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Cambridge Lower Secondary Science

TEACHER'S RESOURCE 9

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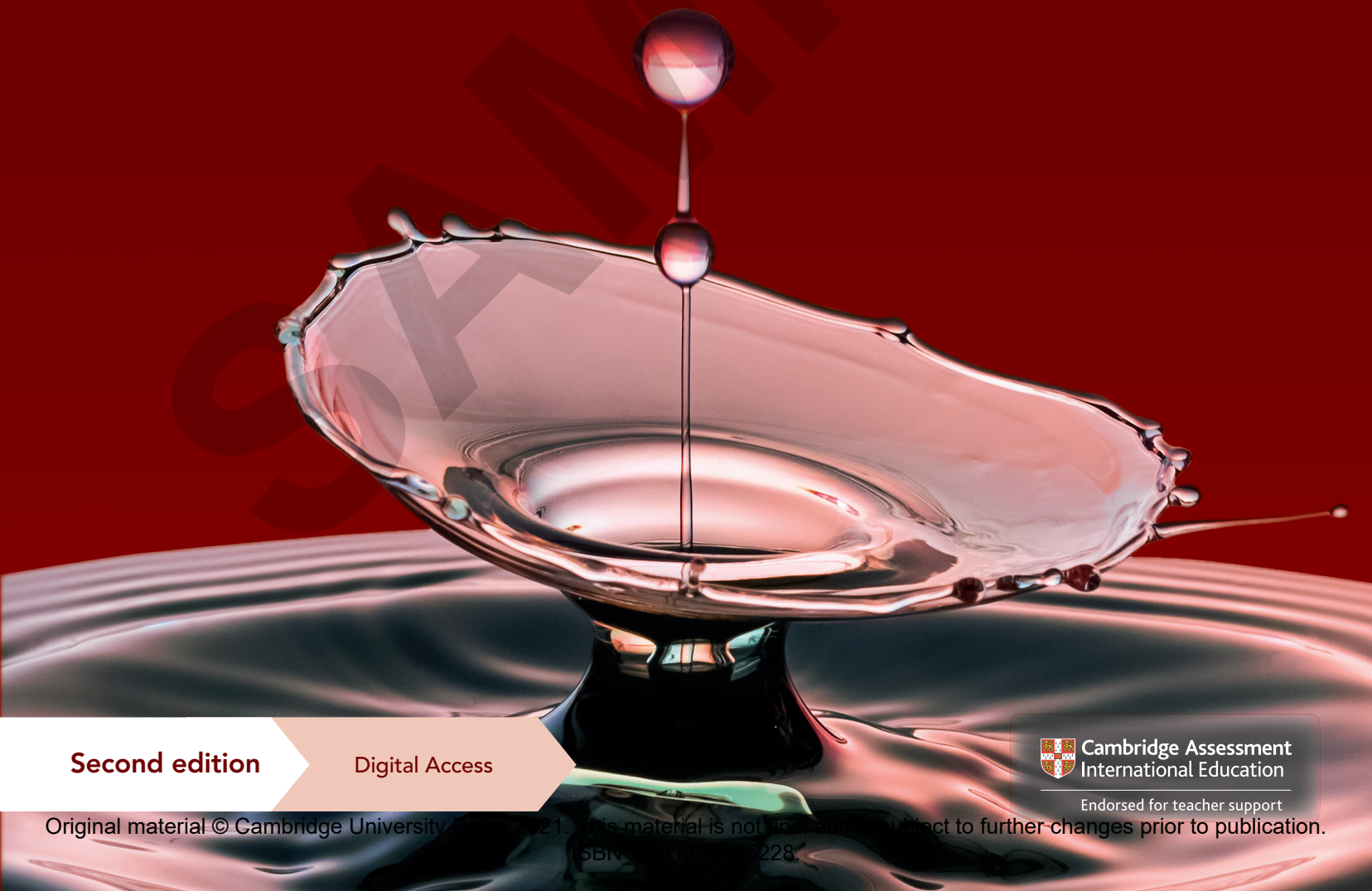

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1 Photosynthesis and the carbon cycle

Unit plan

Topic	Learning hours	Learning content	Resources
1.1 Photosynthesis	-	Introduction to photosynthesis	**Learner's Book:** Questions 1–4 Think like a scientist: Collecting the gas produced in photosynthesis Think like a scientist: Investigating how light intensity affects the rate of photosynthesis Activity: Words beginning with photo- Activity: Photosynthesis and respiration **Workbook:** Exercise 1.1A, How light level affects photosynthesis Exercise 1.1B, The effect of different colours of light on the rate of photosynthesis Exercise 1.1C, Turning an idea into an hypothesis that can be tested **Teacher's Resource:** Worksheets 1.1A, 1.1B, 1.1C, The beginning of photosynthesis Template 1, Results table for *Think like a scientist: Investigating how light intensity affects the rate of photosynthesis*
1.2 More about photosynthesis	-	Chloroplasts and chlorophyll; leaves; mineral ions required by plants.	**Learner's Book:** Questions 1–4 Activity: Which surface of a leaf has most stomata? Think like a scientist: Testing a leaf for starch Think like a scientist: Investigating the effect of fertilisers on plant growth **Workbook:** Exercise 1.2A, Duckweed experiment Exercise 1.2B, Testing a variegated leaf for starch Exercise 1.2C, Floating discs experiment **Teacher's Resource:** Template 2: Planning record for Think like a scientist: Investigating the effect of fertilisers on plant growth

