PEARSON EDEXCEL INTERNATIONAL GCSE (9–1)

BIOLOGY LAB BOOK

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Lab Book

CORE PRACTICAL 1: FOOD TESTS
INVESTIGATE FOOD SAMPLES FOR THE PRESENCE OF GLUCOSE, STARCH, PROTEIN AND FAT

SPECIFICATION REFERENCE
2.9
(2.7, 2.8, 2.24, 2.25, 2.26)

Introduction

You will be given a range of foods. Some are powdered, some solid and some liquid. Use the tests below to identify whether each food contains starch, glucose, protein or fat. Use the reagents and tests described.

Learning tip

- Use a different spatula for each food or wash and carefully wipe the spatula in between foods to avoid cross-contamination (i.e. transferring one food to another).

Your teacher may watch to see if you can:

- follow instructions carefully
- work safely, reducing the risk of harm from hazards.

Method

Learning tip

- Volumes of liquids are measured in millilitres (mL) or litres (L). You will notice that all glassware is calibrated in mL. There are 1000 mL in 1 litre.

Iodine solution test for starch

Iodine solution stains starch blue/black. If the iodine solution remains yellow/brown, then the food does not contain starch.

1. Place one spatula of each food on a white tile or plate.
2. Use a dropper pipette to add 2 or 3 drops of iodine in potassium iodide solution onto each food.
3. Record the results. Which foods stain blue/black and which foods are yellow/brown?

Benedict's reagent test for glucose

When glucose (and some other sugars) are heated with Benedict's reagent, the colour of the reagent changes from blue to red. If there are only small amounts of glucose present, the reagent becomes green or yellow. If the reagent remains blue then there is no glucose present.

1. Place two spatulas of each food into separate, clean test tubes. Label the test tubes so you know which food each contains.
2. Use a syringe to add 5 mL of distilled water to each test tube.
3. Use a syringe to add 5 mL of Benedict's solution to each test tube, and shake the tubes to mix the contents.
4. Place each labelled tube into a water bath, heated to 80 °C for 10 minutes.
5. Record the colour of the solution for each food tested.

Objectives

- To identify starch, glucose, proteins and fat in foods

Equipment

- eye protection
- 5 mL test tubes, racks and bungs
- Benedict's reagent
- water bath set at 80 °C
- marker pen
- spatulas
- test tubes and rack
- biuret reagent
- iodine in potassium iodide solution in a dropping bottle
- dimple tile
- pipette
- distilled water
- ethanol
- paper towels

Safety notes

- Wear eye protection.
- Wash any splashes quickly from skin.
- Do not taste any of the food.
- Biurets reagent can be harmful to skin and eyes. Take care as it is corrosive.
- Take care with hot water in the water bath.
- Benedict's solution can be harmful to skin and eyes.

Biuret test for protein

When dilute potassium or sodium hydroxide solution and copper sulfate solution, combined in biuret reagent, are added to protein the colour changes from blue to deep mauve/purple.

1. Place two spatulas of each food into separate, clean test tubes. Label each tube so you know which food is in it.
2. Use a syringe to add 5 mL of distilled water to each food in its tube and shake to mix.
3. Use another syringe to add 5 mL of biuret reagent to each tube and gently move the tube to mix the contents.
4. After about 2 minutes, note and record the colour of the solution for each food.

Ethanol emulsion test for fats

Fats do not dissolve in water but they do dissolve in ethanol. If ethanol containing dissolved fat is poured into water, the fat comes out of solution and forms an emulsion (droplets of one liquid suspended in another liquid). This emulsion looks white and cloudy.

1. Place two spatulas of each food into separate, clean test tubes.
2. Use a syringe to add 3 mL of ethanol to each tube and shake the contents vigorously to dissolve any fat that is in the food into the ethanol.
3. Allow the tubes to stand for 2–3 minutes so that the contents settle.
4. Carefully pour the ethanol from each tube into another test tube that is half-filled with distilled water.
5. Observe the water in the second tube, near the top and see if there is a white cloudy layer.
6. Record your results for each food.

Learning tip

- Some of the foods you are testing may contain more than one food type.

Results

1 Record your results in a table.

Food	Colour at end of test			
	Iodine solution test	Benedict's test	Biuret test	Ethanol emulsion test

Analysis

1 For each food you tested, fill in the table to show which food types – starch, glucose, protein or fat – it contained. Use a tick (✓) if the food type is present or a cross (✗) if the food type is not present.

Food	Food types			
	Starch	Glucose	Protein	Fat

2 Did any of the tests show you how much of the food type the food contained?

Give a reason for your answer.

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Evaluation

1 Identify any problems you had with this investigation and explain how the method could be improved to reduce or avoid these problems.

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Extension

1 Describe how you could adapt the Benedict's test to show how much glucose is present in foods such as milk, potatoes and cooked rice.

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CORE PRACTICAL 2: TEMPERATURE AND ENZYME ACTIVITY
INVESTIGATE HOW ENZYME ACTIVITY CAN BE AFFECTED BY CHANGES IN TEMPERATURE

SPECIFICATION REFERENCE
2.12
(2.10, 2.11)

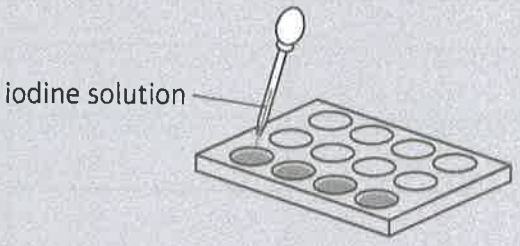
Introduction

Amylase is an enzyme made in salivary glands under your tongue, near and under your jaw and in your mouth. Amylase digests (breaks down) starch into smaller sugar molecules.

Each group will investigate the action of amylase at one or two temperatures. You can then share your results with the others in your class. Temperatures investigated will be 0 °C, 10 °C, 20 °C, 30 °C, 40 °C, 50 °C, 60 °C, 70 °C and 80 °C.

Your teacher may watch to see if you can:

- work safely
- collect accurate data.



Method

1 Using the dropper pipette, drop one drop of iodine in potassium iodide solution into each well on a dimple tile.

Learning tip

- Remember: Volumes of liquids are measured in millilitres (mL) or litres (L). You will notice that all glassware is calibrated in mL. There are 1000 mL in 1 litre. The volume of solids is measured in cm^3 and m^3 but liquids do not form cubes.

2 Use a syringe to place 5 mL 0.5% starch solution into a test tube. Label the tube with your initials.

3 Place the test tube into a water bath at your specified temperature. Leave it there for 5 minutes so that it reaches that temperature.

4 Use a pipette to take a little of the starch solution from the test tube and add 1 drop of it to the iodine in potassium iodide solution in the first well of the dimple tile. Take care NOT to touch the pipette tip onto the iodine solution in the wells. Return the rest of the mixture to the test tube. Rinse the pipette with distilled water.

5 Use another syringe to place 2 mL 0.05% amylase solution into the test tube; stir to mix the contents and start the timer.

Learning tip

- In an enzyme-controlled reaction, always add the enzyme last so that you know when the reaction starts.

6 After 20 seconds, take a little of the mixture from the test tube using a pipette and add 1 drop of it to the second well of the dimple tile. Return the rest of the mixture to the test tube. Rinse the pipette with distilled water.

7 Repeat step **6** at 20-second intervals, using a different well in the dimple tile each time. Do **not** stop the timer when you take the samples.

8 Note the time when the iodine in the potassium iodide solution stays yellow/brown, indicating that there is no starch in the mixture in the test tube.

Objectives

- To investigate the effect of temperature on the rate of digestion of starch by the enzyme amylase

Equipment

- eye protection
- iodine in potassium iodide solution in a dropping bottle
- dimple tile
- 5 mL syringes
- 0.5% solution soluble starch
- test tubes
- marker pen
- test tube rack
- water baths set at 0 °C, 10 °C, 20 °C, 30 °C, 40 °C, 50 °C, 60 °C, 70 °C and 80 °C
- crushed ice for 0 °C and 10 °C water baths
- thermometer to check temperatures of water baths
- pipette
- distilled water
- 0.05% amylase solution
- timer

⚠ Safety notes

- Wear eye protection.
- Do not drink any of the solutions.
- Wash any splashes quickly from skin. (Enzymes/amylase can cause allergic reactions or asthma symptoms.)
- Take care with the enzyme solutions.

9 Carry out a Benedict's test (see CP1) to see if the mixture in the tube now contains sugar.

10 If you have time, carry out this investigation two more times and find the average time taken for the starch to be broken down.

11 Share your results with others in your class and complete the tables below.

Learning tips

- If you do not have time to set up a test tube at each of the temperatures, you may carry out 3 or 4 investigations at different temperatures. Others in your class may carry out investigations at other temperatures and you can share your results.
- When carrying out a reaction at a specific temperature, we place the reactants separately in a water bath at that temperature for 5–10 minutes so they reach the required temperature, before mixing the reactants.

Results

1 Complete the table for your own data.

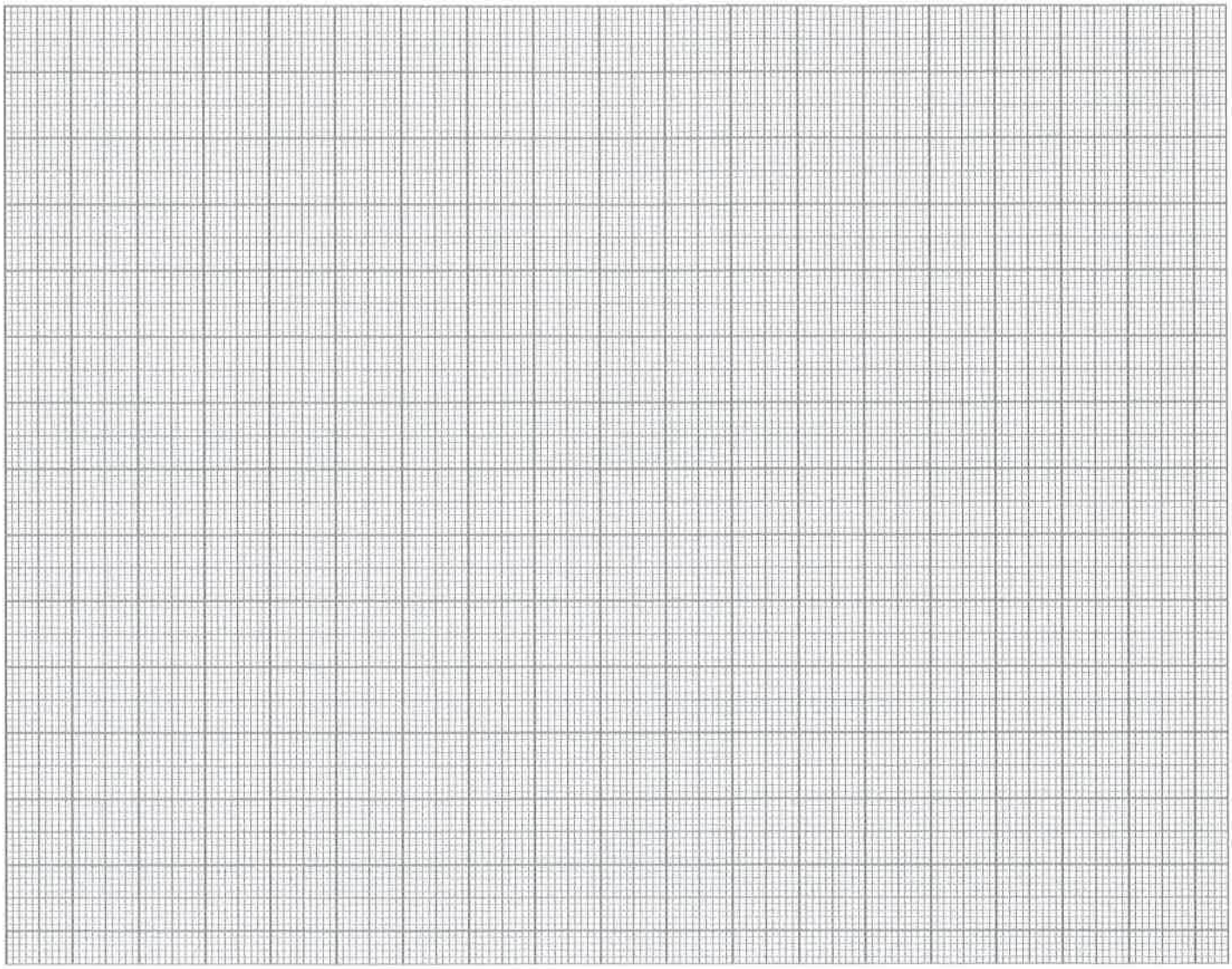
Trial number	Temperature (°C)	Time taken for amylase to digest the starch (s)
1		
2		
3		
Mean time taken for amylase to digest starch (s)		

2 Complete the table using data from the other groups in your class.

Temperature (°C)	Mean time taken for amylase to digest starch (s)

Analysis

1 Plot a bar graph to show the time taken for amylase to digest starch at the different temperatures.



2 Look at your graph and describe how temperature affects the time taken for amylase to digest starch.

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3 A bar graph is a good way to display these data because they are discrete.
Suggest what further investigations you would need to carry out in order to get data suitable for a line graph.

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4 Study the data produced by your class. In which range of temperatures is the optimum temperature (temperature at which the enzyme works fastest) for amylase?

Give reasons for your answer.

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Evaluation

1 Suggest further investigations you could carry out to find more precisely/accurately the optimum temperature for amylase.

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2 Describe any problems you had with carrying out the investigation.

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3 Suggest reasons for the problems and suggest how the method could be changed to help reduce these problems.

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CORE PRACTICAL 3: pH AND ENZYME ACTIVITY
INVESTIGATE HOW ENZYME ACTIVITY CAN BE AFFECTED BY CHANGES IN pH

SPECIFICATION REFERENCE
2.14 B
(2.10, 2.11, 2.31)

Introduction

Protease enzymes digest (break down) proteins to smaller peptides. These smaller molecules are soluble. Pepsin is a protease enzyme made in the stomach. Other protease enzymes are made in the small intestine.

In this investigation you will use pepsin. The substrate is egg white suspension, which is a protein. The egg white suspension is made by mixing egg white with water and heating it. It becomes white and cloudy. When it has been digested by pepsin, it becomes transparent (clear). You can measure the time taken for the cloudy egg white suspension to become clear, at each pH. If you do not have time to set up a test tube at each pH, you may carry out 3 or 4 investigations at different pHs. Others in your class may carry out investigations at other pH values and you can share your results.

Your teacher may watch to see if you can:

- work safely
- collect accurate data.

Learning tip

- In an enzyme-controlled reaction, always add the enzyme last so that you know when the reaction starts.

Method

1. Label 8 test tubes 1, 2, 3, 4, 5, 6, 7, 8.
2. Use a 10 mL syringe to add 10 mL egg white suspension to each tube.
3. Use a clean syringe in each case to add 2 mL of a buffer solution to each tube so that you have a range of pH values, 1–8: pH1 in the tube labelled 1, etc.
4. Place the tubes (in a test tube rack) into the water bath set at 40 °C and leave them for 5 minutes to reach the temperature of the water bath.
5. Use a 10 mL syringe to add 3 mL pepsin solution to each tube. Stir the contents of each tube using the glass rod.
6. Start the timer and note the time taken for the contents of each tube to become transparent.

Results

1. Complete the table.

pH	1	2	3	4	5	6	7	8
Time taken for egg white suspension to become transparent (minutes)								

Objectives

- To investigate the effect of pH on the rate of digestion of protein (egg white suspension) by pepsin (a protease enzyme)

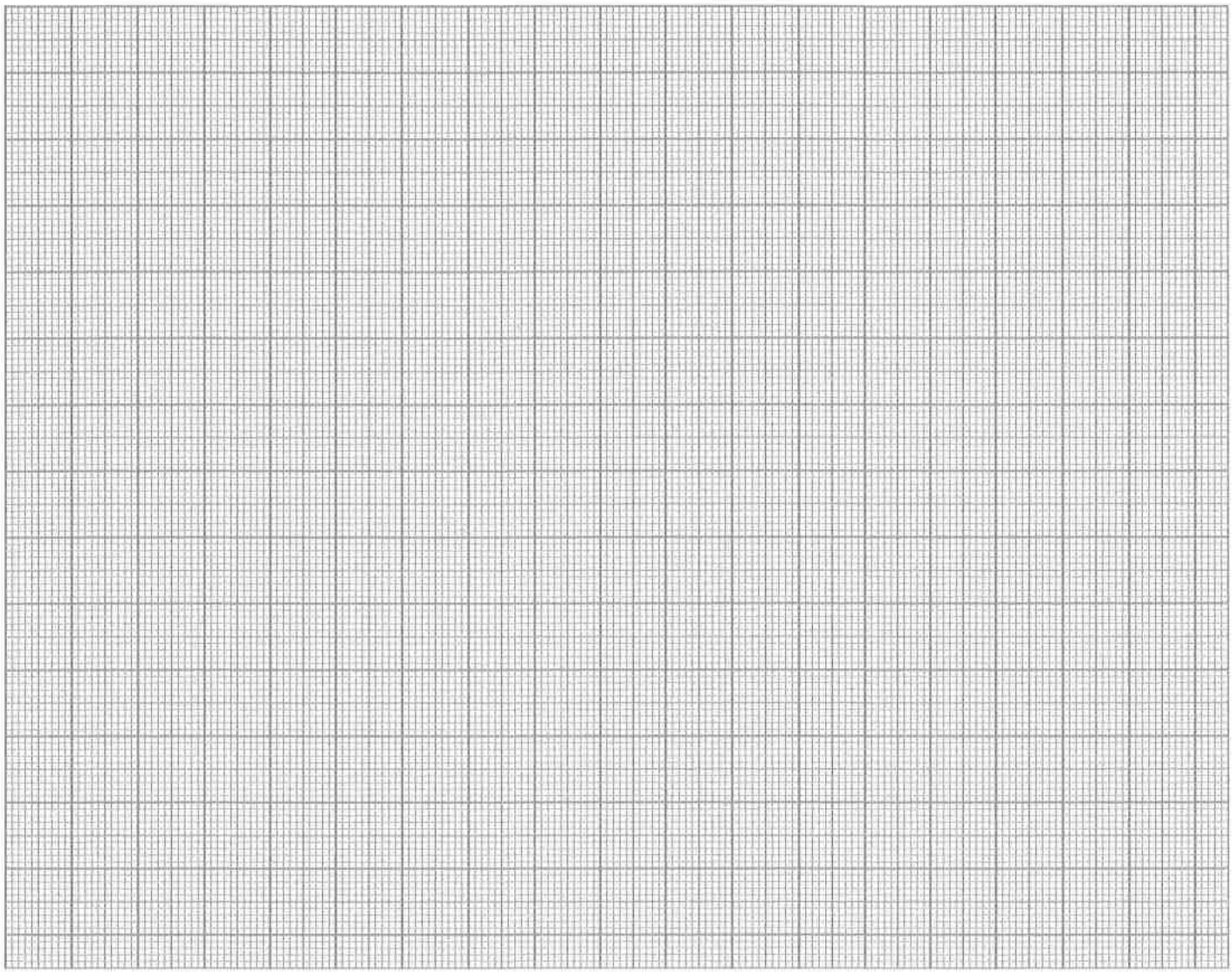
Equipment

- eye protection
- 8 test tubes
- waterproof marker pen
- test tube rack
- 1 × 10 mL syringe
- 100 mL egg white suspension
- 8 × 5 mL syringes
- access to buffer solutions of pH 1, 2, 3, 4, 5, 6, 7, 8
- water bath set at 40 °C
- 30 mL 2% pepsin solution
- stirring rod
- timer

Safety notes

- Wear eye protection.
- Do not drink any of the liquids.
- Wash any splashes quickly from skin. (Enzymes/pepsin can cause allergic reactions or asthma symptoms.) Enzymes are an irritant.
- Wash off any chemical splashes immediately.
- Take care with the buffer solutions.
- Take care with the enzyme solutions.

