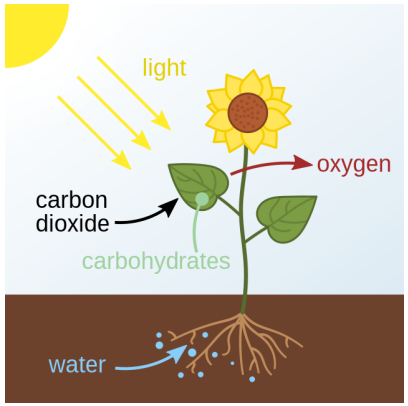
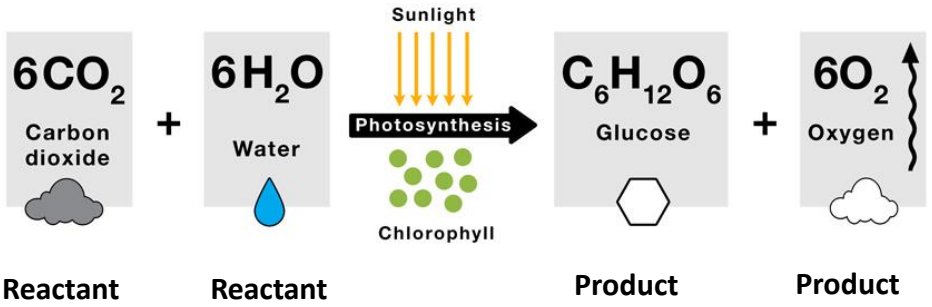
Biology Knowledge Organiser
Bioenergetics

Photosynthesis

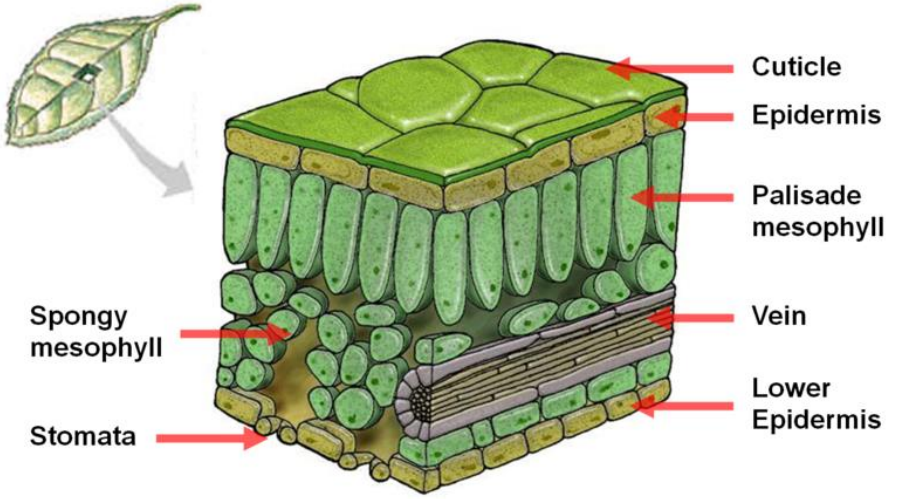
- Photosynthesis is an **endothermic** reaction (it requires an input of energy from the environment to occur (i.e. sunlight)).
- During photosynthesis energy is transferred from the environment to the chloroplast by light.
- The energy converts carbon dioxide (CO_2) from the air and water (H_2O)from the soil (the reactants of photosynthesis) into glucose (the product), oxygen is also produced (this is often referred to as a by-product of photosynthesis)



Photosynthesis Equation

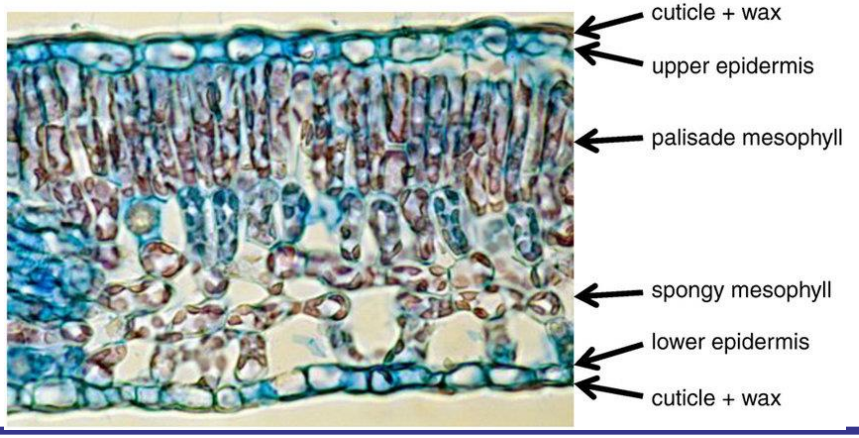


Leaf adaptations



To maximise photosynthesis plants need carbon dioxide, light and water. To obtain these substances, leaves have the following adaptations:

