

JURONG WEST SECONDARY SCHOOL
SECONDARY THREE – SCIENCE BIOLOGY

Chapter 8: NUTRITION IN PLANTS

LEARNING OUTCOMES:

Candidates should be able to:

- a) identify the cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section under the microscope and state their functions:
 - (i) distribution of chloroplasts – photosynthesis
 - (ii) stomata and mesophyll cells – gaseous exchange
 - (iii) vascular bundles – transport
 - b) state the equation, in words only, for photosynthesis
 - c) describe the intake of carbon dioxide and water by plants
 - d) state that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage
 - e) investigate and state the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (e.g. in submerged aquatic plants)
 - f) briefly explain why most forms of life are completely dependent on photosynthesis
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VIDEO:

Watch the video and fill in the blanks with appropriate terms in the transcript below.

Using their leaves, plants combine sunlight, carbon dioxide and water to make glucose and oxygen.

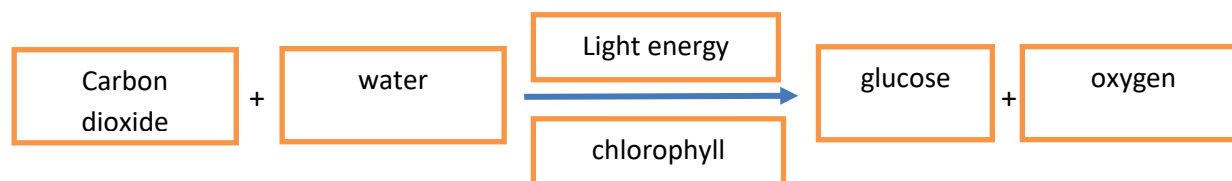
The top of a leaf is exposed to the most sunlight, and so the cells specialised for trapping light are on top of the leaf. These specialised cells are called palisade mesophyll cells. They are packed full of chlorophyll - the green chemical that plants used to absorb light. Most leaves have a large surface area so that they can trap as much sunlight as possible.

Moving onto carbon dioxide. This is where the bottom of the leaf comes in. There are little pores on the bottom of the leaf called stomata. The stomata open up so that carbon dioxide can diffuse into the leaf. The stomata are controlled by 'sausage shaped' guard cells, which open up to let carbon dioxide in. The guard cells can also close the stomata, to stop other things inside the leaf, like water, from escaping. The carbon dioxide comes in from the stomata, and then makes its way up through the leaf, through the gaps in the spongy mesophyll layer in the bottom part of the leaf and heads up to the palisade cells where photosynthesis occurs. Leaves are thin so that the carbon dioxide doesn't have too far to travel.

The final reactant needed for photosynthesis is water. Water comes into the plant through the roots, moves up the stem and enters the leaf through the vascular bundle. The vascular bundle contains a hollow tube specifically for water movement called the xylem. The veins on a leaf are actually the vascular bundle, allowing water to be spread out through the leaf.

SUMMARY

Use the gained knowledge to write the equation for photosynthesis.



Carbon dioxide diffuses into the plant through the **stomata**

Water enters the plant through the **roots** and reaches the leaf cells via **xylem**

Light energy enters the leaf cells as the **chloroplasts** traps light energy.

START VIDEO PART 2

How do leaves manage to let in the wanted things (like water and carbon dioxide) but prevent unwanted things like bacteria getting in and also prevent the reactants from escaping before being used?

At the top and bottom of the leaf are **epidermal cells / epidermis**. These produce a protective **waxy cuticle** layer. The waxy cuticle seals up the leaf so that the only way in and out are through the stomata, which are regulated by the guard cells.

CLASS DISCUSSION:

What do you think these parts do?

