PEARSON

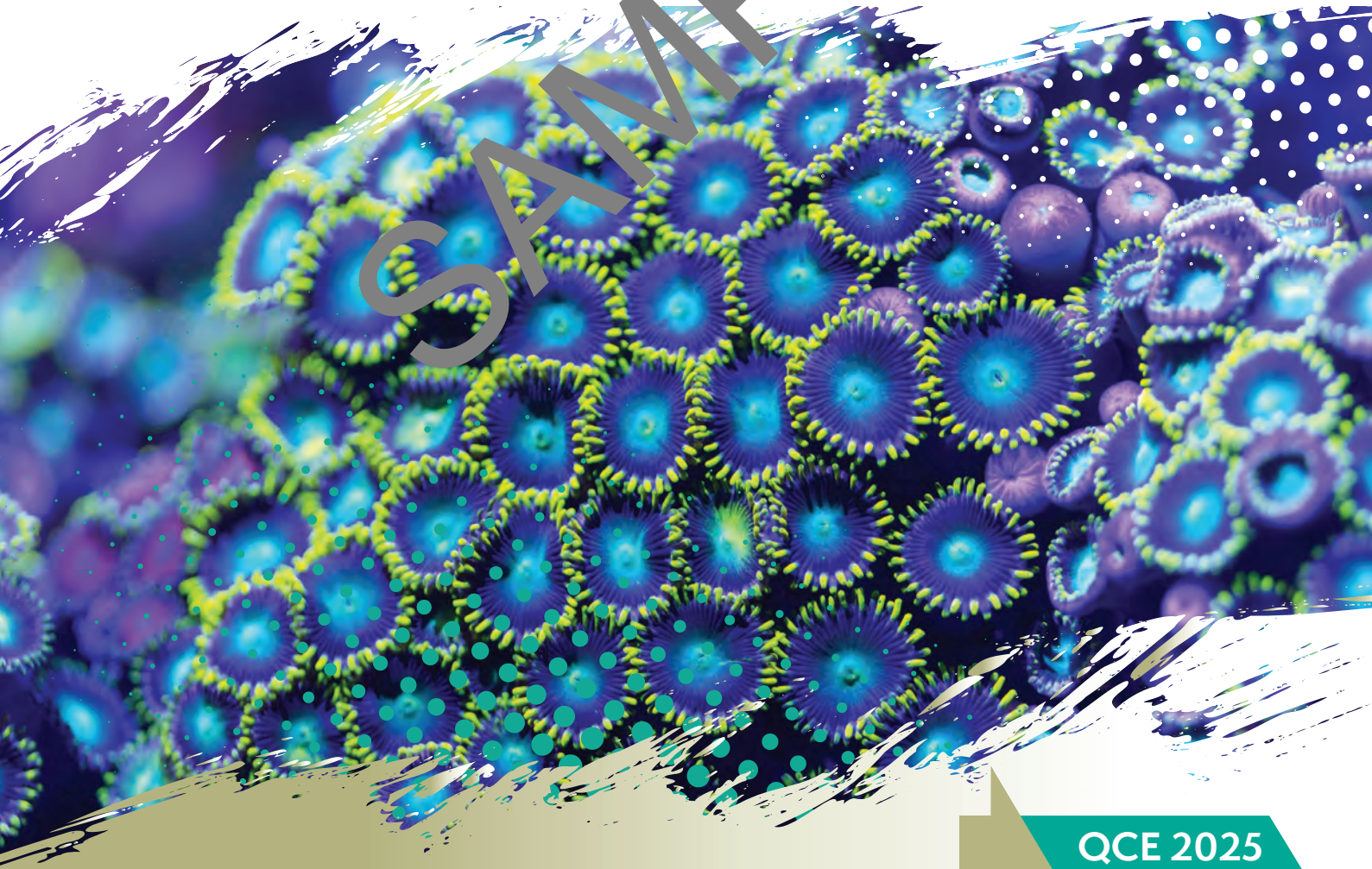
BIOLOGY

QUEENSLAND

UNITS 1 & 2

Yvonne Sanders

2nd EDITION



Skills and Assessment

QCE 2025 Biology SYLLABUS

Contents

Pearson Biology Skills and Assessment Book Units 1 and 2 2nd edition

Contents

UNIT 2: MAINTAINING THE INTERNAL ENVIRONMENT

How to use this book

The *Pearson Biology Queensland Skills and Assessment Book Units 1 & 2* takes an intuitive, self-paced approach to science education that ensures every student has opportunities to practice, apply and extend their learning through a range of supportive and challenging activities.

This resource has been developed by highly experienced and expert author teams, with lead Queensland specialists who have a working understanding of what teachers are looking for to support teaching and learning across the new QCE.

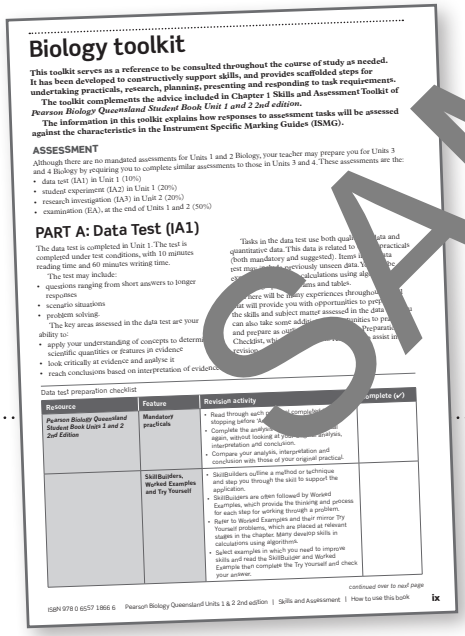
Written to fully support the new QCE Years 11 and 12 syllabus, the *Skills and Assessment Book* is organised by units. The **unit opener** outlines the unit objectives.

The *Skills and Assessment Book* is further organised into topics. Each **topic** addresses all of the subject matter and practicals from the syllabus.

All activities integrate into the *Pearson Biology 11 Queensland Student Book* for a complete teaching, learning and assessment program, making integration of practice and rich learning activities a seamless inclusion. The resource has been designed so it may be used independently of the Student Book, providing flexibility in when and how to engage with it.

Toolkit

A complementary Toolkit supports development of the skills and techniques needed to undertake practical investigations, the data test, the student experiment and research investigation. It covers study skills and also includes checklists and helpful hints to assist in fulfilling all assessment requirements.



Biology toolkit

This toolkit serves as a reference to be consulted throughout the course of study as needed. It has been developed to constructively support skills, and provides scaffolded steps for undertaking practicals, research, planning, presenting and responding to task requirements.

The toolkit complements the advice included in Chapter 1 Skills and Assessment Toolkit of *Pearson Biology Queensland Student Book Unit 1 and 2 2nd edition*.

The information in this toolkit explains how responses to assessment tasks will be assessed against the characteristics in the Instrument Specific Marking Guides (ISMG).

ASSESSMENT

Although there are no mandated assessments for Units 1 and 2 Biology, your teacher may prepare you for Units 3 and 4 Biology by requiring you to complete similar assessments to those in Units 3 and 4. These assessments are the:

- data test (IA1) in Unit 1 (10%)
- student experiment (IA2) in Unit 1 (20%)
- research investigation (IA3) in Unit 2 (20%)
- examination (EA), at the end of Units 1 and 2 (50%)

PART A: Data Test (IA1)

The data test is completed in Unit 1. The test is completed under test conditions, with 10 minutes reading time and 60 minutes writing time.

The test may include:

- questions ranging from short answers to longer responses
- scenario situations
- problem solving.

The key areas assessed in the data test are your ability to:

- apply your understanding of concepts to determine scientific quantities or features in evidence
- look critically at evidence and analyse it
- reach conclusions based on interpretation of evidence.

Tasks in the data test use both qualitative data and quantitative data. This data is related to [illegible] practicals (both mandatory and suggested). Items [illegible] test may include previously unseen data. [illegible] calculations using algorithms and tables.

There will be many experiences throughout [illegible] that will provide you with opportunities to practise the skills and subject matter assessed in the data test. [illegible] can also take some additional opportunities to practise and prepare as [illegible] Checklist, which [illegible] assist in revision.

