

# Unit Preparation Booklet

## B4.3 Plant and Material Cycling

Teacher name:

Science
**Mastery**

ArkCurriculum+

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# Steps to Success

| | | What? | Why? | Who? | Page # |
|---|---|---|---|---|---|
| **Preparing to teach** | **1** | ☐ Print this booklet or save a copy in a personal folder | To allow for engagement during planning and co-planning | *All teachers* | |
| | **2** | ☐ Engage with the unit preparation checklist | To prepare for delivering the sequence of lessons | *All teachers* | 4 |
| | **3** | ☐ Read the scope and sequence for the unit | To review the scope and sequence of the unit | *All teachers* | 5 |
| | **4** | ☐ Complete the pre-unit quiz reflections task after administering to class | To plan how to remedy prior knowledge gaps | *New to teaching the unit only* | 11 |
| | **6** | ☐ Complete the Mastery Quiz and exam-style questions activity | To learn/revisit the key assessment objectives of the unit | *New to teaching the unit only* | 12-21 |
| | **7** | ☐ Complete the misconception activities | To develop a strong understanding of the most common misconceptions for the unit and how to address them | *New to teaching the unit only* | 22-24 |
| **Delivering the unit** | **8** | ☐ Use the lesson by lesson objectives to monitor progression through the unit | To maintain a record of completion and to recognise what needs to be reviewed after each lesson | *Novice teachers only* | 25-37 |

| | | | | | |
|---|---|---|---|---|---|
| **Utilise other features of the booklet** | **9** | ☐ Complete the advanced subject knowledge activity | To develop an understanding of where the unit can lead | *Non A-level specialists* | 39 |
| | **10** | ☐ Engage in the keywords | To identify the correct definitions for keywords throughout the unit | *Novice teachers only* | 41 |

# Unit preparation checklist

**Resources can and should be tailored to meet your pupils' needs**. We have aimed to do as much resourcing as possible so that teachers' time can be spent on co-planning and preparation; however, they are only ready for your pupils once you have decided how to make use of them.

**Here is a suggested checklist:**

**Locate:**

- ☐ **Find** the unit resources using MyMastery or SharePoint

**Engage:**

- ☐ Work through the preparation booklet. Complete the pre-unit quiz and mastery quiz yourself and reflect (all enclosed)
- ☐ Set your class the **pre-unit quiz** (in advance of the unit).
- ☐ Note which topics are **areas of weakness** for the class (space available in this booklet or on the planning pro-forma)
- ☐ **Decide** which topics you will re-visit 'in advance' and which to tackle during the unit (space available in this booklet or on the planning pro-forma)
- ☐ Identify where in the sequence of learning there are opportunities for embedding **guided reading**
- ☐ Use the **lesson planning guidance** to develop a grasp of the purpose of each lesson element

**Adapt:**

- ☐ Consider key timings for each lesson. Identify which lessons may need to be adapted to account for the length of your lessons or ability level of your class
- ☐ Identify what could be used as **homework** activities to support in-class learning in line with school policy
- ☐ Review the resources ahead of each lesson and ensure you are clear on the objectives of each lesson
- ☐ **Select** appropriate activities for each lesson from the selection within each lesson folder/on the slide deck

- ☐ **Administer** exit tickets and use outcomes of this to plan 'fix-it' tasks to tackle misunderstanding or misconception.

- ☐ Set the **mastery quiz** for your class. Use the information to plan a suitable re-teach lesson and further response, using the resources available.

# Scope and Sequence

## Scope

This unit covers plant and material cycling, including the process of photosynthesis and the uses of glucose in a plant, as well as limiting factors of photosynthesis. It also includes a review of the structure of the leaf, linking to plant structures and the processes of transpiration and translocation. It covers the photosynthesis required practical activity, as well as two maths in science lessons, to develop students' understanding of rate and using graphs. Finally, it also covers some of the key ecological cycling processes of decay, the carbon cycle and the water cycle, and particularly the role of plants in these.

## Sequence

The unit starts with a recap of KS3 knowledge about microscopes and leaf structure and function. Then we will learning more detail about the processes of transpiration and translocation, learning about the structure and function and function of xylem and phloem. Then the unit progresses into greater depth about photosynthesis and the various ways that plants use glucose. This is the applied by looking at limiting factors of photosynthesis and how these can be interpreted using graphs. The maths in science lessons allow recap of how to draw and use graphs and for HT only, inverse square law, which support the photosynthesis required practical activity. After students apply the learning so far in the practical investigating photosynthesis rate, they will learn about different types of cycling of materials. Understanding how decay, carbon cycle and water cycle function in ecosystems allows a real life application of the knowledge of photosynthesis and respiration. For Taking it Further (separate science) lessons, students will learn about plant infections and the implications this has for photosynthesis. Also, Taking it Further lessons include the required practical of investigating the rate of decay and biogas generators

A full set of knowledge objectives for this unit can be found as **Appendix 3.**

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Prior knowledge review: The leaf and roots | Microscopes: Investigating Stomatal Density | Transpiration | Translocation |
| **5** | **6** | **7** | **8** |
| Photosynthesis and the uses of glucose | Limiting factors in photosynthesis | Maths in Science Lesson 22: Using Graphs | Maths in Science Lesson 23: Inverse Square Law |
| **9** | **10** | **11** | **12** |
| RPA: The Effect of Light Intensity on Photosynthesis 1 | RPA: The Effect of Light Intensity on Photosynthesis 2 | Taking it Further: Plant Diseases and Defences | Material Cycling: Decay |
| **13** | **14** | **15** | **16** |
| Material Cycling: The Carbon Cycle | Material Cycling: The Water Cycle | Taking it Further: Investigating the Rate of Decay | Taking it Further: Biogas Generators |
| **17** | | | |
| Feedback Lesson | | | |

**TASKS:**

| |
|---|
| *New teachers:* Organise the lesson titles into those you feel most to least confident about<br><br>*Experienced teachers:* Reflect on prior experience of teaching this unit. Which lessons have gone well? Which would you like to target for improvement this year? |
| |

# Pre-unit quiz

**TASK:** Below is the pre-unit quiz available for your pupils. Complete yourself and set for your pupils ahead of starting the unit. There is space to record the key outcomes from marking the quiz for your class. **See Appendix 1 for the mark scheme.**

1. Photosynthesis is carried out by organelles called… [1]

   Tick (✓) **one** box.

   A. mitochondria. ☐

   B. chlorophylls. ☐

   C. chloroplasts. ☐

2. The function of the roots in a plant is… [1]

   Tick (✓) **one** box.

   A. to carry out photosynthesis. ☐

   B. absorb water and minerals from the soil. ☐

   C. to transport water around the plant. ☐

3. A student used a microscope to magnify a specimen from a leaf.

   The student wanted to see one cell in more detail.

   Choose the best way to do this. [1]

   Tick (✓) **one** box.

   A. Use the focus wheels ☐

   B. Increase the magnification of the objective lens ☐

   C. Move the stage closer to the objective lens ☐

4. When using a light microscope you should …[1]

   Tick (✓) **one** box.

   A. ensure that the objective lens is touching the slide. ☐

   B. not put your eye too close to the objective lens. ☐

   C. use the lowest power objective lens first. ☐

5. Active transport is the movement of particles from ...[1]

Tick (✓) **one** box.

A. a low concentration to a high concentration, using energy. ☐

B. a high concentration to a low concentration, using energy. ☐

C. a low concentration to a high concentration, without energy. ☐

D. a high concentration to a low concentration, without energy. ☐

6. Choose the correct word equation for aerobic respiration. [1]

Tick (✓) **one** box.

A. Glucose ⟶ lactic acid ☐

B. Glucose + oxygen ⟶ carbon dioxide + water ☐

C. Carbon dioxide + water ⟶ glucose + oxygen ☐

7. Choose the correct word equation for photosynthesis. [1]

Tick (✓) **one** box.

A. Chlorophyll + carbon dioxide ⟶ glucose + oxygen ☐

B. Glucose + oxygen ⟶ carbon dioxide + water ☐

C. Carbon dioxide + water ⟶ glucose + oxygen ☐

8. Stomata are tiny holes on the underside of a leaf.

Choose why this is a good adaptation for photosynthesis. [1]

Tick (✓) **one** box.

A. They are the site of photosynthesis ☐

B. Oxygen, carbon dioxide and water vapour can pass in and out of the leaf cells ☐

C. Allows the plant to breathe ☐

9. A student wanted to test whether starch was present in a leaf and the start of the method is shown below.

*1. Place leaf in boiling water for 1 minute*
*2. Transfer leaf to test tube containing ethanol*
*3. …*

Choose the correct option to complete method. [1]

Tick (✓) **one** box.

A. If the test tube is black then there is starch present. ☐

B. Take out the leaf and add iodine solution. If it turns to a black colour, then starch is present. ☐

C. Take out the leaf and if there are green patches, then this shows where the starch is. ☐

10. This is an image from a light microscope.




The length of the scale bar is 1 cm.