- Broad shape giving them a **large surface area** to absorb light.
- **Thin** structure to minimise diffusion distances
- Contain **chlorophyll within chloroplasts** to absorb light
- **Veins** to supply **water** to the leaf via the **xylem**
- **Veins** to remove the products of photosynthesis (**glucose**) via the **phloem**
- **Air spaces in the spongy mesophyll** to allow (CO_2) to get into the cells and oxygen to leave by diffusion
- **Guard cells** to open & close stomata to regulate gas exchange & water loss



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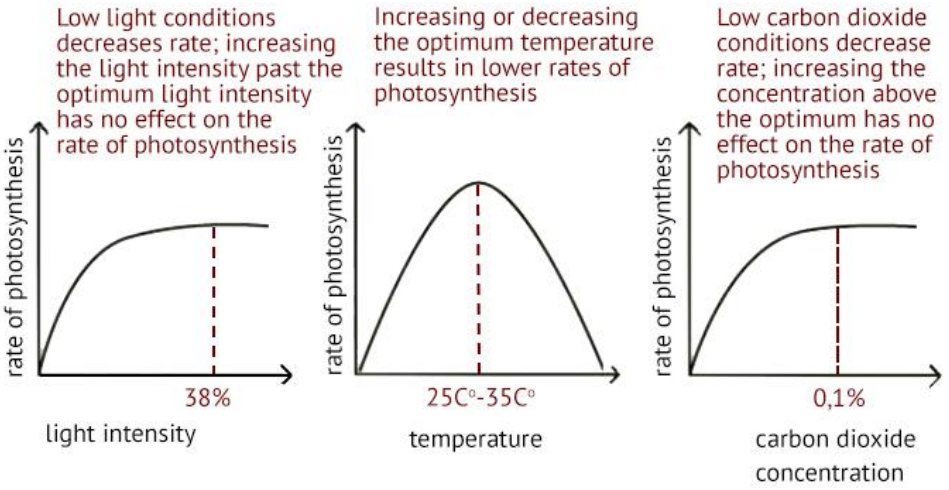
The rate of photosynthesis

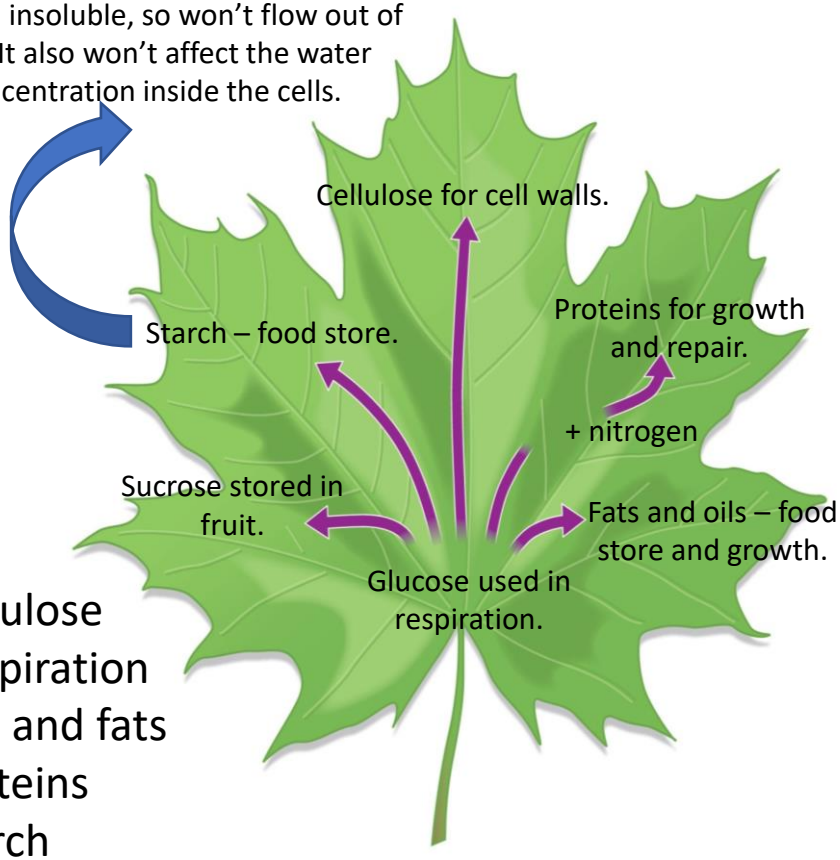
The factors which affect the rate of photosynthesis include:
- Light intensity – as this provides the energy required for this photosynthesis to begin.
- Temperature – due to its effect on the enzymes involved in photosynthesis.
- Carbon dioxide concentration –as this is a reactant for photosynthesis.
- The amount of chlorophyll – as this chemical absorbs light energy to begin the conversion of CO_2 and H_2O into glucose



Sometimes one of more of these things can be in short supply and limit the rate that photosynthesis can take place. This is why they are known as limiting factors.

