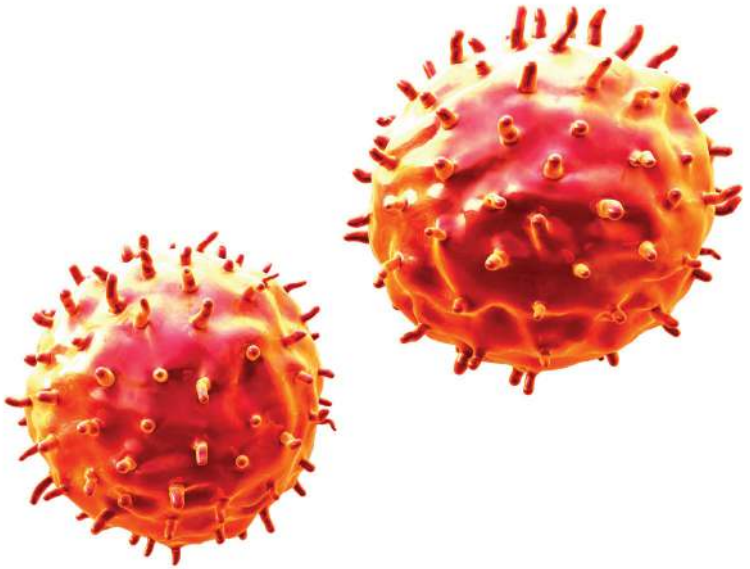
Cambridge Assessment International Education

Scheme of Work

Cambridge IGCSE®
Biology 0610

For examination from 2016



Cambridge Pathway

Version 2.0

In order to help us develop the highest quality resources, we are undertaking a continuous programme of review; not only to measure the success of our resources but also to highlight areas for improvement and to identify new development needs.

We invite you to complete our survey by visiting the website below. Your comments on the quality and relevance of our resources are very important to us.

www.surveymonkey.co.uk/r/GL6ZNJB

Would you like to become a Cambridge International consultant and help us develop support materials?

Please follow the link below to register your interest.

www.cambridgeinternational.org/cambridge-for/teachers/teacherconsultants/

Contents

Introduction

This scheme of work has been designed to support you in your teaching and lesson planning. Making full use of this scheme of work will help you to improve both your teaching and your learners' potential. It is important to have a scheme of work in place in order for you to guarantee that the syllabus is covered fully. You can choose what approach to take and you know the nature of your institution and the levels of ability of your learners. What follows is just one possible approach you could take.

Guided learning hours

Guided learning hours give an indication of the amount of contact time you need to have with your learners to deliver a course. Our syllabuses are designed around 130 hours for Cambridge IGCSE courses. The number of hours may vary depending on local practice and your learners' previous experience of the subject. The table below gives some guidance about how many hours we recommend you spend on each topic area.

Topic	Suggested teaching time (%)	Suggested teaching order
1: Cells and processes	26 hours (20% of the course)	1
2: Animal nutrition	5 hours (4% of the course)	2
3: Plant nutrition and transport	13 hours (10% of the course)	3
4: Respiration and the human transport system	25 hours (19% of the course)	4
5: Coordination, response and homeostasis	20 hours (15% of the course)	5
6: Reproduction	5 hours (4% of the course)	6
7: Human reproduction	4 hours (3% of the course)	7
8: Inheritance and evolution	22 hours (17% of the course)	8
9: Organisms and environment	5 hours (4% of the course)	9
10: Human influences on the environment	5 hours (4% of the course)	10

Resources

The up-to-date resource list for this syllabus, including textbooks endorsed by Cambridge International, is listed at www.cambridgeinternational.org
Endorsed textbooks have been written to be closely aligned to the syllabus they support, and have been through a detailed quality assurance process. As such, all textbooks endorsed by Cambridge International for this syllabus are the ideal resource to be used alongside this scheme of work as they cover each learning objective.

School Support Hub

The School Support Hub www.cambridgeinternational.org/support is a secure online resource bank and community forum for Cambridge teachers, where you can download specimen and past question papers, mark schemes and other resources. We also offer online and face-to-face training; details of forthcoming training opportunities are posted online. This scheme of work is available as PDF and an editable version in Microsoft Word format; both are available on the School Support Hub at www.cambridgeinternational.org/support If you are unable to use Microsoft Word you can download Open Office free of charge from www.openoffice.org

Resource Plus

Throughout this scheme of work, you will find references to experiments from the *Resource Plus* platform.

Resource Plus

Experiment: Biotechnology – juicing apples

This experiment focuses on the use of enzymes in an industrial process (biotechnology).

Resource Plus provides specific information to help you to either carry out, or engage in virtual experiments with your learners. The materials include videos of experiments and accompanying *Skills Packs. The Skills Packs* have detailed lesson plans, extensive teacher advice and worksheets to guide you. If you don't have access to a lab or equipment, then the videos and materials in the *Skills Packs* can be used to provide a virtual experiment for your learners.

As well as the videos and *Skills Packs, Resource Plus* also offers a wide range of other materials for you to use in your classroom.
To try a demo, find out more, or to subscribe, visit www.cambridgeinternational.org/resourceplus

Websites

This scheme of work includes website links providing direct access to internet resources. Cambridge Assessment International Education is not responsible for the accuracy or content of information contained in these sites. The inclusion of a link to an external website should not be understood to be an endorsement of that website or the site's owners (or their products/services).

The website pages referenced in this scheme of work were selected when the scheme of work was produced. Other aspects of the sites were not checked and only the particular resources are recommended.

How to get the most out of this scheme of work – integrating syllabus content, skills and teaching strategies

We have written this scheme of work for the Cambridge IGCSE Biology (0610) syllabus and it provides some ideas and suggestions of how to cover the content of the syllabus. We have designed the following features to help guide you through your course.

Learning objectives help your learners by making it clear the knowledge they are trying to build. Pass these on to your learners by expressing them as 'We are learning to / about…'.

Suggested teaching activities give you lots of ideas about how you can present learners with new information without teacher talk or videos. Try more active methods which get your learners motivated and practising new skills.

Supplement (extended syllabus) is highlighted throughout the scheme of work for both the learning objectives and the suggested teaching activities.

Extension activities provide your abler learners with further challenge beyond the basic content of the course. Innovation and independent learning are the basis of these activities.

Syllabus ref.	Learning objectives	Suggested teaching activities
6.3 Mineral requirements	• Describe the importance of: ○ nitrate ions for making amino acids ○ magnesium ions for making chlorophyll …ain the effects of …te ion and …agnesium ion deficiency on plant growth	Learners should be reminded that carbohydrates contain carbon, hydrogen and oxygen only; plants can therefore make these from carbon dioxide and water. However, proteins also contain nitrogen, so a nitrogen source is necessary before some of the carbohydrate can be converted to protein. Nitrate ions from the soil are the main source of nitrogen for plants. This should be dealt with simply, considering the effects on a growing plant of a shortage of proteins or chlorophyll. **Extension activity:** learners could plan an experiment to investigate mineral requirements in plants. **(I)** A comparison can be made when plants are grown in culture solutions lacking magnesium, nitrates and a control. After a few weeks, the growth of each plant can be compared. ***Suggested practical:*** Set up a simple mineral nutrition experiment with controls to grow cereal seedlings for a few weeks. Practical biology – minerals: www.nuffieldfoundation.org/practical-biology/investigating-effect-minerals-plant-growth
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)** **6.1** Jun 2011 Paper 22 Q7(b) …013 Paper 22 Q6 **6.2** Jun 2011 Paper 22 Q7(a) …n 2011 Paper 32 Q6 **8.3** Jun 2011 Paper 31 Q5 Jun 2011 Paper 21 Q9 **6.3** Jun 2011 Paper 31 Q5(d) Jun 2012 Paper 22 Q3		

Independent study (I) gives your learners the opportunity to develop their own ideas and understanding with direct input from you.

Past papers, **specimen papers** and **mark schemes** are available for you to download at: www.cambridgeinternational.org/support

Using these resources with your learners allows you to check their progress and give them confidence and understanding.

Formative assessment (F) is on-going assessment which informs you about the progress of your learners. Don't forget to leave time to review what your learners have learnt, you could try question and answer, tests, quizzes, 'mind maps', or 'concept maps'. These kinds of activities can be found in the scheme of work.

1: Cells and cell processes

Syllabus ref.	Learning objectives	Suggested teaching activities
1.1 Characteristics of living organisms	• Describe the characteristics of living organisms by defining the terms: ○ *movement* as an action by an organism or part of an organism causing a change of position or place ○ *respiration* as the chemical reactions in cells that break down nutrient molecules and release energy for metabolism ○ *sensitivity* as the ability to detect or sense stimuli in the internal or external environment and respond to changes in the environment ○ *growth* as a permanent increase in size and dry mass by an increase in cell number or cell size or both ○ *reproduction* as the processes that make more of the same kind of organism ○ *excretion* as removal from organisms of the waste products of metabolism (chemical reactions in cells including respiration), toxic materials, and substances in excess of requirements ○ *nutrition* as taking in of materials for energy, growth and development; plants	Section 1.1 of this unit can provide an introduction to the Biology course. The seven characteristics of living things form a basis from which the themes underlying many biological concepts can be developed. Learner activity – characteristics of living things: www.exploratorium.edu/imaging_station/activities/classroom/characteristics/ca_characteristics.php Including video clips and learner worksheet. **Activities:** The comparison of the characteristics of living organisms with those of non-living things – for example, what are the characteristics of life shown by a petrol engine. The comparison is clear when written in a table. The mnemonic, MRS GREN is useful to remember the seven characteristics. Learners should understand that single-celled organisms, plants and animals all have these characteristics. The characteristic of nutrition could be extended to include autotrophic and heterotrophic nutrition and the terms parasite and saprophyte. If models or specimens are available, learners could discuss the importance of having a large surface area in relation to volume for diffusion. The importance of diffusion of gases in respiration will be understood more easily when Unit 4 is studied. Growth could also be explained as an increase in size due to cell division. There might be a change in shape with growth. Examples to explain the need for energy to carry out each of the characteristics should be discussed. Learners will appreciate that energy is required for movement and this can be extended to show that energy is needed for growth, nutrition and sensitivity.

Syllabus ref.	Learning objectives	Suggested teaching activities
	require light, carbon dioxide, water and ions; animals need organic compounds and ions and usually need water	**Extension activity:** learners could perform a search of the characteristics of life. **(I)** Do all scientists use the same list? How do we classify viruses? Revision – characteristics of life: www.s-cool.co.uk/gcse/biology/cells/revise-it/characteristics-of-life
1.2 Concept and use of a classification system	• State that organisms can be classified into groups by the features that they share. • Define *species* as a group of organisms that can reproduce to produce fertile offspring. • Define and describe the *binomial system* of naming species as an internationally agreed system in which the scientific name of an organism is made up of two parts showing the genus and species. • Explain that classification systems aim to reflect evolutionary relationships. • Explain that classification is traditionally based on studies of morphology and anatomy. • Explain that the sequences of bases in DNA and of amino acids in proteins are used as a more accurate means of classification.	Learners may know some binomials, such as *Homo sapiens*. Use this as an introduction of the Latin names for classification of all organisms. Carl Linnaeus can be mentioned and his work discussed. Emphasise the format of binomial names: Genus with a capital letter and species with a lower case letter and the possible use of *italics* or underlining. ***Suggested practical:*** • Use a case study from the DNA to Darwin website to use DNA sequence data to construct a classification tree, e.g. for woolly mammoths. Learners can visit a variety of places to appreciate the variety amongst living things: • local zoo • game park • natural history museum, etc. Online specimen collections: www.nhm.ac.uk/research-curation/collections/index.html The four species of crow can serve to explain the importance of classification. *Corvus corone*: carrion crow *Corvus corax:* raven *Corvus frugilegus*: rook *Corvus monedula*: jackdaw www.rspb.org.uk/wildlife/birdguide/name/c/carrioncrow/index.aspx Bird images: www.allaboutbirds.org/Page.aspx?pid=1189 Species diversity: www.seaworld.org/animal-info/info-books/bio-diversity/index.htm

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Explain that organisms which share a more recent ancestor (are more closely related) have base sequences in DNA that are more similar than those that share only a distant ancestor.	An exploration of Biodiversity
1.3 Features of organisms	• List the features in the cells of all living organisms, limited to cytoplasm, cell membrane and DNA as genetic material, ribosomes for protein synthesis and enzymes involved in respiration. • List the main features used to place all organisms into one of the five kingdoms: Animal, Plant, Fungus, Prokaryote, Protoctist. • List the main features used to place organisms into groups within the animal kingdom, limited to: ○ the main groups of vertebrates: mammals, birds, reptiles, amphibians, fish ○ the main groups of arthropods: myriapods, insects, arachnids, crustaceans.	Model cells are a good way of showing organelles. **(I)** Link to section 2.1 (next page, below) Images of the representative groups, preserved specimens or even live specimens can be used to identify some of the main features and classify animals into their respective groups. Mucor as a fungus can be grown and the gross structure studied under a light microscope. Emphasise the role of spores in dispersal. The use of the internet, photographs or specimens of the five groups of vertebrates can be used to draw up a table or produce a poster to include the main characteristics of each class. **(I)** Learners should understand the specific features that differentiate each class: e.g. birds have feathers, beaks, front limbs modified into wings and lay hard-shelled eggs. Specimens from each group of arthropod can be viewed under the microscope and the main features noted. Emphasis should be given to drawing clear diagrams in pencil. **(I)** Learners can draw a chart to list and then compare the distinguishing features of each group. **(I)** Working in pairs and using a check-list, learners can explore the school grounds and ‘tick off’ as many of the groups of animals as they can spot. Cladistics: www.evolution.berkeley.edu/evolibrary/article/phylogenetics_01 Preserved specimens if available, are excellent for explaining external features.
	• List the main features used to place organisms into groups	A similar activity can include plant groups as well as animal groups.

Syllabus ref.	Learning objectives	Suggested teaching activities
	within the plant kingdom, limited to ferns and flowering plants (dicotyledons and monocotyledons). • List the features of viruses, limited to protein coat and genetic material.	Viruses and bacteria should be studied from photomicrographs or diagrams but their relevance can be mentioned in nutrition and disease ref: Unit 2 and Unit 7. Positive applications of viruses and bacteria can be mentioned in Unit 2 and Unit 8. **Extension activity** – learners could be asked to search the ARKive database and compile a presentation of the listed groups of organisms. ***Suggested practical:*** View prepared specimens with light microscope. Live yoghurt culture and yeast cultures make good sources of bacteria and fungi. A comparison of monocots and dicots: www.csdl.tamu.edu/FLORA/201Manhart/mono.vs.di/monosvsdi.html Infectious diseases – pathogens: www.abpischools.org.uk/page/modules/infectiousdiseases_pathogens/index.cfm An excellent source for images and video clips of animals and plants is ARKive: www.arkive.org/
1.4 Dichotomous keys	• Construct and use simple dichotomous keys based on easily identifiable features.	Many learners have difficulty in constructing dichotomous keys. The concept can be introduced with coins or nails/screws with different shaped heads or even with postage stamps. The learners can then classify a selection of leaves from the school grounds or from a selection of small pictures of different arthropods. **Extension activity:** more complex keys could be used to identify local flora or fauna. **(I)** ***Suggested practicals:*** • Identification of local plants using classification keys. • Specimens of leaves or shells to prepare a simple key.
2.1 Cell structure and organisation	• Describe and compare the structure of a plant cell with an animal cell, as seen under a light microscope, limited to cell wall, nucleus, cytoplasm, chloroplasts, vacuoles,	Palisade cells can be seen using prepared slides or transparencies of leaf sections. **(I)** Learners can make their own slides of freshwater filamentous algae, *Elodea* or moss that can be mounted in a drop of water on a slide and viewed with a microscope. **(I)**

Syllabus ref.	Learning objectives	Suggested teaching activities
	ribosomes on rough endoplasmic reticulum, vesicles, and location of the cell membrane. • State the functions of the structures seen under the light microscope in the plant cell and in the animal cell. • State that almost all cells, except prokaryotes, have mitochondria and rough endoplasmic reticulum. • Identify mitochondria and rough endoplasmic reticulum in diagrams and images of cells. • State that aerobic respiration occurs in mitochondria. • State that cells with high rates of metabolism require large numbers of mitochondria to provide sufficient energy.	Liver cells are difficult to observe, but it may be possible to make temporary mounts of wrist cells. Wash the inside of the wrist and place a piece of scotch tape onto this part of the wrist. Pull off the scotch tape and view the cells under the microscope. **(I)** **Extension activity:** learners can also make models of a plant cell and/or an animal cell to gain an idea of the orientation of the main structures of each type of cell. Candidates should consider functions of features that are common to plant and animal cells and those that are found in plant cells only. **(I)** They should understand how the differences between animal and plant cells relate to their different methods of obtaining nutrients. Examine a temporary mount of epidermal tissue peeled from the inner surface of an onion bulb. **(I)** ***Suggested practicals:*** • Use of microscope, bioviewers or cellsalive.com website to look at palisade cells and liver cells. • Use of light microscopes to view specimens. **Resource Plus** **Experiment:** Cell structure This experiment focuses on the features of plant and animal cells that can be viewed under a light microscope. In this experiment, onion cells and human cheek cells are prepared on slides for viewing. Linked with 2.3 Size of specimens Illustrations of cells: www.cellsalive.com/ Revision – cell structure: www.s-cool.co.uk/gcse/biology/cells/revise-it/plant-and-animal-cells Video clip – cell structure: www.bbc.co.uk/learningzone/clips/plant-and-animal-cell-structures/4188.html