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Topic	Learning hours	Learning content	Resources
1.3 The carbon cycle	-	How carbon atoms move between organisms and the air	**Learner's Book:** Questions 1–4 Think like a scientist: How do plants and animals affect carbon dioxide concentration? Activity: Modelling the carbon cycle **Workbook:** Exercise 1.3, Completing a carbon cycle diagram **Teacher's Resource:** Worksheets 1.3A, 1.3B, 1.3C, Building a carbon cycle Template 3, Results chart for Think like a scientist: How do plants and animals affect carbon dioxide concentration?
1.4 Climate change	-	The effects of greenhouse gases and asteroid collisions on the Earth's climate	**Learner's Book:** Questions 1–4 Think like a scientist: How do rising temperatures affect sea level? Activity: The carbon cycle and climate change **Workbook:** Exercise 1.4, Interpreting graphs about climate change **Teacher's Resource:** Worksheet 1.4, Impacts of climate change
Cross-unit resources			**Learner's Book:** Check your Progress **Project:** What happened to the dinosaurs? **Teacher' resource:** Language development worksheets 1 Completing sentences about the carbon cycle 2 Making predictions

BACKGROUND KNOWLEDGE

It is likely that learners will already know something about photosynthesis. Learners who have followed the Cambridge programme learnt at Stage 4 that plants get energy from light, and they will also know that plants are the producers in food chains, a concept that was first addressed at Stage 6 and again at Stages 7 and 8. They should know something about energy changes, which were covered in the Physics units in Stage 7.

Learners will also need to be confident with word equations. These are first dealt with in the chemistry topics in Stage 8, and learners are also likely to remember using the word equation for respiration which they used in Stage 8.

The work on the carbon cycle requires an understanding of the concept of elements and compounds, which was covered in chemistry at Stage 7. Learners will revisit their earlier work on decomposers from Stage 7, and integrate this with their previous knowledge of respiration, as well as the new work on photosynthesis. They are likely to have met combustion reactions in their chemistry lessons, probably in Stage 8.

The climate change topic builds on earlier work on greenhouse gases in the chemistry topics in Stage 8. Learners are also likely to remember something about asteroids from Stage 8.

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TEACHING SKILLS FOCUS

Assessment for learning

As teachers, we all want to know how our learners are progressing. The learners themselves also want to know this, as do their parents. We give learners tests and examinations to find out, so that we can record their marks. You may also enter your learners for externally marked examinations, such as those provided by Cambridge Assessment International Examinations.

All of these assessments can be thought of as summative assessments. Their purpose is to find out what learners have learnt and how well they understand the material in the test or examination. They give us information on their attainment, and where they stand in the rank order of other learners in the class, the school or in the world. As they get older, learners will also take examinations such as IGCSE, O Level or A Level. Their results in these summative examinations can be used to help them to move into further or higher education courses, or to employment.

However, this is not the only means of assessment that teachers use. Formative assessment – also known as assessment for learning – is a type of assessment that can be used almost all of the time. Its purpose is to find out what our learners can do, so that we can adjust our teaching and the tasks and support that we provide to the learners, to help them to move on and up from their current position. There is much evidence that using assessment for learning can have a significant impact on the standards that can be achieved by learners.

Good formative assessment is at the heart of successful teaching. However well we plan a lesson, and however well we teach a topic, we cannot know how successful we have been until we find out how well the learners have understood what we have taught. As every teacher knows, what we teach is not the same as what out learners learn. If we find that their understanding is not as good as we hoped, then we need to adjust the planned teaching, to take this into consideration. Perhaps we need to revisit the topic in the next lesson for the whole class, approaching it in a different way. Perhaps some learners need to be given a further challenge, while others need more support to help them to grasp the concepts we have been teaching.

How is assessment for learning done? There are several things that you can try to do.

- Find out where individual learners are now – what do they understand? What do they feel less confident about? A good teacher does this constantly – using questioning in class, listening to learners as they talk to each other during group work, watching them doing an experiment, as well as marking written work.
- Share learning intentions and success criteria with learners. Learners need to know what they are supposed to be able to do, and how to judge when they have done it well. Using self- and peer-assessment can really help here, as it gives them clear targets to focus on.
- Give focused, specific and personal feedback to learners to make clear to them what is good about their work and what they can do to improve. Make sure that these targets are achievable, not so broad or ambitious that they are beyond the learner's capability. Develop your learners' confidence to make sure that everyone understands that they can improve.

In the Teacher's Resource for Units 2, 5 and 8, you will find more guidance on using self- and peer-assessment. Units 3, 6 and 9 give advice on giving feedback to learners. In Unit 4, there are suggestions about how to set achievable targets for learners, while Unit 7 includes ideas for how to use reflection to help learners to think about how they learn and how they can improve. There is advice on using questioning in Units 2, 5 and 8 at Stage 8.

