

Unit 8B Respiration

About the unit

In this unit pupils learn:

- how cells are supplied with the materials they need for respiration
- how cells in animals and plants release energy
- that the process of respiration is similar in all cells

In scientific enquiry pupils:

- consider earlier ideas about circulation including how and why these ideas have changed and developed
- make observations and present these in a suitable format
- consider how to deal with factors that cannot be controlled when working with living materials

This unit is expected to take approximately 9 hours.

Where the unit fits in

This unit builds on unit 8A 'Food and digestion', which needs to have been covered first. It is closely linked to the section on breathing and smoking in unit 9B 'Fit and healthy'. The unit relates to work on foods and fuels in unit 7I 'Energy resources' and to work on oxygen and burning in unit 7F 'Simple chemical reactions'.

The unit lays the foundation for work on the composition of the blood, the structure of blood cells and the circulatory system at key stage 4.

The energy transfer ideas of unit 7I 'Energy resources' are used in the context of respiration. Energy should be distinguished from 'stuff' (the food as energy resource or fuel).

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: describe an earlier model of circulation indicating how it does not match present-day evidence; explain why control experiments and sample size are important when investigating living organisms; make appropriate observations, recording them accurately and identifying patterns in data obtained

some pupils will not have made so much progress and will: recognise that ideas about circulation have changed; with help, identify variables relevant to a question; make observations and recognise patterns in data

some pupils will have progressed further and will: describe and explain some of the evidence leading to present-day ideas about how and why blood circulates

in terms of life processes and living things

most pupils will: describe the role of blood in transporting carbon dioxide from, and oxygen to, the lungs and explain why tissues need a good blood supply; describe aerobic respiration as a reaction with oxygen; describe some effects of an inadequate oxygen supply; describe and explain differences between inhaled and exhaled air and identify similarities in aerobic respiration in plants and animals

some pupils will not have made so much progress and will: recognise that oxygen is required for aerobic respiration and that oxygen and glucose are transported in the blood; describe differences between inhaled and exhaled air

some pupils will have progressed further and will: represent the process of aerobic respiration as a word and/or symbol equation and identify similarities with the burning of fuels; describe the features of alveoli and explain how damaged alveoli result in less gas exchange

Prior learning

It is helpful if pupils know:

- that air contains carbon dioxide and oxygen, with other gases
- that smaller molecules, including glucose, are produced from larger ones in digestion
- that the heart pumps blood to circulate it through the body
- that cells are organised into tissues and tissues can form organs
- how breathing varies according to the body's needs

Health and safety

Risk assessments are required for any hazardous activity. In this unit pupils:

- observe energy released in the combustion of sugar
- measure body temperature
- use a variety of materials, some of which are hazardous
- handle living animal material

Model risk assessments used by most employers for normal science activities can be found in the publications listed in the *Teacher's guide*. Teachers need to follow these as indicated in the guidance notes for the activities, and consider what modifications are needed for individual classroom situations.

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly:

- names of organs of the chest linked to breathing, *eg lung, trachea, bronchus, ribcage*
- names of cells and tissue substances linked to circulation, *eg red blood cell, haemoglobin, artery, vein*
- more specialised scientific vocabulary, *eg carbon dioxide, oxygen, diffusion*
- words with similar but distinct meanings, *eg breathing, ventilation, inspire, respire, inhale, exhale*
- words with different meanings in scientific and everyday contexts, *eg inspiration, aerobic, ventilation*

Through the activities pupils could:

- discuss and respond to initial ideas and information, carry out the task and then review and refine ideas
- select relevant information and link to other information from a range of sources

Resources

Resources include:


- a selection of living material, *eg germinating peas, maggots, woodlice*
- thermometers, liquid crystal strips
- reference sources, including ICT sources, providing information about how organisms, including aquatic ones, exchange gases with the environment
- information, *eg labels*, about the content of 'high energy' drinks/food supplements
- secondary sources of information about the heart
- software simulations and video clips illustrating the transport of substances in the blood
- video clips illustrating athletics or other sports
- information about intravenous feeding
- information concerning early ideas about circulation

Out-of-school learning

Pupils could:

- find out what happens in the airways of asthma sufferers
- visit an aquarium and discuss with attendants how animals exchange gases in water
- find out about first-aid courses on artificial ventilation

How do cells use the food molecules absorbed after digestion?

