AQA
GCSE
9–1

Biology
Teacher Support Guide

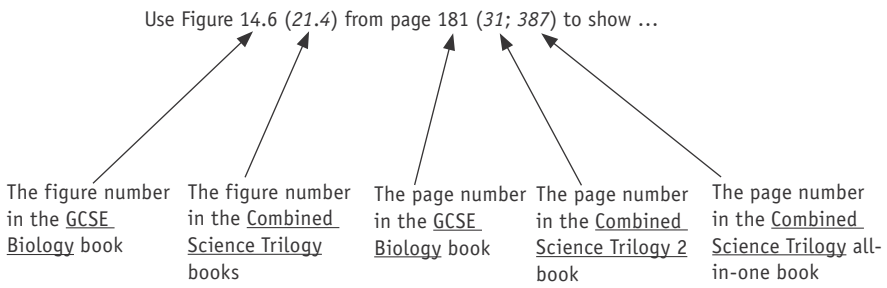
Margaret Royal
Ali Hodgson

DYNAMIC LEARNING
HODDER EDUCATION
AN HACHETTE UK COMPANY

References to the textbooks in this teacher resource guide

References to the student textbooks are given in the following style:

- The first figure or page number always refers to the GCSE Biology book.
- The numbers in brackets refer to the Combined Science Trilogy books.
- Where there are two numbers in brackets, the first is for Combined Science Trilogy 1 or 2; the second number refers to the all-in-one Combined Science Trilogy book.



Orders: please contact Bookpoint Ltd, 130 Milton Park, Abingdon, Oxon OX14 4SB.

Telephone: +44 (0)1235 827720. Fax: +44 (0)1235 400454. Lines are open 9.00a.m.–5.00p.m., Monday to Saturday, with a 24-hour message answering service. Visit our website at www.hoddereducation.co.uk

First published in 2017 by
Hodder Education,
An Hachette UK Company
Carmelite House
50 Victoria Embankment

London EC4Y 0DZ

Impression number 10 9 8 7 6 5 4 3 2 1

Year 2022 2021 2020 2019 2018 2017

Typeset in 11.5/13 pt Officina Sans by Aptara, Inc.

A catalogue record for this title is available from the British Library

ISBN 978 1471 851186

Contents

Cell biology

1 Cell structure

Overview

Specification points

4.1.1.1 Eukaryotes and prokaryotes; 4.1.1.2 Animal cells and plant cells; 4.1.1.3 Cell specialisation; 4.1.1.4 Cell differentiation; 4.1.1.5 Microscopy

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 1 pages 1–17

AQA GCSE (9-1) Combined Science Trilogy 1: Chapter 1 pages 1–17

AQA GCSE (9-1) Combined Science Trilogy: Chapter 1 pages 1–17

Recommended number of lessons: 9

Chapter overview	
AQA required practicals	Biology – RP1 CS Trilogy – RP1
Contains higher-tier only material	No
Contains biology-only material	No

Useful Teaching and Learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Practical
- Teacher and technician notes
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Video: Use of graticule and micrometer to measure cells and calculate magnification (Required practical 1)

Useful prior learning

- Cells are the basic unit of living organisms.
- The functions of the cell membrane, nucleus, cytoplasm, vacuole, chloroplasts and mitochondria
- The similarities and differences between plant and animal cells
- The use of a basic light microscope in observing and identifying cells and larger organelles and structures
- The structure of specialised plant and animal cells is linked to their function.
- The structural adaptations of some unicellular organisms and basic cellular structure of these

Common misconceptions

- There is only one type of plant cell and one type of animal cell. This misconception usually arises due to the introduction of the topic through a diagram of a generic plant and animal cell which students often then assume is what all multicellular animal and plants are made up of. Teaching cell structure alongside specialised cells can overcome this as students can be encouraged to label the organelles and structures of a range of cells.
- Cells do not carry out all the life processes for themselves. It is often misunderstood that cells excrete their own wastes and make their own molecules for growth.
- Students often have misconceptions linked to size and scale. They may think that viruses are larger than bacteria and that bacteria are larger than most human cells.
- Students can be distracted by the size of the numbers in the measurement and ignore the units they are measured in. Therefore they may incorrectly decide that larger numbers are always bigger, for example 10 000 mm is larger than 10 m.

Preparation

The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for the upcoming work on prokaryotic and eukaryotic cells, particularly to get a deeper understanding of common misconceptions and desired prior knowledge from KS3.

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the next few lessons or can be reserved for recap/consolidation at the end of the topic.

Eukaryotes and prokaryotes: Lesson 1

Learning outcomes

1 Describe the structure of bacterial cells (prokaryotic cells).
2 Explain how the structure of bacterial cell components relates to their function.

Suggested lesson plan

Starter
Lesson 1 should assess prior understanding of cells and cellular structures from KS3 to determine the starting points for the group. The **T&L Lesson starter 1** can be used to do this or the Test yourself on prior knowledge questions on page 2.

Main
Introduce students to the key terms 'prokaryotic' and 'eukaryotic'. Explain that eukaryotic organisms can be either single celled or multicellular.

Using page 3 of the textbook discuss with students the main structures found in bacterial cells and their functions. They could complete a simple card sort activity matching the prokaryotic structure to its function.

Students could then use modelling materials to make models of a generalised prokaryotic cell and label the key features using cocktail sticks with flags.

Plenary
To check students' understanding, display images of a range of organisms and ask them to write down whether the organisms are single-celled eukaryotic, multicellular eukaryotic or prokaryotic. Alternatively, ask students to complete the Test yourself questions on page 4.

Support
Students without a firm grasp of KS3 prior knowledge should complete the **T&L Prior knowledge catch-up student sheet**.

As a discussion point, present students with a variety of plant and animal cell pictures such as a muscle cell, nerve cell, egg cell, root hair cell, palisade cell, xylem cell and guard cell and ask them to justify why they think each is a plant or animal cell.

Alternatively, provide the students with a diagram of a cell and ask them to label the substances needed by the cell and the waste products produced by the cell.

Extension
Students could research yeast as an example of a unicellular eukaryote and produce a labelled diagram of the structures in a yeast cell and their roles.

Homework
Students could be asked to produce a summary poster on 'Life on Earth' explaining the differences between the cells of eukaryotes and prokaryotes, including examples of each.

Animal and plant cells: Lesson 2

Learning outcomes

1 Describe the structure of animal, plant and algal cells (eukaryotic cells).
2 Explain how the structure of animal and plant cell components relates to their function.

Suggested lesson plan

Starter
Use **T&L Lesson starter 2** or set a Practice question on the material from the last lesson such as question 2 from page 14.

Main
Discuss the main components of plant and animal cells and get students to label diagrams of each. Students should then complete a table like that shown below to determine which organelles are present in animal and plant cells and the function of each.

Structure	Present in animal cells	Present in plant cells	Function
cell membrane			
cell wall			
chloroplast			
cytoplasm			
mitochondria			
nucleus			
permanent vacuole			
ribosome			

Students could be provided with large images of different unnamed plant and animal cells displayed around the classroom. They will need to move around the room deciding whether each cell is a plant or animal cell and the reasons for each (do not include a root hair cell as this will be used in the plenary). They should try to look for specific structures and decide on which type of cell they think it is based on the presence or absence of each.

Plenary
To check students' understanding, provide them with a generalised diagram of a root hair cell which is not named and ask them to decide whether they think it is a plant or animal cell, justifying their reasons for this. Alternatively, students could answer the Test yourself questions from page 8.

Support
Students without a firm grasp of KS3 prior knowledge should complete the **T&L Prior knowledge catch-up student sheet**.

Extension
Students could be challenged to think about how the different cells are adapted to their function.

Homework
To produce a poster to summarise the key similarities and differences between plant and animal cells, or complete an extended answer question comparing the structure of plant and animal cells.

Cell specialisation: Lesson 3

Learning outcomes

1 Explain how the structure of specialised animal cells relates to their function. This should be limited to sperm cells, nerve cells, red blood cells and muscle cells.
2 Explain how the structure of plant cells relates to their function. This can be limited to root hair cells, xylem cells and phloem cells.

Suggested lesson plan

Starter
Display pictures of a root hair cell, a sperm cell, a xylem cell, a muscle cell, a phloem cell and a nerve cell on the board and ask students to identify what they think the cells are.

Main
Introduce students to the importance of cell differentiation. Explain that as an organism develops, cells will differentiate to form different types of specialised cells. In animals, cells usually differentiate at an early stage, but plant cells are able to differentiate throughout the plant's life span.

Divide the class up into six groups and allow each group to pick out a specialised cell at random. In their groups, students should produce a campaign poster or presentation on why their cell should be chosen as the most important cell. They need to include:

- a fully labelled diagram of the cell
- a description of the cell's function in a tissue, an organ, an organ system or the whole organism
- an explanation of how its structure allows it to carry out its function.

Students should use the internet or pages 8–9 of the textbook to help them gather information and produce their poster.

Explain that the students have this one lesson to produce their posters/presentations and that they will be presenting them and their cell's case for being voted the best cell in the next lesson.

Plenary
To check students' understanding of their own cell, ask them to write down three structures the cell has, two ways it is adapted to carry out its role and one function their cell has.

Support
Students without a firm grasp of KS3 prior knowledge should complete the **T&L Prior knowledge catch-up student sheet**. They could also be provided with a scaffolded poster which clearly highlights what information is needed and where it should go.

Extension
Students could be provided with modelling materials and asked to produce a model of their specialised cell.

Homework
To research the red blood cell and produce a poster to explain how this cell is adapted to carry oxygen around the body.

Cell specialisation 2: Lesson 4

Learning outcomes

1 Explain how the structure of specialised animal cells relates to their function. This should be limited to sperm cells, nerve cells, red blood cells and muscle cells.
2 Explain how the structure of plant cells relates to their function. This can be limited to root hair cells, xylem cells and phloem cells.

Suggested lesson plan

Starter
All students could complete **T&L Quick quiz 1**.

Main
Student groups should take it in turns to present their cell posters/presentations to the rest of the class. As each group is speaking, the rest of the class should make notes on the following:

- the name of the cell
- what it looks like
- what its role is

- the structures/features it has to help it carry out its role.

Students can peer assess each group's presentation and provide constructive feedback. The class can then vote on which cell they think is the most important or which group presented the best campaign.

Plenary
To check their understanding, students can work on the Test yourself questions from page 11 of the textbook or complete **T&L Quick quiz 2**.

Support
Students without a firm grasp of KS3 prior knowledge should complete the **T&L Prior knowledge catch-up student sheet**. Such students could be provided with a more scaffolded grid to collect information on the different types of cells.

Extension
Students could be provided with a card sort activity to sort adaptations and functions for the different cells.

Homework
To produce a model of any prokaryotic or eukaryotic cell which could be displayed in a science museum. They should also produce an information card to be displayed next to it to explain what the cell is, the structures it has and what the cell's function is.

Size and scale: Lesson 5

Learning outcomes

1 Use the prefixes centi-, milli-, micro- and nano-.
2 Convert between centi-, milli-, micro- and nano-.
3 Express answers in standard form.

Preparation
Speak to your school's maths department to find out whether the students have covered standard form yet and discover any strategies that they have used. This will help you establish parity across maths and science.

Suggested lesson plan

Starter
Provide students with the following terms all mixed up and ask them to try to order them in terms of size from smallest to largest: picometre, nanometre, micrometre, metre, kilometre, megametre, gigametre and terametre. Early finishers can try to come up with a common expression for each, for example a millimetre is one thousandth of a metre and a gigametre is one billion metres. If students are struggling, make them think about the larger numbers in terms of computer memory as they have probably encountered terabytes, gigabytes and megabytes.

Main
Discuss with students their ideas and go over the correct order with them, producing a number line on the board. Discuss the terms and what they mean in relation to a metre and write down the terms in words and numbers.

- Terametre = 1 trillion metres = 1 000 000 000 000 m
- Gigametre = 1 billion metres = 1 000 000 000 m
- Megametre = 1 million metres = 1 000 000 m
- Kilometre = 1 thousand metres = 1000 m
- Metre = 1 m
- Millimetre = 1 thousandth of a metre = 0.0001 m
- Micrometre = 1 millionth of a metre = 0.000001 m
- Nanometre = 1 billionth of a metre = 0.000000001 m
- Picometre = 1 trillionth of a metre = 0.000000000001 m

Support students in converting from one measurement unit to another and ensure that they understand when they need to divide and when they need to multiply by a thousand. Students often struggle with this as they mix up what the terms mean with what the units are. So 1 m written in km is not 1000 km but 0.001 km. It is worth taking the time to explain why cm and dm do not fit into this pattern of 1000s.

Provide students with some simple calculations to help them convert between units.

Explain that standard form is a method of writing numbers using powers of 10. Depending on what students know, either ask them to convert the measurements bigger than a metre into standard form or support them to do this based on what they have learnt in maths. There are two ways to approach this. Ask students to think about splitting the number into two parts: a number (1 in our example) multiplied by a power of 10 (e.g. how many times 10 needs to be multiplied to get the large number). Alternatively, students could consider how far the first digit is away from the unit column.

Taking 1 000 000 as an example:

- 1 000 000 is $10 \times 10 \times 10 \times 10 \times 10 \times 10$ and so can be written as 1×10^6
- Or in 1 000 000 the 1 is six places away from the unit column and so can be written as 1×10^6.

Move on to ask students how they would write 1 in standard form and elicit 1×10^0. Use this to get them to think about how the units smaller than

a metre would be written. Some may have come across this previously and know they need to divide by 10 rather than multiply and that this is shown by using a negative power. So a micrometre is 1×10^{-6} or 1/1 000 000. Again, if some have used the unit method, they need to think about how far from the units column the number is so 0.000001 is six steps away from the unit column hence 1×10^{-6}.

Provide students with opportunities to practise writing numbers in standard form and convert between standard form and ordinary numbers.

Plenary
Provide students with a card sort activity where they need to match up different methods of expressing measurements to show they can convert between writing the number out in full (as an ordinary number) and in standard form.

Support
Liaise with the maths department for some support material to help lower attainers or set simpler calculations.

Extension
Ask the maths department for higher level standard form exercises to stretch the most able.

Homework
Provide students with questions to test their understanding of the conversions and units studied.

Microscopy 1: Lesson 6

Learning outcomes

1 Understand how microscopy techniques have developed over time.
2 Compare light and electron microscopes in terms of magnification and resolution.

Preparation
Familiarise yourself with the microscopes in your science department and ensure that you are confident with their use.

Suggested lesson plan

Starter
Provide students with images of the following all mixed up and ask them to arrange them in order of size from the smallest to the largest: a water molecule, a virus, a bacterium, a mitochondrion, a typical animal cell and a typical plant cell. Alternatively the animation from learn.genetics (http://learn.genetics.utah.edu/content/cells/scale/) can be used to give students an appreciation of the size of cells and cellular structures relative to each other.

Main
- Use the TED talk mini lesson to introduce some of the history behind the microscope and cell theory (http://ed.ted.com/lessons/the-wacky-history-of-cell-theory).
- Move on to a discussion of the modern light microscope. Present students with an image of a light microscope or the microscope itself and ask them to name the main parts of it. Discuss with the students the role of each part, how to focus and how to determine total magnification.
- If students are inexperienced with using microscopes, start by providing them with pieces of newspaper which they can mount on slides. They can use this to practise with the microscopes and determine total magnification. Develop this to look at prepared slides and allow students to gain confidence in the use of light microscopes.
- Using the information on pages 11 and 12, students should compare and contrast light and electron microscopes, explaining how they work and the maximum magnification and resolution of each.

Plenary
Provide students with a simple sorting activity in which they need to determine whether the information relates to a light or electron microscope. Alternatively, students can complete the Test yourself questions from page 12 of the textbook.

Support
Provide clear step-by-step instructions on how to use a light microscope. When students are comparing and contrasting light and electron microscopes, provide scaffolding to help them get down the key information on total magnification, resolution, advantages and disadvantages.

Extension
The most able students could research the different between scanning electron microscopes and transmission electron microscopes.

Microscopy 2: Lesson 7

Learning outcomes

1 Demonstrate an understanding of the scale and size of cells.
2 Carry out calculations involving magnification, real size and image size using the formula:

$$\text{magnification} = \frac{\text{size of image}}{\text{real size of object}}$$

Preparation

Familiarise yourself with the microscopes the science department has and ensure you are confident with their use. Review the magnification formula and how it can be rearranged.

Starter

Provide students with an image of a microscope and ask them to label the main parts. Alternatively use **T&L Lesson starter 2**.

Main

Introduce the magnification calculation, magnification = size of image/real size of object. Ask students to explain how to rearrange it and show them the formula triangle which can be used to help them remember what to do. This is a good place to review how to convert between units.

Students then can work through the Working scientifically questions on pages 15–17 of the textbook. Alternatively, magnification problems could be printed out and placed around the room for the students to move around and answer.

Support

Provide students with differentiated questions so all can practise the calculations but with numbers they are comfortable with. Page 11 of the textbook can be used to introduce students to the parts of the microscope and how to calculate total magnification.

Extension

Provide students with prepared slides and ask them to identify whether they think the cells are plant or animal cells and their reasons for this. They could also be encouraged to draw the cells, adding a scale and annotating the main visible structures so they can practise these skills prior to the required practical next lesson.

Homework

Students can complete the **T&L Homework task**.

Preparation for Required practical 1: Use a light microscope to observe, draw and label a selection of plant and animal cells: Lesson 8

Learning outcomes

1 Observe, draw and label plant and animal cells using a light microscope.
2 Describe the method used in this practical.
3 Make judgements about the relative size of cell components.

Preparation

Familiarise yourself with the practical and the requirements using the **Teacher and technician notes**.

Suggested lesson plan

Starter

Introduce the Required practical which asks students to use a light microscope to observe, draw and label a selection of plant and animal cells with a magnification scale. Provide the students with some examples of microscopy drawings. The video **T&L Use of graticule and micrometer to measure cells and calculate magnification** might be useful here. Get the students to work in small groups or pairs and assess them using the following marking points:

Marking point
Sharp pencil used
Clear continuous lines with no overlapping
No shading
Accuracy in drawing (structures are the correct sizes relative to each other)
Labels drawn with a ruler
Labels touching the structure
Labels written horizontally
Magnification or scale bar included

Main

Provide the students with a simple prepared slide of plant or animal tissue and ask them to produce a drawing of three cells.

Plenary

Students should self assess their drawing and use it to come up with a target for improvement for the Required practical.

Support

Use this lesson to help you identify students who will need support and scaffolding in the Required practical which will be carried out in the next lesson.

Extension

Students could produce a guide for other students on how to use a microscope and how to draw correct microscopy drawings.

Homework

Students can complete the **T&L Homework task** or write down three key things needed in the drawing for next lesson.

Required practical 1: Use a light microscope to observe, draw and label a selection of plant and animal cells: Lesson 9

Learning outcomes

1 Observe, draw and label plant and animal cells using a light microscope.
2 Describe the method used in this practical.
3 Make judgements about the relative size of cell components.

Preparation
Familiarise yourself with the practical and the requirements using the **T&L Teacher and technician notes**.

Suggested lesson plan

Starter
Show the video **T&L Use of graticule and micrometer to measure cells and calculate magnification**. This will remind students of what they need to do and how to carry out the practical.

Main
Students should complete the Required practical by following the method from pages 6 and 7(*7*) of the textbook or using the **T&L Practical** worksheet.

Students should then answer the relevant questions from the Required practical.

Plenary
Students could summarise the practical by making a step-by-step guide on how to use a microscope to observe and draw a specimen.

Extension
Students can work through the Chapter review questions on page 13 of the textbook.

Homework
Students can complete the Practice questions from page 14 of the textbook.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge
1 They provide structure for the plant.
2 Plant cells contain chloroplasts, vacuoles and a cell wall, whereas animal cells do not.
3 Leaves contain chloroplasts which are green and are where photosynthesis occurs.
4 Organ systems > organs > tissues > cells

Test yourself
1 Plasmid DNA
2 Bacteria
3 Eukaryotic cells have a nucleus; prokaryotic cells do not.
4 They are the site of protein synthesis.
5 Any two from: chloroplast, cell wall or vacuole
6 Eukaryotic plant and animal cells
7 It supports the nucleus and other cell organelles in the cell and is the site of many chemical reactions.
8 They transmit electrical impulses.
9 Nucleus, membrane, cytoplasm, mitochondria and ribosomes
10 They are biconcave in shape to maximise their surface area to absorb more oxygen.
11 The root hairs increase the surface area in contact with the soil to absorb more water.
12 Between × 50 and × 250
13 0.1 nm
14 The wavelength of electrons is many times smaller than that of light, so higher magnifications can be seen.
15 They are large and expensive and require biological samples to be dead.

Show you can
Page 4

Prokaryotic cells have features that are missing in eukaryotic cells, such as mitochondria.

Page 8

Mitochondria are the site of the cell's respiration.

Page 11

Specialised cells allow organisms to develop tissues and organs. This means they can become more complex.

Page 12

They do not take a whole image in one go but rather scan across it. These images are than added together to make an image that looks three-dimensional.

Required practical 1
Pages 6–7

1 Answers are based on the student's own work.
2 Answers are based on the student's own work.
3 Answers are based on the student's own work.

Chapter review questions
1 Plasmid DNA, flagella, non-cellulose cell wall
2 Dissolved sugars and minerals
3 Water and carbon dioxide

4 They contain chloroplasts which contain a green substance called chlorophyll and are where photosynthesis occurs.
5 They have a tail to propel them towards the ovum and a relatively large number of mitochondria to release the energy from glucose during respiration.
6 Cardiac, smooth and skeletal
7 The sample is placed in a drop of water or stain on a microscope slide. A thin coverslip is placed on top of this. The slide is then placed onto the stage.
8 Flagella rotate to move bacterial cells.
9 a) Left: scanning electron microscope; right: transmission electron microscope
b) Advantage: higher magnification; disadvantage: any from large and expensive and require biological samples to be dead
10 Prokaryotic cells do not have a nucleus whereas eukaryotic cells do, they are single celled and they are smaller than eukaryotic cells.
11 It is the site of chemical reactions and is mainly water.
12 They are where proteins are made.
13 Plant and animal cells both have a cell membrane, which lets substances into and out of the cell. They both have cytoplasm which is the liquid in which reactions occur and cell components such as ribosomes are found. They both have ribosomes which are the site of protein synthesis. They both have mitochondria which are the site of respiration. Only plant cells have chloroplasts which are the site of photosynthesis. Only plant cells have a vacuole in which dissolved sugars and minerals are stored. Plant cells have a cellulose cell wall to provide structure; this is not seen in animal cells.
14 This is filled with water in which dissolved sugars and mineral ions are found. Vacuoles are found in plant cells.
15 A nerve cell has a long section called an axon down which electrical impulses move. This cell is insulated by a myelin sheath to make this movement faster.
16 They have a biconcave shape (dips in the middle on both sides) and no nucleus to maximise their surface area to carry more oxygen.
17 The shortest distance between two points that a microscope can determine as two separate points.
18 a) Sperm cell and ovum
b) Around 20 micrometres (μm)
c) Sperm cells need to be able to swim long distances to reach the ovum and so need the energy released from glucose during respiration in mitochondria.
19 Cells with more mitochondria are able to release more energy from glucose in respiration. Cells with more mitochondria are usually more active, like sperm or muscle cells.
20 'Turgid' is used to describe swollen cells.
21 Carbon dioxide and water move out of animal cells because they are the products of respiration.
22 Xylem cells are long and have thick, reinforced walls to allow water to move up by transpiration.
23 Prokaryotes probably evolved before eukaryotes because they are missing some cell components that eukaryotic cells possess.
24 a) It is 2.6 cm long in the image and so has been magnified 20 times.
b) It has a large surface area to speed up osmosis.

Practice questions

1 a) B: chlorophyll
b) To maximise the light their leaves receive.
c) They are green because they contain chlorophyll in their chloroplasts. These are present in the roots of some orchids because they grow on trees and are able to receive sunlight. This means these cells can photosynthesise.
d) They possess a long extension called a hair. This increases the surface area in contact with water in the soil. This means that the plant can absorb more water.
2 a) A: plasmid DNA; B: cell wall
b) C: nucleus
c) Respiration
3 a) A: eyepiece lens; B: fine focus; C: stage
b) B: objective lens
c) Total magnification = magnification of eyepiece lens × magnificent of objective lens
d) Light microscopes use magnifying lenses. The light passes through the objective lens and then the eyepiece lens before entering your eyes. Electron microscopes are more recently invented and more complicated machines. They use beams of electrons, not light, to magnify images. The wavelength of electrons is shorter than that of light so high resolution and great magnification are seen.
4 Level 3: A clear description covering the key differences and similarities between prokaryotic cells and eukaryotic plant and animal cells *[5–6 marks]*

Level 2: A number of relevant points made, but not precisely *[3–4 marks]*

Level 1: Fragmented points *[1–2 marks]*

No relevant content *[0 marks]*

Indicative content: None can be seen without a microscope

Prokaryotes: are single celled; do not have a nucleus containing their genetic material (DNA); are smaller than eukaryotic cells; may also have small rings of DNA called plasmids.

Eukaryotes: almost always have a nucleus; are larger than prokaryotic cells; have membrane-bound organelles; often make up large multicellular organisms

Plant and animal similarities: nucleus; cell membrane; cytoplasm; mitochondria; ribosomes

Plant cells have in addition: a cell wall; chloroplasts; a (permanent) vacuole

Working scientifically: Dealing with data
Pages 15–17

1 25 mm/2.5 mm = × 10 magnification
2 1.8 × 12.5 = 22.5 mm
3 22.5/7.5 = 3 cm
4 Allow 1.8–1.9 cm
5 Actual size of red blood cell is around 5.5–5.8 μm; do not accept answer in mm.

AQA GCSE (9-1) Combined Science Trilogy
Test yourself on prior knowledge

1 They provide structure for the plant
2 Plant cells contain chloroplasts, vacuoles and a cell wall, where animal cells do not.
3 Leaves contain chloroplasts, which are green and are where photosynthesis occurs.

Test yourself

1 As a single (main) loop and one or more plasmids
2 They are the site of protein synthesis.
3 Any two from: chloroplast, cell wall or vacuole
4 Eukaryotic plant and animal cells
5 It supports the nucleus and other cell organelles in the cell and is the site of many chemical reactions.
6 They transmit electrical impulses.
7 A nerve cell has a long section called an axon down which electrical impulses move. This cell is insulated by a myelin sheath to make this movement faster.
8 The root hairs increase the surface area in contact with the soil to absorb more water.
9 Electron microscopes have a much higher resolution.

Show you can

Page 8: Mitochondria are the site of the cell's respiration.

Page 11: Specialised cells allow organisms to develop tissues and organs. This means they can become more complex.

Required practical 1
Pages 7–8

1 Answers are based on the student's own work.
2 Answers are based on the student's own work.
3 Answers are based on the student's own work.

Chapter review questions

1 Any two from: they do not have a nucleus; they are usually smaller than a eukaryotic cell; they usually have plasmids (small rings of DNA)
2 Dissolved sugars and minerals
3 They contain chloroplasts which contain a green substance called chlorophyll and are where photosynthesis occurs.
4 They have a tail to propel them towards the ovum and a relatively large number of mitochondria to release the energy from glucose during respiration.
5 The sample is placed in a drop of water or stain on a microscope slide. A thin coverslip is placed on top of this. The slide is then placed onto the stage.
6 Prokaryotic cells do not have a nucleus whereas eukaryotic cells do, they are single celled and they are smaller than eukaryotic cells.
7 It is the site of chemical reactions and is mainly water.
8 They are where proteins are made.
9 Only plant cells have chloroplasts, which are the site of photosynthesis. Only plant cells have a vacuole in which dissolved sugars and minerals are stored. Plant cells have a cellulose cell wall to provide structure which is not seen in animal cells.
10 A nerve cell has a long section called an axon down which electrical impulses move. This cell is insulated by a myelin sheath to make this movement faster.
11 The shortest distance between two points that a microscope can determine as two separate points.
12 a) Around 20 micrometres (μm)
   b) Sperm cells need to be able to swim long distances to reach the ovum and so need the energy released from glucose during respiration in mitochondria.
13 Cells with more mitochondria are able to release more energy from glucose in respiration. Cells with more mitochondria are usually more active, like sperm or muscle cells.
14 'Turgid' is used to describe swollen cells.
15 Xylem cells are long and have thick, reinforced walls to allow water to move up by transpiration.
16 a) It is 2.6 cm long in the image and so has been magnified 20 times.
   b) It has a large surface area to speed up osmosis.
17 They are very small (microscopic) structures.

Practice questions

1 a) B: chlorophyll *[1 mark]*

b) To maximise the light their leaves receive *[1 mark]*

c) They are green because they contain chlorophyll in their chloroplasts. *[1 mark]* These are present in the roots of some orchids because they grow on trees and are able to receive sunlight. *[1 mark]* This means these cells can photosynthesise. *[1 mark]*

d) They possess a long extension called hair. [1 mark] This increases the surface area in contact with water in the soil. [1 mark] This means that the plant can absorb more water. *[1 mark]*

2 a) A: plasmid DNA; B: cell wall *[2 marks]*

b) C: nucleus; D: mitochondria *[2 marks]*

3 a) A: eyepiece lens; B: fine focus; C: stage *[3 marks]*

b) B: objective lens *[1 mark]*

c) Total magnification = magnification of eyepiece lens × magnification of objective lens *[1 mark]*

d) Any two of: light microscopes use magnifying lenses. The light passes through the objective lens and then the eyepiece lens before entering your eyes. Electron microscopes are more recently invented and more complicated machines. They use beams of electrons, not light, to magnify images. The wavelength of electrons is shorter than light so high resolution and great magnification are seen. *[2 marks]*

4 Level 3: A clear description covering the key differences and similarities between prokaryotic cells and eukaryotic plant and animal cells *[5–6 marks]*

Level 2: A number of relevant points made, but not precisely *[3–4 marks]*

Level 1: Fragmented points *[1–2 marks]*

No relevant content *[0 marks]*

Indicative content: None can be seen without a microscope.

Prokaryotes: are single celled; do not have a nucleus containing their genetic material (DNA); are smaller than eukaryotic cells; may also have small rings of DNA called plasmids

Eukaryotes: almost always have a nucleus; are larger than prokaryotic cells; have membrane-bound organelles; often make up large multicellular organisms.

Plant and animal similarities: nucleus; cell membrane; cytoplasm; mitochondria; ribosomes

Plant cells have in addition: a cell wall; chloroplasts; a (permanent) vacuole

Working scientifically: Dealing with data

Pages 15–17

1 1.8 × 12.5 = 22.5 mm

2 22.5/7.5 = 3 cm

3 13 mm approx.

4 Allow 5.5–5.8 μm; do not accept answer in mm.

2 Cell division

Overview

Specification points
4.1.2.1 Chromosomes; 4.1.2.2 Mitosis and the cell cycle; 4.1.2.3 Stem cells

Textbook chapter references
AQA GCSE (9-1) Biology: Chapter 2 pages 18–27

AQA GCSE (9-1) Combined Science Trilogy 1: Chapter 2 pages 18–27

AQA GCSE (9-1) Combined Science Trilogy: Chapter 2 pages 18–27

Recommended number of lessons: 4

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	No
Contains biology-only material	No

Useful Teaching and Learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for Homework task
- Answers to all questions
- Animation: Monohybrid crosses
- Personal tutor: Inheritance

Useful prior learning

- Cells are the basic unit of living organisms.
- A simple model of chromosomes, genes and DNA showing how they relate and the differences in size

Common misconceptions

- Students often have misunderstandings linked to when DNA duplication occurs as when mitosis is taught, it is not made fully clear that DNA duplication is a precursor to mitotic cell division.
- There is often confusion between the use of the terms 'chromosomes' and 'chromatids' as they are not correctly introduced and defined.
- Students may not fully understand how the growth of an organism is linked to cell division and cell growth. Some mistakenly think that the cells just grow larger, others do not fully appreciate that during cell division cells must increase in size to avoid becoming smaller and smaller during division.
- Due to how genetics is introduced and the examples used, students may believe that there is only ever one pair of alleles which is responsible for determining a trait, with one always being dominant and one being recessive.

Preparation

The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for the upcoming work on cell division and stem cells. This should allow you to get a deeper understanding of common misconceptions and desired prior knowledge from KS3. Reviewing the terminology to be used in the unit will reduce the possibility of misconceptions which often arise from incorrect use of keywords or using vocab interchangeably. The **T&L Key terms** can assist with this and help you share the key terms with the students.

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the next few lessons or can be reserved for recap/consolidation at the end of the topic.

Chromosomes: Lesson 1

Learning outcomes

1 Describe the arrangement of genetic material within a nucleus.
2 Define the terms gene, chromosome and genome.

Suggested lesson plan

Starter
In the first lesson in this sequence, assess students' prior understanding of cell division and terminology associated with genetic material and its organisation within the cell. The student worksheet **T&L Prior knowledge catch-up student sheet** or the Test yourself on prior knowledge questions from page 19 can be used to assist with this.

Main
Introduce students to the hierarchy of genome organisation. They should be confident with how genes, DNA and chromosomes relate to each other and understand that they are found within the nucleus of a eukaryotic cell. It is often useful to get students to label a diagram to consolidate their understanding.

Alternatively, it can help to introduce the ideas using an analogy. For example, ask students to imagine a library containing many books. The library itself is the nucleus of the cell, the books

are the chromosomes. In the case of human body cells there are 23 books (with two copies of each). Each book contains numerous paragraphs which are the thousands of different genes which make proteins. These paragraphs are made up of words which represent the DNA; the letters making up the words represent the individual DNA bases. (Students should understand, however, that the language of DNA has only four bases rather than the 26 letters in the English alphabet.)

Encourage students to try to come up with their own analogies or provide them with a ball of string and ask them to explain what it could represent.

Move on to a discussion of the difference between haploid and diploid cells and ensure that students are confident with the terminology of each. Students could read and work through the questions for the Working scientifically task on page 27.

To finish, ensure students are confident with the key terms 'genes' and 'alleles' and understand fully why we have two copies of every gene.

Plenary
To assess students' understanding of the key terms you could use a bingo-type activity or keyword test. Alternatively students could complete the Test yourself questions from page 20.

Support
Understanding the terminology is key to understanding the concepts in this topic. Provide students with key term lists, matching activities and mini quizzes to ensure they are confident with the new terms and their meanings.

Extension
Students could examine the karyotypes of a range of species and look for differences in the chromosome numbers. They could also research what traits are carried by specific chromosomes.

Homework
Students could make a poster on where genetic information is found in the cell and how it is organised in order to consolidate their understanding of key terms.

Mitosis and the cell cycle: Lesson 2

Learning outcomes

1 Describe the stages of the cell cycle including mitosis.
2 Identify the stages of mitosis from images.
3 Explain the importance of mitosis.

Suggested lesson plan

Starter
Assess students' understanding of the key terms from the previous lesson through a short quiz or use the **T&L Lesson starter 1** and ask the students to guess how many chromosomes are in each cell and whether they are haploid or diploid.

Main
Introduce students to the cell cycle and mitosis and give detail to what occurs at each stage.

Either show students images of what each stage looks like and explain what is occurring or, if available, allow them to view prepared microscope slides to show it.

To allow students to gain an understanding of what occurs at each stage they could produce a stop–start animation to show what happens during interphase, mitosis and cytokinesis. The Activity box on page 22 gives more guidance on this.

Alternatively, students could work in small groups to make models using paper plates, plasticine and string to show what occurs at each stage (with mitosis being broken down into key events rather than stages).

Plenary
Provide students with pictures showing the stages of the cell cycle and mitosis. They should work in pairs or small groups to put them in the correct order and identify what stage is shown. If available this could be adapted by giving students unlabelled microscope slides to put in order.

Support
To allow less able students to recognise the stage in the cell cycle, they could be provided with a cut-and-stick style activity or a cartoon strip activity where they need to draw pictures to explain writing which is given to them.

Extension
The most able students could be introduced to the phases of mitosis and given more detail on what is occurring and the role of centromeres and spindle fibres. Note that this is not required for the GCSE exam.

Homework
Students could make a comic strip to summarise the key events in the cell cycle and what occurs.

Stem cells: Lesson 3

Learning outcomes

1 Describe the function of stem cells in embryos, adult mammals and plant meristems.
2 Explain how stem cells may be used in medicine.

Suggested lesson plan

Starter
Provide students with images of different specialised cells from Chapter 1 and ask them to identify the cells.

Main
Explain that unlike the specialised cells they have just seen, a stem cell is a cell which can differentiate into any other type of cell.

The video 'What are stem cells' from the Irish Stem Cell Foundation (www.stemcell.ie/) can be used to provide a clear introduction to stem cells. Alternatively, the TED talk 'What are stem cells' (http://ed.ted.com/lessons/what-are-stem-cells-craig-a-kohn) is slightly more complex for more able learners.

Students could research the differences between adult and embryonic stem cells, exploring where they are found, what they can differentiate into and the pros and cons of their use. They could move on to explore the importance of stem cells in different animals such as lizards, amphibians and starfish.

To finish, ask students what happens to a plant if you pull a leaf off. Use this to introduce the ability of plants to produce different types of cells throughout their lives and how we can use this to our benefit when making cuttings. Ensure students are able to describe that plant stem cells are located in regions called meristems.

Plenary
Students could complete a short quiz on the key terms covered in the unit so far or use the **T&L Quick quiz 1**.

Support
Rather than allowing students to research without scaffolding, provide students with a DART reading activity based on the information from pages 22–3 to ensure they research information at the correct level.

Extension
The most able students could be encouraged to research the life span of different cells in the body to get an appreciation for the turnover of new cells and why stem cells are so important.

Homework
Students can complete the **T&L Homework task**.

Stem cell research: Lesson 4

Learning outcomes

1 Describe the process of therapeutic cloning.
2 Explain the uses of therapeutic cloning.
3 Discuss the ethical implications of cloning.

Suggested lesson plan

Starter
Introduce the topic of stem cell research by giving students a short newspaper article to read on the subject or showing a news story video such as www.bbc.co.uk/news/health-15193597.

Main
Discuss with students why stem cell research is an ethical issue, and why some people think it can have enormous medical benefits while others oppose it for moral and religious reasons.

Use the activity on page 24 to get students to think about the issues related to stem cell research. They can complete questions 1 and 2 in small groups and then individually write their letters to the government to summarise their views.

Plenary
Students could work on the Test yourself questions from page 24 or complete the **T&L Quick quiz 2**.

Support
Lower ability students could be provided with a selection of different views that people might have on stem cell research to organise into those for and those against. They could then rank them into those which they think people would consider the most and least important.

Extension
Students could research more fully the stages of therapeutic cloning and produce a flow chart to show how the process occurs.

Homework
Students could complete the Chapter review questions from page 25 or the Practice questions from page 26.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 A short section of DNA that carries information about inherited characteristics.
2 DNA exists in a double helix shape, which is coiled into chromosomes.
3 chromosome > gene > DNA

Test yourself

1 46
2 Red blood cell
3 Alleles are two versions of a gene, with each one coming from a different parent.
4 Chromosomes are made up from genes, which are made from DNA.
5 Daughter cells
6 Growth, repair or replacement
7 A cell that can divide into any other kind of cell
8 Embryonic and adult
9 Some people disagree with it for religious or moral reasons.
10 Matured ova are removed from an ovary in a small operation. They are fertilised outside the body using sperm. The fertilised ova are then implanted back into the woman's uterus and develop in the same way as non-IVF babies.

Show you can

Page 20

Saying '23 pairs' reminds us that half come from one parent and the other half come from the other parent.

Page 22

Chromosomes make copies of themselves and the nucleus disappears. The original and copied chromosomes line up. They move to opposite ends of the cell. The cell divides. Two new nuclei form in each of the two new cells.

Page 24

Stem cell research could be used to grow nerve cells to help paralysed individuals. It could be used to grow brain cells to help after injury or with diseases like Parkinson's. It could eventually be used to grow tissues or organs.

Activity

Page 22

1 Task: no answer needed
2 Task: no answer needed
3 Task: no answer needed

Page 24

1 Task: no answer needed
2 Task: no answer needed
3 Task: no answer needed

Chapter review questions

1 Sperm and ova
2 Gametes
3 23 pairs, or 46
4 Pollen and ova
5 One at the beginning and two at the end
6 Embryonic stem cells can differentiate into any type of cell and adult stem cells can't.
7 Any two from: sperm cell, nerve cell, muscle cell
8 Bone marrow, lipid or fat cells, blood
9 Lizard, starfish
10 An organism produced asexually that has identical genetics to its parent
11 They have the same genes as their one parent.
12 Any cells except for sperm and ova
13 23
14 Eggs
15 46
16 A section of a chromosome made from DNA that carries the code to make a protein.
17 Alleles are alternative versions of a gene, with each allele coming from a different parent.
18 Chromosomes shorten and fatten. They then copy themselves. Then they line up in the middle of the cell, before half of the chromosomes are pulled to each end. Finally the cell splits into two daughter cells.
19 Growth and repair
20 One
21 Because they have half the DNA of each parent and come together to form the one diploid set of DNA of a new organism
22 There is no variation; daughter cells are identical.
23 The process of a stem cell turning into a specialised cell
24 Describes a stem cell capable of growing into any specialised cell found in the adult organism
25 Describes a stem cell capable of growing into several types of specialised cell found in the adult organism (but not any specialised cell)
26 Meristem
27 Any two from: root hair, xylem and phloem
28 A small section of stem usually with a few leaves is removed. This is often dipped into rooting powder which contains plant hormones to speed up differentiation. This cutting is then placed directly into the soil.
29 Plant hormones are present in rooting powder. Cuttings are dipped into this before being planted. This helps roots form from stem tissue.

30 They believe that an embryo is a life.
31 A medical procedure in which ova are fertilised outside of a woman, then placed into her uterus to develop into a baby.
32 One comes from each parent.
33 A chromatid is a copy of a chromosome made during mitosis.
34 A chromatid is a copy of a chromosome.

Practice questions

1 B: 46
2 C: sperm cell
3 A: identical diploid body cells
4 a) Chromosome
b) Six chromosomes should be drawn [1] showing six different sizes [1]
5 a) Mitosis
b) Growth/repair
c) It is replicated/copied
6 a) Cells that can develop into one or more types of specialised cells
b) Bone marrow, brain, blood, fat cells
c) They can grow into any specialised cell found in the adult organism.
d) Any two from: embryonic stem cells come from human embryos; the idea that embryos have a right to life; idea that people have religious views against it; idea that the treatments are not fully tested or may have side effects
7 Level 3: A clear and sequential description covering the main stages of mitosis in human cells *(5–6 marks)*

Level 2: A number of relevant points made, but not precisely and some errors in the order *(3–4 marks)*

Level 1: Fragmented points *(1–2 marks)*

No relevant content *(0 marks)*

Indicative content: chromosomes make copies of themselves; there are 46 chromosomes and 46 copies; chromosomes shorten/fatten/condense; the nucleus disappears/breaks down/disintegrates; chromosomes and their copies move to the centre of the cell; copied chromosomes line up; original and copied chromosomes move to opposite ends of the cell; the cell membrane starts to pinch inwards/invaginates; the cell divides; two new nuclei form in each of the two new cells; two daughter cells are produced; each daughter cell is an exact copy of the original cell

Working scientifically: Experimental skills
Page 27

1–4 There are no specific answers as all are predictions.
5 There is an inactivated centromere present; the two telomere sequences are joined.

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge

1 A short section of DNA that carries information about inherited characteristics.
2 DNA exists in a double helix shape, which is coiled into chromosomes.
3 chromosome > gene > DNA

Test yourself

1 46
2 A haploid cell (nucleus) has half the normal number of chromosomes (one from each pair of chromosomes).
3 A diploid cell (or nucleus) has paired chromosomes (the normal number).
4 Chromosomes are made up from genes, which are made up from DNA.
5 Daughter cells
6 Growth and repair/replacing damaged or old cells
7 A cell that can divide into any other kind of cell
8 Embryonic and adult
9 Some people disagree with it for religious or moral reasons
10 They can grow into any cell types and may be used to treat paralysed patients, replace defective organs and treat conditions such as diabetes by replacing cells that are no longer working properly.

Show you can *Page 20*

Saying '23 pairs' reminds us that half come from one parent and the other half come from the other parent.

Page 22

Chromosomes make copies of themselves and the nucleus disappears. The original and copied chromosomes line up. They move to opposite ends of the cell. The cell divides. Two new nuclei form in each of the two new cells.

Page 24

It could be used to grow nerve cells to help paralysed individuals. It could be used to grow brain cells to help after injury or with diseases like Parkinson's. It could eventually be used to grow tissues or organs.

Activity
Page 22

1 Task: no answer needed
2 Task: no answer needed
3 Task: no answer needed

Page 24

1 Task: no answer needed
2 Task: no answer needed
3 Task: no answer needed

Chapter review questions

1 Gametes
2 23 pairs, or 46
3 One at the start and two at the end
4 Any two from: sperm cell, nerve cell, muscle cell
5 An organism produced asexually that has identical genetics to its parent
6 They have the same genes as their one parent
7 Any cells except for sperm and ova
8 23
9 Eggs
10 A section of a chromosome made from DNA that carries the code to make a protein
11 Growth and repair/replacing damaged or old cells
12 Because they have half the DNA of each parent and come together to form the one diploid set of DNA of a new organism
13 The process of a stem cell turning into a specialised cell
14 Meristem
15 They believe that an embryo is a life

Practice questions

1 B: 46 *[1 mark]*
2 C: sperm cell *[1 mark]*
3 **a)** Chromosome *[1 mark]*
b) Six chromosomes should be drawn *[1 mark]*
showing six different sizes *[1 mark]*
4 **a)** Mitosis *[1 mark]*
b) Growth/repair *[1 mark]*
c) It is replicated/copied *[1 mark]*
5 **a)** Cells that can develop into one or more types of specialised cell *[1 mark]*
b) Bone marrow, brain, blood, fat cells *[1 mark]*
c) They can grow into any specialised cell found in the adult organism *[1 mark]*
d) Any two from: embryonic stem cells come from human embryos; the idea that embryos have a right to life; idea that people have religious views against it; idea that the treatments are not fully tested or may have side effects. *[2 marks]*

Working scientifically: Experimental skills
Page 27

1–4 There are no specific answers as all are predictions.

5 There is an inactivated centromere present; the two telomere sequences are joined

3 Transport in cells

Overview

Specification points

4.1.3.1 Diffusion; 4.1.3.2 Osmosis; 4.1.3.3 Active transport

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 3 pages 28–40

AQA GCSE (9-1) Combined Science Trilogy 1: Chapter 3 pages 28–41

AQA GCSE (9-1) Combined Science Trilogy: Chapter 3 pages 28–41

Recommended number of lessons: 6

Chapter overview	
AQA required practicals	Biology – RP3 CS Trilogy – RP2
Contains higher-tier only material	No
Contains biology-only material	No

Useful Teaching and Learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Practical
- Teacher and technician notes
- Homework task
- Quick quiz
- Answers for homework task
- Answers to all questions
- Key concept: Calculating percentage change
- Key concept: Drawing a graph and finding the intercept
- Animation: Diffusion
- Personal tutor: Movement
- Video: Investigate the effect of salt solutions on plant tissue
- Video: Osmosis in plant cells

Useful prior learning

- Diffusion explained through the particle model
- The role of diffusion in the movement of materials in and between cells
- The structure and adaptations of the human gas exchange system
- The role of leaf stomata in gas exchange in plants
- The role roots play in the uptake of minerals and water from the soil

Common misconceptions

- Selectively permeable membranes will allow all biological molecules to pass through but stop non-biological ones.
- The rate of osmosis is constant.
- Osmosis is limited to liquids and refers only to the movement of water.
- Particles move from high to low concentrations and then stop moving once equal.
- Particles move from areas of high concentration to low concentration because they are too crowded and the particles want to spread out.
- Active transport involves a 'thinking' process to select the particles wanted.

Preparation

The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for this unit on transport within and between cells. This should allow you to get a deeper understanding of common misconceptions and desired prior knowledge from KS3.

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the next few lessons or can be reserved for recap/consolidation at the end of the topic.

Diffusion: Lesson 1

Learning outcomes

1 Describe the process of diffusion.
2 Give examples of diffusion.
3 Explain how different factors affect the rate of diffusion.

Suggested lesson plan

Starter

In the first lesson in this sequence on cellular transport assess students' prior understanding of diffusion, osmosis and active transport. It is likely they will have studied diffusion in KS3 however this may have been in the context of particle theory rather than specific biological examples. The student questions on the worksheet **T&L Prior knowledge catch-up student sheet** can be used to assist with this along with the Test yourself on prior knowledge questions from page 29. Alternatively you could use the **T&L Lesson starter 1**.

Main
Introduce the topic of diffusion. You may want to do this using a scented room spray, asking students to raise their hands once they can smell it. This can be used as a starting point for a discussion on what is happening.

Ensure students are confident with the terminology used to describe diffusion and can discuss it in terms of passive, net movement down a concentration gradient. A diffusion animation can be used to explain diffusion at a particle level.

Allow students to brainstorm what molecules a cell needs to take in and remove. They can begin thinking about which body systems are adapted to maximise diffusion but this will be covered in more detail in the next lesson.

Move on to a discussion of the factors that affect diffusion. Students could carry out a simple practical involving tea bags to come up with their own explanations and suggestions. For example, they could place tea bags in different temperatures of water, use different-shaped tea bags to model different surface areas and use muslin bags with different amounts of tea in them to examine the effect of concentration.

Plenary
Complete the **T&L Quick quiz** for this chapter or the relevant Chapter review questions from page 37(*38*). Alternatively, students could complete a key terms match up of the new terminology learnt.

Support
It is vital that students have an understanding of the particle model from KS3 in order to understand the process of diffusion. If this is lacking, take the time to discuss the particle model for the states of matter. Explain how the particles move in each state and the energy the particles have so students can understand why diffusion can only occur in liquids and gases.

Extension
More able students could try to come up with their own explanations for diffusion. You could provide them with a Petri dish containing agar which has universal indicator in it. They could then use a borer to cut out two small wells and add an acid to one and an alkali to the other. Ask them to try to explain their observations in terms of diffusion.

Homework
Students could make a summary poster on what diffusion is and the key terms that should be used.

Diffusion and exchange surfaces: Lesson 2

Learning outcomes

1 Explain how diffusion limits the size of single-celled organisms.
2 Explain how the exchange of materials occurs in the small intestine, lungs, gills, roots and leaves.
3 Explain how these surfaces are adapted to allow efficient exchange.

Suggested lesson plan

Starter
Begin by asking students why single-celled organisms are so small and what limits their size. You could show a movie trailer for *The Blob* and ask why we would need to worry about this.

Main
Use the Activity on page 32(*33*) to allow students to explore surface area to volume ratios and discuss how this limits the size of single-celled organisms. Alternatively, they could carry out the practical themselves using agar cubes cut to different sizes immersed in dyes.

Move the lesson on to discuss the fact that multicellular organisms have developed specialised exchange surfaces to overcome issues with surface area to volume ratios. Show the students models or images of the lungs and alveoli and ask them to think about how they are adapted to maximise diffusion. You could carry out the Activity from page 30(*31*) as a practical demo and ask students the questions to consolidate the ideas.

Students could dissect a fish head to examine the gills and use this to explain how gills are adapted to maximise diffusion of dissolved oxygen into the bloodstream. Alternatively, you could divide the group up so that they work in small groups to research gas exchange in insects, plant leaves and fish and discover the adaptations of the specialised exchange surfaces they have.

Plenary
To check students' understanding of the features of a specialised exchange system, show them an image of villi in the intestines and ask them how these structures act to maximise the diffusion of sugars from high concentrations in the small intestines into the blood.

Support
When teaching surface area to volume ratios it may be useful to get the class to make model cubes and use them to check students' understanding of how to calculate surface area and volume. Students could be given different-sized cubes and use these to determine how surface area to volume ratios change as the cube gets larger.

Extension
Provide students with more complex surface area to volume ratios to calculate for more irregular shapes, not just cubes. They could be challenged to think about how they could work out their own surface area to volume ratio and use this website to check their ideas against: http://stats.areppim.com/calc/calc_bsa.php.

Homework
Students could work through the Working scientifically task on pages 39–40(*40–41*).

The process of osmosis: Lesson 3

Learning outcomes

1 Describe the process of osmosis using examples.
2 Explain how different factors affect the rate of osmosis.

Suggested lesson plan

Starter
Students could complete the Test yourself questions from page 32 to review their understanding of diffusion. Alternatively, provide students with a small model cell made of Visking tubing containing a starch solution which they can place into a beaker of a dilute iodine solution. This will allow a starting point for discussion about which way the substances are moving and why the starch cannot pass through the membrane but the iodine can.

Main
Introduce osmosis to the students and explain how it occurs. Ensure students understand that water moving through a partially permeable membrane is the example they need to know for GCSE but that water is not the only substance which can be transported by osmosis; this is a common misconception.

Allow students to carry out a simple experiment examining osmosis which can be used to introduce the terms 'hypertonic', 'hypotonic' and 'isotonic'. A possible practical could involve students examining red onion tissue under the microscope, adding pure water to the slide and then observing what happens. They could then add a salt solution and observe the results. This can provoke a discussion about what is happening in terms of movement of water and the impact it has on the onion cell.

Move on to a comparison of how animal cells behave in different solutions (hypertonic, hypotonic and isotonic) and ask the students why animal cells would burst but plant cells will not.

Plenary
Students could complete the Test yourself questions from page 34(*35*) or questions 1–3 from the Practice questions on page 38(*39*).

Support
Students often struggle with osmosis and get confused when discussing concentrated and dilute solutions. To help avoid misconceptions always discuss osmosis in terms of what the water is doing. Help students with the terminology by introducing solutions using a squash-type drink so they understand what you mean when you say concentrated and dilute.

Extension
Students could produce their own models to demonstrate their understanding of osmosis and why it occurs.

Homework
Students could be challenged to explore osmosis at home using jelly/gummy sweets. They could record the mass of sweets before placing them in a glass of water and after a day of being in the water.

Required practical 3(*2*): Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue: Lesson 4

Learning outcomes

1 Determine the effect of osmosis on the mass of plant tissue in different concentrations of salt and sugar solutions.
2 Describe the method used in this practical.
3 Plot, draw and interpret appropriate graphs.

Preparation
Read through the **T&L Teacher and technician notes** so you are confident with what the practical is and the requirements for the task.

Suggested lesson plan

Starter

Use **T&L Lesson starter 2** to review students' understanding of osmosis.

Main

Introduce the Required practical task by allowing the students to read the method from the students' worksheet **T&L Practical** or from page 35 of the textbook. Alternatively, the students can watch the **T&L Video: Investigate the effect of salt solutions on plant tissue**.

Before students begin, ensure they are confident with what they need to do by either demonstrating the methods or asking the students what steps should be followed. They should write a prediction for what they think will happen in each solution.

Allow students to carry out the practical. While the plant tissue is in the solution, students could be taught how to calculate % change in mass or, if they have not completed it for homework, they can work through the Working scientifically task from pages 39–40(*40–1*).

Plenary

Depending on the time of the lesson, students could collect the results and determine % change in mass or you could evaluate the practical together, highlighting any issues or errors which may have occurred.

Support

Ensure students are confident with how to calculate percentage and understand why percentage change in mass is more likely to give valid results than a simple mass change. Use the **T&L Key concept: Calculating percentage change** to support this.

Extension

This practical allows students to review types of error; higher-level students could think about where systematic errors, zero errors and random errors may have occurred.

Required practical 3(*2*) evaluation and write-up: Lesson 5

Learning outcomes

1 Write up the experiment, analyse the results, draw conclusions and evaluate the experimental method.
2 Use simple compound measures of rate of water uptake.
3 Use percentiles and calculate percentage gain and loss of mass of plant tissue.

Suggested lesson plan

Starter

Depending on where the class got up to in the previous lesson, students could be gathering the results, working out percentage change in mass or beginning their graphs.

Main

Students should use the lesson to complete the practical, write up their method, produce a graph of their results, draw a conclusion and evaluate the experiment. The questions on the **T&L Practical** worksheet or page 35(*35–6*) of the textbook can support this.

Plenary

Take the time to summarise the practical with the students and ensure they are confident with the skills learnt, particularly calculating percentage mass and finding intercepts on graphs. This practical also offers an opportunity to discuss errors with the students so they should be confident in evaluating the experiment and explaining why calculating percentage mass is more valid than a simple mass change.

Support

The **T&L Key concept: Drawing a graph and finding the intercept** can be used to support students with this skill. You may also need to support students in how to draw graphs with positive and negative axes.

Extension

This practical allows students to review types of error and higher level students could think about where systematic errors, zero errors and random errors may have occurred.

Homework

Students could make a guide explaining the practical, outlining the issues and errors which could occur.

Active transport: Lesson 6

Learning outcomes

Describe the process of active transport using examples.

Suggested lesson plan

Starter

Show students an image of a plant root with root hairs and ask them how it is adapted to maximise the uptake of water. Ask them what else could be taken in with the water and elicit the idea of

mineral ions. Discuss with them that mineral ions exist at low concentrations in the soil but higher concentrations within the root and allow them to consider how mineral ions could be transported.

