GCSE

WJEC GCSE in

BIOLOGY

APPROVED BY QUALIFICATIONS WALES

GUIDANCE FOR TEACHING

Teaching from 2016



This Qualifications Wales regulated qualification is not available to centres in England.

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UNIT 1 – CELLS, ORGAN SYSTEMS and ECOSYSTEMS

1.1 CELLS AND MOVEMENT ACROSS CELL MEMBRANES

Spec Statement		Comment
(a)	the structure of animal and plant cells, including drawing and labelling diagrams and the function of the following parts: cell membrane, cytoplasm, nucleus, mitochondria, cell wall, chloroplast, vacuole	Know the role of the following structures: cell membrane: controls the entry and exit of substances cytoplasm: site of most cell reactions nucleus: contains chromosomes which carry genetic information and controls the activities of the cell mitochondrion: site of aerobic respiration cell wall containing cellulose: structural support for plant cells chloroplast: site of photosynthesis vacuole: contains a watery sugar solution (sap), a swollen vacuole pushes the rest of the cell contents against the cell wall, making the cell firm
(b)	the use of a light microscope to view animal and plant cells	Calculation of total magnification is achieved by the multiplication of the power of the eyepiece lens by the power of the objective lenses. • how a slide is prepared, including that biological staining allows more detail of the cell to be seen • the limitations of light microscopy in studying cell structure: restriction in maximum magnification • a simple comparison with the electron microscope: greater magnification but can only be used to view dead tissue
(c)	the differentiation of cells in multicellular organisms to become adapted for specific functions - specialised cells	Specialised cells are more efficient in performing specific functions than non-specialised cells.
(d)	the levels of organisation within organisms: tissues are groups of similar cells with a similar function and organs may comprise several tissues performing specific functions; organs are organised into organ systems, which work together to form organisms	

(e)	diffusion as the movement of substances down a concentration gradient; the role of the cell membrane in diffusion; Visking tubing as a model of living material; the results of Visking tubing experiments in terms of membrane pore and particle size	
(f)	diffusion as a passive process, allowing only certain substances to pass through the cell membrane in this way, most importantly oxygen and carbon dioxide	
(g)	osmosis as the diffusion of water through a selectively permeable membrane from a region of high water (low solute) concentration to a region of low water (high solute) concentration	Carry out practical work to show osmosis in living material. The results should be quantitative where possible, giving students opportunities to make calculations and analyse data in order to draw conclusions.
(h)	**active transport as an active process whereby substances can enter cells against a concentration gradient**	**Respiration provides the energy required in the form of ATP. (No detail is required of the process of ATP synthesis or how it is used to release energy)**
(i)	enzyme control of chemical reactions in cells; enzymes are proteins made by living cells, which speed up/catalyse the rate of chemical reactions	Enzymes are involved in all metabolic reactions building large molecules from small ones as well breaking down large molecules into small ones.
(j)	**how different enzymes are composed of different amino acids linked to form a chain which is then folded into a specific shape**	**The importance of specific amino acid sequences in determining protein structure and thus function.**
(k)	how the specific shape of the active site of an enzyme enables it to function, a simple understanding of 'lock and key' modelling and be able to interpret enzyme activity in terms of molecular collisions **resulting in the formation of enzyme-substrate complexes**	Apply knowledge of ‘lock and key’ to the analysis of simple, stylised diagrams of enzyme/substrate interactions.

(l)	the effect of temperature and pH on enzyme activity including the effect of boiling which denatures most enzymes	Understand the term optimum as a particular condition (such as temperature or pH) at which the rate of enzyme action is greatest. Increased temperature results in increased collisions between enzymes and substrates. In a denatured enzyme the specific shape of the active site is destroyed and can no longer bind with its substrate, so no reaction occurs. Analyse data to show how enzyme action is affected by temperature and pH.

SPECIFIED PRACTICAL WORK

- Examination of animal and plant cells using a microscope and production of scientific labelled diagrams
- Investigation into factors affecting enzymes

Examination of animal and plant cells using a light microscope and production of labelled scientific diagrams from observation

Introduction

Cheek cells are typical animal cells, they have a cell membrane, cytoplasm and a nucleus. Onion cells are plant cells, they have a cell wall, cell membrane, cytoplasm, nucleus and vacuole. This practical requires you to prepare cheek cell slides and onion cell slides. These slides can then be observed using a microscope.

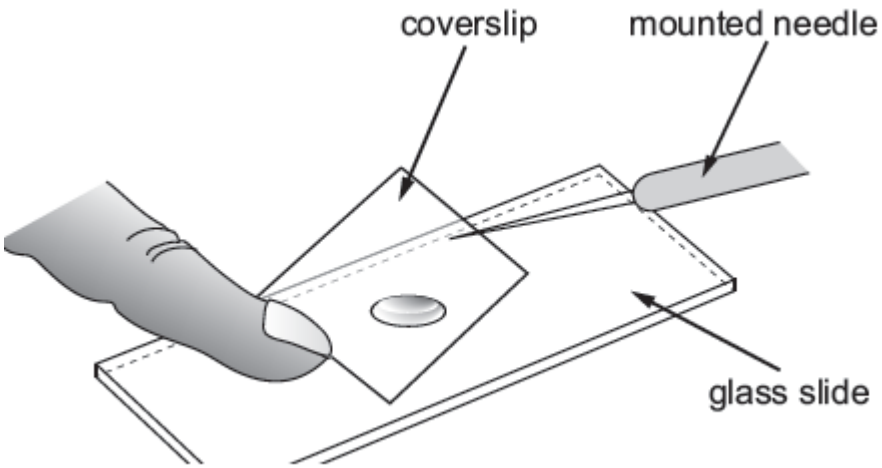
Apparatus

light microscope
2 × glass slides
2 × cover slips
cotton wool bud
mounted needle
forceps
freshly cut onion
0.1% methylene blue solution
iodine solution

Access to:

beaker of disinfectant

Diagram of Apparatus



Method

Cheek Cells:

1. Put a drop of methylene blue on a glass slide.
2. Gently rub the inside of your cheek with a cotton bud.
3. Wipe the end of the cotton bud in the drop of methylene blue on the glass slide.
4. Place the cotton bud in the beaker of disinfectant.
5. Use the mounted needle to gently lower a coverslip onto the glass slide.
6. Using a light microscope, examine the slide using the ×10 objective lens.
7. Use the ×40 objective lens to identify some of the cell structures.
8. Draw a cell diagram. Identify and label: cell membrane, cytoplasm and nucleus.

Onion Cells:

1. Using forceps, peel a thin layer of epidermis from the inside of a freshly cut onion piece.
2. Lay the epidermis onto a glass slide.
3. Add a drop of iodine solution to the onion epidermis on the glass slide.
4. Use the mounted needle to gently lower a coverslip onto the glass slide.
5. Using a light microscope, examine the slide using the ×10 objective lens.
6. Use the ×40 objective lens to identify some of the cell structures.
7. Draw a cell diagram. Identify and label: cell wall, cell membrane, cytoplasm and nucleus.

Analysis

1. Calculate the total magnification of the image seen by multiplying the power of the objective lens by the power of the eyepiece.
2. Your teacher will tell you the actual size of the cell, calculate the magnification of your diagram.

Teacher/Technician notes

Risk Assessment

Hazard	Risk	Control measure
Methylene blue is harmful and/or irritant	Splashing onto hand/skin/you whilst using. Transfer from hand into eye when placing on slide	Wash off/wear gloves Wear eye protection
Cheek cells are a biohazard	Transfer of infection from cheek cell to other people when handling	Only handle samples from your own body. After use, hygienically dispose of cotton buds and slides in a disinfectant such as Milton or Virkon.
Coverslips/ mounted needles are sharp	Coverslip/mounted needle could cut skin when placing on slide.	Only use mounted needle by handle/only handle coverslip by the sides

Methylene blue and iodine solution are stains. Avoid contact with the skin. Iodine is a low hazard chemical as a dilute solution.

Suitable disinfectant would include Milton or Virkon which would need to be diluted to suitable concentrations.

If the lamp is not an integral part of the microscope, a desk lamp will be needed for each group.

Freshly cut onion is recommended. This should be prepared for student use in pieces approximately 1 cm^2.

Students will need to be briefed regarding safe and effective microscope use prior to this practical activity. This practical activity is effective at developing microscope skills and biological drawing skills.

Students can calculate the total magnification of the image as the power of the objective lens multiplied by the power of the eyepiece. The actual size of the cells can be given to the students to enable them to calculate the magnification of their diagrams.

Working scientifically skills covered

1. **Development of scientific thinking**
   Appreciate the power and limitations of science and consider any ethical issues which may arise.

2. **Experimental skills and strategies**
   Apply knowledge of a range of techniques, instruments, apparatus and materials to select those appropriate to this experiment.

   Make and record observations and measurements using a range of apparatus and methods.

3. **Analysis and Evaluation**
   Present observations and other data using appropriate methods.

Investigation into factors affecting enzyme action

Introduction

Iodine is an indicator that turns blue/black when starch is present, but is otherwise brown. In this investigation a blue/black solution of starch and iodine will change to brown as the enzyme amylase digests/breaks down the starch into sugar.
The time taken for this reaction to occur is affected by temperature.

Apparatus

test tube rack and six test tubes
marker pen
stopwatch
25 cm^3 measuring cylinder
10 cm^3 measuring cylinder
beaker of 1 % starch solution
dropper bottle of iodine solution
beaker of 10 % amylase solution
spotting tile
dropping pipette

Access to:

water bath or alternative method of heating water

Method

1. Measure 10 cm^3 of 1 % starch solution into a test tube.
2. Measure 2 cm^3 of 10 % amylase solution into a second test tube.
3. Place both tubes into a water bath set at 20 ºC for 3 minutes.
4. Place a drop of iodine in six wells of a spotting tile.
5. Remove both test tubes from the water bath. Pour the amylase into the starch/iodine solution and start the stopwatch.
6. Immediately, use the dropping pipette to place one drop of the mixture onto the first drop of iodine. Record the colour of the solution.
7. Repeat step 6 every minute for five minutes.
8. Repeat steps 1-7 at 30 ºC, 40 ºC, 50 ºC, 60 ºC.

Analysis

1. Use your observations to reach a conclusion regarding the effect of temperature on enzyme action.
2. Evaluate your method and suggest possible improvements.

Teacher/Technician notes

Risk Assessment

Hazard	Risk	Control measure
10% amylase enzyme solution is irritant	Amylase enzyme could get on to the skin when pouring into the test tube	Wash hands immediately if amylase gets on to them/ wear laboratory gloves
	Amylase enzyme could get transferred to the eyes from the hands when pouring	Wear eye protection.

10% bacterial amylase solution is a suggested concentration. Amylase varies in its effectiveness with source and age, so it will be necessary to try out the experiment before presenting it to students to establish the optimum concentrations of starch and amylase to use.

Iodine solution is a stain. It is a low hazard chemical as a dilute solution, however contact with the skin should be avoided

The method as stated does not include repeats, but students should be encouraged to carry out an appropriate number, if time allows.

Students should be encouraged to look at reproducibility by looking at the results of other groups. Evaluation should include consideration of the end point of the reaction and possible improvements.

Students should design their own table, but a suggested table format is shown below.

	Colour of solution					
Temperature of solution (ºC)	at start	after 1 minute	after 2 minutes	after 3 minutes	after 4 minutes	after 5 minutes
20						
30						
40						
50						
60						

Working scientifically skills covered

2. Experimental skills and strategies

Apply knowledge of a range of techniques, instruments, apparatus and materials to select those appropriate to this experiment.

Evaluate methods and suggest possible improvements and further investigations.

3. Analysis and Evaluation

Evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.

1.2 RESPIRATION AND THE RESPIRATORY SYSTEM IN HUMANS

Spec Statement		Comment
(a)	aerobic respiration as a process that occurs in cells when oxygen is available; respiration as a series of enzyme-controlled reactions within the cell, that use glucose and oxygen to release energy and produce carbon dioxide and water; **energy is released in the form of ATP** and be able to state the word equation to describe aerobic respiration	Use germinating peas to show that energy is released as heat during respiration. This should include the role of Thermos flasks and disinfectant in the experiment.
(b)	anaerobic respiration as a process that occurs in the absence of oxygen; glucose being broken down to release energy and lactic acid; oxygen debt as a result of anaerobic respiration; **anaerobic respiration as a less efficient process than aerobic respiration because of the incomplete breakdown of glucose; less ATP is produced per molecule of glucose in anaerobic respiration than in aerobic respiration** and be able to state the word equation for anaerobic respiration in human cells	Lactic acid is harmful to the body. It has to be removed from cells and broken down following the resumption of aerobic respiration (to repay the oxygen debt). No knowledge of anaerobic respiration in yeast is required.
(c)	the need for and purpose of the respiratory system and be able to label the following structures on a diagram of a vertical section of the human respiratory system: nasal cavity, trachea, bronchi, bronchioles, alveoli, lungs, diaphragm, ribs and intercostal muscles	Large organisms require a complex respiratory system in order to obtain a sufficient volume of oxygen to maintain a high level of aerobic respiration and to remove an equivalent volume of waste carbon dioxide.
(d)	the function of mucus and cilia in the respiratory system	Mucus and cilia help protect the respiratory system. Particles and bacteria stick to mucus and cilia move the mucus out of the respiratory system to the back of the throat.

