

Collins

AQA GCSE
(9-1)
Biology

Required Practicals Lab Book

Emily Quinn

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Biology

~~Chemistry~~ practicals

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I have filled some sample answers in to help you use this booklet for your revision.

Don't forget to check your answers - these are at the back of the workbook.

How to use this book

Practical skills are at the heart of any science qualification. Your AQA GCSE Science course requires you to develop these skills through completing a series of required practicals, which you will then be tested on in your exams. This lab book will help you record the results of your practical work, and provide you with some guidance so that you get the most out of your time completing each practical.

Ensure you write down everything you can about your practical work – remember you can refer back to this book when you're revising!

Learning outcomes

This is a summary of what you should have accomplished by the end of each required practical.

Apparatus list

Your teacher will ensure that all the apparatus you need for the practical can be found in the classroom. You can use this list to check that you have everything you need to start your work.

Maths skills required

This is a good reminder of the skills you will need to master and practise on your science course, which will be tested in your exams. There are also questions included throughout that let you practise your maths skills.

Formulae

Any formulae you need to know to complete your practical work are shown here.

Safety notes

You should always be aware of safety when completing any practical work. This list will help you be aware of any common safety issues! Your teacher will advise on safety information for each practical, so pay attention.

Common mistakes

We've included some of the common mistakes people make during their practical work so that you can look out for them and hopefully avoid making the same mistake!

Method

Always make sure you read every step of the method before you begin work. This will help you avoid mistakes and will give you an idea of what outcomes to look for as you complete each step.

Record your results

At the end of every method is place to record the outcomes of your work. Make sure you keep your notes clear and neat.

Check your understanding and Exam-style questions

For each practical, there are questions designed to check your understanding of the work you've just completed. There are also exam-style questions, which are included to help you prepare you for questions around practical work in the exams. Some of these questions are designed to test your maths skills and to check your understanding of the apparatus and techniques that you've been using, as you'll be tested on these aspects of practical work in your exams.

Higher Tier

HT If you see this symbol next to a question, then it is designed for Higher Tier content only.

Teachers should always ensure they consult the latest CLEAPSS safety guidance before undertaking any practical work.

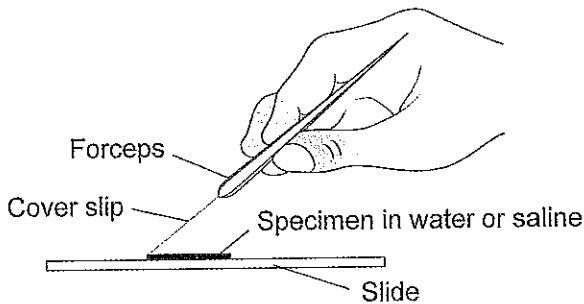
4.1.1.2 Microscopy

The work of Antonie van Leeuwenhoek was pivotal in developments in understanding the microscopic world. The compound microscope he invented was used to observe detail in objects that were far too small for the human eye to see. Your task is to make slides of everyday objects and view them under a light microscope at low and high resolution. You must include a magnification scale. You will draw a scientific sketch of your object at two different magnifications, add labels (if possible) and include a magnification scale.

Learning objectives	Main skills required	Formulae
<ul style="list-style-type: none"> Use a light microscope to observe a range of different objects. Record observations from a light microscope using simple diagrams. Use a scale bar to identify the size of images from microscope slides. 	<ul style="list-style-type: none"> Calculate the size of the real object, the size of the image or the magnification. Express answers in standard form (1×10^x). Use prefixes centi-, milli-, micro- and nano-. 	<ul style="list-style-type: none"> magnification = $\frac{\text{size of image}}{\text{size of real object}}$

Apparatus list
<ul style="list-style-type: none"> light microscope slides cover slips everyday objects – string, newspaper, paper, hair, plastic, insect wings, selection of prepared plant and animal slides forceps adhesive tape

Safety notes
<ul style="list-style-type: none"> If using glass slides and cover slips, be careful as these are delicate and can shatter.

Common mistakes
<ul style="list-style-type: none"> You might struggle drawing a scientific sketch. Draw the outlines of the structures you see and always include a scale. Don't add any shading. You might forget your units. Remember: $1 \text{ m} = 100 \text{ cm} = 1000 \text{ mm} = 1\,000\,000 \mu\text{m} = 1\,000\,000\,000 \text{ nm}$ If using water, saline or a dye for your sample, you might end up with bubbles under your slide. Try lowering your cover sheet at an angle to push out the air bubbles (see Figure 1).
<p style="text-align: center;">Figure 1</p> 

Method

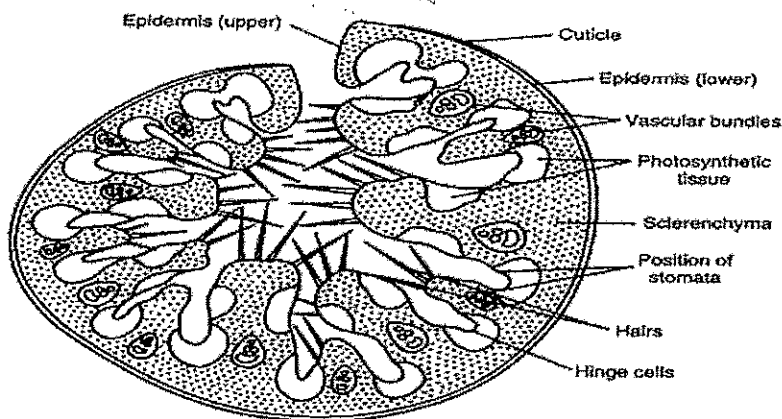
Read these instructions carefully before you start work.

1. Set up the microscope as you have been instructed by your teacher. Be careful with your microscope! It is one of the most expensive pieces of equipment in the laboratory.
2. Place the object on a microscope slide and place a cover slip or adhesive tape on top.
3. View the object under the microscope at low magnification (e.g. $\times 40$).
Draw your object as accurately as you can and label any structures you can see.
4. Now view your object at high magnification (e.g. $\times 400$).
Draw your object as accurately as you can and label any structures you can see.
5. Draw a suitable scale bar for your images.
6. Repeat steps 1–5 for as many objects as you have available.

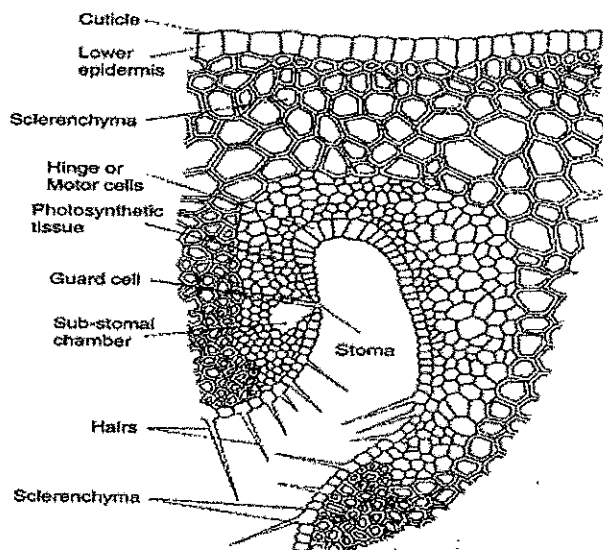
Record your results

*Tissue plan
can be very simple
without individual cell detail* *A few cells*

Draw one object at both low magnification and high magnification.



Structure of xerophytic leaf. T.S. (diagrammatic) of *Ammophila arenaria* leaf showing protected stomata. *Lives in sand dunes so water is scarce*



Structure of xerophytic leaf. Part of T.S. of leaf of *Ammophila arenaria* between two ridges (detail).

Draw another object at both low magnification and high magnification.

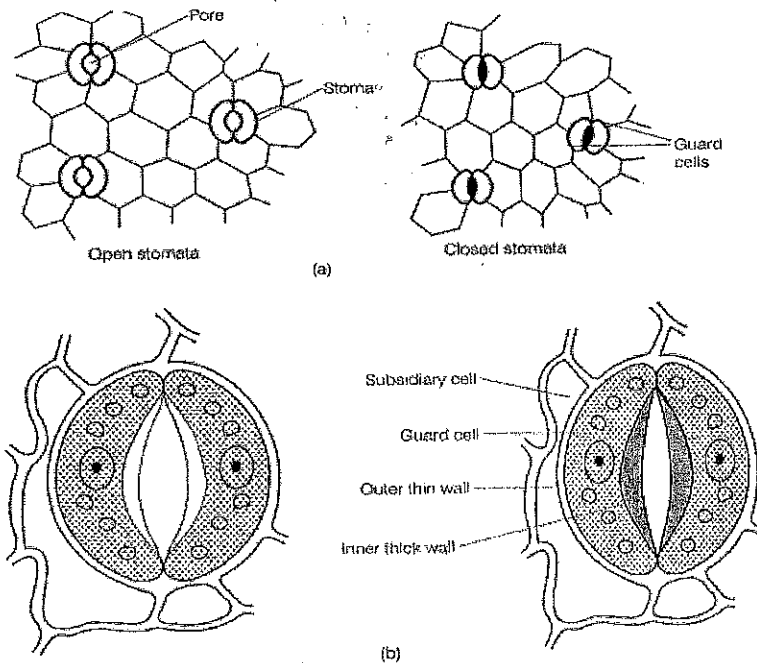


Fig. 3 (a) Open and closed stomata (Under low power)
(b) Open and closed stomata (Under high power of microscope)

Check your understanding

1. Calculate the size of a real object under your microscope.

Use the equation:

$$\text{magnification} = \frac{\text{size of image}}{\text{size of real object}}$$

[2 marks]

.....

.....

2. Explain why a scale bar is an important part of a microscopic drawing.

[1 mark]

.....

.....

3. Explain why it is important to start at a lower magnification and then increase.

[1 mark]

.....

.....

Exam-style questions

1. a. Humans have approximately 37 200 000 000 000 cells in the body.