2 Plot your data on a line graph.



Analysis

1 Look at your graph and describe the effect of pH on time taken for pepsin to digest egg white.

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2 Suggest a reason for the shape of your graph.

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Evaluation

1 Describe any problems you had with carrying out the investigation.

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2 Suggest how the method could be changed to reduce these problems.

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3 Comment on whether you have enough results to support your conclusion.

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Part 1: Simple diffusion

Introduction

Diffusion is the movement of molecules from a region where they are in a higher concentration (a greater number of molecules in that region) to a region where they are in a lower concentration (fewer molecules present). All molecules have kinetic energy and can move. The higher the temperature, the greater their kinetic energy and so the faster they move. You might have noticed that you can smell food cooking even when you are not in the kitchen. That is because some of the molecules of food have diffused (spread) from the kitchen, where there are many of them, to another room in the house where there are fewer of them.

In living organisms, some substances diffuse across cell membranes. Oxygen diffuses from the lungs into the blood and carbon dioxide diffuses from blood into lungs. When a neurone (nerve cell) is stimulated, sodium ions diffuse into the axon of the neurone.

Your teacher may watch to see if you can:

- measure carefully and work safely.

Method

1. Use the measuring cylinder to add 100 mL potassium manganate(VII) solution into the dish.
2. Use the forceps to place an agar jelly cube in the middle of the dish.
3. Start the timer and record how long it takes for the dye to stain the whole of the cube.
4. Use the forceps to take the agar jelly cube out of the dish and discard it.
5. Cut another agar jelly cube into eight equal parts so each measures 2 cm × 2 cm × 2 cm.
6. Place all of these smaller cubes (not touching) into the dish of potassium manganate(VII) solution and repeat steps **3** and **4**. This time you are measuring how long it takes for all of the cubes to be fully stained.
7. Cut the third agar jelly cube into 64 cubes of 1 cm × 1 cm × 1 cm. Place all of these cubes into a dish of potassium manganate(VII) solution and repeat step **6**.

Results

You are going to calculate the volume (length × breadth × depth) in cm^3 and surface area (area of each face × 6) in cm^2 for each size of cube you used. You can then calculate the total volume and surface area for each set of cubes and the surface area : volume ratio for each group of cubes.

Learning tips

- A cube has six faces. When calculating the total surface area of a cube, you need to find the area of one face and then multiply that by 6.
- As we are using solids here, which do form cubes, we use the unit cm^3.
- To find the volume of a cube, multiply the length by the breadth by the depth.

1. Calculate the total volume and the total surface area for each set of cubes (1, 8 and 64) and complete the appropriate columns in the table.
2. Calculate the surface area : volume (SA : V) ratio for each group of cubes and complete the appropriate columns in the table. To do this, divide the surface area by the volume. There are no units for a ratio.

Objectives

- To demonstrate and investigate diffusion and osmosis in non-living and living systems

Equipment

- crystallising dishes
- 100 mL measuring cylinder
- potassium manganate(VII) solution
- blunt forceps
- 3 × agar jelly blocks 4 cm × 4 cm × 4 cm
- timer
- scalpel or sharp knife

Safety notes

- Do not eat the agar jelly.
- Avoid contact between potassium manganate(VII) solution and skin or eyes.
- Wear eye protection.
- Take care with the sharp blade.

Learning tips

- A ratio does not have units because it is comparing one thing to another. Ratios are usually calculated and represented as $x : 1$.

Some of these calculations have been done for you.

3 Complete the table with the time taken for the dye to diffuse into and completely colour all the agar cubes.

Number of cubes	Dimensions of each cube/cm	Area of one face/ cm^2	Surface area of one cube/ cm^2	Total surface area/cm^2	Volume of one cube/ cm^3	Total volume/ cm^3	SA : V ratio of each set of cubes	Time taken for dye to diffuse into all the agar jelly cubes
1	4 × 4 × 4		96	96			1.5 : 1	
8	2 × 2 × 2	4			8	64	3 : 1	
64	1 × 1 × 1	1	6	384	1	64		

Learning tips

- Time is measured in seconds and the unit is 's' or 'seconds' but **not** 'secs'.

Analysis

1 As the cube is cut into smaller cubes, what happens to:

a the total volume?

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b the total surface area?

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c the ratio SA : V (how much surface area for each cm^3 of volume)?

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d the time taken for the dye to diffuse and reach all parts of the agar jelly?

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2 What is the relationship between SA : V ratio and time taken for the dye to reach all of the agar jelly?

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Part 2: Diffusion in a non-living system

Introduction

You can demonstrate the diffusion of glucose through Visking tubing. Visking tubing is partially permeable. It allows small molecules to pass through it.

Your teacher may watch to see if you can:

- work carefully and safely.

Method

1. Half fill the beaker with water.
2. Wrap a length of cotton thread tightly around one end of the Visking tubing and tie it tightly.
3. Dip the other end of the Visking tubing in the water and rub the end between finger and thumb. This will soften the tubing and allow you to open it.
4. Open the tubing and, using a pipette, fill the tubing with the glucose and starch solution.
5. Using the cotton thread, close the other end of the tubing by wrapping the thread around it and tying tightly. You have now made a Visking bag that contains a mixture of starch and sugar.
6. Thoroughly rinse the Visking bag under a tap so that there is no starch and glucose solution on the outside of it.
7. Place the Visking bag into the beaker of water and start the timer.
8. Immediately, using a **clean** syringe, withdraw 5 mL of water from the beaker and place two drops into a well on a dimple tile and the rest into a test tube.
9. Add one drop of iodine solution to the liquid in the well of the dimple tile.
10. Using another clean 5 mL syringe, add 5 mL of Benedict's solution to the liquid in the test tube and place the tube in the water bath. (*Recall your practical on food tests. Iodine solution tests for starch. If starch is present, the iodine in the potassium iodide solution becomes blue/black. Benedict's reagent and heat is the test for glucose. A small amount of glucose will change the Benedict's reagent from blue to green. Higher concentrations of glucose change the Benedict's reagent from blue to yellow or orange; a high amount of glucose changes Benedict's solution to red.*)
11. Repeat steps **8–10** at intervals of every 30 seconds or every minute. Note when the water in the beaker contains glucose or starch.

Results

1. Make a table to record your data.

Equipment

- eye protection
- beaker – 500 mL capacity
- water
- Visking tubing – length of about 10 cm
- cotton thread
- pipette
- solution containing glucose and starch
- 5 mL syringe × 2
- dimple tile
- test tubes and rack
- iodine in potassium iodide solution in a dropper bottle
- Benedict's solution in a dropper bottle
- access to water bath set at 80 °C
- timer

⚠ Safety notes

- Do not drink any of the solutions.
- Wash off any splashes straight away.
- Take care with hot water in the water bath.
- Benedict's solution can be harmful to skin and eyes.

Analysis

1 Give your conclusions from this investigation. Does glucose pass out of the Visking bag into the water of the beaker? By what process does this happen? Does starch pass through the Visking bag?

What can you recall about the sizes of glucose and starch molecules?

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Part 3: Osmosis in a non-living system

Introduction

Osmosis is a special type of diffusion. It is the overall movement of water molecules, through a partially permeable membrane, from a region where they are in higher concentration to a region where they are in lower concentration. You can demonstrate osmosis in a non-living system. To save time, your teacher may demonstrate it to you. Sucrose is a type of sugar. Sucrose molecules are larger than glucose molecules.

Your teacher may watch to see if you can:

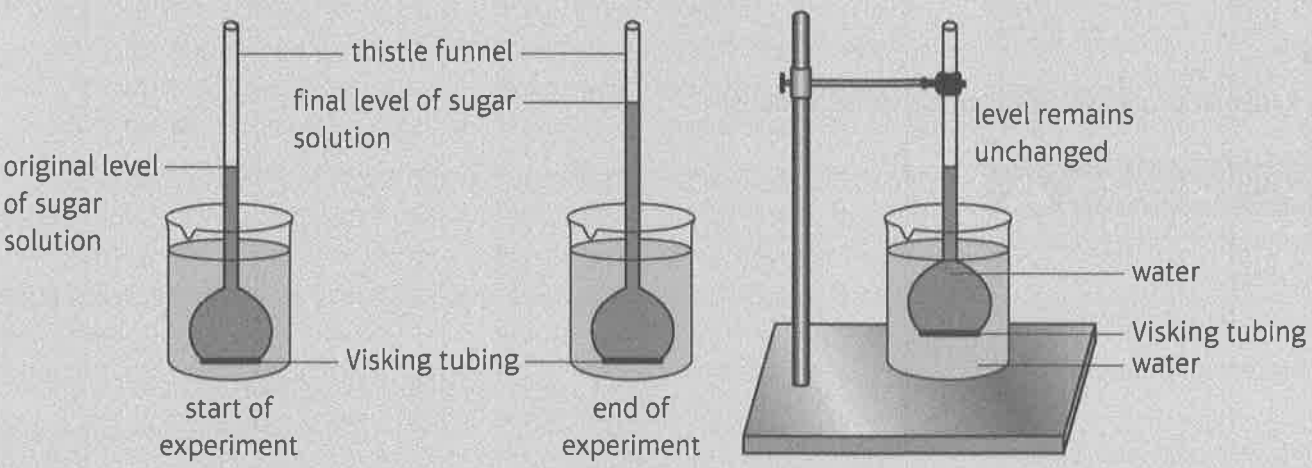
- work safely.

Equipment

- Visking tubing
- cotton thread
- thistle funnel × 3
- pipette or syringe
- 3% sucrose solution
- 15% sucrose solution
- waterproof marker pen
- water
- 3 clamps and stands
- 3 beakers
- timer

Safety notes

- Do not drink any of the solutions.



Method

1. Moisten (make slightly wet) a 10 cm length of Visking tubing to open it and then cut it along one side to make a flat sheet.
2. Tie the sheet of Visking to the base of a thistle funnel as shown in the diagram.
3. Repeat steps **1** and **2** twice more.
4. Use a pipette or syringe to add 3% sucrose solution to one of the thistle funnels to a level just above the bulb of the funnel. Add 15% sucrose solution to another thistle funnel to the same level. Using a marker pen, label with the concentration and mark the levels.
5. Repeat step **4** but use water instead of glucose solution.
6. Invert the thistle funnels and clamp them.
7. Place the bulbs of the thistle funnels into the water in the beakers.
8. Start the timer.
9. Examine each set of apparatus after 5, 10 and 15 minutes.

Results

1 Record your observations.

Analysis

1 What explanation can you give for your observations?

Part 4: Osmosis in potato slices

Introduction

The cells in potato tissue contain many substances dissolved in the water inside the cell. These dissolved substances are called **solutes** or solute molecules. Each cell has a cell membrane around it that is partially permeable. Water molecules can pass through the cell membrane by osmosis, from a region where there are more water molecules per unit volume (higher concentration) to a region where there are fewer water molecules per unit volume (lower concentration). Distilled water has the highest possible concentration of water molecules. Sucrose solution contains the solute sucrose and the solvent water. The more concentrated the sucrose solution, the lower the concentration of water molecules in that solution. In the opposite way, the more dilute the sucrose solution, the greater the concentration of water in that solution.

If potato cells are placed in a solution that is high in water concentration (distilled water or dilute sucrose solution), then water will pass through the cell membranes **into** the potato cells, by osmosis. This is because the solutions contain more water than the potato cells.

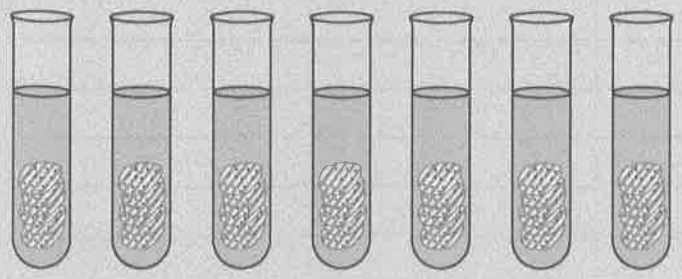
If potato cells are placed in a more concentrated sucrose solution, then water moves through the cell membranes, **out of** the cells and into the surrounding solution, by osmosis. This is because there are more water molecules per unit volume in the cells than in the surrounding sucrose solution.

Your teacher may watch you to see if you can:

- measure accurately
- work carefully.

Learning tip

- When investigating osmosis in potato tissue, do not use sugar at a concentration greater than 15% – it will cause the cells to become totally plasmolysed and sugar solution will fill the space between cell wall and cell membrane. Because sugar solution is denser than water, this will cause the potato tissue to gain mass and this will appear to be an anomalous (not expected) result. It is not an anomalous result because it always happens but it will lead to confusion.



Equipment

- 6 boiling tubes and rack
- waterproof marker pen
- 10 ml syringe
- distilled water (0% sucrose solution)
- 7 sucrose solutions: 0% (distilled water), 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0%
- potato, peeled
- cork borer
- white tile
- knife
- ruler
- forceps
- paper towels/kitchen roll
- accurate balance

⚠ Safety notes

- Do not eat the potatoes or drink any of the solutions.
- Eye protection should be worn.
- Take care when using the cork borer.
- Take care when using the knife.

Method

Learning tip

- Cutting the potato tissue cylinders into discs will increase the surface area and therefore speed up the gain or loss of water.

1 Label the tubes 0%, 2.5%, 5%, 7.5%, 10%, 12.5% and 15%, respectively (i.e. in the same order as the seven sucrose solutions).

2 Use a clean syringe to place 10 mL distilled water into the tube labelled 0%.

3 Use the same syringe to place 10 mL 2.5% sucrose solution into the tube labelled 2.5%.

4 Rinse the syringe with distilled water and then use it to add 10 mL 5% of sucrose solution to the tube labelled 5%.

5 Rinse the syringe with distilled water and then use it to add 10 mL 7.5% of sucrose solution to the tube labelled 7.5%.

6 Rinse the syringe with distilled water and then use it to add 10 mL 10.0 % of sucrose solution to the tube labelled 10%.

7 Rinse the syringe with distilled water and then use it to add 10 mL 12.5% of sucrose solution to the tube labelled 12.5%.

8 Rinse the syringe with distilled water and then use it to add 10 mL 15.0% of sucrose solution to the tube labelled 15%.

9 Use the cork borer to make six cylinders of potato tissue.

10 Place the potato cylinders on a white tile and, using a knife and ruler, cut each one to the same length.

11 Cut each cylinder into 6 equal-sized discs. This gives more surface area/exposed cell membranes for water to pass through.

12 Place each group of 6 discs onto a separate piece of kitchen roll/paper towel.

13 Weigh each group of potato discs and record the mass of each group.

14 Add one group of discs to each boiling tube and start the timer.

15 After 30 minutes, use the forceps to take each group of potato discs out of each tube and place onto clean, separate paper towels. Gently blot the discs to remove any drops of liquid but do **not** press or squeeze them.

16 Weigh and record the mass of each group of discs.

17 Record your data in the table. You can calculate the percentage gain or loss in mass so that the data can be compared as not all the groups of discs will have started with exactly the same mass.

Results

1 Complete the table with your data.

Concentration of sucrose solution (%)	A Mass of potato discs at beginning (g)	B Mass of potato discs after 30 minutes (g)	C Change in mass (B – A) (g)	D % change in mass = C ÷ A × 100 (g)
0.0				
2.5				
5.0				
7.5				
10.0				
12.5				
15.0				

2 Compare your data with that of others in your class. Which solutions caused the potato discs to gain mass and which caused them to lose mass?

