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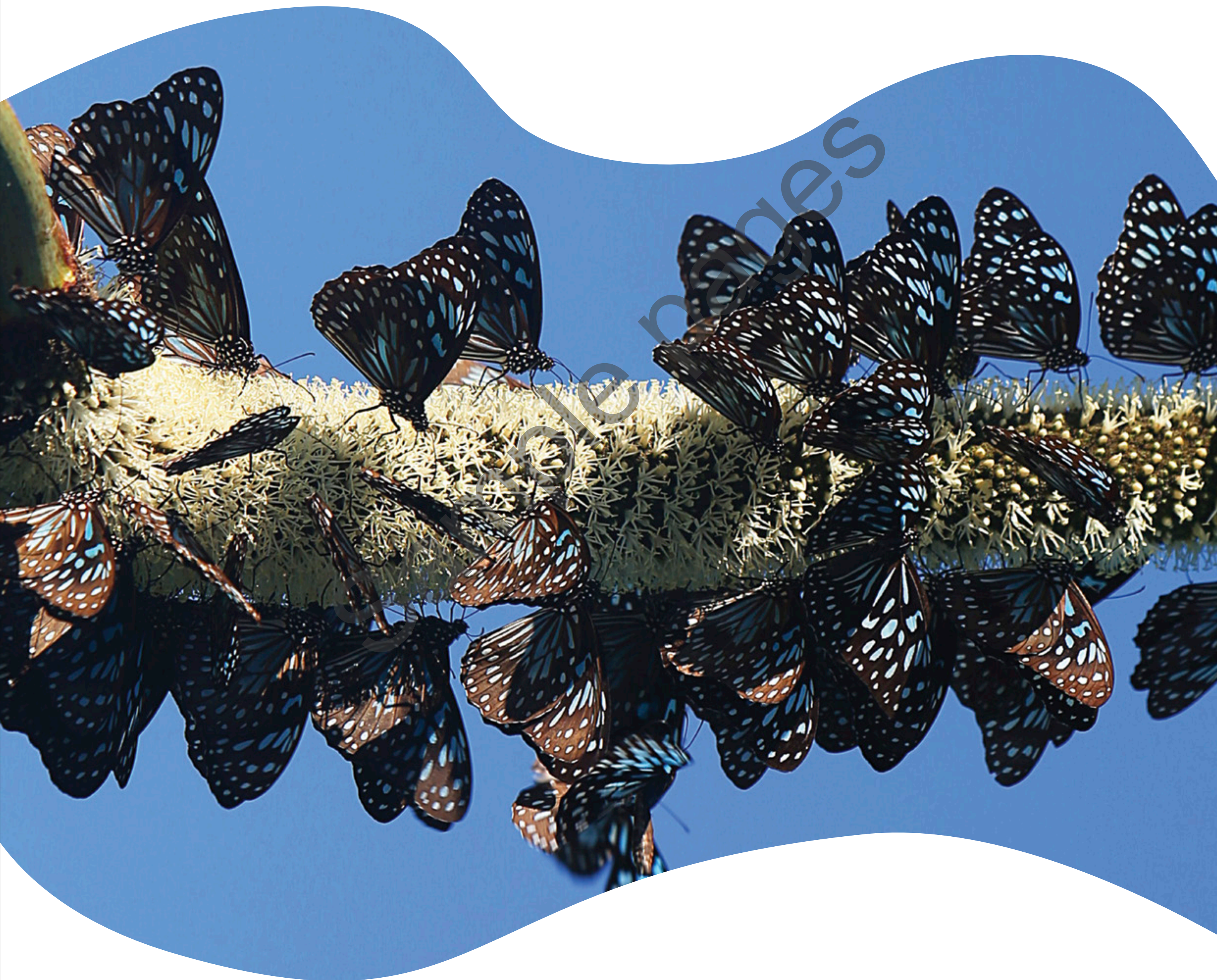
SKILLS AND ASSESSMENT

11

UNITS 1 & 2



Yvonne Sanders

QCE 2019 SYLLABUS

Contents

Pearson Biology 11 QLD Skills and Assessment Book

Contents

UNIT 2: MAINTAINING THE INTERNAL ENVIRONMENT

How to use this book

The *Pearson Biology 11 Queensland Skills and Assessment Book* 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.

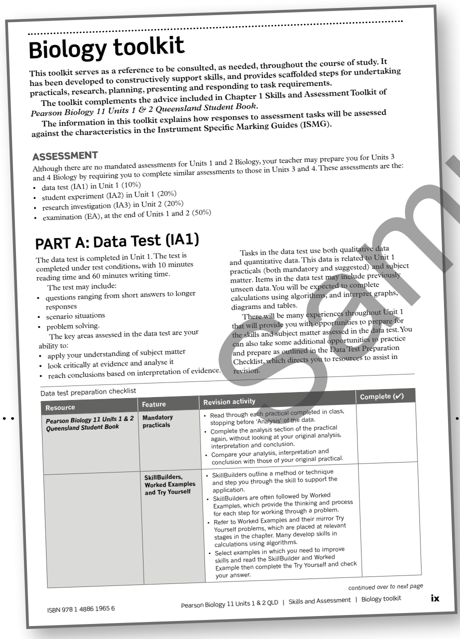
Written to fully support the new QCE Years 11 and 12 syllabus, the *Skills and Assessment Book* is organised by units. The **unit opener** outlines the unit objectives.

The *Skills and Assessment Book* is further organised into topics. Each **topic** addresses all of the subject matter and mandatory 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, as needed, throughout the course of study. 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 11 Units 1 & 2 Queensland Student Book*.

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 subject matter
- 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 Unit 1 practicals (both mandatory and suggested) and subject matter. 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 11 Units 1 & 2 Queensland Student Book	Mandatory practicals	• 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.	

continued over to next page

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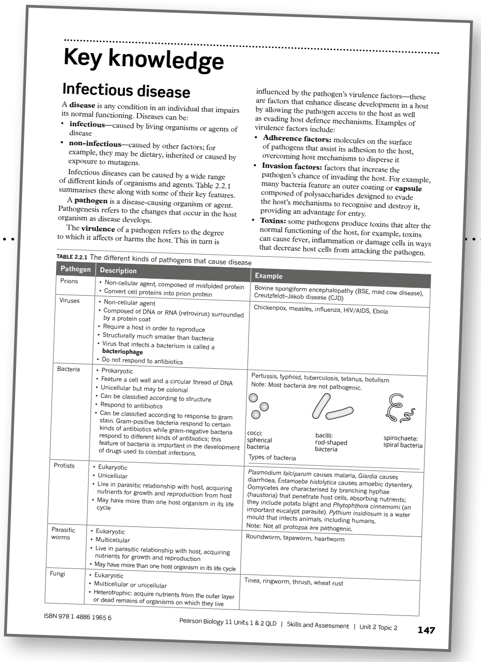
Key knowledge

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 • Composed 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.	Pertussis, typhoid, tuberculosis, tetanus, botulism Note: Most bacteria are not pathogenic. cocci: 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 (haustoria) 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. Note: Not all protozoa are pathogenic.
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	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

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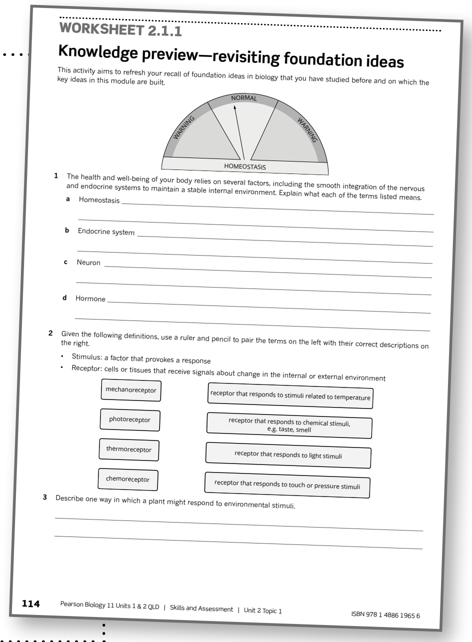
Worksheets

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—revisiting foundation ideas

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.

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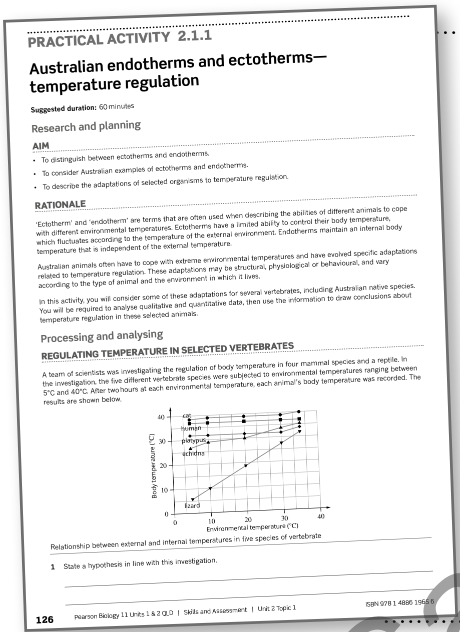
PRACTICAL ACTIVITY 2.1.1

Australian endotherms and ectotherms—temperature regulation

Suggested duration: 60 minutes

Research and planning

AIM

- To distinguish between ectotherms and endotherms.
- To consider Australian examples of ectotherms and endotherms.
- To describe the adaptations of selected organisms to temperature regulation.