Express this number in standard form.

[1 mark]

.....

- b. The size of a human blood cell is 0.000 78 cm.

Convert this from centimetres into micrometres.

[1 mark]

0.000 78 cm = μm

2. A student wants to observe and record the image of a plant root tip under a light microscope.

- a. Describe a method to observe and record the image of a plant root tip under a light microscope.

[3 marks]

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- b. Describe what the student should do to calculate the size of a cell in the plant root tip.

[2 marks]

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4.1.1.6 Microbiology

For hospitals, choosing the right antiseptics or antibiotics to achieve the appropriate hygiene levels is essential. The correct dilution is also important: a concentration high enough to work, but not so high as to be wasteful. You will investigate the effect of antiseptics or antibiotics on bacterial growth using agar plates and measuring zones of inhibition. The most effective antiseptic or antibiotic will prevent the growth of bacterial.

Learning outcomes	Maths skills required	Formulae
<ul style="list-style-type: none"> Investigate the effects of antiseptics. Calculate the area of your zone of inhibition. Suggest improvements to methods to reduce the growth of bacteria. 	<ul style="list-style-type: none"> Measure diameters accurately. 	<ul style="list-style-type: none"> Calculate cross-sectional areas of colonies or clear areas around colonies using $\text{area} = \pi r^2$ where r = half of the mean diameter.

Apparatus list	
<ul style="list-style-type: none"> one agar plate of bacterial cultures, readymade and NOT incubated (<i>Bacillus subtilis</i>, <i>Escherichia coli</i>, or <i>Micrococcus luteus</i>) five pairs of sterile forceps adhesive tape 	<ul style="list-style-type: none"> chromatography paper discs cut with a hole punch beaker of disinfectant five different antiseptic solutions eye protection

Safety notes
<ul style="list-style-type: none"> After you have incubated your plates, make sure they have extra sticky tape around the edge. You do not want any of these bacteria escaping! If you are using ethanol to sterilise to equipment, make sure it is kept well away from any naked flames. Ethanol is very flammable and will catch fire. DISINFECTION: You are dealing with bacteria. Disinfection is VERY important! All equipment and materials and work surfaces must be disinfected using excess 1% Virkon for at least 10 minutes. Always wear eye protection when using Virkon solution. Wash your hands both before and after this practical.

Common mistakes
<ul style="list-style-type: none"> Be careful not to rush your work. While it is important to work quickly in order to minimise contamination, you need to be methodical and careful in your work. Make sure you don't put tape all the way around your closed agar plate. Condensation in the plate needs to be able to escape and oxygen needs to get in. Clear zones might not be perfectly circular. To get an accurate diameter, measure the diameter twice (at 90° to each other) and calculate a mean diameter for each clear zone.

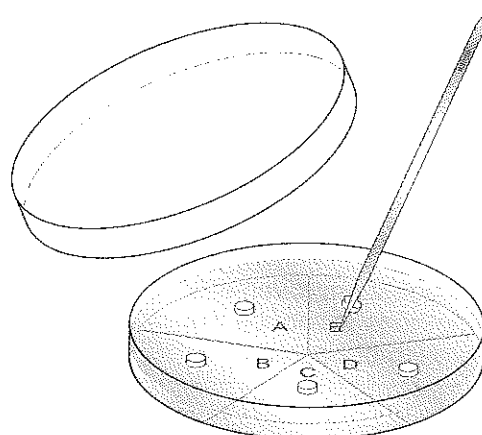
Methods

Read these instructions carefully before you start work.

Activity 1 – Preparation of sample

1. Wash your hands or wear gloves.
2. On the underside of the agar plate, use a marker pen to divide the plate into five equal sections.
3. Using sterile forceps, dip one paper disc into each of the antiseptic solutions and allow excess antiseptic to drain off. (Use a separate pair of forceps for each paper disc.) Place the disc carefully onto the respective section on the unsealed agar plate containing the bacteria, as shown in **Figure 1**.
4. Place the used forceps into the beaker of disinfectant.
5. Seal the plate with tape, ensuring there is a gap so that oxygen can enter and condensation can escape.
6. Place the plate upside down and incubate for three or four days below 25 °C.
7. Place any used equipment in the beaker of disinfectant.

Figure 1



Activity 2 – Analysis of sample

1. Remove your agar plate from where it has been incubating and seal around the edge with extra adhesive tape.
2. Measure the diameter of the clear zone around each disc by placing the ruler across the centre of the disc. Record the measurement in the **Measurement 1** column of **Table 1**.
3. Measure again at 90° to the first measurement and record the measurement in the **Measurement 2** column of **Table 1**.
4. Calculate the mean diameter. Record this in the final column of **Table 1**.

Record your results

Table 1 – Diameter of clear zones

Type of antiseptic	Diameter of clear zone (mm)		
	Measurement 1	Measurement 2	Mean
Dettol	10	8	
Domestos	15	14	
Zirkon	0	7	
Cleany	3	2	
Bactericide	8	8	

Check your understanding

1. Observe your agar plate.

- a. Which of your samples inhibited the growth of bacterial colonies the most, and which inhibited the growth of bacterial colonies the least?

[2 marks]

Sample that inhibited growth the most:

Sample that inhibited growth the least:

- b. Which of these samples would be most effective as an antiseptic?

[1 mark]

.....

2. Calculate the cross-sectional area of your clear areas around colonies.

[1 mark]

Use $\text{area} = \pi r^2$ where r = half of the mean diameter

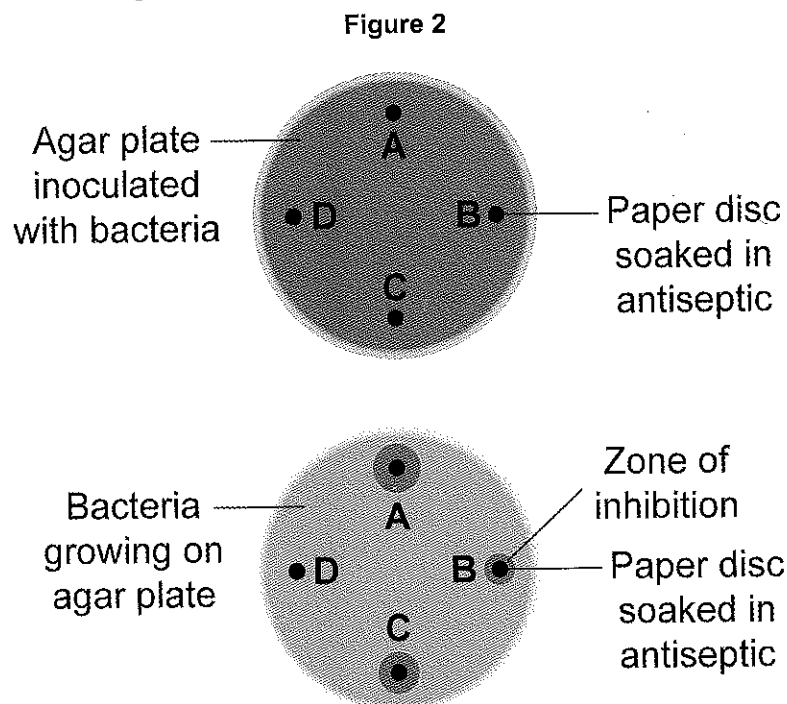
Give your answer in mm^2 .

.....

Exam-style questions

1. Four antiseptics were compared for their effectiveness in inhibiting antibacterial growth.

The results are shown in **Figure 2**.



- a. Identify the independent and dependent variables in this experiment.

[2 marks]

Independent variable:

Dependent variable:

- b.** One variable that needs to be controlled during this experiment is the temperature.

State the temperature at which agar plates in schools should be incubated.

[1 mark]

.....

- c.** Suggest another variable that should be controlled during this experiment.

[1 mark]

.....

- d.** Compare the effectiveness of these different antiseptics.

[3 marks]

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4.1.3.2 Osmosis

Osmosis is the diffusion of water through a partially permeable membrane. The water moves from a dilute solution to a concentrated solution. Plant tissues can be used to investigate osmosis. This experiment uses potato, but other tissues, such as sweet potato, carrot or beetroot, can be used. You are going to investigate the effect of a range of concentrations of salt solutions on the mass of plant tissue. You need use potato samples that are of equal size and place them in different salt solutions and distilled water. The changes in length and mass can then be accurately compared.

Learning outcomes	Maths skills required	Formula
<ul style="list-style-type: none">• Measure changes in plant tissue due to osmosis.• Understand how different concentrations of solution affect plant tissue.	<ul style="list-style-type: none">• Use ratios, fractions and percentages.• Make estimates of the results of simple calculations.• Plot two variables from experimental or other data.• Determine the slope and intercept of a linear graph.	<ul style="list-style-type: none">• $\text{percentage mass change} = \frac{\text{change in mass of potato}}{\text{initial mass of potato}} \times 100$

Apparatus list

- | | |
|---|---|
| <ul style="list-style-type: none">• potato chips• sharp knife• tile• five Petri dishes with labels | <ul style="list-style-type: none">• five different concentrations of salt solution• electronic balance• paper towels• eye protection |
|---|---|

Safety notes

- Be careful when using sharp knives!
- Be careful when using an electronic balance with water near by. Dry your potato samples before measuring their mass by patting them with a paper towel.

Common mistakes

- Do not squeeze the potato samples when you dry them. You are measuring the amount of water gained or lost. By squeezing the potato you will lose water and make your results invalid.

Method

Read these instructions carefully before you start work.

1. Collect five potato chips.
2. Place them on a tile and, using a sharp knife, trim them all to the same length.
3. Pour different concentrations of salt solution into five Petri dishes and label the dishes **1–5**, as shown in **Table 1**.
4. Measure the mass of each potato chip using the electronic balance and record it in **Starting mass in g** column of **Table 1**. Place each one in a separate Petri dish.
5. Repeat this with the other four dishes so that you have one chip in each dish.