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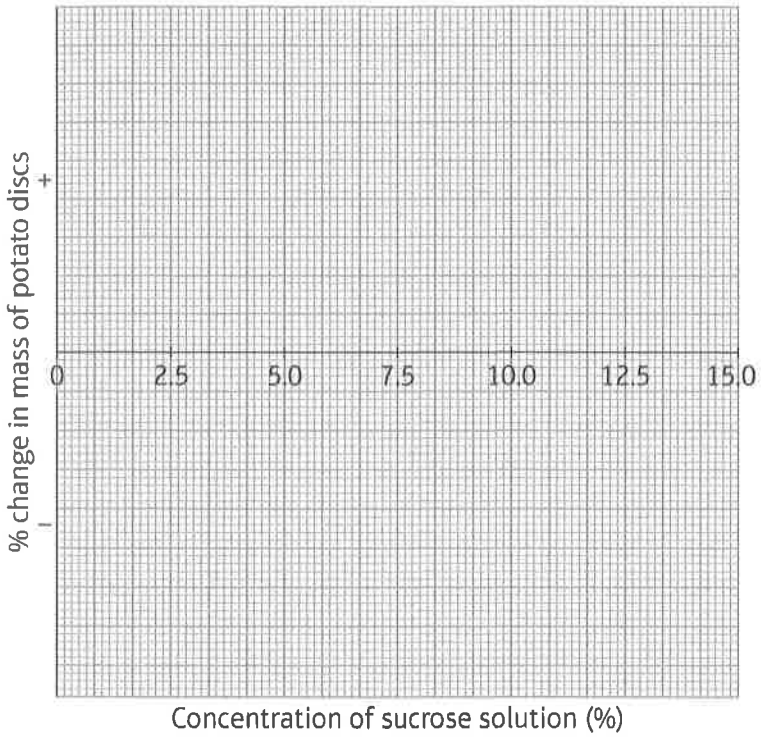
3 Plot the percentage change in mass at each concentration of sucrose solution. Use the graph paper with axes as shown below.



4 Draw a line by joining the plot points dot to dot with ruled lines.

Analysis

1 Explain why the discs in distilled water gained mass.

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2 Explain why the discs in 15% sucrose solution lost mass.

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3 **a** From the graph, read the concentration of sucrose solution that would give no gain or loss of mass in the potato discs.

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b Explain why the sucrose solution you have identified would not cause the discs to lose or gain mass.

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4 You did not have time to repeat your investigation. However, you have the data from the whole class.

a Explain why calculating a mean value for mass lost or gained, is better than using just one value.

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b Explain why it is important to convert the changes in mass to percentage changes in mass.

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Evaluation

1 Describe any problems you had with this investigation. Suggest how these could be reduced or avoided to produce better results.

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2 Suggest how you could improve the investigation to find more precisely/accurately the concentration of sucrose solution that produces no osmosis in the potato cells.

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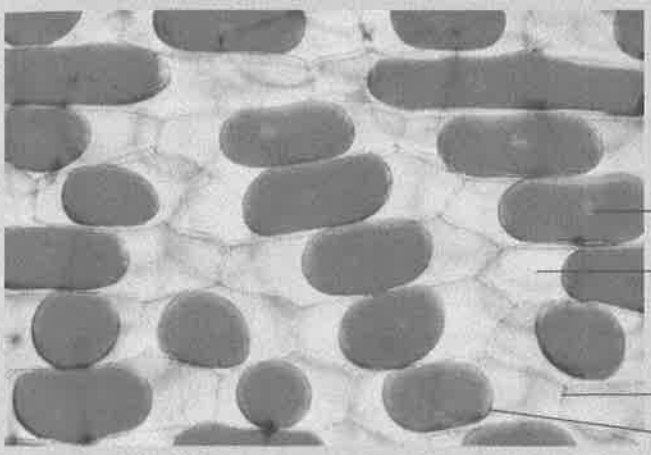
Part 5: Observing osmosis in onion cells

Introduction

If you place pieces of onion epidermis into distilled water, water will enter the cells by osmosis. The cells will then swell and become **turgid** (swollen). If you place onion epidermis into a 10% salt (sodium chloride) solution, water will leave the cells by osmosis and the vacuole and cytoplasm will shrink; the cells will become **plasmloysed**. In a weak salt solution, the onion cells will be neither turgid nor plasmloysed as there is no gain or loss of water by the cells. Using red (purple) onions allows you to see the contents of the cells more clearly.

Your teacher may watch you to see if you can:

- handle microscopes and slides carefully and safely.



Onion cells that are plasmolysed. The cell contents have shrunk and pulled away from the cell walls

Learning tip

- Always observe a slide on the microscope by using low power first.

Method

1. Use fine forceps to obtain a piece of onion epidermis that has been in distilled water.

   Place it flat onto a clean microscope slide and use a pipette to add a drop of distilled water to the slide.
2. Using a mounted needle, carefully lower a coverslip onto the onion epidermis on the slide.
3. Observe the slide under the microscope, using low power first and then a higher power.
4. Draw one cell.
5. Repeat steps **1–4** with a piece of onion epidermis that has been in 10% salt solution.
6. Repeat steps **1–4** with a piece of onion epidermis that has been in weak salt solution.
7. Annotate each of your drawings to indicate how the cell appears – is it turgid or plasmloysed?

Equipment

- pieces of red onion epidermis in distilled water, weak salt solution, 10% salt solution
- fine forceps
- microscope slides and coverslips
- pipettes
- mounted needle
- microscope and light source

⚠ Safety notes

- Wear eye protection.
- Take care with mounted needles.
- Take care with slides and coverslips. They break easily and can be sharp.

Observations

1 Make your annotated drawing here.

CORE PRACTICAL 5: PHOTOSYNTHESIS

INVESTIGATE PHOTOSYNTHESIS, SHOWING THE EVOLUTION OF OXYGEN FROM A WATER PLANT, THE PRODUCTION OF STARCH AND THE REQUIREMENTS OF LIGHT, CARBON DIOXIDE AND CHLOROPHYLL

SPECIFICATION REFERENCE
2.23
(2.18, 2.19, 2.20, 2.21, 2.22)

Part 1: Demonstrating the evolution of oxygen from a water plant

Introduction

Plants make their food by the process of photosynthesis.

The simple equation that summarises this process is

$$\text{carbon dioxide + water} \xrightarrow{\text{in the presence of light and chlorophyll}} \text{glucose + oxygen}$$

In this investigation you will show that oxygen is given off by plants. You will also show that plants need chlorophyll, light and carbon dioxide in order to photosynthesise.

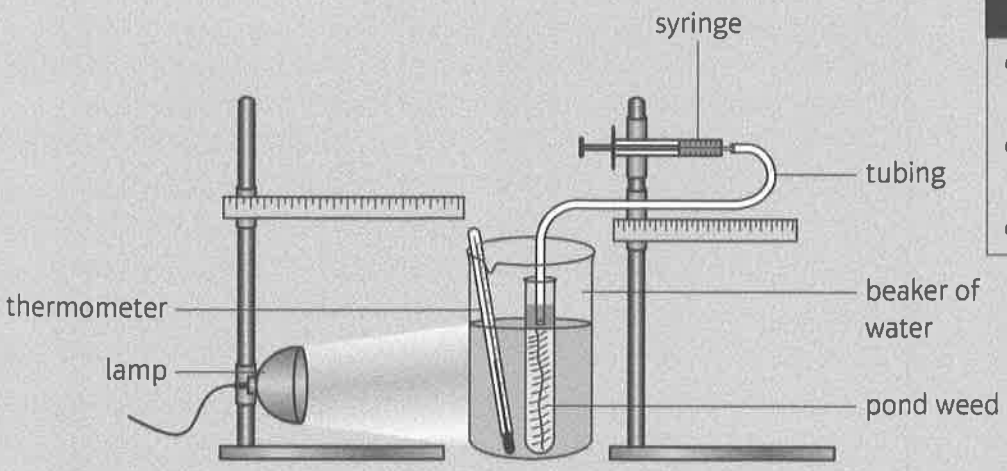
If you put a piece of water plant into a test tube and put the test tube near a lamp, you will see bubbles of a gas coming from the plant. To check if the gas is oxygen, you need to collect enough of the gas and carry out the test for oxygen on it.

Your teacher may watch you to see if you can:

- follow instructions carefully
- work safely and carefully

Learning tip

- Using an aquatic plant allows you to see and collect the bubbles of oxygen gas coming off.



Method

1. Set up the apparatus as shown in the diagram.
2. Push the barrel of the syringe in.
3. Turn on the lamp and leave the apparatus under the lamp for 15–30 minutes.
4. Watch the bubbles of gas coming off and being collected.
5. The syringe barrel should move outwards as the gas is collected.
6. Detach the syringe from the apparatus.
7. Light a splint and blow it out so that it glows red.
8. Take the plunger from the syringe and put the glowing splint into the gas. It should relight, showing that the gas is oxygen.

Objectives

- To investigate photosynthesis and **(1)** demonstrate the evolution of oxygen from a water plant and **(2)** investigate the production of starch and **(3)** the need for (a) light, (b) carbon dioxide and (c) chlorophyll for photosynthesis

Equipment

- lamp
- clamp, boss and stand
- metre ruler
- syringe
- plastic tubing
- 500 mL beaker
- piece of water plant such as *Elodea*
- splint and lit Bunsen burner
- thermometer
- heat-resistant mat

Safety notes

- Take care with glassware and with the lit Bunsen burner.
- Do not stare directly at the lamp bulb.
- The lamp bulb may get hot.

Results

1 Did the splint relight?

.....

Analysis

1 Did the plant give off oxygen?

.....

Evaluation

1 Suggest how you could adapt this experiment to investigate how the rate of photosynthesis is affected by the light intensity.

Learning tip

- Before you start counting the bubbles per minute, leave the plant at a specific light intensity (how bright it is) to reach the appropriate rate of photosynthesis.

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Part 2: To show that leaves make starch

Introduction

The simple equation you have for photosynthesis shows that glucose is made. This is immediately changed to starch and stored in leaves. Overnight, in the dark, the starch in the leaves is changed to sucrose (a sugar) and moved through the phloem to other parts of the plant. If a plant, such as a geranium plant, is put in the dark for 48–72 hours before you set up your investigations, it will be de-starched. You can then put the plant in different conditions to see whether it makes starch or not.

Starch test for a leaf

Your teacher may watch you to see that you can:

- follow instructions closely
- work safely and carefully.

Learning tip

- Dipping the leaf in boiling water kills it. Dipping it in cold water after it has been decolorised softens it before adding the iodine solution.

Method

1. Remove one leaf from the de-starched plant. Use forceps to dip it into the water bath set at 100 °C. This kills the leaf. Do the same with a leaf from the plant that has been exposed to light.
2. Place each leaf in a boiling tube and add ethanol to cover the leaf. Label each boiling tube so you know which leaf is which.
3. Place the tubes into a rack in the water bath at 80 °C and leave until the ethanol has become green. This happens because the chlorophyll has come out of the leaf. Removing the green chlorophyll ensures that when you add iodine solution, you can see whether starch is present or not.
4. Using forceps, take the decolorised leaves out of the ethanol and dip them into the beaker of cold water to soften them.
5. Spread each leaf on a white tile and add a few drops of iodine in potassium iodide solution.
6. Observe which leaf goes blue/black.

Results and analysis

Make notes of what you find out, in the space below.

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Equipment

- de-starched geranium plant
- forceps
- water bath set at 100 °C
- geranium plant that has been exposed to light for 24 hours
- boiling tubes and racks
- ethanol
- waterproof marker pen
- water bath set at 80 °C
- beaker of cold water
- white tile
- iodine in potassium iodide solution in a dropper bottle

⚠ Safety notes

- Take care with the ethanol.
- Take care with hot water.
- Ethanol is flammable. Keep it away from flames. Turn off any Bunsen burners before using ethanol.

CORE PRACTICAL 5: PHOTOSYNTHESIS
INVESTIGATE PHOTOSYNTHESIS, SHOWING THE EVOLUTION OF OXYGEN FROM A WATER PLANT, THE PRODUCTION OF STARCH AND THE REQUIREMENTS OF LIGHT, CARBON DIOXIDE AND CHLOROPHYLL

SPECIFICATION REFERENCE
2.23
(2.18, 2.19, 2.20, 2.21, 2

Part 3: Investigating the conditions needed for photosynthesis

a) Chlorophyll

Chlorophyll is a green pigment that traps light energy. It traps the red and blue light of the spectrum and reflects green light. Chlorophyll also contains nitrogen and magnesium. Plants make chlorophyll.

Some plants have variegated leaves. These are leaves that have white areas, where there is no chlorophyll.

Learning tip

- Variegated leaves have areas that are white where there are no chloroplasts in the cells.

Your teacher may watch you to see that you can:

- follow instructions carefully
- work safely and carefully.

Equipment

- de-starched geranium plant with variegated leaves
- ethanol
- forceps
- water bath set at 100 °C
- boiling tubes and racks
- waterproof marker pen
- water bath set at 80 °C
- beaker of cold water
- white tile
- iodine in potassium iodide solution in a dropper bottle

Safety notes

- Take care with the ethanol.
- Take care with hot water.
- Ethanol is flammable. Keep it away from flames. Turn off any Bunsen burners before using ethanol.

Method

Carry out the starch test (page 27) on a variegated leaf from a plant that has been exposed to light.

Results

1 Draw the leaf showing which areas are white and which are green and show where starch was present in the leaf.

Analysis

1 Is chlorophyll needed for photosynthesis?

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2 What is the function of the chlorophyll in the process of photosynthesis?

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b) Light

Method

1 Choose a leaf on the de-starched plant and fix some aluminium foil over part of the leaf.

2 Leave the plant in the light for 24 hours. Remove the partly covered leaf from the plant. Remove the foil from the leaf and carry out the starch test (page 27).

Results

1 Draw your leaf after the starch test and show which parts of the leaf have starch.

Analysis

1 Is light needed for photosynthesis?

.....

Equipment

- de-starched geranium plant
- aluminium foil
- forceps
- water bath set at 100 °C
- boiling tubes and racks
- ethanol
- waterproof marker pen
- water bath set at 80 °C
- beaker of cold water
- white tile
- iodine in potassium iodide solution in a dropper bottle

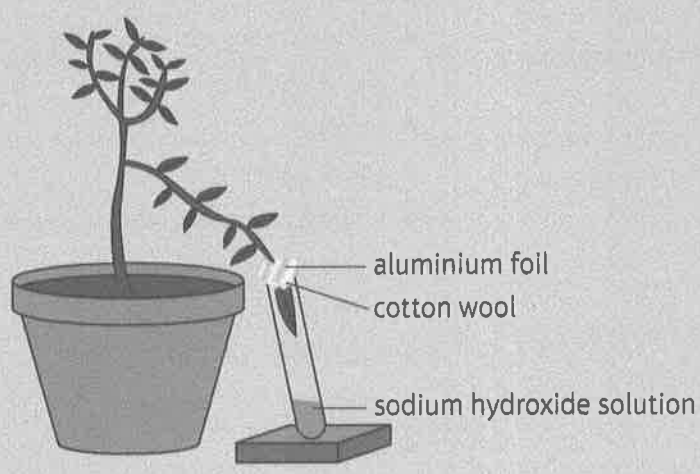
Safety notes

- Ethanol is flammable. Keep it away from flames. Turn off any Bunsen burners before using ethanol.

CORE PRACTICAL 5: PHOTOSYNTHESIS
INVESTIGATE PHOTOSYNTHESIS, SHOWING THE EVOLUTION OF OXYGEN FROM A WATER PLANT, THE PRODUCTION OF STARCH AND THE REQUIREMENTS OF LIGHT, CARBON DIOXIDE AND CHLOROPHYLL

SPECIFICATION REFERENCE
2.23
(2.18, 2.19, 2.20, 2.21, 2.2

c) Carbon dioxide



Method

1 Place a leaf, still attached to a de-starched plant into a boiling tube which has some sodium hydroxide solution (or soda lime) in it, as shown in the diagram. Plug the top of the boiling tube with cotton wool and aluminium foil.

Learning tip

- Sodium hydroxide solution (or soda lime) absorbs carbon dioxide from the air in the tube.

2 Leave the plant exposed to light for 24 hours.

3 Test the leaf that was in the boiling tube for starch.

4 Test another leaf from the plant for starch.

Results

1 Which leaf made starch?

.....

Analysis

1 Is carbon dioxide needed for photosynthesis?

.....

Evaluation

Learning tip

- Plants also respire and produce carbon dioxide. They do this all the time.

1 In this experiment, the carbon dioxide that was made by respiration was removed. How was it removed?

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Equipment

- de-starched geranium plant
- boiling tube with 5 mL potassium hydroxide solution or solid soda lime in the bottom of it
- cotton wool
- aluminium foil
- forceps
- ethanol
- water bath set at 100 °C
- boiling tubes and racks
- waterproof marker pen
- water bath set at 80 °C
- beaker of cold water
- white tile
- iodine in potassium iodide solution in a dropper bottle

⚠ Safety notes

- Ethanol is flammable. Keep it away from flames. Turn off any Bunsen burners before using ethanol.
- Wash chemical spills off skin immediately.

CORE PRACTICAL 6: FOOD ENERGY CONTENT
INVESTIGATE THE ENERGY CONTENT IN A FOOD SAMPLE

SPECIFICATION REFERENCE
2.33 B
(2.24, 2.25, 2.26)

Introduction

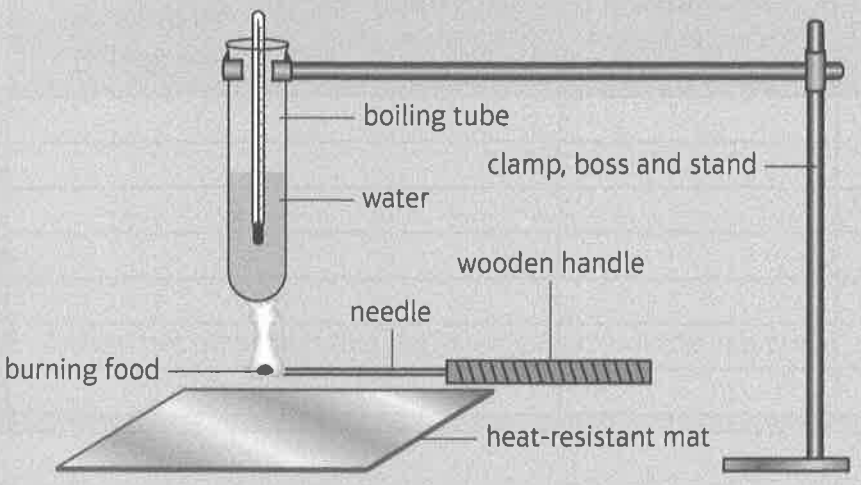
All foods contain stored energy. The energy is in the carbohydrates (sugars and starches), fats and proteins. Plants make those foods, originally, using energy from sunlight. Animals eat the plants or eat other animals that have eaten the plants, and so the energy passes up the food chain.

