Edexcel GCSE (9–1) Biology (separate sciences)
2-year scheme of work

This document provides a scheme of work for teaching the Pearson Edexcel GCSE (9-1) Biology specification in 2 years.

Bold text indicates that the content is for Higher Tier only. An asterisk indicates that you may have covered the specification point if you have been using our transition materials.

The document currently contains exemplar teaching activities and notes on differentiation, but not for all topics. We will update it with this level of detail for the remainder of the course over the coming months. The suggested length for each lesson is indicated next to the title.

Not all of the suggested practicals from the specification have been covered in this scheme of work. Alternative suggested practicals could be substituted into the lessons given here.

B1 Overarching concepts in Biology				
Lesson SB1a: Microscopes (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• *B1.3: Explain how changes in microscope technology, including electron microscopy, have enabled us to see cells with more clarity and detail than in the past and increased our understanding of the role of sub-cellular structures • *B1.4: Demonstrate an understanding of number, size and scale, including the use of estimations and explain when they should be used • *B1.5: Demonstrate an understanding of the relationship between quantitative units in relation to cells, including: a) milli (10^{-3}) b) micro (10^{-6}) c) nano (10^{-9}) d) pico (10^{-12}) …	*Starter* Have a microscope in front of you. Ask students what a microscope is and why this is called a 'light microscope'. *Exploring* Give students a magnified image of a water flea (Daphnia sp.) and asks them to measure parts of the animal and to work out magnifications. *Explaining* Help students to understand the difference between resolution and magnification by using the idea of digital cameras.	*Exploring* Support: Help students with unit conversions. Stretch: Challenge students to download another image from the Internet, and to develop a similar worksheet together with a list of answers. *Explaining* Support: Show students an eye test chart. Point out that an eye test is testing resolution. Stretch: Explain to students that an 'optical zoom' on a camera uses lenses to zoom into an object. A 'digital zoom' uses electronics to magnify part of an image.	• Recognise and use expressions in standard form • Make estimates of the results of simple calculations • Use an appropriate number of significant figures • Make order of magnitude calculations	n/a

Lesson SB1b: Plant and animal cells (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• *B1.1: Explain how the sub-cellular structures of eukaryotic … cells are related to their functions, including: a) animal cells – nucleus, cell membrane, mitochondria and ribosomes b) plant cells – nucleus, cell membrane, cell wall, chloroplasts, mitochondria and ribosomes … • *B1.4: Demonstrate an understanding of number, size and scale, including the use of estimations and explain when they should be used • **B1.6: Core Practical: Investigate biological specimens using microscopes, including magnification calculations and labelled scientific drawings from observations*	*Starter* Ask students to write a simple definition of a cell. *Exploring* Students use a light microscope to look at simple animal and/or plant cells and identify their component parts. (*Core practical*.) *Explaining* Hold up a metre ruler and ask students to estimate the width, height and length of the lab by comparing it with the length of the ruler. Explain that we use this idea on micrographs by using a scale bar, from which we can estimate the sizes of other things. Move on to discuss fields of view.	*Exploring* Support: Have an appropriate micrograph of human cheek cells / onion cells / rhubarb cells / *Elodea* cells on the board to help students identify the cells under the microscope and label them appropriately. Stretch: Encourage students to look at as many different cell types as possible, and to add scale bars to their drawings. *Explaining* Support: Ask students to get out rulers and then work in groups to estimate the sizes of things around them by rough comparison, with their rulers acting as scale bars. Stretch: Challenge students to work out the relationship between an increase in total magnification and the matching decrease in field of view.	• Make estimates of the results of simple calculations • Make order of magnitude calculations • Use an appropriate number of significant figures • Change the subject of an equation	*Core Practical: Investigate biological specimens using microscopes, including magnification calculations and labelled scientific drawings from observations* (See *Exploring*.)

Lesson SB1c: Specialised cells (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B1.2: Describe how specialised cells are adapted to their function, including: a) sperm cells – acrosome, haploid nucleus, mitochondria and tail b) egg cells – nutrients in the cytoplasm, haploid nucleus and changes in the cell membrane after fertilisation c) ciliated epithelial cells • B1.4: Demonstrate an understanding of number, size and scale, including the use of estimations and explain when they should be used	*Starter* Write the word 'adaptation' on the board. Ask students to work in pairs or small groups to write down adaptations of three animal species. *Exploring* Students look at prepared slides of some specialised human cells. (*Core practical*.) *Explaining* Demonstrate the effect of surface area using Visking tubing.	*Exploring* Support: Display one of the slides on the board. Discuss with students which features of the cell are typical of all animal cells and which are specialised. Stretch: Include examples of unfamiliar cells. *Explaining* Support: Prompt students to think about the difference in area of tubing in contact with the water in the beaker. Stretch: Challenge students to apply what they have seen in the demonstration to explain the importance of microvilli on cells lining the small intestine.	• Make estimates of the results of simple calculations • Make order of magnitude calculations	Demonstrate the effect of surface area using Visking tubing. (See *Explaining*.)

Lesson SB1d: Inside bacteria (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B1.1: Explain how the sub-cellular structures of eukaryotic and prokaryotic cells are related to their functions, including: … c) bacteria - chromosomal DNA, plasmid DNA, cell membrane, ribosomes and flagella. • B1.5: Demonstrate an understanding of the relationship between quantitative units in relation to cells, including: a) milli (10^{-3}) b) micro (10^{-6}) c) nano (10^{-9}) d) pico (10^{-12}) **e) calculations with numbers written in standard form**	*Starter* Write the word 'bacteria' on the board. Discuss with students the sub-cellular structures that they would expect to find in bacterial cells. *Exploring* *Exploring* Show students drawings of animal and bacterial cells under light and electron microscopes, and label the features. *Explaining* Write up $A \times 10^n$ on the board and explain how standard form works.	*Exploring* Support: Work through the labelling of the diagrams as a class. Stretch: Find out about one further structure in an animal cell and what it does. *Explaining* Stretch: Challenge each student to design two questions whereby numbers in standard form need to be multiplied, divided, added or subtracted.	• Recognise and use expressions in standard form • Use an appropriate number of significant figures • Make order of magnitude calculations	n/a

Lesson SB1e: Enzymes and nutrition (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• *B1.12: Explain the importance of enzymes as biological catalysts in the synthesis of carbohydrates, proteins and lipids and their breakdown into sugars, amino acids and fatty acids and glycerol	*Starter* Ask students to work in pairs or small groups to write down as many processes and reactions as they can remember that happen in living organisms. *Exploring* Students investigate the action on starch solution of amylase using the iodine test. (*Suggested practical*.) *Explaining* Demonstrate how starch can be synthesised from different substrates, using the enzyme starch synthase from potatoes. (*Suggested practical*.)	*Exploring* Stretch: Students could test the starch/amylase mixture at the start and end of the practical, using the Benedict's test, which indicates the presence of 'simple' (reducing) sugars.	n/a	*Suggested practical:* Investigate the effect of different concentrations of digestive enzymes, using and evaluating models of the alimentary canal. (See *Exploring* and *Explaining*.)

Lesson SB1f: Testing foods (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B1.14B: Explain how the energy contained in food can be measured using calorimetry • *B1.13B: Core Practical: Investigate the use of chemical reagents to identify starch, reducing sugars, proteins and fats*	*Starter* Provide students with a range of examples of food, or images of them from the internet. Give students a few minutes to work in pairs to group the foods according to the major nutrients they contain. *Exploring* Students should test for the presence of starch, lipids, reducing sugars and protein using chemical reagents on powdered foods. Methods could include the iodine test, Sudan III test, Benedict's test and Biuret test. These could be replaced with others if they are more appropriate to your students. (*Core practical.*) *Explaining* Show students how to carry out food tests to produce quantitative information by creating a calibration curve. You will need to have produced most of the data for the calibration curve before the lesson.	*Exploring* Support: Name each powder with its correct food name, and ask students to predict how each will respond to the tests before carrying them out. Stretch: Challenge students to adapt one of the tests to make it more quantitative. *Explaining* Support: Work as a group to produce the calibration curve before asking students to read off the value for the food. Stretch: Students should evaluate the accuracy of their estimate by considering where errors might occur during the experiment.	• Recognise and use expressions in decimal form • Use an appropriate number of significant figures	*Core practical: Investigate the use of chemical reagents to identify starch, reducing sugars, proteins and fats.* (See *Exploring.*)

Lesson SB1g: Enzyme action (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• *B1.7: Explain the mechanism of enzyme action including the active site and enzyme specificity • B1.8: Explain how enzymes can be denatured due to changes in the shape of the active site	*Starter* Students work together to complete a story that describes the role of enzymes in digestion. *Exploring* Investigation on the effect of temperature on the time taken for amylase to digest starch. *(Suggested practical.)* *Explaining* Demonstrate that enzymes are specific to particular substrates by testing a range of enzymes on a range of substrates. *(Suggested practical.)*	*Exploring* Support: If students need support in constructing a table for their results, show them a pre-prepared table. Stretch: Students should plan and carry out their own investigation. *Explaining* Support: Be very clear about the substances that each stain is made of, and how that relates to the type of enzyme that catalyses its breakdown. Stretch: Encourage students to find the link between an enzyme name and its substrate.	n/a	*Suggested practical*: Investigate the effect of temperatures and concentration on enzyme activity. (See *Exploring* and *Explaining*.)

Lesson SB1h: Enzyme activity (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B1.9: Explain the effects of temperature, substrate concentration and pH on enzyme activity • B1.11: Demonstrate an understanding of rate calculations for enzyme activity • *B1.10: Core Practical: Investigate the effect of pH on enzyme activity*	*Starter* On the board, list the results of a 100 m running race for four men and the time they took to complete the distance. Ask students to work in pairs to identify which man had the fastest rate over 100 m, and to work out what that rate was. *Exploring* Practical investigation on the effect of concentration of substrate on enzyme activity. Dilute hydrochloric acid and sodium hydrogen carbonate solution is used to adjust pH. The substrate is hydrogen peroxide and the enzyme is catalase. (*Core and/or suggested practical*.) *Explaining* Demonstration that gives an opportunity to calculate initial rates of reaction. Use a suitable enzyme and substrate to produce numerical data throughout the reaction, such as using catalase/hydrogen peroxide. (*Core and/or suggested practical*.)	*Exploring* Support: Guide students through calculating the rate of oxygen produced, and the analysis of the collated table, including identification of anomalies and calculation of mean values. Stretch: Expect students to produce their own diagrams to explain the shape of the curve. *Explaining* Support: Ask students how the mean rate of reaction from the start to the end of the reaction should be calculated. Stretch: Repeat the experiment at a different pH. Ask students to plot the data and calculate the initial rate of reaction. They should compare their answer with the initial rate of reaction for the first pH to identify which pH is nearer the optimum for that enzyme.	• Recognise and use expressions in decimal form • Use ratios, fractions and percentages • Understand the terms mean, mode and median • Translate information between graphical and numeric form • Plot two variables from experimental or other data	*Core Practical: Investigate the effect of pH on enzyme activity.* (See *Exploring* and *Explaining*) *Suggested practical*: Investigate the effect of temperatures and concentration on enzyme activity. (See *Exploring* and *Explaining*)

Lesson SB1i: Transporting substances (Up to 4 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• *B1.15: Explain how substances are transported into and out of cells, including by diffusion, osmosis and active transport • B1.17: Calculate percentage gain and loss of mass in osmosis • *B1.16: Core Practical: Investigate osmosis in potatoes*	*Starter* Show students the diffusion of potassium manganite (VII) in water either by placing a crystal at the bottom of a large beaker of water or by showing a video of this. *Exploring* Core practical on osmosis in potato slices. *Explaining* Demonstrate diffusion and osmosis in the small intestine using a Visking tubing bag filled with a solution of starch and glucose. (*Suggested practical*.)	*Exploring* Support: Students may need help in drawing up their table and completing the calculations. They may also need help working out how to record negative numbers on their chart. Stretch: Ask students how they could adapt this practical to find the concentration inside potato cells. *Explaining* Support: As there are three kinds of molecule to consider in this demonstration, work with students to consider one kind at a time. Stretch: Expect students to carry out the calculations without guidance. Challenge students to apply what they have seen to red blood cells.	• Recognise and use expressions in decimal form • Use ratios, fractions and percentages • Find arithmetic means • Translate information between graphical and numeric form • Plot two variables from experimental or other data	*Core practical: Investigate osmosis in potatoes.* (See *Exploring*.) *Suggested practical:* Investigate the effect of different concentrations of digestive enzymes, using and evaluating models of the alimentary canal. (See *Explaining*.) *Suggested practical:* Investigate the effect of concentration on rate of diffusion. (See *Explaining*.)

B2 Cells and control				
Lesson SB2a: Mitosis (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B2.1: Describe mitosis as part of the cell cycle including the stages interphase, prophase, metaphase, anaphase and telophase and cytokinesis • B2.2: Describe the importance of mitosis in growth, repair and asexual reproduction • B2.3: Describe the division of a cell by mitosis as the production of two daughter cells, each with identical sets of chromosomes in the nucleus to the parent cell, and that this results in the formation of two genetically identical diploid body cells • B2.4: Describe that cancer is the result of changes in cells that lead to uncontrolled cell division	*Starter* Ask students to outline the stages in the human life cycle: embryo → baby → adolescent → adult; then to identify what is needed for humans to grow; and to discuss whether cell division stops when growth stops. *Exploring* Construct a large diagram of the cell cycle. *Explaining* Model mitosis using clothes pegs with the spring removed from the middle.	*Exploring* Support: Provide students with mixed up diagrams, titles and labels. Stretch: Only give students the diagrams of the cell cycle. Ask them to order the diagrams and then add their own titles and labels. *Explaining* Support: Have different clothes pegs of different shapes and colours. Use two or three students to model the movement of the chromosomes during cell division. Stretch: Students use the clothes pegs to model the process and make a short film of their model in action.	n/a	n/a

Lesson SB2b: Growth in animals (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B2.5: Describe growth in organisms, including: a) cell division and differentiation in animals … • B2.6: Explain the importance of cell differentiation in the development of specialised cells • B2.7: Demonstrate an understanding of the use of percentiles charts to monitor growth	*Starter* Students work in small groups to list as many examples as they can remember of different kinds of cell in the human body, and list details of each type of cell. *Exploring* Students research at least three different kinds of specialised human cells, with an aim of finding the 'strangest' kind of human cell. *Explaining* Show a short video on how a car is built from components. Then explain how the components could be used to model unspecialised and specialised cells.	*Exploring* Support: Give students a list of suitable cells for them to select from to research, such as bone cells, secretory cells such as in the pancreas (islets of Langerhans), kidney tubule cells, brain cells and striated muscle cells. Stretch: Students explain how the specialised structure of each cell type is adapted to its function. *Explaining* Support: Point out to students some of the weaknesses of the model (e.g. some of the components of a car are made from materials other than steel). Stretch: Challenge students to suggest ways in which the model is good and ways in which it is weak.	• Use ratios, fractions and percentages • Translate information between graphical and numeric form	n/a

Lesson SB2c: Growth in plants (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B2.5: Describe growth in organisms, including: … b) cell division, elongation and differentiation in plants • B2.6: Explain the importance of cell differentiation in the development of specialised cells	*Starter* Students work in pairs to jot down the names of at least five different plants and how their chosen plants look different from each other. Explain that the variation is due to different types and arrangements of cells in each type of plant. *Exploring* Ask students to map a range of different plant cell types, including meristem cells and specialised cells. *Explaining* Use a prepared slide or an internet image to point out the features of a longitudinal section of a root and ask the students questions about them.	*Exploring* Support: Discuss the named cell types with students before they start to make sure they understand where the cells are found and what they do. Stretch: Challenge students to compare how plants grow with how a human grows, including the time of life in which growth occurs, and where in the organism cell division and differentiation occur. *Explaining* Support: Discuss the answers to the questions as a group. Stretch: Challenge students to suggest why the meristem occurs at the tip of the root and not further back, and why the first cells that are obviously differentiated in the root are the hair cells and xylem.	n/a	n/a

