Answers to Cambridge IGCSE Biology Laboratory Practical Book

Experimental skills and abilities

Skills for scientific enquiry

1 **(a)** measuring cylinder
(b) digital balance
(c) metre ruler
(d) liquid in glass thermometer
(e) stopwatch
(f) digital timer
(g) ruler

2 **(a)** Time at least 10 oscillations with a stopwatch and divide the result by 10 to obtain the average time for one oscillation.
(b) Weigh at least 20 pins on a balance and divide the result by 20 to obtain the average mass of one pin.

3

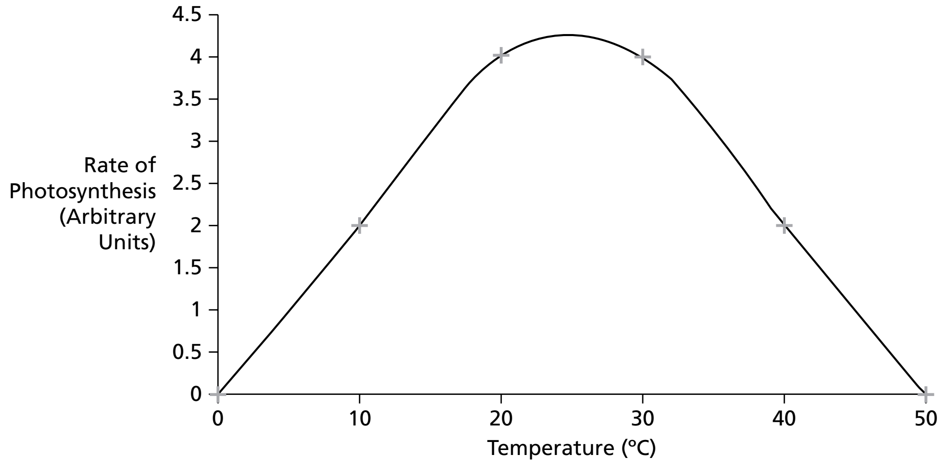
Device	Smallest division of scale
metre ruler	1 mm
vernier scale	0.1 mm
stopwatch	0.5 s
digital timer	1 ms
digital balance	typically 1 g or 0.1 g
liquid in glass thermometer	1.0 °C
100 ml measuring cylinder	1 cm^3

4 **(a)** 9.75 **(b)** 9.8 **(c)** 10

5 **(a)** **(i)** Rate of Photosynthesis, and temperature.
(ii) light intensity, colour of light, carbon dioxide concentration
(iii)

Manipulated variable	Fixed variable	Responding variable
temperature	light intensity, colour of light carbon dioxide concentration	rate of photosynthesis

(b)



(c) An increase in temperature will result in an increase in the rate of photosynthesis, to a point. Then the rate of photosynthesis decreases with a further rise in temperature. These are results from one small school experiment. Many more experiments would need to be carried out to draw more general conclusions.

1 Characteristics and classification of living organisms

1.1 Dichotomous keys

Method

1 Each stage of a dichotomous key presents the reader with *two* choices.

2 In order to produce an effective dichotomous key it is important to identify the *similarities* and *differences* between organisms, so that they can be placed into groups.

Results

Students' own keys.

Conclusions

Students' own conclusions on the effectiveness of their key.

Evaluation

Suggestions will depend on the individual key.

Extension

Students' own keys.

2 Organisation and maintenance of the organism

2.1 Plant cells

Method

1 Care had to be taken when using iodine because it is harmful if breathed in or if it comes into contact with the skin or eyes.
2 Iodine was used because it can help make cell structures more visible under a light microscope.
3 In order to view the plant cells clearly, the magnification needs to be approximately ×100.

Results

Students' own drawings.

Conclusions

The parts of the plant cells that are clearly visible under the light microscope are the nucleus, cytoplasm, vacuole and cell wall.

Evaluation

Investigate more than one type of plant. Consider whether processing of results could have been improved, e.g. more precise diagrams.

Extension

1 Root hair cells have a large surface area for absorption. Xylem vessels are cylindrical, long and narrow, with strong, lignified walls. They are connected to each other to form a hollow tube. They are dead, so have no cytoplasm, and therefore hollow, allowing water to be transported easily.
2 Label upper and lower epidermis, palisade cells, mesophyll cells, stomata, xylem and phloem.

2.2 Animal cells

Method

1 Alcohol and disinfectant are used to ensure that *the microscope slide and cotton buds are disinfected*.
2 In order to view the cells clearly, the magnification needs to be *approximately ×300*.

Results

Students' own drawings.

Conclusions

The parts of animal cells that are clearly visible under the light microscope are the nucleus, cytoplasm and cell membrane.

Evaluation

Investigate more than one type of animal cell. Consider whether processing of results could have been improved, e.g. more precise diagrams.

Extension

Ciliated cells: The cilia project from the cells as microscopic hair-like projections, which act in a sweeping manner to move foreign bodies away.

Muscle cells: Elongated cells with a good supply of blood (blood vessels) and nerves to provide the raw materials and signals for muscle contraction.

Red blood cells: The biconcave disc shape is the result of a lack of nucleus. This increases the surface area for oxygen uptake.

White blood cells: The flexible cell membrane allows them to squeeze through capillary walls to sites of infection.

3 Movement in and out of cells

3.1 Osmosis and water flow

Method

The red dye ensures that the solution in the Visking tubing is clearly visible.