Syllabus ref.	Learning objectives	Suggested teaching activities
2.2 Levels of organisation	• Relate the structure of the following to their functions: ○ ciliated cells – movement of mucus in the trachea and bronchi ○ root hair cells – absorption ○ xylem vessels – conduction and support ○ palisade mesophyll cells – photosynthesis ○ nerve cells – conduction of impulses ○ red blood cells – transport of oxygen ○ sperm and egg cells – reproduction. • Define *tissue* as a group of cells with similar structures, working together to perform a shared function. • Define *organ* as a structure made up of a group of tissues, working together to perform specific functions. • Define *organ system* as a group of organs with related functions, working together to perform body functions. • State examples of tissues, organs and organ systems from sections 6 to 16.	The coverage of these examples of cells and of organs and organ systems could come later when they can be dealt with in context but it may help to introduce the learners to cells with different functions at this stage using a PowerPoint presentation. Learners can select their own specialised cell, draw and label it on A3 paper. **(I)** Flash cards are an interactive way of learning about specialised cells. Learners can draw a flow diagram from cells to the particular organ system to begin to understand the complexity of the human body. **(I)** An outline of the human body can be used to draw in the main organ systems of the body. **Extension activity:** learners could research a greater range of specialised cells. This could link to stem cells and their uses.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Identify the different levels of organisation in drawings, diagrams and images of familiar and unfamiliar material.	
2.3 Size of specimens	• Calculate magnification and size of biological specimens using millimetres and micrometres as units.	Use a temporary mount of epidermal tissue peeled from the inner surface of an onion bulb or rhubarb stem and use an appropriate scale to determine the size of cells. Learners can magnify a piece of hair to understand that magnification is: $\frac{\text{size of image}}{\text{size of object}}$ ***Suggested practical:*** Size/measurement exercises from photomicrographs. Microscope magnification specifications and field of view: www.microscope-microscope.org/advanced/magnification-1.htm Learner activity – specimen size: www.exploratorium.edu/imaging_station/activities/classroom/size/ca_size.php Relative sizes of cells: www.cellsalive.com/howbig.htm Scale: http://learn.genetics.utah.edu/content/cells/scale/
3.1 Diffusion	• Define *diffusion* as the net movement of particles from a region of their higher concentration to a region of their lower concentration down a concentration gradient, as a result of their random movement.	Use a simple demonstration of diffusion, for example a potassium manganate(VII) crystal in a gas jar of water or a drop of methylene dye on gelatine solidified in a test-tube (diffusion of a solute), or ammonia and hydrochloric acid placed at opposite ends of a long glass tube, or simply a perfume container opened in one corner of the room. Bromine in a gas jar (carried out in a fume cupboard) can quickly show diffusion (gaseous diffusion). Emphasise the random motion of particles.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Describe the importance of diffusion of gases and solutes. • State that substances move into and out of cells by diffusion through the cell membrane. • State that the energy for diffusion comes from the kinetic energy of random movement of molecules and ions. • Investigate the factors that influence diffusion, limited to surface area, temperature, concentration gradients and distance.	Variables of temperature, pressure, distance moved, concentration and size of particles. Consider the relevance of diffusion to living organisms – for example, the diffusion of oxygen and carbon dioxide into and out of a plant leaf or across the surface of the alveoli in the human lungs. **Extension activity:** learners could investigate the effects of surface area/volume ratio on rates of diffusion. ***Suggested practicals:*** • Demonstrate diffusion of alkaline or acidic gases along closed glass tubes using appropriate coloured litmus paper, or potassium manganate(VII) crystals dissolving in water. • Plan and investigate the factors (surface area, temperature, concentration gradient, distance) that affect the rate of diffusion using jelly/agar blocks in solutions of potassium manganate(VII). • Demonstrate diffusion though a membrane demonstrated with Visking tubing filled with iodine solution surrounded by a starch solution in a beaker. Practical biology – diffusion: www.nuffieldfoundation.org/practical-biology/diffusion Diffusion animation and text: www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/living/diffusionrev1.shtml

3.2 Osmosis	• Define *osmosis* as the diffusion of water from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a partially permeable membrane. • State that water moves in and out of cells by osmosis through the cell membrane. • Investigate and describe the effects on plant tissues of immersing them in different solutions by using the terms *turgid*, *turgor pressure*, *plasmolysis* and *flaccid*. • Explain the importance of water potential and osmosis in the uptake of water by plants. • Explain the importance of water potential and osmosis on animal cells and tissues. • Explain how plants are supported by the turgor pressure within cells, in terms of water pressure acting against an inelastic cell wall.	Emphasise that water is an important solvent and most cells contain about 75% water. Water transports substances and allows many chemical reactions to take place. Osmosis should be treated as a special case of diffusion, in which only *water* molecules are able to move from one side of a partially permeable membrane to another. Ensure that learners understand what a *solution* is in terms of particles, so that they are able to imagine the water molecules and solute particles behaving independently of each other. Use Visking tubing to demonstrate osmosis. **(I)** Investigation of changes in mass or length of potato chips or of dried raisins placed in a range of different concentrations of sugar solution provides a good opportunity for quantitative treatment of results, as well as enhancing understanding of osmosis. **(I)** Discuss differences in the effects of water uptake and loss on animal cells that lack a cellulose cell wall and plant cells that have a cellulose cell wall. Turgor as an important mechanism of support in plants could be discussed (Unit 3). Relate water uptake by osmosis to the structure of root hair cells covered earlier in this unit. Explain water potential as the tendency for water to leave a solution. The more water (that is then a more dilute the solution) the higher the water potential. Water moves from a high water potential to a low water potential – that is, down a water potential gradient. Do not introduce the idea of negative water potentials at this level. Relate to intake of water by root hairs. ***Suggested practicals:*** • Plant tissue, e.g. potato or other tissue – in salt/sugar solutions of different concentrations – measure mass or length of pieces. • Destruction of membranes by leakage of coloured plant sap, e.g. beetroot sections • Observe plasmolysis in red onion cells with microscope or on video. **Resource Plus** **Experiment:** Investigating osmosis This experiment focuses on the effect of osmosis on plant (potato) cells. Practical biology – osmosis: www.nuffieldfoundation.org/practical-biology/osmosis

Syllabus ref.	Learning objectives	Suggested teaching activities
		Osmosis animation and text: www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/greenworld/waterrev1.shtml Revision – osmosis: www.s-cool.co.uk/gcse/biology/cells/revise-it/moving-molecules
3.3 Active transport	• Define *active transport* as movement of particles through the cell membrane from a region of lower concentration to a region of higher concentration using energy from respiration. • Discuss the importance of active transport as a process for movement across membranes: ○ e.g. ion uptake by root hairs and uptake of glucose by epithelial cells of villi and kidney tubules. • Explain how protein molecules move particles across a membrane during active transport.	A simple explanation is climbing uphill. Learners will understand the importance of the movement of particles by active transport after having studied Unit 2, Unit 3 and Unit 5. Practical biology – active uptake: www.nuffieldfoundation.org/practical-biology/active-uptake
5.1 Enzymes	• Define the term *catalyst* as a substance that increases the rate of a chemical reaction and is not changed by the reaction. • Define *enzymes* as proteins that function as biological catalysts. • Describe why enzymes are important in all living organisms	Simple experiments with catalase are an excellent introduction to enzymes. Revise the meaning of the term 'catalyst'. Ensure that learners understand that enzymes are simple (protein) molecules, not living organisms. They cannot, therefore, be 'killed'. Investigate the effect of temperature on the effect of enzyme activity, for example using starch and amylase, or pepsin and milk powder. Explain the rise in activity with temperature, in terms of kinetic theory and the fall as temperature rises above the optimum in terms of denaturation of the enzyme molecules. Consider the different optimum temperatures of different enzymes, not only those in humans. **Extension activity:** learners could investigate the effectiveness of enzyme-based washing powders.

Syllabus ref.	Learning objectives	Suggested teaching activities
	in terms of reaction speed necessary to sustain life. • Describe enzyme action with reference to the active site, substrate, enzyme-substrate complex and product. • Describe and explain the specificity of enzymes in terms of the complementary shape and fit of the active site of an enzyme with the substrate. • Investigate, describe and explain the effect of changes in temperature on enzyme activity in terms of kinetic energy, shape and fit, frequency of effective collisions and denaturation. • Investigate, describe and explain the effect of changes in pH on enzyme activity in terms of shape and fit and denaturation.	Use the *kscience* animation on an interactive whiteboard to demonstrate enzyme actions. PowerPoint demonstrations and graphs to show the trends of increasing temperature and of different pH solutions provide useful means of interpreting data. The role of amylase in the breakdown of starch to maltose in seeds provides an example of enzymes in plants. Germinating barley seeds, dipped into a sterilising solution to destroy any micro-organisms on their surfaces, can be placed on sterile starch agar in a Petri dish, which can later be tested for starch with iodine solution. **Extension activity:** proteases, lipases and amylases, often with high optimum temperatures, are all used in biological washing products. Investigations can be carried out into the effectiveness of these in removing different types of stains. Simple experiments on the effect of pectinase on the yield of juice from crushed apples or tinned apple purée can be carried out. ***Suggested practicals:*** • Experimental investigation on (i) temperature, (ii) pH using buffers on catalase (from fresh plant tissue) / amylase (diastase / germinating seeds) / protease, e.g. trypsin / lipase / rennin / pectinase / or other available enzyme. • Important that planning of an enzyme investigation is carried out so that control variables and safety factors are fully realised. • Practical – germination of seeds – showing activity of enzymes from seeds breaking down starch in agar plates; or extracting enzymes from cotyledons and breaking down starch in solutions. Practical biology – enzymes: www.nuffieldfoundation.org/practical-biology/investigating-enzymes-used-laundry-detergents Simple account of how enzymes work: www.abpischools.org.uk/page/modules/enzymes/enzymes1.cfm Interactive model of enzyme action: www.kscience.co.uk/aanimations/model.swf

Syllabus ref.	Learning objectives	Suggested teaching activities
		Revision – enzymes: www.s-cool.co.uk/gcse/biology/enzymes/revise-it/enzymes

Past and specimen papers

Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

1.1
Jun 2011 Paper 22 Q1
Jun 2012 Paper 21 Q1
Jun 2013 Paper 21 Q1
2016 Specimen Paper 3 Q1

1.3
2016 Specimen Paper 3 Q2
Jun 2012 Paper 31 Q2
Jun 2013 Paper 22 Q1

1.4
Jun 2012 Paper 22 Q1
Jun 2012 Paper 33 Q1

2.2
Jun 2012 Paper 32 Q1

3.1
Jun 2012 Paper 21 Q3

5.1
Jun 2012 Paper 21 Q8
2016 Specimen Paper 3 Q4

2: Animal nutrition

Syllabus ref.	Learning objectives	Suggested teaching activities
4.1 Biological molecules	• List the chemical elements that make up: ○ carbohydrates ○ fats ○ proteins. • State that large molecules are made from smaller molecules, limited to: ○ starch and glycogen from glucose ○ cellulose from glucose ○ proteins from amino acids ○ fats and oils from fatty acids and glycerol. • State that water is important as a solvent. • Explain that different sequences of amino acids give different shapes to protein molecules. • Relate the shape and structure of protein molecules to their function, limited to the active site of enzymes	Ensure that learners have some understanding of the terms: element, atom, molecule. A simple definition of an organic substance is one whose molecules contain carbon and hydrogen. Beads that string together, or simple chemical modelling kits, can be used to illustrate the idea of small molecules joining together to make larger ones. A table or flash cards can identify the classes of foods. Headings: class of food; source of food; uses of food in body. **(I)** Once Unit 1 is completed, the enzymes and products of digestion could also be added to the summary table. Learners should understand that starch is the carbohydrate stored only in plants. Animals store carbohydrate as glycogen. Extend the use of coloured beads to demonstrate the importance of bead sequence. 3D models of proteins can be useful for showing features such as the active site.

Syllabus ref.	Learning objectives	Suggested teaching activities
	and the binding site of antibodies. • Describe the structure of DNA as: ○ two strands coiled together to form a double helix ○ each strand contains chemicals called bases ○ cross-links between the strands are formed by pairs of bases ○ the bases always pair up in the same way: A with T, and C with G (full names are not required). Describe the roles of water as a solvent in organisms with respect to digestion, excretion and transport.	
4.1 Biological molecules (food tests)	• Describe the use of: ○ iodine solution to test for starch ○ Benedict's solution to test for reducing sugars ○ biuret test for proteins ○ ethanol emulsion test for fats and oils ○ DCPIP test for vitamin C.	Learners should have the opportunity to carry out each of these tests on a range of foods. **(I)** It is a good practical lab in which learners should realise the importance of safety when using a water bath. **Extension activity:** learners can be given a solution containing a mixture of unknowns such as a reducing sugar and a protein. This can also give useful practice in recording qualitative results in a clearly presented results chart. Conclusions can also be written from the observed results. Food tests also enhance the learners' understanding of the main classes of foods. ***Suggested practicals:***

Syllabus ref.	Learning objectives	Suggested teaching activities
		• Carry out food tests for pure substances (fats, proteins, starch, glucose) on different foods. • It is important to be able to prepare the crushed or extracted food materials for comparative testing. Stress safety aspects of handling the reagents. • Use of 'dip' sticks – Clinistix and Albustix – used in health clinic testing of urine. • Estimation of vitamin C with coloured solutions, e.g. DCPIP – compare ascorbic acid with fruit juices. **Resource Plus** **Experiment:** Food tests This experiment focuses on testing for the presence of nutrients in a variety of foods. Five tests are covered: DCPIP test for vitamin C, the iodine test for starch, the biuret test for protein, the Benedict's test for non-reducing sugars, and the emulsion test for fats. Revision – Food tests: lgfl.skoool.co.uk/content/keystage4/biology/pc/modules/digestion/food_tests/index.html
7.1 Diet	• State what is meant by the term *balanced diet* for humans. • Explain how age, gender and activity affect the dietary needs of humans including during pregnancy and whilst breast-feeding. • Describe the effects of malnutrition in relation to starvation, constipation, coronary heart disease, obesity and scurvy.	Diets in most countries depend on a staple food such as bread, potatoes or rice, which is usually the main source of carbohydrate. Learners should be aware of the main sources of each type of nutrient in their own country, but also be prepared to consider how diets differ in other parts of the world. **Extension activity:** the Association for Science Education has a project called Science Across the World, which includes a unit on diet, and encourages schools in different parts of the world to share information. Learners can keep a record of the food that they eat during a short period of time and then consider whether they are obtaining the nutrients that they need. Their diet could be analysed using standard food tables or by accessing the nutrient data laboratory. Alternatively, learners could use the interactive balanced diet activity. **(I)** The information on multi-vitamin tablet packets lists the vitamin contents and their requirements in the human body. **Extension activity:** learners could carry out research into food composition using the site Nutrition.gov. A summary table could be produced with vitamins and minerals, their source, function in the body and details of deficiencies. **(I)**

Syllabus ref.	Learning objectives	Suggested teaching activities
	• List the principal sources of, and describe the roles of: ○ carbohydrates ○ fats ○ proteins ○ vitamins, limited to C and D ○ mineral salts, limited to calcium and iron ○ fibre (roughage) ○ water. • Explain the causes and effects of vitamin D and iron deficiencies. Explain the causes and effects of protein-energy malnutrition, e.g. kwashiorkor and marasmus.	Malnutrition should be considered as the result of eating an unbalanced diet, not just the lack of a particular type of nutrient. Controlled discussion on malnutrition can be useful and the problems associated with starvation can be linked to Unit 10. The long-term problems associated with obesity like late onset diabetes should be discussed. ***Suggested practicals:*** Measure energy content of food using a simple calorimeter. Compare energy content of different foods. Data can be found on food labels. Science Across the World – talking about food: www.nationalstemcentre.org.uk/elibrary/resource/1727/talking-about-food-food-nutrition-and-health Revision – balanced diet: lgfl.skoool.co.uk/content/keystage4/biology/pc/modules/digestion/balanced_diet/index.html National nutrient database: www.nal.usda.gov/fnic/foodcomp/search/ Interactive balanced diet: www.abpischools.org.uk/page/modules/balanceddiet/index.cfm Practical biology – energy in food: www.practicalbiology.org/areas/introductory/energy/energy-in-food Video clips – balanced diet: www.bbc.co.uk/learningzone/clips/a-balanced-diet/10609.html Science Across the World – keeping healthy: www.nationalstemcentre.org.uk/elibrary/resource/1741/keeping-healthy Revision – malnutrition: lgfl.skoool.co.uk/content/keystage4/biology/pc/modules/digestion/malnutrition/index.html

Syllabus ref.	Learning objectives	Suggested teaching activities
		Unit revision: www.s-cool.co.uk/gcse/biology/nutrition/revise-it/nutrition
7.2 Alimentary canal	• Define *ingestion* as the taking of substances, e.g. food and drink, into the body through the mouth • Define *mechanical digestion* as the breakdown of food into smaller pieces without chemical change to the food molecules. • Define *chemical digestion* as the breakdown of large, insoluble molecules into small, soluble molecules. • Define *absorption* as the movement of small food molecules and ions through the wall of the intestine into the blood. • Define *assimilation* as the movement of digested food molecules into the cells of the body where they are used, becoming part of the cells. • Define *egestion* as the passing out of food that	Learners often do not understand that the alimentary canal is a long tube - albeit a coiled one - through which food passes. A long flexible rubber tube can demonstrate the idea. A schematic diagram on A3 paper can clarify the main events that take place from ingestion by the mouth to egestion from the anus. Arrows in different colours can show which enzymes are involved along the canal. Learners should understand that food cannot be considered to have entered the body until it crosses the wall of the canal. The need for digestion to take place before absorption occurs is shown by using Visking tubing (to represent the alimentary canal) containing a mixture of glucose, starch and water. The Visking tubing is placed in a beaker or a large test-tube of water (to represent the blood), and left for several hours to allow the glucose to diffuse across the tubing. The contents of the tubing and of the beaker can be tested for starch and for glucose. **Extension activity:** the importance of active uptake could be considered. Digestion: www.abpischools.org.uk/res/coResourceImport/resources04/digestion/index.cfm **Resource Plus** **Experiment:** Digestion – model gut This experiment focuses on the need for digestion.

Syllabus ref.	Learning objectives	Suggested teaching activities
	has not been digested or absorbed, as faeces, through the anus. • Describe diarrhoea as the loss of watery faeces. • Outline the treatment of diarrhoea using oral rehydration therapy. • Describe cholera as a disease caused by a bacterium and explain that the cholera bacterium produces a toxin that causes secretion of chloride ions into the small intestine, causing osmotic movement of water into the gut, causing diarrhoea, dehydration and loss of salts from blood. • Identify the main regions of the alimentary canal and associated organs, limited to mouth, salivary glands, oesophagus, stomach, small intestine (duodenum and ileum), pancreas, liver, gall bladder and large	

Syllabus ref.	Learning objectives	Suggested teaching activities
	intestine (colon, rectum, anus). • Describe the functions of the regions of the alimentary canal listed above, in relation to ingestion, digestion, absorption, assimilation and egestion of food.	

Syllabus ref.	Learning objectives	Suggested teaching activities
7.3 Mechanical digestion	• Identify the types of human teeth (incisors, canines, premolars and molars). • Describe the structure of human teeth, limited to enamel, dentine, pulp, nerves and cement, as well as the gums. • Describe the functions of the types of human teeth in mechanical digestion of food. • State the causes of dental decay in terms of a coating of bacteria and food on teeth, the bacteria respiring sugars in the food, producing acid which dissolves the enamel and dentine. • Describe the proper care of teeth in terms of diet and regular brushing.	A model of a human skull or lower jawbone is a good way of showing the arrangement of teeth. **Extension activity:** different types of teeth could be studied and related to different diets. ***Suggested practicals:*** • Use mirrors to check own teeth, compare with the ideal set. • Swabs of teeth and saliva tested with indicator to show pH (safety – disinfectant to dispose of used equipment). • Observe diagrams or specimens of different animals' teeth. (Museum visit) Revision - digestion: lgfl.skoool.co.uk/content/keystage4/biology/pc/modules/digestion/digestion_part_1/index.html Video clips – digestion: www.bbc.co.uk/learningzone/clips/the-digestive-system/4180.html
7.4 Chemical digestion	• State the significance of chemical digestion in the alimentary canal in producing small, soluble molecules that can be absorbed	This topic should be linked with earlier work on enzymes, in Unit 1. Learners could draw a spider diagram of the alimentary canal. This can help them visualise from where the enzymes are secreted and where they act on specific substrates. **(I)** The importance of optimum pH and temperature should be emphasised, as well as the importance of enzymes in the whole process of digestion.