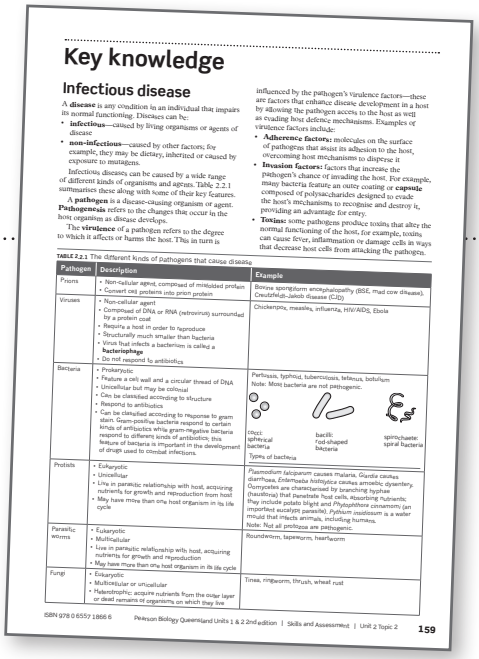
Data test preparation checklist

Resource	Feature	Revision activity	Complete (✓)
Pearson Biology Queensland Student Book Units 1 and 2 2nd Edition	Mandatory practicals	• Read through each [illegible] before stopping before [illegible] • Complete the [illegible] again, without looking at your [illegible] analysis, interpretation and conclusion. • Compare your analysis, interpretation and conclusion with those of your original practical.	
	SkillBuilders, Worked Examples and Try Yourself	• SkillBuilders outline a method or technique and step you through the skill to support the application. • SkillBuilders are often followed by Worked Examples, which provide the thinking and process for each step for working through a problem. • Refer to Worked Examples and their mirror Try Yourself problems, which are placed at relevant points in the chapter. Many develop skills in calculations using algorithms. • Select examples in which you need to improve skills and read the SkillBuilder and Worked Example that complete the Try Yourself and check your answer.	

continued over to next page

Key knowledge

Each topic begins with a key knowledge section. Key knowledge consists of a set of succinct summary notes that cover the subject matter for each topic of the syllabus. This section is highly illustrative and written in a straightforward style to assist students of all abilities to focus on the salient points. Key terms are in bold for ease of navigation and are reflected in the Student Book glossary. Key knowledge also serves as a ready reference when completing worksheets and practical activities. It also provides a handy set of revision and study notes.



Key knowledge

Infectious disease

A **disease** is any condition in an individual that impairs its normal functioning. Diseases can be:

- **infectious**—caused by living organisms or agents of disease
- **non-infectious**—caused by other factors; for example, they may be dietary, inherited or caused by exposure to mutagens.

Infectious diseases can be caused by a wide range of different kinds of organisms and agents. Table 2.2.1 summarises these along with some of their key features.

A **pathogen** is a disease-causing organism or agent. **Pathogenesis** refers to the changes that occur in the host organism as disease develops.

The **virulence** of a pathogen refers to the degree to which it affects or harms the host. This in turn is influenced by the pathogen's virulence factors—these are factors that enhance disease development in a host by allowing the pathogen access to the host as well as evading host defence mechanisms. Examples of virulence factors include:

- **Adherence factors:** molecules on the surface of pathogens that assist its adhesion to the host, overcoming host mechanisms to disperse it
- **Invasion factors:** factors that increase the pathogen's chance of invading the host. For example, many bacteria feature an outer coating or **capsule** composed of polysaccharides designed to evade the host's mechanisms to recognise and destroy it, providing an advantage for entry.
- **Toxins:** some pathogens produce toxins that alter the normal functioning of the host, for example, toxins can cause fever, inflammation or damage cells in ways that decrease host cells from attacking the pathogen.

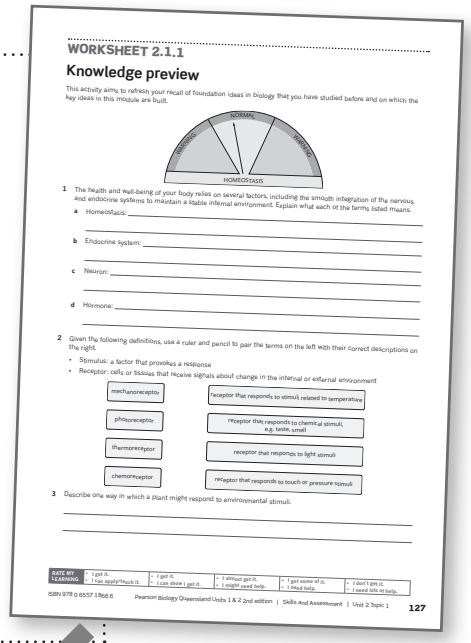
TABLE 2.2.1 The different kinds of pathogens that cause disease

Pathogen	Description	Example
Prions	• Non-cellular agent, composed of misfolded protein • Convert cell proteins into prion protein	Bovine spongiform encephalopathy (BSE, 'mad cow disease'), Creutzfeldt–Jakob disease (CJD)
Viruses	• Non-cellular agent • Comprised of DNA or RNA (retrovirus) surrounded by a protein coat • Require a host in order to reproduce • Structurally much smaller than bacteria • Virus that infects a bacterium is called a **bacteriophage** • Do not respond to antibiotics	Chickenpox, measles, influenza, HIV/AIDS, Ebola
Bacteria	• Prokaryotic • Feature a cell wall and a circular thread of DNA • Unicellular but may be colonial • Can be classified according to structure • Respond to antibiotics • Can be classified according to response to gram stain. Gram-positive bacteria respond to certain kinds of antibiotics while gram-negative bacteria respond to different kinds of antibiotics; this feature of bacteria is important in the development of drugs used to combat infections.	Perfringens, typhoid, tuberculosis, tetanus, botulism Note: Most bacteria are not pathogenic. coccus: spherical bacteria; bacilli: rod-shaped bacteria; spirochaete: spiral bacteria Types of bacteria
Protists	• Eukaryotic • Unicellular • Live in parasitic relationship with host, acquiring nutrients for growth and reproduction from host • May have more than one host organism in its life cycle	*Plasmodium falciparum* causes malaria, *Giardia* causes diarrhoea, *Entamoeba histolytica* causes amoebic dysentery. Oomycetes are characterised by branching hyphae (hausttoria) that penetrate host cells, absorbing nutrients. They include potato blight and *Phytophthora cinnamomi* (an important eucalypt parasite). *Pythium insidiosum* is a water mould that infects animals, including humans.
Parasitic worms	• Eukaryotic • Multicellular • Live in parasitic relationship with host, acquiring nutrients for growth and reproduction • May have more than one host organism in its life cycle	Note: Not all protozoa are pathogenic. Roundworm, tapeworm, heartworm
Fungi	• Eukaryotic • Multicellular or unicellular • Heterotrophic: acquire nutrients from the outer layer or dead remains of organisms on which they live	Tinea, ringworm, thrush, wheat rust

Worksheets

A diverse offering of instructive and self-contained worksheets is included in each topic. Common to all topics are the initial 'Knowledge preview' worksheets to activate prior knowledge; a 'Literacy review' worksheet to explicitly build language and application of scientific terminology; and finally a 'Thinking about my learning' worksheet, which encourages students to reflect on their learning and identify areas for improvement. Other worksheets, with their range of activities and tasks, help consolidate learning and the making of connections between subject matter.

Worksheets may be used for formative assessment and are clearly aligned to the syllabus. A range of questions building from foundation to challenging is included in the worksheets, which are written to reflect the Marzano and Kendall's taxonomy of instructional verbs.



WORKSHEET 2.1.1

Knowledge preview

This activity aims to refresh your recall of foundation ideas in biology that you have studied before and on which the key ideas in this module are built.

1 The health and well-being of your body relies on several factors, including the smooth integration of the nervous and endocrine systems to maintain a stable internal environment. Explain what each of the terms listed means.

a Homeostasis:

b Endocrine system:

c Neuron:

d Hormone:

2 Given the following definitions, use a ruler and pencil to pair the terms on the left with their correct descriptions on the right.

- Stimulus: a factor that provokes a response
- Receptor: cells or tissues that receive signals about change in the internal or external environment

mechanoreceptor	receptor that responds to stimuli related to temperature
photoreceptor	receptor that responds to chemical stimuli, e.g. taste, smell
thermoreceptor	receptor that responds to light stimuli
chemoreceptor	receptor that responds to touch or pressure stimuli

3 Describe one way in which a plant might respond to environmental stimuli.

RATE MY LEARNING

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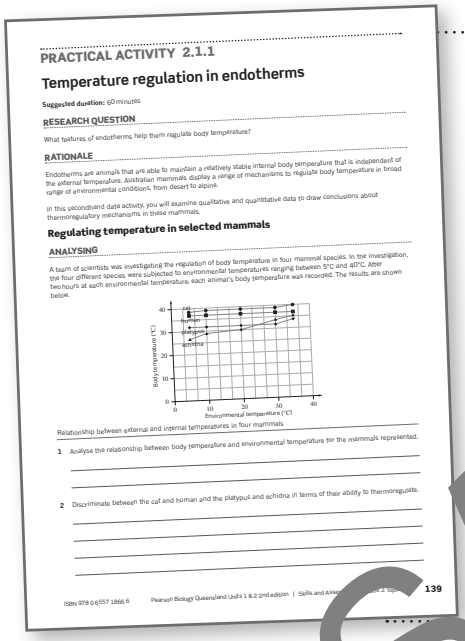

PRACTICAL ACTIVITY 2.1.1

Temperature regulation in endotherms

Suggested duration: 60 minutes

RESEARCH QUESTION

What features of endotherms help them regulate body temperature?

RATIONALE

Endotherms are animals that are able to maintain a relatively stable internal body temperature that is independent of the external temperature. Australian mammals display a range of mechanisms to regulate body temperature in broad range of environmental conditions, from desert to alpine.

In this secondhand data activity, you will examine qualitative and quantitative data to draw conclusions about thermoregulatory mechanisms in these mammals.

Regulating temperature in selected mammals

ANALYSING

A team of scientists was investigating the regulation of body temperature in four mammal species. In the investigation, the four different species were subjected to environmental temperatures ranging between 5°C and 40°C. After two hours at each environmental temperature, each animal's body temperature was recorded. The results are shown below.

