Cambridge (CIE) IGCSE Biology

Your notes

Respiration

Contents

Your notes

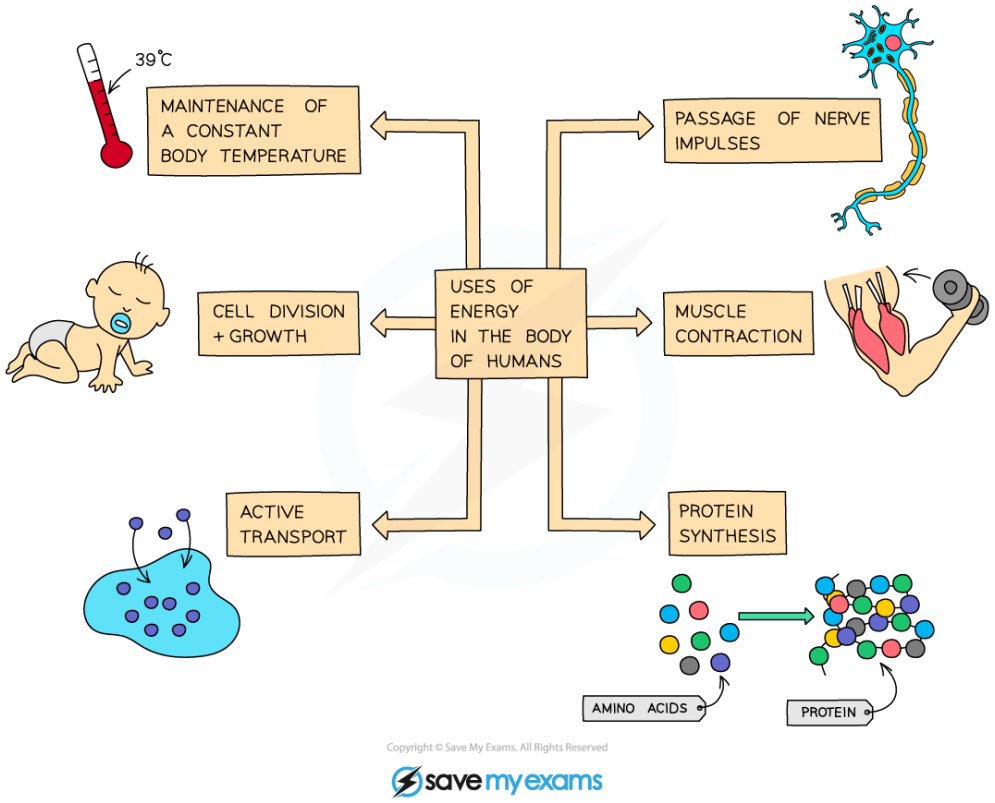
Uses of energy in living organisms

What is respiration?

- Respiration is a chemical process that involves the breakdown of nutrient molecules (specifically glucose) in order to **release the energy** stored within the bonds of these molecules
  - Respiration is **enzyme-controlled**
- Respiration can take place with oxygen (**aerobically**) or without oxygen (**anaerobically**).
  - Much less energy is released for each glucose molecule broken down anaerobically compared to the energy released when it is broken down aerobically
- Respiration occurs **in all living cells**; most of the chemical reactions in aerobic respiration take place in the mitochondria

Uses of energy released in respiration

- Humans need the energy released during respiration to carry out many processes
  - Muscle contraction
  - Protein synthesis
  - Cell division (to make new cells)
  - Growth
  - Active transport across cell membranes
  - Generation of nerve impulses
  - Maintaining a constant internal body temperature



The energy released during respiration is used to fuel many processes in the human body

Examiner Tips and Tricks

Avoid the common misconception that respiration is breathing! Respiration is a series of **chemical reactions that release energy** from glucose inside cells. Be careful that you always state that energy is **released**, it is NEVER made, produce, or created.

The respiration reactions are all controlled by enzymes. You need to be able to state this in an exam!