Results and calculations

Over the course of the experiment, the level of solution in the capillary tube will rise.

Conclusions

This rise demonstrates that there must be a net flow of water through the dialysis tubing into the sugar solution from the beaker of water. The water is moving into an area with fewer free water molecules.

Evaluation

Repeat the experiment to check the result. Investigate the effect of using a range of different concentrations of sugar solution. Include a control experiment where the tube only contains water, to make sure that water does not just tend to flow into the tube whatever the circumstances.

Extension

A more dilute solution would not produce such a sharp rise of liquid in the capillary tube.

3.2 Turgor in potato tissue

Method

Measuring the mass of the potato pieces could be considered as an alternative method to measuring the length.

Results and calculations

At the end of this experiment the potato tube in water should have increased in length. The tube in the sugar solution will shrink slightly, and feel less firm.

Conclusions

The potato cylinder in the water increased in length, as water diffused into the cells by osmosis. The sugar solution was more concentrated than the cell sap, so the potato in that solution lost water by osmosis and the length decreased.

Evaluation

Repeat the experiment three times and then calculate an average. Make sure all other variables that could affect the result (e.g. temperature) are controlled. Ensure that measurements are made as accurately as possible.

Extension

Collate the results from all of the different groups in the class and find the average.

3.3 Osmosis and turgor

Method

1 The Visking tubing containing sugar solution was left in the water for 45 minutes to allow sufficient time for diffusion of water to occur through the partially permeable membrane.
2 Visking tubing acts as a partially permeable membrane. Small particles (such as water) can pass through the pores in the membrane.

Results and calculations

The Visking tube will feel much firmer at the end of the experiment.

Conclusions

The net inflow of water into the Visking tubing, which has fewer free water molecules inside than outside, results in the tubing feeling much firmer than it did at the start of the experiment.

Evaluation

Repeat the experiment to check the result. Investigate the effect of using a range of different concentrations of sugar solution. Include a control experiment where the tube only contains water, to make sure that water does not just tend to flow into the tube whatever the circumstances.

Extension

Prediction based on scientific knowledge. Suitable experiment suggested highlighting requirement for a fair test.

3.4 Plasmolysis

Method

Refer to Page 34 of *Cambridge IGCSE Biology* (3rd edition, Mackean and Hayward, Hodder Education).

Results and calculations

After the cells are exposed to the sugar solution, the vacuoles will shrink resulting in the cytoplasm being pulled away from the cell walls, leaving clear spaces.

Conclusions

The vacuoles lose water by osmosis to the sugar solution, so they shrink and pull the cytoplasm inwards. The cells are then said to be plasmolysed.

Evaluation

Repeat the experiment to investigate the effects of different concentrations of sugar solution. Repeat the experiment using cells from different types of plant. Consider whether processing of results could have been improved, e.g. more precise diagrams.

Extension

A more concentrated sugar solution would result in more rapid or more extensive plasmolysis.

3.5 Partial permeability (dialysis)

Method

Rinsing removes any traces of starch on the outside of the Visking tubing.

Results and calculations

The solution in the test tube should remain yellow-brown, but the starch solution inside the Visking tube should turn blue-black.

Conclusions

This demonstrates that the smaller iodine molecules can diffuse through the tubing, but the larger starch molecules cannot.

Evaluation

Repeat the experiment to check the result. Carry out a control experiment with water inside the Visking tubing instead of starch solution. Consider the implications of subjectivity when measuring colour changes – could a colorimeter be used to provide quantitative readings?

Extension

1 Smaller sugar molecules would not produce the same effect, as they would diffuse out of the Visking tubing and be found in both areas. Sugar can be identified using the Benedict's test.

2 Larger protein molecules would not be able to diffuse out and would give similar results to the starch. Protein could be identified using the Biuret test.

4 Biological molecules

4.1 Food tests

Method

Some of the identified safety precautions could include:

- Test for starch: Care must be taken when heating the solution. If using a Bunsen, heat gently and move in and out of flame to avoid the liquid boiling and spitting out of tube. Avoid direct contact with iodine, wear eye protection.
- Test for reducing sugar: Care must be taken with boiling water to avoid spillages. Avoid direct contact with Benedict's reagent, wear eye protection.
- Test for protein: Sodium hydroxide is caustic, so avoid contact with the skin and eyes, wear eye protection. Avoid direct contact with copper sulfate solution.
- Test for fat: Ethanol is flammable so ensure that there are no naked flames or sources of ignition in the vicinity, wear eye protection.
- Test for vitamin C: Avoid direct contact with DCPIP, wear eye protection.

Results and conclusions

- Test for starch: Iodine turns from yellow-brown to blue-black.
- Test for reducing sugar: Benedict's solution turns from blue to green, then yellow, and finally to red.
- Test for protein: Solution turns from blue to purple.
- Test for fat: Cloudy white emulsion forms.
- Test for vitamin C: Solution turns from blue to colourless.

Evaluation

Repeat each experiment to check the results. Carry out control experiments to observe what happens when the test is negative. When measuring a change in colour, consider the implications of subjectivity. Consider using an instrument that could provide quantitative readings, e.g. a colorimeter.

Extension

Possible answers could include:

Protein – beans, eggs, fish, meat;

Fat – dairy products such as cheese and full-fat milk, red meat, oily fish;

Carbohydrate – fruit, vegetables, rice, pasta.

