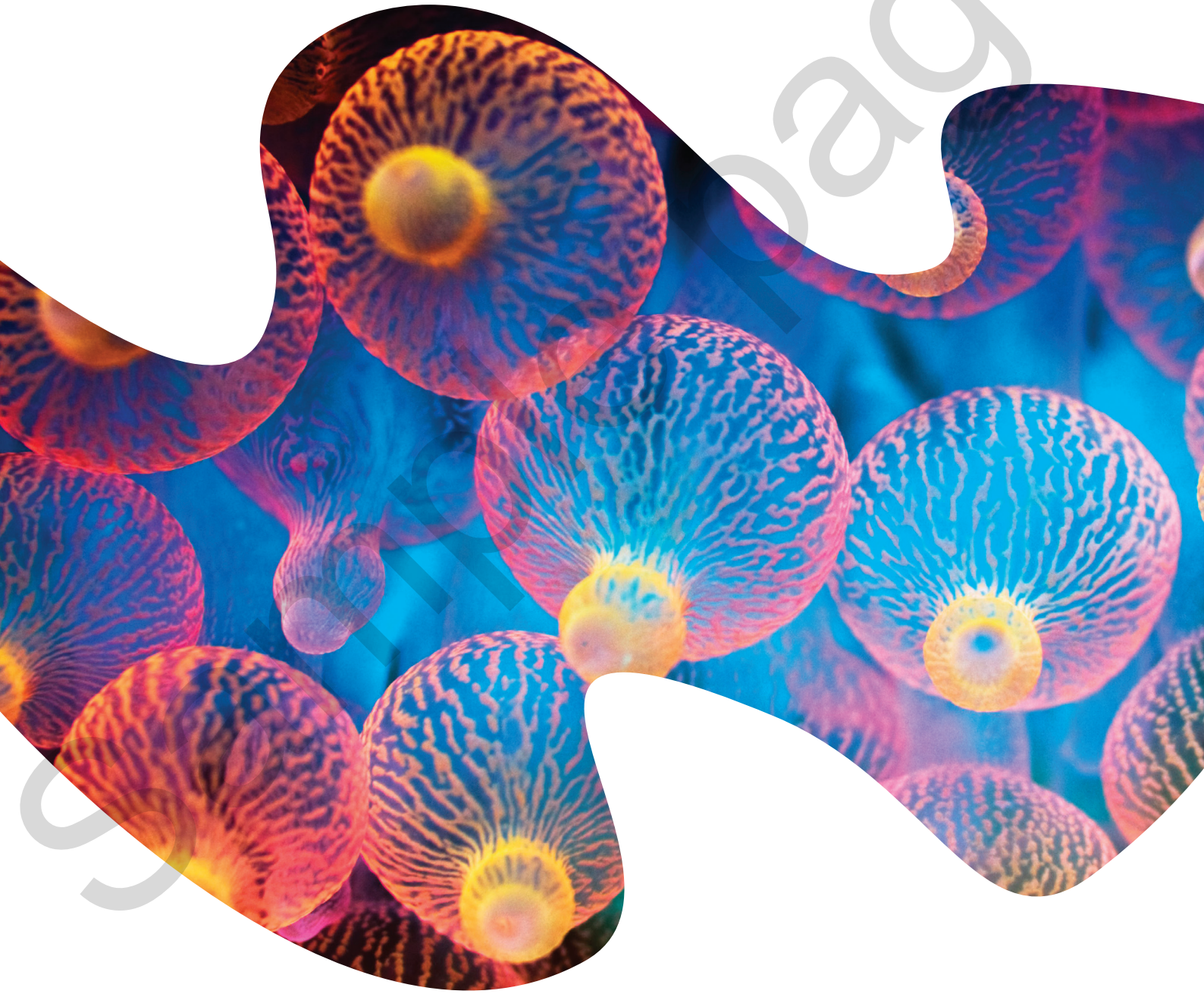
HEINEMANN

BIOLOGY 1

SKILLS AND ASSESSMENT



Yvonne Sanders

VCE UNITS 1 AND 2 • 2022-2026

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HOW TO USE THIS BOOK

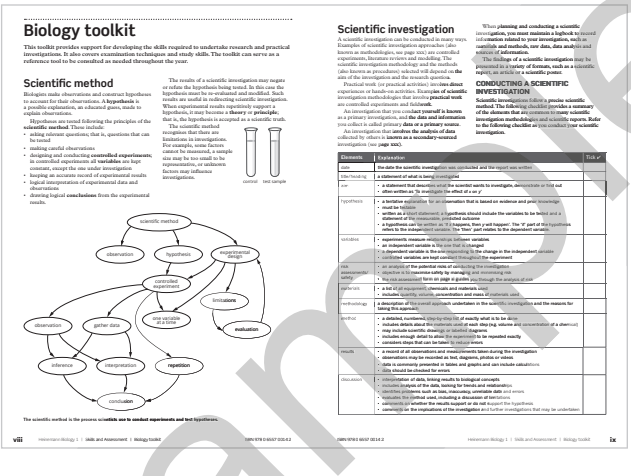
The *Heinemann Biology 1 Skills and Assessment* book provides the opportunity to practise, apply and extend your learning through a range of supportive and challenging activities. These activities reinforce key concepts and skills, and enable a flexible approach to learning. There are also regular opportunities for reflection and self-evaluation in the final worksheet in each Area of Study.

This resource has been written to the VCE Biology Study Design 2022–2026 and is divided into six areas of study—three in Unit 1 and three in Unit 2. Areas of Study 1 and 2 in each unit consist of four main sections:

- key knowledge
- worksheets
- practical activities
- exam-style questions.

BIOLOGY TOOLKIT

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


Biology toolkit

This toolkit provides support for developing the skills required to undertake research and practical investigations. It also covers examination techniques and study skills. The toolkit can serve as a reference tool to be consulted as needed throughout the year.

Scientific method

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

Hypotheses are tested following the principles of the **scientific method**. These include:

- asking relevant questions; that is, questions that can be tested
- making careful observations
- designing and conducting **controlled experiments**; in controlled experiments all **variables** are kept constant, except the one under investigation
- keeping an accurate record 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 refute the hypothesis being tested. In this case the hypothesis is rejected, an adjusted and modified hypothesis or 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

recognition that there are

limitations 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.

control test sample

observation hypothesis experimental design controlled experiment limitations new variable or a trend evaluation gather data tolerance interpretation repetition conclusion

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

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Scientific investigation

A scientific investigation can be conducted in many ways. Examples of scientific investigative approaches (also known as procedures) include laboratory-based experiments, literature reviews and modelling. The scientific investigation methodology and the methods (also known as procedures) selected will depend on the aim of the investigation and the research question.

Practical work (or practical activities) involves **direct** experiences or hands-on activities. Examples of **scientific** investigation methodologies that involve **practical work** are controlled experiments and fieldwork.

An investigation that you conduct **yourself is known** as a primary investigation, and **the data and information** you collect is called primary **data or a primary source**.

An investigation that **involves the analysis of data** collected by others is **known as a secondary-sourced** investigation (see page **xxx**).

Elements	Explanation	Tick ✓
date	**the date the scientific investigation** was conducted and the report was written	
title/heading	**a statement of what is being investigated**	
aim	• a statement that describes what the scientist wants to investigate, demonstrate or find out • often written as 'To investigate the **effect of** a or **y**'	
hypothesis	• a **tentative** explanation for an **observation** that is based on evidence and prior knowledge • must be testable • written as a short statement; a hypothesis should include the variables to be tested and a prediction about the relationship between them • a hypothesis can be written as 'If it happens, then y will happen'. The 'if' part of the hypothesis refers to the independent variable. The 'then' part relates to the dependent variable.	
variables	• **experiments measure** relationships between **variables** • **an independent variable** is the one that is changed • A **dependent variable** is the one responding to the change in the independent variable • **controlled variables are kept constant** throughout the **experiment**	
risk assessment/ safety	• an analysis of the **potential risks** of conducting the investigation • objective is to **maximise safety** by managing and minimising risk • the risk assessment form on page x guides you through the analysis of risk	
materials	• a list of all equipment, **chemicals and materials** used • **includes** quantity, volume, concentration and mass of materials used	
methodology	a description of the overall approach **undertaken** in the scientific investigation **and the reasons for taking this approach.**	
method	• a detailed, numbered, step-by-step list of **exactly what is to be done** • **includes details about the** materials used or **each** step (eg. values and concentration of a chemical) • **may include scientific drawings or labelled diagrams** • **includes enough detail to allow** the experiment **to be repeated exactly** • **consistent steps that can be taken to reduce errors.**	
results	• a **record of all observations and measurements taken during the investigation** • **observations may be recorded as text, diagrams, photos or videos** • **data is commonly presented in tables and graphs and can include calculations** • **data should be checked for errors.**	
discussion	• interpretation of data, **linking results to biological concepts** • includes **analysis of the data, looking for trends and relationships** • identifies problems such as bias, inaccuracy, unreliable data and errors • **evaluates the method used, including a discussion of limitations** • comments on **whether the results support or do not** support the hypothesis • comments on **the implications of the investigation** and further investigations that may be undertaken	

When planning and conducting a scientific investigation, **you must maintain a logbook** to record information **related to your investigation, such as** materials **and methods, raw data, data analysis** and sources of **information.**

The findings **of a scientific investigation** may be presented in a variety **of forms, such as** a scientific report, oral presentation or scientific poster.

CONDUCTING A SCIENTIFIC INVESTIGATION

Scientific investigation follows a **precise scientific method. The following checklist provides a summary of the elements that are common to many scientific investigation methodologies** and scientific **reports. Refer to the following checklist as** you conduct your **scientific investigation.**

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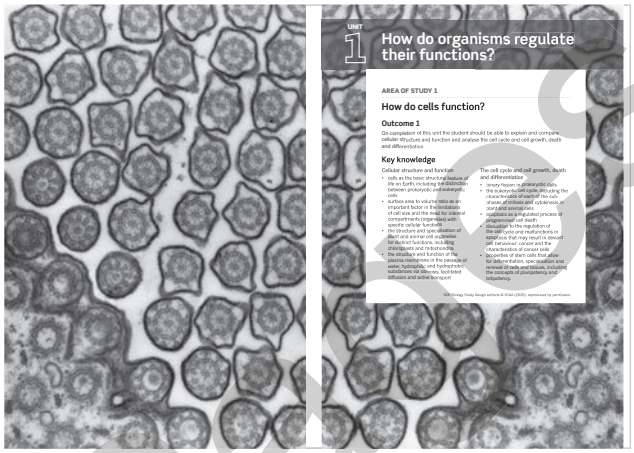
TEACHER SUPPORT

Comprehensive answers and fully worked solutions for all worksheets, practical activities and exam questions are provided via the *Heinemann Biology 1 <TBC>*. In-depth support for Unit 1 Area of Study 3 and Unit 2 Area of Study 3 in the form of samples, templates and teacher notes is also included, along with an interactive SPARKlab for every practical activity.

UNIT AND AREA OF STUDY OPENER

Heinemann Biology 1 Skills and Assessment is structured to follow the study design units and areas of study. The area of study opening page lists the study design key knowledge for easy reference to the following activities.


UNIT 1 How do organisms regulate their functions?

AREA OF STUDY 1

How do cells function?

Outcome 1

On completion of this unit the student should be able to explain and compare cellular structure and function and analyse the cell cycle and cell growth, death and differentiation.

Key knowledge

Cellular structure and function

- cells as the basic structural feature of life on Earth, including the distinction between prokaryotic and eukaryotic cells
- surface area to volume ratio as an important factor in the limitations of cell size and the need for internal complexity in organisms with multicellular organisation
- the structure and specialisation of plant and animal cell organelles for distinct functions, including chloroplasts and mitochondria
- the structure and function of the plasma membrane, including the role of water, hydrophilic and hydrophobic substances via osmosis, facilitated diffusion and active transport

The cell cycle and cell growth, death and differentiation

- binary fission in prokaryotic cells
- the cell cycle in eukaryotic cells, including the characteristics of each of the stages of mitosis and cytokinesis in plant and animal cells
- apoptosis as a regulated process of programmed cell death
- dysregulation to the regulation of the cell cycle and cell growth in tissue and that may result in disrupted cell behaviour, cancer and the characteristics of cancer cells
- properties of stem cells that allow for differentiation, self-renewal and renewal of cells and tissue, including the processes of photosynthesis and transpiration

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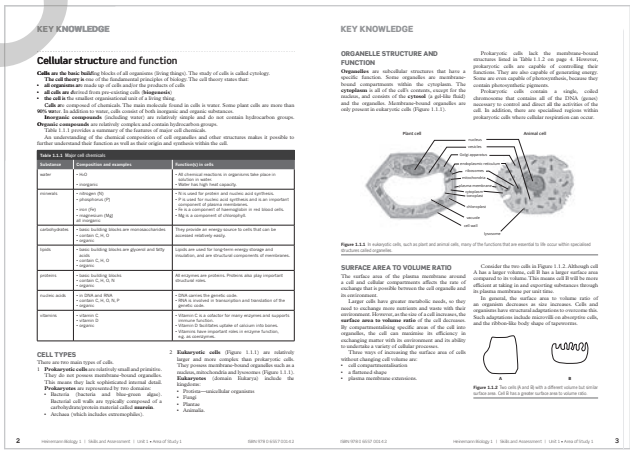
KEY KNOWLEDGE

Each area of study begins with a key knowledge section. This consists of a set of summary notes that cover the key knowledge for that area of study. Key terms are in bold and are included in the glossary of the student book. The section also serves as a ready reference for completing the worksheets and practical activities.


KEY KNOWLEDGE

Cellular structure and function

Cells are the basic building blocks of all organisms (living things). The study of cells is called cytology.

- **Cell theory** is a unifying theory in biology. The cell theory states that:
- **all organisms** are made up of cells and/or the products of cells
- **all cells are** derived from pre-existing cells (**biogenesis**)
- **the cell** is the smallest organisational unit of a living thing.

Cells are composed of chemicals. 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) are relatively simple and do not contain hydrocarbon groups.

Organic compounds are relatively complex and contain hydrocarbon groups.

Table 1.1.1 provides a summary of the features of major cell chemicals.

An understanding of the chemical composition of cell organelles and other structures makes it possible to further understand their function as well as their origin and synthesis within the cell.

