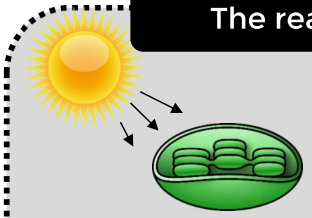
PHOTOSYNTHESIS

The reaction



Photosynthesis is an **endothermic reaction**, because energy from the environment is transferred to chloroplasts via light.

carbon dioxide + water $\xrightarrow{\text{Light energy}}$ glucose + oxygen

$$6CO_2 + 6H_2O \xrightarrow{\text{Light energy}} C_6H_{12}O_6 + 6O_2$$

Uses of glucose made by photosynthesis

Storage as starch
Glucose is soluble in water so would affect osmotic balance of cells if stored as a single sugar molecule. Starch is insoluble in water so doesn't affect water balance.

Producing proteins
Combine glucose with nitrate ions from the soil to produce amino acids for protein synthesis.

Respiration
Making energy for processes in the body.

Storage as lipids/oils
Acts as an energy store and is used to strengthen cell walls.

Producing cellulose
to strengthen cell walls.

Stored in leaves
to provide energy in low light.

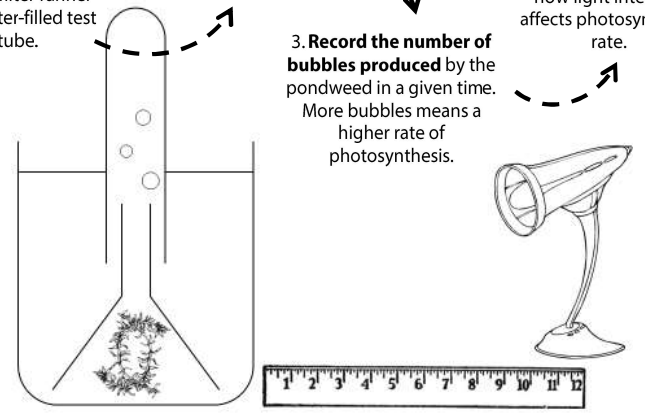
Stored in tubers
to provide energy over winter.

Tests for molecules

Molecule	Test	Colour change
Glucose	Benedict's solution	Blue to orange
Starch	Iodine solution	Yellow/red to blue-black
Protein	Biuret solution	Blue to pink-purple

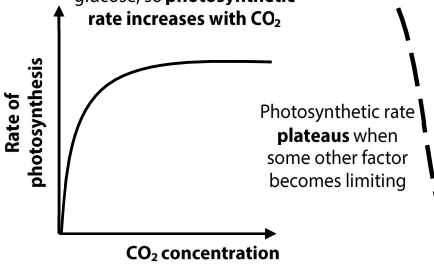
Investigating rate of photosynthesis

1. **Place pondweed in a beaker of water** and cover with a filter funnel and water-filled test tube.
2. Use a ruler to **measure the distance** between the pondweed and light source.
3. **Record the number of bubbles produced** by the pondweed in a given time. More bubbles means a higher rate of photosynthesis.
4. Move the light gradually closer to the pondweed and **repeat the experiment** to see how light intensity affects photosynthetic rate.



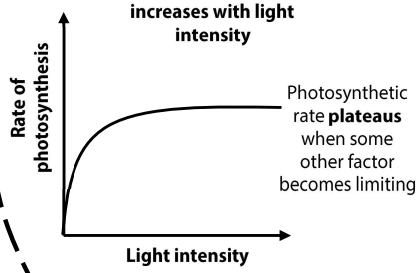
Factors affecting rate of photosynthesis

Plants use CO_2 in photosynthesis to make glucose, so **photosynthetic rate increases with CO_2**



Photosynthetic rate **plateaus** when some other factor becomes limiting

Photosynthetic rate increases with light intensity



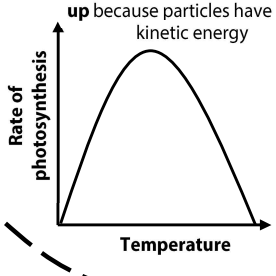
Photosynthetic rate **plateaus** when some other factor becomes limiting

