Bioenergetics: Respiration

Keyword	Definition
Aerobic	The presence of oxygen.
Anaerobic	The absence of oxygen.
Ethanol (alcohol)	A product of anaerobic respiration in plant or yeast cells.
Exothermic	A reaction that transfers energy to the surroundings.
Fermentation	Anaerobic respiration in plant and yeast cells, producing carbon dioxide.
Glucose	A simple sugar, glucose is the most common fuel in respiration.
Lactic acid	The product of anaerobic respiration in animal cells.
Metabolism	The sum of all the chemical reactions in a cell or the body.
Mitochondria	An organelle found in eukaryotic cells. Aerobic respiration occurs here to release energy.
Oxygen	A reactant of aerobic respiration, oxygen is required for the oxidation of glucose in aerobic respiration.

BI 07 Response to exercise

E

More energy required by muscle cells

More respiration occurs to provide energy

More oxygen and glucose required | More carbon dioxide produced

Heart rate increases to provide more oxygen and glucose to muscle cells, and remove more carbon dioxide from the muscle cells

Breathing rate increases to bring more oxygen into the body, and remove more carbon dioxide from the body

- If insufficient oxygen can be delivered to the respiring cells, the cells will begin to respire **anaerobically**.

BI 06 Aerobic Respiration

D

- Aerobic respiration is respiration in the **presence of oxygen**.
- Takes place in the **mitochondria** of eukaryotic cells, or in the cytoplasm of prokaryotic cells, to release energy.
- Aerobic respiration is represented by the following equation:

Glucose + Oxygen → Carbon Dioxide + Water

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

Key Point

- Respiration is an **exothermic** reaction. It transfers energy from the chemical store of glucose into other stores for use in processes such as:
  - Active transport.
  - Muscle contraction.
  - Growth.
  - Protein synthesis.
  - Cell division.
  - Nerve impulses.
- Respiration also transfers energy to the thermal stores of animals (hence they feel warm).

BI 08 Anaerobic Respiration

D

- Anaerobic respiration is respiration in the **absence of oxygen**.
- Takes place in the cytoplasm of cells.
- Whilst still releasing energy for cellular processes, it is much **less efficient** than aerobic respiration since the glucose is not fully oxidised.
- Therefore, less energy is released from each glucose molecule.

Anaerobic Respiration in Animal Cells

Glucose → Lactic Acid

$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$

Anaerobic Respiration in Plant and Bacteria Cells

Glucose → Ethanol + Carbon Dioxide

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Uses of Anaerobic Respiration in Industry

- Anaerobic respiration in yeast is also known as fermentation. It is used in the brewing of alcoholic drinks such as wine or beer.
- The carbon dioxide that is produced in anaerobic respiration in yeast can be used to make bread rise.

BI 08 HT: Removing Lactic Acid

D

- Lactic acid is transferred through the body by the blood to the **liver**.
- In the liver, lactic acid is **converted back to glucose** and stored as glycogen or used in respiration.
- Alternatively, lactic acid can be oxidised to carbon dioxide and water:

Lactic Acid + Oxygen → Carbon Dioxide + Water

- The oxygen required to remove the lactic acid is known as the **oxygen debt**.

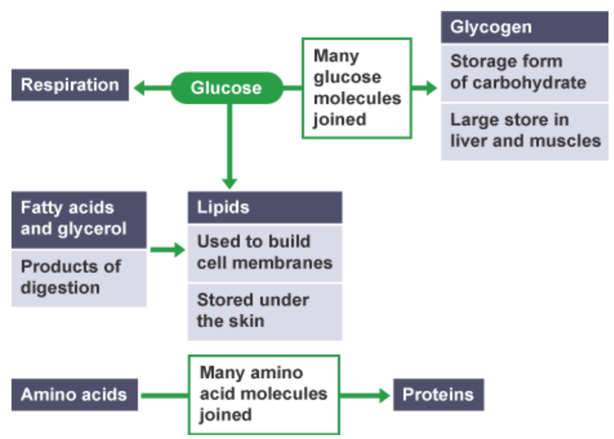
BI 09 Metabolism

- **Metabolism is the sum of all of the chemical reactions in a cell or body**.
- Chemical reactions can build up large molecules, or break them down into small ones.
- The chemical reactions are all controlled by enzymes.

