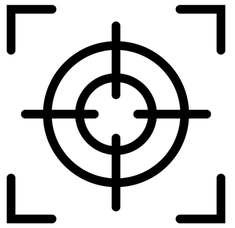
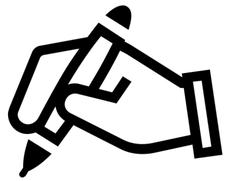
Topic 5:
Nutrition in Plants

Chapter Analysis



FOCUS

- straightforward
- link structure of leaf and photosynthesis knowledge to next chapter



EXAM

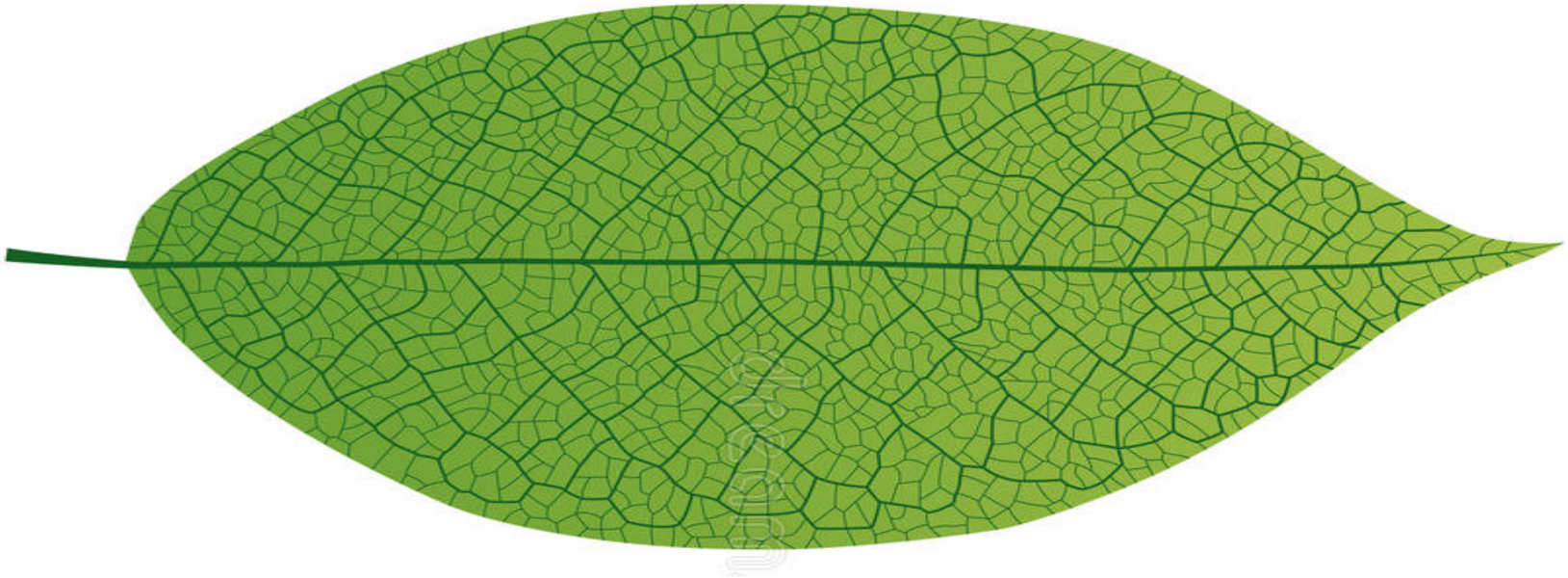
- commonly tested in MCQ and structured questions