(e)	the mechanisms of inspiration and expiration, in terms of changes in thoracic volume and pressure brought about by movements of the diaphragm and rib cage; movement of air takes place due to differences in pressure between the lungs and outside the body	This includes how changes in the position of chest wall and diaphragm affect the lung volume in inspiration and in expiration (viewed from the side and the front).
(f)	the use of a bell jar model to illustrate inspiration and expiration and the limitations of this model	Compare and contrast diagrams of the bell jar model and the gross structures of the human respiratory system.
(g)	the structure of an alveolus and its blood supply and be able to label the following structures on a diagram: end of bronchiole, wall of alveolus, moist lining of alveolus, wall of capillary, red blood cells and plasma	The direction of movement of gases should be shown as arrows on the diagram.
(h)	the percentage composition of inspired and expired air and the reasons for the differences; how gases diffuse between alveolar air and capillaries; the adaptations of alveoli for gas exchange; the use of lime water to indicate the presence of carbon dioxide	The composition of inspired air: 21% Oxygen, 0.04% Carbon Dioxide, 78% Nitrogen, percentage of water vapour varies. The composition of expired air: 16% Oxygen, 4% Carbon Dioxide, 78% Nitrogen, saturated with water vapour. Describe how a simple 'huff and puff' apparatus, with lime water to detect carbon dioxide, is used to compare the carbon dioxide content of inspired and expired air and to explain experimental results. The adaptations of alveoli for gas exchange include large surface area, thin wall, moist lining and a rich blood supply. These adaptations maximise the rate of diffusion of oxygen and carbon dioxide.
(i)	the effects of smoking on cilia and mucus in the respiratory system and the consequences for the individual; the link between cigarette smoking and lung cancer and emphysema and the consequences of these conditions	There are chemicals in cigarette smoke which paralyse cilia and particles which clog the mucus which prevents their function. This increases the risk of disease in the respiratory system. Tar in tobacco smoke contains carcinogens which lead to lung cancer. Cigarettes also contain nicotine which is addictive. Cigarette smoke destroys lung tissue which leads to emphysema.

1.3 DIGESTION AND THE DIGESTIVE SYSTEM IN HUMANS

Spec Statement		Comment
(a)	the need for digestion; the breakdown of large molecules into smaller molecules so they can be absorbed for use by body cells	
(b)	the digestion of larger insoluble molecules into their soluble products which can then be absorbed: fats made up of fatty acids and glycerol; proteins made up of amino acids; starch (a carbohydrate) made up of a chain of glucose molecules	
(c)	the tests for the presence of: starch using iodine solution; glucose using Benedict's reagent; protein using biuret solution	Positive results: Iodine: brown to blue/black Benedict's reagent: blue to brick red Biuret solution: blue to violet
(d)	the role of the following enzymes in digestion: carbohydrase; protease; lipase	Carbohydrase: starch to glucose Protease: protein to amino acids Lipase: fats and oils (lipids) to fatty acids and glycerol
(e)	the structure of the human digestive system and associated structures: the mouth, oesophagus, stomach, liver, gall bladder, bile duct, pancreas, small intestine, large intestine, anus and be able to label these on a diagram	
(f)	the role of the following organs in digestion and absorption: mouth, stomach, pancreas, small intestine, large intestine, liver	Know the role of the following organs: • Mouth - starch digestion begins by carbohydrase/ amylase in saliva • Stomach - secretes protease • Pancreas - secretes lipase, proteases and carbohydrase into the small intestine • Small intestine - continued digestion of carbohydrates to glucose, proteins to amino acids, fats to fatty acids and glycerol and absorption of digested molecules • Large intestine - absorption of water • Liver - secretes bile

(g)	how food is moved by peristalsis	Understand the action of contraction and relaxation of muscles in peristalsis in forcing food through the digestive system.
(h)	the function of bile, secreted by the liver and stored in the gall bladder, in the breakdown of fats	Bile emulsifies large droplets of fat into small droplets to increase the surface area for enzyme action. It also increases the pH in the small intestine to the optimum pH for lipase activity.
(i)	how soluble substances can be absorbed through the wall of the small intestine and eventually into the bloodstream and how Visking tubing can be used as a model gut, including the limitations of the model	This should be limited to knowledge of absorption by diffusion only. The small intestine has a relatively large surface area, created by villi, which contain blood vessels. It has a rich blood supply which maintains a steep diffusion gradient. Visking tubing can be used as a model gut but as it has no blood supply cannot maintain a diffusion gradient.
(j)	the fate of the digested products of fats, carbohydrates and proteins: fatty acids and. glycerol from fats provide energy; glucose from carbohydrate provides energy or is stored as glycogen; amino acids from digested proteins are needed to build proteins in the body	
(k)	the need for a balanced diet, including: protein, carbohydrates and fats, minerals (iron),vitamins (vitamin C), fibre and water	A simple understanding that the dietary nutrients and water necessary to maintain good health will vary with age and activity levels. The functions of protein, carbohydrates and fats are given in (j). Iron is needed for the production of haemoglobin, vitamin C is needed to maintain healthy tissue and fibre provides bulk in the digestive system. Water is an essential part of many body functions and processes.
(l)	the fact that different foods have different energy contents and that energy from food, when it is in excess, is stored as fat by the body	The energy content of food eaten must be balanced with energy needs since excess energy will be stored as fat by the body. Excess stored fat leads to obesity.
(m)	the implications, particularly for health, of excess sugar, fat and salt in foods	Excess sugar can lead to type 2 diabetes, obesity, tooth decay. Excess fat can lead to obesity, heart disease and circulatory disease. Excess salt (sodium) can lead to high blood pressure.

SPECIFIED PRACTICAL WORK

- Investigation into the energy content of foods

Investigation of the energy content of foods

Introduction

Different foods have different energy contents. The energy content of a food can be released when you set it alight. When you hold a burning food underneath a known volume of water, the temperature increase can be measured. A simple calculation can then be used to estimate the amount of energy stored within the food.

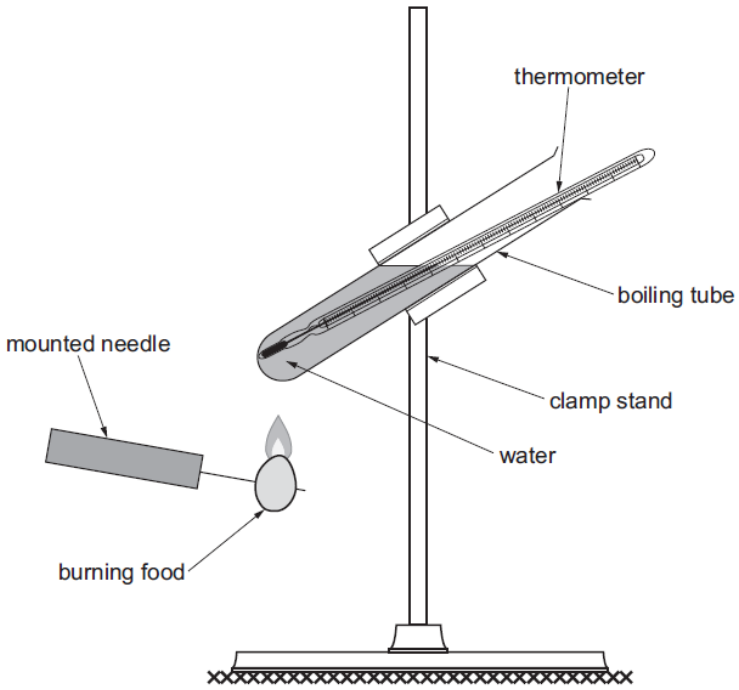
Apparatus

25 cm^3 measuring cylinder
boiling tube
clamp stand, clamp and boss
thermometer
Bunsen burner
heat proof mat
mounted needle
samples of foods

Access to:

electronic balance ± 0.1 g

Diagram of Apparatus



Method

1. Measure 20 cm^3 of water into a boiling tube.
2. Clamp the boiling tube to the clamp stand.
3. Record the temperature of the water using a thermometer.
4. Choose a piece of food and record its mass.
5. Place food onto a mounted needle.
6. Hold the food in the Bunsen burner flame, until it catches alight.
7. As soon as the food is alight, hold it under the boiling tube of water. Keep the flame directly underneath the tube.
8. Hold the food in this position until it has burnt completely. If the flame goes out, but the food is not completely burnt, quickly light it again using the Bunsen burner and hold it directly underneath the boiling tube.
9. When the food has burned completely, and the flame has gone out, immediately record the temperature of the water.
10. Repeat steps 1-9 for other foods.

Analysis

1. Calculate the increase in temperature each time.
2. Calculate the energy released from each food using the formula:

$$\text{Energy released from food per gram (J)} = \frac{\text{mass of water (g)} \times \text{temperature increase (°C)} \times 4.2}{\text{mass of food sample (g)}}$$

3. Compare your results with the theoretical value on the food packet.

4. Evaluate your method and suggest how it could be improved.

Teacher/Technician notes

Risk Assessment

Hazard	Risk	Control measure
Fumes produced from burning foods or foods alone can cause allergic reactions	Risk of allergic reactions (skin rashes/breathing difficulties) or anaphylactic shock whilst handling/burning	Do not use nuts as the food source. Maintain good ventilation of the laboratory. Be prepared to administer first aid.
Hot apparatus can burn	Hot apparatus can burn the skin when moving the apparatus	Leave apparatus to cool before moving
Hot water can scald/burn	Hot water can scald/burn skin/eyes when moving the apparatus/pouring water	Leave water to cool before moving Wear eye protection
Bunsen burner flame can burn	Flame can burn the skin when igniting the crisp	Keep hands a safe distance from the flame
Burning food/dripping fat can burn	Burning food can burn the skin when heating water OWTTE	Keep hands a safe distance from the flame Wear heat proof gloves

4.2 J / kg °C is the value for the specific heat capacity of water. 1 cm^3 of water has a mass of 1 g.

A good range of data can be obtained from comparing the energy values of different crisps, e.g. wotsits, monster munch etc.

The method as stated does not include repeats, but students should be encouraged to carry out an appropriate number, if time allows.

This experiment can be used to compare the energy values quoted on food packaging with the data obtained from the experiment. Students can repeat results to determine repeatability and share results between pupil groups to determine reproducibility of data. This experiment is effective at evaluating the effectiveness of a method. Students can explain why the data obtained from the experiment is significantly different to the energy values quoted on food packaging. The idea of random and systematic errors can be explored.

Students should design their own table, but a suggested table format is shown below.

Type of food	Mass of food (g)	Temperature at start (ºC)	Temperature at end (ºC)	Temperature increase (ºC)	Energy released per gram (J)

Working scientifically skills covered

1. **Development of scientific thinking**
   Explain every day and technological applications of science: evaluate associated personal, social, economic and environmental implications and make decisions based on the evaluation of evidence and arguments

2. **Experimental skills and strategies**
   Make and record observations and measurements using a range of apparatus and methods.

   Evaluate methods and suggest possible improvements and further investigations.

3. **Analysis and Evaluation**
   Carrying out and representing mathematical analysis

   Evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.