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| <ul style="list-style-type: none"> that products of digestion are transported in the blood to other parts of the body | <ul style="list-style-type: none"> Ask pupils for their ideas about why the body needs food, reminding them of work done in unit 8A 'Food and digestion'. Explain that this unit will concentrate on how cells release energy for growth, synthesis of new materials and body heat. | <ul style="list-style-type: none"> identify that the body needs food for growth, synthesis of new materials, production of body heat | <ul style="list-style-type: none"> This activity is designed to find out what pupils know about the products of digestion and how the body makes use of these. Teachers will need to bear this in mind in later work. |
| <ul style="list-style-type: none"> that glucose is an energy resource for cells | <ul style="list-style-type: none"> Ask pupils about 'high energy' drinks, who uses them and what they contain, and provide pupils with secondary sources of information. Establish that glucose is a major constituent of such drinks/foods and ask pupils to relate this to what they learnt about digestion of carbohydrates (starches) in unit 8A 'Food and digestion'. Use secondary sources, <i>eg video clips, software simulations</i>, to show how small molecules, <i>eg glucose</i>, are transported in the blood to other parts of the body, <i>eg muscles, brain</i>. | <ul style="list-style-type: none"> explain that glucose is transported in the blood to other parts of the body, including specific cells, <i>eg muscle cells</i>, where glucose can become an energy resource | <ul style="list-style-type: none"> Extension: pupils could be asked to find out about the composition of intravenous food used in hospitals and to explain why these components are used. |
| <ul style="list-style-type: none"> that respiration is the sum of the chemical reactions which release energy from food molecules | <ul style="list-style-type: none"> Remind pupils of work they did in earlier units on fuels and, by questioning, establish that when fuels burn they react with oxygen and release energy. Demonstrate this using 2.5cm of icing sugar in a tin-can 'bomb', igniting the fine powder with the flame of a candle and showing that this type of dust explosion can blow off the can lid. Emphasise that the chemical reaction in cells is much more controlled than the dramatic demonstration. Explain that, although burning does not occur, a similar reaction takes place between glucose and oxygen in the cells of the body and that this is aerobic respiration. | <ul style="list-style-type: none"> recognise that oxygen is needed for aerobic respiration state that glucose is used for energy release identify differences between reactions in cells and burning, <i>eg in the cell the release of energy is controlled</i> | <ul style="list-style-type: none"> Pupils will have explored burning fuels to release energy in unit 7I 'Energy resources'. In unit 7F 'Simple chemical reactions' they will also have explored the production of carbon dioxide and water during the combustion of fuels containing carbon and hydrogen. The analogy with burning fuels is useful. However, pupils need to be aware that 'fuels' used by cells do not 'burn'. <p> Safety – screens and eye protection should be used and pupils should be seated 2–3 metres away</p> |

Learning objectives

Pupils should learn:

- to use thermometers of different kinds
- that respiration can be represented by a word equation: glucose + oxygen → carbon dioxide + water, and this reaction releases energy
- to explain observations using scientific knowledge and understanding

Possible teaching activities

- Present pupils with a range of observation activities, eg
 - *observing a temperature difference between germinating peas and boiled peas*
 - *yeast generating bubbles of carbon dioxide which are passed into lime water*
 - *germinating peas and maggots in separate gauze cages over hydrogencarbonate indicator*
 - *water weed shielded by black paper in hydrogencarbonate solution producing carbon dioxide*
 - *measuring their own temperature*
- Discuss their observations to establish that the hydrogencarbonate indicators show that the living material was producing carbon dioxide and the increased temperature measured by the thermometers shows that the living material was also releasing energy. Provide pupils with opportunities to discuss, in groups, what they observe and provide an explanation to the whole class.
- Explain that energy is released in cells by respiration, which is a process that uses nutrients from food and oxygen, and releases carbon dioxide, water and energy. Summarise the process of aerobic respiration in a word equation.