Carbohydrates and proteins contain less energy per gram than fats contain.

You can estimate how much energy is in a food sample by burning the food and releasing the energy from it in the form of heat energy. The heat energy can be used to heat up a certain volume of water. In this way, you can calculate how much energy is in 1 g of the food. You can try carbohydrate foods, such as cereal or dried bread, and fats, such as cooking oil.

Your teacher may watch you to see if you can:

- work carefully and safely
- make accurate measurements
- record data accurately.



Learning tip

- Remember that energy cannot be made or destroyed but one form can be changed to another form. In this investigation, the stored chemical energy in food is changed to heat energy.

Method

1. Using a measuring cylinder, add 20 mL water to a boiling tube.
2. Set up the tube of water in a clamp on a stand, as shown in the diagram.
3. Use the thermometer to read the temperature of the water. Write down this temperature.
4. Cut a piece of dried bread about 1 cm^3.
5. Use the accurate balance to weigh this piece of bread. Write down the mass of the bread.
6. Light the Bunsen burner and adjust the flame to hot.

   Keep the boiling tube away from the Bunsen burner.
7. Place the piece of bread on the end of a mounted needle. Hold the bread in the Bunsen flame until it begins to burn.

Objectives

- To investigate the energy content in a food sample/food samples

Equipment

- eye protection
- 50 mL measuring cylinder
- water
- boiling tubes
- clamp, boss and stand
- thermometer
- access to a selection of foods to test (e.g. bread, pasta, crisps, peanuts, pasta, 0.5 g cooking oil in crucibles/watch glasses/very small beakers)
- accurate balance
- Bunsen burner
- heat-resistant mat
- mounted needle
- mineral wool
- metal forceps
- paper to insulate the forceps handles

Safety notes

- Wear eye protection.
- Take care with the Bunsen burner.
- Take care top of test tube is pointing away from people.
- Take care with glassware and the mounted needle.
- Do not eat any of the food samples.
- Do not use nuts if anyone in the class has a nut allergy.

8 Quickly move the needle and bread so that the burning bread is under the boiling tube of water. Keep it there until the bread stops burning. (If the food goes out, it needs to be relit until it will no longer burn). Observe the thermometer and note the highest temperature it reaches.

9 Pour away the hot water from the boiling tube.

10 Repeat the procedure using different food samples.

For cooking oil

a Using the accurate balance weigh a small bundle of mineral wool.

b Use forceps to hold this wool and dip it into cooking oil until all of the oil is absorbed onto the mineral wool.

Learning tip

- 1 mL of water weighs 1 g.

Results

1 Present your data in the table.

Name of food	Mass of food (g)	Temperature of 20 g water before heating (°C)	Temperature of 20 g water after heating (°C)	Temperature change (°C)

Analysis

1 In this investigation identify:

a the independent variable (IV)

.....

b the dependent variable (DV)

.....

2 For an investigation to be valid, all variables other than IV and DV must be kept the constant. These are called the control variables.

One control variable was the mass of water in the boiling tube.

State two other control variables for this investigation and, for each one, describe how you tried to keep it constant.

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3 a Which food contains the most energy?

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b Explain how you reached that conclusion.

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Evaluation

1 Describe any problems you identified while doing this experiment.

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2 Explain why using a larger volume of water may improve the accuracy of the investigation.

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3 Explain two other ways that the investigation could be improved.

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4 4.2 joules is the amount of energy that raises the temperature of 1 g water by 1 °C.
(1 kilojoule, kJ = 1000 joules, J)
Calculate the energy content of the food(s) you tested in kilojoules per gram ($kJ\,g^{-1}$).
Use the equation:

$$\text{Energy transferred from 1 g food} = \frac{\text{mass of water (g)} \times 4.2\ (kJ\,g^{-1}\,°C^{-1}) \times \text{temperature increase (°C)}}{\text{mass of food (g)} \times 1000}\ kJ\,g^{-1}$$

CORE PRACTICAL 7: RESPIRATION
INVESTIGATE THE EVOLUTION OF CARBON DIOXIDE AND HEAT FROM RESPIRING SEEDS OR OTHER SUITABLE LIVING ORGANISMS

SPECIFICATION REFERENCE
2.39
(2.34, 2.35, 2.36, 2.37, 2.38)

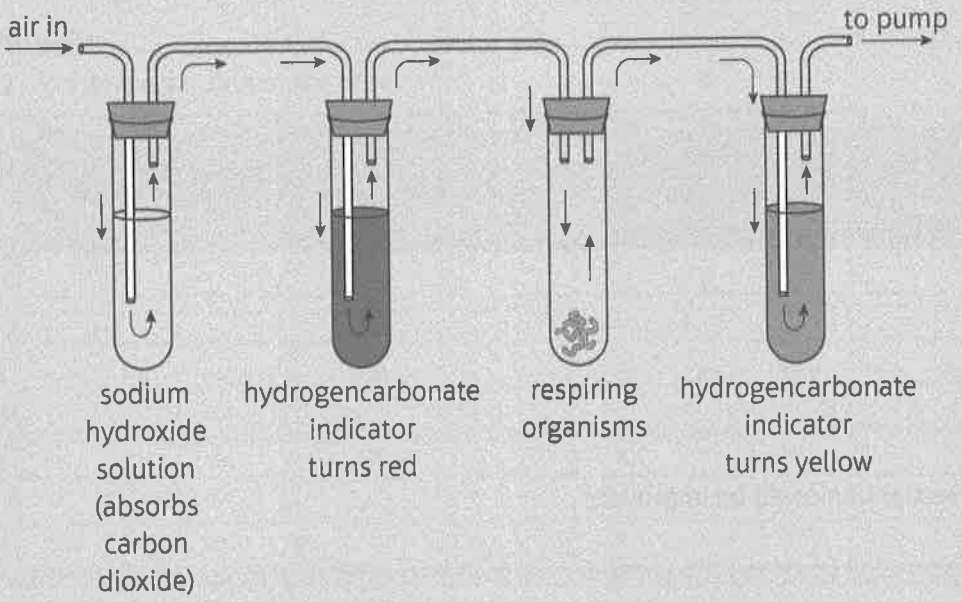
Introduction

Plant cells and animal cells respire all of the time. During aerobic respiration the cells take in oxygen and give out carbon dioxide. The oxygen and glucose react to release energy from glucose and produce carbon dioxide and water as by-products. The energy is used to make ATP that cells can use.

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

Soaked seeds, such as pea seeds, respire because they have to release energy from stored food before they can germinate. The seeds give off carbon dioxide. They do not photosynthesise because there are no leaves.

Certain animals (for example, blowfly maggots or woodlice) may be used for this investigation because they also respire and produce carbon dioxide.



Learning tip

- Any animals, if used, should be returned unharmed to their environment after the experiment.

The living organisms are placed in a flask or boiling tube. The air they are exposed to is first passed through sodium hydroxide (to remove the carbon dioxide) and then through hydrogencarbonate indicator solution (to check that all carbon dioxide has been removed). The air is then passed over the living organisms and is finally passed through another solution of hydrogencarbonate indicator (to show whether or not carbon dioxide is present).

Learning tips

- Hydrogencarbonate indicator solution is purple at alkaline pH, red when neutral and yellow at acidic pH. Carbon dioxide is acidic in solution.
- Hydrogencarbonate indicator solution does not react with oxygen, so the air received by the living organisms contains oxygen and the organisms are respiring aerobically.

Your teacher may watch you to see if you can:

- work carefully
- handle living organisms ethically, safely and carefully
- record data accurately.

Objectives

- To investigate the evolution of carbon dioxide and heat from respiring seeds or other suitable living organisms

Equipment

- 4 boiling tubes in a rack
- 20 mL syringes
- sodium hydroxide solution
- hydrogencarbonate indicator solution
- soaked pea seeds
- maggots or woodlice
- balance
- bungs and glass tubing
- vacuum pump
- access to water tap
- petroleum jelly
- timer
- limewater
- optional: access to test tubes, water bath at 80 °C, food test reagents

Safety notes

- Take care with the indicator solution.
- Take care with sodium hydroxide solution.
- Wear eye protection.
- Take care with glassware.
- Wash hands before and after handling living organisms.
- Wash off any chemical splashes immediately.

Learning tip

- Plant cells can only photosynthesise when light is present, but they respire all of the time – in light and in darkness.

Method

1. Place the four boiling tubes in a row in the rack.
2. Use a syringe to add 20 mL sodium hydroxide solution to the first boiling tube.
3. Use another syringe to add 20 mL neutral (red) hydrogencarbonate indicator solution to the second and fourth boiling tubes.
4. Place 20 g soaked seeds or suitable animals in the third boiling tube.
5. Connect the boiling tubes as shown in the diagram and connect the pump to a water tap.
6. Turn on the tap and check that you can see the bubbles in the liquids. This shows that the air is flowing through the apparatus. If there are no bubbles, the air is not flowing. Use petroleum jelly to seal all the tubes and bungs.
7. Start the timer.
8. Note how long it takes for the indicator solution in the last tube to become yellow.
9. Repeat your investigation twice more or compare your data with that of other students in your class.
10. If you have time, repeat the investigation, with animals if you used seeds first and seeds if you used animals first. See if the time taken is different. Alternatively, half the class could use seeds and the other half use animals and you can compare data.
11. If there is enough time, repeat the investigation using limewater in the final tube and note how long it takes for the limewater to become white and cloudy.

Results

1. Present your data in the table.

Living organisms	Mass of organisms (g)	Time to change colour of indicator solution to yellow (s)			
		1	2	3	mean
Animal	20				
Plant ..... soaked seeds	20				

Analysis

1. Are the animals and plants in the investigation producing carbon dioxide?

.....

2. What evidence supports your conclusion?

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Learning tip

- The time taken for the indicator to become yellow indicates the rate of respiration. The shorter the time taken, the faster the rate of respiration.

3 Did the animal cells or the plant cells have the faster rate of respiration in this investigation? Use your data to support your answer.

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Evaluation

1 Explain why it is important that the same mass of living organisms is used in each investigation.

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2 Explain why it is important that the same volume of indicator solution is used in each investigation.

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3 Explain why you repeated the investigation three times or compared your data to that of others in the class.

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4 Boiling seeds kills them. In another investigation, a control was included using 20 g boiled seeds instead of living seeds. Suggest, with reasons, what would happen to the indicator solution in the last tube.

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5 Respiration is the release of (stored) energy from food. Some of that energy is in the form of heat.
You have two thermos flasks, holed bungs, thermometers, soaked pea seeds and soaked boiled pea seeds.
Plan an investigation to show that respiring seeds produce heat.

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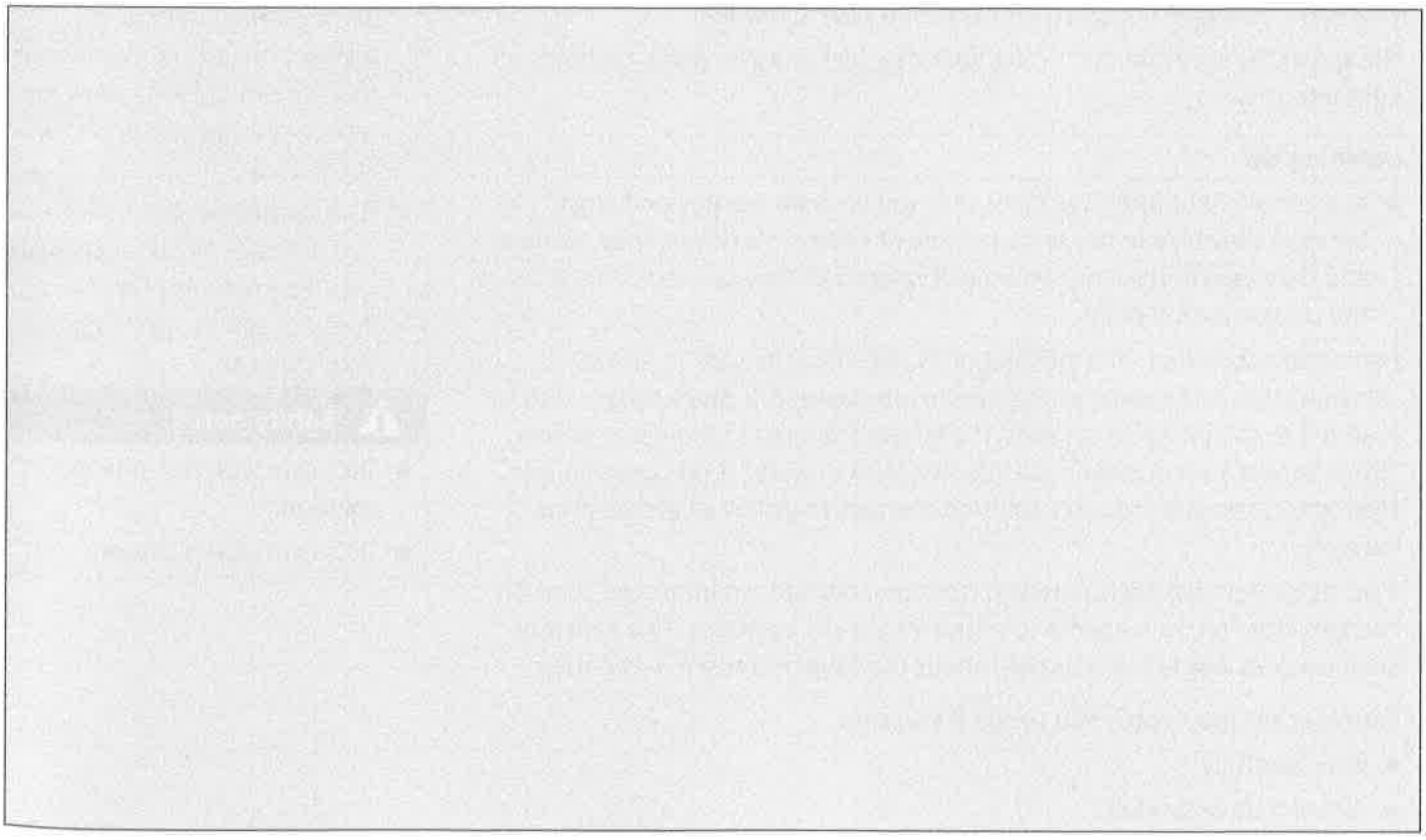


CORE PRACTICAL 8: LIGHT INTENSITY AND PHOTOSYNTHESIS
INVESTIGATE THE EFFECT OF LIGHT ON GAS EXCHANGE IN A PLANT

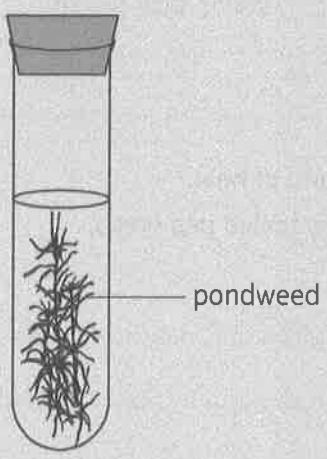
SPECIFICATION REFERENCE

2.45 B

(2.40 B, 2.41 B, 2.42 B, 2.43 B, 2.44 B, 22.18, 2.19, 2.2

Introduction

Plant cells carry out respiration all of the time – night **and** day. During aerobic respiration, plant cells take in oxygen and give out carbon dioxide. During daylight (or under artificial light), plant cells also carry out photosynthesis, for which they take in carbon dioxide and give out oxygen.



in light

Learning tip

- The oxygen evolved during photosynthesis can be used for respiration. The carbon dioxide evolved during respiration can be used for photosynthesis.

If the rate of photosynthesis is greater than the rate of respiration, then the net (overall) effect of the gaseous exchange is that the plant cells give out oxygen and take in carbon dioxide. If the rate of respiration is greater than the rate of photosynthesis, then the net effect of the gaseous exchange is that plant cells give out carbon dioxide and take in oxygen.

Net gas exchange from plant cells, such as a leaf or water plant, depends on light intensity.

Learning tip

- At a certain light intensity, plant cells will have **no** net gas exchange because they take in the same volume of carbon dioxide as they produce and they take in the same volume of oxygen as they produce. This is called the compensation point.

Hydrogencarbonate indicator solution is red when the carbon dioxide concentration is the same as that of the atmosphere. If **more** carbon dioxide is added to the indicator solution, it changes from red to orange to yellow. This is because when carbon dioxide dissolves in water, it produces an acid. Hydrogencarbonate indicator solution changes to yellow when the pH is lowered.

If acidic carbon dioxide is removed from the indicator solution, the solution changes from red to magenta to purple as the pH increases. This indicator solution does **not** tell us anything about the oxygen content in the tube.

Your teacher may watch you to see if you can:

- work carefully
- record data accurately.

Objectives

- To investigate the effect of light on net gas exchange in plant photosynthetic tissue, using hydrogencarbonate indicator solution

Equipment

- 8 boiling tubes in racks
- waterproof marker pen
- 50 mL measuring cylinder or 20 mL syringe
- hydrogencarbonate indicator solution
- aluminium foil
- *Elodea*
- tissue paper, transparent sticky tape
- lamps
- clock or timer
- pH meter and probe

Learning tip

- Hydrogencarbonate indicator solution is purple at alkaline pH, red when neutral and yellow at acidic pH. Because of this, we can use it to show the carbon dioxide concentration in solution.
- Hydrogencarbonate indicator solution tells us about changes in carbon dioxide levels. It does not tell us anything about oxygen.

⚠ Safety notes

- Take care with the indicator solution.
- Take care with glassware.