4. **Scientific vocabulary, quantities, units, symbols and nomenclature**
   Use SI units and IUOAC chemical nomenclature unless inappropriate

1.4 CIRCULATORY SYSTEM IN HUMANS

	Spec Statement	Comment
(a)	the structure of a phagocyte and a red blood cell; be able to draw and label these cells	Drawings are only required to show the general shape of the blood cells. The following labels are required: red blood cell - cell membrane phagocyte - cell membrane, nucleus and cytoplasm.
(b)	the functions of the four main parts of the blood: red cells, platelets, plasma, white cells	The functions include: red blood cells – contain haemoglobin for transport of oxygen; platelets – clotting; plasma – transport of carbon dioxide, soluble food, urea, hormones and the distribution of heat; white blood cells - defence against disease (No details of clotting mechanisms or immunity are required here)
(c)	the fact that the heart is made of muscle, which contracts to pump blood around the body	
(d)	the role of the coronary vessels in supplying the heart muscle with blood	The separate identification of coronary arteries and veins on diagrams will not be required.
(e)	the flow of blood to the organs through arteries and return to the heart through veins	
(f)	the structure of the heart: the left and right atria and ventricles, tricuspid and bicuspid valves, semi-lunar valves, pulmonary artery, pulmonary vein, aorta and vena cava and be able to label these on a diagram	Observe a dissected/ model of heart to include coronary arteries and internal structure. They should understand the significance of the difference in thickness of the muscle in the right and left ventricles.
(g)	the passage of blood through the heart including the functions of the valves in preventing backflow of blood	
(h)	a double circulatory system: involving one system for the lungs – pulmonary and one for the other organs of the body – systemic	

(i)	the fact that in the organs, blood flows through very small blood vessels called capillaries; substances needed by cells pass/diffuse out of the blood to the tissues, and substances produced by the cells pass/diffuse into the blood, through the walls of the capillaries; the thin walls of the capillaries are an advantage for diffusion; capillaries form extensive networks so that every cell is near to a capillary carrying blood	
(j)	the structure of arteries, veins and capillaries and relate this to their function	In diagrams of arteries and veins, label: tough outer coat, muscle layer, endothelium and lumen. Compare the relative thickness of the blood vessel walls and the size of the lumen in arteries and veins. Veins contain valves.
(k)	risk factors for cardiovascular disease and the effects of cardiovascular disease	These include high levels of fat and salt in the diet, high blood pressure, high blood cholesterol, smoking, genetic factors and a lack of exercise. Give a simple description of atheroma and its effects on the body.
(l)	the advantages and disadvantages of the following treatments for cardiovascular disease: • statins • angioplasty • changes to lifestyle diet/exercise	Research the advantages and disadvantages of the treatments for cardiovascular disease such as: • Statins, a daily medication to control blood cholesterol levels, but may cause side effects. • Angioplasty, surgery to place a small balloon in a blood vessel, which is inflated to remove a blockage. This results in improved blood flow e.g. in coronary vessels, but sometimes is only a temporary remedy. • Changes to diet/ lifestyle. These include stopping smoking, taking up regular exercise, eating more healthy food. These can reduce risk and lower blood pressure. However, a high level of self-discipline is needed to maintain these long-term changes.

1.5 PLANTS AND PHOTOSYNTHESIS

Spec Statement		Comment
(a)	the importance of photosynthesis, whereby green plants and other photosynthetic organisms use chlorophyll to absorb light energy and convert carbon dioxide and water into glucose, producing oxygen as a by-product and be able to state the word equation for photosynthesis	The chemical reactions of photosynthesis within the cell are controlled by enzymes. (Details of the enzymes involved in photosynthesis are not required.)
(b)	the conditions needed for photosynthesis to take place and the factors which affect its rate, including temperature, carbon dioxide and light intensity; **these as limiting factors of photosynthesis**	
(c)	the practical techniques used to investigate photosynthesis: the use of sodium hydroxide to absorb carbon dioxide; how to test a leaf for the presence of starch; how oxygen and carbon dioxide sensors and data loggers could be used	The steps within the method for testing a leaf for starch include: killing the leaf by placing in boiling water, decolouration using ethanol, washing to soften, testing with iodine. Understand the need for de-starching the leaf prior to the procedure.
(d)	the uses made by plant cells of the glucose produced in photosynthesis: respired to release energy; converted to starch for storage; used to make cellulose, proteins and oils	
(e)	the structure of a leaf and be able to label the following structures: cuticle, epidermis, stomata, palisade layer, spongy layer, xylem and phloem; the structure of stomata to include guard cells and stoma; the fact that stomata can open and close to regulate transpiration and allow gas exchange	No details of the mechanism of stomatal opening are required.
(f)	the importance of water to plants: use in photosynthesis, transport of minerals and support	Water provides support by filling the vacuoles which push against cell walls. This keeps cells turgid and prevents cells becoming flaccid and wilting. No reference to turgor/pressure potential is required.

(g)	the significance of root hairs in increasing the area for absorption in a root; the role of osmosis in the uptake and movement of water through a plant;	
(h)	**the uptake of mineral salts by root hairs by active transport**	**Cells that are carrying out active transport are actively respiring.**
(i)	the role of xylem in transport of water within plants; the role of transpiration in the movement of water through a plant	Water is carried through the xylem from the root, up the stem and to all parts of the plant.
(j)	the effect of different environmental conditions on the rate of transpiration from a plant / plant cutting	A potometer can be used to measure the effect of different environmental conditions. However it is an indirect measure of transpiration.
(k)	the role of phloem in carrying sucrose from the photosynthetic areas to other parts of the plant for use in respiration or converted into starch for storage	No reference to the mechanism by which sucrose is transported is required.
(l)	the effects of plant nutrient deficiencies on plant growth: lack of nitrates results in poor growth; deficiency of potassium results in yellowing of the leaf; deficiency of phosphate results in poor root growth; the use of NPK fertilisers	

SPECIFIED PRACTICAL WORK

- Investigation into factors affecting photosynthesis
- Investigation into factors affecting transpiration

Investigation of the factors affecting photosynthesis

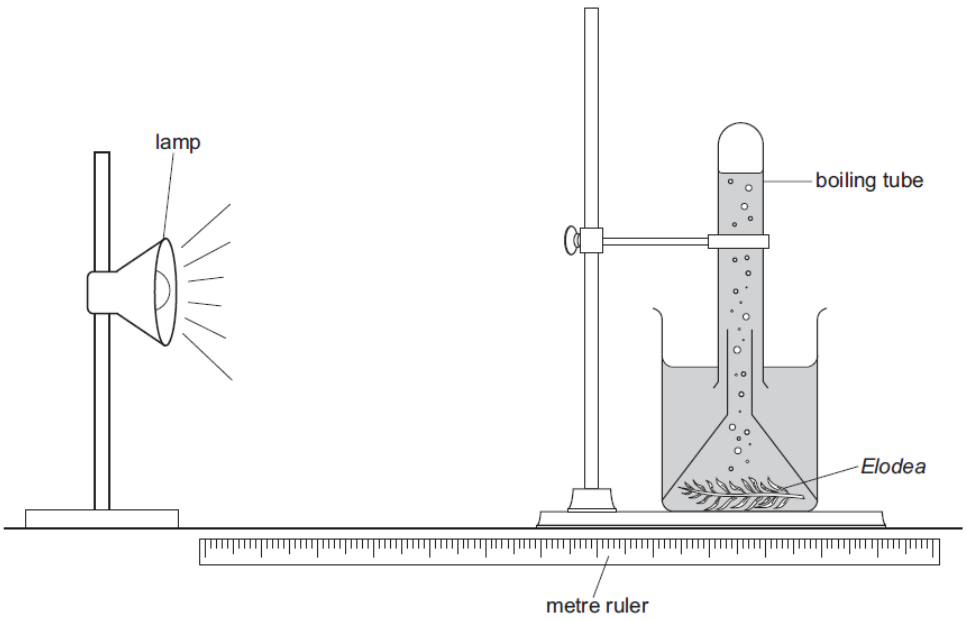
Introduction

Light is one of the factors which affects the rate of photosynthesis.
In this investigation a green plant named Canadian pondweed *(Elodea)* will produce bubbles of oxygen as a result of photosynthesis.
The number of bubbles of oxygen produced is affected by light intensity.

Apparatus

250 cm^3 beaker
lamp
glass funnel
plasticine
test tube
8 cm length of pondweed (*Elodea)*
metre ruler ± 1 mm
sodium hydrogen carbonate powder
clamp stand, clamp and boss
spatula

Diagram of Apparatus



Method

1. Place the *Elodea* in a beaker containing 200 cm^3 of water.
2. Add one spatula of sodium hydrogen carbonate to the water.
3. Stick 3 small pieces of plasticine to the rim of the funnel and place it upside down over the plant.
4. Completely fill a test tube with water and carefully place over the end of the funnel with the end under the water, clamp into place.
5. Place the lamp 5 cm away from the apparatus.
6. Start the stopwatch and record the number of bubbles of oxygen produced in one minute.
7. Repeat the experiment with the lamp 10 cm, 15 cm, 20 cm, 25 cm and 30 cm from the apparatus.

Analysis

1. Plot a graph of the distance against number of bubbles produced in 1 minute.
2. What conclusions can be reached from your results?
3. Evaluate your method and state how it could be improved.

Teacher/Technician notes

Risk Assessment

Hazard	Risk	Control measure
Hot lamps can burn	Contact with skin will cause burns when handling/touching/moving apparatus	Do not touch lamp until it has cooled down.

If the plant is not producing bubbles then the stem might have started to 'heal' up, cutting off the end off may improve bubbling.

Begin the experiment with the lamp closer to the plant and move the plant further away as this seems to give better results.

Cabomba caroliana (and *Elodea crispa*) are no longer available to buy. They have been banned for culturing or sale under European regulations controlling invasive non-native plants. CLEAPSS have worked with native plants (Hornwort and red Cabomba), and they are OK for use. The CLEAPSS method (see the link below) overcomes the problems of the native aquatic plants bubbling slowly.
http://science.cleapss.org.uk/Resource-Info/GL184-Using-video-recording-to-measure-the-rate-of-photosynthesis.aspx

If students have any difficulty in obtaining results, the link below can be used.

http://www.reading.ac.uk/virtualexperiments/ves/preloader-photosynthesis-full.html

The method as stated does not include repeats, but students should be encouraged to carry out an appropriate number, if time allows.

This experiment is ideal for a discussion of the limiting factors of photosynthesis and how they are controlled variables in this experiment. There is also a clear opportunity to discuss the limitations of the investigation such as the difficulty in controlling temperature.

Students should design their own table, but a suggested table format is shown below.

	Number of bubbles produced in one minute			
Distance from plant to lamp (cm)	**Trial 1**	**Trial 2**	**Trial 3**	**Mean**

Working scientifically skills covered

2. Experimental skills and strategies

Apply knowledge of a range of techniques, instruments, apparatus and materials to select those appropriate to this experiment.

Carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.

Make and record observations and measurements using a range of apparatus and methods.

Evaluate methods and suggest possible improvements and further investigations.

3. Analysis and Evaluation

Evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.

Investigation into factors affecting transpiration

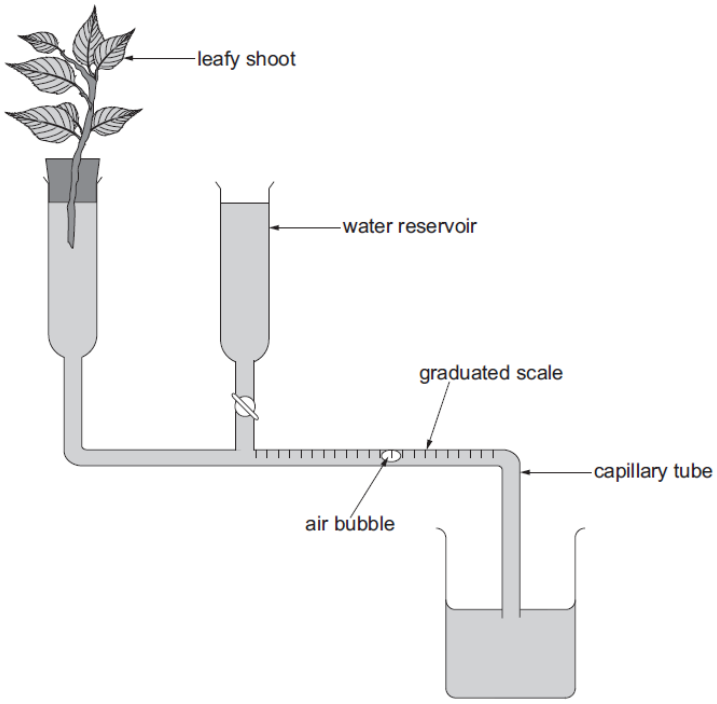
Introduction

Transpiration is the evaporation of water from the leaves of a plant, which causes the uptake of water from the roots. It is assumed that the volume of water taken up at the roots is equal to evaporation from the leaves. In this investigation a freshly cut plant stem will carry out transpiration. The rate of transpiration can be measured by the distance travelled by an air bubble along a capillary tube in a particular time.

Apparatus

potometer
100 cm^3 beaker of water
leafy shoot cut under water
clamp stand, clamp and boss
scissors
stopwatch
Vaseline
paper towel
bowl of water

Diagram of Apparatus



Method

1. Immerse the potometer in the bowl of water and make sure the apparatus is full of water with no air bubbles.
2. Put the cut end of the leafy shoot in the water, taking care to keep the leaves above the surface.
3. Diagonally cut the last centimetre from the stem underwater.
4. With the potometer and stem still underwater, gently push the stem into the bung as shown in the diagram. Make sure it is a tight fit.
5. Remove the assembled apparatus from the water and apply Vaseline to all the joints to avoid air entering the apparatus.
6. Gently dab the leaves with the paper towel to remove excess water.
7. Clamp the potometer in an upright position with the capillary tube in the beaker of water.
8. Remove the capillary tube from the beaker to allow an air bubble to form and then return it to the beaker.
9. When the air bubble reaches the start of the scale begin timing.
10. After a set amount of time record how far the air bubble has travelled along the scale.
11. Repeat steps 8-10 twice more.