Lesson SB2d: Stem cells (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B2.8: Describe the function of embryonic stem cells, stem cells in animals and meristems in plants • B2.9: Discuss the potential benefits and risks associated with the use of stem cells in medicine	*Starter* Use a simple video from the internet on stem cells, and class discussion, to establish that stem cells are cells that can turn into all sorts of more differentiated cells. *Exploring* Students work in pairs to research the development of a new treatment using stem cells. *Explaining* Use a range of coloured beads or buttons, or coloured dots on a presentation, to help students visualise the gradual development of stem cells into differentiated cells.	*Exploring* Support: Give students a pro-forma or table with headings showing what they should record. Stretch: Students should also record the source of the stem cells: embryonic, adult or umbilical cord. *Explaining* Support: Students use beads or buttons to do their own visualisation of stem cell differentiation. Stretch: Students sketch a diagram of a zebrafish embryo and annotate it to explain what it shows in terms of level of differentiation, and which of the cells shown are stem cells.	• Make estimates of the results of simple calculations	n/a

Lesson SB2e: The brain (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B2.10B: Describe the structures and functions of the brain including the cerebellum, cerebral hemispheres and medulla oblongata	*Starter* Ask students to each write down four things that our brains allow us to do. Answers should then be contributed to the class and a summary list of between 5 and 10 things agreed upon. *Exploring* Students make 'thinking caps' using papier mâché or white swimming caps or pale-coloured disposable surgery/scrub/catering/snood caps/hats. They use marker pens to draw the different areas of the brain with their functions so that when the cap is worn, these areas appear in their correct positions. *Explaining* Use an app to show 3D renderings of brains. Illustrate the position of the rod that went through Phineas Gage's brain.	*Exploring* Support: Give students a copy of a diagram that shows the different brain regions. Stretch: Challenge students to do some additional research to find out which scientists discovered what the different parts of the cerebral hemispheres do. *Explaining* Support: Remind students that the brain is constructed of billions of interconnected neurones (nerve cells). Stretch: Challenge students to look at the brains of other animals (models, real brains or images) and identify the different parts, in order to come up with a list of similarities and differences between those brains and human brains.	n/a	n/a

Lesson SB2f: Brain and spinal cord problems (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• **B2.11B: Explain how the difficulties of accessing brain tissue inside the skull can be overcome by using CT scanning and PET scanning to investigate brain function** • **B2.12B: Explain some of the limitations in treating damage and disease in the brain and other parts of the nervous system, including spinal injuries and brain tumours**	*Starter* Download some CT scan images and ask students to suggest how the scans were made. Ask students to identify some of the structures shown in the scans, such as the cerebral cortex, medulla oblongata, cerebellum and spinal cord. *Exploring* Create a brain 'jigsaw' which allows students to build up a picture of the brain and create labels for the picture – students need to pair up the names of the parts with their functions. *Explaining* Use a jelly brain to model the different ways of treating brain tumours, and some of the limitations of each.	*Exploring* Stretch: Students can add to the brain image by drawing on some of the positions of the various parts of the cerebral hemisphere and what they do. *Explaining* Support: Remind students that the brain is constructed of billions of interconnected neurones (nerve cells). Stretch: Challenge students to look at the brains of other animals (models, real brains or images) and identify the different parts, in order to come up with a list of similarities and differences between those brains and human brains.	• Use ratios, fractions and percentages. • Make estimates of the results of simple calculations. • Substitute numerical values into algebraic equations using appropriate units for physical quantities.	n/a

Lesson SB2g: The nervous system (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B2.13: Explain the structure and function of sensory receptors, sensory neurones, relay neurones in the CNS, motor neurones and synapses in the transmission of electrical impulses including the axon, dendron, myelin sheath and the role of neurotransmitters	*Starter* Ask students how many senses they think they have and their reasons for thinking this. Elicit the idea of what a sense is and hint at the fact that there are more than five. *Exploring* Investigation where students use a 'touch tester' with two points to find out which parts of the arms and hands are the most sensitive to touch. (*Suggested practical*.) *Explaining* Hold out an arm with your fingers straight and your thumb up. Ask students which features of the neurone are represented by the different parts of your arm and hand model (dendrites – fingers, dendron – palm, cell body – thumb, arm – axon).	*Exploring* Support: Help students to think about how many times they should repeat their measurements. Help students set the correct distances in the 'touch tester' for each trial. Stretch: Challenge students to plan their own investigations. *Explaining* Support: Draw a sensory neurone on the board and line up your arm under it, pointing out how the parts of the neurone and the 'arm model' relate. Stretch: Challenge students to describe ways in which this is a good model or a poor model.	• Translate information between graphical and numeric form • Use a scatter diagram to identify a correlation between two variables • Plot two variables from experimental or other data	*Suggested practical:* Investigate human responses to external stimuli. (See *Exploring*.)

Lesson SB2h: The eye (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B2.15B: Explain the structure and function of the eye as a sensory receptor including the role of: a) the cornea and lens b) the iris c) rod and cone cells in the retina • B2.16B: Describe defects of the eye including cataracts, long-sightedness, short-sightedness and colour blindness • B2.17B: Explain how cataracts, long-sightedness and short-sightedness can be corrected	*Starter* Ask students why some of them wear glasses/contacts. Explain that in the eye, the lens fine-tunes the focussing of an image, and that short-sighted people have lenses that cannot get thin enough to form a clear image for objects in the distance. Long-sighted people have lenses that cannot get fat enough to form a clear image of close objects. *Exploring* Students use a lens to focus an image of from outside the lab (through a window) onto a white card. They then use a lamp closer to the lens and find out whether a thicker lens or a thinner lens is needed to get the image of the closer object (the lamp) in focus on the card. *Explaining* Create a model of the eye using three convex lenses and a flat-bottomed flask filled with water. Set up the compact light source as the object to be viewed.	*Exploring* Support: Help student to understand why the image appears upside down. Stretch: Challenge students to use the apparatus given to develop their own plans to find out how a converging lens needs to change shape as the distance to an object changes. *Explaining* Support: Relate the parts of the model to the various structures in the eye before looking at the details of correction. Stretch: Ask students to summarise the features of the model that are similar to a real eye, and the features that are different.	• Construct and interpret frequency tables and diagrams, bar charts and histograms	Explore how lenses can be used to focus an image. (See *Exploring*.)

Lesson SB2i: Neurotransmission speeds (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B2.13: Explain the structure and function of sensory neurones, relay neurones in the CNS, motor neurones and synapses in the transmission of electrical impulses including the … myelin sheath and the role of neurotransmitters • B2.14: Explain the structure and function of a reflex arc including sensory, relay and motor neurones	*Starter* Volunteer students have their reaction times measured, e.g. using a smartphone/tablet app or an online reaction timer. Students sketch flow charts to explain what is happening in the nervous system of the person who is being tested (impulse transmission). (*Suggested practical*.) *Exploring* Investigation of the speed of transmission of electrical impulses in the nervous system. (*Suggested practical*.) *Explaining* Students study diagrams of motor neurone, relay neurone and reflex arc, and compare similarities/ differences/ modes of action.	*Exploring* Support: Guide students through the calculations for times, impulse speeds and the mean, and help them draw up a results table. Stretch: Students find the mean speed of the 'squeeze message' through different numbers of students and then measure the distance the impulses have had to travel. *Explaining* Support: Go through the diagrams of the motor neurone and the relay neurone carefully, pointing out the differences and similarities between the two types of neurone. Compare these with the sensory neurone. Stretch: Challenge students to spot the simplification in the reflex arc diagram and decide what else needs to be added to the drawing.	• Use a scatter diagram to identify a correlation between two variables • Translate information between graphical and numeric form • Plot two variables from experimental or other data	*Suggested practical:* Investigate reaction times. (See *Starter*.) *Suggested practical:* Investigate the speed of transmission of electrical impulses in the nervous system. (See *Exploring*.)

B3 Genetics				
Lesson SB3a: Sexual and asexual reproduction (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B3.1B: Explain some of the advantages and disadvantages of asexual reproduction, including the lack of need to find a mate, a rapid reproductive cycle, but no variation in the population • B3.2B: Explain some of the advantages and disadvantages of sexual reproduction, including variation in the population, but the requirement to find a mate	*Starter* Students work in pairs or small groups to construct a concept map around the term 'reproduction'. Prompt with the suggestion of how reproduction varies in different organisms, including animals, plants and bacteria. *Exploring* Students research reproduction in a variety of different organisms, such as budding in *Hydra* or yeast, binary fission (cell division) in single-celled organisms such as *Paramecium*, mammals, sharks, and plants, via flowers or via vegetative structures. *Explaining* Without explaining the relationship, show students a selection of examples of asexual reproduction in plants. Ask students to identify the connection between the examples of asexual reproduction, and the benefits the approach affords.	*Exploring* Support: Before students begin research, discuss specific questions that they should answer. Stretch: Students should research species that show both asexual and sexual reproduction at different stages of their life cycle, and explain the benefits to the organism of each approach. *Explaining* Support: List the advantages of sexual and asexual reproduction on the board. Then work as a group to link each of these to the two forms of reproduction in plants. Stretch: Students could consider and research why asexual reproduction is more common in plants and unicellular organisms than in multicellular animals.	n/a	n/a

Lesson SB3b: Meiosis (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B3.3: Explain the role of meiotic cell division, including the production of four daughter cells, each with half the number of chromosomes, and that this results in the formation of genetically different haploid gametes The stages of meiosis are not required • B3.5: Describe the genome as the entire DNA of an organism and a gene as a section of a DNA molecule that codes for a specific protein	*Starter* Write these words on the board: cell, chromosome, DNA, gene, nucleus. Challenge students to produce a labelled drawing to show the relative positions of these features. *Exploring* Students produce a poster showing the main events that take place during meiosis. *Explaining* Demonstrate meiosis using socks. Using dark and pale socks allows you to model the behaviour of 'sets' of chromosomes; dark colours are one set and pale colours are the other. String can be used to model the nuclear and cell surface membranes.	*Exploring* Support: Give students cards showing the events, which they should put in order. Stretch: Challenge students to show what happens to gametes during fertilisation. *Explaining* Support: Ensure that students understand what each part of the model represents, e.g. the string shows the cell membrane. Stretch: Challenge students to suggest ways in which the model is good and ways in which it is weak.	n/a	n/a

Lesson SB3c: DNA (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B3.4: Describe DNA as a polymer made up of: a) two strands coiled to form a double helix b) strands linked by a series of complementary base pairs joined together by weak hydrogen bonds c) nucleotides that consist of a sugar and phosphate group with one of the four different bases attached to the sugar • B3.6: Explain how DNA can be extracted from fruit	*Starter* Show a video clip of SOCOs at work and ask students what evidence is being looked for [DNA]. Ask students where DNA is found in the body and why it can be used to convict criminals. *Exploring* Make a 3D model of the DNA double helix. *Explaining* Explain to students that the proteins in a chromosome are responsible for protecting and packaging a DNA molecule. Help students to understand the nature of the hydrogen bonding between complementary base pairs.	*Exploring* Support: Help and remind students to colour the same bases in the same colour and to recognise that only certain pairs of bases can be formed. Stretch: Challenge students to evaluate the models that they have made, in terms of good and poor points about the usefulness of their models. *Explaining* Support: Remind students that there are negative and positive charges, and opposite charges attract. Stretch: Challenge students to design a table of bond types, comparing their structures and where they are found.	n/a	n/a

Lesson SB3d: Protein synthesis (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• **B3.7B: Explain how the order of bases in a section of DNA decides the order of amino acids in the protein and that these fold to produce specifically shaped proteins such as enzymes** • **B3.8B: Describe the stages of protein synthesis, including transcription and translation:** **a) RNA polymerase binds to non-coding DNA located in front of a gene** **b) RNA polymerase produces a complementary mRNA strand from the coding DNA of the gene** **c) the attachment of the mRNA to the ribosome** **d) the coding by triplets of bases (codons) in the mRNA for specific amino acids** **e) the transfer of amino acids to the ribosome by tRNA** **f) the linking of amino acids to form polypeptides**	*Starter* Write these words on the board: amino acids, gene, genetic code, keratin, protein. Challenge students to produce sentences using two or more words linked together. *Exploring* Set up some cards with phrases about transcription and translation for students to work in groups and sort into order to describe transcription and translation. *Explaining* Remind students what a binary number is. Ask all students to write down a 3 digit binary number (e.g. 010). Ask students to work in groups and join their 3 digit codes together. Give out coloured beads and string with a code sheet that matches each triplet to a colour. Students then need to complete their coloured chain. Explain that this is a model of what happens in protein synthesis.	*Exploring* Support: Give students the starting point/first card to start with. Stretch: Remove one of the cards before giving to a group and challenge students to complete the missing stage(s). *Explaining* Support: Point out some of the weaknesses of the model e.g. the original code is already on the gene, it doesn't need to be invented randomly. Stretch: Challenge students to suggest ways in which the model is good and ways in which it is weak.	Use of binary numbers in explaining task	n/a

Lesson SB3e: Genetic variants and phenotypes (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• **B3.10B: Describe how genetic variants in the coding DNA of a gene can affect phenotype by altering the sequence of amino acids and therefore the activity of the protein produced** • **B3.9B: Describe how genetic variants in the non-coding DNA of a gene can affect phenotype by influencing the binding of RNA polymerase and altering the quantity of protein produced**	*Starter* Write this sentence on the board 'Some mutations have small effects'. Demonstrate how changing a few words by one letter could change the sentence or not e.g. 'effects' to 'effectt' (misspelt but does not affect meaning), 'have' to 'gave' (similar meaning, but slightly different), 'have' to 'hate' (nonsense). Explain that a similar thing happens in DNA. Some mutations can have no effect on meaning, small effect or large effect (rendering gene useless). *Exploring* Ask each student to think of a code of 12 bases and write it on a piece of paper. Pass to a neighbour who writes the corresponding mRNA code below it. Pass on again, and using a genetic code table, translate code into a protein (show protein as circles in a chain with three letter amino acid symbols in each circle). Give paper back to initial student who checks if it is correct. *Explaining* Model translation and effect of mutation using plastic building bricks. Write out a sequence of mRNA bases that will give a certain order of colours. Point out that each brick corresponds to an amino acid, and the sequence of these dictates how the protein will fold.	*Exploring* Support: give students mRNA codes to begin with, then do activity again as shown. Stretch: tell students that the start code is AUG. Ask students to design a piece of mRNA where translation does not start at the beginning, challenge them to explain why mRNA is usually like this (because RNA polymerase attaches to non-coding DNA before the start of the 'gene') *Explaining* Support: Clearly explain what the model represents, and reiterate this at the end. Stretch: Ask students to evaluate the model and challenge them to come up with one they think may be better.	n/a	n/a