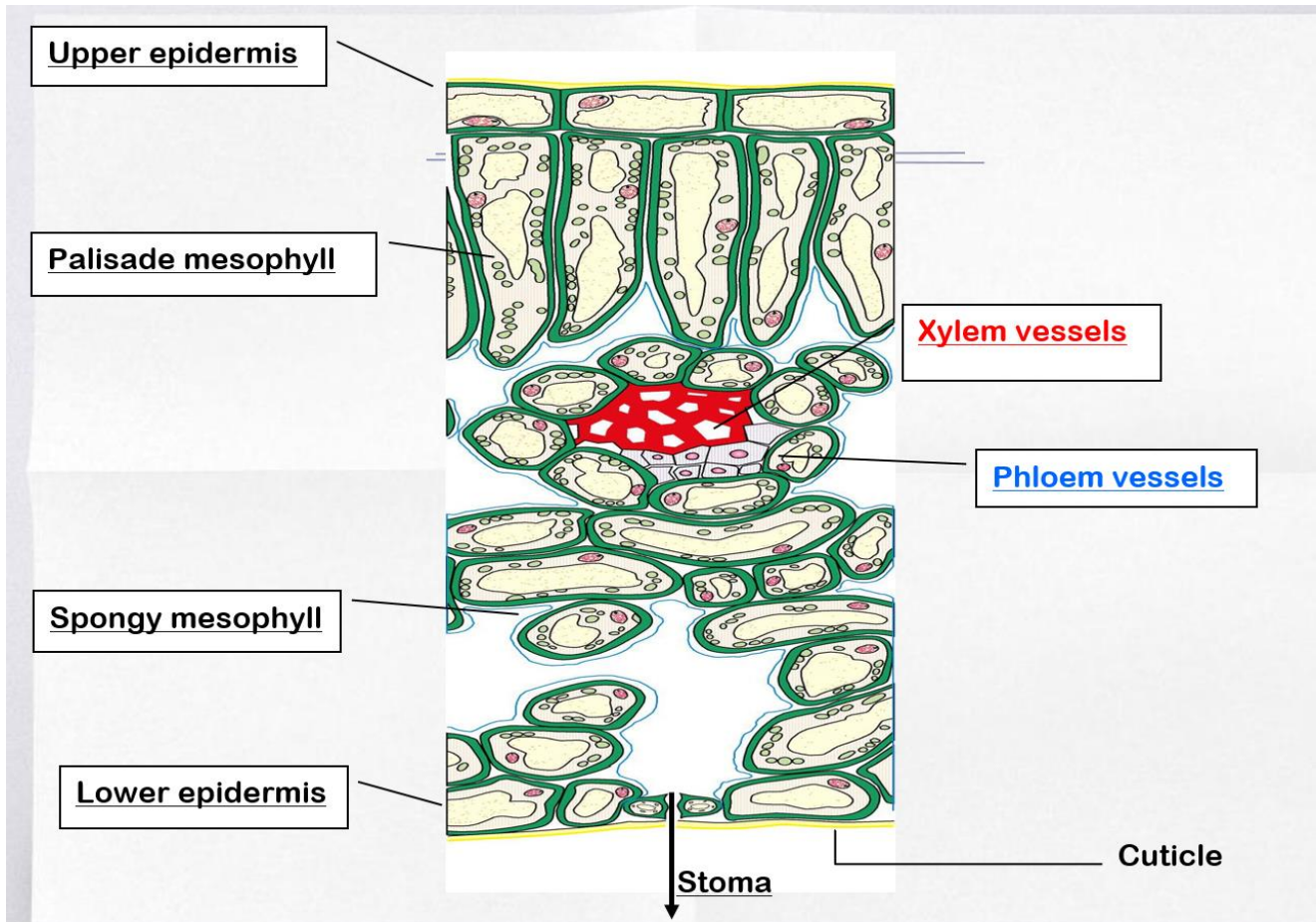
(Use the gained knowledge in the video transcript.)

Let's Discuss!

Adaptations in the Internal Structure of the leaf. (The first adaptation has been filled in for you.)

Structure	Function
Waxy cuticle	Seals up the leaf / waterproof layer to prevent excessive water loss / transparent to allow light energy to pass through
Epidermis / Epidermal cells	Protect the inner leaf cells
Palisade mesophyll cells	Has numerous chloroplasts to trap light energy for photosynthesis
Spongy mesophyll cells	Irregularly shaped to create intercellular air spaces for efficient diffusion of gases
Xylem vessels	Transport water and dissolved mineral salts from the roots to the rest of the plant
Guard cells	Regulate the opening of stomata
Stomata	Opening that allows gases such as carbon dioxide, oxygen and water vapour to enter and exit the leaf

The Internal Structure of Leaf



1. Upper epidermis

- Single layer of closely packed cells
- Cells **do not** contain **chloroplasts**
- Function is to **protect** the internal structure of the leaf
- The epidermal cells **produce the waxy cuticle** to layer to **prevent** excessive water loss

2. Mesophyll cells: (a) Palisade mesophyll and (b) Spongy mesophyll

(a) Palisade mesophyll

- One or two layers of **closely packed**, long and cylindrical cells
- Contains **numerous chloroplasts** to trap light energy for photosynthesis

(b) Spongy mesophyll

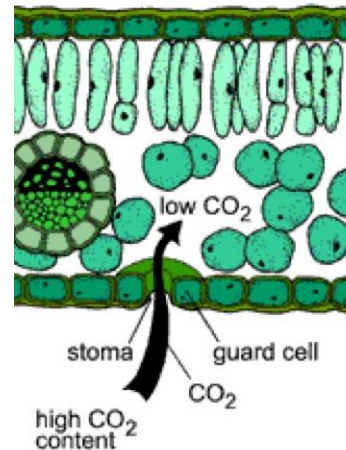
- Irregularly shaped, loosely packed cells
- **Presence of large intercellular air spaces** for rapid **diffusion** of gases
- Presence of vascular bundles (xylem vessels and phloem tubes)