Relationship between external and internal temperatures in four mammals

1 Analyse the relationship between body temperature and environmental temperature for the mammals represented.

2 Discriminate between the cat and human and the platypus and echidna in terms of their ability to thermoregulate.

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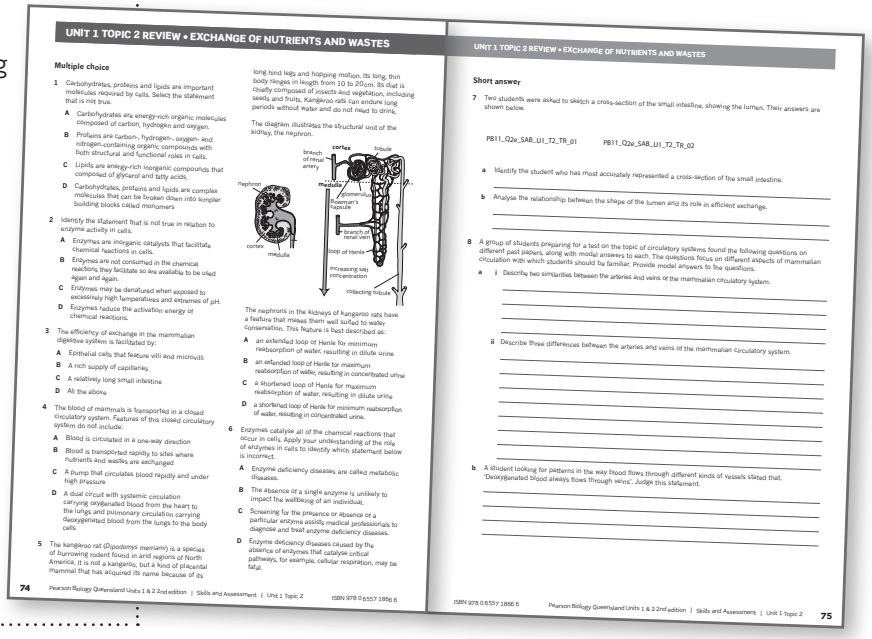
Practical activities

Practical activities take a highly scaffolded approach from beginning to completion and give students the opportunity to complete practical work related to the subject matter covered in the syllabus. Practical activities include a rich assortment of tasks that maximise learning opportunities, while also building experience in skill application to perform calculations and analysis of data, necessary for the Data Test. Every practical is featured, as well as many suggested practicals. As with the worksheets, a range of questions building from foundation to challenging are included, which are written to reflect the Marzano and Kendall's taxonomy of instructional verbs.

Topic review questions

Each topic concludes with a comprehensive set of questions consisting of multiple-choice and short-answer responses written in exam style. This provides students with exposure to, and the opportunity to practise drawing together subject matter and skills to respond to examination-style assessment.



UNIT 1 TOPIC 2 REVIEW • EXCHANGE OF NUTRIENTS AND WASTES

Multiple choice

1 Carbohydrates, proteins and lipids are important molecules required by cells. Select the statement that is not true.

A Carbohydrates are energy-rich organic molecules composed of carbon, hydrogen and oxygen.

B Proteins are carbon-, hydrogen-, oxygen- and nitrogen-containing organic compounds with both structural and functional roles in cells.

C Lipids are energy-rich inorganic compounds that comprised of glycerol and fatty acids.

D Carbohydrates, proteins and lipids are complex molecules that can be broken down into simpler building blocks called monomers

2 Identify the statement that is not true in relation to enzyme activity in cells.

A Enzymes are inorganic catalysts that facilitate chemical reactions in cells.

B Enzymes are not consumed in the chemical reactions they facilitate so are available to be used again and again.

C Enzymes may be denatured when exposed to excessively high temperatures and extremes of pH.

D Enzymes reduce the activation energy of chemical reactions.

3 The efficiency of exchange in the mammalian digestive system is facilitated by:

A Epithelial cells that feature villi and microvilli

B A rich supply of capillaries

C A relatively long small intestine

D All the above

4 The blood of mammals is transported in a closed circulatory system. Features of this closed circulatory system do not include:

A Blood is circulated in a one-way direction

B Blood is transported rapidly to sites where nutrients and wastes are exchanged

C A pump that circulates blood rapidly and under high pressure

D A dual circuit with systemic circulation carrying oxygenated blood from the heart to the lungs and pulmonary circulation carrying deoxygenated blood from the lungs to the body cells

5 The kangaroo rat (*Dipodomys merriami*) is a species of burrowing rodent found in arid regions of North America. It is not a kangaroo, but a kind of placental mammal that has acquired its name because of its long hind legs and hopping motion. Its long, thin body ranges in length from 10 to 20 cm. Its diet is chiefly composed of insects and vegetation, including seeds and fruits. Kangaroo rats can endure long periods without water and do not need to drink.

The diagram illustrates the structural unit of the kidney, the nephron.

The nephrons in the kidneys of kangaroo rats have a feature that makes them well suited to water conservation. This feature is best described as:

A an extended loop of Henle for minimum reabsorption of water, resulting in dilute urine

B an extended loop of Henle for maximum reabsorption of water, resulting in concentrated urine

C a shortened loop of Henle for maximum reabsorption of water, resulting in dilute urine

D a shortened loop of Henle for minimum reabsorption of water, resulting in concentrated urine.

6 Enzymes catalyse all of the chemical reactions that occur in cells. Apply your understanding of the role of enzymes in cells to identify which statement below is incorrect.

A Enzyme deficiency diseases are called metabolic diseases.

B The absence of a single enzyme is unlikely to impact the wellbeing of an individual.

C Screening for the presence or absence of a particular enzyme assists medical professionals to diagnose and treat enzyme deficiency diseases.

D Enzyme deficiency diseases caused by the absence of enzymes that catalyse critical pathways, for example, cellular respiration, may be fatal.

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UNIT 1 TOPIC 2 REVIEW • EXCHANGE OF NUTRIENTS AND WASTES

Short answer

7 Two students were asked to sketch a cross-section of the small intestine, showing the lumen. Their answers are shown below.

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a Identify the student who has most accurately represented a cross-section of the small intestine.

b Analyse the relationship between the shape of the lumen and its role in efficient exchange.

8 A group of students preparing for a test on the topic of circulatory systems found the following questions on different past papers, along with model answers to each. The questions focus on different aspects of mammalian circulation with which students should be familiar. Provide model answers to the questions.

a i Describe two similarities between the arteries and veins of the mammalian circulatory system.

ii Describe three differences between the arteries and veins of the mammalian circulatory system.

b A student looking for patterns in the way blood flows through different kinds of vessels stated that, 'Deoxygenated blood always flows through veins'. Judge this statement.

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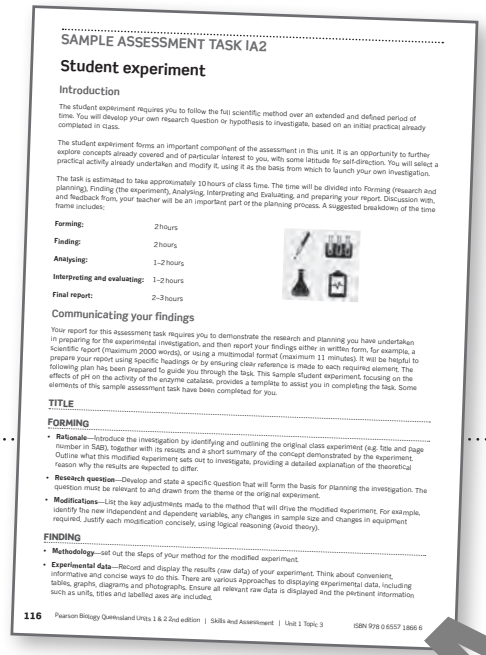
Sample assessment tasks

Sample Assessment Tasks for the **Data Test**, **Student Experiment** and **Research Investigation** provide opportunities for students to practise responding to these assessment tasks. The activities are designed to support students by guiding and scaffolding them through each aspect of these assessments.



SAMPLE ASSESSMENT TASK IA2

Student experiment

Introduction

The student experiment requires you to follow the full scientific method over an extended and defined period of time. You will develop your own research question or hypothesis to investigate, based on an initial practical already completed in class.

The student experiment forms an important component of the assessment in this unit. It is an opportunity to further explore concepts already covered and of particular interest to you, with some latitude for self-direction. You will select a practical activity already undertaken and modify it, using it as the basis from which to launch your own investigation.

The task is estimated to take approximately 10 hours of class time. The time will be divided into Forming (research and planning), Finding (the experiment), Analysing, Interpreting and Evaluating, and preparing your report. Discussion with, and feedback from, your teacher will be an important part of the planning process. A suggested breakdown of the time frame includes:

Forming: 2 hours
Finding: 2 hours
Analysing: 1–2 hours
Interpreting and evaluating: 1–2 hours
Final report: 2–3 hours

Communicating your findings

Your report for this assessment task requires you to demonstrate the research and planning you have undertaken in preparing for the experimental investigation, and then report your findings either in written form, for example, a scientific report (maximum 2000 words), or using a multimodal format (maximum 11 minutes). It will be helpful to prepare your report using specific headings or by ensuring clear reference is made to each required element. The following plan has been prepared to guide you through the task. This sample student experiment, focusing on the effects of pH on the activity of the enzyme catalase, provides a template to assist you in completing the task. Some elements of this sample assessment task have been completed for you.