Calculate the magnification used. [1]

Tick (✓) **one** box.

A. 0.1 ☐

B. 100 ☐

C. 1000 ☐

**Total = ___ /10**

## Pre-unit quiz reflections

*To be completed once you have reviewed your pupils' response to the pre-unit quiz.*

| What topics are your pupils confident with? |
| --- |
| |
| What topics need to be reviewed? |
| |
| What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach? |
| |
| What could be interleaved throughout the unit? |
| |

**Other notes**

# Mastery Quiz

**TASK:** Below is the mastery quiz available for your pupils to sit at the end of the unit. Complete yourself and consider the key misconceptions this quiz aims to address. See **Appendix 2** for the mark scheme.

## Section A

1. Choose the correct word equation for photosynthesis.

   Tick (✓) **one** box. [1]

   A. Water + carbon dioxide → glucose + oxygen ☐

   B. Carbon dioxide + glucose → water + oxygen ☐

   C. Glucose + oxygen → carbon dioxide + water ☐

2. Choose the correct function of xylem.

   Tick (✓) **one** box. [1]

   A. To transport dissolved sugars around the plant ☐

   B. To transport water and minerals from the roots to the stems and leaves ☐

   C. To allow gases to pass into and out of the leaf ☐

3. Plants may use glucose…

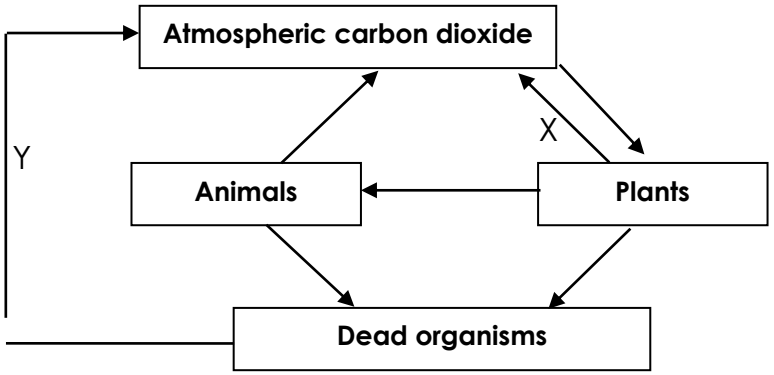
   Tick (✓) **one** box. [1]

   A. to produce amino acids for protein synthesis. ☐

   B. as a reactant for photosynthesis. ☐

   C. in the process of transpiration. ☐

4. Below shows a diagram of the carbon cycle.




(a) Choose the label at **X** on the diagram.

Tick (✓) **one** box. [1]

A. Photosynthesis ☐

B. Respiration ☐

C. Decay ☐

(b) At label Y on the diagram…

Tick (✓) **one** box. [1]

A. bacteria breaks down dead tissues. ☐

B. the process of decay absorbs carbon dioxide. ☐

C. microorganisms involved in decay are respiring. ☐

5. A light microscope can be used to observe a specimen on a slide.

To focus the image the stage must always be moved in one direction, away from the objective lens …

Tick (✓) **one** box. [1]

A. to make the image appear clearer. ☐

B. to prevent causing damage to the slide and lens. ☐

C. because the focusing wheel only rotates one way. ☐

6. A student measured the rate of transpiration of a plant shoot.

The volume of water uptake was 4 $mm^3$ in 2 minutes.

Choose the correct rate of transpiration.

Tick (✓) **one** box. [1]

A. 2 $mm^3$/min ☐

B. 4 $mm^3$/min ☐

C. 0.5 $mm^3$/min ☐

7. The spongy mesophyll is well adapted for its function because…

Tick (✓) **one** box. [1]

A. it contains many chloroplasts for photosynthesis. ☐

B. it has a large surface area to absorb light. ☐

C. it contains air spaces for diffusion of gases. ☐

8. A student investigated how temperature affected the rate of transpiration of a plant shoot.

They repeated the measurements at each temperature and part of the results are shown below.

| **20°C temperature** | |
|---|---|
| Repeat | Transpiration rate ($mm^3$/min) |
| 1 | 7.9 |
| 2 | 42.9 |
| 3 | 27.2 |
| **Mean** | 26.0 |

These results are …

Tick (✓) **one** box. [1]

A. precise because a mean has been calculated. ☐

B. precise because repeat readings have been taken. ☐

C. not precise because the repeat readings vary too much. ☐

D. not precise because repeat 3 is too similar to the mean. ☐

9. Choose the effect on the water cycle if the temperature of an ecosystem increased.

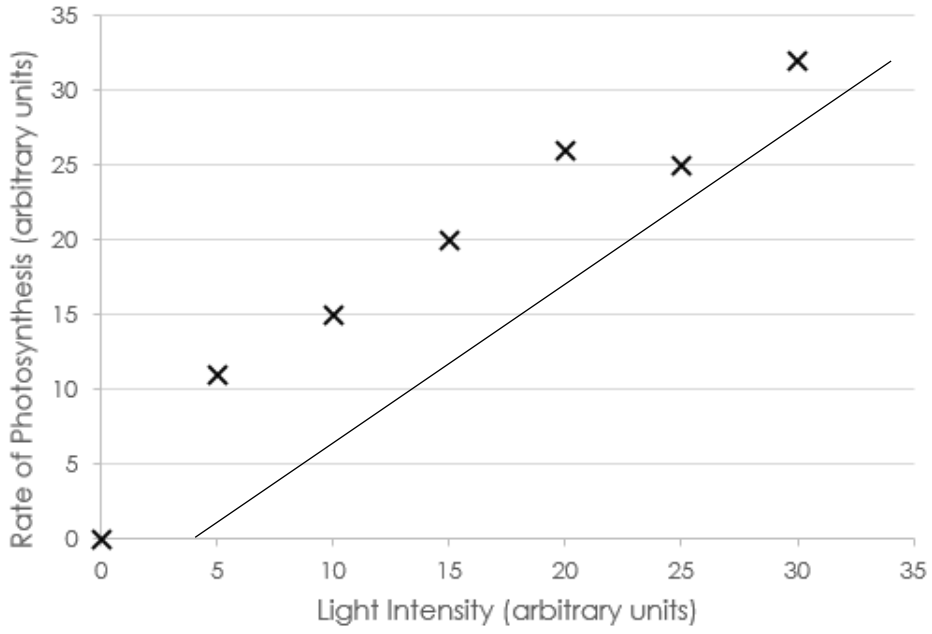
Tick (✓) **one** box. [1]

A. There would be less precipitation ☐

B. Water would evaporate at a greater rate ☐

C. There would be more water in lakes and the sea ☐

10. Choose how to improve the line graph below.




Tick (✓) **one** box. [1]

A. The scales of the axes should be shorter ☐

B. Units need to be included on the axes labels ☐

C. The line of best fit should go through more plot points ☐

11. Phloem in a plant transports…

Tick (✓) **one** box. [1]

A. dissolved sugars from leaves to the rest of the plant for use. ☐

B. water from leaves to roots for cells to carry out photosynthesis. ☐

C. elongated cells for translocation. ☐

12. Guard cells are involved in transpiration because they…

Tick (✓) **one** box. [1]

A. pull water up through the transpiration stream. ☐

B. connect to xylem to transport water efficiently. ☐

C. control whether stomata are open or closed. ☐

13. Someone was growing tomato plants in a greenhouse on a hot, bright summer day.

Choose which of the following is a limiting factor of photosynthesis for tomato plants.

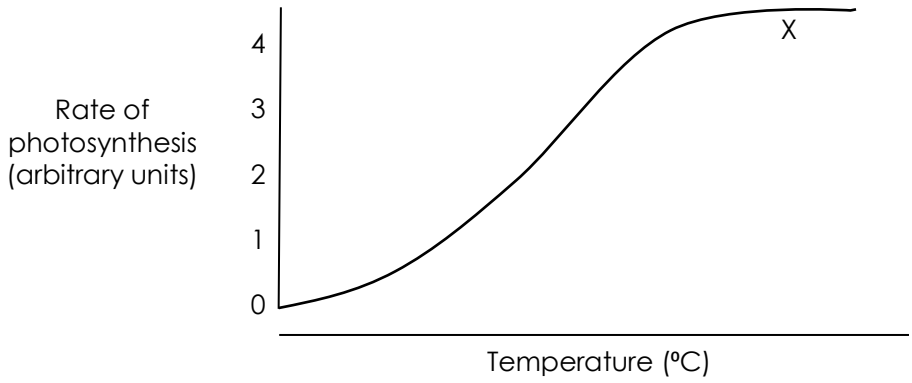
Tick (✓) **one** box. [1]

A. Carbon dioxide ☐

B. Sunlight ☐

C. Temperature ☐

14. The graph below shows how temperature affects the rate of photosynthesis of an aquatic plant.




Choose which is a limiting factor of photosynthesis at point X on the graph.