3. Lower epidermis

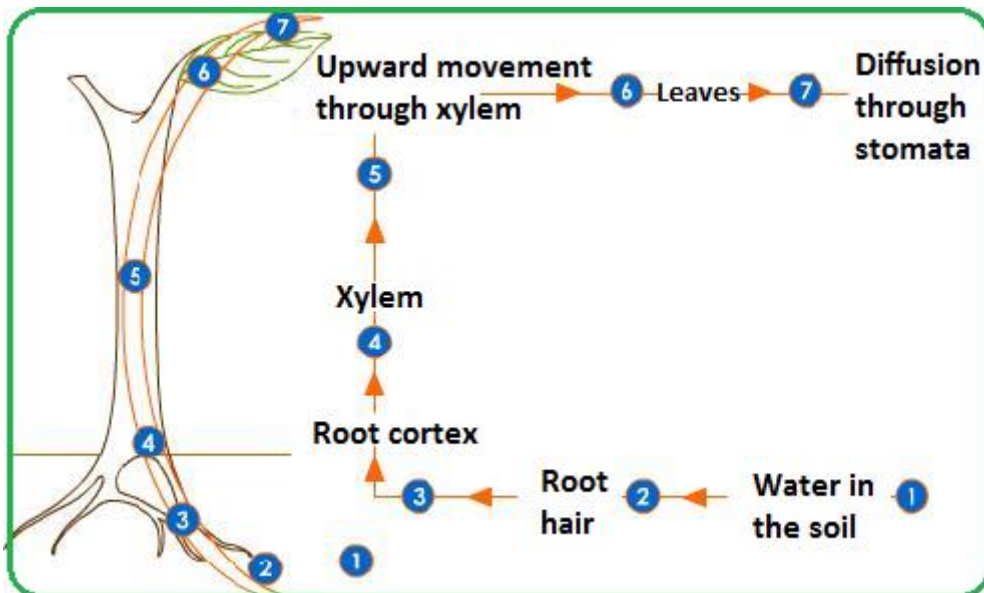
- Single layer of closely packed cells
- Protect the inner cells
- Presence **of guard cells** and **stomata** [Guard cells regulate the size of stomata]

How does carbon dioxide and water enter the plant?

- Carbon dioxide **diffuses** through the **stomata**.
- Carbon dioxide concentration** in intercellular air spaces is **lower** than in the atmosphere.
- CO₂ **diffuses** into the **spongy** mesophyll layer.
- Surfaces of the mesophyll cells are always covered by a **thin film of moisture** for dissolving gases, such as CO₂



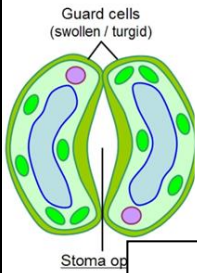
<https://www.showme.com/sh/?h=6iXCO5w>



<https://biology-igcse.weebly.com/passage-of-water-through-root-stem-and-leaf.html>

- Water enters through the **roots**.
- It enters the root cells via **osmosis** until it reaches the xylem vessels in the root.
- Xylem vessels transport **water** (**osmosis**) and **dissolved mineral salts** (**diffusion**) from the roots to all parts of the plants.
- Since there are xylem vessels in the roots, stem and leaves, water is transported to the leaves eventually.

How does guard cell the size of stomata?



In sunlight:

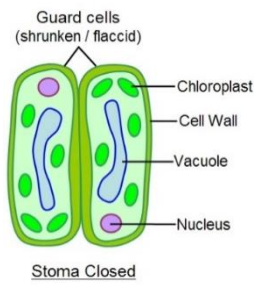
The guard cell photosynthesizes and converts light energy to chemical energy.

This chemical energy is used to pump **potassium ions** into the guard cells from neighbouring epidermal cells.

The **water potential** in the guard cell is lowered.

Water molecules move from a region of **higher water potential (epidermal cells)** to a region of **lower water potential (guard cell)** across **partially permeable membrane**.

Now, the guard cell has a **thicker cell wall** at the stomata pore. The swollen guard cell becomes more **curved** and the **stoma opens**.



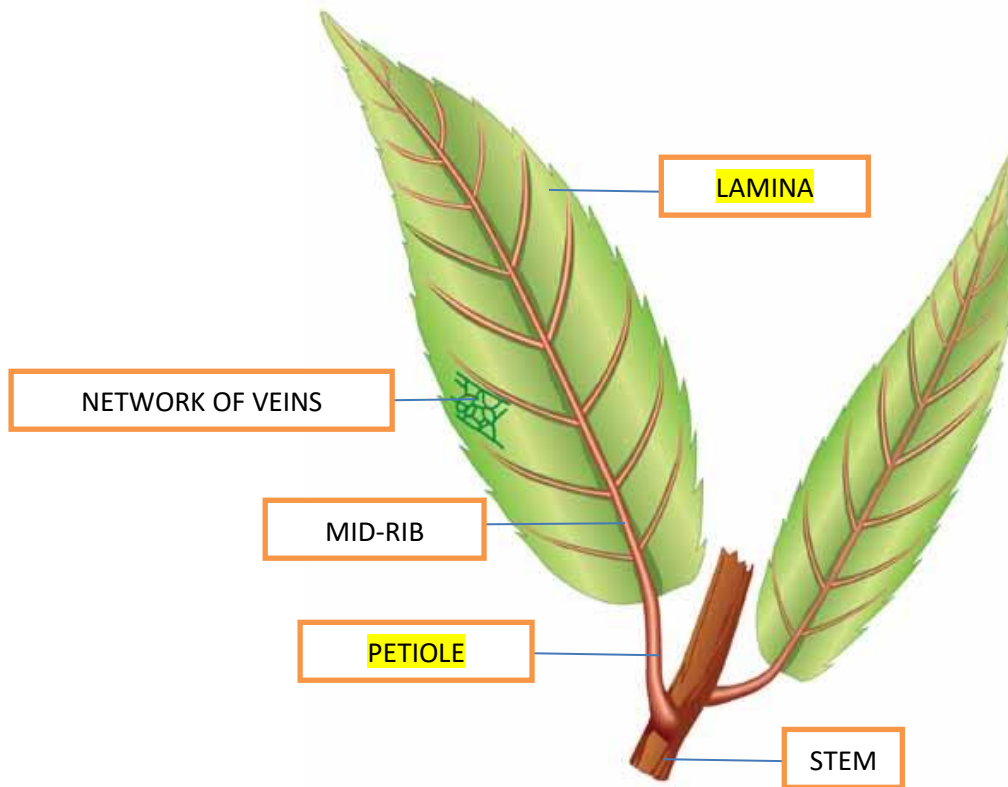
At night:

