Contents

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Module 3: Biological diversity

Module 4: Ecosystem dynamics

How to use this book

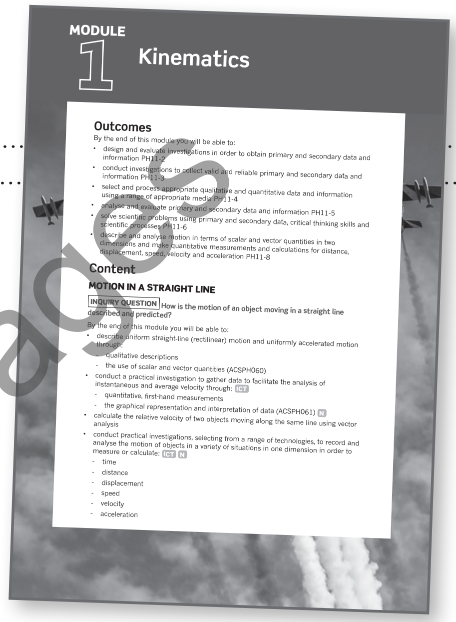
The *Pearson Biology 11 New South Wales* Skills and Assessment Book takes an intuitive, self-paced approach to science education that ensures every student has opportunities to practise, apply and extend their learning through a range of supportive and challenging activities. While offering opportunities for reinforcement of key concepts, knowledge and skills, these activities enable flexibility in the approach to teaching and learning.

Explicit scaffolding makes learning objectives clear, and there are regular opportunities for student reflection and self-evaluation at the end of individual activities throughout the book. Students are also guided in self-reflection at the end of each module. There are rich opportunities to take the content further with the explicit coverage of Working scientifically skills and key knowledge in the depth studies.

This resource has been written to the new New South Wales Biology Stage 6 Syllabus and addresses the first four modules of the syllabus. Each module consists of five main sections:

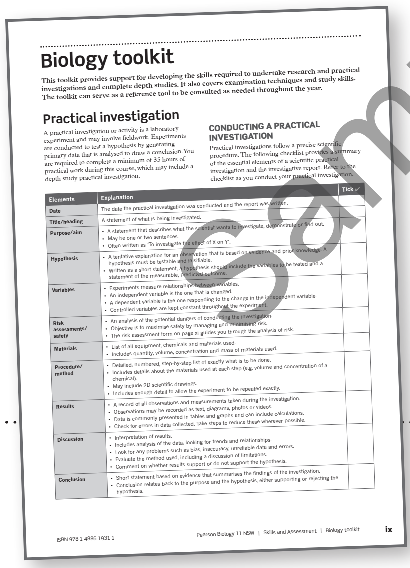
- key knowledge
- worksheets
- practical activities
- depth study
- module review questions.

Explore how to use this book below.



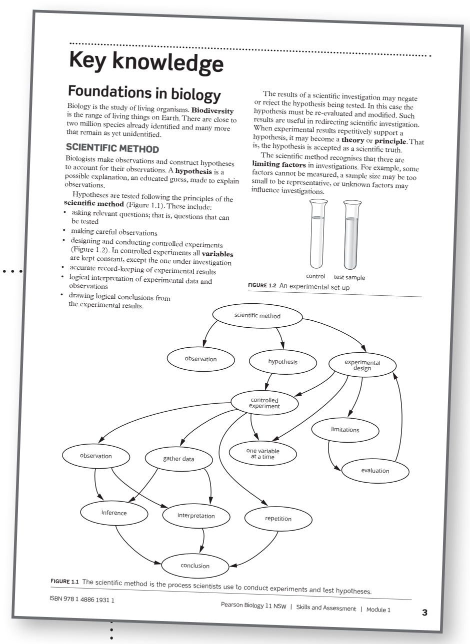
Biology toolkit

The Biology toolkit supports development of the skills and techniques needed to undertake practical investigations, secondary-sourced investigations and depth studies, and covers examination techniques and study skills. It also includes checklists, models, exemplars and scaffolded steps. The toolkit can serve as a reference tool, to be consulted as needed.



Module opener

Each book is divided to follow the four modules of the syllabus, with the module opener linking the module content to the syllabus.



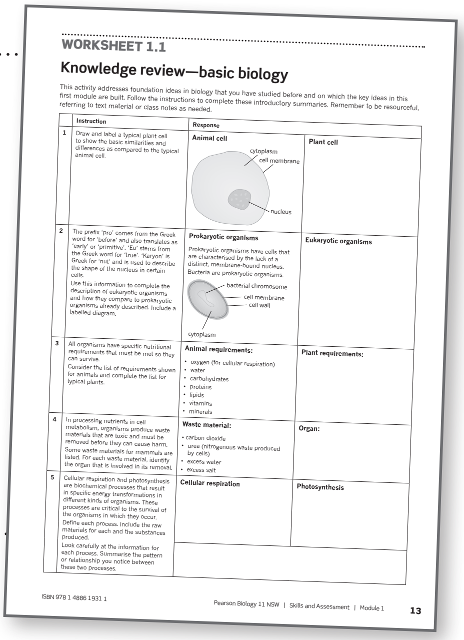
Key knowledge

Each module begins with a key knowledge section. This consists of a set of succinct summary notes that cover the key knowledge set out in each module of the syllabus. This section is highly illustrative and written in a straightforward style to assist students of all reading abilities. Key terms are in bold for ease of navigation. It also serves as a ready reference for completing the worksheets and practical activities.

Worksheets

A diverse offering of instructive and self-contained worksheets is included in each module. Common to all modules are the initial 'Knowledge review' worksheet to activate prior knowledge, a 'Literacy review' worksheet to explicitly build understanding and application of scientific terminology, and finally a 'Thinking about my learning' worksheet, which students can use for reflection and self-assessment. Other worksheet types provide opportunities to revise, consolidate and further student understanding.

All worksheets function as formative assessment and are clearly aligned to the syllabus. A range of questions building from foundation to challenging are included within the worksheets.



WORKSHEET 1.1

Knowledge review—basic biology

This activity addresses foundation ideas in biology that you have studied before and on which the key ideas in this first module 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.	**Animal cell** (cytoplasm, cell membrane, nucleus)	**Plant cell**
2	The prefix 'pro' comes from the Greek word for 'before' and also translates as 'early' or 'primitive'. 'Eu' stems from the Greek word for 'true'. '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** Prokaryotic organisms have cells that are characterised by the lack of a distinct, membrane-bound nucleus. Bacteria are prokaryotic organisms. (bacterial chromosome, cell membrane, cell wall, cytoplasm)	**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 and complete the list for typical plants.	**Animal requirements:** • oxygen (for cellular respiration) • water • carbohydrates • proteins • lipids • vitamins • minerals	**Plant requirements:**
4	In processing nutrients in cell metabolism, organisms produce waste materials that are toxic and must be removed before they can cause harm. Some waste materials for mammals are listed. For each waste material, identify the organ that is involved in its removal.	**Waste material:** • carbon dioxide • urea (nitrogenous waste produced by cells) • excess water • excess salt	**Organ:**
5	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. Define each process. Include the raw materials for each and the substances produced. Look carefully at the information for each process. Summarise the pattern or relationship you notice between these two processes.	**Cellular respiration**	**Photosynthesis**

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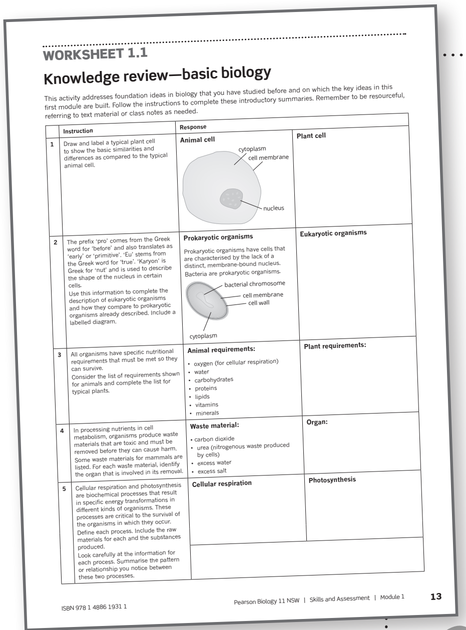

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Practical activities

Practical activities give students the opportunity to complete practical work related to the various themes covered in the syllabus. All practical activities referenced in outcomes within the syllabus have been covered. Across the suite of practical activities, students have opportunities to design, conduct, evaluate, gather and analyse data, appropriately record results and prepare evidence-based conclusions. This can be done directly into the scaffolded practical activities. Students also have opportunities to evaluate safety and risk, and identify any potential hazards.