How plants use glucose

Starch is insoluble, so won't flow out of cells. It also won't affect the water concentration inside the cells.



C ellulose
R espiration
O ils and fats
P roteins
S tarch

Testing for carbohydrates

- To identify starch – iodine is added to a test sample if iodine changes from orange/brown to blue/black starch is present.
- To identify glucose using simple qualitative reagents. Carry out a Benedict's test (Benedict's will change from blue to brick red)

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Making the most of photosynthesis (HT)

Understanding Limiting factors helps maximise the production of plants.

- Improving the growing conditions in greenhouses, polytunnels and hydroponic growing systems enables crops to maximise their rate of photosynthesis
- This increases their yield (the amount of crop grown).
- If growers think carefully they can maximise crop growth while still maintaining profit.
- Investing in artificial light and heating costs money however it will increase yield and therefore their overall profit).

Greenhouse

Polytunnel

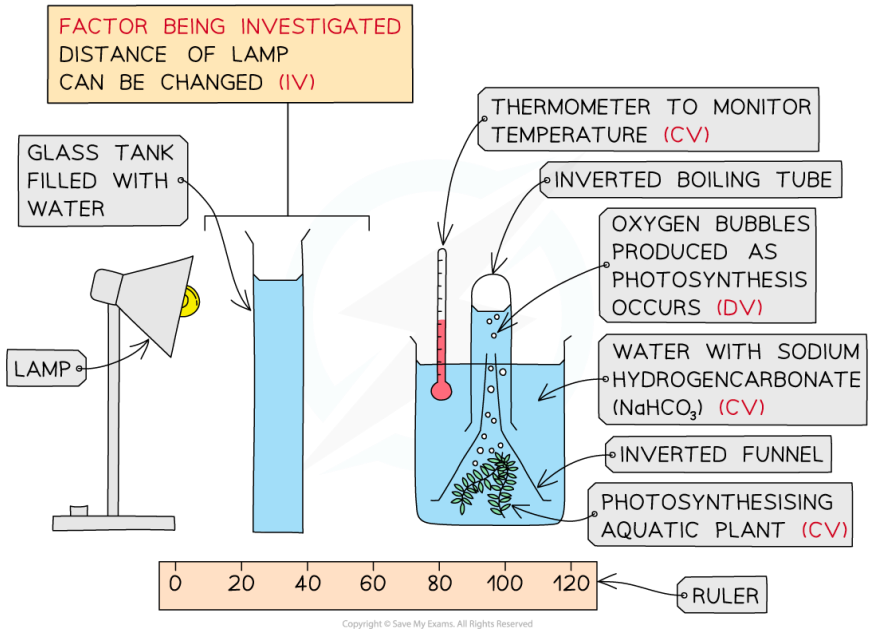
Hydroponics

Required practical

Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.

Hypothesis: Changing the light intensity (distance between the pond weed and the light) will affect the rate of photosynthesis because light is needed for photosynthesis to happen.

Conclusion: as light intensity increases the rate of photosynthesis increases up to a point where another factor may become limiting.



(HT) The relationship between light intensity and the rate of photosynthesis follows the inverse square law:

$$\text{Light intensity} = \frac{1}{\text{Distance}^2}$$

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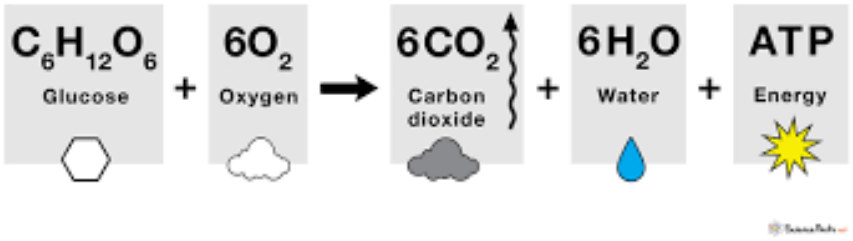
Aerobic respiration

Respiration is an exothermic reaction (transfers energy to the environment) continuously occurring in cells in the mitochondria.