WEIGHTAGE

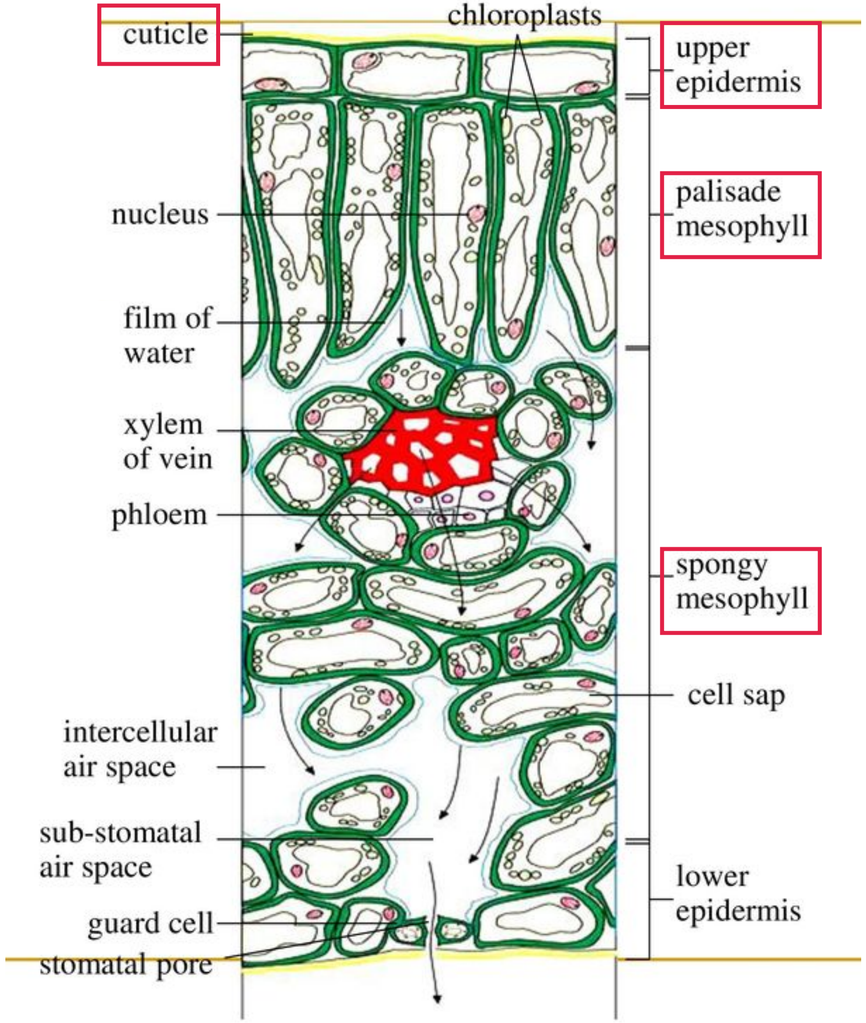
- Constitute to around 8% in Paper 2 in the past 5 years
- Heavily tested in 2020