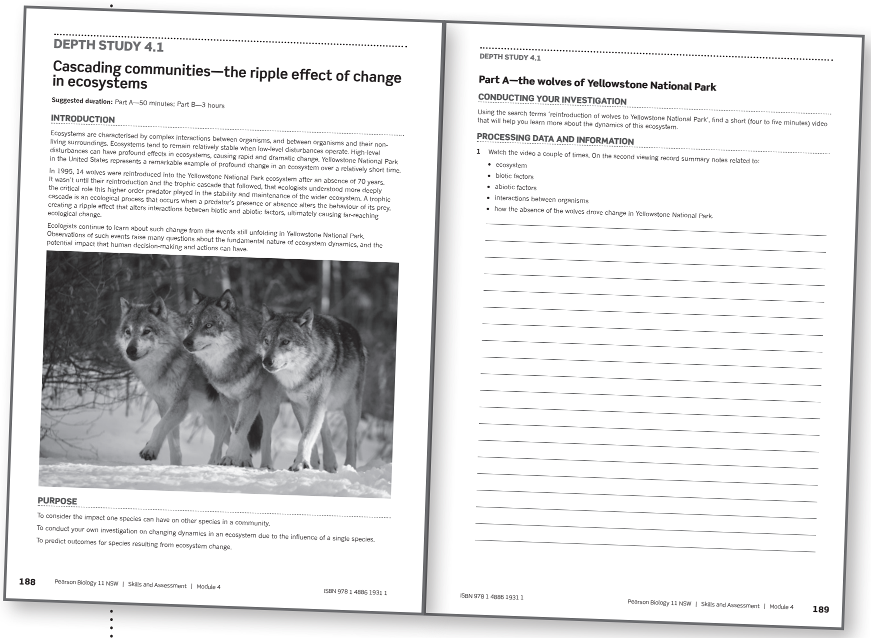
Each practical activity includes a suggested duration. Along with the depth studies, the practical activities meet the 35 hours of practical work mandated for Year 11 in the syllabus. Where there is Key knowledge that will support the completion of a practical activity, students are referred back to it.

Like the worksheets, the practical activities include a range of questions, building from foundation to challenging.

Depth study

Each module contains at least one suggested depth study. The depth studies allow further development of one or more concepts found within or inspired by the syllabus. They allow students to acquire a depth of understanding and take responsibility for their own learning, and promote differentiation and engagement.

Each depth study allows for the demonstration of a range of Working scientifically skills, with all depth studies assessing the Working scientifically outcomes of Questioning and predicting, and Communicating. A minimum of two additional Working scientifically skills and at least one Knowledge and Understanding outcome are also assessed.



DEPTH STUDY 4.1

Cascading communities—the ripple effect of change in ecosystems

Suggested duration: Part A—50 minutes; Part B—3 hours

INTRODUCTION

Ecosystems are characterised by complex interactions between organisms, and between organisms and their non-living surroundings. Ecosystems tend to remain relatively stable when low-level disturbances operate. High-level disturbances can have profound effects in ecosystems, causing rapid and dramatic change. Yellowstone National Park in the United States represents a remarkable example of profound change in an ecosystem over a relatively short time.

In 1995, 14 wolves were reintroduced into the Yellowstone National Park ecosystem after an absence of 70 years. It wasn't until their reintroduction and the trophic cascade that followed, that ecologists understood more deeply the critical role this higher order predator played in the stability and maintenance of the wider ecosystem. A trophic cascade is an ecological process that occurs when a predator's presence or absence alters the behaviour of its prey, creating a ripple effect that alters interactions between biotic and abiotic factors, ultimately causing far-reaching ecological change.

Ecologists continue to learn about such change from the events still unfolding in Yellowstone National Park. Observations of such events raise many questions about the fundamental nature of ecosystem dynamics, and the potential impact that human decision-making and actions can have.

PURPOSE

To consider the impact one species can have on other species in a community.

To conduct your own investigation on changing dynamics in an ecosystem due to the influence of a single species.

To predict outcomes for species resulting from ecosystem change.

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DEPTH STUDY 4.1

Part A—the wolves of Yellowstone National Park

CONDUCTING YOUR INVESTIGATION

Using the search terms 'reintroduction of wolves to Yellowstone National Park', find a short (four to five minutes) video that will help you learn more about the dynamics of this ecosystem.

PROCESSING DATA AND INFORMATION

1 Watch the video a couple of times. On the second viewing record summary notes related to:
- ecosystem
- biotic factors
- abiotic factors
- interactions between organisms
- how the absence of the wolves drove change in Yellowstone National Park.

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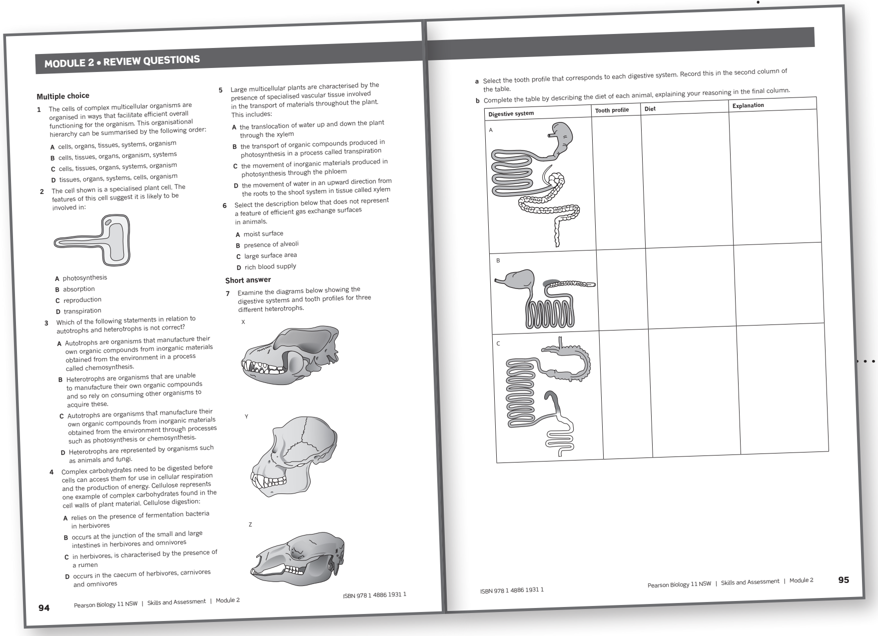
Module review questions

Each module finishes with a comprehensive set of questions, consisting of multiple choice, short answer and extended response, which helps students to draw together their knowledge and understanding and apply it to these styles of question.


MODULE 2 • REVIEW QUESTIONS

Multiple choice

1 The cells of complex multicellular organisms are organised in ways that facilitate efficient overall functioning for the organism. This organisational hierarchy can be summarised by the following order:
A cells, organs, tissues, systems, organism
B cells, tissues, organs, organism, systems
C cells, tissues, organs, systems, organism
D tissues, organs, systems, cells, organism

2 The cell shown is a specialised plant cell. The features of this cell suggest it is likely to be involved in:
A photosynthesis
B absorption
C reproduction
D transpiration

3 Which of the following statements in relation to autotrophs and heterotrophs is not correct?
A Autotrophs are organisms that manufacture their own organic compounds from inorganic materials obtained from the environment in a process called chemosynthesis.
B Heterotrophs are organisms that are unable to manufacture their own organic compounds and so rely on consuming other organisms to acquire these.
C Autotrophs are organisms that manufacture their own organic compounds from inorganic materials obtained from the environment through processes such as photosynthesis or chemosynthesis.
D Heterotrophs are represented by organisms such as animals and fungi.

4 Complex carbohydrates need to be digested before cells can access them for use in cellular respiration and the production of energy. Cellulose represents one example of complex carbohydrates found in the cell walls of plant material. Cellulose digestion:
A relies on the presence of fermentation bacteria in herbivores
B occurs at the junction of the small and large intestines in herbivores and omnivores
C in herbivores, is characterised by the presence of a rumen
D occurs in the caecum of herbivores, carnivores and omnivores

5 Large multicellular plants are characterised by the presence of specialised vascular tissue involved in the transport of materials throughout the plant. This includes:
A the translocation of water up and down the plant through the xylem
B the transport of organic compounds produced in photosynthesis in a process called transpiration
C the movement of inorganic materials produced in photosynthesis through the phloem
D the movement of water in an upward direction from the roots to the shoot system in tissue called xylem

6 Select the description below that does not represent a feature of efficient gas exchange surfaces in animals.
A moist surface
B presence of alveoli
C large surface area
D rich blood supply

Short answer

7 Examine the diagrams below showing the digestive systems and tooth profiles for three different heterotrophs.

X

Y

Z

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a Select the tooth profile that corresponds to each digestive system. Record this in the second column of the table.
b Complete the table by describing the diet of each animal, explaining your reasoning in the final column.

Digestive system	Tooth profile	Diet	Explanation
A			
B			
C			

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Icons and features

The 2018 New South Wales Biology Stage 6 Syllabus Learning Across the Curriculum content is addressed and identified:

AHC A CC CCT DD EU ICT
IU L N PSC S WE

GO TO ➤ **GoTo icons** are used to make important links to relevant content within the book.

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.

Highlight boxes focus students' attention on important information such as key definitions, formulae and summary points.