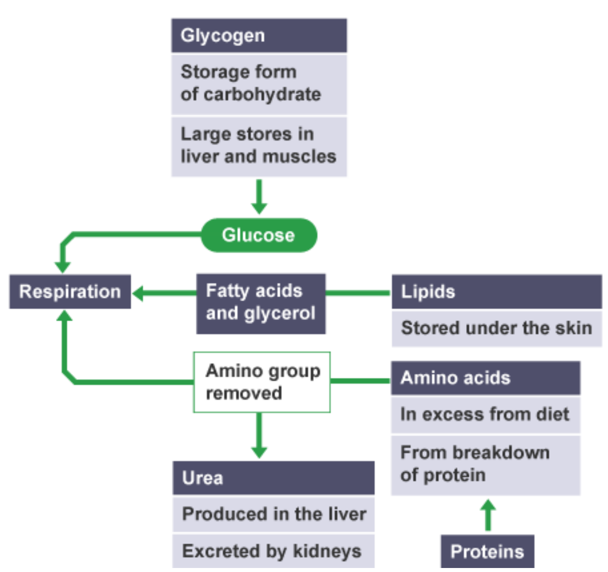
Note: Photosynthesis is NOT a metabolic reaction.

- All of the chemical reactions are summarised in the flow diagrams below.

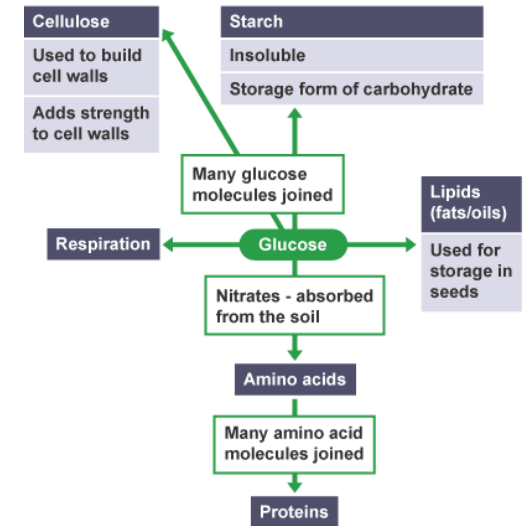
Reactions that build up products of digestion



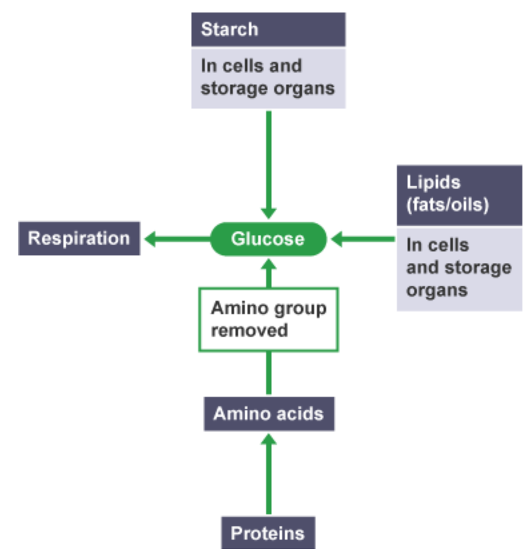
Reactions that break down compounds



Reactions that build up molecules in plants after photosynthesis has produced glucose



Reactions that break down molecules



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Relevant Modules:

AQA

- Cell Biology
- Organisation
- Homeostasis
- Ecology

Useful YouTube links:

Respiration | Exercise | Metabolism

Bioenergetics : Photosynthesis

TPS

Keyword	Definition
Carbon dioxide	Reactant in photosynthesis.
Chlorophyll	Green pigment in chloroplasts where photosynthesis takes place.
Chloroplast	Organelle which is packed full of chlorophyll. They are found in high numbers in the palisade and spongy mesophyll cells.
Endothermic	A reaction that transfers energy into the reactants from the surroundings. Energy from the Sun is transferred by light into the chemical store (glucose) of the plant.
Glucose	A product of photosynthesis. The main energy source in respiration. The starting molecule for many other materials that plants need to live such as starch, cellulose, amino acids and lipids.
Oxygen	A product in photosynthesis.
Water	Reactant in photosynthesis.
Limiting factor	Limits the rate of photosynthesis e.g. temperature, light intensity and carbon dioxide concentration.