The **potassium ions** that have accumulated in the guard cell during the day **diffuse out** of the guard cells.

Hence, the **water potential** of the guard cell **increased**. Water molecules leave the cells by **osmosis down a concentration gradient**.

The cell becomes **flaccid** and **stoma closes**.

The External Structure of Leaf



1. Network of veins

- Veins consist of vascular bundles (xylem vessels and phloem tubes)
- Xylem vessels carry water and mineral salts to the cells in the lamina
- Phloem tubes carry manufacture food (sucrose and amino acids) from these cells to other parts of the plant

2. Petiole

- holds the lamina away from the stem so that the lamina can obtain sufficient sunlight and air

3. Lamina

- Also known as the leaf blade
- It has a large flat surface compared to its volume. This enables it to obtain the maximum amount of sunlight for photosynthesis.
- large, thin lamina also means that carbon dioxide can rapidly reach the inner cells of the leaf

4. Leaf arrangement

- Always organised in a regular pattern
- Leaves grow either in pairs or singly in an alternate position
- Ensuring that the leaves are not blocking one another from obtaining optimum light energy

EXTENSION:

How does the cactus carry out photosynthesis?
(Drawings and research is preferred instead of sweeping statements and general answers.)

Let's Think!



(<https://www.ourhouseplants.com/plants/cactus>)

Cactus does not have leaves, instead they have needle-like leaves.

- This is to reduce water loss in the desert

The green stem has chlorophyll that absorbs light energy for photosynthesis.

On the green stem, there is waxy cuticle on it.

The stem also stores water.

Cactus stores the carbon dioxide as malic acid

Transpiration (loss of water) does not occur in the day but only at night.

Stomata opens at night to allow carbon dioxide to enter and store as malic acid, only to be used in the day when there is sunlight.

Cactus does not have leaves, instead they have needle-like leaves. This is to reduce water loss in the desert. The green stem has chlorophyll that absorbs light energy for photosynthesis. On the green stem, there is waxy cuticle on it. The stem also stores water. Cactus stores the carbon dioxide as malic acid. Transpiration (loss of water) does not occur in the day but only at night. Stomata opens at night to allow carbon dioxide to enter and store as malic acid, only to be used in the day when there is sunlight.

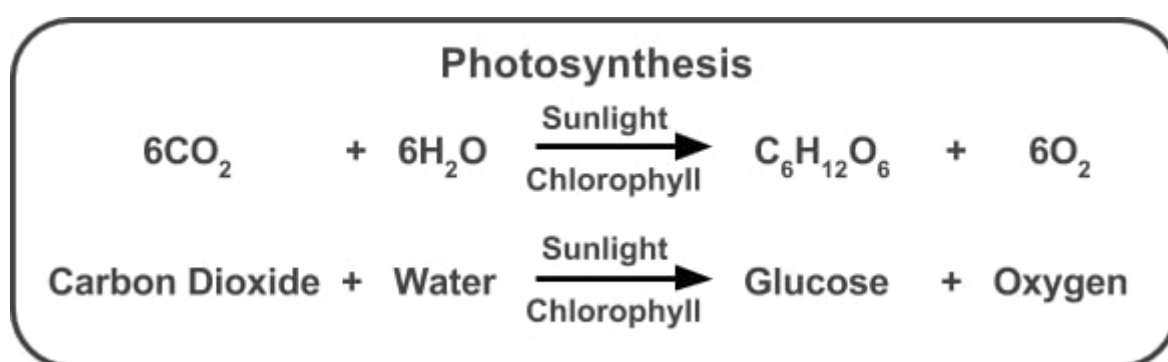
- (b) state the equation, in words and symbols, for photosynthesis
- (d) State that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent uses

What is essential for photosynthesis?

Based on the above investigations, the following are necessary for photosynthesis:

raw material	condition	products
carbon dioxide water	sunlight chlorophyll	glucose oxygen

Word & Chemical equation for photosynthesis



Definition of PHOTOSYNTHESIS:

the process in which **light energy** absorbed by chlorophyll is transformed into **chemical energy**. The chemical energy is used to synthesise carbohydrates from water and carbon dioxide. Water and carbon dioxide are the raw materials. Oxygen is released during the process.

What happens after photosynthesis?