In this unit, you could try:

- watching and listening to learners as they work on *Think like a scientist: Investigating how light intensity affects the rate of photosynthesis*, to check how well everyone understands what they are doing, and what is happening
- using questioning when everyone has finished and is sitting down, to find out what they understand about what they have done
- using peer assessment to help learners to focus on how to design a good results chart
- using what you find to make adjustments to your teaching plans, if need be.

Topic 1.1 Photosynthesis

LEARNING PLAN

Learning Objectives	Learning intentions	Success criteria
9Bp.06 Know that photosynthesis occurs in chloroplasts and is the process by which plants make carbohydrates, using the energy from light. **9Bp.07** Know and use the summary word equation for photosynthesis. **9TWSa.01** Evaluate the strength of the evidence collected and how it supports, or refutes, the prediction. **9TWSa.02** Describe trends and patterns in results, identifying any anomalous results and suggesting why results are anomalous. **9TWSa.03** Make conclusions by interpreting results, explain the limitations of the conclusions and describe how the conclusions can be further investigated. **9TWSa.04** Evaluate experiments and investigations, including those by others, and suggest improvements, explaining any proposed changes. **9TSWa.05** Present and interpret results, and predict results between the data points collected. **9TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. **9TWSc.02** Decide what equipment is required to carry out an investigation or experiment and use it appropriately.	• Learn what happens during photosynthesis, and be able to use and understand the word equation. • Collect the gas produced in photosynthesis, and test it. • Carry out a fair test experiment, to find out how light intensity affects the rate of photosynthesis.	• Be able to write the photosynthesis equation, and use it to name reactants and products.. • Collect and test gas produced by a water plant. • Collect results in the light intensity experiment, draw a graph using these results, and write a conclusion

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CONTINUED

Learning Objectives	Learning intentions	Success criteria
9TWSc.03 Decide when to increase the range of observations and measurements, and increase the extent of repetition, to give sufficiently reliable data. **9TWSc.04** Take appropriately accurate and precise measurements, explaining why accuracy and precision are important. **9TWSc.05** Carry out practical work safely, supported by risk assessments where appropriate. **9TWSc.06** Make an informed decision whether to use evidence from first-hand experience or secondary sources. **9TWSc.07** Collect, record and summarise sufficient observations and measurements, in an appropriate form. **9TWSp.01** Suggest a testable hypothesis based on scientific understanding. **9TWSp.02** Describe examples where scientists' unexpected results from enquiries have led to improved scientific understanding. **9TWSp.03** Make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding. **9TWSp.04** Plan a range of investigations of different types to obtain appropriate evidence when testing hypotheses. **9TWSp.05** Make risk assessments for practical work to identify and control risks.		

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LANGUAGE SUPPORT

Learners will use the following words:

photosynthesis: a series of chemical reactions that take place inside the chloroplasts of plants, in which carbon dioxide and water react together using light energy; the products are glucose (and other carbohydrates) and water

chlorophyll: a green pigment present in chloroplasts, which absorbs energy from light and helps to transfer it to the carbohydrates made in photosynthesis

light intensity: a measure of the quantity of light energy falling onto an object

Common misconceptions

Misconception	How to identify	How to overcome
Learners often say that photosynthesis is the way that plants respire.	The activity: Photosynthesis and respiration, is likely to bring out any difficulties with this concept.	Throughout this unit, make sure that reference is made to respiration in plants.

Starter ideas

1 Getting started (10 mins, including sharing ideas)

Resources: Two plants, or sets of plants; one that has grown in the light and one that has been in the dark. If these are not available, then learners can look at the photographs in the Learner's Book.

Description: Ask learners to work with a partner to make a list of any differences they can see. Use their observations to discuss why plants need light.

2 Title Words beginning with photo- (5 mins)

Description: Organise learners into teams. Ask them to follow the instructions for the activity *Words beginning with photo-*.

Main teaching ideas

1 Collecting the gas produced in photosynthesis (10 mins to set up; leave for one day; another 10 mins to test the gas collected)

Learning intention: To observe photosynthesis in a water plant; to obtain first-hand evidence that plants release oxygen gas.

Resources: Per group: a large beaker; a glass funnel; blocks or modelling dough to hold the funnel off the bottom of the beaker; test tube; pond water (tap water can contain chemicals that harm the water plant); a water plant such as *Elodea* or *Cabomba* – these can be obtained from pet shops or aquarium shops.

Description: Learners can set up the apparatus as shown in the diagram in the Learner's Book.

› **Practical guidance:** Before the lesson, keep the water plants in the water that you will use for the experiment, in bright light, so that they are already photosynthesising. Choose short pieces of plant and cut diagonally across the stem – this makes it easier for the bubbles to emerge. When assembling the apparatus, place the pieces of plant upside down, so that the cut end is pointing upwards.

Raising the funnel above the bottom of the beaker enables good water circulation.

Learners can often be clumsy in placing the test tube full of water over the funnel without the water all falling out, and again when removing it at the end of the experiment. Practise this yourself first, then show the learners how to do it correctly.

› **Differentiation ideas:** All learners should be able to assemble the apparatus, but some may need support with removing the tube and testing the gas at the end.

Questions 1 and 2 are likely to be challenging for some learners, who will need support in thinking out possible answers for them.