BI 01 Photosynthesis

A

- Photosynthesis is a chemical reaction by which plants make their own food.
- It is represented by the following equation:

$$\text{Carbon dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Light}} \text{Glucose} + \text{Oxygen}$$

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

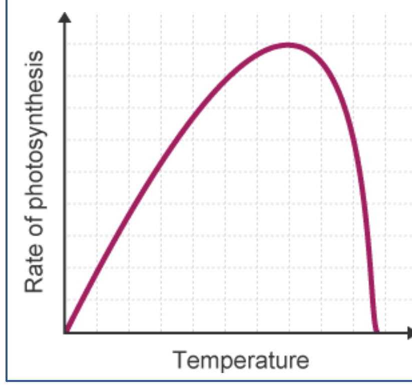
Key Point

- Photosynthesis occurs in the **chloroplasts** of plant or algal cells.
- Chloroplasts are packed with a green pigment called **chlorophyll**.
- Since photosynthesis transfers light energy into the reactants, it is an **endothermic** reaction.

BI 03 Temperature

B

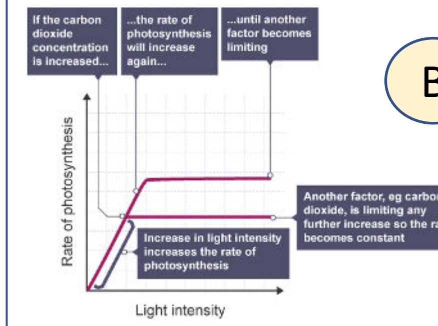
- Photosynthesis is controlled by **enzymes**.
- At low temperatures, the rate of photosynthesis is limited because of the low numbers of collisions between enzyme active sites and the substrates (carbon dioxide and water).
- At high temperatures, the enzymes **denature** causing the rate of photosynthesis to decrease rapidly.



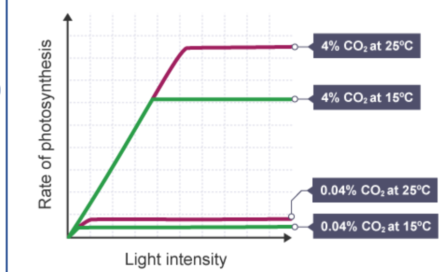
BI 03 HT: Interacting limiting factors

B

You will likely face a question that combines several factors on the same graph. For instance, This graph shows the effect of increasing light intensity at two different carbon dioxide concentrations.



Or, three factors could be represented.



BI 03 Factors affecting the rate of photosynthesis

B

The factors that affect the rate of photosynthesis in a plant are:

- Light **intensity**.
- Temperature.
- Carbon dioxide **concentration**.
- Amount of chlorophyll.

Note: Water is NOT considered a limiting factor of photosynthesis.

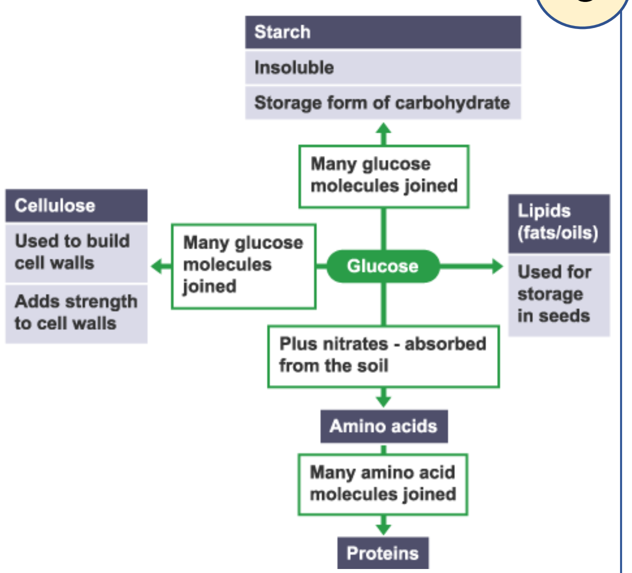
BI 03 Amount of chlorophyll

B

- Plants with more chlorophyll are able to absorb more light, so photosynthese more.
- *Exam hint: you will rarely see 'amount of chlorophyll' as the dependent variable in a question, since it is difficult to change or measure. However, t may become the limiting factor when the graph levels off.*