4.2 Application of the food tests

Method

See the answer provided for Experiment 4.1. Students should not ingest any of the samples tested in the classroom.

Results and conclusions

Milk: tests positive for protein and fat.

Potato: tests positive for starch.

Raisins: test positive for glucose.

Onion: tests positive for glucose.

Beans: test positive for starch and protein.

Evaluation

Carry out each test at least twice for each food to check the results. Test a wider range of different foods. When measuring a change in colour, consider the implications of subjectivity. Consider using an instrument that could provide quantitative readings, e.g. a colorimeter.

Extension

A range of fruit and vegetable juices can be selected. Similar volumes should be prepared in test tubes and tested using the vitamin C test.

5 Enzymes

5.1 Extracting and testing an enzyme

Method

1 The liver was ground up to release *catalase (enzyme)* from the *cytoplasm* of the liver cells.
2 Hydrogen peroxide is broken down into *water* and *oxygen*, which causes the effervescence.

Results and calculations

There will be a reaction (effervescence) in test tube A but no reaction in test tube B.

Conclusions

The liver contains an enzyme that breaks down hydrogen peroxide into water and oxygen. There is no reaction with the boiled enzyme as the protein structure will have been denatured.

Evaluation

Repeat the same experiment to check the result. Repeat the experiment using a different enzyme to see if the same thing happens.

Extension

Students should acknowledge that they will need to observe, measure, graph and calculate the amount of product (oxygen) produced over time.

5.2 The effect of temperature on an enzyme reaction

Method

1 The enzyme amylase catalyses the breakdown of starch into *sugars*.
2 In this investigation the iodine turned from *blue-black* to *brown* as starch was broken down by amylase.

Results and calculations

The colour change will happen more rapidly as the temperature increases. The enzyme will be most active at 35 °C.

Conclusions

1 Increases in temperature increased enzyme activity.
2 The amylase in warmer water broke down the starch more rapidly.
3 35 °C is closer to the enzyme's optimum temperature. At this temperature the molecules have more energy and can react more quickly.

Evaluation

The investigation can easily be expanded to cover a wider and more precise temperature range, in order to observe effects of hotter temperatures.

Extension

Dough mixtures placed in beakers in a range of temperature conditions. The increase in the size of the dough may be taken as an indication of yeast activity.

5.3 The effect of pH on an enzyme reaction

Method

1 The pipette was rinsed between taking samples in order to prevent *contamination*.

2 It was important to note the time at which the samples no longer produced a blue colour with iodine because this signified that all of the starch in that sample had been broken down into *sugar* by the enzyme *amylase*.

Results and calculations

The amylase in the neutral or slightly acidic solution should give the fastest colour change.

Conclusions

The amylase in the neutral solution or in the slightly acidic solution broke down the starch most rapidly. The amylase in the alkaline and more strongly acidic solutions worked more slowly. A neutral or slightly acidic pH is closest to the enzyme's optimum pH (around pH 6.8).

Evaluation

Repeat the experiment three times and then calculate an average. Make sure the temperature is kept exactly the same, so this can't affect the experiment. Investigate a wider range of pH values. Investigate another type of enzyme. Consider the implications of subjectivity when measuring a change in colour. Could an instrument be used to provide quantitative readings, e.g. a colorimeter?

Extension

The pH of the stomach is very different to the optimum pH of salivary amylase, so the activity of amylase will be considerably reduced.

6 Plant nutrition

6.1 Is chlorophyll necessary for photosynthesis?

Method

1 Chlorophyll is removed from the leaf to ensure that iodine can be used to test for starch effectively.
2 The leaf is placed into hot water to ensure that the membranes are destroyed, making the leaf more permeable to iodine solution.

Results and calculations

Only the parts of the variegated leaf that were green will turn blue with iodine.

Conclusions

The part of the variegated leaf where chlorophyll was present will test positive for starch. The parts containing no chlorophyll could not make starch because they were not able to carry out photosynthesis.

Evaluation

Repeat the experiment to check the result. Consider whether processing of results could have been improved, e.g. more precise diagrams. Repeat the experiment with another type of variegated plant to see if the result is the same.

Extension

1 If part of a leaf on a plant was masked with foil, light could not reach the chlorophyll and so photosynthesis would not take place. Starch would not be formed in the covered area.
2 See Experiment 6.2.

6.2 Is light necessary for photosynthesis?

Method

1 The foil blocks out the light and is easy to cut and attach to the leaf.
2 The plant could be kept in air containing no carbon dioxide for 2–3 days (e.g. by using soda lime).

Results and calculations

Only the areas that received light turn blue-black with iodine. On the areas that were covered, the iodine remains yellow-brown.

Conclusions

The absence of the light energy required to drive photosynthesis results in no starch being produced in that particular part of the leaf.

Evaluation

Carry out a control experiment using a transparent material to cover the leaf. Repeat the experiment using different shapes cut into the foil to check the result. Repeat the investigation using a different type of plant to see if the result is the same.

Extension

Adding a control experiment, using a transparent material instead of foil, will demonstrate that the effect observed was due to the absence of light, not carbon dioxide.

6.3 Is carbon dioxide needed for photosynthesis?

Method

Soda lime absorbs carbon dioxide. As a result, the plant with soda lime present should not be producing starch by photosynthesis if carbon dioxide is needed for photosynthesis.

Results and calculations

The leaf from the plant with soda lime present does not turn blue-black when iodine is added. The leaf from the plant with sodium hydrogencarbonate solution does turn blue-black when iodine is added.

