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# Cambridge IGCSE®
# Biology

## Practical Workbook

Matthew Broderick

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The questions, answers and annotation in this title were written by the author and have not been produced by Cambridge International Examinations.



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# Contents

# Introduction

Many of the great biological discoveries of our time have been made as a result of scientific investigation. From the first recorded dissection in 1275, to the first compound microscope in the 16th century, to the work of Pasteur, Pavlov, Mendel, Watson and Crick, practical biology has allowed the greatest scientific minds to measure and record their observations. These scientists followed the same scientific principles that you will follow in order to make their discoveries. It often took them years, and sometimes decades, to present their findings but do not worry, you will not have to do the same unless you are fortunate enough to work in practical biology for your career. The applications of practical biology cover much of science and could lead to careers in bioengineering, medicine, cancer research, plants and so much more. One important thing to remember is that sometimes discoveries can be serendipitous (discovered by accident, such as Tim Hunt's work on cyclins) so observe keenly and you may ascertain something that you were not even looking for.

Practical skills form the backbone of any biology course. It is hoped that, by using this book, you will gain confidence in this exciting and essential area of study. This book has been written to prepare Cambridge IGCSE biology students for both the practical paper and the alternative to practical paper. For either paper, you need to be able to demonstrate a wide range of practical skills. Through the various investigations and accompanying questions you can build and refine your abilities so that you gain enthusiasm in tackling laboratory work. Aside from the necessary exam preparation, these interesting and enjoyable investigations are intended to kindle a passion for practical biology. Great care has been taken to ensure that this book contains work that is safe and accessible for you to complete. Before attempting any of these activities, though, make sure that you have read the safety section and are following the safety regulations of the place where you study.

Answers to the exercises in this Workbook can be found in the Teacher's guide. Ask your teacher to provide access to the answers.

# Safety section

Despite using Bunsen burners and chemicals on a regular basis, the science laboratory is one of the safest classrooms in a school. This is due to the emphasis on safety and the following of precautions set out by regular risk assessment and procedures.

It is imperative that you follow the safety rules set out by your teacher. Your teacher will know the names of materials and the hazards associated with them as part of their risk assessment for performing the investigations. They will share this information with you as part of their safety brief or demonstration of the investigation.

The safety precautions in each of the investigations of this book are guidance that you should follow. You should aim to use the safety rules as further direction to help to prepare for examination when planning your own investigations in the alternative to practical papers.

The following precautions will help to ensure your safety when carrying out most investigations in this workbook.

- Wear safety spectacles to protect your eyes.
- Tie back hair and any loose items of clothing.
- Personal belongings should be tidied away to avoid tripping over them.
- Wear gloves and protective clothing as described in the book or by your teacher.
- Turn the Bunsen burner to the cool, yellow flame when not in use.
- Observe hazard symbols and chemical information provided with all substances and solutions.

Many of the investigations require some sort of teamwork or group work. It is the responsibility of your group to make sure that you plan how to be safe as diligently as you plan the rest of the investigation.

# Skills grid

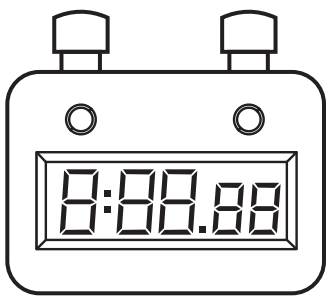
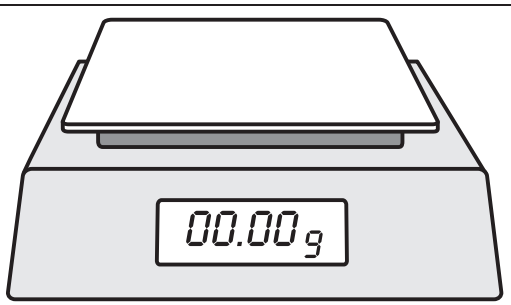
Assessment objective 3 (AO3) 'Experimental skills and investigations' of the Cambridge International Examinations syllabus is about your ability to work as a scientist. Each aspect of the AO3 has been broken down for you below with a reference to the chapters in this title that cover it. This will enable you to identify where you have practiced each skill and also allow you to revise each one before the exam.

| Chapter | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A03: Experimental skills and investigations** | | | | | | | | | | | | | | | | | | | | | | |
| **1.1 demonstrate knowledge of how to safely use techniques** | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **1.2 demonstrate knowledge of how to use apparatus and materials** | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **1.3 demonstrate knowledge of how to follow a sequence of instructions where appropriate** | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **2 plan experiments and investigations** | | X | X | X | | X | X | X | X | X | X | | | | X | X | | | | | X | |
| **3.1 make and record observations** | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **3.2 make and record measurements** | X | X | X | | X | X | X | X | X | X | X | X | X | X | X | | | X | X | X | X | X |
| **3.3 make and record estimates** | | X | | | | X | | | X | X | | | X | | X | X | | X | X | X | X | X |
| **4.1 interpret experimental observations and data** | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **4.2 evaluate experimental observations and data** | | | X | X | X | X | X | | X | X | | | X | X | X | X | | | X | X | X | X |
| **5.1 evaluate methods** | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **5.2 suggest possible improvements to methods** | | X | X | | X | | X | | X | | X | X | X | X | X | | | | X | | X | X |
| **Additional non-A03 skills for biology** | | | | | | | | | | | | | | | | | | | | | | |
| Biological drawings or sketches | X | X | X | X | | X | X | X | X | X | X | X | | | X | X | | | X | | X | |
| Constructing own table | | | X | X | X | | X | X | X | | X | | X | X | X | X | | | X | X | X | |
| Drawing/analysing a graph | | | | | X | X | | X | X | | X | | | X | | | | | X | X | X | |
| Planning safety of an investigation | | X | X | X | | X | X | | X | X | | X | | | X | | | | | | X | |
| Mathematical calculations | | X | | | X | | X | X | | | X | X | X | X | X | X | | | X | | X | |