> Caution: care is required when using sharp equipment such as a scalpel, and chemicals such as hydrogen peroxide. Check any special procedures with your teacher.

Rating my learning

Rating my learning is an innovative tool that appears at the bottom of the final page of most worksheets and all practical activities. It provides students with the opportunity for self-reflection and self-assessment. It encourages them to look ahead to how they can continue to improve, and it helps them to identify focus areas for further skill and knowledge development.

The teacher may choose to use student responses to the 'Rating my learning' feature as a formative assessment tool. At a glance, teachers can assess which topics and which students need intervention for improvement.

RATING MY LEARNING	My understanding improved	Not confident ◄—► Very confident ○ ○ ○ ○ ○	I answered questions without help	Not confident ◄—► Very confident ○ ○ ○ ○ ○	I corrected my errors without help	Not confident ◄—► Very confident ○ ○ ○ ○ ○

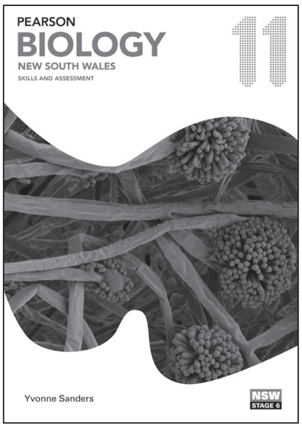
Teacher support

Comprehensive answers and fully worked solutions for all worksheets, practical activities, depth studies and module review questions are provided via the *Pearson Biology 11 New South Wales* Teacher Support. An editable suggested assessment rubric for depth studies is also provided.

Pearson Biology 11 New South Wales

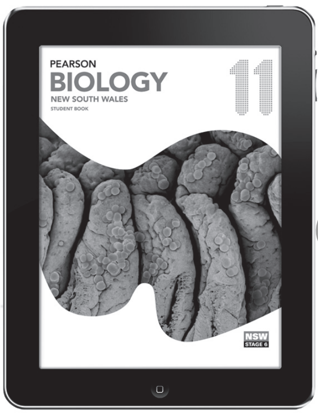
Student Book

Pearson Biology 11 New South Wales has been written to fully align with the 2018 New South Wales Biology Stage 6 Syllabus. The Student Book includes the very latest developments and applications of biology and incorporates best-practice 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. Key features include a toolkit, Key knowledge summaries, worksheets, practical activities, suggested depth studies and module review questions. It provides guidance, assessment practice and opportunities to develop key skills.



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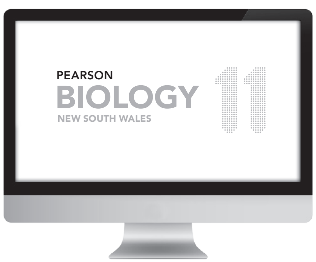

Teacher Support

The Teacher Support available includes syllabus grids and a scope and sequence plan to support teachers with programming. It also includes fully worked solutions and answers to all Student Book and Skills and Assessment Book questions, including all worksheets, practical activities, depth studies and module review questions. Teacher notes, safety notes, risk assessments and laboratory technician's checklists and recipes are available for all practical activities. Depth studies are supported with suggested assessment rubrics and exemplar answers.

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Module 1 • Cells as the basis of life

- investigate cell requirements, including but not limited to:
  - suitable forms of energy, including light energy and chemical energy in complex molecules (ACSBL044)
  - matter, including gases, simple nutrients and ions
  - removal of wastes (ACSBL044)
- investigate the biochemical processes of photosynthesis, cell respiration and the removal of cellular products and wastes in eukaryotic cells (ACSBL049, ACSBL050, ACSBL052, ACSBL053) ICT
- conduct a practical investigation to model the action of enzymes in cells (ACSBL050)
- investigate the effects of the environment on enzyme activity through the collection of primary or secondary data (ACSBL050, ACSBL051) ICT N

Key knowledge

Foundations in biology

Biology is the study of living organisms. **Biodiversity** is the range of living things on Earth. There are close to two million species already identified and many more that remain as yet unidentified.

SCIENTIFIC METHOD

Biologists make observations and construct hypotheses to account for their observations. A **hypothesis** is a possible explanation, an educated guess, made to explain observations.

Hypotheses are tested following the principles of the **scientific method** (Figure 1.1). These include:

- asking relevant questions; that is, questions that can be tested
- making careful observations
- designing and conducting controlled experiments (Figure 1.2). In controlled experiments all **variables** are kept constant, except the one under investigation
- accurate record-keeping of experimental results
- logical interpretation of experimental data and observations
- drawing logical conclusions from the experimental results.

The results of a scientific investigation may negate or reject the hypothesis being tested. In this case the hypothesis must be re-evaluated and modified. Such results are useful in redirecting scientific investigation. When experimental results repetitively support a hypothesis, it may become a **theory** or **principle**. That is, the hypothesis is accepted as a scientific truth.

The scientific method recognises that there are **limiting factors** in investigations. For example, some factors cannot be measured, a sample size may be too small to be representative, or unknown factors may influence investigations.

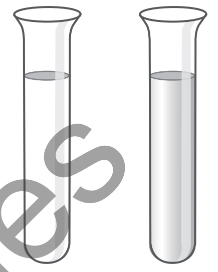

FIGURE 1.2 An experimental set-up

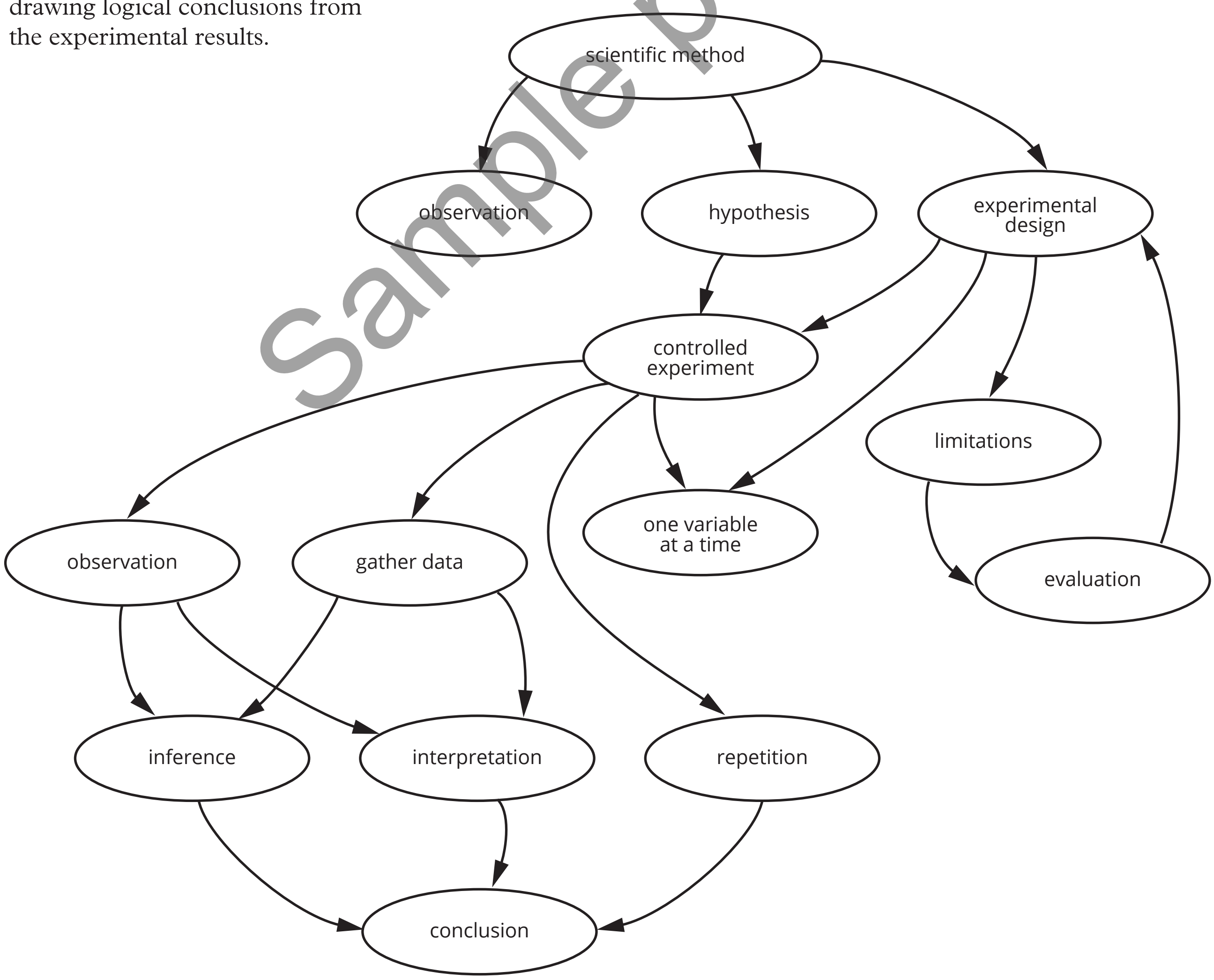

FIGURE 1.1 The scientific method is the process scientists use to conduct experiments and test hypotheses.