Method

1 Use a measuring cylinder or a syringe to add 20 mL neutral (red) hydrogencarbonate indicator solution to each of eight boiling tubes.
2 Label the tubes 1–8 and add your initials.
3 Wrap tube 1 in aluminium foil to exclude light.
4 Leave tube 2 unwrapped so it is exposed to light.
5 Add a piece of pondweed, *Elodea*, to each of the tubes numbered 3–8.
6 Wrap tube 3 in aluminium foil.
7 Leave tube 4 as it is.
8 Wrap tube 5 in one sheet of tissue paper.
9 Wrap tube 6 in two sheets of tissue paper.
10 Wrap tube 7 in three sheets of tissue paper.
11 Wrap tube 8 in four sheets of tissue paper.
12 Place all of the tubes close to a bright lamp. Note the time.
13 After 30 minutes, examine the indicator solution in each tube and note the colour of the solution. Wrap the tubes 1, 3, 5, 6, 7 and 8 again as soon as possible.
14 Repeat step **13** after another 30 minutes.
15 Use the pH meter to measure the pH of each tube.

Results

1 Add your data to complete the table.

Conditions in tube	Tube number							
	1	2	3	4	5	6	7	8
Exposed to light	✗	✓✓✓✓	✗	✓✓✓✓	✓✓✓	✓✓	✓	
Intensity of light	none	high	none	high				
Plant cells present	✗	✗	✓	✓	✓	✓	✓	✓
Colour of indicator solution at beginning	red	red	red	red	red	red	red	red
Colour of indicator solution at end								
Carbon dioxide concentration at end				low				
pH of solution at end								
Has the plant been respiring?	no plant	no plant	✓	✓	✓	✓	✓	✓
Has the plant been photosynthesising?	no plant	no plant	✗	✓✓✓				

Analysis

1 Describe how the colour changes in the indicator solution indicate whether carbon dioxide was being removed from the solution or added to the solution.

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2 State which tubes had a rate of photosynthesis that was greater than rate of respiration.

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3 Deduce whether there was a tube where the rate of photosynthesis equalled the rate of respiration. Give reasons for your answer.

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4 State which tubes had the highest light intensity.

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5 Tissue paper reduced the amount of light reaching the pond plants.

a State how reducing the light intensity affected the rate of photosynthesis in the pond plants.

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b Describe the evidence that supports your conclusion. Give a reason for your answer.

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6 Tubes 1 and 2 were controls. Describe what they showed.

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7 Identify the tubes in which most photosynthesis happened.

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Evaluation

1 Hydrogencarbonate indicator solution does not tell us anything about oxygen.
Describe how you could find out how much oxygen had been added or removed from the solution during this investigation.

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2 Explain the problems with observing the colour changes in hydrogencarbonate indicator solution.

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3 Explain how using a pH probe generates quantitative data.

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Part 1: Humans produce carbon dioxide during respiration

Introduction

Humans are living organisms and our cells carry out respiration all of the time. During aerobic respiration, the cells take in oxygen and give out carbon dioxide. The oxygen and glucose react to release energy from glucose and produce carbon dioxide and water as by-products (something produced in the process of making or destroying something else). The energy is used to make ATP that cells can use:

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

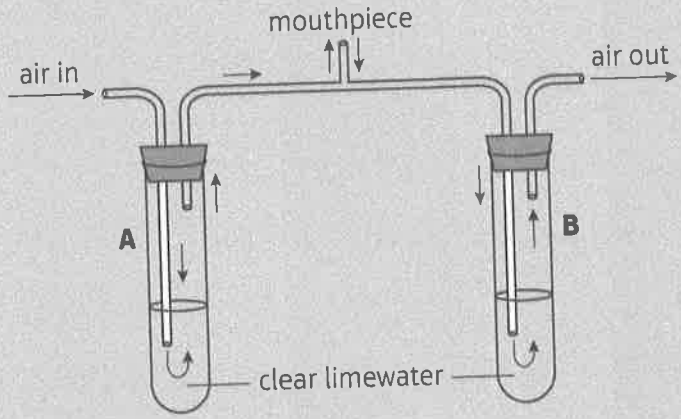
If you breathe out through a straw into red hydrogencarbonate indicator solution, the indicator solution will become yellow, showing that your exhaled air contains carbon dioxide. Alternatively, you can use limewater (calcium hydroxide solution) which becomes white and cloudy when carbon dioxide is added to it.

Your teacher may watch you to see if you can:

- work safely
- record data accurately.

Learning tip

- Limewater (calcium hydroxide) reacts with carbon dioxide to give a white precipitate. So if you add carbon dioxide to limewater the limewater will go from clear to white and cloudy. The cloudier it goes, the more carbon dioxide has been added.



Method

1. Set up the apparatus as shown in the diagram.
2. Use a syringe to add 20 mL limewater solution to each boiling tube.
3. Replace the bungs and tubes as shown in the diagram.
4. Place a nose-clip on your nose or hold your nose so that you must breathe through your mouth.
5. Start the timer and breathe gently in and out through the mouthpiece.
6. Note how long it takes for the limewater in tube B to become cloudy.

Learning tip

- The carbon dioxide content of the air is 0.04%. This may make the limewater go slightly cloudy but higher concentrations of carbon dioxide will make the limewater go very cloudy.

Objectives

- To investigate breathing in humans including the release of carbon dioxide and the effect of exercise on breathing

Equipment

- 2 boiling tubes
- marker pen
- rubber tubing, bungs and mouthpiece
- limewater
- 20 mL syringes
- timer
- nose-clip

Safety notes

- **If you suffer from asthma or have any kind of chest/lung condition, then do not undertake this investigation but record data while others in the class do the exercise.**
- Take care with the limewater.
- Wash off any chemical splashes immediately.
- The mouthpiece must be sterilised before and after each use.

Results

1 Describe what you saw when you breathed out into the limewater.

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Analysis

1 State whether you produced carbon dioxide.

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2 Give evidence to support your conclusion.

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Evaluation

1 Describe the problems with using time taken for the limewater to go cloudy as a measure of the rate of carbon dioxide production.

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2 Suggest another method that would give quantitative data.

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3 Explain how you could use this investigation to measure the change in rate of respiration in a person before and immediately after exercise.

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Part 2: The effect of exercise on the breathing rate of humans

Introduction

When you exercise, your muscles need to contract (become shorter and pull on your bones) more, so they need more ATP (energy). Your respiration rate must increase to release more energy for the increased muscle contraction. If your muscle cells are respiring more, then they need more oxygen. Your breathing rate increases to get more oxygen into the lungs and into the blood. Your heart rate also increases to pump more oxygen-rich blood (oxyhaemoglobin) to the muscle cells. At the beginning of exercise, your breathing rate and your heart rate have not increased enough to supply the extra demand. You meet the deficit by:

- using anaerobic respiration, which produces lactic acid and causes muscle fatigue
- using some stored oxygen from a protein (myoglobin) in your muscles.

After exercise, you continue to breathe faster than when at rest for several minutes because you have to:

- exhale the extra carbon dioxide as that is also acidic and would lower the blood pH and prevent important enzymes from working
- pay back the 'oxygen debt' and replenish the stored oxygen in your myoglobin
- deal with the lactic acid which is harmful because it lowers the pH in muscles and blood

This is called repaying the oxygen debt.

You can measure your breathing rate in breaths per minute by simply counting how many breaths you take in 15 seconds and multiplying by 4. One breath is a breath in **and** out. Or you can use a **spirometer** if your school has one.

You can measure the breathing rate before exercise (at rest), during exercise and after exercise until the breathing rate returns to your resting level.

The time taken for the breathing rate to return to resting level is called the **recovery time**.

Your teacher may watch you to see if you can:

- work safely
- record data accurately.

Equipment

- timer
- access to a step

Safety notes

- **If you suffer from diabetes, asthma or have any kind of chest/lung condition, then do not undertake this investigation. Instead record data while others in the class do the exercise.**

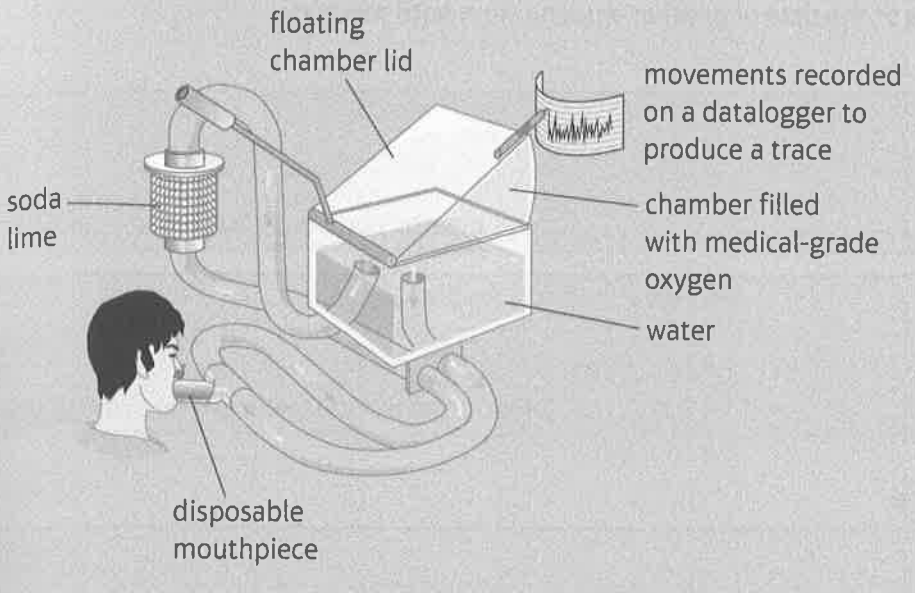
Method 1

1. While sitting down, start the timer and measure how many breaths you take in 1 minute. Repeat three times and find the mean value. Record your data.
2. Step up and down or do star jumps for three minutes. If possible, count your number of breaths in 1 minute whilst doing this.
3. Stop exercising.
4. Now count the number of breaths you take during each minute, until your breathing rate is the same as it was before you exercised.
5. Record your data and calculate your recovery time.

CORE PRACTICAL 9: HUMAN RESPIRATION
INVESTIGATE BREATHING IN HUMANS, INCLUDING THE RELEASE OF CARBON DIOXIDE AND THE EFFECT OF EXERCISE

SPECIFICATION REFERENCE
2.50
(2.34, 2.36, 2.37, 2.38, 2.48)

Method 2



1. Your teacher will have set up the spirometer according to the manufacturer's instructions, checked for leaks, calibrated the spirometer, disinfected the mouthpiece and undertaken a risk assessment.
2. If you do not suffer from asthma or diabetes, have a good level of fitness and are willing to take part, let your teacher know.
3. If you are chosen, sit still on the exercise bike with a nose-clip in place.
4. While the two-way tap is closed and the mouthpiece is connected to the outside air, breathe normally through the mouthpiece so you become familiar with the equipment.
5. A fellow student can now turn the two-way tap so that you are connected to the spirometer chamber and are breathing medical-grade oxygen from the spirometer.
6. Fellow students record your resting rate of breathing for 1 minute (number of breaths per minute). A kymograph can record these data on the spirometer trace – rate of breathing and depth of breathing will be shown.
7. Now pedal the exercise bike for 2 minutes. Fellow students record the rate of breathing manually and the rate and depth of breathing on the kymograph spirometer trace.
8. Stop pedalling. Fellow students record your breathing rate (and depth of breathing using a kymograph) until it is back to the resting rate.
9. Dispose of or disinfect the mouthpiece.
10. Repeat with another student volunteer.

Results

Make sure all your fellow students have a copies of the data generated.

Equipment

- timer
- pen and paper to record data
- soda lime
- disinfectant
- oxygen tank (medical grade)
- nose-clip
- kymograph or motion sensor with data logging software
- exercise bicycle
- spirometer

⚠ Safety notes

- **If you suffer from diabetes, asthma or have any kind of chest/lung condition, then do not undertake this investigation. Instead record data while others in the class do the exercise.**
- Your teacher will have set up and checked the spirometer and will supervise you. Only medical grade oxygen should be used. Soda lime is there to remove the carbon dioxide you breathe out. Take care when handling it.
- Follow the instructions carefully for using the spirometer.
- The mouthpiece must be sterilised before and after each use.

Analysis

1 Calculate the following from your data or the data of another student, from both methods.

a Mean breathing rate at rest

..... breaths per minute (recorded manually)

..... breaths per minute (recorded on kymograph)

b Mean breathing rate during exercise

..... breaths per minute (recorded manually)

..... breaths per minute (recorded on kymograph)

c Breathing rate one minute after exercise stopped

..... breaths per minute (recorded manually)

..... breaths per minute (recorded on kymograph)

d Recovery time

..... minutes (recorded manually)

..... minutes (recorded on kymograph)

2 Compare the data from each method.

.....

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3 a Calculate the increase in breathing rate during exercise.

b Explain the change in breathing rate:

i during exercise

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ii immediately after exercise.

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Evaluation

1 State one advantage and one disadvantage with each method.

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CORE PRACTICAL 10: TRANSPIRATION
INVESTIGATE THE ROLE OF ENVIRONMENTAL FACTORS IN DETERMINING THE RATE OF TRANSPIRATION FROM A LEAFY SHOOT

SPECIFICATION REFERENCE
2.58 B
(2.54, 2.55 B, 2.56 B, 2.57

Introduction

Leaves have small pores, called stomata (singular: stoma) on their surfaces; mostly on the under surface. Most of these stomata are open during daylight so that gaseous exchange can occur and leaf cells can obtain carbon dioxide for photosynthesis and the oxygen produced can be given off. Leaf cells will also be respiring during daylight. At night, fewer stomata are open – enough to allow gaseous exchange for respiration. Water evaporates from the walls of cells within the leaf and the vapour collects in the air spaces of the spongy mesophyll tissue. When the stomata are open, the water vapour can diffuse out into the atmosphere.

If the air outside the leaf is moving (due to wind), is dry and has a high temperature, then more water vapour will leave the leaf. This causes water to move from the xylem into the leaf cells. Water entering the root hair cells of the plant roots replaces the water in the xylem vessels. Transpiration (the loss of water vapour from leaves) cools the plant and brings fresh water with dissolved nutrients up to the leaves for photosynthesis. If water is lost from the leaves faster than it can be replaced, the leaves wilt and droop (hang down) because the cells in them become plasmloysed and the plant tissue becomes flaccid (soft and weak) (see CP 4 E – Observing osmosis in onion cells).

In this investigation, you can see how air movement, temperature, light and humidity affect the rate of transpiration from a leafy shoot.

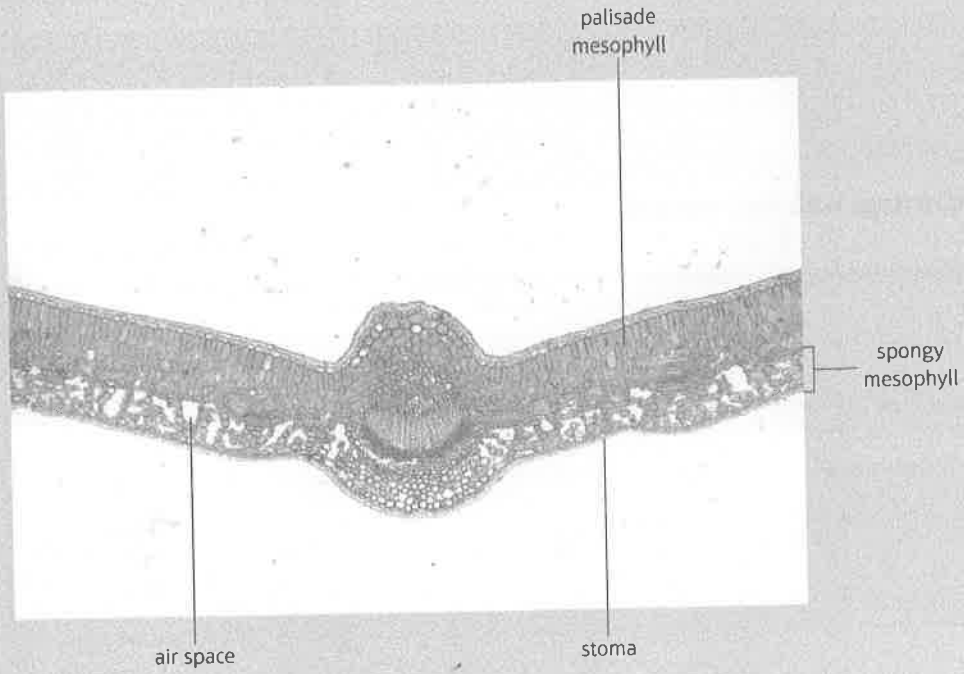
One method is to record loss of mass from a leafy shoot under different conditions. Any piece of apparatus used for measuring rate of transpiration is called a potometer.

Your teacher may watch you to see if you can:

- work safely and carefully
- record and manipulate data accurately.

Learning tip

- Water **vapour** diffuses out of open stomata on the lower surfaces of leaves, **down** a concentration gradient.



Objectives

- Investigate the effect of environmental factors on the rate of transpiration from a leafy shoot

Equipment

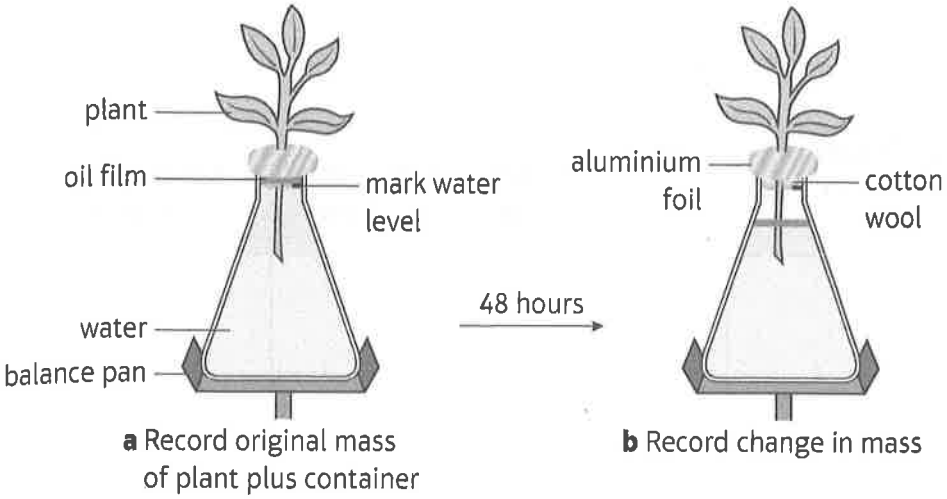
- conical flasks – 4 per group
- water
- leafy shoots – with cut ends of stems underwater – 4 per group
- scissors/secateurs
- oil
- cotton wool
- aluminium foil
- balance
- lamp
- access to a dark area (e.g. a cupboard)
- access to wind generator (e.g. hairdryer)
- thermometer

Safety notes

- Wear eye protection.
- Take care with glassware.
- Take care with scissors/ secateurs.