Syllabus ref.	Learning objectives	Suggested teaching activities

	• State the functions of enzymes as follows:
	  ○ amylase breaks down starch to simpler sugars
	  ○ protease breaks down protein to amino acids
	  ○ lipase breaks down fats to fatty acids and glycerol.
	
	• State where, in the alimentary canal, amylase, protease and lipase are secreted.
	
	• Describe the digestion of starch in the alimentary canal:
	  ○ amylase is secreted into the alimentary canal and breaks down starch to maltose
	  ○ maltose is broken down by maltase to glucose on the membranes of the epithelium lining the small intestine.
	
	• Describe pepsin and trypsin as two protease enzymes that function in different parts of the alimentary canal:
		The importance of emulsifiers (such as bile) can be demonstrated by attempting to mix oil with vinegar in the presence and absence of egg yolk.
		
		Suggested practicals:
		• Amylase – breakdown of starch using iodine test.
		• Link to model gut using Visking tubing.
		• Protease – with milk – breakdown of casein in milk or gelatine on photographic film or fresh meat.
		• Breakdown of fats to form acids with help of bile salts – litmus or pH indicator.
		
		Revision – digestion and absorption:
		lgfl.skoool.co.uk/content/keystage4/biology/pc/modules/digestion/digestion_part_2/index.html
		
		Emulsifiers:
		www.nuffieldfoundation.org/practical-chemistry/emulsifiers

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ pepsin in the stomach ○ trypsin in the small intestine. • State (explain) the functions of the hydrochloric acid in gastric juice, limited to: ○ killing bacteria by denaturing enzymes in harmful micro-organisms in food ○ giving an acid (optimum) pH for enzyme (pepsin) activity. • Outline the role of bile in neutralising the acidic mixture of food and gastric juices entering the duodenum from the stomach, to provide a suitable pH for enzyme action. • Outline the role of bile in emulsifying fats to increase the surface area for the chemical digestion of fat to fatty acids and glycerol by lipase.	
7.5 Absorption	• Identify the small intestine as the region for the	Core learners do not need any detail of the villus structure but they need to understand that the dissolved substances, glucose and amino acids, are transported in the blood to the liver before they can be assimilated into the body.

Syllabus ref.	Learning objectives	Suggested teaching activities
	absorption of digested food. • Describe the significance of villi and microvilli in increasing the internal surface area of the small intestine. • Describe the structure of a villus. • Describe the roles of capillaries and lacteals in villi. • State that water is absorbed in both the small intestine and the colon, but that most absorption of water happens in the small intestine.	It helps the learners to understand the importance of diffusion if the villus is compared with the alveoli in the lungs, Unit 4. The two structures can be compared as having a single cell membrane, good blood supply, moist surface area and a large surface area for efficient diffusion. The absorption of glucose should be linked with earlier work on active transport in Unit 1. ***Suggested practicals:*** Bioviewers and microscope to study wall of small intestine. Revision – digestion: www.s-cool.co.uk/gcse/biology/nutrition/revise-it/digestion

Past and specimen papers

Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

7.1	**7.2**	**7.3**
Jun 2011 Paper 21 Q2 Jun 2011 Paper 22 Q2 Jun 2011 Paper 22 Q6b	Jun 2012 Paper 31 Q1 Jun 2013 Paper 21 Q3	Jun 2013 Paper 21 Q3(c)

3: Plant nutrition and transport

Syllabus ref.	Learning objectives	Suggested teaching activities
6.1 Photosynthesis	• Define *photosynthesis* as the process by which plants manufacture carbohydrates from raw materials using energy from light. • State the word equation for photosynthesis: carbon dioxide + water → glucose + oxygen, in the presence of light and chlorophyll. • State the balanced chemical equation for photosynthesis $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$. • Explain that chlorophyll transfers light energy into chemical energy in molecules, for the synthesis of carbohydrates. • Outline the subsequent use and storage of the carbohydrates made in photosynthesis. • Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls. • Investigate and describe the effects of varying light intensity,	Plants can be considered as food factories, in which all the food in the world is initially made. Learners should compare the needs of animals for organic nutrients, in Unit 2, with those of plants, which only require inorganic compounds such as carbon dioxide and water for photosynthesis. Consumers compared with producers, this is a cross-link to Unit 10. The process of photosynthesis should be considered at a fairly basic level, the light-dependent and light-independent stages should not be introduced. The important point to get across is the conversion of light energy to chemical energy. Chlorophyll absorbs light energy and enables it to be used to drive the reactions. (Ensure that learners do not think that chlorophyll attracts light.) The initial products of photosynthesis are sugars (such as glucose) which can be converted to large, insoluble molecules such as starch for storage within the plant. Reference to fertilisers and agriculture in Unit 10. There is a wide variety of practical work that can be carried out. Learners should know how to test a leaf for starch and to carry out simple experiments into the need for light and chlorophyll for photosynthesis. The importance of controlled variables such as temperature can be introduced. The concentration of carbon dioxide can be changed using sodium hydrogen carbonate solution of different concentrations. The exchange of gases can be more easily understood when the structure of the leaf has been studied (in Unit 3). Investigations with Elodea (Canadian pondweed) can produce good quantitative data to illustrate the effect of light on the rate of photosynthesis. Light can be the limiting factor.

Syllabus ref.	Learning objectives	Suggested teaching activities
	carbon dioxide concentration and temperature on the rate of photosynthesis, e.g. in submerged aquatic plants. • Define the term *limiting factor* as something present in the environment in such short supply that it restricts life processes. • Identify and explain the limiting factors of photosynthesis in different environmental conditions. • Describe the use of carbon dioxide enrichment, optimum light and optimum temperatures in glasshouses in temperate and tropical countries. • Use hydrogencarbonate indicator solution to investigate the effect of gas exchange of an aquatic plant kept in the light and in the dark.	Temperature could also be considered as a limiting factor but this is not so easy to carry out in the school lab. Graphs of processed data can be used in class discussions on limiting factors. Strawberries, raspberries, rhubarb and cucumbers can be grown in glasshouses/under plastic covers where the carbon dioxide content can be increased and the temperature kept warm for maximum photosynthesis. ***Suggested practicals:*** • Carry out a starch test on a leaf using a green leaf and a variegated leaf to show the necessity for chlorophyll. Keep the leaf in the dark for 12 hours to destarch. • Find the effect of lack of light on formation of starch by masking an area with dark card. • There are numerous methods to measure the rate of photosynthesis. 1) use a simple apparatus, e.g. inverted filter funnel to demonstrate and collect oxygen bubbles from water weed, 2) use of hydrogencarbonate indicator – observe change from red to purple by water weed / algae in alginate beads, 3) measure the rate of water-saturated leaf discs to float in a large syringe. The effects of various independent variables (light intensity, light wavelength, carbon dioxide concentration) on the rates of photosynthesis can be planned and measured. The importance of key control variables, e.g. temperature, photosynthetic tissues, should be emphasised. **Resource Plus** **Experiment:** Investigating photosynthesis This experiment focuses on the effect of light intensity on the rate of photosynthesis using pondweed. Practical biology – photosynthesis: www.nuffieldfoundation.org/practical-biology/photosynthesis PowerPoint and worksheets: www.saps.org.uk/secondary/teaching-resources/134-photosynthesis-a-survival-guide Simple photosynthesis experiments: www.saps.org.uk/secondary/teaching-resources/190-using-cabomba-to-demonstrate-oxygen-evolution-in-the-process-of-photosynthesis-

Syllabus ref.	Learning objectives	Suggested teaching activities
		Investigating the behaviour of leaf discs: www.saps.org.uk/secondary/teaching-resources/284-investigating-the-behaviour-of-leaf-discs- Data logging: www.pascophysics.com/file_downloads/experiments/pdf-files/glx/biology/06-Photosynthesis-SV.pdf Investigating photosynthesis using algal balls: www.saps.org.uk/secondary/teaching-resources/235-learner-sheet-23-photosynthesis-using-algae-wrapped-in-jelly-balls Comparison with sun and shade plants: www.saps.org.uk/secondary/teaching-resources/113-the-response-of-leaf-discs-from-sun-and-shade-plants-to-green-light
6.2 Leaf structure	• Identify chloroplasts, cuticle, guard cells and stomata, upper and lower epidermis, palisade mesophyll, spongy mesophyll, vascular bundles, xylem and phloem in leaves of a dicotyledonous plant. • Explain how the internal structure of a leaf is adapted for photosynthesis	Before considering the appearance of a section through a leaf, learners should look at entire leaves and consider how they are adapted for photosynthesis. A section through a leaf can be shown on PowerPoint or from a model of a leaf (plant images available from the database – plantscienceimages.org.uk). A simplified, labelled diagram should be made of a leaf section and the different parts discussed. **(I)** Learners should be familiar with the structure of a palisade cell and they can discuss how it is specialised for photosynthesis. The role of the upper epidermis that allows the maximum sunlight to reach the palisade layers should be mentioned. It can be helpful to think of a leaf as an organ that: • takes in the raw inorganic materials • uses light energy to convert the materials into chemical energy producing organic products. Drawings of leaves, and comparisons between two or more different kinds of leaves, make good practice or assessment material for the practical skills of observation and recording, and also for magnification calculations in Unit 1. **(I)** It is probably best not to go into any detail at this point about xylem and phloem function; they will be covered further later in Unit 3.

Syllabus ref.	Learning objectives	Suggested teaching activities
		Suggested practicals: • Prepare surface views of epidermis to show distribution of stomata – stomatal index. • Use of bioviewers or microscopes to observe sections of leaves.
6.3 Mineral requirements	• Describe the importance of: ○ nitrate ions for making amino acids ○ magnesium ions for making chlorophyll. • Explain the effects of nitrate ion and magnesium ion deficiency on plant growth.	Learners should be reminded that carbohydrates contain carbon, hydrogen and oxygen only; plants can therefore make these from carbon dioxide and water. However, proteins also contain nitrogen, so a nitrogen source is necessary before some of the carbohydrate can be converted to protein. Nitrate ions from the soil are the main source of nitrogen for plants. This should be dealt with simply, considering the effects on a growing plant of a shortage of proteins or chlorophyll. **Extension activity:** learners could plan an experiment to investigate mineral requirements in plants. **(I)** A comparison can be made when plants are grown in culture solutions lacking magnesium, nitrates and a control. After a few weeks, the growth of each plant can be compared. ***Suggested practical:*** Set up a simple mineral nutrition experiment with controls to grow cereal seedlings for a few weeks. Practical biology – minerals: www.nuffieldfoundation.org/practical-biology/investigating-effect-minerals-plant-growth
8.1 Transport in plants	• State the functions of xylem and phloem. • Identify the position of xylem and phloem as seen in sections of roots, stems and leaves, limited to non-woody dicotyledonous plants.	Root hair cells may already have been covered in Unit 1 as an example of a specialised cell. Here root hair cells are dealt with in the context of the whole plant. Osmosis may need to be revised before discussing the uptake of water through the soil, across the root and up through xylem vessels and into the leaves. It should be emphasised that mineral ions enter the roots dissolved in water. Xylem vessels may have been discussed in Unit 1 and earlier in Unit 3. Here xylem vessels are considered in the context of water transport from root to leaves. The structure of xylem vessels should be simply covered stating that the vessels are made of a long column of dead, empty cells with lignified walls, stacked end to end. Xylem vessels provide support to the plant. Learners will find the path taken by the water easier to understand if they have some knowledge of the position of the vascular bundles in the plant. Simple diagrams can be made of the transport system of a root and of a stem, showing the position of the xylem and phloem. **(I)** Large and semi-transparent stems, such as the leaf petioles of celery, can be placed with their bases in a solution of a water-soluble dye (ink or food colouring). After a few days, the dye can be seen in

Syllabus ref.	Learning objectives	Suggested teaching activities
		the xylem vessels, spreading out into the veins in the leaves. If thin sections are cut, the positions of the xylem vessels show up clearly. ***Suggested practicals:*** • Examine whole young herbaceous dicotyledonous plants to observe roots and aerial parts. Grow from seed in pots (link to later sections on growth and germination). • Use of bioviewers or microscopes with prepared slides or photomicrographs. Practical biology – transport in plants: www.nuffieldfoundation.org/practical-biology/investigating-transport-systems-flowering-plant Revision – plant transport: lgfl.skoool.co.uk/content/keystage4/biology/pc/lessons/uk_ks4_plant_transport/h-frame-ie.htm
8.2 Water uptake	• Identify root hair cells, as seen under the light microscope, and state their functions. • Explain that the large surface area of root hairs increases the rate of the absorption of water by osmosis and ions by active transport. • State the pathway taken by water through root, stem and leaf as root hair cell, root cortex cells, xylem and mesophyll cells. • Investigate, using a suitable stain, the pathway of water through the above ground parts of a plant.	The structure of the root hairs can be compared with those of the villi and alveoli in their adaptation to their function of diffusion. (Link to Unit 2 and Unit 4.) **Extension activity:** root hairs can be looked at under a microscope from seeds germinated on cotton wool or blotting paper. **(I)** ***Suggested practicals:*** • Observe root hairs on plants and use hand lens. View under microscope or in photomicrographs. • Measure the rate of food colouring or eosin dye uptake in celery stems and leaves. Solutions must be filtered first and the stems recut under water. Cut cross-sections through the stems and leaves and observe with a hand lens.

Syllabus ref.	Learning objectives	Suggested teaching activities
8.3 Transpiration	• State that water is transported from the roots to leaves through the xylem vessels. • Define *transpiration* as loss of water vapour from plant leaves by evaporation of water at the surfaces of the mesophyll cells followed by diffusion of water vapour through the stomata. • Explain how water vapour loss is related to the large surface area of cell surfaces, interconnecting air spaces and stomata. • Explain the mechanism by which water moves upwards in the xylem in terms of a transpiration pull that draws up a column of water molecules, held together by cohesion. • Explain how and why wilting occurs. • Investigate, describe and explain the effects of variation of temperature and humidity on transpiration rate.	It is important to understand that transpiration involves the loss of water vapour from the underside of the leaf, mostly through open stomata. Water in the cell walls of mesophyll cells evaporates and diffuses through the air spaces and out of the leaf. The effect of transpiration in pulling water up xylem vessels can be compared to the effect of sucking a liquid up a straw. Wilting is a good way for a plant to avoid further water loss, by reducing the leaf area from which evaporation can occur. The concept of turgor can be mentioned as the leaf cells wilt and become flaccid. Candidates may already have met the term 'water potential' in Unit 1. In normal conditions, the water potential in the air is lower than that in the soil solution. Thus water moves down a water potential gradient as it moves from soil to air, through the plant. If learners are shown a wilting plant, they can think about why it is only the leaves that wilt. This can introduce the idea of xylem vessels, present in vascular bundles in leaves and stem, helping with support. Experiments using potometers not only help learners to understand the effects of environmental factors on the rate of transpiration, but also provide good opportunities to improve, or to be assessed on, all four experimental skills. It is important, however, that it is understood that a potometer measures water uptake, which is not absolutely the same as water loss. There is no need for elaborate potometers, a long piece of capillary tubing with a length of rubber tubing at one end into which the cut end of a shoot is pushed is effective. All the apparatus and cut twigs should be kept under water while assembling the apparatus, to avoid air locks. Laurel or Ash leaves work well. The experiments can be extended by removing one leaf from the branch and recording the reduced water uptake. This is repeated until no leaves remain. A graph showing a reduction in water loss (uptake by the potometer) with fewer leaves illustrates the effect of the number of leaves on the transpiration process. Transpiration can also be investigated by using a hair dryer to vary the humidity. **Extension activity:** use of dataloggers to investigate transpiration rates. Although learners should look at examples of plant adaptations using plants that grow locally, it is also very useful to think about plants that grow in especially wet or dry environments, such as rainforests or deserts. ***Suggested practicals:*** • Use of bioviewers or microscopes to observe TS section of leaf. Photomicrographs.

Syllabus ref.	Learning objectives	Suggested teaching activities
		• Preparation of epidermis to show surface view of stomata – wax impression, or peel of nail varnish layer. Some leaves are easier than others to tear in order to obtain a separate epidermis to study. Tradescantia, (has different coloured guard cells compared with epidermis); Peperonia. • Leave cut shoot without water for wilting. • Use of potometer or flasks on top pan balance to show water loss in mass under different conditions, e.g. humidity and temperature. • Use of capillary tubing potometer to measure rate of water uptake to quantify this rate of water uptake. • Observe leaves of succulents, water weeds. Practical biology – transpiration: www.nuffieldfoundation.org/practical-biology/estimating-rate-transpiration-plant-cutting Data logging: www2.vernier.com/sample_labs/BWV-10-COMP-transpiration.pdf Measuring stomatal density: www.saps.org.uk/secondary/teaching-resources/299-measuring-stomatal-density-
8.4 Translocation	• Define *translocation* in terms of the movement of sucrose and amino acids in phloem: ○ from regions of production (source) ○ to regions of storage OR to regions where they are used in respiration or growth (sink) • Explain that some parts of a plant may act as a source and a sink at different times during the life of a plant.	This idea will probably already have been met earlier in this Unit, when discussing the functions of leaves. Here it should be re-emphasised that carbohydrates are transported through a plant in the form of soluble carbohydrates such as sucrose, glucose and proteins as amino acids through the phloem tubes. No detail of phloem structure or function is required. It should be made clear that substances can be transported in any direction in phloem, for example from photosynthesising leaves down to roots for storage or upwards to growing buds, flowers, leaves and fruits for respiration and growth. Translocation also occurs from storage organs such as the root tubers to all parts of the plant. **Extension activity:** consideration of the effects of ringing a tree can help learners to bring together their knowledge of stem structure and function. Ringing removes the phloem, which is near to the surface of a stem. If the ring is cut below the leaves, then all the cells beneath the ring are deprived of products of photosynthesis from the leaves, and eventually die. Grey squirrels and other small mammals gnaw the bark and destroy the phloem that is in the inner bark region.

Syllabus ref.	Learning objectives	Suggested teaching activities
		This section can be explained by drawing a coloured flow diagram to indicate the movement of the solutes to and from different parts of a plant. **(I)** The learners need to understand the term source as where the substance is produced or enters the plant. • sucrose is produced in the leaves • nitrates are absorbed by the root hairs. The term sink refers to the part of the plant where the substrate can be stored. • starch in roots or stem • amino acids in the root tips. Transpiration is important in relocating substances dissolved in water, cell sap such as amino acids. Learners studying the supplement may discuss the role of water in the production of carbohydrates during photosynthesis and their subsequent translocation throughout the plant. ***Suggested practicals:*** • Use of bioviewers or microscopes to study phloem. • Cut bark of tree on one side to observe 'sap' escaping. Analyse sap for sugars or test stickiness.