The effect of temperature on respiration

Respiration in yeast

- An indicator can be used to investigate the effect of **temperature** on the **rate of aerobic respiration** in yeast
- **Methylene blue** dye is a suitable indicator
- This dye can be added to a suspension of living **yeast cells** because it doesn't damage cells

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- Yeast can respire both aerobically and anaerobically, though in this experiment it is their rate of **aerobic respiration** that is being investigated
- The time taken for the methylene blue to discolour (lose its colour) is a measure of the rate of respiration of the yeast cells in the suspension
    - The faster the dye changes from blue to colourless, the faster the rate of respiration

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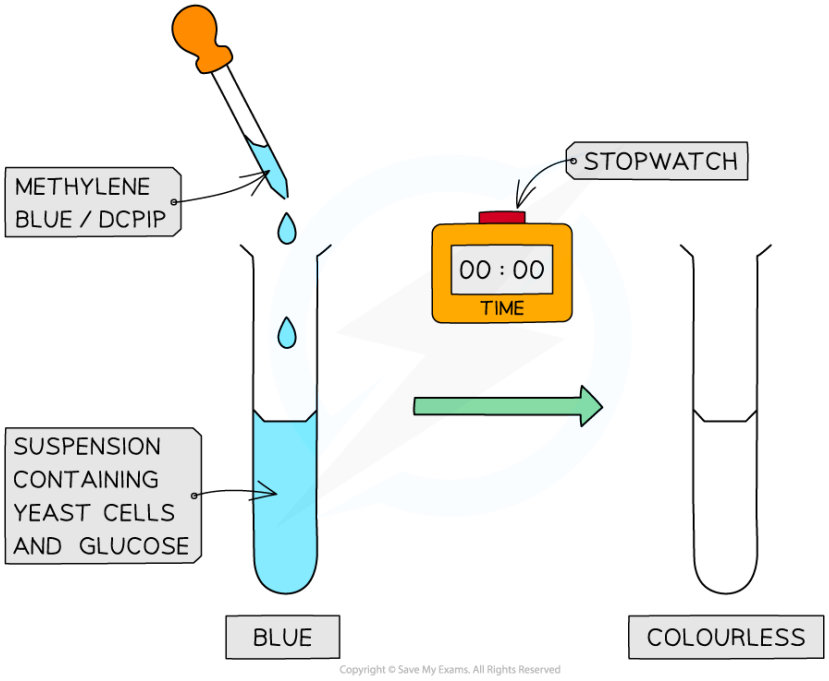
Apparatus

- Yeast suspension
- Glucose solution
- Test tubes
- Stopwatch
- Methylene blue
- Temperature-controlled water bath(s)



Methylene blue is added to a solution of aerobically respiring yeast cells in a glucose suspension. The rate at which the solution turns from blue to colourless gives a measure of the rate of aerobic respiration.

Independent and dependent variables

- The **independent variable** is the variable that is **changed on purpose**
    - Here the investigation studies the **effect of temperature** on respiration rate in yeast, so the independent variable is **temperature**
    - Different temperatures are achieved using **water baths**

- The **dependent variable** is the variable that is **measured**, i.e. the variable that *depends* on the independent variable for its outcome
    - In an investigation into the effect of temperature on the **rate of respiration in yeast,** the **rate of respiration** is the dependent variable
    - The rate is measured here by recording the **time taken** for methylene blue dye to change from **blue to colourless**

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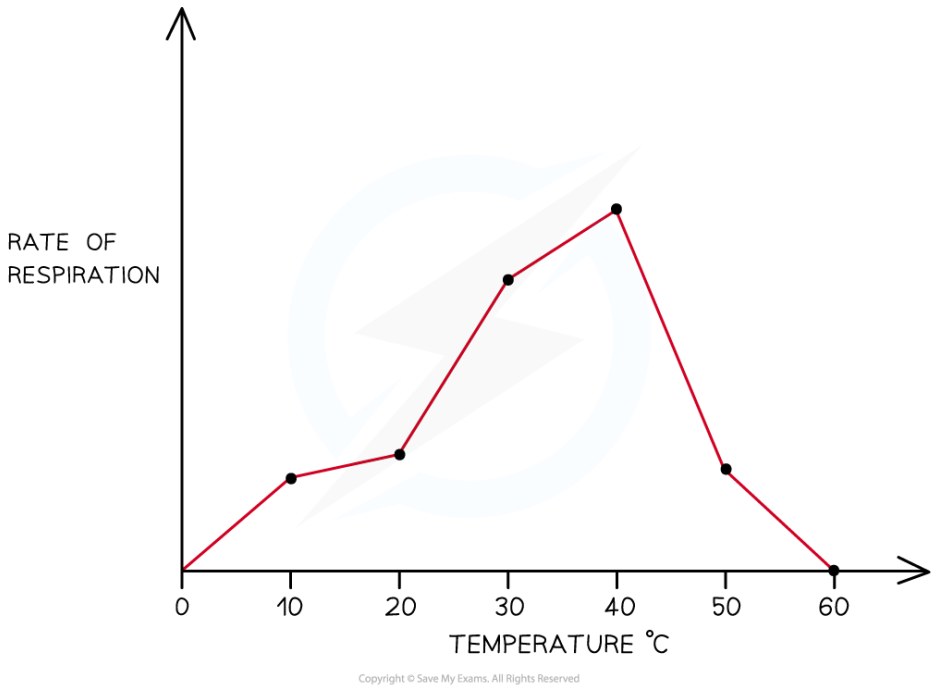
Controlling other variables