CORE PRACTICAL 10: TRANSPIRATION

SPECIFICATION REFERENCE
2.58 B



a Record original mass of plant plus container

b Record change in mass

Method

1. Fill each conical flask with water to the level shown in the flask on the left in the diagram.
2. Choose four leafy shoots, of the same type of plant and with the same number of leaves. Keeping the stems underwater, use secateurs to cut the ends diagonally. This is to prevent any air bubbles entering the xylem tubes because that would obstruct the flow of water.
3. One at a time, take a shoot out of water and immediately place it in the water of one conical flask.
4. Pour oil onto the water surface.
5. Insert cotton wool as a bung around the stem and use aluminium foil to seal the flask, as shown in the diagram.
6. Repeat steps **2**–**5** for three other leafy shoots.
7. Weigh and record the mass of each potometer + shoot.
8. Place one near a bright lamp, one in a dark cupboard, one in light in still air and one in light near a hairdryer.
9. Leave each for 24–48 hours. Record the temperature near each potometer.
10. After the time interval, weigh and record the mass of each potometer + shoot.
11. Calculate the percentage loss of mass for each potometer.
12. Record your data and compare with others in your class to check that the data are reliable.
13. Complete the table with two other sets of results from your class.

Results

1 Record your data and two other sets of data in the table.

Environmental conditions	% loss of mass of leafy shoot and potometer			Mean % loss of mass in ..... hours	% loss of mass per hour
	1	2	3		
Light with no wind Temperature = ...°C					
Light with wind Temperature = ...°C					
Bright light Temperature = ...°C					
No light Temperature = ...°C					

Analysis

1 Calculate the rate of loss of mass per hour for each environmental condition.

2 State:

a the independent variable (IV)

.....

b the dependent variable (DV)

.....

c three control variables.

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3 The loss of mass from the potometer is because water is lost from the flask. The water in the flask has a layer of oil over it and the flask is sealed with a bung.

Explain how the water has been lost.

4 State the conclusions you reached from your data about the factors that affect transpiration.

Evaluation

1 Explain why it is important to calculate percentage loss of mass.

2 Suggest two other combinations of environmental conditions that you could have investigated.

3 a Which environmental conditions lead to a greater transpiration rate?

b Suggest why those conditions increase the rate of transpiration.

4 State the environmental conditions which led to a reduced rate of transpiration.

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5 Suggest a control that could have been set up for this investigation.

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6 Design an investigation to find out how the number of leaves on a twig affect the rate of transpiration.

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CORE PRACTICAL 11: SEED GERMINATION
INVESTIGATE THE CONDITIONS NEEDED FOR SEED GERMINATION

SPECIFICATION REFERENCE
3.5
(3.4, 3.6)

Introduction

Flowers are the reproductive organs of plants. Many flowers, whether wind pollinated or insect pollinated, have both male and female parts and produce male and female gametes. Male gametes are sperm and are inside **pollen** grains. Female gametes are **ovules**.

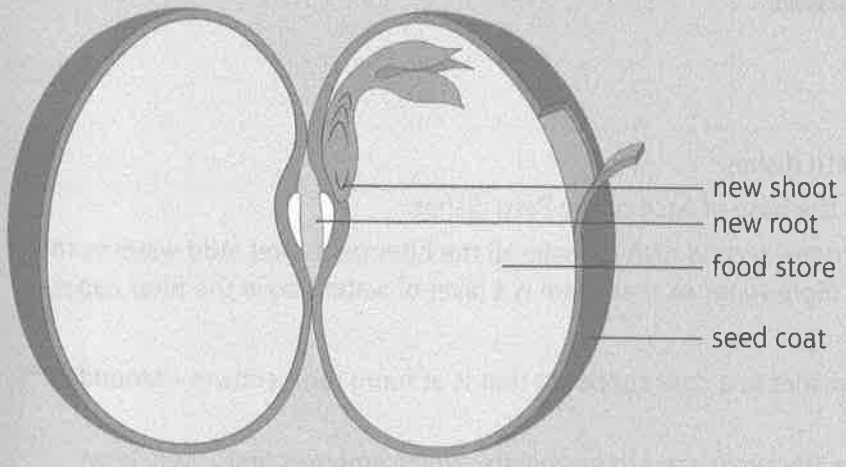
Pollination is the transfer of pollen from **anthers** to **stigma**.

Fertilisation is the fusion (joining together) of a male gamete with a female gamete. The male and female nuclei fuse. Once this has happened, the ovules develop into **seeds** within the ovary. Seeds and ovary form a **fruit**.

Learning tip

- Pollen contains the male plant gametes (sex cells), which are sperm.

Seeds contain stored food. This food is digested by enzymes and respired to provide the ATP (energy) and raw materials (e.g. amino acids) for the seed to germinate and the embryo to start to grow into a new plant. First, a new root (radicle) grows out from the seed. The new shoot (plumule) then grows. When leaves appear above ground, the new plant can photosynthesise. By this time, the food store inside the seed will have been used up.



bean seed

For seeds to germinate (develop into a new plant) they need the following.

Water – The seed absorbs water and swells (becomes bigger). Enzymes inside the seed are activated and start to digest (break down) the food store. Glucose is respired (anaerobically and aerobically) to provide ATP. Amino acids are used to make proteins for new growth and lipids are used to make new cell membranes. All chemical (metabolic) reactions inside cells take place in the watery cytoplasm so the seeds need to be hydrated.

Oxygen – The seed needs to respire aerobically and produce lots of ATP.

Temperature – Germination can be affected by temperature because enzymes work best at their optimum (best possible) temperature and all the processes taking place inside a germinating seed are catalysed by specific enzymes.

pH – Germination can be affected by pH because enzymes work best at their optimum pH values.

Some seeds also need a short burst of light before they will germinate and some need darkness. Some seeds need to be exposed to a cold spell before they will germinate.

Objectives

- Investigate the conditions needed for seed germination

Equipment

- Petri dishes (and lids)
- filter paper discs to fit Petri dishes – alternatively, cut circular pieces of kitchen paper to fit or use cotton wool
- marker pen
- distilled water, pH 7
- seeds that will germinate in darkness – for example, white mustard *Brassica alba*, cress *Lepidum sativum*, radish *Raphanus raphanistrum* subsp. *sativus*
- scissors

Safety notes

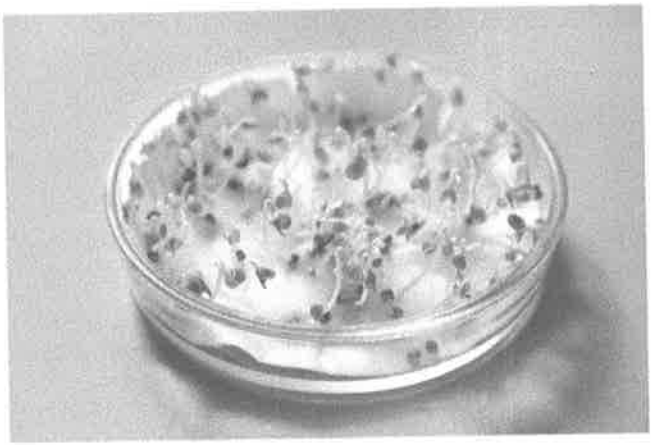
- Wear eye protection.
- Take care with glassware.
- Take care with scissors.
- Wash hands after touching seeds in case of allergens.

Learning tips

- Germination involves many reactions, each catalysed by a specific enzyme.
- When seeds germinate, the new root emerges first and soon has many tiny root hairs. Don't mistake these root hairs for mould.

Your teacher may watch you to see if you can:

- work safely and carefully
- record data accurately.



Part 1: Water

Method

1 Write your initials on the bottom of three Petri dishes.

2 Place about three pieces of filter paper into the base of each of the Petri dishes.

3 Leave one dish dry. Add just enough water to the second dish to make all the filter paper wet. Add water to the third dish so the paper is wet and then add more water so that there is a layer of water above the filter paper.

4 Add 20 seeds to each dish.

5 Place the lid on each dish and place all the dishes in a dark cupboard that is at room temperature – around 20 °C. Measure and note the temperature.

6 Examine the dishes each day and note when the seeds start to germinate. Which emerges first – radicle or plumule?

7 Note when the first leaves appear.

8 Count how many of the seeds have germinated after 7 days.

Results

Record your data in the table.

Type of seeds	Temperature (°C)	Amount of water (none/paper soaked/too much)	Number of germinated seeds after 7 days	% germination after 7 days
	20			
	20			
	20			

Analysis

1 State:

a the independent variable (IV)

.....

b the dependent variable (DV)

.....

c three control variables.

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2 Compare your data with others in your class to check that you all have similar results.

3 State the conclusions you reached from analysing your data.

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Part 2: Temperature

Method

1 Write your initials on the base of four Petri dishes.

2 Set up the four Petri dishes with three layers of filter paper in each. Use a pipette to deliver 10 mL of distilled water to the filter paper in each Petri dish. The paper should be well soaked but not flooded

3 Place 20 seeds on each dish and replace the lids.

4 Wrap each dish in foil to exclude light.

5 Place one in the fridge, one in a cupboard (at room temperature), one in an incubator set at 40 °C and one in an incubator at 60 °C. Note the temperature in the fridge and in the cupboard.

6 Examine the dishes each day and note when germination begins.

Results

1 Record your data in the table.

Type of seeds	Temperature (°C)	Amount of water	Number of germinated seeds after 7 days	% germination after 7 days

Analysis

1 State:

a the independent variable (IV)

.....

b the dependent variable (DV)

.....

c three control variables.

.....

.....

2 Compare your data with others in your class to check that you all have similar results.

3 What conclusions did you reach from analysing your data?

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Equipment

- Petri dishes (and lids)
- filter paper discs to fit Petri dishes – alternatively, cut circular pieces of kitchen paper to fit or use cotton wool
- marker pen
- distilled water, pH 7
- seeds that will germinate in darkness – for example, white mustard *Brassica alba*, cress *Lepidum sativum*, radish *Raphanus raphanistrum* subsp. *sativus*
- thermometer
- aluminium foil
- access to a fridge
- access to incubators set at different temperatures (e.g. 40 °C and 60 °C)
- scissors

Safety notes

- Wear eye protection.
- Take care with glassware.
- Take care with scissors.
- Wash hands after touching seeds in case of allergens.

Evaluation

1 Explain why it is important to calculate percentage germination.

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2 Suggest how you could improve the design of this investigation to obtain data that would allow you to describe a relationship between temperature and germination.

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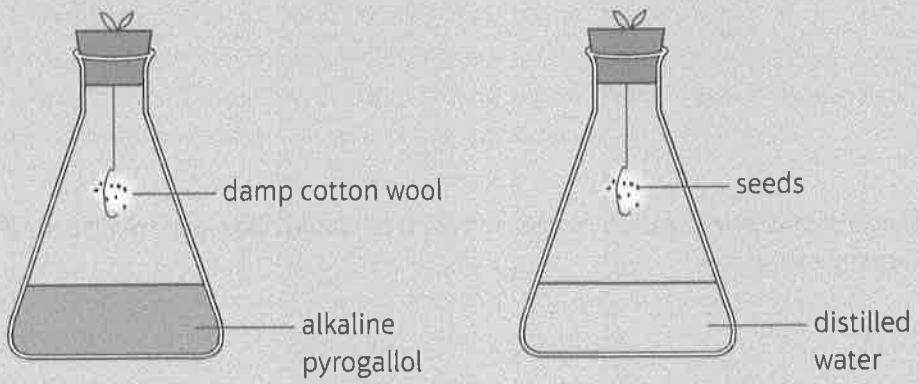
Part 3: Oxygen

Method



1 Write your initials on two conical flasks.
2 Add 50 mL alkaline pyrogallol to one of the conical flasks. Alkaline pyrogallol absorbs oxygen and will remove the oxygen from the air in the flask.
3 Add 50 mL distilled water to the other flask.
4 Make two cotton wool balls, dampen them well with distilled water and roll them in the seeds so that seeds stick to the cotton wool.
5 Tie a piece of thread around each cotton wool ball and then suspend the cotton wool and seeds into each flask as shown in the diagram.
6 Place both flasks in a warm place.
7 Examine after 3–4 days and note if germination has occurred.

Equipment

- marker pen
- distilled water, pH 7
- seeds that will germinate in darkness – for example, white mustard *Brassica alba*, cress *Lepidum sativum*, radish *Raphanus raphanistrum* subsp. *sativus*
- thermometer
- two conical flasks with rubber bungs
- alkaline pyrogallol (1 mmol pyragallol in 0.5 mmol sodium hydroxide or sodium carbonate)
- cotton wool
- thread
- buffer solutions pH 2, pH 3, pH 4, pH 5, pH 6, pH 8
- scissors

⚠ Safety notes

- Wear eye protection.
- Take care with glassware.
- Take care with scissors.
- Wash off any chemical splashes immediately.
- Take care with the alkaline pyrogallol.
- Wash hands after touching seeds in case of allergens.

Results

1 Record your data in the table.

Type of seeds	Temperature (°C)	Alkaline pyrogallol or water in flask?	Number of germinated seeds after 3–4 days

Analysis

1 Do germinating seeds need oxygen?

.....

2 Explain how you reached your conclusion.

.....

.....

.....

Part 4: pH

Method

1 Write your initials on the base of seven Petri dishes.

2 Number the Petri dishes 2–8.

3 Place cotton wool or three sheets of filter paper in the base of each one.

4 Using a measuring cylinder, add a volume of water to dish number 7, so that the cotton wool/paper is well soaked but not flooded. Note the volume added.

5 Add an equal volume of the pH2 buffer to dish 2. Likewise, add the same volume of pH3 buffer to dish 3, pH4 buffer to dish 4, pH5 buffer to dish 5, pH6 buffer to dish 6 and pH8 buffer to dish 8.

6 Add 20 seeds to each dish, scattered and spaced out over the filter paper. Replace the Petri dish lids.

7 Place the seeds in a cupboard at room temperature – around 20 °C. Measure and note the temperature.

8 Examine the dishes each day and count how many seeds have germinated in each one.

Results

1 Record your data in the table.

Type of seeds	Temperature (°C)	Amount of buffer solution	pH	% germination after 7 days

Analysis

1 State:

a the independent variable (IV)

.....

b the dependent variable (DV)

.....

c three control variables.

.....

.....

Equipment

- Petri dishes (and lids)
- filter paper discs to fit Petri dishes – alternatively, cut circular pieces of kitchen paper to fit or use cotton wool
- marker pen
- distilled water, pH 7
- seeds that will germinate in darkness – for example, white mustard *Brassica alba*, cress *Lepidum sativum*, radish *Raphanus raphanistrum* subsp. *sativus*
- thermometer
- buffer solutions pH 2, pH 3, pH 4, pH 5, pH 6, pH 8
- scissors

⚠ Safety notes

- Wear eye protection.
- Take care with glassware.
- Take care with scissors.
- Take care with the buffer solutions.
- Wash off any chemical splashes immediately.
- Wash hands after touching seeds in case of allergens.

2 Compare your data with others in your class to check that you all have similar results.

3 What conclusions did you reach from analysing your data?

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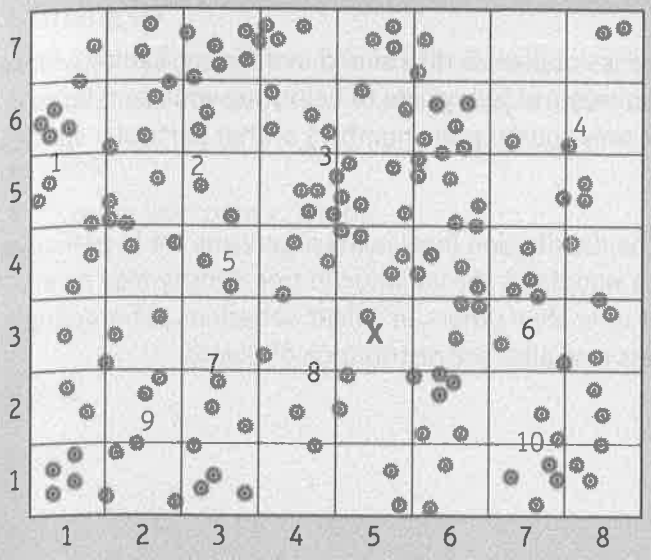
CORE PRACTICAL 12: POPULATION SIZE

INVESTIGATE THE POPULATION SIZE OF AN ORGANISM IN TWO DIFFERENT AREAS USING QUADRATS

SPECIFICATION REFERENCE
4.2
(4.1, 4.3 B, 4.4 B, 4.5)



A pair of dice showing 5 + 3 would mean that you would sample the square marked 'X'.

Introduction

A **population** is the number of organisms of the same species that live in a particular habitat or area at the same time and are able to interbreed (reproduce).

The numbers in a population may fluctuate (change by increasing and decreasing) depending on factors such as food availability, predators and the weather. Thus, population size can vary.

Plants depend on the availability of light, water, carbon dioxide and minerals for them to grow and reproduce. Many plants also respond to soil pH: some only grow at neutral pH but some prefer acid or alkaline environments. Many plants cannot tolerate (be exposed to without being harmed by) salt but some can and will grow near the seashore. Some types of plant (xerophytes) are well adapted to living in dry areas such as deserts.