RATIONALE

Processing and analysing

REGULATING TEMPERATURE IN SELECTED VERTEBRATES

Relationship between external and internal temperatures in five species of vertebrate

1 State a hypothesis in line with this investigation.

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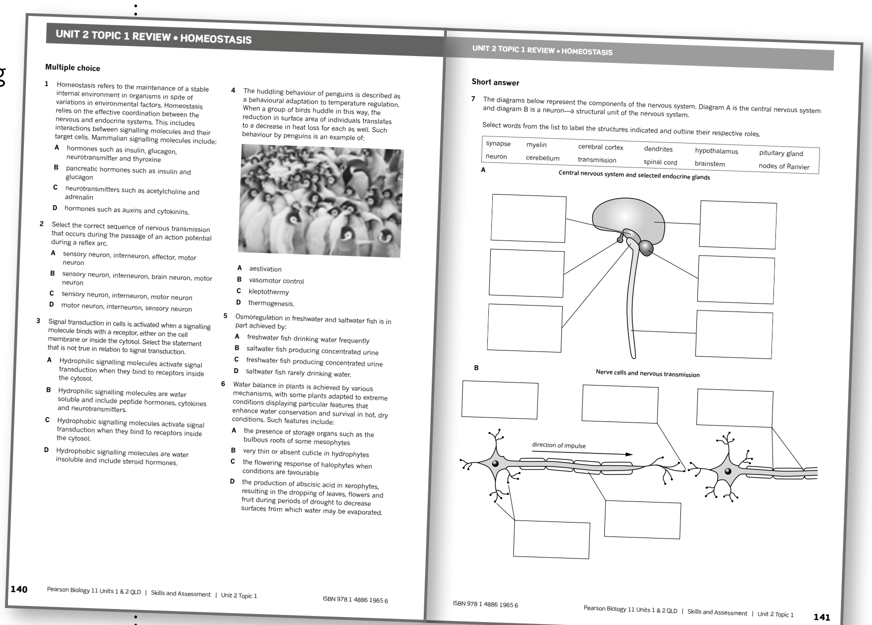
Practical activities

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 mandatory 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 2 TOPIC 1 REVIEW • HOMEOSTASIS

Multiple choice

Short answer

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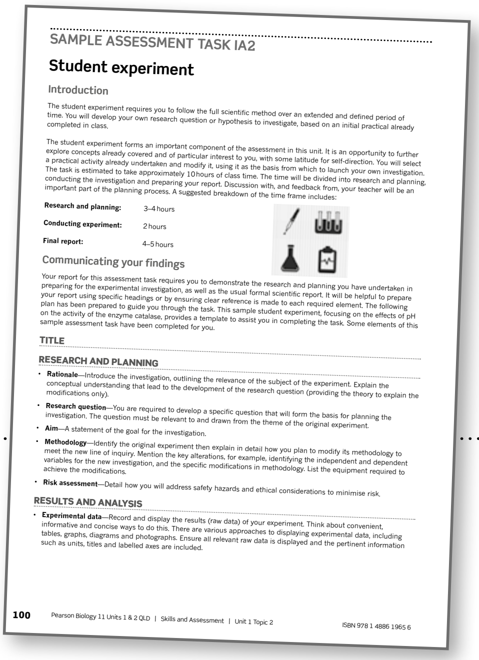
Sample assessment tasks

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 research and planning, conducting the investigation 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:

Research and planning: 3–4 hours

Conducting experiment: 2 hours

Final report: 4–5 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, as well as the usual formal scientific report. 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

RESEARCH AND PLANNING

- **Rationale**—Introduce the investigation, outlining the relevance of the subject of the experiment. Explain the conceptual understanding that lead to the development of the research question (providing the theory to explain the modifications only).
- **Research question**—You are required to develop 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.
- **Aim**—A statement of the goal for the investigation.
- **Methodology**—Identify the original experiment then explain in detail how you plan to modify its methodology to meet the new line of inquiry. Mention the key alterations, for example, identifying the independent and dependent variables for the new investigation, and the specific modifications in methodology. List the equipment required to achieve the modifications.
- **Risk assessment**—Detail how you will address safety hazards and ethical considerations to minimise risk.

RESULTS AND ANALYSIS

- **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 mandatory practical is supported by a complementary SPARKlab alternative practical.

The *Pearson Biology Skills and Assessment Book* icons in the Student Book indicate the best time to engage with an activity from the Skills and Assessment Book. Use the activities for practice, application and revision of subject matter.

The type of activity is indicated by the following icons in the Student Book:

Worksheet (WS)

Topic review (TR)

Mandatory practical (MP)

Practical activity (PA)

Sample Assessment Task (SAT)

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.

Series overview

Student Book

Pearson Biology 11 Units 1 & 2 Queensland has been developed by experienced Queensland teachers to address all the requirements of the new QCE Biology 2019 Syllabus. The series features the latest developments and applications of biology, literacy and instructional design to ensure the content and concepts are fully accessible to all students.

Skills and Assessment Book

The *Skills and Assessment Book* gives students the edge in preparing for all forms of assessment. Specifically prepared to provide opportunities to consolidate, develop and apply subject matter and science inquiry skills, this resource features a toolkit, key knowledge summaries, worksheets, practical activities and guidance, assessment practice and exam-style topic review sets.

Reader+ the next generation eBook

Pearson Reader+ lets you use your Student Book online or offline, anywhere and anytime, on any device. Pearson Reader+ retains the look and integrity of the printed book and includes extras such as videos, interactives and answers.

Teacher Support

Pearson Biology 11 Units 1 & 2 Queensland Teacher Support provides:

- complete answers, fully worked solutions or suggested answers to all Student Book and Skills and Assessment Book tasks
- mandatory practical expected results, common mistakes, suggested answers and full safety notes and risk assessments
- teaching, learning and assessment programs

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TOPIC 1

Cells as the basis of life

- ☐ Worksheet 1.1.1 Knowledge preview—basic biology
- ☐ Worksheet 1.1.2 Poor pot plant—controlled experiments

CELL MEMBRANE

- ☐ Worksheet 1.1.3 Model membranes—structure and function
- ☐ Worksheet 1.1.4 Selective cells—cell membranes and selectivity
- ☐ Practical activity 1.1.1 Partially permeable membranes—diffusion and osmosis
- ☐ Mandatory practical 1 Shaping up—surface area to volume ratio and diffusion

PROKARYOTIC AND EUKARYOTIC CELLS

- ☐ Worksheet 1.1.5 The inside story on cell structure
- ☐ Worksheet 1.1.8 Reciprocal reactions—photosynthesis and cellular respiration
- ☐ Practical activity 1.1.2 Paramount pathways—photosynthesis and cellular respiration
- ☐ Mandatory practical 2 Observing cells—a closer look using the light microscope

INTERNAL MEMBRANES AND ENZYMES

- ☐ Worksheet 1.1.6 Enzyme ABC—amazing biological catalysts
- ☐ Worksheet 1.1.7 Active enzymes—properties of enzymes
- ☐ Mandatory practical 3 Capable catalase—investigating temperature and enzyme efficiency

ENERGY AND METABOLISM

- ☐ Worksheet 1.1.8 Reciprocal reactions—photosynthesis and cellular respiration
- ☐ Practical activity 1.1.2 Paramount pathways—photosynthesis and cellular respiration

- ☐ Worksheet 1.1.9 Literacy review—language to learn from
- ☐ Worksheet 1.1.10 Thinking about my learning
- ☐ **Topic 1 review**

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Key knowledge

Cell structure

CELL THEORY

The **cell theory** is an important theory in the field of biology. The cell theory states that:

- all organisms are made up of cells
- new cells are produced from existing cells (biogenesis)
- the cell is the smallest organisational unit of a living thing.

PROKARYOTIC AND EUKARYOTIC CELLS

Prokaryotic cells are relatively small and less complex than eukaryotic cells. They are unicellular and do not have membrane-bound structures. This means they lack sophisticated internal detail. Bacterial cell walls are typically composed of a carbohydrate–protein material called peptidoglycan (also known as murein).

Although prokaryotic cells lack membrane-bound structures, they are capable of controlling their functions. They can also generate energy. Some can even photosynthesise because they contain photosynthetic pigments.

Prokaryotic cells have a single, coiled chromosome that contains all the DNA (genes) necessary to control and direct all the activities of the cell. There are also specialised regions within prokaryotic cells where cellular respiration can occur.

Prokaryotes are represented by two domains: Bacteria (bacteria and blue-green algae) and Archaea (which includes extremophiles).

Eukaryotic cells are larger and more complex than prokaryotic cells. They have membrane-bound organelles such as a nucleus, mitochondria and lysosomes.

Eukaryotic organisms (domain Eukarya) include the kingdoms:

- Protista—unicellular organisms
- Fungi
- Plantae
- Animalia.

Cell function

MOVEMENT OF MATERIALS IN AND OUT OF CELLS

The **internal environment** of cells is the intracellular fluid—the medium inside cells. The **external environment** of cells is the extracellular fluid—the watery medium surrounding cells.

Cell membrane

The cell membrane (also known as the plasma membrane) controls the entry and exit of substances into and out of cells. It controls which substances leave and enter, when and how much. It responds to instructions from the nucleus. It can detect and respond to external stimuli.