Inverse proportion

In an **inverse relationship**, as one factor goes up, the other goes down. As distance of a plant from light increases, light intensity decreases. Light intensity changes in inverse proportion to the square of the distance:

$$Light\ intensity \propto \frac{1}{distance^2}$$

As temperature increases, the photosynthetic reaction speeds up because particles have more kinetic energy



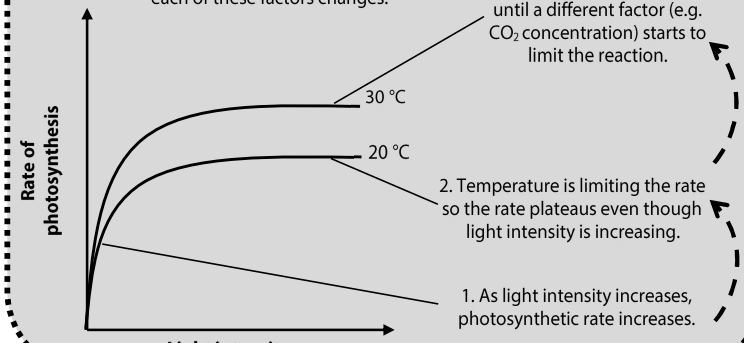
Enzymes in the photosynthetic reaction become **denatured** when the temperature becomes too high, so rate decreases

Mineral ion deficiency

Some mineral ion deficiencies (e.g. magnesium deficiency) **prevent the plant from making chlorophyll** → This **decreases photosynthetic rate** because chlorophyll absorbs energy from light for photosynthesis

HT Interacting limiting factors

Carbon dioxide concentration, light intensity and temperature all interact. The limiting factor of photosynthetic rate can change as the level of each of these factors changes.



3. If temperature increases, the rate increases again, until a different factor (e.g. CO_2 concentration) starts to limit the reaction.

2. Temperature is limiting the rate so the rate plateaus even though light intensity is increasing.

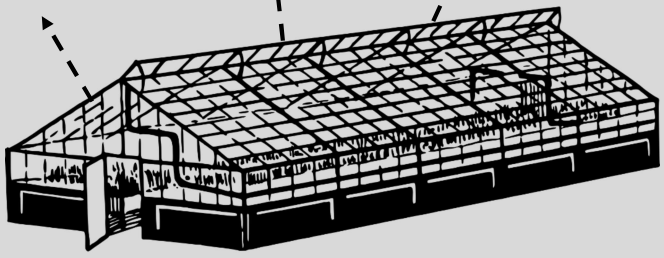
1. As light intensity increases, photosynthetic rate increases.

HT Greenhouse economics

Limiting factors (CO_2, light intensity and temperature) can be **controlled** in greenhouses to increase photosynthetic rate.

Control of limiting factors requires gas and electricity, which can be **expensive**.

Farmers must **weigh up** whether the cost of systems that improve photosynthetic rate are worth it for the profit they gain from the crop yield.



RESPIRATION

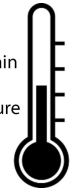
Respiration

What is respiration?

A reaction that is always occurring in all cells, releasing energy (**exothermic**) to drive processes in living things.
It can be **aerobic** (using oxygen) or **anaerobic** (not using oxygen).

Why do organisms need energy from respiration?

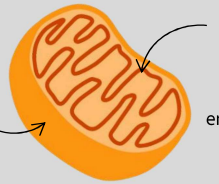
- To make muscles contract
- To drive chemical reactions to synthesise molecules
- For cell transport
- To maintain body temperature



Aerobic respiration

Equation:
glucose + oxygen → carbon dioxide + water
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Takes place in small subcellular structures called **mitochondria**.



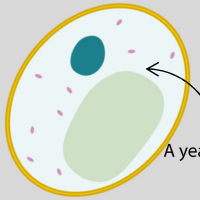
The mitochondrial **inner membrane** is folded to provide a large surface area for enzymes responsible for aerobic respiration.

Anaerobic respiration

Anaerobic respiration takes place **without oxygen**. It transfers **less energy** than aerobic respiration because glucose is not fully oxidised. Therefore, it is a faster process, but less efficient than aerobic respiration.