Analysis

1. Calculate the mean water loss per minute.

Teacher/Technician notes

Risk Assessment

Hazard	Risk	Control measure
Scissors are sharp	Cutting hand when cutting stem	Cut away from hand
Delicate capillary tubing easily breaks	Cutting hand on smashed tubing due to pressure of inserting bung/stem	Use minimal pressure to push stem into bung and bung into tubing.

The setting up of potometers should be carried out as a demonstration or in advance by technicians due to the delicate nature of the capillary tubing and the fact the apparatus needs to be assembled under water. However, if students are to carry out the procedure note the risk assessments.

Use the given method to introduce how to investigate transpiration. Students could then be asked to plan an investigation into the effects of the following factors on the rate of transpiration.

- Light intensity (Lamp)
- Temperature (Incubator)
- Wind speed (Fan)
- Surface area of leaves (Remove leaves one by one and repeat experiment)
- Humidity (Clear bags over leaves)

Different groups of students could be asked to plan investigations into each of the factors above. They could be asked to identify independent and dependent variables and then identify and describe how to control the other variables in the experiment and explain why it is necessary to control them.

If home-made potometers are to be used the web link below leads to an excellent set of teacher/ technician guidance notes on how to make them.

http://www.saps.org.uk/secondary/teaching-resources/1341-a-level-set-practicals-using-a-potometer

The experiment could also be demonstrated or students could use the virtual experiment below to test their predictions.

http://www.reading.ac.uk/virtualexperiments/ves/preloader-transpiration.html

Working scientifically skills covered

2. Experimental skills and strategies

Plan experiments or devise procedures to make observations, produce or characterise a substance test hypotheses, check data or explore phenomena.

Apply knowledge of a range of techniques, instruments, apparatus and materials to select those appropriate to this experiment.

Carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.

Make and record observations and measurements using a range of apparatus and methods.

Evaluate methods and suggest possible improvements and further investigations.

1.6 ECOSYSTEMS, NUTRIENT CYCLES AND HUMAN IMPACT ON THE ENVIRONMENT

Spec Statement		Comment
(a)	food chains and food webs showing the transfer of energy between organisms and involving producers; first, second and third stage consumers; herbivores and carnivores; decomposers	Radiation from the sun is the source of energy for living organisms. Green plants capture only a small percentage of the solar energy which reaches them. Candidates should be aware that alternative terms for the organisms in the trophic levels include: primary consumers, secondary consumers and tertiary consumers
(b)	the fact that at each stage in the food chain energy is used in repair and in the maintenance and growth of cells whilst energy is lost in waste materials and respiration	Draw and label pyramids of number and biomass (to include names and values at each trophic level). Analyse data in terms of: efficiency of energy transfer, numbers of organisms and biomass.
(c)	pyramids of numbers and biomass	
(d)	**how to calculate the efficiency of energy transfers between trophic levels and how this affects the number of organisms at each trophic level**	

(e)	the importance of micro-organisms, bacteria and fungi in decay: micro-organisms feed on waste materials from organisms, when plants and animals die their bodies are broken down by micro-organisms bringing about decay, micro-organisms respire and release carbon dioxide into the atmosphere	Micro-organisms digest materials from their environment for growth and other life processes. These materials are returned to the environment either in waste products or when living things die and decay. When decay is prevented, fossil fuels such as coal, oil and gas are formed and these store energy in carbon compounds.
(f)	the fact that nutrients are released in decay, e.g. nitrates and phosphates, and that these nutrients are then taken up by other organisms resulting in nutrient cycles and in a stable community the processes which remove materials are balanced by processes which return materials	Only the general principle of the cycling of elements is required here (no detail of nitrate or phosphate cycles).
(g)	the carbon cycle: carbon is constantly cycled in nature by photosynthesis which incorporates it and by respiration which releases it; the combustion of fossil fuels releases carbon dioxide	Carbon is taken up by green plants in photosynthesis and is passed to animals when they eat the plants. Some of this carbon then becomes part of carbohydrates, fats and proteins which make up their bodies. Animals and plants release carbon dioxide during respiration
(h)	**the nitrogen cycle: nitrogen is also recycled through the activity of soil bacteria and fungi acting as decomposers, converting proteins and urea into ammonia; the conversion of ammonia to nitrates which are taken up by plant roots and used to make new protein; nitrogen fixation, by which nitrogen from the air is converted to nitrates; the factors which could lead to denitrification**	**This includes the factors that affect bacterial action and influence the decomposition process in compost heaps and landfill sites e.g. temperature, oxygen, pH, heavy metals.** **Nitrogen fixation occurs in bacteria in root nodules of legume plants or free living bacteria in the soil. Some other bacteria break down the nitrate in the soil, returning nitrogen to the atmosphere. These are called denitrifying bacteria and they prefer to live in waterlogged/ unploughed soil.** **Understand that the enzyme urease converts urea in excreted waste to ammonia. An experiment to show this is given below. http://www.scienceinschool.org/2008/issue9/urease**

(i)	the issues surrounding the need to balance the human requirements for food and economic development with the needs of wildlife	The rising human population is causing increased effects on the environment. This includes that more space is needed for housing, industry and agriculture. Where development is proposed, data collected by biologists is used in an assessment of environmental impact, including effects on endangered species. The assessment is used to decide whether the development should be allowed to go ahead, be refused or modified to reduce the effect on wildlife. Government agencies have an important role in monitoring, protecting and improving the environment.
(j)	the advantages and disadvantages of intensive farming methods, such as using fertilisers, pesticides, disease control and battery methods to increase yields	These include: advantages • increased yield of crops and high levels of meat production disadvantages • fertilisers and pesticides- can result in chemicals being washed from soils into waterways • disease control –excess use of antibiotics in farm animals could be present in meat and cause increased bacterial resistance • battery methods – negative impact on animal welfare and the duty of care to treat animals humanely
(k)	how indicator species and changes in pH and oxygen levels may be used as signs of pollution in a stream and how lichens can be used as indicators of air pollution	This should include analysis of first or second hand data from different habitats e.g. abundance and distribution of lichens.
(l)	the fact that some heavy metals, present in industrial waste and pesticides, enter the food chain, accumulate in animal bodies and may reach a toxic level	Bioaccumulation occurs when heavy metals or pesticides, which cannot be broken down in animals tissues, are washed into soils and rivers and pass through food chains. These chemicals reach a toxic level which can result in reduced fertility or death.

(m)	the fact that untreated sewage and fertilisers may run into water and cause rapid growth of plants and algae; these then die and are decomposed; the microbes, which break them down, increase in number and use up the dissolved oxygen in the water; animals which live in the water may suffocate	The term *eutrophication* is not required - if used by the candidate on examination papers, it is not usually sufficient as an answer. Candidates need to be able to explain this term if they use it.

UNIT 2 – VARIATION, HOMEOSTASIS and MICRO-ORGANISMS

2.1 CLASSIFICATION AND BIODIVERSITY

Spec Statement		Comment
(a)	living organisms showing a range of sizes, features and complexity; the broad descriptive grouping into plants - non-flowering and flowering; animals - invertebrates and vertebrates	There is a range of living organisms and they are divided into major groups: non-flowering plants – do not produce flowers e.g. ferns and mosses; flowering plants – produce flowers; invertebrates – do not have a backbone e.g. insects; vertebrates – have a backbone.
(b)	the means by which organisms which have similar features and characteristics are classified into groups; the need for a scientific system for identification and the need for scientific as opposed to 'common' names	A systematic system helps in the understanding of the variety of living things, their trends and relationships. The classification system may be based on morphological features or DNA analysis. The five Kingdom classification uses morphological features and includes Bacteria, Single Celled organisms, Plants, Fungi, and Animals. Each organism has a scientific name to aid its identification and classification. This avoids the confusion and duplication caused by local or common names. The classification of any suitable example to species level should be used to illustrate the system, including use of the following hierarchical taxa: kingdom, phylum, class, order, family, genus, species.
(c)	the fact that organisms have morphological and behavioural adaptations which enable them to survive in their environment	
(d)	individual organisms needing resources from their environment e.g. food, water, light and minerals; how the size of a population may be affected by competition for these resources along with predation, disease and pollution	This would include competition between species (interspecific) and between members of the same species (intraspecific).

(e)	the term biodiversity: the variety of different species and numbers of individuals within those species in an area; why biodiversity is important; the ways in which biodiversity and endangered species can be protected including issues surrounding the use of legislation	Biodiversity is important as it provides food, potential foods, industrial materials, new medicines and for human well-being. Biodiversity and endangered species can be conserved and protected by the following: • Convention on International Trade in Endangered Species • Sites of Special Scientific Interest • captive breeding programmes • national parks • seed/ sperm banks • local biodiversity action plans
(f)	how quadrats can be used to investigate the abundance of species	Any suitable location could be used to show the effect of different environmental factors. This should include the use of line transects and random quadrat distribution. An understanding that the number/ distribution of quadrats used should be enough to give valid results.
(g)	the principles of sampling; the need to collect sufficient data	
(h)	**the principles of capture/recapture techniques including simple calculations on estimated population size**	**Candidates should know how to use the equation:** **population size =** $\frac{\text{number in 1}^{st}\text{ sample x number in 2}^{nd}\text{ sample}}{\text{number in 2}^{nd}\text{ sample previously marked}}$ **When using capture-recapture data, assumptions made include: there is no death, immigration or emigration and that the marking technique does not affect chances of survival.** **Candidates will not be expected to recall the equation.**

(i)	the use of biological control agents and possible issues surrounding this; the introduction of alien species and their effects on local wildlife	Candidates should know that some animals and plants have been introduced, deliberately and accidentally, into areas where they do not naturally occur and some have become invasive and caused problems. Invasive species may grow faster than native species and upset the natural eco-system. Native species may not be able to compete with them. Research into the use of biological control agents takes place, on a world-wide basis, in order to understand how best to control alien species. During the research, trials are needed to assess the effects of biological control agents particularly on non-targeted native species.

SPECIFIED PRACTICAL WORK

- Investigation into the distribution and abundance of organisms

Investigation into factors affecting the abundance and distribution of a species

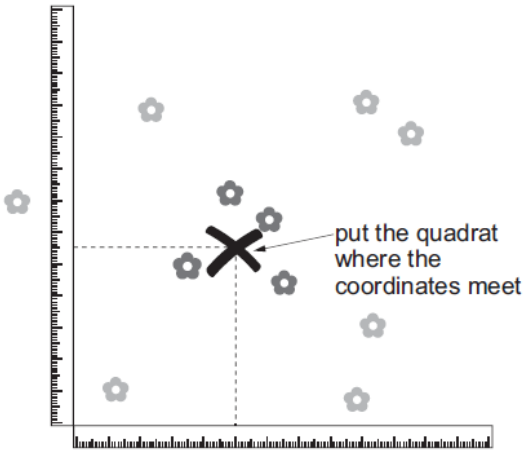
Introduction

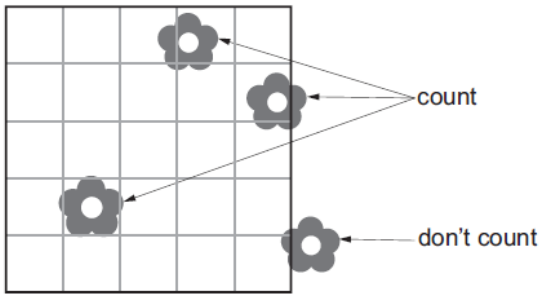
Daisies are a common plant species that can be found on a school field. Using quadrats for random sampling allows you to estimate the numbers of daisy plants growing in this habitat. This technique also reduces sampling bias. A simple calculation can then be used to estimate the total number of daisy species in the entire school field habitat.

Apparatus

2 × 20 m tape measures
2 × 20 sided dice
1 m^2 quadrat

Diagram of Apparatus





Method

1. Lay two 20 m tape measures at right angles along two edges of the area to survey.
2. Roll two 20 sided dice to determine the coordinates.
3. Place the 1 m^2 quadrat at the place where the coordinates meet.
4. Count the number of daisy plants within the quadrat. Record this result.
5. Repeat steps 2-4 for at least 25 quadrats.

Analysis

1. Use the following equation to estimate the total number of daisy plants in the field habitat:

$$\text{Total number of daisy plants in the habitat} = \text{total number in sample} \times \frac{\text{total area } (m^2)}{\text{total sample area } (m^2)}$$

Where:
total area = 400 m^2
total sample area = number of 1 m^2 quadrats used

Teacher/Technician notes

Risk Assessment

Hazard	Risk	Control measure
Some plants have thorns which can cut skin or can sting	Cut/irritate skin when handling plants	Avoid touching plants when identifying wear gloves
Uneven ground	Tripping/falling over when identifying plants	Wear suitable footwear

Students could compare data for mown and unmown areas.

This practical activity is effective at developing practical fieldwork skills. Students can discuss the need for a large sample of data in ensuring that there is confidence in a valid conclusion. Also, students can describe the importance of random sampling techniques in reducing/eliminating bias.