Table 1.1.1 Major cell chemicals

Substance	Composition and examples	Function(s) in cells
water	• H_2O • inorganic	• All chemical reactions in organisms take place in solution in water. • Water has high heat capacity.
minerals	• nitrogen (N) • phosphorous (P) • iron (Fe) • magnesium (Mg) • all inorganic.	• N is used for protein and nucleic acid synthesis. • P is used for nucleic acid synthesis and is an important component of ATP and phospholipids. • Fe is a component of haemoglobin in red blood cells. • Mg is a component of chlorophyll.
carbohydrates	• basic building blocks are monosaccharides • contain C, H, O • organic	They 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 • organic	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 • organic	All enzymes are proteins. Proteins also play important structural roles.
nucleic acids	• ex DNA and RNA • contain C, H, O, N, P • organic	• DNA carries the genetic code. • RNA is involved in transcription and translation of the genetic code.
vitamins	• vitamin C • vitamin D • organic	• Vitamin C is a cofactor for many enzymes and supports immune function. • Vitamin D facilitates uptake of calcium into bones. • Vitamins have important roles in enzyme function, eg. as coenzymes.

CELL TYPES

There are two main types of cells.

1 **Prokaryotic cells** are relatively small and primitive. They do not possess membrane-bound organelles. This means they lack sophisticated internal detail. **Prokaryotes** are represented by two domains:

- Bacteria (bacteria and blue-green algae). Bacterial cell walls are typically composed of a carbohydrate/protein material called **murein**.
- Archaea (which includes extremophiles).

2 **Eukaryotic cells** (Figure 1.1.1) are relatively large and complex and possess membrane-bound organelles. They possess membrane-bound organelles such as a nucleus, mitochondria and lysosomes (Figure 1.1.1). **Eukaryotes** (domain Eukarya) include the kingdoms:

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

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KEY KNOWLEDGE

ORGANELLE STRUCTURE AND FUNCTION

Organelles are subcellular structures that have a specific function. Some organelles are membrane-bound compartments within the cytoplasm. The **cytoplasm** is all of the cell's contents, except for the nucleus, and consists of the **cytosol** (a gel-like fluid) and the organelles. Membrane-bound organelles are only present in eukaryotic cells (Figure 1.1.1).

Prokaryotic cells lack the membrane-bound structures listed in Table 1.1.2 on page 4. However, prokaryotic cells are capable of controlling their functions. They are also capable of generating energy. Some have internal membrane structures, because they contain photosynthetic pigments.

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

Plant cell Animal cell

Figure 1.1.1 In eukaryotic cells, such as plant and animal cells, many of the functions that are essential to life occur within specialised structures called organelles.

SURFACE AREA TO VOLUME RATIO

The surface area of the plasma membrane around a cell and cellular compartments affects the rate of exchange that is possible between the cell organelle and its environment.

Larger cells have greater metabolic needs, so they need to exchange more nutrients and waste with their environment. However, as the size of a cell increases, the **surface area to volume ratio** of the cell decreases. By compartmentalising specific areas of the cell into organelles, the cell can maximise its efficiency in exchanging matter with its environment and its ability to undertake a variety of cellular processes.

Three ways of increasing the surface area of cells without increasing cell volume are:

- cell elongation and flattening
- a flattened shape
- plasma membrane extensions.

Consider the two cells in Figure 1.1.2. Although cell A has a larger volume, cell B has a larger surface area compared to its volume. This means cell B will be more efficient at taking in and exporting substances through its plasma 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.

A B

Figure 1.1.2 Two cells (A and B) with a different volume but similar surface area. Cell B has a greater surface area to volume ratio.

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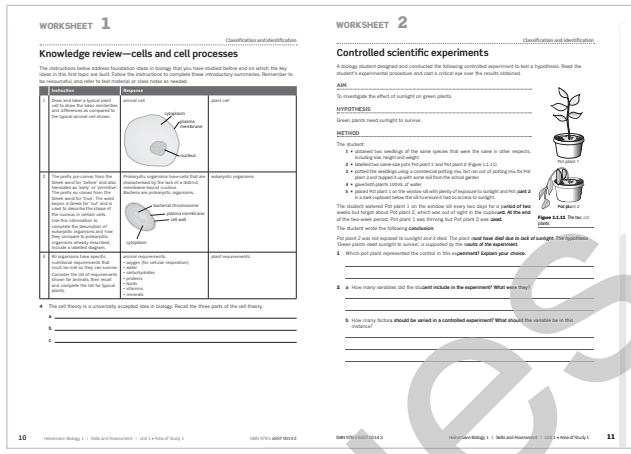
HOW TO USE THIS BOOK

WORKSHEETS

The worksheets feature questions that allow you to practise and apply your knowledge and skills. Each area of study includes a 'Knowledge review' worksheet, to activate prior knowledge, and a 'Reflection' worksheet, which you can use for self-assessment. Other worksheets provide opportunities to revise, consolidate and further your understanding. All worksheets function as formative assessment and are clearly aligned with the study design. A range of questions building from foundation to challenging is included in each worksheet.


WORKSHEET 1

Classification and identification

Knowledge review—cells and cell processes

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, and refer to text material or class notes as needed.

	Instruction	Response	
1	Draw and label a typical plant cell. Include its main features and differences as compared to the typical animal cell shown.	animal cell: cytoplasm, plasma membrane, nucleus	plant cell:
2	The prefix *pro* comes from the Greek word for 'before' and also means '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 prokaryotic cells and how they compare to eukaryotic 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. bacterial chromosome, plasma 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 provided for animals, bacteria and complete the list for typical plants.	animal requirements: • oxygen (for cellular respiration) • water • carbohydrates • proteins • lipids • vitamins • minerals	plant requirements:

4 The cell theory is a universally accepted idea in biology. Recall the three parts of the cell theory.

a _____

b _____

c _____

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WORKSHEET 2

Classification and identification

Controlled scientific experiments

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

AIM

To investigate the effect of sunlight on green plants.

HYPOTHESIS

Green plants need sunlight to survive.

METHOD

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' (Figure 1.1.11)
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 100mL 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.

Pot plant 1 Pot plant 2

Figure 1.1.11 The two pot plants

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.**

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 '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 controlled experiment? What should** the variable be in this instance?

_____

_____

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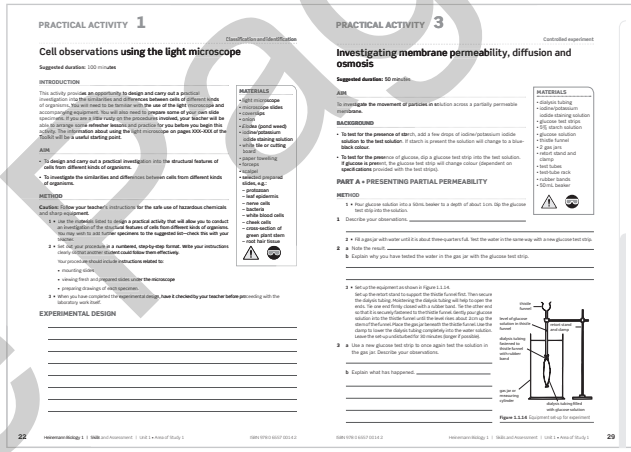
PRACTICAL ACTIVITIES

Practical activities offer you the chance to complete practical work related to the various themes covered in the study design. You have the opportunity to design and conduct scientific investigations, generate, evaluate and analyse data, appropriately record results, and prepare evidence-based conclusions. Where relevant, you will also need to conduct risk assessments to identify any potential hazards.

Each practical activity includes a suggested duration. Together with the Area of Study 3 scientific investigations, the practical activities meet the 34 hours of practical work mandated for Units 1 and 2 in the study design.

Each worksheet and practical activity is mapped to one or more of the scientific investigation methodologies outlined in the study design. Completing these activities gives you experience in applying the methodologies in a wide variety of contexts and prepares you for designing and conducting your own scientific investigation in Unit 1 Area of Study 3.


PRACTICAL ACTIVITY 1

Classification and identification

Cell observations **using the light microscope**

Suggested duration: 100 minutes

INTRODUCTION

This activity provides **an opportunity to design and carry out a practical** investigation into the similarities and **differences between 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 hazy on the procedures **involved, your teacher will be** able to arrange some **refresher lessons** and practice **for you before you begin this** activity. The **information about using the** light microscope **on pages XXX–XXX of the** Toolkit will be a **useful starting point.**

AIM

- **To design and carry out a practical 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.**

METHOD

Caution: Follow your teacher's instructions for the safe use of hazardous chemicals and sharp equipment.

1 • use the materials listed to **design a practical activity that will allow you to conduct** an investigation of the **structural features of cells from different kinds of organisms.** You may wish to ask **further specimens to the suggested list—check this with your** teacher.
2 • Set out your procedure **in a numbered, step-by-step format. Write your instructions** clearly so that another **student could follow them effectively.**

Your procedure should include **instructions related to:**

- mounting slides
- viewing fresh and prepared slides **under the microscope**
- preparing drawings of cells/ specimens.

3 • When you have completed the experimental design, **have it checked by your teacher before pro**ceeding with the laboratory work itself.

MATERIALS

- light microscope
- microscope slides
- coverslips
- onion
- Elodea (pond weed)
- iodine/potassium iodide staining solution
- white tile or cutting board
- paper towelling
- forceps
- scalpel
- selected prepared slides, e.g.:
  - 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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PRACTICAL ACTIVITY 3

Controlled experiment

Investigating membrane permeability, diffusion and osmosis

Suggested duration: 50 minutes

AIM

To investigate **the movement of particles in s**olution across a partially permeable **membrane.**

BACKGROUND

- **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 presen**ce of glucose, dip a glucose test strip into the test solution. **If glucose is present**, the glucose test strip will change colour (dependent on **specifications** provided with the test strips).

MATERIALS

- dialysis tubing
- iodine (potassium iodide) staining solution
- glucose test strips
- 0.5% starch solution
- glucose solution
- thistle funnel
- 2 gas jars
- retort stand and clamp
- test tubes
- test-tube rack
- rubber bands
- 50mL beaker

PART A • PRESENTING PARTIAL PERMEABILITY

METHOD

1 • Pour glucose solution into a 50mL beaker to a depth of about 1cm. Dip the glucose test strip into the solution.

1 Describe your observations. _____

2 • Fill a gas jar with water until it is about three-quarters full. Test the water in the same way with a new glucose test strip.

2 a Note the result. _____

b Explain why you have tested the water in the gas jar with the glucose test strip.

_____

3 • Set up the equipment as shown in Figure 1.1.14.

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 2cm up the dialysis tubing. Secure the thistle funnel in the retort stand with the clamp. Use the clamp to lower the dialysis tubing completely into the water solution. Leave the set-up undisturbed for 30 minutes (longer if possible).

3 a Use a new glucose test strip to once again test the solution in the gas jar. Describe your observations.

_____

b Explain what has happened.

_____

_____

Figure 1.1.14 Equipment set-up for experiment

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WORKSHEET 14

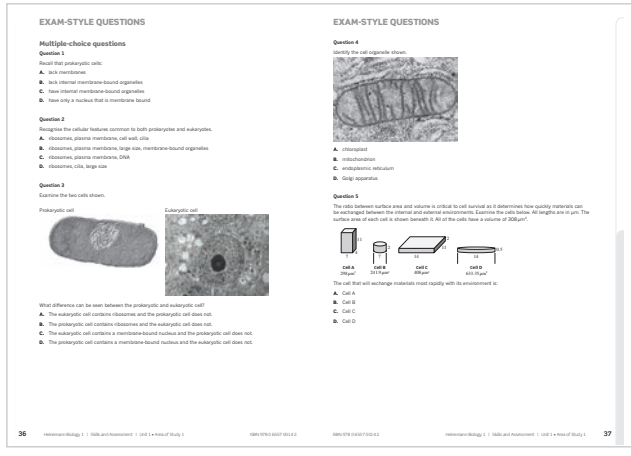
Classification and identification

The mammalian excretory system

1 Read the definitions listed in the boxes on the right-hand side of the page. Choose the correct term from the list below to match each definition and write this term in the corresponding box.

EXAM-STYLE QUESTIONS

Each area of study finishes with a selection of exam-style questions. This gives you the opportunity to gain valuable experience applying your knowledge and understanding to exam-style questions.


EXAM-STYLE QUESTIONS

Multiple-choice questions

Question 1

Recall that prokaryotic cells:

A. lack membranes
B. lack internal membrane-bound organelles
C. have internal membrane-bound organelles
D. have only a nucleus that is membrane bound

Question 2

Recognise the cellular features common to both prokaryotes and eukaryotes.

A. ribosomes, plasma membrane, cell wall, cilia
B. ribosomes, plasma membrane, large size, membrane-bound organelles
C. ribosomes, plasma membrane, DNA
D. ribosomes, cilia, large size

Question 3

Examine the two cells shown.

Prokaryotic cell Eukaryotic cell

What difference can be seen between the prokaryotic and eukaryotic cell?

A. The eukaryotic cell contains ribosomes and the prokaryotic cell does not.
B. The prokaryotic cell contains ribosomes and the eukaryotic cell does not.
C. The eukaryotic cell contains a membrane-bound nucleus and the prokaryotic cell does not.
D. The prokaryotic cell contains a membrane-bound nucleus and the eukaryotic cell does not.

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EXAM-STYLE QUESTIONS

Question 4

Identify the cell organelle shown.

A. chloroplast
B. mitochondrion
C. endoplasmic reticulum
D. Golgi apparatus

Question 5

The ratio between surface area and volume is critical to cell survival as it determines how quickly materials can be exchanged between the internal and external environments. Examine the cells below. All lengths are in µm. The surface area of each cell is shown beneath it. All of the cells have a volume of 308µm³.

Cell A 294µm² Cell B 241.9µm² Cell C 308µm² Cell D 605.19µm²

The cell that will exchange materials most rapidly with its environment is:

A. Cell A
B. Cell B
C. Cell C
D. Cell D

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Biology toolkit

This toolkit provides support for developing the skills required to undertake research and practical investigations. It also covers examination techniques and study skills. The toolkit can serve as a reference tool to be consulted as needed throughout the year.

Scientific method

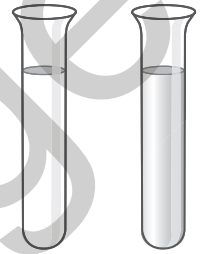
Biologists make observations and construct hypotheses to account for their observations. A **hypothesis** is a possible explanation, an educated guess, made to explain observations.