Learners who need a challenge could be asked if they think that the gas that has collected is likely to be pure oxygen (it is not) and perhaps suggest what other gases might be present.

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› **Assessment ideas:** You could assess learners on their ability to work safely, by watching them as they assemble the apparatus and test the gas.

2 Think like a scientist: Investigating how light intensity affects the rate of photosynthesis (40–45 mins)

Learning intention: To increase confidence in handling apparatus, collecting and analysing results; to practise designing and completing their own results chart.

Resources: Per group:

- a piece of water plant, pre-treated as described in the previous activity
- a large test tube in which the piece of water plant easily fits
- a means of supporting the test tube – for example, a beaker (whatever is used must not prevent light from passing from the lamp to the tube)
- some pond water
- a lamp – make sure that this is safe, as it will be used close to water (though there is no need at all for any water to come into contact with the lamp, if learners obey safety instructions)
- a ruler to measure the distance between the test tube and the lamp
- if necessary, a paperclip to weigh down the piece of plant in the tube of water
- a timer.

Description: Ask learners to follow the instructions in the Learner's Book. They should already be familiar with the idea of a water plant giving off bubbles, if they have done the previous activity.

Emphasise the importance of keeping all electrical components away from the water.

It is best to begin with the tube as close as possible to the lamp, as this will give the plant plenty of light so that photosynthesis should be reasonably rapid. If learners start with the lamp far away, nothing at all may happen.

Learners should make three bubble counts at each distance of the tube from the lamp, so that they can later calculate a mean number.

› **Differentiation ideas:** Some learners are likely to need help with setting up their apparatus and collecting results. They may also need help in designing their results chart. Template 1 is provided for this, which you could hand out to any individual or group that needs it.

Learners who need a challenge could be asked to look at the three readings they have made at each distance. Are the three readings the same. If they are not, what does that indicate? They may be able to see that this could mean that another variable might be affecting the number of bubbles, not only the light intensity (which does not change throughout the three readings) – what could this be, and what does it mean for their experiment? It is likely to be something internal to the plant, which we cannot see or measure.

› **Assessment ideas:** There are many skills that could be assessed here, but perhaps it is best to concentrate on the results charts that learners are asked to construct.

3 Activity: Photosynthesis and respiration (15 mins)

Learning intention: To begin to appreciate the relationship between photosynthesis and respiration.

Description: Organise learners into pairs. Ask them to follow the instructions in the Learner's Book.

Similarities that they might suggest include:

- they are both chemical reactions
- they both have reactants and products
- we can write equations for both
- they both happen inside living cells
- they both involve energy changes
- they both involve carbon dioxide, water, glucose and oxygen.

Differences they might suggest include:

- respiration happens in all cells, but photosynthesis only in some plant cells
- aerobic respiration happens in mitochondria, but photosynthesis happens in chloroplasts
- photosynthesis needs sunlight, but respiration does not
- photosynthesis needs chlorophyll, but respiration does not
- photosynthesis need an energy input, while respiration releases energy.

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› **Differentiation ideas:** All learners can attempt this task. Differentiation will be by outcome, with some pairs providing few or very basic ideas, while others may show greater insight.

Plenary ideas

1 Sharing results charts (15 mins)

Resources: Everyone's results charts from *Think like a scientist: Investigating how light intensity affects the rate of photosynthesis.*

Description: Put all the results charts onto the wall. Ask learners to bring a chair so that everyone sits in front of the display and can see the charts. Join the group (also sitting on a chair) and ask one group to explain their chart to you all. Use questioning to check how well everyone understands what was happening during the experiment, that they know the photosynthesis equation, that they know how to construct a results chart and so on. You can also ask the class to suggest one good point about each result chart that is discussed, and ideas about how each result chart could be improved

› **Assessment ideas:** See above.

2 Mastermind (5 mins)

Resources: A card for each learner, with a tick on one side and a cross on the other side.

Description: Choose a lear ner (or ask for a volunteer) to be Mastermind. You ask the Mastermind a question about photosynthesis based on the work done in this lesson. The Mastermind gives an answer – they can purposefully give a wrong answer if they like. The other members of the class hold up their cards to show whether the answer is correct or incorrect. You can then interrogate the rest of the class to find the correct answer if necessary, or to find out why a learner has identified a correct answer as a wrong one.

Repeat with more questions to the same Mastermind.

› **Assessment ideas:** Use responses of the class to indicate any misunderstandings.

Homework ideas

1 Workbook Exercises 1.1A, 1.1B, 1.1C

2 Worksheets 1.1A, 1.1B, 1.1C

Topic worksheets

- Worksheet 1.1A, The beginning of photosynthesis (Focus)
- Worksheet 1.1B, The beginning of photosynthesis (Practice)
- Worksheet 1.1C, The beginning of photosynthesis (Challenge)