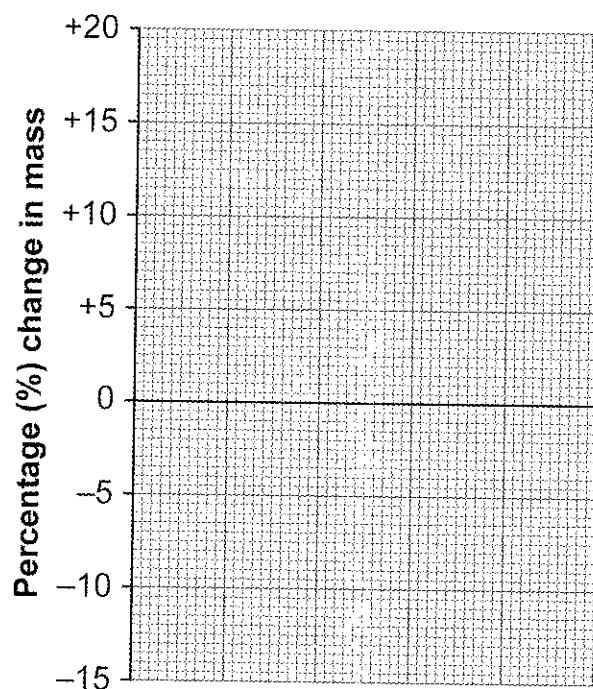
6. Put covers over the dishes and leave for as long as possible but at least 20 minutes.
7. Remove the potato chips from the solution and place on a paper towel to remove the excess liquid.
8. Measure the mass of the chips again and record this in the **Final mass in g** column of **Table 1**. Calculate the change in mass by subtracting the starting mass from the final mass.
9. Calculate the **Percentage (%) change in mass** by dividing the change in mass by the starting mass then multiplying by 100.
10. Plot the percentage change in mass against concentration of salt solution on **Graph 1**. Any results where the potato chip gained mass should be plotted above the 0% change in mass line, while any results where the potato chip lost mass should go below the line.

Record your results

Table 1 – Change in mass of potato samples

Petri dish	Concentration of salt solution in M	Starting mass in g	Final mass in g	Change in mass in g	Percentage (%) change in mass
1	0.0	4.0	4.4		
2	0.2	4.0	4.2		
3	0.4	4.2	4.1		
4	0.6	3.8	3.5		
5	0.8	3.9	3.3		

Graph 1



Check your understanding

1. Explain why is it important to put a lid on the Petri dish, especially if the sample is left for a long time.

[2 marks]

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2. Describe how this method could be changed to improve the accuracy of this experiment. [2 marks]

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3. **HT** Osmosis occurs when there is a concentration gradient.

Use your graph to estimate the concentration of the solution inside the potato cells.

[1 mark]

.....

Exam-style questions

1. A student investigates the effect of different salt solutions on potato tissue.

The results are shown in **Table 2**.

Table 2

Concentration of salt solution in M	Starting mass in g	Final mass in g	Change of mass in g	Percentage (%) change
0.0	1.40	1.62	0.22	15.7
0.2	1.45	1.61	0.16	11.0
0.4	1.40	1.46	0.06	
0.6	1.44	1.39	-0.05	-3.5
0.8	1.32	1.22	0.10	-7.6

- a. Calculate the percentage change in mass for 0.4 M salt solution.

[2 marks]

.....

.....

Percentage change in mass%

- b.** Explain why calculating percentage change of mass is a better method than only looking at change of mass.

[2 marks]

.....

.....

.....

- c.** The student suggests that the concentration of the solution inside the potato cell is between 0.4 M and 0.6 M.

Describe how the student can gain a more accurate estimate of the concentration of the solution inside the potato cell.

[3 marks]

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4.2.2.1 Food tests

Foods can contain carbohydrates (starch and sugars), protein, lipids (fats) and small amounts of minerals and vitamins. Qualitative tests can be used to test for the presence of different food groups using ground-up food. The food is added to distilled water, stirred and filtered.

You are going to test some different foods for glucose (a simple sugar), protein, starch and lipids. This practical may take more than one lesson.

Learning outcomes	Maths skills required
<ul style="list-style-type: none">• Use apparatus methodically when completing food tests.• Understand how to test for carbohydrates, lipids and proteins.• Interpret results to identify the types of substances present in food.	<ul style="list-style-type: none">• Measure small volumes.

Apparatus list	
<ul style="list-style-type: none">• food: potato, carrot, crisps, biscuits, cheese• spotting tile• pipette• 10 cm³ measuring cylinder or plastic syringe• beaker• boiling tubes• test tubes	<ul style="list-style-type: none">• kettle• iodine solution• Benedict's reagent• biuret reagent• ethanol• eye protection

Safety notes
<ul style="list-style-type: none">• Make sure you wear eye protection!• Wash off spills on skin immediately.• Do not eat or drink in the lab!• Do not use ethanol around naked flames.

Common mistakes
<ul style="list-style-type: none">• For the glucose test, make sure you heat the reagents for long enough.• You only need a small amount of the reagents – do not use more than the volumes stated in the method.• The colour change for the protein test is hard to determine – you are looking for blue changing to purple.

Method

Read these instructions carefully before you start work.

1. Choose a sample of food to test.
2. Carry out the four tests as described in **Table 1**.

Table 1 – Instructions for food tests

Food test	Steps
starch	<ol style="list-style-type: none"> 1. Put a small piece of the food to test on a white tile. 2. Add two drops of iodine solution to the food. 3. If the iodine goes blue-black, the food contains starch.
glucose	<ol style="list-style-type: none"> 1. Mix a small sample of the food with 3 cm³ of Benedict's solution in a boiling tube. 2. Heat the mixture in a hot water bath for 3 minutes. 3. If the solution goes a tomato red colour, the food contains sugar.
protein	<ol style="list-style-type: none"> 1. Mix a small sample of the food with 3 cm³ of biuret solution. 2. Leave for 2 minutes. 3. If the mixture goes a pale purple colour, the food contains protein.
lipid	<ol style="list-style-type: none"> 1. Mix a small sample of the food with about 1 cm³ of ethanol in a dry test tube. 2. Pour the ethanol into a test tube full of cold water. 3. If the water goes milky white, the food contains lipid.

3. Record your observations in the row 1 of **Table 2**.
4. Repeat for four more food samples and record your observations in rows 2–5 of **Table 2**.

Record your results

Table 2 – Results of food tests

Food sample	Observations			
	Starch test	Glucose test	Protein test	Lipid test
1.				
2.				
3.				
4.				
5.				

↑
 You can find these :
 - food you eat - on the packet
 - internet.

Check your understanding

1. List two risks associated with this investigation.

[2 marks]

.....

.....

2. Match up each reagent to the nutrient it tests for.

[3 marks]

Benedict's	lipids
biuret	proteins
ethanol	glucose (a simple sugar)
iodine	starch (a complex carbohydrate)

3. This experiment required you to measure very small volumes of reagents.

Suggest an appropriate piece of equipment you can use to measure very small volumes precisely.

[1 mark]

.....

Exam-style questions

1. A student tested three foods using qualitative food tests.

The results are shown in **Table 3**.

Table 3

Food sample	Observations			
	Starch test	Glucose test	Protein test	Lipid test
A	Brown	Blue	Purple	Milky white
B	Black	Tomato red	Blue	Colourless
C	Brown	Tomato red	Purple	Colourless

For each of the food samples, list all the nutrients that are present.

a. Food sample **A** [1 mark]

b. Food sample **B** [1 mark]

c. Food sample **C** [1 mark]

2. Sudan III is a reagent that can also be used to test for lipids.

If lipids are present, a thin red layer is present floating on top of the sample.

Suggest a food that would provide a positive test result with Sudan III.

[1 mark]

.....

4.2.2.1 Enzymes

The activity of enzymes can be affected by a number of factors such as temperature and pH. You are going to investigate the effect of pH on the rate of reaction of the enzyme amylase. This experiment involves a continuous sampling technique to determine the time taken to completely digest a starch solution at a range of pH values. Iodine reagent will be used to test for starch every 30 seconds. When starch is present, a blue-black colour will be seen when the iodine is added. If the starch has been broken down into sugar, then the iodine will remain orange-brown.

As pH is the independent variable being tested, temperature must be controlled. This can be done by using a water bath or immersible electric heater.

Learning outcomes	Maths skills required
<ul style="list-style-type: none">• Use a water bath safely to control the temperature of an enzyme-controlled reaction.• Measure the rate of the reaction by the colour change of an iodine indicator.• Explain the effects of pH on the activity of amylase.	<ul style="list-style-type: none">• Use ratios, fractions and percentages.

Apparatus list	
<ul style="list-style-type: none">• water bath (use a 250 cm³ beaker containing 150 cm³ of water kept at the temperature you require)• thermometer• 10 cm³ plastic syringe or measuring cylinder• two 1 cm³ plastic syringes• starch solution• amylase solution• iodine solution	<ul style="list-style-type: none">• boiling tube• test tube• pipette• spotting tile• buffer solutions• stopwatch• eye protection

Safety notes
<ul style="list-style-type: none">• Eye protection should be worn throughout.• Take care with boiling water.

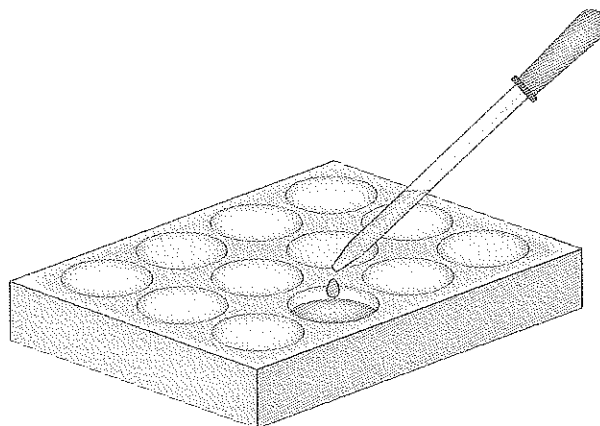
Common mistakes
<ul style="list-style-type: none">• Always ensure you've set up correctly before you begin so that you can test the amylase starch mix every 30 seconds without delays.• Avoid cross-contamination by making sure you use a different pipette for the different solutions.