Past and specimen papers

Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

6.1
Jun 2011 Paper 22 Q7(b)
Jun 2012 Paper 22 Q3
Jun 2012 Paper 33 Q3

6.2
Jun 2011 Paper 22 Q7(a)
Jun 2011 Paper 32 Q6

6.3
Jun 2011 Paper 31 Q5(d)
Jun 2012 Paper 22 Q3

8.1
Jun 2012 Paper 21 Q9
Jun 2013 Paper 22 Q6
Jun 2013 Paper 23 Q1

8.2
Jun 2013 Paper 22 Q6

8.3
Jun 2011 Paper 31 Q5
Jun 2011 Paper 21 Q9

8.4
Jun 2011 Paper 32 Q6(d)
Jun 2012 Paper 21 Q9(b)

4: Respiration and the human transport system

Syllabus ref.	Learning objectives	Suggested teaching activities
12.1 Respiration	• State the uses of energy in the body of humans: muscle contraction, protein synthesis, cell division, active transport, growth, the passage of nerve impulses and the maintenance of a constant body temperature. • State that respiration involves the action of enzymes in cells.	Learners should understand that respiration is a reaction (or series of reactions) that takes place inside living cells: cell respiration. A very common error is to confuse it with breathing, and to think that it takes place only in the lungs. Learners should also realise that every living cell, including plant cells, respire. Explain that carbon dioxide has to be removed from respiring cells. Introduction to respiration: www.biotopics.co.uk/humans/respro.html
12.2 Aerobic respiration	• Define *aerobic respiration* as the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy. • State the word equation for aerobic respiration as glucose + oxygen → carbon dioxide + water. • State the balanced chemical equation for aerobic respiration as $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$. • Investigate the uptake of oxygen by respiring organisms, such as arthropods and germinating seeds	Emphasise that the function of respiration is to release energy from food (usually glucose) in a form that the organism can use. Learners should not state that respiration 'produces' energy. A class discussion will probably pick out a good range of uses of energy. It can be helpful to compare respiration with combustion - the overall equation is the same, but respiration occurs in a series of small reactions that do not suddenly release large amounts of heat energy. (Link to carbon cycle in Unit 9). The energy content of a food, such as a potato crisp or a cube of bread, can be estimated by allowing it to heat a known volume of water as it burns in air. This investigation is often done using peanuts, but teachers should be aware that an increasing number of children are allergic to nuts. This investigation can include variables such as volume of water and the mass of carbohydrate. Discussion about the errors and limitations of the investigation show the learners that science experiments can be inaccurate. **Extension activity:** use of a calorimeter to demonstrate a more accurate method of determining energy content. **Extension activity:** aerobic respiration can also be studied in small invertebrates, maggots or woodlice, or germinating seeds such as mung beans, suspended over a solution of hydrogen carbonate for a few days.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Investigate the effect of temperature on the rate of respiration of germinating seeds	***Suggested practical:*** Investigate respiration rate of germinating seedlings or arthropods at different temperatures using a simple respirometer (absorb carbon dioxide from the system so that oxygen uptake can be measured).
12.3 Anaerobic respiration	• Define *anaerobic respiration* as the chemical reactions in cells that break down nutrient molecules to release energy without using oxygen. • State the word equations for anaerobic respiration in muscles during vigorous exercise (glucose → lactic acid) and the microorganism yeast (glucose → alcohol + carbon dioxide). • State the balanced chemical equation for anaerobic respiration in the microorganism yeast as $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$. • State that anaerobic respiration releases much less energy per glucose molecule than aerobic respiration. • State that lactic acid builds up in muscles and blood during vigorous exercise causing an oxygen debt. • Outline how the oxygen debt is removed during recovery, limited to:	Anaerobic respiration can be investigated using a suspension of yeast in boiled, cooled water. Boiling drives off all dissolved oxygen. The carbon dioxide released can be detected by passing it through limewater or hydrogencarbonate indicator solution. Anaerobic respiration in muscles can be considered when investigating physical activity in Unit 4. **Extension activity:** fermentation experiments. The effects of sugar concentration or ascorbic acid on yeast fermentation in the production of bread could be investigated. It helps learners to understand oxygen debt if they know that lactic acid is oxidised after the exercise in the liver by the extra oxygen provided by fast breathing. ***Suggested practicals:*** Prepare culture of yeast in sugar solution. Observe production of CO_2 by bubbling into water.

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ aerobic respiration of lactic acid in the liver ○ continuation, after exercise, of fast heart rate to transport lactic acid in blood from muscles to the liver ○ continuation, after exercise, of deeper breathing supplying oxygen for aerobic respiration of lactic acid.	
11.1 Gas exchange in humans	• List the features of gas exchange surfaces in humans, limited to large surface area, thin surface, good blood supply and good ventilation with air. • Name and identify the lungs, diaphragm, ribs, internal and external intercostal muscles, larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries. • State the functions of the cartilage in the trachea. • Explain the role of the ribs, the internal and external intercostal muscles and the diaphragm in producing volume and pressure changes leading to the ventilation of the lungs. • State and explain the differences in composition	The idea of gaseous exchange may already have been discussed in Unit 3, in the context of the intake and loss of gases from leaves. A gaseous exchange surface can be defined as a surface across which gases pass as they enter or leave the body. For animals, oxygen enters as carbon dioxide leaves. Learners should relate their understanding of diffusion to the structure of the alveoli and cross reference to Unit 2 and Unit 3. Learners should be able to locate each structure on a diagram and to understand that there are two bronchi and several bronchioles. **(I)** (Link to transport in Unit 4.) Learners should link the structure of the respiratory organs in the Core with the muscles involved in breathing. A wooden or plastic model of the intercostal muscles can clarify the action. Learners often find the topic of rib structure and musculature difficult and it is a good idea to use a model of some kind to illustrate how increasing the volume of the thorax leads to a reduction in pressure. The balloons in a bell jar model, shows this effectively. Physics learners can relate the action to that of an engine piston. The differences between expired and inspired air, in terms of carbon dioxide content and water vapour content, should be investigated experimentally. Limewater or hydrogencarbonate indicator may be used to test for carbon dioxide. Pie charts or tables showing the percentage composition of air are useful and show that nitrogen remains constant. Learners should be able to use their knowledge of gas exchange and respiration to explain these differences.

Syllabus ref.	Learning objectives	Suggested teaching activities
	between inspired and expired air. • Use limewater as a test for carbon dioxide to investigate the differences in composition between inspired and expired air. • Investigate, describe and explain the link between physical activity on rate and depth of breathing in terms of the increased carbon dioxide concentration in the blood, detected by the brain, causing an increased rate of breathing. • Explain the role of goblet cells, mucus and ciliated cells in protecting the gas exchange system from pathogens and particles.	The link between physical activity and rate and depth of breathing should be investigated experimentally. A simple, repeatable form of exercise, such as step-ups, is the most useful for generating quantitative results. Learners can plan their own investigation by comparing activities such as walking, running, skipping or hopping with definite constant variables of time/distance. The importance of three or five trials per exercise can be introduced to obtain the mean of the raw data and to identify anomalies. Learners should use their knowledge of aerobic and anaerobic respiration to explain why breathing rate does not drop immediately to normal when exercise stops. The concept of breathing rate/pulse rate at rest can be introduced. Learners should begin to understand the link between carbon dioxide in the blood and the change of the bloods pH due to carbonic acid. The increase of tidal volume with increased exercise should be understood. The cilia are fine hairs that trap the mucus secreted by the goblet cells. Learners can consider the role of the mucus in relation to coughing, pneumonia and tuberculosis. Asthma may be discussed if appropriate. Unit 5 (Drugs) includes smoking and its effects on the body. Teachers could discuss smoking in this unit. earners should understand that: • cilia become less active, and goblet cells more active, when exposed to cigarette smoke, so that mucus collects in the lungs • bacteria are likely to breed in the mucus, leading to bronchitis and other infections • alveoli lose their elasticity, and coughing may damage their walls, leading to breathlessness and eventually to emphysema • cancer can be triggered by exposure to many of the chemicals in tar. This topic may interest learners and the teacher can ask them to conduct a survey, design a poster on the effects of smoking or prepare a PowerPoint display. The teacher could mention the addictiveness of smoking due to the nicotine and how smoking can lead to taking non-prescribed drugs such as marijuana. Smoking machines where a cigarette is connected to a filter and the air is drawn through the cigarette by a water pump shows the tar extracted from one cigarette.

Syllabus ref.	Learning objectives	Suggested teaching activities
		Suggested practicals: • Obtain a set of lungs from legal source to pump air into lungs (car tyre pump) to observe rise and fall. • Demonstrate indicator colour changes of exhaled air – limewater and hydrogencarbonate. • Compare inhaled and exhaled air using simple apparatus (huff-puff apparatus mouthpiece with tubing). • Use of bell jar apparatus with rubber sheet for diaphragm. • Use of spirometer and recording or use large diagram to show apparatus. • Vital capacity – use balloons or inverted plastic container of bell jar with measurements to determine vital capacity. • Plan experiments, to include control variables, to investigate the effects of physical activity on the rate and depth of breathing. This could be linked with a similar experiment with pulse rate as the dependent variable. Practical biology – gas exchange: www.nuffieldfoundation.org/practical-biology/ventilation-systems Breathing and asthma: www.abpischools.org.uk/res/coResourceImport/resources04/asthma/index.cfm Measuring lung capacity: www.biologycorner.com/worksheets/lungcapacity.html
9.1 Transport in animals	• Describe the circulatory system as a system of blood vessels with a pump and valves to ensure one-way flow of blood. • Describe the single circulation of a fish. • Describe the double circulation of a mammal. • Explain the advantages of a double circulation.	It is recommended that the idea of a double circulatory system, in which blood passes twice through the heart during one complete circuit of the body, is covered here, as this helps to make sense of the structure and function of the heart. Heart and circulation: www.abpischools.org.uk/res/coResourceImport/resources04/heart/index.cfm

Syllabus ref.	Learning objectives	Suggested teaching activities
9.2 Heart	• Name and identify the structures of the mammalian heart; muscular wall, the septum, the left and right ventricles and atria, one-way (atrioventricular and semilunar) valves and coronary arteries. • State that blood is pumped away from the heart into arteries and returns to the heart in veins. • Explain the relative thickness: ○ of the muscle wall of the left and right ventricles ○ of the muscle wall of the atria compared to that of the ventricles. • Explain the importance of the septum in separating oxygenated and deoxygenated blood. • Describe the functioning of the heart in terms of the contraction of muscles of the atria and ventricles and the action of the valves. • State that the activity of the heart may be monitored by ECG, pulse rate and listening to sounds of valves closing.	Diagrams of the heart, showing both external and internal structure, need to be known. Learners could be asked to label a diagram. Ensure that learners realise that both sides of the heart beat together. The direction of blood flow through the heart, the separation of oxygenated and deoxygenated blood, and the functions of the valves should be understood. A model of the heart can be useful when explaining the structure. Diagrams with blue and red arrow lines will help learners to learn the structure of the heart. Learners need to understand that the left ventricle has a thicker muscular wall than the right ventricle. **Extension activity:** a lamb's heart (or whatever is easily available) can be used for dissection. The understanding of the roles of the heart valves can be linked to the double circulatory system in Unit 4. The role of the coronary arteries in supplying the heart muscle with oxygen should be understood. Learners could explore the issues and treatment options for babies born with a 'hole in the heart'. The effect of exercise on heart beat relates closely to the effects of physical activity on rate and depth of breathing, dealt with earlier in this unit. Learners may already have some ideas about factors that increase the likelihood of suffering from heart disease and class discussion will probably bring out most of the major influences. A person's genes are also thought to play a major role in this. There is scope for discussion on the effects of diet, exercise, smoking on the health of the heart throughout a person's life. Stress can cover many situations but at a simple level, learners can understand that problems at work and in the family cause stress and may increase blood pressure in adults. Blockage of the arteries can be covered here as the build-up of plaque. The importance of the coronary arteries in heart disease and the link to a diet high in saturated fats should be made. **Extension activity:** reference could be made to obesity and the possible connection with heart disease.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Investigate, state and explain the effect of physical activity on the pulse (heart) rate. • Describe coronary heart disease in terms of the blockage of coronary arteries and state the possible risk factors as diet, stress, smoking, genetic predisposition, age and gender. • Describe the roles of diet and exercise in the prevention of coronary heart disease. • Describe ways in which coronary heart disease may be treated, limited to drug treatment with aspirin and surgery (stents, angioplasty and by-pass).	***Suggested practicals:*** • Obtain a fresh heart from a legal approved source to demonstrate external and internal structures – especially thickness of the atrial and ventricular walls, the nature of the valves and coronary blood vessels. • Measure pulse rate at wrist. • Plan experiments, to include control variables, to investigate the effects of physical activity on pulse rate. This could be linked with a similar experiment with breathing rate as the dependent variable. **Resource Plus** **Experiment:** Heart dissection This experiment focuses on a heart dissection. Practical biology – heart dissection: www.nuffieldfoundation.org/practical-biology/looking-heart Practical biology – control of heart rate: www.nuffieldfoundation.org/practical-biology/observing-effects-exercise-human-body
9.3 Blood and lymphatic vessels	• Describe the structure and functions of arteries, veins and capillaries and explain how the structures are adapted for their functions. • State the function of arterioles, venules and shunt vessels. • Name the main blood vessels to and from the: ○ heart, limited to vena cava, aorta, pulmonary artery and pulmonary vein	Transparencies or microscope slides of sections through an artery and a vein can be used to help learners to understand the differences in structure. **(I)** A table can be used to compare the structure with the functions. Structure can be related to function between them. **(I)** Emphasise that arteries do not pump blood and that capillaries are one cell thick. Rubber tubing of different sizes can illustrate the difference between an arterial wall and the thinner walls of veins. Learners should understand that arteries have blood flowing at high pressure but at much lower pressure in veins. The narrow lumen of the arteries helps to maintain blood pressure while the large lumen of the veins reduces resistance to blood flow.

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ lungs, limited to the pulmonary artery and pulmonary vein ○ kidney, limited to the renal artery and renal vein. • Outline the lymphatic system in terms of lymphatic vessels and lymph nodes. • Describe the function of the lymphatic system in the circulation of body fluids and the protection of the body from infection.	***Suggested practical:*** Bioviewers of microscope slides of TS artery and vein to see the thickness of walls. Note the arteries and veins seen previously when looking at a fresh heart structure. **Online:** Video clip – human circulatory and digestive system: www.bbc.co.uk/learningzone/clips/human-circulatory-and-digestive-system/12224.html
9.4 Blood	• List the components of blood as red blood cells, white blood cells, platelets and plasma. • Identify red and white blood cells (lymphocytes and phagocytes), as seen under the light microscope, on prepared slides and in diagrams and photomicrographs. • State the functions of the following components of blood: ○ red blood cells in transporting oxygen, including the role of haemoglobin ○ white blood cells in phagocytosis (phagocytes) and antibody production (lymphocytes)	Learners should see transparencies or microscope slides of stained blood samples and be able to distinguish red cells, white cells and platelets. **(I)** They should understand that red cells transport oxygen and also carbon dioxide, and know that they contain haemoglobin but do not have a nucleus. Links can be made back to Unit 2 and the need for iron in the diet. Discuss the adaptations of red blood cells to their functions as reinforcement for the function of specialised cells, covered in Unit 1. White blood cells fight disease by providing protection from pathogens. They contain a nucleus and respond to different antigens. Clotting should be mentioned, as a mechanism to prevent loss of blood and entry of pathogens, but Core learners need no detail at all of how it takes place, other than that platelets are involved. Learners need to understand that fibrinogen is a soluble protein, which is converted to the insoluble fibrin when a blood vessel is damaged. Calcium is required for this, so links can be made back to Unit 2. **Extension activity:** learners could research haemophilia. Learners should appreciate the role of the plasma in transporting many substances including heat from the liver and muscles to all parts of the body.

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ platelets in clotting (as the conversion of fibrinogen to fibrin to form a mesh) and state the roles of blood clotting as preventing blood loss and preventing the entry of pathogens ○ plasma in the transport of blood cells, ions, soluble nutrients, hormones and carbon dioxide. • Describe the transfer of materials between capillaries and tissue fluid (details of the roles of water potential and hydrostatic pressure are not required).	Learners should understand that substances move from blood to tissues and vice versa by diffusion. (Link to respiration in Unit 4.) Tissue fluid can be thought of simply as plasma that has leaked out of capillaries. Diagrams can help learners understand this alternative transport system and links can be made to the lacteals in the villus and the absorption of fatty acids and glycerol: Unit 2. Lymphocytes are produced by lymph glands during an infection. ***Suggested practicals:*** • Use of photomicrographs of blood smears to identify blood cells. • Use of bioviewers or microscopes and prepared slides. For images of blood cells: www.exploratorium.edu/imaging_station/gallery.php Defending against disease: www.bbc.co.uk/schools/gcsebitesize/science/aqa/human/defendingagainstinfectionrev1.shtml
10.1 Diseases and immunity	• Define *pathogen* as a disease-causing organism. • Define *transmissible disease* as a disease in which the pathogen can be passed from one host to another. • State that the pathogen for a transmissible disease may be transmitted either through direct contact, e.g. through blood or other body fluids, or indirectly, e.g. from contaminated surfaces or food, from animals, or from the air.	A relatively simple approach to the complex topic of the body's various defences is required. Some white blood cells are phagocytes and the process of phagocytosis should be understood. Some white blood cells (lymphocytes) secrete antibodies (which are proteins) in response to contact with their particular antigen, which may be an invading pathogen or a foreign tissue that has been transplanted. This topic also links with kidney transplants, covered in Unit 5 – a transplanted organ triggers an immune response, antibodies are secreted and the organ may be rejected. ***Suggested practicals:*** • Make swabs from everyday objects on nutrient agar plates. Incubate for a few days at 25°C and count bacterial colonies. • Compare bacterial colonies from fingers before and after washing hands with different types of soaps using nutrient agar plates. Bacterial and viral infection activity: www.bbc.co.uk/schools/gcsebitesize/science/aqa/human/defendingagainstinfectionact.shtml

Syllabus ref.	Learning objectives	Suggested teaching activities
	• State that the body has defences: ○ mechanical barriers, limited to skin and hairs in the nose ○ chemical barriers, limited to mucus and stomach acid ○ cells; phagocytosis and antibody production by white blood cells ○ which can be enhanced by vaccination. • State that antibodies lock on to antigens leading to direct destruction of pathogens, or marking of pathogens for destruction by phagocytes. • Explain how each pathogen has its own antigens, which have specific shapes, so specific antibodies which fit the specific shapes of the antigens are needed. • Define *active immunity* as defence against a pathogen by antibody production in the body. • Explain that active immunity is gained after an infection by a pathogen, or by vaccination. • Explain the process of vaccination: ○ harmless pathogen given which has antigens	Infectious diseases – immunity: www.abpischools.org.uk/page/modules/infectiousdiseases_immunity/index.cfm **Resource Plus** **Experiment:** Disease transmission This experiment focuses on investigating the importance of hygiene.

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ antigens trigger an immune response by lymphocytes which produce antibodies ○ memory cells are produced that give long-term immunity. • Explain the role of vaccination in controlling the spread of diseases. • Explain that *passive immunity* is short-term defence against a pathogen by antibodies acquired from another individual, e.g. mother to infant. • State that memory cells are not produced in passive immunity. • Explain the importance of passive immunity for breast-fed infants. • State that some diseases are caused by the immune system targeting and destroying body cells, limited to Type 1 diabetes. • Explain the importance of hygienic food preparation, good personal hygiene, waste disposal and sewage treatment in controlling the spread of disease.	