BI 04 Uses of glucose in plants

C

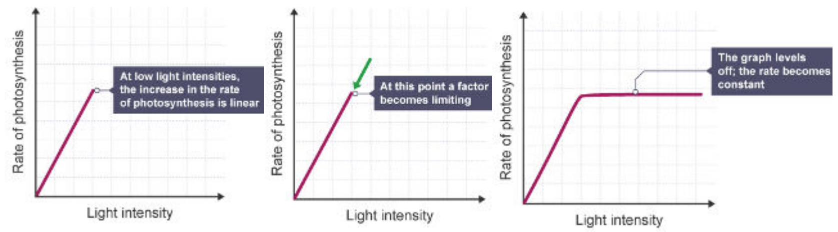


And, of course, **respiration**!

BI 03 Light intensity

B

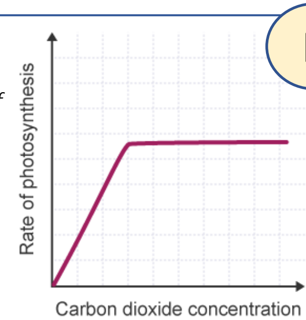
- At low light intensities, the plant will not have sufficient light energy to photosynthesise quickly.
- Therefore, increasing the light intensity increases the rate of photosynthesis, until one of the other three factors becomes limiting.



BI 03 Carbon dioxide concentration

B

At low carbon dioxide concentrations, increasing it will increase the rate of photosynthesis, until *one of the other three factors* becomes limiting. At this point the rate of photosynthesis remains constant.



BI 05 HT: Economical greenhouses

B

- Conditions inside greenhouses can be maintained to maximise crops yield.
- Farmers need to balance the costs against increased profitability.

Light

Greenhouses are made of translucent materials to absorb maximum sunlight.

Artificial light systems:

- increase light intensity.
- Provide optimum wavelengths, or colours, of light.
- Lengthen growing season.

But,

- Cost money in electrical bills.

Carbon dioxide concentration

Paraffin heaters provide warmth and carbon dioxide at the same time but can only be used on a small scale.

Carbon dioxide concentration can also be increased by:

- Piping in waste gases from industry.
- Using liquid carbon dioxide. This is expensive.

Temperature

Paraffin heaters provide warmth and carbon dioxide at the same time, but can only be used on a small scale.

Heaters in a large scale increase the energy bills of the farmer.

Useful YouTube links:

Photosynthesis | Uses of glucose | Limiting Factors

Relevant Modules:

AQA

- Cell Biology
- Organisation
- Ecology

Required Practical:

Investigating the effect of light intensity on the rate of photosynthesis.

Mathematical skills (required practical):

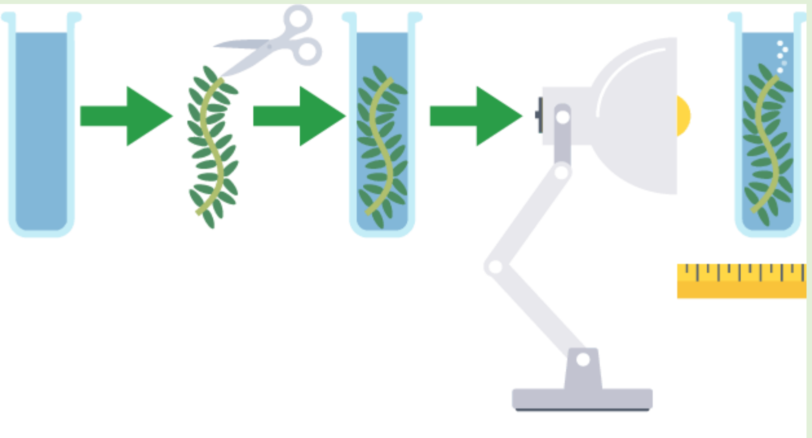
- *Measure and calculate the rate of photosynthesis.*
- *Extract and interpret graphs of photosynthesis rate involving one limiting factor.*
- *Plot and draw graphs of photosynthesis rate.*
- *Translate information between graphical and numeric form.*
- *To understand and use inverse proportion – the inverse square law and light intensity in the context of photosynthesis.*