Main
From the starter activity, introduce the idea of active transport. This can be done with the aid of a demonstration. Use a bowl or tray with small holes in it and fill it with beads small enough to pass through the holes. Ask the students which way the beads are most likely to move based on what they already know about concentration gradients and elicit the idea of movement from the high concentration in the tray to outside the tray. Give the tray a gentle shake to confirm this. Then ask some students to help pick up the beads and add them back to the tray while you continue to shake it. Discuss with the students how it was possible for beads to go the other way from low to high. They should understand that it was only possible with the students helping and that energy was needed to do so.

Using page 36(*36–7*) of the textbook or the internet, students can then research more detail on active transport of mineral ions in plant roots and sugars in the digestive system.

Plenary
Students can complete the Test yourself questions from page 36(*37)* of the textbook. Alternatively, they can compare and contrast the three methods of transport that have been explored in this chapter (osmosis, diffusion and active transport) by making a Venn diagram.

Support
Ensuring students are confident with the differences between diffusion, osmosis and active transport is important to them understanding the processes. Take the time to discuss the similarities and differences with them and the terminology which should be used.

Extension
Students can complete the Chapter review questions or the Practice questions on page 37–8(*38–9*).

Homework
Complete the Chapter 3 **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 Root hair cell
2 Particles spread out from an area of high concentration to an area of low concentration.
3 Breathing is getting gases into and out from the lungs. Respiration is a cellular reaction that releases energy.

Test yourself

1 The net movement of particles from an area of high to lower concentration.
2 Spiracles
3 They have moist, thin walls, a large surface area and rich blood supply to increase diffusion of gases.
4 The particles in solids are fixed and cannot move.
5 The net movement of water from an area of high concentration of water to an area of lower concentration of water across a partially permeable membrane.
6 Root hair cell
7 Osmosis is the movement of water particles only.
8 Osmosis occurs across a membrane.
9 The net movement of particles from an area of low concentration to an area of higher concentration using energy.
10 Sugars are absorbed into the blood by active transport (and diffusion) in the small intestine.
11 Active transport occurs from low to higher concentration.
12 Plant minerals are found in high concentration in the plant so diffuse into the soil.

Show you can

Page 32

Diffusion is the net movement of particles from an area of high to low concentration. When you inhale, the oxygen is in a higher concentration in your lungs than in your blood so diffuses into the blood. This changes the concentration of oxygen in your blood to high. It reaches your tissues, where it is needed in the cells, so it diffuses from a high concentration in the blood to the lower concentration in your cells.

Page 34

Osmosis is the net movement of water from an area of high concentration of water to an area of lower concentration of water across a partially permeable membrane. When it rains, the water is in a high concentration in the soil. This water therefore moves by osmosis into the plant through the membranes of the root hair cells.

Page 36

Active transport is the net movement of particles from an area of low concentration to an area of higher concentration using energy. Because plants absorb mineral ions from the soil they are present

in higher concentrations in the plant than the soil. So plants must take them up using active transport, which requires energy.

Activity
Page 30

1 The scent particles diffused through the wall of the balloon from an area of high concentration to an area of low concentration.
2 Heating the oil, cotton wool or balloon or increasing the concentration of oil used
3 In the alveoli, oxygen moves into the blood down a concentration gradient from where there is a high concentration of oxygen in the alveoli to where there is a lower concentration of oxygen in the blood.

Page 31

This is a model of increased surface area due to villi.

Page 32–3

1 Any two from: sample equipment used, same volume of dye, same soaking time, cubes all made from agar

2–4

Cube	Total surface area in cm^2 [2]	Total volume in cm^3 [2]	Surface area/ volume [3]	SA:V [4]
A	6	1	6	6:1
B	24	8	3	3:1
C	96	64	1.5	1.5:1

5 Cube A
6 Dye would have entered by diffusion (down a concentration gradient).
7 Cells that become too large have a low surface area to volume ratio so they would not be able to take in the substances they need such as oxygen or glucose by simple diffusion alone as the process would be too slow.

Required practical 3
Page 35

1–3 Answers are based on the student's own work.
4 To remove excess water.
5 It took into account starting mass or removed any variation in starting mass.
6 Answer is based on the student's own results.
7 Answer is based on the student's own work.

Chapter review questions
1 The net movement of particles from an area of high concentration to an area of lower concentration.
2 Smelling someone's deodorant or perfume
3 From the lungs into the blood
4 From the blood into the lungs
5 Capillaries
6 Ventilation
7 Diffusion
8 Tiny finger-like projections that increase the surface area of the small intestine
9 The removal of substances from cells or organisms
10 A medical condition in which damage to alveoli causes breathlessness
11 The net diffusion of water from an area of high concentration to an area of lower concentration across a partially permeable membrane
12 When it rains and there is a higher concentration of water in the soil, water will move by osmosis into the plant cell.
13 Stomata
14 The net movement of particles from an area of low concentration to an area of higher concentration using energy
15 Spraying a deodorant causes an area of high concentration. Only here can you smell it. After a while the particles spread out by diffusion. The deodorant smell spreads out because of this.
16 From low to high
17 Tea spreading out from a teabag or juice being diluted with water
18 They have a large surface area, moist thin membranes, a rich blood supply and breathing provides them with a regular supply of fresh air.
19 It has a huge surface area, moist thin membranes which allow substances to diffuse faster across them, and a rich blood supply.
20 Emphysema
21 A membrane in which only small molecules can pass through
22 Because osmosis only involves water
23 Water must cross a partially permeable membrane in osmosis
24 The movement of water from the soil through a plant's roots, stems and leaves and then evaporation through the stomata
25 It would remain the same size.
26 It would swell up, because water would move into it.
27 It would shrink, because water would move out of it.
28 Plant mineral ions exist in low concentration in the soil and in high concentration in the plant. Because the plants need to move the mineral ions from low to high concentrations, against the concentration gradient, they need to use energy. This is active transport.
29 Sugars can be in a low concentration in your digestive system and in high concentration in your blood. Therefore, because you need

to move the glucose from low to high concentration, against the concentration gradient, you need to use energy. This is active transport.

30 Because some of the particles may naturally diffuse back to the area of high concentration they have just come from.

31 The size of insects is limited by the distance that oxygen can diffuse.

32 Wrap a piece of string around your clenched hand and measure the length of string that it takes to go round the largest part. Now do the same with your hand unclenched and your fingers straight.

33 The steeper the concentration gradient, the faster is the rate of diffusion.

34 As the temperature increases, so does the rate of diffusion. Particles have more energy and so move faster.

35 The larger the surface area, the greater the rate of diffusion through it.

36 Make a series of salt solutions of different concentrations and place into beakers. Cut out potato chips to fit inside the beakers. Weigh all the potato chips before soaking in salt. Then, weigh them all again and calculate the percentage change in mass for each solution.

Practice questions

1 a) A

b) i) Diffusion is the movement of gas particles from a high concentration to a low concentration [1] down a concentration gradient [1].

ii) Diffusion is a passive process. This means it does not require additional energy.

2 a) D

b) i) It would increase the rate.

ii) The particles would have more (kinetic) energy [1] so move faster [1].

c) i) B

ii) Idea that concentration/number of particles are the same inside and outside the cell

3 a) Vacuole larger; cell larger/fuller/turgid

b) i) It would burst/lyse.

ii) There is no cell wall in an animal cell.

c) i) Drawing should show a smaller vacuole [1]; cell membrane not fully against cell wall [1]; cell wall the same size [1]

ii) Any three from: water left the cells [1] by osmosis [1]; moved from a solution with a high concentration of water (dilute) to a solution with a low concentration of water (concentrated) [1] down a concentration/water potential gradient [1] through a partially permeable membrane [1], so the membrane came away from the cell wall; the cytoplasm took up less volume/the cell vacuole shrunk [1]

4 Level 3: More than one improvement described and includes collection of more data involving range of salt concentrations and/or recording a change in mass *[5–6 marks]*

Level 2: More than one improvement described *[3–4 marks]*

Level 1: An improvement described *[1–2 marks]*

No relevant content *[0 marks]*

Indicative content: leave longer than 10 minutes; control other factors, such as temperature of solutions; repeat for each concentration of salt solution; increase range of salt concentrations; use pure water or a 0 M salt solution; repeat investigation with other potato varieties; control volume of salt solutions used; record change of mass rather than length; record volume rather than length

Working scientifically: Dealing with data

Pages 39–40

1 No units in headers, units in table, variables in the wrong column, mixed units, inconsistent use of decimal places, no increasing trend in independent variable

2

Room temperature (°C)	Time taken to smell the deodorant (s)
10	105
15	90
20	60
25	54
30	42

3

Beaker	Volume of squash (cm^3)	Volume of water (cm^3)	Total volume (cm^3)
A	100	0	100
B	75	25	100
C	50	50	100
D	25	75	100
E	0	100	100

4

Solution/ beaker	Starting mass (g)	Mass after 5 minutes (g)	Mass after 10 minutes (g)	Mass after 15 minutes (g)	Mass after 20 minutes (g)
A					
B					
C					
D					
E					

Test yourself on prior knowledge

1 Root hair cell
2 Particles spread out from an area of high concentration to an area of low concentration
3 Breathing is getting gases into and out of the lungs. Respiration is a cellular reaction that releases energy.

Test yourself

1 The net movement of particles from an area of high to lower concentration
2 They have moist, thin walls, a large surface area and rich blood supply to increase diffusion of gases.
3 The particles in solids are fixed and cannot move.
4 The net movement of water from an area of high concentration of water to an area of lower concentration of water across a partially permeable membrane.
5 Root hair cell
6 Osmosis is the movement of water particles only
7 The net movement of particles from an area of low concentration to an area of higher concentration using energy.
8 Sugars are absorbed into the blood by active transport (and diffusion) in the small intestine.
9 Active transport occurs from low to higher concentration.

Show you can

Page 32

Diffusion is the net movement of particles from an area of high to low concentration. When you inhale, the oxygen is in a higher concentration in your lungs than in your blood so diffuses into the blood. This changes the concentration of oxygen in your blood to high. It reaches your tissues, where it is needed in the cells, so it diffuses from a high concentration in the blood to the lower concentration in your cells.

Page 35

Osmosis is the net movement of water from an area of high concentration of water to an area of lower concentration of water across a partially permeable membrane. When it rains the water is in a high concentration in the soil. This water therefore moves by osmosis into the plant through the membranes of the root hair cells.

Page 37

Active transport is the net movement of particles from an area of low concentration to an area of higher concentration using energy. Because plants absorb mineral ions from the soil they are present in higher concentrations in the plant than the soil. So plants must absorb them using active transport, which requires energy.

Activity

Page 31

1 The scent particles diffused through the wall of the balloon from an area of high concentration to an area of low concentration.
2 Heating the oil, cotton wool or balloon or increasing the concentration of oil used
3 In the alveoli, oxygen moves into the blood down a concentration gradient from where there is a high concentration of oxygen in the alveoli to where there is a lower concentration of oxygen in the blood.

Page 31

This is a model of increased surface area due to villi.

Page 33

1 Any two from: sample equipment used, same volume of dye, same soaking time, cubes all made from agar

2–4

Cube	Total surface area in cm^2 [2]	Total volume in cm^3 [2]	Surface area/ volume [3]	SA:V [4]
A	6	1	6	6:1
B	24	8	3	3:1
C	96	64	1.5	1.5:1

5 Cube A
6 Dye would have entered by diffusion (down a concentration gradient)

Required practical 2

Pages 35–6

1–3 Answers are based on the student's own work.
4 To remove excess water.
5 It took into account starting mass or removed any variation in starting mass.
6 Answer is based on the student's own results.
7 Answer is based on the student's own work.

Chapter review questions

1 The net movement of particles from an area of high concentration to an area of lower concentration.
2 Smelling someone's deodorant or perfume
3 From the lungs into the blood
4 From the blood into the lungs
5 Capillaries
6 Ventilation
7 Diffusion

8 The net diffusion of water from an area of high concentration to an area of lower concentration across a partially permeable membrane.
9 When it rains and there is a higher concentration of water in the soil, water will move by osmosis into the plant cell.
10 Stomata
11 The net movement of particles from an area of low concentration to an area of higher concentration using energy.
12 From low to high
13 Tea spreading out from a teabag or juice being diluted with water
14 They have a large surface area, moist thin membranes, a rich blood supply and breathing provides them with a regular supply of fresh air.
15 A membrane in which only small molecules can pass though
16 Because osmosis only involves water
17 It would remain the same size.
18 It would swell up, because water would move into it.
19 It would shrink, because water would move out of it.
20 Plant mineral ions exist in low concentration in the soil and in high concentration in the plant. Because the plants need to move the mineral ions from low to high concentrations, against the concentration gradient, they need to use energy. This is active transport.
21 Sugars can be in a low concentration in your digestive system and in high concentration in your blood. Therefore, because you need to move the glucose from low to high concentration, against the concentration gradient, you need to use energy. This is active transport.
22 Because some of the particles may naturally diffuse back to the area of high concentration they have just come from.
23 The size of insects is limited by the distance that oxygen can diffuse.
24 Wrap a piece of string around your clenched hand and measure the length of string that it takes to go round the largest part. Now do the same with your hand unclenched and your fingers straight.
25 As the temperature increases so does the rate of diffusion. Particles have more energy and so move faster.
26 The larger the surface area, the greater the rate of diffusion through it.
27 Make a series of salt solutions of different concentrations and place into beakers. Cut out potato chips to fit inside the beakers. Weigh all the potato chips before soaking in salt. Then, weigh them all again and calculate the percentage change in mass for each solution.

Practice questions

1 **a)** A *[1 mark]*
b) i) Diffusion is the movement of gas particles from a high concentration to a low concentration [1 mark] down a concentration gradient *[1 mark]*.
ii) Diffusion is a passive process. This means it does not require additional energy. *[2 marks]*

2 **a)** Cell A *[1 mark]*
b) i) It would increase the rate *[1 mark]*.
ii) The particles would have more (kinetic) energy so move faster. *[1 mark]*
c) i) B *[1 mark]*
ii) Idea that concentration/number of particles are the same inside and outside the cell *[1 mark]*.
d) Cell A [1 mark]

3 **a)** Vacuole larger, cell larger/fuller/turgid *[1 mark]*
b) i) It would burst/lyse *[1 mark]*
ii) There is no cell wall in an animal cell. *[1 mark]*
c) i) Drawing should show a smaller vacuole [1 mark], cell membrane not fully against the cell wall [1 mark], cell wall the same size *[1 mark]*.
ii) Any three from: water left the cells by osmosis, moved from a solution with a high concentration of water (dilute) to a solution with a low concentration of water (concentrated) down a concentration/water potential gradient through a partially permeable membrane, so the membrane came away from the cell wall, the cytoplasm took up less volume/the cell vacuole shrunk. *[3 marks]*

4 Level 3: More than one improvement described and includes collection of more data involving range of salt concentrations and/or recording a change in mass. *[5–6 marks]*

Level 2: More than one improvement described *[3–4 marks]*

Level 1: An improvement described *[1–2 marks]*

No relevant content *[0 marks]*

Indicative content: leave longer than 10 minutes; control other factors, such as temperature of solutions; repeat for each concentration of salt solution; increase range of salt concentrations;

use pure water or a 0 M salt solution; repeat investigation with other potato varieties; control volume of salt solutions used; record change of mass rather than length; record volume rather than length

Working scientifically: Dealing with data
Pages 40–1

1 No units in headers, units in table, variables in the wrong column, mixed units, inconsistent use of decimal places, no increasing trend in independent variable

2

Room temperature (°C)	Time taken to smell the deodorant (s)
10	105
15	90
20	60
25	54
30	42

3

Beaker	Volume of squash (cm^3)	Volume of water (cm^3)	Total volume (cm^3)
A	100	0	100
B	75	25	100
C	50	50	100
D	25	75	100
E	0	100	100

4

Solution/ beaker	Starting mass (g)	Mass after 5 minutes (g)	Mass after 10 minutes (g)	Mass after 15 minutes (g)	Mass after 20 minutes (g)
A					
B					
C					
D					
E					

Organisation

4 Animal tissues, organs and organ systems

Overview

Specification points

4.2.2.1 The human digestive system; 4.2.2.2 The heart and blood vessels; 4.2.2.3 Blood; 4.2.2.4 Coronary heart disease: a non-communicable disease; 4.2.2.5 Health issues; 4.2.2.6 The effect of lifestyle on some non-communicable diseases; 4.2.2.7 Cancer

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 4 pages 41–66

AQA GCSE (9-1) Combined Science Trilogy 1: Chapter 4 pages 42–66

AQA GCSE (9-1) Combined Science Trilogy: Chapter 4 pages 42–66

Recommended number of lessons: 15

Chapter overview	
AQA required practicals	Biology – RP4, RP5 CS Trilogy – RP3, RP4
Contains higher-tier only material	No
Contains biology-only material	No

Useful Teaching and Learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Practical 1
- Practical 2
- Teacher and technician notes 1
- Teacher and technician notes 2
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Key concept: Factors affecting the rate of enzyme controlled reactions
- Key concept: Enzymes
- Key concept: Using standard form
- Personal tutor: Enzymes
- Video 1: Qualitative tests on carbohydrates, proteins and lipids
- Video 2: The effect of pH on enzyme activity
- Video 3: Investigate the effect of amylase concentration on the rate of starch digestion

Useful prior learning

- The hierarchical organisation of multicellular organisms: from cells to tissues to organs to organ systems to organisms
- What is required in a healthy diet: carbohydrates (starch and sugar), lipids, proteins, vitamins, minerals, fibre and water, and why each is needed
- The organs of the human digestive system and their functions
- Basic knowledge of enzymes in the digestive system and their action
- The structure and functions of the gas exchange system in humans, including adaptations to function

Common misconceptions

- Digestion is the process which releases energy from food.
- Students often believe digestion and absorption only occur in the stomach.
- The location of the stomach is not known, with some students thinking it is in the lower abdomen.
- Enzymes are living and so extremes in temperature or pH can kill them.
- Enzymes denature at low temperatures as well as high temperatures.
- Blood transports oxygen only; sugars and wastes are transported by another means.
- Red blood cells are dead as they have no nucleus and never had one.
- Students understand that blood is a red liquid but have no understanding of what is it made up of.
- Blood from the left side of the heart goes to the left side of the body and blood from the right side of the heart goes to the right side of the body.
- The blood in veins is blue.

Preparation

The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for this unit on organ systems in the human body. This should allow you to get a get a deeper understanding of common misconceptions and desired prior knowledge from KS3.

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the next few lessons or can be reserved for recap/consolidation at the end of the topic.

Levels of organisation and diet: Lesson 1

Learning outcomes

1 Describe the structure of tissues, organs and organ systems in plants and animals.
2 Review what is required for a healthy balanced diet.

Suggested lesson plan

Starter
Provide students with the terms cell, tissue, organ, organ system and organism (mixed up) and get them to order the terms from the smallest to the largest. Students could also be asked to come up with an example for each.

Main
In the first lesson in this sequence on organisation, review students' prior understanding of the digestive system, the gas exchange system and the circulatory system. It is likely they will have studied most of these systems so it is important to know where they are with their current understanding. The student questions on the worksheet **T&L Prior knowledge catch-up student sheet** can be used to assist with this or the Test yourself on prior knowledge questions from page 42(*43*). Alternatively, you could provide three outlines of the human body and ask students to sketch on to them the organs involved in the digestive system, the circulatory system and gas exchange system and annotate them with their names and roles.

Move on to explain that the first system they will be looking at is the digestive system. Ensure students understand the role of the digestive system in breaking down large, insoluble molecules into small, soluble ones which can be transported around the body by the bloodstream.

Ask students to think about which seven components are needed for a healthy diet. You could provide them with the nutrition information from different packets to support this. Ensure students are confident with carbohydrates (sugars and starch), lipids, proteins, vitamins, minerals, dietary fibre and water. Discuss with students the role for each in the body. Allow students to consolidate this information either as a table or a poster.

Plenary
Provide students with a range of foods or images of food and ask them to suggest which of the seven components of a healthy diet they would be high in.

Support
It is worth taking the time to explain that the nutrition groups used in science are different from those used when food groups are discussed. Students often mistakenly think dairy, cereals and meats are examples used in science.

Extension
Able students could begin to discuss which of the components in a healthy diet are large macromolecules which would need to be broken down in order for them to enter the bloodstream and which do not need to be broken down.

Homework
Students could research a dietary deficiency disease and produce a poster or report on what the disease is, what the diet is lacking in, what the symptoms are and how it could be treated.

Required practical 4(*3*): Use qualitative reagents to test for a range of carbohydrates, lipids and proteins: Lesson 2

Preparation
Ensure you take the time to read over the **T&L Teacher and technician notes 1** for the Required practical so you are confident with what the students need to do and the positive and negative results of the different food tests.

Learning outcomes

1 Test for a range of carbohydrates, lipids and proteins.
2 Describe the method used in this practical.

Suggested lesson plan

Starter
Introduce the Required practical to the students, either by showing them the **T&L Video 1: Qualitative tests on carbohydrates, proteins and lipids**, allowing them to read through the method from the **T&L Practical 1** worksheet or using the method on page 47(*48*) of the textbook.

Main
Prior to starting, ensure students are confident with what they need to do in each test and what they will observe in a positive and negative result. Students should then carry out the practical.

Once finished, students can answer the relevant questions from either the textbook (page 48(*49*)) or the **T&L Practical 1** worksheet.

Plenary
Students should produce a poster or pamphlet explaining how to do each food test and the positive results. Alternatively, students could do a short quiz on the reagents, methods and results.

Support
It is important that students are confident with what the results are and that the samples chosen do not confuse the answers. With the Benedict's test students should look for a precipitate not just a colour change which may be caused by the colour of the reagent mixing with the food's colouring.

Extension
Students could be introduced to the terminology of qualitative and quantitative testing and be asked to think of the drawbacks which can be associated with qualitative testing.

Homework
Students could complete their posters/pamphlets.

The digestive system: Lesson 3

Learning outcomes

1 Describe the structure of the digestive system.
2 Explain the functions of the organs of the digestive system.

Suggested lesson plan

Starter
Use the **T&L Lesson starter 1** to check students' understanding of the digestive system.

Main
Discuss the organs of the digestive system, their location and role. You could provide students with a sheet of white wallpaper and ask them to draw around one student and then, using sticky notes, write the organs of the digestive system and stick them into place on the outline.

Alternatively, students could model the digestive system so they are confident with what each organ is doing. You could provide the students with a zip-lock bag and a couple of crackers and some oats. Explain that this is first representing the mouth and get them to 'chew' the food by crunching the bag in their hands. Ask them what gets mixed with the food in the mouth and elicit the idea of saliva. Students can add water from a pipette to represent the salivary glands adding saliva. With this added, they should find that as they 'chew' they create a bolus of food. Ask the students where the food would go next and allow them to squeeze the bolus from one corner of the bag to another to represent food moving down the oesophagus by peristalsis. Ask students what is found in the stomach and add water with food colouring to represent stomach acid. Allow the students to churn the food together. After this, explain that the food passes into the small intestine (you may want to add enzymes and bile to show this happens). This is difficult to model so you could instead get students to dunk a paper towel into the mixture and then move it to a bowl marked 'blood' to highlight that substances are absorbed from the small intestine into the blood. Alternatively, you could place the mixture in a cut-off leg from a pair of tights and allow some of the liquid to pass out into a tray labelled 'blood'. Explain that the rest of the material passes into the large intestine. Students could squeeze out the excess water from the tights to show that the excess water is absorbed in the large intestine and faeces are formed. Finally students can cut the end of the tights and eliminate the indigestible fibre.

Discuss with students the role of the villi in maximising absorption of water and nutrients in the small and large intestine. This provides an opportunity to review exchange systems and their features.

Plenary
Students can complete the Test yourself questions on page 45(*46*) of the textbook.

Support
Ensure students are confident with the correct scientific terminology for the organs of the digestive system (particularly 'oesophagus' rather than 'gullet') and the locations of these organs; students are often unsure of the location of the stomach.

Extension
Students can start thinking about where chemical and physical digestion occur in the digestive system.

Homework
Students can complete question 1 from the Practice questions on page 64.

Enzymes: Lesson 4

Learning outcomes

1 Describe the action of the enzymes of the digestive system and their locations.
2 Describe the effects of bile on fats.
3 Explain how the lock and key hypothesis models enzyme action.

Suggested lesson plan

Starter

Introduce enzymes by demonstrating the effect of catalyse on hydrogen peroxide. Ensure you risk assess first. Add hydrogen peroxide to a measuring cylinder or conical flask, adding a small amount of washing up liquid, and then add some chopped up liver to the mixture. The catalase in the liver will catalyse the breakdown of hydrogen peroxide releasing oxygen which is caught by the washing up liquid. Ensure you explain that the reaction happens without the enzyme, it just happens more slowly.

Main

Explain that enzymes are proteins and that there are three types of digestive enzymes. They should be confident with where they are found and what they act on. The **T&L Key concept: Enzymes** can be used to support this. The lock and key hypothesis can also be introduced here.

Students could be given the opportunity to produce models of this so they can show they understand the specificity of enzymes and importance of the active site being complementary to the substrate.

You may wish to carry out a simple enzyme–substrate reaction involving starch and a carbohydrase in Visking tubing. This will help students understand the role digestive enzymes play in digestion and provides a useful recap of the food tests for carbohydrates.

Plenary

Students could complete **T&L Quick quiz 1**. Alternatively, they could do a matching card sort activity to ensure they are confident with the three types of enzymes, the substrates they act on, what is produced and where they are found in the digestive system.

Support

Ensure that you are linking the action of enzymes back to digestion so the students are confident that enzymes are acting to break down large, insoluble molecules into small, soluble ones which can pass into the blood. This end stage is often forgotten and students think the products remain in the digestive system.

Extension

Students should be encouraged to evaluate the strengths and weaknesses of the lock and key hypothesis.

Homework

Students could research the role that bile plays in the digestive system and how it supports lipase in digesting lipids.

Enzymes 2: Lesson 5

Learning outcomes

1 Describe conditions which denature enzymes.
2 Explain how enzymes are denatured using the lock and key hypothesis.

Suggested lesson plan

Starter

Start with a review of what students have learnt in the previous lesson by either doing a matching activity or a card sort.

Main

Explain that enzymes have an optimal temperature and pH at which they work best and that they become denatured at higher temperatures and extremes of pH. Allow students to explore this through practical work. (pH will be covered in the Required practical.)

Alternatively, you might like to model this with the students. Set up two desks around 3 m apart. On one desk provide a pile of tooth picks. Ask a student to pick up a tooth pick in one hand and then carry it to the other desk where they need to break it (using only one hand). Time how many tooth picks they can break in 15 seconds when they walk between the desks slowly. Ask another student to repeat this process but allow them to walk as quickly as they can. Then with a third student, tape up their hand so they will struggle to pick up and break a tooth pick and allow them move even quicker between the desks. This can be used to model the idea that at low temperatures the enzymes are moving slowly as they have low kinetic energy, and may not have enough activation energy. As the temperature increases, the enzymes move faster. Eventually the temperature will become so high that the active sites will denature and the enzymes can no longer act to break down the substrate.

Students could complete the Activity on page 50 (Biology only) which explores data on enzyme action and pH.

Plenary

The Test yourself questions from page 50 can be used to check students' understanding of enzymes.

Support

Ensure students do not incorrectly assume that all enzymes work best at 37 °C; only human enzymes do as that is our core body temperature. It is also important to check their understanding of denaturing. Make sure students understand that enzymes don't die and that low temperatures do not denature enzymes.

Extension
Students can also investigate the effect of concentration on enzyme action. The **T&L Video 3: Investigate the effect of amylase concentration on the rate of starch digestion** can be used to introduce this.

Homework
Students can complete the Working scientifically task from pages 65–6 of the textbook.

Required practical 5(*4*): Investigate the effect of pH on the rate of reaction of amylase enzyme: Lesson 6

Preparation
Ensure you take the time to read over the **T&L Teacher and technician notes 2** so you are confident with what the students need to do in the Required practical. Trial the practical in advance to ensure that it will work; enzyme-controlled reactions are often temperamental.

Learning outcomes

1 Determine the effect of pH on the rate of reaction of amylase enzyme.
2 Describe the method used in this practical.

Suggested lesson plan

Starter
Introduce the Required practical to the students by showing them the practical video, allowing them to read through the method from the **T&L Practical** worksheet or using the method on page 49(*50*) of the textbook.

Main
Prior to starting, ensure students are confident with what they need to do. Reviewing what the results of the starch test mean before you start is useful; students need to realise they are looking for a negative result to show the starch has been digested. Students should then carry out the practical.

Once finished, students can answer the relevant questions from either the textbook page 49(*50*) or **T&L Practical** worksheet.

Plenary
Take the time to discuss the issues arising from the practical, highlighting the difficulty of determining the exact point when the enzymes have digested the starch with the sampling timing used.

Support
Students may need an explanation of how to carry out rate calculations and what the units are for rate. Scaffolding this for them will support them in understanding what to do and why we use rate rather than time.

Extension
Students could be encouraged to adapt the method used to gain more valid and accurate data.

Required practical 5(*4*) write-up: Lesson 7

Learning outcomes

Write up the experiment, analyse the results, draw conclusions and evaluate the experimental method.

Suggested lesson plan

Starter
Review the findings of the previous lesson and draw together the class results to determine the optimum pH for amylase based on the data obtained.

Main
Students should use the lesson to complete the practical, write up their method, produce a graph of their results, draw a conclusion and evaluate the experiment. The questions on the **T&L Practical** worksheet or page 49(*50*) can support this.

Plenary
Take the time to summarise the practical with the students and ensure they are confident with the skills learnt, particularly continuous sampling techniques and the difficulties with this in determining a valid result.

Support
Students may need an explanation of how to carry out rate calculations and what the units for rate are. Scaffolding this for them will support them in understanding what to do and why we use rate rather than time.

Extension
Students could be encouraged to adapt the method used to gain more valid and accurate data.

Homework
Finish off any write-up or questions from class. Alternatively, students could produce a summary poster on the digestive system or write an account of how a sandwich might get digested.

The heart: Lesson 8

Learning outcomes

1 Describe the structure of the heart.
2 Explain how its structure is related to its function.

Suggested lesson plan

Starter

Introduce the topic of the heart by giving students some questions about the heart and getting them to guess at the correct answer; for example, how many times does a heart beat in an average lifespan.

Main

Explain the external and internal structure of the heart to the students. They should be able to recall the names of the chambers, identify valves and have a basic understanding of the blood vessels which enter and leave the heart.

Allow students to carry out a heart dissection so they can locate and name the structures and vessels. It is useful to provide the students with pins and sticky labels so they can show you what they think the different parts are. The blood vessels may have been removed from the hearts but get students to think about the vessels bringing blood to and away from the heart.

Students can start exploring how the structure of the different sides of the heart and the main blood vessels are adapted to their function.

Explain that the heart muscle can generate its own impulses to make the heart contract due to the myogenic tissue in the pacemaker region.

Develop students' understanding of the route that blood takes around the body and the nature of the double circulatory system in humans.

Plenary

Provide students with a diagram which they can label to show they are confident with the structure of the heart and the route blood takes around the body starting at the left atrium.

Support

When discussing the heart, ensure students are confident with which side of the heart is which and don't simply label based on their own left and right.

Show students pictures of the coronary arteries or get them to label these during the heart dissection. Students often misunderstand how the heart muscle receives blood and think that the blood inside the heart is bringing the oxygen, glucose and other molecules the heart needs.

Extension

Students could research single circulation in fish or open circulation in insects to compare this to our double circulation system.

Homework

Students could be set a research homework to look at diseases of the heart particularly CHD which will be covered later.

Blood vessels: Lesson 9

Learning outcomes

1 Describe the structure of veins, arteries and capillaries.
2 Explain how their structure is related to their function.
3 Carry out rate calculations for blood flow.

Suggested lesson plan

Starter

To begin with, ask the students to name the four main blood vessels that bring blood to and carry blood away from the heart. Use this to introduce the idea that there are three main types of blood vessel which they will need to know about.

Main

Set students a research task where they need to find information on arteries, veins and capillaries. They should explore what the function of each is and how they are adapted to this function.

To show that students are confident with how the structures of the different blood vessels are linked to their function, ask them to produce models from plasticine to show the features of each. They should be able to explain how these features allow the vessels to carry out their role. Alternatively, students could be provided with microscope slides of transects of blood vessels or diagrams for them to identify.

Students could carry out a practical to examine blood flow rates by timing how long it takes for fake blood to pass through tubing of various different diameters and then determining a rate from this. Alternatively, they could look at the effect of blood vessel blockages and narrowing on the blood flow rate.

Plenary

Students could complete the Test yourself questions from page 54.

Support

Ensure students are confident with the relative sizes of the three types of blood vessels. Pictures of capillaries often show them enlarged and students mistakenly think they are large vessels but very thin. Avoid using the term 'wall' when discussing capillaries as students may confuse a cell wall with a capillary wall.

Extension

More able students could be given further detail on the specific tissue layers which make up the internal structure of blood vessels and their roles.

Homework
Students could produce a summary poster on the main types of blood vessels including their structure and function.

Blood: Lesson 10

Learning outcomes

1 Describe the four components of blood.
2 Recognise different types of blood cells in a photograph or diagram.
3 Explain how their structure is related to their function.

Suggested lesson plan

Starter
A nice way to introduce this topic is to demo making blood with the students to show the different components it is made from. This is useful in highlighting to students that blood is not just a red liquid but a mixture of cells, plasma and dissolved substances.

Main
You could carry out a jigsaw activity with the students whereby they work in small groups and each is given a specific component to research, specifically their role and how they are adapted to their role. They then divide up and each member of the group visits another group to discuss and explain their component with them. This way all the students can learn about all the components in blood.

Students could then examine pictures of blood cells or observe slides under the microscope to identify the different blood cells.

Plenary
Students can complete the Test yourself questions from page 56.

Homework
Students could create a summary poster on the circulatory system discussing the heart structure, circulation, blood vessels and blood.

Gas exchange systems: Lesson 11

Learning outcomes

1 Describe the structure of the gas exchange system.
2 Explain how its structure is related to its function.

Suggested lesson plan

Starter
Assess students' prior understanding of the gas exchange system from KS3 by giving them a quick quiz on the main structures and the gases which are exchanged.

Main
Discuss the structures of the gas exchange system and ensure students can label these on a diagram and discuss the route that air takes. If you are able, you could show the students a pluck and use this to bring together all the major organs discussed so far.

Review students' understanding of the alveoli and how they are adapted for gaseous exchange.

You may want the students to produce a working bottle model of the breathing system so they understand how breathing occurs and the role of the diaphragm in breathing.

Plenary
Provide students with a diagram of the gas exchange system and ensure they can label the main parts and describe the adaptations of the alveoli.

Support
Spend time ensuring that students understand the difference between inhaled and exhaled air. It is common for students to simplify this to suggest we breathe in oxygen only and breathe out carbon dioxide only.

Extension
Students could link the adaptations of the gas exchange system to what they have learnt about other exchange systems. If not done previously, they could dissect a fish head to compare the structures of the gills with alveoli.

Homework
Students could complete the Practice questions from page 64 to assess their knowledge of the unit so far.

Coronary heart disease: Lesson 12

Learning outcomes

1 Describe the methods used to treat cardiovascular disease.
2 Evaluate the advantages and disadvantages of these treatments.

Suggested lesson plan

Starter

Start by showing the **T&L Lesson starter 2** to introduce the lesson topic of CHD and the risk factors involved.

Main

Introduce the topic of CHD and explain how a build up of fatty material in the coronary arteries can reduce or even stop the flow of blood to the heart. This means oxygenated blood and glucose cannot get through so the cells can't carry out respiration and may die, causing a heart attack. It is useful to show students a video of this so they understand the process and what occurs in atherosclerosis.

Discuss with the students the risk factors for CHD and how it can be prevented.

Allow the students to explore the topic of heart disease treatment in more detail. They should research the drugs (statins), mechanical devices (stents) and surgical methods used to treat coronary heart disease. Students should be able to evaluate the advantages and disadvantages of these different methods of treating cardiovascular diseases. Useful websites to support their research are:

NHS coronary heart disease

www.nhs.uk/Conditions/Coronary-heart-disease/Pages/Introduction.aspx

The British Heart Foundation

www.bhf.org.uk/heart-health/conditions/coronary-heart-disease

Plenary

Students should produce their own information pamphlet for people suffering from CHD outlining the possible treatments and the benefits and drawbacks of each.

Support

Ensure students understand that it is the coronary arteries which supply the heart muscle with oxygenated blood. Students may mistakenly misinterpret the fact the heart is full of blood and believe that this is how the heart muscle gets the oxygen and nutrients it needs.

Extension

More able students can explore more issues with the heart such as 'hole in the heart' and why some people need an artificial pacemaker.

Homework

Students can research and produce a summary report or poster on the issues that can arise due to faulty heart valves. They should also research methods of replacing the valves with biological or mechanical methods.

Health and disease: Lesson 13

Learning outcomes

1 Define the terms health and disease.
2 Describe factors that affect them.
3 Describe the effects of non-communicable diseases.
4 Discuss the human and financial costs of these diseases.

Suggested lesson plan

Starter

Start by asking the students what the term 'health' means and ask them to write their ideas down on a whiteboard or sticky note. Use this to highlight the fact that the term is used frequently but often without a true understanding of its actual meaning.

Main

Define the term 'health' to students and allow them to come up with ideas for factors which contribute to health. Discuss these and summarise the key components of a healthy lifestyle.

Move on to a discussion of non-communicable diseases and explain that these are diseases which cannot be passed on from person to person. Explain that CHD is a non-communicable disease and ask the students to come up with other examples.

Explain that unlike communicable diseases which are caused by pathogens, it is often difficult to determine the cause of non-communicable diseases and that they can be due to the interaction between many different risk factors.

Use some of the non-communicable diseases the students have suggested and ask them to identify what the different risk factors are. Ensure you discuss how different risk factors can interact to cause disease.

Plenary

Provide the students with some case studies of different patients and get them to read about their lifestyle and determine what risk factors they have and what non-communicable diseases their lifestyles could lead to. Alternatively students could answer the Test yourself questions from page 59.

Support

You could provide lower ability students with a card sort activity with different diseases and ask them

to sort them into those that are communicable and those that are non-communicable diseases.

Extension
You could provide students with data on non-communicable diseases such as cardiovascular disease (www.bhf.org.uk/research/heart-statistics) and get them to work out percentages of incidence of the disease in different areas of the country and look for trends in the data.

Homework
Students should research the human and financial costs of a non-communicable disease such as CHD or lung cancer.

Correlation and causation: Lesson 14

Learning outcomes

Translate information between graphical and numerical forms.

Suggested lesson plan

Starter
Provide the students with spurious correlations such as number of ice cream sales correlating with incidences of drowning or number of churches correlating with number of pubs. Ask them to describe what the graphs are showing and what they think about the data. Use this to start the discussion that correlation does not prove causation.

Main
Provide students with data on smoking and lung cancer from a source such as Action on Smoking and Health (http://ash.org.uk/files/documents/ASH_107.pdf) and get them to plot the data. Use this to start the discussion as to whether this is a simple correlation or if there can be causation.

Move the discussion on to explain that we know now that there are chemicals in tobacco which are known to be mutagenic and so the causation is understood. This archived video from the BBC can be used to show the original news story on this: www.bbc.co.uk/news/health-17232532

Where possible, provide the students with more data on non-communicable diseases which they can interpret and use to describe trends. Students should practise producing graphs of numerical data and interpreting graphs to provide numerical data.

Plenary
Students could self assess or peer assess their graphs. Alternatively, they could be given a range of scientific claims and be asked to decide whether they think they are linked and so show a correlation or if there is causation.

Support
Ensure students are confident with correlations and know how to interpret them as positive and negative. This lesson provides an opportunity to assess students' graphing skills and their interpretation of data. For lower ability students you may want to adapt the data to make it easier for plotting so they can more easily interpret it and describe trends.

Extension
Students can review risk factors in more detail and rank them as those most likely to cause a non-communicable disease and those least likely to.

Homework
Students could produce a poster or timeline on how the link between smoking and cancer was discovered.

Cancer: Lesson 15

Learning outcomes

1 Define the term cancer and describe its effect.
2 Explain the difference between benign and malignant tumours.

Ensure this topic is treated sensitively.

Suggested lesson plan

Starter
Start by asking students what cancer is and what types of cancer they have heard of.

Main
Use a video to introduce what cancer is and how it occurs, for example:

- www.cancercenter.com/what-is-cancer/
- www.macmillan.org.uk/cancerinformation/testfolder/whatiscancer.aspx

Ensure students understand that tumours are formed by uncontrolled mitotic cell division and the difference between malignant and benign tumours. Students could make a flow diagram or comic strip to show how tumours develop.

Students could produce a bar graph or pie chart to show the most common cancers in the UK or interpret this information from given graphs. Alternatively, they could research the risk factors for cancers or sort given risk factors into those that can be controlled or avoided and those that cannot.

Students could summarise their findings into a poster or pamphlet to explain what cancer is, how tumours develop and the causes of cancer.

Plenary
Students could complete the Test yourself questions from page 61 of the textbook.

Support
This topic provides an opportunity to support students in calculating percentages from given data. It may be of benefit to speak to the maths department to find out the methods they use to calculate percentages with population data.

Extension
Students could research treatments for cancer such as chemotherapy and radiotherapy.

Homework
Students can complete the **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 The large intestine
2 They can digest some substances that we can't and they stop harmful bacteria surviving there.
3 Any excess sugar in a person's diet is stored as fat, which can make them obese.

Test yourself

1 7 metres
2 Bile
3 Muscles along the length of the outside of your small intestine contract behind lumps of food to move it along.
4 They have a large surface area and rich blood supply to absorb as much digested food as possible.
5 Amylase
6 Amino acids
7 Breakdown enzymes break substrates down. Synthesis enzymes join substrates together.
8 Extremes of temperature and pH
9 Away from the heart
10 Atria and ventricles
11 They have one-way valves to reduce backflow of blood.
12 It has to pump blood further to the rest of the body.
13 Phagocytes and lymphocytes
14 Straw-coloured or yellow
15 Haemoglobin reacts with oxygen to form oxyhaemoglobin
16 They have a biconcave shape, which increases their surface area to absorb more oxygen, and they have no nucleus, which also enables them to carry more oxygen.
17 A reduction in the flexibility of the blood vessels
18 Arteries, capillaries and veins
19 To generate an electrical impulse to coordinate the pumping of the heart's chambers
20 By eating a balanced diet, not smoking, not drinking too much and taking regular exercise
21 Physical and mental wellbeing
22 Speak to an adult (preferably your parents, a teacher or your doctor)
23 Balanced diet, regular exercise, reduce stress, seek medical help
24 To provide you with key nutrients required
25 Breast, lung, prostate, bowel
26 Men: prostate or testicular cancer; women: cervical or uterine cancer (do not accept breast only for women)
27 Malignant describes a cancerous tumour that spreads; benign describes a tumour that is not cancerous and does not spread.
28 Many cancers can be prevented by living as healthy a lifestyle as possible. This means not smoking, drinking alcohol in moderation, eating a healthy diet and exercising regularly.
29 Cancer
30 Liver and brain
31 Cells stop responding to insulin so excess glucose is not absorbed by the liver cells.

Show you can

Page 45

Mouth: food is broken down by teeth and mixed with saliva. Oesophagus: food moves to the stomach. Stomach: food is mixed with acid and enzymes. Small intestine: nutrients are absorbed into the blood. Large intestine: water is absorbed into the blood. Anus: undigested food passes from the anus.

Page 50

Carbohydrase enzymes are produced in the mouth. Protease enzymes are produced in the stomach. Carbohydrase, lipase and protease enzymes are produced in the pancreas and small intestine.

Page 54

Blood is forced from the left ventricle when it contracts. The blood is pumped into the aorta, which takes it to the rest of the body. After moving through the body's tissues it returns to the right atrium of the heart in the vena cava. It is pumped into the right ventricle and then into the pulmonary artery to the lungs. It returns from the lungs to the heart in the pulmonary vein and enters the left atrium.

Page 56

Red blood cells carry oxygen from the lungs to the cells. White blood cells fight off infection from pathogens. Platelets form scabs. Plasma is the liquid in which the cells are held and substances like glucose are dissolved.

Page 58

Stents are small mesh devices that hold arteries open. A bypass is when a section of artery is moved to the heart. It is used to allow blood to flow around a blockage. Stents are less damaging and so preferred by doctors.

Page 59

Stress is the feeling of being under too much mental or emotional pressure. Anxiety is a feeling of unease which might be worry or fear. Depression can lead to feelings of sadness and hopelessness and losing interest in things you used to enjoy.

Page 61

Chemotherapy uses very powerful drugs to kill cancer cells. Radiotherapy uses X-rays to kill cancer cells. Common side effects are feeling tired and weak, being sick and losing your hair.

Page 62

Causation is the act of causing an outcome. Correlation is when an action and outcome are linked but when the action does not cause the outcome. Lung cancer is caused by smoking. There is a correlation between increasing age and illness.

Required practical 4
Pages 47–8

1 Answers will depend on the school
2 Starch test: iodine solution remains orangey-brown; glucose: Benedict's reagent remains light blue; protein: biuret solution remains pale blue; lipids: no emulsification seen
3 As they deal with perceptions of colour, something that cannot be empirically measured and different people will have different views on them.
4 Task: no answer is required

Required practical 5
Page 49

1 To allow time for the tubes to reach the required temperature
2 Task: no answer is required
3 Answer is based on the student's graph
4 Answer is based on the student's answer
5 Increase the frequency at which the samples are taken and tested.

Activity
Page 50

1 Mean results are: pH2, 32.8; pH4, 19.8; pH6, 5.8; pH8, 0.0; pH10, 1
2 Task: no answer is required
3 Anomalous results are: the pH10 result in Repeat 3, the pH2 result in Repeat 2, the pH6 result in Repeat 3.
4 pH2 is optimal; the enzyme has the highest enzyme activity here, therefore it digests the most gelatine. As the pH changes, the activity of the enzymes decreases as the effectiveness of the reaction is reduced. Eventually there is no activity as the enzyme has denatured.

Chapter review questions

1 To lubricate food as it is swallowed
2 The gall bladder
3 Carbohydrase, lipase and protease
4 Absorption of water
5 The heart
6 Away from the heart
7 Blood passes through it twice on every circuit of the body.
8 Malignant tumours are cancerous and spread; benign tumours are not cancerous and do not spread.
9 Common side effects are feeling tired and weak, being sick and losing your hair.
10 Stents are less invasive and less dangerous. It is faster to recover from an operation in which they are inserted.
11 To break it down into small enough pieces to be absorbed into our blood
12 A biological molecule that speeds up a reaction
13 Protease, amino acids
14 Carbohydrase, sugars
15 Lipase, fatty acids and glycerol
16 Add a small volume of boiled and unboiled amylase to two test tubes of starch and incubate at room temperature. Several minutes later, check for the presence of glucose using the Benedict's test. The unboiled amylase will break down the starch into glucose. The boiled amylase is denatured and so no glucose will be produced.
17 Extremes of temperatures and pH
18 The pH at which the enzyme works most effectively
19 Left atrium, left ventricle, rest of body, right atrium, right ventricle, lungs, left atrium
20 They are extremely thin to allow as much oxygen to diffuse from the blood into the cells and as much carbon dioxide to diffuse the opposite way.
21 They engulf pathogens and destroy them with enzymes

22 Coronary arteries
23 Breathlessness, tiredness, dizziness and chest pain
24 Screening can be feeling a bump to see if it is a tumour, and taking blood tests, urine tests or X-ray images. Doctors can also use monoclonal antibodies.
25 HPV stands for human papillomavirus. Infection with HPV can cause cancer.
26 Sleep badly, lose their appetite and have difficulties concentrating
27 Anxiety is a feeling of unease, which might be worry or fear.
28 Push the ball into the pair of tights. Contract your hands around the tights immediately behind the ball to push it through them. This models the muscles pushing food through the intestines.
29 Peristalsis is the rhythmical contraction of muscle behind food in the digestive system to push it along.
30 The enzyme is specific for the substrate and fits into it to break it down just like a key is specific for a lock and fits into it.
31 The active site
32 The lock has changed shape and the key will no longer fit it. So the enzyme's active site has changed shape and will no longer fit the substrate.
33 The blood does not clot as quickly as it should do.
34 High blood pressure, smoking, excessive alcohol, high cholesterol and poor diet
35 Inserting a stent is less dangerous and faster to recover from

Practice questions

1 a) i) Stomach
ii) Small intestine
b) Absorbing water and salts from the remaining digested food
c) i) B (small intestine)
ii) 1 mark for description, 1 mark for paired explanation. Description – good blood supply; explanation – quickly removes digested products/maintains the concentration gradient. Or: description – thin wall/wall only one cell thick; explanation – short diffusion distance/ small distance for food to travel
d) i) Peristalsis
ii) (Rhythmic) contraction [1] of muscle (in the walls) [1]
2 A: stent
3 a) Too large to be absorbed/pass into the bloodstream or to make them soluble
b) The active site
4 a) A = artery, B = vein, C = capillary
b) (Deposits) slow or stop oxygen reaching heart cells, which causes the cells to die.
c) White blood cells, platelets, plasma, red blood cells
5 Level 3: A correct description of what reagent is used and what positive results look like for each food test; also extra detail of how to carry out the test. *[5–6 marks]*
Level 2: A correct description of what reagent is used and what positive results look like for at least two food tests; may be extra detail of how to carry out one test. *[3–4 marks]*
Level 1: A correct description of what reagent is used or what positive results look like for one food test. *[1–2 marks]*
No relevant content: *[0 marks]*
Indicative content:

Glucose: use Benedict's reagent/solution; positive result is brick red/red/orangey red; around 10 drops or 1–2 cm^3 could be used; the solution needs to be heated; the solution is bright blue to begin with

Starch: use iodine reagent/solution; positive result is blue-black/dark blue; around 5–10 drops could be used; the solution is orangey brown to begin with

Protein: use biuret reagent/solution; positive result is light purple/lilac/mauve; around 10 drops or 1–2 cm^3 could be used; the solution is light blue to begin with

Working scientifically: Scientific thinking
Pages 65–6

1 It shows the specificity of enzymes and how only one substrate can fit into a specific active site.
2 Enzymes are not rigid structures like a lock and key and the active site will change shape slightly to accommodate the substrate as it bonds.
3 It fails to represent that the substrate is changed in the active site as a reaction is catalysed.
4 Visking tubing represents the small intestine or villi; the water represents the blood.
5 Because the amylase enzyme has not digested the starch into glucose at the start. As the experiment proceeds, the starch is broken down into glucose by the action of the enzyme.
6 Starch is too large to pass through the Visking tube membrane.
7 The water does not move or circulate like blood, so there is no concentration gradient established. The digestive system is much more complex and the organs are not all represented. The Visking tube has no villi.
8 Task: no answer is required.

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge

1 The large intestine
2 They can digest some substances that we can't and they stop harmful bacteria surviving there.
3 Any excess sugar in a person's diet is stored as fat, which can make them obese.
4 Organism > organ system > organ > tissue > cell

Test yourself

1 Bile
2 Muscles along the length of the outside of your small intestine contract behind lumps of food to move it along.
3 They have a large surface area and rich blood supply to absorb as much digested food as possible.
4 Amylase
5 Amino acids
6 Breakdown enzymes break substrates down. Synthesis enzymes join substrates together.
7 Extremes of temperature and pH
8 Away from the heart
9 Atria and ventricles
10 They have one-way valves to reduce backflow of blood.
11 It has to pump blood further to the rest of the body.
12 Phagocytes and lymphocytes
13 Straw-coloured or yellow
14 Haemoglobin reacts with oxygen to form oxyhaemoglobin.
15 They have a biconcave shape, which increases their surface area to absorb more oxygen. They have no nucleus, which also enables them to carry more oxygen.
16 To generate an electrical impulse to coordinate the pumping of the heart's chambers
17 By eating a balanced diet, not smoking, not drinking too much and taking regular exercise
18 Physical and mental wellbeing
19 Speak to an adult (preferably a teacher, your parents or your doctor)
20 Balanced diet, regular exercise, reduce stress, seek medical help
21 Breast, lung, prostate, bowel
22 Men: prostate or testicular cancer; women: cervical or uterine cancer (do not accept breast only for women)
23 Malignant describes a cancerous tumour that spreads; benign describes a tumour that is not cancerous and does not spread.
24 Many cancers can be prevented by living as healthy a lifestyle as possible. This means not smoking, drinking alcohol in moderation, eating a healthy diet and exercising regularly.
25 Cancer
26 Liver and brain
27 Cells stop responding to insulin. Excess glucose is not absorbed by the liver cells.

Show you can

Page 46

Mouth: food is broken down by teeth and mixed with saliva. Oesophagus: food moves to the stomach. Stomach: food is mixed with acid and enzymes. Small intestine: nutrients are absorbed into the blood. Large intestine: water is absorbed into the blood. Anus: undigested food passes from the anus.

Page 50

Carbohydrase enzymes are produced in the mouth. Protease enzymes are produced in the stomach. Carbohydrase, lipase and protease enzymes are produced in the pancreas and small intestine.

Page 54

Blood is forced from the left ventricle when it contracts. The blood is pumped into the aorta, which takes it to the rest of the body. After moving through the body's tissues it returns to the right atrium of the heart in the vena cava. It is pumped into the right ventricle and then into the pulmonary artery to the lungs. It returns from the lungs to the heart in the pulmonary vein and enters the left atrium.

Page 56

Red blood cells carry oxygen from the lungs to the cells. White blood cells fight off infection from pathogens. Platelets form scabs. Plasma is the liquid in which the cells are held and substances like glucose are dissolved.

Page 58

Stents are small mesh devices that hold arteries open. A bypass is when a section of artery is moved to the heart. It is used to allow blood to flow around a blockage. Stents are less damaging and so are preferred by doctors.

Page 59

Stress is the feeling of being under too much mental or emotional pressure. Anxiety is a feeling of unease, which might be worry or fear. Depression can lead to feelings of sadness and hopelessness, and losing interest in things you used to enjoy.

Page 62

Causation is the act of causing an outcome. Correlation is when an action and outcome are linked but when the action does not cause the

outcome. Lung cancer is caused by smoking. There is a correlation between increasing age and illness.

Required practical 3

Pages 48–9

1 Answer will depend on the teacher's choice.
2 Starch test: iodine solution remains orangey brown; glucose test: Benedict's reagent remains light blue; protein test: biuret solution remains pale blue; test for lipids: no emulsification seen
3 As they deal with perceptions of colour, something that cannot be empirically measured and different people will have different views on them.
4 Task: no answer is required

Required practical 4

Page 50

1 To allow time for the tubes to reach the required temperature
2 Task: no answer is required
3 Answer is based on the student's graph
4 pH changes will change the structure of the amylase molecule including the shape of the active site.
5 Increase the frequency at which the samples are taken and tested.

Chapter review questions

1 To lubricate food as it is swallowed
2 The gall bladder
3 Carbohydrase, lipase and protease
4 Absorption of water
5 The heart
6 Away from the heart
7 Blood passes through it twice on every circuit of the body
8 Malignant tumours are cancerous and spread; benign tumours are not cancerous and do not spread.
9 Stents are less invasive and less dangerous. It is faster to recover from an operation in which they are inserted.
10 To break it down into small enough pieces to be absorbed into our blood
11 A biological molecule that speeds up a reaction
12 Protease; amino acids
13 Carbohydrase; sugars
14 Lipase; fatty acids and glycerol
15 Add a small volume of boiled and unboiled amylase to two test tubes of starch and incubate at room temperature. Several minutes later, check for the presence of glucose using the Benedict's test. The unboiled amylase will break down the starch into glucose. The boiled amylase is denatured and so no glucose will be produced.
16 Extremes of temperature and pH
17 The pH at which the enzyme works most effectively
18 Left atrium, left ventricle, rest of body, right atrium, right ventricle, lungs, left atrium
19 They are extremely thin to allow as much oxygen to diffuse from the blood into the cells and as much carbon dioxide to diffuse the opposite way.
20 They engulf pathogens and destroy them with enzymes.
21 Coronary arteries
22 Breathlessness, tiredness, dizziness and chest pain
23 Screening can be feeling a bump to see if it is a tumour, and taking blood tests, urine tests or X-ray images. Doctors can also use monoclonal antibodies.
24 Anxiety is a feeling of unease, which might be worry or fear.
25 The enzyme is specific for the substrate and fits into it to break it down just like a key is specific for a lock and fits into it.
26 The active site
27 The lock has changed shape and the key will no longer fit it. So the enzyme's active site has changed shape and will no longer fit the substrate.
28 The blood does not clot as quickly as it should do.
29 High levels of cholesterol lead to fatty substances building up in the walls of the coronary arteries. The arteries get narrower reducing the amount of oxygen getting to the cells of the heart.
30 Inserting a stent is less dangerous and faster to recover from.

