Cambridge IGCSE®
Biology

Practical Workbook

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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

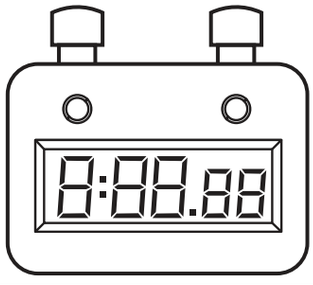
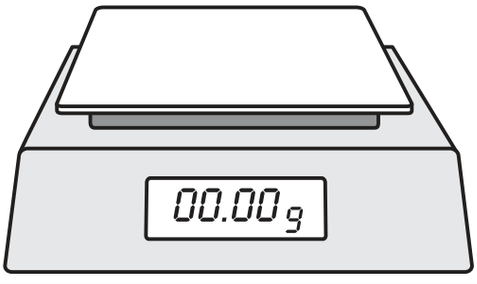
Assessment objective 3 (AO3) 'Experimental skills and investigations' of the Cambridge International Examinations syllabus is about your ability to work as a scientist. Each aspect of the AO3 has been broken down for you below with a reference to the chapters in this title that cover it. This will enable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

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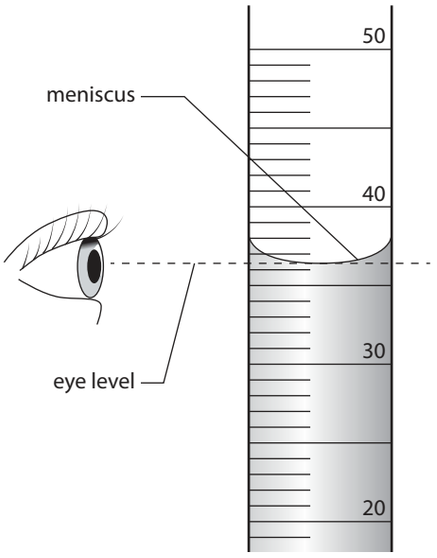
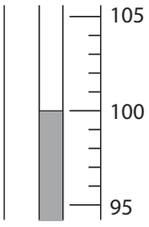
Frontmatter
More Information

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

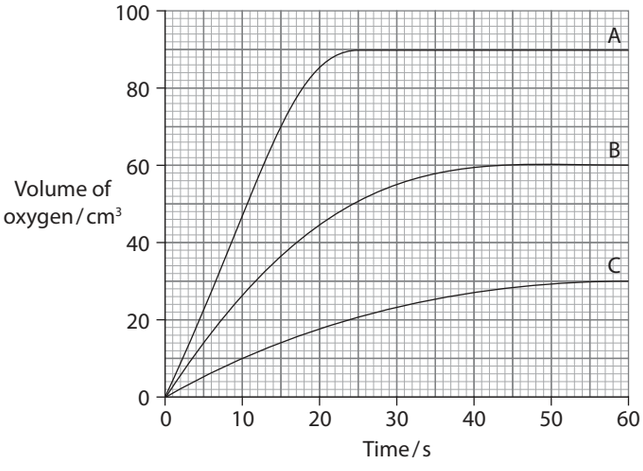
Graphing

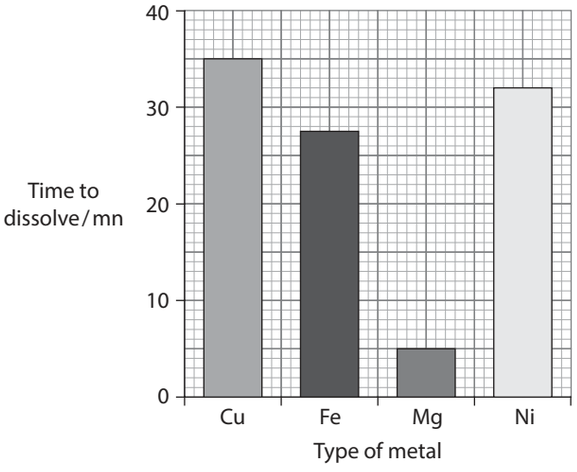
The type of graph you opt to draw is likely to depend on the type of data you are recording:

– 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 when plotting frequency graphs with continuous data. The blocks 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.



