Cambridge IGCSE®

Biology

Laboratory Practical Book

Mike Cole

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Experimental skills and abilities

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Author's acknowledgment

With thanks to, and in memory of, D. G. Mackean (1926–2013) whose first book, *Introduction to Biology*, transformed the appearance of school textbooks in 1962 and who, though this and other books including *GCSE Biology* and *IGCSE Biology*, inspired biology students around the world for over 50 years.

Skills for scientific enquiry

Introduction

The aim of this book is to help you develop the skills and abilities needed to perform practical laboratory work. We start by introducing the apparatus and measuring techniques that you will use most often.

Then we show you how to make and record measurements accurately. Methods for handling the observations and data you have collected will then be described.

Finally we discuss how to plan, carry out and evaluate an investigation. You should then be ready to work successfully through the experiments and laboratory activities that follow.

Using and organising techniques, apparatus and materials

In an experiment you will first have to decide on the measurements to be made and then collect together the apparatus and materials required. The quantities you will need to measure most often in laboratory work are **mass**, **length** and **time**.

- What apparatus should you use to measure each of these?
- Which measuring device is most suitable for the task in hand?
- How do you use the device correctly?

Balances

A **balance** is used to measure the mass of an object. There are several types available.

- In a beam balance the unknown mass is placed in one pan and balanced against known masses in the other pan.
- In a lever balance a system of levers acts against the mass when it is placed in the pan.
- A digital top-pan balance, which gives a direct reading of the mass placed on the pan, is shown in the diagram.

Figure 1 A digital top-pan balance

- The unit of mass is the kilogram (kg).
- The gram (g) is one-thousandth of a kilogram: 1 g = 1/1000 kg = 10^{-3} kg = 0.001 kg.
- The smallest mass that can be measured on the scale setting you are using is probably 1 g or 0.1 g.

Ruler and vernier scales

- The unit of length is the metre (m).
- Sub multiples are:

  1 decimetre (dm) = 10^{-1} m

  1 centimetre (cm) = 10^{-2} m

  1 millimetre (mm) = 10^{-3} m

  1 micrometre (μm) = 10^{-6} m

  1 kilometre (km) = 10^{3} m

- A **ruler** is often used to measure lengths in the centimetre range.
- The correct way to measure with a ruler is shown in Figure 2, with the ruler placed as close to the object as possible.

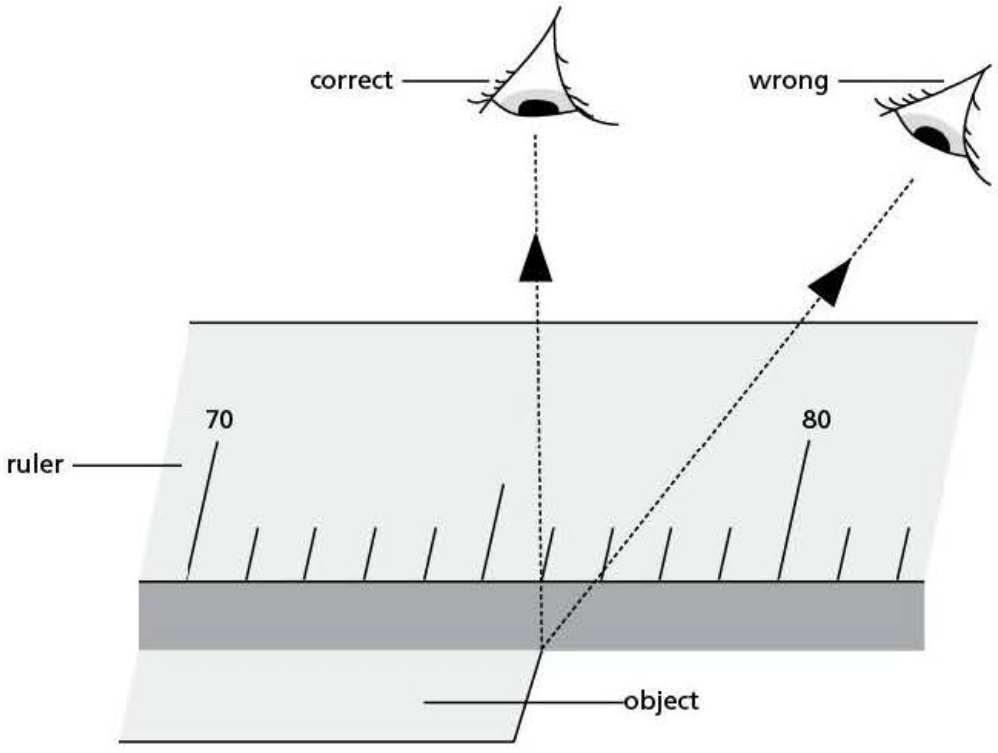


Figure 2 The reading is 76 mm or 7.6 cm. Your eye must be directly above the mark on the scale or the thickness of the ruler causes parallax errors.

- Some instruments such as barometers and microscopes have a **vernier scale** to enable small lengths to be measured, usually to 0.1 mm.
- One end of the length to be measured is made to coincide with the zero of the millimetre scale and the other end with the zero of the vernier scale.

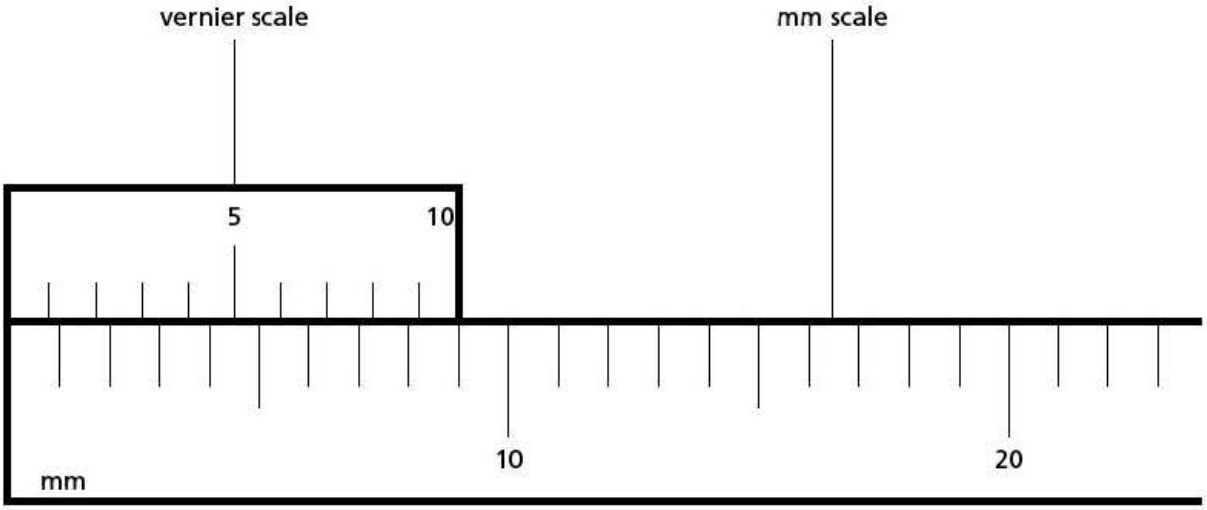


Figure 3a A vernier scale is a small sliding scale that is 9mm long but divided into 10 equal divisions: 1 vernier division = 9/10 mm = 0.9 mm = 0.09 cm

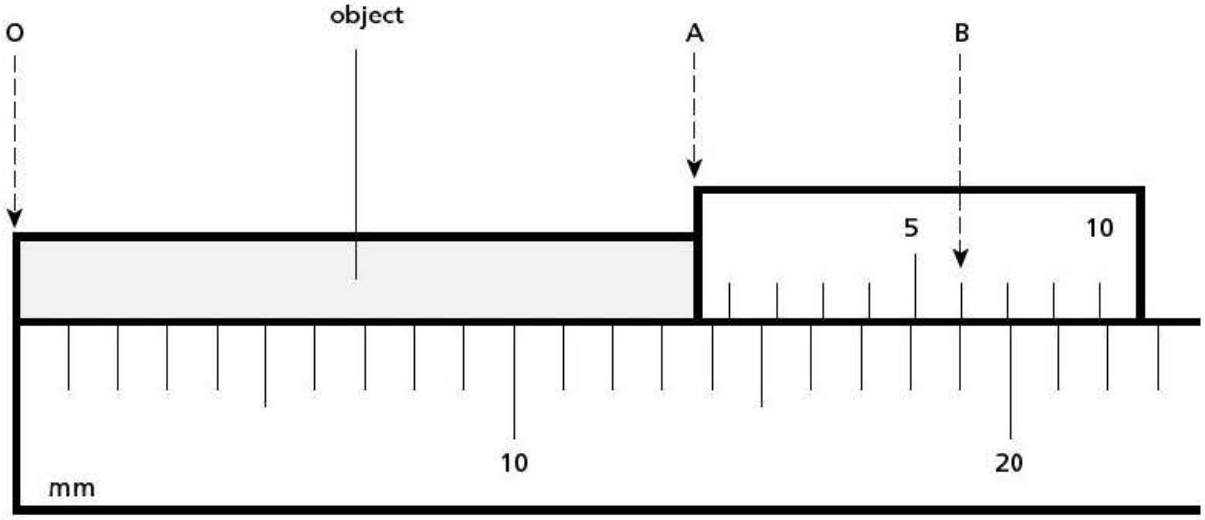


Figure 3b The length of the object is between 1.3 and 1.4 cm. The reading to the next decimal place is found by finding the vernier mark that exactly lines up with a mark on the millimetre scale. Here it is the 6th mark and so the length of the object is 1.36 cm since:

OA = OB – AB

= 1.90 cm – (6 vernier divisions)

= 1.90 – (6 × 0.09) cm

= 1.90 – 0.54 cm

= 1.36 cm

Clocks and timers

- Clocks, watches and timers can be used to measure time intervals. In an experiment it is important to choose the correct timing device for the required measurement.
- The unit of time is the second(s).
- A **stopwatch** will be sufficient if a time in minutes or seconds is to be measured, but if times of less than a second are to be determined then a **digital timer** is necessary.

- When using a stopwatch, reaction times may influence the reading.
- For time intervals of the order of seconds, a more accurate result may be obtained by measuring longer time intervals – for example, time pulse rate over 60 seconds rather than over 15 seconds and then calculate an average value.
- To measure very short time intervals, a digital timer that can be triggered to start and stop by an electronic signal from a microphone, photogate or mechanical switch is useful.

Changing measurements

- Take readings more frequently if values are changing rapidly.
- It will often be helpful to work with a partner who watches the timer and calls out when to take a reading.
- Pressing the lap-timer facility on the stopwatch at the moment you take a reading freezes the time display for a few seconds and will enable you to record a more accurate time measurement.
- For rapidly changing measurements it may be necessary to use a **tickertape timer** or a **datalogger** and computer.

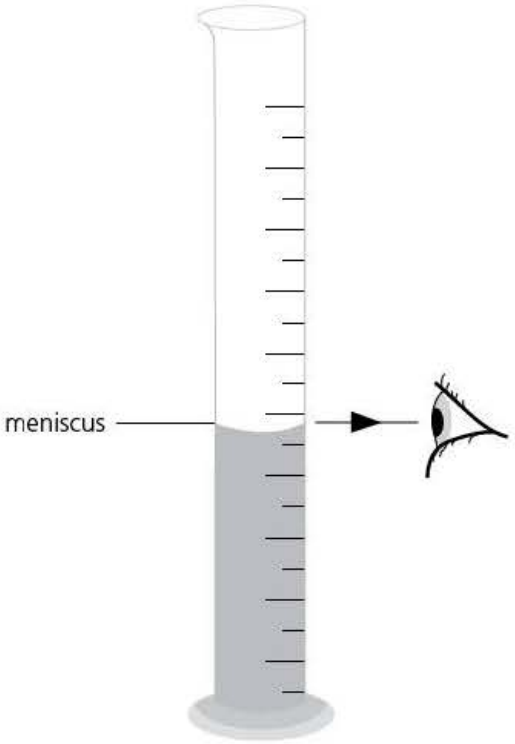


Figure 4 When making a reading the measuring cylinder should be vertical and your eye should be level with the bottom of the curved liquid surface – the meniscus. (For mercury the meniscus formed is curved oppositely to that of other liquids and you should read the level of the top of the meniscus in a mercury thermometer or barometer.)

Measuring cylinders

- The volume of a liquid can be obtained by pouring it into a **measuring cylinder**.
- Measuring cylinders are often marked in millilitres (ml) where 1 millilitre = 1 cm^3.
- Note that 1 litre = 1000 cm^3 = 1 dm^3.

Safety

Here are a few simple precautions to help ensure your safety when carrying out experiments in the laboratory.

- **Always wear shoes** – to protect your feet if a heavy weight should fall on them.
- **Hot liquids and solids** – set in a safe position where they will not be accidentally knocked over; handle with caution to avoid burns.
- **Toxic materials** – materials such as mercury are toxic; take care not to allow a mercury thermometer to roll onto the floor and break.
- **Tie back long hair** – to prevent it being caught in a flame.
- **Personal belongings** – leave in a sensible place so that no one will trip over them!
- **Protect eyes and skin from contact with corrosive and harmful chemicals** – any reagent used for any of the experiments in this book must be treated with caution. Ask for your teacher's advice before handling them. Sodium hydroxide, hydrochloric

acid, pyrogallic acid, enzyme solutions, iodine, Benedict's reagent and other chemicals suggested in this book must be handled with care. Alcohol (ethanol) is flammable.

- **Bunsen flames and flammable liquids** – use the safety flame, or turn the Bunsen burner off when not in use. Make sure the Bunsen flame is out before handling flammable liquids, such as alcohol (ethanol). An alternative may be to heat water up using a kettle.
- **Biological organisms and materials** – ensure biological organisms and materials are sourced and stored appropriately and handled with care. Ensure suitable disposal, as appropriate. Wear eye protection and gloves. Avoid hand to mouth contact and wash hands thoroughly after practical activities.

Observing, measuring and recording

Having collected together and familiarised yourself with the equipment and materials needed for an experiment, you are now ready to start making some observations and measurements.

- It will be helpful at this stage to draw a clearly labelled diagram of the experimental set-up.
- You should also record any difficulties encountered in carrying out the experiment and any precautions taken to achieve accuracy in your measurements.
- Do not dismantle the equipment until you have completed the analysis of your results and are sure you will not have to repeat any measurements!
- How many significant figures will your data have?
- How will you record your results?

Make a list of the apparatus you use in an experiment and record the smallest division of the scale of each measuring device.

Significant figures

Every measurement of a quantity is an attempt to find its true value and is subject to errors arising from the limitations of the apparatus and the experimental procedure.

- The number of figures given for a measurement, called **significant figures**, indicates how accurate we think it is. More figures should not be given than are justified.
- For example, a measurement of 6.7 has two significant figures. The measurement 0.235 has three significant figures, the 2 being most significant and the 5, which we are least sure about (since it could be 4 or 6), being the least significant.
- When doing calculations your answer should have the same number of significant figures as the measurements used in the calculation. For example, if your calculator gives an answer of 1.23578, this would be 1.2 if your measurements have two significant figures and 1.24 if your measurements have three significant figures.
- Note that in deciding the least significant figure you look at the following figure. If that is less than 5, you round down (1.23 becomes 1.2) but if it is 5 or above, you round up (1.235 becomes 1.24).
- If a number is expressed in standard notation, the number of significant figures is the number of digits before the power of 10. For example, 6.24×10^2 has three significant figures.
- If values with different numbers of significant figures are used to calculate a quantity, quote your answer to the smallest number of significant figures.

Systematic errors

The figure shows part of a ruler used to measure the height of a point P above the bench.

- The ruler has a space of length x before the zero of the scale.
- The height of the point P = scale reading + x = 5.9 + x.
- By itself the scale reading is not equal to the height of P; it is too small by the amount x.
- An error of this type is called a **systematic error** because it is introduced by the system.
- A half-metre ruler does not have a systematic error because its zero is at the end of the rule.
- When using a rule to measure a height, the rule must be held so that it is vertical. If it is at an angle to the vertical then a systematic error will be introduced.
- Check for any zero error when using a measuring device. If it cannot be eliminated, correct your readings by adding or subtracting the zero error to them.

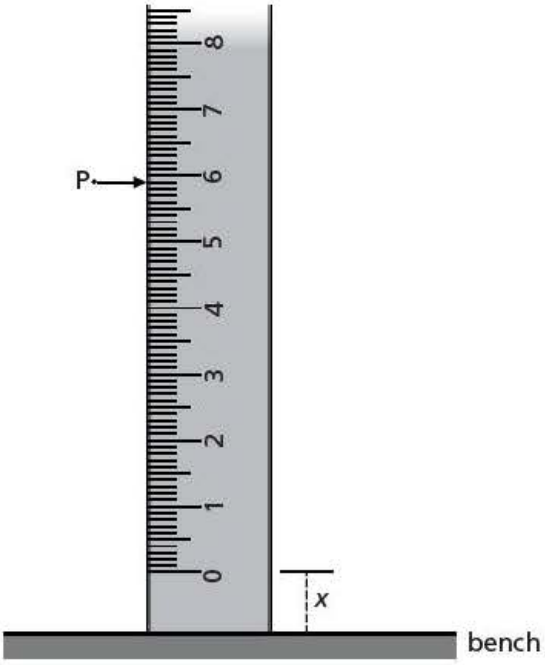


Figure 5 Introducing a systematic error into a measurement

Tables

If several measurements of a quantity are being made, draw up a **table** in which to record your results.

- Use the column headings, or start of rows, to name the measurement and state its unit. For example, in Experiment 9.1 (see page 97) you will use a table similar to one below to record your results.
- Repeat the measurement of each observation if possible and record the values in your table. If repeat measurements for the same quantity are significantly different, take a third reading. Calculate an average value from your readings.
- Numerical values should be given to the number of significant figures appropriate to the measuring device.

Column heading	Repeat 1	Repeat 2	Average

Handling experimental observations and data

Now that you have collected your measurements you will need to process them. Perhaps there are calculations to be made or you will decide to draw a graph of your results. Then you can summarise what you have learnt from the experiment, discuss sources of experimental error and draw some conclusions from the investigation.

- What is the best way to process your results?
- Are there some inconsistent measurements to be dealt with?
- What experimental errors are there?
- What conclusions, generalisations or patterns can you draw?

Calculations

You may have to produce an average value to process your results.

Averages

Sum the values for a quantity you have measured and divide the sum by the number of values to obtain the average.

- For example, if you measure the length of a branch as 81.5 cm and 81.6 cm, then:

$$\text{the average value} = \frac{(81.5 + 81.6)}{2}$$
$$= \frac{163.1\,\text{cm}}{2}$$
$$= 81.55\,\text{cm}$$
$$= 81.6\,\text{cm}$$

- The value has been given to three significant figures because that was the accuracy of the individual measurements.

Graphs

Graphs can be useful in finding the relationship between two quantities.

- You will need about six data points taken over as large a range as possible to plot a graph.
- Choose scales that make it easy to plot the points and use as much of the graph paper as possible.
- Make sure you label each axis of the graph with the name and unit of the quantity being plotted.
- Mark the data points clearly with a circle or a cross, using a sharp pencil.
- Join up your points with a smooth line or curve.

One student's experimental data is displayed below:

Light Intensity (arbitrary units)	Rate of Photosynthesis (arbitrary units)
0	0
1.0	2.0
2.0	4.0
3.0	6.0
4.0	7.8
5.0	8.0

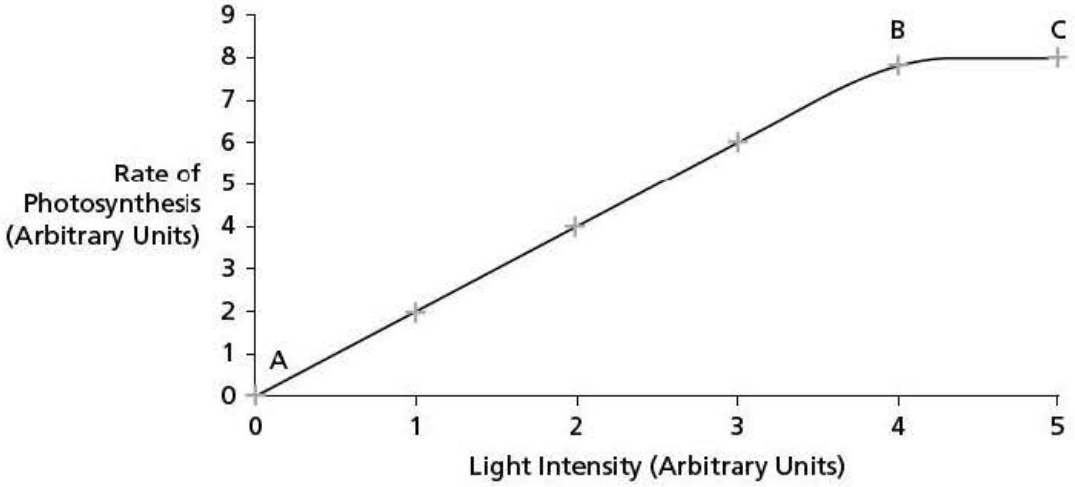


Figure 6 Graph showing effect of light intensity on the rate of photosynthesis.

- When the readings in the table are used to plot a graph, a distinctive shape is formed.
- Between points A and B, an increase in light intensity results in an increase in the rate of photosynthesis.
- Between points B and C the rate of photosynthesis levels off.

Errors

- In practice, points plotted on a graph from actual measurements may not lie exactly on a straight line or curve of a graph due to experimental errors.
- The 'best fit line' is then drawn through them, if appropriate.
- If possible, repeat any anomalous measurements to check that they have been recorded properly or try to identify the reason for the anomaly.

Conclusions

Once you have analysed your experimental results, summarise your conclusions clearly and relate them to the aim of the experiment.

- State whether a hypothesis has been verified. If your results do not, or only partially, support a hypothesis, suggest reasons why.
- If a numerical value has been obtained, state it to the correct number of significant figures. Compare your results with known values if available and suggest reasons for any differences.

- State any relationships discovered or confirmed between the variables you have investigated.
- Mention any patterns or trends in the data.
- Identify and comment on sources of error in the experiment. For example, it may be very difficult to eliminate all heat losses to the environment in a heat experiment; if that is the case, say so. Mention any sources of systematic error in the experiment.