The cell membrane is described as being **semipermeable** (also called partially permeable) because it is permeable to some substances but not others.

The composition of the cell membrane is basically the same as that of all membranes within cells (including the membranes of the nuclear envelope, mitochondria, Golgi apparatus, endoplasmic reticulum, vacuoles, lysosomes and chloroplasts).

The cell membrane consists of a double layer of special lipid molecules called **phospholipids**. This is called the phospholipid bilayer. The bilayer has **protein** and cholesterol molecules scattered through it in a random arrangement. The total structure is fluid. This means that the molecules can move around relative to each other. The structure of the cell membrane is commonly described using the fluid mosaic model.

Carbohydrate molecules linked to membrane proteins are called **glycoproteins**. Carbohydrate molecules associated with membrane lipids are called **glycolipids**. These molecules have various roles, including recognition and regulation.

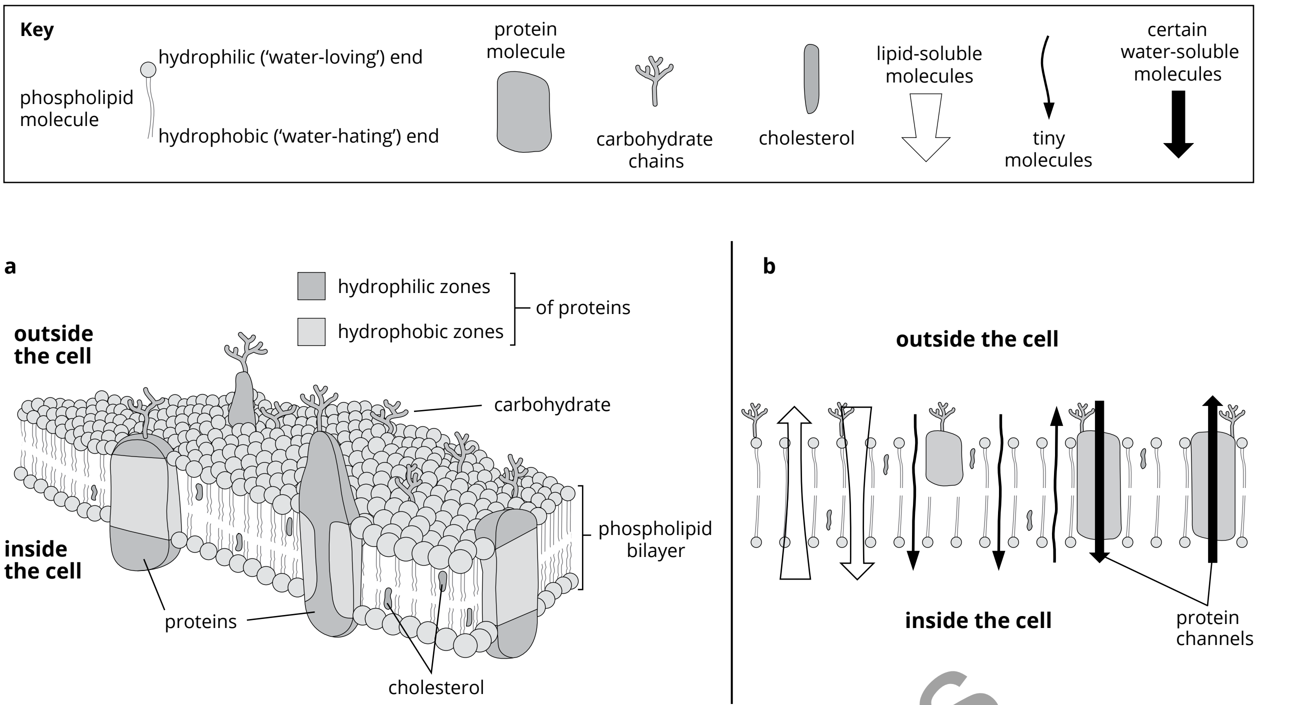

FIGURE 1.1.1 (a) Biological membranes are composed of a phospholipid bilayer with large protein molecules embedded in the bilayer. (b) These proteins provide channels for the passive and active movement of certain molecules across the cell membrane.

In summary, the cell membrane is a flexible, semipermeable barrier between the intracellular and extracellular environments (Figure 1.1.1).

Movement across the cell membrane

Cells maintain relatively stable internal conditions by regulating the passage of materials across cell membranes. The exchange of materials between cells and their external environment occurs through the processes of:

- diffusion
- osmosis
- facilitated diffusion
- active transport.

The process by which substances move across the cell membrane depends on several factors—these include the lipid nature of the cell membrane and the size and polarity of molecules. **Hydrophilic** substances dissolve in water and do not readily pass across phospholipid membranes. **Hydrophobic** substances do not readily dissolve in water—such molecules can dissolve in the phospholipid membrane.

- Lipid-soluble molecules (non-polar), such as chloroform and alcohols, dissolve in the lipid bilayer and pass through.
- Water-soluble molecules tend to be repelled by the phospholipid bilayer. However, very small molecules such as water and urea are small enough to pass directly between the phospholipid molecules.

Table 1.1.1 shows the factors that influence how materials move across the cell membrane.

Other small uncharged molecules, such as oxygen and carbon dioxide, also pass directly across the cell membrane between the phospholipid molecules.

Large water-soluble molecules (polar) such as simple sugars and amino acids cannot pass directly across the hydrophobic cell membrane. The passage of these molecules depends on transport channels that span the cell membrane or on a process called **endocytosis**. Endocytosis occurs when a section of the cell membrane wraps around a substance for import into the cell, pinching off to form a vesicle inside the cytoplasm. **Phagocytosis** is a form of endocytosis. **Pinocytosis** refers to a similar process related to the import of liquid droplets. **Exocytosis** is the opposite of endocytosis and involves vesicles, such as those associated with the Golgi apparatus, merging with the cell membrane to facilitate the export of substances.

Surface area to volume ratio

When substances enter or leave cells, the rate at which they move is determined by a number of factors. These include:

- concentration (a steep concentration gradient causes faster diffusion)
- temperature (higher temperatures increase the rate of movement of molecules)
- surface area to volume ratio (SA : V).

Consider the two cells in Figure 1.1.2. Although cell A has a larger volume, cell B has a larger SA : V. This means it will be more efficient at taking in and exporting substances through its cell membrane per unit time.

Cell size is limited by their SA : V, because it affects a cell's ability to efficiently undergo exchange of nutrients and wastes.

In general, SA : V decreases as the size of the organism increases. Cells and organisms have structural adaptations to overcome this. Such adaptations include microvilli on absorptive cells, and the ribbon-like body shape of tapeworms.

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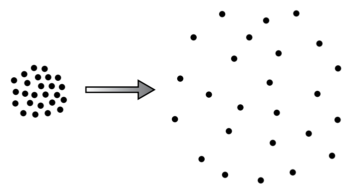
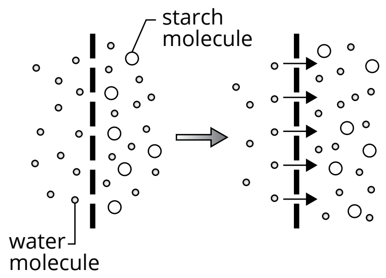
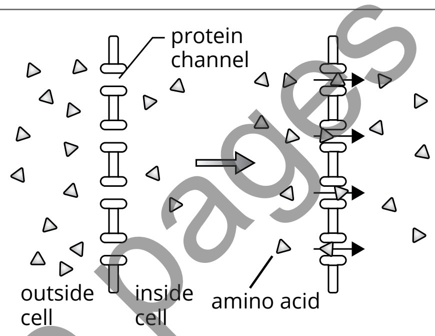
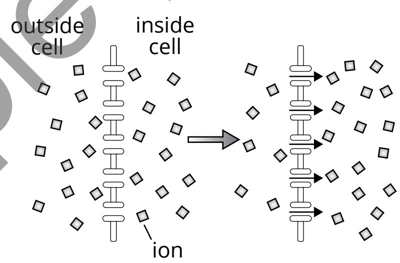
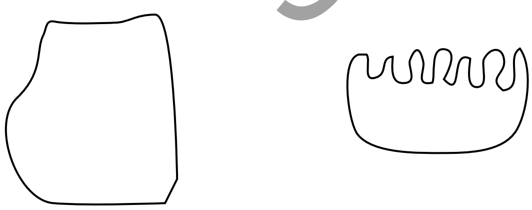
TABLE 1.1.1 Movement across the cell membrane

Process	Description	Active or passive	Diagram	Example in organism
Diffusion	Movement of particles from an area of high concentration to an area of low concentration, along a concentration gradient	Passive (does not require energy)		Oxygen enters body cells (low in O_2 because continually using O_2 in cellular respiration) from the capillaries where it is in high concentration (O_2 replenished at lungs).
Osmosis	Special type of diffusion that involves movement of water molecules across a semipermeable membrane; water moves from an area of high concentration of free water molecules to an area of low concentration of free water molecules, i.e. low solute concentration to high solute concentration	Passive		Cells in the kidney medulla absorb water by osmosis due to the osmotic gradient between ion concentration in tissue fluid and the kidney tubules.
Facilitated diffusion	Movement of particles from high to low concentration through protein channel in cell membrane	Passive		Small molecules such as amino acids and glucose enter cell via protein channel.
Active transport	Movement of particles from an area of relatively low concentration to an area of high concentration, against a concentration gradient	Active (requires input of energy)		Uptake of ions by root hair cells of plants and uptake of nutrients by gut epithelium cells of animals, so that concentration within cells exceeds concentration in external medium.