Practice questions

1 **a) i)** Stomach *[1 mark]*
ii) Small intestine *[1 mark]*
b) Absorbing water and salts from the remaining digested food *[1 mark]*
c) i) B (small intestine) *[1 mark]*
ii) 1 mark for description, 1 mark for paired explanation. Description – good blood supply; explanation – quickly removes digested products/maintains the concentration gradient. Or: description – thin wall/wall only one cell thick; explanation – short diffusion distance/ small distance for food to travel. *[2 marks]*
d) i) Peristalsis *[1 mark]*
ii) (Rhythmic) contraction [1 mark] of muscle (in the walls) *[1 mark]*
2 A: stent *[1 mark]*
3 **a)** Too large to be absorbed/pass into the bloodstream or to make them soluble *[1 mark]*

b) The active site *[1 mark]*

4 **a)** A = artery, B = vein, C = capillary [3 marks]

b) (Deposits) slow or stop oxygen reaching heart cells which causes the cells to die. *[2 marks]*

c) (From top) white blood cells, platelets, plasma, red blood cells *[4 marks]*

5 Level 3: A correct description of what reagent is used and what positive results look like for each food test; also extra detail of how to carry out the test. *[5–6 marks]*

Level 2: A correct description of what reagent is used and what positive results look like for at least two food tests; may be extra detail of how to carry out one test. *[3–4 marks]*

Level 1: A correct description of what reagent is used or what positive results look like for one food test. *[1–2 marks]*

No relevant content: *[0 marks]*

Indicative content:

Glucose: use Benedict's reagent/solution; positive result is brick red/red/orangey red; around 10 drops or 1–2 cm^3 could be used; the solution needs to be heated; the solution is bright blue to begin with.

Starch: use iodine reagent/solution; positive result is blue-black/dark blue; around 5–10 drops could be used; the solution is orangey brown to begin with.

Protein: use biuret reagent/solution; positive result is light purple/lilac/mauve; around 10 drops or 1–2 cm^3 could be used; the solution is light blue to begin with.

Thinking scientifically: Scientific thinking

Pages 65–6

1 It shows the specificity of enzymes and how only one substrate can fit into a specific active site.

2 Enzymes are not rigid structures like a lock and key and the active site will change shape slightly to accommodate the substrate as it bonds.

3 It fails to represent that the substrate is changed in the active site as a reaction is catalysed.

4 Visking tubing represents the small intestine or villi; the water represents the blood.

5 Because the amylase enzyme has not digested the starch into glucose at the start; as the experiment proceeds, the starch is broken down into glucose by the action of the enzyme.

6 Starch is too large to pass through the Visking tubing.

7 The water does not move or circulate like blood, so there is no concentration gradient established. The digestive system is much more complex and the organs are not all represented; the Visking tube has no villi.

8 Task: no answer is required

5 Plant tissues, organs and organ systems

Overview

Specification points

4.2.3.1 Plant tissues; 4.2.3.2 Plant organ systems

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 5 pages 67–77

AQA GCSE (9-1) Combined Science Trilogy 1: Chapter 5 pages 67–77

AQA GCSE (9-1) Combined Science Trilogy: Chapter 5 pages 67–77

Recommended number of lessons: 3

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	No
Contains biology-only material	No

Useful Teaching and Learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz
- Answers for homework task
- Answers to all questions

Useful prior learning

- Hierarchical organisation of multicellular organisms
- How leaves are adapted to carry out photosynthesis
- The role of stomata in gas exchange in plants
- That plants make carbohydrates in their leaves by photosynthesis

Common misconceptions

- Students often hold on to the idea that soil provides food for the plant.
- Students may be confused about the mechanism of stomatal opening and closing and may incorrectly think that as the guard cells become turgid they close the stomata.
- Students often try to make links between animal circulation and plant transport and so have misconceived ideas about exchange and transport in the xylem and phloem. Terminology such as vascular tissue and veins may cement such ideas if not introduced carefully.
- Students may think that the xylem only transports water.
- Students may believe that transpiration alone is responsible for supplying water for all plant cells.

Preparation

The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for this unit on plant tissues, organs and transportation. This should allow you to get a deeper understanding of common misconceptions and desired prior knowledge from KS3. It is also worth reviewing students' understanding of osmosis and active transport from Chapter 3.

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the next few lessons or can be reserved for recap/consolidation at the end of the topic.

If you want students to prepare their own seedlings to use to observe the roots in lesson 2, they could set these up to germinate.

Plant tissues and organs – the leaf: Lesson 1

Learning outcomes

1 Describe the structure of the leaf.
2 Explain how the tissues of the leaf are related to their functions.

Suggested lesson plan

Starter

In the first lesson in this sequence on organisation in plants, review students' prior understanding of plant organs such as the root and leaf. It is also important to review their understanding of diffusion, osmosis and active transport as this chapter provides an opportunity to review these processes. The student questions on the worksheet **T&L Prior knowledge catch-up student sheet** can be used to assist with this, along with the Test yourself on prior knowledge questions from page 68.

Alternatively, you could start the lesson by asking students to name as many plant cells, tissues and organs as they can.

Main

Introduce the topic by explaining the main organs of the plant and recapping their functions with the students. Ensure you explain the difference between shoots, stalks and stems.

Move on to explain that this lesson will focus on the leaf. An activity you might like to use to introduce the leaf is to split the students up into small groups and get them to number themselves 1–4. Then allow all the number 1 students to come to the front or go outside in the corridor to look at a labelled diagram of the structure of the leaf. They have a minute to memorise what they see, then need to return to their group and draw out what they remember and the names of the tissues. Repeat this process with the other students in the group. Once finished, provide the students with the diagram they used and allow them to self assess or peer assess their drawing and labels for accuracy.

Discuss with the students the function of the different cells and tissues which make up the leaf and ask them how each is adapted to its role. For example, the palisade mesophyll tissue has cells which contain more chloroplasts than normal and are packed tightly. Then discuss how this maximises photosynthesis.

Review with students that the leaves are the site of gas exchange and that gases move by diffusion through pores called stomata.

You may want to give students an opportunity to look at prepared slides of the tissues in a leaf using microscopes. Alternatively, students could carry out the practical on page 69 of the textbook to observe stomata.

Plenary
Students could complete the Test yourself questions from page 70.

Support
Ensure you provide students with the correct spellings of the tissues found in plant leaves. Students are usually unfamiliar with plant tissues and so the terminology used can be overwhelming when they have so many new terms given to them in a lesson. With the group activity you may want to explain that there is a diagram and labels so they should focus on one or the other, this reduces the pressure on dyslexic students thinking they need to remember a list of spellings in only a minute.

Extension
You could extend the lesson to review the features of exchange systems covered in Chapter 3 and allow students to explain how a leaf is an organ designed for gaseous exchange in plants.

Homework
Students could research the xylem and phloem in more detail, finding out what they transport and their basic structure.

The root and water uptake: Lesson 2

Learning outcomes

1 Describe the structure of the root.
2 Review how root hair cells are adapted to their function.
3 Review how osmosis and active transport occur in a root.

Suggested lesson plan

Starter
Use the **T&L Lesson starter 1** to review students' understanding of the tissues in the leaf and their functions.

Main
Allow students to examine roots and root hairs, by either looking at prepared slides or making their own slides using the roots from seedlings such as cress.

Review how the root is adapted to maximise the uptake of water and minerals and ask the students to explain how this occurs. They should be familiar with active transport and osmosis so use this activity to check their understanding.

Move on to discuss the plant transportation organ system and explain why substances need to be transported around the plant. If students completed the homework on xylem and phloem you could review their understanding of these two tissues. Alternatively, use the lesson time to introduce them along with their basic structure and functions. Students could observe these tissues by examining prepared slides or making their own slides of vascular bundles from celery stalks.

Explain what translocation is and the role of phloem tissues in this process.

Plenary
Students can complete the Test yourself questions from page 71 or the relevant questions from pages 74 and 75.

Support
Ensure students have no misconceptions about the purpose of the roots and what roots take from the soil. Use this lesson to review students' understanding of osmosis and active transport and go over this content if students are unsure.

Extension
Students could review meristem tissue and identify where this is found in a plant.

Homework
Students could complete the Working scientifically task from pages 76–7 or the relevant sections from the **T&L Homework task**.

Transpiration: Lesson 3

Learning outcomes

1 Describe the process of transpiration.
2 Explain how limiting factors affect the rate of transpiration.
3 Use simple compound measures such as the rate of transpiration.

Suggested lesson plan

Starter
Use **DL Lesson starter 2** to introduce the topic of transpiration and get the students thinking about factors which affect it.

Main
Discuss with students what transpiration is and how it occurs in the plant. Students could annotate a diagram to show the movement of water through a plant.

Allow students to carry out practical work on transpiration using photometers if they are available. They could investigate the effects of temperature, wind, light intensity and humidity on transpiration rates. Alternatively, they could use a virtual lab to investigate this. Here are two good ones:

www.mhhe.com/biosci/genbio/virtual_labs/BL_10/BL_10.html

www.classzone.com/books/hs/ca/sc/bio_07/virtual_labs/virtualLabs.html

Students could complete the Activity on investigating transpiration from page 73 of the textbook or carry out a similar practical for themselves.

Plenary
Students could complete the Test yourself questions from page 73 or the **T&L Quick quiz**. Alternatively, they could produce a summary poster on the tissues, organs and organ systems of a plant.

Support
Ensure you take the time to explain how different factors affect rates of transpiration. Students may not fully understand why high humidity reduces transpiration but this can be explained by discussing sweating in humans in hot, humid environments versus hot, dry environments. Students could produce a summary table to show the factors and how increasing or decreasing them impacts transpiration rates.

Extension
You could provide the class with data on transpiration rates over the course of the day and get students to graph this and then describe the trends and suggest reasons for the patterns. Alternatively, you could provide students with pictures of desert plants and get them to explain how their leaves are adapted to minimise transpiration.

Homework
Students could complete the Chapter review questions from page 74, the Practice questions from page 75 or the **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge
1 Water is absorbed through roots and carbon dioxide through leaves.
2 Stomata open and close to regulate the volume of water vapour and oxygen lost and the volume of carbon dioxide absorbed.
3 Leaves have high numbers of chloroplasts in cells near their surface. They are large and flat to absorb as much sunlight as possible.

Test yourself
1 Xylem and phloem
2 They are full of chloroplasts to maximise the amount of photosynthesis.
3 They have spaces between them to allow gases to diffuse into and out of the cells.
4 Osmosis
5 To absorb water and minerals and to hold the plant in the soil
6 In the tip of the shoot
7 They are not usually exposed to the Sun so do not need to have green chloroplasts for photosynthesis.
8 The leaf
9 The transportation organ system
10 Oxygen is produced during photosynthesis and so moves from the inside of the leaf at high concentration to a lower concentration outside the leaf.

Show you can
Page 70

Epidermis, palisade mesophyll cells, spongy mesophyll cells

Page 71

They are younger and so often have not grown tough secondary cell walls that would make them harder to digest.

Page 73

Dry, warm and windy days

Practical
Page 69

1 Dependent on leaves chosen, but there is likely to be higher stomatal density on the lower side of the leaf as there is less evaporation because it tends to be cooler and receives less light.
2 In a wilted plant the stomata pores become smaller as the guard cells narrow the pore. In a watered plant there would be wide stomata pores as the guard cells are turgid.

Activity
Page 73

1 Allow 40–48 squares as the estimate
2

Leaf	Change in mass in g
A	0.20
B	0.08
C	0.04
D	0.01

3 The leaf with no petroleum jelly lost the most mass as the stomata pores were not sealed, therefore water was lost through evaporation.
4 0.004 g/cm^2
5 The treatment of petroleum jelly
6 Mass
7 Temperature, ideally the surface area of leaf (but this is impractical)

Chapter review questions
1 At the bottom below the palisade mesophyll
2 They contain many chloroplasts to complete a lot of photosynthesis
3 Xylem
4 They do not contain any chloroplasts because they cannot photosynthesise under the ground.
5 To provide water for the plant, to anchor it into the ground, to grow runners to make new plants or to store the glucose made during photosynthesis, usually as starch
6 Meristem
7 Active transport
8 The leaf
9 Palisade mesophyll
10 Roots, shoots and leaves
11 Osmosis
12 Palisade mesophyll cells are long and thin and are tightly packed with no gaps. Spongy mesophyll cells are more circular and have gaps between them.
13 Guard cells sit around the edge of stomata. They open and close to allow water vapour to evaporate out.
14 Paint the surface of the leaf in clear nail varnish then peel it off to count the 'bumps' when it is dry.
15 Xylem and phloem
16 Growing above the ground, for example on another plant
17 An offshoot of a plant on which plantlets are produced by asexual reproduction
18 Water vapour constantly evaporates from stomata in the leaves, which pulls up more water from the roots.
18 Because less water loss occurs from the bottom of leaves
19 The net diffusion of water from an area of high concentration to an area of lower concentration across a partially permeable membrane
20 To protect against water loss and regulate the gases that are exchanged from the plant
21 To regulate the uptake of water and minerals
22 Because less water loss occurs from the bottom of leaves
23 A secondary cell wall
24 When it has just rained and there is lots of water in the soil
25 If this did not continue, the transpiration stream would stop
26 The rate of transpiration would reduce because more humidity means a smaller concentration gradient. This means that diffusion of water out of the leaf by transpiration would happen less quickly.
27 The rate of transpiration would reduce because less heat means less diffusion of water out of the leaf by transpiration.
28 When it is hottest, often at midday
29 On a windy day the air surrounding the leaves is continually replaced. This keeps the concentration gradient steep and the rate of transpiration high.
30 Collect leaves of the same size from a plant. Spread petroleum jelly onto the stalks of the leaves to stop water loss there. Weigh the leaves and hang them up to dry for an hour. Reweigh the leaves to see the water loss through transpiration.

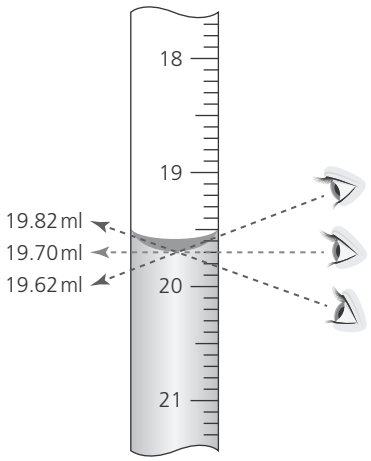
Practice questions
1 a) Spongy mesophyll = C; epidermis = A; palisade mesophyll = B
b) i) Water/dissolved minerals
ii) Sugars/sucrose

2 a) i) Guard cell
ii) To control the size of the stomata
b) B, because it has the lowest number of stomata [1], which means there will be less water loss/transpiration. [1]
c) Any from: reduced surface area, thick cuticle, stomata close in the day
d) (1/0.02) × 12 = 600. Allow 1 mark for working and 1 for correct answer.

3 a) Anything below 250 g
b) As a control, to check the effect of the plant. Do not accept fair test.
c) To reduce/prevent evaporation of water from flask
d) D: transpiration
e) The evaporation of water or loss of water vapour; from the leaves; through the stomata; causing a pull; change in osmotic pressure or osmotic potential; so that water moves up the plant; through the xylem; as the transpiration stream; water absorbed by roots or root hairs
f) C: hot and dry conditions

Working scientifically: Dealing with data
Pages 76–7

1 Kelly's as the data for each repeat vary more
2 Chris started from the bottom of the ruler, not at zero. This is a systematic error. Chris should repeat the experiment measuring correctly.
3 Kelly's method introduced errors because she was not measuring consistently (she was creating a parallax error). She should have measured consistently each time (with her eye in line with the bottom of the meniscus of the bubble).



4 To prevent evaporation of water. If the gaps were not sealed, this would have created higher readings as more water would be lost.
5 Accept any sensible suggestion related to random or systematic error.
6 a) High levels of evaporation as the lamp would heat the plant and increase the rate. Also, more photosynthesis would occur with light and the stomata would open to allow greater gaseous exchange.
b) High levels of evaporation, as the fan would increase the concentration gradient.
c) Low levels of evaporation as the humid environment would lower the concentration gradient.

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge

1 Water is absorbed through roots and carbon dioxide through leaves.
2 Stomata open and close to regulate the volume of water vapour and oxygen lost and the volume of carbon dioxide absorbed.
3 Leaves have high numbers of chloroplasts in cells near their surface. They are large and flat to absorb as much sunlight as possible.

Test yourself

1 Xylem and phloem
2 They are full of chloroplasts to maximise the amount of photosynthesis.
3 They have spaces between them to allow gases to diffuse into and out of the cells.
4 Osmosis
5 To absorb water and minerals and to hold the plant in the soil
6 In the tip of the shoot
7 They are not usually exposed to the Sun so do not need to have green chloroplasts for photosynthesis.
8 The leaf
9 The transportation organ system
10 Oxygen is produced during photosynthesis and so moves from the inside of the leaf at high concentration to a lower concentration outside the leaf.

Show you can
Page 70

epidermis, palisade mesophyll cells, spongy mesophyll cells

Page 71

They are younger and so often have not grown tough secondary cell walls that would make them harder to digest.

Page 73

Dry, warm and windy days

Practical
Page 69

1 Dependent on leaves chosen, but there is likely to be higher stomatal density on the lower side of the leaf as there is less evaporation because it tends to be cooler and receives less light.
2 In a wilted plant the stomata pores become smaller as the guard cells narrow the pore. In a watered plant there would be wide stomata pores as the guard cells are turgid.

Activity
Page 73

1 Allow 40–48 squares as the estimate

2

Leaf	Change in mass in g
A	0.20
B	0.08
C	0.04
D	0.01

3 The leaf with no petroleum jelly lost the most mass as the stomata pores were not sealed, therefore water was lost through evaporation.
4 0.004 g/cm^2
5 The treatment of petroleum jelly
6 Mass
7 Temperature, ideally the surface area of leaf (but this is impractical)

Chapter review questions
1 At the bottom below the palisade mesophyll
2 They contain many chloroplasts to complete a lot of photosynthesis.
3 Xylem
4 They do not contain any chloroplasts because they cannot photosynthesise under the ground.
5 To provide water for the plant, to anchor it into the ground, to grow runners to make new plants or to store the glucose made during photosynthesis, usually as starch
6 Meristem
7 Active transport
8 Leaf; root; stem
9 Palisade mesophyll
10 Roots, shoots and leaves
11 Osmosis
12 Palisade mesophyll cells are long and thin and are tightly packed with no gaps. Spongy mesophyll cells are more circular and have gaps between them.
13 Guard cells sit around the edge of stomata. They open and close to allow water vapour to evaporate out.
14 Paint the surface of the leaf in clear nail varnish before peeling it off to count the bumps when it is dry
15 Xylem and phloem
16 Growing above the ground, for example on another plant
17 Water vapour constantly evaporates from stomata in the leaves, which pulls up more water from the roots.
18 Because less water loss occurs from the bottom of leaves
19 When it has just rained and there is lots of water in the soil
20 If this did not continue the transpiration stream would stop.
21 The rate of transpiration would reduce because more humidity means a smaller concentration gradient. This means that diffusion of water out of the leaf by transpiration would happen less quickly.
22 The rate of transpiration would reduce because less heat means less diffusion of water out of the leaf by transpiration.
23 When it is hottest, often at midday
24 On a windy day the air surrounding the leaves is continually replaced. This keeps the concentration gradient steep and the rate of transpiration high.
25 Collect leaves of the same size from a plant. Spread petroleum jelly onto the stalks of the leaves to stop water loss there. Weigh the leaves and hang them up to dry for an hour. Reweigh the leaves to see the water loss through transpiration.

Practice questions
1 a) Spongy mesophyll = C, epidermis = A, palisade mesophyll = B *[3 marks]*
b) i) Water/dissolved minerals *[1 mark]*
ii) Sugars/sucrose *[1 mark]*
2 a) i) Guard cell *[1 mark]*
ii) To control the size of the stomata *[1 mark]*
b) B: because it has the lowest number of stomata [1 mark], which means there will be less water loss/transpiration. *[1 mark]*
c) Any from: reduced surface area, thick cuticle, stomata close in the day *[1 mark]*
d) (1/0.02) ¬[mult] 12 = 600. Allow 1 mark for working and 1 for correct answer. *[2 marks]*
3 a) Anything below 250 g *[1 mark]*
b) As a control, to check the effect of the plant. Do not accept fair test. *[1 mark]*
c) To reduce/prevent evaporation of water from flask *[1 mark]*
d) D: transpiration *[1 mark]*
e) The evaporation of water or loss of water vapour; from the leaves; through the stomata; causing a pull, change in osmotic pressure or osmotic potential; so that water

moves up the plant; through the xylem; as the transpiration stream; water absorbed by roots or root hairs. *[3 marks]*

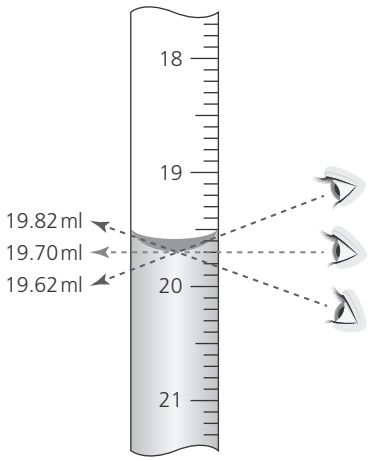
f) C: hot and dry conditions *[1 mark]*

Working scientifically: Dealing with data
Pages 76–7

1 Kelly's as the data for each repeat vary more.

2 Chris started from the bottom of the ruler, not at zero. This is a systematic error. Chris should repeat the experiment measuring correctly.

3 Kelly's method introduced errors because she was not measuring consistently (she was creating a parallax error). She should have measured consistently each time (with her eye in line with the bottom of the meniscus of the bubble).



4 To prevent evaporation of water. If the gaps were not sealed, this would have created higher readings as more water would be lost.

5 Accept any sensible suggestion related to random or systematic error.

6 a) High levels of evaporation as the lamp would heat the plant and increase the rate. Also, more photosynthesis would occur with light and the stomata would open to allow greater gaseous exchange.

b) High levels of evaporation, as the fan would increase the concentration gradient.

c) Low levels of evaporation as the humid environment would lower the concentration gradient.

Infection and response

6 Infection and response

Overview

Specification points

4.3.1.1 Communicable (infectious) diseases; 4.3.1.2 Viral diseases; 4.3.1.3 Bacterial diseases; 4.3.1.4 Fungal diseases; 4.3.1.5 Protist diseases; 4.3.1.6 Human defence systems; 4.3.1.7 Vaccination; 4.3.1.8 Antibiotics and painkillers; 4.3.1.9 Discovery and development of drugs

Textbook references

AQA GCSE (9-1) Biology: Chapter 6 pages 78–96

AQA GCSE (9-1) Combined Science Trilogy 1: Chapter 6 pages 78–94

AQA GCSE (9-1) Combined Science Trilogy: Chapter 6 pages 78–94

Recommended number of lessons: 9

Chapter overview	
AQA required practical	Biology – RP 2
Contains higher-tier only material	Yes
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Practical
- Teacher and technician notes
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Key concept: Bacteria and antibiotics
- Key concept: Bar charts
- Animation: White blood cells
- Personal tutor: Vaccines
- Video: Investigate the effect of different antibiotics on the growth of bacteria

Useful prior learning

- The effects of recreational drugs (including substance misuse) on behaviour, health and life processes

Common misconceptions

- The immune system is often poorly understood by students due to its complex nature. Ensure the different terms are defined and introduced clearly as students often get confused by antibodies, antitoxins, antigens and antibiotics and use them interchangeably.
- Students often struggle with the differences between viruses, bacteria and fungi.
- They may believe that microbes are not living things.
- Some students may think that a virus is a type of bacterium.
- That all diseases are caused by bacteria.

Preparation

The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for this unit on infection and response. The human immune system is not studied at KS3 however this sheet provides information related to health and drugs which are covered.

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the next few lessons or can be reserved for recap/consolidation at the end of the topic.

Infectious diseases: Lesson 1

Learning outcomes

1 Describe how diseases are transmitted.
2 Define the term pathogen.

Suggested lesson plan

Starter
In the first lesson in this sequence on infection and response, review students' prior understanding on drugs and health from KS3. The student questions on the worksheet **T&L Prior knowledge catch-up student sheet** can be used to assist with this or the Test yourself on prior knowledge questions from page 79. Alternatively, you could provide students with a diagram of a typical prokaryote and ask them to label it.

Main
Introduce the term pathogen. Ask the students to come up with examples of pathogens they might already know and sort these in the groups viruses, bacteria, fungi and protists.

Explain that pathogens are infectious and can spread from person to person.

A nice way to capture interest on this subject is to carry out practical work to examine how quickly pathogens spread. This could be done by using UV powder. This powder is placed on a board pen and students are asked to come up to the front of the board and write down how pathogens could spread. You could then find out how many are 'infected' later in the lesson. A different method involves providing students with tubes of milk, some of which contain starch. Students should then choose three people to mix their tube with and at the end, do a simple food test to see how many are 'infected' with the starch.

Ask them to research how pathogens are spread and how this can be prevented.

Plenary
Students could complete the Test yourself questions from pages 79 and 81(*80*).

Support
Ensure you spend time explaining that pathogens can be different types of microorganisms. Students may think of pathogens as only being bacteria so it is important they understand that pathogens can be found in other taxonomic groups. Students should also understand that viruses are not considered living but the rest are.

Extension
Students could research viruses and the debate which still continues over their classification as non-living.

Homework
Students could present their research findings on the spread and prevention of infectious diseases as a poster or presentation.

Culturing microorganisms: Lesson 2 (Biology only)

Learning outcomes

1 Describe how bacteria reproduce.
2 Prepare an uncontaminated culture using aseptic technique.
3 Calculate the number of bacteria in a population.

Suggested lesson plan

Starter
Students could complete the activity from page 83 as a starter or complete a quiz on the content covered in the lesson before.

Main
Describe how bacteria reproduce by simple cell division (binary fission) and explain that they can continue dividing as long as they have enough nutrients and a suitable temperature.

Students could be given data on starting population size and the mean division time to calculate how many bacteria would be present in a population after a certain time.

Explain that bacteria can be grown in a nutrient broth solution or as colonies on an agar gel plate. Allow them to carry out practical work to practise aseptic technique. They could follow the method in the Practical on page 80 (Biology only).

Plenary
Students should write a guide on how to carry out aseptic technique.

Support
Students could be provided with a method for aseptic technique split into stages. They could then order these in the correct sequence.

Extension
Students should be able to express their answers for the sizes of bacterial colonies in standard form (HT only).

Diseases: Lessons 3–4

Learning outcomes

1 Describe the effects of viral, bacterial, fungal and protist diseases.
2 Describe how viral, bacterial, fungal and protist diseases are treated.

Suggested lesson plan

Starter
Use the **T&L Lesson starter 1** to review students' understanding of the different types of pathogens and the diseases they cause.

Main
Split the class into small groups and ask each group to prepare a presentation on a type of pathogen and the disease it causes. They will then teach the information to the rest of the class.

The groups could be:

- viral diseases e.g. measles or HIV/AIDS
- bacterial diseases e.g. salmonella or gonorrhoea
- fungal diseases e.g. athletes foot
- protist diseases e.g. malaria.

Allow them time to research their disease fully and produce either a Powerpoint presentation or poster which will be presented in the following lesson. The textbook pages 81–5 can be used to support this or they can carry out independent research using the internet.

In the next lesson the groups should present their disease and students can make notes so they have all the information required.

Plenary
Students could peer assess each other's presentations and provide feedback to the other groups. The Test yourself questions on pages 81–5 (*81–4*) can be used to support the students.

Support
Organisation of the groups can support students in this activity. Providing a worksheet which structures students' research and note-taking will support students in gathering the correct information.

Human defence systems: Lesson 5

Learning outcomes

1 Describe the first line of defence against infection.
2 Explain the difference between physical and chemical barriers to infection.
3 Describe the second and third lines of defence against infection.
4 Explain the difference between phagocytes and lymphocytes.

Suggested lesson plan

Starter
Ask students how the human body protects itself from disease and infection. Students could annotate a diagram of the body to describe the different defences.

Main
Discuss the body's first line of defence against infection. You may like to do this as a card sort activity with students matching the defence mechanism to the body part that carries it out. Students could then sort them into physical and chemical defences.

You can then introduce the second line of defence and explain the role of phagocytes. Students could produce a comic strip or flow diagram to explain how phagocytes destroy pathogens.

Move on to describe the third line of defence and the specific immunity carried out by the lymphocytes and antitoxins. The **T&L Animation: White blood cells** can be used to support this.

Students could make models on the specificity of antibodies to antigens and how they act to defend the body.

Students could produce a flow chart to explain how lymphocytes function and bring about immunity.

Plenary
Students could complete the Test yourself questions from page 88(*87*).

Support
Ensure you introduce the terms 'antibody', 'antigen' and 'antitoxin' clearly so students understand their meaning fully and are aware that they are distinct terms which cannot be used interchangeably.

Extension
Students could research in more depth the specificity of the lines of defence. They might then explain why the first and second lines of defence are non-specific, the advantages of this and the benefit of the third line of defence being specific.

Students could also look at images or prepared slides of the different types of white blood cells and identify them.

Homework
Students can summarise the information by producing a poster which could be displayed in a science classroom on the immune system and the lines of defences we have.

Vaccination: Lesson 6

Learning outcomes

1 Describe the process of vaccination against a pathogen.
2 Explain what happens in subsequent exposures to the pathogen.
3 Explain how herd immunity prevents the spread of diseases.

Suggested lesson plan

Starter
Ask students to order a series of phrases about the different defences into first, second and third line of defence; for example: lysozymes, lymphocytes, phagocytes, antibodies, stomach acid, skin.

Main
Introduce vaccination and how vaccines work.

The TED talk video 'How do vaccines work' could be used to introduce this:

https://ed.ted.com/lessons/how-do-vaccines-work-kelwalin-dhanasarnsombut

Students could produce a flow diagram, comic strip or stop–start animation to show how vaccination works.

Students should be shown a graph of concentration of antibodies against time and be asked to describe the trends and, from this, explain how vaccines work. Alternatively, they could be given data to plot their own graph.

Plenary
Students can complete the Test yourself questions from page 89(*88*).

Support
Ensure there is careful use of the terminology 'antibodies' and 'antigen' so students understand the differences and can explain how they lead to acquired immunity.

Extension
Students could research the controversy that surrounds the MMR vaccination and why this has led to a decrease in vaccination rates.

Homework
Students could carry out the Working scientifically task on page 96(*94*) to evaluate the risk and benefits of vaccinations.

Antibiotics: Lesson 7

Learning outcomes

1 Describe the effects that antibiotics have on pathogens.
2 Explain how misuse of antibiotics has led to resistant strains and the implications of this.
3 Determine the effect of antiseptics and antibiotics on bacterial growth (Biology only).
4 Describe the method used in the Required practical (Biology only).

Preparation
Read through the **T&L Teacher and technician notes** so you are confident with what the practical is and the requirements for the task.

Suggested lesson plan

Starter
The **T&L Lesson starter 2** for this chapter can be used to introduce the topic of antibiotics and consider what a world without them was like.

Main
Explain how antibiotics help to cure bacterial disease by killing bacteria inside the body. The video from eBug can be used to show this (www.youtube.com/watch?v=X1GT2bKgci8) or the **T&L Key concept: Bacteria and antibiotics**. Students should understand why antibiotics do not work on viral infections.

Explain how antibiotic resistance occurs. The TED talk 'What causes antibiotic resistance?' can be used to support this:

https://ed.ted.com/lessons/how-antibiotics-become-resistant-over-time-kevin-wu?ref=Jobzella.com&utm_source=jobzella.com&utm-ref=jobzella

For biology students, introduce the Required practical to investigate the effect of antiseptics or antibiotics on bacterial growth using agar plates and measuring zones of inhibition.

Start the Required practical task by allowing the students to read the method from the **T&L Practical** worksheet or from page 91 of the textbook (Biology only). Alternatively, the students can watch the **T&L Video: Investigate the effect of different antibiotics on the growth of bacteria**. The plates should be set up this lesson in order to be examined and analysed in the next lesson.

Plenary
Students can complete the **T&L Quick quiz 1 or 2**.

Support
Ensure that students understand that antibiotics are medicines and are not produced by the body.

Extension
Students could research in more detail how the different types of antibiotic work.

Homework
Students could research the work of Fleming and find out how the first antibiotic was discovered.

Antibiotics and painkillers: Lesson 8

Learning outcomes

1 Describe the effects that painkillers have on pathogens.
2 Describe the effects of disinfectants and antibiotics on bacterial growth (Biology only).
3 Calculate the cross-sectional area of a bacterial colony (Biology only).

Suggested lesson plan

Starter
Provide students with the terms 'antigen', 'antibody', 'antitoxin' and 'antibiotic' and ask them to define what they mean or match up a term with its definition.

Main
Biology students should examine their plates from the previous lesson and work through the analysis, determining the area for the zones of inhibition, collating class results, determining means and plotting graphs. This can be supported by using the DL Practical worksheet or by reading page 91 of the textbook.

Move on to a discussion of painkillers and how they are used to treat the symptoms of disease but do not kill pathogens.

Plenary
Students can complete the Test yourself questions from page 92(*90*) or the **T&L Quick quiz 1 or 2** for this chapter.

Support
The **T&L Key concept: Bar charts** can be used to support students with the expectations and conventions to be used when drawing a bar graph.

Extension
Students could be asked to write a method to examine the effectiveness of different types of antibiotics or concentrations of antiseptics.

Homework
Students could research other medicines that have come from plants and their uses.

Discovery and development of drugs: Lesson 9

Learning outcomes

1 Describe and explain the significance of the historical discovery of medicines.
2 Describe the process of drug development.
3 Describe how new drugs are tested rigorously.

Suggested lesson plan

Starter
Introduce the topic by showing a video on the discovery of a drug. Here are two good ones:

www.awesomestories.com/asset/view/Alexander-Fleming-and-Penicillin-The-Wonder-Drug-

www.sciencechannel.com/tv-shows/greatest-discoveries/videos/100-greatest-discoveries-the-discovery-of-penicillin/

Alternatively, provide students with a list of drugs such as aspirin, digitalis and penicillin and ask them to match the drug to the plant or microorganism it was extracted from.

Main
Students should research the stages of modern drug development and produce a piece of writing, a poster or a pamphlet to explain this. Ensure they are confident with the terminology to be used, such as double-blind trials, placebo and toxicity testing.

The video on drug development from the National Institute of Allergy and Infectious Diseases (NIAID) can be used to support this: www.youtube.com/watch?v=U96He401wj4

Plenary
Students can complete the Test yourself questions from page 93(*91*), the Chapter review questions or the Practice questions from pages 94–5(*92–3*).

Support
Students could be given a DART activity based on the information on page 93 to direct their research and reading into drug development.

Extension
Students could research personalised medicine and find out how the human genome is being used in drug development.

Homework
Complete the Chapter review questions or Practice questions from pages 94–5(*92–3*) or work on the **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 Two from: cannabis, ecstasy, speed, cocaine
2 Recreational drugs are used for pleasure without a medical reason. Medicines are drugs that improve health.
3 Because alcohol slows down your reaction times, which makes it more likely that you will have an accident.

Test yourself

1 Measles
2 Athlete's foot
3 A pathogen is highly infectious if it is easily spread from one organism to another.
4 It can then infect more hosts faster.
5 Dirty water
6 By a vector; some farmers believe the vector is badgers
7 Measles
8 A fever and a red skin rash
9 Human immunodeficiency virus
10 A fever and headache
11 *Salmonella*
12 By antibiotics
13 A fever, cramps, vomiting and diarrhoea
14 A painful, burning sensation when urinating and a thick, coloured discharge
15 Athlete's foot
16 By keeping feet dry and applying an antifungal medicine
17 Itching, flaking and blistering between the toes
18 People catch it when they walk barefoot in communal areas where infected people have walked.
19 Malaria
20 A fever, tiredness, vomiting and headaches
21 The blood of an infected organism is sucked by a mosquito. This contains the protist, which is transferred to the next organism that the mosquito drinks blood from.
22 Skin, lysozymes, hairs, cilia or stomach acid
23 Phagocytes and lymphocytes
24 As it is hydrochloric acid, it kills pathogens.
25 Chemical barriers have a chemical compound involved, such as stomach acid or the lysozyme enzymes in tears. Physical barriers such as skin do not.
26 Measles, mumps and rubella
27 B cells
28 A small quantity of a dead, inactive or genetically modified version of a pathogen
29 Antibodies are produced by lymphocytes. Antigens are proteins on the pathogen itself. Antibodies recognise antigens.
30 Penicillin
31 The willow tree
32 Antiseptics are not drugs. They work on the outside of patient or other external surfaces. Antibiotics are medicines and so work inside the patient.
33 To reduce the chance of heart attacks
34 Computer modelling
35 When a patient feels or becomes better even though they have taken a sugar pill instead of the treatment

Show you can

Page 79

A pathogen infects a host. It then reproduces (or replicates if it is a virus). It then spreads from its host and infects other organisms.

Page 81

The four types of pathogen are viruses, bacteria, fungi and protists. An example of a viral pathogen is HIV. This could be spread by sexual contact. An example of a bacterial infection is *Escherichia coli*. This could be spread through uncooked food. An example of a fungal infection is athlete's foot. This could be spread by direct contact. An example of an infection by protist is malaria. This is spread by the mosquito as a vector.

Page 82

HIV infection leads to the condition AIDS. At this point HIV attacks the sufferer's immune system, which is then not so effective at killing pathogens. The AIDS patient is then more likely to catch another infection such as tuberculosis, which they cannot fight off.

Page 83

Many bacteria are pathogens and cause illness. These include salmonella and gonococci which cause gonorrhoea. Others, including those that live in our digestive system, are important and actually help us.

Page 84

Fungi are eukaryotic organisms. This means they have a nucleus. Bacteria are prokaryotic and so do not. Viruses are neither eukaryotic nor prokaryotic. They are not alive.

Page 85

Travellers can take antimalarial tablets, which kill the parasite when infection has occurred. They can also stop infection in the first place by using mosquito nets and sprays.

Page 88

The first line of defence stops you getting infected in the first place. This includes your skin, lysozymes, hairs, cilia and stomach acid. The second line of defence attacks pathogens when you have been infected. Phagocytes attack pathogens. The third line of defence is specific against infection. Lymphocytes produce antibodies and antitoxins.

Page 89

The second time an organism is infected, antibodies are produced faster and in higher volumes. This stops an infection.

Page 92

Fleming made a mistake in his method. His bacterial plates became infected by a fungus. Rather than just throwing these away, Fleming noticed that the fungus stopped the bacterium growing. From here he found the first antibiotic.

Page 93

The first stage is computer modelling. The second stage of drug development involves laboratory testing on live cells or animals. The third and final stage involves clinical trials on humans. The drug is tested on a small number of healthy volunteers, then a small numbers of sick patients and finally it is given to a large number of patients to finalise safe doses and efficacy.

Practical
Page 80

Task: no answer is required

Activity
Page 83

A: *Streptococcus pneumoniae*

B: *Streptococcus pyogenes*

C: *Treponema pallidum*

D: *Salmonella typhi*

E: *Staphylococcus aureus*

F: *Helicobacter pylori*

Required practical 2
Page 91

Answers cannot be given as they will be based on the student's results and the antibiotics used.

Chapter review questions

1 A disease that can be spread from one organism to another
2 Viruses, bacteria, fungi and protists
3 Athlete's foot, ringworm
4 Malaria
5 Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
6 Alexander Fleming
7 Viruses
8 Antibiotics are drugs that are taken to kill bacterial or fungal diseases; antiseptics are substances applied to the skin or other external surfaces to destroy pathogens.
9 Drug companies are companies and need to make money but also the process of drug testing is long and expensive.
10 Sterilise an inoculating loop in a flame or alcohol. Dip the loop into the culture. Open a sterile agar plate. Gently spread the loop across the plate in parallel lines. Turn the plate through 90° and repeat. Turn the plate through 90° and repeat again.
11 A strand of genetic material (DNA or RNA) surrounded by a protein coat
12 In uncooked food
13 A painful burning sensation when urinating and the production of a thick yellow or green fluid (discharge) from the vagina or penis
14 By keeping feet dry and applying an antifungal cream or spray
15 A fever, tiredness, vomiting and headaches
16 By using mosquito nets and insect repellent sprays containing insecticides and medicines such as Malarone
17 It contains hydrochloric acid, which kills many bacterial pathogens.

18 The T and B cells form 'memory' cells, B cells produce larger numbers of antibodies more quickly on subsequent infection.
19 A vaccine is a medicine containing an antigen from a pathogen that triggers a low-level immune response so that subsequent infection by that pathogen is dealt with more effectively.
20 If the vast majority of people in a population have a vaccination, then even if a small number of people become infected, the disease is not likely to spread through the population.
21 Booster injections 'remind' your immune system and refresh the memory of your 'memory' lymphocytes.
22 One of Alexander Fleming's Petri dishes was mistakenly left open and had accidently been contaminated by a fungus called *Penicillium notatum*. Where the fungus grew, the *Staphylococcus* bacteria did not. Fleming realised that the fungus was naturally producing a chemical that killed bacteria. Fleming then isolated the first antibiotic drug, and it was called penicillin after the fungus.
23 Cilia are tiny hair-like projections that protrude into the airway. Goblet cells produce mucus, which they pump into the airway and in which pathogens get stuck. The ciliated cells waft the mucus back up their airway to the back of the throat, where it is swallowed.
24 They engulf (take in) pathogens and destroy them using enzymes.
25 They produce antibodies, which help clump pathogens together. The pathogens can then be engulfed and destroyed by phagocytes.
26 Computer modelling
27 How effective a drug is
28 A trial in which neither the doctors nor the patients know who has received the drug and who has received the placebo.
29 The name of the genus is spelled out in full when first used. It can be abbreviated to its first capital letter when used again, until another species belonging to a different genus is used. After which it must be spelled out in full again for the first time it is next used.

Practice questions

1 **a)** To check work, to find best dose, to ensure safe to trial on people
b) i) Fake drug/drug with no active ingredient
ii) To see if the drug works rather than the process of taking a drug itself/ comparison
iii) In the trial, neither the doctor nor the volunteers know which is the drug and which is the placebo
c) Age, sex, number in each group, other medical issues, size because lung capacity measured
d) 19%
2 **a)** Pathogen
b) They produce toxins, damage cells, reproduce rapidly or reproduce in cells.
c) i) Antibiotics don't kill viruses.
ii) Painkillers: allow name of painkiller; allow any mention of antivirals
d) Idea that antibodies produced [1] by white blood cells, [1] allows quick response to produce white blood cells with subsequent infection [1]
3 **a)** D: protist
b) A: fever and B: vomiting
4 **a) i)** Any two from the following (or specific types of any of the following): bacteria, fungi, protists
ii) Any two from: airborne, through dirty water, by direct physical contact (sexual or non-sexual), through eating contaminated food, through a vector animal
iii) Washing hands, using tissues
b) Stomach; skin; lungs; trachea or bronchi
5 Level 3: A clear description of a method that would produce valid results; students should make it clear that zones of inhibition should be measured; at least two safety precautions described. *[5–6 marks]*

Level 2: A description of a method involving antiseptics and bacterial growth; a basic description of what is measured or at least one safety precaution. *[3–4 marks]*

Level 1: A basic description of a simple method involving antiseptics and bacterial growth; safety precautions lack detail. *[1–2 marks]*

No relevant content: *[0 marks]*

Indicative content: valid results; students' answers should indicate that zones of inhibition should be measured; they may include the formula area = $2\pi r^2$; student's method may make reference to measuring a mean area; equal quantities of each antiseptic should be used; safety precautions: label the Petri dish with the date, wear eye protection, use aseptic technique, use sterile equipment, lid of Petri dish replaced after adding antiseptics/Petri dish lid is partially lifted, spreaders or inoculating loops are flamed or placed in disinfectant after use, tape the plate closed (need to be clear that tabs of tape used and air can get to plate).

Working scientifically: Scientific thinking
Page 96

1 Some examples can be seen in the table below, although this is not exhaustive as it depends on what the sources the students use.

	Positive	Negative	Risk
Vaccination compulsory	Prevention is better than cure Improves overall public health Natural way to strengthen the immune system Can and has eradicated diseases	Side effects Other alternatives might be available Some concern over ingredients and toxicity Efficacy is not always proven Ethical issues Cost	Side effects Disease
Vaccination voluntary	Allow people the freedom to choose Does not impact religious beliefs	Many may not have vaccination programmes Only successful if enough people are vaccinated	Too low vaccination rate, so diseases still spread in the population

2 Dependent on students' responses
3 Allow any sensible diagrams or flowcharts that show the basic idea of vaccination. Key points to be included are:
- Vaccination involves exposing the body's immune system to a weakened or harmless version of the pathogen.
- This causes the white blood cells to produce antibodies specific to it.
- The antibodies remain in the blood in case of exposure by the pathogen.

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge
1 Two from: cannabis, ecstasy, speed, cocaine
2 Recreational drugs are used for pleasure without a medical reason. Medicines are drugs that improve health.
3 Because alcohol slows down your reaction times, which makes it more likely that you will have an accident.

Test yourself
1 Measles, HIV/AIDS, tobacco mosaic virus, mumps, colds and flu or other appropriate answer
2 Athlete's foot, rose black spot or other appropriate response
3 A pathogen is highly infectious if it is easily spread from one organism to another.
4 It can then infect more hosts faster.
5 Dirty water
6 Vector (cattle), airborne (humans); some farmers believe the vector is badgers
7 Measles, HIV/AIDS, tobacco mosaic virus, mumps, colds and flu or other appropriate answer
8 A fever and a red skin rash
9 Human Immunodeficiency Virus
10 A fever and a headache
11 Salmonella, gonorrhoea or other appropriate answer
12 By antibiotics
13 A fever, cramps, vomiting or diarrhoea
14 A painful burning sensation when urinating and a thick coloured discharge
15 Athlete's foot, rose black spot or other appropriate response
16 People catch athlete's foot when they walk barefoot in communal areas where infected people have walked. Rose black spot is spread by wind or in water. Other answers if appropriate to answer to question 15.
17 Malaria or other appropriate response
18 A fever, tiredness, vomiting and headaches
19 The blood of an infected organism is sucked by a mosquito. This contains the protist, which is transferred to the next organism that the mosquito drinks blood from.
20 Skin, lysozymes, hairs, cilia or stomach acid
21 Phagocytes and lymphocytes
22 As it is hydrochloric acid, it kills pathogens.
23 Chemical barriers have a chemical compound involved, such as stomach acid or the lysozyme enzymes in tears. Physical barriers such as skin do not.
24 Measles, mumps and rubella
25 B cells
26 A small quantity of a dead, inactive or genetically modified version of a pathogen
27 Antibodies are produced by lymphocytes. Antigens are proteins on the pathogen itself. Antibodies recognise antigens.
28 Penicillin
29 The willow tree
30 To reduce the chance of heart attacks
31 Computer modelling

Show you can
Page 79

A pathogen infects a host. It then reproduces (or replicates if it is a virus). It then spreads from its host and infects other organisms.

Page 80

The four types of pathogen are viruses, bacteria, fungi and protists. An example of a viral pathogen is HIV. This could be spread by sexual contact. An example of

a bacterial infection is *Escherichia coli*. This could be spread through uncooked food. An example of a fungal infection is athlete's foot. This could be spread by direct contact. An example of an infection by protist is malaria. This is spread by the mosquito as a vector.

Page 82

HIV infection leads to the condition AIDS. At this point HIV attacks the sufferer's immune system, which is then not so effective at killing pathogens. The AIDS patient is then more likely to catch another infection such as tuberculosis, which they cannot fight off.

Many bacteria are pathogens and cause illness. These include salmonella and gonococci which cause gonorrhoea. Others, including those that live in our digestive system, are important and actually help us.

Page 84

Fungi are eukaryotic organisms. This means they have a nucleus. Bacteria are prokaryotic and so do not. Viruses are neither eukaryotic nor prokaryotic. They are not alive.

Travellers can take antimalarial tablets which kill the parasite when infection has occurred. They can also stop infection in the first place by using mosquito nets and sprays.

Page 88

The second time an organism is infected, antibodies are produced faster and in higher volumes. This stops an infection.

Page 90

Fleming made a mistake in his method. His bacterial plates became infected by a fungus. Rather than just throwing these away, Fleming noticed that the fungus stopped the bacterium growing. From here he found the first antibiotic.

Page 91

The first stage is computer modelling. The second stage of drug development involves laboratory testing on live cells or animals. The third and final stage involves clinical trials on humans. The drug is tested on a small number of healthy volunteers, then a small numbers of sick patients and finally it is given to a large number of patients to finalise safe doses and efficacy.

Activity

Page 83

A: *Streptococcus pneumoniae*

B*: Streptococcus pyogenes*

C: *Treponema pallidum*

D: *Salmonella typhi*

E: *Staphylococcus aureus*

F: *Helicobacter pylori*

Chapter review questions

1 A disease that can be spread from one organism to another
2 Viruses, bacteria, fungi and protists
3 Athlete's foot, rose black spot or other appropriate response
4 Malaria or other appropriate response
5 Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
6 Alexander Fleming
7 Viruses
8 Drug companies are companies and need to make money but also the process of drug testing is long and expensive.
9 In uncooked food
10 A painful burning sensation when urinating and the production of a thick yellow or green fluid (discharge) from the vagina or penis
11 A fever, tiredness, vomiting and headaches
12 By using mosquito nets and insect repellent sprays containing insecticides and medicines such as Malarone
13 It contains hydrochloric acid, which kills many bacterial pathogens.
14 The T and B cells form 'memory' cells; B cells produce larger numbers of antibodies more quickly on subsequent infection.
15 A vaccine is a medicine containing an antigen from a pathogen that triggers a low level immune response so that subsequent infection by that pathogen is dealt with more effectively.
16 If the vast majority of people in a population have a vaccination, then even if a small number of people become infected, the disease is not likely to spread through the population.
17 Booster injections 'remind' your immune system and refresh the memory of your 'memory' lymphocytes.
18 One of Alexander Fleming's Petri dishes was mistakenly left open and had accidently been contaminated by a fungus called *Penicillium notatum*. Where the fungus grew, the *Staphylococcus* bacteria did not. Fleming realised that the fungus was naturally producing a chemical that killed bacteria. Fleming then isolated the first antibiotic drug, and it was called penicillin after the fungus.
19 Cilia are tiny hair-like projections that protrude into the airway. Goblet cells produce mucus, which they pump into the airway and in which pathogens get stuck. The ciliated cells waft the mucus back up their airway to the back of the throat, where it is swallowed.

20 They engulf (take in) pathogens and destroy them using enzymes.
21 They produce antibodies, which help clump pathogens together. The pathogens can then be engulfed and destroyed by phagocytes.
22 Computer modelling
23 How effective a drug is
24 A trial in which neither the doctors nor the patients know who has received the drug and who has received the placebo.

Practice questions

1 a) To check work, to find best dose, to ensure safe to trial on people *[1 mark]*
b) i) Fake drug/drug with no active ingredient *[1 mark]*
ii) To see if the drug works rather than the process of taking a drug itself/comparison *[1 mark]*
iii) In the trial, neither the doctor nor the volunteers know which is the drug and which is the placebo *[1 mark]*
c) Age, sex, number in each group, other medical issues, size because lung capacity measured *[1 mark]*
d) 19% *[1 mark]*
2 a) Pathogen *[1 mark]*
b) They produce toxins, damage cells, reproduce rapidly or reproduce in cells. *[1 mark]*
c) i) Antibiotics don't kill viruses. *[1 mark]*
ii) Painkillers: allow name of painkiller; allow any mention of antivirals *[1 mark]*
d) Idea that antibodies produced [1 mark] by white blood cells, [1 mark] allows quick response to produce white blood cells with subsequent infection *[1 mark]*
3 a) D: protest *[1 mark]*
b) A: fever and B: vomiting *[1 mark]*
4 a) i) Any two from the following (or specific types of any of the following): bacteria, fungi, protists *[2 marks]*
ii) Any two from: airborne, through dirty water, by direct physical contact (sexual or non-sexual), through eating contaminated food, through a vector animal *[2 marks]*
iii) Washing hands, using tissues *[1 mark]*
b) From top: stomach; skin; lungs, trachea or bronchi *[3 marks]*
c) i) White blood cells (lymphocytes and phagocytes) *[1 mark]*
ii) Lymphocytes produce antibodies that attach onto the pathogens *[1 mark]* and clump them together *[1 mark]*. Phagocytes engulf and break down pathogens *[1 mark]*

Working scientifically: Scientific thinking
Page 94

1 Some examples can be seen in the table below, although this is not exhaustive as it depends on what the sources the students use.

	Positive	Negative	Risk
Vaccination compulsory	Prevention is better than cure Improves overall public health Natural way to strengthen the immune system Can and has eradicated diseases	Side effects Other alternatives might be available Some concern over ingredients and toxicity Efficacy is not always proven Ethical issues Cost	Side effects Disease
Vaccination voluntary	Allow people the freedom to choose Does not impact religious beliefs	Many may not have vaccination programmes Only successful if enough people are vaccinated	Too low vaccination rate, so diseases still spread in the population

2 Dependent on students' responses
3 Allow any sensible diagrams or flowcharts that show the basic idea of vaccination. Key points to be included are:
- Vaccination involves exposing the body's immune system to a weakened or harmless version of the pathogen.
- This causes the white blood cells to produce antibodies specific to it.
- The antibodies remain in the blood in case of exposure by the pathogen.

7 Monoclonal antibodies (Biology only)

Overview

Specification points
4.3.2.1 Producing monoclonal antibodies; 4.3.2.2 Uses of monoclonal antibodies

Textbook chapter references
AQA GCSE (9-1) Biology: Chapter 7 pages 97–101

Recommended number of lessons: 1

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	Yes
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter
- Key terms
- Homework task
- Quick quiz
- Answers for homework task
- Answers to all questions

Useful prior learning

- There are no key points to remember from previous years' work relating to monoclonal antibodies. The whole of this chapter of the book will be new to all higher tier students.
- Students will have examined antibodies in Chapter 6, however.

Common misconceptions

- The immune system is often poorly understood by students due to its complex nature. Ensure the different terms are defined and introduced clearly as students often get confused between antibodies, antitoxins, antigens and antibiotics and may use them interchangeably.

Preparation

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the lesson.

Ensure Chapter 6 has already been taught so students have an understanding of what antibodies are.

Monoclonal antibodies: Lesson 1

Learning outcomes

1 Describe the production of monoclonal antibodies.
2 Describe the uses of monoclonal antibodies.
3 Explain why monoclonal antibodies have not been as successful as originally expected.

Suggested lesson plan

Starter

Ask students what they think the term 'monoclonal antibody' might mean or use the **T&L Lesson starter 1** to introduce the topic and allow the students to try to order the stages of monoclonal antibody production. You might like to print out the statements and allow students to order them as a card sort activity.

Main

Introduce monoclonal antibodies and explain how they are produced. This can be supported using a video such as:

https://www.youtube.com/watch?v=kcxQyIfca4I

https://www.youtube.com/watch?v=c_krTc9M1WU

https://www.youtube.com/watch?v=5AXApBbj1ps

Allow the students to check their sequence from the starter and see if they were correct and re-order as the video progresses. Ensure students are confident with the names of the cells involved.

Students could make a flow diagram or comic strip to consolidate their understanding of monoclonal antibody production. Additionally they could complete the Test yourself questions from page 99 of the textbook.

Move on to allow the students to research the different uses of monoclonal antibodies including: pregnancy tests, targeted medicine and the location and detection of pathogens and specific molecules. The TED talk video 'How do pregnancy tests work?' (http://ed.ted.com/lessons/how-do-pregnancy-tests-work-tien-nguyen) can be used to introduce this.

To finish, introduce the fact that monoclonal antibodies have some unexpected side effects and use this to set up a discussion or writing task where students need to evaluate the advantages and disadvantages of monoclonal antibodies.

Plenary

Students could complete the Test yourself questions from page 100, the Chapter review questions or the

Practice questions from page 101. Alternatively, they could complete the **T&L Quick quiz**.

Support
You could provide students with statements on the advantages and disadvantages associated with monoclonal antibody use and allow them to sort them into the most and least important. The research activity could also be adapted into a DART activity to support students in the knowledge that they specifically need.

Extension
This is a higher tier topic only so students could be encouraged to produce a pamphlet or poster on monoclonal antibodies explaining their production and uses.

Homework
Students could complete the **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself

1 'mono' = one; 'clonal' = many copies
2 Georges Köhler and César Milstein
3 A fusion between spleen cells and cancerous myeloma cells
4 Pregnancy tests, HIV/AIDS diagnosis test kits, cancer treatments
5 HCG
6 Hepatitis, HIV/AIDS, herpes, *Chlamydia*
7 Monoclonal antibodies are bound to fluorescent dyes, which glow when they are bound to a pathogen.
8 Their use has had a number of side effects and they need to be properly tested.

Show you can
Page 99

A mouse is injected with an antigen. Cells from the mouse's spleen are collected and are fused with myeloma cells to form hybridoma cells. These are grown and continue to produce monoclonal antibodies to the original antigen. These are isolated from the growth medium by centrifugation, filtration and chromatography.

Page 100

Monoclonal antibodies can be designed to bind only to cancerous cells. We can then bind them to drugs that kill cancer. In this way they will carry these drugs to cancerous cells directly without killing other cells.

