OXFORD
INTERNATIONAL
AQA EXAMINATIONS

INTERNATIONAL GCSE BIOLOGY

(9201)
Outline Schemes of Work

For teaching from September 2016 onward
For International GCSE exams in June 2018 onwards

Introduction

This scheme of work suggests possible teaching and learning activities for each section of the specification. There are far more activities suggested than it would be possible to teach. It is intended that teachers should select activities appropriate to their students and the curriculum time available. The first two columns summarise the specification references, whilst the Learning Outcomes indicate what most students should be able to achieve after the work is completed. The Resources column indicates resources commonly available to schools, and other references that may be helpful. The timings are only suggested, as are the Possible Teaching and Learning Activities, which include references to experimental work. Resources are only given in brief and risk assessments should be carried out.

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.1 Organisation All organisms are constituted of one or more cells. Multicellular organisms have cells that are differentiated according to their function. All the basic functions of life are the result of what happens inside the cells which make up an organism. Growth is the result of multiple cell divisions.						
3.1.1 Cell structure						
3.1.1a	Most animal cells (eukaryotic cells) have the following parts: • a nucleus, which controls the activities of the cell • cytoplasm, in which most of the chemical reactions take place • cell membrane, which controls the passage of substances into and out of the cell • mitochondria, which is where most energy is released in respiration	Label diagrams of animal and plant cells. Use a microscope. Prepare slides of plant and animal cells.	2	**Activity:** Revise plant and animal cell structure from KS3 using diagrams, and then extend to include mitochondria and ribosomes. Label diagrams of plant and animal cells.	**Cells:** Microscopes, slides, coverslips, tiles, forceps, mounted needles, iodine solution, methylene blue, onion, rhubarb, spirogyra and moss.	Be able to label a sperm cell with cell membrane, cytoplasm and nucleus.

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3.1.1b	• ribosomes, which is where protein synthesis occurs. In addition to the above, plant cells (eukaryotic cells) often have: • chloroplasts, which absorb light energy to make food • a permanent vacuole filled with cell sap. Plant and algal cells also have a cell wall made of cellulose, which strengthens the cell.	Match cell organelles to their functions.		**Practical:** Prepare slides of onion epidermis, rhubarb epidermis, cheek cells, spirogyra, moss etc. and observe under a microscope. **Video:** Watch video clip on plant and animal structures. **Discuss:** Discuss which structures could be seen and compare with EM images – find some images using your preferred search engine. **Task:** Match organelles with their functions. **Homework:** Competition to make a plant or animal cell model and create a display.	Puzzles, quizzes and images can be found at www.cellsalive.com A video clip on plant and animal structures can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clip '4188'. Useful information on cell structure can be found at www.biology4kids.com	Be able to state two parts of a leaf cell which would not be found in a sperm cell.
3.1.1c	A bacterial cell (prokaryotic cells) consists of cytoplasm and a membrane surrounded by a cell wall; the genes are not in a distinct nucleus; some of the genes are located in circular structures called	Label diagrams of bacterial and yeast cells. Identify diagrams of cells as being from an animal, plant, bacterium or yeast. Identify plasmids in	1	**Practical:** How are bacterial and yeast cells different from plant and animal cells? Observe under microscope. Culture of yeast cells to show budding. **Task:** Label diagrams of bacterial and yeast cells.	Diagrams of bacteria and yeast cells. **Cells:** microscopes, slides, coverslips, yeast culture, bacterial cultures and EM images.	Be able to add labels to a yeast cell for cell membrane, cell wall, nucleus and vacuole.

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	plasmids.	diagrams of cells.		**Activities:** Select activities about plasmids from the National Stemcentre e-library	Further information about cell structure and plasmids can be found at http://www.nationalstemcentre.org.uk/elibrary/science/search?term=plasmids&filter=R&order=score	Be able to give two ways in which a root hair cell is different from an animal cell.

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3.1.1d	Cells may be specialised to carry out a particular function. .	Observe different types of cells under a microscope. Relate their structure to their function. Explain how specialised cells are adapted for their function.	1	**Activity:** Compare with diagrams of plant and animal cells – similarities and differences. Display images of cells to classify as plant, animal, bacterial or yeast and compare sizes of cells and organelles. **Practical:** Observe specialised cells under the microscope and EM images; link structure to function. **Video:** Watch video clip of egg and sperm cells. **How Science Works:** Use bioviewers to observe specialised cells. **Task:** Produce a poster of labelled specialised cells to explain how they are adapted for their function. **Video:** Watch a video on cell structure and function.	Further information on cells can be found at www.cellsalive.com A useful video clip on cell structure can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clip '107'. Cells: Prepared slides of different plant and animal cells, microscopes, cavity slides, coverslips, germinating cress seeds or sprouting mung beans (root hair cells). A useful video clip on cells and their functions can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for '1832'.	Be able, when provided with appropriate information, to relate the structure of different types of cell to their function in a tissue, an organ, or the whole organism.

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3.1.2 Principles of organisation						
3.1.2a	Large multicellular organisms develop systems for exchanging materials. During the development of a multicellular organism, cells differentiate so that they can perform different functions.	Explain why large organisms need different systems to survive. Explain what cell differentiation is. Describe organisation in large organisms.	2	**Activity:** Revise KS3 – show diagrams of the main organ systems to identify and describe their functions. **Activity:** Look at the different types of cells in the stomach and discuss how they were produced – link with lesson on specialised cells.	Torso, posters of organ systems.	Develop an understanding of size and scale in relation to cells, tissues, organs and systems.
3.1.2b	A tissue is a group of cells with similar structure and function.	Define the term tissue. Name the tissues in the stomach and explain what they do.		**Activity:** Look at a model of the stomach showing different tissues. **Task:** Label a diagram of the stomach with the names of the tissues and their functions.		
3.1.2c	Organs are made of tissues. One organ may contain several tissues.	Define the term organ system. Name the main systems in the human body and state their functions.		**Practical:** Investigate a celery stem microscopically to establish a relationship between cells, tissues and organs. **Activity:** Time raiders, In this Science upd8 activity, students evaluate evidence from a recently discovered		

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3.1.2d	Organ systems are groups of organs that perform a particular function.			mummy to work out how it lived and how it died. Through so doing, they learn about the function of its preserved tissues and organs.	Resources for this activity can be found at: http://www.nationalstemcentre.org.uk/elibrary/science/resource/263/time-raiders-death-of-the-mummy	

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3.1.3 Animal Tissues, organs and systems						
3.1.3a	Examples of animal tissues include: • muscular tissue, which can contract to bring about movement • glandular tissue, which can produce substances such as enzymes and hormones • epithelial tissue, which covers some parts of the body.	Recall examples of animal tissue describe the function of examples of animal tissue	1-2	**Activity:** Research examples of animal tissue and produce a presentation/podcast/video to explain the function of these tissues in the working of an organ.	Access to text books/ internet/ presentation materials.	
b)	An example of an animal organ is the stomach, which contains: • muscular tissue, to allow contents to move through the digestive system • glandular tissue, to produce digestive juices	Describe how the tissue examples are important to the function of the organ.		**Activity:** Ask students to consider how the function of the whole organ would be affected if this tissue example were absent or not functioning. What impact would this have on the animal.		

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	• epithelial tissue, to cover the outside and the inside of the stomach.					
3.1.3c	An example of an animal organ system is the digestive system, a system in which humans and other mammals exchange substances with the environment. The human digestive system includes: • glands, such as the pancreas and salivary glands, which produce digestive juices • the stomach and small intestine, where digestion occurs • the liver, which produces bile • the small intestine, where the absorption of	Label a diagram of the digestive system. Describe the functions of the digestive system to digest and absorb food molecules. Describe the functions of the organs in the system – salivary glands, stomach, small intestine, liver, pancreas and large intestine.		**Task:** Label a diagram of the digestive system and colour areas where digestion, digestion and absorption of food, and absorption of water occur. Add labels to diagram to state functions of organs in the system. **Video:** Watch a video about the digestive system. **Task:** Make a life size model of digestive system. **Activity:** Role play – what happens to food as it moves along the digestive system.	Useful information on the human body can be found at http://kidshealth.org/kid by selecting 'How the body works' in the left navigation bar. You can download a digestive system to label from http://klbict.co.uk/interactive/science/digestion2.htm A useful video clip on digestion and absorption can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clip '4180'.	

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	soluble food occurs • the large intestine, where water is absorbed from the undigested food, producing faeces.					

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3.1.4 Plant tissues, organs and systems						
3.1.4a	Examples of plant tissues include: • epidermal tissues, which cover the plant • palisade mesophyll, which carries out photosynthesis • spongy mesophyll, which has air spaces to facilitate diffusion of gases • xylem and phloem, which transport substances around the plant.	Identify different tissues in a leaf and describe their functions.	1-2	**Activity**: construct models to illustrate the structure and function of the plant tissue.	Various materials.	Know structure of a leaf and the position of the xylem and phloem in a dicotyledonous primary root and primary stem.
3.1.4b	Plant organs include stems, roots and leaves.	Label the main organs of a plant and describe their functions.		**Activity:** Look at a flowering plant and identify the main organs. Label a diagram of a plant with names and functions of organs. **How Science Works:** Observe prepared slides or bioviewers of leaves, stems and roots and identify different tissues; hypothesise what they are for. Label a diagram of a cross section of a leaf.	**Plant tissues:** Microscopes, prepared slides and bioviewers.	

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				Demo: Demonstrate transport of coloured dye in celery or a plant – could prepare slides and observe them.		

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3.1.5 Transport in cells: the movement of substances into and out of cells						
3.1.5a	Diffusion is the spreading of the particles of any substance in solution, or particles of a gas, resulting in a net movement from an area of higher concentration to an area of lower concentration. The greater the difference in concentration, the faster the rate of diffusion.	Define the term 'diffusion'. Explain that diffusion is faster if there is a bigger concentration difference.	1-2	**Demo:** Diffusion of ammonium hydroxide and hydrogen chloride in a glass tube; nitrogen dioxide in gas jars; potassium permanganate in beaker of water; potassium permanganate on agar. **Activity:** Time how long it is before students can smell a perfume placed in a corner of the room.	**Demo:** Concentrated NH_4OH, concentrated HCl, gloves, mask, forceps, cotton wool, long glass tube with strips of damp litmus along length; two gas jars of NO_2, two empty gas jars, beaker of water, pot perm crystals; agar in test tube; strong perfume; beetroot.	Be able to state two factors which affect the rate of diffusion.

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3.1.5b	Dissolved substances can move into and out of cells by diffusion.	Give examples of substances that diffuse into and out of cells.		Fresh beetroot placed in iced water and warm water – compare and explain the difference in the depth of colour of the water. **Practical:** Investigate diffusion of different acids and alkalis through agar. **Practical:** Investigate rate of diffusion of glucose through cellulose tubing. **Video:** Watch a video or computer simulation of diffusion – see Mcgraw-Hill website. **Activity:** Role play of diffusion in gases and liquids at different temperatures and concentrations.	**Agar:** Agar plates impregnated with UI solution, cork borers, solutions of acids and alkalis. **Glucose:** Beakers, cellulose tubing, glucose solution, timers, test tubes, Benedict's solution and water bath or glucose test strips. Further information can be found on BBC GCSE Bitesize at www.bbc.co.uk/schools/gcsebitesize A useful video on diffusion can be found on the McGraw-Hill website at http://highered.mcgraw-hill.com/sites/0072495855/student_view0 by selecting 'Chapter 2' and the 'How Diffusion Works' animation.	Be able to name the process by which oxygen passes into a lung cell.

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3.1.5c	Oxygen required for respiration passes through cell membranes by diffusion.					
3.1.5d	Osmosis is the diffusion of water from a dilute to a more concentrated solution through a partially permeable membrane that allows the passage of water molecules.	Define the term 'osmosis' and explain what a partially permeable membrane is.	2	Introduce movement of water molecules as a special type of diffusion through a partially permeable membrane. **Demo:** Set up a simple osmometer at the start of the lesson and measure how far the liquid in the capillary tube rises during the lesson. **Demo:** Fill cellulose tubing 'sausages' with concentrated sugar solution or water and place in beakers of concentrated sugar solution or water.	**Demo:** Cellulose tubing filled with conc sugar solution attached to capillary tube held in clamp, beaker of water. **Demo:** Four beakers (two of water and two of sugar solution); four cellulose sausages (two of water and two of sugar solution).	Be able to explain the difference between diffusion and osmosis.

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3.1.5e	Differences in concentrations of solutions inside and outside a cell cause water to move into or out of the cell by osmosis.	Plot and interpret a graph of change in mass v concentration of solution. Make predictions about osmosis experiments.		**Practical:** Investigate the effect of different concentrations of solution on potato cylinders – mass and size. **or** Find the concentration of salt or sucrose inside potato cells. **Demo:** Model to show osmosis or get students to make a model. **Video:** Watch a computer simulation of osmosis or video on osmosis in living cells – see interactive concepts in biochemistry and cellular transport**.** **How Science Works:** Investigate the effect of different concentrations of solution on beetroot or rhubarb cells. **Video:** Watch a video clip of osmosis in blood cells. **Demo:** Investigate the effect of different concentrations of solution on shelled eggs. **Activity:** Interpret data about osmosis experiments.	**Potato experiment:** Potatoes, cork borers, knives, rulers, balance, test tubes, range of different concentrations of salt or sucrose solutions. Clear plastic box, plasticine for membrane and different sized balls for water and solute. Refer to McGraw-Hill website at http://highered.mcgraw-hill.com/sites/0072495855/student_view0 select 'Chapter 2' and 'How Osmosis works'. **Living cells:** Beetroot slices or rhubarb epidermis, slides, coverslips, pipettes, water, concentrate, solution and blotting paper.	Be familiar with experiments related to diffusion and osmosis. Be familiar with the terms: *isotonic* *hypotonic* *hypertonic* *turgor* *plasmolysis*

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					Useful information on osmosis in chicken eggs can be found at http://practicalbiology.org by searching for 'Investigating osmosis in chickens' eggs'.	
Required practical: Students should investigate the effect of different concentrations of solutions separated by a partially permeable membrane.						
3.1.5f	Substances are sometimes absorbed against a concentration gradient. This requires the use of energy from respiration. The process is called active transport.	Define the term 'active transport'. Label diagrams to show where active transport occurs in humans and plants and what is transported. Explain why active transport requires energy. Relate active transport to oxygen supply and numbers of mitochondria in cells.	1	Recap diffusion and osmosis. Introduce active transport as absorption against the concentration gradient – why might this be useful?	Useful information can be found on BBC GCSE Bitesize at www.bbc.co.uk/schools/gcsebitesize/science by searching for 'active transport'. For interactive animations search for 'interactive biochemistry' in your chosen search engine, then choose the Wiley website.	Remember active transport requires energy. Note: Osmosis and diffusion do not require energy from the organism.