Glucose

1. Used immediately for cellular respiration / form cellulose cell walls
2. Converted into sucrose for translocation to other parts of the plant
3. **Excess** glucose is stored as starch
4. Used to form amino acids (glucose + nitrates) which forms proteins to make new protoplasm for the leaf
5. Used to form fats for storage

Oxygen

1. Diffuses out of the leaf through the stomata
2. Used immediately for cellular respiration

Does photosynthesis occur at a constant rate all the time?

What affects the rate of photosynthesis?

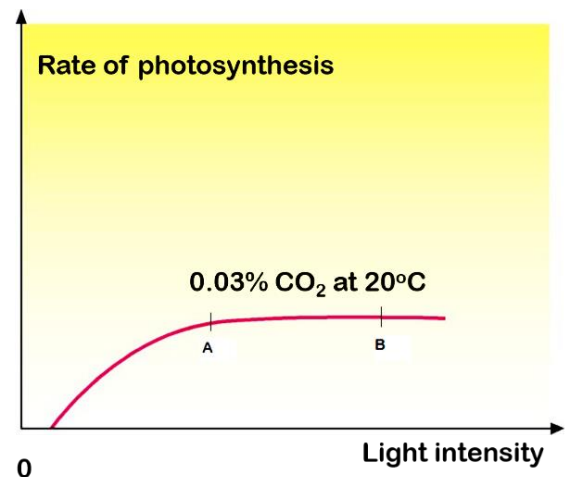
FACTORS OF PHOTOSYNTHESIS

Limiting factor is a factor that **directly affects** the **rate of reaction** if its quantity is changed.

1. Light intensity
2. Carbon dioxide concentration
3. Temperature

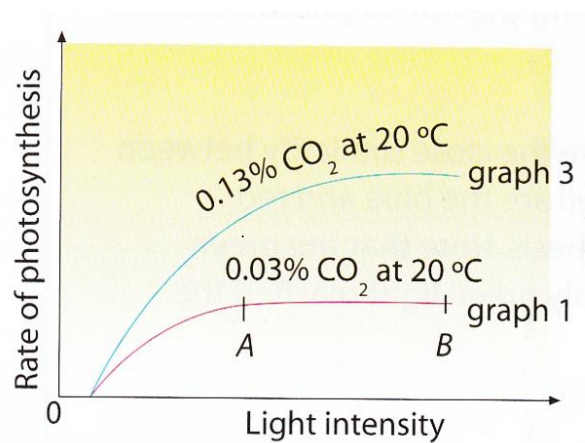
LIGHT INTENSITY

- Light energy is one of the conditions required for photosynthesis.
- As light intensity increases, the rate of photosynthesis increases from 0 to A.
- From 0 to A, light intensity is the limiting factor.
- Beyond A, as light intensity increases, the rate of photosynthesis remains constant.
- Beyond A, light intensity is no longer the limiting factor.



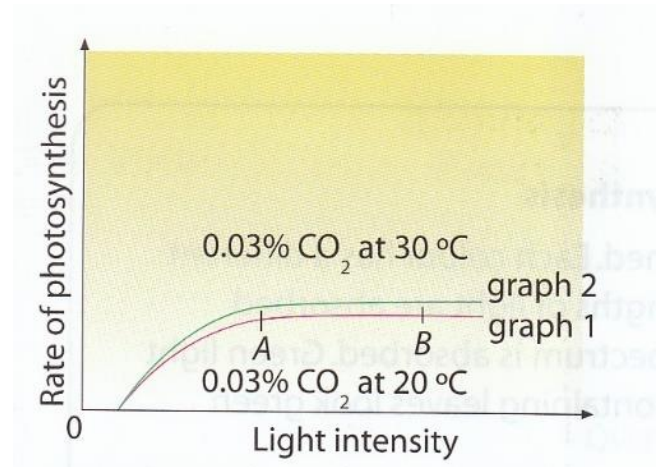
CARBON DIOXIDE CONCENTRATION

- Carbon dioxide is one of the raw materials for photosynthesis.
- When the temperature remains constant and the CO₂ concentration increases to 0.13%, the rate of photosynthesis increases greatly.
- This shows that CO₂ concentration is the limiting factor.