Tick (✓) **one** box. [1]

A. Temperature ☐

B. Carbon dioxide ☐

C. Water ☐

***Questions 15 – 16 are suitable for higher tier only***

15. A student investigated how the distance of a lamp affected the rate of photosynthesis of the aquatic plant, *Elodea*.

(a) They plotted $\frac{1}{d^2}$ on the x-axis (where d is distance) because…

Tick (✓) **one** box. [1]

A. it is proportional to light intensity. ☐

B. distance is directly proportional to light intensity. ☐

C. the rate of photosynthesis is directly proportional to distance. ☐

(b) Using the inverse square law, calculate the light intensity if the distance of the lamp is 2 cm.

Tick (✓) **one** box. [1]

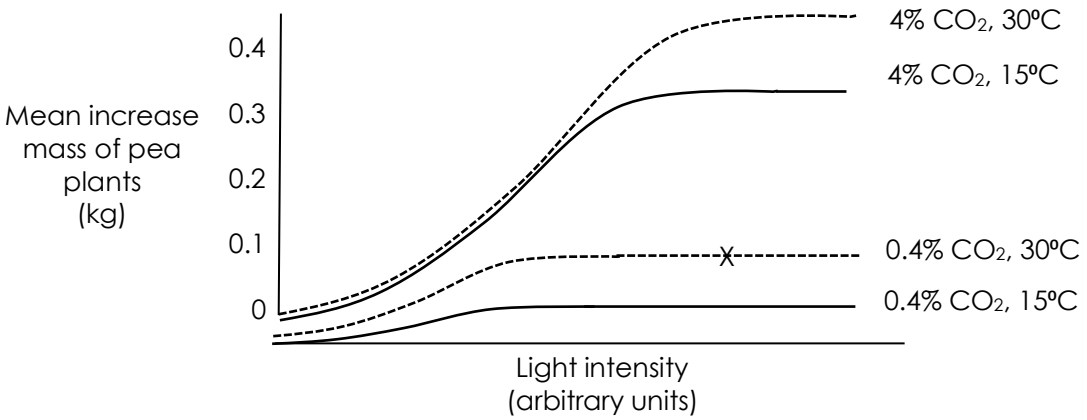
A. 0.25 ☐

B. 4 ☐

C. 0.5 ☐

16. A farmer was growing pea plants in a large greenhouse to sell to supermarkets.

The graph below shows the effect of different factors on the increase in mass of pea plants, 60 days after seedlings were planted.




(a) Choose the best description of what is happening at point X on the graph.

Tick (✓) **one** box.[1]

A. Temperature is a limiting factor of photosynthesis ☐

B. Carbon dioxide concentration is a limiting factor of photosynthesis ☐

C. Light intensity is a limiting factor of photosynthesis ☐

(b) The farmer must increase pea plant growth to maximise profits.

One consideration the farmer must make is…

Tick (✓) **one** box. [1]

A. how to minimise the carbon dioxide concentration. ☐

B. to choose the conditions that produce the greatest mass of pea plants. ☐

C. comparing the cost of heating to the sale cost of the pea plants. ☐

## Section B

1. Write a balanced symbol equation for photosynthesis.

_____

2. Describe two ways that a plant stores glucose.

1. _____
2. _____

3. Below shows a student's method for investigating how light affects the rate of photosynthesis.

1. *Place pondweed in a test tube of water*
2. *Put the test tube in a rack*
3. *Put it near a lamp and count the bubbles of oxygen*
4. *Move the lamp to a different position and count the bubbles again*

Suggest how this method could be improved and explain how this would produce valid results.

4. In winter, some leaves die and fall off blackberry bushes.

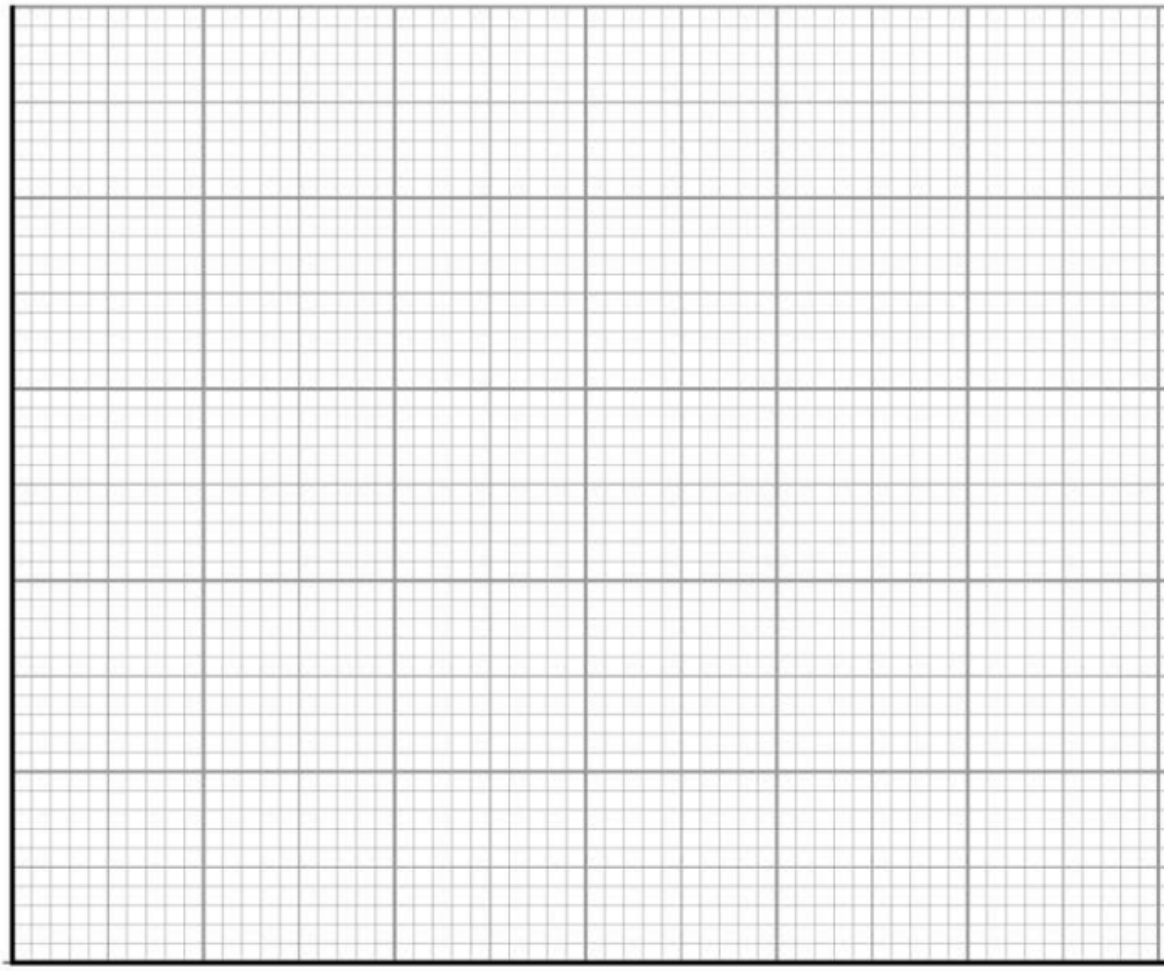
   Explain how carbon from the dead leaves is recycled into the growth of new leaves.

5. The results table below shows how temperature affects the number of oxygen bubbles produced by an aquatic plant.

   Plot a line graph of the results on the graph paper below.

   Draw a line of best fit.

| Distance from light source (cm) | Mean number of bubbles per minute |
|---|---|
| 10 | 49 |
| 20 | 45 |
| 30 | 27 |
| 40 | 26 |
| 50 | 12 |



## Mastery quiz reflections

| Which aspects of this unit are likely to be the most challenging to teach? | |
|---|---|
| | |
| What are your pupils likely to find most challenging and why? | |
| Challenging..... | Because.... |
| *E.g. The number of new keywords* | *They are abstract words that aren't used in other areas of science* |
| | |
| | |

| | |
|---|---|
| | |
| How can you pre-empt some of the key misconceptions the mastery quiz aims to identify? | |
| **Misconception** | **How to avoid** |
| | |
| | |
| | |
| | |

## Exam-style questions

**TASK:** Using Exampro (or the software used by your exam board), look through the typical exam-style questions for this topic. These sorts of questions are posed throughout the unit and pupils should be prepared to answer similar questions in the end-of-year assessments.

Suggested questions to guide this process:

| How is knowledge from this unit typically assessed? What are the most common questions? |
|---|
| |
| Which question types are the most challenging? |

| |
|---|
| |
| What general trends can you spot in the typical errors pupils make (from examiner reports/notes)? |
| |
| How could you help prepare your students for answering these types of questions? |
| |

# Common mistakes, errors and misconceptions

How would you tackle the following common mistakes, errors and misconceptions by pupils?