Lesson SB3f: Mendel (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B3.11B: Describe the work of Mendel in discovering the basis of genetics and recognise the difficulties of understanding inheritance before the mechanism was discovered	*Starter* Ask students to write phrases describing two or three ways in which they are different to a friend. Then write down the reasons for each of these differences. Take random answers from the class and highlight any key terms that have been used (such as variation, inherited/genetic variation, environmental variation, gene, mutation, allele). Go through the meanings of the words and correct any misconceptions. *Exploring* Challenge students to link Mendel's laws of inheritance to some of the evidence Mendel used to draw them up. *Explaining* On the board, draw out part of the mRNA sequence from part of the *Le* gene, which controls plant height in peas: GGU CUC GCC CCG CAC ACA Then draw out the corresponding part of the mutant allele. GGU CUC ACC CCG CAC ACA Ask students to spot the mutation, then translate the code into an amino acid sequence. The *Le* gene codes for an enzyme which is responsible for making a hormone that stimulates plant growth. The mutant allele prevents the active site from working well. This is the mutation that Mendel identified in his experiments on heights in pea plants.	*Exploring* Support: Give students the links between the laws and the evidence *Explaining* Support: Go through the process of translation step-by-step with students Stretch: Challenge students to write out the coding and template strands for the corresponding section of gene for the mRNA strands shown.	• Use ratios, fractions and percentages • Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand simple probability	n/a

Lesson SB3g: Alleles (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B3.12: Explain why there are differences in the inherited characteristics as a result of alleles • B3.13: Explain the terms: chromosome, gene, allele, dominant, recessive, homozygous, heterozygous, genotype, phenotype, gamete and zygote • B3.14: Explain monohybrid inheritance using genetic diagrams … and family pedigrees	*Starter* Write a series of DNA base letters on the board. Invite students to write the correct complementary base pairs underneath. Then ask students what this code is for – making a protein. *Exploring* Eye colour modelling using pale and dark beads. *Explaining* Choose 8 randomly selected students to taste either PTC strip (commercially available) or a control strip (no PTC). The finding that most (or all) of the subjects can detect PTC supports the idea that this phenotype is caused by a dominant allele. Using T and t for the alleles, establish that the tasters could be TT or Tt and then draw out genetic diagrams for TT x TT and TT x Tt and Tt x Tt. Show that only the last combination will produce zygotes that are non-tasters.	*Exploring* Support: Prepare the results table for students to fill in and help them choose appropriate axes for their bar charts Stretch: Challenge students to calculate the ratio of phenotypes predicted by their genetic cross diagrams, and to relate this back to their experimental findings. *Explaining* Support: Before the main part of this activity, remind students of the terms 'dominant' and 'recessive' and explain the circumstances under which a recessive trait will be seen. Stretch: Challenge students to draw genetic diagrams for tasting PTC before you show them on the board.	• Use ratios, fractions and percentages • Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand simple probability • Translate information between graphical and numeric form	n/a

Lesson SB3h: Inheritance (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B3.14: Explain monohybrid inheritance using … Punnett squares • B3.15: Describe how the sex of offspring is determined at fertilisation, using genetic diagrams • B3.16: Calculate and analyse outcomes (using probabilities, ratios and percentages) from monohybrid crosses and pedigree analysis for dominant and recessive traits	*Starter* Tell students that humans have 23 pairs of chromosomes and one of these pairs is a pair of sex chromosomes, of which there are two types, X and Y. Ask students to draw a genetic diagram to explain why about 50% of the UK population is male (XY) and about 50% of the population is female (XX). *Exploring* Provide students with some pieces to cut out and stick in order to construct a family pedigree for a family in which cystic fibrosis occurs. (*Suggested practical*.) *Explaining* Show a video from the internet of someone talking about living with a genetic disorder. Then have a class discussion on what was said, and also on ethical points around testing for the allele.	*Exploring* Support: Consider giving groups of weaker students the family pedigree chart ready-made, so that they only need to fill in the missing genotypes, names and shading. Stretch: Tell students that someone who has one recessive allele, and so can pass the disorder on even though they don't suffer from it, is called a carrier. Ask students to add carriers to the key and to shade them in a different colour. *Explaining* Support: Students write a list of key words they think the speaker will use. Make sure students understand the meanings of these words. Stretch: Challenge students to take notes from the talk and summarise the main points.	• Use ratios, fractions and percentages • Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand simple probability • Translate information between graphical and numeric form	*Suggested practical:* Investigate inheritance using suitable organisms or models. (See *Exploring*.)

Lesson SB3i: Multiple and missing alleles (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B3.17B: Describe the inheritance of the ABO blood groups with reference to codominance and multiple alleles • **B3.18B: Explain how sex-linked genetic disorders are inherited**	*Starter* Give students a simple example of monohybrid inheritance from two heterozygote parents. They should draw a Punnett square to show the possible genotypes and phenotypes of the offspring. *Exploring* Use cards to model inheritance in ABO blood groups. (*Suggested practical.*) *Explaining* Use a blood typing kit to demonstrate to students how ABO blood group is identified, and to explain why knowing a patient's blood group is important before they receive a blood or organ donation.	*Exploring* Support: Work with students to lay out the genetic diagram, and check that they can analyse the results correctly. Stretch: Ask students to use their calculations of theoretical outcomes to predict which blood groups are most common. They should compare these with the actual proportions of people with the four ABO blood groups in the UK: A 38%, B 10%, O 48%, AB 4%. *Explaining* Support: Lead students through the process of identifying the blood group tested, and why other blood groups give other results. Stretch: Explain to students that people of blood group A have anti-B antibodies in their blood plasma, those of blood group B have anti-A antibodies, those of group O have both anti-A and anti-B, and those of group AB have no antibodies. They should use this information to try to explain why blood group O is called the 'universal donor' and blood group AB the 'universal recipient'.	• Use ratios, fractions and percentages • Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand simple probability • Translate information between graphical and numeric form	*Suggested practical:* Investigate inheritance using suitable organisms or models. (See *Exploring*.)

Lesson SB3j: Gene mutations (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B3.19: State that most phenotypic features are the result of multiple genes rather than single gene inheritance • B3.20: Describe the causes of variation that influence phenotype including a) genetic variation – different characteristics as a result of mutation … • B3.21: Discuss the outcomes of the Human Genome Project and its potential applications within medicine • B3.22: State that there is usually extensive genetic variation within a population of a species and that these arise through mutations • B3.23: State that most genetic mutations have no effect on the phenotype, some mutations have a small effect on the phenotype and, rarely, a single mutation will significantly affect the phenotype	*Starter* Arrange students in groups of at least five and ask them to collect data from the group about variation in a few characteristics that are genetically controlled, such as tongue rolling, earlobe shape, straight/hitchhikers thumb, presence or absence of cheek dimples, cleft/smooth chin. *Exploring* Students use a simple eye colour scale to collect data on the variation in eye colour in the class or other groups (e.g. families). (*Suggested practical*.) *Explaining* Use the example of cystic fibrosis to help students make a clear link between mutations in DNA and how these can affect the body.	*Exploring* Support: Work with students to decide on which data to collect and how it should be recorded. Stretch: Students should evaluate the use of the scale for mapping variation by considering other methods that could be used (such as a light meter), and whether eye colour is affected by other factors (e.g. amount of light, colour of light reflected on the face e.g. from clothing near the neck). Students should also consider whether the scale they've used is detailed enough for their conclusions. *Explaining* Support: Use this activity as an opportunity to revise key terms met in this unit so far (e.g. gene, allele, genotype, phenotype, recessive, dominant, mutation, genome, base). Stretch: Explain to students how the CFTR gene was found.	n/a	*Suggested practical:* Investigate the variations within a species to illustrate continuous variation and discontinuous variation. (See *Exploring*.)

Lesson SB3k: Variation (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B3.20: Describe the causes of variation that influence phenotype including a) genetic variation – different characteristics as a result of mutation and sexual reproduction b) environmental variation – different characteristics caused by an organism's environment (acquired characteristics)	*Starter* Ask students to work in pairs and to note down six examples of variation in human characteristics. For each example, they should identify how they vary (can the variations be grouped, as in eye colour, or do they show a range between two extremes, as in height). *Exploring* Provide students with sample data as charts and tables for the variation of continuous and discontinuous characteristics for a plant (such as a holly bush). Ask students to describe what each chart or table shows. *Explaining* Write up a list of characteristics on the board, then draw a Venn diagram on the board of two intersecting circles. Add at least one characteristic to each section of the diagram, and ask students to spot what the labels should be for each of the circles and for the area of intersection.	*Exploring* Support: List the different types of variation for students, and review chart types. Stretch: Students should discuss the importance of grouping continuous data in order to produce a useful chart. *Explaining* Support: Check that students are clear why there is no intersection of the circles for continuous and discontinuous variation, and are certain what the intersection of the circles in the genetic/environment diagram means. Stretch: Ask students to think about examples of variation caused by a single gene (e.g. human ABO blood group) and variation caused by multiple genes (e.g. human eye colour), and to compare the shape of charts of variation that they produce.	n/a	n/a

B4 Natural selection and genetic modification				
Lesson SB4a: Human evolution (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B4.4: Describe the evidence for human evolution, based on fossils, including: a) Ardi from 4.4 million years ago b) Lucy from 3.2 million years ago c) Leakey's discovery of fossils from 1.6 million years ago • B4.5: Describe the evidence for human evolution based on stone tools, including: a) the development of stone tools over time b) how these can be dated from their environment	*Starter* Ask students to think about how humans or other animals might evolve in the future. They could draw a labelled picture to show how humans might change and give a reason why they might evolve in that way. *Exploring* Show an 'evolutionary tree' for humans. Research and create fact cards about the human-like organisms shown, which includes a picture of each species. *Explaining* Demonstrate how fossils form using a narrow glass or plastic tank/beaker, plastic skeleton/small stones, and sand of different colours to build up layers to model the way the sedimentary layers build up.	*Exploring* Support: Give students guidance on which websites to use. Stretch: Ask students to work in a groups and each member of a group to choose a different species to study, then create a poster using the cards. *Explaining* Support: Sort a list of human-like species, in order of the layers in which they would be found. Stretch: Challenge students to use the model to explain why scientists date the rock in a layer where stone tools are found rather than the rocks that the stone tools are made of.	• Recognise and use expressions in decimal form • Recognise and use expressions in standard form • Use ratios, fractions and percentages • Translate information between graphical and numeric form	n/a

Lesson SB4b: Darwin's theory (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B4.2: Explain Darwin's theory of evolution by natural selection • B4.3: Explain how the emergence of resistant organisms supports Darwin's theory of evolution including antibiotic resistance in bacteria	*Starter* Sketch a normal distribution curve on the board and tell students that it shows variation in beak length in a population of sandpipers. Ask students to suggest why there are more birds with the middle beak length and very few with either very short or very long beaks. *Exploring* Play a game to illustrate natural selection using coloured pasta 'insects' (equal amounts, including green). Spread the pasta on a green, grassy area. One student acts as a bird with 2 minutes to pick up as many insects as possible with tongs. Record the proportions of colours collected, and repeat. *Explaining* Discuss Lamarck's theory of evolution that organisms adapted to their surroundings, often by movements of their 'internal fluids' that enabled certain body parts to swell.	*Exploring* Support: Use a pre-prepared spreadsheet for recording the results. Stretch: Ask students to design their own games to show natural selection. *Explaining* Support: Ask students how Lamarck would have explained how giraffes got their long necks. Stretch: In 1889, August Weissman cut off the tails of 21 generations of rats. Ask students why they think he did this, what they think happened and why this experiment does not refute Lamarck's theory.	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Translate information between graphical and numeric form	Natural selection game using coloured pasta 'insects'. (See *Exploring.*)

Lesson SB4c: Development of Darwin's theory (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B4.1B: Describe the work of Darwin and Wallace in the development of the theory of evolution by natural selection and explain the impact of these ideas on modern biology • B4.6B: Describe how the anatomy of the pentadactyl limb provides scientists with evidence for evolution	*Starter* Ask students where they would expect to find crocodiles and establish these animals usually live by bodies of water. Tell students there are also crocodiles that live in the Sahara Desert that survive without food for many months when it is too hot and dry. When the rains arrive they come to the surface to hunt. Challenge students to explain how these crocodiles may have evolved. Ask groups to give short presentations of their answers, and correct misconceptions as they arise. *Exploring* Display a series of kitchen implements used to carry food and compare each one to a type of bird beak e.g. a knife (egret), slotted spoon (flamingo) etc. Demo how these implements can be used to pick up different sized 'foods' e.g. marbles, seeds etc. Establish that some implements are better at picking up certain foods than others. Remove some types of 'foods' and explain how this gives an advantage to some types of 'beak' *Explaining* Show a human skeleton, pointing out the five-digits on the end of each limb (the pentadactyl limb).Compare these to other animal skeletons e.g. rabbit forefeet. Establish idea that all ancestors to all these animals had pentadactyl limbs and at one point there was a common ancestor to all vertebrates.	*Exploring* Support: carefully go through each part of the model, explaining how it relates to natural selection, with a change in the surroundings causing more birds with the better shaped beaks to survive and reproduce. Stretch: Tell students that the finches that originally arrived in the Galapagos had medium-sized beaks. Ask them to suggest how Lamarck might have explained the evolution of only some of the finches. (The way that Lamarck imagined that body parts shrank in size was through lack of use, which cannot really explain how the birds with smaller beaks evolved.) *Explaining* Support: Remind students about the classes of vertebrates and similarities between them. Make sure students understand the similarities between organisms provide evidence that they evolved from a common ancestor, even though there are big differences between individual species. Stretch: Challenge students to find out what pentadactyl means and the roots of the word.	n/a	Modelling bird beaks (*see exploring)*

Lesson SB4d: Classification (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B4.7: Describe how genetic analysis has led to the suggestion of the three domains rather than the five kingdoms classification method	*Starter* Ask students to suggest how a visitor to the area might be able to find an individual student in a school [e.g. school > year group > form > workgroup > individual] *Exploring* Ask students to sort themselves into two groups and then think of another way of dividing themselves into two or more groups. This process can be repeated a number of times. *Explaining* Take students through the classification of several plants and animals, showing how the number of organisms in each group gets smaller and smaller and how the similarities between the organisms increase. Ask students to suggest other members of the groups as you work through the classifications.	*Exploring* Support: Give students a way of splitting themselves into two groups to begin with. Stretch: Ask students to sort themselves into nested groups. *Explaining* Support: For the orders, families and genera, give students a list of organisms and ask them to suggest which one(s) will not be found in the next group down. Stretch: Ask students to prepare their own diagrams to show the full classification of an animal (e.g. lion).	n/a	n/a

Lesson SB4e: Breeds and varieties (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B4.8: Explain selective breeding and its impact on food plants and domesticated animals • B4.10: Describe genetic engineering as a process which involves modifying the genome of an organism to introduce desirable characteristics	*Starter* Challenge students to produce a list of useful characteristics for cattle on a UK farm (e.g. good meat, quick growing, produce a lot of milk, docile). Then ask what other characteristics might be useful for cattle being farmed in northern Scotland (e.g. thick fur) or Africa (thin fur, less requirement for water). *Exploring* Ask students to work in groups to model genetic engineering using a long strip of paper and a short strip, and some scissors and sticky tape. *Explaining* Source a video on selective breeding, using it to discuss how selective breeding is carried out to produce new breeds and varieties, and the impact that this can have on species.	*Exploring* Support: Remind students of the definitions of genes and chromosomes and suggest what each length of paper represents. Stretch: Students brainstorm ideas about the process, i.e. how in practice can chromosomes be 'cut'? *Explaining* Support: Remind students of their work on natural selection and how this process works then show how this relates to artificial selection. Stretch: Challenge students to find out some other examples of GMOs that are currently being developed and how they are being propagated.	n/a	n/a