A B

FIGURE 1.1.2 Two cells (A and B) with a different volume but similar surface area

CELL REQUIREMENTS

The cells of living organisms have similar basic requirements to ensure their survival. These include:

- water—the cytoplasm of cells is largely composed of water; cells also need a watery external environment
- oxygen—for cellular respiration (with the exception of some organisms, such as anaerobic bacteria and the Archaea)
- carbon dioxide for photosynthetic organisms
- inorganic nutrients; for example, minerals
- organic materials; for example, amino acids, fatty acids and glycerol, and carbohydrates
- a source of energy (light or chemical)
- removal of wastes.

Cells also need optimal conditions to maximise their efficiency. These conditions can be different for the cells of different kinds of organisms. For example, the cells of mammals have different temperature requirements from the cells of fish.

All cells need access to nutrients and a means to dispose of wastes. Waste materials include excess water, ions, carbon dioxide and oxygen, as well as nitrogenous substances such as urea (mammals), uric acid (birds and reptiles) and ammonia (fish). Heat is also a by-product of the metabolic activity of cells. The semipermeable membranes of cells allow for this movement of nutrients and wastes.

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In general, the features of cells, including their structure, are related to their function. For example, photosynthetic plant cells contain chloroplasts, the site of photosynthesis. Cell specialisation is considered further in Topic 2 (page 51).

Cells are made of chemicals and require chemicals to function. The main molecule found in cells is water. Some plant cells are more than 90% water. In addition to water, cells consist of both inorganic and organic substances.

Inorganic compounds (including water and ions) are relatively simple and do not contain hydrocarbon groups. **Organic compounds** are relatively complex and contain hydrocarbon groups.

Table 1.1.2 provides a summary of the inorganic and organic compounds that are required by cells.

TABLE 1.1.2 Inorganic and organic compounds required by cells

Substance	Examples	Function(s) in cells
Inorganic compounds		
Water (H_2O)		All chemical reactions in organisms take place in solution in water. Water has high heat capacity.
Oxygen (O_2)		Oxygen is needed for efficient energy supply, achieved by the process of cellular respiration in almost all organisms. It is taken in as a gas by terrestrial organisms and in solution by aquatic ones.
Carbon dioxide (CO_2)		Carbon dioxide is the main source of the carbon atoms for organic molecules, usually starting with carbon fixation by photosynthesis in autotrophs (green plant cells). CO_2 is taken into plant leaves as a gas, is then converted to sugars and eventually returned to the atmosphere in the carbon cycle.
Minerals	Nitrogen (N) Phosphorus (P) Iron (Fe) Magnesium (Mg)	N is used for protein and nucleic acid synthesis. P is used for nucleic acid synthesis and is an important component of cell membranes. Fe is a component of haemoglobin in red blood cells. Mg is a component of chlorophyll.
Organic compounds		
Carbohydrates	Basic building blocks are monosaccharides. Dissaccharides are composed of two simple sugars chemically bonded together. Polysaccharides are complex arrangements of many carbohydrate monomers chemically linked; contain C, H, O, N	Carbohydrates provide an energy source to cells that can be accessed relatively easily.
Lipids	Basic building blocks are glycerol and fatty acids; contain C, H, O	Lipids are used for long-term energy storage and insulation, and are structural components of membranes.
Proteins	Basic building blocks are amino acids; contain C, H, O, N	All enzymes are proteins. Proteins also play important structural roles.
Nucleic acids	In DNA and RNA; contain C, H, O, N, P	DNA carries the genetic code. RNA is involved in transcription and translation of the genetic code.
Vitamins	Vitamin C Vitamin D	Vitamin C prevents scurvy. Vitamin D facilitates uptake of calcium into bones. Bone vitamins have important roles in enzyme function, e.g. as coenzymes.

CELL ORGANELLES

Organelles are distinct structures within cells that perform specific functions. Some organelles are visible by light microscope; others are not. The details of many cell organelles are only visible when using the electron microscope.

Some key organelles are summarised in Figure 1.1.3 and Table 1.1.3.

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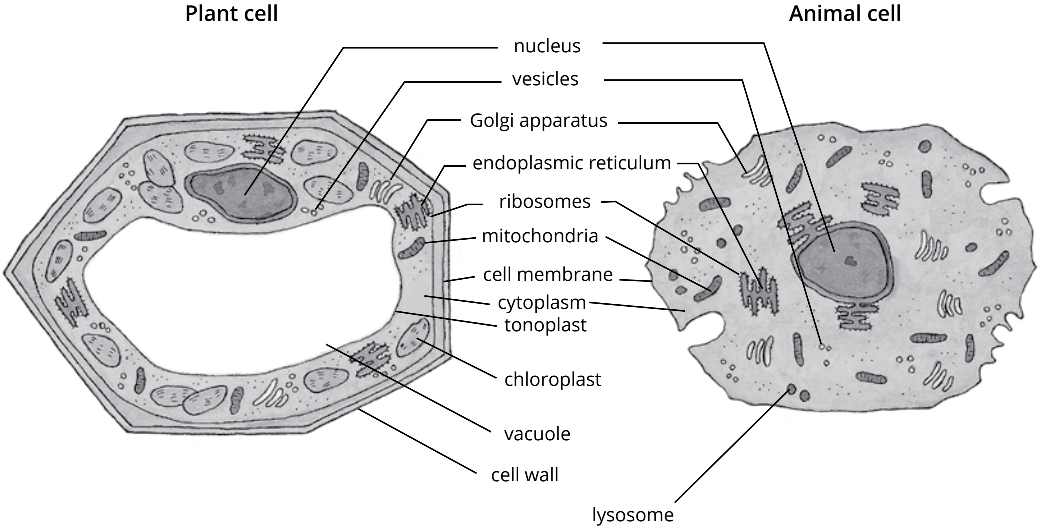

FIGURE 1.1.3 In unicellular and multicellular organisms, many of the functions that are essential to life occur within specialised structures and organelles of individual cells.

TABLE 1.1.3 Cellular organelles and their functions

Organelle	Description and function	Found in both plants and animals
Nucleus	Large spherical organelle; controls cell activities (contains DNA)	Yes
Mitochondrion	Has a folded inner membrane, which is the site of aerobic stages of cellular respiration (contains some DNA); the folded membrane increases the surface area available for enzyme-controlled reactions, thereby maximising the benefit from chemical reactions	Yes
Ribosomes	Tiny spherical organelles; site of protein synthesis (not membrane-bound)	Yes
Endoplasmic reticulum	Network of membranes involved in protein transport within cells; endoplasmic reticulum encrusted with ribosomes is called 'rough' endoplasmic reticulum and is involved in the synthesis of proteins; 'smooth' endoplasmic reticulum synthesises lipids	Yes
Golgi apparatus	Stacks of flattened membranous sacs; modifies and packages substances in preparation for secretion from cell	Yes
Plastid	Small organelle with double membrane; synthesises and stores various organic molecules (contains DNA)	Plant cells only
Chloroplast	Site of photosynthesis (contains chlorophyll)	Plant cells only
Lysosomes	Membrane-bound organelles that produce digestive enzymes; break down complex compounds into simpler molecules; removal of waste	Animals Plants (some evidence)
Vacuoles	Membrane-bound compartments that keep a variety of substances separate from cell contents (large in plant cells, small in animal cells)	Yes
Cilia	Short and hair-like. Generally present in large numbers; rhythmic waves create movement of substances over cell surface, or movement of the cell	Yes
Flagellum	Long and hair-like. Generally singular or present in small numbers; rhythmic contractions enable movement of cell	Yes
Cell wall	Rigid structure surrounding cell; composed of cellulose in plants; limits cell expansion when fully turgid; contributes to structural support of plant	Plant cells only
Cell membrane	Semipermeable, flexible barrier; controls cell inputs and outputs	Yes

ENZYME ACTIVITY IN CELLS

The metabolism of an organism is the sum of all the chemical reactions that occur within its cells. This includes the energy-transforming reactions of cells such as production of organic molecules, and the breakdown, recycling and excretory processes. These biochemical processes are universal—they occur in the cells of all living organisms to ensure the survival of the individual.

Enzymes are biological catalysts—they increase the rate of biochemical reactions in cells; for example, the chemical reactions involved in cellular respiration and photosynthesis.

Properties of enzymes

Enzymes:

- are proteins
- are substrate specific—they only catalyse a chemical reaction involving a particular substrate, or reactant molecule, and not any other. This is due to an enzyme's **active site**, which corresponds to specific substrate molecules. Two theories are used to explain how enzymes interact with their substrates: lock and key, and induced fit (Figure 1.1.4)
- take part in chemical reactions but are not used up or changed by the process. They are released at the end of a reaction and so are available to be used over and over again
- have optimal conditions under which they work most effectively. They will catalyse a reaction so that maximum product is produced per unit of time. For example, the optimal conditions for digestive enzymes in the human duodenum is 37°C and pH 8
- are sensitive to factors such as temperature and pH. When these conditions are not optimal, the activity of enzymes is reduced. Extremes of such factors may lead to enzymes becoming **denatured**; when this happens the enzyme cannot recover its function because the shape of its active site has been permanently altered (Figure 1.1.5).