Key Concept

Leaf Structure
Gaseous exchange

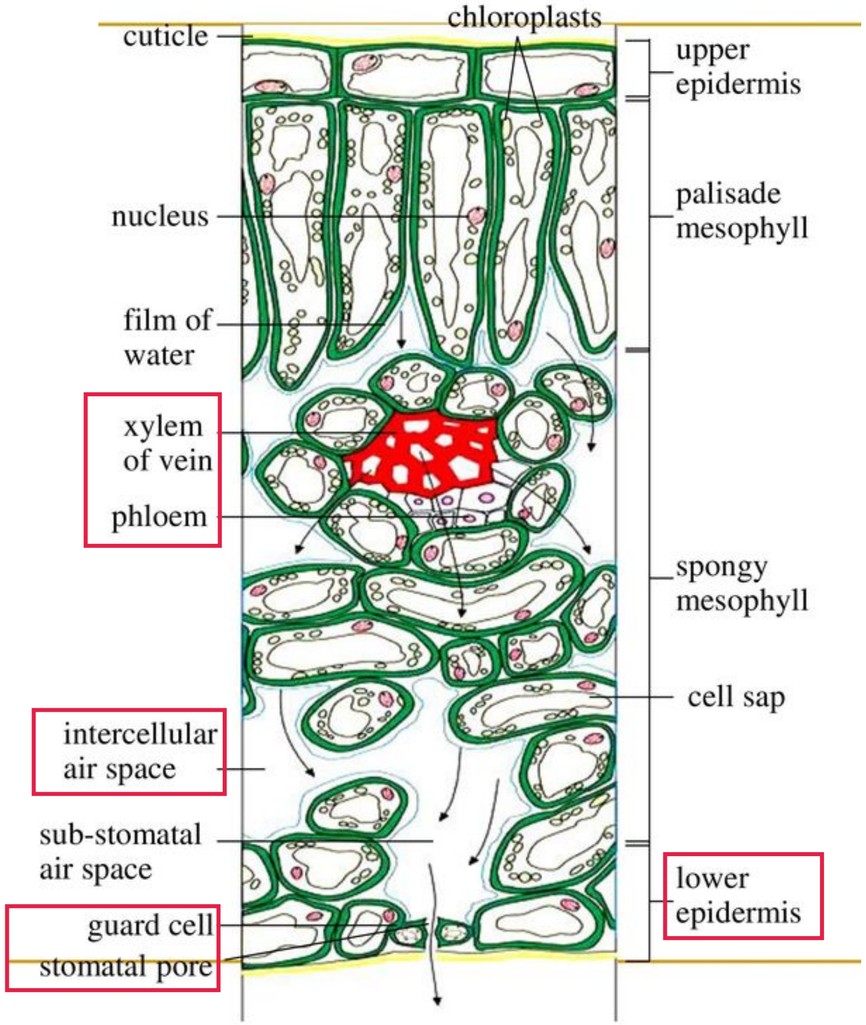


Structure of Leaf



Tissue	Structure & Functions	Chloroplast distribution
Cuticle	• Waxy and transparent layer. • Reduced water loss through evaporation from the leaf	No
Upper epidermis	• Single layer of closely packed cells • Allows light to pass through.	No
Palisade Mesophyll	• Long and cylindrical shape • Main site of photosynthesis	Contain the largest amount of chloroplasts among the tissue in leaves to increase absorption of sunlight for photosynthesis
Spongy Mesophyll	• Irregular shape with large **intercellular air spaces** among the cells to increase surface area for **gaseous exchange**. • covered with a **thin film of moisture** so that carbon dioxide can dissolve in it. • Contains **vascular bundle**.	Contain less chloroplasts than palisade mesophyll

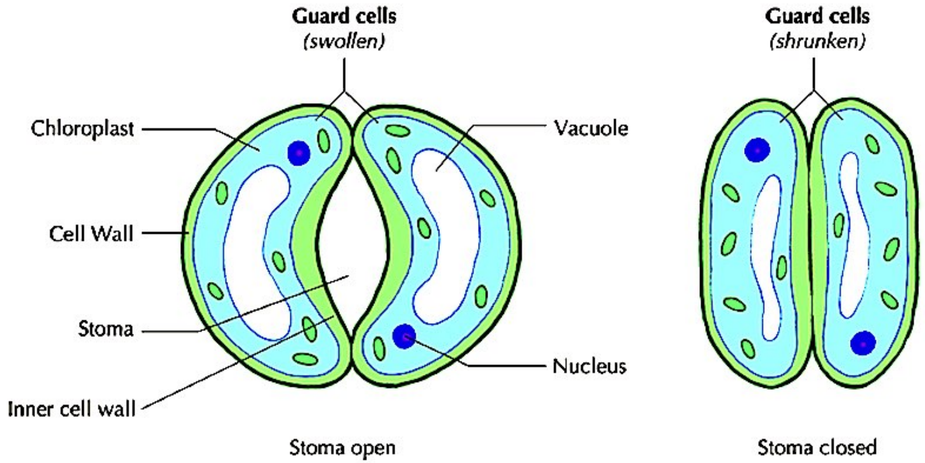
Structure of Leaf



Tissue	Structure & Functions	Chloroplast distribution
Vascular Bundle	• containing **xylem** and **phloem** tissue • Xylem: transport water and mineral salts from roots to other part of plants • Phloem: transport sucrose from leaves to other parts of plants	No
Intercellular air spaces	• The intercellular air spaces in the spongy mesophyll allow circulation of Carbon Dioxide and Oxygen inside leaf for photosynthesis and respiration • rapid diffusion of gases into and out of the cells	No
Lower Epidermis	• Similar to upper epidermis, a single layer of closely-packed cells covered by cuticle	No (but the layer of tissue consists of guard cells which contain chloroplast)
Guard cells	• Guard cells are bean-shaped cells that surround stoma • guard cells have a thicker cellulose cell wall on the side of stomata • Control the opening and closing of the stoma that allow gaseous exchange of leaves	Yes

Gaseous Exchange

Guard cells and stomata



Stoma open

Stoma closed

- Plants open their stomata during the day for carbon dioxide intake and close their stomata during the night to minimise water loss through transpiration.

<u>During the day</u>

- Guard cells **photosynthesise** and **energy** is used to **pump potassium ions** by active transport into the guard cells from neighbouring epidermal cells.
- This **lowers the water potential** of guard cells
- Water from neighbouring cells enter guard cells via **osmosis**
- Guard cells swell and become **turgid**. Due to uneven thickness of cell walls, guard cells become **curved** and lead to the **opening of stoma**

<u>In the night</u>

- Potassium ions move out of the guard cells via **diffusion**
- Water potential is increased in guard cells
- Water moves out of the guard cells to the neighbouring cells
- Guard cells become **flaccid** and the **stoma closes**.