Lesson SB4f: Tissue culture (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B4.9B: Describe the process of tissue culture and its advantages in medical research and plant breeding programmes	*Starter* Write the following words on the board: mitosis, differentiation, cell culture, aseptic technique. Then say that a scientist wants to grow some cells to use in making a replacement windpipe. For each of the terms on the board, ask students to write one sentence that is related to making the windpipe. *Exploring* Create a card sort activity with two sets of cards: one set describes the stages in the process of culturing either plant or animal cells and tissues, the other identifies the advantages of either plant or animal tissue culture. These should be sorted to link with the first set according to which process they link best to. *Explaining* Discuss a few examples of the use of tissue culture in plant breeding with students. Use images or video from the Internet to introduce and describe the examples, asking students in each case to identify the advantage of using tissue culture compared with traditional breeding methods or methods of artificial cloning (e.g. taking cuttings).	*Exploring* Support: Work with students to complete the layout for plant tissue culture. Stretch: Research one of the uses for tissue culture, for example in producing GM cells, or hybridoma cells for making monclonal antibodies *Explaining* Support: Remind students of the differences between asexual and sexual reproduction, and their effect on the amount of genetic variation between parent plant and offspring, to help them understand where lack of variation is an advantage in tissue culture. Stretch: Give students a new example and ask them to research why tissue culture is an advantage in that case.	n/a	n/a

Lesson SB4g: Genes in agriculture and medicine (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B4.14: Evaluate the benefits and risks of genetic engineering and selective breeding in modern agriculture and medicine including practical and ethical implications • **B4.11: Describe the main stages of genetic engineering including the use of:** **a) restriction enzymes** **b) ligase** **c) sticky ends** **d) vectors**	*Starter* Tell students a plant breeder wishes to produce a new variety of orange. Ask them to come up with a list of useful features for the orange to have. *Exploring* Give students cards showing the stages in the process of making recombinant microorganisms. They should work together to produce the correct order of cards. *Explaining* Illustrate the idea of sticky ends using a Lego® model, using four different colours of individual bricks (to represent bases and base pairing) attached to four longer sections so that a break can easily be made.	*Exploring* Support: Go through the sentences on the cards first, and explain the idea of a marker gene. Stretch: Challenge students to research some of the bacteria that have been genetically engineered in this way and the useful substances that we now obtain from them. *Explaining* Support: Remind students of the four bases found in DNA and of the base pairing rules. Stretch: Extend the demonstration by showing what happens if the enzymes make blunt ends and ask students to suggest the disadvantage of this.	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Translate information between graphical and numeric form • Plot two variables from experimental or other data	n/a

Lesson SB4h: GM and agriculture (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B4.12B: Explain the advantages and disadvantages of genetic engineering to produce GM organisms including the modification of crop plants including the introduction of genes for insect resistance from *Bacillus thuringiensis* into crop plants	*Starter* Show students a crop plant such as a tomato or potato plant. Ask students to suggest how the different parts of the plant might show variation. For one variation, suggest how they would genetically engineer it in order to increase yield. *Exploring* Provide students with a mixed-up selection of labels and images explaining the process of modifying crop plants with the Bt toxin gene, to make them resistant to insect pests. Ask students to arrange the cards to model the process. *Explaining* Discuss the advantages and disadvantages of insect-resistant GM crops. Consider the effect of the interrelationship of organisms in food chains and food webs.	*Exploring* Stretch: Encourage students to add their own labels to the diagrams explaining the process. *Explaining* Stretch: Challenge students to compare between developing resistance by insects to GM crops with developing resistance to antibiotics by bacteria.	• Translate information between graphical and numeric form. • Plot two variables from experimental or other data.	n/a

Lesson SB4i: Fertilisers and biological control (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B4.13B: Explain the advantages and disadvantages of agricultural solutions to the demands of a growing human population including use of fertilisers and biological control	*Starter* Display a simple agricultural food web on the board to show a range of insects (and other animals) that feed on the crop, and their predators. Ask simple questions to test understanding of the interrelationship of the organisms. *Exploring* Provide students with data showing the effects of nitrogen fertiliser on the growth of an oilseed rape crop. *Explaining* Ask students to work in pairs or small groups to look at given examples of biological control to identify why some have been successful and others not.	*Exploring* Support: Discuss the chart and graph with students as a group, to help them identify what they show. Stretch: Ask students why it is important that fertiliser is applied to crops at the right time of year. *Explaining* Support: Discuss the examples of biological control with students to help them identify which features of the control organism are linked to the success or failure of biological control. Stretch: Students could research their own examples of successful and failed attempts at biological control.	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Translate information between graphical and numeric form • Plot two variables from experimental or other data	n/a

B5 Health, disease and the development of medicines				
Lesson SB5a: Health and disease (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• *B5.1: Describe health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, as defined by the World Health Organisation (WHO) • *B5.2: Describe the difference between communicable and non-communicable diseases • B5.3: Explain why the presence of one disease can lead to a higher susceptibility to other diseases	*Starter* Write the word health on the board and ask students to try to define it. Take some suggestions and then share the WHO definition with them: a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. *Exploring* Ask students to assess how well their school promotes and supports the health of students. They should make lists of what they know is being done, and also of what they think should be done but they need more information about. *Explaining* Show students a graph of income and life expectancy for different countries using an online data source, such as Gapminder. Ask students to compare the values for the countries, and encourage them to think of as many reasons as possible for the correlation between average income and life expectancy.	*Exploring* Support: For the three areas of well-being in the WHO definition, work with students to identify one example of each that they know is happening in the school, and suggest one example of each that the school might develop. Stretch: Students can compare their lists with the key features outlined in Chapter 1 of *Local Action: Creating Health Promoting Schools,* a guidance document from the World Health Organization. *Explaining* Support: Look at 3 individual data points and discuss the values they represent. Stretch: Challenge students to suggest reasons why the slope is steeper in lower incomes than in higher.	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand the principles of sampling as applied to scientific data • Use a scatter diagram to identify a correlation between two variables • Translate information between graphical and numeric form • Plot two variables from experimental or other data	n/a

Lesson SB5b: Non-communicable diseases (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• *B5.23: Describe that many non-communicable human diseases are caused by the interaction of a number of factors including cardiovascular diseases, many forms of cancer, some lung and liver diseases and diseases influenced by nutrition • *B5.24: Explain the effect of lifestyle factors on non-communicable diseases at local, national and global levels, including: a) … diet on … malnutrition… b) alcohol on liver diseases ...	*Starter* Ask students to jot down the main constituents of food (not including water), an example of a good food source, and the function of that constituent. *Exploring* Students research and debate the question 'Should vitamins be added to more prepared foods than at present?' In groups, they should take one side and write a series of bulleted points that clearly support their decision. Each group presents their three best points to the class, at the end of which allow a class vote on the question. *Explaining* Demonstrate the importance of the liver in the breakdown of toxic substances using hydrogen peroxide.	*Exploring* Support: Prompt students with targeted questions about which vitamins might be added, why, and any possible problems to support their research Stretch: Students should include both benefits and risks in their research, and justify their arguments with evidence. *Explaining* Stretch: Students should explain the correlation between liver disease and other diseases in terms of the build-up of toxic substances.	• Recognise and use expressions in decimal form • Use percentages • Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand the principles of sampling as applied to scientific data • Use a scatter diagram to identify a correlation between two variables • Translate information between graphical and numeric form. • Plot two variables from experimental or other data	Demonstrate the breakdown of hydrogen peroxide by the liver. (See *Explaining*)

Lesson SB5c: Cardiovascular disease (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• *B5.24: Explain the effect of lifestyle factors on non-communicable diseases at local, national and global levels, including: a) exercise and diet on obesity and malnutrition, including BMI and waist:hip calculations using the BMI equation: $$\text{BMI} = \frac{\text{weight (kg)}}{(\text{height (m)})^2}$$ … c) smoking on cardiovascular diseases • B5.25: Evaluate some different treatments for cardiovascular disease including: a) life-long medication b) surgical procedures c) lifestyle changes	*Starter* Use a smoking machine to demonstrate the substances that are taken into the lungs while smoking tobacco. *Exploring* In small groups, students should research the advantages and disadvantages of one of the following treatments for cardiovascular disease: life-long medication, surgical procedures, or lifestyle changes. *Explaining* Present students with a list of measurements that a health professional may take when monitoring health, including BMI. Using yourself as a subject, take measurements of heart rate and breathing rate at rest, after 2 minutes of gentle exercise and after 2 minutes of moderate exercise.	*Exploring* Support: Give students suitable pieces of text from the internet about two or three treatments. Stretch: Students should summarise the outcomes of the research as simple guidance for doctors about how to decide which treatment should be used with patients suffering different kinds of cardiovascular disease. *Explaining* Support: Check that students understand the terms BMI and waist:hip ratio and how they are measured. Stretch: Students should suggest other factors that a health professional might include in a health assessment of someone who is obese, giving explanations for their suggestions.	• Recognise and use expressions in decimal form • Use ratios • Translate information between graphical and numeric form • Understand the principles of sampling as applied to scientific data • Use a scatter diagram to identify a correlation between two variables	Demonstrate the effects of smoking on the lungs using a smoking machine. (See *Starter*)

Lesson SB5d: Pathogens (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B5.4: Describe a pathogen as a disease-causing organism including viruses, bacteria, fungi and protists • B5.5: Describe some common infections, including: a) cholera (bacteria) causes diarrhoea b) tuberculosis (bacteria) causes lung damage c) chalara ash dieback (fungi) causes leaf loss and bark lesions d) malaria (protists) causes damage to blood and liver e) HIV (virus) destroys white blood cells, leading to the onset of AIDS f) stomach ulcers caused by Helicobacter (bacteria) g) Ebola (virus) causes haemorrhagic fever	*Starter* Write the names of the four pathogen groups (bacteria, protists, fungi, bacteria) on the board and ask students to write one sentence about each group. *Exploring* Measure the growth of bacteria in fresh milk kept at different temperatures for the previous 24 hours. (*Suggested practical*) *Explaining* Introduce students to John Snow, a doctor working in Soho during the 1854 outbreak of cholera. Show a copy of his map of deaths and water pumps, and ask them why the distribution of deaths does not support the 'bad air' hypothesis, and does support the idea that water is a source of infection.	*Exploring* Support: Support students in setting up the results table and using their results to draw a line graph Stretch: Ask students to explain how oxygen concentration is related to bacterial concentration in the milk *Explaining* Support: check that students understand that some bacteria are pathogens, and that they remember ways in which pathogens are spread Stretch: Ask students what other evidence could have been used to prove that cholera came from a pathogen in water.	n/a	*Suggested practical:* Investigate the conditions affecting growth of micro-organisms (using resazurin dye). (See *Exploring*)

Lesson SB5e: Spreading pathogens (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B5.6: Explain how pathogens are spread and how this spread can be reduced or prevented, including: a) cholera (bacteria) – water b) tuberculosis (bacteria) – airborne c) chalara ash dieback (fungi) – airborne d) malaria (protists) – animal vectors e) stomach ulcers caused by Helicobacter (bacteria) – oral transmission f) Ebola (virus) – body fluids	*Starter* Ask students to make one sentence using each group of three words: cholera bacteria, water, sickness; chalara, air, fungus; HIV, body fluids, virus. *Exploring* In small groups research on one of the diseases listed in the objectives, focusing on how the disease is transmitted, and how this can be prevented. Students should then prepare a poster to explain to others how to prevent the spread of the disease. *Explaining* Model the spread of an infectious disease, e.g. using a product such as Glo Germ™, or though acting out the process of infection as a group.	*Exploring* Support: Simplify the task by asking students just to answer the questions. Stretch: Ask students to find out about how new technology is being used to stop the spread of diseases that require vectors. *Explaining* Support: Use the analogy of a computer virus to help explain how infection is transmitted. Stretch: Challenge students to design and assess their own models of disease spread using themselves as the 'vectors'.	n/a	n/a

Lesson SB5f: Virus lifecycles (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B5.7B: Describe the lifecycle of a virus, including lysogenic and lytic pathways • B5.19B: Calculate cross-sectional areas of bacterial cultures and clear agar jelly using πr^2	*Starter* Ask students to work together in pairs or small groups to jot down what they already know about viruses. Take examples of selected points from different groups to discuss with the class to identify what students already know about viruses. Note any confusions in understanding to sort out during the study of this topic. *Exploring* Give students some diagrams of three different plaque diameters in three agar plates as a worksheet, and ask them to use these to work out the cross-sectional area of the circles. They can then make a judgement about which virus has the fastest life cycle. *Explaining* Point out to students that, although the term 'life cycle' is used to describe the cycle of development of viruses, most people do not consider viruses to be alive because they do not show the life processes that cells do. Take them through an animation of a virus life cycle and ask students to produce a presentation of the lytic and lysogenic pathways of a virus life cycle with details on the different stages.	*Exploring* Support: Check that students can measure diameters of circles accurately, and work with them to calculate the radius and then the cross-sectional area. Stretch: Ask students to predict what a bacterial plate would look like several days after infection with a virus that enters the lysogenic pathway, and to explain their reasoning. *Explaining* Support: Provide additional links to websites or animations to help students visualise the life cycles Stretch: Challenge students to find out about the structures of two different viruses and compare the similarities and differences in the structures.	• Recognise and use expressions in decimal form • Construct and interpret frequency tables and diagrams, bar charts and histograms • Calculate areas of triangles and rectangles, surface areas and volumes of cubes	tbc

Lesson SB5g: Plant defences (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B5.9B: Describe how some plants defend themselves against attack from pests and pathogens by physical barriers including the leaf cuticle and cell wall • B5.10B: Describe how plants defend themselves against attack from pests and pathogens by producing chemicals, some of which can be used to treat human diseases or relieve symptoms • B5.17B: Explain the aseptic techniques used in culturing microorganisms in the laboratory, including the use of an autoclave to prepare sterile growth medium and petri dishes, the use of sterile inoculating loops to transfer microorganisms and the need to keep petri dishes and culture vials covered	*Starter* Students work in small groups to come up with examples of how plants may be attacked by pests and pathogens. Reference to feeding relationships and food chains should also raise herbivores. Then ask what plants could do to protect themselves from pests that eat parts of the plant, or pathogens that infect/get inside them. *Exploring* Practical to investigate antimicrobial properties of plants. Bacterial lawn plater and plant extracts need to be prepared before the lesson. Suitable extracts include chilli powder, cinnamon, cloves, fennel, garlic. To make extract, grind 3g of plant material with 10cm3 ethanol (IDA) and shake for 10 minutes. Plates should be incubated at 20-25 oC for 2-3 days. Discuss how to record results with students (e.g. measure diameter of clear area/draw diagram). All suggested plant extracts should show some antimicrobial effect. *Explaining* Give students examples of how plants protect themselves – mixing physical barriers and chemical defences. As you present each one, as students to identify which group each example belongs to, and explain how the example helps protect the plant.	*Exploring* Support: Students can work in small groups to discuss their method/thoughts before completing notes. Stretch: Ask students to plan their own experiment and complete write up without scaffolding. *Explaining* Support: Work with students for first couple of examples, then encourage them to work in groups without your support Stretch: Students should research another example and produce a further example in the same way as you have presented yours.	• Calculate areas of triangles and rectangles, surface areas and volumes of cubes	*Suggested practical:* Investigate antimicrobial properties of plants.