BI 02 Required Practical – Rate of Photosynthesis

B

Method

- Set up a boiling tube containing 20 cm^3 of **sodium hydrogen carbonate solution** (1%). Allow the tube to stand for a few minutes and shake to disperse any air bubbles that might form.
- Cut a piece of **pondweed**, *Cabomba*, about 8 cm long.
- Use forceps to place the pondweed in the boiling tube carefully. Ensure the pondweed is fully submerged in the sodium hydrogen carbonate solution.
- Position the boiling tube so that the pondweed is 10 cm away from the light source. Allow the boiling tube to stand for five minutes.
- Count the **number of bubbles** emerging from the cut end of the stems **in one minute**. Repeat the count five times and record your results in a table.
- **Calculate the average** number of bubbles produced **per minute**.
- **Repeat** the experiment at **increasing distances** away from the light source.



Variables

- **Independent Variable:** the distance between the light source and the pondweed, measured using a **ruler**.
- **Dependent Variable:** the rate of oxygen produced per minute, measured by counting the number of bubbled produced by the plant in one minute (measured with a stop clock).
- **Control Variables:**
  - Concentration of sodium hydrogen carbonate solution (this provides the carbon dioxide to the pondweed, so effectively maintains the carbon dioxide concentration).
  - Temperature: this can be maintained by keeping a heat screen between the light source and the pondweed. A low energy or LED light bulb can also reduce the amount of heat that the bulb emits.
  - Amount of pondweed: use the same piece each time.

Risks

Care must be taken when handling the electrical lamp. Ensure that hands are dry.

Useful YouTube links:

Required practical

Measuring the rate of photosynthesis

- The rate of a chemical reaction can be measured in two ways:
  1. Measuring how quickly the reactants are used up.
  2. Measuring how quickly the products are formed.

Measuring the rate at which water or carbon dioxide are used by a plant is difficult. However, there are a number of ways to measure the amount of oxygen or glucose that a plant uses:

Counting bubbles of oxygen produced by pondweed.

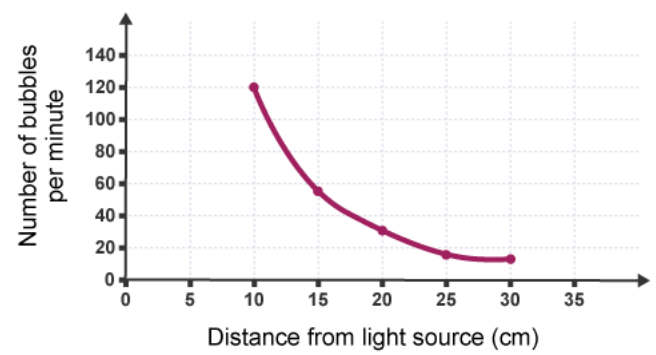
Counting the number of fruit, flowers or leaves that a plant produces, since these are built using glucose.

Exam hint: *when presented with a graph or table of data, they may not explicitly indicate the rate of photosynthesis. However, it may be implied by something else, such as the number of tomatoes produced in a week.*

Results

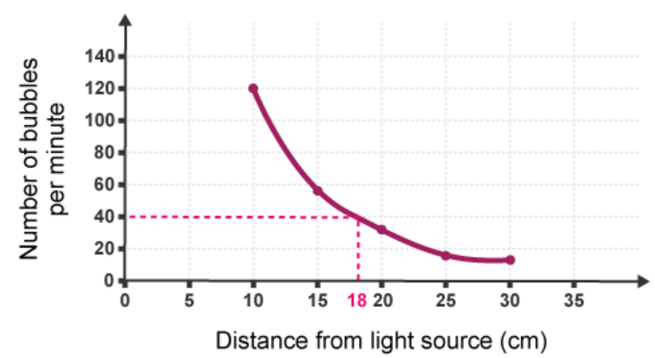
Distance	Rate
10 cm	120
15 cm	54
20 cm	30
25 cm	17
30 cm	13

- Note: Rate = number of bubbles produced per minute.
- The results can be plotted on a graph.



