9B
Plant growth

This unit looks at photosynthesis and aerobic respiration in plants in more detail, and then considers plant adaptations. The products we get from plants are then looked at, before studying farming methods and their problems.

Recommended teaching time for unit: 7.5–10 hours

Topic 9Bd provides an opportunity to look at how material in this unit is used by plant ecologists in doing ecological audits, with a focus on STEM skills (communication). Topic 9Be contains additional work on scientific skills (bias and validity). You may wish to spend additional time on these topics, should you feel that your students would benefit from these skills development opportunities.

From previous work, most students will be able to:

- describe how organisms and organism parts are adapted to their functions (7D)
- interpret food webs (7D, 8D)
- recall the processes of photosynthesis and aerobic respiration (8C, 8D)
- describe the concept of a limiting factor (8D)
- recall the main food groups and their uses (carbohydrates, fats, proteins) (8A)
- describe the importance of pollinators (8B)
- use the carbon cycle model (8D).

Topic 9Ba reminds students of work carried out in Year 8 on the processes of photosynthesis and aerobic respiration. Students will have met the idea of a limiting factor in the context of the growth of microorganisms in Unit 8D, and this is now applied to plants and photosynthesis.

Topic 9Bb looks at the adaptations of plant parts: roots, stems and leaves.

Topic 9Bc considers how a plant makes other substances from glucose.

Topic 9Bd takes a look at how farmers increase yields by the use of machinery, fertilisers, pesticides and crop varieties. The idea of selective breeding is introduced. There is an opportunity to find out about STEM and the skills associated with being a plant ecologist (with a focus on communication).

Topic 9Be concludes the unit by revising ideas about how farming can cause problems for an ecosystem. It includes coverage of bias and validity, an aspect of Working Scientifically.

Curriculum coverage

This unit covers the following:

- cells as the fundamental unit of living organisms
- the role of diffusion in the movement of materials in and between cells, and factors that affect its speed
- plants making carbohydrates in their leaves by photosynthesis and gaining mineral nutrients and water from the soil via their roots
- the role of leaf stomata in gas exchange in plants
- reproduction in plants, including insect pollination, seed and fruit formation
- the adaptations of leaves for photosynthesis
- aerobic respiration
- the interdependence of organisms in an ecosystem, including food webs and insect-pollinated crops
- the importance of plant reproduction through insect pollination in human food security
- how organisms affect, and are affected by, their environment, including the accumulation of toxic materials
- the importance of maintaining biodiversity
- selective breeding.

This unit also has a focus on the following aspects of Working Scientifically/Scientific Enquiry:

- identify and explain bias, suggesting reasons why people may be biased
- explain why some data are/are not valid (in terms of relevance to the initial question)
- identify potential ways in which random and systematic error may be caused
- explain why a conclusion is or is not valid (in terms of using the correct, good-quality data).

STEM skills

This unit explores these STEM skills and how they are used:

- communication (the importance of systematically organised information in reference resources and reports).

Cross-disciplinary opportunities

9Ba – Chemistry 9Eb – exothermic (e.g. respiration) and endothermic (e.g. photosynthesis) reactions

9Ba – Chemistry 9Eb – starch as a polymer

9Bc – Chemistry 9Eb – protein as a polymer

9Be – Chemistry 9Ed – biomagnification of persistent substances

Cross-curricular opportunities

9Bd – Geography – the Green Revolution and the breeding of rice by the International Rice Research Institute

Maths skills

- bar chart and line graph drawing and interpretation
- identifying random samples (and their use in avoiding bias).

9B Background information

9Ba On a farm/Reactions in plants

Photosynthesis is a complex set of over 80 reactions that occur inside chloroplasts. These reactions are catalysed and controlled by enzymes. At lower secondary only the basics are dealt with: carbon dioxide (from the air) and water (from the soil) combine inside the chloroplasts to form glucose and oxygen. The process requires light and chlorophyll. This green molecule covers the layers of membranes that are found within chloroplasts. It is able to absorb energy transferred by light and make the energy available for the synthesis of glucose molecules.

The reactions involved in this process can be divided into groups: those that result in the splitting of water to form oxygen and hydrogen, and those that ultimately form glucose by combining hydrogen with carbon dioxide. The former group is often referred to as the light stage, because these reactions require the presence of both chlorophyll and light. The remaining reactions constitute the dark stage, because they can occur in the dark. This is not studied at lower secondary, but some more able students doing independent research may come across the terms 'dark stage' or 'dark reactions' and may be confused.

In general terms, the speed (or rate) of photosynthesis will increase if the amount of carbon dioxide or of water, intensity of light or temperature increases. If a lack of one of these factors prevents the rate of photosynthesis increasing it is said to have become a limiting factor (a concept previously met in Unit 8D).

It should be noted that increasing the temperature above 40 °C results in a steep decline in the rate of photosynthesis because the enzymes involved start to become denatured (break apart).

Phloem vessels transport sugars and amino acids up and down a plant, with different vessels being used to transport substances in different directions. Xylem vessels carry water and dissolved mineral salts up the plant.

Aerobic respiration

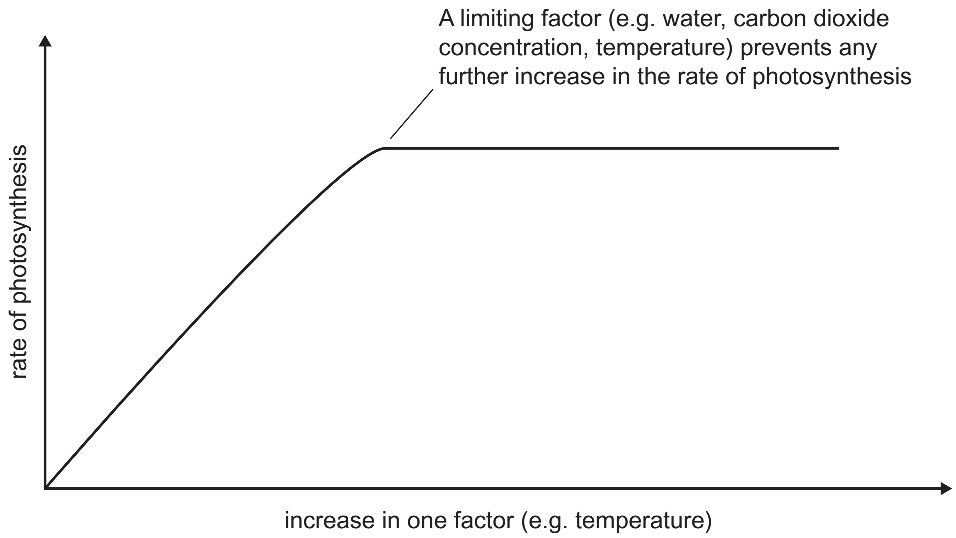
Plants respire using oxygen from the air and glucose, which they make during photosynthesis. Both processes occur at the same time during the day; only respiration continues at night.

All the cells in a plant require oxygen. Root cells usually get this from air spaces in the soil. However, waterlogging prevents this happening and will often kill the roots of land plants. Many plants that live in or close to water, however, are adapted to take oxygen directly out of water.

9Bb Plant adaptations

Roots are spread out and branched to collect as much water as possible in a short space of time. The root hair cells have a large surface area to absorb water quickly. It should be noted that root hair cells do not have hairs, as such, but their cells form a hair-like shape.

Leaves are usually thin so that carbon dioxide does not have to travel far inside the leaf before reaching the photosynthesising cells that need it, and they usually have large surface areas to collect as much sunlight as possible. They are also often arranged so that the leaves do not overlap; thus all the leaves get light. This pattern is known as a leaf mosaic. The palisade cells are packed with chloroplasts and so most photosynthetic activity occurs in this part of the leaf. The layer of cells above them (upper epidermis) contains no chloroplasts and so does not interfere with the light reaching the palisade



The rate of photosynthesis rises as one factor (e.g. temperature) increases, until it reaches a limit caused by the limited availability of another factor (e.g. carbon dioxide).

cells. It is interesting to note that chloroplasts can actually move within palisade cells. Too much light can damage them and therefore in strong light they tend to migrate lower in the cell and turn their edges into the direction of the light. The opposite is true in low light conditions. Note that in some plants chloroplasts can often also be found in the cells of other organs (e.g. the stem), which can therefore also photosynthesise.

Water is transported up plants in hollow xylem vessels formed from dead xylem cells. The cells have strengthening rings that help to support the tubular structure and also provide support for the plant. The xylem is often arranged near the middle of roots and nearer the outsides of stems, because the 'tube-like' ring of supporting struts gives a stronger shape for holding stems upright. In roots, this supporting function is not necessary and flexibility is important; therefore the xylem is found in the middle of the root.

The flow of water up a plant is called the transpiration stream and ends with the 'transpiration' of water from the leaf into the air. Transpiration is a two-stage process: evaporation of the water from the cells into the air spaces, followed by diffusion of the vapour through the stomata. Transpiration is faster when the air temperature is higher, because evaporation occurs more quickly at higher temperatures. It is also higher when the humidity is low or a wind is blowing. The diffused water molecules collect outside the stomata in humid and still conditions, reducing the concentration gradient and therefore slowing the rate of diffusion. The factors that increase the rate of transpiration are therefore: increase in temperature, increase in wind, decrease in humidity and increase in light (stomata open in the light).

There are two main ways in which water is moved upwards through the xylem tubes. Root pressure is a force pushing the water upwards due to the flow of water into the xylem tubes in the root (water enters the xylem by osmosis). As water evaporates from the leaves, the pressure at the top of the plant is reduced and thus water is pushed up the plant by the larger pressure in the roots. The more important force is, however, a pulling force from the leaves. Water molecules are very cohesive and thus tend to stick together, especially in small tubes. This forms a 'chain' of water molecules through the plant and therefore, as water transpires from the leaves, more is pulled up.

The transpiration stream does not just supply leaves with a raw material for photosynthesis. It also helps to transport dissolved mineral salts up the plant, keeping the leaves cool and the cells of the plant filled with water ('turgid') so that they push against one another and provide support for the plant. This is the reason plants wilt if they do not get enough water.

When doing practical work on transpiration with stems it is always advisable to cut them under water immediately before use, because the introduction of air into the xylem tubes breaks the 'chain' of water molecules and therefore disrupts transpiration.

The most important mineral salts for plants are nitrates, phosphates and potassium salts. The table overleaf gives a brief summary of what the different elements found in mineral salts do. The first three are very important and are required in relatively large amounts. These are often known as major elements or macronutrients. The rest are required in much smaller quantities and are often called trace elements or micronutrients. Some elements act as cofactors or enzyme activators; that is, they form a loose association with an enzyme, enabling it to perform its function.

There may be confusion about the terms 'nutrient', 'mineral salt', 'mineral element' and 'mineral'. These are often used interchangeably, although in this course when dealing with plants the term 'mineral salt' is used in preference. A mineral salt is a chemical compound (from a group of compounds called salts, most of which are soluble in water). A mineral is a naturally occurring solid substance with a fixed composition. So, for example, magnesium nitrate is both a mineral and a mineral salt. The elements needed from magnesium nitrate are magnesium (used in the production of chlorophyll) and nitrogen (used in the production of proteins). Both of these elements are sometimes referred to as minerals, but because magnesium does not exist in an elemental form in nature and the element nitrogen is a gas, neither of them qualify as 'minerals'. It is for this reason that the term 'mineral salt' is used.

Magnesium nitrate could also be called a nutrient. However, this often confuses students because they think of the nutrients that humans need in a balanced diet (carbohydrate, fat, protein, vitamins and minerals). So, this term is avoided.

9Bc Plant products

During the day, glucose made by photosynthesis is converted into starch inside chloroplasts. Starch is described as a storage material in the Student Book, but some students may question why the plant does not store glucose. There are two reasons: osmosis and equilibrium.

Photosynthesis is a complex series of chemical reactions and most involve the setting up of an equilibrium – a point is reached when the amount of the reactants turning into products is the same

Mineral salt	Function
Major elements	
N nitrogen (in nitrates)	Needed to make proteins (amino acids are compounds containing hydrogen, carbon, oxygen and nitrogen). Nitrogen is also needed to make DNA and chlorophyll.
P phosphorus (in phosphates)	Needed to make the 'phospholipids' found in cell membranes. Also needed to make DNA and an important molecule involved in energy transfer called ATP (adenosine triphosphate).
K potassium	Cofactor for enzymes involved in respiration and photosynthesis.
Trace elements	
B boron (in borates)	Needed for cell division.
Ca calcium	Used to make calcium pectate, which acts as a glue between cell walls.
Cu copper	Needed for an enzyme in respiration.
Fe iron	Needed to make compounds called cytochromes required for respiration and photosynthesis.
Mg magnesium	Part of the chlorophyll molecule.
Mn manganese	Needed for enzymes involved in DNA manufacture.
Mo molybdenum	Needed for an enzyme involved in protein manufacture.
S sulfur (in sulfates)	Needed to make some amino acids (cysteine and methionine).
Zn zinc	Needed for an enzyme involved in taking carbon dioxide into cells.

as the amount of products being turned back into reactants:

$$A+B \rightleftharpoons C+D$$

Reaching an equilibrium would therefore limit the amount of glucose that could be made. To allow the reactions to continue making glucose, the glucose is removed (by forming starch). The other reason for starch formation relates to osmosis. An increase in the glucose concentration in the chloroplast will cause water to move from the cytoplasm into the chloroplast by osmosis (the diffusion of water molecules from a dilute solution to a more concentrated solution through a partially permeable membrane). The net result of this movement would be the bursting of the chloroplast. Starch, being insoluble, does not increase the solute concentration inside the chloroplast.

At night, the starch is broken down and moved into the cytoplasm, where the products of starch breakdown are used to make sucrose. This is the most commonly used transport sugar in plants.