Past and specimen papers

Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

12.3
Jun 2013 Paper 23 Q6

9.1
Jun 2013 Paper 21 Q8

9.2
Jun 2011 Paper 21 Q8
Jun 2012 Paper 22 Q2
Jun 2012 Paper 32 Q4
Jun 2013 Paper 22 Q8

9.3
Jun 2013 Paper 23 Q9

10
Jun 2012 Paper 31 Q4.
2016 Specimen Paper 3 Q6

5: Coordination, response and homeostasis

Syllabus ref.	Learning objectives	Suggested teaching activities
14.1 Nervous control in humans	• Describe a nerve impulse as an electrical signal that passes along nerve cells called neurones. • Describe the human nervous system in terms of: ○ the central nervous system consisting of brain and spinal cord ○ the peripheral nervous system ○ coordination and regulation of body functions. • Distinguish between voluntary and involuntary actions. • Identify motor (effector), relay (connector) and sensory neurones from diagrams. • Describe a simple reflex arc in terms of receptor, sensory neurone, relay neurone, motor neurones and effector. • Describe a reflex action as a means of automatically and rapidly integrating and coordinating stimuli with the responses of effectors (muscles and glands).	Diagrams or models can be used to illustrate the positions of the brain, spinal cord and peripheral nerves in the body. A model of the human skeleton can also be useful. Learners can label diagrams and should differentiate between the spinal cord and the vertebral column. Learners should be able to suggest voluntary and involuntary responses. They should understand that a voluntary action involves the brain in its initiation, that it is a conscious thought to make an action. Involuntary actions are automatic and faster than voluntary actions. Refer to heart beat in Unit 4 and peristalsis in Unit 2. The structure of nerve cells can lead into the role of a reflex arc. Learners can draw a diagram with annotated labels of a motor neurone. **(I)** The reflex arc is important to many organisms for self-protection. Learners will understand its structure if different reflexes are considered: knee jerk, touching a pin with one finger. It is important to understand the role of the spinal cord in a reflex action and the receptor and effector. Learners should understand that reflex actions are not learnt responses but automatic. This can be shown by the labels on the reflex arc as arm muscles contract and move away from the stimulus, or as salivary glands that respond to food when is in the mouth. ***Suggested practicals:*** • Demonstrations of size of neurones – bioviewers or photomicrographs. • Demonstrations of reflex actions – pupil/iris reflex, blinking, etc. • Plan an investigation to find speed of reaction – dropping the ruler or online tests. Practical biology – human sensation and perception: www.nuffieldfoundation.org/practical-biology/human-sensation-and-perception Practical biology – reflex actions: www.nuffieldfoundation.org/practical-biology/reflex-nerves-and-reactions

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Define a *synapse* as a junction between two neurones. • Describe the structure of a synapse, including the presence of neurotransmitter containing vesicles, the synaptic cleft and neurotransmitter receptor molecules. • Describe how an impulse triggers the release of a neurotransmitter from vesicles into the synaptic gap and how the neurotransmitter diffuses across to bind with receptor molecules, in the membrane of the neurone after the synaptic gap, causing the impulse to continue. • State that in a reflex arc the synapses ensure that impulses travel in one direction only. • State that many drugs, e.g. heroin act upon synapses.	This website has some ideas about reaction time: www.humanbenchmark.com/tests/reactiontime/index.php Measuring reaction time: www.bbc.co.uk/science/humanbody/sleep/sheep/
14.2 Sense organs	• Define *sense organs* as groups of receptor cells responding to specific stimuli: light, sound, touch, temperature and chemicals. • Identify the structures of the eye, limited to cornea, iris, pupil,	Learners should understand that there are different types of stimuli, chemical or mechanical and that a sense organ combines receptors with other cells. Simple experiments can demonstrate the response of sense organs. A circuit around the lab will allow all learners to investigate each stimulus and could include water at different temperatures, different smells, ability to distinguish colours (link to colour blindness) and ability to detect sound using a sound generator to change pitch and amplitude. The relation between the eye as a receptor and an effector in response to the stimulus of light can be used to reinforce the concept of a response to external stimuli.

Syllabus ref.	Learning objectives	Suggested teaching activities
	lens, retina, optic nerve and blind spot. • Describe the function of each part of the eye, limited to: ○ cornea – refracts light ○ iris – controls how much light enters pupil ○ lens – focuses light onto retina ○ retina – contains light receptors, some sensitive to light of different colours ○ optic nerve – carries impulses to the brain. • Explain the pupil reflex in terms of light intensity and pupil diameter (antagonistic action of circular and radial muscles in the iris). • Explain accommodation to view near and distant objects in terms of the contraction and relaxation of the ciliary muscles, tension in the suspensory ligaments, shape of the lens and refraction of light. • State the distribution of rods and cones in the retina of a human. • Outline the function of rods and cones, limited to greater sensitivity of rods for night	A model of the eye can be used to illustrate the relevant structures. **Extension activity:** a sheep's eye (or whatever is easily available) can be dissected in class. A large round flask containing fluorescein with a convex lens at the front can be used to show how light is focused on the retina (at the back of the flask). Learners can be given a large unlabelled diagram of the eye. Laminated cards on which the key labels are written can be used to actively label the eye diagram. The class can be divided into teams to ask questions about structure and function to aid learning and the understanding of the eye. Learners can use small mirrors to draw their own eye(s). If the eyes are moved up and down and from side to side, the whites of the eyes are seen. The pupil reflex is a good example of a reflex action. In it the pupil controls the amount of light falling on the retina for its protection. Learners can work in pairs and investigate the effect on the size of pupils of having the eyes closed for 10 seconds and then opened. The effect of a torch shone into the eye and the change in pupil size when looking at a near and then a distant object can all be investigated. Learners can record their results and compare their reactions. Accommodation is shown by reading and then looking outside to a distant object. Use 'CCC': Close vision: Ciliary muscles Contract. Rods and cones are light-sensitive receptor cells in the retina. Cones for colour in the fovea. Rods for light intensity throughout the retina. Extension activity: learners could investigate colour perception and colour blindness using Ishihara plates, or dot and cross diagrams which locate the blind spot. Possible link to genetics in Unit 8. ***Suggested practicals:*** • Test the distance between touch receptors on different parts of arm using two pins (blunt end) and blind folds.

Syllabus ref.	Learning objectives	Suggested teaching activities
	vision and three different kinds of cones absorbing light of different colours for colour vision. • Identify the position of the fovea.	• Temperature reception of differences not actual temperatures – compare with thermometers. • Opportunity to check colour vision with test charts or books. Revision – the eye: www.bbc.co.uk/schools/gcsebitesize/science/edexcel/electrical/thenervoussystemrev4.shtml www.s-cool.co.uk/gcse/biology/nerves-and-hormones/revise-it/the-eye Revision – reflex actions: www.bbc.co.uk/schools/gcsebitesize/science/aqa/human/thenervoussystemrev3.shtml
14.3 Hormones	• Define a *hormone* as a chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs. • Identify specific endocrine glands and their secretions, limited to adrenal glands and adrenaline, pancreas and insulin, testes and testosterone and ovaries and oestrogen. • Describe adrenaline as the hormone secreted in 'fight or flight' situations and its effects including; increased breathing and pulse rate and widened pupils. • Discuss the role of the hormone adrenaline in the chemical control of metabolic activity, including increasing the blood glucose concentration.	Use a simple diagram of the human body to show the source and the site of action of different hormones. **(I)** Learners will know about the sex hormones and can add adrenaline to their diagram. Adrenaline makes a good introduction to hormones as most learners can relate to its effects. It should be mentioned that adrenaline bridges the gap between nervous and hormonal control because of its fast and short lived action. Learners can discuss the effects on the body of the flight and fight hormone with their own examples. **Learners may produce their own table of comparison between nervous and hormonal control systems with sub-titles of:** • form and pathway of transmission • speed of transmission • duration of effect • response Hormones and their effects: www.abpischools.org.uk/page/modules/hormones/index.cfm Revision – hormones: www.bbc.co.uk/schools/gcsebitesize/science/edexcel/electrical/hormonesrev2.shtml

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Give examples of situations in which adrenaline secretion increases. • Compare nervous and hormonal control systems in terms of speed and longevity of action. • State the functions of insulin, oestrogen and testosterone.	
14.5 Tropic responses	• Define *gravitropism* as a response in which parts of a plant grow towards or away from gravity. • Define *phototropism* as a response in which parts of a plant grow towards or away from the direction from which light is coming. • Investigate gravitropism and phototropism in shoots and roots. • Explain phototropism and gravitropism of a shoot as examples of the chemical control of plant growth. • Explain the role of auxin in controlling shoot growth, limited to: ○ auxin made in shoot tip (only)	Plants are able to respond to certain stimuli. Learners can now study plant response to light and water. Gravitropism and phototropism should be investigated with simple experiments using seeds that have been germinated before the start of the topic. It should be made clear that these are plant growth responses: auxin, a plant hormone, is produced by the shoot and root tips of the growing plant. The direction of growth is related to the direction of the stimulus. Gravitropism and phototropism can be investigated using a clinostat and a light box. Plant hormones are used to make fruit develop at the same time to allow for efficient picking. Weeds in fields of monoculture such as wheat are killed by selective weed killers. Hormones can inhibit the fertilisation of fruit such as grapes that are then seedless. The learners could discuss the advantages and disadvantages of human manipulation of plant development. **Extension activity:** effects of weed killers on growth of seedlings. **Extension activity:** effects of IAA on mustard seedlings. ***Suggested practicals:*** • Grow bean or cereal seedlings in gas jars to keep shoot or coleoptiles and root systems straight. Turn onto side and pin onto board to show positive gravitropism of roots and

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ auxin spreads through the plant from the shoot tip ○ auxin is unequally distributed in response to light and gravity ○ auxin stimulates cell elongation. • Describe the use in weed killers of the synthetic plant hormone 2, 4-D.	negative gravitropism of coleoptiles. Pin some germinating beans to clinostat or keep rotating while growing the seedlings. • Grow cress/cabbage seedlings in pot to show response to light from one side. If possible use different growth boxes with coloured filters to experiment with differing wavelengths. • Grow seedlings of broad leaved plants and grasses together in trays and spray with weed killer of different concentrations to show differential killing of plants (takes several weeks). The response of seedlings to light: www.saps.org.uk/secondary/teaching-resources/185-learner-sheet-8-the-response-of-seedlings-to-light Investigating geotropism: www.saps.org.uk/secondary/teaching-resources/184-learner-sheet-7-the-behaviour-of-hypocotyls Practical biology – plant responses to stimuli: www.nuffieldfoundation.org/practical-biology/interpreting-investigation-plant-hormones Investigating plant growth regulators: www.saps.org.uk/secondary/teaching-resources/183-learner-sheet-6-investigating-plant-growth-regulators
14.4 Homeostasis	• Define *homeostasis* as the maintenance of a constant internal environment. • Explain that homeostasis is the control of internal conditions within set limits. • Explain the concept of control by negative feedback. • Describe the control of the glucose concentration of the blood by the liver and the roles of insulin and glucagon from the pancreas.	The learners should appreciate the importance of maintaining an internal steady state to keep the conditions in the tissue fluid around the cells constant. The concepts of diffusion, osmosis, enzyme activity and respiration will guide the learners to understand the importance of constant pH, oxygen and carbon dioxide concentrations, water, enzymes and hormones. Learners could think how they feel when they have a high fever to discuss the importance of an internal steady state. The control of temperature and glucose can illustrate negative feedback. Flow diagrams can show how this is achieved. The control of glucose content can be linked with diabetes, a relatively common disorder in many countries. The learners should consider why it is important to control blood glucose content, thinking back to what they know about diet, including sweet fizzy drinks, osmosis and respiration. Correct spelling is essential to distinguish between glycogen and glucagon.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Outline the symptoms and treatment of Type 1 diabetes (detail of β cells is not required). • Name and identify on a diagram of the skin: hairs, hair erector muscles, sweat glands, receptors, sensory neurones, blood vessels and fatty tissue. • Describe the maintenance of a constant internal body temperature in humans in terms of insulation, sweating, shivering and the role of the brain (limited to blood temperature receptors and coordination) and vasodilation and vasoconstriction of arterioles supplying skin surface capillaries.	Body temperature is related to homeostasis in which communication is through the nervous system. Learners should understand that the blood capillaries do not move up and down in the skin during vasodilation and vasoconstriction respectively. Emphasise the cooling effect of sweating due to the evaporation of water. The brain receives impulses from sensory receptors and responds by adjusting the condition to maintain an optimum. A clear example linked to the skin is temperature control. **Extension activity:** learners could research hypothermia and heat stroke. ***Suggested practicals:*** • Use various glass containers and coverings to investigate cooling of hot water - effect of size (mother v baby); stature; clothing layers versus wet covering; link to surface area to volume ratios. • Chill factors with varying wind speed. Practical biology – sweating: www.nuffieldfoundation.org/practical-biology/interpreting-information-about-sweating-and-temperature Skin – structure and function: www.abpischools.org.uk/page/modules/skin/index.cfm A website to show penguin huddling: www.coolantarctica.com/Antarctica%20fact%20file/science/cold_penguins.htm Control of blood sugar: www.abpischools.org.uk/page/modules/diabetes/index.cfm
15.1 Drugs 15.2 Medicinal drugs	• Define a *drug* as any substance taken into the body that modifies or affects chemical reactions in the body. • Describe the use of antibiotics for the treatment of bacterial infection.	This topic lends itself to class discussion or group presentations. Learners will understand that accepted drugs are used to relieve pain and to treat a disease or infection. Antibiotics are drugs that either disrupt the metabolic processes of growth of the bacterium or stop the growth of bacterial spores. Viruses do not have their own metabolism but use the pathways of their host cell which prevents them from being destroyed by antibiotics.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• State that some bacteria are resistant to antibiotics which reduces the effectiveness of antibiotics. • Explain how development of resistant bacteria such as MRSA can be minimised, limited to using antibiotics only when essential and ensuring treatment is completed. • State and explain that antibiotics kill bacteria but do not affect viruses.	***Suggested practical:*** • Investigate the effect of caffeine on heart rate of microscopic, invertebrate, aquatic animal, e.g. Daphnia. • Effects of antibiotic disks on growth of bacteria on agar plate (use only recommended permitted bacterial strains from reliable sources) or photographs.
15.3 Misused drugs	• Describe the effects of excessive alcohol consumption and abuse of heroin, limited to: ○ powerful depressant drugs ○ effect on reaction times and self-control ○ addiction and withdrawal symptoms ○ negative social implications, e.g. crime. • Explain how heroin affects the nervous system, limited to its effect on the function of synapses.	The learners should be allowed to discuss the implications of taking recreational drugs both socially and medically including their effect on the nervous system and their possible long-term effects. Learners need to understand the effects, the symptoms and possible problems with taking heroin. Many recreational drugs can become addictive such as nicotine and alcohol. (Cigarette smoking can be linked with Unit 4.) ***Suggested practical:*** Smoking in fume cupboard of cigarette attached to water pump and collect tar on cotton wool. Practical biology – Smoking: www.nuffieldfoundation.org/practical-biology/going-smoke Drug information: www.talktofrank.com/ Drug abuse:

Syllabus ref.	Learning objectives	Suggested teaching activities
	• State that injecting heroin can cause infections such as HIV. • State that excessive alcohol consumption can cause liver damage. • State that tobacco smoking can cause chronic obstructive pulmonary disease (COPD), lung cancer and coronary heart disease. • Describe the effects on the gas exchange system of tobacco smoke and its major toxic components, limited to carbon monoxide, nicotine and tar. • Discuss the evidence for the link between smoking and lung cancer. • State that the liver is the site of breakdown of alcohol and other toxins. • Discuss the use of hormones to improve sporting performance, limited to testosterone and anabolic steroids.	www.abpischools.org.uk/res/coResourceImport/resources04/drugs/index.cfm **Teacher resources:** • Drug scenes complied by: Royal College of Psychiatrists • Drug Abuse published by: Independence Educational Publishers
13.1 Excretion in humans	• State that urea is formed in the liver from excess amino acids by removal of the nitrogen-containing part of amino acids to form urea (*deamination).*	Refer back to the definition of excretion given in Unit 1. Excretion can be considered as another way in which the environment of cells is controlled, by removing toxic materials, waste products of metabolism and substances in excess of requirements. Ensure that they understand the difference between egestion (the removal of substances from the

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Describe the role of the liver in the assimilation of amino acids by converting them to proteins, including plasma proteins, e.g. fibrinogen. • State that carbon dioxide is excreted through the lungs. • State that the kidneys excrete urea and excess water and salts. • Explain that the volume and concentration of urine produced is affected by water intake, temperature and exercise. • Identify on drawings, diagrams and images, the ureters, bladder and urethra. • Explain the need for excretion, limited to toxicity of urea and carbon dioxide. • Outline the structure of the kidney, limited to the cortex, medulla and ureter. • Outline the structure and functioning of a kidney tubule, including: ○ the role of the glomerulus in the filtration from the blood	alimentary canal that have never been part of the body at all) and excretion. Only a simple understanding of the formation of urea from excess amino acids is required. Mention that hormones are also broken down by the liver. It is important to differentiate between ureter and urethra. Labelled diagrams will help the learners to understand the structure of the kidney. Refer to Unit 7 for male reproductive system. **Extension activity:** a kidney from a sheep (or whatever is easily available) can be dissected to show the structure visible without use of a microscope (gross structure). The structure and functioning of a kidney tubule should be dealt with very simply as even learners studying the supplement may find details of nephron structure and the role of the kidney in reabsorption of glucose, salts and water difficult. The structure of the kidney can lead into the use of dialysis and the machine's role in removing excess urea and water. The importance of homeostasis can be reinforced at this point as the kidneys are osmoregulators. The importance of retaining glucose must be emphasised and it is excess water, urea and salts that are excreted in urine. This will link back to Unit 5.4 which considers diabetes. Diagrams of dialysis machines should be studied to enable learners to understand the process and the role of the dialysis fluid. Learners will need to remember what they know about osmosis and diffusion in order to understand how dialysis works. There is a link between the immune system and tissue rejection, when considering kidney transplants. **Extension activity:** dissection of a kidney and teasing out of nephrons from the cortex tissue under a microscope. ***Suggested practicals:*** • Dissection of an animal kidney to show difference between cortex and medulla (to obtain from local butcher or abattoir 'in fat/suet to preserve the ureter and blood vessels). • Use of Visking tubing to demonstrate diffusion. • Simple food test or clinistix to identify samples of fake urine (water with yellow food colouring with and without glucose and/or proteins).