*Remember: the **dependent variable** always goes on the **x axis**.*

- When you are asked to determine the rate of photosynthesis at an unknown light intensity, use a ruler on your graph like so:

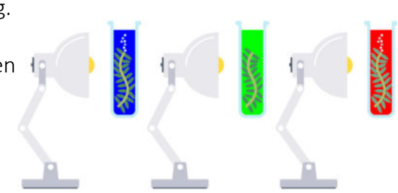


- When the pondweed is 18 cm away from the light source, rate of photosynthesis is 40 bubbles per minute.

Alternatives to Light Intensity

You may be asked to change a different factor. e.g. Colour, or wavelength of light:

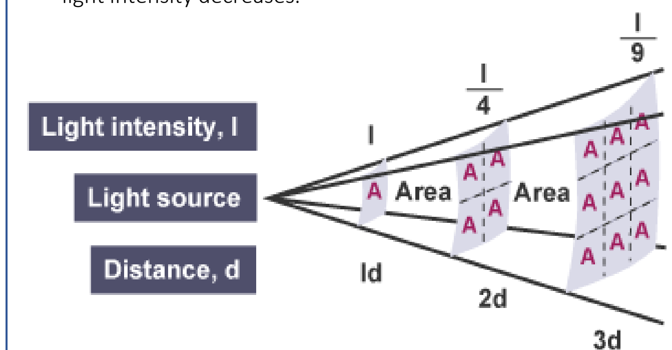
- Different coloured films can be placed between the bulb and the pondweed.
- The number of bubbles of oxygen in one minute is measured.
- The distance of the lamp from the pondweed will now need to be kept the same.



Read the question carefully, do not assume that it is asking you directly about the practical you have done in lesson.

HT: Inverse Square Law (Mathematical skills)

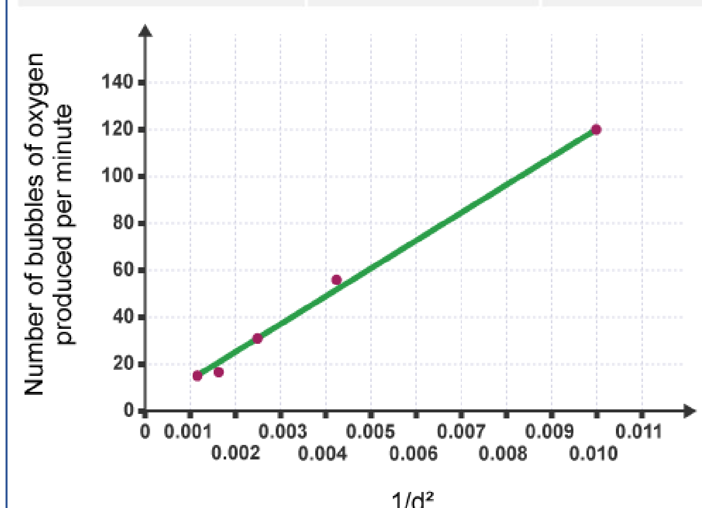
- As the distance between a light source and plant increases, the light intensity decreases.



- The light intensity is **inversely proportional** to the square of the distance, hence the **inverse square law**.
- Light intensity is inversely proportional to distance squared, or d^2.
- Therefore:

  Light intensity = $\frac{1}{d^2}$

Distance	$\frac{1}{d^2}$	Rate
10 cm	0.0100	120
15 cm	0.0044	54
20 cm	0.0025	30
25 cm	0.0016	17
30 cm	0.0011	13



- The graph gives a straight line, therefore the relationship is **inversely linear**.