**TASK:** Consider why each of the following typically seen statements is a mistake/misconception. What possible approaches can you plan to pre-empt and respond to this? Which lessons do these correlate to?

CHALLENGE: Cover the middle column and explain yourself why each is a mistake.

| **Mistake** | **Reason why it's a mistake** | **Possible approaches to pre-empt and respond?** |
|---|---|---|
| Plants carry out photosynthesis instead of respiration | Plants carry out both photosynthesis and respiration. All living things carry out respiration. | |
| Photosynthesis creates energy for plants | Photosynthesis takes in energy from the Sun and use it to build glucose. | |
| Plants don't have tissues or organs because they are not animals | A tissue is a group of the same cells, so plants have tissues and organs. | |
| Decay produces carbon dioxide | Decomposers respire during decay, which produces carbon dioxide | |
| The water cycle only involves evaporation and precipitation | The water cycle involves lots of different processes, of which evaporation and precipitation are just two. | |
| The carbon cycle only involves carbon dioxide. | The carbon cycle involves all carbon compounds, including glucose and other carbohydrates, and hydrocarbons in fossil fuels. | |
| The rate of photosynthesis is only affected by light intensity. | The rate of photosynthesis is affected by light intensity, temperature and carbon dioxide availability. | |
| Light intensity is inversely proportional to distance from a light source. | Light intensity is inversely proportional to the distance from a light source squared. | |

## Planning for the misconceptions

| **Misconception: Plants carry out photosynthesis instead of respiration.** |
|---|
| Many students confuse the processes and struggle to understand that plants can do both. |
| **Supporting pupil understanding**<br>It can be useful to review with students the basics of MRS GREN, of which one of the Rs stands for respiration. This means it is a life process, carried out by all living things.<br><br>Then when covering uses of glucose, it is easier to revisit the use of glucose as a reactant in respiration in plants. |

| **Misconception: The carbon cycle only involves the cycling of carbon dioxide in respiration and photosynthesis.** |
|---|
| The carbon cycle includes the cycling of carbon through many different carbon compounds. |
| **Supporting pupil understanding**<br>When looking at diagrams of the carbon cycle, it is worth explicitly annotating the carbon compounds that are involved at each stage:<br>- $CO_2$ taken in for photosynthesis<br>- $CO_2$ released through respiration<br>- $CO_2$ released by burning fossil fuels<br>- Hydrocarbons formed in fossil fuel formation<br>- Glucose and starch passed on through food chains |

# Unit objectives: knowledge, skills and concepts

As you teach the lessons, track here the objectives you meet.

TKT = to know that  TBAT = to be able to

**Critical:** it is critical that all pupils become proficient; future learning will be very challenging for them if they do not and it is likely they will not come across this content again. These are priority objectives for reteaching, revision, and intervention. Before moving on, discuss a strategy with your HOD if some pupils are not making progress with these objectives.
**Core:** it is important for all pupils to learn this, and it will be essential for success at GCSE. However, it will not impede them in other units if they are not (yet) proficient in it as they are likely to revisit it again in subsequent units.
**Stretch:** pupils should have the opportunity to work on this aspect of science. This content is crucial for pupils to achieve the highest GCSE grades and to succeed at A-level.
**Key skill:** pupils should have the opportunity to develop this key skill as part of this unit.

*Intended outcome for separate sciences pupils are denoted in blue and italised.*

## Lesson 1: Prior Knowledge Review: The Leaf and Roots

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document*<br>**This lesson is a review of content from previously studied units relating to this big idea | |
| TBAT state the word and symbol equation for photosynthesis | State the word equation for photosynthesis<br>State the symbol equation for photosynthesis<br>State the balanced symbol equation for photosynthesis |
| TBAT describe the structure and function of leaf tissues | Describe the adaptations in a leaf<br>Describe how each part of a leaf is adapted for its function<br>State the function of the epidermis<br>State the function of the waxy cuticle<br>Name the gases needed for photosynthesis<br>Describe how plant cells obtain these gases |
| TBAT explain why active transport is needed to transport mineral ions from soil into roots | Define active transport<br>Explain the difference between active transport and diffusion<br>Explain why active transport is needed for mineral ions into the roots |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 2: Microscopes: Investigating Stomatal Density

| Intended outcome | Example questions |
|---|---|
| *These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT describe how to use a light microscope | Name the parts of a microscope<br>Describe the function of the different parts of a microscope<br>Name the part of the microscope that can be used to change the magnification |
| TBAT Use the equation magnification = size of image / actual size of object | State the equation that is used to calculate the actual size of a cell or sample<br>Convert units<br>Calculate magnification<br>Describe how to measure the image length of a cell on a microscope slide |
| TBAT Compare light and electron microscopes | Explain the difference between a light microscope and an electron microscope<br>Compare the resolution and magnification of a light microscope and an electron microscope |
| What did the Exit ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 3: Transpiration

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT describe how water is transported along the transpiration stream | Describe the process of transpiration<br>Name the parts of a plant involved in transpiration<br>Name the process by which water moves from the leaf to the atmosphere |
| TBAT explain why transpiration happens | Explain why transpiration happens<br>Explain why transpiration is important for plants |
| TBAT predict how different factors affect transpiration rate | Name the factors that affect the rate of transpiration<br>Describe how each factor affects the rate of transpiration<br>Predict how given conditions will affect the rate of transpiration |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 4: Translocation

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT describe the process of translocation | Describe the process of translocation<br>Explain why translocation is important for plants |
| TBAT explain how the structure of phloem is adapted to its function | Describe the structure of phloem<br>Explain how the structure of phloem is adapted to its function |
| TBAT compare the functions of xylem and phloem | Compare the functions of xylem and phloem<br>Compare the structures of xylem and phloem |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 5: Photosynthesis and the Uses of Glucose

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT state the word and symbol equation for photosynthesis | State the word equation for photosynthesis<br>State the balanced symbol equation for photosynthesis<br>Describe where each of the reactants, sunlight and chlorophyll come from |
| TBAT describe the function of chlorophyll and chloroplasts | Describe the function of chlorophyll<br>Name the organelle that contains chlorophyll |
| TBAT explain various uses of glucose in plants | Describe the different uses of glucose<br>Describe the function of starch<br>Describe the function of cellulose<br>Explain how plants use glucose |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 6: Limiting Factors in Photosynthesis

| Intended outcome | Example questions |
|---|---|
| *These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT define a limiting factor | Define a limiting factor<br>Describe the factors that can affect the rate of photosynthesis |
| TBAT Interpret graphs showing the effect of limiting factors on the rate of photosynthesis | Explain how each of these factors affects the rate of photosynthesis<br>Identify the limiting factor at point X on the graph |
| TBAT explain graphs showing the effect of limiting factors on the rate of photosynthesis | Explain why one factor is the limiting factor at a point on a graph |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 7: Maths in Science Lesson 22 Using Graphs

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT draw line graphs | Draw suitable scales on each axis<br>Plot two variables on a line graph |
| TBAT draw a line of best fit | Draw a line of best fit<br>Draw a curve of best fit<br>Describe when to use a curve of best fit |
| TBAT calculate gradient of a graph | Describe how to calculate the gradient of a graph<br>Calculate the gradient of a graph |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 8: Maths in Science Lesson 23 Inverse Square Law

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT explain what is meant by inverse square law | Explain what it means for variables to be inversely proportional<br>Explain what inverse square law means |
| TBAT determine inverse square law using a graph | Identify inversely proportional and directly proportional relationships on a graph |
| TBAT interpret values from an inverse square graph | Use inverse square law to determine light intensity at a given distance, using a graph<br>Use inverse square law to determine distance from a lamp with a given light intensity, using a graph |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 9 and 10: Required Practical Activity – The Effect of Light Intensity on Photosynthesis

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT describe how to investigate how light intensity affects the rate of photosynthesis | Describe a suitable method<br>Identify dependent, independent and control variables |
| TBAT calculate rates of photosynthesis | Calculate rate of photosynthesis from a graph |
| TBAT (HT Only) To use the inverse square law to determine light intensity | Use inverse square law to determine light intensity at a given distance, using a graph<br>Use inverse square law to determine distance from a lamp with a given light intensity, using a graph |
| What did the Exit Ticket data tell me?<br><br>• Describe how to investigate how light intensity affects the rate of photosynthesis<br>• Calculate rates of photosynthesis<br>• (HT Only) To use the inverse square law to determine light intensity | |
| What do I need to review in future lessons? | |

## Lesson 11: Taking it Further Plant Diseases and Defences

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT describe TMV and rose black spot diseases in plants | Describe the symptoms of TMV<br>Describe the symptoms of rose black spot |
| TBAT explain how plant diseases affect photosynthesis | Explain how TMV affects a plants ability to photosynthesise<br>Explain how rose black spot affects a plants ability to photosynthesise |
| TBAT describe chemical, physical and mechanical plant defences | Describe chemical defences in plants<br>Describe physical defences in plants<br>Describe mechanical defences in plants |
| TBAT (HT Only) describe methods to identify plant diseases | Describe methods to identify plant diseases |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 12: Material Cycling: Decay