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ of water, glucose, urea and salts ○ the role of the tubule in the reabsorption of all of the glucose, most of the water and some salts back into the blood, leading to the concentration of urea in the urine as well as loss of excess water and salts (details of these processes are not required). • Explain dialysis in terms of salt balance, the maintenance of glucose concentration and the removal of urea. • Describe the use of dialysis in kidney machines. • Discuss the advantages and disadvantages of kidney transplants, compared with dialysis.	Kidneys: www.abpischools.org.uk/res/coResourceImport/resources04/kidneys/index.cfm Revision – kidney failure: www.s-cool.co.uk/gcse/biology/homeostasis/revise-it/dealing-with-kidney-failure

Past and specimen papers

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14.1
Jun 2011 Paper 21 Q4
Jun 2013 Paper 22 Q7
2016 Specimen Paper 4 Q3

14.2
Jun 2012 Paper 22 Q9
Jun 2012 Paper 33 Q2

14.3
Jun 2012 Paper 22 Q6

14.4
Jun 2011 Paper 22 Q3
Jun 2011 Paper 32 Q2
Jun 2012 Paper 21 Q5
Jun 2012 Paper 22 Q6
2016 Specimen Paper 4 Q2

15.2
2016 Specimen Paper 3 Q6

15.3
Jun 2013 Paper 21 Q2
2016 Specimen Paper 3 Q10

15.3
Jun 2011 Paper 31 Q4
Jun 2012 Paper 33 Q4
Jun 2013 Paper 21 Q9
Jun 2013 Paper 22 Q2

6: Reproduction

Syllabus ref.	Learning objectives	Suggested teaching activities
16.1 Asexual reproduction	• Define *asexual reproduction* as a process resulting in the production of genetically identical offspring from one parent. • Identify examples of asexual reproduction from information provided. • Discuss the advantages and disadvantages of asexual reproduction: ○ to a population of a species in the wild ○ to crop production.	Ensure that learners understand that 'asexual' means 'not sexual'. Asexual reproduction involves only one parent, which produces new, genetically identical organisms by mitosis. **Extension activity:** agar plates that have had bacterial colonies grown on them can be set up by the class if great care is taken about safety issues. Fungal spores can be easily seen on bread moulds, soft tomatoes or mushroom gills, if these are allowed to develop well past the edible stage (Unit 1). Asexual reproduction in potatoes is often difficult for learners to understand. 'Old' potatoes can be used to show the 'eyes' and to explain how these can develop and produce new identical tubers. Learners could grow their own potato that should produce many new potatoes in about six months. Flow diagrams help in understanding asexual reproduction in potatoes. Learners can make a table to list the main points to compare asexual and sexual reproduction. Learners should appreciate that many horticulturists exploit asexual reproduction in bulbs and rhizomes, e.g. daffodils, orchids. ***Suggested practicals:*** • Observe various plant specimens, to include the potato and other tubers, runners. • To observe growth of moulds and spore production – can use 'blue-vein' cheese if microscopes are available. • Grow cuttings from plants, e.g. African violets. • Tissue culture explants such as cauliflower. Practical biology – cloning: www.nuffieldfoundation.org/practical-biology/cloning-living-organism
17.3 Mitosis	• Define *mitosis* as nuclear division giving rise to genetically identical cells (details of stages are **not** required).	Learners have no knowledge of genetics that will be studied in Unit 8 but they will probably be aware that the nucleus of a cell contains chromosomes that carry genes. Mitosis is a type of cell division that produces cells with identical chromosomes and genes to the parent cell.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• State the role of mitosis in growth, repair of damaged tissues, replacement of cells and asexual reproduction. • State that the exact duplication of chromosomes occurs before mitosis. • State that during mitosis, the copies of chromosomes separate, maintaining the chromosome number (details of stages of mitosis are not required). • Describe stem cells as unspecialised cells that divide by mitosis to produce daughter cells that can become specialised for specific functions.	Learners should be aware that mitotic division also occurs in body cells for growth or for replacement of worn out cells throughout the organism's life. Mitosis is the cell division that produces identical individuals during asexual reproduction. The word 'clones' could be introduced as many learners will have heard of cloning. A simple series of labelled diagrams showing how chromosomes behave during mitosis, with no names of stages or details of spindles, is all that is required. **Extension activity:** learners could look at cells dividing in garlic or onion root tip. Show video clip – cell division. ***Suggested practical:*** Observe mitosis in garlic/onion root tip squash on a microscope slide. Interactive mitosis: www.cellsalive.com/mitosis.htm Cell division (and cancer): www.abpischools.org.uk/res/coResourceImport/resources04/cancer/index.cfm
16.2 Sexual reproduction	• Define *sexual reproduction* as a process involving the fusion of the nuclei of two haploid gametes (sex cells) to form a diploid zygote and the production of offspring that are genetically different from each other. • Define *fertilisation* as the fusion of gamete nuclei.	Sexual reproduction should be described as a process in which gametes fuse together in a process called fertilisation, producing a zygote. Learners should understand that this need not always involve two parents: self-fertilisation, which is not uncommon in plants, is still sexual reproduction. Unlike asexual reproduction, sexual reproduction introduces genetic variation amongst the offspring. (Link to Unit 8.) A table can be drawn up to compare asexual with sexual reproduction.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Discuss the advantages and disadvantages of sexual reproduction: ○ to a population of a species in the wild ○ to crop production.	
17.4 Meiosis	• State that meiosis is involved in the production of gametes. • Define *meiosis* as nuclear (reduction) division in which the chromosome number is halved from diploid to haploid resulting in genetically different cells (details of stages are **not** required). • Explain how meiosis produces variation by forming new combinations of maternal and paternal chromosomes (specific details are not required).	Learners can use coloured pipe cleaners or wool to visualise the different positions of the chromosomes during meiosis and to understand how the cell chromosome number is halved and how genetic variation can occur. **(I)** At this stage the important concept is that gametes are haploid cells. (Link to Unit 7) The description of meiosis should be kept as simple as possible, concentrating on its results rather than any details of the process itself. Interactive meiosis: www.cellsalive.com/meiosis.htm
16.3 Sexual reproduction in plants	• Identify and draw, using a hand lens if necessary, the sepals, petals, stamens, filaments and anthers, carpels, style, stigma,	Learners should look closely at the structure of a simple, radially symmetrical, insect-pollinated flower. They can dissect it to identify the different parts, using a light microscope or a hand lens. Annotate the diagrams to understand how the structure is adapted to its function. **(I)**

Syllabus ref.	Learning objectives	Suggested teaching activities
	ovary and ovules, of an insect-pollinated flower. • State the functions of the sepals, petals, anthers, stigmas and ovaries. • Use a hand lens to identify and describe the anthers and stigmas of a wind-pollinated flower. • Distinguish between the pollen grains of insect-pollinated and wind-pollinated flowers. • Define *pollination* as the transfer of pollen grains from the anther to the stigma. • Define *self-pollination* as the transfer of pollen grains from the anther of a flower to the stigma of the same flower or different flower on the same plant. • Define *cross-pollination* as transfer of pollen grains from the anther of a flower to the stigma of a flower on a different plant of the same species. • Discuss the implications to a species of self-pollination and cross-pollination in terms of variation, capacity to respond to	This is a good opportunity to develop or assess the practical skills of observation and recording. Learners can find the terminology difficult to learn and different flowers should be available to study. Magnification can be calculated for the parts of the flower. (Link to Unit 1) The functions of these flower parts are more easily understood if they are included when the structure of a flower is being drawn. **Extension activity:** if there is time and the facilities, pollen grains can be collected from anthers of nasturtium, dead nettle or any flower with ripe stamens. A few pollen grains can be transferred to filter paper in a Petri dish and 1 cm^3 of 0.4 M/dm^3 sucrose solution added to the grains. The dish should be kept in the dark at room temperature and the pollen tube growth can be observed under a microscope after an hour or more. A table can be constructed to compare self- and cross-pollination. **(I)** Learners should discuss the possible outcomes of self and cross-pollination in terms of the degree of variation amongst offspring, and to compare the effects this might have on populations. This could be reviewed in Unit 8.4 Variation. Samples of insect-pollinated and wind-pollinated flowers (grasses and cereals are good examples of the latter) can be studied and compared. Fertilisation should be dealt with simply, there is no need for details of embryo sacs or the different nuclei involved. However, teachers should explain that germination involves the growth of a pollen tube from the pollen grain down the style to the ovary wall. The male nucleus (not the pollen grain) is the male gamete and fertilises an ovule. If the ovary contains many ovules, each will need to be fertilised by a different pollen nucleus. The fertilised ovule divides by mitosis (link to mitosis earlier in this unit) to form a seed. The structure of seeds should be investigated practically. Soaked bean seeds are large and easy to see but need to be soaked at least two days before the lesson. **(I)** If possible, learners should be able to watch a flowering plant through all the stages from flowering through to fruit and seed development. This helps them to understand how fruits and seeds develop after fertilisation.

Syllabus ref.	Learning objectives	Suggested teaching activities
	changes in the environment and reliance on pollinators. • Describe the growth of the pollen tube and its entry into the ovule followed by fertilisation (details of production of endosperm and development are not required). • Describe the structural adaptations of insect-pollinated and wind-pollinated flowers. • State that fertilisation occurs when a pollen nucleus fuses with a nucleus in an ovule. • Investigate and state the environmental conditions that affect germination of seeds, limited to the requirement for water, oxygen and a suitable temperature.	A range of fruits should be looked at and the ways in which they are dispersed considered. A very common error is to confuse pollination with seed or fruit dispersal and care should be taken to avoid this. An experiment to measure the time taken for seeds of sycamore, lime or ash to fall can allow the learners to investigate different variables of height, mass of seed and wind currents. At least 10 measurements for each type of seed will allow learners to construct tally charts, to calculate the mean and to discuss the errors in such an investigation. **Extension activity:** the topic of the effect of the environment on germination is an excellent opportunity for candidates to design a simple investigation for themselves. Note that most of the seeds that are used in laboratories are derived from crop plants, and these do not normally require light for germination. ***Suggested practicals:*** • Observe large, insect pollinated flowers from a local source. Use a hand lens to see detail of stigma, nectary, etc. • Germinate pollen grains to view pollen tubes and observing the microscopic extension (in a short time) in suitable medium on glass slides. • Use a hand lens to identify and describe the anthers and stigmas of one, locally available, named, wind-pollinated flower. • Examine the pollen grains under a light microscope or in photomicrographs. • Observe large soaked seeds, e.g. beans to observe cotyledons, plumule and radicle, and grow some seeds to show both hypogeal and epigeal types of germination. • Observe a range of fruits and discuss dispersal means. • Plan experiments and investigate factors (temperature, water, oxygen) affecting the germination of different seeds. Flower structure: www.saps.org.uk/secondary/teaching-resources/547-the-structure-of-flowers www.britannica.com/EBchecked/topic/357598/dicotyledon Video clip – germination: www.bbc.co.uk/learningzone/clips/an-introduction-to-seed-germination-and-growth/63.html

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16.1
Jun 2012 Paper 21 Q6

17.4
Jun 2012 Paper 33 Q5c

16.3
Jun 2011 Paper 32 Q4d and e
Jun 2012 Paper 31 Q3
Jun 2013 Paper 21 Q4
Jun 2013 Paper 22 Q9
Jun 2013 Paper 23 Q7
2016 Specimen Paper 3 Q7
2016 Specimen Paper 4 Q4d

7: Human reproduction

Syllabus ref.	Learning objectives	Suggested teaching activities
16.4 Sexual reproduction in humans	• Identify and name on diagrams of the male reproductive system: the testes, scrotum, sperm ducts, prostate gland, urethra and penis, and state the functions of these parts. • Identify and name on diagrams of the female reproductive system: the ovaries, oviducts, uterus, cervix and vagina, and state the functions of these parts. • Describe fertilisation as the fusion of the nuclei from a male gamete (sperm) and a female gamete (egg cell/ovum). • Compare male and female gametes in terms of size, structure, motility and numbers. • State and explain the adaptive features of sperm, limited to flagellum, mitochondria and enzymes in the acrosome. • State and explain the adaptive features of egg cells, limited to energy stores and the jelly coat that changes at fertilisation.	Diagrams and models can be used to illustrate the structure of the male and female reproductive systems. Learners should be able to interpret either front or side views. Learners need to be able to spell **uterus** and **urethra** correctly. It should be emphasised that ovulation occurs monthly and that the cycle is repeated throughout a woman's fertile life. Mention that fertilisation usually takes place in an oviduct, rather than the uterus. Explain the importance of male and female gametes in sexual reproduction. Gametes could be compared as a table. (Link to specialised cells in Unit 1) **Extension activity:** learners could research the link between the early developing embryo and stem cells. Diagrams should be drawn to show the relationship between the fetus, umbilical cord and placenta. The large surface area of the placenta can be compared to that of the villi or the alveoli that allows for the maximum diffusion across the membrane. Understand that maternal blood and fetal blood do not mix. The mother may have a different blood group and her blood is at a much higher pressure. Protection of the fetus: the amniotic sac prevents entry of bacteria and the amniotic fluid supports the fetus from physical damage and absorbs the excretory materials of the fetus. Learners should understand that glucose and amino acids cross the placenta, not 'large' nutrients. Oxygen, glucose and amino acids diffuse into the blood of the fetus. It is important to emphasise the importance of the mother's diet during pregnancy and to emphasise the possible problems incurred by the fetus if the mother smokes or drinks. (Link to Unit 5) Mention that hormones are involved in the process of birth.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• State that in early development, the zygote forms an embryo which is a ball of cells that implants into the wall of the uterus. • State and describe the functions of the amniotic sac and amniotic fluid, placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products and providing a barrier to toxins and pathogens (structural details are not required). • State that some toxins, e.g. nicotine, and pathogens, e.g. rubella virus, can pass across the placenta and affect the fetus. • Outline the growth and development of the fetus in terms of increasing complexity in the early stages and increasing size towards the end of pregnancy. • Describe the ante-natal care of pregnant women, limited to special dietary needs and the harm from smoking and alcohol consumption. • Outline the processes involved in labour and birth, limited to:	Discussion on the topic of birth may need to be controlled and it can be important for the teacher to have some knowledge of the group's family situation as many learners will talk about cot deaths, stillborn babies, caesarean section births, miscarriages, etc. The topic of breast-feeding can be dealt with through discussion, perhaps after learners have done a little research of their own. The biological advantages of breast-feeding are incontrovertible, but learners should also be aware of social and health reasons why there are benefits to breast feeding. Human fertilisation: www.bbc.co.uk/learningzone/clips/human-fertilisation/1849.html Breastfeeding: www.cyberparent.com/breastfeed/ Bottle and breast feeding: www.nct.org.uk/parenting/feeding Breastfeeding advice: www.nhs.uk/Planners/breastfeeding/Pages/breastfeeding.aspx Revision and animations – human reproduction: www.bbc.co.uk/education/guides/z7mbkqt/revision

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ breaking of the amniotic sac ○ contraction of the muscles in the uterus wall ○ dilation of the cervix ○ passage through the vagina ○ tying and cutting the umbilical cord ○ delivery of the afterbirth. • Discuss the advantages and disadvantages of breast-feeding compared with bottle-feeding using formula milk.	
16.5 Sex hormones in humans	• Describe the roles of testosterone and oestrogen in the development and regulation of secondary sexual characteristics during puberty. • Describe the sites of production of oestrogen and progesterone in the menstrual cycle and in pregnancy. • Describe the menstrual cycle in terms of changes in the lining of the uterus and ovaries. • Explain the role of hormones in controlling the menstrual cycle and pregnancy, limited to FSH, LH, progesterone and oestrogen.	The general characteristics of hormones will already have been covered and here the sex hormones are introduced. Puberty is when the sex organs become mature and start to produce hormones as well as gametes. Learners can make a table to compare the secondary sexual characteristics as shown by males and females. **(I)** Control of the menstrual cycle can be a difficult topic to understand and past questions are a means of reinforcing the ideas. Candidates should be aware of the cyclical secretion of oestrogen and progesterone from the ovary. Progesterone is also secreted by the placenta during pregnancy. (Link to Unit 7 supplement) Learners should draw a chart/graph and write in the hormones (in different colours) at the relevant times within the cycle. **(I)** Hormones in the menstrual cycle: www.bbc.co.uk/education/guides/z7mbkqt/revision

Syllabus ref.	Learning objectives	Suggested teaching activities
16.6 Methods of birth control in humans	• Outline the following methods of birth control: ○ natural, limited to abstinence, monitoring body temperature and cervical mucus ○ chemical, limited to IUD, IUS, contraceptive pill, implant and injection ○ barrier, limited to condom, femidom, diaphragm ○ surgical, limited to vasectomy and female sterilisation. • Outline the use of hormones in contraception and fertility treatments. • Outline artificial insemination (AI). • Outline *in vitro* fertilisation (IVF). • Discuss the social implications of contraception and fertility treatments.	A simple description of the biological basis of the different types of birth control is required. Learners should also understand the relative effectiveness of each and may want to discuss the ways in which religious or cultural beliefs can affect their use. Learners may be shown examples of each type of contraceptive. The advantages of condoms in reducing the risk of transmitting diseases such as HIV/AIDS should also be considered. A simple factual treatment of what artificial insemination is, and the use of fertility drugs, will be required before learners can discuss the social and ethical issues associated with it. **Extension activity:** these issues regularly find their way into the news, and it is useful to collect a range of articles from newspapers and magazines that could form the basis for discussion. Teens condom tips: www.avert.org/teens-condoms.htm
16.7 Sexually transmitted infections (STIs)	• Define *sexually transmitted infection* as an infection that is transmitted via body fluids through sexual contact. • State that human immunodeficiency virus (HIV) is an example of an STI.	Gonorrhoea is used as an example of a relatively common sexually-transmitted disease caused by a bacterium, readily treated with antibiotics. (Link to Unit 5.) HIV, on the other hand, is caused by a virus, and as yet no cure is available. Although no detail is expected of the symptoms of AIDS, it could be useful to deal with these briefly, with reference back to the functions of white blood cells in Unit 4, and how the use of a mechanical barrier such as a condom can control the spread of STIs. Link to Unit 5, the action of antibiotics on bacteria but not on viruses.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Explain how the spread of STIs is controlled. • Describe the methods of transmission of HIV. • State that HIV infection may lead to AIDS. • Outline how HIV affects the immune system, limited to decreased lymphocyte numbers and reduced ability to produce antibodies.	**Extension activity:** learners could research current advances in HIV treatments and drugs. HIV/AIDS: www.abpischools.org.uk/page/modules/diseases/diseases3.cfm

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16.4
Jun 2011 Paper 21 Q3
Jun 2011 Paper 22 Q4
Jun 2011 Paper 31 Q3
Jun 2011 Paper 32 Q3
Jun 2012 Paper 21 Q4
Jun 2012 Paper 22 Q4
Jun 2012 Paper 31 Q5
Jun 2012 Paper 32 Q5
Jun 2012 Paper 33 Q5
Jun 2013 Paper 22 Q5
Jun 2013 Paper 23 Q3
2016 Specimen Paper 3 Q3