Planning, carrying out and evaluating investigations

- Before you start an experiment it is important to define an aim and produce a logical and safe plan for the investigation.
- You should identify the variables in the investigation and decide which ones to manipulate and which ones you should try to keep constant. To discover the relationship between variables you should change only one variable at a time.
- Once you know what you will need to measure, you can decide on the apparatus and materials to be used. You should ensure that your measuring devices have sufficient accuracy for the job required.
- Before you start the experiment, familiarise yourself with how to use the apparatus and develop a plan of work. It will be helpful to decide how to record your results; draw up tables in which to record your measurements if appropriate.
- Describe how you carried out the experiment under 'Method' in your laboratory notes. It is useful to include a sketch of the experimental set-up here for future reference.
- When you have obtained your results, manipulate data, draw graphs and carry out the calculations needed to fulfil the aims of the experiment.
- Then analyse your results and clearly state your conclusions from the investigation.
- Finally, evaluate the experiment and discuss how it could be improved. Could some things have been done better? If so, suggest changes or modifications that could be made to the procedure or the equipment used in the investigation.

Questions

1 What measuring device would you use to obtain values for:

(a) the volume of liquid in a coffee mug

.....

(b) the mass of an apple

.....

(c) the length of the pendulum of a grandfather clock

.....

(d) the temperature of a cup of tea

.....

(e) the time taken to run up 20 stairs

.....

(f) the time taken by an apple to fall through one metre

.....

(g) the dimensions of a textbook.

.....

2 How would you obtain a value for:

(a) the average time for one oscillation of the pendulum of a clock

.....

.....

(b) the average mass of a pin?

.....

.....

→

3 Complete the table below by stating the typical smallest division of scale of each of the measuring devices listed.

Device	Smallest division of scale
metre ruler	
vernier scale	
stopwatch	
digital timer	
digital balance	
liquid-in-glass thermometer	
100 ml measuring cylinder	

4 Write the number 9.753864 to:

(a) 3 significant figures .....

(b) 2 significant figures .....

(c) 1 significant figure .....

5 The measurements in the table below were obtained, during a student's school science experiment.

Temperature (°C)	Rate of Photosynthesis (arbitrary units)
0	0
10	2.0
20	4.0
30	4.0
40	2.0
50	0.0

(a) **(i)** State the variables being measured.

.....

(ii) Name a variable that must be kept fixed.

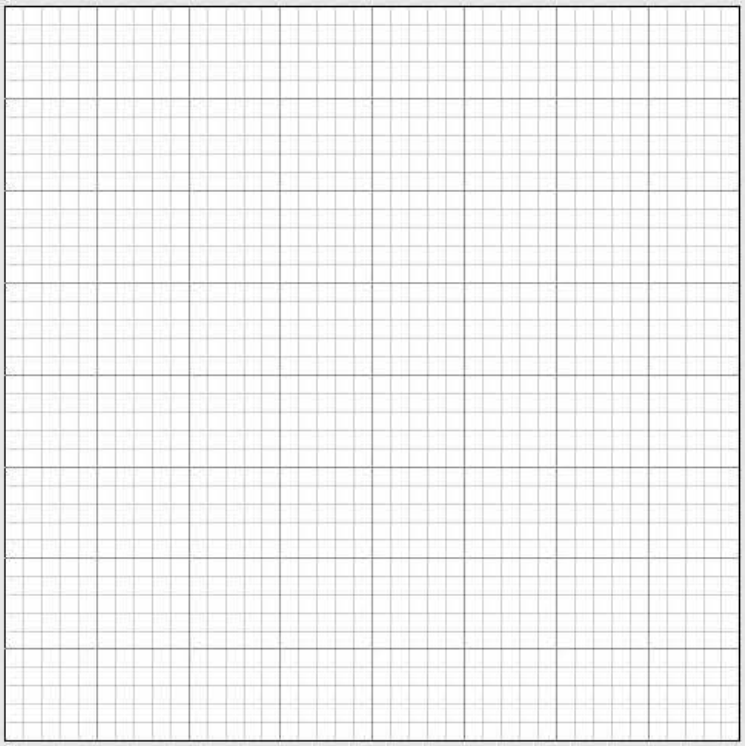
.....

(iii) Complete the following table:

Manipulated variable	Fixed variable	Responding variable

→

(b) Plot a graph of temperature on the horizontal axis and rate of photosynthesis on the vertical axis.



(c) What can you conclude about the relationship between temperature and rate of photosynthesis over the temperature range given?

.....

.....

.....

1 Characteristics and classification of living organisms

1.1 Dichotomous keys

Aim

To produce a dichotomous key for the identification of tree leaves.

Theory

Dichotomous keys help us to identify species.

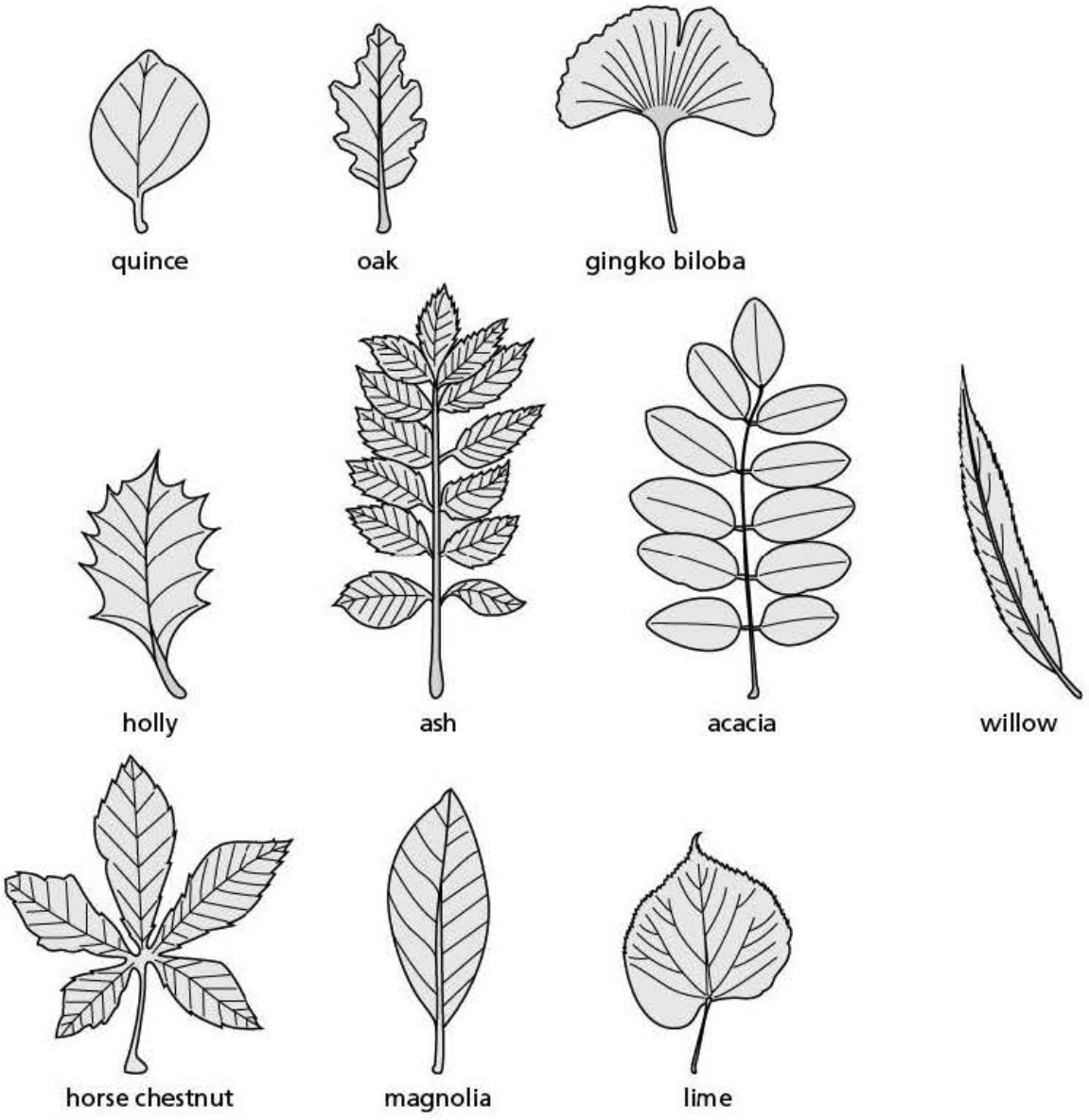


Figure 1 A range of leaves

Apparatus

- ☐ paper
- ☐ pencil
- ☐ ruler
- ☐ the leaf drawings from page 13, or actual specimens of a range of leaves

Procedure

1 Research a range of dichotomous keys using library resources or the internet.

2 Observe the range of leaves and consider the key characteristics of each.

3 Think about the characteristics that are most useful for placing the leaves into different groups.

4 Produce a dichotomous key. You might find it helpful to produce a draft on a piece of rough paper first.

5 Draw your final dichotomous key in the Results section on the next page.

Safety!
Ensure that you wash your hands after handling the leaves.

Method

Complete the following sentences:

1 Each stage of a dichotomous key presents the reader with ..... choices. [1]

2 In order to produce an effective dichotomous key it is important to identify the ..... and ..... between organisms, so that they can be placed into groups. [1]

Results

Present your completed dichotomous key below. [2]

Conclusions

Test your key using a range of different leaves provided by your teacher. Ensure that you wash your hands after handling the leaves. How effective is your key? [1]

.....

.....

.....

.....

Evaluation

Having tested your key, is there anything you would change? [1]

.....

.....

.....

.....

Extension

Create another dichotomous key to identify specimens of shells. [2]

2 Organisation and maintenance of the organism

2.1 Plant cells

Aim

To observe plant cells using a light microscope.

Theory

Plant cells contain: cell wall, cell membrane, cytoplasm, nucleus, sap vacuole and chloroplasts.

Apparatus

- ☐ goggles
- ☐ forceps
- ☐ onion
- ☐ microscope slide and cover slip
- ☐ 0.01 M iodine solution
- ☐ light microscope

Procedure

1. Wear eye protection. Cover any cuts with waterproof dressings or wear gloves.
2. Using forceps, remove a small piece of epidermis from the inside of an onion scale.
3. Place the tissue on a clean microscope slide.
4. Add a drop of weak iodine solution.
5. Gently place a cover slip on the tissue.
6. View under a light microscope.
7. Wash hands throughly after activity.

Method

Complete the following sentences:

1 Care had to be taken when using iodine because [1]

.....

2 Iodine was used because [1]

.....

3 In order to view the plant cells clearly, the magnification needs to be [1]

.....

Results

Draw and label a sample of two or three of the cells as seen under the microscope. [2]

Conclusions

The parts of the plant cells that are clearly visible under the light microsccpe are [2]

.....

.....

.....

.....

Evaluation

Outline how this experiment could be improved, or made more reliable. [2]

.....

.....

.....

.....

.....

Extension

1 Observe a range of specialised cells under a light microscope. In particular, look at root hair cells and xylem vessels. Explain how you think these are adapted to their function. [2]

.....

.....

2 View a cross-section of a dicotyledonous leaf under the microscope. Draw and label the cellular and tissue structures that you observe. [2]

2.2 Animal cells

Aim

To observe animal cells using a light microscope.

Theory

The nucleus, cytoplasm and cell membrane of animal cells can be viewed under a light microscope.

Apparatus

- ☐ sterile cotton bud
- ☐ microscope slide and cover slip
- ☐ beaker containing 70 % ethanol (or 1 % VirKon solution)
- ☐ methylene blue solution
- ☐ light microscope
- ☐ beaker of disinfectant
- ☐ goggles

Procedure

1. Wear eye protection.
2. Gently rub the cotton bud on the inside of your cheek.
3. Rub the bud onto a clean microscope slide.
4. Discard the cotton bud into a beaker of absolute alcohol (ethanol).
5. Cover the smear on the microscope slide with a few drops of methylene blue and place the cover slip over the top.
6. View the slide under a light microscope.
7. When finished, place the microscope slide in a beaker of appropriate disinfectant.
8. Wash hands throughly after activity.

Method

Complete the following sentences:

1 Alcohol (ethanol) and disinfectant are used to ensure that [1]

.....

2 In order to view the cells clearly, the magnification needs to be [1]

.....

Results

Draw and label a sample of two or three of the cells as seen under the microscope. [2]

Conclusions

The parts of animal cells that are clearly visible under the light microscope are [2]

.....

.....

.....

.....

Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

.....

.....

.....

.....

Extension

Observe a range of specialised cells under a light microscope. In particular look at ciliated cells, muscle cells and red and white blood cells.

Explain how you think these cells are adapted to their function. [2]

.....

.....

.....

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.....

.....

.....

.....

3.1 Osmosis and water flow

Aim

To demonstrate the effect of osmosis.

Theory

If two solutions are separated by a partially permeable membrane, water will diffuse across the membrane from the dilute to the concentrated solution. This process is known as osmosis.

Apparatus

- ☐ retort stand and clamp
- ☐ capillary tube
- ☐ Visking dialysis tubing
- ☐ elastic band
- ☐ 30 % sugar solution with red dye
- ☐ beaker with water
- ☐ stopwatch
- ☐ ruler
- ☐ scissors
- ☐ goggles

Procedure

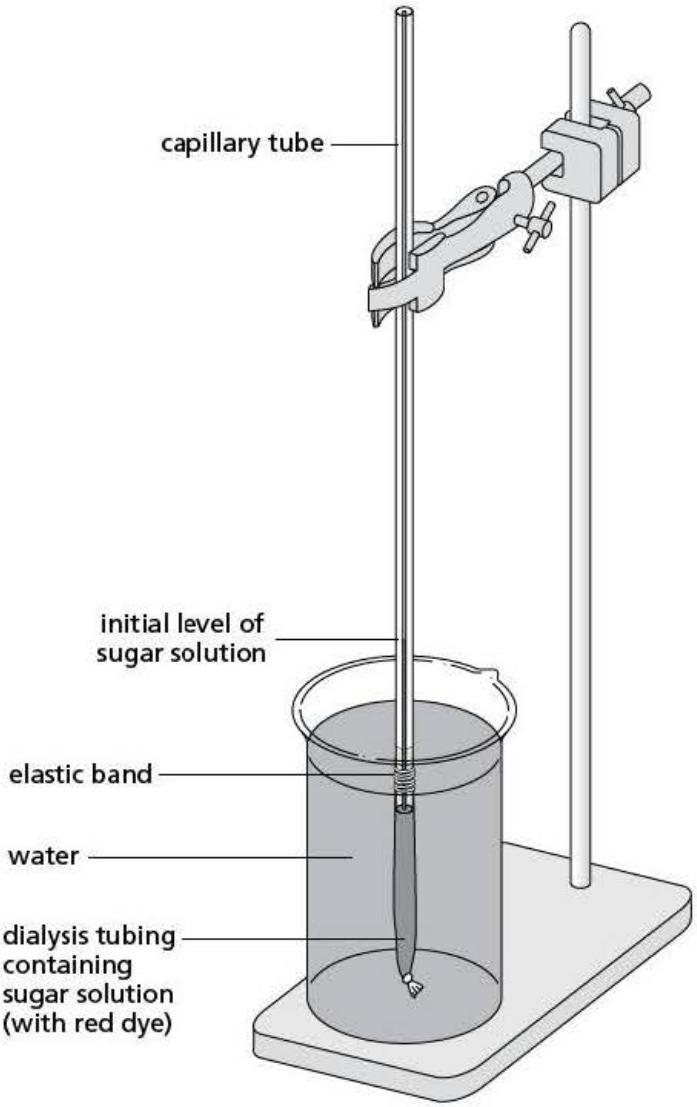

Figure 1

1. Wear eye protection.
2. Cut a 15 cm length of Visking dialysis tubing and soak in water for a few minutes.
3. Tie a knot in one end of the dialysis tubing.
4. Fill the tubing with the sugar solution and red dye.
5. Fit the tubing over the end of a capillary tube, ensuring that the capillary tube is immersed in the sugar solution. Secure in place with an elastic band.
6. Clamp the capillary tube so that the dialysis tubing is immersed in the beaker of water.
7. Note the starting level of the liquid, using the ruler, and then start the clock.
8. Make a note of your observations of the level of liquid in the capillary tube over the next 10 to 15 minutes.

Method

Explain why the red dye was added to the sugar solution. [2]

.....

.....

.....

.....

Results and calculations

Make a note of your observations below. [2]

Conclusions

1 How did the levels of liquid in the capillary tube compare at the beginning and end of the experiment? [1]

.....

.....

.....

.....

2 How can you explain this? [2]

.....

.....

.....

.....

Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

.....

.....

.....

.....

Extension

Explain how you think the levels of liquid at the beginning and at the end of the experiment would compare if the sugar solution was more dilute. [2]

.....

.....

.....

3.2 Turgor in potato tissue

Aim

To investigate turgor in potato tissue.

Theory

If two solutions are separated by a partially permeable membrane, water will diffuse across the membrane from the dilute to the concentrated solution.

Apparatus

- ☐ cork borer
- ☐ knife
- ☐ large potato
- ☐ board
- ☐ ruler
- ☐ 2 test tubes
- ☐ 20 % sugar solution
- ☐ water

Procedure

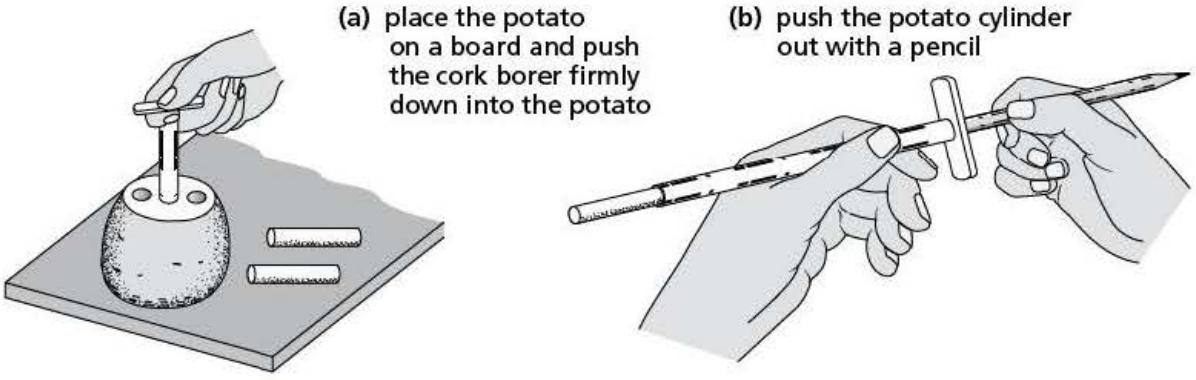

Figure 1

1. Prepare two potato cylinders using a cork borer, as shown in the diagram.
2. **Carefully** cut the two cylinders to the same length, ensuring they are at least 50 mm long. Make a note of this length.
3. Add water to one test tube and the sugar solution to the other.
4. Add a potato cylinder to each tube and leave for 24 hours.
5. Measure the length of each potato cylinder and note your observations in terms of the firmness or flabbiness of each potato cylinder.

Method

What could be an alternative method to measuring the length of potato cylinders? [1]

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Results and calculations

Make a note of your observations below. [2]

Conclusions

1 How did the water and the sugar solution affect the length of the potato cylinders? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Calculate the class average for the change in length for each of the cylinders. [2]

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3.3 Osmosis and turgor

Aim

To review knowledge of diffusion and to illustrate turgor in a plant cell.

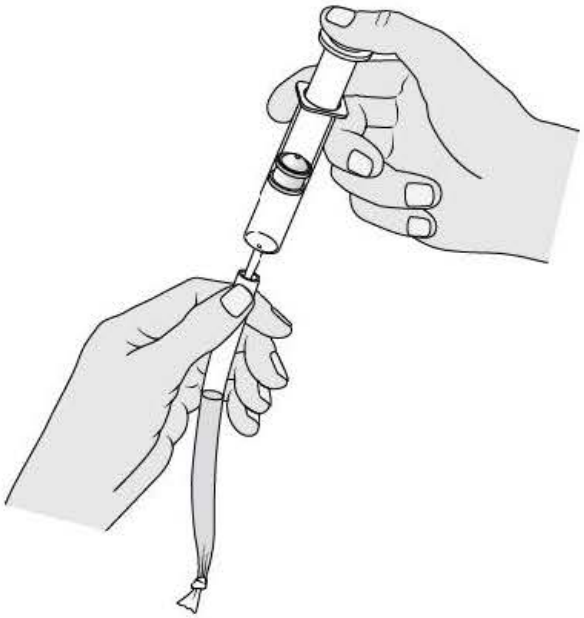
Theory

If two solutions are separated by a partially permeable membrane, water will diffuse across the membrane from the dilute to the concentrated solution.

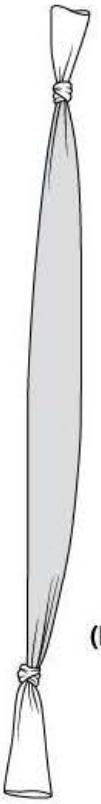
Apparatus

- ☐ syringe
- ☐ Visking dialysis tubing
- ☐ syrup or concentrated sugar solution
- ☐ test tube
- ☐ water
- ☐ stopwatch
- ☐ ruler
- ☐ scissors
- ☐ goggles

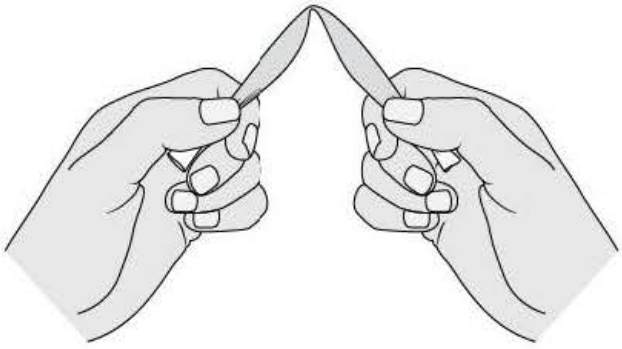
Procedure



(a) place 3 cm^3 syrup in the dialysis tubing



(b) knot tightly, after expelling the air bubbles



(c) the partly filled tubing should be flexible enough to bend

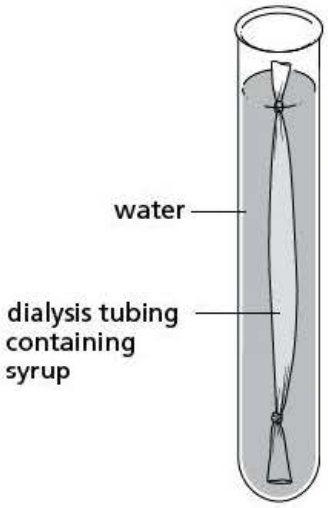


Figure 1

1. Wear eye protection.
2. Cut a 20 cm length of Visking dialysis tubing and soak it in water for a few minutes.
3. Tie a knot at one end.
4. Using a syringe, place 3 cm^3 of syrup or strong sugar solution in the tubing.
5. Tie a knot in the open end of the tubing.
6. Note your observations on the floppiness of the dialysis tubing.
7. Place the tubing in a test tube filled with water for 45 minutes.
8. Once again, note your observations on the floppiness of the dialysis tubing.