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3.1.5g	Active transport enables plants to absorb ions from very dilute solutions, eg by root hair cells. In plants sugar may be absorbed from low concentrations in the intestine and from low concentrations in the kidney tubules.			**Research:** Research where active transport occurs in plants and humans, and label these on diagrams with notes. **Discuss:** Discuss in terms of energy used and show images of kidney and root hair cells with mitochondria. Why must soil and hydroponics solutions be kept aerated? Show computer simulation of active transport.		
3.1.5h	A single-celled organism has a relatively large surface area to volume ratio. All the necessary exchanges occur via its surface membrane.		1-2	**Activity:** Look at image of unicellular organism, eg amoeba and discuss how it obtains food and oxygen and removes wastes; why do larger organisms need specialised systems?	**Useful information** unicellular organism, amoeba, can be found at www.biology-resources.com by searching for 'biological drawing amoeba feeding'.	

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	The increased size and complexity of an organism increase the difficulty of exchanging materials.	Explain why the size and complexity of an organism increases the difficulty in exchanging materials.		**Activity:** Show image of root hair cell and ask how it is adapted to absorb lots of water. **Activity:** Observe prepared slides showing alveoli.	Bioviewers or microscopes, cavity slides and amoeba. Microscopes**,** prepared slides of alveoli and villi.	
3.1.5i	In multicellular organisms many organ systems are specialised for exchanging materials. The effectiveness of an exchange surface is increased by: • having a large surface area that is thin, to provide a short diffusion path • (in animals) having an efficient blood supply • (in animals, for gaseous exchange) being ventilated.	Describe and explain the features of a good exchange surface. Label a diagram of an alveolus and list how it is adapted for gas exchange.		**Activity:** Label a diagram of an alveolus showing exchange of gases and list how it is adapted for its function.		Be able to explain how the small intestine and lungs in mammals, and the roots and leaves in plants, are adapted for exchanging materials.

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3.1.5j	Gas and solute exchange surfaces in humans and other organisms are adapted to maximise effectiveness.	In humans surface area is increased by alveoli in the lungs and villi in the small intestine. Villi have a large surface area and a good blood supply to absorb the products of digestion by diffusion and active transport.		**Activity** Label a diagram of a villus and list how it is adapted for absorption of food molecules. **Discuss:** Discuss where absorption of food occurs and show images of villi. Observe slides of villi. **Activity**: Label a diagram of a villus and list adaptations of the small intestine and a villus for absorption of food. **Activity**: Make a model of the lining of small intestine, use pipe cleaners highly folded to show increase in exchange surface area.		Be able, when provided with appropriate information, to explain how gas and solute exchange surfaces are adapted to maximise effectiveness

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3.2 Bioenergetics Food provides materials and energy for organisms to carry out the basic functions of life and to grow. Some plants and bacteria are able to use energy from the Sun to generate complex food molecules. Animals obtain energy by breaking down complex food molecules and are ultimately dependent on green plants for energy. Topics covered are: • photosynthesis • exchange and transport in plants • circulation • digestion • breathing • respiration.						
3.2.1 Photosynthesis						
3.2.1a	Photosynthesis is represented by the equations: carbon dioxide + water → (light) glucose + oxygen $6CO_2 + 6H_2O \xrightarrow{light} C_6H_{12}O_6 + 6O_2$	Write the word and symbol equations for photosynthesis. Carry out experiments to show that light, carbon dioxide and chlorophyll are needed to make glucose. Explain why plants should be destarched before photosynthesis experiments and describe how this is done.	3	**Activity:** Write word equation for photosynthesis – produce cards for equation and put into correct order. **Discuss:** Brainstorm what plants need to survive and how they are useful to other organisms in order to come up with the word equation for photosynthesis. **Discuss:** How is the leaf adapted for photosynthesis?	Ideas and info can be found at www.s-cool.co.uk Broad leaved plant and bioviewers.	Be able to write word and balanced symbol equations for photosynthesis. Be able to explain the results from photosynthesis experiments.

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3.2.1b	During photosynthesis: – light is absorbed by a green substance called chlorophyll, which is found in chloroplasts in some plant cells and in algae – light is used to convert carbon dioxide (from the air) and water (from the soil) into sugar (glucose) – oxygen is released as a by-product.	Describe experiments to show that plants produce oxygen in the light. Explain the steps involved in testing a leaf for starch.		**Practical:** Where are the stomata? Dip privet leaves into hot water and observe nail varnish imprints of leaves (links with B2.2.2 leaf structure, xylem and phloem, B3.1.3 exchange systems in plants and B3.2.3 transport in plants) **Demo:** Plants produce oxygen in the light. **Demo:** Test a leaf for glucose. **Practical**: Observe starch in an apple and potato. **Activity**: Label diagram of a plant to show that water enters via the roots and travels in the xylem to the leaves; carbon dioxide enters leaves via stomata; light is absorbed by chlorophyll in the leaves.	**Stomata:** Leaves from privet and spider plants, kettle, beakers, nail varnish, slides, coverslips and microscope. Oxygen: Elodea/Cabomba, glass funnel, large beaker, test tube and splints. Glucose: Plant in light, Benedict's solution, boiling tube and Bunsen burner. Starch: Pieces of apple and potato, sharp knives, slides, coverslips, iodine solution and microscopes.	Be able to describe leaf structure in terms of photosynthesis.
Required practical: Students should investigate how variables effect the rate of photosynthesis.						

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3.2.1c 3.2.1d	The rate of photosynthesis may be limited by: -low temperature -shortage of carbon dioxide -shortage of light. These factors interact and any one of them may be the factor that limits photosynthesis. The glucose produced in photosynthesis may be used as a source of chemical energy or converted to larger molecules for storage and use later. The glucose can be: -used for respiration -converted into insoluble starch for storage -used to produce fat or oil for storage -used to produce cellulose, which	Students should be able to relate the principle of limiting factors to the economics of enhancing the following conditions in greenhouses: • temperature • carbon dioxide concentration • light intensity.	2	**Practical**: Investigate the effect of light intensity or temperature on the rate of photosynthesis and plot data. **Practical**: Use sensors to measure oxygen, light, temperature and carbon dioxide levels. **Practical**: Computer simulation to investigate factors that affect the rate of photosynthesis. **Activity**: List factors that affect the rate of photosynthesis. **Activity**: Interpret graphs regarding limiting factors. **Activity**: Design a greenhouse to maintain optimum growth of plants. Explain all its design features. **Practical**: Investigate growth of tomatoes in greenhouse, lab and outside.	**Rate:** Elodea/Cabomba, funnel, large beaker, gas syringe, lamp, thermometer, sodiumhydrogen carbonate. Sensors for use with any of the experiments. Useful information can be found on the BBC GCSE Bitesize at www.bbc.co.uk/schools/gcsebitesize Further information can be found at www.s-cool.co.uk Tomato plants, pots, compost, fertiliser, sensors and balance.	Be able to interpret line graphs to compare the rate of photosynthesis under different conditions. Be able to interpret graphs in terms of what is limiting photosynthesis in a particular situation.

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	strengthens the cell wall -used to produce proteins. Explain why glucose is converted to starch for storage.					
3.2.1e	To produce proteins, plants also use nitrate ions that are absorbed from the soil.					

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3.2.2 Exchange and transport in plants						
3.2.2a	In flowering plants - carbon dioxide enters leaves by diffusion; - most water and ions are absorbed by roots.	Label a diagram of a leaf to explain why the flattened, thin structure is useful for photosynthesis and gas exchange.	1	**Discuss:** Investigate how the leaf is adapted for photosynthesis. **Practical:** Observing guard cells and stomata using nail varnish.	**Leaf structure:** Bioviewers or prepared slides, microscopes.	Be able to relate leaf and root hair structure to an efficient exchange surface.
3.2.2b	The surface area of the roots is increased by root hairs and the surface area to volume of leaves by the flattened shape and internal air spaces.	Draw diagram of root hair cells and explain how they are adapted for their function.		**Practical:** Observe root hair cells of germinating cress seeds.	**Root hair cells:** Microscopes, coverclips, slides and germinating cress seeds. **Demo:** Two long balloons with sellotape stuck on one side of each.	
3.2.2c	Plants have stomata to obtain carbon dioxide and remove oxygen produced in photosynthesis.	Draw diagrams of stomata and guard cells and explain their function.		Show images of stomata open and closed on different types of leaves and root hair cells. **Demo:** How the guard cells control the size of the stomata.	**Stomata**: Leaves from privet and spider plants, kettle, beakers, nail varnish, slides and coverslips, microscope.	Be able to suggest how having more stomata on the lower surface of the leaf helps the plant to survive better.

3.2.2d	Plants mainly lose water through their leaves; most of the loss of water vapour is through stomata. - Evaporation is faster in hot, dry and windy conditions. - If plants lose water faster than it is replaced the stomata can close to prevent wilting.	Define the term 'transpiration'. Explain how a potometer can be used to measure the rate of water uptake by a shoot. Design and carry out an investigation about factors that affect the rate of transpiration. Interpret graphs of water loss from plants v time. Describe the changes that occur in a plant to prevent wilting.	1-2	**Demo**: Plants lose water through their leaves. **Demo**: Measure the water loss from a plant. Introduce the term 'transpiration' and ask for factors that might increase the rate of transpiration. **Demo** : How to set up and use a potometer. **Practical**: Use a potometer to investigate the factors that affect the rate of transpiration. **Practical**: Investigate the effect of Vaseline on the upper and lower surfaces of a leaf – relate results to work done on leaf structure. Interpret graphs showing rate of transpiration.	**Demo:** Plant with plastic bag sealed around the leaves and cobalt chloride paper. **Demo**: Plant with plastic bag sealed around the pot placed on a balance and connect to datalogger. **Demo**: Potometer, Vaseline, leafy shoot cut under water. **Transpiration**: Potometer, leafy shoot, Vaseline, timer, fan, lamp and hairdryer. Four privet leaves, Vaseline, washing line, paper clips and balance. Transpiration experiments can be found at www.skoool.co.uk	Know why windy conditions increase water loss.
3.2.2e 3.2.2f	The size of stomata is controlled by guard cells which surround them. Flowering plants have separate transport systems: • xylem tissue transports water and mineral ions from the	Explain why plants sometimes wilt. Explain the function of xylem and phloem. Label diagrams showing the position of xylem and phloem in roots, stem and leaves.		**Discuss:** Discuss role of guard cells in reducing wilting.		Know that xylem carries water and ions to the leaves and that phloem carries sugars away from the leaves.

	roots to the stem and leaves • the movement of water from the roots through the xylem and out of the leaves is called the transpiration stream • phloem tissue carries dissolved sugars from the leaves to the rest of the plant, including the growing regions and the storage organs. This process is called translocation • the structure of the xylem and the phloem is related to its function.					

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.2.3 Circulation in Humans						
3.2.3a 3.2.3b 3.2.3c	Substances are transported from where they enter the body to the cells, or from the cells to where they are removed from the body, by the circulatory system (the heart, the blood vessels and the blood). The heart is an organ that pumps blood around the body, much of its wall is made from muscle tissue. There are four main chambers to the heart, right and left atria and ventricles.	State the functions of the circulatory system and the heart. Describe the flow of blood from the body, through the heart and lungs and back to the body. Label a diagram of the heart showing 4 chambers, vena cava, pulmonary artery, pulmonary vein and aorta.	1-2	Recap the functions of the heart and circulatory system. **Demo:** Show a model heart and identify the chambers, main blood vessels and valves. Computer simulation to show the flow of blood around the heart, lungs and body. **Demo:** Heart and lungs of a mammal to show the associated vessels. Get students to feel the vessels. Show students how to go about dissecting their mammal hearts and identify the vessels. Dissect a mammal's heart.	Useful information can be found at www.klbict.co.uk/interactive/science/heart.htm Heart animations and interactives can be found at www.smm.org/heart/heart/top.html Video clips on the heart can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clips '5367' and '2270'. **Demo:** Heart and lungs of mammal, board, scissors, mounted needle and gloves. **Dissection:** Mammal hearts.	Have knowledge of the cardiac cycle **Note:** names of the heart valves is **not** required **Note:** Consider **all** members of the class before carrying out the demonstrations.