# Quick skills section

## Apparatus

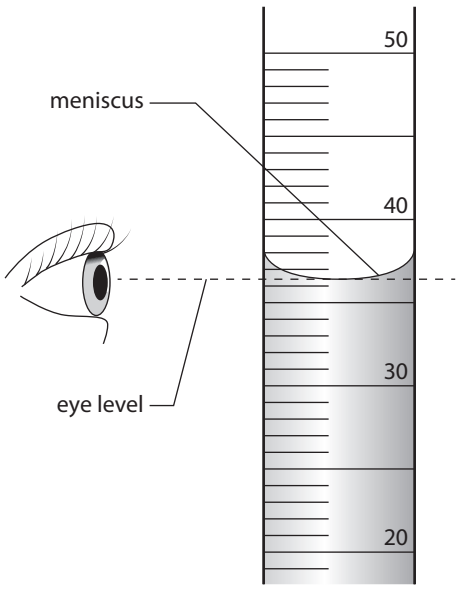
You will need to be able to identify, use and draw a variety of scientific apparatus. Complete the table below by adding a diagram and uses for each piece of apparatus.

| Apparatus | Diagram | Uses |
|---|---|---|
| timer |  | |
| balance/scales |  | |
| beaker | | |
| pipette | | |

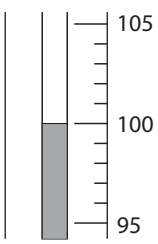
| | | |
|---|---|---|
| burette | | |
| conical flask | | |
| Bunsen burner | | |
| tripod | | |
| test-tube / boiling tube | | |

## Measuring

Being able to take **accurate** measurements is an essential skill for all biology students. As part of the Cambridge IGCSE course you will be expected to be able to take accurate measurements using a variety of different apparatus. When using measuring cylinders, you will need to look for the **meniscus**, which is the bottom of the curve formed by the liquid.




**Thermometers** are a very common tool for measuring temperature in biology experiments so you will need to be able to take **reliable** readings. Not all of the points on the scale on a thermometer will be marked but you will still need to be able to determine the temperature. To do this you will need to work out the value of each graduation. In the diagram below there are four marks between 95 and 100. Each of these marks indicates 1 °C.




## Biological drawings

It is important that you can draw what you see when observing biological specimens, whether this is under a microscope, using a magnifying glass, or observing with your eyes only. You are not expected to be an accomplished artist but your drawing should convey what you see as clearly as possible. Your drawings, sketches and diagrams should meet the following **expectations**:

- Drawn using a sharp pencil
- Draw clear, unbroken lines
- Avoid shading or colouring unless stated otherwise
- Drawn to scale unless stated otherwise
- Drawn as large, or larger, than the specimen unless stated otherwise
- Major structures or features should be clearly labelled using a ruler

## Recording

When working on investigations, the ability to record data accurately is very important. Sometimes a table will be supplied; however, you need to be able to draw your own table with the correct headings and units. The first task is to identify the independent and dependent variables for the investigation you are doing.

- The **independent variable** is the one which you are changing to see if this affects the dependent variable.
- The **dependent variable** is the one which you will measure and record the results of in the table.

The variables and their units need to go into the top two boxes in your results table. The independent variable goes in the left-hand box and the dependent variable goes in the right-hand box. Separate the name of the variables and units using a forward slash /, e.g. time / seconds. Remember that the column headings need to be physical quantities (time, mass, temperature. etc.)

Next, count how many different values you have for the independent variable. This is how many rows you will need to add below the column headings. Finally, add the values for the independent variable into the left-hand column. Your table is now ready for you to add the results from your investigation in the right-hand column.

| Independent variable / units | Dependent variable / units |
|---|---|
| | |
| | |
| | |