Lesson SB5h: Plant diseases (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• **B5.11B: Describe different ways plant diseases can be detected and identified, in the lab and in the field including the elimination of possible environmental causes, distribution analysis of affected plants, observation of visible symptoms and diagnostic testing to identify pathogens**	*Starter* Show students a range of products that can be bought in garden centres to help look after plants (include those used to treat or prevent attack by pests or pathogens, and those that affect environmental conditions, such as fertilisers and water-retaining granules). Students discuss how each product can help plants to grow better, then take examples from around the class to share. Reinforce idea that plants are damaged both by challenging environmental conditions as well as by pests and pathogens, and all these factors must be controlled if a crop plant is to produce a large yield. *Exploring* Students should prepare an advice leaflet or webpage that shows the symptoms and causes of growth problems in one type of vegetable or fruit plant commonly grown by gardeners (e.g. apples, tomatoes). Images should be supported with descriptions to distinguish between various symptoms and what could be causing it (e.g. yellow spots due to a pathogen infection or chemical damage). Allow time for students to check each other's work identifying good/weak points in their work. *Explaining* Invite a member of the school's grounds staff, or someone locally who works with plants (e.g. from a garden centre, arboretum or park), to talk about how they monitor for different diseases and what they do if they find a disease. Students should write questions beforehand. After the talk, students should identify what they have learnt from the answers. This could be extended with a site visit and tour by the grounds staff.	*Exploring* Support: Students should work in pairs and focus on distinguishing between the possible causes of one particular leaf problem (e.g. leaf spots, leaf curl) Stretch: Challenge students to identify the best treatment for each cause. *Explaining* Support: Work as a group to select useful questions before the talk, and to discuss the answers after the talk to identify what has been learnt. Stretch: Students should evaluate the answers they have been given to decide where visible symptoms were sufficient and where further tests were needed to identify the cause of a problem. They should also consider how the solution to the problem was appropriate.	• Understand the principles of sampling as applied to scientific data • Plot two variables from experimental or other data • Calculate areas of triangles and rectangles, surface areas and volumes of cubes	n/a

Lesson SB5i: Physical and chemical defences (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B5.12: Describe how the physical barriers and chemical defences of the human body provide protection from pathogens, including: a) physical barriers including mucus, cilia and skin b) chemical defence including lysozymes and hydrochloric acid • B5.8: Explain how sexually transmitted infections (STIs) are spread and how this spread can be reduced or prevented, including: a) *Chlamydia* (bacteria) b) HIV (virus)	*Starter* Ask students to work in pairs to jot down as many reasons as they can why the clotting of blood is useful when we cut ourselves. *Exploring* Create a set of statements to describe how smoking tobacco leads to lung infections as a result of damage to cilia in the breathing system. Ask students to sort the statements and add diagrams to the description. *Explaining* Watch a video from the internet on the spread of STIs. As a class, discuss ways the spread of infection can be reduced or prevented.	*Exploring* Support: Work with students to help them sort the statements correctly Stretch: Ask students to write a 3-mark question with mark scheme on the importance of cilia and mucus in protecting the lungs from infection. They could then test their question on a partner. *Explaining* Support: Ask students to note down as many suggestions from the video as they can find. Stretch: Show data on the number of people diagnosed with Chlamydia each year and the number of people being screened. Challenge students to explain the link between the data sets.	n/a	n/a

Lesson SB5j: The immune system (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B5.13: Explain the role of the specific immune system of the human body in defence against disease including: a) exposure to pathogen b) the antigens trigger an immune response which causes the production of antibodies c) the antigens also trigger production of memory lymphocytes d) the role of memory lymphocytes in the secondary response to the antigen • B5.14: Explain the body's response to immunisation using an inactive form of a pathogen • B5.15B: Discuss the advantages and disadvantages of immunisation, including the concept of herd immunity	*Starter* Ask students to note down the name of any vaccinations they have had. As a group discuss why they had them, what they remember about how they work, and to describe what they felt during and after the vaccination *Exploring* Students should draw diagrams to describe the stages of the immune response to a first infection by a pathogen, then exchange and evaluate the drawings in pairs. *Explaining* Invite a health professional to a question and answer session with students about vaccinations, including those for sexually transmitted diseases such as HPV, hepatitis A and B.	*Exploring* Support: Provide students with a prompt diagram or descriptions, showing the different stages Stretch: Students should add annotations to indicate when the infected person would feel ill, and when they would start to feel better again *Explaining* Support: Students prepare questions in advance about the diseases covered so far. Stretch: Encourage students to do some research when designing their questions, e.g. to find out about other STIs and the impact of infections	• Construct and interpret frequency tables and diagrams, bar charts and histograms	n/a

Lesson SB5k: Antibiotics (3 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B5.16: Explain that antibiotics can only be used to treat bacterial infections because they inhibit cell processes in the bacterium but not the host organism • B5.20: Describe that the process of developing new medicines, including antibiotics, has many stages including discovery, development, preclinical and clinical testing • *B5.18B: Core practical: Investigate the effects of antiseptics or antibiotics or plant extracts on microbial cultures*	*Starter* Write the word 'antibiotic' in the middle of the board, then form a concept map taking suggestions from the class. *Exploring* Investigate the antimicrobial properties of plants using bacterial lawn plates and plant extracts such as chilli powder, cinnamon, cloves, fennel, garlic, paprika, pepper, and thyme. (*Core and/or suggested practical*.) *Explaining* Ask students to compare the way they carry out their practical investigations and the way clinical trials are carried out. Discuss aspects such as trial size/ sample size, using controls, and placebos and 'blind' trials.	*Exploring* Support: Before recording the results, discuss with students which method to use. Stretch: Challenge students to plan their own experiment, testing the effect of different plant extracts on bacteria. *Explaining* Stretch: The use of placebos and 'blind' trials can be used to challenge more-able students.	• Calculate areas of triangles and rectangles, surface areas and volumes of cubes	*Core practical: Investigate the effects of antiseptics or antibiotics or plant extracts on microbial cultures.* (See *Exploring*) *Suggested practical:* Investigate antimicrobial properties of plants. (See *Exploring*)

Lesson SB5l: Monoclonal antibodies (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• **B5.21B: Describe the production of monoclonal antibodies, including:** **a) use of lymphocytes which produce desired antibodies but do not divide** **b) production of hybridoma cells** **c) hybridoma cells produce antibodies as they divide** • **B5.22B: Explain the use of monoclonal antibodies, including:** **a) in pregnancy testing** **b) in diagnosis including locating the position of blood clots and cancer cells and in treatment of diseases including cancer** **c) the advantages of using monoclonal antibodies to target specific cells compared to drug and radiotherapy treatments**	*Starter* Students should work in pairs or small groups to revise what they have learnt by creating a concept map related to antibodies. *Exploring* Students carry out research on the use of monoclonal antibodies to diagnose and treat particular cancers. They should include the problems of using monoclonal antibodies (such as side effects). Useful information can be found on the websites of some cancer research organisations. *Explaining* Demonstrate the use of a pregnancy test kit using a sample of urine, or show students an appropriate video clip from the Internet. Discuss why the second line appears/why one line appears in negative/why the test includes a line that responds to the substance always found in urine.	*Exploring* Support: Work with students to identify the questions that they should research answers for Stretch: Challenge students to identify different ways in which monoclonal antibodies can affect cancer cells, and therefore explain the different ways in which they can be used to treat cancer. *Explaining* Support: Work with students in a group to discuss answers to the questions Stretch: Students should consider why the test cannot be done any earlier than indicated in the instructions. Should be able to make link to concentration of hormone in blood increasing.	n/a	n/a

B6 Plant structures and their functions				
Lesson SB6a: Photosynthesis (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B6.1: Describe photosynthetic organisms as the main producers of food and therefore biomass • B6.2: Describe photosynthesis in plants and algae as an endothermic reaction that uses light energy to react carbon dioxide and water to produce glucose and oxygen • B6.9: Describe … the structure and function of the stomata	*Starter* Draw an outline of a plant cell on the board, then challenge students to complete the cell diagram using questioning such as 'I'd like you to label the cell wall.' or 'I'd like you to draw in a chloroplast'. *Exploring* Students use iodine solution to test for the presence of starch in variegated leaves exposed to light for 24 hours or darkness for 48 hours. Establish that both chlorophyll and light are needed for photosynthesis. (*Suggested practical.*) *Explaining* Show students a picture of an acorn and an oak tree and ask them to compare the sizes. Ask where the mass comes from? Through questioning, build up the word equation for photosynthesis.	*Exploring* Support: Make sure that students understand the link between starch and photosynthesis. Stretch: Ask students to explain why leaving the plant in a cupboard for a few days leads to destarching. *Explaining* Support: Students could assemble the word equation using prepared cards stating each of the components. Stretch: Ask students what the limitations of the word equation model are; what does it *not* tell us about the process of photosynthesis?	n/a	*Suggested practical:* Investigate how the structure of the leaf is adapted for photosynthesis. (See *Exploring.*)

Lesson SB6b: Factors affecting photosynthesis (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B6.3: Explain the effect of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis • **B6.4: Explain the interactions of temperature, light intensity and carbon dioxide concentration in limiting the rate of photosynthesis** • **B6.6: Explain how the rate of photosynthesis is directly proportional to light intensity and inversely proportional to the distance from a light source, including the use of the inverse square law calculation** • *B6.5: Core practical: Investigate the effect of light intensity on the rate of photosynthesis*	*Starter* Ask students to suggest things that a tomato farmer could do in order to increase the growth of tomato plants and the amount of fruit they produce. *Exploring* Investigate the effect of light intensity on the rate of photosynthesis using immobilized algae in alginate balls and hydrogen carbonate indicator solution. (*Core practical.*) *Explaining* Demonstrate how the principle of limiting factors applies to any process that is dependent on several factors, by using the example of factors that could limit the rate at which students could serve cups of cocoa at the school Christmas Fair.	*Exploring* Support: Students could use smartphones with a light meter app to measure the light intensity at each distance from the lamp. Plotting scatter diagrams/graphs of light intensity against change in pH will show a more obvious pattern than plotting the distance. Stretch: Encourage students, as part of their evaluations, to suggest how they could alter this practical to investigate another factor that affects photosynthesis (e.g. temperature, light wavelength). *Explaining* Support: Use a visual analogy, in which the height of each side of a container represents the abundance of a factor that affects rate of photosynthesis. Stretch: Ask students to think up an entirely different example (perhaps the concept of limiting factors as applied to business models) and sketch a graph to show the possible limiting factors.	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Use a scatter diagram to identify a correlation between two variables • Translate information between graphical and numeric form • Understand that $y = mx + c$ represents a linear relationship • Plot two variables from experimental or other data • Determine the slope and intercept of a linear graph • Understand the terms mean, mode and median • Understand and use the symbols: =, <>, >, ∝, ~ • Change the subject of an equation	*Core practical: Investigate the effect of light intensity on the rate of photosynthesis.* (See *Exploring.)* *Suggested practical:* Investigate the effect of CO_2 concentration or temperature on the rate of photosynthesis.

Lesson SB6c: Absorbing water and mineral ions (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B1.15: Explain how substances are transported into and out of cells, including by diffusion, osmosis and active transport • *B6.7: Explain how the structure of the root hair cells is adapted to absorb water and mineral ions	*Support* Show students some images of plant roots, including roots in soil and less conventional roots (e.g. prop roots of the banyan tree). Ask students to work in groups to discuss the functions of roots. *Exploring* Students examine root hairs using hand lenses. Ask students to make labelled drawings of one or two of the cells that they see and to add scale bars to their drawings, together with labels explaining how these cells are adapted to their functions. *Explaining* Demonstrate root pressure to help students understand the role of active transport in root cells. By killing the root cells of one plant with Roundup™, you can prove that root pressure is an active process, requiring living cells.	*Exploring* Support: Make sure students understand what they are going to be looking for before they start. Stretch: Challenge students to label their drawings using the term 'surface area:volume ratio' *Explaining* Support: Question students about the process to elicit the role of active transport. Stretch: Students should write their own description of the role of active transport in root cells in generating movement of water and minerals in plants.	• Use ratios, fractions and percentages • Substitute numerical values into algebraic equations using appropriate units for physical quantities • Translate information between graphical and numeric form	Examine root hairs. (See *Exploring*.) Demonstrate root pressure. (See *Explaining*.)

Lesson SB6d: Transpiration and translocation (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B6.8: Explain how the structures of the xylem and phloem are adapted to their function in the plant, including: a) lignified dead cells in xylem transporting water and minerals through the plant b) living cells in phloem using energy to transport sucrose around the plant • *B6.9: Describe how water and mineral ions are transported through the plant by transpiration, including the structure and function of the stomata • B6.10: Describe how sucrose is transported around the plant by translocation • B6.12: Explain the effect of environmental factors on the rate of water uptake by a plant, to include light intensity, air movement and temperature • B6.13: Demonstrate an understanding of rate calculations for transpiration	*Starter* Set up a white carnation with a split stem, half in water containing blue food colouring and half in water containing red food colouring. Encourage students to question and suggest what has happened. *Exploring* Students use a potometer to measure the rate at which a plant loses water through transpiration. *Explaining* Using the photometer set-up, vary the independent variable (temperature, light intensity, humidity, surface area). Ask students to predict what will happen and to explain why before demonstrating each variable.	*Exploring* Support: Ask students to predict what would happen to the rate of transpiration if the stomata are blocked (e.g. with petroleum jelly). Stretch: Students should be able to draw up their own tables of results and draw their own conclusions. *Explaining* Support: Ensure that students understand what is happening as each factor is changed. Stretch: Challenge students to examine a printout from a datalogger and to use tangent lines to calculate the rate of transpiration at certain points on the lines.	• Recognise and use expressions in decimal form • Use ratios, fractions and percentages • Find arithmetic means • Construct and interpret frequency tables and diagrams, bar charts and histograms • Translate information between graphical and numeric form • Understand that $y = mx + c$ represents a linear relationship • Plot two variables from experimental or other data • Determine the slope and intercept of a linear graph	*Suggested practical:* Investigate how the loss of water vapour from leaves drives transpiration. (See *Exploring*.)

Lesson SB6e: Plant adaptations (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B6.11B: Explain how the structure of a leaf is adapted for photosynthesis and gas exchange • B6.14B: Explain how plants are adapted to survive in extreme environments including the effect of leaf size and shape, the cuticle and stomata	*Starter* Show students a cactus and a broad-leaved pot plant, side by side. Allow students to identify differences between the two plants and reasons for those differences. Spark discussions on adaptations of a leaf for photosynthesis. *Exploring* Students look at pre-prepared slides of privet (*Ligustrum* sp.) leaves to look at their adaptations for photosynthesis. Students should be able to find four distinct layers of tissue in the privet leaves (two epidermal layers, a layer of palisade tissue and a layer or spongy tissue). *Explaining* Look at stomata and water loss. Hang up four similar-sized cut parts of plants. Paint clear nail varnish over the top surfaces of the leaves of one cutting and the lower surfaces of another, both sides of the third and leave the fourth. See which one dries out fastest.	*Exploring* Support: Provide students with access to a diagram of the leaf structure to compare against. Stretch: Ask students to make scale drawings of cells from one or more layers. *Explaining* Stretch: Challenge students to find a way to measure the rate of water loss	• Understand the principles of sampling as applied to scientific data • Calculate areas of triangles and rectangles, surface areas and volumes of cubes	*Suggested practical:* Investigate how the structure of the leaf is adapted to photosynthesis (*see exploring task)*

Lesson SB6f: Plant hormones (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B6.15B: Explain how plant hormones control and coordinate plant growth and development, including the role of auxins in phototropisms and gravitropisms	*Starter* Prepare a jar of bean seeds planted in different orientations and allow them to germinate. Or download a picture of such an experiment from the internet. Ask students whether all the seeds are the right way up/why all the stems are growing upwards/how this happens. *Exploring* Students investigate whether the colour of light affects the amount of bending of seedlings that are illuminated using a unidirectional light source. Students should be able to see that the plant shoots grow towards the white and blue lights but do not respond in such a marked way to green light and may also not respond in such a marked way to red light (depending on the plant).	*Exploring* Support: Demonstrate to students how to use a protractor to measure the angles of shoots. Stretch: Encourage students to write up their investigations in their own words	• Use angular measures in degrees	*Suggested practical:* Investigate tropic responses.

