- Triple Science Content only in purple
- Triple Science and Higher Content Only in blue

4. Bioenergetics - GCSE AQA Biology Topic 4

4.1 Photosynthesis

- Photosynthesis is the process where plants use **light energy** to make glucose.
  - It is an **endothermic reaction** (absorbs energy).

Word Equation:
Carbon dioxide + Water → Glucose + Oxygen

Symbol Equation:
$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

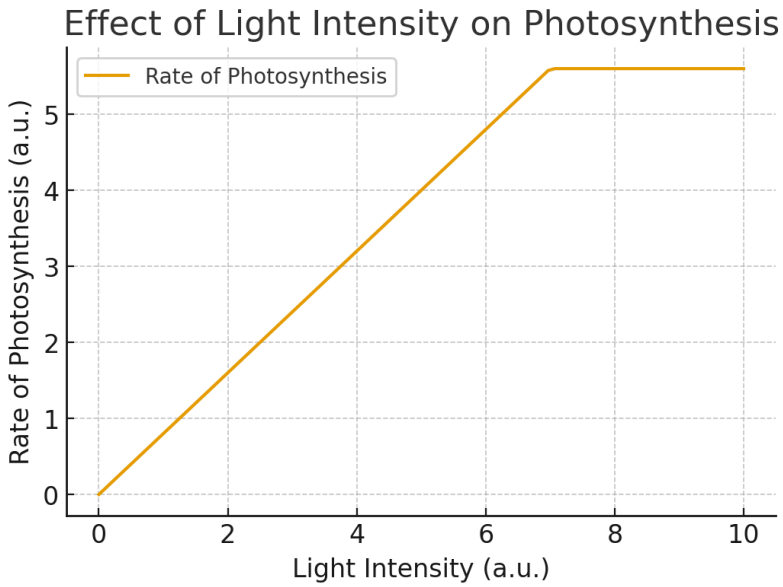
- This process occurs in the **chloroplasts** of plant cells, which contain **chlorophyll** to absorb light.

Factors Affecting the Rate of Photosynthesis

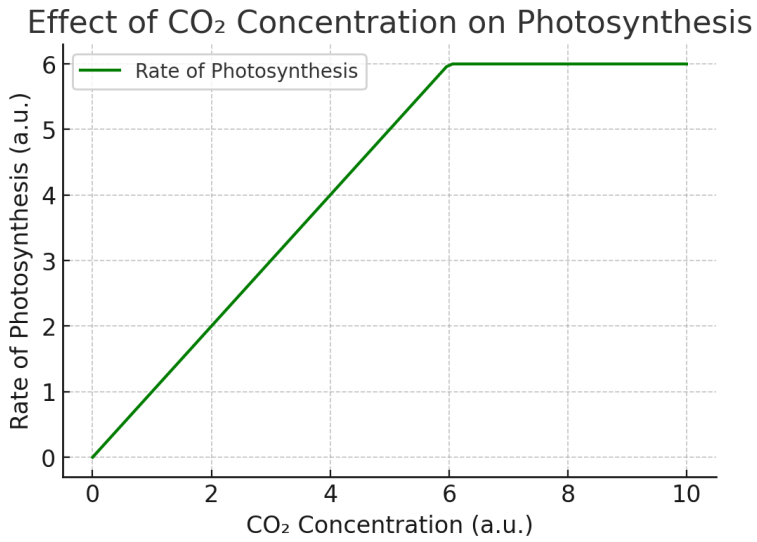
Factor	Effect on Photosynthesis
Light Intensity	More light increases the rate, but only up to a point.
Carbon Dioxide	More CO_2 increases the rate, until the plant has enough.
Temperature	Higher temperatures increase the rate as more particles have more energy, but too hot can cause enzymes to denature and stop the reaction.
Chlorophyll	The more chlorophyll, the more light can be absorbed, increasing the rate of photosynthesis.