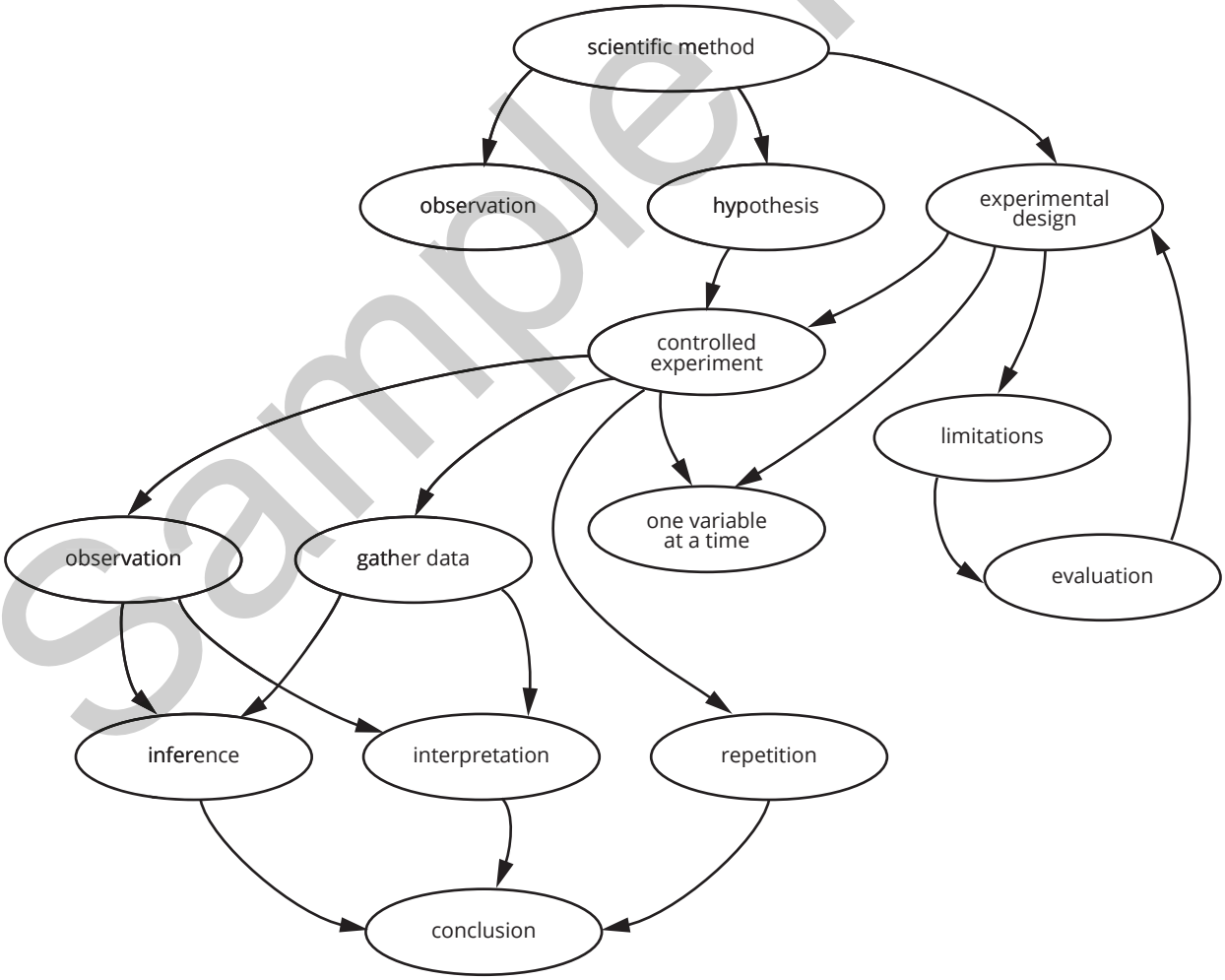
Hypotheses are tested following the principles of the **scientific method**. These include:

- asking relevant questions; that is, questions that can be tested
- making careful observations
- designing and conducting **controlled experiments**; in controlled experiments all **variables** are kept constant, except the one under investigation
- keeping an accurate record 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 refute 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 limitations 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.





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

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EXAMPLES OF SCIENTIFIC REPORTS

It can be difficult to gauge whether you have attained a high standard in your completed scientific report. Looking at sample scientific reports can help you identify what is required. Two sample scientific reports are provided here as a reference: one is prepared to a high standard, while the second has room for improvement. The annotations draw your attention to key points to note on each scientific report. These points are also reflected in the checklist, so you are able to use this as a tool to evaluate whether all requirements of the scientific investigation have been met.

High standard scientific report

Place the heading at the top of the text on page 1 of the report. Heading should be clear and short.

State the reason for doing the investigation.

The hypothesis is based on the aim of the investigation.

Identify the different variables.

List all materials, including numbers of specific items.

Warn of potential hazards and how these can be reduced or eliminated.

Describe the overall approach undertaken in the scientific investigation and the reasons for taking this approach.

Provide clear instructions about each step of the experiment. These should be written in recipe style, with easy-to-follow detailed instructions written in the third person.

The effect of sunlight on seed germination

Aim

To investigate whether wheat seeds need sunlight to trigger germination.

Hypothesis

If wheat seeds need sunlight to germinate, then they will not germinate in the dark.

Variables

Independent variable: sunlight
Dependent variable: seed germination
Controlled variables:

- type of container used for seeds
- type of substrate used to support seeds
- temperature
- number and density of seeds

Materials

- 40 wheat seeds
- 2 × Petri dishes
- cotton wool
- 50 mL measuring cylinder
- spray bottle containing water

Risk assessment

If you are using glass Petri dishes, breakage is a potential risk. Wear disposable gloves to protect your hands. All breakages should be reported to the teacher immediately. The teacher or laboratory technician will dispose of broken glass.

Methodology

A controlled experiment was conducted to determine if sunlight is required for germination to occur.

Method

1. Place 1 cm thick bed of cotton wool in base of each Petri dish.
2. Measure 20 mL of water in the measuring cylinder. Pour over the cotton wool in the first Petri dish until uniformly wet. Repeat this for the second Petri dish.
3. Spread 20 wheat seeds evenly on the cotton wool bed of each Petri dish.
4. Place one Petri dish on the windowsill where it will receive sunlight. Place the second in a dark cupboard nearby.
5. Leave the Petri dishes for seven days. Use the water spray bottle to spray the two Petri dishes every second day to ensure they do not dry out.
6. Compare the seeds of the two set-ups after seven days.

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Results

Wheat seeds placed in light and dark conditions did not show a difference in the mean number of seeds germinated over a period of seven days (Table 1).

TABLE 1 Number of wheat seeds germinated in light and dark conditions over seven days

Group	Number of seeds germinated	
	Light	Dark
1	18	17
2	17	19
3	18	16
4	17	17
5	12	14
Mean	16.4	16.6

Discussion

The data from each set of experiments follows a similar pattern. The majority of wheat seeds germinated, regardless of exposure to light or dark.

The light and dark treatments for Group 5 both have a lower number of germinating seeds than the other groups. As the Group 5 seeds came from the same source as the other groups' seeds, variables other than the seeds need to be considered when accounting for the difference in germination rates between groups. There are several possibilities that might account for the lower rate of germination. For example, the seeds might not have received adequate water. Another reason could be the handling of the seeds by contaminated hands. Such variables should be controlled in future experiments by ensuring all seeds receive equal quantities of water and by wearing disposable gloves when handling the seeds.

Conclusion

This investigation demonstrated that wheat seeds do not require sunlight to germinate. The hypothesis is not supported. The experimental evidence shows that in every instance, wheat seeds germinated when placed in the dark for seven days.

This is a record of all observations and measurements taken during the investigation.

Record your results in an appropriate format. Tables are useful for recording experimental data. Graphs, diagrams and photographs are also useful approaches for recording data.

If you take multiple measurements, calculating the mean (or average) gives a single representative value and can provide a clearer understanding of the data.

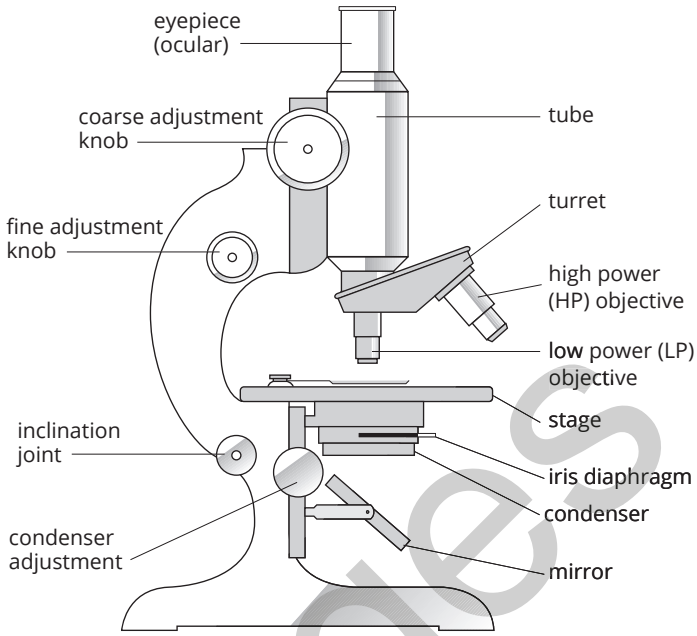
The discussion focuses on the interpretation of the experimental data. What do the results show? Are there any unexpected results? How can we account for this? Evaluation of the procedure is also included here.

The conclusion relates back to the purpose and states whether the hypothesis was supported or not supported. It also outlines the experimental evidence to support this.

Avoid terms such as 'always' and 'never' in scientific writing. Refer to what the data shows—all claims must be supported by the evidence.

User-friendly microscope hints

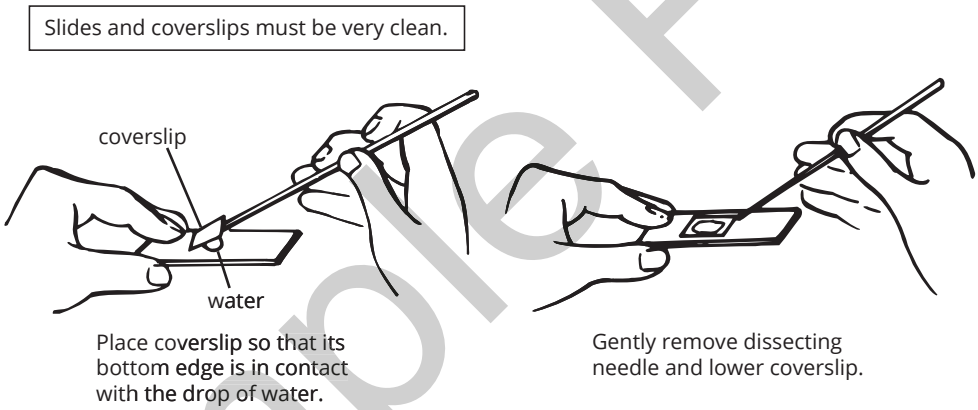
- Look down the eyepiece lens and adjust the light source (mirror, condenser lens and iris diaphragm) so the field of view is uniformly illuminated.
- Place your prepared slide on the microscope stage and centre the object to be viewed. Use the clips to secure the slide in position.
- When setting up the microscope always view the object under low power (LP) first.
- Checking from the side, wind the coarse adjustment 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 lens, 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 in place. Only use the fine adjustment knob when using HP.



A light microscope

Preparing a wet mount slide

The following figure illustrates the best technique for making a wet mount slide.



Making a wet mount slide

BIOLOGICAL DRAWINGS

The following guidelines should help you to make simple and effective biological drawings.

- 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 comparison between specimen sizes can be made—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 do not show the detail of cells, just the 'area of cell types' (Figure 1).
- Drawings of images made under high power show detail of a few cells only of each type (Figure 2).

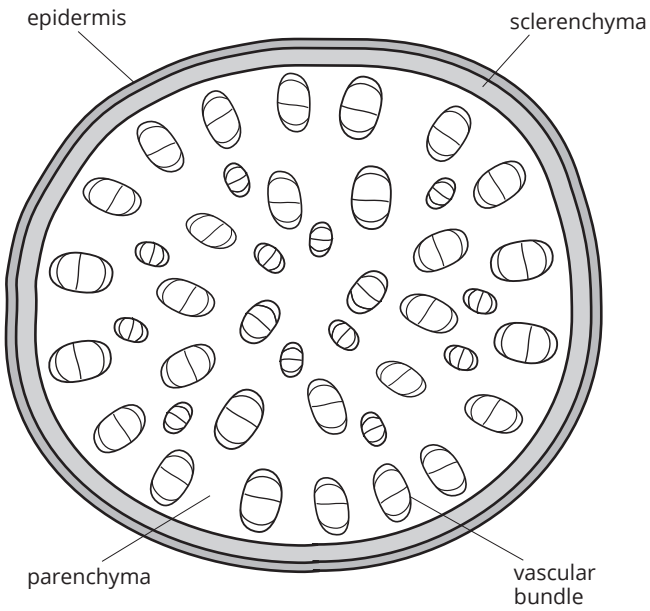


Figure 1 A low power view of zea maize cells (30×)

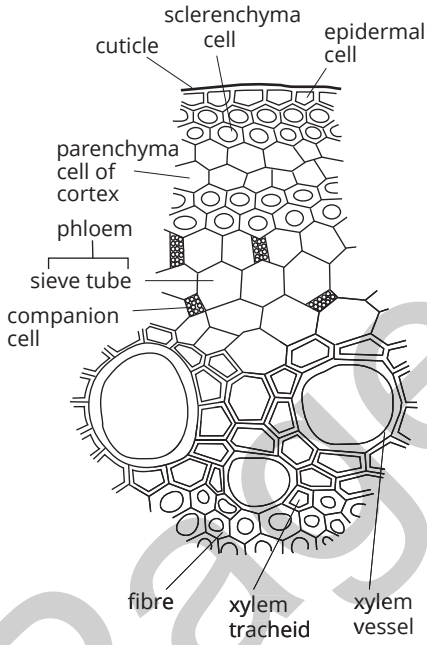


Figure 2 A high power drawing of zea maize cells (600×)

Techniques of monitoring and maintaining ecosystems

When studying ecosystems, it may be necessary to determine the type and number of living organisms in an area. For example, your investigation may look at the population of a particular species in two different areas. There are many different ways to do this, including using quadrats and transects.

QUADRATS AND TRANSECTS

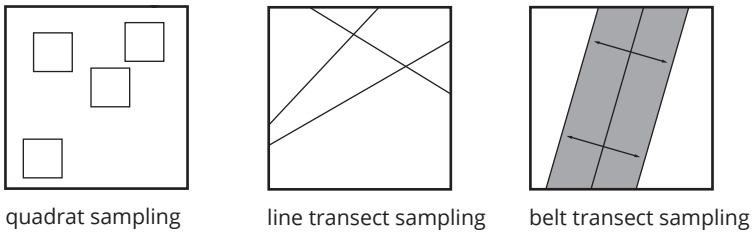
A **quadrat** is an area marked out with a frame for the purpose of gathering data related to populations of organisms in a given area.