Elements in plants

Carbohydrates and lipids are substances made from the elements carbon, hydrogen and oxygen, and plants make both from glucose produced by photosynthesis. Proteins can also be made using the glucose, but their amino acid building blocks require the element nitrogen as well. Nitrogen is found in mineral salts called nitrates. Some amino acids also require other mineral salts.

9Bd Growing crops/Protecting wild plants

Farming

Farmers use many different strategies to achieve higher yields and so higher potential profits. This includes the use of fertilisers to provide mineral salts for plants.

Pests are organisms (including animals, plants and fungi) that compete with humans for crop plants. Chemical pesticides are often used by farmers to kill pests. Many plants grow in similar conditions to those for crops and can compete for the same resources. These are weeds. Farmers usually use chemical herbicides to kill weeds rather than manual removal, which is labour-intensive. Herbicides can kill wild plants in the surrounding environment. Selective herbicides usually kill broad-leaved plants and not narrow-leaved plants, such as cereal crops, and are popular lawn weedkillers, although there are now some available that target narrow-leaved plants.

Greenhouses are used to grow plants independently of environmental changes. The conditions are set for maximum or optimum yields, although there are cost implications.

Selective breeding

Animals and plants are bred to create offspring with characteristics that are beneficial to humans. Humans have used selective breeding for millennia. It involves selecting offspring with desirable characteristics (or 'traits') and using only these organisms to breed the next generation. This process is repeated and repeated, gradually changing the form of an organism and producing a new breed (in animals) or variety (in plants). All breeds of domestic cat are the same species (*Felis catus*) and equally wild mustard plants have been selectively bred to give us cabbages, broccoli, cauliflower, kale, Brussels sprouts, greens and kohlrabi. These all belong to the same species, *Brassica oleracea.*

9Be Farming problems/Bias and validity/ Organic farming

A lot of the world's farming is intensive farming, in which the crops are fertilised and sprayed with pesticides to get the highest yield possible. New varieties of crops may produce a greater yield, have resistance to certain pests or be able to withstand a certain climate. Some modern farms plant vast areas of one crop; this is known as monoculture. All of these practices, whilst ensuring a good-quality food supply, have associated problems.

Monoculture leads to depletion of certain mineral salts in the soil, and repeated ploughing and use of artificial fertilisers causes the soil structure to become fine and crumbly, leading to soil erosion. Using manure prevents the soil structure breaking up as much. Pests also spread quickly throughout a monoculture system, because similar plants are very close together. Monoculture also creates artificial ecosystems in which the variety of organisms (biodiversity) is extremely poor.

Fertilisers are often washed into watercourses, where they encourage the rapid growth of algae (algal bloom) and plants. This is eutrophication (the ecosystem's response to the sudden addition of nutrients). The algae and plants become overcrowded, block out light and so die, resulting in a rich source of organic matter for bacteria to feed on. The bacteria multiply rapidly, depleting the water of oxygen, causing the death and decline of other aquatic organisms (such as fish). Other factors may also be involved, such as the fertilisers causing faster growth of large plants on river banks that then shade out the aquatic plants below. The growth and spreading of the large plants and their root systems also reduces water circulation (and therefore the rate at which oxygen dissolves in the water).

Pesticides damage food chains by removing the food sources of animals that feed on the pests. They may also directly or indirectly reduce the numbers of non-target animals. This is common with insecticides. The harmful effects of DDT on wildlife are well documented (its use is now banned in most countries). This pesticide is persistent (it does not quickly break down naturally). It therefore passes along food chains, and becomes more and more concentrated at each step of the chain (biomagnification). Some top predators (e.g. grebe) are killed by the toxic effects of this build-up. Others (e.g. peregrine falcon) lay eggs with thin shells that easily break. Other insecticides, such as aldrin, dieldrin and endrin, are known to cause cancer in humans, and there are limits on the amounts that may legally be present in drinking water in many countries (for example, in EU countries it is 5×10^{-9} g dm^{-3} for all of these insecticides). Fungicides and herbicides can also cause problems in food chains and be detrimental to human health.

Sometimes biological control is used, particularly in organic farming. This involves introducing a natural predator or a toxin-producing organism to control pest numbers (e.g. ladybirds used against aphids; the bacterium *Bacillus thuringiensis*, which produces a substance toxic to many caterpillars). The advantages include cheapness, specific control of the pest and no build-up of resistance. Disadvantages include slowness, unpredictability, the survival of some of the pests, the fact that chemical insecticides cannot be used on the crop and the risk of the control organisms becoming pests themselves. The cane toad, which was introduced into Australia to control beetles, is now a severe pest.

Bias and validity

Bias is a shift in meaning or data away from the true meaning or true values. One important type of accidental bias is systematic error (e.g. forgetting to zero the balance when measuring a series of masses). Other forms of accidental bias include mistakes in sampling, resulting in samples not being reflective of the population ('selection bias'), or subconscious choice of samples that will support the expected outcome ('confirmation bias' – a celebrated example of which was Jacques Benveniste and his 'memory of water' article in *Nature*). The treatment in the Student Book is basic, setting the scene for students learning about the importance of randomisation and blind/double-blind trials later on in their scientific studies.

Organic farming

It is often thought that organic farming does not involve the use of pesticides. This is not quite the case. Naturally occurring substances can be used, including copper compounds (e.g. copper sulfate), used as a fungicide; rotenone, a naturally occurring insecticide; sulfur, effective mainly against fungi, but also some insect pests; soft soap, used to control aphids.

In many countries, organic farmers need to get permission from an organic farming association to use copper compounds or rotenone and still label their products as 'organic', although they are usually able to use soft soap and sulfur without permission. Organic farmers are encouraged to look for ways of using biological control (see above).

9Ba
Reactions in plants

Objectives
Developing:

1. Model aerobic respiration and photosynthesis using word equations.
2. Explain the functions of light and chlorophyll in photosynthesis (in terms of energy transfer).
3. Recall the factors that affect the rate of photosynthesis.

Securing:

4. Explain how the rate of photosynthesis can be controlled by a limiting factor, including using the equation to identify possible limiting factors.
5. Recall and interpret the balanced symbol equations for photosynthesis and aerobic respiration. (iLS only)

Exceeding:

Exceeding objectives are designed to broaden students' skills and knowledge beyond what is required, often introducing a higher level of challenge.

6. Model reactions using balanced symbol equations.

Student materials

Topic notes
- Misconception: it may be worth pointing out that 'plant food' sold in garden centres contains mineral salts and is not like the food we eat.
- Misconception: students often think that respiration only occurs in animals.
- Note that the equations for photosynthesis and aerobic respiration can be shown with or without some of the reaction conditions (e.g. energy from light, chlorophyll) on the arrow.
- It is important that teachers review all materials that they intend to use with students before use, to ensure suitability.
- It is envisaged that in the course of studying the biology component of this topic, students will use one Starter idea, Explaining 1, one further Exploring or Explaining idea, and one of the plenaries. Additional activities can be added as time allows.

Be prepared
Starter 2 requires flash cards.

Exploring 2, Explaining 3 and Explaining 4 all require pondweed (e.g. *Cabomba*) and may need use of a fish-tank bubbler in the water for 12 hours beforehand.

Explaining 4 may require set-up of apparatus 24 hours before use.

STARTERS

1: Quick Quiz
BA
Use the 9B Quick Quiz for baseline assessment. Students can use the 9B Quick Quiz Answer Sheet to record their answers. You could use all of the Quick Quiz as a starter for the whole unit and then summatively at the end of the unit to show progress. Or just use the first four questions, which relate to this topic.

Once students have carried out the quiz, they will be aware of what they know and any questions they have about the Unit 9B topics. Ask students to decide if they would like to cover all the topics in detail or if there are topics that they think they can just revise quickly. Topics 9Ba and 9Be revise materials from Years 7 and 8 on photosynthesis, respiration and damage to ecosystems, and if students are feeling confident about these topics it is suggested that the material in these topics is revised rather than covered in full. This may include asking groups to prepare and present summaries of the key ideas from Topics 9Ba and 9Be.

Course resources
ASP: 9B Quick Quiz; 9B Quick Quiz Answer Sheet.

2: Photosynthesis equation
BA
Show students a set of flash cards with the words of the photosynthesis word equation on them. Ask students what each thing is, where it comes from and how it fits into photosynthesis. Ask students to divide the cards into 'reactants' and 'products', then to build up the photosynthesis word equation. Get groups to check their word equation with another group. Identify any areas of confusion to address in the following lessons. The AL presentation *Equations* shows the equations for both photosynthesis and aerobic respiration, and shows how the processes are linked. For this Starter, use only the cards for photosynthesis. See Explaining 5.

Course resources
AL: Presentation *Equations*.

3: Jumbled sentences

BA

Ask students to work together in groups to make a sentence out of each of these groups of three words: glucose, oxygen, chloroplast; carbon dioxide, energy, respiration; reactants, products, equation; chloroplasts, plant cell, photosynthesis; limiting factor, photosynthesis, light.

Ask a member of each group to read out the agreed sentences, asking the class to spot any inaccuracies or suggest improvements. Point out aspects that students may want to look at again, and give students an opportunity to amend their work. Ask groups to keep their sentences, which can be used in Plenary 3.

4: Plant cell to label

BA

Remind students what a plant cell is, and what the names and functions of its parts are by asking them to sketch and label a plant cell. Then get one student to draw their plant cell on the board and ask other students to support/correct them as they label the six main parts: cell wall, cell membrane, nucleus, cytoplasm, vacuole, chloroplasts. Ask students to describe the function of each part, revising material from Unit 7A. As a student describes a function correctly, get them to come up and label this on the board: cell wall (supports and protects the cell), cell membrane (controls what goes in and out of the cell), nucleus (controls what the cell does), cytoplasm (the place where the cell's reactions occur), vacuole (a storage place containing cell sap), chloroplasts (contain chlorophyll and are where photosynthesis occurs).

The **AL** interactive *Labelling a plant cell: revision*, first used in Year 8, offers an electronic version of this activity.

Course resources
AL: Interactive *Labelling a plant cell: revision*.

EXPLORING TASKS

1: Should I grow it?

WS

The **AL** spreadsheet *Should I grow it?* provides a data-handling exercise in which students have to work out whether or not it is financially viable for a farmer to grow a certain crop.

Course resources
AL: Spreadsheet *Should I grow it?*

2: Variables that affect photosynthesis

WS

Using *Cabomba* pondweed under an upturned glass funnel in a beaker of pond water/rainwater, it is possible to count bubbles of oxygen given off due to photosynthesis. Students then use this idea to investigate the effects of different variables on the rate of photosynthesis. This practical can be used to carry out a Working Scientifically Investigation. A sheet of descriptions to assign progression bands (developing, securing or exceeding) to the work is provided in the ASP. The use of Worksheets 9Ba-2 and 9Ba-3 will limit the number of strands (mainly planning) that can be assessed.

Developing: Worksheet 9Ba-2 provides a directed practical involving changing light intensity. Ensure that students understand the term 'correlation' before they start on the sheet.

Securing: Worksheet 9Ba-3 is a planning help sheet.

Exceeding: Students should plan the investigation independently, and should consider how human error and accuracy of measurements may affect the collection of data and how these factors can be controlled.

When changing any variable, it is advisable to allow the pondweed to photosynthesise for two or three minutes before taking any measurements so that it adjusts to the new conditions.

Variables: *Light intensity* can be varied by moving a lamp closer and closer to the beaker (1 m to 10 cm) although this will also heat up the water. To make a fairer test, a heat sink (a trough of water) can be placed between the lamp and the beaker. *Carbon dioxide concentration* can be varied by the addition of various quantities of sodium hydrogen carbonate (2–10 g/l). Note, however, that there is some evidence that hydrogencarbonate ions can be toxic to the plant in some concentrations. A better way is to compare aerated water (12 hours with a fish-tank bubbler) with unaerated water. *Temperature* can be altered by doing the investigation in water baths of different temperatures (20–60 °C), although in this case the light source will need to be positioned above the beaker.

Quantitative results: Students count the number of bubbles in one minute from a single cut stem. This is the quickest and easiest method, but yields the least accurate results. An alternative is to measure the time it takes for gas to fill a certain amount of the end of the funnel or calibrated test tubes (calibrated by students themselves using a syringe, adding 0.5 cm^3 quantities of water and marking lines along its length). The tubes are filled with water and placed over the end of the funnel. This will involve using large beakers or troughs so that the funnels are well submerged and there is enough room to fill the tubes and invert them over the funnels. A more complex method involves the apparatus shown below, where the horizontal syringe is used to fill the vertical one.

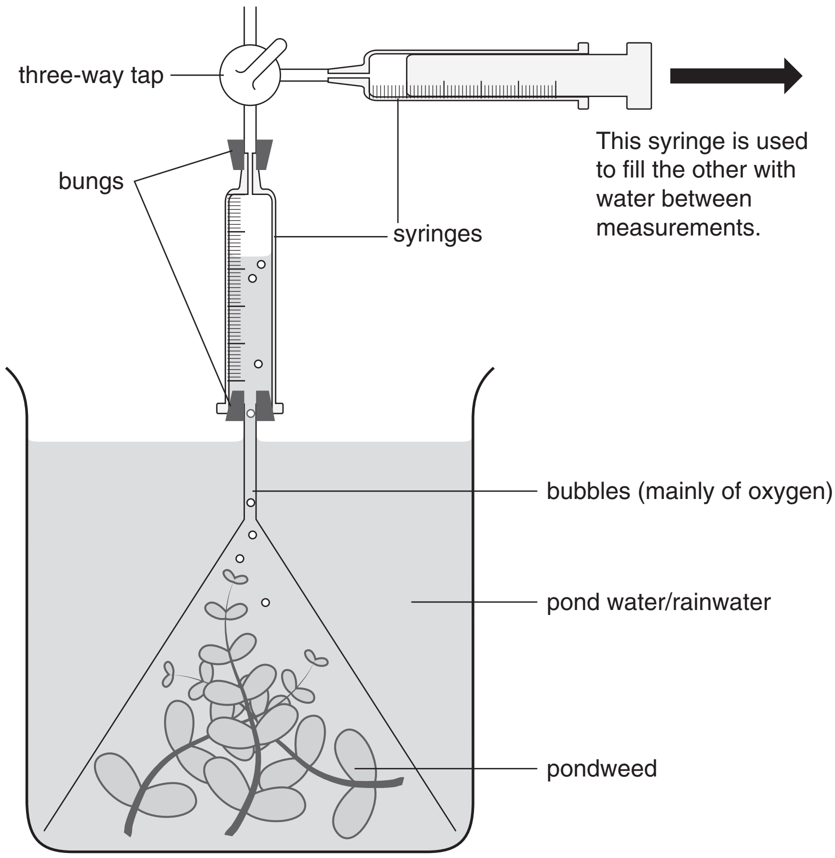
An alternative is to use an oxygen sensor and datalogger – see Explaining 3.