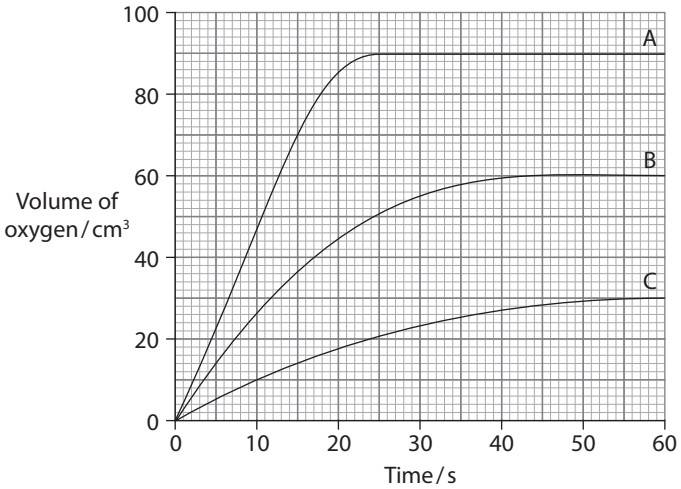
## Graphing

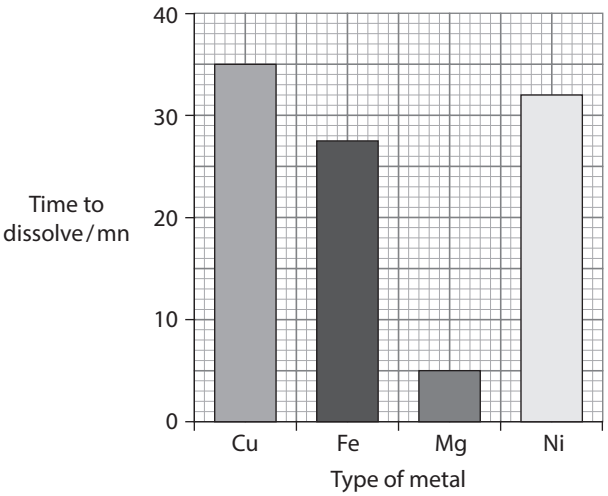
The type of graph you opt to draw is likely to depend on the type of data you are recording:

– Pie charts: These should be drawn with the sectors in rank order, largest first, beginning at 'noon' and proceeding clockwise. Pie charts should preferably contain no more than six sectors.
– Bar charts: These should be drawn when one of the variables is not numerical. They should be made up of narrow blocks of equal width that do **not** touch.
– Histograms: These should be drawn in order of increasing or decreasing magnitude and they **should** touch.

Whichever type of graph you draw however, it is useful you follow a set procedure every time to ensure that, when you are finished, the graph is complete.

**Axes** – You must label the axes with your independent and dependent variables. The independent variable is used to label the *x*-axis (horizontal axis) and the dependent variable is used to label the *y*-axis (vertical axis). Remember to also add the units for each of the variables. An easy way to ensure that you get this correct is to copy the column headings from the table of data you are using to draw the graph.



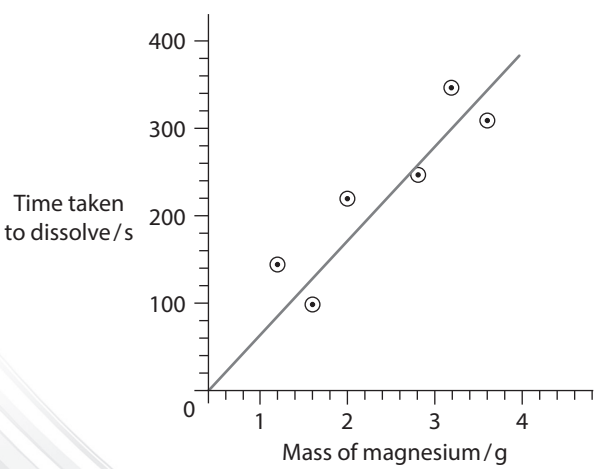



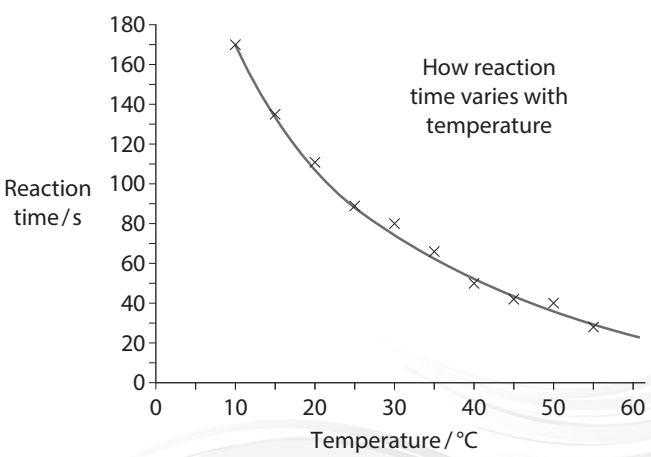

**Tip** – At the top of any table of data you have to use, write the letters X and Y next to the independent and dependent variable to remind you which axis each goes on.

The second stage of drawing a graph is adding a **scale**. You must select a scale that allows you to use more than half of the graph grid in both directions. Choose a sensible ratio to allow you to easily plot your points (e.g. each 1 cm on the graph grid represents 1, 2, 5, 10, 50 or 100 units of the variable). If you choose to use other numbers for your scale, it becomes much more difficult to plot your graph. This skill gets easier the more times you draw a graph. If you have done this lightly with a pencil, you can easily make adjustments until you are fully skilled.

Now you are ready to plot the **points** of data on the graph grid. You can use either crosses (×) or a point enclosed inside a circle to plot your points but take your time to make sure these are plotted accurately. Remember to use a sharp pencil as large dots make it difficult to see the place the point is plotted and may make it difficult for the accuracy of the plot to be decided.

Finally, a **best-fit line** needs to be added. This must be a single thin line or smooth curve. It does not need to go through all of the points but it should have roughly half the number of points on each side of the data scattered. Remember to ignore any anomalous data when you draw your best-fit line. Some good examples of best-fit lines are shown below:



## Variables

The independent and dependent variables have already been discussed but there is a third type of variable that you will need to be familiar with – **controlled variables**. These are variables that are kept the same during an investigation to make sure that they do not affect the results. If these variables are not kept the same, then we cannot be sure that it is our independent variable having an effect on the results. The more variables that you can control, the more reliable your investigation will be.