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
- the cell is the smallest organisational unit of a living thing.

CELL TYPES

There are two different kinds of cells—**prokaryotic** and **eukaryotic**.

Prokaryotic cells are relatively small and primitive. They do not possess 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).

While prokaryotic cells do not feature a membrane-bound nucleus, their cells do contain a single, coiled chromosome that contains all of the **deoxyribonucleic acid (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). Blue-green algae are photosynthetic bacteria.

Eukaryotic cells (Figure 1.3) are relatively larger and more complex than prokaryotic cells. They possess membrane-bound **organelles** such as a nucleus, mitochondria and lysosomes.

Eukaryotic organisms (Domain Eukarya) include the kingdoms:

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

Note: viruses are non-cellular parasitic agents of disease. They are composed of a core of **ribonucleic acid (RNA)** or DNA surrounded by a protein coat. Prions are also non-cellular agents of disease, but they are composed only of protein.

CELL ORGANELLES

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

Some key organelles are summarised in Figure 1.3 and Table 1.1.

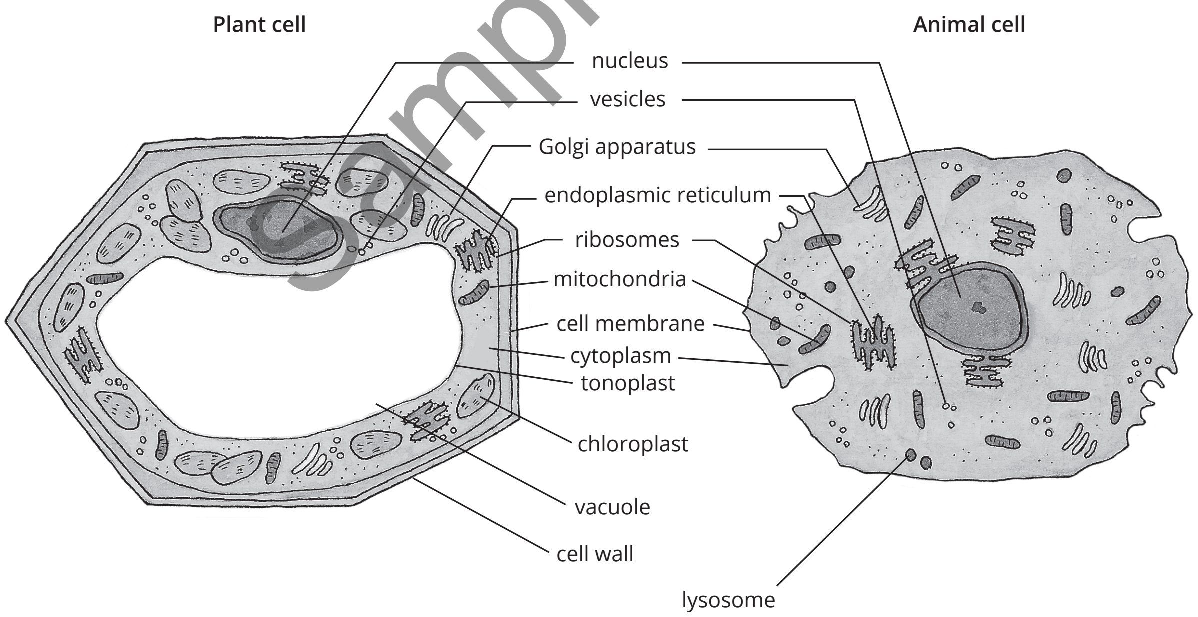

FIGURE 1.3 In unicellular and multicellular organisms, many of the functions that are essential to life occur within specialised structures and organelles of individual cells.

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TABLE 1.1 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	features folded inner membrane; site of aerobic stages of cellular respiration (contains some DNA)	yes
Ribosomes	tiny spherical organelles; site of protein synthesis; not membrane-bound	yes
Endoplasmic reticulum (ER)	network of membranes involved in protein transport within cells; ER encrusted with ribosomes is called 'rough' ER	yes
Golgi apparatus	stacks of flattened membranous sacs; modifies and packages substances in preparation for secretion from cell	yes
Chloroplast	site of photosynthesis (contains chlorophyll)	plant cells only
Lysosomes	membrane-bound organelles that produce digestive enzymes; break down complex compounds into simpler molecules	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

* Present in some cells only.

Endosymbiotic theory

Mitochondria and chloroplasts are organelles that display some unusual features, including their own ribosomes and DNA in the form of a single circular chromosome. They also feature a double membrane and the ability to replicate independently of the cells that contain them. Scientists believe these prokaryotic-like features suggest they originated around 1.5 billion years ago as free-living bacteria that were engulfed by other free-living bacteria in a relationship that offered mutual advantage. This is called the **endosymbiotic theory**.

INVESTIGATING CELLS

Cytology is the study of cells. Cytologists use a variety of tools and techniques to study cells. The main tool used by cytologists is the microscope. There are many different types of microscopes but the two main ones are the light microscope and the electron microscope.

TABLE 1.2 Comparison of microscopes

Feature	Light microscope	Electron microscope
Magnifying power	low	high
Cost	low	high
Level of expertise needed	low	high
Can living specimens be observed?	yes	no

Cell size

Cells vary greatly in size. Most cells are only visible under a light microscope, and their size is usually measured in micrometres (μm). There are 1000 micrometres in 1 millimetre (mm). Although most cells are microscopic, there are some exceptions—the egg cell of some bird species can be many centimetres (cm) in diameter.

Some typical cell sizes are:

- bacterium: 0.1–1.5 μm long
- human: 8–60 μm long
- plant: 10–100 μm long
- paramecium (a single-celled eukaryote): about 150 μm long.

The thickness of cell membranes also differs between cells, and can be between 0.004 and 0.1 μm thick.

The light microscope

Most cells are so small that they can only be seen with a microscope. The light microscope (also called the compound microscope, Figure 1.4) uses light and a system of lenses to magnify the image. One lens is called the objective lens and the other is the eyepiece or ocular lens. The total magnification of a microscope is calculated by multiplying the magnifying power of the ocular lens (eyepiece) by the magnifying power of the objective lens. For example, an ocular lens with a magnifying power of 4 times (×4) used with an objective lens with a magnifying power of 10 times (×10) gives a total magnification of 40 times (×40).

Beneath the microscope stage is a mirror or built-in light source, a condenser lens system to concentrate the light, and an iris diaphragm mechanism to regulate the amount of light passing through the object.

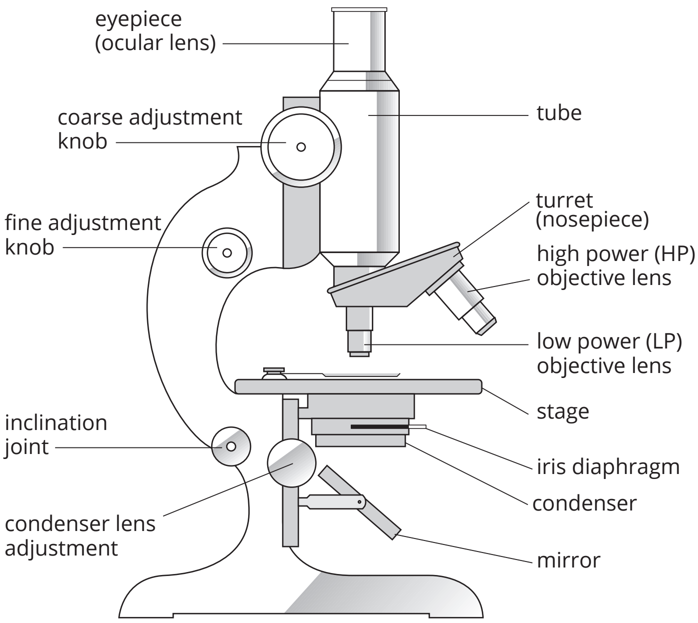


FIGURE 1.4 A light microscope

User-friendly microscope hints

- Look down the eyepiece (ocular lens) and adjust the light source (mirror, condenser lens and iris diaphragm) so the field of view is uniformly illuminated.
- Place your prepared slide on the microscope stage and centre the object to be viewed. Use the clips to secure the slide in position.
- When setting up the microscope always view the object under low power (LP) first (usually ×10).
- Checking from the side, wind the coarse adjustment knob until the LP objective lens is as close as it can go towards the slide (it should be no closer than 2 mm).
- Looking down through the eyepiece, use the coarse adjustment knob to slowly move the LP objective lens away from the slide. When the object is in focus, use the fine adjustment knob to bring the image into even sharper focus.
- Rotate the turret to set a high power (HP) objective lens (×40) in place. Only use the fine adjustment knob when using HP.
- When using the ×100 objective lens, the clarity of the image can be improved by using a technique called oil immersion. Oil immersion involves adding a drop of oil to the coverslip of the slide and carefully rotating the turret so that the ×100 objective lens comes into contact with the drop of oil. Only the fine adjustment knob should be used when using oil immersion.