Lesson SB6g: Uses of plant hormones (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• **B6.16B: Describe the commercial uses of auxins, gibberellins and ethene in plants including:** **a) auxins in weedkillers and rooting powders** **b) gibberellins in germination, fruit and flower formation and the production of seedless fruit** **c) ethene in fruit ripening**	*Starter* Students work in groups to come up with a list of fruits that are available in supermarkets. Ask them to say, for each fruit, whether it is widely available all year round/only at certain times/available all year round but more widely available at certain times. Challenge students to explain why some fruits are available all year round (e.g. reasons include being shipped from other countries, being stored). *Exploring* Investigate the importance of photoperiodicity in plants using e.g. *Arabidopsis* plants. Grow plants in plastic pots with standard compost. Investigate the effect of different lengths of light and dark periods on the flowering of *Arabidopsis* plants to find out whether flowering in *Arabidopsis* plants is triggered by shorter or longer amounts of daylight in 24 hours. Plants moved to long-day conditions will flower, whereas those kept in short-day conditions should not flower. *Explaining* Demonstrate that fruit ripening is affected by proximity to ripe fruit by examining how much starch is found in an unripe pear when placed in a box with a ripe tomato compared with a control unripe pear in a sealed box.	*Exploring* Support: Work with students so they understand what they are expected to do – support practical with a worksheet/questions. Stretch: Students should explain how they would develop the investigation to be certain that changing light conditions, rather than changing temperatures, during different seasons are what stimulates flowering in these plants. *Explaining* Support: Remind students of the starch-testing that they will have done at Key Stage 3 and explain that iodine solution is the test for starch and stains it a blue-black colour. Stretch: Encourage students to develop further questions that could be investigated using this idea (e.g. Does one rotten apple spoil all the others?)	• Translate information between graphical and numeric form • Plot two variables from experimental or other data	*Suggested practical:* Investigate the importance of photoperiodicity in plants (*See exploring)*.

B7 Animal coordination, control and homeostasis				
Lesson SB7a: Hormones (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B7.1: Describe where hormones are produced and how they are transported from endocrine glands to their target organs including the pituitary gland, thyroid gland, pancreas, adrenal glands, ovaries and testes	*Starter* Students write a list of bullet points about what happens when a person is scared or gets a fright. Challenge students to come up with ideas as to what causes these effects, and why they happen at the same time. *Exploring* Students are given key words (hormones, endocrine glands, target cells) and using their research, put together a table to show information about the hormones and their effects clearly. *Explaining* Use the context of sex hormones and puberty to introduce discussion on the importance of concentration in how hormones work. Explain that measurement of blood concentration of oestrogen in girls younger than 8 gives tiny values of around 350 pg dm^{-3}. Demonstrate the difference between 'amount' and 'concentration' by adding the same mass of a substance that produces a coloured solution (e.g. copper sulfate or potassium manganate(VII)) to 100 cm^3 water and 1 dm^3 water.	*Exploring* Support: Students may need support to identify which key words on the list are hormones. Stretch: Students can look for examples of the interaction of hormones e.g. relationship between hormones controlling puberty and growth hormone. *Explaining* Support: Develop a table that shows common terms and their meanings, e.g. mass, volume, concentration. Use this to show why words such as level and amount are not as clear.	n/a	n/a

Lesson SB7b: Hormonal control of metabolic rate (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• **B7.2: Explain that adrenalin can be controlled by a negative feedback mechanism and is produced by the adrenal glands to prepare the body for fight or flight, including:** **a) increased heart rate** **b) increased blood pressure** **c) increased blood flow to the muscles** **d) raised blood sugar levels by stimulating the liver to change glycogen into glucose** • **B7.3: Explain how thyroxine controls metabolic rate as an example of negative feedback, including:** **a) low levels of thyroxine stimulates production of TRH in hypothalamus** **b) this causes release of TSH from the pituitary gland** **c) TSH acts on the thyroid to produce thyroxine** **d) when thyroxine levels are normal thyroxine inhibits the release of TRH and the production of TSH**	*Starter* Ask students to list as many factors as they can think of that require energy during a day e.g. contraction of heart muscle/breathing muscles/digestion of food. *Exploring* Prepare a cut and stick card sort activity to help students understand the effects of negative feedback in relation to the control of blood thyroxine concentration. Students could then carry out further research into the effects of the concentration being too high or too low. *Explaining* Reinforce the concept of negative feedback using a familiar model e.g. heating system in a room (radiator, thermostat). Discuss how changes to the room are compensated for by the system. Compare these components with those involved in the control of metabolic rate.	*Exploring* Support: Work with students to help them put together the card sort. Stretch: Explain to students that there is an additional control in this process. A response by temperature receptors in the skin affects the hypothalamus directly, stimulating it to produce more TRH when it is cold and inhibiting TRH release when it is hot. Students should use their layouts to explain the importance of this additional control. *Explaining* Support: Work with students to draw the simplified thyroxine system, to make sure they fully understand the meaning of negative feedback. Stretch: Challenge students to extend the thermostat example e.g. include a cooling system for when it is too warm. They should then consider how more effective this dual system is in controlling the air temperature of a room than a single-loop negative feedback system.	• Translate information between graphical and numeric form	n/a

Lesson SB7c: The menstrual cycle (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B7.4: Describe the stages of the menstrual cycle including the roles of the hormones oestrogen and progesterone, in the control of the menstrual cycle • B7.6: Explain how hormonal contraception influences the menstrual cycle and prevents pregnancy • B7.7: Evaluate hormonal and barrier methods of contraception	*Starter* Give students 3 minutes to list the changes that occur in male and female bodies during puberty. Then ask students to describe how these changes are coordinated (oestrogen/testosterone). *Exploring* Students should carry out research on the different types of contraception, how they work and how effective they are. Students will need to prepare a leaflet by deciding what information needs to be recorded and how to record it. *Explaining* Invite a health professional to talk to the class about contraception, covering the requirements of the specification. Students should prepare questions beforehand to ask. After the talk, students should complete their answers and identify what they have learnt.	*Exploring* Support: Provide students with an outline table to complete as a starting point for their leaflet. Stretch: Students should produce additional guidance in their leaflet, by listing what they consider to be the main advantage/disadvantage of each form of contraception (taking into account ease of use and effectiveness). *Explaining* Support: Work with students to prepare their questions, to make sure all required knowledge for the specification is covered. Stretch: Challenge students in their evaluation of the different methods by asking them to explain why not everyone uses the same methods that are theoretically least likely to result in pregnancy.	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand the principles of sampling as applied to scientific data	n/a

Lesson SB7d: Hormonal control of the menstrual cycle (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• **B7.5: Explain the interactions of oestrogen, progesterone, FSH and LH in the control of the menstrual cycle, including the repair and maintenance of the uterus wall, ovulation and menstruation** • **B7.8: Explain the use of hormones in Assisted Reproductive Technology (ART) including IVF and clomifene therapy**	*Starter* Revise the menstrual cycle by asking students to come up with three quick-fire questions that they then use on a partner. After testing out their questions, take examples of questions that students found most difficult to answer. *Exploring* Give students some graphical data on hormone concentration during the menstrual cycle (oestrogen, progesterone, LH and FSH). Ask them to compare the different levels of each hormone and link them to the different stages in the menstrual cycle. *Explaining* Remind students of the concept of negative feedback from topic CB7b. Ask them to identify the role of negative feedback in the control of the menstrual cycle in relation to each of the four hormones they need to know.	*Exploring* Support: label key points in the menstrual cycle on the graph e.g. ovulation. Stretch: Students could research the range in variation between women in hormone concentrations through the menstrual cycle by looking for graphs – use this to explain why some women find it difficult to become pregnant. *Explaining* Support: Encourage students to work in pairs to discuss negative feedback in the menstrual cycle. Stretch: Students should explain the importance of negative feedback in the control of the menstrual cycle, so it is possible for a woman to become pregnant each month. This could be linked to the fact that a mature human egg remains healthy for only a couple of days after leaving the ovary unless it is fertilised.	• Translate information between graphical and numeric form • Plot two variables from experimental or other data	n/a

Lesson SB7e: Control of blood glucose (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B7.9: Explain the importance of maintaining a constant internal environment in response to internal and external change • B7.13: Explain how the hormone insulin controls blood glucose concentration • **B7.14: Explain how blood glucose concentration is regulated by glucagon** • B7.15: Explain the cause of type 1 diabetes and how it is controlled	*Starter* Ask students to jot down what they know about insulin (and glucagon if they are covering the Higher content of the course). This should include where the hormone is produced and its target organs. *Exploring* Suggested practical: students use the Benedict's test to identify glucose in samples of artificial urine. Briefly explain how doctors used to test for glucose in urine by tasting it – a sweet taste suggested the patient was suffering from diabetes. After students have completed their investigations, demonstrate the use of glucose-testing sticks on the samples. Students can use the results from the sticks to evaluate their own results. *Explaining* Explain the diagnosis and treatment for type 1 diabetes. Include points on different ways to manage injections. Ask students to discuss the practical issues surrounding using insulin injections.	*Exploring* Support: Demonstrate the practical instructions step-by-step with students copying what you have done at each step. Stretch: students could carry out the glucose-stick tests themselves. *Explaining* Support: students should focus on the importance of matching the glucose concentration from a blood test with deciding on the right dose to inject. Stretch: Students could compare the quality of glucose control using different types of insulin management e.g. comparing twice-daily injections with multiple injections or using a continuous pump.	• Construct and interpret frequency tables/diagrams/bar charts/histograms • Translate between graphical and numeric form • Plot two variables from experimental data or other data.	*Suggested practical:* Investigate the presence of sugar in simulated urine/body fluids *(see exploring)*.

Lesson SB7f: Type 2 diabetes (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B7.16: Explain the cause of type 2 diabetes and how it is controlled • B7.17: Evaluate the correlation between body mass and type 2 diabetes including BMI and waist:hip calculations using the BMI equation: $\text{BMI} = \frac{\text{weight (kg)}}{(\text{height (m)})^2}$	*Starter* Insulin/diabetes revision: Ask students to write down the three most important facts that they learnt in the last topic. They should compare their facts with a partner, to check that they are correct. *Exploring* Arrange students into groups to carry out a research task on type 2 diabetes. Explain they are gathering information that could be used by an advisory group to the school council on improving long-term health prospects for current students. The research should cover the proportion of adults with type 2 diabetes and how this number is changing, why the rate of increase is a problem and what should be done to reduce the problem in the future. *Explaining* Invite a health professional, or someone who has type 2 diabetes, to answer questions from the class about the condition. Students should prepare questions before the visit.	*Exploring* Support: Discuss with students how they will split the work between them and ensure they have a clear plan of how to start their research. Stretch: Students should summarise their advice into 3-5 bullets that could be used in a health advert/poster around the school. *Explaining* Support: Students could work in pairs/groups to prepare their questions. Stretch: Students should summarise the differences between type 1 and type 2 diabetes in a table, comparing their causes, treatment and relationship with body mass.	• Recognise and use expressions in decimal form • Use ratios, fractions and percentages • Construct and interpret frequency tables and diagrams, bar charts and histograms	n/a

Lesson SB7g: Thermoregulation (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B7.10B: Explain the importance of homeostasis, including: a) thermoregulation – the effect on enzyme activity … • B7.11B: Explain how thermoregulation takes place, with reference to the function of the skin, including: a) the role of the dermis b) the role of the epidermis c) the role of the hypothalamus • B7.12B: Explain how thermoregulation takes place, with reference to: a) shivering **b) vasoconstriction** **c) vasodilation**	*Starter* Ask students to suggest a list of conditions inside the body that are kept constant. Write the ideas on the board and elicit the idea that there are many conditions that are kept at reasonably constant levels, e.g. pH, carbon dioxide concentration, oxygen concentration, temperature, water, blood glucose. *Exploring* Practical activity in which students find out how wind speed affects the rate of cooling by evaporation of water, a model for sweating. *Explaining* Create a poster of thermoregulation, showing the role of the dermis, epidermis and hypothalamus to cover the required learning. (HT only))Show a video of vasoconstriction and vasodilation and then ask students to explain step by step what would happen if they put their finger in warm water/cold water.	*Exploring* Support: Ask students to think about what it feels like to be wearing wet clothes when it is windy. Stretch: Students should complete their own analysis of results and evaluation. *Exploring* Support: Provide students with a scaffolded poster where they can fill in certain areas to complete a poster on thermoregulation.	n/a	*Practical:* investigating the effect of wind speed on evaporation of water.

Lesson SB7h: Osmoregulation (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B7.10B: Explain the importance of homeostasis, including: … b) osmoregulation – the effect on animal cells • B7.18B: Describe the structure of the urinary system • B7.21B: Describe the treatments for kidney failure, including kidney dialysis and organ donation • B7.22B: State that urea is produced from the breakdown of excess amino acids in the liver	*Starter* Using the model of a seesaw with one side labelled gains and the other labelled losses, explain to students that it represents the balance of water content in the body. Ask them to list as many examples of gains and losses as they can. *Exploring* Put together a cut and stick activity to help students recognize the structure of the urinary system. This could be a simple diagram that students are asked to label. *Explaining* Demonstrate osmoregulation by asking students to compare the size of three eggs. One which has been hard boiled without its shell, and two that have been placed in vinegar to remove their shells, followed by one being placed in water and another in a sucrose solution for 24 hours. Explain that the membrane that surrounds an egg has similar properties to a cell surface membrane.	*Exploring* Support: Students could use a diagram from another source as guidance. Stretch: Give students a complex image of the urinary system, and ask them to simplify it.	n/a	n/a

Lesson SB7i: The kidneys (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B7.19B: Explain how the structure of the nephron is related to its function in filtering the blood and forming urine including: a) filtration in the glomerulus and Bowman's capsule b) selective reabsorption of glucose c) reabsorption of water • **B7.20B: Explain the effect of ADH on the permeability of the collecting duct in regulating the water content of the blood**	*Starter* Write the word 'kidney' in the middle of the board and ask students to suggest related words and how they should be linked to create a concept map on the topic. Use this to review what students remember from earlier work on kidneys and excretion. *Exploring* Practical activity to model filtration in the kidney using Visking tubing and artificial blood (made using glucose powder, yellow food colouring, salt, protein powder and warm water). Glucose, salt and yellow colour (urea) should diffuse through the tubing, but not the protein. *Explaining* The reabsorption of water and its control are quite complex, and involve understanding of how the solute concentration gradient changes between the fluid inside the nephron and the kidney tissue (and the blood that flows through it). Consider using a model, such as trucks from a child's pull-along train set to model the flow of fluid in the nephron, and marbles, beads or similar small items for the solute and water molecules.	*Exploring* Support: Help students to set up the apparatus. Stretch: Students should evaluate the apparatus thoroughly for its usefulness in modelling filtration in the kidney. *Explaining* Support: Focus only on the exchange of water molecules (though keep solute molecules in place to identify concentration gradients). Stretch: Challenge students to include the role of the flow of blood in the model, to help explain how concentration gradients are maintained, and what impact reabsorption has on the solute concentration of the blood as it flows through the capillary associated with the tubule.	n/a	*Practical:* Modelling filtration in the kidney

B8 Exchange and transport in animals				
Lesson SB8a: Efficient transport and exchange (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B8.1: Describe the need to transport substances into and out of a range of organisms including oxygen, carbon dioxide, water, dissolved food molecules, mineral ions and urea • B8.2: Explain the need for exchange surfaces and a transport system in multicellular organisms including the calculation of surface area:volume ratio • B8.3: Explain how alveoli are adapted for gas exchange by diffusion between air in the lungs and blood in capillaries	*Starter* Ask what process oxygen is needed for (i.e. *aerobic* respiration) and challenge them to write down the word equation. Remind students that oxygen is transported around the body in the blood, and ask students to suggest how oxygen leaves the blood and gets to the mitochondria in the cells. Establish the idea that this is by diffusion. *Exploring* Suggested practical: students study the diffusion of iodine solution into cubes of potato of different sizes to find out how surface area : volume ratio affects the rate of diffusion. After this, students can study how the shapes and structures of cells and organs differ in order to increase their SA:V ratios and why it's necessary. *Explaining* This topic reinforces and builds on previous work in unit CB1c (specialised cells) and CB1h (diffusion and osmosis). Model the diffusion of wastes from cells/organs by using the idea of energy escaping from a potato. Compare a small vs. a large potato, and 2 identical potatoes except for one with 4/5 drilled holes. Create a well in each of the 4 potatoes and, after heating them in an over at 60-70°C for a few hours, insert thermometers into the wells to monitor how the temperature of each potato decreases.	*Exploring* Support: Provide scaffolding so that students can calculate SA:V ratios and record the results of the practical. Stretch: The unstained portion of a potato cube is often roughly spherical. Challenge students to calculate the volume of the sphere that has been stained using the formula for the volume of a sphere ($4/3\pi r^2$). *Explaining* Support: Make sure students understand which parts of the model represent which things in real life Stretch: Challenge students to think of some ways in which the model is not an accurate representation of what actually happens in a cell (e.g. energy is lost from a potato in a different way to wastes diffusing out of a cell/organ; the potato is much more solid than the contents of cells).	• Recognise and use expressions in decimal form • Use ratios, fractions and percentages • Calculate areas of triangles and rectangles, surface areas and volumes of cubes	*Suggested practical:* Investigate how SA:V ratio affects how quickly substances can diffuse to the centre of a cube (See *Exploring)*.