Chapter review questions

1 Proteins
2 They help clump pathogens together for different white blood cells to engulf and destroy them with enzymes.
3 A protein on the surface of a pathogen that is recognised as foreign by the immune system
4 An antibody produced from the fusion of a mouse spleen cell and a myeloma cell
5 Georges Köhler and César Milstein
6 An antigen is injected into a mouse. The mouse's immune response produces antibodies specific to the injected antigen. Spleen cells from the mouse are fused with myeloma cells to form hybridoma cells. Monoclonal antibodies to the original antigen that was injected into the mouse are produced by and collected from the hybridoma cells.
7 Spleen cells and myeloma cells
8 Any two from: pregnancy, HIV/AIDS, herpes, *Chlamydia*
9 Treating cancer
10 Their shapes fit together
11 Antibodies can bind to almost any substance, not just antigens.
12 They contain the antibody-producing white blood cells.
13 A cell from a malignant tumour of bone marrow
14 They identify very small concentrations of HCG hormone in the urine of pregnant women. The monoclonal antibody is stuck to a small strip of paper onto which a woman urinates. If she is pregnant the monoclonal antibodies will bind with the HCG in her urine and turn the strip of paper a different colour.
15 They have produced some unexpected side effects and require more testing.

Practice questions

1 a) i) A chemical that is foreign to the body
ii) White blood cells produce antibodies and make memory (B) cells.
b) Because they can continue to divide indefinitely
c) B: hybridoma
d) Diagnostic tests, pregnancy tests, treating diseases
2 a) Herceptin has a shape complementary to the shape of the antigen on the cancer cell, binds to its antigen, prevents growth factor attaching and slows cell growth
b) Targets only cancer cells, complementary to cancer cells receptors/antigen only, idea of damage compared to non-cancerous cells by conventional treatment

8 Plant disease (Biology only)

Overview

Specification points
4.3.3.1 Detection and identification of plant diseases; 4.3.3.2 Plant defence responses

Textbook chapter references
AQA GCSE (9-1) Biology: Chapter 8 pages 102–9

Recommended number of lessons: 2

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	Yes
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz
- Answers for homework task
- Answers to all questions

Useful prior learning

- There are no key points to remember from previous years' work that are specifically related to plant diseases.
- Students will have examined disease and pathogens in Chapter 6, however.

Common misconceptions

- Only animals suffer from diseases.
- All diseases are caused by bacteria.
- All pathogens are non-living.

Preparation

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the lesson.

Identifying plant diseases: Lesson 1

Learning outcomes

1 Describe how plant diseases can be detected and identified (HT).
2 Describe the symptoms of viral, bacterial, fungal and pest infections in plants.

Suggested lesson plan

Starter

Use the **T&L Lesson starter 1** to introduce the topic and allow the students to start thinking about plant diseases and how they might spread.

Main

Introduce the topic of plant diseases and the pathogens which can infect plants. Provide students with images of plants infected with tobacco mosaic virus and black spot, and infested with aphids. Allow them to research plant disease to try to find out what diseases the plants in the images might be suffering from.

Alternatively, students could produce a pamphlet or poster on plant diseases, the symptoms and how they spread. This should be limited to tobacco mosaic virus as a viral disease, black spot as a fungal disease and aphids as insects.

Students could complete the Working scientifically task on page 109 to practise their handling of data and data interpretation.

Plenary

Students could complete the Test yourself questions from page 105, the relevant Chapter review questions and the Practice questions from pages 107–8.

Support

Provide students with a structure for their pamphlet or poster to help guide them on the information they need to gather.

Extension

Students could complete the Activity on page 104 as an extension, although knowledge of Dutch elm disease is not needed for the exam. Higher tier students should add more detail on how plant diseases can be detected and identified.

Homework

Students could complete questions 1 and 2 from the Practice questions on page 108 of the textbook.

Deficiencies and defences: Lesson 2

Learning outcomes

1 Describe the symptoms of ion deficiencies in plants.
2 Explain how plants defend themselves physically and chemically against infection by pathogens.

Suggested lesson plan

Starter

Use the **T&L Lesson starter 2** to introduce the topic of plant diseases. Alternatively, show the video from Cambridge University entitled 'Don't eat the plants' which can be found at www.cam.ac.uk/research/news/cambridge-ideas-dont-eat-the-plants

Main

Discuss with students a range of physical, mechanical and chemical plant defence responses. You might like to do this by providing students with a range of plants or photographs to examine and asking them to describe how they are adapted to prevent infection and predation. They should decide whether it is a physical or chemical defence.

Students could then be asked to design their own plant and explain how it is adapted to avoid predation or infection.

To summarise this, students could complete the Test yourself questions from page 106.

Move on to a discussion of deficiency diseases in plants caused by ion deficiencies. Students could complete a short piece of writing for a gardening magazine on the symptoms of nitrate and magnesium deficiencies, explaining how these mineral ions are needed by the plant.

Plenary

Students could complete the **T&L Quick quiz**.

Support

You could provide students with a range of plant defence adaptations on cards and get them to sort them into chemical and physical defences.

Extension

Students could complete the Activity on page 105 where they need to plan an investigation to examine ion deficiencies in plants.

Homework

Students could complete the Chapter review questions on page 107 or the Practice questions from page 108. Alternatively, they could complete the **T&L Homework task** for this chapter.

Answers

AQA GCSE (9-1) Biology

Test yourself

1 Tobacco mosaic virus
2 A fungus
3 They would see stunted growth, spots on the leaves, lesions on the stems, areas of decay and the presence of pests.
4 Cellulose
5 A waxy cuticle
6 Butterflies mistake these spots for eggs and so don't lay any of their own. This means that the plants are not eaten by caterpillars.
7 It produces a poison to stop it being eaten by herbivores.

Show you can

Page 105

Tobacco mosaic virus causes discoloured patterns on infected leaves. This reduces photosynthesis. It costs US$60 billion (approximately £45 billion) each year. Rice blast is caused by a fungus. Each year it is estimated to destroy enough rice to feed more than 60 million people. It produces coloured lesions (rough bumpy areas) on rice stems and leaves. Rose black spot marks the leaves of infected plants, turning them purple or black. It reduces their ability to photosynthesise and produce glucose.

Page 106

They have a waxy cuticle and bark to prevent them from being infected. Some plants, such as mint and witch hazel, are naturally antiseptic if infected. Others, such as deadly nightshade, produce poisons to stop being eaten. Others have spines or thorns. Some, such as mimosa, even fold their leaves when touched.

Activity

Page 104

Task: no answer is required

Page 105

Allow any suitable method that suggests that growth of the radish seedlings in the five soils (A–E) could in some way be measured or observed. Students should have only the soil type varying as their independent variable, and the steps they take to control variables such as seedling number, amount of water and amount of soil should be stated clearly.

Chapter review questions

1 Tobacco mosaic virus
2 Rose black spot
3 Mistletoe
4 Aphids
5 They suck the sap from the stems of the plants.
6 Ladybirds
7 They produce chemicals that are poisonous to the herbivores.
8 Leaves of infected plants have discoloured patterns on their leaves that resemble mosaics.

9 It can survive without a host, providing the temperature of its environment remains below about 40°C.
10 Leaves turn purple or black
11 All infected leaves and stems are removed and burned and an antifungal chemical is sprayed on.
12 They reduce the rate at which plants grow, encourage them to wilt and make their leaves curl and discolour.
13 To make proteins
14 To make chlorophyll
15 They use active transport because these elements are found in higher concentrations in the plant than in the soil, and so need energy to move against the concentration gradient.
16 Plant five radish seedlings (or other suitable plant) into pots of different soils that are deficient in nitrogen, potassium, magnesium and phosphorus. Plant five seedlings into a pot of soil that is not deficient in those minerals, as a control. After several weeks compare the growth of the seedlings in the deficient soils with the control.
17 Cell walls are thickened with cellulose, waxy cuticle, bark or woody stems
18 This reduces the infected plant's ability to photosynthesise and therefore produce the glucose needed for growth.
19 US$60 billion (approximately £45 billion) lost each year due to this disease.
20 Chlorosis
21 Stunted growth, spots on leaves or lesions on stems, areas of decay (rotting), the presence of pests
22 By looking in books or on the internet, or by taking their infected plant to a garden centre or laboratory to help
23 Mint and witch hazel
24 Digitalis
25 They look like the eggs of butterflies and so adult butterflies that are ready to lay their eggs will avoid these leaves to minimise any competition for their offspring.

Practice questions

1 a) Rose black spot, rice blast, ash die back
b) Bacterium, virus, parasite, protist
c) i) 45
ii) Increases [1] initially starts low from 3–4 days then dramatically increases [1]. Suitable data quotes to support answer [1].
iii) 3 and 4 days
d) Idea that fungi like damp and moist conditions [1]; after heavy rain soil becomes saturated, which promotes growth of fungi [1]; more fungi to infect more plants [1]; fungi carried from plant to plant in the soil water; do not accept rain
2 a) Must be comparative; healthy is a dark green all over but infected has discolouration over the leaf.
b) Idea less green, less chlorophyll so less able to carry out photosynthesis, less able to produce sugars to support life processes
3 a) i) Stunted growth
ii) Leaves turned yellow
b) Nitrate is required for making amino acids [1]; without these, proteins can't be made and growth is stunted [1]. Magnesium is required for making chlorophyll [1]; this is a green pigment and, if not made, the leaf appears yellow [1].
c) Roots/root hair cells
d) The concentration gradient requires active transport, as there is a higher concentration of mineral ions inside the duckweed than in the solution.
e) A: active transport

Working scientifically: Experimental skills
Page 109

1 A control was used to compare the results to when no essential oil restricted the bacterial growth. The control could have been water.
2 In the control the numbers of bacteria increased, therefore the liquid became more cloudy and less light was transmitted.
3 Grapeseed has the anomaly: 86 at 240 minutes.
4 Task: no answer required
5 Peppermint oil was the most effective as there was no growth of bacteria. Throughout the experiment there was 100% transmission of light. Grapeseed oil inhibited the least amount of growth. At 300 minutes, there was only 5% transmission of light. This percentage is less than the control. Rosemary oil was more effective than grapeseed oil, as after 300 minutes there was 52% transmission of light.
6

Condition	Reduction in transmission of light %T
Control	91
Grape seed	95
Rosemary	48
Peppermint	0

7 Task: no answer required

Bioenergetics

9 Photosynthesis

Overview

Specification points

4.4.1.1 Photosynthetic reaction; 4.4.1.2 Rate of photosynthesis; 4.4.1.3 Uses of glucose from photosynthesis

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 9 pages 110–18

AQA GCSE (9-1) Combined Science Trilogy 1: Chapter 7 pages 95–103

AQA GCSE (9-1) Combined Science Trilogy: Chapter 7 pages 95–103

Recommended number of lessons: 4

Chapter overview	
AQA required practicals	Biology – RP6 CS Trilogy – RP5
Contains higher-tier only material	Yes
Contains biology-only material	No

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Practical
- Teacher and technician notes
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Key concept: Photosynthesis and limiting factors
- Key concept: Plotting a line graph
- Personal tutor: Photosynthesis
- Video: Investigate the effect of light intensity on the rate of photosynthesis in an aquatic plant

Useful prior learning

- Plants make carbohydrates in their leaves by photosynthesis and gain mineral nutrients and water from the soil via their roots.
- The word equation for photosynthesis

Common misconceptions

- Plants get 'food' from the soil.
- Photosynthesis will only occur with sunlight.
- Photosynthesis occurs only in the leaves of plants or in green plants.
- Photosynthesis releases energy or acts to collect heat energy.
- Students may have misunderstandings due to the association of everyday terminology and assume the term producer relates to 'produce'.
- Photosynthesis is a gaseous exchange process in which carbon dioxide is taken in and oxygen is released.
- Photosynthesis is the term given to respiration in plants.

Preparation

The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for this unit on plant tissues, organs and transportation. This should allow you to get a deeper understanding of common misconceptions and desired prior knowledge from KS3. It is also worth reviewing students' understanding of leaf structure from Chapter 3.

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the next few lessons or can be reserved for recap/consolidation at the end of the topic.

Photosynthesis the products and reactants: Lesson 1

Learning outcomes

1 State the word equation for photosynthesis.
2 State the chemical symbols for the reactants and products of photosynthesis.
3 Describe the reaction of photosynthesis as endothermic.
4 Describe the uses of glucose produced in photosynthesis.

Suggested lesson plan

Starter

In the first lesson in this sequence on photosynthesis review students' prior understanding from KS3. The student questions on the **T&L Prior knowledge catch-up student sheet** can be used to assist with this or the Test yourself on prior knowledge questions from page 111(*96*).

Alternatively, you could start the lesson by using the **T&L Lesson starter 1**.

Main

Discuss with students the equation for photosynthesis. You may like to do this as a card sort activity allowing students to work out the word equation for themselves and then match with the symbols to create a balanced equation.

This lesson provides an opportunity to review the organelles within a plant cell and tissues within a leaf and their functions.

You may also want to allow students to carry out practical work to investigate the conditions required for photosynthesis to occur. Students could test leaves for the presence of starch as an indication of whether the plant was photosynthesising. Plants could be prepared so some leaves have foil over them to prevent light reaching them and some are in a clear bag with soda lime to remove the carbon dioxide. Variegated leaves could also be used to show that a pigment such as chlorophyll is needed.

Review the reaction and ensure students understand that photosynthesis is an endothermic reaction.

To finish, explore what happens to the glucose produced from photosynthesis. Students could research this or produce a flow chart to show what happens to the glucose. Alternatively, this could be used as an activity to review food tests as students could test plant products for the presence of protein, fats, glucose and starch.

Plenary

Students could complete the Test yourself questions from page 112(*97*) or the **T&L Quick quiz 1**.

Support

Use the starter activity to reveal what misconceptions students may already hold about photosynthesis. Students may need support to understand what the term 'endothermic' means.

Extension

Develop students' understanding of photosynthesis so they realise that it is not just plants which are capable of carrying out photosynthesis. Algae and other groups are also capable of it.

Homework

Students could complete questions 1 and 2 from the Practice questions on page 117(*102*). Alternatively, they could make a summary poster on photosynthesis.

The rate of photosynthesis: Lesson 2

Learning outcomes

1 Explain the effects of temperature, light intensity, carbon dioxide concentration and the amount of chlorophyll on the rate of photosynthesis.
2 Measure and calculate rates of photosynthesis.
3 Extract and interpret graphs of photosynthesis rate involving one limiting factor (FT) or multiple factors (HT).

Suggested lesson plan

Starter

Students could complete the **T&L Lesson starter 2** to introduce limiting factors or take part in a review quiz on the concepts from the lesson before.

Main

Explain to students what limiting factors are and allow them to discuss what factors might limit photosynthesis. The **T&L Key concept: Photosynthesis and limiting factors** can be used to introduce this.

Students could carry out practical work on limiting factors by investigating the effect of light or concentration of carbon dioxide on algae which has been immobilised. SAPs has a method and protocol which can be followed (www.saps.org.uk/secondary/teaching-resources/235-student-sheet-23-photosynthesis-using-algae-wrapped-in-jelly-balls).

Alternatively, you may wish to provide students with data and allow them to graph it so they can see how the different factors limit the rate of photosynthesis. Students should be able to describe and explain the trends seen (omitting light which will be explored in the Required practical). The **T&L Key concept: Plotting a line graph** can be used to review the skills required.

Students could complete the Activity from pages 114–5 of the textbook (Biology only).

Plenary
Students could complete the Test yourself questions on page 115(*98*) or the **T&L Quick quiz 2**.

Support
Students may need support with interpreting the graphs and understanding how the rate of photosynthesis is calculated.

Extension
Students could be provided with data on the costs of running a greenhouse and determine which levels of light, carbon dioxide and temperature would maximise the rate of photosynthesis while remaining cost effective.

Homework
Students could complete the Working scientifically task from page 118(*103*).

Required practical 6(*5*): Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pond weed: Lesson 3

Learning outcomes

1 Determine the effect of light intensity on the rate of photosynthesis.
2 Describe the method used in this practical.
3 Use the inverse square law for increases in light intensity during photosynthesis (HT).

Preparation
Read through the **T&L Teacher and technician notes** so you are confident with what the practical is and the requirements for the task.

Suggested lesson plan
Starter
Introduce the Required practical task by allowing the students to read the method from the **T&L Practical** worksheet or from pages 113–4(*99*) of the textbook. Alternatively, the students can watch the **T&L Video: Investigate the effect of light intensity on the rate of photosynthesis in an aquatic plant**.

Main
Before students begin, ensure they are confident with what they need to do, by either demonstrating the methods or asking the students what steps should be followed. They should write a prediction for what they think will happen.

Allow students to carry out the practical.

Plenary
Depending on the length of the lesson, students could either collect the results or, for HT students, determine the light intensity for each distance used using the inverse square law. Alternatively, you could evaluate the practical together, highlighting any issues or errors which may have occurred.

Support
Ensure students are confident with collecting data and drawing line graphs. The **T&L Key concept: Plotting a line graph** can be used to support this.

Extension
More able students should think about how the method could be adapted to examine a different limiting factor or gather more accurate results.

Homework
Students could complete the Chapter review questions from page 116(*101*) or the Practice questions from page 117(*102*).

Required practical 6(*5*) evaluation and write-up: Lesson 4

Learning outcomes

Write up the experiment, analyse the results, draw conclusions and evaluate the experimental method.

Suggested lesson plan
Starter
Depending on where they got up to in the previous lesson, students could be gathering their results, working out light intensity or beginning their graphs.

Main
Students should use the lesson to complete the practical, write up their method, produce a graph of their results, draw a conclusion and evaluate the experiment. The questions on the **T&L Practical** worksheet or page 114(*99*) can support this.

Plenary
Take the time to summarise the practical with the students and ensure they are confident with the skills learnt, particularly plotting line graphs.

Support
Ensure students are confident with how to collect data and draw a line graph. The **T&L Key concept: Plotting a line graph** can be used to support this.

Extension
More able students should think about how the method could be adapted to examine a different limiting factor or gather more accurate results.

Homework
Students could complete the **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 Glucose and oxygen
2 Covered in plant hair cells, which increase the surface area to absorb the maximum volume of water
3 Because they are the only organisms that can capture the Sun's energy and convert it into glucose

Test yourself

1 Chlorophyll (not chloroplasts)
2 $C_6H_{12}O_6$ and $6O_2$
3 It is an endothermic reaction and so requires energy (which it gets from light) to work.
4 Photosynthetic algae in the oceans produce about 70% of our oxygen.
5 A variable that reduces and then completely stops a process
6 Temperature, light, carbon dioxide, chlorophyll
7 To make chlorophyll
8 They can optimise light and temperature levels. They can also add carbon dioxide.

Show you can
Page 112

Plants only photosynthesise during the day but they respire throughout the day and night. So oxygen levels would increase during the day and reduce again at night.

Page 115

There is more energy in the products glucose and oxygen than the reactants water and carbon dioxide. Energy from the Sun is used to break the bonds in the reactants and re-form them in the products.

Required practical 6
Pages 113–4

1

Distance (cm)	Light intensity (AU)
10	0.01000 or 0.0100
20	0.00250 or 0.0025
30	0.00110 or 0.0011
40	0.00063 or 0.0006
50	0.00040 or 0.0004

2 Task: no answer is required
3 Answer is based on the student's own results.
4 To act as a heat shield
5 To allow pondweed time to adjust to the new light intensity
6 Use a gas syringe to measure the volume of oxygen produced

Activity
Pages 114–5

1 The rate would reduce by 20% from 100% to 80%.
2 **a)** Increased carbon dioxide levels increase the rate of photosynthesis. This means more glucose was produced that could be used in respiration to release energy for life processes such as growth, so the lettuces got larger. Also the more glucose produced, the more that could be stored in the plant as starch.
b) Allow a 14–16% increase.
3 **a)** Curve is levelling off.
b) It does not have much of an impact on rate. Something else is limiting photosynthesis.
4 As light intensity increases, more photosynthesis will occur, therefore there is more need for carbon dioxide.

Chapter review questions

1 Carbon dioxide and water
2 Leaves
3 Chloroplast
4 Light energy from the Sun
5 To provide themselves with energy
6 Almost all animals eat them or eat other animals that have eaten them
7 Carbon dioxide and water [and light] → glucose and oxygen
8 Chlorophyll
9 Palisade mesophyll
10 Palisade mesophyll
11 Root hair cell
12 Algae
13 $C_6H_{12}O_6$
14 Anything that reduces or stops the rate of a reaction
15 Active transport
16 Magnesium
17 Often they are yellow rather than green
18 The crops are more protected from the wind and pests in polytunnels and greenhouses, but this also allows farmers to control the temperature, carbon dioxide and light needed for maximum photosynthesis.
19 It is used in respiration, converted into insoluble starch and stored, converted into fats and oils and stored, used to make cellulose cells walls for growth, and, along with nitrate ions absorbed from the soil, makes proteins.
20 Cellulose
21 10%
22 Because it requires light energy to work

23 So that the cells can respire to release energy
24 Brown and red
25 $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
26 Temperature, carbon dioxide, light, chlorophyll
27 Because the reactant molecules have less kinetic energy, so collide less, and so react less
28 Because it is one of the key reactants
29 Because light provides the energy necessary for this reaction, so reduced levels mean reduced photosynthesis
30 Put a small length of pondweed into a boiling tube of water and position a short distance from a lamp. After 2 minutes, record the number of bubbles of oxygen produced. Move the tube progressively further away from the lamp and repeat. (More bubbles of oxygen means more photosynthesis.)
31 The amount of an agricultural product
32 Keep the temperature at an optimum, have burners near their plants to produce carbon dioxide for optimal growth and provide their plants with maximum light
33 In the chemical bonds of the glucose molecules
34 Because the plant has used light energy to make glucose
35 Nitrate ions

Practice questions

1 a) X = water, Y = Oxygen
b) Diffusion, through the leaf, through pores or stomata
c) i) Leaf
ii) Light
iii) Chlorophyll
iv) Chloroplasts
2 a) Starch present in A and C [1 mark] but not present in B [1 mark]
b) i) C: iodine solution
ii) B: blue-black
3 a) i) 25°C
ii) 0.11%
iii) 232 arbitrary units
b) Light intensity
4 Level 3: There is a clear description of how the investigation would be carried out and what measurements would be taken. There is a description of what steps would be taken to make it a fair test, including mention of controls and controlled variables. *[5–6 marks]*

Level 2: There is a description of a method involving how a change in light intensity may affect pond weed. A description of what is measured or at least one mention of how the experiment will be a fair test is included. *[3–4 marks]*

Level 1: There is a basic description of a simple method involving light and pond weed. *[1–2 marks]*

No relevant content: (0 marks)

Indicative content: description of what apparatus is needed and how it is used; description of how light intensity would be changed; description of how the rate of photosynthesis would be measured; use of ruler to measure distance of light from beaker/pond weed; higher tier students may also reference calculating light intensity using 1/d; reference to counting the numbers of bubbles/measuring the volume of gas produced; reference to using beaker of water as a heat shield/another method of maintaining the temperature of the water surrounding the pond weed; reference to using the same piece of pond weed throughout; reference to controlling the concentration of carbon dioxide in the water; reference to allowing the pond weed to acclimatise for the same amount of time before starting the experiment.

Working scientifically: Experimental skills
Page 118

1 Time for leaf disc to reach the surface
2 Concentration of sodium hydrogen carbonate
3 Volume of sodium hydrogen carbonate, number of leaf discs, age of leaf discs, distance from lamp, temperature, size of syringe

AQA GCSE (9-1) Combined Science Trilogy
Test yourself on prior knowledge

1 Glucose and oxygen
2 Because they are the only organisms that can capture the Sun's energy and convert it into glucose

Test yourself

1 Chlorophyll (not chloroplasts)
2 $C_6H_{12}O_6$ and $6O_2$
3 It is an endothermic reaction and so requires energy (which it gets from light) to work.
4 A variable that reduces and then completely stops a process
5 Temperature, light, carbon dioxide, chlorophyll
6 To make chlorophyll
7 They can optimise light and temperature levels. They can also add carbon dioxide.

Show you can
Page 97

Plants only photosynthesise during the day but they respire throughout the day and night. So oxygen levels would increase during the day and reduce again at night.

Page 100

There is more energy in the products glucose and oxygen than the reactants water and carbon dioxide. Energy from the Sun is used to break the bonds in the reactants and re-form them in the products.

Required practical 5

Page 99

1

Distance (cm)	Light intensity (AU)
10	0.01000 or 0.0100
20	0.00250 or 0.0025
30	0.00110 or 0.0011
40	0.00063 or 0.0006
50	0.00040 or 0.0004

2 Task: no answer required
3 Answer is based on the student's own results.
4 To act as a heat shield.
5 To allow pondweed time to adjust to the new light intensity.
6 Use a gas syringe to measure the volume of oxygen produced.

Chapter review questions

1 Carbon dioxide and water
2 Leaves
3 Chloroplast
4 Light energy from the Sun
5 Almost all animals eat them or eat other animals that have eaten them
6 Carbon dioxide and water [and light] → glucose and oxygen
7 Chlorophyll
8 Palisade mesophyll
9 Palisade mesophyll
10 Root hair cell
11 $C_6H_{12}O_6$
12 Anything that reduces or stops the rate of a reaction
13 Active transport
14 Magnesium
15 The crops are more protected from the wind and pests in polytunnels and greenhouses, but this also allows farmers to control the temperature, carbon dioxide and light needed for maximum photosynthesis.
16 It is used in respiration, converted into insoluble starch and stored, converted into fats and oils and stored, used to make cellulose cell walls for growth, and, along with nitrate ions absorbed from the soil, makes proteins.
17 Cellulose
18 It requires light energy from the surroundings (Sun).
19 $6CO_2 + 6H_2O$ [+ light] → $C_6H_{12}O_6 + 6O_2$
20 Temperature, carbon dioxide, light, chlorophyll
21 Because the reactant molecules have less kinetic energy, so collide less, and so react less
22 Because it is one of the two key reactants
23 Because light provides the energy necessary for this reaction, so reduced levels mean reduced photosynthesis
24 Put a small length of pondweed into a boiling tube of water and position a short distance from a lamp. After 2 minutes, record the number of bubbles of oxygen produced. Move the tube progressively further away from the lamp and repeat. (More bubbles of oxygen means more photosynthesis.)
25 The amount of an agricultural product
26 Keep the temperature at an optimum, have burners near their plants to produce carbon dioxide for optimal growth and provide their plants with maximum light.
27 Because the plant has used light energy to make glucose
28 Nitrate ions

Practice questions

1 a) X = water, Y = oxygen *[2 marks]*
b) Diffusion, through the leaf, through pores or stomata *[1 mark]*
c) i) Leaf *[1 mark]*
ii) Light *[1 mark]*
iii) Chlorophyl *[1 mark]*
iv) Chloroplasts *[1 mark]*

2 a) Starch present in A and C [1 mark] but not present in B *[1 mark]*
b) i) C: iodine solution *[1 mark]*
ii) B: blue-black *[1 mark]*

3 a) i) 25 C *[1 mark]*
ii) 0.11% *[1 mark]*
iii) 232 arbitrary units *[1 mark]*
b) Light intensity *[1 mark]*

4 Level 3: There is a clear description of how the investigation would be carried out and what measurements would be taken. There is a description of what steps would be taken to make it a fair test, including mention of controls and controlled variables. *[5–6 marks]*

Level 2: There is a description of a method involving how a change in light intensity may affect pond weed. A description of what is measured or at least one mention of how the experiment will be a fair test is included. *[3–4 marks]*

Level 1: There is a basic description of a simple method involving light and pond weed. *[1–2 marks]*

No relevant content: *[0 marks]*

Indicative content: description of what apparatus is needed and how it is used; description of how light intensity would be changed; description of how the rate of photosynthesis would be measured; use of ruler to measure distance of light from beaker/pond weed; higher tier students may also reference calculating light intensity using 1/d; reference to counting the numbers of bubbles/measuring the volume of gas produced; reference to using beaker of water as a heat shield/another method of maintaining the temperature of the water surrounding the pond weed; reference to using the same piece of pond weed throughout; reference to controlling the concentration of carbon dioxide in the water; reference to allowing the pond weed to acclimatise for the same amount of time before starting the experiment.

Working scientifically: Experimental skills
Page 103

1 Time for leaf disc to reach the surface
2 Concentration of sodium hydrogen carbonate
3 Volume of sodium hydrogen carbonate, number of leaf discs, age of leaf discs, distance from lamp, temperature, size of syringe

10 Respiration

Overview

Specification points
4.4.2.1 Aerobic and anaerobic respiration; 4.4.2.2 Response to exercise; 4.4.2.3 Metabolism

Textbook chapter references
AQA GCSE (9-1) Biology: Chapter 10 pages 119–30

AQA GCSE (9-1) Combined Science Trilogy 1: Chapter 8 pages 104–15

AQA GCSE (9-1) Combined Science Trilogy: Chapter 8 pages 104–115

Recommended number of lessons: 4

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	Yes
Contains biology-only material	No

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Personal tutor: Respiration

Useful prior learning

- Aerobic and anaerobic respiration in living organisms
- A word summary for aerobic respiration
- About the process of anaerobic respiration in humans and microorganisms, including fermentation, and a word summary for anaerobic respiration
- The differences between aerobic and anaerobic respiration in terms of the reactants, the products formed and the implications for the organism

Common misconceptions

- Respiration is synonymous with breathing.
- Energy is created in respiration.
- During respiration oxygen is converted into another form of gas, carbon dioxide.
- All living things use oxygen during respiration reactions.
- During anaerobic respiration reactions carbon dioxide is used instead of oxygen.
- Plant respiration is called photosynthesis and involves carbon dioxide being exchanged for oxygen.
- Plants respire during the night only or only during the day.
- Respiration in plants occurs only in the leaves.

Preparation
The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for this unit on respiration.

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the next few lessons or can be reserved for recap/consolidation at the end of the topic.

Aerobic respiration: Lesson 1

Learning outcomes

1 State the word equation for aerobic respiration.
2 Describe the process of aerobic respiration and the uses of energy released.

Suggested lesson plan

Starter
In the first lesson in this sequence review students' prior understanding on respiration from KS3. The student questions on the **T&L Prior knowledge catch-up student sheet** can be used to assist with this or the Test yourself on prior knowledge questions from page 120(*105*). Alternatively, you could use the **T&L Lesson starter 1**.

Main
Discuss the word equation for aerobic respiration. This could be done as a card sort activity allowing students to build up the word equation and then link this to the balanced chemical formula.

Students could carry out a practical examining carbon dioxide production in organisms using either limewater or hydrogencarbonate indicator. If available, students could use a respirometer to measure the rate of respiration. Alternatively, students could complete the Activity from page 121(*106*).

Review respiration as an exothermic reaction and the meaning of this. Discuss the conversion of energy that occurs in respiration. Students could complete a practical activity to measure the heat

production from germinating seeds vs dead plant material, or alternatively complete the Activity from page 122(*107*).

Plenary
Students could complete the Test yourself questions from page 121(*106*).

Support
Ensure respiration is introduced as a chemical reaction and avoid discussing oxygen and carbon dioxide alone as this strengthens the misconception that respiration is a different term for gaseous exchange. Take the time in this first lesson to review students' prior understanding and uncover any misconceptions they may have from KS3.

Extension
Students could compare respiration as an exothermic reaction against photosynthesis as an endothermic reaction and examine the energy conversions in each.

Homework
Students could complete the relevant Chapter review questions from page 127(*112*) or question 1 from the Practice questions on page 128(*113*).

Anaerobic respiration: Lesson 2

Learning outcomes

1 Describe the effects of exercise on heart rate, breathing rate and breathe volume during exercise.
2 Explain how lactic acid is removed from the body (HT).
3 State the word equation for anaerobic respiration.
4 Describe the process of anaerobic respiration and the uses of released energy.
5 Compare aerobic and anaerobic respiration.

Suggested lesson plan

Starter
Introduce the lesson by asking students to hold one hand in the air above their head and the other down by their side and then clench and unclench their fist. **T&L Lesson starter 2** has more details on this.

Main
Discuss what physiological responses the body has to exercise. Depending on your group you might like to carry out a practical examining this, such as measuring students' resting heart rate and/or breathing rate against that after light and moderate exercise. Ensure students can explain why these changes occur.

Move on to discuss what happens if you cannot meet your body's requirements for oxygen and use this to introduce anaerobic respiration and the equation for this. Discuss with students the reactants, products and energy release.

Ask students to explain why after exercising their breathing rate and heart rate remain high for a period of time (recovery rate) and use this to allow students to explore oxygen debt and how lactic acid is broken down and removed from the body.

Plenary
Students could make a poster, table or Venn diagram to compare and contrast aerobic and anaerobic respiration.

Support
Ensure students can compare and contrast aerobic and anaerobic respiration. You may want to provide students with a card sort or statements so you are confident they have the key differences and similarities.

Extension
Students could determine their own recovery rates following exercise. They could also be asked to plot a frequency histogram of heart rate. If available, students could measure oxygen saturation in their blood before and after exercise using a pulse oximeter.

Homework
Students could produce a poster or pamphlet on the body's response to exercise to consolidate their understanding. Alternatively, they could complete the Test yourself questions on page 124(109).

Anaerobic respiration in plants and microorganisms: Lesson 3

Learning outcomes

1 State the word equation for anaerobic respiration in plant and yeast cells.
2 Describe the process of anaerobic respiration in plant and yeast cells.

Suggested lesson plan
Starter
To check students' understanding of the previous lesson, provide the class with some statements and ask them to sort them into those which relate to anaerobic respiration and those which relate to aerobic respiration.

Main
Introduce anaerobic respiration in plants and microorganisms. Ensure you highlight the differences between anaerobic respiration in animals and microorganisms and give students the word equation for fermentation.

Students could carry out practical work exploring fermentation in yeast. They could explore how fermentation is affected by temperature or availability of glucose. A simple practical can involve adding a yeast/glucose mixture to a measuring cylinder and recording the volume of the bubbles produced. Alternatively, students could use a gas syringe to explore this.

Students could then complete the Working scientifically task on pages 129–30(*114–15*) of the textbook.

Plenary
Students could complete the Test yourself questions from page 125(*110*) or the **T&L Quick quiz 1**.

Support
When discussing respiration in plants, ensure you take the time to uncover and overcome any misconceptions students might have with regards to photosynthesis and respiration. You could provide students with a graph showing the rate of photosynthesis against respiration so students are clear that respiration occurs throughout a 24-hour period but photosynthesis only occurs in the presence of light.

Extension
Students could explore the manufacturing processes of wine, beer or bread.

Homework
Students could complete the **T&L Homework task** or the relevant questions from the Chapter review on page 127(*112*).

Metabolism: Lesson 4

Learning outcomes

1 Explain the importance of sugars, amino acids, fatty acids and glycerol in the synthesis and breakdown of carbohydrates, lipids and proteins.
2 Define the term metabolism.

Suggested lesson plan

Starter
Ask students what proteins, carbohydrates and lipids get broken down into during digestion and the enzymes involved.

Main
Introduce students to the term metabolism.

Students can review the breakdown reactions they have explored in digestion if needed (the starter should highlight this) and explore the breakdown of excess proteins to form urea for excretion and other breakdown reactions from the specification.

Students could then be introduced to synthesis reactions such as protein synthesis.

Students could make a poster to summarise these metabolic reactions or a cube where each face has a different reaction with a face colour to indicate whether they are breakdown or build-up reactions. Alternatively, the students could make a stop–start animation to show how enzymes help in breakdown and synthesis reactions.

Plenary
Students could complete the Test yourself questions on page 126 (Biology only) or the Chapter review questions from page 127(*112*).

Support
Use this lesson to review students' understanding of the digestion of macromolecules and the role that enzymes play and provide support as necessary to go over the concepts covered in Chapter 3.

Homework
Students can complete the **T&L Homework task** or the Practice questions from page 128(*113*).

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge
1 Carbon dioxide and water
2 Aerobic respiration happens in the presence of oxygen. Anaerobic doesn't.
3 Yeast respires anaerobically, which we call fermentation. We use this to make bread and beer.

Test yourself
1 Exothermic
2 Mitochondria
3 'With oxygen'
4 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ [+ energy]
5 Carbon dioxide and water
6 Carbon dioxide and water
7 Energy enters photosynthesis from the Sun. It is stored in glucose. This is then released in respiration to be used for the seven life processes.
8 It is converted into thermal energy or a chemical store of energy called adenosine triphosphate (ATP).

9 5%
10 In the liver
11 In the lactic acid
12 'Without oxygen'
13 Glucose → ethanol and carbon dioxide [and energy]
14 C_2H_5OH
15 Beers have about 4%, wines about 12% and spirits have 40%.
16 Bread is baked, which kills the yeast, and beer isn't.
17 The sum of all the reactions in your body
18 In the liver
19 The formation of starch, cellulose or glycogen from glucose, or fats from fatty acids and glycerol
20 The breakdown of protein into amino acids, fats into fatty acids and glycerol, or carbohydrate into sugars

Show you can
Page 121

They require more energy to function. They need to complete more respiration to release this energy from glucose. They have more mitochondria to do this.

Page 123

The reactants and products are opposite. The products of photosynthesis are glucose and oxygen. These are the reactants of respiration. The reactants of photosynthesis are carbon dioxide and water. These are the products of respiration. Energy enters from the Sun in photosynthesis and exits from respiration. Photosynthesis occurs in the day, whereas respiration occurs at all times.

Page 124

At the end of a run your cells lack oxygen. They start to respire anaerobically. This means lactic acid is produced and less energy is released. After you finish the race your body pays the oxygen debt by breathing deeply and quickly. You break down your lactic acid and return to aerobic respiration.

Page 125

They complete fermentation to produce energy for them to complete the seven life processes. Ethanol and carbon dioxide are produced instead of water and carbon dioxide in aerobic respiration of many other organisms like us. Ethanol is a by-product of yeast.

Page 126

Synthesis reactions make larger molecules from smaller ones. Examples are the formation of starch, cellulose or glycogen from glucose or fats from fatty acids and glycerol. Breakdown reactions make smaller molecules from larger ones. Examples include the breakdown of protein into amino acids, fats into fatty acids and glycerol, or carbohydrate into sugars.

Activity
Page 121

1 a) Carbon dioxide
   b) It is absorbed by the soda lime.
2 a) They move left towards the tube.
   b) The invertebrates are using up the oxygen in respiration, therefore the volume of gases in the equipment reduces.
3 The cricket's respirometer, as its scale has a higher resolution

Page 122

1 To allow oxygen to get into the flask for respiration
2 a) Over time the temperature readings would increase.
   b) As respiration occurs heat is released as waste energy.
3 Boiled yeast is a suitable control. Having a control allows you to compare your results.

Chapter review questions
1 Respiration is a chemical reaction that releases energy and ventilation is the process of breathing.
2 Glucose and oxygen
3 'In the presence of oxygen'
4 Glucose and oxygen → carbon dioxide and water [and energy]
5 Ventilation or breathing
6 When cells do not have enough oxygen
7 Glucose → lactic acid [and energy]
8 Muscle fatigue and cramp
9 Diffusion
10 Glucose → ethanol and carbon dioxide [and energy]
11 Anaerobic respiration in microorganisms (fermentation) produces alcohol, which we consume.
12 Beers are 4%, wines are 12% and spirits are 40%.
13 Mitochondria
14 The life processes: movement, reproduction, sensitivity, nutrition, excretion and growth
15 It releases energy.
16 5%
17 The temporary shortage of oxygen in respiring tissues and organs
18 Your body needs to respire more to provide the energy for your muscle cells to keep on exercising. This means you need to breathe faster and deeper to provide oxygen and increase your heart rate to pump this oxygen and more glucose to your muscle cells.

19 The chemical breakdown of glucose into ethanol and carbon dioxide by respiring microorganisms such as yeast
20 The sum of all the chemical reactions that happen in an organism
21 Heat 200 cm^3 of 10% glucose solution to 35°C and add 20 g of baker's yeast. Place in a thermos flask with a thermometer held by a tightly fitting bung. A second hole in the bung relieves pressure inside the flask. Monitor the temperature for the following hour.
22 Energy is not a chemical and so cannot be a product.
23 Energy is required for photosynthesis to occur whereas respiration releases energy.
24 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ [+ energy]
25 Photosynthesis is an endothermic reaction, which requires light energy from its surroundings to occur. Respiration is an exothermic reaction, which releases energy to its surroundings.
26 ATP (adenosine triphosphate)
27 The lactic acid reacts with the new oxygen in your body to produce carbon dioxide and water, which releases the remaining 95% (or 19/20th) of the energy.
28 In the chemical bonds of the lactic acid
29 It diffuses into your blood and is carried to your liver, where it is broken down by an oxidation reaction.
30 Any reaction in which a substance gives up electrons, as when reacting with oxygen
31 Place a grasshopper (or similar small invertebrate) into a boiling tube. Use a cotton wool stopper half way down to trap the grasshopper. Place a small amount of soda lime after the cotton wool. Place a bung with a capillary tube running through it into the boiling tube. Insert a small droplet of water into the tube. Observe the position of the droplet in the tube as the grasshopper respires. Repeat using another small invertebrate such as a cricket. Release the insects safely at the end of the experiment.

Practice questions

1 a) i) To provide, release or transfer energy
ii) A: carbon dioxide, D: water
iii) D: $C_6H_{12}O_6$
b) i) B
ii) To absorb carbon dioxide produced, so the gas does not affect the movement of the liquid

2 a) 60 beats per minute
b) Any three from: to carry the oxygen and glucose; to cells quicker; so more respiration can occur; to release more energy; to allow more muscle contractions, to remove the waste products faster
c) 18 125
d) Increased breathing rate, increased depth for breathing, increased body temperature, dilation of blood vessels

3 a) 'Without oxygen'
b) i) C: glucose → ethanol and carbon dioxide
ii) Humans make lactic acid not alcohol/ethanol.
c) Increased, fast initially between 0 and 12 hours, then slowed production between 12 and 24 hours

4 a) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$; 1 mark for molecules correct and 1 mark for balanced equation
b) i) Lactic acid
ii) The lactic acid is carried back to the liver, and oxygen is used to oxidise the lactic acid to produce glucose.

5 Level 3: A clear description covering the key differences and similarities between aerobic and anaerobic respiration in humans *[5–6 marks]*
Level 2: A number of relevant points made, but not precisely *[3–4 marks]*
Level 1: Fragmented points *[1–2 marks]*
No relevant content: *[0 marks]*
Indicative content: both designed to release energy; both convert chemical energy; both use glucose as a reactant; both occur in cells; aerobic respiration: requires oxygen; produces carbon dioxide and water; releases more energy; glucose + oxygen → carbon dioxide + water; $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$; anaerobic respiration: occurs without oxygen; glucose → lactic acid; produces lactic acid; releases less energy; creates an oxygen debt; lactic acid must be later broken down using oxygen; lactic acid is broken down into carbon dioxide and water.

Working scientifically: Dealing with data
Pages 129–30

1–2

Temperature in °C	Range (1)	Mean (2)
20	345–400	362
35	623–682	651
50	302–520	474
65	105–203	159
80	1–4	2

3 Anomalous results are at temperature 50°C for Repeat 3, at 65°C for Repeat 4 and at 55°C for Repeat 5.
4 Afreen's data

Temperature in °C	Range	Mean
20	14–20	16.6
35	43–45	44.2
50	4–55	36
65	24–28	25.8
80	1–5	2.6

5 In both students' data the volume of gas produced over 10 minutes increases from 20°C to 35°C. It then decreases from 35°C to 80°C. This is because 35°C is closest to the optimal temperature for yeast.
6 Afreen's equipment allowed for more accurate data to be collected because she collected the volume of gas rather than counting the number of bubbles.
7 To allow time for the yeast to adjust to the conditions.
8 To prevent oxygen from reaching the solution, so anaerobic respiration was occurring.
9 Carbon dioxide. Lime water could be used to test for its presence. It would go cloudy if carbon dioxide was present.

AQA GCSE (9-1) Combined Science Trilogy
Test yourself on prior knowledge

1 Carbon dioxide and water
2 Aerobic respiration happens in the presence of oxygen. Anaerobic doesn't.
3 Yeast respires anaerobically, which we call fermentation. We use this to make bread and beer.

Test yourself

1 Exothermic
2 Mitochondria
3 'With oxygen'
4 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ [+ energy]
5 Carbon dioxide and water
6 Carbon dioxide and water
7 Energy enters photosynthesis from the Sun. It is stored in glucose. This is then released in respiration to be used for the seven life processes.
8 It is converted into thermal energy or a chemical store of energy called adenosine triphosphate (ATP).
9 5%
10 In the liver
11 In the lactic acid
12 'Without oxygen'
13 Glucose → ethanol and carbon dioxide [and energy]
14 Bread is baked, which kills the yeast, and beer isn't.

Show you can
Page 106

They require more energy to function. They need to complete more respiration to release this energy from glucose. They have more mitochondria to do this.

Page 108

The reactants and products are opposite. The products of photosynthesis are glucose and oxygen. These are the reactants of respiration. The reactants of photosynthesis are carbon dioxide and water. These are the products of respiration. Energy enters from the Sun in photosynthesis and exits from respiration. Photosynthesis occurs in the day, whereas respiration occurs at all times.

Page 109

At the end of a run your cells lack oxygen. They start to respire anaerobically. This means lactic acid is produced and less energy is released. After you finish the race, your body pays the oxygen debt by breathing deeply and quickly. You break down your lactic acid and return to aerobic respiration.

Page 110

They complete fermentation to produce energy for them to complete the seven life processes. Ethanol and carbon dioxide are produced instead of water and carbon dioxide in aerobic respiration of many other organisms like us. Ethanol is a by-product of yeast.

Activity
Page 106

1 a) Carbon dioxide
   b) It is absorbed by the soda lime
2 a) They move left towards the tube.
   b) The invertebrates are using up the oxygen in respiration, therefore the volume of gases in the equipment reduces.
3 The cricket's respirometer, as its scale has a higher resolution.

Page 107

1 To allow oxygen to get into the flask for respiration.
2 a) Over time the temperature readings would increase.
   b) As respiration occurs heat is released as waste energy.
3 Boiled yeast is a suitable control. Having a control allows you to compare your results.

Chapter review questions

1 Respiration is a chemical reaction that releases energy and ventilation is the process of breathing.
2 Glucose and oxygen
3 'In the presence of oxygen'
4 Glucose and oxygen → carbon dioxide and water [and energy]
5 When cells do not have enough oxygen
6 Glucose → lactic acid [and energy]
7 Muscle fatigue and cramp
8 Diffusion
9 Glucose → ethanol and carbon dioxide [and energy]
10 Anaerobic respiration in microorganisms (fermentation) produces alcohol, which people consume.
11 Mitochondria
12 The life processes: movement, reproduction, sensitivity, nutrition, excretion and growth
13 It releases energy
14 5%
15 The temporary shortage of oxygen in respiring tissues and organs
16 Your body needs to respire more to provide the energy for your muscle cells to keep on exercising. This means you need to breathe faster and deeper to provide oxygen and increase your heart rate to pump this oxygen and more glucose to your muscle cells.
17 The chemical breakdown of glucose into ethanol and carbon dioxide by respiring microorganisms such as yeast
18 The sum of all the chemical reactions that happen in an organism
19 Heat 200 cm^3 of 10% glucose solution to 35°C and add 20 g of baker's yeast. Place in a thermos flask with a thermometer held by a tightly fitting bung. A second hole in the bung relieves pressure inside the flask. Monitor the temperature for the following hour.
20 Photosynthesis is an endothermic reaction, which requires light energy from its surroundings to occur. Respiration is an exothermic reaction, which releases energy to its surroundings.
21 ATP (adenosine triphosphate)
22 In the chemical bonds of the lactic acid
23 It diffuses into your blood and is carried to your liver, where is broken down by an oxidation reaction.
24 Any reaction in which a substance gives up electrons, as when reacting with oxygen
25 Place a grasshopper (or similar small invertebrate) into a boiling tube. Use a cotton wool stopper half way down to trap the grasshopper. Place a small amount of soda lime after the cotton wool. Place a bung with a capillary tube running through it into the boiling tube. Insert a small droplet of water into the tube. Observe the position of the droplet in the tube as the grasshopper respires. Repeat using another small invertebrate such as a cricket. Release the insects safely at the end of the experiment.

Practice questions

1 a) i) To provide, release or transfer energy *[1 mark]*
ii) A: carbon dioxide, D: water *[2 marks]*
iii) D: $C_6H_{12}O_6$ *[1 mark]*
b) i) B *[1 mark]*
ii) To absorb carbon dioxide produced [1 mark], so the gas does not affect the movement of the liquid *[1 mark]*
2 a) 60 beats per minute *[1 mark]*
b) Any three from: to carry the oxygen and glucose; to cells quicker; so more respiration can occur; to release more energy; to allow more muscle contractions, to remove the waste products faster *[3 marks]*
c) 125 × 145 = 18 125 [2 marks, 1 for working, 1 for correct answer]
d) Two of: increased breathing rate, increased depth for breathing, increased body temperature, dilation of blood vessels *[2 marks]*
3 a) 'Without oxygen' *[1 mark]*
b) i) C: glucose → ethanol and carbon dioxide *[1 mark]*
ii) Humans make lactic acid not alcohol/ethanol *[1 mark]*
c) Increased, fast initially between 0 and 12 hours [1 mark], then slowed production between 12 and 24 hours *[1 mark]*
4 a) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$; [2 marks, 1 for molecules correct and 1 for balanced equation]
b) i) Lactic acid *[1 mark]*
ii) The lactic acid is carried back to the liver [1 mark], and oxygen is used to oxidise the lactic acid to produce glucose. *[1 mark]*
5 Level 3: A clear description covering the key differences and similarities between aerobic and anaerobic respiration in humans *[5–6 marks]*

Level 2: A number of relevant points made, but not precisely *[3–4 marks]*

Level 1: Fragmented points *[1–2 marks]*

No relevant content: *[0 marks]*

Indicative content: both designed to release energy; both convert chemical energy; both

use glucose as a reactant; both occur in cells; aerobic respiration: requires oxygen; produces carbon dioxide and water; releases more energy; glucose + oxygen → carbon dioxide + water; $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$; anaerobic respiration: occurs without oxygen; glucose → lactic acid; produces lactic acid; releases less energy; creates an oxygen debt; lactic acid must be later broken down using oxygen; lactic acid is broken down into carbon dioxide and water.

Working scientifically: Dealing with data
Pages 114–5

1–2

Temperature in °C	Range (1)	Mean (2)
20	345–400	362
35	623–682	651
50	302–520	474
65	105–203	159
80	1–4	2

3 Anomalous results are at temperature 50°C for Repeat 3, at 65°C for Repeat 4 and at 55°C for Repeat 5.

4 Afreen's data

Temperature in °C	Range	Mean
20	14–20	16.6
35	43–45	44.2
50	4–55	36
65	24–28	25.8
80	1–5	2.6

5 In both students' data the volume of gas produced over 10 minutes increases from 20°C to 35°C. It then decreases from 35°C to 80°C. This is because 35°C is closest to the optimal temperature for yeast.

6 Afreen's equipment allowed for more accurate data to be collected because she collected the volume of gas rather than counting the number of bubbles.

7 To allow time for the yeast to adjust to the conditions.

8 To prevent oxygen from reaching the solution, so anaerobic respiration was occurring.

9 Carbon dioxide. Lime water could be used to test for its presence. It would go cloudy if carbon dioxide was present.

Homeostasis and response

11 The human nervous system

Overview

Specification points

4.5.1 Homeostasis; 4.5.2.1 The human nervous system: structure and function; 4.5.2.2 The brain; 4.5.2.3 The eye; 4.5.2.4 Control of body temperature

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 11 pages 131–148

AQA GCSE (9-1) Combined Science Trilogy 2: Chapter 19 pages 1–10

AQA GCSE (9-1) Combined Science Trilogy: Chapter 19 pages 357–366

Recommended number of lessons: 6

Chapter overview	
AQA required practicals	Biology – RP7 CS Trilogy – RP6 (Chapter 19)
Contains higher-tier only material	Yes
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter
- Key terms
- Practical
- Teacher and technician notes
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Key concept: Reaction time and response
- Key concept: Calculating a mean
- Animation: Reflex actions
- Animation: Top gun
- Personal tutor: Reflex actions
- Personal tutor: Temperature regulation
- Video: Investigate the effect of changing a factor on human reaction time

Useful prior learning

- The structure of the human eye
- The photosensitive material in the retina

Common misconceptions

- Students are generally unfamiliar with the structure of neurones and the nervous system.
- Students sometimes think that the body performs its functions without needing any internal communication mechanism.
- Nervous system only refers to the brain.
- Neurones are all the same and carry out the same function.

Preparation

The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for this unit on the nervous system, focusing on the structure and function of the eye.

The **T&L Topic overview** highlights key points from the upcoming topic. This can be shared with the class if you would like them to have an overview of what they will be covering in the next few lessons or can be reserved for recap/consolidation at the end of the topic.

Homeostasis and the nervous system: Lesson 1

Learning outcomes

1 Define the term homeostasis.
2 Explain why homeostasis is an essential process.
3 Explain how the structure of the nervous system is adapted to its function.

Suggested lesson plan

Starter

Define the term 'homeostasis' and ask the students to list as many things as they can which the body needs to monitor and control. Explain that in the next two

chapters they are going to examine nervous and hormonal control and why this is so important.

Main
Introduce the nervous system as a system made up of the CNS and the peripheral nervous system. Explain that the nervous system enables the body to respond to changes by having receptors to detect a change, a CNS to coordinate the body's response and effectors to bring about change. You could ask students to carry out the Activity on page 133 (Biology only).

Ask students to think about what receptors we have; associate these to the sense organs if they need help. Students should identify what the stimuli for the receptors are. You could ask students to determine how good their receptors are by doing a circuit of practical activities. This could include smelling crushed up crisps and identifying the flavour, ordering beakers of water into increasing or decreasing temperatures, doing a hearing range test, doing a simple eye test and, if you are able to, a tongue-mapping exercise of sweet, bitter sour and salty.

You could extend this to examine which parts of the body are most sensitive (such as the fingertips, wrist or back of the hand). Students should unfold a paper clip into a 'U' shape and then lightly touch this onto their partner's hand to determine whether there are one or two prongs touching them. Students can decrease the distance to see how closely the prongs can be together and still be correctly identified as one or two.

Finish the lesson by discussing how nervous impulses are sent, the structure of nerves and the role of myelin.

Plenary
You could provide students with a skeleton table like that on page 134(*4; 360*) and ask them to complete it. Alternatively, students could complete the Test yourself questions from page 133(*3; 359*).

Support
Allow students to label a diagram of the CNS so they understand that it comprises both the brain and the spinal cord. Peripheral nerves could also be labelled so students understand that the nervous system is more complex than just the brain.

Extension
Students could explore voluntary and involuntary nervous control.

Homework
Students could make a summary poster on the five senses and the receptors involved.

The reflex arc: Lesson 2

Learning outcomes

1 Describe a reflex arc.
2 Explain the significance of the reflex arc.

Suggested lesson plan

Starter
Give the class the terms 'stimulus', 'receptor', 'coordinator', 'effector' and 'response'; mix the words up and ask students to put them in the order they would appear in a reflex arc.

Main
Introduce the three types of neurones to students so they understand the route a nervous impulse takes within the body. You could ask students to make a model of them and compare and contrast their structures.

Explain what a synapse is and how impulses are transmitted across them. An animation can be used to support an explanation of what occurs. The Science Museum has a simple one: www.sciencemuseum.org.uk/whoami/findoutmore/yourbrain/howdodrugsaffectyourbrain/whatsasynapse.

Students could make a comic strip or flow diagram to explain how a synapse functions.

Move on to a discussion of the reflex arc and reflex responses. The **T&L Animation: Reflex actions** can be used to support this. Students should be given the opportunity to label a diagram of the reflex arc so they understand the route.

Students could also determine how fast their own reactions are using the **T&L Animation: Top gun** or a reaction meter.

Finish the lesson by discussing conscious decision and how you can overcome some reflex actions.

Plenary
Students could complete the Test yourself questions from page 137(*7; 363*) or the **T&L Quick quiz 1**.

Support
Provide students with diagrams and explanations for what occurs at a synapse and get them to match them up and sequence them. Students could also be provided with the diagrams for the different neurones and asked to spot the differences.

Extension
Students could research the effect of different drugs on synapses.

Homework
Students could complete question 1 from the Practice questions on page 147(*9; 365*) or the Chapter review questions from page 146(*8; 364*).

Required practical 7(6): Plan and carry out an investigation into the effect of a factor on human reaction time: Lesson 3

Preparation
Read through the **T&L Teacher and technician notes** so you are confident with what the practical is and the requirements for the task.

Learning outcomes

1 Determine the effect of stimulants on human reaction time.
2 Describe the method used in this practical.

Suggested lesson plan

Starter
Introduce the Required practical task by allowing the students to read the method from the **T&L Practical** worksheet or from pages 136–7(*6–7; 362–3*) of the textbook. Alternatively, students can watch the **T&L Video: Investigate the effect of changing a factor on human reaction time**.

Main
Before students begin, ensure they are confident with what they need to do by either demonstrating the methods or asking the students what steps should be followed. They should write a prediction for what they think will happen in the practical.

Allow students to carry out the practical.