- It is important when investigating the effect of one variable on another to ensure that any other variables that might influence the dependent variable are being controlled, e.g.
    - **Volume/concentration of dye added**: if there are more dye molecules present then the time taken for the colour change to occur may be longer
    - **Volume/concentration of yeast suspension**: if more yeast cells are present then more respiration will be occurring and the dye will change colour more quickly
    - **Concentration of glucose**: if there is limited glucose in one tube then the respiration of those yeast cells will be limited
    - **pH**: pH can influence enzyme activity, and enzymes are involved in the reactions of respiration, so pH can therefore influence the rate of respiration
        - A buffer solution can be used to control the pH level to ensure that no enzymes are denatured

Results

- A graph should be plotted that shows 'temperature' (x-axis) against 'time for colour change' (y-axis)
    - It is also possible to convert 'time for colour change' into a unit of reaction rate; this has been done in the graph shown below
- As the **temperature increases up to 40 °C**, the **rate of respiration increases** so the time taken for the solution to become colourless reduces
    - Raising the temperature of a solution gives the molecules in the solution more kinetic energy, so they move around more and the enzymes and substrates involved in respiration collide with each other more frequently
- As **temperature increases above 40 °C**, the **rate of respiration decreases** so the time taken for the solution to become colourless increases
    - Increasing the temperature above a certain point causes the enzymes involved in respiration to denature; the shape of their active site changes and they can no longer form enzyme-substrate complexes

Temperature and the rate of respiration in yeast graph



The time taken for methylene blue to change colour can be converted into 'rate of respiration' and plotted on a graph. Note that a graph of temperature against 'time for colour change' will look different to the graph shown here.

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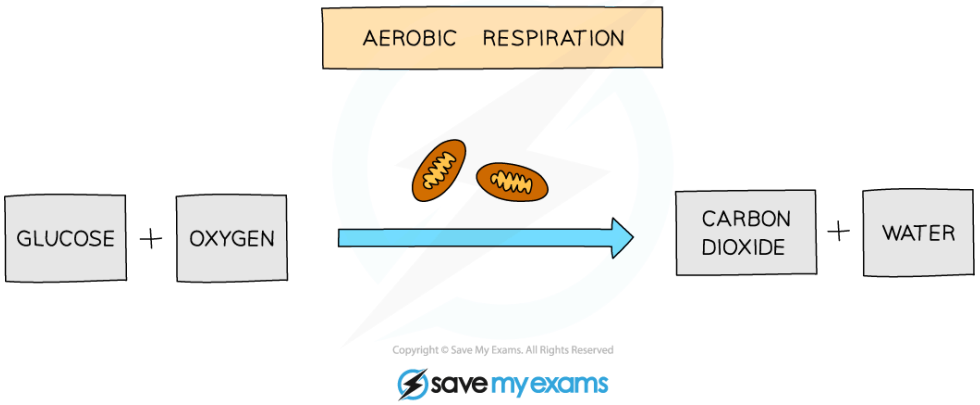
Respiration is a Chemical Reaction

- **Aerobic** respiration requires **oxygen** and is defined as **the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy**
- It is the **complete breakdown of glucose** to release a **relatively large amount of energy** for use in cell processes
- It **produces carbon dioxide and water** as well as releasing useful cellular energy