The **AL** spreadsheet *Pondweed bubbles* provides data from an investigation like this for data handling.

⚠ Students should wash their hands after handling pond water. Students should take care not to touch the lamp, because it may become very hot.

Course resources
AP: Worksheets 9Ba-2; 9Ba-3.
ASP: 9B WS Investigations.
AL: Spreadsheet *Pondweed bubbles*.

Equipment
Freshly cut stem of pondweed (*Cabomba* is recommended, and pondweed that has been kept in an aquarium for a long period may also perform poorly), aerated (12 hours with a fish-tank bubbler) pond water/rainwater (possibly containing 2 g dm^{-3} sodium hydrogen carbonate), intense (at least 80 W) light source (e.g. halogen security light), large beaker, glass funnel, stop clock.
Optional: test tube, syringes, marker pen, three-way tap, narrow bung for end of glass funnel, bored bungs or rubber tube connectors, sodium hydrogen carbonate, access to a range of water baths at different temperatures, conical flask, oxygen probe with support, oxygen sensor, datalogger and display device (such as a computer or tablet).



3: Discovering photosynthesis
Developing: Worksheet 9Ba-4 contains a series of cartoon boxes about the discovery of photosynthesis. Students need to cut out the boxes and arrange them in the order in which they think they should go. They should then use the Internet or a library to check their order and to find out one interesting fact about each of the scientists.

Securing: Worksheet 9Ba-6 contains more detailed information and involves a comprehension exercise. You could challenge students to use the information on the sheet to write short sketches about the scientists. Many history documentary programmes on TV have small sketches to 'bring the characters to life'. Tell students that a documentary is being made about photosynthesis and that the scientists on this worksheet are going to be 'brought to life'. Ask students to select one scientist and write a 30–60 second sketch about that person's discovery.

Course resources
AP: Worksheets 9Ba-4; 9Ba-6.

Equipment
Library/Internet access, scissors, glue.

EXPLAINING TASKS

1: 9Ba On a farm (Student Book)
BA
This page introduces the theme of farming by asking students to consider some of the financial aspects of farming, and how criteria are used by a farmer to decide whether or not to grow a crop. The **AL** spreadsheet *Should I grow it?* (see Exploring 1) may be useful.

Course resources
AL: Spreadsheet *Should I grow it?*

2: 9Ba Reactions in plants (Student Book)
FA
Topic 9Ba Reactions in plants in the Student Book reminds students about photosynthesis and respiration. Worksheet 9Ba-1 is the Access Sheet. Questions 6, 7 and 9 are suitable for formative assessment, with students working on the questions in groups.

Note that there are many ways in which the equations for photosynthesis are presented. Some sources show '+ energy' in brackets on the left of the arrow, and others show 'energy', 'light energy' or 'energy transferred by light' above or below the arrow. Some sources also show 'chlorophyll' above or below the arrow. Terms shown above or below an arrow in an equation are the conditions required for the reaction to occur. Check with your curriculum, scheme of work or syllabus to see what is required for your students.

The **AL** presentation *Equations* shows the equations for both photosynthesis and aerobic respiration and how the processes are linked. See Starter 2 and Explaining 5.

In the **AL** interactive *Limiting factors*, students find out about the factors that affect the rate of photosynthesis.

The **AL** spreadsheet *Pondweed bubbles* provides data from an investigation into the rate of photosynthesis in a pond. See Exploring 2.

The **AL** interactive *Labelling a plant cell: revision,* originally from Year 8, may also be helpful.

The **AL** presentation *9Ba Thinking skills* can be used for this activity. See Plenary 2.

Course resources
AP: Worksheet 9Ba-1.
AL: Interactives *Labelling a plant cell: revision*; *Limiting factors.* Presentations *9Ba Thinking skills*; *Equations*. Spreadsheet *Pondweed bubbles*.

3: Products of photosynthesis and respiration
WS
Traditionally, collecting the gas given off by pondweed (such as *Cabomba*) in an upturned, water-filled test tube and testing with a glowing splint is meant to show that oxygen is produced by photosynthesis. See Exploring 2. If pure oxygen were collected, the splint would relight. However, in this case there is also some carbon dioxide (from respiration) and nitrogen (released from the water) in the collected gas. You may be lucky and get the glowing splint to glow a bit brighter, but this is unlikely to convince students.

A better way is to use a dissolved oxygen sensor, datalogger and display equipment to monitor the build-up of oxygen in the water. The tank is insulated, thus controlling the heating effect of the lamp (an important evaluation point). The addition of a magnetic stirrer will ensure even distribution of gases in the water throughout the experiment. Oxygen concentration can then be monitored using a dissolved oxygen sensor connected to a suitable datalogging unit and display device. Once set up, the apparatus can be used to measure the effect of the following variables.

Light intensity can be varied by moving a lamp closer and closer (1 m to 10 cm). Or place the apparatus in a light-proof box and watch the effect of respiration in the plant (by watching either the decrease in oxygen concentration or the decrease in pH by using a pH probe instead of or in addition to an oxygen sensor).

Carbon dioxide concentration of water can be varied by the addition of various quantities of sodium hydrogen carbonate (2–10 g dm^{-3}). Note, however, that there is some evidence that hydrogencarbonate ions can be toxic to the plant in some concentrations. A better way is to compare aerated water (12 hours with a fish-tank bubbler) with unaerated water.

Temperature can be altered by the addition of water at different temperatures around the inner part of the apparatus.

⚠ Wash your hands after handling pond water. Be aware that the lamp may become very hot.

Equipment
Freshly cut stem of pondweed (*Cabomba* is recommended), aerated (12 hours with a fish-tank bubbler), pond water/rainwater (possibly containing 2 g dm^{-3} sodium hydrogen carbonate), water at different temperatures, ice, intense light source (e.g. halogen security light), photosynthesis tank, magnetic stirrer, dissolved oxygen, pH and temperature sensor, light sensor suitable datalogging unit and display device.

4: Carbon dioxide, photosynthesis and respiration
WS
You may wish to set up this demonstration 24 hours before showing it to the class. Take three boiling tubes and rinse them with distilled water, and then with hydrogen carbonate indicator solution. Avoid breathing out over the tubes as they are set up: exhaled carbon dioxide can alter the colour of the hydrogen carbonate and cause confusion. Place a piece of pondweed into two of the tubes and then fill all with hydrogen carbonate indicator to the same level (covering the pondweed in each of those two tubes). Stopper each tube with a bung. Wrap one tube in foil and place all the tubes in a rack near a strong light source. After a few hours the hydrogen carbonate indicator in the lit tube should turn from pink to purple, indicating a rise in pH – the using up of the carbon dioxide. The hydrogen carbonate indicator in the tube without pondweed should not have changed colour. The tube that was wrapped with foil should get a little paler/yellower due to carbon dioxide produced by respiration.

⚠ Be aware that the lamp may become very hot.

Equipment
Three boiling tubes and bungs, distilled water, red/pink hydrogen carbonate indicator, *Cabomba* (or other) pondweed, intense light source (e.g. halogen security lamp), tube rack, aluminium foil.

5: Respiration and photosynthesis equations
Use the set of flash cards from Starter 2 to show how the word equations (and thus the processes) for aerobic respiration and photosynthesis are linked – essentially this can be shown by reversing the equation. Students should appreciate that one reaction takes in energy (is endothermic) and stores it and the other releases that energy again (is exothermic), which the plant uses to power other reactions needed for growth. Students may not have met the idea of exo- and endothermic reactions if they have not yet covered Unit 9E. The **AL** presentation *Equations* shows the equations for both photosynthesis and aerobic respiration and how the processes are linked.

Course resources
AL: Presentation *Equations*.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check
FA
Assessment: The 9Ba Quick Check sheet provides some sentences about photosynthesis and aerobic respiration. Students note down what the

underlined words mean and indicate how sure they are of their responses.

Feedback: Once students have completed the sheet, take a vote on which word students were least confident about. Then ask them to work in groups to compare their answers and to write in or correct their answers in the 'Certain' column.

Action: Ask random students to read out an answer that they are now certain about, which they were not certain of at the beginning of the exercise. Encourage students to think about how they could become more certain of their responses.

Course resources
ASP: 9Ba Quick Check.

2: Thinking about plant reactions
FA
Assessment:

Plus, Minus, Interesting: Plants should need less light to photosynthesise. (Possible answers: **Plus –** crops would grow more quickly; **Minus –** plants in the park may quickly become overgrown; **Interesting –** some plants are adapted to photosynthesising in low light levels by having more chloroplasts and bigger leaves. Do all plants photosynthesise?)

Plus, Minus, Interesting: Plants should not release carbon dioxide from respiration. (Possible answers: **Plus –** plants would have a store of carbon dioxide for photosynthesis; **Minus –** plants may have to form structures to hold the gas in; **Interesting** – do any plants store gases inside them? Cacti do have a way of storing carbon dioxide for later use.)

Consider All Possibilities: All the crops in a field have died. (Possible answers: they ran out of water; they were waterlogged; they had a disease.)

Consider All Possibilities: Although the amount of light is being increased, the number of bubbles of gas being given off by some pondweed is not increasing. (Possible answers: carbon dioxide is a limiting factor; temperature is a limiting factor; something else is a limiting factor.)

Odd One Out: light, water, oxygen, carbon dioxide. (Possible answers: light is not a substance/raw material; light is not found underground; people do not need sources of carbon dioxide to live; water is the only liquid at room temperature.)

Odd One Out: photosynthesis, aerobic respiration, burning. (Possible answers: photosynthesis is the only one where oxygen is a product; burning is the only process not carried out by plants.)

Feedback: Students answer the thinking skills questions in groups, thereby feeding back their thoughts to one another.

Action: Ask students to choose a best answer from their group and consider why they think it is the best. Ask a spokesperson from a number of groups to read out their best answers. Create an agreed class list of 'what makes a good answer'. If understanding is poor then revise photosynthesis and aerobic respiration with students at the start of the next lesson.

The **AL** presentation *9Ba Thinking skills* can be used for this activity. See Explaining 2.

Course resources
AL: Presentation *9Ba Thinking skills.*

3: More sentences
FA
Ask groups of students to look at the sentences that they constructed in Starter 3 and to come up with some additional sentences using these words, based on what they have learned during this topic. Ask selected groups to give a short presentation about their original sentences, and how and why they have now changed them to make them better.

Consider displaying some key sentences written onto sticky notes on a noticeboard. Students could add a tick or cross onto the sticky notes for sentences that they feel confident or unsure about. This is effectively done by asking students to tick or cross each sentence on their way out of a lesson. Use this feedback to help plan future activities.

Exceeding: Challenge students to develop their own sets of three words that others in the class can use to make sentences.

HOMEWORK TASKS

1: Photosynthesis
Worksheet 9Ba-5 contains straightforward questions about photosynthesis and respiration.

Course resources
AP: Worksheet 9Ba-5.

2: Limiting factors
WS
Worksheet 9Ba-7 is a data-handling exercise on limiting factors of photosynthesis. The first graph on the sheet shows a rate of change and it may be worth checking that students can interpret this

graph before they complete the sheet. Graph paper is required.

Course resources
AP: Worksheet 9Ba-7.

Equipment
Graph paper.

3: Biological symbol equations
Worksheet 9Ba-8 extends the work on equations and symbols from the Student Book by looking at balanced symbol equations for photosynthesis and respiration.

Course resources
AP: Worksheet 9Ba-8.

9Bb
Plant adaptations

Objectives
Developing:

1. Describe the adaptations of leaves and plant cells for photosynthesis and gas exchange.
2. Describe how water and mineral salts are absorbed and moved around a plant, and how water is lost.
3. Recall some of the main nutrients required by plants and what they are needed for (nitrogen from nitrates and magnesium).

Securing:

4. Explain how wilting occurs.
5. Explain how the features of leaves and plant cells are adaptations for photosynthesis.
6. Explain how roots and stems are adapted for their function.

Exceeding:

Exceeding objectives are designed to broaden students' skills and knowledge beyond what is required, often introducing a higher level of challenge.

7. Use a knowledge of diffusion to explain how different conditions cause different rates of transpiration.

Student materials

Topic notes

- It is important that teachers review all materials that they intend to use with students before use, to ensure suitability.
- It is envisaged that in the course of studying the biology component of this topic, students will use one Starter idea, Explaining 1, one further Exploring or Explaining idea, and one of the plenaries. Additional activities can be added as time allows.

Be prepared
Starter 4 needs to be set up 12 or more hours before use.

Explaining 4 requires green *Solenostemon* (Coleus) leaf and may require geranium leaves.

STARTERS

1: Plant organs
BA
Ask students to draw a plant and to label its parts, along with what those parts do. This is simple revision work from Unit 7A. Get students to compare their sketches in pairs, adding any features and labels they have missed out, and then to work in small groups. Each group should agree the final set of features and labels to feed back to the class.