Key Concept

Photosynthesis Limiting Factors

Photosynthesis

Equation

Word equation

$$Carbon Dioxide + Water \xrightarrow[Light Energy]{Chlorophyll} Glucose + Oxygen + Water$$

Chemical equation

$$6CO_2 + 12H_2O \xrightarrow[Light Energy]{Chlorophyll} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Simplified chemical equation

$$6CO_2 + 6H_2O \xrightarrow[Light Energy]{Chlorophyll} C_6H_{12}O_6 + 6O_2$$

Chlorophyll

- Pigment in chloroplast
- traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent uses

Intake of Carbon Dioxide

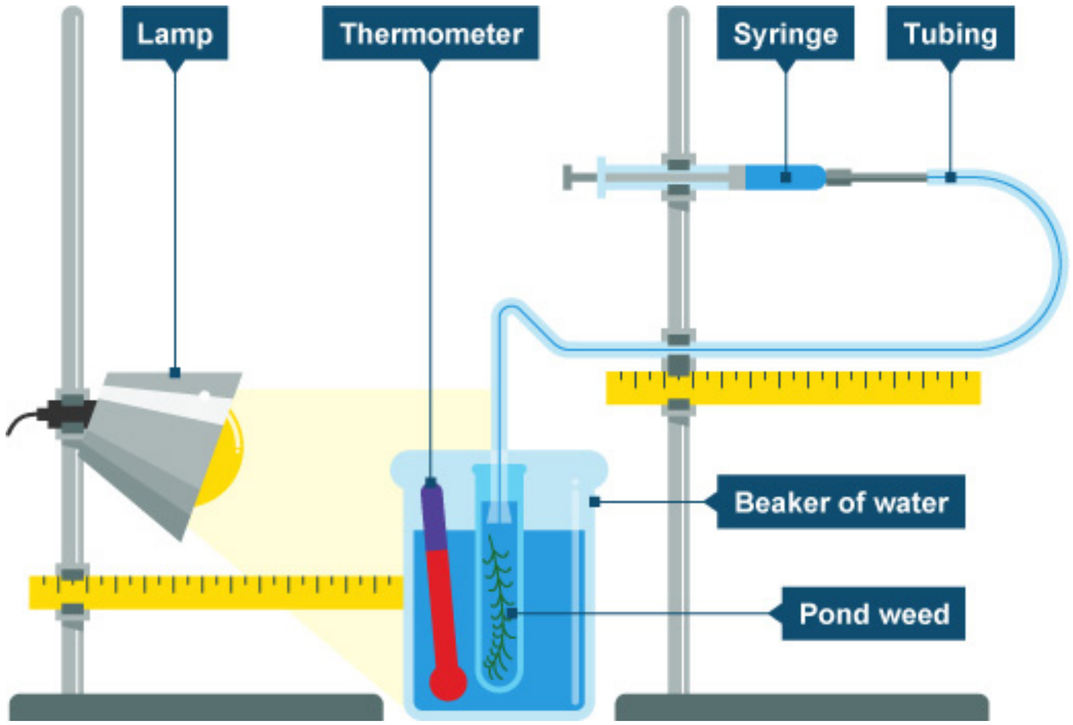
- In daylight when photosynthesis occurs, the carbon dioxide in the leaf is rapidly used up.
- The carbon dioxide concentration in the leaf becomes lower than that in the atmospheric air, so carbon dioxide diffuses from the surrounding air through the stomatal openings into the intercellular air spaces
- The surfaces of the mesophyll cells are covered by a thin film of moisture so that carbon dioxide can dissolve in it and diffuses into the cells.

Intake of water

- The xylem transports water and dissolved mineral salts from roots to the leaves.
- Water moves out of xylem vessels and enters cells via osmosis