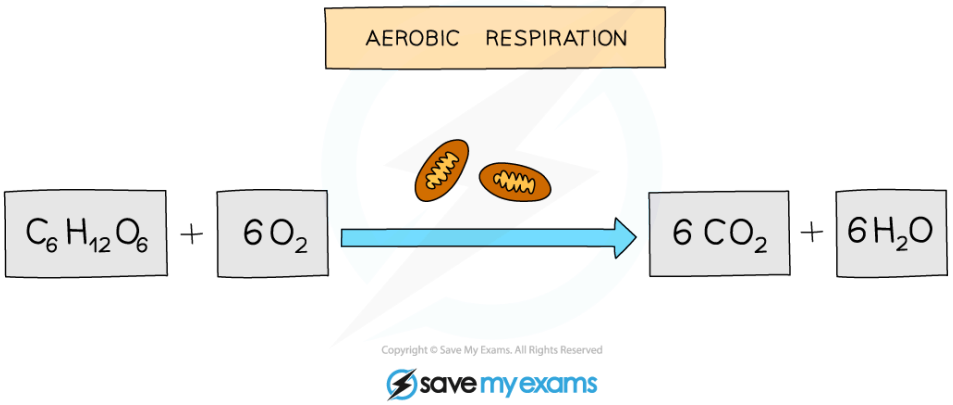


Word equation for aerobic respiration

Examiner Tips and Tricks

Remember this equation is the same as the photosynthesis equation, only the other way around, so if you know one, you know the other one too!

Balanced Chemical Equation for Aerobic Respiration: Extended



Balanced equation for aerobic respiration

Examiner Tips and Tricks

There are usually **3 marks given for the aerobic respiration chemical equation** in an exam:

- one for getting the correct **formula for glucose and oxygen**
- one for getting the correct **formula for carbon dioxide and water**
- one for **balancing the equation** correctly

So make sure you can do all three to gain maximum marks!

Your notes

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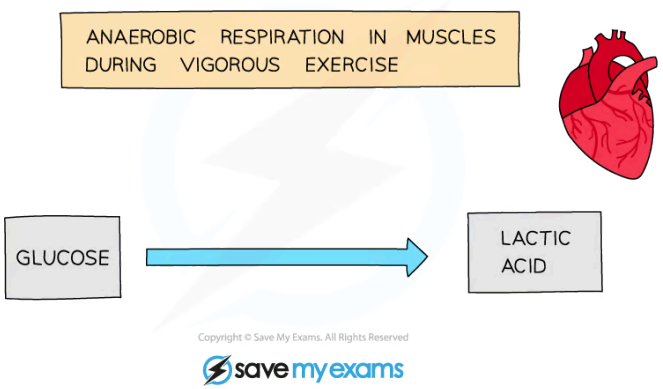
Anaerobic Respiration – Respiration Without Oxygen

- **Anaerobic** respiration does **not require oxygen** and is defined as **the chemical reactions in cells that break down nutrient molecules to release energy without using oxygen**
- It is the **incomplete breakdown of glucose** and releases a **relatively small amount** of energy (compared to aerobic respiration) for use in cell processes
- It produces different breakdown products depending on the type of organism it is taking place in
- You need to know the equations for anaerobic respiration in **humans** (animals) and the microorganism **yeast**

Anaerobic Respiration in Animals

- Anaerobic respiration mainly takes place in muscle cells during vigorous exercise
- When we exercise vigorously, our muscles have a **higher demand for energy** than when we are resting or exercising normally. Our bodies can only deliver so much oxygen to our muscle cells for aerobic respiration
- In this instance, as much glucose as possible is broken down with **oxygen**, and some glucose is broken down without it, producing **lactic acid** instead
- There is still energy stored within the bonds of lactic acid molecules that the cell could use; for this reason, **less energy is released** when glucose is broken down anaerobically