3.2.3d	The natural resting heart rate is controlled by a pacemaker located in the right atrium. Artificial pacemakers are electrical devices used to correct irregularities in the heart rate.	Evaluate information about pacemakers.		Watch video about action of sinoatrialnodec (SAN)	heart.emedtv.com › Heart is video showing insertion of artificial pacemaker.	Know that the natural pacemaker is located in the right atrium. Know that artificial pacemakers correct irregularities in heartbeat.
3.2.3e	In coronary heart disease layers of fatty material build up inside the coronary arteries causing them to narrow. This reduces the flow of blood through the coronary arteries resulting in a lack of oxygen for the heart muscle. Stents are used to keep the coronary arteries open.	Describe problems associated with the heart and explain how they can be treated. Describe what a stent is and what it is used for. Evaluate the use of stents. Evaluate the use of artificial hearts and heart valves.		**Video:** Watch a video clip showing the use of a stent. **Task:** Write a short report to explain what stents are, why they are used and explain how they save lives. **Discuss:** Discuss the different types of heart problems that can occur and how they are treated – heart attack, leaky valves, hole in the heart, blocked coronary arteries, heart transplants, artificial hearts and replacement valves. Illustrate with pictures. Produce a report or PowerPoint presentation – to complete for **homework**.		Explain how fatty build-up of fatty materials in arteries can lead to heart attacks. Explain the function of stents.
3.2.3f	In some people heart valves may become faulty. There are two main faults – the heart valve tissue might stiffen, preventing the	Evaluate information about the use of both biological valves and mechanical valves.			British heart foundation. DVD10 Lifelines - Heart Surgery And After	

	valve opening fully, or the heart valve might develop a leak. Faulty heart valves can be replaced using: biological valves – valves from humans or other mammals; mechanical valves.				This programme follows five patients with coronary arterial disease or requiring valve replacement through three key stages: preparing for heart surgery, what to expect in hospital, and recovery.	
3.2.3 g 3.2.3h	Artificial hearts are occasionally used to keep patients alive whilst waiting for a heart transplant, or to allow the heart to rest as an aid to recovery. Blood enters the atria which contract and force blood into the ventricles. Ventricles contract and force blood out of the heart. Valves ensure blood flows in the correct direction.	Evaluate information about different types of artificial heart. Know difference between atria and ventricles. Know that valves prevent backflow of blood from ventricles to atria and from aorta and pulmonary artery into ventricles.		Discuss ethics of using patients in development of artificial hearts. Watch heart cycle video.	http://www.mayoclinic.com/health/circulatory-system/MM00636 contains video of cardiac cycle.	Know the direction of flow of blood through each heart valve.

3.2.3l	Blood flows from the heart to organs through arteries and returns through veins. There are two separate circulation systems – to the lungs and to the other organs of the body.	Explain the advantage of a double circulation over a single circulation.				Explain what is meant by double circulation. Knowledge of the blood vessels associated with the heart is limited to aorta, vena cava, pulmonary artery, pulmonary vein and coronary arteries.
3.2.3j	Arteries have thick walls containing muscle and elastic fibre. Veins have thinner walls and often have valves to prevent back flow of blood.	Draw and label diagrams of arteries, veins and capillaries. Compare the structure and function of arteries, veins and capillaries. Measure someone's pulse rate and blood pressure and describe factors that affect them	1-2	**Video:** Watch a computer simulation or video clip showing the three types of blood vessels and comparing their functions. **Task:** Draw and label diagrams of the three types of vessels. Produce a table to compare the structure of the vessels and relate to their function.	Useful information on blood vessels and the vascular system can be found at www.ivy-rose.co.uk by searching 'Blood Vessels - Vascular System'.	Be able to recognise veins and arteries from diagrams of blood vessels. **Note:**Knowledge of the names of the heart valves is not required.
3.2.3k	In the organs, blood flows through very narrow, thin walled blood vessels called capillaries. Substances pass from the blood to the body tissue cells and	Structure and function of capillaries.		**How Science Works:** Look at prepared slides showing the three types of blood vessels to compare their structure. **Demo:** Valves in veins prevent backflow of blood using someone with prominent veins.	**Blood vessels:** Bioviewers or microscopes, prepared slides.	

	substances produced by the cells pass into the blood through the walls of the capillaries.			**How Science Works:** Measure pulse rate and blood pressure – lying down, sitting and standing. **Homework:** Research the work of Galen and William Harvey and produce a report.	**Pulse rate:** Timers or pulse rate sensor, blood pressure monitor.	
3.2.3l	Blood is a tissue consisting of a fluid called plasma in which the white blood cells, red blood cells and platelets are suspended.	Describe the constituents of blood. Draw diagrams of red blood cells, white blood cells and platelets. Explain the structure and function of red blood cells, white blood cells and platelets.	1	**How Science Works:** Observe blood smears. **Video:** Watch a video about the composition of blood and the structure and function of its constituents. **Task:** Draw and label diagrams of red blood cells, white blood cells and platelets.	**Blood smears:** microscopes, prepared slides or bioviewers. Useful information can be found at http://kent.skoool.co.uk go to Key stage 4 > Biology > Blood and Circulation.	
3.2.3m	Plasma transports - carbon dioxide to the lungs, - soluble products of digestion from the small intestine and - urea from the liver to the kidneys.	State some substances transported in the blood plasma.		Write notes to explain the composition of blood and describe the functions of plasma, red blood cells, white blood cells and platelets. **Activity:** Make plasticine models of red blood cells and use them to illustrate what happens when they pass through capillaries.		

3.2.3n	Red blood cells have no nucleus. They are packed with a red pigment called haemoglobin. They transport oxygen from the lungs to the organs. Oxygen attaches to the haemoglobin to form oxyhaemoglobin. In other organs oxyhaemoglobin splits up into haemoglobin and oxygen.	Function and structure of red blood cells. Explain why the reversible reaction between oxygen and haemoglobin is important.		Write a word equation for the reaction of oxygen with haemoglobin.		Be able to name the blood part which carries most oxygen.
3.2.3o	White blood cells have a nucleus. They form part of the body's defence system against microorganisms.	Function and structure of white blood cells.				
3.2.3p	Platelets are small fragments of cells. They have no nucleus and help blood to clot at the site of a wound.	Function and structure of platelets.				
3.2.3q	Blood clotting is a series of enzyme controlled reactions, resulting in the change of fibrinogen to fibrin, which forms a network		1	Draw a flow chart to illustrate the clotting process.	http://www.hematology.org/Training/Students/5591.aspx	Names of the enzymes and factors involved in clotting are not required

	of fibres trapping blood cells and forming a clot.					
3.2.3r	Antigens are proteins on the surfaces of cells.	Distinguish between antigen and antibody.				
3.2.3s	In organ transplants a diseased organ is replaced with a healthy one from a donor. The recipient's antibodies may attack the antigens on the donor organ as they do not recognise them as part of the recipient's body. To prevent rejection of the transplanted organ: • a donor organ with a 'tissue-type' similar to that of the recipient is used • the recipient is treated with drugs that suppress their immune system.		1	Evaluate the use of donor organs. Discuss ways of improving the supply of donor organs.	http://scotland.gov.uk/Publications/2003/11/18095/25886 has a good resource bank on this topic.	When provided with appropriate information, to evaluate the advantages and disadvantages of treating organ failure by mechanical devices or transplant.

3.2.3t	There are four main types of human blood, O, A, B and AB. Blood group O is the universal donor.	List the antigens present on each type of red cell. List the naturally occurring antibodies in the plasma of the four different blood groups.	1	Draw a compatibility table. Explain the difference between universal donor and universal recipient.	www.lessonplanspage.com has a good demonstration involving dyes rather than blood. *www.blood.co.uk* › *About Blood* gives the history of the blood transfusion service.	Students should understand: - the need for blood typing; - the ABO compatibility table.

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3.2.4 Digestion						
3.2.4a	Starch (a carbohydrate), proteins and fats are insoluble. They are broken down into soluble substances so that they can be absorbed into the bloodstream in the wall of the small intestine. In the large intestine much of the water mixed with the food is absorbed into the bloodstream. The indigestible food which remains makes up the bulk of the faeces. Faeces leave the body via the anus.	Label a diagram of the digestive system. Describe the functions of the digestive system to digest and absorb food molecules. Describe the functions of the organs in the system – salivary glands, stomach, small intestine, liver, pancreas and large intestine. Explain why food molecules need to be digested.	1	**Activity:** Recap the functions of the digestive system. **Task:** Label a diagram of the digestive system and colour areas where digestion, digestion and absorption of food, and absorption of water occur. Add labels to diagram to state functions of organs in the system. **Video:** Watch a video about the digestive system. **Task:** Make a life size model of digestive system. **Activity:** Role play – what happens to food as it moves along the digestive system (opportunity for investigations – see B2.5.2).	Torso/model of digestive system. The Digestive System builder can be found at http://science.waltermack.com/flashTeacherTools/biology/digestiveSystemBuilder2a.swf http://science.waltermack.com/flashTeacherTools/biology/digestiveSystemBuilder2a.swf Useful information on the human body can be found at http://kidshealth.org/kid by selecting 'How the body works' in the left navigation bar. You can download a digestive system to label from http://klbict.co.uk/interactive/science/digestion2.htm A useful video clip on digestion and absorption can be found on the BBC website	Be able to label a diagram of the digestive system: salivary glands, oesophagus, stomach, liver, gall bladder, pancreas, duodenum, small intestine, large intestine, anus

3.2.4b	Enzymes help the breakdown of food in the digestive system. • Enzymes are large proteins that act as biological catalysts. Catalysts increase the rate of chemical reactions and are utilized in the digestive process to speed up the breakdown of large molecules to small molecules for absorption into the bloodstream. • The shape of an enzyme is vital for the enzyme's function. High temperatures denature the enzyme, changing the shape of the active site. • Different enzymes work best at different pH values. • Some enzymes work outside the body cells. The digestive enzymes are produced by specialised cells in	Explain why enzymes are specific. Define the terms 'catalyst' and 'enzyme'. Explain why enzymes are denatured by high temperatures. Describe and explain the effect of different pH values on the activity of different enzymes. Be able to name the enzyme that digests stains containing fats	6	**Demo:** Action of an inorganic catalyst and catalase on the breakdown of hydrogen peroxide. **Activity:** Make models or cut-outs to demonstrate the shape of the active site of an enzyme and the shape of the substrate(s). **Video:** Computer simulation to show shape of enzymes and substrates and effect of temperature on the shape of an enzyme molecule. **Practical:** Investigate the optimum pH values for pepsin and trypsin enzymes. **Video:** Computer simulation to show shape of enzymes and substrates and effect of pH on the shape of an enzyme molecule.	**Demo:** Manganese dioxide, liver, boiled liver, celery, apple or potato, hydrogen peroxide, test tubes and goggles. An enzyme animation can be found at www.youtube.com by searching for 'CZD5xs OKres'. Further information can be found at www.skoool.co.uk **pH:** Pepsin solution, trypsin solution, buffer solutions at different pH values, UI strips, egg white suspension, test tubes, timers and goggles. **Exhibition:** Biological and non-biological detergents, baby food, sugar syrup and slimming foods containing fructose.	Be able to evaluate the advantages and disadvantages of using enzymes in the home and industry. Be able to name the enzymes used to convert: i) starch to glucose and ii) glucose to fructose.

	glands and in the lining of the gut. The enzymes then pass out of the cells into the gut, where they come into contact with food molecules. They catalyse the breakdown of large molecules into smaller molecules.					
Required practical: Students should investigate how different temperatures and pH affect the rate of digestion.						
3.2.4c	**Digestive Enzymes** - The enzyme amylase is produced in the salivary glands, the pancreas and the small intestine. Amylase catalyses the breakdown of starch into sugars in the mouth and small intestine. - Protease enzymes are produced by the stomach, the pancreas and the small intestine. These enzymes catalyse the breakdown of proteins into amino acids in the stomach and the small intestine.	For amylases, state the organs which produce them, substrates they act on and products of digestion. For proteases, state the, organs which produce them, substrates they act on and products of digestion.	2	**Activity**: Add labels to diagram of digestive system giving names of enzymes produced. Produce table giving names of enzymes, substrates and products. **Practical**: Investigate the effect of temperature on amylase activity – measure time taken for starch to disappear. Different groups do different temperatures and share results. Could be done using a computer simulation instead. Plot results and find optimum temperature for amylase. **Recap** results of trypsin-pepsin experiment – enzymes have an optimum pH. **Research**: Research Alexis St Martin story.	Amylase: Saliva or amylase solution, starch solution, test tubes, water baths at different temperatures, glass rods, spotting tiles, iodine solution and timers.	Be able to state where amylases are produced and the reactions they catalyse. Be able to state where proteases are produced and the reactions they catalyse. Be able to interpret graphs showing the effect of temperature and pH on enzyme activity.