Organisms need energy for:
- Chemical reactions to build larger molecules (in plants and animals).
- Movement (animals - all muscular contractions require energy).
- Keeping warm
- Active transport (e.g., moving mineral ions up a concentration gradient from the soil into root hair cells)

Aerobic Respiration Equation

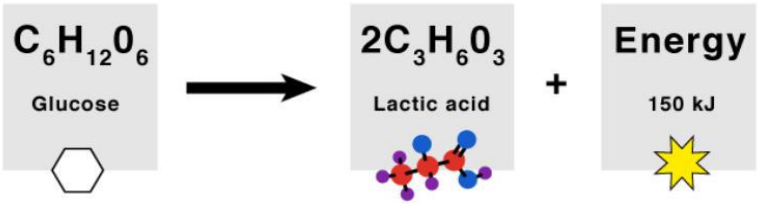


Anaerobic respiration

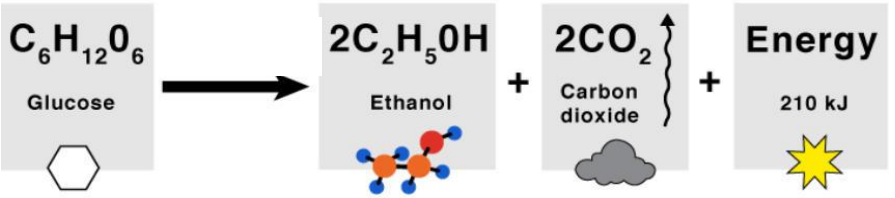
Anaerobic respiration occurs without oxygen. The oxidation of glucose is incomplete (glucose is not broken down completely) so less energy is transferred.

Anaerobic Respiration Equation

Lactic acid fermentation (animals)



Alcoholic fermentation (plants and yeast)



Anaerobic respiration in yeast cells is called fermentation and has economic importance in the manufacture of bread and alcoholic drinks.

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Response to exercise

- Muscle fibres require a lot of energy to contract and cause movement. They contain many mitochondria which carry out aerobic respiration and release the energy needed.
- Muscle fibres also store glycogen which can be rapidly back into glucose for use in respiration in high demand periods.
- The heart rate, breathing rate and breath volume increase during exercise to supply the muscles with more oxygenated blood.
- If insufficient oxygen is supplied anaerobic respiration takes place in muscles. The incomplete oxidation of glucose causes a build up of lactic acid and creates an oxygen debt. During long periods of vigorous activity muscles become fatigued and stop contracting efficiently

Metabolism and the liver

Metabolism is the sum of all the reactions that take place in a cell or the body:

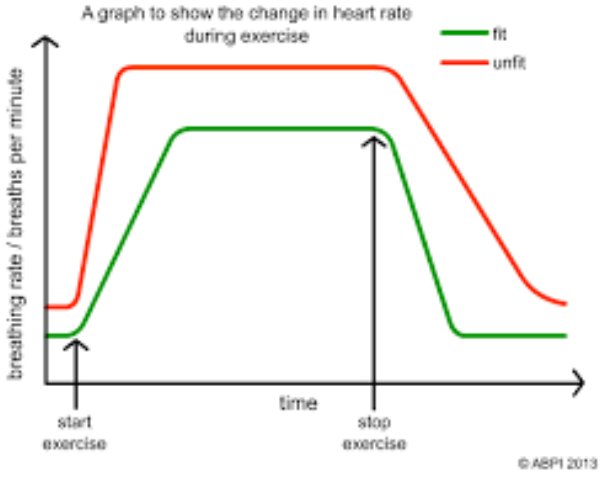
- Conversion of glucose to starch, glycogen and cellulose T
- The formation of lipid molecules from a molecule of glycerol and three molecules of fatty acids
- The use of glucose and nitrate ions to form amino acids which in turn are used to synthesise proteins
- Respiration
- Breakdown of excess proteins to form urea for excretion.

(HT)The liver is a very active organ carrying out many metabolic functions, including the removal of lactic acid.
Blood flowing through the muscles carries the lactic acid to the liver where it is converted back into glucose.
The oxygen debt is repaid once this glucose has been broken down in aerobic respiration to form carbon dioxide & water.
If the glucose is not required, it is converted into glycogen & stored in the liver

Oxygen debt (HT)

- Lactic acid that has built up as a result of anaerobic respiration must be broken down using oxygen, into carbon dioxide & water.
- The amount of oxygen required to break down the lactic acid is called the oxygen debt. Your breathing & heart rates remain high after exercise to provide the extra oxygen required to remove the lactic acid.
- If you are fitter, your breathing rate will return to normal quicker.