### Example

Two students are investigating how changing the temperature affects the rate at which starch is broken down by amylase. They do not control the quantity of amylase or starch used each time. This means that there is no pattern in their results because, if they use more starch and amylase, the amount of glucose produced will be increased regardless of the temperatures used.

## Reliability, accuracy and precision

A common task in this book will be to suggest how to improve the method used in an investigation to improve its reliability/accuracy/precision. Before we come to how these improvements can be made it is important that you have an understanding of what each of these words means.

**Reliability** is about the likelihood of getting the same results if you did the investigation again and being sure that the results are not just down to chance. Reliability is now often called repeatability for this reason. If you can repeat an investigation several times and get the same result each time, it is said to be reliable.

Improve the reliability of your investigation by:

- controlling other variables well so they do not affect the results
- repeating the experiment until no anomalous results are achieved.

**Precision**

Precise results have very little deviance from the mean.

Improve the precision of your investigation by:

- using apparatus that has smaller scale divisions.

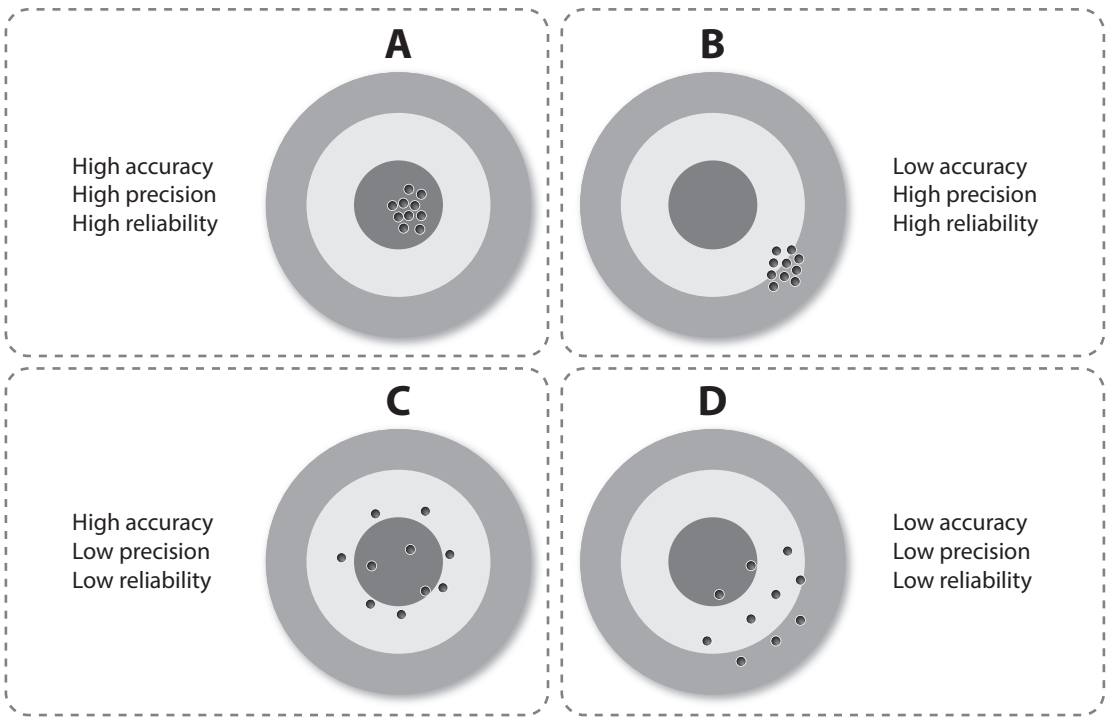
**Accuracy** is a measure of how close the measured value is to the true value. The accuracy of the results depends on the measuring apparatus used and the skill of the person taking the measurements.

Improve the accuracy of your results by:

- improving the design of an investigation to reduce errors
- using more precise apparatus
- repeating the measurement and calculating the mean.

You can observe how these terms are used in the following figure.

**Reliability v Precision v Accuracy**




## Validity

**Validity** is the confidence that scientists put into a set of results and the conclusions that they draw from them. Results are considered valid if they measure what they were designed to, and if they are precise, accurate and reliable.

## Designing an investigation

When asked to design an investigation, you must think carefully about what level of detail to include. The following is an example of how to create a method. Follow these steps to be able to design reliable, accurate investigations.

1. Identify what your independent variable is and the range of values that you are planning to use for it.
2. The dependent variable must also be identified along with how (using equipment and apparatus) you are going to measure it.
3. Suggest how you will control other variables.
4. Outline the method in a series of numbered steps that is detailed enough for someone else to follow.
5. Remember to include repeat readings to help improve reliability.
6. Check the validity of your investigation and results.
7. You must also include any hazards and safety warnings, as well as safety equipment that should be used in the investigation.

# 1 Classification

## Overview

In this chapter, you will review the main characteristics of different organisms and identify different groups of organisms using their features. You should also be able to identify the key features of a living organism in a living thing.

## Practical investigation 1.1 Drawing and labelling organisms

### Objective

The aim is to collect samples of different organisms to draw and label in the classroom. You should consider the key characteristics of life (using the acronym MRSGREN) to confirm whether your chosen specimen is a living organism or not. You should also begin to develop the required skills to draw and label what you can see accurately.