Alternative methods of generating coordinates can be used, such as using a random number generator or random number tables.

Working scientifically skills covered

2. Experimental skills and strategies

Apply knowledge of a range of techniques, instruments, apparatus and materials to select those appropriate to this experiment.

Recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative

Make and record observations and measurements using a range of apparatus and methods.

3. Analysis and Evaluation

Carrying out and representing mathematical analysis.

2.2 CELL DIVISION AND STEM CELLS

Spec Statement		Comment
(a)	chromosomes as linear arrangements of genes, found in pairs in body cells.	Since chromosomes are normally found in pairs in the nucleus of each body cell, the genes, which control particular characteristics, also come as pairs.
(b)	the functions of cell division by mitosis and meiosis	Cell division, by mitosis, enables organisms to grow, replace worn out cells and repair damaged tissues. Cell division by meiosis for the formation of gametes. The exact spelling of mitosis and meiosis is required.
(c)	the outcomes of mitotic and meiotic divisions and be able to compare these	Each mitotic division produces two daughter cells that are genetically identical and have the same number of chromosomes as the mother cell. Each meiotic division produces four daughter cells that are genetically different and have half the number of chromosomes of the mother cell.
(d)	the fact that if mitosis is uncontrolled, cancer can occur	A simple understanding that cancer is a result of uncontrolled mitosis.
(e)	stem cells: the cells in mature tissues have generally lost the ability to differentiate; some cells, in both plants and animals, do not lose this ability and these are called stem cells	The bodies of multicellular organisms consist of a variety of different cells that are adapted for particular functions. These different cells originate from undifferentiated stem cells that have the capacity to develop into specialised cells.
(f)	the potential of both adult and embryonic stem cells to replace damaged tissue	Stem cells are able to treat damaged or diseased tissue, providing a potent medical tool. The benefits of using your own stem cells include: no rejection, no need to find a donor, no need for tissue typing. However, the use of embryonic stem cells raises particular ethical issues.

2.3 DNA AND INHERITANCE

Spec Statement		Comment
(a)	the structure of DNA as two long chains of alternating sugar and phosphate connected by bases; the chains are twisted to form a double helix; there are four types of base, A **(adenine)**, T**(thymine)**, C **(cytosine)** and G **(guanine)**; the order of bases forms a code for making proteins; the code determines the order in which different amino acids are linked together to form different proteins	DNA has a ladder-like structure, the bases forming the rungs. They should have an understanding of complementary base pairing - A **(adenine)** pairs with T **(thymine)** and that C **(cytosine)** pairs with G **(guanine).** **Each triplet code identifies a particular amino acid. In the cytoplasm, these triplet codes are used to identify and link amino acids together to form proteins.**
(b)	complementary base pairing between A and T, C and G **and the role of the triplet code during protein synthesis**	
(c)	the process of 'genetic profiling' which involves cutting the DNA into short pieces which are then separated into bands	The term genetic profiling should be used in place of genetic fingerprinting to avoid confusion with fingerprinting.
(d)	how 'genetic profiling' can be used to show the similarity between two DNA samples, the pattern of the bands produced can be compared to show the similarity between two DNA samples, for instance in criminal cases, paternity cases and in comparisons between species for classification purposes	
(e)	the benefits of DNA profiling, for example to identify the presence of certain genes which may be associated with a particular disease	The ethical issues linked with DNA profiling.

(f)	genes as sections of DNA molecules that determine inherited characteristics and that genes have different forms, called alleles, which are in pairs	
(g)	the following terms: gamete, chromosome, gene, allele, dominant, recessive, homozygous, heterozygous, genotype, phenotype, F1, F2, selfing	The terms gene and allele are <u>not</u> interchangeable.
(h)	single gene inheritance; be able to complete Punnett squares to show this; how to predict the outcomes of monohybrid crosses including ratios	
(i)	the fact that most phenotypic features are the result of multiple genes rather than single gene inheritance	
(j)	sex determination in humans: in human body cells, one of the pairs of chromosomes, XX or XY, carries the genes which determine sex, these separate and combine randomly at fertilisation	The use of Punnett squares to show the inheritance of sex chromosomes.
(k)	the artificial transfer of genes from one organism to another; the potential advantages, disadvantages and issues involved with this technology	Genetic modification includes that genes can be transferred from one species to another. Advantages would depend on the organisms in question, but may include disease resistance and increased yield. Disadvantages and issues may include effects on health and the environment.

2.4 VARIATION AND EVOLUTION

	Spec Statement	Comment
(a)	the variation in individuals of the same species having environmental or genetic causes; **variation being continuous or discontinuous**	The variation in height/length in organisms could be used to show that individuals of the same species are similar but they are never exactly the same. C**ontinuous and discontinuous variation should be illustrated graphically – bell shaped curve for continuous variation and discontinuous variation as discrete groups.**
(b)	sexual reproduction leading to offspring being genetically different from the parents, unlike asexual reproduction where genetically identical offspring called clones are produced from a single parent; sexual reproduction therefore giving rise to variation	In sexual reproduction - fertilisation produces a single cell with a new set of pairs of chromosomes. - this produces variation in the offspring i.e. offspring that are genetically different from the parents. In asexual reproduction a number of genetically identical offspring, clones, are produced from a single parent.
(c)	the facts that new genes result from changes, mutations, in existing genes; mutations occur at random; most mutations have no effect but some can be beneficial or harmful; mutation rates can be increased by ionising radiation	The greater the dose/exposure to ionising radiation the greater the chance of mutation. (No reference to specific ionising radiation is required.)
(d)	some mutations causing conditions which may be passed on in families, as is shown by the mechanism of inheritance of cystic fibrosis; the interpretation of family trees showing this; the issues surrounding the development and use of gene therapy in cystic fibrosis sufferers	Cystic fibrosis is an inherited disease that causes the production of thick mucus that blocks the bronchioles. It arises as a mutation and can be inherited as a recessive allele. The pattern of inheritance of this and other conditions in a family can be shown using family trees. Gene therapy has potential to treat this condition, but is not straightforward as the introduction of genes is not sufficient, they must be able to work within the body. There are also difficulties in targeting the appropriate cells and it is not a cure for the underlying condition. The genes can be introduced into the lung tissue via an inhaler.
(e)	heritable variation as the basis of evolution	Individual organisms in a particular species may show a wide range of variation because of differences in their genes (heritable variation).

(f)	how individuals with characteristics adapted to their environment are more likely to survive and breed successfully; the use and limitations of a model to illustrate the effect of camouflage colouring in predator and prey relationships	Modelling, such as picking up different coloured cards from a suitable 'camouflage' background, may be used to illustrate the effect of camouflage colouring in prey and predator relationships. This has limitations as it cannot exactly reproduce the situation.
(g)	how the genes which have enabled these better adapted individuals to survive are then passed on to the next generation; natural selection as proposed by Alfred Russell Wallace and Charles Darwin; how the process of natural selection is sometimes too slow for organisms to adapt to new environmental conditions and so organisms may become extinct	The term natural selection should be understood. The term 'Survival of the fittest' should only be used with care as it must be qualified in the context of breeding i.e. survival of the fittest to breed. An understanding that Wallace and Darwin were both working on the ideas of evolution and natural selection at around the same time.
(h)	how evolution is ongoing as illustrated by antibiotic resistance in bacteria, pesticide resistance and warfarin resistance in rats	
(i)	the potential importance for medicine of our increasing understanding of the human genome	An understanding that the human genome is important because it uses information from DNA to develop new ways to treat, cure, or even prevent disease.

SPECIFIED PRACTICAL WORK

- Investigation into variation in organisms

Investigation into variation in organisms

Introduction

Snails of two closely related species of *Cepaea* are common in woodland and grassland in Britain. They show a pattern of variation known as polymorphism. This means that there are several different 'types'. The shell may be either yellow or pink/brown, and it may have dark stripes or be plain.

The four types of the snails are as follows:



- Pink/brown, plain
- Yellow, plain
- Pink/brown, striped
- Yellow striped

In this investigation photographs of snails from each area, woodland and grassland will be categorised and counted to determine which variations of snails are most common in each area.

Apparatus

Images of snails (attached)

Method

1. Arrange the photographs of the woodland snails face down and randomly select 50.
2. Categorise the snails selected into one of the 4 different variants and count the number of each.
3. Repeat steps 1- 2 for the grassland snails.

Analysis

1. Draw a bar chart of your results.
2. Analyse your results to reach a conclusion on the effect of habitat on the variation of snails.

Teacher/Technician notes

The photographs of snails need to be copied in colour and in sufficient quantities so that each group is able to collect 50 snails from each habitat, woodland and grassland.

Students should devise a tally chart to record data collected and calculation of the % of each type of snail should also be encouraged.

Snail Type	Woodland		Grassland	
	Numbers	%	Numbers	%
Plain yellow				
Striped yellow				
Plain pink				
Striped pink				

Further discussions could take place on evaluating the difference between this investigation and the reality of sampling snails in their environment, including the concept of sample size and the possible implications of some snails having better camouflage than others.

Working scientifically skills covered

2. Experimental skills and strategies

Recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative

Make and record observations and measurements using a range of apparatus and methods.

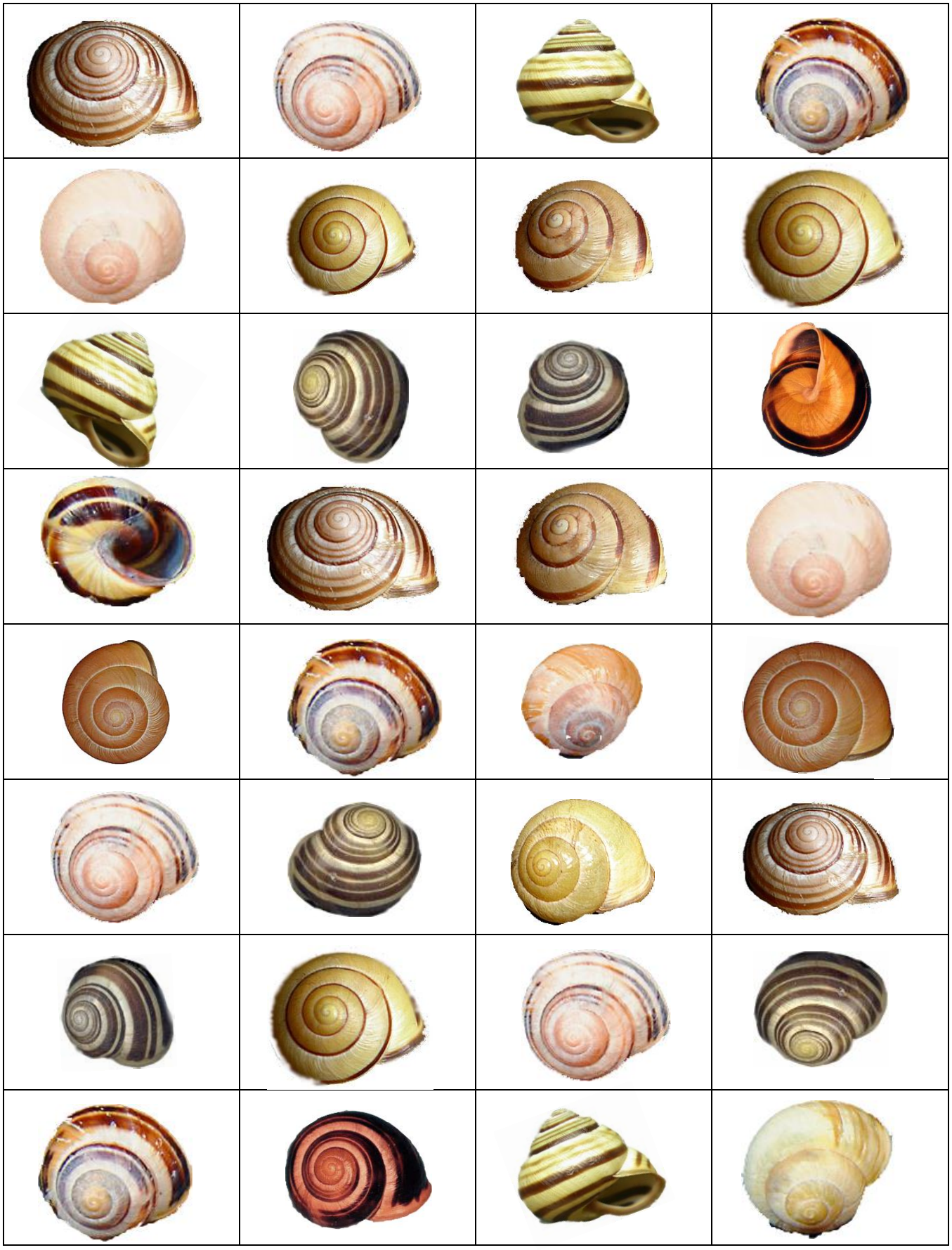
3. Analysis and Evaluation

Presenting observations and other data using appropriate methods

Translating data from one form to another.