16.5
Jun 2012 Paper 22 Q4
Jun 2012 Paper 31 Q5

16.6
Jun 2011 Paper 22 Q4b
Jun 2012 Paper 32 Q5c
Jun 2012 Paper 33 Q5

8: Inheritance and evolution

Syllabus ref.	Learning objectives	Suggested teaching activities
17.1 Inheritance	• Define *inheritance* as the transmission of genetic information from generation to generation.	Learners to come up with a possible definition of inheritance. Overview – genes and inheritance: www.abpischools.org.uk/page/modules/genome/index.cfm
17.2 Chromosomes, genes and proteins	• Define *chromosome* as a thread-like structure of DNA, carrying genetic information in the form of genes. • Define *gene* as a length of DNA that codes for a protein. • Define *allele* as a version of a gene. • Describe the inheritance of sex in humans with reference to XX and XY chromosomes. • Explain that the sequence of bases in a gene is the genetic code for putting together amino acids in the correct order to make a specific protein (knowledge of the details of nucleotide structure is not required). • Explain that DNA controls cell function by controlling the production of proteins (some of which are enzymes), antibodies	Learners should know that a chromosome is a length of DNA and that each chromosome carries a large number of genes. It is important to use the terms 'gene' and 'allele' correctly right from the start. An allele is a variety/an alternative form of a gene, and many genes have many different alleles. Learners can draw the structures and write the definition beside the diagram to help them to learn the words and their definitions. Flash cards for key words and their definitions can be useful for learners to quiz themselves when working in small groups. It may be sufficient to state that males have XY sex chromosomes and females have XX sex chromosomes and to return to their inheritance later in Unit 8 Monohybrid inheritance. At Cambridge IGCSE Core level, it is enough to define a gene as a length of DNA giving instructions for a certain characteristic. However, teachers may say that a gene carries instructions for making a particular protein. **Extension activity:** DNA extraction. Simple gel electrophoresis using coloured dyes. **Extension activity:** learners may be interested to discuss the human genome project, which has mapped all the genes on the human chromosomes. Learners may be familiar with the terms haploid and diploid when considering the processes involved in sexual reproduction. A haploid cell is one with a single set of chromosomes (for example a gamete) while a diploid cell has two complete sets. Meiosis produces haploid cells from a diploid cell. Models using pipe-cleaners can be useful in showing the behaviour of chromosomes in gamete formation and fertilisation. ***Suggested practicals:***

Syllabus ref.	Learning objectives	Suggested teaching activities
	and receptors for neurotransmitters. • Explain how a protein is made, limited to: ○ the gene coding for the protein remains in the nucleus ○ mRNA molecules carry a copy of the gene to the cytoplasm ○ the mRNA passes through ribosomes ○ the ribosome assembles amino acids into protein molecules ○ the specific order of amino acids is determined by the sequence of bases in the mRNA (knowledge of the details of transcription or translation is not required). • Explain that all body cells in an organism contain the same genes, but many genes in a particular cell are not expressed because the cell only makes the specific proteins it needs. • Define a *haploid nucleus* as a nucleus containing a single set of unpaired chromosomes, e.g. in gametes. • Define a *diploid nucleus* as a nucleus containing two sets of	• Extract DNA from fruit using cold ethanol and dish washing liquid. • Identify the sex chromosomes from photographs of karyotypes. • Observe human karyotype to identify trisomy (chromosome 21) with Downs Syndrome and to look at the incidence through data on web sites. **Resource Plus** **Experiment:** Extracting DNA from split peas This experiment focuses on an extraction of DNA from split peas. Links with 1.3 Features of organisms and 4.1 Biological molecules. The Human Genome Project: www.genome.gov/Education/ Includes fact sheets and information on all aspects of genetics. Practical biology – DNA: www.nuffieldfoundation.org/practical-biology/extracting-dna-living-things

Syllabus ref.	Learning objectives	Suggested teaching activities
	chromosomes, e.g. in body cells. • State that in a diploid cell, there is a pair of each type of chromosome and in a human diploid cell there are 23 pairs.	
17.5 Monohybrid inheritance	• Define *genotype* as the genetic make-up of an organism in terms of the alleles present. • Define *phenotype* as the observable features of an organism. • Define *homozygous* as having two identical alleles of a particular gene. • State that two identical homozygous individuals that breed together will be pure-breeding. • Define *heterozygous* as having two different alleles of a particular gene. • State that a heterozygous individual will not be pure-breeding. • Define *dominant* as an allele that is expressed if it is present.	It is best to consider the meanings of these terms before thinking about inheritance. They can best be illustrated and explained with reference to a particular characteristic. Choose something simple and that is likely to appeal to learners, such as coat colour of an animal. It should involve a gene with two alleles, one dominant and one recessive. Learners should learn that one letter is used to represent these alleles, with an upper case letter for the dominant allele and a lower case letter for the recessive allele. They should also learn to write the dominant allele first. They will know that most cells are diploid and so should be able to understand that they therefore carry two copies of each gene. The terms genotype, phenotype, homozygous and heterozygous can be introduced and defined in relation to simple genetic crosses. It is a good idea to spend some time with such examples, using a Punnett square for clarity especially with the Core learners. Ensure that learners are thoroughly confident using the terminology, before beginning to think about how inheritance occurs. Learners should be reminded that gametes are haploid cells and therefore carry only one copy of each gene. They can be asked to work out what kind of gametes will be produced by organisms with a range of different genotypes. It is good practice and avoids confusion, if a circle is drawn around each gamete or the genotype when writing out a genetic cross. Discourage learners from automatically writing down two gametes from each parent. This is only necessary if the parent is heterozygous and producing two different kinds of gamete. If it is homozygous, then only one kind of gamete is made and only one needs to be written down. Learners can then be introduced to the idea of random fertilisation, in which any kind of gamete from the male parent can fuse with any kind of gamete from the female parent. The offspring now have two copies of each gene again. Drawing lines from gamete to gamete often causes errors; drawing a Punnett square is easier for learners to understand.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Define *recessive* as an allele that is only expressed when there is no dominant allele of the gene present. • Interpret pedigree diagrams for the inheritance of a given characteristic. • Use genetic diagrams to predict the results of monohybrid crosses and calculate phenotypic ratios, limited to 1:1 and 3:1 ratios. • Explain how to use a test cross to identify an unknown genotype. • Use Punnett squares in crosses which result in more than one genotype to work out and show the possible different genotypes.	In the boxes, ensure that learners understand that what they have worked out is the probability of particular genotypes being produced. The fact that, for example, four different genotypes are present amongst the offspring does not mean that the parents will have four children. Learners need to be familiar with the monohybrid crosses 1 : 1 and 3 : 1. The inheritance of sex can be dealt with in the same way as the inheritance of genes, but this time the symbols X and Y are used to indicate whole chromosomes, not alleles of a gene. Learners should be able to draw genetic crosses to show the expected 1 : 1 ratio. **Extension activity:** learners could try the Genetics Breeding Game. ***Suggested practicals:*** • Purchase seeds from specific crosses to germinate, e.g. Arabidopsis, tobacco seeds, upon germination have cotyledons with and without chlorophyll in 3 : 1 ratio. • Count seeds on maize cobs from different crosses and compare with predicted ratios. Genotype and phenotype: www.brooklyn.cuny.edu/bc/ahp/BioInfo/GP/Definition.html Video clip – inheritance: www.bbc.co.uk/learningzone/clips/dominant-and-recessive-characteristics/4197.html
17.5 Co-dominance and sex linkage	• Explain co-dominance by reference to the inheritance of ABO blood groups – phenotypes being A, B, AB and O blood groups and alleles being I^A, I^B and I^o . • Define a *sex-linked characteristic* as a characteristic in which the gene responsible is located on a sex chromosome and that this makes it more	Co-dominance is the combination of two different alleles that will produce an effect that is a mixture of both of them. The correct use of symbols should be encouraged; where co-dominance exists, the gene is shown with an upper case letter, with superscripts to represent the different alleles. It is helpful to write down a list of all the possible genotypes for blood groups and the resulting phenotypes before attempting to deal with any crosses. Ensure that the correct symbols, as used in the syllabus, are automatically used by learners. The biology project – blood types: www.biology.arizona.edu/human_bio/problem_sets/blood_types/Intro.html

Syllabus ref.	Learning objectives	Suggested teaching activities
	common in one sex than in the other. • Describe colour blindness as an example of sex linkage. • Use genetic diagrams to predict the results of monohybrid crosses involving co-dominance or sex linkage and calculate phenotypic ratios.	
18.1 Variation	• Define *variation* as differences between individuals of the same species. • Distinguish between phenotypic variation and genetic variation. • State that phenotypic variation is caused by both genetic and environmental factors. • State that continuous variation results in a range of phenotypes between two extremes, e.g. height in humans. • State that discontinuous variation results in a limited number of phenotypes with no intermediates, e.g. tongue rolling. • State that discontinuous variation is mostly caused by	Continuous variation can be illustrated by almost any characteristic that is measurable on a human: height, length of middle finger, wrist circumference, will each give a good range of results and not cause any embarrassment. Leaves or other plant material can also be used to generate a range of results. Learners can see that a range of values is obtained. To show them graphically, they will need to decide on 6 or 7 ranges and then draw up a tally chart to show how many values fit into each range. These can then be plotted on a histogram. A common misconception is that 'continuous variation' means something that changes through your life. Although this is true of the measurements learners are likely to have made to illustrate this, it is not the correct meaning of the term. Use other features, such as hair or eye colour, to emphasise the real meaning of continuous variation. Learners studying the supplement will already be familiar with the A, B, AB and O blood groups. Blood groups are a good example of discontinuous variation. Learners can draw bar charts to show the relative proportions of people with the four blood groups. They will not find it difficult to understand that everyone fits into one of these four categories, with no in-betweens, and this is therefore an example of discontinuous variation. A second example is gender. Learners should understand that discontinuous variation is caused purely by genes but continuous variation often involves influence by the environment as well.

Syllabus ref.	Learning objectives	Suggested teaching activities
	genes alone, e.g. A, B, AB and O blood groups in humans. • Record and present the results of investigations into continuous and discontinuous variation. • Define *mutation* as genetic change. • Define *gene mutation* as a change in the base sequence of DNA. • State that mutation is the way in which new alleles are formed. • State that ionising radiation and some chemicals increase the rate of mutation. • Describe the symptoms of sickle-cell anaemia. • Explain how a change in the base sequence of the gene for haemoglobin results in abnormal haemoglobin and sickle-shaped red blood cells. • Use genetic diagrams to show how sickle-cell anaemia is inherited. • State that people who are heterozygous (Hb^SHb^A) for the	Mutation can be defined as an unpredictable change in the DNA content of a cell. It can affect a single gene, or whole chromosomes, and can happen at any stage, not only during cell division. Mutations can be positive for an organism, as in bacteria that developed resistance to certain antibiotics. (Refer to Unit 8) **Extension activity:** Down's syndrome is used to illustrate a mutation that occurs during meiosis and affects the number of chromosomes in a cell. Learners could look at karyotypes of people with Down's syndrome and compare them with karyotypes of males and females with the normal number of chromosomes. When discussing any genetic condition, it should be done with care and sensitivity. Ionising radiation and mustard gas can be given as examples of factors that may cause mutation. Chernobyl in 1984 is an example of radiation that caused mutations in hundreds of people and unborn babies. The Fukushima nuclear disaster in Japan in 2011 may cause mutations. Sickle cell anaemia can be explained as the result of a mutation in the gene that codes for the production of haemoglobin. The effects of this on the carriage of oxygen and the consequences for respiring cells in body tissues can be discussed. Its inheritance can also be considered. Learners can look at maps showing the distribution of malaria and of sickle cell anaemia. Some learners may have some degree of sickle cell anaemia and will be able to talk about it to the class. It is a good way to introduce the ideas of selection pressures, and natural selection. ***Suggested practicals:*** • To show continuous variation in plants as well as humans, measure size of fruits or seeds, number of beans to be picked up in one hand, height, hand span, etc. Work out the frequency of large data sets and plot histograms. • To discuss inheritance of different characteristics in plants as well as humans to show discontinuous variation. E.g. tasters versus non-tasters, lobed ears v attached ears. Practical biology – variation in humans: www.nuffieldfoundation.org/practical-biology/introducing-ideas-about-inheritance Practical biology – variation in Ivy leaves: www.nuffieldfoundation.org/practical-biology/recording-variation-ivy-leaves Variation – continuous and discontinuous: www.bbc.co.uk/scotland/learning/bitesize/standard/biology/inheritance/ Sources of variation: http://learn.genetics.utah.edu/content/variation/

Syllabus ref.	Learning objectives	Suggested teaching activities
	sickle-cell allele have a resistance to malaria. • Explain the distribution of the sickle-cell allele in human populations with reference to the distribution of malaria.	
18.2 Adaptive features	• Define *adaptive feature* as an inherited feature of an organism that increase its fitness (that helps an organism to survive and reproduce in its environment). • Define *fitness* as the probability of an organism surviving and reproducing in the environment in which it is found. • Interpret images or other information about a species to describe its adaptive features. • Explain the adaptive features of hydrophytes and xerophytes to their environments.	Learners could be asked to investigate the adaptive features of a range of animals and plants living in a variety of habitats. **(I)** These could be presented to the class. ***Suggested practicals:*** • Simulate penguin huddling using test-tubes filled with hot water. Compare the rate of cooling of single test-tubes with those on the edge and in the middle of a huddle of seven test-tubes. • Woodlice choice chambers using wet/dry or light/dark. • Compare density of sowing of seeds, e.g. radish. • Demonstrate camouflage using two different coloured background cards and coloured cocktails sticks of the same colour. Pick them up with different types of forceps. • Investigate the distribution of Pleurococcus at different points around a tree trunk. The BBC has a great number of video clips showing organisms adapted to a range of habitats and lifestyles. www.bbc.co.uk/nature/adaptations **Online:** Desert plant survival: www.desertusa.com/du_plantsurv.html
18.3 Selection	• Describe natural selection with reference to: ○ variation within populations ○ production of many offspring ○ competition for resources ○ struggle for survival ○ reproduction by individuals that are better adapted to the environment than others	If learners have already studied sickle cell anaemia, they will already have thought about the ideas of differential survival and selection. Those individuals better adapted to the environment will pass on their alleles to their offspring, so that the alleles that confer the advantageous characteristics gradually become more common. Over time, this could lead to a change in the overall characteristics of the species. **Extension activity:** natural selection game.

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ passing on of their alleles to the next generation. • Describe evolution as the change in adaptive features of a population over time as the result of natural selection. • Define the *process of adaptation* as the process, resulting from natural selection, by which populations become more suited to their environment over many generations. • Describe the development of strains of antibiotic resistant bacteria as an example of evolution by natural selection. • Describe selective breeding with reference to: ○ selection by humans of individuals with desirable features ○ crossing these individuals to produce the next generation ○ selection of offspring showing the desirable features. • State the differences between natural and artificial selection. • Outline how selective breeding by artificial selection is carried out over many generations to	Learners are already aware that variation occurs within populations of organisms, and they will not find it difficult to think how humans may choose a particular variety of an animal or plant and use this to breed from. Examples of selective breeding by artificial selection include: • Jersey cattle that have a high milk yield. • Wheat that has high seed yield, and shorter stems and so are easier to harvest. • Rice that has roots tolerant to lactic acid. • Maize has been bred to be able to adapt to low carbon dioxide concentrations. It should be made clear that this selection needs to continue for many generations and does not produce immediate results. Learners are interested in this topic and groups within the class could present some ideas to the whole class. Practical biology – modelling natural selection: www.nuffieldfoundation.org/practical-biology/modelling-natural-selection Artificial vs natural selection: http://learn.genetics.utah.edu/content/selection/artificial/ Natural selection game: www.biology4all.com/resources_library/source/200.doc A selection of excellent resources explaining the process of evolution: http://learn.genetics.utah.edu/content/selection/ Selective breeding: www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/living/genesrev2.shtml MRSA: www.dnadarwin.org/casestudies/9/ (advanced, but contains some useful information) Antibiotic resistance: www.abpischools.org.uk/page/modules/infectiousdiseases_medicines/index.cfm

Syllabus ref.	Learning objectives	Suggested teaching activities
	improve crop plants and domesticated animals.	
20.1 Biotechnology and genetic engineering	• State that bacteria are useful in biotechnology and genetic engineering due to their rapid reproduction rate and their ability to make complex molecules. • Discuss why bacteria are useful in biotechnology and genetic engineering, limited to: ○ lack of ethical concerns over their manipulation and growth ○ genetic code shared with all other organisms ○ presence of plasmids.	Use simple diagrams of bacteria containing circular DNA to show how a section of human DNA can be inserted into the bacterial DNA. **(I)** **Extension activity:** learners could research recent advances in biotechnology and report back. This might lead to learner participation in the STEM project "Talking about genetics" (Science Across the World). Science across the world – genetic modification: www.nationalstemcentre.org.uk/elibrary/resource/1750/talking-about-genetics Biotechnology: www.abpischools.org.uk/page/modules/biotech/index.cfm
20.2 Biotechnology	• Describe the role of anaerobic respiration in yeast during production of ethanol for biofuels. • Describe the role of anaerobic respiration in yeast during bread-making. • Investigate and describe the use of pectinase in fruit juice production. • Investigate and describe the use of biological washing powders that contain enzymes.	Links should be made with respiration in Unit 4. Practical work could include the production of bread dough under different conditions (including sugar concentration). Practical work could be the use of pectinase to produce and clarify apple juice, and the use of biological washing powders. Practical work could be the use of enzymes to produce lactose-free milk. ***Suggested practicals:*** • Use immobilised lactase to produce lactose-free milk. • Large flasks can be used to show simple laboratory fermenters. • Investigate the use of pectinase on fruit pulp by filtering juice with and without enzyme. • Make bread using yeast. • Investigate how temperature affects the cleaning power of biological detergents.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Investigate and explain the use of lactase to produce lactose-free milk. • Describe the role of the fungus *Penicillium* in the production of the antibiotic penicillin. • Explain how fermenters are used in the production of penicillin.	**Resource Plus** **Experiment:** Biotechnology – juicing apples This experiment focuses on the use of enzymes in an industrial process (biotechnology).
20.3 Genetic engineering	• Define *genetic engineering* as changing the genetic material of an organism by removing, changing or inserting individual genes. • State examples of genetic engineering: ○ the insertion of human genes into bacteria to produce human insulin ○ the insertion of genes into crop plants to confer resistance to herbicides ○ the insertion of genes into crop plants to confer resistance to insect pests ○ the insertion of genes into crop plants to provide additional vitamins. • Outline genetic engineering using bacterial production of a human protein as an example, limited to:	The genetic modification involves numerous stages, best illustrated with animation. Explain that DNA can be cut in certain places using different restriction enzymes to select the correct gene. If the same restriction enzyme is used to cut the bacterial DNA then the ends of the human and bacterial DNA will stick together. **Extension activity:** simple gel electrophoresis. If time is available learners could attempt start-stop animation methods to produce their own short film of the process. Learners prepare a table of advantages and disadvantages of genetically modified crops. Genetic engineering: www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/living/genesrev3.shtml Advantages and disadvantages of GM: www.bbc.co.uk/schools/gcsebitesize/science/add_edexcel/cells/dnarev6.shtml

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ isolation of the DNA making up a human gene using restriction enzymes, forming sticky ends ○ cutting of bacterial plasmid DNA with the same restriction enzymes, forming complementary sticky ends ○ insertion of human DNA into bacterial plasmid DNA using DNA ligase to form a recombinant plasmid ○ insertion of plasmid into bacteria (specific detail is not required) ○ replication of bacteria containing recombinant plasmids which make human protein as they express the gene. • Discuss the advantages and disadvantages of genetically modifying crops, such as soya, maize and rice.	