The **AL** interactive *Plant parts* offers an electronic version of this activity.

Course resources
AL: Interactive *Plant parts*.

2: Adaptations
BA
Remind students of the meaning of the word 'adapted'. Ask students to work in groups to come up with three examples of adaptation in plants. For each example they need to describe the example, say how it demonstrates adaptation and explain what it is an adaptation for. After a few minutes, ask a spokesperson from selected groups to describe the best example that they have come up with and the worst. Ask them to justify why they think one example is better than the other. Groups can also be asked to comment on each other's examples.

3: Plants brainstorm
BA
Ask students to jot down as many facts about plants as they can. Students should do the first part individually for a couple of minutes and then work in small groups to organise their ideas in a more systematic way (e.g. as lists of crop plants/plants that we eat, ways in which plants are used, adaptations of plants, parts of plants, cells found in plants). A spokesperson for each group should then share with the class one category that they used to organise the information and what information is included in this category. Students should then be given an opportunity to add notes to their own lists and categories.

4: Thoughts about plants
BA
Display a circus of small demonstrations for students to look at. They can use Worksheet 9Bb-2 to record their observations and explanations. Display items should include:

- two beakers of water, one containing a blue dye, each with a white flower in it, prepared about

12 hours beforehand to ensure that the blue dye reaches the flower petals (alternatively, use celery stems with the leaves still on)
- a selection of leaves, some with prickles and some without, some large and some small from the *same* plant (e.g. a tree), some variegated and some not
- a pot plant that has been taken out of its pot so that students can clearly see the roots
- a wilted plant
- a dead plant.

Note that many plants will have bigger leaves where those leaves have grown in the shade. Nettles are a good example (although it is unwise to use these if they can be touched by students). Many trees will also show this (e.g. holly, maple) where leaves exposed to more light are generally smaller than those that are shaded. You may need to do some research to find plants that clearly show this sort of environmental variation in your country.

Students could discuss their observations in pairs before noting them down. Once they have finished, ask students to name and describe any processes or adaptations they saw evidence for – prompting by naming the process or adaptation and asking for examples if needed: for example, water flow, death, avoiding drying out, discouraging herbivores.

Course resources
AP: Worksheet 9Bb-2.

Equipment
Beaker of water in which is placed a white flower (e.g. carnation) for 12 hours, beaker of blue-dyed water (e.g. food colouring) in which is placed a white flower (e.g. carnation) for 12 hours, selection of large and small leaves and/or some leaves with/without prickles and/or variegated/non-variegated leaves, pot plant with roots exposed, wilted pot plant, dead pot plant.

EXPLORING TASKS

1: Water flow
WS
Using celery stems in beakers of water dyed with blue or red food dye allows students to watch the dye move up the xylem tubes. The speed of this process can be roughly determined by taking a celery stem and removing it from the dye after 10–15 minutes. By breaking the stem lengthwise, it is possible to measure how far up the stem the dye has travelled. The investigation can be repeated using different environmental conditions (e.g. placed in a cold room, placed in a warm room, placed near a fan, placed near a fan heater, varying light conditions).

Developing: Students use Worksheet 9Bb-3.

Securing: Extend the practical by cutting out small sections of the stained xylem for microscopic examination. It is best to use cavity slides for this so that students do not push down on the xylem sections with the coverslips and break them. Skills Sheets UE 2 and UE 3 from the Year 7 Activity Pack will help with slide preparation and using a light microscope.

⚠ Wear eye protection. Food dye stains clothes. Do not point microscope mirrors towards the Sun.

Course resources
AP: Skills Sheets UE 2 (Year 7); UE 3 (Year 7). Worksheet 9Bb-3.

Equipment
Celery stems (with/without leaves) left out of water to wilt for 2–3 hours before lesson, beaker, blue or red food dye diluted with water (dilution must leave a dark solution), eye protection, stop clock, ruler.
Optional: microscope, cavity slide, coverslip, water and dropper, forceps, fan, hairdryer, light source.

2: Water loss in whole plants
WS
Small, whole plants (e.g. geraniums) are placed in (graduated) conical flasks, with the roots submerged in water. In each flask, the water is covered with a layer of cooking oil (to prevent evaporation). Putting sponge inside the neck of the flask will support the stem of the plant. The water level is marked on the side of the flask and the masses of the flasks could also be measured. Flasks could be left in different conditions (e.g. placed in a cold room, placed in a warm room, placed near a fan, placed near a fan heater) and readings could be taken of the decrease in water level or decrease in mass. However, it should be noted that a decrease in water level shows water uptake and not just water loss through the leaves. If a graduated flask is used, very rough readings of water loss in cm^3 can be worked out. Measurements should be taken in subsequent lessons as the investigation will not show sufficient change within the course of a single lesson.

As an alternative or addition, a conical flask could be placed on a USB/Bluetooth-compatible balance connected to a datalogger. Students can then analyse the output at a later date.

Developing: Students may have already met the terms dependent and independent variable. Remind students what these words mean and ask them to identify these variables in this investigation, suggesting an appropriate range of values for the independent variable. Ask students to construct tables of their results and to then decide how to display these data: as a chart or graph. Challenge students to justify their choice of chart or graph (these should be bar charts if the dependent variable is 'hot', 'cool', etc. or scatter graphs if actual temperatures are measured). Ask students to explain how using a chart or graph makes the patterns easier to see and ask them to draw a simple conclusion.

Securing: Ask students to design a suitable control for this investigation (conical flask without the plant). Students could also be challenged to modify the experiment, by altering the amount of root that is left on the plant before the experiment is set up, to see if there is a relationship between the 'amount of root' and the rate of water loss.

Exceeding: Challenge students to explain how different conditions cause different rates of transpiration. The second paragraph of information on Worksheet 9Bb-7 may be useful for students.

⚠ Students must wash their hands after handling plant material.

Course resources
AP: Worksheet 9Bb-7 (optional).

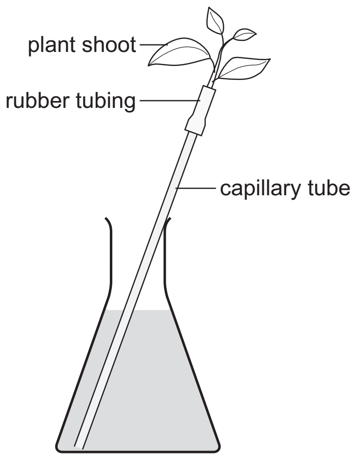
Equipment
One (or more) graduated conical flasks, small soil-less plant (e.g. busy Lizzie, geranium), sponge stopper, cooking oil, balance.
Optional: USB/Bluetooth-compatible balance, datalogger and display device, fan, hairdryer.

3: Simple potometers
WS

Elaborate potometers can be bought, but a simple procedure is described here, using a capillary tube connected to a piece of rubber tubing. The capillary tube should be marked with a line 5 cm from its base.

You will need to ensure that the plant stem is adequately lit; if light levels are too low, the stomata may close, limiting the loss of water.

For best results, the apparatus should be set up under water. Submerge the capillary tube in a trough of water and place a freshly cut plant stem (with leaves) into the rubber tubing, making sure there is a tight seal (petroleum jelly is useful for this). Remove the set-up from the water and rest it in a conical flask. Briefly removing the end of the capillary tube from the water will introduce an air bubble into the end of the tube.



The air bubble will gradually move up the tube as the plant stem loses water. This could be measured in cm/minute to get a quantitative way of measuring water flow through a plant, or students could time how long it takes for the end of the water to get to the 5 cm mark. The investigation can be repeated using different environmental conditions (e.g. placed in a cold room, placed in a warm room, placed near a fan, placed near a fan heater) or by comparing the speed of transpiration in a plant with leaves and a plant without. Challenge students to suggest an appropriate range of values for the independent variable. Between experiments, the rubber seal can be squeezed, forcing all the air out, and then held under water to refill the capillary tube.

Developing: Students may have already met the terms dependent and independent variable. Remind students what these words mean and ask them to identify these variables in this investigation, suggesting an appropriate range of values for the independent variable. Ask students to construct tables of their results and to then decide how to display these data as a chart or graph. Challenge students to justify their choice of chart or graph (these should be bar charts if the dependent variable is 'hot', 'cool', etc. or scatter graphs if actual temperatures are measured). Ask students to explain how using a chart or graph makes the patterns easier to see and ask them to draw a simple conclusion.

Securing: Students could also be challenged to modify the experiment, by altering the amount of leaf that is left on the plant before the experiment is set up, to see if there is a relationship between the 'leaf surface area' and the rate of water loss. The leaf surface area could be quantified by drawing around the leaves on squared paper before setting up the experiment and using the outlines to work out the surface areas by estimating the number of whole squares covered.

Exceeding: Challenge students to explain how different conditions cause different rates of transpiration.

⚠ Students must wash their hands after handling plant material. Be careful with capillary tubes because they can easily break. Students should take care with any light source used, because lamps may become very hot.

Equipment
Potometer (capillary tube, with a mark at 5 cm from one end, and rubber seal), stop clock, ruler, freshly cut plant stem, conical flask, petroleum jelly, light source (e.g. halogen security lamp).
Optional: fan, hairdryer, thermometer.

4: Germinating mung beans
WS
Mung beans grown on the inside of a moist clay pot will produce a good supply of root hairs for examination. Alternatively, they can be grown in vermiculite, which is easily washed off.

Developing: Students observe root hairs with a hand lens (Skills Sheet UE 1 from the Year 7 Activity Pack gives advice).

Securing: Students make microscope slides of root hairs, staining them with methylene blue. It is best to use cavity slides for this so that students do not push down on the hairs with the coverslips and break them. Skills Sheets UE 2 and UE 3 from the Year 7 Activity Pack provide advice on preparing slides and using light microscopes.

⚠ Methylene blue stains clothes. Do not point microscope mirrors towards the Sun.

Course resources
AP: Skills Sheets UE 1 (Year 7); UE 2 (Year 7); UE 3 (Year 7).

Equipment
Clay pot or tray of vermiculite, mung bean seeds, hand lens, methylene blue stain, microscope (and light source), cavity slide, beaker of water, pipette, coverslip, forceps.

5: Stomata
WS
Students make leaf peels to find stomata using a liquid bandage (e.g. New-Skin®) or clear nail varnish. The former is preferable because it dries faster and is easier to work with. Students brush the liquid onto the surface of a leaf and wait for it to dry. Afterwards, they carefully pull the layer of tissue off the top or bottom of a leaf and mount with a drop of water on a microscope slide. Alternatively, pre-prepared slides can be used. Skills Sheets UE 2 and UE 3 from the Year 7 Activity Pack describe how to prepare slides and use a light microscope.

Developing: Students identify the stomata and guard cells on a leaf. Students could compare different leaves and how the stomata are arranged (e.g. monocots tend to have a pattern of stomata in rows, compared with dicots).

Securing: Students compare the number of stomata on the top side of a dicot leaf with the number on the bottom and suggest reasons for the difference observed. Students could also compare leaves from land plants with leaves from floating water plants (stomata on upper rather than lower surface).

Exceeding: Students compare the number of stomata per unit area of a leaf from a plant that grows in wet areas with that of a leaf from a plant from a drier area. They suggest reasons for the differences observed. Stomatal density can be calculated by working out the area (πr^2) of a field of view – see Skills Sheet UE 4 (Year 7 Activity Pack) – and then counting the number of stomata that can be seen.

⚠ Wear eye protection. Do not point microscope mirrors towards the Sun.

Course resources
AP: Skills Sheets UE 2 (Year 7); UE 3 (Year 7); UE 4 (Year 7).

Equipment
Non-hairy leaves with little cuticle (e.g. daffodil, lily (both monocots), *Tradescantia zebrina* (which shows green guard cells against purple epidermis cells), bay), eye protection.

6: Water loss
WS
Worksheet 9Bb-5 is an exercise on how the same set of data can be used to draw two different conclusions. It starts to introduce the idea of bias, which is then further exemplified in the Working Scientifically materials in Topic 9Be. While this is suitable for homework, you may prefer to go through it in class.

Course resources
AP: Worksheet 9Bb-5.

7: Elements for plants
Ask students to do some independent research to find out about some of the elements that plants need from mineral salts, and why they need them. Encourage students to present their research as a table (similar to the one found in the Background Information above).

Equipment
Internet/library access.

EXPLAINING TASKS

1: 9Bb Plant adaptations (Student Book)
FA
Topic 9Bb Plant adaptations in the Student Book reminds students of adaptation and then looks at how roots, stems and leaves are adapted to their function by their shapes and the cells that they contain. Worksheet 9Bb-1 is the Access Sheet.

Questions 3 and 7 are suitable for formative assessment, with students working on the questions in groups.

In the **AL** interactive *Plant parts*, students match different parts of a plant to their functions. See Starter 1.

The **AL** animation *Plant water transport* shows how water is transported through a plant and evaporates through the leaves. It focuses on the tissues involved and includes adaptations of the roots.

The **AL** video *Diffusion through the stomata* shows how different molecules diffuse into and out of a leaf during the day and at night. See Explaining 2.

The **AL** interactive *Leaf adaptations* shows the different parts of the leaf and explains how they help to maximise photosynthesis.

The **AL** presentation *9Bb Thinking skills* can be used for this activity. See Plenary 2.

Course resources
AP: Worksheet 9Bb-1.
AL: Animation *Plant water transport*. Interactives *Leaf adaptations*; *Plant parts*. Presentation *9Bb Thinking skills*. Video *Diffusion through the stomata*.

2: Plant cell models
WS
If you have a model of a plant cell available, show this to students. Ask for their suggestions about what each part does before going on to explain what they do, correcting any misconceptions that students have. Compare this model with the 3D drawing of the leaf cross-section in 9Bb Plant adaptations in the Student Book. Then compare both models to the 2D leaf cross-section on Worksheet 9Bb-6. Finally, compare these with the **AL** video *Diffusion through the stomata*, which shows a 3D leaf section and how gases diffuse into and out of the leaf through the stomata.