Conclusions

The leaf from the plant with a supply of carbon dioxide turned blue-black, indicating that starch was present, whereas the leaf from the plant that had no carbon dioxide contained no starch. This suggests that carbon dioxide is required for photosynthesis.

Evaluation

The experiment could be repeated to check the result. You could extend the investigation to test the effects of different concentrations of carbon dioxide on the rate of photosynthesis (see below).

Extension

Different masses of soda lime could be used to absorb varying amounts of carbon dioxide, and different concentrations of sodium hydrogencarbonate to produce different amounts of carbon dioxide. The rates of photosynthesis in each condition could then be compared to show the effect of the carbon dioxide level.

6.4 Is oxygen produced during photosynthesis?

Method

1 To allow carbon dioxide to diffuse freely from the water in the beaker to the pondweed.
2 The oxygen produced can be tested with a glowing splint – which should relight.

Results and calculations

Bubbles of gas are produced by the pondweed in sunlight (but not in the dark cupboard). The gas relights a glowing splint.

Conclusions

The pondweed left in sunlight produced oxygen gas, showing that oxygen is produced during photosynthesis.

Evaluation

Repeat the experiment to check the result. Repeat the investigation using different types of plants to see whether they all produce oxygen. Consider all other variables that might need to be controlled.

Extension

1 All other variables, other than light level, were kept constant, showing that the difference must be due to the difference in light availability.
2 The oxygen content of ponds will likely be affected by mass of plants, mass of animals such as fish, temperature, eutrophication and amount of decay.

6.5 The effect of light intensity on the rate of photosynthesis

Method

Sodium hydrogencarbonate helps to provide a rich supply of carbon dioxide for the plant.

Results and calculations

Higher light intensities (light placed closer to the pondweed) should, to a point, result in more bubbles being produced.

Conclusions

The rate of photosynthesis as measured by oxygen production is higher at greater light intensities. This is because plant uses the light energy for photosynthesis.

Evaluation

Repeat the experiment three times and then calculate an average. Consider all other variables that might need to be controlled, e.g. temperature. Increase the measurement range by investigating a wider range of light intensities.

Extension

The procedure would be similar to that of this experiment – but this time the temperature of water would be varied, instead of light intensity.

6.6 Gaseous exchange during photosynthesis

Method

In the presence of carbon dioxide (increased acidity) the indicator should turn yellow. In the absence of carbon dioxide (decreased acidity) it should turn red or purple.

Results and calculations

Hydrogencarbonate indicator in tube 1 should turn yellow. In tube 2, the indicator should turn deep purple. In tube 3, there should be no colour change.

Conclusions

In tube 1 carbon dioxide is produced by respiring cells, but there is no photosynthesis to use it up as the tube is in darkness. In tube 2 carbon dioxide is used up during photosynthesis. In tube 3 there is no leaf so the level does not change.

Evaluation

Repeat the experiment to check the result. Consider the implications of subjectivity when measuring colour changes – could a colorimeter be used to provide quantitative readings?

6.7 The importance of different mineral elements

Method

Distilled water does not contain any minerals or nutrients that could affect the experiment.

Results and calculations

The plant in the normal culture solution should be taller with large green leaves. The other plants will be smaller, with pale or yellow leaves.

Conclusions

A full range of nutrients is required for healthy growth.

Evaluation

Several seedlings could be grown in each of the conditions, rather than just one. Different plant species could be investigated, rather than just wheat (which might not be typical of all plants). You should make sure that the seedlings have exactly the same conditions apart from the culture solution (amount of light, temperature, etc.).

Extension

1 Repeat the same experiment, but instead of using different culture solutions, different types of fertiliser should be used.

2 Refer to Figure 16.31 on Page 277 of *Cambridge IGCSE Biology* (3rd edition, Mackean and Hayward, Hodder Education).

7 Human nutrition

7.1 Energy from food

Method

1 If the flame in the crucible goes out before the food sample is fully burnt, then it is important to remove the crucible from under the beaker before the sample is relit. It should then be replaced immediately.
2 Ensure the area being used for the investigation is kept clear of any flammable or combustible materials. Avoid direct contact with the equipment until it is cooled, to avoid burns. Wear eye protection and tie back long hair.

Results and calculations

The lower starting temperature should be subtracted from the higher temperature after the water is heated by the burning sugar to give the temperature change. This is multiplied by 420 to find the energy transfer.

Conclusions

The burning food will increase the temperature of the water. Some of the chemical energy stored in the sugar is transferred to heat energy and used to raise the temperature of the water.

Evaluation

Repeat the experiment three times and then calculate an average. Consider how to minimise heat loss from the equipment, e.g. protect the apparatus from draughts. Ensure that measurements are made as accurately as possible, e.g. by using a digital thermometer. Compare the energy transferred by a range of different foods.

Extension

1 Fat would transfer more energy than sugar; protein would transfer a similar amount of energy to sugar.
2 Secondary sources could be used to check answers and help to provide a list of foods rich in sugar; fat; protein.
3 Students could be encouraged to plot an appropriate graph of the energy content of various foods using secondary sources of information as a reference.

8 Transport in plants

8.1 Transport in vascular bundles

Method

The **longer** the stem of celery is left in the solution, the **further/higher** the solution travels up the stem.

Results and calculations

The blue dye should be seen in the leaf veins.

Conclusions

The dye and water travel up through the stem in the vascular bundles.