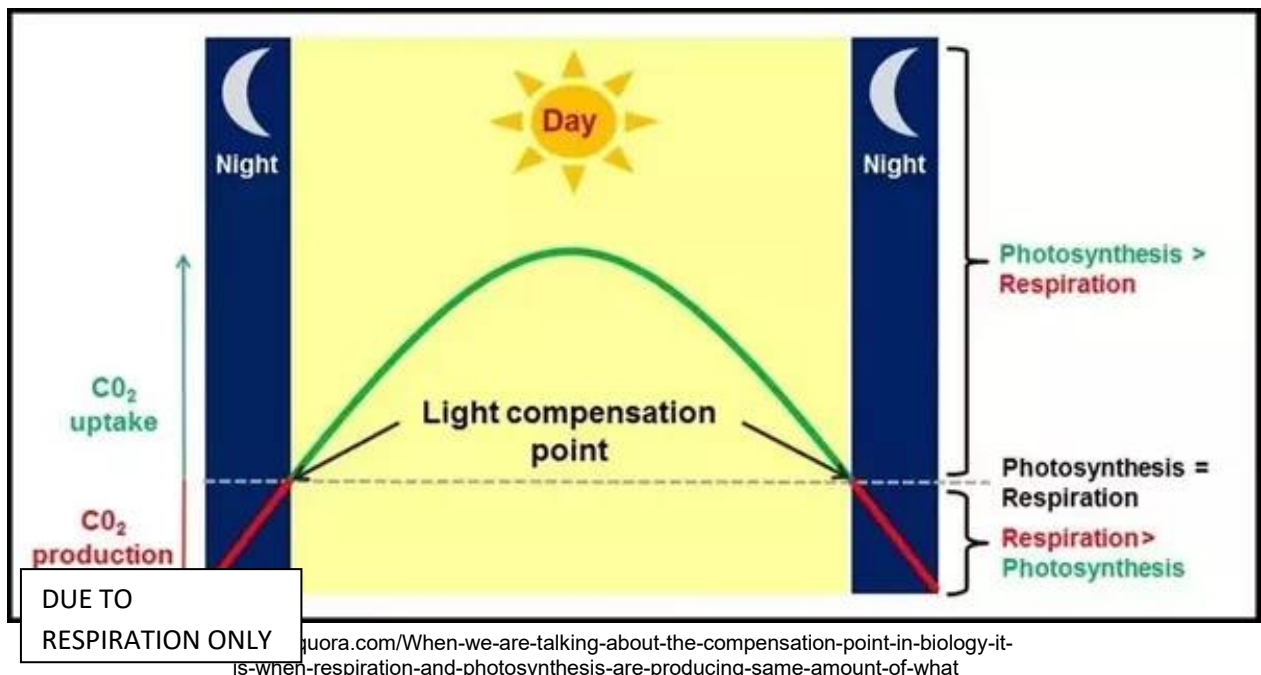
TEMPERATURE

- Photosynthesis is an enzyme-controlled reaction.
- From the graph, increasing the temperature from 20°C to 30°C while keeping the CO₂ concentration constant does not bring about a large increase in rate.
- This shows that **temperature** is not the limiting factor.



Compensation Point

- Rate of photosynthesis = Rate of respiration
- Amount of carbon dioxide absorbed = Amount of carbon dioxide released

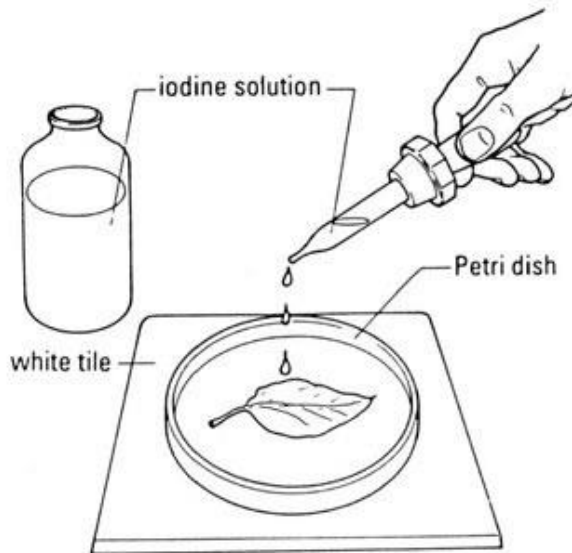


Importance of photosynthesis

- ☐ Photosynthesis produces food (**chemical** energy) in the form of glucose for the consumers
 - Plants are **producers** in the food chain.
- ☐ Photosynthesis provides **oxygen** and **removes** carbon dioxide
 - Essential process in **carbon cycle**
- ☐ Photosynthesis forms energy stored in coal
 - **Fossil fuels** are a source of energy for humans.

How can we show that photosynthesis has taken place? (Page 115-118)

1. How can we test for starch in a leaf? Is this the way? Think of the structure of a leaf. (pg 115)



Ans:

1. Boil the leaf (removes the cuticle and destroy the cell membrane and cell wall)
2. Add leaf into a boiling tube containing some alcohol (This destroys the chloroplast and removes chlorophyll)
3. Take the leaf out and add a few drops of iodine.

2. Aim of this experiment: To investigate if sunlight is necessary for photosynthesis. (pg 116)

1. Destarch a plant

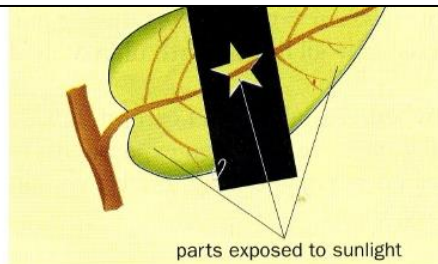
To remove any existing starch. So that any starch produced is due to the experiment