Learning outcomes

Pupils:

- record temperatures, reading scales accurately
- summarise respiration in a word equation: glucose + oxygen → carbon dioxide + water
- explain the increased temperature in terms of energy release during respiration

Points to note

- Teachers will need to explain the use of the hydrogencarbonate indicator if pupils have not used it previously.
- Pupils' attitudes to the appropriate care of living organisms need to be handled sensitively.
- Sensors and computer software can be used to monitor temperature and other changes in germinating peas.
- Pupils with visual impairment could use talking thermometers to record temperature.
- Extension: some pupils' understanding of aerobic respiration could be reinforced using a 'snap' game with cards labelled 'glucose', 'oxygen', 'carbon dioxide', 'water' and a different coloured card for 'energy'.



Safety – the safe approach (including everyday use) to taking body temperature is to use liquid-crystal strips. If clinical thermometers are used, they need to be disinfected each time they are used

How does the oxygen needed for respiration reach the tissues of the body?

- that the exchanges of substances between cells and the blood occur adjacent to the capillaries
- that the blood transports substances to and from the cells of body tissues

- Ask pupils what they know about the heart and circulation of blood in humans. Provide pupils with a simple diagram of blood circulation or a card sort/sequence and labels activity. Ask pupils to describe the route glucose takes from the stomach to reach a leg muscle cell. Establish that oxygen enters the body through the lungs and ask pupils to describe the route oxygen takes from the lungs to a leg muscle cell.

- state that oxygen and glucose are carried in the bloodstream
- explain that oxygen (and glucose) pass from the bloodstream into nearby cells
- explain that carbon dioxide and water pass from cells into the bloodstream

- Pupils are likely to have learnt about the heart as a pump and blood circulating through blood vessels in the body at key stage 2. At key stage 3, emphasis is on blood as a transport medium. Details of the circulatory system are not required at this stage.
- It is not necessary for pupils to go into detail of how a red blood cell is adapted for carrying oxygen.

Pupils should learn:

- why the heart needs to work efficiently
- to select relevant information and link to other information from a range of sources
- how a theory has been modified when predictions made from it are not supported by evidence

- Remind pupils of the heart's structure and function using, *eg illustrations, video clips, models, mammalian hearts, CD-ROMs*. Discuss the heart's pumping action as a double pump, one side supplying the lungs, the other side supplying the other body organs. Provide opportunities for pupils to discuss in groups and then annotate diagrams of the heart using arrows to show the direction of blood flow. Ask pupils to think about and predict the consequences of the heart not working efficiently in terms of blood supply to the tissues and lungs.
- Provide pupils with secondary sources so that they can find out about the development of ideas about the heart and circulation and scientific methods using, *eg Galen, Vesalius, Harvey, Withering, Ibn-al-Nafis*. Help them to draw out the ideas about experimenting and making inferences. Emphasise that scientific theories were based on persuasive argument and that there were long periods of time before ideas, even though not supported by evidence, changed.

Pupils:

- explain why the tissues, including the lungs, need a good blood supply
- synthesise information from a variety of sources
- recognise that theories change when they are not supported by evidence

- There is an opportunity to use IT simulations of heart action.
- Some teachers may wish to discuss holes in the heart leading to depleted oxygen supply to the tissues.
- Extension: pupils could be asked to find out about, *eg*
 - *Galen: content of arteries and movement of blood*
 - *Vesalius: detailed anatomical observation and investigation contradicted earlier ideas*
 - *Harvey: argued only from evidence supported by experiment and observation that blood circulates constantly and the heart pumps blood*
 - *Withering: large number of observations before drawing conclusions, recognition that the popular idea of effect was wrong, first scientific investigation of a drug, *eg digitalis**
 - *Ibn-al-Nafis: discovered pulmonary circulation*
 - *Servetus, Columella, Da Vinci: could be added for studies of heart function. Circulation of the blood was known to the Chinese by the second century BC*

What happens to the oxygen when it reaches the cells?