### Equipment

- Small tray or box
- Latex gloves
- Insect pooter (optional)
- Sharp pencil
- Forceps/tweezers (or small shovel)

### Method

1. You will need to gather the equipment provided by your teacher (this may or may not include an insect pooter).
2. Using the time and area allocated, search the area for organisms that can be collected in your tray. You should use gloves and forceps to protect your hands.
3. Collect at least three items that you consider to be organisms and place them in the tray or collect them by using the insect pooter.
4. Take your samples back to the classroom for drawing and observation.
5. Make large drawings of three of your samples in the boxes in the 'Recording data' section. Use the table in 'Analysis' to help guide your drawings. Label as many obvious or distinguishing features as you can see.
6. Once you have finished, you should safely dispose of any organisms that you collected. Your teacher will advise you on the disposal method. All live animals should be returned to the habitat where you found them.

### Safety considerations

- Wear gloves and use forceps/tweezers when handling organisms.
- Wash your hands afterwards.
- Your teacher will give you any further safety instructions that are relevant to your local environment, such as dangerous insects or plants that can harm you.

## Recording data

**1** Make large labelled drawings of three samples and complete the information next to each box.

Name of organism .....

Location found .....

Observable signs that the sample is a living organism

.....

.....

## Handling data

**2** For any one of your drawings, use a ruler to measure the length of the actual organism and the length of your drawing of that organism. Use this information to calculate the magnification of your drawing.

Magnification: .....

## Analysis

**3** You should select one of your drawings for the analysis of your drawing skills. Complete the table to check the quality of your drawing. Then, swap with one of your classmates and allow them to mark your efforts.

| Drawing skill | Self-graded | Graded by a classmate |
|---|---|---|
| Used a sharp pencil | | |
| Drawn smooth, single lines | | |
| The specimen is the right shape and proportion | | |
| The drawing is larger than the actual specimen | | |
| All observable features are drawn | | |
| Labelled lines are neat and drawn with a ruler, touching the feature | | |
| You have not used shading or colours in your diagram | | |
| Total marks (out of 7) | | |

## Evaluation

**4** Look at the table in the 'Analysis' section. Do you have full marks from yourself and your peer? If not, identify the areas where you could improve and write them in the space below. You will need to refer to this next time you make a biological drawing of a specimen.

- .....
- .....
- .....
- .....

**5** Complete the following table with the missing characteristics of life, then show which of the characteristics, if any, were evident in your collected specimens.

| Characteristics of life | Specimen | Evidence that I could see |
|---|---|---|
| movement | | |
| respiration | | |
| | | |
| growth | | |
| | | |
| excretion | | |
| nutrition | | |

# Practical investigation 1.2 Observation and drawing of pollen tubes

## Objective

The aim of this investigation is to dissect a flower, make a detailed drawing of the inside of the flower, label the features, and identify the different sections within the flower. This builds upon the drawing skills developed in Practical investigation 1.1 and link to knowledge of the plant group that your flower falls into (such as angiosperm/monocot/dicot).

## Equipment

- Scalpel
- Dissection tray or board
- Different types of flower

## Method

1. Set up the dissection area on your workbench.
2. Carefully cut your flower into half to create a cross-section of the inside of the flower. You are aiming to observe the pollen tubes.
3. Repeat this to allow each member of the group to have their cross-section of the flower for drawing.
4. Make a large, detailed drawing of your cross-section of the flower.

## Safety considerations

Take care when using the scalpel. Clear stains using paper towels if they spill onto the workbench.

## Recording data

Make your large, detailed drawing in the box below and label the parts that you know.

Name of flower .....

Class of the flower .....

### Analysis

**1** In the previous investigation, you assessed your biological drawing using the criteria in the table. This time, you should list the criteria below that your diagram meets from that list.

- .....
- .....
- .....
- .....
- .....
- .....
- .....

### Evaluation

**2** Now, refer back to the list and write down the criteria, if any, that you did not meet in your flower drawing.

- .....
- .....
- .....

**3** What class of plant does your flower belong to?

.....

## Exam-style question

**1** The yellow-fever mosquito (*Aedes aegypti*) is found in many tropical regions around the world and is identifiable by white markings on its legs. (Figure 1.1)

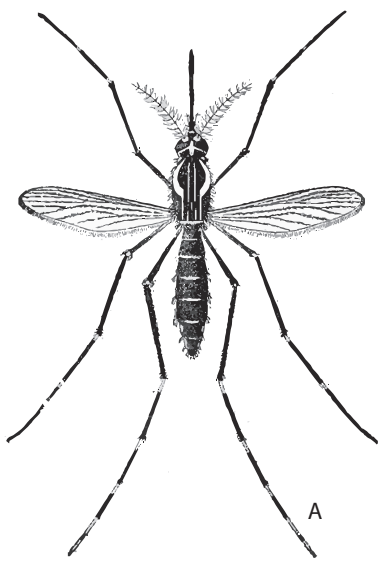



**Figure 1.1**

**a** Make a large drawing of the mosquito in the space below. [5]

**b** What is the actual size of the leg marked 'A' on the mosquito? [1]

.....

**c** What is the size of the same leg in your own drawing? [1]

.....

**d** Use your previous answers to calculate the magnification of your drawing. [3]

.....

**e** Which genus does the yellow-fever mosquito belong to? [1]

.....

**f** Which group of organisms does the yellow-fever mosquito belong to? [1]

.....

Total [12]

# 2 Cells

## Overview

In this chapter, you will review the different structures and organelles that make up different cells in the plant and animal kingdoms. You will observe the similarities and differences between the levels of organisation and be able to recognise these using a light microscope. You will also learn how to calculate the size of specimens and have further opportunities to practise the skill of producing a biological drawing of a specimen learnt in Chapter 1.