Carrying out and representing mathematical analysis.
Interpreting observations and other data, including patterns and trends, making inferences and drawing conclusions

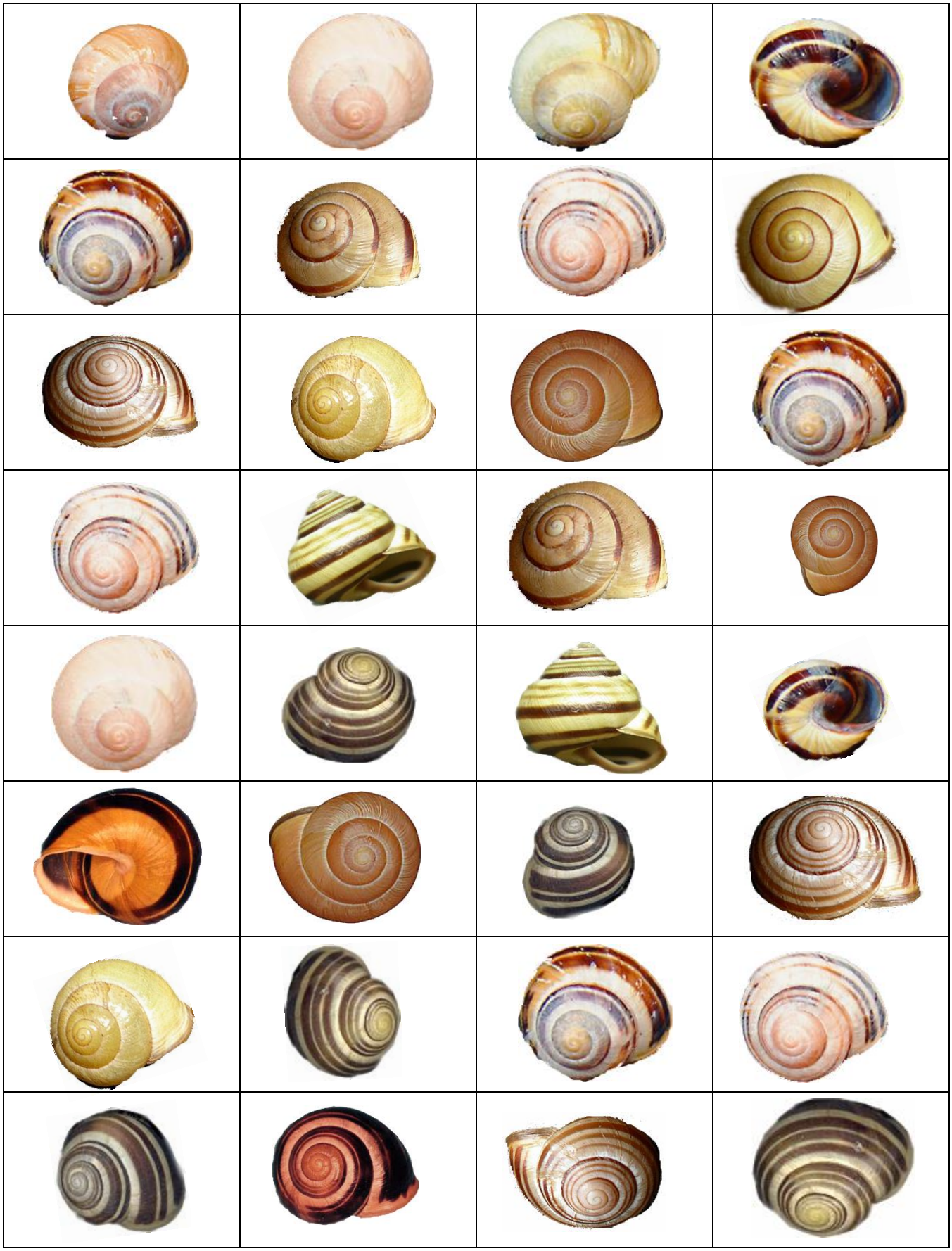
Woodland snails 1



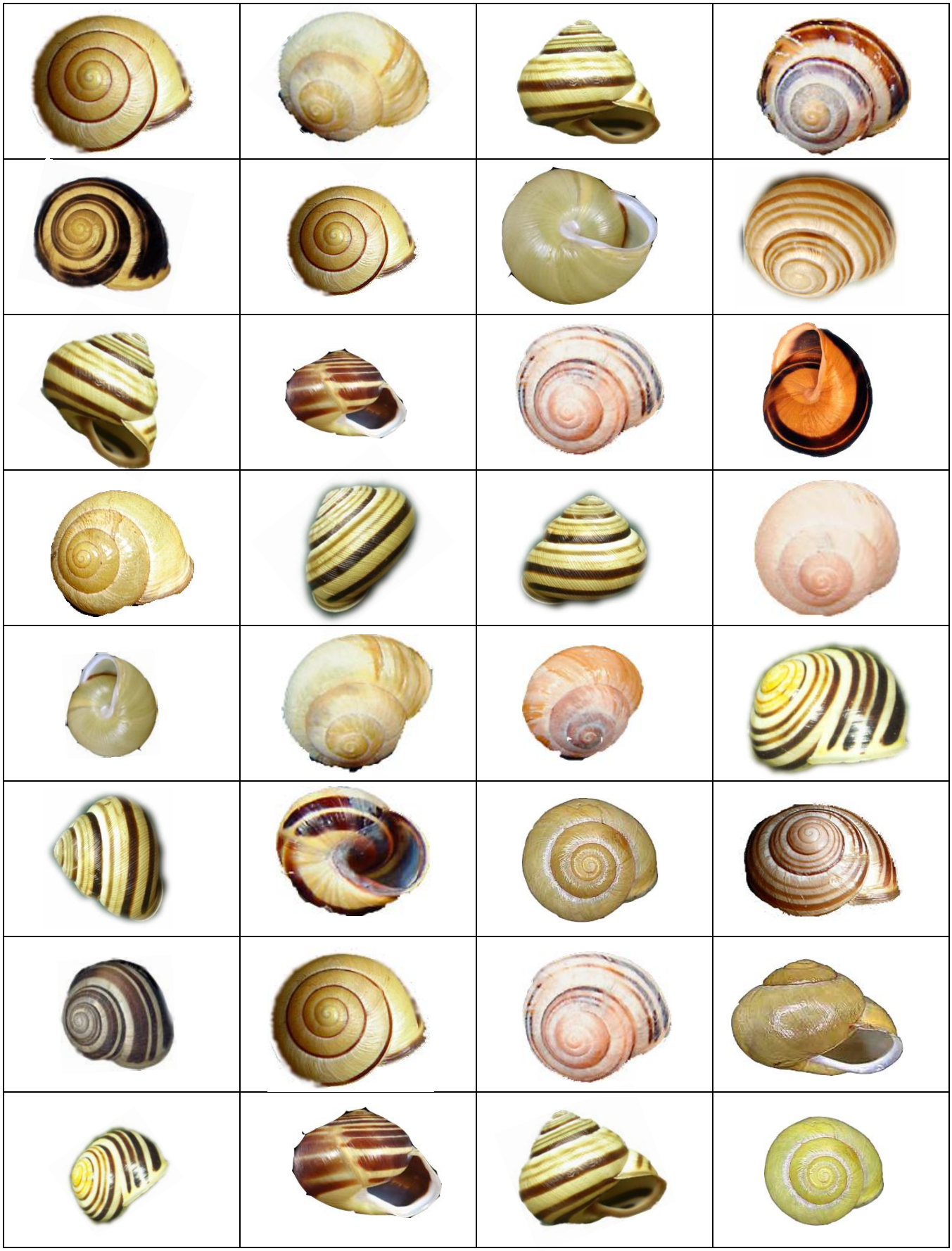
Woodland snails 2



Woodland snails 3



Grassland snails 1



Grassland snails 2



Grassland snails 3



2.5 RESPONSE AND REGULATION

	Spec Statement	Comment
(a)	sense organs as groups of receptor cells which respond to specific stimuli: light, sound, touch, temperature, chemicals and then relay this information as electrical impulses along neurones to the central nervous system	
(b)	the brain, spinal cord and nerves forming the nervous system; the central nervous system consisting of the brain and spinal cord	
(c)	the properties of reflex actions: fast, automatic and some are protective, as exemplified by the withdrawal reflex, blinking and pupil size	
(d)	**the components of a reflex arc: stimulus, receptor, coordinator and effector; be able to label a diagram of a reflex arc to show: receptor, sensory neurone, relay neurone in spinal cord, motor neurone, effector and synapses**	**Candidates need to be able to indicate, on a diagram of a reflex arc, the direction of travel of the impulse.**
(e)	the structure and function of the following parts of the eye: sclera, cornea, pupil, iris, lens, choroid, retina, blind spot and optic nerve and be able to label these on a diagram	The functions include: sclera – protective, tough white outer coat cornea – clear part of sclera allows light to enter and refracts light entering pupil – hole in centre of iris which allows light to enter iris – muscles that alter size of pupil to control amount of light entering lens – changes shape to focus light onto retina choroid – a pigmented layer which absorbs light to prevent reflection, also contains blood vessels retina – light sensitive layer, an image is formed here, impulses sent to optic nerve blind spot – where the optic nerve leaves the eye, there are no light sensitive cells here optic nerve – carries impulses from retina to brain

(f)	the reasons why animals need to regulate the conditions inside their bodies to keep them relatively constant and protected from harmful effects – homeostasis	Metabolism operates only within a narrow range of temperature and pH and requires appropriate nutrients and water.
(g)	hormones as chemical messengers, carried by the blood, which control many body functions	
(h)	the need to keep glucose levels within a constant range, so that when the blood glucose level rises, the pancreas releases the hormone insulin, a protein, into the blood, which causes the liver to reduce the glucose level by converting glucose to insoluble glycogen and then storing it	
(i)	diabetes as a common disease in which a person has a high blood glucose level; type 1 diabetes caused by the body not producing insulin; type 2 diabetes caused by the body cells not properly responding to the insulin that is produced; the causes of both types of diabetes; treatments for diabetes	The detection of glucose in urine is a symptom of diabetes. Candidates should test artificially prepared urine samples for the presence of glucose using Benedict's solution. The methods of treating diabetes include regularly injecting insulin, a low sugar and low carbohydrate diet and possible transplant of pancreatic tissue.
(j)	the structure of a section through the skin: hair, erector muscle, sweat gland, sweat duct, sweat pore, blood vessels; be able to label these structures on a diagram	
(k)	the role of these structures in temperature regulation: change in diameter of blood vessels, sweating, erection of hairs; shivering as a means of generating heat	
(l)	**the principles of negative feedback mechanisms to maintain optimum conditions inside the body as illustrated by the control of glucose levels by insulin and glucagon and by the control of body temperature**	**Any change from the balance in optimal internal conditions results in the body's hormonal and nervous systems compensating for the change and restoring the balance.**

(m)	the fact that some conditions are affected by lifestyle choices; the effects that alcohol and drug abuse have on the chemical processes in people's bodies; the incidence of diabetes (type 2) and the possible relationship with lifestyle	Alcohol changes various chemical processes in the body including reaction time. It may cause people to become dependent on, addicted to and suffer withdrawal symptoms without it. It can also cause long-term physical damage e.g. liver, circulatory and heart diseases. Some drugs are misused e.g. illegal drugs and these drugs affect people's bodies. The link between obesity and type 2 diabetes.
(n)	the positive response of plant shoots to light, phototropism, and plant roots to gravity, gravitropism; phototropism being due to a plant hormone, called auxin	Knowledge of negative responses or other plant hormones is not required.

SPECIFIED PRACTICAL WORK

- Investigation into factors affecting reaction time

Investigation into factors affecting reaction time

Introduction

If you notice a ball moving towards your head, the time it takes from when you first notice the ball to when your arm reaches up to catch it is an example of reaction time. Even though nervous impulses travel very quickly through your nervous system, your body doesn't react instantly. In this activity, you will conduct a simple, measurable experiment to study reaction time and investigate the hypothesis that reaction time improves with practice.