- It is usually 1 m^2 but can be adapted to suit the specific ecosystem.
- A number of quadrats placed randomly around the habitat can provide a useful estimate of the presence, density and abundance of different species within the area.

A **transect** is a line marked out randomly through a habitat.

- Every organism on the line at regular intervals or within the transect is recorded.
- Variations in community composition throughout the habitat can be assessed.
- Line transects are time-efficient and can minimise disturbance to the environment. However, species of low density can be missed.
- Belt transects extend out a specific distance to either side of the line. They are time-intensive but can provide more accurate estimates of community populations.

Permanent quadrats and transects can be used to measure, estimate and predict changes in the diversity and abundance of populations over time.



Sampling methods: quadrat sampling, line transect sampling and belt transect sampling

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UNIT 1

How do organisms regulate their functions?

AREA OF STUDY 2

How do plant and animal systems function?

Outcome 2

On completion of this unit the student should be able to explain and compare how cells are specialised and organised in plants and animals, and analyse how specific systems in plants and animals are regulated.

Key knowledge

Functioning systems

- specialisation and organisation of plant cells into tissues for specific functions in vascular plants, including intake, movement and loss of water
- specialisation and organisation of animal cells into tissues, organs and systems with specific functions: digestive, endocrine and excretory

Regulation of systems

- regulation of water balance in vascular plants
- regulation of body temperature, blood glucose and water balance in animals by homeostatic mechanisms, including stimulus–response models, feedback loops and associated organ structures
- malfunctions in homeostatic mechanisms: type 1 diabetes, hypoglycaemia, hyperthyroidism.

Functioning systems

Many organisms consist of single cells. These are called **unicellular organisms**, and include *Amoeba*, *Paramecium* and bacteria.

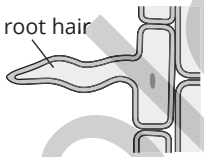
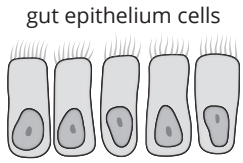
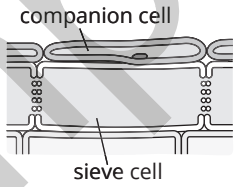
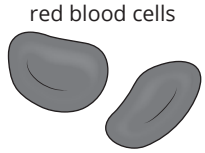
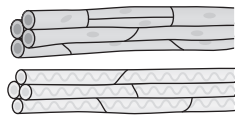
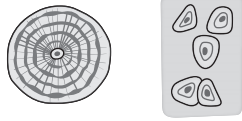
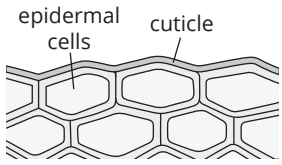
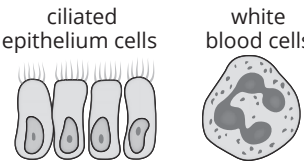
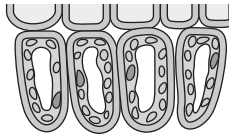
Organisms that have more than one cell are called **multicellular organisms**. Some multicellular organisms are simple and do not possess organs or organ systems while other are very complex in structure—they are composed of many different kinds of cells. As multicellular organisms increase in complexity, their cells work together to achieve higher levels of organisation. The levels of organisation in multicellular organisms are specialised cells, tissues, organs and systems.

MULTICELLULARITY, CELL SPECIALISATION AND ORGANISATION

- Cells have features that make them well suited to carrying out a particular function. Such cells are known as **specialised cells**. For example, muscle cells are specialised cells that contain contractile fibrils that allow cell contraction (Table 1.2.1).
- A group of cells that work together to achieve a particular function is called a **tissue**. For example, a group of muscle cells is called muscle tissue.
- A group of tissues that work together to perform an overall function is called an **organ**. For example, the stomach is composed of muscle tissue and vascular tissue.
- A group of organs that work together to perform an overall function form a **system**. For example, the digestive system is composed of the mouth, stomach, liver and intestine.

Multicellular organisms may be composed of many systems, such as the digestive, respiratory, excretory, nervous and endocrine systems.

Table 1.2.1 Some different types of specialised cells in plants and animals, their appearance and function

Cell function	Cell specialisation	
	Plant cells	Animal cells
exchange		
transport		
strength/support		
protection/defence		
photosynthesis		

TRANSPORT IN VASCULAR PLANTS

Vascular plants feature a series of tubes called **vascular tissues** for the transport of substances throughout the plant (Table 1.2.2).

Vascular tissues

In vascular plants, there are two types of vascular tissue: xylem and phloem.

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

Plasmodesmata (singular plasmodesma), fine channels that link plant vascular cells, allow lateral movement of nutrients from cell to cell.

The transport of organic solutes from the leaves to other tissues in the plant is known as **translocation**.

Table 1.2.2 Characteristics of transport in plants

Vascular tissue	Xylem	Phloem
substances involved	• water • inorganic nutrients	organic nutrients, e.g. sugars
direction of transport	from roots up through the plant	from leaves to rest of plant in both directions (upwards and downwards)
processes involved	• transpiration and root pressure draw water upwards • no energy expenditure by the plant	active process requiring energy

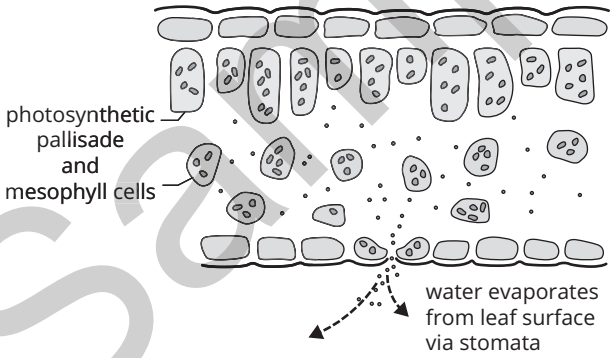


Figure 1.2.1 Cross-section of leaf tissue

Water regulation in vascular plants

Plants control some aspects of their internal environment, including:

- water loss
- concentration of salts.

Stomata (singular stoma) are pores bounded by **guard cells** in the epidermis of leaf and stem tissue (Figures 1.2.1 and 1.2.2). Stomata are responsible for the:

- rate of water loss through transpiration
- exchange of carbon dioxide and oxygen from plants.

Transpiration is the loss of water from plants through evaporation, mainly via stomata.

Guard cells work in pairs and are connected at their ends. When water passes into the guard cells, their internal fluid pressure, or **turgor**, increases and their outer elastic walls bend more than the thickened inner walls, causing the stomatal pore to increase in size and the stomata to open.

Plants that inhabit hot, dry environments have features that allow them to achieve water balance. Some of these features are outlined in Table 1.2.3.

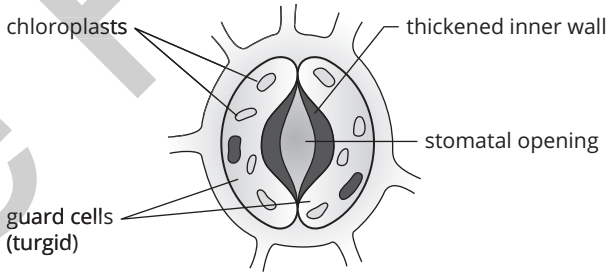


Figure 1.2.2 Stomata and guard cells. Note that with the exception of guard cells, the epidermal cells lack chloroplasts.

Table 1.2.3 Features of plants that inhabit hot, dry environments

Function	Features
reduce water loss	• thick cuticle • leaves with reduced surface area • decreased number of stomata • sunken stomata, hairy leaves and ability to roll leaves create a pocket of humid air around the stoma; this decreases the water–vapour gradient between the intercellular spaces and the external environment, thereby reducing the rate of water loss by evaporation
increase water uptake	shallow, spreading root system
store water	succulent leaves/stems

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ANIMAL SYSTEMS

Complex animals, including humans, are composed of billions or even trillions of specialised cells organised into tissues, organs and systems. The grouping of organs into systems is the highest level of biological complexity. There are eleven organ systems in mammals, each with specialised roles that are essential for the correct functioning of the organism. These systems do not work in isolation; they have vital connections to one another, and many of their functions overlap.

Digestive system

The foods consumed by **heterotrophs** (organisms that obtain nutrients by consuming other organisms) are useful on a cellular level. However, most organic nutrients ingested in the diet are in a form that is too large to enter cells. This organic matter needs to be broken down into simpler forms so that it can ultimately pass across plasma membranes and into cells. This process of breaking large food molecules into smaller ones is called **digestion**. Digestion involves the physical and chemical breakdown of food molecules (Table 1.2.4).

Table 1.2.4 Comparison of physical and chemical digestion

	Physical digestion	Chemical digestion
Type of process	mechanical breakdown of larger food pieces into smaller pieces	chemical change of complex molecules into simpler ones
Purpose	smaller pieces have a relatively larger surface area that allows enzymes to work more efficiently	simpler molecules can pass through plasma membranes and into cells
Requires	teeth and muscles	enzymes and appropriate pH conditions
Where it occurs	mouth and stomach	• mouth, stomach and small intestine • rumen and caecum in herbivores
Examples	• teeth chewing food • muscles of stomach churning food into semi-liquid form called chyme	• lipases act on lipids • proteases act on proteins • amylases act on carbohydrates • gastric lipase begins converting fats into fatty acids and glycerol

Different kinds of heterotrophs have different digestive structures depending on their diets.

Larger, complex animals need to ensure digestion occurs efficiently enough to meet generally higher energy demands. These systems have the following characteristics:

- adaptations for acquiring food
- reliance on physical breakdown of food
- appropriate structures for handling and chewing food
- one-way gut that is compartmentalised into different sections each providing an optimal environment for different digestive enzymes
- high surface area for absorption of nutrients from gut into circulatory system
- movement of food along the system and removal of undigested material.

Features of mammalian digestive systems

Simple animals rely primarily on chemical processes involving **digestive enzymes**. Larger, more complex animals (e.g. humans) also utilise mechanical processes during digestion. Given the relationship between surface area and volume, digestion is much faster if food is in small pieces and the enzymes have a proportionally larger surface area to act upon.

The process of breaking apart complex molecules into simple molecules is called **chemical digestion**, and is carried out by the action of enzymes. Enzymes are important in digestion because they greatly increase the rate of breakdown of food molecules.

Mammalian digestive systems primarily consist of:

- mouth
- oesophagus
- stomach
- small intestine
- large intestine
- rectum
- anus
- associated organs such as salivary glands, liver, gall bladder and pancreas, which release enzymes and other chemicals into the digestive tract (Figure 1.2.3 on page 48).

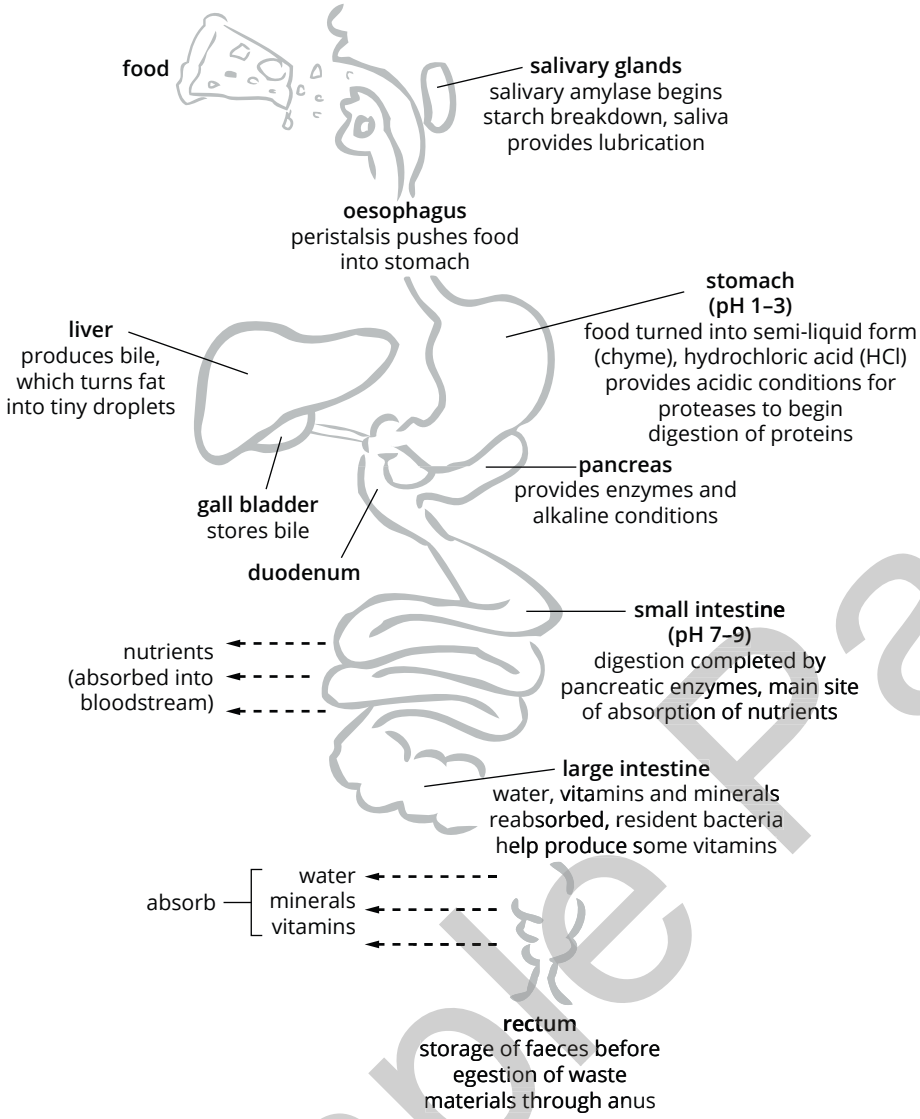

Figure 1.2.3 Schematic diagram of digestive processes in mammals

Excretory system

Animals produce a variety of substances that they no longer need or can tolerate. **Excretion** is the removal of these substances. The main waste products are carbon dioxide from cellular respiration and **nitrogenous waste** from digestion.

Nitrogenous waste is continually produced as a result of the breakdown of proteins. The main waste product is ammonia (NH_3). This is a highly toxic, soluble compound that must be removed by animals.

Kidney

The **kidney** is the main excretory organ in vertebrates. It is involved in removing nitrogenous wastes and maintaining water balance.