## Practical investigation 2.1 Observing plant cells

### Objective

This investigation aims to develop your basic microscope skills in order to safely observe plant cells using a light microscope. You will observe some of the different structures in these cells and relate them to their functions.

### Equipment

- Light microscope
- Microscope slide
- Cover slip
- Forceps
- Scalpel
- Safety spectacles
- Staining solution (1% methylene blue or iodine)
- Sample of onion (or similar)
- Mounted needle
- Filter paper or paper towel

### Method

1. Set up your microscope safely as shown by your teacher.
2. Remove a small piece of the single, inner layer of onion cells (the epidermis) using a scalpel and forceps.
3. Place the layer of epithelial cells onto the microscope slide with no folds.
4. Add a drop of the staining solution to the onion sample. Excess solution can be removed by using filter paper or a paper towel.
5. Place the cover slip onto the sample by lowering at an angle with a mounted needle (or similar) as shown in Figure 2.1.
6. Tap the cover slip lightly with the end of a pencil.
7. Place the specimen onto the microscope stage.
8. Allow light to shine onto the specimen and begin at the lowest magnification.
9. Slowly turn the focusing wheel until you begin to see your specimen.
10. Use the fine focusing wheel to sharpen the image.
11. Sketch a diagram of what you can see through the lens.
12. Repeat using different magnifications – move upwards through the different magnifications of your microscope to see more detail at each level.

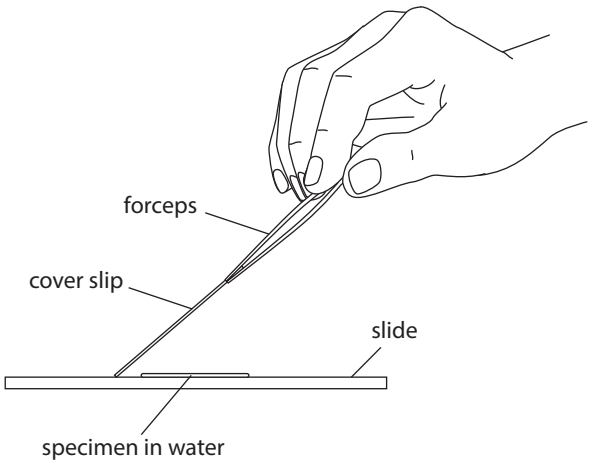



**Figure 2.1**

## Safety considerations

- Wear safety spectacles (and gloves if available) as some staining solutions are irritants.
- Take care when using a scalpel and store it safely when not in use.
- Report broken glass to the teacher.
- Take care with coarse adjustments on the microscope to avoid breaking slides.
- Beware of the lens becoming very hot when using a microscope.

## Recording data

**1** Sketch a diagram of what you observe through the microscope lens in the space below. You may choose to draw more than one cell, as there may be many hundred cells in your field of view. You should label your diagram and use the drawing skills learnt in Chapter 1 to guide you.

Magnification: .....

Magnification: .....

## Handling data

**2** What was the total magnification for the specimen that you drew?
Remember the equation: Total magnification = magnification of objective lens × magnification of eyepiece lens
Total magnification = .....

## Analysis

**3** State the structures of the plant cell that you observed through your light microscope.

.....

.....

.....

**4** State the structures of an onion cell that you cannot see using a light microscope.

.....

.....

.....

## Evaluation

**5** Why was it important to use only a single layer of onion cells for your specimen?

.....

**6** What was the purpose of staining the plant cells?

.....

# Practical investigation 2.2 Observing animal cells

## Objective

To use the microscope skills developed during Practical investigation 2.1 to prepare and observe human cheek cells. The structure of cheek cells makes them more difficult to see under a light microscope but you will see them at different magnifications in this investigation.

## Equipment

- Light microscope
- Cotton bud
- Disinfectant solution
- Safety spectacles
- Disposable gloves
- Staining solution (iodine or methylene blue)
- Microscope slide
- Cover slip
- Mounted needle

## Method

**1** Your teacher will demonstrate how to take a sample of human cheek cells. You should use this demonstration and your knowledge from the previous investigation to plan a method in the space below. Take care to observe the subtle differences in preparing this slide.

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## Safety considerations

- Place cotton buds into the disinfectant solution immediately after use.
- Wear safety spectacles and gloves at all times.
- Report broken glass to the teacher immediately.
- Take care when using a light microscope as the lens can become very hot.

## Recording data

**2** State five different criteria that should be met when drawing a biological specimen.

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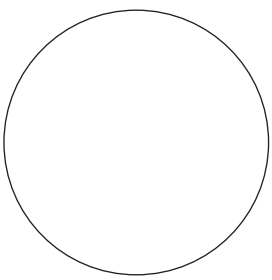
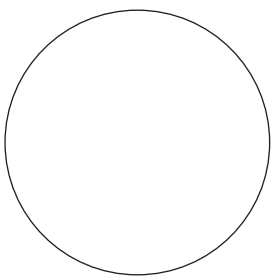
**3** Sketch a diagram of what you observe through the microscope lens in the space below, at two different magnifications. You should label your diagrams and state the magnification used on both occasions.



Magnification: .....



Magnification: .....