Method

1 Explain why the dialysis tubing containing the syrup or strong sugar solution was left in the test tube for 45 minutes. [2]

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2 Explain why dialysis tubing is used. [2]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

1 How did the floppiness/firmness of the dialysis tubing compare at the beginning and end of the experiment? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Explain how you think the floppiness/firmness of the dialysis tubing at the beginning and at the end of the experiment would compare if the sugar solution was more dilute. How could you investigate this? [2]

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3.4 Plasmolysis

Aim

To observe the process of plasmolysis in plant cells.

Theory

If two solutions are separated by a partially permeable membrane, water will diffuse across the membrane from the dilute to the concentrated solution.

Apparatus

- ☐ small piece of red onion scale epidermis
- ☐ glass slide and cover slip
- ☐ dropping pipette
- ☐ 30 % sugar solution
- ☐ light microscope
- ☐ blotting paper

Procedure

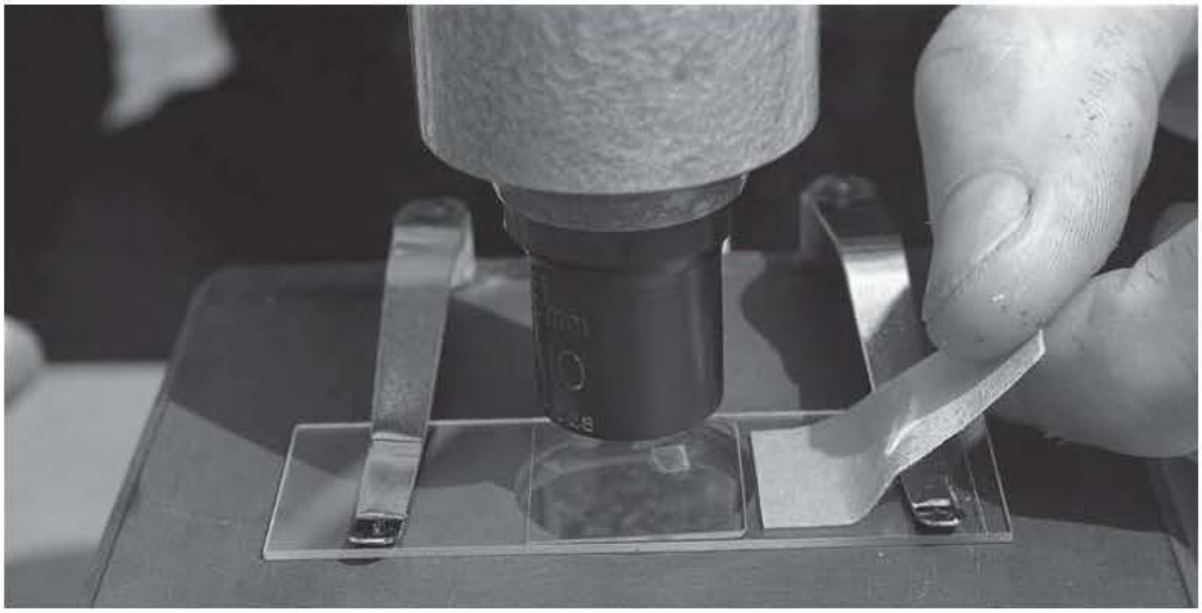

Figure 1 Changing the water for sugar solution

1. Place a small piece of red onion scale on a microscope slide. Add a drop of water and cover with a cover slip.
2. Focus on a small group of cells using a microscope. Draw and label a diagram of what you observe. Not all the cells in red onion epidermis will contain pigmented cytoplasm.

3 Place a few drops of sugar solution on the slide, to one side of the cover slip.

4 Use the blotting paper on the other side of the cover slip to draw the solution across, as shown in the photo.

5 Observe the cells under the microscope. Draw and label a diagram of what you see.

Method

Explain how you could calculate the actual size of an onion cell. [2]

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Results and calculations

Make a note of your observations and diagrams below. [2]

Conclusions

1 How did exposure to sugar solution affect the vacuole and cytoplasm of the cells? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Explain how you think a more concentrated sugar solution would affect the cells. [2]

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3.5 Partial permeability

Aim

To demonstrate dialysis.

Theory

The pore size of a Visking tubing membrane makes it partially permeable with respect to iodine and starch.

Apparatus

- ☐ test tube
- ☐ Visking dialysis tubing
- ☐ dropping pipette
- ☐ 1 % starch solution
- ☐ 0.01 M iodine solution
- ☐ water
- ☐ elastic band
- ☐ stopwatch
- ☐ ruler
- ☐ scissors
- ☐ goggles

Procedure

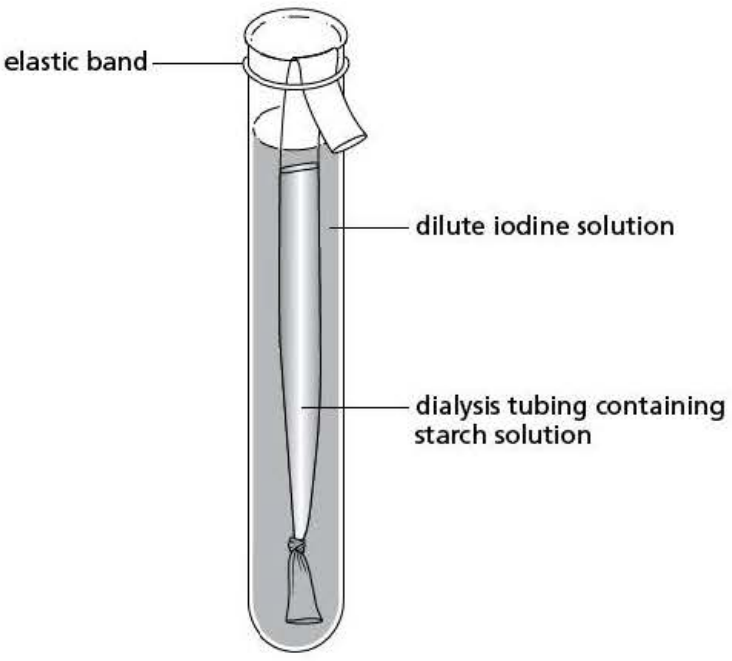

Figure 1

1 Wear eye protection.
2 Cut a 15 cm length of Visking dialysis tubing and soak in water for a few minutes.
3 Tie a knot at one end.
4 Fill the dialysis tubing with the 1 % starch solution.
5 Put the tubing in the test tube and secure with an elastic band.
6 Rinse the dialysis tubing and test tube with cold water.
7 Fill the test tube with water and add a few drops of 0.01 M iodine solution.
8 Leave for 15 minutes.
9 Note your observations in the Results section.

Method

Explain why it is important at step 6 to rinse the Visking tubing and test tube with water. [1]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

How can you explain your observations? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

1 If glucose solution was added to the dialysis tubing instead of starch, what might you expect to observe? How would you test for the presence of glucose both inside and outside the dialysis tubing? [2]

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2 If protein solution was added to the dialysis tubing instead of starch, what might you expect to observe? How would you test for the presence of protein both inside and outside the dialysis tubing? [2]

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4.1 Food tests

Aim

To become familiar with the appropriate 'food tests' to confirm the presence of starch, glucose, protein, fat and vitamin C.

Theory

Different food types can be identified in the laboratory using a number of food tests.

Apparatus

Test for starch

- ☐ starch powder
- ☐ test tube and test tube rack
- ☐ water
- ☐ 0.01 M iodine solution
- ☐ tongs
- ☐ goggles

Test for reducing sugar

- ☐ glucose
- ☐ Benedict's solution
- ☐ test tube
- ☐ goggles
- ☐ beaker of hot water (from a freshly boiled kettle)
- ☐ heat-proof mat

Test for protein

- ☐ test tube
- ☐ 1 % solution of Albumin
- ☐ 0.1 M sodium hydroxide solution
- ☐ 0.01 M copper sulphate solution
- ☐ goggles

Safety!
Sodium hydroxide is caustic.

Test for fat

- ☐ cooking oil
- ☐ alcohol (ethanol)
- ☐ water
- ☐ 2 test tubes
- ☐ goggles

Test for vitamin C

- ☐ fresh lemon juice
- ☐ fresh orange juice
- ☐ plastic syringe
- ☐ 0.1 % DCPIP solution
- ☐ 2 test tubes
- ☐ goggles

Procedure

Test for starch

1. Wear eye protection.
2. Shake a little starch powder in a test tube with 5 cm^3 warm water, to make a suspension.
3. Add a few drops of 0.01 M iodine solution.
4. Record your observations.

Test for reducing sugar

1. Wear eye protection.
2. Place 1 cm^3 glucose solution and a few drops of Benedict's solution in a test tube.
3. Heat the test tube by placing it in a beaker of hot water.
4. Record your observations.

Test for protein (Biuret test)

1. Wear eye protection.
2. Place 1 cm^3 1 % solution of Albumin in a test tube.
3. Add 5 cm^3 0.1 M sodium hydroxide solution.
4. Then add 5 cm^3 0.01 M copper sulphate solution.
5. Record your observations.

Safety!
Sodium hydroxide is caustic.

Test for fat

1 Wear eye protection.
2 Place 2 drops of cooking oil in a test tube with 5 cm^3 alcohol (ethanol).
3 Shake the test tube gently until the fat dissolves.
4 Pour the solution into a test tube containing 3 cm^3 of water.
5 Record your observations.

Test for vitamin C

1 Wear eye protection.
2 Draw up 2 cm^3 fresh lemon juice into a plastic syringe.
3 Add the juice drop by drop to a test tube containing 2 cm^3 0.1 % DCPIP solution.
4 Record your observations.
5 Repeat this process with orange juice, which contains less vitamin C.
6 Again, record your observations.

Method

Remember you will be using sodium hydroxide solution, Benedict's reagent, iodine solution, DCPIP, alcohol (ethanol), a Bunsen Burner, copper sulphate and boiling water. These can all be hazardous. Outline the safety precautions to be taken when carrying out each of the food tests. Check these with your teacher before you begin. [3]

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Results and calculations

Record your observations for each of the food tests below. [2]

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Conclusions

Summarise the positive tests for each of the food types. [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Research the names of a range of foods rich in [2]

protein: .....

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fat: .....

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carbohydrate: .....

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4.2 Application of the food tests

Aim

To carry out food tests on a range of food samples to identify the food types that are present.

Theory

Foods contain a variety of food types, which can be identified using food tests.

Apparatus

- ☐ as for **Experiment 4.1: Food tests** (see pages 40–44)
- ☐ food samples provided by your teacher including milk, potato, onions, raisins and beans

Procedure

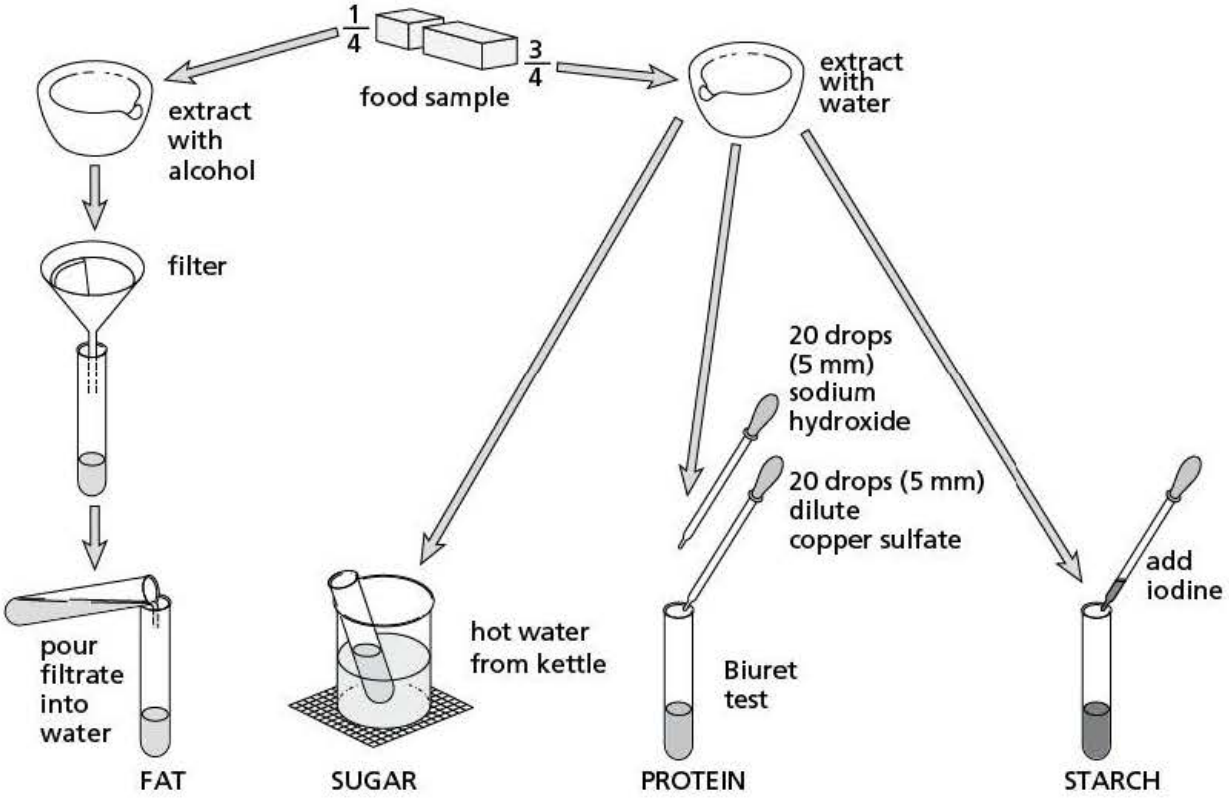

Figure 1

1 Wear eye protection. Do not eat food substances.

2 See **Experiment 4.1** for details of procedure.

Method

Remember you will be using sodium hydroxide solution, Benedict's reagent, iodine solution, DCPIP, alcohol (ethanol), a Bunsen Burner and boiling water. These can all be hazardous. Outline the safety precautions to be taken when carrying out each of the food tests. Check these with your teacher before you begin. [2]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

For each of the food samples, list the food types that were present. [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Outline an investigation to compare the vitamin C content of a range of different fruits and vegetables. [2]

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5.1 Extracting and testing an enzyme

Aim

To test the function of the enzyme catalase after heating.

Theory

Liver cells contain the enzyme catalase, which breaks down hydrogen peroxide.

High temperatures denature enzymes and so prevent them from functioning.

Apparatus

- ☐ fresh piece of liver
- ☐ pestle and mortar, with sand
- ☐ 4 test tubes
- ☐ 2 dropping pipettes
- ☐ filter funnel and paper
- ☐ water
- ☐ 10 Vol/ 3 % hydrogen peroxide solution
- ☐ measuring cylinder
- ☐ beaker of hot water from a kettle
- ☐ goggles

Safety!
Enzymes can cause allergies. Avoid contact with skin and eyes.

Procedure

1 Wear eye protection and gloves. Take care to ensure that you do not touch your face during the practical – in case the glove has had hydrogen peroxide on it.

2 Grind a small piece of liver with 20 cm^3 water and some sand using a pestle and mortar.

3 Filter the mixture into two test tubes. Label them A and B.

4 Pipette a few drops of the filtrate from test tube A into a test tube containing 3 cm^3 10 Vol/ 3 % hydrogen peroxide solution. Record your observations in the Results section.

5 Heat test tube B, containing filtrate, in a beaker of hot water for 2 minutes.

6 Add a few drops of filtrate from test tube B to another test tube containing 3 cm^3 dilute hydrogen peroxide solution. Record your observations in the Results section.

Method

Complete the following sentences:

1 The liver was ground up to release ..... from the ..... of the liver cells. [1]

2 Hydrogen peroxide is broken down into ..... and ....., which causes the effervescence. [1]

Results and calculations

Make a note of your observations below. [2]

Conclusions

Can you explain what you have observed? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Explain how you would modify this experiment to calculate the rate of reaction. Draw a suitable table for collecting results. [2]

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5.2 The effect of temperature on enzyme activity

Aim

To investigate the effect of temperature on an enzyme's activity.

Theory

Enzymes are biological catalysts, which operate best within specific optimum conditions. Temperature will therefore affect activity.

Apparatus

- ☐ 5 % amylase solution
- ☐ 1 % starch solution
- ☐ dilute iodine solution
- ☐ plastic syringes
- ☐ dropping pipette
- ☐ 6 test tubes
- ☐ 3 beakers
- ☐ thermometers
- ☐ stopwatch
- ☐ sources of warm, cold and ice water
- ☐ goggles

Safety!

Enzymes can cause allergies. Avoid contact with skin and eyes.

Temperatures higher than 50 °C should not be used, as there is a risk of scalding.

Procedure

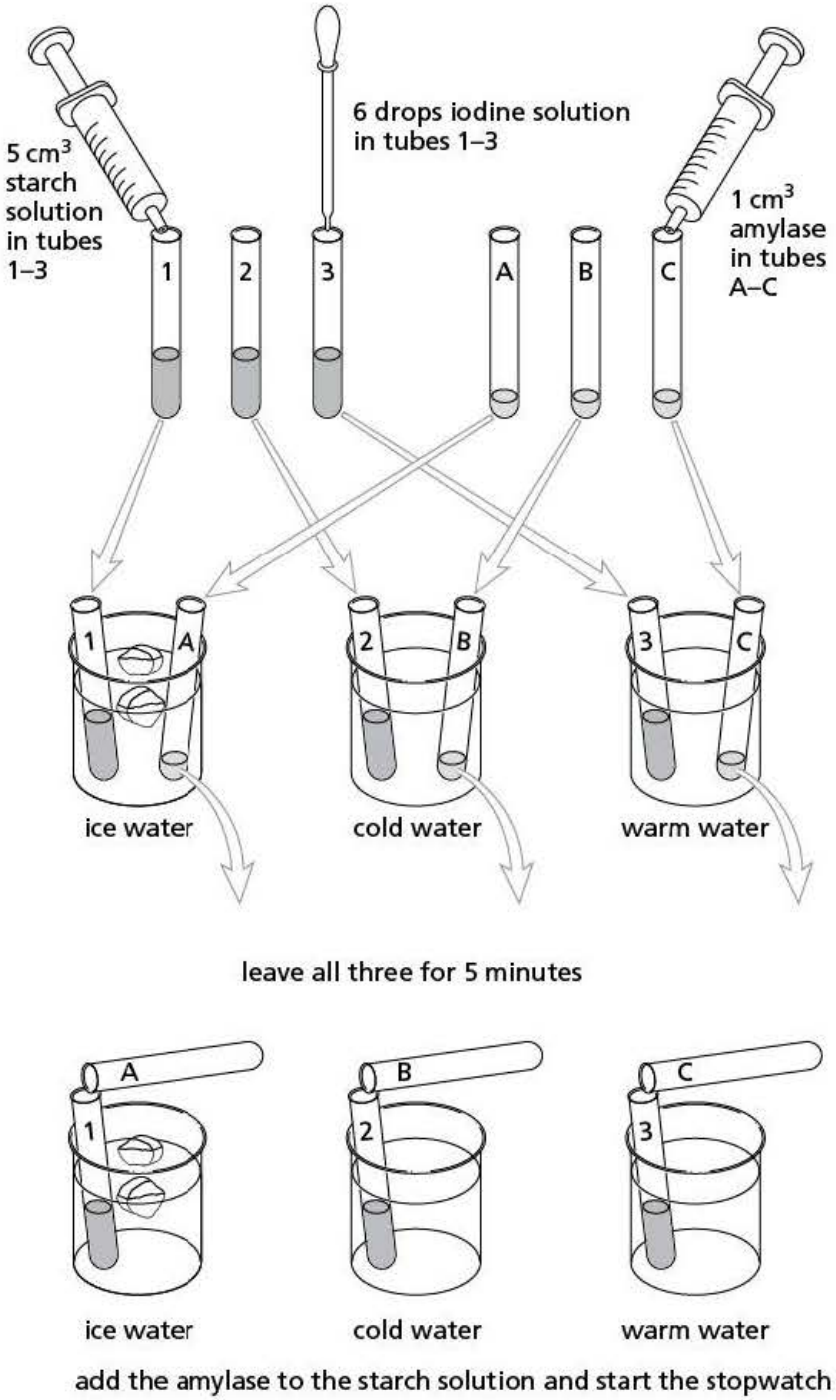

Figure 1

1. Wear eye protection.
2. Label three test tubes A, B and C.
3. Label another three test tubes 1, 2 and 3.
4. Using a syringe (or graduated pipette), place 1 cm^3 of the 5 % amylase solution into test tubes A, B and C.
5. With a clean syringe, place 5 cm^3 of the 1 % starch solution into test tubes 1, 2 and 3.
6. Using the dropping pipette, add six drops of the dilute iodine solution to test tubes 1, 2 and 3.

7 Prepare three beakers with water temperatures of 10 °C, 20 °C and 35 °C.

8 Place the tubes in the beakers so that:
- the ice water (10 °C) contains test tubes 1 and A
- the cold water (20 °C) contains test tubes 2 and B
- the warm water (35 °C) contains test tubes 3 and C.