Topic 1.2 More about photosynthesis

LEARNING PLAN

Learning Objectives	Learning intentions	Success criteria
9Bp.06 Know that photosynthesis occurs in chloroplasts and is the process by which plants make carbohydrates, using the energy from light. **9Bp.07** Know and use the summary word equation for photosynthesis. **9Bp.05** Know that plants require minerals to maintain healthy growth and life processes (limited to magnesium to make chlorophyll and nitrates to make protein).	• Learn about the role of chlorophyll in photosynthesis. • Think about the relationship between structure and function in leaves. • Find out why plants need magnesium and nitrate. • Plan a fair test experiment about the effect of fertilisers on plant growth.	• Explain why chlorophyll is needed for photosynthesis, including explaining the results of testing a variegated leaf for starch. • Answer questions 1 and 2 following the Activity, *Which surface of a leaf has most stomata?* • Produce a workable plan for *Think like a scientist: Planning an Investigation into the effect of fertilisers on plant growth.*

CONTINUED

Learning Objectives	Learning intentions	Success criteria
9TWSc.01 Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. **9TWSc.02** Decide what equipment is required to carry out an investigation or experiment and use it appropriately. **9TWSc.03** Decide when to increase the range of observations and measurements, and increase the extent of repeti tion, to give sufficiently reliable data. **9TWSc.04** Take appropriately accurate and precise measurements, explaining why accuracy and precision are important. **9TWSc.05** Carry out practical work safely, supported by risk assessments where appropriate. **9TWSc.06** Make an informed decision whether to use evidence from first-hand experience or secondary sources. **9TWSc.07** Collect, record and summarise sufficient observations and measurements, in an appropriate form. **9TWSp.01** Suggest a testable hypothesis based on scientific understanding. **9TWSp.02** Describe examples where scientists' unexpected results from enquiries have led to improved scientific understanding. **9TWSp.03** Make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding.		

CONTINUED

Learning Objectives	Learning intentions	Success criteria
9TWSp.04 Plan a range of investigations of different types to obtain appropriate evidence when testing hypotheses. **9TWSp.05** Make risk assessments for practical work to identify and control risks.		

LANGUAGE SUPPORT

Learners will use the following words:

stomata (singular: stoma): a microscopic hole in the surface of a leaf (usually on the underside) through which gases diffuse into and out of the air spaces inside the leaf

fertiliser: a substance containing mineral ions required by plants, which can be added to soil

yield: the quantity of useful crop obtained at harvest

Common misconceptions

Misconception	How to identify	How to overcome
Learners often state that chlorophyll 'attracts' light, rather than absorbing energy from it.	Oral questioning about the role of chlorophyll, and question 4 in Think like a scientist: Testing a leaf for starch.	Constant use of the correct term yourself, and careful checking of learner's spoken and written statements.

Starter ideas

1 Getting started (10 mins, including sharing ideas)

Resources: A complete plant, with roots, stem, leaves and flowers.

If this is not available, learners can look at the diagram in the Learner's Book instead.

Description: Ask learners to work individually to answer the questions in the Learner's Book. Then ask for ideas from some of them, and discuss their answers.

2 What is happening? (5–10 mins)

Description: Show the class the video clip of chloroplasts moving within mesophyll cells. Ask them: What are these structures? (They are cells) What kind of cells are they? (Plant cells) What are the green objects? (Chloroplasts) Do you know what happens inside chloroplasts? Can you suggest why they are moving around inside the cells? (It is thought that they move to control the amount of light they receive.)

Main teaching ideas

1 Think like a scientist: Testing a leaf for starch (25 mins)

Learning intention: To appreciate that plants produce starch and store it; to work safely and observe carefully

Resources: Per group:

- access to a plant, preferably one with variegated leaves
- a burner to heat water in a beaker
- a tripod and gauze (see diagram in the

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Learner's Book)

- a large test tube
- forceps (tweezers) to handle the leaves
- iodine in potassium iodide solution, in a small bottle with a dropper
- a white tile.

Per class:

- ethanol – keep this on your desk and provide it to learners only when they have turned off their burner.

Description: Ask learners to follow the instructions in the Learner's Book.

› **Practical guidance:** The day before the lesson, place a potted plant such as a geranium (*Pelargonium*) in a place where it will get plenty of light, and make sure it is watered. If at all possible, use a plant with variegated leaves.

As burners and ethanol are used in this experiment, it is important that everyone is aware that ethanol is flammable and must not be taken close to a flame. Ensure that the flames are turned out before ethanol is collected and taken back to the working area.

Have a damp cloth to hand, so that if a tube of ethanol does catch light you can quickly and simply drop the cloth over it. The flame will go out immediately.

› **Differentiation ideas:** Some learners may need help to follow the instructions carefully, so it would be a good idea to organise groups so that less-confident learners can work with those who will find this easier.

Questions 1 to 4 are quite challenging, so you may want to ask some learners to try these on their own, while you provide a little more support (perhaps in the form of scaffolding questions) to others.

› **Assessment ideas:** This is a good opportunity to assess the ability of learners to follow instructions carefully, to work safely and to observe carefully.

2 Activity: Which surface of a leaf has most stomata? (10 mins)

Learning intention: To relate a diagrammatic drawing of a leaf to a real leaf, and to think about how it exchanges gases with its environment.

Resources: A fresh leaf and a container (e.g., a cup, a beaker) with some warm water.

Description: Ask learners to follow the instructions in the Learner's Book.

› **Differentiation ideas:** Everyone can do this activity. Differentiation is likely to be in the outcome to the discussion questions. Use scaffolding questions to help learners having difficulty to work their way through to some answers.

