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| **B1.4 Photosynthesis** | **Guided teaching hours:** 4 hours |
| **Chapter overview**  In this chapter, students have studied photosynthesis, and should be able to write an equation for the process. They should know that photosynthesis is an endothermic reaction that requires sunlight energy and, building on knowledge from B1.1 *Cell structures*, that the process occurs in the chloroplasts of plant cells.  In studying the reactants and products of photosynthesis, students should have considered how plants obtain the raw materials and what happens to the glucose produced. In preparation for B4.1 *Ecosystems*, they should understand that plants are producers. They should be aware of the link between respiration and photosynthesis, and that while photosynthesis occurs in sunlight in plant cells, respiration occurs throughout the day and night in all living cells.  Students should have investigated the factors needed for photosynthesis to occur, using the iodine test for starch on de-starched leaves. They should have calculated the rate of photosynthesis and considered the effect on this of light intensity, temperature, and concentration of carbon dioxide. They should link their knowledge of enzymes from B1.2 *What happens in cells?* to their studies of photosynthesis and temperature.  Finally, higher-tier students should have studied the interaction between limiting factors, and have calculated light intensity using the inverse square law. | |

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| **Lesson B1.4.1 Photosynthesis** | | |  |
| **OCR GATEWAY spec link:**  B1.4a Describe photosynthetic organisms as the main producers of food and therefore biomass for life on Earth.  B1.4b Describe the process of photosynthesis. To include reactants and products, location of the reaction (in the chloroplasts).  B1.4c Describe photosynthesis as an endothermic reaction.  WS1.3a Presenting observations and other data using appropriate methods | **Aiming for Grade 4 LOs:**   * State the word equation for photosynthesis. * State that sunlight energy is required for the process of photosynthesis. * State basic facts (about photosynthesis), communicating simply and with some clarity. | **Lesson Overview**  **Starters**  **Sorting out photosynthesis** (10 minutes) Give each group a plant pot with a number of card leaves, each with one word written on it. Some of the words are about the process of photosynthesis, for example, water, chlorophyll, sunlight, glucose, etc. Some of the words name plant parts involved in photosynthesis, for example, leaf, roots, etc. Some of the words are not relevant to photosynthesis, for example, flower, bee, etc. Students sort the leaves, rejecting irrelevant words. They then sort the relevant words to start to explain what happens in photosynthesis and where it occurs.  **Feeding plants** (5 minutes) Place a pot plant on each table. Ask students to discuss how the plant feeds itself. What substances does it need to feed itself, and where does it get them? What waste substances does it produce? Students feedback their ideas to the rest of the class.  **Mains**  **Photosynthesis poster** (30 minutes) Give students 10 minutes to read about photosynthesis. Student pairs then produce posters stating why photosynthesis is important, and giving details of the process, including raw materials, products, a word and symbol equation, and where in plants it occurs. Posters should also describe photosynthesis as an endothermic reaction. Before students start making their posters, share success criteria with the class. Students will use these to peer-evaluate each others’ posters.  **Growing cress** (10 minutes) Provide groups with a beaker, cotton wool pads, cress seeds, and cling film. Recreate the Van Helmont experiment. Place the seeds on the pad, add water, and cover the top in cling film. Measure the mass of the seeds and return to these in about 2–3 days; re-measure the seeds and record the increase in mass.  **Plenaries**  **Photosynthesis** (5 minutes) Use the interactive, where students sort the reactants and products of photosynthesis and then type in missing words to complete sentences about photosynthesis.  **Peer evaluation** (10 minutes) Each group peer-assesses the posters produced by two other groups, using the given success criteria. Students point out where the posters meet the success criteria, and make suggestions for improvement. | **Resources** |
| **Aiming for Grade 6 LOs:**   * State the chemical equation for photosynthesis. * Describe the process of photosynthesis as an endothermic reaction. * Illustrate the process of photosynthesis using labelled diagrams that communicate effectively, making coherent statements. |
| **Aiming for Grade 8 LOs:**   * Discuss the fate of the products of photosynthesis. * Explain that photosynthesis is a two-stage process, and where those stages occur. * Annotate diagrams to explain the process of photosynthesis in detail, communicating coherently and with impact. |

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| **Lesson B1.4.2 Photosynthesis experiments** | | |  |