Limiting Factors

Effect of light intensity

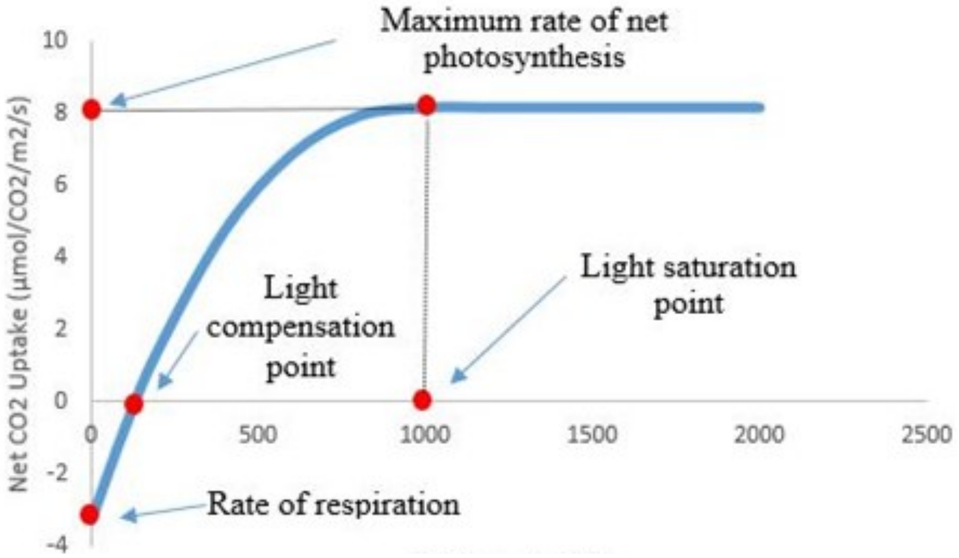


- Limiting factors are factors that **directly affect the process.** By increasing the amount of factors, it increases the **rate of process**
- Light intensity, carbon dioxide concentration and temperature are limiting factors on the rate of photosynthesis
- Rate of photosynthesis can be measured by

1) Measuring the uptake of CO_2
2) Measuring the production of O_2 (an example is shown)
3) Measuring the production of carbohydrates
4) Measuring the increase in dry mass

Limiting Factors

Effect of light intensity

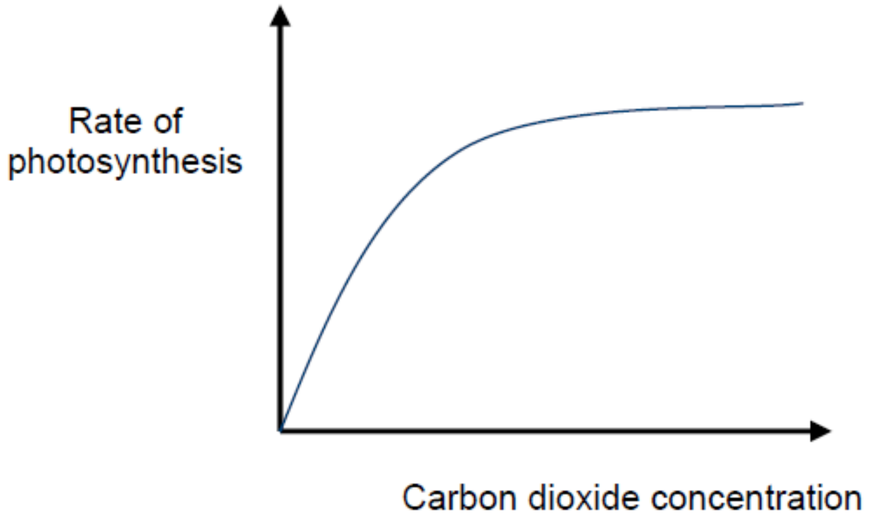


- At a **constant** temperature and carbon dioxide concentration, the rate of photosynthesis **increases with increasing light intensity** until it reaches a **plateau**.
- When the plateau is reached, light is **no longer the limiting factor** in the reaction but other factors such as temperature and concentration of carbon dioxide. This is also called the **light saturation point**
- Raising these factors can increase the plateau

- **light compensation point** is when **rate of respiration = rate of photosynthesis**, so while rate of photosynthesis is increasing, the **net** CO2 uptake or O2 release is **zero**