9 Leave for 5 minutes, so that the test tubes reach the temperature of the water.

10 After 5 minutes record the temperature of each of the beakers.

11 Pour the contents of tube A into tube 1, tube B into tube 2 and tube C into tube 3.

12 Start the stopwatch, and record the time it takes to observe a colour change in each of the tubes.

Method

Complete the following sentences:

1 The enzyme amylase catalyses the breakdown of starch into ..... . [1]

2 In this investigation the iodine turned from ..... to .....
as starch was broken down by amylase. [1]

Results and calculations

Make a note of your observations below.

At what temperature was the enzyme, amylase, most active? [2]

Conclusions

1 How did temperature affect enzyme activity? [2]

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.....

2 What patterns did you see? [1]

.....

.....

3 Can you explain these patterns? [2]

.....

.....

Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Outline an investigation to measure the effect of temperature on the action of baker's yeast. [2]

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5.3 The effect of pH on enzyme activity

Aim

To investigate the effect of pH on an enzyme's activity.

Theory

Enzymes are biological catalysts which operate best within specific optimum conditions. pH will affect enzyme activity.

Apparatus

- ☐ 5 test tubes
- ☐ plastic syringes
- ☐ dropping pipettes
- ☐ 1 % starch solution
- ☐ 0.05 M sodium carbonate solution
- ☐ 0.1 M ethanoic (acetic) acid
- ☐ 0.01 M iodine solution
- ☐ 5 % amylase solution
- ☐ cavity tile
- ☐ beaker of water
- ☐ stopwatch
- ☐ pH paper and colour chart of pH values
- ☐ goggles

Safety!
Enzymes can cause allergies. Avoid contact with skin and eyes.

Procedure

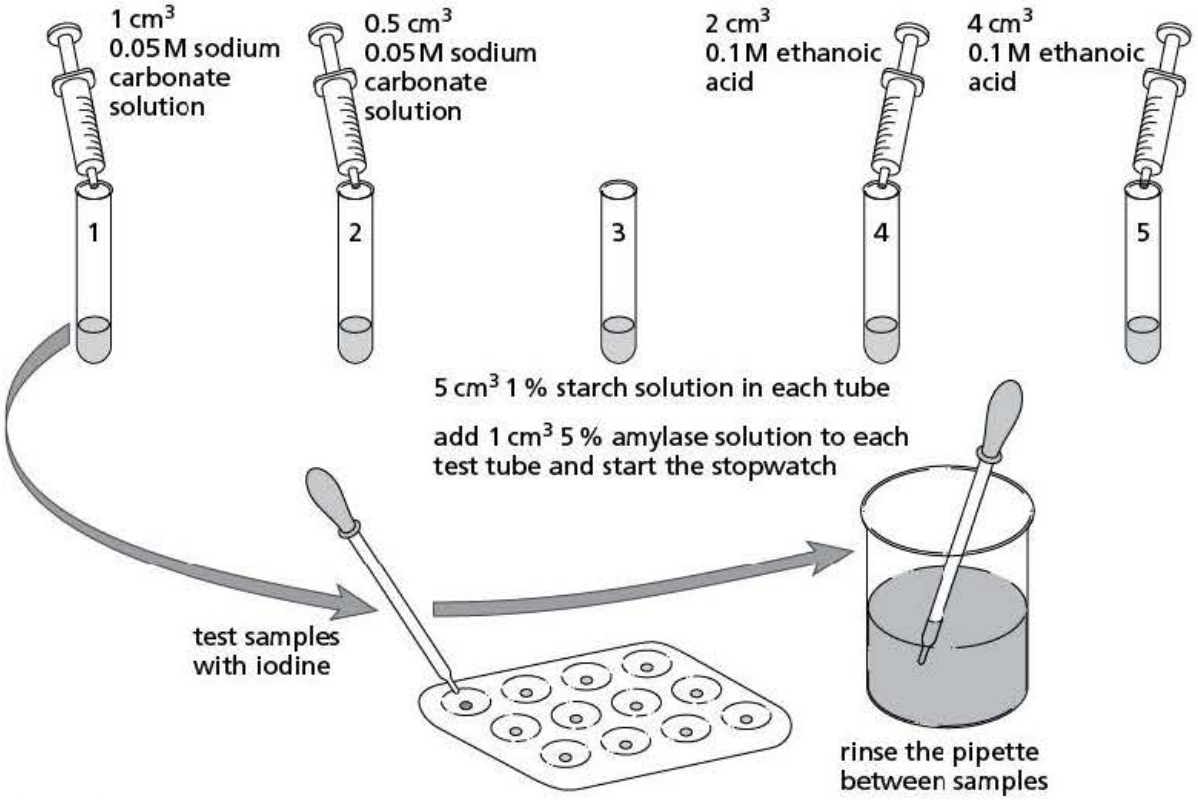

Figure 1

1 Wear eye protection.

2 Label the test tubes 1 to 5.

3 Using the syringe, place 5 cm^3 1 % starch solution in each test tube.

4 Add the following amounts of acid or alkali (as indicated in the table) to the appropriate tubes. Use a clean syringe when changing from sodium carbonate solution to ethanoic acid.

Table 1

Tube	Chemical	Approximate pH	
1	1 cm^3 0.05 M sodium carbonate solution	9	(alkaline)
2	0.5 cm^3 0.05 M sodium carbonate solution	7–8	(slightly alkaline)
3	nothing	7	(neutral)
4	2 cm^3 0.1 M ethanoic (acetic) acid	6	(slightly acidic)
5	4 cm^3 0.1 M ethanoic (acetic) acid	3	(acidic)

5 Using a pipette, place a drop of 0.01 M iodine solution into each cavity of a cavity tile.

6 Place 1 cm^3 of 5 % amylase solution into each of the test tubes.

7 *Gently* agitate the test tube to mix the contents. Take care to avoid spills.

8 Using a clean dropping pipette, remove a small sample from each tube in turn and let one drop fall onto one of the iodine drops on the cavity tile. Return the remainder of the solution in the pipette to the appropriate tube.

9 Rinse the pipette in a beaker of water between samples.

10 When any of the samples no longer gives a blue colour, note the time.

11 Continue until samples from all five tubes no longer produce a blue colour with iodine, but do not continue for more than 15 minutes.

12 Measure the pH of the solutions from each of the tubes by placing a drop from each onto pH paper and compare with a colour chart of pH values.

Method

Complete the following sentences:

1 The pipette was rinsed between taking samples in order to

prevent ..... . [1]

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 ..... by the enzyme ..... . [2]

Results and calculations

Make a note of your observations below.

Using a piece of graph paper plot a graph of your results.

At what pH was the enzyme, amylase, most active? [2]

Conclusions

1 How did pH affect enzyme activity? [1]

.....

.....

2 What patterns did you see? [1]

.....

.....

3 Can you explain these patterns? [2]

.....

.....

Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Describe and explain what you think the activity of amylase would be in the stomach, where the pH is about 2. [2]

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6.1 Is chlorophyll necessary for photosynthesis?

Aim

To investigate whether chlorophyll is necessary for photosynthesis.

Theory

The equation for photosynthesis is given below:

$$6CO_2 + 6H_2O \text{ (plus sunlight and chlorophyll)} \rightarrow C_6H_{12}O_6 + 6O_2$$

According to this equation, chlorophyll is necessary for photosynthesis.

Apparatus

- ☐ plant with variegated leaves (e.g. a geranium)
- ☐ heat-proof tile
- ☐ hot water from a kettle
- ☐ 2 glass beakers
- ☐ test tube
- ☐ forceps
- ☐ alcohol (ethanol)
- ☐ white tile
- ☐ 0.01 M iodine solution
- ☐ stopwatch
- ☐ goggles

Procedure

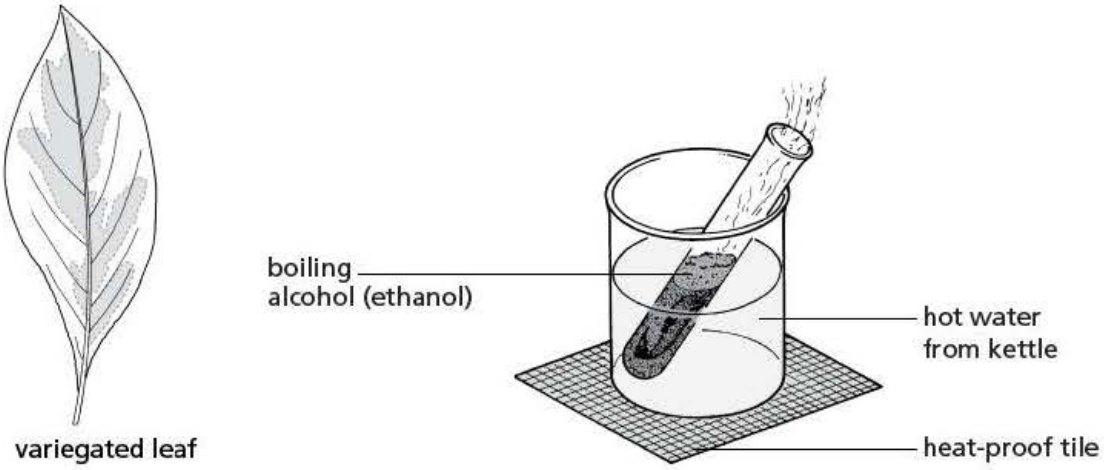

Figure 1

1 Wear eye protection.

2 Remove a variegated leaf from a plant.

3 Draw a diagram of this leaf, noting areas where there is chlorophyll (green) and areas where there is none.

4 Remove the chlorophyll from the leaf by using the following method:
   (a) Half fill a beaker with hot water from a kettle.
   (b) Dip the leaf in the hot water, using forceps, and leave for 30 seconds.
   (c) Place the leaf in a test tube and push to the bottom.
   (d) Cover the leaf with alcohol (ethanol) and add the test tube to the beaker of water.
   (e) Let the alcohol (ethanol) boil and watch as the chlorophyll is dissolved in the alcohol (ethanol).
   (f) Pour the alcohol (ethanol) into a spare beaker.
   (g) Using the forceps, remove the leaf and flatten out onto a white tile.

5 Add a few drops of 0.01 M iodine solution to the leaf.

6 Draw a diagram of your observations of the leaf.

Method

1 Explain why it is important to remove the chlorophyll from the leaf. [1]

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.....

.....

2 Why is the leaf submerged in hot water from a kettle? [1]

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Results and calculations

Make a note of your observations, and draw diagrams of your observations below. [2]

Conclusions

1 What patterns did you observe? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

1 Predict what would happen to the formation of starch if part of a leaf on a plant was masked with foil. [1]

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2 Produce a plan of how you would carry out an investigation to test your prediction. [3]

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6.2 Is light necessary for photosynthesis?

Aim

To investigate whether light is necessary for photosynthesis.

Theory

The equation for photosynthesis is given below:

$$6CO_2 + 6H_2O \text{ (plus sunlight and chlorophyll)} \rightarrow C_6H_{12}O_6 + 6O_2$$

According to this equation, light is necessary for photosynthesis.

Apparatus

- ☐ plant with green leaves that has been left in darkness for a few days, so the leaves become destarched
- ☐ aluminium foil
- ☐ heat-proof tile
- ☐ beaker of hot water from a kettle
- ☐ scissors
- ☐ test tube
- ☐ alcohol (ethanol)
- ☐ 0.01 M iodine solution
- ☐ goggles

Procedure

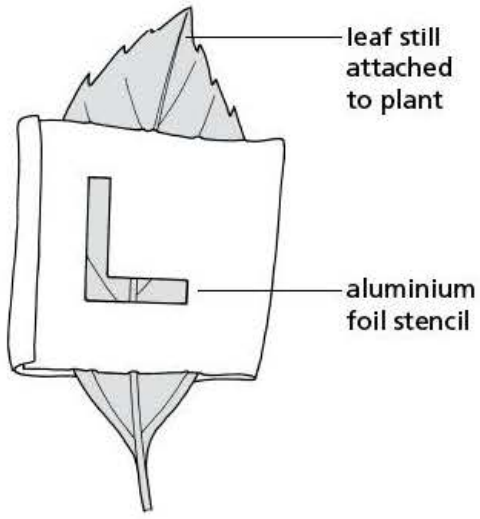

Figure 1

1 Wear eye protection.
2 Cut a shape into a piece of aluminium foil.
3 Attach the foil to a destarched leaf on the plant.
4 Position the plant in sunlight and leave for 6 hours.
5 Remove the chlorophyll from the leaf and test the leaf for starch (see **Experiment 6.1**).

Method

1 Why is aluminium foil used? [1]

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2 Other than placing the plant in a dark cupboard for a few days, how else could the leaf have been destarched? [1]

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Results and calculations

Make a note and draw a diagram of your observations below. [2]

Conclusions

1 What patterns did you observe? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Explain how to design a 'control' experiment to show that the effect you have observed is not due to the aluminium foil preventing carbon dioxide from entering the leaf. This is a plan only. *You should not carry out the activity.* [2]

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6.3 Is carbon dioxide necessary for photosynthesis?

Aim

To investigate whether carbon dioxide is necessary for photosynthesis.

Theory

The equation for photosynthesis is given below:

$$6CO_2 + 6H_2O \text{ (plus sunlight and chlorophyll)} \rightarrow C_6H_{12}O_6 + 6O_2$$

According to this equation, carbon dioxide is necessary for photosynthesis.

Apparatus

- ☐ 2 destarched green plants
- ☐ plastic bags
- ☐ elastic bands
- ☐ soda lime and dilute sodium hydrogencarbonate solution
- ☐ 0.01 M iodine solution
- ☐ goggles

Safety!

To avoid direct contact with soda lime and sodium hydrogencarbonate solution and report any spillages immediately to teacher.

Soda lime is corrosive and damaging to the eyes. Only the teacher or technician should handle the soda lime.

Procedure

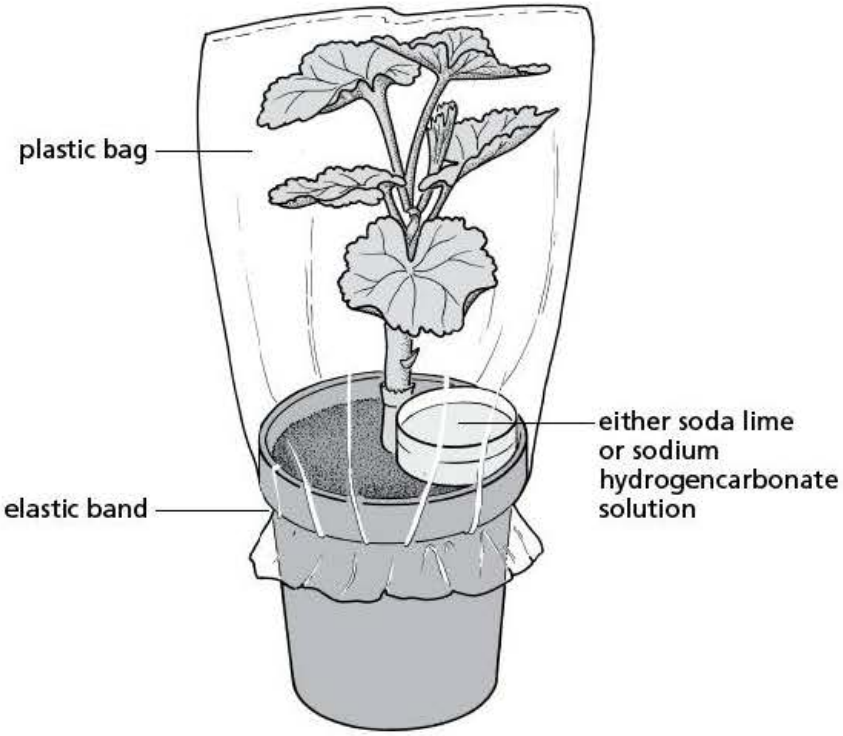

Figure 1

1 Wear eye protection.

2 Place a pot of soda lime onto one of the plant pots and a pot of sodium hydrogencarbonate solution to another plant pot.

3 Cover both of the plants with clear plastic bags and secure with elastic bands.

4 Place both plants in the light for 6 hours.

5 Remove the chlorophyll from a leaf from each plant and test the leaves for starch (see **Experiment 6.1**).

Method

Explain why soda lime was added to one of the plants and sodium hydrogencarbonate to the other. [1]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

1 What patterns did you observe? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Produce a plan of how you would carry out an investigation to test the effects of different concentrations of carbon dioxide on the rate of photosynthesis. [5]

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6.4 Is oxygen produced during photosynthesis?

Aim

To investigate whether oxygen is produced during photosynthesis.

Theory

The equation for photosynthesis is given below:

$$6CO_2 + 6H_2O \text{ (plus sunlight and chlorophyll)} \rightarrow C_6H_{12}O_6 + 6O_2$$

According to this equation, oxygen is produced during photosynthesis.

Apparatus

- ☐ Canadian pondweed or *Cabomaba caroliana* (please ensure this is sourced and disposed of appropriately)
- ☐ 2 glass beakers
- ☐ 2 glass funnels
- ☐ 2 test tubes
- ☐ ® Plasticine (modelling putty)

Procedure

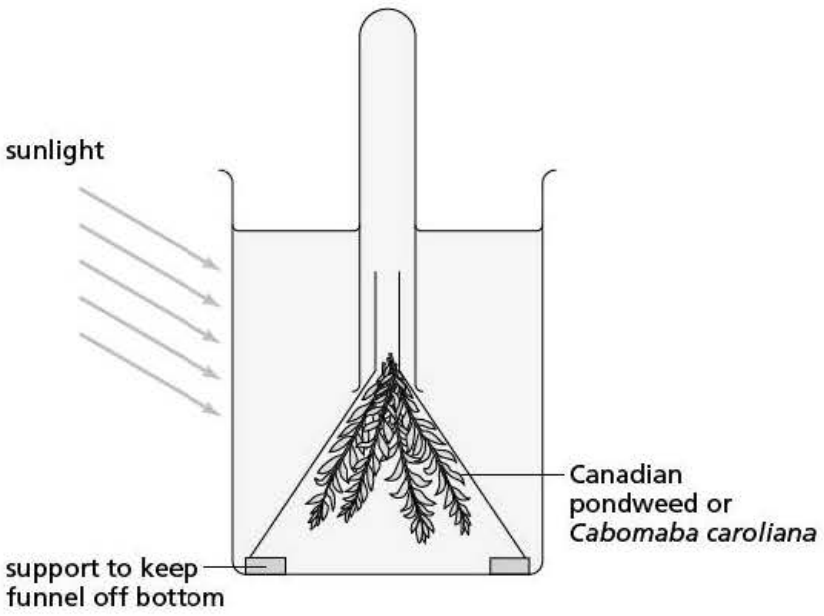

Figure 1

1 Wear eye protection.
2 Place a short-stemmed glass funnel over a piece of pondweed or *Cabomaba caroliana*. Rest the funnel on small blocks of Plasticine® in a beaker of water.
3 Fill a test tube with water. Turn this upside down and place over the end of the funnel.
4 Place the apparatus in sunlight.
5 Repeat this process to create a 'control' and place in a dark cupboard.
6 Make a note of your observations in the Results section.
7 Test that any gas produced is actually oxygen.
8 Wash hands thoroughly.

Method

1 Explain why the funnel is raised above the bottom of the beaker using Plasticine®. [1]

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2 Explain how to test whether the gas is oxygen. [1]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

1 What patterns did you observe? [1]

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2 How can you explain these? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

1 Explain how you can be sure that the differences observed were due to differences in light availability. [2]

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2 The oxygen content of pond water can be measured using an oxygen meter. What factors are likely to affect the oxygen content of ponds? [2]

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6.5 The effect of light intensity on the rate of photosynthesis

Aim

To investigate the effect of light intensity on the rate of photosynthesis.

Theory

Light is essential for photosynthesis. An increase in light intensity will increase the rate of photosynthesis.

Apparatus

- ☐ beaker of water
- ☐ saturated sodium hydrogencarbonate solution
- ☐ Canadian pondweed or *Cabomaba caroliana* (please ensure this is sourced and disposed of appropriately)
- ☐ paper clip
- ☐ bench lamp
- ☐ metre ruler
- ☐ stopwatch
- ☐ measuring cylinder
- ☐ goggles

Procedure

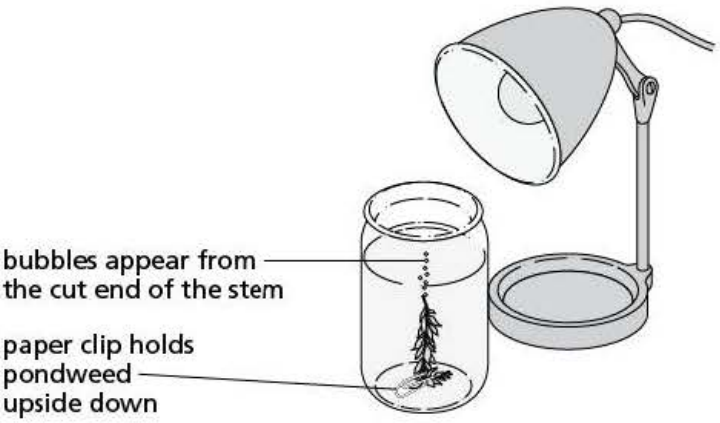

Figure 1

1 Wear eye protection.
2 Add 5 cm^3 of the saturated sodium hydrogencarbonate solution to a beaker of water.
3 Cut a pondweed or *Cabomaba caroliana* shoot to about 10 cm in length.
4 Carefully attach a paper clip to the tip of the shoot and place in the beaker of water.
5 Place a bench lamp close to the beaker and measure the distance between them. Switch on the lamp and start the stopwatch.
6 Count the number of bubbles produced over 1 minute.
7 Switch the lamp off and note your observations.
8 Repeat steps 5, 6 and 7, moving the lamp steadily further away: for example 10 cm further each time. Wash hands thoroughly.

Method

Explain why sodium hydrogencarbonate was added to the beaker of water. [1]

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Results and calculations

Make a note of your observations below. You should also include a table and graph of your results. Remember there is a relationship between the distance of the lamp from the plant and light intensity. [2]

$$\text{Light intensity} = \frac{1}{\text{distance}^2}.$$

Conclusions

1 How did light intensity affect the rate of photosynthesis? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Outline how you would plan to carry out an investigation into the effect of temperature on the rate of photosynthesis. [2]

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6.6 Gas exchange during photosynthesis

Aim

To investigate gas exchange during photosynthesis.