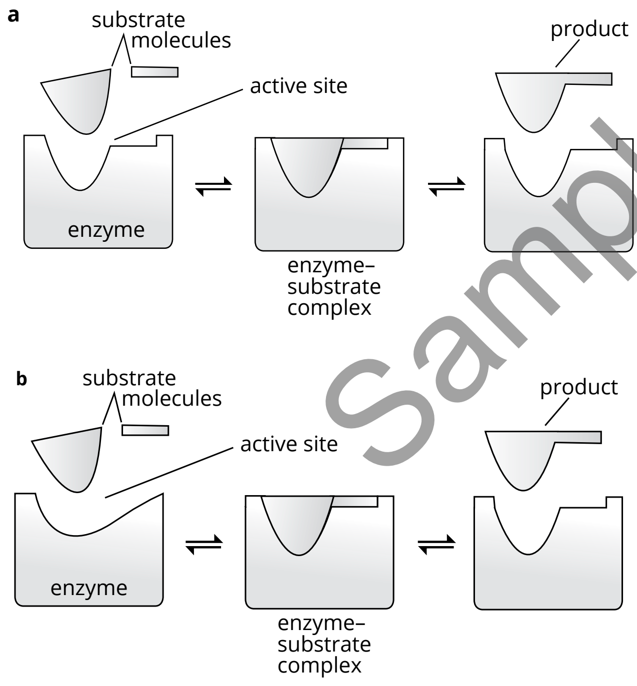

FIGURE 1.1.4 A model of enzyme (a) lock and key and (b) induced fit operation

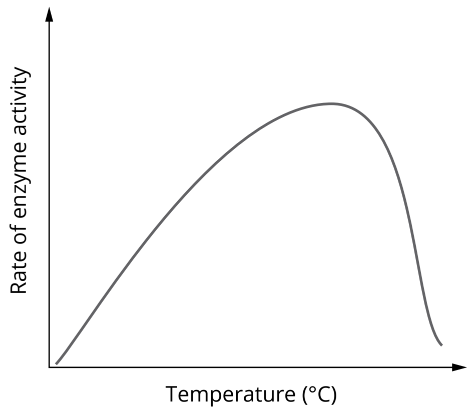

FIGURE 1.1.5 The rate of enzyme activity continues to increase with increasing temperature. Extreme temperatures denature enzymes and activity ceases.

Enzymes are often denoted by the suffix 'ase'; for example, maltase, lactase, protease, amylase and lipase.

The rate of enzyme activity also depends on the:

- concentration of substrate—the higher the concentration of the substrate, the greater the rate of interaction between substrate molecules and enzymes, leading to increased rate of reaction
- concentration of enzyme—the more enzyme available to catalyse a reaction, the more rapidly the reaction will proceed until all enzyme molecules are fully engaged in the reaction (Figure 1.1.6).

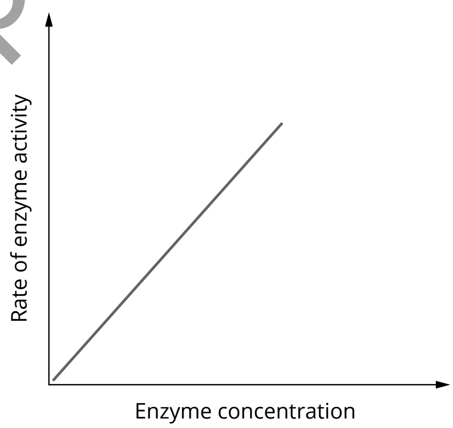

FIGURE 1.1.6 The rate of enzyme activity increases with increasing enzyme concentration.

Activation energy is the energy required to initiate a reaction; even catabolic reactions require an initial input of energy to start the reaction. Enzymes lower the activation energy, making it easier for the reaction to proceed.

Coenzymes are small organic molecules such as vitamins that are important to the normal functioning of enzymes.

Cofactors are inorganic ions, such as Mg^{2+}, that are important to the normal functioning of enzymes.

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Enzyme inhibition

The action of enzymes is also influenced by the presence of chemical competitors at the active site. Competitors inhibit enzyme action by binding to the active site of enzymes. This may be reversible or irreversible.

Irreversible inhibition occurs when molecules form strong, permanent bonds with the active site of enzymes. Penicillin is an irreversible enzyme inhibitor of an enzyme involved in construction of bacterial cell walls, which makes pathogenic bacteria unable to survive. Hence, penicillin is used in medicine as an antibiotic.

Reversible inhibition occurs when molecules form weak, non-permanent bonds with the active site of enzymes. Reversible enzyme inhibition has an important regulatory role in cells. Inhibitors are in place when enzymes are not required and dissociate from the enzyme when the enzyme product is needed.

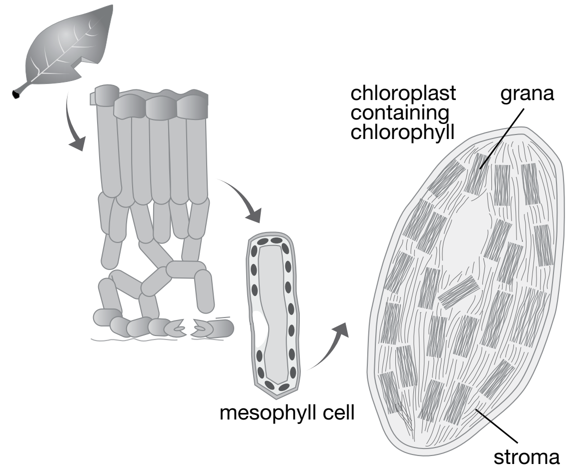

FIGURE 1.1.7 Leaves, and some stems, are green because the mesophyll cells contain many chloroplasts, the organelles in which photosynthesis takes place.

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. Metabolism can be divided up into two main types of processes:

- **endergonic** processes that require a net input or use of energy
- **exergonic** processes that result in a net output or release of energy.

Processes in which energy is changed 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.

Photosynthesis

Photosynthesis involves a series of enzyme-controlled reactions that occur in the chloroplasts of plant cells (Figure 1.1.7). It requires light and involves the conversion of light energy into chemical energy.

A word equation for photosynthesis is:

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

The balanced chemical equation for photosynthesis is:

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

Organisms that produce their own organic compounds are called **autotrophs**. Autotrophs can be photosynthetic (plants) (Figure 1.1.8) or chemosynthetic (some prokaryotes). Organisms such as fungi and animals that obtain their organic compounds from other organisms are called **heterotrophs**.

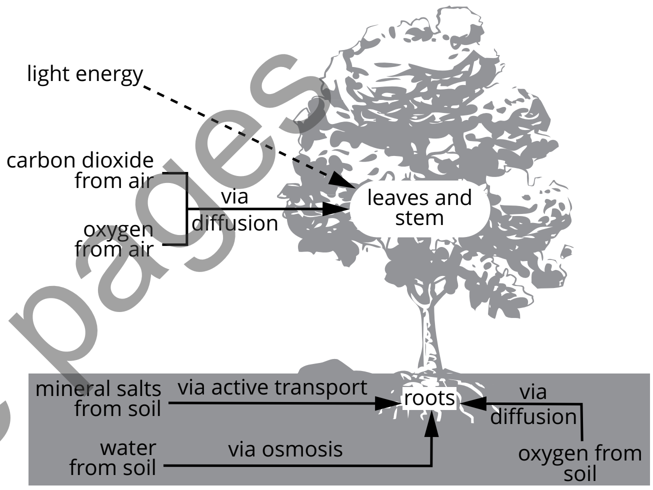

FIGURE 1.1.8 An overview of how plants obtain nutrients

Photosynthesis occurs in two stages: the **light-dependent stage** occurs in grana; the **light-independent stage** occurs in the stroma (summarised in Table 1.1.4). 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 1.1.4 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

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. The useable energy of ATP is contained in the phosphate bonds of the molecule. The cycling of ATP and ADP (adenosine diphosphate) means that energy continues to be available for use in the cell (Figure 1.1.9).

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:

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

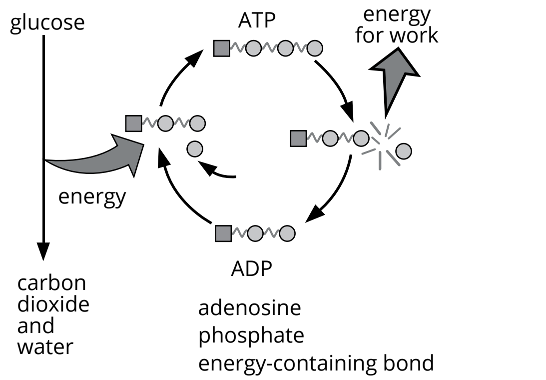

FIGURE 1.1.9 The ATP–ADP cycle

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 1.1.10).