Challenge students to say why using models like this is useful and to identify any ways in which such models are simplifications (e.g. plant cells are not totally rigid, they are not flat, they do not all look so similar). Ask students to choose which of the three models is best to use for thinking about the way in which gases diffuse into and out of a leaf.

Exceeding: Show students a model of a chloroplast, explaining that chlorophyll is found on the membranes inside this organelle. It has stacks of these membranes in order to increase the surface area over which chlorophyll molecules are distributed.

Course resources
AP: Worksheet 9Bb-6.
AL: Video *Diffusion through the stomata*.

Equipment
Model plant cell, model leaf, model chloroplast.

3: Bath towels and roots

WS

Remind students that a cotton bath towel has more ‘projections’ and so soaks up water more quickly than a cotton sheet. Ask students to say how this model helps to demonstrate the idea that root hair cells increase the speed of absorption of water.

Students may have investigated this in Exploring 3 in Topic 8Ae, which could be repeated. Strips (3 cm × 15 cm) of white cotton towelling and cotton sheet material are left for one minute with about 2 cm touching a coloured liquid in a shallow tray. The liquid travels faster up the towelling, which is explained in terms of speed of absorption (although only partly true).

Equipment
Shallow tray, 3 cm × 15 cm strip of white cotton bath towelling, 3 cm × 15 cm strip of white cotton sheeting, coloured liquid (e.g. orange squash).

4: Moving chloroplasts

In levels of very bright light the chloroplasts of some plants are liable to be damaged (particularly shade plants). Therefore, chloroplasts move depending on whether the light source is bright or dim. In dim light they tend to arrange themselves next to cell walls that are at right angles to the light rays, so that their flat surfaces are exposed to as much light as possible. In bright light they arrange themselves next to cell walls that are parallel to the light rays and orient themselves so that their thin edges are exposed to the light. These different orientations can produce a colour change in the leaf.

Take a flat shape (cut out of card) and place it on the base of a Petri dish. On top of this put a green *Solenostemon* (Coleus) leaf, upper surface facing down. Do not use the purple *Solenostemon* varieties. Then place a damp piece of kitchen towel on top of this, so that the whole leaf is covered. Put the top on the Petri dish and place the set-up over a bright light source (e.g. an overhead projector) for 45 minutes. Ensure that the light source does not get so hot that it affects the plastic in the Petri dish. Then carefully remove the leaf and you should see the shape ‘imprinted’ on the leaf, caused by chloroplasts moving away from the light in areas that were exposed to the light, but not in the areas that were protected by the card.

You can experiment with different types of leaves (e.g. geranium) and different types of shapes. It is possible to make shapes with black and white photos or clip art by printing them onto acetate. Place the acetate in the bottom of the Petri dish. If doing this though, make sure you use a laser printer, because inkjet ink will rub off onto the leaf. You could try your school’s crest and even try it on whole plants.

Equipment
Overhead projector, green *Solenostemon* (Coleus) leaf, Petri dish, kitchen towel, card shape.
Optional: different types of leaves (e.g. geranium), clip art or black and white photo printed on acetate with a laser printer.

5: Diffusion speeds

Use a tray with high sides, and two different colours of marbles (or other small spheres).

Set up the tray with all the marbles of one colour on one side and all those of the other colour on the opposite side. Move the tray from side to side to illustrate diffusion (the mixing of one colour of marble with the other). Talk about the diffusion of just one of the colours of marble/particle (rather than both colours). The marbles in the tray are well separated and so model the behaviour of gas particles.

Re-set the marbles and repeat the demonstration but shaking the tray faster. Students should see that diffusion happens more quickly. This is what happens when the temperature is increased because this makes particles move faster.

The demonstration of how concentration gradient affects the speed of diffusion is much more difficult to do, and more difficult for students to visualise. Start by having the marbles mixed, with greater numbers of one colour on one side compared with the other. It may be useful to draw a dividing line to divide the tray into two halves. Count the number of marbles of one colour (red, for example) on each side. When shaken, diffusion will occur and there will be an overall movement of the red marbles from the side where there are more of them to the side where there are fewer of them. Shake the tray for 10 or 15 seconds and show the increase in the number of red marbles on one side. You could calculate this as a percentage increase.

Then repeat this but have all the red marbles on one side and all of the marbles of the other colour on the opposite side. Shake the tray for 10 or 15 seconds to show the increase in the number of red marbles on the opposite side. You could calculate this as a percentage increase. Then show students that within the same short time period, there is a greater percentage increase in the numbers of red marbles when there is a greater difference between the numbers of red marbles on each side of the tray.

Ensure that any dropped marbles are picked up immediately to prevent a slip hazard.

Equipment
Marbles (or other small spheres) of two different colours, high-sided tray.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check

FA

Assessment: Students complete the 9Bb Quick Check sheet, which contains a series of 'answers' linked to the material in Topic 9Bb Plant adaptations in the Student Book. Students need to suggest appropriate 'questions'.

Developing: Students write questions for answers 1–5.

Securing: Students write questions for all the answers.

Exceeding: Students provide at least two questions for each answer.

Feedback: Once students have completed the sheet, ask randomly selected students to read out a question and then another student to identify the answer. Ask a third student if this is a correct pairing of question and answer. Correct misconceptions as they crop up and make a list of them.

Action: Write your list of misconceptions on the board and ask students to look at Topic 9Bb in the Student Book and identify the places in the text that they can use to correct those misconceptions.

Course resources
ASP: 9Bb Quick Check.

2: Thinking about plant adaptations

FA

Assessment:

Plus, Minus, Interesting: Plant stems should have more chlorophyll. (Possible answers: **Plus** – they may be able to carry out more photosynthesis; **Minus** – stems are often shaded by leaves and so would not get very much light; **Interesting** – do some plants have stems with chlorophyll in them? Dodder plants are parasitic and produce practically no chlorophyll.)

Plus, Minus, Interesting: Leaves should have cells like root hair cells to increase their surface area. (Possible answers: **Plus** – the amount of carbon dioxide available for photosynthesis would increase; **Minus** – leaves would be much more susceptible to damage; **Interesting** – why do some leaves (e.g. African violets) have little hairs on them? African violet leaf hairs channel rain away from the centre of the plant, form an air trap slowing down diffusion and help to protect the leaves from chewing pests.)

Consider All Possibilities: A plant grows much more quickly than another. (Possible answers: this is what it normally does; it has lots of mineral salts/water/light.)

Consider All Possibilities: A plant is not growing. (Possible answers: it is too cold; it does not have enough water, light, heat or mineral salts; something has eaten its roots.)

Consider All Possibilities: A plant looks unhealthy. (Possible answers: it has a disease; it is lacking some mineral salts; it does not have enough water and has wilted; it has been left in the dark.)

Consider All Possibilities: A plant loses more water than another. (Possible answers: its stomata are open; it is in a hotter/more windy/drier place.)

Odd One Out: root, stem, leaf, flower. (Possible answers: flower is the only part involved in reproduction; root is the only part where water and mineral salts are taken in, the only part below ground level; leaf is the only part adapted for photosynthesis – students may put this as the only part where photosynthesis is carried out, which is acceptable at this stage, although there are chloroplasts in green stems, which also carry out a little photosynthesis.)

Odd One Out: xylem, phloem, root hair cell. (Possible answers: root hair cell is the only one that absorbs water and mineral salts, the only one that is not a tube to transport liquids; phloem is the only one that transports glucose/dissolved sugars; xylem is the only one made from dead cells.)

Odd One Out: spongy cells, palisade cells, guard cells. (Possible answers: guard cells are the only ones that have to change shape to do their job; guard cells are the only ones on the outside of a leaf; palisade cells are the only ones adapted to maximise photosynthesis; spongy cells are the only ones with large gaps between them.)

Feedback: Students answer the thinking skills questions in groups, thereby feeding back their thoughts to one another.

Action: Ask students to choose a best answer from their group and consider why they think it is the best. Ask a spokesperson from a number of groups to read out their best answers. Create an agreed class list of 'what makes a good answer'. If understanding is poor then revise the plant adaptations with students at the start of the next lesson using 9Bb Plant adaptations in the Student Book.

The **AL** presentation *9Bb Thinking skills* can be used for this activity.

Course resources
AL: Presentation *9Bb Thinking skills.*

3: Quiz design
FA
Ask students to design a quiz sheet about this topic (and the last) and swap their sheets with other students for them to answer. They should provide a mark scheme/model answers for the questions. The questions could be done in the same format as the 9B Quick Quiz (i.e. multiple choice, which will make any marking of correct/incorrect answers easier), in which case students should be encouraged to think carefully about the wording of the answers they offer.

If students write longer-type questions, ask them if the model answers provided were as good as answers written by students using the quiz. What types of questions did students find easiest to write and to answer? Are questions easier when they are about simple factual recall or when they require analysis or problem-solving?

HOMEWORK TASKS

1: Adaptations for photosynthesis
Worksheet 9Bb-4 contains straightforward questions about water transport in plants and the adaptations of roots, stems and leaves.

Course resources
AP: Worksheet 9Bb-4.

2: Leaves and roots
Worksheet 9Bb-6 contains questions about specialised plant cells and their adaptations.

Course resources
AP: Worksheet 9Bb-6.

3: Gas exchange in leaves
WS
Worksheet 9Bb-7 contains information about the particles and rates of diffusion. It challenges students to interpret the information and make reasoned predictions about gas exchange in leaves.

Course resources
AP: Worksheet 9Bb-7.

9Bc
Plant products

Objectives
Developing:

1. Describe how starch is used as a food storage material, and the test for starch. (UK NC and CEE only)
2. Recall that plants use glucose produced by photosynthesis to make new substances, often using mineral salts. (UK NC and CEE only)
3. Explain the need for the different resources by a seed as it germinates. (UK NC and CEE only)

Securing:

4. Describe the synthesis of proteins from amino acid monomers, including the importance of nitrates. (UK NC and CEE only)
5. Describe the synthesis of starch from glucose monomers. (UK NC and CEE only)
6. Recall some functions of different proteins. (UK NC only)

Exceeding:

Exceeding objectives are designed to broaden students' skills and knowledge beyond what is required, often introducing a higher level of challenge.

7. Use the idea of equilibria to explain starch production.

Student materials

Topic notes

- It is important that teachers review all materials that they intend to use with students before use, to ensure suitability.
- It is envisaged that in the course of studying the biology component of this topic, students will use one Starter idea, Explaining 1, one further Exploring or Explaining idea, and one of the plenaries. Additional activities can be added as time allows.

Be prepared
Starter 1 requires a selection of fruits and vegetables.

Starter 3 requires starch packaging 'noodles'/'peanuts'.

Exploring 1 requires a large selection of fruits and vegetables.

Exploring 2 requires a prepared iodine-stained section of potato (or similar) on a slide.

Exploring 4 requires about 48 hours to set up (to de-starch geranium plants for 24 hours and then leave in light or dark conditions for 12–24 hours).

Exploring 5 requires unsalted, unsoaked seeds (e.g. from a health food shop).

STARTERS

1: Plant parts that we eat
BA WS
A selection of fruits and vegetables are laid out and students are asked to design and fill in a table to say what part (stem, leaf, root, fruit or flower) of each plant we eat. Prompt students to think about how the different colours of the plant materials suggest that plants produce a range of different chemicals. Ask for ideas on what chemicals are produced by plants. It should be emphasised that all the materials made by plants rely ultimately on the glucose produced by photosynthesis (and minerals absorbed by the roots) and are produced to meet the needs of the plants.

Get students in small groups to agree which table design displays the information most clearly. Ask for feedback about table design from one or two groups.

The AL presentation *Eating different plant parts* displays a series of different fruits and vegetables. This is useful if you do not want to set up a display.

⚠ Do not use nuts. Some students' skin may be sensitive to handling carrots and parsnips (particularly the leaves). Students should not eat the foods.

Course resources
AL: Presentation *Eating different plant parts*.

Equipment
Optional: a selection of fruits and vegetables.

2: What foods contain
BA
Remind students of the work that they did on food in Unit 8A and ask them to work in pairs to write a list of different fruits and vegetables, and what food substances these are good sources of. This is a quick two-minute activity. Then ask students to read out some of their answers and establish that proteins, fats, starch, sugars, vitamins, fibre and minerals are all found in plants. Challenge students to say what all these different chemicals are made from. The answer is glucose (with small amounts of mineral salts).

3: Packaging noodles
BA WS
Show students some starch packaging 'noodles' and explain that they are often used to pack fragile items. Take one 'noodle' and place it on a white tile, and then add a couple of drops of iodine solution. A blue-black colour will be observed. Challenge students to state what is in the 'noodle' that causes the blue-black colour (answer: starch) and challenge students to explain where the starch that has been used to make the 'noodles' came from (answer: plants).

Extend this demonstration by doing the iodine test on other packaging materials (e.g. expanded polystyrene) and discuss how starch 'noodles' are biodegradable.

⚠ Iodine solution stains skin and clothes, and may irritate the eyes. Wear eye protection. Students should not eat the foods tested.

Equipment
Iodine solution (1 g iodine in 100 cm^3 1.0 mol dm^{-3} potassium iodide solution), white tile, starch packaging 'noodle', eye protection. Optional: other packaging materials (e.g. expanded polystyrene).

4: Products from plants
BA
Ask students to work in groups to produce a list of all the chemical substances they can think of that plants produce. It can help to think of rooms in a house, including 'kitchen' where food is included. Challenge students to suggest what the plant uses the substance for and what humans use the substances for. Ask randomly selected groups to read out their lists and remind students of the work that they have done previously in the study of substances made by plants (e.g. carbohydrates, fats/oils and proteins for food in Unit 8A and substances that give flowers their colour or smell in Unit 8B).