Method

Read these instructions carefully before you start work.

1. Measure 10 cm³ of starch solution using the 10 cm³ plastic syringe and place this into the boiling tube.
2. Measure 1 cm³ of a buffer solution using the 1 cm³ plastic syringe, then add this to the starch solution in the boiling tube.
3. Measure 1 cm³ of amylase solution using the other 1 cm³ plastic syringe, then add this to the test tube.
4. Place both the boiling tube and the test tube into the beaker of water to warm up.
5. Put one drop of iodine solution into each well of the spotting tile.
6. Add the amylase solution to the starch solution and mix. Start the stopwatch.
7. Immediately take out a drop of the starch/amylase mixture and add to a well in the spotting tile as shown in **Figure 1**. This is the sample for 0 seconds.
8. Repeat this every 30 seconds until there is no change in colour or 5 minutes have passed.
9. Repeat steps 1–8 for different pH values.
10. Record the results in **Table 1**.

Figure 1



Record your results

Table 1 – Effect of different pHs on the breakdown of starch by amylase

Time in seconds	Colour of iodine solution							
	pH...7....	pH...6....	pH...6...	pH...6.5	pH...7....	pH...7.5	pH...8...	pH...9....
0	Blue/black	Blue/black	Blue Black	Blue Black	Blue/black	Blue/black	Blue/black	Blue/black
30	↓	↓	↓	↓	↓	↓	↓	↓
60	↓	↓	↓	↓	Brown	↓	↓	↓
90	↓	↓	↓	↓	↓	↓	↓	↓
120	↓	↓	↓	↓	↓	↓	↓	↓
150	↓	↓	↓	↓	↓	↓	↓	↓
180	↓	↓	↓	Brown	↓	Brown	↓	↓
210	↓	↓	↓	↓	↓	↓	↓	↓
240	↓	↓	Brown	↓	↓	↓	Brown	↓
270	↓	↓	↓	↓	↓	↓	↓	↓
300	↓	↓	↓	↓	↓	↓	↓	Brown

Check your understanding

1. Look at your results in **Table 1**.

a. Which pH is the optimum value of pH for your amylase?

[1 mark]

.....

b. At which pH values does your amylase not work?

[1 mark]

.....

2. List two control variables that were controlled during this experiment.

[1 mark]

.....

.....

Exam-style questions

1. Lipase is a digestive enzyme that breaks lipids (fats) down into fatty acids and glycerol. Full fat milk has a pH of 6.5.

a. Predict what will happen to the pH of full fat milk as lipids are broken down.

Explain your prediction.

[2 marks]

.....

.....

b. A student wants to investigate the optimum pH of lipase.

Describe a method the student could use to find the optimum pH of lipase.

[6 marks]

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c. Lipase is an enzyme that works best in the alkaline conditions of the small intestine.

Suggest a simple experiment to find the pH at which lipase works most effectively. [2 marks]

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4.4.1.2 Photosynthesis

Photosynthesis is the process by which green plants produce food. When plants photosynthesise, they absorb light energy to power the reaction. They use carbon dioxide and water to produce glucose and oxygen.

The rate of photosynthesis is affected by many factors, such as:

- light intensity
- light wavelength.

You are going to investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed. The effect of light intensity can be investigated by varying the distance between the pondweed and a light source. The closer the light source, the greater the light intensity.

Learning outcomes	Maths skills required
<ul style="list-style-type: none">• Develop a hypothesis based on your understanding of photosynthesis.• Change one variable and observe the effect.• Control variables to ensure the data you collect is valid.	<ul style="list-style-type: none">• Calculate the mean of a set of figures.• Understand inverse proportions HT• Present information graphically HT

Apparatus list	
<ul style="list-style-type: none">• test tube• freshly cut 10 cm piece of pondweed (<i>Elodea</i> or <i>Cabomba</i> work well)• light source• ruler	<ul style="list-style-type: none">• test tube rack• stopwatch• 0.2% solution of sodium hydrogencarbonate• funnel• eye protection

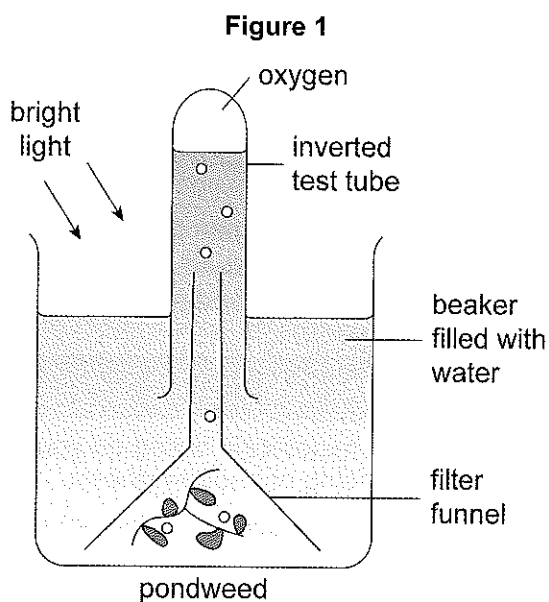
Safety notes
<ul style="list-style-type: none">• Be careful with the lamps – they might get hot enough to burn your skin.• Turn off any lamps when they are not in use.• Clean up any spills immediately.• Do not handle lamps, plugs, sockets or switches with wet hands and do not let water splash on the bulbs.

Common mistakes
<ul style="list-style-type: none">• LEDs work better than lamps for this practical as they don't give out as much thermal energy. If you only have traditional lamps, put a large beaker of water in front of the hot light source; this will absorb the thermal energy but let the light pass through. If you do this, you may have difficulty getting the lamp close enough for your initial readings – see below!• If there aren't any bubbles from the cut end of the pondweed, cut a few millimetres off the end and put it right next to the light source. It should then start bubbling and allow you to do your experiment.

Method

Read these instructions carefully before you start work.

1. Set up the equipment as shown in **Figure 1**.
2. Fill the beaker with water.
3. Place a fresh piece of pondweed into the bottom of the beaker and place a funnel over the top of the plant to hold it in place and help to collect the bubbles. Place your plant under high-intensity light to encourage photosynthesis.
4. Fill a test tube with sodium hydrogencarbonate solution and turn it upside down in the beaker. This is to make sure that there is sufficient carbon dioxide in the water so that carbon dioxide is not a limiting factor.
5. When the pondweed is producing a steady stream of bubbles, place it 10 cm from the light source and **start the stopwatch**. Place the test tube over the top of the funnel to make it easier to count the bubbles.
6. Count bubbles for 1 minute. **Stop the stopwatch** and record the results in the **Trial 1** column in **Table 1**.
7. Repeat twice more for 10 cm distance insert and record the results in the **Trial 2** and **Trial 3** columns in **Table 1**. Then calculate the mean bubbles per minute.
8. Repeat steps 5–7 with the pondweed at distances of 20 cm, 30 cm and 40 cm from the light source.



Record your results

Table 1 – Effect of light intensity on rate of bubble production

Distance between pondweed and light source in cm	Number of bubbles per minute			
	Trial 1	Trial 2	Trial 3	Mean
10	400	401	430	
20	100	103	120	
30	45	42	55	
40	25	26	30	

Inverse square law. $L I$ is inversely proportional to the square of the distance

Check your understanding

1. Consider the experiment.

- a. Write a hypothesis that predicts a link between light intensity and the rate of photosynthesis.

[1 mark]

.....

- b. Explain why you have made this hypothesis.

[1 mark]

.....

2. In the experiment, you controlled the amount of carbon dioxide available.

State another variable that should be controlled and suggest **how** this variable could be controlled.

[2 marks]

.....

.....

Exam-style questions

1. A student is investigating the effect of different wavelengths of light on photosynthesis.

They use the following equipment:

- a lamp
- coloured light filters
- a metre rule
- a conical flask
- 0.2% sodium hydrogencarbonate solution
- a gas syringe
- a sample of pondweed

Plan an experiment to allow the student to collect valid data.

You should identify any control variables.

[6 marks]

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2. **HT** In this experiment, sodium hydrogencarbonate solution is used to make sure carbon dioxide is not a limiting factor of photosynthesis.

State another factor that could be a limiting factor of photosynthesis in plants.

[1 mark]

.....

3. **HT** The relationship between the rate of photosynthesis and the distance of a plant from a light source is inversely proportional.

a. Explain what 'inversely proportional' means.