Apparatus

30 cm ruler

Diagram of Apparatus



Method

1. Ask your first volunteer to sit in the chair with good upright posture and eyes looking across the room.
2. Have the volunteer place their forearm (the part of the arm from elbow to hand) so it extends over the edge of the table.
3. Ask the volunteer to place their thumb and index (pointer) finger on either side of the bottom of the vertically placed ruler. The number “1” should be on the bottom, the “30” near the top.
4. Let your volunteer practice holding the ruler with those two fingers.
5. Now, ask your volunteer to remove their fingers from the ruler while you continue to hold it so that the bottom of the ruler is at a height of 2 cm above the fingers.
6. Tell your volunteer that you will release the ruler without warning. Their job will be to catch it with their thumb and forefinger as soon as they sense it dropping.
7. Drop the ruler. When your volunteer catches it, record the number on the ruler displayed just over the thumb. The lower the number, the faster the reaction time.
8. Conduct five trials with the same volunteer, dropping the ruler from 2 cm above their fingers each time.
9. Repeat the experiment with at least five other volunteers and record your results in a suitable table

Analysis

1. Use the conversion table below to convert the distance measured to a reaction time for each volunteer

Catch distance (cm)	Reaction time (milliseconds)	Catch distance (cm)	Reaction time (milliseconds)
1	50	16	180
2	60	17	190
3	701	18	190
4	80	19	200
5	90	20	200
6	100	21	210
7	120	22	210
8	130	23	220
9	140	24	220
10	140	25	230
11	150	26	230
12	160	27	230
13	160	28	240
14	170	29	240
15	170	30	250

2. Discuss the extent to which your results support the hypothesis.

Teacher / Technician notes

A possible alternative activity could be to compare the volunteer's dominant hand with their non-dominant hand.

Students should design their own table, but a suggested table format is shown below.

	Trial 1		Trial 2 etc	
Volunteer	Distance (cm)	Reaction time (ms)	Distance (cm)	Reaction time (ms)

Working scientifically skills covered

2. Experimental skills and strategies

Use scientific theories and explanations to develop hypotheses

Evaluate methods and suggest possible improvements and further investigations.

3. Analysis and Evaluation

Translate data from one form to another.

Interpret observations and other data, including patterns and trends, making inferences and drawing conclusions.

Present reasoned explanations including relating data to hypotheses.

Evaluate data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.

2.6 ROLE OF KIDNEY IN HOMEOSTASIS

	Spec Statement	Comment
(a)	the functions of the kidneys: to regulate the water content of the blood and remove waste products from the blood and why this is necessary	Excretion is the removal from the body of the waste products of metabolism.
(b)	the structure of the human excretory system to show kidneys, renal arteries, renal veins, aorta, vena cava, ureters, bladder, urethra; be able to label a diagram to show these and indicate the direction of blood flow in the blood vessels	
(c)	the structure of a section through a kidney to include: renal artery, renal vein, cortex, medulla, pelvis, ureter	
(d)	**the structure of a nephron and its associated blood supply to show: capillary knot, Bowman's capsule, tubule, collecting duct, capillary network, arteriole to and from capillary knot and be able to label these on a diagram**	The position of nephrons within the kidney.
(e)	**why the level of substances present in the filtrate changes as it passes through the kidney; the process of filtration under pressure; the selective reabsorption of glucose, some salts and much of the water**	**The significance of the difference in the diameter of the blood vessels entering and leaving the capillary knot in Bowman's capsule. Small molecules, including urea, glucose, salts and water are forced from capillary knot into the Bowman's capsule.**

(f)	the fact that the waste, a solution containing urea and excess salts called urine, passes from the kidneys in the ureters to the bladder where it is stored before being passed out of the body; the presence of blood or cells in the urine indicates disease in the kidney; the presence of glucose in the urine can indicate diabetes	
(g)	how the kidneys regulate the water content of the blood: producing dilute urine if there is too much water in the blood or concentrated urine if there is a shortage of water in the blood; **the role of anti-diuretic hormone (ADH)**	**The concentration of blood is monitored by the brain. As the water level in the blood decreases, there is an increase in the secretion of ADH which causes the kidney to reabsorb more water. This results in the urine becoming more concentrated.**
(h)	the fact that dialysis can be used to treat kidney failure; **how a dialysis machine works**	Treatment by dialysis restores the concentration of dissolved substances in the blood to normal levels**. The principles of the structure and functioning of a dialysis machine and why dialysis fluid must contain the same concentration of glucose and salts as blood plasma. The significance of a counter-current system in a dialysis machine which ensures that a diffusion gradient for urea is always maintained.**
(i)	the fact that a diseased kidney may be replaced by a healthy one by transplant from a donor of a similar 'tissue type' to the recipient; how the donor kidney may be rejected by the body and attacked by the immune system, unless drugs are taken which suppress the immune response	Close family members are more likely to have similar tissue types to the recipient.
(j)	the advantages and disadvantages of the use of dialysis and transplants	An awareness of: kidney donor schemes, the problems of supply and demand of donated kidneys and dialysis machines.

SPECIFIED PRACTICAL WORK

- Test artificial urine samples for the presence of protein and glucose

Test artificial urine samples for the presence of protein and glucose

Introduction

The urine of a patient has been tested and found to contain both protein and glucose. The presence of protein could indicate damage to the kidney and the presence of glucose is an indicator of diabetes. However, the urine samples have become mixed up in the lab. It is important that the person is identified so that they can be treated. There are four people that it could be. Test the four samples of urine to identify the owner of the original sample.

Apparatus

3 test tubes
3 × 5 cm^3 syringe
1 × 10 cm^3 measuring cylinder
dropping bottle of biuret solution
dropping bottle of Benedict's reagent
4 × 30 cm^3 solutions of artificial urine – Samples A, B, C and D

Access to:

water bath set at 80 °C

Method

<u>To test for glucose</u>

1. Using a 10 cm^3 measuring cylinder, add 5 cm^3 of Sample **A** into a test tube
2. Add 5 cm^3 Benedict's reagent and heat in a water bath set at 80 °C
3. Observe and record any colour change
4. Repeat steps 1-3 with Samples **B, C** and **D**

<u>To test for protein</u>

1. Using a 10 cm^3 measuring cylinder, add 5 cm^3 of Sample **A** into a test tube
2. Using a syringe, add 2 cm^3 of Biuret solution
3. Shake the test tube gently
4. Observe and record any colour change
5. Repeat steps 1-4 with Samples **B, C** and **D**

Analysis

1. Conclude which sample is from the original patient.

Teacher / Technician notes

Risk Assessment

Hazard	Risk	Control measure
Biuret solution is an irritant	Biuret could get on to the skin when putting into the test tube	Wash hands immediately if Biuret gets on to them/ wear laboratory gloves
	Biuret could get transferred to the eyes from the hands	Wear eye protection
Hot water can scald	Contact with eye/skin when putting tubes in/out of water bath	Wear eye protection Use test tube holders to hold tubes far enough away from hands

Benedict's reagent and iodine solution are classed as low hazard by CLEAPSS at these concentrations.

The artificial urine samples should be produced so that

A: contains protein only (albumin powder could be used)

B: contains glucose only (glucose powder could be used)

C: contains neither protein or glucose

D: contains both protein and glucose

The samples could be coloured with iodine to make them more authentic looking / alternatively a tea bag could be used to colour the samples.

The volumes of biuret and Benedict's reagent are intended as a guide only and centres may wish to use volumes that have previously been optimised at the centre.

Benedict's reagent can be purchased from a laboratory supplier or can be made
1 dm^3 of Benedict's reagent contains:
100 g anhydrous sodium carbonate
173 g sodium citrate
17.3 g copper(II) sulphate pentahydrate

Protein
Biuret reagent can be purchased from a laboratory supplier or potassium hydroxide and dilute copper(II)sulphate solution can be used as an alternative.

Students should design their own table, but a suggested table format is shown below.

Sample	Biuret test observation	Protein present/ absent	Benedict's test observations	Glucose present/ absent
A				
B				
C				
D				

Working scientifically skills covered

1. **Development of scientific thinking**
   Explain every day and technological applications of science: evaluate associated personal, social, economic and environmental implications and make decisions based on the evaluation of evidence and arguments

2. **Experimental skills and strategies**
   Make and record observations and measurements using a range of apparatus and methods.

3. **Analysis and Evaluation**
   Presenting observations and other data using appropriate methods.

   Interpreting observations and other data, including patterns and trends, making inferences and drawing conclusions.

2.7 MICRO-ORGANISMS AND THEIR APPLICATIONS

Spec Statement		Comment
(a)	the safe use of basic aseptic techniques involved in inoculating, plating and incubating micro-organisms	• Bacteria and fungi can be grown on nutrient agar in a Petri dish, to produce an agar plate. • Petri dishes and nutrient agar should be sterilised before the agar is poured. • An inoculating loop is used to transfer bacteria and is sterilised before and after use by heating it to red heat in a Bunsen flame. • The Petri dish lid prevents micro-organisms from the air contaminating the culture and vice versa. • After inoculation the lid of the Petri dish should be secured in place by strips of adhesive tape for safety reasons • Inoculated agar plates are incubated at 25^0C in school laboratories, which encourages growth of the culture without growing pathogens • For safety reasons plates and equipment should be sterilised after use.
(b)	the link between the number of bacterial colonies on the agar and the number of bacteria in the original sample	One bacterium will give rise to one colony. However, inaccuracies in counting can be caused by the clumping of bacteria.
(c)	the effect of temperature on the growth of bacteria and understand its application in food storage	Refrigeration slows bacterial growth and freezing stops bacterial growth.
(d)	the factors which influence its growth of the fungus *Penicillium* when grown industrially in a fermenter; how the penicillin is extracted from the surrounding medium	In the production of penicillin, a starter culture of the fungus *Penicillium* is added to a liquid nutrient culture medium in a fermenter. In a fermenter, the supply of air, the temperature and pH can be controlled to enable maximum growth to take place. The organism grows and secretes the antibiotic into the surrounding medium. After incubation, the culture medium is filtered and the penicillin extracted.

SPECIFIED PRACTICAL WORK

- Investigation into the effect of antibiotics on bacterial growth

Investigation of the effect of antibiotics on bacterial growth

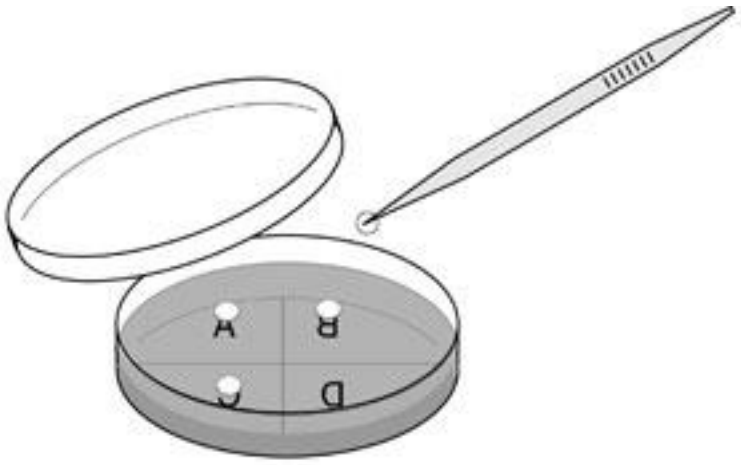
Introduction

Antimicrobials are agents that are able to kill bacteria or halt their growth. They are widely used in medicine to treat bacterial infections. In this experiment you will test different anti-microbial agents to assess how they affect bacterial growth.

Apparatus

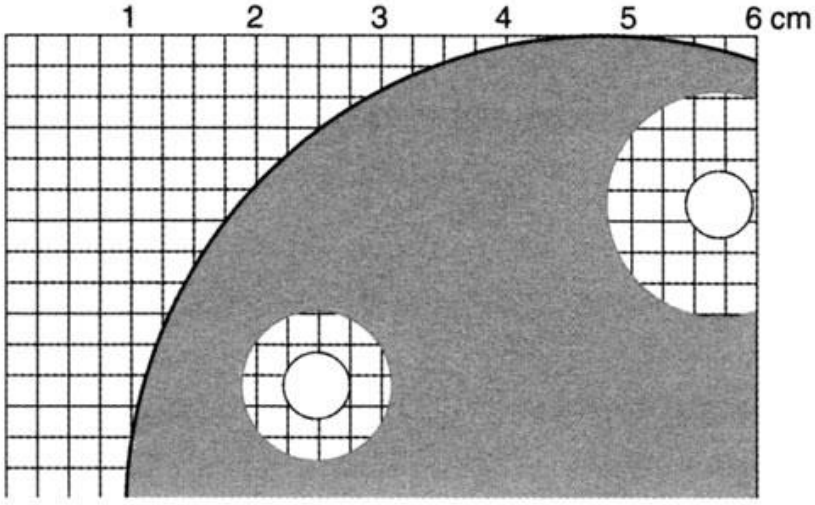
Bunsen burner
1 × pre-prepared agar plate seeded with bacteria
4 × antimicrobial agents, labelled A, B, C and D
4-8 × paper discs (Whatman antibiotic assay paper discs/ or new filter/ chromatography paper cut with a hole punch then sterilised by autoclaving)
sterile forceps
adhesive tape
marker pen
disinfectant solution and cloth

Diagram of Apparatus



Method

1. Wash your hands with the soap or handwash. Wipe down the working area thoroughly with the disinfectant.
2. Work very close to a lit Bunsen burner. Flame the forceps and use them to pick up a filter paper disc and dip the disc into antibiotic A.
3. Allow them to dry for 5 minutes on an open, sterile Petri dish, next to a lit Bunsen burner.
4. Repeat step 3 for antibiotics B, C and D.
5. Use the agar plate that has already been prepared and seeded with bacteria.
6. Turn the dish upside down. Divide the base into four sections by drawing a cross with the marker pen. Label the sections A, B, C, D
7. Flame the forceps and then use them to pick up antibiotic disc **A**. Raise the lid of the Petri dish at an angle and place the disc onto the agar in the centre of section A.
8. Repeat step 5 for the other 3 discs. Make sure the discs are placed in the centre of each section.
9. Label the agar plate with your name and date. Tape the lid securely. Incubate inverted for 2-3 days at 20-25 °C.
10. Observe the plates without opening them.
11. Record the width of the clear zone around each antimicrobial. A piece of squared paper under the agar plate might be helpful here.