Challenge students to say what organic substance is used as the starter material to make all of these substances and establish that this is glucose from photosynthesis.

EXPLORING TASKS

1: Starch in plants
WS
The focus here is to investigate which edible parts of plants contain starch. Students should be supplied with a range of food samples to test. They should place the food sample on a spotting tile and add two drops of iodine. A blue-black colour will appear in the presence of starch. Students should record their results in a table. Some food samples may change colour completely, but some may only have starch present in patches and students should be asked to explain why.

Developing: Students use Worksheet 9Bc-2.

Securing: Students should be able to plan this investigation for themselves after being given the aim.

⚠ Iodine solution stains skin and clothes, and may irritate the eyes. Wear eye protection. Students should not eat the foods tested. Do not use nuts.

Course resources
AP: Worksheet 9Bc-2.

Equipment
Iodine solution, samples of a wide selection of fruit and vegetables – stem (e.g. celery), leaf (e.g. lettuce), root (e.g. parsnip, potato), fruit (e.g. melon), flower (e.g. cauliflower), water, pipettes, spotting tiles, test tubes and stoppers, eye protection.

2: Starch under the microscope
WS
Give students a pre-prepared iodine-stained section of potato (or similar) on a slide to examine under a microscope (Skills Sheet UE 3 from the Year 7 Activity Pack will be useful). Commercial slides are available. Ask students to interpret what they are seeing. Students should be able to spot that there is a lot of starch in a potato and it is stored in granules inside cells (called leucoplasts).

⚠ Wear eye protection. Do not point microscope mirrors towards the Sun.

Course resources
AP: Skills Sheet UE 3 (Year 7).

Equipment
Microscope, eye protection, pre-prepared iodine-stained section of potato (or similar) on a slide.

3: Risk assessments

WS

The practical in Exploring 4 provides a good opportunity for students to assess risks. Show students the apparatus to be used in Exploring 4 and give them a brief outline of the experiment (consider writing outline steps on the board). Students work in groups to identify the risks involved. Skills Sheet PI 4 from the Year 7 Activity Pack may help some students think about the risks.

Developing: Point out the hazards to students and ask them what they would do to avoid harm.

Securing: Ask students to identify the hazards and to develop a set of precautions to avoid harm.

Exceeding: Ask students to carry out a risk assessment. A risk assessment can be carried out in four steps:

1. Identify what the hazards are (a hazard is anything that may cause harm, e.g. chemicals, flames, open drawers).
2. Decide who might be harmed and how.
3. Evaluate the risks (a risk is the chance – high or low – that someone might be harmed by a hazard).
4. Decide on precautions. (Can we get rid of the hazard altogether? What can we do to reduce the risk so that harm is less likely?)

The **AL** presentation *Assessing risk* takes students through the steps listed above for this set of practical apparatus. The presentation includes a photo of the apparatus, which may negate the need to show students the actual apparatus.

> ⚠ Students should not touch any of the apparatus. Wear eye protection.

Course resources
AP: Skills Sheet PI 4 (Year 7).
AL: Presentation *Assessing risk*.

Equipment
For display only: geranium (or similar) leaves, ‘iodine solution’, scissors, ethanol, beaker, test tube, test-tube holder, forceps, pipette, Bunsen burner, tripod, gauze, heatproof mat, eye protection, Petri dish, kettle.

4: Classic starch tests

WS

There are various methods for showing that starch is produced in the photosynthesising parts of a plant. Full details are given in Exploring 5 in Topic 8Be. There are also alternative versions available on many websites, including one using leaf discs outlined on the Science and Plants for Schools (SAPS) website.

Course resources
AP: Worksheets 8Be-3 (Year 8); 8Be-4 (Year 8).

Equipment
Leaves from (e.g. geranium) plants grown in the light and from a de-starched plant (to set up the plants, ‘de-starch’ both of them by putting them in the dark (in a cupboard, or inside a black bin bag) for at least 24 hours, during which time the plants will remove all the stored starch from their leaves; then expose one to strong light for 24 hours and leave the other in the dark), iodine solution, scissors, ethanol, beaker, test tube, test-tube holder, forceps, pipette, kettle, eye protection, Petri dish.
Optional: black card or aluminium foil, window envelopes, scissors, paperclips, soda lime, transparent plastic bag, elastic band.

5: Lipids in seeds

WS

Some seeds contain a store of lipids (solid fats or liquid oils). The lipids are used to help supply some raw materials for growth (e.g. for building cell membranes). They are also used to store energy for seeds. This is true of seeds that are produced in areas where starch may degrade quickly or when a plant needs to produce smaller seeds (because lipids can store more energy than the equivalent mass of starch).

The fact that lipids are insoluble in water but soluble in ethanol can be used to identify whether or not a seed contains lipids. Students take unsoaked seeds and crush them in a pestle and mortar. They then add a spatula of the crushed seeds to a 2 cm depth of ethanol in a test tube and shake well. The liquid is then allowed to settle for three minutes. Then they should carefully pour off some of the top clear layer of the liquid into another test tube containing a 2 cm depth of water. A milky-white emulsion shows the presence of lipids.

> ⚠ Ethanol is highly flammable: do not have naked flames in the laboratory during this investigation. Wear eye protection. Do not use nuts.

Equipment
Test tubes with stoppers, test-tube rack, eye protection, ethanol, distilled water, pestle and mortar, unsoaked and unsalted seeds (e.g. from a health food shop).

6: Germination processes
Worksheet 9Bc-3 provides an activity that enables students to construct a diagram showing what happens inside a seed when it germinates. The overall diagram should look like diagram F in 9Bc Plant products in the Student Book.

Course resources
AP: Worksheet 9Bc-3.

Equipment
Scissors, glue, coloured pencils.

EXPLAINING TASKS

1: 9Bc Plant products (Student Book)
FA
Topic 9Bc Plant products in the Student Book looks at some of the substances that plants make using glucose from photosynthesis (lipids, carbohydrates and proteins). Worksheet 9Bc-1 is the Access Sheet.

Questions 7 and 10 are suitable for formative assessment, with students working on the questions in groups.

The **AL** presentation *Eating different plant parts* displays a series of edible plants. See Starter 1.

The **AL** presentation *Assessing risk* describes the stages of a risk assessment. See Exploring 3.

The **AL** video *Inside a seed during germination* describes how water enters a seed and what happens inside a seed as it germinates, including the release of enzymes to break down starch. See Explaining 2.

The **AL** presentation *Carbohydrate polymerisation* shows how glucose is used to form starch and cellulose polymers.

The **AL** animation *Food tests* can be used to remind students of the different tests for different food substances met in Topic 8Aa.

The **AL** presentation *9Bc Thinking skills* can be used for this activity. See Plenary 2.

Course resources
AP: Worksheet 9Bc-1.
AL: Animation *Food tests*. Presentations *9Bc Thinking skills*; *Assessing risk*; *Carbohydrate polymerisation*; *Eating different plant parts*. Video *Inside a seed during germination*.

2: Germination
The **AL** video *Inside a seed during germination* describes what happens inside a seed as it germinates, including the release of enzymes. Ask students to watch the video and then to work in groups to prepare a flowchart to show the stages.

If you have a cross-sectional model of a seed available, use this to relate what happens in the video to the structures inside the seed and to diagram F in 9Bc Plant products in the Student Book.

Course resources
AL: Video *Inside a seed during germination*.

Equipment
Optional: cross-sectional model of a seed.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check
FA
The 9Bc Quick Check sheet contains a word puzzle that revises important words and concepts from this topic and the previous two. Ask students to work in small groups to complete the puzzle. Ask students to say which the hardest clues to answer were. Write a list of these on the board, together with their answers.

Feedback: Prompt students to explain why some clues were more difficult than others. Is this because they need more than simple recall or are some questions difficult to understand, for example?

Action: Revise the words and concepts that students had the most trouble with, and challenge students to write alternative clues for these, to give the same answers. Ask them to design some easy, some medium and some difficult clues.

Course resources
ASP: 9Bc Quick Check.

2: Thinking about plant products

FA

Assessment:

Plus, Minus, Interesting: Plants should use nitrogen from the air as a raw material for photosynthesis instead of carbon dioxide. (Possible answers: **Plus –** there is much more nitrogen available in the atmosphere; **Minus –** carbon dioxide could build up in the atmosphere, which would be bad for humans and other animals; **Interesting –** nitrogen is not very reactive. Why do plants need nitrogen?)

Plus, Minus, Interesting: We should stop using wood for making paper. (Possible answers: **Plus** – we would not have to cut down trees; **Minus –** paper may become more expensive; **Interesting –** what else can paper be made out of? It is a polymer of glucose called cellulose that forms the fibres in most paper.)

Odd One Out: potatoes, rice, oranges. (Possible answers: potatoes are the only one that grow underground; potatoes do not contain seeds; oranges do not contain much starch; rice plants can cope with being flooded.)

Consider All Possibilities: There is no starch in a leaf. (Possible answers: it is dark and all the starch has been moved out of the leaf; the leaf does not contain chloroplasts/chlorophyll; it is too dark for photosynthesis to occur.)

Feedback: Ask students to compare their answers in groups and pick one question that was more difficult to think of answers for than the others.

Action: Take a class vote for the most difficult question and give students the answers (above) to this question first. Get students to analyse why they found this question difficult. Was it, for example, that they did not understand the question, or do they lack confidence about the science ideas? Ask them to suggest strategies to address these difficulties. Clarify misconceptions by referring to the Student Book.

The **AL** presentation *9Bc Thinking skills* can be used for this activity.

Course resources
AL: Presentation *9Bc Thinking skills*.

3: Tell me three things

FA

Ask students to work in groups to come up with three facts that they know about the substances that plants make. After a few minutes, ask one group to suggest a fact, then ask another group 'Can you add a fact?'. Keep going until there are no more facts to add or time has run out (you could do this against the clock, telling the class that you're going to see how many correct facts they can tell you in one minute). Either correct misconceptions as they arise or note them down and go over them at the end of the starter task.

You could run this as 'last one standing': students all stand up once you start listening to their 'facts' and have to sit down if they cannot think of a new one (or if their 'fact' is incorrect). Keep those sitting down thinking actively by getting them to help spot facts that have already been said.

HOMEWORK TASKS

1: What's in food?
Worksheet 9Bc-4 contains straightforward questions about plant products and germination.

Course resources
AP: Worksheet 9Bc-4.

2: Glucose use
Worksheet 9Bc-6 contains questions about plant products.

Course resources
AP: Worksheet 9Bc-6.

Equipment
Graph paper.

3: Black-eyed peas
Worksheet 9Bc-7 asks students to interpret data about the production of various substances by a plant and introduces the idea of equilibria in chemical reactions.

Course resources
AP: Worksheet 9Bc-7.

9Bd Growing crops

Objectives
Developing:

1. Describe why and how cross-breeding and selective breeding are done, and state why they are done. (ILS only)
2. Explain how attack of plants by pests and pathogens can have an impact on food supply and human populations.

Securing:

3. Explain how food production for humans can be increased using different plant varieties and pest management strategies (including insecticides and herbicides).

Exceeding:

Exceeding objectives are designed to broaden students' skills and knowledge beyond what is required, often introducing a higher level of challenge.

4. Explain why a range of elements (including phosphorus and potassium) are important for plants, and identify signs that a plant may be lacking in those elements.

Student materials

Topic notes

- It is important that teachers review all materials that they intend to use with students before use, to ensure suitability.
- It is envisaged that in the course of studying the biology component of this topic, students will use one Starter idea, Explaining 1, one further Exploring or Explaining idea, and one of the plenaries. Additional activities can be added as time allows.

Be prepared
Exploring 1 requires duckweed and nutrient solution (e.g. commercial fertiliser).

Explaining 4 requires a selection of cross- and selectively bred fruits and/or vegetables.

STARTERS

1: Ultimate crop
BA
Explain to students that crop plants are bred to have certain characteristics. Ask students to design an 'ultimate crop plant' – a plant that would be most useful for farmers to grow. Students should label the features of their plants and explain why those features make them useful. Some students may come up with some fairly wild ideas, but these may be useful for further discussion during the topic, allowing you to mention that although traditionally plants are bred by using sexual reproduction this takes a long time and now scientists have developed other ways of inserting 'genes' for certain characteristics into plants in the hope of making them even more useful. (Note that the term 'genes' will not be clearly understood unless students have already covered Unit 9A.)

Get students to display their designs (e.g. as posters) and ask other students to look at the posters. Each student should write down two ideas from other students that they think would improve their own crop design. Ask for some volunteers to offer the ideas they liked.

Equipment
Optional: poster paper, coloured pencils.

2: That tastes good
BA
Explain to students that crop plants are bred to have certain characteristics. Ask students to note down some useful characteristics that could be bred into apple trees and ask them to identify which characteristics would be useful for particular groups of people (e.g. farmers, shopkeepers and consumers).

3: Increasing the yield 1
BA
Explain to students that a farmer wants to get as much useful product out of their crops as possible. Ask students to work in groups to come up with a list of ideas that the farmer might use to increase the amount of useful product (i.e. the yield). After two minutes ask a spokesperson from each group to suggest one thing and build up a list on the board. Ascertain if any groups had any suggestions that no other group had.

Ask students to list any ideas that they contributed to the group and three ideas they have learned from this discussion.

Securing: Extend this by explaining that organic farmers do not use artificial chemicals on their crops. Ask students to identify which of the ideas that they have come up with would not be used on an organic farm.

4: Increasing the yield 2
BA
Give students Skills Sheet TS 5 and/or TS 6 from the Year 7 Activity Pack. Ask students to fill in the first two columns of a KWL (now, want to know, learned) grid with some things that they know about farming and some things that they would like to know. Ask students to concentrate on how a farmer tries to get the maximum amount of useful crop for the least amount of money (i.e. the yield).