Features of the mammalian kidney that facilitate filtration and water conservation:

- divided into cortex and medulla region
- functional unit is the **nephron**, which is made up of the glomerulus, Bowman's capsule, proximal tubule, loop of Henle, distal tubule, collecting duct
- key waste is **urea**
- able to reabsorb most of the primary filtrate, including glucose, ions, amino acids and water
- capable of producing concentrated **urine** (low water concentration).

The nephron is a structure composed of a tube with specialised regions for carrying out various functions so that, ultimately, concentrated urine is produced.

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The kidneys of desert-adapted mammals feature a relatively long loop of Henle, which results in greater water reabsorption and therefore a smaller volume of concentrated urine (Table 1.2.5 and Figure 1.2.4).

In insects, a series of tubules called the Malpighian tubules are adapted for removing nitrogenous wastes in the form of uric acid.

Table 1.2.5 Major components of the mammalian kidney and their functions

Structure	Function	Location
glomerulus	network of capillaries carrying blood under high pressure in Bowman's capsule of the nephron	cortex
Bowman's capsule	collects primary filtrate (nitrogenous waste and other small water-soluble molecules) forced by the high pressure in the glomerulus	cortex
proximal tubule	site of selective reabsorption of useful substances such as water, glucose, amino acids, salts	cortex
loop of Henle	uses active transport to establish salt concentration gradient to enhance water reabsorption	medulla
distal tubule	tubular resorption of substances such as sodium by active transport (water follows by osmosis)	cortex
collecting duct	reabsorption of water by osmosis so that concentrated urine leaves the nephron	cortex and medulla

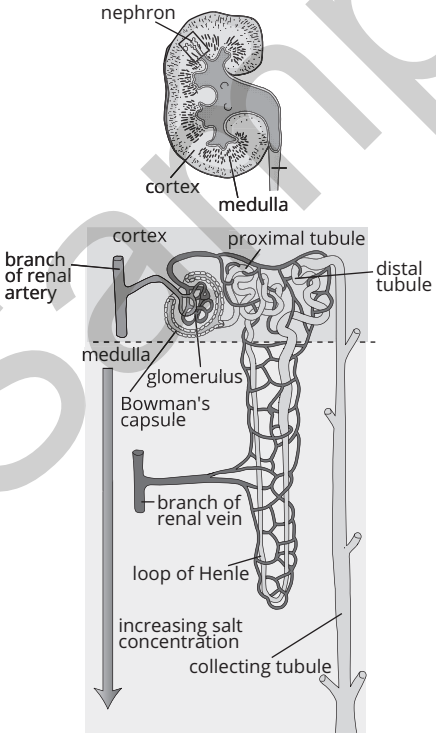

Figure 1.2.4 Mammalian kidney and nephron

Regulation of systems

Multicellular organisms are complex in structure and require communication systems to ensure that their tissues, organs and systems are regulated and coordinated.

DETECTING AND RESPONDING TO CHANGE: HOMEOSTASIS

Detecting and responding to change is critical to the survival of organisms. Plants and animals have different mechanisms for meeting these demands.

Regulation of the internal environment in multicellular animals is more complex than in plants. It relies on the integration and coordination of both the nervous system and endocrine system to maintain internal conditions within a relatively narrow range. This ability to maintain a relatively stable internal environment is called **homeostasis**.

Together the nervous system and endocrine system regulate the activities of other body systems (Figure 1.2.5).

Multicellular organisms may display homeostatic control in relation to many aspects of their internal environment, including:

- core body temperature
- blood concentrations of glucose, hormones (e.g. insulin), carbon dioxide, inorganic ions
- oxygen levels
- pH of blood
- blood pressure
- solute concentration (water balance).

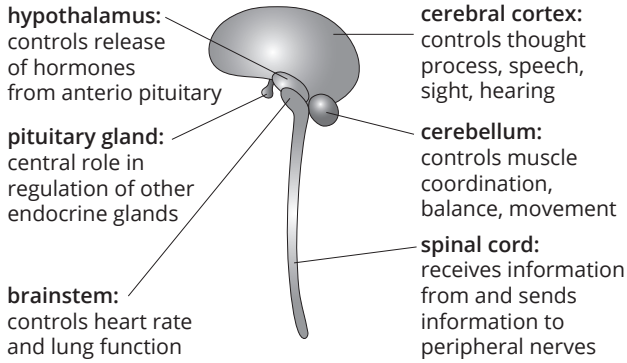

Figure 1.2.5 The central nervous system and selected endocrine glands

The nervous system

The mammalian **nervous system** is composed of:

- the central nervous system (CNS)—brain and spinal cord
- the peripheral nervous system (PNS)—relays information to and from the CNS.

Responses coordinated by the nervous system may be voluntary (under conscious control) or involuntary. Involuntary activities are under the control of the autonomic nervous system, which regulates unconscious activities such as digestion and metabolism, as well as life-sustaining functions such as heartbeat and breathing.

The functional unit of the nervous system is the nerve cell (neuron) (Figure 1.2.6).

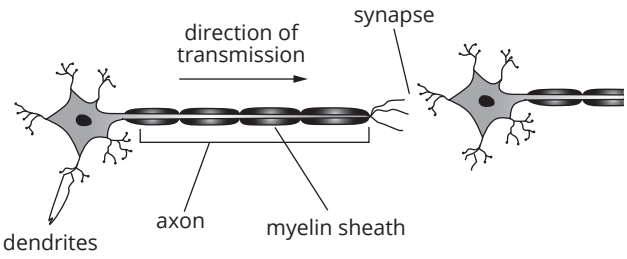

Figure 1.2.6 A neuron

Information is conducted along a nerve cell as an electric impulse, or action potential. The magnitude of an action potential does not vary—when a nerve cell is electrically stimulated, an action potential either occurs or does not occur; that is, the stimulus is sufficient to generate an action potential or not.

Communication between nerve cells occurs by chemical transmission across a synapse—a junction between two neurons. **Neurotransmitters** are a kind of chemical messenger referred to as signalling molecules, because they trigger a response in specific cells called target cells.

The endocrine system

The **endocrine system** is a system of 'ductless' glands that produce **hormones** (another kind of signalling molecule) involved in the regulation of various body functions (Figure 1.2.7). Hormones:

- travel from the glands that produce them to target tissues where they exert their effect
- travel via the bloodstream
- are specific, initiating a response only in target tissue
- are effective in low concentrations
- elicit responses that are relatively slow and long-lasting compared to nervous responses.

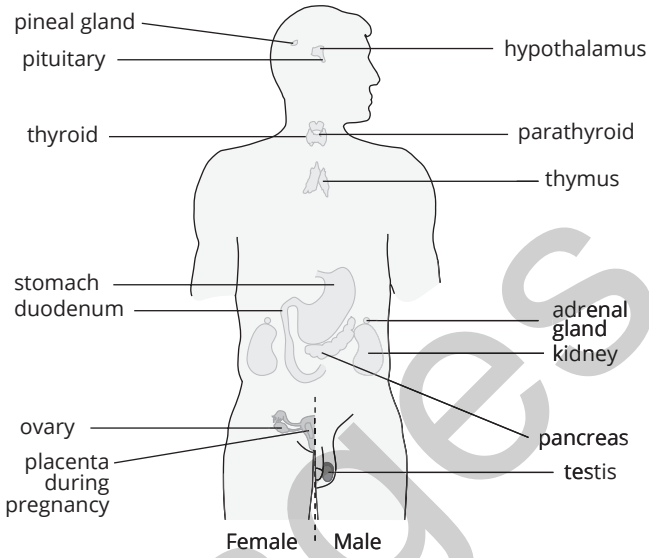

Figure 1.2.7 The endocrine system

Negative feedback loops

Maintaining internal conditions within narrow limits relies on feedback mechanisms called **negative feedback loops**. Negative feedback is an important homeostatic mechanism—it is a **stimulus–response mechanism** in which the response reduces the magnitude of the original stimulus. This returns the internal environment to its original state.

A negative feedback loop acts as follows (Figure 1.2.8a):

1. The system is in a stable state and a change (**stimulus**) occurs.
2. The change is detected by an appropriate **receptor**.
3. The receptor sends a signal to a **control centre** (nervous system or endocrine system).
4. The control centre sends a signal to an appropriate **effector** or a specific effector cell, tissue or organ.
5. The effector responds to the signal and the original state is restored.

Negative feedback loops maintain the stability of various factors of the internal environment in multicellular animals, such as the regulation of blood glucose, water balance and body temperature (Figure 1.2.8b).

When feedback loops fail to maintain homeostasis in any given factor, disease ensues. Diabetes is one example (see page 52).

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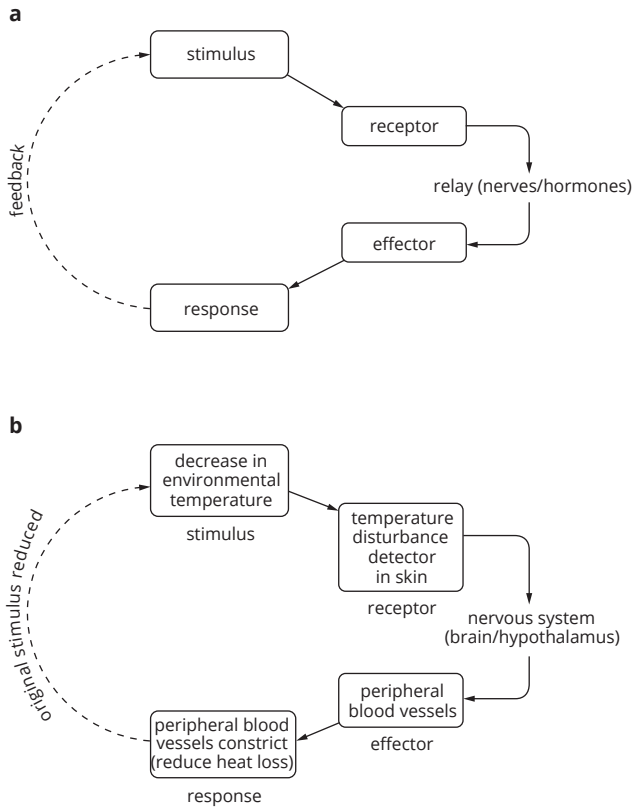

Figure 1.2.8 (a) Negative feedback loop. (b) Negative feedback and temperature control

REGULATION OF BODY TEMPERATURE

The body temperature of **ectotherms** is dependent on their environment, but **endotherms** generate their own body heat through metabolic processes, and tend to maintain an internal body temperature that is above that of the environment.

Temperature disturbance detectors in the skin of endotherms detect changes in the external environment. The body responds in ways that ensure no change to the core body temperature. When these responses are not sufficient to maintain core body temperature within the optimal range, misalignment detectors recognise the change to core body temperature and a more vigorous response is put in place to return the body temperature to normal (Figure 1.2.8b).

REGULATION OF BLOOD GLUCOSE

Blood glucose levels (BGL) are regulated by an interplay of the hormones **insulin** and **glucagon**. Insulin decreases blood glucose level when it is high. Glucagon increases blood glucose level when it is low (Figure 1.2.9).

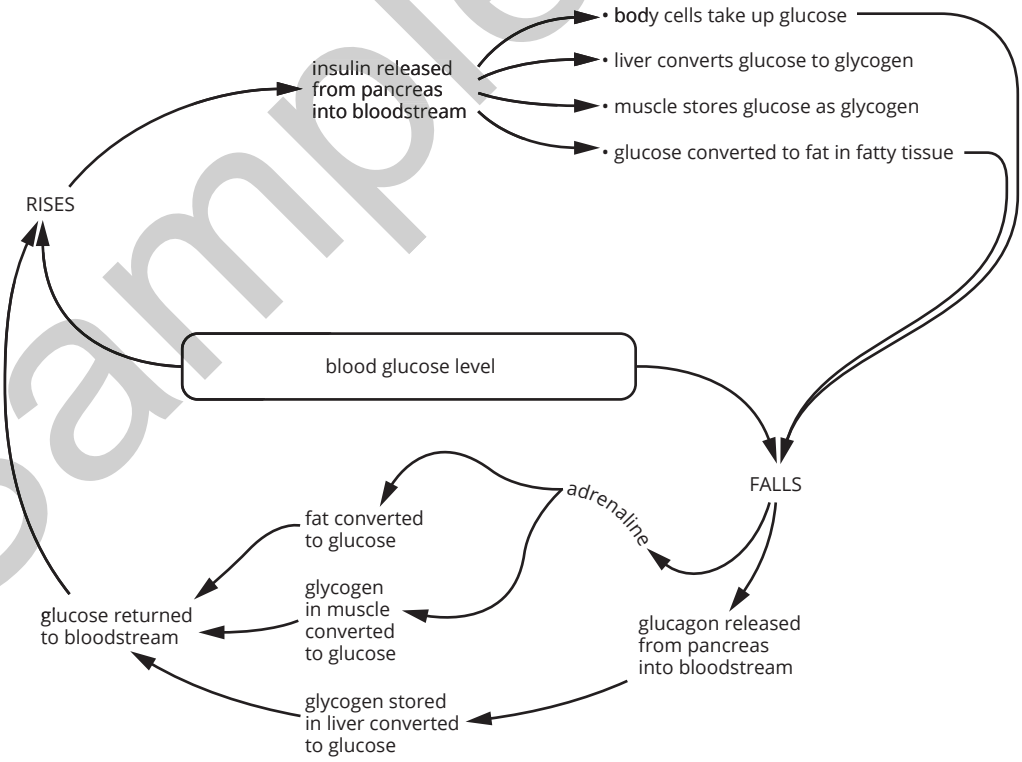

Figure 1.2.9 Concept map—blood glucose level control

REGULATION OF WATER BALANCE

Maintaining water balance presents different challenges for aquatic and terrestrial (land) organisms. Aquatic organisms face challenges in relation to internal solute concentrations and water balance. This varies enormously between saltwater and freshwater environments. **Osmoconformers** are animals that conform to changes in their external environment—the solute concentration in their cells is the same as the solute concentration of their external environment. Most marine organisms are osmoconformers. **Osmoregulators** control their body solute concentrations, maintaining a stable internal environment (Table 1.2.6).

Terrestrial animals face continual water stress. They have different kinds of adaptations to achieve water balance. Water is lost through the excretion of harmful nitrogenous wastes that are produced during metabolism. It is also lost from the respiratory surfaces, from skin and in faeces. Water loss can be reduced, depending on the form in which the nitrogenous wastes are removed from the body. This is specific to different kinds of organisms—the form of nitrogenous waste produced is dependent on the availability of water.

The nitrogenous waste produced by the cells of mammals is called urea. Urea is toxic to cells. It is soluble in water and removed at the kidneys in the urine.