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT define decay | Define decay<br>Describe what happens when plants and other organisms die |
| TBAT describe how decay happens | Describe what happens when organisms decay<br>Explain why decay is important for ecosystems |
| TBAT explain the role of microorganisms in decay | Define decomposers<br>Give examples of types of organisms that are decomposers |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 13: Material Cycling: The Carbon Cycle

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT describe the carbon cycle | Name some processes involved in the carbon cycle |
| TBAT state how different processes affect the carbon cycle | Describe the role of respiration in the carbon cycle<br>Describe the role of photosynthesis in the carbon cycle<br>Describe the role of feeding in the carbon cycle |
| TBAT explain the role of decomposing microorganisms in the carbon cycle | Explain how decomposers are involved in the carbon cycle<br>Name the process by which microorganisms release $CO_2$ to the atmopshere |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 14: Material Cycling: The Water Cycle

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT name the different processes involved in the water cycle | Define evaporation<br>Define condensation<br>Define precipitation<br>Define groundwater flow |
| TBAT identify different processes from the water cycle | Identify process X that adds water vapour to the atmosphere<br>Identify process Y that takes water from the atmosphere |
| TBAT describe the factors that affect the rate of evaporation | Describe the factors that affect the rate of evaporation |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 15: Taking it Further Investigating the Rate of Decay

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT describe the factors that affect rate of decay | Describe the factors that affect rate of decay<br>Explain why each factor affects the rate of decay |
| TBAT describe the relationship between temperature and rate of decay | Describe the effect of temperature on the rate of decay<br>Explain what happens to the rate of decay at high temperatures |
| TBAT explain why gardeners aim to increase the rate of decay | Explain why gardeners want to increase rate of decay<br>Explain the function of compost |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Lesson 16: Taking it Further Biogas Generators

| Intended outcome | Example questions |
|---|---|
| **These are the main objectives of the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document* | |
| TBAT describe the process of anaerobic decay | Describe the conditions for anaerobic decay<br>Name the products of anaerobic decay |
| TBAT explain how biogas generators can be used as an energy resource | Describe how biogas can be used to generate energy<br>Explain why this is a renewable resource |
| TBAT evaluate the environmental impact of biogas generators | Describe the advantages of biogas generators<br>Describe the disadvantages of biogas generators<br>Evaluate the use of biogas generators |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

## Mastery Quiz re-teach planning

*To be completed once you have reviewed your pupils' response to the mastery quiz.*

| What topics are your pupils confident with? |
| --- |
| |
| What topics need to be reviewed? |
| |
| What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach? |
| |
| What could be interleaved throughout another unit? When will that be taught? |
| |

**Other notes**

## Lesson 17: Feedback lesson

| Intended outcome | Example questions |
|---|---|
| Edit based upon your classe's performance in the Mastery Quiz | |
| | |
| | |
| What did the Exit Ticket data tell me? | |
| What do I need to review in future lessons? | |

# Advanced subject knowledge

**Where does this learning lead?**

In A-level biology, many of the fundamental principles of photosynthesis and material cycling are developed into much greater detail.

**Mass transport in plants -** Xylem as the tissue that transports water in the stem and leaves of plants. The cohesion-tension theory of water transport in the xylem.

Phloem as the tissue that transports organic substances in plants. The mass flow hypothesis for the mechanism of translocation in plants. The use of tracers and ringing experiments to investigate transport in plants.

**The light-dependent and light-independent reactions of photosynthesis –** students should be able to identify environmental factors that limit the rate of photosynthesis and evaluate data relating to common agricultural practices used to overcome the effect of these limiting factors.

*Have a look at the questions below and think about what this means for this unit.*

| How does learning from this unit develop at KS5? |
| --- |
| |
| What content from this unit is fundamental to student understanding at KS5? |
| |
| How could you check that students have grasped these fundamentals? |
| |

## Vocabulary and literacy

| | |
|---|---|
| **Amino acids** | **Molecules that are the building blocks that form proteins.**<br>*Protease enzymes break down proteins into **amino acids**.* |
| **Atmosphere** | **The mixture of gases that surround the Earth.**<br>*Carbon is released into the **atmosphere** when organisms respire.* |
| **Biogas Generator** | **A container that produces methane gas as a fuel, using anaerobic decay.**<br>***Biogas generators** are used to produce methane.* |
| **Carbon Cycle** | **A series of different processes that absorb carbon dioxide or release carbon dioxide into the atmosphere. This allows carbon to be cycled around an ecosystem.**<br>*Photosynthesis is a part of the **carbon cycle** because it is a process that absorbs carbon dioxide from the atmosphere.* |
| **Cellulose** | **A substance found in plant cell walls that is made from glucose.**<br>***Cellulose** strengthens cell walls in plants.* |
| **Chloroplast** | **Organelle that contains the green pigment, chlorophyll, which absorbs light energy for photosynthesis**<br>*The **chloroplast**, found only in algal and plant cells, is **a cell organelle that produces energy through photosynthesis.*** |
| **Chlorophyll** | A green pigment used to **convert sunlight energy into chemical energy through the process of photosynthesis.**<br>***Chlorophyll** absorbs energy from sunlight, and this energy is later used to convert carbon dioxide into carbohydrates.* |
| **Compost** | A mixture of decaying organisms that is used to fertilise plants.<br>*The decay of **compost** will be slower when the temperature is lower because microorganisms are less active.* |

| | |
|---|---|
| **Concentration gradient** | When there are two areas where a substance is of different concentrations.<br>*A substance diffuses down its **concentration gradient** from a high concentration to a lower concentration.* |
| **Cuticle** | A **waxy waterproof** layer which reduces water loss, it is transparent to allow light through the leaf.<br>*Leaves have a layer of **cuticle** to reduce water loss.* |
| **Decay** | The breakdown of dead organisms into more basic building blocks.<br>*In order for cycling of materials in ecosystems, dead organisms must **decay**.* |
| **Diffusion** | **Movement of a particles from a region of high concentration to a region of low concentration**.<br>*Oxygen and carbon dioxide enters and leaves plant through the process of **diffusion**.* |
| **Ecosystem** | **Interaction between a community of living organisms and their environment**.<br>*An **ecosystem** is two or more populations of organisms (usually many more) in their environment.* |
| **Epidermis** | Epidermis is **the outermost layer of (skin or leaves).**<br>*The wooden splinter is just beneath the **epidermis** of my left foot.* |
| **Evaporation** | A process that happens at the surface of a liquid as it boils. Evaporation can occur over a large range of temperatures<br>*Water **evaporates** from lakes into the atmosphere.* |
| **Glucose** | One of a group of carbohydrates known as simple sugars<br>***Glucose** is required for respiration.* |
| **Guard Cells** | Cells that surround a stoma and control whether the stoma is open or closed<br>*Two **guard cells** can be seen surrounding a single stoma under the microscope.* |

| | |
|---|---|
| **Humidity** | The concentration of water vapour in the atmosphere<br>*An increase in **humidity** causes the transpiration rate to decrease.* |
| **Interdependence** | Organisms depend on each other to survive.<br>*In biology, we learn about types of **interdependence** in which two organisms feed off each other* |
| **Lignin** | A molecule found in plants that strengthens cell walls.<br>*Xylem vessels are strengthened by **lignin.*** |
| **Limiting Factor** | A variable in the environment that when in limited supply stops the maximum rate of a process.<br>***Light intensity** is a limiting factor of photosynthesis.* |
| **Mesophyll** | The part of a leaf between two thin surface layers containing the cells responsible for photosynthesis.<br>*Plant tissues includes epidermis, palisade **mesophyll** and spongy **mesophyll.*** |
| **Methane** | A small covalent molecule, $CH_4$, that is a gas at room temperature. It is burnt when it is used as a fuel.<br>***Methane** is used in gas taps and in cooking because it is a good fuel.* |
| **Microorganisms** | Microscopic organisms that can survive when unicellular. Also called microbes.<br>*Bacteria, fungi and viruses are all examples of **microorganisms.*** |
| **Mitochondria** | Part of the cell where energy is released.<br>*Most respiration happens in the **mitochondria.*** |
| **Non-photosynthetic** | Plants that does not photosynthesise.<br>*Some plants are **non-photosynthetic** and parasitic, obtaining their food through a host.* |
| **Pathogen** | A microorganism that causes a disease<br>*Some bacteria and viruses are **pathogens.*** |
| **Photosynthesis** | Photosynthesis is a chemical reaction that requires light and takes place in chloroplasts in plant cells. Carbon dioxide and water react to produce glucose and oxygen. |