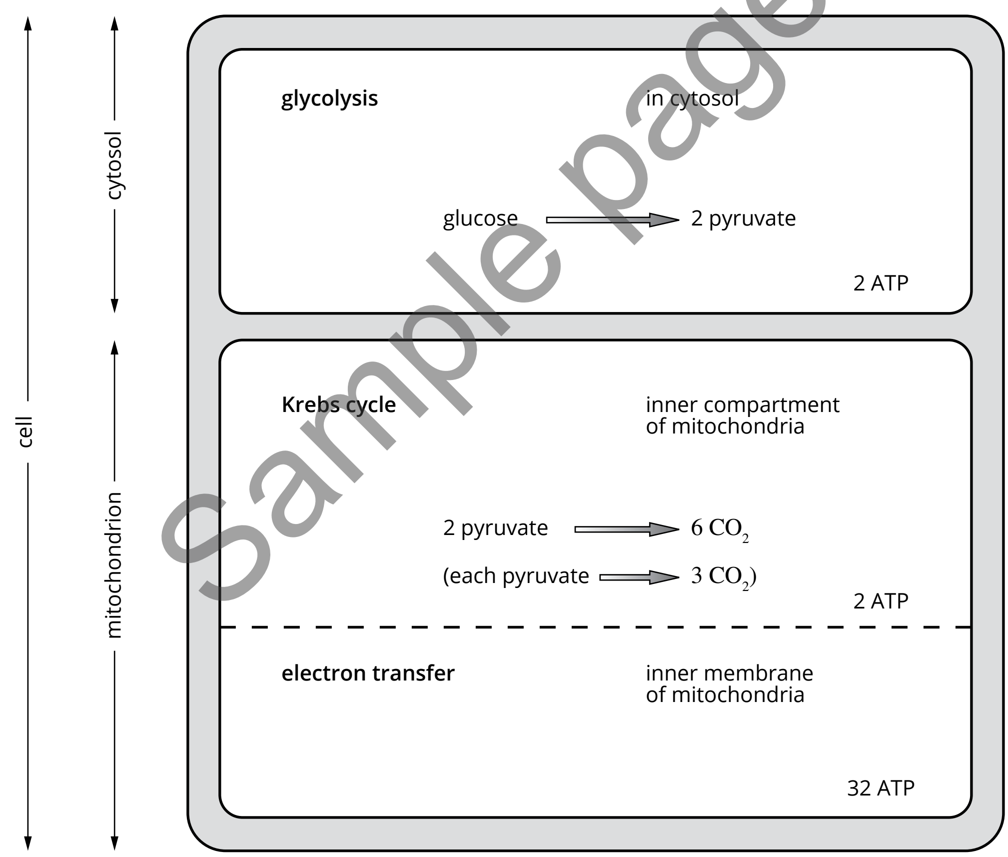

FIGURE 1.1.10 The stages of cellular respiration and associated ATP production

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**.

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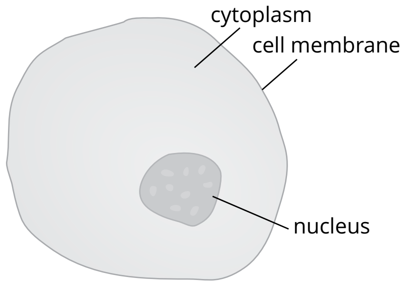
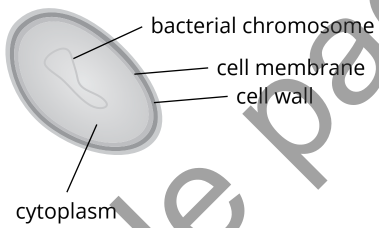
WORKSHEET 1.1.1

Knowledge preview—basic biology

The instructions below address foundation ideas in biology that you have studied before and on which the key ideas in this first topic are built. Follow the instructions to complete these introductory summaries. Remember to be resourceful, referring to text material or class notes as needed.

	Instruction	Response	
1	Draw and label a typical plant cell to show the basic similarities and differences as compared to the typical animal cell shown.	Animal cell 	Plant cell
2	The prefix *pro* comes from the Greek word for 'before' and also translates as 'early' or 'primitive'. The prefix *eu* comes from the Greek word for 'true'. The word *karyon* is Greek for 'nut' and is used to describe the shape of the nucleus in certain cells. Use this information to complete the description of eukaryotic organisms and how they compare to prokaryotic organisms already described. Include a labelled diagram.	Prokaryotic organisms have cells that are characterised by the lack of a distinct, membrane-bound nucleus. Bacteria are prokaryotic organisms. 	Eukaryotic organisms
3	All organisms have specific nutritional requirements that must be met so they can survive. Consider the list of requirements shown for animals, then recall and complete the list for typical plants.	Animal requirements: • oxygen (for cellular respiration) • water • carbohydrates • proteins • lipids • vitamins • minerals	Plant requirements:
4	Cellular respiration and photosynthesis are biochemical processes that result in specific energy transformations in different kinds of organisms. These processes are critical to the survival of the organisms in which they occur. **a** Define each process. Identify the raw materials for each and the substances produced.	Cellular respiration	Photosynthesis
	b Look carefully at the information for each process. Summarise the pattern or relationship you notice between these two processes.		

WORKSHEET 1.1.2

Poor pot plant—controlled experiments

A biology student designed and conducted the following experiment to test a hypothesis. Read the student's experimental procedure and cast a critical eye over the results obtained.

Purpose

To investigate the effect of sunlight on green plants.

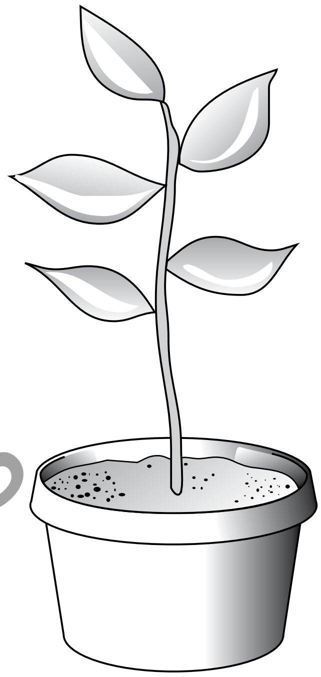
Hypothesis

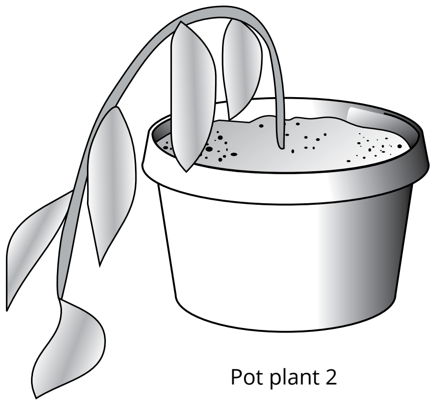
Green plants need sunlight to survive.

Procedure

The student:

- obtained two seedlings of the same species that were the same in other respects, including size, height and weight
- labelled two same-size pots 'Pot plant 1' and 'Pot plant 2'
- potted the seedlings using a commercial potting mix, but ran out of potting mix for pot plant 2 and topped it up with some soil from the school garden
- gave both plants 100 mL of water
- placed pot plant 1 on the windowsill with plenty of exposure to sunlight and pot plant 2 in a dark cupboard below the sill to ensure it had no access to sunlight.


Pot plant 1


Pot plant 2

The student watered pot plant 1 on the windowsill every two days for a period of two weeks but forgot about pot plant 2, which was out of sight in the cupboard. At the end of the two-week period, pot plant 1 was thriving but pot plant 2 was dead.

The student wrote the following conclusion:

Pot plant 2 was not exposed to sunlight and it died. The plant must have died due to lack of sunlight. The hypothesis that 'green plants need sunlight to survive' is supported by the results of the experiment.

1 Identify the pot plant that represented the control in this experiment. Explain your choice.

2 **a** State how many variables the student included in the experiment. Name the variables.

b Recall how many factors should be varied in an experiment. Identify the variable in this instance.

3 Explain whether the student's conclusions are accurate or not.

4 Outline the conclusions that could be drawn from the student's experiment.

5 **a** Describe the changes you would make to ensure this is a properly controlled experiment.

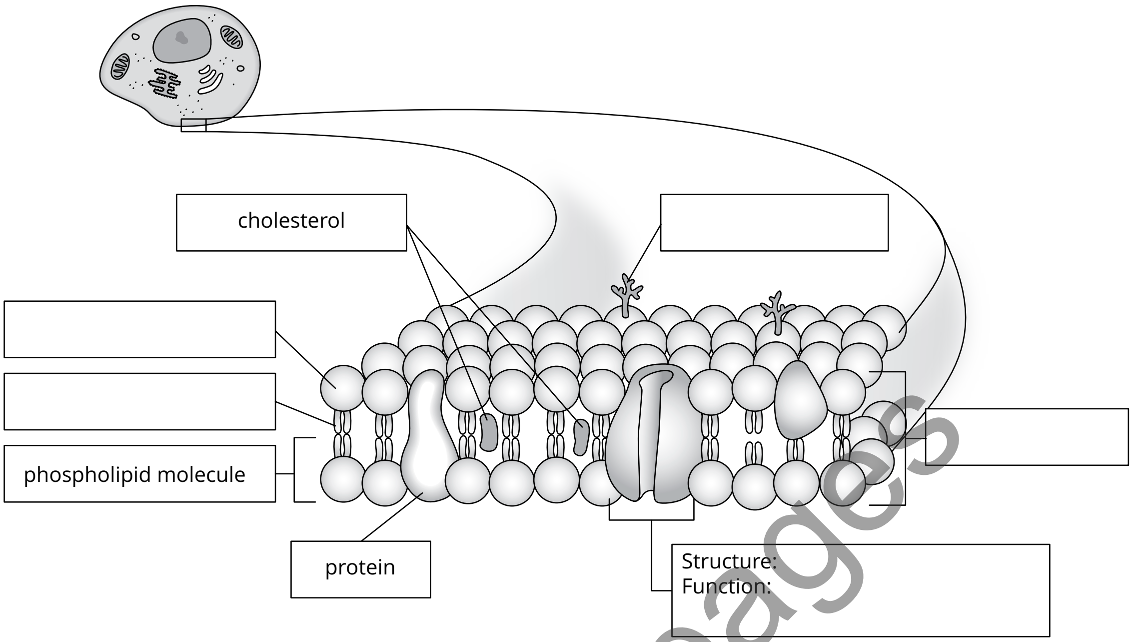
b Summarise the results you would expect and the conclusions you could draw in light of the changes you would make.