Table 1.2.6 Body solute concentration and water balance

Osmoregulator	Body solute concentration	Maintain solute concentration by
freshwater fish	higher than external environment	• rarely drinking • actively take up salts • large volume of dilute urine
saltwater fish	lower than external environment	• drinking sea water • actively excrete salts • small volume of concentrated urine

MALFUNCTIONS IN HOMEOSTATIC MECHANISMS

Malfunctions in homeostatic mechanisms result in a less than optimal function and can be dangerous if not addressed.

Examples:

- **Type 1 diabetes** occurs when an insufficient supply of the hormone insulin is produced by the pancreas. When this happens, patients are reliant on regular daily administration of insulin. Insulin deficiency results in **hyperglycaemia** (high blood glucose levels) and accelerates the breakdown of fat for the body to use as energy.
- At the opposite extreme is **hypoglycaemia**, a condition in which blood glucose levels fall below the safe baseline. This can occur in diabetic patients if too much insulin is taken, when too little food is consumed over a period of time, or when too much exercise depletes blood glucose.
- **Hyperthyroidism** results from an overactive thyroid gland. When this occurs, the thyroid gland produces excessive thyroid hormone, increasing the metabolism of cells. Some symptoms of hyperthyroidism are excessive sweating, heat sensitivity, weight loss, increased heart rate and fatigue. Depending on the severity, this condition may be treated with medication or surgery.

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Knowledge review—structure and function in organisms

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 area of study 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 each of the following terms.

a homeostasis

b endocrine system

c neuron

d hormone

2 Read the definitions provided in the boxes on the right of the page. Choose the correct term from the list below to match each definition and write this term in the corresponding box.

multicellular	herbivore	excretory system	unicellular
tissue	digestive system	root	leaf
organ	carnivore	specialised cell	

	an organism whose diet is composed primarily of the flesh of other animals
	a cell that has features that make it well suited to a particular role
	a plant organ with a structure that makes it specialised for harnessing sunlight in the process of photosynthesis
	a group of different kinds of tissues that work together to perform a specialised overall function
	describes an organism that is composed of many cells

	a body system in animals that is responsible for excreting metabolic wastes
	an organism whose diet is composed primarily of plant material
	describes an organism that is composed of a single cell
	a system in many animals that is responsible for the breakdown of foods into smaller particles that can then be absorbed into the bloodstream
	a collection of similar cells that work together to perform a particular overall function
	an organ responsible for taking up water and nutrients from the soil and transporting these nutrients to other parts of the plant

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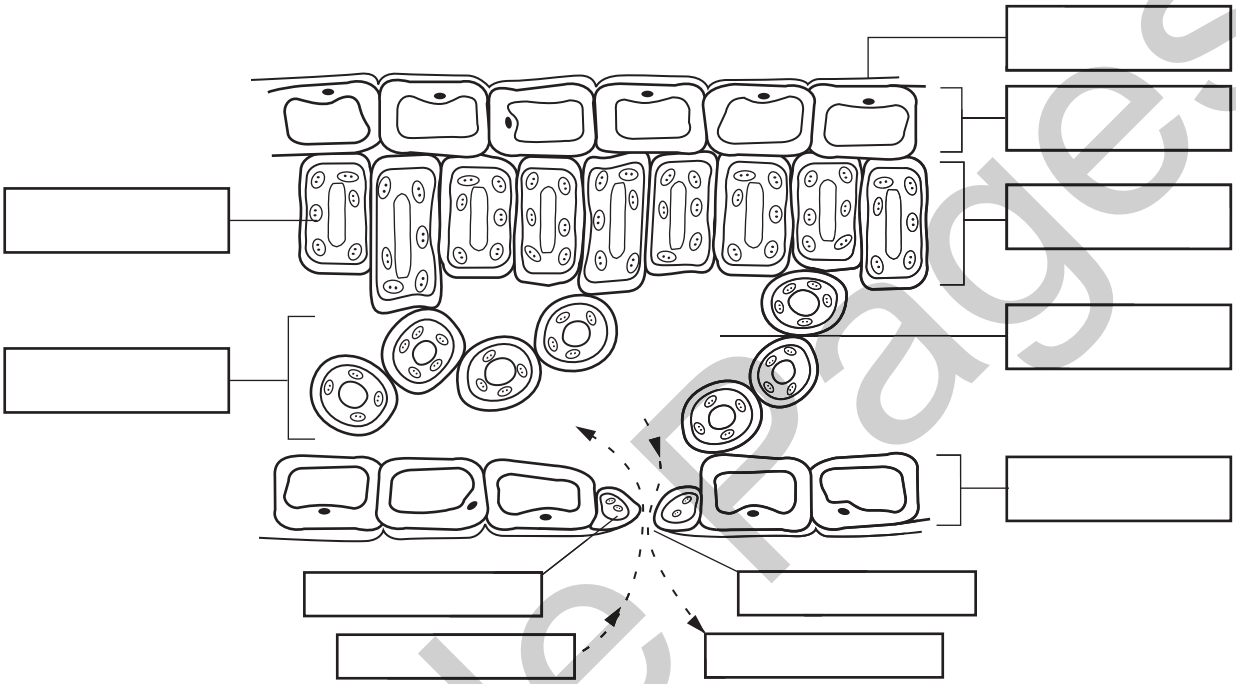
Water and gas regulation in plants

In plants, the regulation of water and gases are strongly interconnected. Pores in the epidermis, called stomata, allow for the passage of water vapour from leaf surfaces, as well as the exchange of oxygen and carbon dioxide with the external environment. Each stoma is bounded by two guard cells.

1 **a** Label the structures shown in the cross-section of a typical leaf.



b What unusual feature do guard cells possess that is different from other epidermal cells?

c The stomata are the site of gas exchange in plants. In many species of plants the distribution of stomata between the upper and lower epidermis is uneven. Suggest an explanation for this.

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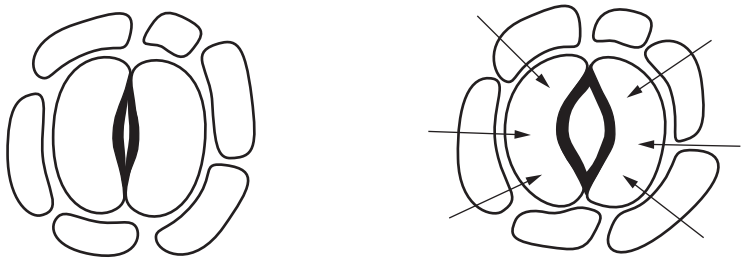
2 Look carefully at the differences between the shapes of the guard cells in the following diagrams.



A closed **B** open

a Label the guard cells in A.

b The arrows in B represent an input into the cell. Suggest what the input is, and outline the effect it has had on the guard cells.

c Describe two features of guard cells that explain their control over the stomatal aperture.

Feature 1:

Feature 2:

3 Water and gas regulation in plants are closely related. Green plants need sunlight to photosynthesise. However, in the hottest part of the day, when sunlight is most intense, plants often close their stomata. This is especially true when conditions are both hot and dry.

a Explain how stomatal closure helps plants regulate water balance.

b Describe the effect that closing stomata is likely to have on the rate of photosynthesis for plants during daytime sunlight conditions.

c Given green plants need sunlight to photosynthesise, comment on the overall costs and benefits for a plant closing its stomata during the heat of the day when sunlight is likely to be most intense.

Negative feedback loops and temperature regulation

Negative feedback loops are important homeostatic mechanisms that ensure the internal environment remains within narrow limits. A model of a negative feedback loop is set out as a guide (Figure 1.2.11).

Example: It's a warm day, you are playing sport and forgot your water bottle.

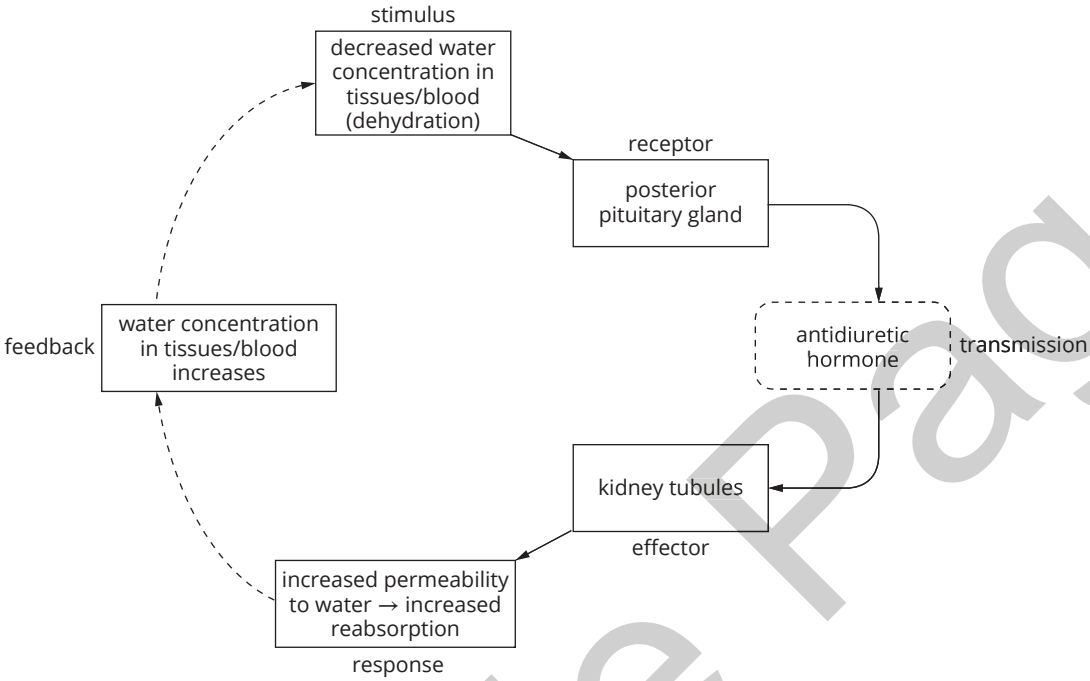
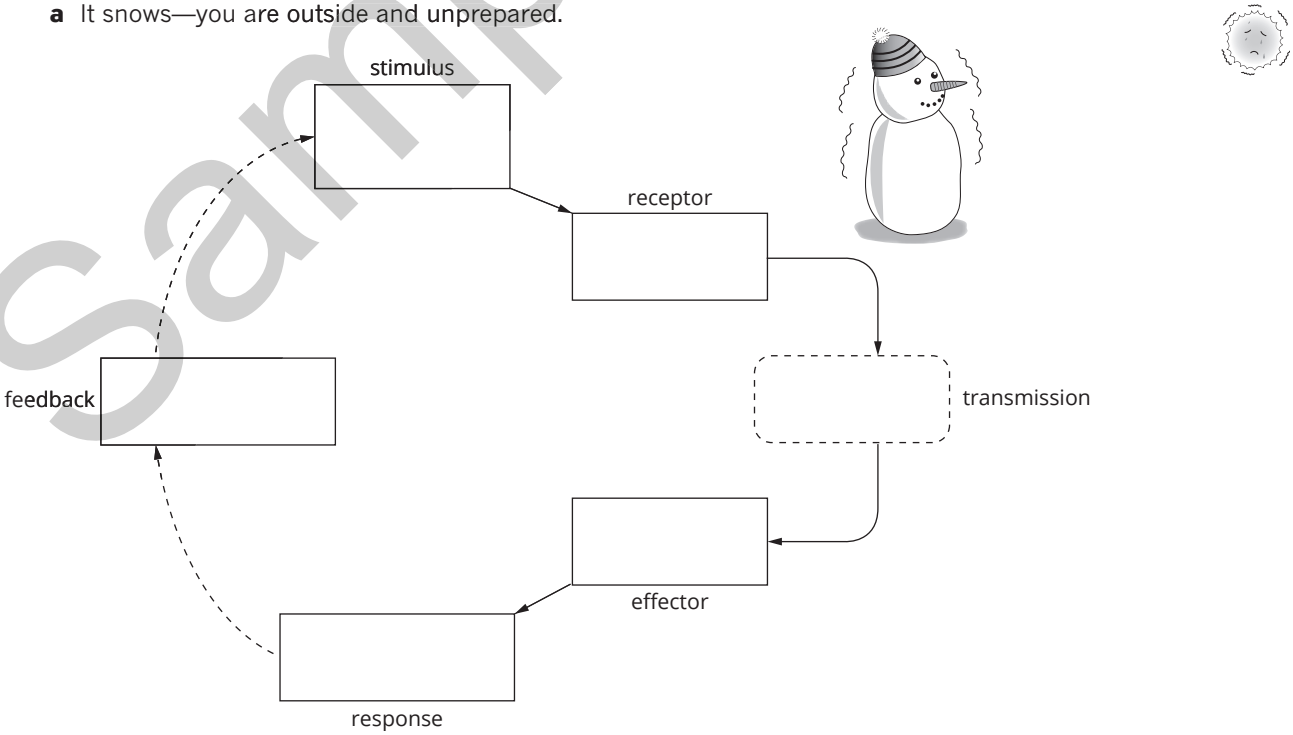


Figure 1.2.11 A negative feedback loop

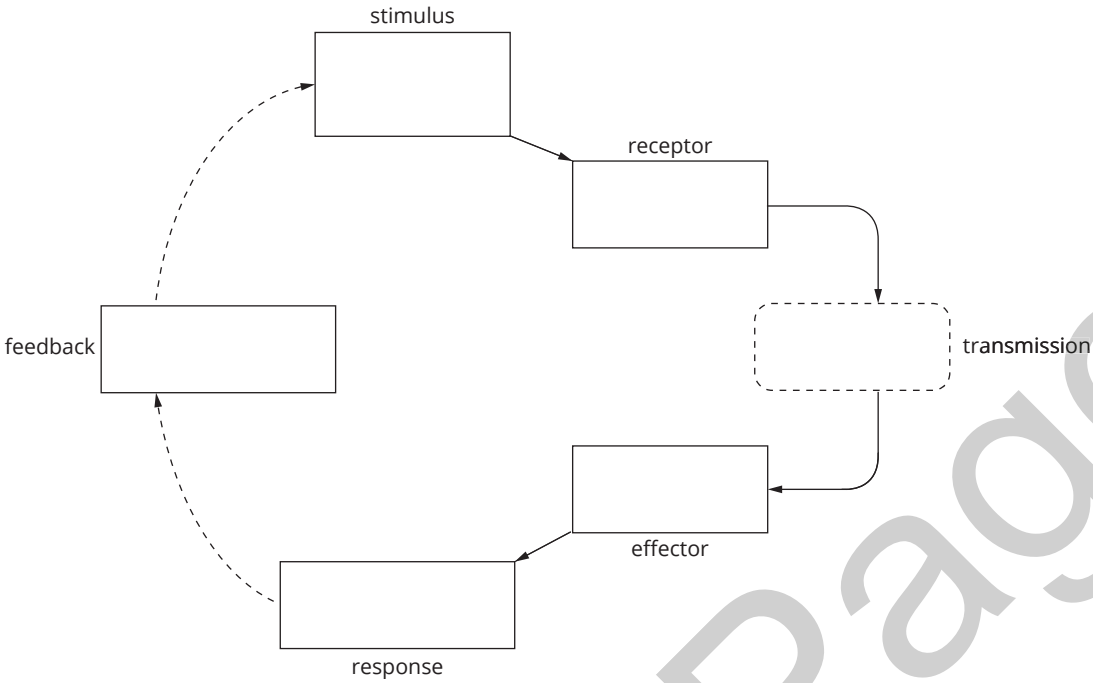
1 Use a pencil to complete the negative feedback loops below. List the receptor, means of transmission, effector, response and feedback for the different stimuli listed. You may include more than one effector and response.