Assessment ideas

3 Think like a scientist: Planning an Investigation into the effect of fertilisers on plant growth (30 mins if done just as planning exercise; about 30 mins to set up experiment, and then 10 mins every week for a few weeks, to collect results)

Learning intention: To suggest a testable hypothesis; to practise planning a fair test experiment to obtain evidence to test the hypothesis.

Resources: If done only as a planning exercise:

- pictures or specimens of duckweed plants.

If done as an experiment:

- duckweed plants
- small containers, e.g., Petri dishes
- distilled water
- several different types of fertiliser
- top pan balance
- spatulas
- forceps.

Description: Ask learners to follow the instructions in the Learner's Book to construct their plan.

If you are able to let learners do their experiment, tell them what fertilisers will be available before they write their plans. Check the completed plans. We recommend that you do not 'correct' mistakes unless they involve safety – it is better for learners to discover faults in their plan when they try to implement it, which they very often manage to do for themselves. You may, however, need to suggest changes to the apparatus or quantities of materials, if you cannot supply them.

This is not the most reliable of experiments, although if done carefully learners are likely to find measurable differences in the growth rates of the plants in different types or concentrations of fertiliser. The plants grow quite quickly, so results should be obtained within three or four weeks, although you may like to leave the experiment running for longer.

› **Differentiation ideas:** All learners can attempt the planning task, and can also make an attempt at

carrying out the experiment. Some will need help with planning, and you may like to provide a copy of Template 2. Otherwise, differentiation will be by outcome, with more competent and confident learners probably producing more robust plans, and working sufficiently carefully to obtain a set of results that they can analyse.

Plenary ideas

1 Sentence starters (5–15 mins)

Resources: Small cards with words used in Topic 1.1 and Topic 1.2 written on them.

Description: Organise learners into groups of three or four. Put all the cards into a bag. Take the bag to the first group and ask them to put their hand into the bag and pick a card. The group then has to make up a sentence that includes that word.

› **Assessment ideas:** Use the sentences to determine how well learners understand what they have learnt in Topics 1.1 and 1.2.

2 Commentary (20–25 mins)

Resources: Video clip of photosynthesis.

Description: Show the class the video clip showing water and oxygen entering a leaf, and oxygen being released. Organise learners into groups and ask each group to produce a commentary for the video clip. Then ask each group in turn to give their commentary as the clip plays.

› **Assessment ideas:** Use their commentaries to check understanding of photosynthesis.

Homework ideas

1 Workbook Exercises 1.2A, 1.2B, 1.2C

2 Writing the plan for *Think like a scientist: Investigating the effect of fertilisers on plant growth* makes a good homework task.

Topic worksheets

- There are no worksheets for this topic.

Topic 1.3 The carbon cycle

LEARNING OBJECTIVES

Learning Objectives	Learning intentions	Success criteria
9ESc.01 Describe the carbon cycle (limited to photosynthesis, respiration, feeding, decomposition and combustion).	• Be able to describe how carbon atoms move between organisms and the environment.	• Complete a diagram of the carbon cycle, and answer questions about it.

LANGUAGE SUPPORT

There is no new vocabulary in this topic.

Common misconceptions

Misconception	How to identify	How to overcome
Learners may not understand the concept of a compound, and not appreciate that carbon atoms can exist on their own, or within compounds.	Try the Getting started task in the Learner's Book.	Discuss any incorrect answers to the Getting started task. The activity *Modelling the carbon cycle* will also help.

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Starter ideas

1 Getting started (10 mins, including sharing ideas)

Resources: None.

Description: Ask learners to work with a partner and follow the instructions in the Learner's Book.

After a few minutes, ask some of them for their responses to the questions. Check that everyone appreciates that carbon atoms are always carbon atoms, no matter where they are or what they are combined with.

2 Why is carbon dioxide important? (10 mins)

Description: Organise learners into groups of three or four. Ask each group to think of two things that they know about carbon dioxide. Allow two or three minutes.

Then ask each group for their suggestions, writing them down on a flip chart. Leave them there, so that they can be referred at appropriate points during the rest of this topic.

Main teaching ideas

1 Building up a diagram of the carbon cycle (30–40 mins)

Learning intention: To gradually construct the carbon cycle.

Resources: Text and diagrams in the Learner's Book.

Description: Work through the text and diagrams in the Learner's Book to slowly build up a complete diagram of the carbon cycle. Involve learners in each step, using questioning to engage them in thinking about what the boxes and arrows mean. Building up the cycle together greatly helps with understanding; the entire cycle can be overwhelming if presented in its entirety.

› **Differentiation ideas:** This is a whole-class activity. Make sure that each learner is involved in answering questions or making suggestions.

2 Think like a scientist: How do plants and animals affect carbon dioxide concentration? (20 mins to set up the experiment; 10 mins to collect results, which can be done at the end of the same lesson, or learners can come back to look at their tubes several hours later)

Learning intention: To bring together earlier work on respiration and photosynthesis.