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 1.1.3

Model membranes—structure and function

1 The composition of the cell membrane is commonly described using the fluid mosaic model. Complete the diagram by adding labels and functions where indicated.



2 Recognise the features of cell membranes that have led to their description as 'fluid mosaic'.

____

____

____

3 Describe the role of the following molecules in cell membranes.

a Cholesterol ____

____

____

b Carbohydrate ____

____

____

4 Explain the link between the terms 'hydrophilic' and 'hydrophobic' in relation to the orientation of phospholipid molecules in cell membranes.

____

____

____

____

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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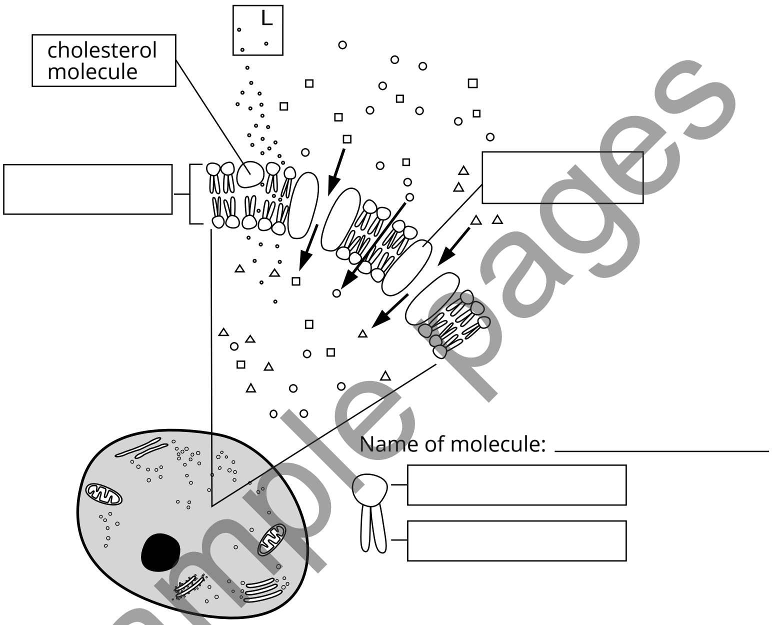
WORKSHEET 1.1.4

Selective cells—cell membranes and selectivity

Cell membranes act as the 'border guards' of cells, selectively determining which molecules enter and leave. As a result, cell membranes are described as selectively permeable or semipermeable. The uptake of molecules by cells depends on several factors, including the concentration of those molecules on either side of the cell membrane. The route taken by different kinds of molecules as they enter and leave cells depends on the type of molecule and whether it is soluble in the phospholipid bilayer of the membrane. Some very small molecules cross the cell membrane by passing between the lipid molecules within the membrane. Larger water-soluble molecules make their way through protein channels embedded across the phospholipid bilayer. Other molecules are actively taken up by cells through the protein channels against a concentration gradient. Others simply dissolve into the lipid of the cell membrane to enter cells.

Look carefully at the illustration of the cell membrane and the different kinds of molecules represented, as well as their respective concentrations inside and outside of the cell.



1 Decide on the process by which each substance enters the cell, giving reasons for your choice. Write your answers in the spaces provided.

○ Water molecules →
Process of movement across membrane: ____________
Reasoning: ____________
____

□ Simple sugars →
Process of movement across membrane: ____________
Reasoning: ____________
____

△ Ions →
Process of movement across membrane: ____________
Reasoning: ____________
____

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2 Molecule L enters the cell by dissolving into the lipid bilayer.

a Describe the kinds of molecules represented by L.

b Name two different kinds of molecules that enter or leave cells in this way.

3 The cell membrane is composed of different kinds of molecules. Recall and label the various parts of the cell membrane indicated, providing information as directed.

4 **a** Compare and contrast the processes of diffusion and osmosis.

b Compare and contrast the processes of facilitated diffusion and active transport.

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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PRACTICAL ACTIVITY 1.1.1

Partially permeable membranes—diffusion and osmosis

Suggested duration: Part A—50 minutes
Part B—50 minutes

Research and planning

AIM

To investigate the movement of particles in solution across a semipermeable membrane.

RATIONALE

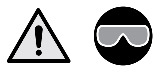
In this activity, you will use a simulation to investigate factors that influence the movement of particles across partially permeable (semipermeable) membranes. Dialysis tubing is used to represent cell membranes. The following simple tests will assist you in determining the presence of particles inside and outside of the tubing during the experiment, and therefore to make inferences about the movement of particles and the properties of semipermeable membranes.

To test for the presence of starch, add a few drops of iodine–potassium iodide solution to the test solution. If starch is present, the solution will change to a blue-black colour.

To test for the presence of glucose, dip a Clinistix™ into the test solution. If glucose is present, the Clinistix will change from pink to purple.

MATERIALS

- dialysis tubing
- iodine–potassium iodide
- Clinistix
- 5% starch solution
- glucose solution
- thistle funnel
- 2 gas jars
- retort stand and clamp
- test-tubes
- test-tube rack
- rubber bands
- 50 mL beaker



Part A Presenting partial permeability

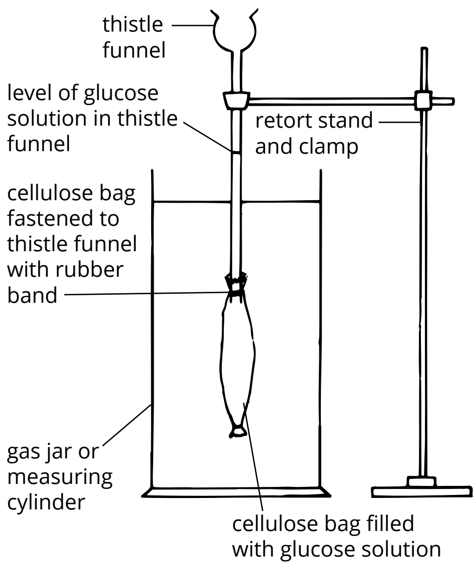
METHOD

1. Pour glucose solution into a 50 mL beaker to a depth of about 1 cm. Dip in the coloured tab of a Clinistix. Describe your observations in question 1.

2. Fill a gas jar with water until it is about three-quarters full. Test the water in the same way with a new Clinistix. Note your result in question 2.

3. Set up the equipment as shown.

   Set up the retort stand to support the thistle funnel first. Then secure the dialysis tubing. Moistening the dialysis tubing will help to open the ends. Tie one end firmly closed with a rubber band. Tie the other end so that it is securely fastened to the thistle funnel. Gently pour glucose solution into the thistle funnel until the level rises about 2 cm up the stem of the funnel. Place the gas jar beneath the thistle funnel. Use the clamp to lower the dialysis tubing completely into the water solution. Leave the set-up undisturbed for 30 minutes (longer if possible). Answer question 3.



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Results and analysis

1 Describe your observations after step 1 of the procedure for the Clinistix dipped in the glucose solution.

2 a Note the result from step 2 of the procedure. Describe the Clinistix colour for the water in the gas jar.

b Explain why you have tested the water in the gas jar with the Clinistix.

3 a Describe your observations for the Clinistix in the gas jar solution after 30 minutes.

b Explain what has happened.

Part B Modelling osmosis

PROCEDURE

1 Pour starch solution into a test-tube to a depth of about 1 cm. Add a few drops of iodine–potassium iodide solution. Describe any colour change that occurs in question 1.

2 Fill the second gas jar with water until it is about three-quarters full. Add several drops of iodine–potassium iodide solution. Answer question 2.

3 Prepare the set-up in the same way as you did for Part A, except that this time you will pour starch solution into the thistle funnel/dialysis tubing. Place the gas jar beneath the thistle funnel. Lower the dialysis tubing completely into the water and iodine–potassium iodide solution. Leave the set-up undisturbed for 30 minutes (longer if possible).