Then watch the **AL** video *Farming for maximum yield*, which explains how intensive farmers try to get the highest yield out of their crops. Ask students to fill in the last column on the sheet and then ask them to contribute questions that the video did not answer for them. Ask students to suggest ways in which they could complete their sheets – and allow other members of the class to provide any of the required answers that they already have.

Course resources
AP: Skills Sheets TS 5 (Year 7); TS 6 (Year 7).
AL: Video *Farming for maximum yield*.

EXPLORING TASKS

1: Duckweed and fertilisers
WS
In this practical, students examine the effect of different nutrient solutions on the growth of common duckweed (*Lemna minor*). There are various ways in which this can be done and the practical can be adapted to yield quantitative or qualitative results.

Ideally, single lobes (the leaf-like part of a duckweed plant) are placed in different nutrient solutions in Petri dishes and left in a well-lit place for 2 weeks. The number of lobes is then counted again. Full instructions are given on Worksheet 9Bd-2. Note that all the lobes need to be counted at the end of the experiment (including the small ones that are beginning to grow from larger lobes). If the number of lobes is too difficult to count at the end, divide the Petri dish into four quarters and count the lobes in one quarter, multiplying the answer by four.

The nutrient solutions could be (a) different fertilisers at the same concentrations (liquid plant feeds are the easiest to use), (b) different concentrations of the same fertiliser, (c) specially prepared growth media lacking in various mineral salts (available from equipment suppliers). Worksheet 9Bd-2 allows any of these to be used.

Note that Petri dishes may need topping up with distilled water during the course of the experiment.

Developing: Students use Worksheet 9Bd-2.

Securing: Students plan the investigation for themselves.

Exceeding: Students carry out independent research on the needs of plants for phosphates and potassium, before designing investigations based on questions that are developed during their research.

If common duckweed is not readily available it can be obtained from educational suppliers. Other free-floating pond weeds are also suitable.

Course resources
AP: Worksheet 9Bd-2.

Equipment (per group)
Selection of different liquid plant fertilisers or one fertiliser made up to different dilutions (e.g. 0, 1, 10, 50, 100, 200 and 500% quantities of the amount recommended on the fertiliser packet) or growth solutions lacking various mineral salts, 50 cm^3 measuring cylinders, distilled water, duckweed (e.g. *Lemna minor,* 20 lobes per Petri dish and best if only single-lobed plants are supplied to students), inoculating loop or paintbrush (to transfer the lobes), Petri dishes (or beakers), access to well-lit area or growth cabinet.

2: IR36 rice
Worksheet 9Bd-3 describes the breeding of IR36 rice in the 1970s. There are drawings to cut out and arrange to show how IR36 was bred, together with information to complete. This rice variety was one of the foundations of the Green Revolution in the 1970s.

Exceeding: Challenge students to complete the worksheet and then do further research to find out about the breeding and advantages of IR72 and/or the Green Revolution.

Course resources
AP: Worksheet 9Bd-3.

Equipment
Scissors, glue.
Optional: Internet/library access.

3: Breeding wheat
Do an Internet search for 'Norman Borlaug video' to find a clip that explains the production of new wheat varieties during the 1950s and 1960s. There is a suitable example on the Science and Plants for Schools (SAPS) website. Tell students that they need to design a question that can be answered from the information in the video that they are about to see. Then show them the video. Give students a few minutes to write down their question, together with an answer. It is helpful if you write a few keywords up on the board (such as 'Norman Borlaug'). Add some questions of your own (such as 'What were the characteristics of the plants that Borlaug crossed in order to get the wheat he wanted?').

Collect the questions and use them as the basis for a short quiz, picking students at random and comparing their answers with the answers given with the questions.

Equipment
Video display linked to the Internet.
Optional: random student picker software.

4: Wild mustard
Worksheet 9Bd-4 challenges students to identify selectively bred characteristics of the plants descended from wild mustard. There are also questions on how and why selective breeding is done.

Course resources
AP: Worksheet 9Bd-4.

Equipment
Scissors, glue.

5: Plant research
Students conduct some independent research into growing crop plants.

Developing: Students find out about some common pests for crop farmers in their country (say five) and produce a table to show the name of the pest, the crop that it attacks and how farmers deal with the problem.

Securing: Students find out about why farmers in their country use different varieties of wheat (or other named crop). They should explain this in terms of characteristics, such as what the wheat is to be used for, local environmental conditions or costs. Students could be challenged to talk about the pros and cons of two different varieties (making sure that their writing is clear, with appropriate emphasis and logical ordering).

Exceeding: Students find out about why a number of nutrients/mineral salts are needed by plants (say five different minerals). Students need to explain what happens if the mineral is lacking and what the plant uses the mineral for.

Equipment
Internet/library access.

6: Breeding plants
Worksheet 9Bd-6 provides an opportunity to revise key ideas about sexual reproduction in plants in the context of plant breeding.

Course resources
AP: Worksheet 9Bd-6.

7: Artificial vs natural fertilisers
Ask students what an artificial fertliser is and what a natural fertiliser is. Establish that the former consists of chemical substances made in factories, and the latter includes animal and plant wastes (e.g. manure, compost).

Ask students to choose one type of fertiliser and construct an argument for its use compared to the other. Skills Sheet RC 9 will give students some guidance on constructing a good argument. Students will also need access to the Student Book and to other library/Internet resources to carry out some research.

Ask randomly chosen students to read out their arguments to the class.

Ideas that students may present include:

- Artificial fertilisers are sometimes cheaper, are good at providing specific nutrients, are good at providing nutrients quickly, and are often easier to apply. However, they can contaminate water supplies, may need frequent application and can help to break down the structure of the soil.
- Natural fertilisers are sometimes cheaper (and may even be free), provide a greater range of nutrients, are less likely to contaminate water by being washed out of the soil by rain, and often help to improve soil structure. However, they are slower to act and can be difficult or unpleasant to apply.

Equipment
Internet/library access.

Course resources
AP: Skills Sheet RC 9.

8: STEM – Ecological audits
At the end of the STEM spread, 9Bd Protecting wild plants, there is an activity in which students design a layout for an ecological audit report.

For Question 1, ask students to work in groups to come up with a list of things that a plant ecologist would do when carrying out an ecological audit. Give students time to write their lists and then ask groups to contribute to a master list on the board. Ideas could include:

- visiting the area to record all the plants that live there
- identifying how abundant different species are in that area
- identify how abundant different species are globally using the IUCN Red List and making comparisons with the area in question
- identifying current and possible future risks to the plants from human activities and other sources.

Then ask students to think about how an ecological audit report would be laid out. You could start by reminding them how scientific papers or investigation reports are structured (using Skills Sheets RC 6, RC 7 and/or RC 8 to illustrate). Challenge students to write a series of headings and subheadings, and then discuss these as a class.

The finished template should have a clear and logical structure to provide information about the results from the audit, e.g. with different sections for each of the elements indicated in students' answers to Question 1, and the criteria for the decision on KBA status should be made clear.

> **Course resources**
> **AP:** Optional: Skills Sheets RC 6, RC 7, RC 8.

EXPLAINING TASKS

1: 9Bd Growing crops (Student Book)
FA
Topic 9Bd Growing crops in the Student Book looks at some of the methods that farmers use to increase yields. If students have studied Unit 9A at this point, consider linking the idea of natural selection with the idea of selective breeding (which uses artificial selection). Worksheet 9Bd-1 is the Access Sheet. Questions 7 and 8 are suitable for formative assessment, with students working on the questions in groups.

The AL video *Farming for maximum yield* explains how intensive farmers try to get the most yield out of their crops. See Starter 4.

The AL animation *Selectively breeding potatoes* shows how cross-breeding can be used to produce potatoes with desirable characteristics.

The AL presentation *9Bd Thinking skills* can be used for this activity. See Plenary 2.

> **Course resources**
> **AP:** Worksheet 9Bd-1.
> **AL:** Animation *Selectively breeding potatoes*. Presentation *9Bd Thinking skills*. Video *Farming for maximum yield.*

2: 9Bd Protecting wild plants (Student Book)
This spread looks at the job of a plant ecologist and the skills and training that plant ecologists need. There is a particular focus on communication, and the importance of systematically organised information in reference resources and reports. Before starting the spread challenge students to suggest some reasons why certain plants may be in danger of becoming extinct.

3: Herbicides and plants
FA WS
Dandelions and plantains are often killed by herbicides on playing fields, and it may be possible to show students an area that has been sprayed a couple of weeks previously to illustrate that the broad-leaved dandelions and plantains have been killed, leaving the narrow-leaved grass plants unaffected.

Alternatively, as a lab demonstration, cress seedlings and grass or cereal seedlings can both be sprayed with a selective herbicide. Results should be obvious in a week.

> ⚠ Read the safety precautions on any herbicide carefully. Spraying should be done in a fume cupboard. Wash hands carefully afterwards.

4: Cross- and selectively bred plant display
FA
Show students some examples of plants that have either been cross-bred or selectively bred. Challenge students to describe the crosses that have been made or which characteristics have been selected.

Possibilities include:

Brassica oleracea is a species that has been selectively bred to give many common foods, such as broccoli, Brussels sprout, cabbage, cauliflower, kale and kohlrabi.

Apples (note that some slight simplifications have been made): Royal Gala (Cox's Orange Pippin × Golden Delicious), Cameo (Red Delicious × Golden Delicious), Rubens (Gala × Elstar), Zari (Elstar × Delbarestivale), Kanzi (Braeburn × Gala), Jazz (Braeburn × Gala).

Pears: Concorde (Conference × Doyenné du Comice (aka Comice)).

Equipment
Range of fruits and/or vegetables to show cross-breeding and/or selective breeding.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check
FA
Assessment: The 9Bd Quick Check sheet poses a question about pesticides and a sample student's answer. You could remove the list of points that should be included in the answer and ask students to think up as many points as they can that would score marks. Alternatively, leave the points in place and ask students to construct a full paragraph using some of the points to get a full 5 marks.

Feedback: Ask students to compare their work with each other and decide whether or not they have got or have made enough points to get 5 marks. Allow students to refine their work using others' ideas.

Action: Go through the points given on the 9Bd Quick Check sheet or in the 9B Mark Scheme, making sure that students understand each point. Show that each point gives a fact that could be worth a mark, but that because the question asks about both herbicides and insecticides both types of pesticides must be included to get full marks.

Ask students to write one point they have learnt that may mean they get better marks in test questions in the future.

Course resources
ASP: 9Bd Quick Check; 9B Mark Scheme.

Equipment
Scissors.

2: Thinking about growing crops
FA
Assessment:

Plus, Minus, Interesting: All crops should be grown in greenhouses. (Possible answers: **Plus** – crops would not be dependent on the weather; **Minus –** it would be expensive to build all the greenhouses needed; **Interesting –** which crops are already grown in greenhouses? 0.25% of the total land area of the Netherlands is covered by greenhouses (nearly 11 000 hectares).)

Plus, Minus, Interesting: An apple that is resistant to apple scab should be crossed with one that is delicious. (Possible answers: **Plus –** we might get a delicious apple that is resistant to apple scab; **Minus –** it is an expensive process to cross-breed; there is no guarantee that the offspring will have all the desirable characteristics that you want; **Interesting** – which common varieties of apples have been cross-bred? Apple scab is a disease caused by a fungus.)

Consider All Possibilities: A greenhouse has become very hot. (Possible answers: it is a very hot day; the windows won't open; the heater was left on.)

Consider All Possibilities: The weeds have all died in the wheat field. (Possible answers: a selective herbicide has been used; the weeds have all been attacked by a pest; the weeds normally die off at this time of year.)

Consider All Possibilities: The leaves on a plant are turning brown at the edges. (Possible answers: the plant has a deficiency; it is autumn and the leaves are changing colour; the plant is being attacked by a microorganism that turns its leaves brown at the edges.)

What Was The Question: selective breeding. (Possible answers: How were cauliflowers produced from cabbages? Suggest one method a plant breeder could use to make apple trees with bigger apples.)

Mnemonics: Think up a mnemonic to remember all the things needed by plants for healthy growth. (Possible answer: LAWWN – light, air (both carbon dioxide and oxygen), water, warmth, nutrients/mineral salts.)

Feedback: Students answer the thinking skills questions in groups, thereby feeding back their thoughts to one another.

Action: Ask students to choose a best answer from their group and consider why they think it is the best. Ask a spokesperson from a number of groups to read out their best answers. Identify any ideas that are missing and share them with the class. If understanding is poor then revise ideas about how crops are grown for maximum yield at the start of the next lesson. Having identified weaker areas, challenge students to design their own thinking skills-type questions on those areas.

The (AL) presentation *9Bd Thinking skills* can be used for this activity.

Course resources
AL: Presentation *9Bd Thinking skills*.

3: Word definitions
FA
Give students copies of the 9B Word Sheets for this topic and the previous three, but with the definitions missing. Ask students to put a number from 1 to 5 against each word to show how confident they are that they know the meaning (5 meaning 'absolutely certain', 1 meaning 'no idea'). Then read out the words one by one and ask for a show of hands for CRI scores of 4 and 5 (see the ASP). Identify the two or three words that students are least sure about and revise their meanings, before quickly running through the meanings of the other words.

Ask students to reflect on why some of these words were less familiar/easy to recall than others. For example, is it because they were only recently introduced, or because they represent a difficult idea (rather than a label), or because they are not in everyday use?

Challenge students to learn all the words on the list by the end of the topic and to support each other by testing a partner as they learn. Re-test the words at the end of the unit.

Course resources
ASP: 9B Word Sheets.

HOMEWORK TASKS

1: Growing and breeding plants
Worksheet 9Bd-5 contains straightforward questions about intensive farming (including plant breeding) and meeting the demand for food.

Course resources
AP: Worksheet 9Bd-5.

2: Farming plants
Worksheet 9Bd-7 contains questions about intensive farming.

Course resources
AP: Worksheet 9Bd-7.