Evaluation

Repeat the experiment to check the results. Carry out the same experiment using some different types of plants to check that the results don't just apply to celery.

Extension

An outline of this possible investigation could include preparing three twigs as follows: Shoot 1: Ring of bark to be removed (about 5mm wide, and 10 mm from the base); Shoot 2: Base covered in Vaseline; Shoot 3: To be left untreated. All three twigs placed in a beaker of water, ensuring the cut ring of bark is above the water line. Observations could then be noted.

8.2 Rates of water uptake in different conditions

Method

1. Humidity, moving air, temperature and light intensity are all factors that affect the rate of transpiration.
2. Using the procedure outlined in the 'Procedure' section, carry out the experiment under one particular condition (e.g. at a temperature of 10 °C). Then change this condition (e.g. increase the temperature to 30 °C) and carry out the experiment again. Make sure that all the other conditions mentioned above are kept the same.

Results and calculations

If investigating wind/air movement, an increase in air movement should increase the rate of water uptake.

If investigating light, an increase in light intensity should increase the rate of water uptake.

If investigating humidity, an increase in humidity should decrease the rate of water uptake.

If investigating temperature, an increase in temperature should increase the rate of water uptake (up to about 35 °C).

Conclusions

Wind: An increase in wind speed increases the movement of air and water away from the leaf surface. More water vapour then diffuses out, from an area of high concentration (inside the leaf) to an area of lower concentration (outside it). More water must then be taken up to replace that lost from the leaf.

Light: More stomata open as the light intensity increases (to allow gaseous exchange for photosynthesis), allowing more water to diffuse out of the leaf.

Humidity: High humidity levels outside the leaf mean there is less of a concentration difference between the inside and the outside of the leaf, and so diffusion of water vapour out happens more slowly.

Temperature: At higher temperatures the water evaporates from the leaf more quickly.

Evaluation

Repeat the experiment three times and then calculate an average. Make sure all other variables are carefully controlled. Increase the measurement range within test groups (e.g. investigate a wider range of temperatures).

Extension

See Method section above.

8.3 To find out which surface of a leaf loses more water vapour

Method

To ensure that water loss cannot happen through the cut stem, and therefore must be through the leaf.

Results and calculations

The leaf with neither surface treated with Vaseline® and that with just the upper surface treated are likely to show the most shrivelling.

Conclusions

This demonstrates that the lower surface of the leaf loses more water than the upper surface.

Evaluation

Deciding on the amount of shrivelling is a very subjective way to assess the results. Weighing the leaves (or plants) before and after the intervention could provide quantitative data on levels of water loss, which would be more accurate.

Extension

The mass of the plant (including pot and soil) could be measured over time at different light intensities.

9 Transport in animals

9.1 Physical activity and pulse rate

Method

1 See below.
2 An adequate risk assessment to ensure the suitability of the type of exercise and of the space/equipment used should be carried out. Suitable footwear should be worn. Any relevant medical conditions should be taken into account.
3 Use a digital pulse meter to measure the pulse rate.

Results and calculations

Pulse rate should increase to a point as the amount of exercise done increases.

Conclusions

Physical activity causes an increase in pulse rate. This is because the muscles require more energy, so the rate of respiration must increase in order to provide this energy. More oxygen and glucose (needed for respiration) must be supplied to the muscles by the blood.

Evaluation

Use a digital pulse meter to measure the pulse rate – this may give a more accurate measurement. Repeat the experiment three times and then calculate average values for your pulse rate after different amounts of exercise. Consider whether processing of results could have been improved, e.g. more accurate graph plotting.

Extension

Temperature, age, sex (gender), digestion (time since last meal), altitude, illness, hormones such as adrenaline, and drugs such as caffeine are some of the factors affecting pulse rate. Comparisons could be made between variations of the same factor, and average values calculated.

11 Gas exchange in humans

11.1 Oxygen in exhaled air

Method

1 See below.
2 This provides an opportunity for students to consider the benefits of an oxygen sensor linked to a computer.

Results and calculations

The candle will not burn as long in the jar of exhaled air compared to ordinary fresh air.

Conclusions

Burning requires oxygen. The candle will not burn as long in the jar of exhaled air because some of the oxygen in it has been used up.

Evaluation

Repeat the experiment three times and then calculate an average time for each jar. Ensure that all other variables that could affect the experiment (e.g. type and size of candle) are kept the same.

Extension

Physical exercise requires additional oxygen, so a possible prediction would be that the candle would burn for an even shorter time in air exhaled immediately after exercise. The planned experiment could be outlined as above, but allowing for quantitative comparisons to be made.

11.2 Carbon dioxide in exhaled air

Method

The lime water in tube A will bubble when breathing in, and the lime water in tube B will bubble when breathing out. Therefore, differences in the amount of carbon dioxide in inhaled and exhaled air can be observed.

Results and calculations

The lime water in tube B only turns milky.

Conclusions

This demonstrates that exhaled air contains more carbon dioxide than inhaled air. Carbon dioxide is produced as a waste product by respiration and exhaled.

Evaluation

Repeat the experiment to check the result. Extend the investigation by examining factors that affect the rate at which the lime water changes colour.

Extension

Level of activity might affect the rate at which the lime water changes colour. This could be investigated by repeating the experiment after exercise and comparing the rate of change in colour of the lime water.