It is not possible to count every plant of a certain species in a whole habitat such as a field, path, wood or a whole mountainside. Instead, we sample each area by randomly placing a square frame, called a **quadrat**, and counting the number of plants of that type in the quadrat. We do this several times for each habitat. Then we can make comparisons.

Objectives

- To estimate the size of a population of a species of plant in two different areas using quadrats

Equipment

- measuring wheel or tape
- pair of dice
- quadrat (e.g. a square of sides 1 m × 1 m or a square of sides 0.5 m × 0.5 m), divided into smaller squares with string
- identification charts to help you identify plant species
- light meter
- humidity sensor
- anemometer (wind speed measurer)
- pH meter and probe
- trowel
- small bags to collect soil samples for testing in the lab
- sticky tape or string to close bags
- marker pen and labels for bags
- disposable gloves
- hand sanitiser
- soil nutrient test kit

⚠ Safety notes

- Wear appropriate clothing and sunscreen for work outdoors.
- Take care when walking over uneven ground.
- Watch out for harmful plants and animals, animal faeces and open water.
- Wear gloves if necessary.
- Clean hands with hand sanitiser at the end of the investigation and wash hands when you return indoors.

Learning tip

- In this investigation you are looking at how one particular species of plant is distributed in different habitats. Once you have identified the species that you are investigating (you may use your guide to help you), you can refer to it by its common name or by its botanical (Latin) name. You are only counting the numbers of that particular species of plant.

Within the same habitat, conditions may vary. Because of this, the distribution (how many organisms are in particular parts of that habitat) of a population may vary. For example, in a woodland, the variation in tree density may mean that some areas of the floor are more shaded than others or are drier than others. In a field, variations in trampling (damage caused by walking on something) by humans or animals may alter the distribution of plants.

Your teacher may watch you to see if you can:

- work carefully
- record data accurately.

Learning tips

- In this investigation you will use a **quadrat**. Do not confuse it with a quadrant, which is a quarter of a circle or an instrument used in navigation.
- Random sampling does not mean just throwing the **quadrat** and sampling where it lands. It means generating random pairs of numbers that you use as coordinates to know where to place your quadrats in the area.

Method

1. Choose an area for sampling. A school field would be suitable.
2. Measure the size of the area and draw a scale map of it. Divide this map into squares that represent 1 m × 1 m in the field. Number each square on the *x* axis and on the *y* axis.
3. Throw a pair of dice. Use the numbers as coordinates, as you would for map coordinates. So if you get a 6 and a 4, go 6 squares along on the *x* axis and then go 4 squares up on the *y* axis. Do this 10 times. These numbers, or co-ordinates, tell you which areas in your field to sample. Throwing the dice generates random numbers for you.
4. Place your quadrat on the field in areas corresponding to each of the randomly chosen squares; count and record how many of your chosen plant species is present each time. This method of sampling is called random sampling.
5. Record the environmental conditions in the area and collect a small sample of soil, place it in a labelled bag and seal it to take back to the lab.
6. Choose another area with different conditions – for example, if the first was on flat ground, choose a sloping area; or choose a woodland area if the first area was open grassland.
7. Repeat steps **2–5** for your second area.
8. In the lab, carry out suitable tests on the soil samples and record your results. You can test for:
   - **a** humus content – shake some soil with water and see how much organic debris floats on the surface
   - **b** air content – place some soil in a measuring cylinder and add water from another measuring cylinder to fill the air spaces in the soil; note how much water you added then calculate the percentage of air in the soil
   - **c** nutrient content – follow the instructions in the soil test kit.

Learning tip

- You will have your raw data in note form. Look at the questions below so you know what you will be asked to do with your data and then design a suitable table to display your data.

Results

1 Present your data in a table.

Analysis

1 Calculate the average number of your chosen plants per sampled area. For example, if you are using a 1 m × 1 m quadrat, each sampled area is 1 m^2; if you are using a 0.5 m quadrat, each sampled area is 0.25 m^2.

2 Calculate the area of your field.

3 Calculate the estimated number of plants of your chosen species in the field.

4 Repeat steps **1–3** for your other area.

Evaluation

1 Describe how you would find out whether different times of the year affected the size of your chosen plant population in one of the areas you sampled.

2 Describe an experiment you could carry out in the lab to find out whether an environmental factor you measured affects the distribution of the organism you studied.

CORE PRACTICAL 13: POPULATION DISTRIBUTION

INVESTIGATE THE DISTRIBUTION OF ORGANISMS IN THEIR HABITATS AND MEASURE BIODIVERSITY USING QUADRATS

SPECIFICATION REFERENCE
4.4 B
(4.1, 4.2, 4.3 B, 4.5)

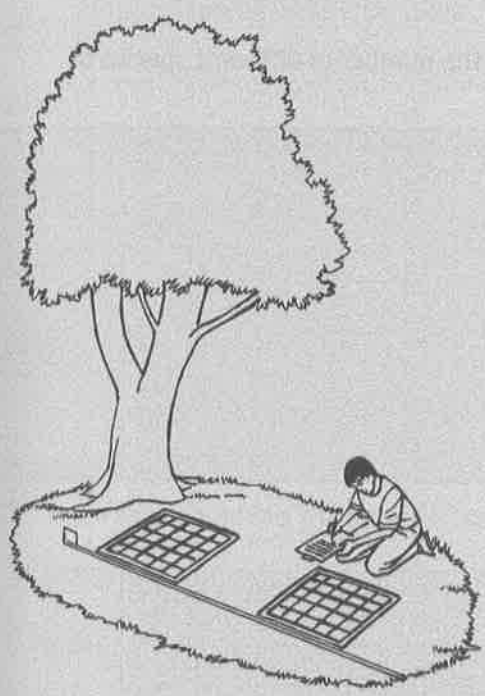
Introduction

A **population** is the number of organisms of the same species that live in a particular **habitat** or area at the same time and are able to interbreed (reproduce).

The numbers in a population may fluctuate (go up and down) depending on factors such as food availability, predators and the weather. Thus, the size of a population and the distribution (the way something is spread over an area) of organisms in that population can vary.

The distribution of a particular species is also affected by competition between members of other species of plants. This is called *interspecific competition*. ('inter' means *between*). They may compete for space, nutrients, light and water.

Interactions between species and the effects of environmental conditions may cause the number of different species in an area to vary. The greater the number of different species in an area, the greater the variety of biological diversity or **biodiversity** in that area.



Learning tip

- In this investigation you will use a **quadrat**. Do not confuse it with a quadrant, which is a quarter of a circle or an instrument used in navigation.

Your teacher may watch you to see if you can:

- work carefully
- record data accurately.

Method

1. Your class will be working in an area where environmental conditions change – for example, from shade to sunshine, or from untrampled and to well-trampled.
2. Decide which environmental factors you will measure and how you will measure them.
3. Peg out your long tape measure along the ground, travelling from one environmental condition (e.g. untrampled field) to the other (e.g. well trampled path at the edge of the field). This is your transect.
4. Place your quadrat at one end of the transect line.

Objectives

- To investigate the distribution of organisms in their habitats and measure biodiversity using quadrats

Equipment

- long tape measure (at least 20 m) with pegs at each end
- quadrat (e.g. square of sides 1 m × 1 m or square of sides 0.5 m × 0.5 m)
- identification charts to help you identify plant species
- light meter
- humidity sensor
- anemometer (wind speed measurer)
- pH meter and probe
- disposable gloves
- trowel
- small bags to collect soil samples for testing in the lab
- sticky tape or string to close bags
- marker pen and labels for bags
- hand sanitiser
- soil nutrient test kit

⚠ Safety notes

- Wear appropriate clothing and sunscreen for work outdoors.
- Take care when walking over uneven ground.
- Watch out for harmful plants and animals, animal faeces and open water.
- Wear gloves if necessary.
- Clean hands with hand sanitiser at the end of the investigation and wash hands when you return indoors.

5 Count how many different species of plants are in that quadrat. Estimate and record how much of the quadrat is covered by each species (e.g. 10%, 50%, 75%). This is called percentage cover.

Learning tip

- You will need to be able to distinguish between different species. You only need to know their common names, not their botanical (Latin) names. Record the environmental conditions and collect a small sample of soil from the quadrat, place it in a labelled bag and seal it to take back to the lab.

6 Move your quadrat along a specified distance (e.g. 2 m) and repeat step **5**.

7 Repeat steps **5** and **6** until, you have sampled the whole transect at 2 m intervals.

8 In the lab, carry out suitable tests on the soil samples and record your results. You can test for:

- **a** humus content – shake some soil with water and see how much organic debris floats to the surface
- **b** air content – place some soil in a measuring cylinder and add water from another measuring cylinder to fill the air spaces in the soil; note how much water you added then calculate the percentage of air in the soil
- **c** nutrient content – follow the instructions in the soil test kit.

Results

1 Pool the results from all the groups in your class. Make a table and record the number of different species of plants along the transect.

2 Display the pooled class data in a suitable chart or graph.

Analysis

1 Describe the changes in biodiversity along the transect.

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2 Describe how the environmental factors that you investigated changed along the transect.

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3 Describe any correlation between the change in biodiversity and the change in an environmental factor.

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Evaluation

1 State which area has the greatest biodiversity.

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2 Suggest reasons for the difference in biodiversity.

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CORE PRACTICAL 14: ANAEROBIC RESPIRATION
INVESTIGATE THE ROLE OF ANAEROBIC RESPIRATION BY YEAST UNDER DIFFERENT CONDITIONS

SPECIFICATION REFERENCE
5.6
(1.2, 2.36, 2.38, 2.39, 5.5

Introduction

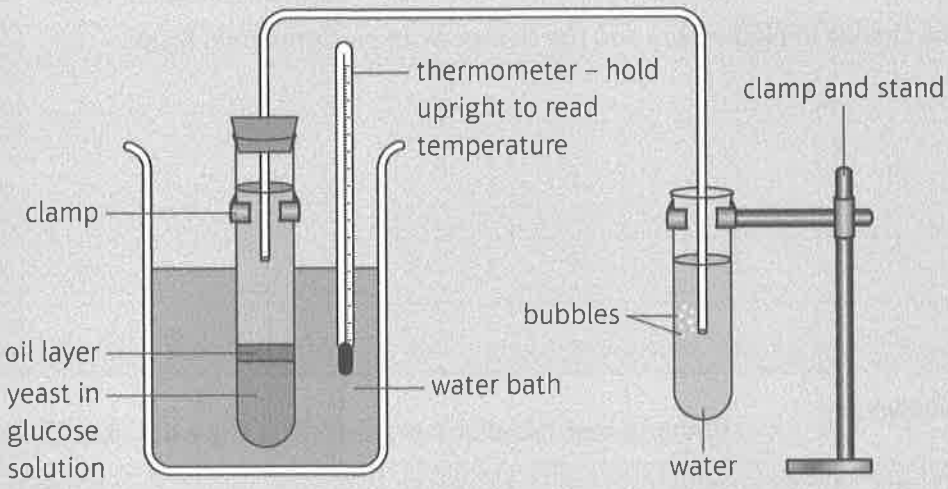
Yeast is a single-celled fungus. If oxygen is present, it will respire **aerobically**. If there is no oxygen, it can respire **anaerobically.**

When yeast is used for making bread, it starts by respiring aerobically and producing carbon dioxide. The bubbles of carbon dioxide take up space causing the dough to rise and become less dense. Later in the breadmaking process, the yeast respires anaerobically producing more carbon dioxide and some ethanol. The ethanol evaporates during cooking.

When yeast is used for brewing, it is reproducing rapidly and soon any oxygen runs out. The yeast then respires anaerobically and produces ethanol and carbon dioxide. You can investigate anaerobic respiration in yeast under different conditions. If you measure the amount of carbon dioxide given off in a unit time, then you have a value for the rate of anaerobic respiration in yeast.

Your teacher may watch you to see if you can:

- work safely
- record data accurately.



Method

1 Using a syringe, add 20 mL sugar solution to the boiling tube. Then, add 2 drops of diazine green indicator to the boiling tube.

- The indicator diazine green can be added to the mixture. It is blue when oxygen is present but turns pink when there is no oxygen. At the start, the yeast respires aerobically; when it has used up all the oxygen, the yeast cells will respire anaerobically.)

2 Place the boiling tube in a water bath at 20 °C for 5 minutes.

Learning tip

- Use the thermometer to check the temperature of the water bath and add hot or cold water as needed.

3 Weigh 0.5 g yeast and add to the boiling tube. Stir with a glass rod.

4 Pour a thin layer of oil onto the yeast in sugar solution to prevent entry of air (oxygen).

5 Place a bung and delivery tube into the boiling tube as shown in the diagram and place the free end of the delivery tube into a test tube containing water.

6 Start the timer.

Objectives

- To investigate the role of anaerobic respiration in yeast under different conditions

Equipment

- 20 mL syringe
- 2% sugar solution, boiled and cooled to sterilise it and to remove oxygen
- boiling tube
- access to thermostatically controlled water baths, set at different temperatures
- balance
- yeast
- glass rod
- oil
- bosses, clamps and stands
- bung and delivery tube
- diazine green indicator
- test tube
- water
- timer

⚠ Safety notes

- Wear eye protection.
- Take care with the indicator solution/limewater.
- Wash off any chemical splashes immediately.
- Take care when using high-temperature water baths.
- Always wash hands after handling yeast.

7 Count and record the number of bubbles produced in one minute.

8 Repeat steps **6** and **7** twice more.

9 Repeat steps **1–8** for different temperatures, for example, 30 °C, 40 °C, 50 °C, 60 °C.

Results

1 Record your data in the table.

Temperature (°C)	Number of bubbles of CO_2 evolved in 1 minute			Mean number of bubbles CO_2 per minute
	1	2	3	
20				
30				
40				
50				
60				

Analysis

1 State:

a the independent variable (IV)

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b the dependent variable (DV)

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c three control variables.

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2 What conclusions did you reach from your data?

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Evaluation

1 You were told that the gas produced by the yeast was carbon dioxide and you counted the bubbles. How could you have used this piece of apparatus, and another reagent in the test tube, to show that the gas was carbon dioxide?

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2 State two sources of error in this investigation.

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3 Suggest how you could improve the investigation to reduce those errors.

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4 Some other factors might affect the rate of anaerobic respiration by yeast.
What other factors could you investigate this using this apparatus?

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5 Carbon dioxide given off by the yeast could be collected over water in a measuring cylinder by downward displacement of the water.
Suggest an advantage of this method compared to counting the bubbles of carbon dioxide.

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PRACTICAL SKILLS TABLE

Tick each technique when you cover it in your practical work.

Practical skill covered	Core practical													
	CP1	CP2	CP3	CP4	CP5	CP6	CP7	CP8	CP9	CP10	CP11	CP12	CP13	CP14
Solve problems set in a practical context														
Apply scientific knowledge and understanding in questions with a practical context														
Devise and plan investigations, using scientific knowledge and understanding when selecting appropriate techniques														
Demonstrate or describe appropriate experimental and investigative methods, including safe and skilful practical techniques														
Make observations and measurements with appropriate precision, record these methodically and present them in appropriate ways														
Identify independent, dependent and control variables														
Use scientific knowledge and understanding to analyse and interpret data to draw conclusions from experimental activities that are consistent with the evidence														
Communicate the findings from experimental activities, using appropriate technical language, relevant calculations and graphs														

Practical skill covered	Core practical													
	CP1	CP2	CP3	CP4	CP5	CP6	CP7	CP8	CP9	CP10	CP11	CP12	CP13	CP14
Assess the reliability of an experimental activity														
Evaluate data and methods taking into account factors that affect accuracy and validity														

Core Practical 1

1C Use ratios, fractions, percentages, powers and roots (if using dilutions for a more quantitative analysis of Benedict's test)

Core Practical 2

2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average)
4A Translate information between graphical and numerical form
4C Plot two variables (discrete and continuous) from experimental or other data
4D Determine the slope and intercept of a linear graph

Core Practical 3

2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average)
4A Translate information between graphical and numerical form
4C Plot two variables (discrete and continuous) from experimental or other data
4D Determine the slope and intercept of a linear graph

Core Practical 4

1C Use ratios, fractions, percentages, powers and roots
2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average)
4A Translate information between graphical and numerical form
4C Plot two variables (discrete and continuous) from experimental or other data
4D Determine the slope and intercept of a linear graph
5C Calculate areas of triangles and rectangles, surface areas and volumes of cubes

Core Practical 5

2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average)
4A Translate information between graphical and numerical form
4C Plot two variables (discrete and continuous) from experimental or other data
4D Determine the slope and intercept of a linear graph

Core Practical 6

1D Make estimates of the results of simple calculations, without using a calculator
2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average)
2C Construct and interpret bar charts
3C Substitute numerical values into algebraic equations using appropriate units for physical quantities

Core Practical 7

2B Understand and find the arithmetic mean (average)
2C Construct and interpret bar charts

Core Practical 9

2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean
2D Construct and interpret frequency tables, diagrams and histograms
2G Understand the terms mode and median
4C Plot two variables (discrete and continuous) from experimental or other data

Core Practical 10

1C Use ratios, fractions, percentages, powers and roots
2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average) of class data
2C Construct and interpret bar charts

Core Practical 11

1C Use ratios, fractions, percentages, powers and roots
2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average) of class data
2C Construct and interpret bar charts

Core Practical 12

1C Use ratios, fractions, percentages, powers and roots
2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average) of class data
2C Construct and interpret bar charts
2D Construct and interpret frequency tables, diagrams and histograms
2E Understand the principles of sampling as applied to scientific data
2G Understand the terms mode and median

Core Practical 13

1C Use ratios, fractions, percentages, powers and roots
2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average) of class data
2C Construct and interpret bar charts
2D Construct and interpret frequency tables, diagrams and histograms
2E Understand the principles of sampling as applied to scientific data
2G Understand the terms mode and median

Core Practical 14

2A Use an appropriate number of significant figures
2B Understand and find the arithmetic mean (average)
4A Translate information between graphical and numerical form
4C Plot two variables (discrete and continuous) from experimental or other data
4D Determine the slope and intercept of a linear graph

Word	Meaning
accuracy	How close a value is to its real value.
anomalous	Does not fit a pattern.
control variables	Variables whose values need to be kept steady during an investigation.
correlation	A relationship between two variables. If an increase in one is linked to an increase in the other, it is 'positive'. An increase in one linked to a decrease in the other is 'negative'.
data	Observations or measurements collected in investigations.
dependent variable	The variable that is measured in an investigation. The values of the dependent variable depend on those of the independent variable.
directly proportional relationship	A relationship between two variables where one variable doubles when the other doubles. The graph is a straight line through (0,0). We say that one variable is directly proportional to the other.
discrete data	Data given in the form of limited values. For example, shoe sizes come in whole sizes and half sizes but not in sizes in between. So size 4, size 4½ and size 5 are all possible, but size 4.149 is not. The number of different shoe sizes is limited.
estimate	An approximate answer, often calculated from a sample or using rounded values.
evidence	Data used to support an idea or show that it is wrong.
hazard	Something that could cause harm.
hazard symbol	A warning symbol that shows why something can cause harm.
hypothesis	An idea about how something works that can be tested using experiments. The plural is *hypotheses*.
independent variable	The variable that you chose the values of in an investigation.
linear relationship	A relationship between variables that produces a straight line when plotted on a scatter graph. The line does **not** have to go through the (0,0) point.
line of best fit	A line going through a set of points on a graph, so that roughly equal numbers of points end up on either side of the line. In biology, we often do **not** use lines of best fit but join the plot points dot to dot with ruled lines.
mean	An average calculated by adding up the values of a set of measurements and dividing by the number of measurements in the set.
model	A way of showing or representing a phenomenon that helps you to think about it or to investigate it.
outlier	Another term for an anomalous reading.
precision	How close a set of repeated measurements are to one another.
prediction	What you think will happen in an experiment.
qualitative data	Data that are not in the form of numbers (e.g. the names of colours).
random error	A mistake made in a measurement, which can be different every time that measurement is made.