Depending on the length of the lesson, students could collate the class data, determine a mean and plot the data as a suitable graph.

Plenary
You could evaluate the practical together, highlighting any issues or errors which may have occurred. Ensure you discuss the issues with using a ruler to determine reaction time and ask students to suggest how the practical could be adapted to give more accurate data.

Support
Ensure students are confident with how to calculate reaction time from a ruler drop and determine either a class or individual mean. The **T&L Key concept: Calculating a mean** can be used to support this if needed.

Extension
You could provide students with the equipment and allow them to come up with their own method, sample size and number of repeats to gain reliable data.

Homework
Students could write a method to explain how the practical could be adapted to examine the effects of caffeine on the body.

The brain: Lesson 4 (Biology only)

Learning outcomes

1 Describe the structure of the brain.
2 Explain the functions of the regions of the brain.
3 Explain some of the difficulties of investigating brain function and disorders (HT).
4 Explain how neuroscientists have been able to map regions of the brain (HT).

Suggested lesson plan

Starter
Provide students with some random facts about the brain, without revealing what organ it is, and ask them to guess. As the facts progress, make them more obvious so all students can guess correctly.

Main
Explain the structure of the brain. Students should be able to identify the main parts of the brain and their functions. Provide students with a diagram and ask them to label the main parts of the brain.

Higher tier students should research how we have been able to map the brain by studying patients with brain damage, electrically stimulating different parts of the brain and using MRI scanning techniques. The textbook pages 138–9 or the time line from PBS can support this: www.pbs.org/wnet/brain/history/index.html. The TED talk on brain mapping can further support this and extend more able students (www.ted.com/talks/allan_jones_a_map_of_the_brain)

Plenary
Students could complete Test yourself questions 8–11 on page 140 of the textbook.

Support
Students could be given names of the main parts of the brain and then label a brain using these. They could also be given a matching activity to link the part to its role.

Extension
Higher tier students have extension tasks built into the SOW.

Homework
Students could be asked to produce a poster on the brain which could be displayed in a high school science lab describing the parts of the brain, their functions and how we learnt about the brain. Alternatively they could complete one of the brain quizzes from the BBC (www.bbc.co.uk/science/humanbody/mind/index_surveys.shtml).

The eye: Lesson 5 (Biology only)

Learning outcomes

1 Identify key parts of the eye and their functions.
2 Explain how the structure of the parts of the eye is related to their function.

Suggested lesson plan

Starter
Review students' prior understanding on the eye from KS3. The student questions on the **T&L Prior knowledge catch-up student sheet** can be used to assist with this or the Test yourself on prior knowledge questions from page 132.

Main
Students could carry out an eye dissection ensuring that they discuss all the key features and their roles. Alternatively they could watch the video of an eye dissection from the Exploratorium (www.exploratorium.edu/learning_studio/cow_eye/).

Students should be given a diagram of the eye and asked to label the key features and briefly explain their functions.

Plenary
Students could complete a matching activity in the form of the card game Snap, in which one student lays down a part of the eye and the other has the function. When the cards match, someone should say 'Snap!' and the student will take both cards until all are matched.

Support
Lower literacy students could be given an adapted worksheet with the function written out for them so they only need to add the parts of the eye.

Extension
Students could research how the eye evolved. PBS has a short video clip which could be used to introduce this (www.pbs.org/wgbh/evolution/library/01/1/l_011_01.html).

Homework
Students could research how the compound eye is different from a human eye.

Sight: Lesson 6 (Biology only)

Learning outcomes

1 Describe the process of accommodation.
2 Explain hyperopia and myopia and how they are treated.
3 Interpret ray diagrams which show these two common defects of the eye.

Suggested lesson plan

Starter
Start the lesson by showing students a range of images of sight disorders such as double vision and the different types of colour blindness to introduce the idea that people can have issues with their sight.

Main
Show students two diagrams of the eye that illustrate the lens focusing on near objects and far objects such as Figure 11.15 from the textbook (page 141). Ask them to spot the difference between them. Explain the process of accommodation and how the lens changes shape. Students should label diagrams or produce a flow chart to explain how accommodation is brought about.

Expand on this by asking the students to find their near point by completing the Activity on page 142.

Move on to explain what occurs in hyperopia and myopia. The animations from Zeiss can be used to support this and help explain how glasses and lenses can correct the problem: https://www.zeiss.co.uk/vision-care/en_gb/better-vision/zeiss-spectacle-lens-guide/vision-animations.html

Students should draw ray diagrams to explain how these conditions affect the eye and how lenses correct this.

If time, students could make models, animations or diagrams to explain fully how the eyes focus.

Plenary
Students can complete the Test yourself questions from page 142.

Support
Students could be given the ray diagrams and asked to work out which is near sighted, which is far sighted and which is eyesight corrected.

Extension
Students could research colour blindness, how ageing affects the eyes and why as we get older people often require glasses.

Homework
Students could complete the relevant questions from the Chapter review questions on page 146 or question 2 from the Practice questions on page 147 of the textbook.

Control of body temperature: Lesson 7 (Biology only)

Learning outcomes

1 Describe how body temperature is monitored and controlled.
2 Describe the processes of vasodilation and vasoconstriction.
3 Explain how body temperature is increased and decreased (HT).

Suggested lesson plan

Starter
Use the **T&L Lesson starter** to get students to think about how the body regulates its temperature.

Main
Explain to the students that body temperature is monitored and controlled by the thermoregulatory centre in the brain. Discuss that we have temperature sensitive receptors in both the brain and the skin and ask the students why they think temperature needs to be monitored both inside and outside the body. Students could be provided with test tubes or beakers with water at different temperatures and be asked to put them in order from hottest to coldest.

Discuss what occurs when the body gets too cold and too hot, focusing on vasoconstriction and shivering, and vasodilation and sweating. Higher tier students should be able to explain how these mechanisms lower or raise body temperature. Students could produce a poster or presentation to summarise these processes, detailing how they maintain body temperature.

Students could also look deeper at the process of sweating by completing the Practical from page 144 of the textbook and answering the questions.

Plenary
Students could answer the Test yourself questions from page 145 of the textbook.

Support
When discussing vasodilation and vasoconstriction ensure students understand that the blood vessels do not move up and down in the skin but that they widen and narrow. Students often mistake more blood flowing closer to the skin with the blood vessels moving.

Extension
Students could research hypothermia and hyperthermia, including when these occur and what is happening in the body. Students could also examine negative feedback loops in the control of maintaining body temperature.

Homework
Students can complete the **T&L Homework task** or alternatively complete the Chapter review questions from page 146 or Practice questions from page 147.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge
1 To allow light into the eye
2 To bend light onto the retina
3 Because lenses turn images upside down; our brains turn the images the right way up again

Test yourself
1 Blood glucose, water, temperature
2 The brain, spinal cord, pancreas
3 Electrical impulses travel faster along nerves than hormones do in the blood.
4 To coordinate all of your voluntary and involuntary actions
5 The brain and spinal cord
6 Muscles and glands
7 It is converted into a chemical signal when neurotransmitters are released into the synapse.
8 The cerebellum
9 Dolphins and chimpanzees
10 It provides visual memories and processes language compression
11 He found that patients who had lesions on their frontal lobe also had speech problems. This proved that this area of the brain was responsible for speech.
12 To transmit electrical impulses from the eye to the brain
13 Hyperopia
14 Tall and thin
15 Glasses, contact lenses, eye surgery
16 Mammals and birds
17 Skeletal muscles
18 So that the sweat evaporates, taking heat from your body with it

Condition	Temperature in °C										
	0 min	1 min	2 min	3 min	4 min	5 min	6 min	7 min	8 min	9 min	10 min
Dry											
Wet											

Show you can
Page 133

Homeostasis is maintaining a constant internal environment. Your body regulates the amount of blood glucose. Too much or too little could make you fall into a coma and/or die.

Page 137

An electrical signal travels along sensory neurones to your spinal cord. To save time, it does not move in relay neurones to your brain but returns along motor neurones to your muscles. These move to stop your finger burning.

Page 140

Because it is protected by the skull and is near the major sense organs, the eyes, ears and nose.

Page 142

Long-sightedness occurs when the eyeball is too short, the cornea is not curved enough or the lens is not thick enough. This means you can't see close up objects. Short-sightedness is when you cannot see objects that are far from you. Most babies are born like this and older people develop this.

Page 145

Vasoconstriction happens when you are too cold. Blood vessels near the surface of the skin constrict. This reduces blood flow, which keeps the warm blood towards the core of the body.

Activity
Page 133

Foot changes direction to match motion of hand.

Page 142

Task: no answer is required

Required practical 7
Pages 136–7

1–3 Answers are based on the student's own results.
4 Light and sound
5 To close your hand
6 Light receptor → sensory neurone → sensory neurone synapse with relay neurone → relay neurone synapse with motor neurone → motor neurone → effector muscle → hand closes
7 Student's own suggestion

Practical
Page 144

1 Any suitable table, such as the one shown above.
2 Task: no answer required
3 Answer is based on the student's own results.

Chapter review questions
1 The central nervous system and peripheral nervous system
2 Bundles of individual neurones
3 Sight, hearing, taste, smell, touch
4 They happen automatically, without you thinking about them.
5 Moving your body away from a painful stimulus, your heart rate, controlling light entering your eye
6 Sweat evaporates, taking heat from your body with it
7 Salts and urea
8 Underarms, palms, feet
9 When you are cold, the skeletal muscles quickly contract and relax to generate heat.
10 Work in pairs. One person holds a ruler above the other person's open hand. The first person drops the ruler and the second person catches it. The distance travelled represents the reaction time; a longer distance is a slower reaction. Repeat before and after drinking caffeine to see the effects of the stimulant.
11 Light receptors (rods and cones)
12 From a receptor to the central nervous system
13 In the brain and spinal cord
14 Glands or muscles
15 Stimulus → receptor → coordinator → effector → response
16 A gap between the axon of one nerve and the dendrites of another where chemical neurotransmitters transmit the impulse
17 Chemical neurotransmitters
18 To save time, which reduces the potential damage to your body
19 The cerebral cortex, cerebellum and medulla
20 It controls the size of the pupil by relaxing and contracting to let more or less light in.
21 It detects light using two types of light-sensitive receptor cells called rods and cones.
22 Glasses, contact lenses, laser surgery
23 Between 36.5 and 37.5°C

24 The reduction in size of blood vessels to reduce the flow of blood to the surface of the skin and therefore reduce heat loss
25 The increase in size of blood vessels to increase the flow of blood to the surface of the skin and therefore increase heat loss
26 Paler
27 Wrap a conical flask with 250 cm^3 of water at 80°C with two dry paper towels. Record the decrease in temperature over 10 minutes. Repeat using two wet paper towels.
28 When an electrical impulse reaches the end of its axon, special areas convert the electrical signal into a chemical signal. These chemical neurotransmitters quickly diffuse across the synapse. They meet the dendrites of the next nerve cell and restart the electrical impulse.
29 The impulse is generated by a receptor and travels along sensory neurones and their synapses to the spinal cord. Here relay neurones take over the signal, but it is not sent to the brain. Instead, the spinal cord sends the signal back along motor neurones to the muscles, which quickly contract.
30 It plays a major role in memories, consciousness, intelligence and the ability to use language.
31 Both types of cell work in a similar way to send electrical impulses to your brain. Cones require bright light to work properly. They allow us to see in colour. Rods work in much lower light.
32 The ciliary muscles in the ciliary bodies relax, which makes the lens longer and thinner so that you can focus on the far-away object.
33 The ciliary muscles in the ciliary bodies contract, which makes the lens shorter and fatter so you can focus on the near object.
34 Hyperopia is a medical condition, also called long-sightedness, in which people cannot clearly see objects close to them. Myopia is a medical condition, also called short-sightedness, in which people cannot clearly see objects far away.

Practice questions

1 a) 1 mark for stimulus first, 1 mark for receptor before coordinator, 1 mark for effector after coordinator, 1 mark for response last
b) i) Sensory neurone
ii) Motor neurone
c) i) A: synapse
ii) Any three from: axons release; chemical signal; diffuses across the gap/synapse; detected by receptors; on dendrites; new electrical impulse/signal generated
d) 1 mark for correct working shown 1.5/120, 1 mark for correct answer 0.0125
e) Alcohol

2 a) i) Object A
ii) Object C
b) Hyperopia

3 a) Cerebral cortex
b) i) Different parts are active during different actions
ii) Idea that writing involves all the other regions: being able to see, move your hand and access the speech centre

4 a) Maintenance of constant internal environment [1], e.g. constant temperature [1]
b) i) Negative feedback
ii) Allow any suitable method. Too low: vasoconstriction, body hairs stand on end; too high: sweating
iii) More blood travels through the capillaries, more heat is lost (radiated); do not accept blood vessel moves towards the surface

5 Level 3: There is a clear description of a method that would produce valid results. A description of what is measured and at least one control variable is included. *(5–6 marks)*
Level 2: There is a description of a method involving reaction time and varying alcohol quantities. A description of what is measured or at least one control variable is included. *(3–4 marks)*
Level 1: There is a basic description of a simple method involving the effects of alcohol on reaction time. *(1–2 marks)*
No relevant content: *(0 marks)*
Indicative content: description of how the ruler would be used to measure reaction time; information about how the ruler should be dropped/held/caught; reference to how the quantities of alcohol would be changed (number of drinks/concentration of alcohol); higher tier students might include a description of how alcohol concentration in the blood could be measured/use of Breathalyzer; do not accept alternative methods to measure reaction times that don't involve a ruler; same ruler used throughout; same drop height; do repeats and calculate a mean; reference to the same person being used in the experiment or closely matched people; if one person used throughout, student needs to make it clear that amount of alcohol should continuously increase throughout the experiment (not decrease).

Working scientifically: Experimental Skills
Page 148

1–2

Thermometer	Most accurate (1)	Least accurate (1)	Mean (2)
1	51.0	47.6	49.7
2	48.1	47.9	48.0
3	51.2	51.7	51.5

3 As it is important that a thermometer gives a reading that is true.
4 Throat or rectum
5 Thermometer 2 as its results are closest to the mean value.
6 Thermometer 3 as its values are closest to the true values measured by the clinical thermometer.
7 As we cannot say with 100% certainty that it is 100% accurate.

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge
1 A specialised cell that conducts nerve impulses.
2 Coordinates voluntary and involuntary actions

Test yourself
1 Blood glucose, water, temperature
2 The brain, spinal cord, pancreas
3 Electrical impulses travel faster along nerves than hormones do in the blood.
4 The brain and the spinal cord
5 Muscles and glands
6 It can cross a synapse and stimulate another neurone or bring about a response in an effector.

Show you can
Page 3(359)

Homeostasis is maintaining a constant internal environment. Your body regulates the amount of blood glucose. Too much or too little could make you fall into a coma and/or die.

Page 7(363)

An electrical signal travels along sensory neurones to your spinal cord. To save time, it does not move in relay neurones to your brain but returns along motor neurones to your muscles. These move to stop your finger burning.

Required practical 6
Page 6–7(362–3)

1–3 Answers are based on the student's own results.
4 Light and sound
5 To close your hand

Chapter review questions
1 The central nervous system and peripheral nervous system
2 Bundles of individual neurones
3 Sight, hearing, taste, smell, touch
4 They happen automatically, without you thinking about them.
5 Moving your body away from a painful stimulus, your heart rate, controlling light entering your eye
6 Work in pairs. One person holds a ruler above the other person's open hand. The first person drops the ruler and the second person catches it. The distance travelled represents the reaction time; a longer distance is a slower reaction. Repeat before and after drinking caffeine to see the effects of the stimulant.
7 From a receptor to the central nervous system
8 In the brain and spinal cord
9 Glands or muscles
10 A gap between the axon of one nerve and the dendrites of another where chemical neurotransmitters transmit the impulse
11 Chemical neurotransmitters
12 When an electrical impulse reaches the end of its axon, special areas convert the electrical signal into a chemical signal. These chemical neurotransmitters quickly diffuse across the synapse. They meet the dendrites of the next nerve cell and restart the electrical impulse.
13 The impulse is generated by a receptor and travels along sensory neurones and their synapses to the spinal cord. Here relay neurones take over the signal, but it is not sent to the brain. Instead, the spinal cord sends the signal back along motor neurones to the muscles, which quickly contract.

Practice questions
1 a) The maintenance of a constant internal environment. *[1 mark]*
b) If blood glucose levels get too high, homeostatic systems reduce [1 mark] the amount of glucose in the blood, so that they return to their normal [1 mark] level.
2 a) 3 *[1 mark]*
b) 2 *[1 mark]*
3 a) 4 marks: 1 mark for stimulus first, 1 mark for receptor before coordinator, 1 mark for effector after coordinator, 1 mark for response last
b) i) Sensory neurone *[1 mark]*
ii) Motor neurone *[1 mark]*

c) i) A: synapse *[1 mark]*

ii) Any three from: axons release; chemical signal; diffuses across the gap/synapse; detected by receptors; on dendrites; new electrical impulse/signal generated *[3 marks]*

d) 1 mark for correct working shown 1.5/120, 1 mark for correct answer 0.0125 *[2 marks]*

e) Alcohol *[1 mark]*

Working scientifically: Experimental skills

Page 10(366)

1–2

Thermometer	Most accurate (1)	Least accurate (1)	Mean (2)
1	51.0	47.6	49.7
2	48.1	47.9	48.0
3	51.2	51.7	51.5

3 As it is important that a thermometer gives a reading that is true.

4 Throat or rectum

5 Thermometer 2 as its results are closest to the mean value.

6 Thermometer 3 as its values are closest to the true values measured by the clinical thermometer.

7 As we cannot say with 100% certainty that it is 100% accurate.

12 Hormonal coordination in humans

Overview

Specification points

4.5.3.1 Human endocrine system; 4.5.3.2 Control of blood glucose concentration; 4.5.3.3 Maintaining water and nitrogen balance in the body; 4.5.3.4 Hormones in human reproduction; 4.5.3.5 Contraception; 4.5.3.6 The uses of hormones to treat infertility; 4.5.3.7 Negative feedback

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 12 pages 149–68

AQA GCSE (9-1) Combined Science Trilogy 2: Chapter 20 pages 11–26

AQA GCSE (9-1) Combined Science Trilogy: Chapter 20 pages 367–82

Recommended number of lessons: 10

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	Yes
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Personal tutor: Hormones
- Personal tutor: Glucose regulation
- Personal tutor: Water content regulation

Useful prior learning

- The consequences of a poor diet, particularly in terms of problems associated with obesity
- An understanding of the term homeostasis and the factors that need to be kept constant
- The idea that sugar intake needs to be controlled in order to prevent medical conditions like diabetes
- The need to remove excess water and poisonous waste materials from the body
- The concept of diffusion as a passive process which requires a concentration gradient
- Changes in the body which occur during puberty
- Reproduction in humans including the menstrual cycle

Common misconceptions

- Students often confuse enzymes and hormones as they are both proteins and are both produced by glands. Enzymes, however, do not travel in the bloodstream. They are poured down ducts into the place where they have their effect. In contrast, hormones are secreted into the blood and travel some distance to their target organ.
- The terms secretion and excretion are often confused. A secretion is the production of a useful substance. Excretion is the removal of waste material.
- Type 1 and type 2 diabetes are not the same condition. Students often fail to realise that type 2 diabetics still produce insulin but the cells no longer respond to the hormone.
- The hormone ADH is produced when blood water levels are low. Students often write the opposite. Try to instil in them that ADH is a water conservation hormone. The body secretes it when water has to be conserved.

Preparation

T&L Prior knowledge catch-up teacher sheets on hormonal control in humans have information on balanced diet and the effects of imbalance on the body as well as information on reproduction.

The **T&L Topic overview** can be used to compare the nervous system with the chemical messengers of the endocrine system

Hormones and the endocrine system: Lesson 1

Learning outcomes

1 Describe how the endocrine system coordinates control of the body using hormones and plays a role in homeostasis.
2 Define the terms hormone and gland.
3 Identify key glands in the body.

Suggested lesson plan

Starter

Students can be reminded of the need to have an internal messaging system to bring about changes in the body in response to stimuli. The reflex arc and the role of neurones can be discussed and revised. Students should appreciate that the nervous

system brings about rapid responses. The **T&L Quick quiz 1** will be ideal to remind them about terms like 'homeostasis', 'glucoregulation' and 'osmoregulation'.

Main
Introduce the terms 'endocrine', 'hormone', 'protein' and 'target organ'. Explain that hormones are carried in the blood.

Draw a large outline diagram of a human body and pin it up. Make cut-outs of the different endocrine organs. Stick these in the correct locations on the diagram with sticky tack while explaining in simple terms what role each of these plays. Consolidate the exercise by writing the terms on the board.

Test student knowledge by removing each organ and getting students to stick the organ back on the model. Alternatively, students can work in groups and make their own diagrams and glands.

Make a version of the table from page 150 of the textbook. Give students the table headings and a list of the hormones and then ask them to complete the table themselves.

Key words or terms can be written down so the spellings are correct.

Plenary
Re-introduce the outline diagram and organs to see how many endocrine glands can be recalled.

Make a version of the table from page 150 (*12; 368*) with gaps so students can fill them in with a list of terms or functions.

Support
Give students a list of the key endocrine glands on a diagram with an outline of their function as a back-up.

Extension
Explain why the pituitary gland is the master endocrine gland.

Homework
Students could complete the Test yourself questions on page 151(*13; 369*) or the **T&L Homework task**.

Controlling blood sugar levels: Lesson 2

Learning outcomes

1 Describe how the body lowers blood glucose concentration.
2 Describe how the body raises blood glucose concentration.

Suggested lesson plan

Starter
T&L Lesson starter 1 reminds students of the terms 'endocrine' and 'hormone' and gives some of the specific examples of these. Lead into a discussion of the pancreas, insulin and glucagon and the role they play in homeostasis.

Main
Draw a graph showing how blood glucose levels fluctuate during the day. Ask students to describe how the graph would change in the following circumstances:

- when the subject has not eaten for several hours
- when the subject has had a meal rich in carbohydrate.

Explain the roles of insulin and glucagon in controlling the levels of sugar. Give students a partially completed diagram showing how insulin and glucagon have their effect. Introduce the idea of negative feedback. Figure 12.3 (*20.3*) on page 152 (*14; 370*) could be adapted so that information can be added.

Students can work in pairs to create their own flow diagram to show the negative feedback system for insulin. A similar diagram can then be used to show negative feedback for glucagon.

Ask students to write out a clear definition of a negative feedback system. This is not easy to do and the best definitions can be written down by everyone.

Plenary
Use **T&L Quick quiz 1**. Get each student to write two of their own questions and throw these open to the class.

Support
Use the **T&L Personal tutor: Hormones** and **T&L Personal tutor: Glucose regulation** for less able students.

Make a cut-and-stick activity to help weaker students understand the antagonistic effects of these two hormones and negative feedback.

Extension
Make a list of definitions to clarify all the words that sound similar. These should include glucagon, glucose and glycogen which are often confused.

Homework
Research the different types of diabetes. Make a table to show how they are different. This should include the symptoms and the treatment.

Complete question 2 on page 166(*24; 380*) of the textbook.

Controlling blood sugar levels: Lesson 3

Learning outcomes

1 Explain the effects, causes and treatments of type 1 and type 2 diabetes.
2 Interpret graphs that show the effect of insulin on blood glucose levels in people with and without diabetes.

Suggested lesson plan

Starter
Students could start by drawing a graph showing blood sugar levels before and after meals in a 24-hour period. This is the same exercise as in lesson 2 but is to be expanded. This will check how many students remember and understand that blood glucose levels are strictly controlled.

Main
Discuss the condition diabetes in general terms as a non-communicable disease.

Ask students to suggest what happens to the blood sugar levels in an uncontrolled diabetic. On their graphs of normal blood sugar fluctuations, students should draw in a line which shows how the blood glucose levels would change in an uncontrolled diabetic.

Explain the different types of diabetes. Students could be asked to research both types themselves using iPads and the internet. The information they obtain could be presented in a table which would show the causes, effects, symptoms and treatments for type 1 and type 2 diabetes.

Plenary
Create a true/false quiz to test whether students have understood the differences between the two types of diabetes.

Support
For less able students, provide a partially completed table on different types of diabetes and a set of key terms which can be used to fill in the gaps.

Extension
Research the discovery and manufacture of insulin.

Homework
Complete the Test yourself questions on page 155 (*16; 372*) of the textbook.

Maintaining water and nitrogen balance in the body: Lesson 4 (Biology only)

Learning outcomes

1 Describe the function of the kidneys in maintaining water balance.
2 Describe how the kidneys produce urine.
3 Translate tables and bar charts of glucose, ions and urea before and after filtration.

Suggested lesson plan

Starter
Students can draw or be given an outline of a human body and add labelled arrows to show the ways in which water is lost and gained. They should also decide on the relative quantities which move in and out in this way i.e. small quantities or larger volumes. Link the information back to the loss of water through the skin and ask why it is important that the levels in and out should balance. Consolidate with Figure 12.8 (page 155) or use the **DL Lesson starter 2** for this chapter.

Main
Ask students to discuss what might be present in urine. Explain that urea is a product of the breakdown of excess protein.

Use Figure 12.9 (page 156) and describe the role of the kidneys and each of the associated structures in excretion and water balance.

Give students a diagram to annotate, writing key terms on the board. Explain that the kidneys are filters that remove some materials and reabsorb others. Students can write in the functions of the different components. Introduce the term nephron as the functional unit of the kidney but details of its structure are not required.

Students could construct a table to show the composition of the blood compared with the composition of the urine.

Plenary
Complete a short quiz on the key terms and processes in the kidney. Alternatively use **T&L Quick quiz 2**.

Support
Use slide 1 from **T&L Personal tutor: Water content regulation**.

Extension
While not needed for the exam, more detail of the structure and function of the components of a nephron could be given to higher level students to enhance their understanding of the processes of filtration and selective reabsorption.

Homework
Write definitions of key terms like 'filtration', 'reabsorption' and 'excretion'.

Maintaining water and nitrogen balance in the body: Lesson 5 (Biology only)

Learning outcomes

1 Understand the role of the hormone ADH in controlling the level of water in the blood.
2 Describe the negative feedback system which controls ADH levels.

Suggested lesson plan

Starter
Re-introduce the hormone ADH which was mentioned at the start of Chapter 12. Remind students where it is produced and what it does. Introduce the term 'osmoregulation' and link osmoregulation to the kidney.

Main
Explain how ADH causes the kidneys to reabsorb water and explain that its release is controlled with a negative feedback system.

Draw a simple flow diagram to explain the negative feedback mechanism of ADH when water levels are low. Now get students in groups and, using the same format, encourage them to produce a similar diagram to show what happens when blood water levels are high. They can then put all the information together into a type of see-saw diagram.

Discuss the effect of different levels of ADH on the water levels in the urine and the composition of the blood to check understanding.

Plenary
Create a quick quiz to assess students' understanding of the feedback system.

Support
Give students a partially completed diagram to show the negative feedback control of ADH production. This could be a cut-and-stick diagram based on Figure 12.10 on page 156 of the textbook.

Extension
Explain how levels of ADH are altered if you drink more or less fluid.

Homework
Complete question 3 on page 166 of the textbook.

Maintaining water and nitrogen balance in the body: Lesson 6 (Biology only)

Learning outcomes

1 Describe and evaluate the different treatments for kidney failure.
2 Explain how a kidney dialysis machine works.

Suggested lesson plan

Starter
Discuss all the possible treatments for a patient with a failing kidney.

Main
Use Figure 12.12 on page 157. This shows a dialysis machine and explains how it functions. Explain the role of the machine as a filter. Remind students about the process of diffusion.

Use slide 2 from the **T&L Personal tutor: Water content regulation** to show the animation of how a dialyser works.

Prepare a diagram of the dialyser which is unlabelled and ask students to label it using a list of key terms. They should use colour-coded arrows and a key to show the direction of movement of urea, water, glucose and salt.

Discuss the transplanting of a kidney.

Plenary
Students could complete Test yourself questions 9 and 10 from page 158.

Support
Weaker students will find the concept of dialysis quite challenging. They should be given a diagram which is partially labelled and key terms.

Extension
Evaluate the advantages and disadvantages of treating organ failure by mechanical device or a transplant.

Homework
Students can make a leaflet or poster which outlines the ethical issues associated with kidney transplants.

Hormones in human reproduction: Lesson 7

Learning outcomes

1 Describe the role of hormones in human reproduction.
2 Describe the role of hormones in the menstrual cycle.
3 Extract and interpret data from graphs showing hormone levels during the menstrual cycle.

Suggested lesson plan

Starter
Assess students' knowledge of the secondary sexual characteristics with a short quiz.

Main
Explain that the hormones oestrogen and progesterone (in females) and testosterone (in males) are responsible for the changes to the body during puberty but that the pituitary gland triggers these hormones.

Describe the menstrual cycle in females.

Give students a diagram showing four main stages of the menstrual cycle and get them to label key events at each stage. They should show menstruation (shedding of uterus lining), repair and rebuilding of uterus lining, ovulation and development of the corpus luteum in the ovary.

Use **Figure 12.13 from the T&L Diagram bank** to illustrate and explain the role of pituitary hormones together with ovarian hormones.

Plenary
Complete a ready prepared diagram showing the interplay of the four hormones. Use a version of Figure 12.14 (*20.8*) from page 160(*18; 374*) of the textbook which has had the labels for the hormones removed.

Support
Create a simplified version of Figure 12.14 (*20.8*) from the textbook. Leave in the names of the hormones but omit the names of the organs. Alternatively, provide students with a matching activity. A named hormone could be matched with its role in the menstrual cycle.

Extension
Describe why the menstrual cycle is an example of negative feedback. Draw a flow diagram to summarise the events taking place.

Homework
Make a table of all the key terms and a definition of each. Answer question 4(*3*) from page 166(*24; 380*) of the textbook.

Contraception: Lesson 8

Learning outcomes

Describe and evaluate different hormonal and non-hormonal methods of contraception.

Suggested lesson plan

Starter
Assess students' knowledge of contraception with a short discussion. Create a list of different methods of contraception. Students should classify these methods into those that use hormones and those that do not.

Main
Students could research the different methods of non-hormonal contraception and write a short summary of each.

Explain how oral contraceptives for females make use of oestrogen and progesterone. Link these to the menstrual cycle.

Plenary
Initiate a discussion on the ethical issues of taking the contraceptive pill.

Support
An understanding of the need for contraception may be more beneficial than trying to understand the complex interplay of the pituitary and ovarian hormones. Weaker students could evaluate why contraception should be practised.

Extension
Higher level students could write an explanation of how the contraceptive pill works.

Homework
Complete the Test yourself questions from page 162(*20; 376*).

Infertility: Lesson 9

Learning outcomes

1 Explain how hormones are used to treat infertility.
2 Describe the process of IVF.
3 Evaluate infertility treatments.

Suggested lesson plan

Starter
Create a quick quiz on ovarian and pituitary hormones and their role in the menstrual cycle.

Main
Students could work in small groups and brainstorm all the causes of infertility. They should list all these and then decide which ones are linked to hormonal problems.

Introduce the terms '*in vitro*' and '*in vivo*' in relation to fertilisation. Students can research both these terms and investigate the role of hormones in the treatment of infertility.

To finish, ask students for their opinions on the ethics of IVF techniques.

Plenary
Answer questions 5(*4*) from page 166(*24; 380*) of the textbook.

Support
Give students a list of key terms and get them to match these up with the correct definitions.

Extension
Higher level students could answer the questions on page 168(*26; 382*) on the ethics of IVF.

Homework
Carry out the Test yourself questions on page 163 (*21; 377*) of the textbook.

Negative feedback: Lesson 10

Learning outcomes

1 Explain the roles of thyroxine and adrenaline in the body.
2 Explain how thyroxine levels are an example of negative feedback.

Suggested lesson plan

Starter
Students have come across the concept of a negative feedback system earlier in the chapter when learning about the effects of insulin and glucagon on blood sugar levels.

Create a copy of Figure 12.20 (20.12) with the labels blanked out. Students can work in groups to fill in the diagram and revise the principles of negative feedback.

Main
Emphasise the role of negative feedback systems in controlling levels of hormones in the body.

Explain the roles of thyroxine and thyroid-stimulating hormone. Students should try to construct a simple flow diagram to show how the level of thyroxine is controlled by a negative feedback loop.

Move on to the hormone adrenaline. Students should be told that this hormone is secreted when the body is preparing for an emergency. They should be able to suggest all the effects that the hormone has on the body, such as increased heart rate.

Plenary
Assess the understanding of key terms; a bingo-type activity, simple crossword or key word test could be used.

Support
Create a cut-and-stick diagram of the feedback control of thyroxine levels or adrenaline levels in the body.

Extension
Create a table with two columns. The first column should be a list of all the 'fight or flight' responses of adrenaline. The second column should give the reason why each of the responses is advantageous in the fight or flight response. For example, increased heart rate (column 1) would be linked to faster delivery of oxygen and glucose to muscles (column 2).

Homework
Answer the Test yourself questions on page 164 (*22; 378*).

Research the effects of over-production of TSH on the development of a goitre.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge
1 Any one from: obesity, diabetes
2 By living a healthy lifestyle, including a balanced diet and regular exercise
3 Because it prepares itself for a fertilised ovum to embed in the lining and grow into a baby

Test yourself
1 ADH and TSH
2 To fight or run away ('fight or flight')
3 In the hypothalamus in the brain
4 Insulin lowers blood sugar concentration and glucagon increases it.
5 Type 1
6 The pancreas
7 Fewer people have allergic reactions to it.
8 Glucagon is released from the pancreas. This hormone converts glycogen into glucose in the liver. The glucose is released into the bloodstream, increasing the blood sugar concentration.

9 Dialysis and transplantation
10 Through urine, sweat and vapour breathed out
11 ADH is produced in your brain. When you are dehydrated you produce more ADH. When you have drunk too much you produce less ADH. The more ADH, the more water your kidneys retain.
12 Negative feedback occurs when your body detects a change and makes an adjustment to return it back to normal. Your body produces more or less ADH to retain or excrete more water.
13 Oestrogen and progesterone
14 In the ovaries
15 Growth of breasts, widening of hips, growth of underarm and pubic hair, growth spurt
16 Negative feedback occurs when your body detects a change and makes an adjustment to return it back to normal. FSH causes an ovum to mature inside a follicle and the ovaries to produce oestrogen. This thickens the lining of the uterus. High levels of oestrogen stop the production of FSH and increase the secretion of LH, which stimulates ovulation. The corpus luteum releases progesterone, which stops the release of both FSH and LH.
17 A contraceptive medical procedure during which a man's sperm ducts are blocked or cut
18 Some people disagree with it for religious or moral reasons.
19 Women take a specific pill each day for 21 days. For the final 8 days of the cycle they either take a placebo pill or no pill. This is when they have their period.
20 FSH and LH
21 The pill, patch, implant
22 A small operation removes ova from a woman. They are fertilised under a microscope by sperm. They are then inserted back into a woman's uterus to develop.
23 FSH and LH are injected to start the maturation of ova in the ovaries.
24 Metabolic rate
25 In the pituitary gland
26 The thyroid gland can swell into a goitre
27 Negative feedback occurs when your body detects a change and makes an adjustment to return it back to normal. The pituitary gland produces TSH, which increases the thyroxine released from the thyroid gland.

Show you can

Page 151

It releases hormones, which have other glands as their target organs so it makes them function. These help control growth and blood pressure, as well partly control functions of your ovaries or testes, pregnancy, childbirth and your kidneys.

Page 155

Type 1 diabetes usually develops when the insulin-producing cells in the pancreas are destroyed by the body's own immune system. People with type 1 diabetes often inject insulin to help reduce their blood glucose concentration. Reduction of sugar in the diet and exercising regularly can also help. People with type 2 diabetes cannot produce enough insulin or, if they can, their liver and muscle cells won't respond to it. This is often linked to obesity. Treatments include eating a balanced, healthy diet and exercising regularly. In type 2 cases liver and muscle cells do not respond to insulin, so injecting insulin is not usually a treatment.

Page 158

Three main processes occur in the nephron: (1) filtration of glucose, urea, salts and water; (2) selective reabsorption of all glucose, some salts and some water; (3) excretion of all urea, excess salts and water.

Page 160

At the start of the cycle, a woman has her period. This lasts several days. A reduction in progesterone triggers this. After this the lining of the uterus thickens. Oestrogen causes this. Ovulation occurs on about day 14 of the menstrual cycle. If a woman becomes pregnant her progesterone levels remain high and she misses her period. If not, the cycle repeats.

Page 162

The pill stops production of FSH hormone. This stops ovulation. The pill can also thicken the mucus in the uterus so it is harder for sperm to travel. It can also thin the lining of the uterus to stop the fertilised ovum implanting.

Page 163

FSH and LH are injected. This may be enough for a woman to become pregnant. If not, she can undergo IVF. FSH and LH are injected to help ova mature. Ova are removed and fertilised by sperm. They are then replaced in a woman's uterus.

Page 164

It increases the heart rate. This gives more oxygen and glucose to the muscles, which can respire more. This releases more energy, which means they can prepare the body for fight or flight.

Activity
Page 154

1 Task: no answer is required
2 Patient B as Patient A's concentration of blood glucose returns to normal after 6 hours. Patient B's concentration of blood glucose was still 18 mg/dL higher than before the meal after 6 hours.
3 Because the meal had to be digested and the glucose had to enter the bloodstream.
4 When the meal is eaten blood glucose rises. The pancreas adds insulin to the blood. Glucose is converted to glycogen in the liver, reducing the levels of glucose in the blood to normal.

Chapter review questions

1 Glands
2 In the blood
3 Through your urine, sweat and breath (as water vapour)
4 Low in volume, concentrated and yellow in colour
5 The hand that you licked will feel colder. This is a model for how sweat reduces your body temperature. Sweat (or saliva here) evaporates, taking heat from your body with it.
6 Testes
7 Methods or devices that stop women becoming pregnant
8 Condoms also stop the spread of sexually transmitted diseases.
9 Target organ
10 It travels to the liver, where it turns excess glucose into glycogen to be stored.
11 Insulin-producing cells in the pancreas are destroyed by the sufferer's immune system by mistake.
12 They reduce the sugar in their diet and exercise regularly.
13 It is a permanent cure.
14 It thickens the lining of the uterus.
15 Menstruation begins
16 The sperm ducts, which carry sperm from the testes to the penis, are tied or cut in an operation.
17 They sit inside the vagina and stop sperm reaching the uterus.
18 Oestrogen and progesterone
19 They contain the same hormones, oestrogen and progesterone, as in the pill but are delivered into a woman's blood by the implant or patch.
20 If women are not producing enough FSH and LH these hormones can be injected into their blood.
21 It controls the release of hormones from the thyroid gland.
22 Because we traditionally only eat three times per day but we require glucose all of the time
23 Negative feedback control means your body will detect a change and respond by returning conditions to normal. If your blood sugar is too high it will be lowered. If your blood sugar is too low it will be raised.
24 Anti-diuretic hormone
25 The pituitary gland
26 When you consume more water, more ADH is produced, and when you consume less water, less ADH is produced
27 Blood enters the glomerulus inside the Bowman's capsule, where proteins, water, urea, dissolved glucose and salts are filtered into the nephron. Then the body selectively reabsorbs the molecules it needs in the loop of Henle. Finally, the mixture of urea, excess salts and water passes along a collecting duct to the bladder, from where it is excreted in the urine.
28 The patient's blood passes alongside a liquid called dialysis fluid but is separated from it by a selectively permeable membrane. Glucose and salts do not diffuse through the membrane, but urea does and moves from the blood into the dialysis fluid. The 'clean' blood is then returned to the patient.
29 FSH is released by the pituitary gland which causes an ovum to mature in a follicle and the ovaries to produce oestrogen. This causes the lining of the uterus to thicken. The pituitary gland detects this high level of oestrogen, stops producing FSH and starts to produce LH. This stimulates ovulation.
30 Follicle
31 The follicle develops into the corpus luteum which releases progesterone which inhibits the release of both FSH and LH.
32 FSH and LH are injected to stimulate the maturation of several ova. A small operation removes these ova from the woman's ovaries and they are fertilised by a man's sperm. Sometimes the nucleus of a sperm cell is injected into the ovum. The fertilised ova then develop into embryos, which are placed into the woman's uterus. Nine months later the woman has her 'test tube' baby or babies.
33 The success rates are not high so doctors implant more fertilised ova to increase the chances of pregnancy.

Practice questions

1 a) i) Protein/chemical message that travels in the blood to bring about a change/ control body functions
ii) C: glands
iii) In the blood

2 a) 185 mg/dL
b) i) Line to start higher, peak higher and level off at a higher level
ii) B: insulin
iii) Insulin
iv) Manage their diet
3 a) i) 800 cm^3
ii) Breathing
b) i) The kidney
ii) Any three from: blood becomes concentrated, low water potential or too salty; this is detected by the hypothalamus; pituitary gland; releases ADH; there is increased reabsorption of water; so less water in urine
4 a) i) Idea that between days 1 and 4 it reduces as period/menstruation is occurring; after this the lining build ups during days 4 to 14, and then the lining is maintained from day 14 to day 28
ii) Day 14
b) Idea that FSH stimulates oestrogen production; begins egg maturation; oestrogen inhibits FSH; oestrogen stimulates pituitary gland to produce LH; development of the uterine lining; LH stimulates the release of the ovum, or ovulation; LH inhibits oestrogen
5 a) The ovaries
b) They do not prevent sexually transmitted disease (accept named diseases); could affect hormones in a woman's body; may have side effects; moral objections to any contraception; may have long-term effects
6 a) Cell allowed to divide/forms an embryo [1], which is then inserted into the uterus [1]
b) i) More likely to succeed/higher success rate
ii) Multiple births; more likely to give birth prematurely; people might not want that many children; could harm the mother

Working scientifically: Scientific thinking
Pages 167–8

1 Answer is based on the student's own opinions.
2 Any two from: religious objections, wastage of embryos, possibility of multiple births, cost, potential to select and modify embryos
3 Any sensible answer relating to the cost of IVF.
4 Task; no answer is required.

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge
1 Any one from: obesity, diabetes
2 By living a healthy lifestyle, including a balanced diet and regular exercise
3 Because it prepares itself for a fertilised ovum to embed in the lining and grow into a baby

Test yourself
1 ADH and TSH
2 To fight or run away ('fight or flight')
3 In the hypothalamus in the brain
4 Insulin lowers blood sugar concentration and glucagon increases it.
5 Type 1
6 The pancreas
7 Glucagon is released from the pancreas. This hormone converts glycogen into glucose in the liver. The glucose is released into the bloodstream, increasing the blood sugar concentration.
8 In the ovaries
9 Growth of breasts, widening of hips, growth of underarm and pubic hair, growth spurt
10 Negative feedback occurs when your body detects a change and makes an adjustment to return it back to normal. FSH causes an ovum to mature inside a follicle and the ovaries to produce oestrogen. This thickens the lining of the uterus. High levels of oestrogen stop the production of FSH and increase the secretion of LH, which stimulates ovulation. The corpus luteum releases progesterone, which stops the release of both FSH and LH.
11 A contraceptive medical procedure during which a man's sperm ducts are blocked or cut
12 Some people disagree with it for religious or moral reasons.
13 Women take a specific pill each day for 21 days. For the final 8 days of the cycle they either take a placebo pill or no pill. This is when they have their period.
14 FSH and LH
15 The pill, patch, implant
16 A small operation removes ova from a woman. They are fertilised under a microscope by sperm. They are then inserted back into a woman's uterus to develop.
17 FSH and LH are injected to start the maturation of ova in the ovaries.
18 Metabolic rate
19 In the pituitary gland

Show you can
Page 13(*369*)

It releases hormones, which have other glands as their target organs so it makes them function. These help control growth and blood pressure, as well partly control functions of your ovaries or testes, pregnancy, childbirth and your kidneys.

Page 16(*372*)

Type 1 diabetes usually develops when the insulin-producing cells in the pancreas are destroyed by

the body's own immune system. People with type 1 diabetes often inject insulin to help reduce their blood glucose concentration. Reduction of sugar in the diet and exercising regularly can also help. People with type 2 diabetes cannot produce enough insulin or, if they can, their liver and muscle cells won't respond to it. This is often linked to obesity. Treatments include eating a balanced, healthy diet and exercising regularly. In type 2 cases liver and muscle cells do not respond to insulin, so injecting insulin is not usually a treatment.

Page 19(*375*)

At the start of the cycle, a woman has her period. This lasts several days. A reduction in progesterone triggers this. After this the lining of the uterus thickens. Oestrogen causes this. Ovulation occurs on about day 14 of the menstrual cycle. If a woman becomes pregnant her progesterone levels remain high and she misses her period. If not, the cycle repeats.

Page 20(*376*)

The pill stops production of FSH hormone. This stops ovulation. The pill can also thicken the mucus in the uterus so it is harder for sperm to travel. It can also thin the lining of the uterus to stop the fertilised ovum implanting.

Page 21(*377*)

FSH and LH are injected. This may be enough for a woman to become pregnant. If not, she can undergo IVF. FSH and LH are injected to help ova mature. Ova are removed and fertilised by sperm. They are then replaced in a woman's uterus.

Page 22(*378*)

It increases the heart rate. This gives more oxygen and glucose to the muscles, which can respire more. This releases more energy, which means they can prepare the body for fight or flight.

Activity

Page 16(*372*)

1 Task: no answer is required
2 Patient B as Patient A's concentration of blood glucose returns to normal after 6 hours. Patient B's concentration of blood glucose was still 18 mg/dL higher than before the meal after 6 hours.
3 Because the meal had to be digested and the glucose had to enter the bloodstream.
4 When the meal is eaten blood glucose rises. The pancreas adds insulin to the blood. Glucose is converted to glycogen in the liver, reducing the levels of glucose in the blood to normal.

Chapter review questions

1 Glands
2 In the blood
3 Testes
4 Methods or devices that stop women becoming pregnant
5 Condoms also stop the spread of sexually transmitted diseases.
6 Target organ
7 It travels to the liver, where it turns excess glucose into glycogen to be stored.
8 They reduce the sugar in their diet and exercise regularly.
9 It thickens the lining of the uterus.
10 The sperm ducts, which carry sperm from the testes to the penis, are tied or cut in an operation.
11 They sit inside the vagina and stop sperm reaching the uterus.
12 Oestrogen and progesterone
13 They contain the same hormones, oestrogen and progesterone, as in the pill but are delivered into a woman's blood by the implant or patch.
14 If women are not producing enough FSH and LH these hormones can be injected into their blood.
15 It controls the release of hormones from the thyroid gland.
16 Because we traditionally only eat three times per day but we require glucose all of the time
17 Negative feedback control means your body will detect a change and respond by returning conditions to normal. If your blood sugar is too high it will be lowered. If your blood sugar is too low it will be raised.
18 FSH stimulates the development of an ovum in the ovary and stimulates the production of oestrogen by the ovary. LH stimulates ovulation.
19 FSH and LH are injected to stimulate the maturation of several ova. A small operation removes these ova from the woman's ovaries and they are fertilised by a man's sperm. Sometimes the nucleus of a sperm cell is injected into the ovum. The fertilised ova then develop into embryos, which are placed into the woman's uterus. Nine months later the woman has her 'test tube' baby or babies.
20 More than one of the embryos placed in the uterus develops into a foetus and/or hormone treatment causes two or more ova to be released from an ovary at the same time.

Practice questions

1 **a)** Protein/chemical message that travels in the blood to bring about a change/control body functions *[1 mark]*
b) C: glands *[1 mark]*

c) In the blood *[1 mark]*

2 a) 185 mg/dL *[1 mark]*

b) i) Line to start higher, peak higher and level off at a higher level *[3 marks]*

ii) B: insulin *[1 mark]*

iii) Manage their diet *[1 mark]*

c) i) For respiration *[1 mark]*

ii) Pancreas *[1 mark]*

d) Pancreas detects the low blood sugar level [1 mark]; glucagon is released into the blood by the pancreas [1 mark]; this converts glycogen to glucose [1 mark] in the liver and muscles *[1 mark]*.

3 a) i) Idea that between days 1 and 4 it reduces as period/menstruation is occurring; after this the lining build up during days 4 to 14, and then the lining is maintained from day 14 to day 28 *[3 marks]*

ii) Day 14 *[1 mark]*

b) Idea that FSH stimulates oestrogen production; begins egg maturation; oestrogen inhibits FSH; oestrogen stimulates pituitary gland to produce LH; development of the uterine lining; LH stimulates the release of the ovum, or ovulation; LH inhibits oestrogen *[4 marks]*

4 The ovaries *[1 mark]*

5 a) Cell allowed to divide/forms an embryo [1 mark], which is then inserted into the uterus *[1 mark]*

b) i) More likely to succeed/higher success rate *[1 mark]*

ii) Multiple births; more likely to give birth prematurely; people might not want that many children; could harm the mother *[1 mark]*

Working scientifically: Scientific thinking

Pages 25–6(*381–2*)

1 Answer is based on the student's own opinions.

2 Any two from: religious objections, wastage of embryos, possibility of multiple births, cost, potential to select and modify embryos

3 Any sensible answer relating to the cost of IVF.

4 Task; no answer is required.

13 Plant hormones (Biology only)

Overview

Specification points

4.5.4.1 Control and coordination; 4.5.4.2 Use of plant hormones

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 13 pages 169–76

Recommended number of lessons: 4

Chapter overview	
AQA required practical	Biology – RP 8
Contains higher-tier only material	Yes
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter
- Key terms
- Practical
- Teacher and technician notes
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Key concept: Plant hormones
- Personal tutor: Auxins
- Video: Investigate the effect of light on the growth of newly germinated cress seedlings

Useful prior learning

- The structure of plant cells and the organisation of these into tissues and organs
- Diffusion and osmosis as mechanisms by which molecules move down concentration gradients

Common misconceptions

- Plant hormones, unlike those produced by animals, do not travel widely through plants. Animal hormones circulate in the bloodstream and therefore move all around the body.
- The same plant hormone has a different effect in the shoot from the effect it has in the root. This can cause confusion particularly when studying the effect of auxin. In a shoot, auxin speeds up elongation of the cells. In a root, auxin slows down cell elongation.
- Hormones in plants are really growth regulators. Students should understand that plant hormones bring about growth responses rather than movement.
- Hormones like auxin bring about a response in which the plant grows towards or away from a stimulus. The growth response is due to cell elongation. Students often think that the cells are replicating or reproducing rapidly and increasing in number. The process of elongation is the stretching of a cell by taking in more water. Hence the cell increases in size.

Preparation

The **T&L Prior knowledge catch-up teacher sheet** can be used to prepare for the application of knowledge which is required in this section. The **T&L Prior knowledge catch-up student sheet** will remind students about what they have learned so far on plant structure and photosynthesis.

The **T&L Topic overview** can be used at the end. This has the main points covered and can be shared with the class to consolidate the work covered.

Plant hormones: Lesson 1

Learning outcomes

1 Define the terms phototropism and gravitropism.
2 Explain how plants use hormones in these processes.

Suggested lesson plan

Starter

The simple activity **T&L Lesson starter** will get students thinking about the effects of different stimuli on plants.

Main

Students should be asked to explain (in simple terms) why plants grow towards the light. They should also be able to suggest reasons why roots grow towards the soil.

Introduce the terms ‘phototropism’ and ‘gravitropism’. Ask students to suggest a term for a response to water.

Prepare some diagrams of seedlings which have sprouted and are planted at different angles. Get students to predict how the shoots and roots will grow by drawing the outcomes on the diagrams. This can be done on the board or by providing individual worksheets.

Explain the role of auxins as plant growth factors. Give details as to how the auxin causes shoots to bend towards the light. Explain that the tip is the source of the auxin and that the presence of the tip is essential.

Plenary
Create a series of diagrams showing plant shoots treated in different ways. Figure 13.2 can be adapted for this exercise. Ask the students to predict how the shoots will respond. Alternatively, answer question 2 on page 175 of the textbook.

Support
Use the **T&L Personal tutor: Auxins** to support students where necessary.

Extension
Higher level students could complete questions 20–3 from page 174 of the textbook.

Homework
Complete the Activity on auxin and plant growth on page 172 of the textbook.

Use of plant hormones: Lesson 2 (HT)

Learning outcomes

1 Describe the effects of some plant hormones.
2 Describe the different ways they are used to control plant growth.

Suggested lesson plan

Starter
Answer the Test yourself questions on page 172 of the textbook. Use the text to find the answers.

Main
Students can watch the **T&L Key concept: Plant hormones**. This will consolidate information on tropisms, the effects of auxin, ethene and gibberellins and introduces the idea of useful plant hormones.

Create a 'fill in the gap' information sheet for students to complete on selective weed killers, rooting powder, tissue culture and fruit ripening. They should use information they heard in the presentation.

Answer question 1 of the Practice questions on page 175.

Plenary
Work through the **T&L Quick quiz 2** for this chapter.

Support
Provide a list of key words to help students fill in the gaps in the information sheet.

Extension
Answer Chapter review questions 14–18 on page 174 of the textbook.

Homework
Complete the **T&L Homework task**.

Required practical 8: Investigate the effect of light or gravity on the growth of germinated seedlings: Lesson 3

Learning outcomes

1 Determine the effect of light and gravity on the growth of germinating seeds.
2 Describe the method used in this practical.

Preparation
Familiarise yourself with the practical and the requirements using the **T&L Teacher and technician notes**.

Suggested lesson plan
Starter
Tell the students the title of the practical and ask questions to get them thinking about how they will tackle it before you give them the instruction sheet.

- What conditions must seeds be given in order for them to start germinating?
- What type of seeds could be used for this experiment?
- How many seeds should be used?
- How long should the seeds be left?
- How can any changes be assessed?

Main
Students should complete the Required practical by following the method from page 171 of the textbook or using the **T&L Practical** worksheet.

Give students the first page only. They will then be able to think about creating their own table.

Plenary
Design and construct a table which will be suitable to record all the results.

Support
Weaker students may have to be given a table to complete.

Required practical 8 write-up: Lesson 4

Learning outcomes

Write up the experiment, analyse the results, draw conclusions and evaluate the experimental method.

Starter
Ask students to predict any changes that they are likely to see.

Main
Give out page 2 of the student practical sheet. This will ensure that all students have a correctly constructed table in which results can be recorded.

Measure the length and record the direction of any changes to the seedlings in the table.

Write up the experiment, analyse results, draw conclusions and evaluate the experimental method.

Plenary
Discuss briefly what the results show.

Support
Provide a set of secondary data for students who have failed to obtain any valid results.

Homework
Answer the questions on page 171 of the biology student book.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 Carbon dioxide and water
2 Plant leaves have holes called stomata through which carbon dioxide diffuses. Inside leaves are large spaces, which give a large surface area for absorption of the carbon dioxide.
3 Because more light means more photosynthesis, which means they can produce more glucose.

Test yourself

1 Gibberellin, ethene
2 Gravitropism or geotropism
3 Cut the top off one shoot but leave another next to it. If only the one with the tip grows towards the light, then auxins are made in the tip.
4 They release a lot of ethene, which causes other fruits to ripen too quickly.
5 Auxins, gibberellins, ethene
6 Increasing the number of plants
7 A cutting is taken from a parent plant. Normally the stem is cut to do this. The stem is then dipped into rooting powder and then placed in soil to grow.

Show you can
Page 172

Auxins concentrate on the shaded side of the plant. These cause the cells here to grow longer (elongate). This means the plant bends towards the light.

Page 173

Plant hormones are used in selective weed-killers. They are absorbed by weeds but not by grasses and so can be used to kill dandelions in lawns. Plant hormones are used to help cuttings form roots. They are also used to help fruit ripen before being sold.

Required practical 8
Page 171

1 Task: no answer required
2 Task from students' graphs; no answer is required
3 Students should explain how the growth in each pot differed and link this to tropism. They should be able to account for why shoots bend towards the light (due to auxins increasing cell growth on the dark side of the shoot, so the shoot bends towards the light). They should also be able to explain that, when lit from above, the auxin is evenly distributed so the seedling grows straight up. In the container without light, seedlings grow faster in order to try and find the light; they grow straight up as there is no light to react to.
4 In order to grow towards the light, which maximises the amount of light they receive to carry out photosynthesis.

Activity
Page 172

1 Task: no answer required
2 Task from students' graphs; no answer is required
3 So the seedlings did not respond to light, only treated lanolin
4 The angle of growth increased as the concentration of IAA increased, because IAA is auxin and auxin promotes growth. Cells on the side treated with IAA would have grown more, causing the seedling to bend more and increasing the angle of growth.

Chapter review questions

1 The ability of plant shoots to grow towards the light
2 The ability of plant roots to grow downwards in response to gravity
3 They make the cells longer (elongation).