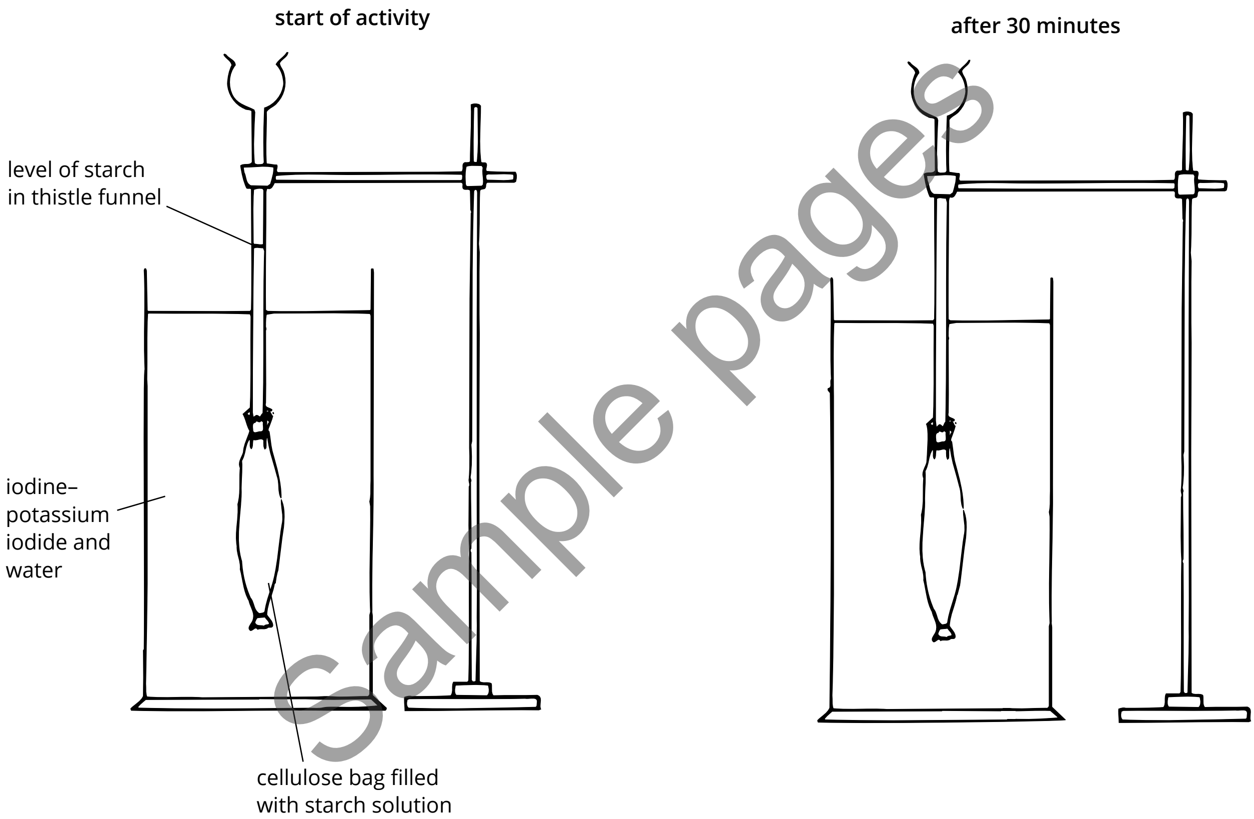
Results and analysis

1 Describe any colour change that occurs when iodine is added to the starch.

2 **a** Describe the colour of the solution in the gas jar.

b Outline what the colour of the solution indicates about the presence of starch.

3 Use coloured pencils to colour and label the figures to reflect your observations at the start of the activity and again after 30 minutes.



4 Describe any changes you observe.

5 Account for the colour changes you have observed. Where did the molecules of water, iodine–potassium iodide and starch begin and where did they move to?

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Interpreting and communicating

CONCLUSIONS

In this activity, you considered evidence that indicates some kinds of molecules move across semipermeable membranes while others do not.

1 Write the definitions for:

a osmosis

b diffusion

2 Explain why certain molecules pass through semipermeable membranes while others do not. Use specific examples.

EVALUATION

3 a Describe two limitations encountered during this investigation and outline how each may have impacted on the experiment.

b Suggest improvements to reduce or eliminate these limitations in subsequent experiments.

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.

MANDATORY PRACTICAL 1

Shaping up—surface area to volume ratio and diffusion

Suggested duration: 50 minutes

Research and planning

INTRODUCTION

Sea lettuce (*Ulva lactuca*) is a green marine alga that looks like lettuce. It grows abundantly on sheltered rocky coasts. Its structure is very simple—it consists of just two layers of cells. When the algae is submerged in water at high tide, raw materials enter the cells directly, and wastes leave the cells and diffuse into the surrounding water.

If a small piece of raw liver is put on the bottom of a freshwater pond, it will soon attract a number of small khaki-grey planarians, commonly called flatworms. Like *Ulva*, these worms are very thin and flat. They have few internal organs. Gas exchange occurs directly across the body surface.

Both of these aquatic organisms depend on their shape to obtain requirements and remove wastes efficiently. Very few terrestrial organisms have this 'flattened' appearance (see figure at right).

MATERIALS

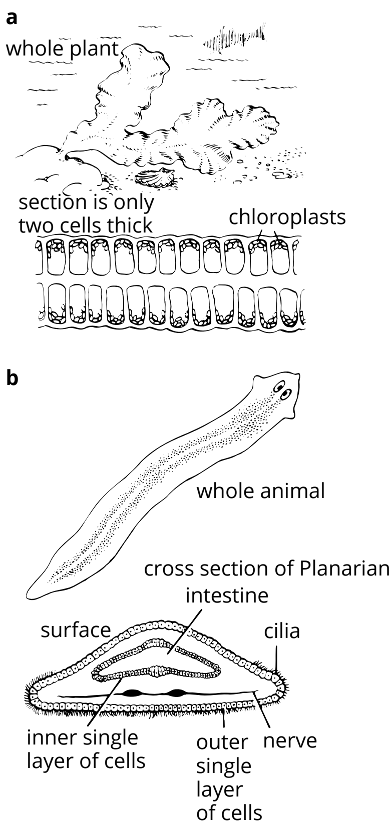
- prepared sheets of agar–phenolphthalein jelly
  - 20 mm thick
  - 10 mm thick
  - 5 mm thick
- 0.1 M sulfuric acid (class supply)
- 250 mL beaker
- plastic teaspoon
- scalpel
- clear plastic ruler
- tile or large petri dish lid
- strip of paper towel
- disposable gloves
- calculator

AIM

To investigate the relationship between the surface area to volume ratio and the diffusion rates of materials.

RATIONALE

In this activity, you will use a simulation to investigate the effect of surface area to volume ratio on the diffusion of substances and consider the importance of this on the efficient exchange of materials for organisms. The shapes of organisms will be simulated by blocks of agar jelly. The jelly is a pink colour due to the presence of sodium hydroxide (an alkali) and phenolphthalein indicator. Phenolphthalein is colourless in acid. When the blocks are placed in an acid solution, the acid diffuses into the jelly, causing a colour change from pink to clear. The time taken for a block to totally decolourise is a measure of the rate of diffusion of acid into the jelly.



(a) Sea lettuce (*Ulva lactuca*) and (b) a planarian, commonly called a flatworm

METHOD

1 Put on the disposable gloves, then accurately measure and cut a 20 mm × 20 mm block of jelly from each of the sheets provided, i.e. 20 mm, 10 mm and 5 mm thick sheets.

2 Half-fill a 250 mL beaker with sulfuric acid from the class stock.

3 Add the blocks of jelly to the acid. Watch until the first block becomes completely clear. In the results table, write '1st' in red pen in the top of the column for the block that became clear first.

4 Immediately remove all of the blocks from the acid, using the spoon. Quickly pat the blocks dry with paper towel. Cut them in half with the scalpel and measure, in mm, the depth of the clear layer in each block. Record the depth of the clear layer in each block; that is, the depth to which the acid has penetrated each block.

5 Dispose of the acid and the jelly blocks as directed by your teacher.

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Results

1 a Identify the independent variable in this experiment.

b Identify the dependent variable in this experiment.

2 a Calculate the surface area for each block of jelly and enter the data into the table.

b Calculate the volume of each block. Enter the data into the table.

c Use a calculator to find the surface area to volume ratio for each of the blocks. Enter the data into the table.

Block number	1	2	3
Block dimensions (cm)	2 × 2 × 2	2 × 2 × 1	2 × 2 × 0.5
Diagram			
Depth of clear layer of block (mm)			
Surface area (SA, cm^2)			
Volume (V, cm^3)			
Surface area to volume ratio (SA : V)	: 1	: 1	: 1

Analysis

3 Explain what has caused the blocks to become clear. Include a discussion of both substances and processes.

4 a Identify the first block to become completely clear.

b From your observations of the other two blocks, predict which would be the next to become clear. Explain why you think so.

5 a Name the block that has the largest surface area (SA).

b Name the block that has the largest volume (V).

c Name the block that has the largest surface area in proportion to its volume (i.e. surface area to volume ratio or SA : V).

6 Describe what happens to the SA : V ratio of a block as its size gets smaller.

Interpreting and communicating

CONCLUSIONS

7 Describe the relationship between the size and shape of a block and the rate at which acid diffuses into it.

8 Given that cells need to obtain all the materials required for life from the surrounding environment and remove wastes to the surrounding environment, suggest why cells are usually microscopic in size.

EVALUATION

9 **a** Describe two limitations encountered during this investigation and outline how each may have impacted on the experiment.

b Suggest improvements to the method that would help to reduce or eliminate these limitations next time.

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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