TITLE

FORMING

- **Rationale**—Introduce the investigation by identifying and outlining the original class experiment (e.g. title and page number in SAB), together with its results and a short summary of the concept demonstrated by the experiment. Outline what this modified experiment sets out to investigate, providing a detailed explanation of the theoretical reason why the results are expected to differ.
- **Research question**—Develop and state a specific question that will form the basis for planning the investigation. The question must be relevant to and drawn from the theme or the original experiment.
- **Modifications**—List the key adjustments made to the method that will drive the modified experiment. For example, identify the new independent and dependent variables, any changes in sample size and changes in equipment required. Justify each modification concisely, using logical reasoning (Avoid theory).

FINDING

- **Methodology**—set out the steps of your method for the modified experiment.
- **Experimental data**—Record and display the results (raw data) of your experiment. Think about convenient, informative and concise ways to do this. There are various approaches to displaying experimental data, including tables, graphs, diagrams and photographs. Ensure all relevant raw data is displayed and the pertinent information such as units, titles and labelled axes are included.

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Icons and features

Every practical is supported by a complementary SPARKlab alternative practical.

The **safety icon** highlights significant hazards, indicating caution is needed.

The **safety glasses icon** highlights that protective eyewear is to be worn during the practical activity.

Rate my learning

This innovative feature appears at the end of most worksheets, all practical activities and sample assessment tasks. It provides students with the opportunity for self-reflection and self-assessment. Students are encouraged to consider how they can continue to improve, and identify areas of focus for further skill and subject matter development. This tool has been based on the Marzano and Kendall's taxonomy of instructional verbs.

RATE MY LEARNING					
	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

Teacher support

Fully worked solutions, suggested answers and responses to sample assessment tasks, as well as practical activity support including full **risk assessments**, **expected results** and **handy hints** are provided for teachers, through the teacher support subscription.

Biology toolkit

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The toolkit complements the advice included in Chapter 1 Skills and Assessment Toolkit of *Pearson Biology Queensland Student Book Unit 1 and 2 2nd edition*.

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- reach conclusions based on interpretation of evidence.

Tasks in the data test use both qualitative data and quantitative data. This data is related to Unit 1 practicals. Items in the data test may include previously unseen data. You will be expected to complete calculations using algorithms, and interpret graphs, diagrams and tables.

There will be many experiences throughout Unit 1 that will provide you with opportunities to prepare for the skills and subject matter assessed in the data test. You can also take some additional opportunities to practice and prepare as outlined in the Data Test Preparation Checklist, which directs you to resources to assist in revision.

Data test preparation checklist

Resource	Feature	Revision activity	Complete (✔)
Pearson Biology Queensland Student Book Units 1 and 2 2nd Edition	**Practical Activities**	• Read through each practical completed in class, stopping before 'Analysis' of the data. • Complete the analysis section of the practical again, without looking at your original analysis, interpretation and conclusion. • Compare your analysis, interpretation and conclusion with those of your original practical.	
	SkillBuilders, Worked Examples and Try Yourself	• SkillBuilders outline a method or technique and step you through the skill to support the application. • SkillBuilders are often followed by Worked Examples, which provide the thinking and process for each step for working through a problem. • Refer to Worked Examples and their mirror Try Yourself problems, which are placed at relevant stages in the chapter. Many develop skills in calculations using algorithms. • Select examples in which you need to improve skills and read the SkillBuilder and Worked Example then complete the Try Yourself and check your answer.	

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Resource	Feature	Revision activity	Complete (✓)
	Questions/ instructions	• Refer to module and chapter reviews, focusing on instructions listed under 'Analysis'; many of these tasks require the same skills needed to complete the data test. • Select appropriate instructions and complete them. • Check your answers against fully worked solutions provided in your ebook.	
	Chapter 1 Skills and Assessment Toolkit	• Refer to chapter 1 Skills and Assessment Toolkit, Part A, in the ebook. • Use this reference tool as needed, to improve your mathematical skills, analysis and visual interpretation skills.	
Pearson Biology Queensland Skills and Assessment Book Units 1 & 2 2nd edition	**Practical Activities**	• See suggestions and support for practical activities, which include working with data.	
	Topic Review	• Refer to topic review tasks for samples of the style of items on data test.	
	Practice Data Test	• Complete the practice Sample Assessment Task—Data Test provided on page 112 • Complete these questions as a practice test.	

PART B: Student Experiment (IA2)

The Student Experiment (IA2) investigates a research question, that has been generated from the modification of a class practical activity, to draw a conclusion from the analysis of the primary data.

The student experiment uses practical investigation methodology including a research question developed by the student, the collection of primary data, and then analysis and synthesis of that data.

The research question must:

- relate back to a completed practical related to the subject matter
- modify, refine, extend or redirect the class practical.

CONDUCTING THE STUDENT EXPERIMENT

A great deal of preparation is needed before starting the experiment and much thought throughout the internal assessment task. Use the Student experiment checklist below as a guide.

Refer to Chapter 1 eBook in Pearson Biology Queensland Student Book Units 1 & 2 2nd edition.

- Part A covers Scientific skills such as mathematical basics, representations in graphics, tables and graphs, data analysis.
- Part B covers all aspects of the student experiment and includes a sample student report.

Student experiment checklist

Task		Activity	Due date	Complete (✓)
Form ideas and develop the research question	Initial practical	• Identify the practical to be modified for your experiment.		
	Background	• Commence a journal to record all aspects of the assessment task. • Research relevant background information. • Understand the data of original experiment.		
	Variables	• Identify the dependent and independent variables of original experiment.		
	Modification	• Modify the original experiment.		
	Justification	• Justify/provide rationale for the modification for the new experiment question.		

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	Methodology	• Plan the modifications to the original method to be followed for the experiment.
		• Write a statement of the aim which will be used as the opening statement of your introduction or rationale.
		  • May be expressed as a statement or question.
		  • May be one or two sentences.
		  • Often written as 'To investigate the effect of ... on ... ' or 'To investigate if a correlation exists between ... and ... '.		

	Materials	• Make a list of all equipment, chemicals and materials used in the modified experiment. • Include quantities (consumables) and sizes (equipment).		
Find the methodology and data	Risk assessment	• Identify and manage risks and potential dangers by completing the Risk Assessment Form on page XX.		
	The experiment	• Conduct the experiment. • Collect the relevant data to answer the research question.		
	Results	• Prepare a data plan that includes what will be observed and what data will be recorded. Include how data will be recorded by preparing a table in your journal for results. • Record all measurements taken during the experiment as well as observations. • Collect sufficient and relevant data. • Observations may be recorded as text, diagrams, photos or videos. • Process data and present it correctly. • Most common records of primary data are tables with titles and units. • Most common records of processed data are tables, graphs and can include calculations such as mean and uncertainty. Remember to include units and measurement uncertainty in the column titles of tables. • Check for errors and mistakes in data collected. • Repeat measurements where there are obvious anomalies.		
Analyse the evidence	Organise data collected	• Process the data using mathematical techniques and graphs. • Identify the trends, patterns or relationships. • Identify the uncertainties and limitations of the evidence. • Include the interpretation of results.		
Interpret and evaluate the evidence	Work with data collected and relate back to the experiment question	• Draw conclusions from the evidence that addresses the experiment question. • Evaluate the reliability and validity of the experimental process. • Provide suggestions to improve and/or extend the experiment. Evaluate the method used. • Comment on whether results relate to the experiment question. • Provide suggestions for improvements and extensions to the experiment.		
The experiment report	Presentation format	• Decide on the presentation format; written or multi modal. • Check length requirements for your selected format.		
	Communication	• Communicate ideas in scientific language and representations. • Include in-text citations and reference list. • Write using your own words to avoid plagiarising. • Ensure length requirements are not exceeded.		

TOPIC 3

Cellular energy, gas exchange and plant physiology

- ☐ Worksheet 1.3.1 Knowledge preview
- ☐ Worksheet 1.3.2 Energy transformations in cells
- ☐ Worksheet 1.3.3 Mitochondria and cellular respiration
- ☐ Worksheet 1.3.4 Gas exchange in the mammalian respiratory system
- ☐ Worksheet 1.3.5 Chloroplasts and photosynthesis
- ☐ Worksheet 1.3.6 Photosynthesis and gas exchange in plants
- ☐ Worksheet 1.3.7 Literacy review
- ☐ Worksheet 1.3.8 Thinking about my learning
- ☐ Practical activity 1.3.1 Cell processes—photosynthesis and cellular respiration
- ☐ Practical activity 1.3.2 Gaseous exchange in mammals
- ☐ Practical activity 1.3.3 Xylem and phloem—plant vascular tissues
- ☐ **Topic 3 Review**
- ☐ **Sample assessment task IA1: Data test**
- ☐ **Sample assessment task IA2: Student experiment**

Key knowledge

ENERGY AND METABOLISM

Biochemical processes in cells

Biochemical processes (chemical reactions) occur constantly in cells. Indeed, the survival of cells relies on these chemical reactions. Collectively, these chemical reactions are called the metabolism.

Chemical reactions in cells may be anabolic or catabolic. **Anabolic** reactions involve the contruction of complex molecules from simpler ones and require an input of energy. **Catabolic** reactions involve the contruction of complex molecules from simpler ones and require an input of energy.