11.3 Volume of air in the lungs

Method

1 When measuring tidal volume, silicon tubing should be placed at position *B* and when measuring vital capacity it should be placed at position *A*.
2 Volume of air is measured in cm^3 or ml.

Results and calculations

These will vary depending on the individual.

Conclusions

1 Result for vital capacity – result for tidal volume
2 During rest the smaller tidal volume is sufficient to provide oxygen for cellular respiration. During exercise more energy is needed so a larger volume of oxygen is required to provide this.

Evaluation

Repeat the experiment three times and then calculate an average value for each measurement. Extend the experiment by investigating the effect of exercise on the values recorded for each measurement.

Extension

Measure and compare the volume of air exchanged by the lungs during normal breathing with the volume exchanged following exercise. The rate of breathing could also be measured before and after exercise.

Exercise will increase both the rate and depth of breathing, to allow more oxygen to be taken in and more waste carbon dioxide to be removed.

12 Respiration

12.1 Using up oxygen during respiration

Method

1 *Soda lime* is used to absorb the carbon dioxide given out by the seedlings.
2 The beaker of water is used to keep the *temperature* of the tubes as constant as possible.

Results and calculations

The level of liquid goes up more with the germinating seedlings than with the dead seedlings. It may not move at all for the dead seedlings.

Conclusions

1 Respiration increased the level of liquid in the tube.
2 The germinating seedlings will be respiring, so they use up oxygen from the air. This draws up liquid from the capillary tube. The dead seedlings are not respiring and do not use up oxygen.

Evaluation

Repeat the experiment three times to check the result. The investigation could be repeated with the water bath at different temperatures to investigate the effect of temperature on respiration. The investigation could be repeated using different types of seeds, or seedlings at different stages of germination.

Extension

Opportunity for ICT data logging activity.

12.2 Releasing energy in respiration

Method

Wear eye protection when handling disinfectants, avoid sources of ignition, take care to avoid spillages. Wash hands after handling seeds. Ask teacher to provide you with a source of dead seeds.

Results and calculations

The temperature in the flask with germinating seeds will be 5–10 °C higher than that in the flask with dead seeds.

Conclusions

The temperature in the flask with germinating seeds will rise due to the release of energy during respiration.

Evaluation

Repeat the experiment three times and then calculate an average. Consider all other variables that could affect the temperature and make sure they are controlled. Ensure that measurements are made as accurately as possible, perhaps using a digital thermometer.

Extension

Bacteria and fungi on the surface of the seeds may increase temperature, due to energy released as they respire.

12.3 Anaerobic respiration in yeast

Method

1 The high temperature of the boiled water would have killed any microbes present, and reduced oxygen concentration.
2 The layer of paraffin acts as a barrier, keeping oxygen out of the solution.

Results and calculations

There will be evidence of fermentation taking place in the glucose-yeast mixture, in the form of bubbles being given off. The lime water will turn a milky colour.

Conclusions

The change of colour in the lime water is a positive test for carbon dioxide. This supports the word equation for anaerobic respiration provided in the 'Theory' section.

Evaluation

Carry out a control experiment using boiled (killed) yeast to show that the carbon dioxide is being produced by respiration and not some other process. Expand the investigation by measuring the amount of carbon dioxide produced by the yeast under different conditions.

Extension

1 Comparison with a boiled (killed) yeast and glucose solution would demonstrate that the carbon dioxide is produced by a living process.
2 Temperature, concentration of yeast and glucose, and pH are factors likely to affect production of carbon dioxide.

14 Co-ordination and response

14.1 Gravitropism in pea radicles

Method

A clinostat is a device that rotates the seedlings slowly.

Results and calculations

The pea radicles in the stationary jar will have grown vertically downwards. Those in the clinostat will continue to grow horizontally.

Conclusions

The pea radicles in the stationary jar grow downwards because they have responded to the stimulus of gravity. This is known as a positive geotropic response. It ensures the roots grow in the right direction: down into the ground.

The clinostat constantly rotates the radicles, and so the stimulus of gravity affects them equally on all sides. Hence they grow straight in a horizontal direction.

Evaluation

Repeat the experiment to check the results. Use more peas in each condition. Repeat the investigation using another type of seedlings to see if the results are similar.

Extension

The pea radicles are positively geotropic.

14.2 Phototropism in shoots

Method

The plant on the clinostat acts as the control, as each side of the shoot will be exposed to light equally.

Results and calculations

The stem of the stationary plant in the box will have grown towards the light (the stimulus). The plant on the clinostat will grow vertically upwards.

Conclusions

The clinostat rotates the plant so that light affects it equally on all sides. Therefore it grows straight up. The stationary plant grows towards the light, which allows it to maximise the amount of light reaching its leaves. This is considered to be a positive phototropic response.

Evaluation

Use a greater number of seedlings in each condition. Ensure that all other variables are kept constant (e.g. temperature, amount of water given, etc.).

Extension

Only a single plant was used, so you cannot be certain that the results apply to green plants generally. To increase confidence that these findings apply to green plants as a whole, a larger number of plants should be used, as well as plants from different species.

14.3 Region of response

Method

The regions of curvature in the horizontal seedlings can be compared with the regions of extension in the vertical seedlings.

Results and calculations

The ink marks will have become more widely spaced in the region of greatest extension. The radicles in dish B will also have curved downwards. The region of extension in the seedlings in dish A will correspond to the region of curvature in the dish B seedlings.

Conclusions

The response to the stimulus of gravity happens in the region of extension.