-	- Lipase enzymes are produced by the pancreas and small intestine. They catalyse the breakdown of lipds into fatty acids and glycerol. - The stomach also produces hydrochloric acid. The enzymes in the stomach work most effectively in acid conditions. - The liver produces bile, which is stored in the gall bladder. Bile neutralises the acid added to food in the stomach and provides alkaline conditions in the small intestine for the enzymes there to work effectively - Bile also emulsifies fats (breaks large drops of fats into smaller droplets). This increases the surface area of fats for lipase enzymes to act upon. - Some microorganisms produce enzymes that pass out of cells. These have many uses in the home and industry.	For lipases, state the organs which produce them, substrates they act on and products of digestion. Know that the stomach produces hydrochloric acid. Know that the liver produces bile which is stored in the gall bladder. Know that bile makes the contents of the small intestine alkaline. State that microorganisms produce enzymes that we use in the home and in industry. For example, biological detergents, baby foods, sugar syrup and fructose syrup.		**Demo**: Effect of bile salts on rate of digestion of milk. **Activity**: Use computer simulations to model effect of temperature, pH and concentration on enzyme activity. **Demo:** Exhibition to illustrate uses of enzymes in the home and industry. **Activity:** Could taste glucose and fructose solutions.	Demo: Two tubes, milk, sodium carbonate solution, phenolphthalein solution, lipase solution, +/- washing up liquid and timer. Further information can be found at www.skoool.co.uk **Detergents:** Liquid detergents, white cotton stained with fat and protein, kettle, beakers, cylinders, stirring rods, thermometers and white tiles.	Be able to state where lipases are produced and the reactions they catalyse. Know that enzymes in the stomach work best in acid conditions and that enzymes in the small intestine work best in alkaline conditions. Be able to use a line graph to describe the effect of increasing temperature on the time taken by

				Make a table to show names of enzymes used in home and industry and what they are used for.		a detergent to remove a stain. Students should be able to give examples of some enzymes used in the home and industry and relate data to the properties of enzymes.
		Give examples of enzymes used in industry – proteases, carbohydrases and isomerase. Explain why biological detergents work better than non-biological detergents at removing protein and fat stains. Explain the advantages and disadvantages of biological and non-biological detergents. Explain the advantages and disadvantages of enzymes in industry.		**Practical:** Investigate the effect of temperature on stain removal using biological and non-biological detergents. **or** Simplify to investigate which type of detergent removes fat and protein stains best at 40 °C. Students can stain the cotton for homework or in a previous lesson or test on different types of stains. **Video:** Watch a video about uses of enzymes in industry. Produce a table to show the advantages and disadvantages of using enzymes in industry.	Information and test questions for enzymes in industry can be found at www.absorblearning.com	Be able to explain why the detergent does not work well at 60°C.

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
4.1 Breathing						
4.1a	The respiratory (breathing) system takes air into and out of the body so that oxygen from the air can diffuse into the bloodstream and carbon dioxide can diffuse out of the bloodstream into the air. The lungs are in the upper part of the body (thorax), protected by the ribcage and separated from the lower part of the body (abdomen) by the diaphragm.	Label a diagram of the breathing system. The breathing system – lungs, thorax, ribcage, diaphragm and abdomen. State the function of the breathing system.	1	**Activity:** Identify the main organs of the breathing system and discuss the function of the system. **Practical**: Lung dissection. **Task:** Label a diagram showing the position of the lungs, ribcage, rib muscles, diaphragm, abdomen, thorax, trachea, bronchi, bronchioles and alveoli. **Video:** Watch a video clip showing structure of the breathing system.	Torso or model of the breathing system. **Dissection:** Lungs with heart and trachea, board, tube, foot pump, large plastic bag and knife. A video clip on Anatomy and physiology of the lungs can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clip '5373'.	Be able to identify the main parts of the breathing system on a diagram. For example, add labels to a diagram for alveolus, diaphragm, rib and trachea. **Note:** Consider all members of the class before carrying out the lung dissection.
4.1b	To inhale: • the intercostal muscles contract, pulling the ribcage upwards • at the same time the diaphragm muscles contract, causing the diaphragm to flatten	Explain the changes that occur to bring about inhalation and exhalation -ventilation of the lungs in terms of relaxation and contraction of muscles, movement of the ribcage and diaphragm, changes	1	Think about the changes that occur when you breathe in and out. Try to explain what is moving. **Demo:** Model lungs – relate the model to the structure of the breathing system. Evaluate how good a model it is.	Model lungs -balloons in bell jar with moveable rubber sheet. See human lungs article at http://science.nationalgeographic.com/science/health-and-human-body/human-body/lungs-article.html or	Remember that breathing is a result of volume and pressure changes in the thorax.

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
	• these two movements cause an increase in the volume of the thorax • the consequent decrease in pressure to below that of the air surrounding the body results in atmospheric air entering the lungs. To exhale: • the intercostal muscles relax, allowing the rib cage to move downwards • at the same time the diaphragm muscles relax, allowing the diaphragm to resume its domed shape • these two movements cause a reduction in the volume of the thorax • the consequent increase in pressure results in air leaving the lungs.	in volume and pressure in the thorax. Calculate mean, median, mode and range of lung volumes. Interpret spirometer traces.		Computer simulation to show the changes that occur during breathing in and out. **Task:** Write down what happens to the diaphragm, ribcage and thorax during breathing in and breathing out. Describe the associated changes in volume and pressure. Complete a table of differences. **Practical:** Investigate variation of each student of lung volume. Interpret spirometer traces from practical measurement or from past exam papers.	search 'lungs article National Geographic' in your search engine. **Lung volume:** 5 litre plastic bottle marked every 0.5 ltrs, tube, large trough with water, mouth pieces or Dettol solution or spirometer.	

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4.1c	The alveoli provide a very large surface area, richly supplied with blood capillaries, so that gases can readily diffuse into and out of the blood.	List the adaptations of alveoli for gaseous exchange.		Relate the features of alveoli to the general features of exchange surfaces.		
4.1d	A healthy person breathes automatically 24 hours each day. Spontaneous breathing may stop due to disease or injury. Patient can be helped to breathe using a mechanical ventilator.	Evaluate the development and use of artificial aids for breathing, including the use of artificial ventilators. There are two types of mechanical ventilator: *Negative pressure* ventilator which causes air to be drawn into the lungs *Positive pressure ventilator* which forces air into the lungs.	1	**Discuss:** Brainstorm situations that would require the use of artificial aids for breathing. **Discuss:** Discuss what machines have been used to aid breathing – show pictures or actual aids and work out how they work. Produce a poster or PowerPoint presentation on the development of artificial aids for breathing.		

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3.2.6 Respiration						
3.2.6a	Respiration in cells can take place aerobically (using oxygen, or anaerobically (without oxygen) to release energy.		1-2			Be able to write word and balanced symbol equations for aerobic respiration.
3.2.6b	During aerobic respiration glucose and oxygen react to release energy.	Explain what aerobic means. Write the word equation for aerobic respiration. Write a balanced symbol equation for aerobic respiration.		**Activity**: Ask what substance the body uses to release energy from and build up the word equation for aerobic respiration; what does aerobic mean?		
3.2.6c	Aerobic respiration is represented by the equations: glucose + oxygen → carbon dioxide + water $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$					

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3.2.6d	Aerobic respiration occurs continuously in plants and animals.					
3.2.6e	Most of the reactions in aerobic respiration take place inside mitochondria.	State the site of aerobic respiration and be able to give examples of cells that contain a lot of mitochondria.		**Activity:** Show energy drink and glucose tablets and ask what they are used for. Lead in to discussion on the uses of energy in animals and plants; explain all the reactions involved are controlled by enzymes. List uses of energy in plants and animals.	Bottle of Lucozade, glucose tablets and a plant.	
3.2.6f	Energy released during respiration is used - to build larger molecules, - to enable muscle - contraction in animals, - in mammals and birds to maintain a steady body temperature in colder surroundings, - in plants, to build up sugars, nitrates and other nutrients into	State some uses of energy in animals and in plants. Explain why respiration has to occur continually in plant and animal cells. Describe the test for carbon dioxide.		**Demo:** Heat production from germinating peas. Highlight need for energy even when asleep or the need for a glucose drip if in a coma. **Activity:** Where does aerobic respiration occur? Show EM images of mitochondria in cell. Compare number of mitochondria in muscle and skin cells. Why are there so many in muscle cells? What other cells will have a lot of mitochondria? Show EM images and include mitochondria in plant cells.	**Peas:** Soaked peas, boiled and cooled peas and thermos flasks with temperature probes. Information and images on mitochondria can be found at www.Biology4kids.com	

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
	amino acids, which are then built up into proteins.			**Practical:** Investigate the composition of exhaled air. **Homework:** Research composition of inhaled and exhaled air and display as pie charts or bar charts.	**Exhaled air:** Carbon dioxide in inhaled and exhaled air apparatus, limewater, mirrors, cobalt chloride paper and thermometers.	
3.2.6g	During exercise the human body needs to react to the increased demand for energy. A number of changes take place: • the heart rate increases, increasing blood flow to the muscles • the rate and depth of breathing increases • glycogen stored in the muscles is converted back to glucose.	Design an investigation to find out the effect of exercise on heart and breathing rates. Plot the results in a graph. Explain why heart rate and breathing rate increase during exercise.	1-2	**Practical:** Investigate the effect of exercise on heart rate, breathing rate and depth of breathing. **Video:** Effect of exercise on the body. **Video:** Use of spirometer. **Activity:** Use spirometer tracing to calculate breathing rate and depth of breathing.	Timer, pulse sensor and spirometer if available.	Be able to interpret line graphs and spirometer tracings to compare rate of breathing before, during and after exercise.

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	Muscles store glucose as glycogen, which can be converted back to glucose for use during exercise.	Write equations and explain the conversion between glucose and glycogen in liver and muscle cells.		**Discuss:** Discuss the sources of glucose during exercise and link to storage and conversion of glycogen in liver and muscles back into glucose (links with B3.1.2 and B3.3.3).		Be able to explain the advantages to the body of the walking.
3.2.6h	These changes increase the supply of sugar and oxygen to, and increase the rate of removal of carbon dioxide from, the muscles.	Interpret data relating to the effects of exercise on the body, eg spirometer tracings.				
3.2.6i	During exercise, if insufficient oxygen is reaching the muscles they use anaerobic respiration to obtain energy.	Write the equation for anaerobic respiration in animal cells.		**Practical:** Investigate how long it takes muscles to fatigue – repetitive actions, eg step ups or holding masses at arm's length. **Practical:** Investigate effect of muscle fatigue on muscle strength.	Timers, masses. Force meters.	Be able to write word and balanced symbol equations for anaerobic respiration. Be able to explain why muscles become fatigued during exercise.
3.2.6j	Anaerobic respiration is the incomplete breakdown of glucose and produces lactic acid. It results in an oxygen debt that is repaid in order to oxidise lactic acid to	Explain the effect of lactic acid build up on muscle activity.		**Discuss:** Discuss causes and effects of muscle fatigue; relate to lactic acid build up. Write the word equation for anaerobic respiration in animal cells.		Be able to understand that the build-up of lactic acid leads to oxygen debt.

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
	carbon dioxide and water.			**Video:** Watch a video showing sprinters and discuss how the body reacts at the end of the race – paying back the oxygen debt. Make notes and write equation for the breakdown of lactic acid.		
3.2.6k	As the breakdown of glucose is incomplete, much less energy is transferred in anaerobic respiration than during aerobic respiration.	Explain why anaerobic respiration is less efficient than aerobic respiration. Define the term oxygen debt. Write the equation for the breakdown of lactic acid into carbon dioxide and water.				
3.2.6l	During long periods of vigorous activity muscles become fatigued and stop contracting efficiently. One cause of muscle fatigue is the build-up of lactic acid in the muscles. Blood flowing through the muscles eventually					

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
	removes the lactic acid.					
3.2.6m	Anaerobic respiration in plant cells and in some microorganisms results in the production of ethanol and carbon dioxide.	Compare anaerobic respiration in animals, plants and microorganisms.		**Practical**: investigate production of ethanol and carbon dioxide by yeast.		Be able to compare anaerobic respiration in animals, plants and microorganisms.
Required practical: Students investigate the effects of exercise on the human body.						

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.3 Ecology						
3.3.1 Energy transferred in ecosystems						
3.3.1a	Radiation from the Sun is the source of energy for most communities of living organisms. Plants and algae transfer about 1% of the incident energy from light for photosynthesis. This energy is stored in the substances that make up the cells of the plants.	Explain why energy and biomass is reduced at successive stages in a food chain. .	2	**How Science Works:** Investigate leaf litter – separate into plant material and different types of animals; construct pyramids biomass. **Activity:** Compare information shown in pyramids of biomass and discuss why biomass decreases at each level. **Interpret:** Data on energy transfer in food chains and list energy losses at each level.	Useful information can be found at www.gould.edu.au/foodwebs Leaf litter, identification charts, balance and containers.	Note: Students do not need to be able to interpret pyramids of number.

3.3.1b	Only approximately 10% of the biomass from each trophic level is transferred to the level above it because: • some materials and energy are always lost in the organisms' waste materials • respiration supplies all the energy needs for living processes, including movement. Much of this energy is eventually transferred to the surroundings.	Describe how energy and mass is transferred along a food chain		**Demo**: Heat produced by germinating peas (links with B2.3 and B3.4.4).	Germination: Flasks of soaked peas and boiled peas with thermometers.	

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.3.1c 3.3.1d	The biomass at each stage can be drawn to scale and shown as a pyramid of biomass. The efficiency of food production can be improved by reducing the number of stages in a food chain.	Explain how energy is lost at each level in a food chain and calculate percentage energy losses. Explain why shorter food chains are more efficient for food production. State how energy losses from food animals can be reduced. Evaluate the positive and negative effects of managing food production. Explain why people buy foods that have travelled a long way and the effect of this on the environment. Recognise that practical solutions for human needs may require compromise between competing priorities.	1-2	**Recap** food chains and pyramids of biomass. **Interpret:** data on energy transfer in food chains and list energy losses at each level. **Task:** Calculate the percentage of energy transferred at each stage. **Activity:** Ask students what they had for lunch and write food chains for them. Consider different food chains relating to food production and evaluate how efficient each is in terms of energy produced for consumption per unit of land. **Video**: Watch video clips showing battery hens, animals reared indoors and free range animals. **Discuss**: Discuss how energy losses are reduced when animals are reared indoors.	Useful information on farming can be found at www.thisisdairyfarming.com and www.small-farm-permaculture-and-sustainable-living.com	Be able to use data provided to calculate the % energy lost in urine and faeces. Students should be able to interpret pyramids of biomass and construct them from appropriate information. Be able to suggest one reason why calves raised indoors grow faster than those raised outdoors. Be able to suggest one reason why some people prefer to buy meat from animals that have been kept outdoors.