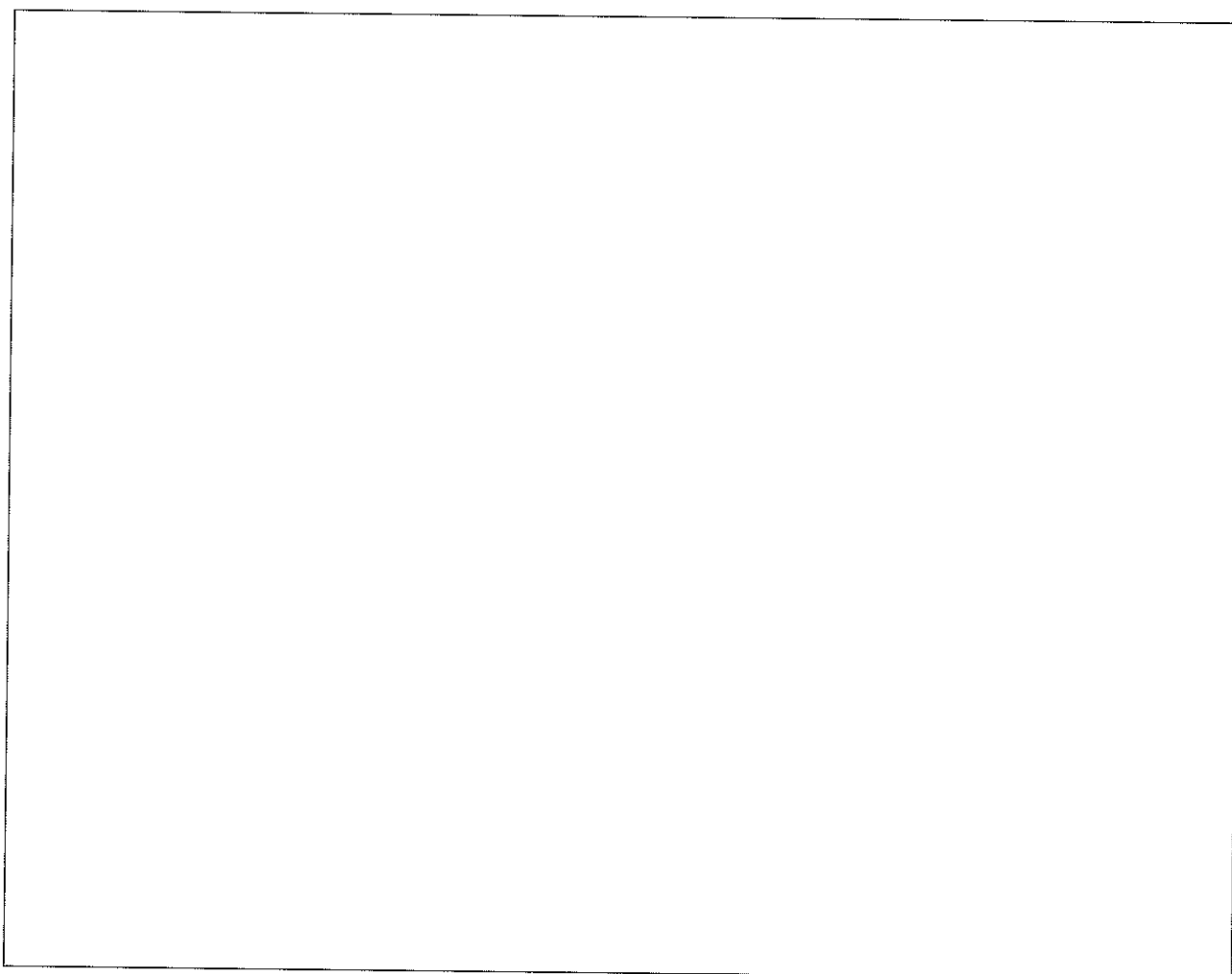
[1 mark]

.....

.....

b. Draw a sketch graph to show the relationship between distance from a light source and rate of photosynthesis.

[3 marks]



4.5.2.1 Reaction time

Your nervous system carries messages very quickly around your body to enable you to respond to changes in the environment. The amount of time it takes for you to respond to a change is called your reaction time.

There are different ways to improve your reaction time. For example, runners practise responding faster to the starting pistol. Also, some substances, such as caffeine, may improve reaction time.

You will conduct a simple, measurable experiment with a partner called the ruler drop test. From this you can determine whether your reaction time can be reduced.

Learning outcomes	Maths skills required
<ul style="list-style-type: none">• Devise a hypothesis linking practice and reaction time.• Record and analyse data.	<ul style="list-style-type: none">• Solve simple algebraic equations.• Translate information between numerical and graphical forms.• Plot two variables from experimental or other data.

Apparatus list
<ul style="list-style-type: none">• metre ruler• chair or stool• eye protection

Safety notes
<ul style="list-style-type: none">• Try not to hit yourself or your partner with the falling ruler.

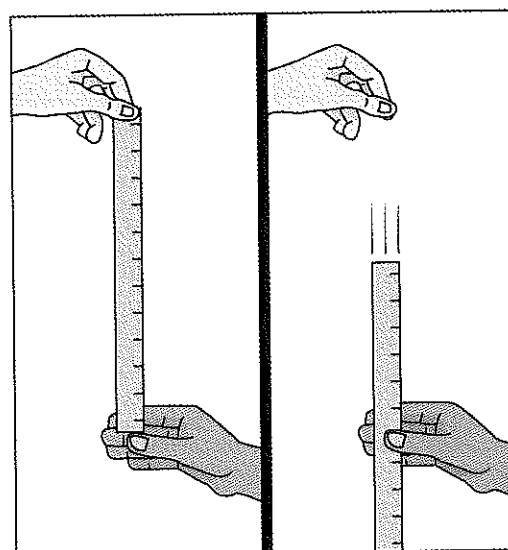
Common mistakes
<ul style="list-style-type: none">• Make sure you don't practise beforehand – this will make your results unreliable.

Methods

Read these instructions carefully before you start work.

1. Write a hypothesis in **Check your understanding, Question 1**, predicting how the amount of practice will affect the reaction time (for example, the more practice, the ... the reaction time).
2. Use your non-dominant hand during this experiment. For example, if you use your right hand for writing, your non-dominant hand is your left hand and vice versa.
3. Sit on a chair or stool and place your non-dominant hand out in front of you. Your partner will stand and hold a ruler vertically with the bottom end (the end with the 0 cm) in between your thumb and first finger, as shown in **Figure 1**.

Figure 1



4. Your partner will drop the ruler **without telling you when**.
5. Catch the ruler as quickly as you can.
6. Read the number level with the top of your thumb. Record this in **Table 1**.
7. Rest for 30 seconds and then repeat steps 3–6 so you have 10 results.
8. Repeat the entire experiment with the roles reversed – that is, with you dropping the ruler and your partner catching it – in order to get your partner's reaction results.
9. Use **Table 2** to convert your ruler measurements into reaction times.

Record your results

Table 1 – Distance dropped and reaction time

Drop test attempts	Ruler measurements in cm		Reaction times in seconds	
	Person 1	Person 2	Person 1	Person 2
1	30	11		
2	28	10		
3	21	11		
4	21	10		
5	30	9		
6	20	3		
7	19	4		
8	21	3		
9	30	7		
10	18	6		

Reaction time in **Table 2** is calculated using the following formula:

$$t = \sqrt{(2d/g)}$$

where d = distance the ruler fell (m)

g = the acceleration of gravity (9.8 m/s^2)

t = the time the ruler was falling (s)

Table 2 – Reaction time data

Distance (cm)	Reaction time (s)	Distance (cm)	Reaction time (s)	Distance (cm)	Reaction time (s)
1	0.05	34	0.26	67	0.37
2	0.06	35	0.27	68	0.37
3	0.08	36	0.27	69	0.38
4	0.09	37	0.27	70	0.38
5	0.10	38	0.28	71	0.38
6	0.11	39	0.28	72	0.38
7	0.12	40	0.29	73	0.39
8	0.13	41	0.29	74	0.39
9	0.14	42	0.29	75	0.39
10	0.14	43	0.30	76	0.39
11	0.15	44	0.30	77	0.40
12	0.16	45	0.30	78	0.40
13	0.16	46	0.31	79	0.40
14	0.17	47	0.31	80	0.40
15	0.17	48	0.31	81	0.41
16	0.18	49	0.32	82	0.41
17	0.19	50	0.32	83	0.41
18	0.19	51	0.32	84	0.41
19	0.20	52	0.33	85	0.42
20	0.20	53	0.33	86	0.42
21	0.21	54	0.33	87	0.42
22	0.21	55	0.34	88	0.42
23	0.22	56	0.34	89	0.43
24	0.22	57	0.34	90	0.43
25	0.23	58	0.34	91	0.43
26	0.23	59	0.35	92	0.43
27	0.23	60	0.35	93	0.44
28	0.24	61	0.35	94	0.44
29	0.24	62	0.36	95	0.44
30	0.25	63	0.36	96	0.44
31	0.25	64	0.36	97	0.44
32	0.26	65	0.36	98	0.45
33	0.26	66	0.37	99	0.45

Check your understanding

1. Write a hypothesis for this experiment, linking the amount of practice and the reaction time.

[1 mark]

.....

2. This is an experiment where it is difficult to take repeat readings using the same person.

- a. Explain why it is hard to take repeat readings using the same person.

[1 mark]

.....

- b. Suggest how you could improve the reliability of this experiment.

[1 mark]

.....

3. Caffeine is a stimulant that can be used to speed up reaction times.

Plan a practical to find the effect of caffeine on reaction time.

[2 marks]

.....

.....

Exam-style questions

1. A student planned an investigation into the effect of caffeine on reaction time.

The student dropped a ruler for their partner to catch, first without caffeine, and then after having drunk a high-caffeine drink.

The student measured how far the ruler dropped before their partner caught it.

The results are in **Table 3**.

Table 3

Test number	Experiment 1: student with no caffeine	Experiment 2: student after caffeine
	Distance the ruler dropped (mm)	
1	119	98
2	116	97
3	117	94
4	113	93
5	150	93
6	113	93
7	108	92
8	109	92
9	108	91
10	107	91

a. Describe any trends in the data.

Identify any anomalous results.

[3 marks]

.....

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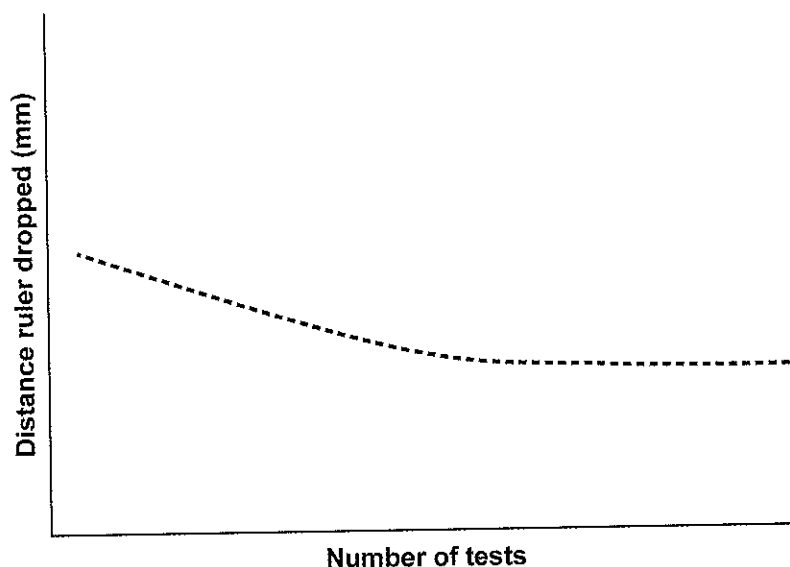
b. **Graph 1** shows a sketch graph of the data for **Experiment 2** given in **Table 3**.