Evaluation

Use more than two seedlings in each condition. Repeat the investigation using another type of seedling to increase confidence that the results apply to plants generally.

Extension

The response to the stimulus of gravity takes place in the region of extension, but this does not mean that this is also the area that detects the stimulus.

16 Reproduction

16.1 Insect pollinated flowers

Method

Identify a range of insect pollinated plants within your local environment.

Results and calculations

Students should observe and label petals; stamens; filaments and anthers; carpels; style, stigma, ovary and ovules.

Conclusions

Some of the major differences are likely to include:

- Insect pollinated flowers are likely to contain large, bright petals, with scent and nectar.
- Pollen tends to be produced in smaller quantities in insect pollinated flowers and tends to be sticky.
- In wind pollinated flowers the anther and stigma often hang outside the flower. In insect pollinated flowers they are found inside the flower.
- The stigma is sticky in insect pollinated flowers, as opposed to the more feathery stigma of wind pollinated flowers.

16.2 The growth of pollen tubes

Method

1 Method 1: Refer to page 226 of *Cambridge IGCSE Biology* (3rd edition, Mackean and Hayward, Hodder Education), but ensure you refer to latest guidance from CLEAPSS.
Method 2: Suitable plants could include honeysuckle, crocus, evening primrose or chickweed.

2 This can be done by touching the anther (which should be open with pollen exposed) to the drop of solution on the microscope slide, or by scraping the anther with a mounted needle.

3 Students' own answers.

Results and calculations

The pollen grain and pollen tube should be visible under the microscope. Figure 16.16 on page 220 of *Cambridge IGCSE Biology* (3rd edition, Mackean and Hayward, Hodder Education) will give you an indication of the structures.

Conclusions

Pollen tubes have been observed growing from the pollen grains. This is an essential part of sexual reproduction in plants, as genetic material travels from the pollen grain through the pollen tube towards the ovary.

Evaluation

More than one species of flower could be examined in each method. Consider whether processing of results could have been improved, e.g. more precise diagrams.

Extension

Different rates of pollen tube growth may be observed in the different plants.

16.3 Germination: The need for water

Method

See below.

Results and calculations

Seeds in A will not germinate. Seeds in B will germinate normally. Seeds in C may start to germinate but will probably be stunted or have died.

Conclusions

Water is required for germination, although too much water may inhibit it by reducing oxygen availability.

Evaluation

Repeat the experiment to check the results. Consider all other variables that should be controlled, e.g. amount of light.

Extension

Aquatic plants are adapted to their environment, so the seeds would have likely germinated without any problems when completely covered with water (unlike terrestrial seeds, which are not adapted to a very wet environment).

16.4 Temperature and germination

Method

1 To ensure that light does not account for any differences in this investigation, the levels of light must be kept constant. This is done by placing all the seeds in the dark.

2 See below.

Results and calculations

The warmer conditions should result in seedlings being more advanced than those at lower temperatures.

Conclusions

Increasing the temperature increased the rate of development in the seeds. The enzymes needed for germination function more quickly at warmer temperatures.

Evaluation

Repeat the experiment to check the results. Carry out the same experiment but using seeds from other species of plants to see if the results are similar. Investigate a wider range of temperatures.

Extension

1 Repeat the experiment using exactly the same procedure but seeds from different plant species. The results will depend on which species are chosen.

2 Height of plants should be measured instead of time taken/number of seeds germinated. The seeds should be germinated at same time but in different conditions and left to grow over several weeks, to produce quantitative measurements of effect on height. The height should be measured at regular intervals. Factors that could affect growth include temperature, amount of light, amount of water, amount of carbon dioxide, nutrients provided, etc. All of these must be kept the same except for the one factor being investigated.

20 Biotechnology and genetic engineering

20.1 The effect of pectinase on fruit pulp

Method

1 Wear gloves and eye protection when handling the pectinase enzyme. Wipe up spillages immediately, rinsing cloth thoroughly. Do not allow spillages to dry up. Wash hands thoroughly after activity.

2 Encourage pupils to suggest a range of suitable temperatures to investigate. An appropriate table should be drawn in order to record results.

Results and calculations

Students own results.

Conclusions

1 Pectinase increased fruit juice production.

2 The pectinase catalysed the breakdown of pectin in the cell walls. This softened the fruit pulp and allowed more juice to be released.

Evaluation

Repeat the experiment three times and then calculate an average. Keep all other variables that could affect the experiment (e.g. temperature) constant.

Extension

This could be approached from a number of angles: the comparison of different biological washing powders or the factors that might affect the activity of a biological washing powder, such as temperature. The dependent variable could be the breakdown of a protein sample.