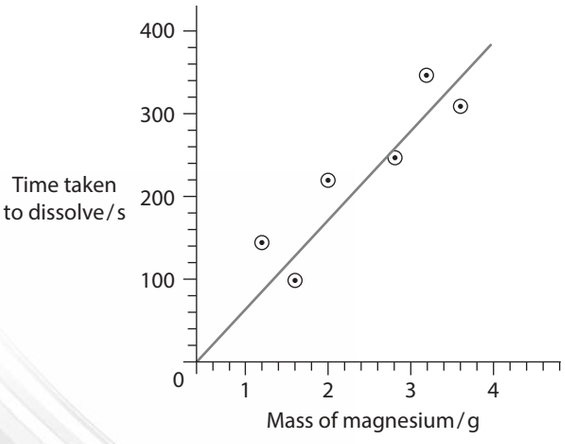


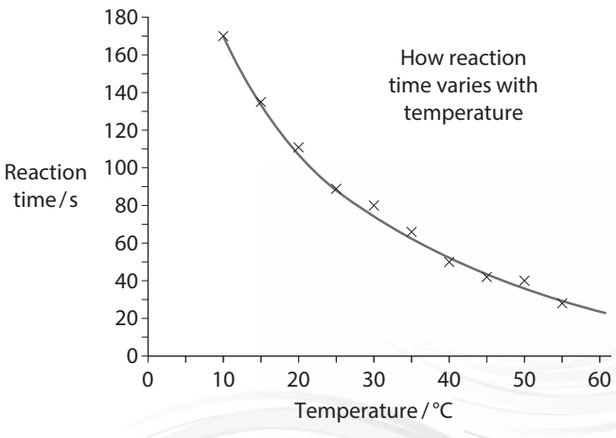
Tip – At the top of any table of data you have to use, write the letters X and Y next to the independent and dependent variable to remind you which axis each goes on.

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.

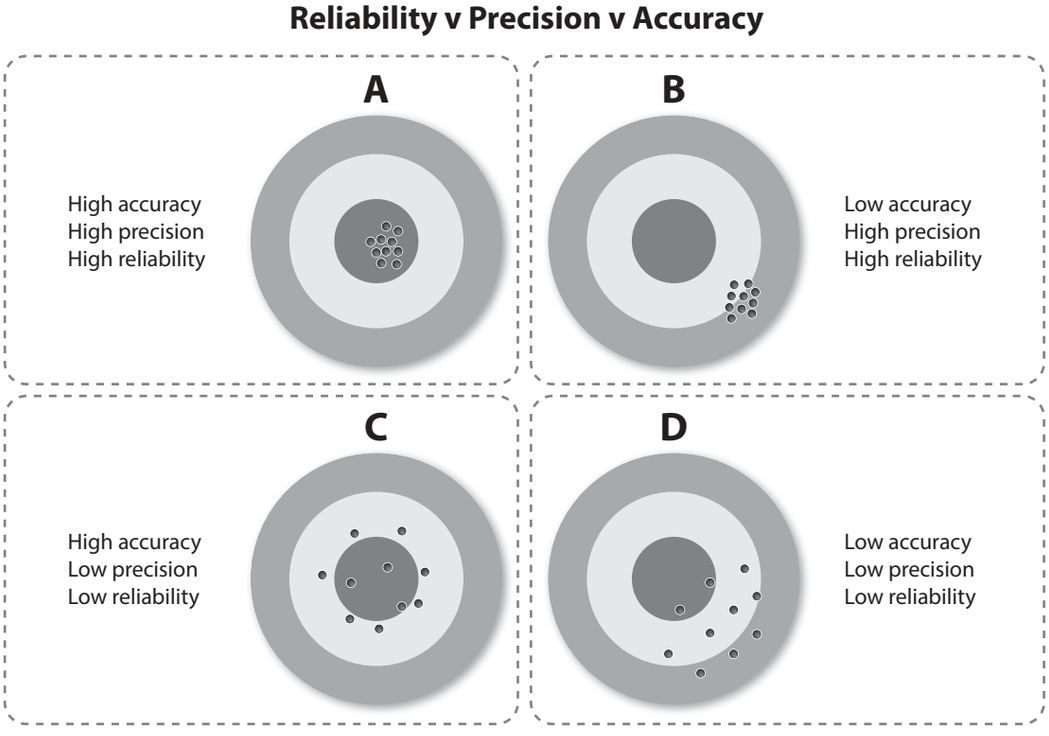
Precision
Precise results have very little deviance from the mean.

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.



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.