Stimulus

a It snows—you are outside and unprepared.



b You are outside on a very hot summer day.



2 Outline the difference between a stimulus–response mechanism and a negative feedback loop.

3 Summarise the importance of negative feedback loops to the body.

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PRACTICAL ACTIVITY 7

Case study • Modelling

Regulation of blood glucose

Suggested duration: 50 minutes

AIM

- To consider the hormones and negative feedback systems that are in place to control blood glucose levels.
- To explore the effects on blood glucose levels and the individual in the case of hormone deficiency, such as occurs in diabetes.

PART A • NORMAL BLOOD GLUCOSE REGULATION

BACKGROUND

In 1868 at the University of Freiburg in Germany, Paul Langerhans, a professor of pathology, was examining pancreas sections under the microscope. At that time, it was known that the pancreas secreted digestive enzymes that were carried in ducts to the duodenum. Langerhans observed several small areas of cells that looked quite different from the other cells of the pancreas. These clusters of cells appeared to have no ducts associated with them and they were well supplied with blood vessels. They become known as 'islets of Langerhans'. Scientists were interested to learn the function of these clusters of cells. A number of observations were made.

- Animals from which the pancreas had been removed developed symptoms similar to those shown by diabetics; that is, they excreted large amounts of glucose in their urine.
- Tying off the pancreatic duct that carried the digestive enzymes to the duodenum caused the pancreas to partially degenerate, but the islet cells were not affected and the animals did not develop diabetes.

By 1912, scientists were almost certain that the islet cells produced the substance that prevented the onset of diabetes. They named the substance insulin, from the Latin *insula*, meaning islands.

Today we know that the pancreas is involved in the production of two important hormones that together control the levels of glucose in the bloodstream. These hormones are insulin and glucagon.

Insulin

Insulin is produced in the beta (β) cells of the islets of Langerhans of the pancreas in response to rising blood glucose levels, and travels in the bloodstream. It enhances the rate at which cells take up glucose from the blood. There are receptor sites on plasma membranes that bind insulin, altering the permeability of the plasma membranes to glucose and altering the rate of activity of the enzyme systems within the cell. In the liver, for example, glucose is converted to glycogen, fat and carbon dioxide.

Glucagon

Glucagon is produced in the islets of Langerhans by cells called the alpha (α) cells. It is one of a number of hormones that act to increase the level of blood glucose if the level in the blood falls. Glucagon molecules bind to receptor sites on the liver plasma membranes and stimulate the breakdown of stored glycogen to glucose, which is then released into the bloodstream to increase blood glucose levels.

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1 **a** Insulin and glucagon are hormones. Define the term 'hormone'.

b Hormones travel throughout the body in the bloodstream but they only trigger a response in the target tissue. Suggest why only target cells respond to these hormones and not other cells that might be exposed to the hormones.

2 Name the target tissue or cells upon which these hormones have their effect and describe their effect in each case.

Insulin:

Glucagon:

Consider the graphs in Figure 1.2.16 showing the relationship between blood glucose level and insulin levels.

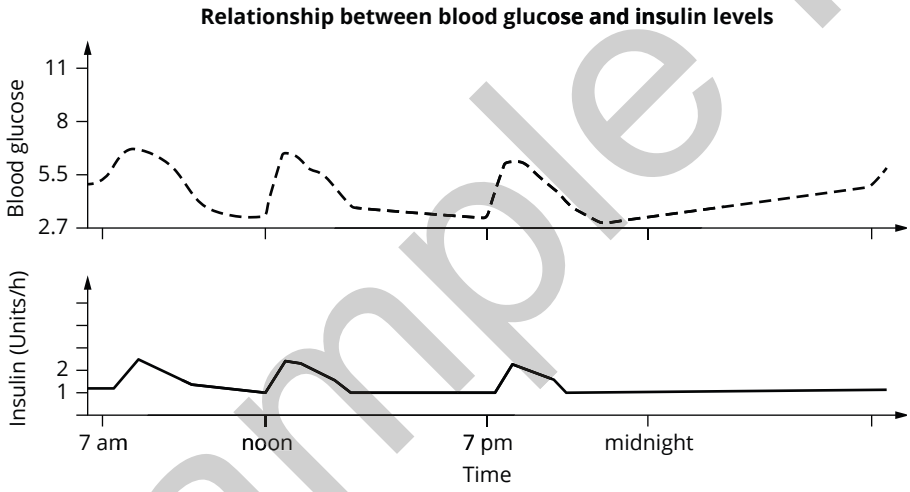


Figure 1.2.16 Relationship between blood glucose and insulin levels

3 **a** Describe the relationship between blood glucose level and insulin level.

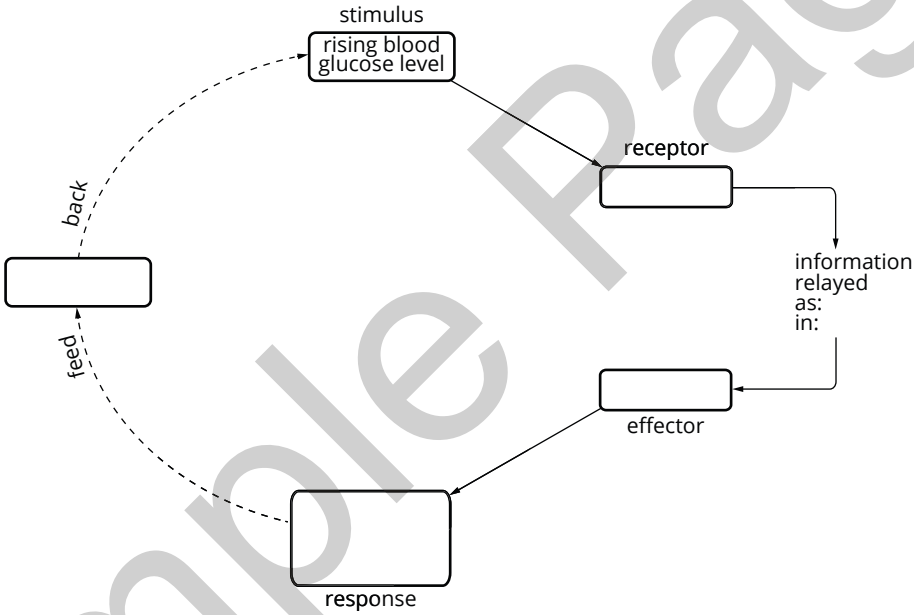
b Describe when in the day your pancreas is likely to be releasing insulin into the bloodstream. Explain your reasoning.

c When is glucagon most likely to be released? Explain.

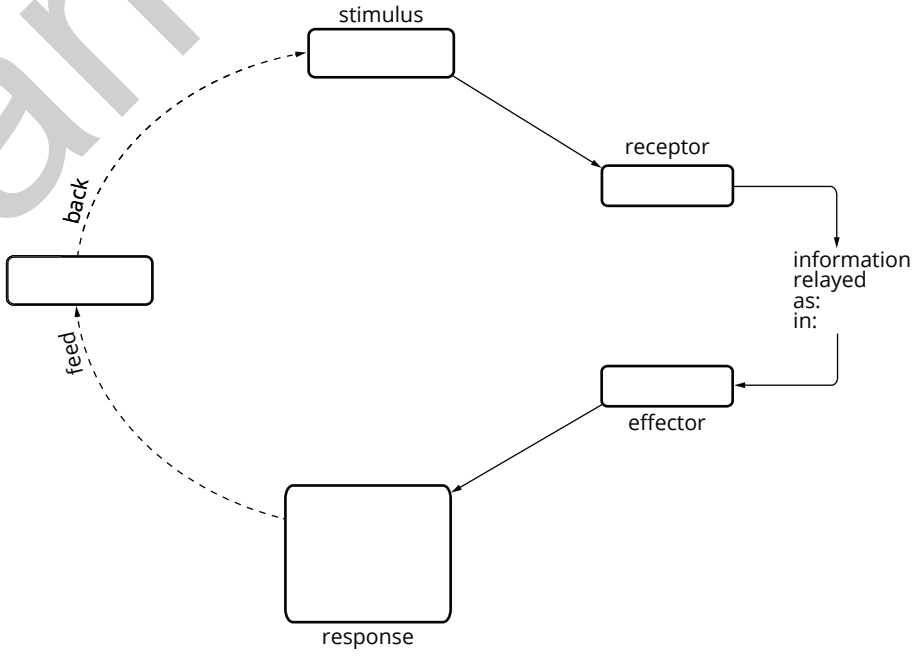
4 **a** Define the term 'negative feedback loop'.

b Use your knowledge and understanding of negative feedback loops and the homeostatic mechanisms involved in the control of blood glucose levels to complete the negative feedback models below.

i Blood glucose levels rising



ii Blood glucose levels falling



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PART B • INSUFFICIENT INSULIN

BACKGROUND

Diabetes mellitus is a disorder of the body's blood glucose regulatory mechanism. In everyone, diabetics and non-diabetics alike, the digestion of carbohydrates results in a rise in the levels of glucose in the blood. In a non-diabetic, this causes an increase in the level of insulin, which in turn leads to a reduction in blood glucose level. In diabetics, this either does not occur or occurs at a greatly reduced rate, so that levels of glucose in the blood remain so high as to be outside the normal tolerance range required to maintain a healthy individual.

There are different forms of diabetes with different causes, but they are all characterised by high levels of blood glucose. The treatment for patients depends on the particular form of diabetes. Type 1 diabetes is a form of the disease in which the beta cells of the pancreas have deteriorated to the point where they no longer produce insulin or sufficient insulin to adequately reduce high blood glucose levels. Type 1 diabetes is also called insulin-dependent diabetes because those affected must administer regular injections of insulin during the day to replace the insulin that is no longer produced by the pancreas. Symptoms often occur suddenly and treatment involves lifelong administration of insulin via injections or an insulin pump. In Australia, there are over 100 000 type 1 diabetes patients, the majority of them diagnosed as children.

5 Explain why diabetes results in high blood glucose levels.

6 Symptoms of excessively high blood glucose levels include:

- excessive urination
- increased thirst
- tiredness
- weight loss.

Use your knowledge and understanding of the role of glucose in the body and the osmotic effect of high levels of glucose in kidney filtrate to explain why each of these symptoms occurs.

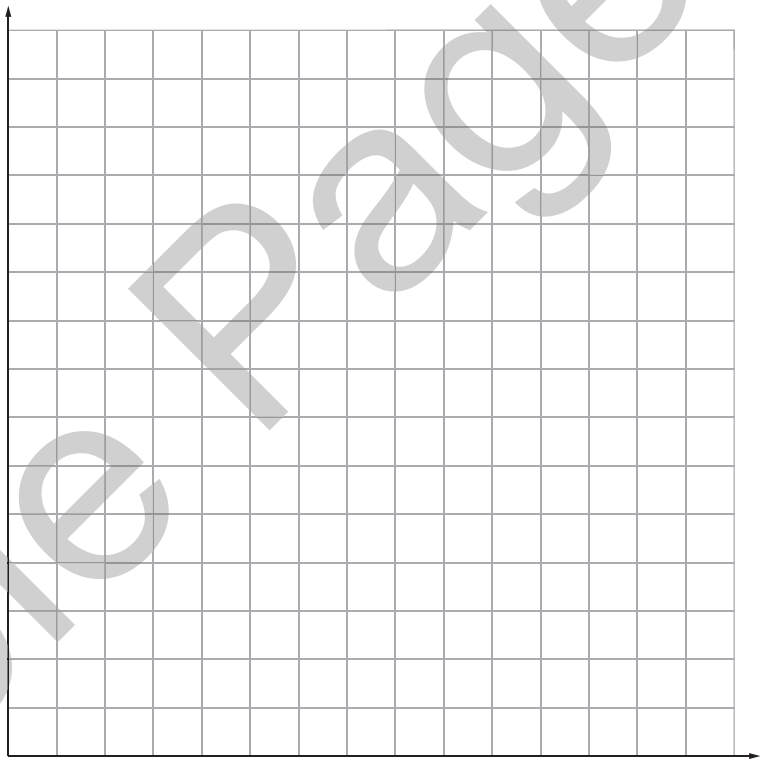
Those affected by diabetes must check their blood glucose levels several times each day before administering insulin. Blood glucose levels are measured in millimoles of glucose per litre of blood (mmol/L) using a portable blood glucose monitor. The patient takes a small sample of blood, usually from a finger, using an automatic finger-prick device that retains the sample in a small tube. The tube is placed into the blood glucose monitor where it is quickly analysed. In non-diabetics, the normal blood glucose level is about 5 mmol/L. Soon after a meal it may rise to 7 mmol/L, and after not eating for several hours it may fall to 3.5 mmol/L.

Table 1.2.7 shows the daily record of blood glucose levels of an 11-year-old boy with type 1 diabetes, taken during the week that he was on camp. His blood glucose levels were being controlled using daily insulin injections.

7 Plot the data in Table 1.2.7 on the graph paper provided. Take care to allow for the whole week on the time axis. Label both axes.

Table 1.2.7 Blood glucose levels of a diabetic boy over seven days

Day	Time	Blood glucose level (mmol/L)
Sunday	5.30 pm 10.00 pm	3.6 2.4
Monday	2.00 am 7.30 am 5.30 pm 10.00 pm	10.0 5.6 8.3 3.1
Tuesday	1.00 am 7.30 am 5.30 pm 10.00 pm	12.1 13.8 6.4 15.5
Wednesday	1.30 am 7.30 am 5.30 pm 10.00 pm	15.5 9.8 4.1 13.4
Thursday	7.30 am 5.30 pm 10.00 pm	20.3 5.8 2.0
Friday	12.00 am 7.30 am 12.00 pm 10.00 pm	15.4 18.4 25.0 2.0
Saturday	1.00 am 7.30 am	21.0 15.4



8 On the graph, mark horizontal lines to indicate the upper and lower range for normal blood glucose readings.

a Summarise the boy's fluctuating blood glucose levels over the week. Comment on any patterns that are observed.

b Suggest reasons that may account for particularly high blood glucose levels for this boy.

c Outline some strategies that might help the boy achieve lower overall blood glucose levels.