				Activity: Carry out a survey to find out what sort of eggs people buy and why. List the advantages and disadvantages of factory farming animals. **Homework:** survey where food in the fridge at home has come from and calculate the air miles. Consider the pros and cons of eating foods that have travelled a long way.		

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.3.2 Adaptations, interdependence and competition						
3.3.2a 3.3.2b	To survive and reproduce, organisms require a supply of materials from their surroundings and from the other living organisms there. Plants often compete with each other for light and space, and for water and nutrients from the soil.	List factors that affect the survival of organisms in their habitat. Give examples of resources that plants and animals compete for in a given habitat.	2-3	**Discuss:** Brainstorm factors that affect the survival of organisms in a habitat. Discuss resources that organisms may compete for and the effect on populations.	refer to Encyclopaedia Britannica website www.britannica.com	Be able to name two things for which plants compete.
3.3.2c	Animals compete for food, mates and territory.	Describe adaptations that some organisms have to avoid being eaten. Interpret population curves.		**Activity:** Interpret population curves, eg hare and lynx, red and grey squirrels, and native and American crayfish. Encyclopaedia Britannica: population ecology. **Activity:** Camouflage game on the school field. Exhibition of camouflaged organisms.	Camouflage: Equal numbers of red and green cocktail sticks and timer. Pictures showing camouflaged organisms. Distribution: Quadrats, identification sheet, sensors and dataloggers.	

				Practical: Investigating the distribution of plants on the school field or relationship between light intensity and types of plants. **Practical:** Competition in radish seedlings – spacing trials and height	Competition: Radish seeds, potting trays and compost.	
3.3.2d	Organisms, including microorganisms, have features (adaptations) that enable them to survive in the conditions in which they normally live. For example, some organisms live in environments that are very extreme, containing high levels of salt, high temperatures or high pressures. These organisms are called extremophiles. Adaptations include: • structural adaptations, eg the ways in which organisms are shaped, or coloured	Observe adaptations of a range of organisms. Explain how organisms are adapted to survive in their habitat. Students should be able to explain how some parasites are adapted for living on or inside their hosts. For example: • fleas live amongst the hair of mammals • tapeworms live inside the intestines of mammals • malaria parasites are	2	**Activity:** Produce a display of plants, animals and microorganisms with labels to explain how their adaptations help them to survive in their habitat. Include examples of extremophiles and desert and arctic organisms. Prepare a presentation about adaptations. Look at different types of plants – succulents, cacti, broad leaved and Venus fly trap. **Practical:** Investigate the rate of cooling – either surface area (SA)/Volume ratio, colour of body, body covering or huddling. Link results to different organisms.	Useful information can be found on the BBC website at www.bbc.co.uk by searching 'adaptations and behaviours'. Further information can be found at www.yourdiscovery.com Useful video clips can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for extremophile bacteria (clip 10469), plant adaptations – extreme cold (clip 5506), and plant adaptations – extreme heat (clip 5514). Cooling: Different sized containers with lids, different coloured containers, insulation materials, test tubes for huddling, thermometers or temperature probes and timers.	Be able to relate features seen in a diagram to the organism's survival.

	• behavioural adaptations, eg migration, huddling together • functional adaptations, related to processes such as reproduction and metabolism.	single-celled organisms that cause malaria in humans. Students given appropriate information should be able to suggest how animals and plants are adapted to their environment.		**Homework:** Design and label an imaginary creature to survive in a given habitat. The more unusual the better!		
3.3.3 Decay and the carbon cycle						
3.3.3a	Living things remove materials from the environment for growth and other processes; these are returned to the environment in wastes and when organisms die and decay.	Describe how plants and animals return materials to the environment.	2	**Discuss:** Show some examples of rotting foods; discuss what has caused the food to rot. What would happen if things didn't rot when they died? Sort items into biodegradable and non-biodegradable.	Rotting tomato and other foods. Materials to sort.	Be able to name the type of living organism which causes leaves to decay? Be able to give one reason why leaves decay faster in summer than winter.
3.3.3b	Materials decay because they are broken down (digested) by microorganisms. Microorganisms are more active and digest materials faster in warm, moist, aerobic conditions.	Describe the role of microorganisms in decay. State factors affecting the rate of decay.		**Practical:** Investigating the factors that affect decay, eg temperature and decay of bread or fruit.	**Decay:** Moist food, incubator, fridge, containers with lids.	Be able to name the gas needed for decay.

3.3.3c 3.3.3d	The decay process releases substances that plants need to grow. In a stable community, the processes that remove materials are balanced by processes that return materials. The materials are part of a constant cycle.	Explain how decay is useful to plants. Evaluate the necessity and effectiveness of recycling organic kitchen or garden wastes.		**Discuss:** Discuss why plants in a wood continue to grow without the use of fertilisers and relate to recycling of materials. **Research:** Look at how kitchen and garden wastes can be recycled. **Practical:** Investigate the rate of decay of grass clippings. **Practical:** Competition – whose potato will decay the fastest? Plan the best conditions for decay. **Demo:** Set up a wormery and observe how they improve the soil and breakdown dead leaves. **Online activity:** Earthworm investigation.	Pictures of decaying plants and animals in the wild. **Grass clippings:** Thermos flasks with thermometers/temperature probe, disinfectant, wet and dry grass and composting agent. Useful information on earthworms can be found at www.curriculumbits.com by searching for 'Earthworm investigation'.	
3.3.3e	The constant cycling of carbon is called the carbon cycle. In the carbon cycle: • carbon dioxide is removed from the environment by green plants and algae during photosynthesis • the carbon from the carbon dioxide is	Explain the carbon cycle in terms of photosynthesis, respiration, feeding, death and decay, combustion of wood and fossil fuels. Explain the role of microorganisms and detritus feeders in decay. Students should be able to apply the principles of the carbon cycle.	1	**Demo:** Use a sensor to measure carbon dioxide levels in the air; show a piece of coal and discuss what it is and how it was formed. **Activity:** Revise how carbon dioxide is used by plants in photosynthesis and why this is of use to animals. What happens to the carbon? How the carbon passes from plants to animals; how it is returned to the air; what happens when things die; formation and combustion of fossil fuels.	Carbon dioxide sensor, coal and oil. Demo: fuels, inverted glass funnel to direct fumes	Be able to give two reasons why deforestation increases the amount of carbon dioxide in the atmosphere. Be able to describe how the carbon in dead bodies may be recycled. Be able to describe

	used to make carbohydrates, fats and proteins, which make up the body of plants and algae • when green plants and algae respire, some of this carbon becomes carbon dioxide and is released into the atmosphere • when green plants and algae are eaten by animals and these animals are eaten by other animals, some of the carbon becomes part of the fats and proteins that make up the bodies of the consumers • when animals respire, some of this carbon becomes carbon dioxide and is released into the atmosphere • when plants, algae			**Demos**: Show examples of fossil fuels; burn a fossil fuel and bubble the fumes through limewater. **Cut-out** different coloured cards for processes and organisms and arrange them as in the carbon cycle.	through tube of limewater and pump.	the stages in the carbon cycle.

	and animals die, some animals and microorganisms feed on their bodies • carbon is released into the atmosphere as carbon dioxide when microorganisms respire • by the time the microorganisms and detritus feeders have broken down the waste products and dead bodies of organisms in ecosystems and cycled the materials as plant nutrients, all the energy originally absorbed by green plants and algae has been transferred • combustion of wood and fossil fuels releases carbon dioxide into the atmosphere.					

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3.3.4 Humans and their effects on the environment						
3.3.4a 3.3.4b	Rapid growth in the human population and an increase in the standard of living mean that increasingly more waste is produced. Unless waste and chemical materials are properly handled, more pollution will be caused. Waste may pollute: • water, with sewage, fertiliser or toxic chemicals • air, with smoke and gases such as sulfur dioxide, which contributes to acid rain	List the problems associated with an increasing human population. Interpret graphs showing human population growth. Describe how water can be polluted with sewage, fertiliser or toxic chemicals. Describe the stages in eutrophication following pollution by fertilisers or sewage Analyse and interpret data about water pollution.	4	**Demo:** Show how fast the world human population is increasing using the counter on the Worldometers' website. **Activity:** Interpret graphs showing human population growth and extrapolate. **Discuss:** Brainstorm the effects of an increasing population and write a list. **Discuss:** Discuss what water may become polluted with. Show images of sewage, industries, eutrophication and effects on water life. **Demo:** set up an experiment to investigate the effect of fertiliser on growth of duckweed and oxygen levels to be monitored and results explained later.	**Demo:** Beakers containing different concentrations of fertiliser, duckweed plants, oxygen sensors and dataloggers.	**Note:** Details of eutrophication **are** required. Be able to analyse and interpret scientific data concerning environmental issues. Be able to evaluate methods used to collect environmental data and consider their validity and reliability for environmental change.

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
	• land, with toxic chemicals such as pesticides and herbicides, which may be washed from land into water • sewage and fertilisers may cause eutrophication: - an increase in the concentration of mineral ions in the water stimulates the growth of algae and/or plants - eventually the growth of the algae and / or plants results in some of these being unable to receive sufficient light for	Give examples of air pollutants and where they come from. Describe the effects of smoke on buildings, humans and plant photosynthesis. Explain how carbon dioxide contributes to global warming. Describe how acid rain is formed. Describe the effects of acid rain on living organisms. Carry out an experiment to investigate the effect of sulfur dioxide on seed germination. Analyse and interpret data about air pollution.		Interpret data about water pollutants. **Discuss:** Discuss what air may be polluted with and where the pollutants come from. Show images illustrating the effects of acid rain on buildings, trees, lakes and images of smog. Discuss: Discuss the Clean Air Act. **Practical:** Investigate the effect of sulfur dioxide on the germination of cress seeds. Measure the pH of rain water samples. **Activity:** Produce poster(s) or diagrams to describe the causes and effects of sulfer dioxide, carbon dioxide and smoke pollution to complete for homework. Interpret data about air pollution.	Examples of toxic chemicals with hazard symbols and some pesticides and herbicides. Sulfur dioxide: Petri dishes, cotton wool, water, small pots of sodium metabisulfite solution, cress seeds, plastic bags with ties and goggles.	

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
	photosynthesis and these organisms die - there is a large increase in the population of microorganisms that feed on these dead organisms - the respiration of the microorganisms depletes the oxygen concentration in the water, leading to the death of aerobic organisms.					

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3.3.4c	Large-scale deforestation in tropical areas has led to reduction in biodiversity.	Define the term 'deforestation'. Explain why vast tropical areas have been cleared of trees. Explain how deforestation increases the amount of carbon dioxide in the atmosphere and leads to a reduction in biodiversity. Explain how deforestation could lead to an increase in methane in the atmosphere.	1-2	**Show** images or video clips of deforestation taking place – clearing, burning, rotting and destruction of habitats. **Discuss**: Discuss what effects this has on the environment – carbon dioxide, methane and reduction in biodiversity. **Discuss:** Discuss why areas of tropical rain forest are being cleared with images or video clips – timber, land for biofuel crops, cattle and rice – and how this can lead to global warming.	Video clips on rainforest destruction and changing ecosystems can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clips '3096' and '3234'.	Students should be able to describe the effects of deforestation.

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3.4 Organisms interaction with the environment						
3.4.1 The human nervous system						
3.4.1a 3.4.1b	The nervous system enables humans to react to their surroundings and coordinate behaviour. Information from receptors passes along cells (neurones) as impulses to the central nervous system (CNS). The CNS is the brain or the spinal cord. The brain coordinates the response.	Describe the functions of the main structures in the nervous system. Explain the importance of being able to respond to environmental changes.	1-2	**Activity:** Label diagrams to show the brain, spinal cord, nerves; neurones within nerve. **Practical:** Investigate sensitivity of different areas of the body. **Activity:** shade in and label the cerebral cortex, the cerebellum and the medulla on a diagram of the brain.	**Skin sensitivity:** Hairpin set with 1 cm gap, blindfolds.	Be able to label the cerebral cortex, the cerebellum and the medulla and describe the function of each of these parts of the brain. Be aware of the techniques, but need not know technical details of their functioning.
3.4.1c	Reflex actions are automatic and rapid. They often involve sensory, relay and motor neurones.	Explain the importance of reflex actions and be able to give examples. Describe the pathway of a nerve impulse in a reflex	1	**Demo:** Knee-jerk and pupil reflexes. Discuss their importance and gather other examples leading into explanation of why they are faster than a voluntary action.		

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
	• In a simple reflex action such as a pain-withdrawal reflex: • impulses from a receptor pass along a sensory neurone to the CNS • at a junction (synapse) between a sensory neurone and a relay neurone in the CNS, a chemical is released that causes an impulse to be sent along a relay neurone • a chemical is then released at the synapse between a relay neurone and motor	response and explain the roles of the structures involved. stimulus→receptor→sensory neurone→relay neurone→motor neurone→effector→response Explain the role of chemicals at synapses. Describe different ways of measuring reaction time.		Try the Sheep Dash activity. **Practical:** Investigate reaction time using different combinations of receptors. **Activity:** Use cards to sequence the pathway of a nerve impulse. Arrange students holding cards in this sequence and discuss role of each and how impulse passes from one to another. Match structures in nerve pathway to different reflex actions, eg production of saliva when smelling food; pupil response to light. **Homework:** Research diseases of the nervous system.	The Sheep Dash activity can be found on the BBC website at www.bbc.co.uk/science/humanbody/sleep/sheep **Reaction time:** Metre-rulers and blindfolds or sensors and dataloggers. Cards.	Students should be able, when provided with appropriate information, to analyse a particular given example of behaviour in terms of: stimulus → receptor → coordinator → effector → response

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
	neurone in the CNS, causing impulses to be sent along a motor neurone to the effector • the effector is either a muscle or a gland: a muscle responds by contracting and a gland responds by releasing (secreting) chemical substances.					