Theory

Carbon dioxide and oxygen are exchanged by a leaf during photosynthesis.

Apparatus

- ☐ 3 test tubes with bungs
- ☐ dilute hydrogencarbonate indicator
- ☐ 2 green leaves
- ☐ aluminium foil
- ☐ distilled water
- ☐ stopwatch
- ☐ measuring cylinder
- ☐ goggles

Procedure

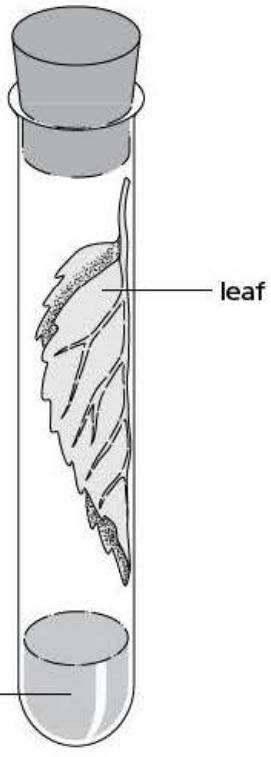

Figure 1

1 Wear eye protection.
2 Wash the inside of each of the three test tubes in tap water, then distilled water, then dilute hydrogencarbonate indicator.
3 Place 2 cm^3 of hydrogencarbonate indicator into each of the tubes.
4 Label the tubes 1–3.
5 Place a green leaf in tubes 1 and 2, making sure the leaves do not touch the indicator.
6 Place bungs into each of the tubes.
7 Cover tube 1 with aluminium foil.
8 Place all three tubes in sunlight.
9 Leave for 40 minutes.

Safety!
Wash hands after handling leaves.

Method

Describe how the indicator should change colour in the presence and absence of carbon dioxide. [2]

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Results and calculations

Make a note of your observations below. [2]

Conclusions

1 What did you observe? [1]

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2 How can you explain these observations? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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6.7 The importance of different mineral elements

Aim

To investigate the importance of different mineral elements for plant growth.

Theory

A full range of essential mineral elements are necessary for growth in plants.

Apparatus

- ☐ 5 test tubes
- ☐ 5 wheat seedlings
- ☐ 5 different culture solutions (normal culture solution; no nitrates; no calcium; no phosphates; distilled water)
- ☐ aluminium foil
- ☐ cotton wool
- ☐ distilled water
- ☐ goggles

Procedure

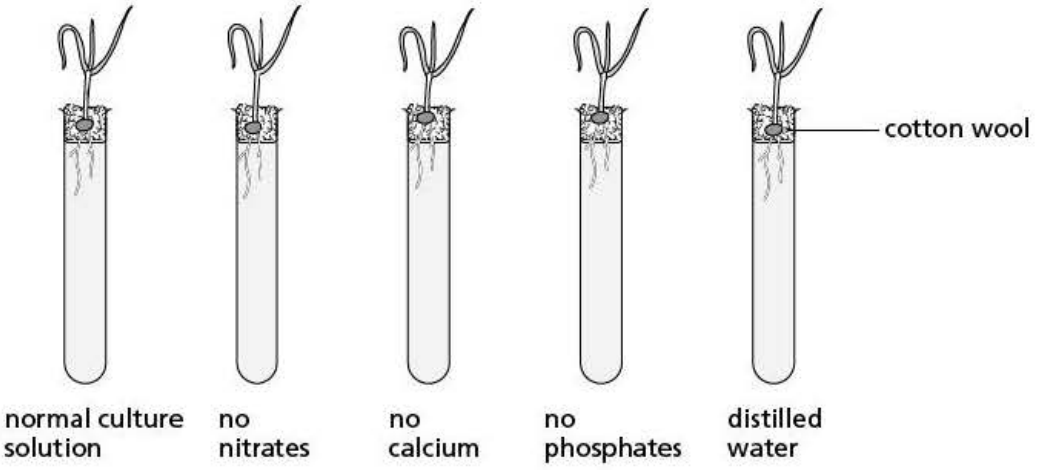

Figure 1

1. Wear eye protection.
2. Place the five wheat seedlings in the test tubes containing the five different water cultures.
3. Cover the test tubes with foil.
4. Leave the seedlings to grow in these solutions for 3 weeks, making sure you keep the tubes topped up with distilled water.

Method

Explain why the test tubes should be topped up with distilled water and not tap water. [2]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

1 What patterns did you observe? [1]

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2 How can you explain these? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

1 Plan an investigation to investigate the effectiveness of different fertilisers as provided by your teacher. [2]

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2 Observe a range of herbaceous dicotyledonous plants as provided by your teacher. Examine the root structure and identify the aerial parts of the plants. Make a note of your observations. [4]

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7.1 Energy from food

Aim

To measure the energy content of food.

Theory

The temperature rise of water that results from the burning of a sample of food gives a measure of the energy transferred.

Apparatus

- ☐ tripod
- ☐ nickel crucible and holder
- ☐ Bunsen burner and heat-proof mat
- ☐ retort stand and clamp
- ☐ metal can
- ☐ measuring cylinder
- ☐ water
- ☐ stirrer
- ☐ thermometer
- ☐ food sample (no nuts)
- ☐ goggles

Procedure

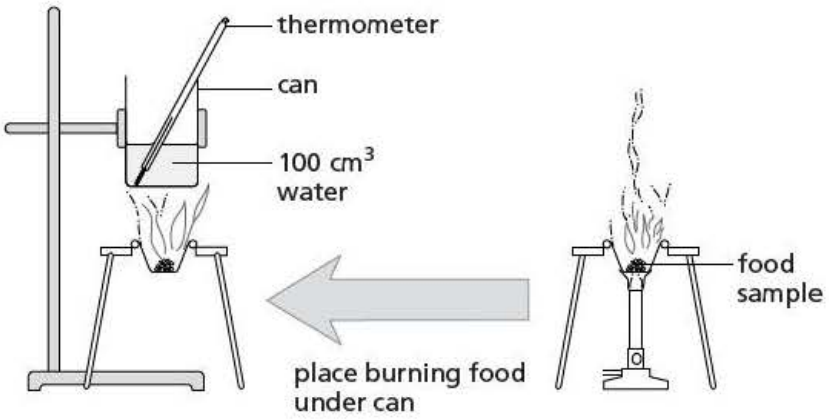

Figure 1

1 Wear eye protection.

2 Set up the apparatus as shown in the diagram above.

3 Place 100 cm^3 of cold water in the metal can.

4 Make a note of the temperature of the water.

5 Add 1 g of your food sample to the nickel crucible and heat it with a Bunsen flame until it begins to burn.

6 Place the crucible under the can of water until the food stops burning.

7 Stir the water gently and note the new temperature.

8 Ensure care with the burning food, and with the can of very hot water.

Method

1 Explain what you should do if the flame goes out before all of the food is burnt. [2]

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2 Make a note of the safety precautions to be taken. [2]

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Results and calculations

1 Make a note of the temperature readings below. [2]

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2 Use the following formulae to calculate the quantity of energy transferred to the water from the burning food. [2]

Let the rise in water temperature be T°C (remember to subtract the first temperature from the second temperature to work out the rise)

100 cm^3 cold water weighs 100 g

To raise 1 g water by 1 °C requires 4.2 joules

To raise 100 g water by 1 °C requires 100 × 4.2 joules

To raise 100 g water by T °C requires T × 100 × 4.2 joules

1 g burning food produced 420 × T joules

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Conclusions

1 How did the burning food affect the temperature of the water? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

1 Think about the main food type contained in your food sample – for example, carbohydrate, protein or fat. How do you think your results would compare if you burnt a similar sample of a food containing a different food type? [2]

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2 Research information from secondary sources to check your answer to Extension question 1. [2]

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3 Using a piece of graph paper plot a graph to compare the energy content of a range of your favourite foods.

8.1 Transport in vascular bundles

Aim

To investigate the transport of water in vascular bundles.

Theory

Water travels up the vascular bundles in plants.

Apparatus

- ☐ celery stalk with leaves
- ☐ 1 % methylene blue solution
- ☐ glass beaker
- ☐ stopwatch
- ☐ goggles

Procedure

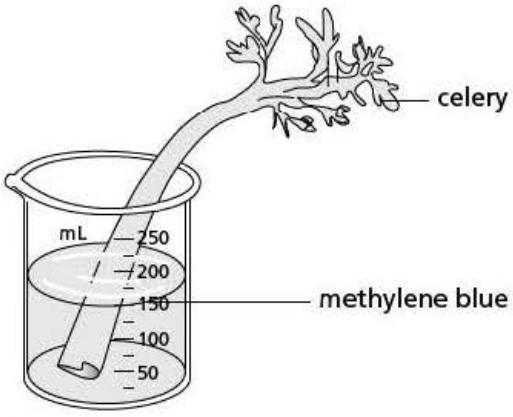

Figure 1

1. Wear eye protection.
2. Add the celery stalk to a solution of methylene blue, ensuring the bottom of the stem is submerged in the dye.
3. Leave the apparatus in the light for at least 30 minutes.
4. Make a note of your observations in the Results section.
5. Wash hands after handling plant stems.

Method

The ..... the stem of celery is left in the solution, the ..... the solution travels up the stem.

Results and calculations

Make a note of your observations below. [2]

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Conclusions

How can you explain your observations? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Outline a procedure for identifying which vessels of the vascular bundle are responsible for the transport of water. [2]

8.2 Rates of water uptake in different conditions

Aim

To investigate the rate of water uptake in a plant shoot under different conditions.

Theory

The rate of uptake of water in a plant shoot is affected by a number of different environmental factors.

Apparatus

- ☐ leafy shoot
- ☐ potometer
- ☐ water
- ☐ stopwatch

Procedure

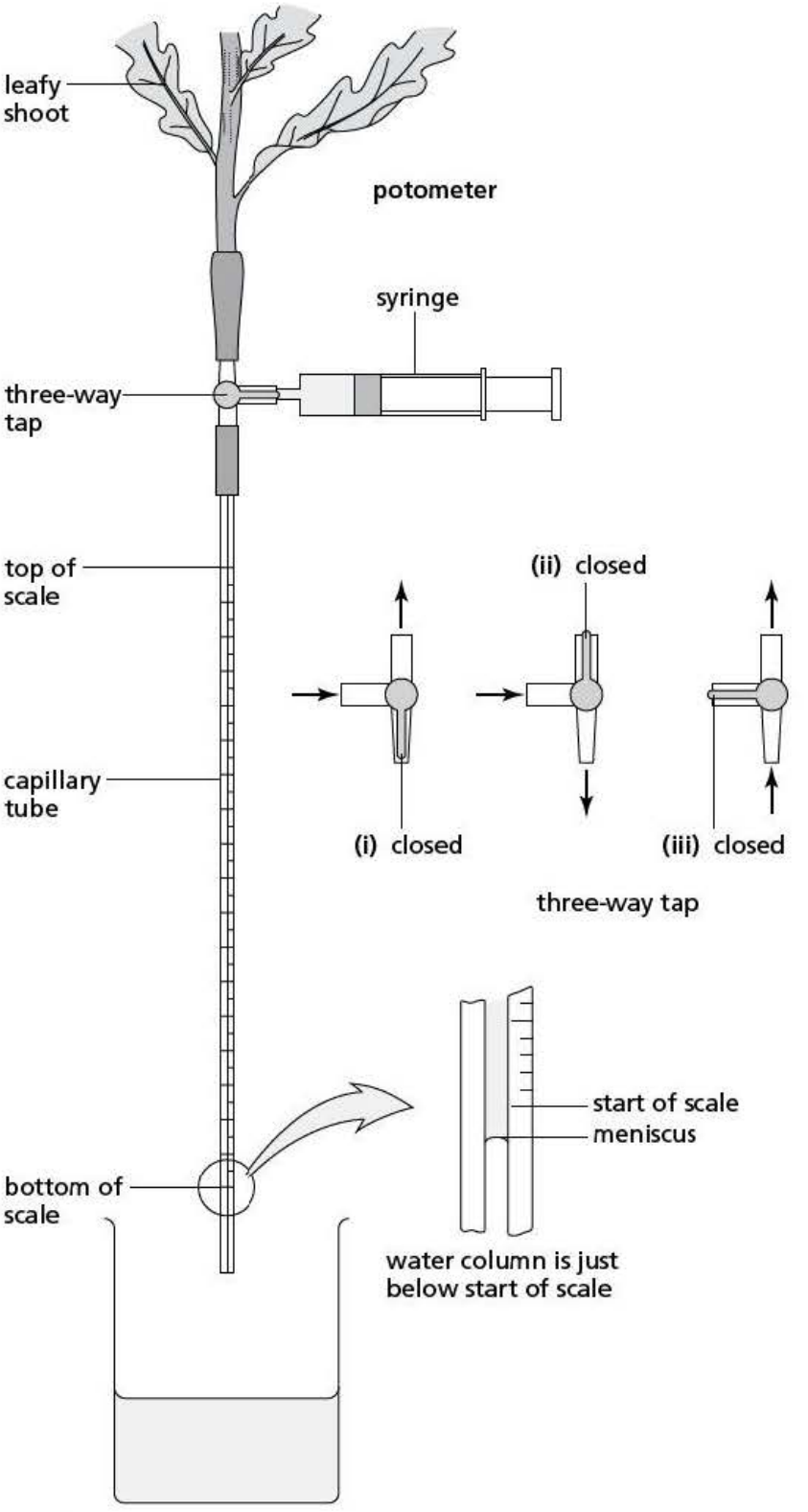

Figure 1

1 Without adding the leafy shoot, set up the apparatus as shown in the diagram above, in a part of the room that is not in direct sunlight.

2 Turn the three-way tap downwards and push the syringe until water comes out of the rubber tubing at the top.

3 Now add the leafy shoot.

4 Turn the three-way tap upwards and press the syringe so that water comes out of the bottom of the capillary tube. Then turn the tap horizontally.

5 As the leaves transpire, water will be drawn from the capillary tube.

6 Record the distance moved by the water meniscus after 30 seconds.

7 Turn the tap upwards, and using the syringe push more water to the bottom of the capillary tube. Turn the tap horizontally again.

8 Wash hands after handling plant stems.

Method

1 Outline **three** environmental conditions that could be changed to investigate their effect on water uptake. [2]

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2 Focus on just **one** of these conditions and carry out an investigation into its effect on the rate of water uptake. Outline your procedure below and check this with your teacher before you begin your investigation. [2]

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Results and calculations

Make a note of your observations below. Include a table of results. [2]

Conclusions

1 How did the factor you chose to investigate affect the rate of water uptake? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Outline a further investigation to test one other factor that could affect water uptake. [2]

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

Aim

To investigate which side of a leaf loses more water vapour.

Theory

The lower surface of the leaf has more stomata than the top surface, so potentially will lose more water.

Apparatus

- ☐ 4 leaves (as close to the same size as possible)
- ☐ Vaseline® (petroleum jelly)
- ☐ newspaper to protect bench
- ☐ retort stand
- ☐ cotton thread

Procedure

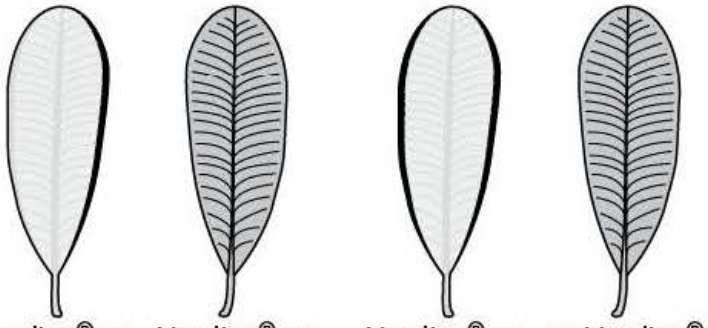

Figure 1

1 Treat each of the leaves as follows:
   - Leaf 1: Vaseline® on the lower surface only.
   - Leaf 2: Vaseline® on the upper surface only.
   - Leaf 3: Vaseline® on both sides.
   - Leaf 4: No Vaseline® on either side.

2 Add Vaseline® to the end of each leaf stalk.

3 Suspend the leaves from a retort stand on cotton thread for a few days.

4 Make a note of your observations. Wash hands after handling plant stems.

Method

Explain why Vaseline® is added to the cut end of each leaf stalk. [2]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

1 What patterns did you observe? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Outline an investigation to quantify the amount of water loss from plants grown in the science laboratory at room temperature but at different levels of light intensity. [2]

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9.1 Physical activity and pulse rate

Aim

To investigate the effect of physical activity on pulse rate.

Theory

Pulse rate is affected by a range of factors, including physical activity.

Apparatus

- ☐ aerobics bench or step
- ☐ stopwatch

Procedure

Measuring resting pulse rate

1. Practise measuring your pulse rate by finding your pulse in your wrist or neck.
2. Count the number of beats over the duration of 30 seconds. Double your answer. This is your resting pulse rate, measured in beats per minute.

Effect of physical exercise on pulse rate

1. Make a record of your resting pulse rate as described above.
2. Exercise for 1 minute. Measure your pulse rate again and record your findings.
3. Allow your pulse rate to return to normal (your resting pulse rate).
4. Repeat this activity for 2, 3, 4 and 5 minutes of exercise.

Method

1 State your prediction, giving reasons. [2]

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2 Outline the essential safety procedures required for this activity.
Check these with your teacher before you begin. [2]

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3 How could the measurement of your pulse rate be made easier for you, or more accurate? [1]

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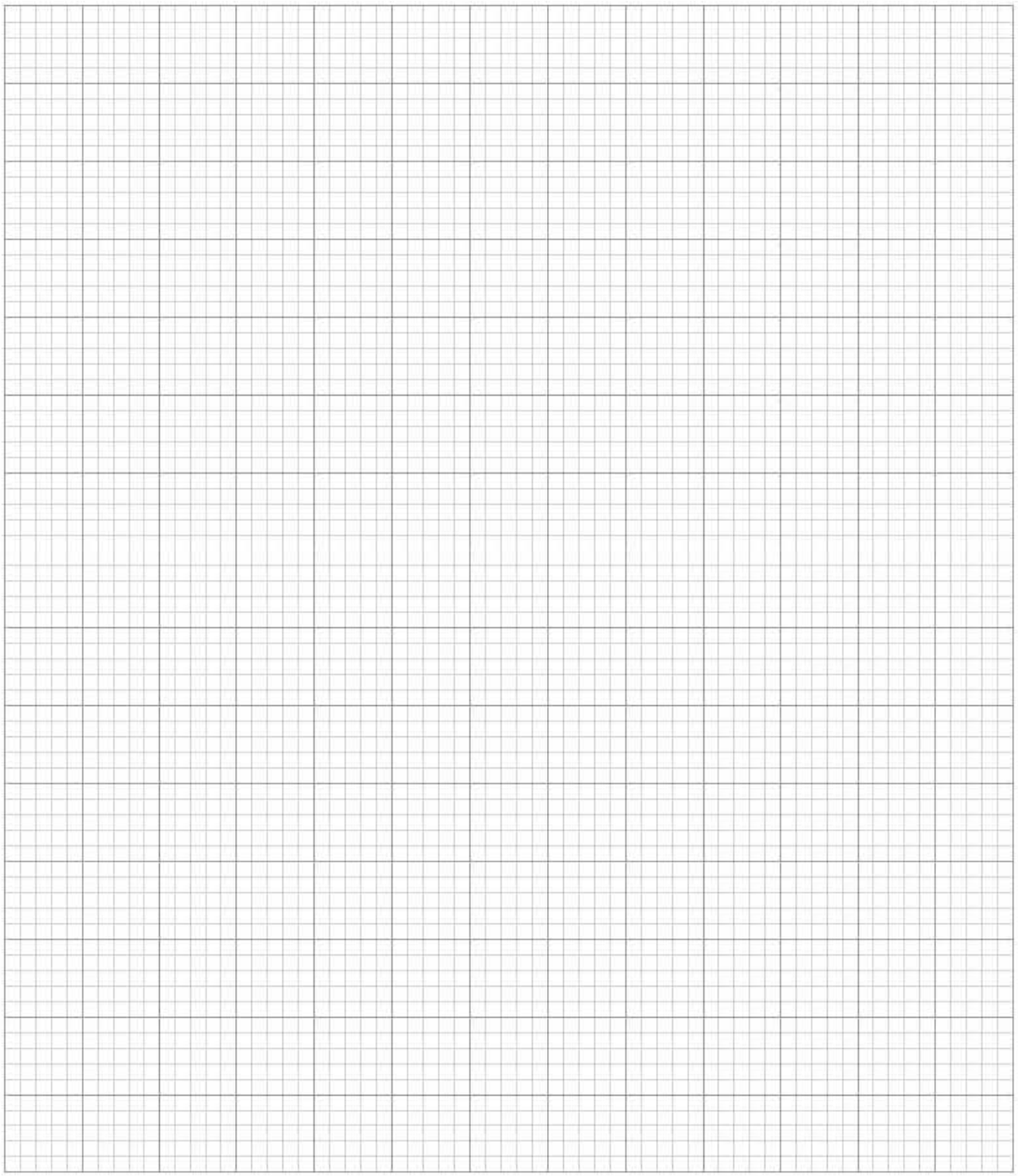
Results and calculations

Draw a table of your results below. Include a graph to represent your data. [4]



Conclusions

1 State the effect of physical activity on pulse rate. [1]

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2 Explain as clearly as you can, using your scientific knowledge, the reasons for the observations you made. [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

What are some of the other factors that could affect pulse rate? How might the effect of these factors on pulse rate be investigated? [4]

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10 Diseases and immunity

No practical experiments are provided for this chapter. Discuss with your teacher the current developments and emerging research in this area.

11.1 Oxygen in exhaled air

Aim

To investigate the relative amount of oxygen in exhaled air.

Theory

Exhaled air will contain less oxygen than inhaled air.