Resources: Per group:

- six large test tubes, each fitted with a little platform made out of perforated metal (or you can give the pieces of metal to the learners and ask them to make the platforms), and each with a rubber bung to fit tightly
- hydrogencarbonate indicator solution; this must be fresh, and preferably kept with air bubbling through it to ensure it is in equilibrium with the carbon dioxide concentration in the air
- water plants that have been kept in the light and are photosynthesising
- small invertebrate animals; for example, you may be able to obtain fly larvae (maggots) from shops that sell fishing equipment
- blunt forceps
- black paper and sticky tape.

Description: Show learners how to set up the experiment. Ask them to predict the results. Then ask them to follow the instructions in the Learner's Book.

› **Differentiation ideas:** Some learners will need further support in setting up their experiment.

The questions at the end of this task are quite challenging, and it is likely that only some learners will be able to work their way through to question 5 to give successful answers. Be prepared to give more support if necessary.

› **Assessment ideas:** Answers to the questions will give a good indication of how well learners understand the relationship between the gases used and emitted during respiration and photosynthesis.

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3 Activity: Modelling the carbon cycle (20–25 mins)

Learning intention: To make the abstract concept of the carbon cycle more concrete, and hence deepen understanding.

Resources: Coloured card and marker pens for making labels; see the instructions about this in the Learner's Book.

Description: Explain to learners that each of them is going to be a carbon atom. Talk through the instructions with them and explain what they are all going to do. Write the processes that match each number on the die on the board so that everyone can see them clearly.

Place all the 'carbon atoms' in the five labelled places, with roughly equal numbers in each place.

Roll a die and call out the number on it (or you can ask a learner who is not a carbon atom to do this). The learners who are affected by the process indicated by this number move to the appropriate place. Watch them carefully — there is likely to be confusion to start with, but this is all part of the learning process!

Continue until you feel that enough has been done, or all the carbon atoms have ended up together.

› **Differentiation ideas:** Everyone can do this activity. Some learners may find it difficult to link the number to a process, and to link a process to what they are supposed to do; they are likely to cope by following others. Learners who need a challenge can think about the shortcomings of this model, in particular the way in which every carbon atom in one place moves to another at the same time. They could be asked to try modifying the model so that it works better.

Plenary ideas

1 Events in the carbon cycle (10 mins)

Resources: Images of stages in the carbon cycle from the LB or from an online search, or a video clip of events in the carbon cycle from an internet search.

Description: Show learners the pictures of the different stages, or show learners a video clip of the carbon cycle. Ask learners how what they can see in each image (or each stage if using a video clip) relates to a stage in the carbon cycle.

› **Assessment ideas:** Use questioning about the images or the video clip, and answers, to determine how well learners understand the events in the carbon cycle.

2 Fill in the blanks: carbon cycle (10 mins)

Resources: Whiteboard and markers

Description: Set this up as a class exercise. Organise learners into pairs or threes. On the whiteboard, write one stage of the carbon cycle in a box and draw an arrow leading from the box. Ask the first group of learners to suggest which stage comes next. Then move on to the next group to suggest another stage or an arrow, and so on until the whole cycle has been completed.

Homework ideas

1 Workbook Exercise 1.3

2 Worksheets 1.3A, 1.3B, 1.3C

Topic worksheets

- Worksheet 1.3A, Building a carbon cycle (Focus)
- Worksheet 1.3B, Building a carbon cycle (Practice)
- Worksheet 1.3C, Building a carbon cycle (Challenge)

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Topic 1.4 Climate change

LEARNING PLAN

Learning Objectives	Learning intentions	Success criteria
9ESc.02 Describe the historical and predicted future impacts of climate change, including sea level change, flooding, drought and extreme weather events. **9ESs.01** Describe the consequences of asteroid collision with the Earth, including climate change and mass extinctions.	• Be able to relate understanding of the carbon cycle to the causes of global warming • Explain some of the consequences of climate change. • Describe the effects of asteroid collisions with the Earth.	• Be able to list current and predicted impacts of climate change. • Explain how asteroid collisions have affected life on Earth.

LANGUAGE SUPPORT

Learners will use the following words:

slush: partly-melted snow

mass extinction: the complete loss of a very large number of species

meteoroids: objects in space that are smaller than an asteroid

meteors: a meteoroid when it moves through the Earth's atmosphere

meteorite: part of a meteor that reaches the Earth's surface

Common misconceptions

Misconception	How to identify	How to overcome
It is very common for learners to think that the greenhouse effect is a 'bad thing'.	Use questioning after the Getting started activity, to ask: What would the Earth be like if there was no carbon dioxide in the atmosphere? What happens if there is too much?	Take care to use the term 'enhanced greenhouse effect' when you mean the result of increased carbon dioxide in the atmosphere.

Starter ideas

1 Getting started (5–10 mins)

Resources: Diagram in the Learner's Book.

Description: Ask learners to work in pairs to match the statements to the diagram. Then ask for their suggestions and determine the correct label for each arrow.

2 What do you know about climate change? (5–10 mins)

Description: Ask learners: 'Tell me one thing about climate change.'

Go round the class, asking each learner to tell you what they have thought of. Make sure that you limit each learner to only one statement. You may like to write the statements on the board or a flip chart, to refer to as you work through the rest of the topic.

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This activity will elicit preconceptions and help you to determine where you are starting from as you work through this topic.

Main teaching ideas

1 Climate change in the past (20–30 mins)

Learning intention: To understand that climate change is not 'new', and how climate has differed in the past, and why.