- that cells need a good supply of oxygen in order to release energy
- that carbon dioxide is produced during aerobic respiration
- Remind pupils of earlier work and review their understanding of the reaction in the cells between oxygen and glucose. Ask them to think about what happens if the blood cannot supply enough oxygen for the cell's needs, *eg during intense physical activity*.
- Ask them about their own experiences and illustrate, *eg with video clips of athletics*. Ask pupils about the meaning of the word 'aerobic' and why aerobics in relation to exercise is so called.
- Extend to other situations where there may be a reduced oxygen supply, *eg through illness, mountaineering*. Reinforce the idea that carbon dioxide and water, as well as energy, are released from aerobic respiration and that carbon dioxide is removed from the cells in the bloodstream.
- state that oxygen is needed for cellular aerobic respiration
- describe some effects on the body of an inadequate oxygen supply
- state that carbon dioxide and water are products of respiration
- 'Oxygen debt' and the production of lactic acid in anaerobic respiration are dealt with in key stage 4. Some teachers may wish to introduce some pupils here to the idea of lactic acid formation.

Checking progress

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| <ul style="list-style-type: none"> • about the reaction in cells between glucose and oxygen • how the blood transports glucose and oxygen around the body | <ul style="list-style-type: none"> • Provide pupils with a series of true/false statements or flashcards about respiration and the transport role of blood. Ask them to work in groups to classify the statements and to provide reasons for their choices. They should be shown how to discuss and respond to initial ideas and information, carry out the task, and then review and refine ideas. Use the work to form the basis of a summary of key points. | <ul style="list-style-type: none"> • identify the reactants and the products of respiration • explain the role of the blood in supplying and removing substances to cells • identify some effects of a reduced oxygen supply to respiring cells • contribute to sustained group work to carry out and report on a task | <ul style="list-style-type: none"> • At this point teachers may wish to reinforce the idea that respiration and breathing have different scientific meanings. |
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What is the role of the lungs?

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| <ul style="list-style-type: none"> • that lungs are specialised organs where oxygen from the air enters the blood and carbon dioxide in the blood passes into the alveoli • how the alveoli provide a large surface area for gas exchange | <ul style="list-style-type: none"> • Review, using quick questions, pupils' understanding of the composition of air breathed into the lungs and the importance of oxygen for aerobic respiration. Ask pupils to suggest what happens to air when it enters the lungs. Establish, <i>eg using simulation software</i>, that oxygen enters the blood and is transported elsewhere, and that carbon dioxide produced in the cells passes out of the blood. • Show illustrations, models or animated pictures of the fine structure of the lungs and ask pupils to suggest why the alveoli have so many blood vessels around them. Provide information about carbon dioxide and oxygen concentrations in the blood. Ask pupils to predict what happens in the alveolus. Help pupils to annotate diagrams with arrows to show the direction of movement of oxygen and carbon dioxide and describe gas exchange in terms of a supply of oxygen to the blood and removal of carbon dioxide from the blood. • Show illustrations of damaged lungs from, <i>eg emphysema, dust damage</i>. Ask the pupils to describe the differences and predict what effects this damage may have on gas exchange. | <ul style="list-style-type: none"> • describe features of the alveoli, <i>eg very thin walls, large surface area, the network of blood capillaries around the alveoli</i> • describe the movement of gases from air to blood and blood to air • describe how carbon dioxide and oxygen are exchanged at the surface of an alveolus • describe how damaged lungs will result in less gas exchange | <ul style="list-style-type: none"> • Pupils often focus on the body's need for oxygen and should be reminded about the importance of the removal of carbon dioxide as a waste product. Air as a mixture with varying composition is covered in unit 8F 'Compounds and mixtures'. |
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How are inhaled and exhaled air different?