| | |
|---|---|
| | ***Photosynthesis*** *happens in the leaves of a plant.* |
| **Photoautotroph** | Plants that make their own food using photosynthesis.<br>*Most plant are* ***photoautotroph****.* |
| **Phloem** | Tissue that forms vessels to transport dissolved sugars and other nutrient molecules around the plant.<br>***Phloem*** *tissue is adapted to its function because it is formed of elongated tubes, ideal for transporting solution.* |
| **Precipitation** | Liquid or solid water formed in the atmosphere than falls back to Earth.<br>***Precipitation*** *could fall as rain, snow, sleet or hail.* |
| **Products** | **Substance that is formed as the result of a chemical reaction.**<br>***Lactic acid is the product of anaerobic respiration.*** |
| **Producers** | Plants or algae which photosynthesise.<br>*At the base of almost every food chain is a* ***producer.*** |
| **Profit** | The money gained when a product is sold for more than it cost to produce.<br>*A farmer maintains* ***profits*** *by selling crops for more money than it cost to produce them****.*** |
| **Rate** | The change of a quantity, per unit time.<br>*The* ***rate*** *of a reaction is a measure of how quickly a reactant is used up, or a product is formed.* |
| **Reactants** | Substance that is used up in a chemical reaction<br>*Glucose is one of the* ***reactants*** *of respiration.* |
| **Respiration** | A chemical reaction that happens in every cell of every living thing. It is essential for life because it releases energy.<br>Oxygen + glucose → carbon dioxide + water<br>***Respiration*** *is carried out in all cells continuously.* |
| **Rose Black Spot** | A fungal disease of plants where purple/black spots form on leaves. |

| | |
|---|---|
| | *Plants with **rose black spot** cannot photosynthesise because they cannot absorb light where there are black spots on leaves.* |
| **Stomata**<br>**(sing. stoma)** | **Microscopic pores found on the epidermis of plants**.<br>*Guard cells control whether a **stoma** is open or closed. Most **stomata** are found on the underside of leaves.* |
| **Synthesis** | **Producing a compound by a chemical reaction of simpler substances.**<br>*Glucose is used to **synthesise** cellulose.* |
| **Tobacco Mosaic Virus (TMV)** | **A viral disease of plants that causes a distinct 'mosaic' pattern of discolouration on leaves.**<br>*Plants with **tobacco mosaic virus** cannot photosynthesise because they cannot absorb light where leaves are discoloured.* |
| **Translocation** | The movement of dissolved sugars/food molecules through phloem tissue<br>***Translocation** ensures that important nutrient molecules such as glucose are transported to where they are needed by the plant.* |
| **Transpiration** | Movement of water through a plant from where is absorbed at the roots to where it evaporates through stomata.<br>*The **transpiration stream allows water to be transported around a plant.*** |
| **Xylem** | **A type of tissue that forms vessels that transport water and minerals from the roots up the plant stem and into the leaves**.<br>*The cells that make up the **xylem** are adapted to their function because they are strengthened with lignin.* |

# Appendices

## Appendix 1: Mark scheme for pre-unit quiz

| Qu | Answer | Marks | Supporting information for fix-it tasks |
|---|---|---|---|
| 1 | C | 1 | Answering A suggests the common confusion of where respiration and photosynthesis are carried out. *To fix it, ask students to complete a table about photosynthesis and respiration with the headings: function, where carried out, word equation.*<br><br>Answering B suggests a misconception that chlorophyll is an organelle. *To fix it, recap that chlorophyll is a green pigment that is contained in chloroplasts and has the function of absorbing light for photosynthesis. Then ask students to explain the difference between chloroplasts and chlorophyll.* |
| 2 | B | 1 | Answering A suggests the misconception that all organs of plants carry out photosynthesis. *To fix it, ask students to explain why there are no chloroplasts in root hair cells.*<br><br>Answering C suggests a confusion between xylem/transpiration stream with the function of the roots. *To fix it, recap how water is transported from the soil to out of the stomata and then ask students to write a flow chart showing where water is transported in a plant.* |
| 3 | B | 1 | Answering A or C shows confusion about the functions of different parts of the microscope. *To fix it, ask students to compare the functions of the objective lens, eyepiece lens and focussing wheels to reinforce the different functions. This can be done as an annotation of a diagram following a discussion or as a written paragraph.* |
| 4 | C | 1 | Answering A suggests a gap in knowledge because option A is an example of what students should **not** do. *To fix it, students should annotate a microscope diagram with the steps they should follow to view cheek cells under the light microscope.*<br><br>Answering B suggests that students have confused the objective and eyepiece lens. *To fix it, students should label a microscope diagram with particular focus towards the different lenses and then students should describe the functions of the eyepiece and objective lenses.* |
| 5 | A | 1 | Answering B suggests the correct knowledge that energy is required, but the concentration gradient described is for diffusion. *To fix it, ask students to describe an example in* |

| | | | |
|---|---|---|---|
| | | | *an organism where active transport is used, ensuring they include the concentration gradient.*<br><br>Answering C suggests some understanding, since the concentration gradient here is correct, however it identifies a gap in knowledge that energy is required. *To fix it, ask students to explain why energy is required in active transport.*<br><br>Answering D suggests a confusion with the definition for diffusion. *To fix it, ask students to compare and contrast diffusion and active transport.* |
| 6 | B | 1 | Answering A suggests a confusion between aerobic and anaerobic respiration in animals. *To fix it, ask students to explain the difference between aerobic respiration and anaerobic respiration.*<br><br>Answering C suggests a confusion between aerobic respiration and photosynthesis. *To fix it, reteach the different purposes and word equations for aerobic respiration and photosynthesis.* |
| 7 | C | 1 | Answering A suggests the misconception that chlorophyll is a reactant in photosynthesis. *To fix it, ask students to write out the correct word equation for photosynthesis and then describe the role of chlorophyll in photosynthesis.*<br><br>Answering B suggests a confusion about the reactants and products of photosynthesis vs respiration. *To fix it, ask students to copy out the correct word equations and then annotate each substance to describe where the plant gets reactants from or where the products go/are used.* |
| 8 | B | 1 | Answering A suggests the misconception that stomata are the site of photosynthesis. *To fix it, ask students to describe the function of leaf cells and the function of stomata.*<br><br>Answering C suggests the misconception that plants breathe. *To fix it, ask students to describe how carbon dioxide gets into leaf cells.* |
| 9 | B | 1 | Answering A suggests some recollection about there being a colour change in this practical, however it shows a gap in knowledge about the iodine solution test for starch. *To fix it, reteach how to test for the presence of starch and then ask students to write out a complete method for this.* |

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|---|---|---|---|
| | | | Answering C suggests a misconception that chlorophyll and starch are the same. *To fix it, ask students to write descriptions of the functions of starch and chlorophyll using these key words: store, sunlight, glucose, absorb, green* |
| 10 | C | 1 | Answering A suggests that students have not converted the values to have the same unit before performing the division calculation. *To fix it, ask students to practice converting values from mm to µm and cm to mm.*<br><br>Answering B suggests an error in converting units for this calculation. *To fix it, ask students to write out how many mm in 1 cm, µm in 1 mm, etc to practise this.* |

## Appendix 2: Mark scheme for mastery quiz

### Section A

| Qu | Answer | Marks | Supporting information for fix-it tasks |
|---|---|---|---|
| 1 | A | 1 | Answering B suggests a misconception that glucose is a reactant of photosynthesis, rather than the product. *To fix it, recap the word and symbol equation for photosynthesis and then ask students to write them out, adding on annotations of where the reactants come from and what happens to the products.*<br><br>Answering C suggests a confusion between respiration and photosynthesis. *To fix it, recap the difference between the two processes and then ask students to write out the word equations for both, labelling each one with the name of the process and whether they are carried out by only plants or by all organisms.* |
| 2 | B | 1 | Answering A suggests a confusion between xylem and phloem. *To fix it, ask students to compare the function of xylem and phloem.*<br><br>Answering C suggests a confusion between xylem and the spongy mesophyll. *To fix it, ask students to compare the function of xylem and the function of the spongy mesophyll.* |
| 3 | A | 1 | Answering B suggests a misconception that glucose is a reactant for photosynthesis. To *fix it, ask students to write out the word equation for photosynthesis and label which are reactants and which are products.*<br><br>Answering C suggests a misconception that transpiration requires glucose/an energy input. *To fix it, ask students to describe how water is transported along the transpiration system.* |
| 4a | B | 1 | Answering A suggests the common misconception that plants only photosynthesis in the carbon cycle. *To fix it, ask students to explain why plants carry out respiration and to write out the work equation for aerobic respiration.*<br><br>Answering C suggests a misconception the only way plants release carbon back into the carbon cycle is through decay. *To fix it, ask students to list which* |