Lesson SB8b: Factors affecting diffusion (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B8.4B: Describe the factors affecting the rate of diffusion, including surface area, concentration gradient and diffusion distance • B8.5B: Calculate the rate of diffusion using Fick's law: rate of diffusion ∝ (surface area × concentration difference) / thickness of membrane	*Starter* Demonstrate the reaction between ammonia and hydrogen chloride by dipping cotton-wool bud into the two chemicals and placing them at either end of a tube. Show how it takes longer for the reaction to take place in a longer tube. *Exploring* Suggested practical: Investigate the effect of concentration on the rate of diffusion. Students place pink agar blocks into different concentrations of acid, and time how long the blocks take to decolorise as the acid diffuses into them. *Explaining* A simple demonstration of diffusion can be done in a Petri dish using deionised water and crystals of lead nitrate and potassium iodide. If the colourless crystals are placed either side of the Petri dish, they will dissolve and diffuse and then react to form yellow lead iodide.	*Exploring* Support: Carefully go through each part of the experiment, showing students what to do before allowing them to carry out the main experiment. Stretch: Challenge students to relate breathing and blood flow to this practical, in terms of maintaining concentration gradients to increase diffusion rates. *Explaining* Support: Remind students that, when potassium iodide and lead nitrate dissolve, their ions diffuse through the water. The precipitate of lead iodide occurs where lead and iodide ions meet. Stretch: Challenge students to predict what will happen in each experiment before performing it.	• Recognise and use expressions in decimal form • Understand and use the symbols: =, <, <<, >>, >, ∝, ~ • Change the subject of an equation Solve simple algebraic equations	*Suggested practical:* Investigate the effect of concentration on the rate of diffusion (see *Exploring*)

Lesson SB8c: The circulatory system (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B8.7: Explain how the structure of the blood vessels is related to their function • B8.6: Explain how the structure of the blood is related to its function: a) red blood cells (erythrocytes) b) white blood cells (phagocytes and lymphocytes) c) plasma d) platelets	*Starter* Ask students to find and measure their pulses and what might be the purpose of measuring a pulse rate (e.g. a health check). Ask them what they think a pulse actually is… i.e. a pressure wave in the wall of the arteries. *Exploring* Students match drawings of the components of blood with their names and functions. Students should then choose four of the components of blood and write down another fact for each one. It is envisaged that students then give their new facts (written on the blank cards on the sheet) to a partner to add to their work, but the cards could be collected and worked through as a class, with students identifying which fact goes with which blood component. *Explaining* It may be possible to show students veins and arteries from a lamb/sheep or other farm animal, if a local butcher can supply such things. If 'plucks' (heart, liver and lungs together) are obtained, the hearts can be cut out for use in the next topic with plenty of vein and artery material for this demonstration. Show students the differences in thickness between the walls of the two types of blood vessel, and the differences in size between the central channels.	*Exploring* Support: Work with students to look at a projected image of a prepared slide Stretch: Show students how to use a graticule and ask them to use it to estimate the ratio of red:white blood cells. *Explaining* Support: Some students may have difficulty imagining how a valve works. It may be helpful to show students images (or point out where they can find one around the school) of a simple flap valve Stretch: Challenge students to find out about the different types of white blood cells and what they do. (Note that students are only required to have knowledge of phagocytes and lymphocytes.)	• Recognise and use expressions in decimal form • Recognise and use expressions in standard form • Make order of magnitude calculations	*Suggested practical:* Study human blood cells using a microscope.

Lesson SB8d: The heart (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B8.8: Explain how the structure of the heart and circulatory system is related to its function including the role of the major blood vessels, the valves and the relative thickness of chamber walls • B8.12: Calculate heart rate, stroke volume and cardiac output, using the equation cardiac output = stroke volume × heart rate	*Starter* Ask students to work in groups to think up some idioms about the heart (cry your heart out, heart of stone, etc.). Run through these to confirm that the heart is often perceived to be the seat of our emotions, and then ask students whether they think this is true or whether the heart just has a more mundane purpose. *Exploring* Suggested practical: Students should work in pairs. The resting breathing and heartbeat rates of one student should be measured. The student then exercises for a time and then stops and measures his or her own breathing rate whilst the partner measures the student's heart rate. The measurements are repeated every other minute until the rates return to the resting values. Students then swap roles. *Explaining* Show students a sheep's (or other animal's) heart. Identify the external blood vessels before cutting the heart, and identify those going into the heart (veins) and those coming out of the heart (arteries). Identify the chambers and demonstrate that one side of the heart (the left side) has more muscle than the other side.	*Exploring* Support: Help students to use equations to calculate the different variables. Stretch: Challenge students to come up with a list of factors that might affect heart rate and a list of factors that might affect stroke volume. They could also find out how stroke volumes are measured in a hospital (using an echocardiogram). *Explaining* Support: Ask students to compare the heart they have seen dissected with a model human heart, and help them to identify the structures. Stretch: Ask students to do some research to find out how the structure of the human heart differs from that of other vertebrate hearts.	• Recognise and use expressions in decimal form • Use an appropriate number of significant figures • Construct and interpret frequency tables and diagrams, bar charts and histograms • Substitute numerical values into algebraic equations using appropriate units for physical quantities	*Suggested practical:* Investigate the short-term effects of exercise on breathing rate and heart rate.

Lesson SB8e: Cellular respiration (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B8.9: Describe cellular respiration as an exothermic reaction which occurs continuously in living cells to release energy for metabolic processes, including aerobic and anaerobic respiration • B8.10: Compare the process of aerobic respiration with the process of anaerobic respiration • *B8.11: Core practical: Investigate the rate of respiration in living organisms*	*Starter* Give students the following anagrams: ECO SLUG, GENY OX, ANDROID ICEBOX, ART WE (glucose, oxygen carbon dioxide, water). Challenge students to work in groups to solve the anagrams and arrange them into a process that occurs in animals (i.e. the equation for aerobic respiration). *Exploring* Core practical: Students use a simple respirometer to investigate the effect of temperature on the rate of aerobic respiration in some small invertebrates. *Explaining* Use a tower of six plastic interlocking building blocks (or similar) to demonstrate the amount of energy stored in glucose. Snap the tower, and point out that they can hear energy being transferred to the surroundings. Snap the tower into six blocks to represent aerobic respiration; a lot of energy is transferred to the surroundings, and the products contain much less energy. Rebuild the tower and snap it once. Explain that this represents anaerobic respiration; much less energy is transferred to the surroundings, and the products still contain a lot of energy.	*Exploring* Support: Explain the purpose of the soda lime and that as oxygen is used, the total volume of gas is reduced, affecting the atmospheric pressure. Stretch: Encourage students to calculate respiratory rate in terms of oxygen use per minute per gram of living materials. *Explaining* Support: Before starting the demonstration, go through the word equations for aerobic and anaerobic respiration on the board. Remind students of what happens in both processes and that importantly both processes release energy. Stretch: Challenge students to use their knowledge from chemistry to identify the problem with this model, i.e. the endothermic nature of bond breaking.	• Recognise and use expressions in decimal form • Use an appropriate number of significant figures • Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand the terms mean, mode and median • Translate information between graphical and numeric form • Plot two variables from experimental or other data	*Core practical:* Investigate the rate of respiration in living organisms (see *Exploring*). *Suggested practical:* Investigate the effect of glucose concentration on the rate of anaerobic respiration in yeast.

B9 Ecosystems and material cycles				
Lesson SB9a: Ecosystems (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.1: Describe the different levels of organisation from individual organisms, populations, communities, to the whole ecosystem • B9.6: Explain how to determine the number of organisms in a given area using raw data from field-work techniques, including quadrats and belt transects • B9.3: Describe the importance of interdependence in a community • B9.6: Explain how to determine the number of organisms in a given area using raw data from field-work techniques, including quadrats and belt transects	*Starter* Ask students to name organisms that might be seen locally (perhaps prompting for plants or those that aren't usually visible in the soil or in water). Students work in pairs to arrange organisms into a food web and also identify food chains. *Exploring* Ecosystem research: Students should work in pairs or small groups to carry out research on a specific ecosystem. Either provide examples of ecosystems on the board for students to select from, or check that students have chosen something reasonable before they start. Suitable examples include: a coral reef, a rainforest, a desert, African savannah, polar ocean. Students should identify organisms in the ecosystem, and then show how they are grouped into populations and communities. From these they should create a food web to identify feeding relationships. Results could be displayed on a poster or in a presentation. *Explaining* Display a food web on the board where a change has been made, or is being considered, to the community (e.g. introducing non-indigenous species or reintroducing a species such as wolves in the Scottish Highlands or beavers in Devon). Ask questions along the lines of 'what might/will happen if…' and encourage explanation and development, and introduce the concept of interdependence.	*Exploring* Support: Give students a familiar ecosystem and the names of a selection of organisms in it to get started. Stretch: Students should choose an ecosystem with a challenging 'storyline' such as dying coral reefs or replacement of rainforest with palm oil plantations. Students can then focus on the impact of ecosystem-level destruction and the importance of interdependence. *Explaining* Support: Only ask questions that consider species that directly affect each other (e.g. a predator and one species of prey). Stretch: Students could think up their own questions using the food web and test each other. Take examples from around the class to find 'really challenging' examples of interactions.	• Use ratios, fractions and percentages • Make estimates of the results of simple calculations • Find arithmetic means • Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand the principles of sampling as applied to scientific data • Use a scatter diagram to identify a correlation between two variables • Translate information between graphical and numeric form • Plot two variables from experimental or other data	n/a

Lesson SB9b: Energy transfer (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.7B: Explain how some energy is transferred to less useful forms at each trophic level and that this affects the number of organisms at each trophic level, limits the length of a food chain and determines the shape of a pyramid of biomass in an ecosystem • B9.8B: Calculate the efficiency of energy transfers between trophic levels and percentage calculations of biomass	*Starter* Ask students to work in pairs or small groups to discuss how they would estimate the amount of biomass in all the organisms of a particular trophic level in a community, such as all the producers in a grassland. *Exploring* Suggested practical: Investigate some of the issues with gathering accurate data for constructing pyramids of biomass. Each group will need about one-quarter of a large lettuce. Snails can be collected from the local environment. An aquarium/tank is left for a few days and the mass before and after is measured. *Explaining* Demonstrate how to interpret energy transfers, as well as the impact of energy transfers on the shape of pyramids of number, pyramids of biomass and the length of food chains.	*Exploring* Support: Students may need help with the calculations. Stretch: Students should use their findings to suggest the advantages and disadvantages of displaying pyramids of biomass that consider all organisms in the different trophic levels. *Explaining* Stretch: Students could research examples of pyramids of number and biomass that do not have the usual pyramid shape. They should sketch the shapes they find and annotate them to show how they differ from the normal shape and give explanations why they differ.	• Recognise and use expressions in decimal form • Recognise and use expressions in standard form • Use ratios, fractions and percentages • Construct and interpret frequency tables and diagrams, bar charts and histograms Translate information between graphical and numeric form	*Suggested practical:* Investigate some of the issues with gathering accurate data for constructing pyramids of biomass (see *Exploring*).

Lesson SB9c: Abiotic factors and communities (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.2: Explain how communities can be affected by abiotic and biotic factors, including: (a) temperature, light, water, pollutants • *B9.5: Core practical: Investigate the relationship between organisms and their environment using field-work techniques, including quadrats and belt transects*	*Starter* Write on the board the names of some plants and animals you would expect to find in particular ecosystems (e.g. polar bears, camels, cacti, water lilies, fish). Students should work in pairs to identify the ecosystems in which the organisms are found and describe any adaptations to live there. *Exploring* Core practical: Using transects and quadrats to measure the effect of environmental factors on the distribution related to environmental change, such as the distribution of plants between shade and bright light, or from a well-trampled area to an area of little trampling, or the distribution of seaweed or shellfish on a rocky seashore from low to high tide. *Explaining* Set up a 'choice chamber' that provides areas with different climates, for example by using a petri dish. 'Wet' is created by soaking cotton wool in water; 'dry' with a drying agent such as silica gel. These are placed in the base of the dish. 'Dark' is created by covering the top of the dish with foil or black paper, and 'light' by not covering the top. Add the lid 5mins before, place the animals (e.g. woodlice) in the centre of the chamber for 10mins and then record how many moved to each area. Link these choices to the natural environments in which they live and their role in the food web.	*Exploring* Support: Make sure students know how to set out transects and quadrats for sampling. When recording and analysing results, work with students to draw up the record table and chart(s). Stretch: Challenge students to consider all the environmental factors that might affect the distribution of the organisms and which are the most significant. *Explaining* Support: Construct part of a food web including woodlice, to help students make the link with interdependence. Woodlice eat decaying plant material, including dead wood and leaves. Stretch: Challenge students to explain why repeats are necessary in experiments with living organisms.	• Find arithmetic means • Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand the principles of sampling as applied to scientific data • Understand the terms mean, mode and median • Use a scatter diagram to identify a correlation between two variables • Translate information between graphical and numeric form • Plot two variables from experimental or other data	*Core practical:* Investigate the relationship between organisms and their environment using field-work techniques, including quadrats and belt transects (see *Exploring*) *Suggested practical:* Investigate animal behaviour using choice chambers. *Suggested practical:* Investigate tropic responses.

Lesson SB9d: Biotic factors and communities (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.2: Explain how communities can be affected by abiotic and biotic factors, including:… (b) competition, predation	*Starter* Show students photos that demonstrate competition between different species over resources (Avoid examples of competition between individuals of the same species). Ask students what is happening and why, i.e. competition between individuals occurs when resources are limited. *Exploring* Use a graph showing the correlation of population sizes in a predator-prey cycle (e.g. Snowshoe hare vs. Canadian lynx). Make sure students appreciate that one predator vs. one prey is rare. However, it shows the interdependence of organisms as a result of predation. Students should work in pairs to link descriptive statements to the correct point on the graph. *Explaining* The YouTube video on 'How Wolves Change Rivers' (narrated by George Monbiot) documents some of the changes in Yellowstone Park since the reintroduction of wolves in 1995. Write a list of the relevant species on the board: wolf, deer (elk), aspen, cottonwood, willow, beaver, otter, coyote, rabbit, weasel, bald eagle and bear. Give different species to students and ask them to answer questions during the video, such as 'How did the reintroduction of wolves affect this species in the park?'. Students should draw simple flow charts. Take examples from around the class, to compare and contrast the interactions and their effects.	*Exploring* Support: Work as a group to decide suitable points on the graphs Stretch: Students could carry out further research on the example to evaluate this interpretation of the graph. E.g. some research has shown that the number of hares is more closely correlated with the availability of food (mainly lichens in winter) than with lynx numbers. *Explaining* Support: Students should find information for the species that are most directly affected by wolves, e.g. deer, coyotes. Stretch: There are plans to reintroduce wolves to parts of Scotland, to control the number of red deer where human control (by culling) is not effective. Students should consider the benefits and risks of these plans, and draw a conclusion about whether the plans should be carried out or not.	• Translate information between graphical and numeric form • Plot two variables from experimental or other data	*Suggested practical:* Investigate animal behaviour using choice chambers. *Suggested practical:* Investigate tropic responses.