Processes that change energy from one form to another are energy transformations. **Photosynthesis** and **cellular respiration** are examples of energy transformations that occur in living organisms.

- Photosynthesis is an example of an endergonic process.
- Cellular respiration is an example of an exergonic process.

Cellular respiration

ATP (**adenosine triphosphate**) is the immediate source of energy for cells. It is produced in a series of enzyme-controlled chemical reactions that involves the breakdown of organic molecules by catabolic reactions. The useable energy of ATP is contai[illegible] in the phosphate bonds of the molecule. The cycli[illegible] of ATP and ADP (adenosine diphosphate) means tha[illegible] energy continues to be available for use [illegible] a cell (Figure 1.3.1).

Cells access the energy available in organic molecules through **glycolysis** (anaerobic) and either cellular respiration (aerobic) or **fermentation** (anaerobic).

Cellular respiration is the process in which complex organic compounds are broken down to release energy (ATP). Water is a by-product.

A word equation for aerobic cellular respiration is:

glucose + oxygen → carbon dioxide + water + energy

A balanced chemical equation for cellular respiration is:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy (36–38 ATP)

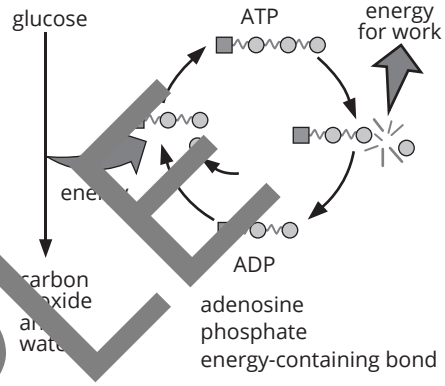

FIGURE 1.3.1 The ATP–ADP cycle

The process of cellular respiration typically occurs by three biochemical pathways: glycolysis (the splitting of glucose molecules), which occurs in the cytoplasm, the Krebs cycle and the electron transfer chain, both of which occur in the mitochondria (Figure 1.3.2).

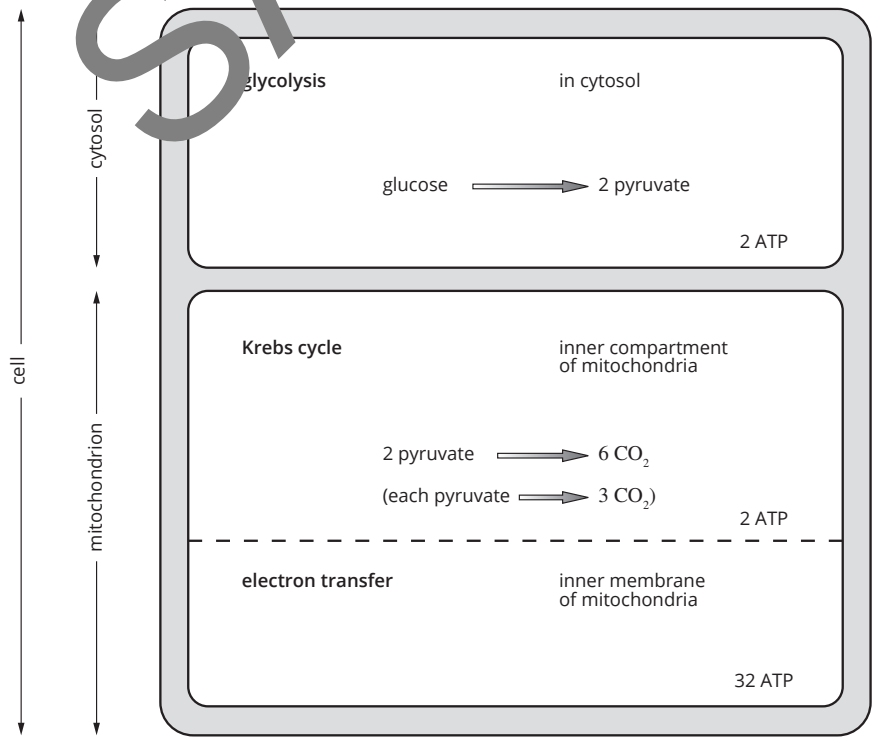

FIGURE 1.3.2 The stages of cellular respiration and associated ATP production

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Anaerobic respiration

If oxygen is not available to meet the cell's energy requirements, **anaerobic respiration** (fermentation) occurs. Different cells produce different products. Lactic acid is produced in animal cells. Ethanol and carbon dioxide are produced in plant and yeast cells. Less ATP is produced during anaerobic respiration. (A lot of energy is still bound up in the end products.) Anaerobic respiration is less efficient than **aerobic respiration**.

EFFICIENT EXCHANGE OF OXYGEN AND CARBON DIOXIDE IN MAMMALS

The different systems of the body work together to maintain the needs of cells and therefore the whole individual. For example, the circulatory and respiratory systems are closely integrated, ensuring materials needed by cells are delivered, and wastes are removed.

In Unit 1 Topic 2 we considered features of the circulatory system that ensure the efficient delivery of the products of digestion to the body cells, including the thin walls of capillaries to enhance exchange, and the large surface area of capillaries at sites of exchange.

Oxygen and carbon dioxide need to be exchanged continuously for an organism to function efficiently. In large, multicellular organisms such as mammals, the respiratory system is responsible for this exchange of gases.

Efficient respiratory surfaces feature:

- a large surface area
- thin (one or two cells thick), moist and easily penetrable surfaces
- adequate ventilation
- efficient transport of carrier fluid (blood) across the respiratory surface.

The mammalian respiratory system features structures and processes that result in the efficient exchange of oxygen and carbon dioxide. It is composed of:

- lungs
- respiratory passages—nasal passages, **trachea**, **bronchi** and **bronchioles** that end in sacs called **alveoli** (the site of gaseous O_2 and CO_2 exchange).

The epiglottis prevents food from travelling down the trachea and blocking the passage of air.

Contraction and relaxation of the diaphragm muscle results in changes in pressure within the lung cavity, forcing air in and out. Alveoli have a large surface area due to their structure for gas exchange and are extensively surrounded by capillaries. Gas exchange relies on diffusion, which depends on concentration gradients being maintained. For oxygen to continually diffuse into the capillaries it needs to be transported away from the site. The respiratory pigment, **haemoglobin**, carries oxygen in the blood from the lungs and releases oxygen into cells around the body. Rhythmic pumping of the heart ensures the continuous flow of blood along capillaries surrounding the alveoli.

Haemoglobin and oxygen bind in a reversible reaction:

$$2Hb + 4O_2 \rightleftharpoons Hb(O_2)_4$$

haemoglobin + oxygen $\rightleftharpoons$ oxyhaemoglobin

The reaction proceeds to the right in areas of high oxygen concentration, such as when oxygen diffuses into the capillaries in the lungs. The reaction proceeds to the left in areas of low oxygen concentration, such as in capillaries near body cells. The reaction is shown in Figure 1.3.3. The released oxygen can now diffuse into nearby cells. Diffusion of each gas occurs down its concentration gradient, whether it is in the alveoli of the lungs or in capillaries near body cells.

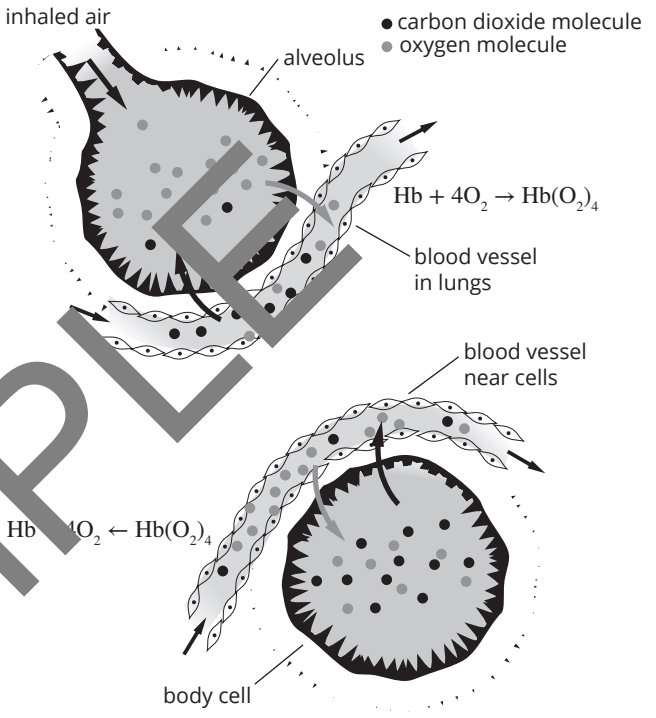

FIGURE 1.3.3 Diffusion of gases in the lungs and body cells

Photosynthesis

Photosynthesis involves a series of enzyme-controlled reactions that occur in the chloroplasts of plant cells (Figure 1.3.4). Photosynthesis is an anabolic reaction, because it involves the construction of complex molecules from simpler ones. It requires light and involves the conversion of light energy into chemical energy.