- to make comparisons between the composition of inhaled and exhaled air
- to present findings in a suitable format
- to discuss and respond to initial ideas and information, carry out the task and then review and refine ideas
- Ask pupils to use what they know about respiration to predict the differences between inhaled and exhaled air.
- Show pupils how to demonstrate changes in oxygen concentration, *eg length of time a candle burns in exhaled air compared to normal air, volume changes when oxygen is absorbed by alkaline pyrogallate*. Ask pupils to investigate other changes in the air as they breathe in and out, *eg presence of more carbon dioxide in expired air, pupils breathe onto cold mirrors or glass and test the moisture with cobalt chloride paper*. Discuss the results with the pupils. Ask pupils to use reference sources to present their findings, including a table of changes in composition of air when it is breathed. Relate this to knowledge of respiration, deciding whether their predictions were correct.
- While the pupils are waiting for results, ask them to use reference sources to find out how aquatic animals and plants obtain oxygen from water.

- describe the differences in the concentrations of oxygen, water vapour and carbon dioxide in inhaled and exhaled air
- present their results in a table which relates their findings to other data about the composition of the air and their knowledge of respiration

- Pupils will have used the lime water test for carbon dioxide in unit 7E 'Acids and alkalis' and unit 7F 'Simple chemical reactions', and hydrogencarbonate indicator earlier in this unit.
- ⚠ **Safety** – pyrogalllic acid (benzene 1,2,3 triol) can be dissolved in saturated sodium hydrogencarbonate to produce a less hazardous solution, with a lower pH than that commonly used. Pupils require eye protection during use. If pupils breathe into lime water, eye protection and sterilised mouthpieces are required

Do other organisms respire in a similar manner?

- to turn ideas into a form that can be investigated
- to make decisions about how to deal with factors which cannot be controlled
- to use controls for comparisons
- how to work with living materials
- Ask pupils about the organisms they used earlier in the unit and ask them how they could find out if other living things also produce carbon dioxide during respiration. Provide suitable apparatus for holding living material, *eg gauze platform in a boiling tube above a hydrogencarbonate indicator solution*.
- Discuss the selection of living organisms, *eg yeast, germinating lentils, small fruit woodlice, maggots*, the use of a control apparatus without living material and relevant factors, *eg mass of living material, temperature, activity, sensitivity of the indicator, length of time to leave it*. Ask the pupils to write a plan for their investigation.

- identify factors that could affect the quantity of carbon dioxide produced
- recognise the need for a control

- Pupils should be encouraged to think of the welfare of small animals. It is more convenient to use invertebrates.
- Germinating lentils are convenient plants and work well.
- ⚠ **Safety** – wash hands and wipe the bench with disinfectant after handling live material

Learning objectives

Pupils should learn:

- that plants and other animals produce carbon dioxide during respiration
- to make careful observations and draw conclusions explaining these in terms of scientific knowledge and understanding
- to use scientific terminology effectively and accurately in writing

Possible teaching activities

- Help pupils to carry out the investigation they planned. Compare results from different investigations and ask the pupils to identify any trends, *eg plant material produced less carbon dioxide than animal material, the more active animals produced more carbon dioxide.*
- Draw together the results of the investigations and establish respiration as a process that takes place in the cells of plants and animals.

Learning outcomes

Pupils:

- recognise that other living things, including plant material, produce carbon dioxide during respiration
- integrate the results of others with their own to draw conclusions
- identify and describe patterns in the data

Points to note

- Pupils should consider the welfare of small invertebrates.
- It may be necessary to leave the plant investigations set up for a longer period of time. Pupils will need to take this into consideration in any comparison of results.
- Photosynthesis is covered in unit 9C 'Plants and photosynthesis'. Pupils often think that plants photosynthesise but do not respire. It is helpful to emphasise that plants do respire before photosynthesis is studied.



Safety – wash hands and wipe the bench with disinfectant after handling live material

Reviewing work

- to summarise and make connections between key ideas in the unit
- Provide pupils with a diagram showing the gut, lungs, blood supply, heart and cells, and help them to produce a flow chart showing how expired carbon dioxide is derived from glucose, made available by digestion, and its reaction with inhaled oxygen.
- As appropriate, supply pupils with prepared phrases with which to label the flow chart and/or structured questions.
- connect ideas appropriately, *eg in a flow chart, responses to questions*