Practical Test past exam questions

1 **(a)** Appropriate, scientifically drawn diagram with indication of a number of layers (3 marks)
Correct labels for roots, shoots, skin, leaves (any three) (1 mark each)

(b) **(i)** Both similar shape; both have protective covering; both have shoots/buds (any one for 1 mark)
(ii) Accept any reasonable differences including: differences in colour, number of layers, location of buds (any two differences – 2 marks)

(c) **(i)** and **(ii)**

test	observations	
	S1	S2
starch	remains brown/ orange colour	changes to blue/ black colour

(award 1 mark for each correct observation)

(d) **(i)** Add 2–3 cm^3 Benedict's solution to sample
Heat in a water bath (around 70 °C)
Leave for 5–10 minutes and observe colour change
Allow 1 mark for water bath safety examples, such as: avoid splashes and spillages; ensure test-tubes are placed in a test-tube holder
Allow 1 mark for Benedict's safety examples, such as: wear safety goggles/eye protection; avoid splashes and spillages (4 marks in total)

(ii)

Test	S1	S2
reducing sugar	changes to brick-red colour	remains blue/ green colour

(award 1 mark for each correct observation)

(e) Food tests:
S1 contained no starch but did have reducing sugar present.
S2 did contain starch but no reducing sugar (or possibly a little reducing sugar). (1 mark for each)
Structure:
Both S1 and S2 are storage organs – containing either starch or sugar.
They are an onion bulb and a potato tuber. (1 mark for each)

2 **(a)**

Amylase concentration	Observation
R1	remains blue/black
R2	changes to brown/orange
R3	changes to brown/orange

(1 mark for table correctly drawn; 1 mark for headings correctly labelled; 1 mark for each correct observation)

(b) R1 had no amylase present so there was no colour change. R2 and R3 contained amylase, which broke the starch down into smaller sugars, so the iodine turned orange. (3 marks)

(c) Keep the following variables constant:
- amylase concentration
- starch concentration
- temperature.

Change the pH of the solutions the discs are soaked in, ensuring a suitable range of pH values.
Place the discs on the paper stained with iodine and record observations in a table.
Repeat at least three times and calculate a mean.
Ensure safety procedures are applied, e.g. goggles. (4 marks)

(d) (i) 60 + 12 = 72 (1 mark)

72 + 6 = 78 (1 mark)

(ii) X-axis: Time (minutes)

Y-axis: Number of new areas where there had been a reaction

Most of available grid used

Accuracy of plots (within ½ small square)

Line drawn either point to point (with a ruler) **or** smooth curve (5 marks)

(iii) Any two from:

- different species of goats
- different age of goats
- different gender of goats
- difference in hunger levels between goats
- different concentrations of amylase. (2 marks – 1 mark for each point)

(e) Any three from:

- Ensure all variables are controlled, so that only one variable is tested at a time.
- Repeat the experiment and calculate a mean.
- Use more precise monitoring equipment.
- Sample until there are no more new areas of reaction.
- Reduce the time interval between sampling. (3 marks – 1 mark for each point)

3 (a) (i)

Time (min)	Test tube 1	Test tube 2	Test tube 3
0 (initial)			
1			
2			
3			
4			
5			
6			

- Correct rows
- Correct columns
- Correct units (3 marks)

(ii) Students' own observations correctly recorded in table (1 mark for each correctly completed column)

(iii) X-axis: Time (min)

Y-axis: Temperature (°C)

Most of available grid used

Accuracy of plots (within ½ small square)

Three lines plotted on one graph (5 marks)

(iv) Description of which test tube held the most heat

Description of which test tube held the least heat

Explanation justified in terms of effectiveness of insulation

One test tube had no insulation so will have lost most heat

Foil better at trapping heat than tissue paper (or the reverse) (5 marks)

(b) Correct shape; correct labels for: barb, shaft, vane (4 marks)

(ii) W1 – insulation

W2 – assist with flight (2 marks)

Alternative to Practical past exam questions

1 **(a)** **(i)** 2, 11, 15, 20, 26, 27 (3 marks – 1 mark for every two correct answers)

(ii) X-axis: Temperature (°C)
Y-axis: Volume of juice collected (cm^3)
Most of available grid used
Accuracy of plots (within ½ small square)
Smooth curve plotted, or straight lines plotted from point to point (5 marks)

(iii) The higher the temperature, the greater the volume of juice collected, up to a point (when the effect begins to tail off). (2 marks)

(b) Control appropriate variables including:
- volume/concentration/amount and type of enzyme
- temperature
- type of pulp/consistency of pulp/volume of pulp.

Change the variable to be tested: pH of the pulp (suggest a suitable range to test).
Suitable details of how the investigation will be carried out, e.g. how pH will be varied, amounts of different substances used, timings, how results will be collected, etc.
Repeat measurements/readings and calculate a mean.
Collect data in a suitable table and plot the data in a line graph.
Consider health and safety – wear goggles, lab coat, avoid spillages. (6 marks)

2 **(a)** **(i)** Chip in salt solution: length 55 mm; change in length of –5 mm
Chip in distilled water: length 63 mm; change in length of +3 mm
(Allow ±0.5 mm) (2 marks)

(ii) Salt solution: Water (net flow) moves from the potato tissue into the solution, as potato tissue solution is less concentrated (has a higher water potential) than the surrounding solution (allow inverse). (2 marks)
Water solution: Water (net flow) moves from the solution into the potato tissue, as potato tissue solution is more concentrated (has a lower water potential) than the surrounding solution (allow inverse). (2 marks)

(b) **(i)** (–0.14/1.45) × 100 = –9.66% (allow –9.65% to –9.66%) (2 marks)

(ii) Starting mass will not be the same for all chips (so difference in mass will not always give a clear idea of the change as a proportion of starting mass). (1 mark)

(iii) Axes scales numbered correctly, with positive and negative signs used on y-axis
Most of grid used
Accuracy of plots (within 1 small square)
Smooth curve plotted (4 marks)

(c) **(i)** Concentration calculated from graph – check against student's graph (1 mark)

(ii) The potato tissue and surrounding solution are of the same concentration/have same water potential, so no net flow of water. (1 mark)