| | | | |
|---|---|---|---|
| | | | *processes in the carbon cycle increase the amount of atmospheric carbon.* |
| 4b | C | 1 | Answering A or B suggests the common misconception that the mere process of decay releases carbon dioxide, whereas students must be able to explain that the carbon dioxide released is from the respiring microorganisms carrying out the decay process. |
| 5 | B | 1 | Answering A suggests a gap in knowledge because focussing required moving the stage up and down, not just moving it down/away from the objective lens. *To fix it, ask students to explain why focussing requires moving the stage up and down.*<br><br>Answering C suggests a misconception that focussing wheels only rotate one way. *To fix it, ask students to describe how to focus the image of a specimen if it appears blurry when using the light microscope.* |
| 6 | A | 1 | Answering B suggests the misconception that rate is simply the measured value, rather than being per unit time. *To fix it, ask students to write out the definition of rate and then explain why the rate in option B has to be incorrect.*<br><br>Answering C suggests the misconception that you divide time by the quantity to calculate rate. *To fix it, model how to calculate this rate and then give practice examples.* |
| 7 | C | 1 | Answering A suggests a confusion of the spongy mesophyll with the palisade mesophyll. *To fix it, ask students to compare the spongy mesophyll and the palisade mesophyll structure and function.*<br><br>Answering B suggests a misconception that the large surface area associated with the spongy mesophyll structure is required for absorbing light. *To fix it, ask students to state which organelle absorbs light for photosynthesis and then explain why the spongy mesophyll is not adapted for photosynthesis.* |
| 8 | C | 1 | Answering A or B suggests a fundamental gap in knowledge about the definition of precise results. *To fix it, recap the definition of precise results and show some model precise results for this experiment. Then ask students to explain fully why these results are not precise.*<br><br>Answering D suggests a misconception that results are not precise just because they are similar to the mean. *To* |

| | | | |
|---|---|---|---|
| | | | *fix it, ask students to explain why the mean of repeat results is calculated.* |
| 9 | B | 1 | Answering A or C suggests a gap in knowledge about the increase in temperature causing an increase in the rate of evaporation. *To fix it, recap the how wind and temperature can affect the rate of evaporation of water from a lake and then ask students to state whether the rate of evaporation would increase or decrease in low temperature and with no wind.* |
| 10 | C | 1 | Answering A or B suggests a gap in knowledge about how to draw an appropriate line of best fit. *To fix it, ask students to draw a new LOBF on the graph in the question and then write a sentence to explain why it is more appropriate.* |
| 11 | A | 1 | Answering B suggests a gap in knowledge about the function of the phloem. *To fix it, recap the functions of phloem and xylem and then as students to compare the functions of xylem and phloem.*<br><br>Answering C suggests a confusion of the phloem's structure with its function. *To fix it, ask students to write a sentence to explain how the structure of phloem is related to its function.* |
| 12 | C | 1 | Answering A suggests a misconception that guard cells themselves somehow pull water upwards through the transpiration stream. *To fix it, ask students to state the function of guard cells and then explain how this affects the transpiration rate.*<br><br>Answering B suggests a misconception that xylem is directly attached to guard cells. *To fix it, ask students to describe the journey of water from the soil to stomata.* |
| 13 | A | 1 | Answering B or C suggests a gap in knowledge about the definition of limiting factors. *To fix it, ask students to write a definition for a limiting factor of photosynthesis and then explain why carbon dioxide is a limiting factor in this example.* |
| 14 | B | 1 | Answering A suggests the common misconception that what ever the variable on the x-axis, this is the limiting factor at all points on the graph. *To fix it, ask students to sketch the graph from the question and then annotate where temperature is a limiting factor and where $CO_2$ is a limiting factor.*<br><br>Answering C suggests the misconception that water is a limiting factor even though the aquatic plant is in water. |

| | | | |
|---|---|---|---|
| | | | *To fix it, ask students to write a definition for a limiting factor of photosynthesis and then explain why water is not a limiting factor in this example.* |
| 15a | A | 1 | Answering B suggests the common misconception that the distance of the light source is directly proportional to light intensity. *To fix it, ask students to describe how light intensity changes as the distance of the light source increases. Then ask students to explain why this is an inverse relationship.*<br><br>Answering C suggests a misconception that there is a proportional relationship between distance of the light source and rate of photosynthesis. *To fix it, show students a graph showing the inversely proportional relationship on a line graph showing increasing distance of the light source and respiration. Then ask students to explain why this does NOT show a directly proportional relationship.* |
| 15b | A | 1 | Answering B suggests the misconception that to calculate the inverse square, you simply square the value. *To fix it, reteach how to calculate the inverse square and then ask students to discuss why simply squaring the value is different to the inverse square.*<br><br>Answering C suggests the misconception that to calculate the inverse square, you calculate ½. *To fix it, reteach how to calculate the inverse square and then give an example results table of distance of the lamp and ask students to calculate the light intensity for each distance.* |
| 16a | B | 1 | Answering A suggests the misconception that the more intense the factor, then it must limit the rate of photosynthesis. *To fix it, recap how limiting factors affect the rate of photosynthesis when there is two or more factors present. Then ask students to add annotations different parts of the curve to state where each of the factors is a limiting factor.*<br><br>Answering C suggests the misconception that when the rate levels off when the factor is increasing on the x-axis, then it must be limiting photosynthesis. *To fix it, ask students to highlight the increasing gradient on the graph and label what is the limiting factor (answer = light intensity).* |
| 16b | C | 1 | Answering A suggests a fundamental gap in knowledge or inability to read the graph. *To fix it, ask students to* |

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| | | | *explain why an increase in carbon dioxide concentration would increase the rate of photosynthesis.*<br><br>Answering B suggests a misconception that farmers will do anything to increase the yield despite costs affecting profit. *to fix it, ask students to define profit in this context and then explain why the farmer must compare the cost of the heating bill to the amount of money the supermarket will pay for the pea crop.* |

## Section B

| Qu | Model answer | Marks | Supporting information<br>***Suggestions for fix-it tasks*** |
|---|---|---|---|
| 1 | $6CO_2 + 6H_20 \rightarrow C_6H_{12}O_6 + 6O_2$ | 2<br><br>*Allow 1 mark for a correct unbalanced equation* | Students may struggle to balance this equation. *To fix it, remind students of the method used in balancing equations in chemistry and then give students another symbol equation to balance for practise.* |
| 2 | Any two from:<br>• (converted to) starch<br>• (stored as) fat/oils<br>• (converted to) amino acids/proteins<br>(converted to) cellulose/for cell walls | 2 | Students may include uses of glucose that are not specific to storage. *To fix it, model for students how to underline/highlight command words/key words in the question so their answer remains focussed.* |

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| 3 | • State/use a specific/given distance<br><br>• (so that) the independent variable can be quantified<br>Or<br>• To allow a conclusion to be drawn (about the relationship between light intensity and the rate of photosynthesis)<br><br>**Or**<br><br>• State a time period for recording/counting the number of bubbles<br><br>• (so that) the rate of reaction can be measured | 1<br><br>1<br><br>1<br><br>1<br><br>*The improvement must be linked to the correct explanation for two marks.* | Students may struggle to link an explanation about validity to a suggested change to the method. *To fix it, firstly, recap the definition of validity. Then provide students with one of these model answers and ask them to annotate which is the suggested improvement to the method and which is the explanation of why this increases validity.* |
| 4 | This should be level assessed<br>**5-6 marks** – A detailed explanation is given which links the carbon in dead leaves to how carbon is used by a growing plant<br>**3-4 marks** – A description is given with some attempts at explanation, but it is not clear<br>**1-2 marks** – Some parts are described but no attempts made at explanations<br><br>**Suggested content:**<br>• Decomposers break down dead leaves<br>• Decomposers respire<br>• Releasing carbon dioxide<br>• Leaves take in carbon dioxide<br>• For photosynthesis | 6 | This is an 'explain' question which requires explanations of facts using phrases/word such as 'this means that', 'because', 'therefore'. Students may forget to include this and instead simply describe aspects of the carbon cycle. |

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| | • Carbon is used to synthesise glucose<br>• Glucose is used to new molecules for growth<br>• Including amino acids (for proteins)<br>• And cellulose<br><br>**Model exemplar answer (6/6):**<br>Carbon compounds in the dead leaves are broken down by microorganisms called decomposers. These microorganisms respire <u>which means that</u> carbon dioxide is released into the atmosphere.<br><br>The carbon dioxide from the atmosphere is taken into leaves <u>because</u> photosynthesis uses carbon dioxide as a reactant. The carbon then becomes part of glucose molecules because glucose is a product of photosynthesis. Glucose is used to make new molecules for growth such as amino acids and cellulose. <u>Therefore,</u> the carbon that has cycled from the dead leaves has become part of new leaf growth. | | Students may struggle to link the two separate knowledge points of the carbon cycle and the uses of glucose in plants. *To fix it, recap both topics and ask students to make brief notes about each, then ask them to re do the question using their notes.* |
| 5 | **Model answer** | **Marks** | Students find drawing a line of best fit challenging and may join the dots, sketch a curve or join the first and last plots with a line. *To fix it, recap, using the visualiser or on the board, how to draw a line of best fit. Then ask students to write instructions for how to draw a line of best fit when the plot points on a graph are not in a straight line.* |