Analysis

1. Which antimicrobial agent was the most efficient in your investigation? Give reasons for your answer.

Teacher / Technician notes

Risk Assessment

Hazard	Risk	Control measure
Bacteria can be pathogenic	Contracting infection from touching bacteria on open plate	Wash hands after placing discs Seal plate after placing discs
Bunsen burner flame and Forceps can burn	Burning skin when sterilising forceps	Care must be taken to keep hands a safe distance away from the flame. Do not touch tip of forceps after flaming

Detailed instructions are given on the link below.
http://www.nuffieldfoundation.org/practical-biology/investigating-anti-microbial-action

Making agar and pouring plates

a Calculate the quantity required and prepare just enough agar for the investigation – around 15 cm^3 for normal depth in a 90 mm Petri dish. Any surplus will keep for 6-12 months in tightly-sealed screw-top bottles if sterile.

b Weigh out the agar medium powder containing the gel and chosen nutrients, add water and sterilise the mixture for the time, and at the temperature, specified by the manufacturer.

c Heat agar and water at 95 °C to dissolve the agar. Always use a water bath to boil agar, and never add agar to boiling water.

d Stopper flasks with a well-fitting plug of non-absorbent cotton wool. Cover with greaseproof paper or aluminium foil before sterilising by autoclaving.

e After autoclaving, transfer to a water bath to equilibrate at 50 °C. Stack plates after pouring to minimise condensation except in the top plate(s).

f Warm the Petri dishes before pouring to minimise condensation.

g Keep poured plates in a sealed plastic bag until needed to reduce dehydration of the media.

Making a spread plate

1 Sterile spreaders are used to distribute inoculum of *Bacillus subtilis* over the surface of prepared agar plates. You can sterilise a wrapped glass spreader in a hot air oven or sterilise by flaming with alcohol.

2 To flame a spreader with alcohol:

a Dip the lower end of the spreader into a small volume of alcohol (70% IDA) contained in a vessel with a lid (either a screw cap or aluminium foil) or in a glass (not plastic) Petri dish with a lid. Keep the alcohol container covered and 1 metre away from the Bunsen burner flame.

b Pass quickly through a Bunsen burner flame to ignite the alcohol. Ensure the spreader is pointing downwards when and after igniting the alcohol to avoid burning yourself.

c Remove the spreader from the flame and allow the alcohol to burn off. The burning alcohol will sterilise the glass.

d Do not put the spreader down on the bench.

3 Cotton wool swabs can be used instead of glass spreaders. They may be preferable as they avoid the need for using alcohol as a sterilising agent. Prepare them by rolling small pieces of absorbent cotton wool around one end of a cocktail stick. Wrap individually in aluminium foil or place inside a universal bottle to sterilise in an autoclave or pressure cooker. These sterile swabs can then be dipped into the solution or culture to be transferred, rubbed on the surface of the agar plate, and immediately disposed of into disinfectant. (Note: Cotton buds from a pharmacist are not sterile and may be impregnated with an antimicrobial agent.)

4 Use agar plates with a well-dried surface so that the inoculum dries quickly. Dry the surface of agar plates by incubating for several hours (perhaps overnight) or put them in a hot air oven (at 55-60 °C) for 30-60 minutes with the two halves separated and the inner surfaces directed downwards.

The antibiotics can be bought as ready made discs or solutions can be made from everyday ingredients. Many types of toothpaste contain low concentrations of anti-microbials, and mouthwashes claim plaque-killing potential.

The ten spices with the most potent antibacterial effects are garlic, onion, allspice, oregano, thyme, cinnamon, tarragon, cumin, cloves and lemon grass. Many spices with relatively weak antibacterial effects become much more potent when combined; examples are in chili powder (typically a mixture of red pepper, onion, paprika, garlic, cumin and oregano) and five-spice powder (pepper, cinnamon, anise, fennel and cloves). Lemon and lime juice, while weak inhibitors themselves, also have synergistic effects.

It is also possible to investigate different dilutions of a particular anti-microbial.

Students should be made aware of aseptic techniques before starting the practical activity. It is possible that students can prepare their own pour plates and inoculate them if you wish.

Working scientifically skills covered

1. Development of scientific thinking

Explain every day and technological applications of science: evaluate associated personal, social, economic and environmental implications and make decisions based on the evaluation of evidence and arguments

2. Experimental skills and strategies

Apply knowledge of a range of techniques, instruments, apparatus and materials to select those appropriate to the experiment.

Carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.

Make and record observations and measurements using a range of apparatus and methods.

3. Analysis and Evaluation

Presenting observations and other data using appropriate methods.

Interpreting observations and other data, including patterns and trends, making inferences and drawing conclusions.

2.8 DISEASE, DEFENCE AND TREATMENT

Spec Statement		Comment
(a)	the harmless nature of most micro-organisms, many performing vital functions; some micro-organisms called pathogens, cause disease	
(b)	the fact that pathogens include micro-organisms such as bacteria, viruses, protists and fungi; the basic structure of a bacterial cell and virus	Bacterial cells consist of a cell wall, cell membrane and cytoplasm, no distinct nucleus. Viruses consist of a number of genes surrounded by a protein coat.
(c)	the types of organisms which can cause communicable diseases: viruses, bacteria and fungi; the means by which they can be spread: by contact, aerosol, body fluids, water, insects, contaminated food	

(d)	the following diseases: HIV / AIDS, Chlamydia and Malaria, this should include the causative agent, the effect on the infected organism and how they can be prevented from spreading	**AIDS (Acquired Immune Deficency Syndrome)** is caused by HIV (Human Immunodeficiency Virus). The virus infects lymphocytes which are part of the body's immune system. Without immunity, the body can become infected with a variety of micro-organisms, e.g. tuberculosis or pneumonia. The virus is spread by blood to blood contact, especially during sexual intercourse. Methods of prevention include the use of condoms and disposable gloves should be used where there is any danger of contact with contaminated blood. Antiviral agents can be used, but they only prevent the multiplication of the virus inside cells and must be taken throughout life. **Chlamydia**, this is the most common sexually transmitted disease in Britain. It is caused by the bacterium *Chlamydia trachmatis* and is spread during sexual intercourse via the vagina and urethra. Its spread can be prevented by the use of condoms. It can be treated with antibiotics such as tetracycline or erythromycin. However, if left untreated, it could cause infertility in adults. It could also cause conjunctivitis in babies during the process of birth if the mother is infected. It can also spread to the babies lungs. **Malaria** - This kills over a million people in the world each year. It is caused by the single celled organism – *Plasmodium*. *Plasmodium* is spread via female mosquitoes of the genus *Anopheles*. *Anopheles* mosquitoes bite humans and inject *Plasmodium* into the blood stream. *Plasmodium* causes a fever when it destroys red blood cells in humans. Treatment consists of killing *Plasmodium* with anti-malarial drugs, such as paludrine or daraprim. A vaccine against *Plasmodium* has been developed. Prevention methods include: killing mosquitoes with insecticide, releasing large numbers of infertile male mosquitoes, biological control of mosquitoes, use of mosquito nets and repellents.
(e)	the means by which the body defends itself from disease: intact skin forming a barrier against micro-organisms; blood clots to seal wounds; phagocytes in the blood ingesting micro-organisms; lymphocytes producing antibodies and antitoxins	Blood clots seal wounds to prevent entry of microbes. White cells in the blood help to defend the body against microbes by • ingesting bacteria • producing antibodies which inactivate particular bacteria or viruses • producing antitoxins which counteract the toxins released by bacteria. The community of microorganisms on the skin, the skin flora, make it difficult for pathogens to become established.

(f)	an antigen as a molecule that is recognised by the immune system; foreign antigens triggering a response by lymphocytes, which secrete antibodies specific to the antigens; the function of antibodies	One type of white blood cell, called a lymphocyte, multiplies to form clones of cells. These secrete antibodies specific to the foreign antigen that is present. Antibodies eventually assist in the destruction of the cells bearing the foreign antigen.
(g)	how vaccination can be used to protect humans from infectious disease; the factors influencing parents in decisions about whether to have children vaccinated or not	Candidates should consider the consequences for individuals and society of when individuals decide not to be vaccinated. There should be an awareness of the influence of the media.
(h)	**the fact that a vaccine contains antigens derived from a disease-causing organism; how a vaccine will protect against infection by that organism, by stimulating the lymphocytes to produce antibodies to that antigen; how vaccines may be produced which protect against bacteria and viruses**	**Vaccines generally use 'non-active' microorganisms, antigens or parts of antigens to stimulate an immune response (the details of individual vaccines and the detail of vaccine production are not required).**
(i)	**how after an antigen has been encountered, memory cells remain in the body and antibodies are produced very quickly if the same antigen is encountered a second time; how this memory provides immunity following a natural infection and after vaccination; the highly specific nature of this response**	**The specific response is relatively slow if the body has not previously encountered the relevant antigen. However, antibodies are produced very quickly and in large numbers if the same antigen is encountered a second time.**

(j)	the fact that antibiotics, including penicillin, were originally medicines produced by living organisms, such as fungi; how antibiotics help to cure bacterial disease by killing the infecting bacteria or preventing their growth but do not kill viruses	Antibiotics are now often chemically modified and so are semi-synthetic or synthetic.
(k)	how some resistant bacteria, such as MRSA, can result from the over use of antibiotics; effective control measures for MRSA	Some bacteria have become resistant to antibiotics. The use of antibiotics in animal feed, in some countries, could be discussed as well as over-prescription for humans. MRSA control measures could include: • hand washing • thorough cleaning of hospital wards • use of alcohol gels • MRSA screening
(l)	how some conditions can be prevented by treatment with drugs or by other therapies	An understanding that some conditions can be prevented by good hygiene, clean water, improved diet, and vaccination. Some can be treated by drugs such as antibiotics. (No detail of individual diseases is required)
(m)	how new drug treatments may have side effects and that extensive, large scale, rigorous testing is required; the associated risks, benefits and ethical issues involved in the development of new drug treatments, including the use of animals for testing drugs and whether this is superseded by new technologies	All drugs may have side effects. New drugs, including medicinal drugs, may cause side effects that do not show up until lots of people use them.
(n)	the process of discovery and development of potential new medicines, including preclinical and clinical testing: preclinical stages involve testing on human cells grown in the laboratory, then on animals and finally a group of healthy volunteers, the new medicines are then taken for clinical testing using small groups of patients	The use of the terms blind, double blind and placebo in the context of drug development should be understood.

(o)	**how monoclonal antibodies are produced from activated lymphocytes which are able to divide continuously, this produces very large numbers of identical antibodies, specific to one antigen**	**B-lymphocytes are fused with tumour cells forming a hybridoma - this divides rapidly in laboratory conditions to form a clone. The hybridoma continuously produces specific antibodies called monoclonal antibodies.**
(p)	**the medical uses of monoclonal antibodies including:** **• diagnosis of diseases including Chlamydia and HIV** **• tissue typing for transplants** **• monitoring the spread of malaria** **• supporting chemotherapy for cancers**	**Immunoassays are used in the diagnosis of diseases caused by *Chlamydia trachmatis, HIV*, and *Plasmodium*. Labelled (via radioactivity or fluorescence) monoclonal antibodies are added to test samples of infected body fluids and attach to specific antigens. The extent of the infection is related to the extent of the labelling.** **Tissue typing for transplants - The concentration of non-self-antigens in tissues is assessed. Monoclonal antibodies can be used against helper T-cells (T-lymphocytes) so B-lymphocytes, normally causing rejection, are prevented from functioning.** **Monitoring the spread of malaria – blood is taken from samples of people (even if they do not show any malarial symptoms) and tested with labelled monoclonal antibodies. Monoclonal antibodies will detect the presence of *Plasmodium* in the bloodstream (even if they are dead - killed by anti-malarial drugs) as they have specific antigens and will attach to the labelled monoclonal antibodies. This enables the success of anti-malarial drugs and the potential spread of malaria to be monitored.** **The destruction of cancer cells can be targeted with the use of monoclonal antibodies. Some types of cancer cells have specific antigens called tumour markers. Monoclonal antibodies can be produced that act against tumour markers. If these are attached to anti-cancer drugs, they will deliver the drug directly to the cancer cells.**