Apparatus

- ☐ bowl of water
- ☐ screw-top jar with two lids, one plain and the other with a candle holder
- ☐ silicon tube
- ☐ candle and wire holder
- ☐ sterilising fluid
- ☐ stopwatch

Procedure

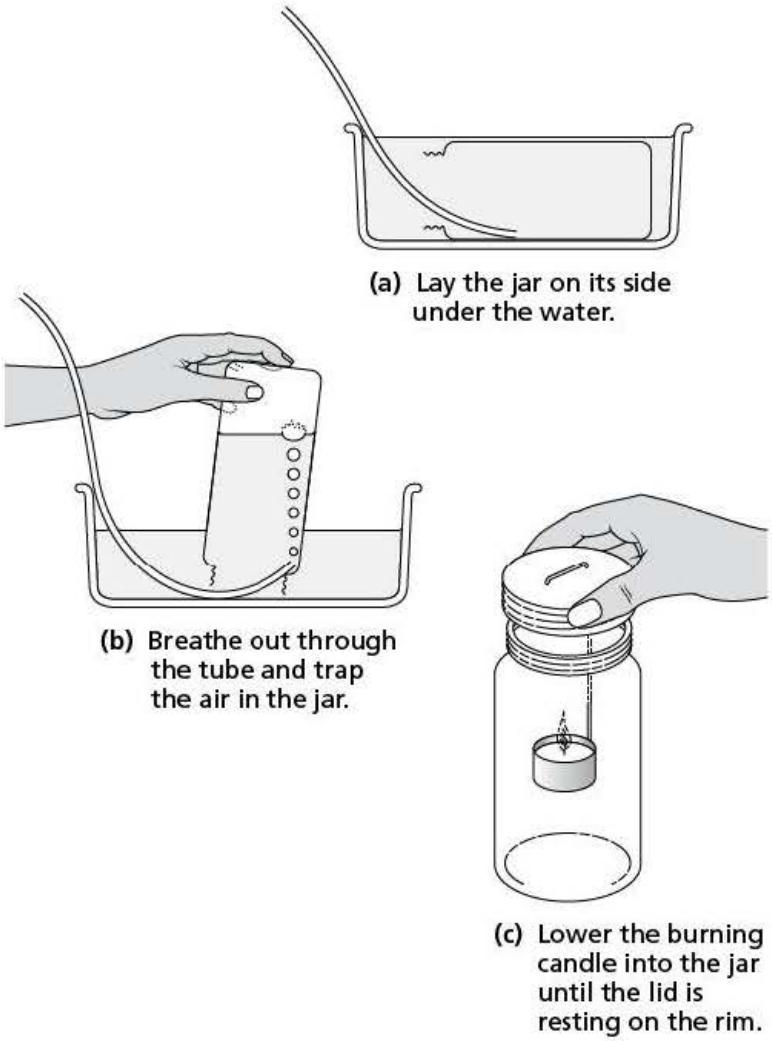

Figure 1

1. Place the screw-top jar on its side in the bowl of water, without the lid on.
2. Put one end of the tube in the mouth of the jar, leaving the mouth piece out of the water.
3. Turn the jar upside down, ensuring the water and tubing remain inside.
4. Close your finger over the mouth piece while you inhale, and then breathe out again through the tube into the jar. Take care not to inhale water.
5. Place the screw–top back onto the jar under the water, and place it upright on the bench. Now carefully replace this lid with the second lid (the lid with candle holder).
6. Light the candle in the special wire holder.
7. Open the jar and lower the candle in its holder into the jar.
8. Count the number of seconds the candle stays alight.
9. Compare this with how long a candle stays alight in a fresh jar with ordinary air in it.

Safety!
The mouth pieces must be sterilised before re-use with another person. Refer to the CLEAPSS handbook and guidance for suitable steriliser fluids.

Method

1 Outline what you expect to observe. [1]

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2 Outline a way in which this type of enquiry could be enhanced with the use of ICT. [2]

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Results and calculations

Make a note of your measurements and observations below. [2]

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Conclusions

1 What patterns did you see? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

How do you think these results would compare if you had just finished carrying out some physical activity or exercise? Plan an investigation to find out how exercise affects the amount of oxygen in exhaled air. [2]

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11.2 Carbon dioxide in exhaled air

Aim

To investigate the relative amount of carbon dioxide in exhaled air.

Theory

Exhaled air will contain more carbon dioxide than inhaled air.

Apparatus

- ☐ 2 large test tubes
- ☐ lime water
- ☐ silicon tube
- ☐ delivery tubes and bungs prepared as indicated in the diagram below
- ☐ stopwatch
- ☐ goggles

Procedure

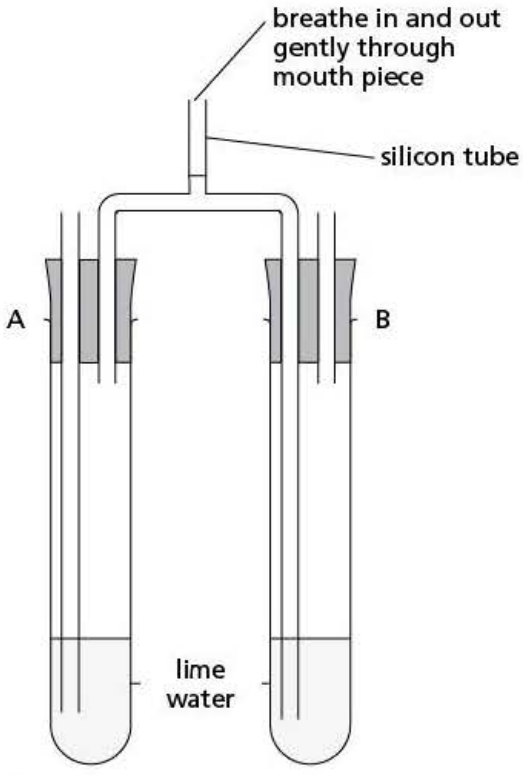

Figure 1

1 Wear eye protection.
2 Prepare two large test tubes, A and B, as shown in the diagram above.
3 Ensure that each tube contains clear lime water.
4 Place the mouth piece in your mouth.
5 Breathe in and out **gently** through the tubes for about 15 seconds.
6 Make a note of your observations.

Safety!

Avoid over-vigorous breathing.

Wash off splashes on skin, so that lime water is not rubbed into eyes.

The mouth pieces must be sterilised before re-use with another person. Refer to the CLEAPSS handbook and guidance for suitable steriliser fluids.

Take care to avoid spillages of lime water. Wash off spillages immediately. Limewater is skin and eye irritant.

Method

Explain why the tubes have been set up in the way they have. [2]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

How did exhaled air affect the lime water? How did inhaled air affect the lime water? How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

What factors might affect the rate at which the lime water changes appearance? How could you investigate this? [3]

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11.3 Volume of air in the lungs

Aim

To investigate the volume of air exchanged in the lungs.

Theory

The volume of air exchanged in the lungs can be measured using school laboratory equipment.

Apparatus

- ☐ bowl of water
- ☐ calibrated 5 litre plastic bottle
- ☐ silicon tube

Procedure

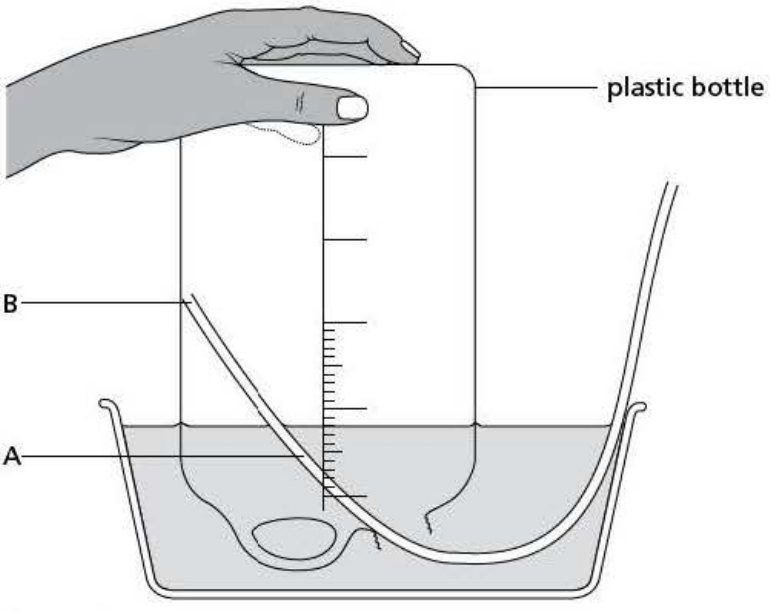

Figure 1

Safety!
Sterilise mouth pieces before re-use with another person. Refer to CLEAPSS guidance for suitable steriliser fluids.

Measuring maximum usable lung volume – vital capacity

1 Fill the plastic bottle with water and put on the screw top.

2 Fill the bowl with water to a depth of about 50 mm.

3 Hold the bottle upside down with its neck in the bowl of water. Remove the screw top.

4 Push the silicon tube into the bottle so that the end is at position A, shown in the diagram. Note that the bottle is still filled with water, not mostly filled with air as the diagram show.

5 Take a deep normal breath and exhale as much air as possible through the tubing and into the bottle. Take care not to inhale water.

6 Make a note of the volume of air exhaled.

Measuring the volume exchanged in normal breathing – tidal volume

1 Set up the apparatus as shown in the diagram, with the end of the tubing at position B, and the water level outside and inside the bottle the same.

2 Blow out any water in the tubing. Take care not to inhale water.

3 Breathe quietly in and out through the tube.

4 Make a note of the volume of air exchanged. Take care with spilt water, report spillages immediately.

Method

1 When measuring tidal volume, the end of the tubing should be placed at position

..... and when measuring vital capacity it should be placed at position

..... .

2 Volume of air is measured in ..... .

Results and calculations

Make a note of your measurements below. [2]

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Conclusions

1 Calculate the difference between your vital capacity and tidal volume. [1]

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2 What might explain the difference? [1]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Plan an investigation into the effect of exercise on the rate and depth of breathing. Use your scientific knowledge to make a prediction. [5]

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12.1 Using up oxygen during respiration

Aim

To investigate whether oxygen is taken up in respiration.

Theory

Aerobic respiration is a cellular process summarised by the following equation:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$$

Oxygen is used up in this process.

Apparatus

- ☐ respirometer
- ☐ germinating seeds
- ☐ seeds killed by boiling
- ☐ cotton wool
- ☐ soda lime
- ☐ goggles

Safety!

Soda lime is corrosive and damaging to the eyes. Only the teacher or technician should handle the soda lime.

Procedure

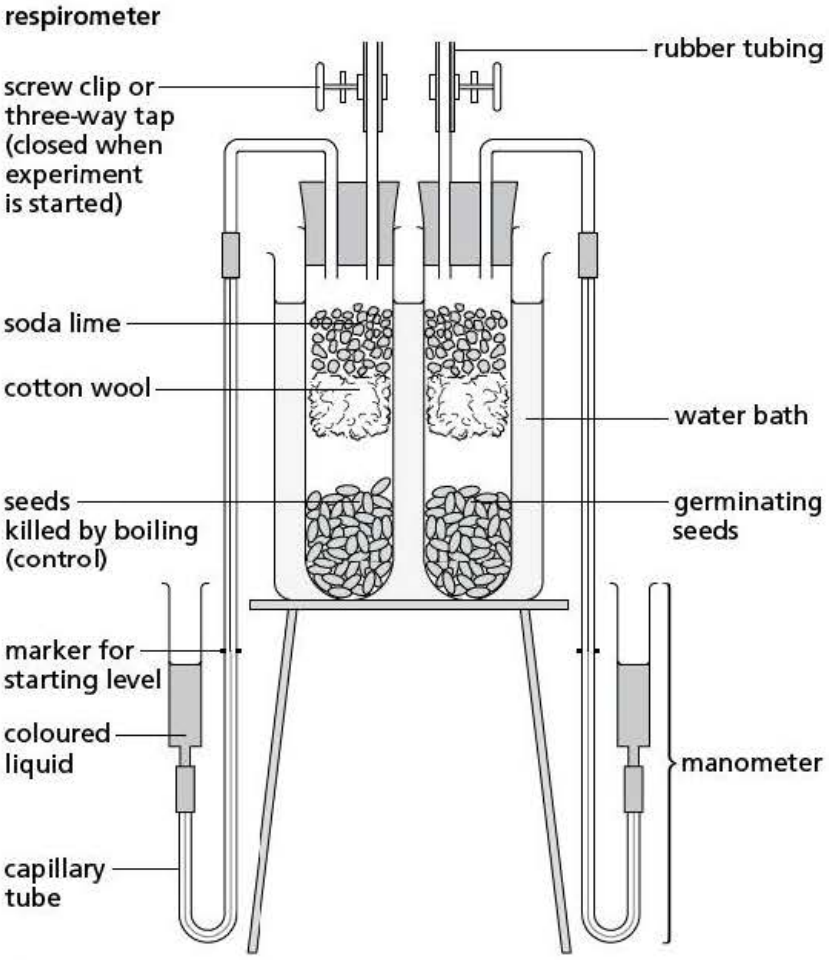

Figure 1

1 Wear eye protection.

2 Set up the respirometer as shown. The water bath temperature should be 30 °C.

3 Add the germinating seedlings to one tube and the dead seedlings to the other.

4 Open the screw clips to ensure the coloured liquid is at the starting level.

5 Close the screw clips.

6 Leave for 30 minutes and then observe the level of the coloured liquid in each capillary tube.

Method

Complete the following sentences:

1 ..... is used to absorb the carbon dioxide given out by the seedlings. [1]

2 The beaker of water is used to keep the ..... of the tubes as constant as possible. [1]

Results and calculations

Make a note of your observations below. [2]

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Conclusions

1 How did respiration in the germinating seedlings affect the level of liquid in the capillary tube? [1]

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2 Explain the reasons for any changes in the level of liquid in the capillary tubes. You should account for the differences observed between the dead seedlings and the germinating seedlings. [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Explain how you could test whether it is in fact oxygen being used up by the seedlings. [2]

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12.2 Releasing energy in respiration

Aim

To investigate whether energy is released by germinating seeds.

Theory

Aerobic respiration is a process summarised by the following equation:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy released}$$

Energy is released during the process.

Apparatus

- ☐ germinating seeds
- ☐ dead seeds (boiled for 5 minutes and then cooled)
- ☐ 2 vacuum flasks
- ☐ 2 thermometers
- ☐ cotton wool
- ☐ goggles
- ☐ 70 % ethanol or 1 % VirKon solution
- ☐ CLEAPSS Disinfectants Student Safety Sheet

Procedure

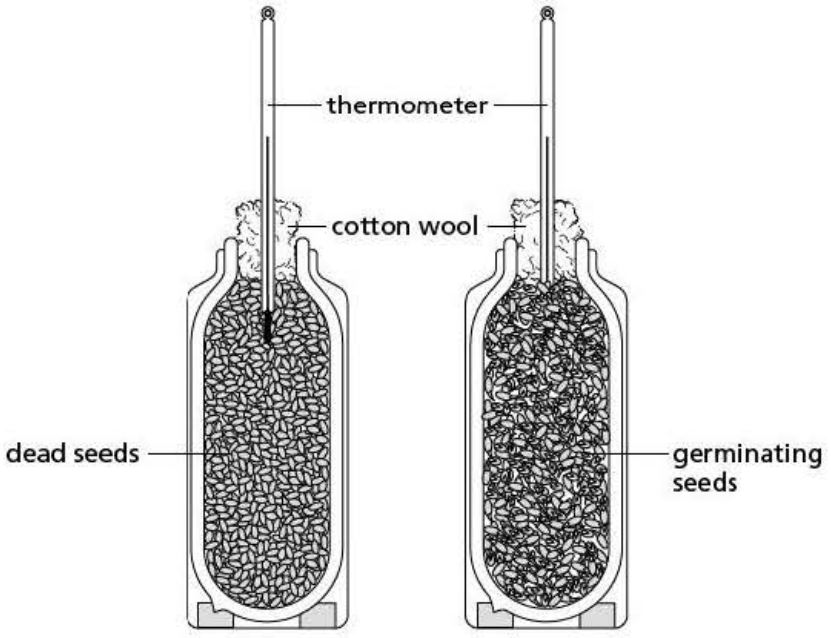

Figure 1

1 Wear eye protection.
2 Fill a vacuum flask with the germinating seeds and another with the dead seeds.
3 Place a thermometer in each flask, ensuring that the bulb is amongst the seeds.
4 Plug the mouth of each flask with cotton wool.
5 Leave for several days.
6 Record differences in temperature at regular intervals over this period.
7 Sterilise seeds in the flasks at the end of the experiment using 70 % ethanol or 1 % VirKon.

Method

Outline safety precautions. [3]

Results and calculations

Make a note of your observations below. [2]

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Conclusions

How can you explain your observations? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

How do you think bacteria and fungi left on the surface of the seeds would affect the results? [2]

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12.3 Anaerobic respiration in yeast

Aim

To investigate anaerobic respiration.

Theory

Anaerobic respiration is a process summarised by the following equation:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH \text{ alcohol (ethanol)} + 2CO_2 + \text{energy}$$

Apparatus

- ☐ 2 test tubes
- ☐ delivery tube
- ☐ rubber bung
- ☐ screw clip
- ☐ liquid paraffin
- ☐ lime water
- ☐ 1 % yeast suspension – made with boiled water, allowed to cool
- ☐ 5 % glucose solution – made with boiled water, allowed to cool
- ☐ stopwatch
- ☐ measuring cylinder
- ☐ goggles

Safety!

Take care to avoid spillages of lime water. Wash off spillages immediately. Limewater is skin and eye irritant.

Procedure

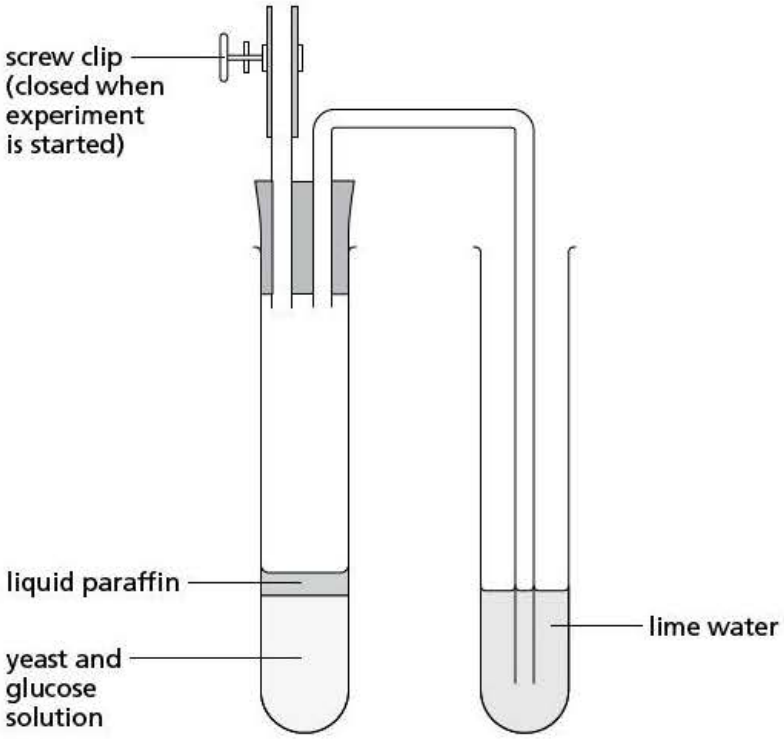

Figure 1

1 Wear eye protection.

2 Add 5 cm^3 of glucose solution and 1 cm^3 of yeast suspension to one of the test tubes and cover with a thin layer of liquid paraffin.

3 Set up the apparatus as shown in the diagram above.

4 Leave for 15–20 minutes.

Method

1 Explain why the glucose solution and the yeast suspension were made from boiled water. [2]

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2 Explain why the layer of paraffin was added. [2]

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Results and calculations

Make a note of your observations below. Make notes of what you observe happening in both of the tubes. [2]

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Conclusions

1 What caused the change in appearance of the lime water? [1]

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2 Explain whether your results support the word equation given for anaerobic respiration. [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

1 How could you demonstrate that the carbon dioxide produced by the yeast is produced by a living process? [2]

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2 What factors might affect the rate of production of carbon dioxide? How could you investigate these factors? [2]

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13 Excretion in humans

No practical experiments are provided for this chapter. Discuss with your teacher the current developments and emerging research in this area.

14.1 Gravitropism in pea radicles

Aim

To illustrate gravitropism in pea radicles.

Theory

Pea radicles grow vertically downwards, as they grow towards gravity.

Apparatus

- ☐ 20 peas (soaked in water for 24 hours and then germinated in moist blotting paper in a plastic bag for 3 days)
- ☐ clinostat
- ☐ 12 pins
- ☐ cork
- ☐ wide-mouthed jar

Procedure

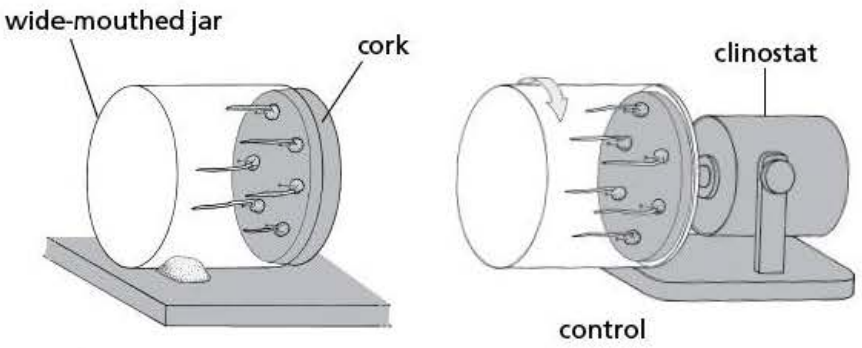

Figure 1

1 Choose 12 pea seedlings with straight radicles.

2 Pin six of these seedlings to the turntable of a clinostat so that the radicles are horizontal.

3 Pin another six seedlings to a cork that will fit in a wide-mouthed jar, and leave the jar on its side.

4 Place the clinostat and wide-mouthed jar in the same lighting conditions and temperature for 2 days.

5 Record your observations.

Method

Describe what a clinostat is. [1]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

1 How did gravity affect the pea radicles? [1]

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2 How can you explain your observations? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Explain whether the pea radicles are positively gravitropic or negatively gravitropic. [1]

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14.2 Phototropism in shoots

Aim

To illustrate phototropism in shoots.

Theory

Plant shoots grow towards the light.