| **OCR GATEWAY spec link:**  B1.4d Describe experiments to investigate photosynthesis.  WS1.1h Evaluate risks both in practical science and the wider societal context.  WS1.2c Apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment.  WS1.3a Presenting observations and other data using appropriate methods  WS1.3e Interpreting observations and other data. | **Aiming for Grade 4 LOs:**   * Describe how to test a leaf for the presence of starch. * Use the correct apparatus to follow a method with help, having due regard for some health and safety considerations. * State a simple conclusion from a scientific observation. | **Lesson Overview**  **Starters**  **Iodine and starch** (5 minutes) Have ready a piece of potato or bread and some iodine. Elicit that one of the products of photosynthesis is glucose. Point out that in plants some glucose molecules join together to form starch, which plants store in roots and seeds. Ask how we can show that starch is present – students might have covered this at Key Stage 3. Demonstrate the colour change when adding iodine to potato or bread, and tell students that the blue-black colour shows that starch is present.  **Risk assess** (5 minutes) Provide the method for the practical in the main activity. Students do a simple risk assessment, identifying hazards and risk levels, and suggesting how to minimise risks from the hazards.  **Main**  **Light in photosynthesis** (40 minutes) Use the practical sheet (or a standard method) to investigate the need for light in photosynthesis, using a leaf that has been partly covered with foil or card for two days. Then follow the method for the starch test using iodine. Include questions about the procedure, and health and safety, and ask students to write a conclusion for the experiment.  **Plenaries**  **Why all the steps?** (5 minutes) Use the interactive where students put sentences in order to show how you test a leaf for starch and then match the step to why it is done.  **Dinosaur extinction** (5 minutes) One theory for the extinction of dinosaurs is that herbivorous dinosaurs ran out of food. (The meteor hit the Earth, creating a massive dust cloud: this prevented photosynthesis, due to the light being blocked. The plants died and this then had an effect on the food chain.) Student pairs discuss how today’s experiment provides evidence to support this theory. | **Resources** |
| **Aiming for Grade 6 LOs:**   * Explain how to use the starch test to investigate the factors that affect whether or not photosynthesis occurs. * Follow a method to carry out an experiment appropriately and independently, having due regard for most health and safety considerations. * Interpret experimental observations, drawing a valid conclusion. |
| **Aiming for Grade 8 LOs:**   * Justify the use of each of the steps in the test for starch. * Follow a method to carry out an experiment appropriately and independently, having due regard for the correct manipulation of apparatus and all health and safety considerations. * Interpret fully all experimental observations, to provide a detailed conclusion. |

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| **Lesson B1.4.3 Factors affecting photosynthesis** | | |  |
| **OCR GATEWAY spec link:**  B1.4e Explain the effect of temperature, light intensity, and carbon dioxide concentration on the rate of photosynthesis.  WS1.2e Evaluate methods and suggest possible improvements and further investigations.  WS1.3a Present observations and other data using appropriate methods.  WS1.3b Translate data from one form to another.  WS1.4c Use SI units and IUPAC chemical nomenclature unless inappropriate.  WS2a Carry out experiments.  WS2b Make and record observations and measurements using a range of apparatus and methods.  BM1.4i Understand and use simple compound measures, such as the rate of a reaction (M1a, M1c).  BM1.1.4iii Plot and draw graphs, selecting appropriate scales and axes (M4a, M4c). | **Aiming for Grade 4 LOs:**   * State the factors affecting the rate of photosynthesis. * Record data from an experiment in the table provided. * State any difficulties encountered carrying out this method. | **Lesson Overview**  **Starters**  **Three factors** (5 minutes) Use the interactive where students select a series of true or false sentences that describe the effect of the three factors on the rate of photosynthesis.  **Growth spurt** (10 minutes) Show the class a plant and ask them to suggest ways in which the plant could be made to grow faster on a farm. They will suggest factors like light, but might need prompting to suggest increasing the temperature and adding extra carbon dioxide. Ask them to describe the relationship between the factor and the rate of photosynthesis. Ask students why it is important to obtain maximum growth rates in crops on farms or plant nurseries, focusing on two contrasting examples: rice (a staple food in many parts of the world) and cut flowers (a luxury product).  **Mains**  **How does light intensity affect the rate of photosynthesis?** (40 minutes) Follow a standard method to measure the effect of changing the light intensity on the rate of photosynthesis. Use *Elodea* or *Cabomba* andchange the distance of the pondweed from a lamp, recording the time taken to produce a set number of bubbles of oxygen. It is vital to test the experiment beforehand in order to gauge the number of bubbles likely to be produced, which will vary with time of year, type of pondweed and so on.  As students work through the experiment, encourage them to discuss which variables are independent, dependent, and which are control variables. Results should give: distance between light and pondweed; time to produce a set number of bubbles. You might like to calculate a class value of the mean time to produce a set number of bubbles. Plot a graph of distance against rate (1/time). Students write a conclusion to their investigation.  SAFETY: *Cabomba* may be an invasive species: do not dispose of in rivers or ponds.  **Plenaries**  **How good was my experiment?** (5 minutes) Provide each group with a series of cards that contain words connected to the experiment, for example, temperature; bubbles; time; distance; carbon dioxide; light. Ask the class to decide if each variable was controlled, independent (changed), or dependent (recorded). Ask them to identify a problem that each variable might have caused in the experiment.  **Photosynthesis chain game** (10 minutes) Divide the class into groups of six. Issue each group nine sheets of A4 card. Within each group of six one pair writes a factor that affects the rate of photosynthesis on each of the three cards (a different factor on each card). Another pair writes a quick description of the relationship between each of these factors and the rate (one on each of the three cards). The third pair writes a quick explanation for each relationship, again on three separate cards. Then the teacher selects a group and asks them to hold up a card with a factor. The group nominates a new group, who hold up and read the description of the relationship. If they are right, they nominate a third group who hold up the explanation. Repeat until all factors have been discussed. | **Resources**  **Practical sheet:**  Light intensity and  photosynthesis |
| **Aiming for Grade 6 LOs:**   * Describe the effect of light intensity, carbon dioxide concentration, and temperature on the rate of photosynthesis. * Calculate a class average (mean) from data collected in an experiment. * Suggest how any difficulties have affected the repeatability of the results. |
| **Aiming for Grade 8 LOs:**   * Explain the effect of light intensity, carbon dioxide concentration, and temperature on the rate of photosynthesis. * Calculate the mean rate of photosynthesis from data collected in an experiment, and plot a rate graph as a line graph. * Evaluate the method, discussing the impact upon the validity of the results, and suggest improvements. |

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| **Lesson B1.4.4 Interaction of limiting factors** | | |  |
| **OCR GATEWAY spec link:**  B1.4f Explain the interaction of these factors in limiting the rate of photosynthesis.  WS1.3a Present observations and other data using appropriate methods.  WS1.3b Translate data from one form to another.  WS1.3c Carry out and represent mathematical and statistical analysis.  WS1.3e Interpret observations and other data.  WS1.3f Present reasoned explanations including relating data to hypotheses.  WS1.4e Interconvert units.  BM1.7 Translate information between graphical and numeric form.  BM1.4iv Extract and interpret information from charts, graphs, and tables (M2c, M4a).  BM1.4v Understand and use inverse proportion – the inverse square law and light intensity in the context of factors affecting photosynthesis (M1c). | **Aiming for Grade 6 LOs:**   * Explain the concept of a limiting factor. * Calculate relative light intensity using the inverse square law. * Describe how light intensity, carbon dioxide concentration, and temperature can be controlled. | **Lesson Overview**  **Starters**  **Spreading it thin** (5 minutes) Shine a torch light held by a student on a sheet of paper. Record the distance between the torch and paper, and estimate the proportion of the page lit. Ask students to predict what will happen if you increase the distance. Then double the distance and again estimate the area lit: it should have increased four-fold. Link this to a decrease in the light intensity.  **Limiting production** (10 minutes) Divide the class into groups of three (or use three students in a demonstration). Each group builds one tower from four coloured bricks, starting when you tell them to. Person 1 joins a red brick to a white brick and passes to person 2; who adds a blue brick and passes to person 3; who adds a yellow brick to complete the process. Now, limit one of the individuals, by slowing them in some way. Ask about the overall effect on the process of slowing down just one student. Explain the idea of limiting factors.  **Mains**  **Inverse square law** (20 minutes) Using data collected from the pondweed experiment in B1.4.3, calculate the relative light intensity for each distance value using the formula light intensity = 1/distance2. Use this data to plot a graph of rate of photosynthesis (*y-*axis) against relative light intensity (*x-*axis). Remember to plot in terms of increasing light intensity, because, as the distance increases, the light intensity will decrease. Students identify the relationship between light intensity and rate.  **Greenhouse economics** (20 minutes) Introduce to students how greenhouses can be used to increase the growth of plants and therefore profits for growers. Link each feature of a greenhouse to the limiting factors of photosynthesis. Students are then presented with data looking at the costs of running a greenhouse and the potential profits. They use the data to decide on the cost-effectiveness of adding extra carbon dioxide, heat, and light to the greenhouse.  **Plenaries**  **Increasing yield** (5 minutes) Use the interactive where students look at a graph and decide which factor is affecting the rate of photosynthesis, and how certain conditions will affect the rate of photosynthesis.  **Gardeners’ world problem page** (10 minutes) Give each group a problem involving poor plant growth that they offer a solution for, such as: ‘Why do the plants at the centre of my field grow slower during a warm summer day?’ ‘My house plants don’t grow well in the centre of my room.’ ‘An old gardener told me to heat my greenhouse with a paraffin heater instead of an electric heater. Why?’ ‘I have a plant in sunny porch, why doesn’t it grow in winter?’ | **Resources**  **Activity sheet:**  Three scenario cards |
| **Aiming for Grade 8 LOs:**   * Explain how factors interact to limit the rate of photosynthesis. * Explain the relationship between light intensity and distance from a lamp. * Discuss how controlling the factors that affect the rate of photosynthesis can affect the yield of a plant crop. |