4 Diffusion
5 Hydrotropism
6 In selective weed-killers, in rooting powder, for fruit ripening
7 Place a lamp to one side of a pot of newly germinated cress seedlings. After 5 days the seedlings will have adjusted to grow towards this light.
8 To anchor the plant into the ground and to reach water. With more water plants can complete more photosynthesis, which means they will produce more glucose. They can release the energy in this during respiration to complete the seven life processes.
9 Auxins concentrate on the dark side of the stem. These cells elongate to bend the stem towards the light.
10 The lengthening of specific cells by plants as a result of hormones
11 It would grow straight upwards. Auxins are produced in the tip of the plant, which now cannot bend towards the light.
12 It would grow straight upwards. Auxins are produced in the tip of the plant and cannot pass through the mica to cause the plant to bend towards the light.
13 It would grow towards the light. Auxins are produced in the tip of the plant and can pass through the gelatine to cause the plant to bend towards the light.
14 Its main role is the ripening of fruit, but it does also help flowers to open and leaves to drop.
15 Some help with stem elongation, whilst others are involved in the dormant period before a seed germinates and the germination process itself. Others help form flowers and fruit.
16 They cause plants to grow uncontrollably and others to stop growing, which kills the plant.
17 The cut end of the stem is dipped in rooting powder and placed into the soil. Rooting powder contains auxins, which help the cutting to form roots.
18 Because it takes so long to sail fruits from the tropical places, many are picked before they are fully ripe. This stops them rotting on the journey. They are sprayed with ethene a short time before arriving so that the fruit is beginning to ripen as it placed on the shelves.
19 Place a lamp to one side of two pots of newly germinated cress seedlings grown in different concentrations of IAA auxin. After 5 days the seedlings will have adjusted to grow towards this light. Measure the angle of growth towards light against the vertical.
20 Charles Darwin and his son
21 The auxins are produced in the tip of a shoot, so they are in a high concentration. Diffusion is the movement of particles from areas of high concentration to areas of lower concentration. So the particles spread out by diffusion from the high concentration in the tip to the lower concentration elsewhere in the plant.
22 It would grow straight upwards and not to the light. Auxins are produced in the tip of the plant and would not be able to move to the cells on the dark side because of the mica.
23 It would grow towards the light. Auxins are produced in the tip of the plant and would be able to move to the cells on the dark side because the mica is on the light side.
24 When they are rotting
25 Agriculture is the rearing of animals and growing of crops for food, fuels or medicines. Horticulture is the growing of plants.

Practice questions

1 a) i) 8
ii) Rooting powder is more effective than water; Rapid-Root produces the most roots.
b) Not valid, calculation $\left(\frac{5}{8}\right) \times 100 = 62.5\%$ (accept 63%)
c) i) Auxin
ii) Ethene for ripening or gibberellins for germination/seed dormancy/stem elongation
d) Red flowers/variegated leaves (do not accept number of leaves, stems, etc.)

2 a) B and E vertical growth [1]; A and D bending towards the lamp [1]; C tip bending towards the lamp [1]
b) A
c) i) D
ii) Geotropism/gravitropism or hydrotropism

3 Level 3: There is a clear and detailed method that is easy to follow and logically sequenced and uses all of the equipment and seedlings. *[5–6 marks]*

Level 2: There is a method that is detailed or easy to follow and makes use of the majority of the equipment. *[3–4 marks]*

Level 1: There is a basic description of a simple method that may not use all of the equipment. *[1–2 marks]*

No relevant content: *[0 marks]*

Indicative content: cotton wool placed in Petri dish; measuring cylinder used to collect/pour water; cotton wool wetted using water; higher tier students may reference using same amount of water; four seedlings added to each

Petri dish; length of seedlings measured and recorded; the three boxes are placed over three of the Petri dishes; one is left without a box; all four are lit using the lamps; seedlings are left for period of time (must be more than 24 hours); boxes are removed and growth is remeasured

Working scientifically: Dealing with data
Page 176

1 As the test is detecting starch, number 1 has the most starch as shown by the blue-black colour. Number 10 has the least starch shown by the lack of blue-black colour. This indicates that in 10 the starch has been broken down into sugar, making the fruit more ripe.

2 Task: no answer is required
3 Task: no answer is required
4 Answer is based on the student's own data.
5 They are subjective.
6 A measurement is repeatable if the original experimenter repeats the investigation using the same method and equipment and obtains the same results. A measurement is reproducible if the investigation is repeated by another person, or using different equipment or techniques, and the same results are obtained.
7 Any sensible answer, such as a Benedict's test for sugar, a test to measure softness, or a taste test.

Inheritance, variation and evolution

14 Reproduction

Overview

Specification points

4.6.1.1 Sexual and asexual reproduction; 4.6.1.2 Meiosis; 4.6.1.3 Advantages and disadvantages of sexual and asexual reproduction; 4.6.1.4 DNA and the genome; 4.6.1.5 DNA structure; 4.6.1.6 Genetic inheritance; 4.6.1.7 Inherited disorders; 4.6.1.8 Sex determination

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 14 pages 177–96

AQA GCSE (9-1) Combined Science Trilogy 2: Chapter 21 pages 27–44

AQA GCSE (9–1) Combined Science Trilogy: Chapter 21 pages 383–400

Recommended number of lessons: 10

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	Yes
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter
- Key terms
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions

Useful prior learning

- Heredity is the process by which genetic information is transmitted from one generation to the next.
- A simple model of chromosomes, genes and DNA in heredity
- Reproduction in plants and humans
- A knowledge of mitosis from Chapter 2

Common misconceptions

- Students find the idea of meiosis difficult to grasp. This form of cell division only takes place when gametes are created in the sex organs. All other cells and tissues replicate using mitosis.
- Chromosomes are only seen in cells which are about to divide. In a non-dividing cell, the DNA is not tightly wound into chromosomes.
- When given a diagram of a cell and asked to state the number of chromosomes in it, students frequently write either 23 or 46. They fail to understand that the number of chromosomes is different in different species and that they should simply count visible chromosomes on a diagram.
- Students often fail to understand that genes are sections of DNA. They know that genes result in the development of features or characteristics but they now need to understand that genes are the coded instructions for the creation of proteins. It is the different blend of proteins that a cell creates that gives it its different characteristics.
- For many of the processes that students need to comprehend, a visual image or short film clip is ideal. There are many animations on YouTube which are ideal and only last a matter of minutes.

Preparation

The **T&L Prior knowledge catch-up student sheet** reminds students of the basics of human reproduction and genetics.

The **T&L Prior knowledge catch-up teacher sheet** gives an outline of the topics that students should have covered at KS3. Some common misconceptions are also outlined on this sheet.

Meiosis: Lesson 1

Learning outcomes

1 Describe the process of meiosis.
2 Explain the similarities and differences between meiosis and mitosis.

Suggested lesson plan

Starter
Use **T&L Lesson starter 1**. This reminds students of the terms 'haploid' and 'diploid'. Use **T&L Lesson starter 2** to remind students of the process of mitosis.

Main
Explain that meiosis is the type of cell division that results in a diploid cell splitting into four haploid cells.

Use Figure 14.6(*21.4*) from page 181(*31; 387*) for this chapter to explain the main stages of meiosis. The names of the stages are not necessary but an understanding of the fact that there are two divisions of the cell is important.

Get students in groups to draw out a summary of meiosis. Give them a starting point by suggesting they have an imaginary cell with a diploid number of four. Students should draw the outcome of this cell undergoing meiosis. They should draw four new cells with two chromosomes in each. Get them to differentiate between the homologous chromosomes by colour coding or drawing chromosomes of different lengths.

Create a simplified version of Figure 14.6 (*21.4*) and get students to describe what is happening at each stage. They do not need to be able to remember the information on DNA crossover.

Plenary
Create a quick quiz and get students to write down the number of chromosomes in different species. For example, tell them that a horse has 64 chromosomes. Suitable questions could be: How many chromosomes are in a horse sperm cell? How many in a horse zygote? This helps them manipulate numbers of chromosomes and gets them used to the terms haploid and diploid.

Support
Provide a very simple diagram showing three stages of meiosis only. Get students to write in the number of chromosomes in each and add the labels haploid and diploid.

Extension
Higher level students could explain how we know that a mother's ova and a father's sperm are all genetically different. Alternatively they could answer Test yourself questions 1–4 on page 182 (*33; 389*) of the textbook.

Homework
Create a table to show the main differences between mitosis and meiosis.

Sexual and asexual reproduction: Lesson 2

Learning outcomes

1 Describe the similarities and differences between sexual and asexual reproduction using examples.
2 Explain the advantages and disadvantages of sexual and asexual reproduction (Biology only).

Suggested lesson plan

Starter
Show students pictures of three different organisms and get them to write down how they think they reproduce. Select something like a bacterium, a strawberry runner with a little plant at the end and a mammal.

Main
Introduce the terms 'sexual' and 'asexual'. Get students to create a list of advantages and disadvantages of both methods of reproduction. Students should recognise that sexual reproduction results in variation. Discuss sexual reproduction in plants and explain the terms self-pollination and cross-pollination. Use the **T&L Topic overview** (slides 1–5 and 7) to consolidate learning.

Students can research selective breeding briefly to link in with the idea of variation and changing characteristics which are more advantageous to humans.

Plenary
Use **T&L Quick quiz 1**.

Support
Give out lists of key terms with definitions and create a mix-and-match exercise to test understanding.

Extension
More able students could research the differences between identical and non-identical twins.

Homework
Answer Practice question 2 on page 195 and Test yourself questions 5–8 on page 183 of the textbook (Biology only).

DNA and the genome: Lesson 3

Learning outcomes

1 Describe the structure of DNA (Biology only).
2 Define the terms gene, chromosome and genome.

Suggested lesson plan

Starter
Create a worksheet using Figure 14.10 (*21.7*) and get students to identify and label the DNA, chromosomes, gene, nucleus and cell.

Main
Use slides 14 and 15 from the **T&L Topic overview** to explain the term genome. The slides can also be used to show the exact location of the DNA in a cell.

Explain that chromosomes are made of DNA but they are only visible when a cell is about to divide. A chromosome is a tightly coiled strand of DNA. Use Figure 14.12 to illustrate this (Biology only).

Explain the double helix structure of DNA using slide 16 from the **T&L Topic overview**. The base pairing rule should be clarified.

Create a simple diagram of part of a DNA molecule for students to label so they can become familiar with complementary bases.

Plenary
Make a quick quiz of key terms or a matching exercise showing how complementary bases fit together. Alternatively use **T&L Quick quiz 2**.

Support
Create a cut-and-stick jigsaw-type activity so students can make a double-stranded DNA molecule. The bases A and T should interlock and so should C and G.

Extension
Introduce the term 'nucleotide'. Get more able students to draw and label a nucleotide and explain how many nucleotides bond together to form DNA. Link the structural components of a nucleotide with the name deoxyribose nucleic acid.

Homework
Research the process of DNA fingerprinting in crime scene investigations. Alternatively answer Chapter review questions 1–7 from page 194 (*questions 1–4 from page 42(395)*).

Understanding the human genome: Lesson 4

Learning outcomes

1 Discuss the importance of understanding the human genome.
2 Describe ethical considerations of this.

Suggested lesson plan

Starter
Discuss the term 'ethical'. What is an ethical issue? Get students to give examples of ethical topics.

Main
In small groups, students should research the Human Genome Project. They should understand what the project is, who was involved and why it was carried out.

Students should discuss the ethical issues behind the project and make a list of the pros and cons. Give students a set of questions to guide them so they find relevant information and do not write too extensively.

Plenary
Hold a short debate on whether the outcome of the HGP is beneficial or not.

Support
Give students a prepared list of facts about the HGP and its findings and get them to sort these into ethical or unethical statements.

Extension
Students could research how the results of the HGP can help us understand the way in which humans originally migrated from Africa.

Homework
Make a poster or pamphlet outlining the Human Genome Project and why it is important for advances in medicine.

Protein synthesis: Lesson 5 (HT)

Learning outcomes

1 Recall a simple description of protein synthesis.
2 Explain the importance of the shape of a protein.

Suggested lesson plan

Starter
Get students to recall their work on enzymes by drawing diagrams showing the lock and key mechanism. Use this to illustrate the fact that enzymes (proteins) will only work if they are folded into a specific shape.

Main
Remind students that they have already learned that DNA codes for proteins and explain that proteins are created from amino acids.

Create a simple diagram that shows the stages of transcription and translation. This could be based on Figure 14.26 in the Practice questions on page 195 (Biology only). One strand of the DNA is given with the bases arranged in groups of three (codons). Explain how the complementary mRNA strand is built upon this and that groups of three bases correspond to one amino acid which is brought by tRNA.

Find a YouTube clip which animates the process of protein synthesis.

Give students an unlabelled diagram which shows the entire process of protein synthesis. Working in groups, get students to label the different stages using key words.

Explain that after the protein has been synthesised, it folds into its specific shape.

Plenary
Test knowledge of key terms with a quiz or matching activity. Alternatively, create a series of statements about protein synthesis. Put them in the wrong order and get students to arrange them correctly.

Support
Create a simple diagram showing four stages of protein synthesis in the wrong order. Students could either order these correctly or cut them out and stick them together properly.

Extension
Create an exercise where students are given the DNA codons for some amino acids. Provide a single strand of DNA showing the bases and get the students to translate the codons on the DNA into a chain of amino acids (polypeptide).

Homework
Chapter review questions 19–21 on page 194 of the textbook (Biology only).

Mutations: Lesson 6 (HT)

Learning outcomes

1 Describe the different types of mutations and their consequences.
2 Explain the potential consequences of mutations to the formation of proteins.

Suggested lesson plan

Starter
Find some pictures of organisms which have undergone a distinct mutation. Ask the students to explain why these may have happened.

Main
Introduce the term mutation and explain that these are changes to the DNA.

Create a diagram similar to Figure 14.26 on page 195 (Biology only). This can be used to show how groups of three bases code for one amino acid. The diagram can then be altered by adding or deleting bases. The codons will change and so will the amino acids that are inserted in the polypeptide. The diagram can also be altered to show silent mutations.

Students can research different mutagenic agents and how they affect DNA.

Plenary
Discuss how mutations may affect proteins like collagen or enzymes.

Support
Give students a paragraph on mutation and its effect and leave gaps in the text. Supply words from a list for students to insert in the text.

Consolidate learning using the **T&L Key terms** for this chapter.

Extension
Explain how mutations may be lethal or beneficial to the evolution of a species.

Homework
Answer Chapter review questions 22–24 on page 194 of the textbook (Biology only) or the killer question from the **T&L Homework task**.

Genetic inheritance: Lesson 7

Learning outcomes

Define the terms gametes, chromosome, gene, allele/variant, dominant, recessive, homozygous, heterozygous, genotype and phenotype.

Suggested lesson plan

Starter
Get students to put the following structures in order of size (largest first): nucleus, gamete, chromosome, gene.

Main
Create a student sheet using the **T&L Animation: Monohybrid crosses**. Use this as a base for introducing a Punnett square and explaining the terms that students may not have come across before. Explain that in a monohybrid cross there is a dominant and a recessive allele. Get students to fill in the Punnett square with as many combinations as they can.

Students can complete a table similar to those on pages 189 and 190 (*36 and 37; 392 and 393*) which has gaps for them to fill in with 'genotype', 'phenotype' or any other correct terminology.

Plenary
Create a quick quiz testing the understanding of the terms in the learning objectives.

Support
Create a mix-and-match exercise for matching terms with definitions.

Extension
Explain how two parents who can roll their tongue can have a baby that cannot.

Homework
Create a crossword of the key terms, writing clear definitions as the clues.

Monohybrid crosses: Lesson 8

Learning outcomes

1 Complete genetic crosses using Punnett square diagrams.
2 Use direct proportion and simple ratios to express the outcome of a genetic cross.
3 Make predictions using the theory of probability.

Suggested lesson plan

Starter
Use **T&L Lesson starter** to introduce this lesson.

Main
Show the **T&L Personal tutor: Inheritance**.

Give students some examples to try themselves. For each one they should try to predict the outcome by looking at the genotypes of the parents before they create a Punnett square. The probability of the different genotypes and phenotypes created should be expressed in different ways.

Work through Practice question 3 on page 195 (*question 2 on page 43(399)*).

Plenary
Ask students to predict outcomes merely by looking at the parents' genotypes.

Quick fire questions on Punnett squares testing an understanding of homozygous, heterozygous, genotype and phenotype.

Support
Give a partially completed Punnett square for students to complete. They should be able to present the outcome as a percentage, fraction or ratio.

Extension
Give students a more challenging cross. For example, they could be given one on co-dominance in flowers. This would enable them to suggest that both alleles were having an effect. Multiple alleles and the ABO blood grouping also generate more challenging crosses.

Homework
Work through more examples of monohybrid inheritance. For each, present the genotypic and phenotypic ratios.

Genetic disorders: Lesson 9

Learning outcomes

1 Complete genetic crosses using Punnett square diagrams to explain the inheritance of genetic disorders.
2 Describe the symptoms of genetic disorders.

Suggested lesson plan

Starter
Use a modified version of the family tree Figure 14.22(*21.15*) from page 192(*39; 395*). Show the genotypes of the first two generations. Ask students to predict the possible genotypes and phenotypes of the subsequent generations.

Main
Explain how a family tree works. Explain that cystic fibrosis is a recessive condition that can be inherited.

Students should research cystic fibrosis. They should understand how it is inherited, the symptoms and the treatment of the condition.

Get students to draw the same type of family tree as they have been shown for cystic fibrosis. Change the condition to polydactyly which is caused by a dominant allele. Show pictures of the condition polydactyly. Students should select a capital letter for the dominant condition and the same letter (lower case) for the recessive.

Plenary
Students should work through Practice question 5 on page 195 of the textbook (Biology only).

Support
Give students a complete family tree for polydactyly which has gaps for them to fill in with the correct genotype.

Extension
Students could carry out some research into how genetic engineering may be able to cure cystic fibrosis permanently.

Homework
Explain how two parents without cystic fibrosis can have a baby that has the disorder.

Sex determination: Lesson 10

Learning outcomes

Complete genetic crosses using Punnett square diagrams to explain the inheritance of sex.

Suggested lesson plan

Starter
Show a picture of the human karyotype. Figure 14.13 on page 186 (*Figure 21.18 on page 41(397)*) is a good example. Point out the 22 pairs of chromosomes and the sex chromosomes. Explain that males have XY and females are XX.

Main
Create a diagram similar to Figure 14.24 on page 193 (*Figure 21.17 on page 40(396)*). Remove all labels and get students to fill in key terms. They should be able to label each structure as well as the number of chromosomes in each nucleus. Explain the process of fertilisation.

Explain that the sex of an individual is determined by the sex chromosome carried by the sperm. Remind students that only one copy of each chromosome will go into each gamete. Encourage students to create a Punnett square to show the probable outcomes when a sperm and an egg fuse together. Write down all the possible phenotypes and the probability that the offspring will be a male or a female.

Plenary
Practice question 1 on page 195(*43; 399*).

Support
Create a diagram showing the inheritance of sex with gaps for students to fill in.

Extension
Research some of the chromosomal mutations that result from a disparity in the number of sex chromosomes.

Homework
Students could complete the **T&L Homework task**. This should be differentiated according to ability.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 Pollen and ova
2 A fertilised ovum splits into two, which develop into two identical organisms.
3 Cross-pollination is between two different plants, whereas self-pollination is between two flowers of the same plant.
4 Chromosomes, genes, DNA

Test yourself

1 23
2 Two in meiosis and one in mitosis
3 Mitosis produces identical cells, whereas meiosis produces non-identical ones.
4 Gametes/sperm or pollen and ova
5 One
6 Binary fission
7 The offspring are not clones and so are more likely to adapt to environmental changes or infection from pathogens.
8 It can be faster than sexual reproduction and only involves one parent.
9 All the DNA of an organism
10 A short section of DNA that controls a characteristic; a short section of DNA that provides the code to make a protein
11 Coding DNA has the genetic code to make a protein. Non-coding DNA doesn't.
12 23
13 A, T, G, C
14 Some people disagree with it for religious or moral reasons.
15 The development of genetic tests to show that people may be more likely to develop breast cancer and cystic fibrosis, for example.
16 Amino acids

17 Polypeptides are chains of amino acids. These are folded into a specific shape and become a protein.
18 Bases come in threes. Each triplet of bases corresponds to one amino acid.
19 Alleles
20 Brown eyes, tongue rolling, attached ear lobes
21 BB and Bb give brown eyes, whereas bb gives blue eyes
22 Neither parent has a recessive gene, so it is 100%.
23 Cystic fibrosis, polydactyly, haemophilia
24 Cc
25 Mucus in the lungs
26 Babies are born with six fingers or toes
27 XY
28 XX
29 All offspring of the same parents are not clones and show variation.
30 XX (X from the sperm and X from the ovum)

Show you can

Page 182

If you have siblings, then you would be a clone of your brother or sister if they weren't.

Page 183

Plants can produce asexually by making plantlets on runners. This is called vegetative reproduction. They can also reproduce asexually when bees pollinate their ova with pollen from their own flowers. This is called self-pollination. Plants can reproduce sexually when bees pollinate their ova with pollen from other plants. This is called cross-pollination.

Page 184

DNA is made from the base pairs A–T and G–C. A short section of this DNA that codes for a protein is called a gene. A chromosome is made from coding and non-coding regions of DNA that are coiled into an X shape. A genome is the sum of all the DNA in all an organism's chromosomes.

Page 186

Some people think that genetic prejudice may exist in the future when people's jobs or insurance might be determined by their genetics (over which they have no control).

Page 188

During protein synthesis, an enzyme attaches to DNA and uncoils and unzips it. Messenger RNA (mRNA) bases line up opposite the coding strand of the DNA. When complete, the mRNA strand leaves the nucleus and the DNA returns to its double helix shape. During translation, the mRNA strand attaches to a ribosome. For every three mRNA bases, a corresponding transfer RNA molecule attaches. It then detaches but leaves behind an amino acid. The amino acids form a polypeptide chain and are folded into a protein.

Page 191

Both parents are heterozygous for tongue rolling (Tt). They have a one in four chance of producing a baby that is homozygous recessive (tt).

Page 192

Both parents are heterozygous for cystic fibrosis (Cc). They have a one in four chance of producing a baby who is homozygous recessive (cc) and will have the disorder.

Page 193

As women are XX, all their eggs will contain an X chromosome. As men are XY, either the X will fertilise the egg, making it XX and a girl, or the Y will, making it XY and a boy. There is a 50:50 chance of this, as the choice is either X or Y from the sperm.

Practical

Page 185

Task: no answer is required

Page 190

Task: no answer is required

Chapter review questions

1 One copy of all the DNA found in your diploid body cells.
2 You have inherited one from each of your two parents.
3 A short section of DNA (part of a chromosome) that provides the code to make a protein.
4 The analysis of differences in DNA to identify individuals.
5 To determine the parents of a child or to identify a criminal from DNA evidence left at a crime scene.
6 A, T, G, C
7 A double helix
8 A decision that some people disagree with for religious or moral reasons.
9 Ultraviolet (UV) rays, X-rays, gamma rays, tar, asbestos
10 A cancer-causing substance
11 It is the code that tells your body which proteins to make.
12 Red blood cells
13 Identical twins
14 The four letters A, T, C and G, which are always paired A–T and G–C in DNA
15 The 23rd pair
16 The identification of the sequence of every one of the three billion base pairs from a random male and female volunteer

17 Working together
18 Some people believe that some employers might be prejudiced about the genetics of those that they employ. Others worry that health insurance companies that knew our genetics might charge some people more than others.
19 Amino acids
20 Ribosomes
21 Because the mRNA bases line up opposite the three bases of the tRNA molecule
22 A permanent change to DNA
23 Some mutations have no effect, and others even have a positive effect.
24 A base or bases can be deleted, inserted or swapped in a section of DNA
25 A small stem of a plant containing several leaves is cut cleanly from a plant. This is dipped into rooting powder containing plant hormones. This is then gently pushed into soil to grow.
26 Mash up a kiwi fruit and strain the mixture. Put 90 cm^3 of this into a small beaker and add 10 cm^3 of washing-up liquid. Incubate at 60 °C for 10 minutes. Filter 10 cm^3 of filtrate. Add two drops of protease enzyme and mix. Slowly pour chilled ethanol down the side of the tube to form a layer on the filtrate containing white DNA strands.
27 The development of genetic tests, which show the likelihood of some illnesses developing, including breast cancer and cystic fibrosis
28 The future of many medicines and medical treatments is likely to involve the follow-up work to the Human Genome Project.
29 The shape of the protein can be changed; in the case of enzymes this can alter the active site or stop it functioning.

Practice questions

1 **a)** Sexual, gametes/sex cells, variation, homozygous, heterozygous, XY
b) Punnett square: correct parent gametes [1], correct genotypes for offspring [1], correct genders of offspring deduced [1]
2 **a)** C: cross-pollination
b) B: The new plants will be genetically different; C There is more variation to allow for natural selection
3 **a)** A version of a gene
b) An allele is dominant (e.g. B) if it is expressed in the heterozygous phenotype; a recessive allele (e.g. b) is only expressed if both alleles are recessive.
c) Punnett square: correct parent genotypes (Bb × Bb) [1]; the different offspring produced (BB, 2 × Bb and bb) [1]; bb identified as white [1]; correct probability of 0.25 given [1] (do not accept a ratio/fraction, as not asked for in the question)
4 **a)** The nucleus
b) i) Double helix
ii) TCATGTCATGAC
c) i) A gene
ii) Level 3: A clear explanation with logical links *[5–6 marks]*
Level 2: A number of relevant points made, but not precisely; the logic is unclear *[3–4 marks]*
Level 1: Fragmented points with no logical structure *[1–2 marks]*
No relevant content: *[0 marks]*
Indicative content: idea that a single strand of DNA is used as a template to make an mRNA; idea that the DNA molecule is transcribed; mRNA leaves the nucleus; proteins are synthesised on ribosomes; idea that the mRNA is translated; idea that every three bases code for an amino acid; idea that tRNA molecules bring specific amino acids to the ribosome; idea that the order of bases determines the order of amino acids; idea that amino acids are assembled to make a protein; idea that protein folds in to a specific shape.
d) i) 1
ii) Idea that it would be a different shape/have a different function/not be produced
iii) Carcinogen/named substance, ionising radiation, ultraviolet (UV) light
5 **a)** D: respiratory system
b) B: ff

Working scientifically: Scientific thinking
Page 196

Task: no answer is required

AQA GCSE (9-1) Combined Science Trilogy
Test yourself on prior knowledge

1 Pollen and ova
2 A fertilised ovum splits into two, which develop into two identical organisms.
3 Cross-pollination is between two different plants, whereas self-pollination is between two flowers of the same plant.
4 Chromosomes, genes, DNA

Test yourself

1 23
2 Two in meiosis and one in mitosis
3 Mitosis produces identical cells, whereas meiosis produces non-identical ones.
4 Gametes/sperm or pollen and ova
5 All the DNA of an organism
6 A short section of DNA that controls a characteristic; a short section of DNA that provides the code to make a protein

7 Some people disagree with it for religious or moral reasons.
8 The development of genetic tests to show that people may be more likely to develop breast cancer and cystic fibrosis, for example.
9 Alleles
10 Brown eyes, tongue rolling, attached ear lobes
11 BB and Bb give brown eyes, whereas bb gives blue eyes
12 Neither parent has a recessive gene, so it is 100%.
13 A medical condition that is caused by one or more genes passed down from parent(s).
14 Cc
15 Mucus in the lungs
16 Babies are born with six fingers or toes.
17 XY
18 XX
19 All offspring of the same parent are not clones and show variation.

Show you can

Page 33(*389*)

If you have siblings, then you would be a clone of your brother or sister if they weren't.

Page 34(*390*)

DNA is made from the base pairs A–T and G–C. A short section of this DNA that codes for a protein is called a gene. A chromosome is made from coding and non-coding regions of DNA that is coiled into an X shape. A genome is the sum of all the DNA in all an organism's chromosomes.

Page 35(*391*)

Some people think that genetic prejudice may exist in the future when people's jobs or insurance might be determined by their genetics (over which they have no control).

Page 38(*394*)

Both parents are heterozygous for tongue rolling (Tt). They have a one in four chance of producing a baby that is homozygous recessive (tt).

Page 39(*395*)

Both parents are heterozygous for cystic fibrosis (Cc). They have a one in four chance of producing a baby who is homozygous recessive (cc) and will have the disorder.

Page 41(*397*)

As women are XX, all their eggs will contain an X chromosome. As men are XY, either the X will fertilise the egg, making it XX and a girl, or the Y will, making it XY and a boy. There is a 50:50 chance of this, as the choice is either X or Y from the sperm.

Chapter review questions

1 One copy of all the DNA found in your diploid body cells.
2 You have inherited one from each of your two parents.
3 A short section of DNA (part of a chromosome) that provides the code to make a protein.
4 A decision that some people disagree with for religious or moral reasons.
5 It is the code that tells your body which proteins to make.
6 Identical twins
7 The 23rd pair
8 The identification of the sequence of every one of the three billion base pairs from a random male and female volunteer
9 Working together
10 Some people believe that some employers might be prejudiced about the genetics of those that they employ. Others worry that health insurance companies that knew our genetics might charge some people more than others.
11 Amino acids
12 Ribosomes
13 The future of many medicines and medical treatments is likely to involve the follow-up work to the Human Genome Project.
14 Two heterozygote parents
15 One parent heterozygous and one homozygous recessive.

Practice questions

1 a) Sexual; gametes/sex cells; variation; homozygous; heterozygous; XY *[6 marks]*
   b) Punnett square: correct parent gametes [1 mark], correct genotypes for offspring [1 mark], correct genders of offspring deduced *[1 mark]*
2 a) A version of a gene *[1 mark]*
   b) An allele is dominant (e.g. B) if it is expressed in the heterozygous phenotype; a recessive allele (e.g. b) is only expressed if both alleles are recessive. *[2 marks]*
   c) Punnett square: correct parent genotypes (Bb × Bb) [1 mark]; the different offspring produced (BB, 2 × Bb, and bb) [1 mark]; bb identified as white [1 mark]; correct probability of 0.25 given [1 mark] [do not accept a ratio/fraction, as not asked for in the question]
3 a) The nucleus *[1 mark]*
   b) Double helix *[1 mark]*
   c) A gene *[1 mark]*
4 B: cc *[1 mark]*

Working scientifically: Scientific thinking

Page 44(*400*)

Task: no answer is required

15 Variation

Overview

Specification points
4.6.2.1 Variation; 4.6.2.2 Evolution; 4.6.2.3 Selective breeding; 4.6.2.4 Genetic engineering; 4.6.2.5 Cloning

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 15 pages 197–210

AQA GCSE (9-1) Combined Science Trilogy 2: Chapter 22 pages 45-56

AQA GCSE (9–1) Combined Science Trilogy: Chapter 22 pages 401–412

Recommended number of lessons: 6

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	Yes
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Animation: Cloning

Useful prior learning
- Variation can be continuous and discontinuous.
- Variation between members of the same species or between members of different species means that some organisms can compete more successfully and can drive natural selection.

Common misconceptions
- There are three causes of variation (genetic, environmental and both) but only two types of data (continuous and discontinuous).
- Give clear instructions when asking students to draw a graph, histogram or bar chart. Students will often present data in the wrong format.
- The technique of cloning a mammal like a sheep seems to be a difficult idea for students. They need to be able to work out logically who the parent of the cloned lamb is. Clips and animations from YouTube are very useful in illustrating these concepts and some are quite amusing.

Preparation
The **T&L Prior knowledge catch-up student sheet** and the **T&L Prior knowledge catch-up teacher sheet** for this chapter are both useful.

Variation: Lesson 1

Learning outcomes

1 Describe how the environment can affect the genome.
2 Explain the consequences of mutations on phenotypes.

Suggested lesson plan

Starter
T&L Lesson starter 1 will remind students that characteristics can be inherited or influenced by the environment or both.

Main
Give details on continuous and discontinuous variation. Explain that continuous data come within a range. When plotted, the data will create a normal distribution. Discontinuous variation falls within distinct categories or groups. There are no in-betweens. These data are plotted on a bar chart.

Students should collect their own data. Anything suitable that can be measured could be chosen. Simple exercises to illustrate continuous variation could involve measuring and recording the hand span of everyone in the class. The length of holly leaves or the number of spines on holly leaves would be suitable plant examples. Students can then plot their data on a graph similar to that shown by Figure 15.4 (*22.4*) on page 199(*47; 403*). Collect as much data as possible so that the students' data will show a bell-shaped curve or normal distribution.

For discontinuous variation, count the number of students who can roll their tongues or have attached ear lobes.

Plenary
Use the **T&L Quick quiz 1** for this chapter.

Support
Ask students to classify different examples of variation into continuous or discontinuous. Get them to think about whether each example could show a range of values or not.

Extension
Answer Chapter review questions 1–4, on page 207(*53; 409*).

Homework
Students should attempt the Activity on pages 199–200(*47–8; 403–4*). This will involve plotting the data and answering the questions.

Selective breeding: Lesson 2

Learning outcomes

Describe the process of selective breeding using examples in animals and plants.

Suggested lesson plan

Starter
Show students a picture of an assortment of animals or plants that belong to one species. For example, the dogs in Figure 15.5 (*22.5*) on page 200 (*49; 405*) of the textbook. Ask students to list how these organisms differ, even though they belong to the same species. Encourage them to suggest how this variation came about.

Main
Introduce the term selective breeding. Organise the class into groups and give each group an organism to research. This could include wheat, dairy cattle, flowering plants or cats. Students should understand the process of selecting the best organisms, interbreeding these together and repeating the process over many years.

Introduce the term 'inbreeding'. Students should be able to write some reasons why inbreeding over several generations is disadvantageous to the species and find some examples of continuous inbreeding.

Plenary
Students should complete Test yourself questions 5–8 on page 201(*50; 406*).

Support
Create a flow diagram to show how a species could be selectively bred over three generations. Choose two starting species that look uninspiring and end with a super species. Get students to annotate the diagram to explain the basic stages. They can also compare the characteristics of the original parents to the new super offspring.

Extension
Higher ability students could explain how dogs have been selectively bred from wolves.

Homework
Practice question 2 on page 208(*54; 410*).

Genetic modification: Lesson 3

Learning outcomes

1 Describe the process of genetic modification using examples in animals and plants.
2 Describe the process of genetic modification of bacteria to produce human insulin.

Suggested lesson plan

Starter
Find pictures of an extreme example of genetic modification such as glow-in-the-dark rabbits. Ask students how they think these animals could be produced. Now show pictures of the two organisms that were used to create the modified version: a green glow jelly fish and a normal rabbit.

Main
Introduce the key terms associated with the example shown in the starter. These should include 'genetic engineering', 'genetic modification', 'transgenic organisms' and 'cloning'. Explain that many useful products can be made using this process.

Create a worksheet showing the genetic modification of a bacterial cell to produce insulin. This can be a simple flow diagram that students fill in with key terms.

Show students Figure 15.9(*22.10*) from page 203(*51; 407*) and explain how sheep can be genetically modified to produce blood-clotting factors in their milk.

Plenary
Students should complete the **T&L Quick quiz 2**.

Support
Give students a set of diagrams on the genetic modification of 'glow-in-the-dark' rabbits. These should be in a random order. Get students to cut them out and stick them down into the correct order. Supply labels of key words to be included in numbered positions on the diagram.

Extension
Students should work through Test yourself questions 12 and 13 on page 203(*52; 408*).

Homework
Chapter review questions 17 and 20 from page 207 (*questions 16 and 19 from page 53(409)*).

Benefits and risks of genetic engineering: Lesson 4

Learning outcomes

1 Explain the potential benefits and risks of genetic engineering in agriculture and in medicine.
2 Discuss ethical considerations of genetic engineering.

Suggested lesson plan

Starter
Ask students to list the differences between genetic engineering and selective breeding.

Main
Students can research the benefits and risks of genetic engineering in agriculture and medicine. They could work in groups and be given one topic each. Their findings could be fed back to the class.

Students can create a table of benefits and risks of genetic engineering using information from the different groups.

Plenary
A brief discussion of what an ethical issue is.

Support
Give students sets of opinions for and against genetic modification. Get them to sort them into risks or benefits or ethical and unethical.

Extension
Suggest why some people do not like the idea of genetic modification.

Homework
Make a balanced list of the ethical issues associated with genetic engineering. Include arguments for and against.

Benefits and risks of genetic engineering: Lesson 5

Learning outcomes

1 Describe the main steps in the process of genetic engineering.
2 Define the terms plasmid and vector.

Suggested lesson plan

Starter
Give students a set of statements associated with genetic engineering and get them to put them in the correct order. These could include statements on insulin production which could be rearranged.

- A plasmid is taken from a bacterial cell.
- The plasmid is cut with enzymes.
- An insulin gene is removed from a human cell with the same enzymes.
- The human gene is sealed into the plasmid.
- The modified plasmid is inserted into the bacterial cell.
- The bacteria manufacture insulin.

Main
Remind students of the terms 'plasmid' and 'vector'.

Show how genes can be transferred from one species to another. Figure 15.15(*22.13*) from page 208(*54; 410*) illustrates how golden rice is created. Create a student copy of this diagram or another similar one which shows gene transfer. Get students to label the key processes.

Plenary
Students can make their own set of statements on the production of rice and get their peers to put these in the correct order.

Support
Use slides 4 and 5 from the **T&L Topic overview** to consolidate key terms.

Extension
Students could complete Practice question 4 on page *208* (*question 3 on page 54(410)*).

Homework
Research some more useful products that are created by genetically modified bacteria. What other organisms can act as gene vectors? Describe how these can be used to transfer useful genes.

Cloning: Lesson 6 (Biology only)

Learning outcomes

1 Describe the process of tissue culture and cuttings of plants.
2 Describe the process of embryo transfer and adult cell cloning in animals.

Suggested lesson plan

Starter
Use **T&L Lesson starter 2**. This will re-introduce the idea of cloning.

Main
Show diagrams of how plant cuttings can be made. Explain that this is a form of asexual reproduction

and that all the plants produced will be genetically identical. Explain that tissue culture is also a type of cloning starting with single cells or tiny plant fragments.

Show Figure 15.10 from page 204. Use this to explain how a sheep could be cloned. Ask students to decide which sheep the cloned lamb is genetically identical to. They should be able to give a reason for their choice.

Students should draw out a flow diagram of their own to explain the procedure involved in cloning a lamb.

Plenary
Show students the **T&L Animation: Cloning**.

Support
Create an unlabelled flow diagram of the cloning of a sheep. Provide a list of labels for students to write or stick onto the diagram. Create a similar exercise but with a different animal, such as a dog.

Extension
Explain the terms 'embryo transfer' and 'embryo splitting'. Describe how these processes have helped increase the number of farm animals with favourable characteristics.

Homework
Work through Test yourself questions 14–17 on page 206 of the textbook.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 Continuous and discontinuous
2 By genetic factors, which are inherited, or by the environment in which an organism lives
3 Because discontinuous data come in groups that are best represented by bars rather than points joined up.

Test yourself

1 Genetic and environmental
2 Continuous and discontinuous
3 On a line graph with a line of best fit
4 A bell-shaped curve that rises in the middle and is low at both sides.
5 Cats, all farmyard animals
6 A measure of the total genes of a population
7 Disease-resistance has been bred by breeding only those parent plants that are resistant to disease.
8 Any negative characteristics are magnified as well as the desired ones, and the gene pool is reduced, meaning adaptation may be harder.
9 Carotene
10 To be drought-resistant
11 Some people disagree with it for religious or moral reasons.
12 A small circle of DNA that is present in bacterial cells
13 Plasmids can move from one bacterium to another. In genetic engineering the plasmids are removed from bacteria and have a gene inserted into them. They then are used to 'infect' other bacteria and take the gene with them.
14 One
15 Clone
16 One embryo with desired characteristics can be split, and then each part will grow into a clone with those characteristics.
17 Dolly's face was white like her mother, not like either of the other sheep involved in the process.

Show you can

Page 200

A mutation is a change in DNA. This can be harmful, have no effect or actually be an advantage. Any change in DNA can be inherited, at which point it becomes a source of genetic variation.

Page 201

Our ancestors bred together wolves with certain characteristics such as size or aggression. The offspring of these crosses are likely to inherit the characteristics from their parents. Those that did were crossed again with other individuals like them. Soon these characteristics were magnified into the dog breeds we have today.

Page 203

The gene for glowing in the dark in jellyfish was identified and removed using enzymes. The same enzymes were used to cut open the DNA of a rabbit embryo. The gene was sealed into the rabbit DNA using a different enzyme. The embryo was implanted into a female rabbit.

Enzymes are used to cut out the gene for insulin; the same enzymes are used to cut a small circle of DNA found in bacteria called a plasmid. The human gene is then inserted into the plasmid.

Page 206

An udder cell was removed from the one parent. An ovum was removed from another sheep and all the DNA was removed. All chromosomes from the diploid udder cell were inserted into the ovum. This was then placed in the uterus of a third sheep to develop.

Activity
Pages 199–200

1 Task: no answer is required
2 Yes
3 Variation is continuous
4 Allow any sensible suggestion for non-continuous variation such as eye colour, gender, hair colour or blood type.
5 Student B has the most accurate data for the mass of 11 year olds, as the sample size is much larger.

Practical
Page 206

1 To prevent contamination
2 Auxin could have been added to stimulate growth.
3 The crop would all be identical with the desired characteristics and may also be quicker.

Chapter review questions
1 The differences that exist within a species or between different species
2 Genetic and environmental
3 Eye colour, blood group
4 Scars, tattoos
5 A scientific technique in which a gene is moved from one species to another
6 Because all of her DNA came from one udder cell of one parent. She was made by asexual reproduction, not sexual. She had only one parent.
7 Height, weight
8 Environmental
9 Continuous, discontinuous
10 Data that come in a range and not in groups
11 Data that come in groups and not a range
12 Bell-shaped with more common values in the middle and fewer common values at each side
13 If you want to breed a big dog, you choose a big bitch and big dog and let them mate. You then choose the biggest bitch and dog in the next generation and let them breed. You repeat this process over many generations and you will end up with big breeds like the Great Dane.
14 Cows for lots of milk, cows for creamy milk, cows and pigs for lots of meat
15 Artificial selection
16 It reduces the variation in the gene pool, which magnifies some negative characteristics by mistake alongside the desirable ones.
17 A genetically engineered organism
18 The glow-in-the-dark gene was cut out from the DNA of a jellyfish using enzymes. The same enzyme was then used to cut open the DNA of a rabbit embryo. The jellyfish gene was then inserted into the DNA of the rabbit and sealed into place using a different enzyme. The embryo was then inserted into the uterus of a rabbit, which from this point onwards had a normal pregnancy.
19 To contain carotene to reduce the chance of vitamin A deficiency which causes blindness
20 To be herbicide-resistant, which means that herbicides can be sprayed all over fields of it to kill all plant life other than the soya
21 A small, circular section of DNA that can be moved between bacterial cells.
22 An organism produced asexually that has identical genetics to its parent.
23 In a sterile environment, remove a sample piece of tissue from a carrot root. Using aseptic technique, place your sample in nutrient agar with growth hormones. Incubate for around 10 days. Plantlets should be starting to form from the original sample.
24 Because their primary purpose was to hunt mice and rats and they have always been good at this.
25 It might be difficult to evolve to a changing environment or combat a new communicable disease.
26 Some say that this is 'humans playing God' and that the process is unnatural. Others think that the genes might spread into the wild gene pool.
27 Blood clotting proteins (called factors)
28 The plasmid is cut open using the same enzymes that cut open the DNA. The gene is then inserted into the plasmid and sealed in using a second enzyme. The plasmid is then allowed to move into bacterial cells to deliver the gene.
29 One body cell from the udder of the parent sheep and its nucleus was removed. An ovum cell was removed from the ovaries of a second sheep. The haploid nucleus of this cell was removed during a process is called enucleation. The nucleus from the cell was then inserted into the empty ovum from the second and was treated with a small electrical charge to encourage the cell to divide by mitosis. This was then transplanted into the uterus of a third sheep.
30 Moving fertilised embryos into other animals to increase the number of offspring produced
31 The separation of cells of an embryo to increase the number of offspring produced

Practice questions
1 a) i) 9
ii) C: 55
b) i) Discontinuous
ii) Genetic/inherited
iii) Accept any inherited trait, such as eye colour, gender, attached or unattached ear lobes, tongue rolling. Do not accept height, weight, skin colour or hair colour, as these are affected by the environment too.

2 a) i) Selective breeding/artificial selection
ii) Idea that it can cause inbreeding, magnify negative characteristics, reduce genetic variation
b) Any four from: male and female individuals chosen, both with large muscles, allowed to breed or artificially inseminated, offspring inspected for larger muscle trait, more muscled offspring mated, repeated over many generations
3 a) Genetically modified/transgenic
b) To save thousands of lives, prevent blindness
c) i) Gene to produce carotene cut out from corn; using enzymes; inserted into bacteria; specifically the plasmid; bacteria allowed to multiply; bacteria infect rice embryos; gene transferred into the rice cells; embryos develop into golden rice
ii) Idea that concern about effect on wild plants, insect populations, effect of eating the crops on health, accept specific examples, only accept unnatural if explained why

Working scientifically: Dealing with Data
Pages 209–10

1 Qualitative: C, D, F. Quantitative: A, B, E
2 Task: no answer is required
3 Task: no answer is required
4 Task: no answer is required
5 Centimetres provide greater accuracy and allow the data to be continuous.

AQA GCSE (9-1) Combined Science Trilogy
Test yourself on prior knowledge
1 Continuous and discontinuous
2 By genetic factors, which are inherited, or by the environment in which an organism lives
3 Because discontinuous data come in groups that are best represented by bars rather than points joined up.

Test yourself
1 Genetic, environmental, and genetic and environmental
2 Continuous and discontinuous
3 On a line graph with a line of best fit
4 A bell-shaped curve that rises in the middle and is low at both sides
5 Cats, all farmyard animals
6 A measure of the total genes of a population
7 Disease-resistance has been bred by breeding only those parent plants that are resistant to disease.
8 Any negative characteristics are magnified as well as the desired ones, and the gene pool is reduced, meaning adaptation may be harder.
9 Carotene
10 To be drought-resistant
11 Some people disagree with it for religious or moral reasons.
12 A small circle of DNA that is present in bacterial cells
13 Plasmids can move from one bacterium to another. In genetic engineering the plasmids are removed from bacteria and have a gene inserted into them. They then are used to 'infect' other bacteria and take the gene with them.

Show you can
Page 48(*404*)

A mutation is a change in DNA. This can be harmful, have no effect or actually be an advantage. Any change in DNA can be inherited, at which point it becomes a source of genetic variation.

Page 50(*406*)

Our ancestors bred together wolves with certain characteristics such as size or aggression. The offspring of these crosses are likely to inherit the characteristics from their parents. Those that did were crossed again with other individuals like them. Soon these characteristics were magnified into the dog breeds we have today.

Page 51(*407*)

The gene for glowing in the dark in jellyfish was identified and removed using enzymes. The same enzymes were used to cut open the DNA of a rabbit embryo. The gene was sealed into the rabbit DNA using a different enzyme. The embryo was implanted into a female rabbit.

Page 52(*408*)

Enzymes are used to cut out the gene for insulin; the same enzymes are used to cut a small circle of DNA found in bacteria called a plasmid. The human gene is then inserted into the plasmid.

Activity
Pages 47–8(*403–4*)

1 Task: no answer is required
2 Yes
3 Variation is continuous
4 Allow any sensible suggestion for non-continuous variation such as eye colour, gender, hair colour or blood type.
5 Student B has the most accurate data for the mass of 11 year olds, as the sample size is much larger.

Chapter review questions
1 The differences that exist within a species or between different species

2 Genetic, environmental, and genetic and environmental
3 Eye colour, blood group
4 Scars, tattoos
5 A scientific technique in which a gene is moved from one species to another
6 Height, weight
7 Environmental
8 Continuous, discontinuous
9 Data that come in a range and not in groups
10 Data that come in groups and not a range
11 Bell-shaped with more common values in the middle and fewer common values at each side
12 If you want to breed a big dog, you choose a big bitch and big dog and let them mate. You then choose the biggest bitch and dog in the next generation and let them breed. You repeat this process over many generations and you will end up with big breeds like the Great Dane.
13 Cows for lots of milk, cows for creamy milk, cows and pigs for lots of meat
14 Artificial selection
15 It reduces the variation in the gene pool, which magnifies some negative characteristics by mistake alongside the desirable ones.
16 A genetically engineered organism
17 The glow-in-the-dark gene was cut out from the DNA of a jellyfish using enzymes. The same enzyme was then used to cut open the DNA of a rabbit embryo. The jellyfish gene was then inserted into the DNA of the rabbit and sealed into place using a different enzyme. The embryo was then inserted into the uterus of a rabbit, which from this point onwards had a normal pregnancy.
18 To contain carotene to reduce the chance of vitamin A deficiency which causes blindness
19 To be herbicide-resistant, which means that herbicides can be sprayed all over fields of it to kill all plant life other than the soya
20 A small, circular section of DNA that can moved between bacterial cells
21 Some say that this is 'humans playing God' and that the process is unnatural. Others think that the genes might spread into the wild gene pool.
22 Blood clotting proteins (called factors)
23 The plasmid is cut open using the same enzymes that cut open the DNA. The gene is then inserted into the plasmid and sealed in using a second enzyme. The plasmid is then allowed to move into bacterial cells to deliver the gene.

Practice questions

1 a) i) 9 *[1 mark]*
ii) C: 55 *[1 mark]*
b) i) Discontinuous *[1 mark]*
ii) Genetic/inherited *[1 mark]*
iii) Accept any inherited trait, such as eye colour, gender, attached or unattached ear lobes, tongue rolling. Do not accept height, weight, skin colour or hair colour, as these are affected by the environment too. *[1 mark]*

2 a) i) Selective breeding/artificial selection *[1 mark]*
ii) Idea that it can cause inbreeding, magnify negative characteristics, reduce genetic variation *[1 mark]*
b) Any four from: male and female individuals chosen, both with large muscles, allowed to breed or artificially inseminated, offspring inspected for larger muscle trait, more muscled offspring mated, repeated over many generations *[4 marks]*

3 a) Genetically modified/transgenic *[1 mark]*
b) To save thousands of lives, prevent blindness *[1 mark]*
c) i) Gene to produce carotene cut out from corn; using enzymes; inserted into bacteria; specifically the plasmid; bacteria allowed to multiply; bacteria infect rice embryos; gene transferred into the rice cells; embryos develop into golden rice *[5 marks]*
ii) Idea that concern about effect on wild plants, insect populations, effect of eating the crops on health, accept specific examples, only accept unnatural if explained why *[2 mark]*

Working scientifically: Dealing with data
Pages 55-6(*411–12*)

1 Qualitative: C, D, F. Quantitative: A, B, E
2 Task: no answer is required
3 Task: no answer is required
4 Task: no answer is required
5 Centimetres provide greater accuracy and allow the data to be continuous.

16 The development of understanding of genetics and evolution

Overview

Specification points

4.6.3.1 Theory of evolution; 4.6.3.2 Speciation; 4.6.3.3 The understanding of genetics; 4.6.3.4 Evidence for evolution; 4.6.3.5 Fossils; 4.6.3.6 Extinction; 4.6.3.7 Resistant bacteria

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 16 pages 211–26

AQA GCSE (9-1) Combined Science Trilogy 2: Chapter 23 pages 57–66

AQA GCSE (9-1) Combined Science Trilogy: Chapter 23 pages 413–422

Recommended number of lessons: 6

Chapter overview		
Contains AQA required practicals	**N/A**	
Contains higher-tier only material	**No**	
Contains biology-only material	**Yes**	

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions

Useful prior learning

- Inheritance and the role of chromosomes, DNA and genes
- Simple genetic crosses using Punnett squares
- The variation between species and between individuals of the same species means that some organisms compete more successfully and this can drive natural selection.
- Changes in the environment may leave individuals within a species and some entire species less well adapted to compete successfully and reproduce. This in turn may lead to extinction.

Common misconceptions

- Evolution is a slow process and takes millions of years. However, in a species like a bacterium or some insects, evolution can be relatively fast.
- Ensure that students always use the term 'resistant' when referring to bacteria and the effect of antibiotics. They frequently write that bacteria are 'immune' to antibiotics, which is incorrect.
- Students may believe that evolution goes against the teachings of their own religious beliefs. The topic should be taught on evidence alone so that only the science behind the process is considered.

Preparation

- **T&L Prior knowledge catch-up teacher sheet.**
- **T&L Prior knowledge catch-up student sheet.**

Evolution: Lesson 1 (Biology only)

Learning outcomes

1 Describe the process of evolution.
2 Define the term speciation.

Suggested lesson plan

Starter

Students could work on the Test yourself on prior knowledge questions on page 212 of the textbook.

Main

Get students to think about why there is so much variety of life on Earth. They could suggest ways in which life arose and will have different views on this. Explain that evolution is a theory based on scientific evidence. Introduce the term 'common ancestor' and explain that all life today could have evolved from this. Explain the term 'speciation'.

Give students a set of questions to research. These should focus on the life and work of Charles Darwin and should guide the students to understand his role in developing the theory of evolution by natural selection. Students should then write out a summary of the theory of evolution as a set of bullet points.

Plenary

Use slides 1–4 from the **T&L Key terms**.

Support

Create a version of **Figure 16.6 from the T&L Diagram bank** so that students need to match the shape of the beak to the most appropriate food.

Carry out the Practical on page 214 which models natural selection.

Extension
Give an example of the co-evolution of two different species and ask students to explain how this is a survival advantage.

Homework
Answer the Chapter review questions 1–7 on page 224 of the textbook. As an alternative, students could answer Practice question 3 on page 225 of the textbook.

Evolution: Lesson 2 (Biology only)

Learning outcomes

1 Explain why Darwin was reluctant to publish his theory of evolution.
2 Describe the work of Wallace in the development of the theory of evolution.
3 Describe the mechanism of inheritance suggested by Lamarck.

Suggested lesson plan

Starter
Test yourself questions 1 and 2 from page 215 of the textbook.

Main
Give students a brief text on the work of Lamarck and his theory of acquired characteristics. They should then answer the questions on page 216.

Students could then research the work of Alfred Russel Wallace in developing the theory of evolution. This exercise should be controlled through a set of questions that they can find the answers to. For example: Who was Wallace? Which countries did he travel in? What was his relationship with Darwin? How was his theory different? Why is he less well known than Darwin?

Plenary
Students could complete **T&L Quick quiz 1** for this chapter.

Support
Create a mix-and-match exercise so students can match up the scientist (Darwin, Lamarck and Wallace) with the most important aspects of their work.

Extension
More able students could be asked to explain how geographical isolation can cause speciation.

Homework
Answer questions 14–17 on page 224 of the textbook.

Mendel and inheritance: Lesson 3 (Biology only)

Learning outcomes

1 Describe the role that Mendel played in the development of our understanding of inheritance.
2 Complete genetic crosses using Punnett square diagrams.

Suggested lesson plan

Starter
Create a Punnett square with a simple genetic cross for students to complete. This could be with red and white flowers or tall and short plants. Make sure they know the correct notation of using a capital letter for the dominant and a lower case letter for the recessive characteristic.

Main
Describe the life and role of Gregor Mendel and his work on pea plants.

Explain the genetic cross shown in Figure 16.12 of the textbook. Use this to illustrate the laws of genetics that Mendel devised and that we still use today.

Students should select a letter and write out the genetic crosses for the diagram shown in Figure 16.12 of the textbook, including a Punnett square. They could then draw genetic crosses for other characteristic features of the peas that Mendel observed. For example, yellow and green pods, round or wrinkled seeds.

Plenary
Students could complete **T&L Quick quiz 2**.

Support
Create Punnett squares which are partially completed so students can fill in the gaps.

Extension
Ask the more able students to explain how Mendel could have bred a pea plant with yellow seeds from two pea plants with green seeds. Use Y to represent yellow seeds and y to represent green.

Homework
Complete Test yourself questions 11–14 on page 218 of the textbook.

Fossils: Lesson 4

Learning outcomes

1 Describe how fossils are formed.
2 Explain why scientists are unsure about how life began on Earth.
3 Explain how fossils provide evidence for evolution.

Suggested lesson plan

Starter

Show students slide 1 from the **T&L Topic overview** for this chapter. This gives a definition of evolution by natural selection. Ask students to make suggestions as to what evidence we may have for evolution.

Main

Show slide 7 from the **T&L Topic overview**. This introduces the idea of fossils and what they are.

Students could carry out a simple practical using a leaf from a fern, plaster of Paris and a polystyrene cup. The cup is half filled with plaster of Paris and the fern is laid on top and then covered with the rest of the plaster. Leave the plaster to dry and then carefully crack it open. An imprint of the fern leaf is created.

Show the class a YouTube clip on how fossils are formed. Explain to students that the fossil record is incomplete. Get students to write out a flow diagram of how an organism becomes fossilised.

Plenary

Students could work in groups and suggest all the possible reasons why the fossil record is incomplete.

Support

Show students a set of diagrams of organisms. Get them to select those which could become fossils and those that would not and give a reason for their choice. Each organism should have a brief description. Suitable examples would be a jellyfish, a leaf, a woodlouse and a mushroom.

Extension

Explain why the remains of organisms are often found preserved in peat bogs.

Homework

Students could explain how the evolution of horses' hooves is linked to a changing environment or attempt Test yourself question 15 on page 222 (*question 1 on page 63(419)*).

Extinction: Lesson 5

Learning outcomes

1 Define the term extinction.
2 Describe factors that may contribute to extinctions.

Suggested lesson plan

Starter

Show students a picture of a dodo. Tell them that there are no photographs of the animal because it no longer exists. Get students to suggest why the animal is extinct. They could simply describe any undesirable features of the animal.

