

Respiration

Revision notes · Uses of energy, aerobic and anaerobic respiration, their equations, the yeast investigation, and removing the oxygen debt.

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). **Supplement** is Extended content, only examined on Papers 2 and 4.

Respiration Spec 12.1, 12.2, 12.3

Respiration and the uses of energy Spec 12.1.1, 12.1.2

Respiration is how cells release **energy** from nutrient molecules such as glucose. Every living cell respire all the time, because every living cell needs energy to stay alive.

Uses of energy in living organisms

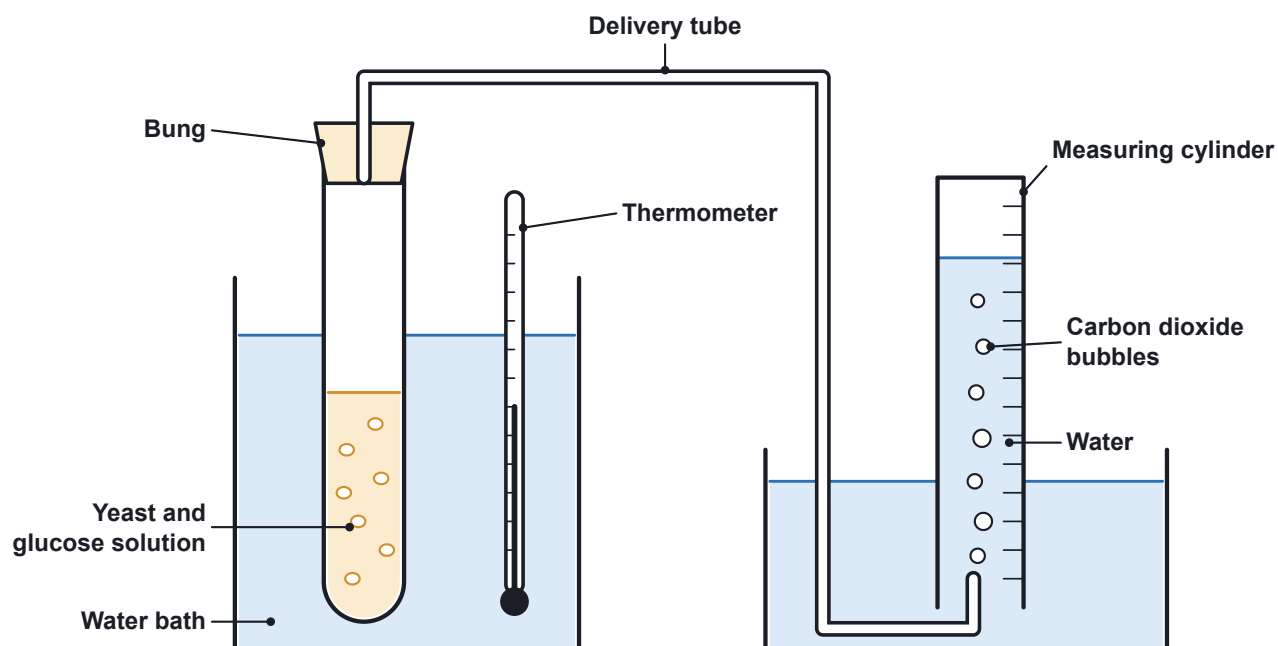
- muscle contraction
- protein synthesis
- cell division
- active transport
- growth
- the passage of nerve impulses
- the maintenance of a constant body temperature

*Exam tip: Do not write "to make energy". Energy cannot be made. Say that respiration **releases energy**, or that the energy is used for one of the processes in the list.*

Investigating the effect of temperature on respiration in yeast

Yeast is a single-celled fungus. It respire glucose and releases carbon dioxide, so the rate of carbon dioxide production shows the rate of respiration.

1. Mix yeast with a glucose solution in a boiling tube. Use the same mass of yeast and the same volume and concentration of glucose solution in every tube.
2. Place each tube in a water bath at a different temperature, for example 10, 20, 30, 40 and 50 °C. Leave the tubes for a few minutes to reach the temperature.
3. Fit a bung and delivery tube to each boiling tube. Lead the delivery tube into a test tube of water (to count bubbles) or into an upturned measuring cylinder filled with water or a gas syringe (to collect the gas). Bubbling the gas through limewater, which turns cloudy, shows that it is carbon dioxide.
4. Count the bubbles of carbon dioxide produced in a fixed time (for example 2 minutes), or measure the volume of gas collected.
5. Repeat at each temperature and calculate a mean. Plot rate against temperature.



Count the **carbon dioxide bubbles**, or measure the volume of gas collected, at each water bath temperature.

Planning the investigation

Variable	What to do
Independent	temperature of the water bath / °C
Dependent	number of bubbles per minute, or volume of gas / cm ³
Controlled	mass of yeast, volume and concentration of glucose solution, counting time, pH

*Practical skill: Rate increases with temperature up to an **optimum**, then falls because the enzymes involved in respiration are denatured at high temperatures. Expect little or no bubbling at very high temperatures such as 60 °C. Take care with hot water baths.*

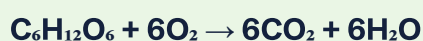
Aerobic respiration Spec 12.2.1, 12.2.2, 12.2.3

Aerobic respiration the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy

Aerobic respiration needs **oxygen**. It takes place in cells all the time. Glucose is the nutrient molecule usually used, and the products are **carbon dioxide and water**.

glucose + oxygen → carbon dioxide + water

Supplement



Supplement

The balanced chemical equation shows that one molecule of glucose reacts with six molecules of oxygen to produce six molecules of carbon dioxide and six molecules of water. There are the same numbers of each type of atom on both sides.