Lesson SB9e: Assessing pollution (2 hours)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• **B9.16B: Evaluate the use of indicator species as evidence to assess the level of pollution, including:** **a) polluted water – bloodworm, sludgeworm** **b) clean water – freshwater shrimps, stonefly** **c) air quality – different species of lichen, blackspot fungus on roses**	*Starter* Show students a flask of tap water and ask them to write down five things that they might find in the water. Then ask students how they could test for dissolved transparent substances. *Exploring* Investigate the nutrient and oxygen concentrations in water and the organisms that live in the water. The pollution scores from organisms should be compared with the nutrient concentration and oxygen concentration results. Note that in a small water body, e.g. a pond, it may not be possible to show variation in oxygen or chemical analyses. In which case use examples from the Internet as a comparison. *Explaining* Investigate how indicator species (e.g. lichen) can be used to assess levels of pollution in water or the atmosphere. This can be done as a data analysis activity where students compare the extent of lichen recorded at 3 different sites.	*Exploring* Support: Work with students to calculate the mean pollution scores for each sampling site. Stretch: Students could research and evaluate the pollution scores for other water bodies. *Explaining* Support: Describe the relationship between fungi and an alga in a lichen as an example of mutualism, which is where all the organisms in the relationship benefit. Stretch: Students could carry out research on the Internet about lichen surveys in the UK, such as by Open Air Laboratories (OPAL) a UK-based citizen science initiative led by Imperial College London Students should find out what results from these surveys can tell us about changes in air pollution over the last few decades.	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Translate information between graphical and numeric form • Plot two variables from experimental or other data	*Suggested practical:* Investigate the nutrient and oxygen concentrations in water and the organisms that live in the water. *Suggested practical:* Investigate how indicator species can be used to assess levels of pollution in water or the atmosphere.

Lesson SB9f: Parasitism and mutualism (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.4: Describe how the survival of some organisms is dependent on other species, including parasitism and mutualism • B9.6: Explain how to determine the number of organisms in a given area using raw data from field-work techniques, including quadrats and belt transects	*Starter* Write the words 'headlice' and 'malaria protist' on the board, and ask students what they have in common. If the idea of parasitism isn't raised, add the words 'tapeworm' and 'flea' and ask again. Ask what humans get from the relationship with each of these organisms, to elicit the idea that humans are harmed. *Exploring* Provide a cut-and-paste activity to create the life cycle of the protest that causes malaria. This links back to work in topic *SB5e Spreading pathogens*, which covered the role of mosquitoes as vectors in the spread of the protists (*Plasmodium*) that cause malaria. Students use their completed life cycle to answer questions on the role of the protist and the human in this relationship. *Explaining* Show students examples of the life cycles of different human parasites. Choose 'macroparasites', e.g. *Trypanosoma* (the cause of sleeping sickness), *Schistosoma* (a blood fluke that causes schistosomiasis or bilharzia), and *Wuchereria bancrofti* (the cause of filariasis or elephantiasis). Ask students to make comparisons. Where appropriate draw attention to 'vectors'. Students could also consider any adaptations of the parasite that enables them to be a successful parasite. This should include how they get what they need from the host and also how they reach other hosts.	*Exploring* Support: Check that students have arranged the life cycle correctly, and work with them to find the information needed to answer the questions. Stretch: Explain that protists go through sexual reproduction inside the mosquito but asexual reproduction in human cells. Students revise the differences in outcomes and suggest the advantages for the different stages of the protist's life cycle. *Explaining* Support: Use just one example and focus clearly on the advantages of the relationship for the parasite and the harm that the human suffers as a result of being parasitised. Stretch: Students could research the effect of human parasites on the immune system, which helps them to avoid being attacked when they enter a human body	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Understand the principles of sampling as applied to scientific data • Use a scatter diagram to identify a correlation between two variables • Translate information between graphical and numeric form	*n/a*

Lesson SB9g: Biodiversity and humans (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.9: Explain the positive and negative human interactions within ecosystems and their impacts on biodiversity, including: a) fish farming b) introduction of non-indigenous species c) eutrophication	*Starter* Write the word pollution in the middle of the board and ask students to suggest words that link, and how they should be linked, to construct a concept map. If needed, draw out the source of the pollution, as well as its effects, in order to highlight the impact of human activities on ecosystems. *Exploring* Students work in groups to carry out a research task on the impact of the introduction of a non-indigenous species into a new area. They start by deciding what questions the project should answer, including why the species was introduced and evidence of the impact on indigenous (native) species. Each group should prepare a poster or a web article of 3 or 4 paragraphs that cover a different part of the story. Allow time for each group to present their findings to the class. Those who are listening should then identify two good points from the presentation, and one area for improvement. *Explaining* Discuss how the scale of fish farming has changed dramatically as the human population has grown, the resources required and the impacts (e.g. eutrophication, attraction of predators, escape of parasites/diseases and farmed fish). Students work in groups to produce a diagram or table to show the benefits and risks.	*Exploring* Support: Work with students to determine the questions they should answer or the titles for each section of their poster or article. Stretch: Students should suggest how problems caused by the non-indigenous species could be tackled, or how such problems could be avoided in future similar circumstances. *Explaining* Support: Give students examples of how fish farming can change the environment Stretch: Ask students to compile a set of regulations that could be used to minimise the impact of fish farming on the local natural environment, including what should be monitored to make sure that the impact is minimal.	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Use a scatter diagram to identify a correlation between two variables • Translate information between graphical and numeric form • Plot two variables from experimental or other data	*Suggested practical:* Investigate the effect of different nutrient concentrations on the growth of algae.

Lesson SB9h: Preserving biodiversity (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.10: Explain the benefits of maintaining local and global biodiversity including the conservation of animal species and the impact of reforestation	*Starter* Tell students that a new forest (the National Forest) is being planted in the UK. Students should work in small groups to suggest changes that might happen to the ecosystem as a result of planting large areas of trees. Ask students to suggest the impact of planting one tree species only (as in a plantation) compared with a mixture of species (as found in a natural forest) and to justify their answers. *Exploring* Show students a wide range of examples of plants and animals on the IUCN Red List in the critically endangered category. Identify how many are left in the wild or in captivity and why they are critically endangered. Students work in groups to come up with questions that need to be answered to help conserve the species. Discuss as a class before students carry out research on their choice of species. Allow time to present their findings. The class could vote on which species are the best candidates to receive funding from a limited conservation budget. *Explaining* Invite someone from a local wildlife trust or nature conservation group to talk to the students about a local example of conservation. Students should prepare for the visit by writing suitable questions to ask. This could be done as a KWL (Know, Want to learn, Learned) exercise.	*Exploring* Support: Work with students to prepare the list of questions, and take them through one example to model what information to look for. Stretch: Students should consider whether conservation of some species is 'worth the money', such as the effort to save giant pandas from extinction. Justification should consider how conservation of the habitat affects other species in that community, which are not as iconic as pandas. *Explaining* Support: Work with students to prepare the questions, prompting where needed with key words Stretch: Students should consider both the benefits and problems of conservation efforts, with the aim of answering the question 'is conservation worth it?'	n/a	*n/a*

Lesson SB9i: Food security (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.11B: Describe the biological factors affecting levels of food security, including: a) increasing human population b) increasing animal farming and the increased meat and fish consumption c) the impact of new pests and pathogens d) environmental change caused by human activity e) sustainability issues, e.g. use of land for biofuel production and the cost of agricultural inputs	*Starter* Write the word' sustainability' in the middle of the board and ask students to suggest words that relate to it, and to explain how they are related. Use the discussion to draw out a definition of the term. Then focus discussion on the sustainability of food production. *Exploring* Hold a class debate on the statement, 'This house believes that the UK Government should encourage farmers to grow biofuel crops.' The debate should consider not only the advantages and disadvantages to the Government and individual farmers, but also the impact on the environment and sustainability of food and fuel supply. Students could also carry out research to add to their arguments. *Explaining* Use a video from the internet about food security and how farming is changing. Ask students to consider the long-term impact of changes on food security and sustainability.	*Exploring* Support: Suggest headings or questions that students could use to structure their thoughts. Stretch: Many countries have created a list of criteria that define how biofuels should be grown and used for maximum sustainability. Ask students to create their own list of criteria, then compare them with those of the UK Government or European Union. *Explaining* Support: Encourage discussion before coming up with a group answer. Stretch: Students could draw up a list of risks and benefits, to food security and to sustainability, for the factors mentioned in the video.	• Construct and interpret frequency tables and diagrams, bar charts and histograms • Translate information between graphical and numeric form Plot two variables from experimental or other data	n/a

Lesson SB9j: The water cycle (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.12: Describe how different materials cycle through the abiotic and biotic components of an ecosystem • B9.14: Explain the importance of the water cycle including the processes involved and the production of potable water in areas of drought including desalination	*Starter* Give students the names of key points in the physical water cycle (e.g. sea, river, rain, cloud) and ask them to work in groups to create a water cycle. Compare examples to produce a single class response. *Exploring* Students will have met the idea of distillation and stills in Topic SC2e *Drinking water*. Challenge students to design and build a solar still. You could provide a context for this challenge, such as a still that could be used on a survival challenge in a remote area, or to provide clean water for as many people as possible in a disaster area where there is no drinking water. *Explaining* Cloud demonstration: Fill a clear, 2-litre fizzy drinks bottle with 50–60 cm^3 of warm. Screw the cap on and shake the bottle well. Hold the bottle up to the light, shake the bottle again, then squeeze the bottle and release it. It is unlikely that cloud will form in the bottle. Light a match, then blow it out and lower it into the bottle so that smoke particles enter the bottle. Quickly replace the bottle cap, shake the bottle again, squeeze it and then release the squeeze, forming a cloud, which disappears after a further squeeze. Ask students to suggest why adding smoke to the bottle allowed a cloud to form.	*Exploring* Support: Work with students to identify the processes required to get clean water form dirty water, and what parts of the sill design should be focused upon to achieve this. Stretch: Students should explain as clearly as possible how specific features of their designs maximise the rate of water collection. *Explaining* Support: Ensure that students understand that evaporation of liquid water produces an invisible gas (water vapour), and that what we see as clouds, aircraft contrails or the 'steam' coming from kettles is condensed droplets of water Stretch: Challenge students to explain why the cloud only forms as the pressure is released in the bottle.	• n/a	*Suggested practicals:* Creating a solar sill or cloud-in-a-bottle

Lesson SB9k: The carbon cycle (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.13: Explain the importance of the carbon cycle including the processes involved and the role of microorganisms as decomposers	*Starter* Provide each student with a word related to the carbon cycle. Ask students to hold up their word if they think it is the answer to your question: e.g. I'm an organism that photosynthesises (low challenge), I'm a carbon compound in an animal. (medium challenge), I'm a process that does the opposite of respiration (higher challenge) *Exploring* Provide a cut-and-stick exercise in which students work out the steps in the carbon cycle. Students arrange the picture and word cards, and explain why they have arranged them that way. Then they identify the processes that change carbon from one compound into another, and the carbon 'sinks' where carbon is stored out of the cycle for some time. This will link back to work on reforestation and its potential impact on atmospheric carbon dioxide and climate change. *Explaining* Remind students of how the carbon in carbon dioxide finds its way into glucose, and then into other compounds in plant biomass (for example, proteins, fats, starch). Then give each student a card with one of the following words or phrases: carbon dioxide; glucose; fats, proteins and starch; complex carbon compounds. Ask students to hold up the correct card to answer questions on the carbon cycle along the lines of, 'Which form of carbon…?'.	*Exploring* Support: Work with students to help construct the cycle, encouraging discussion about the correct arrangement. Students could then compare their arrangement with a diagram this is provided Stretch: Students could research alternative versions of the carbon cycle, which identify different carbon 'sinks'. They should make any adjustments to their arrangement that they consider are reasonable. *Explaining* Support: Where students have difficulty with an answer, encourage discussion to help them find the correct one. Stretch: Provide students with the answers and ask them to write questions on the carbon cycle that have one of those answers. Students then take turns to ask their question of the rest of the class.	• n/a	*Suggested practical:* Investigating the rate of carbon dioxide production from recently cut grass or defrosted garden peas

Lesson SB9l: The nitrogen cycle (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.15: Explain how nitrates are made available for plant uptake including the use of fertilisers, crop rotation and the role of bacteria in the nitrogen cycle	*Starter* Ask students to jot down three consequences of using nitrate fertiliser on growing crops. Then ask students to share their ideas with a neighbour and select the three most important consequences. Take examples from around the class to compile on the board. The class should then agree the most important positive and negative consequences. *Exploring* Students should carry out research to compare the use of fertilisers in organic and intensive farming. Explain that organic farming avoids the use of man-made fertilisers and other chemicals. Students should use their knowledge of the nitrogen cycle to explain why each method that farmers use improves soil fertility. *Explaining* This topic links with eutrophication covered in CB9e *Biodiversity and humans*. The topic also links with mutualism in CB9d *Parasitism and mutualism* with the example of nitrogen-fixing bacteria in the root nodules of legume plants. Ask students to a diagram of the nitrogen cycle to identify the different roles of bacteria in the nitrogen cycle. For each role, they should write one sentence that describes the effect of those bacteria on crop growth. Students could compare sentences to decide on the best descriptions.	*Exploring* Support: Students may need help planning out what to research. Work with them to identify suitable questions to answer from their research Stretch: Challenge students to evaluate the sustainability of using organic methods of fertilising soil with using inorganic fertilisers. They should search for evidence of the long-term impact on the environment as well as the impact on crop yields. *Explaining* Support: Work with students to come up with their descriptions Stretch: Students should consider other ways in which farmers should prepare fields before planting, to help maximise the soil nitrogen content	• n/a	*Suggested practical:* Investigate root nodules using microscopes

Lesson SB9m: Rates of decomposition (1 hour)				
Specification points	**Exemplar teaching activities**	**Differentiation**	**Maths skills**	**Practicals**
• B9.17B: Explain the effects of temperature, water content and oxygen availability on the rate of decomposition in food preservation • B9.18B: Explain the effects of temperature, water content and oxygen availability on the rate of decomposition in composting • B9.19B: Calculate rate changes in the decay of biological material	*Starter* Using a banana skin as a prompt, ask students to suggest what would happen if it were left in the bin for the next four weeks, and why it would change. Take suggestions from the class and make sure responses link back to work on decomposers in previous topics. *Exploring* Challenge students to design a compost heap to produce compost as quickly as possible. If practical, allow students to test their designs. However, make sure that only vegetable/plant waste is placed in the heap. *Explaining* Provide a range of examples about how food is preserved, with questions asking why each method works.	*Exploring* Support: Provide fact-cards and swtudents could use examples from the internet. Stretch: Students should explain why they think their design will be effective in producing compost quickly. They should also describe how they would compare the rate of compost formation in different heap designs, in order to identify which design is best. *Explaining* Support: Discuss the questions with students and provide hints that help them find the correct answers Stretch: Students could carry out research into methods of food preservation that are no longer used, and suggest why they are not used now.	n/a	n/a

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