Word	Meaning
repeatable	Results that are similar when repeated by the same experimenter. You can be more certain that a set of repeatable results is correct.
reproducible	Results that are similar when repeated by different experimenters.
sample	To take a small part of something to investigate. You use a sample to draw conclusions about the larger whole.
scatter graph	A graph in which data for two variables are plotted as points. This allows you to see whether there is a relationship between the two variables.
significant figures	The number of digits of a value, starting from the first non-zero digit.
specimen	The part of a sample studied using a microscope.
systematic error	An error that is the same for all readings, such as forgetting to zero a balance before using it to measure a series of masses or an error in the equipment used.
theory	A hypothesis (or set of hypotheses) that has been repeatedly tested and supported by evidence from experiments and for which there is a high degree of agreement in the scientific community.
variable	Conditions that might affect the results of an experiment.

Core Practical 1

Results

1 Your data in the table – depends which foods were tested.

Analysis

1 Your data in the table – depends which foods were tested.

2 Benedict's test can show if a lot (red) or a little (green or yellow) of the sugar is present; emulsion test – the more fat present, the more intense the white cloudiness; starch test – depth of blue-blackness may indicate more starch; protein – greater depth of the colour indicates more protein (amino acids); students may develop the idea that you can make up standards with known concentrations of the foods and then compare test results with those.

Evaluation

1 Any problems identified and suitable method to mitigate suggested. For example, colour of some foods may mask end result of test – e.g. oranges or green vegetables – so could extract the juice from these foods and test that.

Extension

1 Run a series of Benedict's tests with glucose of known concentrations. Keep these as standards and/or take a photograph of them to use as standards; compare results with the standards to give estimate of concentration of sugar in the foods tested.

Core Practical 2

Results

1 and **2** Your results.

Analysis

1 Bar graph; plots should cover at least half of graph paper in both directions; there should be gaps between bars; bars of equal width. Label *y*-axis 'time taken to digest starch (s)' and label *x*-axis with the different temperatures.

2 Trend will be that at lower temperatures it takes longer, it takes a shorter time around 30 °C, 40 °C, 50 °C and a longer time at temperatures above 50 °C.

3 Intermediate temperatures used (e.g. every degree or every two degrees).

4 Probably between 30 °C and 50 °C because less time is taken.

Evaluation

1 Repeat but using intervals of 1 degree between 30 °C and 50 °C.

2 Your problems – e.g. time between extracting sample and adding to iodine; solution not properly mixed.

3 Use magnetic stirrer and instead of extracting samples at intervals, dip a piece of starch paper into the solution at intervals; any valid response.

Core Practical 3

Results

1 Your results in the table.

2 Suitable graph: *y*-axis 'time taken (minutes)' and *x*-axis 'pH'; graph covers more than half the space; correct plotting; join points dot to dot with ruler.

Analysis

1 At low pH values, the time taken is shorter; as pH is raised above 2, then the time taken is longer.

2 This enzyme has optimum pH of between 1 and 2 / 1 and 3 but is denatured/shape of active site changes at higher pH values so it takes longer to catalyse reaction.

Evaluation

1 Any suitable problems.

2 Any suitable and valid means of mitigation.

3 Need to carry out more tests at smaller intervals between pH 1 and 3.

Core Practical 4, part 1

Number of cubes	Dimensions of each cube (cm)	Area of one face (cm^2)	Surface area of one cube (cm^2)	Total surface area (cm^2)	Volume of one cube (cm^3)	Total volume (cm^3)	SA : V ratio of each set of cubes	Time taken for dye to diffuse into all the agar jelly
1	4 × 4 × 4	16	96	96	64	64	1.5:1	
8	2 × 2 × 2	4	24	192	8	64	3:1	
64	1 × 1 × 1	1	6	384	1	64	6:1	

Results

1, 2, 3 Given in graph above.

Analysis

1

a remains the same

b increases

c increases

d decreases

2 Inverse proportionality/negative correlation/ as SA : V ratio increases, so the time taken for diffusion to all of jelly decreases (because there is more surface for diffusion to occur).

Core Practical 4, part 2

Results

1 Your own table. Column headings should be:

Time (s)	Is starch in beaker water?	Is glucose in beaker water?

Analysis

1 Glucose molecules diffuse out of the Visking bag into the water because they are small(er).

Starch molecules do not diffuse through the Visking bag because they are too large.

Core Practical 4, part 3

Results

1 Your data should show that the level rises in the thistle funnel that contains sucrose solution. It rises higher in the one with 15% sucrose. In the apparatus with water in the thistle funnel, the level of water in the tube does not rise.

Analysis

1 With 3% sucrose – there is a higher water concentration in the beaker than in the tube so water passes through the Visking tubing, by osmosis, into the thistle funnel and the level rises in the tube.

With 15% sucrose solution, there is a higher concentration of water in the beaker than in the thistle funnel and the difference in concentration is greater than when there is 3% sucrose solution in the thistle funnel so more water enters by osmosis and the level in the flask rises higher.

With water inside the thistle funnel, there is no difference in water concentration on either side of the Visking tubing so no net osmosis. Some water molecules will enter the funnel but some will leave and so the level in the tube remains the same.

Core Practical 4, part 4

Results

1 Table completed and % mass changes calculated.

2 The answer depends on your data. It is likely that the discs in 5% and 7.5% sucrose solution will gain mass and all the others (those in 10%, 12.5% and 15% sucrose solution) will lose mass.

3 Suitable graph

4 Appropriately drawn line.

Analysis

1 The concentration of water inside the potato cells is lower than in the tube so water enters the cells, by osmosis, through the partially permeable cell membranes.

2 The concentration of water inside the potato cells is higher than in the tube so water leaves the cells, by osmosis, through the partially permeable cell membranes.

3 **a** The strength of sucrose solution you need is shown where the graph line crosses the *x*-axis/where no gain or loss of mass of the potato discs.

b The concentration of water inside the cells is the same as of that strength of sugar solution so there is no net osmosis.

4 **a** If there are repeats and the data show concordance (agree) then a more accurate mean value can be calculated.

b Not all the discs have the same mass so by finding % changes, the discs in each tube/from others in the class, can be compared.

Evaluation

1 Any valid problems and suggestions.

2 Use strengths of sucrose solution in smaller increments around the value where there is no gain or loss.

Core Practical 4, part 5

Observations

1 Drawings made with sharp HB pencil and clear unbroken lines. Scale shown. Each drawing to have a heading. Annotations to show in which solution cells were kept and whether plasmolysed, turgid or neither.

Core Practical 5, part 1

Results

1 Yes, the gas given off reignites a glowing splint

Analysis

1 The gas given off is therefore oxygen.

Evaluation

1 Could change light intensity, keep all other factors the same and measure how much oxygen given off per minute at each intensity.

Core Practical 5, part 2

Results and analysis

Destarched leaf did not become black when iodine/KI solution added showing that the leaf did not contains starch at the beginning of the experiment. The decolorised leaf that had been allowed to photosynthesise became black when iodine/KI solution added, showing that starch is present.

Core Practical 5, part 3a

Results

1 Drawing should show starch present only where leaf was green.

Analysis

1 Chlorophyll is needed for photosynthesis.

2 Chlorophyll traps light energy.

Core Practical 5, part 3b

Results

1 Drawing should show starch made only where leaf was exposed to light.

Analysis

1 Light is needed for photosynthesis.

Core Practical 5, part 3c

Results

1 The leaf without carbon dioxide did not make starch.

Analysis

1 Carbon dioxide is needed for photosynthesis.

Evaluation

1 Carbon dioxide diffuses out of stomata and is absorbed by the sodium hydroxide solution.

Core Practical 6

Results

1 Your data in the table.

Analysis

1 **a** IV is heat given off/energy in food sample

b DV is type of food

2 Mass of food – weigh food

Distance between burning food and tube – measure that distance and keep the same

Other valid points

3 **a** Look at your data – it should be one of the fats.

b More heat/increase in water temperature per unit mass of food.

Evaluation

1 Not all of the food burned – didn't weigh what was left.

Some heat energy lost to surroundings/air.

Some heat energy is used to heat up the boiling tube and not the water.

Oil may drip from the mineral wool.

Distance between food and bottom of tube may not be same in each case.

Other valid points.

2 Less discrepancy if volume not measured accurately.

3 Have an insulating jacket around boiling tube to prevent heat loss to air.

More accurate thermometer.

Other valid points.

4 Your data correctly substituted into the equation and answer calculated.

Core Practical 7

Results

1 Your data in the table.

Analysis

1 Yes

2 Hydrogencarbonate indicator solution with the expired air passing through it becomes yellow/limewater becomes cloudy.

3 Animal – shorter time for indicator to change.

Evaluation

1 To make a valid comparison.

2 To make a valid comparison – so carbon dioxide given off is reacting with same volume of indicator.

3 To check reliability/reproducibility.

4 Remains red because no carbon dioxide given off because no respiration.

5 Put soaked living seeds in one flask, soaked dead pea seeds in other. Bung and thermometer in each. Measure temperature inside each flask at beginning. Leave for a day or two and note temperatures.

Core Practical 8

Results

1 Your data in the table.

Analysis

1 Goes yellow when carbon dioxide is added and purple when it is removed.

2 The tubes where indicator solution went darker red/purple – tube numbers according to your data.

3 Any tube where indicator solution remained orange/red.

4 Tubes 2 and 4.

5 **a** Reduced photosynthesis

b Indicator did not go darker red/purple so less carbon dioxide absorbed or became yellow – more carbon dioxide given out by respiration than absorbed by photosynthesis.

6 That without a plant the indicator does not change colour/indicator not reacting to light or darkness.

7 Tubes 4 and 5

Evaluation

1 Use an oxygen meter.

2 Subjective; only qualitative data.

3 Gives numerical values and not subjective.

Core Practical 9, part 1

Results

1 Limewater went cloudy.

Analysis

1 Yes

2 Limewater went cloudy.

Evaluation

1 Subjective and qualitative.

2 Use pH meter and measure drop in pH.

3 Measure how long it takes for a certain volume of limewater to go cloudy when breathing out into it at rest; repeat after exercise.

Core Practical 9, part 2

Analysis

1 **a–d** These results depend on your data.

2 Any valid comment such as: more accurate and quantitative with spirometer/results very similar.

3 **a** This depends on your data.

b i Breathing rate increases to remove excess carbon dioxide and bring in more oxygen for increased aerobic respiration in muscles to meet increased energy demand.

ii Breathing rate remains at a higher level to repay oxygen debt – replenishing oxymyoglobin and breaking down lactic acid.

Evaluation

1 Method A: advantage: no need for equipment/quick to carry out; disadvantage: less accurate.

Method B: advantage: more accurate data; disadvantage: expensive equipment and difficult to use.

Core Practical 10

Results

1 Your data tabulated correctly and means calculated.

Analysis

1 Mean % loss of mass divided by number of hours in each case.

2 **a** IV – Environmental condition/example.

b DV – (%) Loss of mass/transpiration rate.

c Control variables – type of shoot; mass of water added to flask; time; other valid answer.

3 Water enters the stem of shoot from flask, it travels up xylem/stem to leaves where it moves, by osmosis, from xylem to cells in leaves, then some evaporates from cells in leaves into air spaces and water vapour diffuses out of stoma.

4 Transpiration is increased by higher temperatures, moving air/wind, light intensity.

Or decreased by lower temperatures, less light, still air.

Evaluation

1 Because not all the potometers will start at the same mass/for fair comparison.

2 Any valid suggestions such as light and dry air, light and humid air; no light with and without wind.

3 **a** Bright light, higher temperatures, wind, dry air/low humidity.

b More stomata open in light so more loss of water vapour by diffusion, from stomata.

More kinetic energy of molecules in higher temperatures so more loss of water vapour by diffusion from stomata.

Dry air has less water vapour so there is a greater gradient between leaf and outside air, therefore more diffusion of water vapour from leaf.

Moving air carries away the water vapour that has just diffused out of leaf so maintains higher gradient for more diffusion.

4 Less light/darkness because more stomata are closed as no photosynthesis happening; still air because water vapour that has diffused out of from leaves not carried away; lower temperatures because molecules of water vapour have less kinetic energy so move more slowly, therefore less diffusion per unit time.

5 A flask with the same volume of water, layer of oil and bungs, placed in the same environmental conditions as the test flasks, to ensure that no water is lost directly by/from the flask.

6 Suitable apparatus listed; set up with same types of leafy twigs but each with a different number of leaves; control – twig with no leaves; record mass loss or movement of air bubble; calculate transpiration rate.

Graph rate/water loss against number of leaves.

Core Practical 11, part 1

Results

Your data tabulated and % germination calculated correctly.

Analysis

1 **a** IV – amount/volume/mass of water.

b DV – % germination.

c Control variables – any three from: temperature; type of seed; exposure to light; pH; number of pieces of filter paper.

2 Comparison of your data with others in your class.

3 Any sensible conclusions you reached from your data.

Core Practical 11, part 2

Results

1 Your data tabulated and % germination calculated correctly

Analysis

1 **a** IV is temperature.

b DV is % germination.

c Control variables – any three from: volume of water; type of seed; exposure to light; pH; number of pieces of filter paper.

2 Comparison of your data with others in your class.

3 There was very little or no germination at low temperatures; % germination is greatest at 40 °C but no germination at 60 °C.

Evaluation

1 To standardise data/allow fair comparison.

2 More interval data – for example, every 5 or 10 degrees between 0 °C and 60 °C.

Core Practical 11, part 3

Results

1 Your data correctly tabulated.

Analysis

1 Yes

2 No or little germination in flask with alkaline pyrogallol/oxygen removed.

Core Practical 11, part 4

1 Your data in table and % germination calculated correctly.

Analysis

1 **a** IV – pH.

b DV – % germination.

c Control variables – any three from: volume buffer solution used; temperature; oxygen concentration; exposure to light; type of seeds; other valid point.

2 Comparison of your data with others in your class.

3 Seeds need oxygen to germinate because they need to carry out aerobic respiration to make ATP (there may be a little germination where no oxygen as seeds can respire anaerobically but not for long and this produces less ATP).

Core Practical 12

Results

1 Your data tabulated.

Analysis

1–4 Correct calculations using your data

Evaluation

1 Repeat the investigation throughout the year and graph the data to identify trends and patterns.

2 Grow the organisms with varying amounts of the factor and record the growth/numbers of them.

Core Practical 13

Results

1 and 2 Table and graph of the data.

Analysis

1–3 Answers according to the data.

Evaluation

1 This will depend on your data.

2 Suitable suggestions relating to abiotic and biotic factors of the two areas.

Core Practical 14

Results

1 Your data tabulated and means calculated correctly.

Analysis

1 **a** IV – temperature.

b DV – bubbles of carbon dioxide per minute/rate of anaerobic respiration.

c Control variables – any three from: concentration of sugar solution; type of sugar; species of yeast; mass of yeast; volume/concentration of limewater.

2 Rate of anaerobic respiration changes with temperature; slower at lower temperatures, fastest at around 40 °C and slows at higher temperatures; because enzymes are involved

Evaluation

1 Bubble the gas given off through limewater; if limewater goes cloudy the gas is carbon dioxide.

2 Systematic error with equipment such as thermometer, syringes and measuring cylinders; errors of timing; errors of counting; bubbles not always same size.

3 Digital thermometer; collect carbon dioxide and measure volume; use larger volumes

4 pH; type of sugar; concentration of sugar.

5 Collecting the gas in a measuring cylinder so can measure the volume is more accurate than counting bubbles (where could miscount)/bubble size may vary so counting each time does not give accurate measure of how much gas given off.

NOTES

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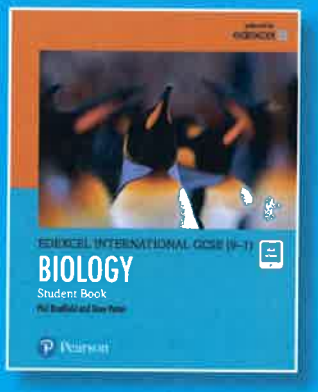

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