Common mistake: Respiration is not the same as breathing. Breathing moves air in and out of the lungs. Respiration is the chemical reaction that happens inside cells.

Exam tip: Learn the definition word for word: "chemical reactions in cells that use oxygen to break down nutrient molecules to release energy". Check that the word equation has the reactants and products the right way round.

Anaerobic respiration Spec 12.3.1, 12.3.2, 12.3.3, 12.3.4, 12.3.5

Anaerobic respiration the chemical reactions in cells that break down nutrient molecules to release energy without using oxygen

Anaerobic respiration releases **much less energy** per glucose molecule than aerobic respiration. This is because the glucose is only partly broken down.

In yeast

Yeast respires anaerobically when there is no oxygen. This is called fermentation. It is used to make bread (the carbon dioxide makes the dough rise) and alcoholic drinks.

glucose → alcohol + carbon dioxide

Supplement



In muscles during vigorous exercise

When muscles cannot get oxygen fast enough during vigorous exercise, they also respire anaerobically. The product is **lactic acid**. No carbon dioxide is produced.

glucose → lactic acid

Aerobic and anaerobic respiration compared

Feature	Aerobic	Anaerobic
Oxygen needed	yes	no
Energy released per glucose	much more	much less
Products in yeast	carbon dioxide and water	alcohol and carbon dioxide
Products in muscles	carbon dioxide and water	lactic acid

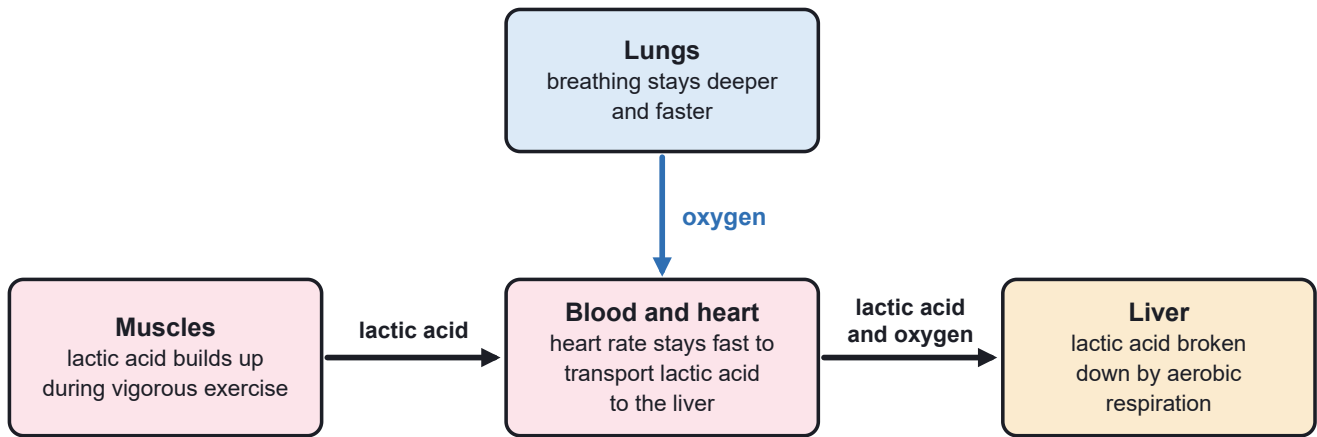
Common mistake: Yeast makes alcohol and carbon dioxide; muscles make only lactic acid. Do not mix up the two equations.

Lactic acid and oxygen debt Spec 12.3.6, 12.3.7 Supplement

During vigorous exercise, **lactic acid** builds up in the muscles and blood. This causes an **oxygen debt**: the extra oxygen needed after exercise to break down the lactic acid.

How the oxygen debt is removed after exercise

- The heart rate stays fast, to transport lactic acid in the blood from the muscles to the liver.
- Breathing stays deeper and faster, to supply oxygen for aerobic respiration of the lactic acid.
- The lactic acid is broken down by aerobic respiration in the liver.



A fast heart rate and deep, fast breathing deliver lactic acid and oxygen to the **liver**, where the lactic acid is broken down by **aerobic respiration**.

*Exam tip: Write that lactic acid is broken down by **aerobic respiration** in the liver. Do not say it is "converted back to glucose"; that is not what the syllabus says. Explain why the heart and breathing rates stay high after stopping.*

Quick check

1. State three uses of energy in living organisms.
2. Write the word equation for aerobic respiration.
3. Write the word equation for anaerobic respiration in yeast.
4. Which product forms in muscles during anaerobic respiration?
5. **Supplement** Why does breathing stay deep and fast after exercise?

Quick check answers

Respiration

1. Any three from: muscle contraction, protein synthesis, cell division, active transport, growth, nerve impulses, maintaining body temperature.
2. $\text{glucose} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water}$
3. $\text{glucose} \rightarrow \text{alcohol} + \text{carbon dioxide}$
4. Lactic acid.
5. To supply oxygen for aerobic respiration of lactic acid in the liver.