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.4.2 Homeostasis						
3.4.2a	Automatic control systems in the body keep conditions inside the body relatively constant.		2			
3.4.2b	Control systems include: • cells called receptors, which detect stimuli (changes in the environment) • coordination centres that receive and process information from receptors • effectors, which bring about			**Activity:** Label diagrams to show the brain, spinal cord, nerves; neurones within nerve; light receptor cell. Involve students to demonstrate stimuli we detect – loud bang, light, touch, movement, smell and taste. **Demo:** response to different temperatures. **Practical:** Detecting different tastes on the tongue – draw results on diagram of tongue.	**Response to temperature:** three bowls of water – hot, warm and ice-cold. **Taste receptors:** Salt, sugar, coffee and lemon solutions to taste.	Be able to sequence a reflex action from stimulus to response. Be able to match the organ containing receptors to the stimulus detected.
3.4.2c	Receptors are found in many organs, including: • the eyes. sensitive to light • the ears . sensitive to	Match receptors of the eye, ear, tongue and skin with the stimuli they detect.		**Discuss**: Discuss the senses and complete a table to show name of sense, main organ and stimulus it responds to.		Knowledge and understanding of the structure and functions of sense

3.4.2d	sound, and to changes in position (which enables us to keep our balance) • the tongue and in the nose . sensitive to chemicals (enable us to taste and to smell) • the skin. sensitive to touch, pressure, Coordination centres include the brain and spinal cord and the pancreas.			**Practical:** Investigate sensitivity of different areas of the body.	**Skin sensitivity:** Hairpin set with 1 cm gap, blindfolds.	organs such as the eye and the ear is not required
3.4.2e	Internal conditions that are controlled include: • temperature • the water content of the body • the ion content of the body.	Describe some conditions that need to be controlled in the body. Measure body temperature. Explain why body temperature has to be controlled.	1-2	Label the body's inputs and outputs on a diagram of the body. Practical: Investigate what is normal body temperature. **Practical:** Investigate the effect of exercise on body temperature and/or sweating. **Practical:** Investigate the effect of temperature on enzyme activity, eg digestion of starch. Investigating claims of sports drinks manufacturers.	Body temperature: Digital and forehead thermometers. Exercise: Thermometers, cotton wool and balance. Temperature and enzymes: Starch and amylase solutions, tubes, water baths, ice, iodine solution or Benedict's solution and goggles.	

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.4.3 Control of water and ion content of the body						
3.4.3a	Water leaves the body via the lungs when we breathe out and the skin when we sweat. Excess water is removed via the kidneys in the urine.	Define the term 'homeostasis'.	1	Recap inputs and outputs of the body.		
3.4.3b	Urea and ions are lost via the skin when we sweat.	Give examples of waste products that have to be removed and explain where they are excreted from the body.		**Discuss:** Discuss how urea is produced in the body and why it must be excreted from the body.		Remember that urea is produced by the liver and excreted by the kidneys.
3.4.3c	In the liver: • excess amino acids are deaminated to form ammonia, which is converted into urea for excretion • poisonous	Explain why waste products have to be excreted from the body.		**Activity:** Use an outline of the body with liver, kidney and skin labelled. Cut out labels to stick on showing substances produced/excreted by these organs.		

	substances are detoxified, and the breakdown products excreted in the urine via the kidneys • old blood cells are broken down and the iron is stored. .					
3.4.3d d	In a healthy kidney: • the blood is filtered • all the glucose is reabsorbed • the dissolved ions needed by the body are reabsorbed • as much water as the body needs is reabsorbed • urea, excess ions and excess water are released as urine	Label a diagram of the excretory system and state the functions of the kidneys and bladder. Produce a flow diagram to explain how urine is made. Interpret data relating to the composition of blood, kidney fluid and urine.	1	**Activity:** Locate the positions of the liver, kidneys and bladder in the human body after seeing them in a torso. Discuss the need to excrete urea. **Video:** Watch a video clip or computer simulation to show how urine is produced by the kidney. Dissect a mammal's kidney. **Activity:** Use cards to sequence how urine is made and produce a flow diagram. Interpret data about concentration of water, ions, glucose etc in blood, kidneys and urine.	Model of human body torso. **Dissection:** Kidneys, boards, scalpels and gloves.	Be able to name the organ which stores urine. Be able to name two substances which will pass through the filter from blood plasma into the filtrate. Be able to explain why protein is not found in the urine of a healthy person. **Note:** Consider all students before undertaking any dissection.

3.4.3e	If the water content of the blood is too low, the pituitary gland releases a hormone called ADH into the blood. This causes the kidneys to reabsorb more water and results in a more concentrated urine.					
3.4.3f	If the water content of the blood is too high, less ADH is released into the blood. Less water is re-absorbed in the kidneys resulting in a more dilute urine.					
3.4.3g	The production of ADH is controlled by a negative feedback mechanism.			Use models and simulations to research negative feedback.	IT programmes http://www.nationalstemcentre.org.uk/elibrary/science/search?term=homeostasis&filter=R&order=score	Be able to use data from tables to calculate the volume of urine lost by the body/ the proportion of water gained by the body from food eaten. **Note:** The name of the hypothalamus is **not** required.

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.4.4 Temperature control						
3.4.4a 3.4.4b	Body temperature is monitored and controlled by the thermoregulatory centre in the brain. The thermoregulatory centre has receptors sensitive to the temperature of the blood. Temperature receptors in the skin send impulses to the thermoregulatory centre giving information about skin temperature.	State that normal body temperature is around 37 °C. Describe different methods to measure body temperature. Calculate a mean and state the range of body temperatures for the class. Compare the changes that occur when body temperature is too high or too low. State that body temperature is monitored and controlled by the thermoregulatory centre in the brain, using information about blood and skin temperature.	1	**Practical:** Investigate the range of normal body temperature in the class and calculate the mean. **Practical:** Monitor skin temperature in different conditions using surface temperature sensors. **Discuss:** Brainstorm changes that occur when body temperature is too high and too low and write notes in the form of a table or a flow chart. **Discuss:** Discuss how the body detects and controls core body temperature.	**Body temperature:** Clinical thermometers, forehead thermometers. Skin temperature sensors and dataloggers.	

3.4.4c	If core temperature is too high • blood vessels supplying the skin capillaries dilate so more blood flows through the capillaries and more heat is lost • sweat glands release more sweat, which cools the body as sweat evaporates.	Explain the changes in blood vessels supplying skin capillaries when the body is too hot or too cold. Explain why we drink more fluid during hot weather.	1	**Video:** Watch a video clip or computer animation showing changes that occur when body temperature is too high or too low and make notes. Show a model of the structure of the skin.		
3.4.4d	Sweating helps to cool the body. More water is lost when it is hot, and more fluid has to be taken through drink or food to balance this loss. If the core body temperature is too low: • blood vessels supplying the skin capillaries constrict to reduce the flow of blood through the capillaries	Explain how sweating cools the body as it evaporates. Explain why the skin looks red when you are hot and pale when you are cold.		**Discuss:** Discuss the effects of sweating on urine formation and why we drink more fluids in hot weather. **Task**: Draw diagrams to explain the changes in blood vessels supplying skin capillaries when the body temperature is too high or too low. **Demo:** Demonstrate the effect of cooling by ethanol on the skin. Discuss the effect of evaporation – relate to kinetic theory. **Practical:** Investigate the effect of sweating on the rate of cooling using tubes of hot water wrapped in wet and dry paper towels. Plot cooling curves and make conclusions.	**Sweating:** Boiling tubes, paper towels, elastic bands, thermometers **or** temperature sensors, pipettes and timers.	Be able to apply ideas in new contexts. For example, the kangaroo rat does not sweat. Explain why this could be dangerous for the animal. **Note:** Never say that blood capillaries near the surface of the skin dilate.

	• muscles may ‘shiver’ – their contraction needs respiration, which transfers some energy to warm the body					

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.4.5 Control of blood glucose						
3.4.5a 3.4.5b 3.4.5c	The blood glucose concentration is monitored and controlled by the pancreas. Much of the glucose is stored as glycogen in the liver and muscles. When these stores are full, excess glucose is stored as lipid. If blood glucose levels are too high, the pancreas produces the hormone insulin, which allows the glucose to move from the blood into the cells. When blood glucose levels fall, the pancreas produces a second hormone,	State that insulin is produced by the pancreas and explain its effect on blood glucose levels. State that glucagon is also produced by the pancreas and explain its effect on	1-2	Ask if anyone knows someone who has diabetes and if anyone knows what it is. **Demo:** Demonstrate how doctors used to diagnose diabetes by tasting fake urine, then test with Benedict's solution and glucose test strips. Which gives the most accurate results? Show the position of the pancreas in the body.	**Demo:** weak tea samples with and without glucose, glucose test strips, Benedict's solution and water bath. Model of human body torso. Blood testing meters and test strips.	Be able to give one way other than using insulin of treating diabetes. Be able to state which organ controls blood glucose concentration.

	glucagon. This causes glycogen to be converted into glucose and released into the blood.	blood glucose levels.				
3.4.5d 3.4.5e	In Type 1 diabetes glucose levels may rise too high because the pancreas does not produce enough insulin. Type 1 diabetes can be controlled by diet, exercise and injecting insulin. Type 2 diabetes develops when the body does not respond to its own insulin. Obesity is a significant factor in the development of Type 2 diabetes. Type 2 diabetes can be controlled by careful diet, exercise and by drugs that help the cells to respond to insulin.	Explain the cause, effects, treatment and problems associated with the disease. Interpret glucose tolerance test. Evaluate modern methods of treating diabetes. Explain the difference between type 1 diabetes and type 2 diabetes		If possible get someone who has type 1 diabetes to explain the initial symptoms, how they were diagnosed, what they have to do to control the disease – blood testing, injections, diet, exercise, demonstrate blood testing and show the vials of insulin and pens used today. Question and answer session. Ask if anyone can explain why one of the first symptoms is extreme thirst (links with B3.1.1). **Video:** Watch a video about type 1 diabetes. **Research:** Research and produce a report to explain the cause, effects, treatment and problems associated with the disease. Interpret data on glucose tolerance tests in healthy people and diabetics. **Research:** Research the work of Banting and Best.	Video clips on blood sugar levels and diabetes can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clips '7314' and '5371'. Further information on diabetes can be found at www.diabetes.org.uk	Be able to describe how insulin reduces the concentration of glucose in the blood. Know that type 1 diabetes is caused by insufficient insulin and that type 2 diabetes is caused when body cells do not react to insulin

				Research: Research how treatment of diabetes has developed including use of human insulin produced by bacteria, current research into pancreas cell transplants and stem cell research.		

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.4.6 Behaviour						
3.4.6a	Animals exhibit different behaviours. Sexual reproduction requires the finding and selection of a suitable mate, and can involve courtship behaviours that advertise an individual's quality. Animals have different mating strategies, including: • a mate for life • several mates over a life time • a mate for a breeding season • several mates over one breeding season.	Describe some examples of animal selection of a mate.		Research courtship behaviours of different animals and present to group. Analyse data on courtship and mating strategies and suggest which are most successful in maintaining a species.	Resources can be located on the National Stemcentre elibrary http://www.nationalstemcentre.org.uk/elibrary/resource/9244/animal-behaviour-practical-work-and-data-response-exercises	

3.4.6b	Some animals have developed special behaviours for rearing their young. Parental care can be a successful evolutionary strategy, including: • increased chance of survival of offspring • increased chance of parental genes being passes on by the offspring.	Explain how successful parenting can ensure chances of survival and passing on of genes.		**Research:** The social lifecycle of an ant community Watch video of Parenting investment and construct table/diagrams of types of parenting, duration, gender interaction etc. Consider courtship and breeding in stickleback. Watch a video of Emperor penguin breeding colonies.	http://www.bbc.co.uk/nature/adaptations/Parental_investment	Students should be able to explain how, within the animal kingdom, parental care may involve risks to the parents.
3.4.6c	The different behaviours displayed by animals include: • innate behaviour • imprinting • habituation • classic conditioning • operant conditioning.	Describe behaviour of a selection of animals in different situations.		Study • woodlice orientation behaviour using choice chambers • breeding ground imprinting, eg salmon • Pavlovian responses, eg feeding times for animals –fish in a pond, pet animals • Skinner box for operant conditioning.	Woodlice, choice chambers, lamp, cotton wool, water.	

3.4.6d	Humans can make use of conditioning when training captive animals for specific purposes, including: •sniffer dogs •police horses.			Research how sniffer dogs are trained and the types of materials they can detect. Find out how animals can be used to support children and adults with disabilities eg hearing dogs for the deaf, guide dogs for a person with blindness.		
3.4.6e	Methods of communication within the animal kingdom. Animals use a variety of types of signals to communicate.					

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.4.7 Infection and response						
3.4.7a	Microorganisms that cause infectious disease are called pathogens.	Explain how pathogens cause disease. Carry out and describe aseptic techniques.	2	**Ta**sk: Look at pictures of bacteria, viruses and fungi and link these to diseases. **Research:** Conduct research into different diseases. **Online task:** Complete a table giving examples of diseases caused by viruses and bacteria. **Practical:** Use agar plates to compare the growth of micro-organisms from unwashed and washed hands (to be observed in later lesson).	Pictures/bioviewers. A useful website is www.curriculumbits.com – Microbes and disease. Information on health conditions can be found in the Health section of the BBC website at www.bbc.co.uk by searching 'Medical Conditions'. Unwashed and washed hands: Agar plates, biohazard tape, incubator and hand wash. The BBC website has video clips on microbes and the human body (clip 207) and hand washing and food hygiene (clip 2883). These can be found at www.bbc.co.uk/learningzone/clips	Be able to use data from a bar chart to compare the numbers of deaths from different pathogens. **Note:** Structure of bacteria and viruses is **not** required.