Past and specimen papers

Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

17.5
Jun 2011 Paper 31 Q4c
Jun 2011 Paper 32 Q4
Jun 2013 Paper 21 Q7
Jun 2013 Paper 22 Q3
2016 Specimen Paper 3 Q11

17.5
Jun 2012 Paper 31 Q4
2016 Specimen Paper 4 Q4

18.1
Jun 2011 Paper 21 Q5b
Jun 2011 Paper 22 Q5
Jun 2013 Paper 22 Q9

18.3
Jun 2011 Paper 31 Q6
Jun 2012 Paper 32 Q6

20.2
2016 Specimen Paper 3 Q8
2016 Specimen Paper 4 Q5

9: Organisms and environment

Syllabus ref.	Learning objectives	Suggested teaching activities
19.1 Energy flow	• State that the Sun is the principal source of energy input to biological systems. • Describe the flow of energy through living organisms including light energy from the sun and chemical energy in organisms and its eventual transfer to the environment.	Having looked at the range of different types of organisms that live in different habitats, learners now consider the relationships between them. The concept of energy is not an easy one, and learners who are not studying physics or chemistry will need an opportunity to discuss what it means. There is an important link to be made between photosynthesis and respiration including the concept that animals obtain energy-rich nutrients from plants. Cross reference with food chains and food webs. All organisms directly or indirectly get their energy from the Sun. Energy given out by organisms is lost to the environment.
19.2 Food chains and food webs	• Define a *food chain* as showing the transfer of energy from one organism to the next, beginning with a producer. • State and describe how energy is transferred between organisms in a food chain (trophic levels) by ingestion. • Define *trophic level* as the position of an organism in a food chain, food web, pyramid of numbers or pyramid of biomass. • Construct simple food chains. • Define a *food web* as a network of interconnected food chains. • Define *producer* as an organism that makes its own organic	If learners have an opportunity to visit a habitat, even if only in the school grounds, then they should be able to construct food chains and food webs for themselves. The Sun should not be included in a food chain or food web. Emphasise that the arrows in a food chain represent the direction of energy flow, towards the eater. Definitions of each of the terms can be built up once learners are comfortable with the concept of food chains. Learners who have studied physics may already understand that energy transfers are never 100% efficient, and that some energy is always lost as heat when energy is transferred from one form to another. To understand the concept of heat lost from food chains and webs, learners should discuss a particular example, such as energy transfer from grass in a field to the cattle that are eating it. Once energy losses are understood, it should become apparent that food chains cannot go on forever. Emphasise that short food chains are more efficient in providing energy to the top consumer. Emphasise that approximately 90% of energy is lost to the environment between each trophic level.

Syllabus ref.	Learning objectives	Suggested teaching activities
	nutrients, usually using energy from sunlight, through photosynthesis. • Define *consumer* as an organism that gets its energy by feeding on other organisms. • State that consumers may be classed as primary, secondary and tertiary according to their position in a food chain. • Define *herbivore* as an animal that gets its energy by eating plants. • Define *carnivore* as an animal that gets its energy by eating other animals. • Interpret food chains and food webs in terms of identifying producers and consumers. • Identify producers, primary consumers, secondary consumers, tertiary consumers and quaternary consumers as the trophic levels in food webs, food chains, pyramids of numbers and pyramids of biomass. • Explain why the transfer of energy from one trophic level to another is inefficient.	Learners studying the supplement can now take the ideas of energy flow and losses between trophic levels a little further, and think of their implications for human populations. Some farmers keep their animals in pens to restrict the loss of energy from the animals. Learners could consider why, if it is inefficient in terms of energy, that so many human populations use animals for food. (Links with Unit 2 and Unit 8) Pyramids of numbers, biomass and energy can be drawn for a particular food chain or web. Learners can think of them as a kind of graph, in which the areas of the boxes represent values for whatever is being plotted. Learners can understand that producers that have the largest numbers and access to a field or wood will illustrate this. Pyramids of numbers should be drawn with accurate horizontal bars. Exceptions should be shown; a single tree, for example. Pyramids of biomass represent the amount of living material. **Extension activity:** collection of leaf litter and construction of a pyramid of numbers or mass based on classification of organisms found. ***Suggested practicals:*** • Explore a natural area locally and identify the feeding relationships of the organisms which can be seen. • When searching for living specimens in leaf litter or on plants for animals, identify (recall use of keys to identify organisms) and assign to trophic feeding levels. These can be weighed (fresh weight) or counted to draw the trophic blocks in pyramid diagrams.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Explain why food chains usually have fewer than five trophic levels. • Explain why there is a greater efficiency in supplying plants as human food, and that there is a relative inefficiency in feeding crop plants to livestock that will be used as food. • Draw, describe and interpret pyramids of numbers and biomass. • Discuss the advantages of using a pyramid of biomass rather than a pyramid of numbers to represent a food chain. • Define *decomposer* as an organism that gets its energy from dead or waste organic material. • Use food chains and food webs to describe the impacts humans have through over-harvesting of food species and through introducing foreign species to a habitat.	
19.3 Nutrient cycles	• Describe the carbon cycle, limited to photosynthesis, respiration, feeding,	Learners could be given cards showing stages of the carbon cycle or water cycle and arrange them into a complete cycle.

Syllabus ref.	Learning objectives	Suggested teaching activities
	decomposition, fossilisation and combustion. • Discuss the effects of the combustion of fossil fuels and the cutting down of forests on the carbon dioxide concentrations in the atmosphere. • Describe the water cycle, limited to evaporation, transpiration, condensation and precipitation.	These could then be turned into posters. **Extension activity:** what is meant by 'carbon neutral'? ***Suggested practicals:*** • Compare rates of decay of potatoes under different conditions. Could be set as a competition. • Build a compost heap. • Observe plant roots of the pea and bean family. (legumes). • Look for the pink coloration as these are actively fixing nitrogen (symbiosis / mutualism – explain term). • Use of bioviewers, microscopes or photomicrographs to observe sections through nodules. Practical biology – carbon cycle: www.nuffieldfoundation.org/practical-biology/microbes-ate-my-homework Revision – carbon cycle: www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/foodchains/foodchains5.shtml
	• Describe the nitrogen cycle in terms of: ○ decomposition of plant and animal protein to ammonium ions ○ nitrification ○ nitrogen fixation by lightning and bacteria ○ absorption of nitrate ions by plants ○ production of amino acids and proteins ○ feeding and digestion of proteins ○ deamination ○ denitrification. • State the roles of micro-organisms in the nitrogen cycle,	Learners could be given cards or statements describing stages of the nitrogen cycle and arrange them into a complete cycle. These could then be turned into posters. **(I)** Video clip – nutrient recycling: www.bbc.co.uk/learningzone/clips/recycling-nutrients/4172.html

Syllabus ref.	Learning objectives	Suggested teaching activities
	limited to decomposition, nitrification, nitrogen fixation and denitrification (generic names of individual bacteria, e.g. *Rhizobium*, are not required)	

Past and specimen papers

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19.1
Jun 2013 Paper 23 Q8

19.2
Jun 2011 Paper 21 Q6
Jun 2011 Paper 22 Q6c
Jun 2011 Paper 22 Q8
Jun 2011 Paper 32 Q1
Jun 2012 Paper 22 Q8
Jun 2012 Paper 31 Q6
Jun 2013 Paper 21 Q6
Jun 2013 Paper 22 Q10
Jun 2013 Paper 23 Q8
2016 Specimen Paper 4 Q1

19.3
Jun 2011 Paper 21 Q7
2016 Specimen Paper 3 Q9
Jun 2011 Paper 31 Q2
Jun 2012 Paper 32 Q6

10: Human influences on the environment

Syllabus ref.	Learning objectives	Suggested teaching activities
19.4 Population size	• Define *population* as a group of organisms of one species, living in the same area, at the same time. • Define *community* as all of the populations of different species in an ecosystem. • Define *ecosystem* as a unit containing the community of organisms and their environment, interacting together, e.g. a decomposing log, or a lake. • Identify and state the factors affecting the rate of population growth for a population of an organism, limited to food supply, predation and disease. • Identify the lag, exponential (log), stationary and death phases in the sigmoid population growth curve for a population growing in an environment with limited resources. • Explain the factors that lead to each phase in the sigmoid curve of population growth, making	Adequate food will enable the organisms to breed and to produce more offspring. A shortage of food can result in death, emigration and a decrease in the population. Predation can illustrate the delayed effect on the population and graphs to illustrate this are helpful. The interrelated populations of the snowshoe hare and the lynx in Canada are a clear example. Disease can spread quickly in crowded populations like myxomatosis that killed many rabbits in the UK about 40 years ago. The class could discuss how populations grow. Simple sketch graphs should be drawn to illustrate population growth, and possible factors that might cause a levelling off in population growth should be considered. Limiting factors affect the size of the population such as lack of food when the population is too big for the available resources. Lack of oxygen may affect a fish population in a polluted lake. **Extension activity:** modelling population growth. The ideas developed in the previous section are now applied to human population growth. Graphs showing how the human population has changed over the last two centuries and predictions for the future should be drawn. Learners could be introduced to population pyramids and their interpretation for their own country. Comparisons could be made between developed and less developed countries and this would form a link to Geography for some learners. They should discuss the possible implications of continued growth of the world human population, if possible with reference to particular examples collected from newspapers and other sources of up-to-date information and data. To include food and water shortages. (Link to Unit 7). ***Suggested practicals:***

Syllabus ref.	Learning objectives	Suggested teaching activities
	reference, where appropriate, to the role of limiting factors. • Discuss the increase in human population size over the past 250 years and its social and environmental implications. • Interpret graphs and diagrams of human population growth.	• Grow a yeast culture in a flask with low sugar content. Start with low density of cells and observe. • Data handling of count numbers or test turbidity of yeast culture.
21.1 Food supply	• State how modern technology has resulted in increased food production in terms of: ○ agricultural machinery to use larger areas of land and improve efficiency ○ chemical fertilisers to improve yields ○ insecticides to improve quality and yield ○ herbicides to reduce competition with weeds ○ selective breeding to improve production by crop plants and livestock, e.g. cattle, fish and poultry. • Describe the negative impacts to an ecosystem of large-scale monocultures of crop plants. • Describe the negative impacts to an ecosystem of intensive livestock production.	Material to illustrate this topic, and to form the basis of discussion, can be collected from newspaper and television reports. Learners may like to consider whether new technologies, such as the development of genetically modified varieties of crops, are likely to improve the situation or exacerbate it. **Extension activity:** learners could consider 'food miles' (a way of attempting to measure how far food has travelled before it reaches the consumer). Drought and flooding can be linked to Unit 10. Science across the world – how plants grow: www.nationalstemcentre.org.uk/elibrary/resource/1725/how-plants-grow Food miles: www.saps.org.uk/primary/teaching-resources/151-food-miles

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Discuss the social, environmental and economic implications of providing sufficient food for an increasing human global population. • Discuss the problems which contribute to famine including unequal distribution of food, drought and flooding, increasing population and poverty.	
21.2 Habitat destruction	• Describe the reasons for habitat destruction, limited to: ○ increased area for food crop growth, livestock production and housing ○ extraction of natural resources ○ marine pollution. • State that through altering food webs and food chains, humans can have a negative impact on habitats. • List and explain the undesirable effects of deforestation as an example of habitat destruction, to include extinction, loss of soil, flooding and increase of carbon dioxide in the atmosphere.	Deforestation may already have been considered in relation to the carbon cycle and more wide-ranging effects should be considered, such as loss of habitat and biodiversity and the increased soil erosion and flooding. The flooding of the river Indus in Pakistan in 2010 could be discussed or the Three Gorges dam on the Yangtze River in China. It is a good idea to try to introduce at least one specific example, as well as discussing the problems in general. Video clip – deforestation: www.bbc.co.uk/learningzone/clips/sustainable-forestry-using-animal-power/11966.html Video clip – threat to rainforest: www.bbc.co.uk/learningzone/clips/natural-balance-threats-to-the-rainforest/4712.html Video clip – sea and river pollution: www.bbc.co.uk/learningzone/clips/why-have-fish-stocks-decreased-in-the-north-sea-pt-1-2/4687.html
21.3 Pollution	• State the sources and effects of pollution of land and water, e.g. rivers, lakes and the sea, by	Learners could research recent news articles on different types of pollution and report back. Show video clips – pollution:

Syllabus ref.	Learning objectives	Suggested teaching activities
	insecticides, herbicides and by nuclear fall-out. • State the sources and effects of pollution of water (rivers, lakes and the sea) by chemical waste, discarded rubbish, untreated sewage and fertilisers. • Explain the process of eutrophication of water in terms of: ○ increased availability nitrate and other ions ○ increased growth producers ○ increased decomposition after death of producers ○ increased aerobic respiration by decomposers ○ reduction in dissolved oxygen death of organisms requiring dissolved oxygen in water. • Discuss the effects of non-biodegradable plastics in the environment, in both aquatic and terrestrial ecosystems.	www.bbc.co.uk/learningzone/clips/the-effect-of-human-activity-on-the-environment/4173.html www.bbc.co.uk/learningzone/clips/carbon-dioxide-in-the-atmosphere/4417.html **Extension activity:** different types of pesticide could be studied (link to bioaccumulation). The use of fertilisers containing nitrate can be concentrated on here and related back to the nitrogen cycle (dealt with in Unit 9 Nutrient cycles). Ensure that learners realise that both organic (for example manure) and inorganic fertilisers can cause pollution problems. Leaching into waterways and subsequent eutrophication, should be described and explained. **Extension activity:** possible solutions to eutrophication could be researched. **(I)** Non-biodegradable materials will be detrimental to the environment if they are put in land fill sites. There is also a problem of too many huge land fill sites in many countries. Biodegradable plastics are being produced that are slow to be decomposed but this is an improvement on the removal of plastic waste and its recycling. Explain why plastics will produce air pollution if they are burnt in an incinerator. The environmentally friendly option is to recycle materials such as paper, glass, metal and batteries. This reduces environmental pollution and saves energy in production costs although there is some disagreement about paper recycling as the chlorine required to bleach the paper and the temperature require energy. Practical biology – indicator species: www.nuffieldfoundation.org/practical-biology/monitoring-water-pollution-invertebrate-indicator-species
	• State the sources and effects of pollution of the air by methane and carbon dioxide, limited to the enhanced greenhouse effect and climate change. • Discuss the causes and effects on the environment of acid rain.	The effects of deforestation on global climate could be discussed using newspaper/media articles on deforestation. Learners should understand that acid rain is caused by sulfur dioxide (released from the burning of oil and coal, for example in power stations) and nitrogen oxides (present, for example, in car exhausts). They should know something of the biological effects of acid rain. **Extension activity:** learners could investigate the effects of acid on germination rate.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• State the measures that are taken to reduce sulfur dioxide pollution and reduce the impact of acid rain. • Explain how increases in carbon dioxide and methane concentrations in the atmosphere cause an enhanced greenhouse effect that leads to climate change. • Describe the negative impacts of female contraceptive hormones in water courses, limited to reduced sperm count in men and feminisation of aquatic organisms.	The effect of greenhouse gases on climate should be discussed. The fact that no agreement has been made globally is relevant and many learners will have an opinion on this problem that has many factors to be considered besides burning of wood and fossil fuels. ***Suggested practicals:*** • Visit to sample local streams or rivers to find diversity of invertebrates to estimate biological oxygen demand and determine level of pollution. • Measure biological oxygen demand of water from ponds using methylene blue tests or oxygen meters if available. • Possible to show bleaching effect of sulfur dioxide in a fume cupboard on paper or mosses (effective at low concentrations). • Investigate the effect of acid on germination of seedlings or young plants. • Investigate the effect of increasing concentrations of phosphate (liquid plant food containing phosphate) on chlorella growth. Measure dissolved oxygen over a few weeks. **Resource Plus** **Experiment:** Environmental factors affecting germination This experiment focuses on the effect of acid rain on the germination of seedlings. This could be linked to the discussion of the sources and effects of pollution, particularly the negatives associated with burning fossil fuels. Video clip – greenhouse effect: www.bbc.co.uk/learningzone/clips/carbon-dioxide-in-the-atmosphere/4417.html Extension – acid rain: www.nationalstemcentre.org.uk/elibrary/resource/1728/acid-rain Acid rain investigation: www.saps.org.uk/secondary/teaching-resources/186-learner-sheet-5-investigating-seed-germination
21.4 Conservation	• Define a *sustainable resource* as one which is produced as rapidly as it is removed from the environment so that it does not run out.	It is best to look at some specific examples, either relating to the learners' home country, or of international importance such as: tigers in India, elephants in Africa, sun bears from Cambodia or orang-utans in Borneo. **Extension activity:** learners could become involved in the Science Around the World conservation project.

Syllabus ref.	Learning objectives	Suggested teaching activities

	• Define the term *sustainable development* as development providing for the needs of an increasing human population without harming the environment.
	• Explain the need to conserve non-renewable resources, limited to fossil fuels.
	• State that some resources can be maintained, limited to forests and fish stocks.
	• State that products can be reused or recycled, limited to paper, glass, plastic and metal.
	• Explain how forests and fish stocks can be sustained using education, legal quotas and re-stocking.
	• Explain that sustainable development requires:
	  ○ management of conflicting demands
	  ○ planning and co-operation at local, national and international levels.
	• Outline how sewage is treated to make the water that it contains safe to return to the environment or for human use.
		The influence of humans and the need for populations to maintain their viable numbers could be discussed.
		
		The importance of maintaining biodiversity on the planet for ecosystems, chemical compounds used for medicines and for their genetic diversity.
		
		Tropical rainforests have millions of species that should be preserved.
		
		The practice of recycling and its importance is covered in many aspects throughout the Cambridge IGCSE courses.
		
		Emphasis could be given to metals, batteries, glass as well as paper.
		
		Learners should learn how sewage is dealt with in their own local area, and there may be an opportunity to visit a sewage treatment plant, or to obtain information from the water company responsible for this.
		
		Suggested practicals:
		• Build a bug hotel in the school grounds and observe (long- term project).
		• Put up local nesting boxes for birds. Keep an area of garden for wildlife. Plant insect loving shrubs and flowering plants, e.g. Buddleja.
		• Opportunity to visit sewage treatment plant and to refer to a simple flow chart to understand the processes.
		
		Science around the world – conserving biodiversity:
		www.nationalstemcentre.org.uk/elibrary/resource/1738/biodiversity-around-us
		
		Video clip – conservation:
		www.bbc.co.uk/learningzone/clips/biodiversity-and-the-human-implications/5505.html
		
		Video clips **–** sewage:
		www.bbc.co.uk/learningzone/clips/sewage-treatment/4199.html
		
		www.bbc.co.uk/learningzone/clips/micro-organisms-at-work-in-a-sewage-farm/2278.html

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Explain why organisms become endangered or extinct, limited to climate change, habitat destruction, hunting, pollution and introduced species. • Describe how endangered species can be conserved, limited to monitoring and protecting species and habitats, education, captive breeding programmes and seed banks. • Explain the risks to a species if the population size drops, reducing variation (knowledge of genetic drift is not required). • Explain reasons for conservation programmes, to include: ○ reducing extinction ○ protecting vulnerable environments ○ maintaining ecosystem functions, limited to nutrient cycling and resource provision, e.g. food, drugs, fuel and genes.	

Past and specimen papers

Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

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