## Appendix 3: Core knowledge statements

- The leaf is a plant organ, containing the epidermis, palisade and spongy mesophyll, xylem and phloem, and guard cells surrounding stomata.
- Meristem tissue, containing stem cells, is found at the growing tips of shoots and roots
- The leaf epidermis is adapted for transmitting light to the palisade layer because it is the transparent top layer
- The leaf epidermis is adapted for preventing water loss from leaf cells because it has a waterproof, waxy cuticle surrounding it
- The palisade mesophyll is adapted for carrying out photosynthesis because it contains many palisade cells which contain many chloroplasts
- The spongy mesophyll is adapted for diffusion of gases for photosynthesis because it contains air spaces between cells
- Guard cells open and close small holes called stomata on the underside of the leaf to control gas exchange and water loss
- Xylem are vessels that transport water and minerals from the roots up the plant stem and into the leaves.
- Phloem are vessels that transport nutrients, such as sugars, around a plant.
- Root hair cells are adapted for the efficient uptake of water by osmosis because they have a large surface area
- Root hair cells are adapted for the efficient uptake mineral ions by active transport because they have a large surface area and many mitochondria
- Active transport moves substances from a more dilute solution to a more concentrated solution, requiring energy from respiration
- Guard cells open and close small holes called stomata on the underside of the leaf to control gas exchange and water loss
- Microscopy is the field of using microscopes to view samples that cannot be seen with the naked eye
- Light microscopes allow us to see the largest organelles, including the nucleus, cell membrane, cell wall and cytoplasm. A stain is often used to make the organelles clearer
- The parts of a light microscope include the eyepiece lens, objective lenses, stage, coarse focusing wheel, fine focusing wheel, light/mirror
- A sample used with a light microscope must be very thin to allow light to pass through
- The specimen to be viewed under a microscope is placed on the stage and secured with stage clips
- The eyepiece lens and objective lens are used to increase the size of the image
- The coarse focusing wheel is used to move the stage and get the cells into frame
- The fine focusing wheel is used to sharpen an image
- The total magnification of a microscope can be calculated using the following equation: Total magnification = Objective lens x eyepiece lens
- Electron microscopes have a greater magnification and resolution than light microscopes. They are much more expensive than light microscopes
- Magnification is the number of times larger an image is than the object
- Resolution is the ability to distinguish between two points
- Electron microscopes allow are to see more organelles and study cells in greater detail
- A scale bar can be used to calculate the magnification of an irregular object
- Magnification does not have a unit because it is a ratio

- Magnification = size of image/size of object
- Rate is the change of a quantity, per unit time.
- The roots, stem and leaves form a plant organ system for transport of substances around the plant.
- Transpiration is the process of water moving through a plant and its evaporation from parts such as through the stomata on the undersside of leaves.
- Changing temperature, humidity, air movement and light intensity affect the rate of transpiration.
- Xylem tissue transports water and mineral ions from the roots to the stems and leaves
- It is composed of hollow tubes strengthened by lignin adapted for the transport of water in the transpiration stream.
- The role of stomata and guard cells are to control gas exchange and water loss.
- Phloem tissue transports food molecules, including dissolved sugars, from the leaves to the rest of the plant for immediate use or storage.
- The movement of dissolved sugars/food molecules through phloem tissue is called translocation.
- Phloem is composed of tubes of elongated cells.
- Dissolved sugars/food molecules can move from one phloem cell to the next through pores in the end walls.
- Photosynthesis is represented by the word equation: carbon dioxide + water → glucose + oxygen
- Photosynthesis is represented by the symbol equation: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
- Photosynthesis is a (endothermic) chemical reaction in which energy is transferred from the environment to the chloroplasts by light
- Photosynthesis is carried out in chloroplasts
- Chlorophyll is a green pigment found in chloroplasts that absorbs the sunlight required for photosynthesis
- The glucose produced in photosynthesis may be used as a reactant for respiration
- The glucose produced in photosynthesis may be converted into insoluble starch for storage
- The glucose produced in photosynthesis may be used to produce fat or oil for storage
- The glucose produced in photosynthesis may be used to produce cellulose, which strengthens the cell wall
- The glucose produced in photosynthesis may be used to produce amino acids for protein synthesis
- To produce proteins, plants also use nitrate ions that are absorbed from the soil
- Temperature, light intensity, carbon dioxide concentration, and the amount of chlorophyll affect the rate of photosynthesis
- A limiting factor of photosynthesis is something that, when in limited supply, stops the maximum rate of photosynthesis
- Increasing the carbon dioxide concentration or the intensity of light increases the rate of photosynthesis proportionally until there is a limiting factor that causes the rate to become constant
- Increasing the temperature increases the rate of photosynthesis proportionally until it reaches the optimal temperature for enzymes then the rate decreases
- (HT Only) Limiting factors of photosynthesis interact and any one of them may be the factor that limits photosynthesis
- (HT Only) Explain graphs of photosynthesis rate involving two or three factors and decide which is the limiting factor

- (HT Only) Limiting factors are important in the economics of enhancing the conditions in greenhouses to gain the maximum rate of photosynthesis while still maintaining profit
- Decay is the breakdown of dead organisms into more basic building blocks.
- Decomposers are organisms that carry out decay using enzymes
- Microorganisms, such as some bacteria and fungi, are decomposers
- Microorganisms help to cycle materials through an ecosystem by returning carbon to the atmosphere as carbon dioxide during respiration and mineral ions to the soil.
- Many different materials cycle through the abiotic and biotic components of an ecosystem.
- All materials in the living world are recycled to provide the building blocks for future organisms.
- The carbon cycle is important for the survival of living organisms.
- In the carbon cycle, carbon dioxide is absorbed by plants for photosynthesis
- In the carbon cycle, carbon dioxide is released by animals and plants during respiration
- In the carbon cycle, carbon is transferred to consumers in the food chain
- The carbon cycle returns carbon from organisms to the atmosphere as carbon dioxide
- Microorganisms help to cycle materials through an ecosystem by returning carbon from dead organisms to the atmosphere as carbon dioxide
- The water cycle is important for the survival of living organisms.
- Water is continuously evaporated and precipitated.
- The water cycle provides fresh water for plants and animals on land before draining into the seas.

**Biology Only**

- Tobacco mosaic virus (TMV) infects many plants including tomato plants
- TMV causes a distinct 'mosaic' pattern of discolouration on leaves. This means that leaves cannot absorb light for photosynthesis so the plant does not grow normally
- Fungal infections are treated using fungicide chemicals
- Rose black spot is a fungal disease where purple/black spots form on leaves. This means that leaves cannot absorb light for photosynthesis so the plant does not grow normally
- Rose black spot is spread by water and by wind
- Plants have to defend themselves; they can be infected by a range of viral, bacterial and fungal pathogens as well as by insects.
- Physical defence responses which resist invasion of microorganisms include; Cellulose cell walls, Tough waxy cuticle on leaves, and layers of dead cells around stems (bark on trees) which fall off.
- Chemical plant defence responses include antibacterial chemicals and poisons to deter herbivores.
- Mechanical adaptations of plants include thorns and hairs deter animals and leaves which droop or curl when touched.
- (HT Only) Plant diseases can be detected by stunted growth, spots on leaves, areas of decay (rot, growths, malformed stems or leaves, discolouration, the presence of pests.
- (HT Only) Identification can be made by: reference to a gardening manual or website, taking infected plants to a laboratory to identify the pathogen, using testing kits that contain monoclonal antibodies
- Decreasing the temperature lowers the rate of decay because decomposing microorganisms are less active

- Decreasing the availability of oxygen lowers the rate of decay because decomposing microorganisms cannot respire
- Decreasing the availability of water lowers the rate of decay because decomposing microorganisms cannot survive
- Gardeners and farmers try to provide optimum conditions for rapid decay of waste biological material. The compost produced is used as a natural fertiliser for growing garden plants or crops.
- Anaerobic decay produces methane gas.
- Biogas generators can be used to produce methane gas as a fuel.

**Disciplinary Knowledge**

54. a. Assess whether sufficient, precise measurements have been taken in an experiment.
b. Evaluate methods with a view to determining whether or not they are valid.
57. Decide on a suitable scale for x and y-axis when drawing a graph
60. Draw a line of best fit
69. Determine the slope and intercept of a linear graph
72. Use technology such as MS Excel and data loggers to generate a graph of results digitally.

**Practical Skills**

31. Observing and measuring biological changes and/or processes, including safe and ethical use of living organisms
32. Measurement of rates of reaction by a variety of methods including production of gas, uptake of water and colour change of indicator.
34. Prepare a slide with cells for viewing under the light microscope
35. Use of appropriate techniques and qualitative reagents to identify biological molecules and processes in more complex and problem-solving contexts