Main

In groups, get students to discuss all the factors that could bring about the extinction of a species. Tell them that some of the factors should link to Darwin's theory of evolution by natural selection. Students should also think about and describe examples of organisms that humans would like to become extinct, for example, certain bacteria.

Plenary

Create a quick test of the key terms associated with extinction.

Support

Give students a list of factors, some of which could cause the extinction of a species mixed in with factors beneficial to a species. Ask them to sort them into good and bad and give reasons for each.

Extension

Carry out some rese[a]rch to help explain how the dinosaurs may have become extinct.

Homework

Test yourself questions 19–22 from page 223 (*questions 5–7 on page 64(420)*). Alternatively, Practice questions 1 and 2 from page 225(*66; 422*).

Antibiotic resistance: Lesson 6

Learning outcomes

1 Explain how antibiotic-resistant bacteria have evolved.
2 Explain how antibiotic resistance provides evidence for evolution.

Suggested lesson plan

Starter

Give students a version of question 5 from the **T&L Quick quiz 2** for this chapter. There are four gaps to fill in and the key words are given.

Main

Explain that evolution can happen very quickly and does so in bacteria. Remind students how bacteria divide by binary fission.

Create a big diagram showing a large number of circles which represent bacteria. These circles should be identical. Now colour one circle in. Explain that this is the mutation.

Describe how, if the bacteria are given an antibiotic, they will all die apart from the mutant. Explain that this one mutant could be MRSA. Cross out all the circles except the one that is coloured in.

Ask what is going to happen to the coloured (resistant) bacterium. Students should say that it is going to replicate and increase in number. Give students a timeline for this activity and ask them to suggest how this is linked to evolution.

Ask students to draw their own diagrams showing how antibiotic resistance develops. They can do this as a cartoon strip with 4–6 slides.

Plenary

Show slide 8 of the **T&L Topic overview**.

Support

Give students a cartoon strip showing antibiotic resistance in bacteria and get them to label the different stages. Alternatively, provide labels which they have to sort out and stick onto the pictures.

Extension

Carry out the Activity on page 221(*63; 419*).

Homework

Test yourself questions 16–18 on page 222 (*questions 2–4 on page 63(419)*).

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 Charles Darwin
2 They have white fur for camouflage and a thick layer of fat for insulation.
3 Because if organisms cannot adapt to these changes they will be outcompeted and all may die out.

Test yourself

1 Charles Darwin
2 Alfred Russel Wallace
3 Soft inheritance
4 Jean-Baptiste Lamarck
5 He thought that the neck would become longer by the giraffe stretching upwards for leaves.
6 With disbelief
7 The three-spined stickleback
8 Between Australia and South-East Asia
9 Organisms on either side of it have evolved very differently.
10 He independently thought of the theory of evolution but only after Darwin. Darwin is the scientist most remembered for the theory these days.
11 Gregor Mendel
12 Pea plants
13 Shape and colour of pea pods, flowers and seeds
14 At this time most people believed in blended inheritance
15 Archaeopteryx
16 Antibiotics
17 By the misuse or overuse of antibiotics
18 Using antiseptics
19 99%
20 The dodo
21 Without it, the chances of catching malaria would reduce
22 A mass extinction is when many, many species become extinct at the same time. This happened when the dinosaurs died out and is happening now as a result of the activities of humans.

Show you can

Page 215

In every population there is variation. Some organisms will be better adapted to the environment than others. These are more likely to survive and reproduce. Their offspring are likely to have these same characteristics. If this is repeated over many generations, new species will evolve.

Page 216

Some scientists now think that the characteristics of an organism can be altered by their environment, when genes are switched on or off.

Page 217

Speciation is the formation of new species. When a population is geographically split, the smaller groups can be isolated. If this happens then they can evolve separately until they cannot interbreed anymore.

Page 218

Both parents are heterozygous for colour (Yy), so they are green. They have a one in four chance of producing a plant that is homozygous recessive (yy), which will be yellow.

Page 222

Antibiotics are used to kill bacteria. Variation exists in bacteria. Some are not killed and are resistant to antibiotics (MRSA). These breed and pass on their resistance to their offspring. This provides evidence for evolution by natural selection.

Page 223

A meteor hit the Earth near Mexico and sent a huge cloud of dust into the air. This blocked light and prevented plants from photosynthesising. The plants died, along with many animals that depended upon them, including the dinosaurs.

Practical
Page 214

1–3 Task: no answer is required

Activity
Page 221

1 Task: no answer is required
2 Infection rates increased from 1993 to 2005 for a rate of infection per million of the population from 1 to 26. They then decreased from 2005 to 2011 from 26 to 5.
3 Increased hygiene and control measures in hospitals
4 A mutation arises that makes the bacteria resistant to antibiotics. These bacteria survive antibiotic treatment. They reproduce, passing the genetic advantage on to the next generation.

Chapter review questions
1 Charles Darwin
2 Galapagos Islands
3 Finches
4 A belief that God created all the organisms on Earth
5 In every population there is variation among individuals. Some variations will mean that some individual organisms are better adapted to the environment than others. These will have an advantage and are more likely to survive and reproduce. (This is natural selection.) Their offspring are likely to have these same characteristics. If this is repeated over many generations, new species will be formed.
6 The process of forming new species of life.
7 The smallest group of classifying organisms; individuals of the same species are able to interbreed to produce fertile offspring
8 All of the fossils that have been discovered so far
9 An organism from which others have evolved
10 A small, single-cell organism
11 The natural process by which organisms that are better adapted are more like to survive, which was first described by Charles Darwin.
12 At this time the Church was very powerful and many people believed in creationism.
13 He thought that the finches all originally belonged to one species that was probably blown over to the Galapagos Islands from Chile by a storm. Small variations in this original population meant that some birds were better adapted to certain islands. Here they settled. Many generations later the small differences that made the birds settle in the first place have been magnified by evolution and the birds are now different species.
14 The theory of inheritance of acquired characteristics
15 A giraffe that spends its whole life straining to reach the highest branches for food will have a longer neck.
16 Lamarck could not prove it
17 It is a narrow strait of water between Australia and South East Asia. Speciation has occurred separately on either side of the line.
18 Mendel established the rules of inheritance, which are now known as the laws of Mendelian inheritance.
19 Pea plants; the shape and colours of pea pods, flowers and seeds
20 Fossils are the remains of organisms from hundreds of thousands of years ago. We can look at the fossil record and see changes between species as a result of evolution. The Archaeopteryx fossil shows us that reptiles evolved into birds. It has teeth like a reptile but feathers like a bird.
21 Because there is no oxygen and the water has a low pH, which stops decaying microorganisms from breaking down the body
22 Not all fossils have been found yet. Many fossils will have been destroyed in hot volcanic lava. In addition, many organisms died and were not preserved.
23 A large number of extinctions occurring at the same time (humans are the latest cause of a mass extinction)
24 Punch 25 paper circles out of newspaper and out of a brightly coloured paper. Randomly spread out the discs. Ask your partner to use forceps to pick up as many discs of either colour as they

can in 30 seconds. Repeat several times. (It is likely they will pick up more of the brightly coloured discs. This models a predator killing less camouflaged prey. If this was repeated many times a new species might evolve.)

25 Some scientists believe that the phenotype (physical characteristics) of an organism can be altered by their environment if genes are switched on or off.

26 Wallace developed his own theory of evolution by natural selection. He wrote to Darwin describing it in 1859, and their joint publication occurred a year later. Darwin is the scientist who is remembered as the 'father of evolution'.

27 During the last ice age, a large population of sticklebacks was geographically separated by frozen lakes and rivers. The smaller populations developed in isolation in slightly different environments that they adapted to. Natural selection operated differently in the smaller populations until they could no longer interbreed to produce fertile offspring. At this point they became different species.

28 Fossils show that the horse's hoof evolved over time as a result of the drying of marshes. Originally horses were smaller and had bigger feet to stop them getting stuck in the marshes. As the marshes started to dry up, it was the individuals with smaller feet that had the evolutionary advantage. They could run away from predators faster because they had smaller feet. The fossil record shows this gradual change.

29 Antibiotics were discovered around 80 years ago. At that point no bacteria were resistant. Several years after their first use some bacteria, such as MRSA, had evolved resistance.

Practice questions

1

a) Species no longer living

b) Any two from: natural catastrophe, e.g. volcano eruption, meteorite; climate change, increased sea temperatures or change to environment; sea dried out; new predator; due to disease or new disease developing; outcompeted; prey died out or food source lost

c) Any three from: fish died in the sea and sank to the bottom; covered with layers of sand, volcanic ash, mud or silt from the bottom of rivers and seas; hard parts did not decay or soft parts did decay; the layers above them pushed down, compressing the organisms; minerals entered bones or hard parts; the surrounding water dried, leaving mineral salts, which turned to stone/rock

d) Idea that skin not preserved, or only bones so can't see; accept fossil the colour of the minerals that made them

2 a) Caribbean Porkfish has black stripes/white face

b) Level 3: A clear explanation with logical links *[5–6 marks]*

Level 2: A number of relevant points made, but not precisely; the logic is unclear *[3–4 marks]*

Level 1: Fragmented points with no logical structure *[1–2 marks]*

No relevant content: *[0 marks]*

Indicative content: the idea that the two populations isolated when the land emerged; the idea that each population shows genetic variation; the idea that in each population different mutations or alleles emerged; the idea that there may have been different environmental conditions; the idea that this led to different selection pressures; the idea of survival of the fittest; the idea that favourable genes/alleles passed on to new generation; the idea that eventually two types couldn't interbreed successfully or produce fertile offspring

3 a) Tree

b) i) An organism from which other organisms have evolved

ii) Tragulidae

4 a) Simple

b) A: There was not enough evidence; D: It went against people's religious views

Working scientifically: Scientific thinking

Page 226

Task: no answer is required

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge

1 Charles Darwin

2 They have white fur for camouflage and a thick layer of fat for insulation.

3 Because if organisms cannot adapt to these changes they will be outcompeted and all may die out

Test yourself

1 Archaeopteryx

2 Antibiotics

3 By the misuse or overuse of antibiotics

4 Using antiseptics

5 99%

6 The dodo

7 A mass extinction is when many, many species become extinct at the same time. This happened when the dinosaurs died out and is happening now as a result of the activities of humans.

Show you can

Page 63(419)

Antibiotics are used to kill bacteria. Variation exists in bacteria. Some are not killed and are resistant to antibiotics (MRSA). These breed and pass on their resistance to their offspring. This provides evidence for evolution by natural selection.

Page 64(420)

A meteor hit the Earth near Mexico and sent a huge cloud of dust into the air. This blocked light and prevented plants from photosynthesising. The plants died, along with many animals that depended upon them, including the dinosaurs.

Activity

Page 63(420)

1 Task: no answer is required
2 Infection rates increased from 1993 to 2005 for a rate of infection per million of the population from 1 to 26. They then decreased from 2005 to 2011 from 26 to 5.
3 Increased hygiene and control measures in hospitals
4 A mutation arises that makes the bacteria resistant to antibiotics. These bacteria survive antibiotic treatment. They reproduce, passing the genetic advantage on to the next generation.

Chapter review questions

1 Charles Darwin
2 The smallest group of classifying organisms; individuals of the same species are able to interbreed to produce fertile offspring
3 All of the fossils that have been discovered so far
4 An organism from which others have evolved
5 The natural process by which organisms that are better adapted are more like to survive, which was first described by Charles Darwin.
6 Fossils are the remains of organisms from hundreds of thousands of years ago. We can look at the fossil record and see changes between species as a result of evolution. The Archaeopteryx fossil shows us that reptiles evolved into birds. It has teeth like a reptile but feathers like a bird.
7 Because there is no oxygen and the water has a low pH, which stops decaying microorganisms from breaking down the body
8 Not all fossils have been found yet. Many fossils will have been destroyed in hot volcanic lava. In addition, many organisms died and were not preserved.
9 A large number of extinctions occurring at the same time (humans are the latest cause of a mass extinction)
10 Natural selection favours beneficial characteristics in a species or converse. Evolution is the change in a species over time (change usually as a consequence of natural selection).
11 The hooves got smaller as the land became drier. In wet marshy conditions larger hooves were an advantage and natural selection favoured them. As the land got drier (marshes became grassland) smaller hooves were selected for as the horses could run faster with smaller hooves.
12 Antibiotics were discovered around 80 years ago. At that point no bacteria were resistant. Several years after their first use some bacteria, such as MRSA, had evolved resistance.
13 In natural selection the environment (nature) determines which characteristics are favoured. In selective breeding man determines which characteristics are favoured.

Practice questions

1 a) Species no longer living *[1 mark]*
b) Any two from: natural catastrophe, e.g. volcano eruption, meteorite; climate change, increased sea temperatures or change to environment; sea dried out; new predator; due to disease or new disease developing; outcompeted; prey died out or food source lost *[2 marks]*
c) Any three from: fish died in the sea and sank to the bottom; covered with layers of sand, volcanic ash, mud or silt from the bottom of rivers and seas; hard parts did not decay or soft parts did decay; the layers above them pushed down, compressing the organisms; minerals entered bones or hard parts; the surrounding water dried, leaving mineral salts, which turned to stone/rock *[3 marks]*
2 Simple *[1 mark]*

17 Classification of living organisms

Overview

Specification points

4.6.4 Classification of living organisms

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 17 pages 227–34

AQA GCSE (9-1) Combined Science Trilogy 2: Chapter 24 pages 67–73

AQA GCSE (9-1) Combined Science Trilogy: Chapter 24 pages 423–429

Recommended number of lessons: 2

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	No
Contains biology-only material	No

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz
- Answers for homework task
- Answers to all questions

Useful prior learning

- The bulk of this chapter will be new material for students.
- Some of the terms from the previous chapter will be reintroduced. These include species, speciation and common ancestor.

Common misconceptions

- The Latin binomial name given to all species is universal. Students often fail to recognise the need for this common approach. If they are shown a picture of something like a buttercup, it can be explained that this plant will be called many different things depending on the country or even an area within a country. Scientists need to know which species is being referred to, hence the common approach adopted across the globe.
- The Latin name should be written in italics. The genus name should have a capital letter and the species a lower-case letter.

Classification: Lesson 1

Learning outcomes

1 Describe how organisms are classified using the system developed by Linnaeus.
2 Define the term species.

Suggested lesson plan

Starter

Open the lesson with **T&L Lesson starter 2**.

Main

Explain the need for a classification system. Introduce Linnaeus who is the father of classification. Use slide 1 from the **T&L Topic overview**. Explain the need for a binomial Latin name. Describe the main classes that Linnaeus devised. Use slide 2 from the **T&L Topic overview**.

Create a simple table for students to fill in. Give them the full classification for a human and a recognisable plant (something like sweetcorn). Students should now research the full classification of any other chosen organisms and include these in the table. They do not need to know the full details of any particular organism but should know the hierarchy from kingdom to species.

Explain the terms 'kingdom', 'genus' and 'species'. Show pictures of some organisms of the same genus to illustrate the fact that they are of different species. Figure 17.2 (*24.2*) on page 228 (*68; 424*) shows five members of the *Panthera* genus.

Use Figure 17.3(*24.3*) from page 229(*69; 425*) to explain that vertebrates in different classes may have had a common ancestor and have features in common. Students could list the ways in which the five classes of vertebrates are similar and different. What features might the common ancestor have had?

Plenary

Give students the full classification of a different organism like the domestic cat. These should be in the wrong order. Ask students to order them correctly according to the conventional hierarchy.

Support

Give students a set of pictures of different organisms and get them to put them into the five main kingdoms. Alternatively, give students **T&L Lesson starter 1**.

Extension
More able students could research an animal that is created by the mating of two different species. What are the problems that this animal will encounter? What species does the offspring belong to?

Homework
Answer Practice questions 1 and 2 on page 233 (*72; 428*).

Classification: Lesson 2

Learning outcomes

1 Describe the impact of new technology on the process of classification.
2 Describe the three-domain system proposed by Woese.
3 Explain the use of evolutionary trees and interpret information within them.

Suggested lesson plan

Starter
Show students Figure 17.3(*24.3*) from page 229 (*69; 425*). Tell them that this was worked out by Linnaeus. Get them to think about the scientific tools Linnaeus may have had access to. What real evidence did he have for his classification system? What modern techniques are available today?

Students should be able to assess how reliable Linnaeus's system actually is.

Main
Explain the work of Carl Woese and how he refined the classification system to create a three-domain system.

Show students Figure 17.7(*24.6*) from page 231 (*70; 426*). Encourage students to compare this three-domain system with the classification system developed by Linnaeus. Students could produce a table to show similarities and differences.

Answer Chapter review questions 14–16 on page 232 of the textbook (Biology only).

Plenary
Students could take the **T&L Quick quiz**.

Support
Work through the **T&L Topic overview** to consolidate the different systems of classification.

Try Practice questions 2 and 4 on page 233 (*72; 428*).

Extension
Work through the Activity on page 231(*70; 426*). Alternatively answer Chapter review questions 19–21 on page 232 of the textbook (Biology only).

Homework
Work through the **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself
1 Kingdom, phylum, class, order, family, genus and species
2 Ligers are infertile offspring from lions and tigers.
3 Before the work of Carl Woese using DNA and RNA, all organisms were classified into five kingdoms. These are animals, plants, algae, bacteria and single-celled organisms. The three domain system only has eukaryota (with all animals, plants, fungi and protists), bacteria and archaea (primitive bacteria).

Show you can
Page 231

They are divided into five groups. (1) Mammals have fur and give birth to live young. (2) Birds are warm blooded and most can fly. (3) Reptiles are cold blooded and lay eggs. (4) Amphibians have moist skin and lay eggs. (5) Fish have gills and lay eggs.

Activity
Page 231

1 Any sensible response, such as long tentacles, colour, shape
2 a) Any sensible response, such as the observations of anatomical features can lead to connections based on superficial links that may be due to convergent evolution, similar body shapes or features for similar roles, and DNA reveals similarities on the genetic level.
b) Because conclusions are based on evidence, scientists must be willing to change their conclusions when new evidence arises.

Chapter review questions
1 Putting species into groups based upon their characteristics or genetics
2 The smallest group of classifying organisms, all of which are able to interbreed to produce fertile offspring
3 Animals, plants, fungi, protists and prokaryotes
4 *Homo sapiens*

5 Family tree
6 Carl Linnaeus
7 Genus and species
8 The largest group of classifying organisms, e.g. the animal kingdom
9 In italics with a capital letter for the genus
10 Kingdom, phylum, class, order, family, genus, species
11 Class; amphibians, fish, birds
12 Genome mapping
13 A species is a group of organisms that can interbreed to produce fertile offspring. A lion can mate with a tiger to produce a liger, but this is infertile. So lions and tigers are different species.
14 He classified organisms into the animal kingdom, the plant kingdom and the mineral kingdom
15 The mineral kingdom
16 He originally classified whales as fish
17 *Homo erectus*, *H. neanderthalensis*
18 Common names like 'daddy longlegs' are not used throughout the world, whereas binomial names are.
19 Carl Woese
20 The three domain system uses DNA and RNA technology to refine classification of organisms
21 Primitive bacteria usually found in extreme environments like hot springs

Practice questions

1 a) i) A group of organisms that can interbreed; to produce fertile offspring
ii) Genus name or first name first letter should be in capitals and should be underlined or in italics
iii) Genus
b) Carl Linnaeus
2 a) Kingdom: Animalia, accept animal. Phylum. Class: Mammalia, do not accept mammal. Family: Ursidae. Genus. Species: maritimus, arctos
b) Give birth to live young, feed their young milk, have hair/fur
3 a) i) (Cellulose) cell wall, chloroplasts, large/permanent vacuole
ii) Any three from: animals, fungi, bacteria or protists
b) i) Bacteria, archaea, eukaryota
ii) Classification systems change over time as scientists develop greater knowledge about living organisms [1] e.g. genome mapping [1]
4 a) *Lutra lutra*
b) B: skunk (*Mephitis mephitis*)
c) A: leopard (*Panthera pardus*)

Working scientifically: Scientific thinking
Page 234

1 a) Common octopus
b) Great barracuda
c) Nile crocodile
d) Indian elephant
e) Tiger
2 a) Common seahorse
b) Red chicken (wild chicken)
c) Grey kangaroo
d) Common fox
e) Bottle-nosed dolphin
3 Task: no answer required

AQA GCSE (9-1) Combined Science Trilogy

Test yourself

1 Kingdom, phylum, class, order, family, genus and species
2 Ligers are infertile offspring from lions and tigers
3 Before the work of Carl Woese using DNA and RNA, all organisms were classified into five kingdoms. These are animals, plants, algae, bacteria and single-celled organisms. The three domain system only has eukaryota (with all animals, plants, fungi and protists), bacteria and archaea (primitive bacteria).

Show you can
Page 70(*426*)

They are divided into five groups. (1) Mammals have fur and give birth to live young. (2) Birds are warm blooded and most can fly. (3) Reptiles are cold blooded and lay eggs. (4) Amphibians have moist skin and lay eggs. (5) Fish have gills and lay eggs.

Activity
Page 70(*426*)

1 Any sensible response, such as long tentacles, colour, shape
2 a) Any sensible response, such as the observations of anatomical features can lead to connections based on superficial links that may be due to convergent evolution, similar body shapes or features for similar roles, and DNA reveals similarities on the genetic level
b) Because conclusions are based on evidence, scientists must be willing to change their conclusions when new evidence arises.

Chapter review questions

1 Putting species into groups based upon their characteristics or genetics

2 The smallest group of classifying organisms, all of which are able to interbreed to produce fertile offspring
3 Animals, plants, fungi, protists and prokaryotes
4 *Homo sapiens*
5 Family tree
6 Carl Linnaeus
7 Genus and species
8 The largest group of classifying organisms, e.g. the animal kingdom
9 In italics with a capital first letter for the genus
10 Kingdom, phylum, class, order, family, genus, species
11 Class; amphibians, fish, birds
12 Genome mapping
13 A species is a group of organisms that can interbreed to produce fertile offspring. A lion can mate with a tiger to produce a liger, but this is infertile. So lions and tigers are different species.
14 *Homo erectus*, *H. neanderthalensis*
15 Common names like 'daddy longlegs' are not used throughout the world, whereas binomial names are.
16 The three domain system uses DNA and RNA technology to refine classification of organisms
17 Primitive bacteria usually found in extreme environments like hot springs

Practice questions

1 a) i) A group of organisms that can interbreed [1 mark]; to produce fertile offspring *[1 mark]*
ii) Genus name or first name first letter should be in capitals and should be underlined or in italics *[1 mark]*
b) Carl Linnaeus *[1 mark]*

2 *[8 marks]*

Level of classification	Polar bear	Brown bear
Kingdom	Animalia	Animalia
Phylum	Chordata	Chordata
Class	Mammalia	Mammalia
Order	Carnivora	Carnivora
Family	Ursidae	Ursidae
Genus	*Ursus*	*Ursus*
Species	*maritimus*	*arctos*

3 a) i) (Cellulose) cell wall, chloroplast, large/permanent vacuole *[2 marks]*
ii) Any three from: animals, fungi, bacteria or protists *[3 marks]*
b) i) Bacteria, archaea, eukaryota *[3 marks]*
ii) Classification systems change over time as scientists develop greater knowledge about living organisms [1 mark] e.g. genome mapping *[1 mark]*
4 a) *Lutra lutra* *[1 mark]*
b) B: skunk (*Mephitis mephitis*) *[1 mark]*
c) A: leopard (*Panthera pardus*) *[1 mark]*

Working scientifically: Scientific thinking
Page 73(*429*)

1 a) Common octopus
b) Great barracuda
c) Nile crocodile
d) Indian elephant
e) Tiger
2 a) Common seahorse
b) Red chicken (wild chicken)
c) Grey kangaroo
d) Common fox
e) Bottle-nosed dolphin
3 Task: no answer is required

Ecology

18 Adaptations, interdependence and competition

Overview

Specification points

4.7.1.1 Communities; 4.7.1.2 Abiotic factors; 4.7.1.3 Biotic factors; 4.7.1.4 Adaptations

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 18 pages 235–49

AQA GCSE (9-1) Combined Science Trilogy 2: Chapter 25 pages 74–87

AQA GCSE (9-1) Combined Science Trilogy: Chapter 25 pages 430–443

Recommended number of lessons: 5

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	No
Contains biology-only material	No

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz
- Answers for homework task
- Answers to all questions

Useful prior learning

- Inheritance, chromosomes, DNA and genes
- Differences between species
- Relationships in an ecosystem
- The interdependence of organisms in an ecosystem including food webs and insect-pollinated crops

Common misconceptions

- The two types of competition can be easily confused. Inter- and intra- are not familiar terms and their differentiation can be reinforced by carrying out the exercise suggested in the Support section.
- Students often confuse abiotic and biotic factors. There are fewer biotic ones to consider. Stress that the abiotic ones are physical factors in the environment.
- The predator–prey graphs have two vertical axes, one for the number of predators and the other for the prey numbers. Each axis has a different scale and students frequently read the wrong one. They need to think which animal is smaller (prey) and will therefore be in greater numbers.

Preparation

- **T&L Prior knowledge catch-up teacher sheet**
- **T&L Prior knowledge catch-up student sheet**

Ecology: Lesson 1

Learning outcomes

1 Describe how ecosystems are organised into different levels.
2 Define the term interdependence.
3 Explain how plants and animals compete for resources.

Suggested lesson plan

Starter

Work through the Test yourself on prior knowledge questions on page 236(*75; 431*).

Main

Remind students what the definition of a species is. Explain that ecosystems are divided up in terms of the organisms that live there. Introduce the key terms 'population' and 'community'.

Students should be able to write down their own examples of populations and communities. Suggest that they select both plant and animal examples.

Show students a picture of an ecosystem with a wide range of different organisms. A freshwater pond is a good example. Encourage students to work in groups and suggest how all the life in a pond is sustained. Lead them up to the idea of interdependence and competition. Describe the two different types of competition.

Create diagrams or pictures of a wide range of different ecosystems. Get students working in small groups. Give each group a different ecosystem. Ask

the students to look at how the organisms interact with each other. What factors are the organisms competing for?

Plenary
Students could complete the **T&L Quick quiz 1**.

Support
Show students pictures of pairs of organisms competing. Some should be the same species and some pairs should be of different species. Get students to sort these into interspecific and intraspecific competition.

Extension
Chapter review questions 1–5 on page 246 (*questions 1–4 on page 84(440)*).

Homework
Work through Practice question 3 on page 247 (*85; 441*).

Abiotic factors: Lesson 2

Learning outcomes

1 Define the term abiotic factor using examples.
2 Explain how changes in abiotic factors affect populations.
3 Interpret information from charts, graphs and tables showing interactions within a community.

Suggested lesson plan

Starter
Give groups of students different pictures of ecosystems. These could include a desert with cacti, small rodents, palm trees; a freshwater pond; a rocky shore; Arctic tundra. Students should list as many non-living factors as they can see in their picture.

Main
Ask for feedback from all the groups. This should generate a significant list of factors. Introduce the term 'abiotic'.

Working in groups, get students to discuss how each different abiotic factor will affect the organisms in their pictured ecosystem. For example, light levels will affect the growth of green plants and soil pH will restrict the growth of certain plants.

Use the **T&L Key concept: Populations** to consolidate abiotic factors.

Now get the students to think about how the organisms in their pictured ecosystem are adapted. What would happen if you put an organism in an alternative ecosystem?

Plenary
Practice question 1 on page 247(*85; 441*) or Chapter review questions 10–14 on page 246 (*questions 9–12 from page 84(440)*).

Support
Create a worksheet showing four different ecosystems. Get students to write down as many non-living parts of the ecosystem as they can see. Give them a list of key words to guide them.

Extension
Source some charts, graphs or tables showing interactions within a community and ask higher level students to describe what they show.

Homework
Test yourself questions on page 240(*79; 435*).

Biotic factors: Lesson 3

Learning outcomes

1 Define the term biotic factor using examples.
2 Explain how changes in biotic factors affect populations.
3 Interpret information from charts, graphs and tables showing interactions within a community.

Suggested lesson plan

Starter
Ask students to suggest what other factors may be influencing organisms in an ecosystem. They should be able to come up with a list of biotic factors.

Alternatively, use the **T&L Key concept: Populations** to consolidate abiotic factors.

Main
Explain the term 'biotic' and discuss the three main biotic factors which will affect organisms in ecosystems. These include predators, disease and other competing species.

Students should research each factor. They should source an example of each and explain the effect of this factor on the other organisms in the ecosystem.

Draw a large clear graph showing the relationship between a predator and its prey. This should be a very simple graph with two axes and two plots. Explain what is being shown as the graph is drawn. State that the predator is a large carnivore and the prey is a smaller herbivore. Ask students to describe what is happening. Ask why there are two different axes.

Now show Figure 18.6(*25.6*) from page 238(*77; 433*). This figure uses actual data and shows the relationship between the snowshoe hare and the lynx.

Plenary
Find a YouTube clip or photographs of the snowshoe hare and the lynx. Alternatively work through Practice question 5 on page 247 of the textbook (Biology only).

Support
Create a quick quiz where students have to state whether a particular factor is biotic or abiotic.

Extension
Work through Test yourself questions 12–15 on page 242(*80; 436*).

Homework
Find a question on predator–prey graphs to test the students' ability to interpret such a graph. Alternatively, give students a copy of Figure 18.6 and create a set of questions. For example, in what year was the lynx population almost wiped out? What factors may have caused this?

Adaptations: Lesson 4

Learning outcomes

1 Explain how organisms are adapted to live in their natural environment.
2 Define these adaptations as structural, behavioural or functional.

Suggested lesson plan

Starter
Students could look at the **T&L Lesson starter 1**.

Main
Explain that organisms are adapted to their environments and that the adaptations are structural, behavioural and physiological. Organisms that are not highly adapted will not be able to compete and will not survive.

Get students to research one specific organism in small groups. They should research the structural, behavioural and physiological adaptations. Give a wide range of organisms so that there is variety in the class. More obscure ones could include a bracket fungus, an aardvark, a saltwater fish and an insectivorous plant.

Students can feed back to the class.

Plenary
Suggest what structural adaptations have evolved in a shark.

Support
Create a table for students to complete. There should be four headings: 'Name of Organism' in the first column and 'Adaptations' covering the next three. The last three columns should be sub-headed 'Structural', 'Behavioural' and 'Functional', respectively. Give students pictures of a range of organisms and get them to fill in the visible adaptations in the correct column.

Extension
Work through Practice question 4 on page 247 (*85; 441*) of the textbook.

Homework
Create a poster showing an organism that has become extinct because it was not correctly adapted to its environment. Highlight the features that had developed and that gave it its disadvantages.

Extreme environments: Lesson 5

Learning outcomes

1 Explain how organisms are adapted to live in extreme environments.
2 Define these adaptations as structural, behavioural or functional.

Suggested lesson plan

Starter
Students should write a list of extreme environments and suggest what conditions would be present in each.

Main
Discuss with the class what an extreme environment is. What are the features? What are the problems associated with these environments? Introduce the term 'extremophile'.

Find a film clip of extremophiles such as those which inhabit deep sea hydrothermal vents. The film should contain enough information for students to be able to answer questions on it.

Create a worksheet with questions on hydrothermal vents. These could include: What are hydrothermal vents? Where are they located? What are the conditions in these vents? What are the conditions surrounding these vents? Why has the discovery of these hydrothermal vents changed our way of thinking about food chains and food webs?

Plenary
Students could complete the **T&L Quick quiz 2**.

Support
Create a mix-and-match exercise with pictures of extremophiles in one column and a set of environmental conditions in the second column. Students could match the organism to the conditions in which they live.

Extension
Able students could work through the 'Killer question' on the **T&L Homework sheet** for this chapter.

Homework
Work through the **T&L Homework task**.

Answers

AQA GCSE Biology (9-1)

Test yourself on prior knowledge

1 Variation (interspecific)
2 They have large feet to stop them sinking into the sand. They have thick fur on the top of their body for shade and thin fur everywhere else to allow heat loss.
3 Photosynthetic organisms (producers) are the only ones that can convert the Sun's energy into glucose.

Test yourself

1 Struggle for existence
2 Interspecific competition is between different species, whereas intraspecific competition is within a species.
3 Territory, food, mates
4 Decrease
5 Predator–prey cycling
6 Idea that all species that live in a community depend on each other
7 A greater number of species and more interdependence between them
8 The non-living parts of the environment
9 Lime
10 It grows in both acidic soil, with blue flowers, and alkaline soils, with pink flowers.
11 There is not enough light for them to complete enough photosynthesis.
12 To do with living organisms
13 The introduction of a new predator
14 They are being outcompeted by the larger and more reproductively active grey squirrels.
15 The cane toad does not have any natural predators like the caiman in Australia. It is poisonous when eaten. Other predators in Australia are not immune to the poison. The cane toad outcompetes other similar organisms.
16 One in which most organisms would be challenged to live
17 A yellow-and-black pattern mimics that of bees and wasps to stop it being eaten
18 The penguins huddle together in winter to keep warm

Show you can
Page 238

They would compete for light and water. More light and more water would mean more photosynthesis and so more formation of glucose for growth. They would compete to absorb minerals from the soil. They would compete for space to grow.

Page 239

An increase in predators means fewer prey. After a while this reduced number of prey cannot support the predators, so some predators die. After a while the numbers of prey increase because of the reduced numbers of predators. The number of predators then increases.

Page 240

Light, water and pH are all abiotic factors. More light means more photosynthesis, which is often a good thing. Too much light will kill a plant. Too little water or too much water will kill plants. Water is required for photosynthesis. The correct soil pH also helps plants grow most effectively.

Page 242

Biotic factors are those that relate to living organisms. So if more zebras moved closer to the original group they would compete for mates. If other herbivores moved closer, they would compete for food. If predators such as a pride of lions moved closer, the zebras would be threatened. All other animals are likely to compete for water.

Page 245

They are the only places in the world where life has originated that is not dependent upon light. In all other places, light drives photosynthesis at the bottom of all other food chains. Here bacteria feed directly on the chemicals from the vents.

Practical
Page 237

1 Light, minerals, space, water
2 So there is less competition for light as the trees do not have leaves
3 If bluebells flower too early, some might be killed by poor weather. Also, if it is too cold, pollinators would not be active.

Activity
Page 240

Task: no answer is required

Page 243

Task: no answer is required

Chapter review questions

1 The total number of all the organism of the same species or the same group of species that live in a particular geographical area
2 A group of two or more populations of different species that live at the same time in the same geographical area
3 Its flowers actually change colour depending upon the type of soil it grows in. If it grows in acidic soil it has pink flowers. If it grows in alkaline soil its flowers are blue.
4 The contest for resources between organisms within a community
5 The dominant male in a group of animals
6 The way in which an organism is suited to live where it does
7 Other primates, elephants, bears, some birds, alligators, crocodiles, some fish, octopuses, some insects
8 An organism that survives in an environment in which it is challenging for most organisms to live
9 The North and South Poles, deserts, volcanoes, deep seabed
10 The non-living parts of the environment; can be chemical or physical, but not biological
11 Sunlight, water, pH, mineral content of soil
12 By adding peat
13 By adding lime
14 It helps plants to absorb major nutrients, including phosphorus, potassium and nitrogen, which they need to make protein.
15 It stops moss growing, because moss prefers more acidic soil
16 A living part of the environment
17 Any two from: food, new predators, diseases, new species
18 Biodiversity or number of species
19 Light, water, space, nutrients
20 Food, mates, territory
21 Idea that all the organisms in a community depend upon each other; because of this, changes to them or their environment can cause unforeseen damage
22 They are disadvantaged against other members of their own species (intraspecific competition) and other species (interspecific competition). They are likely to die without reproducing.
23 Structural, behavioural, physiological
24 Streamlined body to swim faster, sense of smell to detect prey, sharp teeth to kill prey
25 A structural adaptation evolved by one organism that is similar to that of another organism
26 They have evolved a similar black-and-yellow banding to that of wasps.
27 Males have elegant tail feathers, which they display to attract a mate.
28 It produces poison, which can kill the victim if the rattlesnake bites
29 The male birds looking after the ova on their feet huddle into a tight circle to keep warm during the cold winter months.
30 They have a small head and ears to reduce heat loss. They have a thick layer of fat (up to 11 cm) under their thick fur to keep warm.
31 High temperatures, high pressures, high concentrations of dissolved minerals
32 Light is not living. The amount of light determines how successful plants are at growing in an ecosystem.
33 Put a small length of pondweed into a boiling tube of water and position a short distance from a lamp. After 2 minutes, record the number of bubbles of oxygen produced. Move the tube progressively further away from the lamp and repeat. (More bubbles of oxygen means more photosynthesis.)
34 *Hydrangea*
35 Manure adds key nutrients such as nitrogen for plants. But it can turn soil acidic, so farmers might then have to add lime to reduce this.
36 Hair grass, pearlwort
37 As the numbers of prey increase, so do the numbers of predators after a short lag phase. As the numbers of predators increase, the numbers of prey decrease, as they are being eaten. Eventually, the reduced number of prey means that the numbers of predators fall because there is not enough food.
38 They are the only place on Earth where life does not depend upon photosynthetic organisms such as plants or algae but on bacteria that obtain their energy from the chemicals released by the vent.

Practice questions

1 A: light, C: mineral nutrients
2 a) i) Accept any appropriate abiotic factor: temperature of water, oxygen availability, river current speed, soil type on river bank, water chemistry
ii) Any two from: food availability, predation, competition, disease, parasites, mates, territorial behaviour
b) i) Describes an organism that is not native and causes negative effects on an ecosystem
ii) Any two from: idea that the American signal crayfish is larger and more

aggressive so likely to outcompete the white-clawed crayfish for food; larger so outcompete for the best nesting sites or shelter; larger so likely to predate on the white-clawed crayfish; could carry diseases, which can be passed on to white-clawed crayfish; could carry a parasite that could infect the white-clawed crayfish

3 a) i) The total number of all the organisms of the same species or the same group of species that live in a particular geographical area
ii) Any two from: competition for food, space, loss of habitat, disease
b) i) Idea of winning the competition for resources
ii) Any two from: grey squirrels larger/heavier, more of them, have a greater range of food sources, larger numbers of young
iii) Interspecific competition
c) 2 500 000 + 160 000 = 2 660 000
(160 000/2 660 000) × 100 = 6%
d) Any suitable adaptation, e.g. tail for balancing on branches, clawed feet to hold onto bark, strong leg muscles/large back legs to jump from branch to branch

4 a) i) Any one from: have horns, to defend themselves, long legs so can run far and fast, adults are large so avoided
ii) Idea that live in herd, so more individuals to watch out for predators/strength in numbers
b) Idea that can run away from predators/not left behind by the herd

5 1 mark for continued line showing up and down fluctuations in population size for the hare; 1 mark for similar fluctuations for the lynx but a smaller population; 1 mark for the lynx population cycle lagging behind the peaks and troughs for hares

Working scientifically: Experimental skills
Pages 248–9

Answer is based on the student's own data.

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge

1 Variation (interspecific)
2 Photosynthetic organisms (producers) are the only ones that can convert the Sun's energy into glucose.

Test yourself

1 Struggle for existence
2 Interspecific competition is between different species, whereas intraspecific competition is within a species.
3 Territory, food, mates
4 The numbers of prey would decrease
5 Predator–prey cycling
6 Idea that all the species that live in a community depend on each other
7 A greater number of species and more interdependence between them
8 The non-living parts of the environment
9 Lime
10 It grows in both acidic soil, with blue flowers, and alkaline soils, with pink flowers.
11 There is not enough light for them to complete enough photosynthesis
12 To do with living organisms
13 The introduction of a new predator
14 They are being outcompeted by the larger and more reproductively active grey squirrels.
15 The cane toad does not have any natural predators like the caiman in Australia. It is poisonous when eaten. Other predators in Australia are not immune to the poison. The cane toad outcompetes other similar organisms.
16 One in which most organisms would be challenged to live
17 A yellow-and-black pattern mimics that of bees and wasps to stop it being eaten
18 The penguins huddle together in winter to keep warm.

Show you can
Page 77(433)

They would compete for light and water. More light and more water would mean more photosynthesis and so more formation of glucose for growth. They would compete to absorb minerals from the soil. They would compete for space to grow.

An increase in predators means fewer prey. After a while this reduced number of prey cannot support the predators, so some predators die. After a while the numbers of prey increase because of the reduced numbers of predators. The number of predators then increases.

Page 79(435)

Light, water and pH are all abiotic factors. More light means more photosynthesis, which is often a good thing. Too much light will kill a plant. Too little water or too much water will kill plants. Water is required for photosynthesis. The correct soil pH also helps plants grow most effectively.

Page 80(436)

Biotic factors are those that relate to living organisms. So if more zebras moved closer to the original group they would compete for mates. If other herbivores moved closer, they would compete for food. If predators such as a pride of lions moved closer, the zebras would be threatened. All other animals are likely to compete for water.

Page 83(439)

They are the only places in the world where life has originated that is not dependent upon light. In all other places, light drives photosynthesis at the bottom of all other food chains. Here bacteria feed directly on the chemicals from the vents.

Practical

Page 76(432)

1 Light, minerals, space, water
2 So there is less competition for light as the trees do not have leaves
3 If bluebells flower too early, some might be killed by poor weather. Also, if it is too cold, pollinators would not be active.

Activity

Page 79(435)

Task: no answer is required

Page 82(438)

Task: no answer is required

Chapter review questions

1 The total number of all the organisms of the same species or the same group of species that live in a particular geographical area
2 A group of two or more populations of different species that live at the same time in the same geographical area
3 Its flowers actually change colour depending upon the type of soil it grows in. If it grows in acidic soil it has pink flowers. If it grows in alkaline soil its flowers are blue.
4 The contest for resources between organisms within a community
5 The way in which an organism is suited to live where it does
6 An organism that survives in an environment in which it is challenging for most organisms to live
7 The North and South Poles, deserts, volcanoes, deep seabed
8 They can store large amounts of water in their stems and their leaves are reduced to spines with very small surface areas to reduce water loss. The spines also prevent animals from eating the succulent stems.
9 Living organisms and the environment (the biotic and abiotic parts of the environment)
10 The non-living parts of the environment; can be chemical or physical, but not biological
11 Sunlight, water, pH, mineral content of soil
12 A living part of the environment
13 Any two from: food, new predators, diseases, new species
14 Biodiversity or number of species
15 Light, water, space, nutrients
16 Food, mates, territory
17 Idea that all the organisms in a community depend upon each other; because of this, changes to them or their environment can cause unforeseen damage
18 They are disadvantaged against other members of their own species (intraspecific competition) and other species (interspecific competition). They are likely to die without reproducing.
19 Structural, behavioural, physiological
20 Streamlined body to swim faster, sense of smell to detect prey, sharp teeth to kill prey
21 They can produce venom
22 The male birds looking after the ova on their feet huddle into a tight circle to keep warm during the cold winter months.
23 They have a small head and ears to reduce heat loss. They have a thick layer of fat (up to 11 cm) under their thick fur to keep warm.
24 High temperatures, high pressures, high concentrations of dissolved minerals
25 Light is not living. The amount of light determines how successful plants are at growing in an ecosystem.
26 Put a small length of pondweed into a boiling tube of water and position a short distance from a lamp. After 2 minutes, record the number of bubbles of oxygen produced. Move the tube progressively further away from the lamp and repeat. (More bubbles of oxygen means more photosynthesis.)
27 *Hydrangea*
28 Hair grass, pearlwort
29 As the numbers of prey increase, so do the numbers of predators after a short lag phase. As the numbers of predators increase, the numbers of prey decrease, as they are being eaten. Eventually, the reduced number of prey means that the numbers of predators fall because there is not enough food.

Practice questions

1 A: light, C: mineral nutrients *[2 marks]*

2 a) i) Accept any appropriate abiotic factor: temperature of water, oxygen availability, river current speed, soil type on river bank, water chemistry *[1 mark]*

ii) Any two from: food availability, predation, competition, disease, parasites, mates, territorial behaviour *[2 marks]*

b) i) Describes an organism that is not native and causes negative effects on an ecosystem *[1 mark]*

ii) Any two from: idea that the American signal crayfish is larger and more aggressive so likely to outcompete the white-clawed crayfish for food; larger so outcompete for the best nesting sites or shelter; larger so likely to predate on the white-clawed crayfish; could carry diseases, which can be passed on to white-clawed crayfish; could carry a parasite that could infect the white-clawed crayfish *[2 marks]*

3 a) i) The total number of all the organism of the same species or the same group of species that live in a particular geographical area *[1 mark]*

ii) Any two from: competition for food, space, loss of habitat, disease *[2 marks]*

b) i) Idea of winning the competition for resources *[1 mark]*

ii) Any two from: grey squirrels larger/heavier, more of them, have a greater range of food sources, larger numbers of young *[2 marks]*

iii) Interspecific competition *[1 mark]*

c) 2 500 000 + 160 000 = 2 660 000
(160 000/2 660 000) × 100 = 6%
[2 marks]

d) Any suitable adaptation, e.g. tail for balancing on branches, clawed feet to hold onto bark, strong leg muscles/large back legs to jump from branch to branch *[1 mark]*

4 a) i) Any one from: have horns, to defend themselves, long legs so can run far and fast, adults are large so avoided *[1 mark]*

ii) Idea that live in herd, so more individuals to watch out for predators/strength in numbers *[2 marks]*

b) Idea that can run away from predators/not left behind by the herd *[2 marks]*

Working scientifically: Experimental skills
Pages 86–7(442–3)

Answer is based on the student's own data.

19 Organisation of an ecosystem

Overview

Specification points

4.7.2.1 Levels of organisation; 4.7.2.2 How materials are cycled; 4.7.2.3 Decomposition; 4.7.2.4 Impact of environmental change

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 19 pages 250–68

AQA GCSE (9-1) Combined Science Trilogy 2: Chapter 26 pages 88–101

AQA GCSE (9-1) Combined Science Trilogy: Chapter 26 pages 444–457

Recommended number of lessons: 12

Chapter overview	
AQA required practicals	Biology – RP9, RP10 CS Trilogy – RP7
Contains higher-tier only material	Yes
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Practical 1
- Practical 2
- Teacher and technician notes 1
- Teacher and technician notes 2
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Key concept: Decay
- Key concept: Sampling
- Key concept: Calculating surface area
- Key concept: Using ratios
- Key concept: Populations
- Video 1: Estimate the population size of daisy plants on a lawn using a quadrat
- Video 2: Investigate the effect of surface area on the rate of leaf decay
- Video 3: Rate of decay

Useful prior learning

- Relationships in an ecosystem including food webs and insect-pollinated crops
- Photosynthesis and the dependence of almost all life on Earth on the ability of photosynthetic organisms like plants and algae to use sunlight to build organic molecules that are an essential energy store and to maintain levels of oxygen and carbon dioxide in the atmosphere
- Earth and atmosphere from KS3 Chemistry
- The carbon cycle

Common misconceptions

- Students often confuse respiration and photosynthesis. They also incorrectly assume that plants carry out photosynthesis only during the day when light is available and respiration only when it is dark. They need to understand that plants respire all the time but only photosynthesise when light is available.
- It is a common mistake for students to state that respiration generates energy. The energy of the Universe is constant and cannot be created or destroyed. It is important to stress that energy can be converted from one form to another and that energy can be *released* from chemicals during respiration.
- The arrows in food chains should show the direction of the flow of energy. Students often put arrows going the wrong way.
- When drawing tables and graphs, students often put data in the wrong place. Stress that the independent variable (the one that has been selected and is changed by the experimenter) goes in the first column of a table and forms the *x*-axis (horizontal) of a graph. The final column of the table should be the dependent variable or a calculation using the dependent variable (for example the mean of several repeats). The values in this column are always on the *y*-axis (vertical axis) of the graph.

Preparation

- **T&L Prior knowledge catch-up teacher sheet**
- **T&L Prior knowledge catch-up student sheet**

Production of biomass: Lesson 1

Learning outcomes

1 Explain why biomass in almost all food chains begins with photosynthesis.
2 Describe ecological techniques used to sample ecosystems.

Suggested lesson plan

Starter

Create a set of food chains from different ecosystems. These should be of different lengths.

For example, one could be: lettuce, slug, thrush. A second could be: plankton, krill, herring, shark. Muddle up each food chain and get students to order them correctly. This will remind them of the work they did at KS3 where they learnt that food chains start with producers.

Main
Introduce the term 'biomass'. Explain that the biomass in an ecosystem can be sampled using different techniques.

Use the **T&L Key concept: Sampling** to introduce students to the idea of sampling techniques.

Introduce the idea of sampling an area. Students should come up with their ideas on why it is impossible to count the number of plants or the number of invertebrates in a large area such as a field. They should also be able to suggest how many quadrats would give sufficient data for confident conclusions to be drawn.

Describe how to divide up an area to be studied. Use Figure 19.2(*26.3*) from page 252(*90; 446*). This shows how to place a quadrat at the intersection of two points which have been designed by a random number generator.

Show students a quadrat and explain how to estimate the number of organisms inside that quadrat. Use Figure 19.4(*26.5*) from page 254(*92; 448*) to show how to decide which species to include in the count.

Explain the use of a transect line in conjunction with a quadrat for a more systematic approach to sampling.

Plenary
Students could work through the **T&L Quick quiz 1**.

Support
Give students a diagram of a rectangular field. Supply them with a series of random co-ordinates. Get the students to plot the points on the diagram where the quadrats would be placed. Create a series of quadrat diagrams showing the position of different species; call these A, B and C. The students should then try to assess the percentage cover of each species in each quadrat.

Extension
Read through the Working scientifically section on experimental skills on pages 267–8(*100–1; 456–7*) of the textbook and answer all the questions.

Homework
Work through Practice questions 2 and 5 on page 266 (*question 2 on page 99(455)*).

Feeding relationships: Lesson 2

Learning outcomes

1 Define the terms producers and consumers.
2 Explain how energy is passed along food chains.
3 Describe the process of predator–prey cycling.
4 Interpret graphs used to model these cycles.

Suggested lesson plan

Starter
Use the **T&L Lesson starter 2** for this chapter.

Main
Remind students that the majority of food chains start with producers which can carry out photosynthesis. Ask them to recall any food chains that may not start in this way to remind them about the hydrothermal vents and extremophiles.

Introduce the term 'consumer'. Encourage students to think about the different types of consumer and give them the correct terminology for these (herbivore and carnivore). Ask students for examples of each type of consumer and introduce the terms 'omnivore', 'predator' and 'decomposer'. They should be able to give examples of each group.

Remind students of the term 'biomass' and explain how this represents the available material that can be passed on as food to the next level in a food chain. Use Figure 19.6(*26.7*) from page 257(*94; 450*) to explain what happens to the energy *released* from the food the cow eats.

Plenary
Create some calculations associated with Figure 19.6 for students to try. For example: what percentage of the total energy taken in by the cow is lost in urine and faeces?

Support
Give students lists or pictures of different organisms and ask them to sort the lists into producer, herbivore, carnivore or decomposer.

Extension
Describe the flow of energy in a food chain. Why do food chains only have a maximum of about six organisms?

Homework
Students could complete Chapter review questions 12–17 on page 265 (*questions 6–10 on page 98 (454)*).

Required practical 9*(7)*: Measure the population size of a common species in a habitat. Use sampling techniques to investigate the effect of a factor on the distribution of this species: Lesson 3

Learning outcomes

1 Use sampling techniques to investigate the population size of daisies in well-trampled and untrampled parts of a school.
2 Measure the population size of a common species in a habitat. Use sampling techniques to investigate the effect of a factor on the distribution of this species.
3 Describe the method used in this practical.

Preparation

- Familiarise yourself with the practical and the requirements using the **T&L Teacher and technician notes 1**.
- Show students what a daisy plant looks like. Demonstrate how to count the whole plant not just the number of flowers.
- Point out possible hazards. Ensure that students wash their hands thoroughly if they get soil on them.

Suggested lesson plan

Starter

Watch the **T&L Video 1: Estimate the population size of daisy plants on a lawn using a quadrat**.

Main

Tell the students the title of the practical and ask them to think about how they will tackle it before being given the instruction sheet.

Provide students with the equipment, the method sheet and a table for results. Let students carry out the practical.

Plenary

Discuss the sampling technique. Was it systematic or random? What problems did students encounter when carrying out their measurements?

Support

Show students how to calculate a mean and the area covered by the site.

Extension

Students should be encouraged to devise their own tables to put in results before they start.

Homework

Answer questions 4 and 5 on page 254(*92; 448*) using the collected data.

Required practical 9*(7)* write-up: Lesson 4

Learning outcomes

Write up the experiment, analyse the results, draw conclusions and evaluate the experimental method.

Suggested lesson plan

Starter

Collate the results for all students in the class.

Main

Write up the experiment, analyse the results, draw conclusions and evaluate the experimental method.

Plenary

Answer question 7 on page 255(*93; 449*).

Support

Provide a set of secondary data for students who have failed to obtain any valid results.

Extension

Answer questions 1, 2 and 3 on the Student practical sheet.

Homework

Answer all questions on the Student practical sheet.

Required practical 9*(7)* write-up: Lesson 5

Learning outcomes

1 Use sampling techniques to determine the effect of a factor on the distribution of this species.
2 Describe the method used in this practical.

Suggested lesson plan

Starter

Discuss abiotic factors that could be encountered from the previous investigation. How could each be measured?

Main

Select an abiotic factor. Carry out Part 2: method of the Required practical on page 255(*93; 449*). Encourage students to predict what results they are likely to see.

Students should be encouraged to design a simple table for recording their results.

Plenary

Did the predicted results match the actual results obtained?

Support
Give students a ready-made table to fill in.

Extension
Predict how other abiotic factors could have affected the results obtained.

Required practical 9*(7)* write-up: Lesson 6

Learning outcomes

Write up the experiment, analyse the results, draw conclusions and evaluate the experimental method.

Suggested lesson plan

Starter
Briefly discuss how the chosen abiotic factor has affected the results.

Main
Write up the experiment, analyse the results, draw conclusions and evaluate the experimental method.

Plenary
Discuss the students' conclusions and evaluation of the experiment.

Support
Provide a set of secondary data for students who have failed to obtain any valid results.

Extension
Draw a graph of the results from page 255(*93; 449*) showing how light intensity affects the abundance of grass. Explain the link between light intensity and abundance.

Homework
Students could answer questions 1, 2 and 3 on page 255(*93; 449*).

The carbon cycle: Lesson 7

Learning outcomes

Describe the processes of the carbon cycle.

Suggested lesson plan

Starter
Open the topic using the **T&L Lesson starter 1**.

Main
Use **Figure 19.8 from the T&L Diagram bank**. Edit the diagram so the following key terms have been removed: photosynthesis, respiration, decomposition and combustion.

Discuss the cycling of carbon. Students should be familiar with many of the processes from previous chapters and their study of chemistry.

Put the key terms only on the board and get students in groups to create large posters showing the carbon cycle. These can be illustrated with pictures of plants, animals, fungi, factories etc. The key terms should be inserted onto the posters in the correct places.

Students should include summaries of the processes of photosynthesis, respiration and combustion as word equations in their posters.

Plenary
Provide students with sticky notes and get them to work in pairs. One student will write a key word from the carbon cycle on the note and stick it on their partner's forehead. The partner needs to ask Yes or No questions and work out what the word is. Partners then swap positions.

Support
Give students a carbon cycle diagram that is partially complete and a set of labels to insert in the correct positions.

To reinforce the key terms, create a mix-and-match exercise so students can pair key words with their correct definition.

Extension
Describe the journey of a carbon atom from a molecule of carbon dioxide in the atmosphere through a plant, an animal, a decomposer and back into the air. Name all the compounds that the carbon atom forms with the relevant elements. Include the names of the key processes.

Homework
Work through Practice question 1 on page 266 (*99; 455*).

The water cycle: Lesson 8

Learning outcomes

Describe the processes of the water cycle.

Suggested lesson plan

Starter
Water is one of the most important compounds on the planet. Students should think about all the ways in which water is vital to living organisms.

Main
Write a list of all the forms that water takes in different environments.

Use an edited version of Figure 19.10(*26.11*) from page 260(*97; 453*) in which some of the labels have been removed. Explain the different changes of state that are shown. Students should be familiar with these terms and be able to supply answers for processes like evaporation, condensation and precipitation.

Give students individual diagrams to complete. This can be done in pairs. Get students to write clear definitions of each of the processes. Test the clarity of the written definitions by getting students to pick one statement at random and read this out. The class should be able to state which key term has been described from a well-written statement.

Plenary
Students could work on **T&L Quick quiz 2**.

Support
Create a crossword of key terms and definitions as clues for students to complete. Alternatively, create or source a word search on the water cycle.

Extension
Students could complete Chapter review questions 29–31 on page 265 of the textbook (Biology only).

Homework
Test yourself questions 11–14 on page 260 (*questions 10–11 on page 97(453)*).

Decomposition: Lesson 9 (Biology only)

Learning outcomes

1 Explain how temperature, water and availability of oxygen affect the rate of decay.
2 Draw graphs of and calculate rate changes of decay.
3 Describe how gardeners provide optimum conditions for this process.