Draw a sketch graph line on **Graph 1** for the **Experiment 1** data from **Table 3**.

Take into account any anomalous results.

[1 mark]

Graph 1



c. Suggest a reason for why the reaction time does not continue to decrease for **Experiment 2**.

[1 mark]

.....

4.5.4.1 Plant responses

Light and gravity affect the distribution of auxin within the shoots and roots of newly germinated seeds. Auxin affects the growth of cells in shoots and roots. The effect of light on this growth can be determined by measuring the height of shoots with a ruler. You are going to investigate the effect of light on the growth of newly germinated seedlings. You will record results as both length measurements and as carefully labelled biological drawings.

Learning outcomes	Maths skills required
<ul style="list-style-type: none">• Undertake an investigation to identify the effect of light on the growth of seedlings.• Record observations and produce labelled scientific drawings.• Explain your results using ideas about tropisms.	<ul style="list-style-type: none">• Plot two variables from experimental or other data.

Apparatus list	
<ul style="list-style-type: none">• 20 seedlings of radish or white mustard or cress• light source, e.g. window• ruler• aluminium foil for caps	<ul style="list-style-type: none">• scissors• water• cotton wool• container for seedlings, for example a Petri dish lid or base

Common mistakes
<ul style="list-style-type: none">• Do not cut the tip off the shoot! That is where auxin is produced and your shoot won't grow at all without any auxin.• If measuring the length, be careful. Seedlings are fragile and will break if you are too rough, ruining your experiment.• Be careful not to overwater your plants.

Method

Read these instructions carefully before you start work.

1. Split your sample of 20 seedlings into five groups of four.
Place one group of four into a Petri dish with damp cotton wool.
Repeat for the remaining groups of seedling with four more Petri dishes.
2. Place each group of four seedlings at set distances from the window – for example, next to the window (i.e. 0 cm), 20 cm, 40 cm, 60 cm and 80 cm. If this will not work in your classroom, you could place in five different areas of light intensity (for example, next to the window, in a cupboard, in a darker corner of the classroom).
3. Water the seedlings with 10 cm³ of water at the beginning and end of each day.
4. Use the aluminium foil to make small caps that will cover the tip of a seedling. The caps need to cover the same length of seedling. When the shoots have grown, place a cap over two of the seedlings in each set. Leave the other two seedlings without caps.
5. Leave the seedlings for a few days and draw your observations as accurately as possible.

Record your results

Draw an appropriate table to record the height of your seedlings.

① Independent variable 1st
↓

② Then the dependent variable
Make sure you have room to record all raw results.

Distance from window (cm)	Seedling height at start (mm)				Seedling height after 3 days mm				
	1	2	3	4	1	2	3	4	
0									
20									
40									
60									
80									?

③ Rule lines to complete: You can add columns of processed results eg change in length + averages. It is the raw data that is most important

Draw appropriate biological sketches of your seedlings that have grown **without** caps. They would bend towards the light

Check your understanding

1. The growth of a seedling is affected by the amount of light it receives.
 - a. Describe the effect of varying light intensity on the growth of the seedlings. [1 mark]

.....
 - b. Explain why varying the light intensity affects the growth of seedlings. [1 mark]

Use your understanding of photosynthesis in your explanation.

.....
2. The direction of the light source affects the growth of the seedlings.
 - a. Describe the effect of the aluminium caps on the growth of the seedlings. [1 mark]

.....
 - b. Explain why the caps affect the growth of seedlings. [2 marks]

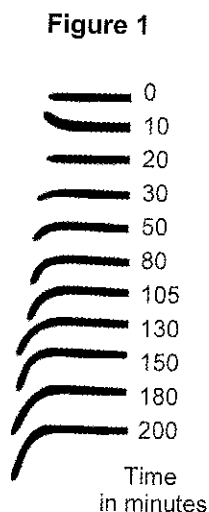
Use your understanding of auxin in your explanation.

.....

.....

Exam-style questions

1. A student wants to investigate the effects of gravity on root growth. They remove a cress plant from a Petri dish and fix it so it is positioned horizontally. The results of this experiment are shown in **Figure 1**.



- a. What could the student measure from these results? [1 mark]

.....

.....

b. List two variables that should be controlled during this experiment.

[2 marks]

.....

c. The student suggests that an uneven distribution of auxin has caused the root to bend downwards.

Plan an experiment to find the effect of light on distribution of auxin in plant *shoots*. [6 marks]

[illegible]

4.7.2.1 Field investigations

It is impossible to count every plant or animal in a habitat, but total numbers can be estimated by taking samples of the organisms from the habitat. The larger the sample, the more accurate your estimate of the population size is likely to be. This allows population sizes to be compared between different areas.

Plants can be sampled more easily than animals because they cannot move around.

You are going to measure the population size of a common species in a habitat using random sampling. You will then use a different technique to investigate the effect of an abiotic factor on the distribution of this species.

There are two parts to this investigation:

1. measuring the population size of a plant species using random sampling
2. investigating the effect of a factor on that plant's distribution using a transect line.

Learning outcomes	Maths skills required	Formulae
<ul style="list-style-type: none">• Use results of an investigation to estimate the population.• Investigate the effects of an abiotic factor on population size.	<ul style="list-style-type: none">• Make estimates of the results of simple calculations.• Find arithmetic means.	<ul style="list-style-type: none">• estimated population size = mean population in 1 m² × total area (m²)

Apparatus list	
<ul style="list-style-type: none">• 1 m by 1 m quadrat• 2 × 30 m tape measures• clipboard	<ul style="list-style-type: none">• 10 pieces of paper, marked 1 to 10• 10 pieces of paper, marked A to J• two bags

Safety notes
<ul style="list-style-type: none">• Be careful around plants: some can sting or cause allergic reactions. If you don't know what a particular plant is, don't touch it!• Be careful when working in bushes or overgrown areas – there may be obstacles that you can't see.

Common mistakes
<ul style="list-style-type: none">• Throwing a quadrat is not truly random as you are unlikely to throw it close to you and are limited by how far you can throw. It is also dangerous and you may break the quadrat.• Don't move the quadrat to an area where there are more plants to count just to make things more interesting – your results will be invalid and you will have to repeat the experiment.• Similarly, don't move the quadrat to where there are no plants so you have less to do – your results will be invalid and you will have to repeat the experiment.• Depending on the time of year, there may be no flowers, only plant leaves. Ask your teacher for help with identifying plants by their leaves.

Methods

Read these instructions carefully before you start work.

There are two activities to complete.

Activity 1 – Estimating the population size of a plant species using random sampling

1. On the school field, look for a common plant that grows throughout the habitat such as dandelion.
2. Randomly place your quadrat by placing two tape measures alongside the 'x-axis' and 'y-axis' of the field.

Divide the area into intervals the same size as your quadrat – for example, if you have a 1 m by 1 m quadrat, your intervals will be 1 m, 2 m, 3 m, etc.

Figure 1

J										
I										
H										
G										
F										
E										
D										
C										
B										
A										
	1	2	3	4	5	6	7	8	9	10

3. Place the numbers 1–10 in one bag and the letters A–J in another bag. Pull letters and numbers out of the bags to determine the ten areas you will sample. Replace the pieces of paper after each pair has been selected. Record your sample areas in **Table 1**.

Figure 1 shows one result of such a random selection of ten quadrat positions.

4. Place your quadrat at each of the selected areas and record the number of the plants you are sampling in **Table 1**.
5. Calculate the mean number of plants per m² for your sample area.
6. Calculate the estimated population size for your sample area.

Activity 2 – Investigating the effect of an abiotic factor on that plant distribution using a transect line

1. On the school field, look for two areas where dandelions are growing, ideally under a tree starting in the shade and getting lighter as you move from under the tree.
2. Put down a transect line going from the shady area into the sunny area. Decide on the intervals at which you are going to place the quadrats. At least 10 samples should be taken – for example, for a 30 m transect, place a quadrat at 3 m intervals – 0 m, 3 m, 6 m, etc.

- Place the quadrat down next to the line at the start. Use a light meter to measure the light intensity. Record the light intensity in **Table 2**.
- Look inside the quadrat and count how many of the plants you are sampling there are. Record the number of plants in **Table 2**.
- Repeat for each position along the transect line.

Record your results

Table 1 – Quadrat sampling: estimating population size

Quadrat number	Quadrat position	Number of plants
1	B 2	0
2	B 8	15
3	C 8	20
4	D 5	8
5	E 4	3
6	9 1	2
7	9 7	18
8	9 10	30
9	1 8	30
10	J 1	1
Mean		

Table 2 – Transect sampling: effect of light intensity on population

Distance along the transect line in m	Number of plants	Light intensity (LUX)
1	0	100
2	0	200
3	0	80
4	19	210
5	30	400
6	35	1000
7	100	1500
8	150	1300
9	125	1400
10	155	1500

Light meters fluctuate so wait for most stable reading

Check your understanding

1. In **Activity 1**, you collected data for an area of 10 m^2 ($10 \times 1 \text{ m}^2$) (or a different area if you had a different-sized quadrat).

Calculate the percentage of the total area that you sampled.

[1 mark]

.....