LACTIC ACID + OXYGEN → CARBON DIOXIDE + WATER



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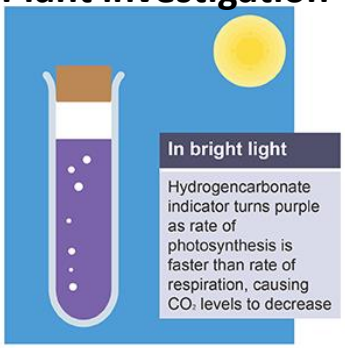
Photosynthesis and respiration investigation

Hydrogencarbonate indicator can detect increases and decreases in carbon dioxide concentration. It is red when carbon dioxide levels are at normal air levels. However, an increase in carbon dioxide changes the indicator to yellow and a decrease in carbon dioxide changes it to purple.

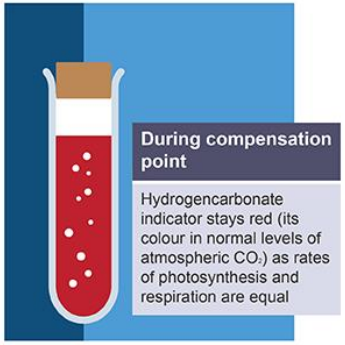
Plant investigation



***Remember * - photosynthesis only happens in the light. Respiration happens all the time.**

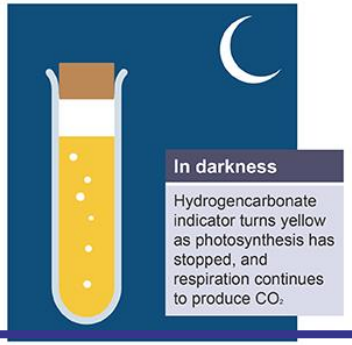
In bright light

Both photosynthesis and respiration are occurring but the rate of photosynthesis is higher than the rate of respiration, therefore the net gas exchange happening is carbon dioxide into and oxygen out of the leaf. The removal of carbon dioxide from the hydrogencarbonate indicator into the leaf would change the indicator from red to purple.



At dusk/dawn

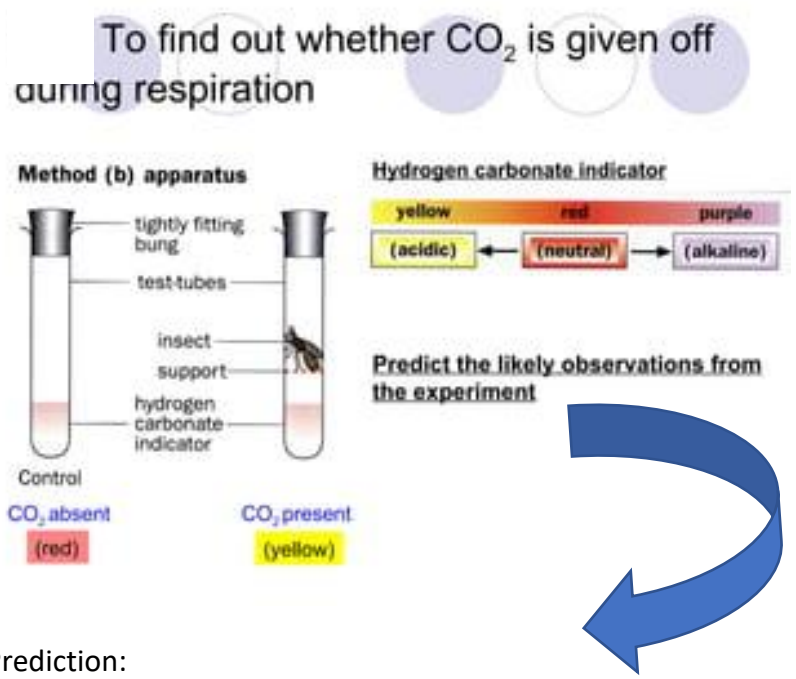
When light intensity is low the rates of photosynthesis and respiration are equal. This is known as the compensation point and there is no net gas exchange. No net gas exchange would cause the hydrogencarbonate to remain red because no change in carbon dioxide concentration will be detected.



In the dark

Only respiration is occurring as there is no light for photosynthesis, therefore the only gas exchange happening is oxygen into and carbon dioxide out of the leaf. The release of carbon dioxide from the leaf into the hydrogencarbonate indicator changes the indicator from red to yellow.

Animal investigation



Prediction:

- The insect in the tube will respire.
- This means it will give off carbon dioxide.
- The hydrogen carbonate indicator will turn from red to yellow in the presence of the carbon dioxide.

***Remember* - the purpose of the control is for comparison.**