2. Remove a leaf and test for starch

3. Sandwich a leaf between 2 pieces of black paper; each paper has a pattern cut on it

4. After a few hours, remove the leaf and test it for starch

5. Make a drawing of the leaf to show the region stained blue black

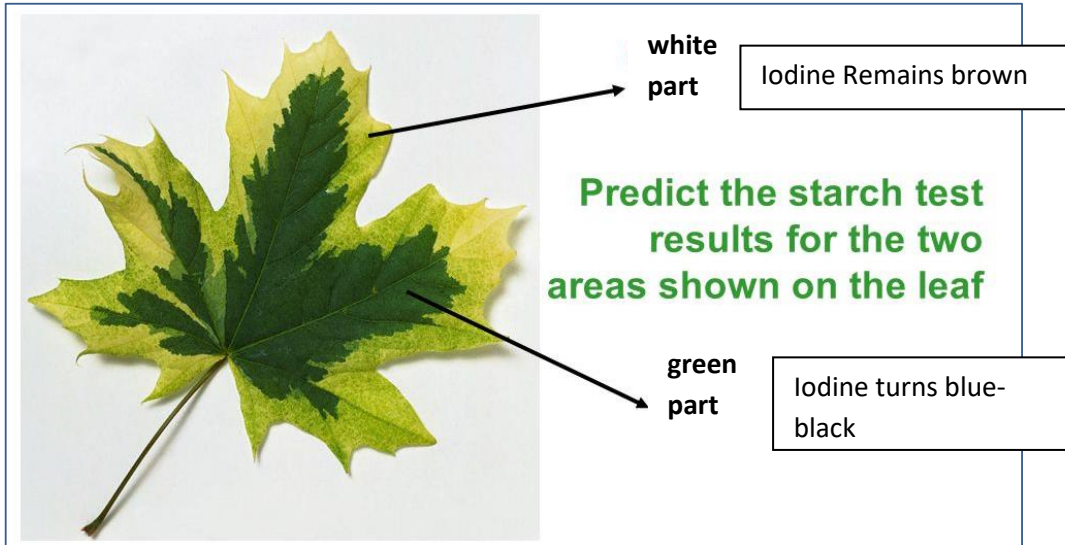


Why is it important to destarch the plant before the experiment? ->

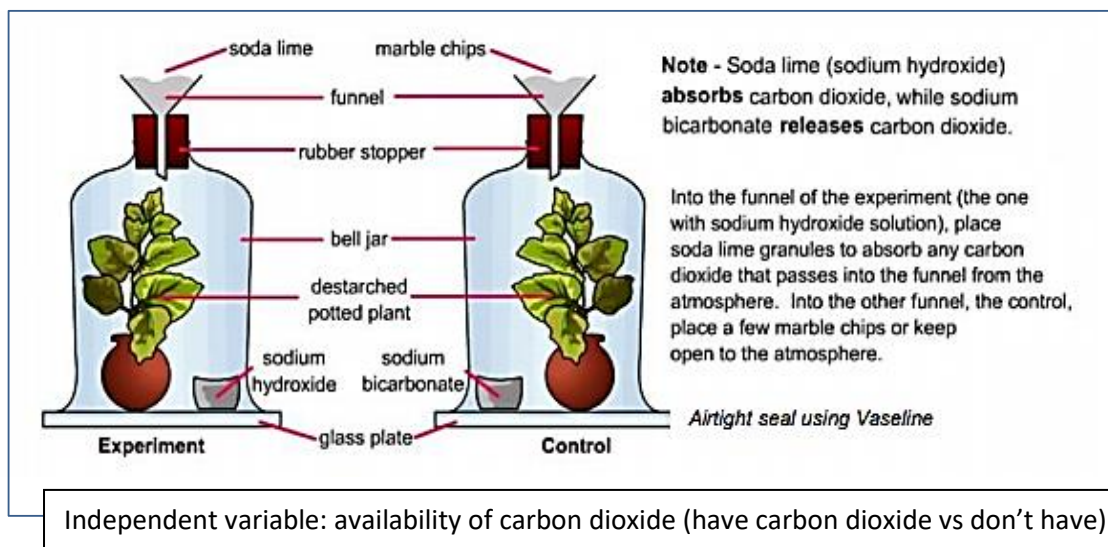
What is the purpose of boiling the leaf in water and then putting it in alcohol before the experiment? -> boiling to remove cuticle,

Why must remove cuticle?