## Analysis

**4** Complete the following table by ticking the boxes to show which organelles are visible when using a light microscope.

| Organelle | Onion cell | Human cheek cell | Function |
|---|---|---|---|
| nucleus | | | |
| cell wall | | | |
| cell membrane | | | |
| cytoplasm | | | |
| ribosomes | | | |
| chloroplasts | | | |

**5** Give the name of the organelle that is the site of aerobic respiration.

.....

## Evaluation

**6** How could you view parts of organelles that were not visible using a light microscope?

.....

.....

**7** Explain why the cotton buds were placed into disinfectant or sterilising fluid after being used to collect the cell sample.

.....

# Practical investigation 2.3 Drawing different specimens

## Objective

In this investigation, you will observe some microscope slide preparations of specialised cells and tissues from different organisms to further develop your microscope skills. Some of the samples may have complicated structures which will allow you to practise your drawing skills, and some samples will have very small cells that require you to demonstrate, and develop, your microscope skills.

## Equipment

- Light microscope
- Pre-mounted slides of different cells and tissues

## Method

1. Set up your microscope carefully and safely like you have done in the previous investigations.
2. View the different slides available under your microscope. View your specimen using the different magnifications to find the clearest view of the specimen.
3. Draw and label the different cells and tissues that you observe. It may be that you only find one or two cells and can draw them. If you have a large number of cells or tissue, you can draw a section of what you can see in your field of view.
4. Working in pairs, take turns to find a specimen and explain to each other what you can see and how the structure of that cell/tissue allows it to carry out its function.

## Safety considerations

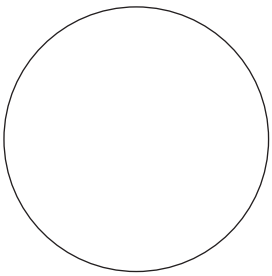
Notify your teacher of any broken glass.

## Recording data

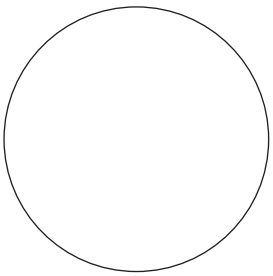
1. Make labelled drawings of what you see in the spaces below. Include a description of what you were looking at and the magnification of the microscope. This is the third time that you have done this; it is expected that you are meeting all of the minimum criteria of a good biological drawing.

Magnification: .....

Magnification: .....



Magnification: .....



Magnification: .....

## Analysis

**2** Define the term **tissue**, giving one example from the slides that you viewed.

.....

.....

**3** Name the organ that your answer to Question 2 might be found in.

.....

## Evaluation

**4** This exercise requires excellent focusing skills when using the microscope to view your specimen as clearly as possible. Describe how you used the microscope to achieve this, naming the different parts that are required.

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# Practical investigation 2.4 Measuring and calculating the size of specimens

## Objective

In this investigation, you will use the following formula to calculate the real size of the cells or tissue that you view under the microscope:

$$\text{Magnification} = \frac{\text{image size of specimen}}{\text{actual size of specimen}}$$

You will measure specimens using millimetres (mm) and micrometres (μm) as standard units. You will demonstrate the ability to plan an investigation independently that will allow you to observe human cheek cells under the microscope.

## Equipment

**1** Complete the list of equipment required to observe a sample of your cheek cells.

- Light microscope
- .....
- .....
- .....
- .....
- .....
- .....
- .....
- .....

## Method

**2** Plan a suitable method for obtaining, and observing, a sample of your cheek cells.

**1** .....

**2** .....

**3** .....

**4** .....

**5** .....

**6** .....

**7** .....

**8** .....

## Safety considerations

**3** Note down the safety precautions you should take for this investigation.

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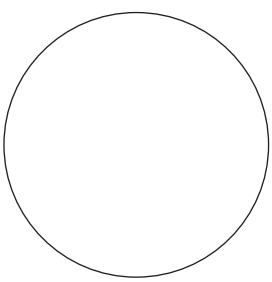
## Recording data

**4** In the space provided below, make a labelled drawing of what you see. Include a description of what you are looking at and the magnification of the microscope. You should aim for this exercise to see at least one cheek cell at the highest magnification possible.



Magnification: .....

## Analysis and handling data

**5** Once you have found your image, you will be able to calculate the actual size of the cells in view by using this method:

**a** Place a clear plastic ruler on the stage with one of the scale marks on the edge of the field of view.

**b** Count the number of millimetre (mm) spaces in the field of view to measure the size of the field of view

Size of field of view .....mm

**c** Convert this to micrometres (μm) by multiplying by 1000

Size of field of view .....μm

**d** Estimate the number of cells across your field of view. (In other words, how many of your cheek cells would cross from one side to the other in a straight line?)

Number of cells across the field of view .....

**e** You can then use the following formula:

$$\text{Length of one cell} = \frac{\text{diameter of field of view}}{\text{estimated number of cells across the field of view}}$$

Length of one cell = ..... μm

For example, if the diameter of the field of view is 4.2 mm (or 4200 μm) and you estimate that 24 cells would cross the diameter from end to end, then 4.2 mm ÷ 24 cells = 0.175 mm (or 175 μm)

### Evaluation

**6** Explain why calculating the size of onion cells is easier than calculating the size of cheek cells. Think about how the onion cells would have been arranged in your field of view.

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**7** Onion epidermal cells do not contain chloroplasts. Give the name of one plant cell that does contain a large number of chloroplasts.