Suggested lesson plan

Starter
Show students pictures of Tollund Man (Figure 16.13 (*23.3*) from page 219(*59; 415*)), an Egyptian mummy that has been removed from its bandages and a human skeleton. Explain that they are all thousands of years old. Ask students to look for similarities and differences between them.

Main
Ask students to try to explain why the earth is not full of dead bodies. What happens to them? Students should be able to make sensible suggestions about tissues being broken down. From previous work they should suggest that decomposers are organisms that live in the soil. Remind them that enzymes will be produced by the microorganisms and it is these that will be digesting the dead organisms.

Show the **T&L Key concept: Decay**.

Students could research the different types of decomposers that are found in a compost heap. For each one, they should explain how environmental factors can speed up the rate of decomposition.

Plenary
Show a YouTube time-lapse film clip on decomposition. This could be a bowl of fruit decaying to a pulp or an animal carcass finishing up as a skeleton.

Support
Create a quick quiz where students pick out the decomposers from a list of organisms.

Extension
Explain why bodies such as Tollund Man are preserved in peat bogs.

Homework
Work through Practice question 3 on page 266 of the textbook.

Required practical 10: Investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change: Lesson 10 (Biology only)

Learning outcomes

1 Determine the effect of temperature on the rate of decay of fresh milk.
2 Describe the method used in this practical.

Preparation
Familiarise yourself with the practical and the requirements using the **T&L Teacher and technician notes 2**.

Suggested lesson plan

Starter
Show students the **T&L Video 3: Rate of decay**.

Remind students of the safety precautions that should be taken. All students should wear goggles.

Main
Students should complete the Required practical by following the method from the worksheet **T&L Practical 2**.

Plenary
Discuss the results obtained.

Support
Give students a complete table outline so they can fill in the results they collect.

Extension
Students should be given the opportunity to design their own table for the results.

Homework
Read through the Required practical on pages 261–2 of the textbook. This is a version of the practical that students have done in class. In preparation, students should work through questions 1–5 on page 262.

Required practical 10 write-up: Lesson 11 (Biology only)

Learning outcomes

Write up the experiment, analyse the results, draw conclusions and evaluate the experimental method.

Suggested lesson plan

Starter
Discuss the results and give out secondary data if required.

Main
Write up the experiment. Draw a graph of results. Answer the questions.

Plenary
Discuss the evaluation of the experiment. How can the experiment be improved so that the results become more reliable?

Support
Provide students with notes on how to draw a graph or give an example of a similar graph to show how the data should be presented. Tell students which variables go on the *x*- or the *y*-axis.

Extension
Explain why temperature speeds up the rate of decay.

Homework
Complete the write up.

Environmental change: Lesson 12 (Biology only)

Learning outcomes

Evaluate the impact of environmental changes on the distribution of species in an ecosystem (HT).

Suggested lesson plan

Starter
Show the class the **T&L Animation: Human impact on the environment**.

Main
Discuss the environmental factors that affect the distribution of organisms on the planet. Working in groups, students should research either the effects of global warming and the greenhouse effect or air and water pollution.

Students can report back their findings and write summary notes on the effects of each of these environmental factors.

Introduce the term 'bioindicators'. Show students Figure 19.15 from page 263. Choose the Chironomid midge larva and the Rat-tailed maggot. By looking at the descriptions of these invertebrates, students should explain how these organisms are adapted to living in polluted water with low oxygen levels.

Plenary
Describe how lichens are a bioindicator for pollution.

Support
Imagine swapping a polar bear and camel. Put the polar bear in the desert and the camel in the arctic. Make a list of reasons why they would not survive. Describe what you think may happen to each if global warming increased the temperature of the planet.

Extension
Describe how lichens would look if you completed an ecological investigation into their growth in areas with polluted air and areas with clean air.

Homework
Work through the **T&L Homework task**. Differentiate the questions for the weaker students.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 Idea that all the organisms in an ecosystem require each other
2 Respiration converts carbon in glucose to carbon in carbon dioxide, and releases it into the atmosphere.
3 Deciduous trees have leaves that absorb more carbon dioxide.

Test yourself

1 Quadrat
2 Transect
3 To save time and money by looking at a part of habitat to draw conclusions about all of it
4 By using random numbers as grid coordinates
5 Fungi, bacteria
6 Seaweed, plankton
7 Respiration, photosynthesis, combustion
8 0.04%
9 Carbon, in the form of a fuel like natural gas, is converted into carbon dioxide.
10 Carbon, in the form of glucose, is converted into carbon dioxide.
11 Precipitation, runoff, infiltration, evaporation
12 More than 85%
13 Water moves from the surface into aquifers to become groundwater.
14 Precipitation is often rain, but it can also be snow, hail and sleet.
15 Warmth, oxygen, moisture
16 Fungi, bacteria
17 The breakdown of once living organisms into much smaller substances
18 To add nutrients such as nitrogen which is used to make proteins
19 Lichens
20 By concentrating their urine
21 They will migrate from hotter regions near the equator towards the cooler areas at the poles.
22 They are born in freshwater rivers, migrate to the sea to live and return to freshwater to reproduce before they die.

Show you can

Page 253

You would use random sampling if you were looking at an area without any features or trends, such as a flat school field. You would use a transect if your area had features or trends, such as a school field getting wetter near a stream or shadier near a building.

Page 257

As energy is passed along a food chain the amount reduces by 90% at each trophic level. This is because energy is lost in various ways, including heat loss. Only 10% is passed to the organisms above.

Page 259

There are three processes in the carbon cycle. During photosynthesis carbon is converted from carbon dioxide to glucose. During respiration carbon is converted from glucose to carbon dioxide. During combustion carbon is converted from a fuel to carbon dioxide.

Page 260

There are four main processes in the water cycle. Precipitation occurs after evaporation when water returns to the Earth as rain, snow, hail and sleet. Runoff is when precipitation moves across land like water in streams and rivers. Farmers use this. Infiltration is when water sinks into the ground to become groundwater. Evaporation is when heat turns liquid water into a gas in our atmosphere.

Page 262

Peat bogs have low temperatures, a lack of oxygen and acidic water. These conditions reduce decomposition by decomposers.

Page 264

The distribution of water is key for many animals. They will not move too far away from it. Areas surrounding water, such as oases in deserts, have more animals than areas without water. Temperature affects the distribution of animals and plants. Cacti are found in the desert, whereas pine trees are found in the Arctic regions. Gases in our atmosphere also affect where organisms are found. Lichens will only grow in areas without much air pollution.

Required practical 9

Pages 254–5

1 Answer is based on the student's own data.
2 Reason is based on the student's own data.
3 Your data would be more representative with more transects.

Required practical 10

Pages 261–2

1 As milk decays, the pH is decreased as lipid molecules break down to produce fatty acids (and glycerol). Additionally, bacteria carry out chemical processes to produce lactic acid.
2 In the warmer samples, there was more bacterial growth and the rate of decay processes was increased.
3 There would be reduced decay because the bacteria and other microbes will have been killed by the high temperatures.

4 Any sensible suggestion, including using a pH probe
5 Answer is based on the student's own results.

Chapter review questions

1 The process of recording a smaller amount of information to make wider conclusions
2 Quadrats
3 Animals can move into or out of the quadrat after we have placed it.
4 Photosynthesis, respiration, combustion
5 Precipitation, runoff, infiltration, subsurface flow
6 The breakdown of once living organisms into much smaller substances
7 They have spines as leaves to minimise water loss through transpiration.
8 They absorb as much water as possible from their food and concentrate their urine.
9 The effects of an increase in temperature as a result of the greenhouse effect
10 Melting ice caps, rising sea levels, species migration, more tropical diseases in temperate regions
11 Biotic (living) and abiotic (non-living) factors
12 The placement of quadrats must be random.
13 0.25 m^2
14 The study of distribution and abundance
15 The regular distribution (not random) of a survey to answer a specific question, usually about a trend
16 Instead of randomly placing a quadrat, you place it in a systematic (or regular) way. You would do this only when you wanted to check whether the distribution of an organism changed in an area.
17 A transect
18 It is converted from carbon dioxide to glucose.
19 It is converted from glucose to carbon dioxide.
20 It is converted from a fuel such as coal to carbon dioxide.
21 When plants die and rot, they release their carbon back into the soil. When animals die and rot, they release carbon dioxide into the atmosphere.
22 It recycles the basic compounds, such as amino acids, that are needed for other life to grow.
23 Warmth, oxygen, moisture
24 The low temperature, lack of oxygen and acidic water helped reduce decomposition.
25 An organism whose presence or absence tells you about the cleanliness of an ecosystem.
26 Increased carbon dioxide and other gases trap more of the Sun's solar radiation in the Earth's atmosphere, leading to global warming.
27 The number of a species, the total number of different species, the percentage cover of one plant species
28 If you wanted to look at whether there was more seaweed above or below the waterline, or if you wanted to look at whether the species of seaweed changed with their height on the shore
29 The movement of water into the ground to become groundwater
30 The movement of underground water towards the sea and oceans
31 Aquifers
32 To survive a change in seasons, to find mates, to find food, to reproduce
33 Lichens are particularly sensitive to air pollution and will only be found in large numbers or large size in clear air.
34 Lichens are a bioindicator of air quality. That is, their size and abundance gives an indication of how polluted an area is. Large, bushy lichens present in high numbers means relatively clean air. Small, crusty lichens (or none at all) means relatively polluted air.

Practice questions

1 a) i) Gas
ii) B and D
b) Change: 9.9 – 5.4 = 4.5; $\left(\frac{4.5}{5.4}\right) \times 100 =$ 83.00% (allow 1 mark for $\left(\frac{5.4}{9.9}\right) \times 100$ if answer given is 54.5%, as has the idea of a percentage just not change)
c) Global warming
2 C: random sampling using quadrats
3 a) i) The oak woodland
ii) 154 g
iii) Month 5 for the pine forest, or 387
b) Idea that water was evaporating from leaves or leaf litter was drying out
c) Bacteria and fungi
4 a) Any two from: idea that not random, not representative, biased, creates overestimate, may miss species
b) Any four from: need a study area with strips and without strips to compare; use either a transect or random sampling; use quadrats at regular intervals or at random sampling points; record the presence or absence of species; determine % cover or abundance of species; credit ACFOR scale or named stats test, e.g. Simpson's index of diversity
5 Level 3: There is a clear and detailed method of how random sampling would be carried out that makes reference to the size of the school field.
(5–6 marks)

Level 2: There is a method that is detailed and includes random sampling techniques.
(3–4 marks)

Level 1: There is a basic description of a simple method. *(1–2 marks)*

No relevant content: *(0 marks)*

Indicative content: a quadrat is used; there is mention of the size of the quadrat; random sampling points are determined; there is a description of how sampling points are found (using a random number generator/random sampling table); there is a description of how the quadrat is used to determine the number of daisies; there is a mention of repeats (at least 10) determining a mean abundance; there is a description of how the average abundance could be used to determine the number of daisies in the whole school field; higher tier students may make reference to the calculation: total area m^2 × average abundance of plant = abundance of plants per m^2.

Working scientifically: Experimental skills
Pages 267–8

1 Accuracy is a measure of how close a measurement is to the true value. Precision relates to the spread of measurements about the mean value. Precision depends only on the extent of random errors; it gives no indication of how close the results are to the true value.
2 Ecologists ensure their results are precise by repeating their samples and taking enough samples to make them representative.
3 Because they have a vested interest in the success of a drug as it is linked to a company's profit.
4 Barnacles
5 Answer is based on the student's own results.
6 Because the community cannot support a population of predators that is more abundant than its prey.

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge
1 Idea that all the organisms in an ecosystem require each other
2 Respiration converts carbon in glucose to carbon in carbon dioxide and releases it into the atmosphere.
3 Deciduous trees have leaves that absorb more carbon dioxide.

Test yourself
1 Quadrat
2 Transect
3 To save time and money by looking at a part of habitat to draw conclusions about all of it
4 By using random numbers as grid coordinates
5 Seaweed, plankton
6 Respiration, photosynthesis, combustion
7 0.04%
8 Carbon, in the form of a fuel like natural gas, is converted into carbon dioxide.
9 Carbon, in the form of glucose, is converted into carbon dioxide.

Show you can
Page 91(447)

You would use random sampling if you were looking at an area without any features or trends, such as a flat school field. You would use a transect if your area had features or trends, such as a school field getting wetter near a stream or shadier near a building.

Page 95(451)

As energy is passed along a food chain the amount reduces by 90% at each trophic level. This is because energy is lost in various ways, including heat loss. Only 10% is passed to the organisms above.

Page 96(452)

There are three processes in the carbon cycle. During photosynthesis carbon is converted from carbon dioxide to glucose. During respiration carbon is converted from glucose to carbon dioxide. During combustion carbon is converted from a fuel to carbon dioxide.

Page 97(453)

There are four main processes in the water cycle. Precipitation occurs after evaporation when water returns to the Earth as rain, snow, hail and sleet. Runoff is when precipitation moves across land like water in streams and rivers. Farmers use this. Infiltration is when water sinks into the ground to become groundwater. Evaporation is when heat turns liquid water into a gas in our atmosphere.

Required practical 7
Pages 92–3(448–9)

1 Answer is based on the student's own data.
2 Reason is based on the student's own data.
3 Your data would be more representative with more transects.

Chapter review questions
1 The process of recording a smaller amount of information to make wider conclusions
2 Quadrats
3 Animals can move into or out of the quadrat after we have placed it.
4 Photosynthesis, respiration, combustion
5 Precipitation, runoff, infiltration, subsurface flow

6 The placement of quadrats must be random.
7 The study of distribution and abundance
8 The regular distribution (not random) of a survey to answer a specific question, usually about a trend
9 Instead of randomly placing a quadrat, you place it in a systematic (or regular) way. You would do this only when you wanted to check whether the distribution of an organism changed in an area.
10 A transect
11 It is converted from carbon dioxide to glucose.
12 It is converted from glucose to carbon dioxide.
13 It is converted from a fuel such as coal to carbon dioxide.
14 When plants die and rot, they release their carbon back into the soil. When animals die and rot, they release carbon dioxide into the atmosphere.
15 If you wanted to look at whether there was more seaweed above or below the waterline, or if you wanted to look at whether the species of seaweed changed with their height on the shore.

Practice questions

1 **a) i)** Gas *[1 mark]*
ii) B and D *[2 marks]*
b) Change: 9.9 – 5.4 = 4.5; $\left(\frac{4.5}{5.4}\right) \times 100 =$ 83.00% [allow 1 mark for $\left(\frac{5.4}{9.9}\right) \times 100$ if answer given is 54.5%, as has the idea of a percentage just not change) *[2 marks]*
c) Global warming *[1 mark]*
2 C: random sampling using quadrats *[1 mark]*
3 **a) i)** The oak woodland *[1 mark]*
ii) 154 g *[1 mark]*
iii) Month 5 for the pine forest, or 387 *[1 mark]*
b) Idea that water was evaporating from leaves or leaf litter was drying out *[1 mark]*
c) Bacteria and fungi *[2 marks]*

Working scientifically: Experimental skills
Pages 100–1(456–7)

1 Accuracy is a measure of how close a measurement is to the true value. Precision relates to the spread of measurements about the mean value. Precision depends only on the extent of random errors; it gives no indication of how close the results are to the true value.
2 Ecologists ensure their results are precise by repeating their samples and taking enough samples to make them representative.
3 Because they have a vested interest in the success of a drug as it is linked to a company's profit.
4 Barnacles
5 Answer is based on the student's own results.
6 Because the community cannot support a population of predators that is more abundant than its prey.

20 Biodiversity and the effect of human interaction on ecosystems

Overview

Specification points

4.7.3.1 Biodiversity; 4.7.3.2 Waste management; 4.7.3.3 Land use; 4.7.3.4 Deforestation; 4.7.3.5 Global warming; 4.7.3.6 Maintaining biodiversity

Textbook chapter references

AQA GCSE (9-1) Biology: Chapter 20 pages 269–86

AQA GCSE (9-1) Combined Science Trilogy 2: Chapter 27 pages 102–16

AQA GCSE (9-1) Combined Science Trilogy: Chapter 27 pages 458–472

Recommended number of lessons: 5

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	No
Contains biology-only material	No

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz 1
- Quick quiz 2
- Answers for homework task
- Answers to all questions
- Animation: Human impact on the environment

Useful prior learning

- The importance of maintaining biodiversity
- How organisms are affected by their environment, including the accumulation of toxic materials like nitrogen compounds as well as pollutants
- The production of carbon dioxide by human activity and the impact on climate

Common misconceptions

- Students need to understand that the maintenance of biodiversity is not only important for the aesthetics of our surroundings. Valuable plants and animals may be lost through human activity and the removal of vast tracts of forest will have an impact on global warming. All organisms are part of food chains and food webs and removal of even one organism can have a knock-on effect on others in feeding relationships.
- Students frequently confuse the greenhouse gases which cause global warming with the hole in the ozone layer which allows more UV light to penetrate.

Preparation

- **T&L Prior knowledge catch-up sheet for teachers**
- **T&L Prior knowledge catch-up sheet for students**
- There are many key words and definitions in this section for students to learn. The **T&L Key terms** is useful for consolidation and testing of these terms.

Biodiversity: Lesson 1

Learning outcomes

1 Define the term biodiversity.
2 Explain the importance of maintaining biodiversity.

Suggested lesson plan

Starter

Use **T&L Lesson starter 1**.

Main

Working in groups, students should be allocated a specific ecosystem which has a high biodiversity. A photograph or picture should be given to act as stimulus material. Different ecosystems could include a rainforest, a chalk grassland, a coral reef, an English oak woodland and a rocky shore. Students should examine these ecosystems and explain why they have a high biodiversity. They should list all the reasons they can for maintaining the biodiversity in each area. They should also discuss the effects of a loss of biodiversity and how this may come about in each area.

Plenary

Each group feeds back on their findings. Students should list all the benefits of maintaining high biodiversity.

Support

Give students two pictures to compare. One should show an ecosystem rich in different species and the second should show the same ecosystem after it has been urbanised or has mining operations. Get the students to make comparisons between the two areas and suggest why it is important for the

organisms living in that particular ecosystem to have a wide number and range of different species.

Extension
Explain why some countries with rainforests have high biodiversity.

Homework
Create a poster or pamphlet on ecotourism explaining how to maintain high levels of biodiversity in a rainforest.

Waste: Lesson 2

Learning outcomes

1 Describe the impact of human activity on biodiversity.
2 Describe the impact of the increasing human population.
3 Describe examples of water and air pollution.

Suggested lesson plan

Starter
Use **T&L Lesson starter 2**.

Main
Working in groups, students should start to think about the ways in which humans affect biodiversity. Encourage them to think of everyday examples that they might see in their own town as well as examples they will have come across on the news.

Work through the Activity on page 273 of the textbook (Biology only). This can be done in pairs or in small groups.

In the same groups, make a list of the ways we can try to change our habits so that we reduce pollution, land fill etc. and maintain high levels of biodiversity in our environment.

Use the **T&L Topic overview** to consolidate the main points that should have been raised.

Plenary
Students could work through the **T&L Quick quiz**.

Support
Give students lists of examples of different forms of pollution and ask them to sort these into one of three groups: air pollution, water pollution, land pollution. They could use slides 2–6 of the **T&L Topic overview** to consolidate their understanding or watch the **T&L Animation: Human impact on the environment**.

Extension
Draw a fully annotated diagram which explains how fertilisers can cause water pollution or answer Practice question 2 on page 284(*114; 470*).

Homework
Work through Test yourself questions 3–6 on page 273 and 8–11 on page 276 (*questions 3–5 on page 106(462)*).

Land use: Lesson 3

Learning outcomes

1 Describe how building, quarrying, farming and waste management reduce land available for animals.
2 Define the term deforestation.
3 Explain the effects of large-scale deforestation.

Suggested lesson plan

Starter
Students should list all the ways in which humans use the land.

Main
Explain the historical background behind farming. Ask students to suggest why raising animals and growing crops was a more favourable way of life than being a hunter–gatherer.

Introduce the term 'sustainable'. Discuss examples of sustainable practice.

Describe deforestation. Get students to think about the consequences of widespread deforestation and suggest how forests can be managed in a sustainable way. Show the slide on deforestation from the **T&L Topic overview**.

Create a worksheet with different scenarios for students to consider. For example, a tribe living in the Amazon will cut down valuable trees to sell and use the money for food. Students should produce a list of ethical arguments for and against this action.

Plenary
Discuss the best way to manage forests in a sustainable way. Make a list of all the main points raised.

Support
Create a mix-and-match exercise where students sort statements of activities into those that are sustainable and those which will use up valuable resources.

Extension
Explain how we have changed our environment since the Stone Age.

Homework
Students should complete Test yourself questions 16–18 on page 278 (*questions 9–12 on page 108 (464)*).

Peat bogs: Lesson 4

Learning outcomes

1 Describe how peat bogs are formed.
2 Explain the importance of preserving peat bogs.

Suggested lesson plan

Starter

T&L Quick quiz 2 can be used as a recap of terms from previous lessons.

Main

Show students a YouTube clip on the formation of peat bogs. Students can make their own notes on the conditions required for the formation of peat. They should explain why organic remains in peat bogs are well preserved.

Research the reason why peat bogs should be preserved. This section should remind students about Tollund man. Why was this human of such great interest?

Plenary

Discuss the adaptations of plants to survive in or on a peat bog.

Support

Give students a list of conditions found in a peat bog. For each one they should try to link it to how it helps preserve an animal's body.

Extension

Define the term 'sink of carbon' and give an example of a carbon sink.

Homework

Give students an outline map of the UK. Ask them to research the places in the UK where peat bogs are common and plot them on the map. Why do peat bogs develop in these areas? How have they benefited the local population? Explain, with examples, whether peat bogs have a high or low biodiversity.

Global warming: Lesson 5

Learning outcomes

1 Define the term global warming.
2 Explain how global warming is caused.
3 Describe the effects of global warming.

Suggested lesson plan

Starter

T&L Quick quiz 1 will remind students of previous material which can lead on to a lesson on global warming.

Main

Explain how a greenhouse works by trapping heat inside. Expand this explanation by describing how greenhouse gases in the atmosphere trap heat from the Sun. Source simple diagrams of both a greenhouse and the atmosphere to show how heat is trapped.

Ask students to work in groups and write down a list of reasons why the levels of greenhouse gases have increased through human activity.

Research answers to Test yourself questions 20–23 on page 280 (*questions 13–16 on page 110(466)*).

Plenary

List ways in which humans can attempt to reduce global warming.

Support

Work through Practice question 3 on page 284 (*114; 470*).

Use the **T&L Key terms** to create a matching exercise where students have to match key words with their correct definitions.

Extension

Higher level students could research conservation and find out how it is helping to maintain biodiversity on Earth. Alternatively, they could read though the information on 'Dealing with data' on pages 285–6(*115–6; 471–2*) and answer the questions.

Homework

Research the captive breeding programme of one named species and explain how successful it has been. Alternatively, work through the **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 The range of living organisms in the area
2 The ice caps melt leading to sea level rises.
3 Toxic materials cannot be excreted. Because top predators are at the top of a food chain they absorb all the toxic chemicals that were in all organisms below them.

Test yourself

1 Rainforest, ancient woodland
2 Desert, polar region
3 6 to 16 billion people
4 Alaska, the Gulf of Mexico, France and the Galapagos Islands
5 Plastic does not decompose, but just breaks into smaller and smaller pieces, which have entered the food chain.

6 Damage to vision, hearing and speech
8 Reduce, reuse, recycle
9 Sulfur dioxide
10 Trees and other plants are killed and statues and other stonework can be eroded.
11 More of the Sun's ultraviolet rays can enter our atmosphere through the hole and can cause cancer.
12 120 per square mile
13 Many major cities, Bingham Canyon Mine in Utah
14 Acidic soils, high rainfall, cool temperatures
15 They did very little damage to the environment, only taking from it what they needed.
16 Half
17 80%
18 To sell the wood or make room for crops or animals such as cattle
19 The rainforest is being cut down to grow crops for biodiesel.
20 Coal, oil, natural gas
21 China
22 Because we are burning fossil fuels
23 Species will move from their current location towards the poles to find areas of land with temperatures that suit them.
24 Desert, polar region
25 Rainforest, ancient woodland
26 Many animals and plants live in hedgerows and depend upon them for food and shelter.
27 The number of different species of plants, animals and microorganisms that live in an area

Show you can
Page 270

Because they are made up of many different habitats in which different organisms can live.

Page 273

They kill zooplankton at the bottom of the food web, which affects the birds, fish and dolphins at much higher trophic levels. The oil remains in the ecosystem even after 25 years. The oil causes short-term problems such as lesions on fish and longer-term ones such as mutations in shrimp.

Page 276

Fertilisers run off fields into stream and rivers. They concentrate in ponds and lakes. Here the excess nutrients cause algae to grow quickly and form a bloom. This blocks off light, which kills aquatic plants. The plants rot and the decomposers use all the oxygen. All animals in the water then die.

Page 277

In the Stone Age most of the UK was covered with trees and very little was farmed. The trees have been cut down and were replaced with fields. Villages turned into giant cities, which replaced fields and woodland.

Page 278

When trees are cut down the biodiversity reduces massively. Large numbers of animals, plants and microorganisms will live in or near the trees and depend upon them for shelter or food. Soils can dry up and turn into desert.

Page 280

We are creating more carbon dioxide by burning fossil fuels and cutting down forests. This creates a layer around the Earth which traps the Sun's thermal radiation. This 'greenhouse effect' causes global warming, which is the gradual increase in the average temperature.

Page 282

By not using pesticides and fertilisers in your garden, leaving areas to become wild (perhaps with a stack of wood in which creatures can hide), using environmentally friendly detergent and washing-up liquid, growing wild flowers, putting waste food into compost not landfill, buying organic foods

Activity
Pages 273–4

Answers are based on the student's own results.

Page 279

Task: no answer needed

Page 282

Task: no answer needed

Chapter review questions
1 Food shortages, pollution, deforestation, global warming
2 Death of local wildlife, including birds, fish, otters, seals
3 Fog or haze as a result of smoke or other polluting gases
4 Death of trees and plants and erosion of stone statues and buildings
5 Because they contain CFCs, which damage the ozone layer when released
6 It shields us from much of the Sun's harmful ultraviolet (UV) radiation.

7 Because they contain heavy metals and other toxic chemicals, which can easily pollute local soil and water
8 Reduce, reuse, recycle
9 Glass, plastic, paper
10 The clearance of trees from an area that will then be used for other purposes, such as farming or building
11 It reduces photosynthesis, which increases carbon dioxide levels in the atmosphere, causing global warming. Trees are very biodiverse, so cutting them down destroys habitats for many other organisms. Soils can quickly become poor quality and wash away. Cures for diseases may be lost forever.
12 A measure of the different species present in a community
13 Neurological issues, including damage to vision, hearing and speech
14 Mutations in local species, e.g. shrimp, including being born without eyes or eye sockets
15 Eutrophication
16 Nitrogen dioxide and sulfur dioxide react to form sulfuric acid. This can lower the pH of water and so result in the formation of acid rain.
17 It reduces the need for landfill and the heat from the incinerator can be used to generate electricity. Some examples of air pollutants have been found in higher concentrations close to incinerators.
18 Describes an activity that can continue without damaging the environment
19 Reusing does not require any energy, whereas recycling does.
20 Farming crops for food
21 They have high rainfall, low temperatures and high acidity, which means it is difficult for decomposing microorganisms to live there.
22 A long-term store of carbon such as coal, oil, natural gas and peat
23 Ice caps melt leading to rising sea levels. Tropical diseases occur in temperate regions. Species migrate. Flash floods and other freak weather events become more common.
24 How safe the supply of our food is
25 Carbon dioxide, methane, water vapour
26 An activity in zoos to breed captive animals together to increase their gene pool
27 Protecting an ecosystem or species of organisms from reduced numbers and possible extinction
28 Organisms within them are protected from theft or hunting.
29 Hedgerows are very diverse. Their removal results in the death of many organisms that live in them or find food in them.
30 1.2 billion
31 Mercury bioaccumulates because it cannot be excreted. This means it is found in small quantities in zooplankton at the bottom of the food web, then in slightly higher levels in the next trophic level, and so in. It is found in much higher concentrations in humans, in the highest trophic level.
32 Excessive fertilisers wash from fields into streams and rivers and concentrate in ponds and lakes. Algae use these fertilisers to grow faster than the plants in the lake and so form a 'bloom', which covers its surface. The plants below the bloom do not receive enough light for photosynthesis and die. They begin to rot and the decomposing microorganisms use up much of the oxygen in the lake. Without this all other life dies.
33 Hunter–gatherers moved from place to place, leaving very little evidence of their impact. They only killed animals and collected plants they needed.
34 They are very important areas of biodiversity, often containing species that are not found elsewhere.
35 The increases in carbon dioxide concentration are relatively small.
36 By drilling ice cores and looking at the levels of carbon dioxide in them

Practice questions

1 a) i) At risk of extinction
ii) Freshwater fish (do not accept plants, as question stated animals)
iii) 6285 × 0.3 = 1886 (accept 1885.5)
b) i) Any two from: habitat loss, habitat degradation, over-hunting, loss of prey species, chemicals, climate change
ii) Captive breeding: advantage – increases number of individuals; disadvantage – not always successfully reintroduced into the habitat/also not changing the underlying reasons for them being endangered. Education: advantage – long-term change as local communities change what they are doing likely to result in habitat protection and reduced poaching; disadvantage – not directly increasing numbers, individual leopards might be too spread out to breed, takes too long, leopards may leave the area

2 a) i) To increase crop yield/make the plants grow better
ii) Fungicide, pesticide, herbicide (do not accept water)
b) Idea that when it rains, chemicals in the fertiliser dissolve into the water [1]; as the rain percolates through the soil it picks up the chemicals, and washes into the river by groundwater or surface runoff [1]
c) Nitrates increase growth of plants and algae; this reduces the light available for photosynthesis; this leads to the death of plant species; as the plants decay, microorganism numbers increase; they use up oxygen from the water in their respiration; leading to oxygen depletion; fish die, as they can't get enough oxygen

3 a) B: carbon monoxide
b) C: carbon dioxide, D: methane
c) D: reduced sea levels

4 Level 3: A clear description covering the major impacts on both the environment and on biodiversity *[5–6 marks]*

Level 2: A number of relevant points made, but not precisely *[3–4 marks]*

Level 1: Fragmented points *[1–2 marks]*

No relevant content: *[0 marks]*

Indicative content: a clear definition of what deforestation is; idea of deforestation as the clearance of trees from an area

Environment: idea that trees take in carbon dioxide from the atmosphere; fewer trees mean less carbon dioxide is stored; more carbon dioxide in the atmosphere increases the greenhouse effect; this leads to more global warming; the water cycle is affected; less transpiration by trees; may cause dry climates; soils hold less water and fewer roots; more likely that erosion and landslides occur

Biodiversity: biodiversity is reduced; idea that organisms that use the trees as their habitats can't survive; number of tree species is reduced; idea that food chains/food webs break down

Working scientifically: Dealing with data
Pages 285–6

1 There is a correlation between levels of carbon dioxide and temperature anomalies. As the levels of CO_2 in ppm have increased, the temperature anomalies in ^{o}C have also increased.
2 This is a strong positive correlation.
3 Human activities, such as burning fossil fuels and deforestation.
4 Carbon dioxide is a greenhouse gas, so can contribute to the greenhouse effect and increase global warming.
5 Any sensible ideas, such as different people have different conclusions based on the data, some people argue that global temperatures always change
6 Task: no answer is required
7 There is a correlation between increasing human populations and number of extinctions.
8 This is a moderate positive correlation overall; at low numbers there is no correlation but as the values increase there is greater correlation.
9 Any valid response, such as deforestation, urbanisation, over-harvesting, hunting, etc.

AQA GCSE (9-1) Combined Science Trilogy

Test yourself on prior knowledge

1 The range of living organisms in the area
2 The ice caps melt leading to sea level rises.
3 Toxic materials cannot be excreted. Because top predators are at the top of a food chain they absorb all the toxic chemicals that were in all organisms below them.

Test yourself

1 Rainforest, ancient woodland
2 Desert, polar region
3 Landfill sites attract vermin and produce toxic liquids. They can also be unsightly and use up valuable land.
4 Reduce, reuse, recycle
5 Trees and other plants are killed and statues and other stonework can be eroded.
6 120 per square mile
7 Many major cities, Bingham Canyon Mine in Utah
8 Acidic soils, high rainfall, cool temperatures
9 Half
10 80%
11 To sell the wood or make room for crops or animals such as cattle
12 The rainforest is being cut down to grow crops for biodiesel
13 Coal, oil, natural gas
14 China
15 Because we are burning fossil fuels
16 Species will move from their current location towards the poles to find areas of land with temperatures that suit them.
17 Desert, polar region
18 Rainforest, ancient woodland
19 Many animals and plants live in hedgerows and depend upon them for food and shelter.
20 The number of different species of plants, animals and microorganisms that live in an area

Show you can

Page 103(459)

Because they are made up of many different habitats in which different organisms can live

Page 106(462)

Fertilisers run off fields into streams and rivers. They concentrate in ponds and lakes. Here the excess nutrients cause algae to grow quickly and form a bloom. This blocks off light, which kills aquatic plants. The plants rot and the decomposers use all the oxygen. All animals in the water then die.

Page 107(463)

In the Stone Age most of the UK was covered with trees and very little was farmed. The trees have been cut down and were replaced with fields. Villages turned into giant cities, which replaced fields and woodland.

Page 108(464)

When trees are cut down the biodiversity reduces massively. Large numbers of animals, plants and microorganisms will live in or near the trees and depend upon them for shelter or food. Soils can dry up and turn into desert.

Page 110(466)

We are creating more carbon dioxide by burning fossil fuels and cutting down forests. This creates a layer around the Earth, which traps the Sun's thermal radiation. This 'greenhouse effect' causes global warming, which is the gradual increase in the average temperature.

Page 112(468)

By not using pesticides and fertilisers in your garden, leaving areas to become wild (perhaps with a stack of wood in which creatures can hide), using environmentally friendly detergent and washing-up liquid, growing wild flowers, putting waste food into compost not landfill, buying organic foods

Activity

Page 109(465)

Task: no answer needed

Page 112(468)

Task: no answer needed

Chapter review questions

1 Food shortages, pollution, deforestation, global warming
2 Because they contain heavy metals and other toxic chemicals, which can easily pollute local soil and water
3 Reduce, reuse, recycle
4 Glass, plastic, paper
5 The clearance of trees from an area that will then be used for other purposes, such as farming or building
6 It reduces photosynthesis, which increases carbon dioxide levels in the atmosphere, causing global warming. Trees are very biodiverse, so cutting them down destroys habitats for many other organisms. Soils can quickly become poor quality and wash away. Cures for diseases may be lost forever.
7 A measure of the different species present in a community
8 Nitrogen dioxide and sulfur dioxide react to form sulfuric acid. This can lower the pH of water and so result in the formation of acid rain.
9 It reduces the need for landfill and the heat from the incinerator can be used to generate electricity. Some examples of air pollutants have been found in higher concentrations close to incinerators.
10 Describes an activity that can continue without damaging the environment
11 Reusing does not require any energy, whereas recycling does.
12 They have high rainfall, low temperatures and high acidity, which means it is difficult for decomposing microorganisms to live there.
13 Ice caps melt leading to rising sea levels. Tropical diseases occur in temperate regions. Species migrate. Flash floods and other freak weather events become more common.
14 How safe the supply of our food is
15 Carbon dioxide, methane, water vapour
16 An activity in zoos to breed captive animals together to increase their gene pool
17 Protecting an ecosystem or species of organism from reduced numbers and possible extinction
18 Organisms within them are protected from theft or hunting.
19 Hedgerows are very diverse. Their removal results in the death of many organisms that live in them or find food in them.
20 They are very important areas of biodiversity, often containing species that are not found elsewhere.
21 The increases in carbon dioxide concentration are relatively small.

Practice questions

1 a) i) At risk of extinction *[1 mark]*

ii) Freshwater fish (do not accept plants, as question stated animals) *[1 mark]*

iii) 6285 × 0.3 = 1886 (accept 1885.5) *[2 marks]*

b) i) Any two from: habitat loss, habitat degradation, over-hunting, loss of prey species, chemicals, climate change *[2 marks]*

ii) Captive breeding: advantage – increases number of individuals; disadvantage – not always successfully reintroduced into the habitat/also not changing the underlying reasons for them being endangered. Education: advantage – long-term change as local communities change what they are doing likely to result in habitat protection and reduced poaching; disadvantage – not directly increasing numbers, individual leopards might be too spread out to breed, takes too long, leopards may leave the area. *[4 marks]*

2 a) i) To increase crop yield/make the plants grow better *[1 mark]*

ii) Fungicide, pesticide, herbicide (do not accept water) *[1 mark]*

b) Idea that when it rains, chemicals in the fertiliser dissolve into the water [1 mark]; as the rain percolates through the soil it picks up the chemicals, and washes into the river by groundwater or surface runoff *[1 mark]*

c) Nitrates increase growth of plants and algae; this reduces the light available for photosynthesis; this leads to the death of plant species; as the plants decay, microorganism numbers increase; they use up oxygen from the water in their respiration; leading to oxygen depletion; fish die, as they can't get enough oxygen. *[4 marks]*

3 a) C: carbon dioxide, D: methane *[2 marks]*

b) D: reduced sea levels *[1 mark]*

Working scientifically: Dealing with data

Pages 115–6(471–2)

1 There is a correlation between levels of carbon dioxide and temperature anomalies. As the levels of CO_2 in ppm have increased, the temperature anomalies in °C have also increased.

2 This is a strong positive correlation.

3 Carbon dioxide is a greenhouse gas, so can contribute to the greenhouse effect and increase global warming.

4 Any sensible ideas, such as different people have different conclusions based on the data, some people argue that global temperatures always change.

5 Task: no answer is required

6 There is a correlation between increasing human populations and number of extinctions.

7 This is a moderate positive correlation overall; at low numbers there is no correlation but as the values increase there is greater correlation.

8 Any valid response, such as deforestation, urbanisation, over-harvesting, hunting, etc.

21 Trophic levels in an ecosystem (Biology only)

Overview

Specification points
4.7.4.1 Trophic levels; 4.7.4.2 Pyramids of biomass; 4.7.4.3 Transfer of biomass

Textbook chapter references
AQA GCSE (9-1) Biology: Chapter 21 pages 287–94

Recommended number of lessons: 2

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	No
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter 1
- Lesson starter 2
- Key terms
- Homework task
- Quick quiz
- Answers for homework task
- Answers to all questions

Useful prior learning

- The interdependence of organisms in an ecosystem including food webs and insect-pollinated crops.

Common misconceptions

- Food chains and food webs show how one organism feeds off another. They should always start with a producer which is a photosynthetic organism. The arrows in a food chain show the direction in which energy flows from one organism to the next. The direction is from the producer (which converts sunlight energy into chemical bond energy) to the primary consumer and then to the secondary consumer and so on. Students do not always understand this flow and they may place arrows in the wrong direction.
- The concept of energy is often misunderstood. Students need be reminded constantly that energy cannot be created or destroyed but can be converted from one form to another.

Preparation

- **T&L Prior knowledge catch-up sheet for teachers**
- **T&L Prior knowledge catch-up sheet for students**

Trophic levels: Lesson 1

Learning outcomes

1 Define the term trophic level.
2 Describe the differences between the trophic levels of organisms within an ecosystem.

Suggested lesson plan

Starter
Use the **T&L Lesson starter 1**.

Main
Explain the term 'trophic level'. Use the food chains drawn in the starter activity to explain the terms 'producer', 'primary consumer', 'herbivore', 'secondary consumer', 'carnivore' and 'apex predator'.

Ask students to research food chains that include six or more trophic levels. Get them to suggest why food chains are rarely this length. Encourage them to think about the size and number of organisms at each trophic level. Is there a correlation?

Remind students of the term 'biomass'.

Plenary
Create several food chains for students to assemble in the correct order (with arrows going the right way).

Alternatively, get the students to create their own disassembled food chains for their partners to arrange correctly.

Support
Show students pictures of different organisms and get them to categorise them according to the type of feeding they carry out. For example, all green plants would be categorised as producers.

Create cut-and-stick food chains to be assembled correctly.

Extension
Students could complete the Test yourself questions on page 290 of the textbook.

Homework
Chapter review questions 1–3 and 5–9 on page 291 of the textbook.

Pyramids of biomass and transfer of biomass: Lesson 2

Learning outcomes

1 Construct pyramids of biomass for food chains.
2 Explain how energy is used at each trophic level.
3 Explain how energy is transferred between trophic levels.

Suggested lesson plan

Starter
Use the **T&L Lesson starter 1**.

Main
Remind students of the term 'biomass'. Show students how to construct a pyramid of biomass from a food chain. Explain that a pyramid of biomass is always a perfect pyramid and shows that the amount of available energy at the bottom gets less as you move up through the trophic levels. Encourage students to suggest reasons for this decrease. They should be able to think of ways in which energy can be lost as this has already been covered. Students should be able to link this information to explain the limited number of trophic levels that can be sustained in a food chain.

Students can work through the Activity on page 289 of the textbook to enable them to construct a food web and a pyramid of biomass.

Plenary
Students could work through the **T&L Quick quiz**.

Support
Draw a pyramid of biomass and get students to transfer the data from a food chain to the correct sections of the pyramid. Create several different food chains of different lengths for them to work on.

Extension
Practice questions 2 and 3 on page 292 of the textbook. Alternatively work through the Energy calculations in the section 'Dealing with data' on pages 293–4 of the textbook.

Homework
Ask students to complete the **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge
1 Top predators
2 A food web is made from interconnecting food chains.
3 Because if there were more predators they may eat all of the prey.

Test yourself
1 The mass of any living or recently dead organism
2 At the bottom of the pyramids
3 There are fewer predators than prey, or all the prey would be eaten.
4 Herbivores
5 The transfer of energy
6 The fifth trophic level is the quaternary consumer.

Show you can
Page 289

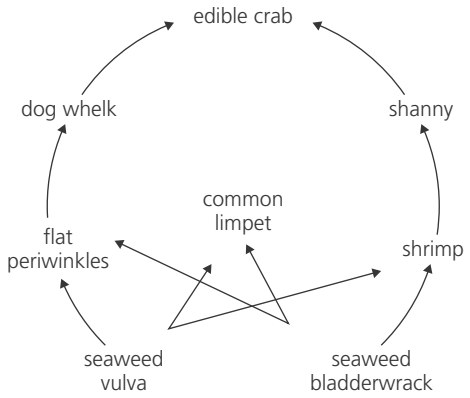
To stop water affecting the results

Page 290

Energy and biomass are interchangeable. The organisms at a lower trophic level use energy for life processes so only a small part of this can be passed to the next trophic level.

Activity
Page 289

1



2

Species	Total biomass in g
Seaweed ulva	768
Seaweed bladder wrack	632
Flat periwinkle	138
Edible crab	80
Common limpet	132
Dog whelk	60
Shanny	40
Shrimp	30

3

Trophic level	Total biomass in g
Producer	1400
Primary consumer	300
Secondary consumer	100
Tertiary consumer	80

4 Task: no answer required

Chapter review questions

1 Any organism that photosynthesises, e.g. a plant or alga
2 Tissue from living or recently dead organisms
3 Any organism in a feeding relationship that eats other organisms for food, e.g. humans
4 The total mass of organisms in a food chain at their different trophic levels
5 A stage in a feeding relationship representing an organism in a food chain or a group of organisms in a food web
6 Producers, photosynthetic plants or algae
7 Apex predator
8 All the food chains of an ecosystem fit together to form a food web.
9 The movement of energy
10 10%
11 It is used by the organisms at each trophic level to complete the life processes.
12 1%
13 An organism that eats both plants and meat, e.g. humans, bears, rats
14 Any organism that breaks down the remains of a dead organism, e.g. bacteria, fungi and worms
15 Pyramid drawn with four layers: grass at the bottom, then rabbit, then fox, and then fleas at the top; each layer labelled; size of bars proportional to biomass
16 The fleas would die. The rabbits would increase in number because they would not have any predators. The rabbits would eat lots of the grass.
17 The rabbits would decrease in number because they would have two predators. This would mean the foxes would have less food so their numbers would decrease. The grass would increase because there would be fewer rabbits.
18 If there were more predators than prey, it is likely that most of the prey would be eaten, which might mean that the predators would starve.
19 Only 10% of the energy is transferred between each trophic level.
20 Synthesis reactions (e.g. protein synthesis), breakdown reactions to remove waste, movement through muscle contraction, homeostatic maintenance of temperature regulation in warm-blooded animals
21 70%

Practice questions

1 **a) i)** Producer
ii) Quaternary consumer or apex predator
b) i) 1300 g
ii) Pyramid drawn with five layers: producer at the bottom, each layer labelled, size of bars proportional to biomass
c) Plankton too small to count/measure mass correctly
d) i) 72/91 × 100 = 79%; 1 mark correct for working, 1 mark for the correct answer and rounding
ii) Idea that the heavier/larger the bird the less food eaten as a % of its body mass
e) Idea that bullfinch needs to eat over 1.5 times its body mass
2 **a)** B: herring
b) D: Antarctic petrel

Working scientifically: Dealing with data

Pages 293–4

1 71 932 kJ
2 **a)** 32 kJ
b) Movement, growth, reproduction, sensory response, gaining nutrition and/or digestion
3 912.5 kJ
4 8212.5 kJ
5 1642.5 kJ
6 11 520 kJ
7 More of the producer is eaten. On land, herbivores tend not to eat all of the producer.
8 All the light reaching a plant cannot be used because not all the light is of the correct wavelength. Light passes through the plant and does not hit chloroplasts. Light is reflected from the surface of the plant.
9 Between producer and primary consumer, 7%. Between primary consumer and secondary consumer, 11%. Between secondary consumer and tertiary consumer, 8%.

22 Food production (Biology only)

Overview

Specification points
4.7.5.1 Factors affecting food security; 4.7.5.2 Farming techniques; 4.7.5.3 Sustainable fisheries; 4.7.5.4 Role of biotechnology

Textbook chapter references
AQA GCSE (9-1) Biology: Chapter 22 pages 295–306

Recommended number of lessons: 3

Chapter overview	
AQA required practicals	N/A
Contains higher-tier only material	No
Contains biology-only material	Yes

Useful teaching and learning resources

- Learning outcomes
- Prior knowledge catch-up student sheet
- Prior knowledge catch-up teacher sheet
- Topic overview
- Lesson starter
- Key terms
- Homework task
- Quick quiz
- Answers for homework task
- Answers to all questions

Useful prior learning

- Reproduction in plants, including flower structure, wind- and insect pollination, fertilisation, seed and fruit formation and dispersal, including quantitative investigation of some dispersal mechanisms
- Relationships in an ecosystem
- The importance of plant reproduction through insect pollination in human food security

Common misconceptions

- Students do not readily grasp the term 'food security'. They think it refers to food being locked up in a supermarket or shop.

Preparation

- **T&L Prior knowledge student catch-up sheet**
- **T&L Prior knowledge teacher catch-up sheet**

Factors affecting food security: Lesson 1

Learning outcomes

1 Describe some of the biological factors affecting levels of food security.
2 Explain how the efficiency of food production can be increased.

Suggested lesson plan

Starter
Work through the Test yourself on prior knowledge questions on page 296 of the textbook.

Main
Use the answers to the questions above to develop the topic. Students may not be familiar with the term 'food security'.

Use slide 1 from the **T&L Topic overview** to explain the concept of food security.

Encourage students to think of all the reasons why there may not be enough food to feed everyone in the world. Get them to explain some of the causes of famine.

Put students into groups and get each group to research different ways in which more food can be generated. This should include different agricultural techniques, raising animals, hydroponics and biotechnology. For each technique, they should make a table listing the advantages and disadvantages of each. For example, battery-farmed chickens ensure a plentiful supply of lean, protein-rich meat but the chickens do not have long, happy lives.

Discuss the findings.

Plenary
Use **T&L Lesson starter** to discuss the pros and cons of organic farming.

Support
Create a piece of written text which outlines the factors affecting food security. Leave out words and get students to fill these in. Supply a list of words if necessary.

Extension
Higher level students could complete Chapter review questions 1–6 from page 303 of the textbook.

Homework
Answer Practice questions 1 and 3 on page 304 of the textbook.

Sustainable fisheries: Lesson 2

Learning outcomes

1 Define the term sustainable fishery.
2 Explain how fish stocks have been increased.

Suggested lesson plan

Starter
Show students Figure 22.8 and Figure 22.9 from page 300. Ask students to compare the two techniques.

Main
Explain the different techniques for catching fish. Introduce the term 'sustainable'. Ask students to suggest what would happen if there were no limits on fishing in different waters.

Research the overfishing of a species of fish and describe all the problems that will arise from this. For example, find out how fish stocks can be protected and how fishing can be carried out responsibly to prevent the depletion of fish species.

Plenary
Discuss the main ideas which have come from the research exercise.

Support
Watch the **T&L Animation: Human impact on the environment**.

Extension
Answer the Test yourself questions on page 300 of the textbook.

Homework
Students should answer Practice question 2 on page 304 of the textbook.

Role of biotechnology: Lesson 3

Learning outcomes

Describe possible biotechnical and agricultural solutions to the demands of the growing human population.

Suggested lesson plan

Starter
Give students the Quorn challenge. This involves cooking some chicken nuggets and some Quorn nuggets. Both these foods look identical. Give students pieces of each on cocktail sticks. They should not know which is real chicken and which is the substitute. Get them to describe the flavours and textures of both and decide which one is the real chicken.

Main
The Quorn challenge sets the scene to discuss artificially produced meat substitutes and the topic of biotechnology. Explain that Quorn is mycoprotein made from fungus. Show Figure 22.10 from page 301 and explain how the mycoprotein is made by a fermentation technique. Explain that the mycoprotein is made by a biotechnological technique but has not been genetically modified.

Students could research a comparison between the production and nutritional value of Quorn versus another high-protein food like steak. This could be presented as a table.

Get students to recall genetic modification that was covered in previous chapters. Use Figure 22.11 from page 302 to show how insulin is created by genetic modification of a bacterial cell.

Students should be able to list reasons why it is more beneficial to organisms to have genetically modified insulin rather than insulin from slaughtered animals.

Plenary
Students should work on the **T&L Quick quiz**.

Support
Present students with data on the nutritional value of 100 g of Quorn and 100 g of beefsteak. Get students to decide which of these food materials would be more beneficial. They could then create a poster or pamphlet outlining the benefits of Quorn.

Extension
More able students could answer Practice question 3 on page 304 of the textbook.

Homework
All students could work through the **T&L Homework task**.

Answers

AQA GCSE (9-1) Biology

Test yourself on prior knowledge

1 Pollen and ova
2 Without it people do not have enough food. This sometimes leads to demonstrations or riots.
3 Because bees pollinate many of our important crops.

Test yourself

1 How easy it is for us to access food
2 Half
3 By rioting
4 Millions of people are likely to be unable to feed themselves.
5 Pyrethrin from chrysanthemum flowers
6 To save time and money
7 Organic farming does not use chemical pesticides or fertilisers, but conventional farming does.
8 The evolution of antibiotic-resistant bacteria
9 A limit on the total amount of fish caught by a boat or country
10 Cod
11 Many local people depend upon fishing to support their families.
12 Sea turtles, dolphins and rays are often caught and killed by mistake in the nets.
13 The use of living organisms to develop and make products
14 A fungus
15 Fewer people have allergic reactions to it.
16 Oxygen and glucose syrup for aerobic respiration and nitrogen to make protein

Show you can

Page 297

Droughts make crops harder to grow, which leads to crop failure. Population increases mean that more food needs to be produced. Some government policies have prioritised some areas and left people in other areas without food. Armed conflict has drawn money from agriculture and destroyed farming land.

Page 299

Monoculture, which often occurs in intensive farming, reduces biodiversity and damages soil. Animal welfare issues are often increased in intensive farming. Battery chickens and keeping fish in underwater cages are examples of this. Fertilisers, pesticides and antibiotics are also used. Machines increase yield but burn fossil fuels to do this. The removal of hedgerows reduces biodiversity.

Page 300

Fishing times and the total number of boats have been reduced. Quotas have been introduced to limit the total amount of fish caught. Nets with larger size holes are used, which kill fewer juvenile fish.

Page 302

The human gene for insulin was cut out of a human cell using an enzyme. The same enzyme was used to cut open a plasmid. This is a small, circular section of DNA than can move between bacteria. The DNA was sealed in the plasmid using another enzyme. The plasmid was then allowed to infect a bacterium. As the bacterium began to grow and divide it produced human insulin.

Activity

Page 299

	Benefits	Negative impacts
Removal of hedgerows	Increases yields as farmers use heavy machinery which is only efficient in large fields in order to minimise turning	Reduces habitat for native species Soil erosion Loss of biodiversity
Increase in fertilisers	Increases yields and extends growing seasons for some crops	Can cause eutrophication in rivers and ponds Production of fertilisers impacts on the environment
Increase in pesticides	Increases yields as less is lost to pests	Pesticides can harm non-target insects such as pollinators Pesticides can enter food chains and cause the death of larger organisms through bioaccumulation
Deep ploughing	Increases yields through modifying soil water retention	Ploughing can cause soil compaction Ploughing can cause the loss of top soil Ploughing can reduce the fertility of the land

Activity

Page 299

Task: no answer is required

Activity

Page 301

Task: no answer is required

Chapter review questions

1 How safe the supply of our food is
2 Drought, crop failure, population increase, government policies, armed conflict
3 Rearing livestock using highly intensive methods
4 Chickens, fish
5 An issue that some people disagree with it for religious or moral reasons
6 Non-intensive farming that uses natural fertilisers and pesticides

7 Cod (*Gadus morhua*)
8 Fungus
9 In huge vats rather like the fermenters in which beer is produced
10 Half
11 Sustained growth of one species of crop
12 Crop rotation
13 Two from: the use of machines, chemical fertilisers and pesticides
14 It limits their movement, which restricts their energy loss, which means they can produce a higher yield.
15 Hedgerows are very biodiverse places that provide food and shelter for many organisms.
16 Higher costs to produce the food and lower yields
17 A fixed entitlement to catch a specified volume of fish or other yield
18 Fishing on a scale so large that the population of species is threatened
19 The use of living organisms to develop and make products
20 Vegetarians can eat it. It is a good source of fibre. It is low in fat and contains no cholesterol.
21 Less land is required to produce it than for meat.
22 It means that the farm can specialise in one product only, becoming more efficient in planting and harvesting.
23 Nutrient deficiencies in soil are reduced because different crops may need different nutrients and pests have less time to become established.
24 Overuse of antibiotics is likely to be a cause of the development of antibiotic-resistant bacteria.
25 Manure or bone meal
26 Pyrethrin from *Chrysanthemum cinerariifolium* flowering plants
27 The times at which boats can fish has been reduced and the total number of boats has been limited. The total amount of fish caught by boats has also been reduced. Fishing is now occurring using nets with larger size holes.
28 Fewer juvenile fish will be caught, which increases the likelihood of the fish reproducing and returning population levels.
29 Oxygen and glucose syrup are added to allow the fungi to respire aerobically. To help make the protein, nitrogen is also added in the form of ammonia.
30 The human gene for insulin was cut out using enzymes. The same enzyme was used to cut open a plasmid. A second enzyme was used to seal in the gene. The plasmid was allowed to infect a bacterium. As the bacterium began to grow and divide by binary fission it began to produce human insulin.
31 No one is allergic to it; it is cheaper and easier than collecting from pigs; vegetarians can use it
32 Haemophilia sufferers cannot clot their blood very easily. Bacteria have been genetically modified to produce clotting factors to help this process.

Practice questions

1 a) Idea of a measure of how easy it is for individuals to access supplies of food
b) A: Ethiopia, C: Afghanistan
c) Idea of growing population, food shortages, drought, poor yields/quality of food, high cost of food, war or civil unrest, government corruption

2 a) 1991
b) i) Idea that it is impossible to count all and judge biomass of all haddock in the North Sea
ii) Idea that fishing quota set too high as high numbers estimated for the year before
c) i) Net size, size of mesh
ii) Small fish can escape the net, they then can grow large enough to breed/ensure only fish that have bred are caught

3 a) i) Rearing livestock using highly intensive methods
ii) Award one mark for suggestion and one mark for paired explanation. Any two from: keep factory building warm – to reduce energy loss from maintaining body temperature; restrict the cattle's movement – to reduce energy use to bring about muscle contraction/movement so more energy can be used for growth; select breed of cattle that mature and grow quickly – less time to reach size and less energy wasted to do this; high energy foods/easily digestible foods – less energy wasted in digestion or lost in wastes
b) Any two from: factory farming is cruel; intensive labour; more chance of disease/ spread of disease; antibiotic resistance can occur; antibiotics can be found in food
c) i) Fungus/mycoprotein
ii) Any three from: grown in vats/ fermenters; which are kept at constant temperature; often by a water-cooled jacket surrounding them; oxygen is supplied so the fungus can grow aerobically; glucose syrup is added as a source of food; ammonia is added for a source of nitrogen; once grown, liquid is removed; purified before being sold

Working scientifically: Experimental skills
Pages 305–6

Task: no answer is required