Plant and yeast cells

Equation:
glucose → ethanol + carbon dioxide

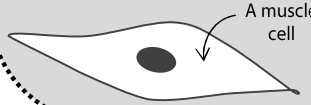


A yeast cell

Known as **fermentation** in yeast cells (used to make bread and alcohol)

Muscles

Equation:
glucose → lactic acid

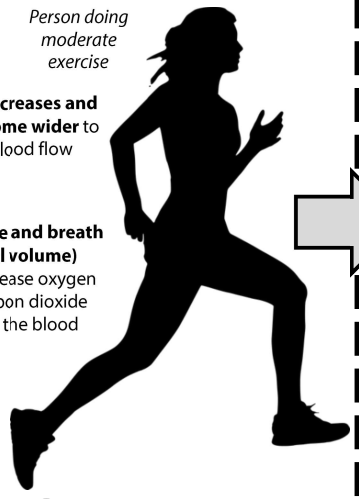


A muscle cell

Exercise

Exercise increases the amount of energy required by muscles for contraction. Changes must happen in the body to meet this demand.

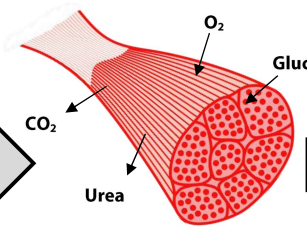
Person doing moderate exercise



1. **Heart rate increases and arteries become wider** to increase blood flow
2. **Breathing rate and breath volume (tidal volume) increase** to increase oxygen intake and carbon dioxide removal from the blood

Aerobic respiration

Combined, these factors **increase supply of oxygen and glucose to the muscle cells**…



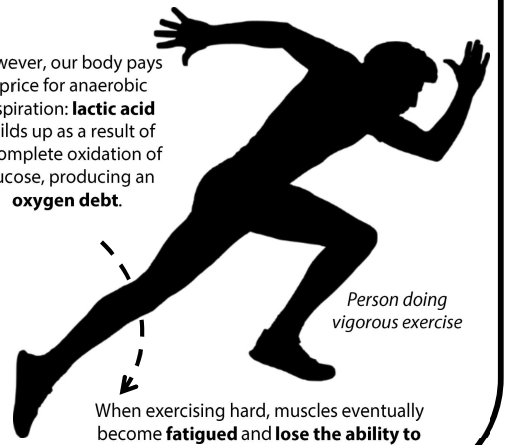
… **and increase rate of waste product removal** from the cells. This means that **aerobic respiration rate can increase**.

This results in an **increased supply of ATP energy** for muscle cell contraction.

Anaerobic respiration

Anaerobic respiration comes into play when the muscles are not receiving enough oxygen to meet their needs. This can happen during **vigorous exercise**, such as sprinting.

However, our body pays a price for anaerobic respiration: **lactic acid** builds up as a result of incomplete oxidation of glucose, producing an **oxygen debt**.



Person doing vigorous exercise

When exercising hard, muscles eventually become **fatigued** and **lose the ability to contract efficiently**.

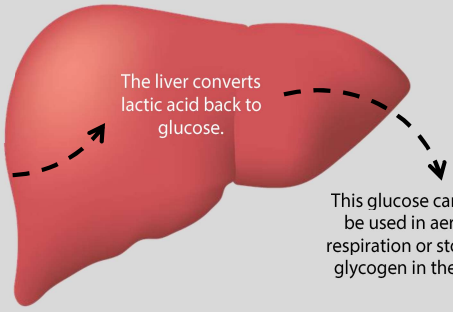
HT Oxygen debt

During an intense workout, we tend to get out of breath. Even once we've stopped, it can take a while for our breathing rate to return to normal. This is because we have accumulated an **oxygen debt** through anaerobic respiration.
Lactic acid build-up affects **blood pH**, so it needs to be **broken down**.
To break down the lactic acid produced by this process, we need a good supply of oxygen.

Oxygen debt = the amount of oxygen required to oxidise lactic acid back to glucose.

The liver helps our body pay off oxygen debt:

Lactic acid is carried from the muscles to the liver via the blood.



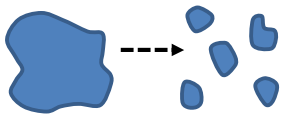
This glucose can then be used in aerobic respiration or stored as glycogen in the liver.

Metabolism

What is metabolism?

The total of all the chemical reactions that occur in an organism or a cell.

Metabolic reactions include the **breakdown** of substances…



… or the **building** of bigger molecules from smaller ones.