3: Greenhouse growing
Worksheet 9Bd-8 contains questions about greenhouse farming, including the need for various mineral salts.

Course resources
AP: Worksheet 9Bd-8.

9Be
Farming problems

Objectives
Developing:

1. Use food webs to predict the effects of changes in biological factors (including human activity).
2. Explain why preserving habitats is important, and suggest ideas on how to achieve this through more sustainable development.
3. Model the recycling of carbon in an ecosystem using the carbon cycle.

Securing:

4. Make predictions about how changes in abiotic (physical) and biotic (biological) factors will affect carbon supply in an ecosystem.
5. Make predictions about how changes in physical and biological factors will interact with adaptations and affect survival (e.g. effects of disease on monoculture).
6. Explain the effects of phosphates, nitrates and persistent pesticides on ecosystems.

Exceeding:

Exceeding objectives are designed to broaden students' skills and knowledge beyond what is required, often introducing a higher level of challenge.

7. State the names of compounds in which nitrogen is held in an ecosystem.
8. Describe the methods by which nitrogen is recycled in an ecosystem.

Focused Working Scientifically/Scientific Enquiry objectives

1. Identify and explain bias, suggesting reasons why people may be biased.
2. Explain why some data are/are not valid (in terms of relevance to the initial question).
3. Identify potential ways in which random and systematic error may be caused.
4. Explain why a conclusion is or is not valid (in terms of using the correct, good-quality data).

Student materials

Topic notes

- It is important that teachers review all materials that they intend to use with students before use, to ensure suitability.
- It is envisaged that in the course of studying the biology component of this topic, students will use one Starter idea, Explaining 1, one further Exploring or Explaining idea, and one of the plenaries. Additional activities can be added as time allows.

Be prepared
Exploring 1 requires clean, pesticide-free pesticide packets (or labels).

STARTERS

1: Farming revision
BA
Ask each student to write down a question about something from the first four topics of this unit. They should write the question on the left of a strip of paper and the answer on the right and then tear the strip in half. Appoint a student to collect all the questions and another to collect all the answers. Once collected, hand out the questions and answers so that each student gets one question and one answer. Then get a selected student to read out their question. The student with the right answer then stands and reads out the answer. Challenge students to think of the correct answer as questions are read out – and to keep a private score of how many they got right. You may need to restart this activity if the original answers to questions are wrong. Do not identify individuals who have made these mistakes: they will learn from any discussion what the answer should be.

Get students to write down a private rating of their own ability to answer the questions as they were read out.

2: Damaging food webs
BA
The **AL** presentation *Damaging food webs* revises the concept of food webs from Unit 7D and asks students to predict the consequences of using a herbicide or an insecticide on the different populations in some food webs.

Get students to work on this in groups, then to compare and improve their responses by pairing with a second group.

Course resources
AL: Presentation *Damaging food webs*.

3: Farming and the environment

BA

Ask students to suggest methods by which farmers could increase their yields (revising material from the previous topic, 9Bd). Then ask students to work in groups to suggest and explain problems that each method could cause. Ask spokespersons from the groups to contribute ideas and prepare a table on the board. Each group should make a note of ideas they did not think of but other groups did.

EXPLORING TASKS

1: Pesticides

WS

Photocopies of packets or the actual (empty) clean, pesticide-free packets of pesticides are examined by the students. They use their findings to design a summary table to show the benefits and drawbacks of using each pesticide.

⚠ Ensure that any bottles or packaging are free from any traces of pesticide.

Equipment
Selection of clean, pesticide-free pesticide packets or photocopies of the packets.

2: Farming for wildlife

Worksheet 9Be-3 contains a set of cards for students to cut out and put in order to show some of the problems caused by farming and how they might be solved.

Developing: Ask students to work in groups to arrange the cards under the headings 'What happens?', 'Problems this causes', 'Possible solutions'.

Securing: Students group the cards as they see fit.

Course resources
AP: Worksheet 9Be-3.

Equipment
Scissors.

3: Lakes and fertilisers

Worksheet 9Be-4 contains a set of cards for students to cut out and put in order to show how fertilisers result in the death of fish in lakes and other waterways. The **AL** interactive *Eutrophication* provides an electronic version of this activity.

Course resources
AP: Worksheet 9Be-4.
AL: Interactive *Eutrophication*.

Equipment
Scissors.

4: Selection bias

WS

Worksheet 9Be-2 provides a model for students to explore how biodiversity is measured. The model is somewhat simplified, because ecologists will generally look at the number of species as well as the populations of each species when coming up with a measure of biodiversity. In this case, only the estimation of the number of different species in an area is being modelled. The method uses a quadrat (which should be familiar to students from previous work in this course, but it may be useful to remind students what a quadrat looks like). Note that some students may find handling a small 1 cm × 1 cm quadrat a bit fiddly. They could use forceps to handle the squares or you could make a ×2 enlargement of the map and ask students to use a 2 cm × 2 cm piece of acetate.

There are two versions of the same exercise on the sheet – Method 1 and Method 2. Method 2 will allow random sampling. Method 1 is prone to a type of accidental bias (something called 'selection bias', although its name is not important at this stage). If you give half the class Method 1 and half the class Method 2, you should find that Method 1 gives a greater number of species being detected in total, because students will think that the total number of species found is what is important.

When students have come up with their totals for the number of species, ask each group to say which method they used and how many species in total they reckon were living in the area. There are 15. Discuss why one method produced a greater number of species than the other and use this to illustrate the fact that the person doing the experiment can unwittingly cause bias, by having an idea of what he or she thinks the results should be.

Exceeding: You can increase the demand of this activity by removing the symbols from the results tables, instructing students to draw these in as they find them.

Course resources
AP: Worksheet 9Be-2.

Equipment (per group)
Two dice, square of clear acetate.
Optional for display: a quadrat, forceps.

5: Dihydrogen monoxide
WS
Worksheet 9Be-7 contains information about the supposedly deadly dihydrogen monoxide. Ask students to draw posters, as detailed on the sheet. Many will choose to draw a poster campaigning against using dihydrogen monoxide, although some might do further research to find out what this substance is and twig that it is in fact water.

Once students have finished their posters, ask them if they thought about what dihydrogen monoxide is. If no student has worked it out, draw the molecule on the board and elicit the response that it is water. Ask students what they think now and how they feel. Ask them what they can learn from this exercise – the main point being that it is quite easy to use correct scientific facts to back up a false point or theory. It is a good example of bias. Ask students why Martin might want to campaign against the farmer (e.g. a personal grudge).

Course resources
AP: Worksheet 9Be-7.

Equipment
Poster paper, coloured pencils.

6: Debate
There is an opportunity for a debate presented in Topic 9Be Organic farming in the Student Book. Refer to Skills Sheet RC 5 from the Year 7 Activity Pack for ideas on how to run a debate.

Course resources
AP: Skills Sheet RC 5 (Year 7).

EXPLAINING TASKS

1: 9Be Farming problems (Student Book)
FA
Topic 9Be Farming problems in the Student Book looks at some of the problems caused by modern, intensive farming methods and revises the idea of the carbon cycle. Worksheet 9Be-1 is the Access Sheet. Questions 4, 8 and 9 are all suitable for formative assessment, with students working on the questions in groups.

The AL presentation *Damaging food webs* revises the concept of food webs from Unit 7D and asks students to predict the consequences of using a herbicide or an insecticide on the different populations in some food webs. See Starter 2.

The AL presentation *9Be Thinking skills* can be used for this activity. See Plenary 3.

Course resources
AP: Worksheet 9Be-1.
AL: Presentations *9Be Thinking skills*; *Damaging food webs*.

2: 9Be Bias and validity (Student Book)
FA WS
Topic 9Be Bias and validity in the Student Book looks at bias, both intentional and accidental, and validity. Skills Sheets PI 2 (Year 7 Activity Pack) and PI 8 (Year 8 Activity Pack) can also be used to help support the work on this spread.

Questions 4 and 5 are suitable for formative assessment, with students working on the questions in groups.

The AL spreadsheet *Bias* shows how data can be selected to cause bias.

The AL presentation *Validity* explains the concept of validity and asks students to say whether or not certain datasets and conclusions are valid.

Course resources
AP: Skills Sheets PI 2 (Year 7); PI 8 (Year 8).
AL: Presentation *Validity*. Spreadsheet *Bias*.

3: 9Be Organic farming (Student Book)
FA
The last page in this topic in the Student Book looks at organic farming and uses this concept to review some of the themes running through this unit.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check
FA
Assessment: The 9Be Quick Check sheet poses some questions for which students need to design mark schemes. Consider giving different members of the class different questions to work on. The mark schemes should be simple bullet lists of points that could be included in an answer. There should be one point for each of the marks available (see the Mark Scheme in the ASP).

Feedback: Go through the questions and write an answer on the board for each. Ask random students to say how many marks he or she would give you for the answer and explain to you how to improve your answer. Note down misconceptions as they crop up.

Action: Go through the misconceptions that have arisen with reference to the Student Book. Get students to list three techniques that gain extra marks in exams.

Course resources
ASP: 9Be Quick Check; 9B Mark Scheme.

2: Quick Check WS
FA WS
Assessment: The 9Be Quick Check WS contains some questions on bias and validity.

Feedback: Ask students to compare their finished answers, explaining their reasoning to one another.

Action: Use the board to construct a paragraph about 'bias', inviting students to provide phrases to use. This should include different types of bias. Then ask students to suggest short definitions for the term 'validity'. Write these on the board and decide, as a class, which one is best. Refer back to the Student Book to provide reinforcement, if necessary.

Ask students, in their pairs, to think of one new example sentence using each of these terms – then spot check to measure students' understanding.

Course resources
ASP: 9Be Quick Check WS.

3: Thinking about farming problems
FA
Assessment:

Plus, Minus, Interesting: All pests should be killed. (Possible answers: **Plus** – crops would not be damaged by pests; **Minus** – all animals that eat pests would have to eat something else; **Interesting** – how would the food web involving the pest be affected? Countries sometimes spread general 'pesticides' over enemy areas to destroy hiding places and food supplies.)

Consider All Possibilities: Fish in a lake on a farm die. (Possible answers: the farmer has just sprayed pesticide, which has run into the lake, and is poisonous to fish; fertilisers have encouraged the growth of plants and algae, which have died and the decay bacteria have used up all the oxygen; there is a drought and the water has dried up.)

Consider All Possibilities: All of a farmer's crops die. (Possible answers: they were all the same crop of the same variety and one disease has killed them all; there is a drought; the farmer sprayed a herbicide onto the crops instead of an insecticide by mistake; the land was flooded.)

Consider All Possibilities: There is more carbon dioxide entering the atmosphere now than there was 100 years ago. (Possible answers: there are more people and so more respiration; there are fewer forests and so less photosynthesis; we are burning more fossil fuels.)

Odd One Out: butterfly, snail, aphid. (Possible answers: butterfly is the only animal that isn't a pest (but caterpillars can be); snail is a mollusc.)

Feedback: Students answer the thinking skills questions in groups, thereby feeding back their thoughts to one another.

Action: Ask students to choose a best answer from their group and consider why they think it is the best. Ask a spokesperson from a number of groups to read out their best answers. Identify any ideas that are missing and share them with the class. If understanding is poor then revise the problems of modern farming techniques. Having identified weaker areas, challenge students to design their own thinking skills-type questions on those areas.

The AL presentation *9Be Thinking skills* can be used for this activity.

Course resources
AL: Presentation *9Be Thinking skills.*

4: Quick Quiz revisited
FA
Assessment: Revisit the 9B Quick Quiz to test students' knowledge of the content of this unit. Students could fill in their answers on the 9B Quick Quiz Answer Sheet. Encourage students to identify areas for themselves that are still weak and decide how they are going to remedy this.

Course resources
ASP: 9B Quick Quiz; 9B Quick Quiz Answer Sheet.

5: End of Unit Test
Use either or both of the End of Unit Tests. Mark Schemes are given in the ASP. Encourage students to identify areas that are still weak and to formulate plans to strengthen those areas. Summary Sheets are provided to help students with revision.

Course resources
ASP: 9B End of Unit Test Standard (S); 9B End of Unit Test Higher (H); 9B Mark Scheme; 9B Summary Sheets.

6: Progression Check
Students should circle the stars next to each statement on the Progression Check to record what they feel they know, and how certain they are of it. Encourage students to plan how to do further work on the things about which they remain unsure.

If students do this in pairs, they could then test each other after a period of revision.

Course resources
ASP: 9B Progression Check.

7: Smallholding shooting script: Open-ended Assessment Task
FA
The top of the Assess Yourself! sheet asks students to develop some video material for a new website that is aiming to help people set up small farms to grow crops and to sell their produce in a local farmers' market. Students are not expected to film things although, of course, this may prove a popular way of doing this task. It is, however, envisaged that students will prepare a shooting script for the video, which contains detailed notes on what will be covered in the video. The notes should cover what facts are to be presented and what the visuals will show.

You can assess this activity by using the Open-ended Assessment Task sheet or students can rate their own performance by using the Assess Yourself! sheet (see the ASP). Get students to reflect on what they did well in this activity and what they need to improve on. After feedback, give students an opportunity to improve their work and have it reassessed.

Course resources
ASP: 9B Assess Yourself!; 9B Open-ended Assessment Task.

HOMEWORK TASKS

1: Farm food webs
Worksheet 9Be-5 contains straightforward questions about the problems of intensive farming methods and the carbon cycle.

Course resources
AP: Worksheet 9Be-5.

2: Sugar cane farming
Worksheet 9Be-6 contains questions about the effects of different ways of farming sugar cane in Australia.

Course resources
AP: Worksheet 9Be-6.

3: Natural cycles
Worksheet 9Be-8 introduces the idea of the nitrogen cycle and contains longer answer questions on this and the carbon cycle.

Course resources
AP: Worksheet 9Be-8.