2. Describe what you could do to improve the accuracy of this experiment.

[1 mark]

.....

3. In **Activity 2**, your transect went from a shaded area to an area with higher light intensity.

Describe any relationship between the number of plants and the light intensity.

[1 mark]

.....

4. Grass plants are too numerous to count different each individual plant.

Explain how you could use a quadrat to gather data for a species like grass.

[1 mark]

.....

Exam-style questions

1. Some students want to investigate the relationship between which species are found on a tidal beach and the total time that the part of the beach is covered by sea water each day.

They decide to use a transect.

- a. Suggest where the students should lay their transect.

[1 mark]

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- b. Describe a method that would allow the students to gather reliable data.

[4 marks]

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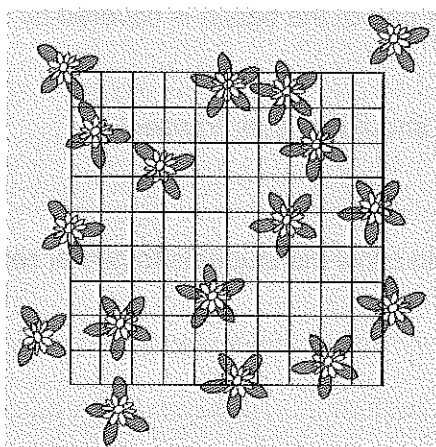
2. A student is surveying a population of daisies on the school field. The total area of the school field is 144 m². **Table 3** shows the results.

Table 3

Quadrat number	Number of plants
1	12
2	8
3	10
4	10
5	7
6	2
7	15
8	14
9	9
10	
Total	

Figure 2 shows the results for quadrat 10.

Figure 2



- Fill in the result for Quadrat 10 in **Table 3**. [1 mark]
- Estimate the population of daisies in the field. [2 marks]

Use the equation:

$$\text{estimated population size} = \text{mean population in } 1 \text{ m}^2 \times \text{total area (m}^2\text{)}$$

.....

.....

4.7.2.3 Decay

When milk 'goes off', it is because bacteria in the milk break down lactose, a sugar in milk, into lactic acid. As milk decays, the pH will decrease (become more acidic). The natural process of decay in milk is too slow to get results in class. This experiment uses an enzyme called lipase to model the effect of bacteria making lactic acid. Lipase breaks down fat in milk to produce fatty acids, and the fatty acids cause the pH to decrease.

You will investigate how changing the temperature affects the rate of decay of milk. You will use an alkaline solution of milk.

Phenolphthalein is an indicator that is pink in alkaline solutions of about pH 8–14. When the pH drops below pH 7, phenolphthalein becomes colourless.

Learning outcomes	Maths skills required
<ul style="list-style-type: none">• Measure volume accurately when investigating decay of fresh milk.• Measure the pH of a reaction to show the rate of decay at different temperatures.	<ul style="list-style-type: none">• Calculate rate changes in the decay of biological material.• Translate information between numerical and graphical form.• Plot and draw appropriate graphs selecting appropriate scales for the axes.

Apparatus list
<ul style="list-style-type: none">• water bath (use a 250 cm³ beaker containing 150 cm³ of water kept at the temperature you require)• 100 cm³ beaker• thermometer• 50 cm³ measuring cylinder• 10 cm³ plastic syringe or measuring cylinder• 0.1 M sodium carbonate solution• milk• stirring rod• 5% lipase solution (<i>harmful</i>)• 3% bile salts solution (<i>irritant</i>)• pipette• phenolphthalein• stopwatch• eye protection

Safety notes
<ul style="list-style-type: none">• If you have sensitive skin, especially to biological washing detergents, do not touch the lipase. It may cause irritation. <p>Always be careful when handling chemicals. Follow your teacher's safety advice about these:</p> <ul style="list-style-type: none">• 5% lipase solution (<i>harmful</i>)• 3% bile salts solution (<i>irritant</i>)

Common mistakes
<ul style="list-style-type: none">• This experiment is easier if water baths are used, but if there are not enough, hot water in beakers will do – just be careful that the temperature is kept as constant as possible.• Do not put the enzymes in hot water and then wait for the water to cool down – if the water is too hot, the enzymes will denature and this will ruin the experiment.

Method

Read these instructions carefully before you start work.

1. Add 20 cm³ of milk to the 100 cm³ beaker.
2. Add 5 cm³ of bile salts solution using a 10 cm³ measuring cylinder. Clean the measuring cylinder.
3. Add 10 cm³ of sodium carbonate solution using a 10 cm³ measuring cylinder. Clean the measuring cylinder.
4. Add 10 drops of phenolphthalein to the beaker. The mixture should be pink.
5. Put the beaker into a water bath at 20 °C and stir. Leave for 5 minutes for the contents of the beaker to reach the correct temperature.
6. Add 5 cm³ of the lipase solution and **start the stopwatch**.
7. Stir the contents of the beaker until the mixture loses the pink colour. **Stop the stopwatch**. At this point the mixture has become acidic.
8. Record how long it takes until the pink colour disappears in **Trial 1** of **Table 1**. Repeat twice more for **Trial 2** and **Trial 3**.
9. Repeat steps 1–8 at 30 °C, 40 °C, 50 °C and 60 °C.
10. Record these results in **Table 1** and calculate the mean for each temperature.

Record your results

Table 1 – Effect of different temperatures on the breakdown of fats by lipase

Temperature of milk in °C	Time taken for phenolphthalein to turn colourless (s)			
	Trial 1	Trial 2	Trial 3	Mean
20	580	600	590	
30	250	260	245	
40	125	130	125	
50	—	—	500	
60	—	—	—	

Check your understanding

Does not change by the end of the experiment

1. State the temperature at which bacteria would be killed (and the enzymes stop working). [1 mark]

.....

2. Describe the relationship between enzyme activity and temperature. [2 marks]

.....

.....

3. State the range of temperature used in this experiment. [1 mark]

.....

4. Phenolphthalein changes from pink to colourless as the pH decreases below pH 7.

Universal indicator turns through many colours as pH decreases.

Suggest why phenolphthalein is a better choice of indicator than universal indicator for this experiment. [2 marks]

.....

.....

Exam-style questions

1. A student wants to investigate the rate of decay in milk stored at different temperatures.

First, she chooses three suitable locations – a fridge, a dark corner of the classroom and a sunny windowsill.

At each location she places 100 cm³ of milk in a beaker.

She records the pH and temperature at the same time of day, every 24 hours.

The results are shown in **Table 2**.

Table 2

Location	24 hours		48 hours		72 hours	
	Temperature (°C)	pH	Temperature (°C)	pH	Temperature (°C)	pH
Fridge	2	6	2	6	2	6
Classroom	23	6	21	5	26	4
Sunny windowsill	30	5	33	4	31	

- a. Suggest a pH value for the milk left on a sunny windowsill for 72 hours. [1 mark]

.....

- b. The temperatures recorded for the fridge **are** accurate. The temperatures recorded for the classroom and the sunny windowsill are **not** accurate.

Suggest why. [2 marks]

.....

.....

.....

- c. Describe **two** different methods that the student could use to measure more accurate values for the temperatures of the classroom and the sunny windowsill. [2 marks]

.....

.....

- d. Describe **two** different methods that the student could have used to measure the pH of the milk. [2 marks]

.....

.....

Answers

For 6 mark method questions you will need to consider:

0 marks: No relevant content.

1-2 marks: Simple statements are made. Some understanding is demonstrated. Some scientific techniques and procedures are relevant. Lacks logical structure. Valid results cannot be produced.

3-4 marks: Majority of method is present in detail. Reasonable understanding is demonstrated. Most scientific techniques and procedures are relevant. Mostly logical sequence but some may be illogical and not detailed. Valid results may be produced.

5-6 marks: Coherent method is present in detail. Good understanding is demonstrated. Broad understanding of scientific techniques and procedures. Logical sequence to method. Valid results can be produced.

4.1.1.2 Microscopy

Check your understanding

- Use your own results and the following equation:

$$\text{magnification} = \frac{\text{size of image}}{\text{size of real object}}$$

- accurate measurement [1]
 - rearranging and using equation [1]
- With a scale bar, it is always possible to see the size of the cell/object even if the picture is increased or decreased in size (e.g. by a photocopier). [1]
- It is easier to locate the specimen when you start at a lower magnification; you can then increase the magnification to see more detail. [1]

Exam-style questions

- 3.72×10^{13} [1]
 - $7.8 \mu\text{m}$ [1]
- Any three from: [3]
 - Place the object on a microscope slide.
 - Place a cover slip on top.
 - View the object under the microscope at low magnification (e.g. $\times 40$).
 - Draw the object and label any structures.
 - Increase the magnification (e.g. $\times 400$).
 - Draw your object at higher magnification and label any structures.
 - Draw a suitable scale bar for the images.
 - Measure the size of the image. [1]
Divide the size of the real image by the magnification. [1]

4.1.1.6 Microbiology

Check your understanding

- the sample that inhibited growth the most: your result with largest zone of inhibition [1]
 - the sample that inhibited growth the least: your result with smallest zone of inhibition [1]
- your own result: $(\frac{1}{2} \text{ mean diameter})^2 \times \pi$ [1]

Exam-style questions

- independent variable = type of antiseptic [1]
dependent variable = diameter/size of zone of inhibition [1]
 - 25°C [1]
 - One answer from: [1]
 - the amount of antiseptic

- the size of the paper disk
- how long the paper disk was soaked for.