3.4.7b 3.4.7c	Bacteria and viruses may reproduce rapidly inside the body. Bacteria may produce poisons (toxins) that make us feel ill. Viruses live and reproduce inside cells, causing damage. White blood cells help to defend against pathogens by: • ingesting pathogens (phagocytosis) • producing antibodies, which destroy particular bacteria or viruses • producing antitoxins, which counteract the toxins released by the pathogens.	Describe ways in which the body defends itself against disease. Explain how microbes make us feel ill and how viruses damage cells. Describe the actions of white blood cells using terms 'ingest', 'antibodies' and 'antitoxins'.	1	**Task**: Label diagram to show how body prevents entry of microbes. **Compare:** viral and bacterial infections. **Practical**: Use microscope or bioviewers to view blood smears. **Activity:** Draw diagrams or cartoon strip to show actions of white blood cells. **Video**: BBC clip or video on defence against disease.	Microscopes or bioviewers and slides of blood smears. A video clip on white blood cells can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clip '1838'.	Be able to explain why bacteria and viruses make us feel ill. Be able to explain how to reduce risk of infection. Note: knowledge of the structure of viruses is not required. Be able to explain why schools do not incubate above 25°C.
3.4.7d	The immune system of the body produces specific antibodies to kill a particular	Explain the processes of natural and acquired immunity.	1	**Task:** Card sorting exercise to sequence how a vaccine can give immunity to a disease.		Be able to use data from a line graph to describe the relationship

	pathogen. This leads to immunity from that pathogen. In some cases, dead or inactivated pathogens stimulate antibody production. If a large proportion of the population is immune to a pathogen, the spread of the pathogen is very much reduced.			**Activity:** Look up and interpret child immunisation programmes.		between the per cent vaccinated and frequency of the disease.
3.4.7e	People can be immunised against a disease by introducing small quantities of dead or inactive forms of the pathogen into the body (vaccination). Vaccines stimulate the white blood cells to produce antibodies that destroy the pathogen. This makes the person immune to future infections by the microorganism, because the body can respond by rapidly making the	Evaluate the advantages and disadvantages of being vaccinated against a disease, eg the measles, mumps and rubella (MMR) vaccine.		**Activity:** Role play on whether to give your child vaccinations. Consider the actions of Dr Wakefield and the MMR vaccine. **Homework:** research Edward Jenner.	Information on vaccinations can be found on the NHS website at www.nhs.uk by searching 'When are vaccinations given?'. Information on the MMR vaccine can be found on the BBC website at www.bbc.co.uk by searching 'MMR debate'. Information about the history of medicine can be found on the GCSE Bitesize section of the BBC website at www.bbc.co.uk by searching 'Medicine through time'.	

	correct antibody, in the same way as if the person had previously had the disease. The MMR vaccine is used to protect children against measles, mumps and rubella.					
3.4.7f	Antibiotics, such as penicillin, are medicines that help to cure bacterial disease by killing infective bacteria inside the body. It is important that specific bacteria should be treated by specific antibiotics. The use of antibiotics has greatly reduced deaths from infectious bacterial diseases.	Use aseptic techniques and explain the precautions taken when handling microorganisms.		**Discuss**: Brainstorm medicines used to relieve symptoms and treat disease. **Practical:** Antibiotics or antiseptics etc and growth of microbes (area of clearance to be measured in later lesson). Investigate type of agent or concentration. Names of some antibiotics.	Samples of medicine packaging. Antibiotic investigation: Agar plates inoculated with bacteria, antibiotic discs, forceps, incubator and ruler. .	
3.4.7h	Mutations of pathogens produce new strains. Antibiotics and vaccinations may no longer be effective	Explain that antibiotics kill individual pathogens of the non-resistant strain but individual resistant pathogens survive and reproduce, so the population of the resistant		**Research:** MRSA and C. difficile infections and treatment. BBC website is a good place to start. **Research:** flu pandemics.	Useful information can be found on the BBC website at www.bbc.co.uk	Be able to explain why drugs that kill bacteria cannot be used to treat viral infections.

	against a new resistant strain of the pathogen. The new strain will then spread rapidly because people are not immune to it and there is no effective treatment.	strain rises.				
3.4.7i	Many strains of bacteria, including MRSA, have developed resistance to antibiotics.	Explain why overuse and inappropriate use of antibiotics has increased the rate of development of antibiotic-resistant strains of bacteria. Know that antibiotics are not currently used to treat non-serious infections such as mild throat infections, in order to slow down the rate of development of resistant strains.	1	**Task**: Draw a timeline to show how treatment of disease has changed over the years.		
3.4.7j	The development of antibiotic-resistant strains of bacteria necessitates the development of new antibiotics.	Evaluate the consequences of mutations of bacteria and viruses in relation to epidemics and pandemics. Explain what we should do to slow down the rate of development of resistant strains of bacteria				
Required practical: Students investigate the effect of disinfectants and antibiotics on uncontaminated cultures of microorganisms.						

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.5 Inheritance						
3.5a	There are two forms of reproduction: • sexual • asexual	• Describe sexual reproduction as the joining (fusion) of male and female gametes. The mixture of the genetic information from two parents leads to variety in the offspring. • Describe asexual reproduction – no fusion of gametes and only one individual is needed as the parent. There is no mixing of genetic information and so no genetic variation in the offspring. These genetically identical individuals are known as clones.	1	Draw a flow chart to show the events in fertilisation.	Show animation of fertilisation.	

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3.5.2 Cell division						
3.5.2a 3.5.2b	The nucleus of a cell contains chromosomes. Chromosomes carry genes that control the characteristics of the body. Each chromosome carries a large number of genes. Many genes have different forms called alleles, which may produce different characteristics.	Label diagrams to illustrate the order of size of cell, nucleus, chromosome and gene. State that the genetic information is carried as genes on chromosomes.	1	**Task:** Draw and label diagrams showing cell, nucleus, chromosome and gene; sort cards showing names of these structures into order of size. Look at chromosomes on slides or bioviewers. Look at photographs of chromosomes from a male and a female or cut and pair chromosomes from photos of male and female karyotypes. **Homework:** Use the Science Museum site to find out more about genes.	Name cards to sort. Microscopes, prepared slides, and bioviewers. Photos of karyotypes – partially paired chromosomes. Variation: Plant identification charts, rulers and clipboards. An interesting flash presentation on genes can be found at www.sciencemuseum.org.uk/WhoAmI/FindOutMore/Yourgenes this is also available for download in PDF.	Students should understand the difference between a gene and an allele.

3.5.2c	In body cells the chromosomes are normally found in pairs.					
3.5.2d	Body cells divide by mitosis. Mitosis occurs during growth or to produce replacement cells.	Recognise from photos of karyotypes that chromosomes are found in pairs in body cells. State that body cells divide by mitosis. Draw simple diagrams to describe mitosis.	1	**Activity:** Recap work covered in – genes, chromosomes, nuclei, cells; look at photos of male and female karyotypes. **Discuss:** Discuss how organisms grow and relate this to cell division. Use bioviewers, root tip squashes or a video clip to show chromosomes and mitosis.	Photos of karyotypes. Bioviewers, microscopes, slides, coverslips and germinating pea seeds.	Be able to interpret genetic diagrams. Be able to complete a simple diagram to show cell division producing two daughter cells.
3.5.2e	When a body cell divides by mitosis: •copies of the genetic material are made •the cell then divides once to form two genetically identical body cells.			**Activity:** Produce notes with simple diagrams to explain mitosis in terms of copies of genetic information being made and cell division to produce two identical daughter cells. Use Science and Plants for Schools (SAPS) and Scottish Schools Equipment Research Centre (SSERC) sites for images, activities etc.	Useful information can be found at www.science3-18.org by searching 'Investigating cell division'. A useful animation on mitosis can be found at www.cellsalive.com by searching 'mitosis'. A video clip on cell division by mitosis can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clip '4189'.	**Note:** Knowledge and understanding of the stages in mitosis are **not** required.

3.5.2f 3.5.2g 3.5.2h	Cells in reproductive organs divide to form gametes. A cell divides to form gametes by meiosis. When a cell divides to form gametes: •copies of the genetic information are made •the cell then divides twice to form four gametes, each with a single set of chromosomes.	State that sex cells are called gametes and are produced when cells in the sex organs divide by meiosis. Explain why sex cells (gametes) have only one set of chromosomes. Draw diagrams to explain how gametes are formed in meiosis. Compare mitosis and meiosis.	1	**Activity:** Consider fusion of sex cells at fertilisation and why gametes have only one set of chromosomes – use models or diagrams.	Lots of class clips can be found on the BBC website at www.bbc.co.uk/learningzone/clips	Be able to spell mitosis and meiosis and know which type of cell division each is. **Note:** Knowledge and understanding of the stages in meiosis are not required.
3.5.2i	Gametes join at fertilisation to form a single body cell with new pairs of chromosomes. This cell repeatedly divides by mitosis to form many cells. As an organism			**Activity:** Make models to show what happens during fertilisation. **Activity:** Make models or draw diagrams to show how gametes are formed during meiosis.		

	develops, these cells differentiate to form different kinds of cells.			**Demo:** Use bioviewers, video clips or images to show chromosomes and meiosis. **Homework:** Produce a poster to compare mitosis and meiosis.	A video clip on cell division by mitosis and meiosis can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clip '6022'.	
3.5.2j	Most animal cells differentiate at an early stage whereas many plant cells retain the ability to differentiate throughout life. In mature animals, cell division is mainly restricted to repair and replacement.	Describe cell differentiation in plants and animals.	2	**Video:** Watch a video clip showing cell differentiation in plants and animals.		
3.5.2k 3.5.2l	Cells from human embryos and adult bone marrow called stem cells can be made to differentiate into many types of human cells. In therapeutic cloning an embryo is produced with the same genes as the patient. Stem cells from the	Name the sources of stem cells in humans. Explain the function of stem cells. Explain how stem cells could be used to help treat some medical conditions.		**Video:** Watch the stem cell story at Euro Stem Cell site. **Activity:** Provide students with a help sheet to direct them in researching stem cells – where they are produced in humans; their uses; how they could be used to treat some medical conditions; pros and cons of stem cell research. Use research to produce a poster, carry out role play or a debate about	information on stem cells can be found at www.eurostemcell.org Video clips on embryo stem cells and stem cell research can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clips '6581' and '6013'. Useful information can be found at	Be able to give one use of stem cells. Be able to give one reason why some people might object to using stem cells from embryos. **Note:** Stem cell techniques are not

	embryo will not be rejected by the patient and may be used for medical treatment			stem cell research (links with B3.3).	www.christopherreeve.org and www.ukscf.org	required.
3.5.2m	Treatment with stem cells may be able to help conditions such as paralysis.	Make informed judgements about the social and ethical issues concerning the use of stem cells from embryos in medical research and treatments.				Knowledge and understanding of stem cell techniques is not required. Students should be able, when provided with appropriate information, to make informed judgements about the social and ethical issues concerning the use of stem cells from adult bone marrow and embryos in medical research and treatments.
3.5.2n	Tumours result from the abnormal, uncontrolled growth of cells. Benign tumours do not invade other	Explain how tumour cells differ from other cells in the body. Explain why malignant tumour cells are particularly dangerous.	1	Explain the aims of the lesson. Use a thought shower as a warm up to find out what students already know about cancer. Divide the class in to groups and give them copies of cancer case studies to discuss possible causes of the	Lesson plan from *www.cancerresearchuk.org › News & Resources › Teaching resources* Another useful site:	Be able to explain how tumour cells differ from other body cells, and how tumours may spread to other

	tissues. Cells from malignant tumours invade healthy tissue. Some malignant cells may enter the bloodstream and circulate to other parts of the body, forming secondary tumours.			disease. Group feedback to the rest of the class. Explain the biology of cancer to the class/ Web-based investigation.	*www.teenage**cancer**trust.org/ what-we-do/**education**/*	parts of the body.
3.5.2o	Tumours can be caused by chemical carcinogens, eg those found in tobacco smoke and in asbestos, and by ionising radiation, eg UV and X-rays.	Give at least two causes of cancer.		See lesson plan given in resource column	www.ash.org.nz/site.../Health../**Smoking**_bomb_kit_**lesson_plan**.pdf gives a good lesson plan on carcinogens.	Be able to give at least two causes of cancer.

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3.5.3 Genetic variation						
3.5.3a	Differences in the characteristics of individuals of the same kind may be due to differences in: • the genes they have inherited (genetic causes) • the conditions in which they have developed (environmental causes) • a combination of genetic and environmental causes.	Classify characteristics as being due to genetic or environmental causes. Decide the best way to present information about variation in tables and charts.	1-2	**Discuss:** Brainstorm ways in which humans show variation. **Discuss:** Discuss why organisms of the same species show variation – genetic and environmental variation. Class survey of characteristics – collate results in a table and produce a display of the results as bar charts. **Discuss** continuous and discontinuous variation. Include in the table whether each characteristic is due to genetic or environmental causes, or both. **Homework:** Produce a bar chart to display some of the information. Follow-up lesson to complete display. **Activity:** Examine the benefits of knowing how genes are linked to diseases.	**Survey:** Height measure, bathroom scales. Useful information can be found at www.UPD8.org.uk by searching 'the future in your genes'.	