Preparing a wet mount slide

Figure 1.5 illustrates the best technique for making a wet mount slide.

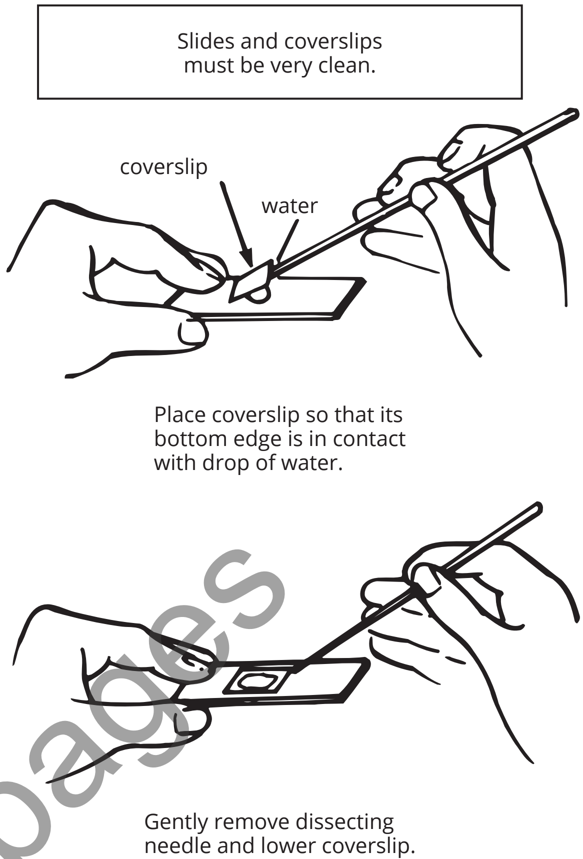


FIGURE 1.5 Making a wet mount slide

Biological drawings

The following guidelines should help you to make simple and effective scaled diagrams of biological structures.

- Drawings should be:
  - made in grey lead pencil
  - large
  - fully labelled with the name of the specimen, the type of preparation and the magnification
  - given a size perspective so that comparisons can be made between specimen sizes—draw each specimen in relation to the size of the field of view observed.
- Lines to labels should be ruled—they should not have 'arrowheads' and should not cross over.
- Drawings of low-power images should not show the detail of cells, just the 'area of cell types' (Figure 1.6).
- Drawings of images made under high power should show the detail of a few cells only of each type (Figure 1.7).

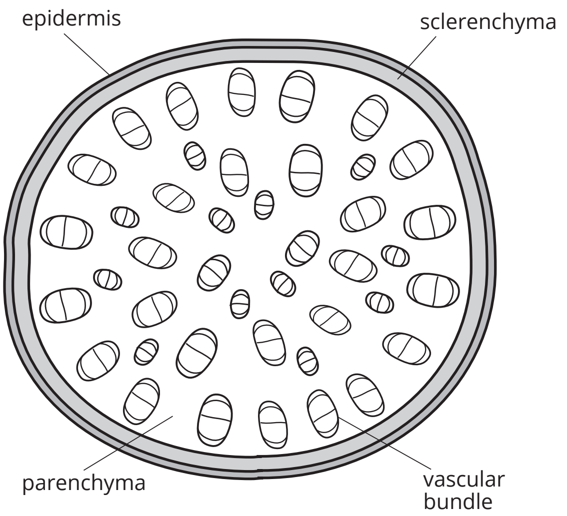


FIGURE 1.6 A low-power view of a zea maize stem (×30)

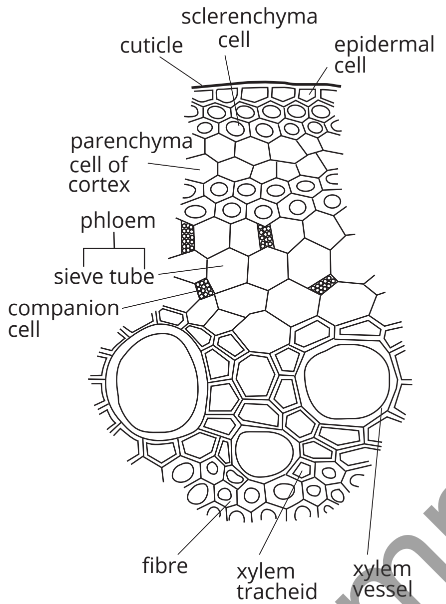


FIGURE 1.7 A high-power view of zea maize cells (×600)

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 membranes

The **cell membrane** (also known as the plasma membrane) controls entry and exit of substances into and out of cells (Figure 1.8). It controls which substances leave and enter, when and how much (Table 1.3). 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 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**.

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

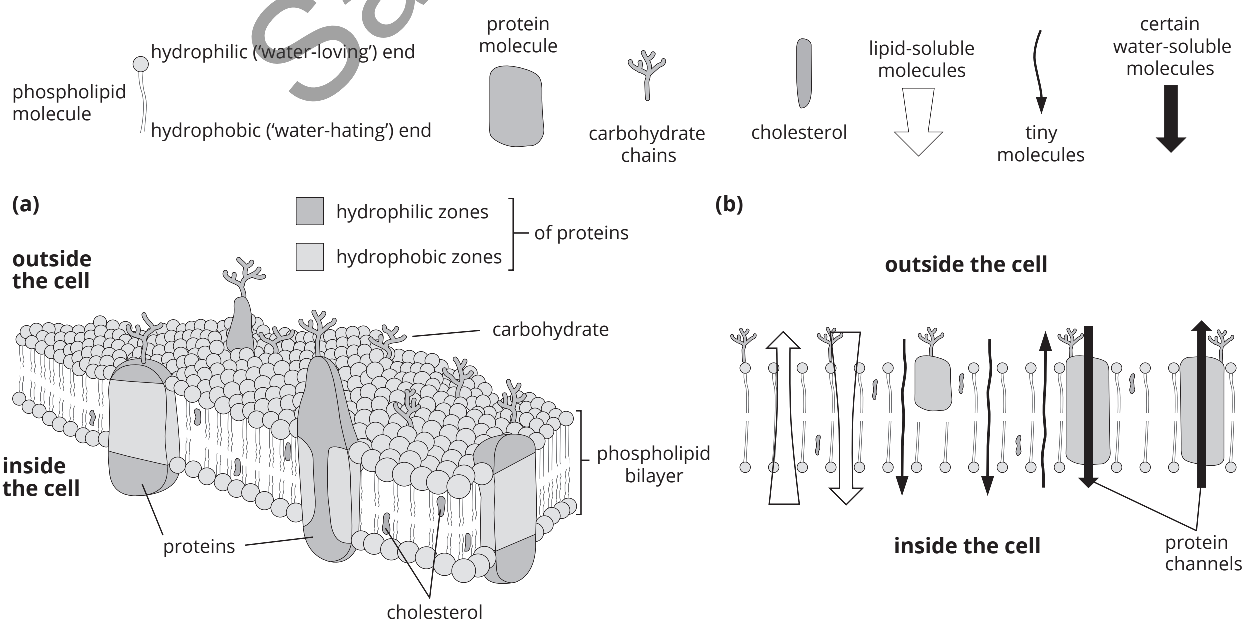


FIGURE 1.8 (a) Biological membranes are composed of a phospholipid bilayer with large protein molecules embedded in the bilayer. These proteins provide channels for the passive and active movement of certain molecules across the cell membrane. (b) Short carbohydrate molecules attached to the outside of the membrane are involved in cell adhesion and cell recognition.

Movement across the cell membrane

The exchange of materials between cells and their external environment occurs through the processes of:

- **diffusion**
- **osmosis**
- **facilitated diffusion,** or
- **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 alcohol 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.
- 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 cell membrane. The passage of these molecules depends on transport channels that span the cell membrane.

Table 1.3 shows the factors that influence how materials move across the cell membrane.

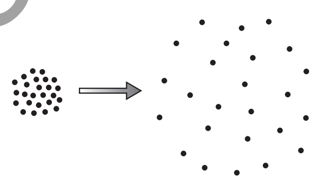
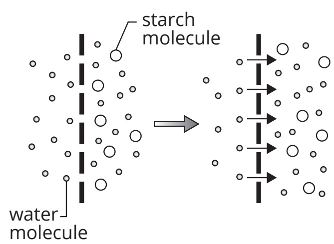
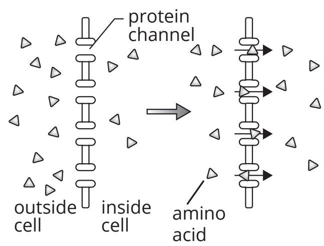
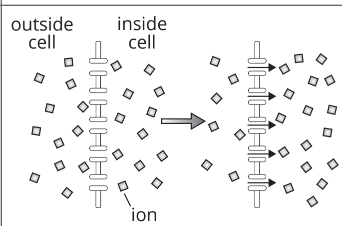
Some substances enter and leave cells by other means. When a section of the cell membrane wraps around a substance for import into the cell, pinching off to form a vesicle inside the cytoplasm, the process is called **endocytosis**. **Pinocytosis** refers to a similar process related to the import of 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).