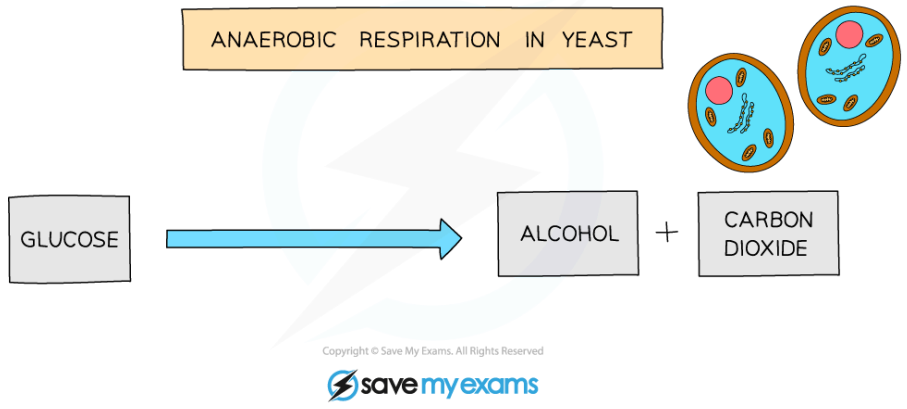


Word equation for anaerobic respiration in animals

Anaerobic Respiration in Yeast

- We take advantage of the products of anaerobic respiration in **yeast** by using it in **bread making**, where

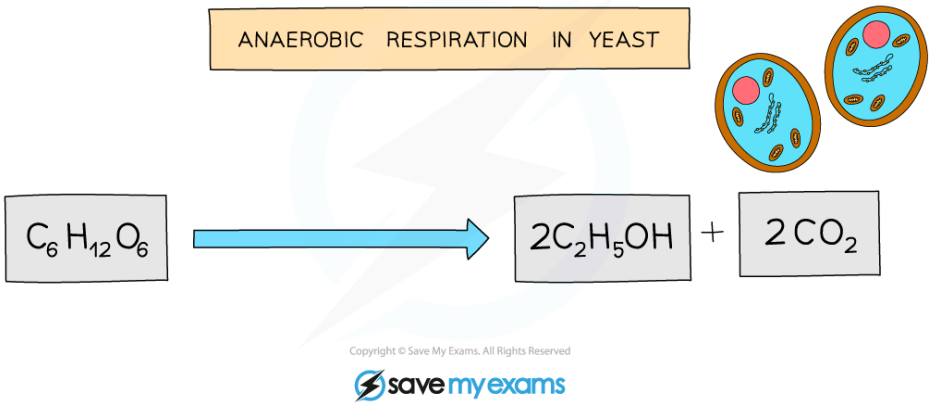
- The carbon dioxide produced causes dough to rise
- And in **brewing**, where
  - The ethanol produced gives the beer its alcoholic nature
  - The carbon dioxide produced gives beer its fizz



Word equation for anaerobic respiration in yeast

Balanced Chemical Equation for Anaerobic Respiration: Extended

- The balanced chemical equation for anaerobic respiration in yeast is:



Balanced equation for anaerobic respiration in yeast

Anaerobic Respiration & Oxygen Debt: Extended

- **Lactic acid** builds up in muscle cells and **lowers the pH** of the cells (making them more acidic)

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- This could **denature the enzymes in cells** so it needs to be removed
- Cells excrete lactic acid into the blood. When blood passes through the **liver**, lactic acid is taken up into liver cells where it is **oxidised,** producing carbon dioxide and water (Lactic acid reacts with oxygen - this is actually **aerobic respiration** with lactic acid as the nutrient molecule instead of glucose)
- So the waste products of lactic acid oxidation are carbon dioxide and water
- This is the reason we **continue to breath heavily** and our **heart rate remains high** even after finishing exercise - we need to transport the lactic acid from our muscles to the liver, and continue getting larger amounts of oxygen into the blood to oxidise the lactic acid
- This is known as **'repaying the oxygen debt'**

Examiner Tips and Tricks

It's easy to get confused about the products of anaerobic respiration in animals: The ONLY product made is **lactic acid**. Carbon dioxide is NOT one of the products made in anaerobic respiration in animals: It is made in **aerobic** respiration!

Comparing Aerobic & Anaerobic Respiration

Comparing types of respiration:

	AEROBIC	ANAEROBIC
OXYGEN	NEEDED	NOT NEEDED
GLUCOSE BREAKDOWN	COMPLETE	INCOMPLETE
PRODUCTS	CARBON DIOXIDE AND WATER	ANIMAL CELLS: LACTIC ACID YEAST: CARBON DIOXIDE AND ETHANOL
ENERGY RELEASED	A LOT	A LITTLE

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