A word equation for photosynthesis is:

$$\text{carbon dioxide + water} \xrightarrow[\text{chlorophyll}]{\text{light}} \text{glucose + oxygen + water}$$

The balanced chemical equation for photosynthesis is:

$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Organisms that produce their own organic compounds are called **autotrophs**. Autotrophs can be photosynthetic (plants) (Figure 1.3.5) or chemosynthetic (some prokaryotes). Organisms such as fungi and animals that obtain their organic compounds from other organisms are called **heterotrophs**.

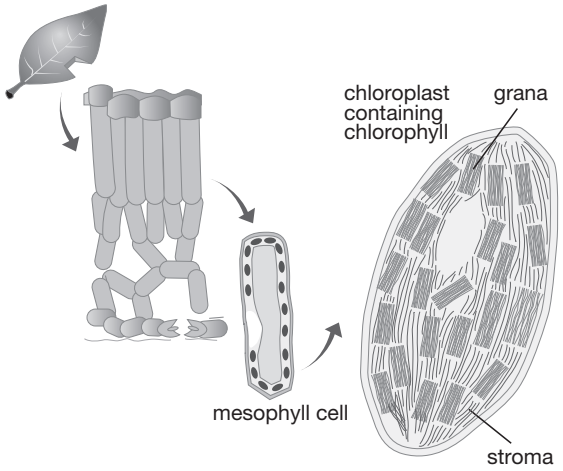

FIGURE 1.3.4 Leaves, and some stems, are green because the mesophyll cells contain many chloroplasts, the organelles in which photosynthesis takes place.

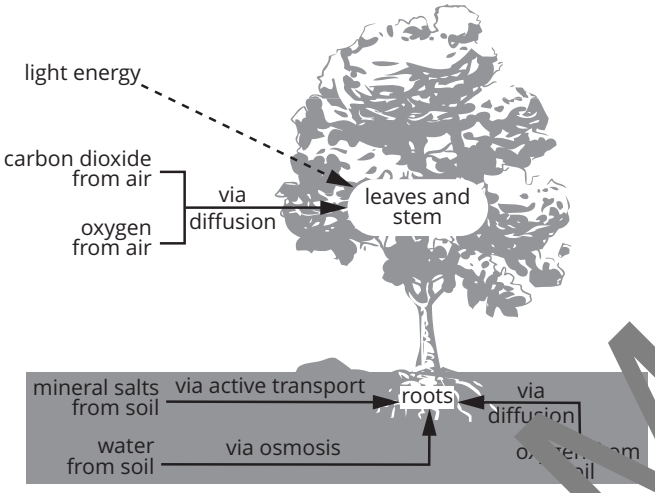

FIGURE 1.3.5 An overview of how plants obtain nutrien

Photosynthesis occurs in two stages: the **light-dependent stage** occurs in grana, the **light-independent stage** occurs in the stroma (Table 1.3.1). The products of the light-dependent stage of photosynthesis constitute the reactants required by the light-independent stage, so it must proceed first.

Factors that may limit the rate of photosynthesis include light intensity, carbon dioxide concentration and temperature. Photosynthesis and cellular respiration occur simultaneously in green plants during periods of light exposure.

TABLE 1.3.1 Overview of stages involved in photosynthesis

First stage light-dependent	Second stage light-independent
• occurs in grana • red and blue light absorbed • light absorbed by chlorophyll • energy used to split water molecules • produces O_2 (by-product) and H^+ ions • ATP also produced (used in second stage)	• occurs in stroma • carbohydrate produced – in the form of glucose – stored as starch • H^+ ions and CO_2 (from air) combined • ATP from first stage consumed in glucose manufacture

Gas exchange and transportation in vascular plants

GAS EXCHANGE IN PLANTS

Gas exchange structures in plants are relatively simple, compared to the complex structures that are present in multicellular animals. Openings in leaves, **stomata**, allow carbon dioxide (for photosynthesis) and oxygen (for cellular respiration) to enter the leaf, where gas exchange occurs directly with cells by diffusion. Opening and closing of stomata is controlled by a pair of **guard cells** (Figures 1.3.6 and 1.3.7). Cells are arranged in a loosely packed fashion that allows diffusion to occur more rapidly (Figure 1.3.7). The size of the stomatal aperture is regulated by the turgidity of the guard cells. When the guard cells are turgid—under water pressure—they swell and buckle, and the stoma becomes larger. A loss of turgor leads to guard cells straightening and the stomatal pore closes.

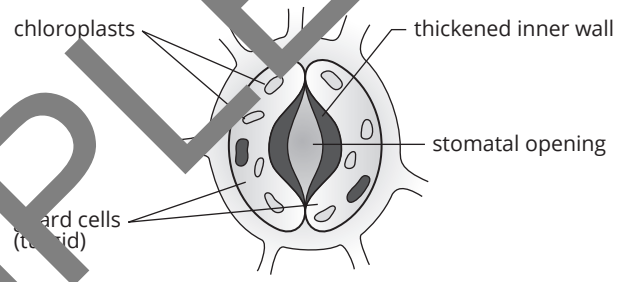

FIGURE 1.3.6 Stomata and guard cells

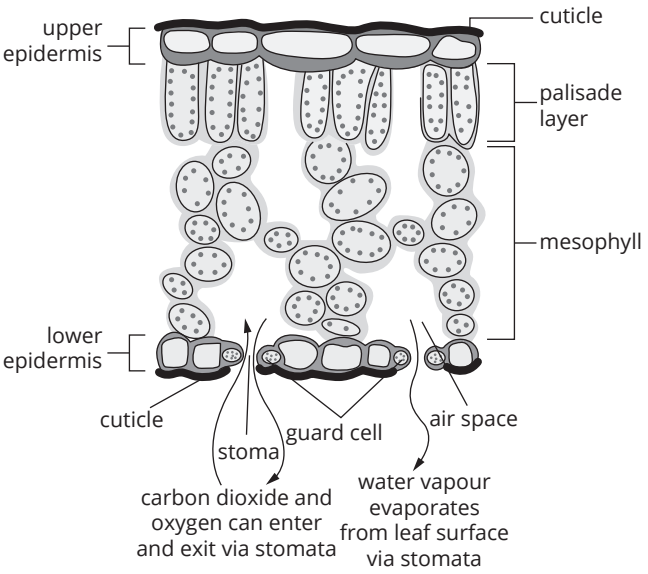

FIGURE 1.3.7 Cross-section of leaf tissue

Gas exchange in plants needs to be balanced with water conservation. While stomata are open, water vapour can be lost to the environment. This poses problems for plants that live in dry environments. To overcome this, arid-adapted plants only open their stomata during cooler parts of the day.

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TRANSPORT IN PLANTS

Plants feature a series of tubes called **vascular tissue** for the transport of substances. There are two key types of vascular tissue in plants.

- **Xylem** is composed of non-living tissue; remnants of cells reinforced with lignin.
- **Phloem** consists of living cells; end plates of cells sieve-like; associated with companion cells that control activities of nucleus-free sieve cells.

Plasmodesmata are fine channels that link plant vascular cells, allowing lateral movement of nutrients from cell to cell.

Transpiration is the loss of water from plants through evaporation, mainly via stomata. The cohesion of water molecules means that as water vapour is evaporated at the leaf surface, the entire water column is drawn up through the xylem.

Translocation refers to the movement of organic solutes from the leaves, where they are produced during photosynthesis, to other parts of the plant.

Table 1.3.2 summarises the roles of xylem and phloem in transport in plants.

NATURAL SYSTEMS AND NEW TECHNOLOGIES

With Earth's human population having already surpassed eight billion, the challenge of supporting our vast energy needs is immense. Scientists look to the natural world for inspiration, where observation and understanding natural systems has so often revealed the way forward. Understanding the natural world has meant the development of sustainable energy sources such as solar, wind, geothermal and tidal. Current research is focussed on mimicking the photosynthetic work of leaves to manufacture energy-rich hydrocarbons, but with an output of environmentally friendly liquid fuel that can be used in industry. Artificial leaves are used to harness solar energy to split water molecules into oxygen and hydrogen, then engineered bacteria are employed to combine the hydrogen with carbon dioxide to produce liquid fuel. Besides providing an alternative to fossil fuels, the technology has the advantage of mitigating atmospheric carbon dioxide levels. Such solar fuel technologies are not currently commercially viable, but demonstrate a promising future.

TABLE 1.3.2 Characteristics of transport in plants

	Vascular tissue	
	Xylem	**Phloem**
Substances involved	• water • inorganic nutrients	• organic nutrients, e.g. sugars
Direction of transport	• from roots upwards through the plant	• from leaves to rest of plant in both directions (upwards and downwards)
Processes involved	• cohesion of water molecules together with transpiration pull not pressure draw water upwards • no energy expenditure by the plant; instead, environmental heat, for example from the sun, evaporates water from leaf surfaces, drawing water columns upwards through the plant; dry and windy conditions increase the water gradient between the intercellular leaf spaces and the external air, increasing evaporation; by contrast, humid conditions decrease this gradient, causing a decrease in water loss by evaporation	• active process requiring energy

WORKSHEET 1.3.1

Knowledge preview

Cellular respiration and photosynthesis are biochemical processes that result in specific energy transformations in organisms. These processes are critical to survival.