- Antiseptic **A** is the most effective, as the zone of inhibition is the largest. [1]

Antiseptic **C** is the second most effective; **B** is the third most effective; **D** is not effective at all as there is no zone of inhibition. [1]

1 mark for correct order: **A, C, B, D** [1]

4.1.3.2 Osmosis

Check your understanding

- The water in the solution could evaporate, which would make the solution more concentrated. [1]
- Repeat each reading at least twice more. [1]
Calculate a mean for each reading. [1]
- HT** Your own result: the value where the line of best fit crosses the x-axis. [1]

Exam-style questions

- $(0.06/1.40) \times 100$ [1]
percentage change in mass = 4.3% [1]
 - The potato chips had different masses at the start. [1]
Percentage change shows how much water has been absorbed relative to the mass of the sample. [1]
 - The student could plot the points on a graph of concentration against % change; [1]
then draw a straight line of best fit [1]
and use that point to estimate the isotonic point (or where it crosses the x-axis) (and so the concentration of the solution inside the cells). [1]
OR
The student could repeat the experiment using smaller intervals between 0.4 mol/dm^3 and 0.6 mol/dm^3 . [1]
The isotonic point will be close to 0 change in mass. [1]
Then repeat with even smaller intervals until no change in mass is measured. [1]

4.2.2.1 Food tests

Check your understanding

- Any two from: [2]
 - Ethanol is flammable and could catch fire.
 - Boiling water could cause burns.
 - Reagents could get into eyes/on skin.
 - People could have food allergies.
 - Any other reasonable risk (check with your teacher).

- | | |
|------------|---------------------------------|
| Benedict's | lipids |
| biuret | proteins |
| ethanol | glucose (a simple sugar) |
| iodine | starch (a complex carbohydrate) |

All four correct [3]

2 marks for three correct; 1 mark for two or one correct; delete a mark each time more than one line is used from either a reagent or a nutrient.

3. Any one from: [1]
 - pipette
 - 10 cm³ measuring cylinder (volume must be specified – just 'measuring cylinder' is not enough)
 - syringe
 - burette

Exam-style questions

1. a. Food sample **A**: protein, lipid [1]
 b. Food sample **B**: starch, glucose [1]
 c. Food Sample **C**: glucose, protein [1]
2. Any food that contains fat, e.g. butter, cheese, cream, oil, nut butters, fatty meat, avocado, etc. [1]

4.2.2.1 Enzymes

Check your understanding

1. a. your own result: the pH where the solution turns from black to brown fastest [likely to be between pH 5 and pH 7] [1]
 b. your own results: the pH where there is no change from black to brown [you might have two answers here, one for too acidic and one for too alkaline] [1]
2. Any two from: [2]
 - temperature
 - volume of starch solution
 - volume of amylase
 - volume of buffer solution
 - volume of iodine
 - interval between times
 - any other valid control variable.

Exam-style questions

1. a. The pH will rise [1]
 as fatty acids are made. [1]
 b. Answer should include: [6]
 - measure an amount of a solution of fats (any named fat, e.g. milk, oil)
 - measure an amount of lipase
 - record the temperature
 - add lipase to the fat solution and start the timer
 - every 30 seconds, measure the pH
 - with a pH probe / universal indicator / any appropriate indicator to test for acids
 - repeat at different temperatures
 - heated by a water bath / hot water in a beaker
 - cooled by an ice bath.
- c. Test a range of pH values from 7 to 14. [1]
 Find the one where lipase breaks down lipids fastest. [1]

4.4.1.2 Photosynthesis

Check your understanding

1. a. As light intensity increases, the rate of photosynthesis also increases. [1]
 b. Photosynthesis needs light. The more light there is, the greater the rate of photosynthesis. [1]
2. any control variable [1]

a valid suggestion for how it could be controlled [1]

Answer could include:

- the wavelength of light – use the same light bulb
- the temperature of the water – use an LED bulb (to release less heat) / use a beaker of water in front of the plant to absorb any thermal energy but allow light to pass through
- the mass of the plant – use the same piece of plant
- any valid control variable and suggestion.

Exam-style questions

1. Your answer should include the following points:

Method [up to 4 marks]

- Place the plant in the conical flask of water / sodium hydrogencarbonate solution.
- Place the flask in front of a light source.
- Attach the gas syringe to the conical flask.
- Leave for a period of time.
- Return and record the amount of gas produced.
- Repeat the experiment using a different light filter to only let a specific wavelength of light through.

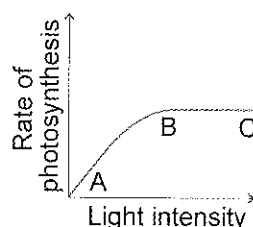
Control variables [up to 2 marks]

- Ensure flask is same distance from light source.
- Allow same period of time for gas to be produced.
- Ensure flask has same sized piece of pondweed.
- Use the same bulb if filters are changed.
- Use the same gas syringe.

2. **HT** either temperature or light intensity [1]

3. **HT** a. As one factor increases, the other decreases in proportion. [1]

- HT** b. See graph below:



- Both axes labelled correctly. [1]
- Line goes up (section A to B). [1]
- Line levels off (section B to C). [1]

4.5.2.1 Reaction time

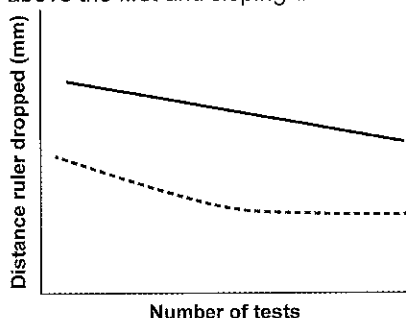
Check your understanding

1. Any one from: [1]
 - As the number of times practised increases, the reaction time decreases.
 - The fewer the practices, the longer the reaction time.
 - Any other sensible/valid hypothesis involving these two variables.
2. a. Repeating the same experiment is impossible as the person would have practised. (You could do it with different hands, but that would not be a fair test, as the variables are not the same.) [1]
 b. Use other activities for the experiment OR repeat the test with different people. [1]

3. First record the reaction times of a person without caffeine/coffee/cafeinated fizzy drink. [1]
Then record the reaction times of the same person after they have consumed caffeine/coffee/cafeinated fizzy drink. [1]

Exam-style questions

1. a. The data shows **two** main things:
• Caffeine reduces the distances the ruler drops. [1]
• The distance the ruler dropped decreases with more practice / reaction time decreases with more practice. [1]
Anomaly: Experiment 1, test number 5 (150 mm) [1]
b. As in the graph below, the second line should be above the first and sloping down to the right. [1]



- c. There is a limit to how fast humans can react. [1]

4.5.4.1 Plant responses

Check your understanding

1. a. As light intensity increases, the amount of growth/height of the seedling increases. [1]
b. More light available = more photosynthesis = more glucose available for growth. [1]
2. a. The plants with aluminium caps grew straight up / The plants without aluminium caps grew towards the sun. [1]
b. Light from one direction causes an uneven distribution of auxin in the shoot tip, which causes the plant to grow towards the light. [1]
OR
Auxin in the shoots causes cell elongation on the side in the shade, causing the shoot to bend towards the light. [1]

Exam-style questions

1. a. the angle of the bend in the root tip [1]
b. any two from: [2]
• amount of moisture
• the angle the growing container is kept at
• the type of plant being used
• any other valid control variable.
c. Answer should include: [6]
• Take several seedlings.
• Allow them to germinate.
• Place them in an area with a light source (or a named light source, such as a window).
• Ensure they have sufficient water.
• When shoots appear, place caps on the heads of some of the shoots.

- Leave some shoots uncapped.
 - Monitor the shoots over time to see the effects of auxin.
- But **subtract** 1 mark if you have included:
• Cut the shoots – auxin production would stop and the shoots would not grow.

4.7.2.1 Field investigations

Check your understanding

1. calculate your answer using:
(sampled area ÷ total area) × 100 [1]
2. take more samples (e.g. 20 or another named figure) [1]
3. Your answer will depend on your results – you may even have found no relationship. [1]
4. estimate surface cover / percentage cover [1]

Exam-style questions

1. a. from the shoreline up the beach / from the sea at low tide to the top of the beach (high tide) [1]
b. Place the transect and then place a quadrat at equal intervals along the transect. [1]
Record the number/type of species / surface cover in each quadrat. [1]
Move the transect along the beach. [1]
Repeat at least twice more. [1]
2. a. 11 (or 12 as daisy on the mid left edge could be included) [1]
b. mean calculated: 9.8 or 9.9 [1]
total: 1411 or 1425 daisies (either answer valid) [1]
If you counted the daisies incorrectly in 2a but worked out a **correct** mean in 2b and then multiplied your **correct** answer to 2b by 144, award yourself both marks for 2b.
If you counted the daisies incorrectly in 2a and worked out a **wrong** mean in 2b, but then you multiplied your **wrong** answer to 2b by 144, score 1 mark for 2b.

4.7.2.3 Decay

Check your understanding

1. Temperature given should be from your practical work: when the pH does not fall at all / when pH stays the same / when phenolphthalein stays pink, as this is the temperature at which the enzymes are not working. [1]
2. As temperature increases, so does enzyme activity up until X °C where enzymes are denatured / no longer work / no longer break down lipids to fatty acids (and glycerol). [1]
3. The range listed here is 20 °C to 60 °C = 40 °C [1]
4. Phenolphthalein gives a specific indication when the solution has become acidic. [1]
Universal indicator has a range of colours so it is harder to make a judgement as to whether it is alkaline, neutral or acidic. [1]

Exam-style questions

1. a. any value below 4 [1]
b. The temperature in the fridge is controlled (by a thermostat) so is always kept constant. [1]

The temperature of the room and of the windowsill fluctuate/change, especially at night, so the temperature is not kept constant. [1]

c. Any two from: [2]

- The student could take the temperature more often and calculate the mean temperature.
- They could use a digital thermometer and data-logger on a computer.
- They could put the beakers in a large water bath; the water bath would act as a larger thermal store so the temperature would vary less overnight.
- Any other reasonable method to improve accuracy of temperature measurement.

d. Any two from: [2]

- They could have used a pH probe – by dipping the end of the probe in the milk and recording the reading.
- They could have used universal indicator and taken a sample to test every 24 hours.
- They could have used any appropriate indicator that can determine between pH 6 and pH 3.
- Any other reasonable method to improve accuracy of pH measurement.