Limiting Factors

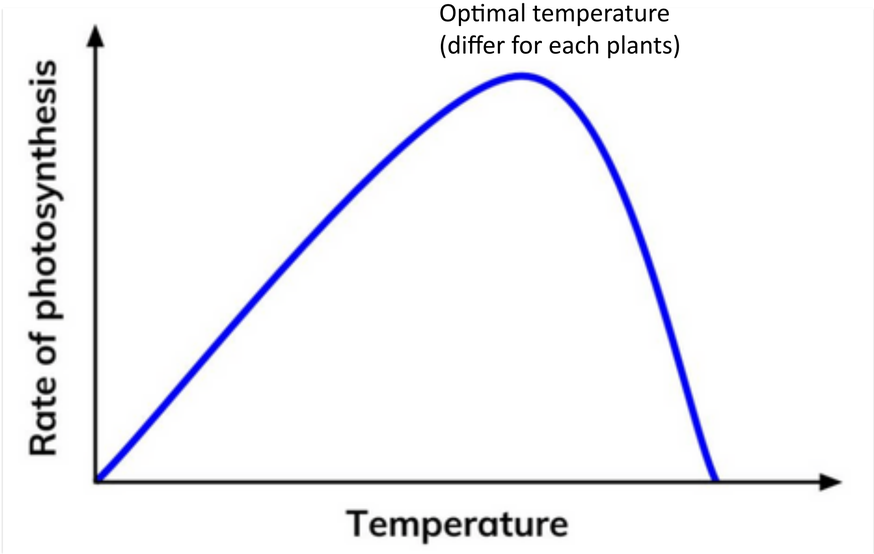
Effect of carbon dioxide concentration



- An increase in the carbon dioxide concentration increases the rate of photosynthesis, until it reaches plateau
- Beyond this point, rate of photosynthesis is limited by another factor such as light intensity or temperature and carbon dioxide is no longer the limiting factor.
- Under normal circumstances, carbon dioxide is an important limiting factor since atmospheric carbon dioxide remains constant at about 0.03%

Limiting Factors

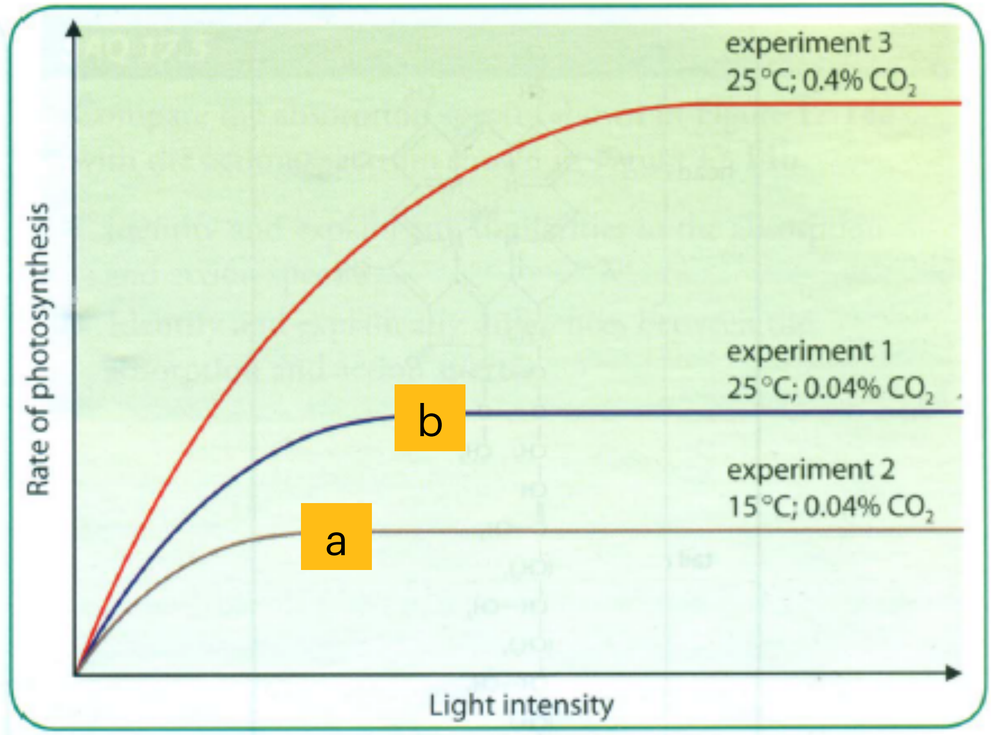
Effect of temperature



- Photosynthesis is a process that is highly dependent on enzymes (thus a similar graph to enzyme activity against temperature)
- When temperature increases, **kinetic energy** increases which increases the **frequency of effective collision** between enzymes and substrates, increase the **formation of enzyme substrate complex**, thus increasing the **rate of photosynthesis.**
- Rate of photosynthesis is at the maximum at optimum temperature
- When the temperature increases beyond the enzymes' optimum temperatures, the rate of photosynthesis begins to decrease until it stops as the enzymes are denatured.

Limiting factors

an example



explain the graph:

- increasing light intensity increases the rate of photosynthesis as seen from increasing graph
- At a , light intensity is no longer a limiting factor but temperature because increasing temperature from 15°C to 25°C increases the rate of photosynthesis.
- At b , light intensity and temperature is no longer the limiting factor, but concentration of carbon dioxide. this is because increasing concentration of carbon dioxide to 0.4% greatly increases the rate of photosynthesis.

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