Apparatus

- ☐ 2 potted seedlings (e.g. sunflower or runner bean) of similar size
- ☐ clinostat
- ☐ 2 cardboard boxes with a window cut into one side

Procedure

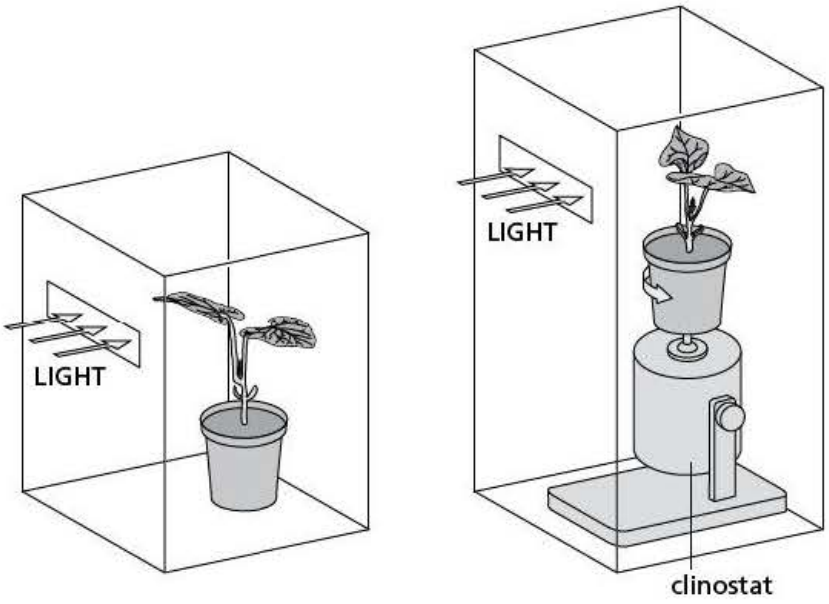

Figure 1

1. Water both of the potted seedlings.
2. Place each plant into a cardboard box, one of them on a clinostat.
3. Leave the plants for 2 days, and then record your observations.

Method

Explain which of the plants acts as the control, and why. [2]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

1 How did light affect the seedlings? [1]

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2 How can you explain your observations? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Explain how certain you can be that your conclusions can be applied to green plants generally. [2]

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14.3 Region of response

Aim

To investigate the regions in pea radicles that respond to the stimulus of gravity.

Theory

Not all regions of the pea radicle respond to the stimulus of gravity equally.

Apparatus

- ☐ 10 peas (soaked in water for 24 hours and then germinated in moist blotting paper in a plastic bag for 3 days)
- ☐ hairpin and cotton as in the photograph, with pot of black ink to dip the cotton into
- ☐ ruler
- ☐ 2 Petri dishes with lids
- ☐ 4 strips of moist cotton wool

Procedure

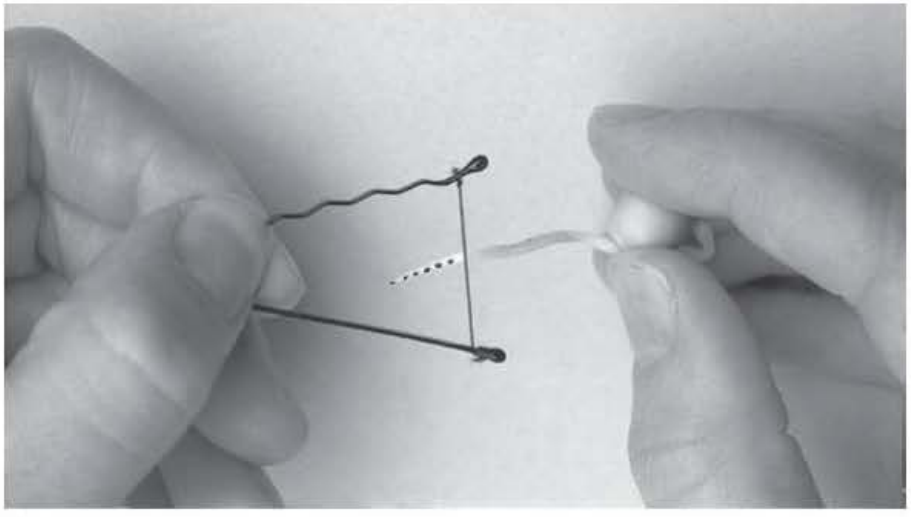

Figure 1

1. Select four pea seedlings with straight radicles about 25 mm long.
2. Mark all the pea radicles with lines about 1 mm apart, as in the photograph above.
3. Use the strips of moist cotton wool to wedge two seedlings in each of the two Petri dishes, as shown in the diagram on the next page.
4. Leave the dishes on their sides for 2 days, one dish (A) with the radicles vertical and the other dish (B) with the radicles horizontal.
5. Record your observations, using diagrams to help.

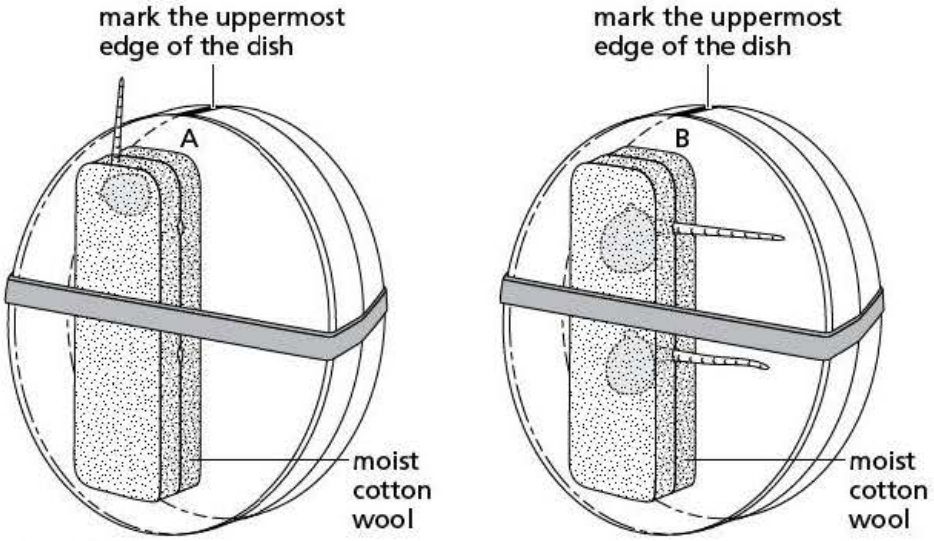

Figure 2

Method

Explain why one set of radicles was placed horizontally whilst the other set was placed vertically. [2]

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Results and calculations

Make a note of your observations below, using diagrams to help you. [2]

Conclusions

How can you explain your observations? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Explain whether or not you could conclude from this investigation that the region that responds to the stimulus of gravity is also the region that detects the stimulus. [2]

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15 Drugs

No practical experiments are provided for this chapter. Discuss with your teacher the current developments and emerging research in this area.

16.1 Insect-pollinated flowers

Aim

To identify the structures of an insect-pollinated flower.

Theory

Reproductive parts of insect-pollinated flowers can be observed using the eye and hand lens.

Apparatus

- ☐ insect-pollinated flower(s) from a local source, as provided by your teacher
- ☐ hand lens

Procedure

1. Cover cuts with waterproof dressings, or wear gloves. Wash hands thoroughly after activity.
2. View the insect-pollinated flower using a hand lens.
3. Draw a diagram of your observations, labelling the petals, stamens, filaments and anthers, carpels, style, stigma, ovary and ovules.

Method

Make a list of insect-pollinated flowers that can be found in your local environment. Check with your teacher and with secondary sources of information to identify which of these flowers will be appropriate and safe to use. [2]

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Results and calculations

Draw annotated diagrams below. Make sure you label petals, stamens, filaments and anthers, carpels, style, stigma, ovary and ovules. [3]

Conclusions

Summarise your observations. [2]

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16.2 The growth of pollen tubes

Aim

To observe the growth of pollen tubes.

Theory

Pollen tubes grow from pollen grains.

Apparatus

Method 1

- ☐ beaker containing solution of 15 g sucrose and 0.1 g sodium borate (see CLEAPSS recipe sheet and guidance) in 100 cm^3 water
- ☐ dropping pipette
- ☐ cavity slide and cover slip
- ☐ pollen grains
- ☐ light microscope
- ☐ stopwatch
- ☐ goggles

Method 2

- ☐ stigma from mature flower
- ☐ 2 microsccpe slides with cover slips
- ☐ 0.5 % methylene blue solution
- ☐ dropping pipette
- ☐ tweezers
- ☐ filter paper
- ☐ light microscope
- ☐ stopwatch
- ☐ goggles

Procedure

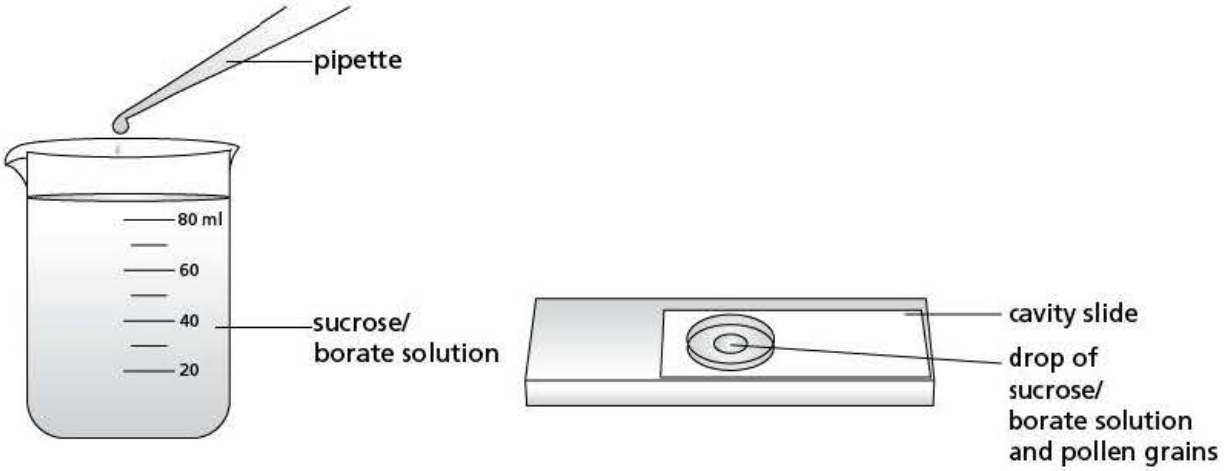

Figure 1

Method 1

1 Wear eye protection.

2 Put a drop of the sucrose/borate solution on the cavity slide.

3 Scatter pollen grains onto the drop of solution.

4 Cover the drop with a cover slip.

5 Examine under the microscope at regular 15-minute intervals. Note your observations, using annotated diagrams. It may be necessary for your teacher to set this up in advance of the lesson.

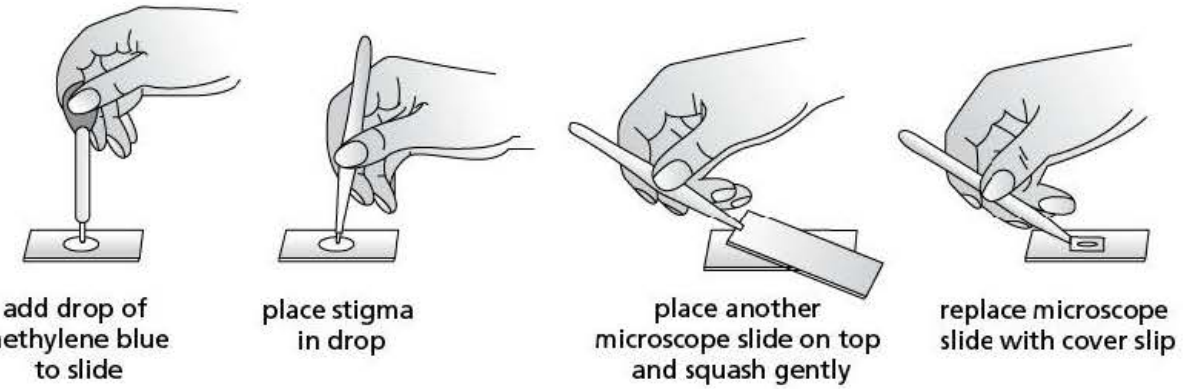

Figure 2

Method 2

1 Wear eye protection.

2 Remove the stigma from a mature flower.

3 Place a drop of the methylene blue solution on a microscope slide.

4 Place the stigma in the drop of methylene blue.

5 Place another microscope slide on top and squash gently.

6 Replace the microscope slide with a cover slip and then leave for 5 minutes.

7 Place a drop of water to one side of the cover slip and draw it under the cover slip using filter paper.

8 Examine the slide under the microscope and note your observations.

Method

1 List the names of some suitable plants that could be used in each of the methods. [2]

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2 Describe how you plan to transfer the pollen from your chosen plant in Method 1 to the drop of sucrose/borate solution on the microscope slide. [1]

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3 Which of the two methods did you find most effective for observing pollen tube growth? Give a reason why. [1]

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Results and calculations

Make a note of your observations, and draw your annotated diagrams below. [2]

Conclusions

How can you explain what you observed? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Repeat this experiment with pollen from a range of different plants provided by your teacher. [2]

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16.3 Germination: the need for water

Aim

To investigate the effect of water on the process of germination.

Theory

Germination is affected by a number of environmental conditions, including the availability of water.

Apparatus

- ☐ 3 containers with lids
- ☐ cotton wool
- ☐ soaked seeds

Procedure

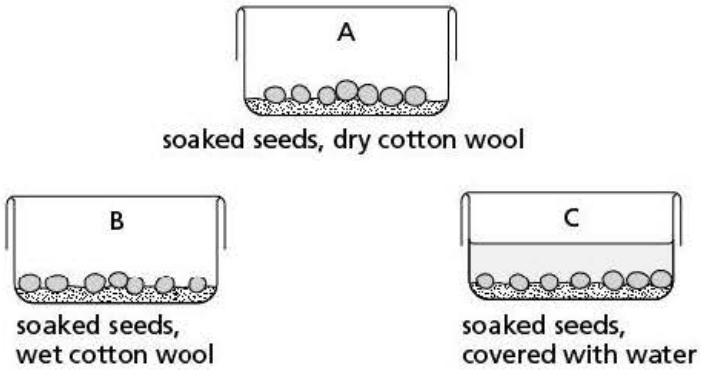

Figure 1

1. Label the containers A, B and C.
2. Place dry cotton wool in the bottom of each.
3. Add an equal number of soaked seeds to each of the containers.
4. Prepare the containers as follows:
   - A: cotton wool left dry
   - B: cotton wool is moist
   - C: seeds are completely covered with water.
5. Place lids onto each of the containers and leave at room temperature for a week.
6. Make a note of your observations.

Method

Write a prediction of what you think you will observe. [1]

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Results and calculations

Make a note of your observations below. [2]

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Conclusions

1 How did water affect germination? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

How might these results vary if using seeds from aquatic plants? [1]

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16.4 Temperature and germination

Aim

To investigate the effect of temperature on the process of germination.

Theory

Germination is affected by a number of environmental conditions, including temperature.

Apparatus

- ☐ soaked maize grains
- ☐ blotting paper
- ☐ opaque plastic bags
- ☐ paper clips
- ☐ ruler

Procedure

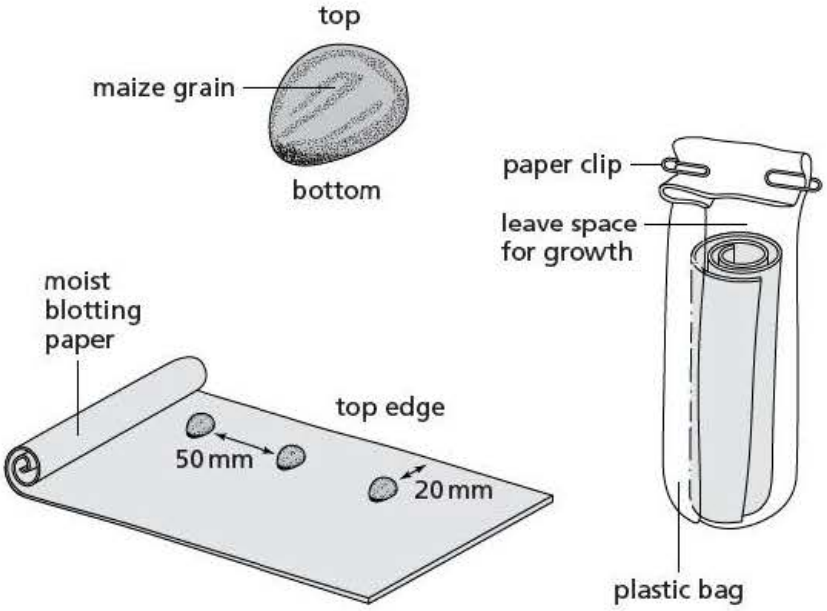

Figure 1

1 Cut three strips of blotting paper and moisten them.

2 Place an equal number of soaked maize seeds onto each strip.

3 Roll up the strips of blotting paper and place each into a plastic bag. Seal with paper clips.

4 Place a bag in each of the following locations:
- a refrigerator (at about 4 °C)
- in a room (at about 20 °C)
- on top of a radiator or in an incubator (at about 30 °C).

5 Leave for a week and then examine the seeds. Make a note of your observations.

Method

1 Outline the measures taken to rule out light as the factor affecting germination. [2]

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2 Using your knowledge of enzyme function, make a prediction as to what you will observe. [2]

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Results and calculations

Make a note of your observations below. Use a table to present your results. [2]

Conclusions

1 How did temperature affect germination? [1]

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2 How can you explain this? [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

1 Investigate the effect of temperature on germination of a range of different types of seeds, as provided by your teacher. Record your results. [2]

2 Plan an investigation into the growth of plants by measuring increase in height over several weeks. What are the factors that might affect growth over this time frame? [2]

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17 Inheritance

No practical experiments are provided for this chapter. Discuss with your teacher the current developments and emerging research in this area.

18 Variation and selection

No practical experiments are provided for this chapter. Discuss with your teacher the current developments and emerging research in this area.

19 Organisms and their environment

No practical experiments are provided for this chapter. Discuss with your teacher the current developments and emerging research in this area.

20 Biotechnology and genetic engineering

20.1 The effect of pectinase on fruit pulp

Aim

To investigate the effect of pectinase on fruit pulp.

Theory

Pectinase is an enzyme that catalyses the breakdown of pectin. Pectin forms part of the structure of plant cell walls.

Apparatus

- ☐ 2 stirring rods
- ☐ apple pulp
- ☐ 2 glass or plastic 250 cm^3 beakers
- ☐ 2 100 cm^3 measuring cylinders
- ☐ 2 funnels with filter paper
- ☐ stopwatch
- ☐ balance
- ☐ pectinase (follow manufactures guidelines for preparation, refer to safety instructions, and refer to CLEAPSS guidance)
- ☐ goggles and gloves

Procedure

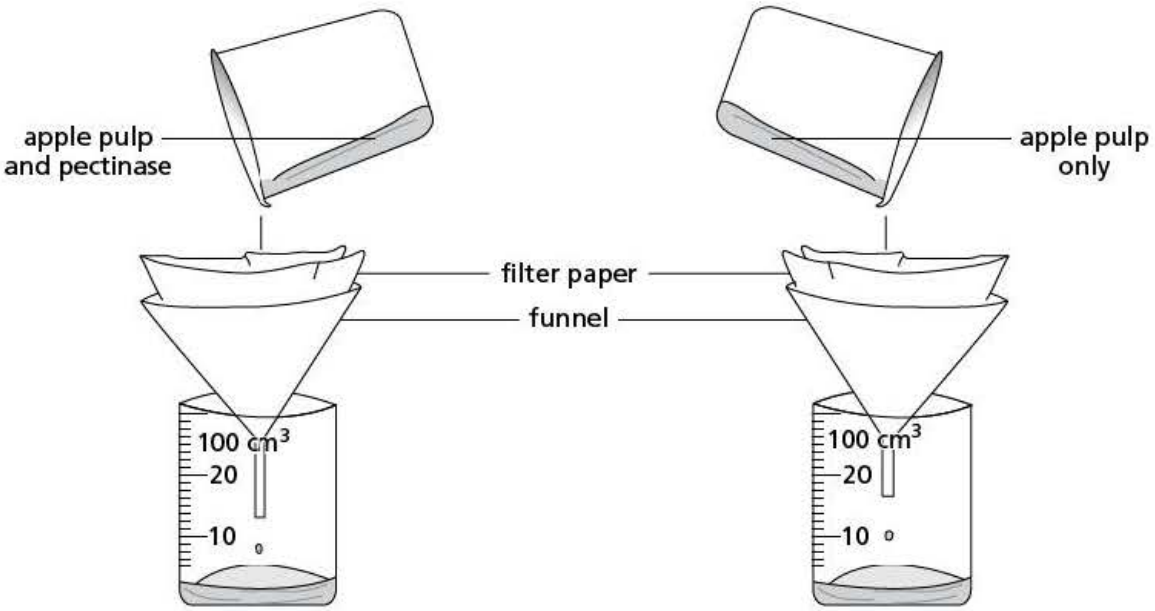

Figure 1

1 Wear eye protection and gloves.

2 Collect 100 cm^3 apple pulp from your teacher.

3 Transfer the pulp to a 250 cm^3 beaker.

4 Add 2 cm^3 of pectinase enzyme (care needed – see safety note), stir the mixture and leave it for about 5 minutes.

5 Place a funnel in the top of a 100 cm^3 measuring cylinder and line the funnel with a folded filter paper.

6 Transfer the pulp into the filter funnel and leave it in a warm place for up to 24 hours.

7 Other measuring cylinders could be set up in the same way, with pulp left to stand at different temperatures to compare the success of juice extraction.

8 Set up an identical control experiment without including pectinase.

Safety!

Take particular care to avoid skin or eye contact with the enzyme powder and solutions. Enzyme powder and solutions can cause allergies. Wipe up any spillages immediately and rinse the cloth thoroughly with water. Do not allow spillages to dry up.

Method

1 Outline the safety precautions to take when carrying out this investigation. [1]

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2 If using a range of temperatures to compare the success of juice extraction, list the temperature you will use below. Then draw a suitable table to collect your results in the Results and Calculations section. [1]

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Results and calculations

Make a note of your observations below.