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.5.3b 3.5.3c	The information that results in plants and animals having similar characteristics to their parents is carried by genes, which are passed on in the sex cells (gametes) from which the offspring develop. The nucleus of a cell contains chromosomes. Chromosomes carry genes that control the characteristics of the body. Chromosomes are normally found in pairs.	Label diagrams to illustrate the order of size of cell, nucleus, chromosome and gene.	1	**Task**: Draw and label diagrams showing cell, nucleus, chromosome and gene; sort cards showing names of these structures into order of size. **Demo:** Look at chromosomes on slides or bioviewers. **Demo:** Look at photographs of chromosomes from a male and a female or cut and pair chromosomes from photos of male and female karyotypes. **Practical**: Measure variation in a plant species growing in different areas of school grounds, eg leaf length in areas of sun/shade. **Homework**: Use the Science Museum site to find out more about genes.	Name cards to sort. Microscopes, prepared slides, and bioviewers. Photos of karyotypes – partially paired chromosomes. Variation: Plant identification charts, rulers and clipboards. An interesting flash presentation on genes can be found at www.sciencemuseum.org.uk/WhoAmI/FindOutMore/Yourgenes this is also available for download in PDF.	

3.5.3d 3.5.3e	In human body cells one of the 23 pairs of chromosomes carries the genes that determine sex; the sex chromosomes in females are XX and in males are XY. Different genes control the development of different characteristics of an organism. Some characteristics are controlled by a single gene. Each gene may have different forms called alleles.	Explain using a Punnett square and genetic diagram how sex is determined in humans.	1	**Activity:** Look at male and female karyotypes and identify the number of pairs of chromosomes and each pair of sex chromosomes. **Use a Punnett square** to illustrate the inheritance of sex; work out the chance of producing a male or female.	A video clip on dominant and recessive characteristics can be found on the BBC website at www.bbc.co.uk/learningzone by searching for clip '4197'.	Be able to use a Punnett square to show the inheritance of sex.
3.5.3f	If both chromosomes in a pair contain the same allele of a gene, the individual is homozygous for that gene. If the chromosomes in a pair contain different alleles of a gene, the individual	Describe some of the experiments carried out by Mendel using pea plants. Explain why Mendel proposed the idea of separately inherited factors and why the importance of this discovery was not recognised until after his death.	2	**Video**: Watch a video/computer simulation of Mendel's experiments. **Activity**: Draw and label genetic diagrams to explain Mendel's experiments. **Interpret** genetic diagrams of Mendel's experiments. Use past exam questions to draw and interpret genetic diagrams**.**	A video clip on dominant and recessive characteristics can be found on the BBC website at www.bbc.co.uk/learningzone by searching for clip '4197'. Variety of pea seed, plants and pods or diagrams of them.	Be able to draw and interpret genetic diagrams. Students should understand that genes operate at a molecular level to develop

	is heterozygous for that gene. 3.5.3g An allele that controls the development of a characteristic when it is present on only one of the chromosomes is called a dominant allele. An allele that controls the development of a characteristic only if the dominant allele is not present is called a recessive allele.	Predict and explain the outcome of crosses using genetic diagrams based on Mendel's experiments and using unfamiliar information. Define the terms homozygous, heterozygous, phenotype and genotype. Students should understand that genetic diagrams are biological models which can be used to predict the outcomes of crosses. Students should be able to interpret genetic diagrams, including family trees.				characteristics that can be seen. Students should be familiar with principles used by Mendel in investigating monohybrid inheritance in peas. They should understand that Mendel's work preceded the work by other scientists which linked Mendel's 'inherited factors' with chromosomes.
3.5.3h	Chromosomes are made up of large molecules of DNA. DNA contains the coded information that determines inherited characteristics.	Describe the structure of chromosomes and DNA.	1	**Video:** Watch a video about Watson and Crick – discovery of the structure of DNA. **Task:** Make a model of DNA.	Further information on Watson and Crick can be found at www.bbc.co.uk by searching 'historic figures Watson and Crick'.	
3.5.3i	A gene is a small section of DNA. Each gene codes for a particular combination of	State that a gene is a small section of DNA.		**Activity:** Extract DNA from fruits such as kiwi fruit or strawberry.	How to extract DNA from fruits can be found at www.funsci.com/fun3_en/dna/dna.htm	

	amino acids, to make a specific protein.					
3.5.3j	DNA is made of very long strands, twisted to form a double helix, which contain four different compounds, called bases.					
3.5.3k	A sequence of three bases is the code for a particular amino acid. The order of bases controls the order in which amino acids are assembled to produce a particular protein.	Each gene codes for a particular combination of amino acids which makes a specific protein. State that each gene codes for a particular sequence of amino acids to make a specific protein.		A video clip on DNA and the Human Genome Project can be found on the BBC website at www.bbc.co.uk/learningzone by searching for clip '6015'. Useful information on the DNA timeline can be found at www.timelineindex.com by searching 'DNA'. Note: The names of the four bases are not required.		

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3.5.4 Genetic disorders						
3.5.4a 3.5.4b	Some disorders are inherited. Some inherited conditions are caused by inheritance of abnormal numbers of chromosomes, eg Down's Syndrome is caused by the presence of an extra chromosome.	Interpret data relating to genetic disorders such as polydactyly, cystic fibrosis, and sickle cell anaemia. Explain why people with sickle cell anaemia are less likely to get malaria.	1	Show images or video clips to show polydactyly. **Video:** Watch a video to explain what cystic fibrosis is, how it is inherited and to illustrate the severity of the disorder. **Activity:** Produce notes and draw genetic diagrams to explain how polydactyly and cystic fibrosis are inherited. Interpret genetic diagrams relating to these disorders. Examine karyotypes of Down's and non-Down's. **Activity:** Produce notes and draw genetic diagrams to explain how sickle cell anaemia is inherited. Interpret genetic diagrams relating to this disorder.	A video clip on gene therapy and cystic fibrosis can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clip '6014'. www.bbc.co.uk/health/physical_health/conditions/sicklecell1.shtml provides a good summary of the condition *news.bbc.co.uk/2/hi/health/4587311.stm* explains why people with sickle cell anaemia are less likely to get malaria.	

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3.5.5 Genetic manipulation						
3.5.5a	Modern cloning techniques include: • tissue culture – using small groups of cells from part of a plant • cuttings – an older, but simple, method used by gardeners to produce many identical new plants from a parent plant'. • embryo transplants – splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos	Describe the process of adult cell cloning in animals. Interpret information about cloning techniques. Explain advantages and disadvantages of cloning techniques. Make informed judgements about the economic, social and ethical issues concerning cloning. Describe the process of tissue culture in plants. Explain the importance of cloning to plant growers. Describe the process of embryo transplants in animals.	1	**Video:** Watch the clip on cloning in Jurassic Park. **Practical:** Grow new plants from tissue cultures. **Video:** Watch a video clip of adult cell cloning/Dolly the sheep. **Task:** Produce a flow diagram to describe the process of adult cell cloning or carry out card sorting activity. **Research:** Research and debate the advantages and disadvantages of cloning plants and animals. **Research:** Latest legislation on human cloning and discuss social and ethical issues in regards to human cloning. Interpret information about cloning techniques.	Video clips on cloning can be found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clips '4140' and '4139'. Useful websites are www.bbc.co.uk and www.hfea.gov.uk	Be able to present arguments for and against human cloning.

	into host mothers • adult cell cloning – the nucleus is removed from an unfertilised egg cell and the nucleus from an adult body cell, eg a skin cell, is inserted into the egg cell. An electric shock then acts as the catalyst for the egg cell to begin to divide to form embryo cells. These embryo cells contain the same genetic information as the adult skin cell. When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development.			**Discuss:** Discuss how identical twins are formed and lead on to embryo transplants. Draw diagrams to show the method of embryo transplants.		
3.5.5b	In genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' and	Define the term 'genetic engineering'. Describe the process of genetic engineering to produce bacteria that can produce insulin and crops	1-2	**Discuss**: Brainstorm what the terms genetic engineering, genetic modification and gene therapy mean. List examples of genetic engineering. **Activity:** Produce a diagram to explain how human insulin is produced by	Information on genetically modified food can be found at www.curriculumbits.com	

	transferred to cells of other organisms: • enzymes are used to isolate the required gene • this gene is inserted into a vector, usually a bacterial plasmid or a virus • the vector is used to insert the gene into the required cells.	that have desired characteristics. Interpret information about genetic engineering techniques.		bacteria and discuss the advantages of this over porcine insulin. **Video**: Watch a video clip on genetic engineering.		
3.5.5c	Genes can also be transferred to the cells of animals, plants or microorganisms at an early stage in their development so that they develop with desired characteristics.					
3.5.5d	Crops that have had their genes modified in this way are called genetically modified (GM) crops. GM crops include ones	Make informed judgements about the economic, social and ethical issues concerning genetic engineering. Explain advantages and		**Research:** Research advantages and disadvantages of GM crops; what characteristics may be modified; produce a poster or a table of benefits versus concerns for homework.		Be able to give reasons why farmers are in favour of growing GM crops and why others are

	that are resistant to insect attack or to herbicides. 3.5.5e GM crops generally show increased yields. 3.5.5f Concerns about GM crops include the effect on populations of wild flowers and insects, and uncertainty about the effects of eating GM crops on human health.	disadvantages of genetic engineering.		**Activity**: Interpret information about genetic engineering techniques. Consider benefits, drawbacks and risks of using GM mosquitoes.	Information on genetic engineering can be found at www.UPD8.org.uk by searching for 'mosquitoes vs malaria'.	against it. Students should be able, when provided with appropriate information, to interpret information about cloning techniques and genetic engineering techniques and to make informed judgements about issues concerning cloning and genetic engineering, including GM crops.

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.6 Variation and Evolution						
3.6.1 Continuous and discontinuous variation						
3.6.1	The causes of variation include: • genetic variation – different characteristics as a result of mutation or reproduction • environmental variation – different characteristics caused by an organism's environmental (acquired characteristics).	Classify characteristics as being due to genetic or environmental causes. Decide the best way to present information about variation in tables and charts.	1-2	**Discuss:** Brainstorm ways in which humans show variation. **Discuss:** Discuss why organisms of the same species show variation – genetic and environmental variation. **Class surve**y of characteristics – collate results in a table and produce a display of the results as bar charts. Discuss continuous and discontinuous variation. Include in the table whether each characteristic is due to genetic or environmental causes, or both. **Homework:** Produce a bar chart to display some of the information. Follow-up lesson to complete display. **Activity:** Examine the benefits of knowing how genes are linked to diseases.	**Survey:** Height measure, bathroom scales. Useful information can be found at www.UPD8.org.uk by searching 'the future in your genes'.	Be able to give two reasons why people were against Darwin's ideas at that time.

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most students should be able to do*	Suggested timing (lessons)	Possible teaching and Learning Activities *Homework*	Resource	Examination 'hints and tips' *Students should:*
3.6.2 Natural Selection						
3.6.2a	Theories of how organisms have evolved include: • Darwin's theory of evolution by natural selection states that all species of living things have evolved from simple life forms that first developed more than three billion years ago • Other theories, including that of Lamarck, are based mainly on the idea that changes that occur in an organism during its lifetime can be inherited. We	Identify differences between Darwin's theory of evolution and conflicting theories. Suggest reasons for the different theories. Explain the terms 'inherited' and 'acquired' characteristics. Describe the stages in natural selection. Define the term 'mutation'. Explain why mutation may lead to more rapid change in a species. Suggest reasons why Darwin's theory was only gradually accepted. Interpret evidence relating to evolutionary theory.	1	**Discuss:** Recap findings on evolutionary theories – which seems most plausible and why? **Activity:** Natural selection role play activities. Peppered moth game; explain in terms of natural selection. **Produce** flow diagram to explain evolution by natural selection. **Look** at pictures of Darwin's finches and match up with the Galapagos Island they lived on based on food available there. **Discuss:** Brainstorm why Darwin did not publish his theory straight away and why it was only gradually accepted. Look at cartoons of Darwin drawn after he published his work.	A video clip on evolution can be found at www.teachers.tv/videos/evolution Further online resources for teachers at www.echalk.co.uk Cartoons of Darwin, picture of his book.	Be able to use an evolutionary tree to describe relationships between organisms and the time scales involved in evolution. A study of creationism is not required.

	now know that in the vast majority of cases this type of inheritance cannot occur.					
3.6.2b	Evolution occurs via natural selection. • Individual organisms within a particular species may show a wide range of variation because of differences in their genes. • Individuals with characteristics most suited to the environment are more likely to survive to breed successfully. • The genes that have enabled these individuals to survive are then passed on to the next generation.	Develop an understanding of the timescales involved in evolution.		Consider how ‘super bugs’ arise in hospitals. Ask students to research endemic species of islands such as Madagascar and why these species evolved here. Use card sort to illustrate stages of evolution as different pathways to variant individuals.		

3.6.2c	New species arise as a result of: • isolation: two populations of a species become separated, eg geographically • genetic variation: each population has a wide range of alleles that control their characteristics • natural selection: in each population, the alleles that control the characteristics which help the organism to survive are selected • speciation: the populations become so different that successful interbreeding leading to fertile offspring, is no longer possible.	Define the term ‘species’. Explain how new species arise using the term ‘isolation’. Include, explain and use the terms ‘genetic variation’, ‘natural selection’ and ‘speciation’.	1	**Recap** what a species is and write a definition. Students require knowledge and an understanding of isolation. **Discuss:** Brainstorm organisms that are only found in Australia and ask why this is; support with projected images or video clips. **Activity**: Produce a flow diagram or cut-out to illustrate how new species arise.		Understand that it takes millions of years for a new species to form.