1 Complete the table to summarise key information for the processes of cellular respiration and photosynthesis.

a Define the process.

b Identify the raw materials for each process.

c Look at the information for each process carefully. Summarise the pattern or relationship you notice between these two processes

	Cellular respiration	Photosynthesis
a Definition		
b Raw materials		
c Relationship		

2 Defend the statement that 'cellular respiration is a critical biochemical process in the cells of organisms'.

3 Cellular respiration is a process occurring in the cells of all organisms, including both animals and plants, whereas photosynthesis occurs in plants but not animals. Recall when in the day/night cycle the two processes occur in animals and plants.

Kind of organism	Cellular respiration	Photosynthesis
Animals		
Plants		

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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WORKSHEET 1.3.3

Mitochondria and cellular respiration

1 Define aerobic cellular respiration.

_____

_____

2 Write a balanced equation for cellular respiration in the space below.

3 Cellular respiration occurs in three stages. These are glycolysis, _____ _____ and

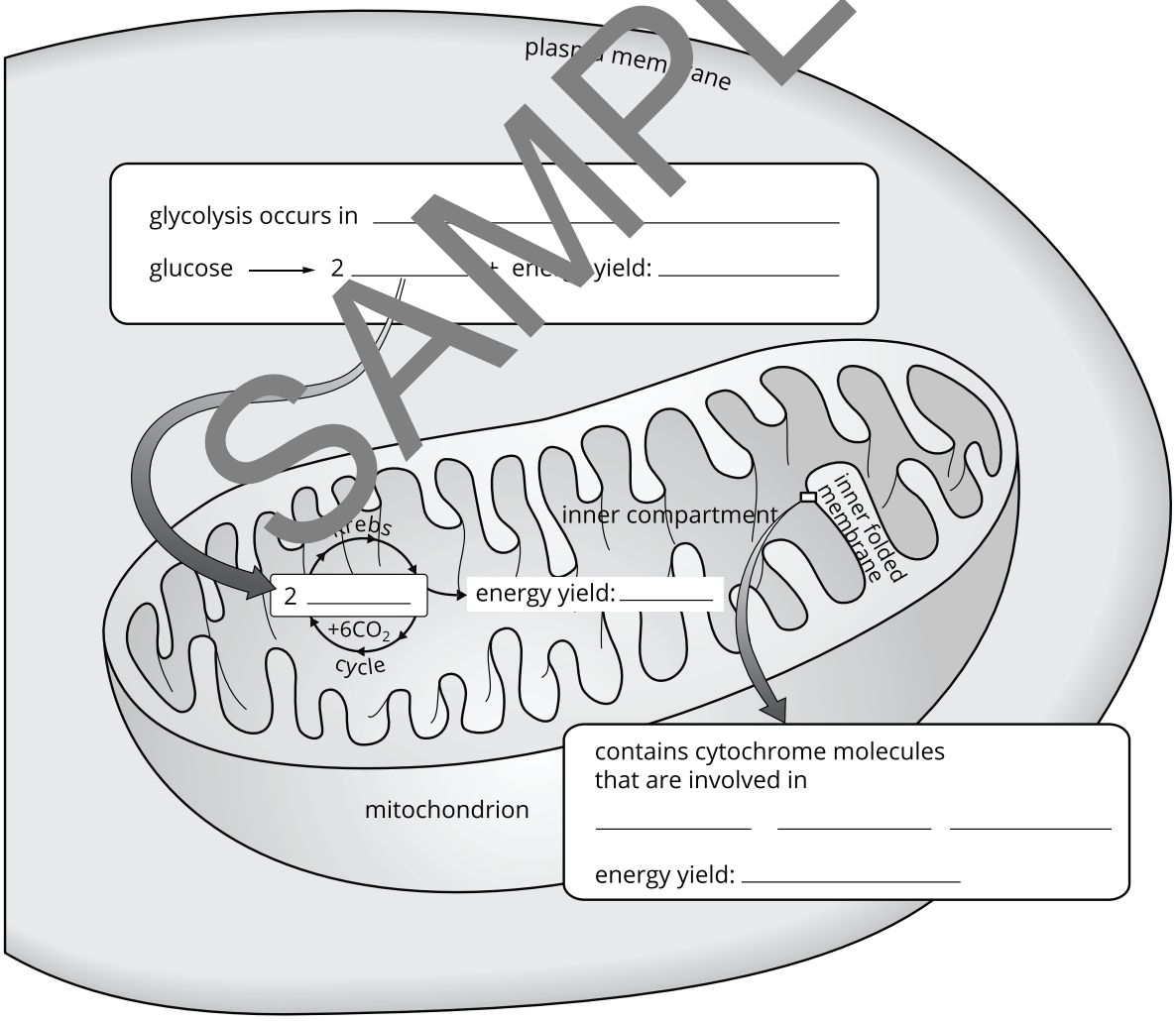
_____ _____ _____.

_____ occurs in the cytoplasm.

The Krebs cycle and the _____ _____ _____ occur in the

_____.

4 Complete the pictograph of the cell and mitochondrion to build a summary of the different steps involved in the process of cellular respiration and the sites where each step occurs within the cell.



5 Mitochondria are sometimes referred to as the 'powerhouse' of cells. Suggest the reason for this.

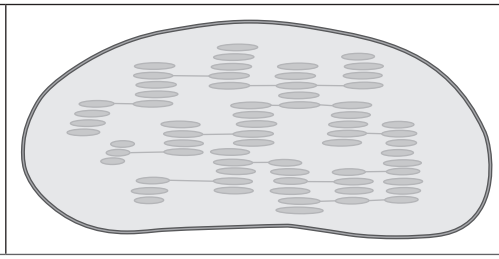
_____

_____

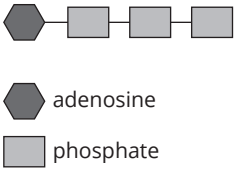
WORKSHEET 1.3.7

Literacy review

Use your knowledge and the information provided below to recall the meaning of each term. Provide examples or further explanatory notes where it is helpful to give extra context.

	Scientific term	Meaning
1	respirate	to breathe in and out
	cellular respiration	
2	cata	down, destructive
	ana	up, constructive
	meta	to change
	catabolic reaction	Describes a reaction in the metabolism of cells in which larger molecules are broken down into smaller ones; energy is released in catabolic reactions as a result of chemical bonds being broken.
	anabolic reaction	
3	photo	light
	synthesis	to make or produce
	photosynthesis	
4	chloro	green
	plastid	organelle that produces and stores organic molecules
	chloroplast	
5	*hydro*	water
	glyco	sweet
	lysis	to split
	hydrolysis	
	glycolysis	

6 Examine the diagram of adenosine triphosphate (ATP) shown. Explain the meaning of this term.



RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

WORKSHEET 1.3.8

Thinking about my learning

On completion of Topic 3: Cellular energy, gas exchange and plant physiology. You should be able to work with data, to interpret, analyse and evaluate it.

Consider how aware you are of how you learn. Consider how much control you take for your own learning. Thinking about how you learn is called metacognition and includes:

- being aware of your learning goals
- knowing the best ways for you to learn
- identifying your learning strengths and weaknesses
- planning how to tackle difficult tasks
- monitoring your own progress
- working out how to correct your own errors.

1 Refer to page 1 of the *Skills and Assessment Book* to read the content outline for this unit.

Read each dot point relevant to Topic 2. Reflect on how well you understand each concept. Indicate your level of understanding by using highlighters to colour code each point:

- green—very confident
- yellow—in the middle
- red—starting to get the idea.

2 Think about the different methods or learning strategies you used in this topic. Different learning strategies suit different situations and different people. Some common learning strategies are:

- memory devices, such as lists
- studying and discussing concepts in a group
- restating information in your own words
- using charts such as flow charts and concept maps to represent information and show relationships
- relating concepts to your own experiences
- summarising notes
- teaching someone else
- frequently rereading class notes
- highlighting key points in notes
- making flash cards.

a In the following table, list two learning strategies you used during this topic, and describe a situation when each learning strategy was used.

b Place a cross along the scale on the right of the table, to indicate how effective each strategy was for you.

Learning strategy/situation when used	Effectiveness of learning strategy for my learning	
	⟷	
	Not effective This strategy was not very helpful for my understanding and learning.	**Very effective** This strategy was very helpful for my understanding and learning.
	⟷	
	Not effective This strategy was not very helpful for my understanding and learning.	**Very effective** This strategy was very helpful for my understanding and learning.

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PRACTICAL ACTIVITY 1.3.3

Xylem and phloem—plant vascular tissues

Suggested duration: 90 minutes

RESEARCH QUESTIONS

- Do plants conduct materials through specialised vascular tissues?
- What are the features of plant vascular tissues?

RATIONALE

Tissues that are specialised for transporting substances to and from cells in plants are called vascular tissues. One tissue transports water and inorganic nutrients upwards through the plant and is called xylem. The other tissue transports sugars (in solution) produced by photosynthesis and other manufactured products throughout the plant and is called phloem. In stems, xylem and phloem tissue form vascular bundles, with the phloem on the outer surface of the bundle. A layer of cells called the cambium (a layer of cells that produces secondary tissues) runs through the vascular bundle separating the xylem and phloem.