What was the difference in the amount of fruit juice produced in each of the measuring cylinders?

What is the percentage difference? [2]

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Conclusions

1 How did pectinase affect fruit juice production? [1]

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2 Can you explain this? Relate your findings to your scientific knowledge. [2]

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Evaluation

Outline how this experiment could be improved, or made more reliable. [1]

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Extension

Outline how you would carry out an investigation into the effectiveness of biological washing powders. [2]

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21 Human influences on ecosystems

No practical experiments are provided for this chapter. Discuss with your teacher the current developments and emerging research in this area.

Practical Test past exam questions

Read the whole question before starting work.

1 You are provided with two specimens, **S1** (onion) and **S2** (potato).

(a) Make a labelled drawing of the cut surface of **S1**. [6]

(b) (i) State **one** visible similarity between **S1** and **S2**. [1]

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(ii) State **two** visible differences between **S1** and **S2**. [2]

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(c) Test samples of **S1** and **S2** for starch, using the following procedure:

- Cut a piece of **S1** that is approximately 1 cm^3.
- Chop and crush this sample using the tools provided.

- Fill one test tube half full of water. Label this tube **S1a**. Add the crushed sample of **S1** to this tube.
- Shake the test tube **S1a** well to mix the sample. Let the pieces of solid settle.
- Label another test tube **S1b**.
- Pour half of the liquid of test tube **S1a** into test tube **S1b**. Leave the solid pieces in test tube **S1a**.
- Test the contents of **S1a** for starch using the iodine solution provided.

(i) Record your observation of **S1** in Table 1.1. [1]

- Using clean test tubes labelled **S2a** and **S2b**, repeat the procedure in **(c)** with **S2**.

(ii) Record your observations of **S2** in Table 1.1. [1]

(d) (i) Describe how you would carry out a test for reducing sugar. Include all the safety precautions that you would take while carrying out this test. [4]

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At this stage you will need to attract the attention of your Supervisor by raising your hand. The Supervisor will fill the empty container with hot water.

- Test the contents of the two tubes labelled **S1b** and **S2b,** for reducing sugar.

(ii) Record your observations in Table 1.1. [2]

Table 1.1

Test	Observations	
	S1	**S2**
starch		
reducing sugar		

(e) State the conclusions you could make about the specimens **S1** and **S2** from your observations from the food tests and the structure of **S1** and **S2**. [4]

Food tests

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Structure

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[Total: 21]

(*Cambridge IGCSE Biology 0610, Paper 50 Q1, June 2009*)

2 Amylase is an enzyme that breaks down starch.

You are provided with three different concentrations of amylase solution, labelled **R1**, **R2** and **R3**.

You are going to test the activity of these solutions on plain paper.

Read all the instructions before you begin work.

Proceed as follows:

- Take three small discs of filter paper. Place one disc into each of the solutions **R1**, **R2** and **R3**.
- Cut out one circle from the sheet of plain paper. The paper should just fit into the bottom of the Petri dish as shown in Figure 2.1.
- Add enough water to wet the paper. Pour away any excess water.
- Cover the wet paper with iodine solution so that it is evenly stained.
- Pour away any excess iodine solution and rinse the paper with water using the dropping pipette.

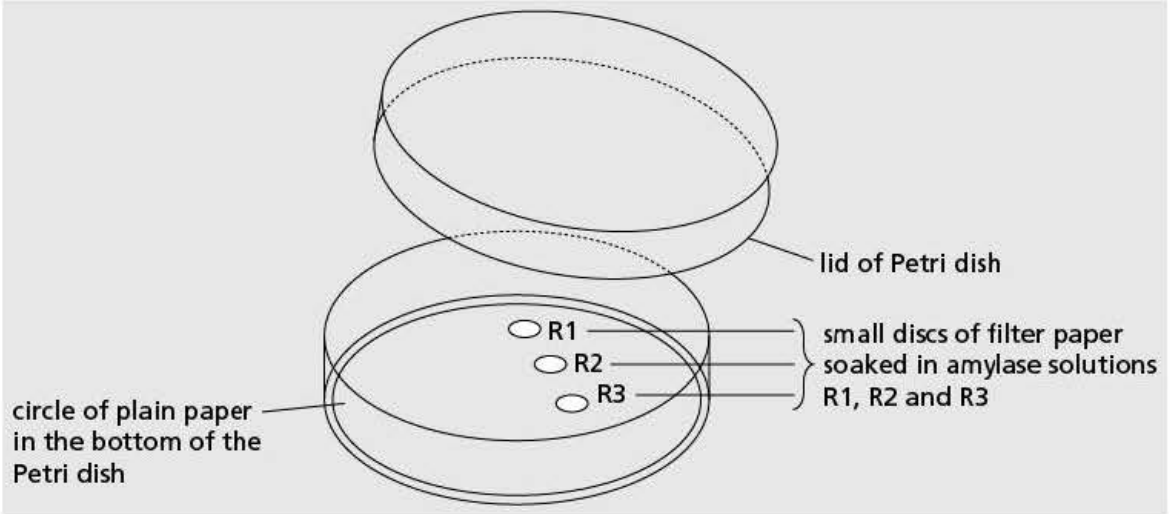

Figure 2.1

- Using forceps, remove the small disc of filter paper from solution **R1** and place it carefully on the paper you have stained, as shown in Figure 2.1.
- Using the forceps, gently press the disc of filter paper onto the surface of the stained paper.
- Repeat the procedure with the discs of filter paper from solutions **R2** and **R3** as shown in Figure 2.1.
- Put the lid on the Petri dish. Note the time. Leave the three discs in the Petri dish for 10 minutes.

During the 10 minutes you should prepare a table in which to record your observations, in the space in question (a).

- Remove the lid from the Petri dish.
- Using forceps, gently lift each disc of filter paper out of the Petri dish, taking care not to tear the stained paper underneath.
- Look carefully at the stained paper.

(a) Record your observations in the table that you have prepared. [5]

(b) Explain the observations that you have recorded for the three different concentrations of amylase. [3]

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(c) Students wanted to find out the effect of different pH values on amylase activity.

Describe how you would change the experiment you carried out in part **(a)** so that you could investigate the effect of pH. Do **not** carry this out. [4]

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(d) Students investigated samples of amylase from 100 goats.

100 small filter paper discs were each soaked with a different sample of goat amylase.

The discs were placed on iodine-stained plain paper.

The students lifted the filter paper discs at 1-minute intervals and recorded the number of areas where there had been a reaction.

If there had been no reaction they replaced the disc of filter paper for another minute. This procedure was repeated for 5 minutes.

Their results are recorded in Table 2.1.

Table 2.1

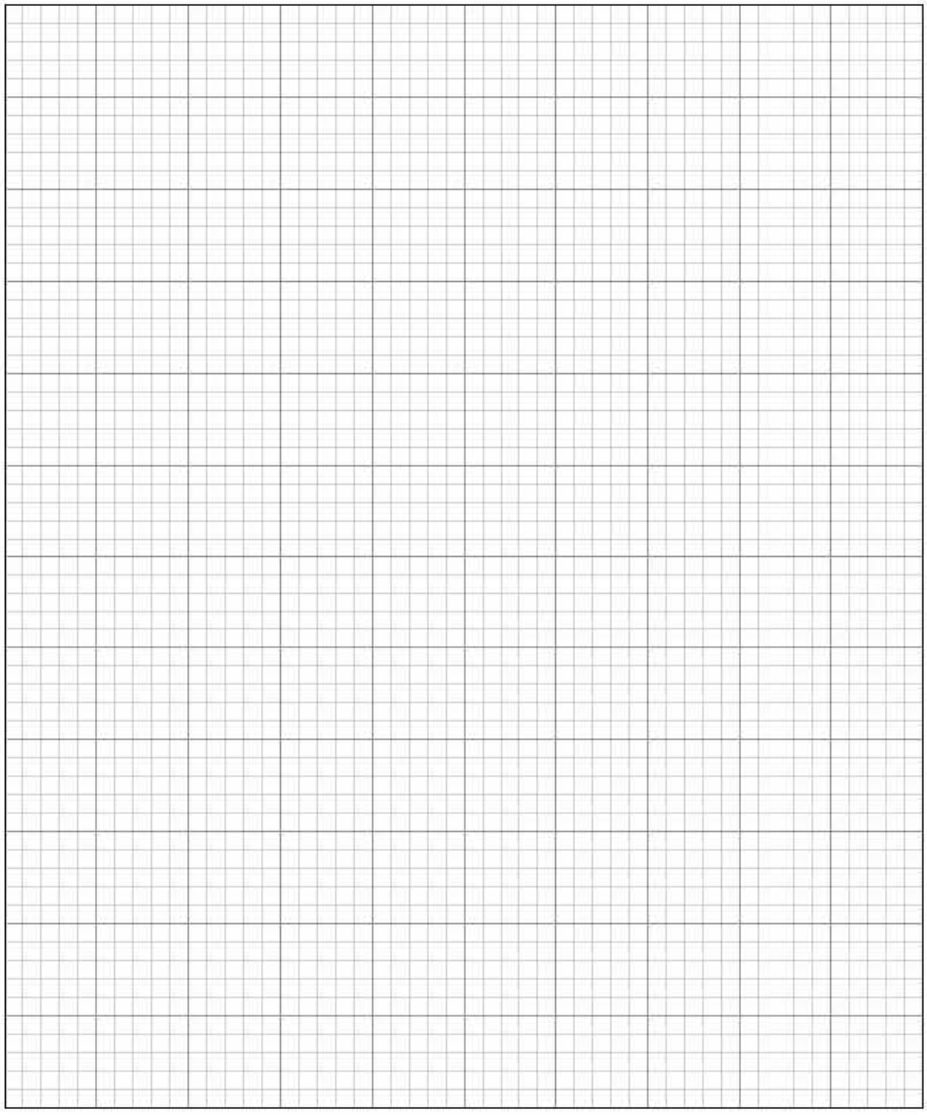
Time/ minutes	Number of new areas where there had been a reaction	Total number of areas where there had been a reaction
1	14	14
2	28	42
3	18	60
4	12	.....
5	6	.....

(i) Complete Table 2.1 by calculating the total number of areas where there had been a reaction after 4 and 5 minutes.

Write your answers in the spaces in Table 2.1.

Show your working in the space below. [2]

(ii) Plot the data from the **first two columns** in Table 2.1, to show the variation in the activity of amylase. [5]



(iii) Suggest **two** reasons for the variation in amylase activity of the samples. [2]

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(e) Suggest **three** ways in which you could improve this investigation. [3]

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[Total: 24]

(*Cambridge IGCSE Biology 0610, Paper 51 Q1, June 2011*)

3 You will investigate the rate of cooling of water in test tubes that are wrapped with different materials.

You are provided with three large test tubes and a thermometer. When each test tube has been prepared, stand it in the rack provided.

- Wrap one of these test tubes with one layer of paper tissue.
  Use an elastic band to fix the paper tissue in position.
- Wrap the second test tube with one layer of foil.
  Use an elastic band to fix the foil in position.
- The third test tube will remain unwrapped.

Read through the method before starting the experiment.

The test tubes are going to be filled with equal volumes of hot water. You will be recording the **initial** temperature of the water in each test tube and then every minute for a total of 6 minutes.

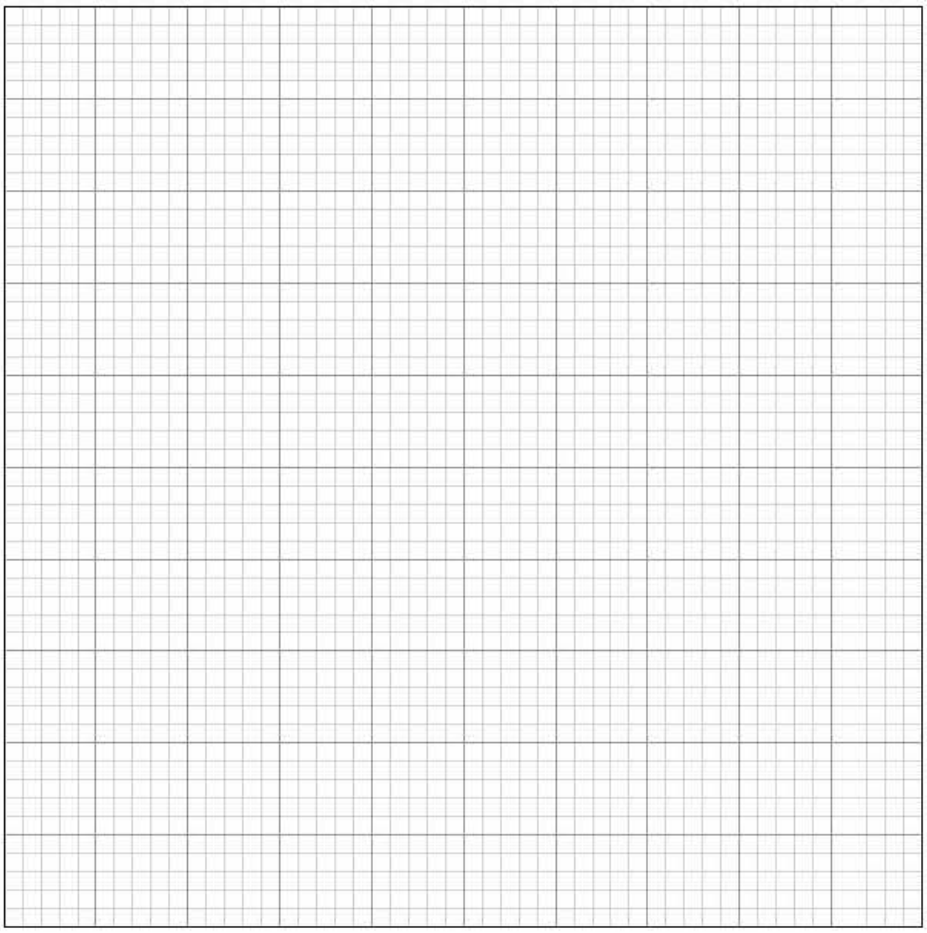
(a) (i) Design a suitable table to record your results. [3]

When you are ready, raise your hand and the Supervisor will add hot water to your test tubes.

Take the **initial** temperature of the water in each test tube and then every minute for a total of 6 minutes.

(ii) Record the results in your table. [3]

(iii) Plot a graph to show the temperature of the water in each test tube against time. Use the same axes for the three sets of data. [5]



(iv) Describe and explain your results. [5]

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(b) Birds have feathers covering their bodies. You are provided with two types of feather.

Feather **W1** is from a bird's chest and feather **W2** is from a wing or tail.

(i) Make a labelled outline drawing of feather **W1**. [4]

(ii) Describe the function of each feather. [2]

feather **W1**

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feather **W2**

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[Total: 22]

(Cambridge IGCSE Biology 0610, Paper 51 Q2, November 2011)

Alternative to Practical past exam questions

1 Enzymes are used commercially to extract fruit juices. The use of enzymes increases the volume of juice produced.

An investigation was carried out to determine the volume of apple juice produced at different temperatures.

Mixtures of apple pulp and enzyme were left for 15 minutes at different temperatures.

After 15 minutes, the mixtures were filtered and the juice collected.

Figure 1.1 shows the volume of juice collected from each mixture.

(a) (i) Record the volume of juice in each measuring cylinder in Table 1.1. [3]

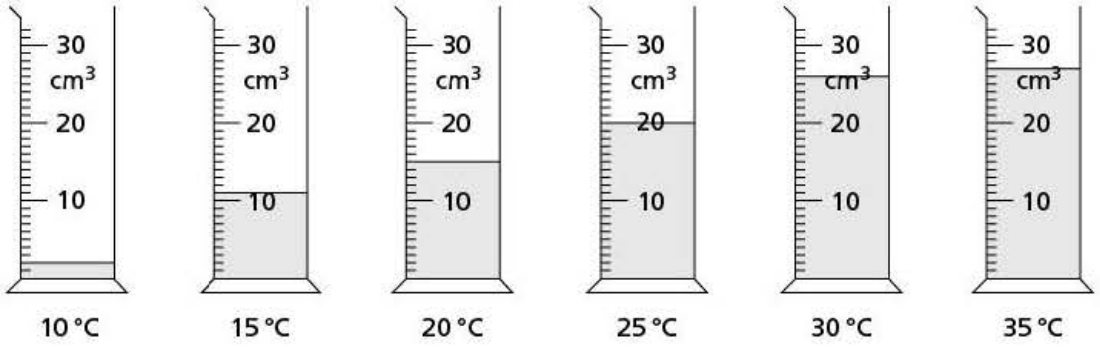
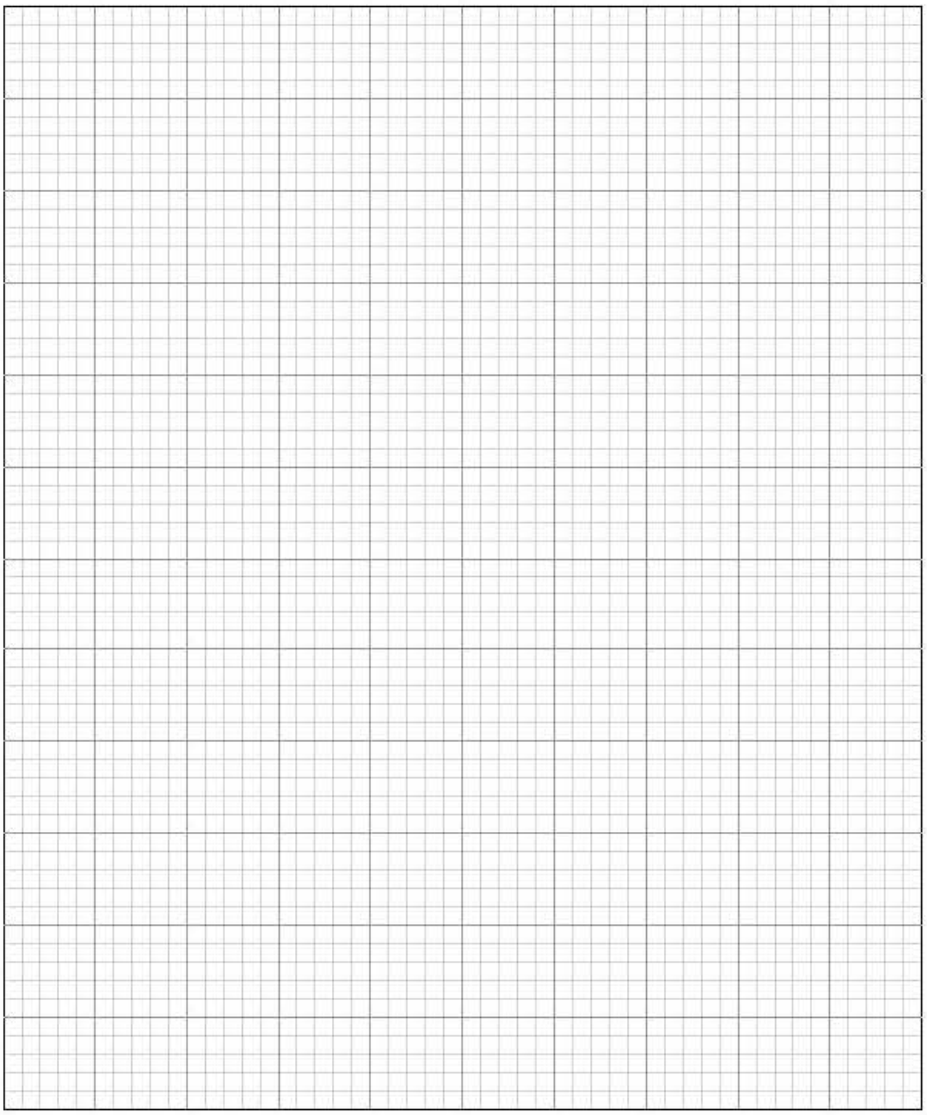


Figure 1.1

Table 1.1

Temperature/°C	Volume of juice collected/cm³
10	
15	
20	
25	
30	
35	

(ii) Present the data in a suitable graphical form. [5]



(iii) Describe the results. [2]

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(b) Describe an investigation to show the effect of pH on the activity of the enzyme that is used to extract apple juice. [6]

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[Total: 16]

(*Cambridge IGCSE Biology 0610, Paper 61 Q1, November 2010*)

2 An investigation was carried out to find the effect of salt (sodium chloride) solution, on potato tissue.

A large potato was cut into long, thin strips, called chips. Each chip measured 60 mm in length.

One chip was placed in a concentrated salt solution and another chip was placed in distilled water.

After three hours these chips were removed from the liquids.

The chips are shown in Figure 2.1.

Figure 2.1

(a) (i) Measure the length of the chips in Figure 2.1.

Calculate any change in length.

Record your measurements in Table 2.1. [2]

Table 2.1

	Chip in salt solution	Chip in distilled water
length/mm		
change/mm		

(ii) Explain the changes that you have recorded for these two chips. [4]

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(b) A similar investigation was carried out by a group of students.

They measured the mass of five chips before putting each chip in a different concentration of **sucrose** solution.

The chips were left in the solution for two hours.

After two hours each chip was removed from the sucrose solution and its mass measured.

Their results are shown in Table 2.2.

Table 2.2

Concentration of sucrose solution/g dm^{-3}	Mass at start/g	Mass after 2 hours/g	Difference in mass/g	Percentage change
0.0	1.36	1.49	+0.13	+9.56
35.0	1.41	1.48	+0.07	+4.96
70.0	1.46	1.47	+0.01	+0.68
175.0	1.47	1.38	−0.09	−6.12
345.0	1.45	1.31	−0.14	.....

(i) Complete Table 2.2 by calculating the percentage change in mass for the most concentrated solution. Show your working. [2]

(ii) Suggest why it is necessary to calculate the percentage change in mass when comparing the chips. [1]

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(iii) Plot a graph to show the percentage change in mass against the concentration of the sucrose solution. Use the grid and axes provided. [4]

(c) (i) Use your graph to find the concentration of sucrose solution in which the mass of chip would stay the same.

..... g dm^{-3} [1]

(ii) Explain why the mass of a chip in this solution would stay the same. [1]

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[Total: 15]

(*Cambridge IGCSE Biology 0610, Paper 62 Q2, November 2011*)