TABLE 1.3 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 since 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 kidney medulla absorb water by osmosis due to osmotic gradient between ion concentration in tissue fluid and the kidney tubules
Facilitated diffusion	movement of particles from high to low concentration through a 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

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Consider the two cells in Figure 1.9. Which cell has the larger SA : V? The answer is Cell B. Although Cell A has a larger volume, Cell B has a larger surface area compared to its volume (a larger surface-area-to-volume ratio). This means it will be more efficient at taking in and exporting substances through its cell membrane per unit time.

In general, the surface-area-to-volume ratio of an organism decreases as size 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.

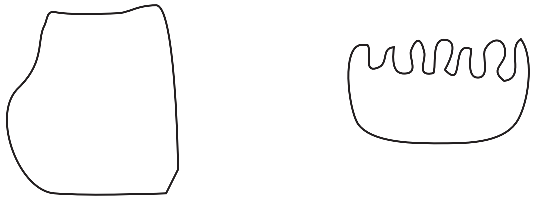

FIGURE 1.9 Two cells (A and B) with a different volume but similar surface area

CELL REQUIREMENTS

The cells of living organisms share some 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)
- inorganic nutrients (for example, minerals).

The photosynthetic cells of plants also require an input of carbon dioxide.

Cells also need optimal conditions to maximise their efficiency. This can be different for the cells of different kinds of organisms; for example, the temperature requirements of cells are different for animals such as mammals and fish.

All cells have in common a need to access nutrients and dispose of wastes. The semipermeable membranes of cells allow for this. 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**. This specialisation of cells is considered further in Module 2.

Inorganic and organic materials

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

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

Table 1.4 provides a summary of the inorganic and organic compounds that are required by cells.

TABLE 1.4 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, 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; 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; 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 the uptake of calcium into bones. Bone vitamins have important roles in enzyme function, for example as coenzymes.

BIOCHEMICAL PROCESSES IN CELLS

Some cell functions have already been listed and described above. Cell functioning relies on chemical reactions that occur within and between cells. The chemical reactions that take place in an organism are known as biochemical processes or **metabolism**. Metabolism can be divided 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 is performed by plant cells that contain **chlorophyll** (Figure 1.10). It requires light and involves the conversion of light energy into chemical energy.

A word equation for photosynthesis is as follows.

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

A simple balanced equation for photosynthesis is:

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

We can also represent photosynthesis in the following way, as water is in fact an input and an output for this process.

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

Organisms that produce their own organic compounds are called **autotrophs**. Autotrophs can be photosynthetic (plants) or chemosynthetic (some prokaryotes) (Figure 1.11). Organisms such as fungi and animals that obtain their organic compounds from other organisms are called **heterotrophs**.

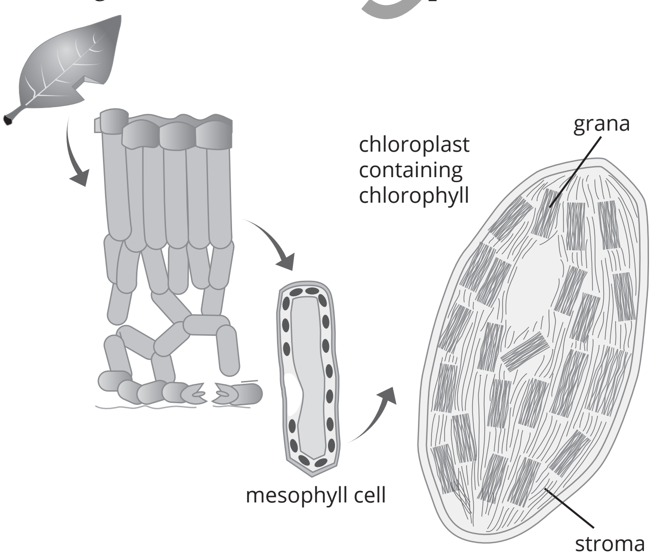

FIGURE 1.10 Leaves, and some stems, are green because the mesophyll cells contain many chloroplasts (the organelles in which photosynthesis takes place).

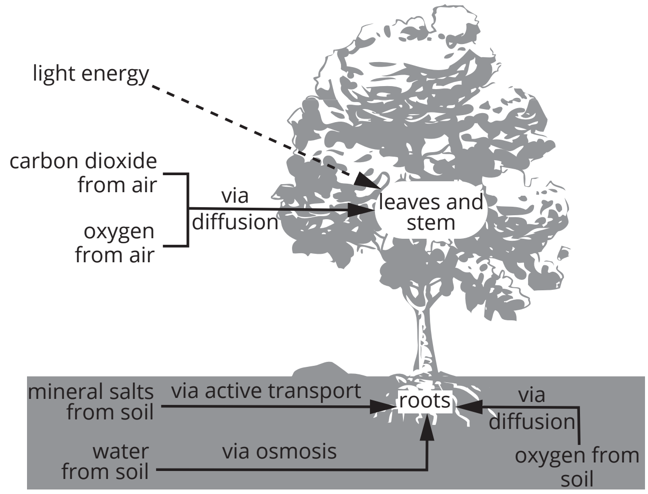

FIGURE 1.11 Overview of how plants obtain nutrients

Photosynthesis occurs in two stages: the **light-dependent reaction** occurs in **grana**; the **light-independent reaction** occurs in the **stroma** (Table 1.5).

Adaptations such as smaller leaves and orientation of leaves can reduce water loss. Some plants are adapted to hot, dry conditions by closing **stomata** during the day and opening them at night to take up the carbon dioxide needed for photosynthesis.

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. The point at which the products of photosynthesis are consumed in the process of cellular respiration is called the **light compensation point**.

TABLE 1.5 Overview of stages involved in photosynthesis

1st stage	2nd stage
Light-dependent	**Light-independent**
• occurs in grana • red and blue light absorbed • light absorbed by chlorophyll • energy used to split water molecules • creates O_2 (by-product) and H^+ ions • ATP also produced (used in 2nd stage)	• occurs in stroma • carbohydrate produced - in the form of glucose - stored as starch • H^+ ions and CO_2 (from air) combined • ATP from 1st stage consumed in glucose manufacture

Cellular respiration

Adenosine triphosphate (ATP) is the immediate source of energy for cells. It is produced in a series of 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 **adenosine diphosphate (ADP)** means that energy continues to be available for use in the cell (Figure 1.12).

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

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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 as follows:

glucose + oxygen → carbon dioxide + water + energy

A balanced chemical equation for cellular respiration is:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{energy}$$

36 (ADP + Pi) → 36 ATP

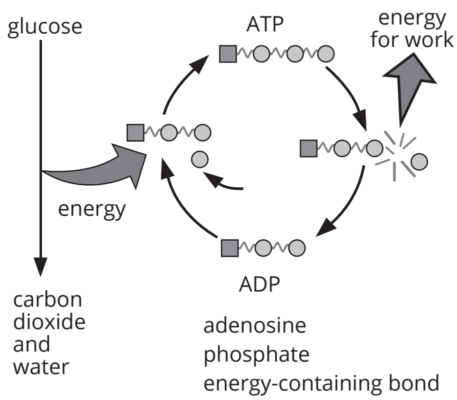

FIGURE 1.12 ATP/ADP cycle

Anaerobic respiration

If oxygen is not available to meet the cell's energy requirements, **anaerobic respiration** will occur (fermentation). 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. Anaerobic respiration is less efficient than aerobic respiration.

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 usually denoted by the suffix 'ase', for example maltase, lactase, protease, amylase and lipase.

Enzymes:

- are composed of protein
- are substrate specific—they catalyse a chemical reaction involving a particular substrate molecule, and not any other. There are two theories used to explain how enzymes interact with their substrates: **lock-and-key**, and **induced fit** (Figures 1.13a and b).

