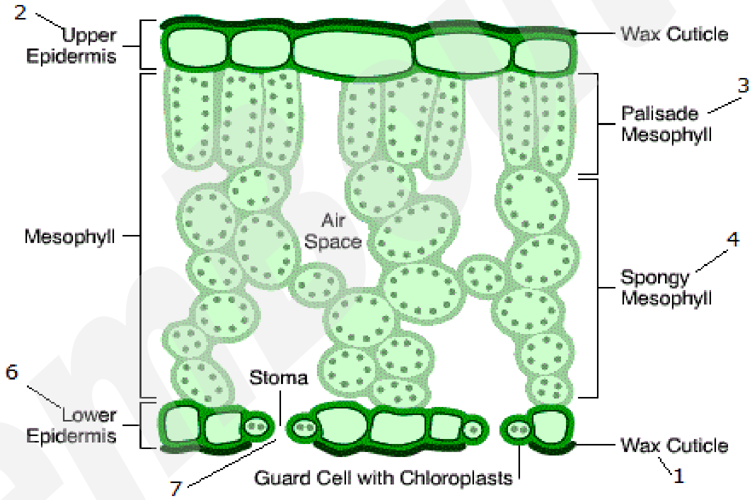
Glasshouse Systems

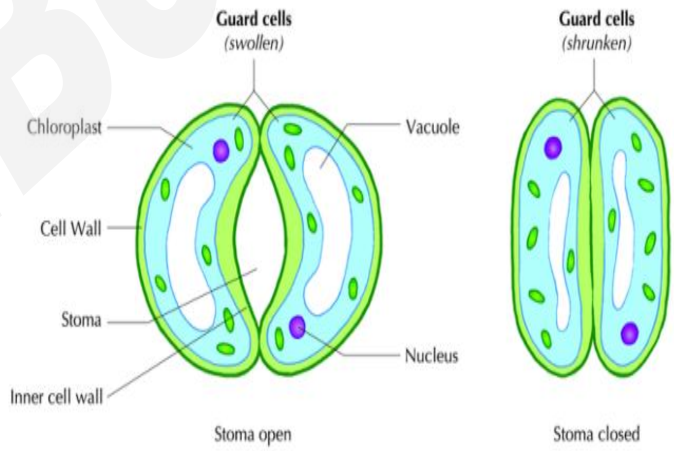
To increase the crop yield, farmers control the limiting factors:

- Carbon dioxide enrichment: paraffin is burnt to increase carbon dioxide concentration by three times the original amount and doubling the yield
- Optimum temperature: thermostatically controlled heaters make the temperature right for enzymes to work
- Optimum light: light has a high intensity for more photosynthesis, the correct wavelengths (red and blue not green) and duration controls production of fruit

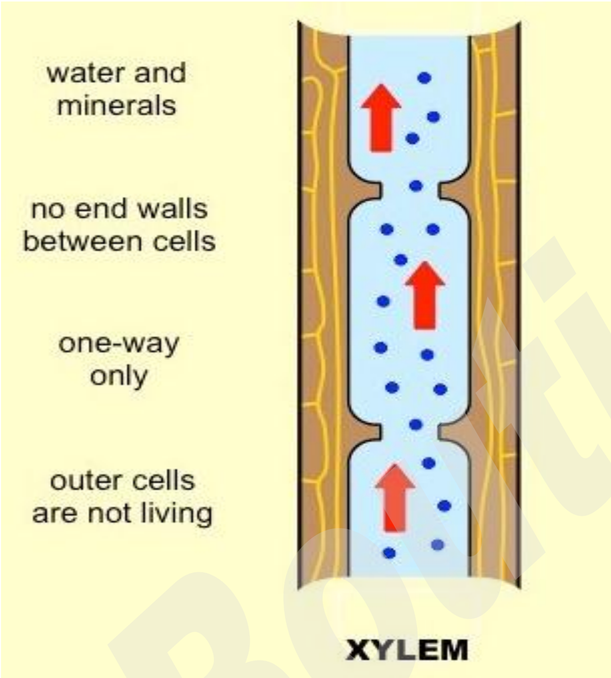
Leaf Structure



Leaf structure	**Function**
Cuticle	Waxy layer that prevents water loss from top of the leaf
Epidermis	Transparent cell that allows sunlight to pass through to the palisade cell
Palisade	Found at the top of the cell and contains many chloroplasts which absorbs sunlight
Spongy mesophyll layer	Irregular shaped cells which create air spaces to allow gaseous exchange to take place, do not contain many chloroplasts
Vascular bundle	Made up of xylem and phloem
Xylem	Vessel which transports water and dissolved minerals and has lignified walls made of cellulose
Phloem	Vessel which transports nutrients
Stomata	Little holes that opens and closes to allow gaseous exchange to take place. The stomata close to prevent water loss and open to let gases come in and out. When guard cells lose water, the stomata close (at night), while the stoma open when guard cells gain water and swell (during the day)

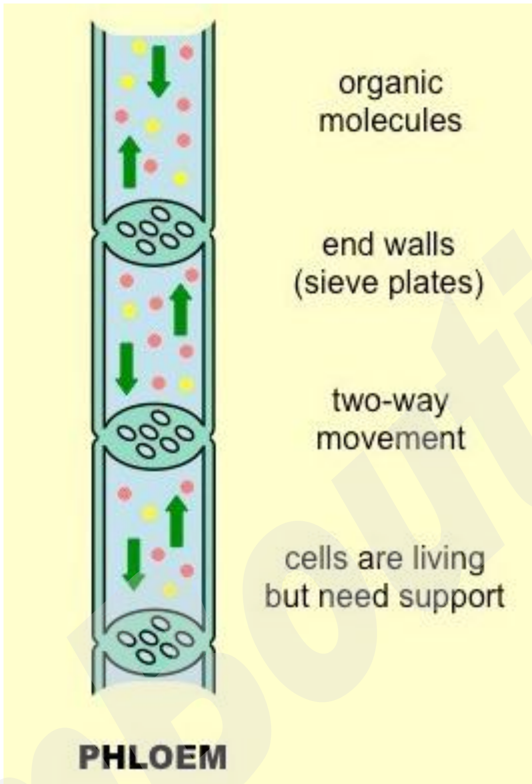


Xylem



- Unidirectional vessel which transports water and dissolved minerals
- Walls are made out of waterproof lignin
- Water moves up due to transpiration and osmosis

Phloem



- Bidirectional vessel
- Contains sieve elements which allow sugars to pass from one cell to next downwards
- Contains companion cells which provide energy for active transport of sugars all over plant
- Translocation moves organic molecules (sugars, amino acids) from source to sink
- Phloem vessels still have to cross walls called sieve plates that contain pores
- Companion cells actively load sucrose into the phloem
- Water follows high solute in phloem by osmosis. A positive pressure potential develops moving mass of phloem sap forward
- Phloem still contains small amount of cytoplasm along the walls but the organelle content is greatly reduced
- Companion cells actively unload the organic molecules

Mineral Requirements

Nitrogen	Magnesium
- Needed for protein synthesis - Deficiency: small plant, slow growth, top leaves pale, bottom leaves dead and roots slightly affected	- Needed for chlorophyll synthesis - Deficiency: plant lack chlorophyll, leaves yellow but normal roots

- Nitrogen fertilisers: provide nitrogen in the form of nitrate ions, nitrate ions or ammonium ions. But using fertilisers can lead to eutrophication, which is when the fertilisers is transported by rain and leaches into stagnant water e.g. pond or river