Limiting Factors:

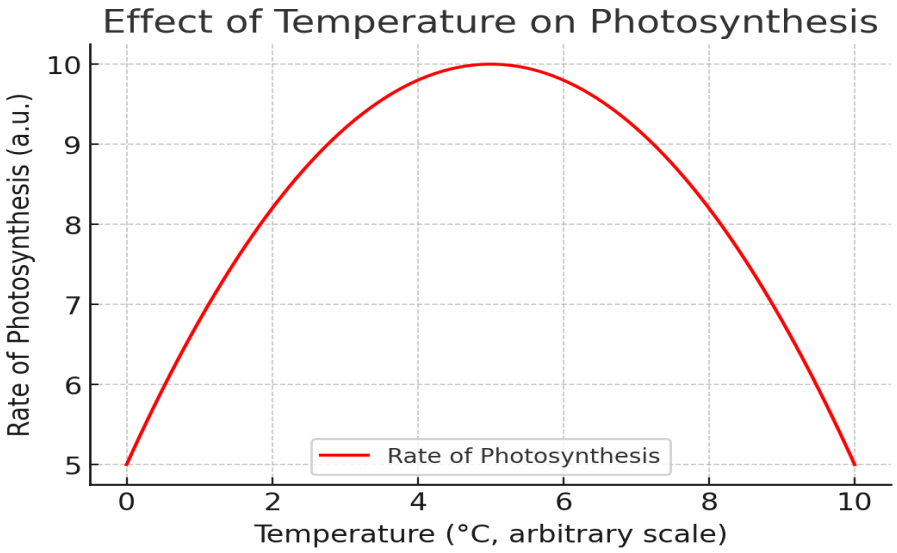
- Any of the factors above can limit the rate of photosynthesis if they are in short supply.



Light intensity vs rate of photosynthesis – increases steadily but plateaus when another factor becomes limiting.



CO_2 concentration vs rate of photosynthesis – similar pattern, rising then leveling off.



Temperature vs rate of photosynthesis – rises to an optimum, then drops as enzymes denature.

Uses of Glucose from Photosynthesis

Plants use glucose in many ways:

- **Respiration** → release energy.
- **Storage** → glucose converted to **starch** (insoluble, stored in roots/leaves).
- **Cell walls** → glucose converted to **cellulose**.
- **Lipids** → fats and oils stored in seeds.
- **Proteins** → glucose + nitrates → amino acids for growth.

Required Practical: Investigating Photosynthesis

- Common experiment: **pondweed (Elodea)** placed under a lamp. Count the number of bubbles produced as light intensity changes.
- **Independent variable**: distance of lamp from pondweed.
- **Dependent variable**: number of bubbles / volume of oxygen produced.
- **Control variables**: temperature, species of plant, CO_2 supply.

📏 **Inverse Square Law**:
Light intensity ∝ 1 ÷ distance²

So if you double the distance, light intensity falls to a quarter.

Respiration

- **Respiration** is the process of releasing energy from **glucose**, which happens continuously in all living cells.
    - It is an **exothermic reaction**, meaning it gives out energy.

Aerobic Respiration:

- Happens with **oxygen** and produces **a lot of energy**.
    - **Glucose + oxygen → carbon dioxide + water**

Anaerobic Respiration:

- Happens **without oxygen**, producing **less energy**.
    - In muscles: **Glucose → lactic acid**
    - In plants and yeast: **Glucose → ethanol + carbon dioxide**
    - **Anaerobic respiration in yeast** is called **fermentation**, used in baking and brewing.

Response to Exercise

- When you exercise, your muscles need more energy, so **respiration** increases. To meet this demand:
    - **Heart rate** increases to pump more oxygenated blood to muscles.
    - **Breathing rate and breathing volume** increases to get more oxygen into the body and remove carbon dioxide faster.

Oxygen Debt:

- After intense exercise, **lactic acid** builds up in muscles, causing fatigue.
    - The body needs extra oxygen to **break down the lactic acid**, which is called an **oxygen debt**.
- **Lactic acid** is transferred back into the liver through the bloodstream converted back into glucose.

Metabolism

- **Metabolism** is the sum of all the chemical reactions in a cell or organism.
    - This includes:
        - **Converting glucose** to starch, glycogen, or cellulose.
        - **Making lipids** from glycerol and fatty acids.
        - **Using glucose and nitrates** to make amino acids.
        - **Breaking down excess proteins** to make urea.