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9 Hyperglycaemia describes the condition of excessive blood glucose levels that are common in diabetic patients. The administration of insulin is one strategy that helps overcome this problem.

a Suggest a dietary strategy that a diabetic might follow in attempting to achieve relatively even blood glucose levels.

b Explain what is meant by 'hypoglycaemia'.

c Diabetics must be on the alert to avoid episodes of hypoglycaemia. Describe a situation in which a diabetic might be vulnerable to hypoglycaemia.

d Suggest an appropriate action that a diabetic might take to avoid hypoglycaemia when they are aware that an episode is likely to occur.

CONCLUSIONS

10 Describe the role of the endocrine system in the regulation of blood glucose levels.

11 Summarise the importance of negative feedback mechanisms in the regulation of blood glucose levels.

12 Outline the importance of modern technologies in the management of insulin-dependent diabetes.

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PRACTICAL ACTIVITY 8

Case study

Temperature regulation in Australian endotherms and ectotherms

Suggested duration: 50 minutes

INTRODUCTION

Ectotherm and endotherm are terms that are often used when describing the abilities of different animals to cope with different environmental temperatures. Ectotherms have a limited ability to control their body temperature, which fluctuates according to the temperature of the external environment. Endotherms maintain an internal body temperature that is independent of the external temperature.

Australian animals often have to cope with extreme environmental temperatures and have developed different ways of achieving this. The features and responses that allow animals to regulate body temperature may be structural, physiological or behavioural. These vary according to the type of animal and the environment in which it lives. For example, bilbies, which live in desert and semi-desert conditions, use a structural approach to thermoregulation, using their large ears, which are rich in capillaries, to radiate excess heat to the environment. Kangaroos and other mammals use the behaviour of licking their fur as a means of temperature regulation—when the saliva evaporates the skin cools; a form of evaporative cooling. Dilation of surface blood vessels is a physiological strategy that increases heat loss during hot conditions in humans; conversely, contraction of peripheral blood vessels reduces heat loss during cold conditions.

AIM

- To distinguish between ectotherms and endotherms.
- To identify Australian examples of ectotherms and endotherms.
- To describe ways in which these organisms regulate body temperature.

PART A • TYPES OF TEMPERATURE REGULATION

A team of scientists set about investigating the regulation of body temperature in four mammal species and a reptile species. In the investigation, five different vertebrate species were subjected to environmental temperature ranges of between 5°C and 40°C. After two hours at each environmental temperature, the animal's body temperature was recorded. The results are shown in Figure 1.2.17.

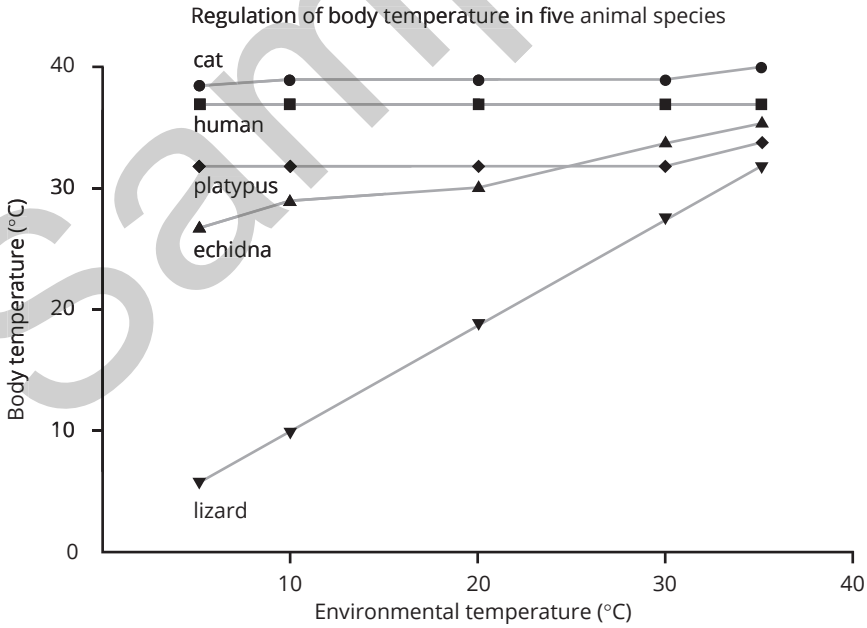

Figure 1.2.17 Relationship between external and internal temperatures in five species of vertebrate

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1 Write down the meaning of the following terms:

a endotherm

b ectotherm

2 **a** Which of the animals in the graph could be described as true endotherms? Explain.

b Which of the animals in the graph could be described as true ectotherms? Explain.

3 Suggest why there is an advantage to both endotherms and ectotherms in having a warm body temperature (within limits).

PART B • SOME METHODS OF MAMMALIAN TEMPERATURE REGULATION

4 The table below describes different responses to temperature in a range of mammals. Think about how the different responses described help these mammals to regulate their body temperature. Complete the table by entering your explanation and identifying the type of feature represented.

Temperature control in mammals		
Observation	**Explanation (how the observation relates to the regulation of body temperature)**	**Type of feature (structural, physiological or behavioural)**
An echidna living in cold regions hibernates during winter.		
Your skin often feels quite flushed on a hot day.		
Whales have a thick layer of blubber (fat) under their skin.		
You tend to feel cooler on a hot, dry day than on a humid day of the same temperature.		
Dogs pant on a hot day.		
Cats often look 'fatter' on a cold day.		

PART C • EXAMPLES OF AUSTRALIAN ENDOTHERMS

Potoroo

Temperature regulation in marsupials has been the subject of a number of investigations. One such investigation resulted in some interesting discoveries about the long-nosed rat-kangaroo or potoroo (*Potorus tridactylus*). The potoroo is a marsupial mammal about 60 cm long and weighing about 1 kg. It lives mainly along the east coast of Australia in forests and heathlands, where there is relatively thick ground cover. It sleeps by day in a nest of vegetation, and feeds at night, digging for roots, fungi and insect larvae.

The breathing rate of potoroos was measured in response to changing air temperatures. The results are shown in Figure 1.2.18.

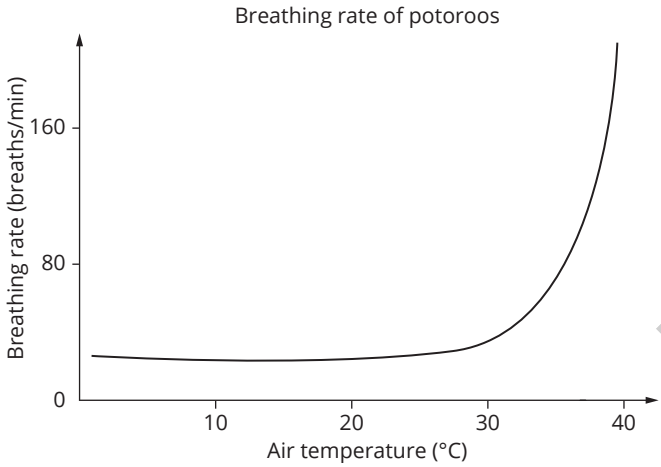

Figure 1.2.18 Variation in breathing rate with changing air temperature in the potoroo

5 **a** Describe the relationship between air temperature and breathing rate in potoroos, as shown in Figure 1.2.18.

b Outline the significance of the relationship between breathing rate and air temperature in terms of temperature regulation in potoroos.

6 A number of interesting observations not seen in most other marsupials were made about the potoroo. Complete the table below for these observations.

Temperature control in the potoroo		
Observation	**Explanation (how the observation relates to the regulation of body temperature)**	**Type of feature (structural, physiological or behavioural)**
The tail lacks hair.		
Sweat glands are observed in dense rings around the tail.		
At high temperatures, the tail appears to be quite wet.		
At high temperatures, potoroos continually twitch their tails from side to side.		

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Echidna

Biologists have studied the behaviour of the Australian echidna (*Tachyglossus aculeatus*) during winter months at high altitudes. Much of their experimental work has been carried out in Kosciuszko National Park. In one controlled experiment they captured five echidnas and implanted a miniature temperature-sensitive radio transmitter into each. These devices transmit a continuous radio signal that carries information about changes in body temperature to radio receivers that record the information.

Figure 1.2.19a shows the body temperature changes in one echidna (Figure 1.2.19b) over a 10-week period in autumn/winter. The other tagged echidnas showed similar temperature fluctuations. The biologists considered these temperatures to be evidence of the echidna entering into states of torpor punctuated by brief periods of activity. (Torpor is when an animal is sluggish and inactive.) It is still unknown what causes the periodic brief return to normal temperature every 20–25 days during autumn/winter.

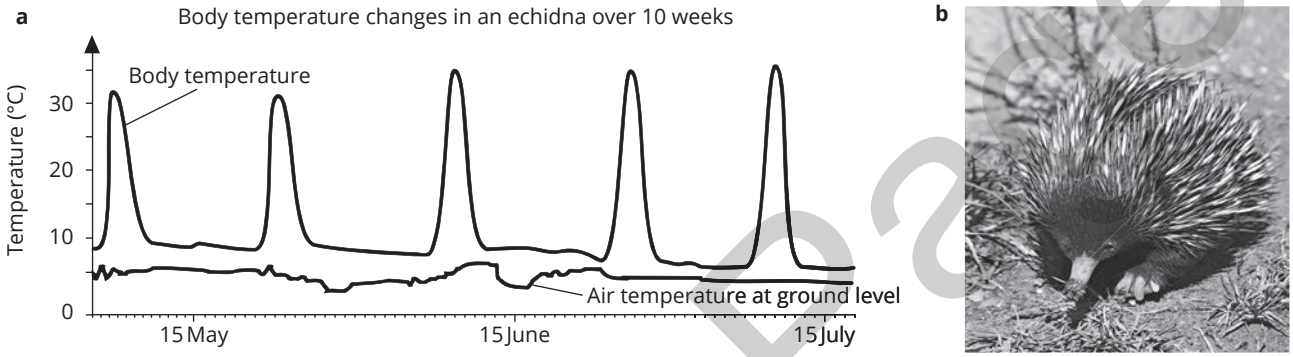

Figure 1.2.19 (a) Body temperature (upper trace) of a hibernating echidna on Prussian Plain, Kosciuszko National Park, over 10 weeks in autumn/winter. The lower trace is ground temperature. (b) An echidna

7 Describe the evidence that suggests that the echidna enters a state of torpor.

8 If measurements were made of the echidna's heart rate, oxygen consumption and overall metabolic rate when in torpor, how do you think these would differ from measurements when the echidna was active? Why do you think so?

9 Suggest how the echidna's ability to enter torpor helps it survive in very cold conditions during autumn/winter.

10 Examine the graph for human body temperature in Figure 1.2.17 on page 84, which demonstrates extremely stable internal body temperature despite a wide environmental temperature range.

a Describe a response to high environmental temperatures in humans that is:

i structural: _____

ii behavioural: _____

iii physiological: _____

b Describe a response to low environmental temperatures in humans that is:

i structural: _____

ii behavioural: _____

iii physiological: _____

CONCLUSIONS

11 a Describe two advantages of being an endotherm.

_____

_____

b Describe two disadvantages of being an ectotherm.

_____

_____

12 a Referring to the graph in Figure 1.2.17 on page 84, summarise the pattern of temperature regulation for mammals and reptiles. Use the graphical data to support your response.

_____

_____

_____

_____

b Comment on the reliability of this conclusion.

_____

_____

_____

_____

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EXAM-STYLE QUESTIONS

Multiple-choice questions

Question 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

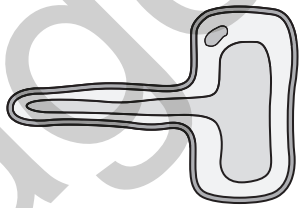
B. cells, tissues, organs, organism, systems

C. cells, tissues, organs, systems, organism

D. tissues, organs, systems, cells, organism

Question 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

Question 3

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

Question 4

Stomata in plants typically close on hot, dry days. The advantage to plants is:

A. prevention of water loss by transpiration

B. prevention of water loss by active transport

C. prevention of water loss by osmosis

D. increased water uptake by the roots

Question 5

Which statement best describes translocation?

A. the transport of water from the roots to the leaves

B. the diffusion of gases into and out of the leaf

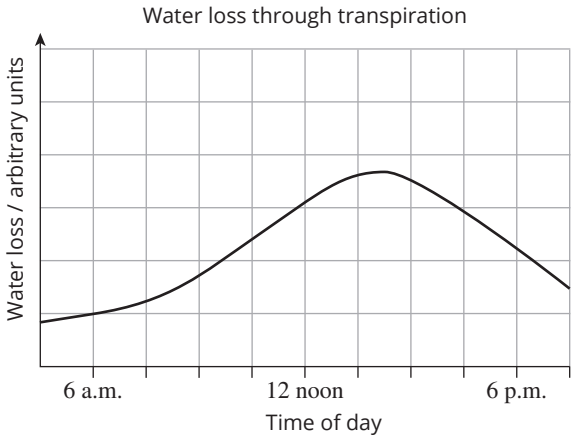
C. the transport of mineral ions from the roots and throughout the plant

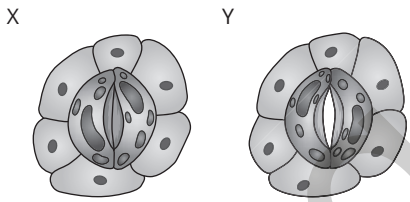
D. the transport of organic solutes from the leaves and throughout the plant

EXAM-STYLE QUESTIONS

Question 3 (10 marks)

The graph summarises water loss through transpiration from a garden plant throughout the day.





a. Define 'transpiration'. 2 marks

b. At what time of the day was the temperature likely to have been the hottest? Explain why you think so. 2 marks

c. Describe the mechanism that occurs in the guard cells as they change from state X to state Y. 2 marks

d. Consider the diagrams of stomata shown. Decide in which state the stomata of this plant are likely to be at the time you have identified in part b. Explain why you think so. 2 marks

e. Explain how the stomata operate to balance the carbon dioxide (for photosynthesis) and water conservation needs of plants. 2 marks