3. Aim of the experiment: To investigate if chlorophyll is necessary for photosynthesis.



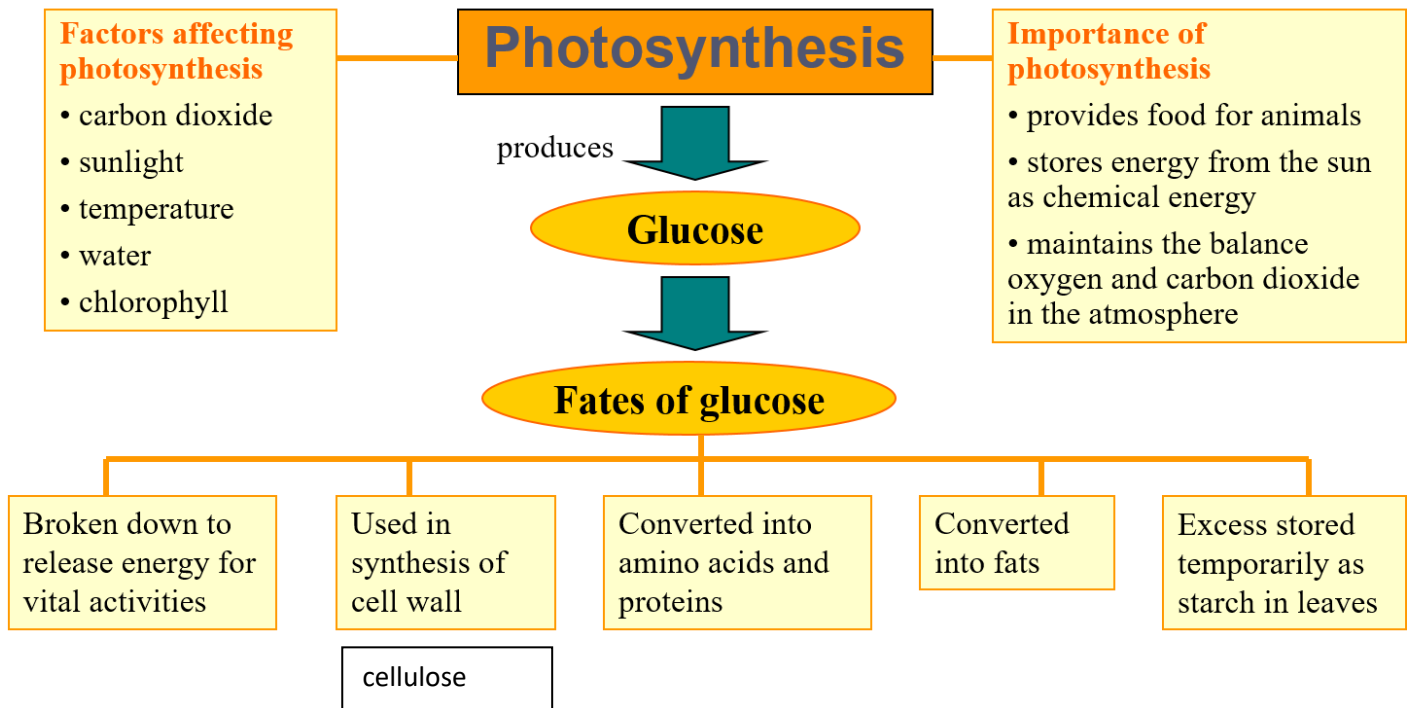
4. Aim of the experiment: To investigate if carbon dioxide is necessary for photosynthesis.

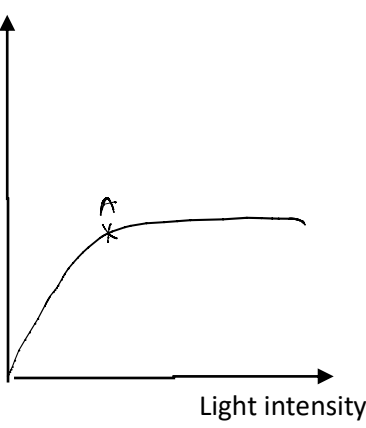
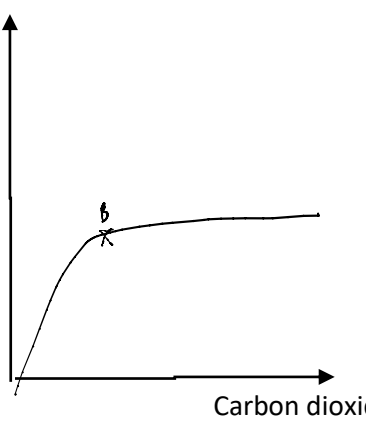
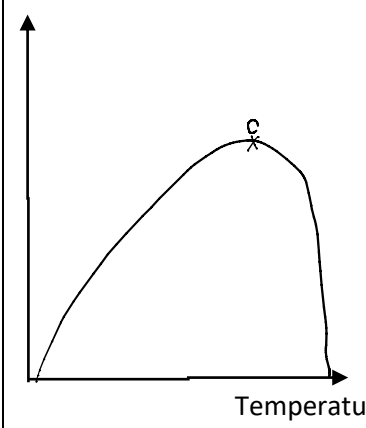


Think about what other experiments can be performed to investigate the factors involved in photosynthesis. How would you carry out these experiments?

IN SUMMARY

(Use the space below to construct a more detailed concept map)



Factor	Light intensity	Carbon dioxide concentration	Temperature
Graph	Rate of photosynthesis  Light intensity	Rate of photosynthesis  Carbon dioxide concentration	Rate of photosynthesis  Temperature
Explanation	Until pt A: LF is light intensity After pt A: LF could be CO₂ or temperature As light intensity increases until A, the rate of photosynthesis increases. Light intensity is a condition needed for photosynthesis. However at high light intensity (above), light intensity is no longer the limiting factor. Temperature OR CO₂ conc could be the limiting factor.	Until pt B: LF is CO₂ Conc After pt B: LF could be light intensity or temperature As carbon dioxide conc increases, the rate of photosynthesis increases. Carbon dioxide conc is a condition needed for photosynthesis. However at high CO₂ conc above B, CO₂ is no longer the limiting factor. Light intensity OR temperature could be the limiting factor.	C: Optimum temp As temperature increases until C, the rate of photosynthesis increases. Enzymes and substrates of photosynthesis gain kinetic energy. Hence the rate of enzyme-substrate complex formation increases. At high temperatures above C, these enzymes denature, thus causing the rate of photosynthesis to decrease until it reaches 0.