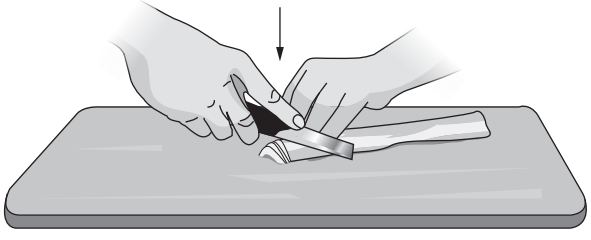
Vascular tissue is easily visible in leaves. The parallel veins of grasses and the branching veins in most other leaves are part of the vascular network of the plant. Vascular tissue extends from the roots to the very tips of leaves, and into developing buds and fruit.

In this activity, you will investigate the transport system in a typical vascular plant. The activity includes tracing the pathway of materials through vascular tissue in the stem of celery, as well as the use of microscopy to examine the composition of vascular bundles in the cross-section of leaf tissue.

METHOD

1 Collect a celery petiole (stalk that attaches leaf to stem) that has been standing in coloured dye solution. Rinse the dye from the end and examine the petiole and leaf for evidence of dye distribution. Holding it up to the light may be helpful.

2 Place the petiole on a dissecting board and, using the razor blade, cut transverse sections (across the stalk) as thinly as possible (1–2 mm thickness) in the positions shown in the figure on the right. Be sure to slice the petiole in a downwards direction onto the cutting board. Arrange the sections on a microscope slide. A coverslip is not needed. Put the slide under a stereoscopic microscope and examine the cut surface of each section for the presence of dye. Answer question **1**.



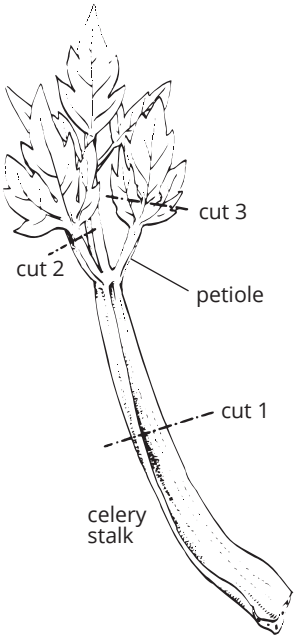
Technique for cutting sections

MATERIALS

- stick of celery that has been standing in a solution of water and water-soluble food dye
- stick of celery that has been standing in water without dye
- iodine stain
- stereoscopic microscope
- light microscope
- scalpel
- two dissecting needles
- forceps
- microscope slides and coverslips
- single-edged razor blade (new or in very good condition)
- dissecting board
- paper towel and paper tissues

Extension

- prepared slides—transverse and longitudinal sections of a sunflower (*Helianthus* sp.) stem



Positions for cutting celery

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Multiple choice

1 For every molecule of glucose ($C_6H_{12}O_6$) consumed in anaerobic respiration, two molecules of lactic acid ($C_3H_6O_3$) are produced. Identify the statement that is incorrect.

A Anaerobic respiration in mammalian cells is also referred to as fermentation.

B Anaerobic respiration in plant cells produces ethanol and carbon dioxide.

C Anaerobic respiration is a catabolic reaction.

D Anaerobic respiration is an anabolic reaction.

2 Aerobic and anaerobic respiration in mammals are metabolic processes that:

A produce oxygen for cells.

B consume carbon dioxide.

C consume glucose.

D are completed in the mitochondria.

3 Scientists observe natural systems to try to understand and mimic them to solve challenges of the modern world. Artificial leaves are one example being researched. Which statement is correct?

A Artificial leaf technology aims to convert hydrogen and carbon dioxide into liquid fuel.

B Artificial leaf technology mimics a green plant's ability to produce carbohydrates and oxygen.

C Artificial leaf technology has the disadvantage of increasing atmospheric carbon dioxide levels.

D Artificial leaf technology consumes hydrocarbons and produces carbon dioxide and water.

4 Select the description that does not represent a feature of efficient gas exchange surfaces in mammals:

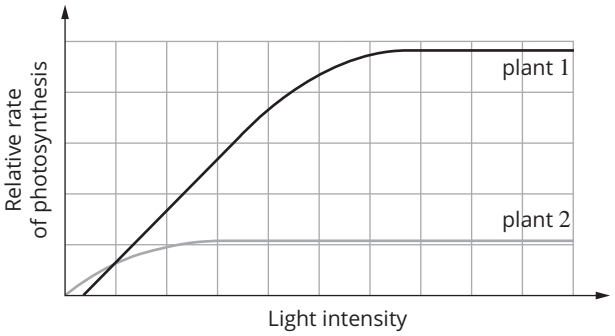
A moist surface

B concentration gradient

C large surface area

D rich blood supply.

5 The graph below shows the rate of photosynthesis in two plants as light intensity increases.



The factor most likely to cause the difference in the rate of photosynthesis between plant 1 and plant 2 is:

A water availability

B oxygen availability

C carbon dioxide availability

D light intensity.

6 Large multicellular plants are characterised by the presence of specialised vascular tissue involved in the transport of materials throughout the plant. This includes the:

A translocation of water up and down the plant through the xylem

B transport of organic compounds produced in photosynthesis in a process called transpiration

C movement of inorganic materials produced in photosynthesis through the phloem

D movement of water in an upward direction from the roots to the shoot system in tissue called xylem.

SAMPLE ASSESSMENT TASK IA1

Data test

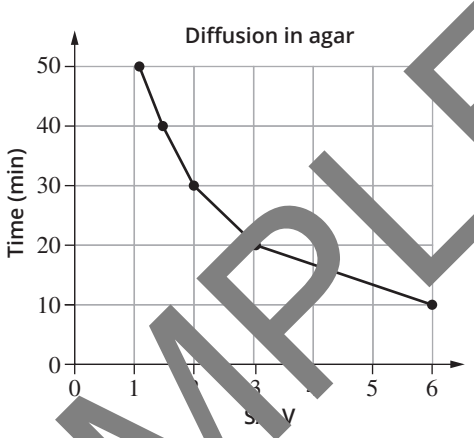
Suggested duration: 10 minutes reading time and 60 minutes to complete the test

Task

The data test requires you to apply a range of cognitions to respond to scientific data. The test will be held in a set timeframe under test conditions.

Dataset 1

Students used five cubes of agar jelly of graduating size, from 1 cm × 1 cm × 1 cm to 5 cm × 5 cm × 5 cm, infused with sodium hydroxide (alkali) and phenolphthalein indicator to investigate the relationship between surface area to volume ratio and the rate of diffusion. When the agar blocks were immersed in dilute hydrochloric acid, the phenolphthalein indicator changed colour from pink (in alkali) to clear (in acid). They used the data to generate a graph of SA : V against time taken for the phenolphthalein to diffuse to the centre of each block.



Item 1: Identify the time taken for a 1 cm^3 block to change from pink clear. (1 mark)

Item 2: Calculate the volume of the block that took 30 minutes to change colour. (3 marks)

Item 3: Calculate the rate of diffusion in mm/min observed in this experiment. (2 marks)

Item 4: Describe the trend between block size and efficiency of diffusion. (2 marks)

SAMPLE ASSESSMENT TASK IA2

Student experiment

Introduction

The student experiment requires you to follow the full scientific method over an extended and defined period of time. You will develop your own research question or hypothesis to investigate, based on an initial practical already completed in class.

The student experiment forms an important component of the assessment in this unit. It is an opportunity to further explore concepts already covered and of particular interest to you, with some latitude for self-direction. You will select a practical activity already undertaken and modify it, using it as the basis from which to launch your own investigation.

The task is estimated to take approximately 10 hours of class time. The time will be divided into Forming (research and planning), Finding (the experiment), Analysing, Interpreting and evaluating, and Preparing your report. Discussion with, and feedback from, your teacher will be an important part of the planning process. A suggested breakdown of the time frame includes:

Forming:	2 hours
Finding:	2 hours
Analysing:	1–2 hours
Interpreting and evaluating:	1–2 hours
Final report:	2–3 hours

Communicating your findings

Your report for this assessment task requires you to demonstrate the research and planning you have undertaken in preparing for the experimental investigation, and then report your findings either in written form, for example, a scientific report (maximum 2000 words) or using a multimodal format (maximum 11 minutes). It will be helpful to prepare your report using specific headings by ensuring clear reference is made to each required element. The following plan has been prepared to guide you through the task. This sample student experiment, focusing on the effects of pH on the activity of the enzyme catalase, provides a template to assist you in completing the task. Some elements of this sample assessment task have been completed for you.

TITLE

FORMING

- **Rationale**—Introduce the investigation by identifying and outlining the original class experiment (e.g. title and page number in SAB), together with its results and a short summary of the concept demonstrated by the experiment. Outline what this modified experiment sets out to investigate, providing a detailed explanation of the theoretical reason why the results are expected to differ.
- **Research question**—Develop and state a specific question that will form the basis for planning the investigation. The question must be relevant to and drawn from the theme of the original experiment.
- **Modifications**—List the key adjustments made to the method that will drive the modified experiment. For example, identify the new independent and dependent variables, any changes in sample size and changes in equipment required. Justify each modification concisely, using logical reasoning (avoid theory).
- **Methodology**—Set out the steps of your method for the modified experiment.

FINDING

- **Experimental data**—Record and display the results (raw data) of your experiment. Think about convenient, informative and concise ways to do this. There are various approaches to displaying experimental data, including tables, graphs, diagrams and photographs. Ensure all relevant raw data is displayed and the pertinent information such as units, titles and labelled axes are included.