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## Exam-style questions

**1** Look at the invertebrate shown in Figure 2.2.

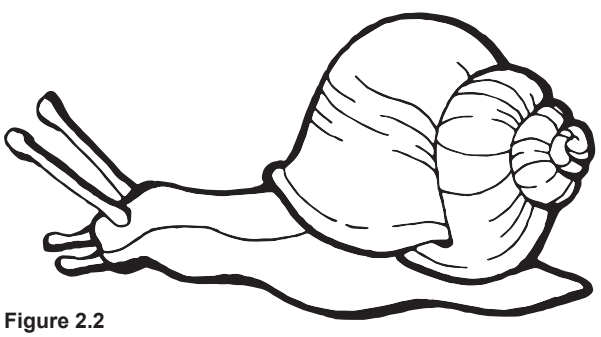

**Figure 2.2**

**a** Make a large, detailed drawing of this animal. [5]

**b** Measure the length of the animal in Figure 2.2. ..... [1]

**c** Measure the length of the same animal in your drawing. ..... [1]

**d** Calculate the magnification of your drawing.

Magnification of drawing = ..... [3]

Total [10]

**2** Heather is preparing a sample of human cheek cells on a microscope slide. She uses a 1% methylene blue solution to stain the cells and views the cells at a magnification of × 400.

**a** What safety precautions should Heather take when preparing and viewing her cheek cells? [3]

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**b** Which organelles should Heather expect to see at × 400 under a light microscope? [2]

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**c** Heather calculates that the image size of her cheek cell is 0.2 mm. What is the actual size of one of Heather's cheek cells? [2]

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Total [7]

# 3 Movement in and out of cells

## Overview

In this chapter, you will observe the processes of diffusion and osmosis. This provides you with the opportunity to test the predictions that you make about how some substances will behave when placed in different solutions.

## Practical investigation 3.1 Diffusion in gelatine products

### Objective

The objective of this investigation is to observe diffusion in action. This requires some chemistry knowledge as you will be using gelatine. Gelatine contains a chemical that is an excellent indicator of pH because the chemical is red in alkaline conditions but turns yellow under acidic conditions. You will test your observation skills here and you will be expected to link what is happening to your knowledge of diffusion to explain what happens.

### Equipment

- Red gelatine/jelly
- Scalpel or knife
- (1 mol $dm^{-3}$) hydrochloric acid
- Test-tube and bung
- Safety spectacles

### Method

1. Cut a piece of gelatine that will fit inside a test-tube.
2. Add the hydrochloric acid to cover the gelatine.
3. Place the bung firmly into the top of the test-tube.
4. Place the test-tube horizontally (making sure it cannot roll off the table).
5. Observe what happens to the colour of the gelatine.

### Safety considerations

- Take care when using the scalpel.
- Wear safety spectacles when handling hydrochloric acid.

### Recording data

1. Write down what happened to the block of red gelatine.

.....

.....

## Analysis

**2** Using your knowledge of diffusion, explain what happened to cause the change in colour that you observed. You should aim to use the following words in your explanation.

| | | | |
|---|---|---|---|
| diffusion | higher concentration | acidic | movement |

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## Evaluation

**3** You decide to repeat this experiment three times to check your results. What steps would you take to ensure that you carry out a reliable test?

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# Practical investigation 3.2 Osmosis in potatoes

## Objective

The objective of this investigation is to gather reliable data and use this to support knowledge about the process of osmosis. You will control the variables of the investigation to ensure its validity. This investigation will provide you with a real example of osmosis taking place to support your understanding.

## Equipment

- Potato
- Cork borer
- Clear plastic ruler
- Distilled water
- 30% sucrose solution
- 70% sucrose solution
- Test-tubes × 6 and rack
- Scalpel or knife
- Pen/marker for writing on test tubes
- Safety spectacles
- Measuring cylinder
- Paper towel

## Method

1. Use the cork borer to bore out six cylinders of potato tissue of similar length.
2. Use the ruler and scalpel to cut the cylinders of potato tissue to exactly the same length.
3. Record this length in the table in the 'Recording data' section.
4. Pour the same amount of distilled water into two of the test-tubes and mark them for identification.
5. Pour the same amount of 30% sucrose solution into two of the test-tubes and mark them.
6. Pour the same amount of 70% sucrose solution into two of the test-tubes and mark them.
7. Add the potato sections at the same time and leave for 15 minutes.
8. After 15 minutes, remove the potato tissue samples from the solutions and pat dry using a paper towel.
9. Measure the length of each potato tissue sample and record the details in the table.

## Safety considerations

- Take care when using the borer and the scalpel.
- Wear safety spectacles at all times.

## Recording data

1. Complete the table and record your results. Make sure that you add the units to your table headings and the types of solution that you used in this investigation.

| Solution | Length of potato tissue sample before treatment / ..... | | | Length of potato tissue sample after treatment / ..... | | | Average change in length / ..... |
|---|---|---|---|---|---|---|---|
| | Sample 1 | Sample 2 | Average | Sample 1 | Sample 2 | Average | |
| distilled water | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**2** Look closely at the appearance of the potato tissue samples. Describe the differences between the tissue samples that were in the different solutions. Use keywords such as turgid and flaccid as part of your answer.

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## Handling data

**3** Describe how you calculated the average length of each of the potato tissue samples.

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## Analysis

**4** Describe and explain the results that you observed in your investigation. Use the data from your completed table to support your answer.

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## Evaluation

**5** State what you did in this investigation to make your results more valid.

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**6** Identify the possible source of error in step 4 of the method and make a suggestion for improvement.

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