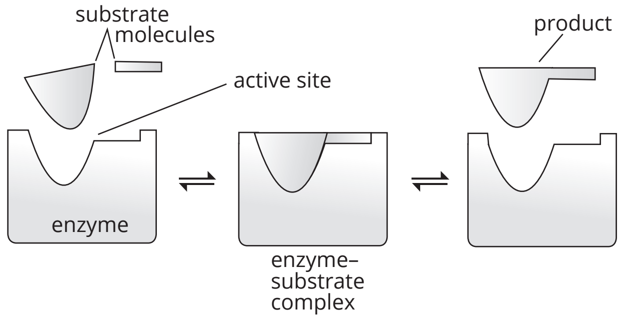

FIGURE 1.13a Model of enzyme 'lock-and-key' operation

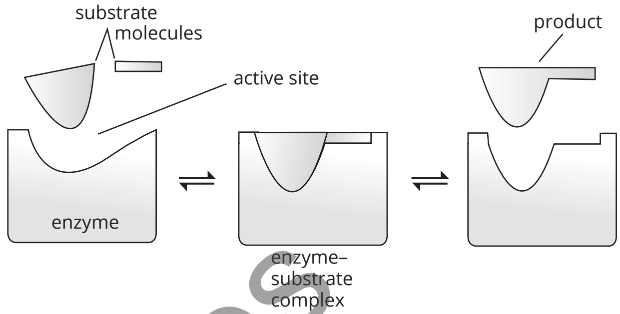

FIGURE 1.13b Model of enzyme 'induced fit' operation

- 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 duodenum of humans is a temperature of 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 1.14).

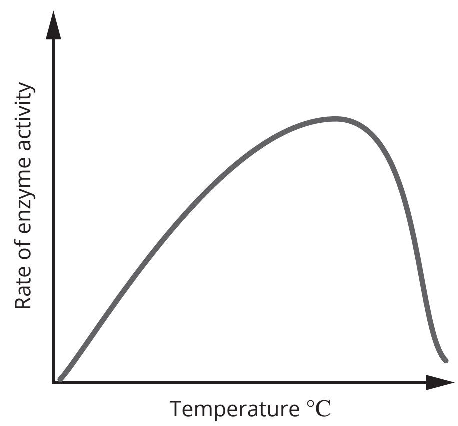

FIGURE 1.14 Rate of enzyme activity continues to increase with increasing temperature. Excessive temperature denatures enzymes and activity ceases.

The rate of enzyme activity is dependent upon the:

- concentration of substrate—the higher the concentration of the substrate, the greater the rate of interaction between substrate molecules and enzymes, leading to an 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 1.15).

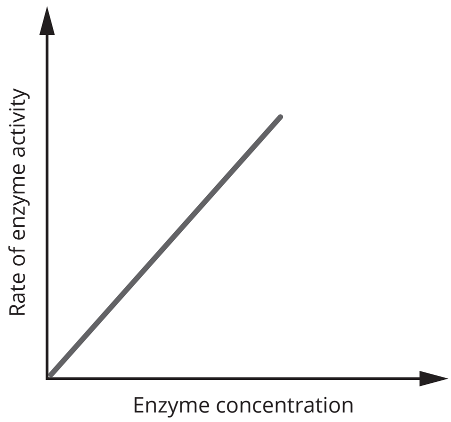

FIGURE 1.15 Rate of enzyme activity increases with increasing enzyme concentration

Reversible and irreversible 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.

Penicillin is an example of an irreversible enzyme inhibitor. Strong covalent bonds means the competitor is permanently attached to the active site of an enzyme involved in construction of the bacterial wall. This outcome renders pathogenic bacteria unable to survive, hence the use of penicillin in medicine.

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.

- **Activation energy**: the energy expended 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**: small organic molecules important to the normal functioning of enzymes.
- **Cofactors**: inorganic ions important to the normal functioning of enzymes, for example Mg++.

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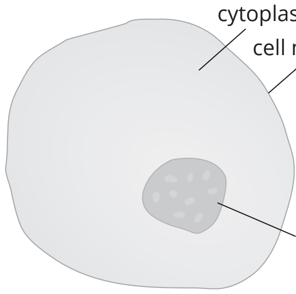
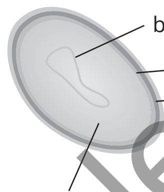
WORKSHEET 1.1

Knowledge review—basic biology

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

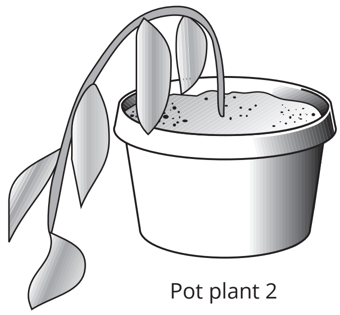
	Instruction	Response	
1	Draw and label a typical plant cell to show the basic similarities and differences as compared to the typical animal cell.	**Animal cell** 	**Plant cell**
2	The prefix 'pro' comes from the Greek word for 'before' and also translates as 'early' or 'primitive'. 'Eu' stems from the Greek word for 'true'. '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** 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 and complete the list for typical plants.	**Animal requirements:** • oxygen (for cellular respiration) • water • carbohydrates • proteins • lipids • vitamins • minerals	**Plant requirements:**
4	In processing nutrients in cell metabolism, organisms produce waste materials that are toxic and must be removed before they can cause harm. Some waste materials for mammals are listed. For each waste material, identify the organ that is involved in its removal.	**Waste material:** • carbon dioxide • urea (nitrogenous waste produced by cells) • excess water • excess salt	**Organ:**
5	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. Define each process. Include the raw materials for each and the substances produced. Look carefully at the information for each process. Summarise the pattern or relationship you notice between these two processes.	**Cellular respiration**	**Photosynthesis**

WORKSHEET 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.

Pot plant 1



Pot plant 2

Purpose

To investigate the effect of sunlight on green plants.

Hypothesis

If green plants need sunlight to survive, then plants that do not receive sunlight will die.

Procedure

The student:

1 obtained two seedlings of the same species that were the same in other respects, including size, height and weight

2 labelled two same-size pots 'Pot plant 1' and 'Pot plant 2'

3 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

4 gave both plants 100 mL of water

5 placed Pot plant 1 on the window sill 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.

The student watered Pot plant 1 on the window sill 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.

Conclusion

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 Which pot plant represented the control in this experiment? Explain your choice.

____

____

2 a How many variables did the student include in the experiment? What were they?

____

____

b How many factors should be varied in a properly controlled experiment? What should the variable be in this instance?

____

____

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3 Are the student's conclusions accurate? Explain.

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 In light of the changes you would make, outline the results you would expect and the conclusions you could draw.

RATING MY LEARNING	My understanding improved	Not confident ◯ ◯ ◯ ◯ ◯ Very confident	I answered questions without help	Not confident ◯ ◯ ◯ ◯ ◯ Very confident	I corrected my errors without help	Not confident ◯ ◯ ◯ ◯ ◯ Very confident

PRACTICAL ACTIVITY 1.1

Distinguishing cells—an observational activity

Suggested duration: 100 minutes

INTRODUCTION

This activity provides an opportunity to design and carry out a practical investigation into the similarities and differences between the cells of different kinds of organisms. You will need to be familiar with the use of the light microscope and accompanying equipment. You will also need to prepare some of your own slide specimens. If you are a little rusty on the procedures involved, your teacher may be able to arrange some refresher lessons for you before you begin this activity. See Investigating cells on pages 5–7 for details on using a light microscope and preparing specimens and biological drawings.

PURPOSE

To design and carry out a laboratory investigation into the structural features of cells from different kinds of organisms.

To investigate the similarities and differences between cells from different kinds of organisms.

PROCEDURE

1 Use the materials listed to design a laboratory experiment that will allow you to investigate the structural features of cells from different kinds of organisms. You may wish to add further specimens to the suggested list—check this with your teacher.

2 Set out your experiment procedure in a numbered, step-by-step format. Write your instructions clearly so that another student could follow them easily. Your procedure should include instructions related to:

- mounting slides
- viewing fresh and prepared slides under the microscope
- preparing drawings of each specimen.

When you have completed the experimental design, have it checked by your teacher before proceeding with the laboratory work itself.

> Caution: safety instructions need to be provided in relation to the use of hazardous chemicals and sharp equipment.

MATERIALS

- light microscope
- microscope slides
- coverslips
- onion
- *Elodea* (pond weed)
- iodine
- white tile or cutting board
- paper towel
- forceps
- scalpel
- selected prepared slides, for example:
  - protozoan
  - leaf epidermis
  - nerve cells
  - bacteria
  - white blood cells
  - cheek cells
  - cross-section of green plant stem
  - root hair tissue

Experimental design

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Cell drawings

3 Table 1 includes a number of features found in eukaryotic cells. Complete the table by indicating whether or not you were able to identify the features listed for each specimen you observed.

TABLE 1 Summary of cell features of organelles

Cell type	Features or organelles observed										Type of organism
	Cell membrane	Cell wall	Nucleus	Cytoplasm	Chloroplast	Mitochondria	Ribosomes	Vacuoles	ER	Golgi apparatus	

4 Decide upon a key to indicate that particular features were identified. For example, a tick may indicate that a feature has been clearly identified, a dash might be used to indicate that a feature was not observed.

Key

PROCESSING DATA

1 Suggest why it might not be helpful to use a cross to indicate that a feature has not been observed in a particular specimen.

2 Outline the role of the light microscope in the study of cells.

3 Outline any limitations that you encountered in this activity, and the impact they had on the investigation.

4 Suggest how these might be overcome in the future to ensure the greatest success in your experimental work.

CONCLUSION

5 Prepare a summary of your findings in this activity. Group the specimens according to common features. Include a discussion of:

- similarities between different kinds of cells
- differences between different kinds of cells.