Resources: Text and images in the Learner's Book.

Description: Use the Learner's Book as a scaffold for discussing how and why the Earth's climate has changed in the past. You could ask learners for spoken answers to questions 1, 2, 3 and 4.

› **Differentiation ideas:** Use questioning to involve everyone in the discussion, ensuring that even the least-confident learners are encouraged to make a contribution. All learners can contribute, and differentiation will be by the type of questions that they ask and answer.

2 Think like a scientist: How do rising temperatures affect sea level? (30–40 mins)

Learning intention: To understand how melting ice affects sea level.

Resources: Per group:

- two large measuring cylinders
- a large funnel (to hold at least 10 ice cubes)
- access to at least 20 ice cubes
- a conical flask, fitted with a two-hole bung, with a thermometer in one hole and a glass or plastic tube in the other (see the diagram in the Learner's Book); just before the activity begins, fill each flask right to the top with cold water
- a lamp
- optional – a timer

Description: Instructions for this experiment are given in the Learner's Book. You may like to demonstrate how to set up each experiment before asking learners to do so themselves.

› **Practical guidance:** Try to ensure that all the ice cubes are roughly the same size. It is a good idea to trial the experiments yourself, to get an idea of how long it will take the ice to melt. If this takes too long use smaller cubes.

For the second experiment there is no need to record the time at which readings were taken. It is the relationship between temperature and the water level that is being investigated. However, learners may want to make sure that they take readings at roughly the same time intervals, and it is fine for them to do this.

› **Differentiation ideas:** Some learners may need help with constructing the graph, and could be given axes, perhaps with scales, to start them off.

Learners who need a further challenge could be asked to suggest how well these experiments represent what happens in the real world, and how they might modify them to make their models more realistic.

› **Assessment ideas:** Use the results tables, graphs and answers to questions to assess learners.

3 Activity: The carbon cycle and climate change (20–30 mins)

Learning intention: To think about how the carbon cycle affects climate; to begin to think about how we might be able to reduce the negative impacts of climate change.

Note that there is no requirement in the Curriculum Framework to discuss actions that can be taken to mitigate climate change, but it is important to give learners the idea that we *can* do something about it.

Resources: Diagram of the carbon cycle from the Learner's Book. You could also use the video of events in the carbon cycle.

Description: Organise learners into groups of three or four, and ask them to answer the two questions about activities that increase and decrease carbon dioxide concentration. Then, in their group, they should write a list of suggestions about how the increases in carbon dioxide concentration can be halted or even reversed.

You can then chair a discussion, allowing each group to put forward their views.

› **Differentiation ideas:** Everyone should be able to take part in this activity. Working in groups will give confidence to less self-assured learners. More confident learners are likely to suggest a wider range of ideas and have deeper insights into the difficulties in implementing targets that could reduce the impacts of climate change.

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Plenary ideas

1 Impacts of climate change (20–25 mins)

Resources: Learners' responses to Worksheet 1.4, Impacts of climate change.

Description: As you near the end of this topic, set learners Worksheet 1.4. This could be done individually or in small groups, in class or for homework. Each learner puts themselves in the place of one of the people listed on the Worksheet, or someone else of their own choosing, and describes how climate change is affecting their life.

During this plenary session, ask for volunteers to share their descriptions with the rest of the class. Use these descriptions to stimulate discussion of climate change impacts.

› **Assessment ideas:** The descriptions given by the learners, and the discussion, will show how well learners understand the impacts that climate change is having and will have in the future.

2 Team quiz (20–30 mins)

Description: Organise learners into teams of three or four.

Remind them of the topics they have covered in this unit: photosynthesis, the carbon cycle and climate change.

Ask each group to write one question about each of these topics (three questions in all). They must also write the answers.

The first group asks their first question and the other groups try to answer it. The person who gives the correct answer then asks their first question, and so on.

If any group does not answer enough questions to be automatically able to ask their questions you can intervene to give them the opportunity to do so.

› **Assessment ideas:** Both the questions and the answers to them will indicate how well learners remember and understand the facts and concepts covered in this unit.

Homework ideas

1 Workbook Exercise 1.3

2 Worksheet 1.4; this could be done for homework before the final lesson in this topic, and answers used in a plenary session.

Topic worksheets

- Worksheet 1.4, Impacts of climate change

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PROJECT GUIDANCE

This project provides learners with the opportunity to work together to discover more about the events that we believe happened about 67 million years ago when an asteroid collided with Earth.

It is best if you, or the class, decide at an early stage what form the final presentation will take. It could be a display of posters to put onto the wall, or a series of talks or perhaps a video containing presentations from each group.

The guidance in the Learner's Book suggests five different issues to research. Depending on the size of your class, you might like to reduce this number, or possibly add more (or split some of these to make more). You may also like to do your own research first, using the suggested search terms. If learners are not very confident in using the internet and finding reliable information, you may like to suggest some specific websites for them to look at.

The size and make-up of your class will determine how best to organise the groups. Groups of three or four generally work well, ensuring that everyone can be actively involved, and that the workload on any one person is not too great. For this project you may prefer to have mixed-ability groups so that less-confident learners can be supported by others in the group.

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