RATING MY LEARNING	My understanding improved	Not confident ◄——► Very confident ○ ○ ○ ○ ○	I answered questions without help	Not confident ◄——► Very confident ○ ○ ○ ○ ○	I corrected my errors without help	Not confident ◄——► Very confident ○ ○ ○ ○ ○

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DEPTH STUDY 1.1

Enterprising enzymes—investigating enzyme activity

Suggested duration: Part A—90 minutes; Part B—120 minutes

INTRODUCTION

In this activity you will consider the importance of enzymes in living things by investigating a plant enzyme (primary investigation) and an enzyme in humans (secondary-sourced investigation).

In Part A you will plan and conduct an investigation that further develops your knowledge and understanding of enzyme activity. The investigation involves developing a question and hypothesis, which you will test. You will make predictions based on your knowledge and understanding of enzymes, then conduct the experiment you have designed. After recording the experimental data you will interpret and analyse it. You will communicate the findings of your investigation by completing the practical report, following the standard structure of a scientific report. To guide you through this a template is provided below.

As your experience in conducting laboratory investigations increases, so does your familiarity with the elements of a sound scientific method. You will be guided through the planning and conducting of this activity with a view to working more independently in subsequent investigations.

In Part B you will focus on an enzyme that is absent in humans suffering a selected enzyme deficiency disease. This will be a secondary-sourced investigation in which you will research the enzyme and its role, and communicate your findings in a digital presentation.

MATERIALS

- 3 x water baths set at 0°C, 20°C and 40°C
- 3 x thermometers
- 3 x clean test-tubes (approximately 20 mL)
- test-tube rack
- 2 x 10 mL measuring cylinders
- iodine solution
- 1% starch solution
- 1% diastase solution
- marker pen
- spotting tile
- 2 x dropping pipettes

PURPOSE

To investigate the effect of temperature on the activity of the plant enzyme diastase.

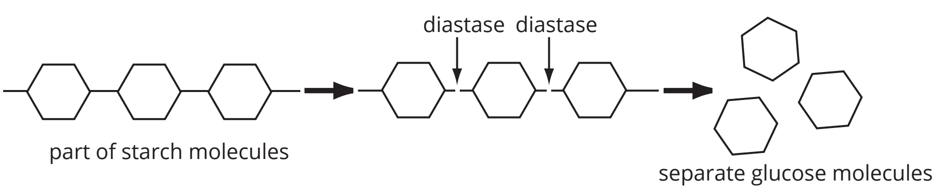
To investigate the role of a selected enzyme in the human body.

Part A—plant enzyme diastase

BACKGROUND

The cells of living organisms are like tiny factories, each the centre of a great deal of activity, including biochemical reactions that involve the breakdown of some molecules and the construction of others. Enzymes are the biological catalysts that facilitate these biochemical reactions. Without them, critical chemical reactions cannot occur or occur too slowly to maintain the wellbeing of cells. As a result, cell function is compromised, sometimes leading to cell death and the death of the organism.

As well as cellular respiration and photosynthesis, many other life-sustaining biochemical pathways occur in cells. In plant cells, the carbohydrate-reducing enzyme diastase (an amylase) is an important enzyme involved in converting starch in storage organs to simple sugars that can be transported to growing tissue.



Effect of diastase on starch

Starch is a complex carbohydrate molecule made up of many glucose molecules (single sugars) joined together by chemical bonds. Starch stains a deep blue-black colour when mixed with iodine solution. Glucose and other simple sugars are not affected by iodine solution and so remain the yellow/brown colour of the iodine solution.

 ISBN 978 1 4886 1931 1

QUESTIONING AND PREDICTING

1 Laboratory investigations inevitably commence with observations and questions. In view of the purpose of this investigation, there are several questions we could ask. For example:

- Does temperature have an effect on the activity of enzymes?
- Do extremes of temperature have the same effect on enzymes?

Write out two more questions raised by the consideration of enzymes and temperature.

2 Refer to the purpose of this investigation and the two questions you have posed. Use these to develop a hypothesis that can be tested in this investigation. Write your hypothesis in the space provided below.

PLANNING YOUR INVESTIGATION

3 Consider the list of materials as the starting point for this activity. How could you use these materials to set up an experiment to test your hypothesis? Use the space below to write out a logical sequence of steps as the procedure for this investigation. Remember to use detailed, numbered, step-by-step instructions that another student could easily follow. Procedural steps should be written in the third person. It will be important to check your procedure with your teacher before commencing the activity. This includes safety considerations and disposal steps.

4 You will also need to think about effective ways of recording your experimental data. Experimental data is recorded under 'Results' in your report. Tables are an effective way of recording data. Table 1 has already been prepared for you. Think about why you would need to record this information. You will need a separate table for the experimental data.

5 As well as keeping a record of your experimental results, scientific reports record other important information about the investigation under the heading 'Discussion'. Often you will do this by answering set questions that guide the structure of your discussion. When you plan the investigation, you need to ensure these items are addressed. They include:

- identifying the variables
- describing ways in which the experiment was controlled
- interpreting the experimental data—summarising what the data means (Processing data and information)
- analysing the experimental data—explaining what the data tells you in terms of the purpose and hypothesis (Analysing data and information)
- evaluating the scientific method—this includes identifying any limitations and how these might have impacted on the investigation, and suggestions about how to reduce or eliminate these in future investigations
- describing and discussing other relevant observations or information.

6 The final element of a scientific report is the conclusion. This is a clear and concise statement that summarises the findings of the investigation. The conclusion should respond to the purpose and state whether the hypothesis is supported or not supported, drawing on experimental evidence to support this. Write your conclusion for this investigation in the space provided on the next page.

CONDUCTING YOUR INVESTIGATION

Procedure

PROCESSING DATA AND INFORMATION

Results

TABLE 1 Colour results

Solution	Iodine
starch	
diastase	

COMMUNICATING

Discussion

CONCLUSION

Part B—a selected human enzyme

PLANNING YOUR INVESTIGATION

Enzymes play critical roles in the ongoing metabolism in the cells of all organisms. In Part B you will select a human enzyme and investigate its role and the consequences of insufficient supply or absence of the enzyme. Such conditions are called enzyme-deficiency diseases. It is only when these enzymes are in short supply or missing that we are fully able to appreciate the critical nature of their presence. Such diseases have long been the subject of scientific and medical research. This research informs us about the role of specific enzymes and their importance.

ISBN 978 1 4886 1931 1

In this secondary-sourced investigation, your research will help to answer questions but is sure to raise others. Keep a record of questions that arise from your research and include them in your presentation. You are not required to answer the questions that might arise, but they demonstrate a deeper level of thinking and consideration, and reflect society's need for information. Such questions drive further research that assists scientists in getting closer to solutions that improve the quality of life for people with these conditions.

Some examples of enzyme-deficiency diseases are listed below. You may select one of these or choose another in consultation with your teacher.

- Lactose intolerance
- Galactosaemia
- Globoid cell leukodystrophy (Krabbes disease)
- Phenylketonuria (PKU)
- Tay-Sachs disease

COMMUNICATING

Criteria

You are required to address each of the following criteria in your investigation:

a Name the deficiency disease and identify the enzyme missing in sufferers of this condition.

b Outline the role of this enzyme in human metabolism.

c Describe the symptoms of the enzyme deficiency disease.

d Describe treatments/management strategies.

e Outline the prognosis for patients given current treatments/management.

f Present statistical data about the prevalence of this condition.

g Name and describe medical technologies/drugs that are currently the subject of research and development of more effective treatments and potential cures.

h Include other relevant information around the condition, for example, approximate age when symptoms typically develop, cause of condition (genetic or other triggers).

i Record any questions that arise from the research.

j Summarise the significance of enzymes in the functioning of cells and the body.

Guidelines

i You will communicate your findings about your selected enzyme and the related enzyme-deficiency disease using a digital format of your choice. This is an opportunity to showcase your research and communication skills. There are some important protocols that you are required to follow. These include:

- writing your own notes from your research. Writing these in your own words demonstrates your understanding of the information
- using your research notes to plan and construct your presentation of the information
- using appropriate terminology to demonstrate you are familiar with the language of the subject and the topic
- defining new terms for your audience, again, in your own words
- using footnotes to reference factual information, scientific studies and data
- preparing a bibliography according to expected guidelines.

ii It will be helpful to refer to page xiv of the Biology toolkit to guide you through the elements of a secondary-sourced investigation. You will be required to locate relevant and reliable resources, organise your notes, analyse the information you uncover and organise and present it in an appropriate fashion. GO TO ➤ page xiv

iii As a guide to length for this task, a student selecting a PowerPoint presentation for delivery should employ a maximum of 12 slides, including the title slide and bibliography.

iv Keep your work concise and to the point. You will be assessed on addressing each criterion logically and clearly, not on volume.